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Institut d'Aéronomie spatiale de Belgique (IASB)
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Error budget closure of satellite total ozone validation

based on NDACC/GAW ground-based reference measurements

Tijl Verhoelst, Jean-Christopher Lambert, and José Granville

NORS/NDACC/GAW workshop, 5-7/10/2014, Brussels

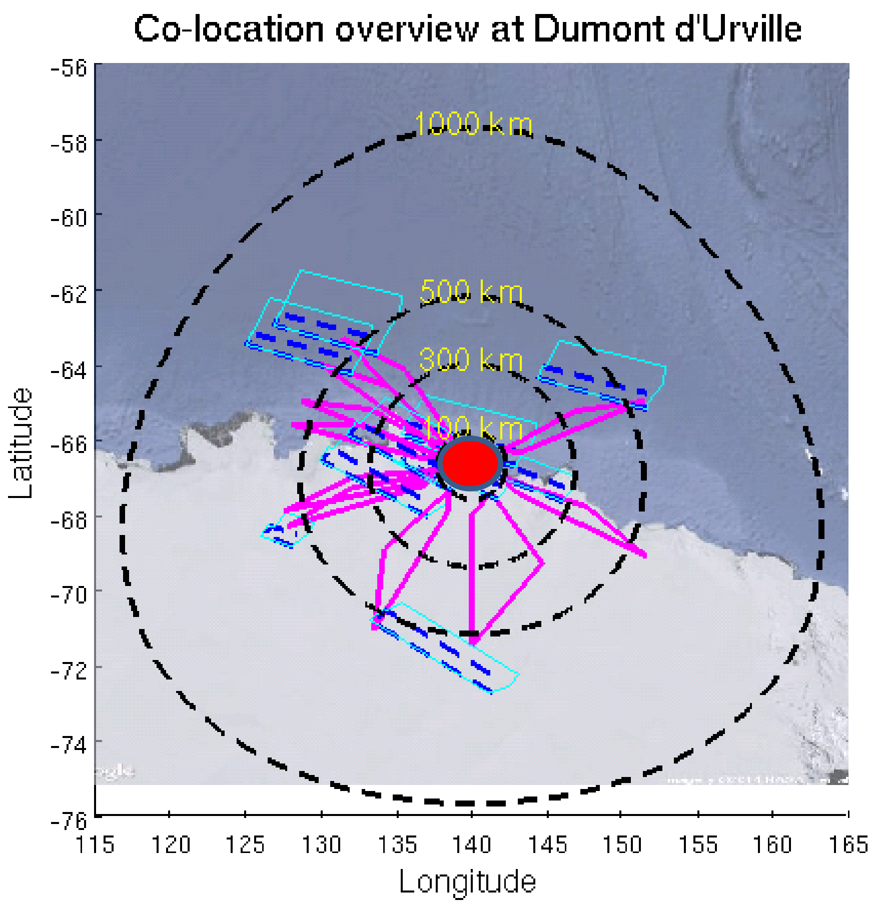
Rationale and outline

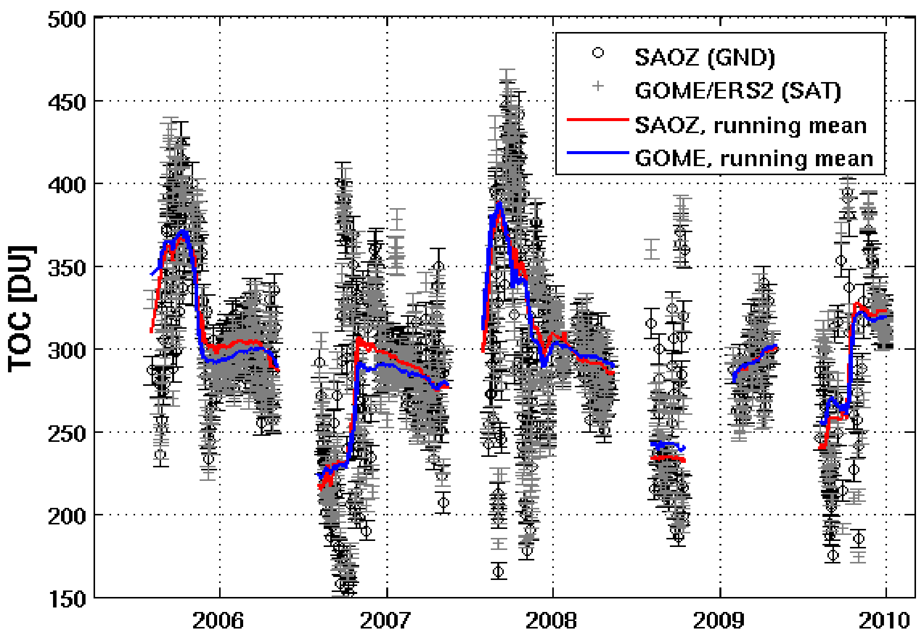
Interpretation of the comparisons between satellite and ground-based total ozone measurements in terms of data quality requires a **quantified understanding** of **all terms** contributing to the **error budget** of the comparisons.

