Comparison of Internal Tides in a High Resolution Ocean Circulation Model with Altimetric Estimates

Presented by: J.F. Shriver[1]

Additional Key Performers: B.K. Arbic[2], J.G. Richman[1], R.D. Ray[3], E.J. Metzger[1], A.J. Wallcraft[1], P.G. Timko[2]

[1] Naval Research Laboratory, [2] University of Michigan, [3] NASA Goddard Space Flight Center

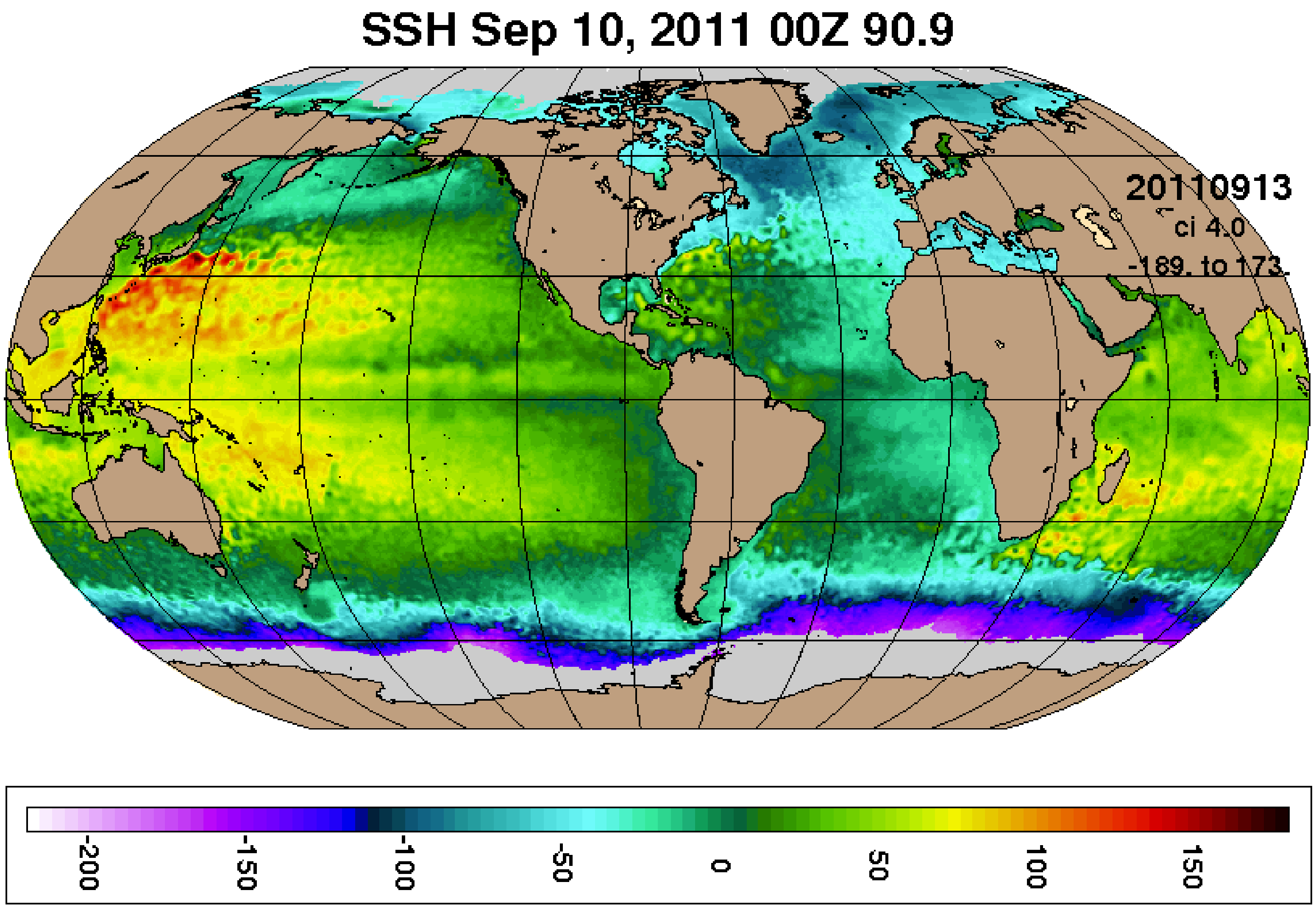
OSTST 2011
San Diego, CA
19-21 Oct 2011

Objective

- To compare the modeled internal tides to that seen by satellite altimetry
  - Globally
  - All eight tidal constituents in global HYCOM
  - 1year of model SSH

