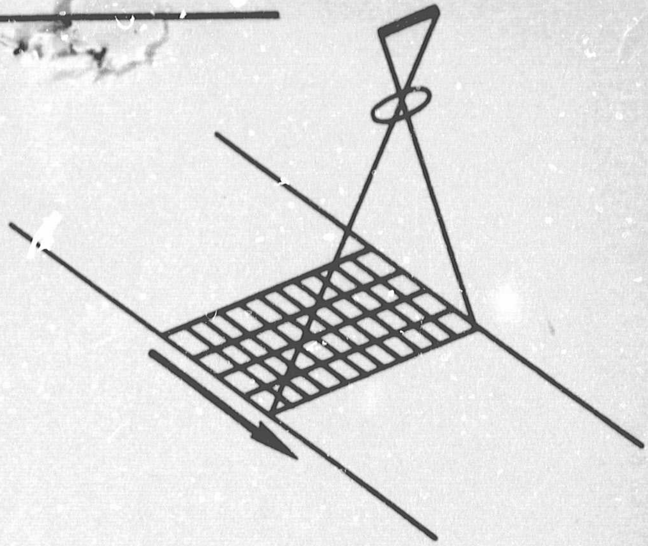
NASA

NASA CR-166670



MRS

LITERATURE SURVEY OF ATMOSPHERIC CORRECTIONS

(NASA-CR-166670) MULTISPECTRAL RESOURCE SAMPLER (MPS): PROOF OF CONCEPT. LITERATURE SURVEY OF ATMOSPHERIC CORRECTIONS (Operations Research, Inc.) 58 p HC A04/MF A01 CSCL 04A G3/46
N81-25608
Unclas
28178

PREPARED FOR
NASA—
GODDARD SPACE FLIGHT CENTER
GREENBELT, MD. 20771

BY
ORI, INC.
1400 SPRING ST.
SILVER SPRING, MD. 20910

GSFC

MULTISPECTRAL RESOURCE SAMPLER
"PROOF OF CONCEPT"

LITERATURE SURVEY OF
ATMOSPHERIC CORRECTIONS

PREPARED FOR
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

TABLE OF CONTENTS

I. INTRODUCTION

The Multispectral Resource Sampler "Proof-of-Concept" Study is intended to be a comprehensive analysis of the corrections that must be applied to MRS data to allow for atmospheric correction factors and the variability of bidirectional reflectance from the scene.

In order to assess the present state-of-the-art in these areas a literature review and analysis was initiated at the outset of the study. The reviews and analyses which are included have been compiled by:

DR. James A. Smith ........................BIDIRECTIONAL REFLECTANCE
MR. Kenneth J. Ranson ...................BIDIRECTIONAL REFLECTANCE

DR. Philip N. Slater ....ATMOSPHERIC CORRECTIONS
DR. Robert A. Schowengerdt ....ATMOSPHERIC CORRECTIONS

Their efforts include short descriptions of the more pertinent papers and bibliographies of the materials which have been reviewed.

The two Literature Surveys, Bidirectional Reflectance and Atmospheric Corrections, have been published under separate covers for ease of reference.

II

Literature Survey and Review of Atmospheric Effects in Remote Sensing and Their Influence on Classification

Robert A. Schowengerdt

Philip N. Slater

Committee on Remote Sensing

University of Arizona

September, 1979

PREFACE

This report is divided into five sections.

The introduction refers 1) to work done in combining spectral bands to reduce atmospheric effects on spectral signatures, 2) to the development of atmospheric models and their use with ground and aerial measurements in correcting spectral signatures, 3) to other methods of making such corrections, and 4) to some second order atmospheric effects.

The second section of the report provides an overview of studies of atmospheric effects on the accuracy of scene classification.

The third section describes some of the more important publications selected from the previous section, summarizing the results in graphical and tabular form.

The fourth section summarizes the results reported in the previous sections and suggests aspects of the work that merit further study.

The fifth section mentions the various sources referred to in the literature survey that were used to produce the alphabetical and chronological listing of 59 entries.

2.0 INTRODUCTION

While a very large amount of research on atmospheric properties, models, and measurements has been reported in the physics, optics, and meterological literature, the emphasis in this survey is on work related to remote sensing of the earth's surface from aircraft and spacecraft. Much of the pioneering atmospheric research was done at the Environmental Research Institute of Michigan in connection with airborne multispectral scanners. It was soon realized that the effects of atmospheric variations along a flight path, from one date to another, and as a function of scanner look angle were severely limiting development of reliable classification procedures for multispectral data.

One of the first approaches to alleviating atmospheric problems (and other sources of variability such as scanner calibration shifts and changes in sun angle) was the application of various combinations of spectral band differences and ratios (Crane, (1971), Kriegler, et al (1969)). The work of Horvath, et al (1970) studied the apparent ground radiance as a function of aircraft altitude and derived sensor signal-to-noise ratios as a function of altitude for both electro-optical and photographic systems.

At the same time as the development of these empirical techniques was accelerating, there were parallel efforts in development of atmospheric models (Potter (1969), Turner, et al (1971)). Improvements in atmospheric models and their application have been made by Herman & Browning (1975), Turner (with Spencer (1972), (1975), (1977), (1978)) and Fraser ((1974, et al (1977)). Models which permit direct estimation of aerosol content in the atmosphere from Landsat imagery of water bodies have also been developed (Griggs (1973, 1974) and, Mekler, et al (1977)).

Because of the requirement of many models from ancillary ground or aerial measurements (Rogers and Peacock (1973), Hulstrom (1975), Dana (1975, 1978)), there has been continuing interest in atmospheric correction techniques which utilize only information available in the imagery itself. One of the most widely used techniques involves measurement of the darkest (minimum radiance) pixels in the image (Potter and Mendolowitz (1975) and Chavez, (1975)). Other approaches require deep water bodies, such as lakes, within the image (Rochon, et al (1978)). One of the difficulties with such techniques is that turbidity caused by rain, wind, etc. can alter lake spectral signatures (Erb (1974)). Some atmospheric correction techniques are intimately related to classification procedures by comparison of training and study area spectral signatures followed by corrective transformations (Henderson (1975), Lambeck and Rice (1976)).

There has been research into some of the secondary atmospheric problems, such as the influence of pixel neighborhood radiance variations on the apparent pixel radiance (Turner (1975), Buznikov, et al (1975), Pearce (1977), Kawata et al (1978), Otterman and Fraser (1979)). The thermal spectral regions has also received attention (Boudreau (1972), Kumar (1977)).

2.1 ATMOSPHERIC EFFECTS ON CLASSIFICATION

There has been surprisingly little investigation of the effects of the atmosphere on classification accuracies. One of the first examples is the work of Nalepka and Morgenstern (1972). This study showed considerable improvement in agricultural signature extension of airborne multispectral scanner data after application of band-to-band ratios and an average signal versus scan angle normalization, both examples of the self-correction approach. Rogers, et al (1973, third ERTS-1 Symposium) simulated atmospheric changes in transmittance and path radiance in a single Landsat scene and classified the data with a fixed (originally correct) set of training signatures. Parametric curves of classification accuracy for eight urban and rural classes were generated as a function of change in atmospheric transmittance (path radiance fixed) and in path radiance (transmittance fixed). Accuracies for signature extension over a four month period were also reported. An improved classification was obtained of a March scene using April training signatures and a transformation of variables using data from a ground radiometer but no accuracy figures were given.

Pitts, et al (1974) simulated the effect of an increase in atmospheric water vapor on an agricultural classification. The cause of classification degradation in this case was absorption of radiation in band 7 of Landsat, which can be simply modeled as a multiplicative factor in band 7 alone. Pitts, et al, determined that training in low humidity areas to classify relatively high humidity areas was preferable to the reverse situation.

Turner (1975, NASA report) simulated an atmospheric scattering gradient over a regular pattern of simulated corn and soybean fields. The gradient varied from a visual range of 23 km at one end of the pattern (also the visual range of the training data) to 13 km and 8 km at the other end. In the former case the corn classification accuracy decreased by 1.4% while the soybean accuracy <u>increased</u> by 2%. This is an example of the complex interaction between atmospheric scattering and spectral signatures of surface features. Generally, the overall recognition accuracy decreased very little for these scattering gradients.

Potter (1974) used a similar set of actual Landsat data of corn and soybean fields. A set of five spatially uniform simulated atmospheres with optical depths of 0.1, 0.2, 0.3, and 0.4 were applied to this data with no retraining for spectral signatures the accuracies for both corn and soybeans remained within 3% up to an optical depth of 0.1 and decreased rapidly for greater haze levels. As expected from theoretical predictions, if retraining is performed, the atmospheric conditions are uniform, and there are no neighborhood interactions Potter's data showed virtually no effect on classification accuracy up to an optical depth of 0.4. He also reproduced similar results to the "train low, test high" results of Pitts et al (1974). One interesting effect noticed in Potter's data is the strong (negative) effect thresholding of the classification has when combined with increased haze levels.

Fraser (1977) applied an atmospheric scattering gradient, measured from Landsat over a portion of the Atlantic Ocean near Africa, to another Landsat scene of Pennsylvania. The intent was to apply a realistic, large area gradient in a controlled manner. As Fraser points out, the spatial and temporal correlations of atmospheric properties have not been determined in continental regions. The unmodified Landsat data of Pennsylvania was clustered in an unsupervised mode into ten classes. The modified data, created by addition of the atmospheric gradient, were also clustered and compared to the clusters of the unmodified data. Changes in class means and variances were tabulated. A maximum likelihood classification was then performed using both sets of training clusters. Without retraining 22% of the pixels changed classification from the original unmodified classification. With retraining, only 3% changed classifications. The net change in turbidity simulated was 1.3 between the modified and unmodified data sets.

A comparison of performance among several signature extension algorithms was reported by Abotteen, et al (1977). Two sets of data were used, one a simulated set of normally-distributed agricultural crops and the other seven pairs of consecutive-day passes over an agricultural area. The authors found little difference in performance among the algorithms but in almost all cases the signature extension approach was less accurate than retraining.

2.2 DETAILED REVIEW OF SELECTED PAPERS

A useful reference to representative values of atmospheric quality for urban, suburban and rural conditions has been provided by Flowers et al (1969), they reported the results of a five-year study of atmospheric turbidity measurements from a network of stations in the U.S. The following general conclusions were drawn from the study: 1) an annual mean pattern of turbidity across the U.S. was noted that varied from a low of near 0.05 over the western plains and Rocky Mountains to a high of near 0.14 in the east; 2) the observed minimum value of turbidity was near 0.02; 3) an annual cycle exists of low turbidity in winter and high in summer; 4) lowest turbidity conditions occur for continental polar air masses and highest turbidity occurs under maritime tropical conditions; 5) there is no noticable lowering of turbidity following precipitation.

The turbidity coefficient, B, used by Flowers et al is the decadic extinction coefficient at a wavelength of 0.5 μm and is related to the often-used atmospheric optical depth, τ, by $B = 2.3\tau$. τ is often quoted for $\lambda = 0.55\mu m$ whereas B was determined at $\lambda = 0.5$ μm. The effect of the change in wavelength depends on the atmospheric particle-size distribution, however, as a first approximation $\tau_{0.55} = 0.9\ \tau_{0.5}$. The plot of Flowers et al of the cumulative frequencies of the daily average turbidity for typical urban, suburban and rural conditions is presented in tabular form in Table 1 in terms of optical depth (recall that the optical depth, τ , in the table is for a wavelength of 0.5 μm). Note that 95% of the days in rural areas have τ values of less than 0.3 which corresponds to a visibility or meteorological range of about 25 km.