- An example of satellite-ground comparisons
- The error budget
- An Observing System Simulation Experiment (OSSE), including detailed metrology
- Case studies
- Different co-location criteria
- Conclusions and prospects

Satellite vs. ground based TOC measurements

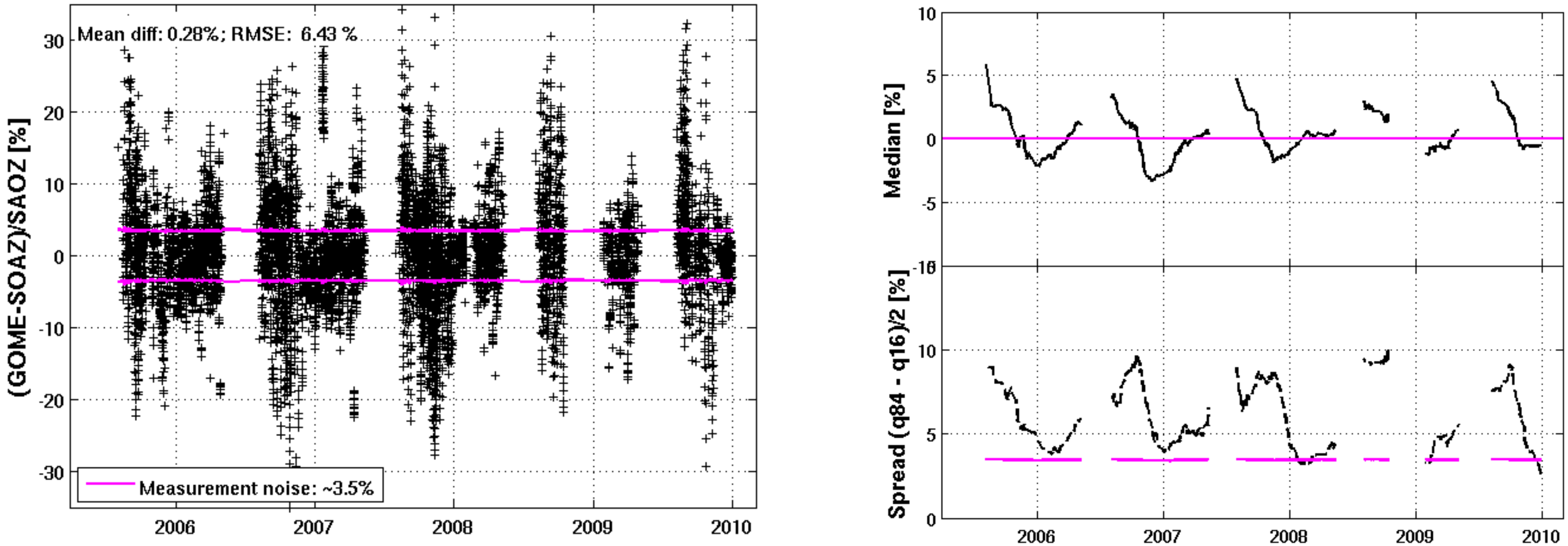
Example: GOME/ERS-2 (ESA Ozone_cci GODFITv3) vs. NDACC SAOZ (Latmos_v2) total ozone at Dumont d'Urville (Antarctica):





The error budget of TOC comparisons

GOME/ERS-2 (ESA Ozone_cci GODFITv3) vs. NDACC SAOZ (Latmos_v2) total ozone at Dumont d'Urville (Antarctica):



Bias and spread exceed combined measurement uncertainty.

Measurement uncertainty:

- ❖ GOME GODFITv3: 1.6-2.7% random (depending on SZA), 3.6-5.3% systematic; Lerot et al. 2014
- ❖ SAOZ (LATMOS v2): 3.3 – 4.7% random (depending on clouds), 3.6% systematic; Hendrick et al. 2011

Error budget of TOC comparisons

$$S_{diff,random} = S_{sat,random} + S_{gnd,random} + S_{smoothingdiff,random} + S_{spatialmismatch,random} + S_{temporalmismatch,random}$$

$$S_{diff,sys} = S_{sat,sys} + S_{gnd,sys} + S_{smoothingdiff,sys} + S_{spatialmismatch,sys} + S_{temporalmismatch,sys}$$

How significant are the errors due to sampling mismatches and smoothing differences?

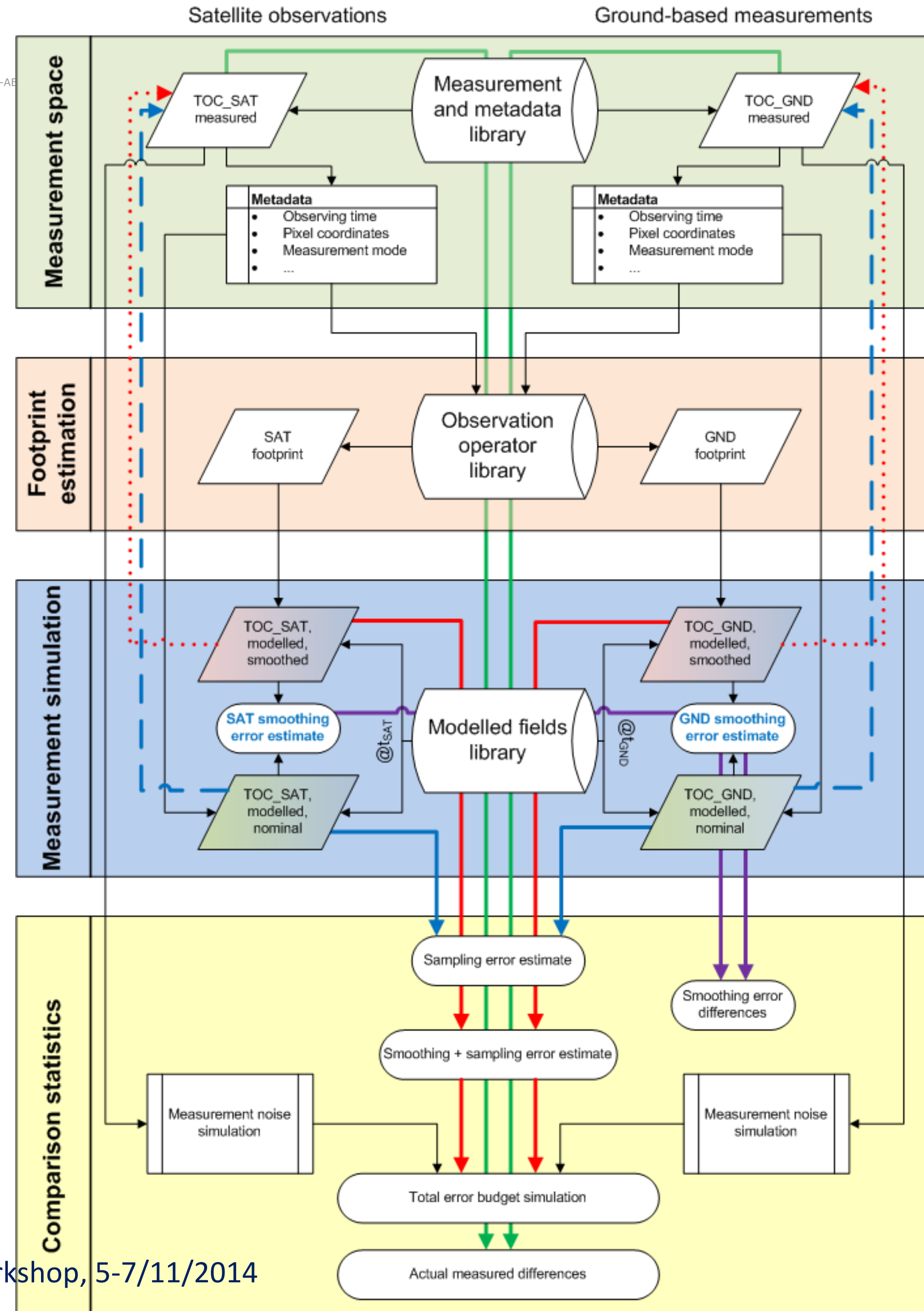
Develop a metrology OSSE to quantify those missing terms.

