High-Altitude Data Assimilation/ Forecast Activities at NRL-DC

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Motivation

- Standard data assimilation products are typically provided up to the upper stratosphere or lower mesosphere (e.g, NCEP and NASA). Emphasis is on tropospheric forecasts.

- There is a growing need for reliable, homogeneous (in space and time) assimilation products at higher altitudes.

  - ✓ Support for satellite missions and validation: AIM (sophie), TIMED (saber)

  - ✓ Research: PMC, chemistry, tides, planetary waves, gravity waves, MLT and beyond.

Forecast Model: NOGAPS-ALPHA (α)

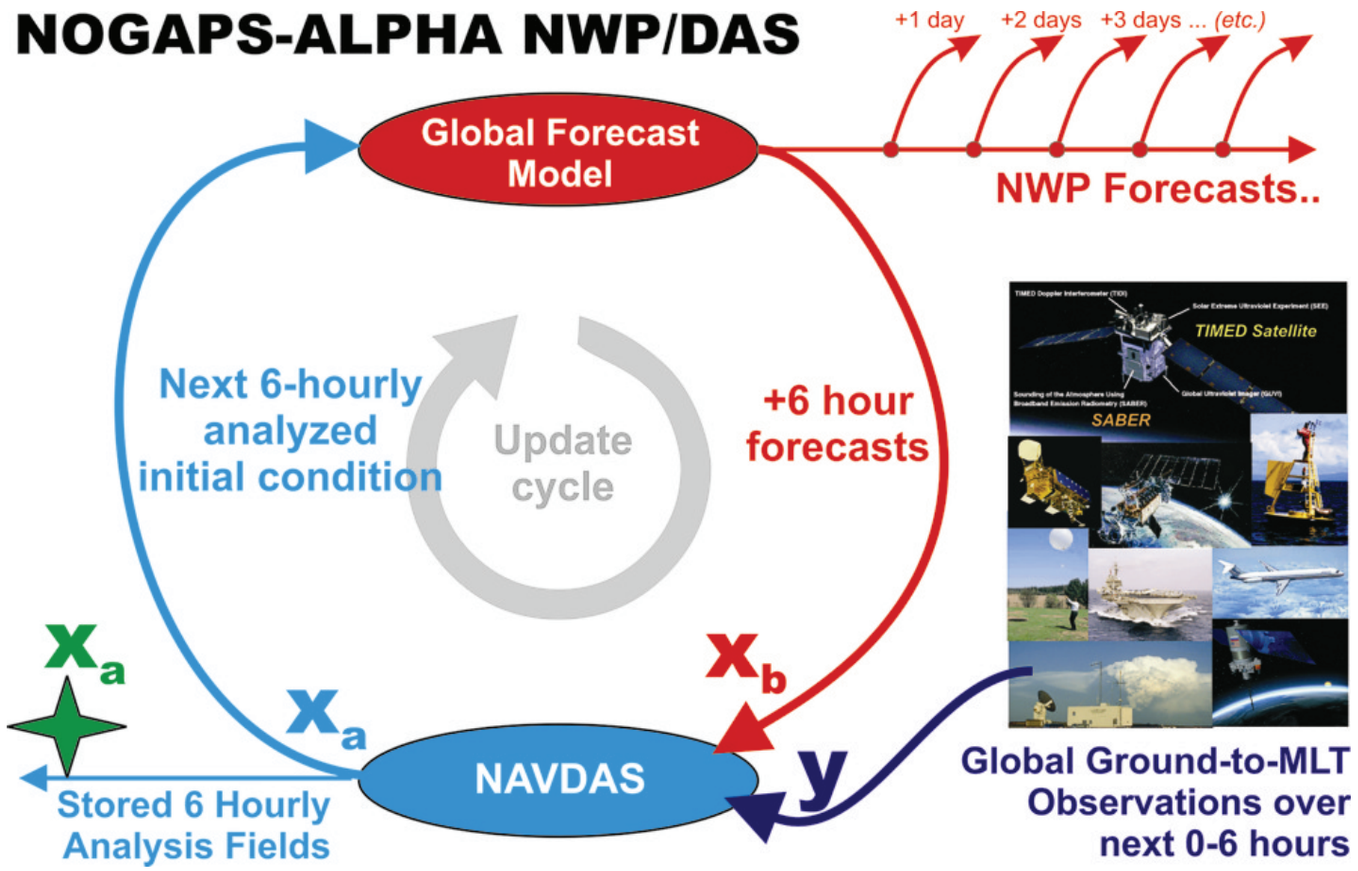
- Based on the Navy Operational Global Atmospheric Prediction System (NOGAPS) with the inclusion of the physics and parameterized chemistry that extend its validity up to the MLT region: Advanced Level Physics High Altitude (ALPHA).

