Impacts of different representations of ozone on tropospheric weather forecasts

Mike Keil

David Jackson and Camilla Mathison

Is the middle atmosphere necessary for NWP tropospheric forecasting?

Mike Keil

Yes and no

Impacts of different representations of ozone on tropospheric weather forecasts

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Overview

- Why bother assimilating ozone?
- Ozone assimilation in 3D-Var
- Impact of EOSMLS and SBUV data
- Ozone/radiation interaction experiments
- Impact on tropospheric weather forecasts
- Where can we find consistent signals?

Why bother assimilating ozone?

- Potential benefits for NWP:
  - Improved radiative heating rates
  - Better forecasts of surface UV
  - Possible impact on UTLS wind fields
  - Improved radiance assimilation – AIRS, IASI?
- Exploitation of research satellite data :
  - MIPAS (ASSET project) (Geer et al, 2006a,b, 2007; Lahoz et al, 2007)
  - EOSMLS – see below

Ozone assimilation at the Met Office

- N48L50 3D-Var (upgrading to 4D-Var)
- Univariate.
- **B** from ECMWF data
- Ozone modelled by tracer transport plus chemistry (Cariolle parametrization).
- SBUV and research satellite (eg EOSMLS, MIPAS) data can be assimilated

Current focus is on EOSMLS and SBUV data

SBUV

- Nadir viewing, low vertical resolution (1000-16, 16-8, 8-4, 4-2, 2-1 and 1-0.1 hPa layers)
- horizontal resolution ~ 200 km. No obs in polar night
- available in near real time from NOAA operational satellites

EOSMLS

- profiles from 215-0.46 hPa with vertical resolution ~ 3km
- along track resolution of 165km. Global coverage
- flies on NASA Aura research satellite – soon available in NRT

Future Operational Data

- GOME II
- OMPS

Results from EOSMLS / SBUV study

- Jackson (2007) investigated impact of assimilation of SBUV and EOSMLS
- Experiments chiefly for Jan/Feb 2005
- Based on 3 experiments:
  - CTRL: ozone not assimilated
  - SBUV: SBUV data assimilated
  - MLS: SBUV+EOSMLS assimilated

Errors v ozonesonde: MLS(red), CTRL(black), SBUV(blue)

