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PRODEX BACCHUS

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Fitness of meteorological analyses by ECMWF and CMC to model tracer transport in the Arctic vortex 2010-2011

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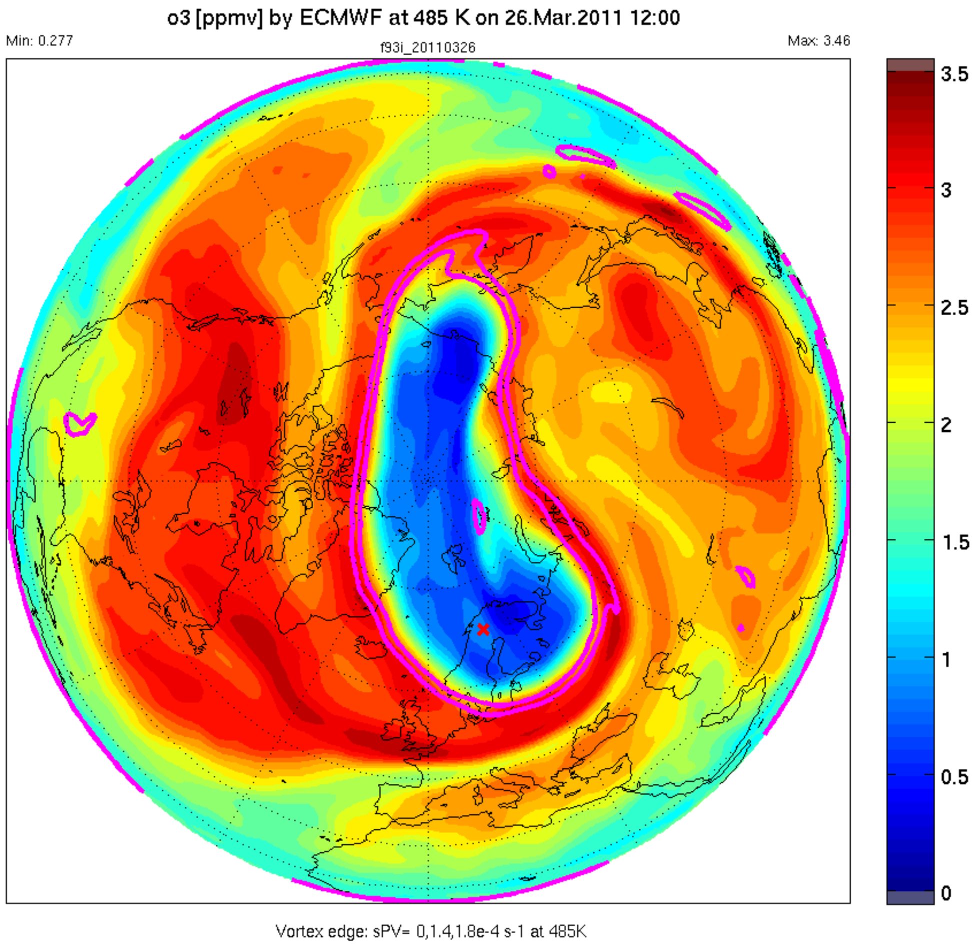
Motivation: simulate Arctic "ozone hole" of 2011

IFS-MOZART analysis of O3 at 485K
2011/03/26

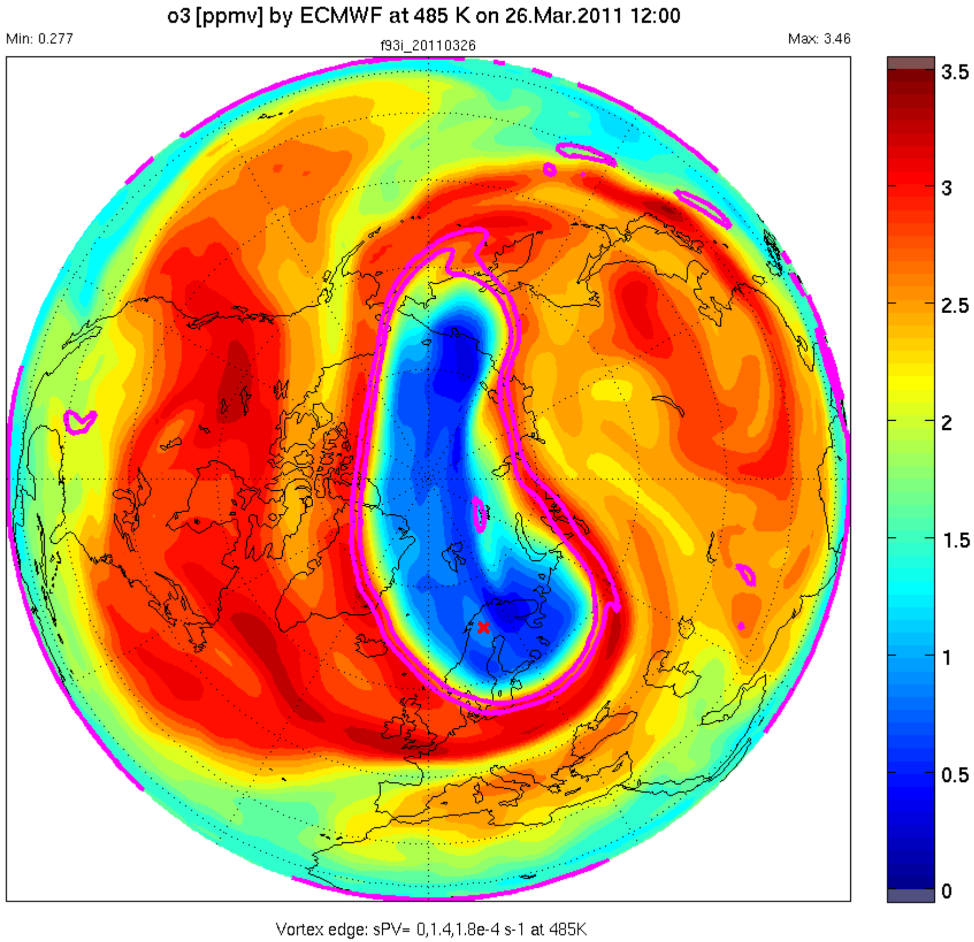


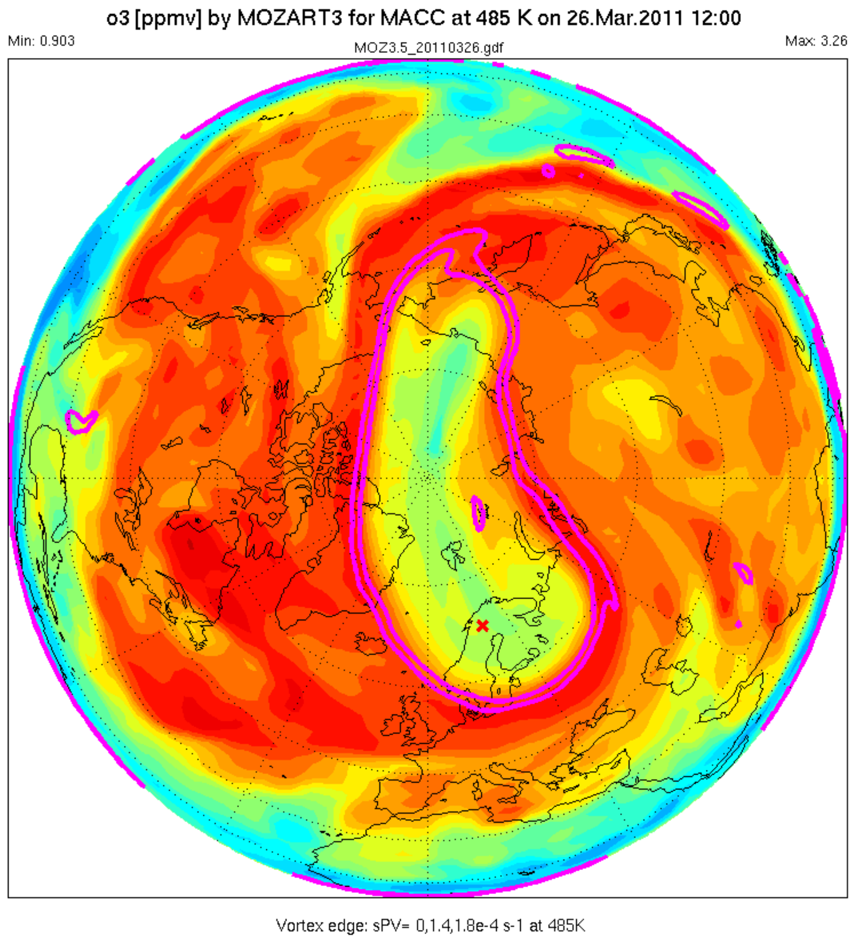
- Magenta lines: vortex edge (outer: sPV=1.4e-4 s-1; inner: sPV=1.8e-4 s-1)

Motivation: simulate Arctic "ozone hole" of 2011

IFS-MOZART <u>analysis</u> of O3 at 485K
2011/03/26

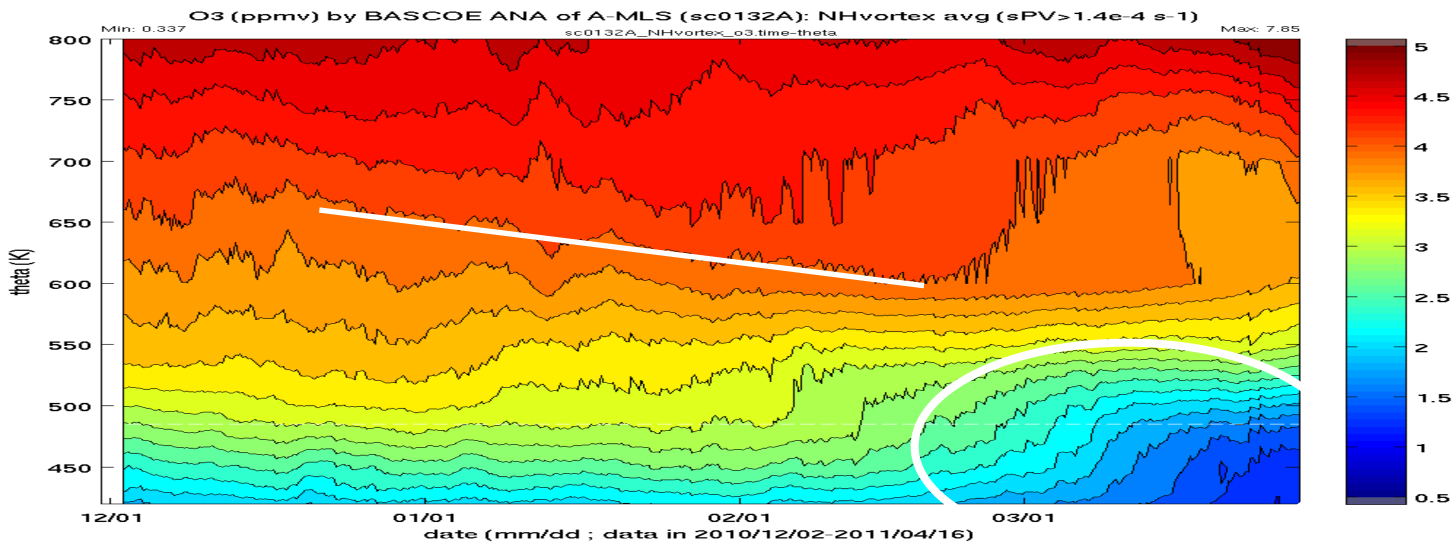
same by MOZART CTM
(simul started on 2010/01/01)





