



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

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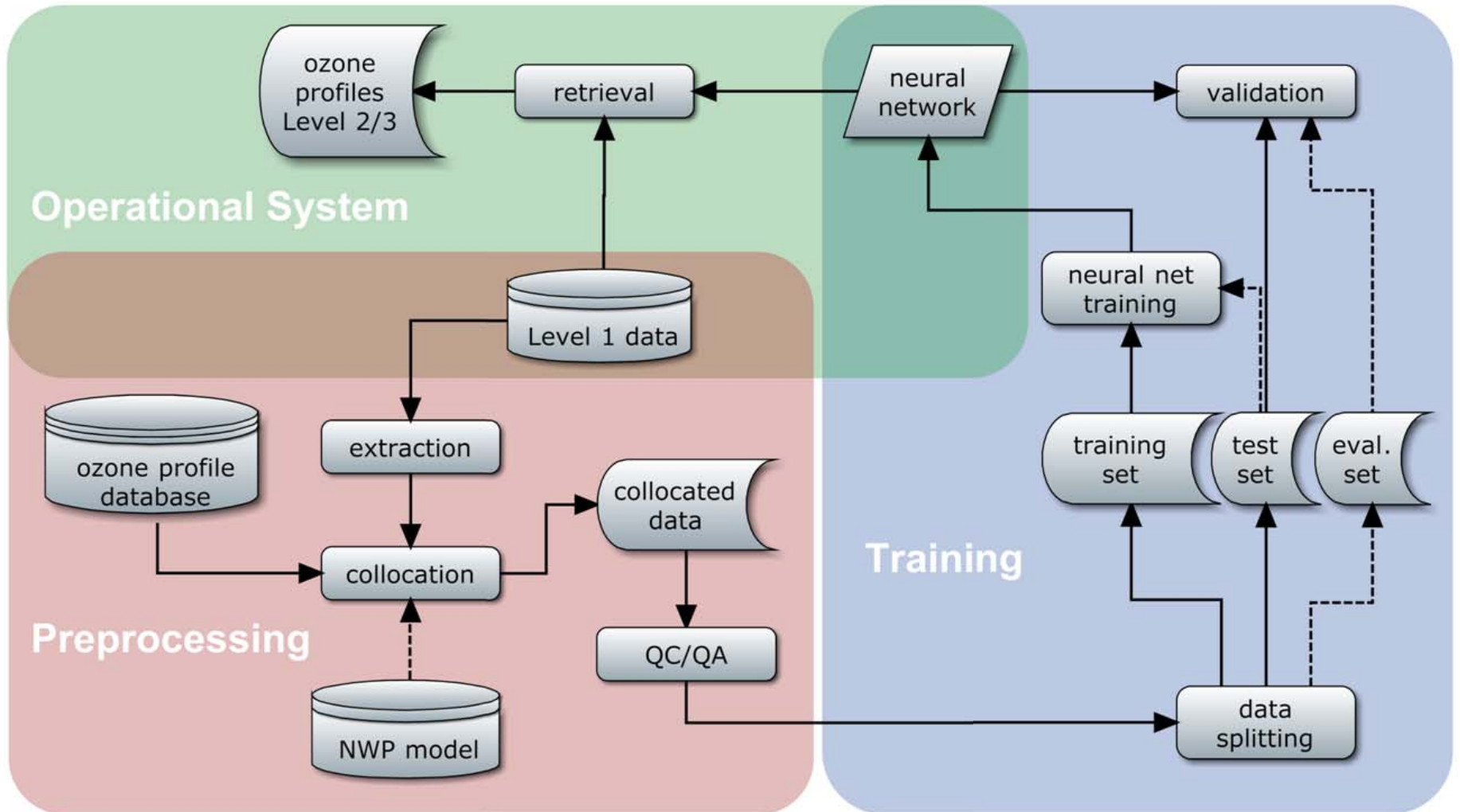
NNORSY - METOP

Study partly funded by Eumetsat

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



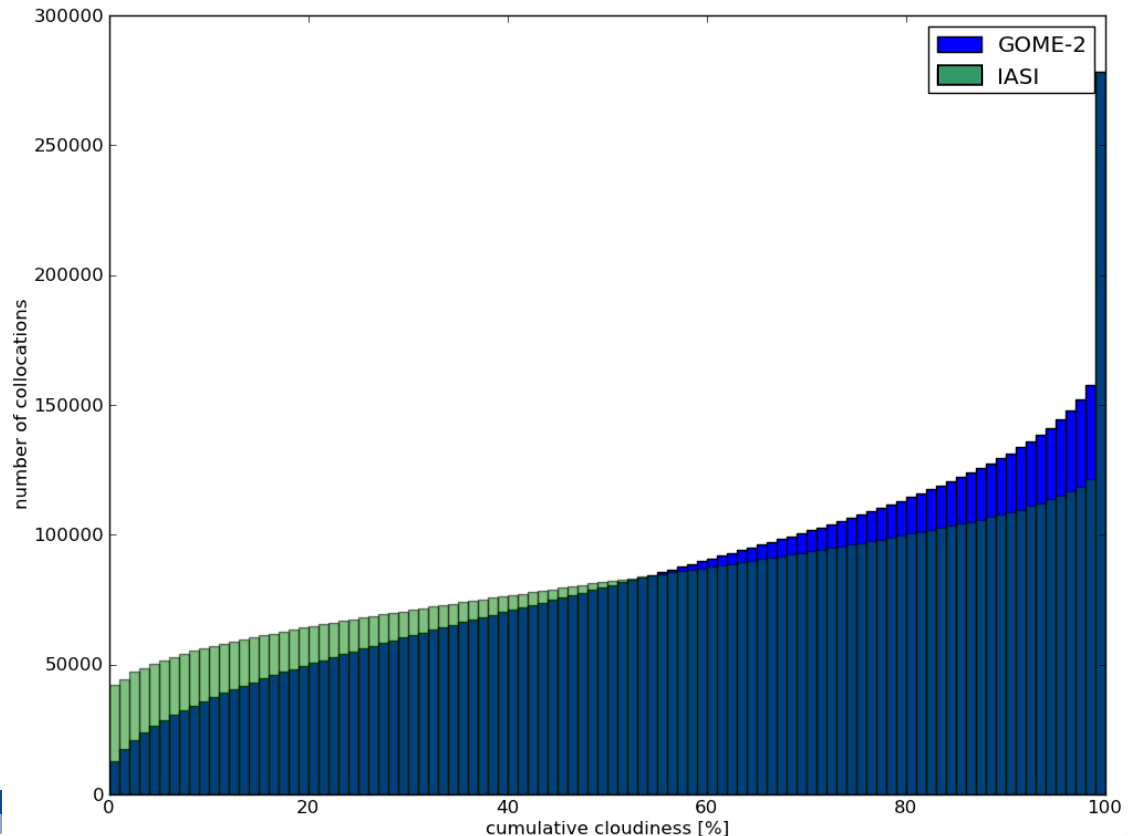
Co-registration and Clouds on GOME-2/IASI

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

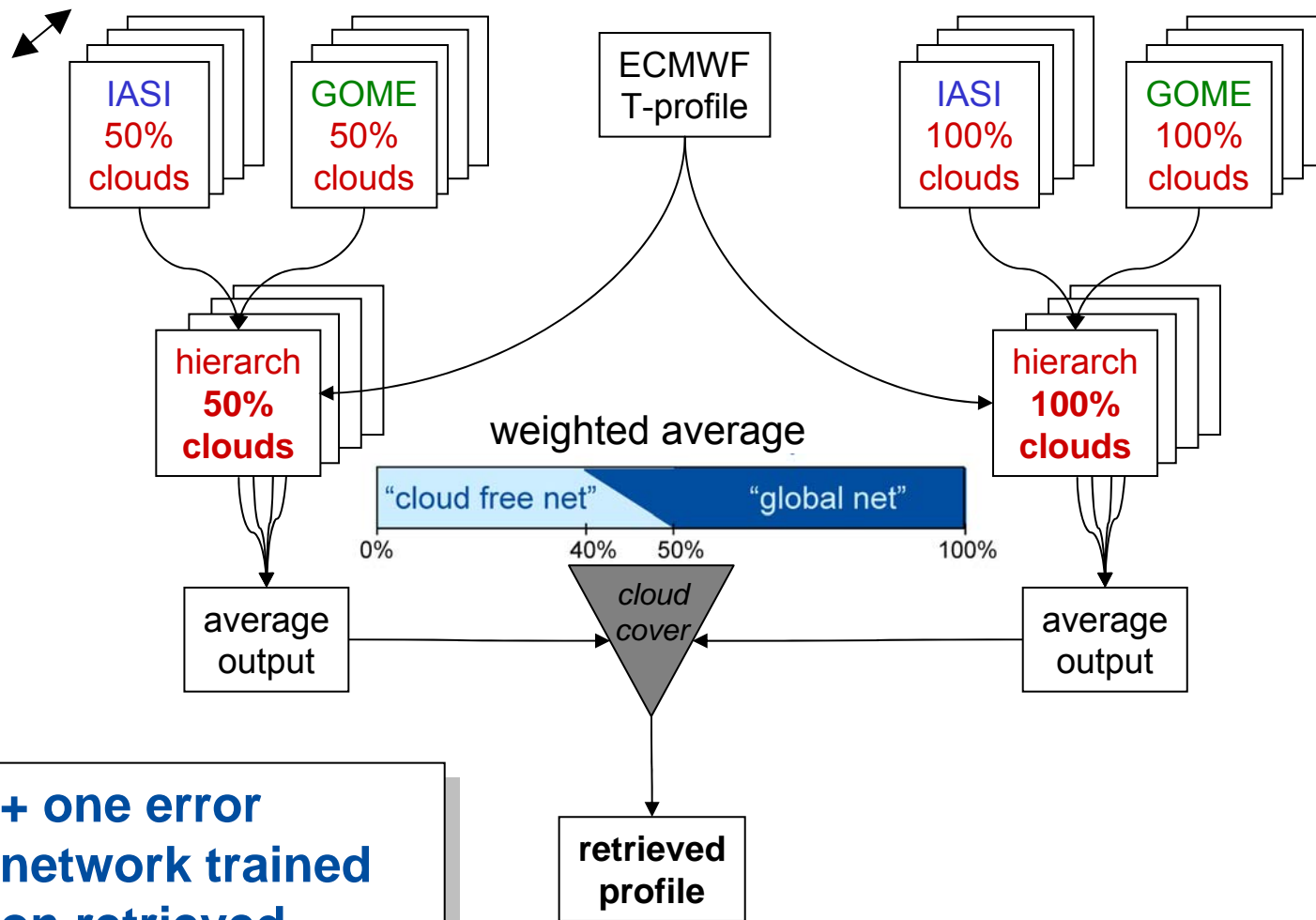
- ~ 90 000 each for
- ozone sondes
- ACE-FTS
- AURA-MLS



