AN IMPROVED OBJECTIVE ANALYSIS SCHEME OF SCANNING RADIOMETER MEASUREMENTS TO COMPUTE THE WATER VAPOUR PATH DELAY FOR ALTIMETRY

Jacques STUM, Antoine Delepoulle*, Philippe SICARD* and Amandine Guillot***

(*) Collecte Localisation Satellites, 8-10 rue Hermès, 31520 Ramonville, France
(**) Centre National d'Etudes Spatiales, 18 avenue Edouard Belin, 31055 Toulouse, France

Introduction

- Atmospheric water vapour induces path delay to pulses emitted by spaceborne radar altimeters to measure sea surface height
- Most altimeter missions embark a MWR to compute this path delay. ECMWF analyses may also be used, but are less accurate, and at a lower resolution
- As an alternate approach, objective analysis of all existing scanning MWR to compute the WV path delay for altimetry looks promising (see Stum et al, IEEE Geos Rem Sens, 2011)
- This talk is devoted to recent improvements of the method, and to its application to operational NRT altimeter data processing

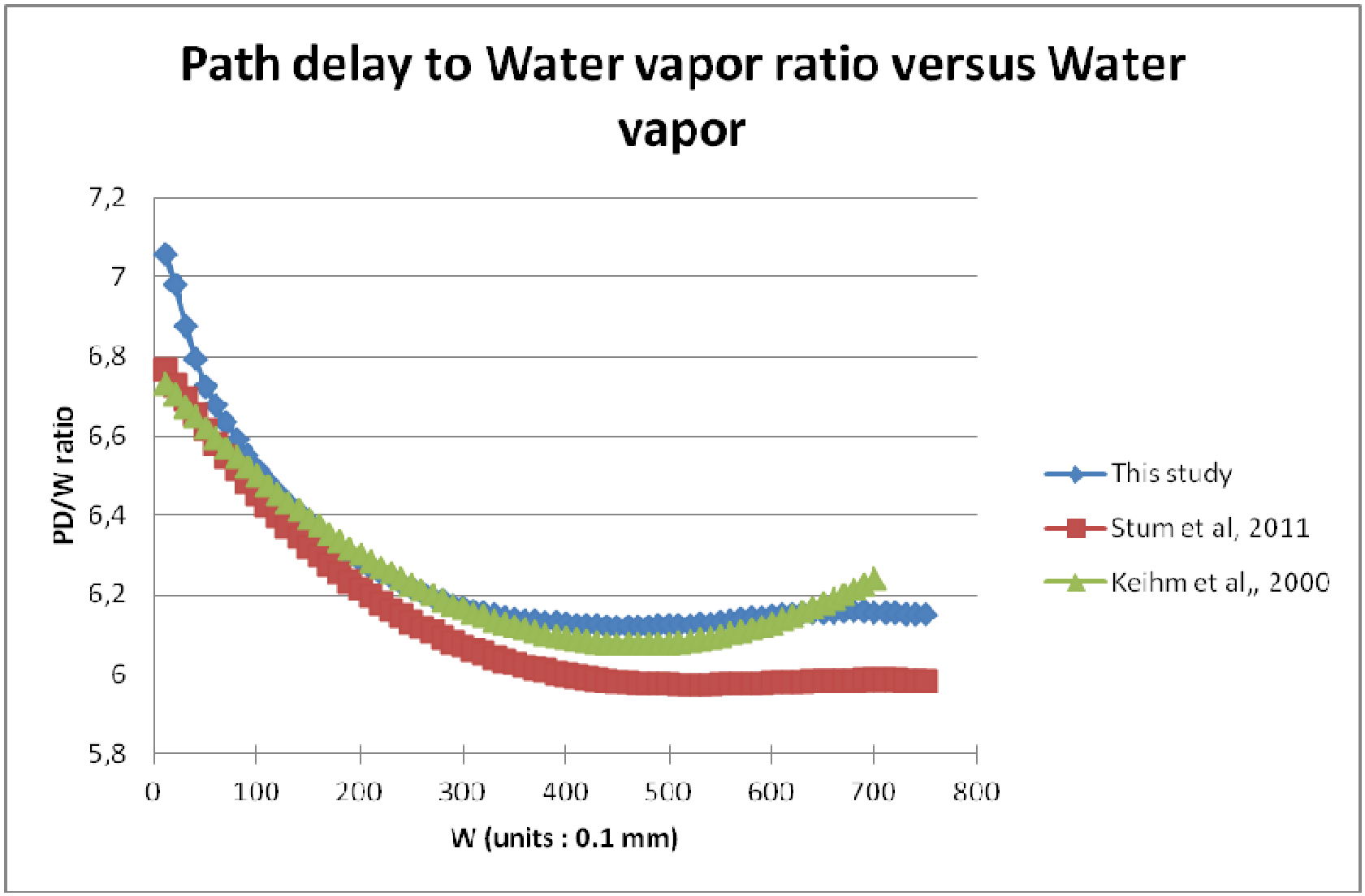
Summary

1. From integrated water vapor products to wet tropospheric correction
2. Available observations
3. Errors characterization
4. Revisit of Stum, 2011 for variance and correlation radii
5. Validation over 1 year JMR data
6. Application to NRT over current IGDR Jason-2 data
7. Conclusions

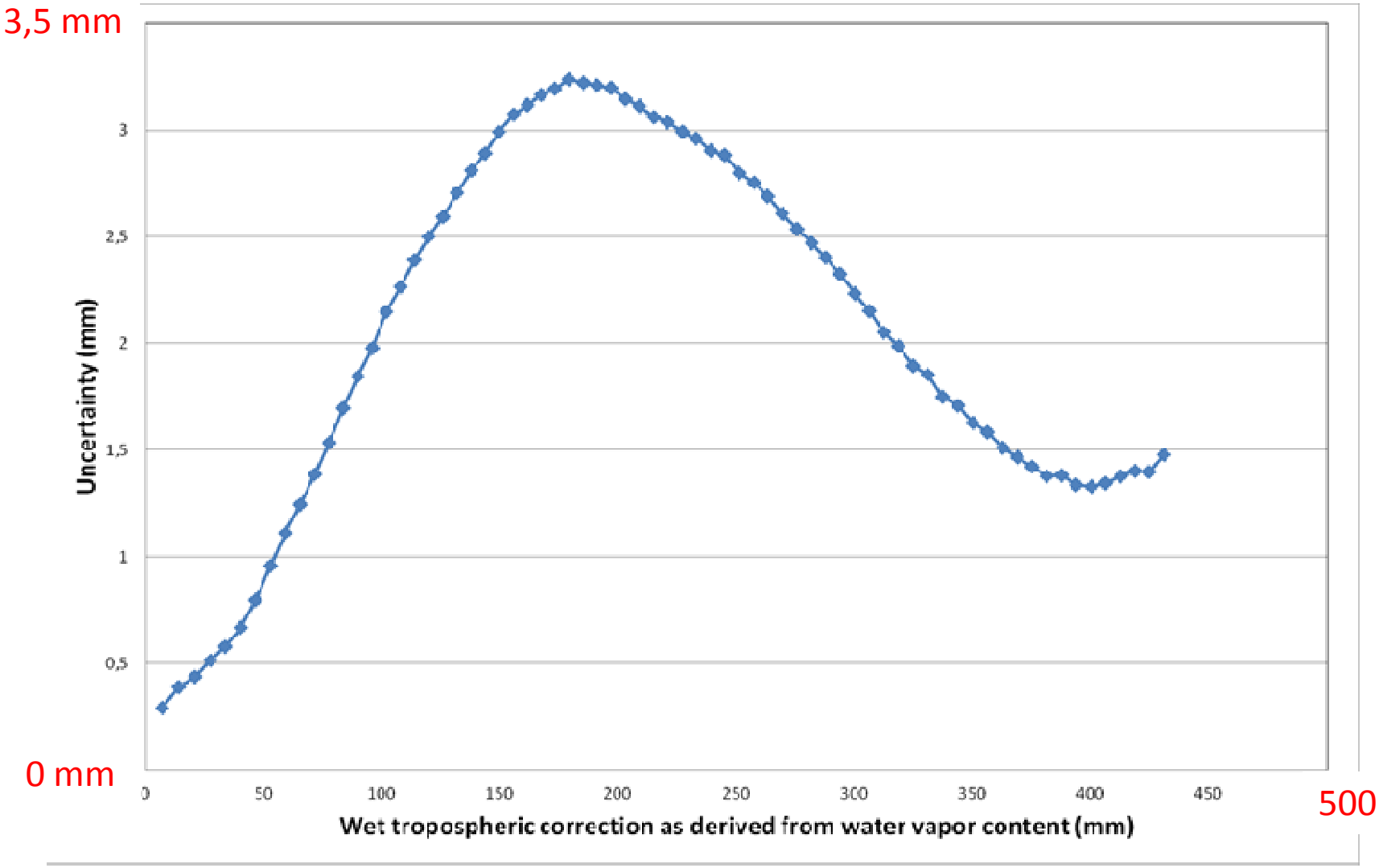
From water vapor to wet tropospheric correction