- Extension to the MLT region replaces the SW/LW radiation scheme with Chou and Fomichev; includes trace transport of Q, O3, CH4, N2O (McCormack) and parameterized chemistry of Q, O3 (McCormack); also, gravity wave drag (Garcia). Ref: Eckermann et al (2007, 2009)

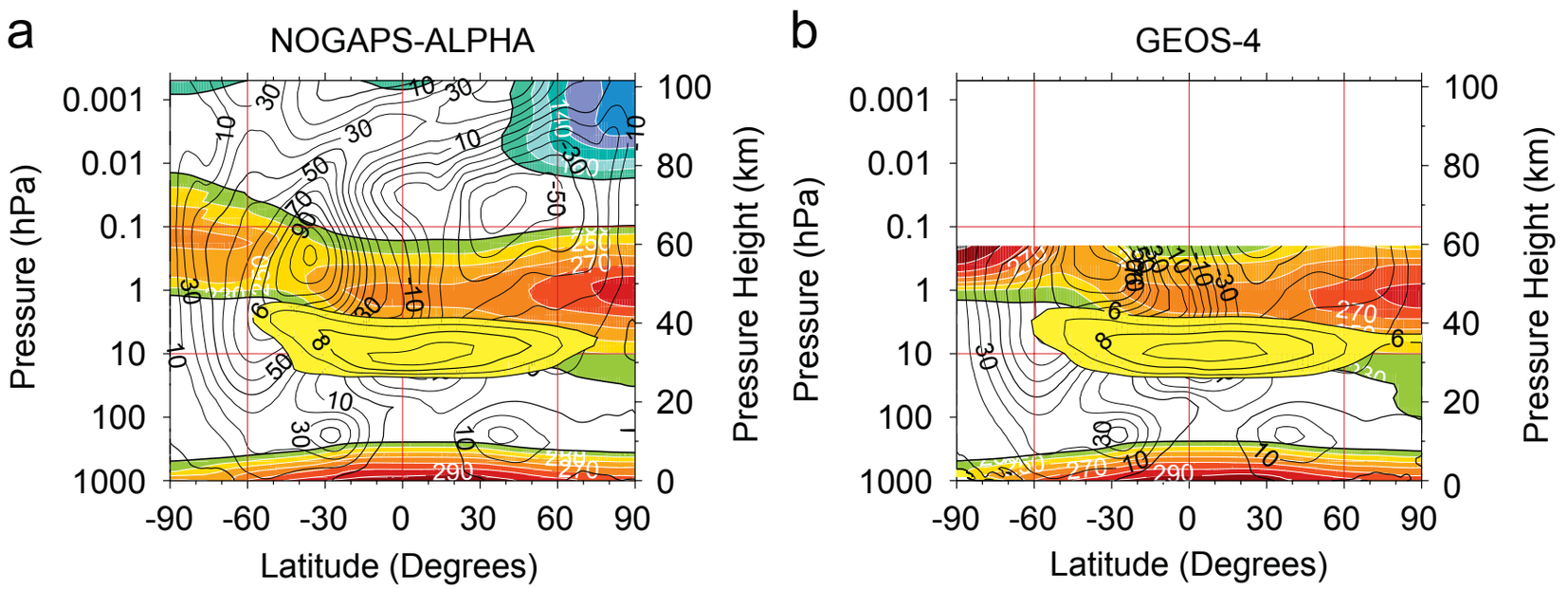
- NOGAPS-α can be run with different resolutions both horizontally and vertically. Typical configuration is T79L68.

