GEOS-5 Forecasts of the Stratospheric Sudden Warming (SSW) in January 2013

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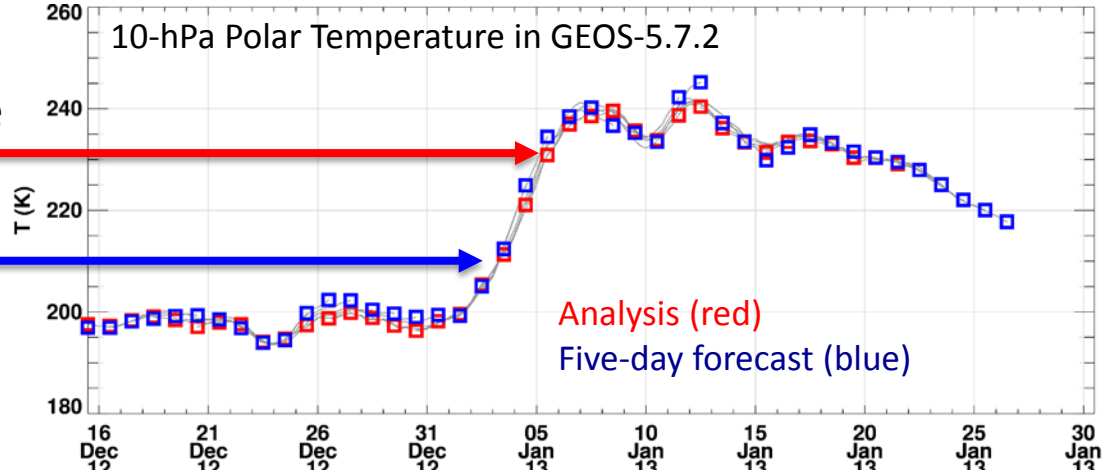
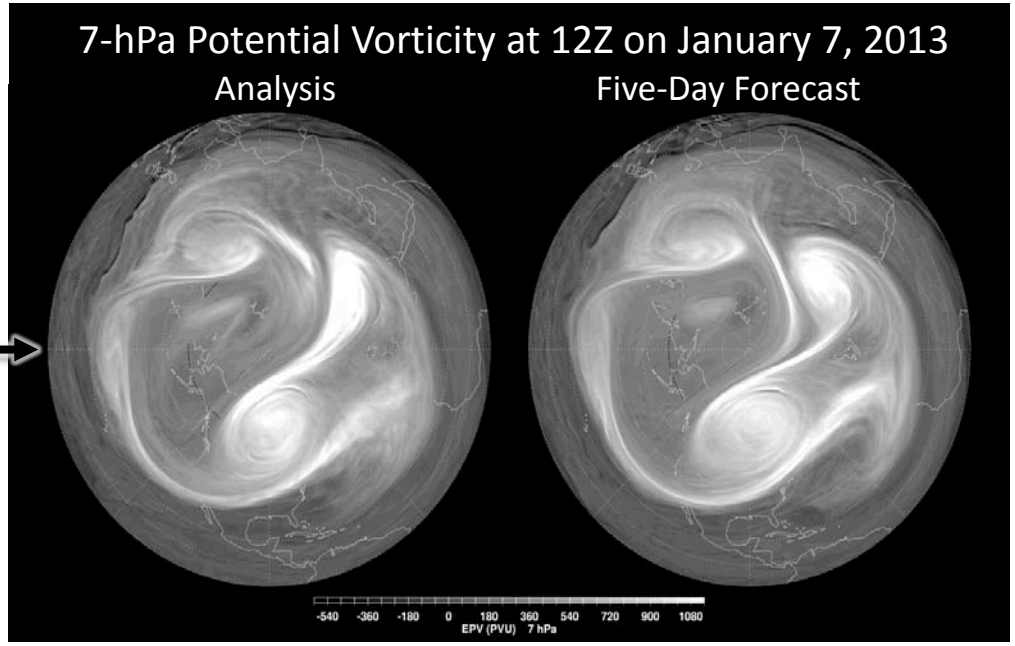
- SSWs are characterized by rapid polar temperature increases – by 35K in the first week of January 2013 (red)
- Five-day forecasts captured this temperature increase very well (blue)
- SSWs are dynamical events that help define stratospheric climate and that impact polar ozone distributions and can impact the troposphere as well
- Potential vorticity fields define the fragmented polar vortex (bright white shades) at the peak of the SSW on January 7, 2013
- Throughout this SSW event, the complex PV structure was well captured five days in advance





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Background:

GEOS-5 five-day forecasts are routinely produced twice daily. The model, which includes the effects of aerosols and trace gasses, is run at a 1/4 degree horizontal resolution with 72 vertical levels to 0.01 hPa. Initial conditions are provided by real-time analyses of assimilated satellite and ground based observations. Observations constrain the analysis well up to about 2 hPa.

Result:

A major midwinter stratospheric sudden warming (SSW) occurred, peaking on January 7, 2013.

- GEOS-5 assimilated fields demonstrate the evolution of the event. Temperatures at 10hPa in the polar region (top Figure) clearly show a warming of almost 40K over seven days. Zonal winds (not shown) undergo a reversal from westerlies to easterlies at 60°N. These are the WMO-defined criteria for a major SSW.
- GEOS-5 five-day forecasts predicted the warming with a high degree of integrity. The polar temperatures (blue symbols in the top figure) agree to within a couple of degrees throughout the period shown. Historically, forecast models had difficulties in predicting the transition from an undisturbed flow to the disturbance of the SSW at lags of five days. These GEOS-5 forecasts demonstrate that this event was very well represented at a five-day lead time and makes the case for running ten-day forecasts.
- Ertel's Potential Vorticity (EPV) is a dynamical quantity that also serves as a quasi-conservative tracer of atmospheric motions. The high-resolution EPV maps from GEOS-5 represent the transition from an atmospheric polar vortex structure in middle December, with disturbances that lead to a vortex distortion and breakdown. This evolution is illustrated dramatically in an animation of EPV at 7hPa, that uses six frames per day from the assimilation (slide 3). The left panel in the bottom figure on slide 1 shows the EPV field from the assimilation on January 7, with three distinct peaks in (cyclonic) vorticity around the globe and lower values, typical of lower latitudes, transported into the polar region. This disturbed state aligned with anomalous circulations in the troposphere, such as the warm air over the Eastern part of North America in early January 2013.
- The five-day forecast for January 7 (right panel in bottom figure on slide 1) demonstrates that GEOS-5 has substantial skill in predicting the fragmentation and distortion of the polar vortex at the peak of the warming. Even though the precise locations of the vortex fragments are not correctly captured in the forecasts, the general structure and dynamical features of the vortex are extremely well represented. This suggests that the dynamical behavior of the vortex is correctly represented and supports the investigation of trace-gas transport (of ozone and related species).

Future:

Performance metrics associated with prediction of different phenomena help in the evaluation of the GEOS-5 modeling and assimilation system. Most forecast metrics focus on the troposphere. SSWs provide a good opportunity to evaluate the system in the stratosphere. To facilitate future comparisons and earlier forecasts of these events that can impact weather in the troposphere (as for the current event), the GEOS-5 forecasts initialized at 00Z will be extended from 5 days to 10 days. Two key questions pertain to the ability of the system to predict vortex breakdowns at longer lead times and the realism of ozone transport in the stratosphere.

Further Information:

Description and discussion of SSW: http://gmao.gsfc.nasa.gov/researchhighlight/SSW/

Movie: http://gmao.gsfc.nasa.gov/researchhighlight/SSW/epv_7mb_20121215_20130128_1080.mov