AFCRL-67-0444

GCA-TR-67-8-A

STANDARD ATMOSPHERIC SUPPLEMENTS, 1966

R. A. MINZER

GCA
CORPORATION
Bedford, Massachusetts

FINAL REPORT
PERIOD COVERED: 1 JULY 1966 THROUGH 31 MARCH 1967
CONTRACT NO. AF19(628)-6085
PROJECT NO. 5710

Contract Monitor
Frank A. Marcos
Upper Atmosphere Physics Laboratory

Prepared for
AIR FORCE CAMBRIDGE RESEARCH LABORATORIES
OFFICE OF AEROSPACE RESEARCH
UNITED STATES AIR FORCE
BEDFORD, MASSACHUSETTS

July 1967

This research was sponsored by the Defense Atomic Support Agency
Washington, D.C.

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Washington, D.C.

PREFACE

This Final Report is submitted in fulfillment of Contract No. AF19(628)-6085 monitored for AFCRL by Mr. Frank Marcos.

ABSTRACT

Tables of the U.S. Standard Atmosphere 1962 were computed and tabulated up to only 90 km as functions of integer kilometer values of both geometric and geopotential altitudes. The geopotential tables have now been extended to 120 km altitude. This extension involved the development of an empirical function relating geopotential to geometric altitude. A discussion of this function along with limited geopotential tables was prepared for the U.S. Standard Atmosphere Supplements 1966. This function has also been used to prepare more extensive tables relating geopotential to geometric altitude and vice versa up to 10,000 km for latitudes from 0 to 90 degrees. In addition, a computer method was developed for automatically generating multilayer atmospheric models which rigorously fit arbitrary upper and lower boundary conditions.

SECTION I

INTRODUCTION

Contract AF19(628)-6085 dealt with work performed in the fulfillment of the following five items of the Work Statement:

Item 1 - Develop, and program for computer, a method of generating temperature-density vs. altitude profiles which match temperature and density boundary conditions at two altitudes for the case in which the two altitude boundaries encompass a number of atmospheric layers characterized by an isothermal layer at the bottom, and monotonically increasing values of temperature gradient in the successively higher layers.

Item 2 - Expand the existing "U.S. Standard Atmosphere, 1962" by extending tables of the properties as a function of integral multiples of geopotential kilometers in the altitude region 90-120 geometric kilometers.

Item 3 - Develop a simplified function for relating geopotential and geometric altitude which would be in substantial agreement with the relationship used in the standard atmosphere while not having its complexity.

Item 4 - Prepare tables relating geometric altitudes at various latitudes through their equivalent values of geopotential.

Item 5 - Prepare text, graphs, and tables, which may be used in the "U.S. Supplemental Atmospheres, 1966."

While the five items of the Work Statement all fall within the general field of atmospheric models, each item posed a separate specific problem. Each work unit was performed independently and the results of each investigation were reported in a Scientific Report when that unit was completed. Consequently there remains no portion of the overall investigation which has not already been thoroughly reported.

The results of the investigation performed under items 2 and 3 were reported simultaneously in Scientific Report 2 (Ref. 1). The results of each of the remaining three investigations were reported in three separate Scientific Reports (Ref. 2,3,4).

The results of the investigations were reported almost in inverse order to the work-statement number as shown in the following table.

Work Statement Item	Corresponding Scientific Report Number
1	4
2&3	3
5	2
4	1

Because of the extensive tables in each of the Scientific Reports, no attempt has been made to present abridged versions of these reports as chapters in this final report. Rather, the remainder of this report consists of a reproduction of the Title Page, the Preface (Report 1 did not have a Preface), the Abstract, the Table of Contents, and the References of each of the four Scientific Reports. These are presented sequentially according to Scientific Report number. These reproduced portions provide in essence a summary of the work reported and also indicate its scope.

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2. Minzner, R. A., "Geopotential Versus Geometric Altitude from 0 to 10,000 Kilometers for Various Latitudes," GCA-TR-66-10A, AFCRL-66-786, Scientific Report #1 on contract AF19(628)-6085, October 1966.

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4. Minzner, R. A., "A Method for Fitting Linearly Segmented Multi-layer Atmospheric Models to an Arbitrary Set of Upper and Lower Boundary Conditions," GCA-TR-67-6-A, AFCRL-67-0198, Scientific Report #4 on contract AF19(628)-6085, March 1967.