Operational Setup for NNORSY-METOP Version 3

Combining Hierarchical Networks and Averaging

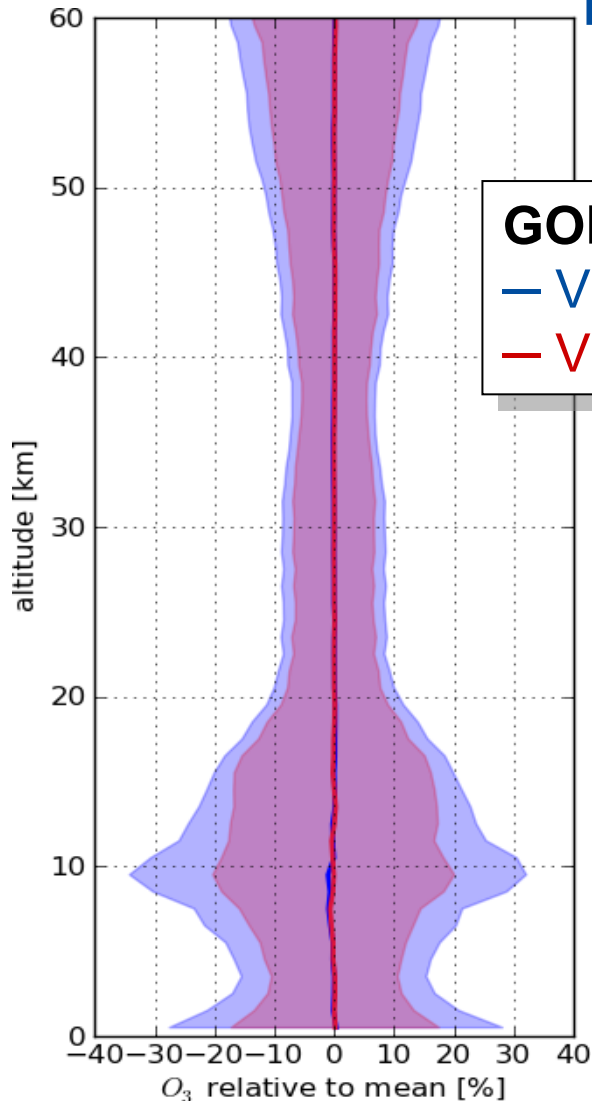
same or slightly different config.



+ one error network trained on retrieved profile errors

Improvements of NNORSY V3 compared to V2

NNORSY Methodology

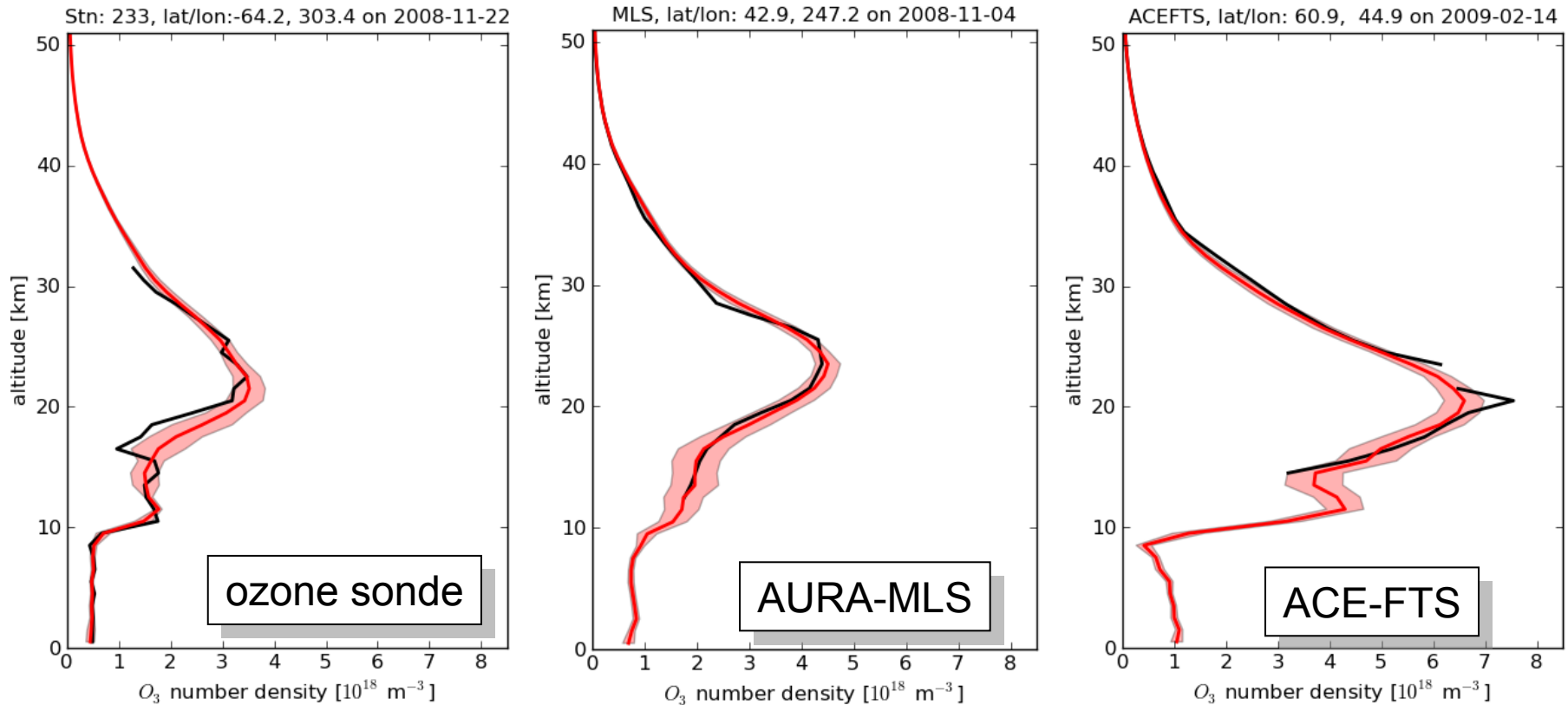


GOME2 + IASI + T: on test data set

- Version 2: simple combination of neural networks
- Version 3: hierarch + cloud 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



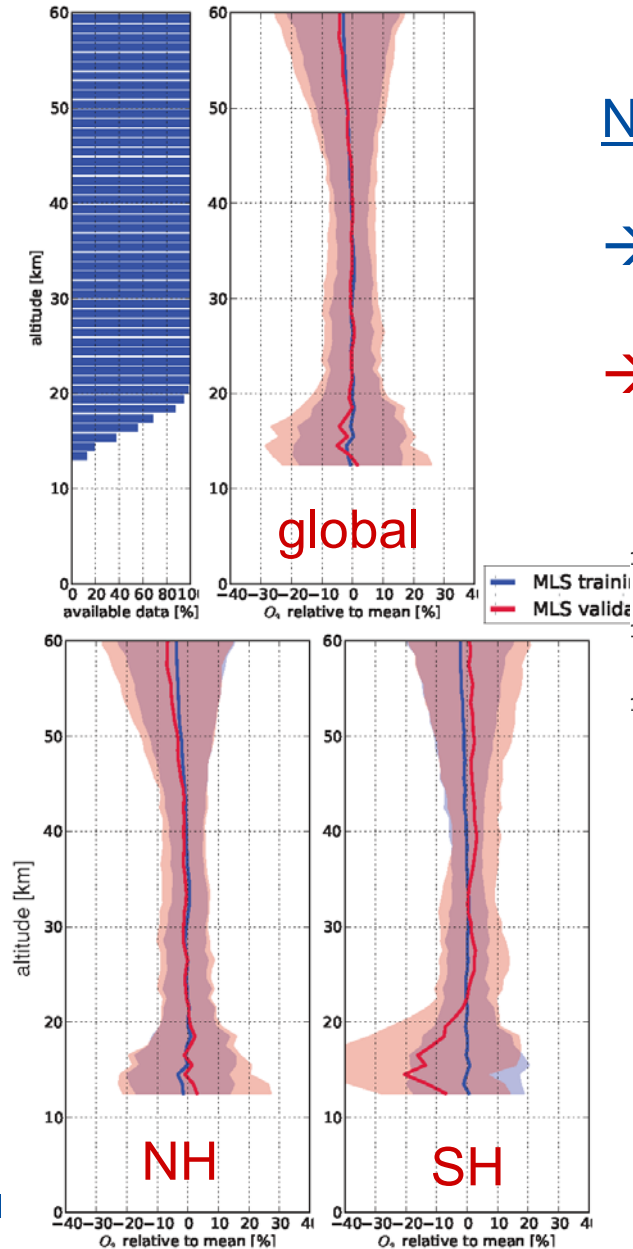
→ Multiplying error output by factor ~ 1.2 yields approximate standard deviation

Difference between Training and Validation Data Set

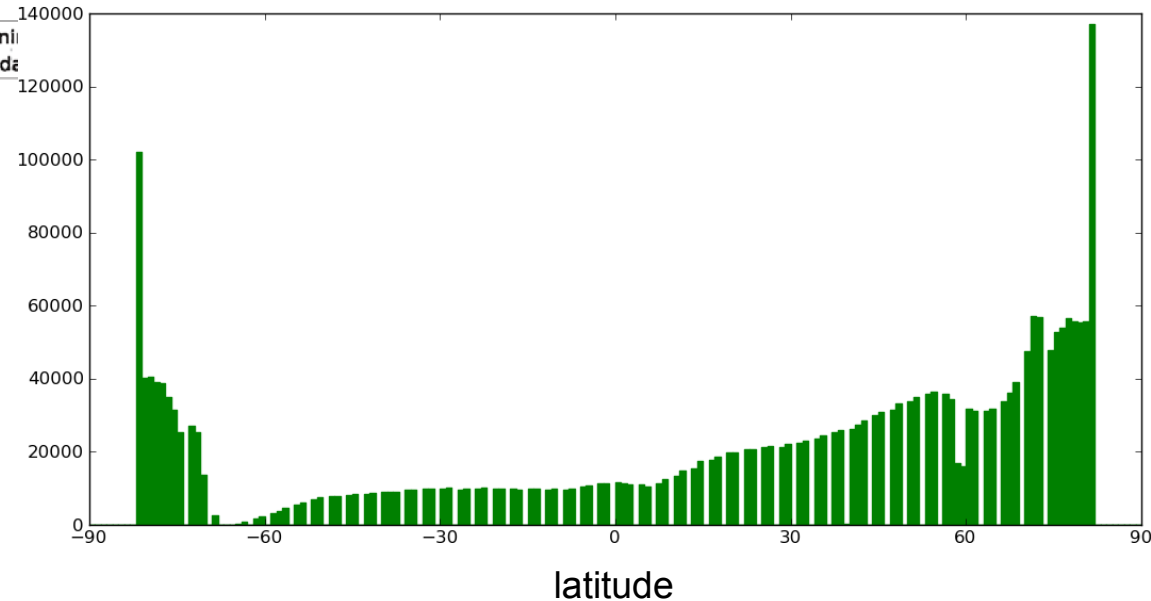
NNORSY-METOP V3:

→ MLS training data: ~35 Td.