- Water vapour observations over the ocean can be provided by scanning microwave radiometers
- Need first to be converted into path delay
- We start from W = $\int_0^H \rho_v dz$
- We need to compute PD ≈ 1720.6 x $\int_0^H \frac{\rho_v}{T} dz$
- 4 months of ERA-Interim temperature and humidity profiles to compute (and tabulate) the PD/W ratio

Related uncertainty



Uncertainty of the wet tropo as derived from water vapour



Scanning microwave radiometers

12 microwave scanners available in 2008 :

- 5 AMSU-A :
  - NOAA-15, NOAA-16, NOAA-17, NOAA-18, METOP-A
- 3 SSMI :
  - F13, F14, F15
- 2 SSMI/S :
  - F16, F17
- AMSR-E
- TMI

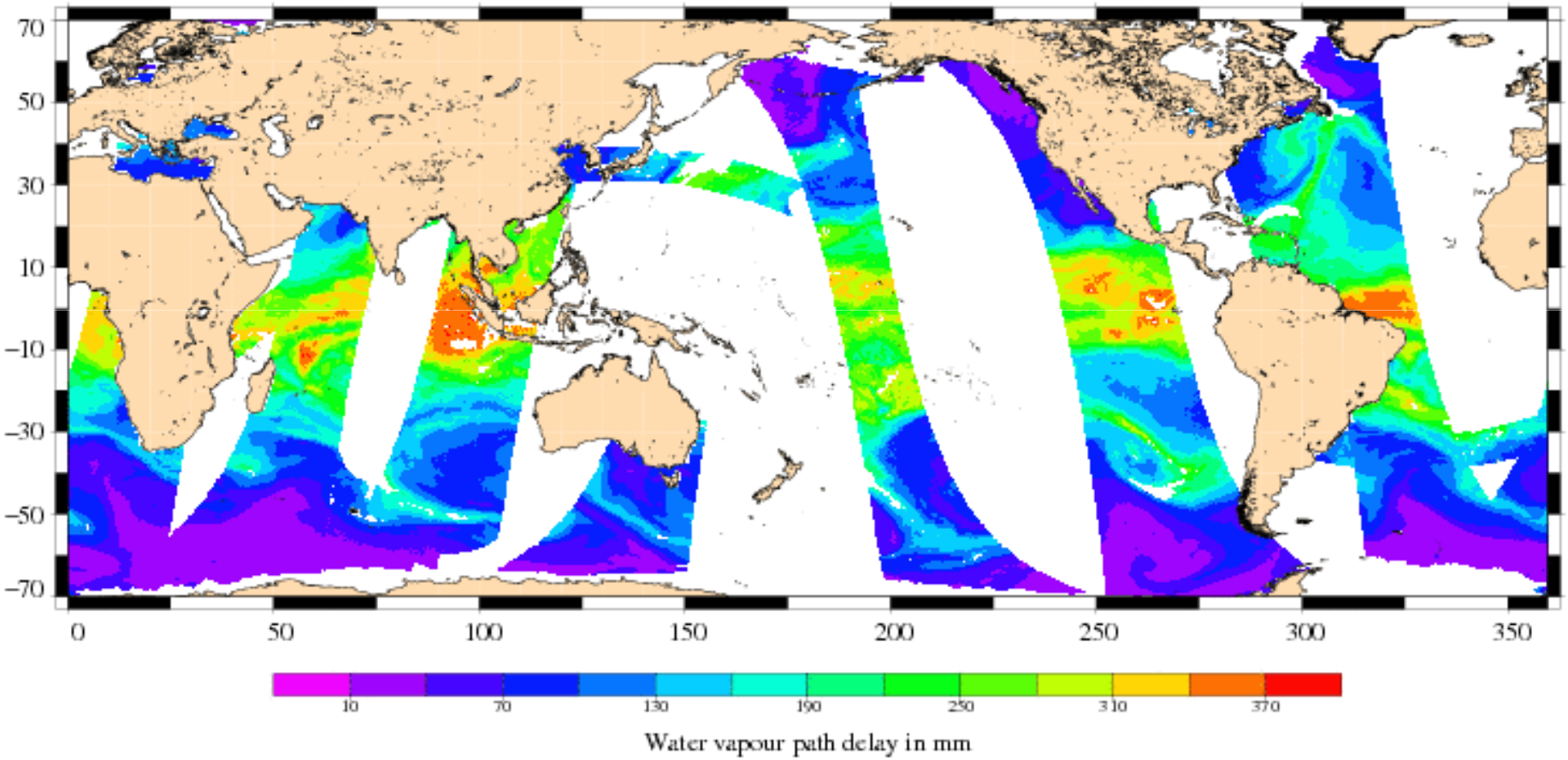
Data products and Providers

- AMSU-A : level 2 products from NOAA CLASS
- SSMI : level 2 products from NOAA CLASS and level 3 daily products from RSS
- SSMI/S : level 1B (NetCDF SDR) from NOAA CLASS and level 3 daily products from RSS
  - ➢Goal : to chose the best SSMI provider for OA
- TMI : level 2 products from GHRC
- AMSR-E : level 2 products from NSIDC