- This work extends that of Arbic et al. (2010), which examined a region around Hawaii
  - M_2 only
  - 1 day of model output

Global HYCOM Nowcast/Forecast System



http://hycom.org/ocean-prediction

HYCOM = Hybrid Coordinate Ocean Model

1/12° horizontal resolution 32 vertical layers

Tides in Global HYCOM

- Additions to global model
  - Tidal astronomical forcing corrected for solid earth body tides
  - Topographic wave drag applied to the tidal flow
  - Self attraction and loading through the scalar approximation

- Tidal Forcing with 8 constituents:
  - Semidiurnal M_2, S_2, N_2 and K_2
  - Diurnal O_1, P_1, Q_1 and K_1

Data Sets

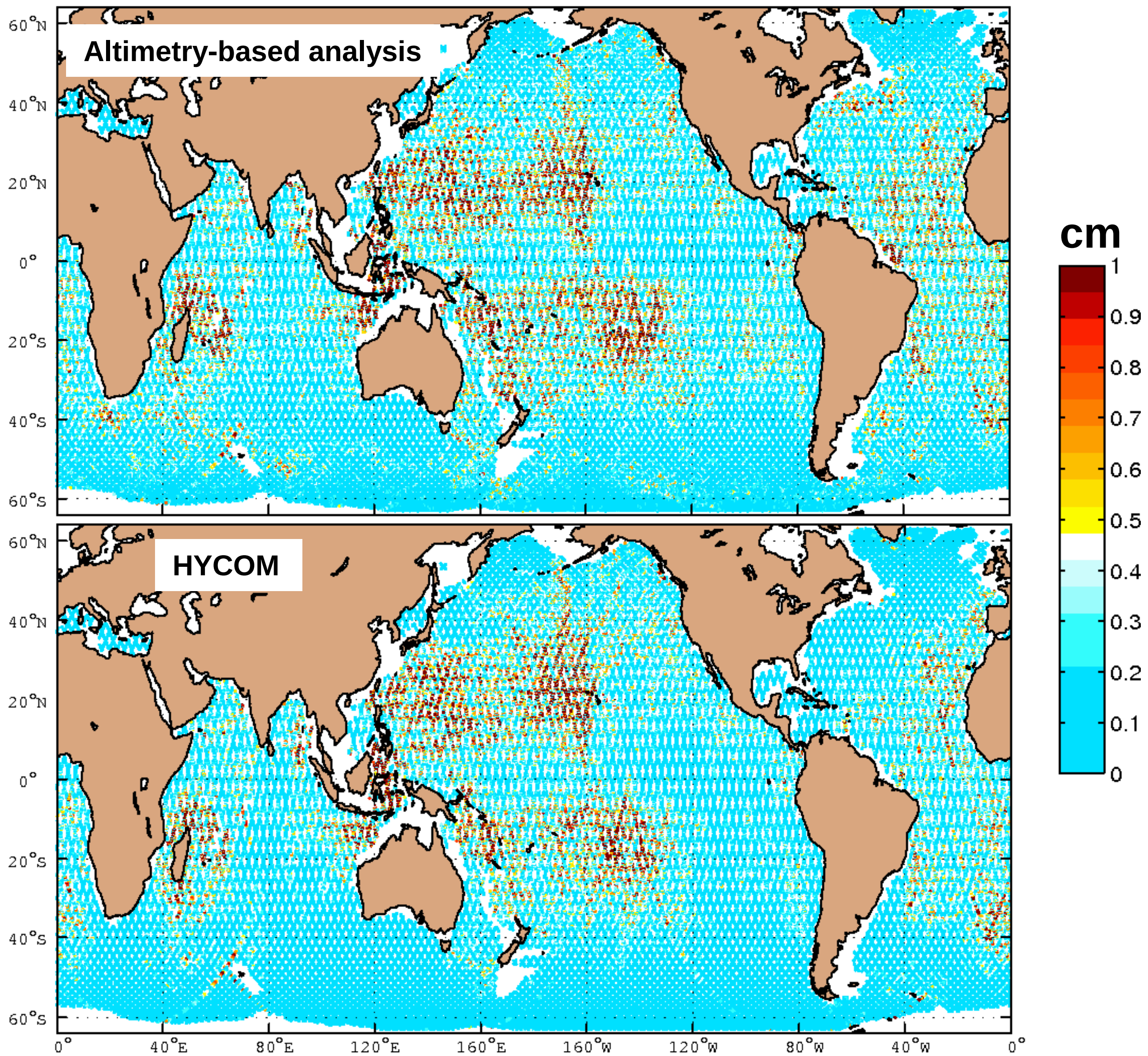
1/12° global HYCOM with tides

- 2006
- 1x/hour snapshots of total SSH
- No data assimilation

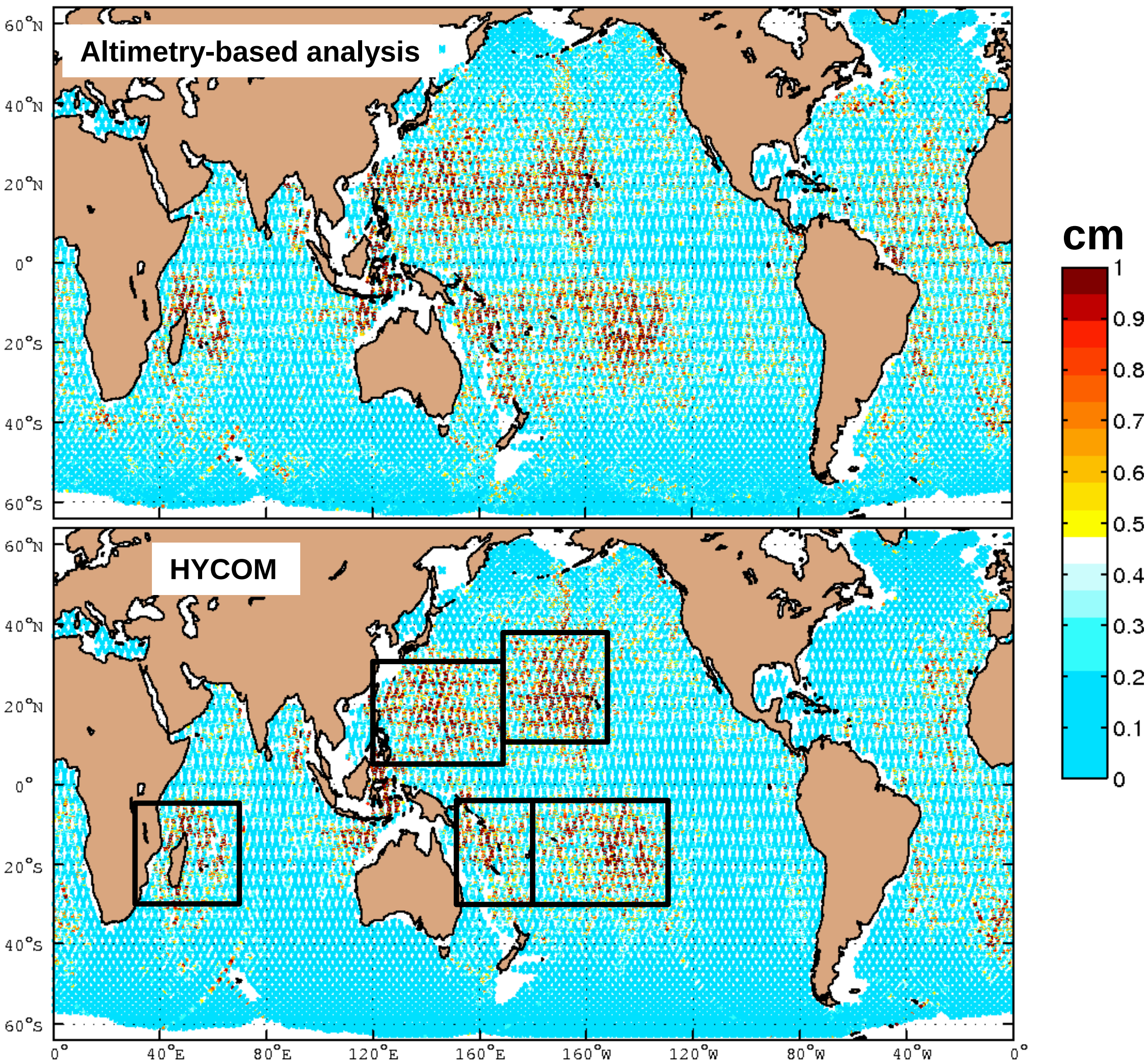
Altimetric-based tidal analysis (Ray and Mitchum, 1996)

