Towards a Representation of Vertically Resolved Ozone Changes in Reanalyses

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Summary of Issues

Ozone poses a unique set of challenges for reanalysis.
Chemically: the distribution is controlled by sunlight and human-emitted pollutants that rise between 1960 and 1997, then decline after the Montreal Protocol becomes effective.
Radiatively: ozone in the upper troposphere and lower stratosphere is a climate gas; it also impacts the use of infrared radiances to constrain the 3D thermal field.
Observationally: It is the most widely observed trace gas, yet the observations are inhomogeneous in space and time, especially when information about vertical profiles is needed.

Main points

Ozone observations differ in periods of decline and recovery
1980s and 1990s: While total and partial columns are well observed by SBUV and TOMS, there are only sporadic times when ozone profiles are observed using limb profilers.
Challenge: exploit the model to effectively derive profiles.
21st Century (EOS and JPSS eras): Advanced technologies provide better spatial resolution in the total and partial column observations. EOA-Aura and the OMPS-LP instruments provide prolonged coverage of ozone profiles.
Challenge: merge data types to a trend-quality product.

Characterizing the Observations in Periods of Ozone Decline and Expected Recovery

A juxtaposition of past and future ozone change from the WMO-UNEP (2014) assessment and near-global satellite observations of total-column, partial-column, and profile ozone that can be used in reanalyses.

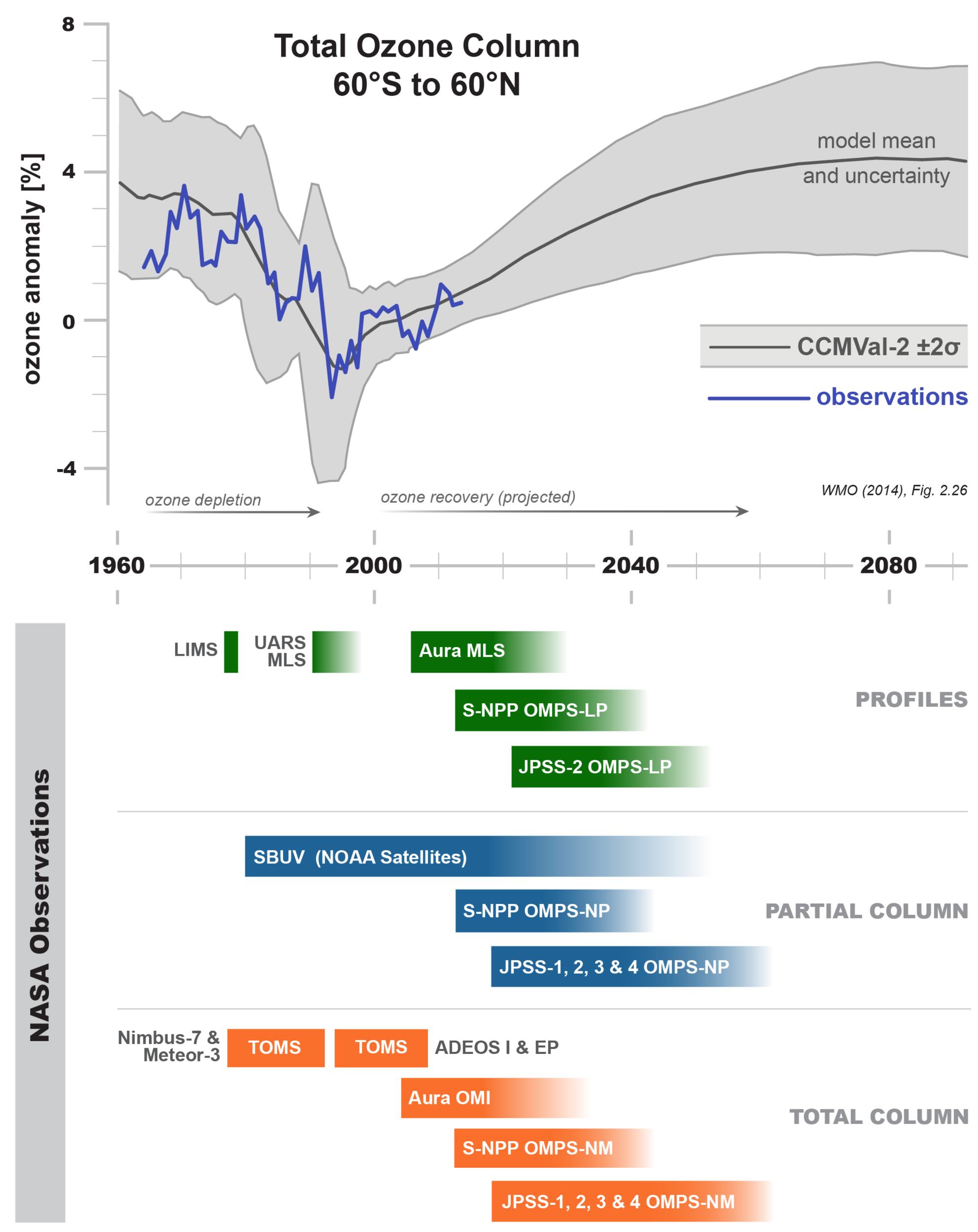
WMO-UNEP documents the global ozone decline between about 1980 and 1997; this is also captured in chemistry-climate models.