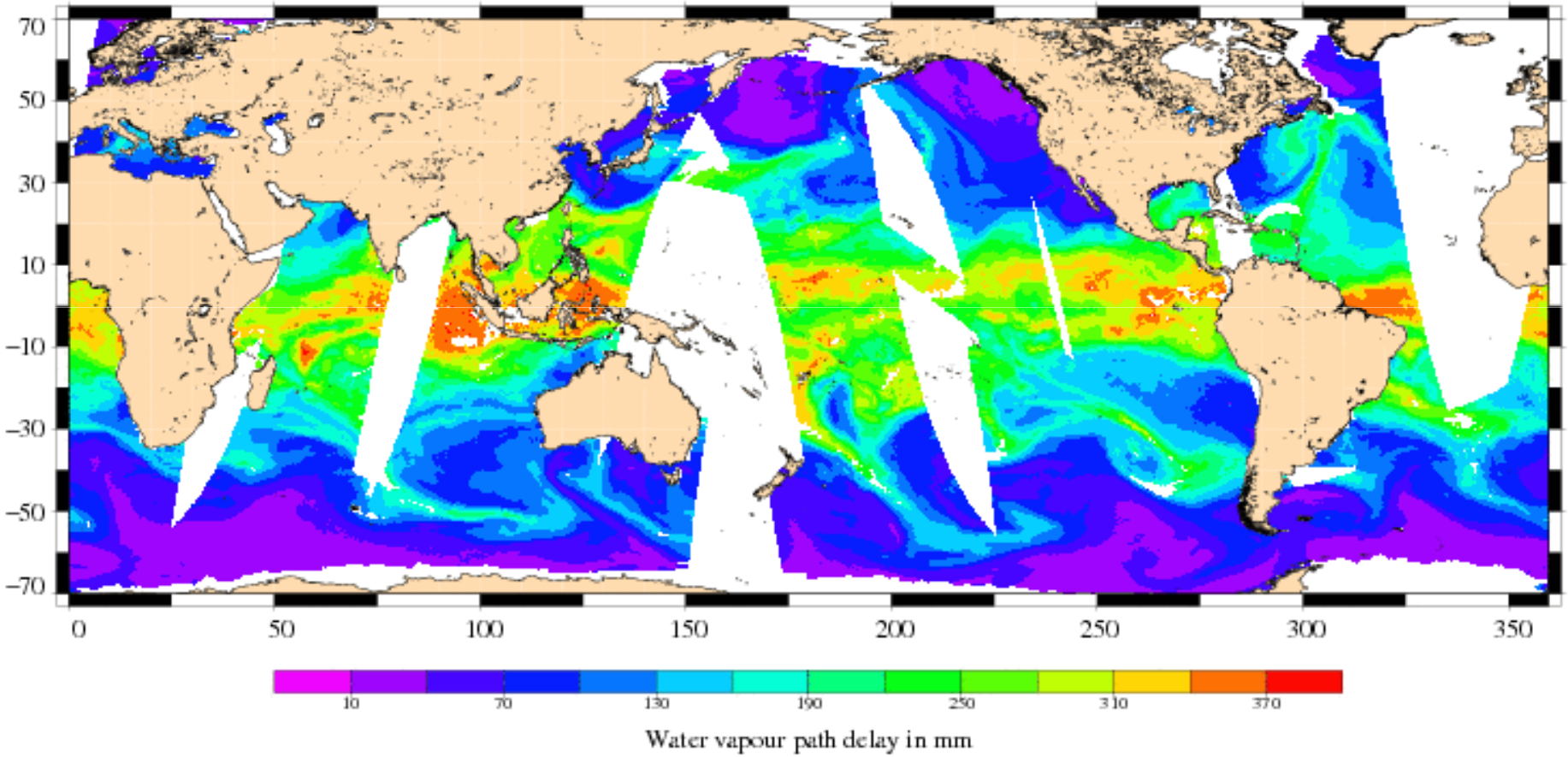
Microwave radiometer data editing

- Use of product quality flags often lead to over (under) estimated ice concentration
- Choice of a common external sea ice mask derived from the OSI/SAF sea ice concentration daily files : improves product data quality
- Revisiting the use of product rain flags to better edit data contaminated by rain

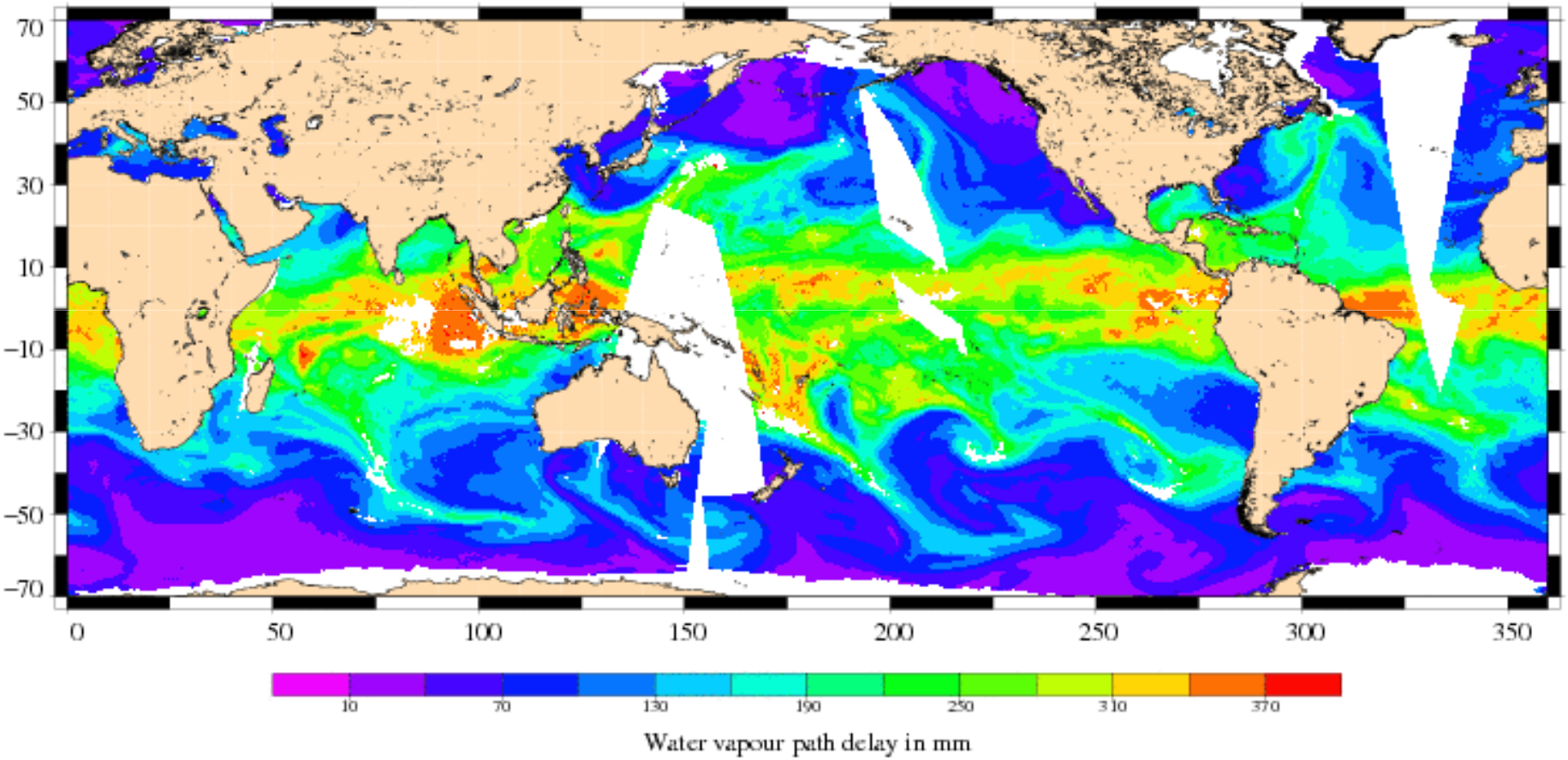
All–sensor coverage within 1 hour (47%)



