Ocean Tides and SWOT: Status and Achievements

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Tides *for* and *from* SWOT

From the *Mission Science Document*, Fu et al:

- *For* SWOT: “The SWOT mission should aim toward internal-tide corrections accurate to the sub-centimeter level.”

- *From* SWOT: “We foresee advances in three areas: high-latitude tides, near-coastal tides, and internal tides.”

Tides *for* SWOT: consider tidal alias periods

CalVal orbit: 0.99349-day-repeat

Science orbit: 20.86455-day-repeat

Tide	CalVal [days]	Science [days]	Amp. [cm]
M_2	12	66	58
S_2	76	77	14
N_2	9	47	12
K_1	262	266	37
O_1	13	53	23
M_4	6	57	2.3
MK_3	12	88	2.0
MS_4	11	462	1.0

Amplitude at San Francisco.

Tides *from* SWOT

- Favorable tidal separations, SWOT vs. T/P-Jason:
  K_1–S_{sa}: 1.6 yr (SWOT) vs. 9 yr (T/P)

- Unfavorable during Science phase:
  M_2–$2MK_3$: 791 days
  (e.g., 3.5m M_2 and 10cm $2MK_3$ in Anchorage, AK)

- Biggest “win” will come from higher spatial resolution of SWOT.

Status & Accomplishments

15 publications on tides (12 baroclinic, 3 barotropic) in the SWOT/OSTST publications database, 2016–2019.

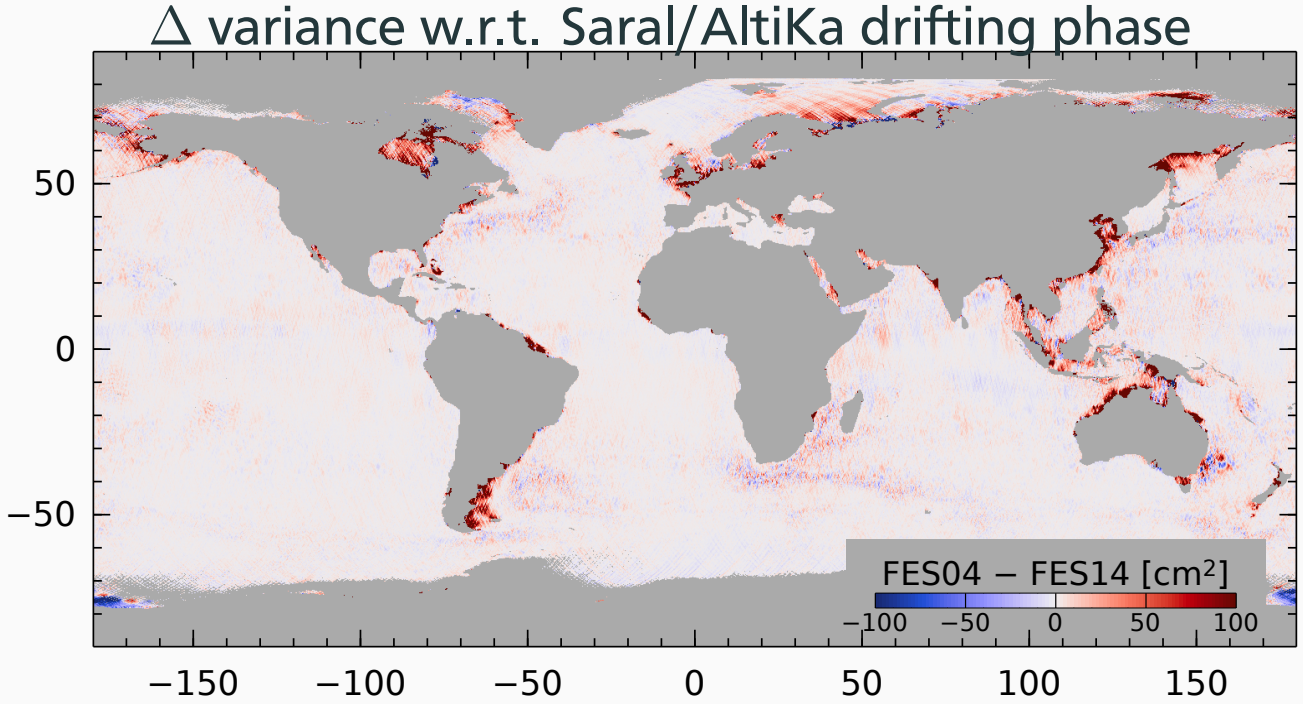
Barotropic tide modeling: “usually-neglected sources of error are being revisited” – Lyard

1. FES2014 – refined grid, better topography
2. GOT4.10c – geocenter corrections, T/P vs. Jason data
3. TPXO9-Atlas – more and higher-resolution regional models
4. FES2014 and GOT4.10c are now in RADS.
5. New high-latitude tide models have been developed using both empirical mapping and data assimilation.
6. GRACE data are being used for model validation.

