Comparison of internal tides corrections for global ocean

L. Carrere, F. Lyard, R. Baghi, N. Picot

Context

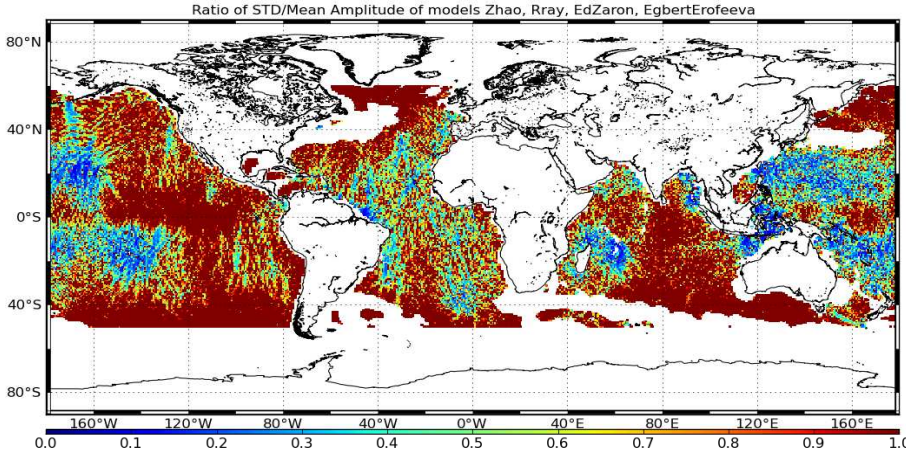
- Internal tide are a major source of dissipation of barotropic tide in the global ocean
- Internal tides surface signature can reach several cm
- IT wavelengths range between 50-250 km which is close to sub-mesoscale/mesoscale spatial scales
- Internal tides correction remains a challenge for coming HR missions like SWOT
- Different scientific teams are working on developing new IT models
- We focus on coherent IT

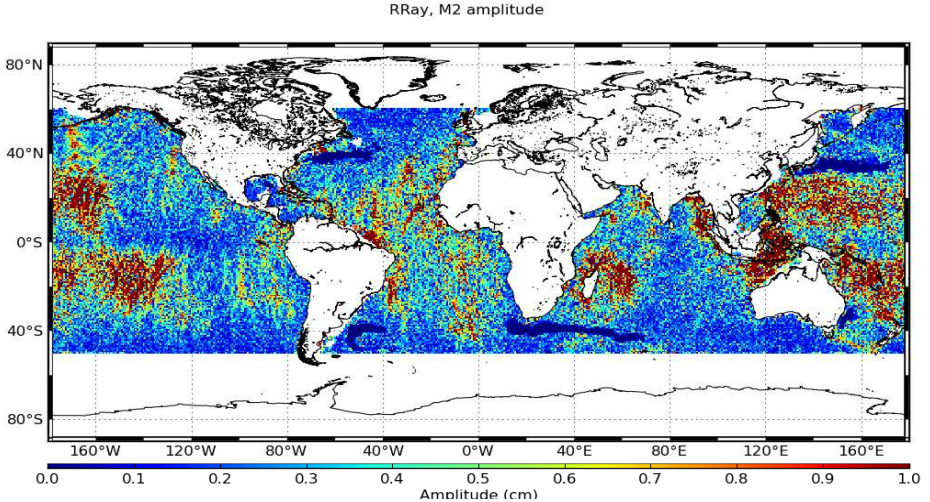
6 models provided for the study

- Ed. Zaron (filtered version)
  - Grid: 1/20°
  - Use J2 + C2 data
  - Waves: **M2**, **K1**
  - Spatial cover: -65° < lat < 65°
- Z. Zhao :
  - Grid: 1/10°
  - Use GFO+ERS-EN+TP-Jason data
  - Wave: **M2**, **recently K1**
  - Spatial cover : -65° < lat < 65°
- R. Ray :
  - Grid : 1/20°
  - Use GFO+ERS-EN+TP-Jason data
  - Wave : **M2**
  - Spatial cover: -50° < lat < 60°
- G. Egbert & L. Erofeeva :
  - Grid : 1/30°
  - Waves : **M2**, **K1**
  - Spatial cover: -60° à 60° Latitudes
- B. Dushaw :
  - Grid: 1/20°
  - Use TP + Jason data
  - Waves: **M2**, **K1**
  - Spatial covering: only regional grids available (11°x11°), no continuity ensured between regions
- B. Arbic :
  - 3D Model extracted along TP-J tracks => not usable for the comparison study
  - Waves: **M2**

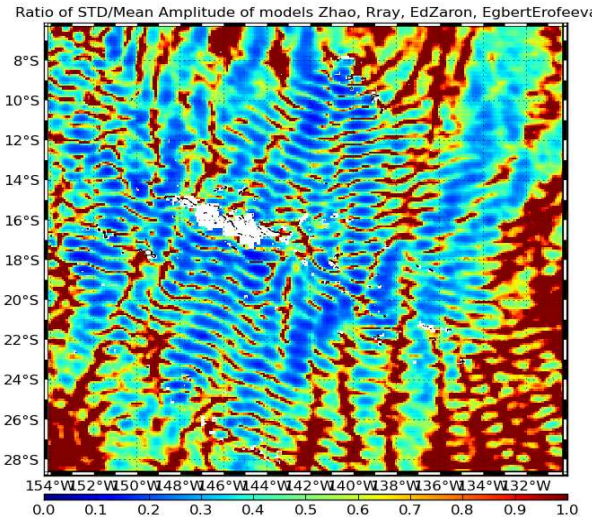
Normalized STD for M2

(ratio of STD / mean amplitude, 4 models)