Observing System Simulation Experiment

Principle:

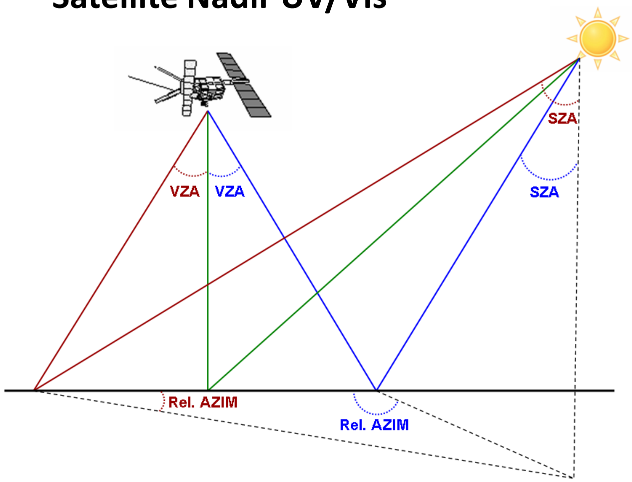
Apply observation operators, specified following the actual observation metadata and observing conditions, on global gridded fields of appropriate resolution, to simulate the observations and their differences

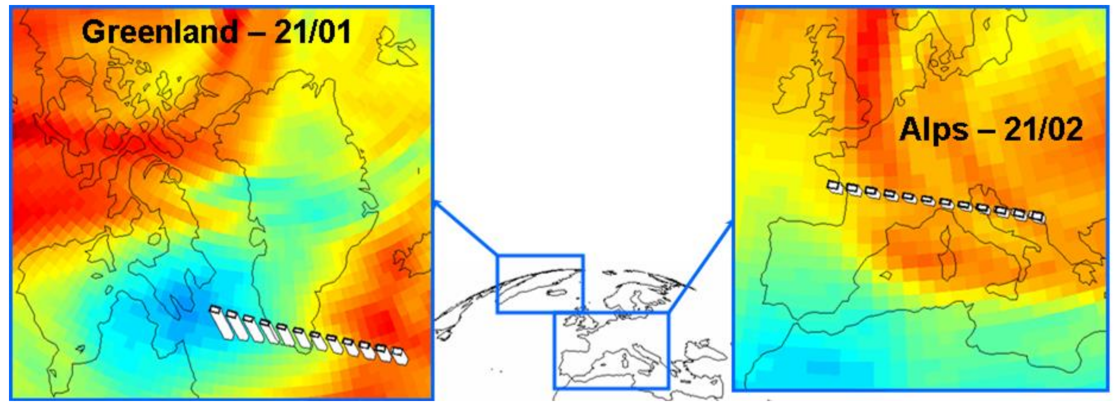
OSSSMOSE flow chart for SAT-GND TOC comparison error budget simulations