Lyard and Allian 2018 SWOT-ST presentation summarizes barotropic model developments.

Status & Accomplishments: Barotropic Tide Example

Improvement in SSH variance reduction with FES14 vs. FES04 tide correction.

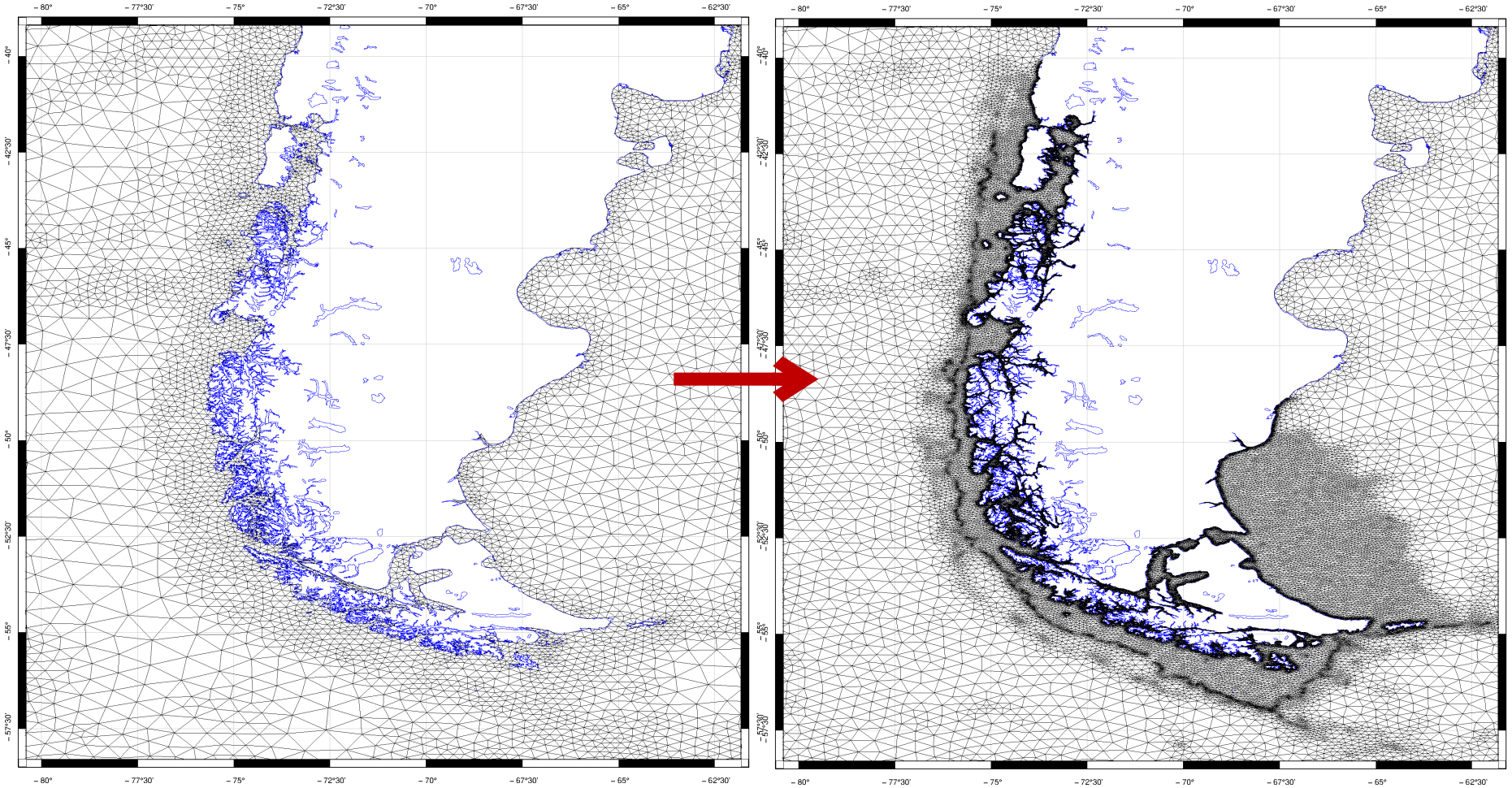


(Red is “good”, more variance explained by FES14.)

