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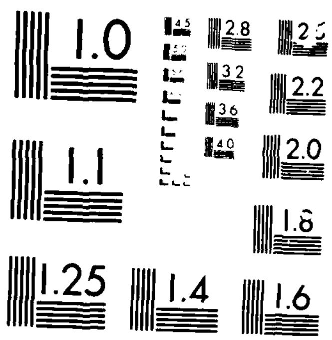

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ULTRAVIOLET STUDIES

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AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
HANSCOM AIR FORCE BASE, MASSACHUSETTS 01731

This report has been reviewed by the ESD Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS).

This technical report has been reviewed and is approved for publication.

PAUL TSIPOURAS
Contract Manager

FOR THE COMMANDER

LT COL J.E. Holdner, Director
Research Services Division

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This paper describes the technical and software procedures provided by Rio Grande Associates for the Air Force Geophysics Laboratory at Hanscom Air Force Base in Lexington, MA for Contract Number F19628-81-C-0128.

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1.0 INTRODUCTION

1.1 Overview

This paper describes the technical and software procedures provided by Rio Grande Associates for the Air Force Geophysics Laboratory at Hanscom Air Force Base in Lexington, Massachusetts for contract Number F19628-81-C-0128

1.2 Outline

The report is divided into fourteen sections. The first is an introduction to the report. The second covers analysis and numerical solutions for systems of differential equations. The third covers solar ultraviolet transmission. Section four deals with frequency propagation. Section five covers the study of an integral differential equation. The sixth section encompasses radar intensity of a flat beam incident on fibers. Ultraviolet radiation due to solar sunspots is covered in section seven. Electromagnetic properties of a simple diode circuit are covered in section eight. The ninth section deals with sonde data with balloons. The tenth section covers oceanic geoids and the Earth's gravity field. Computer assistance is described in section eleven. Section twelve covers the new NOS system on the Cyber at AFGL. Section thirteen entails the work done on an ultraviolet transmission problem. The last section, section fourteen, covers the VAX computer center at AFGL.

2.0 ANALYSIS AND NUMERICAL SOLUTIONS FOR SYSTEMS OF DIFFERENTIAL EQUATIONS

Some of the projects addressed:

a) modification of some Bessel function evaluation subroutines,

b) implementation of a spline interpolation program,

c) a search of literature on current multidimensional algorithms,

d) analysis of some approaches to solving a quasilinear diffusion problem.

Several optimization algorithms were evaluated. Included among these were: Powell's method, Fibonacci search, Davidson-Fletcher-Powell algorithm and gradient search. Work on longitudinal intensity variation of a flat incident beam-4 medium fiber programs and plots were expanded and completed. New approaches were tested to extract data from a relatively bad data source. Analog data was digitized and various signal slope analyses were attempted.

A set of assembler programs for transferring Honeywell 316 source files on magnetic tape to a PDP-11, operating under RSX-software, for the Honeywell-316 computer was edited, and archived to disks on the PDP-11. Source programs created on the PDP-11 greatly reduced the program development cycle time. The H-316 source files were transferred to the H-316 for actual assembly and execution. Assistance in mathematical analysis and programming was provided for a problem requiring the estimations of the first three derivatives using a set of discrete observations. A comparison of methods, both theoretically and numerically, was undertaken using real and simulated data. The method under study was a collocation of polynomial techniques, a cubic spline method and a least square method. Additionally, recursive methods were investigated (i.e., recursive cubic spline), as were methods appli d after a preliminary least square smoothing.

The study of the estimation of the univariate probability distribution from a finite sample of a stochastic process and the effect of the temporal correlations on the estimates were done. For a Gaussian process, a theorem was proven that demonstrates the monotonic relationship between the correlation and the variance of the empirical distribution via simulations of random processes.

A study of the method of solutions of integral and integro-differential equations that occur in electromagnetic theory was prepared. Special emphasis was given to the equations that occur in the scattering and radiation problems. The study includes both analytical methods (such as iterative schemes of the Born approximation type) and numerical techniques (such as the moment method and point-matching technique). Special attention was directed toward the formulation of electromagnetic problems in the form of integral equations.

Another focus was the formulation of electromagnetic problems in the form of integral solutions. This involved the study of the Strattin-Chu solution, the Schelkunoff Equivalence Theorem and the derivation of the electric and magnetic field integral equations (EFIE and MFIE, respectively). Integral equation formulation, both in the time and frequency domains, were studied with emphasis on those based on the electric field and magnetic field integral equations. The solution of these equations by the method of moments was investigated as were the mathematical foundations of this technique.

Work on this project proceeded along two fronts. First, a summary of the work performed was written. This summary involved extensive analytical mathematics to prove the existence of finite solutions of the singular differential equation. In particular, it was established that any solution of the equation can be constructed by a linear combination of the two fundamental solutions generated numerically. The second aspect of the work is a graphical and numerical investigation of the various solutions of these linear combinations. The goal here is to choose a particular combination which was predefined in the beginning of the job. Work entailed cosmetic changes on a multiple regression program to facilitate interactive use. A binary deck was created from this package.