TABLE 1

PERCENT OF DAYS WITH HAZE LEVEL IN INDICATED RANGE

Lower bound for τ	0	0.1	0.2	0.3	0.4
Upper bound for τ	0.1	0.2	0.3	0.4	∞
Rural	10	65	20	4	1
Suburban	7	28	35	12	18
Urban	2	13	15	15	55

Potter (1974) and Potter and Shelton (1974) studied the effect on classification accuracy of changes in atmospheric conditions. They simulated various haze levels by adding values of of 0.1, 0.2, 0.3 and 0.4 to a given atmospheric condition to provide a table of multispectral scanner responses in counts corresponding to these haze levels. This table was used to transform the input data in LARSYS format to data corresponding to the simulated haze level also in LARSYS format.

The effect of the addition of simulated haze was to increase the number of counts and to decrease or compress the range of response. As an extreme example, Potter and Shelton show graphically that the addition of an optical depth of 0.8 increases the number of counts for MSS band 4 from 0 (in the no haze case) to 20 and at the same time decreases the total response range for band 4 from 127 to 107 counts.

Two crop types, corn and soybeans were studied by the authors. The initial statistics were obtained from a Landsat data set obtained over an area in Illinois in which about two thirds of the planted farmland contained these crops. It was assumed for this analysis that this data set represented a target without haze. The effect of an increasing haze level is shown in Tables II and III.

TABLE II.

MEANS, μ, AND STANDARD DEVIATIONS, σ, FOR CORN

Haze Level		0.0	0.1	0.2	0.3	0.4
Channel 1	μ	22.00	24.00	26.00	27.66	29.10
	σ	1.38	1.18	1.16	0.88	1.01
Channel 2	μ	13.27	15.21	16.22	18.21	19.96
	σ	1.11	1.08	1.11	1.08	0.85
Channel 3	μ	46.95	47.94	48.01	48.94	49.86
	σ	4.92	4.84	4.83	4.83	4.72
Channel 4	μ	30.35	30.35	30.35	30.36	30.77
	σ	3.47	3.47	3.47	3.46	3.15

TABLE III

MEANS, μ, AND STANDARD DEVIATIONS. σ, FOR SOYBEANS

Haze Level		0.0	0.1	0.2	0.3	0.4
Channel 1	μ	23.11	25.11	27.09	28.42	30.13
	σ	1.27	1.27	1.21	0.97	1.23
Channel 2	μ	15.68	15.66	16.68	18.66	20.24
	σ	1.66	1.61	1.69	1.61	1.40
Channel 3	μ	61.97	62.49	63.02	63.51	64.17
	σ	11.45	11.05	11.33	11.00	11.10
Channel 4	μ	38.56	38.56	38.56	38.60	38.70
	σ	8.04	8.04	8.04	7.94	7.80

Note how the means, μ, increase and the standard deviations, σ, in general decrease as the τ values increase. (The cases where the σ values decrease result from the quantization of the response). Note also how the changes are much more pronounced for the shorter wavelengths because Rayleigh and aerosol scattering both increase with decreasing wavelengths for the model used.

If the addition of a uniform haze layer over the training and test areas causes a linear transformation of the data, then the presence of haze will have no effect on classification accuracy. The results in Table IV substantiate this conclusion.

TABLE IV

CLASSIFICATION ACCURACIES FOR UNIFORM HAZE LEVELS

Haze Level	0.0	0.1	0.2	0.3	0.4
CORN	97.4	97.5	97.4	97.5	97.4
SOYBEANS	99.0	99.2	99.0	99.2	98.2

A minimal amount of thresholding was used; in all cases the thresholding used to yield the 97.4% and 99% values in the first column. The variations in the values in the table are due to quantization effects.

The effects on classification accuracy of a haze level that changed from training site to test site were next explored. The training site was first assumed to have zero haze (see Table V). The same input data for corn and soybeans was used as before but in this case two threshold levels were used.

TABLE V

CLASSIFICATION ACCURACIES FOR TRAINING ON ZERO HAZE

Test Haze Level		0.0	0.1	0.2	0.3	[illegible]
CORN	Low Thresholding Moderate Thresholding	97.4 94.6	95.6 79.1	56.1 12.9	1.8 0.0	0.0 0.0
SOYBEANS	Low Thresholding Moderate Thresholding	99.0 95.0	96.4 82.1	70.7 23.7	28.0 1.0	0.0 0.0

The low threshold level in Table V is the same as that used in Table IV, the moderate level is more typical of that used in practice. There are several points of interest:

1. Up to a haze level of 0.1 there is a relatively small effect.
2. For values of $\tau > 0.1$ there is a rapid decrease in classification accuracy.
3. The rate of decrease in accuracy depends on the threshold level, the decrease being more rapid with moderate than with low thresholding.
4. The effect for soybeans is smaller than that for corn.

This last point can probably be explained by the narrower distribution of the corn data. As the authors point out, if the standard deviation does not change, a classification based on data from one band decreases in accuracy as a monotonically increasing function of a single variable, $\Delta \mu / \sigma$, where $\Delta \mu$ is the change in the mean, σ, due to the addition of haze. Tables 2 and 3 show that for all four bands, $\Delta \mu / \sigma$ is larger for corn than for soybeans mainly because of the smaller value for σ. Because $\Delta \mu / \sigma$ decreases very rapidly as the spectral bands go to longer wavelengths, it is probable that bands 4 and 5 account for most of the effect.

Pitts et al (1974) showed that classification accuracy was higher for the case of training under clear atmospheric conditions and testing under hazy conditions than vice versa. Potter and Shelton verified this conclusion using the same statistics for corn and soybeans as before. Table VI summarizes their results. The first column of numbers is a repeat of the corresponding column in Table V to show the levels of thresholding used. The next two columns show the effects of training at a low haze level and testing at a high level and vice versa. Clearly the "train low, test high" sequence gives the better results and the low thresholding is preferred. The last two columns are for training with τ = 0 and testing with τ = 0.3 and vice versa. As expected the decrease in accuracy is even more marked in this case. (The low thresholding result follows the tendency of the τ = 0.2 results, the moderate thresholding does not, however, the accuracies are so low as to be susceptible to errors induced by quantization.)

TABLE VI

CLASSIFICATION ACCURACY

TABLE VI. CLASSIFICATION ACCURACY.

Test Haze Level		0.0	0.2	0.0	0.3	0.0
Train Haze Level		0.0	0.0	0.2	0.0	0.3
CORN	Low Thresholding	97.4	56.1	49.5	1.8	0.5
	Moderate Thresholding	94.6	12.9	7.8	0.0	0.1
SOYBEANS	Low Thresholding	99.0	70.7	59.4	28.0	4.8
	Moderate Thresholding	95.0	23.7	15.7	1.0	1.0

It should be noted that the results of Pitts et al were due to compression of the data. The Potter and Shelton results were mainly additive with little compression. For symmetrical data there should be no difference between training high and testing low and vice versa. The results in Table VI are therefore attributable to a skew in the data. If this is true, then Potter and Shelton suggest that no general statement can be made as to whether or not it is better to train low and test high.

The effect on clustering of using reflectance values instead of uncorrected digital values from the original data is shown in Figures 1 and 2. The clustering of uncorrected data, taken over a period of many months is shown in Figure 1, due to Paris (1974). The plot is of band 5 MSS values against band 7 MSS values, note the considerable overlap of the data. Correcting the data for τ and zenith angle variations results in data values more characteristic of the features of interest. In Figure 2, Paris shows that the clusters are more clearly separated, resulting in a more accurate classification.

Turner (1975) simulated a variable atmosphere in which the visual range was first changed from 23 km to 13 km across the scene and each data point was modified according to the particular atmospheric conditions chosen. First, corn and soybean fields under the clearer atmosphere were used as the training fields in the classification procedure. The percentage of correctly classified areas changed slightly from 87.6% and 87.1% for a uniform atmosphere to 86.2% and 89.1% for the variable case for corn and soybeans respectively. (Note that for soybeans the accuracy increased). Second, using values from the entire scene, instead of only the clearest conditions, the classification accuracy remained about the same at 87.6% for corn and 87.8% for soybeans.

Turner summarized his results in the form of histogram plots of the number of fields with a given classification accuracy, Figure 3. As the change in atmospheric haze becomes more pronounced, the histogram has a greater spread and the accuracy of classification for corn decreases from 87.6% to 83.6%.

Abotteen et al (1977) conducted comparative tests on seven signature extension algorithms to determine their effectiveness in correcting for changes in atmospheric haze and sun angle. Four of the alogrithms (OSCAR, MOD OSCAR,

Figure 1. Landsat 1 Gray Scale Units of Coastal Features in MSS Bands 5 and 7 (Paris, 1974)

