Update on Derived Meteorological Products and Related Analyses for SOSST

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1 Derived Meteorological Product Files and Descriptions

NCEP Derived Meteorological Products Database for SAGE II

Field	Units	Description
Alt	km	(2D) Altitudes
Lat	deg	(2D) Latitudes as a function of Altitude
Lon	deg	(2D) Longitudes as a function of Altitude
SunDir	deg	(2D) Line-of-Sight (LOS, degrees clockwise from N) as a function of Altitude
θ	K	(2D) Potential Temperature from meteorological data
Temperature	K	(2D) Temperature from meteorological data
Hor T Grad	K/km	(2D) Horizontal temperature gradient at SAGE observation location
LOS T Grad	K/km	(2D) Temperature gradient along SAGE LOS
Geop Hgt	m	(2D) Geopotential Height
Zonal Wind	m/s	(2D) Zonal Wind
Merid Wind	m/s	(2D) Meridional Wind
PV	10^{-4} K m^2 kg^{-1} s^{-1}	(2D) Potential Vorticity
Scaled PV	10^{-4} s^{-1}	(2D) Scaled PV, in "vorticity units"
EqL	deg	Equivalent Latitude
Hor PV Grad	–	(2D) Normalized (with respect to average at θ level) horizontal PV gradient
LOS PV Grad	(10^{-4} K m^2 kg^{-1} s^{-1})/km	(2D) PV gradient along SAGE LOS
EqL - VEC	deg	(2D) Distance in EqL of observation from vortex edge center
EqL - VEI	deg	(2D) Distance in EqL of observation from inner vortex edge
EqL - VEO	deg	(2D) Distance in EqL of observation from outer vortex edge
Dyn Tropopause	km	(1D) Dynamical tropopause altitude - "3.5 PVU" definition
TG Tropopause	km	(1D) Temperature gradient tropopause altitude - WMO definition

An effort was initiated last year to produce and distribute derived meteorological products (DMPs) for many of the SOSST datasets. During the year,

- The SAGE II DMPs described last year have been tested further and updated
- SAGE II DMPs have now been calculated from both NCEP/CPC (hereinafter NCEP) and Met Office meteorological datasets
- DMPs have been produced for ACE-FTS using Met Office data and provided to and used by members of the ACE Science Team, for the entire retrieved ACE dataset; they are set up to be routinely produced from future data versions
- Calculations of derived products for SAGE III from Met Office data have been set up, and DMPs calculated for the 2004-2005 Arctic winter; routine calculation of these on incoming data is being initiated
- Currently DMP files are produced and distributed on the grids native to the instruments, and with file formats analogous to those of the SOSST instrument data

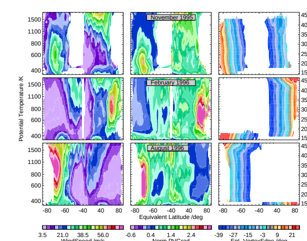
The DMP products are summarized in the Table:

- 2D products are a function of altitude at each observation location; 1D are single value for each observation.
- First four fields are from the observing geometry; line-of-sight (LOS) information is not currently available from ACE, thus quantities in grey are not calculated for ACE
- Latitude, longitude and line-of-sight (LOS) direction for each observation as a function of altitude, along with pressure provided in the instruments' data files, are used to interpolate meteorological data and derived quantites to the observation locations.

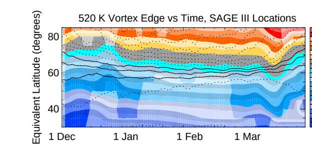
- Temperature, geopotential height, horizontal winds interpolated bilinearly in the horizontal and linearly in log(p) in the vertical to SAGE locations.
- Horizontal and LOS temperature gradients are calculated using the temperature field at the pressure of each observation.
- Other 2D quantities (related to PV) are interpolated linearly in log(θ) in the vertical, and gradients are calculated on the θ surface of the observation.
- Scaled PV (sPV) is in "vorticity units" [*Dunkerton and Delisi*, 1986], as described by *Manney et al.* [1994].
- EqL of the vortex edge center and inner and outer boundaries are calculated as the location of the maximum of (windspeed)×(normalized PV gradient) as discussed in more detail later

- Tropopause heights are calculated from temperature or PV profiles after interpolation to the SOSST locations:
  - "Dynamical" tropopause – altitude of 3.5 $\times 10^{-6}$ K m^2 kg^{-1} s^{-1} PV contour in the extratropics; joined to 380 K potential temperature surface in the tropics.
  - Temperature gradient (WMO) tropopause – the lowest altitude at which the magnitude of the lapse rate drops below 2 K/km and remains below that value for at least 2 km – calculated as in *Reichler et al.* [2003].