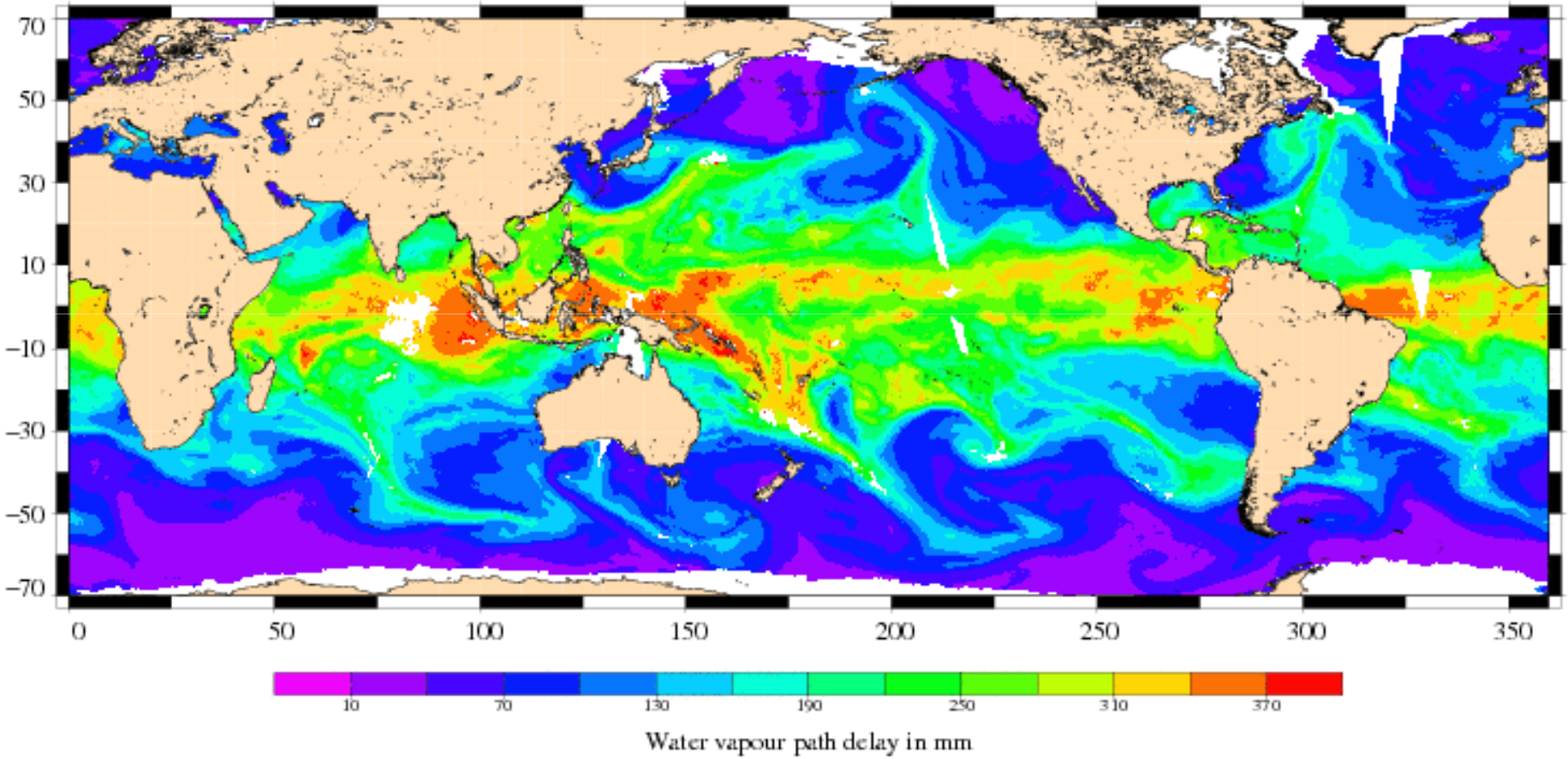
All–sensor coverage within 2 hours (71%)



All−sensor coverage within 3 hours (84%)



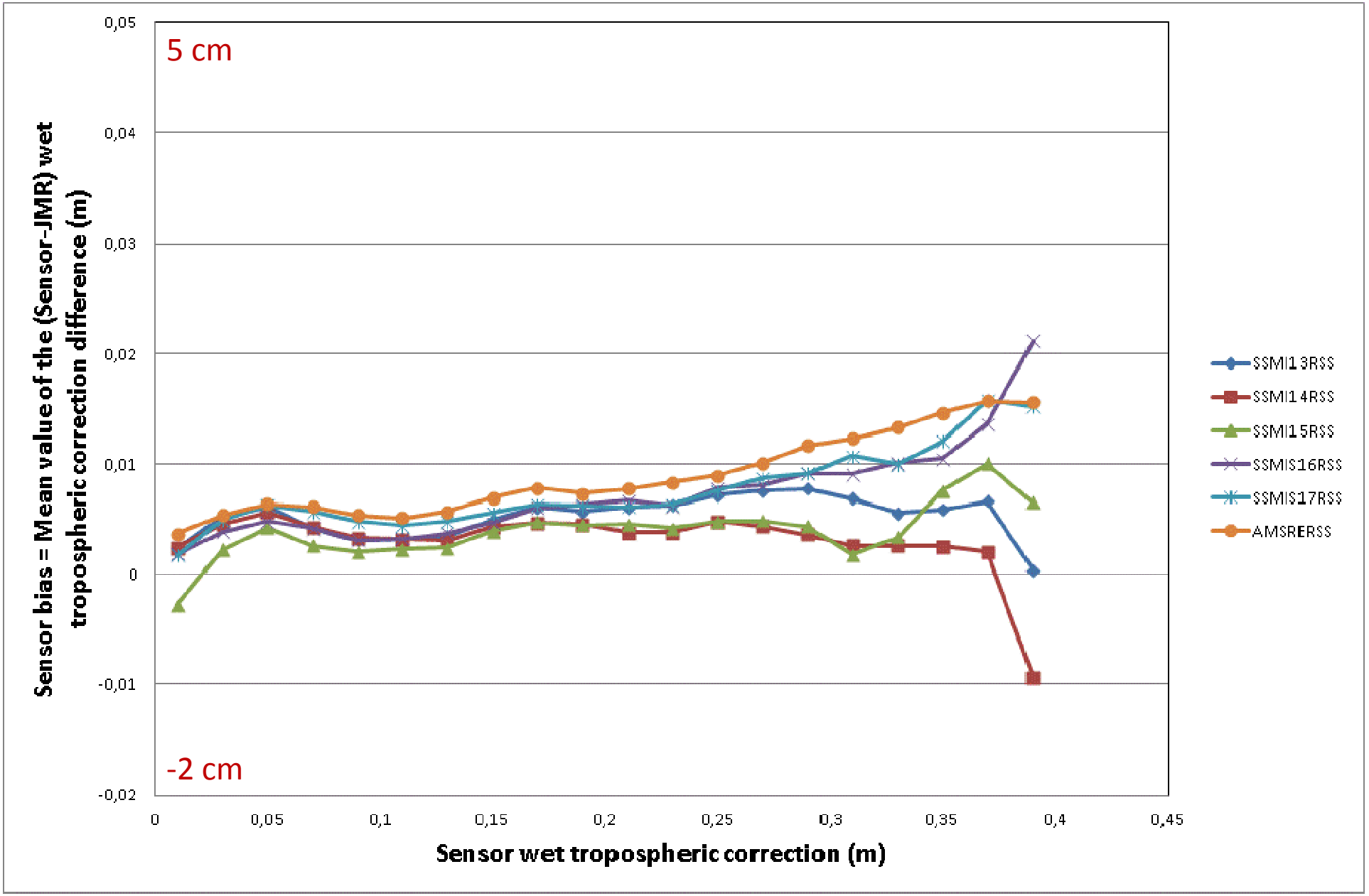
All–sensor coverage within 4 hours (92%)



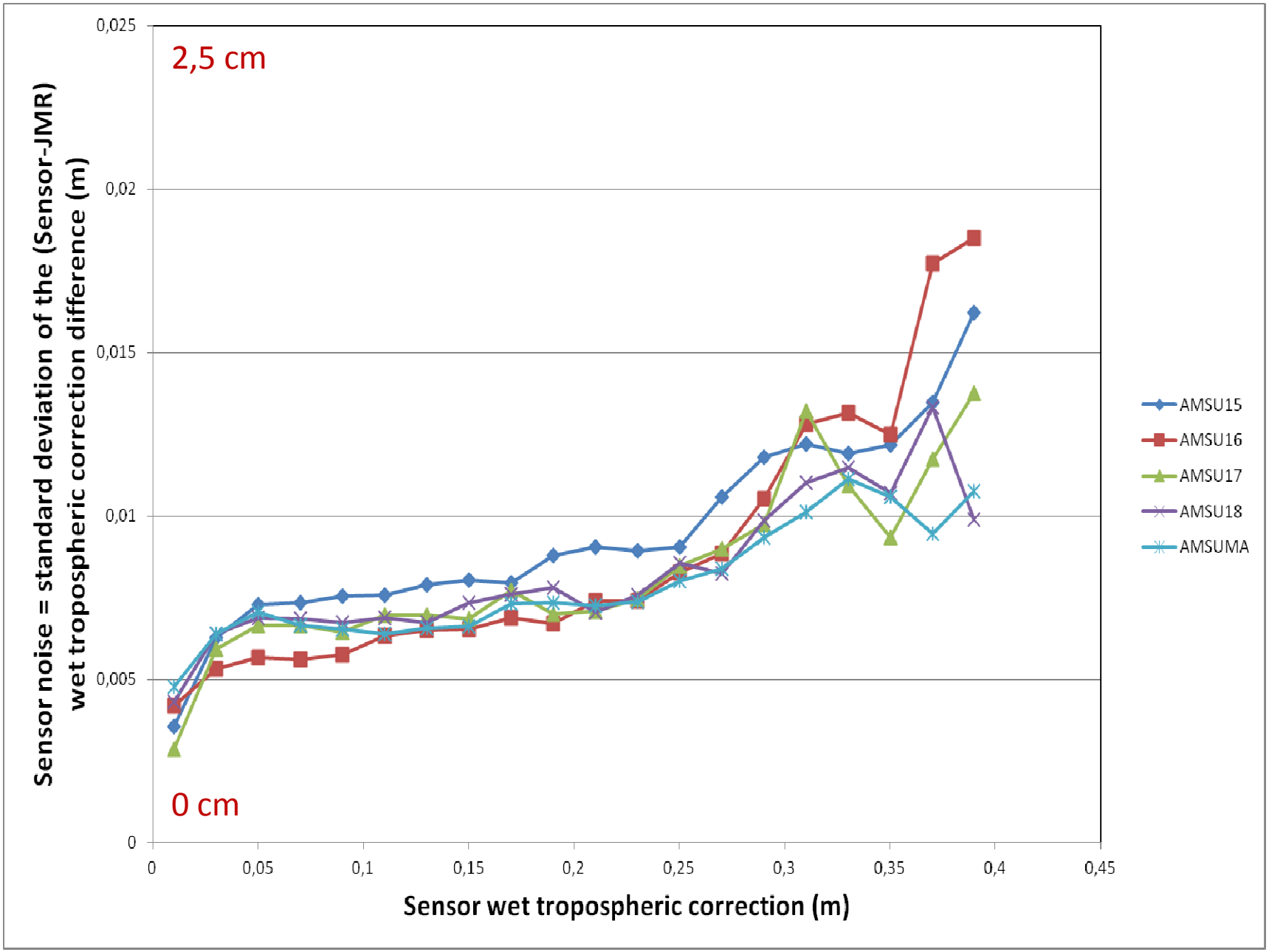
Sensor PD bias and noise characterization