Motivation: simulate Arctic "ozone hole" of 2011

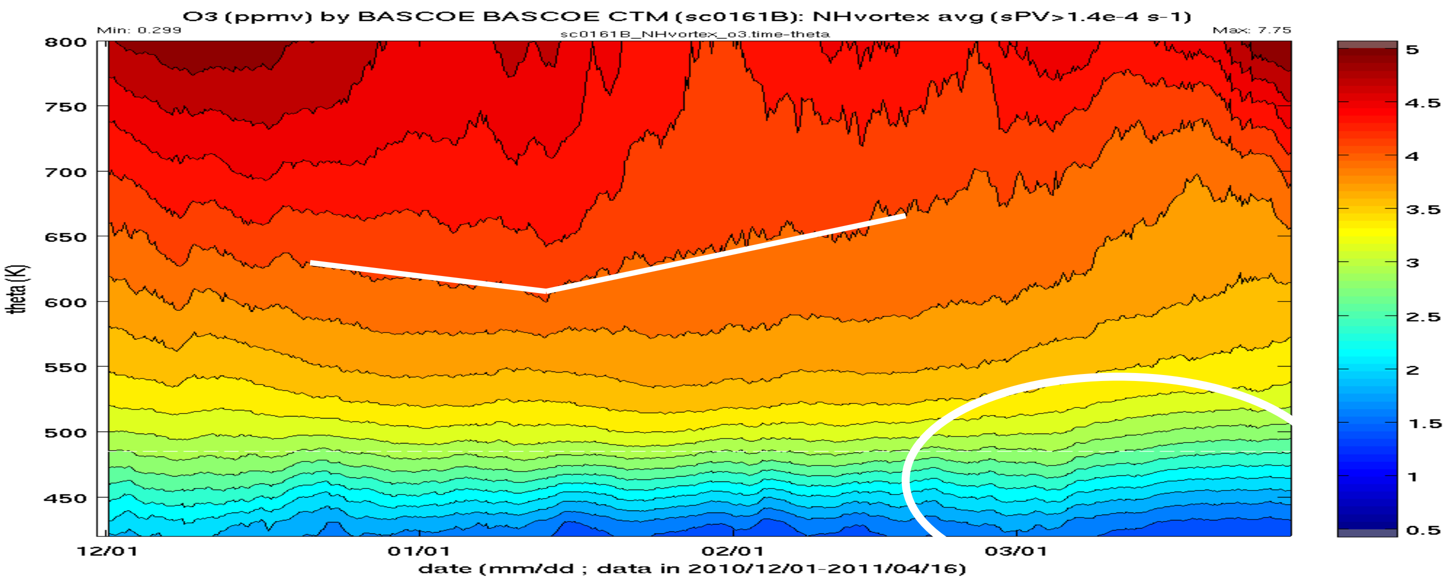
Time evolution of vortex-averaged ozone (sPV>1.4e-4 s-1)



BASCOE analysis of Aura-MLS

→period of interest: 2010/12/01 to 2011/03/26 (MLS tmp out-of-service)

→excludes final warming



BASCOE CTM driven by ECMWF-OD

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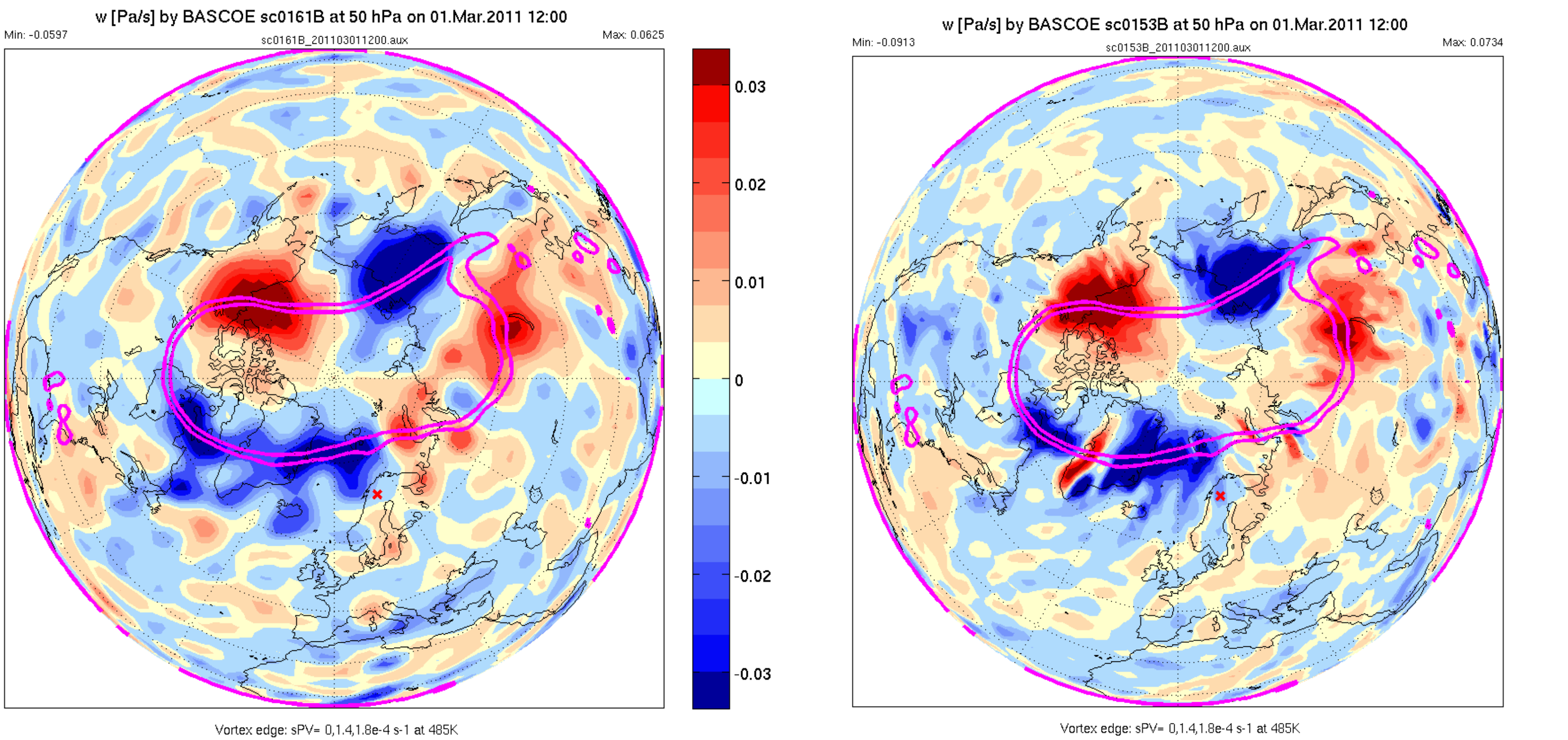
Motivation: simulate Arctic "ozone hole" of 2011

- Transport looks wrong !
- Must be checked prior to chemistry (PSC parameterizations)
- Is it the transport model or the meteo analyses?
- Use different meteo analyses (ERA-I, ECMWF OD, CMC) and different models both offline (BASCOE, MOZART) and online (IFS-MOZART, SACADA, GEM-BACH)

Can we look directly at *w* from transport models ?

BASCOE driven by ECMWF-OD

BASCOE driven by CMC-OD



Direct comparison is difficult:

- ***w* is residual from u,v: very sensitive to pre-processing of meteo analyses**
- ***w* is max along vortex edge →result will depend a lot on its location**

1. Motivation
2. **Vortex-averaged analyses of Aura-MLS N2O as a diagnostic of vertical transport**
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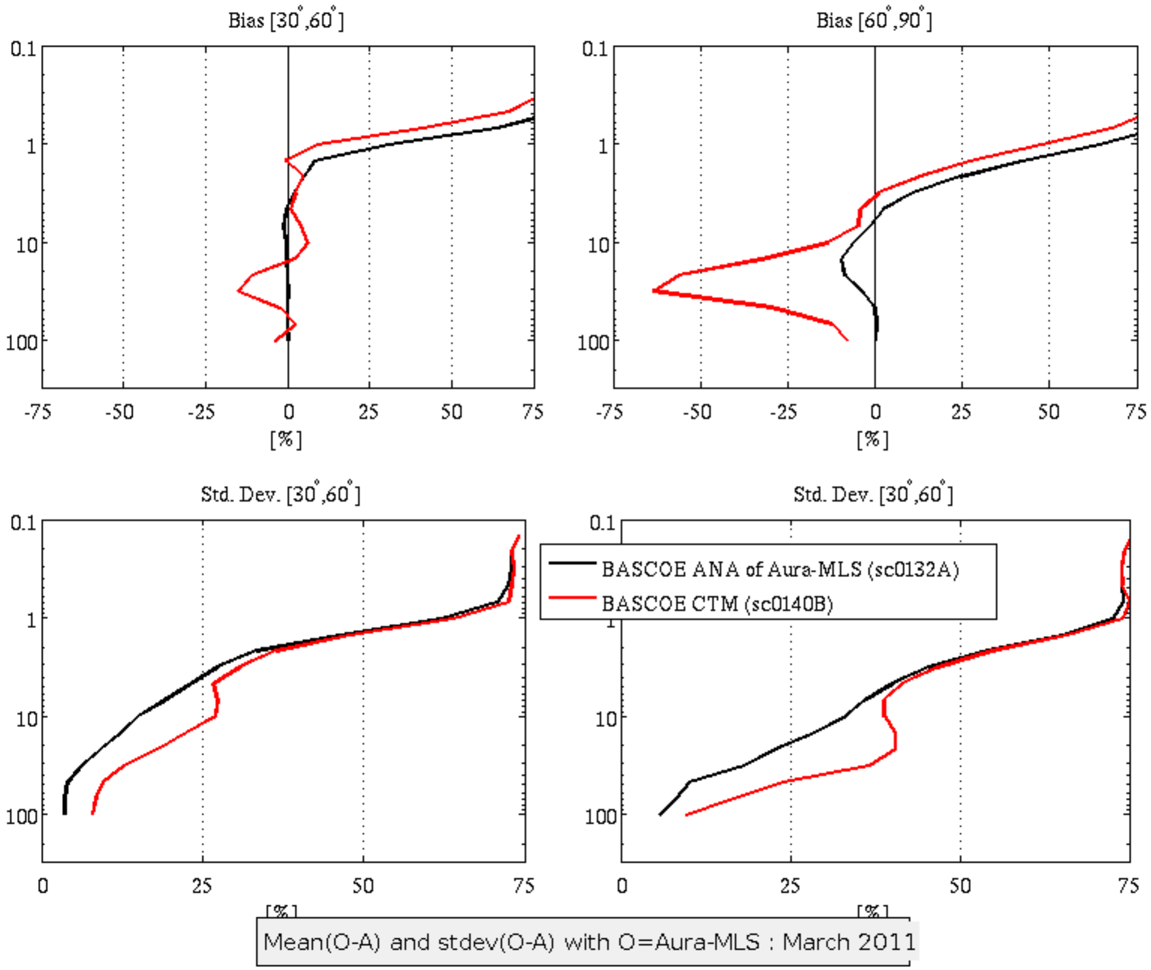
Using here an older version of BASCOE DAS: diagonal BECM; analysis of A-MLS v3.3