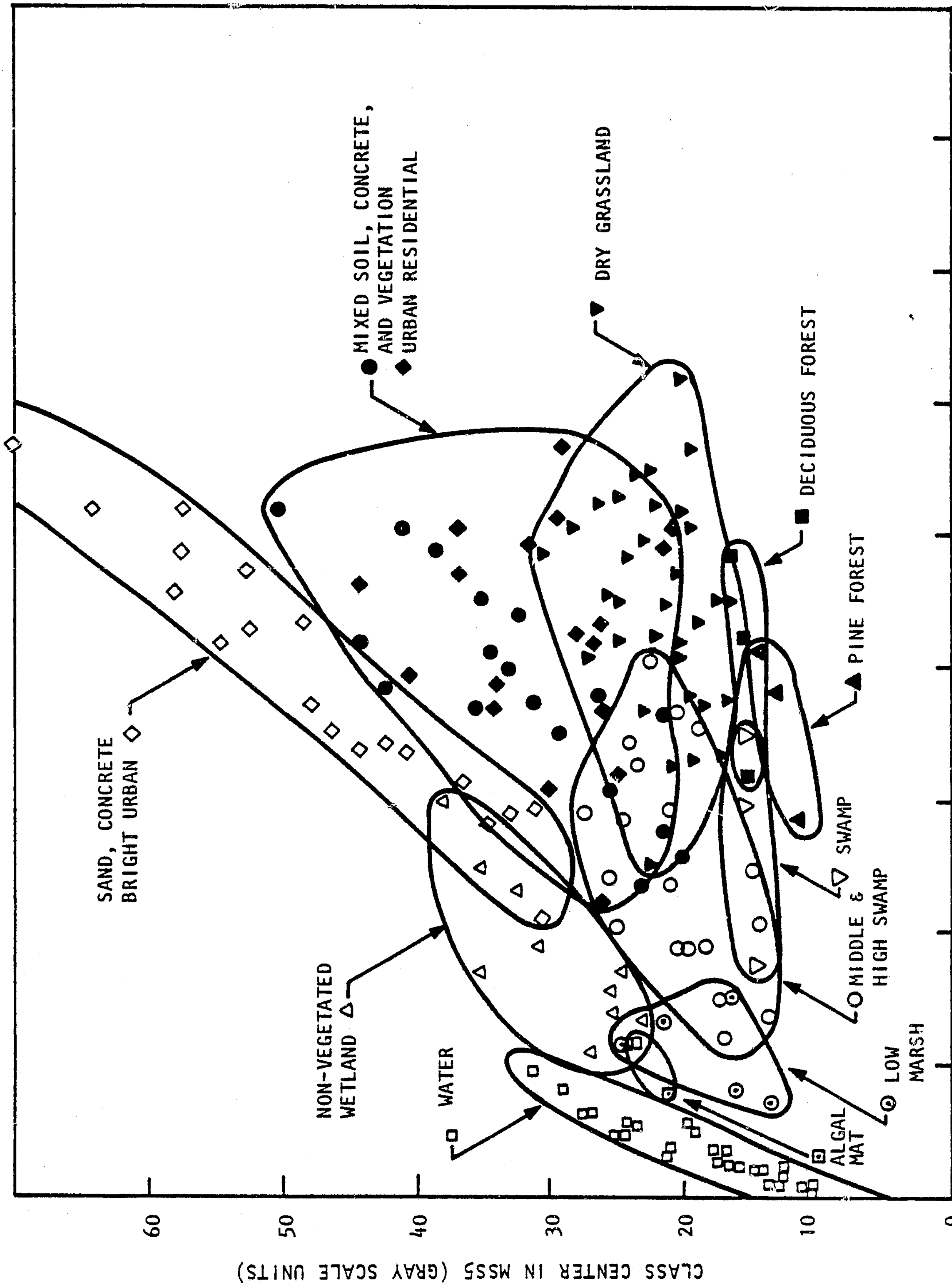
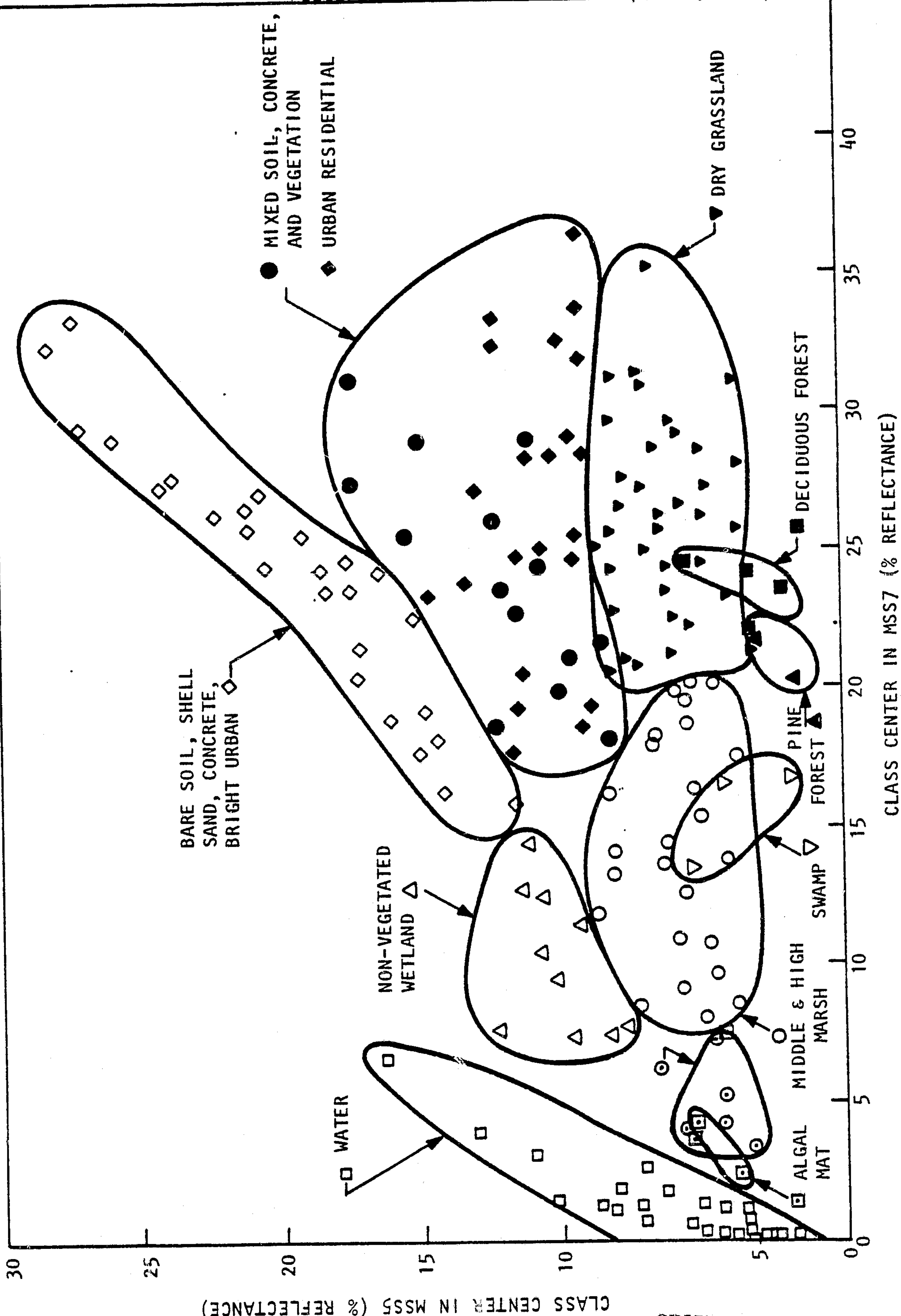
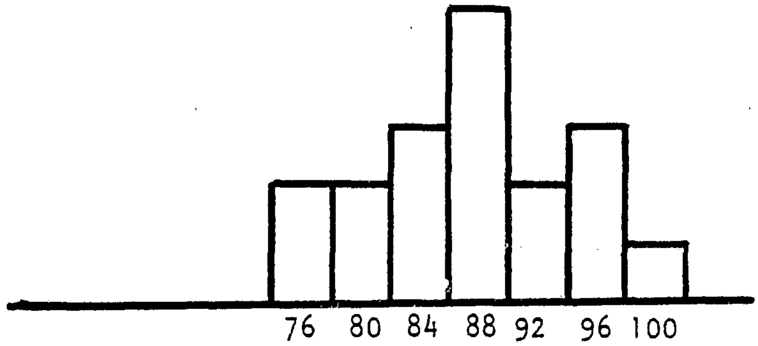


Figure 2. Landsat-1 Reflectance Signatures of Coastal Features in MSS Bands 5 and 7 (Paris, 1974)

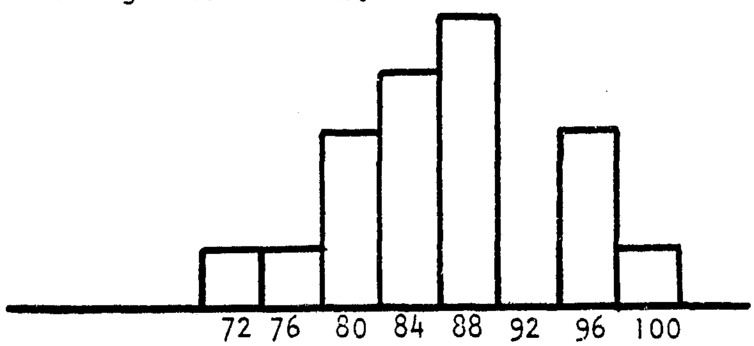


ORIGINAL PAGE IS OF POOR QUALITY

Case 1: Uniform atmosphere, V = 23 km
Mean recognition = 87.6%



Case 2: Non-uniform atmosphere, 13 ≤ V ≤ 23 km
Mean recognition = 86.2%



Case 3: Non-uniform atmosphere, 8 ≤ V ≤ 23 km
Mean recognition = 83.6%

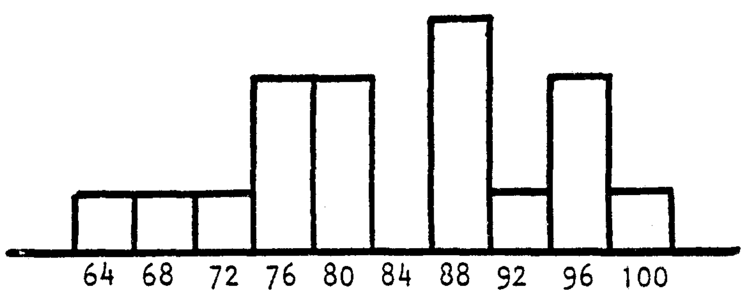


FIGURE 3. Number of fields versus classification accuracy Turner (1975).

ROOSTER & MOD ROOSTER) were cluster matching, two were maximum likelihood (MLEST & UHMLE) and the last (ACTOR) determined the haze level in the training and test areas and used a set of tables from an atmospheric model to correct the training signatures. Simulated and consecutive-day data were used in the comparison. The simulated data were obtained from means and covariance matrices determined from four passes of two training areas in Montana. An algorithm was used to generate multivariate normal data with the same statistics. This was done separately for the four passes of the first area. Then each pass of the second area was created from the distributions used in the corresponding pass of the first area by transforming them with an affine transformation so that the data corresponded to a different sun angle. The data for the first area were used as the training data and the data for the second area were used for the test area. All classifications were made in four bands. The consecutive-day data were from seven sets of consecutive-day Landsat-1 passes over test sites in Kansas. Ground truth was available for all fields in all the test areas. A subset was selected for training fields, and fields were grouped into subclasses with the aid of cluster maps. A signature extension area was defined in each site that included a ground-truth area in each case. The approach was to make signature extension runs using the above mentioned algorithms and to compare the results with local classification results or ground truth. The algorithms were to provide modified training statistics which then were used to classify the test areas. The UHMLE algorithm computed these modified statistics directly; all the other algorithms computed an affine transformation that was then used to modify the training statistics.

The results of the study are summarized in Table VII. The first two columns list the algorithms in the order in which they performed in the accuracy test for simulated and consecutive-day imagery and the numbers listed are the mean percentage differences between the accuracy obtained using the algorithms and local accuracy. (The minus sign indicates that the algorithm was less accurate than local classification.)

TABLE VII

SUMMARY OF TEST RESULTS

Percentage difference between local accuracy and that obtained with various algorithms				Wheat proportions difference from local				Wheat proportion difference from ground truth			
Simulated data		Consecutive-day data		Simulated data		Consecutive-day data		Simulated data		Consecutive-day data	
R(S)	0.0	R(S)	-1.6	R(S)	0.2	R(S)	2.7	R(S)	0.8	UH all	8.6
MLEST	-1.7	MLEST	-1.8	R(C)	1.3	REGRES	3.3	R(C)	1.1	REGRES	9.8
UH fields	-7.1	OSCAR	-2.4	MLEST	2.4	OSCAR	3.6	MLEST	3.0	UH all MLE	10.0
R(C)	-9.4	REGRES	-2.8	UH fields MLE	5.0	MOD R	3.8	UH fields MLE	4.9	R(S)	10.0
UT	-44.1	MOD R	-2.8	UH fields	6.4	UT	4.1	UH fields	6.3	ATCOR	10.5
		R(C)	-3.7	UT	13.5	MLEST	4.2	UT	12.8	OSCAR	10.8
		MOD OSCAR	-3.8			ATCOR	4.3			MOD R	11.2
		ATCOR	-4.3			MOD OSCAR	4.8			R(C)	11.3
		UH fields	-5.1			R(S/C)	5.2			MLEST	11.7
		UT	-6.6			R(C)	6.4			MOD OSCAR	11.7
		R(S/C)	-7.1			UH all	12.8			UH fields	12.6
		UH all	-10.6			UH fields	13.2			UT	12.9
						UH all MLE	13.6			R(S/C)	14.9

A statistical analysis of the accuracy results for the consecutive-day data (except for the three versions of UHMLE which were omitted because of large variances) indicated:

1. No significant difference between the algorithms
2. Greater classification accuracy when the training was done on the hazier site, this was in contrast to the test site being hazier than the training site or when the atmosphere over both sites was clear.