There is a well-documented series of total and partial column ozone data (SBUV, TOMS) for this period of ozone decline.

NASA's research observations provide only "snapshots" of the ozone profiles, in 1978-1979 with LIMS and the 1990s with Aura-MLS.

Non-NASA satellite data are also available.

Challenge is to integrate the model, with chemistry, to the observations.



Early signs of the projected 21st century ozone recovery, as CFCs decline and the stratosphere cools, are evident in satellite observations.

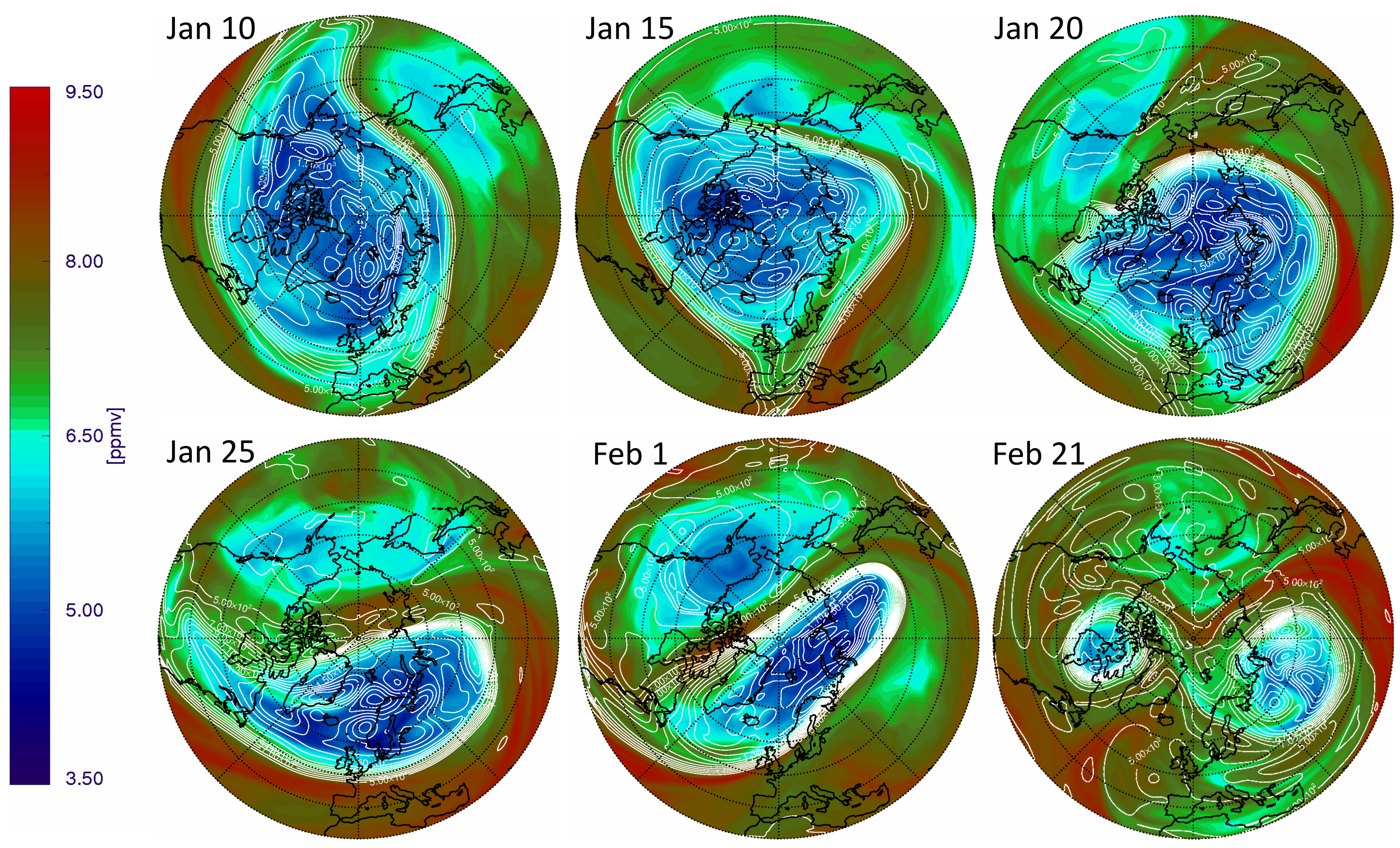
Partial and total column ozone data persist. Additional constituent observations open the pathway to analyses of air pollution.

