

NNORSY-GOME Ozone Profile Retrieval Products and Climatology

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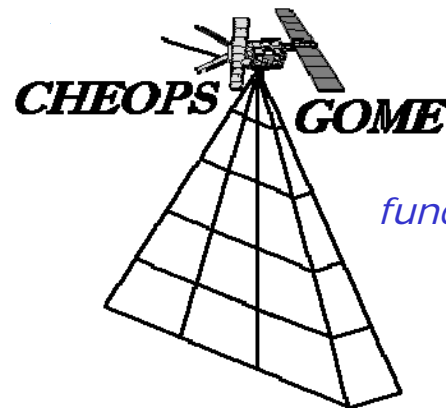
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Outline

1. *NNORSY and Optimal Estimation (OE)*
2. *Approach for NNORSY*
3. *Local error estimation*
4. *NNORSY-GOME ozone profile products*
5. *Validation: Geophysical and data assimilation*
6. *Application for NNORSY-GOME data set*
7. *Dynamic ozone profile climatology*
8. *Summary*



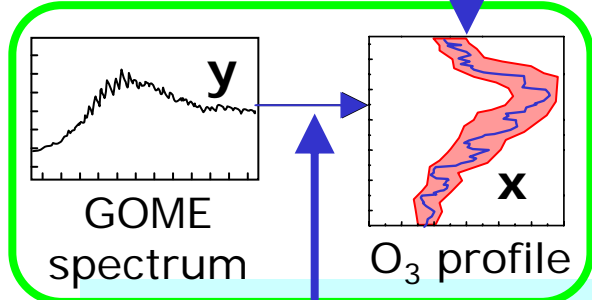
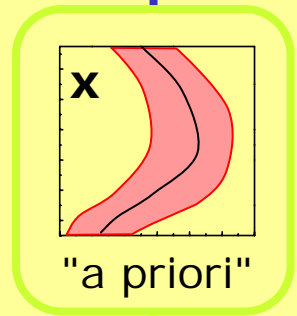
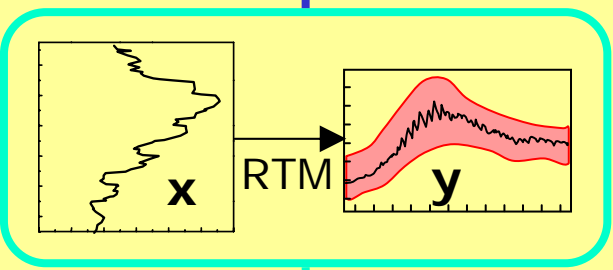
Comparison of retrieval approaches

Optimal Estimation

Optimal Estimation

z.B. FURM, OPERA, ...

~ 1 min/profile



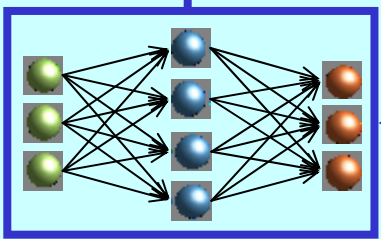
$$p(\mathbf{x}|\mathbf{y}) = \frac{p(\mathbf{y}|\mathbf{x}) p(\mathbf{x})}{p(\mathbf{y})}$$

$$p(\mathbf{y}|\mathbf{x}) p(\mathbf{x})$$

$$p(\mathbf{y})$$

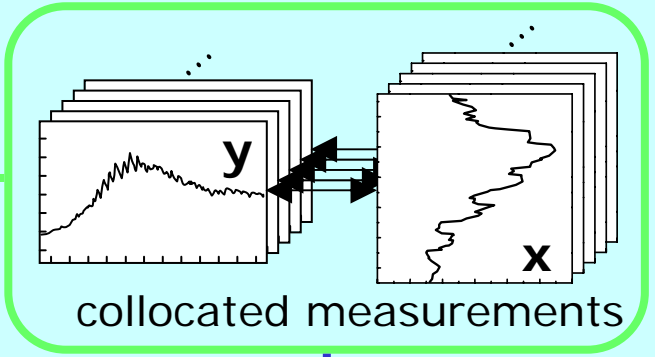
NNORSY

~ 1 ms/profile



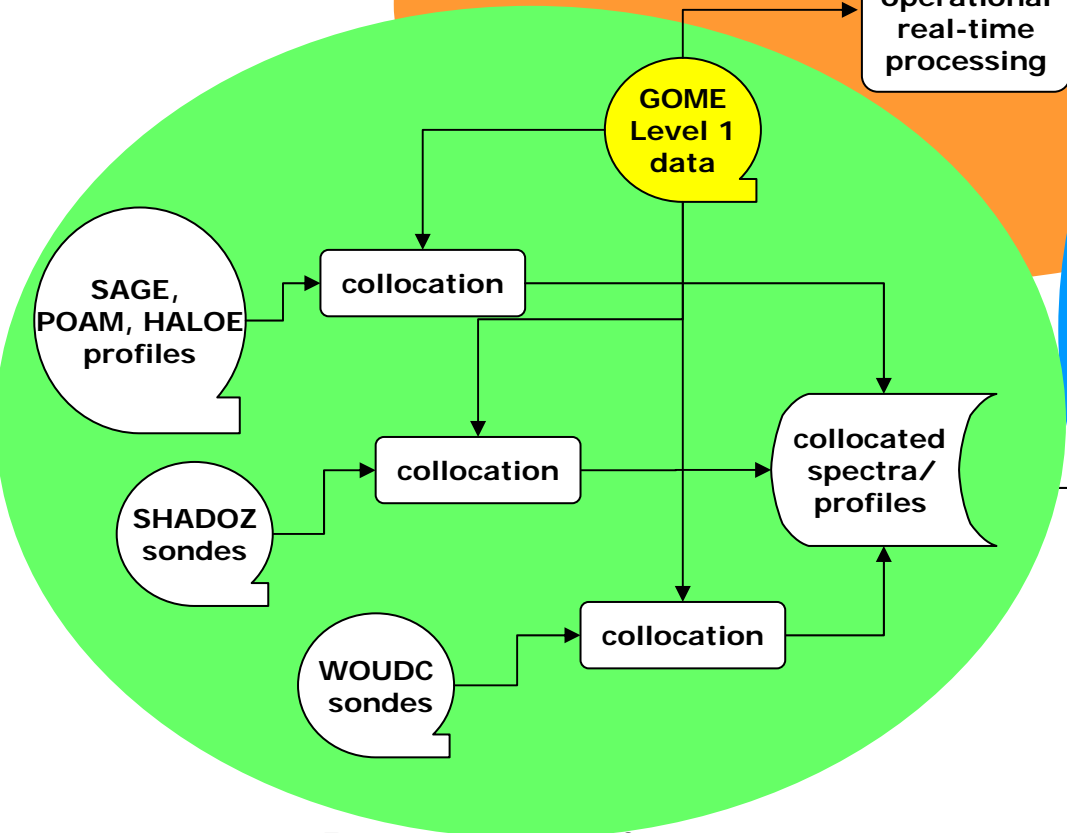
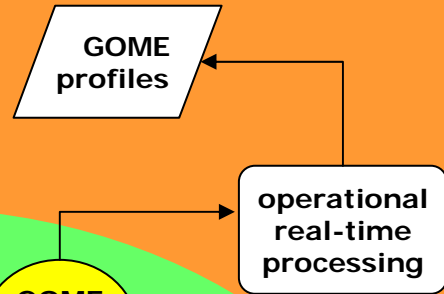
NNORSY

$$k(\mathbf{x}, \mathbf{y})$$

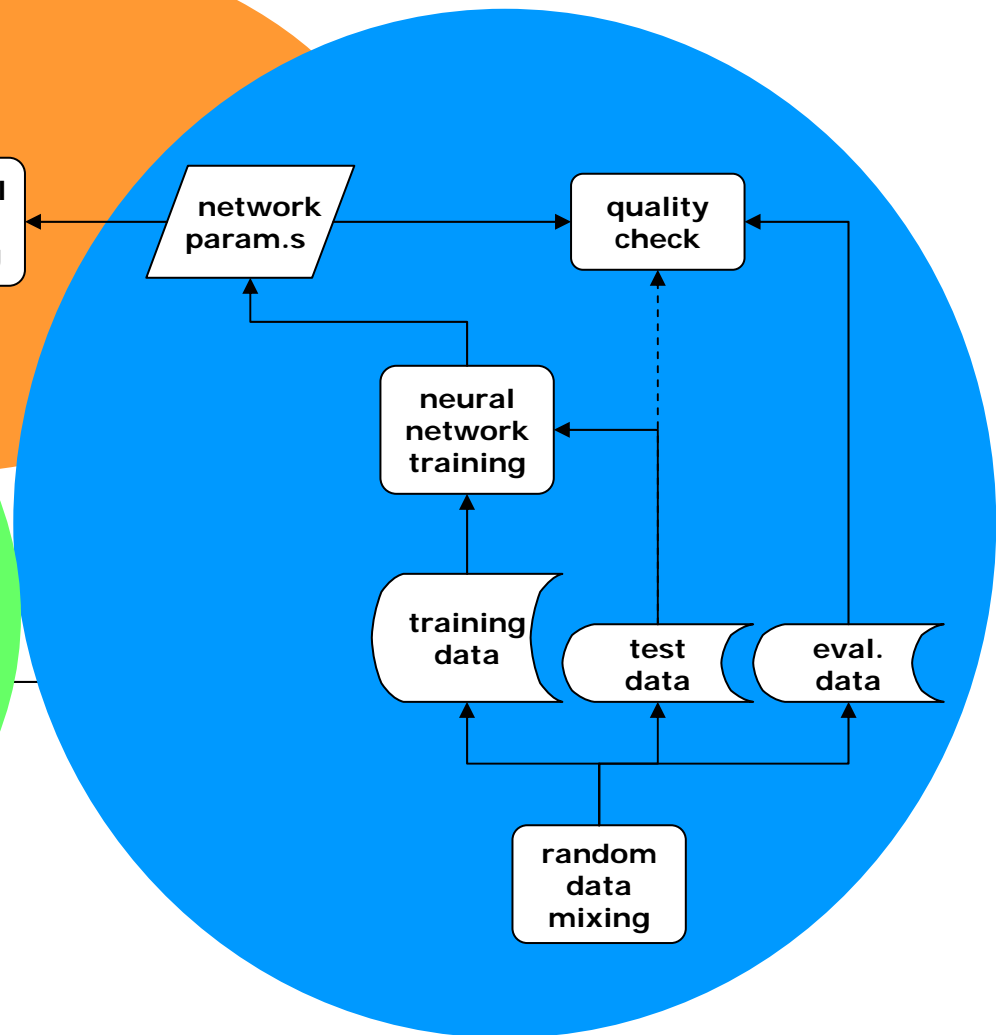


Overview NNORSY-GOME

Operation



Preprocessing

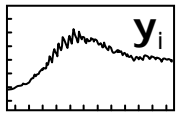


Training



NNORSY-GOME Input Parameters

Input data for neural network



GOME
spectral
data

270 – 325 nm (O₃ Hartley & Huggins)
380 – 385 nm (atmosph. window)
598 – 603 nm (O₃ Chappuis)
758 – 772 nm (O₂ → cloud info)

geolocation

SZA, SAA
sensor scan angle
LOS type (east, nadir, west)