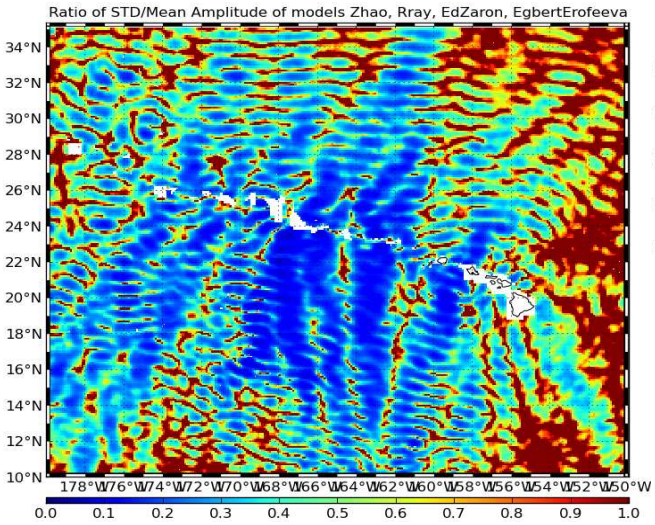




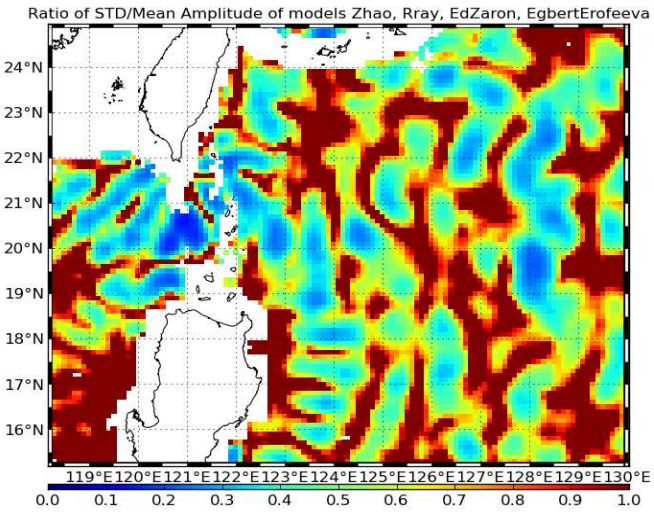
Tahiti



Hawaii

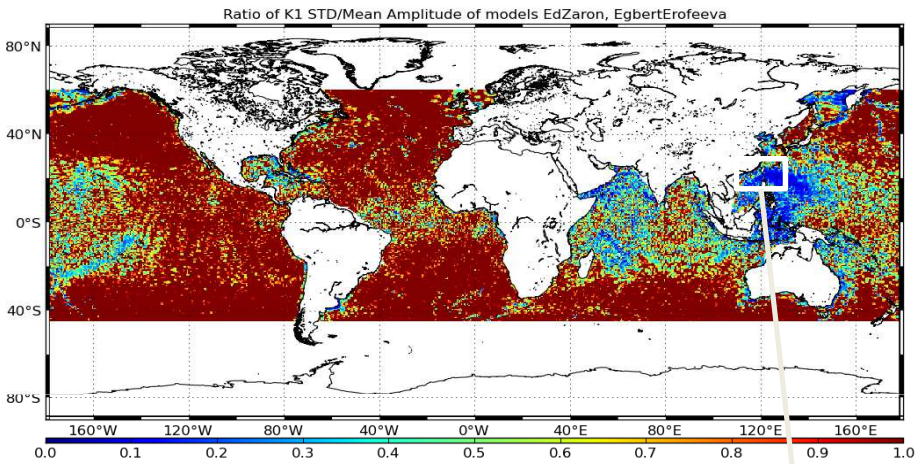


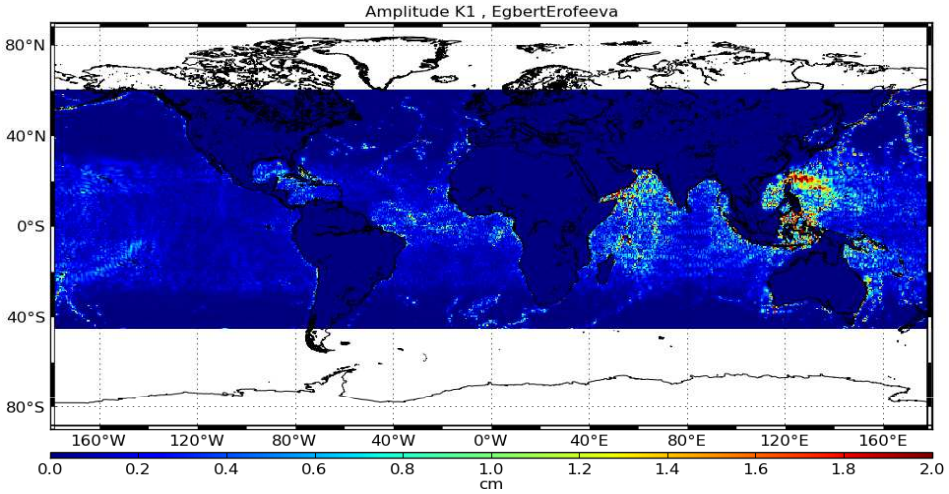
Luzon



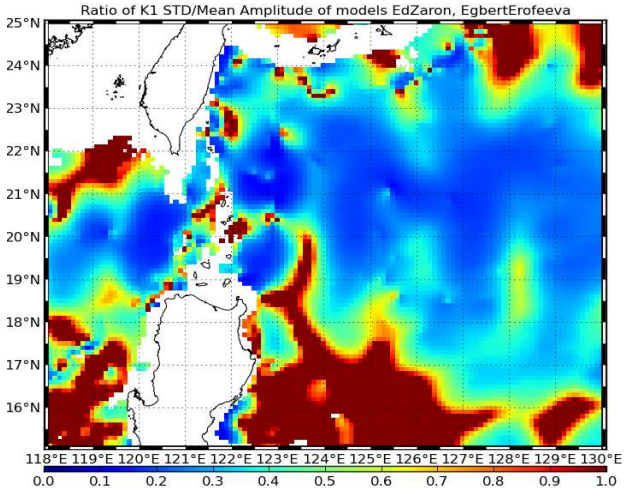
Normalized STD for K1

(ratio of STD / mean amplitude, 2 models)





Luzon

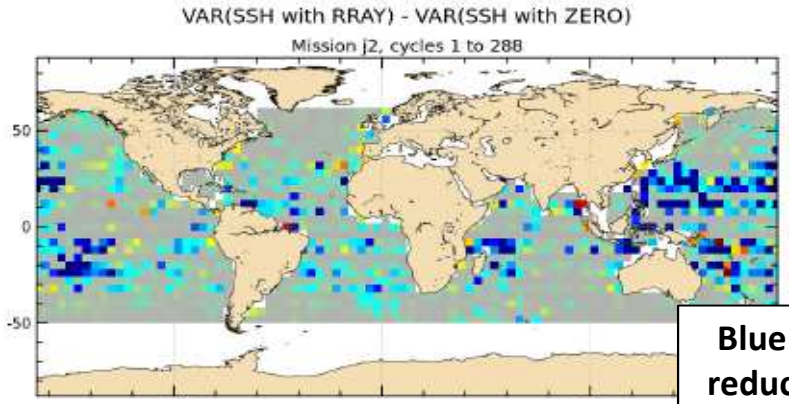


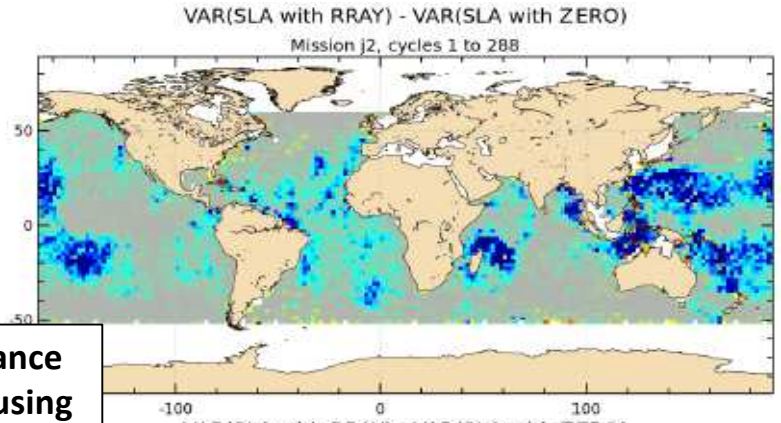
Variance reduction of altimeter measurements

- Missions studied = J2, AL and C2
- FES2014b model used as barotropic tide correction
- Variance reduction computed for SSH crossovers differences and for along-track SLA
- M2, K1 tested separately:
  - M2: Ray, Zaron, Zhao, Egbert, Dushaw
  - K1: Zaron, Egbert, Dushaw

Comparison of Rray IT correction vs no correction – M2

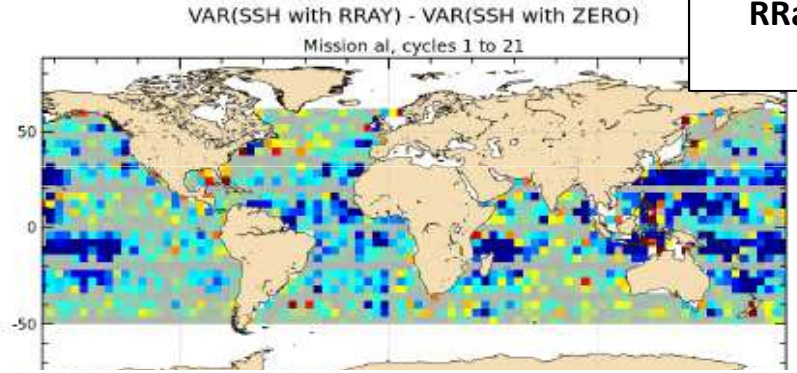
J2

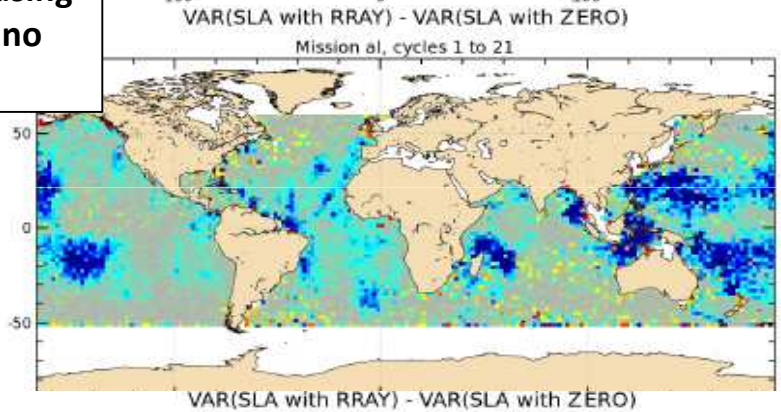




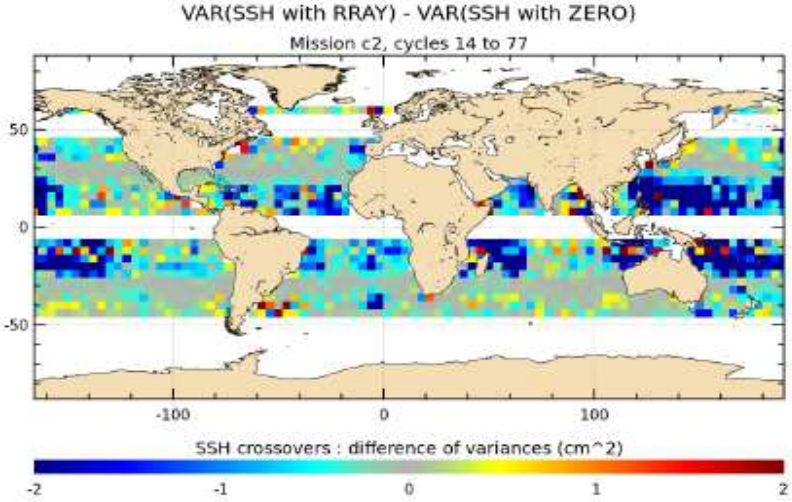
Blue shows variance reduction when using RRay model vs no correction