Data Assimilation System: NAVDAS-α

- 3DVAR system: Naval Research Laboratory Atmospheric Variational DAS (NAVDAS). Ref: Daley and Baker.
- It is interfaced to NOGAPS-α to run as an NWP system extending to the MLT. Ref: Hoppel et al. (2008), Eckermann et al. (2009).
- In addition to routinely assimilated sensor data used operationally by Fleet, the NAVDAS-α includes: AURA/MLS T, Q and O3; TIMED/SABER T.
- NAVDAS-α products are valid through 0.002 hPa (~92 km).



Schematic depiction of the NOGAPS-ALPHA 6-hourly forecast-assimilation update cycle, including observations (O), depicted by the vector **Y** (dark blue), forecasts (F), depicted by the vector **Xb** (red), and the analysis (A), depicted by the vector **Xa** (blue, green).



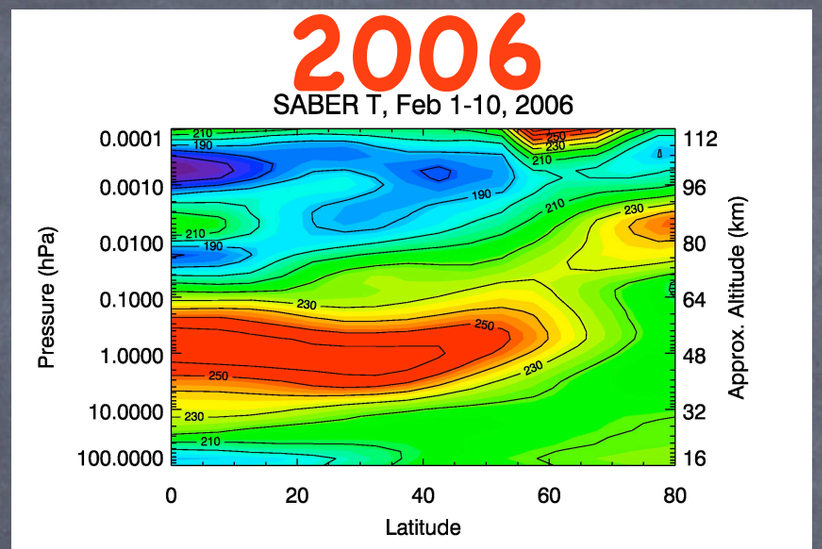
Eckermann et al., 2009

Dynamics and Chemistry in the Winter Mesosphere

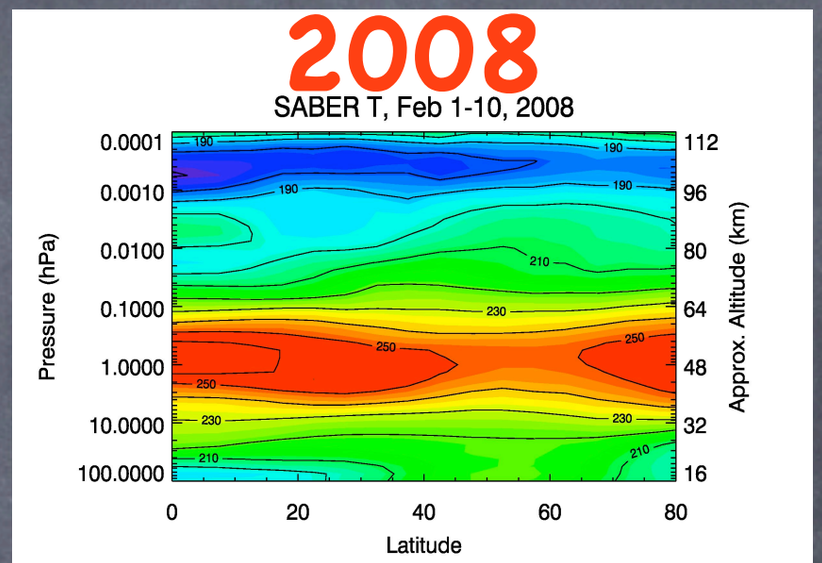
P.I.: Siskind (NRL)

