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Quarterly Progress Report

on the

Utilization of UARS data in Validation of Photochemical and Dynamical Mechanism in Stratospheric Models

(Contract NAS5-32844)

by

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1. Introduction

AER proposed model-data intercomparison studies for UARS data. In the past three months, we have been working on constructing analysis tools to diagnose the UARS data. The "Trajectory mapping" technique, which was developed by Morris (1994), is adapted to generate synoptic maps of trace gas data from asynoptic observations. An in-house trajectory model (kinematic methods following Merrill et al., 1986 and Pickering et al., 1994) has been developed in AER under contract with NASA/ACMAP and the trajectory mapping tool has been applied to analyze UARS measurement.

The comparisons with Morris's results will be shown in the following. UARS data for these studies were obtained from the DAAC system. The CD ROM of UARS data, including the data from CLAES, ISAMS, MLS and HALOE instrument as well as daily meteorological data sets from the National Meteorological Center (NMC) and the United Kingdom Meteorological Office (UKMO), has been ordered.

2. Methodology

Due to the fact that UARS measurements from different instruments are not collocated, it is important to utilize an analysis tool which allows to obtain synoptic maps from the asynoptic data. Several methods have been developed to produce synoptic maps from asynoptically collected data: Kalman filtering (Haggard, 1986), Fourier Transform method (Salby, 1982 a, b; Lait and Stanford, 1988), constituent reconstruction technique (Schoeberl and Lait, 1992). Different from the above methods, trajectory mapping (Morris, et al, 1994) utilizes the meteorological analyses under fewer assumptions to produce synoptic maps by advecting forward and backward a group of measurements at a same instant. A two-dimensional trajectory model is employed on the isentropic surface for the trajectory mapping.

The trajectory mapping technique has several advantages over the other methods. The motions of real atmosphere are incorporated in the calculations. A single measurement can contribute to the constituent fields at different times. Trajectory maps can be generated outside of periods during which measurements are made as long as wind fields exist. Missing points in the constituent measurement relatively have no effects on the mapping.

The trajectory mapping tool also has some disadvantages. First, the quality of a trajectory map substantially depends upon the meteorological analysis. The inaccurate meteorological fields would degrade the quality of the original data. Second, the trajectory maps are not uniformly gridded. But generally, in the analysis of UARS data set, the trajectory mapping technique generates synoptic maps superior to or comparable with other methods (Morris 1994).

3. Comparison with Morris's Results

To apply the trajectory mapping technique, an in-house trajectory model at AER is used to create synoptic maps for UARS data. A set of balanced wind data were used in the trajectory model. The balanced wind fields were calculated from NMC daily analyses following Randel's method (1987). We concentrate on the same cases as Morris has done for direct comparisons: CLAES N_2O mapping on September 9, 1992 and MLS H_2O mapping during period of February 18-23, 1993. Morris's calculations were also based on NMC meteorological data, but different wave numbers were chosen in his calculation of balanced winds.

To check the capabilities of trajectory mapping, the measurements of long-lived tracer gas N_2O from CLAES were used to create the synoptic maps. The global synoptic map of N_2O at 800K isentropic surface at 12 UT on September 9, 1992 was calculated using the trajectory filling technique. The measurements during periods of September 6-13, 1992 were used. The data points measured before noon on September 9, 1992 were calculated forwardly using trajectory model while those measured after noon on September 9, 1992 were done backwardly. The asynoptic map of N_2O at 800K is shown in Figure 1a, in which measurements are from 00UT, September 9, to 00UT, September 10 by CLAES. The synoptic maps calculated from AER's and Morris's trajectory model are shown in Figure 1b and Figure 1c individually. The smaller dots represent the parcels added more than 12 hours from the time of the synoptic map while larger dots represent the parcels have been advected by the trajectory models in less than 12 hours. In comparison with the asynoptic map, data coverage is largely improved in the synoptic maps which combine the data at several days. The mapping of N_2O from AER trajectory model is very close to Morris's result.

Barnes's scheme was applied to get the gridded product of trajectory map. The result from AER model is shown in Figure 2. The wave-breaking event in the middle latitude of Southern Hemisphere shows clearly from N_2O synoptic map. The potential vorticity on 800K isentropic surface (calculated from NMC analysis) at 00UT, September 9, 1992, is given in Figure 3. If the vortex edge in the southern polar region is defined as $3.0X10^{-4}$ (Km^2/kgs) PV contour, we can see that the gradients of N_2O across the vortex boundary are well maintained in the synoptic map (Figure 2).

