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INTRODUCTION

There are two steps for the recovery of the vector winds from the backscatter measurements made by the SEASAT-SASS. They are a representation for the functional relationship between backscatter, wind speed, aspect angle and incidence angle as in $F(\sigma^o, V, \chi, \theta) = 0$ and, equally important, a method for using the model function, as above, to recover the wind speed and direction plus one to three false solutions, known as ambiguities, from at least two backscatter measurements with pointing directions 90^o apart.

The SASS-1 model function is one possible relationship for $F(\sigma^o, V, \chi, \theta)=0$. The consensus is that it appears to yield winds that are biassed high and that winds recovered from V-pol pairs differ from winds recovered from H-pol pairs in a systematic way as in Woiceshyn, et al. (1984). For low winds, the discrepancies that have been found are not solely the result of any errors in the SASS-1 model function.

Another reason for the discrepancies that have been found at low winds lies in the use of the SOS (Sum of Squares) algorithm described in Jones, et al. (1982). The algorithm incorrectly forced the backscatter measurements as logarithms (i.e. $\hat{\sigma}_b^o$ in bels) to fit a normal probability density function. The correct procedure is to obtain maximum likelihood estimates (MLE) of wind speeds and directions and to use $\hat{\sigma}^o$ in antilog form to recover the winds.

There are a number of consequences of the incorrect forced use of logarithms to recover the wind. This precedure causes light wind data to be omitted and areas of calm to be lost so that the sample distribution and climatological averages of the winds recovered by the SOS algorithm are biassed too high. A very simple Monte Carlo experiment has been carried out to illustrate the differences between the SOS and MLE algorithms for recovering light winds. Also the SASS-1 model function was fitted to the JASIN data by means of the SOS wind recovery algorithm, thus biassing the SASS-1 high since only high values of backscatter, due to sampling variability, were used.

THEORY

The Probability Density Function for $\hat{\sigma}^o$

The theory of the scatterometer design can be used to show that the estimate of the received power, $\hat{P}_R$, is a normally distributed random variable as defined by equations (1), (2) and (3).

$$f(P_R) = (2\pi \text{ VAR } (\hat{P}_R))^{-\frac{1}{2}} \exp\left[- ((\hat{P}_R - P_R)^2/2 \text{ VAR } (\hat{P}_R))\right] \tag{1}$$

$$E(\hat{P}_R) = P_R \tag{2}$$

$$\text{VAR } \hat{P}_R = \alpha \, (P_R + N)^2 + \beta N^2 \tag{3}$$

The estimate of the normalized radar cross section is given by equation (4) where R and R* represent various terms in the radar equation.

$$\hat{\sigma}^o = \hat{P}_R \, R/P_T = \hat{P}_R \, R^* \tag{4}$$

Consequently (1), (2) and (3) can be transformed to (5), (6) and (7).

$$f(\hat{\sigma}^o) = (2\pi \text{ VAR } (\hat{\sigma}^o))^{-\frac{1}{2}} \exp\left[- ((\hat{\sigma}^o - \sigma^o)^2/2 \text{ VAR } (\hat{\sigma}^o))\right] \tag{5}$$

$$E(\hat{\sigma}^o) = \sigma^o \tag{6}$$

$$\text{VAR } (\hat{\sigma}^o) = \alpha(\sigma^o + N \, R^*)^2 + \beta N^2 \, R^{*2} \tag{7}$$

Equation (7) can also be rewritten as (8).

$$\text{VAR } (\hat{\sigma}^o) = A(\sigma^o)^2 + B\,\sigma^o + C \tag{8}$$

To transform (5) to a zero mean unit variance normal probability density function, one uses (9).

$$t = (\hat{\sigma}^o - \sigma^o)/(\text{VAR}(\hat{\sigma}^o))^{\frac{1}{2}} \tag{9}$$

so that estimates of the backscatter can also be represented both for the actual data and for Monte Carlo simulations by the various forms in (10) where σ^o would be the noise-free, "error free", measurement for a given V, χ and θ.

$$\hat{\sigma}^o = \sigma^o + t\ (\mathrm{VAR}\ (\hat{\sigma}^o))^{1/2}$$

$$= \sigma^o\ (1 + \frac{t\ (\mathrm{VAR}\,(\hat{\sigma}^o))^{1/2}}{\sigma^o})$$

$$= \sigma^o\ (1 + tK_p) \quad (10)$$

Equation (5) has many strange properties. Given the noise level and the design parameters of the scatterometer, the variance of the pdf is a function of the expected value of $\hat{\sigma}^o$ contrary to most normally distributed random variables where the first moment and the variance are not related to each other. Also if it was calm, one would expect the backscatter to be zero. If σ^o (the unknown true value of the backscatter) were zero, equation (5) would still be valid and the variance would equal C from (8). For areas of calm, or very light winds, the backscatter estimates are equally likely to be either negative or positive. Moreover in (10) as σ^o approaches zero, the value of K_p approaches infinity.

The SOS Algorithm

The SASS-1 model function related backscatter in bels to aspect angle (degrees clockwise from beam 1), incidence angle, and wind speed by an equation of the form of (11).

$$\sigma^o_b = G(\chi,\ \theta) + H(\chi,\ \theta)\ \log_{10} V \quad (11)$$

In antilog form the backscatter is given by (12).

$$\sigma^o = (10^{G(\chi,\ \theta)})\ V^{H(\chi,\theta)} \quad (12)$$

To stay in logarithm space, the SOS algorithm used the estimates of $\hat{\sigma}_b$ (in bels) and forced these numbers to fit a normal probability density function. From equation (10), one can obtain (13).

$$\hat{\sigma}^o_b = \log_{10} \hat{\sigma}^o = \log_{10} \sigma^o + \log_{10}\ (1 + tK_p) \quad (13)$$

The fit was a compromise so that with t equal to plus and minus one the pdf in log space had standard deviations that would come close to $\hat{\sigma}^o$ at plus and minus one standard deviation if K_p was not too large.

The standard deviation of $\hat{\sigma}_b^o$ was fitted by equation (14).

$$SD(\hat{\sigma}_b^o) = (\log_{10}(1 + K_p) - \log_{10}(1 - K_p))/2 \quad (14)$$

Consequently, the incorrect pdf for $\hat{\sigma}_b^o$ was given by (15).

$$f(\hat{\sigma}_b^o) = (2\pi)^{-\frac{1}{2}}(SD(\hat{\sigma}_b^o))^{-1}\exp\left\{-\tfrac{1}{2}\left(\frac{\hat{\sigma}_b^o - \sigma_b^o}{SD(\hat{\sigma}_b^o)}\right)^2\right\} \quad (15)$$

The notation is that "hatted" quantities are random variables and that "unhatted" quantities are population parameters. It should be noted that the standard deviation in (14) and (15) is a function of σ_b^o and not $\hat{\sigma}_b^o$. Various papers that follow the lines that lead to (15) have referred to the pdf involved as the log normal pdf. Equation (15) is not the pdf of a log normal distribution (See Mood, et al. (1963)). It basically assumes that $\hat{\sigma}_b^o$ is normally distributed. This error has propagated into the more recent literature.

In modes 3 and 4, two measurements for horizontal polarization and two for vertical polarization for "cells" with nearly the same location for nearly the same incidence angle were made with the pointing directions of the radar beams 90^o apart. If the first beam is the one considered to rotate clockwise by 90^o to the second beam, then the measurements (estimates) of the backscatter are given by (16) and (17) where χ_0 is the wind direction relative to the pointing direction of beam 1.

$$\hat{\sigma}_1^o = \hat{\sigma}^o\ (\chi_0,\ \theta_1,\ V) \quad (16)$$

$$\hat{\sigma}_2^o = \hat{\sigma}^o\ (\chi_0 - 90^o,\ \theta_1,\ V) \quad (17)$$

The problem is to recover V and χ_0 given two (or more) backscatter measurements (estimates) as perturbed from their expected value by the combined effects of communication noise and attitude errors as absorbed in the quantities A, B and C above.

The SOS wind recovery algorithm minimized equation (18) by finding those values of V and χ_0, from two to four pairs,that minimized SOS as in (18).

$$\text{SOS} = \frac{(\hat{\sigma}^o_{b1} - G(\chi_0, \theta_1) - H(\chi_0, \theta_1) \log_{10}V)^2}{(SD(\hat{\sigma}^o_{b1}))^2}$$

$$+ \frac{(\hat{\sigma}^o_{b2} - G(\chi_0 - 90^o, \theta_1) - H(\chi_0 - 90^o, \theta_1) \log_{10}V)^2}{(SD(\hat{\sigma}^o_{b2}))^2} \tag{18}$$

There are problems with (18). The values to be used in the denominator are unknown as in (8). The estimates, i.e. $\hat{\sigma}^o_1$ and $\hat{\sigma}^o_2$, were used to find K_p and the value of (14). This introduces an additional error because, if $\hat{\sigma}^o$ is less than σ^o, K_p is over estimated and the standard deviation is too large.

Moreover for low winds as V approaches zero, σ^o from (12) approaches zero and σ^o_b approaches minus infinity. Also from the correct pdf (5) and the correct equation for the variance, as σ^o approaches zero, it is possible to obtain negative values for $\hat{\sigma}^o$. Clearly (15) admits of no negative values for $\hat{\sigma}^o$ since $\hat{\sigma}^o_b$ equal to minus infinity corresponds to $\hat{\sigma}^o$ equal to zero.

So as to be able to use equations (14) and (18) on the data obtained by the SEASAT-SASS perfectly good data were rejected if (1) $\hat{\sigma}^o$ was negative, (2) $K_p > 1$, and (3) $\hat{\sigma}^o_b$ was less than -5 bels (-50 db). Deleterious consequences of throwing out these data are considered in forthcoming reports by a group that includes P. Woiceshyn, D. Boggs, G. Cunningham, M. Wurtele and W. Pierson. The cumulative effect of these missing data is to bias areas of light winds too high and to produce misleading analyses near the centers of anticyclonic flows and over other selected oceanic areas.

If A, B, and C in (8) all become small, the pdf in (5) becomes more and more concentrated around σ^o, which would correspond to error free measurements. Given the model function, either (11) or (12) can be solved for V, or $\log_{10}V$. With θ_1 known, V can be graphed as a function of χ (or χ_0) to obtain graphs such as those in Figure 1 where the solid curve is for V pol and the dashed curve is for H pol. For V pol, the two curves are equal at 0^o and at two points near 180^o for the top curves. The dashed curves are equal only at 0^o. For the middle illustration, the solid curves cross at four values of χ and the dashed curves cross at four slightly different values. These V-χ values (three or four) are the only possible values of V and χ that could have produced the two backscatter values that were used. The so-called "chicken track" plots as in Brown (1983) and Wurtele, et al. (1982) are thus "I's", "Y's" or "X's".

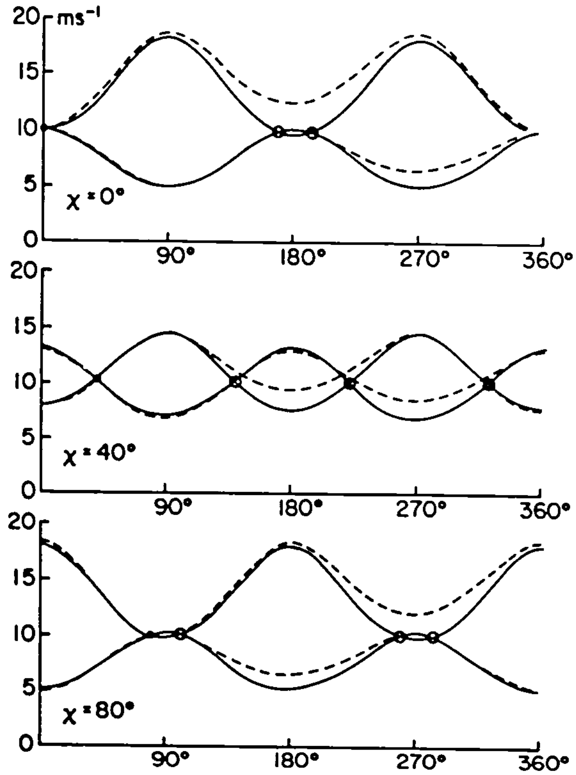


FIG. 1 Error free graphs of V versus χ for a given incidence angle and input values of the backscatter corresponding to a 10 m/s wind from 0^o, 40^o and 80^o.

For the actual recovery of the SASS winds, data were discarded according to the above three criteria. Then a two dimensional search was made over the V-χ plane to find the minima of (18). For the "X's" and the tops of the "Y's", the values of SOS are identically zero. The search procedure was not very effective so that for the "X's" four slightly different minima were found. A great deal of effort was wasted in trying to correlate the minimum SOS value with the true vector wind with, obviously, no success. If an analytical representation for the model function is available as in the research of Pierson and Salfi (1982), and if the two curves involved in pairs of backscatter measurements cross as in Figure 1, the appropriate wind vectors are simply a problem in algebra, or analysis, and not statistics.

Problems arise for the SOS near upwind or downwind relative to either beam of the scatterometer. For example, for the top curves in Figure 1, if t_1 in (10) is positive for the upwind measurement and t_2 is negative for the crosswind measurement, the upper curve will move up and the lower curve will move down so that they will not cross at all. The SOS will have two non-zero minima one exactly at 0^o and the other exactly at 180^o that correspond to the "I" solutions generated from the data. Whether or not the values for the wind speed produced by the non-zero minima of the SOS for this situation are the best speeds is questionable. The question becomes critical when an additional measurements as in the planned NROSS scatterometer for a different aspect angle are incorporated by means of additional terms in (18).

An MLE Algorithm

The two measurements (estimates) of backscatter made by the SASS are independent. Their joint pdf is consequently the product of two pdf's of the form given by (5) as in (19).

$$f(\hat{\sigma}_1^o, \hat{\sigma}_2^o) = (2\pi)^{-1}(\mathrm{VAR}(\hat{\sigma}_1^o))^{-\frac{1}{2}}(\mathrm{VAR}(\hat{\sigma}_2^o))^{-\frac{1}{2}} \cdot \exp(-\tfrac{1}{2}\Phi) \tag{19}$$

where

$$\Phi = ((\hat{\sigma}_1^o - \sigma_1^o)^2/2\ \mathrm{VAR}(\hat{\sigma}_1^o)) + ((\hat{\sigma}_2^o - \sigma_2^o)^2/2\ \mathrm{VAR}(\hat{\sigma}_2^o)) \tag{20}$$

The maximum likelihood estimate of the unknown parameters, σ_1^o and σ_2^o, treats σ_1^o and σ_2^o as variables related to each other by the model function constraint, that is

$$\sigma_1^o = (10^{G(\chi,\ \theta_1)})V^{H(\chi,\ \theta_1)} \tag{21}$$

and

$$\sigma_2^o = (10^{G(\chi-90^o,\ \theta_1)})V^{H(\chi-90^o,\ \theta_1)} \tag{22}$$

such that (19) is a maximum. If (19) has a maximum, then the natural log of (19) also has a maximum, and equation (23) is the result.

$$\ell n\ (f(\hat{\sigma}_1^o,\ \hat{\sigma}_2^o) = -\frac{1}{2}\Phi - \frac{1}{2}\ell n\ (\mathrm{VAR}(\hat{\sigma}_1)) - \frac{1}{2}\ell n\ (\mathrm{VAR}(\hat{\sigma}_2)) \tag{23}$$

Any constant can be added to (23) and the location of the maxima will not change so that a maximum likelihood estimator of V and χ would be given by (24).

$$\begin{aligned} \mathrm{MLE} = & -\frac{1}{2}((\hat{\sigma}_1^o - \sigma_1^o)^2/(A(\sigma_1^o)^2 + B\ \sigma_1^o + C)) \\ & -\frac{1}{2}((\hat{\sigma}_2^o - \sigma_2^o)^2/(A(\sigma_2^o)^2 + B\ \sigma_2^o + C)) \\ & -\frac{1}{2}\ell n\left[\frac{(A(\sigma_1^o)^2 + B\ \sigma_1^o + C)}{(A(\hat{\sigma}_1^o)^2 + B\ \hat{\sigma}_1^o + C)}\right] \\ & -\frac{1}{2}\ell n\left[\frac{(A(\sigma_2^o)^2 + B\ \sigma_2^o + C)}{(A(\hat{\sigma}_2^o)^2 + B\ \hat{\sigma}_2^o + C)}\right] \end{aligned} \tag{24}$$

where σ_1^o and σ_2^o are defined by (21) and (22). The only constants are the two estimates, $\hat{\sigma}_1^o$ and $\hat{\sigma}_2^o$, plus the parameters A, B and C. Changing the minus signs to plus signs in (24) and dropping the last two terms would require the function to be minimized. There would be a superficial resemblance to the SOS with however very important differences especially if a wind recovery method such as the NROSS SCATT requiring additional terms is to be used.

For the SEASAT pairs, if the curves in Figures 1 intersect four values (or two) of V and χ can be found such that $\sigma_1^o = \hat{\sigma}_1^o$ and $\sigma_2^o = \hat{\sigma}_2^o$ and (24) becomes identically zero. Actually the maximum of (24) can be slightly positive and slightly different values for the vector winds are found.

The major differences between the SOS (equation 18) and the MLE (equation 24) is that (24) is defined for all sample values of $\hat{\sigma}_1^o$ and $\hat{\sigma}_2^o$. There is no need to discard data for any of the three reasons that were used to recover winds with the SOS algorithm.

The lowest possible physical value for the backscatter is zero. Both estimates, i.e. $\hat{\sigma}_1^o$ and $\hat{\sigma}_2^o$, can be negative. The value of V that maximizes (24) is then zero, or calm. Thus two paired negative values of backscatter imply a wind speed of zero. Note that from equation (7) the variance can never be negative even for a negative $\hat{\sigma}^o$.

If one estimate (measurement) is negative and the other positive, (24) can still be maximized with the wind direction either upwind or downwind relative to the beam with the positive backscatter value. All positive pairs of estimates yield two, three or four solutions, one of which is close to the true vector wind. From Figure 1, if the two curves in the top drawing are shifted by sampling variability effects so that they do not cross, there will be two solutions 180^o apart, and neither the SOS nor the MLE will be close to zero. Similarly these two curves could shift to a pattern like the middle curves. If there were indeed a truely upwind wind or a downwind wind, the two algorithms would return two winds near upwind or downwind with directions to each side of the true directions. Since the curves in Figure 1 have zero slopes at 0^o, 90^o, 180^o and 270^o, small sampling variability effects can produce large changes in direction.

Wentz and Peteherych (1984) write:

> "The preaveraging of σ^o before retrieving wind speed increases the signal-to-noise ratio (SNR). In a 150 km cell in the middle of the SASS primary swath, there are typically 9 observations from each beam. Averaging these observations increases the SNR by a factor of 3. For light winds below 6 m/s, the SNR is poor, and the preaveraging helps considerably. In the original SASS algorithm (Jones, et al. (1982)), no preaveraging was done. The low SNR measurements were simply excluded from processing, which resulted in data gaps in low wind speed areas and a positive bias in the retrieved wind speeds for moderate wind speed areas."

This statement misses the point completely. The SASS-1 model function could have been used to recover the winds for all pairs of backscatter measurements if a correct wind recovery algorithm had be used. The SOS algorithm is at fault, not necessarily only the model function.

DESIRABLE THEORETICAL PROPERTIES OF EMPIRICALLY DETERMINED MODEL FUNCTIONS

The SASS-1 model function can be used in two different ways, one as a G-H table as in Schroeder, et al. (1982), the other in a quasi-analytical form as in Pierson and Salfi (1978). Given an incidence angle, the model function becomes an analytical function of aspect angle and wind speed. For winds less than about 100 m/s if represented by, say, (21), for either polarization and, in a shortened notation, by, $\sigma^o = \sigma^o(V, \chi, \theta)$, then for any fixed χ and θ, if $V_2 > V_1$, then

$$\sigma^o (V_2; \chi_1, \theta_1) > \sigma^o (V_1 ; \chi_1 \theta_1) \qquad (25)$$

also, if $V = 0$, $\sigma^o = 0$.

Also, if $\theta_2 > \theta_1$, then

$$\sigma^o (V_1, \chi_1, \theta_2) < \sigma^o (V_1, \chi_1, \theta_1) \qquad (26)$$

for $\theta > 20^o$, or so.

It was more difficult to obtain the following properties.

For fixed V_1 and θ_1,

$$\frac{d\sigma^o}{d\chi} = 0 \text{ and } \frac{d^2\sigma^o}{d\chi^2} < 0 \qquad \text{at } \chi = 0 \qquad (27)$$

$$\frac{d\sigma^o}{d\chi} = 0 \text{ and } \frac{d^2\sigma^o}{d\chi^2} > 0 \qquad \text{at } \chi = 90^o \qquad (28)$$

and $$\frac{d\sigma^o}{d\chi} = 0 \text{ and } \frac{d^2\sigma^o}{d\chi^2} < 0 \qquad \text{at } \chi = 180^o \qquad (29)$$

Also σ^o is an even function of χ for χ varying from, say -180^o to $+ 180^o$. Finally, σ^o at $\chi = 0$ can be made greater than, less than or equal to σ^o at 180^o without displacing the minima at 90^o and -90^o (or 270^o).

The analytical expression is given in powers of $\cos\chi$ as in $(\cos \chi)^n$ for n equal to 2 to 7 which allows some control of the shape of the curves. The analysis was done in log σ^o- log V space, which may have complicated the procedures,but the curve fitting methods all attempted to obtain the best prediction of V as a function of σ^o, not the other way around.

Whether or not conditions, (27) to (29) actually hold concurrently with the requirement that upwind can differ from downwind is difficult to establish. It is also difficult to show that crosswind backscatter must be a minimum at 90^o. A minimum that varies in an uncontrolled way and occurs either for $\chi < 90^o$ or for $\chi > 90^o$ is equally hard to justify especially for cell sizes such as those of the SASS and instruments in the planning stage. Ignoring the above requirements, and whether or not they are needed, does not make them go away.

Three recent papers, Schroeder, et al. (1984), Wentz, et al. (in press) and Britt and Schroeder (1984) have provided results on the possible form of a model function. Schroeder, et al. (1984) represented backscatter by equations of the form

$$\sigma^o = A_0 + A_1 \cos \chi + A_2 \cos 2\chi \qquad (30)$$

,which was called a second order model, and by

$$\sigma^o = a_0 + b_0 \theta + (a_1 + b_1\theta) \cos \chi + (c_1 + d_1 \theta) \sin \chi$$

$$+ (a_2 + b_2 \theta) \cos 2\chi + (c_2 + d_2\theta) \sin 2\chi \qquad (31)$$

which was called a ninth order model.

Equation (31) is not an even function of χ and most of the analysis concentrated on (30). The nomenclature is strange because a higher order model would, per se, have to include higher harmonics of cos χ to be legitimate. In (30), it is not possible to control the location of the minimum near 90^o and whether or not upwind is greater than or less than downwind. In (30), σ^o at upwind is given by

$$\sigma^o(0) = A_0 + A_1 + A_2 \qquad (32)$$

at downwind it is

$$\sigma^o(180^o) = A_0 - A_1 + A_2 \qquad (33)$$

and at 90^o (crosswind?), it is

$$\sigma^o(90^o) = A_0 - A_2 \qquad (34)$$

The value of (30) at 90^{o} is not its minimum because

$$\frac{d\sigma^{o}}{d\chi} = - A_1 \sin \chi - A_2 \, 2 \sin 2\chi$$
$$= - A_1 \sin \chi - 4 A_2 \sin \chi \cos \chi$$
$$= 0 \qquad (35)$$

yields

$$\cos \chi = \frac{- A_1}{4A^2} \qquad (36)$$

or

$$\chi = \cos^{-1}\left[- A_1/4A_2\right] \qquad (37)$$

In (35) the sine of χ can be cancelled for χ near 90^{o} since it is not zero. If A_1 is zero in (37), χ is 90^{o}. If A_1 is positive, i.e., upwind backscatter is greater than downwind, then χ is greater than 90^{o}, and conversely if A_1 is negative, χ is less than 90^{o}. In Fig. (21) of Schroeder, et al. (1984) the values of A_1 scatter positive and negative as a function of wind speed and incidence angle. The minima for the various circle flights as plotted in their Figs 10 to 16 scatter to either side of 90^{o} and 270^{o} solely as a function of the sign of A_1. The scatter of the raw data does not justify such an arbitrary relationship. A model based on only three parameters cannot distinguish these properties.

Although the model function developed for the SASS called GHTBW7 in Schroeder, et al. (1982) closely followed the CWK model function and had minima at 90^{o} (and 270^{o}), the results of Wentz, et al. (1984), see also Wentz and Peteherych (1984), do not have this property. Backscatter in antilog space is represented by an equation of the form (38).

$$\sigma^{o} = A_0(V, \theta) + A_1 (V, \theta) \cos \chi + A_2(V, \theta) \cos 2\chi \qquad (38)$$

This equation can also be written as, say,

$$\sigma^{o} = \beta(\theta) \, V^{H(\theta)} \cdot \left[1 + \beta_1 (V, \theta) \cos \chi + \beta_2 (V, \theta) \cos 2\chi\right] \qquad (39)$$

The wind speed dependence for β_1 and β_2 is mild, and the model no longer has a power law relationship. The minima near 90^{o} are uncontrolled and occur at values given by equation (40).

$$\chi_m = \cos^{-1}\left\{-\beta_1 (V, \theta)/4\beta_2 (V, \theta)\right\} \tag{40}$$

The minimum value of the backscatter at $\chi = \chi_m$ can be shown to be equal to (41).

$$\sigma^o_m = \beta(\theta)\ V^{H(\theta)} \cdot \left[1 - \beta_2(V, \theta) - \frac{(\beta_1(V, \theta))^2}{8 (\beta_2(V, \theta))}\right] \tag{41}$$

The minimum is thus always less than the value at 90^{o} if β_1 is not zero. In bels, (39) can be written as (42) and (41) as (43).

$$\sigma^o_b = \log_{10} \beta(\theta) + H(\theta) \log_{10} V + \log_{10} \left\{1 + \beta_1(V, \theta) \cos \chi + \beta_2(V, \theta) \cos 2\chi\right\} \tag{42}$$

$$\sigma^o_{bm} = \log_{10} \beta(\theta) + H(\theta) \log_{10} V + \log_{10} \left[1 - \beta_2(V, \theta) - \frac{(\beta_1(V, \theta))^2}{8\,\beta_2(V, \theta)}\right] \tag{43}$$

Minimum backscatter occurs at values of χ of as much as 105^{o} and as little as 255^{o}. There also appear to be values of V and θ such that the last term in (41) is negative and the last term in (43) is undefined. Negative theoretical values for σ^{o} are a physical contradiction.

A Fourier series representation of (42) would require many higher harmonics of cos χ but the properties of the SASS-1 described above would not be reproduced.

Wentz, et al. (1984) compare this new model function with the SASS-1 and find rather large direction differences that are immediately ascribed to errors in SASS-1 without any comparison to actually measured wind directions. The superiority, if any, of this new model function has yet to be demonstrated.

Britt and Schroeder (1984) obtained a multiple regression fit to the backscatter of the form of equation (44) for both V pol and H pol where the coefficients corresponding to b_3, b_6 and b_8 were found to be of no importance.

$$\sigma^o_{db} = b_{12} + b_1 (\sin\theta)^2 + b_2 (\sin\theta)^3$$
$$+ \left\{b_4 + b_5 (\sin\theta)^2 + b_7 (\sin\theta)^4\right\} \log W$$
$$+ \left\{b_9 (\sin\theta)^2 (\cos\chi)^2 + b_{10} (\sin\theta)^2 (\cos\chi)^3\right.$$
$$\left. + b_{11} (\sin\theta)^2 (\cos\chi)^4\right\} \log W \tag{44}$$

Also higher powers of log W were tested but found to be of no importance for the range of wind speeds available and the method of analysis. From the above analysis, the minima are always exactly at 90^o in contrast to the other two studies. The results are still a power law for the wind speed once θ and χ are fixed. The form yields an upwind downwind difference ($(\cos\chi)^3$) as well as a modest control of the shape function ($(\cos\chi)^4$) at high incidence angles. Although greater weight is placed on the higher winds, one notes that backscatter is still being predicted from wind speed and not vice versa. The goal of remote sensing is to predict wind velocity from backscatter, not the other way around. The SOS wind recovery algorithm was used with some modifications. This model function would not fare much better than the one for SASS 1 if the SOS recovery algorithm is used.

A MONTE CARLO SIMULATION OF THE SOS VERSUS THE MLE FOR UPWIND AND DOWNWIND AT SELECTED INCIDENCE ANGLES

If only vertically or horizontally polarized pairs are considered for simplicity, two measurements (or estimates) of the backscatter will most frequently yield a pair of values from which a pair of curves similar to the pairs in the center drawing of Figure 1 would result. If calculated to sufficient accuracy both the SOS and MLE would yield nearly the same four solutions because both the SOS and the MLE would identically equal zero at the crossing points.

The SOS, even for this situation, makes an unnecessary error. Before calculating the vector winds for the SOS, the K_p values are needed so as to calculate the denominators in Eqn. (18). If either one of the two exceeds one, Equation (14) cannot be evaluated, and the measurements of backscatter were discarded.

If the wind is actually near upwind, or downwind, for either of the two beams, a pair of curves similar to those at the top or bottom of Figure 1 will result. Sampling variability as a result of communication noise and attitude error can then cause the appropriate two curves either to shift apart so that they do not cross at all or to shift so that they cross and yield two solutions near upwind and two near downwind, with all four, plus and minus up to 30 degrees, or so.

If the curves in Fig. 1 do not cross, both the SOS and the MLE yield winds at upwind and downwind in the real situation. However, even here many SOS values were thrown out, especially those for backscatter measured near cross wind because K_p was greater than one.

To show what happens when the SOS and the MLE are compared, with the assumption that the SASS-1 is correct, a simplified Monte Carlo simulation was developed. Only incidence angles of 26, 36, 40, 46 and 52 degrees were used. The input winds were either upwind or downwind, and therefore only values from the G-H tables for 0, 90 and 180 degrees for the aspect angle were needed since upwind would be at 0 degrees, downwind at 180 degrees and crosswind always at 90°.

The values of A, B and C from Equation (8) are also needed. These are cell number dependent and may vary with the noise background. Representative values for these three constants were found by means of the data tabulated by the NASA Langley Research Center and used in the study by Pierson, et al. (1984). The data contained values of the backscatter, incidence angle and K_p for each pair of measurements that were used to recover a wind vector.

The values were sorted on polarization and incidence angle with the result that there was a large data set for each incidence angle in a one degree range, X.00 to X.99. For this set, each pair of values of σ^o (antilog) and K_p (percent) should satisfy an equation of the form of Equation (45).

$$A(\sigma^o)^2 + B(\sigma^o) + C = (K_p)^2 (\sigma^o)^2/10^4 \qquad (45)$$

Representative values of A, B and C can be found by minimizing a quadratic of the form given by (46) summed over the whole data set.

$$Q = \sum_i \left[A(\sigma^o_i)^2 + B(\sigma^o_i) + C - (K_p)^2 (\sigma^o_i)^2/10^4\right]^2 \qquad (46)$$

The values of A, B and C found in this way for each incidence angle range were then smoothed by a three point running average (0.25, 0.50, 0.25) and the values for A, B and C for the above values of θ were read off for the program.

The values for A, B and C that were used are given in Table 1. If the true values of the noise free backscatter were known, the variance of the randomly varying backscatter estimates is high on the inner and outer edge of the swath, especially compared to the values for a 46^o incidence angle. Table 1 agrees well with the known design features of the SEASAT SASS.

TABLE 1 Representative Values of A, B and C as a Function of Incidence Angle. They do not depend on polarization.

THETA (DEG)	A	B	C
26	7.6×10^{-2}	1×10^{-4}	3.6×10^{-6}
36	2.49×10^{-3}	2.85×10^{-5}	7.2×10^{-7}
40	1.56×10^{-3}	1.2×10^{-5}	2.2×10^{-7}
46	9×10^{-4}	4.9×10^{-6}	2.2×10^{-7}
52	2.75×10^{-3}	9.5×10^{-6}	7×10^{-7}

The program listing for IBM PC BASIC is given in an appendix along with an accompanying annotation to describe the program flow. The goals of the program are (1) to simulate finding four co-located backscatter measurements, two vertical polarization and two horizontal, that will return exactly two upwind (or downwind) wind speeds from the MLE given that the correct wind is upwind, or downwind, and that the true input wind speed is known, (2) to determine whether or not the SOS would have recovered a wind from these backscatter values and, if so, the wind speed, (3) to determine whether or not two solutions near upwind, or downwind, would have been recovered and, if so, whether or not the SOS would have recovered them, (4) to determine the number of times a report of "calm" should have been returned, (5) to determine the number of times a large direction error would have occurred and (6) to accumulate appropriate statistics on the Monte Carlo results.

To test the program, only one wind speed is done ($Y = 0$). To get winds from the highest input integer value decreasing by 1 m/s and ending at 0.01 m/s, N = 1 (line 41) is entered. A random number seed, the number of sets of four required, the highest wind to be used, the required incidence angle and whether upwind or downwind is to be done are then input. This starts the program running until one way or the other it reaches lines 3246 and 3250 and stops.

Starting values are set to zero or one. There are two kinds of PRINT statements, one to keep track of the program flow on the screen and the other to write the data to a diskette for printout as the final results. Each time the program passes line 320, the count for that wind speed (CT) and the total count (TCT) for the full run are incremented by one.

The program is somewhat reminiscent of a child's game whereupon if a player reaches certain squares on a board he has to start over at line 250. This can happen in a number of different ways because the goal is to obtain four winds from the same direction, one each for SOS (H pol), MLE (H pol), SOS (V pol) and MLE (V pol) if the MLE solutions exist at, say, upwind.

With H pol to start, the subroutine at line 3260 is entered to find the values of $G(\chi,\theta)$, $H(\chi,\theta)$, A, B and C needed for that look direction and incidence angle. The backscatter in bels at upwind (or downwind) and at crosswind for the true input wind are found (say SU and SC) as well as the variances (VU and VC), lines 360 and 370, and so on. The values in bels are converted to antilogs as in S1 and S2. Subroutine 3730 generates random values from an approximately normal pdf with a zero mean and a unit variance. These numbers are multiplied by the theoretical standard deviation and added to the noise-free backscatter values to generate RU and RC, say.

The result is two values for the backscatter for that wind for that polarization for that incidence angle that have had the effect of communication noise and attitude error added. If the input winds is light (say 1 cm/sec) strange results can occur.

One is that the upwind value of the backscatter can be less than the cross wind value in which case the program goes to line 1950. At line 1950 if RC is positive, this means that the wind that would be recovered by the MLE would have a large direction error. Since the H pol values are being used, B1 is incremented by one, P is set to zero and the program returns to line 250 to try again.

If, on the other hand RC is negative (RU must be still more negative), both perturbed values are negative. The SOS cannot handle this problem so a default value of 99.99 for V1 is given for the SOS H wind. The MLE would return a zero speed, but to tabulate it, a value of .001 m/s is used. B2 is incremented by one to keep track of the number of calms for H pol. The polarization is changed to V pol and the program returns to line 260.

If RU is not less than RC, then RU is greater than RC, and, line 500, if RU is negative both backscatter values are negative. The program goes directly to 2010, outputs a 99.99 default SOS H and a .001 MLE for H pol, changes the polarization to V pol and returns to line 260.

For H pol (P = 0), if none of the above happens, the program goes to line 800 where it recovers the needed parameters, just be sure, from the subroutine. For H pol and upwind lines 810 to 860 do nothing. RU must be positive if this point is reached so that the wind that would give the upwind perturbed backscatter value is found (line 870). The crosswind backscatter value can still be negative so the crosswind wind speed is set to zero if it is and the program goes to line 1100. The count for a negative value of the backscatter at crosswind at H pol is incremented by one, and since the SOS fails, the default value of 99.99 for V1 is set (line 1240).

An MLE solution still exists so the program continues to line 1260 to recover an MLE for H pol. If something has gone wrong, line 1280 exits to 3250 (STOP).

The MLE will be described later, but if the program gets to line 900, two wind speeds are available as well their accompanying backscatter values. The squares of K_p can be found (910, 920) and if either is greater than one the SOS then defaults. A double error in the SOS theory occurs here because the backscatter estimate is used which worsens the situation at low winds by throwing out values that would recover low winds and keeping only those values that would recover winds that were too high.

If either K_p is greater than one, 930 and 940 go to 1130, and increment B4 by one. If CR < UR an MLE exists at upwind (for this example) for H pol and the default value for SOS H of 99.99 is entered. If CR > UR, two solutions exist near upwind, B6 is incremented by one, polarization is set to H pol, and the program starts over at line 250.

At line 950 if CR > UR, the SOS would recover two solutions near upwind (or downwind) since the K_p values are less than one. These events are counted by incrementing B5, polarization is set to H pol and the program returns to line 250.

If the program reaches line 960, all conditions are satisfied for the SOS to return a wind at upwind, for example, for H pol. Since χ is fixed, equation (18) is only a function of $\log_{10} V$. Equation (18) can be minimized by setting the derivative with respect to log V equal to zero and solving for $\log_{10} V$. This is done by means of lines 960 to 1050. The antilog to two places after the decimal is found, 0.001 is added to it, and the result for the SOS wind is shown on the screen for the polarization of the backscatter values that were used. The useless $(0.07)^2$ for model error is added in the denominator.

The program then moves to line 1260. At this point, line 1260 has been reached in two different ways, one with a positive upwind backscatter and a negative crosswind backscatter and the other with two positive backscatter values for a condition such that the two appropriate curves in Fig. 1 do not cross. An exactly upwind (or downwind) value for the speed can be found by the MLE. The SOS could have defaulted to 99.99 and the MLE would still exist. If the SOS defaulted and the MLE returned "calm", the program goes to V pol.

Lines 1260 to 1910 find the wind speed for the MLE. The wind at upwind from the perturbed backscatter value for upwind is divided into 20 equal steps by $W = J \cdot UR/20$ at line 1300. The negative of (28) is calculated such that all terms vary as a function of W except the two "hatted" perturbed backscatter values.

As J is incremented by one, with special treatment near J = 1, 2 and 3, X = -MLE first decreases and then for some J = J* + 1 is greater than the value at J*. The minimum of X is then somewhere between J* - 1 and J* + 1 and the wind speed for that minimum is somewhere between W =(J*-1)UR/20(= W1), and W = (J* + 1) UR/20 (=W3). The MLE wind is then close to that value of K that minimizes X in 1400 where Y = W1 + K (W3 - W1)/40 as K is varied from zero through positive values and X is computed for each trial wind. For a UR of 10 m/s the wind at minimum X is within 0.025 m/s of the true MLE wind. The search starts by incrementing K from zero and if X(K* +1) > X(K*) the wind at K* is used as the MLE, rounded to two decimal places with 0.001 added and assigned the MLE speed value for H pol.

The program goes to 2070, finds out that P = 0 (H pol), continues to 2080 where P is set to 1 (V pol) and returns to 260 to start over along similar paths to try to get the corresponding V pol winds. Lines 810 to 860 simply make V pol data and downwind data look like upwind data at H pol to the SOS problem and the MLE problem.

The counts are C1 to C6 for V pol. For various defaults such as a large direction error or two solutions near upwind (or downwind) for V pol, the results for H pol are forgotten by setting P = 0 and the program starts over for H pol at line 250. (There are some redundant lines, in a few places). Not doing so would correspond to an "I" solution for H pol and an "X" for V pol, for example, at the same place, which can happen for actual data. One result of this step is to produce greater totals for the B's than the C's in the final tables. Conditions for which H pol fails and V pol would have succeeded are not found.

Sooner or later two solutions at V pol are found as either a default SOS value or an actual SOS wind speed and as either an MLE calm or an MLE wind speed. These four values correspond to PP = 1 at line 120. The screen shows the four values that were found, and the line to the disk is opened to save the data so as to be able to print a table for results. For the first four values, some blank lines are entered to space subsequent tables. A table heading is written to the disk along with the parameters for the table and headings for the columns.

The four results are then placed under the column headings with the 0.001's deleted. Lines 2280 to 2490 begin to accumulate statistics on the output such as the number of times the speed is within ± 1 or ± 2 m/s of the input wind, the number of SOS defaults, the number of calms and the sums and the sums of squares of the non-default values.

When this is done, it is time to do the next pass, if necessary, PP is incremented by one, the polarization is set to zero, the output to the disk is ended if the required total (line 50) has not been reached and the program returns to 250. The process continues until 25 (for the tables to be given) results for SOS H, MLE H, SOS V and MLE V are found. The rest of the output for a given run is better explained by means of the totals that were generated.

When the output tables are completed and stored on the diskette for a particular input wind, if the run is a test (line 3244), the program stops. Otherwise, the input wind is decreased by 1 m/s, unless it is 1 m/s, in which case it is set to 0.01 m/s. The program returns to line 90, zeros out previous data and counts, and starts a new table. When the table for 0.01 is completed the program stops.

The addition of $(0.07)^2$ to the denominator of (18) for "model error" changes the upwind or downwind results (I and Y) but not the four solution results (X). Whether or not the SOS would have been closer to the input winds without this constant is undetermined. Only what was done for Seasat is modeled.

Program Errors and Notation

Two errors were found in the program at lines 2350 and 2450. For 2350, the first VW had been entered as a W1. In 2450, 0.999 had been entered as 1.999. The listing has been corrected, and the counts for V1-4, 2 under MLE H and V1-4,1 under MLE V have been corrected, as have the figures and tables. Appendix B contains an explanation for the mysterious appearance of 0.001 throughout and of some of the symbols used in the code.

Subroutines

The two subroutines start at lines 3260 and 3730. The first one provides the upwind, downwind and crosswind values of G and H along with the values of A, B and C for the chosen incidence angles

The second generates a random variable with a zero mean and a standard deviation of one that is close to being normally distributed. Twenty five random numbers that are rectangularly distributed between -0.5 and + 0.5 are stored as F(0), F(1), ... F(JJ).... F(24). These are added to get F1. The quantity $G = (12)^{\frac{1}{2}}$ (F1)/5 is the desired random variable. It ranges from - 8.660254 to + 8.660254 instead of having an infinite range. Since the probability of being outside ± 4.417 for the unit normal pdf is 10^{-5}, 25 terms probably suffice. The theory can be found in Mood, et al.(1963), pgs. 238. and 195.