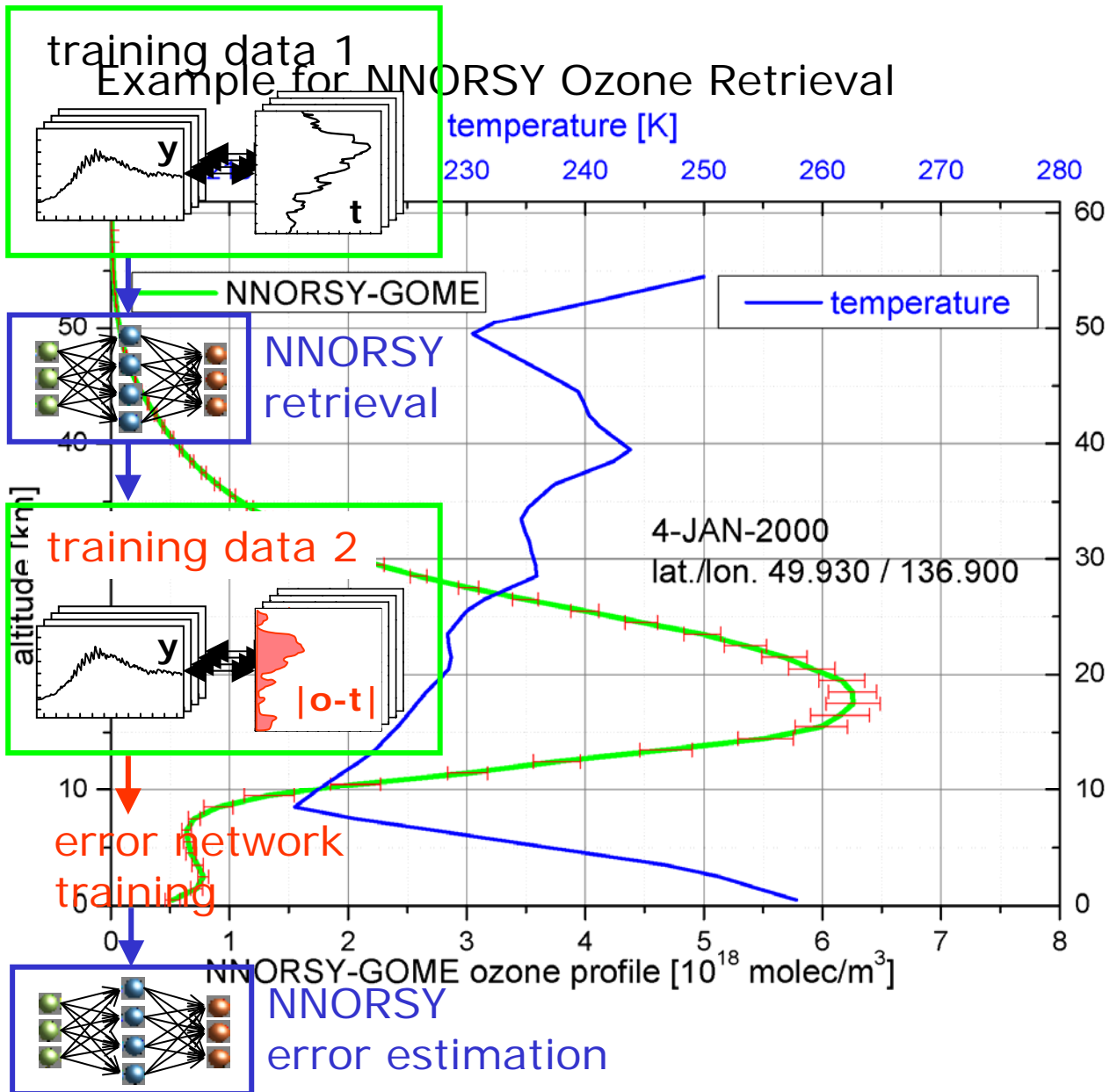
meteorol. info

GEOS4 temperature profile

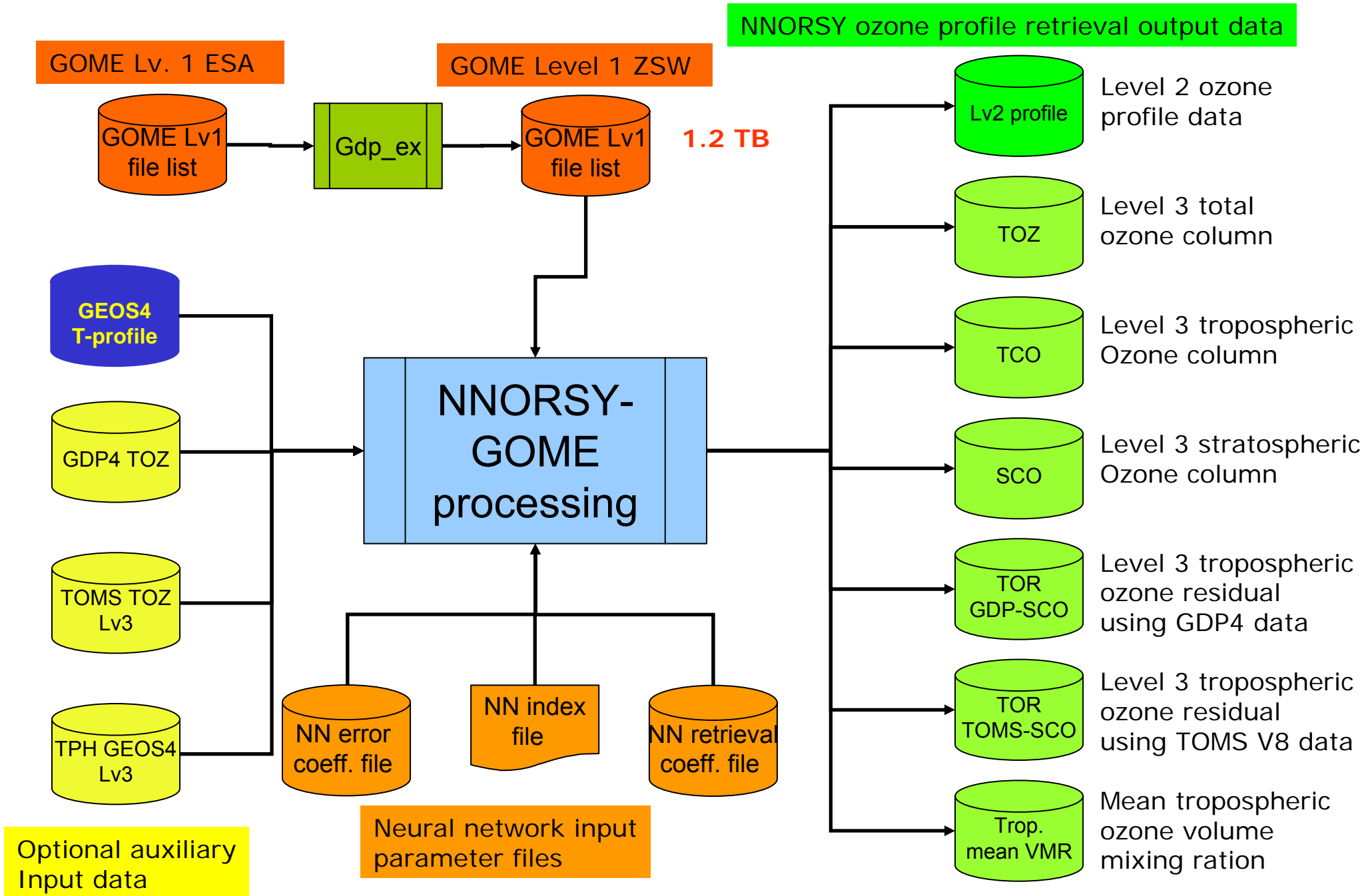
climatological
predictors

Latitude
Season and sensor age

Estimation of Local Retrieval Error



NNORSY-GOME Processing Model



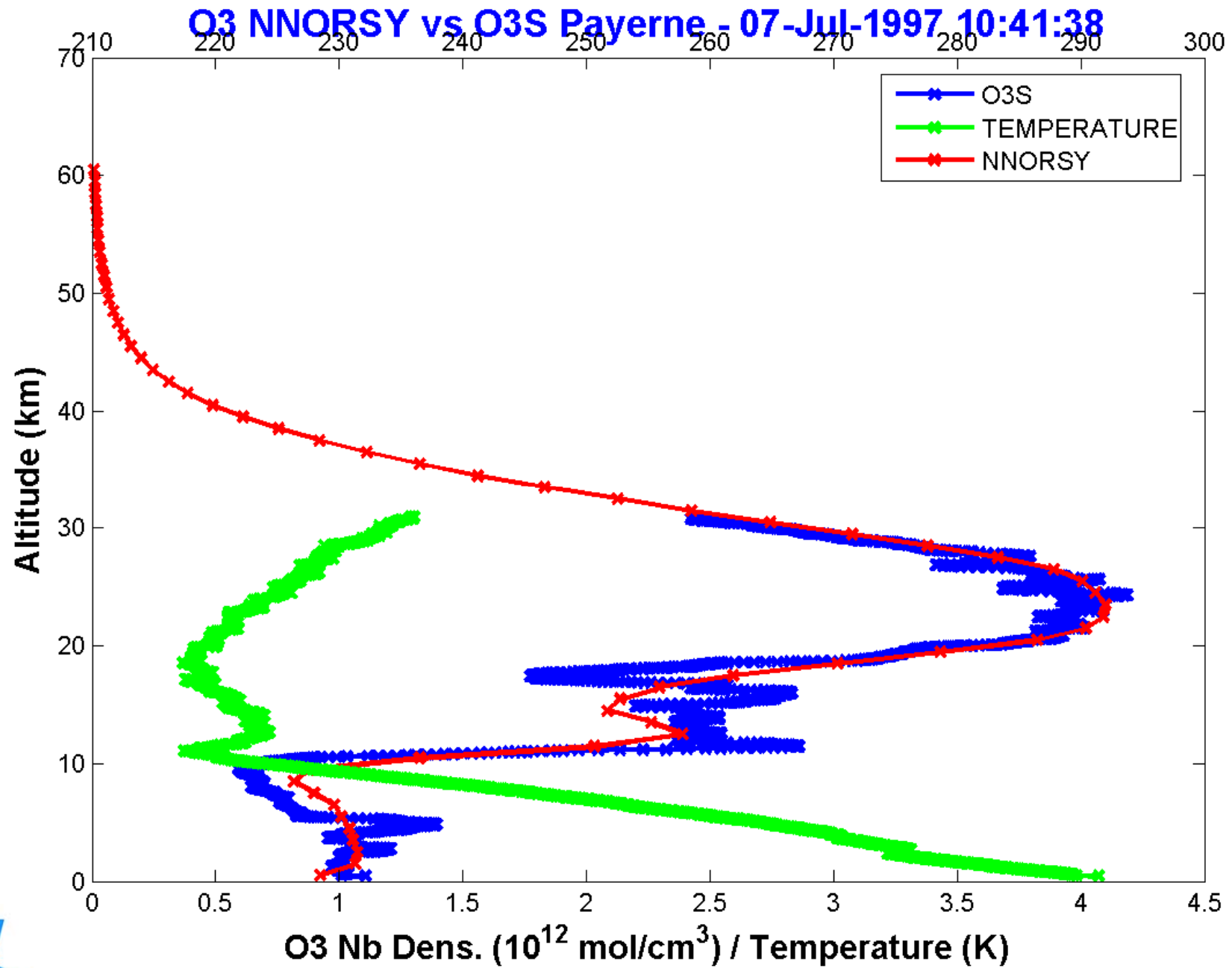
NNORSY-GOME Ozone Profile Data Set

Temporal coverage
Start Date: 09/01/1995
End Date: 05/31/2003
Number of Orbits/Profiles: 36694/48.579.769
Level 2 Profiles
Minimum Altitude: surface
Maximum Altitude: 61 km
Vertical Sampling: 1 km
Ozone Number Density: $1e18/m^3$
Ozone Error: %