BASCOE Analyses of Aura-MLS v2.2 N2O: O-A verification

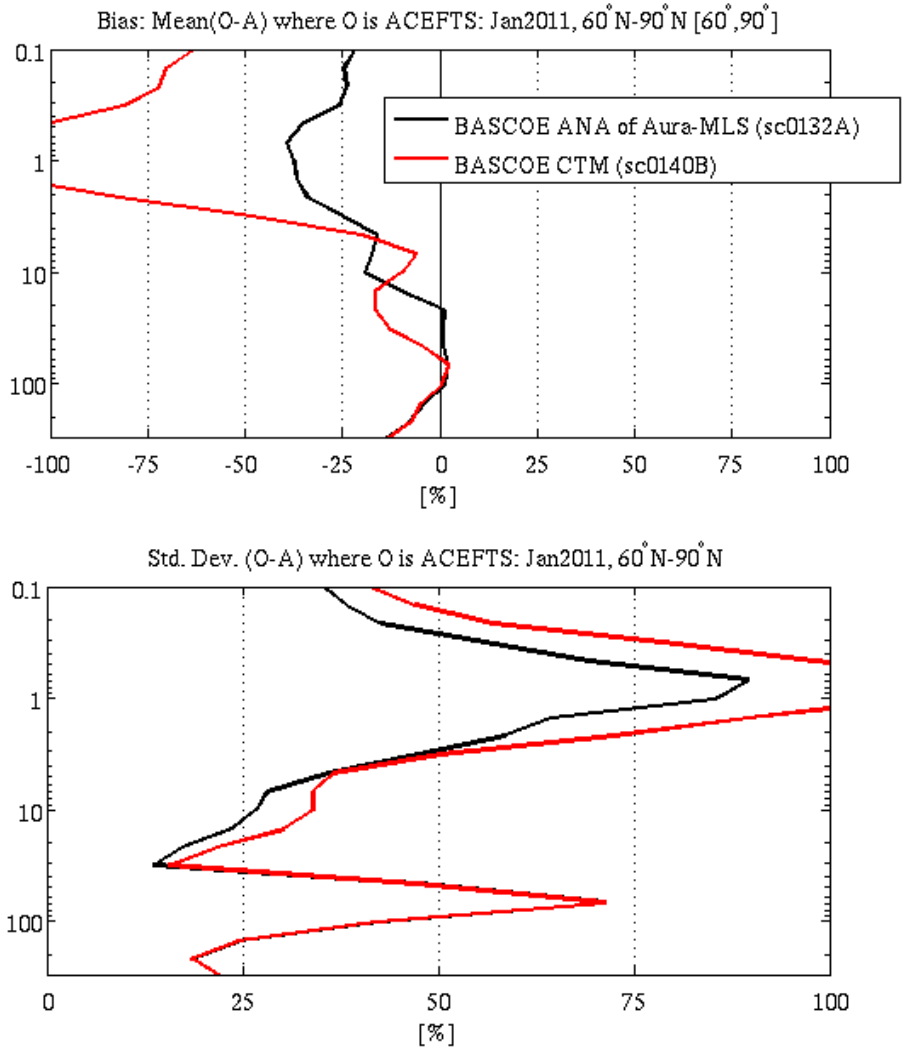


- Below 10hPa: clear improvement, even though some bias remains (up to 10%)
- Above 10hPa : |O-A| and σ(O-A) not better than free CTM; Data quality of Aura-MLS v2.2 reports precision error > 20% above 10hPa

→We choose to use these analyses only in *p* range 10-100 hPa (~800-485 K). Precision better in AMLS v3.3: assim is underway.

N2O analyses as a diagnostic of stratospheric transport

BASCOE Analyses of Aura-MLS v2.2 N2O: quick validation against ACE-FTS



- Clear bias reduction in whole polar stratosphere
- σ(O-A) seems not improved below 30hPa ? *(check this diag)*
- Another type of validation against independent obs is required (e.g. time-series of ground-based FTIR)

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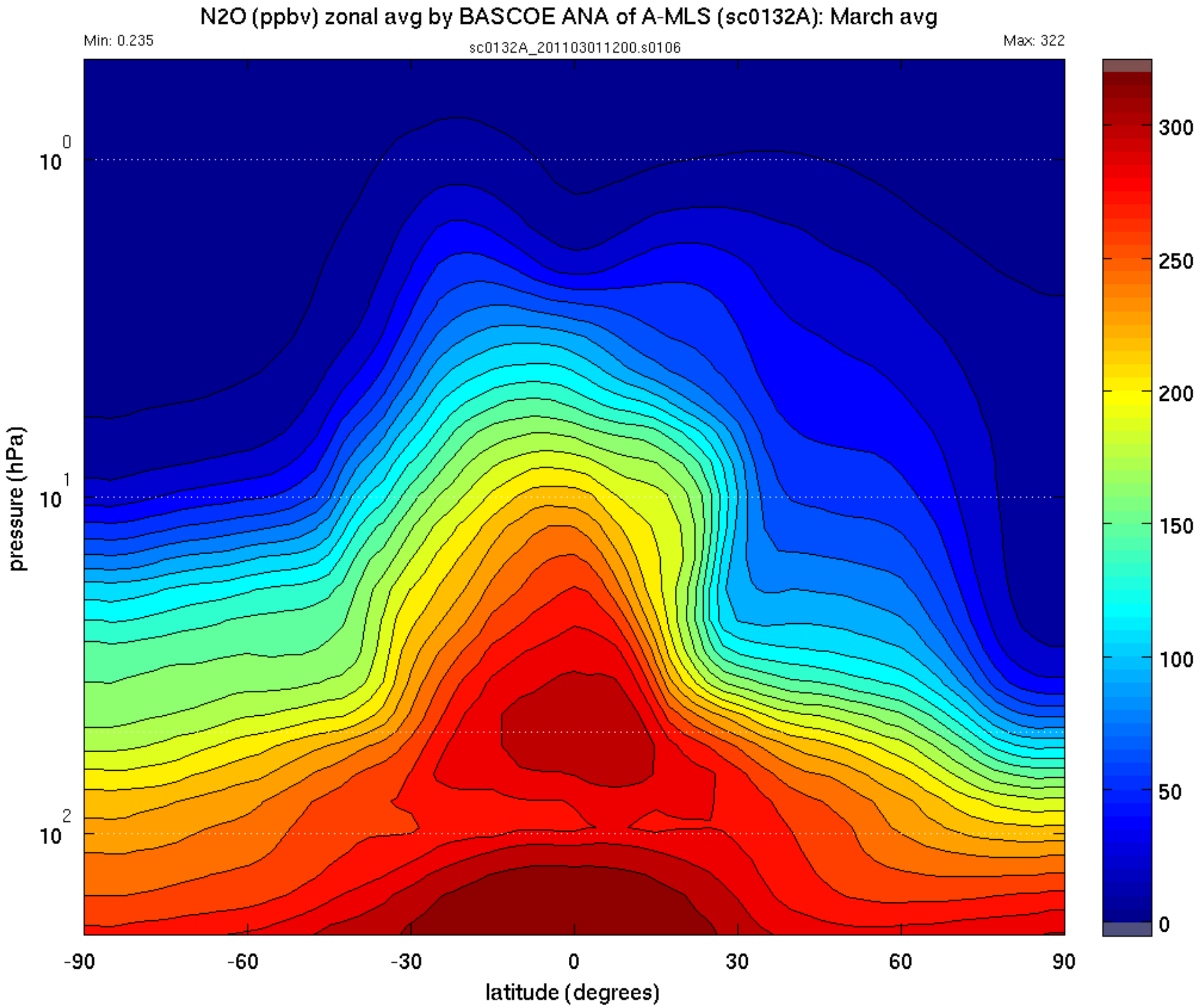
N2O analyses as a diagnostic of stratospheric transport