The trajectory mapping technique has been used to study the history of atmospheric events, such as the time sequence of the wave breaking. The large scale intrusion of tropical air to middle and high latitude in the Northern Hemisphere in February 1993 is detected very well in MLS H_2O data. The sequence synoptic maps of MLS H_2O at 800 K isentropic surface from both AER and Morris trajectory models are shown in Figure 4. The constituents from tropics (the dots in dark green color) gradually moved to middle and high latitudes (where red color dots are in the background) from February 20, 1993 to February 23, 1993. The thick black line represents $3.0X10^{-4}$ (Km^2/kgs) NMC PV contour line. The gradients of H_2O and NMC PV show high correlations in both results, which provide the validity of trajectory mapping technique.

4. Future works

Applying trajectory mapping technique and AER photochemical models, we are going to work on two tasks in the next three months:

(1) Continue comparison of our synoptic maps with Morris's results.

(2) Special case study on Pinatubo's eruptions

With the arrival of the Pinatubo volcanic aerosols, large decreases of NO_2 column amounts were observed at midlatitudes in both hemispheres. Increases in HNO_3 were observed (Koike et al., 1994) as expected. Model calculations qualitatively agree with the observational trends, but the observed response is much larger than model calculations (Moike et al., 1994). We are going to focus on special case studies for characterization of heterogeneous chemistry, such as the response of stratospheric constituents with altitudes to the Mt. Pinatubo eruption.

To determine the extent of response due to the Pinatubo eruption, the measurements of NO_x and HNO_3 in UARS will be examined during the period from the eruptions (June, 1991) to the recovery of the stratosphere when the volcanic aerosols subsided (later in 1993). The UARS data has global coverage, and also extends the sampling at different altitudes from the upper troposphere to the thermosphere. Thus, the heterogeneous mechanisms can be tested over extended regions and further understanding of heterogeneous chemistry could be made. We will identify ground-based data from NSSDC network that will allow the above intercomparison.

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Asynoptic map of CLAES N2O at 800K (09/09/92–09/10/92)