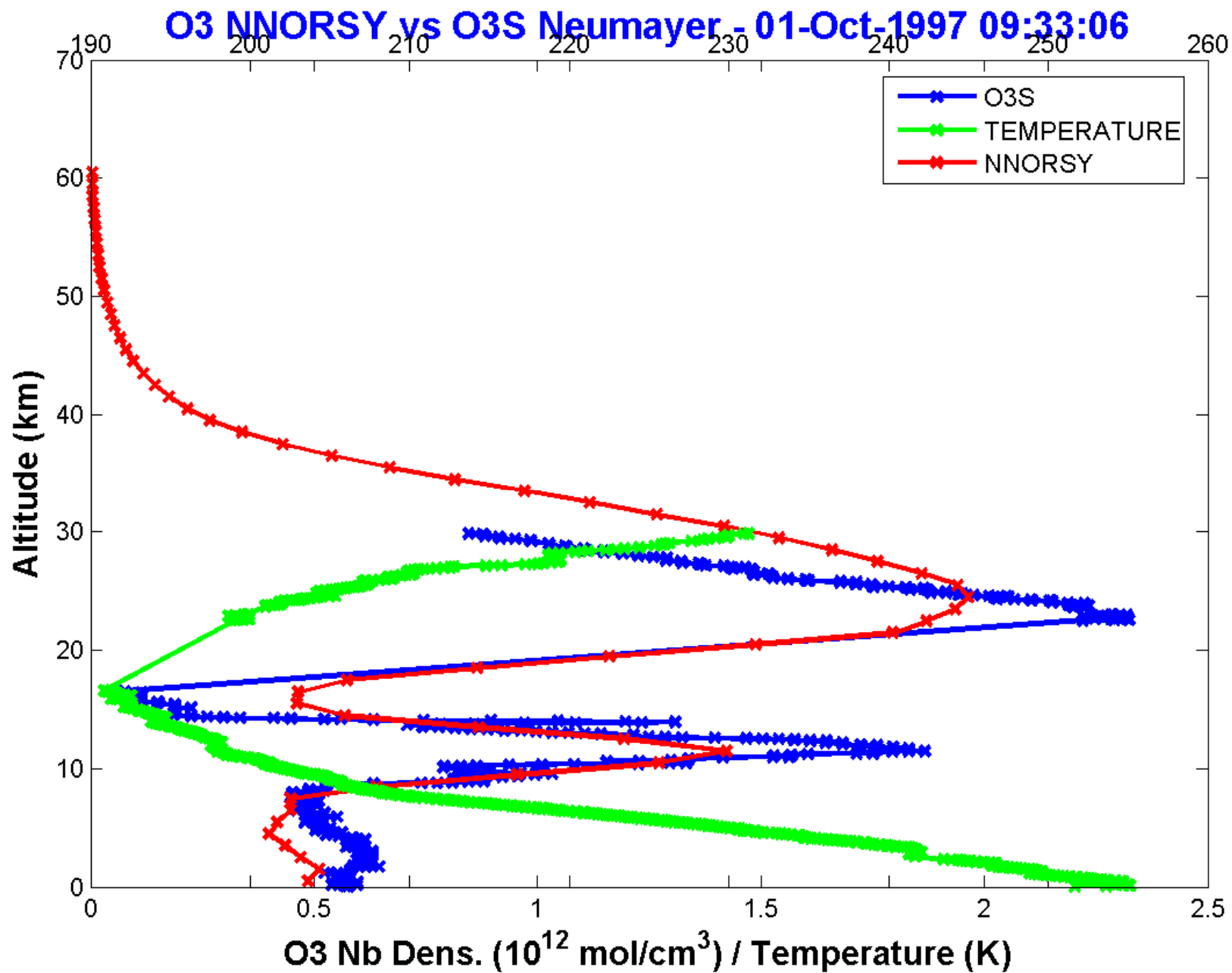
Additional Data
Pressure: hPa
Total Ozone: Integr. NNORSY-profiles & TOMS (DU)
Tropopause Height: km
Tropospheric Ozone: DU
Stratospheric Ozone: DU
GEOS4 T-profile
GEOS4 surface pressure



