Towards a NNORSY Synergistic GOME-2/IASI Ozone Profile ECV

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NNORSY-METOP

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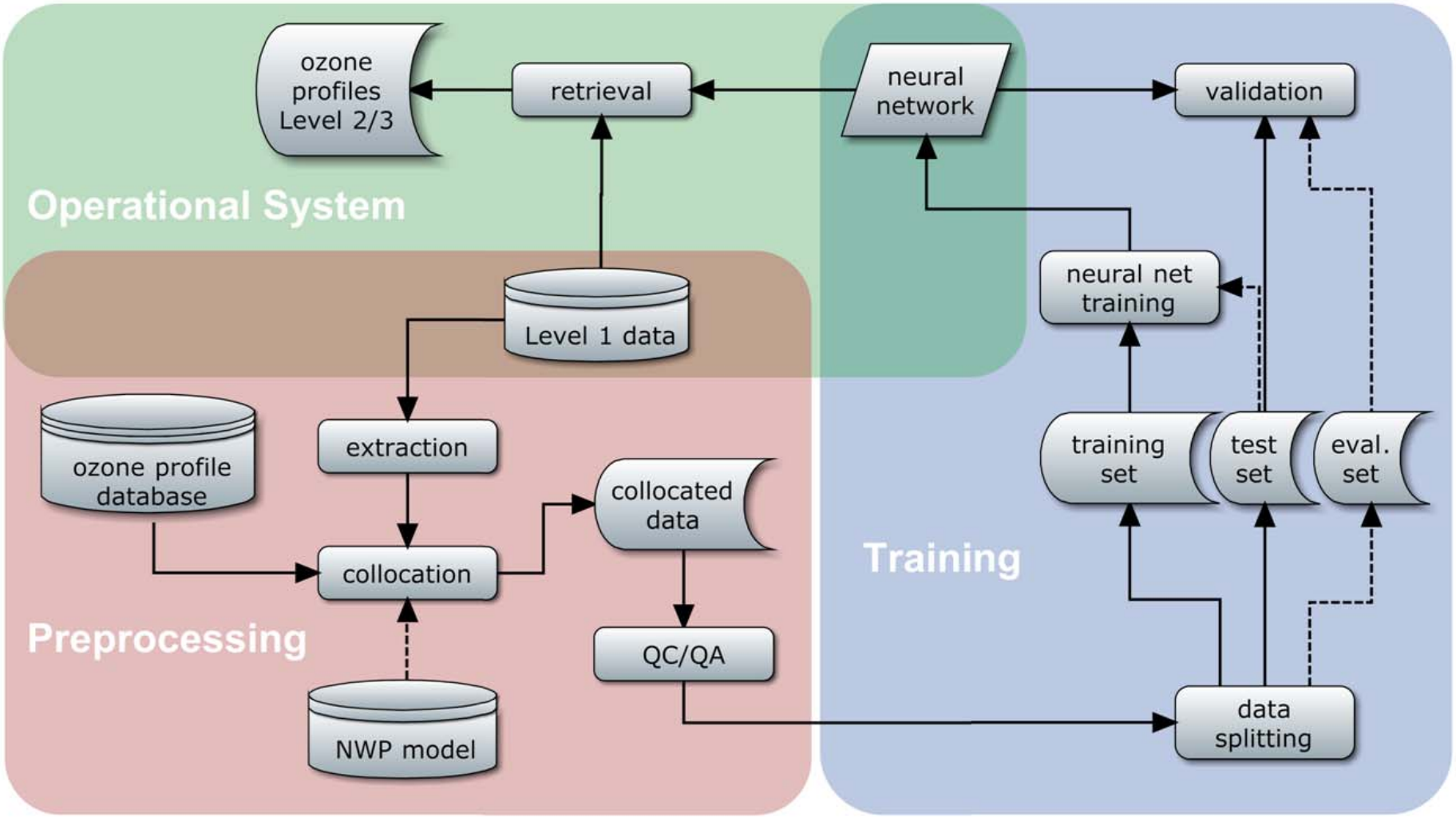
Outline

1. NNORSY Overview
2. Co-registration of METOP data and clouds
3. NNORSY-METOP Version 3
4. Learn-O-Matic: NNORSY-METOP Version 4 and channel selection
5. Conclusions

NNORSY-METOP Processing Overview



Co-registration and Clouds on GOME-2/IASI

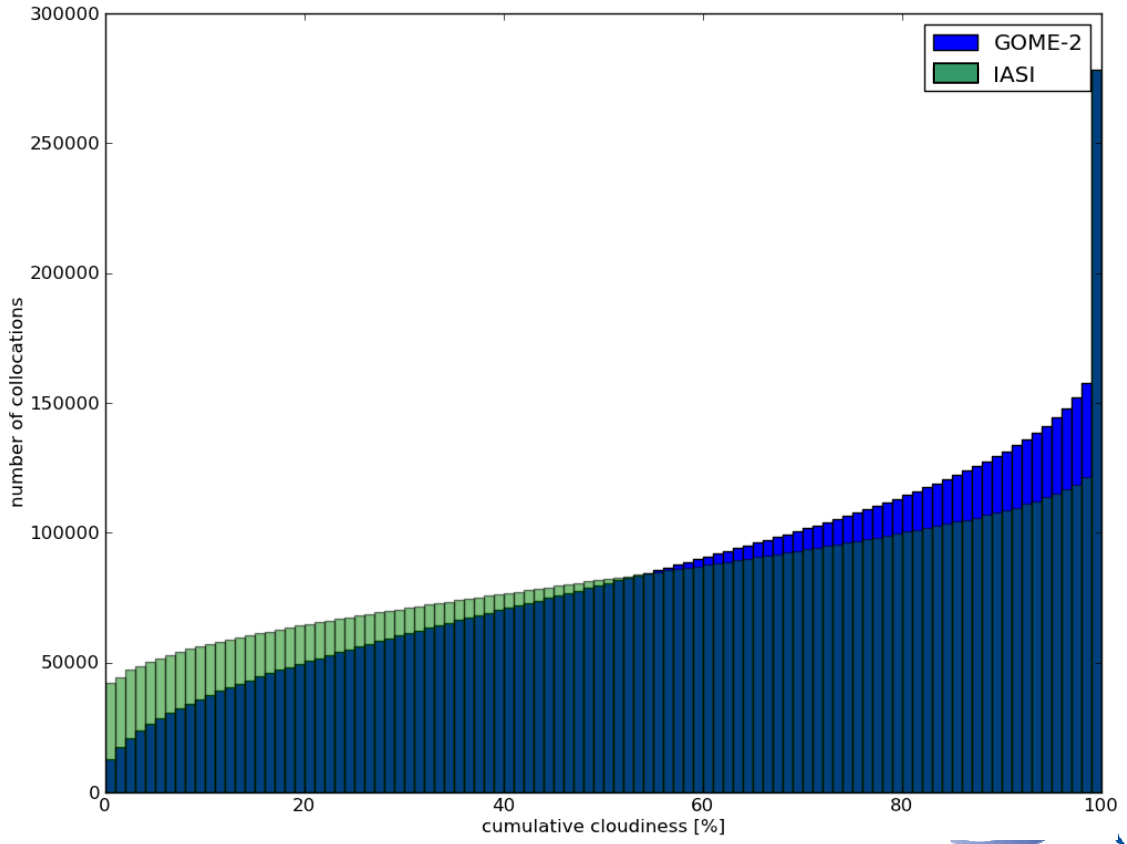
GOME-2 FOV used as base grid for retrieval

- → Collocation GOME-2 & IASI
- → Collocation GOME-2 & AVHRR
- → Collocation IASI & AVHRR

