AN IMPROVED WET TROPOSPHERIC CORRECTION FOR THE CRYOSAT MISSION OVER THE OCEAN

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Introducing the Cryosat-2 context

- Cryosat-2 satellite launched in April 2010
- Cryosphere mission, but will also measure the ocean surface topography.
- No MWR on board : the wet tropospheric correction relies on ECMWF model analyses
- Perform objective analysis of all ancillary scanning MWR WV measurements to improve the WTC for Cryosat-2 over the ocean.

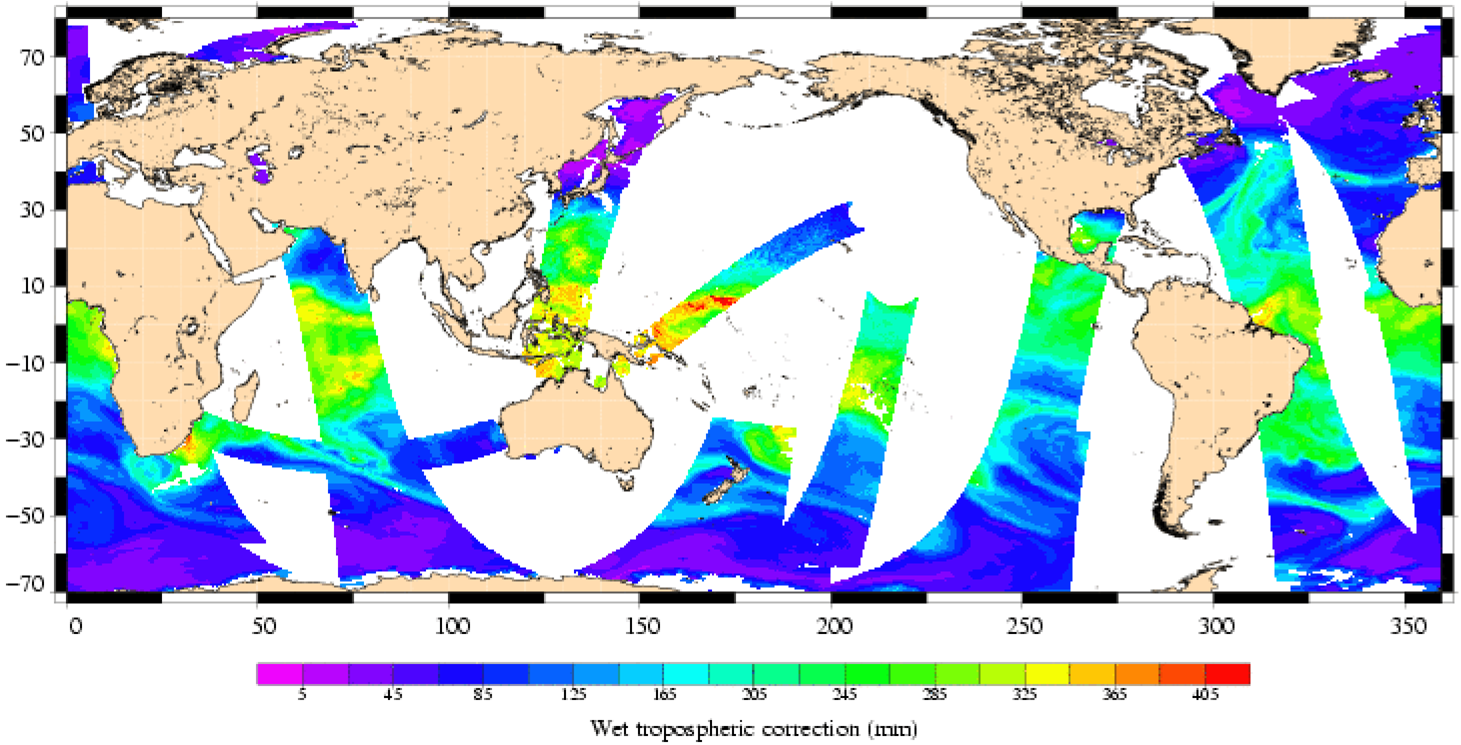
Presentation outline

- The scanning radiometers WV observations :
  – Sensors and products
- The objective analysis
  – Math background, covariance model calculation
- The method validation
  – 4-month run, statistical comparison with JMR and ECMWF path delay (crossover analysis…)

The scanning radiometers WV observations (status in 2008)

- AMSU-A, aboard the NOAA and METOP series (2 channels, large swath, 50-km product resolution) : 5 available sensors in 2008
- SSMI, aboard DMSP F13 (3 channels, medium swath, 25-km product resolution)
- TMI, aboard TRMM (3 channels, small swath, 10-km product resolution)
- AMSR-E, aboard AQUA (3 channels, medium swath, 10-km product resolution)