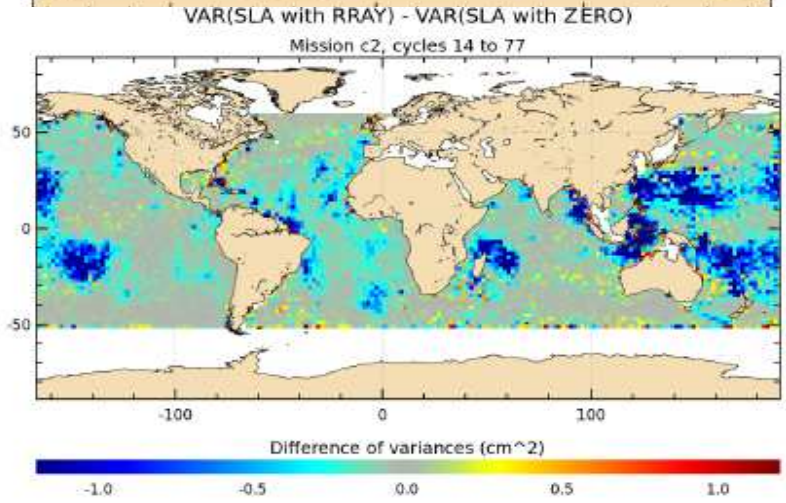
AL





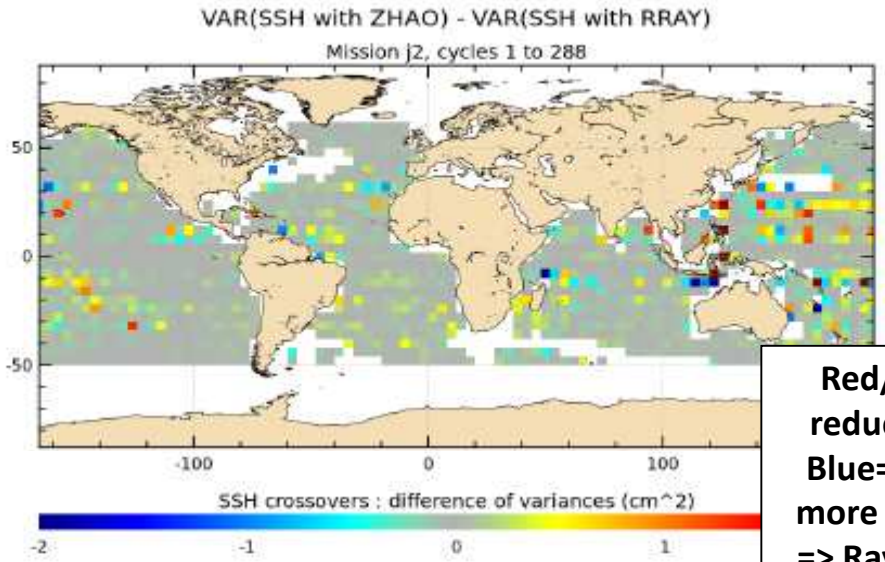
C2

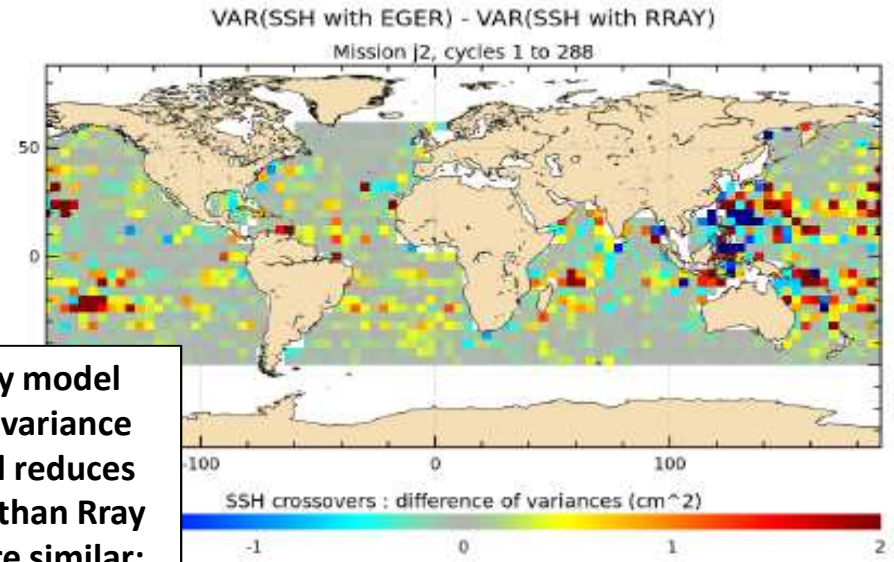




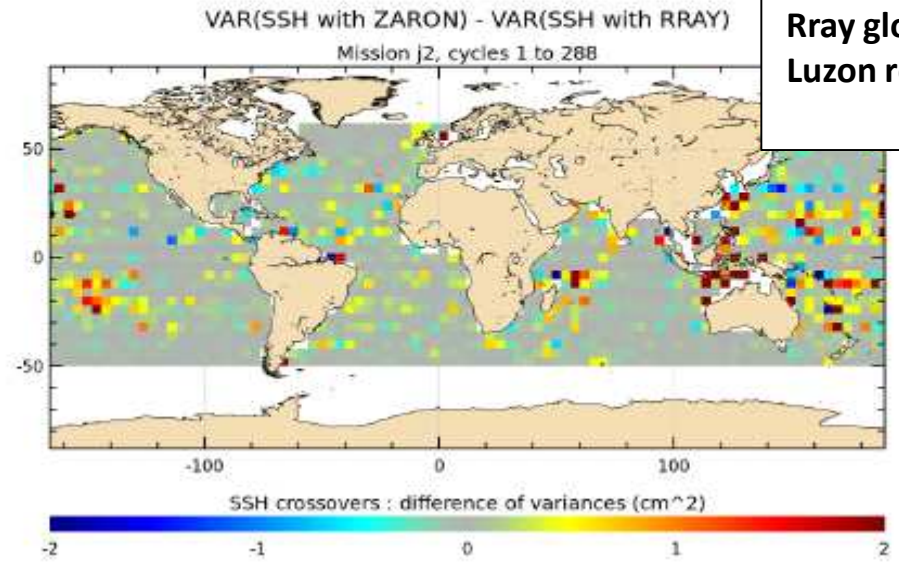
Comparison of IT corrections vs RRay's one – M2