Collocations with ozone profile measurements

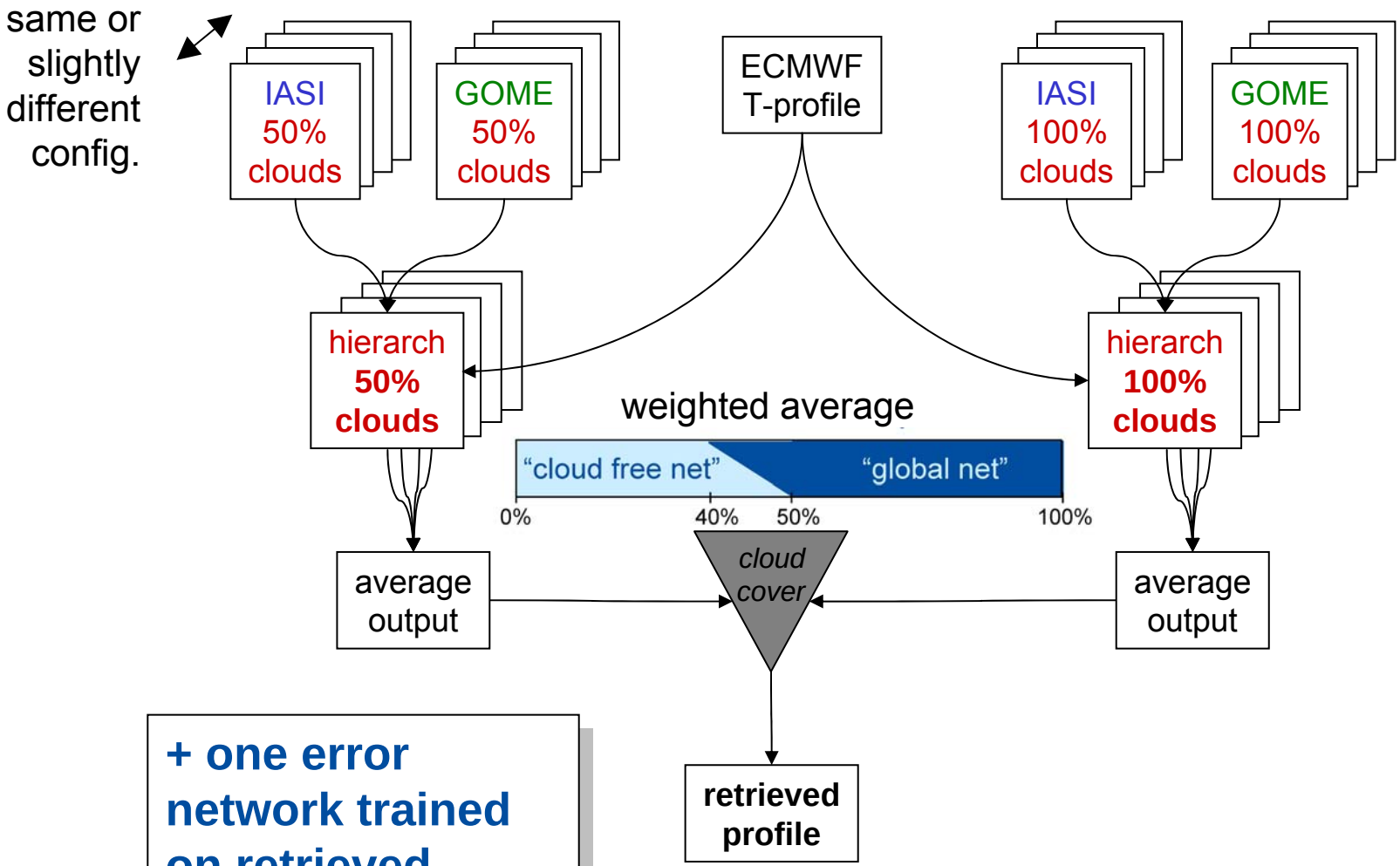
~ 90 000 each for

- → ozone sondes
- → ACE-FTS
- → AURA-MLS



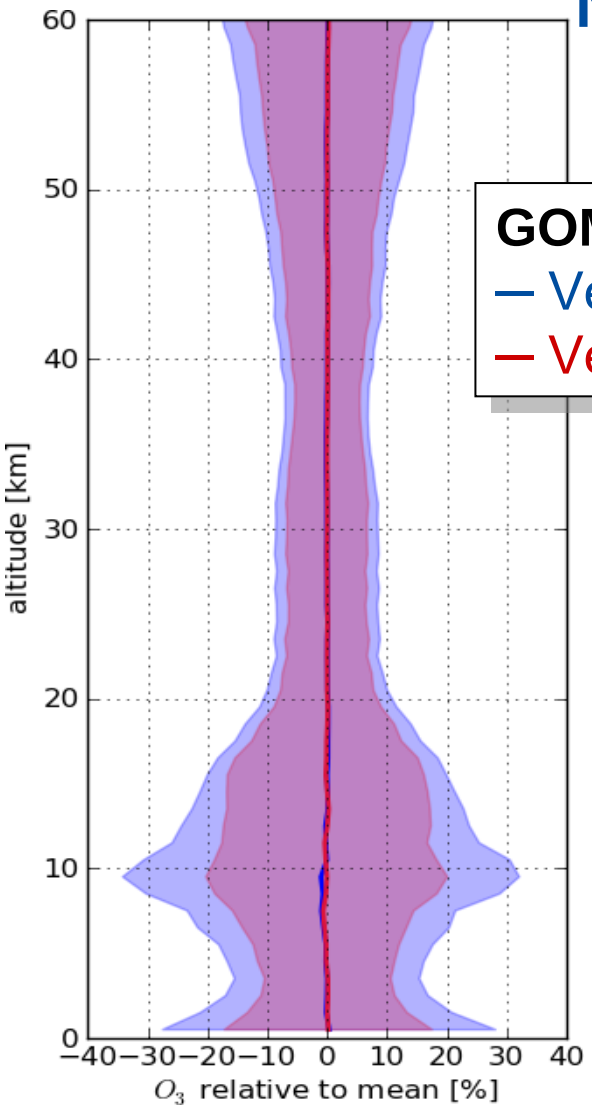
Operational Setup for NNORSY-METOP Version 3

Combining Hierarchical Networks and Averaging



+ one error network trained on retrieved profile errors

Improvements of NNORSY V3 compared to V2
NNORSY Methodology



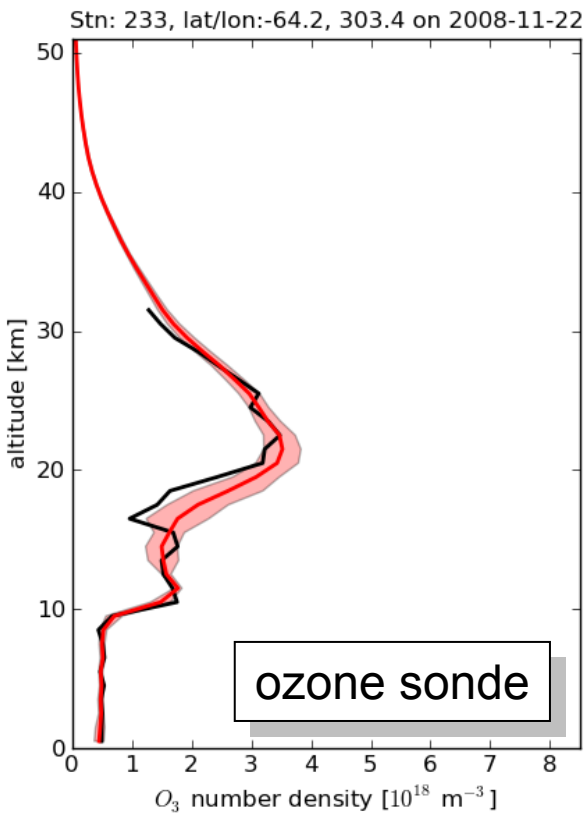
GOME2 + IASI + T: on test data set

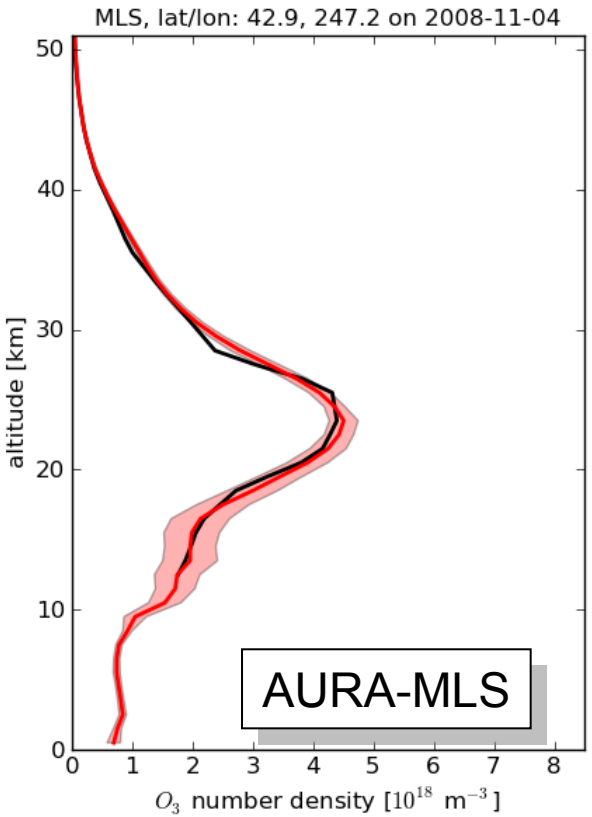
– Version 2: simple combination of neural networks

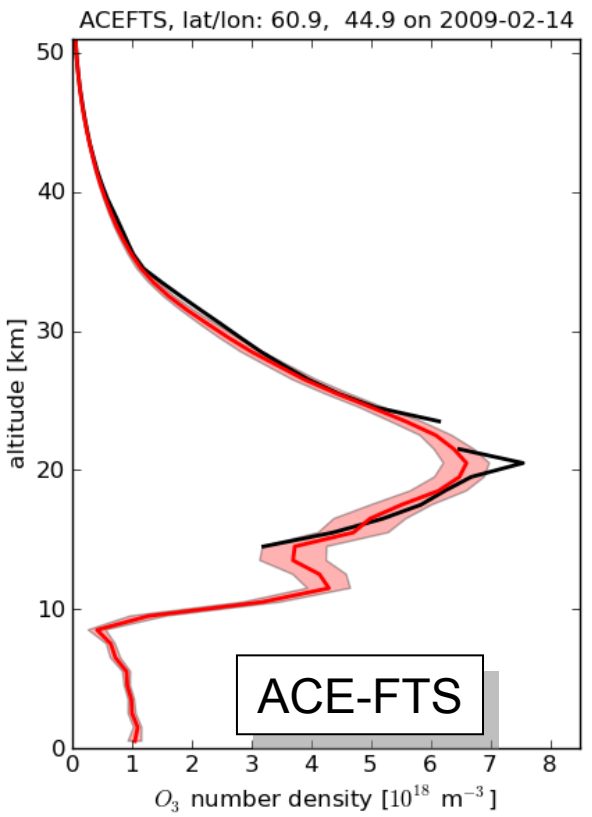
– Version 3: hierarch + clould fraction + averaging

- V2 scheme's RMSE was higher by a factor of **1.2** to **1.5**
- Strongest RMSE reductions in the most critical regions (UTLS, troposphere)

Retrieval Error Assignment Examples

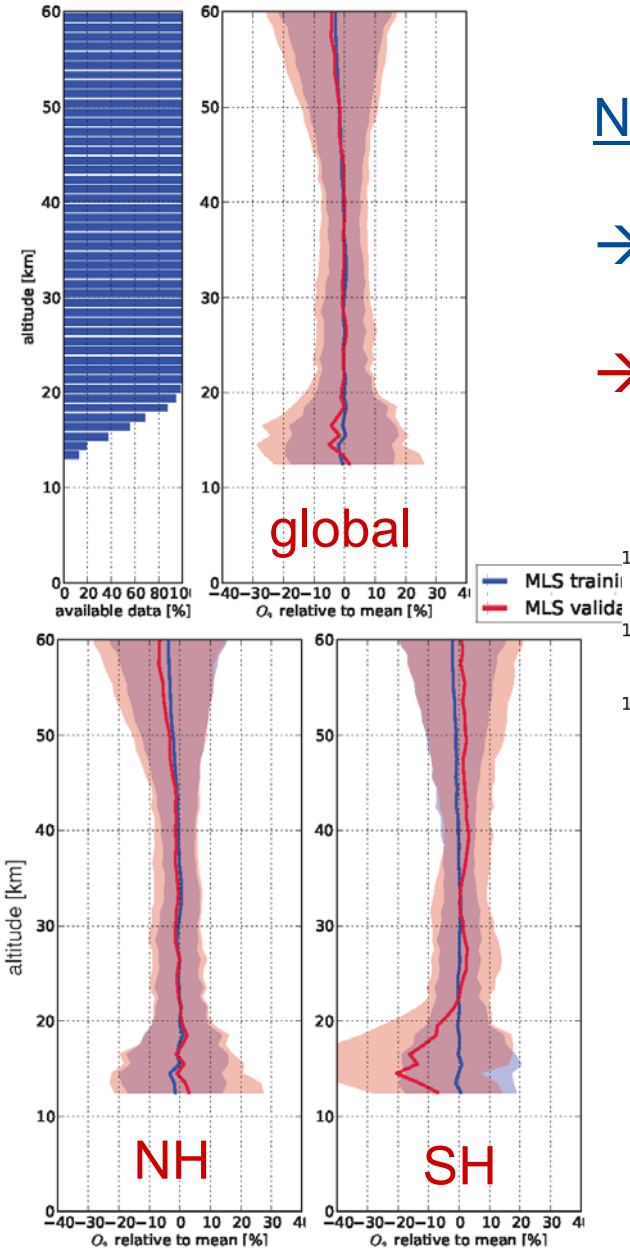






→ Multiplying error output by factor ~1.2 yields approximate standard deviation

Difference between Training and Validation Data Set

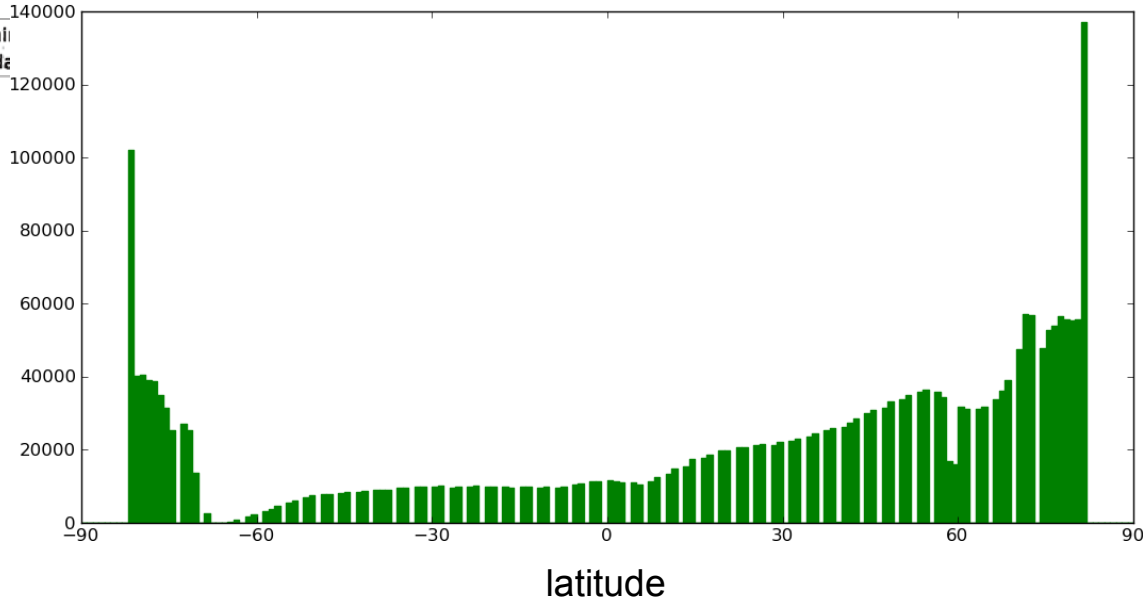


NNORSY-METOP V3:

→MLS training data: ~35 Td.