AMSU15 + AMSU16 + AMSU17 + AMSU18 + AMSUMA + SSMI13 + AMSRE + TMITR
January 5th, 2008, from 16h to 17h GMT



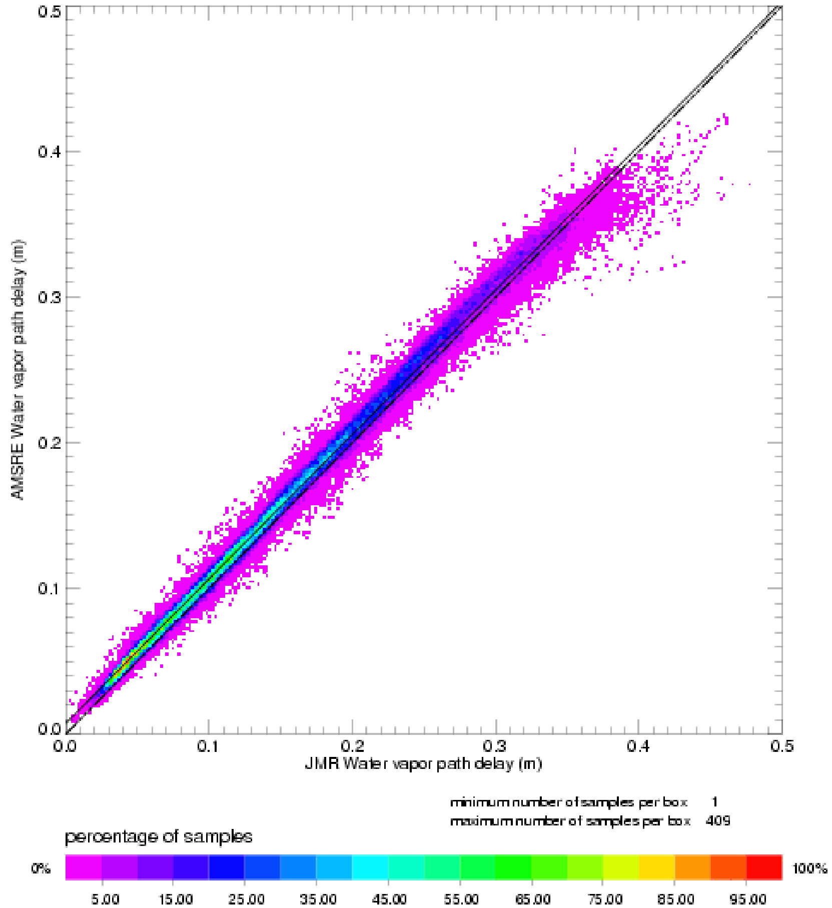
Products

- Level 2 products (swath data) of year 2008 downloaded from NOAA (AMSUs and SSMI), NSIDC (AMSR-E) and GHRC (TMI)
- Quality flags used to edit data contaminated by rain or ice
- Computing the water vapor path delay (= wet tropospheric correction) from total precipitable water

Sensor PD intercomparison

- 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 0.5 hour time lag
- Global statistics of the (sensor – JMR) PD difference over 12 Jason-1 cycles (4 months)

One example: AMSR-E versus JMR



Statistics Y–X

mean = 0.00599
rms = 0.00929
std = 0.00710

Statistics Y,X

samples = 168563
covar = 0.00804
r = 0.99686

Linear regression

type : least squares y=f(x)

y = ax + b
a = 0.99142485 +/− 0.00037582
b = 0.00740078

Statistics X

mean = 0.16116
rms = 0.18461
std = 0.09005

Statistics Y

mean = 0.16718
rms = 0.18966
std = 0.08956

Legend

Linear regression
Bisectrix
y=x

Objective analysis

- Bretherton et al., 1976
- Applied to SST (Reynolds and Smith, 1994), altimetry (Le Traon et al., 1998), Ocean Color (Pottier et al., 2006)
- $F(P) = G(P) + \sum_{i=1}^{N} W_i \times Anom_i$
  - F(P) : field to be estimated at a given position P
  - G(P) : first-guess field
  - $Anom_i = F_i – G(P)$
  - Wi : weights

