Comparison of models for coherent internal tides on 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
- These IT surface signatures need to be corrected for coming HR missions like SWOT to access to other ocean signals

6 models provided for the study

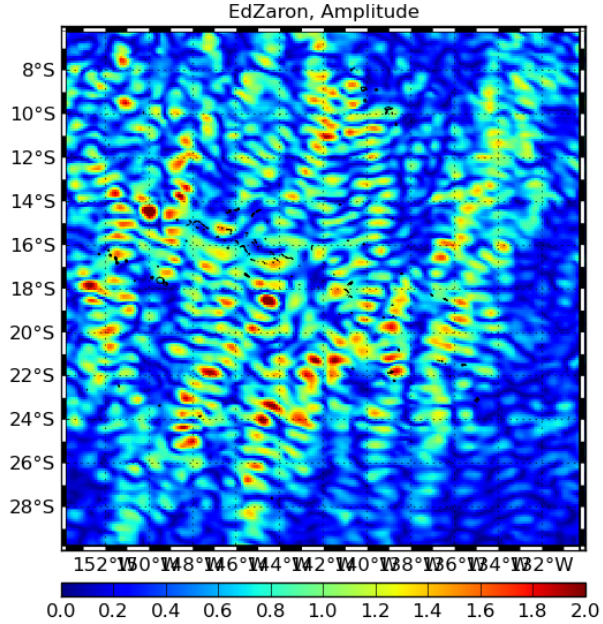
Thanks for providing the data !

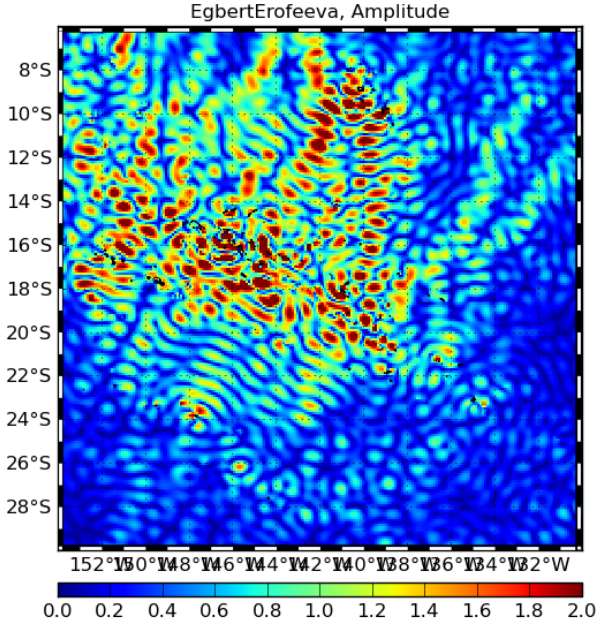
- **Ed. Zaron** (filtered version)
  - Grid: 1/20°
  - Use J2 + C2 data
  - Waves: **M2**, **K1**
  - Spatial cover: -65° < lat < 65°
- **Z. Zhao** :
  - Grid: 1/10°
  - Use GFO+ERS-EN+TP-Jason data
  - Wave: **M2**, **K1**
  - Spatial cover : -65° < lat < 65°, K1 +/-30°
- **R. Ray** :
  - Grid : 1/20°
  - 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 yet for the comparison study
  - Waves: **M2**

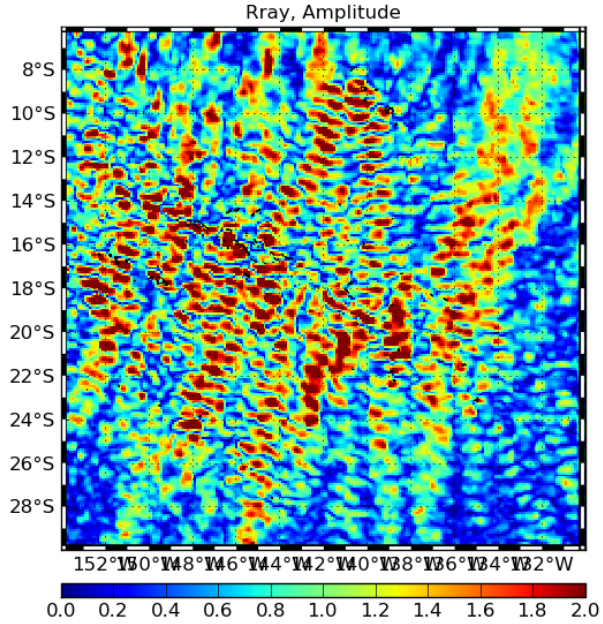
Validation diagnostics

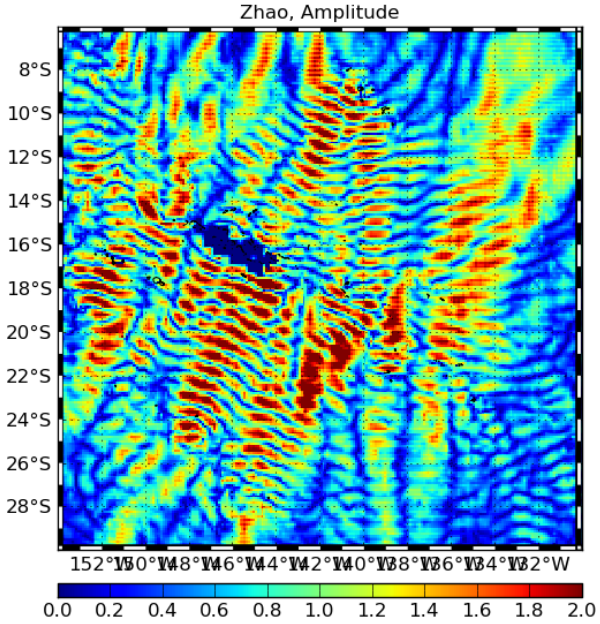
- Analysis of models' differences for each wave
- Variance reduction analysis using global altimeter databases: J2, AL, C2
- Spectral analysis to quantify the impact of the IT corrections and the residual part at tides frequencies
- Variance reduction analysis using some in situ dataset = thermistors (HOME, AMODE, RTE87)

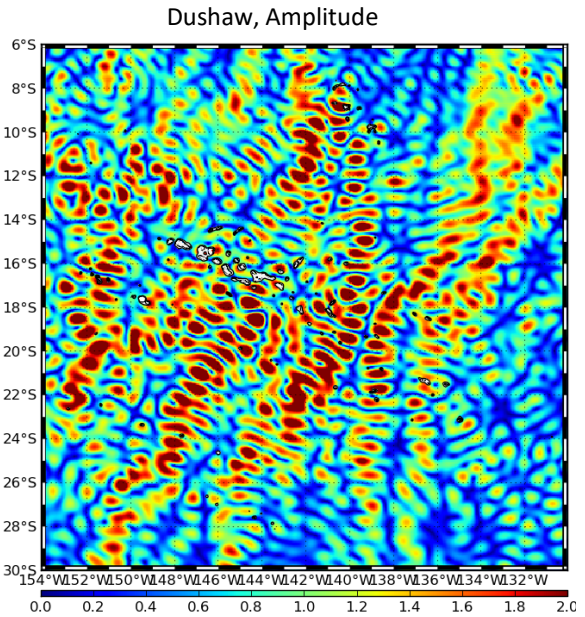
Comparison for M2 (Tahiti)