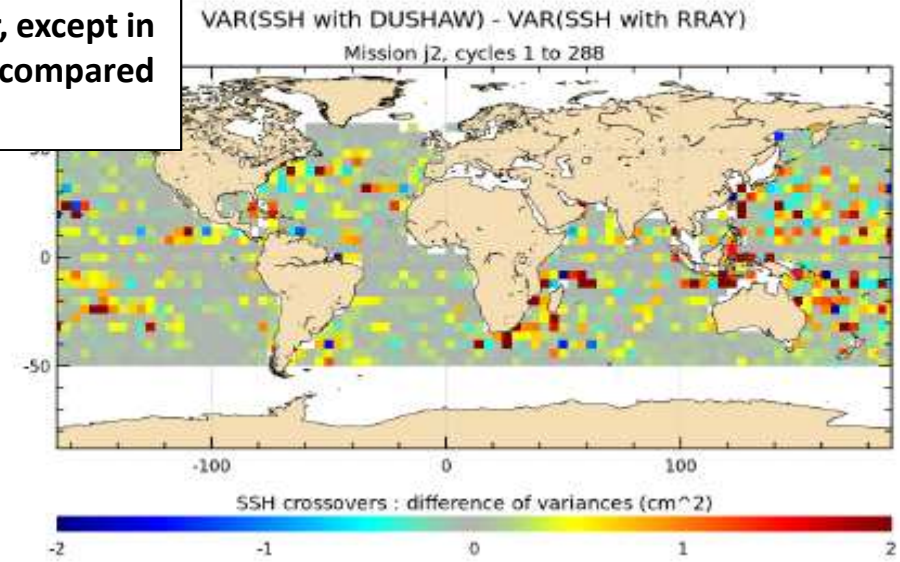
J2 mission - SSH crossovers





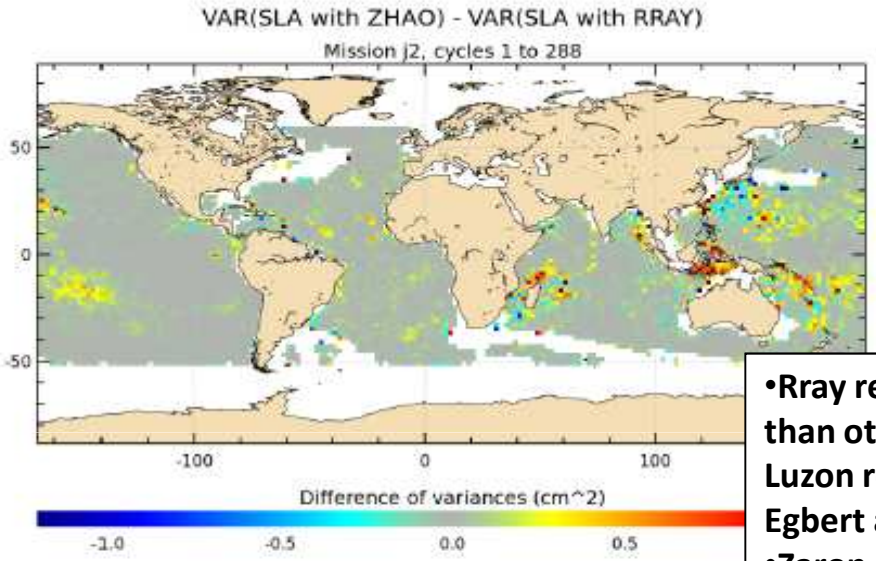
Red/yellow= RRay model reduces more the variance
Blue= other model reduces more the variance than Rray
=> Ray and Zhao are similar; Rray globally better, except in Luzon region when compared to Egbert

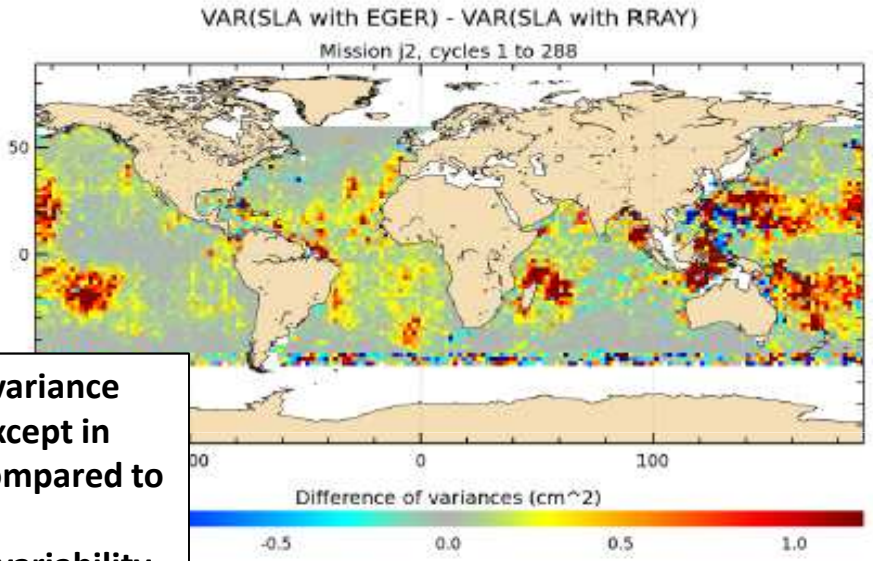




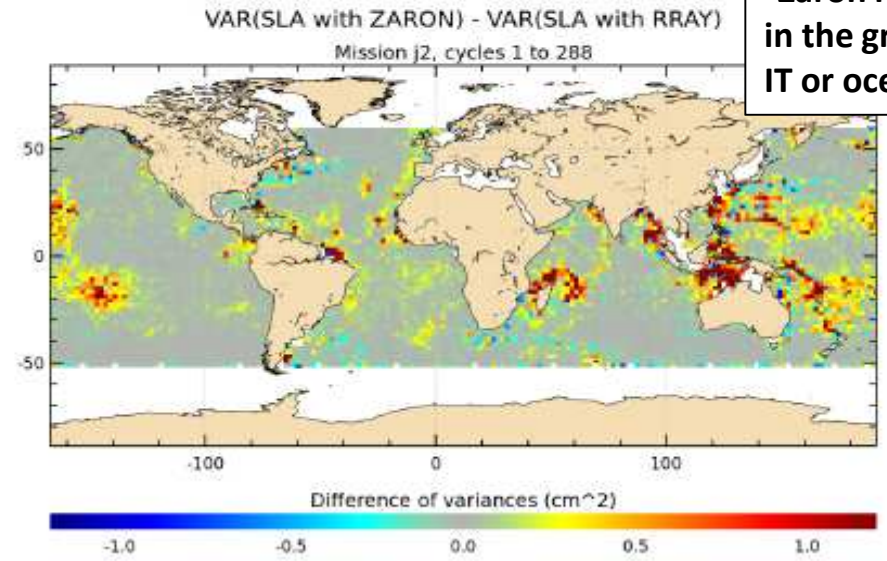
Comparison of IT corrections vs RRay's one – M2

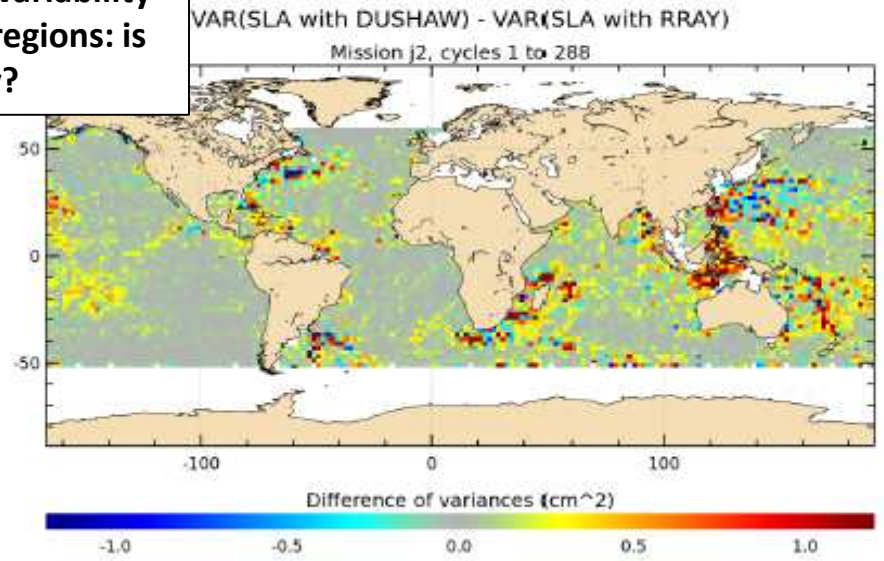
J2 mission - SLA





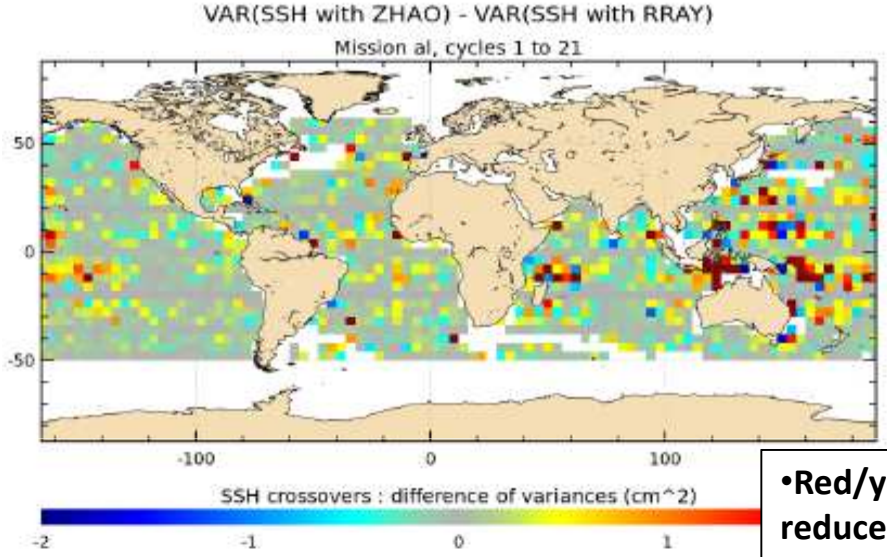
- **Rray removes more variance than other models, except in Luzon region when compared to Egbert and Zhao**
- **Zaron remove some variability in the great currents regions: is IT or ocean variability?**