Around the time when the stratospheric zonal winds reverse (SSWs), the mesosphere shows dynamical and chemical changes: elevated stratopause, downward transport of NOx, anomalous distribution of radiatively active constituents. Is the observed mesospheric warming associated with dynamics (GWD) or chemistry (airglow)?

2006



2008



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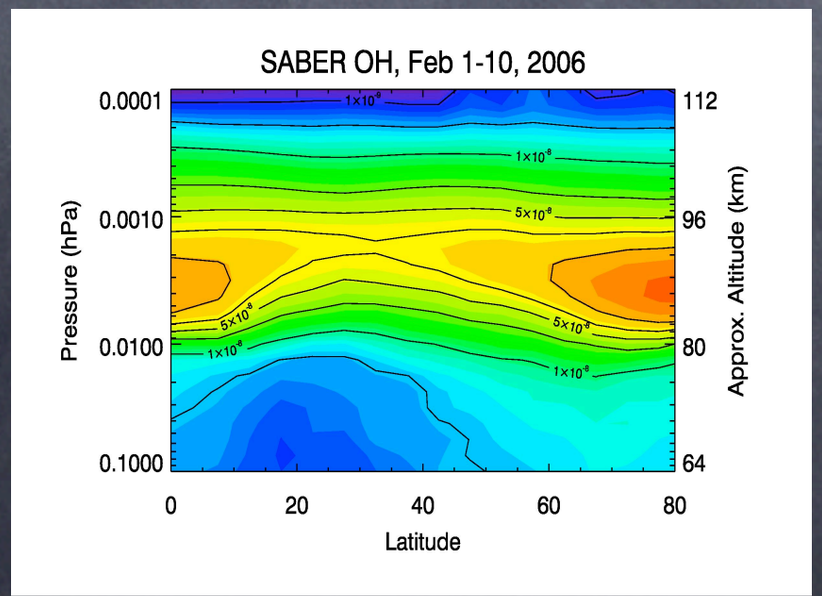