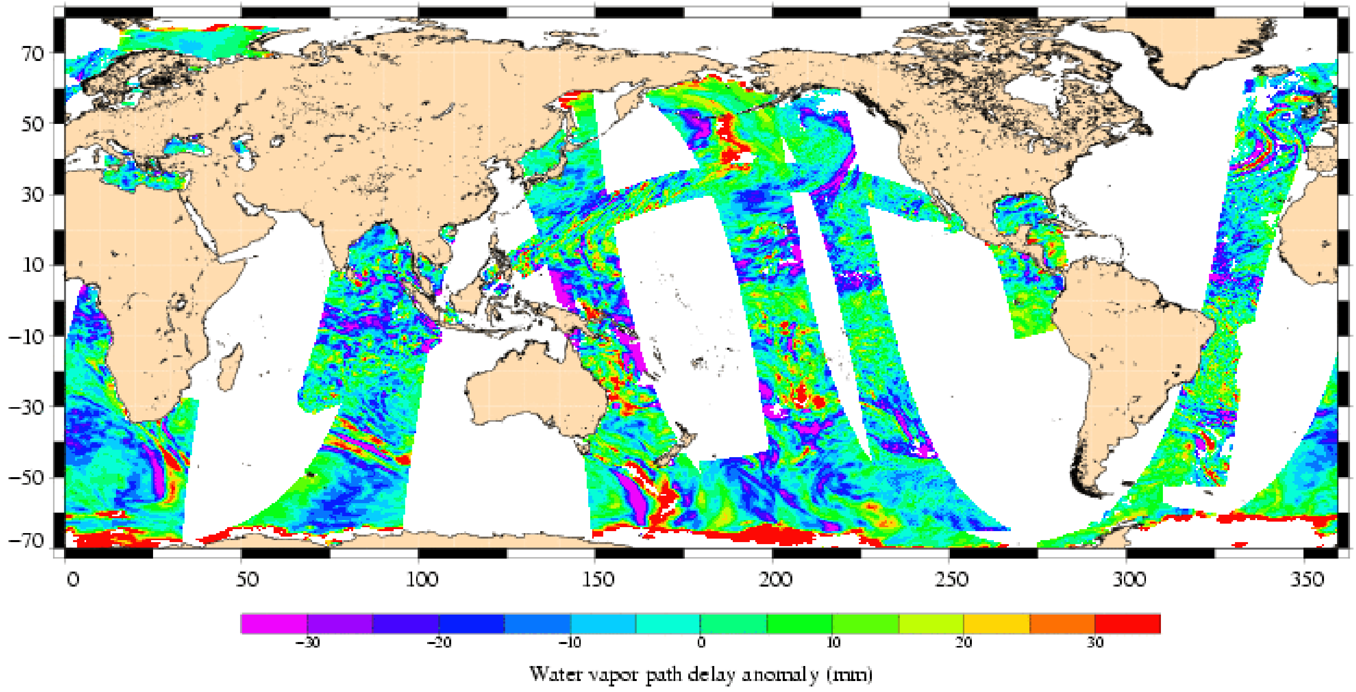
Objective analysis

- Four quantities are needed to compute F(P) :
  - the first guess value G(P)
  - the variance of the measurement error
  - the signal variance
  - the correlation function of the anomaly field