The wheat proportion differences between ground truth and local results are listed in the last four columns of Table VII. The results show that the performance ratings for the algorithms are the same for simulated data but different for consecutive-day data. This was because local results were different from ground-truth results for the consecutive-day data. A statistical analysis of the consecutive-day data for wheat proportion differences from local results (with the omission of data from R(S/C), a variant of ROOSTER, and UHMLE because of large variances) revealed no significant differences between the algorithms tested. The best results were again for the case of training under hazy conditions. The three algorithms tested on the simulated data produced significant improvements over the results obtained using untransformed signatures. For the consecutive-day data, the tested algorithms produced improvements in most but not all cases.

Fraser (1977) studied the effect of differences in atmospheric turbidity on the classification of Landsat MSS observations of a rural scene in Pennsylvania. The original observations were classified by an unsupervised clustering procedure, LARSYS Version 3. The resulting classes served as a training set for use with a maximum likelihood algorithm. From another Landsat image, of an area of the Atlantic Ocean just west of the Spanish Sahara, the differences in radiance were determined for two points 90 km apart over the deep ocean during a period of mild outflow of Sahara dust. This difference was subtracted from the Pennsylvania data and amounted to decreasing the atmospheric turbidity over the rural scene from 5.7 to 4.41, a decrease of 1.3 standard deviations for rural regions. (Note that the turbidity of the unmodified Pennsylvania scene of 5.7 is 2.8 standard deviations above the mean for the rural U.S. Fraser's experiment then simulates a reduction in turbidity from a large value of 2.8 to 1.5 standard deviations above the mean.) As shown in Table VIII, 22% of the pixels in the rural data, classified by the maximum likelihood algorithm, were changed as a result of the modification. The modified data were then reclassified but this time with the statistics of their own data and, as shown in Table IX, only 3% of the pixels in the two sets of data then had different classifications. Hence, if classification errors of rural errors are not to exceed 15%, a new training set has to be developed whenever the atmospheric turbidity changes by one standard deviation.

TABLE VIII

THE CLASSIFICATION MATRIX OF UNMODIFIED AND MODIFIED DATA USING THE UNMODIFIED STATISTICS

Class: Modified → / ↓ Unmodified	Number of pixels					Number of pixels in unmodified classification
	1-6	7	8	9	10	
1-6	750 (75.6)[a]	218 (22.0)	0	24 (2.4)	0	992
7	0	93 (30.8)	187 (61.9)	22 (7.3)	0	302
8	0	0	340 (68.0)	159 (31.8)	1 (0.2)	500
9	0	0	0	959 (100.0)	0	959
10	0	0	0	1 (2.1)	46 (97.9)	47
Number of pixels in modified classification	750	311	527	1165	47	Total = 2800

[a]The numbers in parentheses show the transition percentages of a class of unmodified pixels to the various classes of modified classification.

TABLE IX

THE CLASSIFICATION MATRIX OF UNMODIFIED AND MODIFIED DATA SETS USING THEIR OWN STATISTICS, WHICH ARE INDEPENDENT FOR EACH OTHER

Class: Modified → / ↓ Unmodified	Number of Pixels					Number of pixels in unmodified classification
	1-6	7	8	9	10	

2.3 SUMMARY

Several points can be made based on the research in this area:

1) Atmospheric changes are significant enough in many cases to make signature extension or retraining necessary

2) Although signature extension algorithms work generally quite well, retraining appears to be more accurate for multi-date imagery. The problem of normalizing spatially variable atmospheric conditions does not appear to have been addressed for satellite imagery.

3) The relatively few quantitative studies of atmospheric effects and their correction in the context of classification accuracies have yielded results which are not easily generalized. This fact arises from the complex and diverse nature of spectral signatures of interest. There appears to be a need for simple, conceptual experiments which could lead to a better understanding of the interactions underlying atmospheric effects on classification.

4) To underscore this last point, we should point out that, in spite of the results of the many studies reported here, we are still unable to predict in general the effect of a given change in atmospheric conditions on classification accuracy or the spectral signatures of commonly occuring ground features. (Potter's results show that a change in τ of 0.2 across a scene can catastrophically reduce classification accuracy. However, such a large change in τ is unlikely to occur often across a Landsat scene.) The most important recommendation resulting from this literature review is that a generalized study is needed, for commonly occuring surface features, of the changes in their spectral signatures and in the accuracy of their classification introduced by changes in τ of between 0 and 0.2.

2.4 LITERATURE SURVEY

Several computer bibliographic data bases were searched in compilation of the enclosed literature survey. They were:

EROS Data Center Remote Sensing Bibliography
Department of Energy Energy Information Data Base (RECON)
Department of Interior Office of Water Research and Technology
Water Resources Thesaurus, 2nd Edition (RECON)

In addition the proceedings of prominent professional symposia were reviewed. These included:

Proceedings of the International Symposium on Remote Sensing of Environmental Research Institute of Michigan, 1969, 1971, 1972, 1974, 1975, 1977, 1978.

Proceedings of the Machine Processing of Remotely Sensed Data Symposium, IEEE, 1973, 1975, 1976, 1977, 1979.

Proceedings of Society of Photoptical Instrumentation Engineers, SPIE.

Proceedings of the American Society of Photogrammetry, ASP.

Proceedings of the Symposium on Significant Results Obtained from the ERTS-1, NASA SP-327, March 1973.

Proceedings of the Third ERTS-1 Satellite Symposium, NASA-351, December 1973.

Finally, the indices of two remote sensing journals were reviewed. They were:

Photogrammetric Engineering and Remote Sensing, ASP.

Remote Sensing of Environment, Elsevier North-Holland, Inc.

2.5 ALPHABETICAL COMPUTER PRINT-OUT

BIBLIOGRAPHY

0006

ABOTTEEN, R./LEVY, S./MENDLOWITZ, M./MORITZ, T./POTTER, J./THADANI, S./ WEHMANEN, O.

PERFORMANCE TESTS OF SIGNATURE EXTENSION ALGORITHMS

1977

PROC. OF THE ELEVENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM,,PP. 1523-1532

CLASSIFICATION/ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS

0045

AHERN, F. J./TEILLET, P. M./GOODENOUGH, D. G.

OPERATIONAL IMPLEMENTATION OF ATMOSPHERIC AND ILLUMINATION CORRELATIONS

1979

PROC. OF THE 1979 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE, JUNE, 1979

ATMOSPHERIC EFFECTS

0009

BELOV, V. V./KREKOV, G. M.

EFFECT OF MULTIPLE SCATTERING ON THE POINT-SPREADFUNCTIONS AND MODULATION-TRANSFER FUNCTIONS OF THE AEROSOL ATMOSPHERE IN THE PROBLEMS OF SPACE-METEOROLOGICAL PHOTOGRAPHY

1979

OPTICS LETTERS, VOL. 4, NO. 5, MAY, 1979, PP. 158-160

ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS/SENSOR DESIGN/IMAGE QUALITY

0023

BOUDREAU, R. D.

CORRECTING AIRBORNE SCANNING INFRARED RADIOMETER MEASUREMENTS FOR ATMOSPHERIC EFFECTS

1972

NASA REPORT TM-X-69940, SEPTEMBER, 1972, 43 P.

ATMOSPHERIC EFFECTS/OCEANS/THERMAL

BOX, M. A./DEEPAK, A.

ATMOSPHERIC SCATTERING CORRECTIONS TO SOLAR RADIOMETRY

1979

APPLIED OPTICS, VOL. 18, NO. 12, JUNE 15, 1979, PP. 1941-1949

ATMOSPHERIC DATA/ATMOSPHERIC MODELS

0018

BUZNIKOV, A. A./KONDRATYEV, K. YA./SMOKTY, O. I.

FORMATION OF REFLECTION SPECTRUM OF THE EARTH NEAR THE BOUNDARY DIVIDING TWO UNIFORM SURFACES

1975

PROC. OF THE TENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT
ERIM, OCTOBER, 1975, PP. 319-325

SATELLITE IMAGERY/ATMOSPHERIC EFFECTS/IMAGE QUALITY

Chavez, P. Jr. (1975)
Atmospheric, Solar, and MTF Corrections for ERTS Digital Imagery
Proc. of ASP Conv. Phoenix, AZ
Atmospheric Effects/Atmospheric Models

0031

Crane, R. B.

Preprocessing Techniques to Reduce Atmopsheric and Sensor Variability in Multispectral Scanner Data
1971
Proc. of the Seventh International Symposium on Remote Sensing of Environment
Erim, May, 1971, pp. 1345-1350

0013

DANA, ROBERT W.

USING AIRBORNE RADIOMETRY TO DETERMINE ATMOSPHERIC EFFECTS IN LANDSAT DATA

1978

PROC. OF THE AM. SOC. OF PHOTOGRAMMETRY FALL TECHNICAL MEETING, OCTOBER, 1978, PP. 117-129

ATMOSPHERIC DATA/SATELLITE IMAGERY

0017

DANA, ROBERT W.

SOLAR AND ATMOSPHERIC EFFECTS ON SATELLITE IMAGERY DERIVED FROM AIRCRAFT REFLECTANCE MEASUREMENTS

1975

PROC. OF THE TENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, OCTOBER, 1975, PP. 683-694

ATMOSPHERIC DATA/SATELLITE IMAGERY

0010

DAVE, J. V.

CONTRAST ATTENUATION FACTORS FOR REMOTE SENSING

1979

IBM JOURNAL OF RESEARCH AND DEVELOPMENT, VOL. 23, NO. 2, MARCH, 1979, PP. 214-224

ATMOSPHERIC MODELS/SATELLITE IMAGERY/ATMOSPHERIC EFFECTS

0061
ERB, R. B.

THE ERTS-1 INVESTIGATION (ER-600), VOLUME 6:ERTS-1 SIGNATURE EXTENSION ANALYS
1974
NASA REPORT TM-X-58122, June 1974, 88 pages
ATMOSPHERIC EFFECTS/LAKES/CLASSIFICATION

Flowers, E. E.: McCormick, R. A. and Kurfis, K. R.

"Atmospheric Turbidity Over the United States, 1961-1966"
J. of Applied Meteorology, Vol, 8, p. 955, 1969
Atmospheric Data

0038

FRASER, ROBERT S.

COMPUTED ATMOSPHERIC CORRECTIONS FOR SATELLITE DATA

1974

PROC. OF THE SPIE CONFERENCE ON SCANNERS AND IMAGERY SYSTEMS FOR EARTH OBSERVATION, SPIE, AUGUST, 1974, VOL. 51, PP. 64-72

ATMOSPHERIC MODELS/ATMOSPHERIC EFFECTS

0012

FRASER, ROBERT S./BAHETHI, OM P./AL-ABBAS, A. H.