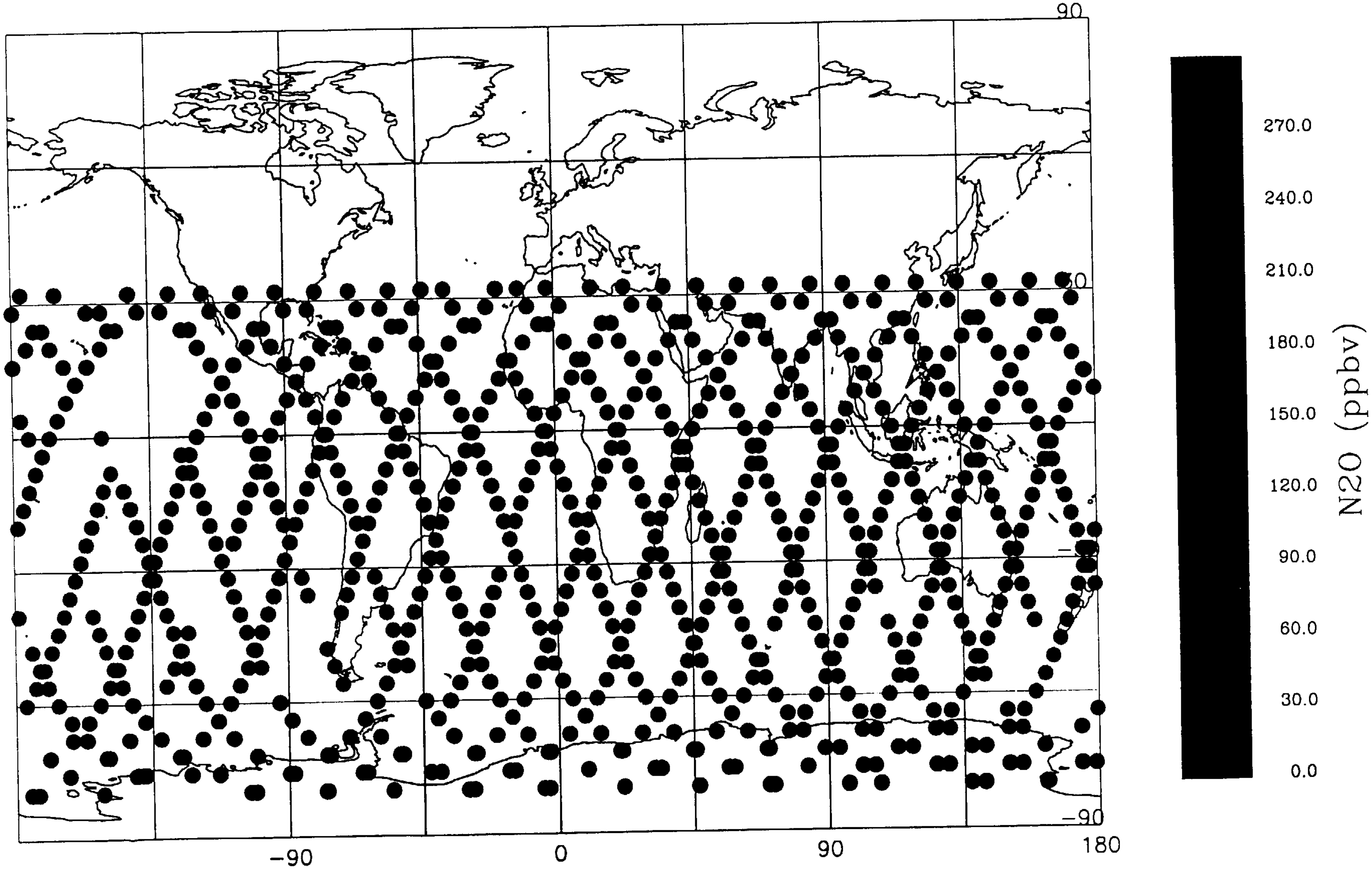

Figure 1a: Asynoptic map of CLAES N_2O at 800K isentropic surface measured during 00UT, September 9 1992 to 00UT, September 10,1992.