THREE TABLES AS EXAMPLES

One hundred and ten tables (eleven different winds, 10, 9, ... 1, 0.01, five incidence angles, 26, 36, 40, 46 and 52, and upwind and downwind looks), were generated. Three examples will be discussed, and all are given in an appendix. There is a complex interaction between the model function, the antenna pattern of the SEASAT SASS and the subsequent behavior of the variance of the estimate that determines the characteristics of the results. To show what happens when the wind speed is decreased, the results for downwind looks for an incidence angle of 40° and input winds of 5, 3 and 0.01 m/s will be described.

Table 2 gives the results for 5 m/s. Out of twenty five tries the SOS would fail to return a wind speed at downwind five times. Since there was no negative backscatter value (B3 = 0) at crosswind, the SOS failed because K_p was greater than one.

There were no large direction errors and no calms for either H pol (B1 and B2 = 0) or V pol (C1 and C2 = 0). These would have been 27 SOS solutions (B5 = 27) yielding two wind directions near downwind for H pol and 15 SOS solutions (C5 = 15) at V pol. For none of the randomizations would two solutions near downwind for either H pol or V pol been rejected (B6 = C6 = 0).

From the next table, all 20 of the SOS horizontal polarization recoveries were within ± 1 m/s of 5 m/s as were all 25 for the other three kinds of

TABLE 2

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 5
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
5.15	5.17	4.94	5.04	1
99.99	4.04	5.05	5.07	2
4.78	4.73	5.12	5.18	3
5.03	4.95	4.75	4.84	4
5.07	4.96	4.97	5.09	5
4.76	4.68	4.86	4.96	6
5.45	5.42	5.00	5.02	7
4.96	4.96	4.94	4.98	8
4.78	4.78	5.14	5.23	9
99.99	4.92	5.22	5.30	10
4.42	4.40	5.24	5.25	11
99.99	4.70	5.07	5.15	12
5.07	5.07	4.83	4.91	13
5.03	4.96	4.95	5.07	14
4.88	4.87	5.28	5.39	15
99.99	4.56	4.95	4.97	16
5.08	5.08	5.16	5.16	17
5.55	5.57	4.87	4.97	18
4.41	4.41	5.04	5.06	19
99.99	4.98	5.35	5.45	20
4.49	4.48	4.65	4.66	21
5.32	5.14	4.98	5.06	22
5.42	5.43	4.99	4.99	23
5.30	5.14	4.99	5.01	24
5.46	5.49	4.96	5.07	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 5 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 27 C5 = 15
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	20	25	25	25
V1-4,2	20	25	25	25
V1-4,9,0	5	0	0	0

CT = 67 TCT = 579

	N	MEAN	VARIANCE	STD-DEV
SOSH	20	5.02	.11	.33
MLEH	25	4.92	.13	.36
SOSV	25	5.01	.02	.14
MLEV	25	5.08	.03	.18

solutions.

There were 67 passes through the program to find the twenty five sets that were first tabulated.

The means for the four columns tabulated, with defaults omitted, are within 10 cm/s of the input wind, and the standard deviations for H pol are about double those for V pol.

Table 3 gives the results for 3 m/s. For H pol, the SOS failed 22 times and only recovered 3 winds. For V pol, the SOS recovered 10 winds. The MLE's went happily along and recovered 25 winds for both H and V pol.

The perturbed backscatter values at H pol would have produced large direction errors. (If the MLE had been used and, perhaps, if the SOS had had K_p's less than one). There were no backscatter values corresponding to calm.

Negative values for the received power, and hence for backscatter, occurred 19 times for H pol and 2 times for V pol at crosswind. The MLE still exists. For 27 times there would have been a downwind solution for H pol MLE but not for H pol, SOS and correspondingly for V pol for 14 times.

The SOS would have recovered 31 H pol and 20 V pol solutions with two directions near downwind for K_p's less than one. It would have discarded 3 solutions at H pol and 1 at V pol for K_p's greater than one.

All three SOS H and all ten SOS V recoveries were within ± 1 m/s. One of the twenty five MLE H recoveries was outside of ± 1 m/s (Number 7 was 1.78 m/s).

The program cycled 89 times to recover the 25 sets for four winds given in the first part of the table. The number of returns is 9 + 31 + 20 + 3 + 1 = 64. This plus 25 gives the 89.

The three SOS H values give a mean biassed high by 0.75 m/s. The standard deviation of the MLE H recoveries are double (or so) the V pol recoveries.

Table 4 is for an input wind of 1 cm/sec. It could equally well have been 1 mm/sec, or even less, just as long as the program was not required to compute the log of zero.

The SOS computations give up completely and return default values. The MLE's return either a calm (0.00) or some wind speed. The highest for H pol is 2.01 m/s and the highest for V pol is 1.51. Logarithmically computed the H pol value is 23 db too high, and as a percentage 20100% too high, compared to the input. The danger of working solely in double log space and of the present SASS-1 tables and

TABLE 3

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 3
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	2.92	3.34	3.34	1
99.99	3.28	99.99	3.19	2
3.66	3.63	99.99	3.03	3
99.99	2.62	99.99	3.15	4
3.87	3.83	99.99	3.20	5
99.99	3.36	2.96	2.95	6
99.99	1.78	99.99	2.94	7
99.99	3.04	3.03	3.01	8
99.99	3.12	3.49	3.49	9
99.99	3.09	99.99	3.13	10
99.99	2.17	99.99	3.29	11
99.99	2.49	99.99	3.07	12
99.99	2.30	99.99	2.83	13
99.99	2.64	99.99	3.06	14
99.99	2.67	99.99	2.84	15
99.99	3.12	99.99	3.12	16
3.72	3.70	3.14	3.13	17
99.99	3.58	99.99	2.36	18
99.99	2.63	3.11	3.09	19
99.99	2.79	99.99	3.06	20
99.99	2.86	3.01	3.00	21
99.99	2.48	3.51	3.50	22
99.99	2.40	3.17	3.16	23
99.99	2.70	3.36	3.32	24
99.99	3.01	99.99	3.43	25

LARGE DIRECTION ERROR: RETURNS
B1 = 9 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 19 C3 = 2
NO SOS: CONTINUES
B4 = 27 C4 = 14
SOS: TWO SOLUTIONS: RETURNS
B5 = 31 C5 = 20
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 3 C6 = 1

	SOSH	MLEH	SOSV	MLEV
V1-4,1	3	24	10	25
V1-4,2	3	25	10	25
V1-4,9,0	22	0	15	0

CT = 89 TCT = 755

	N	MEAN	VARIANCE	STD-DEV
SOSH	3	3.75	.01	.10
MLEH	25	2.89	.24	.49
SOSV	10	3.21	.03	.18
MLEV	25	3.11	.05	.23

TABLE 4

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = .01
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.02	99.99	0.72	1
99.99	0.00	99.99	0.00	2
99.99	0.76	99.99	0.00	3
99.99	0.00	99.99	0.00	4
99.99	0.00	99.99	0.90	5
99.99	1.24	99.99	0.00	6
99.99	1.16	99.99	0.00	7
99.99	0.00	99.99	0.00	8
99.99	0.00	99.99	0.00	9
99.99	0.00	99.99	0.00	10
99.99	1.63	99.99	1.12	11
99.99	0.00	99.99	0.78	12
99.99	0.00	99.99	0.00	13
99.99	1.52	99.99	1.10	14
99.99	0.00	99.99	1.25	15
99.99	0.00	99.99	0.00	16
99.99	1.88	99.99	0.82	17
99.99	0.00	99.99	0.00	18
99.99	0.00	99.99	0.00	19
99.99	1.59	99.99	0.00	20
99.99	0.00	99.99	0.06	21
99.99	2.01	99.99	0.00	22
99.99	0.00	99.99	0.00	23
99.99	0.00	99.99	1.51	24
99.99	0.00	99.99	0.00	25

LARGE DIRECTION ERROR: RETURNS
B1 = 47 C1 = 19
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 29 C2 = 15 (16)
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 17 C3 = 9
NO SOS: CONTINUES
B4 = 9 C4 = 6
SOS: TWO SOLUTIONS: RETURNS
B5 = 1 C5 = 1
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 5 C6 = 5

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	18	0	21
V1-4,2	0	24	0	25
V1-4,9,0	25	16	25	16

CT = 103 TCT = 1047

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	.47	.52	.72
SOSV	0	88.88	88.88	88.88
MLEV	25	.33	.25	.50

SOS recovery algorithm is clearly shown. All values still meet the ± 2 m/s design objective for the SASS as far as the MLE is concerned.

There were 47 H pol situations and 19 V pol where a large direction error would have resulted. There were 29 calms for H pol and 15 for V pol. There were 29 calms for H pol but some were lost, because V pol lead to a return before the set of four was completed at V pol.

The SOS would have recovered one solution each for H and V pol with two directions close to downwind. It would have failed because K_p was greater than one 5 times for both H pol and V pol.

The H pol MLE recovered 18 solutions and the V pol MLE recovered 21 solutions within ± 1 m/s. The line V1 - 4, 9, 0 counts the number of default SOS (25 in each case) and the number of calms for the MLE (16 in each case).

The program cycled 103 times to get the 25 sets of 4 solutions.

The default value for the mean is 88.88, and if there is no mean the default standard deviation is also 88.88. If one SOS is recovered, the mean is that value and the default standard deviation is 77.77. For the MLE solutions, mean winds of 47 cm/sec ± 72 cm/sec and 33 cm/sec ± 50 cm/sec provide a pretty good idea that the winds for a given area are nearly calm. This is useful information for a synoptic scale meteorological analysis.

The full set of 110 tables ordered by increasing incidence angle, then by upwind and downwind and finally by increasing wind speed is given in Appendix A. The program cycled 10,376 times to find the 2,550 values that Monte Carlo the upwind-downwind results to simulate pairs of H pol and V pol measurements near a single point on the ocean that would both return either a "calm" or an upwind or downwind direction relative to one of the beams.

Were the wind direction 45^o or 135^o relative to one of the beams, the SOS would do a little better for light winds. This analysis is a worst case analysis since crosswind backscatter is a minimum and has a high probability of being discarded for the reasons given on page 5.

AN ANALYSIS OF THE SIMULATION

Compounded Errors

Recovering vector winds from measurements of backscatter by an instrument on a spacecraft orbiting the earth at 800 km is a multifaceted, difficult problem. The successes of the SASS on SEASAT, with due considerations of the difficulties as in the Jet Propulsion Lab. Workshop Reports, shown by Peteherych, et al. (1984) and Pierson, et al. (1984) provide assurance that the successor to the SASS will perform far better than the SASS.

An improved theory and model for the relationship between backscatter, wind speed, aspect angle and incidence angle will be needed. It is already clear that the SASS-1, especially when combined with the SOS wind recovery algorithm, is inadequate. Although some of the results of Woiceshyn, et al. (1984) can be explained by the incorrect used of the SOS wind recovery algorithm, many of the results that have been obtained cannot be explained on this basis.

This study is an analysis of "what would be if". The assumption that the SASS-1 model function is correct is made, and then the differences between the recoveries of the SOS algorithm and the MLE algorithm are analysed. With qualifications, to be discussed in a following section, the same kind of results would have been obtained if an absolutely correct model function had been used.

The point of the analysis is simply that the SOS wind recovery algorithm is incorrect, both from a theoretical and an applied point of view. The conclusions of Rumsey (1979), see Schroeder, et al. (1982), page 3321, were incorrect. The assembled experts were not expert enough to recognize the inherent fallacy of forcing the random variations of the backscatter estimates to fit the totally incorrect probability density function given by eqn. (15).

The inability to fit this incorrect probability density function for values of K_p greater than one, and the consequences of this failure for all subsequent efforts to obtain a model function and to obtain the best possible winds from the SEASAT SASS were not recognized.

By throwing out data because K_p was larger than one, samples for light winds, for which good solutions could have been obtained, were discarded. The values of backscatter that were kept would be too high on the average for low wind speeds, and the process of "fine tuning", in this case forcing the model function to fit an improperly drawn sample, would produce a model function that required backscatter values that were too high for light winds. The error in using the SOS algorithm consequently made it impossible to obtain a correct model function at light winds. If the light winds are incorrect, and if a "power law" fit is being sought over a limited range of quality comparison data, moderately good, but deceptive, agreeement can be found over the range of the higher winds in the sample.

There are other aspects of this problem having to do with the communication between the modelers of the backscatter-wind speed data processing and the meteorologists who were given the final product for analysis that will be treated in a following section. Coded symbols on the "chicken track" plots representing the various contingencies in this Monte Carlo simulation would have made it immediately obvious to meteorologists that areas of light winds and calms could be identified.

SOS Defaults

For a low enough wind and for conditions for which the MLE will return either a calm or a wind speed either at upwind or downwind relative to one of the SASS beams, the SOS algorithm must fail for the reasons given on page 5. The simulation did not test for backscatter less than -5 bels and $K_p < 1$, but from Table,1 K_p would have to greater than one.

Table 5 summarizes the total SOS defaults in this simulation as a function of incidence angle and polarization. Table 6, when analyzed along with Table 5, shows the range of speeds for which the defaults occurred.

At 26^o and 36^o in Table 6 all defaults occurred for input winds of 0.01 and 1 m/s. There are 100 possibilities for these two speeds combined so that when the winds are 1 m/s or less about 80 to 85% of the data are discarded.

TABLE 5 TOTAL SOS DEFAULTS FOR H AND V POL VERSUS INCIDENCE ANGLE. THE TOTAL NUMBER OF TRIALS FOR EACH POLARIZATION IS 550. (PERCENT IN PARENTHESES).

THETA	26^o	36^o	40^o	46^o	52^o
H POL	80 (15)	80 (15)	231 (42)	81 (15)	509 (93)
V POL	86 (16)	84 (15)	191 (35)	90 (16)	333 (61)

TABLE 6 WIND SPEEDS FOR SOS DEFAULTS VERSUS INCIDENCE ANGLE.

	V POL						H POL					
	UPWIND			DOWNWIND			UPWIND			DOWNWIND		
INCIDENCE ANGLE	1ST	>12	ALL	1ST	>12	ALL	1ST	>12	ALL	1ST	>12	ALL
26°	1	1	.01	1	1	.01	1	1	.01	1	1	.01
36°	1	1	.01	2	1	.01	1	1	.01	1	1	.01
40°	5	4	2	5	3	2	4	3	2	4	3	2
46°	2	1	.01	3	.01	.01	2	1	.01	4	1	.01
52°	10+	9	7	10+	10	7*	8	6	5	5	5	4*

*25 Defaults for this speed, a few successes for lower speeds; + or greater.

At 40°, from Table 6, the SOS defaults completely for winds of 2 m/s or less accounting for 150 out of both the 231 and an 191 totals in Table 5. More than half of the 25 possible returns are lost for 4 m/s H pol upwind and for 3 m/s for the other three stratifications. Defaults start to occur for input winds of 5 m/s for H pol and 4 m/s for V pol.

At 46°, the results show an improvement for the SOS. The defaults are for winds of 2 m/s and less for upwind and 3 and 4 m/s for downwind, H pol and V pol, respectively. The totals are spread over a wider range of input speeds, but calms and winds under 1 m/s are mostly discarded.

At 52°, the SOS collapses almost completely by defaulting 93% for H pol and 61% for V pol out of 550 tries. The SOS defaults completely at 7 m/s for upwind and downwind H pol and at 5 and 4 m/s respectively for upwind and downwind V pol.

An incidence angle of 52° is representative of the outer edges of the SASS swath. The peak gain of the antenna pattern is near 46°, which accounts for the improved statistics for 46° compared to 40° and 52°. The roll-off of the antenna gain plus the decrease of backscatter in the model function combine to produce the much larger values of A, B and C in Table 1 for 52° and the consequent failures of the SOS.

Calms

The SOS ignores the possibility that there is no wind. Negative backscatter values are treated as bad data instead of data where the backscatter could be fluctuating about a value of zero because of the noise in the measurements. If two negative estimates (i.e. measurements) of the received power, and hence, backscatter, found 90° apart, are interpreted as calm, the question arises as to how often there would have been a wind at the ocean surface. Surely a 1 cm/sec constant mean wind, that is, in the absense of convective activity, cannot generate the capillary waves that are the backscatter mechanism. Whether or not 1 m/s and 2 m/s winds generate such waves is presently a subject of both theoretical and experimental investigations.

The counts for calms in Appendix A under B2 for H pol exceed the number in the tabulation of the 25 sets of successful sets of four that are first tabulated. Part way through the program, an SOS H and an MLE H were obtained consisting of a default SOS and a calm MLE, and the program continued to the V pol part of the search for four solutions. The H pol results would be forgotten in the tabulation of the 25 successful sets if either a large direction error or two solutions near the input wind directions for V pol would result as described on page 20. The totals for H pol are, in part, a consequence of this aspect of the simulation.

If at V pol, a calm is found the set of four would be completed by an SOS default and a calm for the MLE. The value of C2 should consequently agree with the total under MLE of values of 0.00. For some reason, C2 was less than this for input winds of 0.01 in six of the tables in Appendix A. The reason for this error is not immediately apparent, but it does not affect the rest of the statistics other than the possibility that calms at H pol may be under counted. The values of C2 are shown correctly in parentheses in the appendix.

TABLE 7 TOTAL CALMS VERSUS INPUT WIND AND INCIDENCE ANGLE, POLARIZATION AND UPWIND-DOWNWIND.

	26°				36°				40°				46°				52°			
	H POL		V POL		H POL		V POL		H POL		V POL		H POL		V POL		H POL		V POL	
WIND	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D
.01	18	16	12	14	27	10	14	11	23	29	18	16	25	22	13	19	29	25	14	12
1									13	11	1	6					20	32	7	7
2																	27	13		14
3																	18	19		2
4																	14	11		
5-7																	7	13		

Table 7 shows the number of calms returned by the MLE as a function of incidence angle, polarization, upwind, downwind and input wind speed. Except for 52° incidence angle, calms are returned only for inputs of 0.01 and 1 m/s. Even for an input wind of 2 m/s a return of calm is still correct within the required ± 2 m/s of the original SASS specifications. All reported calms in Table 7 except those for 3 m/s and higher are, in this sense, correct. With this criterion, the V pol returns are 96% correct at 52° and even the H pol returns are 67% correct.

Large Direction Errors

Especially for light winds, but also for any wind, it is possible for the estimates of the backscatter (i.e. the measurements) to have the property that the value at crosswind is greater than the value at upwind (or downwind) when, in fact, one beam is looking upwind (or downwind). In Fig. 1, this corresponds to looking for a solution near chi equal to zero and recovering two solutions even past chi equal to 40 and perhaps somewhere in the range of chi greater than 45° but less than or equal to 90° and less than 315° but greater than or equal to 270°. Errors of 90° in direction would occur if the crosswind backscatter was so large and the upwind backscatter so small that the bottom curves in Fig. 1 would shift so that they did not cross whereas the correct situation would be the top figure. The extreme is thus a large direction error, and B1 and C1 count those conditions for which the direction errors are large, say, 40° or more.

It would be possible to determine 90° direction errors by a few more lines of programming. Also the SOS might or might not have returned a solution for these conditions. These contingencies were not tested further. Instead only the possibility that crosswind backscatter was larger than upwind backscatter was tested, and if found, counted as a large direction error. Then B1 and C1 were counted, and the search for solutions was reinitialized by starting over. Only the counts for a particular polarization should be compared since the search for four solutions always started with H pol. (A more refined version of the program could start by choosing H pol or V pol by flipping a coin or perhaps chosing alternate polarizations at each completion of a set of four).

As shown in Table 8, large direction errors happen mostly for the lower winds speeds and a 52° incidence angle. This is confirmed in part by the various tables and figures in Jones, et al. (1982) and Schroeder, et al. (1982).

TABLE 8 LARGE DIRECTION ERRORS VERSUS INPUT WIND AND INCIDENCE ANGLE, POLARIZATION AND UPWIND-DOWNWIND.

	26°				36°				40°				46°				52°			
	H POL		V POL		H POL		V POL		H POL		V POL		H POL		V POL		H POL		V POL	
WIND	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D
.01	47	25	19	18	43	24	24	28	37	47	22	19	33	25	30	15	53	37	26	16
1	2	15		2	3	15	2	2	34	31	10	9	4	13		2	34	26	11	18
2	1	9	1	2	2	13			8	39		5	1	4	3		22	31	11	12
3	1	6	1	1	2	6				9				5		1	28	22		9
4	1	6			1	3	1			2			1	8			22	43		7
5	2	4		1	1	6	1						3	2	1		27	31		1
6		8	2			9							2	4	2	2	17	29		1
7	3	4		1	1	6		1					1	11		2	8	28		
8	1	7	1	1		9	1						2			2	4	17		
9	1	12		2	5	7	1						3	5	1	1	2	22		
10	3	6	1	1	2	5		1					2		1			10		

The a priori probability of an error greater than 45° (plus or minus) for a no-skill algorithm is 0.25. Were the data in Fig. 13 of Schroeder, et al.(1982) stratified by comparison data wind speed (i.e. what is called ground truth; there is no "truth"), and incidence angle, those for higher speeds and the middle range of incidence angles would probably fall much closer to the 45° degree line for perfect agreement. (The backscatter variance for incidence angles between 20° and 25° gets large also in the calculations of A, B and C described previously).

Biasses and Standard Deviations for Upwind and Downwind

Tables 9A to 9E summarize some of the statistics for the tables in Appendix A for each incidence angle, wind direction and input wind speed. The sample size, the difference between the sample mean, if it exists, and the input wind and the standard deviation are tabulated for a given incidence angle versus wind speed for SOS and MLE recoveries and upwind and downwind.

The sample biasses are small and the standard deviations tend to increase with increasing wind speed for 26°, 36° and 46° but not for an incidence angle of 40°.

For 52°, they are exceptionally high for low winds and require further interpretation. The standard deviations are biassed somewhat low because the sample size was used instead of the sample size minus one for the estimate of the variance.

The same sort of results are plotted in Figs. 2-1 to 2-20 for the various combinations of paired SOS and MLE values for V pol and H pol, upwind and downwind and incidence angle.

For incidence angles of 26^o and 36^o, the standard deviations increase with wind speed. Even the bias plus or minus one standard deviation is less than 2 m/s for both the SOS and the MLE. The only difference as in the tables is the failures of the SOS at low winds.

There is a dramatic difference for an incidence angle of 40^o as in Table 9C and Figs. 2-9 to 2-12. The standard deviations are much smaller. The SOS fails for light winds, but for the higher winds the scatter in the data is much less than for the other incidence angles.

At 46^o, the scatter plus the bias almost reaches 2 m/s for high winds. The lower number of SOS defaults at 46^o compared to 40^o and 52^o and the smaller standard deviations at 40^o are somewhat contradictory.

Table 9E and Figs. 2-17 to 2-20 illustrate problems at 52^o that are only partially solved by the use of the MLE. The SOS defaults most of the time for H pol. Those recovered for H pol by the SOS are biassed high. The SOS for V pol gives a few more returns and the V pol biasses are not exceptionally high. For the MLE the biasses and standard deviations at V pol are small especially above 4 m/s, but at H pol the MLE returned values from 8.26 m/s to calm at upwind and from calm to 9.26 m/s at downwind for an input wind of 5 m/s. The 10 db lower, or so, H pol backscatter values at 52^o incidence angle in the model function impose a heavy penalty on attempts to recover the wind for low winds.

The small sample size of 25, at most, does not provide very reliable results on the potential biasses of the SOS and the MLE. A graph of the SOS as a function of wind speed for fixed chi, as in these analyses, will not have a minimum at the same wind speed as a graph of the MLE for the same input parameters.

Since the theory of the SOS is incorrect, it does not seem worthwhile to try to derive the expected value of the minimum SOS, which is a statistic and therefore has a pdf with an expected value, to see if it is unbiassed. Maximum likelihood estimators are, in general, biassed. An empirical fit of any model function by either the SOS or the MLE by means of actual data immediately loses the ability to detect possible biasses for either method.

TABLE 9A SAMPLE SIZE, BIAS AND STANDARD DEVIATION FOR THETA EQUAL TO 26°.

SPEED	0.01						1						2						3					
	H POL			V POL			H POL			V POL			H POL			V POL			H POL			V POL		
	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD
SOS UP	0	-	-	0	-	-	8	+.29	.20	10	+.23	.10	25	+.05	.30	25	+.05	.27	25	-.07	.39	24	-.08	.39
MLE UP	25	+.07	.14	25	+.11	.18	25	-.06	.23	25	+.01	.18	25	-.02	.30	25	-.02	.27	25	-.15	.36	25	-.13	.40
SOS DOWN	0	-	-	0	-	-	12	+.18	.14	4	+.30	.18	25	+.02	.28	25	+.03	.28	25	+.05	.50	25	-.10	.36
MLE DOWN	25	+.09	.14	25	+.8	.14	25	+.08	.14	25	-.02	.18	25	-.05	.28	25	-.05	.30	25	+.01	.47	25	-.15	.35

SPEED	4						5						6						7					
	H POL			V POL			H POL			V POL			H POL			V POL			H POL			V POL		
	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD
SOS UP	24	-.02	.59	25	+.10	.60	25	0	.50	25	-.25	.62	25	-.08	.71	25	-.20	.63	25	+.10	.95	25	-.43	.89
MLE UP	25	-.10	.60	25	+.06	.52	25	-.09	.49	25	-.31	.52	25	-.15	.64	25	-.30	.65	25	+.03	.92	25	-.57	.91
SOS DOWN	25	+.18	.55	25	-.14	.56	24	-.21	.66	25	-.21	.55	25	-.15	.69	25	-.01	.71	25	-.27	.76	25	-.18	.83
MLE DOWN	25	+.10	.50	25	-.21	.52	25	-.32	.61	25	-.09	.51	25	-.16	.71	25	-.13	.69	25	-.37	.71	25	-.24	.72

SPEED	8						9						10					
	H POL			V POL			H POL			V POL			H POL			V POL		
	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD
SOS UP	25	+.15	1.33	25	+.09	.89	25	-.02	1.36	25	-.47	1.19	25	-.57	1.64	25	+.07	1.47
MLE UP	25	+.06	1.20	25	+.02	1.00	25	-.05	1.28	25	-.47	1.00	25	-.57	1.52	25	-.10	1.28
SOS DOWN	25	+.11	.97	25	-.30	1.13	25	-.32	1.13	25	+.15	.88	25	+.19	1.04	25	-.28	1.69
MLE DOWN	25	+.01	.81	25	-.36	1.05	25	-.32	1.15	25	-.02	.83	25	+.02	.93	25	-.22	1.52

S = SAMPLE SIZE
B = BIAS
SD = STANDARD DEVIATION

TABLE 9B SAMPLE SIZE, BIAS AND STANDARD DEVIATION FOR THETA EQUAL TO 36°.

SPEED	0.01						1						2						3					
	H POL			V POL			H POL			V POL			H POL			V POL			H POL			V POL		
	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD
SOS UP	0	-	-	0	-	-	12	+.16	.10	3	+.17	.10	25	+.04	.25	25	-.07	.27	25	-.08	.50	25	-.01	.40
MLE UP	25	.06	.10	25	0.9	.14	25	-.05	.18	25	-.15	.20	25	-.04	.25	25	-.15	.28	25	-.11	.50	25	-.04	.44
SOS DOWN	0	-	-	0	-	-	10	+.24	.14	13	+.17	.10	23	+.03	.25	25	-.02	.28	25	-.09	.47	25	+.01	.43
MLE DOWN	25	+.11	.18	25	+.18	.23	25	-.06	.27	25	-.03	.25	25	-.06	.27	25	-.10	.30	25	-.14	.48	25	-.03	.41

SPEED	4						5						6						7					
	H POL			V POL			H POL			V POL			H POL			V POL			H POL			V POL		
	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD
SOS UP	25	-.03	.72	25	-.01	.55	25	-.13	.84	25	-.30	.74	25	-.17	.85	25	-.08	.92	25	-.35	.87	25	-.35	1.16
MLE UP	25	-.08	.67	25	-.07	.52	25	-.20	.79	25	-.33	.72	25	-.19	.76	25	-.04	.82	25	-.50	.83	25	-.44	1.02
SOS DOWN	25	-.29	.36	25	-.10	.51	25	-.14	.78	25	+.03	.68	25	-.16	.74	25	-.15	.87	25	-.24	1.05	25	-.21	.90
MLE DOWN	25	-.36	.33	25	-.14	.47	25	-.26	.77	25	-.04	.64	25	-.15	.78	25	-.03	.80	25	-.37	.97	25	-.33	.83

SPEED	8						9						10					
	H POL			V POL			H POL			V POL			H POL			V POL		
	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD
SOS UP	25	-.03	1.04	25	-.28	.95	25	-.32	.86	25	-.10	1.03	25	-.35	1.02	25	-.20	.92
MLE UP	25	-.10	1.00	25	-.44	.87	25	-.41	.76	25	-.33	1.04	25	-.19	1.02	25	-.37	.92
SOS DOWN	25	-.16	.76	25	-.21	1.10	25	-.31	1.39	25	-.43	1.45	25	-.83	.87	25	+.14	1.09
MLE DOWN	25	-.20	.64	25	-.22	.93	25	-.19	1.27	25	-.43	1.23	25	-.97	.74	25	+.15	1.01

S = SAMPLE SIZE
B = BIAS
SD = STANDARD DEVIATION

TABLE 9C SAMPLE SIZE, BIAS AND STANDARD DEVIATION FOR THETA EQUAL TO 40°.

SPEED	0.01						1						2						3					
	H POL			V POL			H POL			V POL			H POL			V POL			H POL			V POL		
	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD
SOS UP	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	1	+.21	-	2	+.21	.06
MLE UP	25	+.69	.57	25	+.09	.20	25	-.04	.71	25	-.03	.36	25	-.08	.56	25	-.04	.25	25	0	.32	25	0	.18
SOS DOWN	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	3	-.25	.10	10	+.21	.18
MLE DOWN	25	+.46	.72	25	+.32	.50	25	+.18	.96	25	-.16	.61	25	-.45	.60	25	0	.50	25	-.11	.49	25	+.11	.23

SPEED	4						5						6						7					
	H POL			V POL			H POL			V POL			H POL			V POL			H POL			V POL		
	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD
SOS UP	9	+.07	.28	23	0	.03	22	+.01	.32	25	-.10	.10	25	-.04	.23	25	-.16	.14	25	-.07	.25	25	-.08	.10
MLE UP	25	-.04	.23	25	+.01	.10	25	-.01	.32	25	+.01	.10	25	+.04	.25	25	-.06	.10	25	+.02	.23	25	+.01	.14
SOS DOWN	14	+.15	.38	24	-.02	.14	20	+.02	.33	25	+.01	.14	25	-.06	.32	25	-.04	.14	25	-.04	.27	25	-.09	.10
MLE DOWN	25	-.15	.50	25	-.02	.18	25	-.08	.36	25	+.08	.18	25	-.03	.32	25	+.03	.14	25	+.01	.27	25	-.02	.14

SPEED	8						9						10					
	H POL			V POL			H POL			V POL			H POL			V POL		
	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD
SOS UP	25	-.11	.27	25	-.14	.14	25	-.15	.27	25	-.17	.10	25	-.08	.25	25	-.15	.14
MLE UP	25	-.02	.25	25	-.04	.18	25	-.03	.27	25	+.01	.18	25	+.01	.20	25	-.09	.20
SOS DOWN	25	-.02	.27	25	-.09	.14	25	-.09	.23	25	-.07	.14	25	-.09	.23	25	-.04	.10
MLE DOWN	25	+.07	.25	25	-.02	.18	25	0	.23	25	+.01	.18	25	-.02	.23	25	+.02	.18

S = SAMPLE SIZE
B = BIAS
SD = STANDARD DEVIATION

TABLE 9D SAMPLE SIZE, BIAS AND STANDARD DEVIATION FOR THETA EQUAL TO 46°.

SPEED	0.01						1						2						3					
	H POL			V POL			H POL			V POL			H POL			V POL			H POL			V POL		
	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD
SOS UP	0	-	-	0	-	-	10	+.12	.10	4	+.15	.03	24	-.01	.22	24	-.04	.27	25	-.03	.47	25	-.05	.38
MLE UP	25	+.08	.10	25	+.10	.14	25	-.05	.18	25	-.09	.18	25	-.09	.30	25	-.15	.28	25	-.18	.46	25	-.08	.36
SOS DOWN	0	-	-	0	-	-	13	+.26	.20	10	+.16	.10	23	+.15	.33	23	+.02	.20	24	-.04	.40	25	-.04	.32
MLE DOWN	25	+.09	.18	25	+.03	.10	25	0	.28	25	-.04	.10	25	+.04	.32	25	-.07	.25	25	-.13	.38	25	-.03	.33

SPEED	4						5						6						7					
	H POL			V POL			H POL			V POL			H POL			V POL			H POL			V POL		
	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD
SOS UP	25	-.26	.67	25	-.02	.43	25	+.02	.54	25	+.11	.53	25	-.40	.75	25	-.13	.85	25	+.03	1.19	25	+.18	.70
MLE UP	25	-.30	.66	25	-.12	.39	25	+.04	.44	25	+.02	.56	25	-.52	.75	25	-.28	.81	25	-.01	.98	25	+.16	.86
SOS DOWN	25	-.11	.43	24	+.02	.44	25	-.19	.61	25	-.18	.53	25	+.18	.75	25	-.17	.79	25	-.15	.77	25	+.10	.77
MLE DOWN	25	-.15	.38	25	-.07	.45	25	-.29	.57	25	-.20	.47	25	+.09	.63	25	-.23	.68	25	-.27	.75	25	-.03	.68

SPEED	8						9						10					
	H POL			V POL			H POL			V POL			H POL			V POL		
	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD
SOS UP	25	-.26	1.14	25	-.23	1.18	25	-.07	1.55	25	+.37	1.28	25	-.58	1.38	25	-.48	1.18
MLE UP	25	-.26	1.23	25	-.33	1.13	25	-.18	1.32	25	+.24	1.12	25	-.60	1.09	25	-.41	1.01
SOS DOWN	25	+.08	.89	25	-.38	1.29	25	-.62	1.28	25	-.26	1.27	25	-.23	1.44	25	-.29	1.61
MLE DOWN	25	-.08	.86	25	-.30	1.17	25	-.84	1.12	25	-.28	1.02	25	-.05	1.20	25	-.29	1.39

S = SAMPLE SIZE
B = BIAS
SD = STANDARD DEVIATION

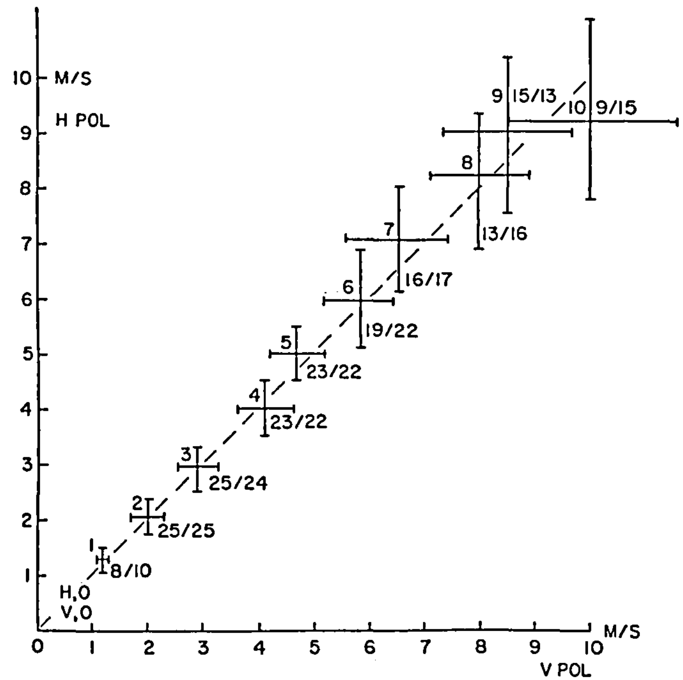
TABLE 9E SAMPLE SIZE, BIAS AND STANDARD DEVIATION FOR THETA EQUAL TO 52^{o}.