THE EFFECT OF THE ATMOSPHERE ON THE CLASSIFICATION OF SATELLITE OBSERVATION TO IDENTIFY SURFACE FEATURES

1977

REMOTE SENSING OF ENVIRONMENT, VOL. 6, 1977, PP. 229-249

CLASSIFICATION/ATMOSPHERIC EFFECTS/ATMOSPHERIC DATA/OCEAN/ATMOSPHERIC MODEL

0001

GORDON, HOWARD R.

REMOVAL OF ATMOSPHERIC EFFECTS FROM SATELLITE IMAGERY OF THE OCEANS

1978

APPLIED OPTICS, VOL. 17, NO. 10, MAY 15, 1978

ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS/SATELLITE IMAGERY/OCEAN

0003

GRIGGS, M.

DETERMINATION OF THE AEROSOL CONTENT IN THE ATMOSPHERE FROM ERTS-1 DATA

1974

PROC. OF THE NINTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, APRIL, 1974, PP. 471-481

AEROSOLS/OCEAN/SATELLITE IMAGERY

0007

GRIGGS, M.

COMMENT ON 'RELATIVE ATMOSPHERIC CONTENT FROM ERTS OBSERVATIONS' BY YU. MEKLER, ET AL.

1977

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 82, NO. 31, OCTOBER 20, 1977, PAGE 4972

ATMOSPHERIC DATA/AEROSOLS/OCEAN/SATELLITE IMAGERY

GRIGGS, M.

MEASUREMENTS OF ATMOSPHERIC AEROSOL OPTICAL THICKNESS OVER WATER USING ERTS DATA

1975

JOURNAL OF THE AIR POLLUTION CONTROL ASSOCIATION, VOL. 25, NO. 6, JUNE, 1975, PP. 622-626

AEROSOLS/ATMOSPHERIC DATA/OCEAN/SATELLITE IMAGERY

0024

GRIGGS, M.

DETERMINATION OF AEROSOL CONTENT IN THE ATMOSPHERE FROM LANDSAT DATA

1975

NASA PROGRESS REPORT E76-10067, NOVEMBER, 1975, 13 P.

ATMOSPHERIC AEROSOLS/SATELLITE IMAGERY

0058

GRIGGS, MICHAEL

DETERMINATION OF AEROSOL CONTENT IN THE ATMOSPHERE

1973

PROC. OF THE SYMPOSIUM ON SIGNIFICANT RESULTS OBTAINED FROM THE ERTS-1, NASA SP-327, MARCH 1973, PP 1105-1113

ATMOSPHERIC DATA/IMAGE QUALITY/AEROSOLS

0060

GRIGGS, MICHAEL

A METHOD TO MEASURE THE ATMOSPHERIC AEROSOL CONTENT USING ERTS-1 DATA
1973
PROC. OF THE THIRD ERTS-1 SYMPOSIUM, NASA SP-351, DECEMBER 1973, pp 1505-1517
AEROSOLS/SATELLITE IMAGERY

HERMAN, B. M. and S. R. BROWNING (1975)

"The Effect of Aerosols on the Earth-Atmosphere Albedo", J. Atmos. Sci., 32, 1430
ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS

0053

HENDERSON, P. G.

SIGNATURE EXTENSION USING THE MASC ALGORITHM

1975

PROC. OF THE 1975 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE 75CH 1009-0-C, JUNE 1975, PP 1A-31 - 1A-37

ATMOSPHERIC MODELS/ATMOSPHERIC EFFECTS/CLASSIFICATION

0043

HORVATH, ROBERT/BRAITHWAITE, JOHN G./POLCYN, FABIAN C.

EFFECTS OF ATMOSPHERIC PATH ON AIRBORNE MULTISPECTRAL SENSORS

1970

REMOTE SENSING OF ENVIRONMENT, VOL. 1, NO. 4, 1970, PP 203-215

ATMOSPHERIC EFFECTS/SENSOR DESIGN/IMAGE QUALITY

0041

HULSTROM, ROLAND L.

SPECTRAL MEASUREMENTS AND ANALYSES OF ATMOSPHERIC EFFECTS ON REMOTE SENSOR DATA

1974

PROC. OF THE SPIE CONFERENCE ON SCANNERS AND IMAGERY SYSTEMS FOR EARTH OBSERVATION, SPIE, AUGUST, 1974, VOL. 51, PP. 90-100

ATMOSPHERIC DATA/ATMOSPHERIC EFFECTS

0021

KAWATA, Y./HABA, Y./KUSAKA, T./TERASHITA, Y./UENO, S.

ATMOSPHERIC EFFECTS AND THEIR CORRECTION IN AIRBORNE SENSOR AND LANDSAT MS DATA

1978

PROC. OF THE TWELFTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONM ERIM, APRIL, 1978, PP. 1251-1257

ATMOSPHERIC EFFECTS/SATELLITE IMAGERY/ATMOSPHERIC MODELS/IMAGE QUALITY

0050

KIANG, R. K./UNGAR, S. G./BRYANT, E. S.

PRECISION REQUIREMENT IN MEASURING AEROSOL LOAD FOR REMOTE SENSING APPLICATI

1979

PROC. OF THE 1979 SYMPOSIUM ON MACHINE PROCESSING OF REMOTELY SENSED DATA, IEEE, JUNE, 1979, PP.81-

ATMOSPHERIC AEROSOLS/ATMOSPHERIC MODELS/CLASSIFICATION/ATMOSPHERIC DATA /ATMOSPHERIC EFFECTS

0051

KIANG, RICHARD K./COLLINS, WILLIAM E.

LINEAR ATMOSPHERIC TRANSFORM ON LANDSAT MEASUREMENTS

1976

PROC. OF THE 1976 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE 76CH 1103-1MPRSD, JUNE 1976, ABSTRACT, PG. 2B-5

ATMOSPHERIC MODELS/AEROSOLS

0002

KIDD, R. H./WOLFE R. H.

PERFORMANCE MODELING OF EARTH RESOURCES REMOTE SENSORS

1976

IBM JOURNAL OF RESEARCH AND DEVELOPMENT, VOL. 20, NO. 1, JANUARY, 1976, PP. 29-39

SENSOR DESIGN/ATMOSPHERIC MODELS

0014

KIM, SOON T./SMITH, DAVID W.

ELIMINATION OF ENVIRONMENTAL EFFECTS FROM LANDSAT RADIANCE DATA

1979

PROC. OF THE AM. SOC. OF PHOTOGRAMMETRY ANNUAL MEETING, MARCH 1979, PP. 694-699

ATMOSPHERIC EFFECTS/SATELLITE IMAGERY

0033

KRIEGLEP, F. J./MALILA, W. A./NALEPKA, R.F./RICHARDSON,W.

PREPPOCESSING TRANSFORMATIONS AND THEIR EFFECTS ON MULTISPECTRAL RECOGNITI

1969

PROC. OF THE SIXTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMEN
ERIM, OCTOBER, 1969, PP. 97-132

ATMOSPHEPIC EFFECTS/CLASSIFICATION

0027

KRIEGLER, FRANK J./MARSHALL,ROBERT F./HORWITZ, HOWARD/GORDON, MICHAEL

ADAPTIVE MULTISPECTRAL RECOGNITION OF AGRICULTURAL CROPS

1972

PROC. OF THE EIGHTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONME
ERIM, OCTOBER, 1972, PP. 833-849

ATMOSPHERIC EFFECTS/CLASSIFICATION

0050

KUMAR, RAVINDRA

EFFECTS OF ATMOSPHERE, TEMPERATURE AND EMITTANCE ON REMOTELY SENSED DATA

1977

PROC. OF THE 1977 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM,
IEEE 77CH 1218-7MPRSD, JUNE 1977, ABSTRACT, PG. 145

ATMOSPHERIC MODELS/SATELLITE IMAGERY/THERMAL

0052

LAMPECK, PETER F./PICE, DANIEL P.

SIGNATURE EXTENSION THROUGH THE APPLICATION OF CLUSTER MATCHING ALGORITHMS
TO DETERMINE APPROPRIATE SIGNATURE TRANSFORMATIONS

1976

PROC. OF THE 1976 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM,
IEEE 76CH 1103-1MPRSD, JUNE 1976, PP 4A-45 - 4A-51

ATMOSPHERIC EFFECTS/CLASSIFICATION

0005

MALILA, W. A./GLEASON, J. M./CICONE, R. C.

MULTISPECTRAL SYSTEM ANALYSIS THROUGH MODELING AND SIMULATION

1977

PROC. OF THE ELEVENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT,ERIM,1977,PP 1319-1328

ATMOSPHERIC MODELS/SENSOR DESIGN

0057

MALILA, WILLIAM A./NALEPKA, RICHARD F.

ATMOSPHERIC EFFECTS IN ERTS-1 DATA, AND ADVANCED INFORMATION EXTRACTION TECHNIQUES

1973

PROC. OF THE SYMPOSIUM ON SIGNIFICANT RESULTS OBTAINED FROM THE ERTS-1, NASA SP-327, MARCH 1973, PP 1097-1104

ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS/SATELLITE IMAGERY

0035

MEKLER, YU./QUENZEL, H./OHRING, G./MARCUS, I.

RELATIVE ATMOSPHERIC AEROSOL CONTENT FROM ERTS OBSERVATIONS

1977

JOURNAL OF GEOPHYSICAL RESEARCH, VOL 82., NO. 6, FEBRUARY 20, 1977, PP. 967-970

ATMOSPHERIC AEROSOLS/ATMOSPHERIC DATA/ATMOSPHERIC MODELS/SATELLITE IMAGERY

0046

MORIMOTO, R./KUMAR, R./MOLION, L.

EFFECT OF THE ATMOSPHERE ON THE CLASSIFICATION ACCURACY OF LANDSAT DATA

1979

PROC. OF THE 1979 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE, JUNE, 1979

ATMOSPHERIC EFFECTS/CLASSIFICATION

NACK, M. L./CURRAN, R. J.

TRANSFORMATION OF SURFACE ALBEDO TO SURFACE ATMOSPHERE SURFACE AND IRRADIANCE AND THEIR SPECTRAL AND TEMPORAL AVERAGES

1978

NASA REPORT TM-78057, AUGUST, 1978, 49 P.

ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS

0028

NALEPKA, RICHARD F./MORGENSTERN, JAMES P.

SIGNATURE EXTENSION TECHNIQUES APPLIED TO MULTISPECTRAL SCANNER DATA

1972

PROC. OF THE EIGHTH INTERNATIONAL SYSMPOSIUM ON REMOTE SENSING OF ENVIRONMEN ERIM, OCTOBER, 1972, PP. 881-893

ATMOSPHERIC EFFECTS/CLASSIFICATION

0011

OTTERMAN, J./FRASER, R. S.