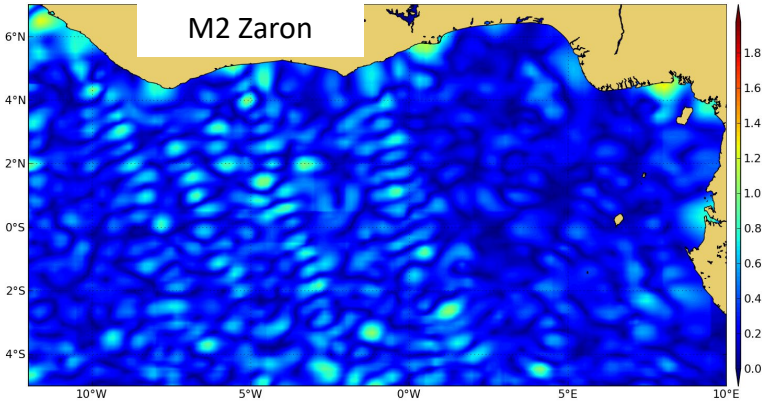


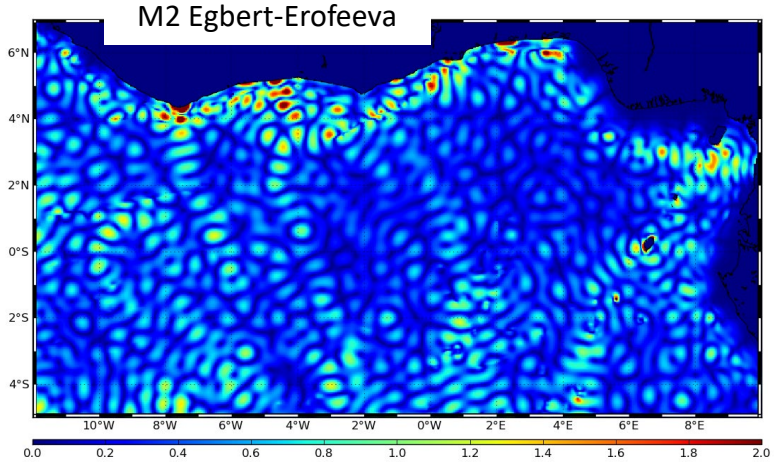


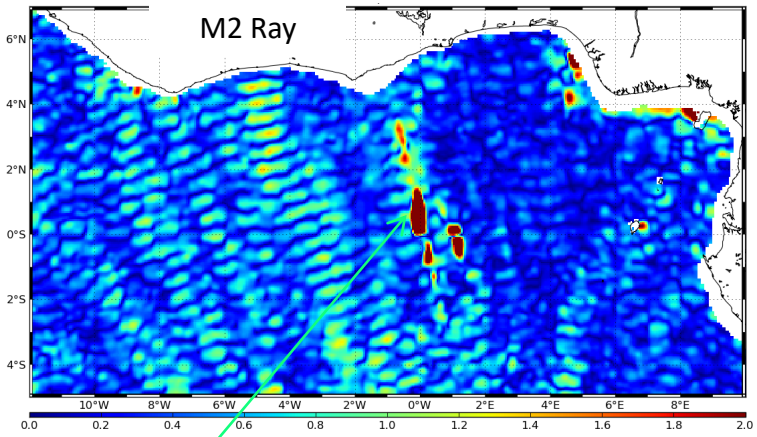


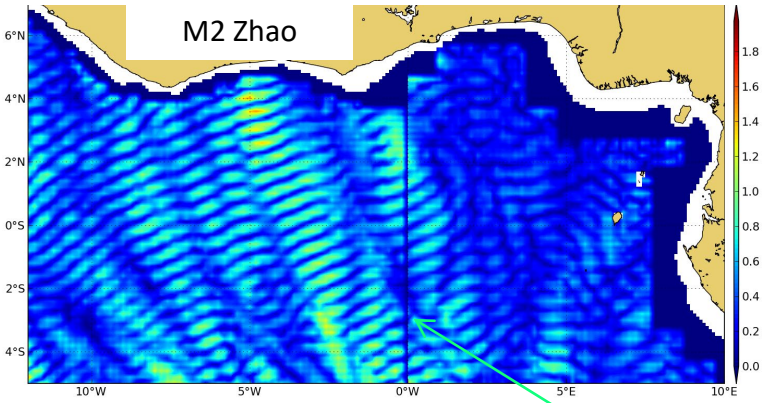


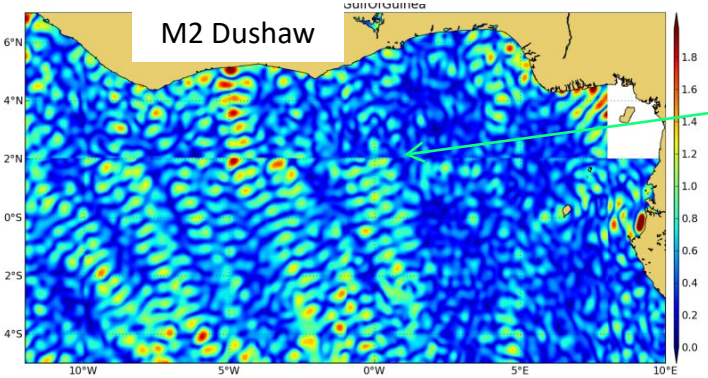
Comparison for M2 (Gulf of Guinea)