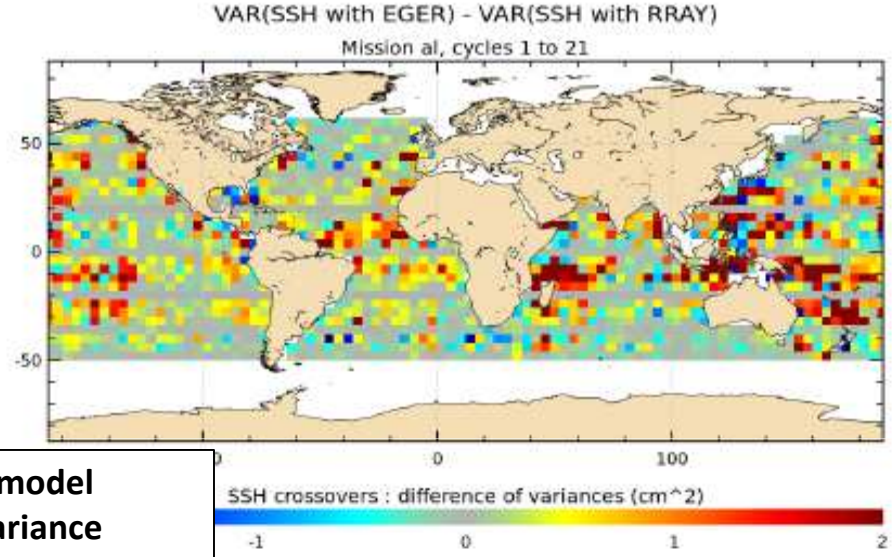




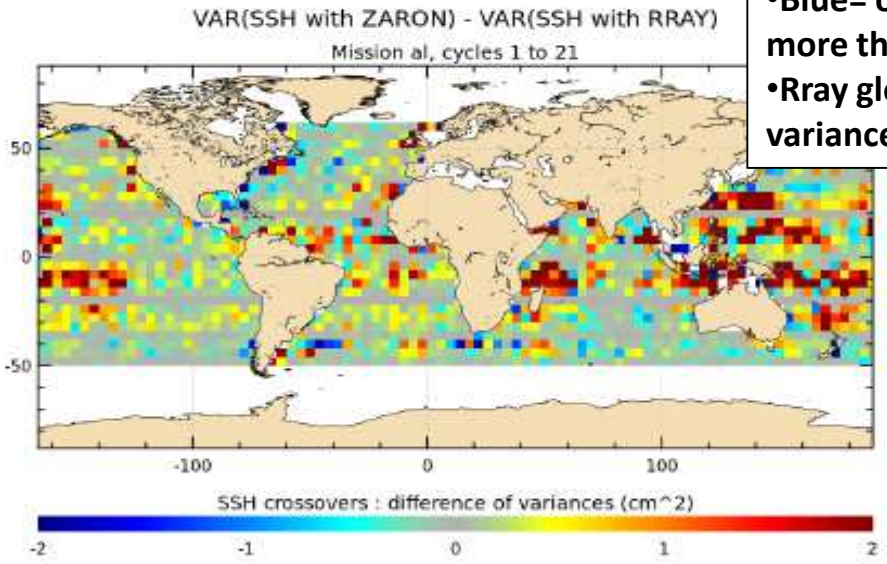
Comparison of IT corrections vs RRay's one – M2

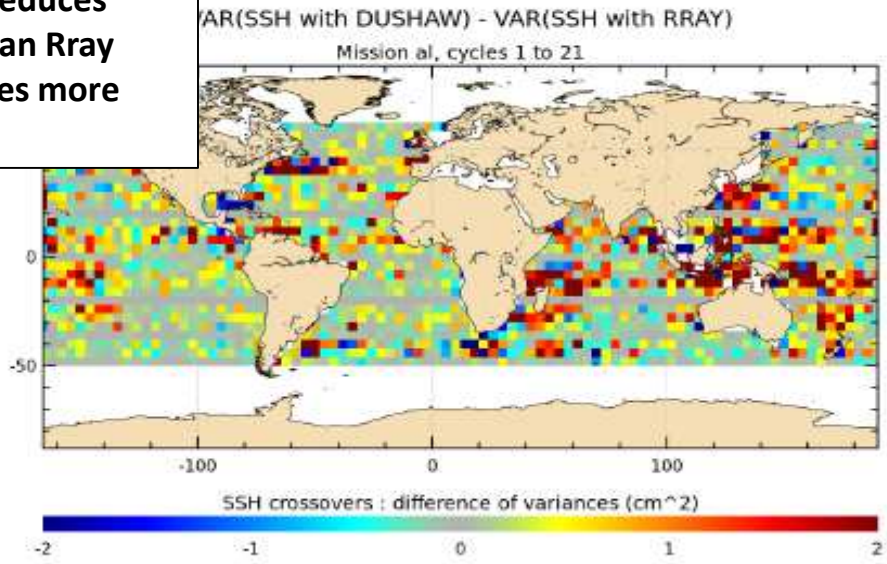
AL mission - SSH crossovers





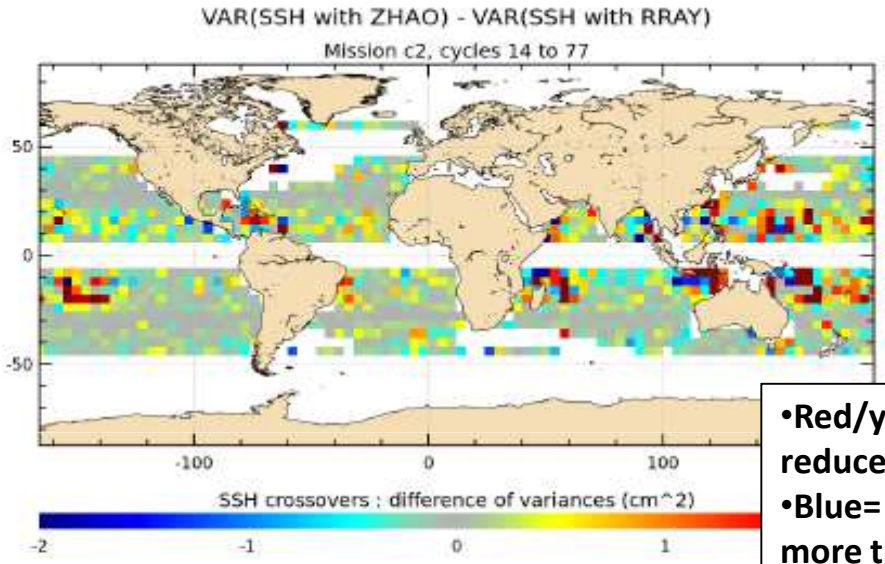
- **Red/yellow= RRay model reduces more the variance**
- **Blue= other model reduces more the variance than Rray**
- **Rray globally removes more variance**