→ MLS validation data: 2.9 Million

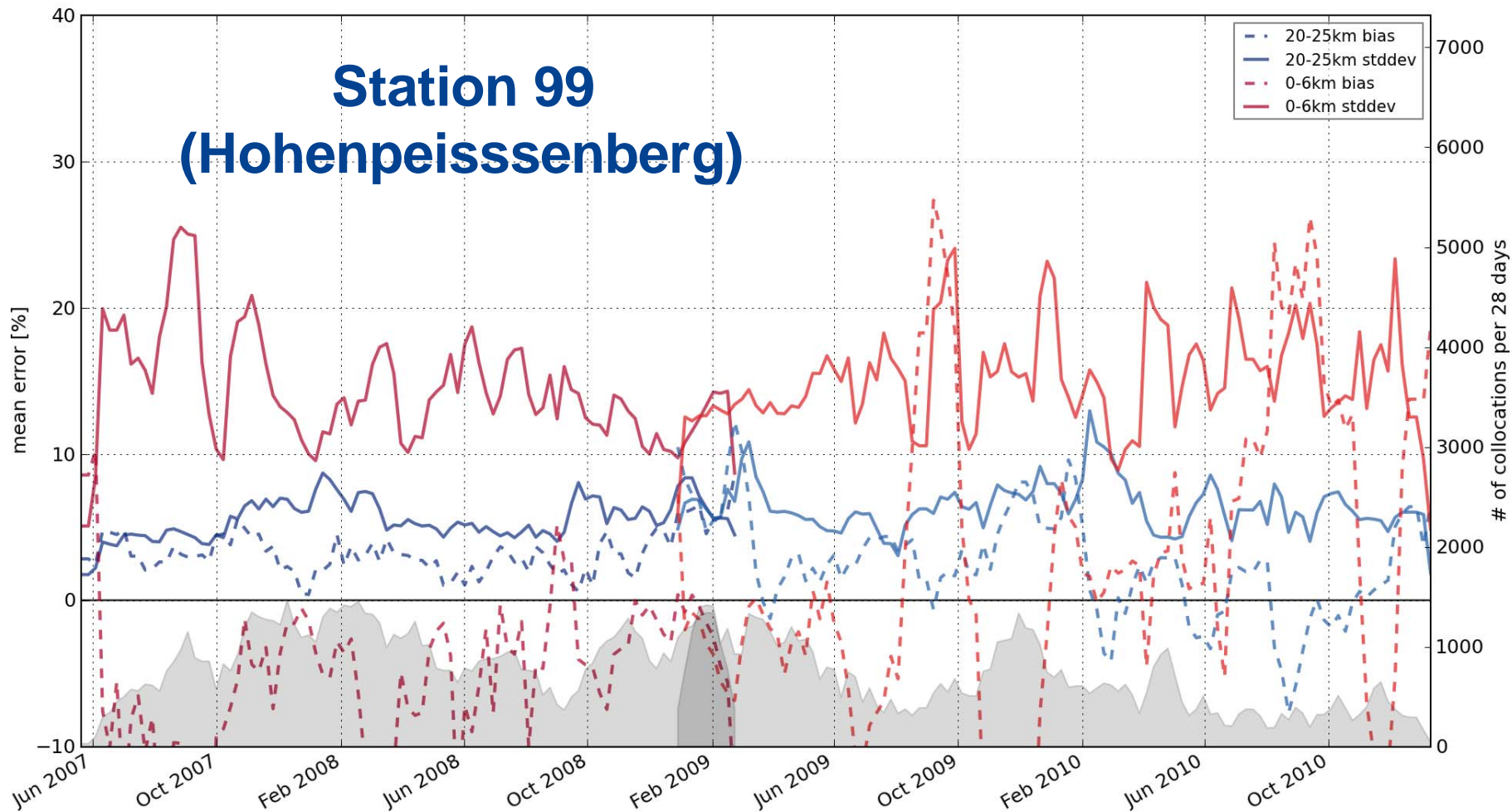


Latitudinal distribution of MLS validation data



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**

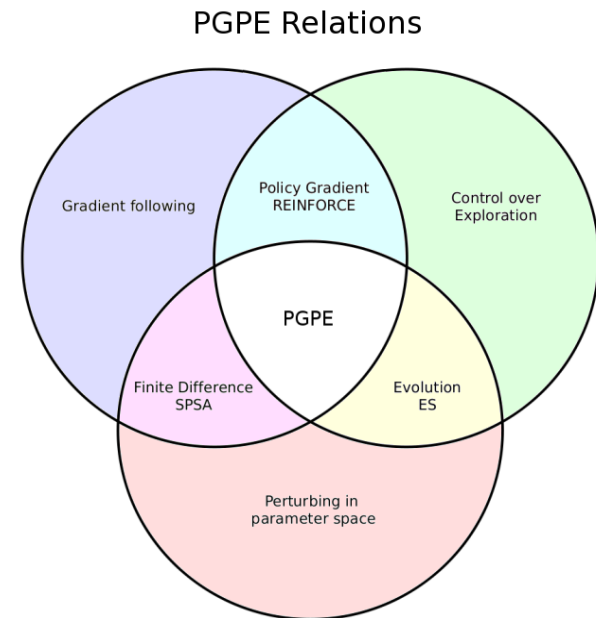
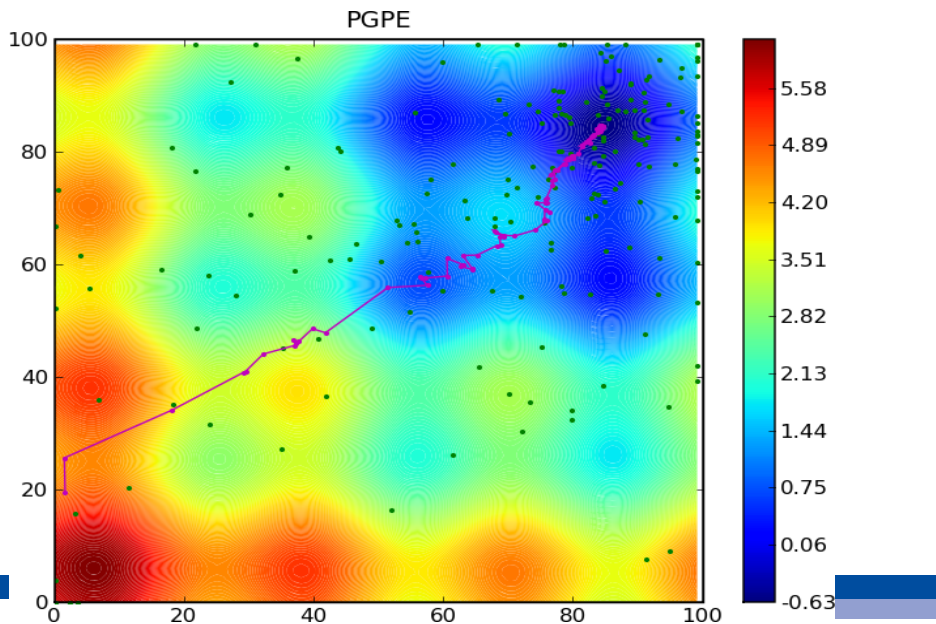
Learn-O-Matic

The screenshot displays the Learn-O-Matic web interface. At the top, there are several tabs: Maulaf, GTXPower01, GTXPower02, GTXPower03, GTXPower04-0, GTXPower04-1, FeatSel (highlighted in green), Pulsar, Upload, and Results. Below the tabs, the interface is divided into several sections. On the left, there is a 'Pattern Discriminator' section with a dropdown menu showing 'c251_SWAMIA2' and a 'Select Source' button. In the center, there is a 'Zone Name' section with a dropdown menu showing 'E12' and a 'Select Zone' button. The main area is split into two panels: 'PGPE Overview' on the left, showing a neural network diagram with 4 layers of nodes, and 'Convergence Details' on the right, showing a neural network diagram with 4 layers of nodes and numerical values: 62, 384, 384, and 2176. Below the panels, there is a 'FeatSel notes' section with a text input field and a 'Send' button. On the right side, there is a 'Debug Messages' section with a text input field and a 'Send' button. A large 'ZSW' logo is visible in the bottom right corner of the interface.

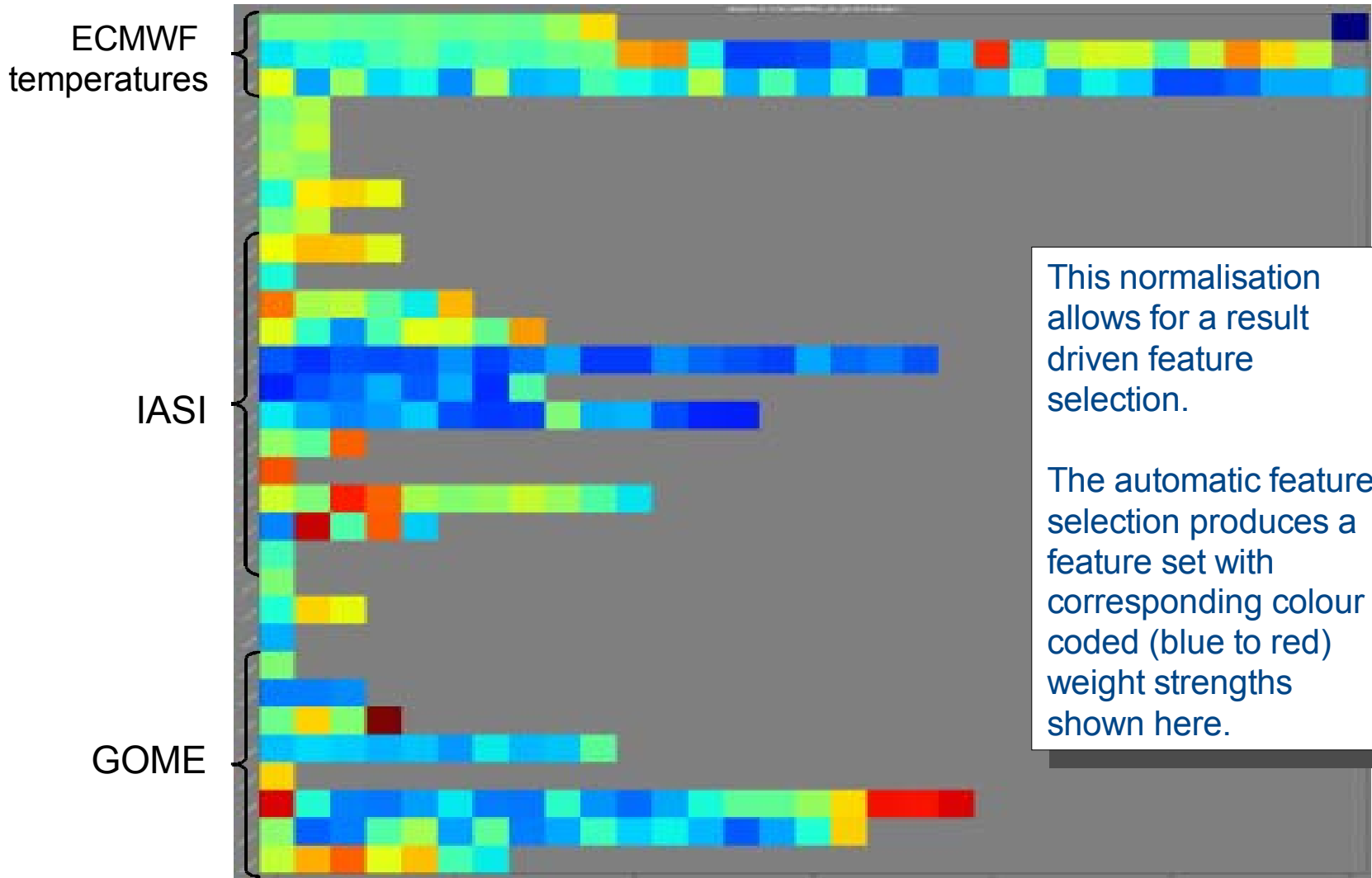
*) Sehnke et al. 2012, Learn-O-Matic - Fully automated Machine Learning, ZSW internal Tech. Note