Synoptic map of CLAES N2O at 800K (09/09/92 at 12UT)--AER

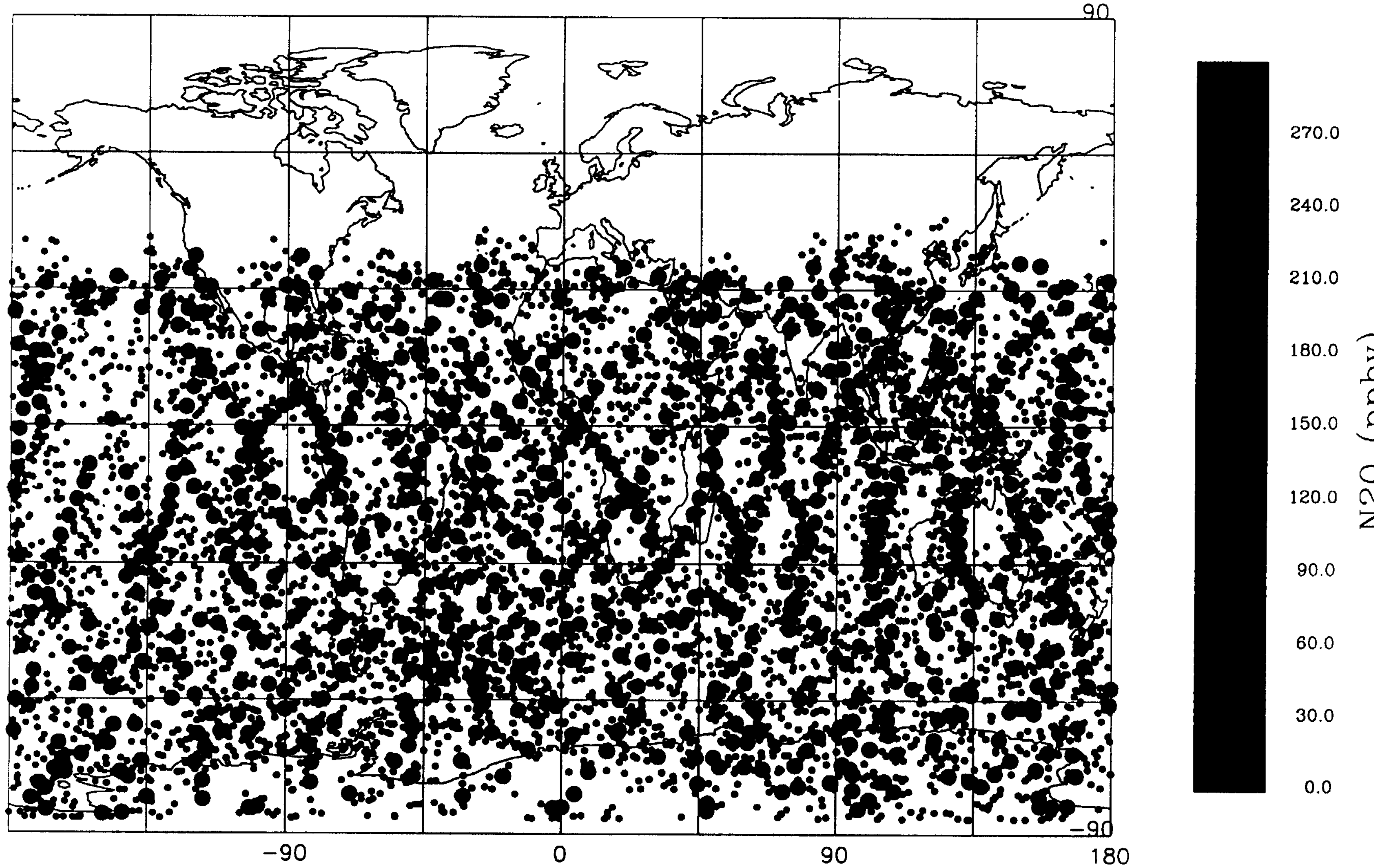

Figure 1b: Synoptic map of CLAES N_2O at 800K isentropic surface at 12UT on 09/09/92 from trajectory filling techniques using AER trajectory model. Asynoptic data period is from 09/06/92 to 09/13/92.