- Jason-1 microwave radiometer (JMR) taken as a reference
- Sensor-JMR matchups : bilinear interpolation at JMR location of the four sensor surrounding pixels, with less than half an hour time lag
- Global statistics of the (sensor – JMR) PD difference over 12 Jason-1 cycles (4 months)

Example: RSS SSMI Bias characterization



Example: AMSU-A noise characterization



Sensor bias and noise characterization

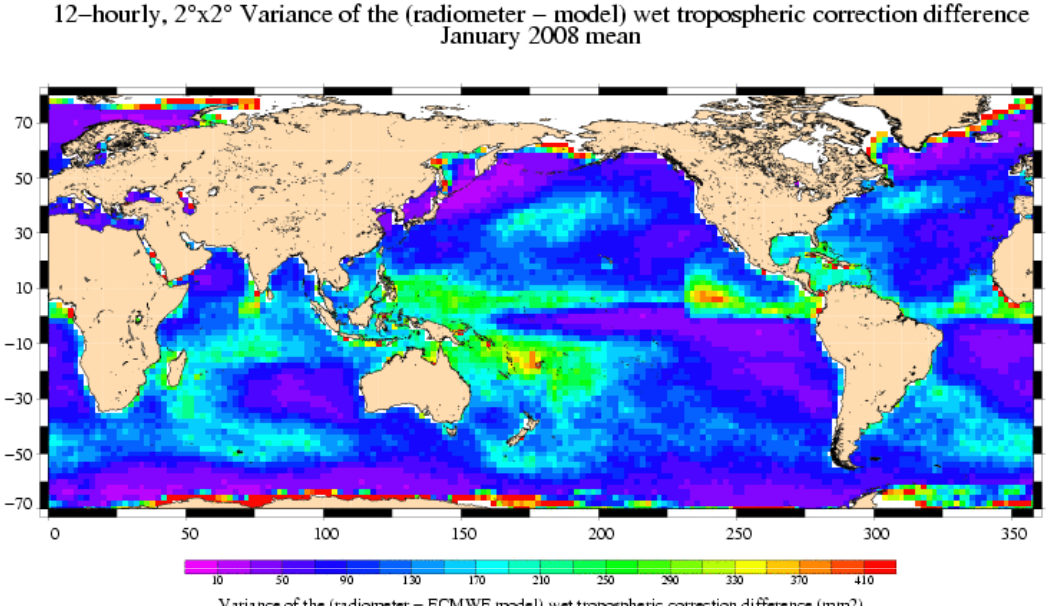
- Conclusions
  - SSMI/SSMIS :
    - NOAA Level 2 products are less accurate than the RSS Level 3 ones.
    - Despite the better coverage of NOAA products, RSS provider chosen.
  - AMSR-E is the most accurate sensor
  - AMSU-A are the less accurate ones but provide good coverage

Variance and correlation radii

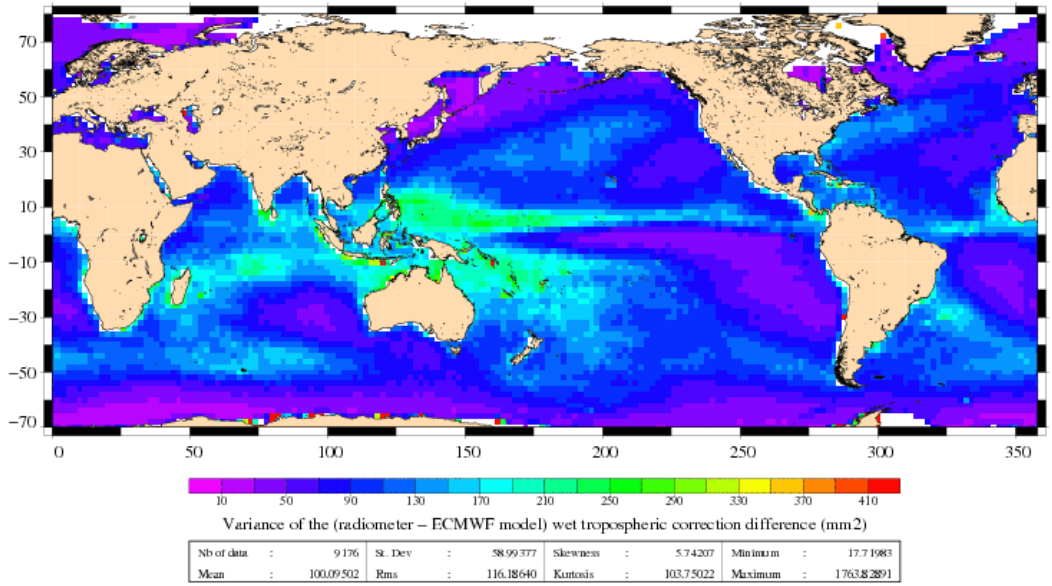
- Estimation of the variance and correlation radii of the anomalies (sensor PD – ECMWF PD) revisited :
  - Benefit from the increased number of sensors (12 versus 7 in Stum et al., 2011)
  - Also benefit from the improved data editing

Variance of the anomalies (sensor-ECMWF)

