538517

Final Report

Numerical Simulations and Diagnostic Studies of Meteorological Conditions During PEM-Tropics B

NASA Grant NCC 1-308

FSU Number 1338-783-26

Submitted to

James Raper
NASA Langley Research Center
Hampton, VA 23681

Prepared by

Henry E. Fuelberg
Principal Investigator
Department of Meteorology
Florida State University
Tallahassee, FL 32306-4520
fuelberg@met.fsu.edu
850-644-6466

July 2001

1. Introduction

Florida State University's research for PEM-Tropics B involved the three components that are described below. Prof. Henry Fuelberg served as principal investigator. He was assisted by graduate students Joe Maloney, Brian Martin, and John Hannan.

2. Mission Meteorologist Component

Prof. Fuelberg served as Mission Meteorologist for the DC-8 component of PEM-Tropics B. As part of his responsibilities while in the field, he collaborated with the Science Team on flight planning, prepared forecasts and presented map discussions for each flight, and served as a resource person about meteorological issues during each flight. Prof. Fuelberg's students prepared meteorological forecast products, including backward trajectories, in real time at Florida State University and transferred them to Prof. Fuelberg at the remote field sites for use in the flight planning. Once the field phase was completed, Prof. Fuelberg prepared a revised set of backward trajectories for use by the Science Team. These products, constituting his "data set", were placed into the GTE archive and on a web site at Florida State University.

Prof. Fuelberg prepared a manuscript for the *Journal of Geophysical Research* (Fuelberg et al. 2001) that summarizes meteorological conditions during PEM-T B. The manuscript describes mean flow patterns during the period. Important features near the surface included subtropical anticyclones, the South Pacific Convergence Zone (SPCZ), and the Intertropical Convergence Zone (ITCZ). The ITCZ was found to exhibit a double structure, with branches at ~5°N and ~5°S. Both the ITCZ and SPCZ were areas of widespread cloudiness and convection. Extensive lightning occurred over the land masses surrounding the Pacific Basin and over the central South Pacific Ocean itself. PEM-T B occurred during a La Nina period of relatively cold sea surface temperatures in the tropical Pacific. Compared to climatology, the PEM-T B period exhibited deep convection located west of its typical position, stronger than normal easterly trade winds, a relatively strong (weak) northern (southern) hemispheric jet stream, the SPCZ located west of its normal position, and an upper tropospheric cyclonic wind couplet that straddles the equator. Circulation patterns during PEM-T B were compared with those of PEM-T A which was conducted during August - September 1996. PEM-T B was found to exhibit a less organized ITCZ, a comparatively weak jet stream in the southern hemisphere, a relatively strong jet stream in the northern hemisphere, and enhanced convection over the central Pacific. Finally, meteorological conditions for selected flights were discussed utilizing streamlines, ten-day backward trajectories, thermodynamic soundings, and satellite imagery. Air parcels sampled by the aircraft were found to originate or pass over diverse regions, including Asia, South America, southern Africa, and Australia. Some parcels remain over the Pacific Ocean during the preceding ten-day period.

3. Sources of Various Chemical Signatures

Graduate student Joe Maloney was supported by the grant. His M.S. thesis (Maloney 2000) related various origins of trajectories with their chemical signatures. The thesis was transformed into a manuscript for JGR (Maloney et al. 2001). Highlights of the research follow.

Ten-day backward trajectories were used to determine the origins of air parcels arriving at locations of airborne DC-8 chemical measurements during PEM-T B. Chemical data at sites where the trajectories had a common geographical origin and transport history were grouped together, and statistical measures of chemical characteristics were computed. Temporal changes in potential temperature were used to determine whether trajectories experienced a significant convective influence during the 10-day period. Trajectories describing the aged marine Southern Hemispheric category remained over the South Pacific Ocean during the 10-day period, and their corresponding chemical signature indicated very clean air. The category aged marine air in the Northern Hemisphere was found to be somewhat dirtier. Sub-dividing its trajectories based on the direction from which the air had traveled was found to be important in explaining the various chemical signatures. Similarly, long range northern hemispheric trajectories passing over Asia were sub-divided depending on whether they had followed a mostly zonal path, had originated near the Indian Ocean, or had originated near Central or South America and subsequently experienced a stratospheric influence. Results showed that the chemical signatures of these sub-categories were different from each other. The chemical signature of the southern hemispheric long range transport category apparently exhibited the effects of pollution from Australia, southern Africa, and South America. Parcels originating over Central and northern South America were found to contain the strongest pollution signature of all categories, due to biomass burning and other sources. The convective category exhibited enhanced values of nitrogen species, probably due to emissions from lightning associated with the convection. Values of various species, including peroxides and acids, confirm that parcels were influenced by the removal of soluble gas and particle species due to precipitation. Finally, current results were compared with those from the first PEM-Tropics mission that was conducted in the same region during the southern hemispheric dry season (August – October 1996) when extensive biomass burning occurred. Results showed that air samples during PEM-Tropics B were considerably cleaner than those of its dry season counterpart.