EARTH-ATMOSPHERE SYSTEM AND SURFACE REFLECTIVITIES IN ARID REGIONS FROM LANDSAT MSS DATA

1976

REMOTE SENSING OF ENVIRONMENT, VOL. 5, 1976, PP. 247-266

ATMOSPHERIC MODELS/SATELLITE IMAGERY

0056
OTTERMAN, J./FRASER, R. S.

ADJACENCY EFFECTS ON IMAGING BY SURFACE REFLECTION AND ATMOSPHERIC SCATTERING CROSS RADIANCE TO ZENITH
1979
APPLIED OPTICS, VOL, 18, NO. 16, August 15, 1979, PP 2852-2860
ATMOSPHERIC MODELS/SATELLITE IMAGERY

PARIS, J. F. (1974)

COASTAL ZONE MAPPING FROM ERTS-1 DATA USING COMPUTER-AIDED TECHNIQUES.
PROCEEDINGS OF 2ND CANADIAN SYMPOSIUM ON REMOTE SENSING VOL. 2,
CANADIAN REMOTE SENSING SOCIETY
CLASSIFICATION/ATMOSPHERIC EFFECTS

PEARCE, W. A. (1977)

"A STUDY OF THE EFFECTS OF THE ATMOSPHERE ON THE THEMATIC MOPPER OBSERVATIONS",
FINAL REPORT UNDER CONTRACT NAS5-23639
ATMOSPHERIC MODELS

0040
PIECH, KENNETH R./SCHOTT, JOHN R.

ATMOSPHERIC CORRECTIONS FOR SATELLITE WATER QUALITY STUDIES
1974
PROC. OF THE SPIE CONFERENCE ON SCANNERS AND IMAGERY SYSTEMS FOR EARTH
OBSERVATIONS, SPIF, AUGUST, 1974, VOL. 51, PP. 84-89
ATMOSPHERIC DATA/LAKES

0004

PITTS, DAVID E./MCALLUM, WILLIAM E./DILLINGER, ALYCE E.

THE EFFECT OF ATMOSPHERIC WATER VAPOR ON AUTOMATIC CLASSIFICATION OF ERTS DATA

1974

PROC. OF THE NINTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, APRIL, 1974, PP. 483-497

ATMOSPHERIC EFFECTS/CLASSIFICATION/ATMOSPHERIC DATA

0049

POTTER, J. F.

CORRECTING LANDSAT DATA FOR CHANGES IN SUN ANGLE, HAZE LEVEL, AND BACKGROUND REFLECTANCE

1976

PROC. OF THE 1976 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE 76CH 1103-1MPPSD, JUNE 1976, ABSTRACT, PG. 2B-6

ATMOSPHERIC MODELS

0019

POTTER, J. F./MENDLOWITZ, M. A.

ON THE DETERMNATION OF HAZE LEVELS FROM LANDSAT DATA

1975

PROC. OF THE TENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, OCTOBER, 1975, PP. 695-703

ATMOSPHERIC DATA/SATELLITE IMAGERY

POTTER, J./SHELTON, M.

EFFECT OF ATMOSPHERIC HAZE AND SUN ANGLE ON AUTOMATIC CLASSIFICATION OF ERTS-1 DATA

1974

PROC. OF THE NINTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONME
ERIM, APRIL, 1974, PP. 865-874

ATMOSPHERIC EFFECTS/SATELLITE IMAGERY/CLASSIFICATION/ATMOSPHERIC MODELS

0032

POTTER, JOHN F.

SCATTERING AND ABSORPTION IN THE EARTH'S ATMOSPHERE

1969

PROC. OF THE SIXTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONME
ERIM, OCTOBER, 1969, PP. 415-429

ATMOSPHERIC MODELS

0039

POTTER, JOHN F.

HAZE AND SUN ANGLE EFFECTS ON AUTOMATIC CLASSIFICATION OF SATELLITE DATA-SIMULATION AND CORRECTION

1974

PROC. OF THE SPIE CONFERENCE ON SCANNERS AND IMAGERY SYSTEMS FOR EARTH OBSERVATIONS, SPIE, AUGUST, 1974, VOL. 51, PP.73-83

ATMOSPHERIC EFFECTS/CLASSIFICATION/ATMOSPHERIC MODELS

0048

POTTER, JOHN F.

THE CORRECTION OF LANDSAT DATA FOR THE EFFECTS OF HAZE, SUN ANGLE, AND BACKGROUND REFLECTANCE

1977

PROC. OF THE 1977 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE 77CH 1218-7MPRSD, JUNE 1977, PP 24-32

ATMSPHERIC MODELS

0016

ROCHON, G./AUDIRAC, H./AHERN, F. J./BEAUBIEN, J.

ANALYSIS OF A TRANSFORMATION MODEL OF SATELLITE RADIANCES INTO REFLECTANCES

1978

PROC. OF THE TWELFTH INTERNATION SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, APRIL, 1978, PP. 1267-1277

ATMOSPHERIC MODELS/SATELLITE IMAGERY

0054

ROGERS, ROBERT H./PEACOCK, KEITH

MACHINE PROCESSING OF ERTS AND GROUND TRUTH DATA

1973

PROC. OF THE 1973 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE 73CHO 834-2GE, OCTOBER 1973, PP 4A-14 - 4A-26

ATMOSPHERIC DATA/ATMOSPHERIC MODELS/SATELLITE IMAGERY

0059

ROGERS, ROBERT H./PEACOCK, KEITH

A TECHNIQUE FOR CORRECTING ERTS DATA FOR SOLAR AND ATMOSPHERIC EFFECTS

1973

PROC. OF THE SYMPOSIUM ON SIGNIFICANT RESULTS OBTAINED FROM THE ERTS-1, NASA SP-327, MARCH 1973, PP 1115-1122

ATMOSPHERIC DATA/SATELLITE IMAGERY

0034

SHARMA, RAVI D.

ENHANCEMENT OF EARTH RESOURCES TECHNOLOGY SATELLITE (ERTS) AND AIRCRAFT IMAGERY USING ATMOSPHERIC CORRECTIONS

1972

PROC. OF THE EIGHTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, OCTOBER, 1972, PP. 137-152

ATMOSPHERIC MODELS/ATMOSPHERIC DATA/SATELLITE IMAGERY

TURNER, P. E.

ATMOSPHERIC TRANSFORMATION OF MULTISPECTRAL REMOTE SENSOR DATA

1977

NASA FINAL REPORT E79-10006, NOVEMBER, 1977, 128 P.

ATMOSPHERIC MODELS/LAKES

0044

TURNER, P. E.

REMOTE SENSING IN HAZY ATMOSPHERES

1972

PROC. OF THE ANNUAL ACSM/ASP MEETING, AM. SOC. OF PHOTOGRAMMETRY, MARCH
1972

ATMOSPHERIC EFFECTS

0030

TURNER, R. E./MALILA, W. A./NALEPKA, R.F.

IMPORTANCE OF ATMOSPHERIC SCATTERING IN REMOTE SENSING, OR EVERYTHING YOU'V
ALWAYS WANTED TO KNOW ABOUT ATMOSPHERIC SCATTERING BUT WERE AFRAID TO ASK

1971

PROC. OF THE SEVENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONME
ERIM, MAY, 1971, PP. 1651-1697

ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS/ATMOSPHERIC DATA

0015

TURNER, ROBERT E.

ELIMINATION OF ATMOSPHERIC EFFECTS FROM REMOTE SENSOR DATA

1978

PROC. OF THE TWELFTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONME
ERIM, APRIL, 1978, PP. 783-793

ATMOSPHERIC MODELS/SATELLITE IMAGERY

0020

0020

TURNER, ROBERT E.

SIGNATURE VARIATIONS DUE TO ATMOSPHERIC EFFECTS

1975

PROC. OF THE TENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, OCTOBER, 1975, PP. 671-682

ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS

0047

TURNER, ROBERT E.

ATMOSPHERIC EFFECTS IN MULTISPECTRAL REMOTE SENSOR DATA

1975

NASA REPORT CR-141863, ERIM, MAY 1975, 111 PAGES

ATMOSPHERIC EFFECTS/SATELLITE IMAGERY/CLASSIFICATION/ATMOSPHERIC MODELS/ ATMOSPHERIC DATA

0042

TURNER, ROBERT E./MALIKA, WILLIAM A./NALEPKA, RICHARD F./THOMSON, FREDERICK

INFLUENCE OF THE ATMOSPHERE ON REMOTELY SENSED DATA

1974

PROC. OF THE SPIE CONFERENCE IN SCANNERS AND IMAGERY SYSTEMS FOR EARTH OBSERVATION, SPIE, AUGUST, 1979, VOL. 51, PP. 101-114

ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS/CLASSIFICATION

0029

TURNER, ROBERT E./SPENCER, MARGARET M.

ATMOSPHERIC MODEL FOR CORRECTION OF SPACECRAFT DATA

1972

PROC. OF THE EIGHTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMEN ERIM, OCTOBER, 1972, PP. 895-934

ATMOSPHERIC MODELS/SATELLITE IMAGERY

2.6 CHRONOLOGICAL COMPUTER PRINT-OUT

BIBLIOGRAPHY

FLOWERS, E. C.; McCormick, R. A. and Kurfis, K. R.

"Atmospheric Turbidity Over the United States, 1961-1965"
J. of Applied Meteorology, Vol, 8, p. 955, 1969
ATMOSPHERIC DATA

0032
POTTER, JOHN F.

SCATTERING AND ABSORPTION IN THE EARTH'S ATMOSPHERE
1969
PROC. OF THE SIXTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT,
ERIM, OCTOBER, 1969, PP. 415-429
ATMOSPHERIC MODELS

0033

KRIEGLER, F. J./MALILA, W. A./NALEPKA, R.F./RICHARDSON,W.

PREPROCESSING TRANSFORMATIONS AND THEIR EFFECTS ON MULTISPECTRAL RECOGNITION

1969

PROC. OF THE SIXTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT,
ERIM, OCTOBER, 1969, PP. 97-132

ATMOSPHERIC EFFECTS/CLASSIFICATION

0043

HORVATH, ROBERT/BRAITHWAITE, JOHN G./POLCYN, FABIAN C.

EFFECTS OF ATMOSPHERIC PATH ON AIRBORNE MULTISPECTRAL SENSORS

1970

REMOTE SENSING OF ENVIRONMENT, VOL. 1, NO. 4, 1970, PP 203-215

ATMOSPHERIC EFFECTS/SENSOR DESIGN/IMAGE QUALITY

0030

TURNER, R. E./MALILA, W. A./NALEPKA, R.F.

IMPORTANCE OF ATMOSPHERIC SCATTERING IN REMOTE SENSING, OR EVERYTHING YOU'VE
ALWAYS WANTED TO KNOW ABOUT ATMOSPHERIC SCATTERING BUT WERE AFRAID TO ASK

1971

PROC. OF THE SEVENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMEN
ERIM, MAY, 1971, PP. 1651-1697

ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS/ATMOSPHERIC DATA

0031

CRANE, R. B.

PREPROCESSING TECHNIQUES TO REDUCE ATMOSPHERIC AND SENSOR VARIABILITY IN MULTISPECTRAL SCANNER DATA

1971

PROC. OF THE SEVENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMEN
ERIM, MAY, 1971, PP. 1345-1350

ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS

0023

BOUDREAU, P. D.

CORRECTING AIRBORNE SCANNING INFRARED RADIOMETER MEASUREMENTS FOR ATMOSPHERI
EFFECTS

1972

NASA REPORT TM-X-69940, SEPTEMBER, 1972, 43 P.