After the graphical and numerical investigation of various solutions of the integro-differential equation was completed, a report summarizing both the numerical and graphical results as well as analytical results was written. Also included in this study of solutions of integral equations was an investigation of the use of conformal mapping, in particular, the Schwarz-Christoffel transformation, for the transformations of complex geometrics into simple geometrics. These transformations were to be used in the solution of two-dimensional boundary value problems. An investigation of the use of Green's function methods for solving inhomogeneous differential equations was also done. The emphasis was on the vector equations of mathematical physics. Emphasis was placed on Fredholm equations, the Hilbert Schmidt theory and also numerical techniques. Integral equations that occur in electromagnetic theory were analyzed using the Galerki's method and the method of moments. In addition, programming assistance was provided for a curve fitting problem. This was an algorithm for a seventh order polynominal. The program was applied to some experimental data. The investigation of the problems that arise in estimating the probability distribution from a finite sample of a stochastic process was studied. The case of the Gaussian process was used to study the effects of correlations on the variance of the empirical distribution function.

3.0 SOLAR ULTRAVIOLET TRANSMISSION

Software for the Control Data computer at AFGL was designed to duplicate the data analysis capabilities of NASA's SIGMA 9 computer. The first phase of the programming task involved the accessing and manipulation of complex magnetic tape data files. Data was collected for a presentation at Goddard Space Flight Center. Calculations using analytical formulas of solar distance were done. Several "test" programs were written, entered, edited and executed interactively on the AFGL Cyber 750. Also many programs were run by batch from a terminal. Parts of one program were changed so that it could run on the CDC 6600. Cards were punched to submit various computer programs dealing with the ionospheric range. The numerical results were plotted. Data was also plotted from the results of the ultraviolet radiation experiments. Once this was done, the data was drafted and prepared for publication.

Several tapes containing Atmosphere Explorer Satellite experiment data from Computer Science Corporation were received and copied onto the AFGL Computer Center tapes. This data was analyzed and plotted on the Calcomp plotter. The drafted charts show the relative flux intensity of several EUV spectrum lines, Including HL-O and LY-O observed by the satellite for 1979 and 1980.

Collaboration was done with AFGL scientists to create a program that performs regression analysis of experiment data. The program was debugged and tested.

Modifications were done on an existing program that analyzes models via data comparison for optical depth. The testing and debugging of the program was completed. This comparison of optical depth uses data from EUV satellite experiments.

Tapes received from Goddard Space Flight Center were transfered to AFGL Computer Center tapes. The development and execution of a program to change some EBCDIC data to binary data was done. The programs that analyze EUV satellite data were tested and debugged.

Analysis was accomplished for EUVS satellite data from a few programs that operate on the SIGMA 9 computer to programs that run on the CDC computer.

Synthesis was completed of detailed spectra for solar EUVS transmission. This was based on all of the existing observed data bases and the theoretical knowledge of certain relationships of solar physics. All this work was aimed at creation of reference files for aeronomical applications, including variations of solar EUVS irradiance for all phases of the present cycle of solar activity (sunspot cycle #21).

A program was written that performs interpolation on orbit-altitude data from Atmosphere Exlorer satellite experiments. Extensive testing was done on another program that performs absorption analysis on data from EUVS experiments.

Final phase activities on Daily Solar Indices Data was developed, and then completed. Tasks included report generating, proofing, editing and light programming of numerical data. Two programs were created.

The first program, program 'A', stripped out two specific data fields. Calculations were made on these two fields and the result was stored in an output file. The second program, program 'B', stripped data from an additional data file. The stripped data was merged into the output of program 'A' that created the final Daily Solar Indices File. The final formatted file was printed, bound and delivered.

4.0 FREQUENCY PROPAGATION

The study of one-dimensional acoustic bulk wave propagation in an anisotropic piezoelectric media was done. Using a given set of equations, the frequencies of wave propagation as a function of temperature and crystal orientation was determined. The object of this study was to develop numerical routines for optimizing these frequencies in various ways.

A FORTRAN program was written that determines the boundaries between turnover and no turnover regions in each of the three modes of the frequency propagation. Also for a given Θ and Q and A; the program calculated

$$I(O,Q) = \int_A^B 1RFD1$$

Where $RFD = 1F(X-25) + 2F(X-25)^2 + 3F(X-25)^3$.

The above is all preliminary to the construction of a program, PRESCAN, to minimize I(Θ,Q) over the two regions for each mode.

After PRESCAN was written, more modifications followed. A new program, COUPLX, that calculated the coupling constant associated with the angles and the temperature frequency coefficient found in PRESCAN, was developed. This involved taking the eigen value and the eigen vector of the matrices associated with the angle for the cut quartz crystals. These results were then plotted for comparison with reference material.

We utilized our two previous programs (the minimization program and the coupling constant program) to find coupling constants at minimum points of the RFD curve. Results were plotted and checked for accuracy with published material.