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

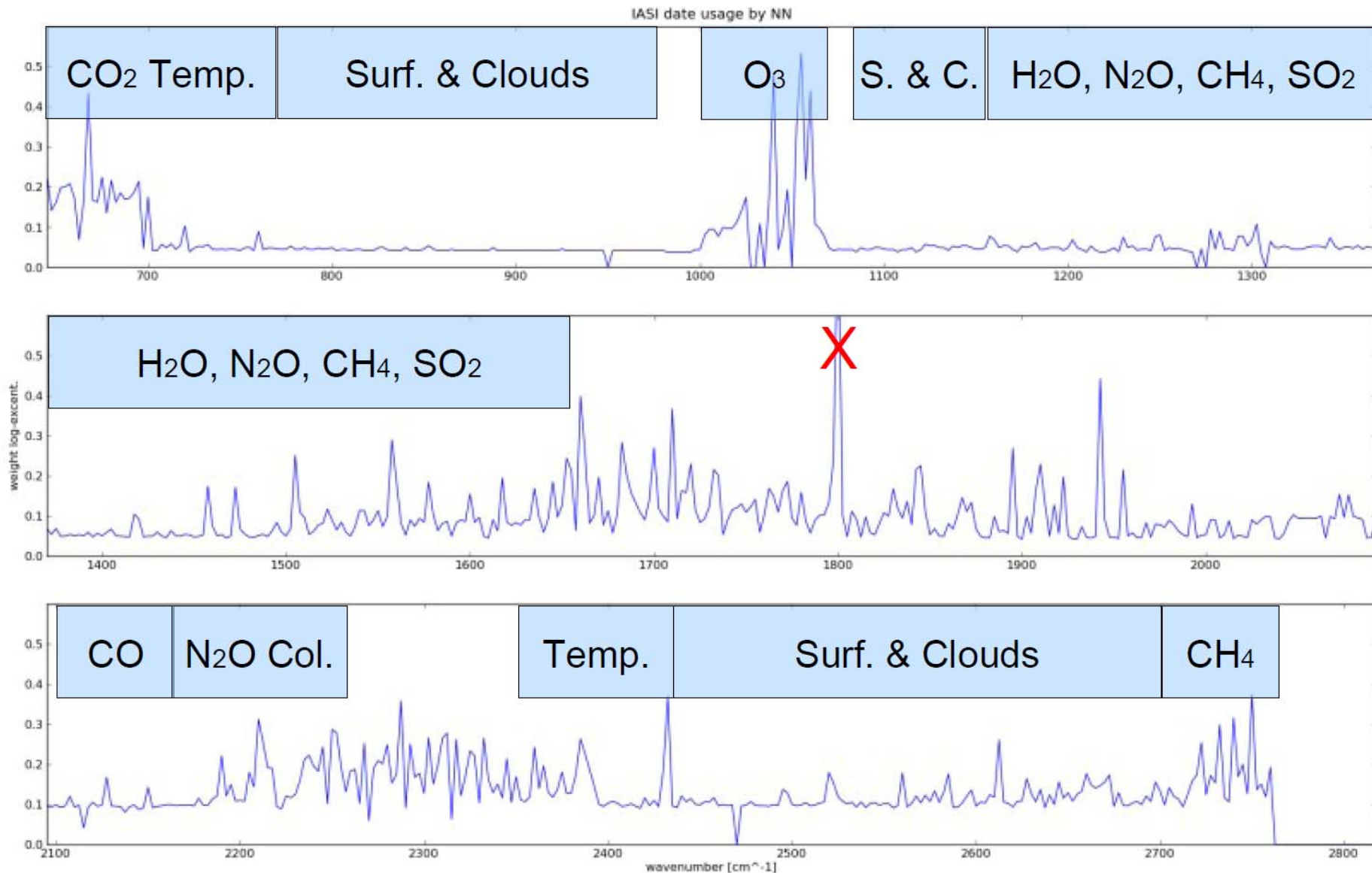


This normalisation allows for a result driven feature selection.

