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A posteriori estimates of random uncertainties

Experience of the SUNLIT data homogenization and beyond

Viktoria Sofieva

Synergy of Using Nadir and Limb Instruments for Tropospheric ozone monitoring

- Scientific objective:

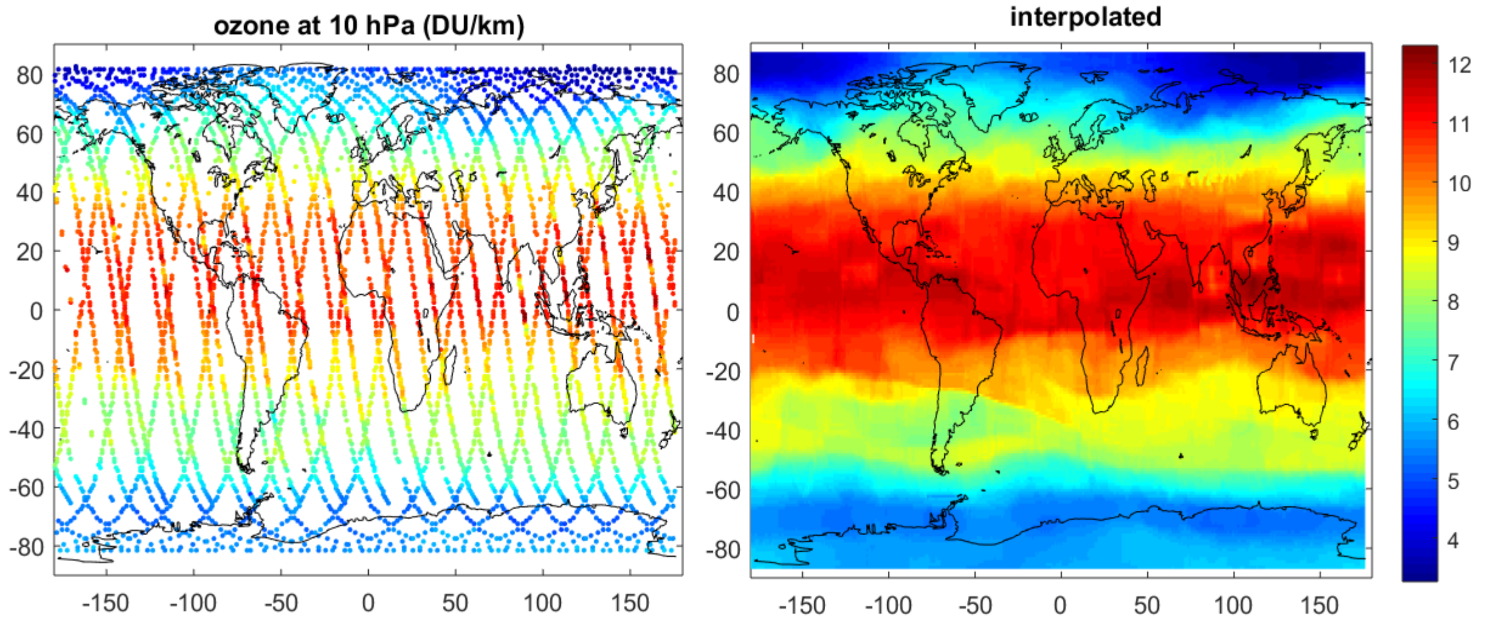
  Application of residual method to create tropospheric ozone column data

  - TROPOMI combined with MLS, OMPS-LP, OSIRIS
  - OMI combined with MLS, GOMOS, MIPAS, SCIAMACHY, OSIRIS, OMPS-LP

- Novelty and challenge: stratospheric ozone is estimated using data from several satellite instruments

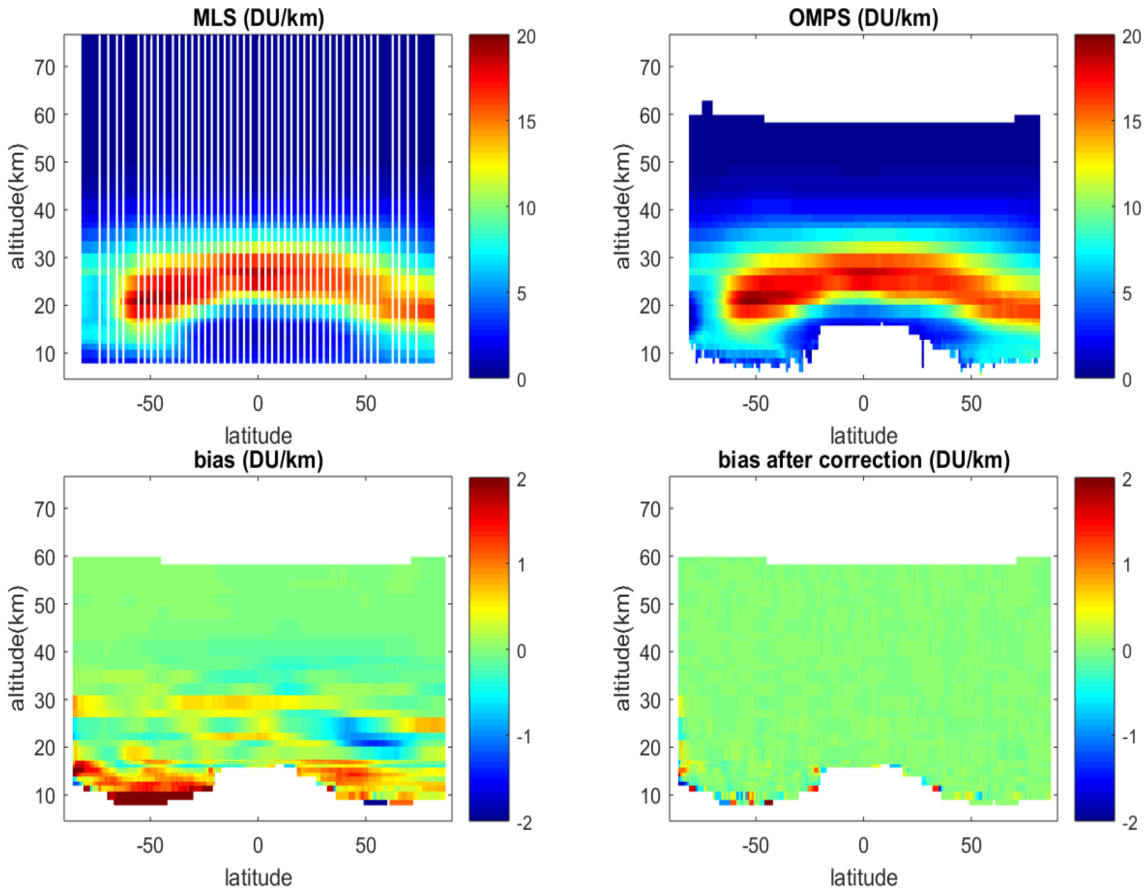
- New development: high vertical and horizontal resolution dataset of ozone profiles