NNORSY-GOME Single Ozone Profile I

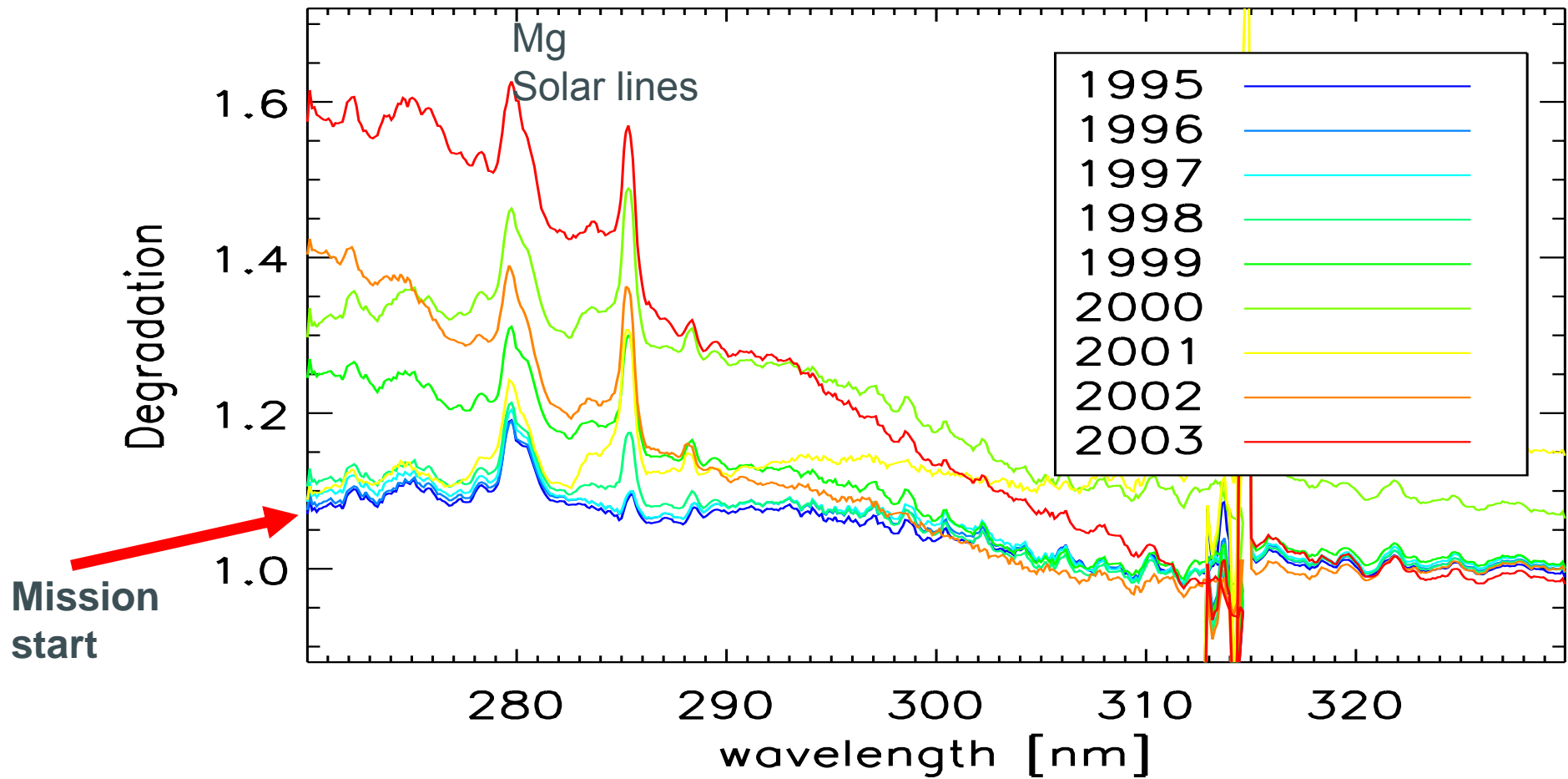


NNORSY-GOME Single Ozone Profile II

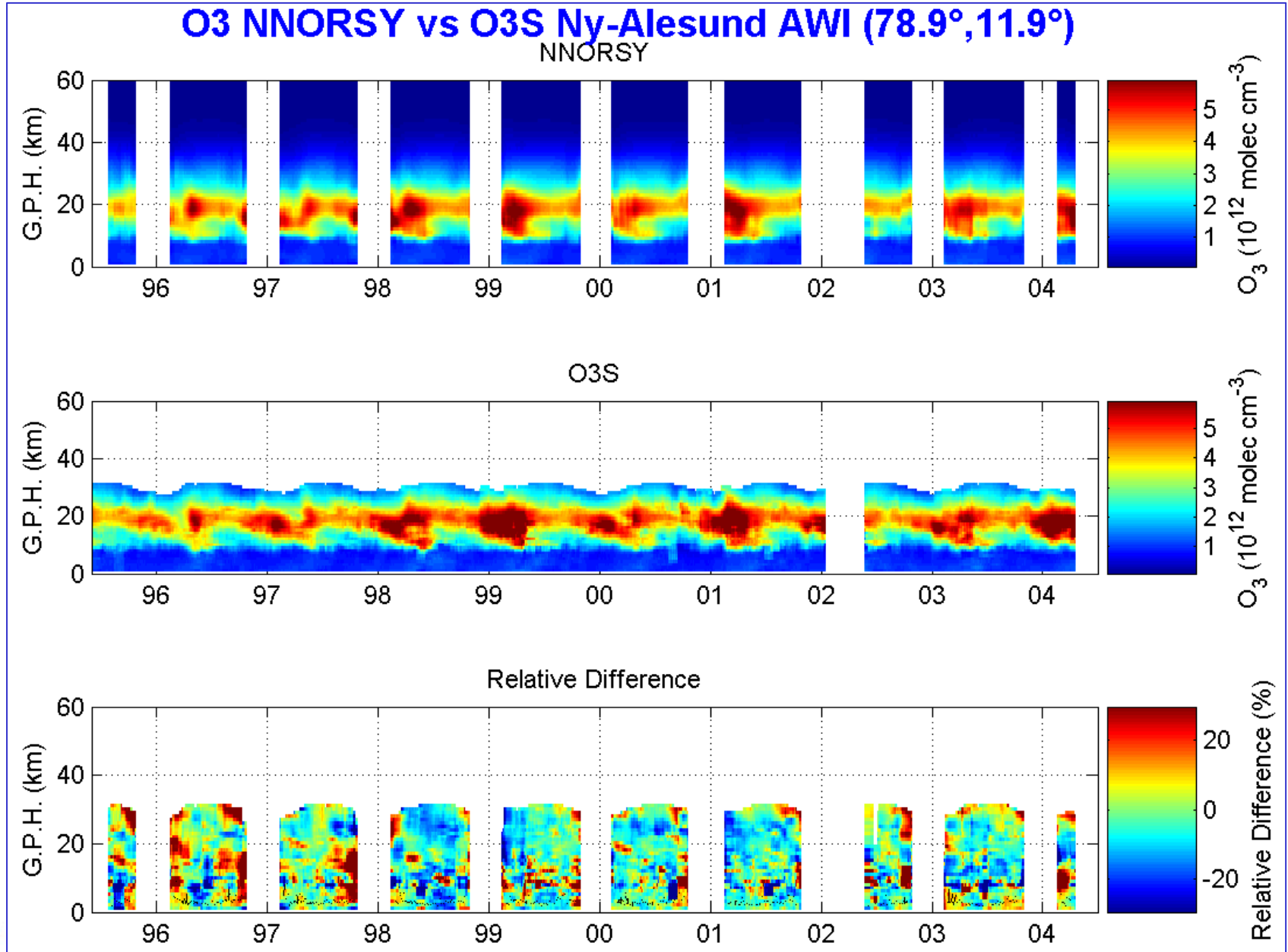


GOME Instrument Degradation

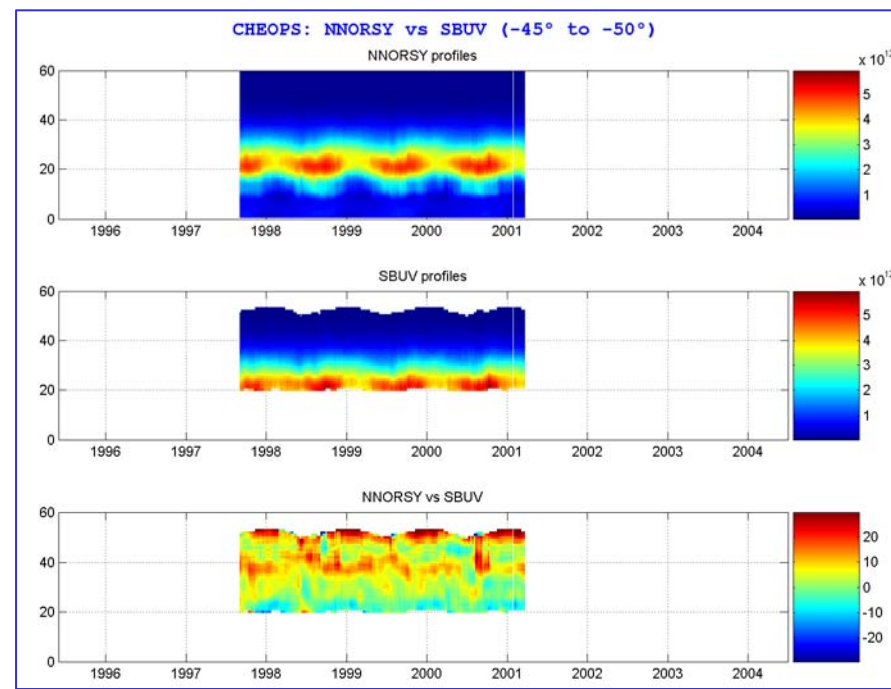
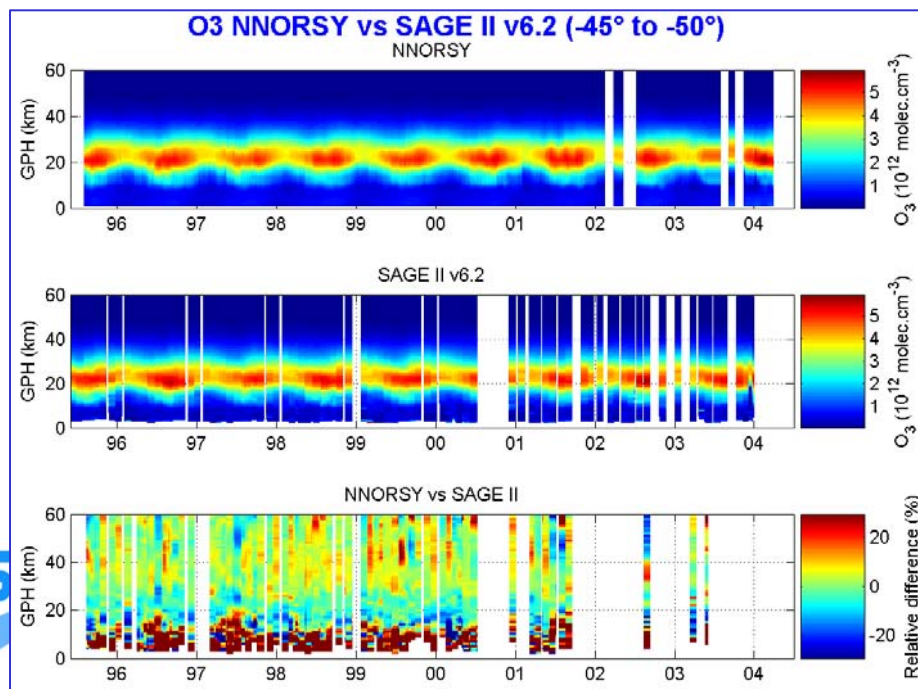
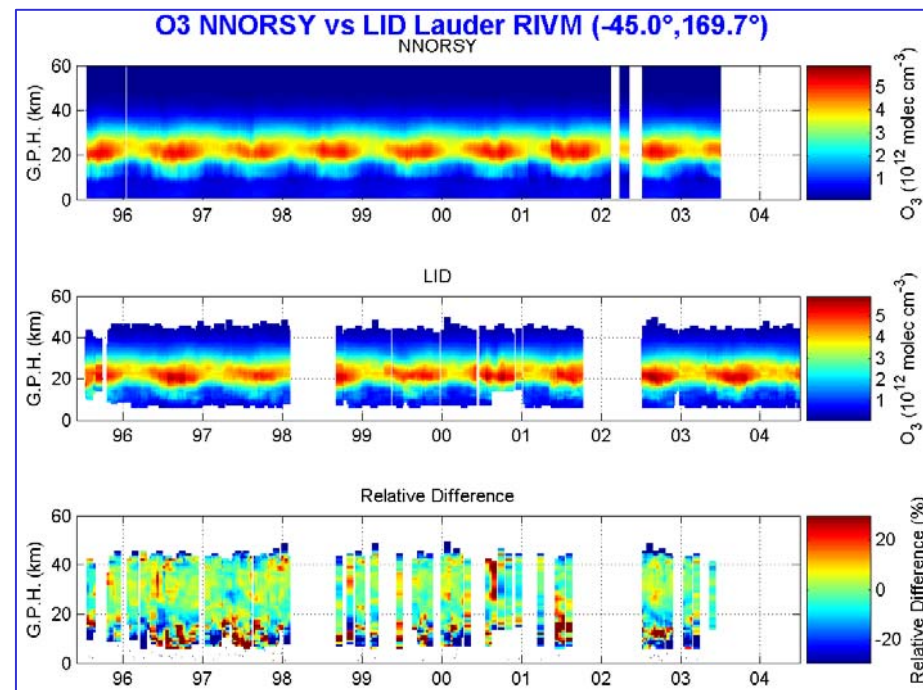
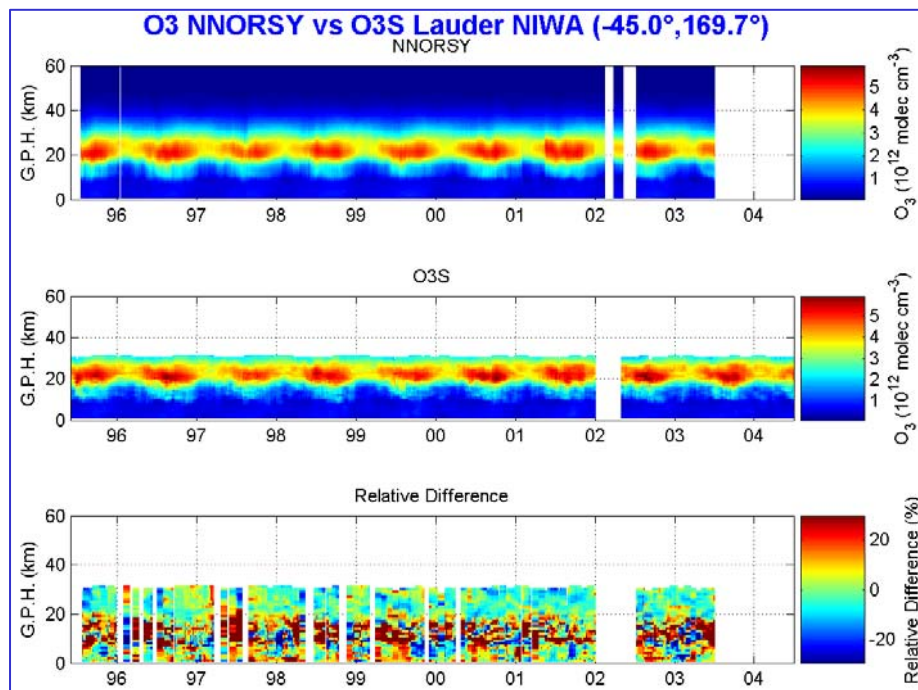
Ratio between model and measurement (yearly average)



Correlative Analysis: Artic



Correlative Analysis: 40° S / New Zealand



Validation with Data Assimilation

Why

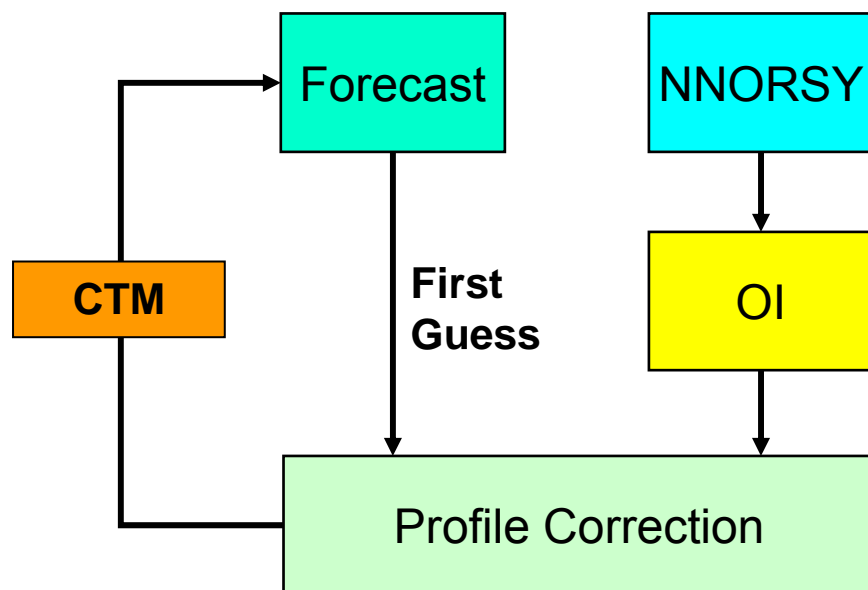
- Global quality control by first guess and error statistics
- Identification of outlier or systematic errors
- Check of retrievals for areas of known GOME problems (SAA)
- Grid parameter:

