Comparison of new internal tides corrections for global ocean

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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
- Different scientific teams are working on developing IT models => **new releases have been provided this year**
- We focus on coherent IT

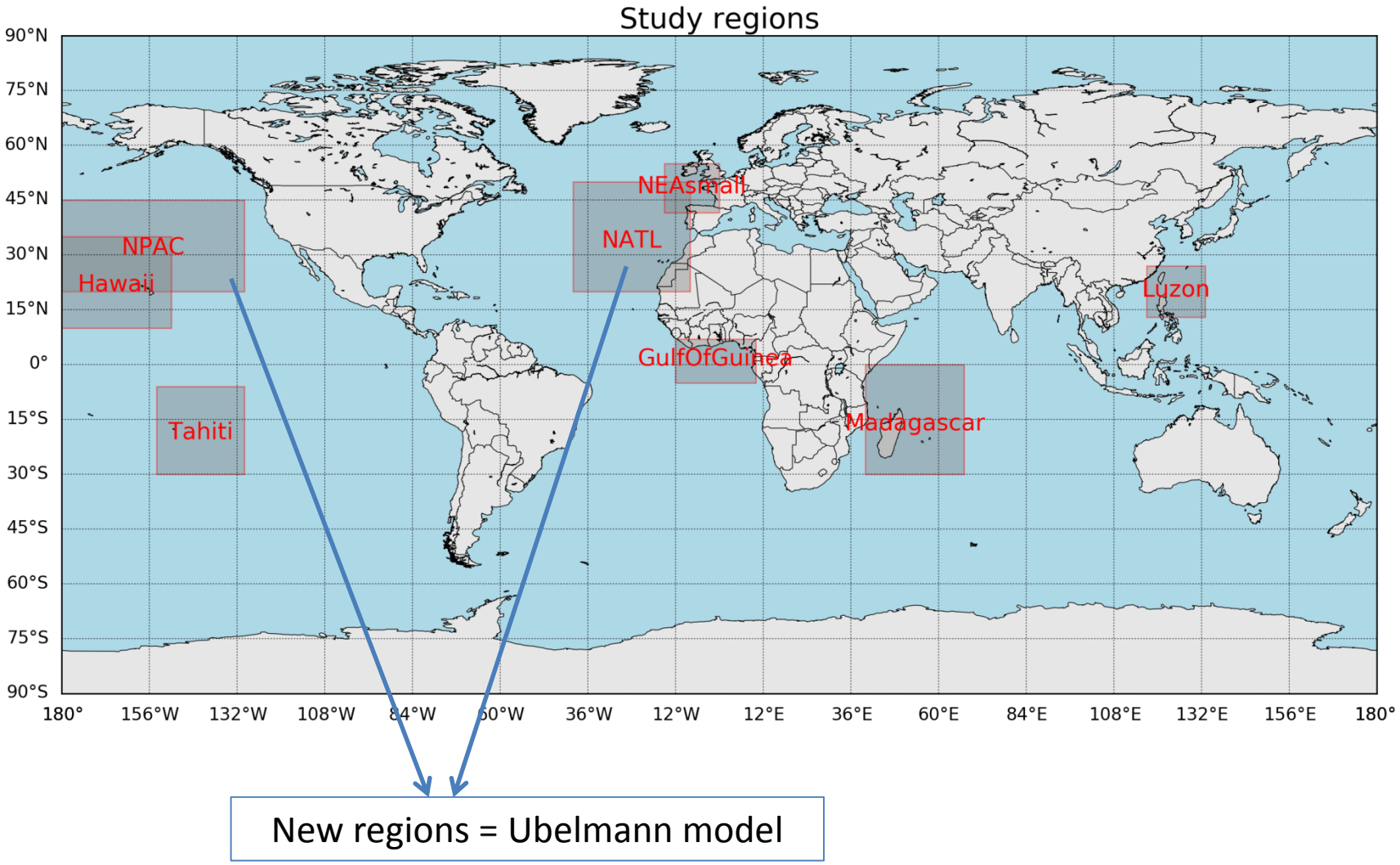
5 models tested the 2016 study (V1)

- **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**
  - regional grids available (11°x11°), some discontinuities between regions
- **B. Arbic** :
  - 3D Model extracted along TP-J tracks => not usable yet

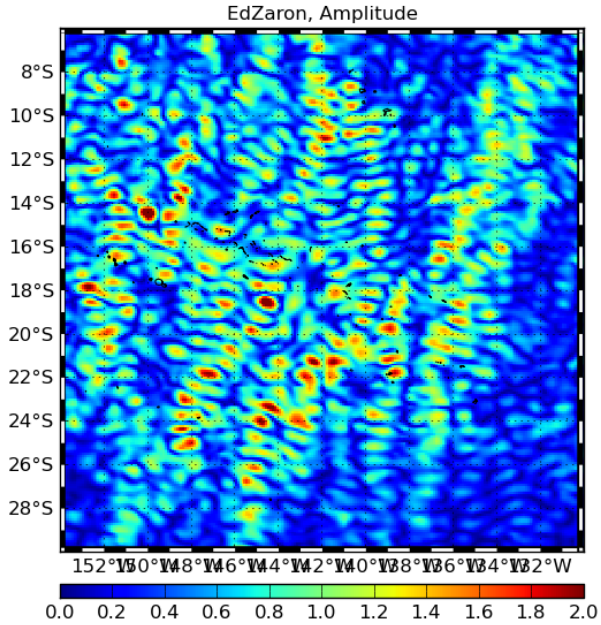
7 models – 5 new releases tested in the V2 study (2017)

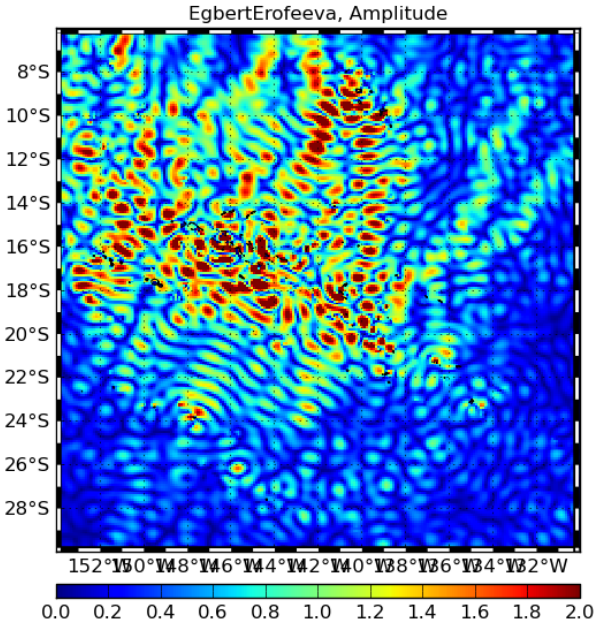
Thanks for providing the data !

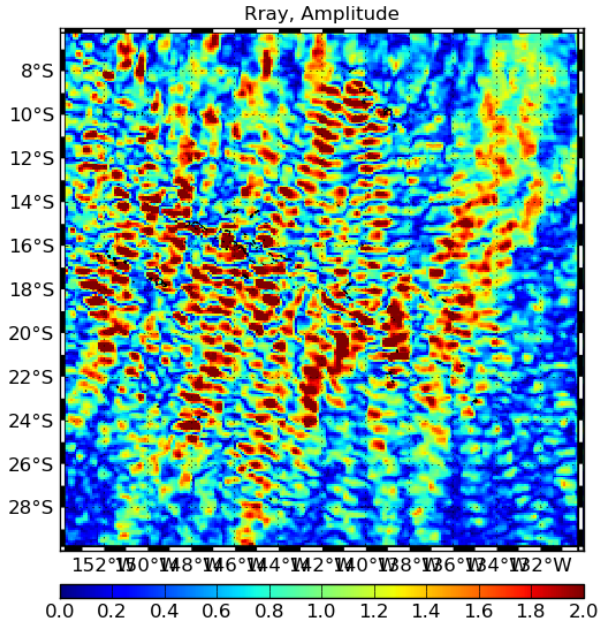
- **Ed. Zaron** (filtered version)
  - Grid: 1/20°
  - Use J2 + C2 data
  - Waves: **M2**, **K1** , **O1, S2, N2, P1**
  - Spatial cover: -65° < lat < 65°
- **Z. Zhao** :
  - Grid: 1/10°
  - Use GFO+ERS-EN+TP-Jason data
  - Wave: **M2**, **K1** **O1, S2**
  - Spatial cover : -65° < lat < 65°, K1 +/-30°
- **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**, **O1, S2**
  - Spatial cover: -60° à 60° Latitudes
- **B. Dushaw** :
  - Grid: 1/20°
  - Use TP + Jason data
  - Waves: **M2, K1**
  - regional grids available (11°x11°), some discontinuities between regions
- **B. Arbic** :
  - 3D hydrodynamic model HYCOM => sea level grids 1/12 °
  - 3 different releases available for **M2**
- **C. Ubelmann** :
  - Empirical estimation on 2 regional grids Hawaï + Azores
  - Waves: **M2**

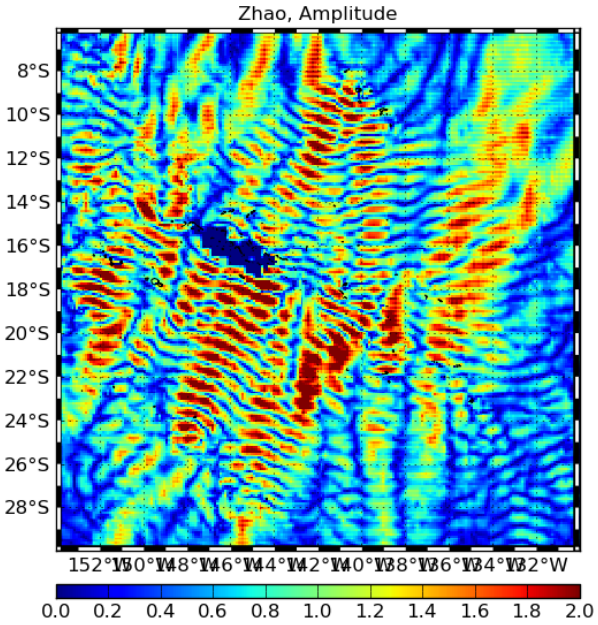

Study regions
90°N
75°N
60°N
45°N
30°N
15°N
0°
15°S
30°S
45°S
60°S
75°S
90°S
180°
156°W
132°W
108°W
84°W
60°W
36°W
12°W
12°E
36°E
60°E
84°E
108°E
132°E
156°E
180°
NPAC
Hawaii
Tahiti
NEAsmall
NATL
GulfOfGuinea
Madagascar
Luzon
New regions = Ubelmann model