From Stum et al, 2011



This study

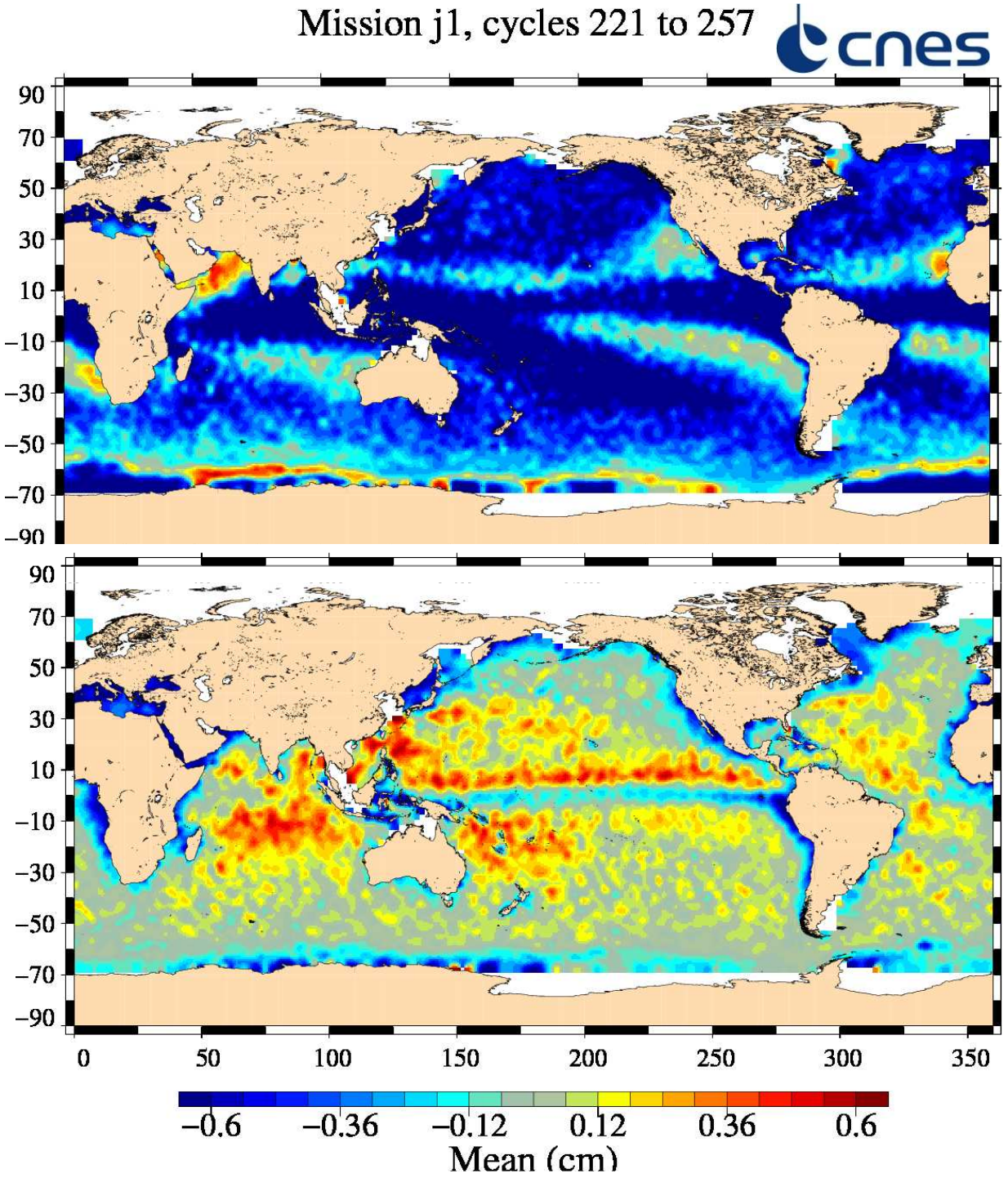


Validation

- OA run over year 2008 (Jason-1 cycles 221 to 256)
- OA wet tropo correction compared to JMR and ECMWF wet tropo
  - Along track statistics
  - Crossover statistics

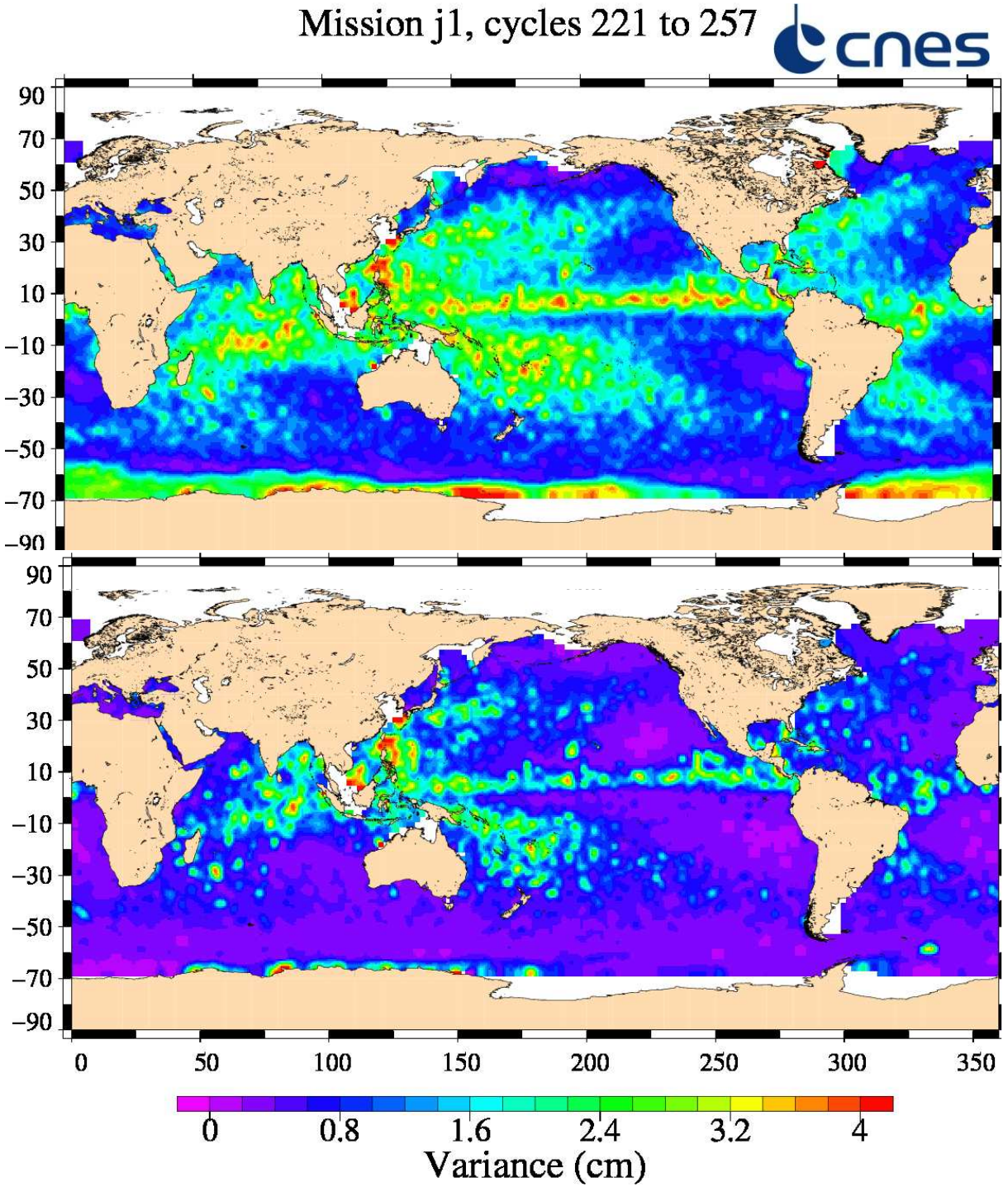
Mean of
(ECMWF – JMR)

Mean of
(OA – JMR)