SPEED	0.01						1						2						3					
	H POL			V POL			H POL			V POL			H POL			V POL			H POL			V POL		
	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD
SOS UP	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
MLE UP	25	1.09	2.01	25	.62	.79	25	1.58	2.38	25	+.05	.92	25	-.06	2.09	25	- .34	.59	25	-1.02	1.93	25	-.07	.66
SOS DOWN	0	-	-	0	-	-	0	-	-	0	-	-	2	9.01	.40	0	-	-	0	-	-	0	-	-
MLE DOWN	25	+1.91	2.17	25	+1.08	1.35	25	0.12	2.05	25	0.56	1.27	25	1.53	2.95	25	-1.03	1.20	25	- .88	2.76	25	-.13	1.10

SPEED	4						5						6						7					
	H POL			V POL			H POL			V POL			H POL			V POL			H POL			V POL		
	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD
SOS UP	0	-	-	1	+1.38	-	0	-	-	0	-	-	0	-	-	11	+.10	.28	0	-	-	21	-.05	.28
MLE UP	25	-.52	2.75	25	+ .09	.62	25	+ .05	2.50	25	+.06	.35	25	-.13	1.91	25	-.05	.35	25	-.22	1.05	25	-.03	.32
SOS DOWN	0	-	-	0	-	-	1	+4.35	-	1	1.05	-	0	-	-	16	+.37	.39	0	-	-	19	+.14	.36
MLE DOWN	25	+.30	2.78	25	-0.95	.86	25	-.68	2.99	25	-.05	.75	25	-1.26	2.51	25	+.13	.50	25	-.85	2.33	25	+.02	.38

SPEED	8						9						10					
	H POL			V POL			H POL			V POL			H POL			V POL		
	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD	S	B	SD
SOS UP	1	+2.00	-	24	-.08	.33	7	+.85	.69	25	-.07	.36	15	+.33	.32	25	-.17	.27
MLE UP	25	+.04	.99	25	-.05	.38	25	+.17	.81	25	+.04	.40	25	-.03	.79	25	-.01	.28
SOS DOWN	2	+1.26	1.20	24	+.03	.36	10	+1.04	.49	25	-.02	.40	11	+.50	.97	25	-.16	.36
MLE DOWN	25	.17	1.20	25	+.03	.36							25	-.36	1.08	25	-.06	.36

S = SAMPLE SIZE
B = BIAS
SD + STANDARD DEVIATION

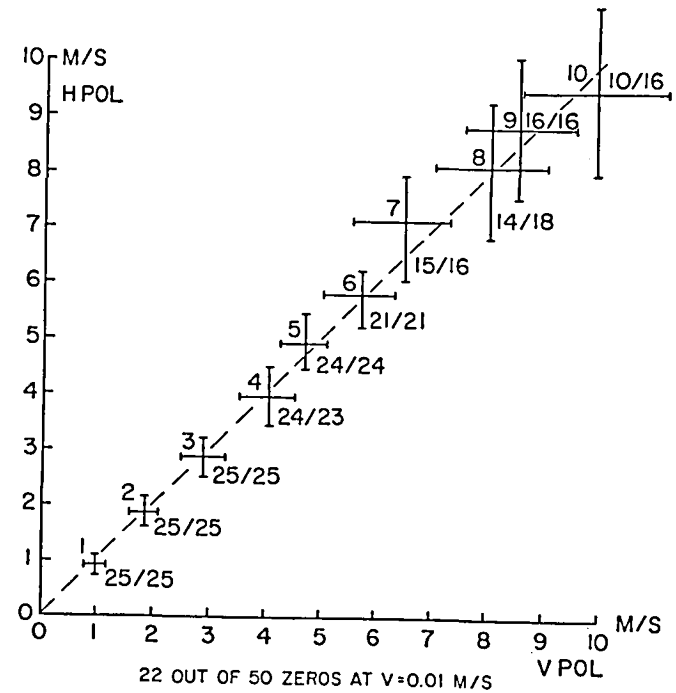


UPWIND LOOK SOS THETA = 26°

1115 TRIES TO GET 275 SETS

N_1/N_2 (NUMBER H POL RETURNS/NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-1



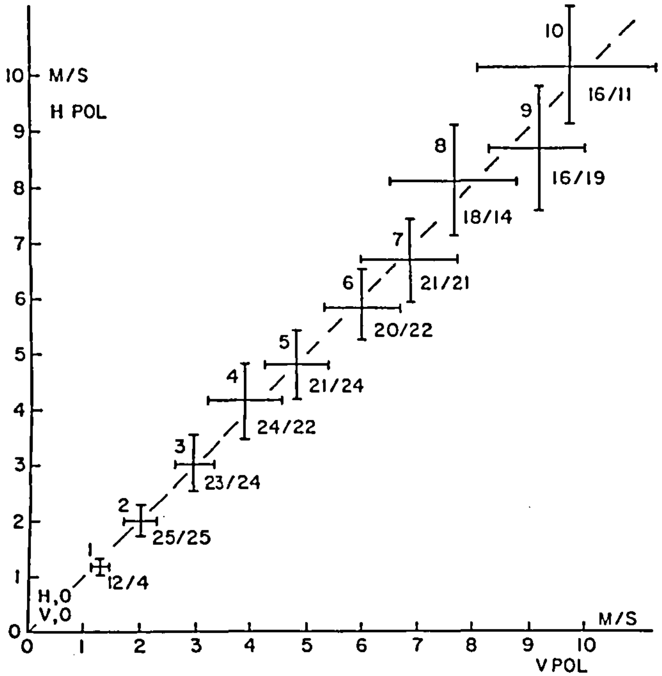
22 OUT OF 50 ZEROS AT V = 0.01 M/S

UPWIND LOOK MLE THETA = 26°

1115 TRIES TO GET 275 SETS

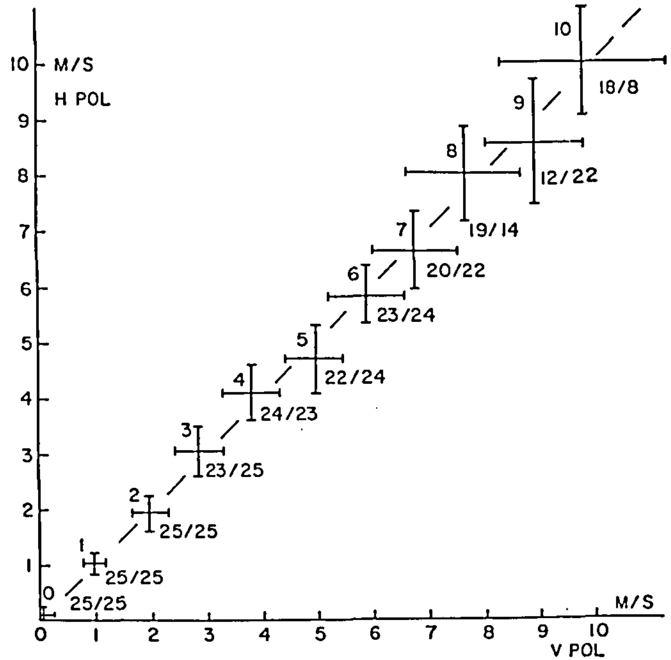
N_1/N_2 (NUMBER H POL RETURNS/NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-2



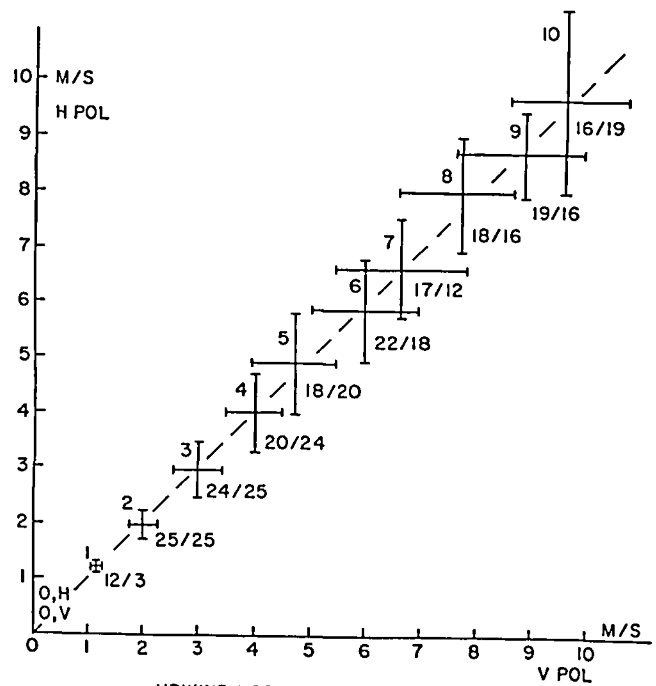
DOWNWIND LOOK SOS THETA = 26°
1033 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS/ NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-3



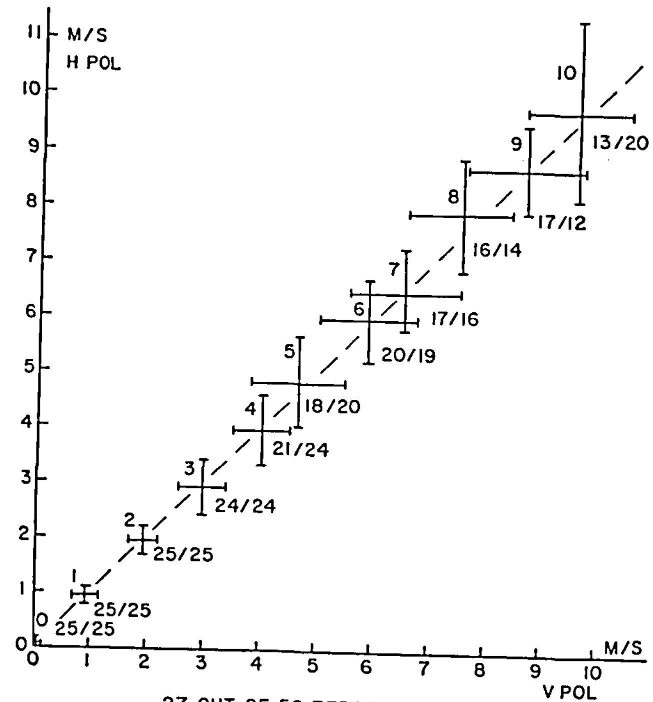
28 OUT OF 50 ZEROS AT V = 0.01 M/S
DOWNWIND LOOK MLE THETA = 26°
1033 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS / NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-4



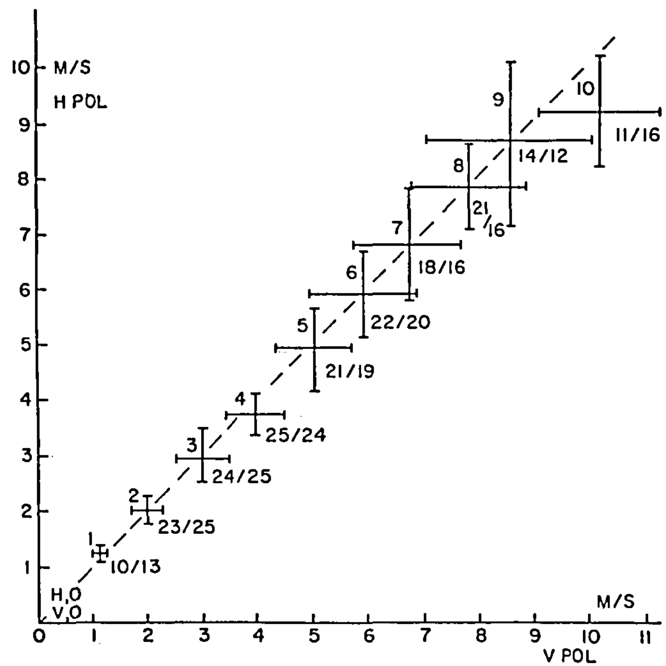
UPWIND LOOK SOS THETA = 36°
1183 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS / NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-5



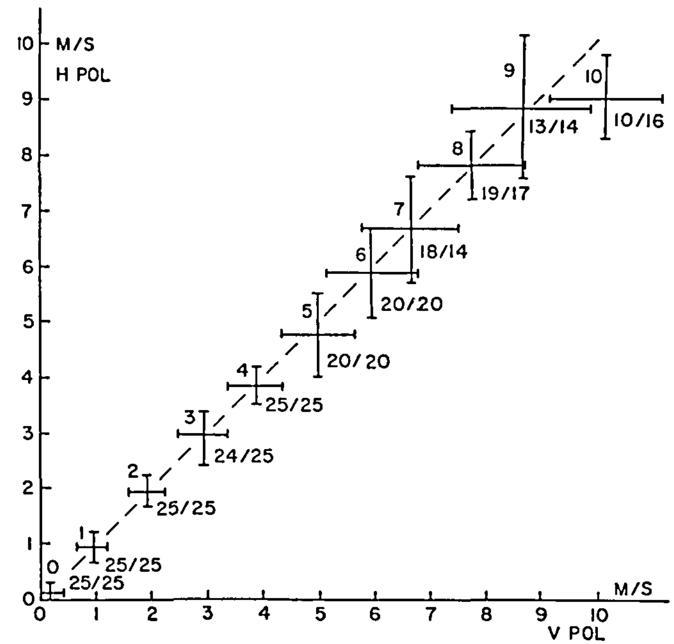
27 OUT OF 50 ZEROS AT V = 0.01 M/S
UPWIND LOOK MLE THETA = 36°
1183 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS / NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-6



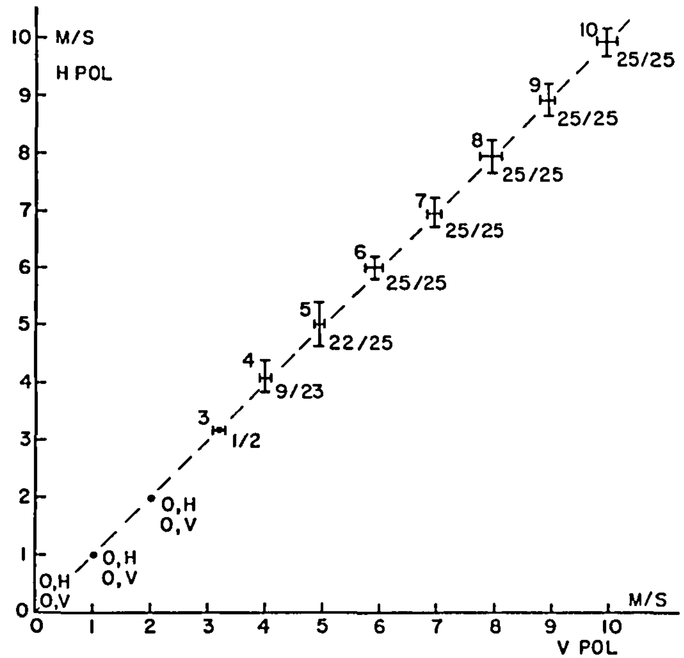
DOWNWIND LOOK SOS THETA = 36°
1183 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS / NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-7



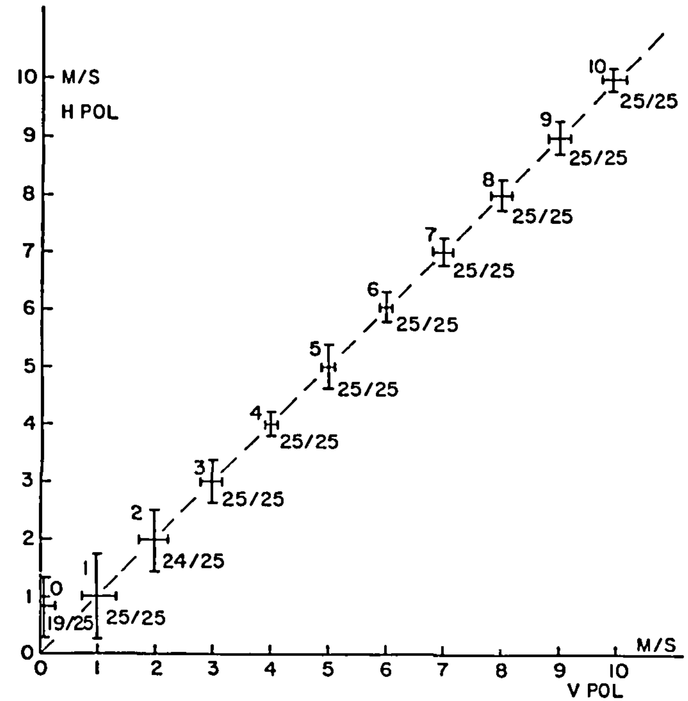
27 OUT OF 50 ZEROS AT V = 0.01 M/S
DOWNWIND LOOK MLE THETA = 36°
1183 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS / NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-8



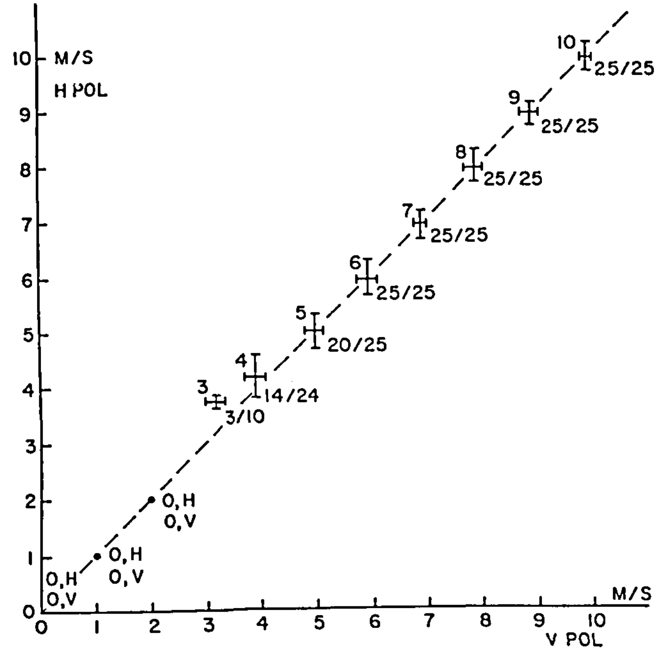
UPWIND LOOK SOS THETA = 40°
1173 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS/NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-9



26 OUT OF 50 ZEROS AT V=0.01 M/S
UPWIND LOOK MLE THETA = 40°
1173 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS/NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-10

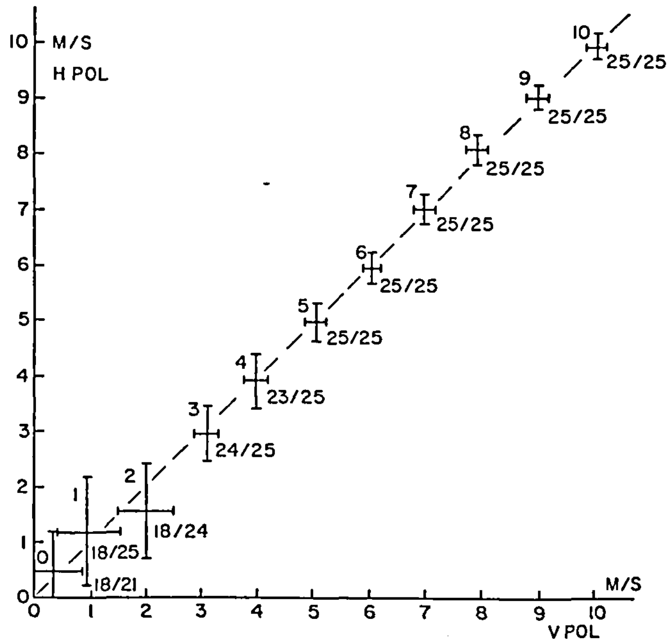


DOWNWIND LOOK SOS THETA = 40°

1047 TRIES TO GET 275 SETS

N_1/N_2 (NUMBER H POL RETURNS / NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-11



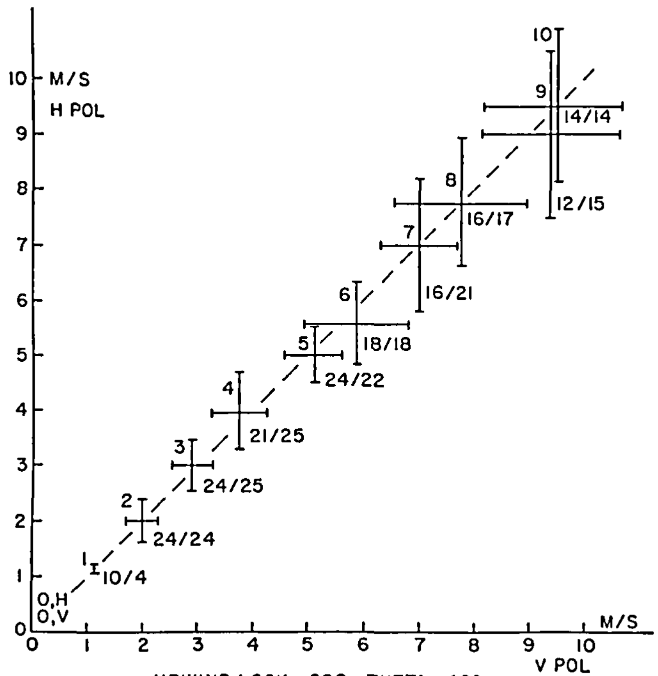
32 OUT OF 50 ZEROS AT V = 0.01 M/S

DOWNWIND LOOK MLE THETA = 40°

1047 TRIES TO GET 275 SETS

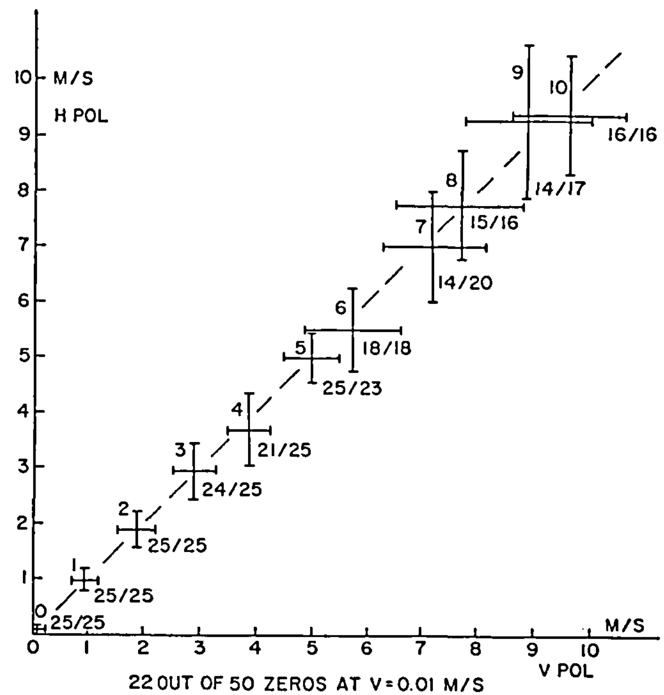
N_1/N_2 (NUMBER H POL RETURNS / NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-12



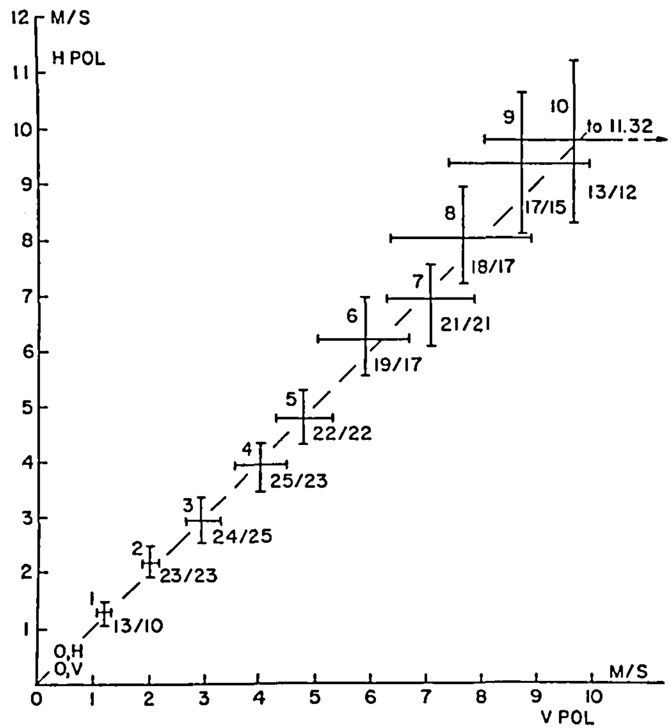
UPWIND LOOK SOS THETA = 46°
1121 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS / NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-13



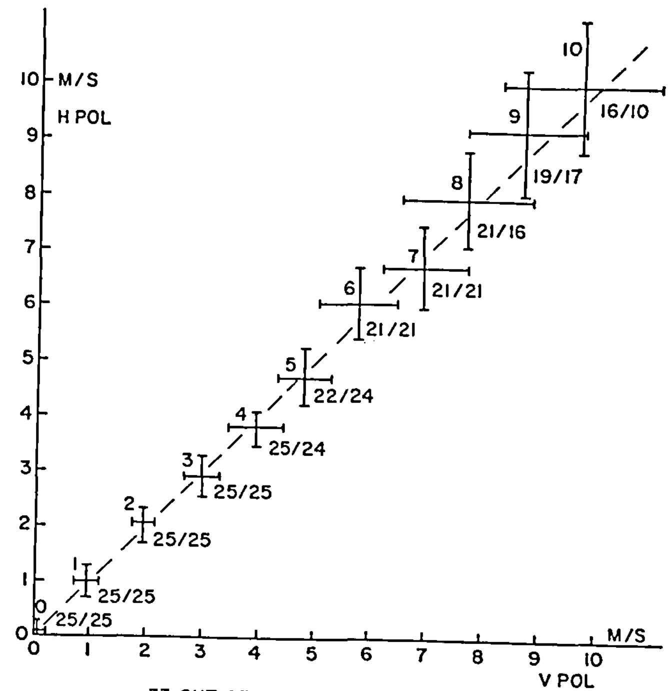
22 OUT OF 50 ZEROS AT V = 0.01 M/S
UPWIND LOOK MLE THETA = 46°
1121 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS / NUMBER V POL RETURNS ± 1 M/S)

FIG 2-14



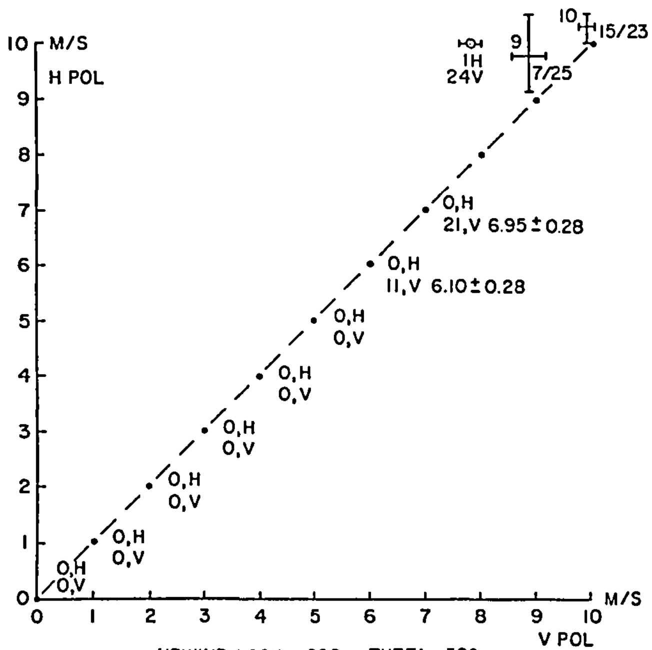
DOWNWIND LOOK SOS THETA = 46°
898 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS / NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-15



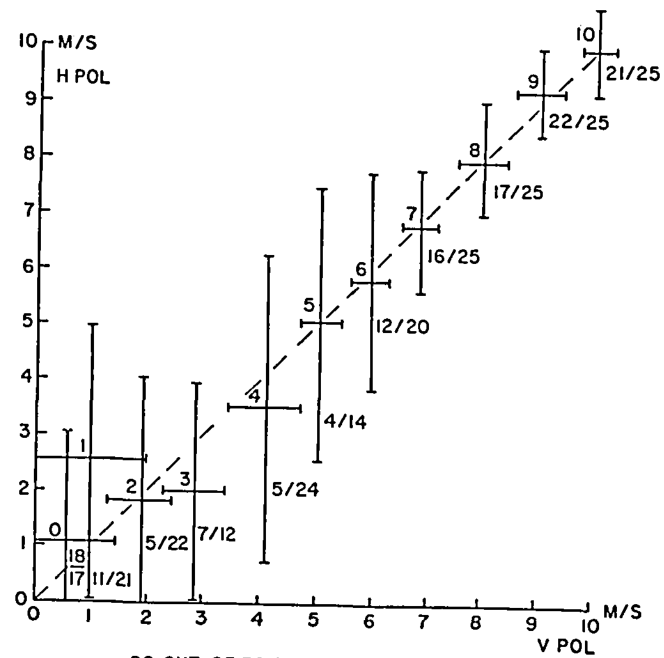
33 OUT OF 50 ZEROS AT V = 0.01 M/S
DOWNWIND LOOK MLE THETA = 46°
898 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS / NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-16



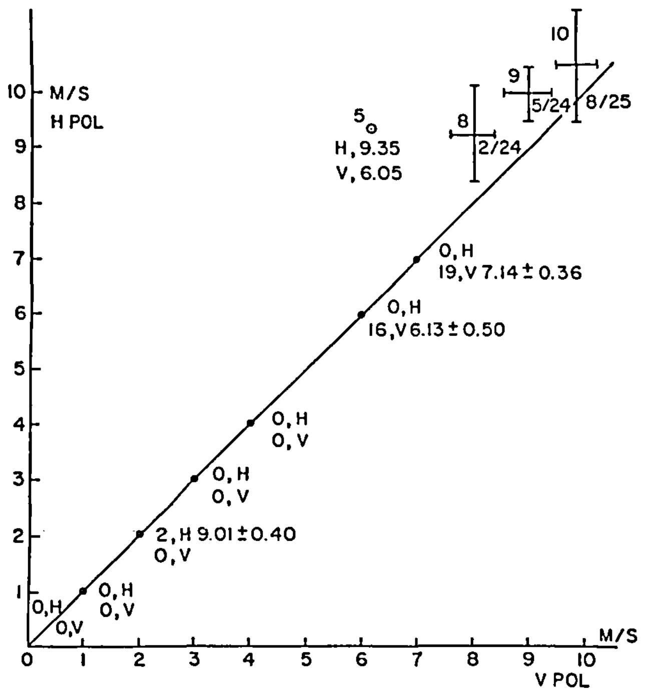
UPWIND LOOK SOS THETA = 52°
1051 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS/NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-17



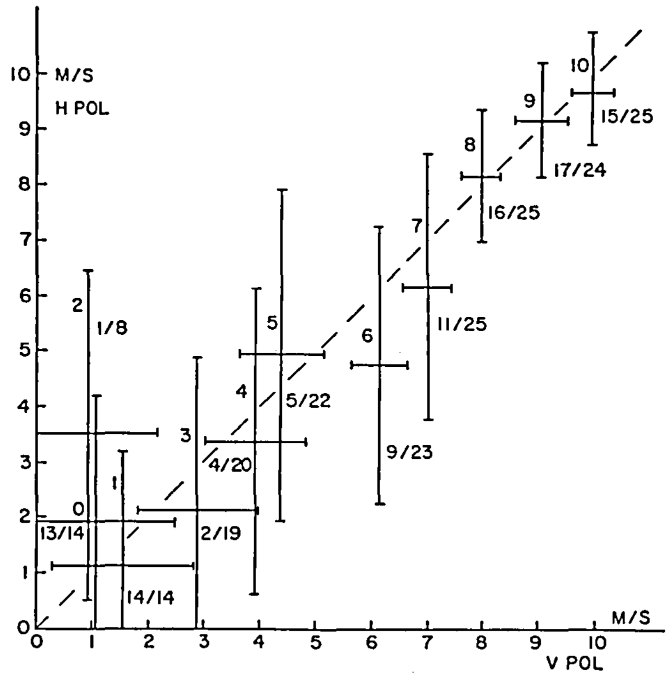
28 OUT OF 50 ZEROS AT V = 0.01 M/S
UPWIND LOOK MLE THETA = 52°
1051 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS/NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-18



DOWNWIND LOOK SOS THETA = 52°
970 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS / NUMBER V POL RETURN ± 1 M/S)

FIG. 2-19



22 OUT OF 50 ZEROS AT V = 0.01 M/S
DOWNWIND LOOK MLE THETA = 52°
970 TRIES TO GET 275 SETS
N_1/N_2 (NUMBER H POL RETURNS / NUMBER V POL RETURNS ± 1 M/S)

FIG. 2-20

This simulation assumes a correct model function. Whether or not biasses within this context exist then becomes a question that can be investigated. Table 10 shows counts of the number of times the biasses for the SOS and MLE were within ± .10 cm/sec and ± .20 cm/sec, as counted, from Tables 9A to 9E. The counts for the MLE are higher suggesting that the SOS in more biassed than the MLE for this simulation.

TABLE 10 COUNTS FOR SAMPLE BIASSES OF 0.10 M/S OR LESS AND 0.20 M/S OR LESS VERSUS INCIDENCE ANGLE, POLARIZATION, UPWIND, DOWNWIND, AND SOS VERSUS MLE.

THETA	26^{o}		36^{o}		40^{o}		46^{o}		52^{o}		
	H	V	H	V	H	V	H	V	H	V	SUM
$\lvert B\rvert \leq 0.10$											
SOS U	7	5	4	5	5	3	5	3		4	41
SOS D	2	3	2	4	6	7	2	4		2	32
SUM	9	8	6	9	11	10	7	7		6	73
MLE U	8	5	5	4	10	11	5	4	4	9	65
MLE D	7	5	2	5	6	8	6	6		5	50
SUM	15	10	7	9	16	19	11	10	4	14	105
$\lvert B\rvert \leq 0.20$											
SOS U	8	6	7	8	7	7	6	6		5	60
SOS D	6	5	5	7	7	7	7	7		4	55
SUM	14	11	12	15	14	14	13	13		9	105
MLE U	10	7	9	6	10	11	7	7	6	9	82
MLE D	8	7	7	8	9	10	8	7	2	7	73
SUM	18	14	16	14	19	21	15	14	8	16	156
DEFAULT	2	2	2	2	6	6	2	2	14	8	46

These small biasses are not the cause of the discrepancies between V pol and H pol at low winds found by Woiceshyn, et al. (1984). Their results will be interpreted in terms of this simulation in a following section.

Negative Backscatter at Crosswind

The backscatter estimates at crosswind can be negative and the one at upwind (or downwind) positive. The SOS will default and the MLE will return a solution. Table 11 shows the counts for the number of times this happened in the simulation. The counts for H pol can exceed 25 because upon proceeding to V pol the program can find values of backscatter that give two solutions near upwind or downwind, forget the H pol result and return to H pol to start over.

TABLE 11 COUNTS OF THE NUMBER OF TIMES BACKSCATTER ESTIMATE WAS NEGATIVE AT CROSSWIND AND POSITIVE AT UPWIND SO THAT SOS WOULD FAIL AND MLE RETURN A WIND.

	26°				36°				40°				46°				52°			
	H POL		V POL		H POL		V POL		H POL		V POL		H POL		V POL		H POL		V POL	
WIND	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D
.01	27	20	12	13	21	24	11	12	31	17	8	9	33	18	10	8	25	18	11	13
1	8	60	1	10	9	11	6	4	40	25	22	18	8	6	4	4	24	18	18	17
2									32	32	12	12					20	20	22	10
3									20	19	1	2					32	11	23	17
4									4	2							27	27	14	18
5									1								36	23	7	11
6																	33	29	5	2
7																	26	24		
8																	16	13		
9																	10	11		
10																	5	2		

Two Solution Cases Near Upwind and Downwind

With an input wind at either upwind or downwind, only those solutions that returned a wind exactly at upwind or downwind were recovered if they existed. For many pairs of randomized backscatter values, two directions near the input upwind or downwind directions will be returned. The SOS, if it exists, and the MLE will return almost identical solutions for these conditions.

In a sense, the wind that is returned is incorrect because it has the wrong direction, but for any actual situation this should happen frequently when one of the beams of the SASS is pointing nearly upwind or downwind.

For the assumptions of the simulation, the direction errors can be as much as about ± 45° with the upwind backscatter still stronger than the crosswind backscatter and with both values positive.

The rejection of backscatter pairs such that K_p is greater than one is really not necessary for the SOS. Simply setting K_p equal to 0.9 and defaulting the estimate of the standard deviations of speed and direction, which have not been used by most analysts, would have recovered a wind.

TABLE 12 COUNTS OF NUMBER OF TIMES TWO SOLUTIONS NEAR UPWIND OR DOWNWIND WOULD YIELD SOS SOLUTIONS (Y) AND WOULD NOT YIELD SOS SOLUTIONS (N) VERSUS INCIDENCE ANGLE, POLARIZATION, DIRECTION AND SPEED.

	26°				36°				40°				46°				52°			
	H POL		V POL		H POL		V POL		H POL		V POL		H POL		V POL		H POL		V POL	
	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D		
.01 Y	3	1	1	1	1			1	2	1		1	2	1	1		3	2		
.01 N	9	2	1		12	1	5	4	5	5	9	5	8	2	6	3	4	3	6	8
1 Y	28	21	17	17	43	40	29	32	4	5	10	3	31	36	19	28	1		3	1
1 N	1	1		3	1	4	1	4	1	4	16	9	13	6	2	1	9	2	11	7
2 Y	63	37	20	29	53	56	26	46	7	5	10	10	56	43	23	15	1		6	
2 N									7	9	8	9					4	8	9	5
3 Y	65	41	28	23	44	39	20	25	58	31	29	20	41	37	31	18	2	3	14	1
3 N									7	3		1					14	4	20	2
4 Y	52	43	26	22	56	40	26	21	68	37	36	23	41	32	24	28	2	1	9	11
4 N																	9	8	11	9
5 Y	61	44	29	26	47	56	23	23	48	27	21	15	46	41	19	30	10	3	32	14
5 N																	13	6	1	2
6 Y	43	30	37	25	68	41	18	32	52	55	21	36	45	25	18	10	9	5	23	20
6 N																	10	10		
7 Y	43	55	19	30	38	53	27	39	54	24	32	16	56	32	26	30	39	15	21	29
7 N																	15	12		
8 Y	41	24	11	11	30	55	23	39	51	70	24	31	58	43	28	32	36	13	15	20
8 N																	5	6		
9 Y	44	36	24	30	44	46	19	21	64	63	34	33	57	38	29	21	39	39	37	25
9 N																	3	3		
10 Y	57	48	31	27	33	37	13	28	69	40	28	19	55	46	24	27	54	21	19	17
10 N																				

Table 12 shows the counts of the number of times two solutions near upwind or downwind would have resulted divided into two categories, which are the number of times the SOS would succeed (Y) and the number of times it would fail because K_p was greater than one (N). The counts for H pol are larger than for V pol for the same reason as before. The SOS would default frequently for light winds and at 40^o and 52^o, as expected from the properties of the model function and the behavior of the variance at different incidence angles.

The counts at V pol, which cause the program to forget any successful H pol recovery and start over at H pol, for winds above some lower value at each incidence angle, fluctuate about values near twenty five. For a correct model function and for winds that are, in fact, at upwind or downwind, chicken track plots ought to have nearly equal amounts of "I's", "Y's" and "X's". For some of the fields that have been produced, there are larger concentration of "I's" which suggests that the upwind, or downwind, versus crosswind ratio is too low.

ANALYSIS AND IMPLICATIONS

Climatology

According to F. H. Ludlam's article on "wind" in the 1972 edition of the Encyclopaedia Brittanica, there are large areas of calms over the ocean near the centers of the subtropical highs and near the Equator. He writes:

> "These winds (the trades) blow toward an equatorial zone of light winds or calms, the doldrum belt, in which the pressure is low." ---" on the poleward side, the trade-wind belts are followed by the subtropical high-pressure belts in which calm or light winds prevail."--- "In the day of sailing ships the doldrums and the subtropical high pressure belts were often difficult to cross the latter zone receiving the name 'horse latitudes'. The explanation given for this name is that ships with cargoes of horses were often becalmed in these regions and ran out of water so that the horses had to be disposed of." †

Another example is the motion picture 'Moby Dick". A dramatic scene showed the becalmed whaling ship being towed by the crew rowing the long boat over a glassy calm sea surface. There were no Bragg scatterers in evidence.

These facts about the winds over the ocean are well documented in climatological atlases that show the percent frequency of calms over the ocean to be high near the centers of the subtropical highs found in each hemisphere as they shift from season to season. Some kinds of meteorological data processing loose these features, but for the standard six hourly synoptic charts areas of light to calm winds can frequently by identified.

The Definition of Calms and Light Wind Areas

A correct theoretical relationship between the wind and radar backscatter ought to be able to predict the absence of backscatter from the surface. Proper interpretation of the estimated backscatter should be able to tell that estimated backscatter values are simply noisy fluctuations about a true value of zero and return the useful information that the wind is below a speed such that the required Bragg scatterers are not generated. The results of Donelan and Pierson (1984) that show that $(U(\lambda/2)/C(\lambda))-1$, where $U(\lambda/2)$ is measured at a half wavelength above the Bragg wave, correlates better with the wave spectrum region responsible for Bragg scatterers that either u_* or $U_{19.5}$, also indicate that if $U(\lambda/2)$ is less than $C(\lambda)$ there will be no waves and, hence, no backscatter below a certain threshold wind.

† Deletions ---, underline added for emphasis, ( ) inserted in text.

Comparison With Other Results

This investigation was initiated because of the results of Woiceshyn, et al. (1984) and the claim (or assumption) by Wentz, et al. (1984) that the probability density function for the entire sample of wind speeds from SASS was a Rayleigh distribution, which implies a zero probability of calms. Fig. 5 in Woiceshyn, et al. (1984b) for the pooled results for incidence angles from 48.5 to 62^{o} that plots the distribution of paired H pol and V pol return speeds from the SASS 1-SOS wind recovery method shows absolutely no winds below 4 m/s for H pol for the large data set that was analysed. When H pol winds are averaged for a fixed range of V pol winds as in their Fig. 6 a systematic effect of increasing incidence angle becomes evident for low winds in that the mean value for the H pol winds increases for a given V pol wind with increasing incidence angle. When stratified the other way as also in their Fig. 6, the effect goes away.

As the band of pooled incidence angles is made to corresponds to lower incidence angles as in their Fig.5 for 34.5^{o} to 41.5^{o} and for 20^{o} to 27.5^{o}, lighter H pol winds are found in the samples.

For all of the figures, however, there is an unrealistic absence of light winds in the zero to three or four m/s range. The probability of a wind speed over the ocean between zero and, say, 1 m/s is undoubtedly much higher than any possible value that could be obtained by any attempt to fit a Rayleigh pdf to the actual winds.

The reason for these results of Woiceshyn, et al. (1984) is demonstrated by this simplified model. The SOS algorithm cannot handle light winds and throws them out, especially for some incidence angles. Moreover, if the SOS does recover a wind from an area where the wind is light, it will do so more often if the estimated (measured) backscatter is greater than its expected value, because the incorrectly computed K_p will be smaller and have a better chance of being less than one. Thus light winds when they are recovered will be too high if the model function is correct.

As mentioned briefly before, the processing of the SASS data was done by different teams for different parts of the total effort. The documentation provided in Wentz (1978) does not provide a description of the SOS algorithm. Indeed, it is more like some of the equations found in the GOASEX I and II Jet Propulsion Laboratory reports. The SOS algorithm, if it is documented at all, does not seem to be readily available except as described in the document prepared by Boggs (1982). Boggs (1982) also gives assorted MLE estimators based on Wentz (1978) which are not MLE estimators. Equations (7-6), (7-7) and (7-8) of Boggs (1982) have little to do with either Bayesian statistics or maximum likelihood estimators, and the final form for the SOS essentially throws away the irrelevant denominators in these equations and settles on equation (7-9) with the added error of treating the δ_i^2 as constant. No readily available reference appears to have documented the criteria that were used for the rejection of data prior to the extensive data processing effort that was made and that is still being made. Warning flags might have been raised even at that time if sufficient documentation had been made available. Even then a crude MLE was available that would have maximized eqn. (19) for upwind-downwind, including one negative backscatter value. An algebraic solution for curves that cross as in Fig 1 was also available that did not need a variance that might be undefined and that would thus recover winds from any positive pair of backscatter measurements. For future systems adequate documentation, properly circulated prior to an extensive data processing effort, would be a desirable objective.

Another aspect of the problem of recovering the best possible winds from the SASS backscatter values lies in the fact that the azimuth angles relative to north for the two beams are off by as much as 14^o (See Boggs (1982) Sec 9.2). These effects combined with the built in error of fine tuning the SASS-1 model function by means of the SOS raise further questions that are difficult to answer even at this time. Fortunately, this particular error can be avoided for NROSS.

The quotation on page 9 is an example of the motto: "When in doubt average." Even if averaged in antilog form, which is the logical way to proceed, there are two contributions to the variability of the sample backscatter values. One is the sampling variability in backscatter space as a result of communication noise and attitude errors. The other is the effect of the mesoscale variability of the wind from one backscatter cell to another. The latter is a non-linear transformation on the backscatter, which is a function of the unknown mesoscale wind over the cell. The pdf of such an average is thus unknown, which would follow from the results of Pierson (1983). The methods of Pierson, et al. (1984) avoid all of these difficulties. Knowledge of the pdf of the winds over a given area is not even needed.

For NROSS, pooled cells will be contiguous and those for different beams will be co-located. The analysis of such a situation will be considerably simpler.

Catch 22

The result is a "catch 22" situation for the present data set on winds over the ocean. The model function was fine tuned with the SOS wind recovery method. For this reason the model function is too high for light winds. It does not agree with the final analysis of the circle flight data for light winds published by Schroeder, et al. (1984). This compounded error may reduce the errors in the winds recovered from the SASS because it compensates for the basic error. Exactly how good this compensation is is not known. For light enough winds it must fail when the SOS is used.

The "catch 22" situation arises when attempts to obtain a valid model function and to verify it against error - full conventional meteorological data are made by means of the SOS wind recovery algorithm. Good agreement requires that light winds be discarded and introduces contradictions between H pol and V pol. Moreover the model function so obtained will not verify against circle flight data, where noise problems are lessened, for low winds. Such a procedure is a never-ending series of contradictions.

To avoid a "catch 22" situation, it is necessary to move out of the frame of reference that involves these self contradictions. Correct theories must be used wherever possible to minimize the inherent difficulties of solving the total problem, in part, empirically. The MLE is a correct theory. The SOS must therefore be abandoned.

Implications for SEASAT are that the entire model function must be re-derived and verified against MLE estimates of the winds. Research is in progress that will provide good theoretical guidance on how this can be done. Then the data need to be reprocessed cell pair by cell pair by means of the improved model function and the MLE, including negative estimates of backscatter. It is to be hoped that the reprocessed data up to σ^{o} for each cell have not degraded the data base by either averaging backscatter values or throwing out negative values.

For the NROSS, the results of this analysis are extremely valuable. Additional antennas and multiple looks at the same area of the sea surface will only compound the errors of using the SOS. The MLE is easily extended to a multiple beam design as in Pierson and Salfi (1982), and such as procedure is clearly the only correct way to proceed. Ways to make the computer processing of the data efficient and rapid then need to be developed.

IMPLICATIONS FOR FUTURE SCATTEROMETER DESIGNS

Review

The first scatterometer on a spacecraft was on Skylab manned for 171 days, May 1973 to February 1974. The total data base was about the equivalent of one or two complete SEASAT orbits. Even then encouraging results were obtained (Pierson, et al. (1978)). The circle flight data of the AAFE RADSCAT program suggested the way to recover the winds that was applied to the SEASAT SASS measurements (Pierson, Cardone and Greenwood (1974)).

The second scatterometer on a spacecraft was on SEASAT, placed in orbit on June 28, 1978m which failed 105 days later. The results of the SEASAT SASS have already been sufficiently impressive for a number of new scatterometers to be in various stages of planning.

