Can Geodetic-Mission Altimetry be used to Improve Maps of the Internal Tide?

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Summary

Due to the large inter-track spacing of exact-repeat missions (ERM), direct estimates of the internal tide field are necessarily of coarse resolution, even when data from multiple exact-repeat altimeter missions are combined. Here, ERM, long-repeat (Cryosat2), and geodetic mission (GM) data are combined to map the tide at higher resolution. The proposed approach is likely to be useful only in special cases where the tide varies by 1 cm or more over length scales of 50 km.

Spatial Density of Altimeter Data

At the latitude of Hawaii ERM pass density is approximately 280 passes per degree-squared; GM pass density is approximately 52 passes per degree-squared.

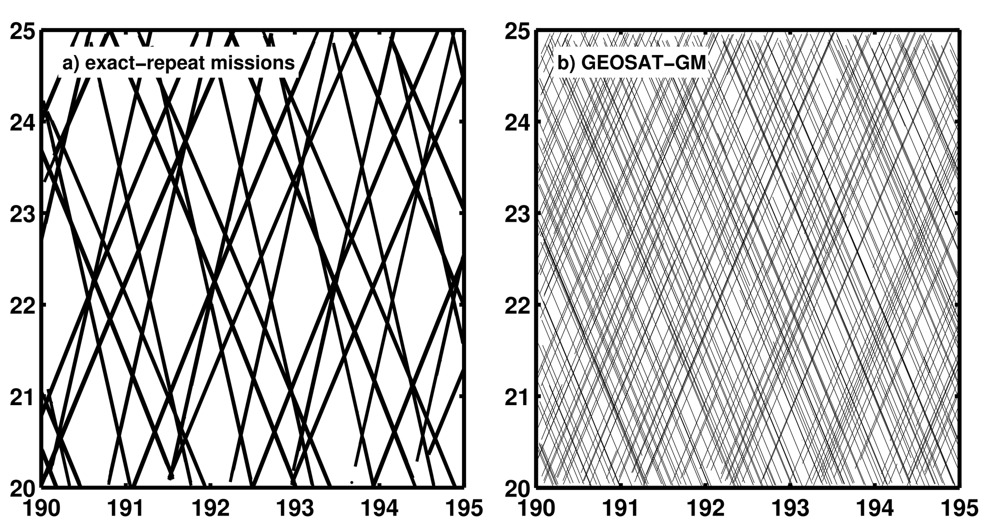


Table 1: ERM

Name	Start	End	# Repeats	Period
TOPEX-a	25 Sep 1992	11 Aug 2002	363	10
TOPEX-b	20 Sep 2002	08 Oct 2005	112	10
JASON1-a	15 Jan 2002	26 Jan 2009	258	10
JASON1-b	10 Feb 2009	03 Mar 2012	112	10
ERS2-a	29 Apr 1995	04 Jul 2011	169	35
ENVISAT1-b	14 May 2002	22 Oct 2010	88	35
GFO1-a	07 Jan 2000	17 Sep 2008	192	17
JASON2-a	04 Jul 2008	05 Sep 2013	190	10