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

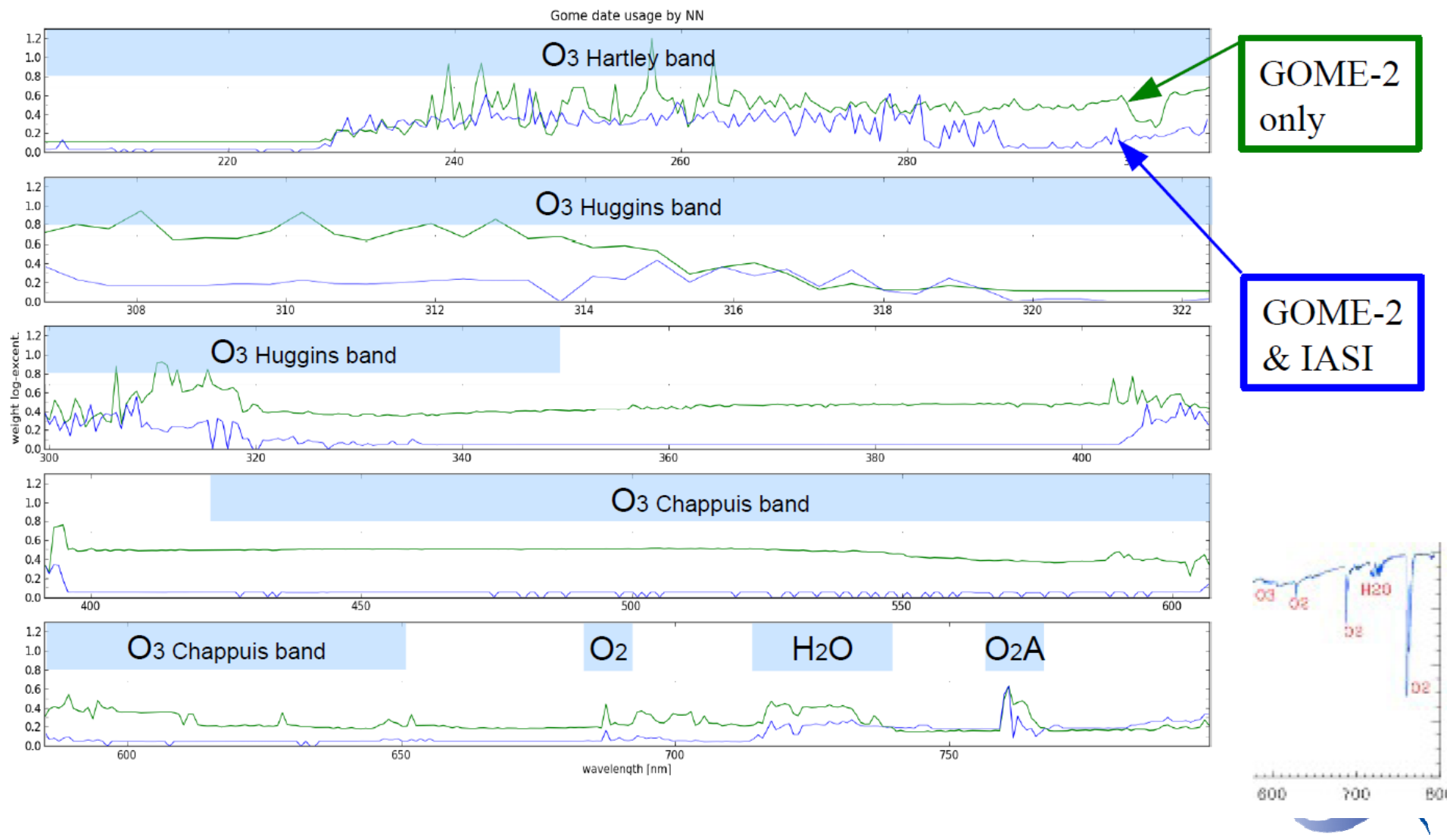
Learn-O-Matic: IASI Channel Selection

Joined GOME-2 & IASI retrieval

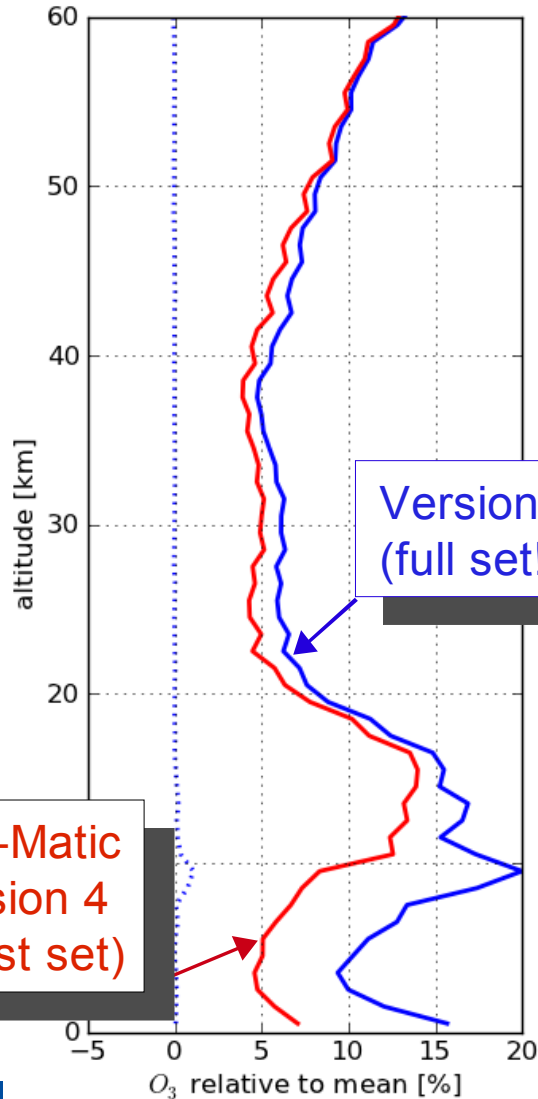


Learn-O-Matic: GOME-2 Channel Selection

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



NNORSY-METOP V3/V4 Comparison



Version 3 vs. 4

→ Version 3 hierarchical and averaging

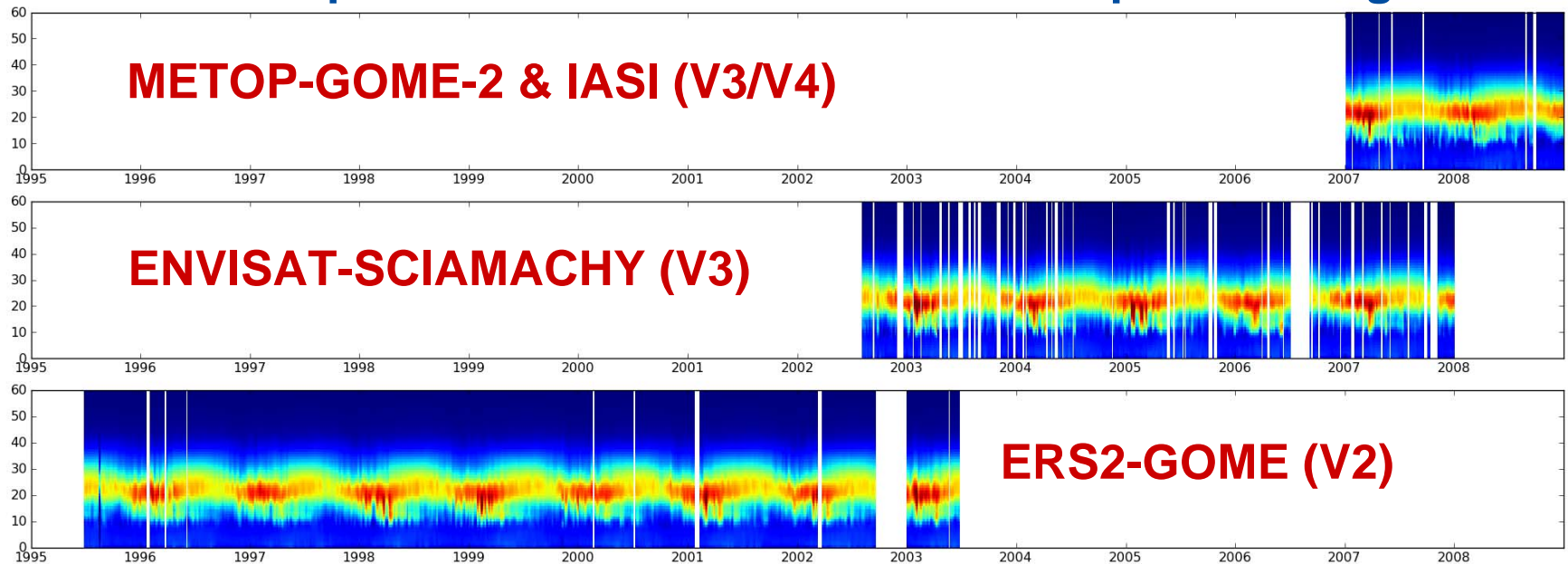
→ Version 4 single deep NN with automatic channel selection

Version 3
(full set!)

Learn-O-Matic
Version 4
(test set)

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

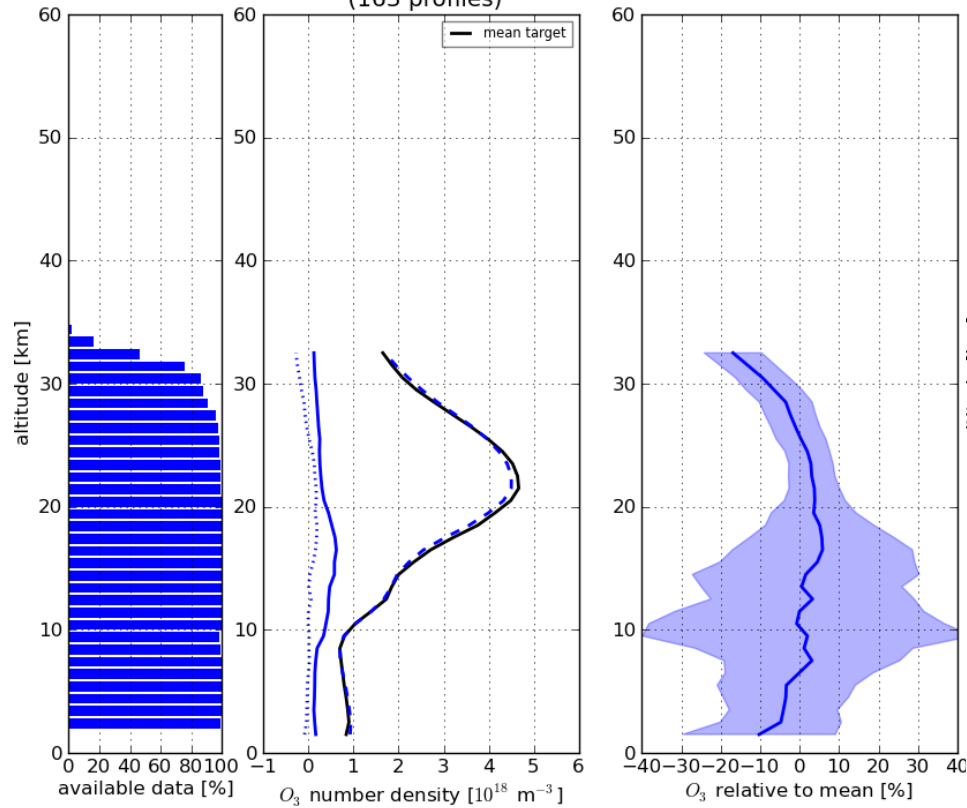


Backup Slides

NNORSY-METOP V3: Validation Single Stations

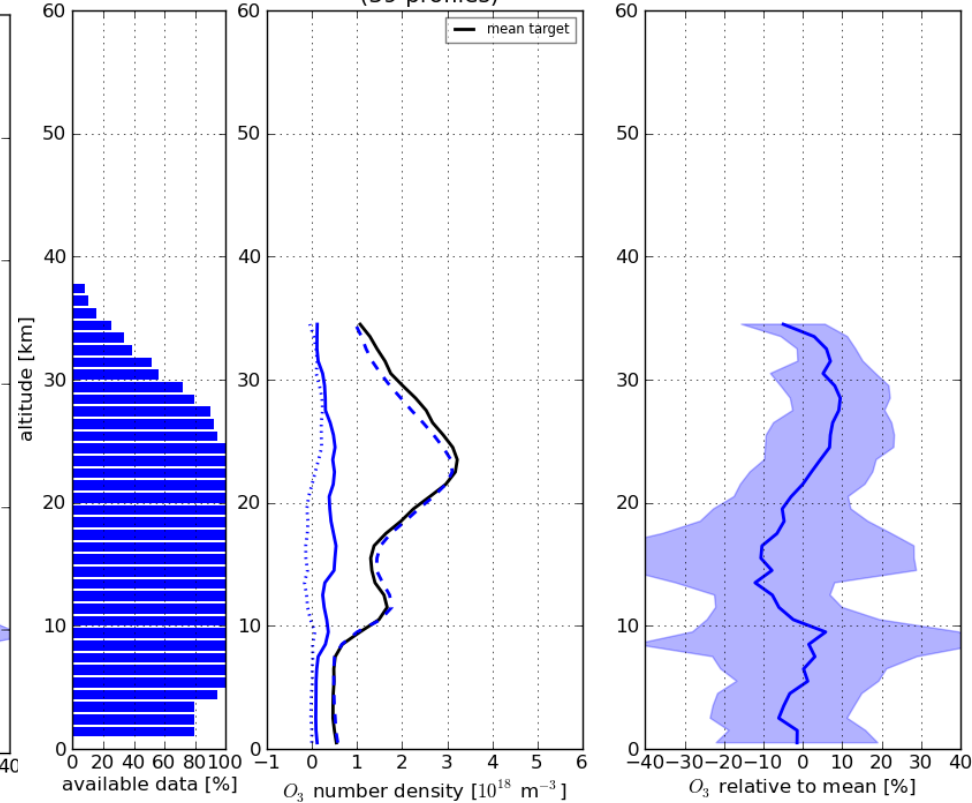
Hohenpeissenberg

(163 profiles)