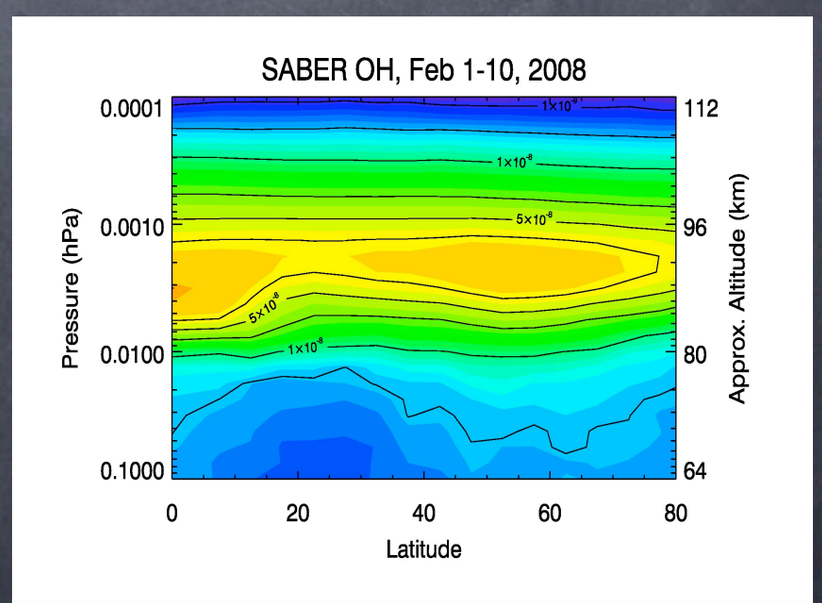

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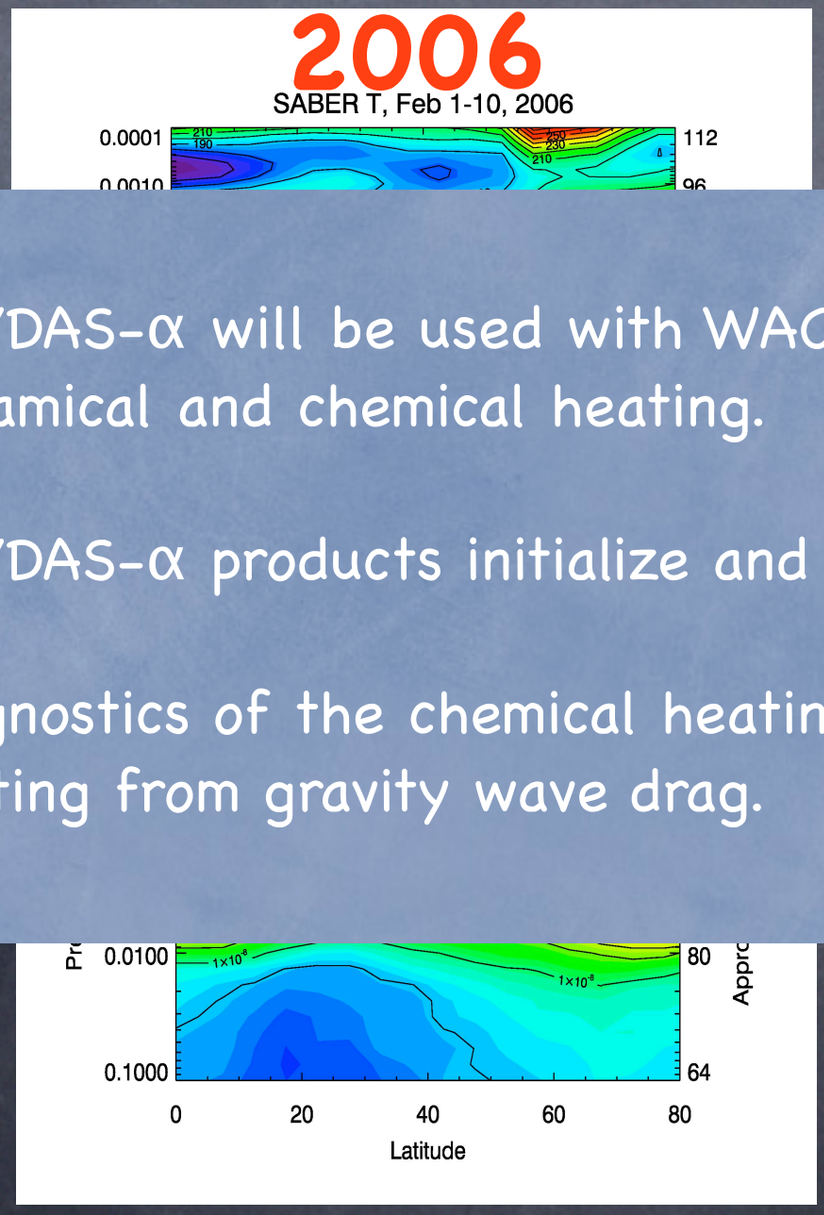

- NAVDAS-α will be used with WACCM to disentangle the roles of dynamical and chemical heating.
- NAVDAS-α products initialize and constrain WACCM-SD.
- Diagnostics of the chemical heating of Ox and HOx and the dynamical heating from gravity wave drag.