- Along-track tidal analysis
- Based on 17 years of Topex/Poseidon and Jason data
- Near-global, 63°N - 63°S

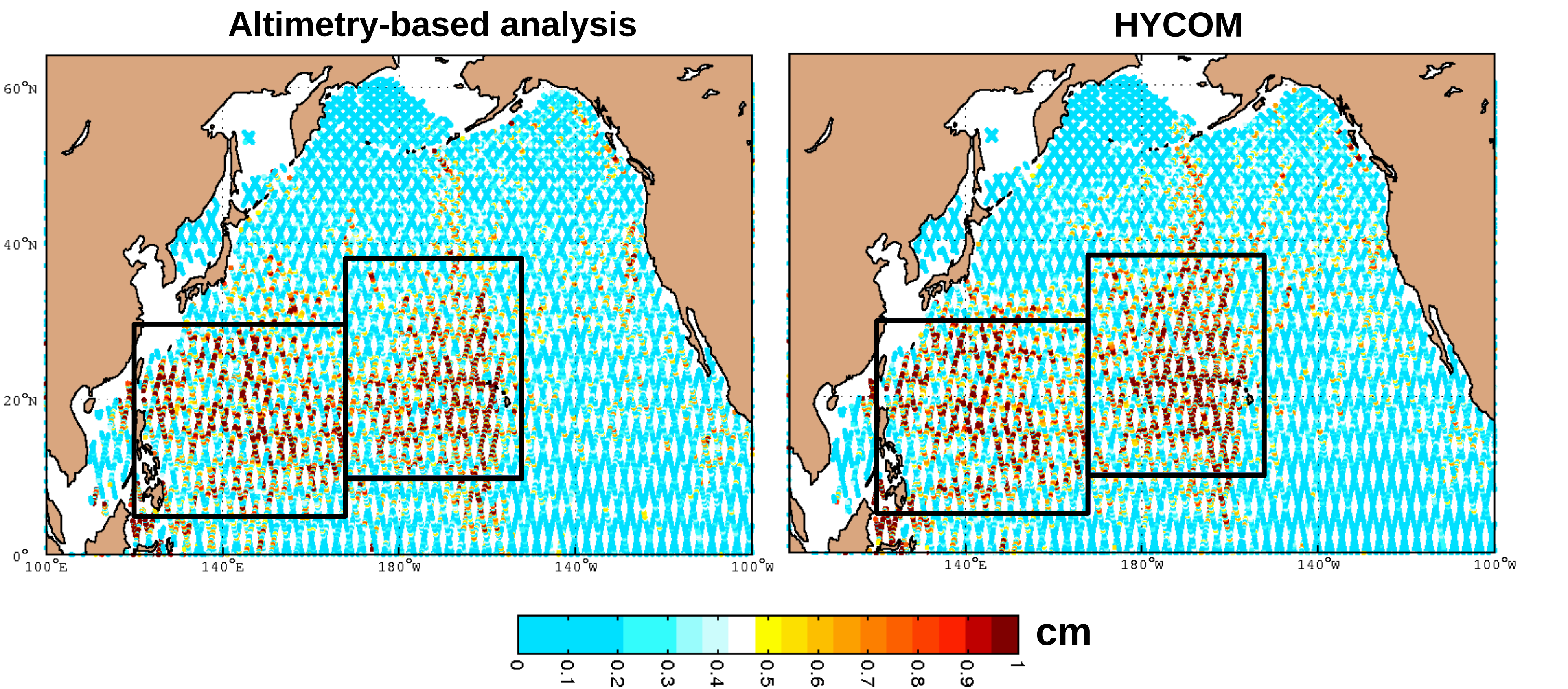
M_2 internal tide amplitude: along-track altimetry data vs 1/12° Global HYCOM