NASA's EOS-Aura MLS so far spans the period 2004-2017. The OMPS-LP record will continue that record into the late 2020s and beyond.

Geostationary data are also expected.

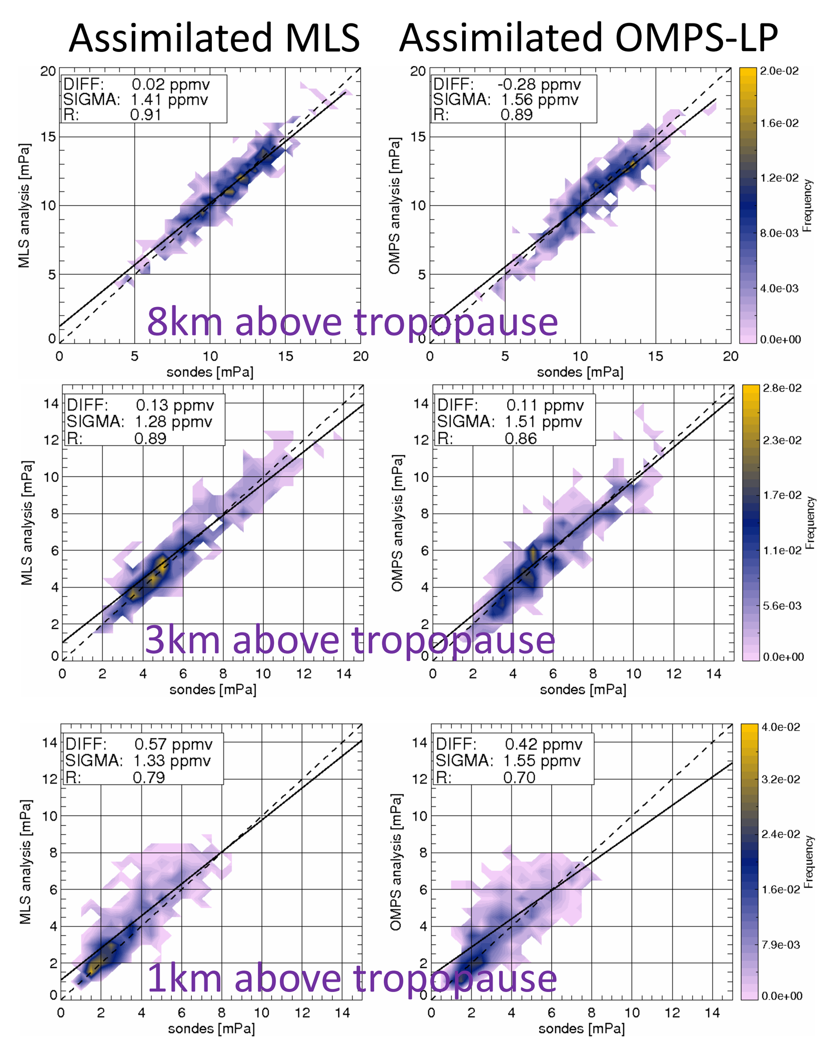
Challenge is to effectively use the assimilation to produce a steady long-term ozone record.