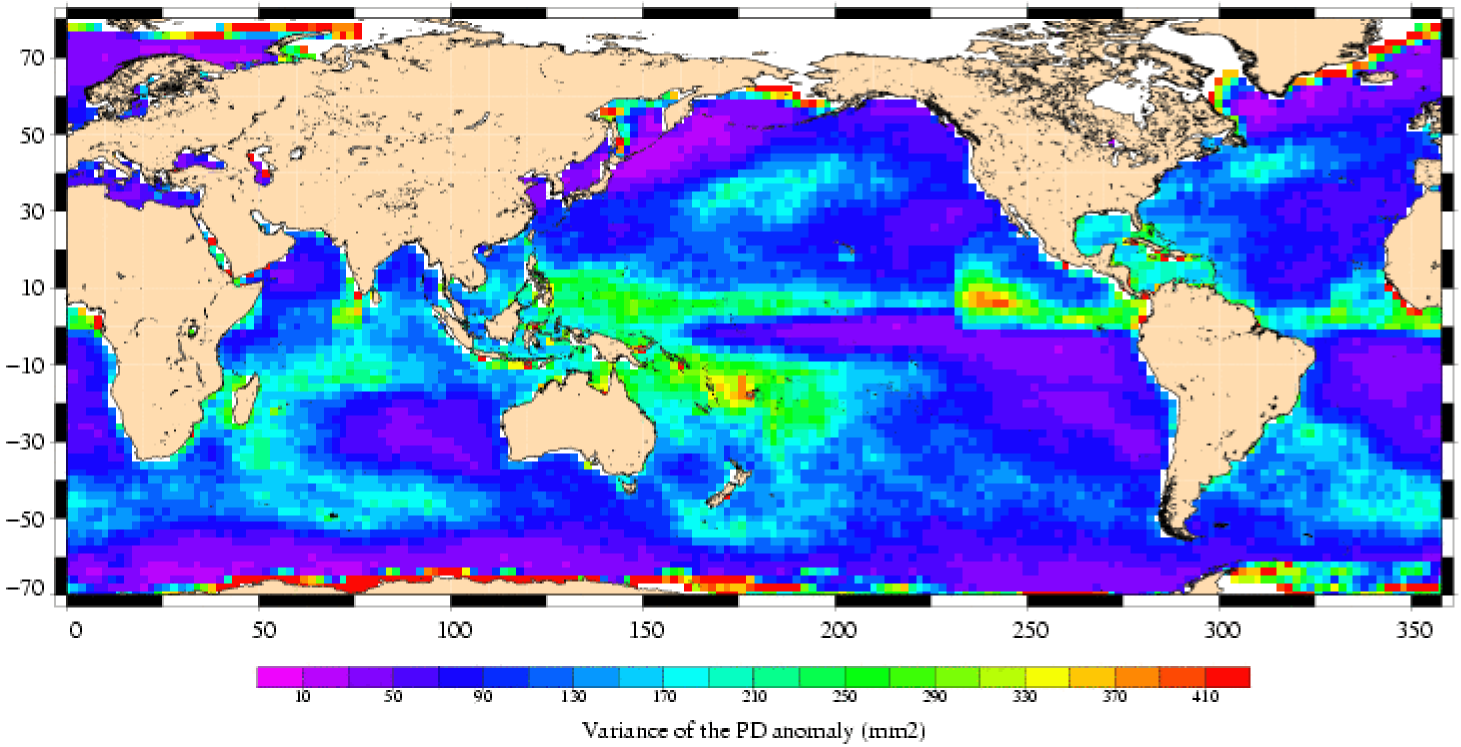
Objective analysis

- The ECMWF PD is used as first guess field : allows to get a seamless PD correction
- VarErr taken as the square of the (Sensor – JMR) PD standard deviation
- Signal variance and correlation function to be computed *a priori* from the (radiometer – ECMWF) PD anomalies