  - Using the FMI chemistry-transport model SILAM for optimal data interpolation and improved data quality in the UTLS



Homogenization: bias correction

- This is an intermediate step in producing interpolated dataset of ozone profiles
- MLS is reference
- Biases are evaluated for each month and each latitude using 10° overlapping zones
- Biases are corrected   via adding latitude-dependent offset



Homogenization:
Validation/ a posteriori estimation of random uncertainties

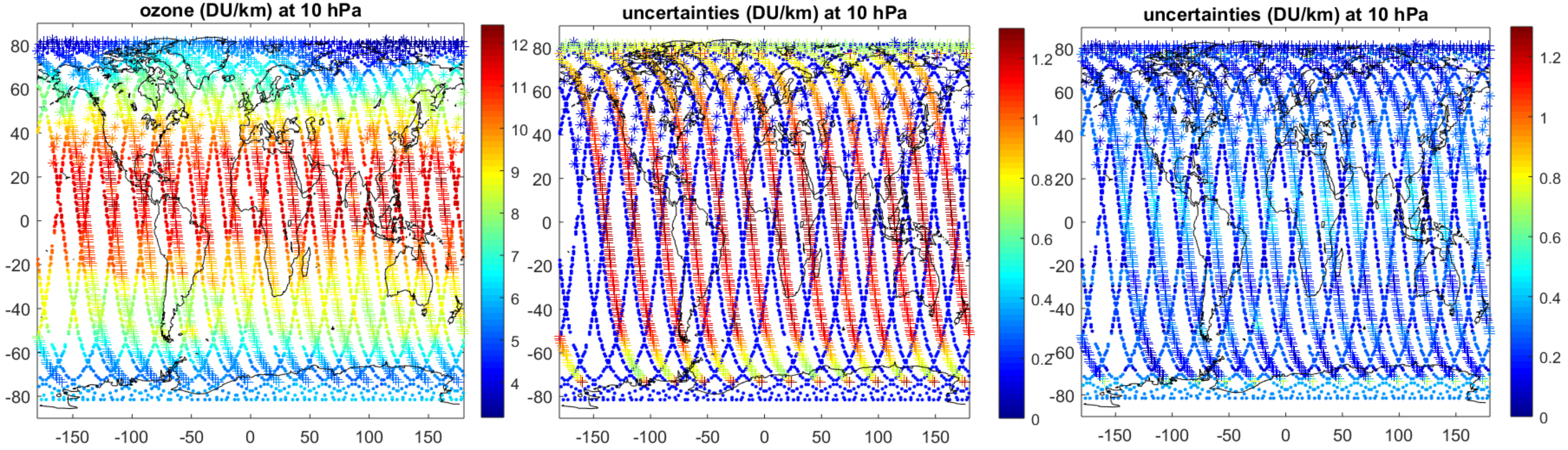
$$\sigma^2_{ex-poste} = s^2 - \sigma^2_{nat}$$