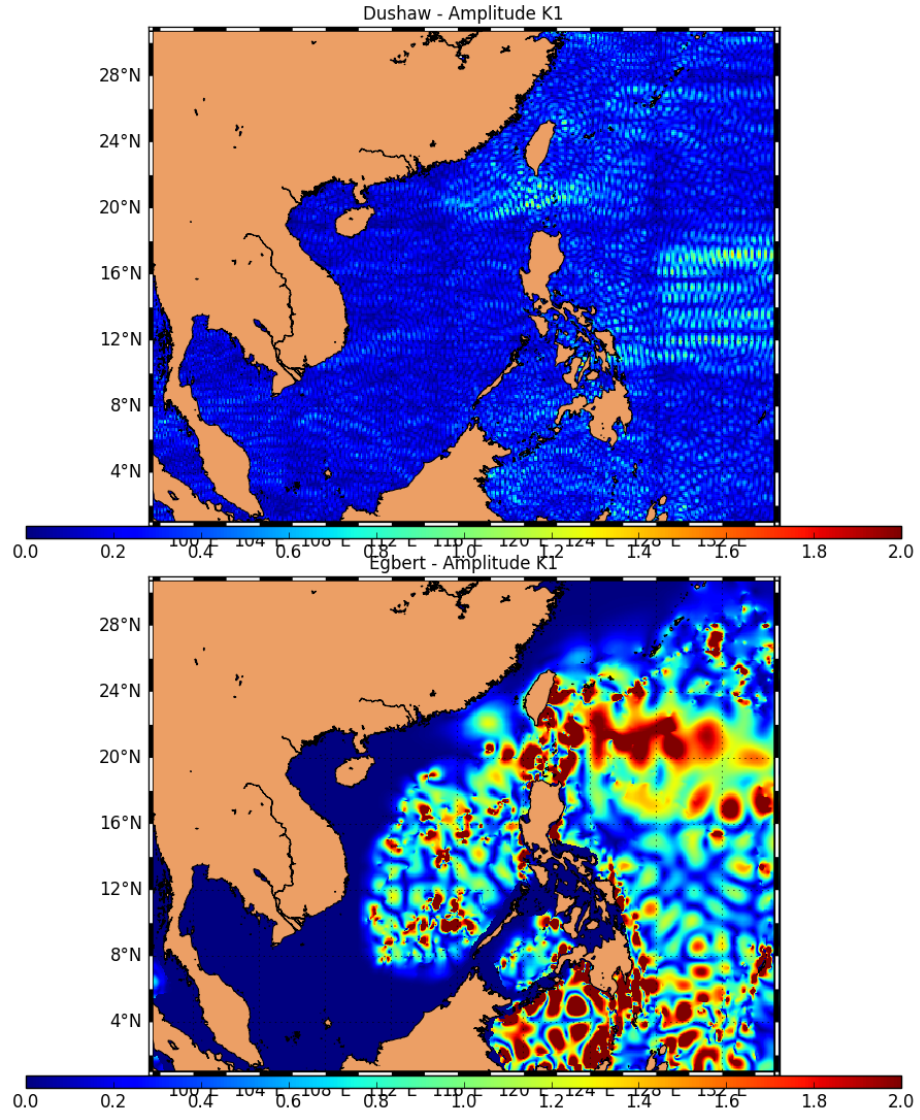


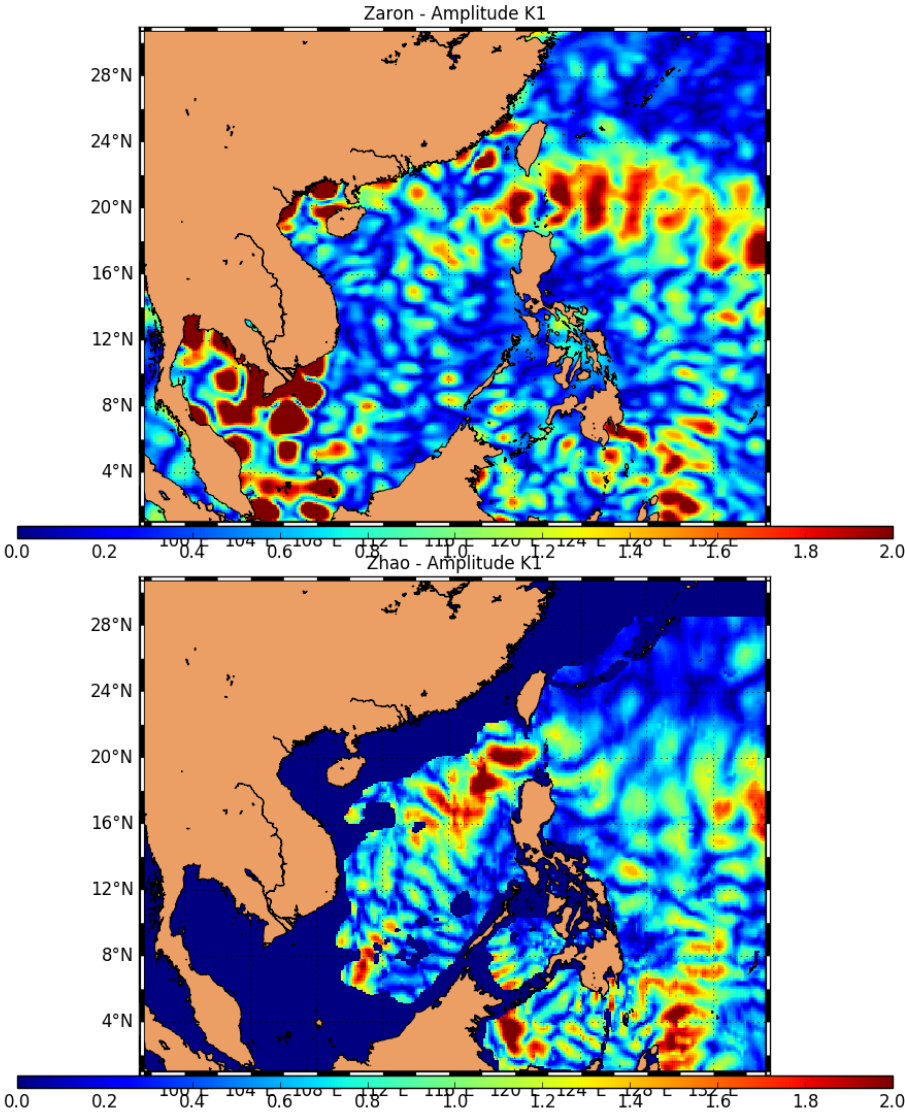


?

discontinuity

Comparison for K1 (Luzon, philippines)



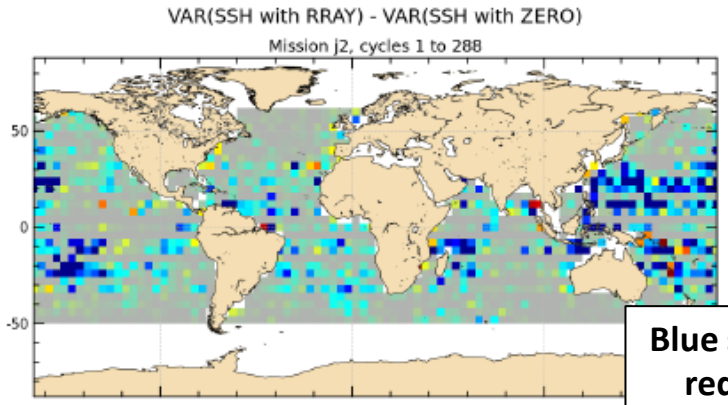


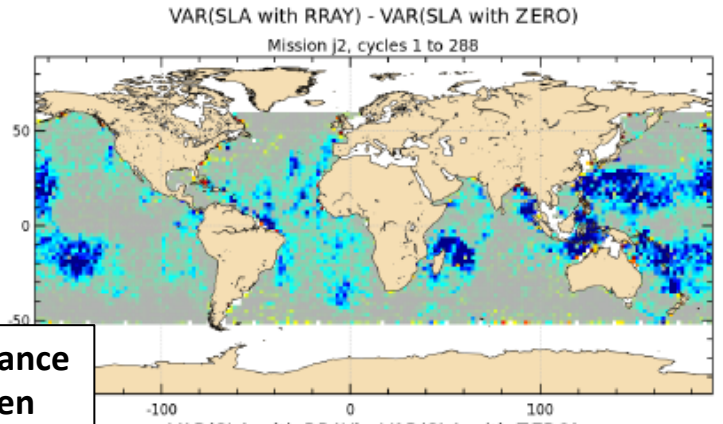
Variance reduction of altimeter measurements

- 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

Comparison of Rray IT correction vs no correction – M2

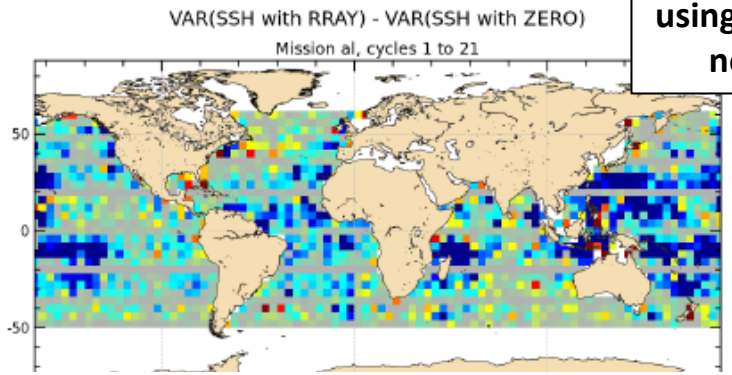
J2

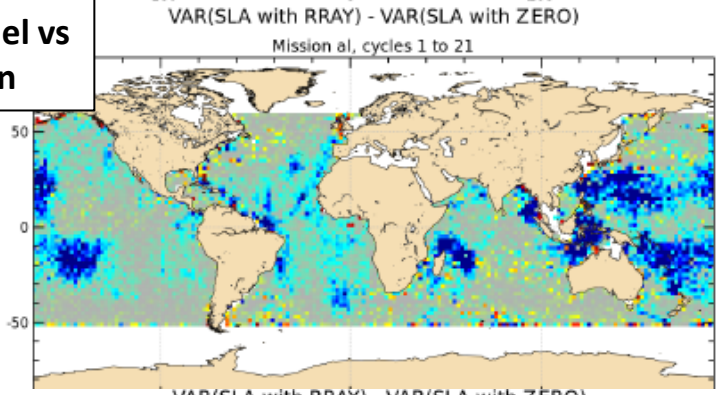




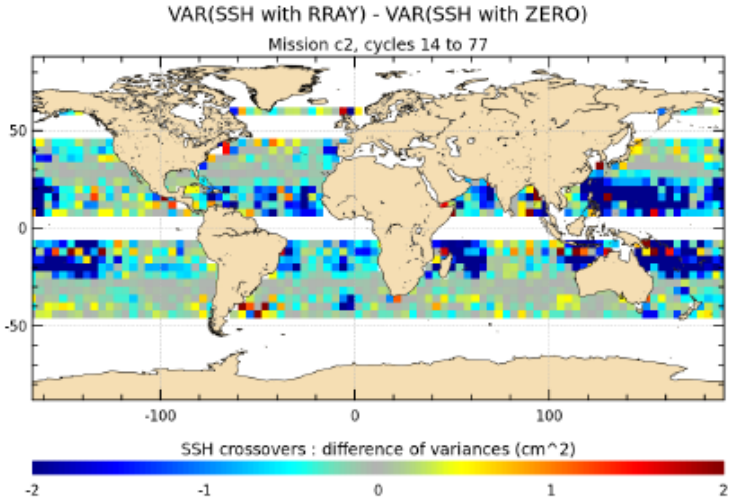
Blue shows variance reduction when using RRay model vs no correction