Obs-analysis diffs

% error shown

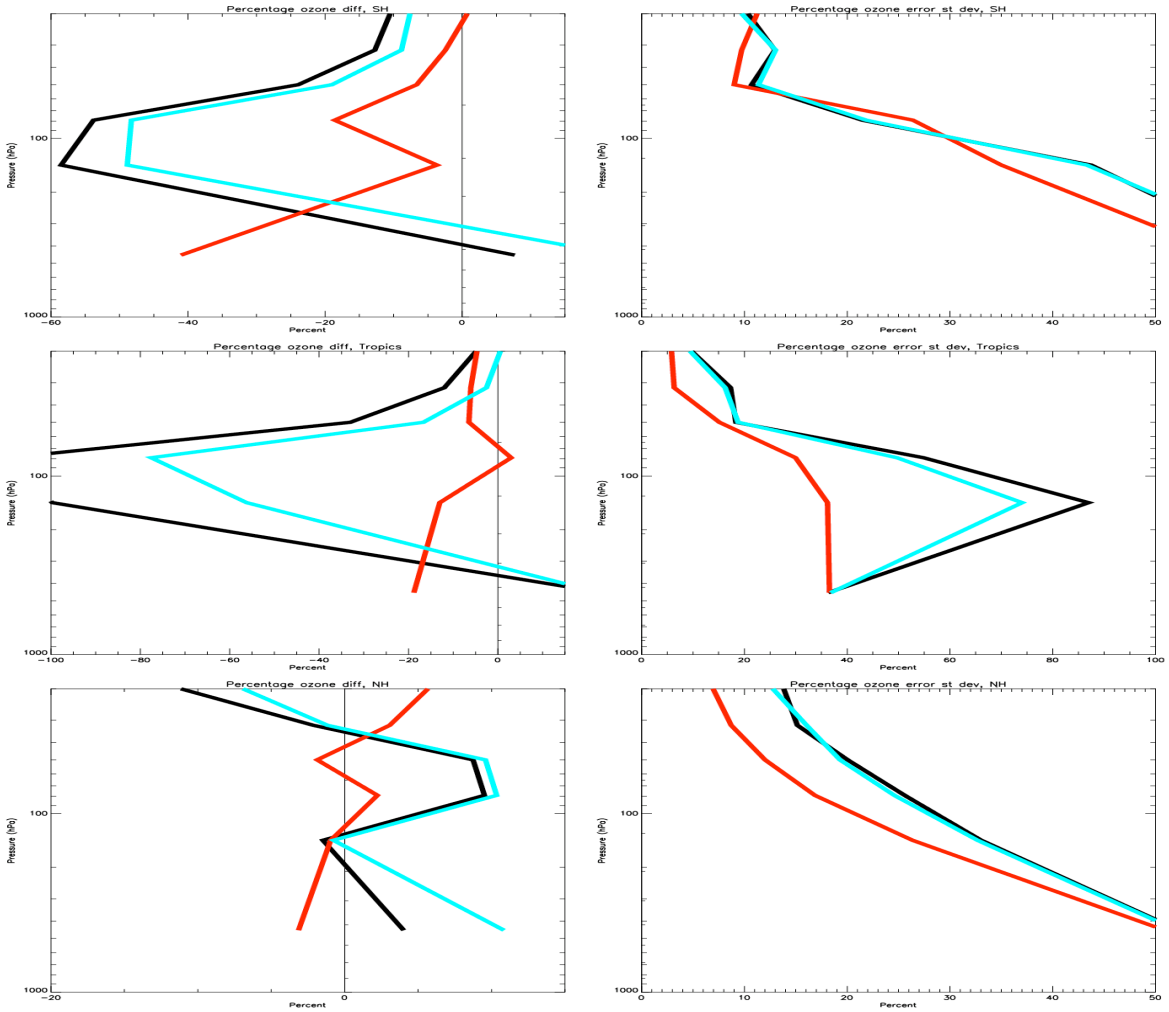
mean

st. dev

SH

Tropics

NH



Winter polar ozone depletion

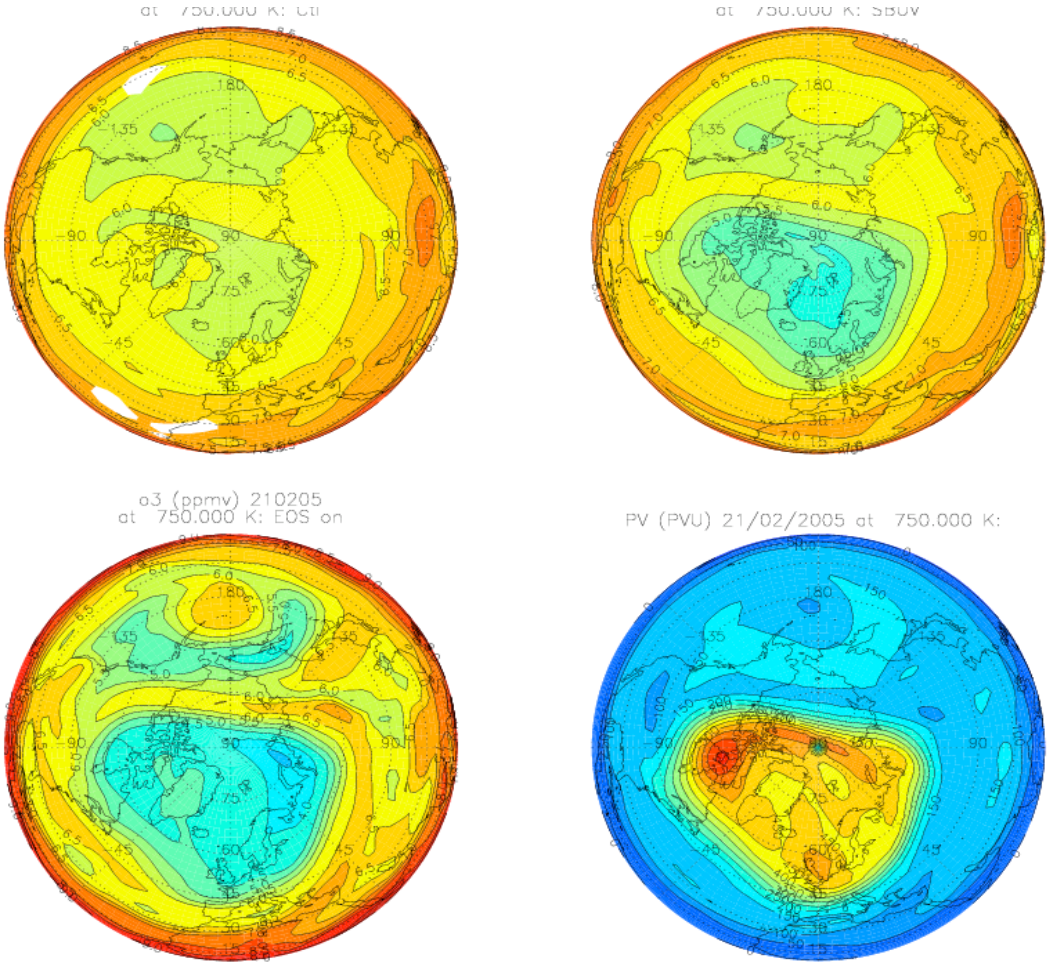
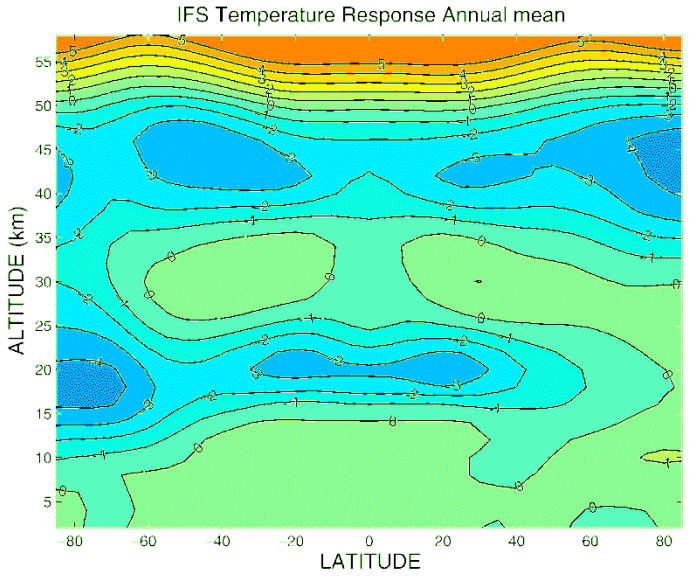


Figure 7: Ozone on the 750 K isentropic surface on 21/02/2005. Units are ppmv. run CTRL run (top left); run SBUV (top right), run MLS (bottom left). Also shown is the Ertels' PV field at 750 K (bottom right). Units are PVU.