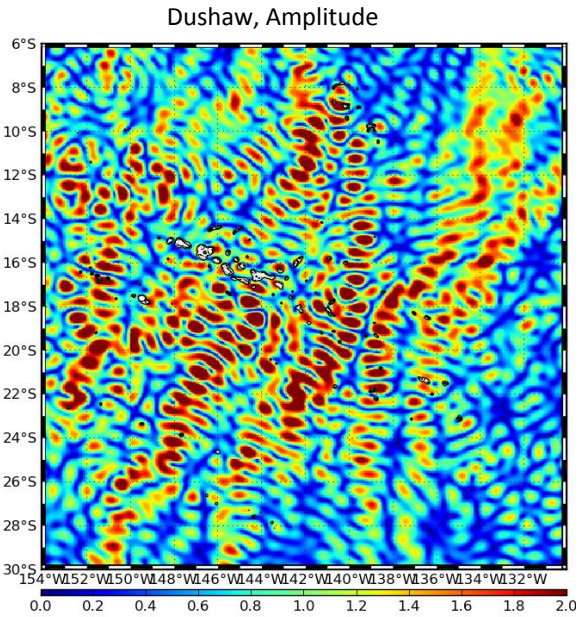
Comparison for M2 (Tahiti) – V1











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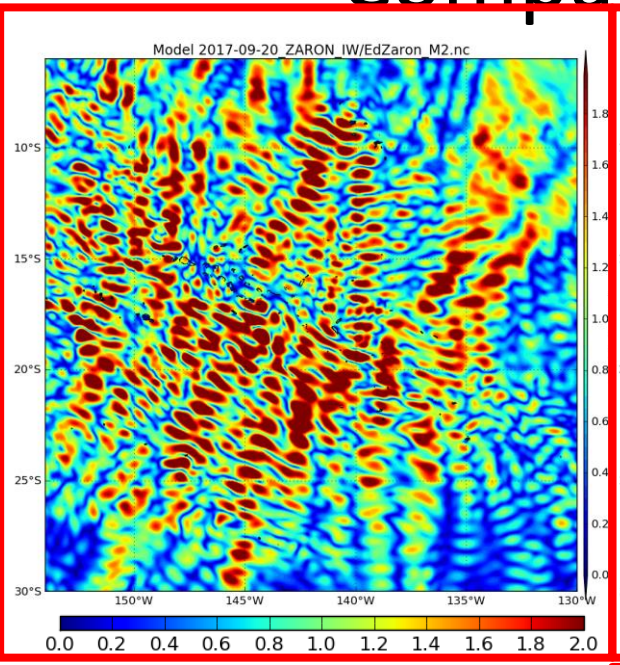
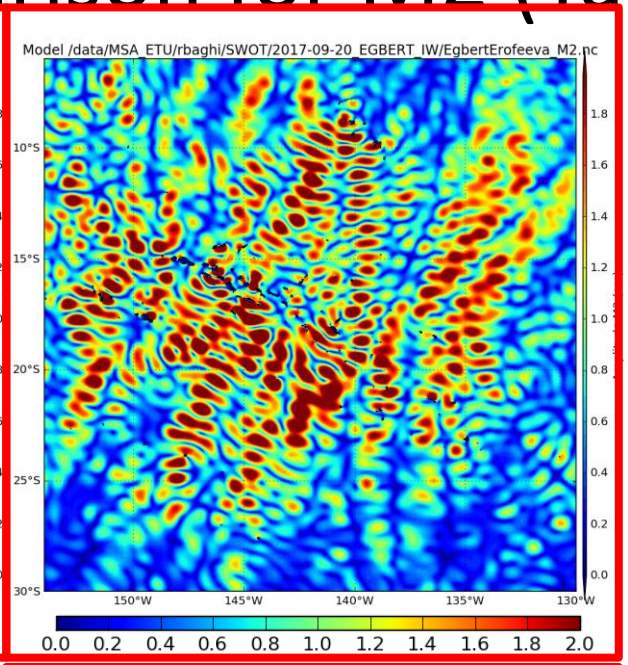
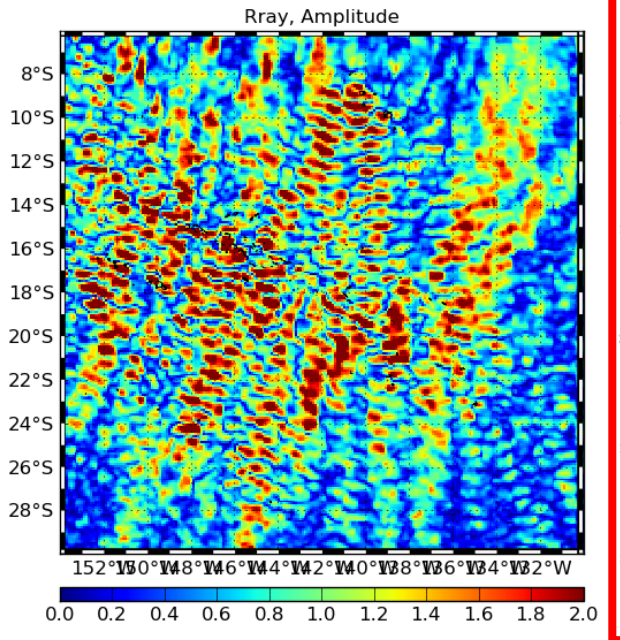
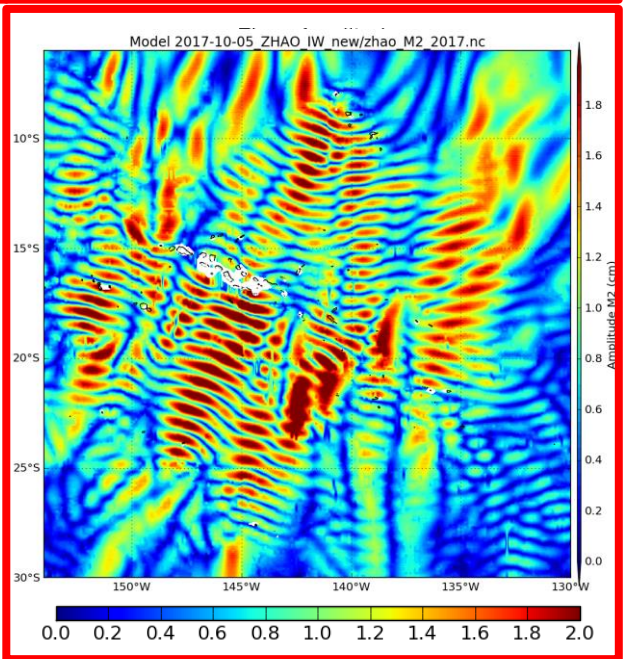
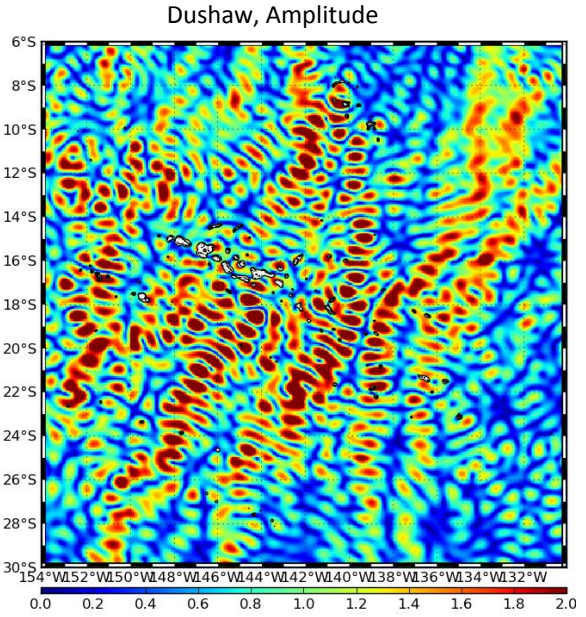