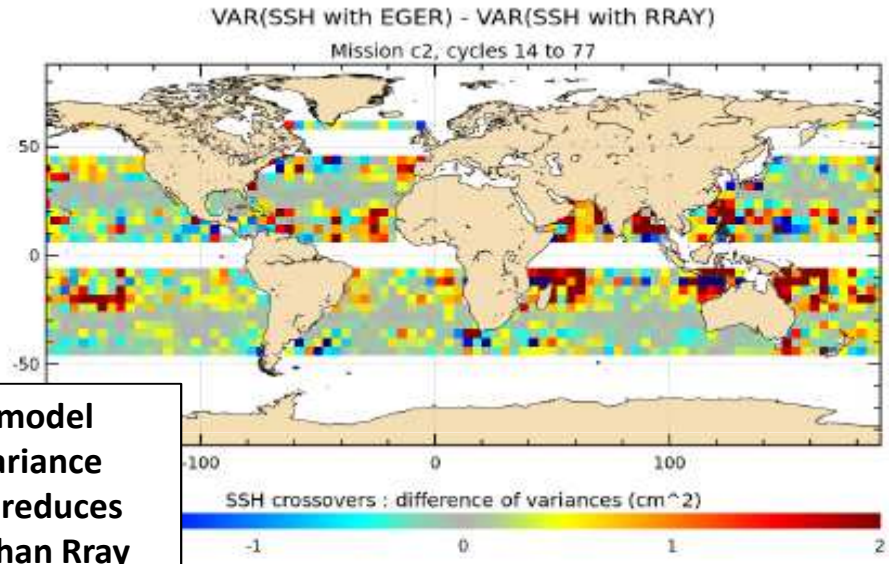




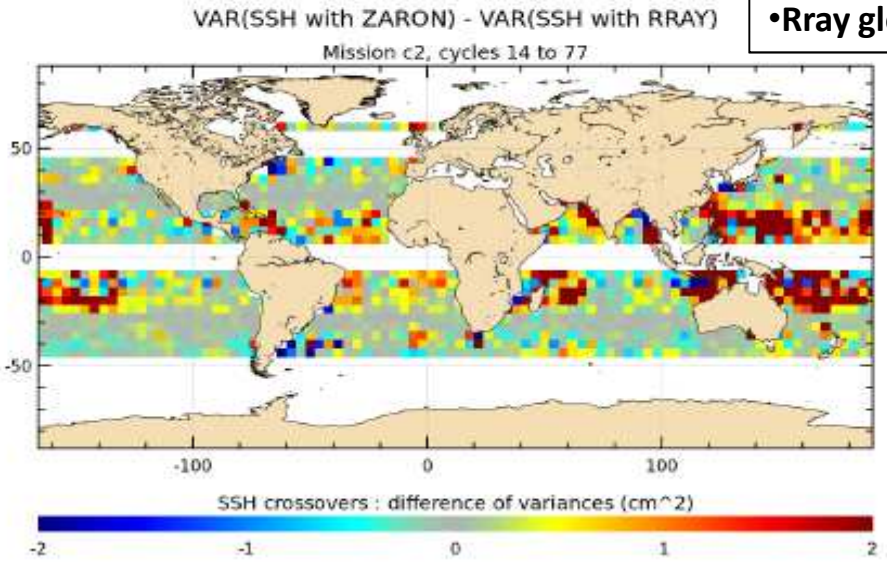
Comparison of IT corrections vs RRay's one – M2

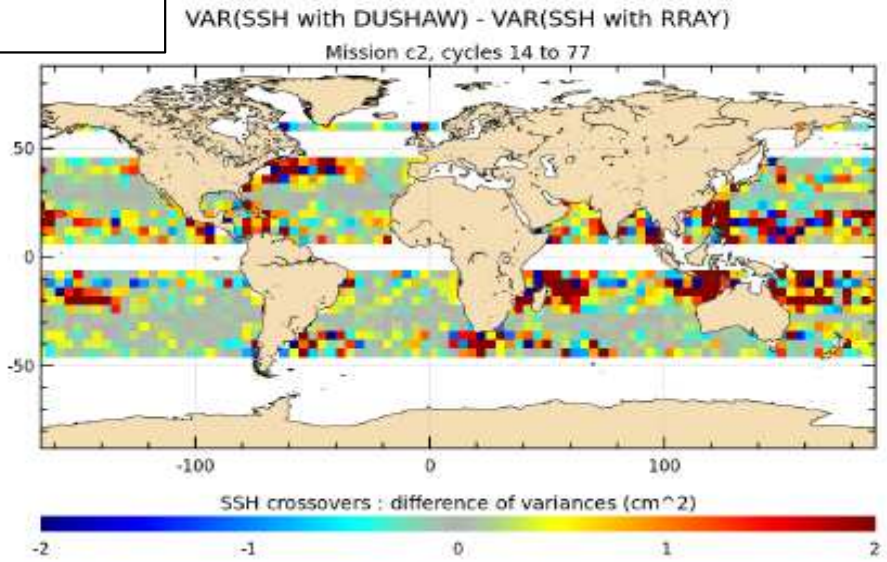
C2 mission - SSH crossovers





- **Red/yellow= RRay model reduces more the variance**
- **Blue= other model reduces more the variance than Rray**
- **Rray globally better**