CTM Model

- Based on ROSE/DLR assimilation system, Version 3.0 (Baier et al., 2006)
- Horizontal optimum interpolation scheme with analyzed error (Kalman Filter)
- Comprises all relevant chemical and dynamical processes of stratosphere
- DA system driven by UK Met Office wind and temperature fields
- Grid parameter:
 - Vertical coverage: 1000 – 0.1 hPa
 - Vertical discretisation: 43 Levels
 - Horizontal resolution: 2.5° x 3.75° resolution

Data Assimilation Overview

Input = NNORSY-GOME retrievals



Output = 3D global ozone analysis

Diagnostic parameters derived

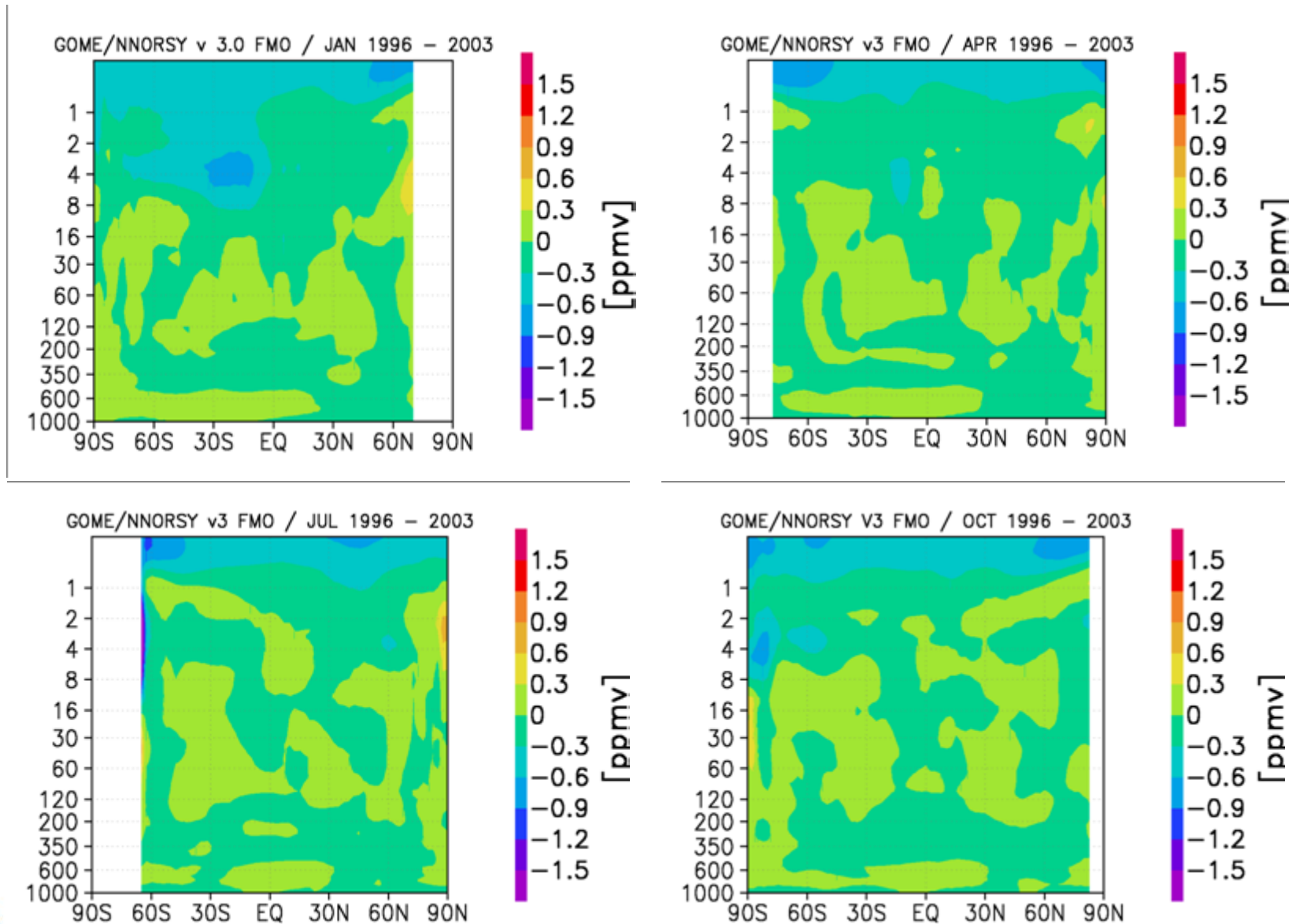
OMF = observation minus first-guess

AMO = analysis minus observation

AMF = analysis minus first-guess

Validation with Data Assimilation

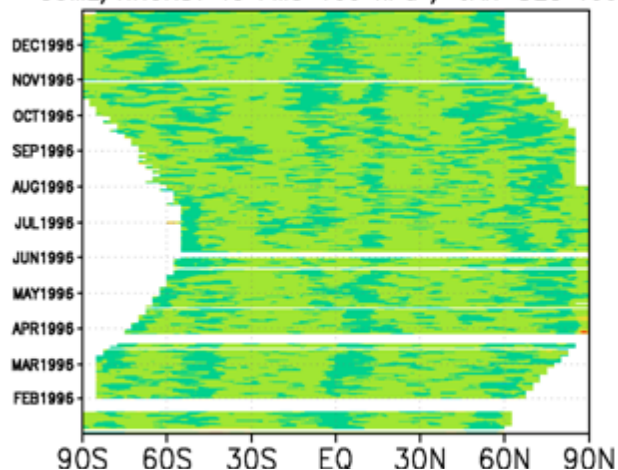
Zonal Means of **First-Guess** minus **Observation Error (FMO)**
January, April, July, October



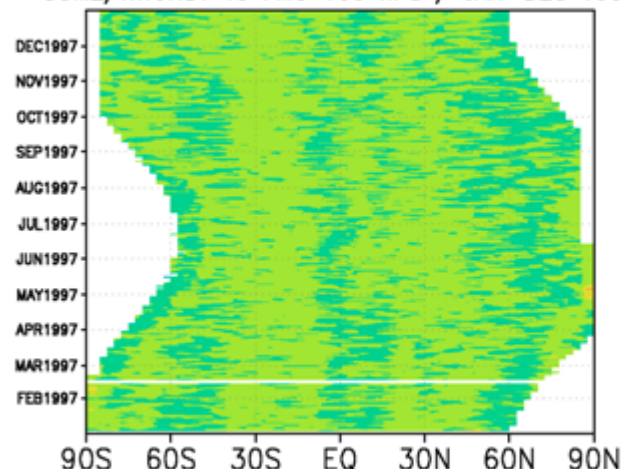
Validation with Data Assimilation

Daily zonal means of **FMO Error** at 100 hPa

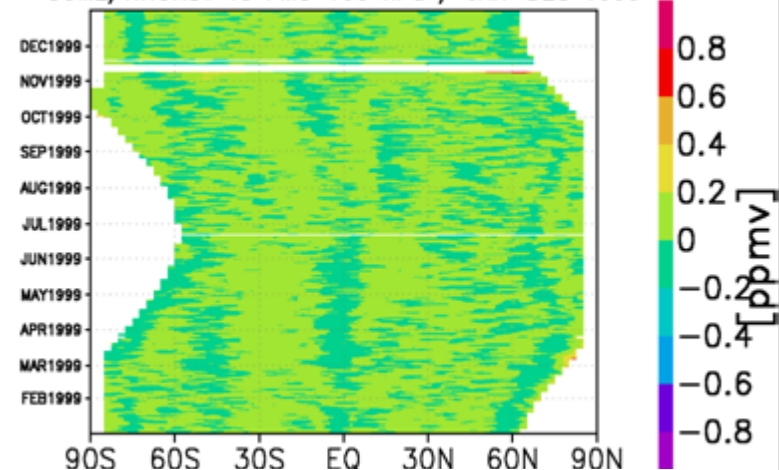
GOME/NNORSY v3 FMO 100 hPa / JAN-DEC 1996



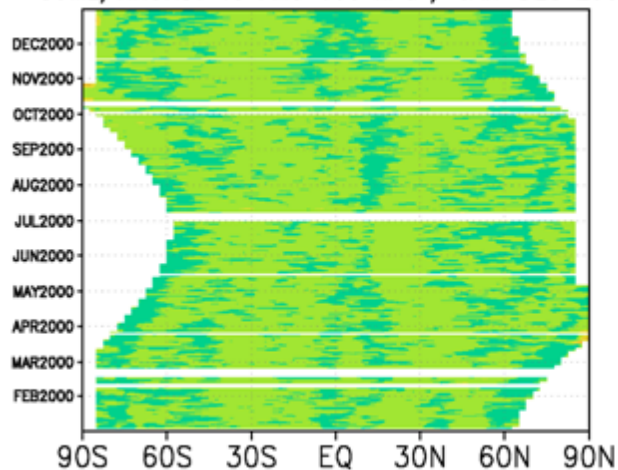
GOME/NNORSY v3 FMO 100 hPa / JAN-DEC 1997



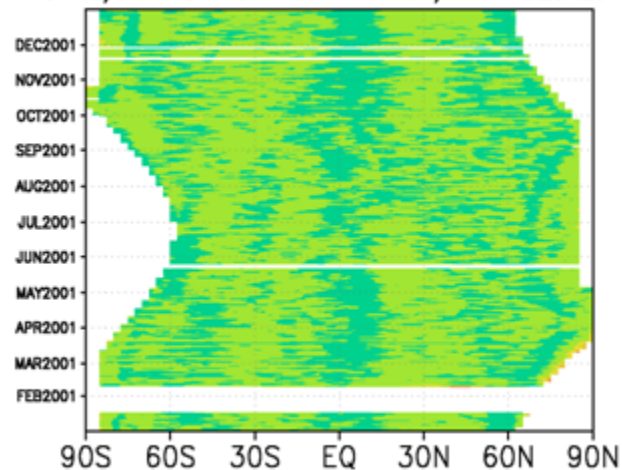
GOME/NNORSY v3 FMO 100 hPa / JAN-DEC 1999



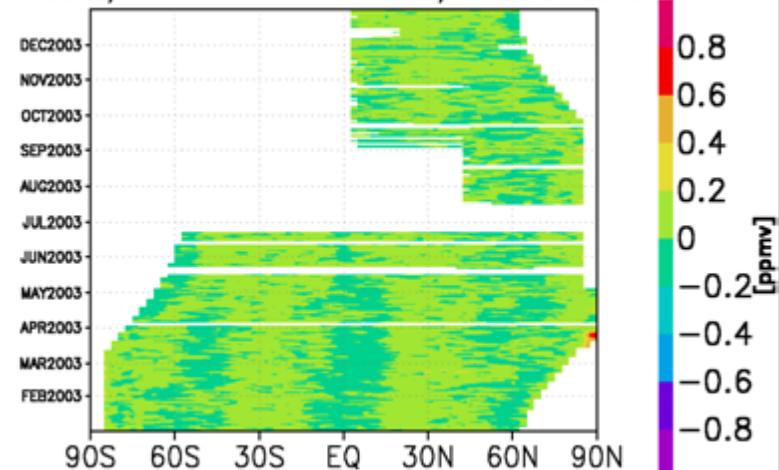
GOME/NNORSY v3 FMO 100 hPa / JAN-DEC 2000