AFCRL-66-786 GCA Technical Report No. 66-10-A

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GEOPOTENTIAL VERSUS GEOMETRIC ALTITUDE FROM 0 TO 10,000 KILOMETERS FOR VARIOUS LATITUDES

R. A. Minzner

GCA CORPORATION
GCA TECHNOLOGY DIVISION
Bedford, Massachusetts

SCIENTIFIC REPORT NO. 1

Contract No. AF19(628)-6085

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OFFICE OF AEROSPACE RESEARCH
UNITED STATES AIR FORCE
BEDFORD, MASSACHUSETTS 01730

ABSTRACT

Simple analytical relationships between geopotential H_ϕ and geometric altitude Z_ϕ for various latitudes ϕ are presented with the required constants for relating H_ϕ to Z, and Z_ϕ to H at each of eight latitudes 0°, 15°, 30°, 45°, 60°, 75°, 90°, and at the reference latitude R equal to 45° 32'33" which latitude corresponds to the standard sea-level gravity, 9.80665 m sec^{-2}. Values of $H_R(Z)$ were computed for geometric altitudes between 0 and 10,000 km: values of $Z_R(H)$ were computed for the equivalent range of geopotentials, between 0 and 3900 standard geopotential kilometers (km'). Computed values of Z_ϕ and H_ϕ for the other latitudes are presented as differences $(Z_\phi - Z_R)$ and $(H_\phi - H_R)$ as functions of both argument pairs $H_R(Z)$ and $Z_R(H)$, thereby leading to four sets of tables. Values of $H_R(Z)$ and $Z_R(H)$ are compared with the corresponding values from the U. S. Standard Atmosphere $H_S(Z)$ and $Z_S(H)$. These comparisons show the difference $(H_S - H_R)$ to be -33 meters at Z_R = 700 km, while the difference $(Z_S - Z_R)$ is shown to be 55 meters at the corresponding value of H_R = 630 km'.

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AFCRL-66-787 GCA Technical Report No. 66-12-A

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GEOPOTENTIAL - GEOMETRIC ALTITUDE RELATIONS

R. A. Minzner

GCA CORPORATION
GCA TECHNOLOGY DIVISION
Bedford, Massachusetts

SCIENTIFIC REPORT NO. 2

Contract No. AF19(628)-6085

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BEDFORD, MASSACHUSETTS 01730

PREFACE

In keeping with the considerable accumulation of atmospheric data above 30 km altitude, since the preparation of the U.S. Standard Atmosphere, 1962, the Committee on Extension to the U.S. Standard Atmosphere, COESA, of which the writer is a member, considered it prudent to prepare "U.S. Standard Atmosphere Supplements, 1966" which, unlike the existing Standard Atmosphere, contains tables of atmospheric properties for various latitudes as a function of geopotential, but with equivalent geometric altitudes only for 45° latitude. To relate these tables to the appropriate geometric altitudes at other latitudes required the preparation of a transformation table. Such a table and appropriate text was prepared by the writer for the inclusion in U. S. Standard Atmosphere Supplements, 1966. This technical report contains the transformation table and text for use in anticipation of the Government Printing Office Publication of the larger document. The numbering paragraphs, tables and figures follows that of the larger document.

The writer prepared the text and tables at the request of COESA, and made the preliminary investigations and ground-work study under the sponsorship of Contract NASw-1225. The final versions of table and text are presented here in fulfillment of the requirements of Item 5 of Contract AF19(628)-6085.

ABSTRACT

The influence of the acceleration of gravity on atmospheric properties varies with latitude and with altitude as the acceleration of gravity similarly varies with these parameters. One method for normalizing the variation of atmospheric properties with respect to the variation of the acceleration of gravity is to express the values of the atmospheric properties as a function of geopotential. The relationships between geopotential and geometric altitude are then used to apply the atmospheric data to the proper altitudes at any particular latitude. Tables of such relationships for altitudes from 0 to 1000 km for latitudes from 0 to 90 degrees are presented.

