

THE EFFECTS OF ENTRAINMENT ON STABILITY OF THE MARINE CLOUD LAYERS

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Award No. N00014-96-1-0973

LONG TERM GOALS

Goals of this project are to identify physical processes that determine the dynamics of the marine cloud layers and to quantify the roles of turbulence, convection and thermal radiation that play in formation, dissipation and stability of the marine cloud layers.

OBJECTIVES

Our immediate objectives are to advance theoretical models, use efficient numerical schemes and develop computer programs to simulate the marine cloud layers. Comparison of computer results with published field observations will yield insights into the cloud-layers' physical processes.

APPROACH

Attention has been given to include the physical factors: thermal radiation, turbulence scales and convective circulation. Consideration has been given to grid generation, structures of discretization equations and solution algorithms. Computational speed and computer memory sizes have been optimized. Simulation results will be compared with the published observations.

WORK COMPLETED

Second-order turbulence and thermal radiation models were developed by the author (Chi, 1996). In 1997, a large eddy simulation (LES) method has been developed to increase the calculation efficiency. A tridiagonal-matrix algorithm (TDMA) has been developed to solve the resultant large-scale matrix equations in multi dimensions. The model has been used to study the effects of warm-air entrainment at cloud tops on stability of the marine cloud layers.

RESULTS

Fig. 1 shows contours of stream functions of an atmospheric domain with entrainment at the top. The steady-state cloud layer established by simulation at the 40th hour (Chi, 1996) is used as an initial condition in the present computer simulation study of the cloud-layer stability. Contours plotted in Fig. 2 are the initial steady-state potential temperature values, total moisture humidity

Report Documentation Page

Form Approved
OMB No. 0704-0188

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1. REPORT DATE 30 SEP 1997		2. REPORT TYPE		3. DATES COVERED 00-00-1997 to 00-00-1997	
4. TITLE AND SUBTITLE The Effects of Entrainment on Stability of the Marine Cloud Layers				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of the District of Columbia, Department of Mechanical Engineering, Washington, DC, 20008-1174				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a REPORT unclassified	b ABSTRACT unclassified	c THIS PAGE unclassified			

ratio values and liquid moisture humidity values, respectively. Results of transient simulation of the effects of warm air entrainment at the cloud top using these initial conditions are shown in Fig. 3. From snapshots shown in Fig. 3 of the cloud contours at different times (i.e., half, one, five and ten hours) from the start of the simulation run, dissipation of the cloud layer can be observed.

IMPACT

In the previous year, a computer simulation of the air-and-sea boundary layer heat and moisture transfer was made to observe theoretically the growth of marine cloud layers. In 1997, an extension of the theory was made to include the effects of convective entrainment of air at the cloud top on the dynamics of the marine cloud layers. These quantitative results will provide us with theoretical tools to identify processes observed physically in the marine cloud layers.

TRANSITIONS

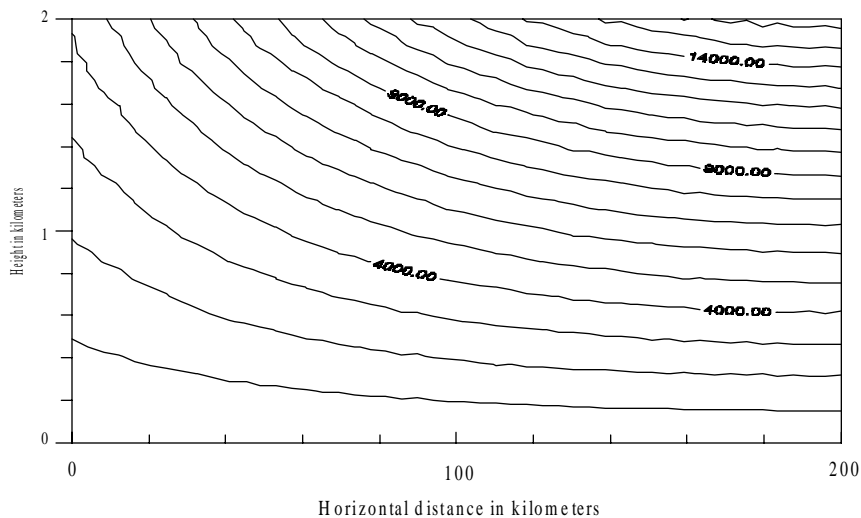
An article is being considered for presentation at the 1998 ASME Annual Conference as a symposium paper, entitled: "A Large Eddy Simulation Model for the Dynamics of Marine Cloud Layers."