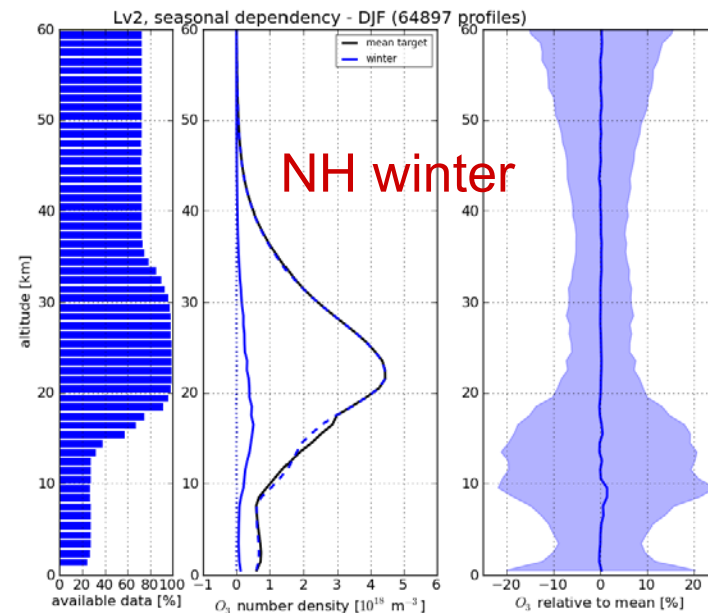
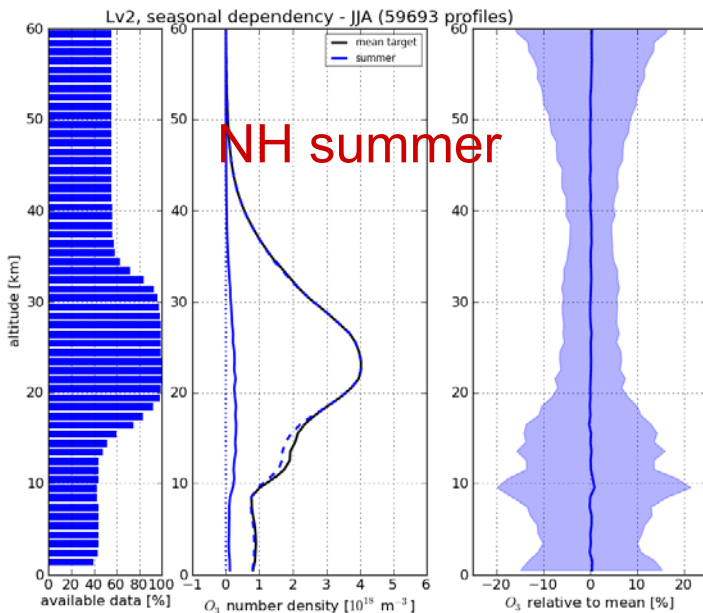
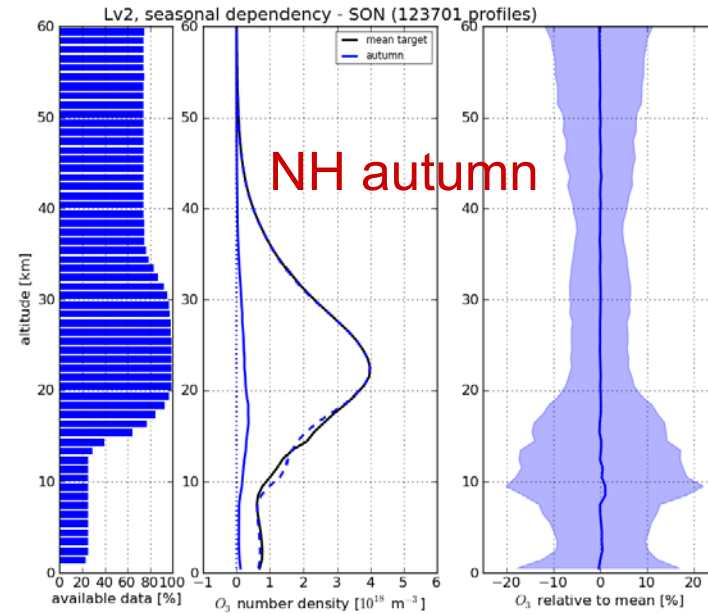
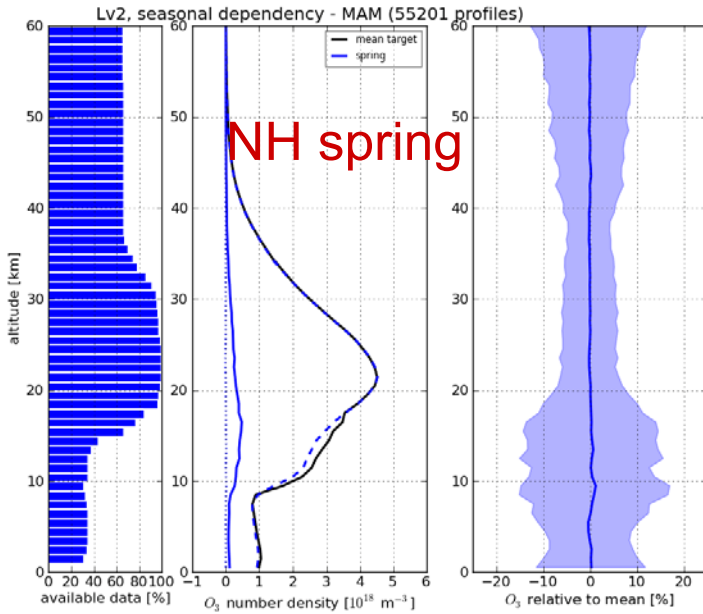


Syowa

(39 profiles)

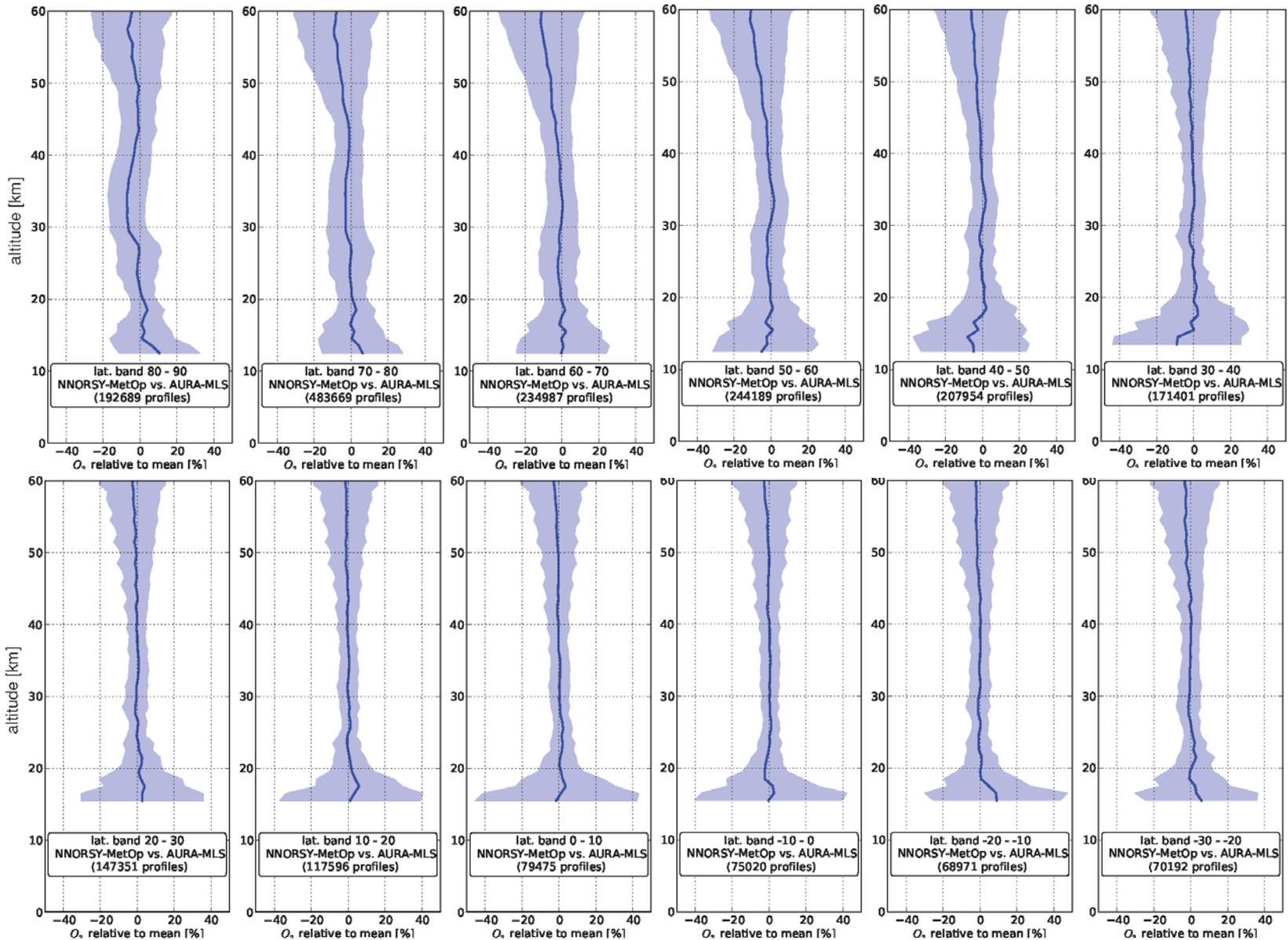


Training Data: Seasonal Dependency



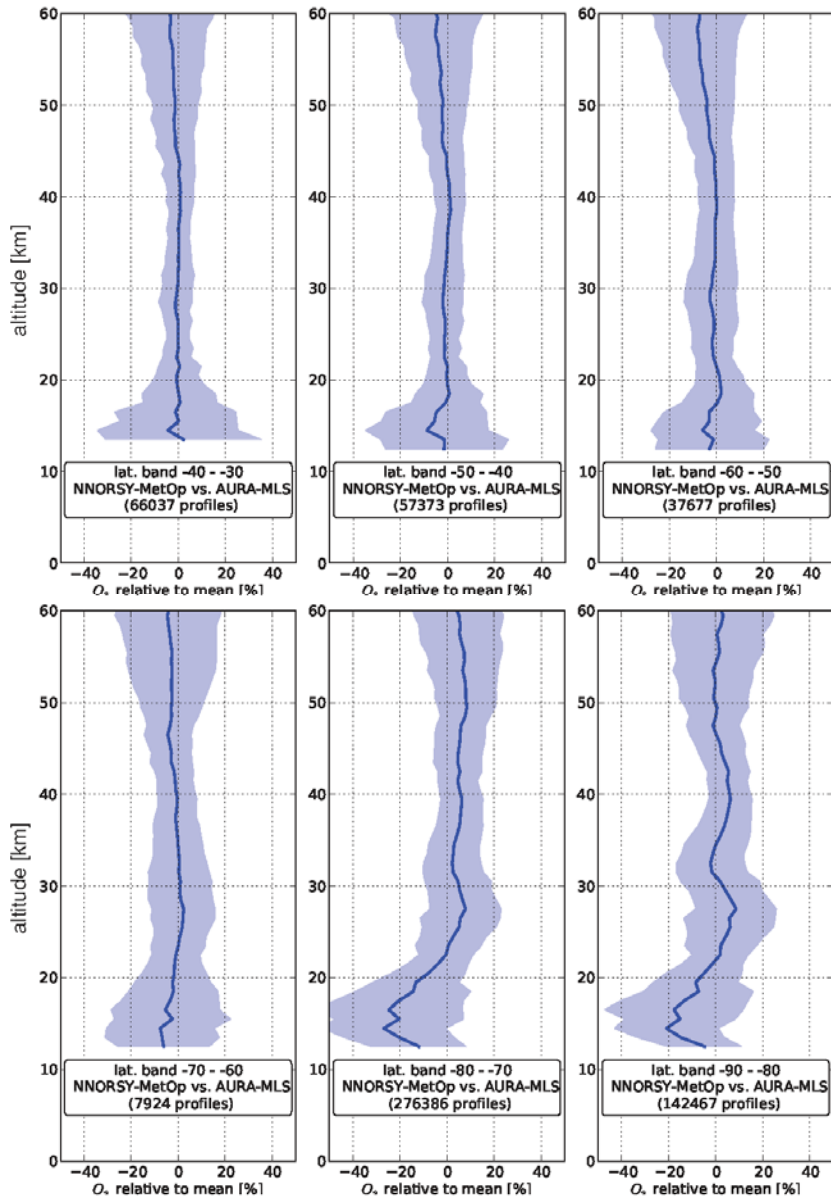
Validation Data: AURA-MLS Latitude Bands