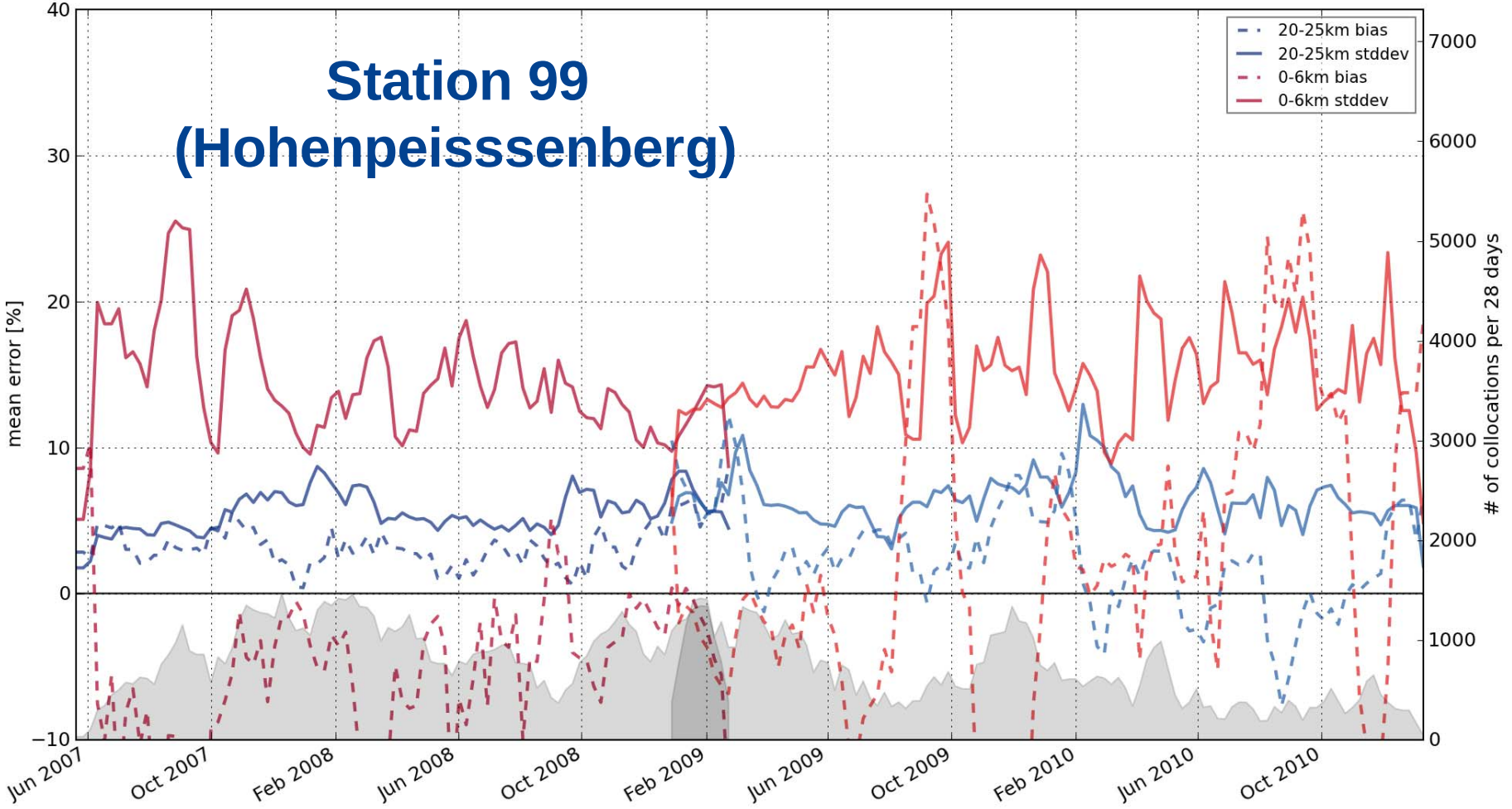
→ MLS validation data: 2.9 Million

Latitudinal distribution of MLS validation data



NNORSY-METOP V3: Long Term Performance

Time series with 4 week moving average

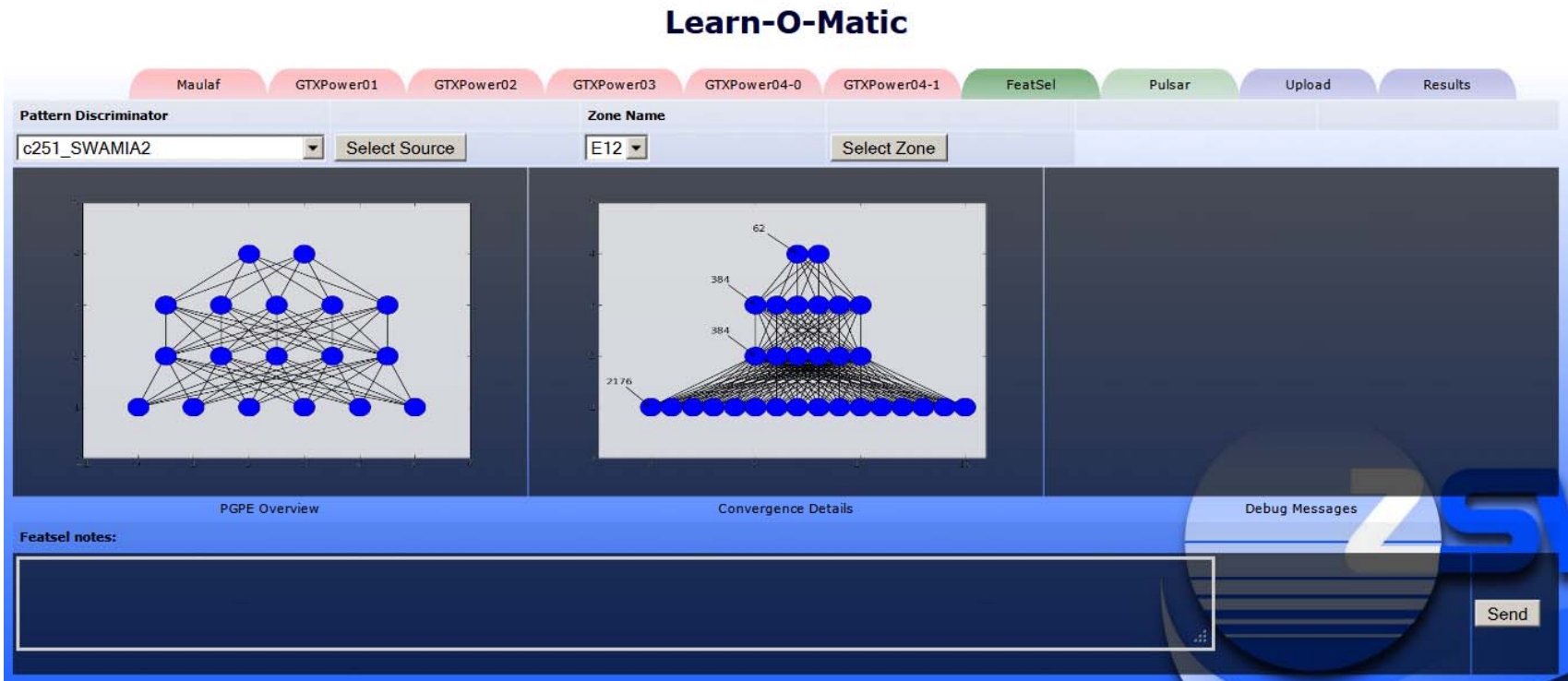


Learn-O-Matic

Machine Learning and Optimization Tool including Deep Learning and Automatic Feature Selection for NNORSY*

➔ Multi-tier **GPU** based machine learning system with user friendly web-frontend

➔ ~ 250 time faster compared to high performance **CPU**



*) Sehnke et al. 2012, Learn-O-Matic - Fully automated Machine Learning, ZSW internal Tech. Note

Learn-O-Matic: Implemented Features

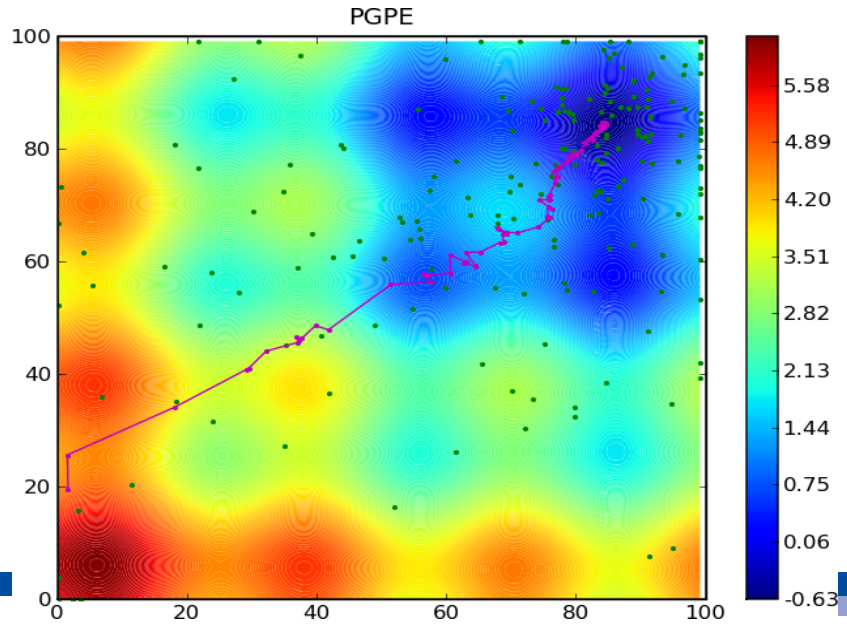
➔ Deep neural networks

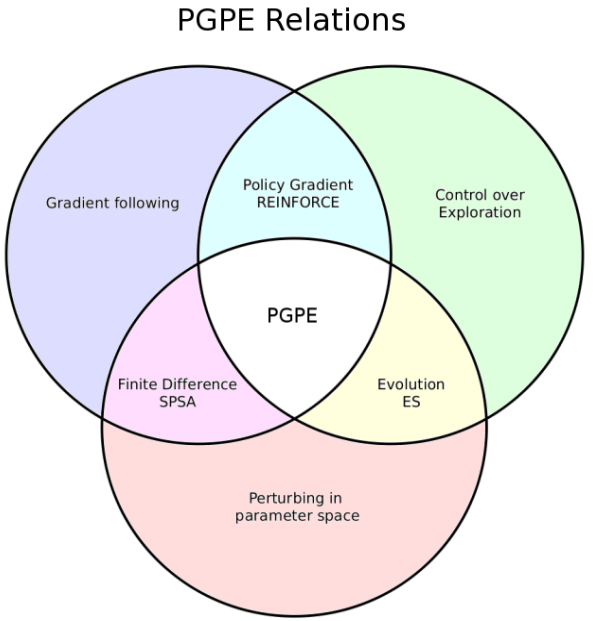
➔ Reduced Boltzmann machines (Hinton et al. 2006)