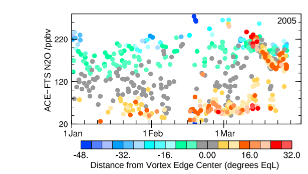
2 Vortex Edge Identification and Applications



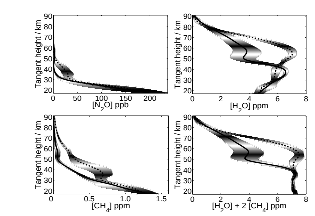
- The figure above illustrates vortex characteristics from Met Office DMP files at SAGE II observation locations in November 1995, February 1996 and August 1996 (patterns are also typical of other years).
- High windspeeds and strong normalized PV gradients are associated with the vortex edge regions.
- Vortex edge center is defined as location of maximum of (windspeed)×(normalized PV gradient); test for the vortex edge extends out to 35°EqL. Vortex is defined only if windspeed is greater than 15.2 m/s, normalized PV gradient is greater than 1.1, and the EqL of the maximum is less than 80°.
- Distance in EqL from vortex edge center quantifies this.
- Any automated vortex edge definition comes with many caveats. This definition has been compared with that of *Nash et al.* [1996], and other variations based on using the PV gradients and/or windspeed.
- All methods produced similar results for the mid-winter middle to lower stratosphere. In the upper stratosphere, and in fall and spring, the advantages or disadvantages of various methods vary with the particular meteorological situation.
- SAGE II observed well into the NH polar vortex in February 1996 and into the (decaying) SH polar vortex in November 1995 (because of asymmetry/motion of the vortex), but not into the SH vortex in August 1996, when that vortex is relatively quiescent and symmetric.



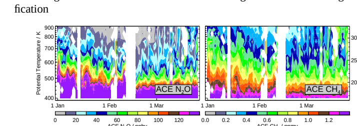
- The vortex edge from SAGE III DMPs in the lower stratosphere in the 2004-2005 winter is shown above
- The definition is conservative, well inside the start of the region of strong PV gradients
- Variations with respect to the PV field (overlaid contours) reflect partly sampling effects.



- The above figure shows ACE N_2O as a function of time in the lower stratosphere during January through March 2005, color-coded by distance from vortex edge
- In January and February, there is good separation of high and low N_2O values between inside and outside the vortex
- The vortex break up began suddenly in early March, with a "major-final warming"; after this time, the mixing of vortex and extra vortex air is apparent



- The vortex edge definitions from the ACE DMP files were used to classify profiles inside and outside the vortex in the 2003-2004 Arctic winter [*Nassar et al.*, 2005] to study descent in the vortex
- Above figure shows vortex and extravortex trace gases from ACE using this classification

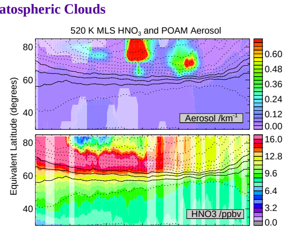


- Simpler definitions, such as an sPV contour, can also effectively be used to demark the vortex edge
- Above example shows vortex-averaged N_2O and CH_4 in January through March 2005 based on this definition, showing the effects of confined descent in the vortex

3 Examples from the 2004-2005 Arctic Winter: Combining MLS and SOSST Data Using DMPs

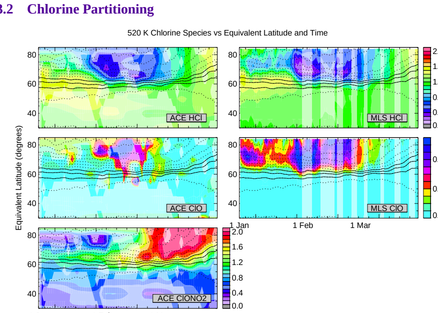
DMPs such as PV and EqL are invaluable in intercomparing [e.g., *Manney et al.*, 2001] and combining datasets with different sampling. The following figures show several examples illustrating polar processes in the 2004-2005 Arctic winter, demonstrating the combined use of Microwave Limb Sounder (MLS) data from NASA's new Aura satellite and data from several SOSST instruments. DMPs for MLS are currently calculated on the fly, but DMP files will be produced in the future. A Kalman filter is used to smooth the fields below for plotting [e.g. *Santee et al.*, 2004]; pale colors denote places/times with poor precision, i.e., when regions with little or no data are filled in by smoother.