Metrology OSSE: *The observation operators*

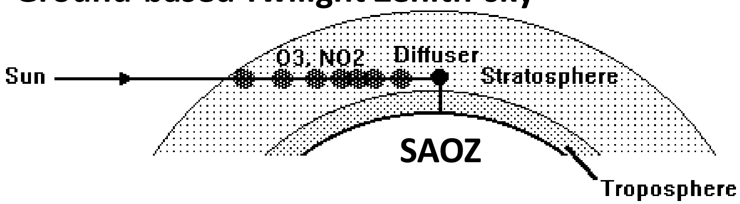
Satellite Nadir UV/Vis

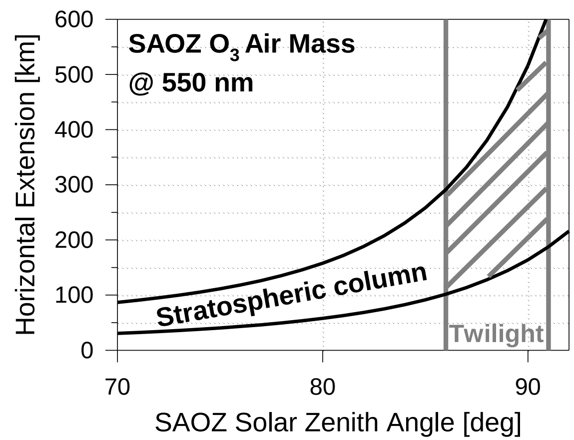


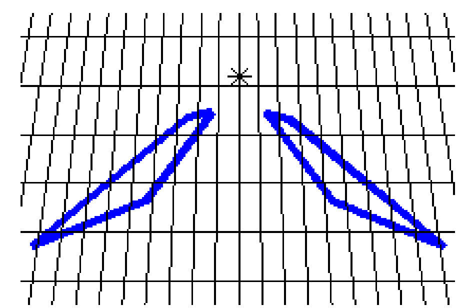


Vandenbussche et al., EC FP6 GEOmon Tech. Note D4.2.2, BIRA-IASB, 2009

Ground-based Twilight Zenith-sky

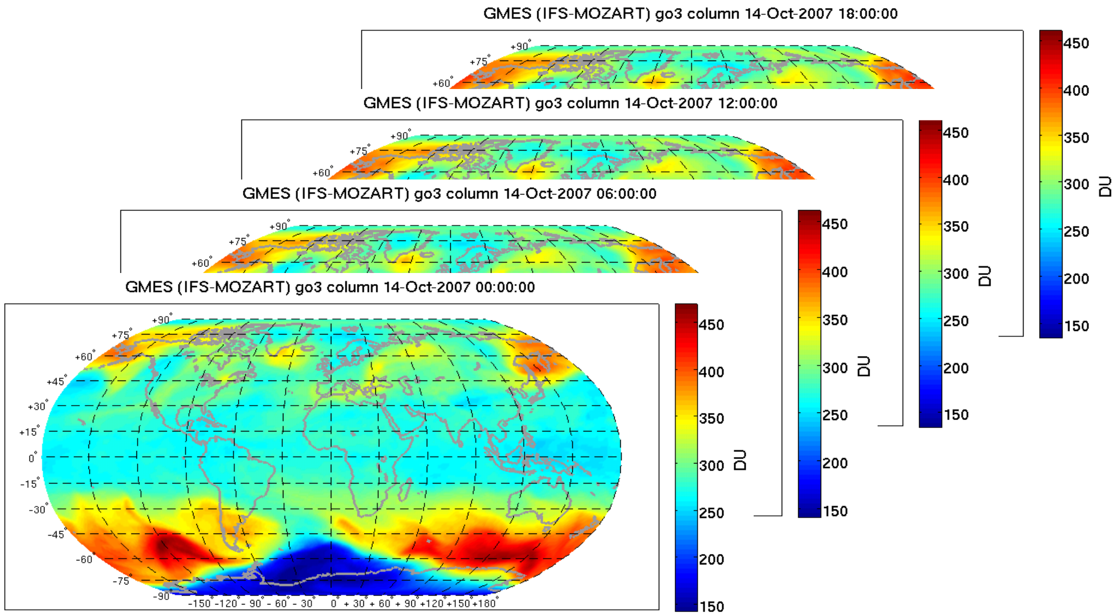






Lambert et al., EC FP6 GEOmon Tech. Note D4.2.1, BIRA-IASB, 2009

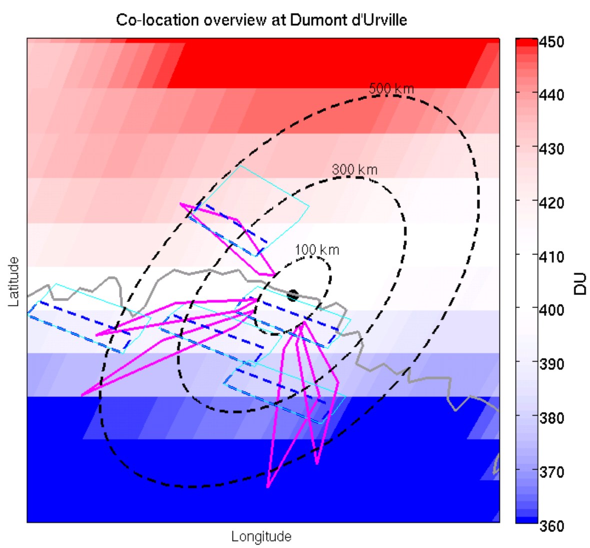
Metrology OSSE: *The global gridded data*