Dynamical Influence of the Winter Stratosphere in the Thermosphere

P.I.: Sassi (NRL)

NAVDAS-α 2009 SSW: T and Z

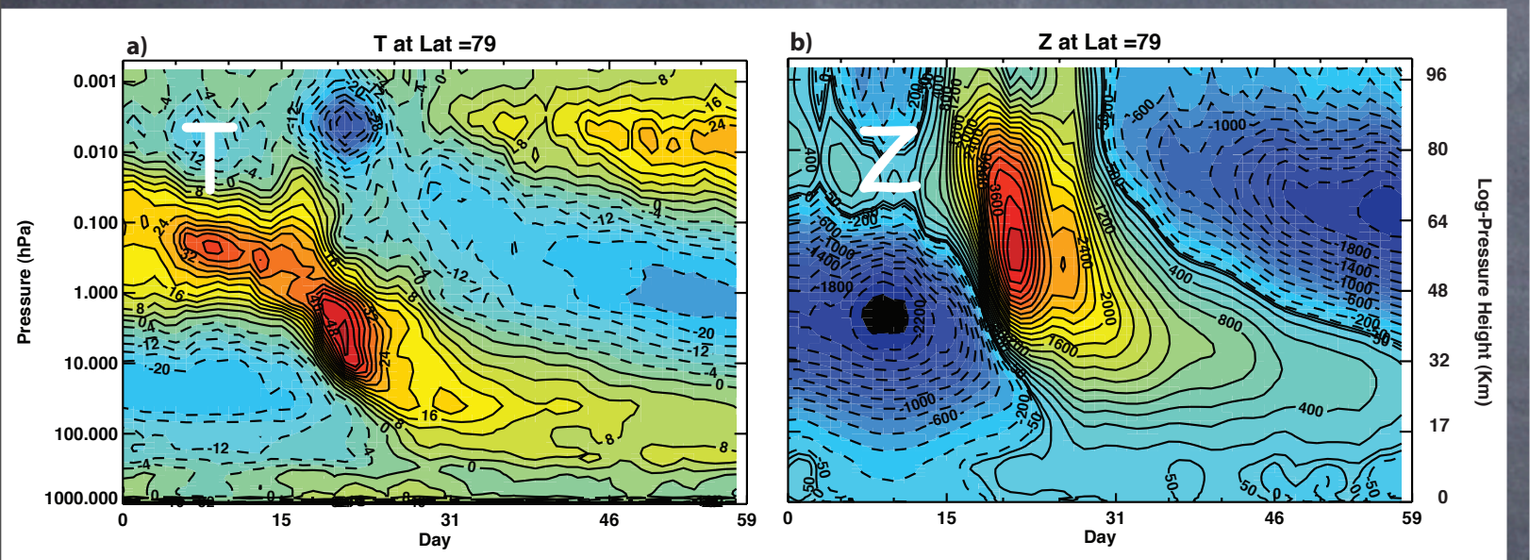

Figure 1. NAVDAS products for January/February 2009. (a) Anomaly of temperature (K; c.i.=4 K). (b) Anomaly of geopotential height (m; c.i.=200 m). Anomalies are calculated against the January-February time mean.