Previous work on ozone/radiation interaction

- Morcrette (2003) found little positive impact on ECMWF temperature forecasts
- Cariolle and Morcrette (2006) showed T in UTLS highly sensitive to vertical ozone gradient there, so perhaps ozone observations with ~1 km vertical resolution are needed?

Del T (model o3-climy) from C&M(06). Pattern takes up to 60 days to establish in UTLS.



Ozone / radiation questions

- Is EOSMLS good enough to produce measurable benefits?
- Experiments performed to test the alternatives for representing ozone
- Interactive ozone/radiation used
- Results from the experiments in terms of tropospheric impact

Experiments

Five experiments were run:

- Control
- Alternative climatology – SPARC
- Inclusion of ECMWF ozone field
- Assimilation of EOSMLS and SBUV observations into 3D-Var system
- Assimilation of SBUV observations into 3D-Var System.

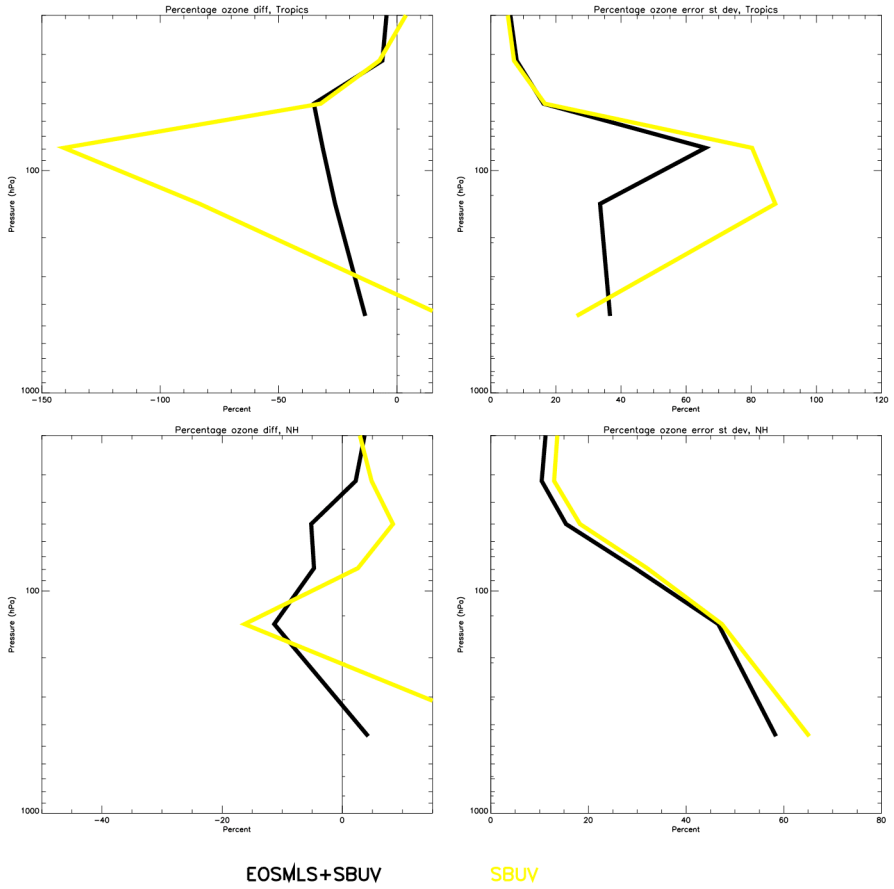
All experiments run from 02/01-15/02/2006

Quality of these ozone representations

Errors v o3sondes: mean st dev

Tropics

NH



Quite similar to corresponding errors in Jan/Feb 2005

Importing ECMWF ozone into the UM

•Why?

- ECMWF already assimilate ozone in their model
  - •More efficient to use their field than to carry out the assimilation in the Unified model
  - •The ECMWF ozone field might be better
  - •One thing less to have to do
  - •Interesting thing to do

How?

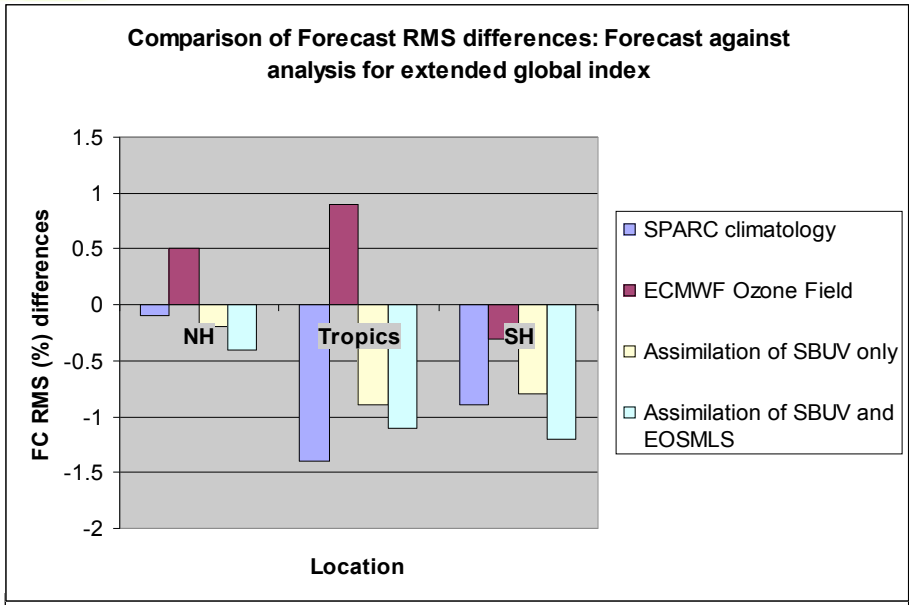
- Not a straightforward process
- Requires the use of reconfiguration
- Ozone is updated 4 times a day