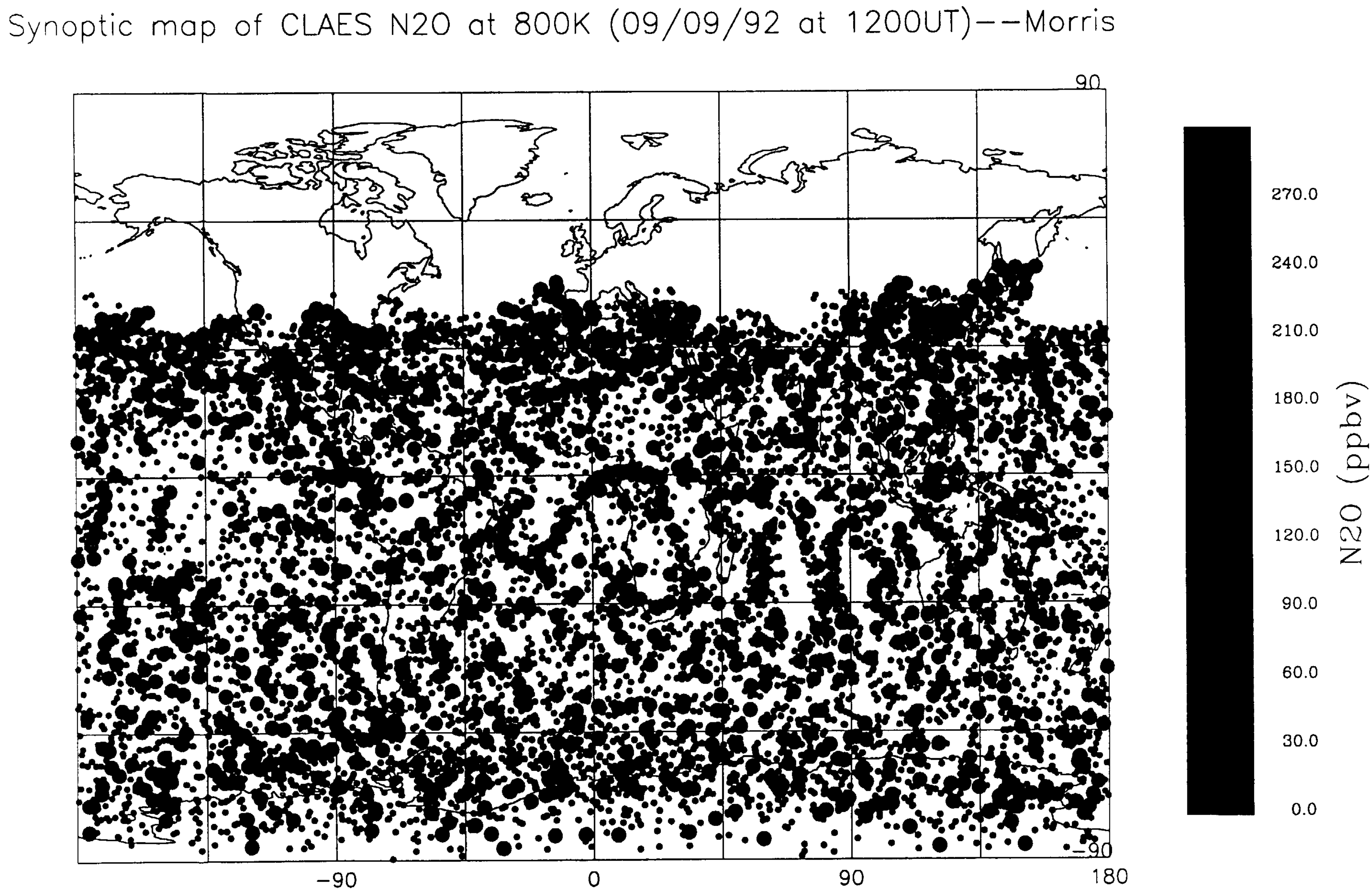

Figure 1c: Synoptic map of CLAES N_2O at 800K isentropic surface at 12UT on 09/09/92 using trajectory filling techniques from Morris et al (1995). Data period is from 09/06/92 to 09/13/92.