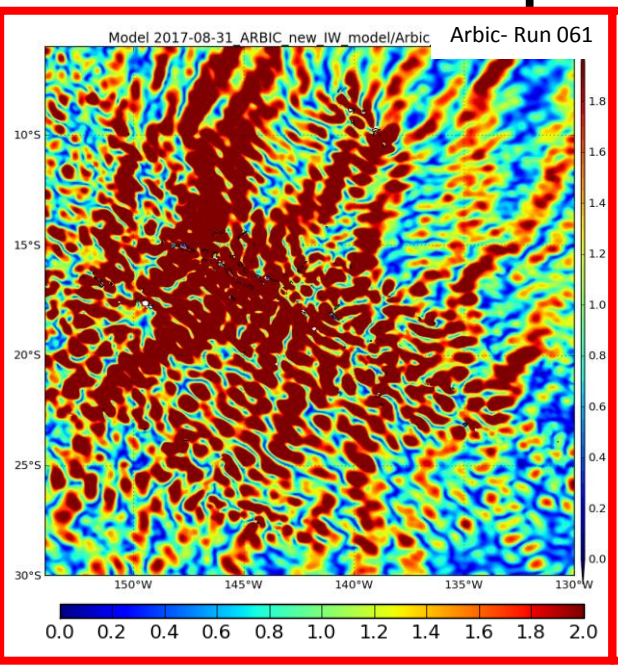


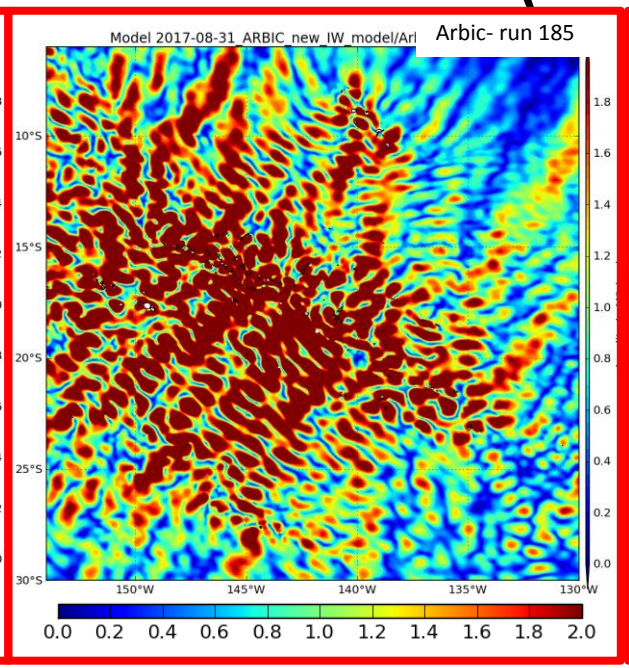


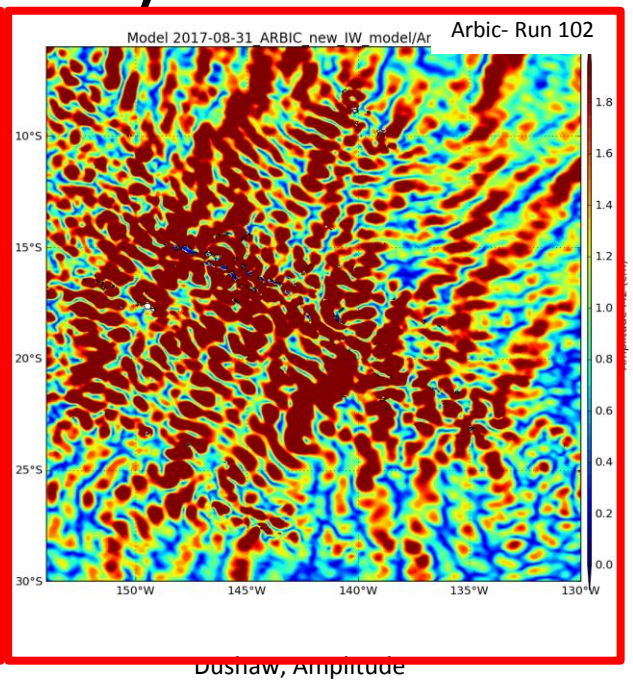


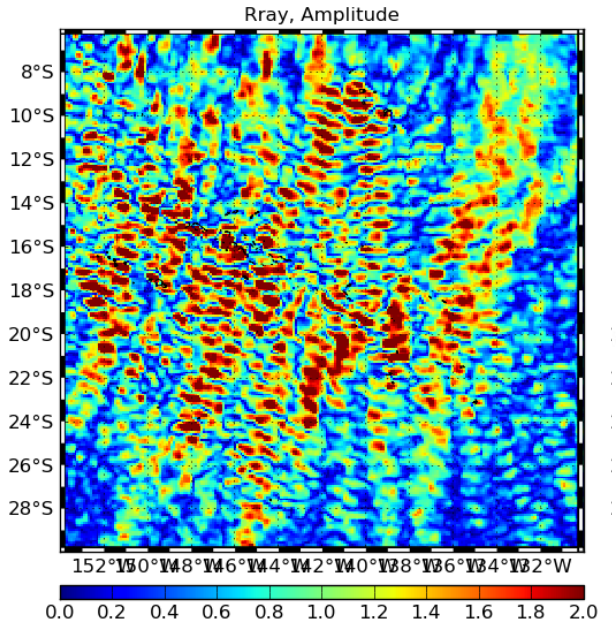


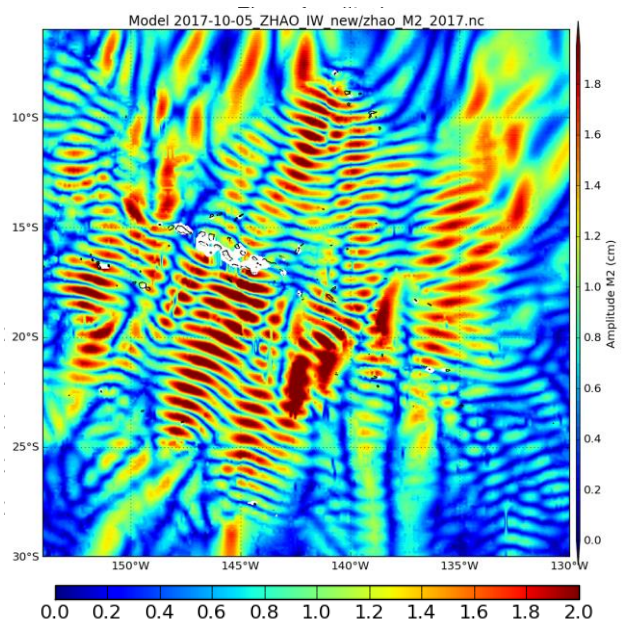
Comparison for M2 (Tahiti) – V2

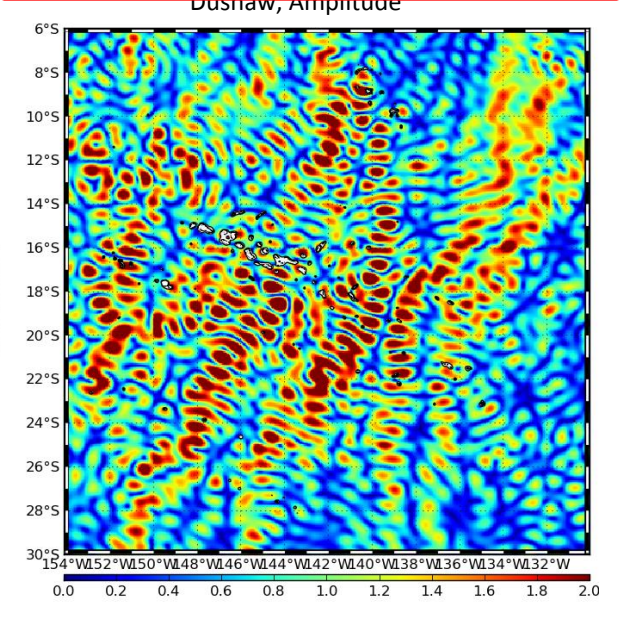