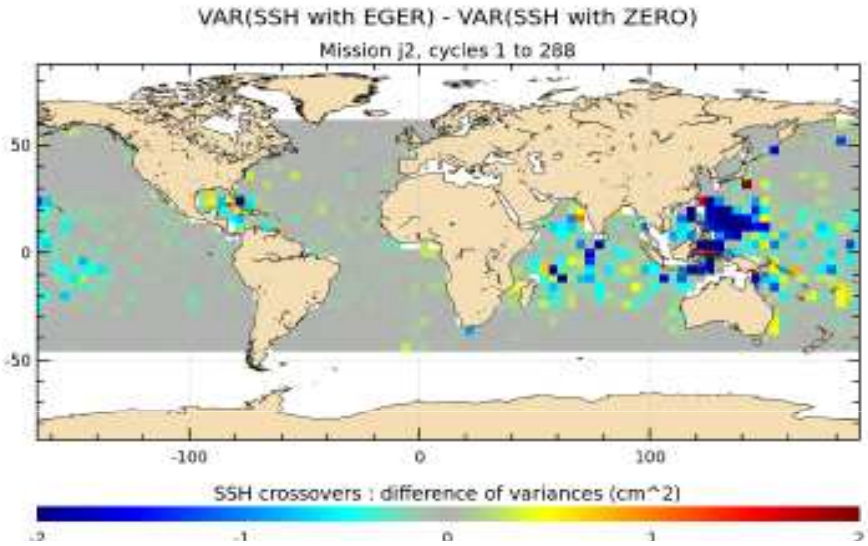


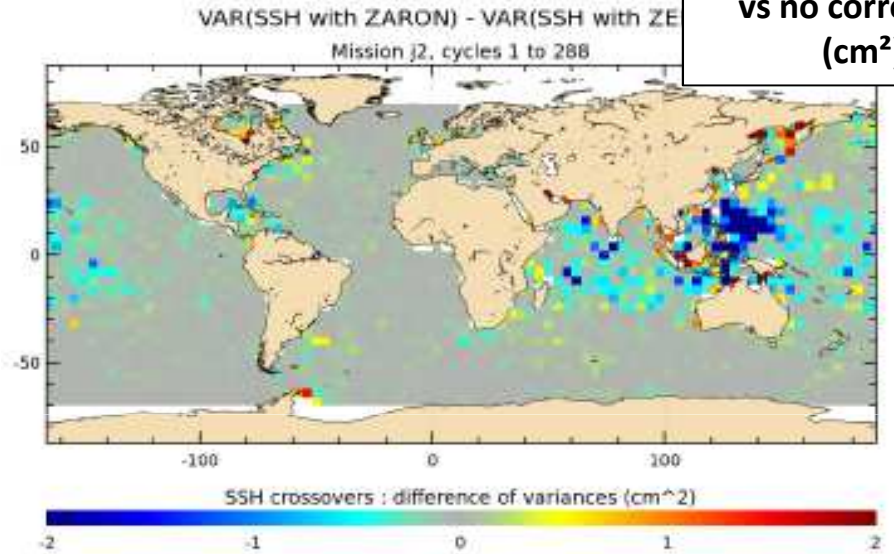


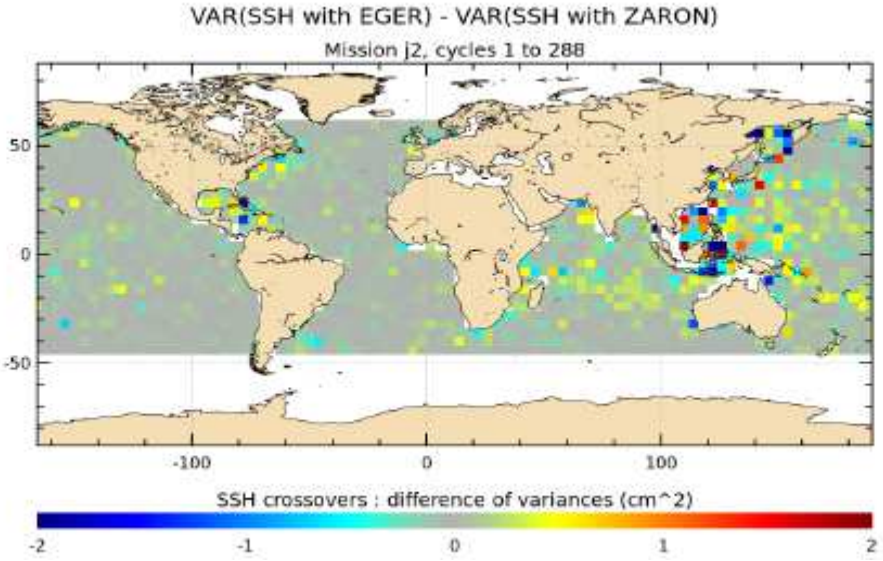
Comparison of IT corrections – K1

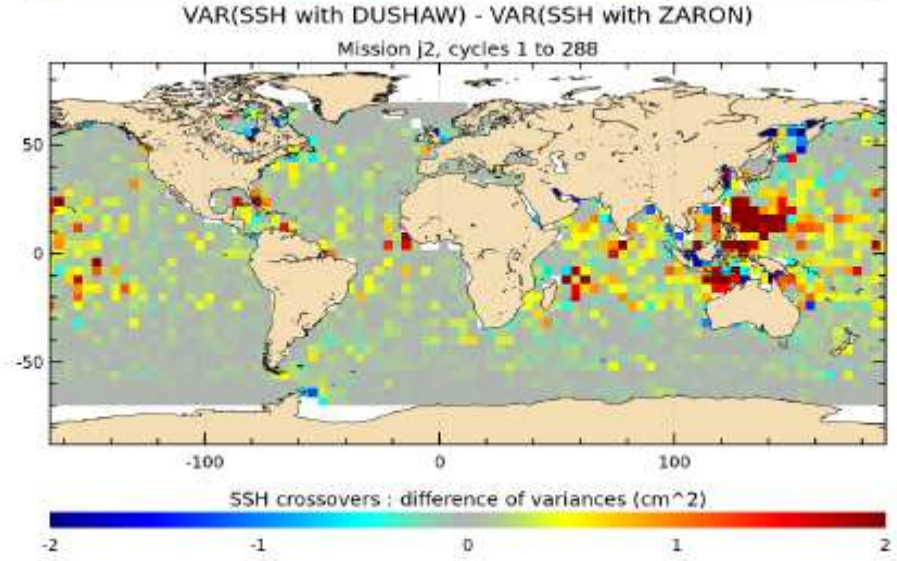
J2 mission - SSH crossovers

Blue shows variance reduction when using either EGBERT or ZARON K1 model vs no correction (cm^2)