➔ Support vector machines

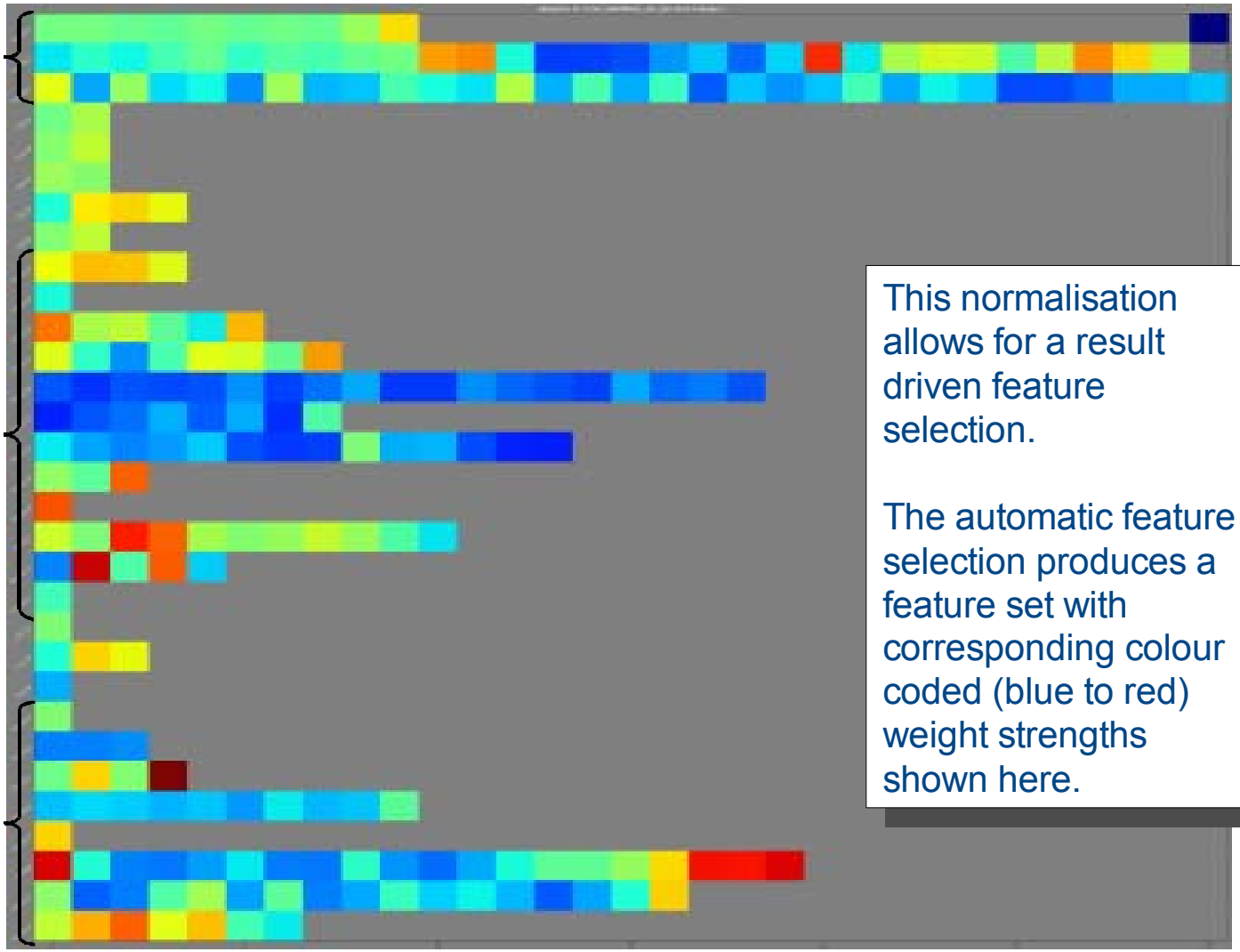
➔ Gaussian Processes (sparse approximation/regression scheme)

➔ Policy Gradient with Parameter-based Exploration (PGPE): reinforcement learning scheme for all kind of optimization tasks (Sehnke et al. 2010, 2011)





Learn-O-Matic: GOME-2/IASI Channel Selection

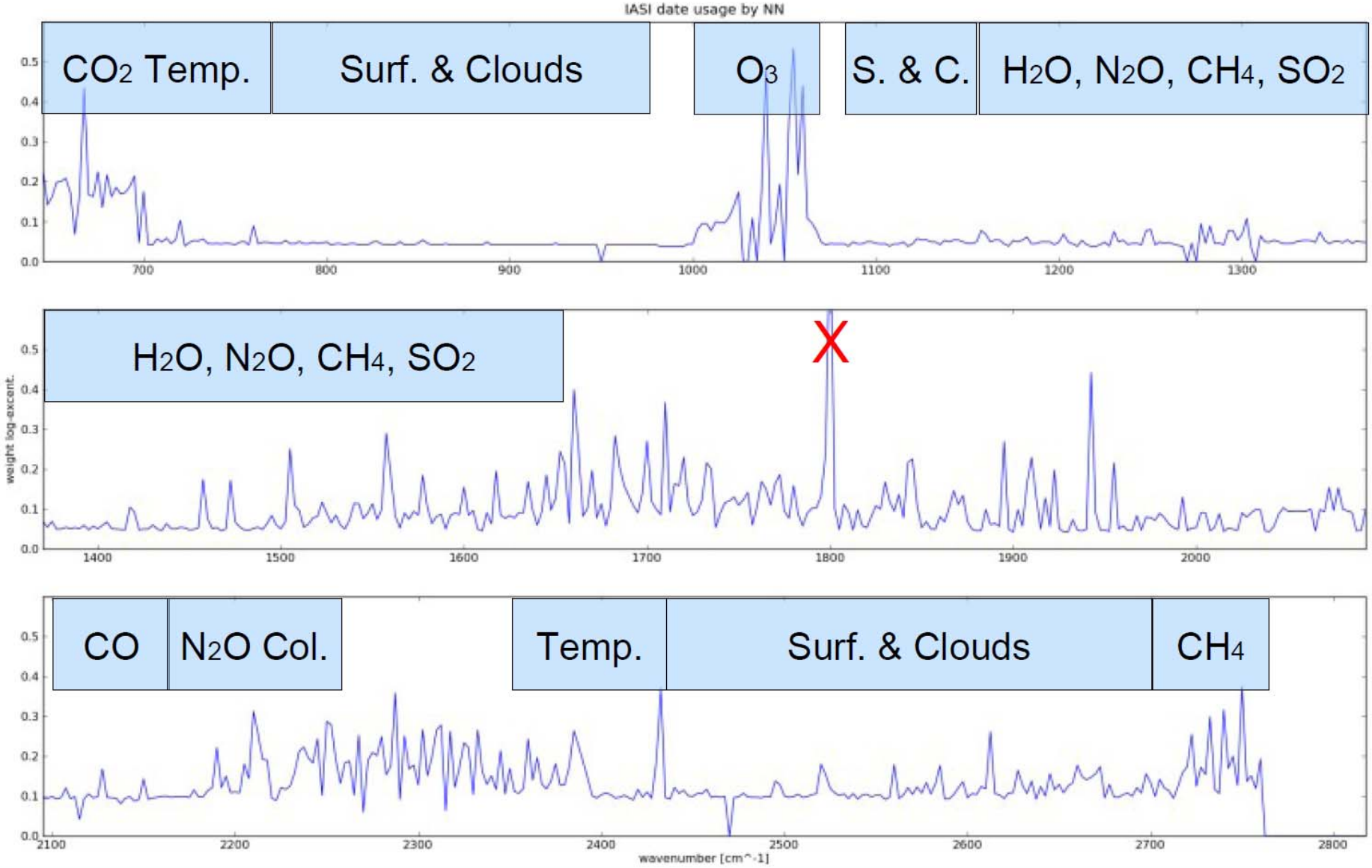


This normalisation allows for a result driven feature selection.

The automatic feature selection produces a feature set with corresponding colour coded (blue to red) weight strengths shown here.

