Ozone Data Assimilation at the Met Office

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Overview

- Summary of DA system
- Impact on NWP
- Using Ozone DA to estimate Arctic chemical ozone loss

Why assimilate ozone?

- Potential benefits for NWP
  - improved radiance assimilation
  - improved radiative heating rates
  - impact on UTLS wind fields
  - surface UV forecasts.
- Quality controlled 4D ozone analyses for climate-chemistry studies (exploiting research satellite data (eg EOS MLS, MIPAS)).
- Useful new technique for estimating stratospheric polar ozone loss.
- Assessment of aspects of model performance through DA (eg chemistry parametrizations (Geer et al, 2007))

Ozone DA Overview

- Uses 3D-Var (4D-Var in development). GCM not CTM approach.
- Results shown for N48L50 model
- Parametrized ozone chemistry (Cariolle scheme)
- Can assimilate both operational data (eg HIRS radiances, SBUV and GOME-II Level 2 data) and research satellite data (SWIFT, MIPAS, EOS MLS)

Impact on NWP

Experiments with different ozone representations

Different representations of ozone were used in the forecast model radiation scheme:

- Li and Shine climatology (control)
- Alternative climatology (SPARC)
- Ozone analyses imported from ECMWF
- 3D-Var ozone assimilation (EOS MLS +SBUV)
- 3D-Var ozone assimilation (SBUV only)

NWP: Impacts on Met Office Global Index

	Alternative Ozone Climatology	ECMWF full ozone field	Full Met Office 3D-Var (EOSMLS + SBUV)	Full Met Office 3D-Var (SBUV only)
Global index (compared with analysis)	+0.314	-0.027	+0.413	+0.112
Global index (compared with observations)	+0.051	-0.216	+0.182	+0.289

Mathison et al, 2007.

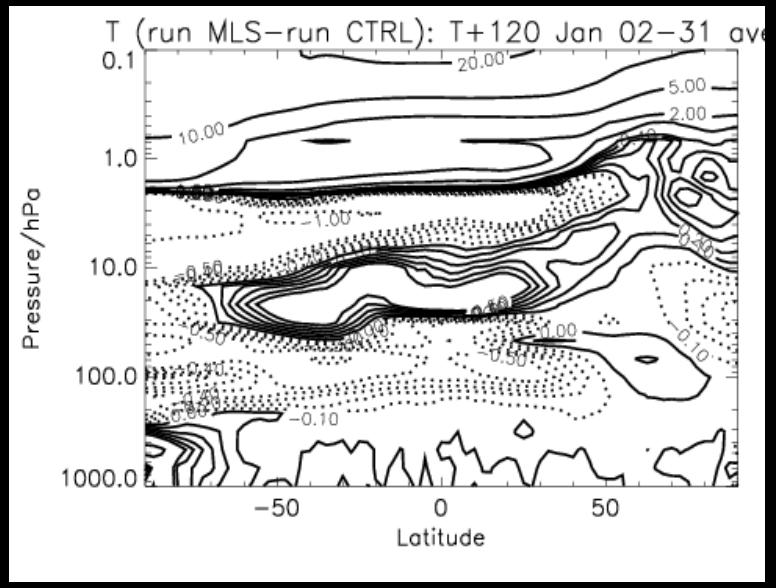
Index change ~%. >0.2-0.4 is stat. significant