BASCOE Analyses of Aura-MLS v2.2 N2O: zonal average, March 2011

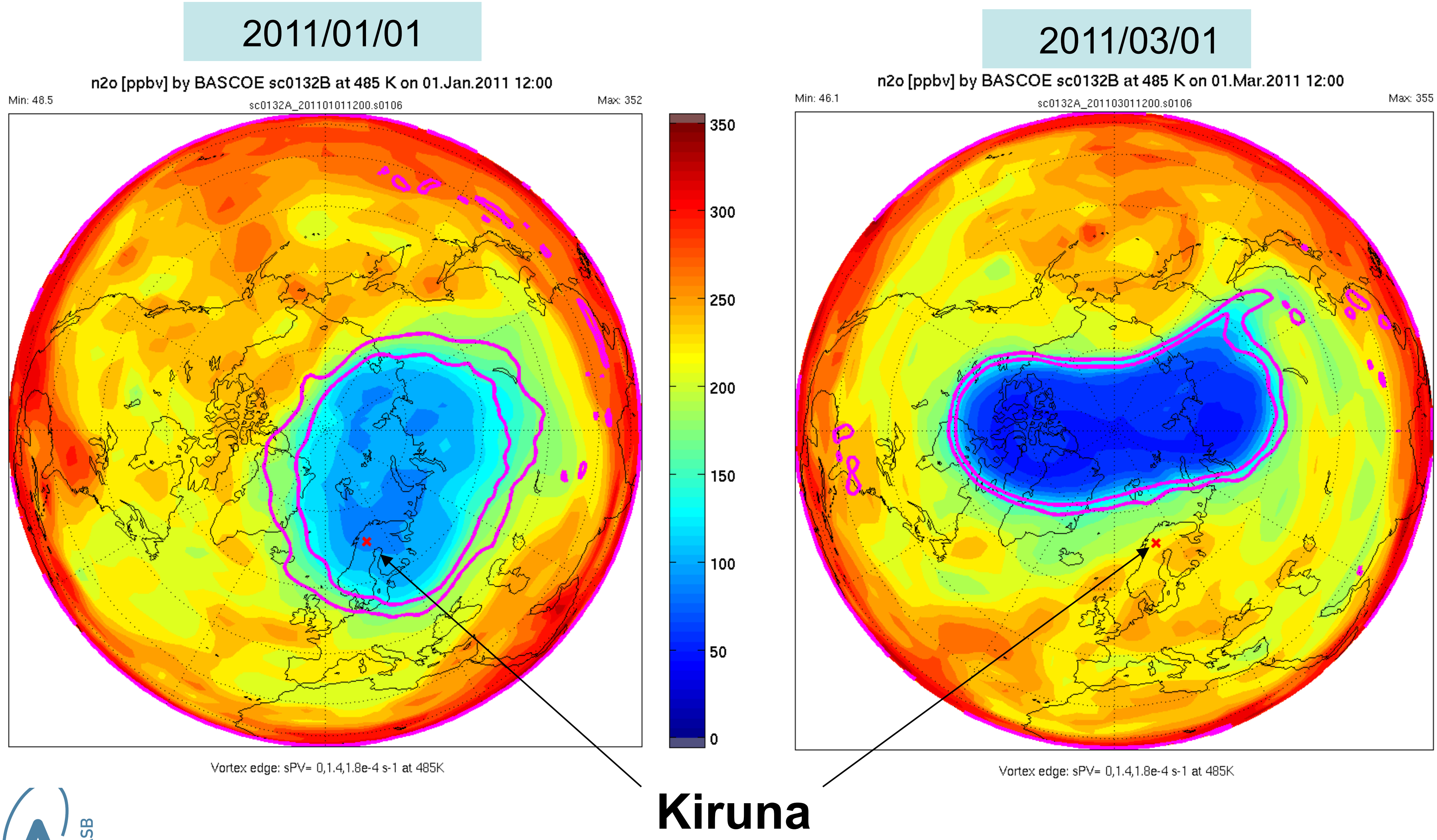


Vertical gradient (nearly) always negative

Downward transport in vortex →vmr decreases with time

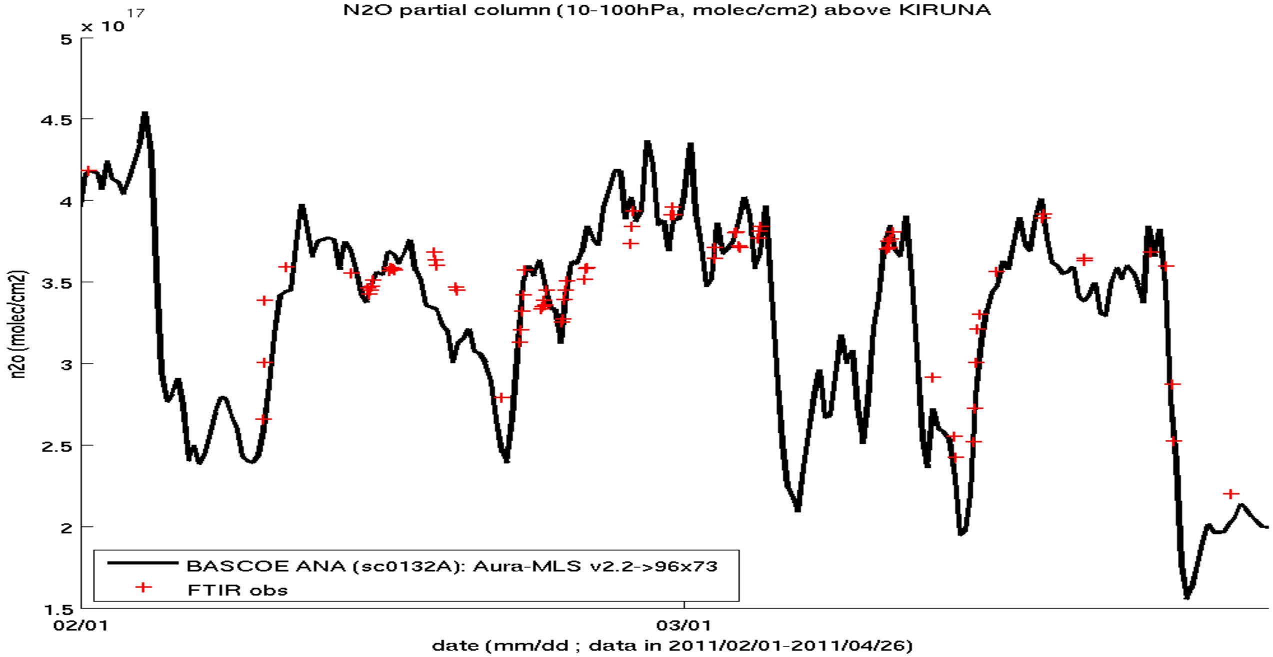
N2O analyses as a diagnostic of stratospheric transport

BASCOE analysis of N2O at 485K

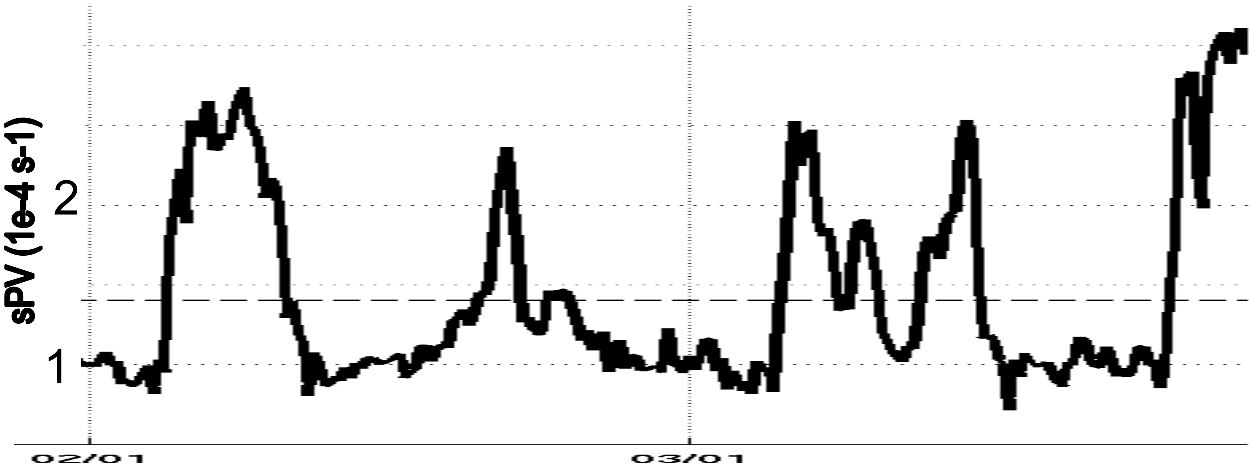


N2O analyses as a diagnostic of stratospheric transport

BASCOE Analyses of Aura-MLS v2.2 N2O above Kiruna:



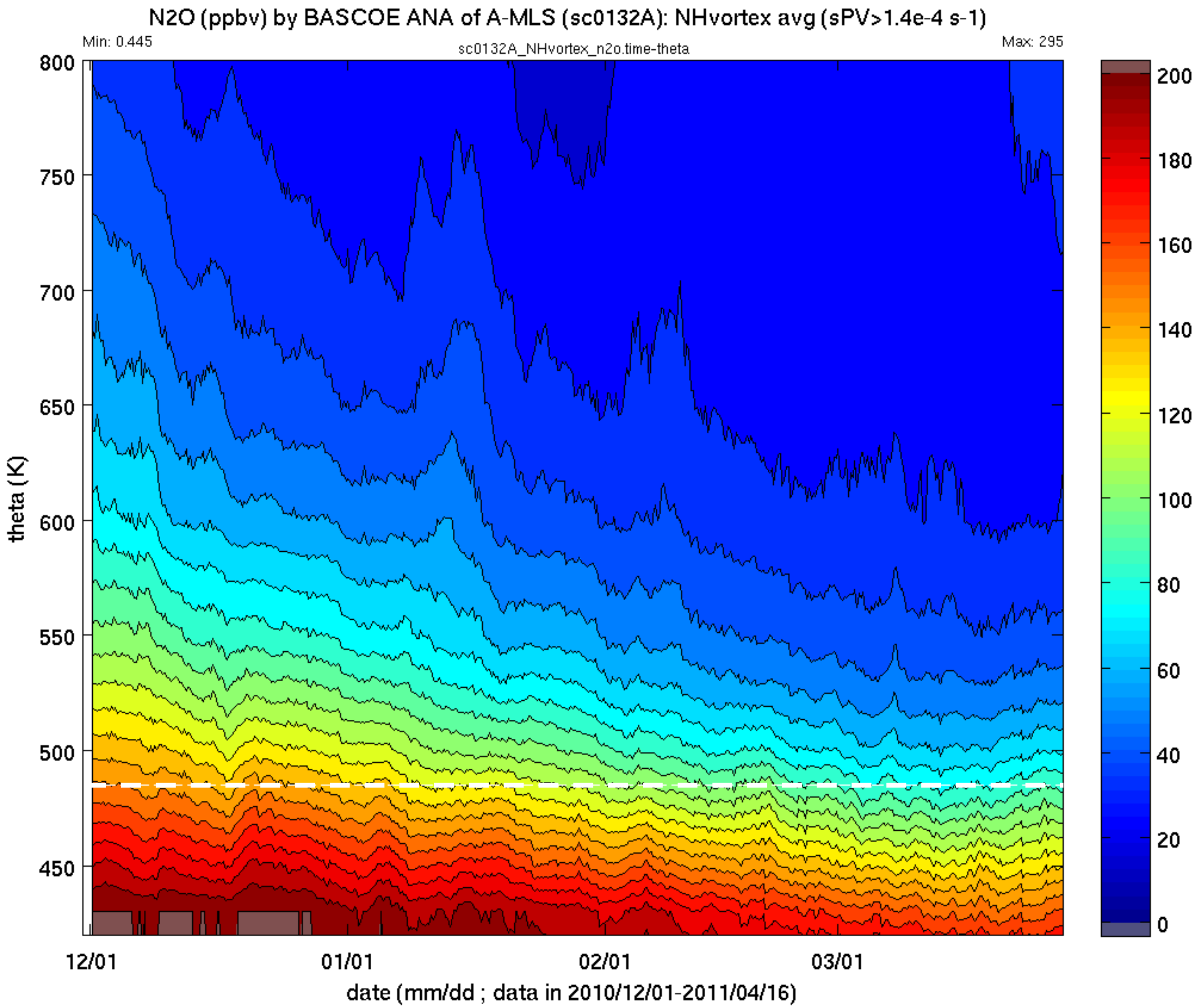
Partial column : 10-100 hPa



scaled PV

N2O analyses as a diagnostic of stratospheric transport

Vortex-averaged descent of N2O-poor air masses:



Much slower at 485K than at 800K but definitely present for whole period of interest