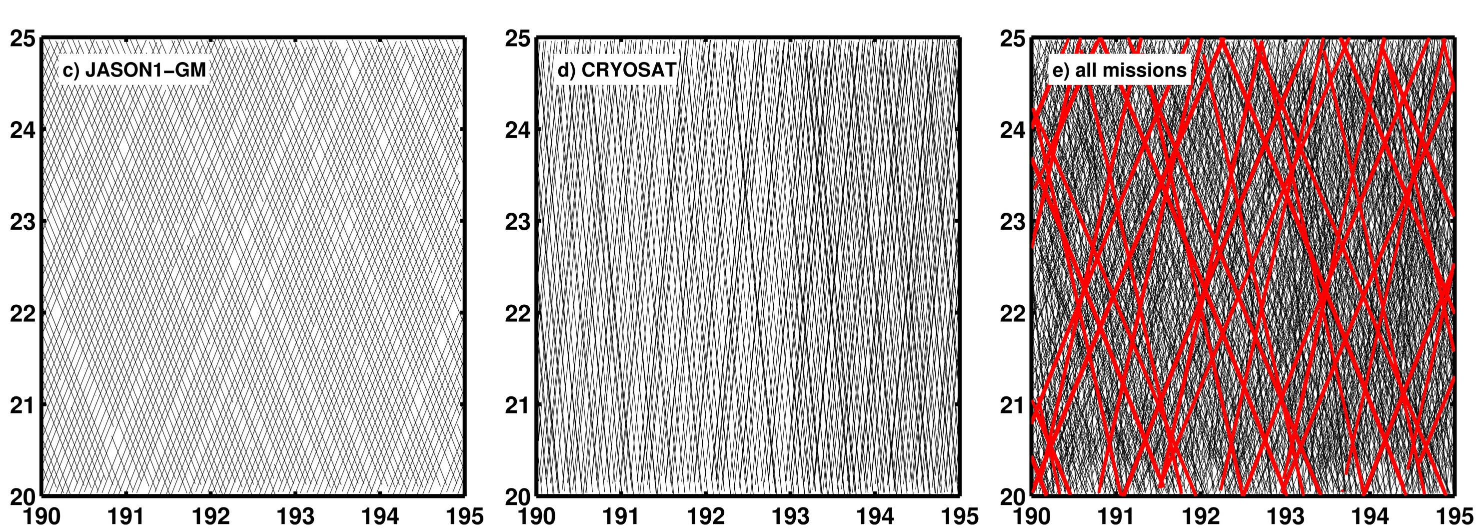


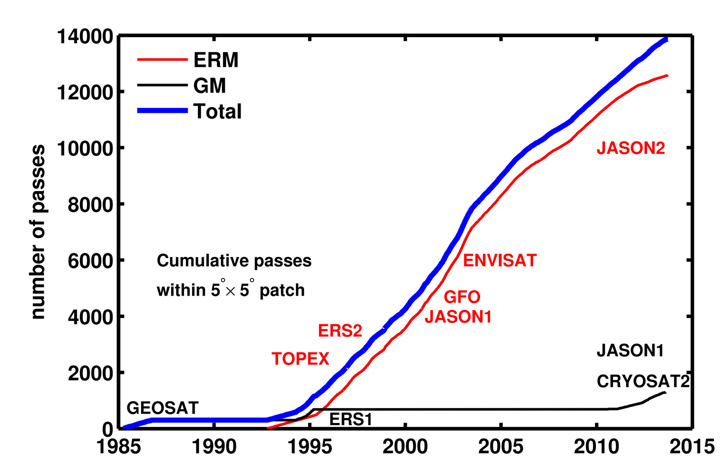
Table 2: GM and Cryosat2

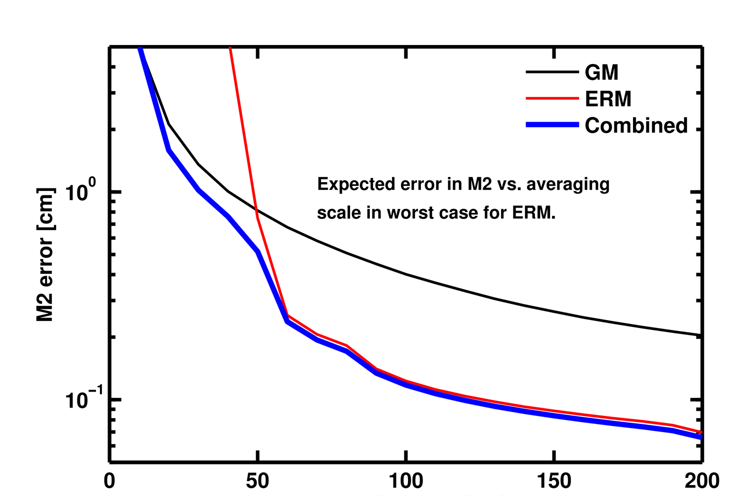
Name	Start	End
GEOSAT-a	31 Mar 1985	30 Sep 1986
ERS1-e	10 Apr 1994	28 Sep 1994
ERS1-f	28 Sep 1994	21 Mar 1995
JASON1-c	07 May 2012	20 Jun 2013
CRYOSAT2-a	14 Jul 2010	06 Sep 2013

Harmonic Analysis of Multi-Mission Data

Harmonic analysis with error estimates are computed using the standard least-squares methods. Nominal values of 3 cm for measurement noise and 15 cm for non-tidal SSH variability are assumed. Measurement precision of individual altimeters is not included. Precision of mean sea surface (and other corrections) along different ground tracks is not included.