A-posteriori uncertainty

Sample variance

Natural variability from SILAM

$$\Delta = \sigma_{ex-poste} - \sigma_{ex-ante}$$



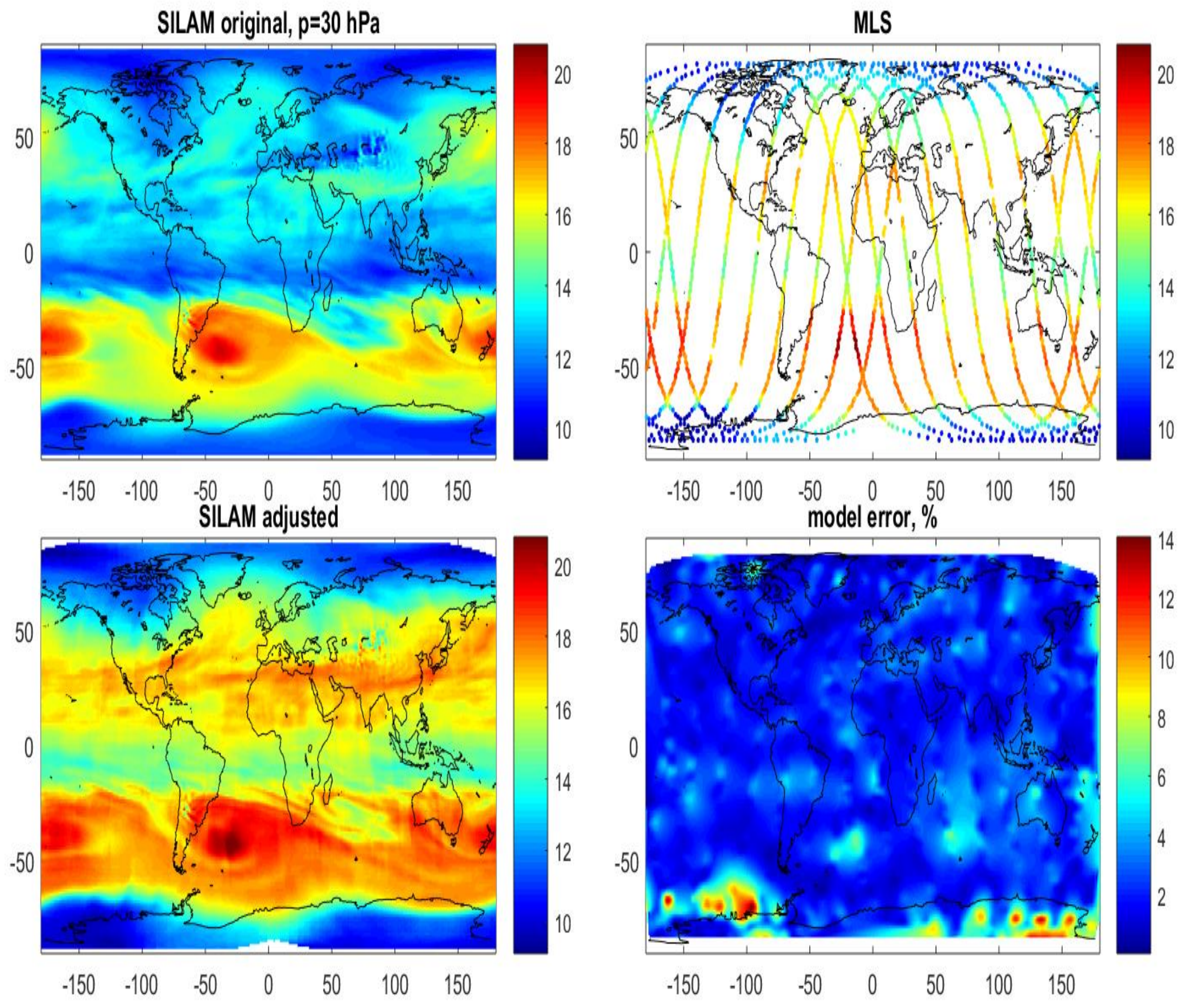
Debiased ozone at 10 hPa for 1 Sep 2018 (left), corresponding original uncertainties (center), and corrected uncertainties (right). MLS data are indicated by dots, OSIRIS - by stars and OMPS by plusses.

Technical realization

- SILAM is used for evaluation of natural variations
  - SILAM is debiased to MLS
- Latitude and altitude dependent uncertainty offset is evaluated for each month in 10° latitude zones

$$\Delta = \sigma_{ex-poste} - \sigma_{ex-ante}$$

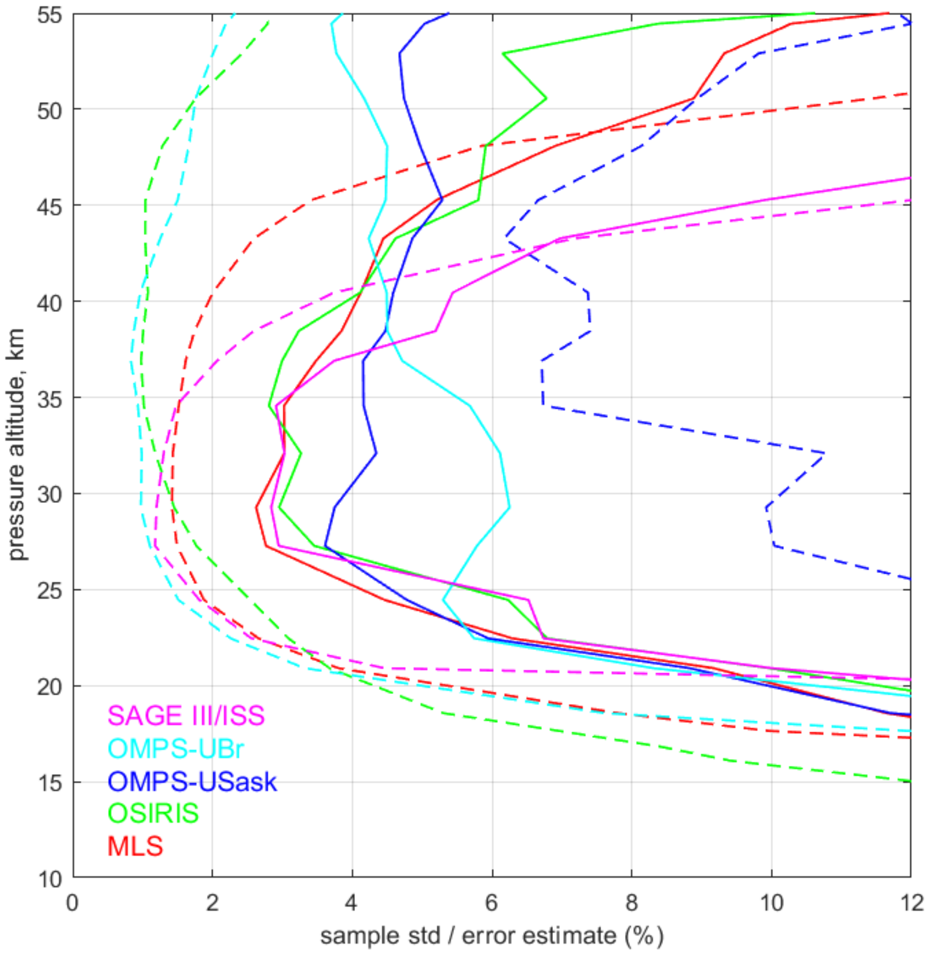
- This simple correction of the uncertainty estimates makes them comparable
- By the construction, the derived a posteriori uncertainty estimated are also compatible with the observed ozone variability