10 degree latitude bands: 90N – 20S



Validation Data: AURA-MLS Latitude Bands

10 degree latitude bands: 30S – 90S



On global scale:

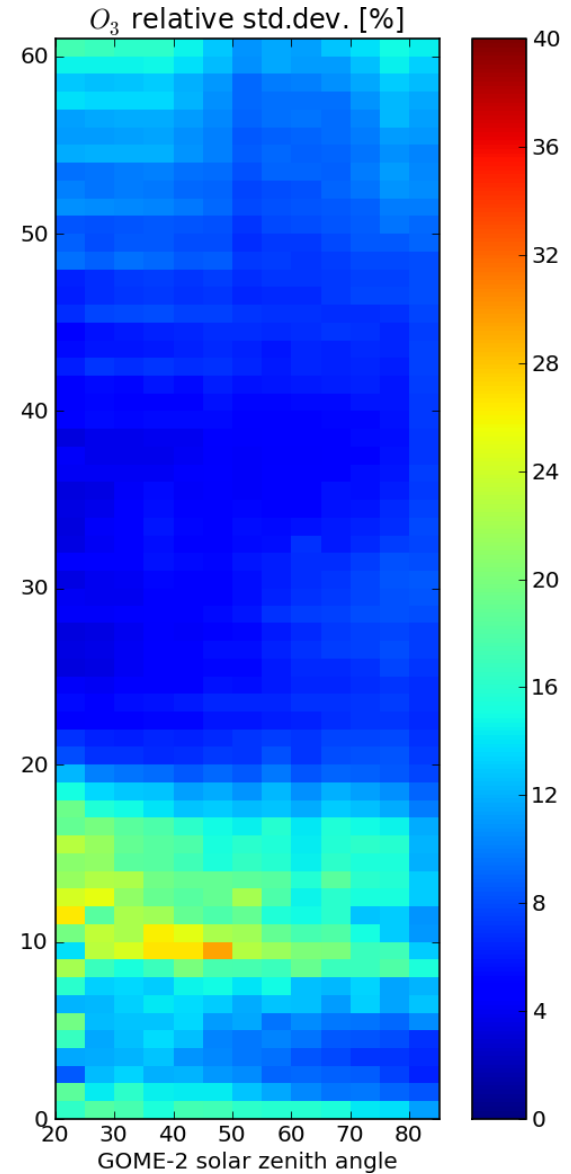
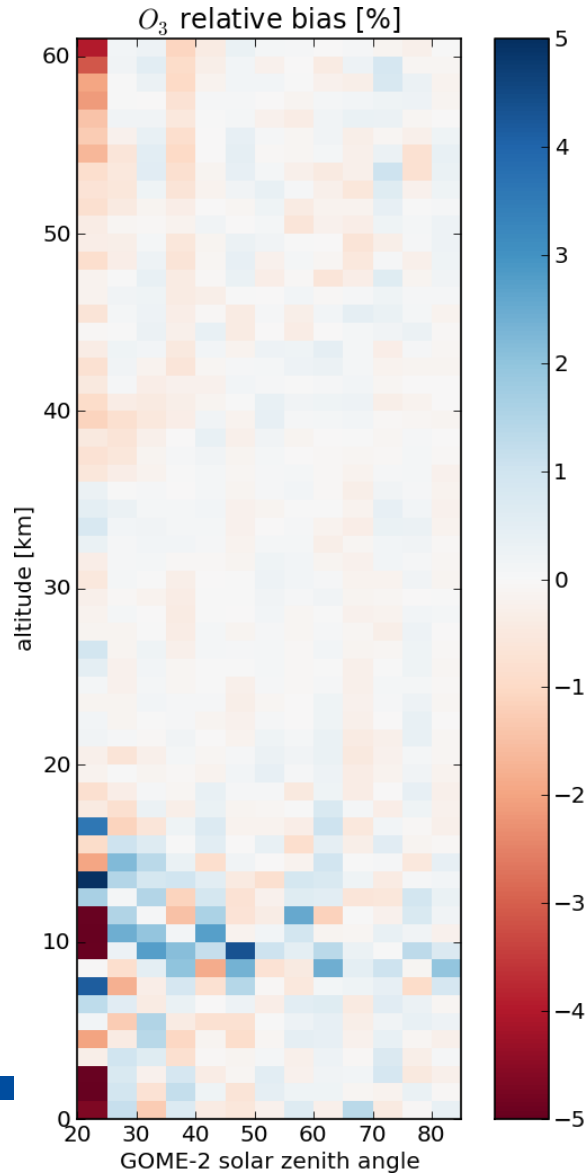
- no offset but STD on validation slightly higher
- STD > 40km up to 20% → MLS itself
- SH: STD + 5% higher
- NH: STD – 5 % higher

Latitude bands:

- MLS scan pattern visible
- negative bias over Antarctica

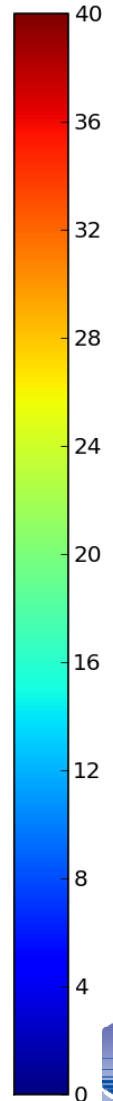
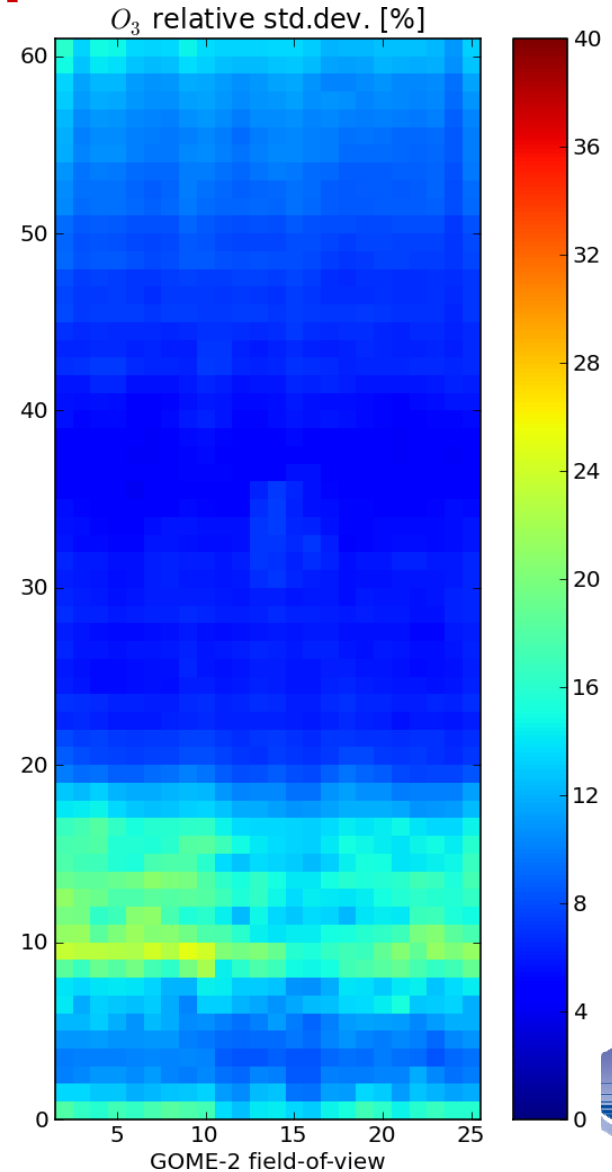
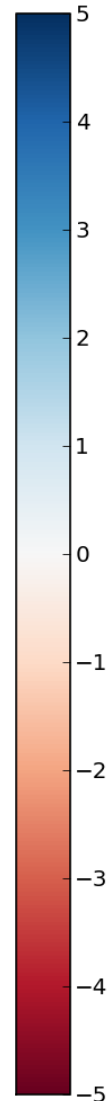
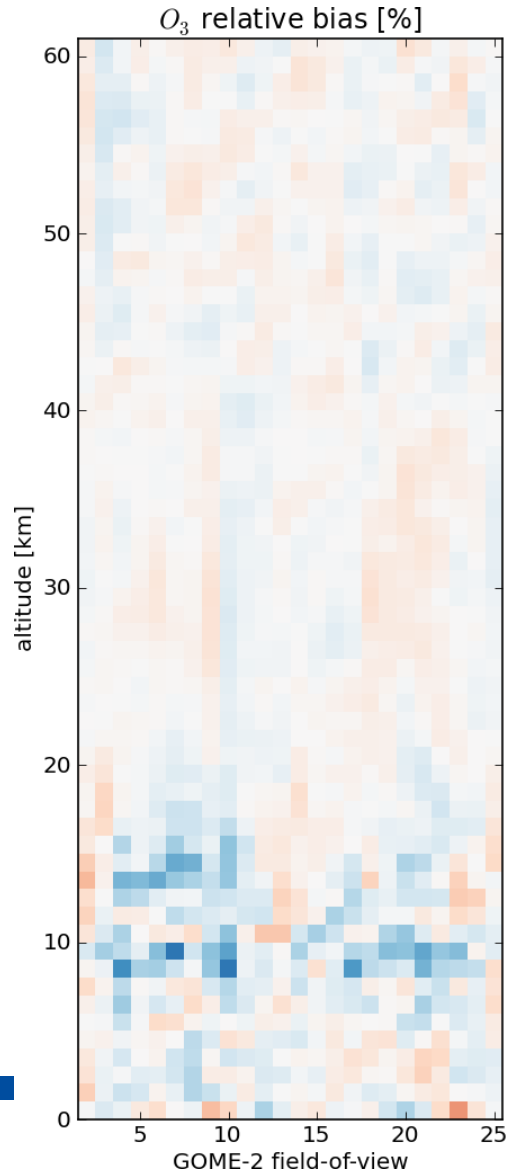
SZA Dependency

Relative [%]