ATMOSPHERIC EFFECTS/OCEANS/THERMAL

0027

KRIEGLER, FRANK J./MARSHALL,ROBERT E./HORWITZ, HOWARD/GORDON, MICHAEL

ADAPTIVE MULTISPECTRAL RECOGNITION OF AGRICULTURAL CROPS

1972

PROC. OF THE EIGHTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT
ERIM, OCTOBER, 1972, PP. 833-849

ATMOSPHERIC EFFECTS/CLASSIFICATION

0028

NALEPKA, RICHARD F./MORGENSTERN, JAMES P.

SIGNATURE EXTENSION TECHNIQUES APPLIED TO MULTISPECTRAL SCANNER DATA

1972

PROC. OF THE EIGHTH INTERNATIONAL SYSMPOSIUM ON REMOTE SENSING OF ENVIRONMEN
ERIM, OCTOBER, 1972, PP. 881-893

ATMOSPHERIC EFFECTS/CLASSIFICATION

TURNER, ROBERT E./SPENCER, MARGARET M.

ATMOSPHERIC MODEL FOR CORRECTION OF SPACECRAFT DATA

1972

PROC. OF THE EIGHTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, OCTOBER, 1972, PP. 895-934

ATMOSPHERIC MODELS/SATELLITE IMAGERY

0034

SHARMA, RAVI D.

ENHANCEMENT OF EARTH RESOURCES TECHNOLOGY SATELLITE (ERTS) AND AIRCRAFT IMAGERY USING ATMOSPHERIC CORRECTIONS

1972

PROC. OF THE EIGHTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, OCTOBER, 1972, PP. 137-152

ATMOSPHERIC MODELS/ATMOSPHERIC DATA/SATELLITE IMAGERY

0044

TURNER, R. E.

REMOTE SENSING IN HAZY ATMOSPHERES

1972

PROC. OF THE ANNUAL ACSM/ASP MEETING, AM. SOC. OF PHOTOGRAMMETRY, MARCH 1972

ATMOSPHERIC EFFECTS

0054

ROGERS, ROBERT H./PEACOCK, KEITH

MACHINE PROCESSING OF ERTS AND GROUND TRUTH DATA

1973

PROC. OF THE 1973 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE 73CHO 834-2GE, OCTOBER 1973, PP 4A-14 - 4A-26

ATMOSPHERIC DATA/ATMOSPHERIC MODELS/SATELLITE IMAGERY

0057

MALILA, WILLIAM A./NALEPKA, RICHARD F.

ATMOSPHERIC EFFECTS IN ERTS-1 DATA, AND ADVANCED INFORMATION EXTRACTION TECHNIQUES

1973

PROC. OF THE SYMPOSIUM ON SIGNIFICANT RESULTS OBTAINED FROM THE ERTS-1, NASA SP-327, MARCH 1973, PP 1097-1104

ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS/SATELLITE IMAGERY

0058

GRIGGS, MICHAEL

DETERMINATION OF AEROSOL CONTENT IN THE ATMOSPHERE

1973

PROC. OF THE SYMPOSIUM ON SIGNIFICANT RESULTS OBTAINED FROM THE ERTS-1, NASA SP-327, MARCH 1973, PP 1105-1113

ATMOSPHERIC DATA/IMAGE QUALITY/AEROSOLS

0059

ROGERS, ROBERT H./PEACOCK, KEITH

A TECHNIQUE FOR CORRECTING ERTS DATA FOR SOLAR AND ATMOSPHERIC EFFECTS

1973

PROC. OF THE SYMPOSIUM ON SIGNIFICANT RESULTS OBTAINED FROM THE ERTS-1, NASA SP-327, MARCH 1973, PP 1115-1122

ATMOSPHERIC DATA/SATELLITE IMAGERY

0060

GRIGGS, MICHAEL

A METHOD TO MEASURE THE ATMOSPHERIC AEROSOL CONTENT USING ERTS-1 DATA

1973

PROC. OF THE THIRD ERTS-1 SYMPOSIUM, NASA SP-351, DECEMBER 1973, PP 1505-151

AEROSOLS/SATELLITE IMAGERY

PARIS, J. F. (1974)

COASTAL ZONE MAPPING FROM ERTS-1 DATA USING COMPUTER-AIDED TECHNIQUES.
PROCEEDINGS OF 2ND CANADIAN SYMPOSIUM ON REMOTE SENSING VOL. 2,
CANADIAN REMOTE SENSING SOCIETY
CLASSIFICATION/ATMOSPHERIC EFFECTS

GRIGGS, M.

DETERMINATION OF THE AEROSOL CONTENT IN THE ATMOSPHERE FROM ERTS-1 DATA
1974
PROC. OF THE NINTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF
ENVIRONMENT, ERIM, APRIL, 1974, PP.471-481
AEROSOLS/OCEAN/SATELLITE IMAGERY

0004

PITTS, DAVID E./MCALLUM, WILLIAM E./DILLINGER, ALYCE E.

THE EFFECT OF ATMOSPHERIC WATER VAPOR ON AUTOMATIC CLASSIFICATION OF ERTS DATA

1974

PROC. OF THE NINTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, APRIL, 1974, PP. 483-497

ATMOSPHERIC EFFECTS/CLASSIFICATION/ATMOSPHERIC DATA

0022

POTTER, J./SHELTON, M.

EFFECT OF ATMOSPHERIC HAZE AND SUN ANGLE ON AUTOMATIC CLASSIFICATION OF ERTS-1 DATA

1974

PROC. OF THE NINTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, APRIL, 1974, PP. 865-874

ATMOSPHERIC EFFECTS/SATELLITE IMAGERY/CLASSIFICATION/ATMOSPHERIC MODELS

0038

FRASER, ROBERT S.

COMPUTED ATMOSPHERIC CORRECTIONS FOR SATELLITE DATA

1974

PROC. OF THE SPIE CONFERENCE ON SCANNERS AND IMAGERY SYSTEMS FOR EARTH OBSERVATION, SPIE, AUGUST, 1974, VOL. 51, PP. 64-72

ATMOSPHERIC MODELS/ATMOSPHERIC EFFECTS

HAZE AND SUN ANGLE EFFECTS ON AUTOMATIC CLASSIFICATION OF SATELLITE DATA-SIMULATION AND CORRECTION

1974

PROC. OF THE SPIE CONFERENCE ON SCANNERS AND IMAGERY SYSTEMS FOR EARTH OBSERVATIONS, SPIE, AUGUST, 1974, VOL. 51, PP.73-83

ATMOSPHERIC EFFECTS/CLASSIFICATION/ATMOSPHERIC MODELS

0040

PIECH, KENNETH R./SCHOTT, JOHN R.

ATMOSPHERIC CORRECTIONS FOR SATELLITE WATER QUALITY STUDIES

1974

PROC. OF THE SPIE CONFERENCE ON SCANNERS AND IMAGERY SYSTEMS FOR EARTH OBSERVATIONS, SPIE, AUGUST, 1974, VOL. 51, PP. 84-89

ATMOSPHERIC DATA/LAKES

0041

HULSTROM, ROLAND L.

SPECTRAL MEASUREMENTS AND ANALYSES OF ATMOSPHERIC EFFECTS ON REMOTE SENSOR DATA

1974

PROC. OF THE SPIE CONFERENCE ON SCANNERS AND IMAGERY SYSTEMS FOR EARTH OBSERVATION, SPIE, AUGUST, 1974, VOL. 51, PP. 90-100

ATMOSPHERIC DATA/ATMOSPHERIC EFFECTS

0042

TURNER, ROBERT E./MALIKA, WILLIAM A./NALEPKA, RICHARD F./THOMSON, FREDERICK

INFLUENCE OF THE ATMOSPHERE ON REMOTELY SENSED DATA

1974

PROC. OF THE SPIE CONFERENCE IN SCANNERS AND IMAGERY SYSTEMS FOR EARTH OBSERVATION, SPIE, AUGUST, 1979, VOL. 51, PP. 101-114

ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS/CLASSIFICATION

THE ERTS-1 INVESTIGATION (ER-600), VOLUME 6:ERTS-1 SIGNATURE EXTENSION ANAL

1974

NASA REPORT TM-X-58122, JUNE 1974, 88 PAGES

ATMOSPHERIC EFFECTS/LAKES/CLASSIFICATION

0008
GRIGGS, M.

MEASUREMENTS OF ATMOSPHERIC AEROSOL OPTICAL THICKNESS OVER WATER USING ERTS DATA
1975
JOURNAL OF THE AIR POLLUTION CONTROL ASSOCIATION, VOL. 25, NO. 6, June, 1975 PP. 622-626
AEROSOLS/ATMOSPHERIC DATA/OCEAN/SATELLITE IMAGERY

HERMAN, B. M. AND S. R. BROWNING (1975)

"THE EFFECT OF AEROSOLS ON THE EARTH-ATMOSPHERE ALBEDO", J. ATMOS. SCI., 32, 1430
ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS

0017

DANA, ROBERT W.

SOLAR AND ATMOSPHERIC EFFECTS ON SATELLITE IMAGERY DERIVED FROM AIRCRAFT REFLECTANCE MEASUREMENTS

1975

PROC. OF THE TENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, OCTOBER, 1975, PP. 683-694

ATMOSPHERIC DATA/SATELLITE IMAGERY

0018

BUZNIKOV, A. A./KONDRATYEV, K. YA./SMOKTY, O. I.

FORMATION OF REFLECTION SPECTRUM OF THE EARTH NEAR THE BOUNDARY DIVIDING TWO UNIFORM SURFACES

1975

PROC. OF THE TENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, OCTOBER, 1975, PP. 319-325

SATELLITE IMAGERY/ATMOSPHERIC EFFECTS/IMAGE QUALITY

POTTER, J. F./MENDLOWITZ, M. A.

ON THE DETERMNATION OF HAZE LEVELS FROM LANDSAT DATA

1975

PROC. OF THE TENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, OCTOBER, 1975, PP. 695-703

ATMOSPHERIC DATA/SATELLITE IMAGERY

0020

TURNER, ROBERT E.

SIGNATURE VARIATIONS DUE TO ATMOSPHERIC EFFECTS
1975
PROC. OF THE TENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, OCTOBER, 1975, PP. 671-682
ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS

CHAVEZ, P. Jr. (1975)

ATMOSPHERIC, SOLAR, AND MTF CORRECTIONS FOR ERTS DIGITAL IMAGERY
PROC. OF ASP CONV. PHOENIX, AZ
ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS

0024

GRIGGS, M.

DETERMINATION OF AEROSOL CONTENT IN THE ATMOSPHERE FROM LANDSAT DATA

1975

NASA PROGRESS REPORT E76-10067, NOVEMBER, 1975, 13 P.

ATMOSPHERIC AEROSOLS/SATELLITE IMAGERY

0047

TURNER, ROBERT E.

ATMOSPHERIC EFFECTS IN MULTISPECTRAL REMOTE SENSOR DATA

1975

NASA REPORT CR-141863, ERIM, MAY 1975, 111 PAGES

ATMOSPHERIC EFFECTS/SATELLITE IMAGERY/CLASSIFICATION/ATMOSPHERIC MODELS/ ATMOSPHERIC DATA

0053

HENDERSON, R. G.

0003

HENDERSON, P. G.