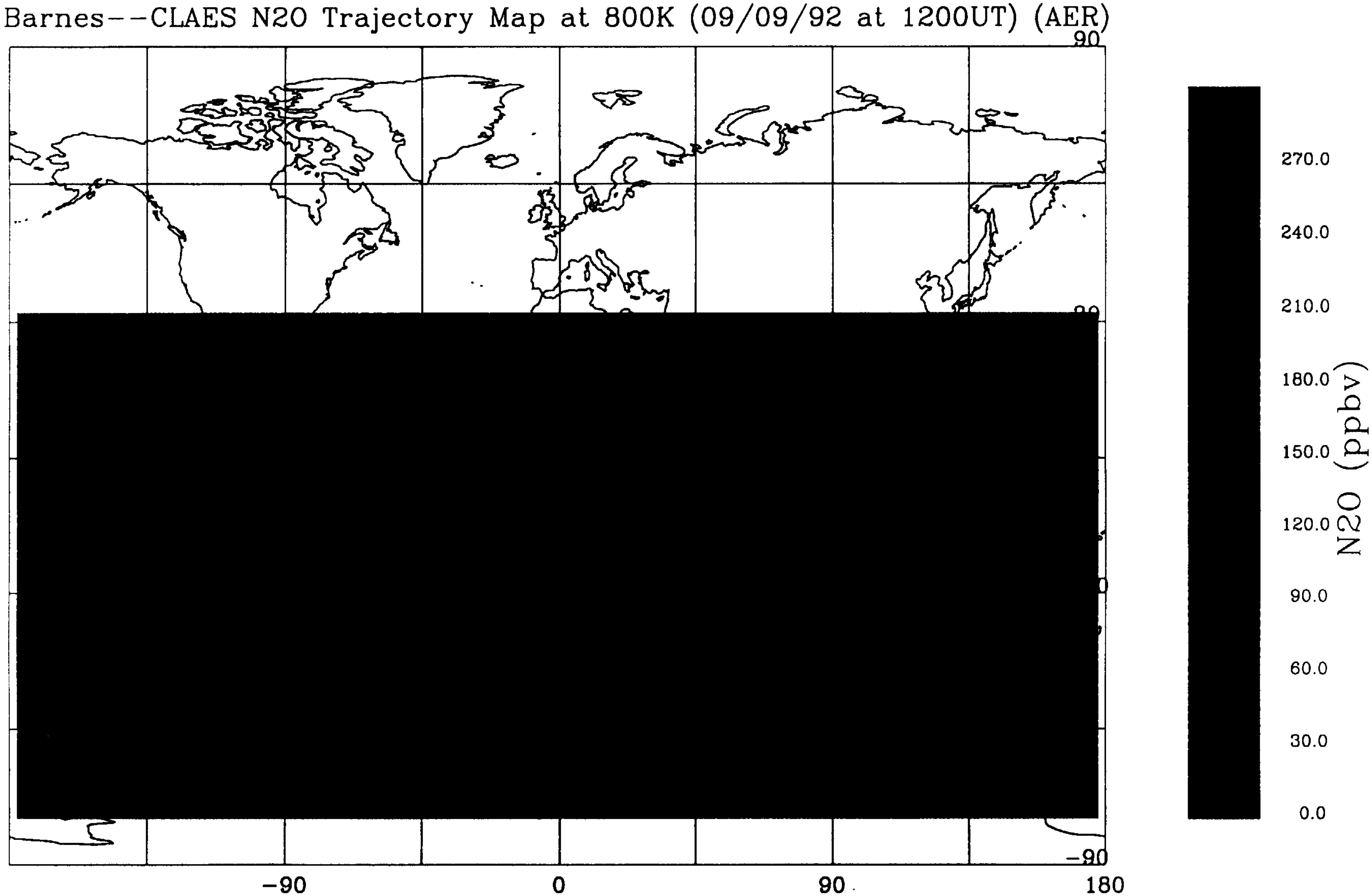

Figure 2: Gridded synoptic map of CLAES N_2O at 800K isentropic surface at 12UT on 09/09/92 calculated from AER trajectory model. Barnes scheme is used to interpolated data to the gridded points. Asynoptic data period is from 09/06/92 to 09/13/92.

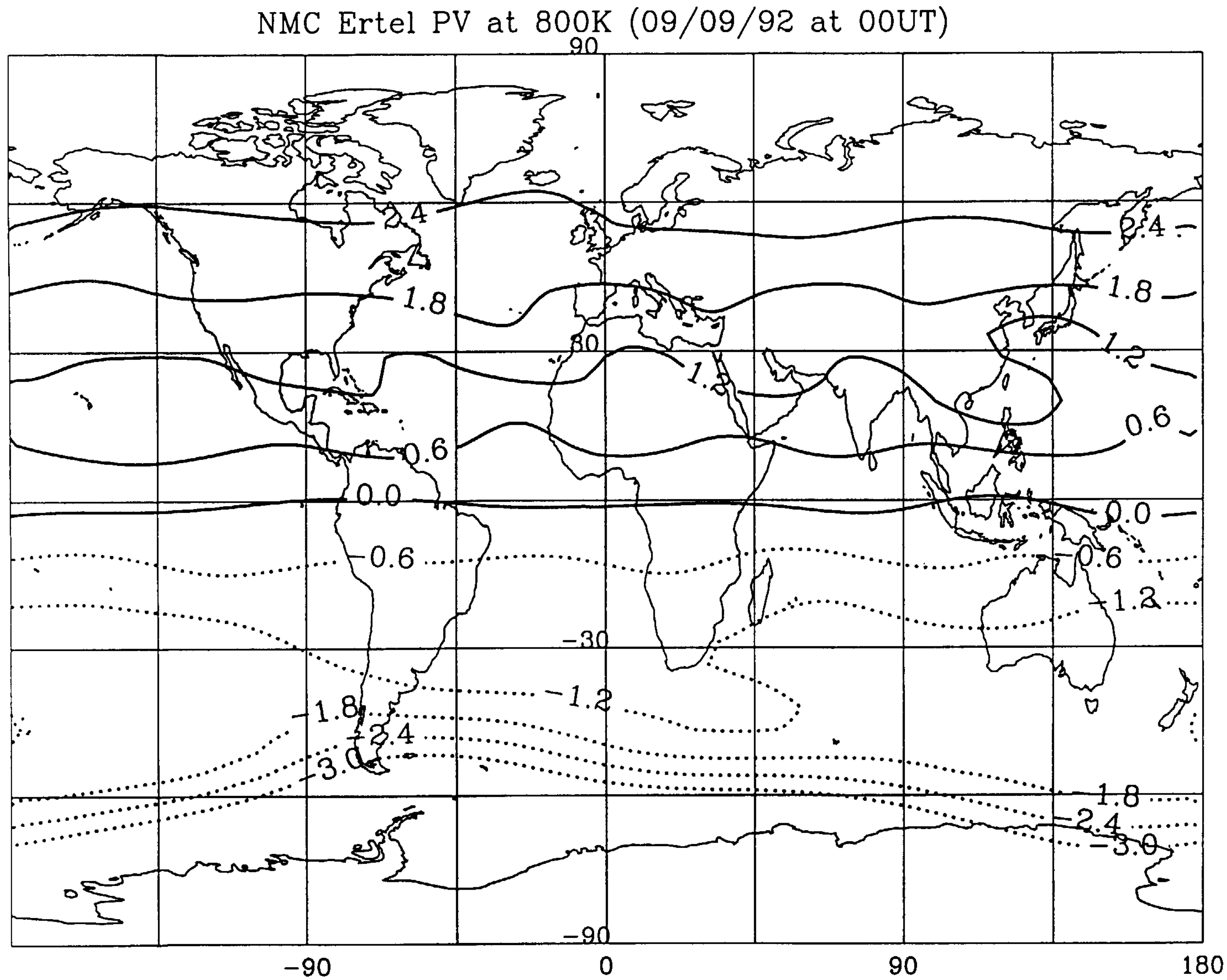

Figure 3: NMC Ertel PV at 800K at 00UT, September 9, 1992.
Unit: 1.0E−4 Km^2/kgs.