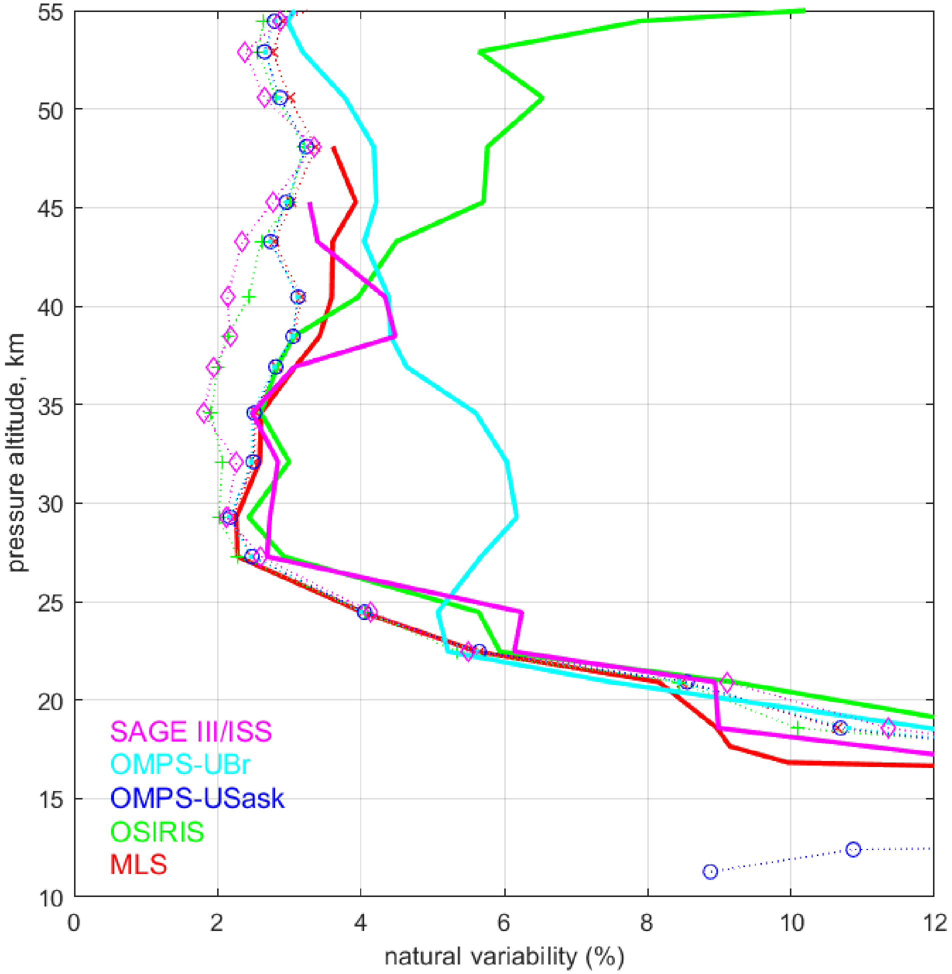


Is the method suitable for validation of random uncertainties?

- Sensitivity
- Limitations

Sample standard deviation and uncertainties in the tropics (20S-20N)