This project involves numerical calculation of various properties of quartz. The resonance temperature sensitivity of different double rotated cuts (i.e., cuts which are specific by two rotation angles, Θ and Q), was investigated graphically. The sensitivity was measured using an integral of the relative frequency change. The value of this integral for fixed Θ was calculated for Θ in the range of 0 to 90 degrees, and plots were created. In this fashion, a set of graphs were generated for Θ in the range of 0 to 60 degrees, in increments of 10 degrees. These provide a good representation of the temperature dependence and indicate the presence of several local minima of sensitivity for all three modes.

In order for a minimum to be useful, it must also satisfy other criteria. One of these criteria is based on the piezoelectric coupling constant. For this reason, a companion set of plots of the coupling constants versus angle was created for all three models.

The graphical study of the temperature dependence of quartz resonance frequencies demanded a set of graphs to be generated for the temperature range of -40 to 80 degrees.

This first set of graphs indicated the cut angle for several local minima of sensitivity. The relative frequency difference curve for these angles were then calculated and plotted.

The behavior of the piezoelectric coupling constants for the 3 modes was investigated in the neighborhood of the newly discovered cuts. This led to extensive calculations which were all plotted. All of this work was delivered to the project conference at which time additional work was outlined.

During a conference that was held with other scientists, it was decided that a report of this work should be written up. This was done after the completion of a last project.

Our previous work demonstrated that the standard cuts of quartz had the minimum temperature sensitivity. The question that was next investigated was, are the effects of minor deviations in the cut angle for the AT type good? For this purpose, a minimization program was written and was used to accurately determine the minima for the AT type cuts.

The investigation of quartz temperature sensitivity was broadened to include different measures of sensitivity, with a maximum slope criterion. Graphs of this measure versus cut angles were created. The cut angles that minimize this criterion were accurately determined and plotted. Another graphical and numerical investigation was also performed using a range measure of sensitivity.

The temperature sensitivity of quartz was investigated between two modes. The cut angles that minimize this sensitivity measure were accurately determined and plotted.

Previous work determined the cut angle of quartz which minimizes various measures of temperature sensitivity. These minima were investigated further by calculating coupling constants and separation between modes and also by plotting.

An effort was made in two areas. First, a graphical and numerical investigation of quartz plate resonance was done using a difference measure, with model frequencies.

Second, work was performed in finding a cut of quartz with stable temperature characteristics. Additionally, this report contains a summary of the theory of piezoelectric plate vibrations, the approximations made for quartz plates and the phenomenological theory of temperature effects on the nodal resonance.

The draft version of the final report on the temperature sensitivity of quartz resonance was written. This report contains a summary of the theory of piezoelectric plate vibrations, the approximations made for quartz plates, and the theory of the temperature effects on the nodal resonance. The extensive numerical calculations have been summarized and presented in a set of desirable temperature behavior and discusses their relative advantages and disadvantages.

5.0 THE STUDY OF AN INTEGRO-DIFFERENTIAL FUNCTION EQUATION

This problem was to study an integro-differential function equation with both advanced and retarded arguments that come from considering the physics of charged particles in the earth's atmosphere.

A number of specific cases of this general equation are important - a constant coefficient, an integral equation and a difference equation with no integral of differential terms - all with advanced arguments. The equations were to be studied on both semi-infinite intervals and finite intervals with a view towards determining if solutions to differennt types of equations on adjacent intervals can be pieced together to accurately predict the flux over the combined interval.

Techniques used included finite interval and half range Fourier transformations, Green's functions, setting up the equations as operators on functions spaces and using functional analysis to determine their spectral properties, approximations and other special analytic techniques that were developed to provide information on the solutions of the equations and their properties.

Two different expressions for the solutions of the pure finite difference equations were studied to determine how they differ and how the convergence of the two expressions compare. A number of special cases of this general equation were found to be important, i.e., a constant coefficient, an integral equation and a difference equation with no integral or differential terms.

All had advanced arguments. The equations were to be studied on both semi-finite and on finite intervals with a view towards determining if solutions to different types of equations on adjacent intervals can be pieced together in order to accurately predict flux density over the combined interval. After studying the different ways of constructing solutions to the finite difference equation

$Y(E) = S(E) + E\ D\ (E + L)Y(E + L)$

to see which ones can represent physical solutions and to try and understand the relation between the different methods, our conclusions were as follows:

If S(E) goes to zero fast enough relative to the functions D(E) as E goes to infinity, then the solution of this finite difference equation postulated by the initiator does converge. (One such criteria is the S(E) vanishes past a certain point.)

The solution in this case is unique in the sense that there is no other solution which goes to zero just as fast or faster. However, the possibilities still exist that there are nonnegative, integrable solutions which do not go to zero as fast.

After this conclusion was established, we studied the possibilities of generalizing the results obtained earlier for a functional integral equation with a special kernal to such equations with more general kernal. We also spent a good deal of time organizing all the previous results and a report was written.

6.0 RADAR INTENSITY OF A FLAT BEAM INCIDENT ON FIBERS

This problem involved the calculation of intensity variations of a flat beam incident on various optical fibers. The problem was to calculate longitudinal and radial intensity variations of the beam. The intensity was calculated as a function of radius and a longitudinal coordinate, Z. It is periodic in the latter variable. By evaluating incrementally defined expressions for I stated in terms of definite integrals involving I, J, K and Y Bessel functions, the period of I was determined and plotted for I versus the radial coordinate, for increments of Z generated.