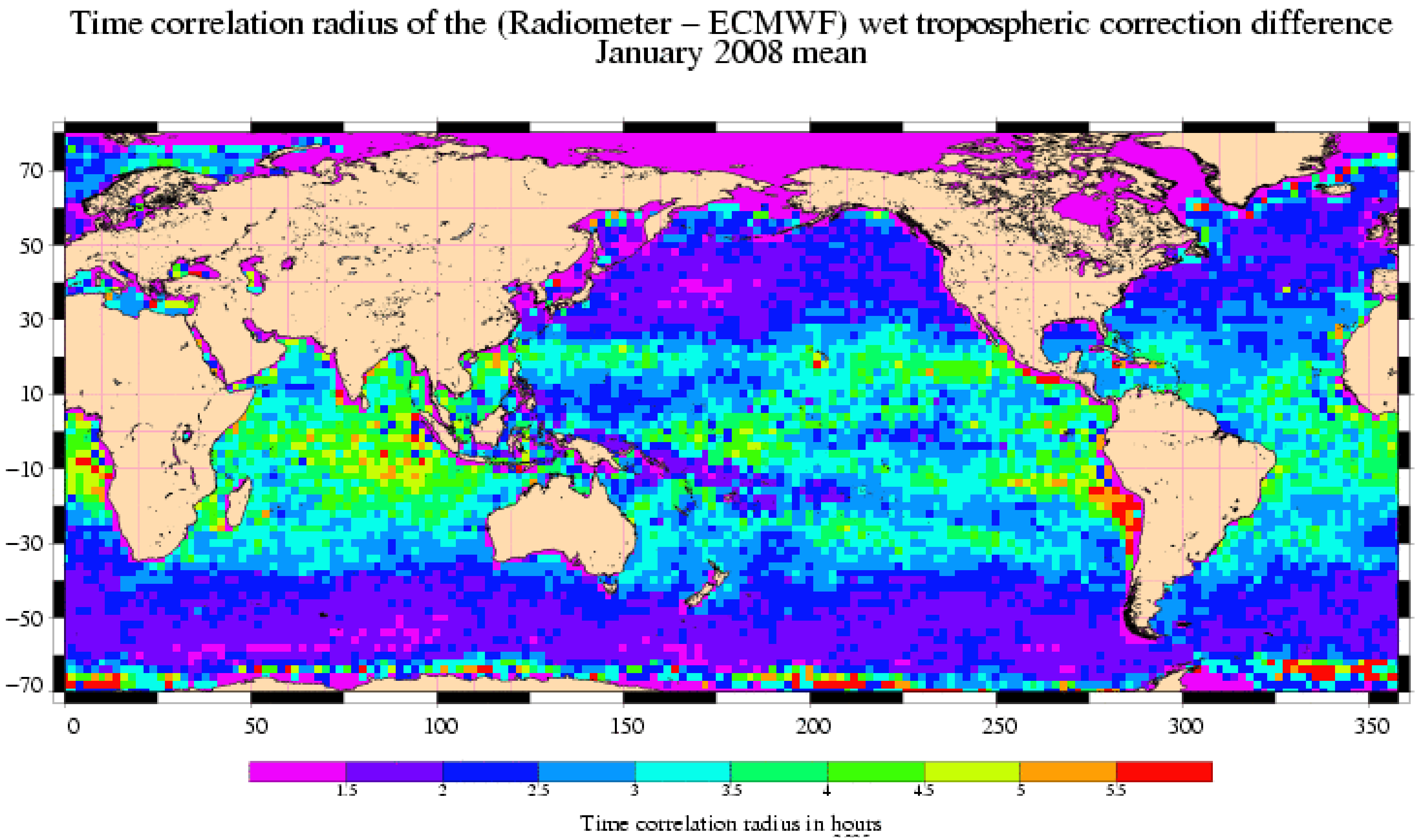
Hourly PD anomaly map



January mean of the PD anomaly variance

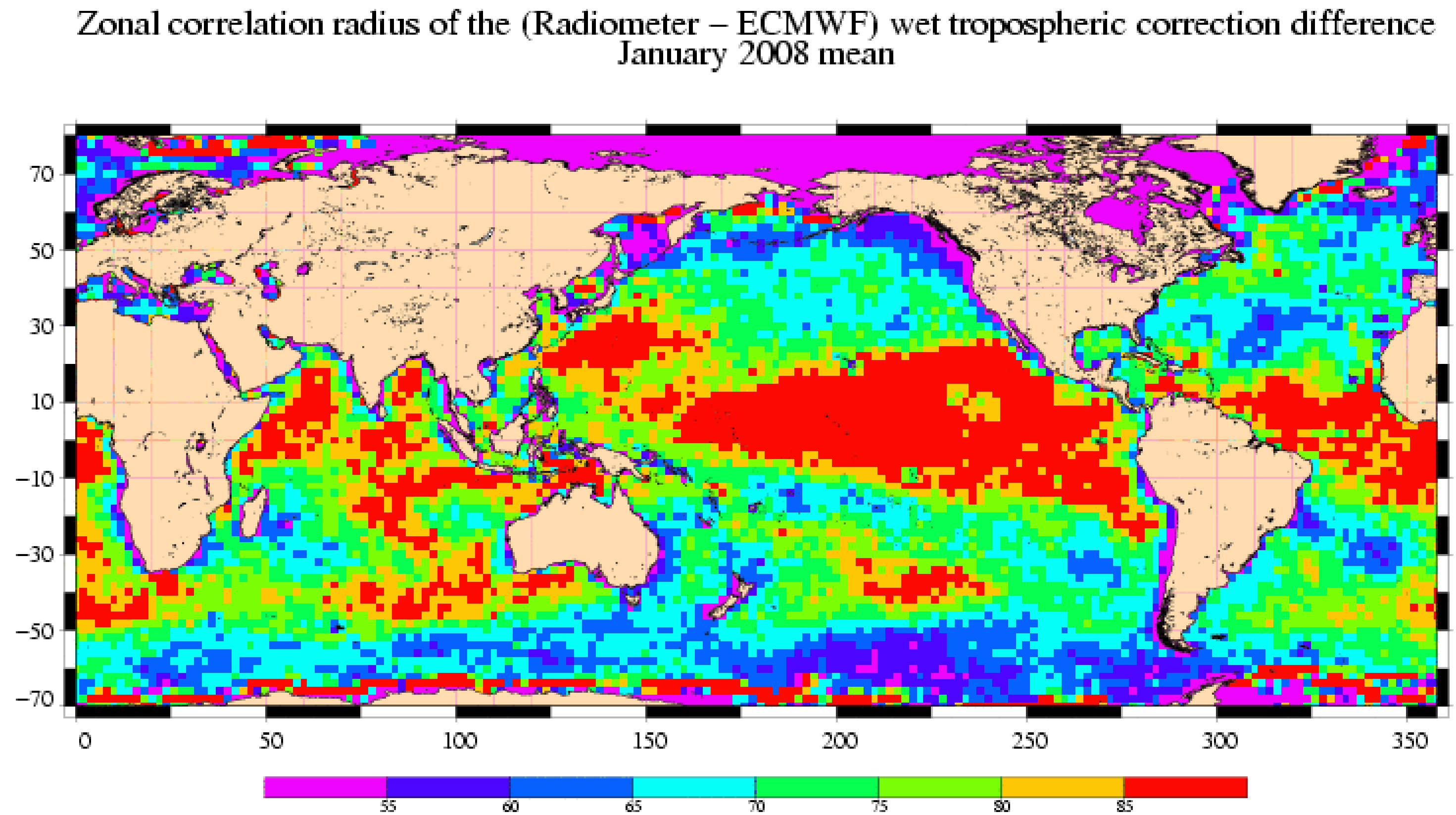


Time correlation radius



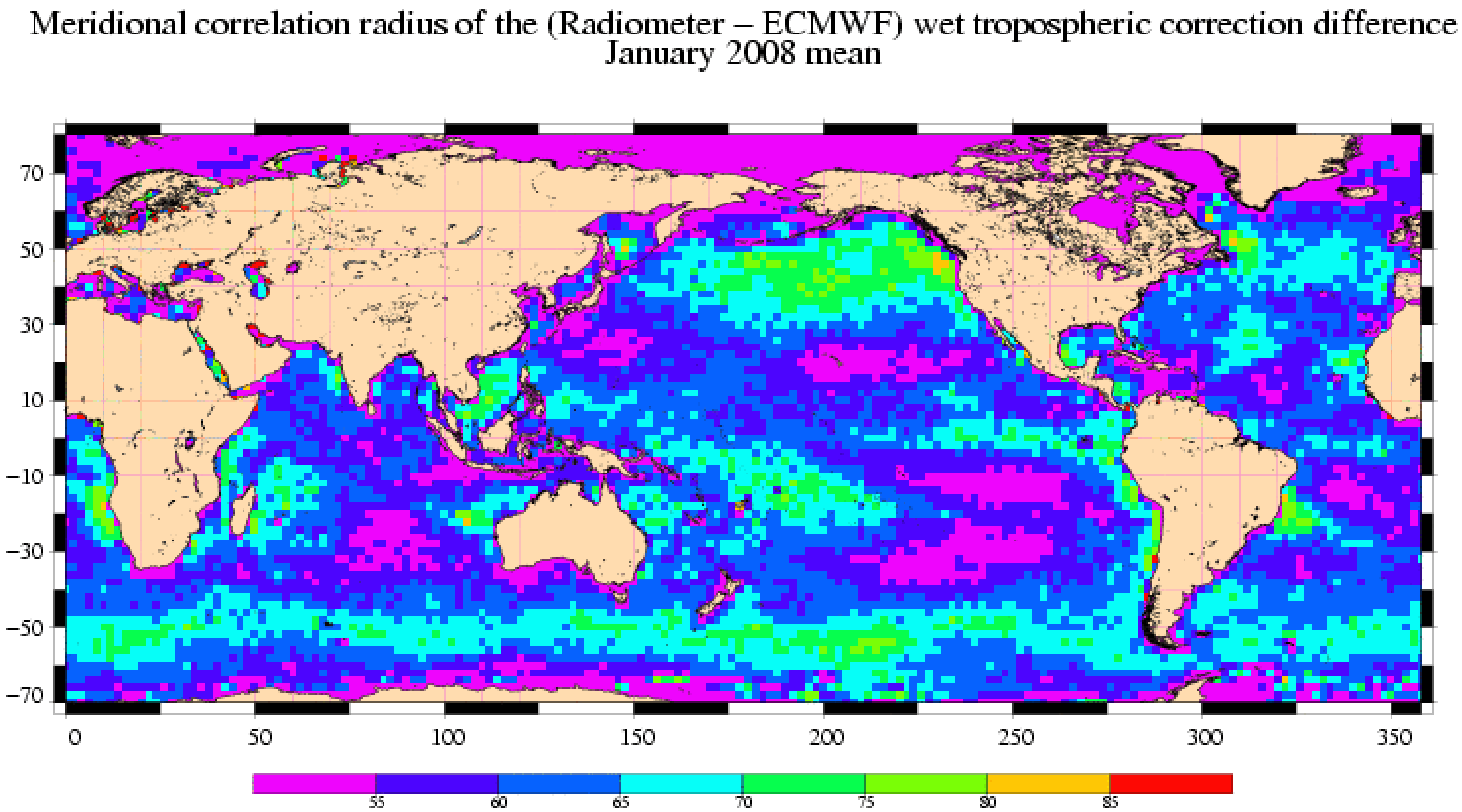
Mean value = 2 hours

Zonal correlation radius



Mean value = 70 km

Meridional correlation radius



Mean value = 60 km

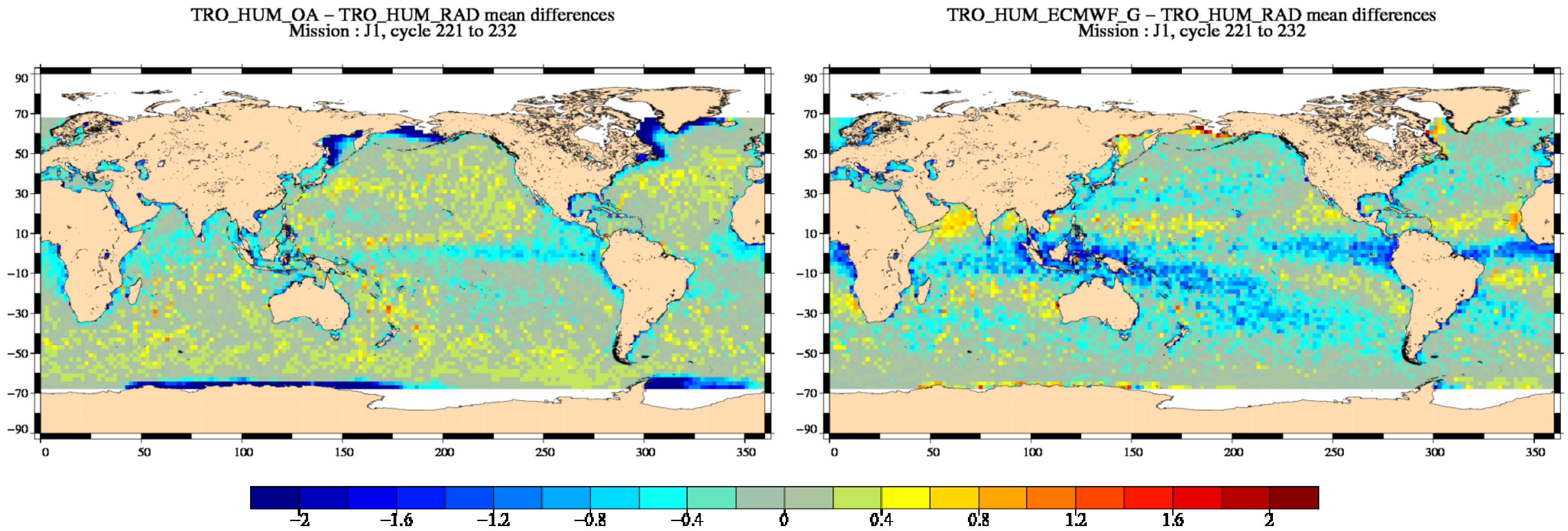
