Closing the error budget of atmospheric data comparisons:

An essential prerequisite for accurate and informed satellite validation

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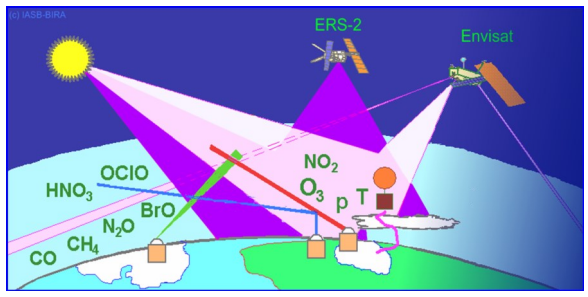
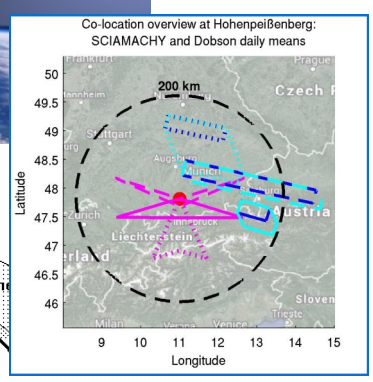
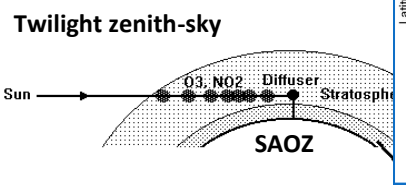
Rationale

With ever-increasing atmospheric EO data accuracy and resolution, proper interpretation of validation results requires now a corresponding effort to better understand the comparison error budget. Missing components of this budget include uncertainties of metrological nature: spatial and temporal co-location mismatch in presence of atmospheric gradients and variability, differences in horizontal and vertical smoothing of atmospheric gradients (cfr. the sketch on the right-hand side), and differences in pseudo-global sampling of patterns. To this end, we present a versatile metrology simulator for atmospheric remote sensing systems: OSSSMOSE, Observing System of Systems Simulator for Multi-missiOn Synergies Exploration. A few applications illustrate how the system can be used to analyze co-location mismatch, smoothing differences and representativeness issues.



A versatile simulator of atmospheric remote sensing systems





Module 2: Metadata from Module 1 are used to build up **observation operators**. These describe the airmass to which the observation is sensitive. They can be simple assumptions such as e.g. the satellite footprint and the 100km radius around a station. They can also be more complex and describe the multi-dimensional airmass contributing information to the retrieved value (magenta and cyan polygons in right-hand graph).

OSSSMOSE

Observing systems metadata library — 1

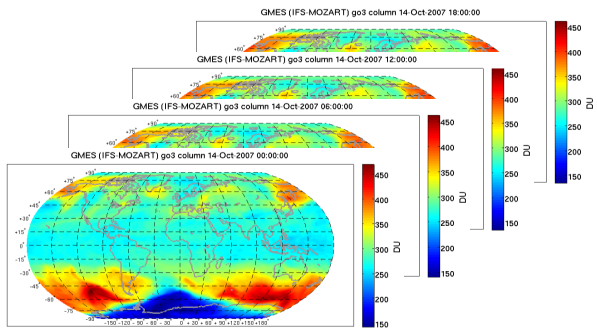
Multi-dimensional observation operators library — 2

High resolution atmospheric fields library — 3

Satellite

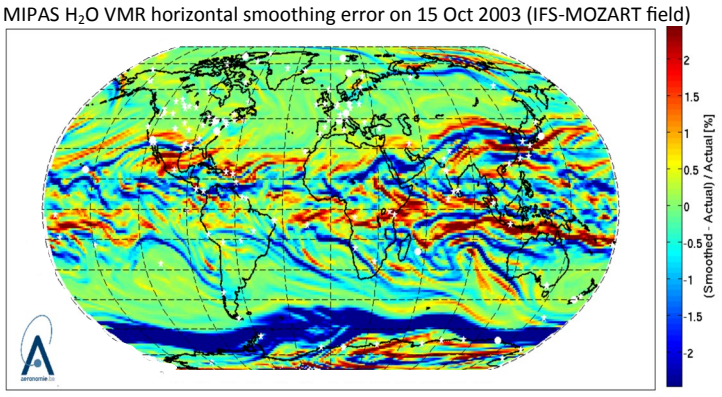
Sub-orbital

Module 1: Starting point of the simulations are either existing or virtual **observing system metadata**, including information such as observation date and time, pixel coordinates or station geolocation, ground altitude, measurement geometry, radiation source and spectral range, solar zenith and azimuth angles…