- Uncertainty of tides from GM data are a factor of 3 to 4 worse than from combined ERM data when the averaging scale is greater than 70 km.
- GM data can be used to identify a 1 cm M_2 tide at scales larger than 50 km.
- Alternately, GM data may be useful in resolving large amplitude (1 cm or more for M_2) spatial variability in tidal fields at scales smaller than 50 km.
- Conclusion: GM data may contribute to tidal estimation only in special cases where there is sufficient tidal SSH variance at scales smaller than ERM ground track spacing.





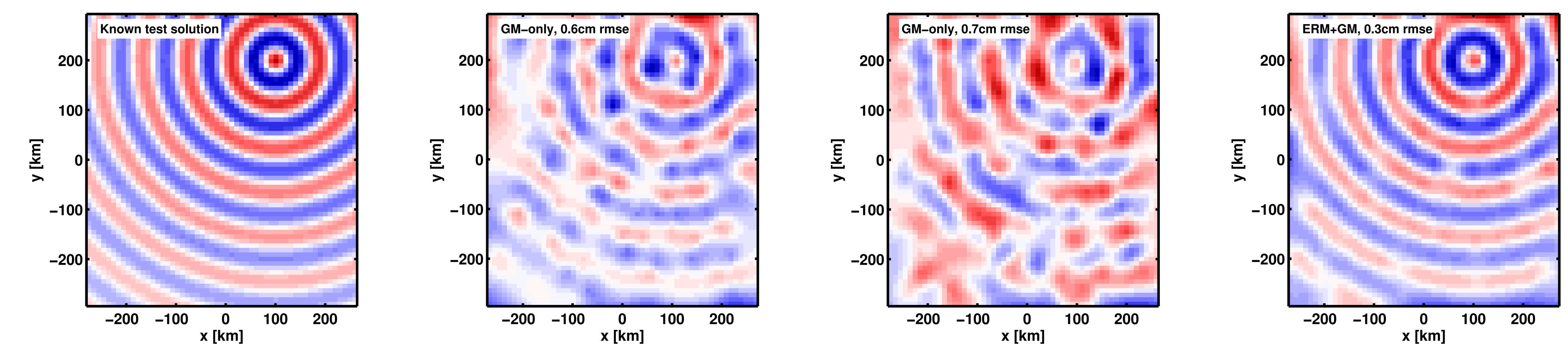
Tidal Mapping via Spatially-Regularized Harmonic Analysis

Tides are mapped here by representing the SSH as a product of thin-plate splines in space and harmonic functions in time. The representation can be written as