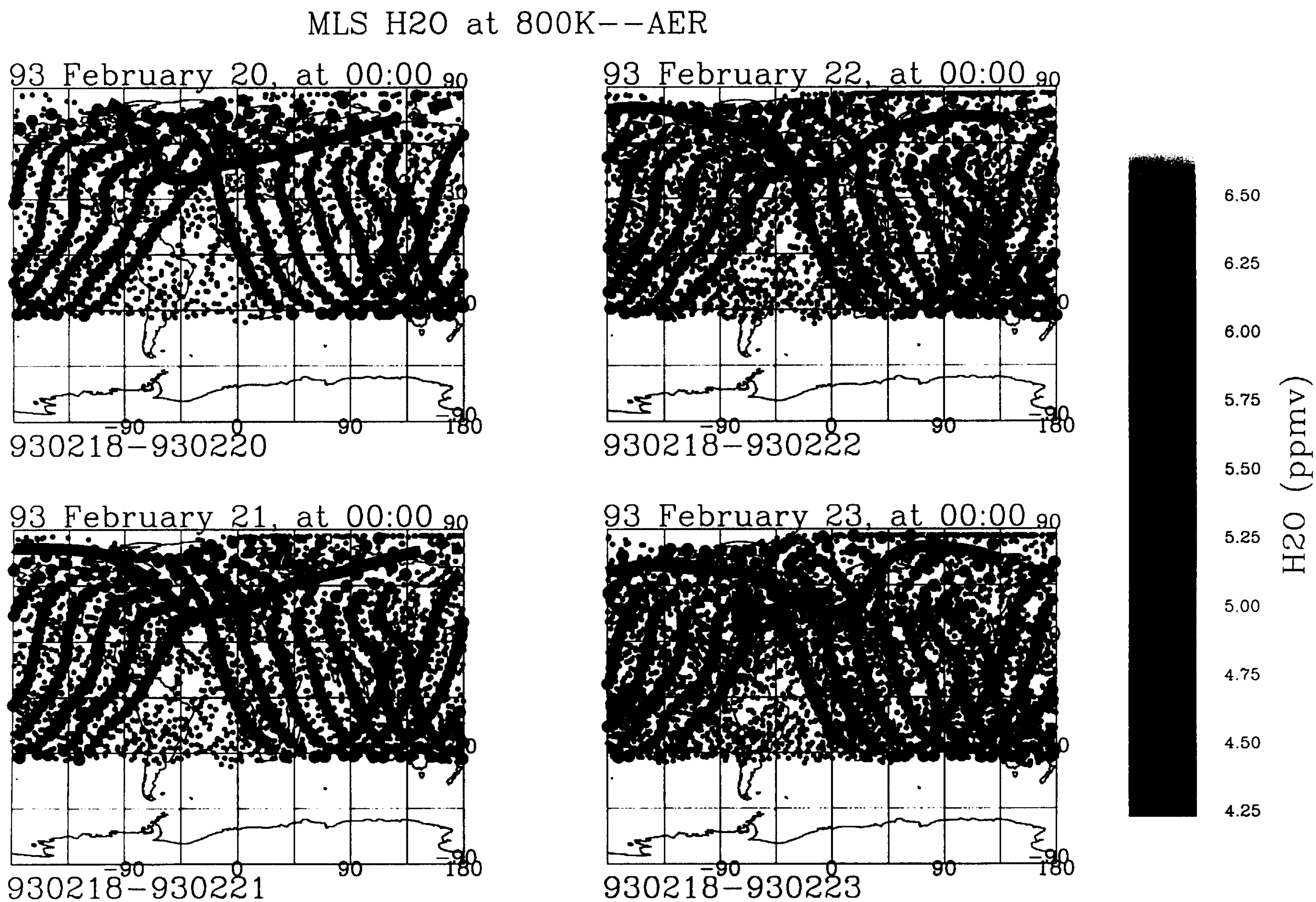

Figure 4a: Synoptic maps of MLS H2O at 800K isentropic surface from AER trajectory model. Data period is from 02/20/92 to 02/23/92. The dark line is $3X10^{-4}$ Km^2/kgs NMC PV contour.