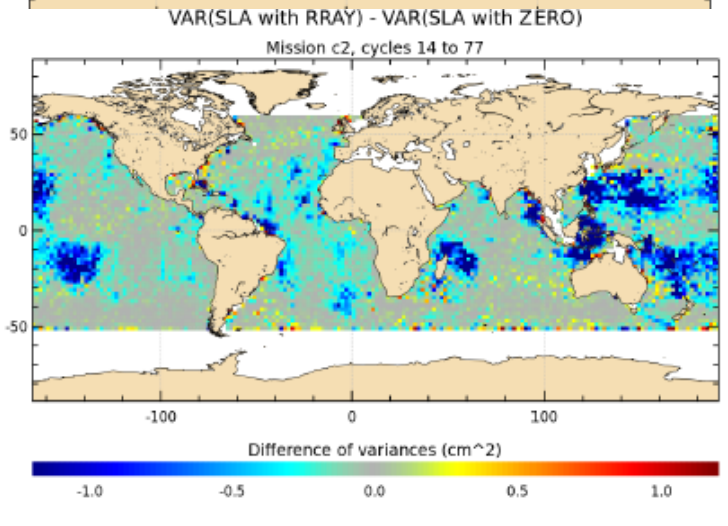
AL





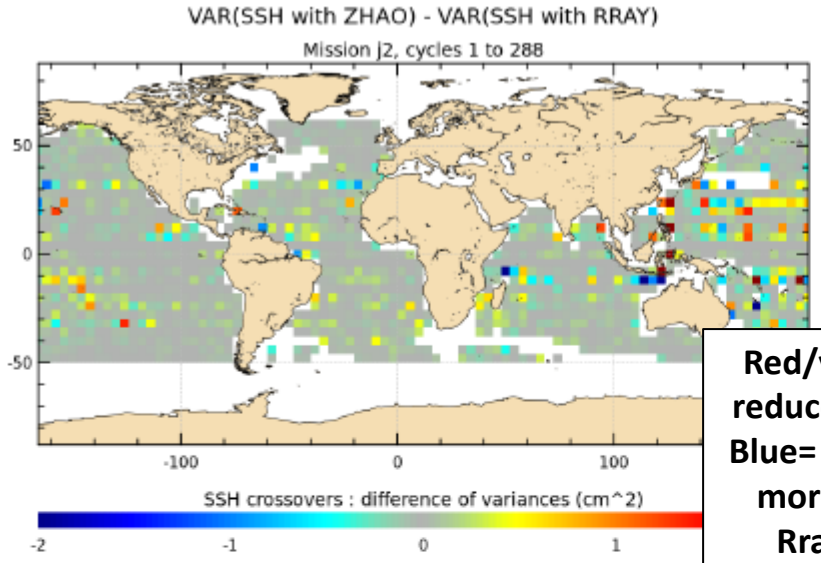
C2

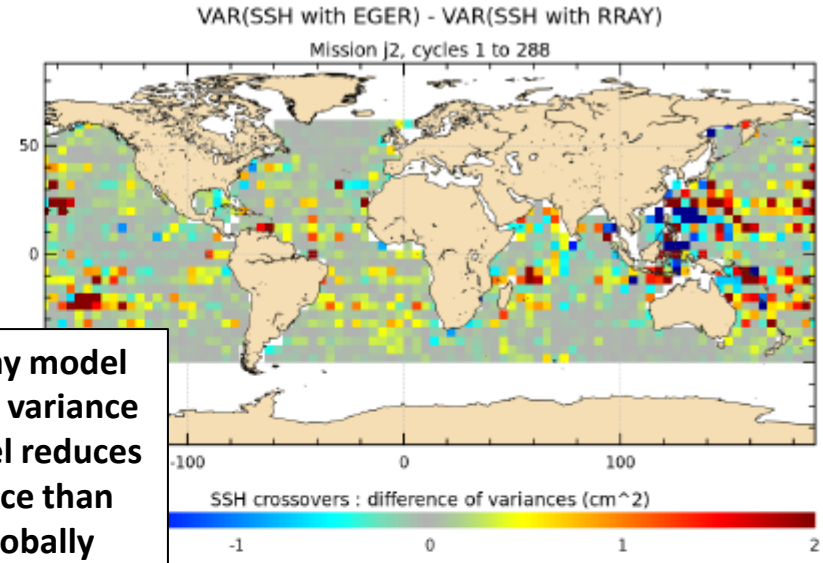




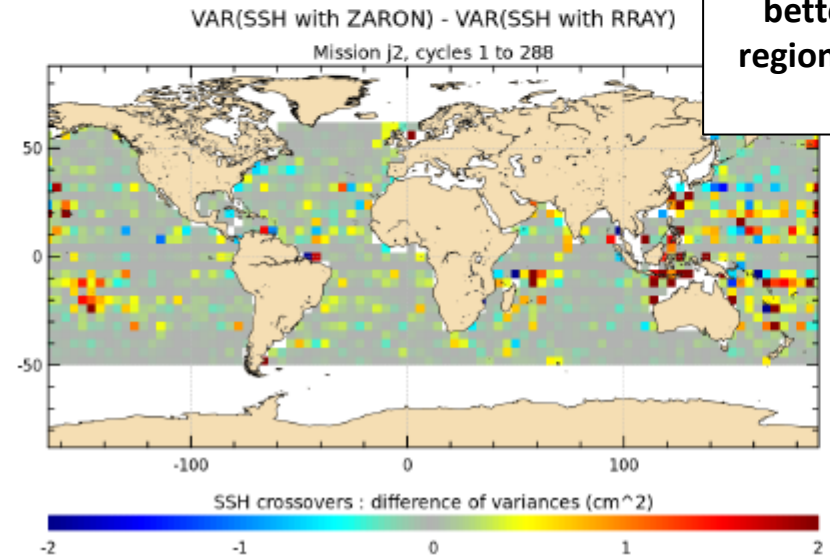
Comparison of IT corrections vs RRay's one – M2

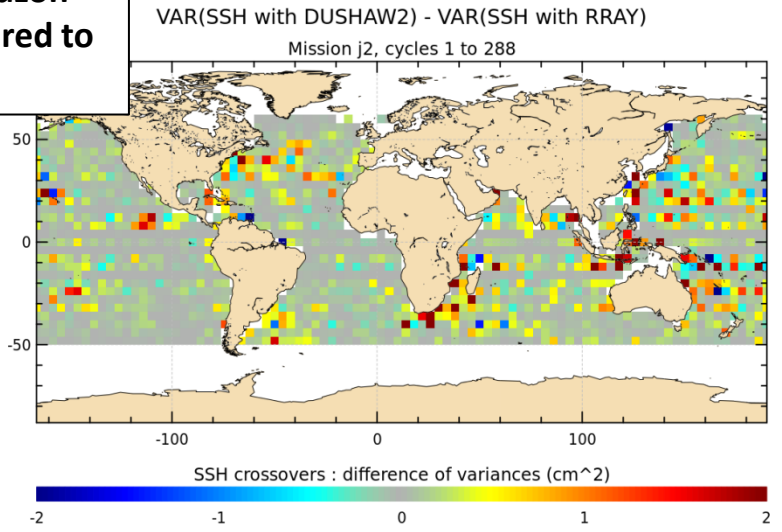
J2 mission - SSH crossovers





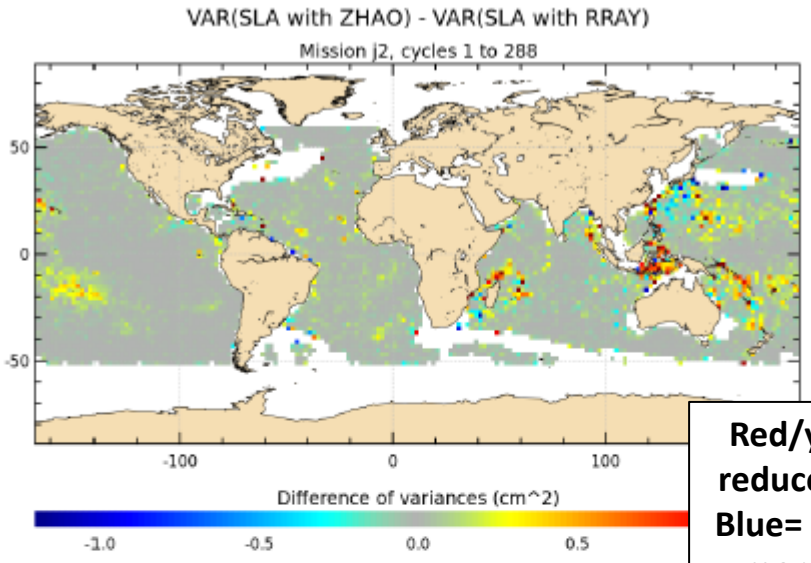
Red/yellow= RRay model reduces more the variance Blue= other model reduces more the variance than Rray => Rray globally better, except in Luzon region when compared to Egbert