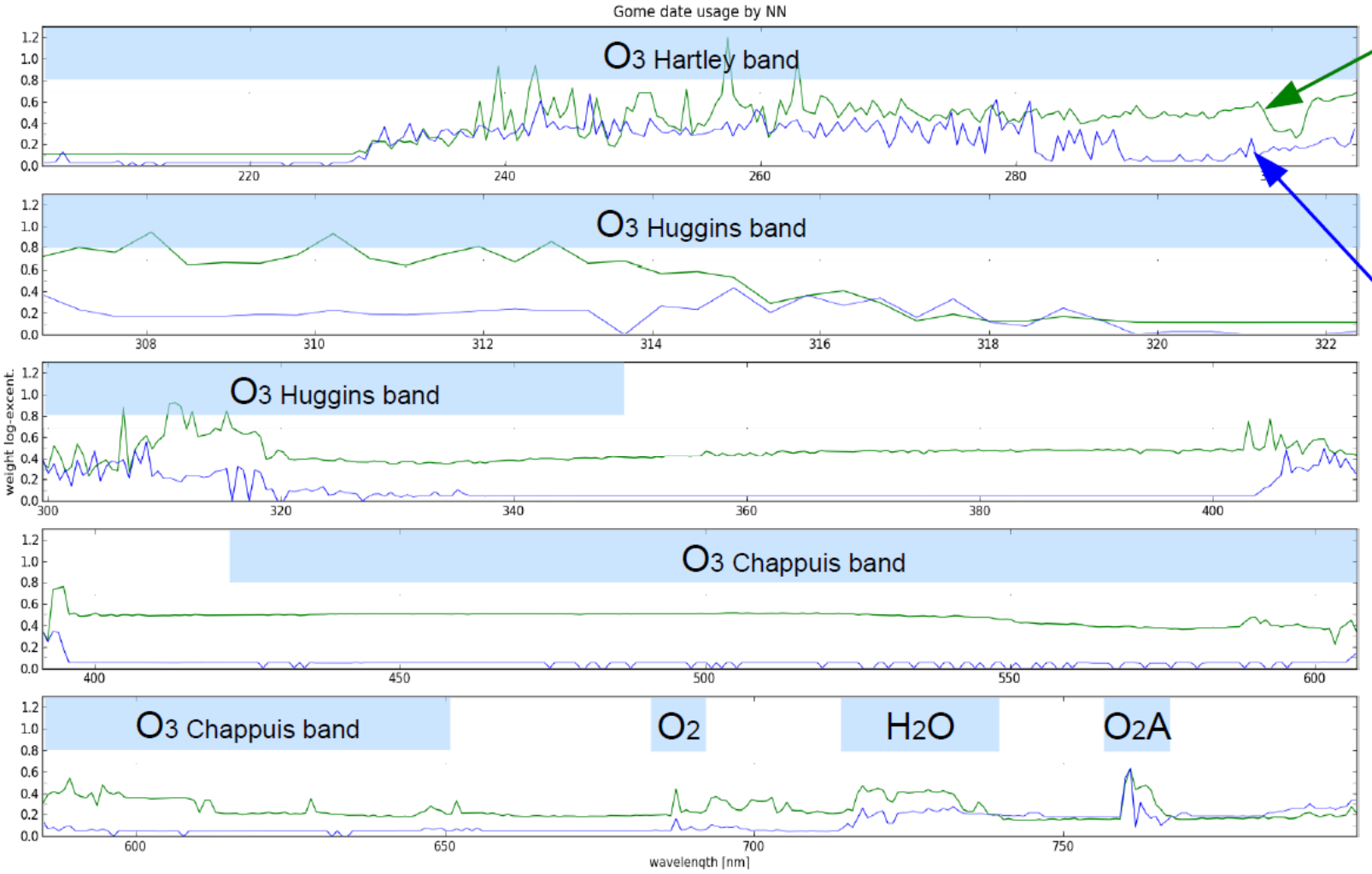
Learn-O-Matic: IASI Channel Selection

Joined GOME-2 & IASI retrieval



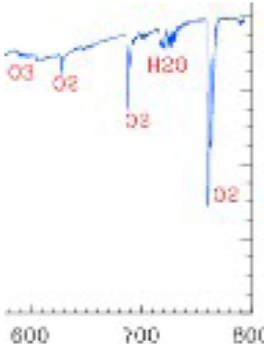
Learn-O-Matic: GOME-2 Channel Selection

Comparison Joined GOME-2 & IASI and GOME-2 only

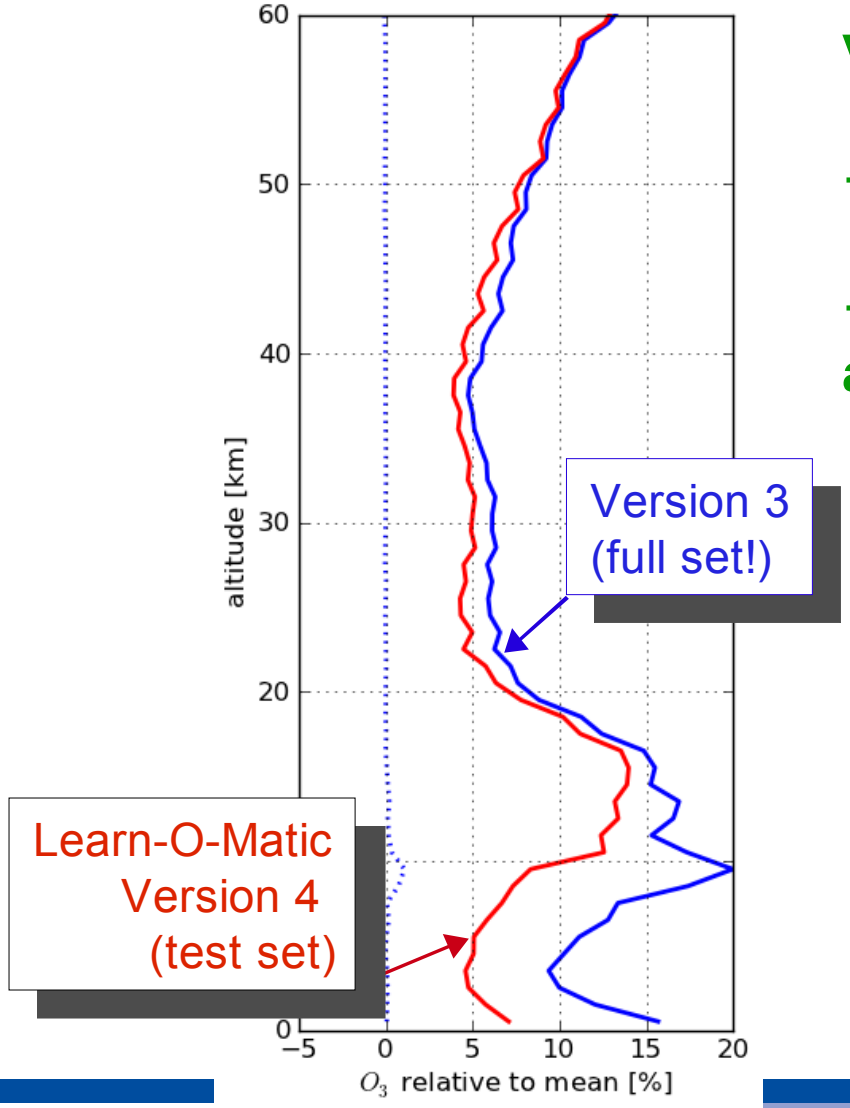


GOME-2 only

GOME-2 & IASI



NNORSY-METOP V3/V4 Comparison



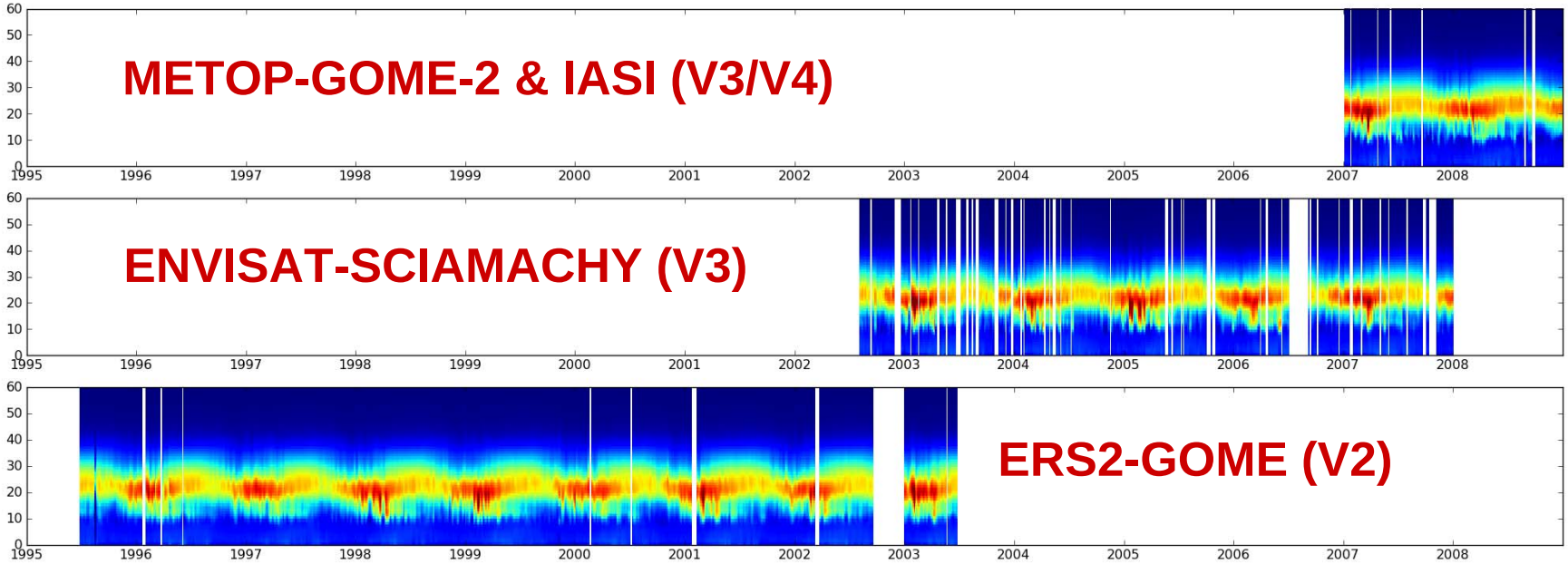
Version 3 vs. 4

→Version 3 hierarchical and averaging

→ Version 4 single deep NN with automatic channel selection

NNORSY Nadir Satellite Instruments Already Processed

Example NNORSY timeseries for Hohenpeissenberg



➔ NNORSY-METOP: two different ozone profile data sets

- ➢ GOME-2 spectra only
- ➢ Synergistic retrieval using GOME-2 and IASI spectra

Conclusion

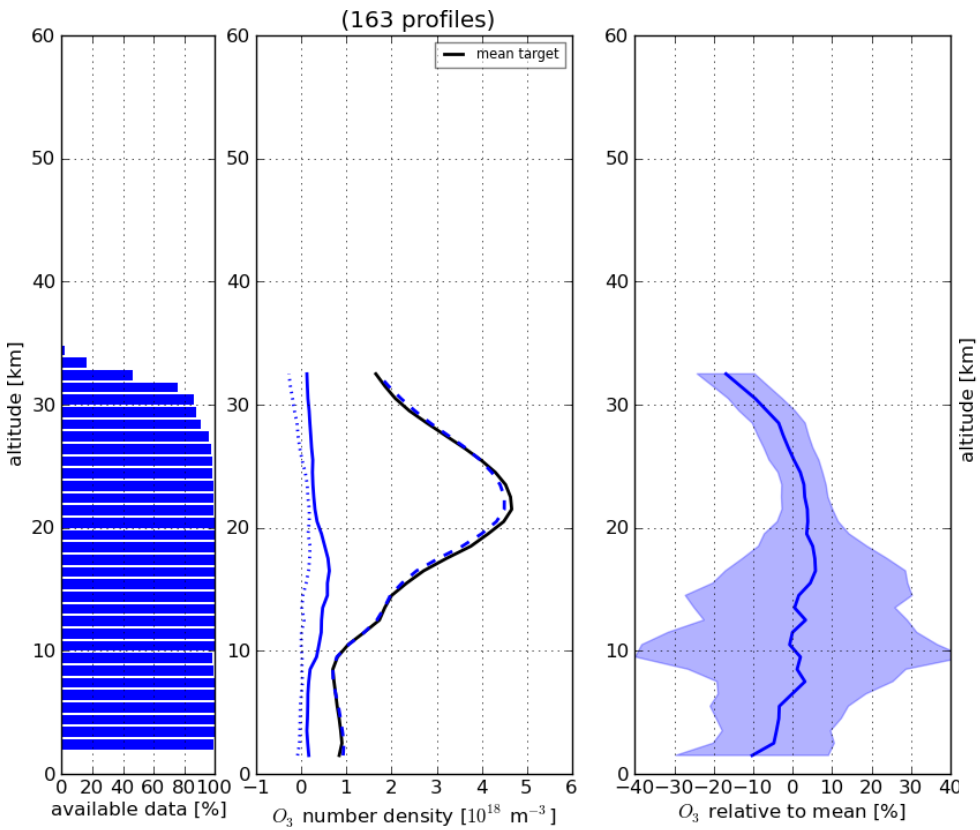
1. NNORSY-METOP Version 3 with hierarchical approach
   - First full joined GOME-2/IASI retrieval
   - IASI improves ozone profile retrieval in UTLS and troposphere
2. Learn-O-Matic
   - Fully automated machine learning tool with channel selection for GOME-2 and IASI → NNORSY-METOP Version 4
   - Already further improvements for ozone profile retrieval with only one deep neural network → expecting more improvements with averaging
3. NNORSY ozone profiles using ERS2/GOME, SCIAMACHY and GOME-2/IASI → long term ozone profile ECV (July 1995 – present)