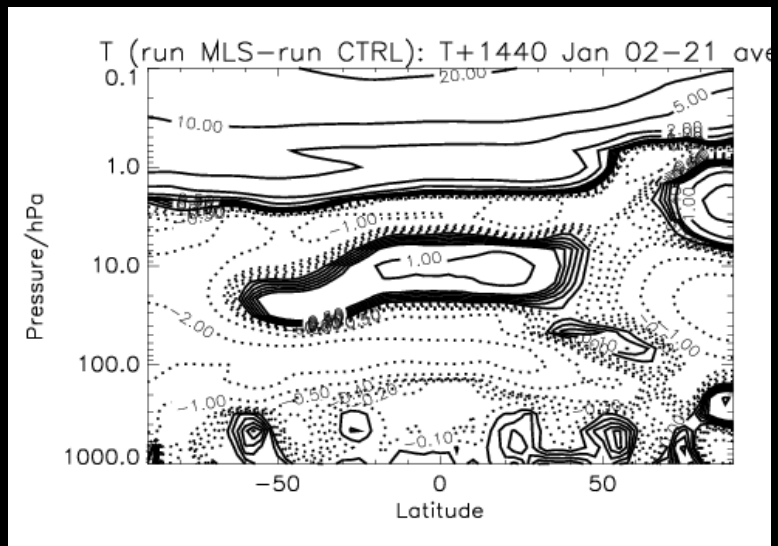
Temperature fields

Difference between the T+120 and 1440 h (5 and 60 day) temperature forecasts for EOSMLS+SBUV and Control runs, averaged for January.

Long radiative relaxation time in UTLS (20-40 days). So radiative impacts of ozone changes may be more obvious at longer forecast lengths.

Larger T diffs near 100 hPa with time: -0.1K at T+24, -0.5K at T+120, -2K at T+960 and longer.





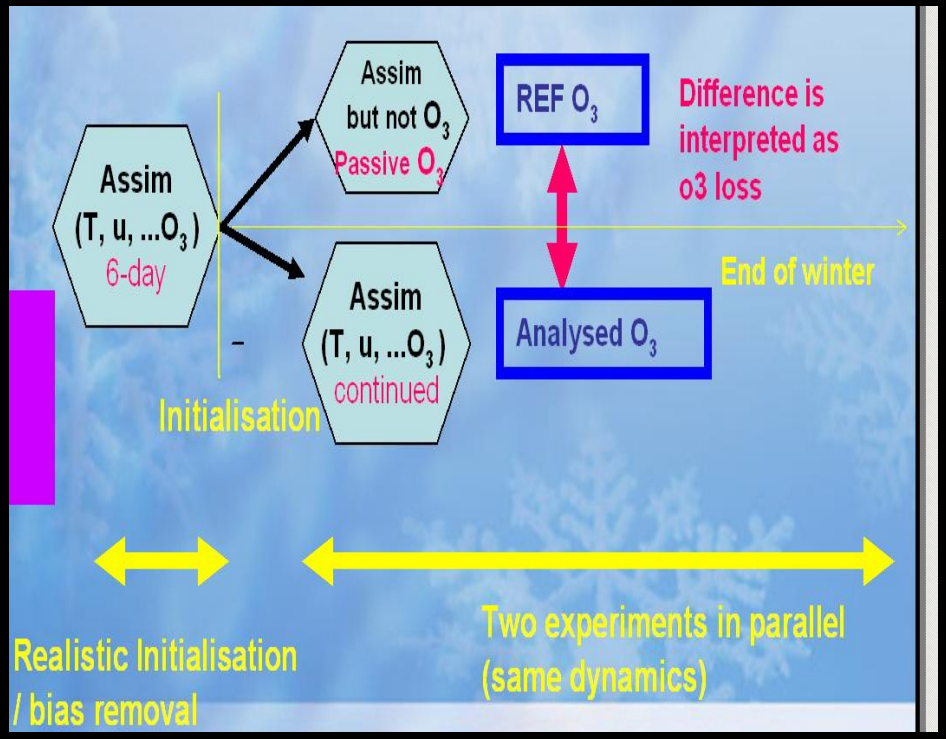
Next steps

- Collaborative project with Imperial College London (Kris Wargan, Jo Haigh):
  - Understand impact of changed ozone in 0-120 h range
  - Examine impact of ozone changes in 15-30 day forecasts
- Assimilate GOME II (later, OMPS) data
- Develop 4D-Var for ozone
- Improved ozone control variable (see below)

Using Ozone DA to estimate Arctic chemical ozone loss

Using data assimilation to estimate polar ozone loss (I)

- Large ozone loss in NH winter 04/05
- Many estimates of ozone loss published – these vary a lot (up to factor of 2)
- Other methods suffer from:
  - -difficulty in separating transport and chemistry impacts
  - - lack of representativeness
  - - lack of accounting for transport at vortex edge
  - - initialisation or bias correction issues