Six years have passed since SEASAT and more than a decade has passed since Skylab. There have been three generations of altimeters placed in Earth orbit, S193 on Skylab, the GEOS-3 altimeter and the SEASAT altimeter, but these have been only two generations of scatterometers. The SEASAT SASS is thus comparable to the GEOS-3 altimeter in its inheritance and design sophistication. The next generation of scatterometers can be as much of an improvement over the SEASAT SASS as the SEASAT altimeter was over the GEOS-3 altimeter because of its improved design.

Improvements of the NROSS-NSCATT

Managers of NASA programs often speak of the heritage from past programs. This heritage consists of the knowledge gained from past programs and includes both the successes and the failures of these programs. It is possible to learn from past failures and mistakes and to eliminate them in the planning of new programs and new scatterometers systems. An instrument design that is capable or showing up the theoretical errors made in analysing the data must be considered to be successful as a step toward improved designs and corrected theories.

As examples, some of the deficiencies of the SASS on SEASAT are being corrected in the design stage for NROSS. Attitude measurement errors, which the reader can verify increased the variance of the backscatter estimates by about a factor of ten for high winds as in the constant, A, in Table 1, will be greatly reduced. (One could imagine the results of this simulation had the values in Table 1 all been either reduced by a factor of 10 or had equaled the values at 46^{o}).

An improved antenna pattern that will not send about one third of the transmitted power over the horizon, never to return, is possible.

The effects of Earth rotation, which caused the doppler cells to move in and out relative to the subsatellite track, will be eliminated. Additional antennas will make it possible to eliminate most of the time two of the three aliases (or ambiguities) if the MLE is used, and greatly simplify data processing.

The combined effects of all of these design improvements might will be that the scatter in the data, as a result of instrument design and not of meso-scale variability, will be like that in Figs. 2-10 and 2-12 for the entire swath for winds above some threshold speed (see page 54).

Consequences

An improved design for a future scatterometer will necessarily provide incorrect results if the SASS-1 model function is used to recover the winds for reasons given herein. The greater the reduction in the variance of the backscatter estimates the more inaccurate the SASS-1 model function will become (see pages 19 and 28, catch 22, again).

There are other reasons why the SASS-1 is incorrect that will be documented in a report in preparation by M. Donelan and W. Pierson. They will substantiate some of the results of Woiceshyn, et al. (1984). The assumed power law model of the SASS-1 is probably incorrect.

An improved scatterometer design might conceiveably reduce the variance of the backscatter estimates by enough to make the SOS a tolerable approximation to the MLE as in Pierson and Salfi (1982) in one of the Appendicies. However, the computational simplicity of the SOS compared to the MLE is lost if the power law assumption is incorrect. Also, the SOS can never work for light enough winds.

Dr. Robert Frosch, at a luncheon speech in New Orleans, during a conference on the accomplishments of GEOS-3 described how scientists (including engineers, who are a subset of all scientists) actually solve complicated problems as opposed to how the public (and some, but not all, managers) think that they solve problem. There is no inexorable march from part one to part two to part three, --- to part n, to the final solution. In fact, it is often possible to reach part $n-q$ toward the goal and find out that part four, with $n-q>4$, say, was done incorrectly. It is then necessary to back up and start over, correcting all steps, to reach $n-q$ and then proceed to the final goal. A few steps backward can result in giant leaps forward.

The Outlook

Pierson ((1978), (1981), (1983)) is on record as being a total optimist on the potential of scatterometry for measuring the winds over the global ocean far more accurately than by any other conceivable method. The optimism is still present, but it has been tempered by more recent results on the study of the SASS data, especially those of Woiceshyn, et al. (1984) and by discussions with P. Woiceshyn on recently obtained results. A few steps backward, to gain a foothold, before further advances in a different direction, are, however, necessary and unavoidable.

Concern has been expressed by some that the SEASAT SASS did not meet its design objectives and that, ipso facto, the NROSS scatterometer will not meet its design objectives. This is a fallacy because it fails to consider what has been, and is being, learned from SEASAT scatterometer data. Incorrect theories can be corrected. A better model function can be obtained. Inconsistancies betweeen the AFFE RADSCAT circle flight data and the SASS-1 model function can be explained and eliminated. Correctly interpreted SEASAT scatterometer data can be used to obtain and verify a far superior model function prior to the launch of NROSS, especially for data from modes 3 and 4. These results, plus the vastly improved design of the NROSS scatterometer, will assure that the requirements as to the accuracy of the system will be more than satisfied.

To conclude, an edited portion of Pierson (1983) still sums up the present situation with the added comment that the learning process has continued so that what needs to be done is more clearly in focus.

> ---"Ideas that were set forth crudely in the 1960s have progressed to the point of practical global application. As in all science, the work is unfinished. Scientists have been trying to measure the winds, the waves, and other effects of the winds for centuries. It is not to be expected that the definitive answers to the full understanding of radar scatterometry have been found. There is much that still needs to be learned.
>
> However, there is no reason to wait until all is understood perfectly. Enough has been proved to make it undeniably clear that radar scatterometry can measure the winds over all the oceans

of the Earth twice a day, and that these winds are already superior to the conventionally measured winds when processed correctly and used for numerical weather prediction and ocean models. Further improvements over the next few years and the next few decades will follow, based on a deeper understanding of the physical processes that are involved and on better data processing and analysis procedures."

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APPENDIX A

TABLES FOR THE MONTE CARLO SIMULATION

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = .01
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.00	99.99	0.00	1
99.99	0.00	99.99	0.26	2
99.99	0.35	99.99	0.02	3
99.99	0.09	99.99	0.50	4
99.99	0.00	99.99	0.00	5
99.99	0.00	99.99	0.00	6
99.99	0.09	99.99	0.11	7
99.99	0.00	99.99	0.00	8
99.99	0.46	99.99	0.00	9
99.99	0.00	99.99	0.06	10
99.99	0.20	99.99	0.00	11
99.99	0.01	99.99	0.00	12
99.99	0.00	99.99	0.01	13
99.99	0.00	99.99	0.00	14
99.99	0.01	99.99	0.53	15
99.99	0.17	99.99	0.25	16
99.99	0.00	99.99	0.24	17
99.99	0.00	99.99	0.00	18
99.99	0.00	99.99	0.00	19
99.99	0.00	99.99	0.36	20
99.99	0.00	99.99	0.24	21
99.99	0.00	99.99	0.27	22
99.99	0.09	99.99	0.00	23
99.99	0.28	99.99	0.09	24
99.99	0.26	99.99	0.00	25

LARGE DIRECTION ERROR: RETURNS
B1 = 47 C1 = 19
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 18 C2 = 12
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 27 C3 = 12
NO SOS: CONTINUES
B4 = 10 C4 = 2
SOS: TWO SOLUTIONS: RETURNS
B5 = 3 C5 = 1
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 9 C6 = 1

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	25	0	25
V1-4,2	0	25	0	25
V1-4,9,0	25	14	25	12

CT = 105 TCT = 1115

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	.08	.02	.14
SOSV	0	88.88	88.88	88.88
MLEV	25	.12	.03	.18

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 1
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
1.66	1.45	1.22	1.15	1
99.99	0.56	99.99	0.97	2
1.35	1.23	1.32	1.25	3
99.99	0.84	99.99	0.90	4
1.15	1.08	99.99	0.81	5
99.99	0.77	99.99	0.81	6
99.99	0.86	99.99	1.25	7
99.99	1.19	1.12	1.06	8
99.99	0.83	1.33	1.22	9
99.99	0.89	1.17	1.11	10
1.34	1.27	99.99	0.69	11
99.99	0.78	99.99	0.95	12
1.17	1.08	99.99	1.00	13
99.99	0.94	1.31	1.22	14
0.97	0.90	1.39	1.32	15
99.99	0.63	1.11	1.05	16
99.99	0.80	99.99	0.88	17
1.22	1.08	99.99	0.71	18
99.99	0.88	1.16	1.07	19
99.99	0.77	1.12	1.04	20
99.99	1.09	99.99	0.98	21
99.99	0.81	99.99	0.90	22
99.99	0.63	99.99	1.08	23
99.99	0.95	99.99	1.05	24
1.46	1.30	99.99	0.70	25

LARGE DIRECTION ERROR: RETURNS
B1 = 2 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 8 C3 = 1
NO SOS: CONTINUES
B4 = 20 C4 = 14
SOS: TWO SOLUTIONS: RETURNS
B5 = 28 C5 = 17
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 1 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	8	25	10	25
V1-4,2	8	25	10	25
V1-4,9,0	17	0	15	0

CT = 73 TCT = 1010

	N	MEAN	VARIANCE	STD-DEV
SOSH	8	1.29	.04	.20
MLEH	25	.94	.05	.23
SOSV	10	1.23	.01	.10
MLEV	25	1.01	.03	.18

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 2
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
2.18	2.12	1.85	1.79	1
2.05	1.97	1.77	1.69	2
1.54	1.47	1.50	1.42	3
2.12	2.04	2.14	2.09	4
1.99	1.91	2.05	1.95	5
1.94	1.90	1.98	1.88	6
2.03	1.94	1.98	1.93	7
1.21	1.14	2.29	2.26	8
1.96	1.90	2.70	2.58	9
2.38	2.45	1.82	1.76	10
2.26	2.23	2.04	1.99	11
1.48	1.37	1.97	1.88	12
1.97	1.89	2.26	2.18	13
2.19	2.15	2.42	2.33	14
1.87	1.81	2.02	1.95	15
2.14	2.01	1.66	1.59	16
2.19	2.12	2.14	2.08	17
2.23	2.15	2.31	2.22	18
2.25	2.14	2.11	2.06	19
1.96	1.90	2.34	2.38	20
2.17	2.07	2.17	2.12	21
1.96	1.92	1.63	1.56	22
1.90	1.83	1.71	1.63	23
2.66	2.53	2.09	2.01	24
2.55	2.44	2.25	2.15	25

LARGE DIRECTION ERROR: RETURNS
B1 = 1 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 1 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 63 C5 = 20
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	25	25	25	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0
CT =	109 TCT = 937			

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	2.05	.09	.30
MLEH	25	1.98	.09	.30
SOSV	25	2.05	.07	.27
MLEV	25	1.98	.07	.27

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 3
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
2.72	2.62	3.02	2.94	1
2.64	2.57	2.98	2.84	2
3.20	3.05	2.98	2.92	3
3.22	3.08	3.26	3.22	4
3.08	3.00	2.87	2.98	5
3.06	2.95	3.08	2.94	6
2.58	2.53	2.21	2.15	7
2.73	2.60	2.84	2.74	8
2.24	2.28	3.75	3.62	9
2.94	2.84	2.60	2.60	10
2.73	2.78	3.19	3.12	11
2.85	2.78	2.13	2.01	12
3.04	3.13	2.82	2.93	13
2.29	2.27	3.39	3.38	14
2.47	2.46	3.10	2.96	15
2.73	2.70	2.92	2.79	16
3.81	3.79	2.55	2.45	17
3.66	3.48	3.19	3.33	18
2.91	2.85	2.10	2.07	19
3.33	3.20	2.85	2.79	20
3.33	3.18	3.03	3.03	21
2.78	3.00	99.99	2.87	22
3.29	3.20	3.48	3.38	23
2.56	2.55	2.64	2.52	24
2.54	2.42	3.17	3.15	25

LARGE DIRECTION ERROR: RETURNS
B1 = 1 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 1
SOS: TWO SOLUTIONS: RETURNS
B5 = 65 C5 = 28
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	25	25	24	25
V1-4,2	25	25	24	25
V1-4,9,0	0	0	1	0
CT =	120 TCT = 828			

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	2.91	.15	.39
MLEH	25	2.85	.13	.36
SOSV	24	2.92	.15	.39
MLEV	25	2.87	.16	.40

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 4
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
3.49	3.42	3.28	3.37	1
3.70	3.74	3.48	3.31	2
4.05	4.43	3.91	3.77	3
3.44	3.63	4.19	4.25	4
3.35	3.26	4.49	4.28	5
99.99	2.63	4.12	3.94	6
3.68	4.24	3.33	4.06	7
3.62	3.47	4.27	4.15	8
4.41	4.25	4.05	4.09	9
4.84	4.88	3.70	3.58	10
4.69	4.61	5.03	4.89	11
3.82	3.83	3.64	3.77	12
3.64	3.50	4.62	4.41	13
3.82	3.63	4.55	4.35	14
4.03	4.01	4.02	3.86	15
3.17	3.08	5.10	4.88	16
3.32	3.17	3.98	4.00	17
4.34	4.21	4.94	4.92	18
5.09	4.91	3.22	3.67	19
4.95	4.76	3.00	2.96	20
4.32	4.14	3.51	3.35	21
3.30	3.22	3.84	3.99	22
4.52	4.32	5.24	5.01	23
3.09	3.68	4.49	4.32	24
4.76	4.60	4.46	4.29	25

LARGE DIRECTION ERROR: RETURNS
B1 = 1 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 1 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 52 C5 = 26
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4, 1	23	24	22	23
V1-4, 2	24	25	25	25
V1-4, 9, 0	1	0	0	0

CT = 104 TCT = 708

	N	MEAN	VARIANCE	STD-DEV
SOSH	24	3.98	.35	.59
MLEH	25	3.90	.36	.60
SOSV	25	4.10	.36	.60
MLEV	25	4.06	.27	.52

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 5
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
4.75	4.94	5.45	5.21	1
4.70	4.47	5.61	5.37	2
4.91	4.88	4.51	4.31	3
4.28	4.10	4.71	4.50	4
4.65	4.79	5.69	5.44	5
4.45	4.67	4.73	4.51	6
4.95	4.85	4.42	4.22	7
5.53	5.33	5.62	5.85	8
4.90	4.74	5.07	4.95	9
5.19	5.28	4.39	4.21	10
5.87	5.63	5.34	5.10	11
4.50	4.28	4.76	4.57	12
5.03	4.85	4.28	4.82	13
5.01	4.92	4.76	4.56	14
5.21	5.00	4.70	4.53	15
6.01	5.74	4.66	4.60	16
5.06	4.82	4.47	4.31	17
4.37	4.51	3.28	4.00	18
4.64	4.43	4.38	4.23	19
5.00	4.80	3.62	4.11	20
4.54	4.37	5.66	5.58	21
6.13	6.11	5.18	4.94	22
5.72	5.64	3.85	3.70	23
5.08	5.18	5.25	5.04	24
4.41	4.31	4.45	4.46	25

LARGE DIRECTION ERROR: RETURNS
B1 = 2 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 61 C5 = 29
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4, 1	23	24	22	24
V1-4, 2	25	25	25	25
V1-4, 9, 0	0	0	0	0

CT = 117 TCT = 604

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	5.00	.25	.50
MLEH	25	4.91	.24	.49
SOSV	25	4.75	.38	.62
MLEV	25	4.69	.27	.52

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 6
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
5.93	5.66	6.16	5.98	1
5.03	4.80	5.23	5.03	2
5.81	5.54	4.78	4.91	3
5.76	5.91	4.45	4.28	4
4.69	4.66	6.01	5.79	5
6.37	6.10	6.90	7.04	6
5.35	5.37	6.36	6.09	7
5.80	5.55	6.16	5.89	8
5.06	4.87	6.35	6.12	9
6.27	5.97	6.48	6.94	10
5.39	5.21	6.00	6.24	11
5.78	5.89	5.27	5.36	12
7.14	6.91	6.29	6.13	13
5.73	6.46	4.83	4.74	14
6.98	6.67	5.30	5.09	15
4.94	5.98	5.63	5.44	16
6.53	6.27	6.67	6.48	17
7.04	6.71	5.18	5.10	18
5.94	5.73	6.73	6.44	19
5.94	6.26	5.51	5.56	20
6.15	5.87	5.27	5.29	21
4.96	4.82	5.66	5.41	22
7.19	6.90	6.03	5.75	23
6.76	6.47	6.01	5.76	24
5.44	5.58	5.72	5.64	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 2
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 43 C5 = 37
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	19	21	22	21
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 107 TCT = 487

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	5.92	.51	.71
MLEH	25	5.85	.41	.64
SOSV	25	5.80	.39	.63
MLEV	25	5.70	.42	.65

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 7
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
7.54	7.26	6.13	5.98	1
6.45	6.15	5.91	5.93	2
5.65	5.74	7.77	7.91	3
7.27	7.60	7.35	7.07	4
7.28	8.09	6.79	6.54	5
6.07	6.53	7.36	7.09	6
8.15	8.36	5.87	5.97	7
5.35	5.45	7.15	7.04	8
7.36	7.11	7.01	6.69	9
8.29	8.06	5.38	5.20	10
7.41	7.11	5.53	5.28	11
5.49	5.60	7.05	6.82	12
7.01	6.69	5.34	5.29	13
6.85	6.59	5.64	5.73	14
7.07	6.76	7.94	7.65	15
7.41	7.39	7.36	7.18	16
6.82	7.10	6.82	6.59	17
6.03	5.73	4.24	4.05	18
7.68	7.46	7.36	7.85	19
7.06	7.00	6.50	6.43	20
9.05	8.73	6.80	6.52	21
7.46	7.21	7.52	7.33	22
8.06	7.73	7.02	6.74	23
8.74	8.49	5.69	5.44	24
5.99	5.80	6.72	6.51	25

LARGE DIRECTION ERROR: RETURNS
B1 = 3 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 43 C5 = 19
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	16	15	17	16
V1-4,2	24	25	24	24
V1-4,9,0	0	0	0	0

CT = 90 TCT = 380

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	7.10	.91	.95
MLEH	25	7.03	.84	.92
SOSV	25	6.57	.79	.89
MLEV	25	6.43	.82	.91

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 8
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
8.20	7.85	7.40	7.09	1
6.84	6.92	8.91	8.52	2
9.75	9.37	6.89	6.60	3
8.86	8.47	9.41	9.00	4
9.34	9.09	9.02	8.63	5
6.86	7.46	8.55	8.28	6
8.45	8.04	8.11	8.13	7
8.37	8.01	6.63	6.83	8
8.55	8.23	9.00	8.70	9
8.35	8.72	9.43	9.06	10
8.98	8.60	7.95	7.68	11
9.39	8.98	8.12	7.84	12
8.08	9.15	7.52	8.24	13
5.25	5.00	7.08	6.78	14
8.01	8.74	8.23	7.89	15
7.31	7.32	7.45	8.66	16
6.40	6.14	7.36	7.19	17
9.81	9.46	8.27	7.91	18
9.89	9.44	8.79	8.40	19
10.31	9.90	9.39	10.60	20
8.92	8.50	6.20	5.91	21
7.23	7.48	8.27	9.25	22
6.48	6.47	7.70	7.43	23
8.53	8.21	9.22	8.82	24
5.52	6.01	7.36	7.03	25

LARGE DIRECTION ERROR: RETURNS
B1 = 1 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 41 C5 = 11
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	13	14	16	18
V1-4,2	22	25	25	23
V1-4,9,0	0	0	0	0

CT = 79 TCT = 290

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	8.15	1.77	1.33
MLEH	25	8.06	1.44	1.20
SOSV	25	8.091001	.79	.89
MLEV	25	8.02	1.00	1.00

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 9
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
8.11	7.78	8.26	9.01	1
6.90	6.91	10.07	10.01	2
11.51	11.32	7.47	7.17	3
10.62	10.25	10.02	10.71	4
7.89	8.69	9.94	9.52	5
8.62	8.27	5.51	7.12	6
10.20	9.90	7.99	8.22	7
10.10	9.61	8.32	8.09	8
8.50	8.73	6.24	7.38	9
9.66	9.24	10.38	9.96	10
7.90	7.84	7.79	7.48	11
8.23	7.84	9.31	8.97	12
12.23	11.66	7.43	7.28	13
9.14	9.17	8.05	8.13	14
8.85	8.56	8.64	8.48	15
7.32	7.18	7.55	7.21	16
9.96	9.53	8.76	8.64	17
8.58	8.22	9.74	9.35	18
9.59	9.15	8.88	8.60	19
9.15	8.99	8.80	8.70	20
9.87	9.90	7.57	7.30	21
8.10	9.89	9.23	8.83	22
8.93	8.71	10.29	9.85	23
8.59	8.20	8.74	8.92	24
6.02	5.74	8.26	8.31	25

LARGE DIRECTION ERROR: RETURNS
B1 = 1 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 44 C5 = 24
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	15	16	13	16
V1-4,2	21	21	23	25
V1-4,9,0	0	0	0	0

CT = 94 TCT = 211

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	8.98	1.84	1.36
MLEH	25	8.85	1.65	1.28
SOSV	25	8.53	1.42	1.19
MLEV	25	8.53	.99	1.00

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 10
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
8.88	8.50	99.99	9.57	1
9.05	8.65	9.51	9.90	2
10.98	10.58	12.75	12.43	3
12.16	12.06	8.02	9.07	4
11.64	11.17	7.79	7.97	5
6.92	6.63	10.31	10.19	6
11.94	11.39	10.48	10.02	7
8.61	8.20	10.32	9.85	8
9.45	10.50	9.48	9.19	9
11.20	11.03	13.03	12.44	10
6.38	9.16	10.36	10.02	11
12.47	12.68	12.29	11.90	12
9.10	8.74	10.10	9.67	13
8.94	8.57	9.06	8.70	14
10.54	10.09	10.23	9.80	15
10.07	9.67	12.08	11.66	16
8.92	9.19	9.40	9.73	17
7.51	7.19	10.13	9.78	18
7.17	6.89	8.16	8.17	19
8.94	8.78	10.09	10.22	20
7.62	7.66	12.00	11.51	21
8.09	9.02	9.05	8.89	22
10.35	10.07	9.32	9.43	23
9.57	9.54	10.10	10.09	24
9.32	9.15	7.53	7.21	25

LARGE DIRECTION ERROR: RETURNS
B1 = 3 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 1
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 57 C5 = 31
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	9	10	15	16
V1-4,2	18	20	17	21
V1-4,9,0	0	0	1	0

CT = 117 TCT = 117

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	9.43	2.69	1.64
MLEH	25	9.40	2.31	1.52
SOSV	24	10.07	2.16	1.47
MLEV	25	9.90	1.63	1.28

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = .01
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.00	99.99	0.00	1
99.99	0.28	99.99	0.01	2
99.99	0.00	99.99	0.00	3
99.99	0.00	99.99	0.00	4
99.99	0.00	99.99	0.00	5
99.99	0.00	99.99	0.00	6
99.99	0.32	99.99	0.21	7
99.99	0.40	99.99	0.34	8
99.99	0.00	99.99	0.14	9
99.99	0.00	99.99	0.28	10
99.99	0.00	99.99	0.00	11
99.99	0.00	99.99	0.00	12
99.99	0.00	99.99	0.11	13
99.99	0.14	99.99	0.15	14
99.99	0.00	99.99	0.00	15
99.99	0.00	99.99	0.00	16
99.99	0.00	99.99	0.17	17
99.99	0.30	99.99	0.26	18
99.99	0.44	99.99	0.00	19
99.99	0.07	99.99	0.00	20
99.99	0.10	99.99	0.00	21
99.99	0.00	99.99	0.35	22
99.99	0.19	99.99	0.00	23
99.99	0.05	99.99	0.33	24
99.99	0.10	99.99	0.00	25

LARGE DIRECTION ERROR: RETURNS
B1 = 25 C1 = 18
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 16 C2 = 11 (14)
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 20 C3 = 13
NO SOS: CONTINUES
B4 = 10 C4 = 1
SOS: TWO SOLUTIONS: RETURNS
B5 = 1 C5 = 1
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 2 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	25	0	25
V1-4,2	0	25	0	25
V1-4,9,0	25	14	25	14

CT = 72 TCT = 1033

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	.10	.02	.14
SOSV	0	88.88	88.88	88.88
MLEV	25	.09	.02	.14

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 1
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.73	1.25	1.19	1
99.99	0.92	99.99	0.74	2
1.11	1.03	1.32	1.20	3
99.99	1.03	99.99	1.00	4
99.99	0.74	99.99	0.84	5
1.21	1.15	99.99	1.20	6
0.99	0.92	99.99	0.81	7
99.99	1.19	99.99	1.15	8
99.99	0.85	99.99	1.05	9
1.01	0.96	99.99	0.97	10
1.08	1.00	99.99	0.76	11
99.99	0.81	99.99	1.12	12
1.50	1.38	99.99	0.87	13
99.99	0.91	1.05	0.98	14
1.21	1.14	99.99	1.03	15
1.40	1.33	99.99	0.85	16
99.99	1.02	1.56	1.44	17
99.99	1.00	99.99	0.94	18
99.99	1.14	99.99	1.00	19
1.33	1.26	99.99	1.13	20
1.23	1.14	99.99	0.70	21
99.99	0.97	99.99	0.86	22
1.00	0.92	99.99	0.84	23
1.09	0.99	99.99	1.14	24
99.99	1.05	99.99	0.72	25

LARGE DIRECTION ERROR: RETURNS
B1 = 15 C1 = 2
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 6 C3 = 10
NO SOS: CONTINUES
B4 = 19 C4 = 14
SOS: TWO SOLUTIONS: RETURNS
B5 = 21 C5 = 17
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 1 C6 = 3

	SOSH	MLEH	SOSV	MLEV
V1-4,1	12	25	4	25
V1-4,2	12	25	4	25
V1-4,9,0	13	0	21	0

CT = 84 TCT = 961

	N	MEAN	VARIANCE	STD-DEV
SOSH	12	1.18	.02	.14
MLEH	25	1.02	.03	.18
SOSV	4	1.30	.03	.18
MLEV	25	.98	.03	.18

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 2
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
2.06	2.01	2.27	2.22	1
1.94	1.90	2.18	2.13	2
1.87	1.81	2.02	1.96	3
1.84	1.75	2.34	2.25	4
1.75	1.68	1.76	1.55	5
2.15	2.08	1.92	1.83	6
2.39	2.42	2.14	2.11	7
2.24	2.18	1.87	1.81	8
1.94	1.86	2.06	2.01	9
2.35	2.27	2.17	2.15	10
2.04	1.96	1.68	1.61	11
2.43	2.32	1.98	1.92	12
2.13	2.04	1.66	1.59	13
2.04	1.94	2.21	2.19	14
2.05	1.95	2.45	2.36	15
1.90	1.83	2.01	1.96	16
1.53	1.46	1.23	1.14	17
2.21	2.14	1.75	1.66	18
1.82	1.73	2.19	2.10	19
2.04	1.95	2.55	2.44	20
2.38	2.29	2.24	2.17	21
2.02	1.95	2.06	1.93	22
1.11	1.05	2.16	2.10	23
2.20	2.15	1.56	1.49	24
2.14	2.05	2.25	2.16	25

LARGE DIRECTION ERROR: RETURNS
B1 = 9 C1 = 2
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 1 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 37 C5 = 29
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4, 1	25	25	25	25
V1-4, 2	25	25	25	25
V1-4, 9, 0	0	0	0	0

CT = 102 TCT = 877

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	2.02	.08	.28
MLEH	25	1.95	.08	.28
SOSV	25	2.03	.08	.28
MLEV	25	1.95	.09	.30

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 3
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
3.82	3.65	3.37	3.36	1
3.27	3.14	4.01	3.83	2
2.97	2.95	3.12	3.24	3
3.08	3.02	2.28	2.20	4
3.48	3.40	2.77	2.67	5
3.42	3.30	2.92	2.80	6
2.90	3.03	2.59	2.55	7
2.38	2.38	2.62	2.76	8
3.03	3.00	2.98	3.01	9
2.52	2.50	2.98	2.85	10
2.69	2.61	3.54	3.36	11
3.50	3.36	2.66	2.54	12
2.66	2.72	2.98	2.84	13
3.48	3.36	2.73	2.63	14
2.67	2.59	2.61	2.70	15
2.76	2.99	2.66	2.54	16
3.03	2.92	3.02	2.98	17
2.70	2.82	2.78	2.75	18
2.97	2.83	2.33	2.27	19
4.27	4.12	2.60	2.51	20
1.86	1.79	3.16	3.17	21
3.49	3.38	3.10	2.98	22
3.42	3.27	2.76	2.64	23
2.65	2.54	2.91	2.92	24
3.22	3.53	3.06	2.96	25

LARGE DIRECTION ERROR: RETURNS
B1 = 6 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 41 C5 = 23
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4, 1	23	23	24	25
V1-4, 2	25	25	25	25
V1-4, 9, 0	0	0	0	0

CT = 96 TCT = 775

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	3.05	.25	.50
MLEH	25	3.01	.22	.47
SOSV	25	2.90	.13	.36
MLEV	25	2.85	.12	.35

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 4
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
4.64	4.47	3.75	3.68	1
4.07	3.96	3.27	3.14	2
4.46	4.34	4.18	4.14	3
3.56	3.40	3.54	3.67	4
3.88	3.77	4.64	4.61	5
4.62	4.46	4.32	4.14	6
5.46	5.28	3.75	3.71	7
3.50	3.37	2.76	2.93	8
4.44	4.24	5.31	5.07	9
3.87	3.87	3.62	3.48	10
4.35	4.26	3.98	3.84	11
3.27	3.82	3.73	3.60	12
4.07	3.89	3.75	3.69	13
4.68	4.48	3.68	3.64	14
3.40	3.53	3.77	3.71	15
3.22	3.07	4.53	4.35	16
4.18	4.44	4.34	4.14	17
4.28	4.32	4.47	4.42	18
4.95	4.74	2.71	2.66	19
4.18	4.05	3.93	3.92	20
4.07	3.95	3.27	3.14	21
4.67	4.63	4.22	4.05	22
3.95	3.77	3.64	3.96	23
4.98	4.75	3.76	3.60	24
3.79	3.62	3.59	3.43	25

LARGE DIRECTION ERROR: RETURNS
B1 = 6 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 43 C5 = 22
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	24	24	22	23
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 96 TCT = 679

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	4.18	.30	.55
MLEH	25	4.10	.25	.50
SOSV	25	3.86	.31	.56
MLEV	25	3.79	.27	.52

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 5
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
3.99	3.99	5.17	4.96	1
4.17	4.12	5.02	5.32	2
5.41	5.32	4.44	4.26	3
4.43	4.43	4.03	4.05	4
5.70	5.44	5.02	4.88	5
5.05	5.39	4.22	4.66	6
4.89	4.67	5.49	5.39	7
5.25	5.05	3.91	3.86	8
3.83	3.82	4.66	4.89	9
5.48	5.22	4.33	4.17	10
99.99	4.52	5.61	5.94	11
4.27	4.12	4.44	4.68	12
5.11	4.94	4.19	5.04	13
4.73	4.52	5.64	5.50	14
4.12	4.03	5.02	5.78	15
5.87	5.65	5.59	5.39	16
3.80	3.94	4.99	4.78	17
4.52	4.33	5.56	5.33	18
4.52	4.34	4.52	4.91	19
5.88	5.61	4.59	4.39	20
5.01	5.10	4.05	4.86	21
4.11	4.18	5.40	5.17	22
5.97	5.83	5.29	5.12	23
4.24	4.05	4.44	4.55	24
4.61	4.42	4.18	4.86	25

LARGE DIRECTION ERROR: RETURNS
B1 = 4 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 1 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 44 C5 = 26
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	21	22	24	24
V1-4,2	24	25	25	25
V1-4,9,0	1	0	0	0

CT = 100 TCT = 583

	N	MEAN	VARIANCE	STD-DEV
SOSH	24	4.79	.44	.66
MLEH	25	4.68	.37	.61
SOSV	25	4.79	.30	.55
MLEV	25	4.91	.26	.51

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 6
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
6.34	6.19	5.67	6.55	1
7.12	6.81	5.83	5.58	2
6.56	6.44	5.77	5.53	3
5.76	5.51	5.40	6.10	4
6.81	6.54	5.67	5.52	5
6.50	6.23	5.32	5.13	6
5.33	5.43	5.83	5.60	7
5.88	6.21	5.77	5.74	8
5.46	5.21	6.55	6.41	9
4.91	4.95	5.85	5.64	10
5.44	5.53	5.18	5.24	11
5.39	5.30	6.95	6.65	12
4.92	4.72	7.02	6.81	13
5.44	5.67	5.37	5.13	14
5.87	5.75	6.96	6.74	15
6.04	6.67	4.06	3.88	16
6.12	5.85	5.33	5.09	17
6.19	5.94	5.61	5.44	18
5.70	5.44	7.26	6.98	19
4.23	5.59	6.57	6.41	20
7.18	6.95	6.56	6.28	21
5.55	5.61	6.10	6.01	22
5.53	5.59	6.80	6.58	23
6.42	6.19	6.07	5.87	24
5.44	5.65	6.14	5.88	25

LARGE DIRECTION ERROR: RETURNS
B1 = 8 C1 = 0
CALM: BOTH SIGMAS NEGATIVE: CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 30 C5 = 25
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	20	23	22	24
V1-4,2	25	25	25	24
V1-4,9,0	0	0	0	0
CT =	88 TCT = 483			

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	5.85	.47	.69
MLEH	25	5.84	.31	.56
SOSV	25	5.99	.50	.71
MLEV	25	5.87	.48	.69

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 7
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
6.44	7.18	6.50	6.41	1
7.14	6.85	7.32	7.05	2
7.15	6.97	6.98	6.74	3
7.44	7.10	7.78	7.67	4
6.57	6.32	5.78	5.86	5
7.50	7.15	6.67	6.38	6
6.01	5.75	7.35	7.02	7
6.64	7.22	6.62	6.80	8
7.45	7.09	6.26	6.06	9
7.26	6.95	7.25	5.93	10
6.81	6.73	6.58	6.66	11
6.34	6.63	4.82	5.68	12
7.33	7.14	7.12	6.93	13
7.39	7.06	7.70	7.36	14
5.01	5.02	6.94	6.92	15
6.09	5.83	6.34	6.72	16
6.42	6.67	7.92	7.57	17
6.47	6.58	6.30	6.21	18
5.90	5.65	7.04	6.95	19
7.33	7.01	6.70	6.48	20
4.68	4.62	8.00	7.75	21
6.87	7.05	4.61	4.52	22
6.95	6.83	7.87	7.63	23
8.09	7.74	7.06	7.92	24
6.94	6.71	6.97	6.69	25

LARGE DIRECTION ERROR: RETURNS
B1 = 4 C1 = 1
CALM: BOTH SIGMAS NEGATIVE: CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 55 C5 = 30
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	21	20	21	22
V1-4,2	24	24	23	24
V1-4,9,0	0	0	0	0
CT =	115 TCT = 395			

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	6.73	.58	.76
MLEH	25	6.63	.51	.71
SOSV	25	6.82	.68	.83
MLEV	25	6.76	.53	.73

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 8
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
8.46	8.09	6.66	6.41	1
7.25	7.18	8.51	8.14	2
8.29	8.14	9.47	9.12	3
8.55	8.17	6.86	6.78	4
8.22	7.89	8.64	8.52	5
7.35	7.07	5.75	5.52	6
8.27	8.05	8.31	8.19	7
7.38	7.07	8.54	8.50	8
7.07	7.51	6.39	6.40	9
8.75	8.63	7.87	7.64	10
7.71	8.37	7.05	7.67	11
6.30	6.19	7.20	6.90	12
8.20	7.94	8.74	8.45	13
9.97	9.61	10.20	9.80	14
8.28	7.90	7.10	6.79	15
9.04	9.00	6.48	7.26	16
9.44	9.19	7.44	7.15	17
5.95	7.01	8.17	8.06	18
8.21	7.85	6.61	7.08	19
7.58	7.88	7.48	7.16	20
9.38	9.02	6.28	6.73	21
7.56	7.21	8.49	8.44	22
8.12	7.77	8.09	7.90	23
9.86	9.50	6.56	6.61	24
7.49	7.96	9.47	9.81	25

LARGE DIRECTION ERROR: RETURNS
B1 = 7 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 24 C5 = 11
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	18	19	14	14
V1-4,2	24	25	23	24
V1-4,9,0	0	0	0	0

CT = 68 TCT = 280

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	8.11	.94	.97
MLEH	25	8.01	.66	.81
SOSV	25	7.70	1.27	1.13
MLEV	25	7.64	1.10	1.05

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 9
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
9.21	9.08	7.79	7.52	1
5.90	5.91	9.42	9.22	2
9.79	10.04	9.06	8.77	3
10.02	9.56	10.01	9.59	4
9.71	10.71	9.47	9.08	5
9.08	8.76	9.97	9.59	6
7.75	7.43	8.36	8.05	7
7.98	8.07	9.36	9.02	8
9.45	9.07	10.06	9.65	9
8.30	7.95	8.37	8.01	10
8.06	7.83	8.42	8.89	11
8.56	8.19	9.37	9.54	12
7.18	6.99	6.79	7.29	13
10.07	10.21	9.72	9.74	14
9.65	9.49	8.39	8.43	15
6.61	7.09	9.22	8.86	16
8.89	8.52	8.87	8.51	17
9.82	9.57	9.76	9.99	18
9.15	8.97	8.45	8.10	19
8.09	7.96	8.97	8.59	20
10.40	10.05	8.65	8.37	21
7.32	7.35	11.19	10.78	22
9.32	9.49	9.03	9.59	23
8.52	8.16	10.19	9.94	24
8.08	7.73	9.29	8.92	25

LARGE DIRECTION ERROR: RETURNS
B1 = 12 C1 = 2
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 36 C5 = 30
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	16	12	19	23
V1-4,2	23	23	23	25
V1-4,9,0	0	0	0	0

CT = 105 TCT = 212

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	8.68	1.27	1.13
MLEH	25	8.57	1.33	1.15
SOSV	25	9.15	.77	.88
MLEV	25	8.98	.68	.83

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 10
TH = 26
NO = 25

SOSH	MLEH	SOSV	MLEV	PO
10.83	10.62	11.54	11.22	1
12.09	11.65	11.32	11.21	2
11.01	10.51	11.05	11.96	3
10.30	10.30	9.04	8.84	4
9.53	9.28	6.42	6.28	5
11.94	11.61	10.37	10.29	6
9.17	8.86	9.46	9.71	7
9.53	9.21	12.94	12.43	8
10.62	10.48	13.51	12.98	9
9.66	9.92	10.13	11.42	10
11.57	11.32	9.50	9.18	11
10.39	10.01	9.36	8.97	12
11.51	11.39	9.09	9.78	13
10.61	10.47	6.42	8.88	14
8.29	8.24	7.01	8.24	15
9.72	9.37	10.28	10.22	16
9.55	9.23	11.26	10.76	17
11.21	10.83	8.70	8.31	18
11.47	10.94	9.00	8.61	19
9.51	9.10	8.76	8.51	20
8.42	9.99	8.77	8.55	21
9.52	9.19	9.99	9.56	22
9.71	9.28	8.93	8.57	23
9.00	8.89	11.10	10.63	24
9.49	9.72	9.02	8.81	25

LARGE DIRECTION ERROR: RETURNS
B1 = 6 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 48 C5 = 27
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	16	18	11	8
V1-4,2	24	24	20	22
V1-4,9,0	0	0	0	0

CT = 107 TCT = 107

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	10.19	1.08	1.04
MLEH	25	10.02	.86	.93
SOSV	25	9.72	2.87	1.69
MLEV	25	9.76	2.30	1.52

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = .01
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.00	99.99	0.00	1
99.99	0.00	99.99	0.00	2
99.99	0.00	99.99	0.00	3
99.99	0.00	99.99	0.30	4
99.99	0.00	99.99	0.00	5
99.99	0.00	99.99	0.00	6
99.99	0.15	99.99	0.00	7
99.99	0.27	99.99	0.00	8
99.99	0.00	99.99	0.05	9
99.99	0.25	99.99	0.00	10
99.99	0.00	99.99	0.00	11
99.99	0.00	99.99	0.01	12
99.99	0.00	99.99	0.28	13
99.99	0.00	99.99	0.00	14
99.99	0.07	99.99	0.00	15
99.99	0.37	99.99	0.00	16
99.99	0.00	99.99	0.32	17
99.99	0.26	99.99	0.23	18
99.99	0.00	99.99	0.25	19
99.99	0.15	99.99	0.43	20
99.99	0.20	99.99	0.00	21
99.99	0.34	99.99	0.01	22
99.99	0.00	99.99	0.00	23
99.99	0.00	99.99	0.38	24
99.99	0.00	99.99	0.30	25

LARGE DIRECTION ERROR: RETURNS
B1 = 43 C1 = 24
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 27 C2 = 12 (14)
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 21 C3 = 11
NO SOS: CONTINUES
B4 = 18 C4 = 7
SOS: TWO SOLUTIONS: RETURNS
B5 = 1 C5 = 0
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 12 C6 = 5

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	25	0	25
V1-4,2	0	25	0	25
V1-4,9,0	25	17	25	14

CT = 110 TCT = 1065

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	.07	.01	.10
SOSV	0	38.88	88.88	88.88
MLEV	25	10	.02	.14

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 1
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.58	99.99	0.77	1
99.99	0.88	99.99	0.90	2
99.99	0.69	1.30	1.24	3
1.23	1.13	99.99	0.96	4
1.26	1.17	99.99	0.95	5
1.22	1.16	99.99	0.66	6
1.16	1.10	99.99	0.37	7
99.99	0.90	99.99	0.99	8
0.87	0.81	99.99	0.97	9
99.99	0.79	99.99	0.83	10
99.99	1.04	99.99	0.95	11
1.13	1.01	99.99	0.80	12
1.16	1.10	0.99	0.94	13
0.95	0.88	99.99	1.12	14
99.99	0.94	99.99	0.73	15
99.99	0.97	99.99	0.78	16
1.29	1.19	99.99	0.72	17
1.22	1.13	99.99	0.76	18
99.99	0.74	99.99	0.90	19
99.99	0.79	1.21	1.14	20
99.99	0.66	99.99	0.61	21
1.15	1.08	99.99	0.49	22
99.99	0.95	99.99	0.86	23
99.99	0.94	99.99	0.99	24
1.25	1.18	99.99	0.86	25

LARGE DIRECTION ERROR: RETURNS
B1 = 3 C1 = 2
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 9 C3 = 8
NO SOS: CONTINUES
B4 = 26 C4 = 15
SOS: TWO SOLUTIONS: RETURNS
B5 = 43 C5 = 29
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 1 C6 = 1