3.1 Polar Stratospheric Clouds



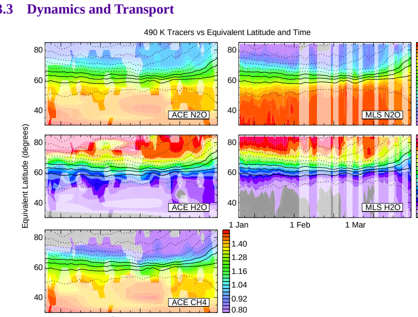
- POAM III (V4) aerosols and MLS HNO_3 (POAM EqL was calculated on the fly, but DMP files will be available in the future)
- Some, but not close, correspondence between depressions in MLS HNO_3 and enhanced POAM aerosol
- Close attention to sampling needed to understand this, but DMPs give us the tools to look at this
- Compared to observations from UARS MLS, EOS MLS observations show much larger depletions in gas-phase HNO_3 in December and January, suggesting greater PSC activity during those times

3.2 Chlorine Partitioning



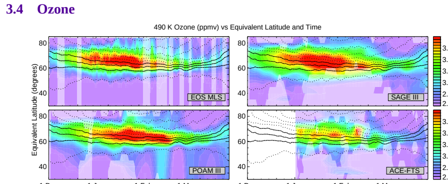
- EqL-Time plots of ACE (V2.1) and MLS Chlorine species
- ACE has species (e.g., $ClONO_2$) that MLS does not, but MLS has coverage that ACE does not
- Intercomparisons of species with few other correlative measurements
- Combining ACE and MLS data for detailed studies of chlorine partitioning promises to be very fruitful and is being actively pursued by ACE and MLS teams
- Substantial recovery into $ClONO_2$ is seen by early February, but significant recovery into HCl is not apparent until late February

3.3 Dynamics and Transport



- EqL-Time plots of ACE and MLS long-lived trace gases
- ACE and MLS long-lived tracers show broad overall agreement, and very good agreement in morphology and time evolution, when viewed as a function of EqL
- Tracer evolution suggests significant mixing across the vortex edge during much of the winter
- Increasing N_2O and CH_4, and decreasing H_2O after mid-February suggest that mixing processes dominate over descent after this time

3.4 Ozone



- EqL-time plots provide a overview comparison of ozone from many instruments (SOSST instruments with good polar coverage are shown with MLS)
- All instruments show similar morphology and evolution of ozone
- Poorer quantitative agreement with ACE may be related to sampling
- Ozone during the 2004-2005 winter declined steadily starting in late January, then increased rapidly as the vortex began to erode in early March
- Because of the unusual morphology of ozone before ozone loss began, and the substantial effects of mixing, chemical ozone loss is even more difficult than usual to quantify for the 2004-2005 winter, and sampling effects can be particularly important
- Several preliminary estimates from MLS suggest ozone loss up to over 2 ppmv in a band near the vortex edge, and up to about 1.5 ppmv averaged over the vortex; vortex-average estimates from POAM give similar results

References

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4 Future Plans: Calculations, Distribution, Climatologies

4.1 Further Calculations

- Production of DMP files for HALOE and POAM II/III datasets
- Production of DMP files for EOS MLS data
- Calculation of DMPs for all instruments from all of NCEP, Met Office, and GEOS-4 meteorological datasets
- Comparisons with similar products produced by other research groups

4.2 Distribution (for discussion)

- DMPs for publically available datsets are currently being distributed from anonymous ftp site at JPL, advertised only by word-of-mouth
- We are considering setting up a website from which we could distribute the DMPs for all the SOSST instruments (those from datasets that are not publically available could be password-protected)
- This distribution would be in the formats we are currently calculating, that is, analogous to the formats in which each SOSST dataset is distributed, and on the grids of those distributions
- A subset of the most useful quantities in the DMP files is expected to be included in a unified SOSST dataset (see Randall et al. poster), but the web distribution would be in advance of that, and provide the full files on each instrument's native grid
- This could then be linked to SOSST and the instruments' webpages
- Comments on/discussion of this idea are most welcome

4.3 Climatologies (for discussion)

- One very useful product from the DMPs is EqL/θ and EqL/time climatologies and monthly/yearly fields of SOSST data.
- Figures below show examples of such climatologies from SAGE II using the NCEP DMPs, from 18 years of data (excluding the partial years 1984, 2000, and 2005)
- Such fields are valuable for model initialization/comparison
- Climatologies such as the examples below could easily be distributed on the website as well.
- In addition, individual monthly EqL/θ-mapped fields and yearly EqL/Time fields could be made available.
- We invite and welcome comments/discussion on what products would be useful