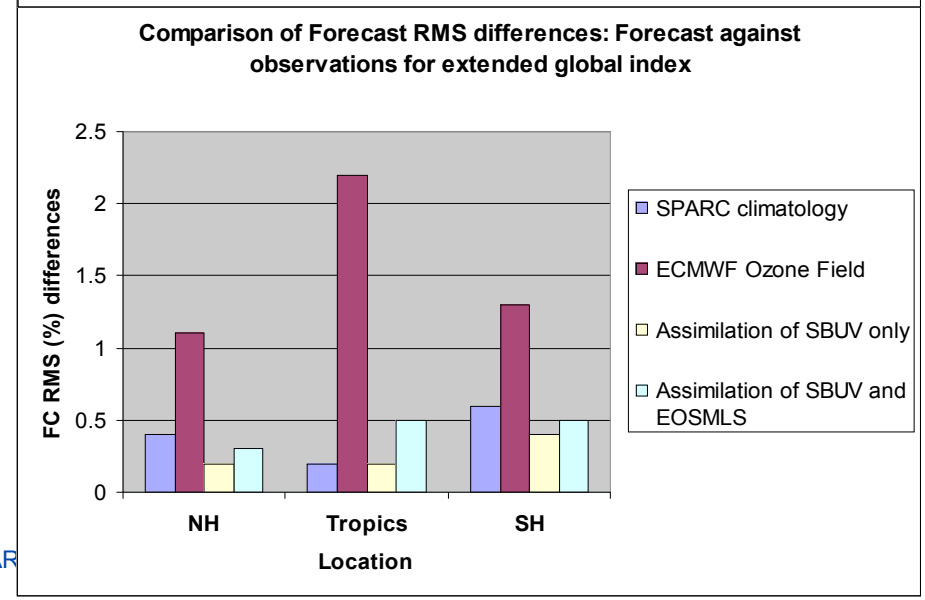
Impacts on NWP Global index

Only Tropospheric components make up the 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