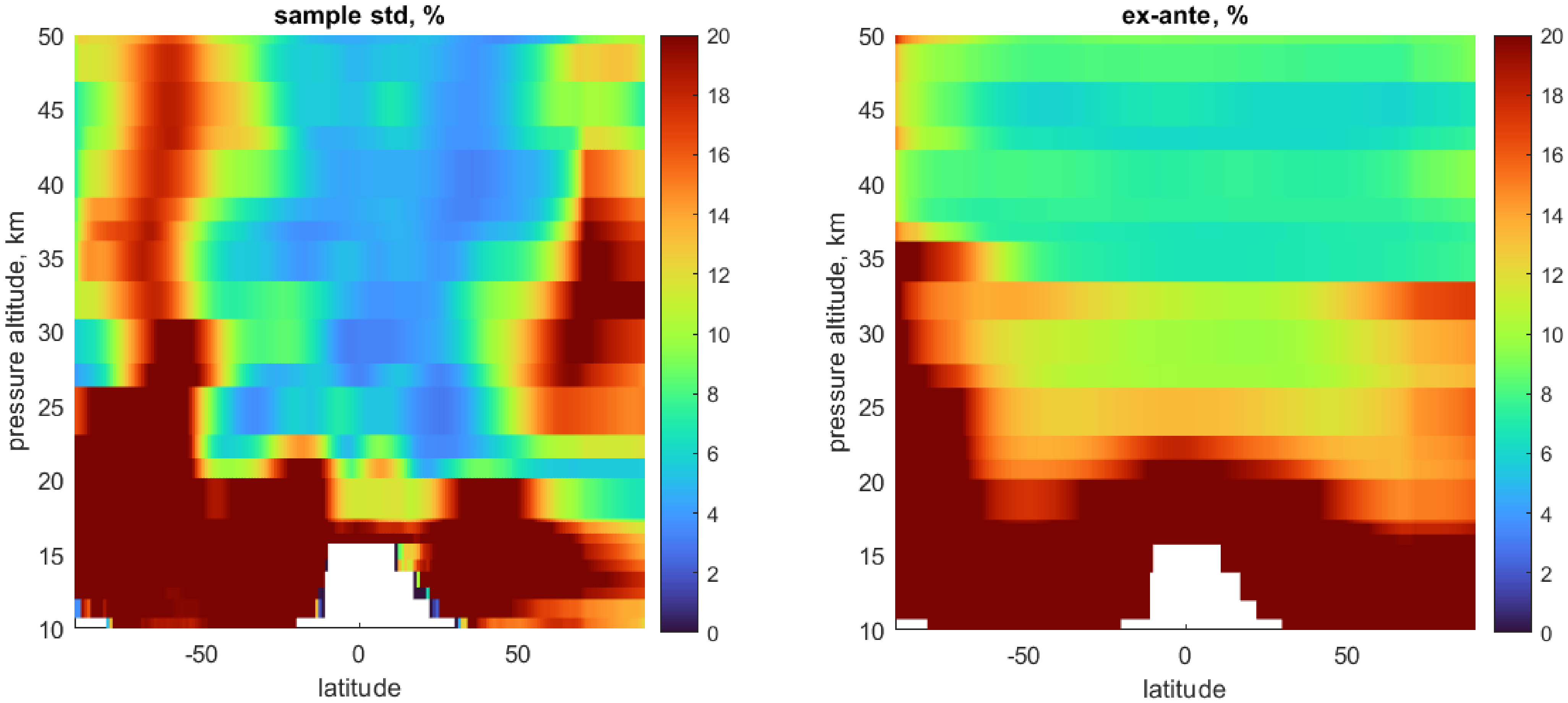




- Largely overestimated uncertainties for OMPS-Usask
- MLS and SAGE III: Overestimation at upper altitudes
- OMPS- Ubr: increased sample std is not reflected in errorbars

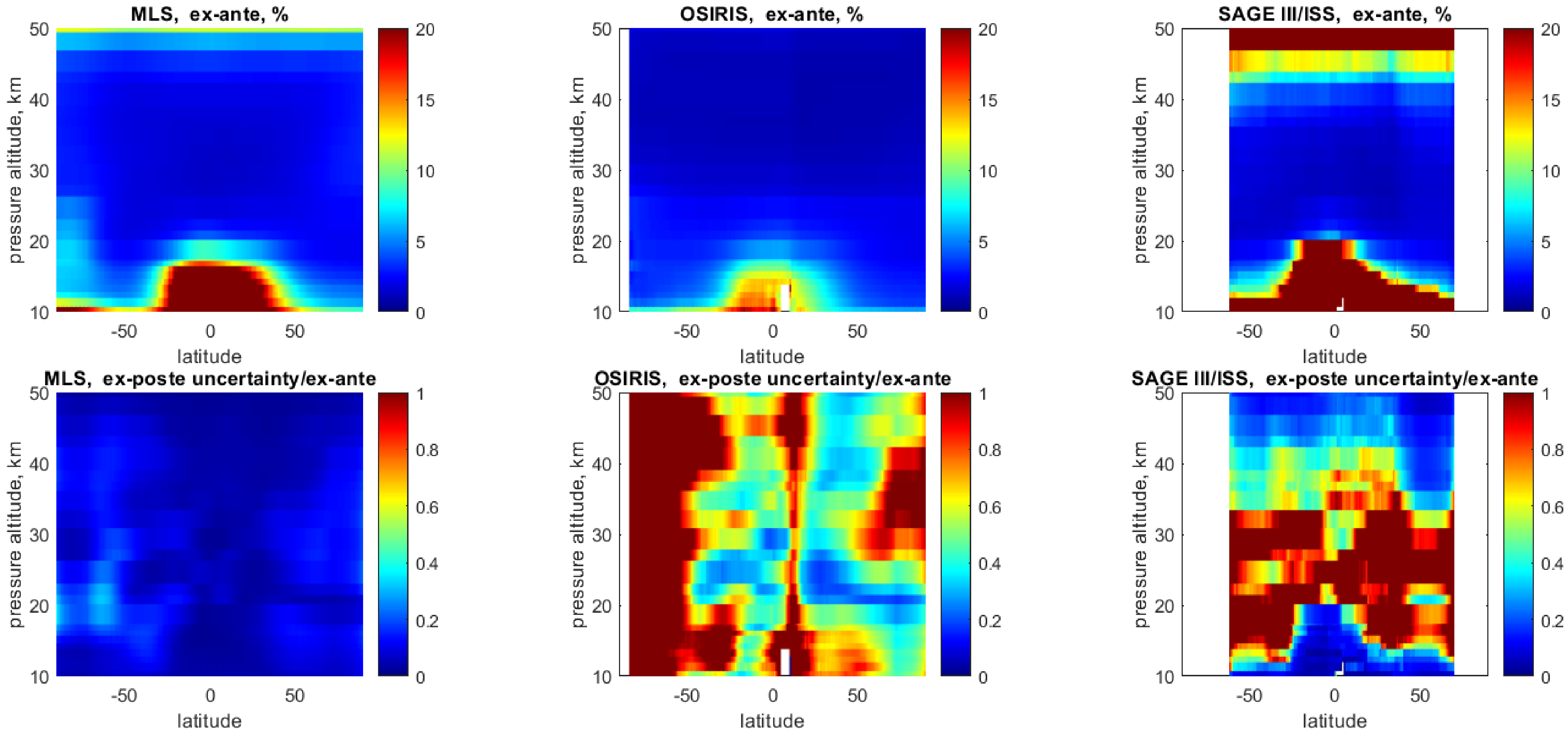
- Adjusted-SILAM variability is very close to that from MLS
- OMPS-Ubr reports larger variability