Coding and debugging for the preliminary stages of the problem was the first step that was completed. The next stage was to code a program for the determination of intensity I and generation of a plot.

All of the various cases dealing with laser intensity when traveling down an optical fiber were done. Part A and the variations therein dealt with the 2-Medium Fiber, 2-Mode Case. The results of this part were computed and plotted. The period of Part B, which was a 2-Medium Fiber, 4-Mode Case, was calculated and plotted, along with varying intensities for a large range of two values. A similar procedure followed in Part 1, which dealt with the 5-Medium, 4-Mode Case. All results that were checked from other programmers' work in this area agreed. Each case consisted of different numbers of modes and types of mediums of fibers. The sum of a number of terms of Fourier were also plotted in order to produce different graphs of truncated Fourier Series. After another error was discovered in the original model, more changes were made to Part 1. The final results were calculated.

7.0 ULTRAVIOLET RADIATION DUE TO SOLAR SUNSPOTS

This study included analysis and numerical study of the ultraviolet radiation induced from solar activity during the contemporary sunspot cycle. Work included error checking of E. M. printouts, preparation of materials for meetings and an analysis of atmospheric data using a Texas Instruments programmable desk calculator. The preparation that was done for the international meetings that were held in August, 1981, consisted of organizing, editing, xeroxing and collating the proper materials.

Some of the materials included graphic layouts for future publications, sorting and filing EUVS data received from Goddard Space Center, and checking on the Sigma 9 sunspot data.

Other tasks completed under this project were the drafting of different plots and graphs for satellite data, calculations and statistical work, investigations of different methods of analysis, proofreading of papers, and plotting of solar cycle information.

Work on this project entailed mainly the drafting of plots and graphs. A bibliography was written for several papers that were to be published within the following years. Other work done included sorting out publications and calculating vector spaces. Work consisted of cross reference indexing done on all of Dr. Hinteregger's papers, articles and manuals. Also some calculations for several plots were completed.

Literature concerning the research of ultraviolet radiation from the sun and its effects on the earth's atmosphere was organized. All of the published work by Dr. Hinteregger was put in chronological order with indexes. Tapes, programs and data from Goddard Space Center were processed. This required familiarization with tape reading and writing, due to the obscure fashion in which the tapes were written. Time was spent becoming familiar with the Sigma 9, the AFGL CDC computer systems, and also with the analytical and numerical techniques for treating ultraviolet radiation satellite data. Some programming and troubleshooting was necessary. The programming project focused on the development of in-depth tape directory listing and the manipulation of solar data files.

The Sigma 9 EUVS account was kept up to date. Programs were written to generate numerical solar data files. These files were then proofed, edited and backed up onto tapes at Goddard Space Center. The project entered an analytical phase in which a program to analyze the data based on various algorithms was created.

8.0 ELECTROMAGNETIC PROPERTIES OF A SIMPLE DIODE CIRCUIT

This problem was to provide mathematical modeling support to RADC/EEC's in-house effort. Tasks were directed through discussions with RADC staff, including any necessary software that was developed and delivered. The study of the electromagnetic properties of a simple diode circuit with both a sinusoidal applied voltage and an RSG voltage due to an antenna was started. The diode was modeled by a parallel combination of a capacitor and a non-linear resistor. With this model, a non-linear differential equation was derived for the circuit. This equation was solved to second order by a Volterra series technique. A manuscript detailing this solution was written and given to the initiator. The extension of this solution by a third order Volterra series analysis was also undertaken.

The Volterra series solution of the resulting non-linear differential equation was extended to the third order. A manuscript with this extension was written and given to the initiator. FORTRAN coding of this solution so as to produce graphical and numerical output was also done. After a focus on the effort had shifted to the computer simulation of the third order Volterra series solution, a program was written to calculate the antenna impedance from audio frequencies up through the third resonance. This computation utilized Schelkunoff's method in the vicinity of the resonance and the short dipole method at a longer wavelength. Using this realistic antenna model, the simulation of the Volterra series solution was accomplished.

The initial phase of the computer simulation of the third order Volterra series solution was completed. This program included accurate theoretical models for both the antenna impedance and effective length. Numerical data as well as graphical data were created for the first, second and third order transfer functions. A second program was written to calculate the current in the antenna and the scattered power at all the frequencies generated by the non-linearity. Refinement of the diode model was included.

Three FORTRAN V plot programs were written for the Volterra series terms: linear, quadratic and cubic series. They range from 0.0 HZ to 1.5 GIGA HZ. The three were merged into one large program in order to plot the three series adjacent to each other so that they could be easily compared. The plots were not accurately scaled because the frequency spread was too great to display on one page. Instead, an eye approximation of the frequency positions was used to portray the idea behind the research that was done. The final plots were generated on the Calcomp plotter at AFGL for a published paper.

Another aspect of this project was to focus on using a standard shieldroom. The electromagnetic properties of a simple diode circuit with both a sinusoidal applied voltage and an RC voltage due to an antenna were investigated. This was modeled using several simplifying assumptions, especially the approximation of the diode by a switch. A Fourier representation of the antenna current was obtained for the antenna in series with the diode. This category includes certain non-linear equations. The programs will emphasize the graphical presentation of the solutions.