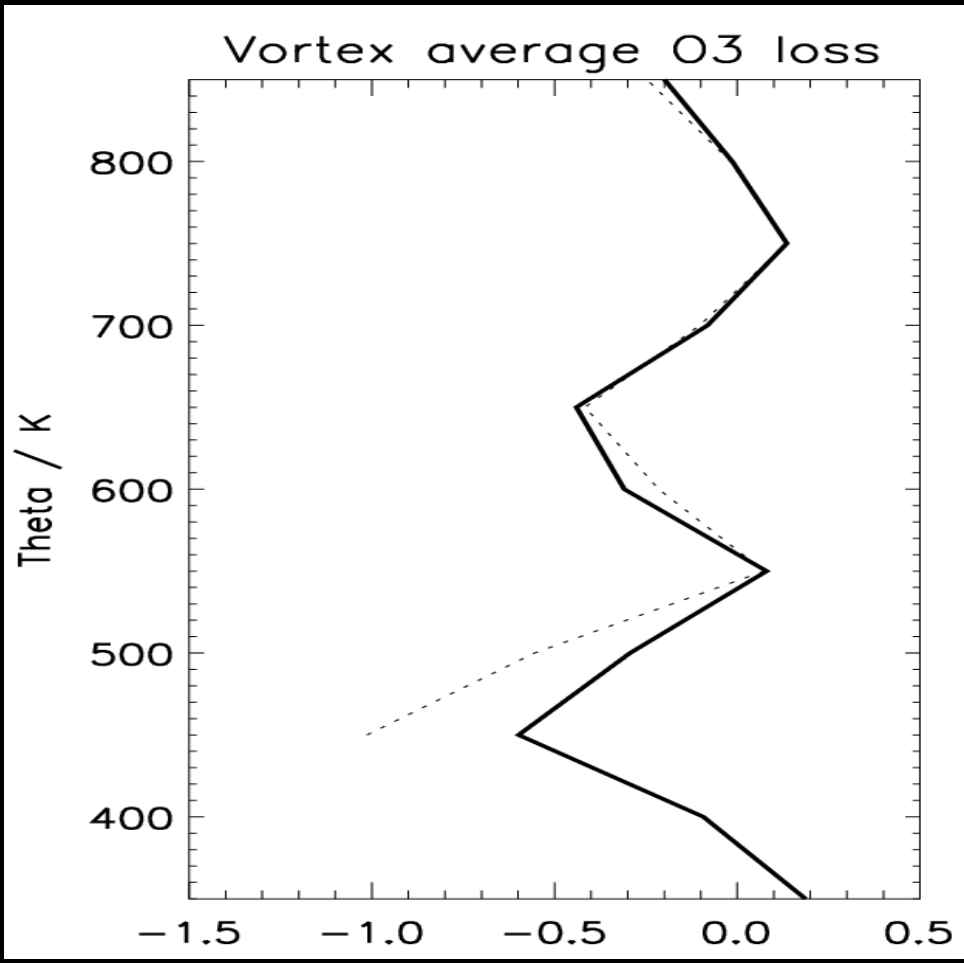


Jackson and Orsolini (2008) – thanks to Yvan Orsolini for this slide

our method

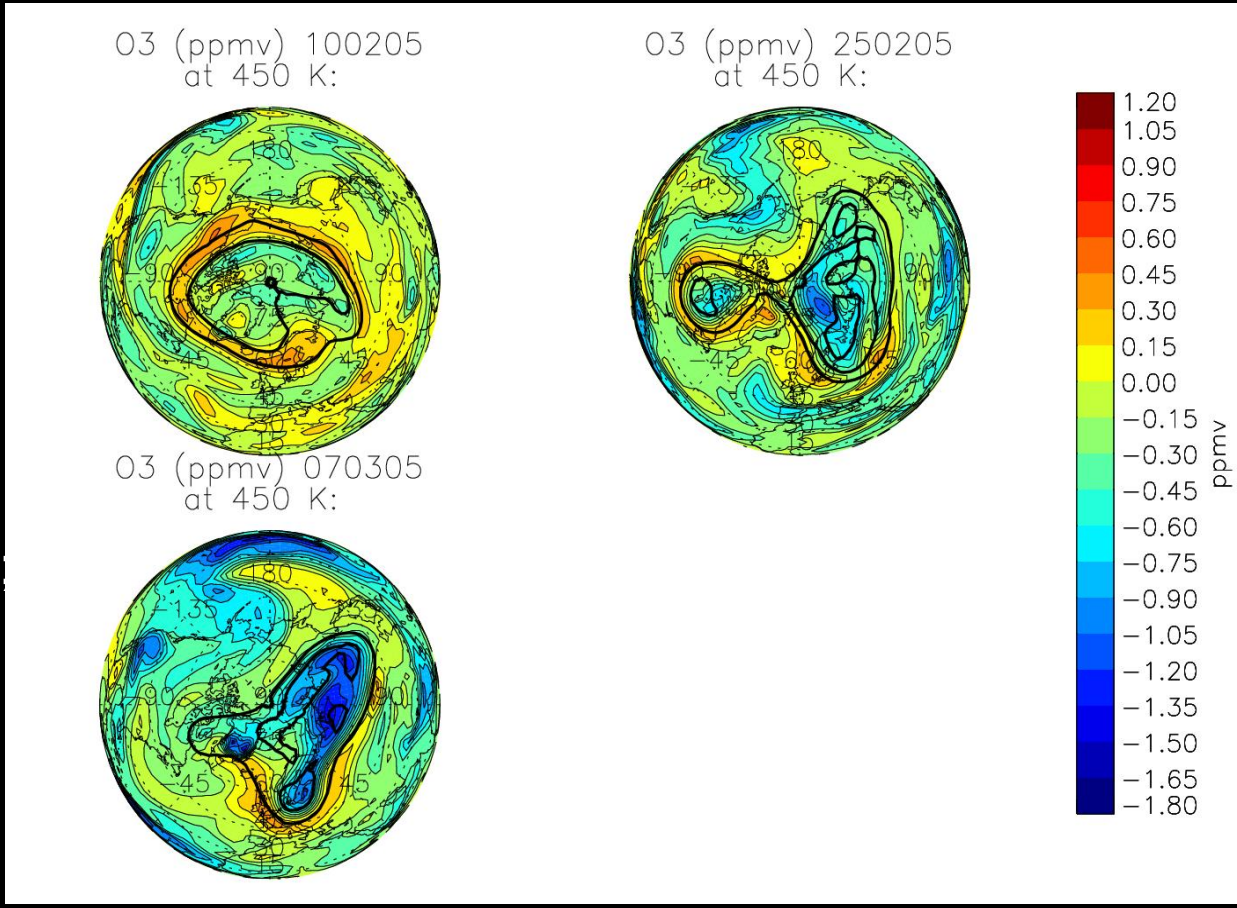
Using data assimilation to estimate polar ozone loss (II)

- Assimilation run uses EOSMLS+SBUV (good representation of ozone in/near vortex (Jackson, 2007))
- Ozone loss for Feb1 – Mar10 2005
- Peak of 0.6 ppmv at 450 K (other studies: 0.6-1.2 ppmv)
- 0.4 ppmv at 650 K (other studies: 0.6 ppmv)
- Closest agreement with other study that uses DA



Using data assimilation to estimate polar ozone loss (III)

- Ozone loss initiated at vortex periphery, gradually spreads to all parts of the vortex
- Positive values at vortex edge due to smearing of collar in reference run
- At 650 K ozone loss probably due to NOx cycle; "Low ozone pocket" outside vortex, with loss greater than inside vortex