M_2 internal tide amplitude: along-track altimetry data vs 1/12° Global HYCOM

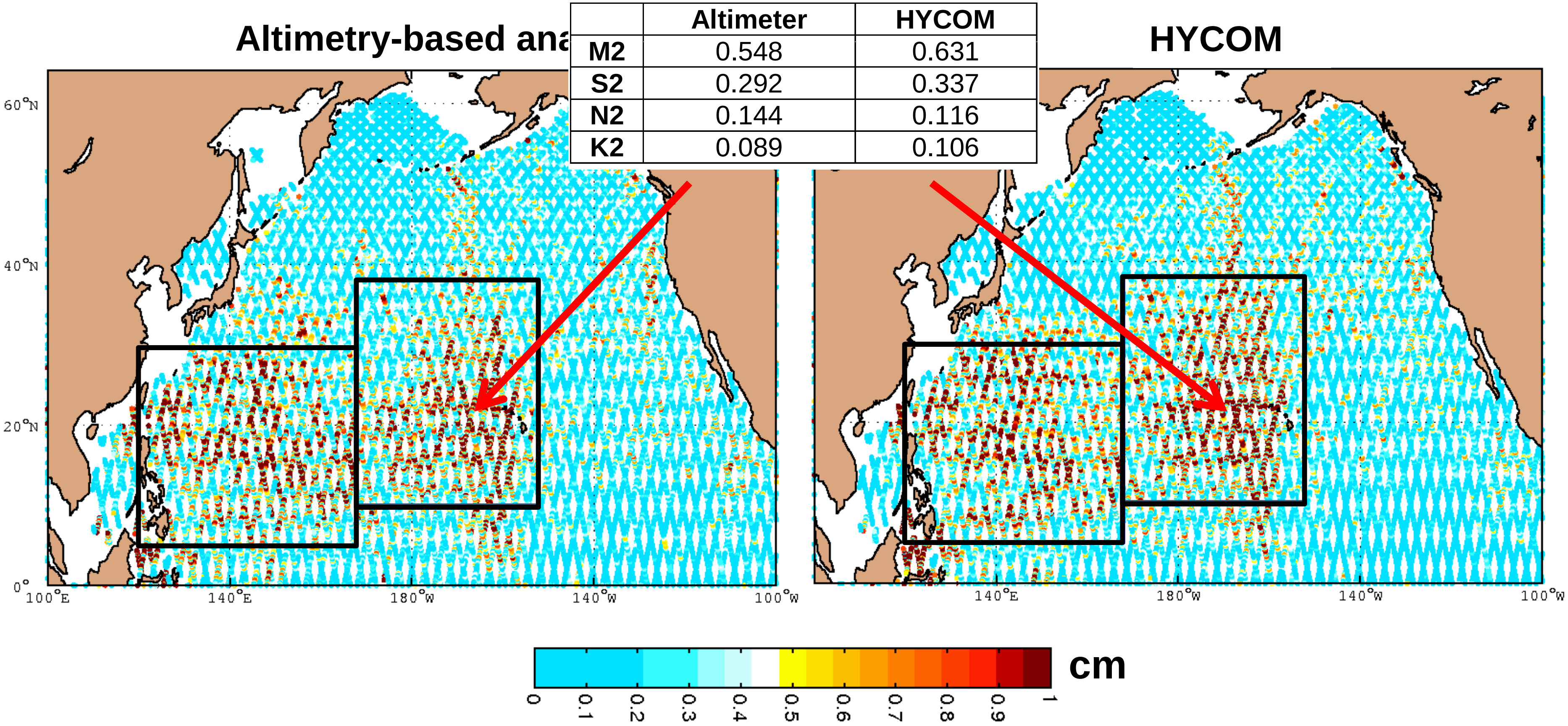


M_2 internal tide amplitude: along-track altimetry data vs 1/12° Global HYCOM