9.0 SONDE DATA WITH BALLOONS

This project involved processing meteorological data from several balloon flights and reduction of that data. The final results were presented as graphs of the fluctuations of the index of refraction versus altitude in a comparison of several different measuring techniques. In addition, experimental results and a theoretical model were compared.

The first step was to process the meteorological data from the balloon flights. The raw data was stored on magnetic nine-track data tapes in the form of digitized radiosonde signals. It was checked for time errors. This data was then unpacked and transformed into a form that was more accessible to subsequent processing, i.e., the data tape was converted to a permanent disk file. The next stage of processing involved the computation of relevant quantities from the frequency data. This stage was imperative, in the sense that pressure and the computations are then refined. Reduction and smoothing of the thermosonde data from the flights was done. Several plots comparing the thermosonde value versus the model value were generated.

The analysis of one flight was completed which included correcting the raw data for pressure errors. The data reduction scheme for this corrected data consists of both graphical and numerical output.

Graphs of index of refraction versus altitude comparing Van Zabdt model and experimental data were also done.

A program was created to analyze balloon flight data, plots of relative humidity and temperature versus altitude of the balloon. A program was created to compute dry radar values from radar data.

The processing of meteorological data from balloon flights was prepared. Preliminary analysis of six flights was completed, including correcting for time and pressure errors and generation of graphs. Additional analysis of these flights and the preliminary analysis of additional flights was done.

The final results were presented as graphs of the fluctuation of the index of refraction versus altitude in a comparison of several different measuring techniques. In addition, experimental results and a theoretical model were compared.

Preliminary analysis of a total of twenty flights was completed. Correcting for time and pressure errors and generating graphs was also done. For the five flights that did not have thermosonde data, the additional analysis was completed. For the remaining flights with thermosonde data, further treatment of this data was required, using a new program that was developed.

Several programs that generate plots of balloon data were created and executed. The plots consist of values: speed versus direction of wind data, temperature, and humidity of Hawaii data files. Also, a calculation of a smoothed value for every 500 meters and a merge of this value with the orginal Hawaii data files to create new files was done.

A second phase of analysis of thermosonde data was completed for all flights. In addition, a program to calculate derivatives numerically via a cubic spline was written.

A new method of analyzing and treating thermosonde data was initiated and several flights were processed. In addition, the initial treatment and unpacking of the raw radiosonde data of four new flights was completed.

The data reduction of 19 flights was completed. This included the correction of time errors, pressure errors and thermosonde errors due to baseline drift. The end-product of this processing was a series of graphs and numerical tables of corrected meteorological data and the atmosphere index of refraction structure parameter. The initial processing of 17 new flights was done next.

During the processing of meteorological data from balloon flights, the data reduction of 19 flights was completed. This included the time, pressure and thermosonde error corrections. The end-product of this processing was reduced and processed. Xerox copies of the output were made. The final representation was put in graphical form and all data was stored in nine-track tapes for the AFGL CDC computer.

The early work in this project was done using the lengthy process of data encoding and decoding on large magnetic tapes. The idea of creating a smaller data manipulation package was proposed by the company. This was accepted, and the project was started. The data manipulation package consisted of programs written on the IBM PC and involved extensive modification of a system designed by Beukers Laboratories, in order to include thermosonde measurements. The initial phase of this work involved the study of the existing programs and their analysis methods and the reconstruction of the logical flow, with special emphasis on the acquisition of meteorological and wind data. Coding of new subroutines to perform the data acquisition was done.

The design and programming of a software package for the IBM PC was created to perform real-time analysis and display of balloon flight data. A collection of subroutines were written, including meteorological and wind data aquisition, pressure, temperature, humidity and switch resistant calculations. An assembly language graphics scroll routine was also coded.

Subroutines were also implemented to perform temperature, humidity, pressure and switch resistance calculations. An assembly language program was written to display the temperature, pressure and humidity.

Work was done to the main program to perform thermosonde calibration and on subroutines for the inflight program to perform the calculation of the index of refraction structure factor and its display.

The main program to perform thermosonde calibrations, incorporating graphics display and interactive decisions, was completed and debugged. The inflight program was expanded to include subroutines to calculate electronics temperature, and to calculate and display the refractive index structure constant. In addition, disk output of all the calculated quantities was incorporated. The package of preflight programs, calibration programs and inflight analysis and display were chained together to form the prototype executable analysis package. Work was begun on including the Loran data into the inflight analysis and display.

Efforts focused on implementing wind velocity and balloon position calculations from the Loran navigational signals. Algorithms to acquire the Loran data, smooth it and complete balloon positions were implemented into the inflight analysis program. Simple, preliminary velocity estimates were also encoded and a velocity display subroutine incorporated in the inflight program. Work was under way to allow selection of any of the 13 worldwide Loran chains for use in position and velocity computations.