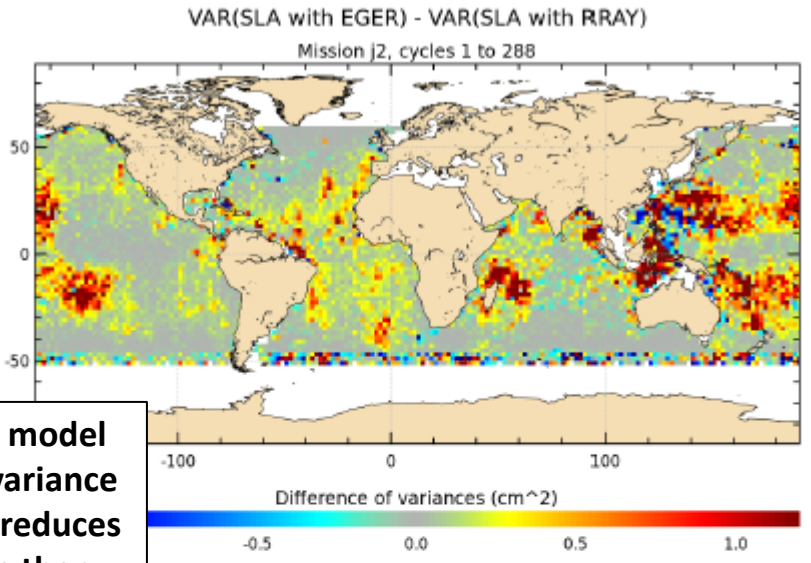




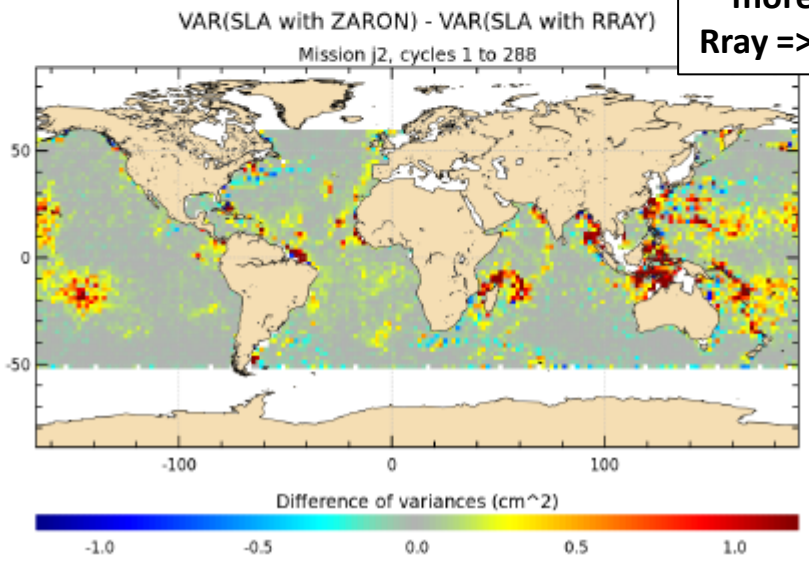
Comparison of IT corrections vs RRay's one – M2

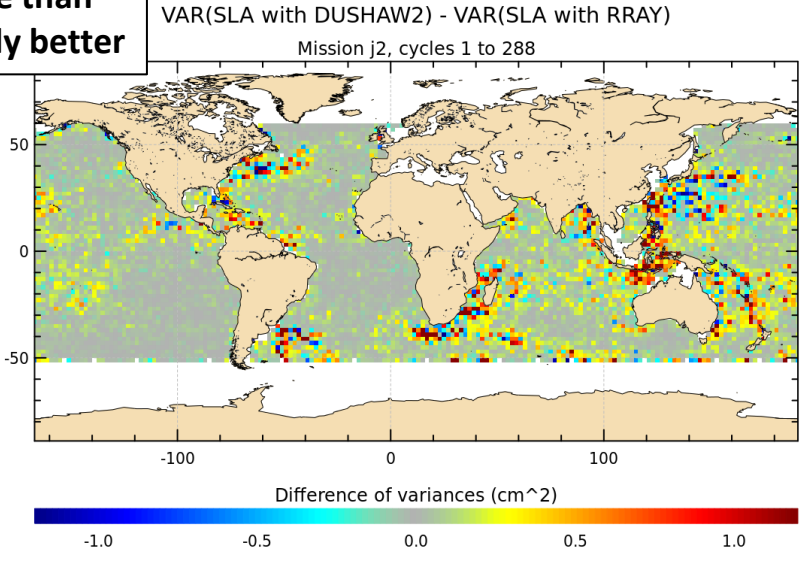
J2 mission - SLA





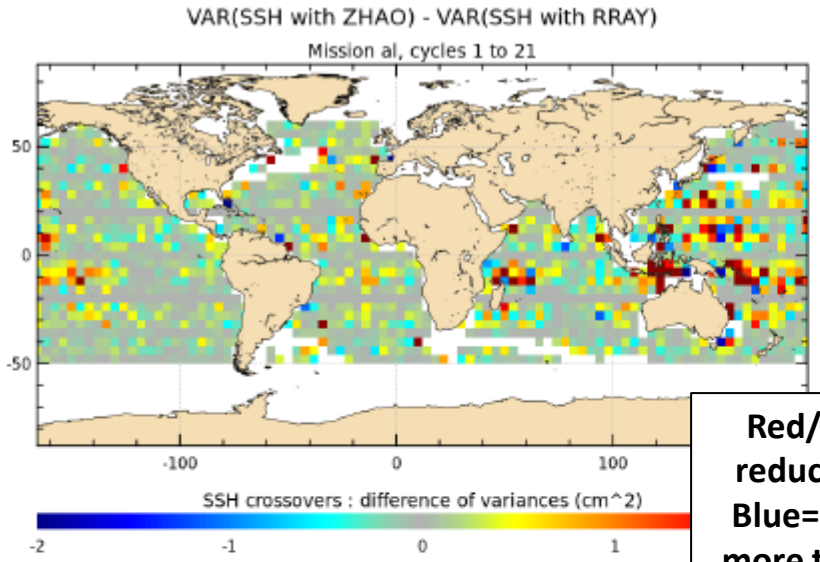
Red/yellow= RRay model reduces more the variance
Blue= other model reduces more the variance than Rray => Rray globally better

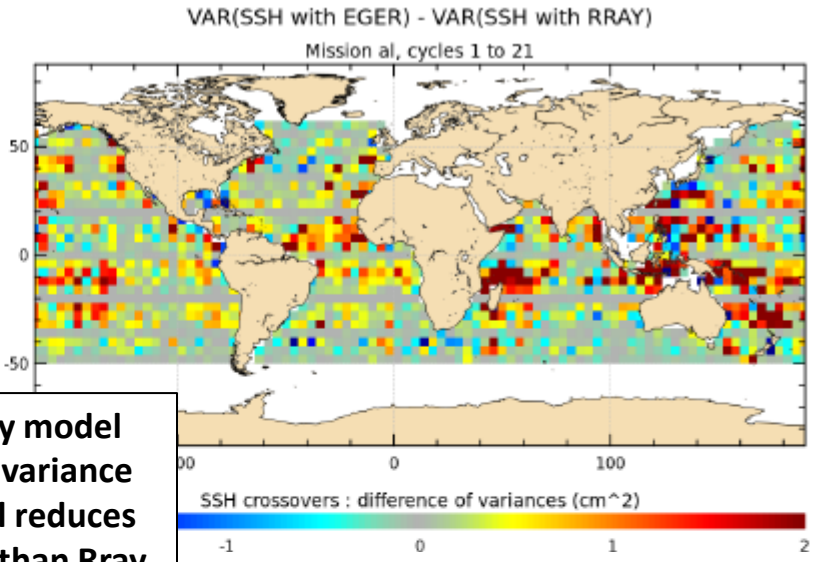




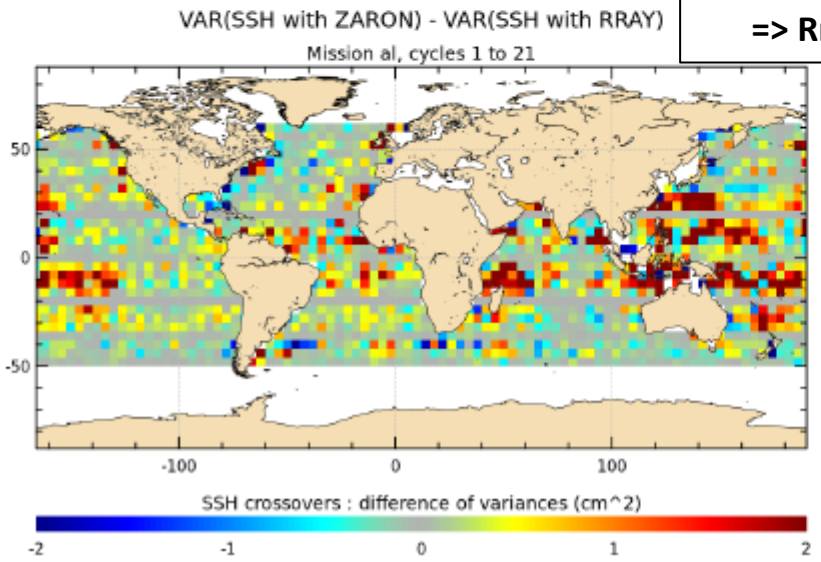
Comparison of IT corrections vs RRay's one – M2