GOME/NNORSY v3 FMO 100 hPa / JAN-DEC 2001



GOME/NNORSY v3 FMO 100 hPa / JAN-DEC 2003



NNORSY-GOME Application: Ozone Reanalysis for Climate Model Evaluation (1/2)

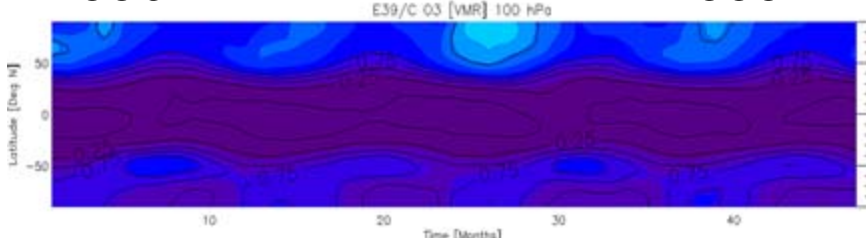
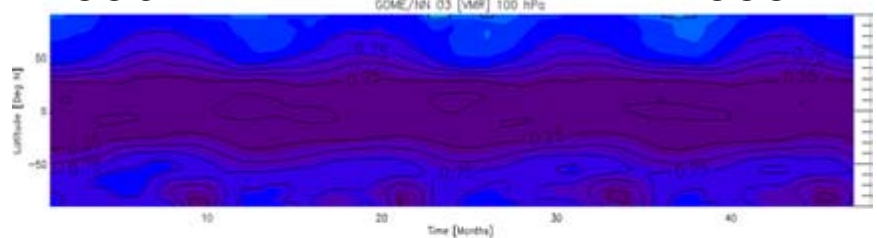
GOME/NNORSY reanalysis vs ECHAM E39/C

1996

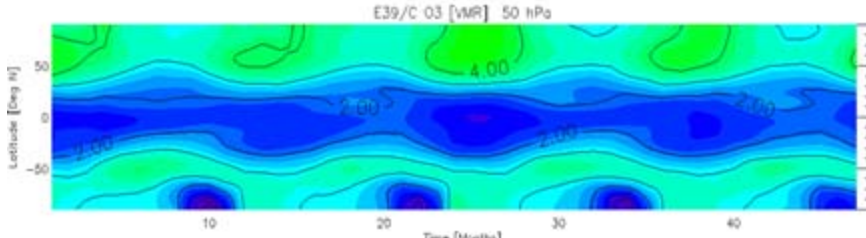
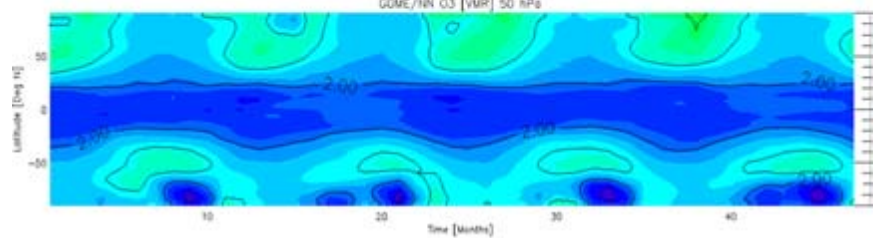
1999

1996

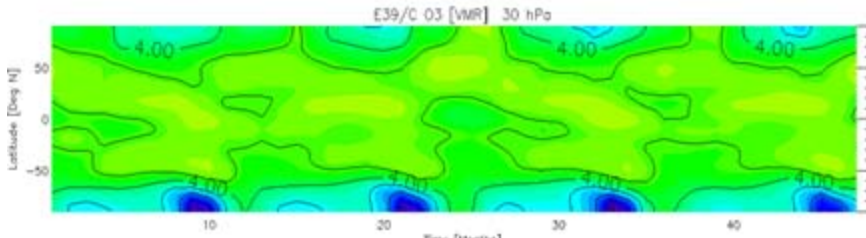
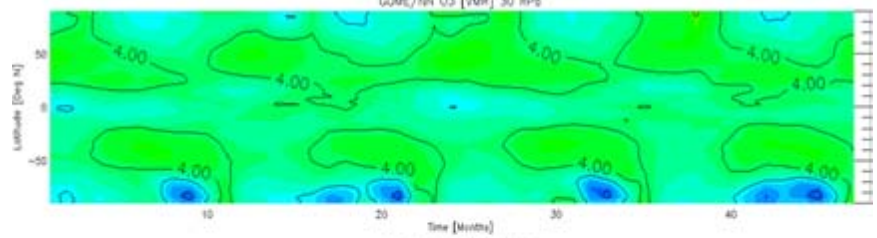
1999



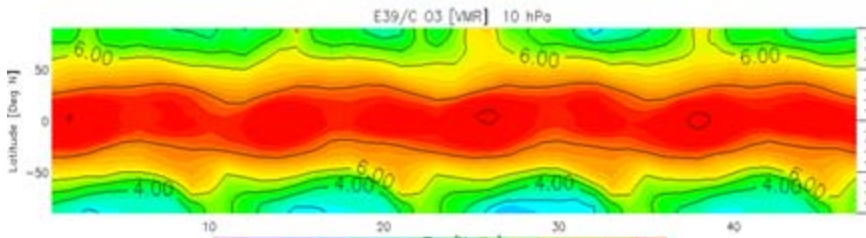
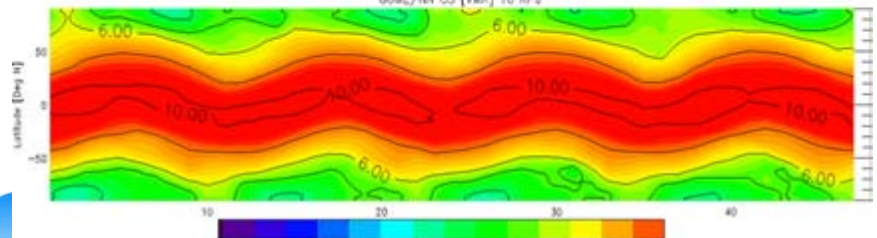
100 hPa



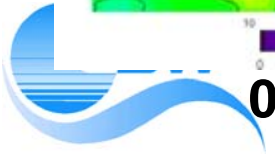
50 hPa



30 hPa



10 hPa

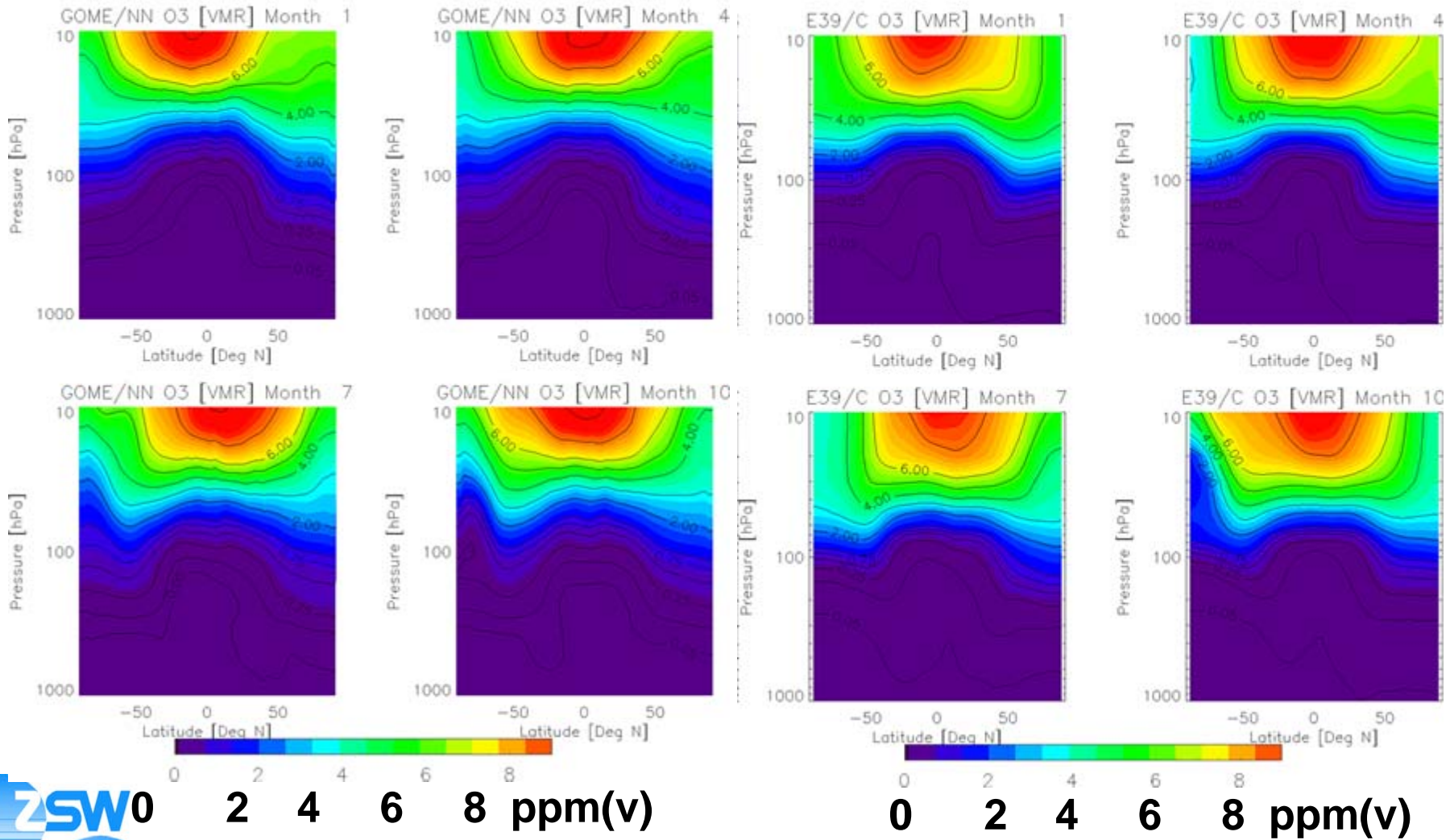


NNORSY-GOME Application: Ozone Reanalysis for Climate Model Evaluation (2/2)