Localized comparisons provide information not evident from area-average metrics.

Status & Accomplishments: Barotropic Tide Example

New FES2020 mesh in Southern Chile/Patagonia region:



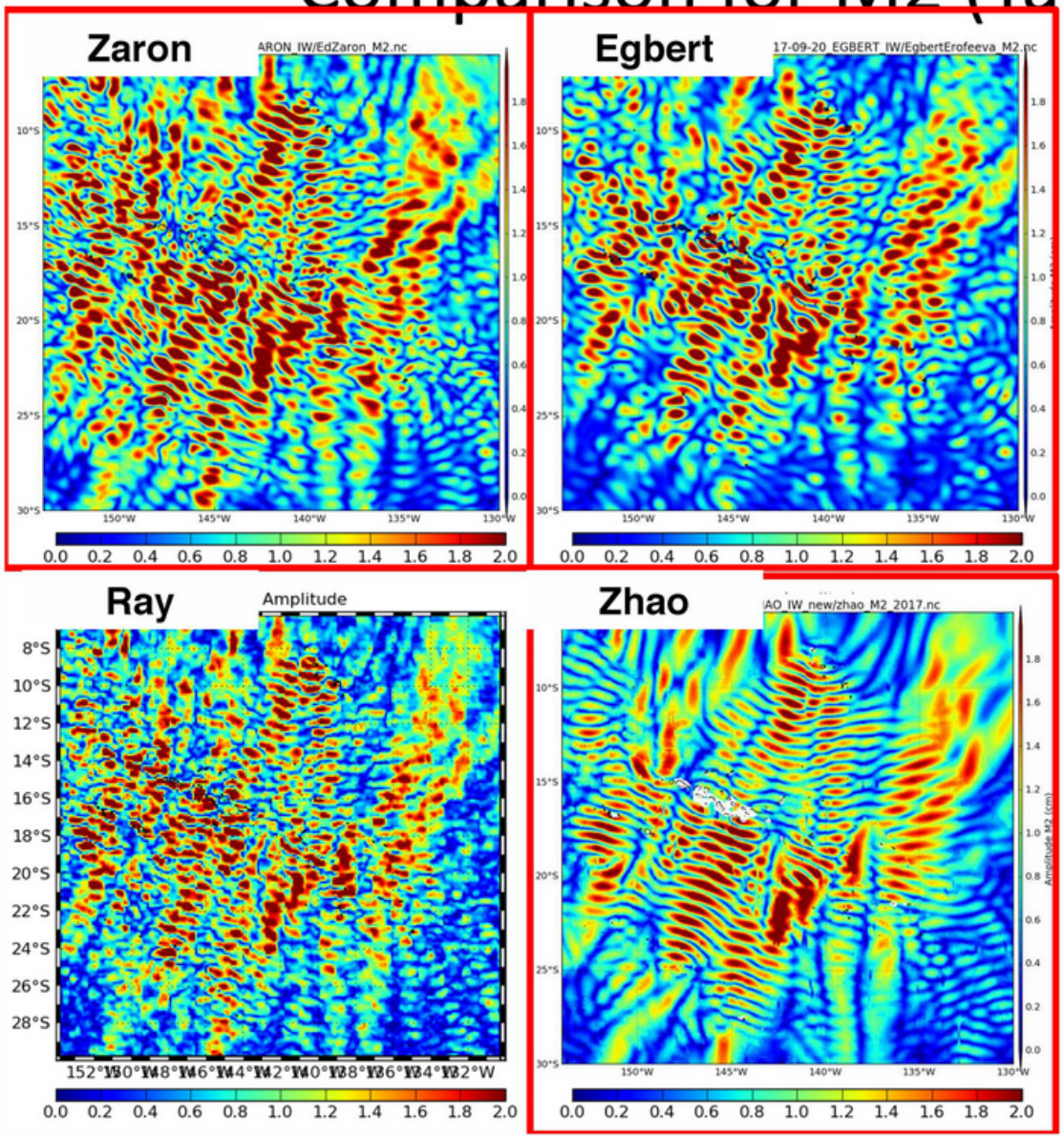
15 km element coastal resolution
(~7,5 km numerical resolution)