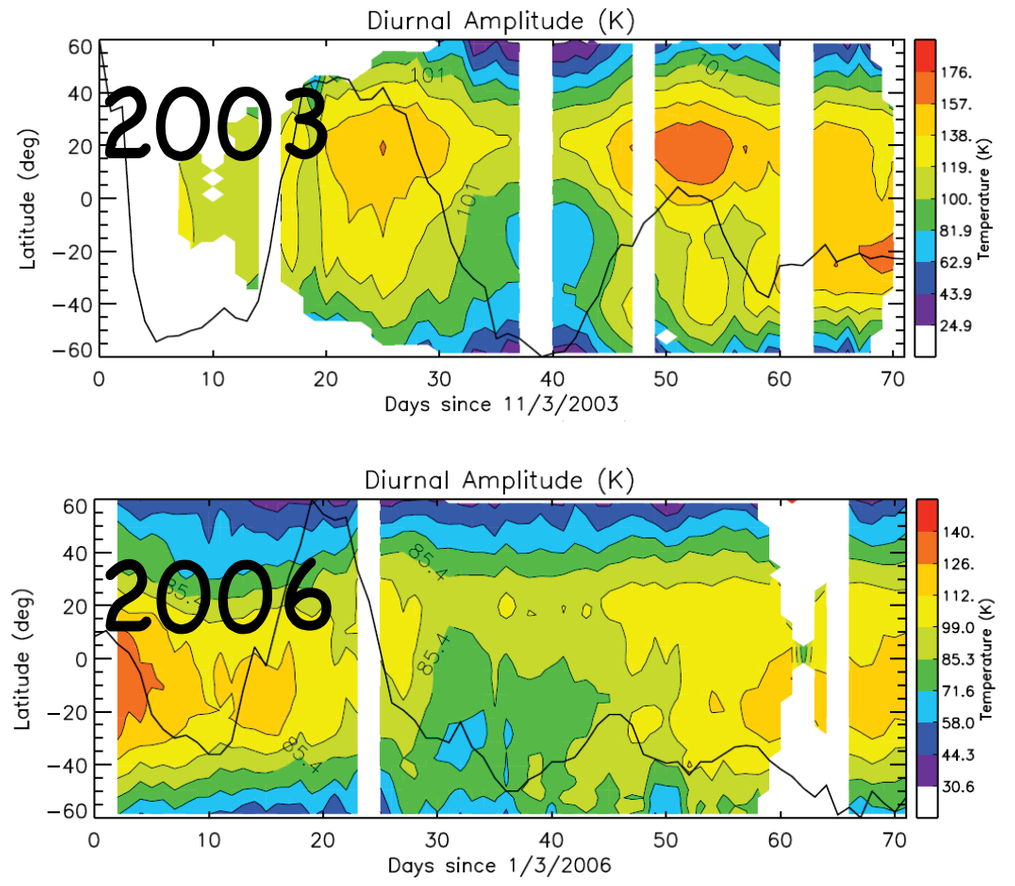

Figure 8. Day-to-day variability of the diurnal tidal exosphere temperature during January-February 2003 (top) and 2006 (bottom). The black line is the daily 10.7-cm solar radio flux.