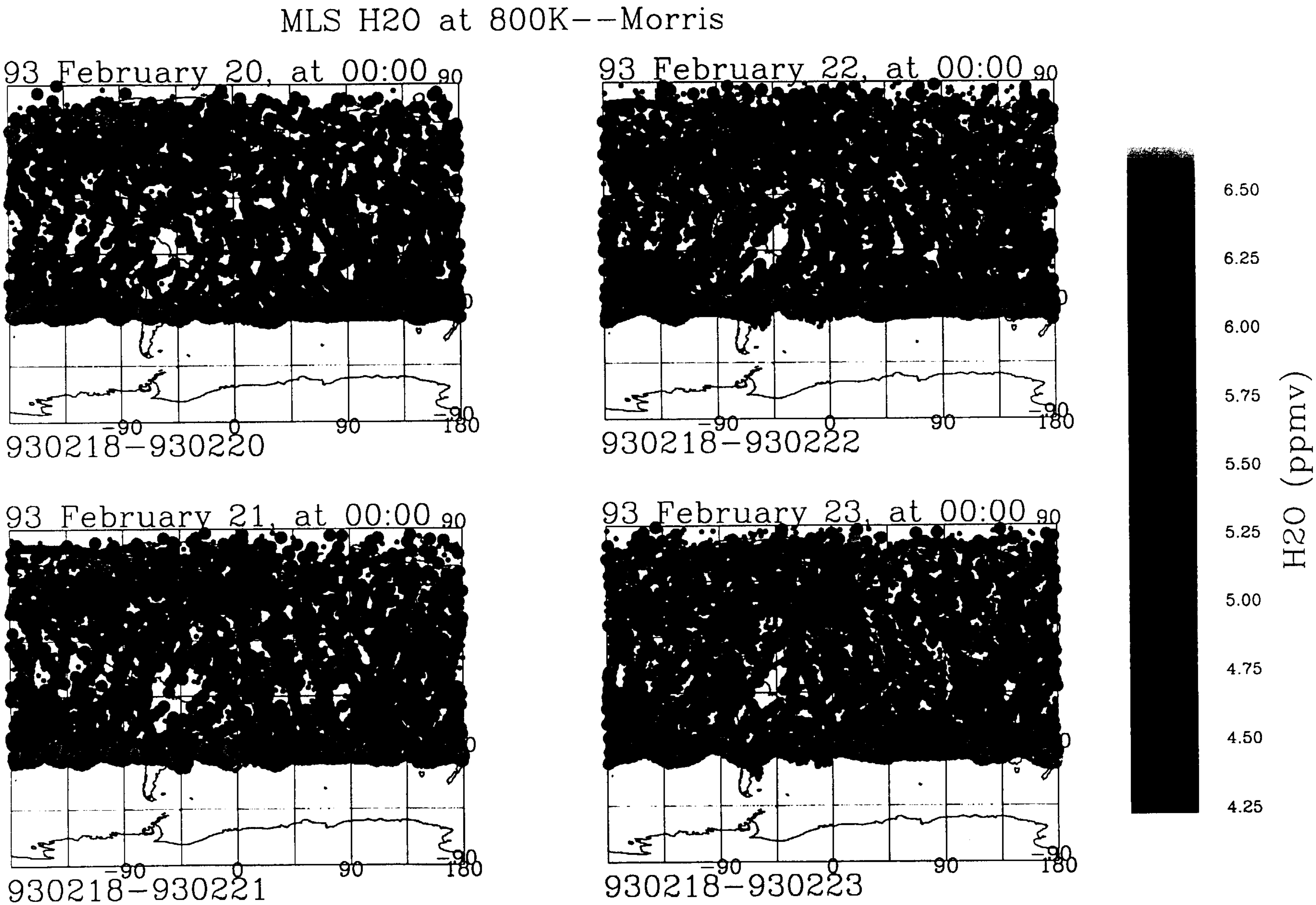

Figure 4b: Synoptic maps of MLS H20 at 800K isentropic surface from Morris trajectory model. Data period is from 02/20/92 to 02/23/92. The dark line is $3X10^{-4}$ Km^2/kgs NMC PV contour.

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