SIGNATURE EXTENSION USING THE MASC ALGORITHM

1975

PROC. OF THE 1975 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE 75CH 1009-0-C, JUNE 1975, PP 1A-31 - 1A-37

ATMOSPHERIC MODELS/ATMOSPHERIC EFFECTS/CLASSIFICATION

0002

KIDD, R. H./WOLFE R. H.

PERFORMANCE MODELING OF EARTH RESOURCES REMOTE SENSORS

1976

IBM JOURNAL OF RESEARCH AND DEVELOPMENT, VOL. 20, NO. 1, JANUARY, 1976, PP. 29-39

SENSOR DESIGN/ATMOSPHERIC MODELS

0011

OTTERMAN, J./FRASER, R. S.

EARTH-ATMOSPHERE SYSTEM AND SURFACE REFLECTIVITIES IN ARID REGIONS FROM LANDSAT MSS DATA

1976

REMOTE SENSING OF ENVIRONMENT, VOL. 5, 1976, PP. 247-266

ATMOSPHERIC MODELS/SATELLITE IMAGERY

0049

POTTER, J. F.

CORRECTING LANDSAT DATA FOR CHANGES IN SUN ANGLE, HAZE LEVEL, AND BACKGROUND REFLECTANCE

1976

PROC. OF THE 1976 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE 76CH 1103-1MPRSD, JUNE 1976, ABSTRACT, PG. 2B-6

ATMOSPHERIC MODELS

0051

KIANG, RICHARD K./COLLINS, WILLIAM E.

LINEAR ATMOSPHERIC TRANSFORM ON LANDSAT MEASUREMENTS

1976

PROC. OF THE 1976 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE 76CH 1103-1MPRSD, JUNE 1976, ABSTRACT, PG. 2B-5

ATMOSPHERIC MODELS/AEROSOLS

0052

LAMBECK, PETER F./RICE, DANIEL P.

SIGNATURE EXTENSION THROUGH THE APPLICATION OF CLUSTER MATCHING ALGORITHMS TO DETERMINE APPROPRIATE SIGNATURE TRANSFORMATIONS

1976

PROC. OF THE 1976 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE 76CH 1103-1MPRSD, JUNE 1976, PP 4A-45 - 4A-51

ATMOSPHERIC EFFECTS/CLASSIFICATION

PEARCE, W. A. (1977)

"A STUDY OF THE EFFECTS OF THE ATMOSPHERE ON THE THEMATIC MOPPER OBSERVATIONS",
FINAL REPORT UNDER CONTRACT NAS5-23639
ATMOSPHERIC MODELS

0005
MALILA, W. A./GLEASON, J. M./CICONE, R. C.
MULTISPECTRAL SYSTEM ANALYSIS THROUGH MEODLING AND SIMULATION
1977
PROC. OF THE ELEVENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM, 1977, PP 1319-1328
ATMOSPHERIC MODELS/SENSOR DESIGN

0006

ABOTTEEN, R./LEVY, S./MENDLOWITZ, M./MORITZ, T./POTTER, J./THADANI, S./ WEHMANEN, O.

PERFORMANCE TESTS OF SIGNATURE EXTENSION ALGORITHMS

1977

PROC. OF THE ELEVENTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, ERIM,,PP. 1523-1532

CLASSIFICATION/ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS

0007

GRIGGS, M.

COMMENT ON 'RELATIVE ATMOSPHERIC CONTENT FROM ERTS OBSERVATIONS' BY YU. MEKLER, ET AL.

1977

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 82, NO. 31, OCTOBER 20, 1977, PAGE 4972

ATMOSPHERIC DATA/AEROSOLS/OCEAN/SATELLITE IMAGERY

0012

FRASER, ROBERT S./BAHETHI, OM P./AL-ABBAS, A. H.

THE EFFECT OF THE ATMOSPHERE ON THE CLASSIFICATION OF SATELLITE OBSERVATIONS TO IDENTIFY SURFACE FEATURES

1977

REMOTE SENSING OF ENVIRONMENT, VOL. 6, 1977, PP. 229-249

CLASSIFICATION/ATMOSPHERIC EFFECTS/ATMOSPHERIC DATA/OCEAN/ATMOSPHERIC MODELS

0025

TURNER, R. E.

ATMOSPHERIC TRANSFORMATION OF MULTISPECTRAL REMOTE SENSOR DATA

1977

NASA FINAL REPORT E79-10006, NOVEMBER, 1977, 128 P.

ATMOSPHERIC MODELS/LAKES

0035

MEKLER, YU./QUENZEL, H./OHRING, G./MARCUS, I.

RELATIVE ATMOSPHERIC AEROSOL CONTENT FROM ERTS OBSERVATIONS

1977

JOURNAL OF GEOPHYSICAL RESEARCH, VOL 82., NO. 6, FEBRUARY 20, 1977, PP. 967-970

ATMOSPHERIC AEROSOLS/ATMOSPHERIC DATA/ATMOSPHERIC MODELS/SATELLITE IMAGERY

0048

POTTER, JOHN F.

THE CORRECTION OF LANDSAT DATA FOR THE EFFECTS OF HAZE, SUN ANGLE, AND BACKGROUND REFLECTANCE

1977

PROC. OF THE 1977 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE 77CH 1218-7MPRSD, JUNE 1977, PP 24-32

ATMSPHERIC MODELS

0050

KUMAR, RAVINDRA

EFFECTS OF ATMOSPHERE, TEMPERATURE AND EMITTANCE ON REMOTELY SENSED DATA

1977

PROC. OF THE 1977 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE 77CH 1218-7MPRSD, JUNE 1977, ABSTRACT, PG. 145

ATMOSPHERIC MODELS/SATELLITE IMAGERY/THERMAL

0001

GORDON, HOWARD R.

REMOVAL OF ATMOSPHERIC EFFECTS FROM SATELLITE IMAGERY OF THE OCEANS

1978

APPLIED OPTICS, VOL. 17, NO. 10, MAY 15, 1978

ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS/SATELLITE IMAGERY/OCEAN

0013

DANA, ROBERT W.

USING AIRBORNE RADIOMETRY TO DETERMINE ATMOSPHERIC EFFECTS IN LANDSAT DATA

1978

PROC. OF THE AM. SOC. OF PHOTOGRAMMETRY FALL TECHNICAL MEETING, OCTOBER, 1978, PP. 117-129

ATMOSPHERIC DATA/SATELLITE IMAGERY

0015

TURNER, ROBERT E.

ELIMINATION OF ATMOSPHERIC EFFECTS FROM REMOTE SENSOR DATA

1978

PROC. OF THE TWELFTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT
ERIM, APRIL, 1978, PP. 783-793

ATMOSPHERIC MODELS/SATELLITE IMAGERY

0016

ROCHON, G./AUDIRAC, H./AHERN, F. J./BEAUBIEN, J.

ANALYSIS OF A TRANSFORMATION MODEL OF SATELLITE RADIANCES INTO REFLECTANCES

1978

PROC. OF THE TWELFTH INTERNATION SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT,
ERIM, APRIL, 1978, PP. 1267-1277

ATMOSPHERIC MODELS/SATELLITE IMAGERY

0021

KAWATA, Y./HARA, Y./KUSAKA, T./TERASHITA, Y./UENO, S.

ATMOSPHERIC EFFECTS AND THEIR CORRECTION IN AIRBORNE SENSOR AND LANDSAT MSS
DATA

1978

PROC. OF THE TWELFTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT
ERIM, APRIL, 1978, PP. 1251-1257

ATMOSPHERIC EFFECTS/SATELLITE IMAGERY/ATMOSPHERIC MODELS/IMAGE QUALITY

0026

NACK, M. L./CURRAN, R. J.

TRANSFORMATION OF SURFACE ALBEDO TO SURFACE ATMOSPHERE SURFACE AND IRRADIANCE
AND THEIR SPECTRAL AND TEMPORAL AVERAGES

1978

NASA REPORT TM-78057, AUGUST, 1978, 49 P.

ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS

0009

BELOV, V. V./KPEKOV, G. M.

EFFECT OF MULTIPLE SCATTERING ON THE POINT-SPREADFUNCTIONS AND MODULATION-TRANSFER FUNCTIONS OF THE AEROSOL ATMOSPHERE IN THE PROBLEMS OF SPACE-METEOROLOGICAL PHOTOGRAPHY

1979

OPTICS LETTERS, VOL. 4, NO. 5, MAY, 1979, PP. 158-160

ATMOSPHERIC EFFECTS/ATMOSPHERIC MODELS/SENSOR DESIGN/IMAGE QUALITY

0010

DAVE, J. V.

CONTRAST ATTENUATION FACTORS FOR REMOTE SENSING

1979

IBM JOURNAL OF RESEARCH AND DEVELOPMENT, VOL. 23, NO. 2, MARCH, 1979, PP. 214-224

ATMOSPHERIC MODELS/SATELLITE IMAGERY/ATMOSPHERIC EFFECTS

0014

KIM, SOON T./SMITH, DAVID W.

ELIMINATION OF ENVIRONMENTAL EFFECTS FROM LANDSAT RADIANCE DATA

1979

PROC. OF THE AM. SOC. OF PHOTOGRAMMETRY ANNUAL MEETING, MARCH 1979, PP. 694-699

ATMOSPHERIC EFFECTS/SATELLITE IMAGERY

0036

KIANG, P. K./UNGAR, S. G./BRYANT, E. S.

PRECISION REQUIREMENT IN MEASURING AEROSOL LOAD FOR REMOTE SENSING APPLICATION.

1979

PROC. OF THE 1979 SYMPOSIUM ON MACHINE PROCESSING OF REMOTELY SENSED DATA, IEEE, JUNE, 1979, PP.81-

ATMOSPHERIC AEROSOLS/ATMOSPHERIC MODELS/CLASSIFICATION/ATMOSPHERIC DATA /ATMOSPHERIC EFFECTS

0037

BOX, M. A./DEEPAK, A.

ATMOSPHERIC SCATTERING CORRECTIONS TO SOLAR RADIOMETRY

1979

APPLIED OPTICS, VOL. 18, NO. 12, JUNE 15, 1979, PP. 1941-1949

ATMOSPHERIC DATA/ATMOSPHERIC MODELS

0045

AHERN, F. J./TEILLET, P. M./GOODENOUGH, D. G.

OPERATIONAL IMPLEMENTATION OF ATMOSPHERIC AND ILLUMINATION CORRELATIONS

1979

PROC. OF THE 1979 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE, JUNE, 1979

ATMOSPHERIC EFFECTS

0046

MORIMOTO, R./KUMAR, R./MOLION, L.

EFFECT OF THE ATMOSPHERE ON THE CLASSIFICATION ACCURACY OF LANDSAT DATA

1979

PROC. OF THE 1979 MACHINE PROCESSING OF REMOTELY SENSED DATA SYMPOSIUM, IEEE, JUNE, 1979

ATMOSPHERIC EFFECTS/CLASSIFICATION

0056

OTTERMAN, J./FRASER, R. S.

ADJACENCY EFFECTS ON IMAGING BY SURFACE REFLECTION AND ATMPSPHERIC SCATTERING CROSS RADIANCE TO ZENITH

1979

APPLIED OPTICS, VOL. 18, NO. 16, AUGUST 15, 1979, PP 2852-2860

ATMOSPHERIC MODELS/SATELLITE IMAGERY