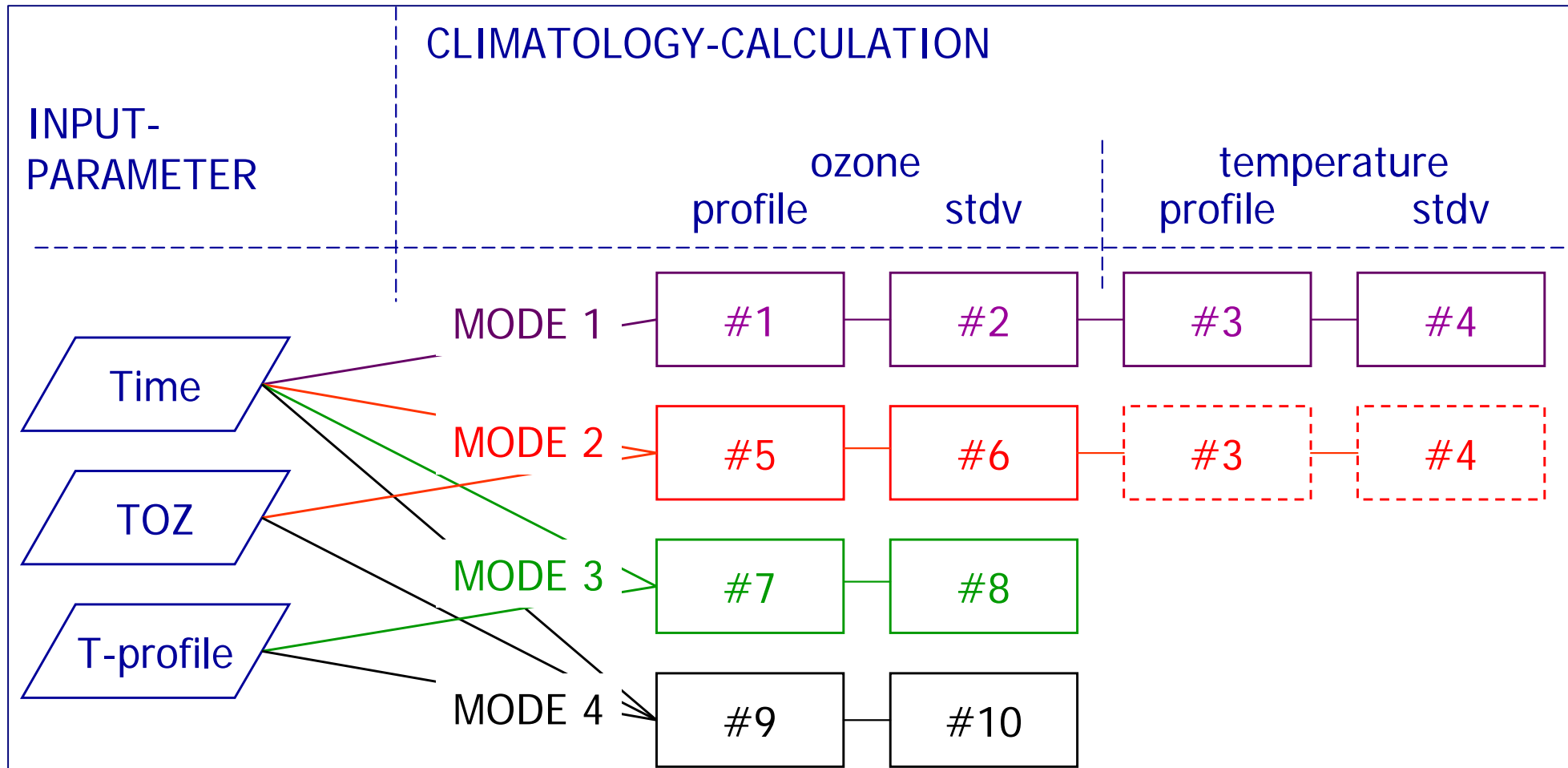
NNORSY-GOME reanalysis vs ECHAM E39/C

GOME O3 VMR zonal mean for selected months 1999

E39/C O3 VMR zonal mean for selected months 1999



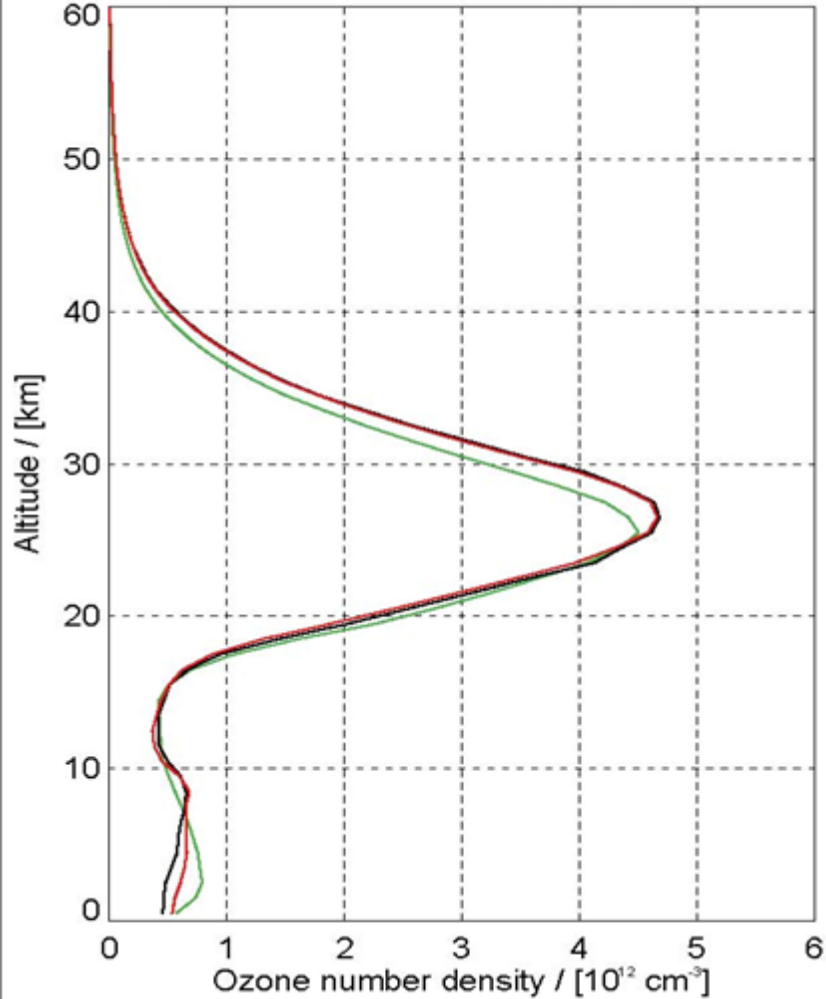
NNORSY Dynamic Ozone Profile Climatology



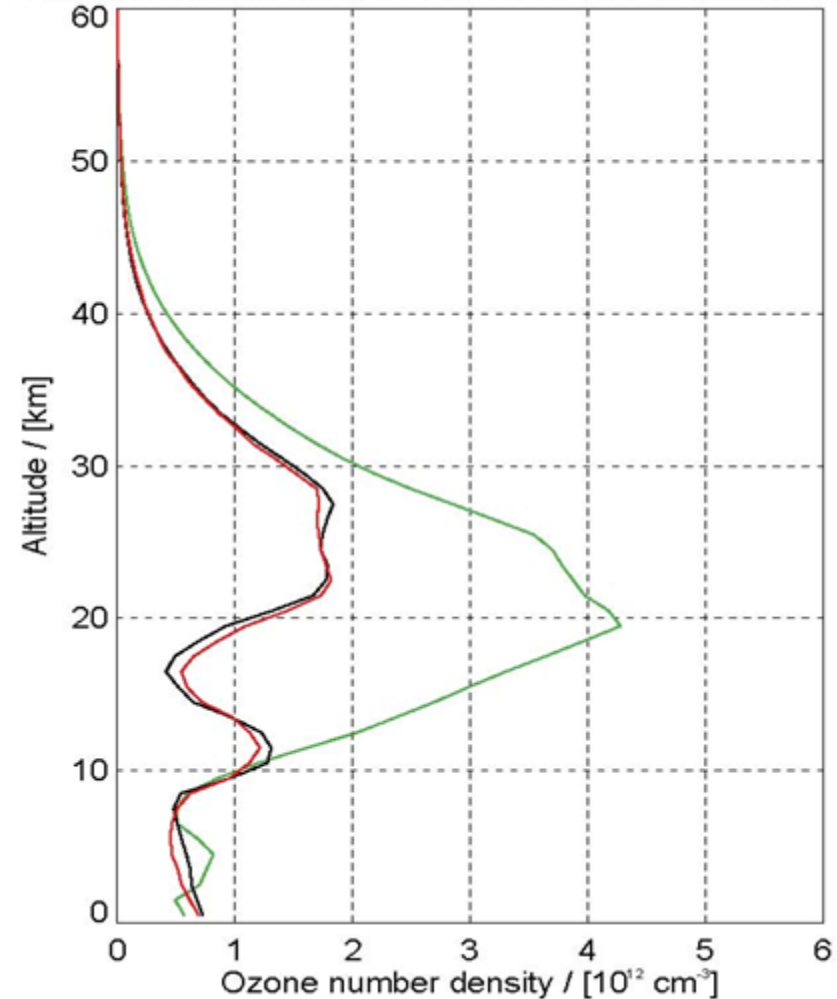
NNORSY Ozone Profile Climatology

Example for single profiles: Tropics, Antarctica

1101 Date: 14/11/98-2146 Lat:-14.62 Lon: 189.5 DU: 272.



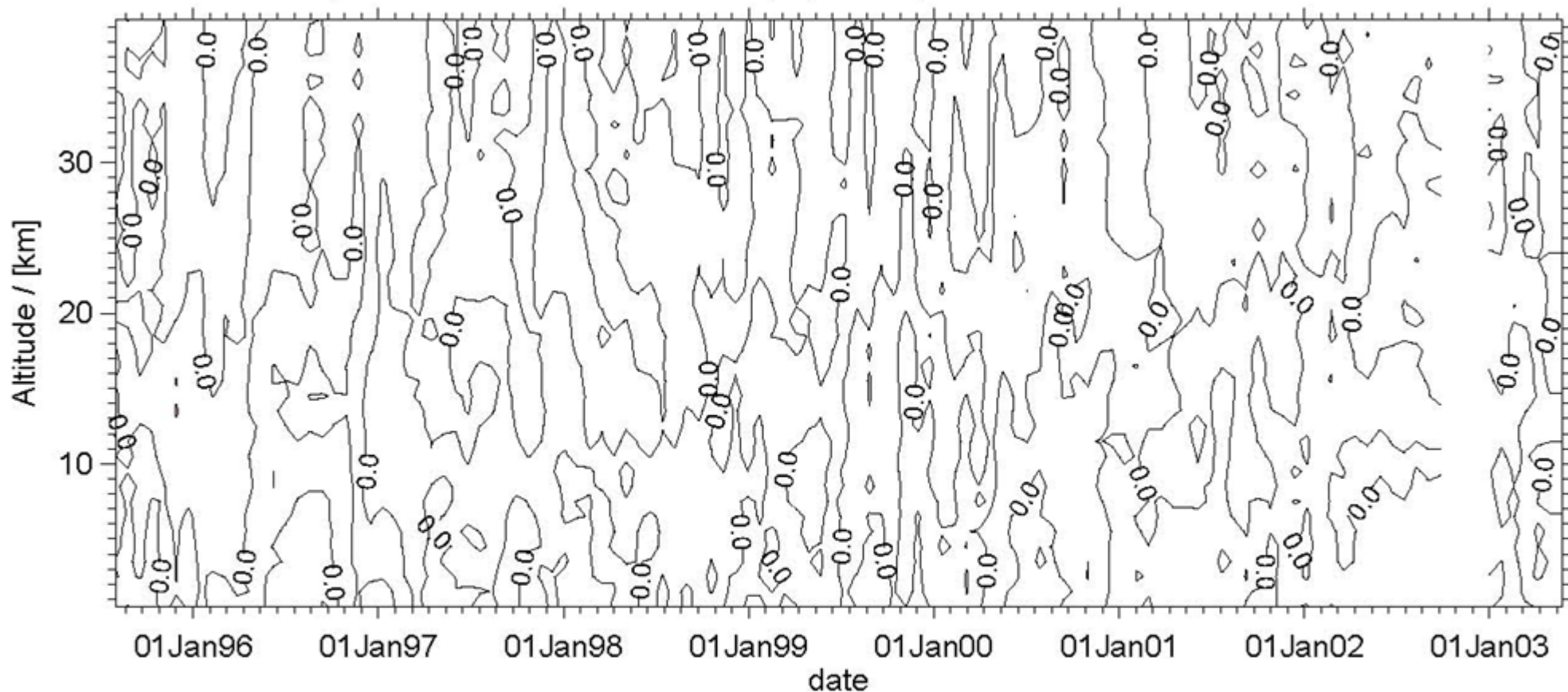
1948 Date: 18/09/96-0551 Lat:-68.88 Lon: 38.6 DU: 149.



