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SSEC Publication No.95.09.S1.

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Annual Report for NOAA Grant NA36GP0481
Covering the period 9/1/94-9/30/95

This annual report summarizes the UW-Madison participation in the ASHOE/MAESA (Airborne Southern Hemisphere Ozone Experiment / Measurements for Assessing the Effects of Stratospheric Aircraft) field program, supported by NOAA Grant NA36GP0481. There were two separate activities supported by this grant; one activity supports the participation of the High resolution Interferometer Sounder (HIS) aboard the ER-2 aircraft in the data gathering campaign, and the other activity supports onsite forecasts of isentropic atmospheric structure and circulation in support of the ER-2 flights and modeling the global hydrologic cycle.

1. HIS field program participation during ASHOE/MAESA

ASHOE/MAESA was sponsored by NASA, NOAA, NSF and others to address questions about the causes of the year round mid latitude ozone loss observed in the Southern Hemisphere (S.H.) in the last 15 years. A major goal of these programs was to gain an understanding of the composition of the lower stratosphere and its consequent effects on the radiative balance of the atmosphere. To support this and other requirements, flights of the NASA ER-2 high altitude aircraft were conducted to provide observations from which to diagnose the chemistry, physics and motion of the air in the lower stratosphere and troposphere. Measurements were made at four separate time periods; March, June, August and October to capture the seasonal cycle of S.H. circulation.

The UW-Madison HIS instrument participated in all four phases of the dynamics and radiation field campaign aboard the ER-2 aircraft; the first three phases were during the period covered in this report. Table 1 summarizes the data gathering flights made from Christchurch, New Zealand (NZCH), primarily flying south into the polar vortex.

Summary of UW HIS Experiment Data Collection Flights during ASHOE/MAESA

Date	Launch – Return time	Flight Location	Mission
04/13/94	1930 - 0330 UTC	NZCH - 68S	Antarctic vortex
04/15/94	0052 – 0350 UTC	NZCH – 38S	Volcano overflight
06/05/94	2000 - 0200 UTC	NZCH – 68S	Antarctic vortex
06/08/94	2000 – 2100 UTC	NZCH – 45S	Test flight
08/08/94	2200 – 0620 UTC	NZCH – 69S	Antarctic vortex
08/10/94	2100 – 0430 UTC	NZCH – 67S	Antarctic vortex
10/03/94	2130 – 0530 UTC	NZCH – 68S	Antarctic vortex
10/05/94	2100 – 0445 UTC	NZCH – 65S	Antarctic vortex

This grant provided support for the deployment of the HIS science and technical support team to Ames Research Center for pre-experiment instrument checkout and to Christchurch, New Zealand on four separate occasions for the measurement campaign. Partial support to CIMSS for deployment in the field phase of ASHOE/MAESA was also provide by NASA.

From the HIS measurements taken during the ASHOE/MAESA field campaign, software developed under year 1 funding was applied to the HIS radiance spectra to calculate temperature, moisture and ozone structure in the upper troposphere and lower stratosphere. The vertical profiles below the ER - 2 are computed from the HIS radiance observations using a retrieval method which is totally independent of contemporary meteorological data and as such the results are totally independent of the numerical model analyses which are to be validated. HIS temperature and water vapor profile data were used to validate the thermodynamic characteristics of global data assimilation / forecast models that provide the global circulation patterns used to analyze the transport of the constituents associated with the Ozone depletion process. HIS temperature and moisture retrievals were also used to calculate atmospheric cooling rates, which were compared to cooling rates calculated using input from global forecast models. As the time period for this report covers the field phase of ASHOE/MAESA, results of the data analysis efforts will be provided in the final report.

2. Isentropic model forecast support during ASHOE/MAESA

As part of the 1994 Airborne Southern Hemisphere Ozone Experiment /Measurement for Assessing the Effect of Stratospheric Aircraft (ASHOE/MAESA) program under the direction of Dr. Adrian Tuck of the NOAA Aeronomy Lab, the UW θ-σ modeling group under Professor Donald Johnson's direction was deployed to provide onsite forecasts of isentropic atmospheric structure and circulation in support of ER-2 flights carried out from Christchurch, New Zealand during the four Intense Observation Periods (IOPs). Daily 0 to 84 hour forecasts of tropospheric/stratospheric winds, temperature, water vapor, potential vorticity and corresponding transport processes were provided to determine the most beneficial flight path for each mission.

Several events during the IOPs were selected for scientific study. Emphasis was placed on investigating the Southern Hemisphere hydrologic cycle and the role of amplifying baroclinic waves on the meridional transport of water vapor, ozone and other trace constituents. Comparisons were made with corresponding forecasts from the nominally identical UW sigma coordinate model in order to investigate the impact of the vertical coordinate on simulation of atmospheric circulation and hydrologic processes.

An experiment was initiated to examine the relative capabilities of isentropic and sigma coordinate models to conserve joint distributions of potential vorticity (PV) and trace constituent transport for an ASHOE IOP using simulations from the UW θ-σ and σ coordinate models and the National Center for Atmospheric Research (NCAR) Community Climate Model (CCM2). An initial proxy distribution of ozone (O_3) was specified analytically as a function of the initial PV on each model level. The capability of a model to retain a correlation of unity through the integration is a measure of its predictability of transport processes within the atmospheric continuum. At and above 370 K, the UW θ-σ model correlations remained above 0.99 throughout the 10-day simulation while correlations in the UW σ model simulation decreased to 0.50 by day 10 in the lower stratosphere. The corresponding correlations in simulations from CCM2, a state of the art climate model, decreased to near 0.95 in the low stratosphere at day 10. The correlations in the upper troposphere were further reduced in CCM2 compared to the UW θ-σ model with some decreasing to 0.6. These results, presented in Zapotocny et al. (1996a), document the superior conservation characteristics in the upper troposphere and lower stratosphere of models based on isentropic coordinates.