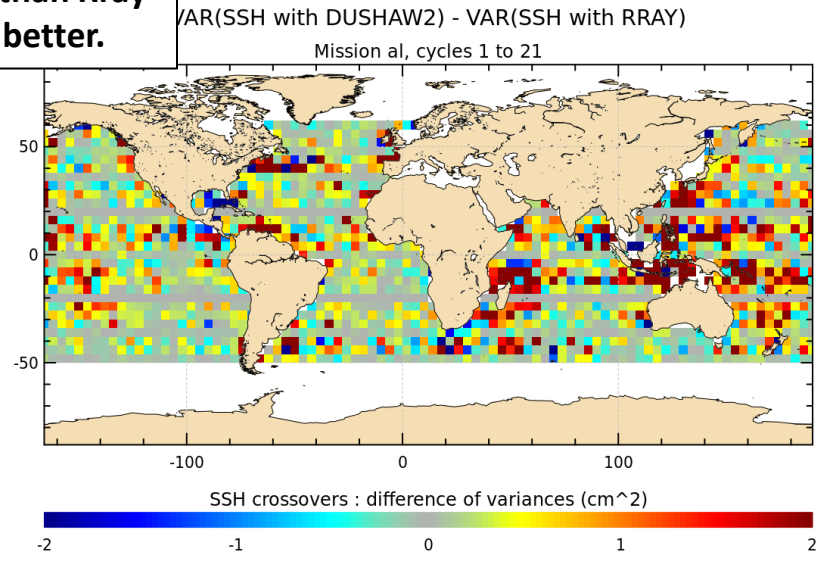
AL mission - SSH crossovers





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

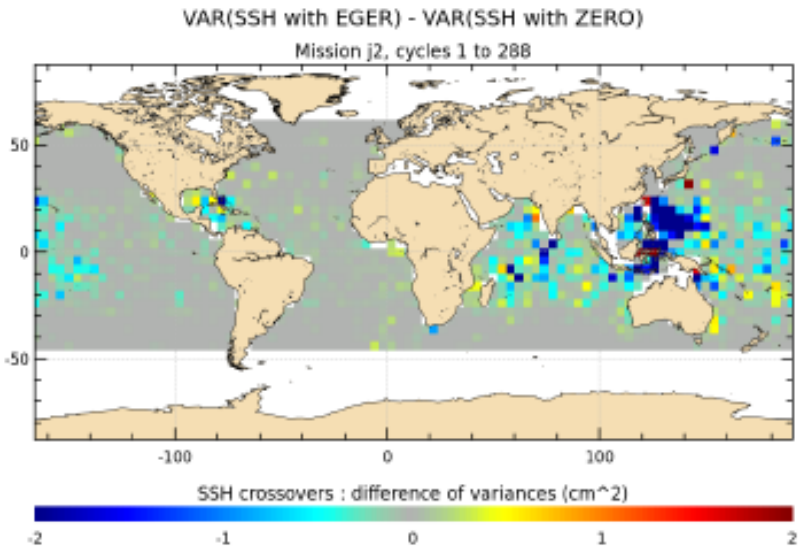


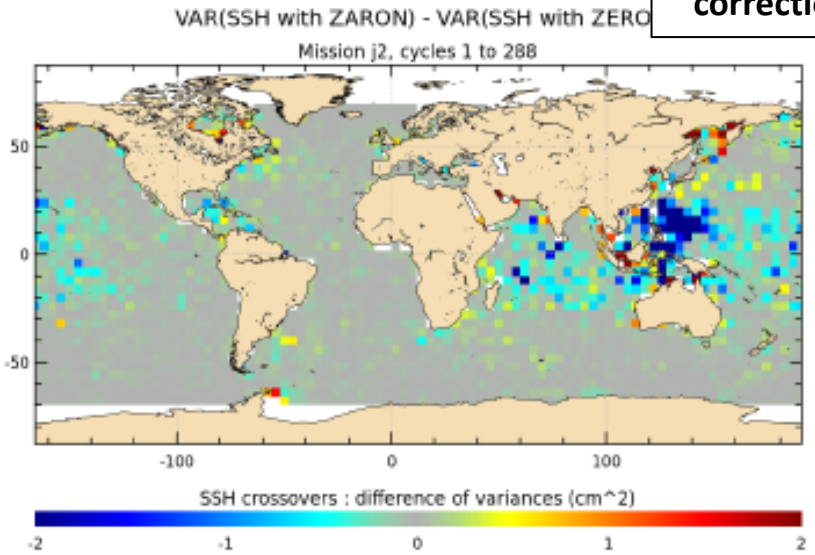


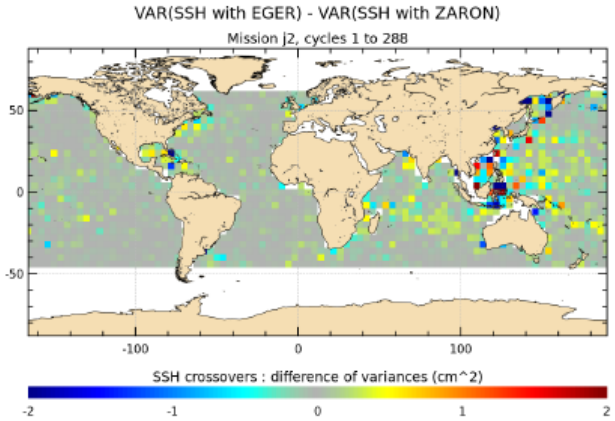
Comparison of IT corrections – K1

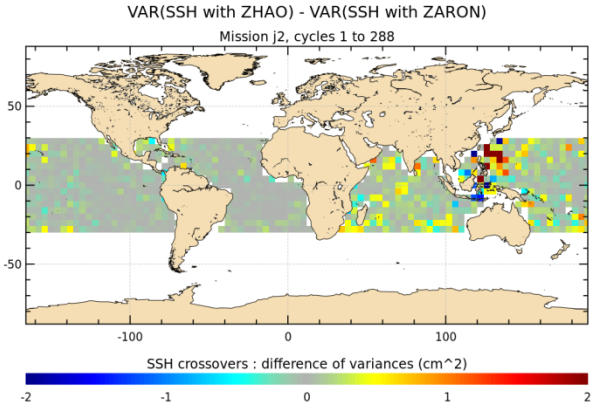
J2 mission - SSH crossovers

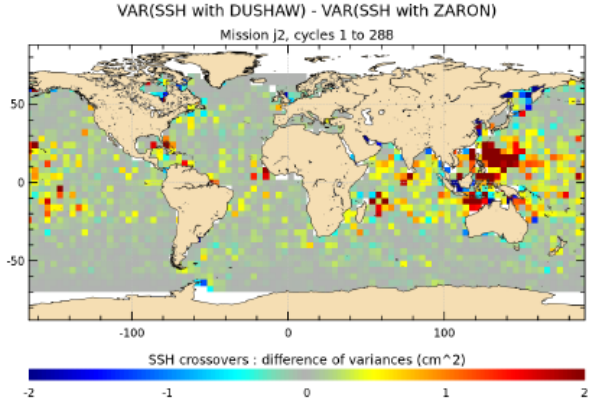
Blue shows variance reduction when using either EGBERT or ZARON K1 model vs no correction (cm²)