Evident case: overestimated uncertainty for OMPS-USask



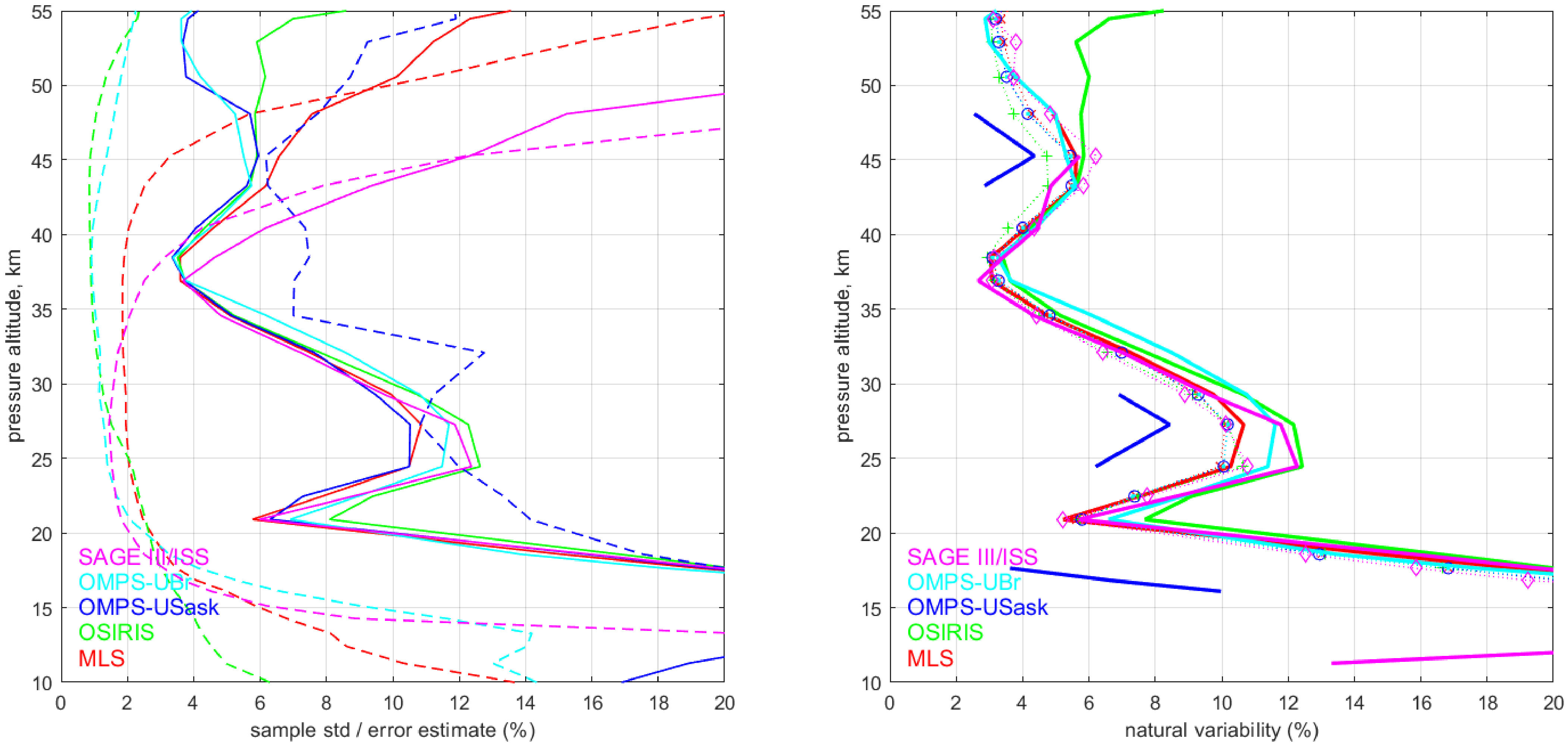
Sep 2018

Uncertainty of ex-poste estimate



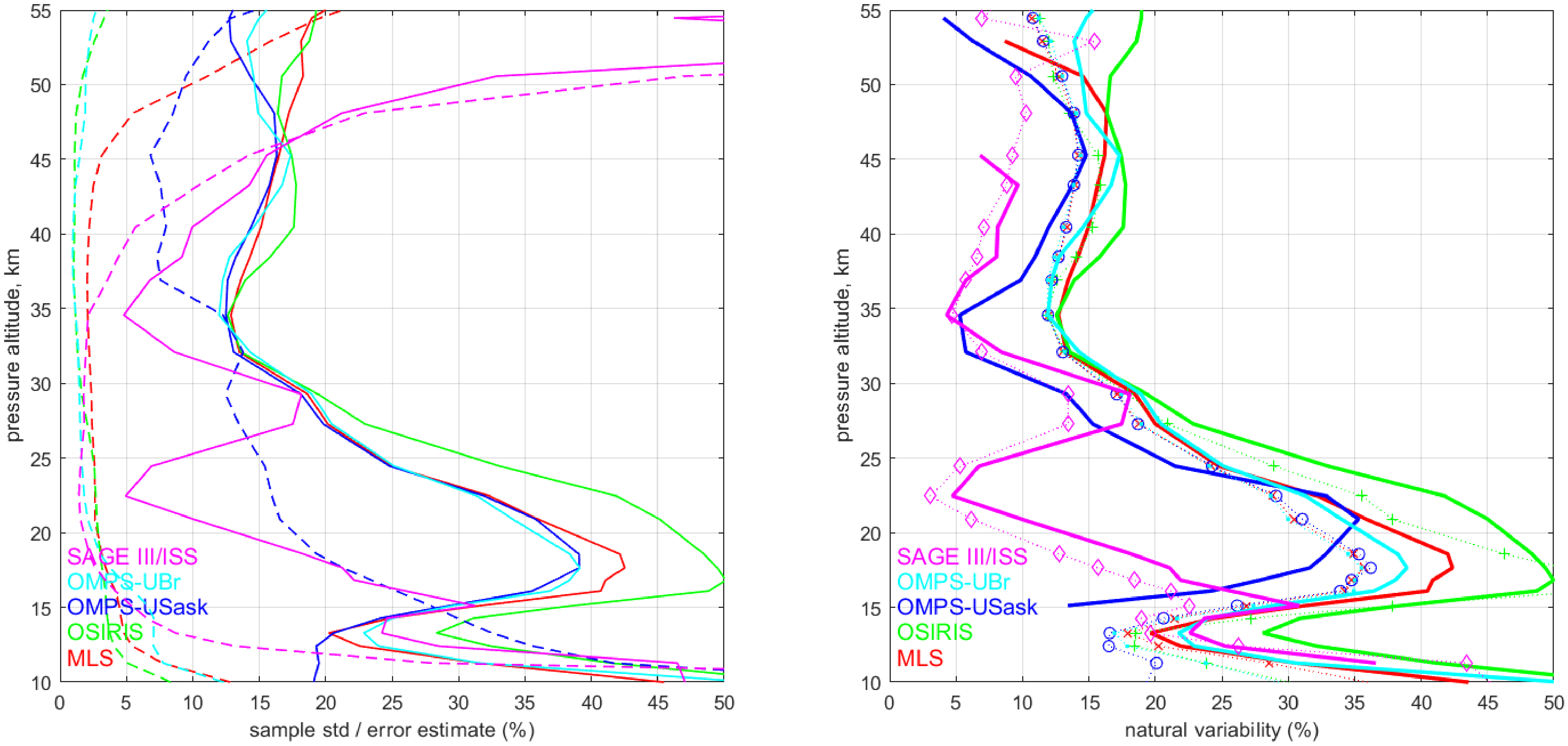
Ex-poste uncertainty = sample_std* 2/sqrt(N)