Courtesy of Prof. J. Forbes

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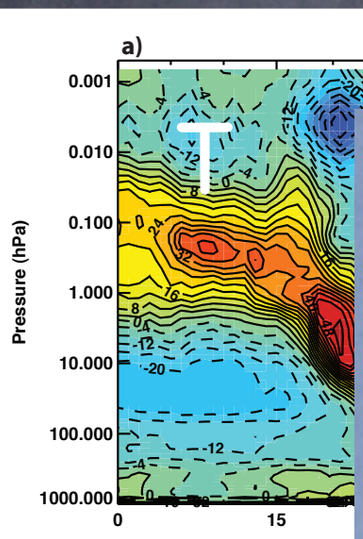
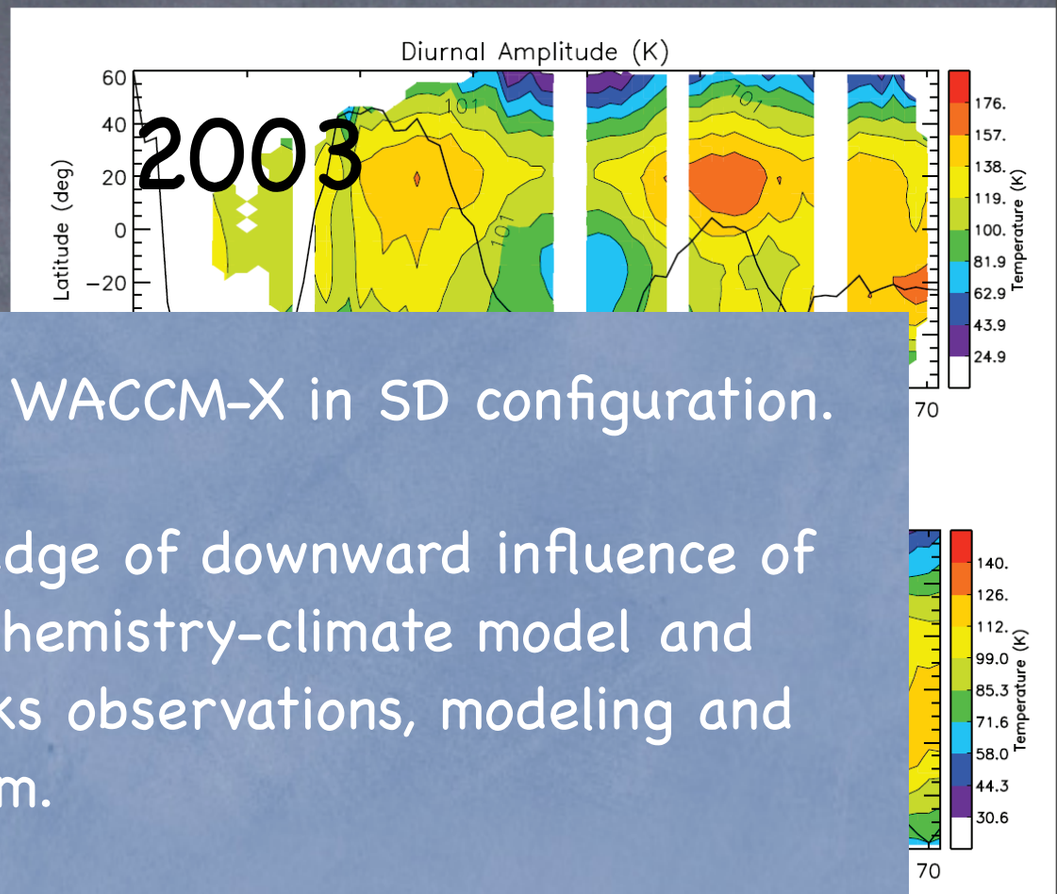


Figure 1. NAVDAS products
geopotential height (m; c.i.=

- NAVDAS-α initialize and constrain WACCM-X in SD configuration.
- The goal is to advance the knowledge of downward influence of the solar variability in a coupled chemistry-climate model and provide an innovative tool that links observations, modeling and physics from the ground to 500 km.



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Seasonal Predictability

- There is observational evidence that the Arctic sea ice extent is decreasing in summer: model projections indicate that by ~2100 the Arctic Ocean will be free of ice in summer.
- The future of Arctic sea ice (extent, thickness, dynamics, radiative properties) is of interest to the US Navy: exploitation of new shipping routes for economic and strategic reasons.
- Current research has pointed out the potential interactions between sea ice reduction and the weather. It is still unclear what (or even, if at all) interaction exists between the state of the stratosphere and the Arctic sea ice in wintertime.
- Is there a role to be played by WACCM with a DAS? WACCM fully coupled with NAVDAS initial conditions. Consistent with the CLIVAR Stratosphere resolving Historical Forecast Project (SHFP); supports some of the SPARC DynVar activities.

Conclusions

- NRL-DC has a unique capacity to produce high altitude DAS products that have a variety of applications and uses.
- The goal of this presentation is to motivate interest from the WACCM community in these data products and find innovative applications that combine NAVDAS and WACCM.

Acknowledgments

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