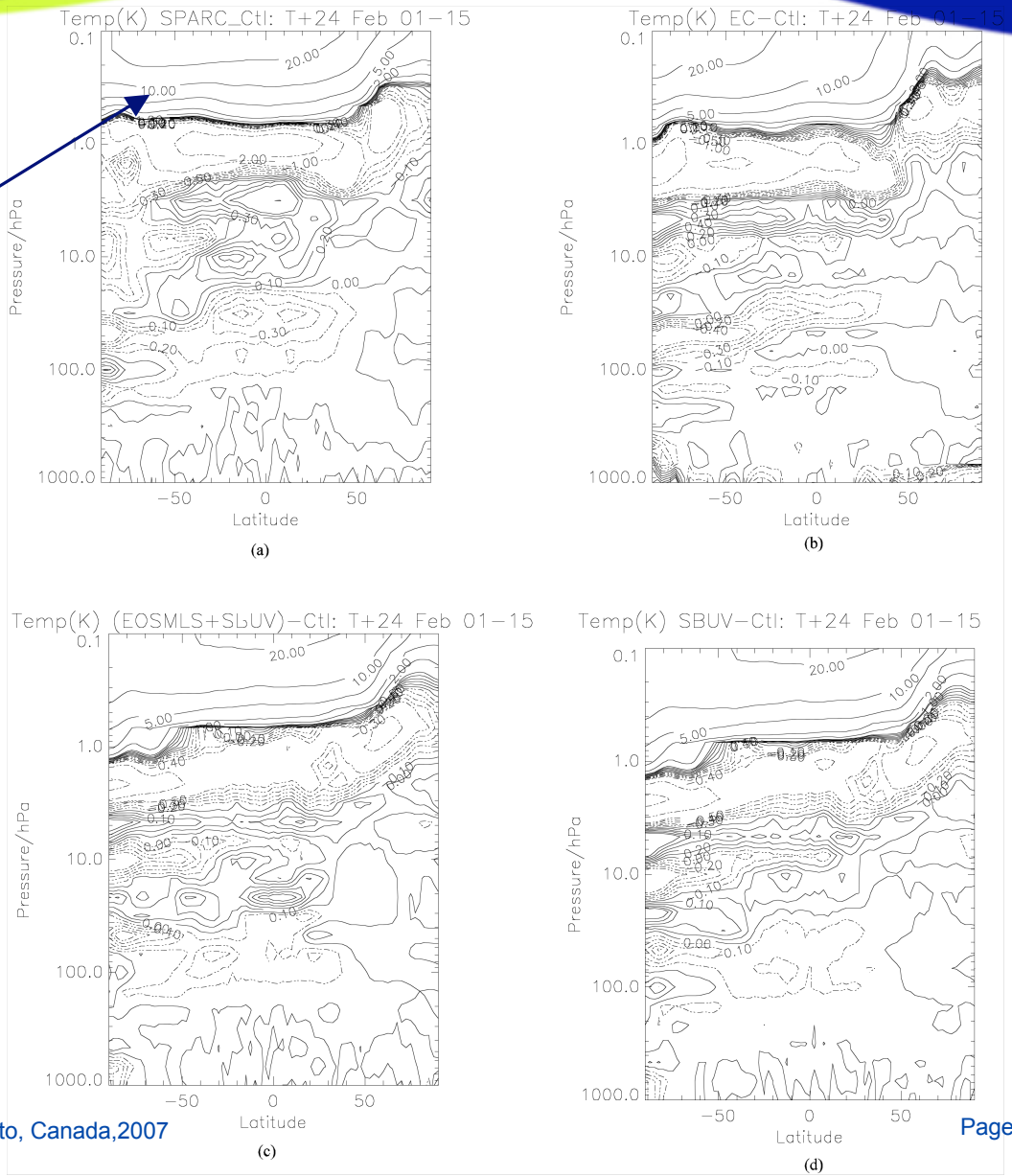
Comparison of Extended Index



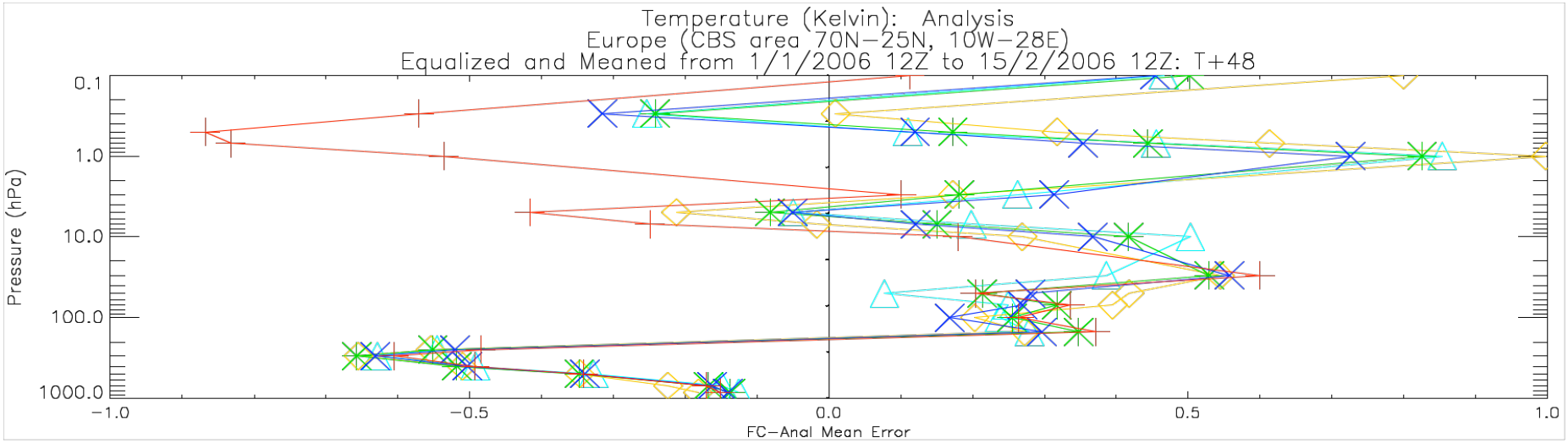


Temperature fields

Increase in temperature compared to Li and Shine climatology in upper levels corresponds to increase of ozone at this level.



Plots of Temperature verification statistics



Cases: Control, SBUV EOSMLS Ozone Assimilated, SBUV Ozone Assimilated, ECMWF Ozone, SPARC Ozone Climatology

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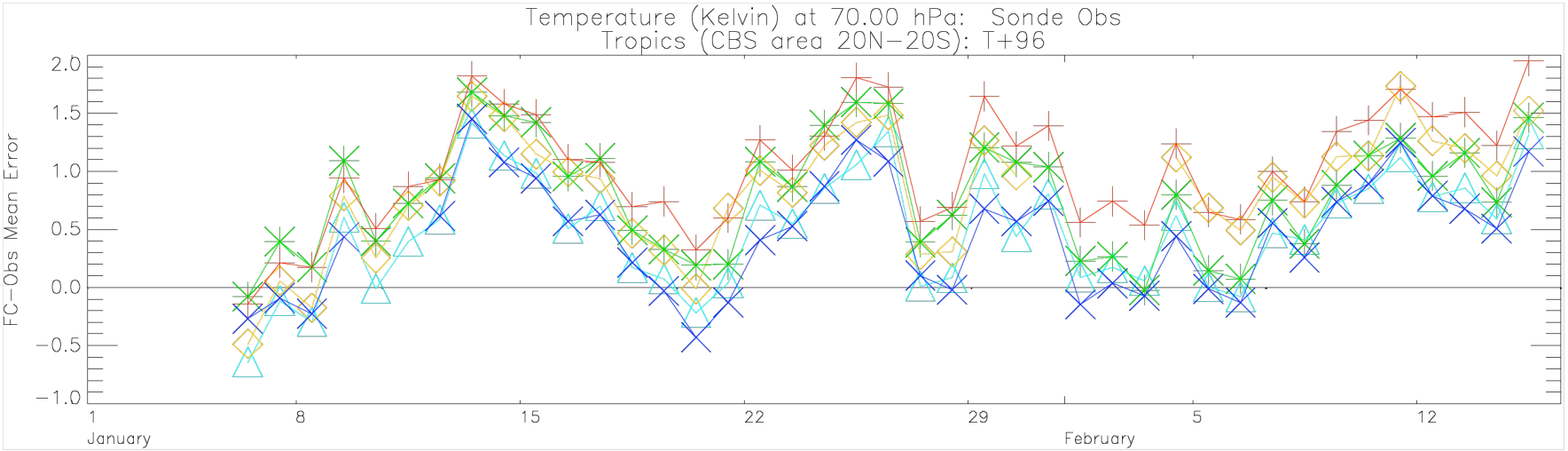