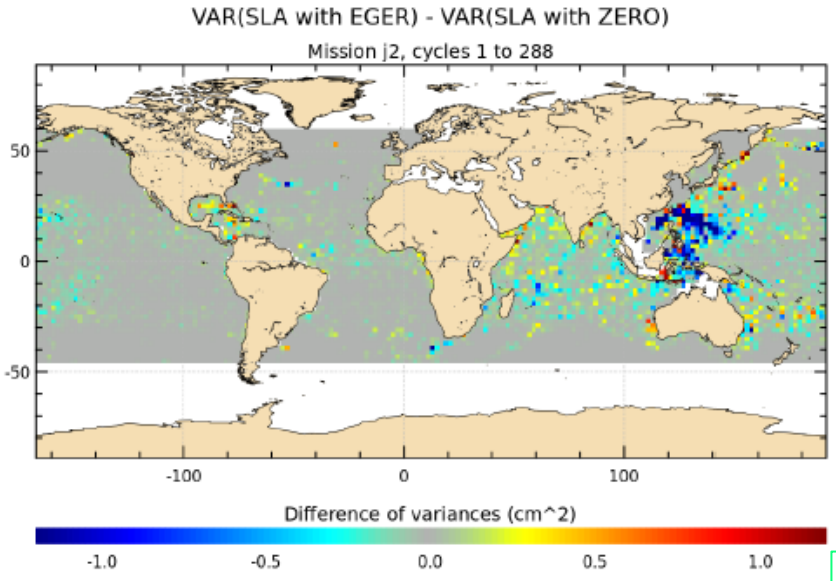


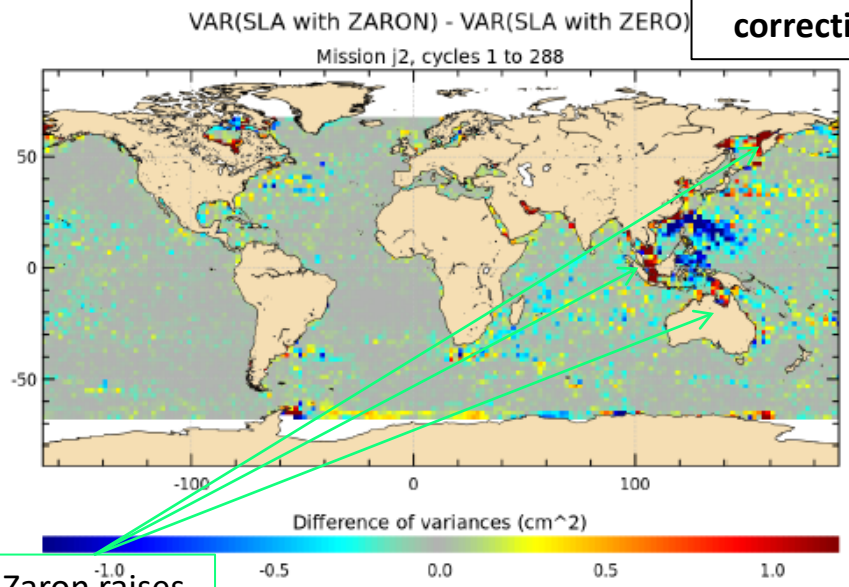


Comparison of IT corrections – K1

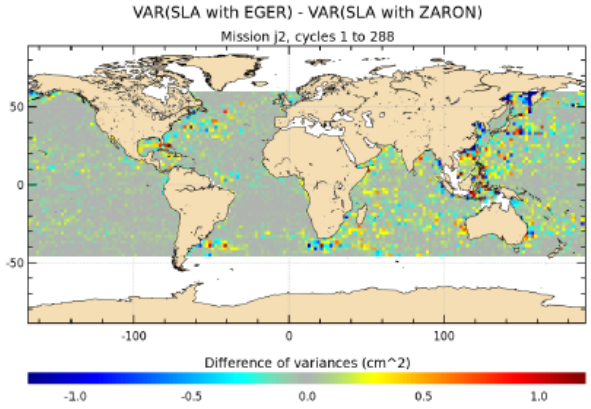
J2 mission - SLA

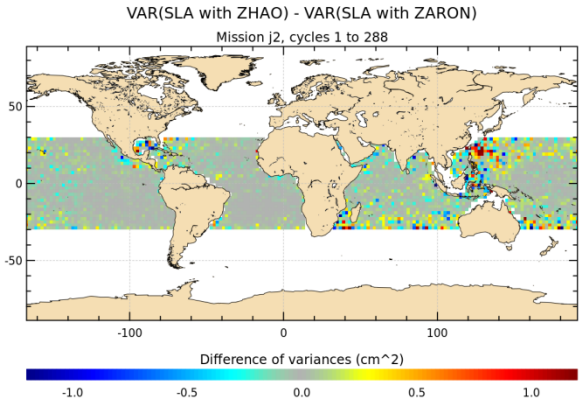
Blue shows variance reduction when using either EGBERT or ZARON K1 model vs no correction (cm²)

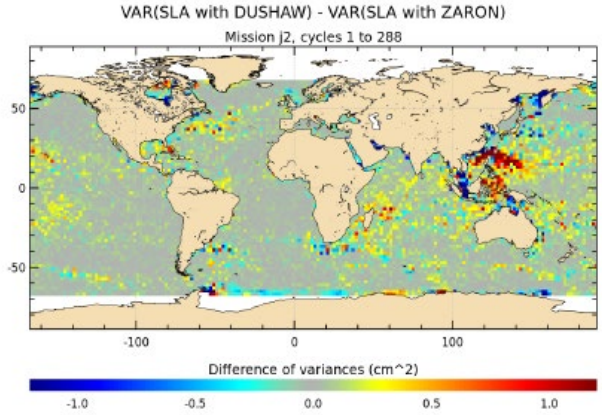




Zaron raises variance near coasts







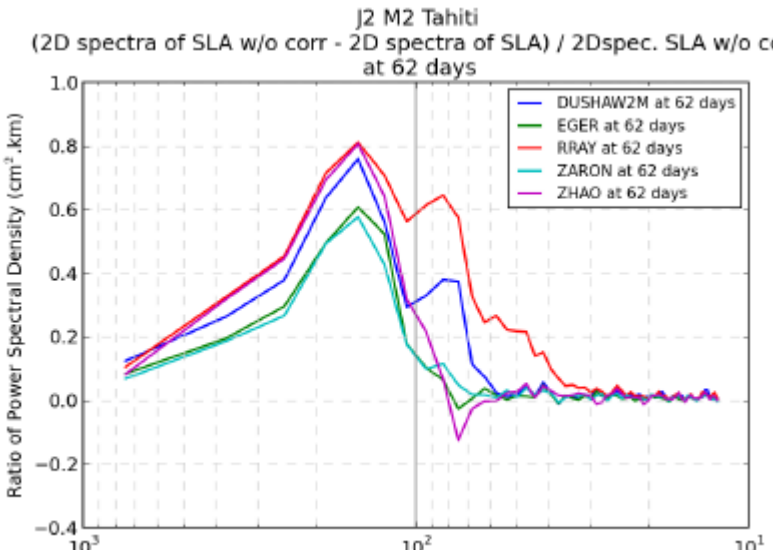
Spectral analysis

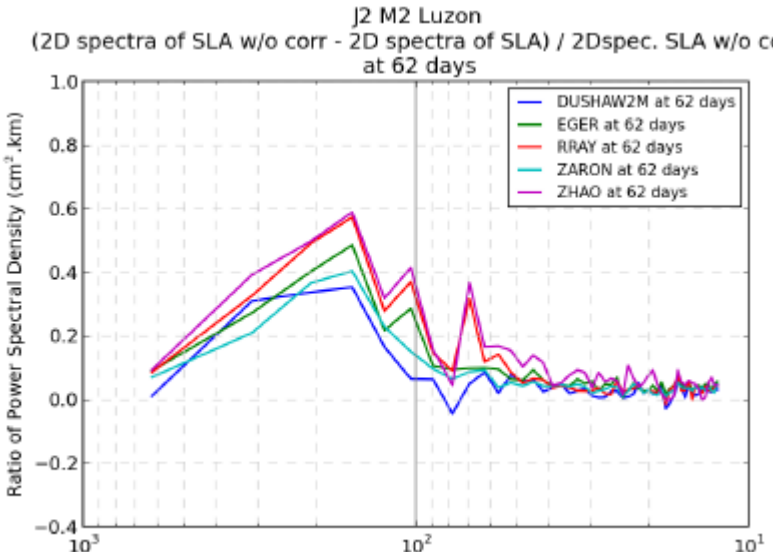
- **2D spectral analysis of Jason-2 SLA**

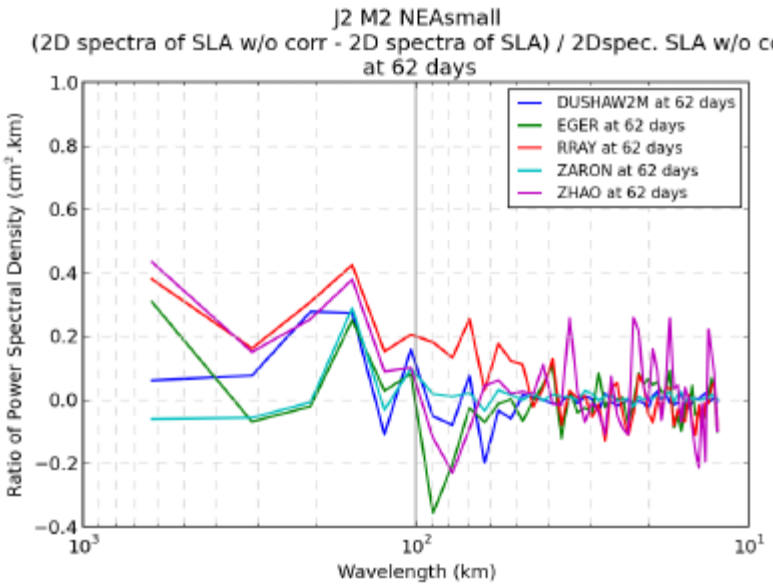
- **Objectives**:
  - Quantify the impact of the IT corrections
  - Quantify the residual energy at tidal frequencies = errors of IT models + residual non-coherent IT signal

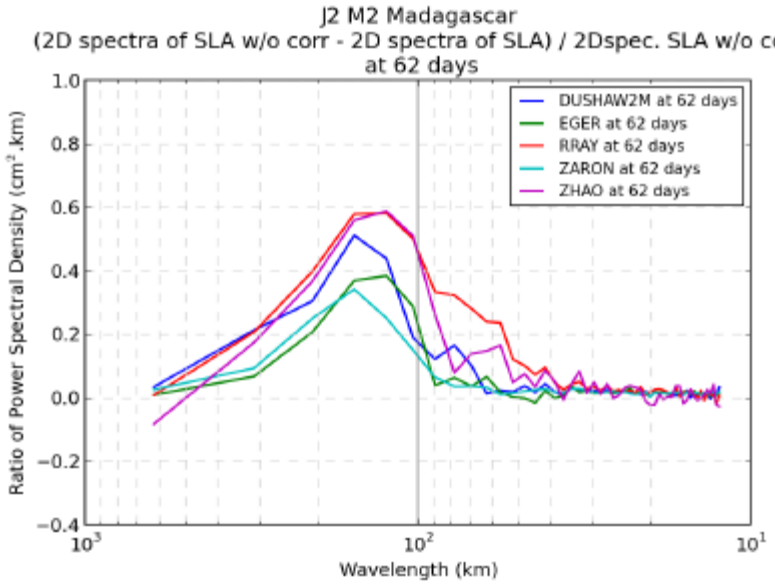
- **Focus on M2 frequency because K1 hardly separated from semi-annual signal (aliasing K1=173d)**