	SOSH	MLEH	SOSV	MLEV
V1-4,1	12	25	3	25
V1-4,2	12	25	3	25
V1-4,9,0	13	0	22	0

CT = 104 TCT = 955

	N	MEAN	VARIANCE	STD-DEV
SOSH	12	1.16	.01	.10
MLEH	25	.95	.03	.18
SOSV	3	1.17	.01	.10
MLEV	25	.85	.04	.20

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 2
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
1.73	1.67	1.34	1.25	1
1.87	1.80	1.70	1.63	2
2.13	2.08	1.78	1.69	3
2.17	2.06	2.25	2.16	4
2.20	2.09	1.91	1.83	5
1.97	1.90	2.24	2.22	6
2.45	2.39	1.52	1.44	7
1.79	1.72	1.86	1.79	8
1.63	1.55	1.60	1.52	9
2.01	1.91	1.65	1.58	10
1.80	1.72	1.67	1.59	11
1.67	1.59	1.89	1.74	12
2.20	2.09	2.35	2.36	13
2.05	1.96	2.04	1.99	14
1.64	1.49	2.22	2.12	15
2.32	2.24	1.71	1.63	16
2.21	2.17	1.95	1.90	17
2.10	2.01	1.94	1.85	18
1.78	1.70	2.30	2.21	19
2.31	2.21	1.93	1.82	20
2.06	2.03	1.79	1.73	21
2.42	2.35	2.12	2.03	22
2.44	2.33	2.07	2.03	23
2.23	2.09	1.87	1.72	24
1.90	1.84	2.54	2.45	25

LARGE DIRECTION ERROR: RETURNS
B1 = 2 C1 = 0
CALM: BOTH SIGMAS NEGATIVE: CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 53 C5 = 26
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	25	25	25	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 106 TCT = 851

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	2.04	.06	.25
MLEH	25	1.96	.06	.25
SOSV	25	1.93	.07	.27
MLEV	25	1.85	.08	.28

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 3
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
2.47	2.39	3.38	3.23	1
3.09	2.95	3.13	3.08	2
2.44	2.47	2.92	3.25	3
2.67	2.68	2.65	2.56	4
3.29	3.18	3.20	3.07	5
3.88	3.78	3.68	3.84	6
2.62	2.53	3.04	3.21	7
2.87	2.77	3.27	3.41	8
3.30	3.14	3.82	3.66	9
3.88	3.70	2.00	1.93	10
2.72	2.78	3.28	3.25	11
2.43	2.35	2.66	2.57	12
3.16	3.59	2.80	2.69	13
2.49	2.60	3.18	3.07	14
3.68	3.67	2.28	2.24	15
1.90	1.82	2.97	3.22	16
3.32	3.25	3.02	2.89	17
3.43	3.32	2.38	2.28	18
2.30	2.21	3.32	3.17	19
2.40	2.33	2.71	2.75	20
2.81	3.08	3.29	3.19	21
2.61	2.59	2.91	2.82	22
3.11	2.98	3.24	3.22	23
3.02	3.00	3.04	3.08	24
3.16	3.16	2.56	2.43	25

LARGE DIRECTION ERROR: RETURNS
B1 = 2 C1 = 0
CALM: BOTH SIGMAS NEGATIVE: CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 44 C5 = 20
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	24	24	25	24
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 91 TCT = 745

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	2.92	.25	.50
MLEH	25	2.89	.25	.50
SOSV	25	2.99	.16	.40
MLEV	25	2.96	.19	.44

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 4
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
4.17	3.97	5.32	5.08	1
5.61	5.37	3.22	3.24	2
3.47	3.57	3.75	3.58	3
3.74	3.79	3.42	3.64	4
3.18	3.09	3.14	3.00	5
4.75	4.65	4.04	3.95	6
3.48	3.64	4.06	3.90	7
4.17	4.02	4.13	3.99	8
3.99	4.18	3.40	3.31	9
3.69	3.88	4.69	4.53	10
3.89	3.74	4.12	3.93	11
3.53	3.54	4.93	4.73	12
2.37	2.28	4.38	4.20	13
4.53	4.49	3.86	3.72	14
5.22	5.00	4.24	4.06	15
5.09	4.87	4.13	3.99	16
3.19	3.12	4.38	4.33	17
4.01	3.87	3.27	3.50	18
4.17	4.01	4.82	4.60	19
4.19	4.05	3.76	3.73	20
3.96	3.92	4.01	4.80	21
3.56	4.03	3.78	3.75	22
4.41	4.21	4.14	3.95	23
4.12	3.96	3.52	3.36	24
2.75	2.63	3.22	3.34	25

LARGE DIRECTION ERROR: RETURNS
B1 = 1 C1 = 1
CALM: BOTH SIGMAS NEGATIVE: CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 56 C5 = 26
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	20	21	24	24
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 109 TCT = 654

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	3.97	.52	.72
MLEH	25	3.92	.45	.67
SOSV	25	3.99	.30	.55
MLEV	25	3.93	.27	.52

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 5
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
6.39	6.14	5.22	5.04	1
5.86	5.67	4.84	4.76	2
5.34	5.16	4.18	4.47	3
4.67	4.48	4.37	4.18	4
4.70	4.55	5.75	5.58	5
3.50	3.37	5.08	5.04	6
4.15	3.98	3.88	3.75	7
4.03	4.16	4.93	5.03	8
4.51	4.41	4.61	4.39	9
5.50	5.26	4.40	4.29	10
4.57	5.00	5.23	5.13	11
3.63	3.47	5.38	5.14	12
5.13	4.94	4.96	4.82	13
4.69	4.51	3.02	2.96	14
4.54	4.84	4.45	5.36	15
3.46	3.46	5.53	5.51	16
4.08	4.83	5.09	4.88	17
6.13	6.16	3.78	3.62	18
6.07	5.83	5.26	5.49	19
4.96	4.80	3.23	3.58	20
4.69	4.48	5.93	5.86	21
6.37	6.07	4.35	4.17	22
4.39	4.24	3.55	3.68	23
4.76	4.61	5.23	4.98	24
5.56	5.48	5.16	4.94	25

LARGE DIRECTION ERROR: RETURNS
B1 = 1 C1 = 1
CALM: BOTH SIGMAS NEGATIVE: CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 47 C5 = 23
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	18	18	20	20
V1-4,2	25	25	25	24
V1-4,9,0	0	0	0	0

CT = 97 TCT = 545

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	4.87	.71	.8409999
MLEH	25	4.80	.62	.79
SOSV	25	4.70	.55	.74
MLEV	25	4.67	.52	.72

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 6
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
5.46	5.20	6.43	6.18	1
5.73	5.61	4.97	4.86	2
5.51	5.46	5.01	4.85	3
5.65	5.39	5.36	7.24	4
5.03	4.92	6.53	6.66	5
5.78	5.73	6.69	6.39	6
6.28	5.98	5.53	5.89	7
5.83	5.94	7.03	6.97	8
6.12	5.94	7.14	6.92	9
7.75	7.52	6.16	6.75	10
6.07	5.81	6.12	5.90	11
5.06	4.89	3.71	4.89	12
6.82	6.82	5.28	5.43	13
5.62	5.45	6.38	6.12	14
6.06	5.86	5.61	5.53	15
3.38	4.30	5.44	5.56	16
5.57	6.40	7.10	6.83	17
6.99	6.70	5.12	5.33	18
5.80	5.89	4.51	4.32	19
5.41	5.41	6.00	5.72	20
5.87	5.67	5.43	5.18	21
4.56	4.40	6.18	6.07	22
5.53	6.12	5.57	5.34	23
6.95	6.84	7.84	7.50	24
6.83	6.94	6.93	6.61	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE: CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 68 C5 = 18
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	22	20	18	19
V1-4,2	24	25	24	25
V1-4,9,0	0	0	0	0
CT =	111 TCT = 448			

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	5.8:	.73	.85
MLEH	25	5.61	.58	.76
SOSV	25	5.92	.84	.92
MLEV	25	5.96	.67	.82

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 7
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
6.40	6.17	8.32	7.99	1
6.75	6.44	5.59	5.52	2
6.11	6.07	7.07	7.19	3
7.05	6.73	7.73	7.54	4
5.95	5.76	5.21	5.03	5
7.24	6.95	3.61	4.17	6
6.74	6.42	5.55	6.40	7
7.95	7.80	5.99	5.72	8
7.32	6.99	6.93	6.77	9
6.00	5.78	4.96	5.08	10
8.69	8.62	8.10	7.98	11
6.90	6.61	5.72	5.56	12
5.29	5.04	6.37	6.42	13
5.03	5.09	7.45	7.10	14
6.63	6.32	5.94	5.83	15
6.60	6.36	7.43	7.13	16
7.45	7.16	7.65	7.54	17
6.63	6.57	5.92	5.93	18
7.17	6.82	7.16	6.84	19
6.93	6.59	7.34	7.06	20
8.13	8.16	7.56	7.25	21
6.49	6.19	7.86	7.51	22
5.88	6.49	5.53	5.63	23
5.67	5.49	7.05	6.74	24
5.34	5.82	8.13	7.97	25

LARGE DIRECTION ERROR: RETURNS
B1 = 1 C1 = 0
CALM: BOTH SIGMAS NEGATIVE: CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 38 C5 = 27
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	17	17	12	16
V1-4,2	25	25	23	24
V1-4,9,0	0	0	0	0
CT =	91 TCT = 337			

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	6.65	.76	.87
MLEH	25	6.50	.68	.83
SOSV	25	6.65	1.35	1.16
MLEV	25	6.56	1.03	1.02

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 8
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
8.62	8.86	6.67	6.71	1
7.75	7.41	6.16	6.22	2
9.32	9.01	8.26	8.35	3
7.34	6.99	9.24	8.84	4
9.10	9.00	7.11	6.94	5
8.01	8.17	7.05	6.75	6
8.83	8.81	8.97	8.57	7
7.09	7.73	6.99	6.72	8
6.88	6.67	9.95	9.52	9
6.24	6.13	7.34	7.03	10
6.43	6.47	8.59	8.21	11
8.16	8.07	6.71	7.16	12
8.82	8.58	6.98	7.07	13
8.91	8.64	6.56	6.41	14
7.36	7.15	7.13	7.58	15
7.06	6.89	8.75	8.73	16
8.58	8.17	7.29	6.96	17
10.97	10.53	9.36	9.01	18
6.79	7.16	7.92	7.57	19
7.21	6.87	7.68	7.37	20
7.38	7.79	8.13	7.77	21
7.88	8.84	7.91	7.66	22
7.70	7.36	7.00	6.72	23
8.76	8.43	7.31	6.98	24
8.15	7.77	7.84	8.08	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 30 C5 = 23
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	18	16	16	14
V1-4,2	24	24	25	25
V1-4,9,0	0	0	0	0

CT = 79 TCT = 246

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	7.97	1.09	1.04
MLEH	25	7.90	.99	1.00
SOSV	25	7.72	.91	.95
MLEV	25	7.56	.76	.87

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 9
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
7.53	7.30	8.55	8.23	1
7.84	7.86	9.94	10.23	2
8.11	8.84	8.94	8.60	3
8.75	9.00	9.55	9.81	4
8.91	8.98	8.11	7.99	5
9.09	8.88	7.73	7.39	6
9.35	8.92	7.90	7.60	7
8.65	8.24	7.24	7.00	8
9.37	9.07	8.34	7.96	9
9.27	8.90	10.49	10.03	10
9.78	9.31	8.29	7.91	11
8.86	8.98	9.78	10.01	12
6.81	7.61	7.77	7.49	13
7.48	7.31	8.39	8.85	14
8.61	8.57	11.51	11.02	15
7.47	7.18	8.97	8.67	16
9.55	9.12	8.53	8.15	17
8.52	8.24	9.58	9.16	18
9.19	8.76	9.51	9.12	19
9.98	10.16	8.43	8.24	20
8.19	7.99	8.90	8.52	21
9.85	9.52	7.49	7.51	22
8.82	9.24	10.32	9.93	23
7.84	7.50	8.14	7.80	24
9.20	9.17	10.09	9.65	25

LARGE DIRECTION ERROR: RETURNS
B1 = 5 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 44 C5 = 19
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	19	17	16	12
V1-4,2	24	24	24	24
V1-4,9,0	0	0	0	0

CT = 94 TCT = 167

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	8.68	.67	.82
MLEH	25	8.59	.58	.76
SOSV	25	8.90	1.06	1.03
MLEV	25	8.67	1.09	1.04

SOS, MLE, MONTE CARLC
UPWIND
INPUT WIND = 10
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
10.03	9.71	10.10	9.64	1
10.30	10.28	9.33	8.95	2
9.38	9.80	9.43	10.13	3
8.05	7.99	9.27	9.03	4
10.79	10.82	10.02	9.91	5
12.13	11.58	10.20	9.74	6
12.73	12.15	11.96	12.32	7
9.54	9.11	10.10	9.69	8
9.01	10.75	10.07	9.99	9
5.01	4.89	9.48	9.60	10
10.13	10.49	8.23	9.02	11
7.84	7.52	8.84	9.12	12
9.57	9.21	10.54	10.08	13
9.53	10.16	10.74	10.41	14
9.71	11.34	9.44	9.25	15
8.93	8.87	10.48	10.05	16
12.23	12.47	7.76	7.42	17
9.97	10.07	10.01	9.85	18
10.65	11.03	9.83	9.64	19
10.42	9.95	8.02	7.66	20
10.42	10.32	9.79	9.54	21
10.51	11.10	10.39	10.06	22
7.66	8.19	10.46	10.02	23
9.45	9.48	9.39	8.96	24
7.25	7.86	11.13	10.72	25

LARGE DIRECTION ERROR: RETURNS
B1 = 2 C1 = 0
CALM: BOTH SIGMAS NEGATIVE: CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 33 C5 = 13
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	16	13	19	20
V1-4,2	18	20	24	22
V1-4,9,0	0	0	0	0
CT =	73 TCT = 73			

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	9.65	2.62	1.62
MLEH	25	9.81	2.61	1.62
SOSV	25	9.80	.84	.92
MLEV	25	9.63	.84	.92

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = .01
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.00	99.99	0.00	1
99.99	0.00	99.99	0.00	2
99.99	0.43	99.99	0.44	3
99.99	0.30	99.99	0.00	4
99.99	0.00	99.99	0.00	5
99.99	0.56	99.99	0.80	6
99.99	0.00	99.99	0.42	7
99.99	0.00	99.99	0.30	8
99.99	0.00	99.99	0.29	9
99.99	0.00	99.99	0.00	10
99.99	0.00	99.99	0.00	11
99.99	0.13	99.99	0.38	12
99.99	0.00	99.99	0.44	13
99.99	0.00	99.99	0.05	14
99.99	0.49	99.99	0.10	15
99.99	0.00	99.99	0.51	16
99.99	0.00	99.99	0.00	17
99.99	0.17	99.99	0.17	18
99.99	0.00	99.99	0.26	19
99.99	0.48	99.99	0.00	20
99.99	0.00	99.99	0.00	21
99.99	0.00	99.99	0.00	22
99.99	0.19	99.99	0.25	23
99.99	0.00	99.99	0.25	24
99.99	0.13	99.99	0.00	25

LARGE DIRECTION ERROR: RETURNS
B1 = 24 C1 = 18
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 20 C2 = 11
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 24 C3 = 12
NO SOS: CONTINUES
B4 = 5 C4 = 6
SOS: TWO SOLUTIONS: RETURNS
B5 = 0 C5 = 1
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 1 C6 = 4

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	25	0	25
V1-4,2	0	25	0	25
V1-4,9,0	25	16	25	11

CT = 73 TCT = 1183

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	.12	.03	.18
SOSV	0	88.88	88.88	88.88
MLEV	25	.19	.05	.23

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 1
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.60	0.96	0.90	1
99.99	0.62	1.32	1.23	2
1.39	1.32	99.99	1.04	3
99.99	0.37	0.93	0.88	4
1.34	1.27	1.12	1.07	5
1.25	1.11	1.01	0.96	6
99.99	0.73	99.99	0.91	7
99.99	0.86	1.09	1.03	8
99.99	0.75	99.99	0.78	9
99.99	0.64	1.28	1.22	10
1.49	1.42	99.99	0.55	11
1.34	1.23	99.99	0.55	12
1.27	1.13	99.99	0.99	13
99.99	0.69	99.99	0.66	14
0.93	0.88	1.26	1.16	15
99.99	1.00	99.99	1.25	16
99.99	0.78	1.21	1.12	17
99.99	0.91	1.18	1.09	18
99.99	0.91	99.99	0.87	19
1.19	1.12	1.29	1.23	20
99.99	0.64	99.99	0.29	21
1.10	1.04	1.20	1.14	22
1.15	1.08	99.99	0.99	23
99.99	0.75	1.29	1.22	24
99.99	1.35	99.99	1.20	25

LARGE DIRECTION ERROR: RETURNS
B1 = 15 C1 = 2
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 11 C3 = 4
NO SOS: CONTINUES
B4 = 33 C4 = 12
SOS: TWO SOLUTIONS: RETURNS
B5 = 40 C5 = 32
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 4 C6 = 4

	SOSH	MLEH	SOSV	MLEV
V1-4,1	10	25	13	25
V1-4,2	10	25	13	25
V1-4,9,0	15	0	12	0

CT = 122 TCT = 1110

	N	MEAN	VARIANCE	STD-DEV
SOSH	10	1.24	.02	.14
MLEH	25	.94	.07	.27
SOSV	13	1.17	.01	.10
MLEV	25	.97	.06	.25

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 2
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	1.54	1.83	1.76	1
2.19	2.19	2.08	2.04	2
2.50	2.41	2.27	2.19	3
1.73	1.65	2.06	1.97	4
2.31	2.25	1.75	1.67	5
1.25	1.18	2.14	1.95	6
2.06	1.97	1.82	1.75	7
2.08	2.06	1.85	1.78	8
1.87	1.80	1.90	1.82	9
2.08	2.02	1.83	1.69	10
2.29	2.31	2.37	2.31	11
99.99	1.84	2.39	2.37	12
1.90	1.85	2.18	2.12	13
1.95	1.86	1.79	1.72	14
1.90	1.82	1.67	1.59	15
2.39	2.31	2.30	2.23	16
1.81	1.74	2.69	2.63	17
2.04	1.98	1.92	1.86	18
1.86	1.71	1.48	1.38	19
2.13	2.03	1.99	1.94	20
1.85	1.78	1.70	1.62	21
2.19	2.09	1.98	1.93	22
2.06	2.01	1.69	1.82	23
2.21	2.19	1.46	1.39	24
2.00	1.92	2.17	2.07	25

LARGE DIRECTION ERROR: RETURNS
B1 = 13 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 1 C3 = 0
NO SOS: CONTINUES
B4 = 3 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 56 C5 = 46
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	23	25	25	25
V1-4,2	23	25	25	25
V1-4,9,0	2	0	0	0

CT = 140 TCT = 988

	N	MEAN	VARIANCE	STD-DEV
SOSH	23	2.03	.06	.25
MLEH	25	1.94	.07	.27
SOSV	25	1.98	.08	.28
MLEV	25	1.90	.09	.30

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 3
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
1.57	1.44	3.65	3.58	1
3.26	3.12	3.29	3.15	2
2.51	2.61	2.72	2.63	3
2.92	2.88	2.81	3.00	4
2.76	2.97	3.69	3.55	5
3.13	3.22	2.51	2.48	6
2.29	2.30	3.26	3.20	7
3.71	3.74	3.19	3.04	8
2.85	2.73	2.91	2.80	9
3.44	3.28	3.47	3.34	10
2,53	2.49	2.54	2.62	11
2.87	2.76	2.82	2.91	12
2.63	2.58	2.78	2.72	13
2.91	2.81	2.21	2.11	14
3.49	3.50	2.63	2.71	15
3.29	3.13	2.80	2.93	16
2.93	2.80	3.41	3.29	17
2.26	2.21	3.47	3.34	18
2.87	3.17	2.53	2.62	19
2.95	3.03	3.22	3.19	20
3.40	3.26	3.24	3.52	21
3.16	3.24	3.81	3.68	22
3.22	3.07	2.56	2.83	23
2.45	2.35	2.21	2.15	24
3.46	3.31	3.02	2.97	25

LARGE DIRECTION ERROR: RETURNS
B1 = 6 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 39 C5 = 25
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	24	24	25	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 95 TCT = 848

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	2.91	.22	.47
MLEH	25	2.88	.23	.48
SOSV	25	3.01	.18	.43
MLEV	25	2.97	.17	.41

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 4
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
3.33	3.18	2.96	3.21	1
3.24	3.47	3.62	3.70	2
3.21	3.76	4.48	4.29	3
4.23	4.05	3.52	3.58	4
3.70	3.54	4.41	4.47	5
4.11	3.98	3.31	3.45	6
3.62	3.59	3.60	3.79	7
3.63	3.47	3.82	3.81	8
3.74	3.57	3.89	3.73	9
3.31	3.28	3.51	3.43	10
3.70	3.55	4.19	4.26	11
3.33	3.35	4.88	4.67	12
3.40	3.33	4.87	4.83	13
3.84	3.67	4.61	4.54	14
3.57	3.54	4.15	3.98	15
3.83	3.68	3.55	3.68	16
4.40	4.34	3.47	3.67	17
3.49	3.33	3.70	3.57	18
3.50	3.35	3.33	3.18	19
4.42	4.34	4.78	4.57	20
4.39	4.33	3.62	3.47	21
3.39	3.41	3.71	3.60	22
3.66	3.54	3.42	3.28	23
3.64	3.47	4.09	3.93	24
4.11	3.93	4.09	3.95	25

LARGE DIRECTION ERROR: RETURNS
B1 = 3 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 40 C5 = 21
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	25	25	24	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 89 TCT = 753

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	3.71	.13	.36
MLEH	25	3.64	.11	.33
SOSV	25	3.90	.26	.51
MLEV	25	3.87	.22	.47

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 5
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
3.63	3.53	5.02	4.60	1
4.40	4.21	3.97	3.82	2
6.23	6.29	4.64	4.44	3
5.29	5.53	4.59	4.38	4
4.20	4.10	4.63	4.47	5
4.37	4.26	4.37	4.40	6
5.59	5.47	6.61	6.34	7
4.05	3.87	4.83	4.80	8
4.66	4.48	4.18	4.39	9
5.44	5.21	3.88	3.83	10
4.33	4.14	4.58	4.78	11
5.34	5.12	6.07	6.03	12
4.99	4.79	5.02	4.97	13
4.40	4.65	4.99	4.77	14
3.24	3.23	5.36	5.18	15
4.25	4.07	5.45	5.25	16
6.72	6.45	6.28	6.11	17
5.16	5.10	5.03	4.93	18
4.98	4.76	6.09	5.86	19
5.25	5.16	5.16	5.18	20
5.44	5.21	4.42	4.53	21
4.55	4.41	5.31	5.38	22
5.60	5.43	5.57	5.33	23
4.14	4.16	4.50	4.76	24
5.13	4.93	4.93	5.30	25

LARGE DIRECTION ERROR: RETURNS
B1 = 6 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 56 C5 = 23
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	21	20	19	20
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 110 TCT = 664

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	4.86	.60	.78
MLEH	25	4.74	.59	.77
SOSV	25	5.03	.46	.68
MLEV	25	4.96	.41	.64

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 6
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
6.13	5.88	4.78	5.14	1
6.35	6.08	5.17	4.96	2
6.48	7.06	5.70	6.33	3
4.61	4.65	5.17	5.25	4
6.20	5.96	6.61	6.46	5
5.66	6.27	4.59	4.84	6
6.61	6.32	6.62	6.35	7
6.97	7.33	7.78	7.95	8
6.36	6.76	5.18	5.09	9
5.40	5.53	6.48	6.24	10
4.72	5.28	5.83	5.92	11
6.23	5.94	4.57	5.54	12
5.25	5.06	5.36	5.13	13
5.29	5.06	6.01	6.32	14
5.91	5.64	6.96	6.73	15
6.67	6.96	5.27	5.27	16
5.20	4.97	5.95	5.73	17
5.01	5.48	6.78	7.13	18
4.10	3.95	5.03	6.56	19
6.27	6.33	5.99	5.81	20
6.99	6.73	5.09	4.88	21
5.77	5.52	5.20	5.63	22
5.91	5.75	6.69	6.49	23
6.41	6.24	6.16	6.26	24
5.53	5.40	7.59	7.27	25

LARGE DIRECTION ERROR: RETURNS
B1 = 9 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 41 C5 = 32
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	22	20	20	20
V1-4,2	25	24	25	25
V1-4,9,0	0	0	0	0

CT = 107 TCT = 554

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	5.84	.54	.74
MLEH	25	5.85	.61	.78
SOSV	25	5.86	.76	.87
MLEV	25	5.97	.64	.80

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 7
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
7.22	7.35	5.65	6.20	1
6.21	7.18	6.88	6.57	2
7.75	7.48	5.64	6.35	3
6.74	6.43	8.02	7.96	4
5.36	5.13	8.24	7.99	5
8.45	8.11	6.73	6.80	6
4.09	4.10	6.80	6.52	7
6.02	5.76	5.28	5.61	8
6.97	6.67	7.65	7.36	9
6.01	5.75	8.17	7.83	10
7.39	7.21	7.11	6.83	11
5.16	4.91	6.99	6.68	12
7.28	7.06	6.76	6.56	13
6.05	6.33	6.69	6.39	14
5.25	5.44	5.51	5.27	15
8.04	7.75	7.75	7.46	16
6.96	6.80	6.09	5.84	17
7.34	7.00	6.37	6.27	18
7.71	7.34	7.29	7.05	19
6.69	6.54	7.96	8.05	20
5.82	6.07	7.80	7.53	21
7.11	6.80	6.95	6.68	22
7.64	7.28	6.39	6.14	23
7.92	7.58	5.67	5.49	24
7.80	7.62	5.43	5.20	25

LARGE DIRECTION ERROR: RETURNS
B1 = 6 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 53 C5 = 39
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	18	18	16	19
V1-4,2	24	23	25	25
V1-4,9,0	0	0	0	0

CT = 124 TCT = 447

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	6.76	1.11	1.05
MLEH	25	6.63	.94	.97
SOSV	25	6.79	.81	.90
MLEV	25	6.67	.68	.83

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 8
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
8.94	8.53	7.98	7.71	1
7.13	6.85	5.16	7.59	2
8.27	9.07	7.41	8.00	3
7.18	7.90	7.69	7.47	4
7.94	7.73	7.31	7.26	5
8.19	7.88	6.59	6.39	6
7.36	8.25	7.61	7.30	7
7.96	7.77	9.50	9.11	8
6.86	6.88	7.75	7.60	9
8.83	8.61	6.55	6.66	10
8.39	8.46	9.51	9.54	11
5.85	7.31	9.74	9.64	12
7.81	7.47	8.38	8.08	13
7.72	7.48	7.24	7.04	14
8.15	7.78	6.49	6.75	15
9.40	9.11	8.85	8.47	16
6.90	6.65	10.03	10.03	17
8.17	7.92	6.94	7.04	18
8.58	8.21	7.08	6.80	19
7.50	7.70	7.73	7.77	20
7.50	7.17	7.32	7.03	21
7.04	6.88	8.53	8.18	22
8.32	7.96	7.55	7.81	23
7.58	7.59	7.81	7.48	24
7.94	7.69	8.07	7.74	25

LARGE DIRECTION ERROR: RETURNS
B1 = 9 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 55 C5 = 39
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	21	19	16	17
V1-4,2	24	25	23	24
V1-4,9,0	0	0	0	0

CT = 128 TCT = 323

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	7.82	.57	.76
MLEH	25	7.80	.41	.64
SOSV	25	7.79	1.21	1.10
MLEV	25	7.78	.87	.93

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 9
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
4.76	5.77	10.82	10.53	1
9.62	9.18	10.38	9.95	2
6.41	6.68	8.72	8.41	3
9.07	9.30	7.35	8.85	4
8.04	10.23	10.93	10.66	5
8.35	8.31	7.45	7.25	6
8.80	8.43	8.04	7.94	7
8.61	8.51	9.60	9.18	8
9.29	8.89	8.46	8.27	9
10.79	10.71	9.65	9.34	10
10.32	10.28	9.25	8.86	11
7.36	7.40	6.40	6.91	12
8.29	8.11	8.56	8.24	13
8.20	7.91	7.98	8.04	14
7.93	7.77	6.77	6.49	15
10.25	10.82	7.35	7.70	16
9.04	9.76	7.87	7.53	17
9.86	9.51	8.24	8.25	18
7.18	7.63	9.95	9.91	19
7.92	9.00	6.79	7.71	20
9.13	9.13	9.13	9.85	21
9.13	9.38	11.42	11.06	22
11.28	10.87	8.55	8.38	23
7.85	7.52	5.59	6.39	24
9.66	9.22	9.01	8.66	25

LARGE DIRECTION ERROR: RETURNS
B1 = 7 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 46 C5 = 21
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	14	13	12	14
V1-4,2	22	22	20	21
V1-4,9,0	0	0	0	0

CT = 99 TCT = 195

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	8.69	1.92	1.39
MLEH	25	8.81	1.61	1.27
SOSV	25	8.57	2.09	1.45
MLEV	25	8.57	1.52	1.23

SOS,MLE,MONTE CARLO
DOWNWIND
INPUT WIND = 10
TH = 36
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
8.73	8.37	10.39	10.91	1
10.45	10.03	11.17	10.69	2
7.90	7.80	10.02	11.20	3
10.27	9.79	9.49	10.86	4
8.43	8.44	9.58	9.40	5
8.38	9.24	10.62	10.16	6
8.22	7.97	11.68	11.16	7
10.11	9.73	8.55	9.26	8
11.20	11.05	10.37	10.09	9
8.67	8.99	9.65	9.52	10
8.59	8.29	10.15	10.16	11
8.52	8.34	10.90	10.61	12
9.52	9.28	10.80	11.07	13
7.62	8.59	11.98	11.54	14
8.75	9.18	11.80	11.28	15
8.84	8.70	11.79	11.75	16
8.70	8.62	9.47	9.08	17
9.22	8.80	9.95	9.74	18
9.60	9.18	10.66	10.49	19
9.20	8.85	7.67	7.97	20
10.50	10.03	8.57	8.22	21
8.92	8.58	9.64	9.78	22
9.23	8.99	8.31	8.30	23
9.37	9.02	10.02	10.17	24
10.23	9.98	10.25	10.40	25

LARGE DIRECTION ERROR: RETURNS
B1 = 5 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 37 C5 = 28
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	11	10	16	16
V1-4,2	23	23	24	24
V1-4,9,0	0	0	0	0

CT = 96 TCT = 96

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	9.17	.76	.87
MLEH	25	9.03	.54	.74
SOSV	25	10.14	1.18	1.09
MLEV	25	10.15	1.02	1.01

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = .01
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.62	99.99	0.00	1
99.99	0.00	99.99	0.19	2
99.99	1.48	99.99	0.44	3
99.99	0.73	99.99	0.25	4
99.99	0.00	99.99	0.00	5
99.99	0.69	99.99	0.00	6
99.99	0.85	99.99	0.42	7
99.99	0.81	99.99	0.00	8
99.99	1.05	99.99	0.00	9
99.99	0.00	99.99	0.00	10
99.99	0.92	99.99	0.00	11
99.99	0.96	99.99	0.00	12
99.99	2.03	99.99	0.00	13
99.99	0.73	99.99	0.54	14
99.99	1.51	99.99	0.00	15
99.99	1.36	99.99	0.00	16
99.99	0.00	99.99	0.00	17
99.99	0.00	99.99	0.00	18
99.99	0.91	99.99	0.00	19
99.99	0.00	99.99	0.00	20
99.99	0.82	99.99	0.63	21
99.99	1.06	99.99	0.00	22
99.99	0.98	99.99	0.11	23
99.99	0.00	99.99	0.00	24
99.99	0.00	99.99	0.00	25

LARGE DIRECTION ERROR: RETURNS
B1 = 37 C1 = 22
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 23 C2 = 17 (18)
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 31 C3 = 8
NO SOS: CONTINUES
B4 = 7 C4 = 9
SOS: TWO SOLUTIONS: RETURNS
B5 = 2 C5 = 0
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 5 C6 = 9

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	19	0	25
V1-4,2	0	24	0	25
V1-4,9,0	25	8	25	18

CT = 100 TCT = 1173

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	.70	.32	.57
SOSV	0	88.88	88.88	88.88
MLEV	25	.10	.04	.20

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 1
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	2.10	99.99	0.91	1
99.99	1.57	99.99	1.09	2
99.99	1.01	99.99	1.61	3
99.99	1.59	99.99	1.30	4
99.99	0.75	99.99	0.36	5
99.99	0.00	99.99	0.88	6
99.99	1.16	99.99	1.01	7
99.99	0.00	99.99	0.87	8
99.99	2.23	99.99	0.56	9
99.99	0.00	99.99	1.01	10
99.99	0.92	99.99	0.94	11
99.99	1.55	99.99	0.58	12
99.99	0.18	99.99	1.12	13
99.99	1.48	99.99	1.58	14
99.99	0.26	99.99	1.21	15
99.99	1.06	99.99	0.85	16
99.99	1.40	99.99	0.79	17
99.99	0.00	99.99	1.49	18
99.99	0.78	99.99	1.35	19
99.99	1.53	99.99	1.07	20
99.99	1.91	99.99	0.81	21
99.99	0.00	99.99	0.00	22
99.99	1.57	99.99	1.00	23
99.99	0.75	99.99	1.21	24
99.99	0.20	99.99	0.75	25

LARGE DIRECTION ERROR: RETURNS
B1 = 34 C1 = 10
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 13 C2 = 1
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 40 C3 = 22
NO SOS: CONTINUES
B4 = 21 C4 = 15
SOS: TWO SOLUTIONS: RETURNS
B5 = 4 C5 = 10
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 16 C6 = 13

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	23	0	25
V1-4,2	0	25	0	25
V1-4,9,0	25	5	25	1

CT = 112 TCT = 1073

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	.96	.50	.71
SOSV	0	88.88	88.88	88.88
MLEV	25	.97	.13	.36

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 2
TH = 40
ND = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	1.57	99.99	1.92	1
99.99	2.38	99.99	1.95	2
99.99	1.83	99.99	1.96	3
99.99	1.56	99.99	1.94	4
99.99	2.57	99.99	1.80	5
99.99	2.64	99.99	2.13	6
99.99	1.51	99.99	2.39	7
99.99	2.06	99.99	1.67	8
99.99	2.18	99.99	2.14	9
99.99	2.93	99.99	1.98	10
99.99	1.66	99.99	2.16	11
99.99	2.32	99.99	2.02	12
99.99	1.35	99.99	1.92	13
99.99	2.31	99.99	1.75	14
99.99	1.73	99.99	2.09	15
99.99	1.26	99.99	2.00	16
99.99	1.49	99.99	2.19	17
99.99	2.41	99.99	1.92	18
99.99	1.34	99.99	1.14	19
99.99	2.11	99.99	1.93	20
99.99	0.52	99.99	2.23	21
99.99	2.38	99.99	2.20	22
99.99	2.73	99.99	1.76	23
99.99	1.58	99.99	1.56	24
99.99	1.67	99.99	2.22	25

LARGE DIRECTION ERROR: RETURNS
B1 = 8 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 32 C3 = 12
NO SOS: CONTINUES
B4 = 18 C4 = 21
SOS: TWO SOLUTIONS: RETURNS
B5 = 7 C5 = 10
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 7 C6 = 8

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	24	0	25
V1-4,2	0	25	0	25
V1-4,9,0	25	0	25	0

CT = 65 TCT = 961

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	1.92	.31	.56
SOSV	0	88.88	88.88	88.88
MLEV	25	1.96	.06	.25

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 3
TH = 40
ND = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	2.69	3.27	3.24	1
99.99	3.29	99.99	3.03	2
99.99	3.09	99.99	3.06	3
99.99	2.76	99.99	2.84	4
99.99	2.91	99.99	3.15	5
3.21	3.21	99.99	3.05	6
99.99	3.33	99.99	2.58	7
99.99	3.23	99.99	3.09	8
99.99	3.48	99.99	2.88	9
99.99	2.97	99.99	2.79	10
99.99	2.97	99.99	3.13	11
99.99	2.27	99.99	3.05	12
99.99	3.11	99.99	2.95	13
99.99	3.11	3.15	3.15	14
99.99	3.09	99.99	2.83	15
99.99	3.18	99.99	2.97	16
99.99	3.14	99.99	3.31	17
99.99	3.34	99.99	2.89	18
99.99	2.25	99.99	2.90	19
99.99	2.85	99.99	3.25	20
99.99	3.13	99.99	3.04	21
99.99	3.43	99.99	2.83	22
99.99	2.99	99.99	2.95	23
99.99	2.48	99.99	3.06	24
99.99	2.79	99.99	3.01	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 20 C3 = 1
NO SOS: CONTINUES
B4 = 39 C4 = 22
SOS: TWO SOLUTIONS: RETURNS
B5 = 58 C5 = 29
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 7 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	1	25	2	25
V1-4,2	1	25	2	25
V1-4,9,0	24	0	23	0

CT = 119 TCT = 896

VR3 NEG
VR3=-2.820969E-03

	N	MEAN	VARIANCE	STD-DEV
SOSH	1	3.21	77.77	77.77
MLEH	25	3.00	.10	.32
SOSV	2	3.21	.00	.06
MLEV	25	3.00	.03	.18

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 4
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
3.77	3.75	4.18	4.22	1
99.99	3.94	4.06	4.10	2
99.99	3.89	4.02	4.03	3
99.99	3.85	3.89	3.93	4
4.16	4.15	4.03	4.05	5
99.99	4.05	4.05	4.10	6
3.70	3.67	3.94	3.96	7
99.99	3.58	4.03	4.07	8
99.99	3.55	3.91	3.90	9
99.99	3.95	4.08	4.14	10
99.99	4.00	3.93	3.97	11
4.19	4.19	4.01	4.05	12
99.99	4.11	4.06	4.13	13
99.99	4.02	3.74	3.75	14
99.99	3.88	4.11	4.12	15
99.99	3.75	4.20	4.25	16
4.65	4.60	4.10	4.07	17
4.01	3.98	99.99	3.86	18
4.37	4.36	3.99	4.01	19
99.99	3.96	3.89	3.87	20
99.99	4.15	99.99	3.91	21
3.92	3.91	3.99	4.02	22
99.99	3.93	3.85	3.89	23
3.89	3.86	4.06	4.09	24
99.99	3.89	3.86	3.87	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 4 C3 = 0
NO SOS: CONTINUES
B4 = 32 C4 = 2
SOS: TWO SOLUTIONS: RETURNS
B5 = 68 C5 = 36
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	9	25	23	25
V1-4,2	9	25	23	25
V1-4,9,0	16	0	2	0

CT = 129 TCT = 777

	N	MEAN	VARIANCE	STD-DEV
SOSH	9	4.07	.08	.28
MLEH	25	3.96	.05	.23
SOSV	23	4.00	.00	.03
MLEV	25	4.01	.01	.10

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 5
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
4.81	4.83	4.80	4.94	1
4.43	4.43	5.08	5.21	2
4.70	4.67	4.81	4.93	3
4.78	4.80	4.84	4.92	4
5.05	5.06	4.98	5.20	5
99.99	4.89	5.07	5.14	6
5.30	5.19	4.87	5.05	7
4.79	4.82	5.04	5.14	8
5.35	5.34	4.93	5.08	9
5.50	5.57	4.92	5.03	10
5.47	5.51	4.85	4.88	11
5.07	5.09	4.82	4.96	12
99.99	4.69	4.68	4.88	13
5.40	5.43	4.84	4.92	14
4.89	4.91	5.07	5.12	15
5.20	5.23	4.82	4.91	16
99.99	4.79	4.79	4.86	17
4.85	4.88	4.92	5.09	18
5.50	5.54	4.80	4.99	19
5.12	5.16	4.71	4.79	20
4.63	4.56	5.02	5.13	21
5.00	5.03	4.89	4.91	22
4.59	4.61	4.91	5.08	23
5.28	5.24	4.90	4.99	24
4.57	4.57	4.95	5.14	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 1 C3 = 0
NO SOS: CONTINUES
B4 = 6 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 48 C5 = 21
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	22	25	25	25
V1-4,2	22	25	25	25
V1-4,9,0	3	0	0	0

CT = 34 TCT = 648

VR3 NEG
VR3=-3.948212E-04

	N	MEAN	VARIANCE	STD-DEV
SOSH	22	5.01	.10	.32
MLEH	25	4.99	.10	.32
SOSV	25	4.90	0.01	0.1
MLEV	25	5.01	.01	.10

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 6
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
6.07	6.13	5.70	5.85	1
6.04	6.15	5.90	6.00	2
5.66	5.75	5.91	5.95	3
5.98	6.09	5.77	5.84	4
6.31	6.33	6.16	6.20	5
5.93	5.94	5.88	5.98	6
6.07	6.08	6.12	6.11	7
6.05	6.15	5.77	5.84	8
6.22	6.24	5.75	5.82	9
5.88	5.94	5.84	5.88	10
5.78	5.81	6.11	6.11	11
5.49	5.57	6.04	6.12	12
5.54	5.57	6.02	6.04	13
6.08	6.12	5.77	5.98	14
5.82	5.91	5.76	5.97	15
5.95	6.02	5.77	5.91	16
6.08	6.10	5.65	5.80	17
5.87	5.99	5.47	5.81	18
5.84	5.85	5.87	5.93	19
6.18	6.34	5.68	5.82	20
6.00	6.05	5.85	5.88	21
5.61	5.69	5.88	5.94	22
6.41	6.58	6.11	6.11	23
6.20	6.34	5.67	5.78	24
6.05	6.17	5.59	5.83	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 52 C5 = 21
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	25	25	25	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 98 TCT = 554

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	5.96	.05	.23
MLEH	25	6.04	.06	.25
SOSV	25	5.84	.02	.14
MLEV	25	5.94	.01	.10