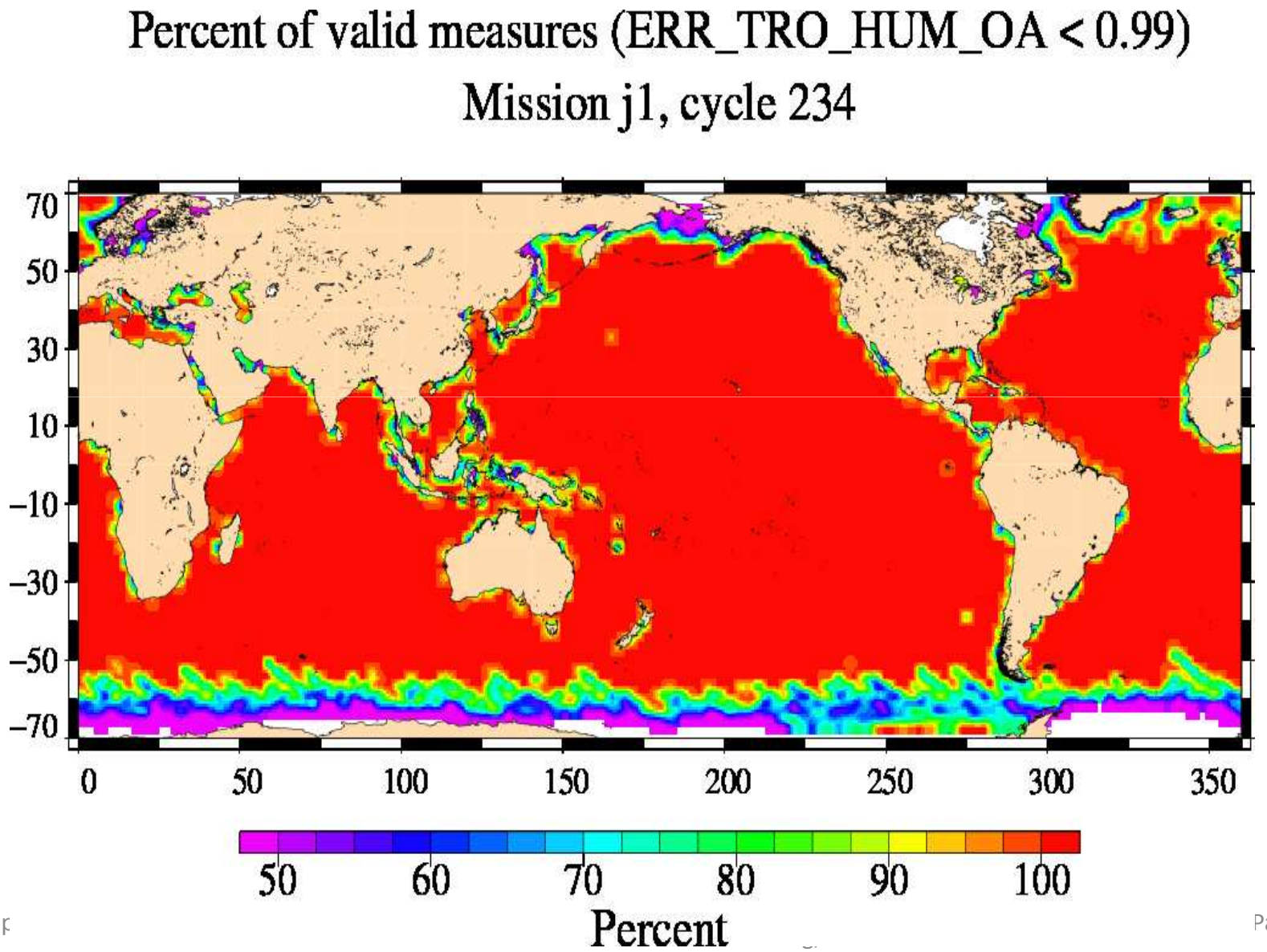


Variance of
(ECMWF – JMR)

Variance of
(OA – JMR)

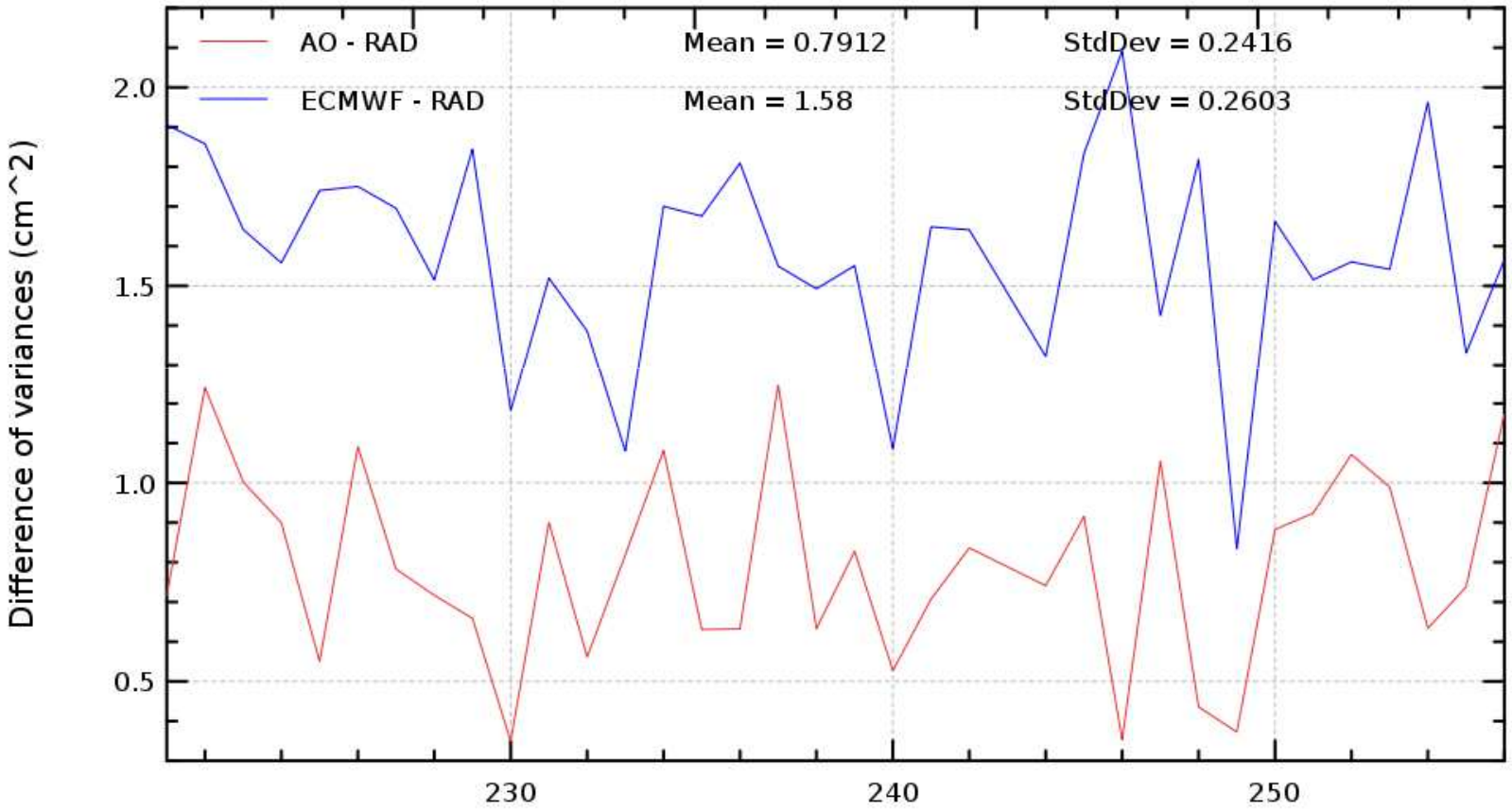


Percentage of computed OA wet tropo



SSH Crossover statistics

VAR(SSH_OA)-VAR(SSH_RAD) & VAR(SSH_ECMWF)-VAR(SSH_RAD)



Application to NRT

- Goal : to check the robustness of the method
- Applicability of the method to NRT Jason-2 IGDR production
- 11 sensors available in NRT in 2012 :
  - 6 AMSU-A (from NOAA CLASS) :
    - NOAA-15, NOAA-16, NOAA-17, NOAA-18, METOP-A, NOAA-19
  - AMSU-A on board AQUA (from GES DISC)
  - 1 SSMI and 2 SSMI/S (from RSS) :
    - F15, F16, F17
  - TMI (from GSFC for NRT availability)