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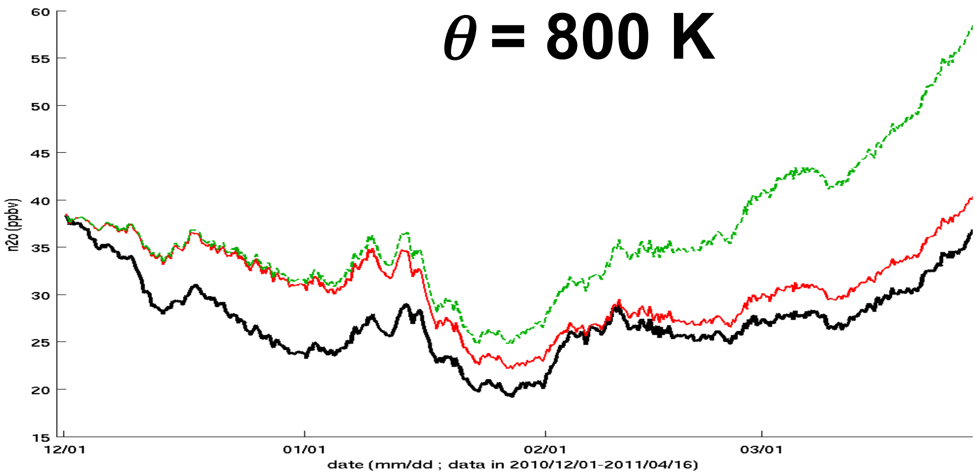
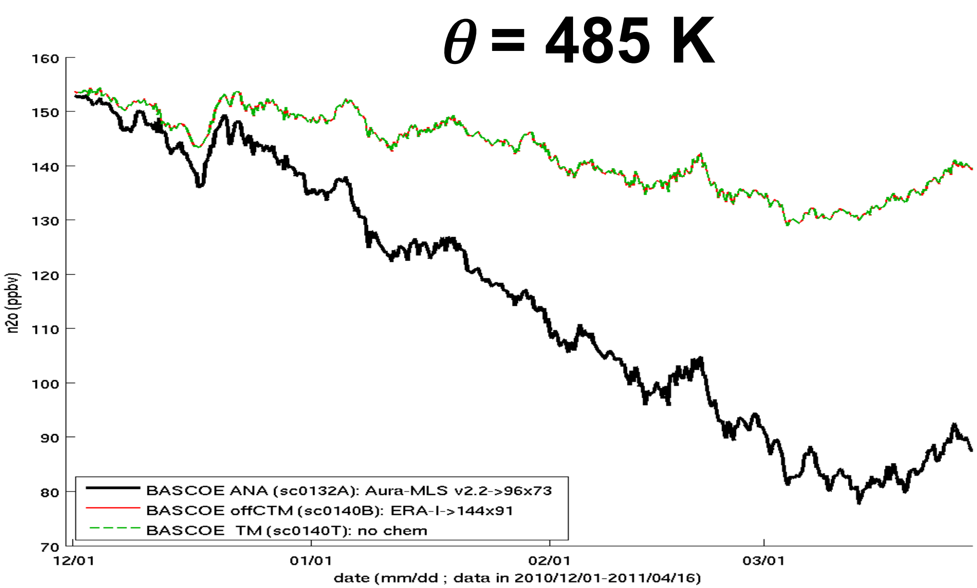
Vortex-averaged N2O : models vs analysis

Black : analysis	**BASCOE CTM (driven by ERA-I)**	**BASCOE TM (same, no chemistry)**



→at 800K, N2O is <u>not</u> a "pure" tracer. The CTM has downdraft but too slow. At end January analysis shows that downdraft ends *(SSW?)* allowing a chemical sink *(which?)* to bring CTM closer to obs



→at 485K, N2O really is a "pure" tracer. The CTM underestimates downdraft during whole season

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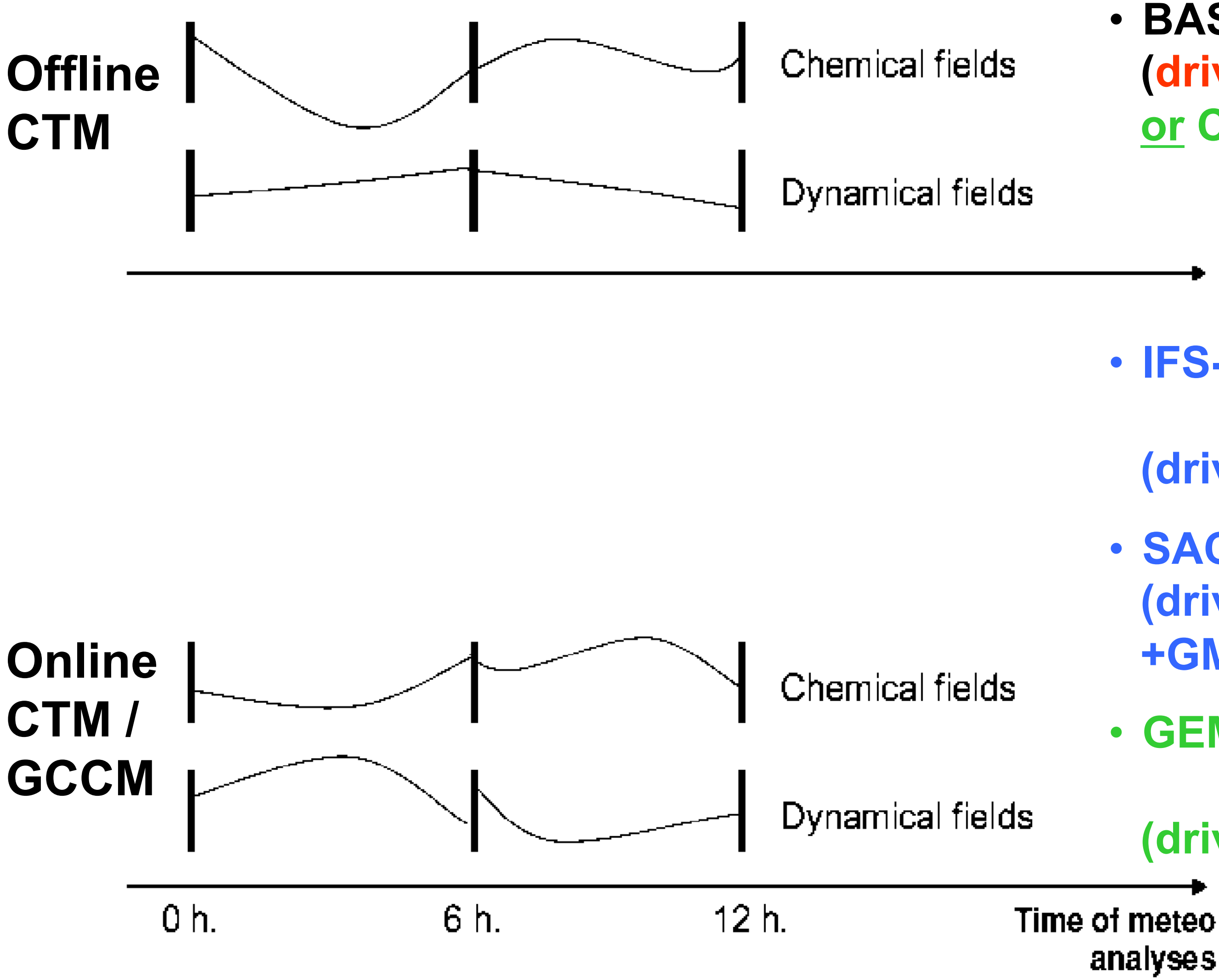
Offline CTM versus online CTM



- **MOZART** [NCAR+FZJ] **(driven by ECMWF AN)**
- **BASCOE** [BIRA] **(driven by ECMWF AN or CMC AN+GEM)**

- **IFS-MOZART** [ECMWF+FZJ] **(driven by ECMWF AN)**
- **SACADA** [DLR] **(driven by ECMWF AN +GME)**
- **GEM-BACH** [CMC+BIRA] **(driven by CMC AN)**

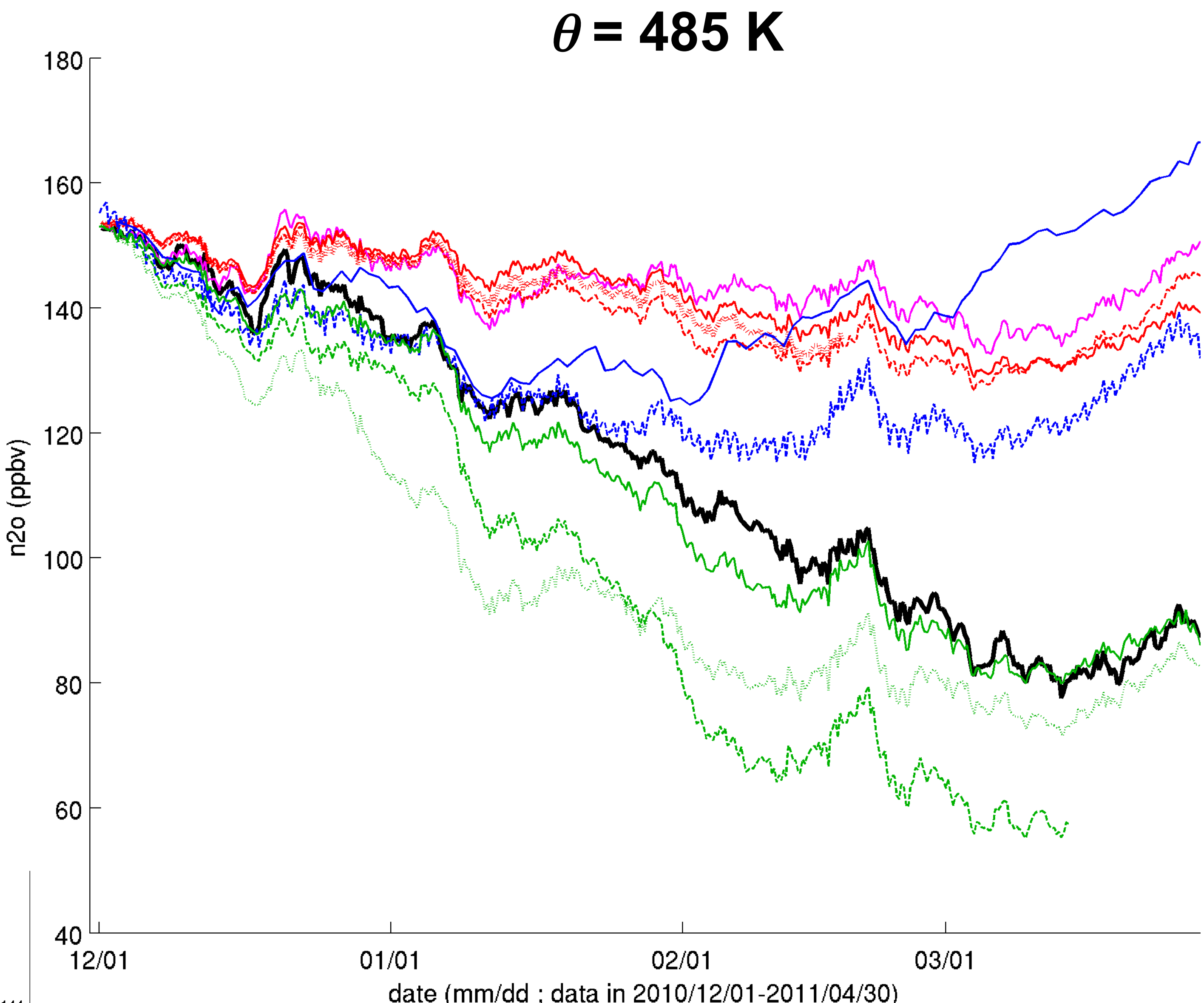
Vortex-averaged N2O : models vs analysis