2 km element coastal resolution
(~1 km numerical resolution)

~120 000 additional elements (over 1 500 000)

Status & Accomplishments: Baroclinic Tide Examples

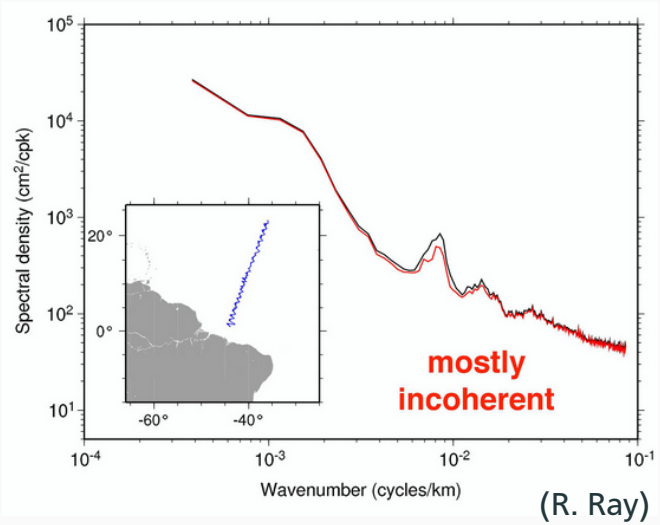
Comparison for M2 (Tahiti) – V2



Carrère compared five internal tide models in 2017 and 2018. Revisions exhibit increased agreement and performance. Scharoo is testing Zaron's model on S3 products.

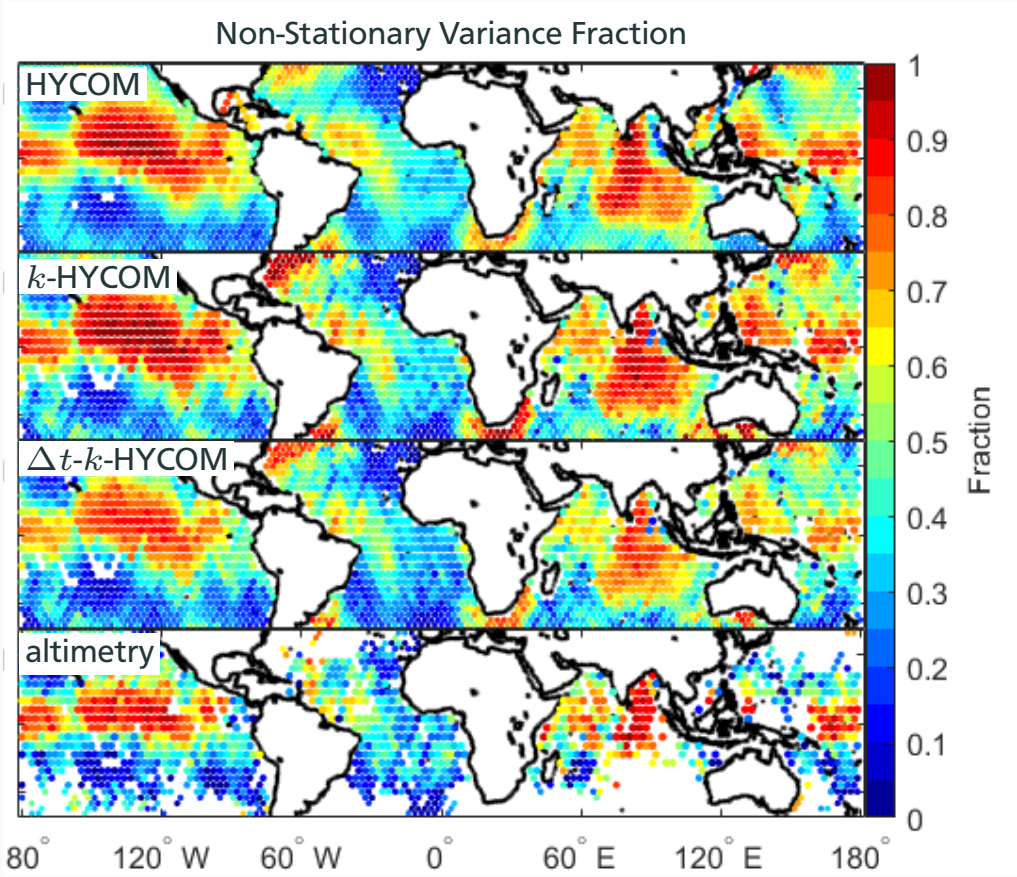
Slide thanks to L. Carrère and R. Ray.