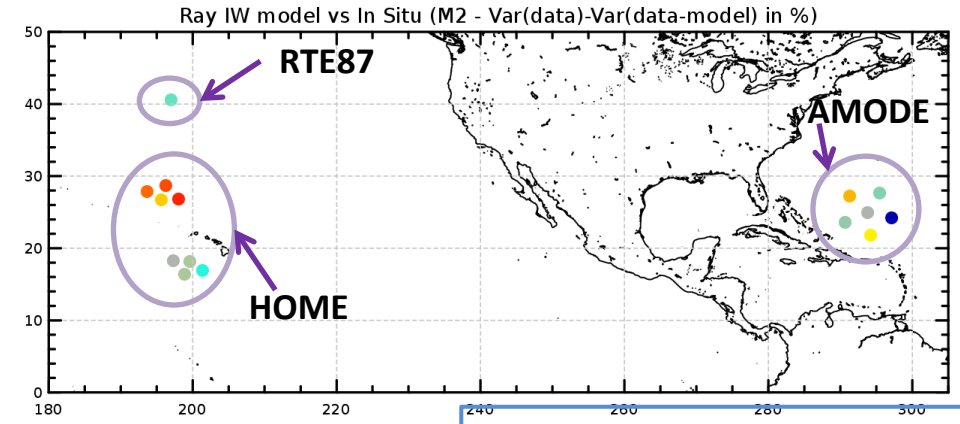
% of energy removed at M2 frequency, thanks to each IT correction, for J2 SLA

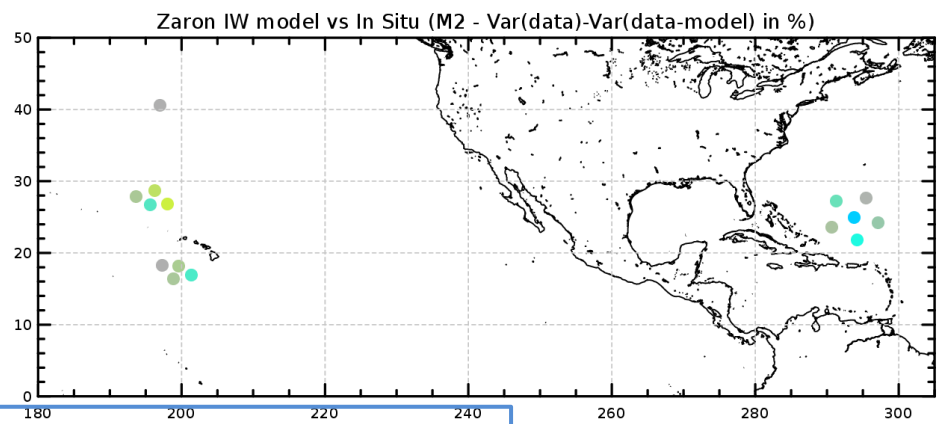




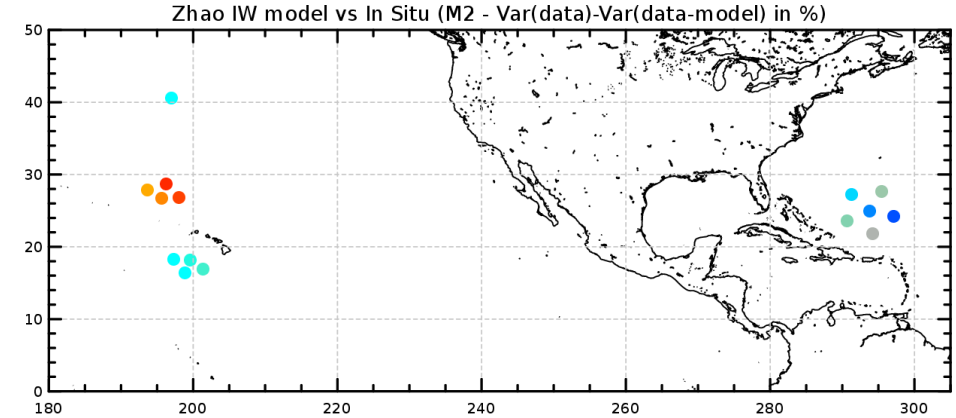


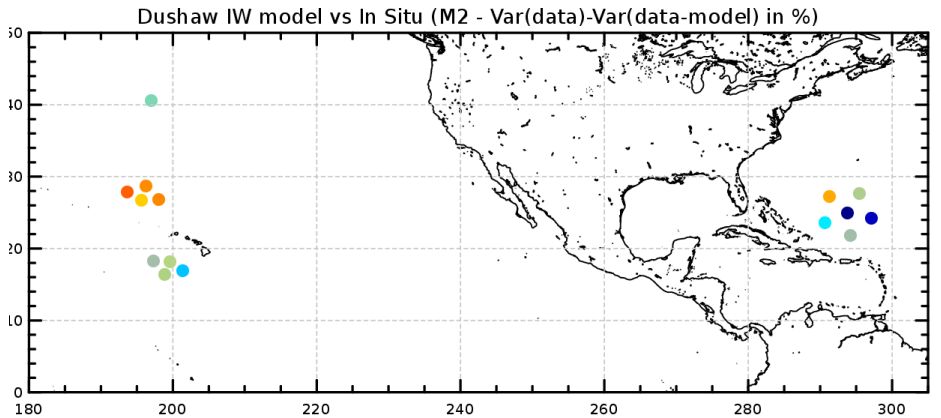


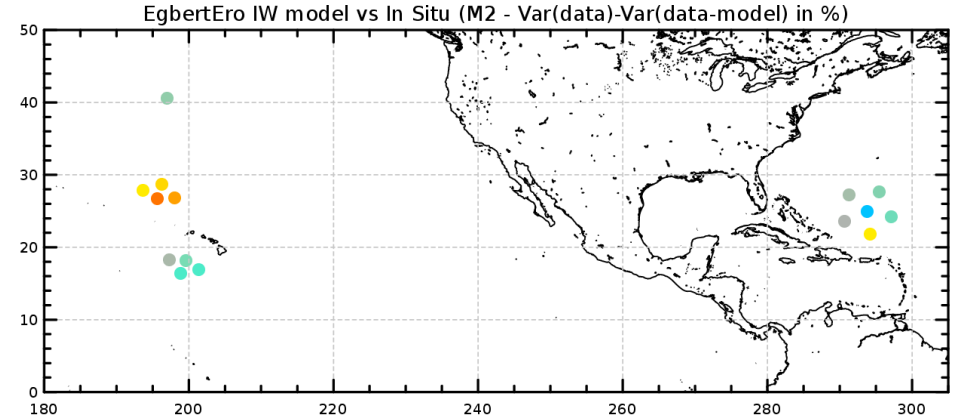




In situ comparison - Thermistors



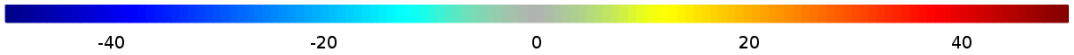




Variance reduction in %:

Yellow-orange-red dots show that the model tested reduces the variance for the in situ time series.

- Most of models show good performances for HOME north, except Zaron
- Models not so good on other regions; Ray shows 2 good point in AMODE and Egbert and Dushaw one.



Conclusions

- **M2: Ray and Zhao models are close**
  - Ray a bit better and it removes smaller scales (2nd and higher modes of IT)
- **K1: Egbert and Zaron models are close**
  - Variance reduction mostly in Luzon region
  - But Zaron raises variance in coastal regions=> can be improved
- **At this stage, a first IT correction can be proposed for nadir altimeters + SWOT**
  - **M2 from Ray model + K1** from Egbert or Zaron (with coastal regions removed)

Perspectives

- **Analysis will be continued with new IT model :**
  - B. Arbic, G. Egbert, E. Zaron, **C. Ubelmann** this summer and Z. Zhao after OSTST ?
  - M2 and K1
- **More comparison can be done with in situ data:**
  - Tomography data provided by Dushaw
  - or Surface drifters database as done by Zaron et al. 2017
- **Write a scientific paper on those results …**