Analysis

Offline CTM driven by ECMWF

Online CTM driven by ECMWF

Online/offline CTM driven by CMC



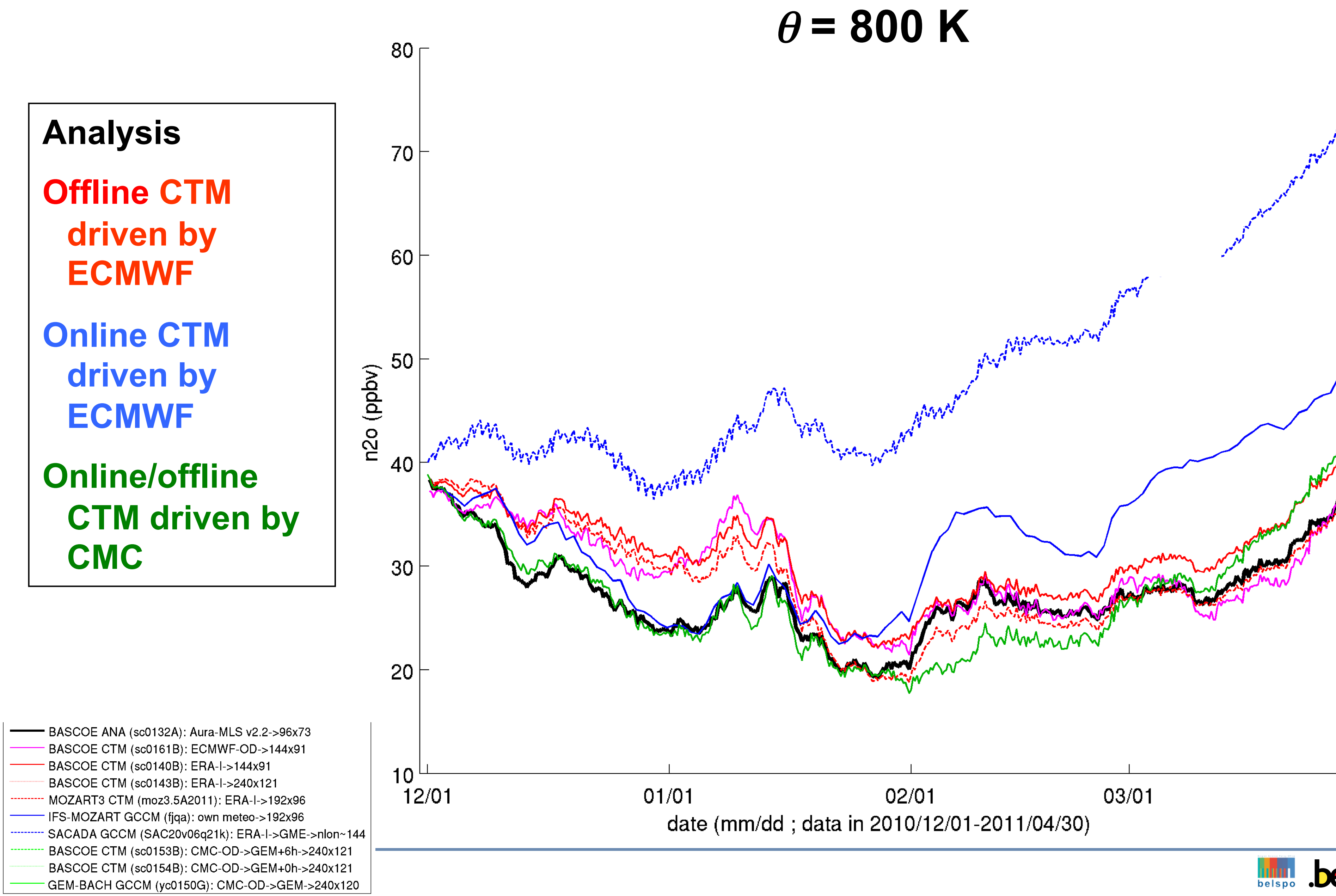
Vortex-averaged N2O : models vs analysis