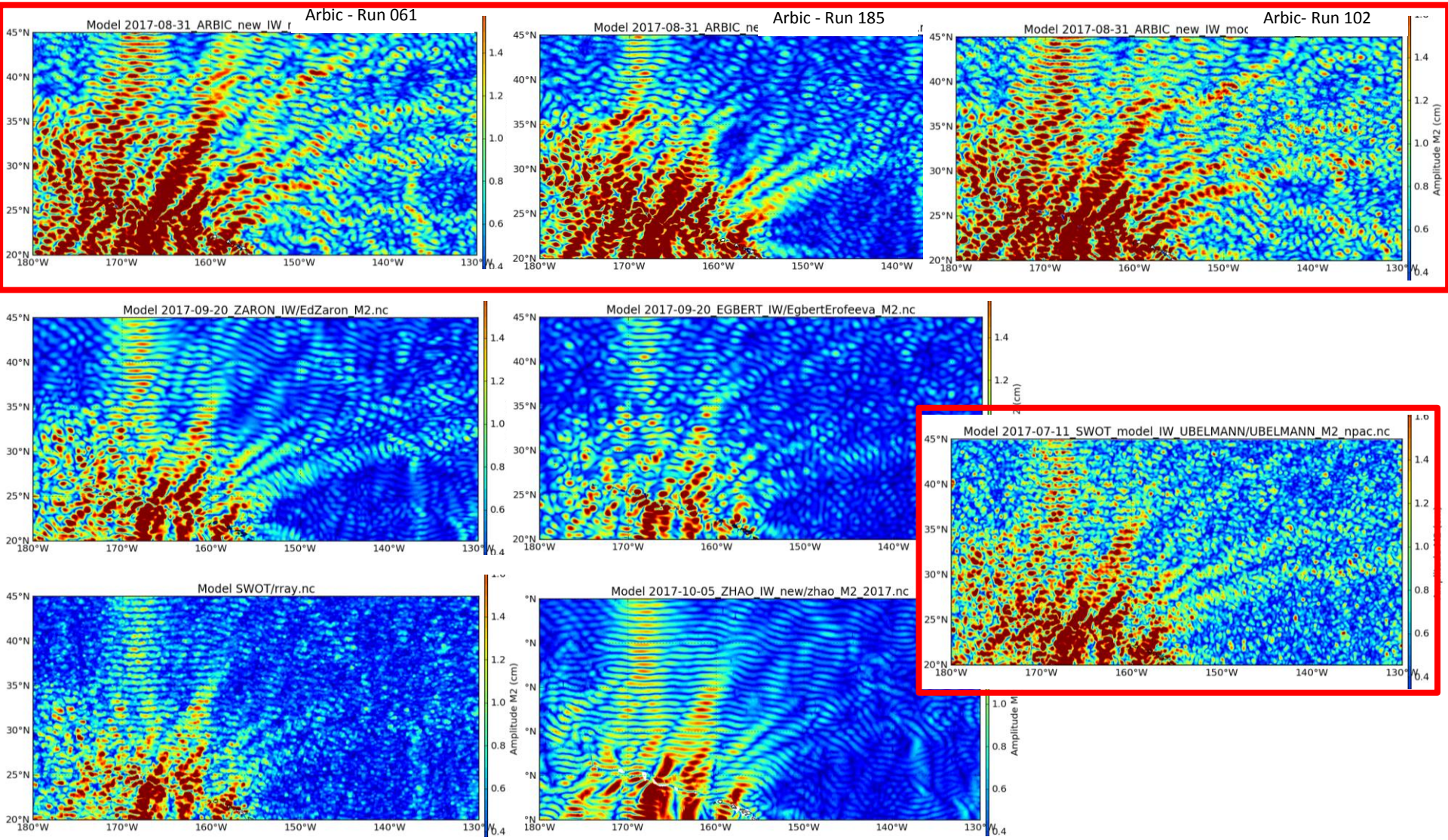




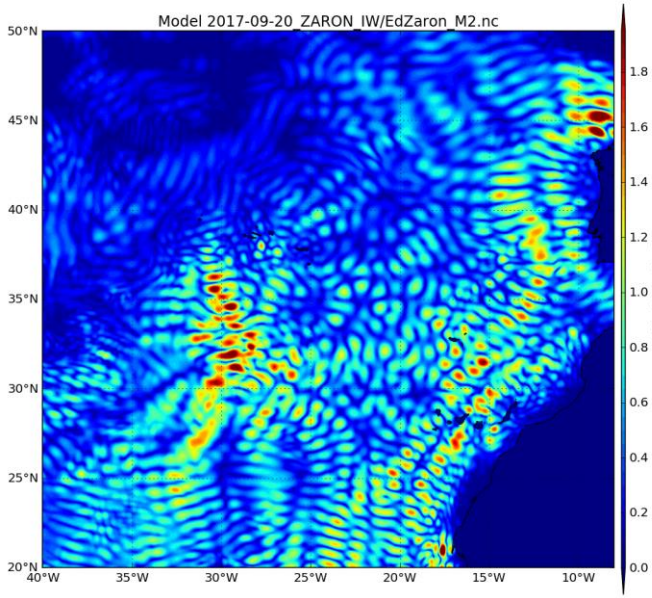


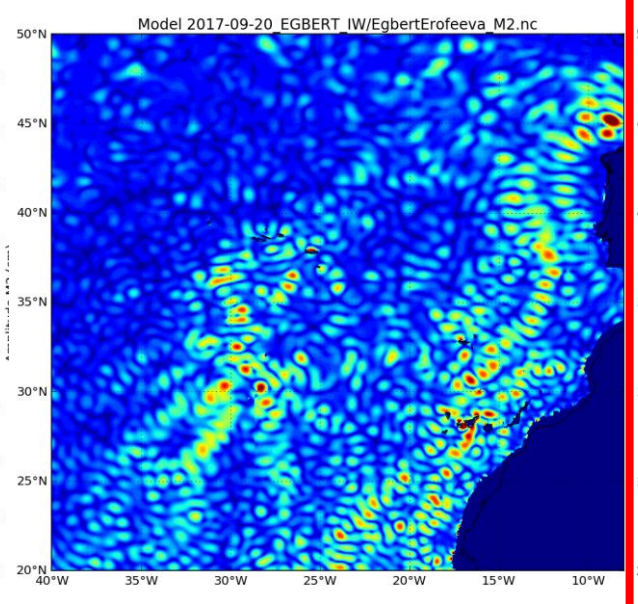


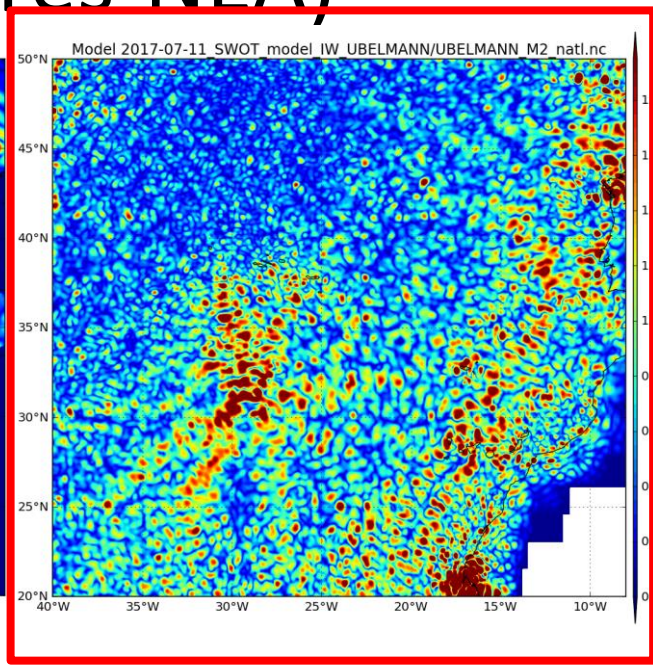
Comparison for M2 (NPAC)- V2

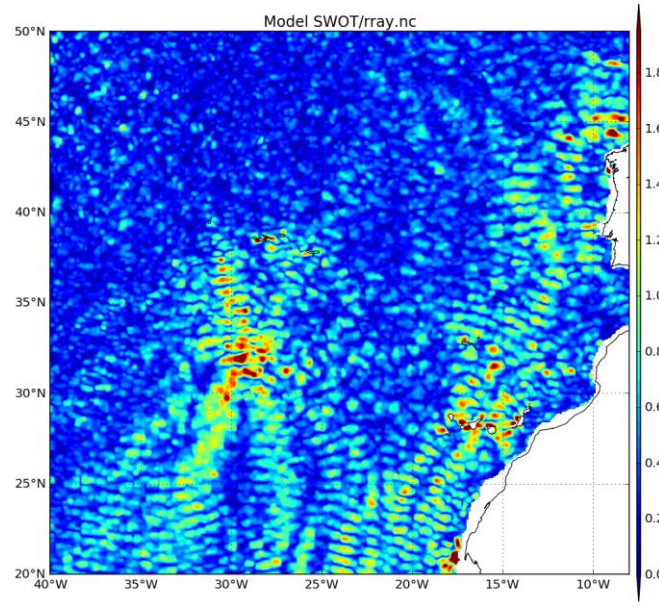


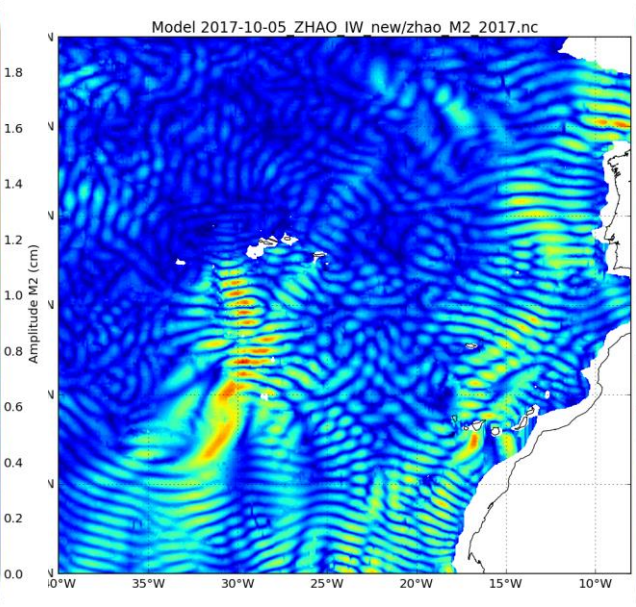
Comparison for M2 (Azores-NEA)