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 7
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
6.65	6.86	6.85	6.99	1
7.06	7.09	7.13	7.33	2
6.79	6.96	7.06	7.13	3
6.66	6.68	7.01	7.07	4
7.25	7.25	6.86	6.86	5
7.02	7.12	7.03	7.07	6
7.33	7.38	6.92	6.94	7
6.99	7.13	6.92	7.07	8
7.01	7.06	6.90	6.94	9
7.35	7.38	7.01	7.05	10
7.27	7.27	7.01	7.07	11
6.85	7.12	6.76	6.85	12
6.58	6.68	7.18	7.22	13
6.99	6.99	6.82	6.99	14
6.75	7.01	6.77	6.85	15
6.65	6.68	7.17	7.19	16
6.68	6.86	6.95	7.04	17
7.02	7.04	6.72	6.97	18
7.04	7.11	6.69	6.96	19
7.21	7.27	6.85	6.86	20
6.74	6.76	7.06	7.13	21
7.02	7.12	6.78	6.88	22
6.91	6.97	6.72	6.86	23
7.10	7.22	6.90	6.93	24
6.38	6.44	6.97	7.01	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 54 C5 = 32
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	25	25	25	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 111 TCT = 456

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	6.93	.06	.25
MLEH	25	7.02	.05	.23
SOSV	25	6.92	.01	.10
MLEV	25	7.01	.02	.14

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 8
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
7.96	8.17	8.00	8.01	1
7.88	7.90	7.91	8.17	2
7.89	7.94	7.81	7.83	3
7.76	7.98	8.03	8.05	4
8.41	8.48	7.66	7.82	5
7.33	7.59	7.96	8.21	6
8.18	8.20	7.97	7.96	7
7.77	7.78	8.08	8.18	8
8.26	8.30	7.56	7.73	9
7.98	8.14	7.77	7.82	10
7.57	7.73	7.96	8.06	11
7.87	7.96	7.64	7.70	12
7.92	8.04	8.08	8.21	13
7.60	7.62	7.99	8.04	14
8.14	8.15	8.02	8.06	15
8.00	7.99	7.70	7.86	16
8.05	8.18	7.73	7.78	17
7.83	7.89	7.63	7.76	18
7.45	7.46	8.32	8.40	19
8.01	8.09	8.04	8.15	20
8.27	8.33	7.72	7.83	21
7.71	7.86	7.87	7.95	22
7.70	7.79	7.79	7.87	23
7.97	8.03	7.65	7.78	24
7.63	7.82	7.71	7.76	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 51 C5 = 24
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	25	25	25	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 100 TCT = 345

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	7.89	.07	.27
MLEH	25	7.98	.06	.25
SOSV	25	7.86	.02	.14
MLEV	25	7.96	.03	.18

SOS, MLE, MONTF CARLO
UPWIND
INPUT WIND = 9
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
8.46	8.66	8.80	8.88	1
9.07	9.06	9.17	9.21	2
9.10	9.16	9.00	9.01	3
8.45	8.45	9.11	9.14	4
8.87	9.04	8.97	9.01	5
9.00	9.13	8.92	8.91	6
8.78	9.09	9.05	9.07	7
9.35	9.38	9.12	9.16	8
8.72	8.93	8.99	9.06	9
8.64	3.83	8.54	8.59	10
9.05	9.05	8.92	9.03	11
9.08	9.11	8.66	8.82	12
8.89	9.06	8.97	9.18	13
8.91	9.26	8.88	8.90	14
8.43	8.49	8.72	8.81	15
9.07	9.22	9.03	9.03	16
8.78	8.95	8.79	9.06	17
8.69	8.75	8.89	8.93	18
9.49	9.54	9.17	9.42	19
8.76	8.86	8.99	9.15	20
8.68	8.83	9.00	9.01	21
8.40	8.60	8.95	8.96	22
9.10	9.13	8.68	8.81	23
8.85	8.93	8.77	8.86	24
8.71	8.81	9.06	9.15	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 64 C5 = 34
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	25	25	25	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 123 TCT = 245

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	8.85	.07	.27
MLEH	25	8.97	.07	.27
SOSV	25	8.93	.01	.10
MLEV	25	9.01	.03	.18

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND ,= 10
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
9.90	9.93	9.82	9.88	1
10.27	10.30	9.93	10.00	2
9.92	10.04	9.81	9.91	3
9.93	9.98	9.77	9.79	4
9.64	9.79	9.70	9.76	5
9.66	9.81	9.98	10.11	6
9.57	9.65	10.33	10.36	7
9.68	9.81	9.83	9.89	8
10.08	10.11	9.87	9.91	9
9.94	10.02	10.00	10.03	10
9.99	10.06	9.99	10.01	11
9.90	10.00	9.40	9.43	12
9.78	9.85	9.99	10.09	13
9.60	9.66	10.24	10.23	14
10.05	10.03	9.76	9.86	15
10.43	10.53	9.69	9.69	16
10.30	10.36	10.02	10.12	17
9.56	9.87	10.08	10.07	18
9.98	9.97	9.50	9.61	19
10.25	10.27	9.73	9.80	20
10.18	10.19	9.87	9.93	21
9.81	9.90	9.57	9.63	22
9.70	9.86	9.87	9.89	23
10.03	10.14	9.73	9.82	24
9.94	10.01	9.81	9.83	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 69 C5 = 28
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	25	25	25	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 122 TCT = 122

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	9.92	.06	.25
MLEH	25	10.01	.04	.20
SOSV	25	9.85	.02	.14
MLEV	25	9.91	.04	.20

SOS,MLE,MONTE CARLO
DOWNWIND
INPUT WIND = .01
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.02	99.99	0.72	1
99.99	0.00	99.99	0.00	2
99.99	0.76	99.99	0.00	3
99.99	0.00	99.99	0.00	4
99.99	0.00	99.99	0.90	5
99.99	1.24	99.99	0.00	6
99.99	1.16	99.99	0.00	7
99.99	0.00	99.99	0.00	8
99.99	0.00	99.99	0.00	9
99.99	0.00	99.99	0.00	10
99.99	1.63	99.99	1.12	11
99.99	0.00	99.99	0.78	12
99.99	0.00	99.99	0.00	13
99.99	1.52	99.99	1.10	14
99.99	0.00	99.99	1.25	15
99.99	0.00	99.99	0.00	16
99.99	1.68	99.99	0.82	17
99.99	0.00	99.99	0.00	18
99.99	0.00	99.99	0.00	19
99.99	1.59	99.99	0.00	20
99.99	0.00	99.99	0.06	21
99.99	2.01	99.99	0.00	22
99.99	0.00	99.99	0.00	23
99.99	0.00	99.99	1.51	24
99.99	0.00	99.99	0.00	25

LARGE DIRECTION ERROR: RETURNS
B1 = 47 C1 = 19
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 29 C2 = 15 (16)
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 17 C3 = 9
NO SOS: CONTINUES
B4 = 9 C4 = 6
SOS: TWO SOLUTIONS: RETURNS
B5 = 1 C5 = 1
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 5 C6 = 5

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	18	0	21
V1-4,2	0	24	0	25
V1-4,9,0	25	16	25	16

CT = 103 TCT = 1047

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	.47	.52	.72
SOSV	0	88.88	88.88	88.88
MLEV	25	.33	.25	.50

SOS,MLE,MONTE CARLO
DOWNWIND
INPUT WIND = 1
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.00	99.99	0.32	1
99.99	2.30	99.99	0.00	2
99.99	0.00	99.99	1.08	3
99.99	0.00	99.99	0.00	4
99.99	2.74	99.99	0.89	5
99.99	2.14	99.99	0.34	6
99.99	2.20	99.99	1.29	7
99.99	0.73	99.99	1.67	8
99.99	1.24	99.99	0.94	9
99.99	1.78	99.99	1.75	10
99.99	1.08	99.99	1.28	11
99.99	0.00	99.99	0.00	12
99.99	1.75	99.99	0.53	13
99.99	1.87	99.99	1.42	14
99.99	1.55	99.99	1.33	15
99.99	0.00	99.99	1.47	16
99.99	2.32	99.99	0.77	17
99.99	0.00	99.99	0.92	18
99.99	0.64	99.99	0.00	19
99.99	2.30	99.99	1.59	20
99.99	2.51	99.99	0.83	21
99.99	0.00	99.99	0.00	22
99.99	1.59	99.99	0.98	23
99.99	0.71	99.99	1.74	24
99.99	0.00	99.99	0.00	25

LARGE DIRECTION ERROR: RETURNS
B1 = 31 C1 = 9
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 11 C2 = 6
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 25 C3 = 18
NO SOS: CONTINUES
B4 = 16 C4 = 7
SOS: TWO SOLUTIONS: RETURNS
B5 = 5 C5 = 3
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 9 C6 = 6

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	18	0	25
V1-4,2	0	25	0	25
V1-4,9,0	25	8	25	6

CT = 88 TCT = 944

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	1.18	.93	.96
SOSV	0	88.88	88.88	88.88
MLEV	25	.84	.37	.61

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 2
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	1.85	99.99	1.67	1
99.99	1.52	99.99	2.19	2
99.99	2.28	99.99	2.28	3
99.99	1.81	99.99	1.70	4
99.99	1.13	99.99	2.32	5
99.99	1.57	99.99	2.26	6
99.99	2.78	99.99	1.54	7
99.99	0.94	99.99	2.30	8
99.99	2.68	99.99	1.84	9
99.99	2.04	99.99	2.42	10
99.99	0.56	99.99	1.98	11
99.99	1.04	99.99	2.12	12
99.99	2.44	99.99	1.54	13
99.99	0.00	99.99	2.65	14
99.99	1.50	99.99	1.74	15
99.99	0.30	99.99	2.19	16
99.99	2.18	99.99	2.43	17
99.99	2.05	99.99	2.32	18
99.99	0.38	99.99	2.65	19
99.99	1.07	99.99	2.18	20
99.99	0.65	99.99	0.10	21
99.99	2.46	99.99	1.96	22
99.99	2.05	99.99	2.08	23
99.99	2.53	99.99	1.86	24
99.99	0.83	99.99	1.73	25

LARGE DIRECTION ERROR: RETURNS
B1 = 38 C1 = 5
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 3 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 33 C3 = 12
NO SOS: CONTINUES
B4 = 22 C4 = 22
SOS: TWO SOLUTIONS: RETURNS
B5 = 5 C5 = 10
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 9 C6 = 9

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	18	0	24
V1-4,2	0	23	0	25
V1-4,9,0	25	1	25	0

CT = 101 TCT = 856

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	1.55	.64	.80
SOSV	0	88.88	88.88	88.88
MLEV	25	2.00	.25	.50

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 3
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	2.92	3.34	3.34	1
99.99	3.28	99.99	3.19	2
3.66	3.63	99.99	3.03	3
99.99	2.62	99.99	3.15	4
3.87	3.83	99.99	3.20	5
99.99	3.36	2.96	2.95	6
99.99	1.78	99.99	2.94	7
99.99	3.04	3.03	3.01	8
99.99	3.12	3.49	3.49	9
99.99	3.09	99.99	3.13	10
99.99	2.17	99.99	3.29	11
99.99	2.49	99.99	3.07	12
99.99	2.30	99.99	2.83	13
99.99	2.64	99.99	3.06	14
99.99	2.67	99.99	2.84	15
99.99	3.12	99.99	3.12	16
3.72	3.70	3.14	3.13	17
99.99	3.58	99.99	2.36	18
99.99	2.63	3.11	3.09	19
99.99	2.79	99.99	3.06	20
99.99	2.86	3.01	3.00	21
99.99	2.48	3.51	3.50	22
99.99	2.40	3.17	3.16	23
99.99	2.70	3.36	3.32	24
99.99	3.01	99.99	3.43	25

LARGE DIRECTION ERROR: RETURNS
B1 = 9 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 19 C3 = 2
NO SOS: CONTINUES
B4 = 27 C4 = 14
SOS: TWO SOLUTIONS: RETURNS
B5 = 31 C5 = 20
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 3 C6 = 1

	SOSH	MLEH	SOSV	MLEV
V1-4,1	3	24	10	25
V1-4,2	3	25	10	25
V1-4,9,0	22	0	15	0

CT = 89 TCT = 755

	N	MEAN	VARIANCE	STD-DEV
SOSH	3	3.75	.01	.10
MLEH	25	2.89	.24	.49
SOSV	10	3.21	.03	.18
MLEV	25	3.11	.05	.23

SOS,MLE,MONTE CARLO
DOWNWIND
INPUT WIND = 4
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
4.46	4.46	3.73	3.73	1
4.22	4.12	99.99	3.72	2
4.14	4.06	3.92	3.92	3
99.99	2.99	4.03	4.07	4
3.79	3.75	4.05	4.08	5
99.99	4.55	3.87	3.88	6
4.33	4.23	4.04	4.01	7
4.18	4.16	4.20	4.24	8
4.34	4.33	4.04	4.07	9
3.52	3.51	3.88	3.90	10
99.99	2.68	3.73	3.71	11
3.32	3.30	4.11	4.11	12
4.69	4.65	4.01	4.00	13
4.58	4.52	4.15	4.18	14
99.99	3.33	3.98	4.00	15
99.99	3.69	4.20	4.14	16
99.99	3.65	3.91	3.91	17
99.99	3.52	4.05	4.06	18
99.99	4.09	4.00	4.02	19
4.11	4.10	3.74	3.75	20
99.99	3.48	3.93	3.96	21
4.30	4.29	3.99	4.00	22
99.99	3.97	4.11	4.13	23
99.99	3.10	4.23	4.23	24
4.06	3.98	3.66	3.60	25

LARGE DIRECTION ERROR: RETURNS
B1 = 2 C1 = 0
CALM BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 2 C3 = 0
NO SOS: CONTINUES
B4 = 17 C4 = 1
SOS: TWO SOLUTIONS: RETURNS
B5 = 37 C5 = 23
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	14	23	24	25
V1-4,2	14	25	24	25
V1-4,9,0	11	0	1	0

CT = 87 TCT = 666

	N	MEAN	VARIANCE	STD-DEV
SOSH	14	4.15	.14	.38
MLEH	25	3.88	.25	.50
SOSV	24	3.98	.02	.14
MLEV	25	3.98	.03	.18

SOS,MLE,MONTE CARLO
DOWNWIND
INPUT WIND = 5
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
5.15	5.17	4.94	5.04	1
99.99	4.04	5.05	5.07	2
4.78	4.73	5.12	5.18	3
5.03	4.95	4.75	4.84	4
5.07	4.96	4.97	5.09	5
4.76	4.68	4.86	4.96	6
5.45	5.42	5.00	5.02	7
4.96	4.96	4.94	4.98	8
4.78	4.78	5.14	5.23	9
99.99	4.92	5.22	5.30	10
4.42	4.40	5.24	5.25	11
99.99	4.70	5.07	5.15	12
5.07	5.07	4.83	4.91	13
5.03	4.96	4.95	5.07	14
4.88	4.87	5.28	5.39	15
99.99	4.56	4.95	4.97	16
5.08	5.08	5.16	5.16	17
5.55	5.57	4.87	4.97	18
4.41	4.41	5.04	5.06	19
99.99	4.93	5.35	5.45	20
4.49	4.48	4.65	4.66	21
5.32	5.14	4.98	5.06	22
5.42	5.43	4.99	4.99	23
5.30	5.14	4.99	5.01	24
5.46	5.49	4.96	5.07	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 5 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 27 C5 = 15
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	20	25	25	25
V1-4,2	20	25	25	25
V1-4,9,0	5	0	0	0

CT = 67 TCT = 579

	N	MEAN	VARIANCE	STD-DEV
SOSH	20	5.02	.11	.33
MLEH	25	4.92	.13	.36
SOSV	25	5.01	.02	.14
MLEV	25	5.08	.03	.18

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 6
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
5.41	5.42	6.25	6.27	1
5.32	5.34	5.95	6.02	2
6.39	6.45	5.98	6.03	3
6.28	6.30	5.91	5.90	4
5.66	5.68	5.99	6.06	5
5.69	5.73	5.72	5.95	6
5.94	5.99	6.19	6.20	7
6.06	6.12	6.08	6.14	8
5.95	6.00	5.65	6.01	9
5.70	5.70	5.79	5.87	10
5.59	5.60	6.05	6.07	11
6.45	6.53	6.03	6.05	12
6.21	6.22	5.64	5.96	13
5.77	5.80	5.95	6.01	14
5.75	5.79	6.19	6.23	15
6.34	6.30	6.05	6.11	16
6.04	6.09	5.89	5.95	17
5.71	5.76	6.00	6.06	18
6.04	6.05	6.09	6.26	19
6.34	6.38	5.69	5.88	20
5.80	5.84	6.01	6.01	21
5.68	5.69	5.55	5.61	22
6.20	6.21	5.77	5.86	23
5.74	5.78	6.12	6.14	24
6.41	6.41	6.09	6.18	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 55 C5 = 36
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	25	25	25	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 116 TCT = 512

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	5.94	.10	.32
MLEH	25	5.97	.10	.32
SOSV	25	5.96	.02	.14
MLEV	25	6.03	.02	.14

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 7
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
7.01	7.11	6.75	6.83	1
7.21	7.31	6.93	6.92	2
7.23	7.27	7.09	7.08	3
6.72	6.81	7.36	7.38	4
7.03	7.04	6.83	6.93	5
6.89	6.89	6.90	6.93	6
7.13	7.13	7.06	7.06	7
6.75	6.74	6.83	7.06	8
6.68	6.77	6.61	6.78	9
7.01	7.16	6.91	7.10	10
7.04	7.09	7.08	7.13	11
7.07	7.13	6.78	6.86	12
6.77	6.79	6.88	6.92	13
6.86	6.95	7.04	7.12	14
7.14	7.20	6.77	6.92	15
7.24	7.25	6.89	6.88	16
6.79	6.91	6.92	7.01	17
6.97	6.97	7.01	7.04	18
6.42	6.41	7.07	7.07	19
6.52	6.52	6.58	6.81	20
6.97	7.08	6.78	6.87	21
7.03	7.07	7.05	7.06	22
6.78	6.92	6.90	6.91	23
6.92	6.99	6.88	6.87	24
7.73	7.77	6.84	6.87	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 24 C5 = 16
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	25	25	25	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 65 TCT = 396

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	6.96	.07	.27
MLEH	25	7.01	.07	.27
SOSV	25	6.91	.01	.10
MLEV	25	6.98	.02	.14

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 8
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
8.55	8.58	7.81	7.81	1
7.52	7.63	7.76	7.85	2
8.07	8.14	8.00	8.01	3
7.73	7.85	7.78	7.89	4
8.30	8.41	7.62	7.89	5
8.01	8.14	7.98	8.06	6
7.76	7.62	7.81	7.96	7
7.94	8.06	8.13	8.27	8
8.65	8.65	7.82	7.88	9
7.82	7.85	7.50	7.60	10
7.98	8.13	7.81	7.87	11
8.12	8.15	7.89	8.01	12
8.01	8.07	7.75	7.77	13
7.60	7.80	7.81	7.95	14
7.64	7.74	8.08	8.10	15
8.07	8.20	8.21	8.26	16
7.98	8.17	8.19	8.17	17
7.67	7.78	7.54	7.61	18
7.92	8.04	7.55	7.99	19
7.96	8.03	7.93	8.05	20
8.21	8.25	8.15	8.16	21
7.75	7.80	7.97	8.00	22
8.20	8.23	7.76	7.84	23
8.06	8.17	8.28	8.30	24
7.93	8.02	7.97	8.10	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 70 C5 = 31
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	25	25	25	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 126 TCT = 331

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	7.98	.07	.27
MLEH	25	8.07	.06	.25
SOSV	25	7.91	.02	.14
MLEV	25	7.98	.03	.18

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 9
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
8.92	9.12	8.60	8.62	1
8.84	8.92	9.00	9.11	2
8.90	8.94	8.93	8.93	3
8.73	8.90	9.06	9.07	4
8.88	8.93	9.05	9.14	5
8.84	8.93	9.15	9.21	6
8.91	9.02	9.02	9.05	7
9.14	9.16	8.80	8.87	8
8.75	8.87	8.98	9.08	9
8.61	8.61	9.22	9.21	10
9.08	9.23	8.76	8.89	11
8.59	8.71	8.82	8.96	12
8.72	8.76	8.40	8.62	13
9.34	9.47	8.83	8.87	14
8.60	8.70	8.91	9.03	15
8.98	9.00	8.87	9.06	16
8.90	8.97	9.15	9.17	17
8.72	8.78	9.03	9.22	18
9.25	9.34	9.07	9.10	19
8.65	8.74	9.02	9.04	20
8.62	8.62	8.76	8.76	21
8.84	8.98	9.01	9.08	22
9.04	9.18	8.76	8.90	23
9.34	9.37	9.11	9.10	24
9.39	9.44	8.93	9.05	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 63 C5 = 33
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	25	25	25	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 121 TCT = 205

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	8.91	.05	.23
MLEH	25	9.00	.05	.27
SOSV	25	8.93	.02	.14
MLEV	25	9.01	.03	.18

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 10
TH = 40
NO = 25

SOSH	MLEH	SOSV	MLEV	PR
10.01	10.25	9.92	9.99	1
9.72	9.71	9.90	9.97	2
9.88	9.96	10.06	10.07	3
10.07	10.12	10.03	10.08	4
10.04	10.04	9.99	9.99	5
10.05	10.14	9.77	9.87	6
9.41	9.50	10.15	10.18	7
9.95	10.04	9.53	9.56	8
9.91	9.96	10.08	10.15	9
10.23	10.23	10.02	10.12	10
10.14	10.16	9.93	10.09	11
10.27	10.30	9.69	9.73	12
10.18	10.25	9.95	9.99	13
9.87	10.05	10.20	10.18	14
10.08	10.14	10.09	10.13	15
9.43	9.56	9.85	9.96	16
9.77	9.80	9.96	10.03	17
10.01	10.13	10.18	10.27	18
10.00	10.04	9.89	9.93	19
10.18	10.25	10.05	10.05	20
9.72	9.77	9.99	10.05	21
9.46	9.49	9.64	9.81	22
9.71	9.50	9.80	9.88	23
9.81	9.83	10.10	10.08	24
9.92	10.01	10.28	10.37	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 40 C5 = 19
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	25	25	25	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 84 TCT = 84

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	9.91	.06	.25
MLEH	25	9.98	.05	.23
SOSV	25	9.96	.01	.10
MLEV	25	10.02	.03	.18

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = .01
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.14	99.99	0.00	1
99.99	0.21	99.99	0.00	2
99.99	0.19	99.99	0.30	3
99.99	0.00	99.99	0.13	4
99.99	0.23	99.99	0.36	5
99.99	0.14	99.99	0.42	6
99.99	0.17	99.99	0.00	7
99.99	0.05	99.99	0.29	8
99.99	0.06	99.99	0.00	9
99.99	0.27	99.99	0.00	10
99.99	0.00	99.99	0.00	11
99.99	0.00	99.99	0.11	12
99.99	0.14	99.99	0.00	13
99.99	0.03	99.99	0.00	14
99.99	0.00	99.99	0.37	15
99.99	0.21	99.99	0.00	16
99.99	0.11	99.99	0.02	17
99.99	0.00	99.99	0.33	18
99.99	0.00	99.99	0.00	19
99.99	0.00	99.99	0.00	20
99.99	0.18	99.99	0.00	21
99.99	0.18	99.99	0.35	22
99.99	0.00	99.99	0.00	23
99.99	0.02	99.99	0.01	24
99.99	0.00	99.99	0.17	25

LARGE DIRECTION ERROR: RETURNS
B1 = 33 C1 = 30
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 25 C2 = 13
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 33 C3 = 10
NO SOS: CONTINUES
B4 = 12 C4 = 8
SOS: TWO SOLUTIONS: RETURNS
B5 = 2 C5 = 1
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 8 C6 = 6

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	25	0	25
V1-4,2	0	25	0	25
V1-4,9,0	25	9	25	13

CT = 105 TCT = 1121

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	.09	.01	.10
SOSV	0	88.88	88.88	88.88
MLEV	25	.11	.02	.14

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 1
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.68	99.99	0.47	1
99.99	0.87	99.99	0.93	2
99.99	0.88	99.99	0.60	3
99.99	0.67	1.15	1.09	4
1.05	0.99	99.99	0.76	5
99.99	1.08	99.99	1.03	6
99.99	0.81	99.99	0.81	7
99.99	0.94	99.99	0.76	8
99.99	0.83	1.24	1.16	9
1.21	1.12	99.99	0.91	10
1.09	1.03	99.99	0.88	11
99.99	0.79	1.08	1.02	12
99.99	0.66	99.99	0.78	13
1.11	1.05	99.99	1.05	14
0.91	0.86	1.13	1.08	15
99.99	0.94	99.99	1.00	16
1.09	1.03	99.99	1.03	17
1.01	0.95	99.99	0.65	18
1.30	1.23	99.99	0.77	19
99.99	1.36	99.99	0.91	20
1.09	1.03	99.99	0.77	21
1.32	1.26	99.99	1.25	22
99.99	1.06	99.99	1.02	23
99.99	0.67	99.99	0.91	24
99.99	1.00	99.99	1.14	25

LARGE DIRECTION ERROR: RETURNS
B1 = 4 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 8 C3 = 4
NO SOS: CONTINUES
B4 = 19 C4 = 17
SOS: TWO SOLUTIONS: RETURNS
B5 = 31 C5 = 19
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 2 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	10	25	4	25
V1-4,2	10	25	4	25
V1-4,9,0	15	0	21	0

CT = 81 TCT = 1016

	N	MEAN	VARIANCE	STD-DEV
SOSH	10	1.12	.01	.10
MLEH	25	.95	.03	.18
SOSV	4	1.15	.00	.03
MLEV	25	.91	.03	.18

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 2
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
1.69	1.62	2.01	1.92	1
2.25	2.17	1.72	1.65	2
99.99	1.77	2.18	2.11	3
2.58	2.50	2.42	2.33	4
1.84	1.76	1.85	1.78	5
1.77	1.70	1.87	1.79	6
1.87	1.77	2.12	2.04	7
2.09	2.04	2.10	2.00	8
2.06	1.98	2.14	2.07	9
1.67	1.58	1.81	1.73	10
1.49	1.41	1.96	1.87	11
1.80	1.74	1.28	1.21	12
1.67	1.59	1.56	1.44	13
2.55	2.46	1.98	1.90	14
1.72	1.66	1.95	1.82	15
2.13	2.12	2.04	1.97	16
2.03	1.95	2.06	2.01	17
1.78	1.66	2.05	1.96	18
2.05	2.01	99.99	1.31	19
1.99	1.96	2.13	2.09	20
1.82	1.74	1.54	1.46	21
2.64	2.53	1.67	1.59	22
1.71	1.65	2.45	2.36	23
2.40	2.33	2.21	2.11	24
2.26	2.15	1.90	1.80	25

LARGE DIRECTION ERROR: RETURNS
B1 = 1 C1 = 3
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 1 C4 = 1
SOS: TWO SOLUTIONS: RETURNS
B5 = 56 C5 = 23
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	24	25	24	25
V1-4,2	24	25	24	25
V1-4,9,0	1	0	1	0
CT =	108 TCT = 935			

	N	MEAN	VARIANCE	STD-DEV
SOSH	24	1.99	.10	.32
MLEH	25	1.91	.09	.30
SOSV	24	1.96	:07	.27
MLEV	25	1.85	.08	.28

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 3
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
2.47	2.57	2.64	2.56	1
2.51	2.53	2.96	2.83	2
3.31	3.35	2.21	2.11	3
2.48	2.39	2.74	2.86	4
2.38	2.30	2.61	2.61	5
2.44	2.38	2.78	2.72	6
2.95	2.82	3.18	3.33	7
2.63	2.50	3.02	2.92	8
2.98	3.24	2.70	2.92	9
2.54	2.53	3.28	3.17	10
3.45	3.35	2.97	3.02	11
3.85	3.72	3.97	3.80	12
2.89	2.84	2.75	2.71	13
2.76	2.73	3.34	3.25	14
2.96	2.87	3.24	3.10	15
3.09	3.02	2.93	2.85	16
3.03	2.90	3.03	2.89	17
2.62	2.62	2.99	3.14	18
3.34	3.25	3.66	3.68	19
3.78	3.63	2.64	2.82	20
3.52	3.36	2.40	2.45	21
2.94	2.91	2.59	2.49	22
1.93	1.88	3.19	3.14	23
2.25	2.16	2.75	2.83	24
2.61	2.51	3.10	2.98	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 41 C5 = 31
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	24	24	25	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0
CT =	97 TCT = 827			

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	2.87	.22	.47
MLEH	25	2.82	.21	.46
SOSV	25	2.95	.14	.38
MLEV	25	2.93	.13	.36

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 4
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
4.28	4.29	3.96	3.83	1
5.48	5.24	4.66	4.47	2
3.76	4.13	4.44	4.25	3
3.93	3.79	4.39	4.21	4
4.40	4.19	3.33	3.17	5
2.13	2.03	4.12	3.94	6
2.89	2.79	4.76	4.54	7
3.30	3.13	3.52	3.41	8
3.92	3.83	4.43	4.30	9
3.52	3.76	3.85	3.69	10
3.64	3.48	4.32	4.29	11
3.93	3.98	3.53	3.37	12
3.24	3.11	4.31	4.21	13
3.70	3.87	4.16	4.00	14
3.35	3.18	4.14	3.98	15
4.09	4.17	3.52	3.49	16
4.59	4.46	4.41	4.28	17
3.33	3.17	3.82	3.82	18
2.60	2.75	4.35	4.22	19
3.87	3.97	3.68	3.88	20
3.77	3.62	3.91	3.80	21
3.43	3.27	3.87	3.75	22
4.42	4.21	3.49	3.47	23
3.47	3.54	3.16	3.48	24
4.35	4.46	3.34	3.21	25

LARGE DIRECTION ERROR: RETURNS
B1 = 1 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 41 C5 = 24
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	21	21	25	25
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 91 TCT = 730

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	3.74	.45	.67
MLEH	25	3.70	.44	.66
SOSV	25	3.98	.18	.43
MLEV	25	3.88	.15	.39

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 5
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
4.67	4.52	5.43	5.31	1
4.95	4.72	5.43	6.31	2
4.50	4.77	5.38	5.21	3
4.59	4.38	5.25	5.14	4
4.94	4.71	4.87	4.65	5
5.42	5.22	5.35	5.52	6
4.54	4.44	5.32	5.24	7
5.12	5.31	4.76	4.68	8
6.20	5.90	4.91	4.70	9
4.74	5.18	4.19	3.99	10
5.66	5.41	4.56	4.43	11
4.49	4.36	6.06	5.78	12
4.02	4.91	5.10	4.89	13
5.04	5.01	5.38	5.27	14
4.56	4.73	6.13	5.86	15
5.90	5.73	4.22	4.27	16
5.80	5.53	5.40	5.15	17
4.96	4.93	5.08	5.02	18
4.72	4.54	5.21	5.04	19
4.36	5.38	4.94	4.71	20
5.08	5.17	6.05	5.79	21
5.20	5.60	4.04	4.06	22
4.80	4.78	4.37	4.42	23
5.85	5.65	5.18	5.02	24
5.39	5.15	5.12	5.06	25

LARGE DIRECTION ERROR: RETURNS
B1 = 3 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 46 C5 = 19
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	24	25	22	23
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 94 TCT = 639

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	5.02	.29	.54
MLEH	25	5.04	.19	.44
SOSV	25	5.11	.28	.53
MLEV	25	5.02	.31	.56

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 6
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PD
7.01	6.92	4.80	4.93	1
4.47	4.65	6.11	6.02	2
6.27	6.10	5.98	5.80	3
5.24	5.00	6.76	6.69	4
5.69	5.44	7.36	7.10	5
4.48	4.28	6.28	6.01	6
5.46	5.42	5.59	5.35	7
6.85	6.55	6.15	6.05	8
5.06	5.15	6.23	6.05	9
4.58	4.66	6.14	5.92	10
6.03	6.15	5.48	5.24	11
5.48	5.23	4.95	4.78	12
5.76	5.55	5.48	5.40	13
5.18	4.96	3.70	3.81	14
5.55	5.36	6.58	6.38	15
6.25	6.72	5.28	5.23	16
6.09	5.60	5.42	5.19	17
4.20	4.00	7.45	7.12	18
5.88	5.69	6.81	6.88	19
6.22	5.93	6.21	5.93	20
6.72	6.40	6.00	5.77	21
4.91	4.85	5.59	5.57	22
5.88	5.70	6.76	6.55	23
5.93	6.01	4.87	4.81	24
4.80	4.57	4.70	4.51	25

LARGE DIRECTION ERROR: RETURNS
B1 = 2 C1 = 2
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 45 C5 = 18
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	18	18	18	18
V1-4,2	25	25	24	24
V1-4,9,0	0	0	0	0

CT = 92 TCT = 545

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	5.60	.56	.75
MLEH	25	5.48	.56	.75
SOSV	25	5.87	.73	.85
MLEV	25	5.72	.65	.81

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 7
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PD
8.92	8.50	6.55	7.61	1
6.97	6.83	6.98	6.72	2
5.60	5.35	6.84	6.58	3
6.07	6.53	7.71	7.47	4
8.64	8.26	5.79	5.53	5
7.43	7.37	8.22	7.95	6
6.50	6.28	7.01	6.78	7
6.04	6.95	4.92	4.71	8
7.47	7.30	7.30	7.17	9
7.67	7.40	7.89	7.60	10
7.77	7.41	7.20	7.08	11
6.77	6.59	7.33	8.13	12
7.88	7.58	7.09	6.83	13
6.14	5.87	7.01	7.24	14
5.76	5.51	6.68	6.42	15
9.00	8.59	7.24	6.95	16
8.60	8.27	7.25	6.98	17
8.82	8.44	8.25	9.04	18
6.47	6.45	7.41	8.03	19
7.72	7.81	7.91	7.58	20
4.78	5.86	6.57	6.33	21
5.36	5.83	7.65	7.97	22
7.32	7.63	7.42	7.10	23
6.02	5.84	7.73	7.76	24
6.05	6.23	7.60	7.31	25

LARGE DIRECTION ERROR: RETURNS
B1 = 1 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 56 C5 = 26
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	16	14	21	20
V1-4,2	24	25	24	23
V1-4,9,0	0	0	0	0

CT = 108 TCT = 453

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	7.03	1.41	1.19
MLEH	25	6.99	.96	.98
SOSV	25	7.18	.49	.701
MLEV	25	7.16	.74	.86

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 8
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
7.32	6.98	7.94	7.89	1
5.51	6.00	9.85	9.52	2
7.12	7.15	6.87	6.91	3
7.12	7.33	8.42	8.27	4
7.57	7.35	4.33	4.42	5
7.53	7.49	8.04	7.99	6
6.07	6.06	9.50	9.23	7
6.51	6.53	9.22	8.83	8
9.98	9.96	6.87	6.59	9
9.66	9.20	8.31	8.79	10
5.70	8.53	8.40	8.04	11
7.71	7.57	5.47	5.51	12
8.82	8.47	7.53	7.40	13
9.08	8.69	7.59	7.28	14
8.83	8.41	7.98	8.02	15
7.13	6.79	7.09	7.96	16
8.69	8.45	9.72	9.32	17
6.75	6.74	7.08	6.75	18
6.79	6.46	8.35	8.34	19
8.53	8.33	7.39	7.10	20
8.13	7.82	7.19	6.88	21
7.90	7.52	8.34	8.24	22
8.10	7.73	7.53	7.60	23
8.69	8.30	7.70	7.55	24
8.19	9.68	7.63	7.33	25

LARGE DIRECTION ERROR: RETURNS
B1 = 2 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 58 C5 = 28
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	16	15	17	16
V1-4,2	23	25	23	23
V1-4,9,0	0	0	0	0

CT = 113 TCT = 345

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	7.74	1.30	1.14
MLEH	25	7.74	1.07	1.03
SOSV	25	7.77	1.40	1.18
MLEV	25	7.67	1.28	1.13

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 9
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
9.90	9.58	9.09	9.17	1
10.78	10.94	8.37	8.09	2
11.72	11.20	11.20	10.94	3
8.57	8.59	8.16	8.51	4
8.19	7.88	10.79	10.41	5
10.24	9.79	11.27	10.87	6
9.03	8.99	8.98	8.61	7
7.17	6.94	11.37	10.88	8
8.07	7.85	8.91	8.97	9
9.77	9.44	10.62	10.40	10
11.40	11.01	6.97	8.26	11
5.85	5.58	8.97	9.29	12
10.27	9.83	9.64	9.28	13
7.13	6.95	9.88	9.75	14
10.23	9.77	7.54	7.30	15
10.11	9.65	11.71	11.20	16
5.28	8.79	10.09	9.70	17
8.20	7.87	8.99	8.74	18
8.88	8.48	9.27	8.86	19
7.88	7.71	8.93	8.55	20
8.89	8.70	9.60	9.21	21
9.74	9.64	9.64	9.92	22
9.16	8.91	8.40	8.83	23
9.13	8.80	9.23	8.84	24
7.72	7.56	6.68	6.48	25

LARGE DIRECTION ERROR: RETURNS
B1 = 3 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 57 C5 = 29
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	12	14	15	17
V1-4,2	21	20	19	23
V1-4,9,0	0	0	0	0

CT = 115 TCT = 232

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	8.93	2.40	1.55
MLEH	25	8.82	1.74	1.32
SOSV	25	9.37	1.65	1.28
MLEV	25	9.24	1.26	1.12

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 10
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
8.87	9.32	9.47	9.07	1
9.93	9.73	8.83	8.43	2
11.06	10.69	10.24	11.55	3
9.77	9.47	10.09	9.84	4
10.30	10.49	8.79	8.44	5
11.13	10.59	10.71	10.25	6
9.01	8.60	9.51	9.10	7
10.04	9.67	8.47	9.57	8
9.99	9.80	9.50	9.12	9
9.80	9.34	9.39	9.03	10
10.11	9.63	8.08	8.05	11
8.73	8.99	7.18	7.91	12
9.98	9.59	7.02	8.18	13
9.06	8.74	11.27	11.16	14
12.22	12.19	10.34	9.88	15
10.10	10.28	9.19	8.81	16
8.84	8.59	8.91	8.90	17
8.08	8.34	9.55	9.14	18
9.80	9.33	9.91	10.94	19
9.77	9.43	10.69	10.21	20
8.47	9.01	10.41	10.50	21
7.75	7.40	11.23	10.73	22
4.58	6.67	10.28	9.84	23
8.98	10.48	7.59	10.20	24
9.06	8.69	11.32	10.85	25

LARGE DIRECTION ERROR: RETURNS
B1 = 2 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 55 C5 = 34
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	14	16	14	16
V1-4,2	22	22	22	24
V1-4,9,0	0	0	0	0

CT = 117 TCT = 117

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	9.42	1.91	1.38
MLEH	25	9.40	1.18	1.09
SOSV	25	9.52	1.39	1.18
MLEV	25	9.59	1.02	1.01

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = .01
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.26	99.99	0.00	1
99.99	0.50	99.99	0.00	2
99.99	0.00	99.99	0.37	3
99.99	0.00	99.99	0.00	4
99.99	0.00	99.99	0.00	5
99.99	0.09	99.99	0.00	6
99.99	0.00	99.99	0.26	7
99.99	0.00	99.99	0.00	8
99.99	0.23	99.99	0.24	9
99.99	0.00	99.99	0.00	10
99.99	0.00	99.99	0.00	11
99.99	0.00	99.99	0.00	12
99.99	0.24	99.99	0.00	13
99.99	0.00	99.99	0.00	14
99.99	0.46	99.99	0.00	15
99.99	0.00	99.99	0.02	16
99.99	0.12	99.99	0.18	17
99.99	0.13	99.99	0.00	18
99.99	0.00	99.99	0.00	19
99.99	0.01	99.99	0.00	20
99.99	0.46	99.99	0.00	21
99.99	0.04	99.99	0.05	22
99.99	0.00	99.99	0.00	23
99.99	0.00	99.99	0.00	24
99.99	0.00	99.99	0.00	25

LARGE DIRECTION ERROR: RETURNS
B1 = 25 C1 = 15
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 22 C2 = 16 (19)
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 18 C3 = 8
NO SOS: CONTINUES
B4 = 5 C4 = 4
SOS: TWO SOLUTIONS: RETURNS
B5 = 1 C5 = 0
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 2 C6 = 3

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	25	0	25
V1-4,2	0	25	0	25
V1-4,9,0	25	14	25	19

CT = 71 TCT = 898

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	.10	.03	.18
SOSV	0	88.88	88.88	88.88
MLEV	25	.04	.01	.10

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 1
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
1.16	1.04	99.99	0.72	1
1.13	1.07	99.99	1.11	2
99.99	0.78	99.99	0.95	3
99.99	0.96	1.37	1.29	4
1.31	1.24	1.14	1.09	5
1.65	1.57	99.99	0.96	6
99.99	0.78	99.99	0.70	7
1.51	1.43	99.99	1.02	8
1.27	1.16	1.07	0.99	9
99.99	0.79	99.99	0.89	10
1.05	0.99	99.99	0.95	11
99.99	0.91	1.01	0.95	12
1.18	1.12	99.99	0.53	13
99.99	0.82	99.99	0.96	14
99.99	0.63	1.23	1.17	15
99.99	1.21	1.25	1.19	16
1.37	1.18	1.30	1.20	17
1.42	1.35	99.99	0.73	18
99.99	0.12	1.15	1.06	19
99.99	0.98	99.99	0.71	20
1.39	1.30	1.11	1.05	21
99.99	0.78	0.92	0.87	22
0.99	0.93	99.99	1.05	23
0.96	0.88	99.99	0.82	24
99.99	1.03	99.99	1.16	25

LARGE DIRECTION ERROR: RETURNS
B1 = 13 C1 = 2
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 6 C3 = 4
NO SOS: CONTINUES
B4 = 19 C4 = 12
SOS: TWO SOLUTIONS: RETURNS
B5 = 36 C5 = 20
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 1 C6 = 1