A preliminary form of the package was completed and tested. This package includes an option for selecting any of the Loran chains for use in position and velocity calculations. To accomplish this, a completely revised preflight program was written and debugged. The complete package of programs was also edited and changed so as to enable error trapping. Subroutines were coded and rendered operational which intercept hardware and software errors and thus increase the reliability of the software.

A new algorithm for wind velocity measurement from Loran signals was designed and implemented. A comparison of this new method with a position differencing method was performed and a theoretical analysis of the errors and accuracy was also made. Additional major effort was devoted to the coding of altitude calculations using meteorology. Further refinement and fine tuning of the package of programs was also performed; for example, a scroll down routine was devised and coded in assembly language and implemented in the real-time display.

Work was done on the post flight analysis programs. This effort included the interfacing and programming of a H.P. (HEWLETT PACKARD) pen plotter and an I.D.S. Prism Color/Graphic printer. An interpolation algorithm to fill in the missing altitude data was devised and programmed. Various altitude plots on the H.P. were programmed, including altitude versus humidity. The raw data was also used to initiate in running logarithmic average using a .5 km sliding window. This average was then plotted on the H.P. as well as the screen. The standard deviation of this average was also computed and used to plot confidence intervals.

An overview of this project was to design and program a software package for the IBM PC to perform real-time analysis and display of balloon flight data. The effort was in two areas. First, work was done on preparing a version of the programs to be used for demonstration purposes for AFGL visitors. This version utilized built-in information. Several such demonstrations were made. Second, work was done on extending the post-flight analysis. The Prism printer was set up in graphics mode to generate strip charts of CT versus time for both high and low gain channels. The analysis of wind speed and direction versus altitude was implemented. In addition, the wind speeds were used to implement the calculation and display of the Hufnagel Model of time versus altitude. Finally, an algorithm to compute wind speeds using a least square parabolic fit of position was devised and written.

10.0 OCEANIC GEOID AND THE EARTH'S GRAVITY FIELD

Development of a technique to represent the oceanic geoid and the earth's gravity field was pursued. In processing the satellite SEASAT ocean surface altimetry measurements at AFGL, the input geoid was considered as the sum of the Standard Reference Eclipse and a 14 degree spherical harmonic field. This processing resulted in anomalies representing higher degree corrections to that input geoid for the earth's ocean surface. These anomalies are said to be accurate to possibly a quarter of a meter. Indeed, as expected, they show a remarkably high correlation with the topography of the ocean floor.

In addition to determining the shape of the geoid, another fundamental role of geodesy is to determine the earth's gravity field. Geoid anomalies are functionally related to variations in the gravity field. The gravitational variation calculated for the above mentioned geoid anomaly is the correction to the gravity field as calculated for that input geoid. Two techniques to be used for calculating the variation are: a) the Molodenskii integral (Molodenskii, Eremeev and Yurkimi, Eq. 111. 2-4, 1962) and b) the fundamental equation of physical geodesy (Heiskanen and Moriti, Eq. 2-154, 1967).

In the processing of the SEASAT satellite altimetry measurements at AFGL, the geoid was considered as a summation of the Standard Reference Eclipse and a 14 degree spherical harmonic model. The processing thereby resulted in separations (residuals or anomalies) related to that input geoid for the entire ocean surface. These separations for the geoid are, in turn, functionally related to variations or anomalies in the earth's gravity field. During this period the main effort was investigating the two two-dimensional based techniques for calculating gravity anomalies.

In a prior study, the geoid variations available were along an arc or segment of the satellite track with spacing of 26 kilometers. For two selected tracks, data were made available at increments of 3 km. Gravity anomalies were again calculated and tracks of data were made available at increments of three km. Gravity anomalies were again calculated and compared to the earlier calculations. The agreement is good but the later calculations have a much higher noise level.

In one of the techniques, these calculations are inversely dependent upon the square of the distance between the point of the calculation and the points where the geoid separations were measured. Hence, the closest points have the most influence and, should they have small background noise, this technique is a bit too sensitive.

During the next period of research on this, tape CC 341 was remade. This tape contained corrections for the 14 spherical harmonic geoid model. This tape was made new because of difficulties in retrieving the stored data and also to modify the computation of the adjusted mean for the corrections. The latter is now that mean when measurements greater than one sigma are omitted.

Processing for selected locations in the mid-Atlantic region were made. Gravity calculations were done using all of the measured geoid corrections. Those having only the one qualified for a lengthy arc and not suspected of having noise were used. The results were compared. No significant discrepancies were noted.

The gravity calculation program was duplicated. A subprogram was added to the copy to generate artificial geoid corrections. These later corrections will be made by sampling a sum of Bessel functions. Processing of these corrections can measure the correctness and quality of the gravity calculations.

During this period, the study of calculating gravity anomalies in the Atlantic region continued. The areas of study were the ocean surfaces near Puerto Rico and the Falkland Islands, in accordance with the following:

(a) using all the AFGL determined measurements of geoid height corrections;

(b) repeating the calculations but omitting those measurements when they were determined from a short satellite arc (less than $2\frac{1}{2}$ minutes) or being labeled as possible noise.

No significant disagreements were noted in the comparison of the calculations for steps (a) and (b).