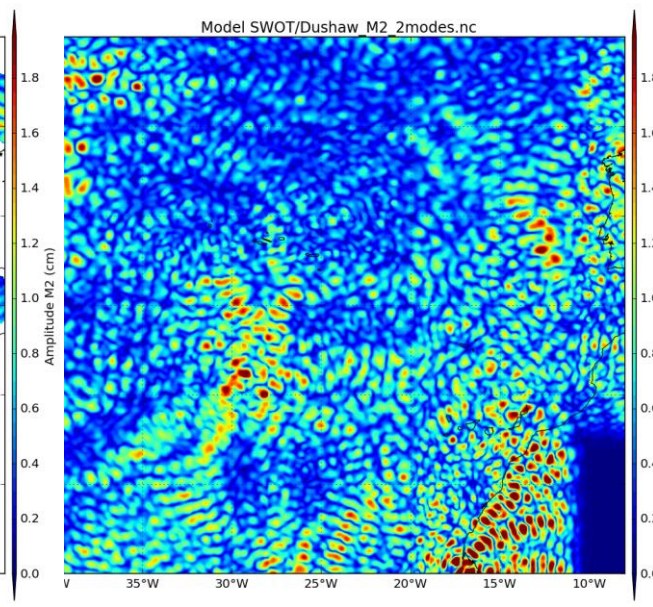




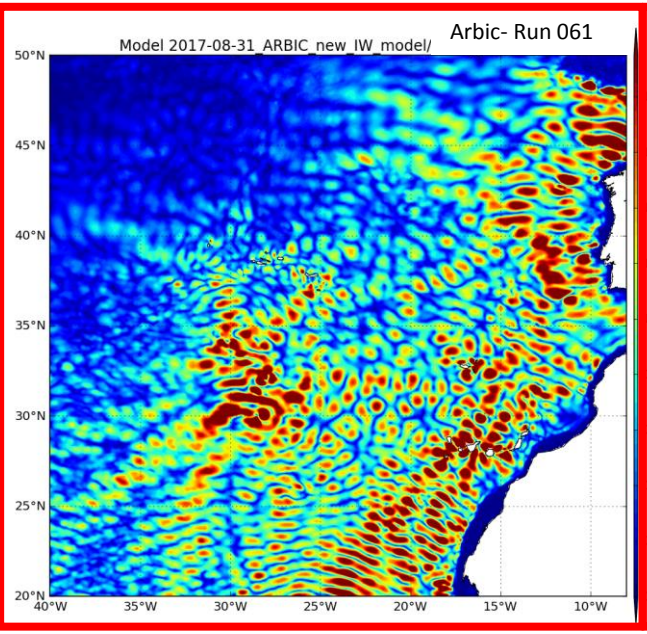


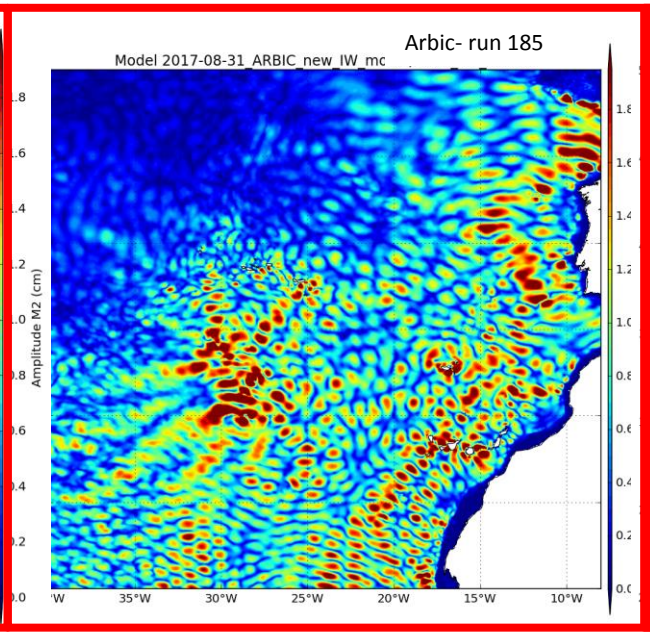


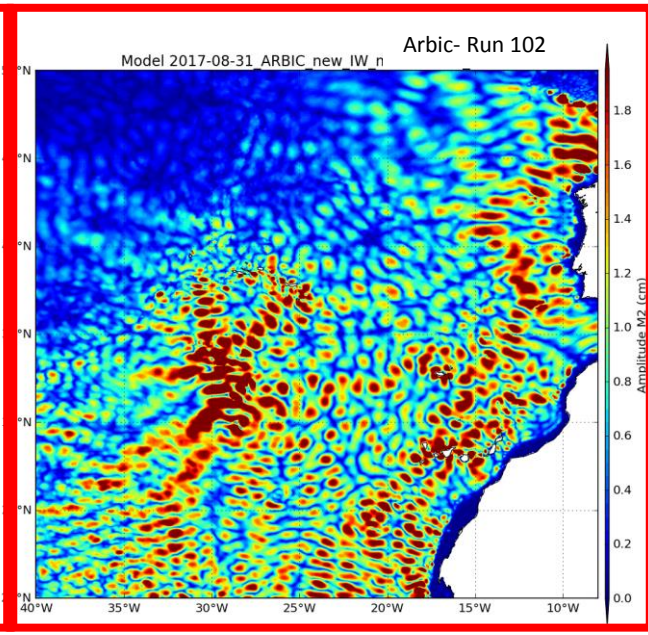


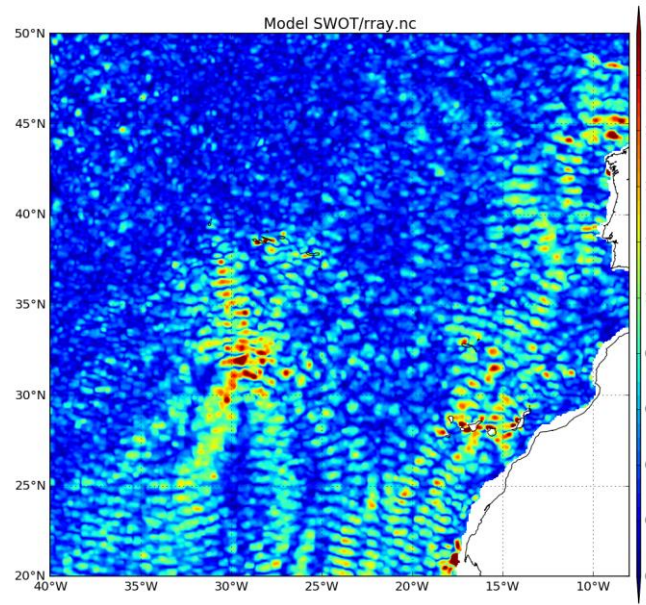


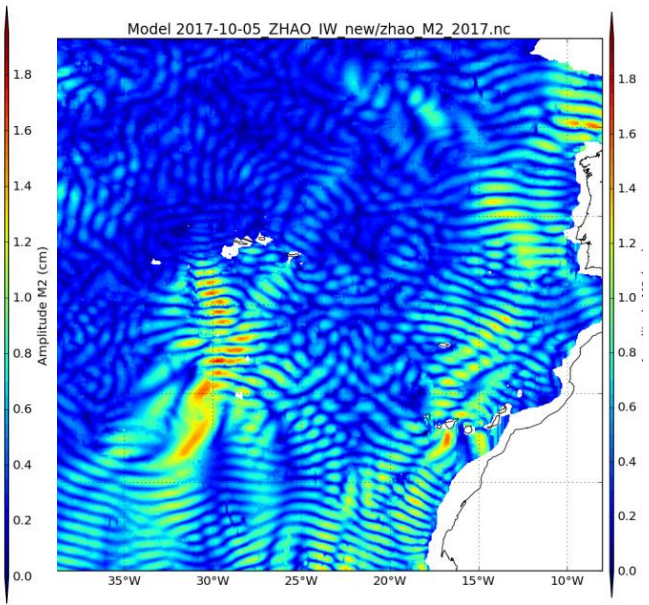
Comparison for M2 (Azores-NEA)

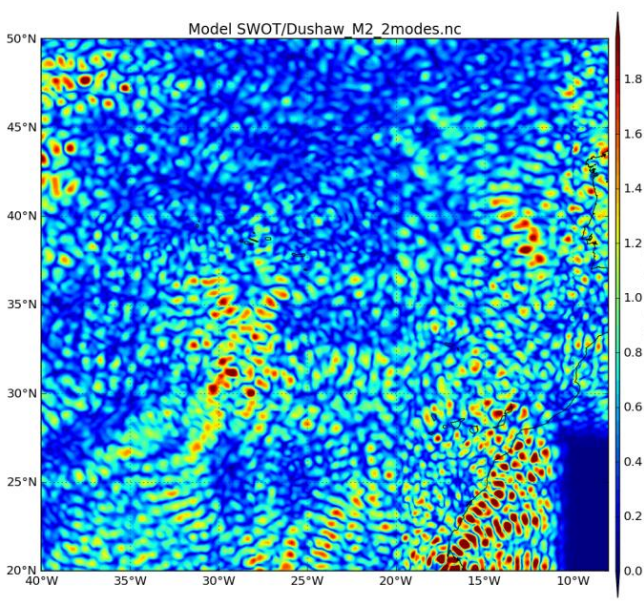












Variance reduction of altimeter measurements

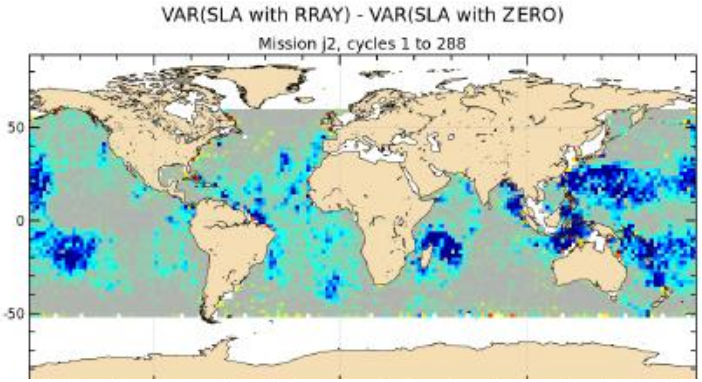
- Validation on global ocean
- Missions studied = J2, C2
- FES2014b model used as barotropic tide correction, but some tests made with GOT4v10
- Variance reduction computed for SSH crossovers differences and for along-track SLA
- Each wave tested separately

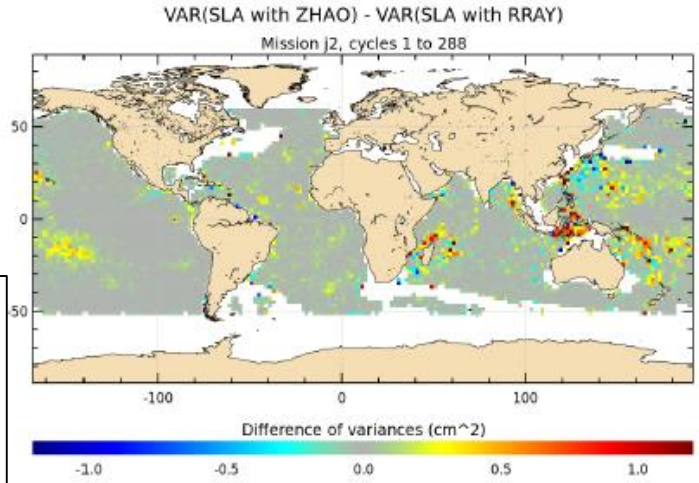
Variance analysis of **J2 SLA** – V1 models

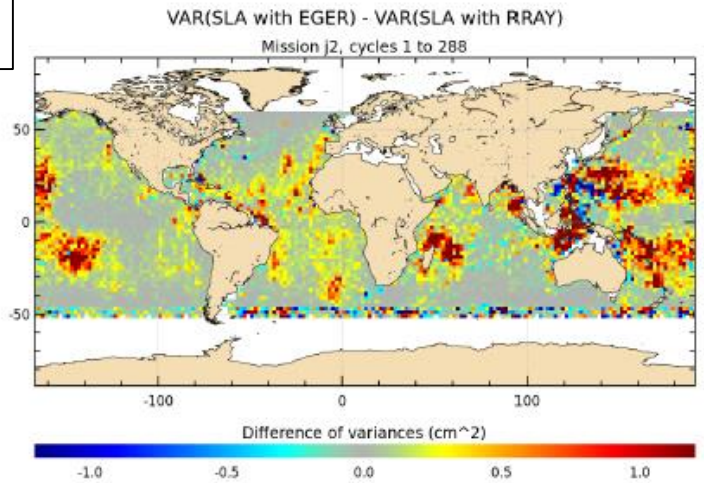
Blue shows variance reduction when using RRay model vs no correction

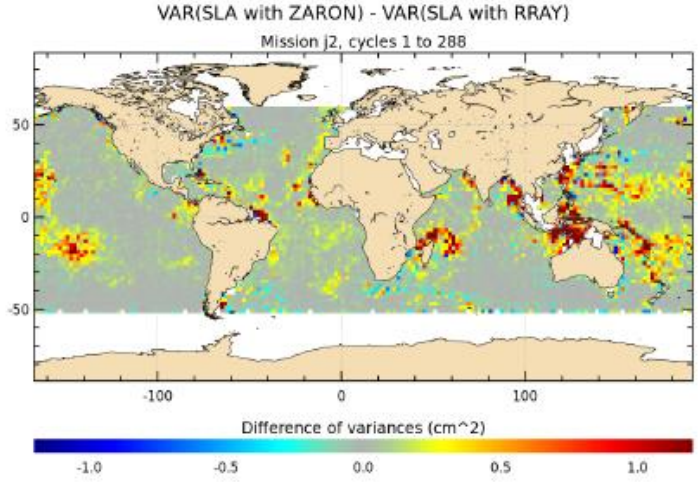
Red/yellow= RRay model reduces more the variance
Blue= other model reduces more the variance than Rray