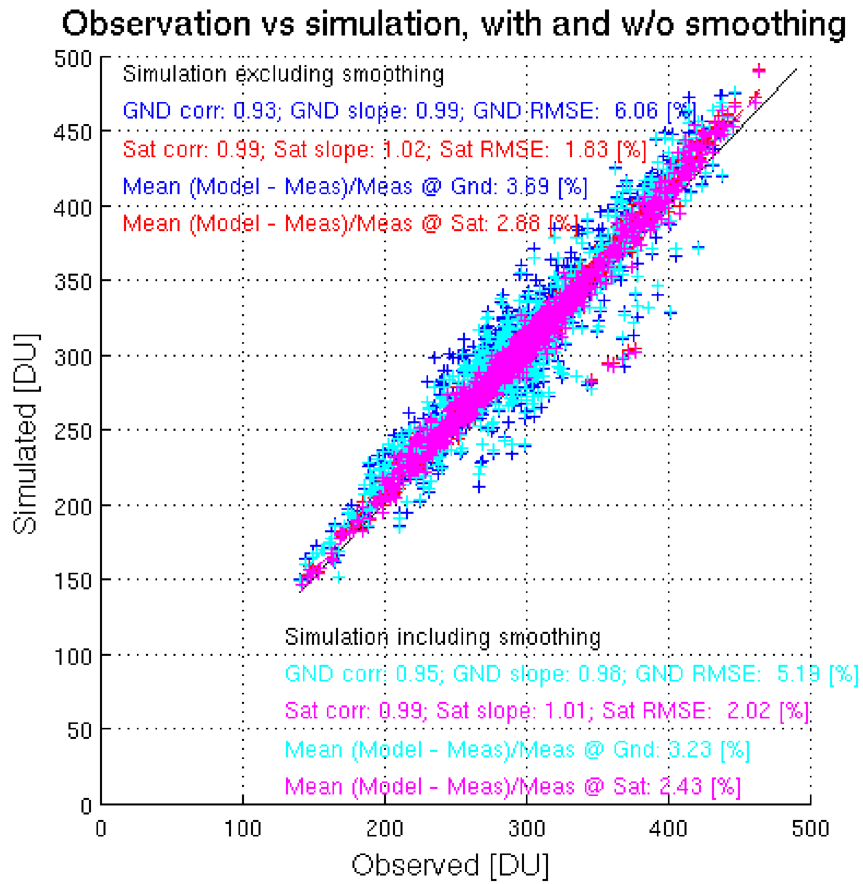


Name	Office	Time step	Lat-lon grid	Vertical grid	Assimilated ozone obs.
ERA-I	ECMWF	6-hourly	1.0° x 1.0°	60 levels	TOMS, SBUV, SCIA, GOME, MIPAS, OMI, MLS
MACC	ECMWF	6-hourly	1.125° x 1.125°	60 levels	GOME, MIPAS, SCIA, SBUV, OMI, MLS
MERRA	NASA GMAO	3-hourly	1.25° x 1.25°	42 levels	SBUV2

Metrology OSSE: *Simulated observations*

GOME/ERS-2 (ESA Ozone_cci GODFITv3) vs. NDACC SAOZ (Latmos_v2) total ozone at Dumont d'Urville (Antarctica):





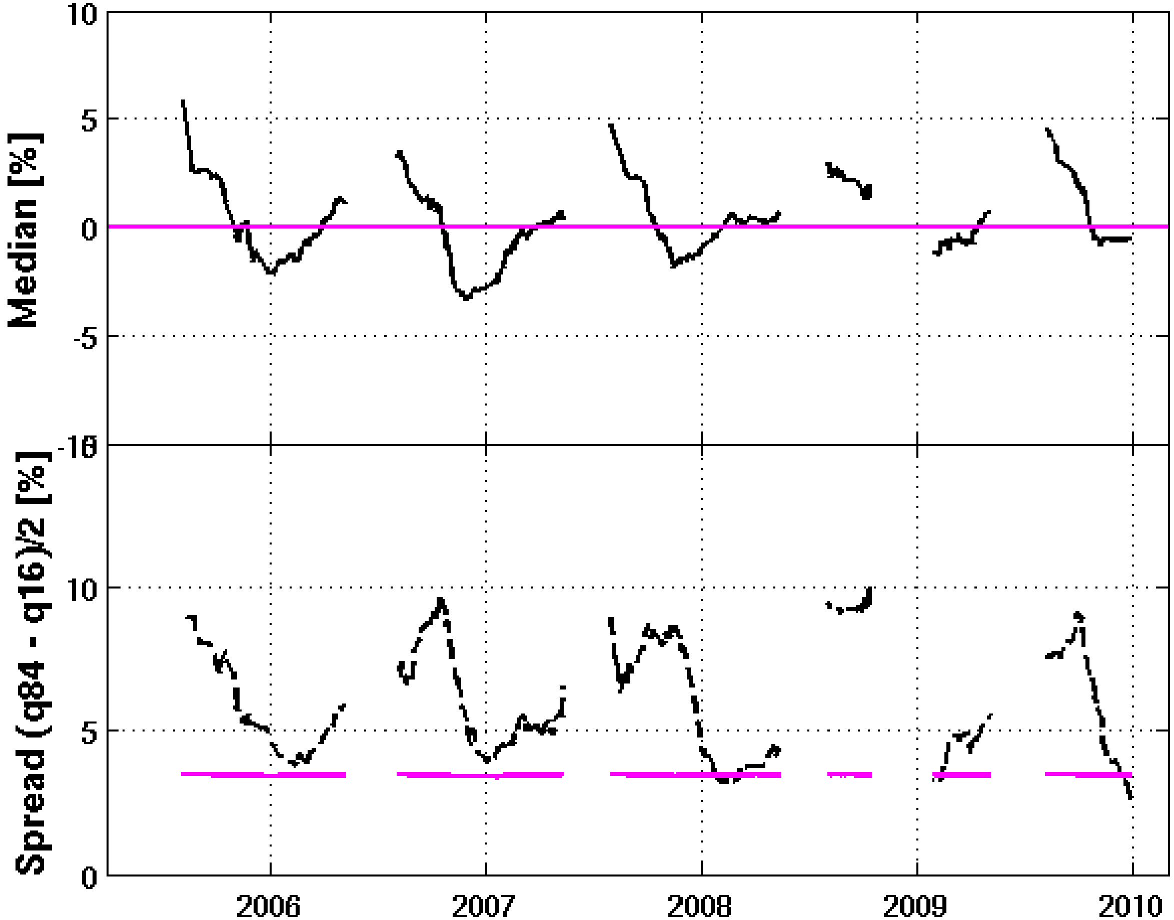
Agreement between IFS-MOZART simulated observations and both GOME and SAOZ real measurements is close to the measurement uncertainty.