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AFCRL-67-0335 GCA-TR-67-1-A

EXTENSION TABLES FOR THE U.S. STANDARD ATMOSPHERE, 1962, WITH SPECIAL ATTENTION TO THE CALCULATION OF GEOPOTENTIAL

R.A. Minzner

GCA CORPORATION
GCA TECHNOLOGY DIVISION
Bedford, Massachusetts

Contract No. AF19(628)-6085

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Scientific Report No. 3

January 1967

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Frank A. Marcos
Upper Atmosphere Physics Laboratory

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BEDFORD, MASSACHUSETTS

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PREFACE

This report is submitted in fulfillment of items 2 and 3 of Contract AF19(628)-6085 monitored for AFCRL by Frank Marcos. It presents a set of tables consisting of an extension of the U.S. Standard Atmosphere in the altitude region of 90 to 120 km for which region tables had originally been published only as a function of integral multiples of one geometric kilometer. The tables in this report are presented as a function of integral multiples of one standard geopotential kilometer and includes a discussion of the various equations and constants involved.

This report also includes the development of a simplified function for accurately relating geopotential and geometric altitude.

ABSTRACT

The "United States Standard Atmosphere, 1962", was published with two kinds of metric-unit tables for the altitude interval from -5000 to 90,000 meters. One kind of table presented the atmospheric properties as a function of integral multiples of particular numbers of geopotential meters while the second presented the atmospheric properties as a function of integral multiples of similar numbers of geometric meters. For the region above 90,000 meters, altitude only one type of metric table was published. This type presented atmospheric properties in integral multiples of particular numbers of geometric meters. A similar situation prevailed for the English-unit tables. The need for both metric-unit and English-unit tables as a function of integral multiples of specific numbers of geopotential meters for altitudes above 90 kilometers has prompted a new set of calculations, which required the use of equations not specifically presented in the United States Standard Atmosphere, 1962. The development of these equations is discussed and the value of all constants employed are given. The calculations involve a transformation between geopotential and geometric altitude, and the development of an empirical analytical expression relating these quantities is presented. This empirical function yields results which differ by less than 0.1 meter at 700 km altitude, from those computed in an unspecified manner for the United States Standard Atmosphere, 1962.

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AFCRL-67-0198 GCA-TR-67-6-A

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A METHOD FOR FITTING LINEARLY SEGMENTED MULTI-LAYER ATMOSPHERIC MODELS TO AN ARBITRARY SET OF UPPER AND LOWER BOUNDARY CONDITIONS

R. A. Minzner

GCA CORPORATION
GCA TECHNOLOGY DIVISION
Bedford, Massachusetts

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BEDFORD, MASSACHUSETTS 01730

PREFACE

Atmospheric models are frequently generated for specific regions of the atmosphere in accordance with a particular set of observations. For example, for the region 20 to 90 km or for the region 120 to 100 km altitude. These models are not necessarily extended to sea level, neither are they designed to be continuous with some other existing model at either end of the included range. In some instances it becomes desirable to exactly connect two such models with a transition model atmosphere which for the examples cited would extend between 90 and 120 km. This report discusses a method suitable for generating such transition models.

ABSTRACT

Any set of temperature,pressure and density values which are realistic for one altitude can be exactly connected to another set of temperature, pressure and density values at a second altitude, with a model atmosphere defined by the appropriate linearly segmented two-layer temperature-altitude profile provided one of these layers is isothermal and the second is a nonzero constant gradient of temperature with respect to height.

The altitude comprising the intersection of the two segments of the required temperature-altitude profile is determined mathematically. The method for generating two-layer models is applied to the generation of three-layer and four-layer models.

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13. ABSTRACT

Tables of the U.S. Standard Atmosphere 1962 were computed and tabulated up to only 90 km as functions of integer kilometer values of both geometric and geopotential altitudes. The geopotential tables have now been extended to 120 km altitude. This extension involved the development of an empirical function relating geopotential to geometric altitude. A discussion of this function along with limited geopotential tables was prepared for the U.S. Standard Atmosphere Supplements 1966. This function has also been used to prepare more extensive tables relating geopotential to geometric altitude and vice versa up to 10,000 km for latitudes from 0 to 90 degrees. In addition, a computer method was developed for automatically generating multilayer atmospheric models which rigorously fit arbitrary upper and lower boundary conditions.

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