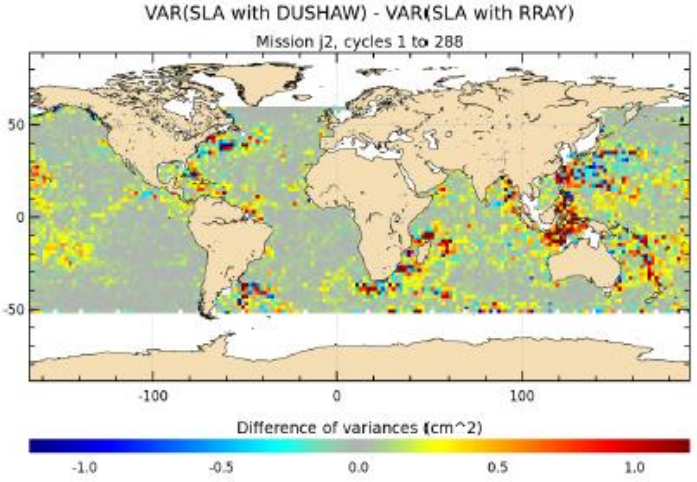
M2



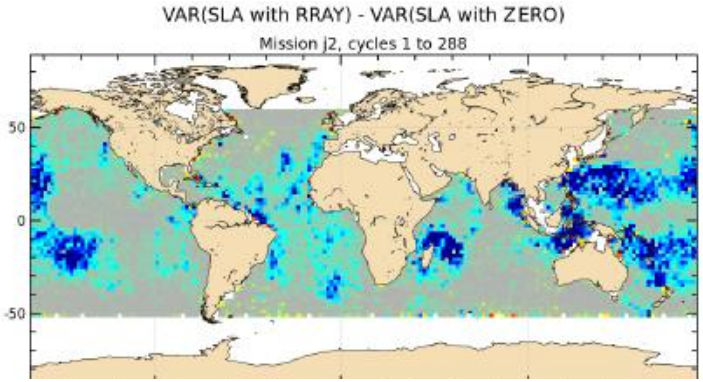




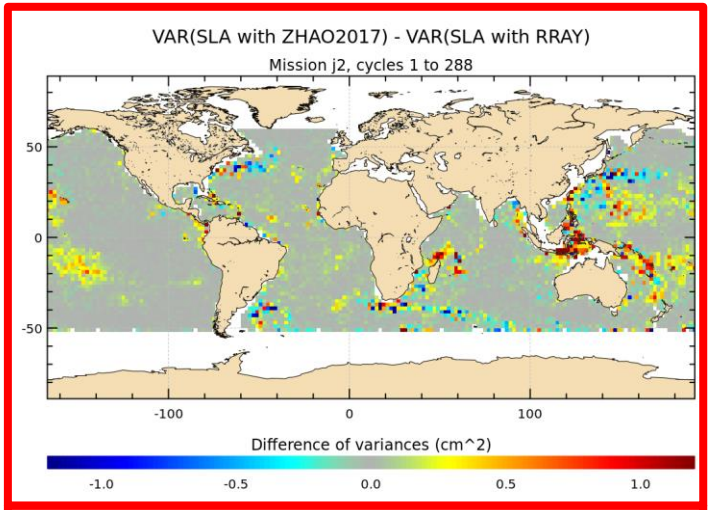


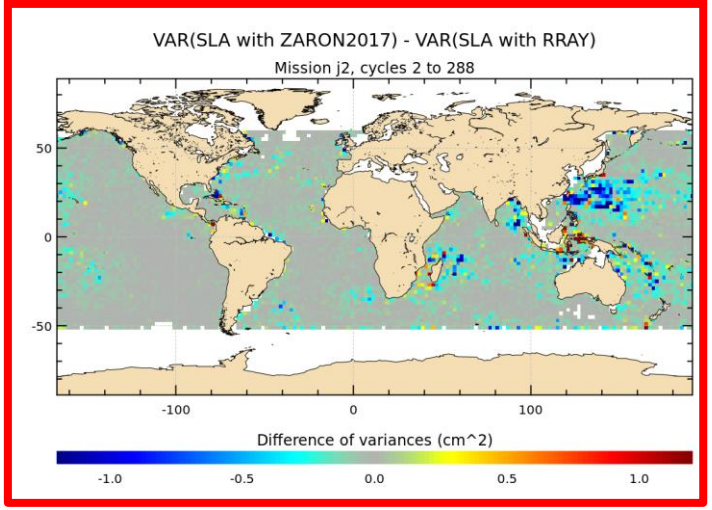


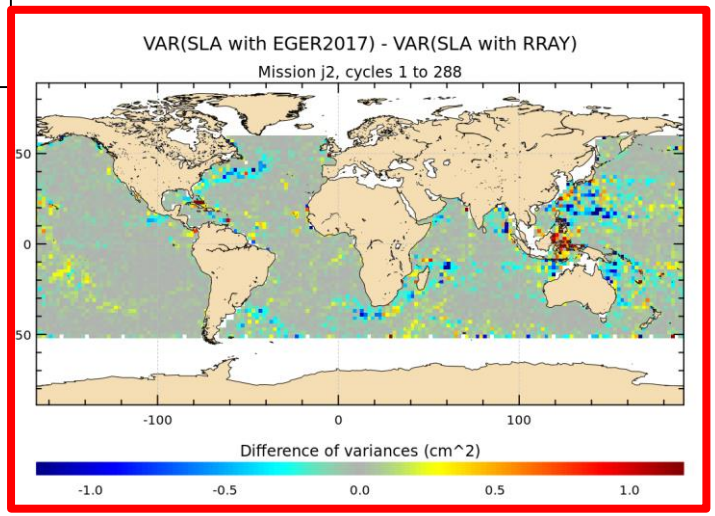
Variance analysis of **J2 SLA** – V1 models

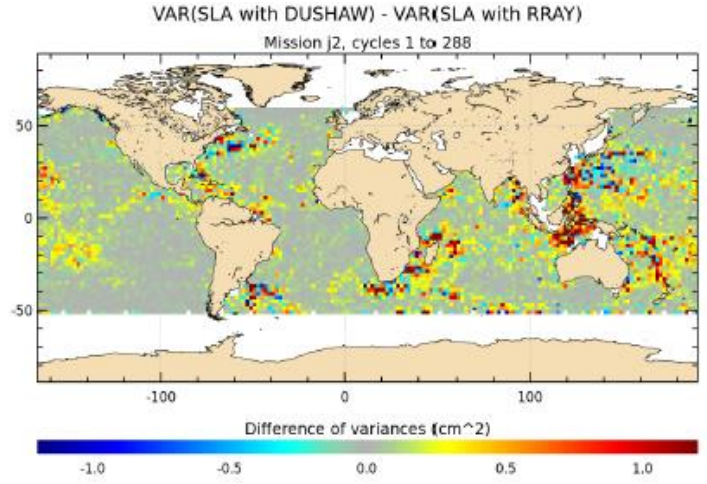


M2



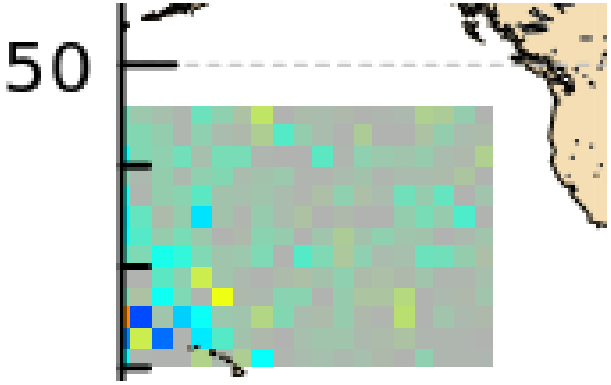






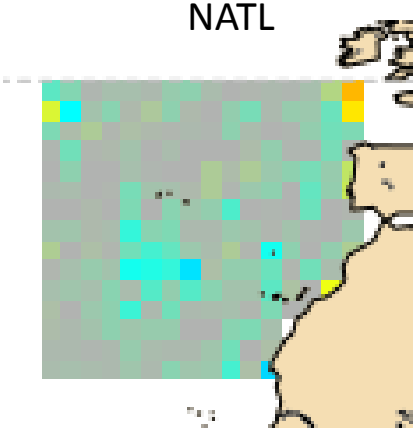
Variance analysis of **J2 SLA** – V1 models