RELATED PROJECTS

Contacts have been made with the NASA/GSFC in obtaining their satellite data to be analyzed by our computer simulation model for comparison to increase confidence in our theoretical results.

REFERENCES

Chi, J., 1996:
Turbulent
Moisture
the Dynamics
Cloud
ASME Fluids
Summer
227-232, San



The Effects of
Heat and
Transfer on
of Marine
Layers, Proc.
Engineering
Meeting, 236,
Diego, CA.

Fig 1: Contours of Stream Functions with Entrainment at the Top

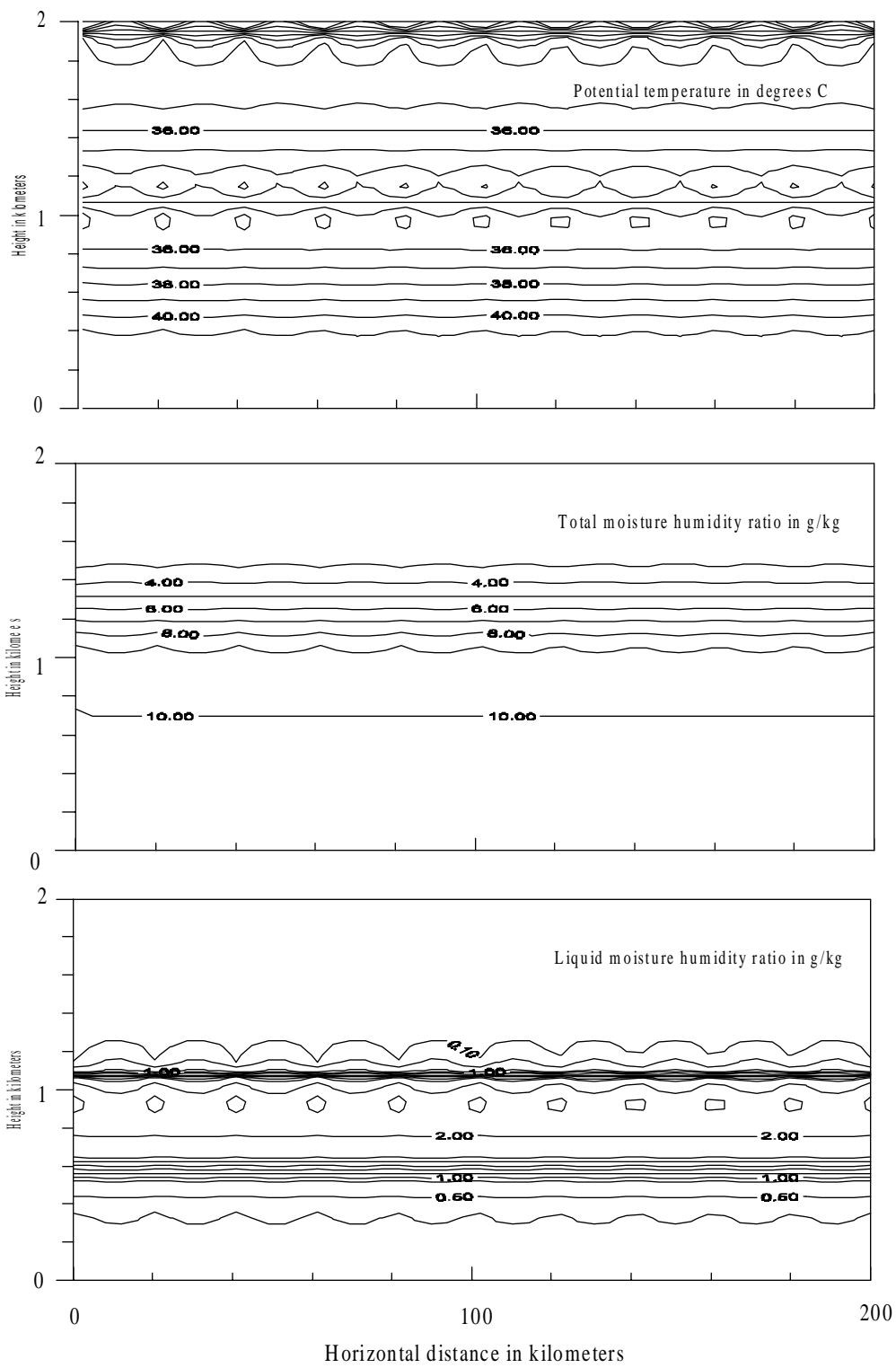


Fig. 2: Initial Steady state at the Zeroth Hour

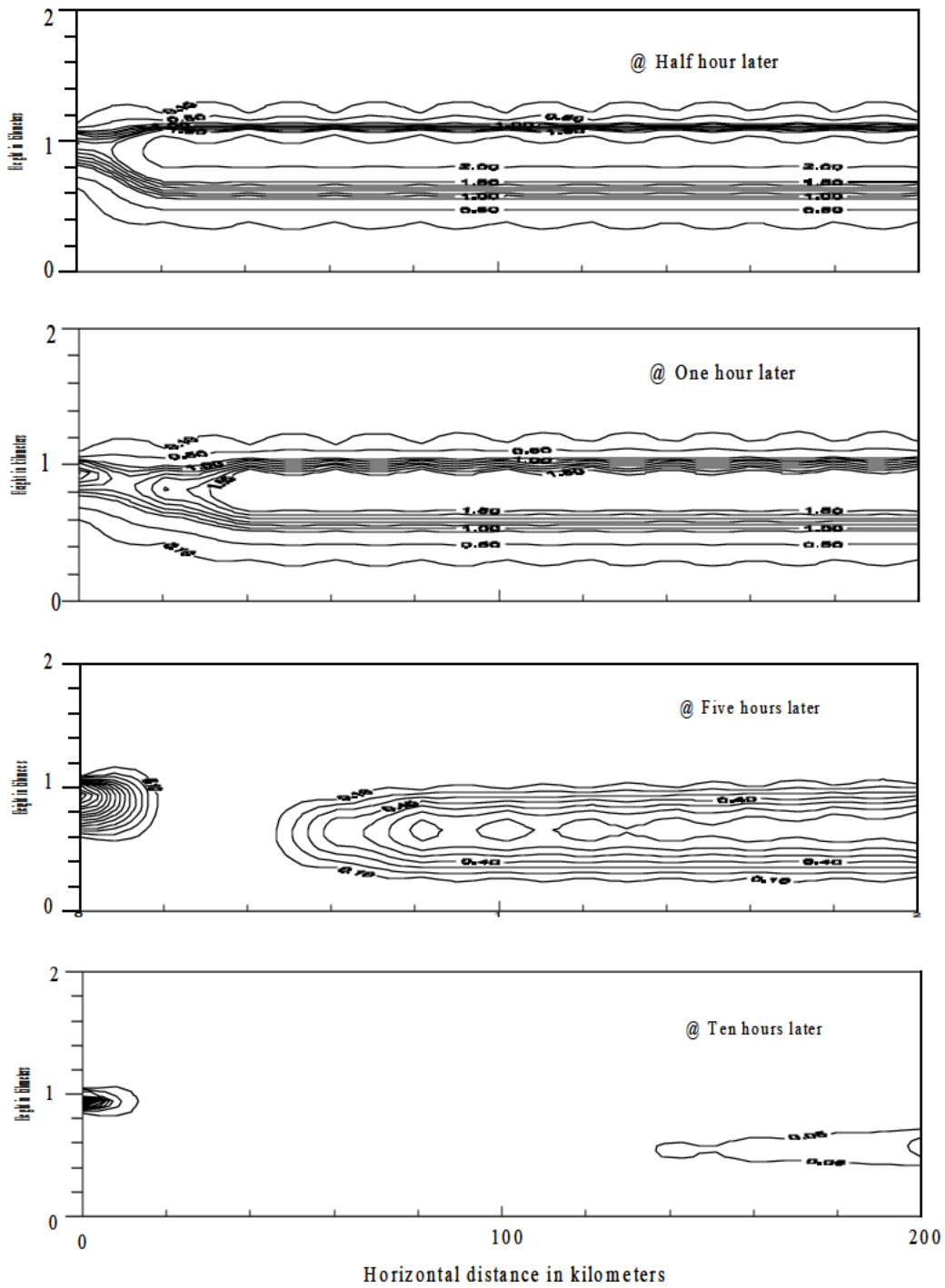


Fig. 3: Predicted Effects of Warm-Air Entrainment on the Cloud Stability (Plotted contours at different time are for liquid water humidity ratio values in grams per kilogram)