MACC (IFS-MOZART) fields

Metrology OSSE: *Simulated comparisons*

GOME/ERS-2 (ESA Ozone_cci GODFITv3) vs. NDACC SAOZ (Latmos_v2) total ozone at Dumont d'Urville (Antarctica):

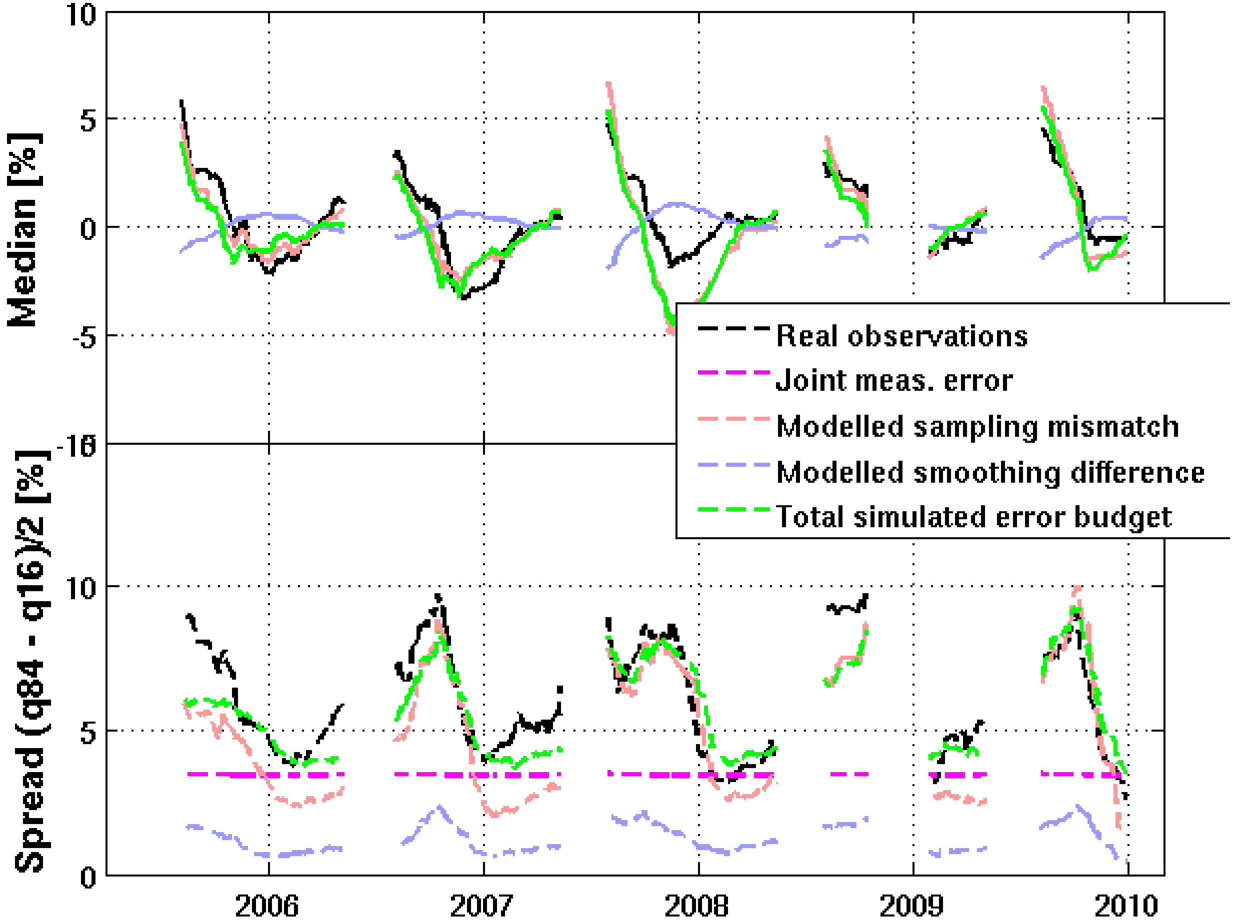
Bias and spread exceed the combined measurement uncertainty



Metrology OSSE: *Simulated comparisons*

GOME/ERS-2 (ESA Ozone_cci GODFITv3) vs. NDACC SAOZ (Latmos_v2) total ozone at Dumont d'Urville (Antarctica):

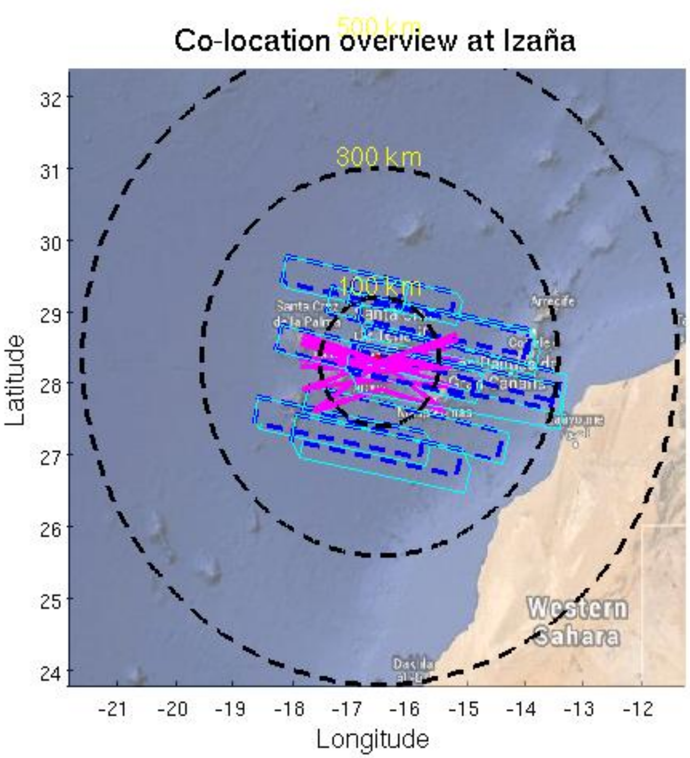
The simulations match the measured differences quantitatively, and they consistently reproduce the seasonal behaviour of both bias and spread.

