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VECTOR WIND PROFILE GUST MODEL

FINAL REPORT

(For the Period April 14, 1982 – April 13, 1983)

Prepared For

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Under Contract NAS8-33433

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INTRODUCTION

This report summarizes the work under Contract NAS8-33433 during the 12-month period beginning April 14, 1982. The work during this period has been fully documented in a NASA Technical Memorandum, a journal article, and two papers prepared for presentation at national meetings. One of the papers was presented at the Annual Meeting of the American Statistical Association (ASA) at Cincinnati, Ohio, in August 1982. The other paper was submitted in February 1983 to the American Meteorological Society (AMS) for presentation at the Ninth Conference on Aerospace and Aeronautical Meteorology at Omaha, Nebraska, in June 1983; the paper will be published in the conference proceedings. The published work and conference presentations are described below.

PUBLICATION SUMMARY

1. NASA TECHNICAL MEMORANDUM

This report was prepared from a paper presented at the ASA National Annual Meeting, August 16-19, 1982, at Cincinnati. A version of this report was also submitted to the ASA for consideration for publication in the Quarterly Journal, Technometrics. The editor has suggested revisions to the paper that are not acceptable to the authors and it has been decided to withdraw the paper and submit it for publication in Communications in Statistics, B, Simulation and Computation.

Smith, O.E., S. I. Adelfang, and J. D. Tubbs, 1982: A Bivariate Gamma Probability Distribution with Application to Gust Modeling. NASA TM-82483, NASA George C. Marshall Space Flight Center.

Abstract

A five-parameter gamma distribution (BGD) having two shape parameters, two location parameters, and a

correlation parameter is investigated. This general BGD is expressed as a double series and as a single series of the modified Bessel function. This general BGD reduces to the known special case for equal shape parameters. Practical functions for computer evaluations for the general BGD and for special cases are presented. Applications of the general BGD are to be found in reliability theory, signal noise, and meteorology. In this paper, applications to wind gust modeling for the ascent flight of the Space Shuttle are illustrated.

2. PAPER FOR AMS/AIAA MEETING

This paper, submitted in February 1983 for presentation in June 1983, will be published in the Proceedings of the Ninth Conference on Aerospace and Aeronautical Meteorology at Omaha, Nebraska.

Adelfang, S. I., and O. E. Smith, 1983: Information Retrieval from Wide Band Meteorological Data; An Example

Abstract

The advent of the NASA Jimsphere FPS-16 nearly 20 years ago represented a significant improvement in the resolution and accuracy of winds aloft measurement systems (Eckstrom (1965), Camp (1971)). Retrieval of pertinent information from these profiles for vehicle design, preflight simulation, and post-flight evaluation requires special analytical tools. Samples of Jimsphere profiles are currently being analyzed to obtain an improved understanding of the probability distribution of wind profile perturbations and associated length scales. In an earlier paper (Smith and Adelfang, 1981), new concepts for analysis of wind perturbations in Jimsphere wind profiles are described. Digital filters are used to extract wind

component perturbations in various wavelength bands and a model is proposed for absolute component gust amplitude and gust length based on the bivariate gamma distribution. A new set of results is presented herein for sets of band-pass filtered profiles with essentially nonoverlapping wavelengths. Smith et al. (1982) suggest methods for estimating probabilities over different geometrically shaped regions within the domain of bivariate gamma distributed variables. In this paper, these methods are used to calculate probabilities over rectangles and sectors of the gust magnitude-gust length plane; probabilities over the same regions are also calculated from the observed distributions and a comparison is presented to illustrate the accuracy of the statistical model. These and other statistical results are calculated from samples of Jimsphere wind profiles at Cape Canaveral, Florida (KSC). The results are presented for various wavelength bands, altitudes, and seasons.

RECOMMENDATIONS

The climatological analyses and development of the vector wind gust model for the Space Shuttle launch environment have been primarily concerned with the Cape Canaveral, Florida, launch location. As the Space Shuttle program evolves beyond the flight test phase, a significant number of launches will be from Vandenberg Air Force Base (VAFB), California. In anticipation of these launches, there is a requirement to obtain a better understanding of the launch environment at VAFB. Preliminary analyses of wind profiles have indicated that wind perturbation magnitude and temporal variability are larger at VAFB; therefore, launch constraints imposed by wind may have a stronger impact at VAFB. It is recommended that further studies of the winds aloft environment at VAFB be initiated with the aim of developing more realistic launch rules and constraints.

The proposed studies would include further development of mathematical probability concepts for description of the wind perturbation environment for launch vehicles. The proposed studies would include the following tasks:

- Development of new concepts in wind gust analysis for description of the STS launch environment
- Calculation of vector wind model parameters from sample data at Vandenberg Air Force Base for seasonal reference periods and comparison with existing statistics for Cape Canaveral
- Comparison of the vector wind gust model with other gust models used in aerospace engineering
- Examination of examples of skewed bivariate distributions in aerospace science and representation of these distributions with the bivariate gamma distribution
- Analysis of existing NASA and Air Force tower data for utilization in describing ground winds for STS launches
- Establishment and documentation of computer codes and gust models for practical application and use on NASA computers.