Questions and Comments

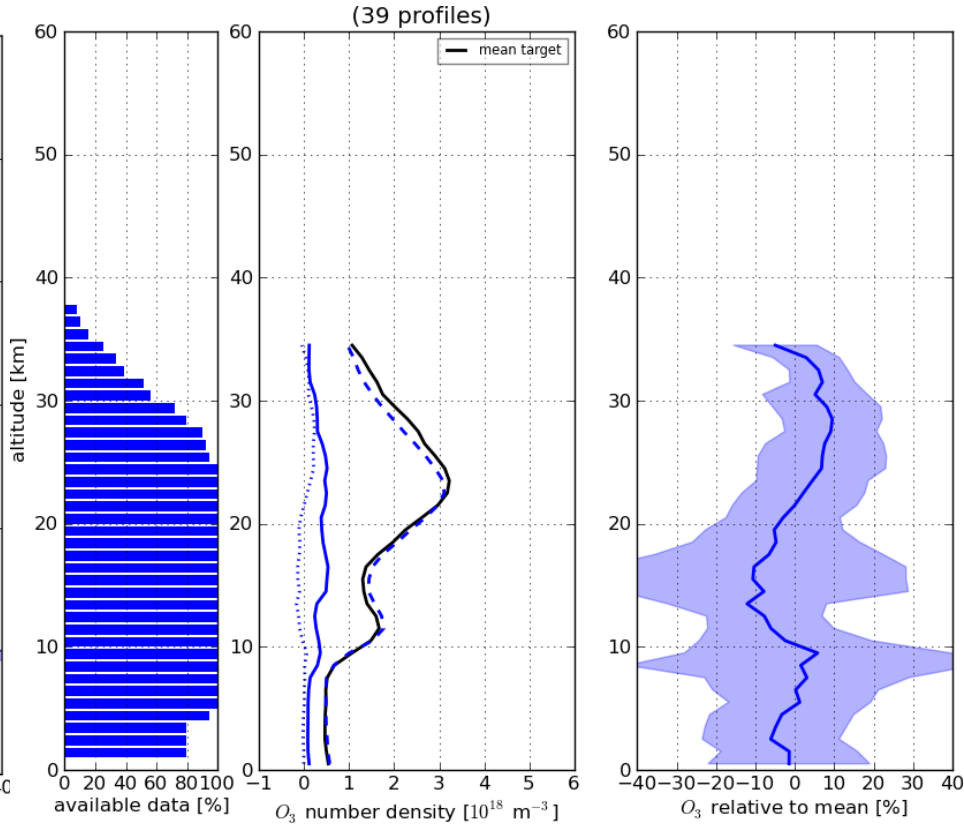
Backup Slides

NNORSY-METOP V3: Validation Single Stations

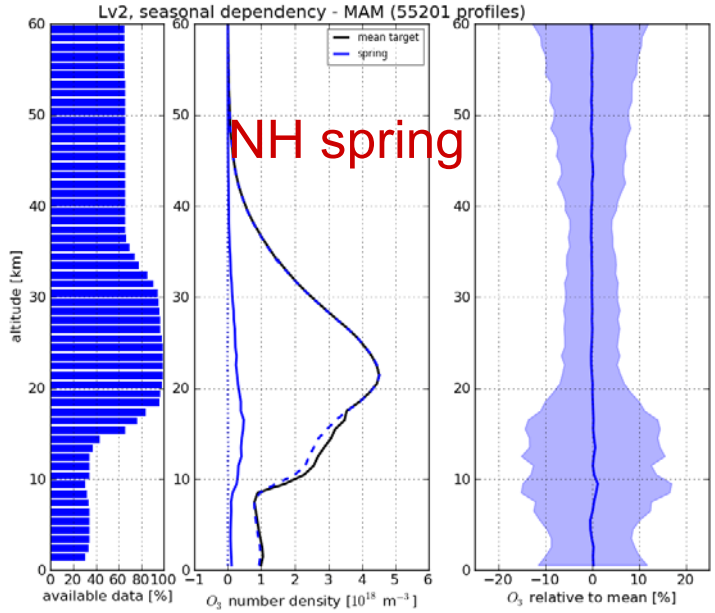
Hohenpeissenberg

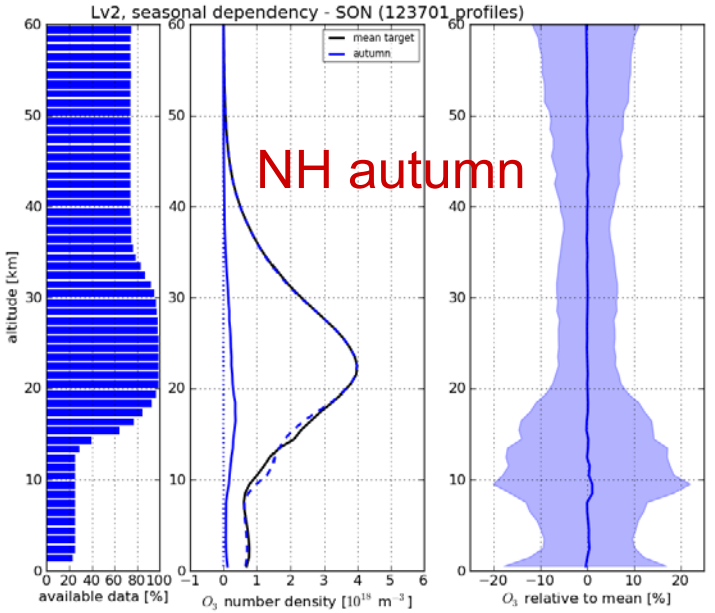


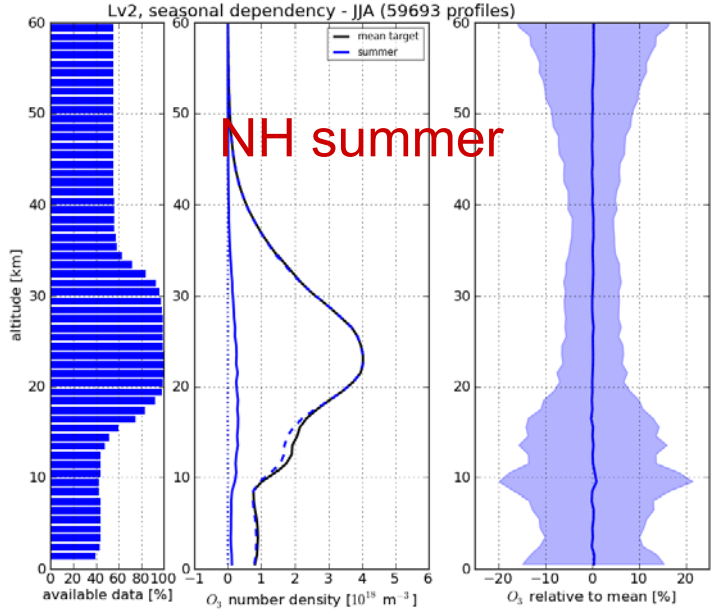
Syowa

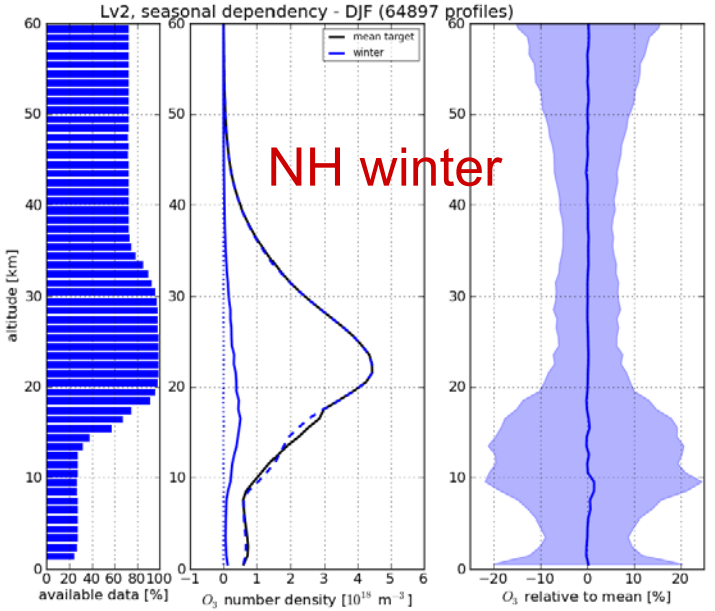


Training Data: Seasonal Dependency



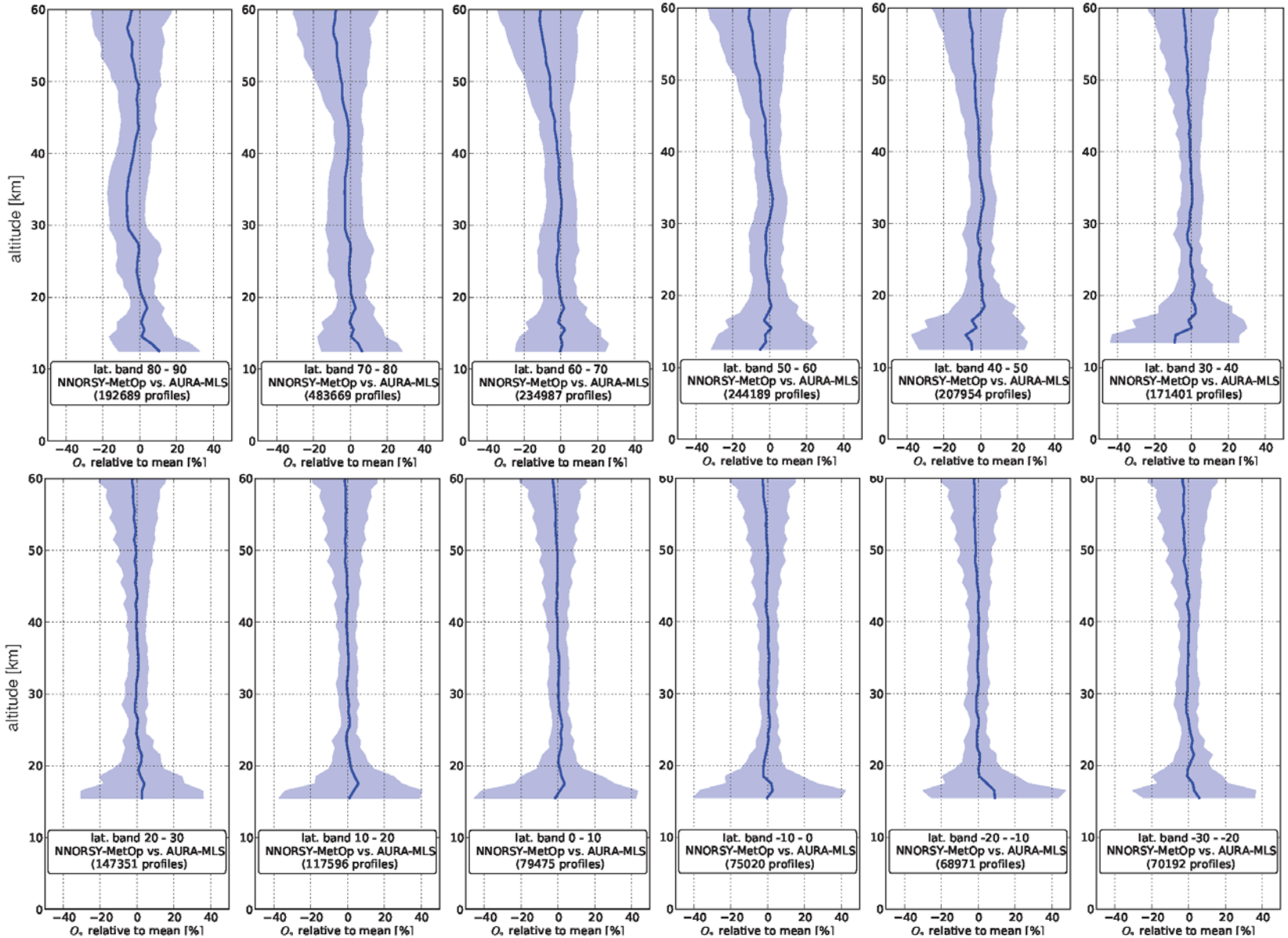






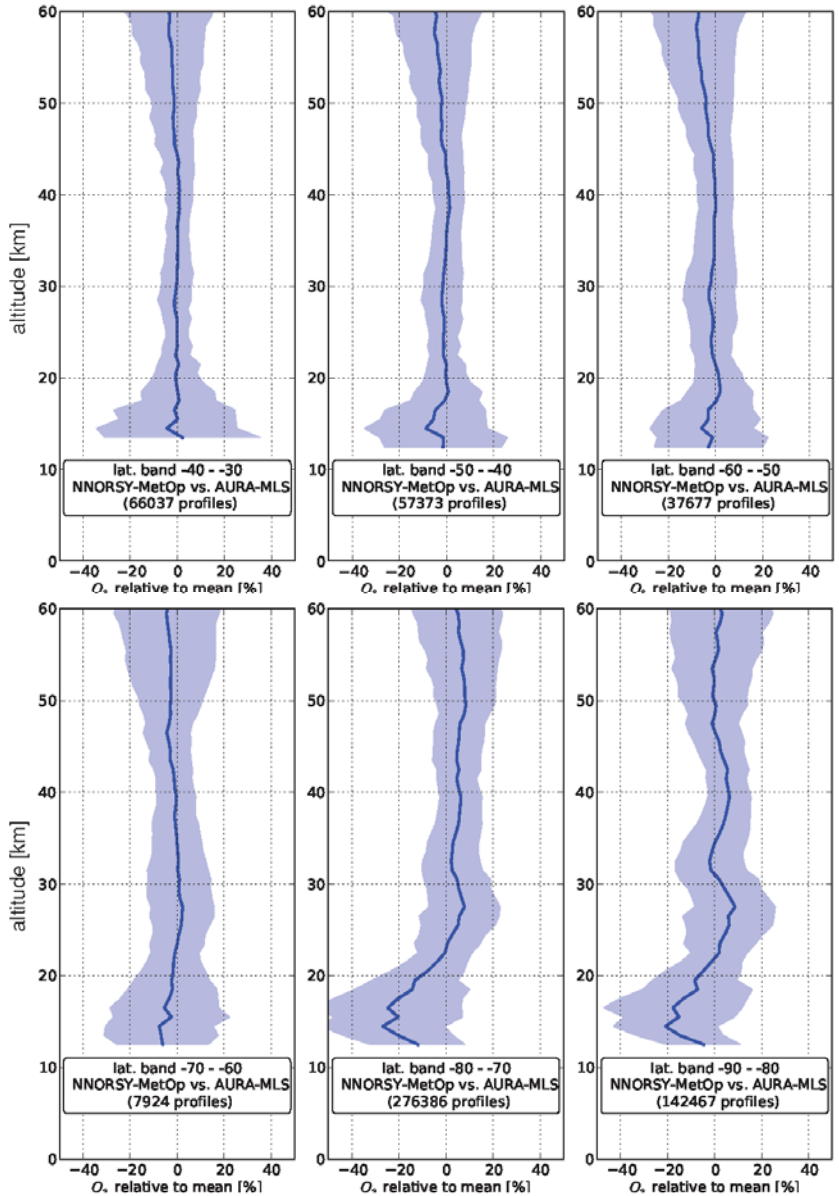
Validation Data: AURA-MLS Latitude Bands