Cases: Control SBUV EOSMLS Ozone Assimilated SBUV Ozone Assimilated ECMWF Ozone
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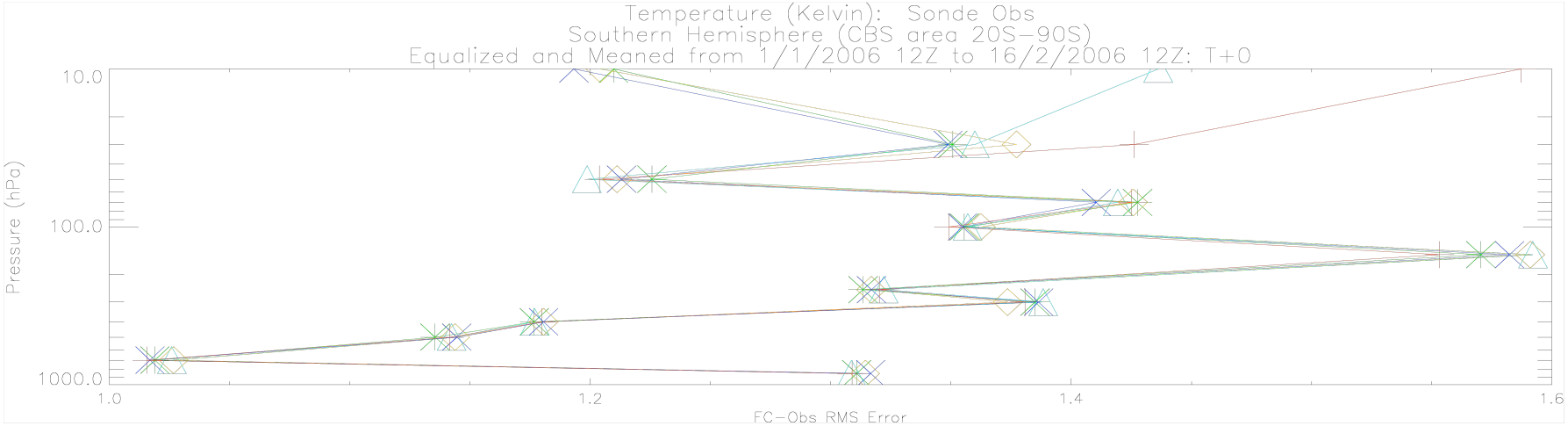
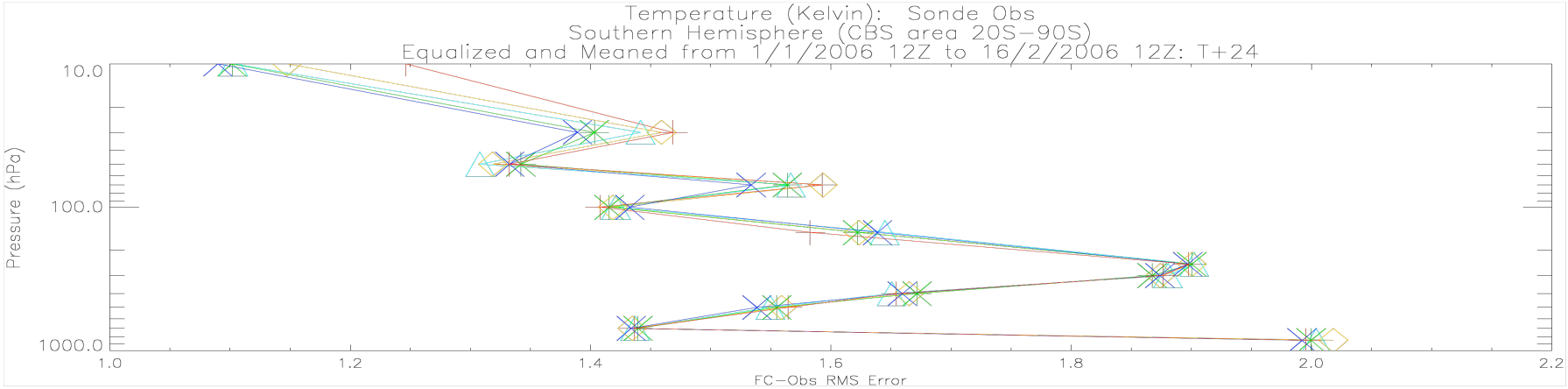
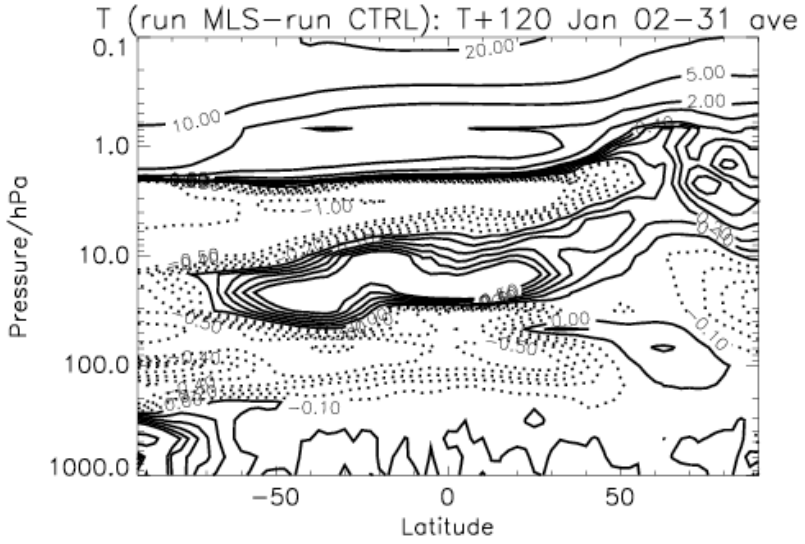
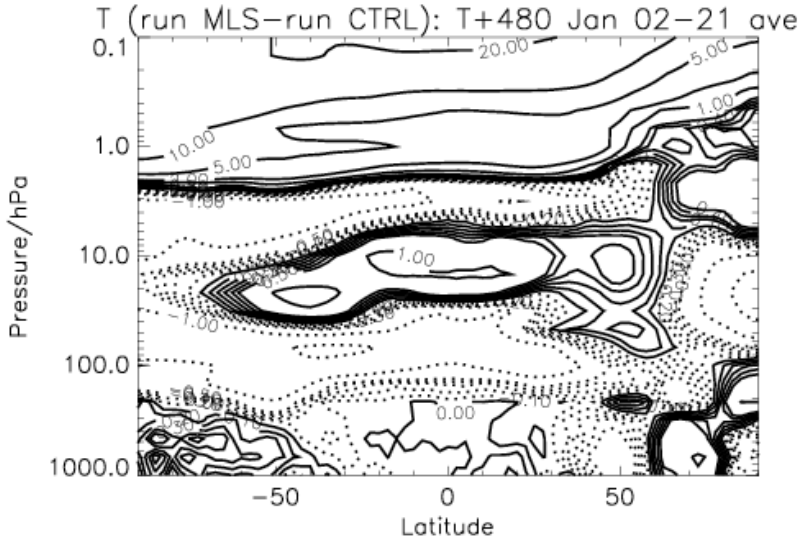
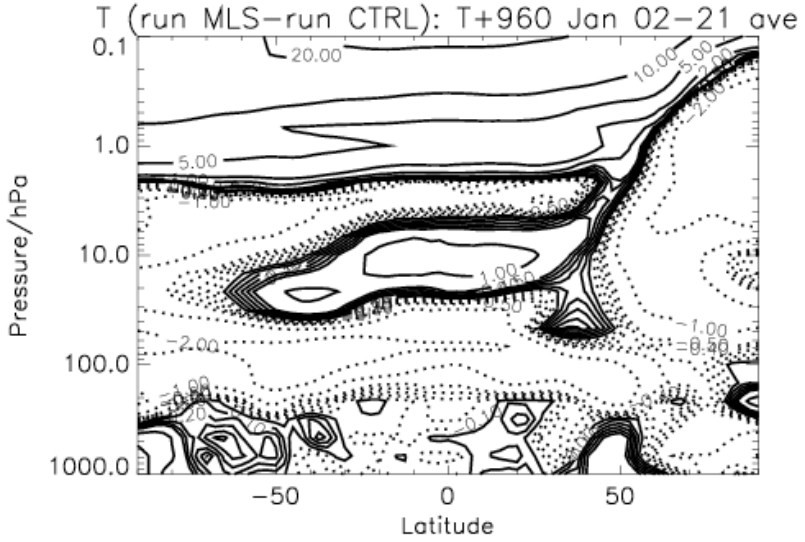