A previously written program to compute gravity anomalies related to these filed geoid separations was then implemented to input the format of this later data. The preprogrammed gravity anomalies based on the Bessel Function are as expected. However, the added programming of the ring integration of the surface Molodenskii integration is in question. Preliminary processing was analyzed and processed.

The study of gravity calculations was done with several modifications made in the subprogram, FILL. This is the subroutine that fills and/or smooths "measurement" in subdivisions at and near the point of gravity.

The driver or main program was then extended to evaluate the integration by using either 48 or 24 subdivisions. It was mainly the finer subdivisions of 48 that needed assigned measurements for the inner most subdivisions.

The above programming requirements were done, tested and analyzed to determine the correctness and quality of the gravity calculation.

The most significant feature of the editing was the identification of spikes or erroneous measurements enclosed in a sequence of acceptable measurements. A good criterion appears to be that each measurement be less than two meters of the average of the two nearest or neighboring measurements.

Should a measurement fail this test, then it would be retested against both neighboring points to determine if that difference is within a meter. The displacement of the measurements was approximately 26 kilometers in lateral distance. If both of the above requirements fail, that measurement would then be considered questionable.

The measurements were then sorted and filed in increments of 12 degrees in latitude. The tentative or first area selected for study was from -72 degrees to +72 degrees North latitude for the region of the Atlantic Ocean. This data was then set on to twelve files. These are currently stored on tape.

The primary basis for the outline was the geometry for the three-dimensional gravity model. This model requires that all measurements be used that are within a twelve degree radius to the point of the gravity calculation.

Only three of the above files needed to be searched to find the geoid anomalies inside a 12 degree radius of that point. This reduced the search time by one-eighth of the time that it took in an earlier study. The data in these files were put in blocks of up to 100 sets. Each set contains the measured geoid anomaly, its latitude and longitude, and the mean of these measurements for the satellite track or arc in which it was contained. These were taken after the measurements with the largest variances were removed and a log indicating the quality was established: 1 = normal, 2 = from an extra short track, 3 = noise, 4 = both 2 and 3. During this phase, an outline or pattern was established for proceeding with calculation of the oceanic surface gravity anomalies corresponding to the AFGL measured geoidal anomalies:

(a) Several spikes were removed by hand editing;

(b) The tracks were adjusted such that the first and the last points of data were of nearly equal magnitude (one of the techniques is based on the Fourier coefficients);

(c) Fourier fit the data then rebuilt the data using only the lower harmonics;

(d) Use the four point Lagrange formula to fill in missing data points or to smooth out selected sections;

(e) Use every other point along the track (7 km spacing);

(f) Use a running average.

These adjustments have considerably lowered the background noise in the calculated gravity anomalies. However, there is still some noise.

The effort turned into the three-dimensional-based technique for calculating the gravity anomalies. It is the intent to calculate these anomalies for a one degree grid of the entire ocean surface. A program was implemented to provide a listing of the coordinates for such a grid. Another program was set up to sort the geoid separation data by ocean and in twelve degree increments in latitude from -72 degrees to +72 degrees North. This was explained previously.

In addition to determining the shape of the geoid, another fundamental role of geodesy is to determine the earth's gravity field. Geoid anomalies are functionally related to variations in the gravity. Thus, the gravitational variation calculated for the above mentioned geoid anomaly is the correction to the gravity field as calculated for that input geoid. Two techniques to be used for calculating the variation are:

a) the Molodenskii integral (Molodenskii, Eremeev and Uyrkimi, Eq. 111. 2-4, 1962) and,

b) the fundamental equation of physical geodesy (Heiskanen and Moritz, Eq. 2-154, 1967).

Calculations were repeated for both (a) and (b) by using a "mean" corrected measurement. The results are not as expected and suggest an error in the procedure for this calculation.

Detailed analysis of the calculations were made by direct integration of the Molodenskii integral and suggest the following:

(a) 90% of the calculated value is determined within three or four degrees to the observation point;

(b) this procedure is very sensitive since a 10% or 20% change at or near the observation point causes a 50 or 60 percent change in the calculated gravity anomaly.

11.0 COMPUTER AID AND ASSISTANCE: PROGRAM PORTING

Twenty-eight programs were transferred from the CDC Cyber to the VAX 780. The MUXX 200 emulator was used. Then the programs were rewritten using VAX/VMS EDIT/EDT, in order for them to compile and run properly on the VAX-11/780 at AFGL. When this was finished, the plotting calls in some of the programs were also changed in order for the programs to produce graphs on the AFGL VAX-11 dot matrix plotter. Other files were put on the CDC Cyber from magnetic tapes, and then sent over to the VAX-11 using the MUXX-200 emulator.

More magnetic tapes, which contained files from outside sources, were put onto the VAX-11/780 directly from the VAX-11 tape drives. These magnetic tapes were foreign to the VAX-11 so the tape copy utility, USER$LIB:TAPECOPY, had to be used. This utility may be used as long as the record length for each file is known. Unfortunately, this was not the case in this situation. Therefore, the recorded length for each file had to be guessed, until the correct one was found. This was done and all of the files were put on the VAX-11/780. A hard copy of each file was created for quick reference.