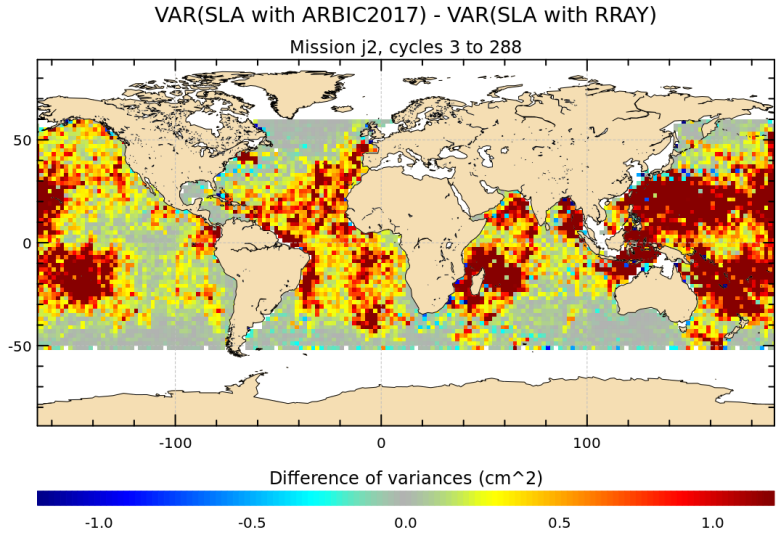
Var(SLA-UBEL) – var(SLA-RRAY)
NPAC



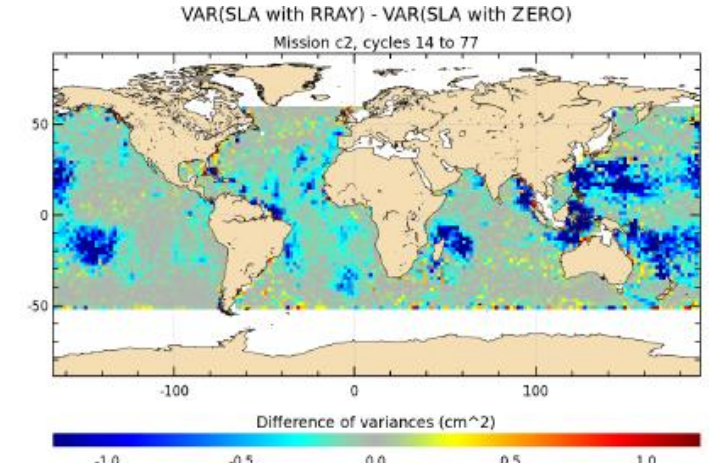
M2

Var(SLA-UBEL) – var(SLA-RRAY)
NATL

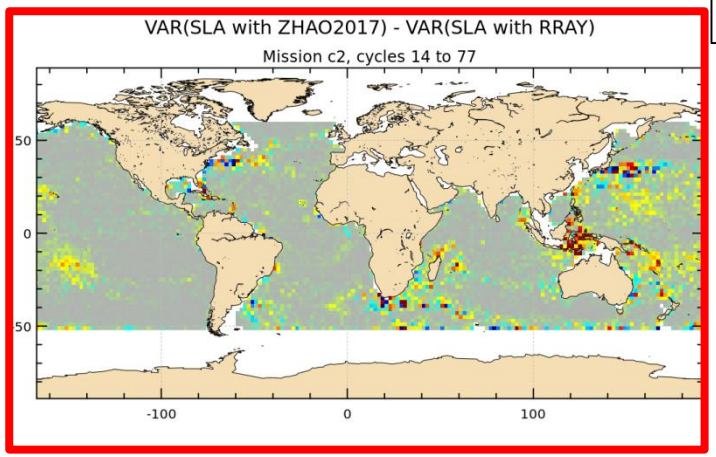


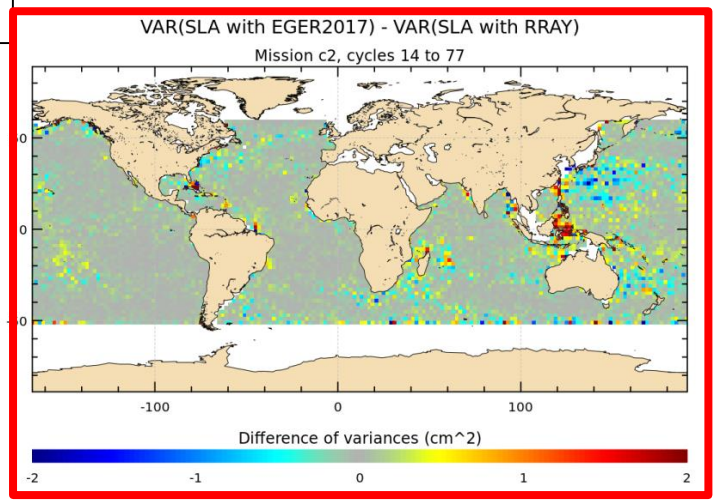


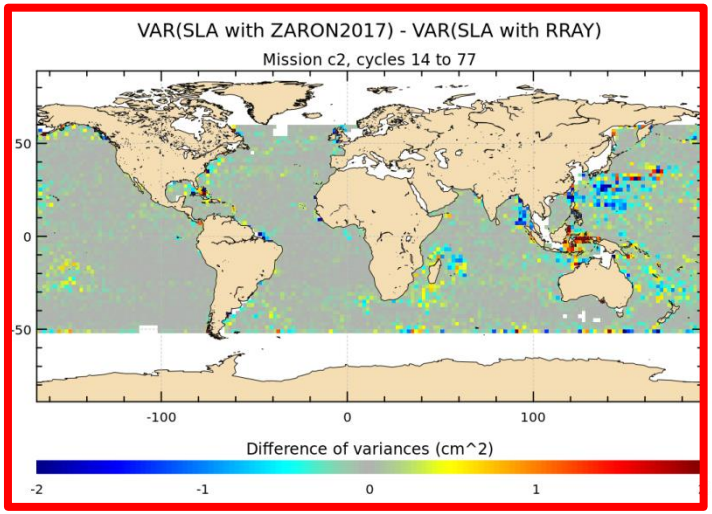
Variance analysis of **C2 SLA** – V2 models



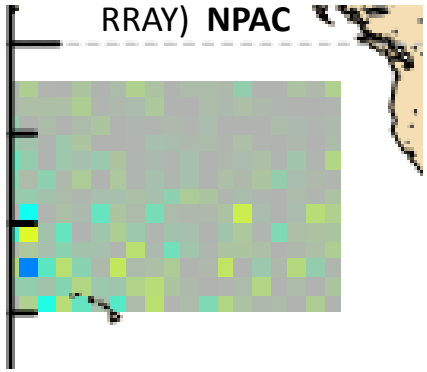
M2



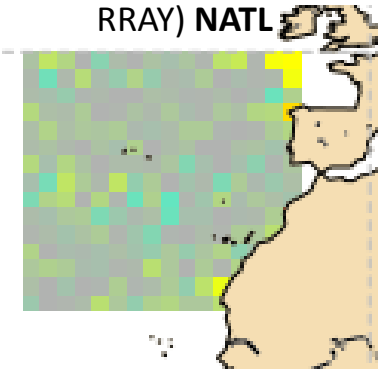




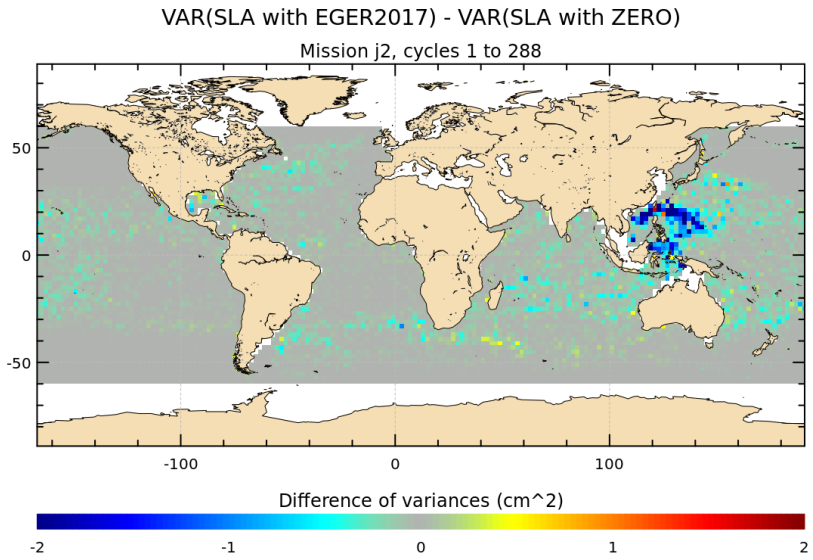
Var(SSH-UBEL) – var(SSH-RRAY) **NPAC**

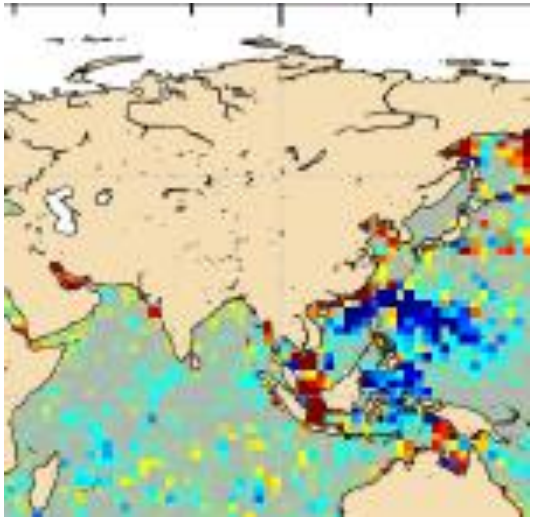


Var(SSH-UBEL) – var(SSH-RRAY) **NATL**



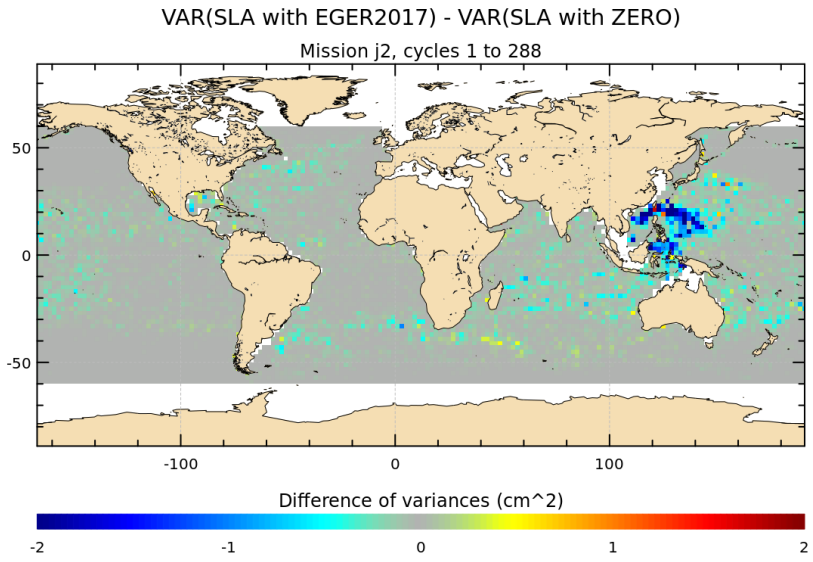
Variance analysis for J2 SLA – K1

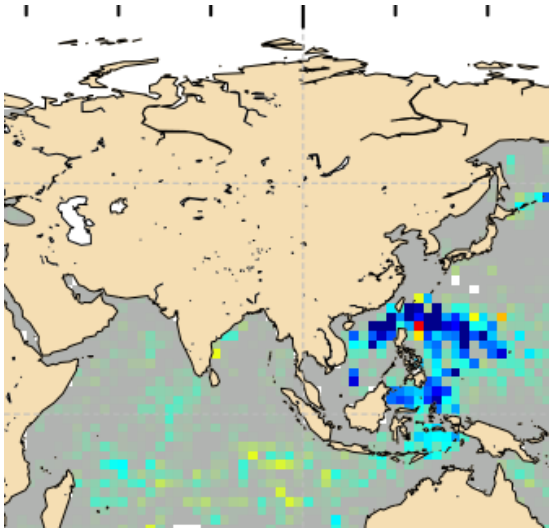




Var(SSH-Zaron2016) – var(SSH-RRAY)

Variance analysis for J2 SLA – K1





Var(SSH-Zaron2017) –
var(SSH-RRAY)