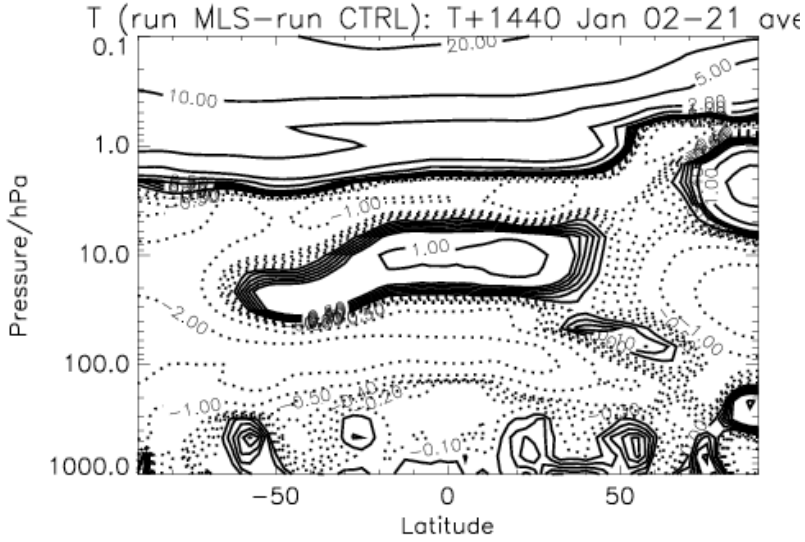


Impact on temperature forecasts: 5 to 60 days









Summary of the results

- The addition of EOSMLS data improved the assimilated ozone fields
- SPARC climatology performs much better than Li and Shine climatology especially in tropics
- Tropospheric forecast scores against analysis and observations have been improved when ozone has been assimilated.
- Importing ECMWF ozone in the UM had a negative impact on the index

Conclusions

- A simple and cheap first step to improve the ozone representation in the UM would be to change the climatology to SPARC Climatology
- Importing a field from another model introduces inconsistencies that have been seen in the case of ozone to cause a deterioration in the forecast skill.
- In the longer term a greater improvement could be gained by developing the operational system to assimilate ozone.