10 degree latitude bands: 90N – 20S



Validation Data: AURA-MLS Latitude Bands

10 degree latitude bands: 30S – 90S



On global scale:

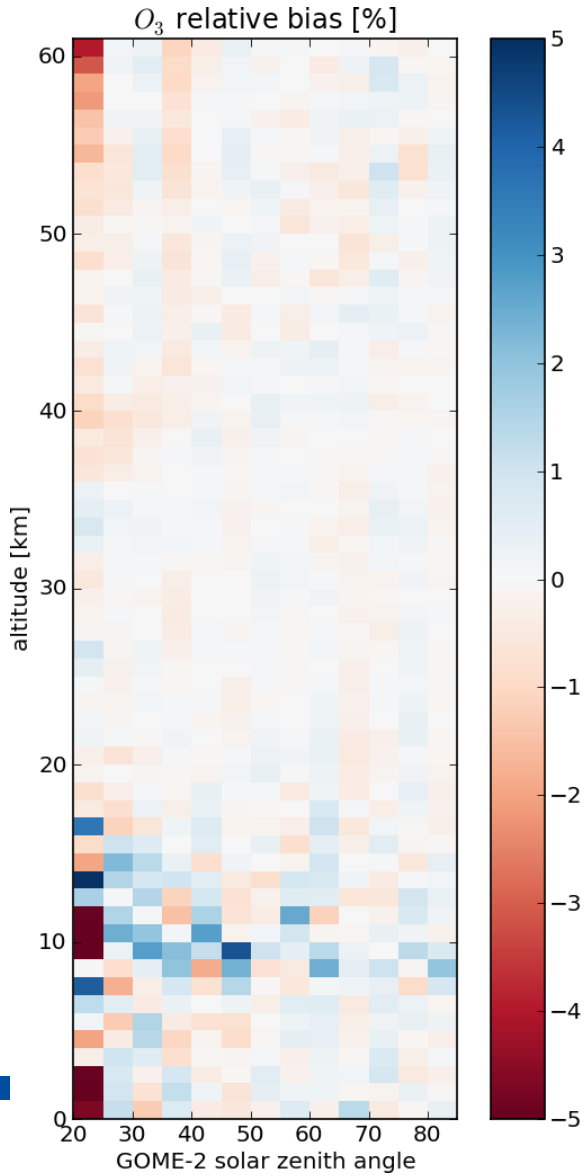
- no offset but STD on validation slightly higher
- STD > 40km up to 20% → MLS itself
- SH: STD + 5% higher
- NH: STD – 5 % higher

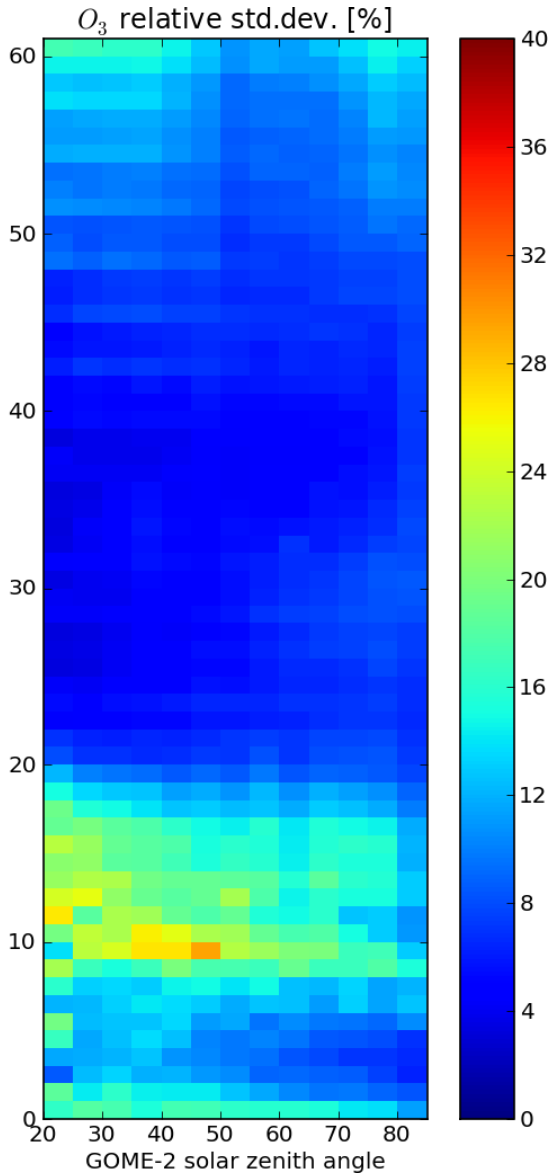
Latitude bands:

- MLS scan pattern visible
- negative bias over Antarctica

SZA Dependency

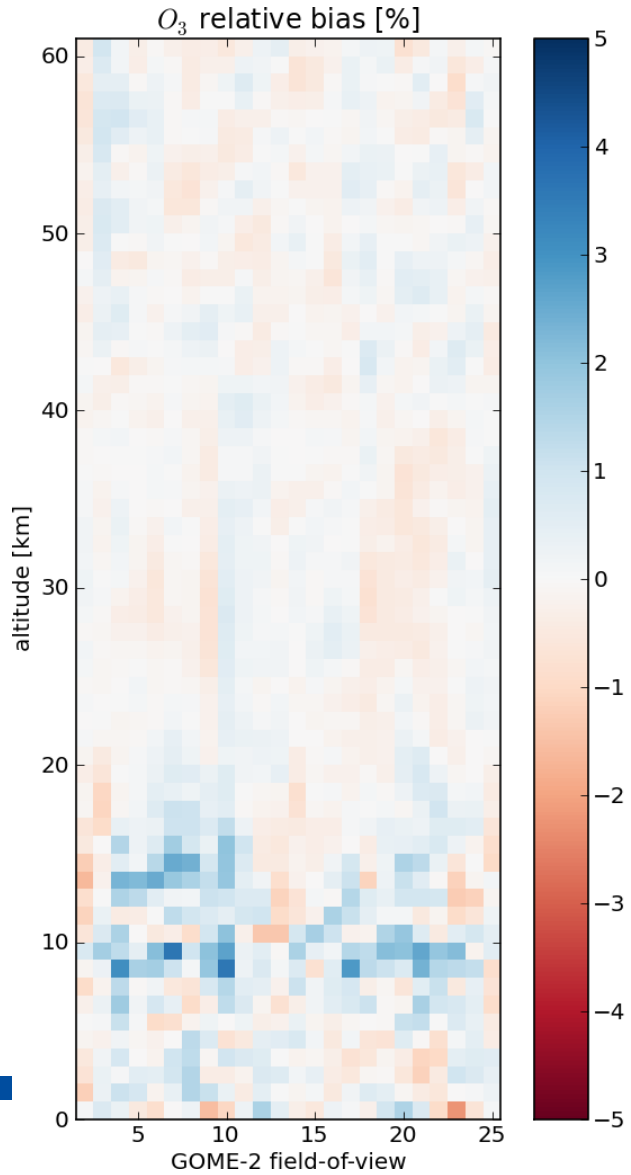
Relative [%]