Sample standard deviation , uncertainties, variability at 40-60N



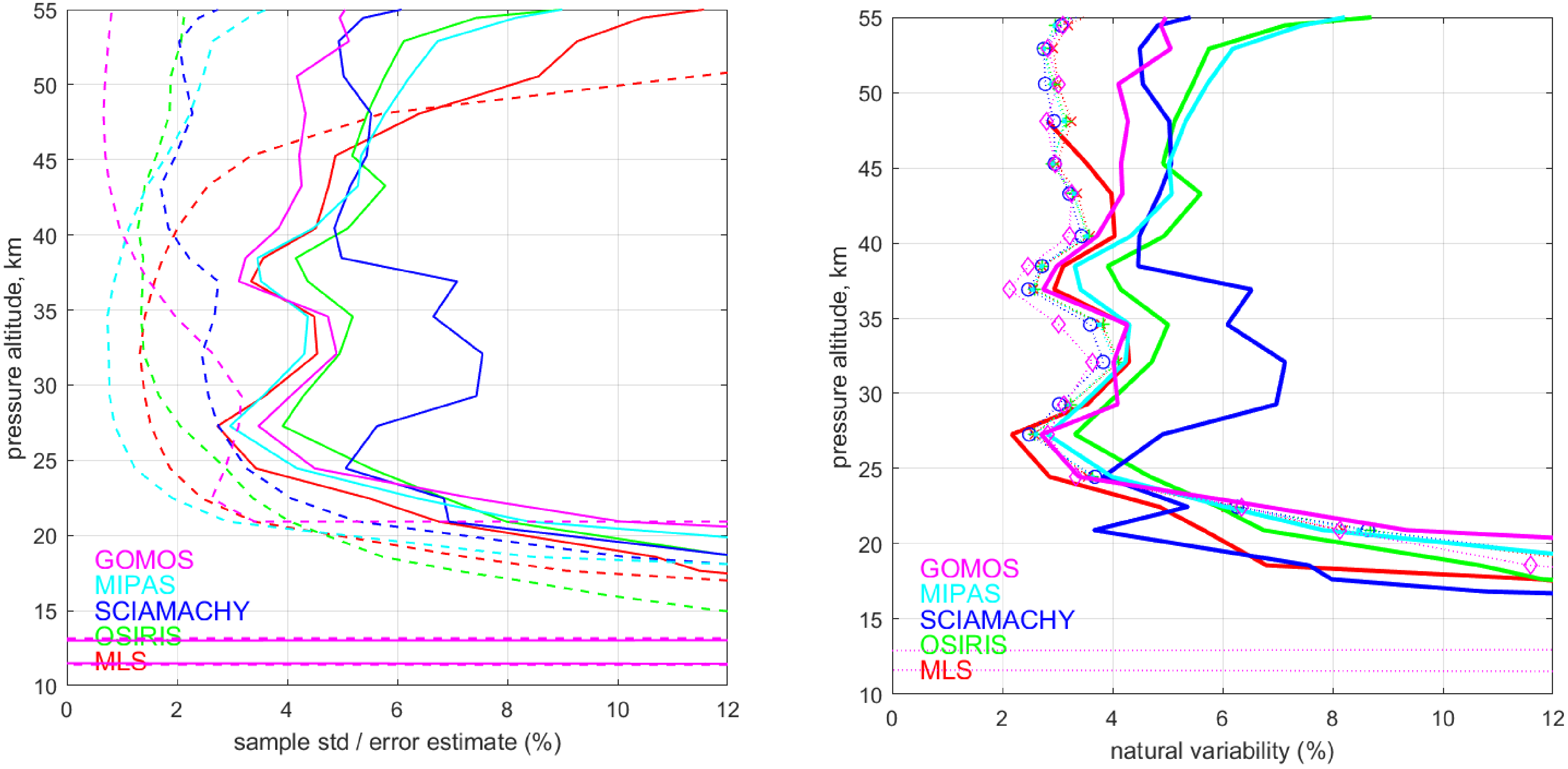
- Analogous behavior of OMPS- Usask
- Larger natural variability estimates in model and observations
  - Nearly perfect agreement with MLS
  - Experimental is ~2 % larger in other datasets