Recommendations for future work

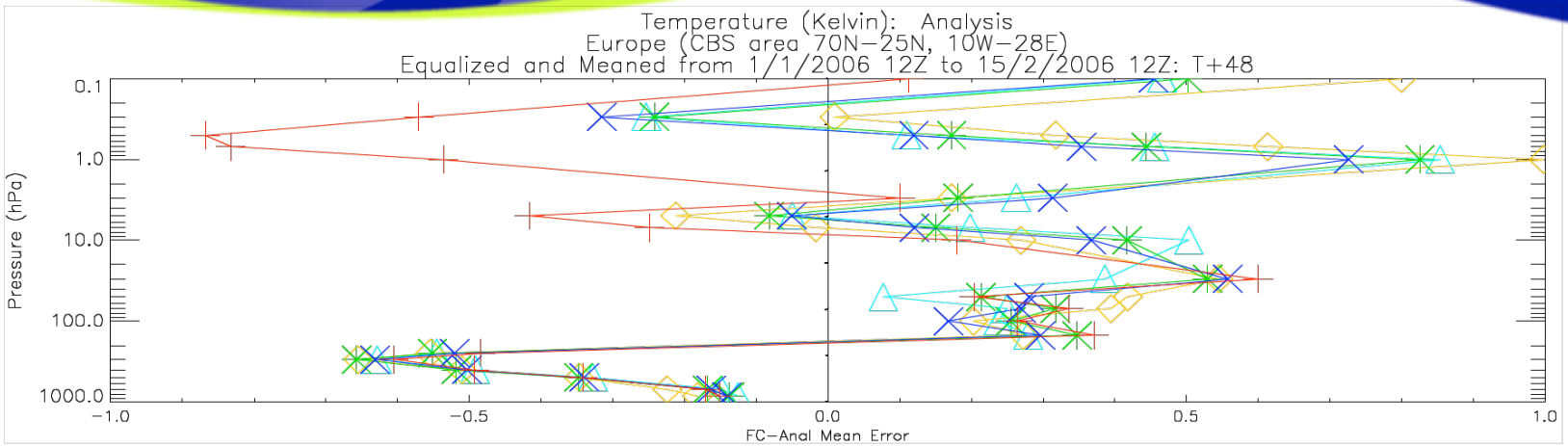
- Changing climatology from Li and Shine to SPARC climatology is a cheap first step.
- Development current ozone assimilation system to run in 4D-Var.
- Test a 4D-Var system to establish how it could be implemented operationally to have minimum cost impact.

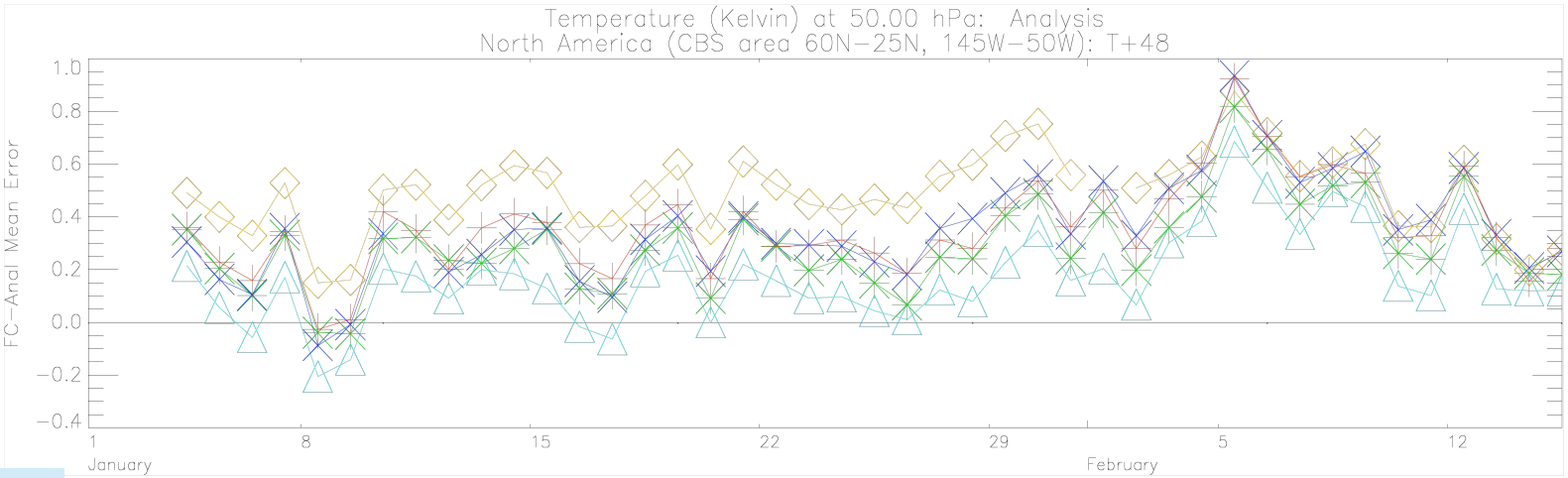
Questions

Recap…

- Ozone analyses a lot better when EOSMLS added – benefit of high vertical resolution data.
- Other studies (eg Cariolle and Morcrette) say good ozone in UTLS => better radiative heating there => possibly better temperature forecasts and analyses
- Need high resolution ozone observations for better ozone UTLS analysis fields

Plots of Temperature verification statistics





Legend

Cases: Control; SBUV EOSMLS Ozone Assimilated; SBUV Ozone Assimilated; ECMWF Ozone; SPARC Ozone Climatology