4. The "River of Pollution"

Graduate student Brian Martin also was supported by the grant. His M.S. thesis (Martin 2001) investigated the transport of pollution from Asia to the tropical Pacific Ocean. The thesis currently is being transformed into a manuscript for JGR. Highlights of the research follow.

Four representative flights from PEM-T B that ranged as far northeast as California to as far southwest as coastal New Guinea were examined for possible long-

rang Asian pollution signatures. The signatures were studied to determine their ages and chemical evolution during transport. The chemical species include non-methane hydrocarbons, selected halocarbons, and carbon monoxide. Time traces of species are examined along with enhancement ratios relative to CO. Wind data from the European Centre for Medium Range Weather Forecasting were used to calculate backward trajectories along the four flight tracks. Results showed that some pollutants from the Asian continent were transported across the Pacific by the middle latitude westerly winds and reached the subtropical Pacific anticyclone where they subsided and turned southwestward under the influence of the low level trade winds. The parcels ultimately reached the western Pacific near coastal New Guinea after ~ 20 to 25 days of transit. The GTE scientific community has denoted this chemical transport as the "river of pollution".

5. Publications Prepared at Florida State University

Fuelberg, H.E., R.E. Newell, D.J. Westberg, J.C. Maloney, J.R. Hannan, B.D. Martin, M.A. Avery, and Y Zhu, A meteorological overview of the second Pacific exploratory mission in the tropics. J. Geophys. Res., in press, 2001.

Maloney, J.C. III, Chemical characteristics of air from different source regions during the second Pacific exploratory mission in the tropics (PEM-Tropics B), M.S. thesis, Florida State University, Tallahassee, 79 pp, 2000.

Maloney, J.C., H.E. Fuelberg, M.A. Avery, D.R. Blake, B.G. Heikes, G.W. Sachse, S.T. Sandholm, H. Singh, and R.W. Talbot, Chemical characteristics of air from different source regions during the second Pacific exploratory mission in the Tropics (PEM-Tropics B). J. Geophys. Res., in press, 2001.

Martin, B.D., Long range transport of Asian outflow to the deep tropical Pacific, M.S. thesis, Florida State University, Tallahassee, 63 pp, 2001.

Martin, B.D., H.E. Fuelberg, J. Crawford, N. Blake, and J. Logan, Long range transport of Asian outflow to the deep tropical Pacific, draft manuscript to be submitted to J. Geophys. Res., 2001.

5. Publication on which Florida State University was a co-author

Raper, J.L., M.M. Kleb, D.J. Jacob, D.D. Davis, R.E. Newell, H.E. Fuelberg, R.J. Bendura, J.M. Hoell, and R.J. McNeal, Pacific exploratory mission in the tropical Pacific: PEM-Tropics B, March-April 1999. J. Geophys. Res., in press.

Browell, E.V., M.A. Fenn, C.F. Butler, W.B. Grant, S. Ismail, R.A. Ferrare, S.A. Kooi, V.G. Brackett, M.B. Clayton, M.A. Avery, J.D.W Barrick, H.E. Fuelberg, J.C. Maloney, R.E. Newell, Y Zhu, M.J. Mahoney, B.E. Anderson, D.R. Blake, W.H. Brune, B.G. Heikes, G.W. Sachse, S.T. Sandholm H.B. Singh, and R.W. Talbot,

2000: Large-scale air mass characteristics observed over the remote tropical Pacific Ocean during March-April 1999: Results from PEM Tropics-B field experiment. J. Geophys. Res., in press.

Avery, M.A., D.J. Westberg, H.E. Fuelberg, R.E. Newell, B.E. Anderson, S.A. Vay, G.W. Sachse, and D.R. Blake, Chemical transport across the ITCZ in the central Pacific during an ENSO cold phase event in March/April of 1999. J. Geophys. Res., in press.

Clarke, A., W. Collins, P. Rasch, V. Kapustin, K. Moore, S. Howell, and H. Fuelberg, Dust and pollution transport on global scales: Aerosol measurements and model predictions. J. Gephys. Res., in press.