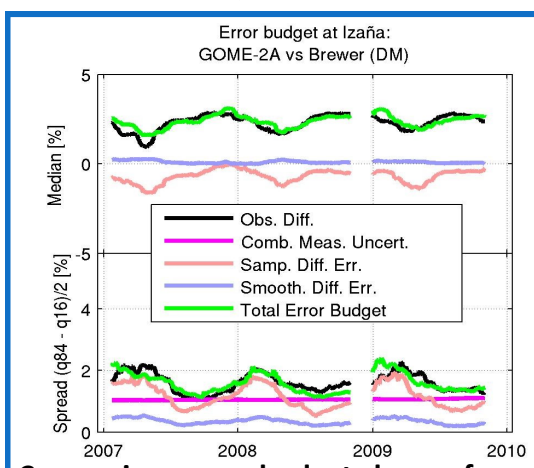


Module 3: The system simulates each observation by applying the set of specific observation operators from Module 2 onto **high-resolution atmospheric fields**, e.g. from reanalyses (ERA-I, MERRA, IFS-MOZART).

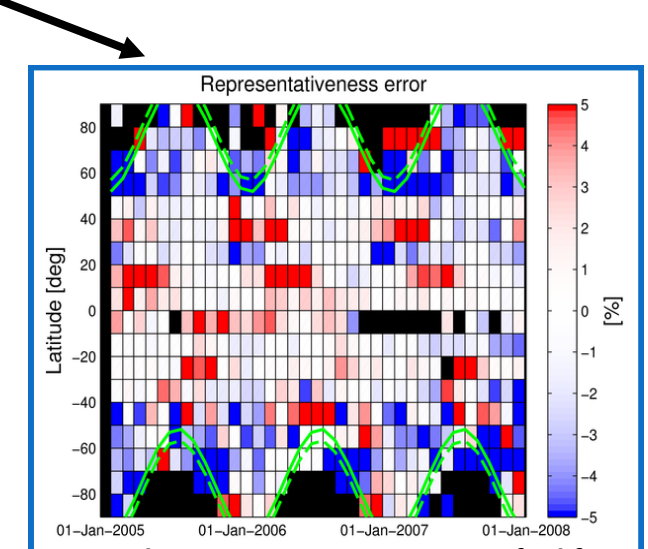
Application: Quantifying metrological errors associated with an observation and with a data comparison



Estimating horizontal smoothing errors for MIPAS limb retrievals of H_2O VMR. This simulation uses MIPAS horizontal averaging kernels (von Clarmann et al., 2009) as a proxy for the actual multi-dimensional sensitivity. In October 2003, a systematic offset of the actual measurement sensitivity at 18km w.r.t. the tangent point, in combination with a dry polar vortex, leads to a marked underestimation of the actual H_2O VMR around 70°S. See Lambert et al. (2012) for further work on H_2O.



Comparison error budget closure for total O_3 column validation. Taking into account comparison errors due to spatio-temporal sampling and smoothing differences between the satellite and the ground-based reference measurements, the spread and median of the ozone differences can be brought into agreement with the measurement uncertainties (Verhoelst et al., 2015).



Network representativeness quantified for level-3 total O_3 column validation. Zonal monthly means derived from the NDACC and WMO/GO3OS ozone monitoring stations can be expected to differ from zonal monthly means derived from a satellite global product by up to 5% and more (Coldewey-Egbers et al., 2015), revealing the need for alternative validation strategies.

References

Von Clarmann, T. et al., AMT v2, p47, 2009
Coldewey-Egbers, M. et al., AMTD v8, p4607, 2015
Lambert, J.-C. et al., ISSI book, ch9, p177, 2012
Verhoelst, T. et al, submitted to AMTD, 2015

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