Baroclinic Tide: non-phase-locked variability



(R. Ray)

Analysis of non-phase-locked tides in HY-COM (Nelson et al, submitted).



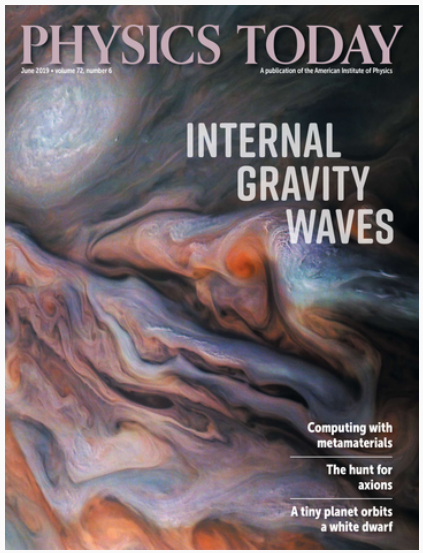
(A. Nelson)

Status & Accomplishments

From survey of 2016–2018 SWOT-ST Presentations:

1. Barotropic tides, incl. river tides and storm surges – 7 talks
2. Baroclinic tide prediction – 4 talks
3. Baroclinic tide in situ observation – 4 talks
4. Baroclinic tide modeling, and non-stationary tides – 9 talks
5. Interpretation of spectra, balanced motion, internal tides, IGW – 5 talks

Presentations at the 2018 AGU Ocean Sciences meeting and the co-located Portland workshop discussed broader implications of non-phase-locked internal tides in ocean dynamics.



Shakespeare, 2019

Key Tasks for the Future

1. Improve and validate the accuracy of tide predictions at high latitudes and at small scales in coastal areas.
2. Better quantify the non-phase-locked tidal signals, and higher vertical modes, and understand their phenomenology.
3. Continue to validate numerical ocean models and develop data assimilation strategies which account for baroclinic tidal SSH.
4. Contribute to planning for SWOT CalVal field campaigns.

Further refinement of the DAC, barotropic, and low-mode baroclinic models is ongoing.

Extra Slide #1: SWOT/OSTST Publications Mentioning Tides

- Zhao et al (2019) Decomposition of the multimodal multidirectional M_2 internal tide field, JTech.
- Zaron (2019) Baroclinic tidal sea level from exact-repeat mission altimetry, JPO.
- Arbic et al (2018) Primer on global internal tide and internal gravity wave continuum modeling in HYCOM and MITgcm.
- Zaron (2018, 2019) Weddell Sea tides, JPO and JGR.
- Buijsman et al (2017) Semidiurnal internal tide incoherence in the Equatorial Pacific, JGR.
- Dunphy et al (2017) Low-mode internal tide propagation in a turbulent eddy field, JPO.
- Ponte et al (2017) Low-mode internal tides and balanced dynamics disentanglement in altimetric observations: synergy with surface density observations, JGR.

Extra Slide #2: SWOT/OSTST Publications Mentioning Tides

- Zaron and Ray (2017) Using an altimeter-derived internal tide model to remove tides from in-situ data, GRL.
- Zaron (2017) Mapping the non-stationary internal tide, JPO.
- Kelly (2016) The vertical mode decomposition of surface and internal tides in the presence of a free surface and arbitrary topography, JPO.
- Ngodock et al (2016) On improving the accuracy of the M_2 barotropic tides embedded in a high-resolution global ocean circulation model, OM.
- Ray and Zaron (2016) Internal tides and their wavenumber spectra, JPO.
- Zhao (2016) Using CryoSat-2 altimeter data to evaluate M_2 internal tides observed from multisatellite altimetry, JGR.
- Zhao et al (2016) Global observations of open-ocean mode-1 M_2 internal tides, JPO.