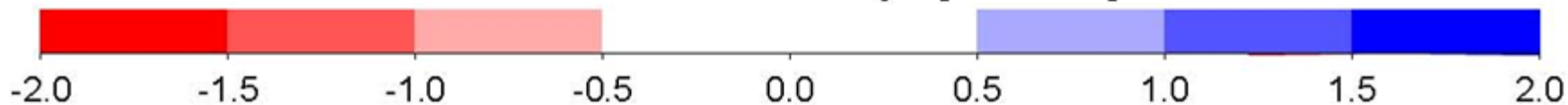
NNORSY Climatology vs. Retrieval

#099 Hohenpeissenberg/ Germany (lat 47.80 / lon 11.02)

DIFFERENCE (RETRIEVAL - CLIMATOLOGY) (TLLTO)

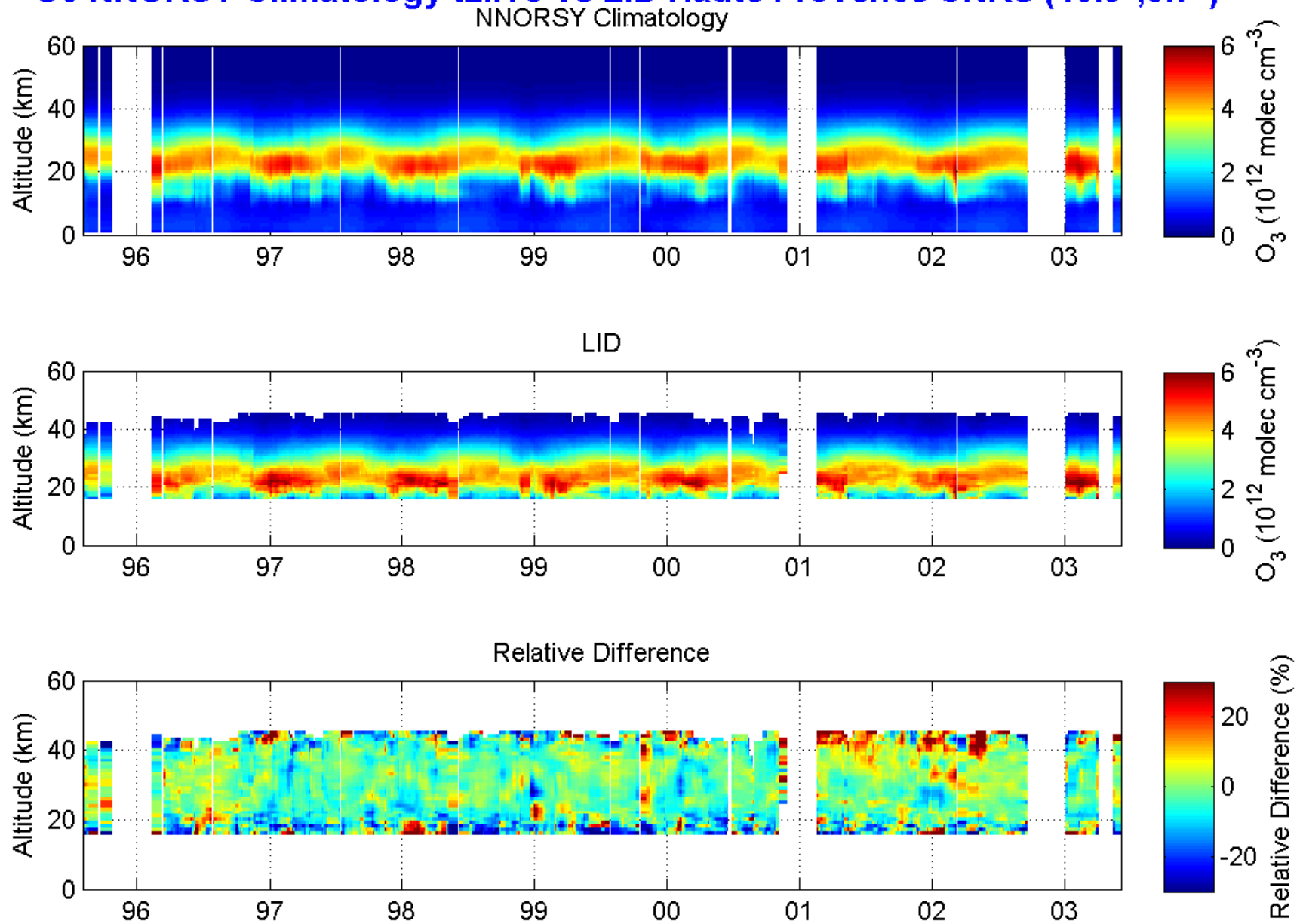


Ozone number density / [10^{12} cm^{-3}]



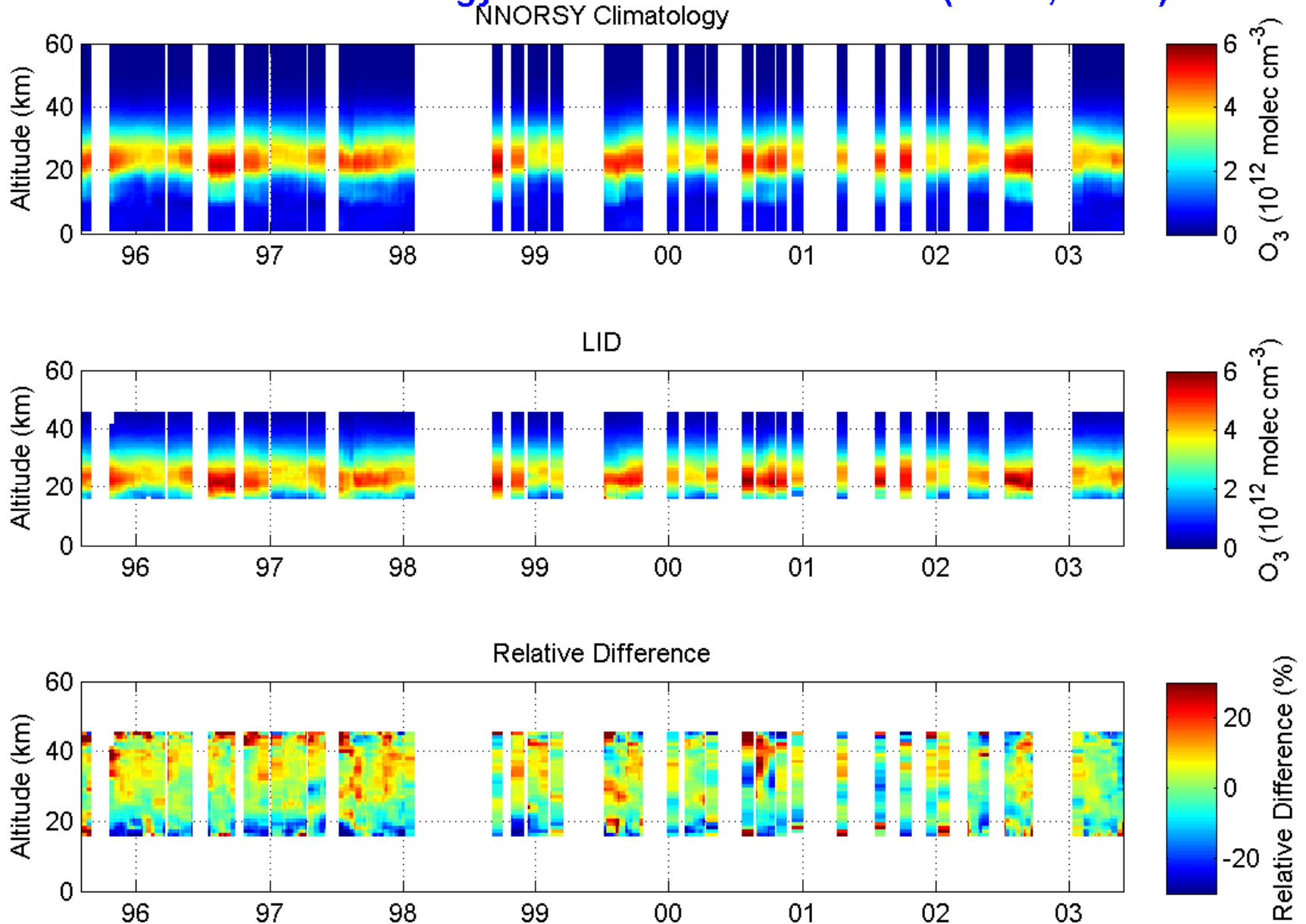
NNORSY Climatology vs. Ground Based (1/2)

O₃ NNORSY Climatology t2IITo vs LID Haute Provence CNRS (43.9°, 5.7°)



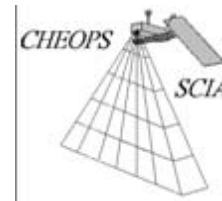
NNORSY Climatology vs. Ground Based (2/2)

O₃ NNORSY Climatology t2IITo vs LID Lauder RIVM (-45.0°, 169.7°)



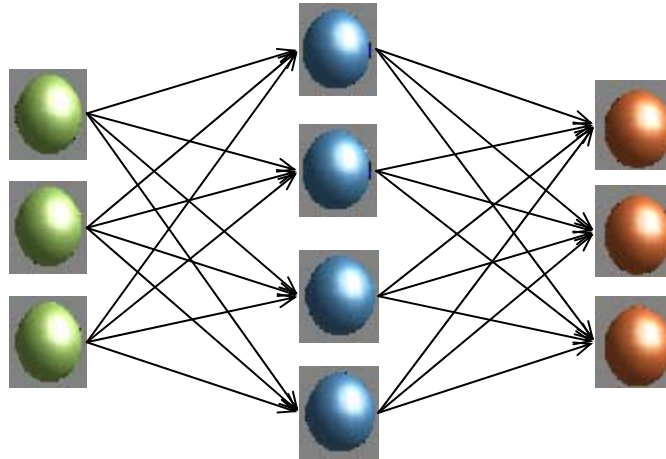
NNORSY-GOME: Summary

- ▶ Almost 10 year global NNORSY-GOME ozone profile data set
- ▶ Geophysical validation and comparison with sonde/lidar/satellite
- ▶ Validation and global consistency check with data assimilation
- ▶ Various tropospheric ozone column products
- ▶ NNORSY compensate for instrument degradation
- ▶ New dynamic ozone profile climatology
- ▶ All products and data are available: <http://nnorsy.zsw-bw.de>
- ▶ Extending GOME ozone profile data record with SCIAMACHY
 - ▶ NNORSY application to SCIAMACHY nadir



NNORSY-GOME: The End

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