	SOSH	MLEH	SOSV	MLEV
V1-4,1	13	25	10	25
V1-4,2	13	25	10	25
V1-4,9,0	12	0	15	0

CT = 98 TCT = 827

	N	MEAN	VARIANCE	STD-DEV
SOSH	13	1.26	.04	.20
MLEH	25	1.00	.08	.28
SOSV	10	1.16	.01	.10
MLEV	25	.96	.03	.18

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 2
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
1.58	1.49	1.92	1.85	1
2.14	2.09	2.00	1.93	2
1.83	1.74	99.99	1.96	3
2.38	2.28	1.92	1.86	4
2.07	2.01	1.61	1.55	5
2.14	2.04	2.15	2.10	6
1.76	1.67	1.94	1.86	7
1.96	1.90	2.40	2.36	8
2.37	2.28	2.19	2.09	9
2.84	2.73	1.93	1.88	10
1.73	1.66	99.99	1.48	11
2.66	2.54	2.01	1.97	12
2.23	2.18	2.01	1.93	13
99.99	1.69	1.86	1.79	14
2.05	1.95	1.92	1.87	15
2.39	2.29	1.89	1.84	16
1.98	1.89	2.21	2.12	17
99.99	1.73	1.93	1.87	18
1.55	1.48	2.31	2.21	19
2.24	2.26	2.33	2.24	20
2.23	2.20	2.30	2.25	21
2.55	2.44	1.75	1.54	22
2.12	2.04	2.03	1.99	23
1.97	1.92	1.60	1.54	24
2.60	2.47	2.33	2.27	25

LARGE DIRECTION ERROR: RETURNS
B1 = 4 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 2 C4 = 2
SOS: TWO SOLUTIONS: RETURNS
B5 = 43 C5 = 15
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	23	25	23	25
V1-4,2	23	25	23	25
V1-4,9,0	2	0	2	0

CT = 87 TCT = 729

	N	MEAN	VARIANCE	STD-DEV
SOSH	23	2.15	.11	.33
MLEH	25	2.04	.10	.32
SOSV	23	2.02	.04	.20
MLEV	25	1.93	.06	.25

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 3
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
2.41	2.39	3.10	2.97	1
2.93	2.79	2.60	2.49	2
3.23	3.08	2.60	2.48	3
2.50	2.46	3.06	3.20	4
2.68	2.67	2.44	2.44	5
3.45	3.30	3.02	2.94	6
3.10	3.26	2.66	2.81	7
2.94	2.81	3.32	3.24	8
3.16	3.05	2.37	2.34	9
2.32	2.29	2.85	2.95	10
3.30	3.15	2.58	2.49	11
99.99	2.64	3.43	3.59	12
2.53	2.45	2.73	2.82	13
3.07	2.97	2.81	3.03	14
2.82	2.70	3.42	3.33	15
2.47	2.40	3.14	3.47	16
3.55	3.42	3.38	3.25	17
2.70	2.59	3.34	3.20	18
2.71	2.58	2.81	2.97	19
3.35	3.22	2.75	2.62	20
3.03	3.07	2.74	2.91	21
2.48	2.50	3.27	3.12	22
3.61	3.53	3.19	3.09	23
3.65	3.50	3.20	3.30	24
3.17	3.02	3.28	3.14	25

LARGE DIRECTION ERROR: RETURNS
B1 = 5 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 1 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 37 C5 = 18
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	24	25	25	25
V1-4,2	24	25	25	25
V1-4,9,0	1	0	0	0

CT = 86 TCT = 642

	N	MEAN	VARIANCE	STD-DEV
SOSH	24	2.96	.16	.40
MLEH	25	2.87	.14	.38
SOSV	25	2.96	.10	.32
MLEV	25	2.97	.11	.33

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 4
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
3.98	3.86	3.98	3.83	1
4.23	4.13	3.87	4.39	2
4.76	4.53	4.12	3.98	3
3.15	3.12	3.97	3.79	4
4.40	4.32	3.84	3.69	5
3.84	3.67	3.67	4.08	6
4.55	4.36	4.02	4.01	7
4.57	4.44	99.99	3.42	8
3.95	4.15	3.87	3.85	9
3.63	3.48	4.39	4.30	10
3.29	3.29	4.14	4.07	11
3.62	3.66	3.46	3.48	12
3.58	3.52	4.38	4.24	13
3.26	3.14	4.48	4.31	14
3.65	3.78	3.57	3.42	15
3.92	3.84	4.66	4.51	16
3.86	4.07	2.68	2.57	17
4.08	3.90	3.55	3.40	18
4.37	4.26	3.73	3.62	19
3.78	3.61	4.86	4.67	20
3.33	3.68	4.38	4.27	21
3.68	3.72	4.08	4.03	22
3.70	3.72	4.55	4.38	23
4.29	4.14	4.07	3.94	24
3.67	3.77	4.10	3.93	25

LARGE DIRECTION ERROR: RETURNS
B1 = 8 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 1
SOS: TWO SOLUTIONS: RETURNS
B5 = 33 C5 = 28
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	25	25	23	24
V1-4,2	25	25	24	25
V1-4,9,0	0	0	1	0

CT = 94 TCT = 556

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	3.89	.18	.43
MLEH	25	3.85	.14	.38
SOSV	24	4.02	.19	.44
MLEV	25	3.93	.20	.45

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 5
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
5.12	4.99	5.00	4.82	1
5.32	5.08	5.56	5.48	2
4.69	4.51	4.51	4.37	3
4.76	4.55	3.89	4.45	4
4.31	4.13	5.25	5.02	5
4.78	5.17	4.76	4.88	6
4.97	4.81	4.49	4.34	7
5.18	4.95	5.17	4.96	8
4.58	4.40	4.68	4.74	9
3.93	3.82	5.30	5.07	10
4.90	4.83	4.55	4.75	11
5.24	5.09	5.10	4.97	12
5.89	5.61	4.58	4.43	13
5.29	5.06	5.49	5.26	14
3.57	3.58	4.97	4.95	15
4.35	4.18	4.54	4.79	16
4.53	4.96	4.77	4.56	17
4.63	4.71	4.48	4.42	18
4.53	4.41	5.06	4.98	19
5.24	5.01	4.80	4.64	20
5.57	5.34	3.99	4.59	21
3.31	3.26	5.75	5.55	22
4.90	5.02	3.32	3.27	23
4.97	4.87	5.36	5.12	24
5.79	5.53	5.06	5.66	25

LARGE DIRECTION ERROR: RETURNS
B1 = 2 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 41 C5 = 30
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	22	22	22	24
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 98 TCT = 462

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	4.81	.37	.61
MLEH	25	4.71	.32	.57
SOSV	25	4.82	.28	.53
MLEV	25	4.80	.22	.47

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 6
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
6.22	6.10	7.13	6.86	1
6.41	6.13	5.15	5.11	2
6.67	6.39	6.79	6.57	3
5.53	5.32	4.69	4.61	4
6.54	6.52	6.66	6.42	5
5.05	4.99	6.82	6.62	6
5.32	5.65	4.79	4.79	7
6.58	6.49	5.41	5.47	8
6.33	6.41	5.83	5.91	9
4.72	4.63	5.41	5.18	10
6.30	6.21	6.13	5.95	11
7.51	7.23	7.65	7.35	12
6.82	6.77	4.85	5.43	13
7.08	6.50	5.56	5.35	14
6.19	5.94	6.55	6.27	15
4.50	5.26	6.12	6.05	16
6.16	5.68	4.96	5.28	17
5.70	5.92	5.60	5.35	18
7.04	6.77	4.70	5.05	19
5.67	5.41	6.37	6.32	20
6.06	5.78	6.07	5.94	21
7.39	7.12	4.91	4.96	22
6.64	6.33	5.62	5.93	23
6.06	6.24	5.59	5.49	24
6.12	5.87	6.29	6.06	25

LARGE DIRECTION ERROR: RETURNS
B1 = 4 C1 = 2
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 25 C5 = 10
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	19	21	17	21
V1-4,2	25	25	25	25
V1-4,9,0	0	0	0	0

CT = 66 TCT = 364

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	6.18	.56	.75
MLEH	25	6.09	.40	.63
SOSV	25	5.83	.63	.79
MLEV	25	5.77	.46	.68

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 7
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
7.52	7.22	7.20	6.92	1
7.81	7.44	7.76	7.44	2
7.54	8.34	7.36	7.06	3
7.05	6.80	7.74	7.41	4
5.99	5.75	6.50	6.24	5
6.21	6.28	7.29	7.00	6
7.90	7.58	8.74	8.38	7
6.42	6.15	6.52	6.26	8
6.27	6.11	6.55	6.92	9
6.66	6.35	7.78	7.45	10
6.01	6.06	5.29	5.71	11
7.83	7.96	7.57	7.57	12
7.54	7.42	6.52	6.57	13
5.15	5.53	7.17	6.89	14
6.92	6.64	6.88	6.61	15
7.65	7.45	7.60	7.77	16
7.13	7.00	6.55	6.27	17
6.26	6.16	6.97	6.67	18
8.08	7.80	6.75	6.53	19
5.68	5.69	8.70	8.35	20
6.91	6.81	6.07	7.13	21
6.63	6.36	7.45	7.53	22
6.28	6.02	7.22	6.91	23
7.43	7.11	5.86	5.64	24
6.35	6.27	7.45	7.12	25

LARGE DIRECTION ERROR: RETURNS
B1 = 11 C1 = 2
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 32 C5 = 30
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	21	21	21	21
V1-4,2	25	24	25	25
V1-4,9,0	0	0	0	0

CT = 100 TCT = 298

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	6.85	.59	.77
MLEH	25	6.73	.56	.75
SOSV	25	7.10	.59	.77
MLEV	25	6.97	.46	.68

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 8
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
8.81	8.42	8.84	9.58	1
8.25	8.25	7.22	7.06	2
8.22	7.65	5.10	5.01	3
9.14	8.74	8.31	8.28	4
7.32	7.09	7.58	7.74	5
7.63	7.36	10.33	9.91	6
8.52	8.40	10.81	10.38	7
7.70	7.93	8.12	9.12	8
9.27	9.06	7.60	7.34	9
8.32	8.02	7.48	7.15	10
9.22	9.16	7.29	7.84	11
8.51	8.39	5.26	7.06	12
6.61	6.59	5.65	6.62	13
8.20	8.07	8.23	8.17	14
7.63	7.37	8.49	8.17	15
9.01	8.72	6.95	6.66	16
9.19	8.77	7.21	6.88	17
7.58	7.26	7.02	6.81	18
8.08	8.01	7.97	7.64	19
7.78	7.43	6.52	6.44	20
7.18	7.09	8.50	8.54	21
7.60	7.77	7.81	7.49	22
8.22	8.07	6.94	6.70	23
5.25	5.25	8.37	8.19	24
8.74	8.95	8.03	7.76	25

LARGE DIRECTION ERROR: RETURNS
B1 = 6 C1 = 2
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 43 C5 = 32
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	18	21	17	16
V1-4,2	24	24	20	23
V1-4,9,0	0	0	0	0

CT = 108 TCT = 198

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	8.08	.80	.89
MLEH	25	7.92	.74	.86
SOSV	25	7.68	1.67	1.29
MLEV	25	7.70	1.37	1.17

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 9
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
9.52	9.12	10.73	10.37	1
9.37	9.53	10.33	9.93	2
11.87	11.40	6.43	6.46	3
9.28	9.08	8.83	8.55	4
7.83	7.62	8.37	8.16	5
7.62	7.27	7.58	7.26	6
9.83	9.52	8.08	7.73	7
8.32	8.03	7.00	6.98	8
10.36	9.93	9.56	9.26	9
8.78	8.58	8.49	8.26	10
9.51	9.14	9.62	9.57	11
8.55	8.28	10.21	10.05	12
12.43	12.01	7.98	8.10	13
8.82	8.55	8.21	7.86	14
8.39	8.02	5.23	7.67	15
11.24	10.97	8.22	8.77	16
8.39	8.15	9.27	9.17	17
9.78	9.38	9.02	8.64	18
10.39	9.93	8.27	8.69	19
6.34	7.88	8.30	8.30	20
9.66	9.26	9.56	9.31	21
9.72	9.79	9.50	9.73	22
9.58	9.18	9.04	9.20	23
9.72	9.56	10.34	10.07	24
9.23	8.83	10.30	9.84	25

LARGE DIRECTION ERROR: RETURNS
B1 = 5 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 38 C5 = 21
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	17	19	15	17
V1-4,2	21	23	23	23
V1-4,9,0	0	0	0	0

CT = 90 TCT = 90

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	9.38	1.64	1.28
MLEH	25	9.16	1.25	1.12
SOSV	25	8.74	1.62	1.27
MLEV	25	8.72	1.04	1.02

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 10
TH = 46
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
11.40	12.01	8.18	8.55	1
11.48	11.24	9.17	9.17	2
7.55	8.46	11.07	11.02	3
8.74	9.99	7.56	8.62	4
10.14	10.14	10.14	10.92	5
10.16	10.39	12.69	12.28	6
12.55	12.11	9.49	9.29	7
8.75	8.40	6.18	7.04	8
10.61	10.32	12.82	12.27	9
11.20	10.70	10.66	10.19	10
6.71	9.03	8.75	8.44	11
10.32	11.36	9.27	10.04	12
11.17	11.00	9.00	8.61	13
6.81	6.54	9.01	9.90	14
9.92	9.64	9.13	9.08	15
10.74	10.53	8.30	8.01	16
9.22	10.32	9.55	9.15	17
9.95	9.74	11.88	11.38	18
8.54	8.58	10.39	9.97	19
10.46	10.05	8.23	8.37	20
10.46	10.56	11.87	11.91	21
7.32	9.11	11.69	11.34	22
9.75	9.32	10.49	10.09	23
9.66	9.35	9.03	8.77	24
10.20	9.74	8.10	8.43	25

LARGE DIRECTION ERROR: RETURNS
B1 = 8 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 0 C3 = 0
NO SOS: CONTINUES
B4 = 0 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 46 C5 = 27
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	13	16	12	10
V1-4,2	20	22	21	22
V1-4,9,0	0	0	0	0

CT = 106 TCT = 106

	N	MEAN	VARIANCE	STD-DEV
SOSH	25	9.77	2.08	1.44
MLEH	25	9.95	1.44	1.20
SOSV	25	9.71	2.59	1.61
MLEV	25	9.71	1.92	1.39

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = .01
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.00	99.99	0.84	1
99.99	1.40	99.99	1.77	2
99.99	2.64	99.99	0.00	3
99.99	0.00	99.99	1.51	4
99.99	4.52	99.99	0.00	5
99.99	0.00	99.99	1.82	6
99.99	0.00	99.99	0.00	7
99.99	0.00	99.99	0.00	8
99.99	0.00	99.99	0.47	9
99.99	0.00	99.99	1.06	10
99.99	1.65	99.99	0.93	11
99.99	0.01	99.99	0.00	12
99.99	0.00	99.99	0.00	13
99.99	0.00	99.99	0.00	14
99.99	0.01	99.99	2.14	15
99.99	0.00	99.99	2.00	16
99.99	0.00	99.99	0.00	17
99.99	0.00	99.99	1.68	18
99.99	0.00	99.99	0.00	19
99.99	0.00	99.99	0.00	20
99.99	0.01	99.99	0.00	21
99.99	0.86	99.99	2.05	22
99.99	6.83	99.99	0.00	23
99.99	6.51	99.99	1.48	24
99.99	3.01	99.99	0.00	25

LARGE DIRECTION ERROR: RETURNS
B1 = 53 C1 = 26
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 29 C2 = 14
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 25 C3 = 11
NO SOS: CONTINUES
B4 = 7 C4 = 6
SOS: TWO SOLUTIONS: RETURNS
B5 = 3 C5 = 0
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 4 C6 = 6

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	18	0	17
V1-4,2	0	20	0	23
V1-4,9,0	25	14	25	14

CT = 117 TCT = 1059

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	1.10	4.03	2.01
SOSV	0	88.88	88.88	88.88
MLEV	25	.63	.62	.79

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 1
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	5.26	99.99	0.00	1
99.99	2.98	99.99	0.96	2
99.99	1.40	99.99	1.71	3
99.99	4.61	99.99	0.00	4
99.99	6.05	99.99	0.00	5
99.99	3.47	99.99	0.62	6
99.99	0.00	99.99	0.00	7
99.99	2.20	99.99	1.01	8
99.99	5.92	99.99	0.00	9
99.99	0.00	99.99	0.35	10
99.99	0.00	99.99	0.15	11
99.99	3.15	99.99	2.86	12
99.99	0.00	99.99	2.51	13
99.99	3.97	99.99	1.69	14
99.99	0.00	99.99	1.89	15
99.99	6.28	99.99	1.74	16
99.99	5.90	99.99	1.28	17
99.99	0.00	99.99	0.70	18
99.99	5.96	99.99	1.43	19
99.99	0.00	99.99	0.00	20
99.99	2.78	99.99	0.62	21
99.99	0.58	99.99	2.33	22
99.99	0.00	99.99	2.50	23
99.99	3.92	99.99	0.00	24
99.99	0.00	99.99	1.80	25

LARGE DIRECTION ERROR: RETURNS
B1 = 34 C1 = 11
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 20 C2 = 7
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 24 C3 = 18
NO SOS: CONTINUES
B4 = 15 C4 = 11
SOS: TWO SOLUTIONS: RETURNS
B5 = 1 C5 = 3
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 9 C6 = 11

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	11	0	21
V1-4,2	0	14	0	25
V1-4,9,0	25	9	25	7

CT = 94 TCT = 942

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	2.58	5.65	2.38
SOSV	0	88.88	88.88	88.88
MLEV	25	1.05	.85	.92

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 2
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	4.11	99.99	2.24	1
99.99	5.71	99.99	2.27	2
99.99	1.66	99.99	1.60	3
99.99	4.79	99.99	1.66	4
99.99	3.25	99.99	2.74	5
99.99	2.09	99.99	0.57	6
99.99	0.02	99.99	1.56	7
99.99	2.73	99.99	1.07	8
99.99	0.00	99.99	2.01	9
99.99	5.01	99.99	3.17	10
99.99	0.00	99.99	1.87	11
99.99	0.00	99.99	1.71	12
99.99	0.00	99.99	2.54	13
99.99	0.00	99.99	2.19	14
99.99	0.00	99.99	0.94	15
99.99	0.00	99.99	2.35	16
99.99	5.75	99.99	1.89	17
99.99	2.57	99.99	1.36	18
99.99	0.00	99.99	2.33	19
99.99	4.39	99.99	1.41	20
99.99	3.85	99.99	2.42	21
99.99	0.00	99.99	1.27	22
99.99	2.58	99.99	1.45	23
99.99	0.00	99.99	2.24	24
99.99	0.00	99.99	1.70	25

LARGE DIRECTION ERROR: RETURNS
B1 = 22 C1 = 11
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 27 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 20 C3 = 22
NO SOS: CONTINUES
B4 = 8 C4 = 12
SOS: TWO SOLUTIONS: RETURNS
B5 = 1 C5 = 6
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 4 C6 = 9

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	5	0	22
V1-4,2	0	19	0	25
V1-4,9,0	25	11	25	0

CT = 78 TCT = 848

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	1.94	4.36	2.09
SOSV	0	88.88	88.88	88.88
MLEV	25	1.86	.35	.59

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 3
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.00	99.99	2.19	1
99.99	0.00	99.99	3.20	2
99.99	0.00	99.99	2.29	3
99.99	1.36	99.99	2.17	4
99.99	0.00	99.99	3.07	5
99.99	4.64	99.99	3.96	6
99.99	3.36	99.99	3.23	7
99.99	2.81	99.99	3.06	8
99.99	5.35	99.99	2.87	9
99.99	0.00	99.99	2.76	10
99.99	0.00	99.99	3.15	11
99.99	0.68	99.99	3.89	12
99.99	2.88	99.99	2.64	13
99.99	0.00	99.99	2.77	14
99.99	4.41	99.99	2.70	15
99.99	0.00	99.99	1.52	16
99.99	0.00	99.99	2.86	17
99.99	0.00	99.99	2.35	18
99.99	3.40	99.99	3.15	19
99.99	4.34	99.99	3.07	20
99.99	5.62	99.99	2.67	21
99.99	1.73	99.99	1.06	22
99.99	2.82	99.99	3.40	23
99.99	3.35	99.99	3.26	24
99.99	2.87	99.99	3.60	25

LARGE DIRECTION ERROR: RETURNS
B1 = 28 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 18 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 32 C3 = 23
NO SOS: CONTINUES
B4 = 23 C4 = 22
SOS: TWO SOLUTIONS: RETURNS
B5 = 2 C5 = 14
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 14 C6 = 20

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	7	0	23
V1-4,2	0	12	0	25
V1-4,9,0	25	10	25	0

CT = 103 TCT = 770

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	1.98	3.73	1.93
SOSV	0	88.88	88.88	88.88
MLEV	25	2.83	.43	.66

SOS,MLE,MONTE CARLO
UPWIND
INPUT WIND = 4
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	3.88	99.99	4.26	1
99.99	7.83	99.99	3.34	2
99.99	0.00	99.99	4.72	3
99.99	6.59	99.99	4.23	4
99.99	0.00	99.99	4.48	5
99.99	4.75	99.99	3.53	6
99.99	0.00	99.99	4.83	7
99.99	5.27	99.99	4.78	8
99.99	0.00	99.99	4.15	9
99.99	2.01	99.99	3.63	10
99.99	3.80	99.99	4.87	11
99.99	5.30	99.99	4.09	12
99.99	0.00	99.99	4.08	13
99.99	6.72	99.99	4.39	14
99.99	5.19	99.99	3.62	15
99.99	4.72	99.99	3.77	16
99.99	0.00	99.99	3.54	17
99.99	5.03	99.99	3.82	18
99.99	0.00	5.38	5.37	19
99.99	5.41	99.99	4.79	20
99.99	3.36	99.99	3.72	21
99.99	7.33	99.99	3.25	22
99.99	2.31	99.99	4.36	23
99.99	0.00	99.99	4.03	24
99.99	7.51	99.99	2.54	25

LARGE DIRECTION ERROR: RETURNS
B1 = 22 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 14 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 27 C3 = 14
NO SOS: CONTINUES
B4 = 13 C4 = 21
SOS: TWO SOLUTIONS: RETURNS
B5 = 2 C5 = 9
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 9 C6 = 11

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	5	0	24
V1-4,2	0	12	1	25
V1-4,9,0	25	8	24	0

CT = 78 TCT = 667

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	3.48	7.58	2.75
SOSV	1	5.381	77.77	77.77
MLEV	25	4.09	.38	.62

SOS,MLE,MONTE CARLO
UPWIND
INPUT WIND = 5
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	6.49	99.99	5.15	1
99.99	6.14	99.99	4.95	2
99.99	6.78	99.99	5.75	3
99.99	0.00	99.99	5.23	4
99.99	7.24	99.99	4.69	5
99.99	2.53	99.99	5.23	6
99.99	2.02	99.99	4.24	7
99.99	6.48	99.99	5.66	8
99.99	6.67	99.99	5.30	9
99.99	0.00	99.99	5.02	10
99.99	6.63	99.99	4.92	11
99.99	5.93	99.99	5.41	12
99.99	3.57	99.99	4.99	13
99.99	7.19	99.99	5.27	14
99.99	5.13	99.99	4.88	15
99.99	8.26	99.99	4.92	16
99.99	4.10	99.99	4.53	17
99.99	6.69	99.99	5.32	18
99.99	0.00	99.99	5.23	19
99.99	6.61	99.99	5.04	20
99.99	4.81	99.99	4.64	21
99.99	1.96	99.99	5.08	22
99.99	7.37	99.99	4.57	23
99.99	6.34	99.99	5.38	24
99.99	7.26	99.99	5.08	25

LARGE DIRECTION ERROR: RETURNS
B1 = 27 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 6 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 36 C3 = 7
NO SOS: CONTINUES
B4 = 29 C4 = 19
SOS: TWO SOLUTIONS: RETURNS
B5 = 10 C5 = 32
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 13 C6 = 1

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	3	0	25
V1-4,2	0	14	0	25
V1-4,9,0	25	3	25	0

CT = 108 TCT = 589

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	5.05	6.23	2.50
SOSV	0	88.88	88.88	88.88
MLEV	25	5.06	.12	.35

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 6
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PD
99.99	5.37	99.99	6.34	1
99.99	4.70	99.99	5.96	2
99.99	5.85	6.07	6.07	3
99.99	5.89	99.99	5.00	4
99.99	5.37	99.99	6.27	5
99.99	5.30	6.23	6.24	6
99.99	6.59	99.99	5.88	7
99.99	8.89	99.99	5.64	8
99.99	7.56	99.99	5.59	9
99.99	2.27	99.99	5.47	10
99.99	8.40	99.99	5.60	11
99.99	7.53	99.99	6.07	12
99.99	4.49	6.00	5.97	13
99.99	5.82	99.99	5.71	14
99.99	6.73	6.65	6.66	15
99.99	5.24	6.26	6.28	16
99.99	7.54	6.34	6.34	17
99.99	5.47	5.66	5.66	18
99.99	4.53	5.83	5.82	19
99.99	5.69	99.99	5.98	20
99.99	7.12	5.57	5.55	21
99.99	3.64	99.99	5.87	22
99.99	8.22	99.99	6.07	23
99.99	6.11	6.15	6.16	24
99.99	0.00	6.31	6.31	25

LARGE DIRECTION ERROR: RETURNS
B1 = 17 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 1 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 33 C3 = 5
NO SOS: CONTINUES
B4 = 24 C4 = 9
SOS: TWO SOLUTIONS: RETURNS
B5 = 9 C5 = 23
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 10 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	13	11	25
V1-4,2	0	20	11	25
V1-4,9,0	25	1	14	0
CT =	84 TCT = 481			

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	5.77	3.64	1.91
SOSV	11	6.10	.08	.28
MLEV	25	5.95	.12	.35

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 7
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PD
99.99	7.21	7.09	7.12	1
99.99	7.71	7.00	6.99	2
99.99	7.60	6.57	6.55	3
99.99	4.25	7.24	7.29	4
99.99	6.63	6.95	6.99	5
99.99	7.01	6.63	6.65	6
99.99	7.25	6.80	6.80	7
99.99	5.13	6.82	6.82	8
99.99	5.56	99.99	7.19	9
99.99	7.34	7.47	7.52	10
99.99	7.00	7.06	7.00	11
99.99	8.31	99.99	6.80	12
99.99	6.18	6.78	6.74	13
99.99	7.25	6.54	6.54	14
99.99	8.37	6.49	6.51	15
99.99	7.22	7.49	7.49	16
99.99	5.23	7.21	7.27	17
99.99	5.89	99.99	6.68	18
99.99	6.15	99.99	7.51	19
99.99	8.34	7.14	7.15	20
99.99	7.49	7.18	7.13	21
99.99	6.47	6.63	6.64	22
99.99	5.50	6.80	6.81	23
99.99	7.56	6.63	6.64	24
99.99	6.85	7.33	7.37	25

LARGE DIRECTION ERROR: RETURNS
B1 = 8 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 26 C3 = 0
NO SOS: CONTINUES
B4 = 35 C4 = 4
SOS: TWO SOLUTIONS: RETURNS
B5 = 39 C5 = 21
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 15 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	16	21	25
V1-4,2	0	24	21	25
V1-4,9,0	25	0	4	0
CT =	108 TCT = 397			

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	6.78	1.10	1.05
SOSV	21	6.95	.08	.28
MLEV	25	6.97	.10	.32

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 8
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	7.16	7.77	7.68	1
99.99	6.32	8.01	8.10	2
99.99	9.39	7.45	7.48	3
99.99	8.76	8.24	8.03	4
99.99	9.31	7.57	7.61	5
99.99	8.18	7.56	7.64	6
99.99	6.43	8.10	8.11	7
99.99	7.18	8.54	8.62	8
99.99	7.62	8.22	8.37	9
99.99	7.39	7.88	7.39	10
99.99	6.52	7.33	7.38	11
99.99	8.45	8.34	8.45	12
99.99	7.58	8.35	8.46	13
99.99	7.91	8.28	8.41	14
99.99	8.51	7.07	7.05	15
99.99	8.28	7.92	7.81	16
99.99	7.23	8.24	8.28	17
10.00	9.94	8.09	8.10	18
99.99	9.55	7.83	7.94	19
99.99	8.60	7.84	7.88	20
99.99	7.13	99.99	7.71	21
99.99	9.32	8.01	8.13	22
99.99	8.15	7.78	7.84	23
99.99	8.36	8.15	8.23	24
99.99	7.75	7.52	7.43	25

LARGE DIRECTION ERROR: RETURNS
B1 = 4 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 16 C3 = 0
NO SOS: CONTINUES
B4 = 27 C4 = 1
SOS: TWO SOLUTIONS: RETURNS
B5 = 36 C5 = 15
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 5 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	17	24	25
V1-4,2	1	25	24	25
V1-4,9,0	24	0	1	0

CT = 85 TCT = 289

	N	MEAN	VARIANCE	STD-DEV
SOSH	1	10	77.77	77.77
MLEH	25	8.04	.97	.99
SOSV	24	7.92	.11	.33
MLEV	25	7.95	.14	.38

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 9
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	9.44	8.55	8.61	1
99.99	9.44	9.18	9.34	2
8.74	8.70	8.82	9.04	3
99.99	9.35	9.47	9.53	4
9.77	9.75	9.30	9.49	5
99.99	9.29	9.35	9.60	6
99.99	9.48	8.56	8.70	7
99.99	9.61	9.24	9.37	8
99.99	9.32	8.40	8.42	9
99.99	8.72	8.66	8.72	10
11.12	11.13	9.27	9.27	11
99.99	6.74	8.82	9.23	12
9.91	9.85	9.40	9.42	13
9.40	9.38	8.77	8.77	14
99.99	8.41	9.36	9.53	15
99.99	9.24	8.86	8.95	16
99.99	8.31	9.36	9.45	17
10.37	10.35	8.32	8.49	18
9.61	9.53	8.76	8.83	19
99.99	9.45	9.33	9.47	20
99.99	8.96	8.80	8.92	21
99.99	8.02	8.91	9.08	22
99.99	9.44	8.98	9.09	23
99.99	8.78	8.06	8.06	24
99.99	8.58	8.58	8.78	25

LARGE DIRECTION ERROR: RETURNS
B1 = 2 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 10 C3 = 0
NO SOS: CONTINUES
B4 = 39 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 39 C5 = 37
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 3 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	5	22	25	25
V1-4,2	6	23	25	25
V1-4,9,0	18	0	0	0

CT = 106 TCT = 204

	N	MEAN	VARIANCE	STD-DEV
SOSH	7	9.85	.48	.69
MLEH	25	9.17	.66	.81
SOSV	25	8.93	.13	.36
MLEV	25	9.04	.16	.40

SOS, MLE, MONTE CARLO
UPWIND
INPUT WIND = 10
TH = .52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
10.79	10.55	9.64	9.92	1
10.22	10.13	9.67	9.77	2
99.99	9.35	9.26	9.49	3
9.91	9.85	9.97	10.13	4
9.80	9.78	9.82	10.14	5
10.43	10.44	9.91	10.02	6
99.99	7.74	10.46	10.51	7
10.54	10.42	9.85	10.05	8
11.08	11.00	9.48	9.65	9
99.99	10.80	10.07	10.07	10
9.95	9.68	9.87	10.15	11
99.99	8.23	9.96	10.08	12
10.24	10.23	9.76	9.66	13
99.99	9.73	10.33	10.33	14
99.99	10.08	10.16	10.28	15
99.99	9.99	9.50	9.58	16
10.39	10.36	9.48	9.77	17
10.58	10.58	10.34	10.36	18
10.32	10.27	10.02	10.43	19
99.99	10.57	9.65	9.72	20
10.22	10.20	10.01	10.00	21
99.99	8.23	9.63	9.74	22
10.23	10.18	9.98	10.34	23
10.27	10.27	9.56	9.73	24
99.99	10.30	9.40	9.54	25

LARGE DIRECTION ERROR: RETURNS
B1 = 0 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 5 C3 = 0
NO SOS: CONTINUES
B4 = 15 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 54 C5 = 19
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	14	21	25	25
V1-4,2	15	24	25	25
V1-4,9,0	10	0	0	0

CT = 98 TCT = 98

	N	MEAN	VARIANCE	STD-DEV
SOSH	15	10.33	.10	.32
MLEH	25	9.97	.62	.79
SOSV	25	9.83	.07	.27
MLEV	25	9.99	.08	.28

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = .01
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	4.37	99.99	1.98	1
99.99	4.00	99.99	0.00	2
99.99	0.00	99.99	0.00	3
99.99	0.00	99.99	0.00	4
99.99	5.55	99.99	3.20	5
99.99	1.74	99.99	0.00	6
99.99	0.00	99.99	0.00	7
99.99	0.00	99.99	1.91	8
99.99	0.00	99.99	1.19	9
99.99	0.50	99.99	2.99	10
99.99	0.00	99.99	0.00	11
99.99	0.00	99.99	0.00	12
99.99	0.00	99.99	2.86	13
99.99	0.00	99.99	0.00	14
99.99	0.00	99.99	0.00	15
99.99	0.00	99.99	0.06	16
99.99	4.05	99.99	4.38	17
99.99	4.49	99.99	0.34	18
99.99	4.86	99.99	0.00	19
99.99	5.68	99.99	0.00	20
99.99	1.74	99.99	0.00	21
99.99	0.00	99.99	1.85	22
99.99	5.31	99.99	3.27	23
99.99	2.28	99.99	1.26	24
99.99	3.47	99.99	1.99	25

LARGE DIRECTION ERROR: RETURNS
B1 = 37 C1 = 16
CALM: BOTH SIGMAS NEGATIVE: CONTINUES
B2 = 25 C2 = 11 (12)
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 18 C3 = 13
NO SOS: CONTINUES
B4 = 9 C4 = 9
SOS: TWO SOLUTIONS: RETURNS
B5 = 2 C5 = 0
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 3 C6 = 8

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	13	0	14
V1-4,2	0	15	0	20
V1-4,9,0	25	12	25	12

CT = 91 TCT = 970

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	1.92	4.71	2.17
SOSV	0	88.88	88.88	88.88
MLEV	25	1.09	1.82	1.35

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 1
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.00	99.99	0.00	1
99.99	6.47	99.99	3.23	2
99.99	0.00	99.99	2.01	3
99.99	0.00	99.99	1.78	4
99.99	0.00	99.99	2.22	5
99.99	3.47	99.99	3.26	6
99.99	0.00	99.99	2.58	7
99.99	0.00	99.99	1.25	8
99.99	5.59	99.99	0.70	9
99.99	0.00	99.99	2.09	10
99.99	0.00	99.99	3.62	11
99.99	6.14	99.99	0.00	12
99.99	0.00	99.99	2.34	13
99.99	0.00	99.99	0.01	14
99.99	2.62	99.99	1.60	15
99.99	0.00	99.99	3.40	16
99.99	0.00	99.99	3.33	17
99.99	0.00	99.99	0.00	18
99.99	0.00	99.99	0.00	19
99.99	2.34	99.99	0.00	20
99.99	0.56	99.99	0.00	21
99.99	0.91	99.99	0.00	22
99.99	0.00	99.99	1.82	23
99.99	0.00	99.99	2.20	24
99.99	0.00	99.99	1.34	25

LARGE DIRECTION ERROR: RETURNS
B1 = 26 C1 = 18
CALM: BOTH SIGMAS NEGATIVE: CONTINUES
B2 = 32 C2 = 7
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 18 C3 = 17
NO SOS: CONTINUES
B4 = 3 C4 = 8
SOS: TWO SOLUTIONS: RETURNS
B5 = 0 C5 = 1
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 2 C6 = 7

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	19	0	14
V1-4,2	0	21	0	20
V1-4,9,0	25	17	25	7

CT = 79 TCT = 879

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	1.12	4.19	2.05
SOSV	0	88.88	88.88	88.88
MLEV	25	1.56	1.60	1.27

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 2
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	4.64	99.99	0.00	1
99.99	5.16	99.99	1.90	2
99.99	3.42	99.99	1.46	3
99.99	0.00	99.99	0.00	4
99.99	0.00	99.99	0.00	5
99.99	5.95	99.99	1.66	6
99.99	5.16	99.99	0.00	7
9.41	9.38	99.99	2.19	8
99.99	4.85	99.99	0.00	9
99.99	0.00	99.99	0.00	10
8.60	8.56	99.99	2.80	11
99.99	3.34	99.99	3.26	12
99.99	0.71	99.99	1.40	13
99.99	5.14	99.99	0.00	14
99.99	5.56	99.99	0.00	15
99.99	0.00	99.99	1.17	16
99.99	0.00	99.99	1.87	17
99.99	3.75	99.99	0.00	18
99.99	0.00	99.99	0.00	19
99.99	5.70	99.99	3.48	20
99.99	0.00	99.99	0.00	21
99.99	2.84	99.99	0.00	22
99.99	6.48	99.99	0.00	23
99.99	7.54	99.99	3.01	24
99.99	0.00	99.99	0.00	25

LARGE DIRECTION ERROR: RETURNS
B1 = 31 C1 = 12
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 13 C2 = 14
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 20 C3 = 10
NO SOS: CONTINUES
B4 = 15 C4 = 6
SOS: TWO SOLUTIONS: RETURNS
B5 = 0 C5 = 0
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 8 C6 = 5

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	1	0	8
V1-4,2	0	13	0	25
V1-4,9,0	23	8	25	14

CT = 81 TCT = 800

	N	MEAN	VARIANCE	STD-DEV
SOSH	2	9.01	.16	.40
MLEH	25	3.53	8.72	2.95
SOSV	0	88.88	88.88	88.88
MLEV	25	.97	1.45	1.20

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 3
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.00	99.99	4.15	1
99.99	2.73	99.99	3.45	2
99.99	4.14	99.99	2.61	3
99.99	0.00	99.99	3.26	4
99.99	0.00	99.99	3.21	5
99.99	0.00	99.99	2.60	6
99.99	7.17	99.99	3.60	7
99.99	0.00	99.99	2.05	8
99.99	0.00	99.99	4.15	9
99.99	3.41	99.99	3.42	10
99.99	5.55	99.99	1.85	11
99.99	0.00	99.99	3.91	12
99.99	6.69	99.99	2.50	13
99.99	0.00	99.99	0.00	14
99.99	0.00	99.99	2.40	15
99.99	0.00	99.99	3.37	16
99.99	0.00	99.99	2.93	17
99.99	4.39	99.99	2.20	18
99.99	5.59	99.99	3.48	19
99.99	0.00	99.99	4.35	20
99.99	6.17	99.99	4.24	21
99.99	0.00	99.99	0.00	22
99.99	6.84	99.99	2.70	23
99.99	0.00	99.99	3.20	24
99.99	0.00	99.99	2.03	25

LARGE DIRECTION ERROR: RETURNS
B1 = 22 C1 = 9
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 19 C2 = 2
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 11 C3 = 17
NO SOS: CONTINUES
B4 = 11 C4 = 8
SOS: TWO SOLUTIONS: RETURNS
B5 = 3 C5 = 1
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 4 C6 = 2

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	2	0	19
V1-4,2	0	4	0	23
V1-4,9,0	25	15	25	2

CT = 66 TCT = 719

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	2.12	7.62	2.76
SOSV	0	88.88	88.88	88.88
MLEV	25	2.87	1.22	1.10

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 4
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	0.00	99.99	4.58	1
99.99	0.00	99.99	3.86	2
99.99	5.16	99.99	4.63	3
99.99	0.03	99.99	5.15	4
99.99	8.01	99.99	2.53	5
99.99	7.18	99.99	3.13	6
99.99	0.00	99.99	4.52	7
99.99	4.77	99.99	3.84	8
99.99	5.35	99.99	3.84	9
99.99	4.35	99.99	3.31	10
99.99	0.00	99.99	4.23	11
99.99	5.31	99.99	3.17	12
99.99	4.75	99.99	5.42	13
99.99	5.90	99.99	4.32	14
99.99	2.02	99.99	4.56	15
99.99	2.61	99.99	3.31	16
99.99	3.98	99.99	3.02	17
99.99	6.28	99.99	3.95	18
99.99	7.05	99.99	4.95	19
99.99	6.60	99.99	4.81	20
99.99	2.79	99.99	4.21	21
99.99	0.00	99.99	2.50	22
99.99	0.00	99.99	2.11	23
99.99	0.01	99.99	4.81	24
99.99	0.42	99.99	4.08	25

LARGE DIRECTION ERROR: RETURNS
B1 = 43 C1 = 7
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 11 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 27 C3 = 18
NO SOS: CONTINUES
B4 = 22 C4 = 16
SOS: TWO SOLUTIONS: RETURNS
B5 = 1 C5 = 11
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 8 C6 = 9

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	4	0	20
V1-4,2	0	10	0	25
V1-4,9,0	25	6	25	0

CT = 104 TCT = 653

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	3.30	7.72	2.78
SOSV	0	88.88	88.88	88.88
MLEV	25	3.95	.74	.86

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 5
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	4.91	99.99	2.89	1
99.99	0.09	99.99	5.33	2
99.99	6.64	99.99	4.75	3
99.99	0.02	99.99	5.40	4
9.35	9.26	99.99	4.18	5
99.99	0.19	99.99	5.61	6
99.99	2.82	99.99	4.49	7
99.99	6.20	99.99	5.02	8
99.99	0.00	99.99	4.74	9
99.99	0.00	99.99	4.77	10
99.99	5.41	99.99	5.21	11
99.99	0.94	99.99	5.02	12
99.99	4.34	99.99	4.12	13
99.99	7.91	99.99	4.93	14
99.99	6.37	99.99	5.16	15
99.99	6.38	99.99	5.32	16
99.99	0.07	99.99	5.90	17
99.99	5.73	99.99	4.08	18
99.99	6.06	99.99	5.52	19
99.99	7.56	99.99	6.12	20
99.99	4.30	99.99	5.55	21
99.99	6.77	99.99	5.07	22
99.99	3.21	99.99	3.41	23
99.99	6.47	6.05	6.00	24
99.99	6.33	99.99	5.06	25

LARGE DIRECTION ERROR: RETURNS
B1 = 31 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 4 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 23 C3 = 11
NO SOS: CONTINUES
B4 = 20 C4 = 15
SOS: TWO SOLUTIONS: RETURNS
B5 = 3 C5 = 14
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 6 C6 = 2

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	5	0	22
V1-4,2	0	14	1	24
V1-4,9,0	24	2	24	0