Application to NRT

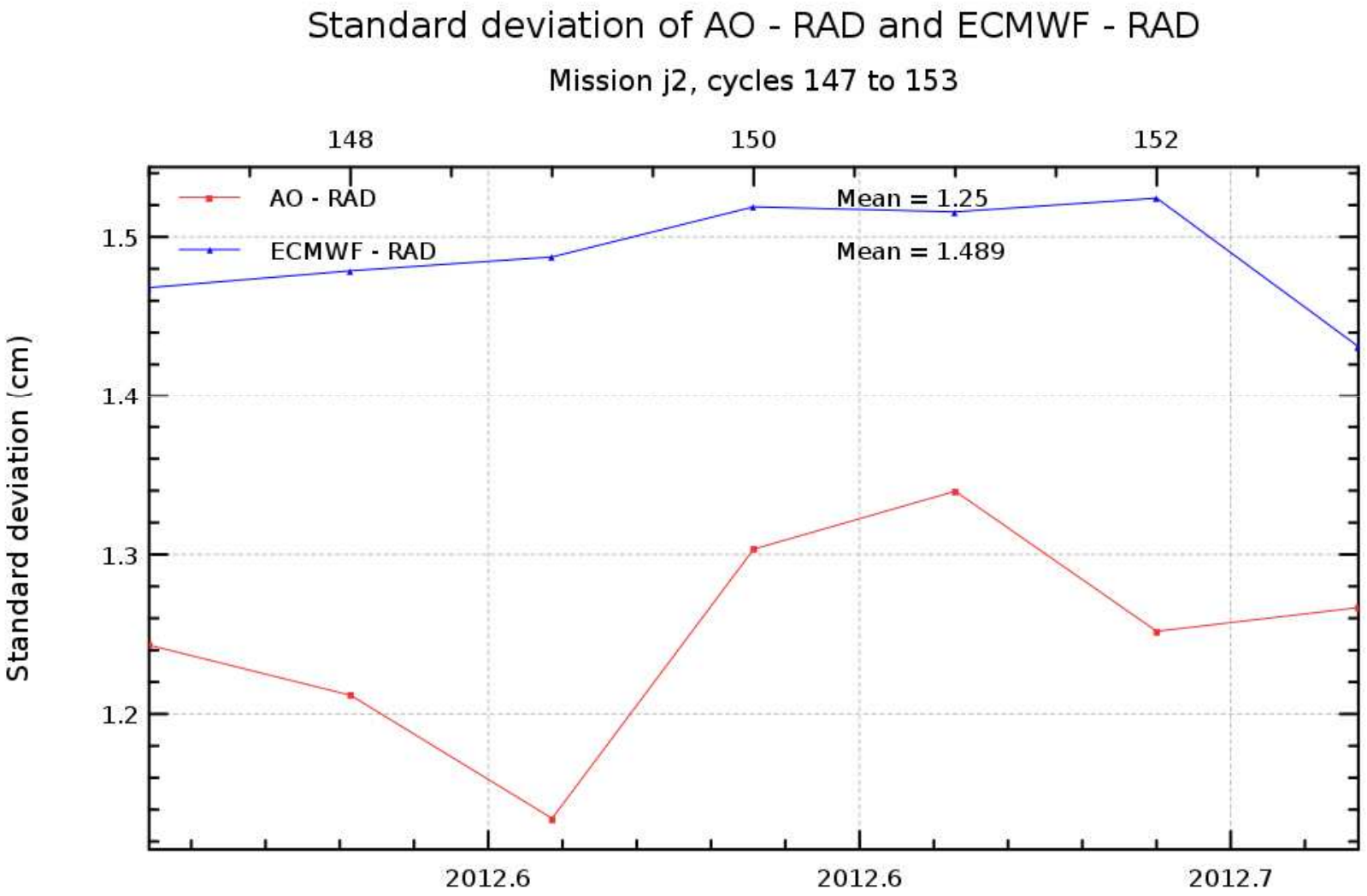
- Automatic processing run from July 1st, 2012
- 6-month duration (end 2012)
- Data acquisition from providers every 3 hours starting at 5h (Sea ice conc. needed first)
- OA run every day D at 12h on altimeter tracks of day D-2
- Uses sensor data from D-3 18h to D-1 06h :
    - All sensors available excepted : AMSU/Aqua and TMI GSFC data missing for D-1

Application to NRT

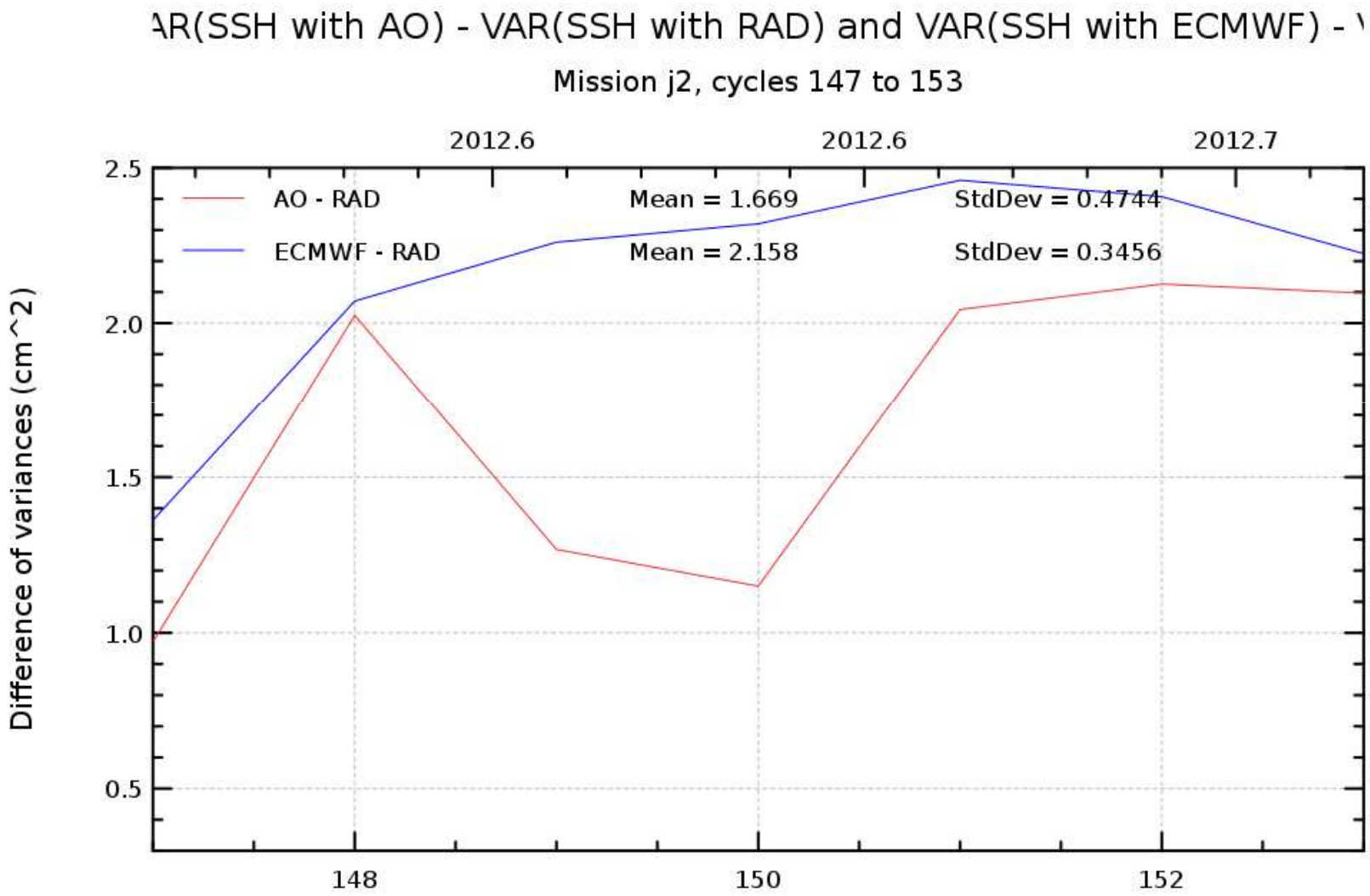
- Automatic data validation procedures run :
  - Every day to check the data availability and plot the OA, ECMWF and AMR wet tropo corrections
  - Every 2 months for more in-depth evaluation

- To be done :
  - Recharacterization of sensor bias and noise relative to Jason-2 AMR (as soon as enough matchups available)

Along-track statistics



Crossover SSH statistics



Conclusions

- The calculation of the wet tropo correction by OA of ancillary radiometers has been improved.
- The JMR correction remains the best one for Jason-1. but the new OA correction performs significantly better than the ECMWF one.
- Application to NRT is underway (Jason-2), first results demonstrate the feasibility and robustness of the method (linked to sensor products availability).

We are ready to serve Cryosat-2 mission !