Main features of correlation scales

- Space and time correlation scales of PD anomaly are geographically dependent, and to a lesser extent, seasonally dependent
- Meridional scales are generally shorter (~60 km) than zonal ones (~80 km)
- Size and shape of the subdomain used to select observations around P will thus be strongly geographic dependent

Validation exercise

- Running the OA using Jason-1 altimeter positions (12 cycles, January to April 2008)
- Assessing the performance of the OA-derived PD (only for formal error < 1)
  - Comparison of the JMR, ECMWF and OA PDs
  - Sea surface height crossover analysis

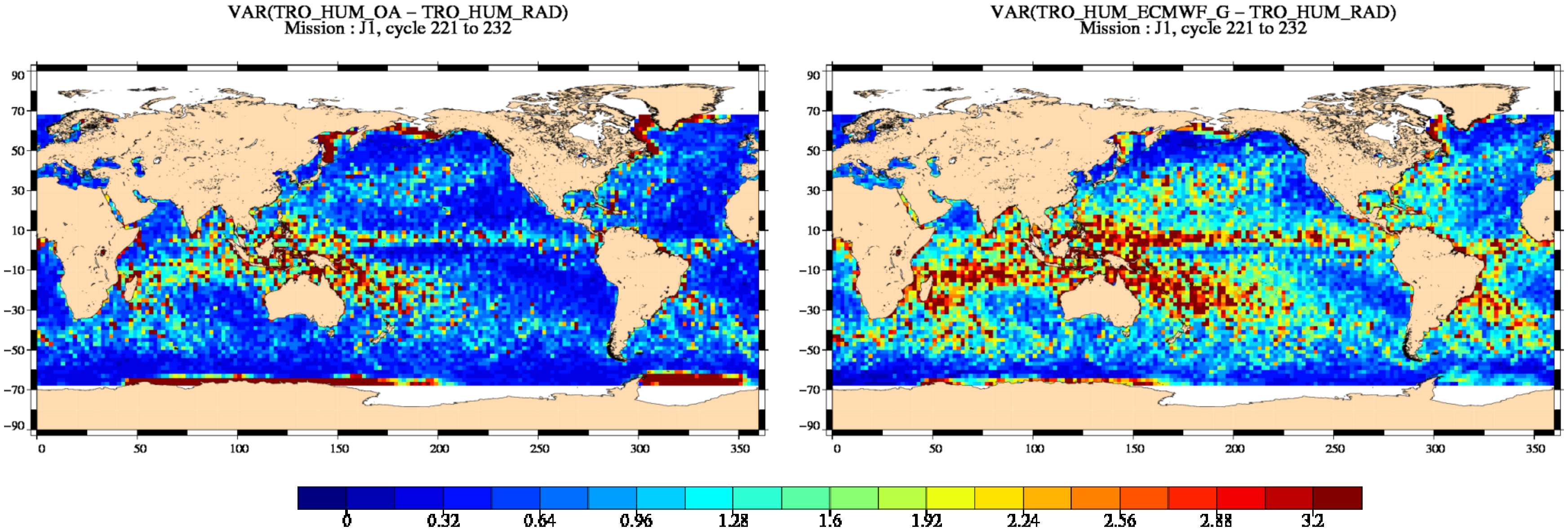
Statistical comparison of the 3 PD corrections