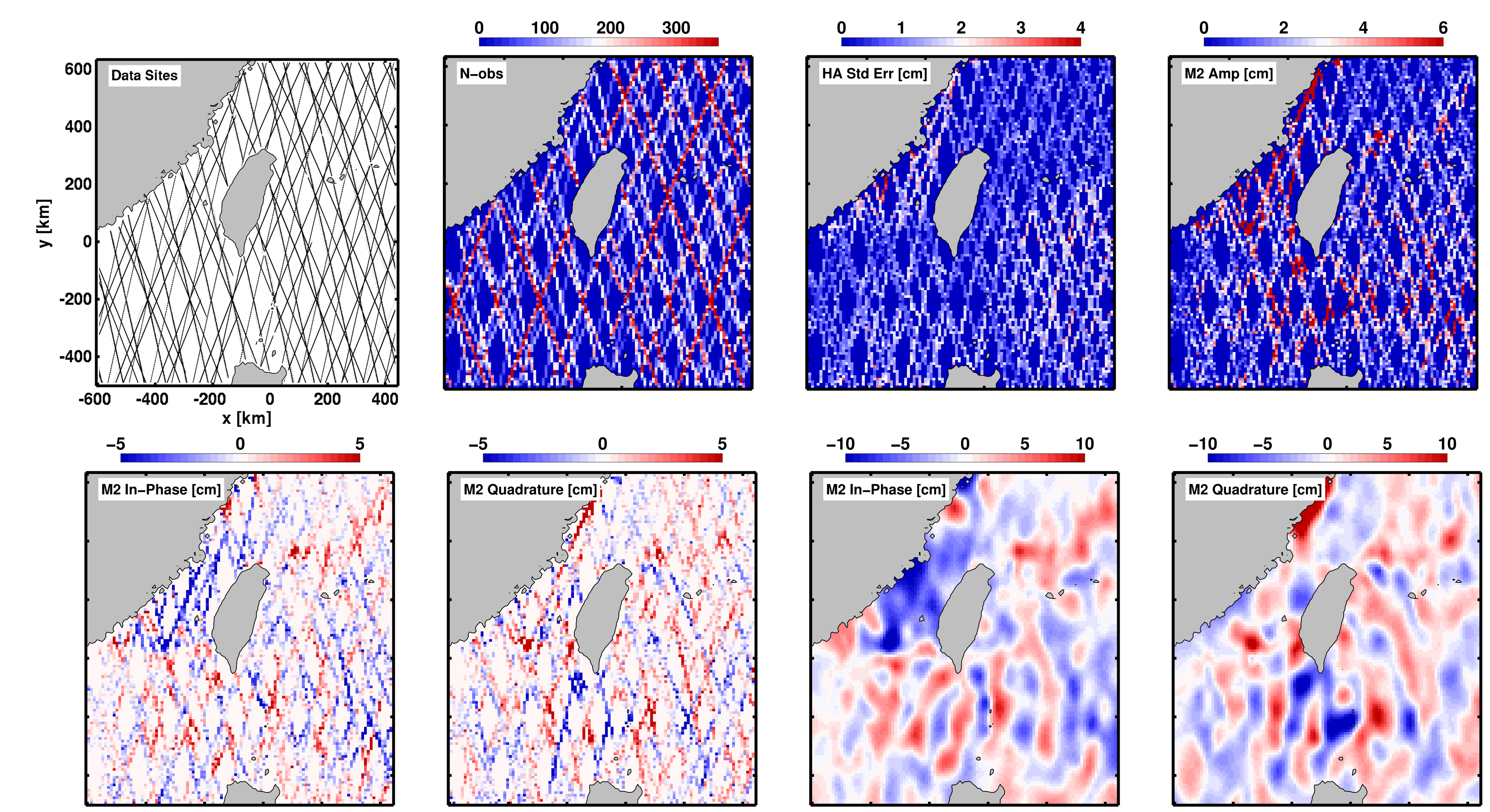
$$\hat{h}(\boldsymbol{x},t) = \sum_{kl} \alpha_{kl}\phi_k(\boldsymbol{x})\zeta_l(t) + \sum_{il} \beta_{il}\kappa(\boldsymbol{x}-\boldsymbol{x}_i)\zeta_l(t). \qquad (1)$$

Test Case: Reconstructing a 2.5 cm Mode-2 M_2 Signal in the Presence of 15 cm Non-Tidal Noise

In this test case a known solution is reconstructed from synthetic data based on ERM sampling, GM sampling, and their combination.



Application: Mapping M_2 Near Taiwan and Luzon Strait



Conclusions

- The problem of tidal estimation using Geodetic Mission (GM) altimetry has been analyzed and compared to approaches which use Exact Repeat Mission (ERM) data alone.
- A new approach to empirical mapping of tides has been implemented which combines harmonic analysis and thin-plate splines.
- GM altimetry will contribute to tidal estimation only in special cases where there is substantial coherent tidal SSH variance at scales smaller than ERM ground track spacing.
- NEXT STEPS: continue to validate the methodology; compute error estimates using estimate-based bootstrap; use physically-based basis functions instead of thin-plate splines.

Acknowledgements

The altimeter data used here were extracted from the Radar Altimeter Database System (RADS).

2013 OSTST Meeting
Boulder, CO
October 6–11, 2013

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