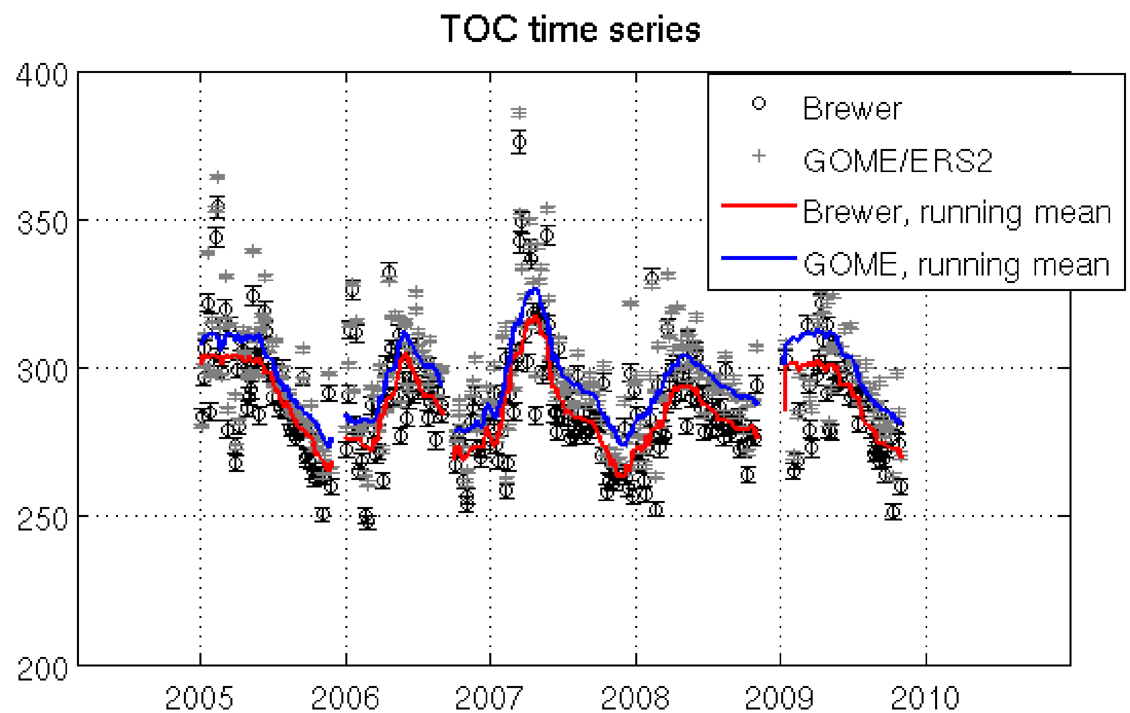


Metrology OSSE: *Simulated comparisons*

2nd Case study: a subtropical direct-sun instrument as a reference:

GODFITv3 GOME/ERS2 vs the Izana Brewer, using D150 co-locations.