The next step for this project was to copy one of the directories on to a 6250 BPI magnetic tape in order for a scientist to have copies of his programs and files after they were ported from the Cyber to the VAX-11. Five files from an IBM magnetic tape were compared with nine files on the directory using the "DIFF" utility. This was done so that the scientist may delete certain files from the directory because he already had them on magnetic tape for storage.

A program used for plotting was modified so that the final program contained the option of using a probability scale or a linear one. After this was completed, the program, which was originally written to be used on the CDC Cyber with the Calcomp plotter, was rewritten so that it could be used on the VAX-11/780 with the plotting routine. Plots were error-checked on a VT125 and then hard copies were produced on a Tektronix 4115.

A sequence of commands was prepared in order to compile, link, run and plot a graph on the LXY-11 printer-plotter using the PLXY-11 software package on the VAX/VMS-11/780. A demoprogram was run in order to display a plot from the LXY-11 printer-plotter. Then several plots were made using the LXY-11 printer-plotter.

12.0 THE NEW NOS SYSTEM ON THE CDC CYBER

Work was done to make changes for the new operating system on the CDC Cyber at AFGL. It began with the familiarization of the current NOS/BE operating system and operating procedure of the computer center. Documentation on the new Cyber 170 computer which was recently installed and the NOS Version 2.0 operating system was studied. Assistance was also given to users in debugging their programs.

The new NOS Version 2 operating system was modified and several new programs were added to the current operating system. The Cyber interactive debug system was installed onto the Cyber. The routine PACK and COPTEI were modified on the NOS 2.2 to make them work on the NOS/BE operating system. Also modified and installed were: ULOADTP and RETRNTP.

The procedures IMSLPROC was modified to include compilation of IMSL routines by the FTN5 compiler. Documentation was written to instruct users on how to use routines of the IMSL tapes. A program was written that sorted AFGL telephones and data lines by category, number, and division.

The program routine REQTP was coded and tested in assembler code. This was to be installed and used by FORTRAN programmers to request magnetic tape drives from within their FORTRAN routines. When completed REQTP will be capable of processing sixty-three different parameters. Forty-five of the parameters were already decoded. The NOS 2.2 system routine, QAP, was corrected to generate output banner pages. There were also errors in the system file management routines, audit/purge, which were corrected. These errors have been the cause of unnecessary removal of files from the system.

The COMPASE routine REQTP was completed and documented. This routine will also allow FORTRAN users on the NOS 2.2 system to request the use of a magnetic tape from within their programs. Eighteen of sixty-three different parameters were coded to the new system.

The NOS/BE system routine LABEL was modified so that the default density for a nine-track tape is 1600 BPI. The Cyber Interactive Debug package was installed onto the NOS/BE system.

The NOS/BE Cyber Language package was updated to level 587. The PASCAL compiled on the NOS/BE system can be installed on the NOS 2.2 system.

Plot 10 graphics routines were tested and edited. TEK1 graphics software was converted from NOS/BE to NOS version 2.2.

The new NOS version 2.2 operating system replaced the old NOS/BE operating system at AFGL. Also a new hyper-channel was installed in order to transfer files from the Cyber to the AFGL VAX-11/780, and back again.

13.0 ULTRAVIOLET TRANSMISSION AT 2050 A

An ultraviolet transmission problem was introduced to the project. It entailed the calculation of the ultraviolet radiation transmitted to different elevation levels in the atmosphere from a source radiating at sea level. The equation for the total transmission at any point in the atmosphere was given as the sum of three integral equations, which contained function of the altitude and other various atmospheric conditions. The equation was solved for each specified level on the AFGL Cyber 750 using a FORTRAN program. The Trapezoidal Rule was used in the FORTRAN code in order to calculate the integrals. The results were stored in a computer file on the system. The next step was the creation of a graphics program that plotted the results of the initial program. The initial program solved the transmission equation eighty-one times at one meter increments, from 20 km to 100 km above sea level. The graphic program that was used utilized the Cyber plotting library calls. A written report was submitted with the graphed results.

14.0 VAX COMPUTER CENTER

This included the following work : Start up files were modified to reset the systems according to the proper specifications. Field services personnel were assisted in running error-log reports, performing system start up and shut downs and determining tasks to be completed during scheduled time periods.

Software assistance was also given during some of the software modifications to the systems. Help was given in establishing and modifying new accounts for ORACLE and ALL-IN-ONE. SPM and ACCOUNTING were used in an effort to project the best time for scheduled PM's. TIMER15 was removed from the system, and monitoring was done by the creation of in-house command procedures to provide system security. Other command procedures were developed to take on the task of ensuring that proper system processes continue to run at all times. Accounting files were closed and backed-up on a scheduled basis so that entry level operators are limited to a menu environment. Shared accounts of the operation staff provide a means of sending mail to each other. Work was completed on the modification of the utilities: DISKQUOTA, UAF, and QUEUE. A new back up procedure was developed for the lab personnel to run on the clustered nodes.

Support work was done through the contract on a monthly basis to do stand-alone back-ups, and to rotate five file volumes.

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