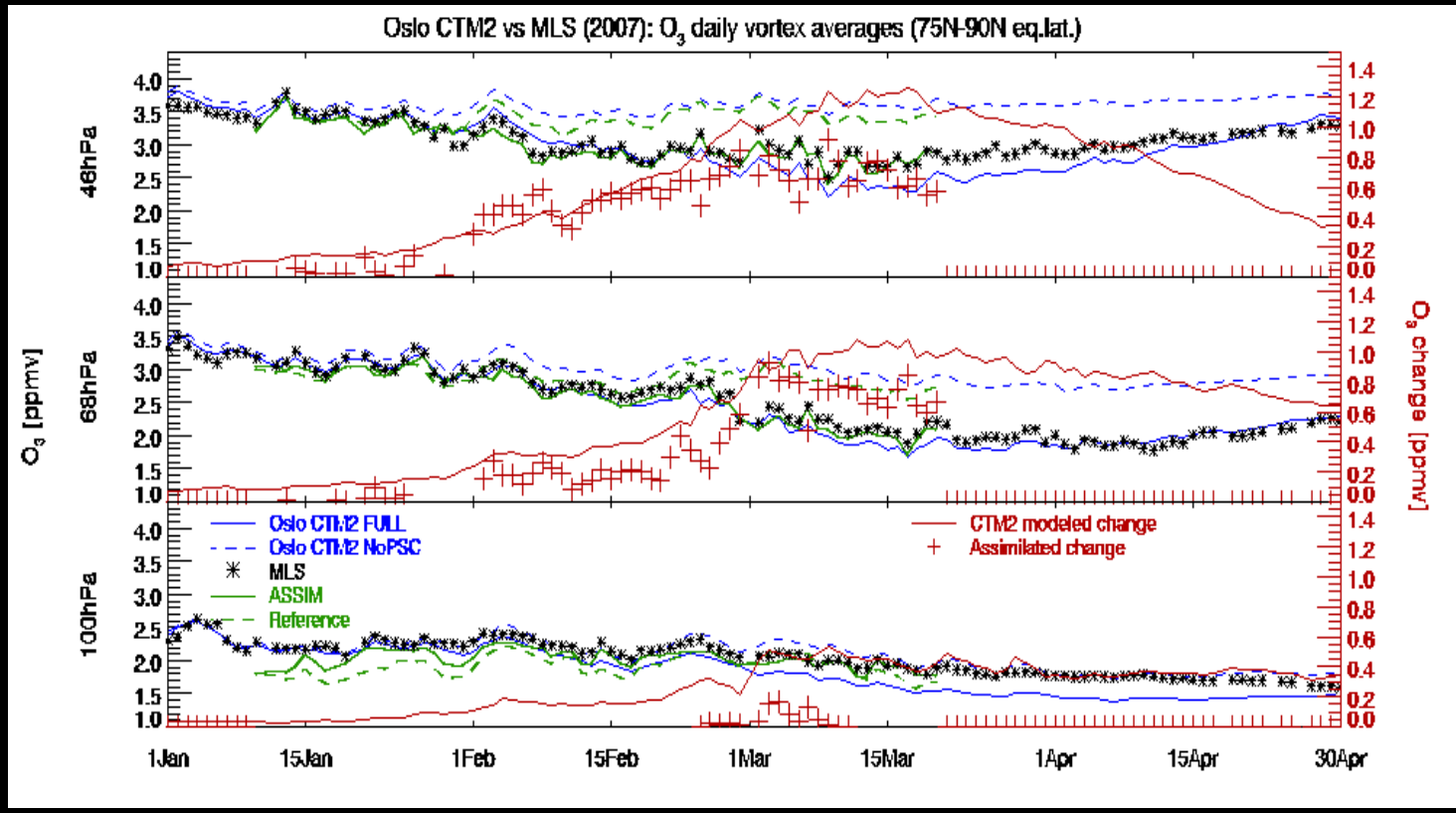
Ozone loss at 450 K

Ozone loss for 2006/7 – comparison with Oslo CTM

CTM ozone loss is difference of full and no-PSC chemistry runs

Good agreement, but differs in March (CTM NOx too low (=>ClO too high) (CTM aerosol/PSC scheme, solar proton event?)

Benefit of DA?



Amund Søvde et al (in prep.)

Future work on ozone loss estimates

- Estimate ozone loss for 2010/11 winter and compare with other methods (eg Match) (RECONCILE project)
- Introduce new ozone control variable
  - based on Holm (ECMWF) humidity variable
  - should have more Gaussian PDF and perform better near strong gradients (vortex edge, tropopause)
- Issue of transport errors in control run
  - new control variable
  - 4D-Var instead of 3D-Var dynamics
  - higher horizontal resolution

Summary

- Indications that ozone DA may benefit NWP. Further investigation needed at short (to 120 h) and medium (15-30 days) timescales
- Further development of ozone DA (4D-Var, new control variable, GOME II and OMPS data) may enhance benefits to NWP
- Ozone loss estimates using DA a useful new technique. Further research planned to enhance understanding and reduce uncertainties

Questions and answers