Analysis

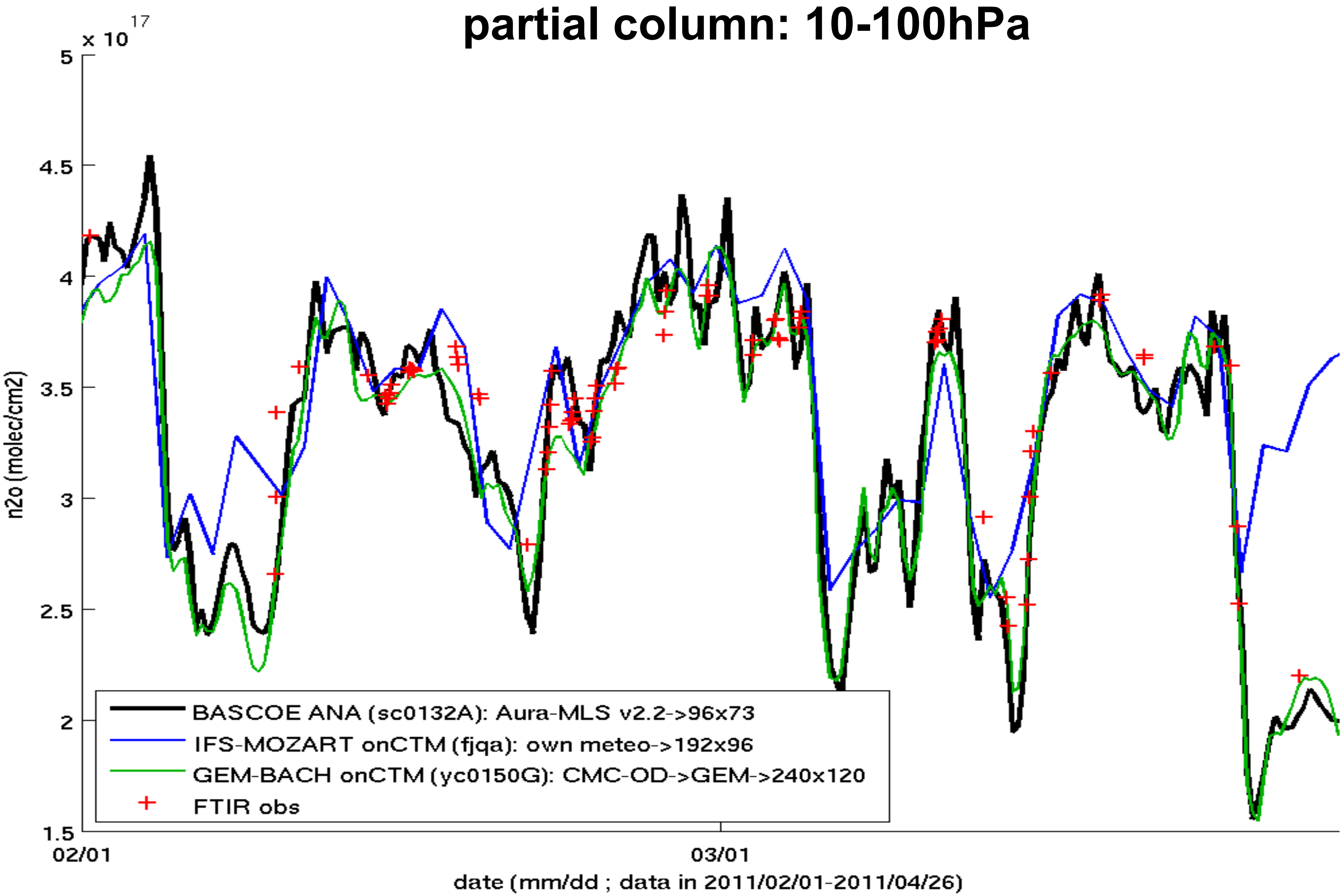
Offline CTM driven by ECMWF

Online CTM driven by ECMWF

Online/offline CTM driven by CMC



N2O above Kiruna : models vs analysis



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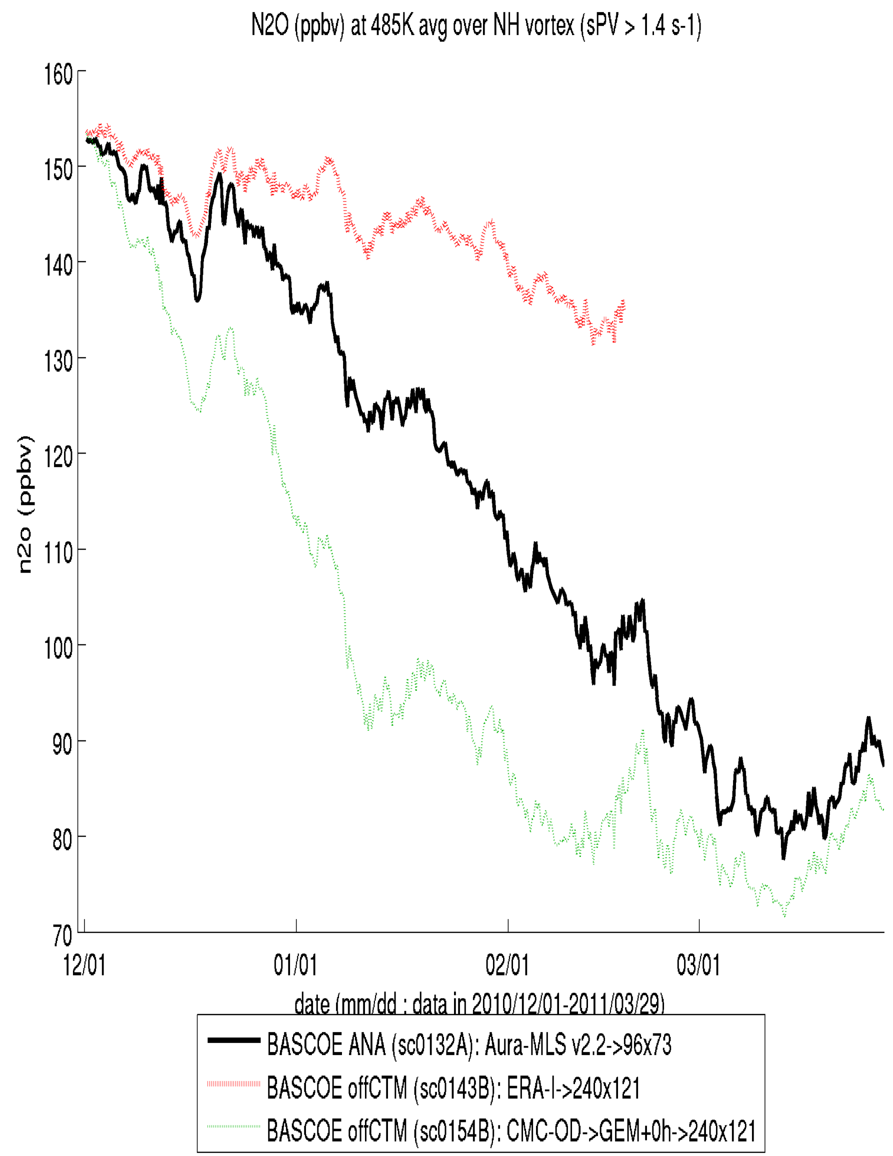
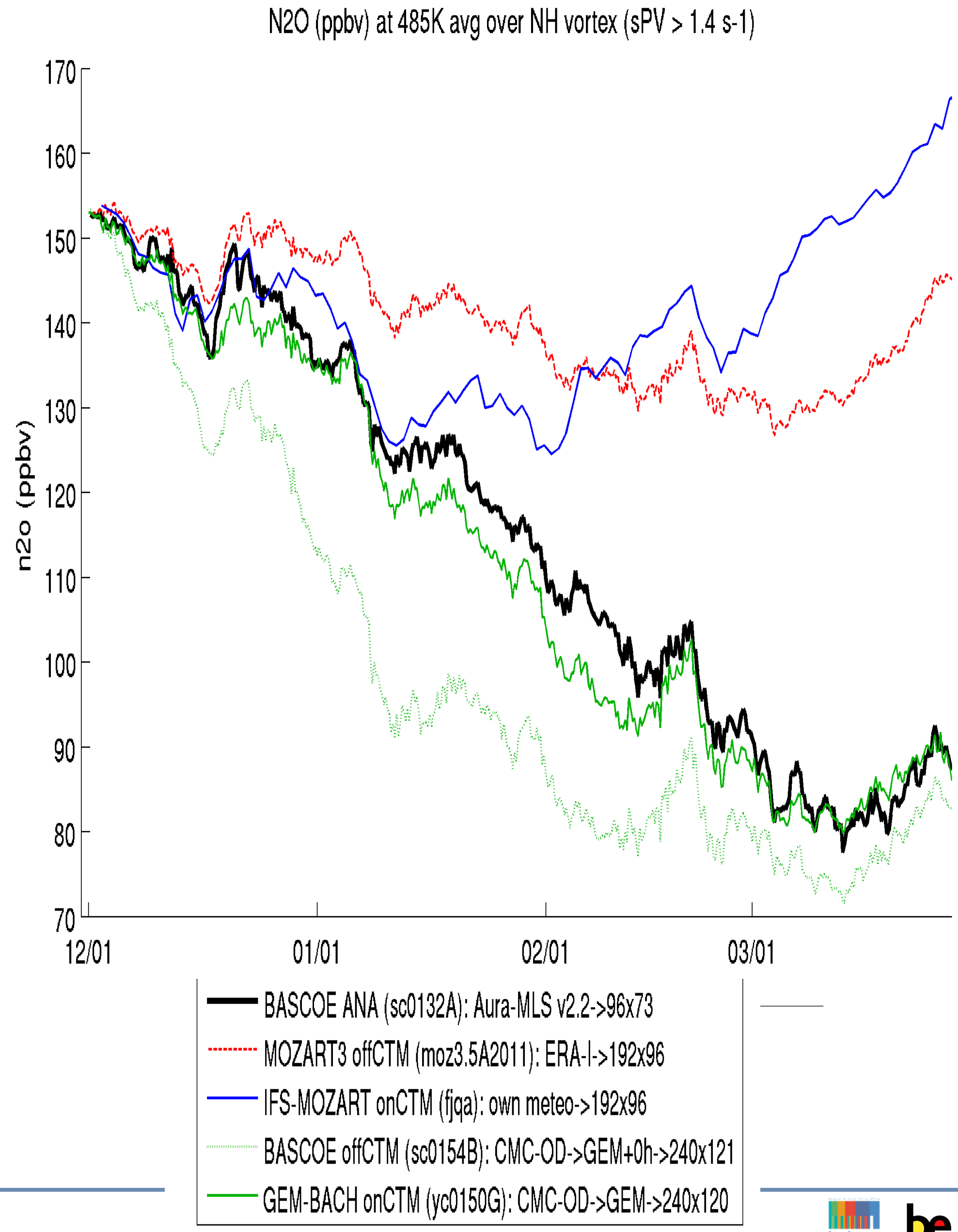
Discussion

- What is necessary to get right downward transport in lower strato vortex ?
- Initial (naïve) idea: if offline CTM is correctly set-up (pre-processing of meteo analyses), correct meteo analyses are necessary and sufficient
- Until now, no offline CTM succeeded to match analysis of vortex-averaged N2O



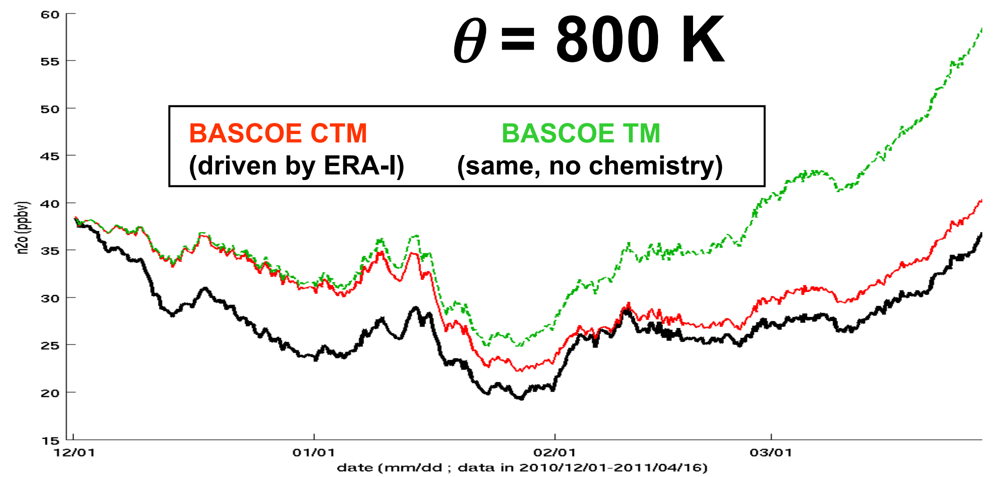
Discussion

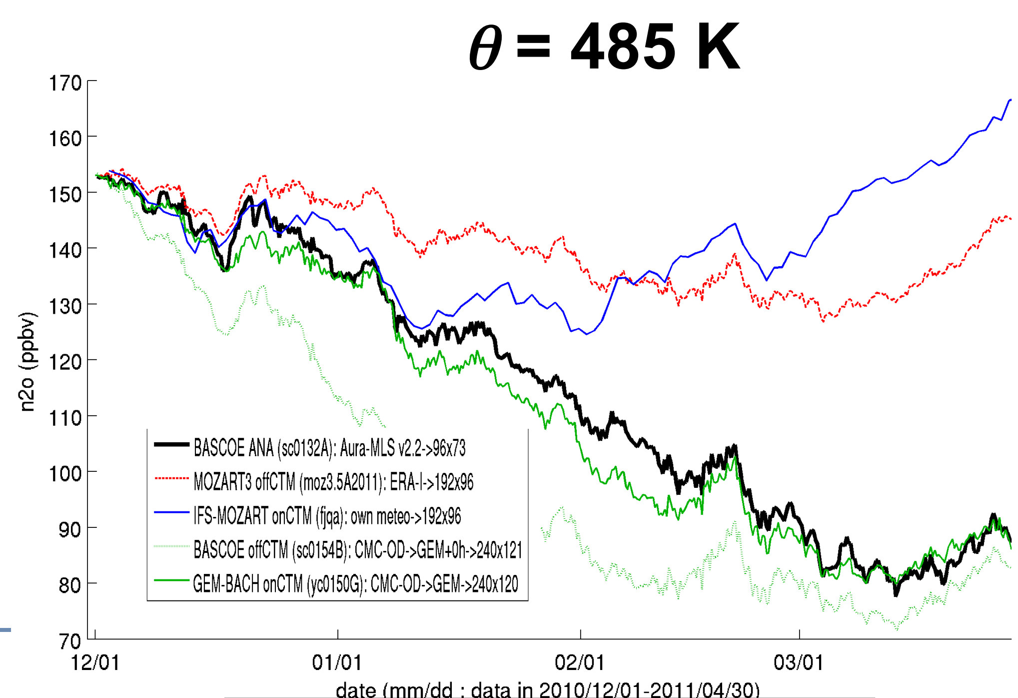
- What is necessary to get right downward transport in lower strato vortex ?
- Online CTM ? That worked in only one case: GEM-BACH (240x120X80) driven by CMC analyses (GEM 4D-VAR, 800x600x80)



Discussion

At 485K, the online CTMs driven by ECMWF (IFS-MOZART, SACADA) are correct during 1st half of period than go completely out: behaviour very similar to transport-only BASCOE driven by ECMWF. Could chemistry (or its absence) actually play a role? To investigate…





Discussion

Possible extensions for this study:

1. **Use analyses of Aura-MLS v3.3 (better)**
   →Extend to upper stratosphere (NO_2, CO)
2. **Look for matches between these timeseries and the SSW.**
   Caution: **ECMWF has right timing of SSW but wrong vertical structure of T during these episodes ! (see G. Manney's poster). Better to use T by Aura-MLS.**
3. **Run BASCOE as "online CTM" (i.e. winds updated every tstep)**
   →find if helps. If not: cause is in BASCOE model (e.g. inadequate preproc of meteo fields)