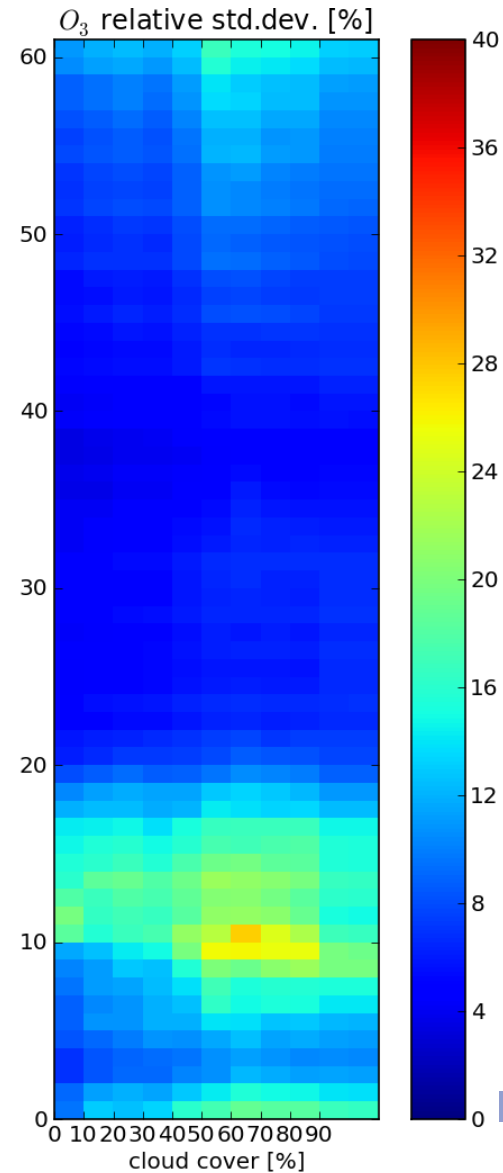
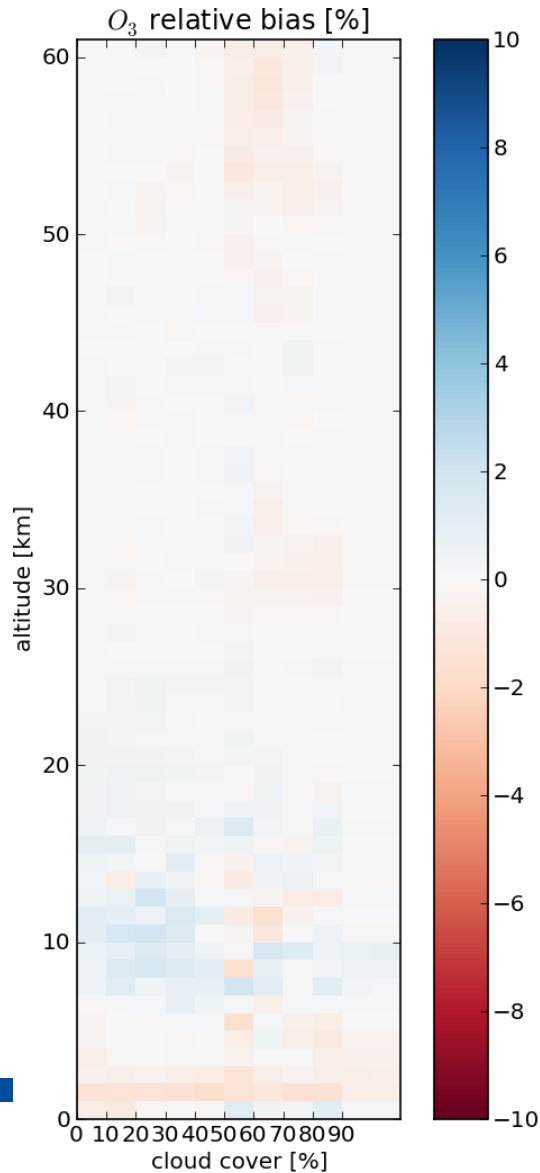
GOME-2 FOV Dependency

Relative [%]



Cloud Fraction Dependency

Relative [%]

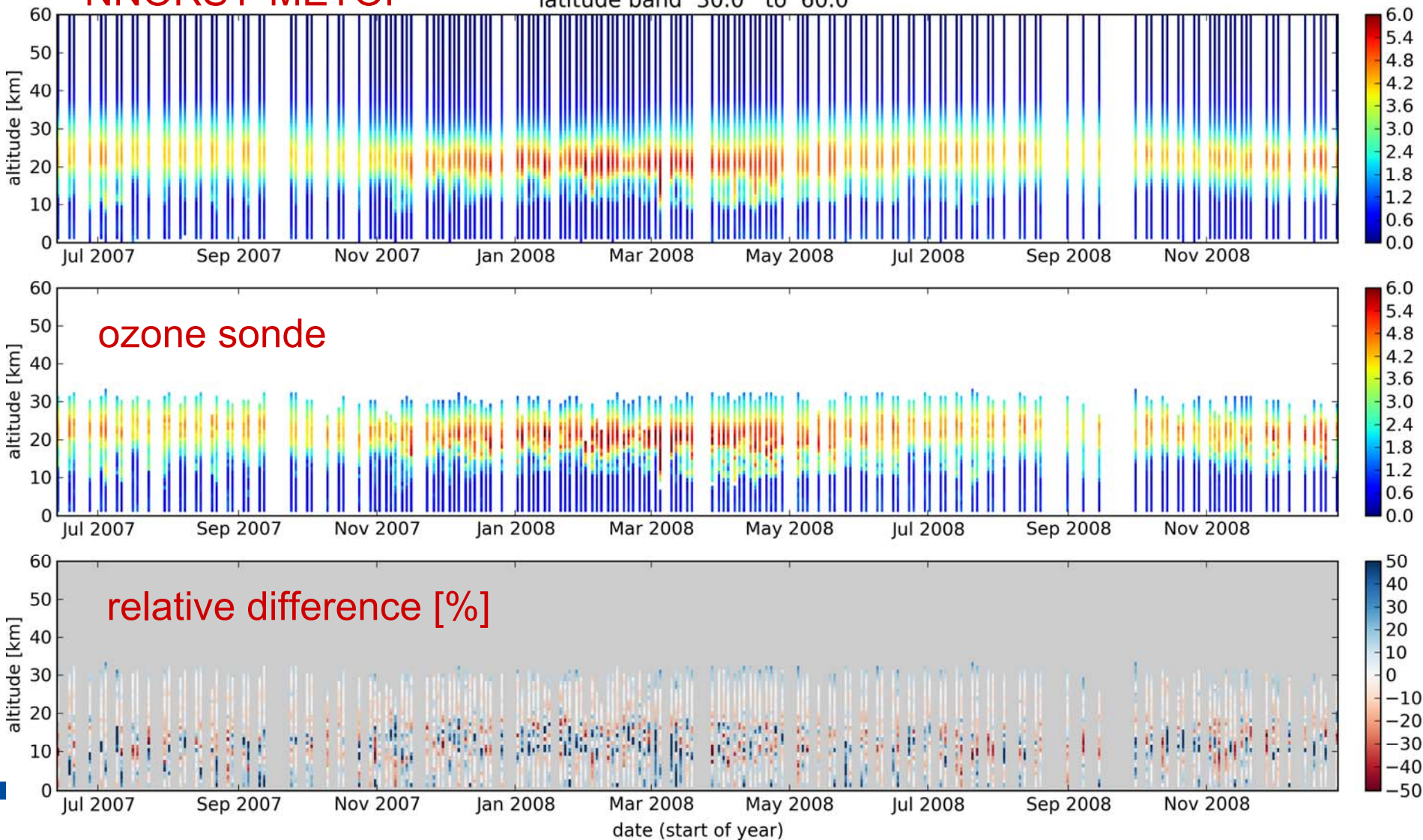


Validation Data: Single Station

Hohenpeissenberg (mid latitude)

NNORSY-METOP

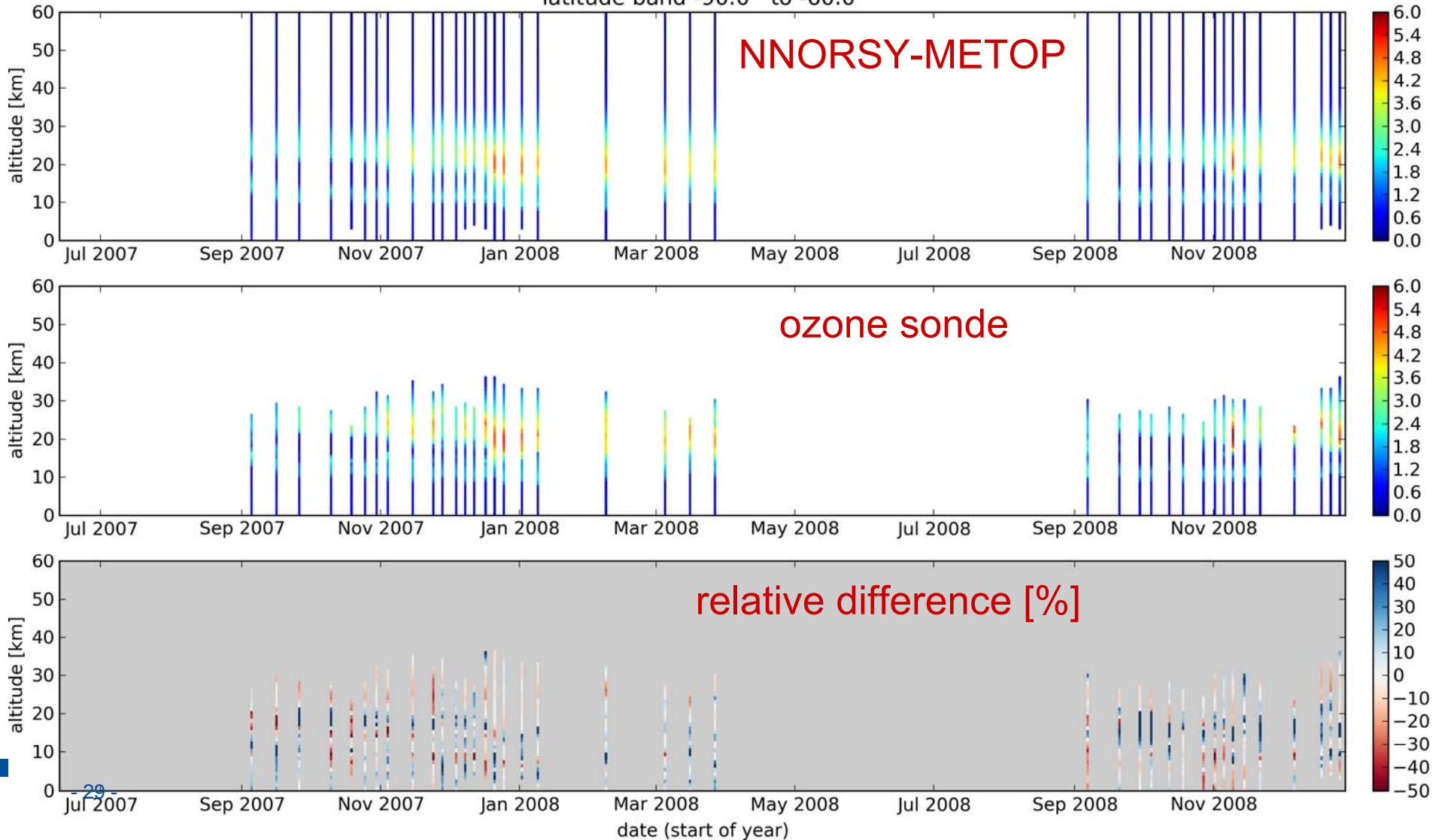
latitude band 30.0° to 60.0°



Validation Data: Single Station

Syowa: Antarctica

latitude band -90.0° to -60.0°



Backup