Metrology OSSE: *Simulated comparisons*

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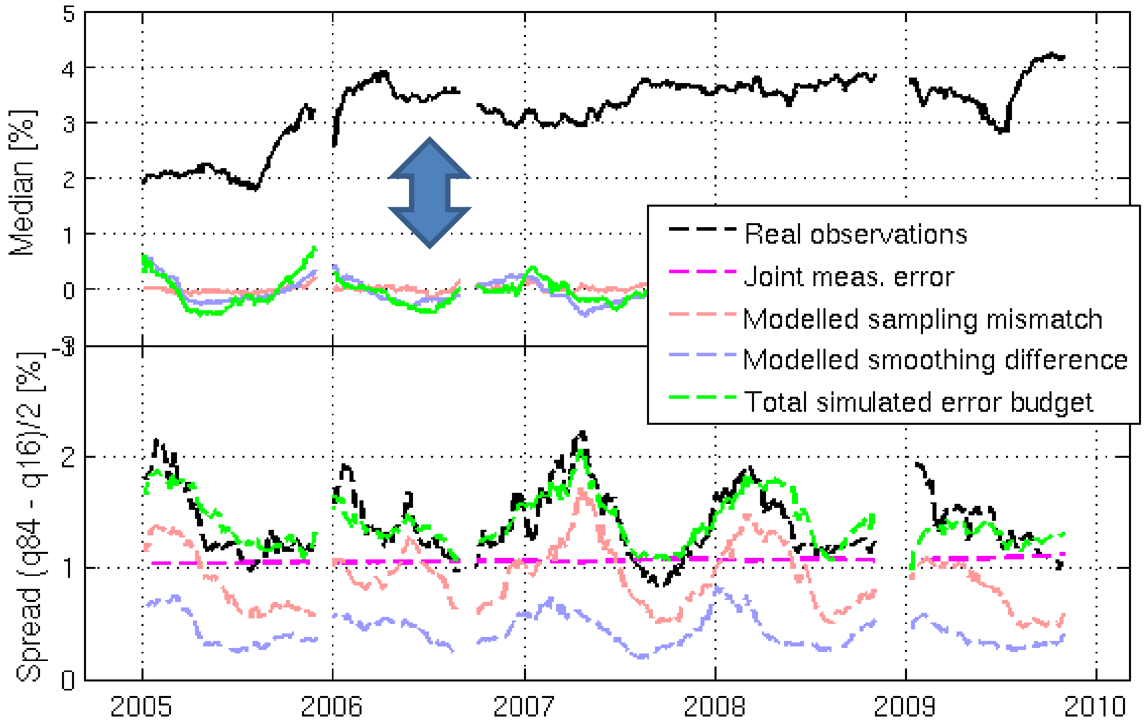
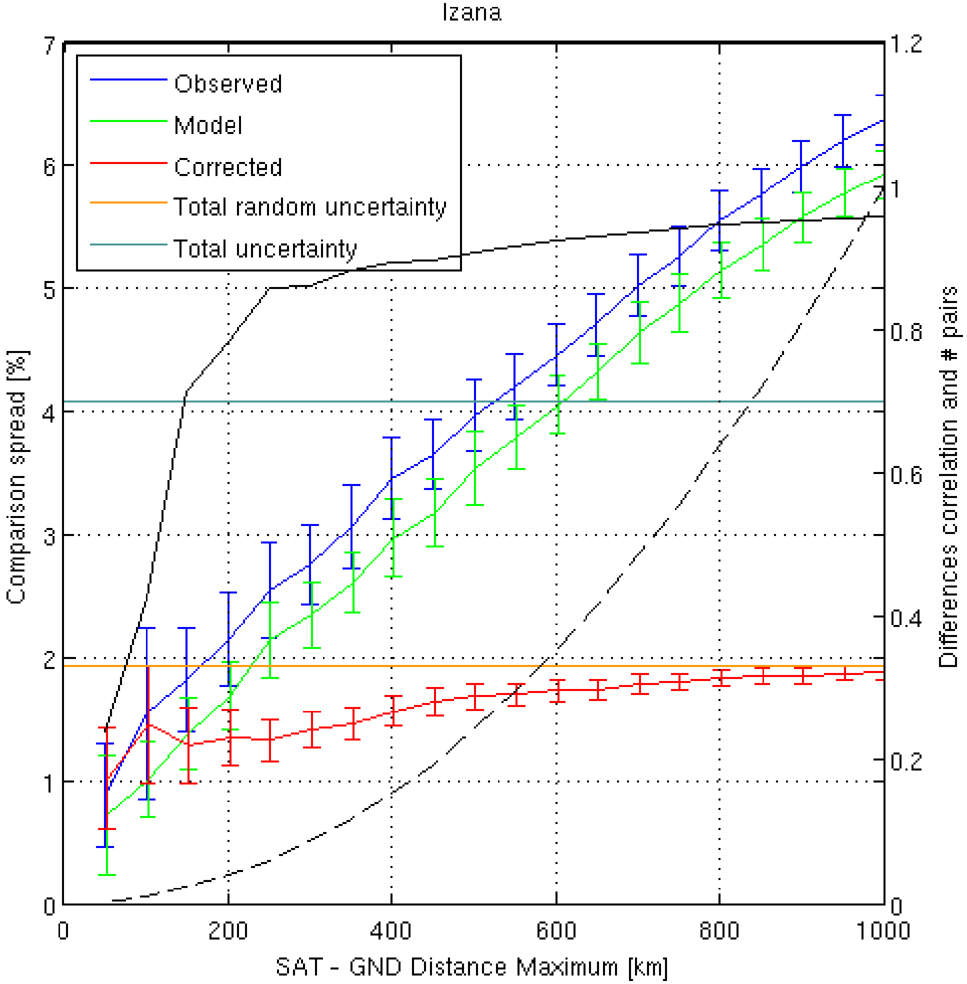


OSSE of the missing column due to the Brewer's mountain top location: **3.1% +/- 0.45%** (2006 only)

Measurement uncertainty:
- GOME GODFITv3: 0.3 – 0.5%, from the files (SNR only?)
- Brewer: 1%, from the files (via NDACC)

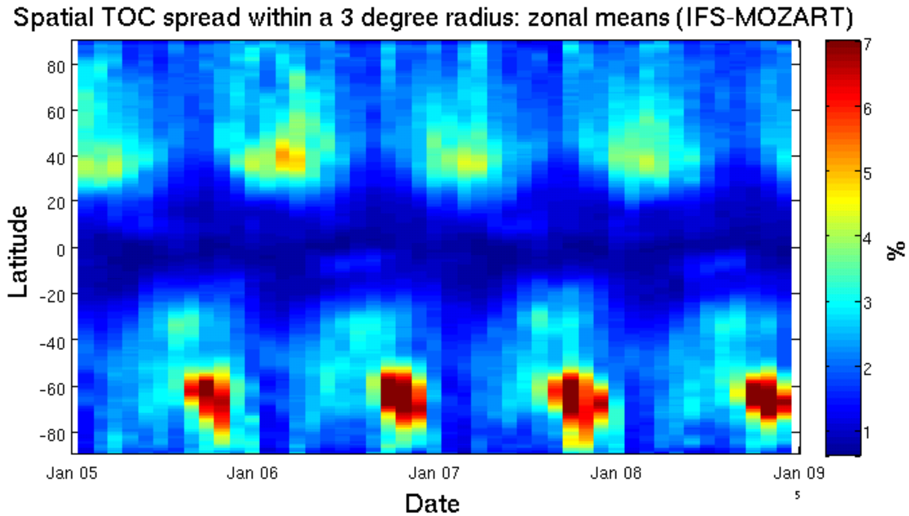
Metrology OSSE: *Optimization of co-location criteria*

GODFITv3 GOME/ERS2 vs the Izana Brewer:



Conclusions and prospects

- Even when using optimized co-location criteria, sampling mismatches, and to a lesser extent smoothing differences, lead to non-negligible error terms, both random and systematic.
- A metrology OSSE based on multi-dimensional observation operators and modelled fields yields quantified estimates of these additional error terms.
- The uncertainties provided with some products need streamlining. For some instruments, the uncertainties described in the literature appear somewhat too conservative.
- Metrology based OSSEs support current developments of advanced QA systems for ECV production (see QA4ECV pres. Thursday morning), and open new perspectives on co-location optimization, validation campaign design, and network design (see GAIA-CLIM presentation by P. Thorne at 17:10).



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Thank you for your attention!