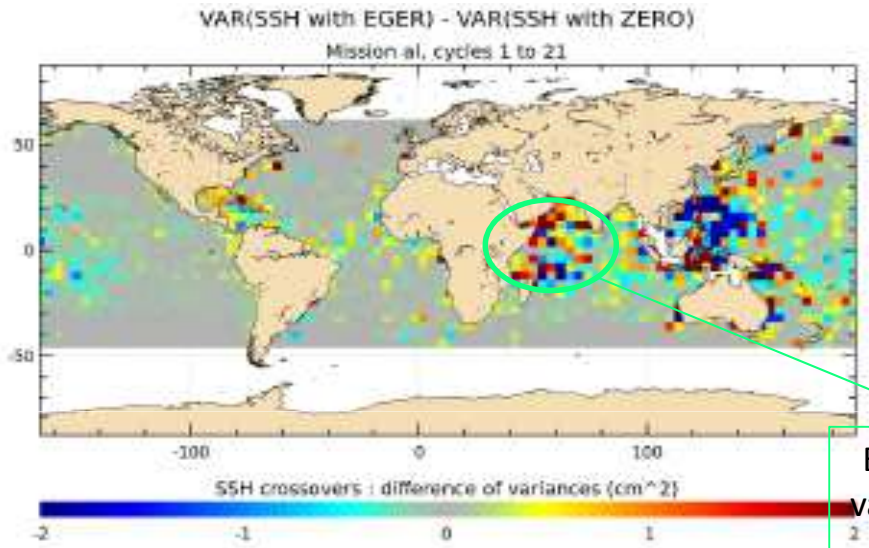


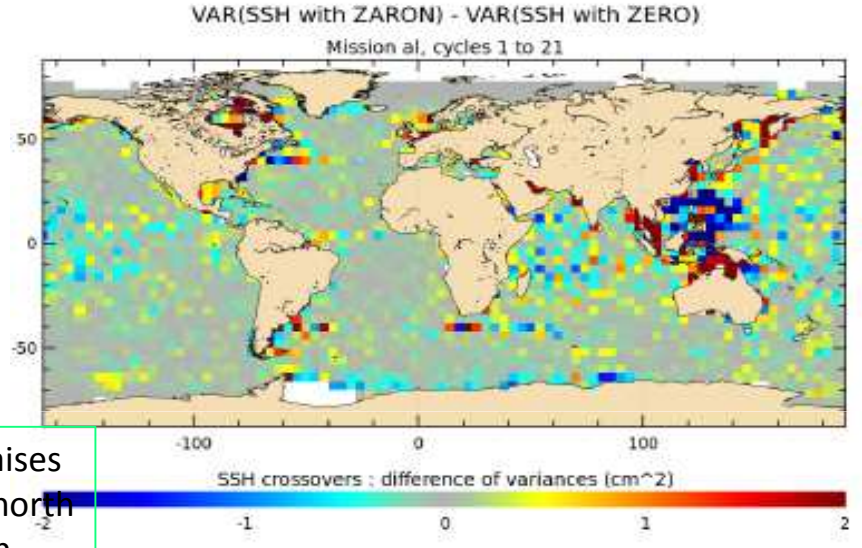




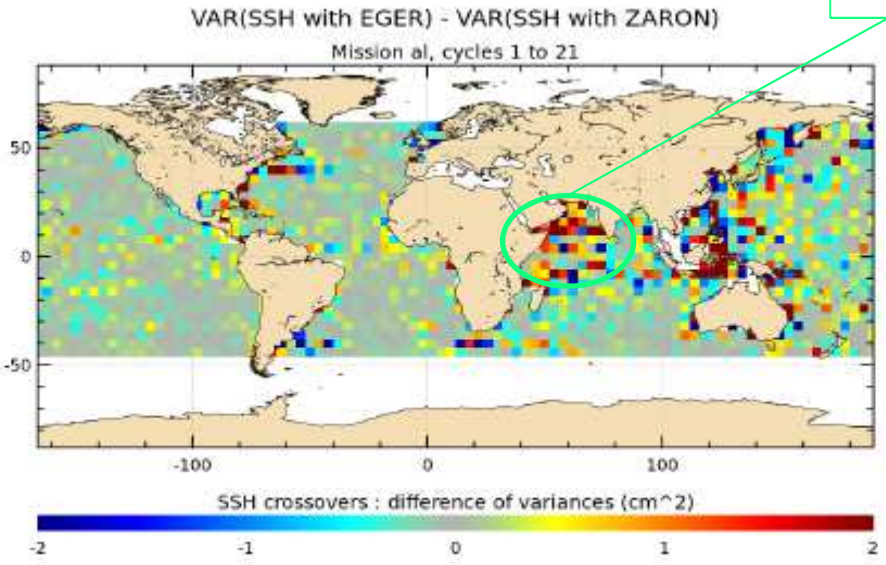
Comparison of IT corrections – K1

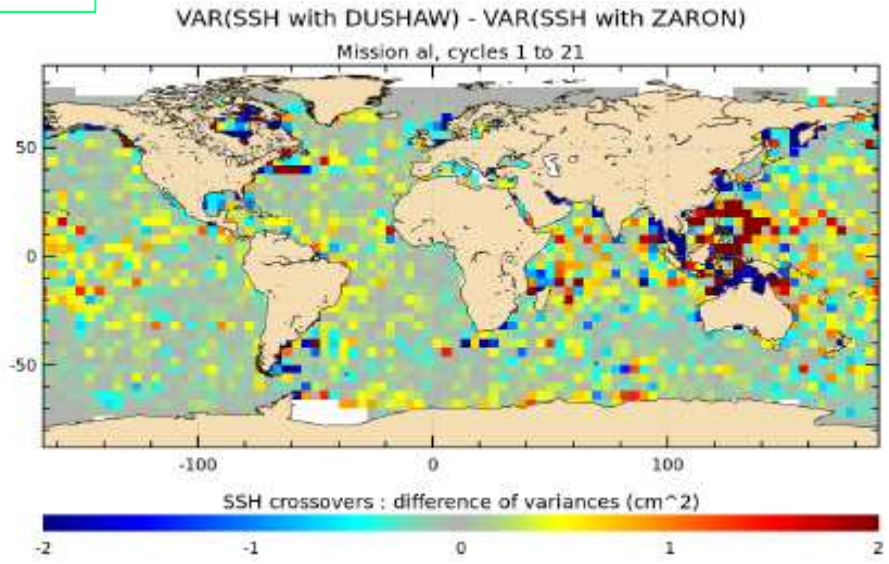
AL mission - SSH crossovers





Egbert raises variance north Indian





Spectral analysis

- **2D spectral analysis of SLA**

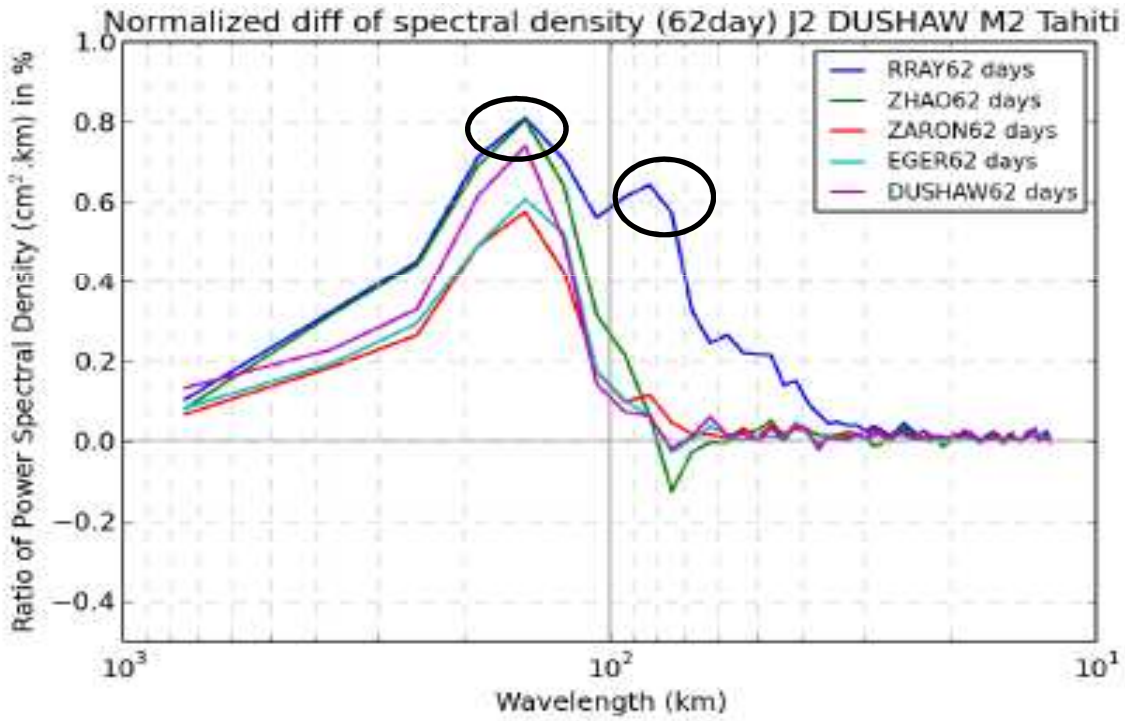
- **Objectives**:
  - Quantify the impact of the IT corrections
  - Quantify the residual energy at tidal frequencies = errors of IT models + residual non-coherent IT signal

- **SLA J2**

- **Focus on M2 frequency because K1 hardly separated from semi-annual signal (aliasing K1=173d)**

Tahiti area

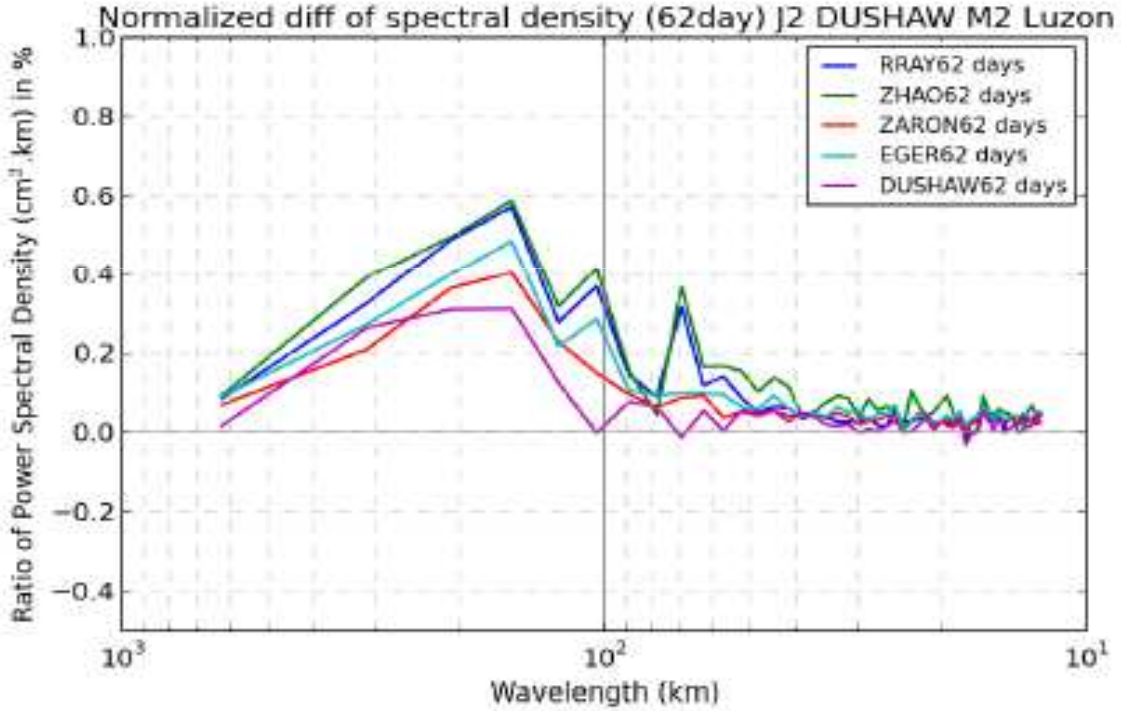
% of energy removed at M2 frequency, thanks to each IT correction



- Ray, Zhao remove ~80% for mode 1; other models are less efficient
- Ray removes 60% energy at 2nd mode wavelength

Luzon area

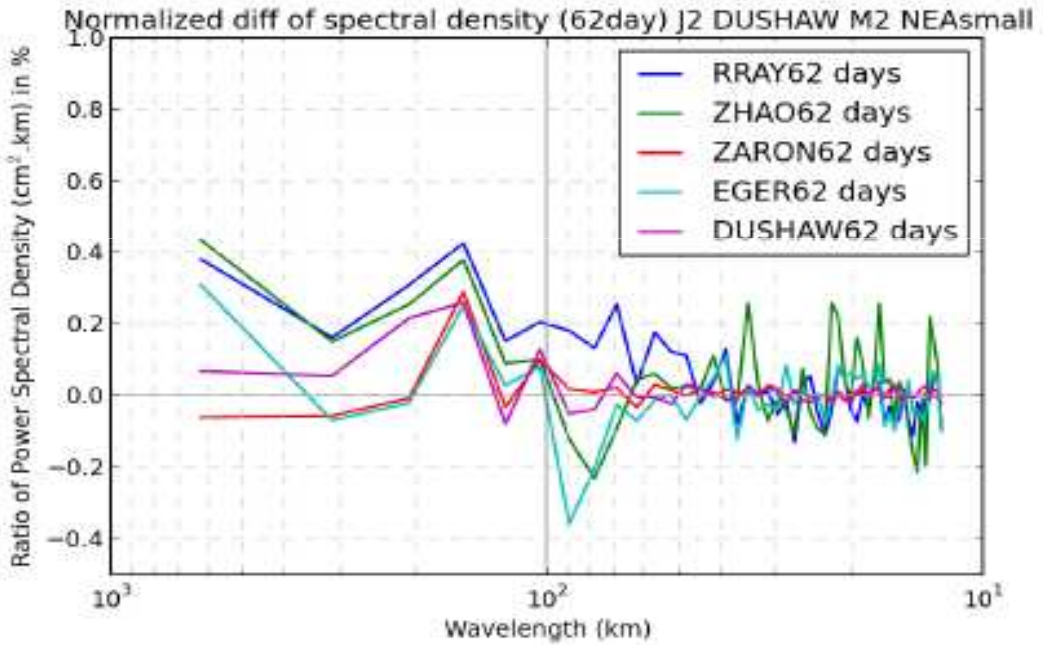
% of energy removed at M2 frequency, thanks to each IT correction



- Ray and Zhao remove ~60% energy for mode 1; other models are less efficient
- Ray, Zhao and Egbert remove energy at 2nd mode wavelength (40%)
- Ray and Zhao even remove energy at 3rd mode (35%)

NEA area

% of energy removed at M2 frequency, thanks to each IT correction



- Ray and Zhao remove ~40% energy for mode 1; other models are less efficient
- Ray removes energy at 2nd mode and even 3rd wavelengths; other models increase energy : 2nd mode is significant in this region but is has strong variability and it is hardly separable from other ocean variability …

Conclusions- perspectives

- M2: Ray and Zhao models are close
  - Ray removes more variability and also the 2nd mode of IT on Tahiti/Hawaii /NEA regions
  - Zhao also remove short scales on Luzon area
- K1: Egbert and Zaron are close
  - Zaron raises variance in coastal regions
  - Egbert raises variance north of Indian for AL (?)
- At this stage, a first IT correction can be proposed for nadir altimeters + SWOT :
  - **M2 Ray**
  - **K1** from Egbert or Zaron (with coastal regions removed) or even Zhao to be tested ?
- Analysis could be continued if any new IT model is available
- Use more in situ data for comparison