CT = 82 TCT = 549

	N	MEAN	VARIANCE	STD-DEV
SOSH	1	9.35	77.77	77.77
MLEH	25	4.32	8.40	2.90
SOSV	1	6.05	77.77	77.77
MLEV	25	4.95	.56	.75

SOS,MLE,MONTE CARLO
DOWNWIND
INPUT WIND = 6
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	6.51	6.17	6.15	1
99.99	5.64	99.99	6.09	2
99.99	6.55	99.99	5.70	3
99.99	0.00	6.64	6.51	4
99.99	5.94	99.99	6.17	5
99.99	6.21	6.83	6.85	6
99.99	0.00	7.06	7.05	7
99.99	3.20	99.99	6.32	8
99.99	2.33	5.86	5.85	9
99.99	7.89	6.25	6.22	10
99.99	4.41	99.99	5.05	11
99.99	6.92	7.05	7.02	12
99.99	6.41	6.22	6.20	13
99.99	7.55	5.84	5.80	14
99.99	3.16	99.99	5.64	15
99.99	7.26	6.32	6.30	16
99.99	3.85	5.96	5.94	17
99.99	5.35	99.99	5.02	18
99.99	0.00	6.92	6.92	19
99.99	4.48	6.28	6.23	20
99.99	7.31	99.99	6.03	21
99.99	5.36	5.88	5.85	22
99.99	4.93	6.31	6.30	23
99.99	7.24	6.38	6.33	24
99.99	0.00	99.99	5.79	25

LARGE DIRECTION ERROR: RETURNS
B1 = 29 C1 = 1
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 6 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 29 C3 = 2
NO SOS: CONTINUES
B4 = 21 C4 = 7
SOS: TWO SOLUTIONS: RETURNS
B5 = 5 C5 = 20
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 10 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	9	14	23
V1-4,2	0	17	16	25
V1-4,9,0	25	4	9	0

CT = 90 TCT = 467

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	4.74	6.31	2.51
SOSV	16	6.37	.15	.39
MLEV	25	6.13	.25	.50

SOS,MLE,MONTE CARLO
DOWNWIND
INPUT WIND = 7
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	6.07	7.09	7.09	1
99.99	0.00	7.34	7.31	2
99.99	5.72	6.86	6.78	3
99.99	6.82	7.39	7.39	4
99.99	4.94	6.90	6.86	5
99.99	7.10	6.19	6.17	6
99.99	5.91	7.25	7.10	7
99.99	7.42	6.69	6.58	8
99.99	3.33	99.99	7.05	9
99.99	10.00	7.12	7.10	10
99.99	0.00	7.29	7.29	11
99.99	7.46	6.53	6.53	12
99.99	8.22	7.02	7.02	13
99.99	7.48	7.80	7.83	14
99.99	8.13	7.28	7.23	15
99.99	7.62	7.16	7.16	16
99.99	6.61	7.62	7.41	17
99.99	4.66	99.99	6.94	18
99.99	4.03	99.99	6.40	19
99.99	8.16	99.99	6.77	20
99.99	7.89	7.40	7.42	21
99.99	8.11	7.60	7.60	22
99.99	6.75	7.10	7.10	23
99.99	5.16	99.99	6.66	24
99.99	6.11	99.99	6.74	25

LARGE DIRECTION ERROR: RETURNS
B1 = 28 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 3 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 24 C3 = 0
NO SOS: CONTINUES
B4 = 35 C4 = 6
SOS: TWO SOLUTIONS: RETURNS
B5 = 15 C5 = 29
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 12 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	0	11	19	25
V1-4,2	0	17	19	25
V1-4,9,0	25	2	6	0

CT = 109 TCT = 377

	N	MEAN	VARIANCE	STD-DEV
SOSH	0	88.88	88.88	88.88
MLEH	25	6.15	5.45	2.33
SOSV	19	7.14	.13	.36
MLEV	25	7.02	.14	.38

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 8
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	6.38	8.06	8.12	1
99.99	7.41	7.70	7.68	2
99.99	8.18	8.67	8.35	3
10.10	10.00	7.51	7.53	4
99.99	10.17	8.08	8.08	5
99.99	9.59	7.92	7.95	6
99.99	5.88	7.98	8.02	7
99.99	7.21	8.59	8.62	8
99.99	6.75	99.99	7.86	9
99.99	8.56	8.15	8.19	10
99.99	7.39	8.37	8.43	11
99.99	7.38	8.52	8.59	12
8.41	8.36	8.11	8.14	13
99.99	8.30	7.89	7.90	14
99.99	7.94	7.10	7.09	15
99.99	7.86	8.08	8.08	16
99.99	8.13	7.71	7.71	17
99.99	7.10	8.37	8.38	18
99.99	8.43	8.22	8.27	19
99.99	8.73	7.73	7.76	20
99.99	6.68	8.21	8.25	21
99.99	9.76	7.90	7.92	22
99.99	8.49	7.33	7.35	23
99.99	10.68	8.00	7.99	24
99.99	8.82	8.41	8.48	25

LARGE DIRECTION ERROR: RETURNS
1 = 17 C1 = 0
CALM: BOTH SIGMAS NEGATIVE: CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 13 C3 = 0
NO SOS: CONTINUES
B4 = 36 C4 = 1
SOS: TWO SOLUTIONS: RETURNS
B5 = 13 C5 = 20
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 6 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	1	16	24	25
V1-4,2	1	22	24	25
V1-4,9,0	23	0	1	0

CT = 81 TCT = 268

	N	MEAN	VARIANCE	STD-DEV
SOSH	2	9.26	.71	.84
MLEH	25	8.17	1.44	1.20
SOSV	24	8.03	.13	.36
MLEV	25	8.03	.13	.36

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 9
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	PP
99.99	7.36	8.30	8.38	1
10.24	10.18	9.16	9.22	2
9.62	9.48	8.81	8.83	3
9.93	9.72	8.69	8.80	4
99.99	9.82	8.06	8.10	5
9.61	9.53	9.32	9.47	6
99.99	8.40	8.91	9.02	7
99.99	7.79	8.31	8.37	8
99.99	8.40	9.04	9.05	9
10.07	9.96	8.90	9.02	10
99.99	8.57	8.88	8.87	11
10.60	10.57	9.26	9.31	12
99.99	9.05	8.74	8.72	13
9.93	9.90	9.26	9.31	14
10.28	10.11	9.53	9.60	15
99.99	10.95	9.00	9.14	16
99.99	9.47	8.84	8.84	17
99.99	6.89	8.87	8.92	18
99.99	9.66	9.30	9.44	19
99.99	9.28	8.63	8.74	20
99.99	8.58	8.73	8.81	21
10.94	10.71	10.09	10.10	22
99.99	8.74	9.30	9.46	23
99.99	8.18	9.24	9.36	24
9.13	8.95	9.40	9.45	25

LARGE DIRECTION ERROR: RETURNS
B1 = 22 C1 = 0
CALM: BOTH SIGMAS NEGATIVE: CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 11 C3 = 0
NO SOS: CONTINUES
B4 = 27 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 39 C5 = 25
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 3 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	5	17	24	24
V1-4,2	10	24	25	25
V1-4,9,0	15	0	0	0

CT = 114 TCT = 187

	N	MEAN	VARIANCE	STD-DEV
SOSH	10	10.04	.24	.49
MLEH	25	9.21	1.01	1.01
SOSV	25	8.98	.161	.401
MLEV	25	9.05	.18	.43

SOS, MLE, MONTE CARLO
DOWNWIND
INPUT WIND = 10
TH = 52
NO = 25

SOSH	MLEH	SOSV	MLEV	FP
99.99	9.58	9.60	9.79	1
99.99	8.80	10.34	10.35	2
10.29	10.16	10.01	10.17	3
99.99	10.29	9.77	9.77	4
99.99	8.53	10.05	10.06	5
10.26	10.25	9.61	9.61	6
99.99	10.29	9.59	9.70	7
9.82	9.71	9.94	10.19	8
10.27	10.24	9.75	9.88	9
99.99	8.19	10.30	10.40	10
12.02	11.97	10.02	10.20	11
9.19	9.09	9.08	9.24	12
99.99	9.40	10.14	10.29	13
99.99	8.82	9.63	9.67	14
99.99	9.05	9.67	9.84	15
99.99	8.12	10.19	10.23	16
99.99	9.44	9.33	9.46	17
99.99	8.39	10.40	10.44	18
99.99	8.72	9.48	9.52	19
12.65	12.63	9.16	9.30	20
9.94	9.93	10.13	10.25	21
10.18	9.93	10.61	10.65	22
99.99	8.85	9.91	10.01	23
11.00	10.94	9.97	10.00	24
9.88	9.66	9.28	9.38	25

LARGE DIRECTION ERROR: RETURNS
B1 = 10 C1 = 0
CALM: BOTH SIGMAS NEGATIVE:CONTINUES
B2 = 0 C2 = 0
NEGATIVE SIGMA: CROSS WIND: CONTINUES
B3 = 2 C3 = 0
NO SOS: CONTINUES
B4 = 19 C4 = 0
SOS: TWO SOLUTIONS: RETURNS
B5 = 21 C5 = 17
NO SOS: TWO SOLUTIONS: RETURNS
B6 = 0 C6 = 0

	SOSH	MLEH	SOSV	MLEV
V1-4,1	8	15	25	25
V1-4,2	9	24	25	25
V1-4,9,0	14	0	0	0

CT = 73 TCT = 73

	N	MEAN	VARIANCE	STD-DEV
SOSH	11	10.50	.94	.97
MLEH	25	9.64	1.16	1.08
SOSV	25	9.84	.13	.36
MLEV	25	9.94	.14	.38

APPENDIX B

PROGRAM LISTING FOR MONTE CARLO STUDY OF SOS VERSUS MLE WIND VECTOR RECOVERY ALGORITHMS FROM THE SASS-1 AT UP-WIND AND DOWNWIND FOR INCIDENCE ANGLES OF 26, 36, 40, 46 AND 52 DEGREES

ANNOTATED IBM PC BASIC PROGRAM

```
10 M=2.302585        LOG 10, BASE e    (NOTE P=0 AT START).
20 DIM F(25)         NEEDED FOR LAST SUBROUTINE.
30 TCT =0            TOTAL COUNT.
40 REM bill 8        PROGRAM NAME.
41 PRINT "TEST Y=0,N=1":INPUT Q    ( Ø ONE WIND, 1 DO ALL WINDS).
45 RANDOMIZE         SEED RANDOM NUMBER GENERATOR.
50 PRINT  "?number":INPUT NO (HOW MAY TRIALS?)
60 PRINT "vw":INPUT VW  WIND SPEED OR HIGHEST WIND SPEED.
70 PRINT  "?th,26,36,40,46,52":INPUT TH  INCIDENCE ANGLE.
80 PRINT  "lk, up(0) down(1) ":INPUT LK  LOOK UP OR DOWN.
90 B1=0:B2=0:B3=0:C1=0:C2=0:C3=0
100 B4=0:B5=0:B6=0  90 - 110 ZEROS B's AND C's
110 C4=0:C5=0:C6=0
120 PP=1:CT=0:          COUNTS SUCCESSES AND TOTAL TRIALS.
130 V11=0: V21=0: V31=0: V41=0
140 V12=0: V22=0: V32=0: V42=0
150 V19=0: V20=0: V39=0: V40=0
180 VB1=0: VN1=0: VR1=0: SD1=0
190 VB2=0: VN2=0: VR2=0: SD2=0   130-230 ZEROS OUT ALL VARIABLES.
200 VB3=0: VN3=0: VR3=0: SD3=0
210 VB4=0: VN4=0: VR4=0: SD4=0
220 MB1=0: MB2=0:MB3=0: MB4=0
230 VS1=0: VS2=0: VS3=0: VS4=0

250 V1=0: V2=0     250 ZEROS SOS H  AND MLE H IF MLE V DOES NOT HAVE SOLUTION.
260 V3=0: V4=0: SU=0: VU=0
270 SC=0:VC=0:SD=0:VD=0:RU=0:RC=0
280 RD=0:S1=0:S2=0:S3=0:TU=0:UU=0  260-310 ZEROS VARIABLES BEFORE NEXT
290 TC=0:UC=0:TD=0:UD=0:T1=0:T2=0  CALCULATIONS.
300 T3=0:WU=0:WC=0:WD=0
310 IF P = 1 GOTO 570
320 P=0   320 FOR HORIZONTAL POLARIZATION
330 CT=CT+1:TCT=TCT+1   IF 320 IS CONFIRMED, COUNTS INCREMENTED BY ONE.
335 PRINT "VW";VW;"CT";CT;"TCT";TCT;"PP";PP 335-336 SHOWS STATUS ON SCREEN.
336 PRINT "V1";V1;"V2";V2;"V3";V3;"V4";V4
340 GOSUB 3260
350 IF LK=1 GOTO 380                  340-390 GETS UNPERTURBED UPWIND (SU) AND
360 SU=GU+HU*LOG(VW)/M:S1=10^SU      CROSSWIND (SC) BACKSCATTER IN BELS, CONVERTS
370 VU=(A*S1+B)*S1+C                 TO ANTILOG.GETS VARIANCES FOR H POL.
380 SC=GC+HC*LOG(VW)/M:S2=10^SC  380-420 SAME FOR CROSSWIND AND DOWNWIND.
390 VC=(A*S2+B)*S2+C
400 IF LK=0 GOTO 440
410 SD=GD+HD*LOG(VW)/M:S3=10^SD
420 VD=(A*S3+B)*S3+C
430 IF LK=1 GOTO 460
440 GOSUB 3730
450 G1=G:RU=S1+G1*SQR(VU)          450-550 GETS RANDOM t's AND PERTURBS NOISE
460 GOSUB 3730                      FREE VALUES,  CHECKS FOR VARIOUS NEGATIVE
470 G2=G:RC=S2+G2*SQR(VC)          ANTILOG BACKSCATTER VALUES AND FOR CROSSWIND
480 IF LK=1 GOTO 520                BACKSCATTER GREATER THAN UPWIND AND IF FOUND
490 IF RU<RC GOTO 1950              EXITS TO 1950 OR 2010. t's ARE REPRESENTED
500 IF RU<0 GOTO 2010               BY G1, G2, ETC. FOR GAUSSIAN.
510 IF LK=0 GOTO 560
520 GOSUB 3730
530 G3=G:RD=S3+G3*SQR(VD)
540 IF RD<RC GOTO 1950
550 IF RD<0 GOTO 2010
560 IF P=0 GOTO 800      560 GOES TO SOS ROUTINE.
```

```
570 P=1     570-800 REPEATS ABOVE FOR V POL .
580 GOSUB 3260
590 IF LK=1 GOTO 620
600 TU=GU+HU*LOG(VW)/M:T1=10^TU
610 UU=(A*T1+B)*T1+C
620 TC=GC+HC*LOG(VW)/M:T2=10^TC
630 UC=(A*T2+B)*T2+C
640 IF LK=0 GOTO 680
650 TD=GD+HD*LOG(VW)/M:T3=10^TD
660 UD=(A*T3+B)*T3+C
670 IF LK=1 GOTO 700
680 GOSUB 3730
690 G4=G:WU=T1+G4*SQR(UU)
700 GOSUB 3730
710 G5=G:WC=T2+G5*SQR(UC)
720 IF LK=1 GOTO 760
730 IF WU<WC GOTO 1970
740 IF WU<0 GOTO 2010
750 IF LK=0 GOTO 800
760 GOSUB 3730
770 G6=G:WD=T3+G6*SQR(UD)
780 IF WD<WC GOTO 1970
790 IF WD<0 GOTO 2010
800 GOSUB 3260     800-860 GET G,H, A, B, C, DATA.MAKES V POL LOOK LIKE H POL
810 IF LK=1 THEN HU=HD  AND DOWNWIND LOOK LIKE UPWIND TO SOS AND MLE
820 IF LK=1 THEN GU=GD  ROUTINES.
830 IF P=1 THEN RU=WU
840 IF P=1 THEN RC=WC
850 IF P=1 THEN RD=WD
860 IF LK=1 THEN RU=RD
870 UR=10^(((LOG(RU)/M)-GU)/HU)     870 GETS UPWIND RANDOMIZED WIND, UR, FOR
880 IF RC<=0 THEN CR=0              CHI = 0 (SEE FIG. 1)
890 IF RC<=0 GOTO 1100              880 CHECKS THAT CROSSWIND BACKSCATTER NOT
900 CR=10^(((LOG(RC)/M)-GC)/HC)     NEGATIVE.IF IT IS, CR=0, AND EXITS TO 1100
910 JU=A+(B/RU)+(C/(RU*RU))         910-920 FINDS (K_p)^2 FROM RU AND RC.
920 JC=A+(B/RC)+(C/(RC*RC))
930 IF JU>1 GOTO 1130               930-940 SOS FAILS, EXITS TO 1140 . (THE SQUARE
940 IF JC>1 GOTO 1130               OF K_p IS GREATER THAN ONE).
950 IF CR>UR GOTO 1200                   950 SOS SUCCEEDS BUT TWO SOLUTIONS
960 Q1=LOG(1+SQR(JU)):Q2=LOG(1-SQR(JU))  NEAR UPWIND OR DOWNWIND, EXITS TO 1200 .
970 DU=((Q1-Q2)/(2*M))^2+.0049           960-1090 SOLVES FOR SOS, REPORTS RESULT
980 Q3=LOG(1+SQR(JC)):Q4=LOG(1-SQR(JC))  ON SCREEN, ROUNDS, AND ASSIGNS RESULT
990 DC=((Q3-Q4)/(2*M))^2+.0049           TO V1 (SOS H) OR V3 (SOS V). EXITS
1000 DX=DU*DC*HU*HC                      TO 1260.
1010 D3=((HU^2)*DC)+((HC^2)*DU)
1020 D4=DX/D3
1030 EX=((LOG(RU)/M)-GU)/(DU*HC)
1040 FX=((LOG(RC)/M)-GC)/(DC*HU)
1050 LV=D4*(EX+FX)
1060 VL=INT(100*(10^LV)+.5)/100 +.001
1061 PRINT "P"; P;"VL";VL
1070 IF P=0 THEN V1=VL
1080 IF P=1 THEN V3=VL
1090 GOTO 1260
```

```
1100 IF P=0 THEN B3=B3+1     1100-1120 NEG BACKSCATTER AT CROSSWIND, COUNTS,
1110 IF P=1 THEN C3=C3+1     GOES TO 1240.
1120 GOTO 1240
1130 IF P=0 THEN B4=B4+1     1130-1150 NO SOLUTION SOS, COUNTS, IF AT UP-
1140 IF P=1 THEN C4=C4+1     WIND OR DOWNWIND, GOES TO 1240.
1150 IF CR<UR GOTO 1240
1160 IF P=0 THEN B6=B6+1     1160-1190 NO SOLUTION SOS FOR TWO NEAR UPWIND
1170 IF P=1 THEN C6=C6+1     OR DOWNWIND, COUNTS, SETS P=0, STARTS OVER.
1180 P=0
1190 GOTO 250
1200 IF P=0 THEN B5=B5+1     1200-1230 TWO SOLUTIONS FOR SOS NEAR UPWIND OR
1210 IF P=1 THEN C5=C5+1     DOWNWIND, COUNTS,SETS P=0, STARTS OVER.
1220 P=0
1230 GOTO 250
1240 IF P=0 THEN V1=99.99    1240 ASSIGNS DEFAULT VALUES TO SOS H AND SOS V
1250 IF P=1 THEN V3=99.99    IF MLE WILL RECOVER WIND AT UPWIND OR DOWNWIND.
```

```
1260 J=1                            1260-1270 INITIALIZES MLE.
1270 JJ=0
1280 IF CR>UR GOTO   3250           1280-1290 MAKES SURE NOTHING WENT WRONG.
1290 REM "DEFAULT"
1300 W=J*UR/20                      1300 DIVIDES 0 TO UR INTO 20 STEPS.
1310 FU=(10^GU)*(W^HU)              1310-1400 CALCULATES NEGATIVE OF MLE FOR
1320 FC=(10^GC)*(W^HC)              INPUT W.
1330 U1=(A*FU+B)*FU+C
1340 U2=(A*FC+B)*FC+C
1350 U3=(A*RU+B)*RU+C
1360 U4=(A*RC+B)*RC+C
1370 M1=(RU-FU)*(RU-FU)/U1
1380 M2=(RC-FC)*(RC-FC)/U2
1390 M3=LOG((U1*U2)/(U3*U4))
1400 X=M1+M2+M3                     1400 EQUAL TO NEGATIVE OF EQUATION 24.
1410 IF J=1 THEN W1=W               1410-1460 CALCULATES FIRST THREE PAIRS OF
1420 IF J=1 THEN  X1=X               W(J)  AND X(J) .  GOES TO 1510.
1430 IF J=2 THEN  W2=W
1440 IF J=2 THEN  X2=X
1450 IF J=3 THEN  W3=W
1460 IF J=3 THEN  X3=X
1470 IF J=3 GOTO 1510
1480 IF J>3 GOTO 1530
1490 J= J+1
1500 GOTO 1300
1510 IF X1<X2 THEN W1=0             1510-1512 IF MIN X IS AT J=1, REDEFINES 1630
1511 IF X1<X2 THEN W2=W3            AND GOES TO 1620.
1512 IF X1<X2 GOTO 1620
1520 IF X2<X3 GOTO 1620             1520 IF MIN X IS AT J=2, GOES TO 1620.
1530 IF JJ=1 GOTO 1570
1540 J=J+1
1550 JJ=1
1560 GOTO 1300
1570 X1=X2:W1=W2: X2=X3: W2=W3  1570 IF MIN X IS AT J=3, FORGETS J=1 FINDS
1580 X3=X: W3=W                     J=4 VALUES AND CONTINUES UNTIL MIN X IS IN
1590 JJ=0                           MIDDLE OF SET OF THREE.
1600 IF X2<X3 GOTO 1620             1600 GOES TO 1620 WHEN THIS HAPPENS.
1610 GOTO 1540
```

```
1620 K=0: KK=0                         1620-1910 DOES HIGHER RESOLUTION ON MLE SPEED
1630 Y=W1+K*(W3-W1)/25                 FOR Y (=NEW WIND) OVER RANGE COVERING MINIMUM
1640 FU=(10^GU)*(Y^HU)                 OF PREVIOUS X
1650 FC=(10^GC)*(Y^HC)                 1640-1730 DOES NEGATIVE OF MLE AS Z.
1660 U1=(A*FU+B)*FU+C
1670 U2=(A*FC+B)*FC+C
1680 U3=(A*RU+B)*RU+C
1690 U4=(A*RC+B)*RC+C
1700 M1=(RU-FU)*(RU-FU)/U1
1710 M2=(RC-FC)*(RC-FC)/U2
1720 M3=LOG((U1*U2)/(U3*U4))
1730 Z=M1+M2+M3
1740 IF K=1 GOTO 1790                  1740-1890 FINDS WIND SPEED, Y, MINIMUM, Z.
1750 IF K>1 GOTO 1850
1760 Y1=Y: Z1=Z
1770 K=1
1780 GOTO 1630
1790 Y2=Y: Z2=Z
1800 IF Z1<Z2 THEN VM=Y1
1810 IF Z1<Z2 GOTO 1910
1820 IF KK=1 GOTO 1850
1830 K=K+1: KK=1
1840 GOTO 1630
1850 Y1=Y2:Z1=Z2
1860 Y2=Y: Z2=Z
1870 KK=0
1880 IF Z1<Z2 THEN VM= Y1
1890 IF Z1<Z2 GOTO 1910
1900 GOTO 1830
1910 VM=INT((100*VM)+.5)/100 +.001
1911 PRINT "P";P; "VM"; VM      1911 SHOWS RESULT ON SCREEN.
1920 IF P=0 THEN  V2=VM         1920-1930 ASSIGNS MLE H AND MLE V VALUES TO V2
1930 IF P=1 THEN  V4=VM         AND V4.
1940 GOTO 2070
```

```
1950 IF RC<=0 GOTO 2010                 1950  BOTH SIGMAS NEGATIVE.
1960 IF P=0 THEN B1=B1+1                1960-1980 COUNTS LARGE DIRECTION ERRORS.
1965 GOTO 1990
1970 IF WC <= 0 GOTO 2010               1970 BOTH SIGMAS NEGATIVE.
1980 IF    P =1 THEN C1= C1+1
1990 P=0                                1990-2000 GOES TO H POL AND STARTS OVER.
2000 GOTO 250
2010 IF P=0     THEN  V1=99.99          2010-2060 DEFAULTS SOS CALMS AND ASSIGNS
2020 IF P =0 THEN  V2=.001              MLE CALMS THE VALUE .001.  COUNTS CALMS.
2030 IF P=1 THEN  V3= 99.99
2040 IF P=1 THEN  V4=.001
2050 IF P=0 THEN B2=B2+1
2060 IF P=1 THEN C2=C2+1
2070 IF P=1 GOTO 2081                   2070 FOUR VALUES AVAILABLE, GOES TO TABLE (2081).
2080 IF P=0 THEN  P=1: GOTO 260         2080 ONLY H POL DONE, SETS V POL, GOES TO 260.
```

```
2081 PRINT "V1";V1;"V2";V2;"V3";V3;"V4";V4  SHOWS ON SCREEN.
2090 OPEN "b:data.ta" FOR APPEND AS #1       OPENS LINE TO DISK.
2110 IF PP>1 GOTO 2260  SKIPS SPACING AND TABLE HEADING.
2120 PRINT #1,"
2121 PRINT #1, "
2122 PRINT #1, "
2123 PRINT #1, "
2124 PRINT #1, "
2125 PRINT #1, "
2126 PRINT #1, "
2127 PRINT #1, "
2128 PRINT #1, "
2129 PRINT #1, "
2130 PRINT #1,"
2131 PRINT #1, "  MAKES BLANK  SPACE BETWEEN TABLES.
2132 PRINT #1, "
2133 PRINT #1, "
2134 PRINT #1, "
2135 PRINT #1, "
2136 PRINT #1, "
2137 PRINT #1, "
2138 PRINT #1, "
2140 PRINT #1,"
2150 PRINT #1,"
2160 PRINT #1,"SOS,MLE,MONTE CARLO"  2160-2250 HEADING FOR TABLE.
2170 IF LK=1 GOTO 2210
2180 A$="UPWIND"
2190 PRINT #1,A$
2200 GOTO 2220
2210 PRINT #1, "DOWNWIND"
2220 PRINT #1, "INPUT WIND =";VW
2230 PRINT #1," TH =";TH
2240 PRINT #1, "NO =";NO
2250 PRINT #1, " SOSH "," MLEH ","SOSV ","MLEV","PP"
2260 PRINT #1,USING " ##.##        ";V1,V2,V3,V4,  FIRST AND SUBSEQUENT
2270 PRINT #1,USING "   ##";PP                      ANSWERS.
```

```
2280 IF VW-1.001<=V1 AND V1<=VW+.999 THEN V11=V11+1      2280-2490 ACCUMULATES
2290 IF VW-2.001 <=V1 AND V1 <=VW+1.999 THEN V12=V12+1    STATISTICS ON V ± 1 M/S,
2300 IF V1=99.99 THEN V19=V19+1                           V ± 2 M/S, SOS DEFAULTS,
2310 IF V1=99.99 GOTO 2340                                CALMS AND DATA FOR MEANS,
2320 MB1=MB1+V1-.001: VN1=VN1+1                           VARIANCES AND STANDARD
2330 VS1=VS1+(V1-.001)*(V1-.001)                          DEVIATIONS. ERRORS HAVE
2340 IF VW-1.001<=V2 AND V2<=VW+.999 THEN V21=V21+1       BEEN CORRECTED.
2350 IF VW-2.001<=V2 AND V2<=VW+1.999 THEN  V22=V22+1     SEE PAGE 21.
2360 IF V2=.001 THEN  V20=V20+1
2370 MB2=MB2+V2-.001: VN2=VN2+1
2380 VS2=VS2+(V2-.001)*(V2-.001)
2390 IF VW-1.001<=V3 AND V3<=VW+.999 THEN V31=V31+1
2400 IF VW-2.001<=V3 AND V3<=VW+1.999 THEN V32=V32+1
2410 IF V3=99.99 THEN V39=V39+1
2420 IF V3=99.99 GOTO 2450
2430 MB3=MB3+V3: VN3= VN3+1
2440 VS3=VS3+(V3-.001)*(V3-.001)
2450 IF VW-1.001<=V4 AND V4<=VW+0.999 THEN V41 = V41+1
2460 IF VW-2.001<V4 AND V4<=VW+1.999 THEN V42=V42+1
2470 IF V4=.001 THEN V40=V40+1
2480 MB4=MB4+V4-.001:  VN4=VN4+1
2490 VS4=VS4+(V4-.001)*(V4-.001)
2500 PP=PP+1                          2500 INCREMENTS COUNT.
2510 P=0                              2510 SET POL TO H POL.
2515 IF PP<=NO THEN CLOSE #1          2515 IF NOT DONE CLOSES DISK.
2520 IF PP<=NO GOTO 250               2520 IF NOT DONE GETS NEXT FOUR.
2530 PRINT #1,"                       SPACE                 "
2540 PRINT #1,"     LARGE  DIRECTION ERROR: RETURNS"  2540-2700 IF DONE LISTS
2550 PRINT #1,"B1    =     ";B1 "      C1    =     ";C1   COUNTS.
2570 PRINT #1," CALM: BOTH SIGMAS NEGATIVE:CONTINUES"
2580 PRINT #1,"B2    =     ";B2 "      C2    =     ";C2
2600 PRINT #1,"NEGATIVE SIGMA: CROSS WIND: CONTINUES"
2610 PRINT #1,"B3    =     ";B3 "      C3    =     ";C3
2630 PRINT #1," NO SOS: CONTINUES "
2640 PRINT #1,"B4    =     ";B4 "      C4    =     ";C4
2660 PRINT #1," SOS: TWO SOLUTIONS: RETURNS                  "
2670 PRINT #1,"B5    =     ";B5 "      C5    =     ";C5
2690 PRINT #1," NO SOS: TWO SOLUTIONS: RETURNS"
2700 PRINT #1,"B6    =     ";B6 "      C6    =     ";C6
2710 PRINT #1, "                      SPACE                  "
2720 PRINT #1,"              SOSH          MLEH          SOSV          MLEV"
2730 PRINT #1,"V1-4,1",               2730-2740 V ± 1 M/S
2740 PRINT #1,V11,V21,V31,V41
2750 PRINT #1,"V1-4,2",               2750-2760 V ± 2 M/S.
2760 PRINT #1,V12,V22,V32,V42
2770 PRINT #1,"V1-4,9,0",             2770-2780 SOS DEFAULTS, MLE CALMS.
2780 PRINT #1,V19,V20,V39,V40
2800 PRINT #1,"   CT =       ";CT ; "TCT  ="; TCT    CT = TOTAL CYCLES THIS WIND.
2810 PRINT #1,"                       SPACE              " TCT = TOTAL CYCLES SINCE
                                                            START.
```

```
2820 IF VN1=0 GOTO 2890        2820-3090 COMPUTES MEANS, VARIANCES,AND STANDARD
2830 IF VN1=1 GOTO 2910        DEVIATIONS FOR VALUES IN TABLE WITH DEFAULT VALUE
2840 VB1=MB1/VN1: VR1=(VS1/VN1)-(VB1*VB1)    WHEN NEEDED.
2841 IF VR1<0 THEN PRINT #1, "VR1 NEG" (2841 CHECKS POSSIBLE BAD ANSWER AS
2850 VB1=.01*INT((100*VB1)+.5) +.001    ALSO IN SIMILAR LINES).
2851 IF VR1<0 THEN  PRINT #1,"VR1=";VR1
2852 IF VR1<0 GOTO 2920
2860 VR1=.01*INT((100*VR1)+.5) +.001
2870 SD1=.01*INT((100*SQR(VR1))+.5) +.001
2880 GOTO 2920
2890 VB1=88.88: VR1=88.88: SD1=88.88
2900 GOTO 2920
2910 VB1=MB1: VR1=77.77: SD1=77.77
2920 VB2=MB2/VN2: VR2=(VS2/VN2)-(VB2*VB2)
2921 IF VR2<0 THEN PRINT #1, "VR2 NEG"
2930 VB2=.01*INT((100*VB2)+.5) +.001
2931 IF VR2<0 THEN PRINT #1, "VR2=";VR2
2932 IF VR2<0 GOTO 2960
2940 VR2=.01*INT((100*VR2)+.5) +.001
2950 SD2=.01*INT((100*SQR(VR2))+.5) +.001
2960 IF VN3=0 GOTO 3030
2970 IF VN3=1 GOTO 3050
2980 VB3=MB3/VN3: VR3=(VS3/VN3)-(VB3*VB3)
2981 IF VR3<0 THEN PRINT #1, "VR3 NEG"
2990 VB3=.01*INT((100*VB3)+.5) +.001
2991 IF VR3<0 THEN  PRINT #1, "VR3=";VR3
2992 IF VR3<0 GOTO 3060
3000 VR3=.01*INT((100*VR3)+.5) +.001
3010 SD3=.01*INT((100*SQR(VR3))+.5) +.001
3020 GOTO 3060
3030 VB3=88.88: VR3=88.88: SD3=88.88
3040 GOTO 3060
3050 VB3=MB3: VR3=77.77:  SD3=77.77
3060 VB4=MB4/VN4: VR4=(VS4/VN4)-(VB4*VB4)
3061 IF VR4<0 THEN PRINT #1, "VR4 NEG"
3070 VB4=.01*INT((100*VB4)+.5) +.001
3071 IF VR4<0 THEN PRINT #1, "VR4=";VR4
3072 IF VR4<0 GOTO 3100
3080 VR4=.01*INT((100*VR4)+.5) +.001
3090 SD4=.01*INT((100*SQR(VR4))+.5) +.001  3100-3200 PRINTS RESULTS TO DISK.
3100 PRINT #1,"       N        MEAN     VARIANCE     STD-DEV"
3110 PRINT #1,"SOSH  ";VN1;"    ";VB1;"      ";VR1;"        ";SD1
3140 PRINT #1,"MLEH  ";VN2;"    ";VB2;"      ";VR2;"        ";SD2
3170 PRINT #1,"SOSV  ";VN3;"    ";VB3;"      ";VR3;"        ";SD3
3200 PRINT #1,"MLEV  ";VN4;"    ";VB4;"      ";VR4;"        ";SD4
3230 REM store and print
3240 CLOSE #1                   CLOSE DISK.
3241 IF VW=.01 GOTO 3246       IF LAST WIND GOES TO 3246 .
3242 IF VW =1 THEN VW =.01     IF WIND 1 M/S SETS IT 0.01 M/S.
3243 IF VW >1 THEN VW=VW-1     DECREASES WIND BY 1 M/S .
3244 IF Q=0 GOTO 3246          3244 STOPS, IF TEST.
3245 GOTO 90                   3245 STARTS WITH NEW WIND AT 90.
3246 PRINT "FINISHED !"        3246 SHOWS ON SCREEN .
3250 STOP                      3250 STOPS.
```

SUBROUTINE RETURNS G's, H's, A, B, AND C FOR GIVEN THETA AND LOOK.

```
3260 IF P=1 GOTO 3450
3270 IF TH=26 GOTO 3300: IF TH=36 GOTO 3330
3280 IF TH=40 GOTO 3360: IF TH=46 GOTO 3390
3290 IF TH=52 GOTO 3420
3300 GU=-1.943: HU=1.343: GC=-2.512
3310 HC=1.512: GD=-2.182: HD=1.453
3320 GOTO 3630
3330 GU=-3.139:HU=1.343:GC=-2.512
3340 HC=2.095: GD=-3.471: HD=1.91
3350 GOTO 3650
3360 GU=-3.588: HU=1.908: GC=-4.474
3370 HC=2.29: GD=-3.933: HD=2.084
3380 GOTO 3670
3390 GU=-4.176: HU=2.135: GC=-5.094
3400 HC=2.534: GD=-4.524: HD=2.295
3410 GOTO 3690
3420 GU=-4.612: HU=2.275: GC=-5.562
3430 HC=2.715: GD=-4.951: HD=2.412
3440 GOTO 3710
3450 IF TH=26 GOTO 3480: IF TH=36 GOTO 3510
3460 IF TH=40 GOTO 3540: IF TH=46 GOTO 3570
3470 IF TH=52 GOTO 3600
3480 GU=-1.955: HU=1.398: GC=-2.568
3490 HC=1.599: GD=-2.036: HD=1.498
3500 GOTO 3630
3510 GU=-2.833: HU=1.665: GC=-3.919
3520 HC=2.199: GD=-3.212: HD=1.983
3530 GOTO 3650
3540 GU=-3.057: HU=1.708: GC=-4.29
3550 HC=2.356: GD=-3.548: HD=2.108
3560 GOTO 3670
3570 GU=-3.283: HU=1.724: GC=-4.69
3580 HC=2.516: GD=-3.906: HD=2.219
3590 GOTO 3690
3600 GU=-3.439: HU=1.724: GC=-4.929
3610 HC=2.602: GD=-4.092: HD=2.241
3620 GOTO 3710
3630 A=.076: B=.0001: C=.0000036
3640 RETURN
3650 A=.00249: B=.0000285: C=7.2E-07
3660 RETURN
3670 A=.00156: B=.000012: C=2.2E-07
3680 RETURN
3690 A=.0009: B=.0000049: C=2.2E-07
3700  RETURN
3710 A=.00275: B=9.499999E-06: C=.0000007
3720 RETURN
```

SUBROUTINE RETURNS RANDOM NUMBER, APPROXIMATELY NORMAL, ZERO MEAN, UNIT VARIANCE.

```
3730 JJ=0
3770 F(JJ) = RND -(1/2)
3780 IF JJ= 24 GOTO 3800
3790 JJ=JJ+1: GOTO 3770
3800 KK=0
3810 F1=F(0)
3820 KK=KK+1
3830 F1=F1+F(KK)
3840 IF KK=24 GOTO 3860
3850 GOTO 3820
3860 G=(SQR(12))*F1/5
3870 RETURN
```

Program Notes

There are numerous lines in the program such as line 1060 where .001 has been added to a result after rounding to two decimal places. The program used after executing the INT instruction would frequently return numbers such as 8.9799999 instead of 8.98. The idea was to fool it so that the output would line up in vertical columns and to use "White Out" where needed to remove the trailing ones. The idea did not work as shown by the bottom tables in each listing for the mean, variance, and standard deviation, for which numerous columns are misaligned. Lines such as 2260 and 2270 might have fixed the problem, but lines 3110 to 3200 were used instead. It was not considered to be worthwhile to edit all of the lines necessary to remove the .001's. Rarely for the ± 1 and ± 2 counts, a value that is listed as exactly ± 1 or ± 2 of the input wind does not get counted because the value tested is not the value listed. This slight number of events may not have been corrected every where throughout the tables.

Variables

Counting variables; TCT, total count of successes plus returns since start of run. CT, count of successes plus returns for this wind speed. PP, count of successful completion of a set of four for a given wind speed. B1 to B6 counts of various events when doing horizontal polarization, C1 to C6, counts of various events when doing vertical polarization. VN1, VN2, VN3, VN4, the number of non default values for SOS H, MLE H, SOS V and MLE V respectively as each set of four is completed. V11, V21, V31, V41, counts of number of times SOS H, MLE H, etc. are within ± 1 m/s. V12, etc., same for ± 2 m/s. V19, etc. number of SOS defaults. V20, etc., number of MLE calms.

Control Variables

Q, test, no-test. NO, the number of successful completions required for sets of four for a given wind. VW, input starting wind, an integer. TH, incidence angle. LK, upwind look (0) downwind look (1). P polarization, 0 for H pol, 1 for V pol.

Equation Variables

SU, log of backscatter for Upwind, no noise, H pol, S1, antilog of SU. VU, Variance of Upwind backscatter, H pol. SC, S2, VC, same as above for crosswind, SD, S3, VD, same but for downwind. RU, Randomized Upwind backscatter, H pol. G, zero mean, unit variance, Gaussian random variable (almost, see text). G1, G2, G3, etc., renaming G, probably irrelevant. RC, Randomized Crosswind backscatter, H pol. RD, Randomized Downwind backscatter H pol. TU T substituted for R throughout for V pol, log of upwind backscatter, no noise, V pol. VU, U substituted for V throughout, variance of Upwind backscatter, V pol, etc. UR, Upwind (or downwind) value of the wind, that would have produced the randomized value of RU (with similar interpretation for downwind and V pol). CR Crosswind value of the wind that would have produced the randomized value of RC. JU, and JC, value of $(K_p)^2$ (not in percent) from the randomized backscatter values. DU and DC, the denominators of the terms in Eqn. (18) if they exist. LV, log, base 10, of the Sum of Squares wind recovered by the algorithm for either H or V pol if it exists. V1, renames LV for SOS H pol. V3, renames LV for SOS V pol. W, trial wind speed for MLE first pass. X, trial value of MLE (times minus one) first pass. Y, trial wind speed for MLE, higher resolution. Z, trial value of MLE (times minus one), higher resolution VM, speed recovered by MLE, V2 renames VM for H pol, V4 renames VM for V pol.

Constants

GU, HU, GC, HC, GD, HD, values from G-H tables at Upwind (0^o), Crosswind (90^o) and Downwind (180^o) for appropriate incidence angle. A, B, C, constants for the variance at appropriate incidence angle.

Defaults

If no SOS exists and if MLE would recover a wind at Upwind or Downwind (i.e. two solutions are not possible instead of one) SOS defaults to 99,99. If SOS defaults all 25 times, the mean, variance and standard deviation default to 88.88. If SOS defaults 24 times and returns one speed, the mean is that value and the variance and standard deviation default to 77.77. (See pages A-26, A-53, and A-57).

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16. Abstract

Backscatter measurements at upwind and crosswind are simulated for five incidence angles by means of the SASS-1 model function. The effects of communication noise and attitude errors are simulated by Monte Carlo methods, and the winds are recovered by both the Sum of Square (SOS) algorithm and a Maximum Likelihood Estimater (MLE). The SOS algorithm is shown to fail for light enough winds at all incidence angles and to fail to show areas of calm because backscatter estimates that were negative or that produced incorrect values of K_p greater than one were discarded. The MLE performs well for all input backscatter estimates and returns "calm" when both are negative. The use of the SOS algorithm is shown to have introduced errors in the SASS-1 model function that, in part, cancel out the errors that result from using it, but that also cause disagreement with other data sources such as the AAFE circle flight data at light winds. Implications for future scatterometer systems are given.

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