Sample standard deviation , uncertainties, variability at 50-70S



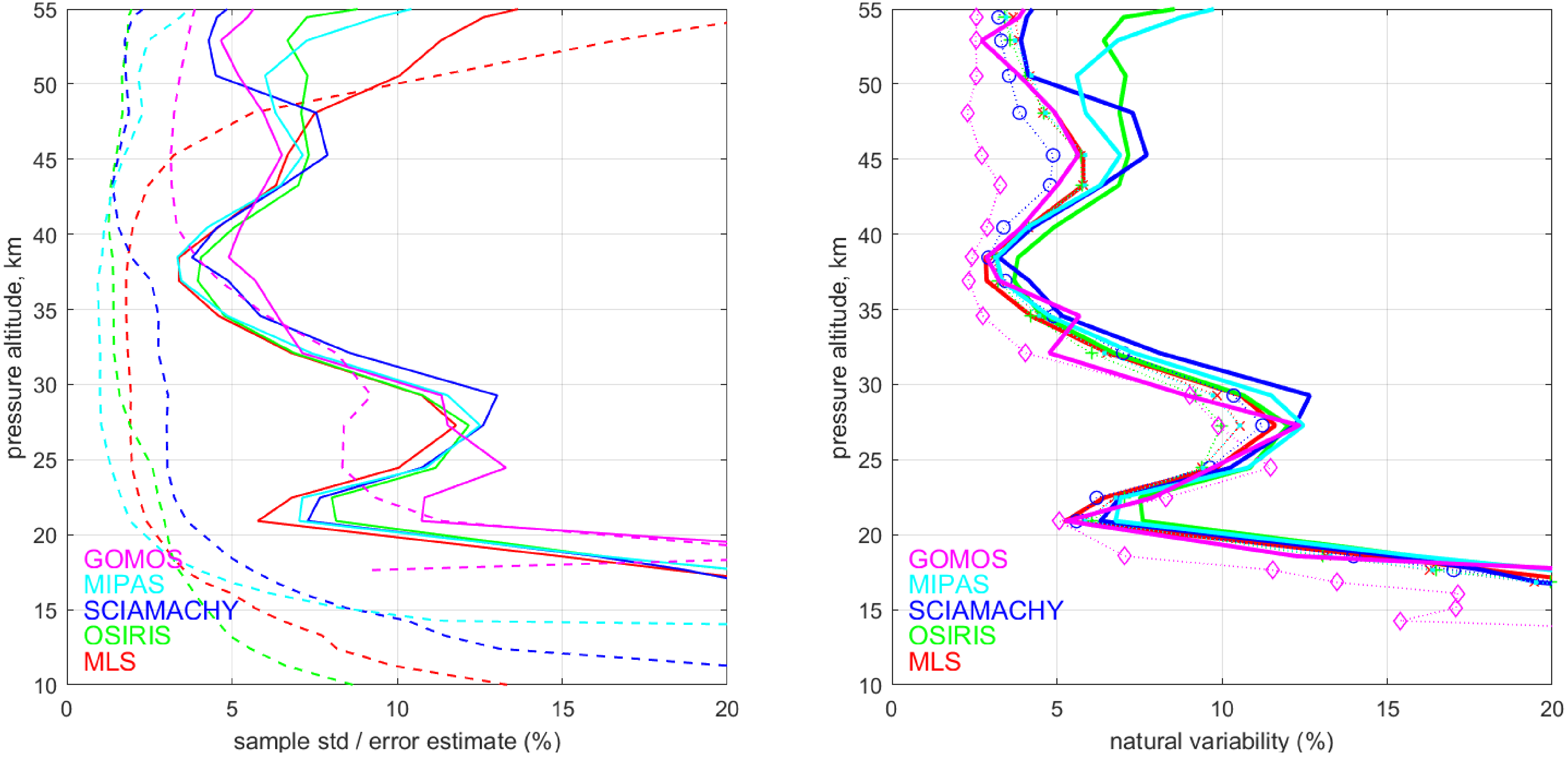
- Very large variability
- Estimates of natural varibility is different because of instrument sampling
- Model captures well the varibility, but it is slighly smaller than in experimental data

September 2008, 20S-20N



- Good consistency of natural variability estimates from GOMOS, MLS, SCIA, and OSIRIS
- Larger variability for SCOAMACHY, which is not explaned by reported uncertainties

September 2008, 40-60 N



- Nearly perfect agreement between datasets and between model and observations

Conclusions and discussion

- Largely overestimated error estimates can be easily detected by comparison of sample std in the tropics
- Observations related to the SUNLIT processing
  - SILAM ozone field adjusted to MLS describes rather realistically zonal ozone variability
  - Evident problems with uncertainty estimates are detected and corrected
  - Processing development
    - Uncertainty correction in polar regions can be extrapolated from tropics/mid-latitudes
    - It is probably not needed to correct uncertainties from OSIRIS, GOMOS, MIPAS, and MLS
    - It is probably better to use pure ex-poste uncertainty for OMPS-Usask (without correcting at daily level)