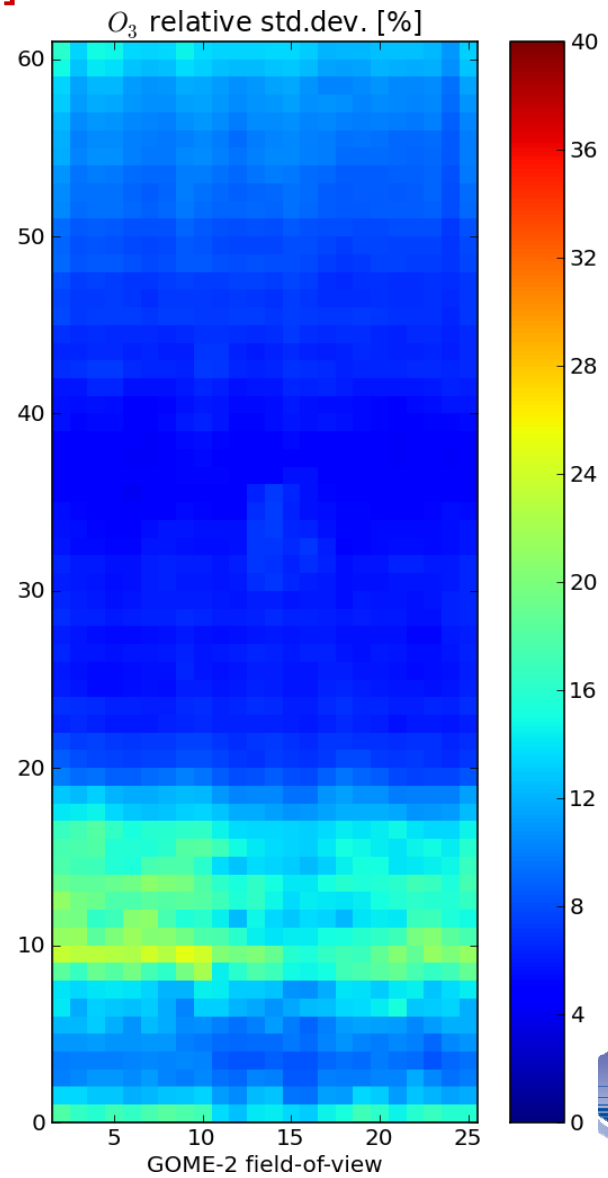




GOME-2 FOV Dependency

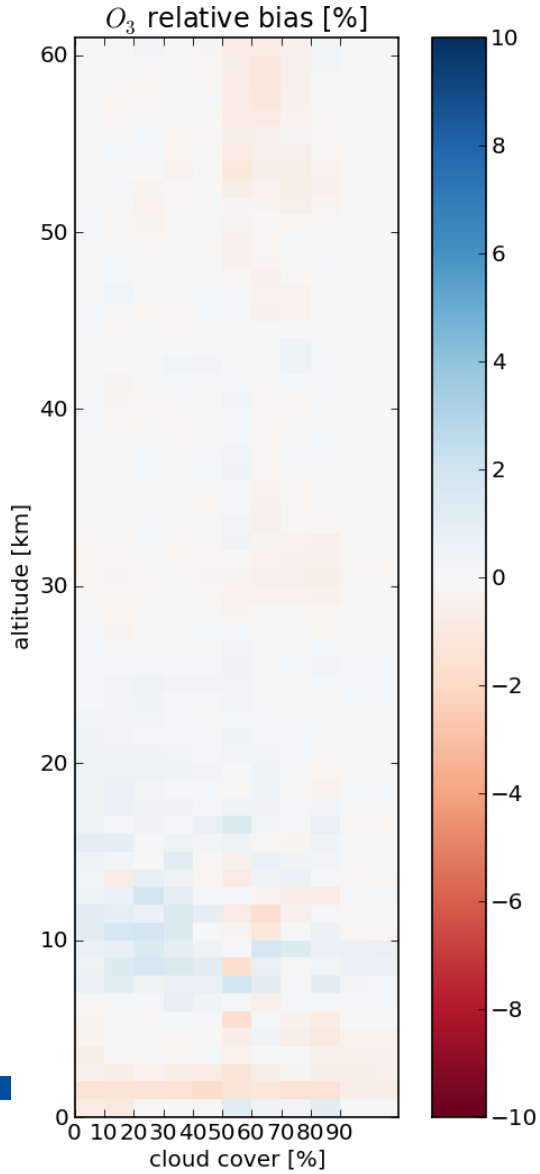
Relative [%]

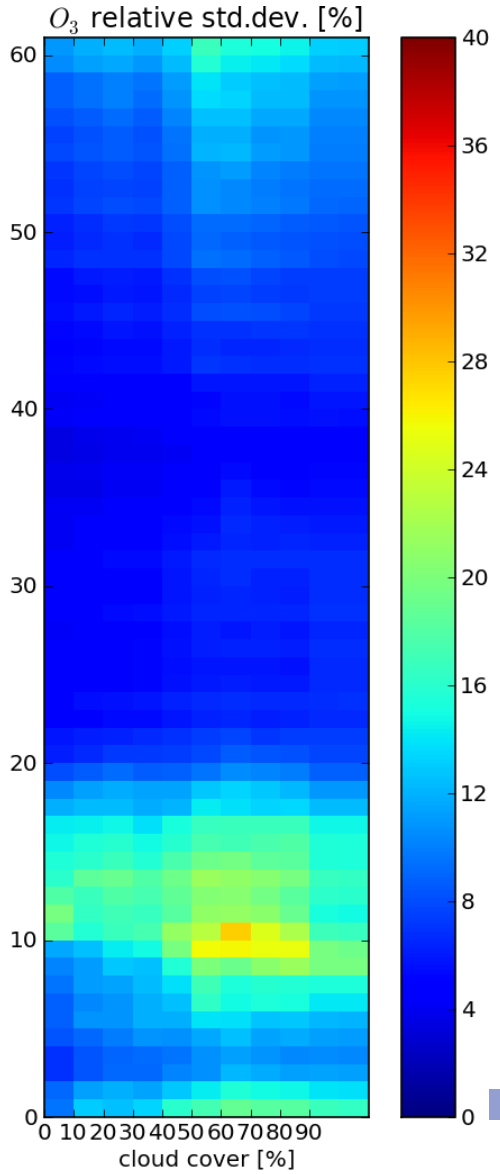




Cloud Fraction Dependency

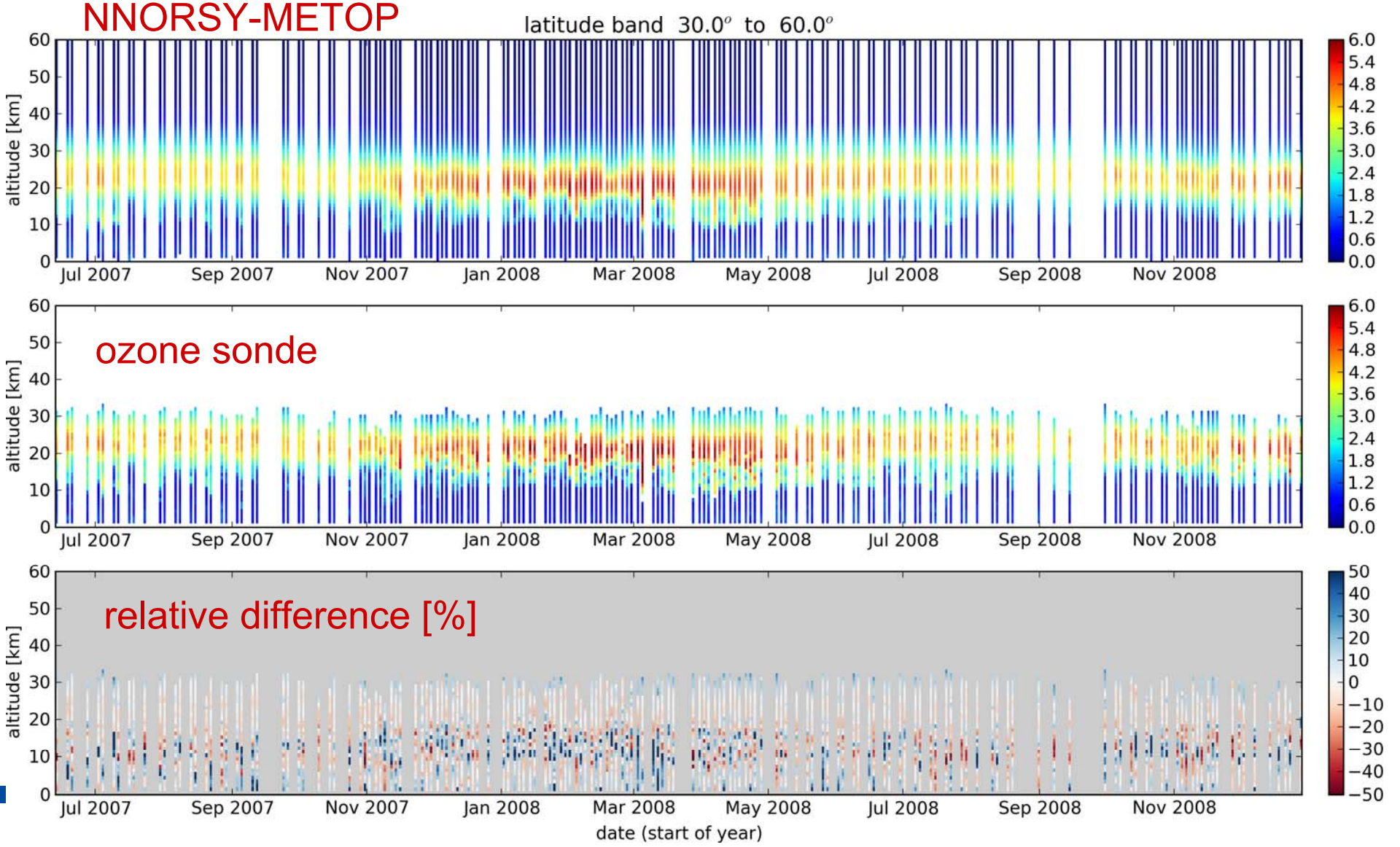
Relative [%]





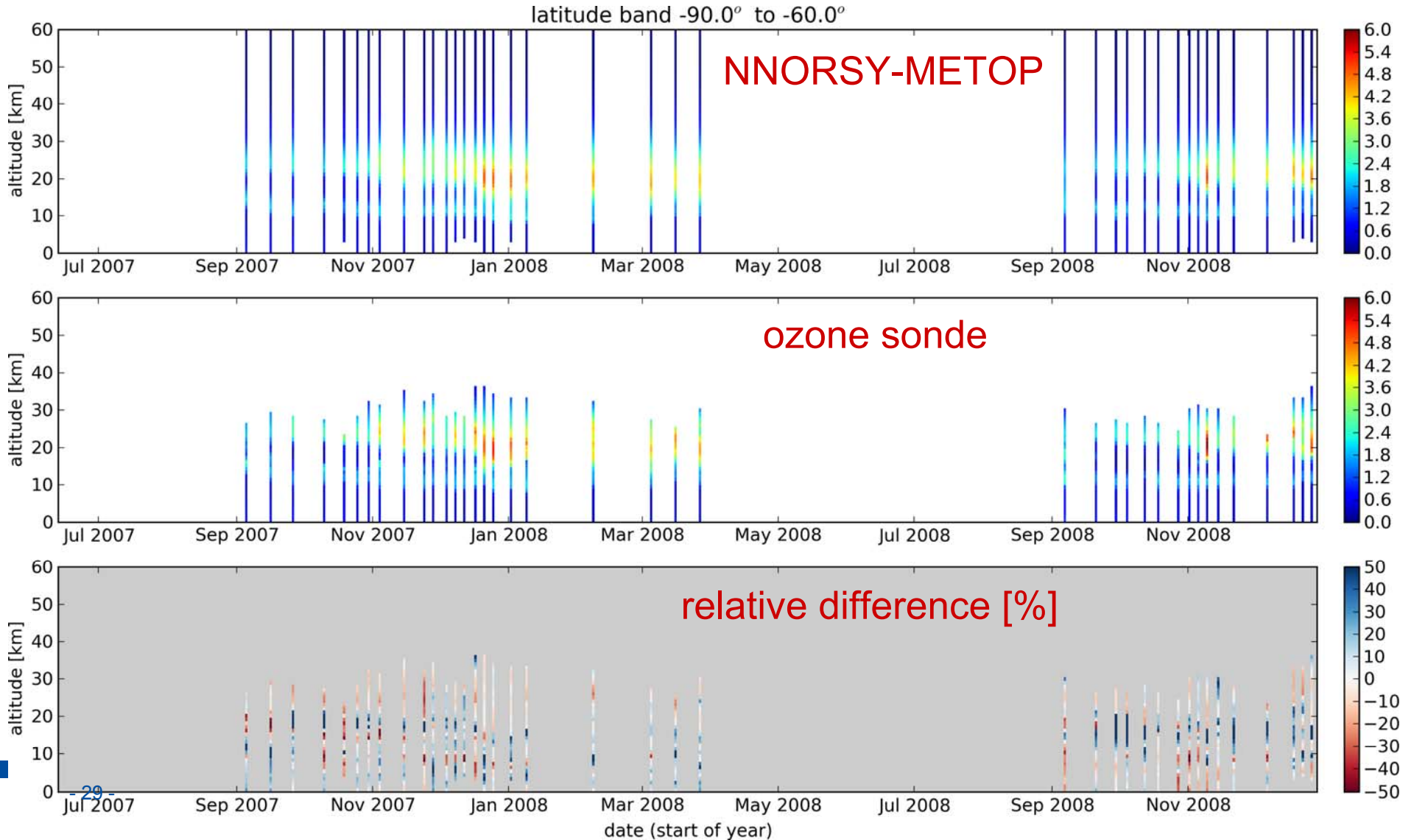
Validation Data: Single Station

Hohenpeissenberg (mid latitude)



Validation Data: Single Station

Syowa: Antarctica



Backup