Example 1: Assimilating LIMS Ozone

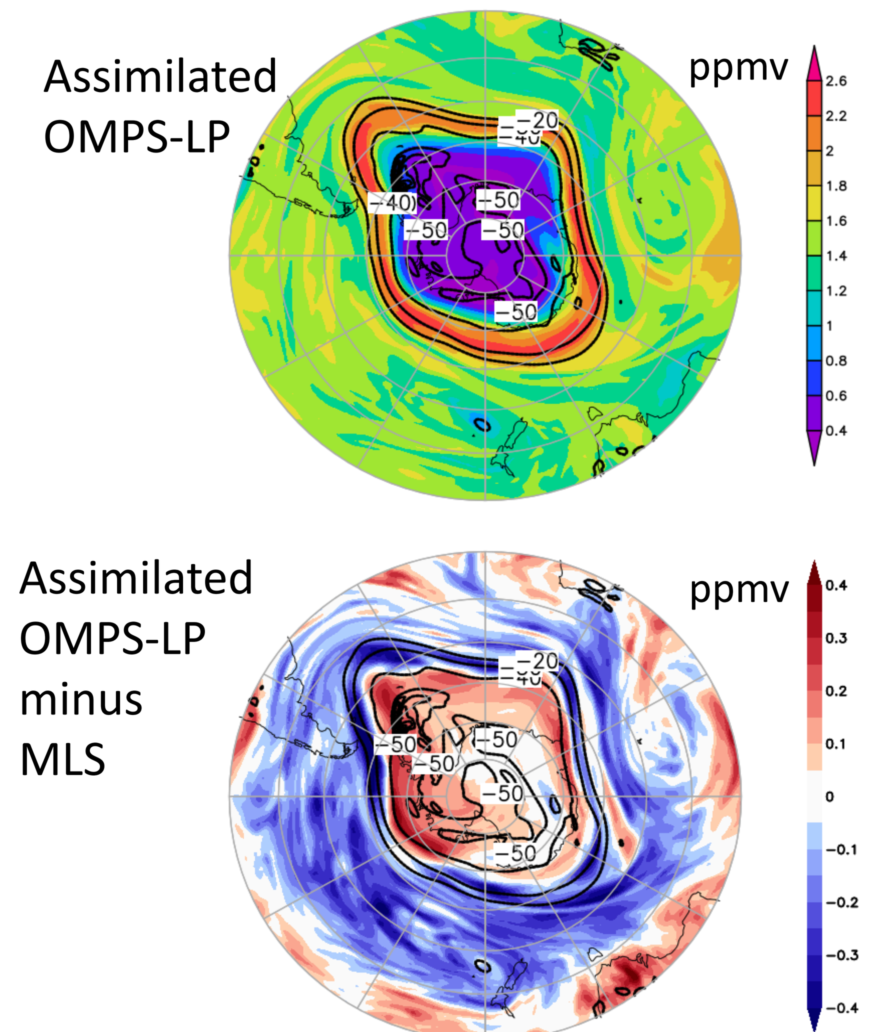


LIMS observed ozone profiles through the winter of 1978-1979. Assimilating it into the GEOS system highlights the ability of this early stratospheric ozone dataset to realistically constrain the fields in this dynamically active time.

Example 2: MLS/OMPS-LP Agreement



Comparing assimilated data with in-situ sondes shows similar overall agreement for both MLS and OMPS-LP



460K isentrope (~20km)

Lower stratospheric ozone over Antarctica shows that OMPS-LP values are higher inside and lower outside the vortex

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