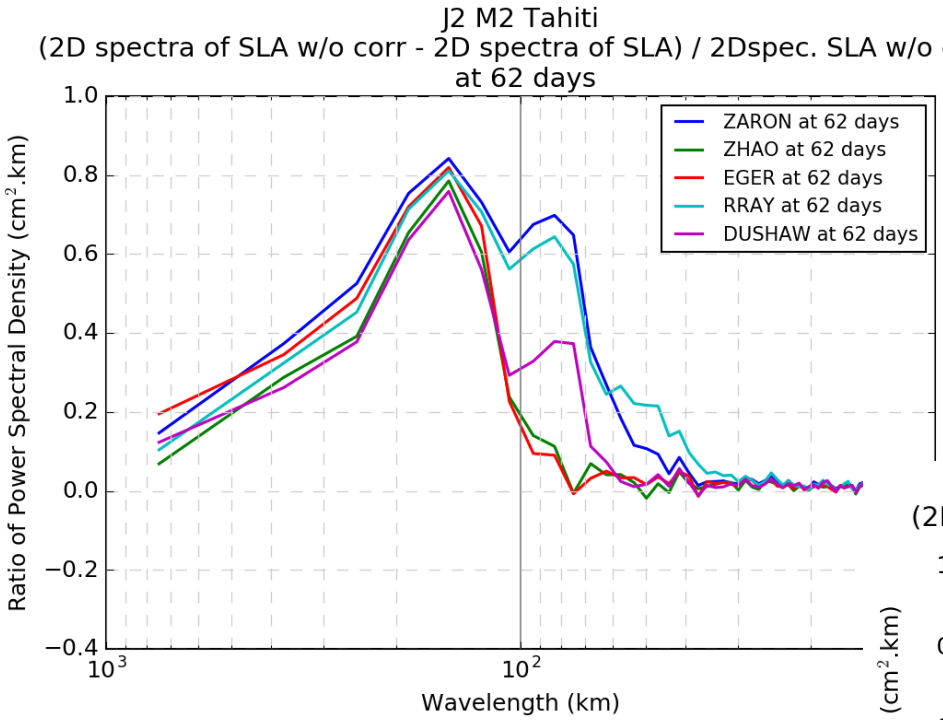
Spectral analysis

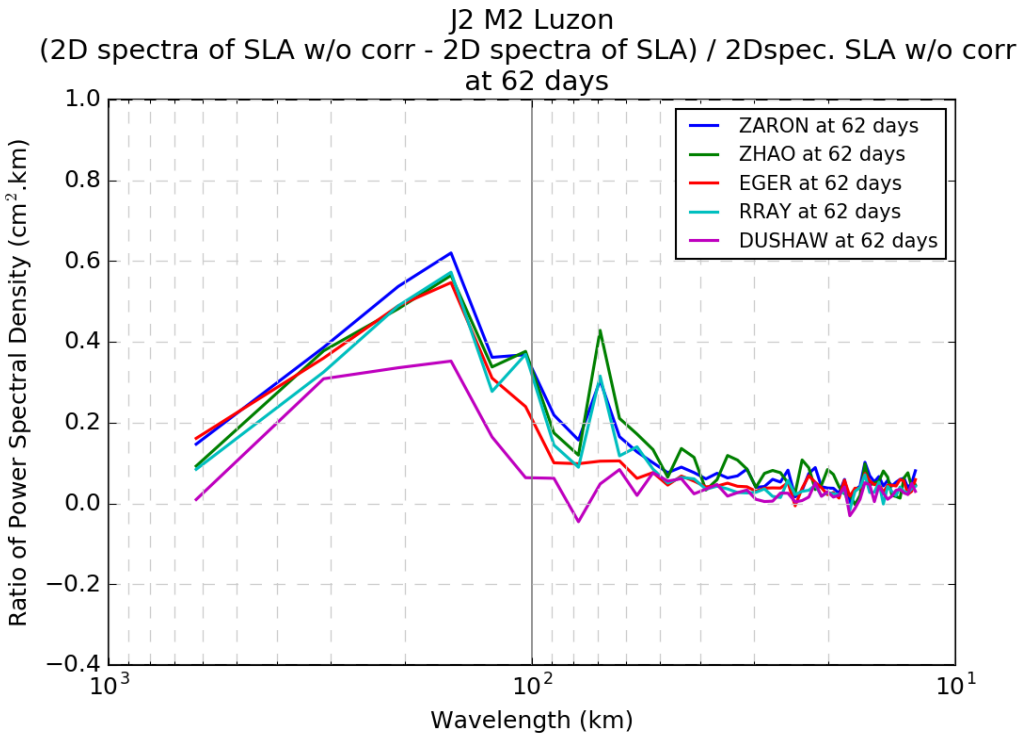
- **2D spectral analysis of Jason-2 SLA**

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

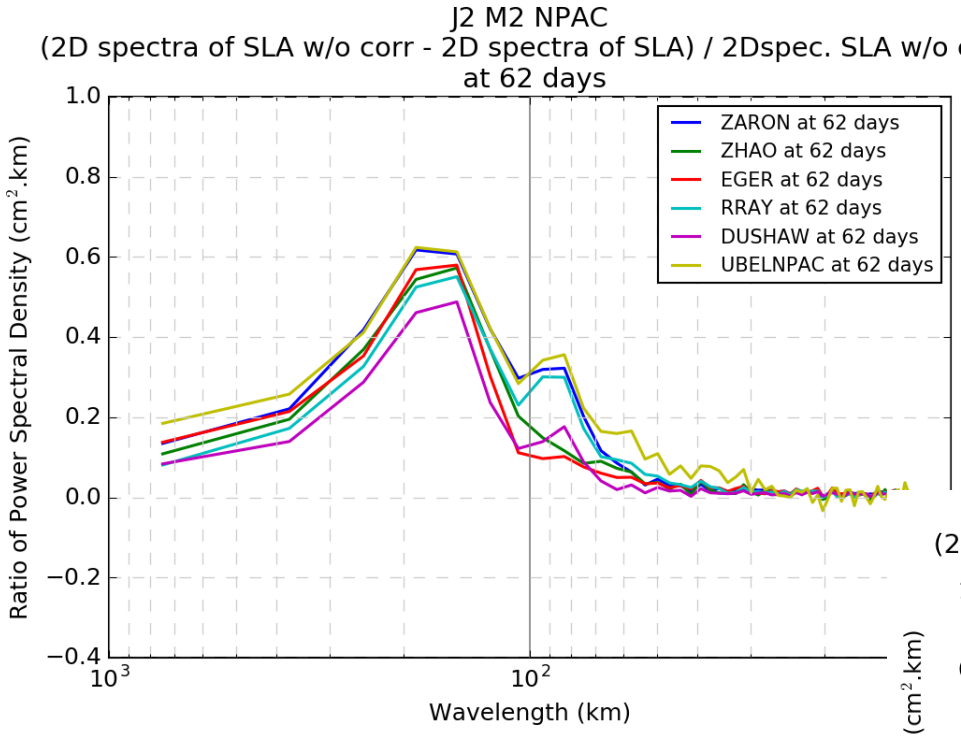
- **Focus on M2 frequency (K1 hardly separated from semi-annual signal)**

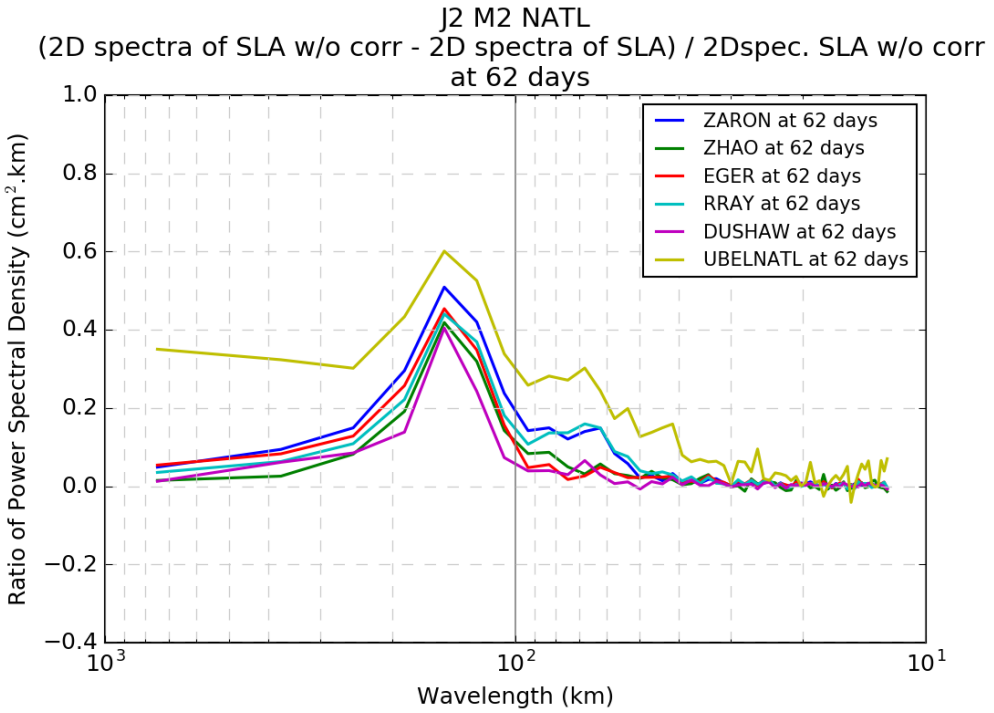
% of energy removed at M2 frequency, thanks to each IT correction, for J2 SLA – V2





% of energy removed at M2 frequency, thanks to each IT correction, for J2 SLA – V2





Summary

- 3 new releases + 2 new models provided
- **M2**:
  - Zaron ans Ray are close but Zaron removes more variability than Ray on many IT regions
  - Zhao and Egbert have been improved since last release:
    - Remove variability in great currents areas
  - Ubelmann models show promising results:
    - Variance reduced in both areas, but seems to remove some large scale/barotropic signal also ?
  - HYCOM solution not as good as empirical models
    - Strong amplitude (tidal cusps) and shift in phase
    - Pure IT hydrodynamic modeling is not yet mature => room for improvement with assimilation …
- **K1**:
  - Zaron and Egbert reduce more variance than Zhao
  - Coastal pb have been corrected in Zaron solution

- **Next steps :**
  - finalize the intercomparison study + test O1 + S2
  - add some in situ data comparison (Thermistors + Tomography …)
  - Still work on IT models :
    - feasibility of Ubelmann model on global ocean ?
    - data assimilation in B. Arbic model ?
    - new Ph-D starting on modeling IT with TUGO model

Comparison for K1 (Luzon, philippines)-V2

Dushaw