Mean of (OA – JMR) PD difference (left)

Mean of (ECMWF – JMR) PD difference (right)

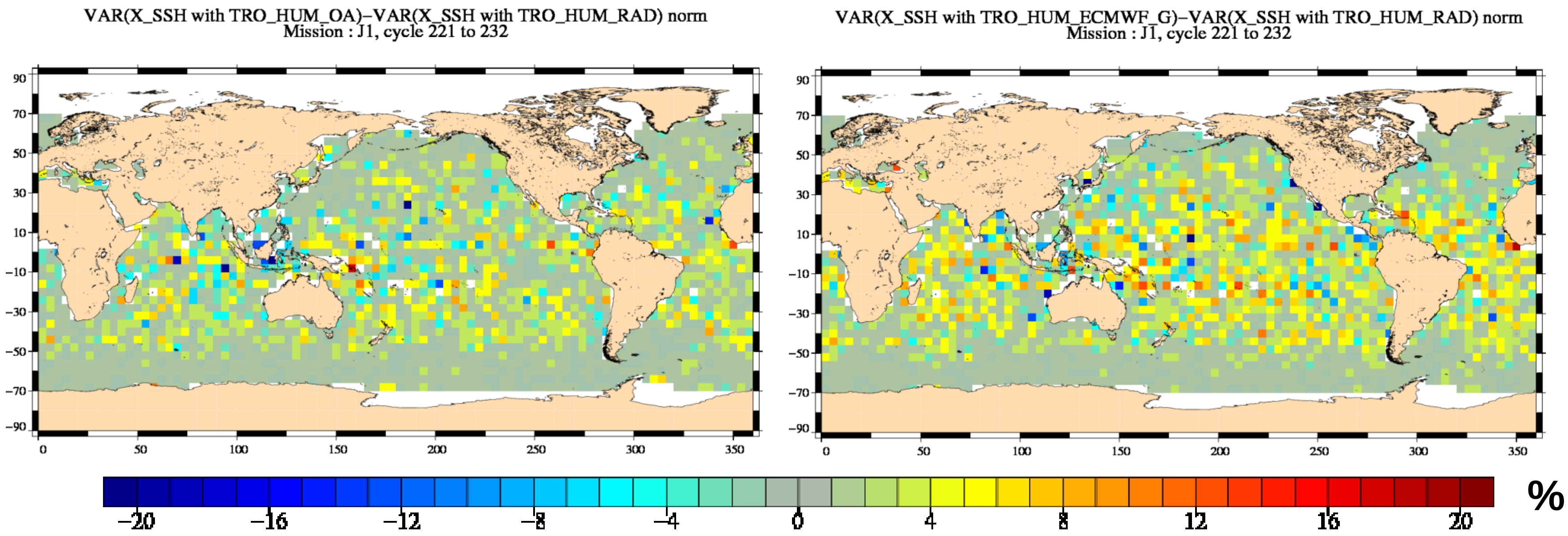
Statistical comparison of the 3 PD corrections



Variance of (OA – JMR) PD difference (left)

Variance of (ECMWF – JMR) PD difference (right)

Sea surface height performance analysis



$$\frac{Var(SSH_{OA}) - Var(SSH_{JMR})}{Var(SSH_{JMR})}$$

$$\frac{Var(SSH_{ECMWF}) - Var(SSH_{JMR})}{Var(SSH_{JMR})}$$

Conclusions

- OA of scanning radiometers measurements using ECMWF as first-guess allows to compute a reliable PD correction for altimetry
- OA correction performs better than the ECMWF one, but the JMR remains the best one
- OA correction accuracy is governed by :
  – 1 : the number and accuracy of observations
  – 2 : the knowledge of the covariance model, including the sensor errors (to be improved !)

Conclusions

- OA software is close to « operational » and may be implemented in delayed time for Cryosat-2 over the ocean
- Acknowledgments to all data providers :
  - NSIDC
  - GHRC
  - NOAA CLASS staff (for unusual 1-year bulk data orders for AMSU and SSMI !)
- Certain potential to complement radiometer estimation (extrapolation accross track, SWOT mission for example)