Conclusions

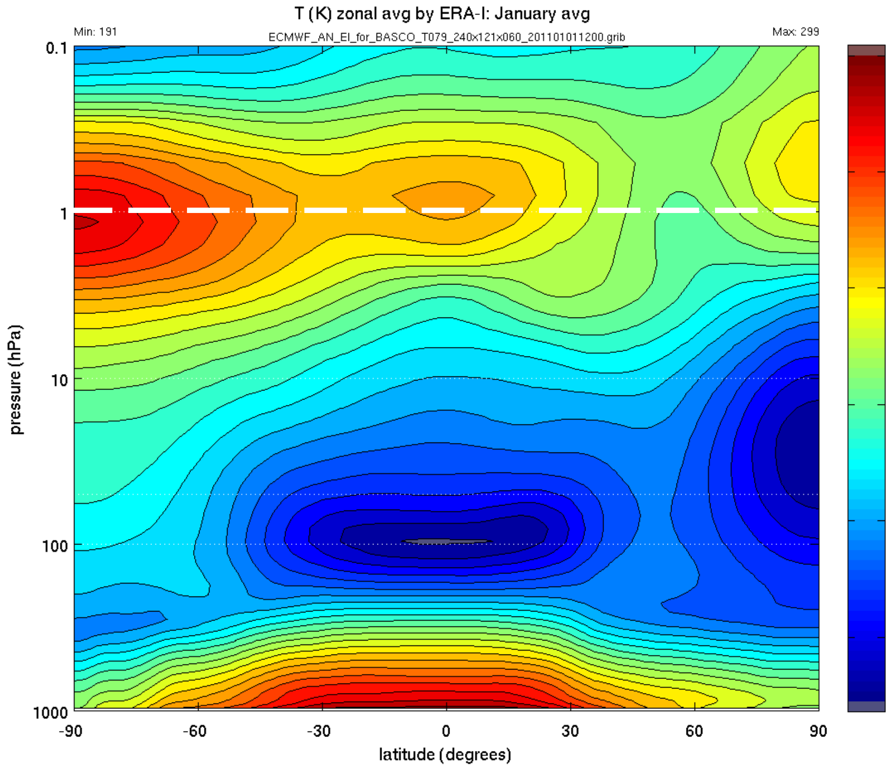
- **Analyses of chemical tracers are a very good tool for <u>quantitative</u> evaluation of transport processes (including meteo analyses) in 3D models.**
- **For Arctic vortex 2010-2011, in lower strato: GEM-BACH driven by CMC meteo gets the best results (by far)**
- **Why is that: better GWD or assim ? Maybe both… (e.g. better T analyses in USLM →better GWD)**
- **No ECMWF-driven model obtains correct transport**

Thank you !

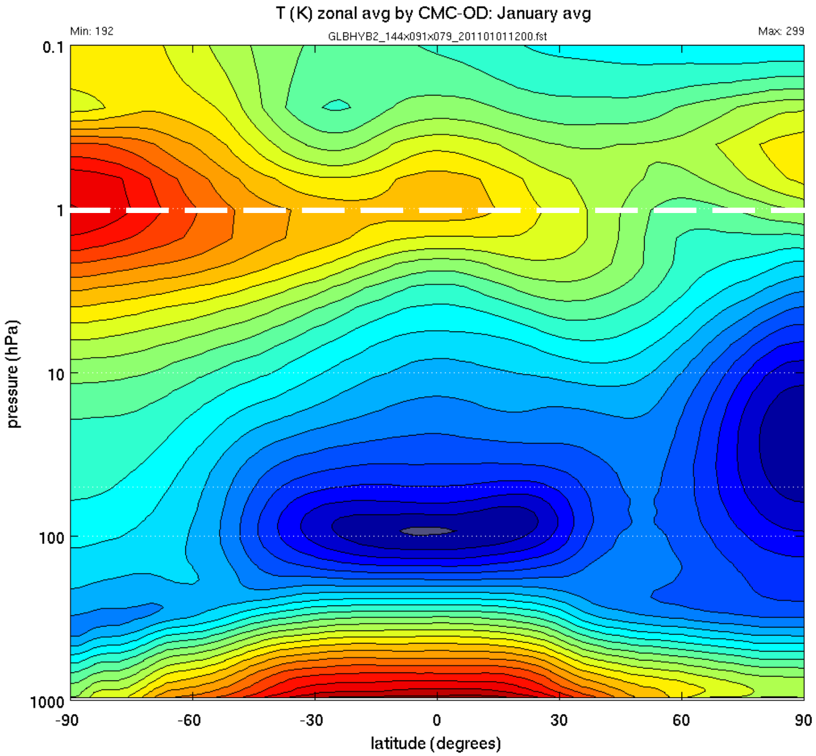
Differences between meteo analyses ?

$\overline{T}$ average, January 2011

ERA-I

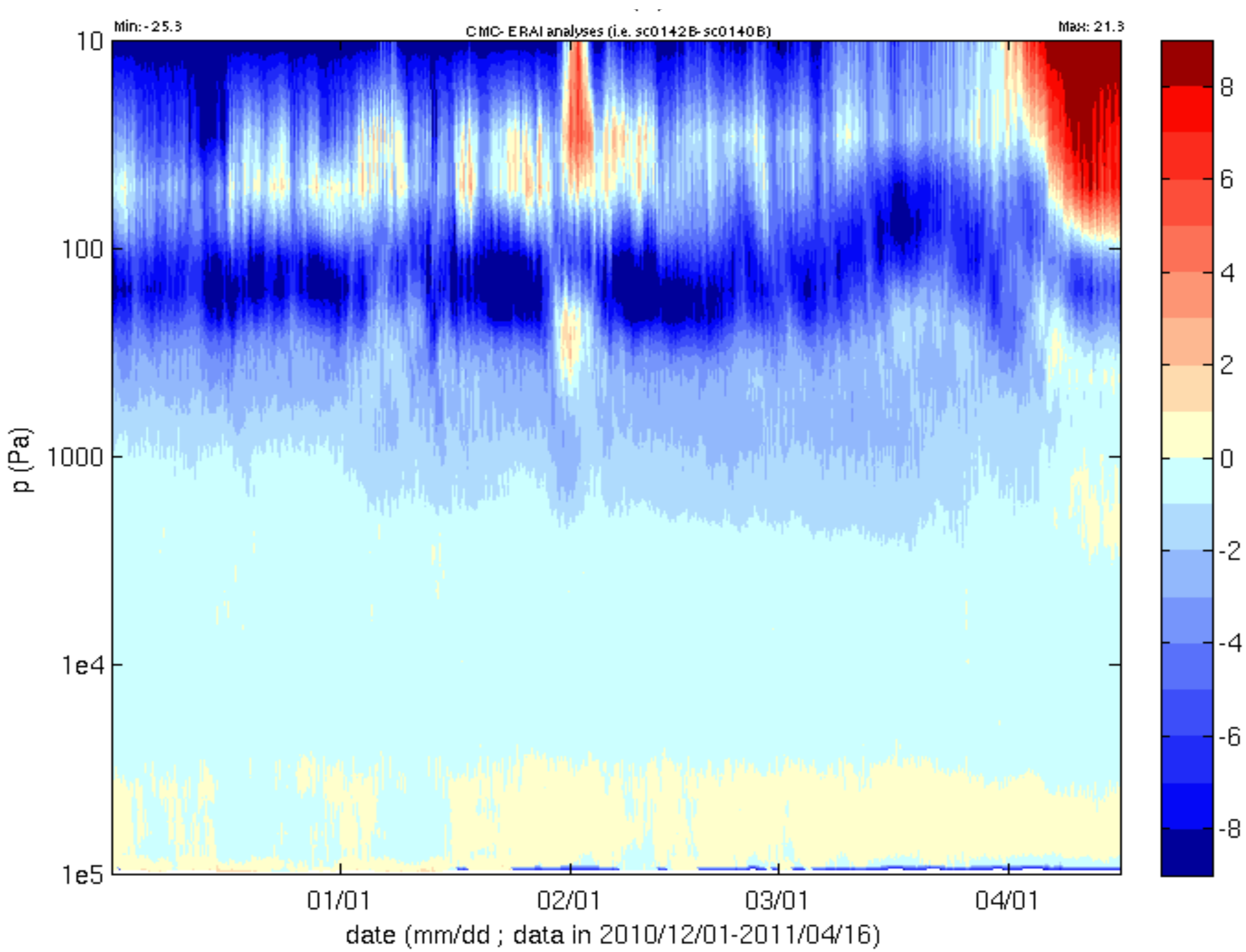


CMC-OD



Differences between meteo analyses ?

time-series of mean T difference over polar cap (lat>70°N): CMC-ERAI



No mean bias in lower strato but in upper strato, ERA-I warmer by up to 10K.

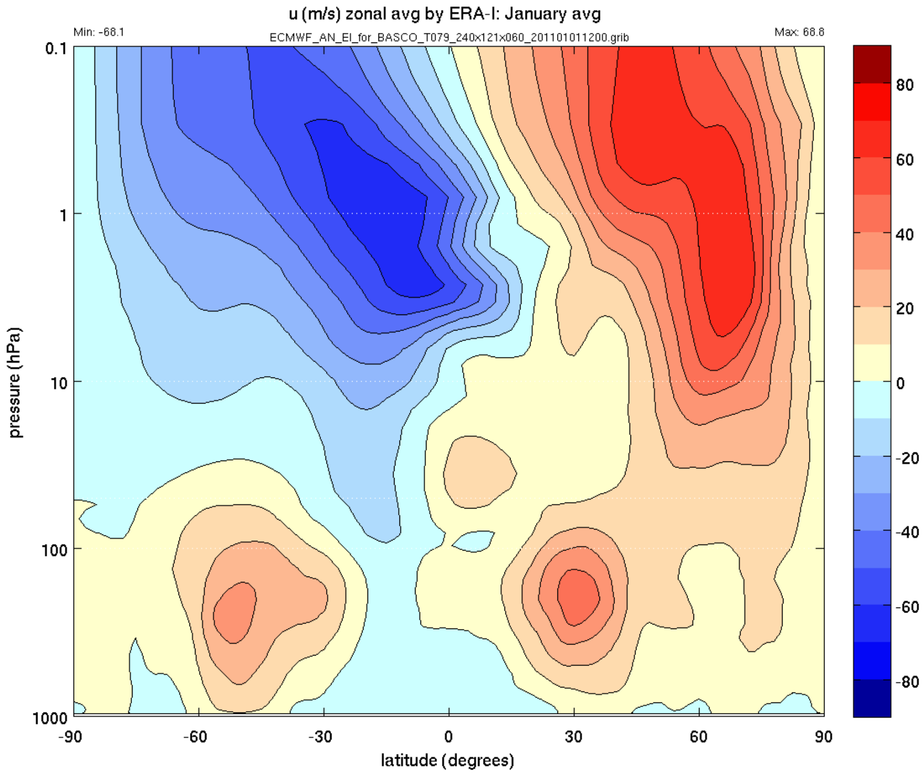
Notes:

- **IASI vs ECMWF-OD show ECMWF may be too warm by up to 12 K in USLM (Masiello et al, ACP, 2011)**
- **Similar clues already in MIPAS vs ECMWF (Ridolfi et al, ACP, 2007)**
- **Quantitative Comparison of T by CMC & ECMWF with T by Aura-MLS: Has this been done ?**

Differences between meteo analyses ?

$\overline{u}$ average, January 2011

ERA-I



CMC-OD