Semi-Annual Status Report on the
NASA-Sponsored Research Project
"Reinterpretation of Mariner 9 IRIS
Data on the Basis of a Simulation
of Radiative-Conductive Transfer
in the Dust-Laden Martian Atmosphere"

Under Principal Investigator

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(NASA-CR-138835) REINTERPRETATION OF MARINER 9 IRIS DATA ON THE BASICS OF A SIMULATION OF RADIATIVE-CONDUCTIVE TRANSFER IN THE DUST-LADEN MARTIAN (St. Louis Univ.) 9 p HC $4.00 CSCL 03B G3/30

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Introductory Remarks

Due to the fact that research work on this project was scheduled to begin only after the academic year had started at Saint Louis University, the principal investigator found himself in a bind concerning personnel for research assistance. He resolved this question by restructuring the work plan. By allotting more sponsored research time for the period from May to October 1974, he began the first phase of the project with two graduate students who committed together 25% of their time.

Foremost in the research projection for the first six months was the conceptualization and subsequent computerization of convective heat transport as an essential thermal energy transfer mechanism near the ground and at the top of the dust layer. Its incorporation into the existing time-dependent radiative-conductive computer model was offered in the latter revision of the original proposal.

Furthermore, the systematic reappraisal of the existing model led to the formulation of a manuscript which is attached. It became obvious that in the time-integration a shorter time-step (7.5 min) was needed. Our search for improved spectroscopic data was successful. Travel to Ohio State University last March secured the AFCRL/OPI data.

Finally, two doctoral dissertations are being developed which attack the questions of convective heat transport near the surface in the mid-latitudes and the interaction between radiative transfer and the diffusive mass sublimation over the polar ice cap.

Convective Adjustment

The existing radiative-conductive computer model, developed earlier under NASA grant NGL 26-006-016, lacked the capability of simulating convective transport of heat near the ground and at the top of the dust layer. This transfer mechanism is considered essential in the thermal energetics of the Martian dust-laden atmosphere-soil system. The systematic reappraisal of existing simulative capabilities generated the finding that reliable reinterpretation of Mariner 9 IRIS data by means of modeling heat transport mechanisms cannot be achieved without incorporating convective transfer. Therefore, it was decided to use enthalpy balance considerations to estimate the depth of a ground-based convective layer induced by surface heating. The underlying assumption was a resulting adiabatic redistribution of temperature in this layer. This approach is similar to a model described by Tennekes (1973).

Manuscript

In order to enhance clarifying insight into the effect of convective transfer of heat upon time-dependent radiative-conductive temperature profiles for a dust-laden atmosphere, a research paper was readied for publication stating in detail purpose and secondary objectives of the research project*. The convective adjustment was achieved by making allowance for an enthalpy transport from the ground into the atmospheric layers such that adiabatic stratification is reached. This was a straightforward method intended to yield some preliminary results which were needed for guidance. Superadiabatic stratification which was generated near the top of the dust layer by radiative heating was also convectively adjusted.

The manuscript presents some results of interest such as

1 - atmospheric counter-radiation is increased by more than 50% in the presence of dust;

2 - tropospheric convection mixing is confined to the lowest 5 km;

3 - quasi-isothermal stratification results in the upper part of the dust layer during the period of intense solar heating;

4 - a highly effective radiation-convection layer exists at the top of the dust stratum with a diurnal temperature variation of 40^{o}k.

Improved Spectroscopic Data

Our former NASA-sponsored research on the structure of the lower Martian atmosphere has relied on CO_2 spectroscopic

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* A copy of the manuscript is enclosed which has been accepted for publication.

data originally developed by Stull, Wyatt, and Plass (1963). Numerous discussions with various spectroscopists, especially Dr. John H. Shaw, convinced the principal investigator that he would be better off with the "AFCRL Atmospheric Absorption Line Parameters Compilation", produced by McClatchey et alii (1973).

The refined spectral resolution (2.4 cm^{-1}) of the IRIS experiment indicated a lower limit for the spectroscopic increments in our simulation procedure. On the other hand, the quasi-random model for the CO_2 transmission, as used in our model, required within each spectral increment a sufficiently large number of CO_2 absorption lines which were available from the AFCRL compilation. By way of optimizing it was decided that 9.6 μm was the spectral interval to be used in the numerical integration over the wave number. This procedure is a step in the attempt to atune our model to the directly measured output data (radiance) of the Mariner 9 IRIS experiment.

Dissertation Research I: Evolution of Thermal Convection in a Radiatively-Heated Ground-Atmosphere System.

A more direct approach to the time-dependent problem of restructuring the atmospheric thermal stratification due to convective overturn is being developed as a dissertation research. It utilizes an appropriate solution of the fluid dynamic equations representing three-dimensional thermal convection induced by surface heating (Rayleigh-Benard problem) as modified by the influence of radiative heating/cooling in the boundary layer. A spectral version of the governing equations is solved as an initial value problem. The interface heat flux processes provide the primary time-dependent driving mechanism.

This approach is free of externally specified parameters and does not require an assumption of constant flux layer, nor complete adiabatic redistribution of temperature throughout the affected layer. For these reasons, this model will be capable of simulating the time-evolution of the convective layer under the impact of an arbitrary surface heating/cooling history.

The computational complexity of this model precludes its direct interfacing with the radiative-conductive transfer model. However, it is thought that a viable parameterization scheme (based on the surface heating/cooling function, surface physical properties, and initial temperature profile) can be derived from the model. This would allow estimation of the impact of convective overturn on the boundary layer temperature profile.

<u>Dissertation Research II:</u> CO_2 Sublimation and Diffusion from the Martian Polar Ice-Cap and the Repercussion on Radiative Transfer and Thermal Energetics.

This approach aims at the thermal energetics of the polar ice cap-atmosphere interface systems considering the fluxes crucial in the vertical transfer of heat and mass.

Absorbed solar radiation maintains a process of sublimation which leads to CO_2 mass transfer in the vertical.

The particular purpose of this research is to simulate numerically the interaction between the sublimation-diffusion mechanism and radiative transfer and to determine the impact of such a coupled system on the thermal stratification of the atmosphere.

This investigation will assist the NASA-sponsored project in interpreting IRIS measurements over the Martian polar cap region in the presence of a dust layer overlying a solid CO_2 ice surface.

Concluding Remarks

During the time period from October 1973 to April 1974, the above mentioned approaches have led to a series of analytical computer runs. They were designed to generate quantitative insights into the question as to how to arrange, in the main program and its subroutines, the modifications necessary to atune the existing model to the IRIS measurements of outgoing planetary spectral radiance. By incorporating convective overturn, we have made allowance for a more realistic vertical temperature distribution which in turn controls the upwardly directed radiative fluxes, within the spectral range from 200 to 2,000 cm^{-1}, collected at the top of the atmosphere.

In the second phase of the research project (April - October 1974), we stand ready to assess the sensitivity of outgoing radiance to details of the near-surface and dust layer top temperature distribution, and the ability of the integral inversion technique to resolve these temperature profile details. (Actual T-plots will be presented in the Final Report by October 1974).

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See under References in the manuscript attached to this status report.

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