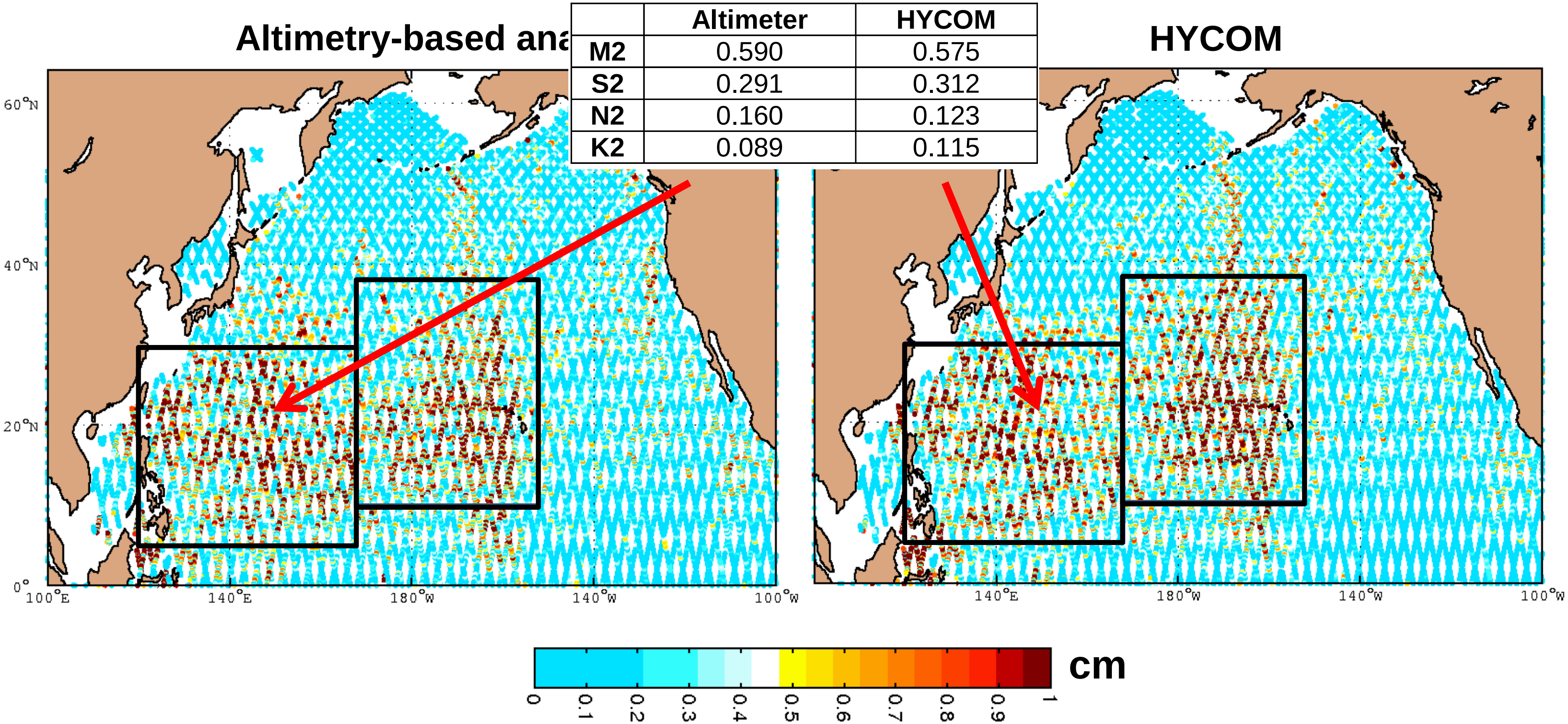
M_2 internal tide amplitude: along-track altimetry data vs 1/12° Global HYCOM

	Altimeter	HYCOM
M2	0.548	0.631
S2	0.292	0.337
N2	0.144	0.116
K2	0.089	0.106

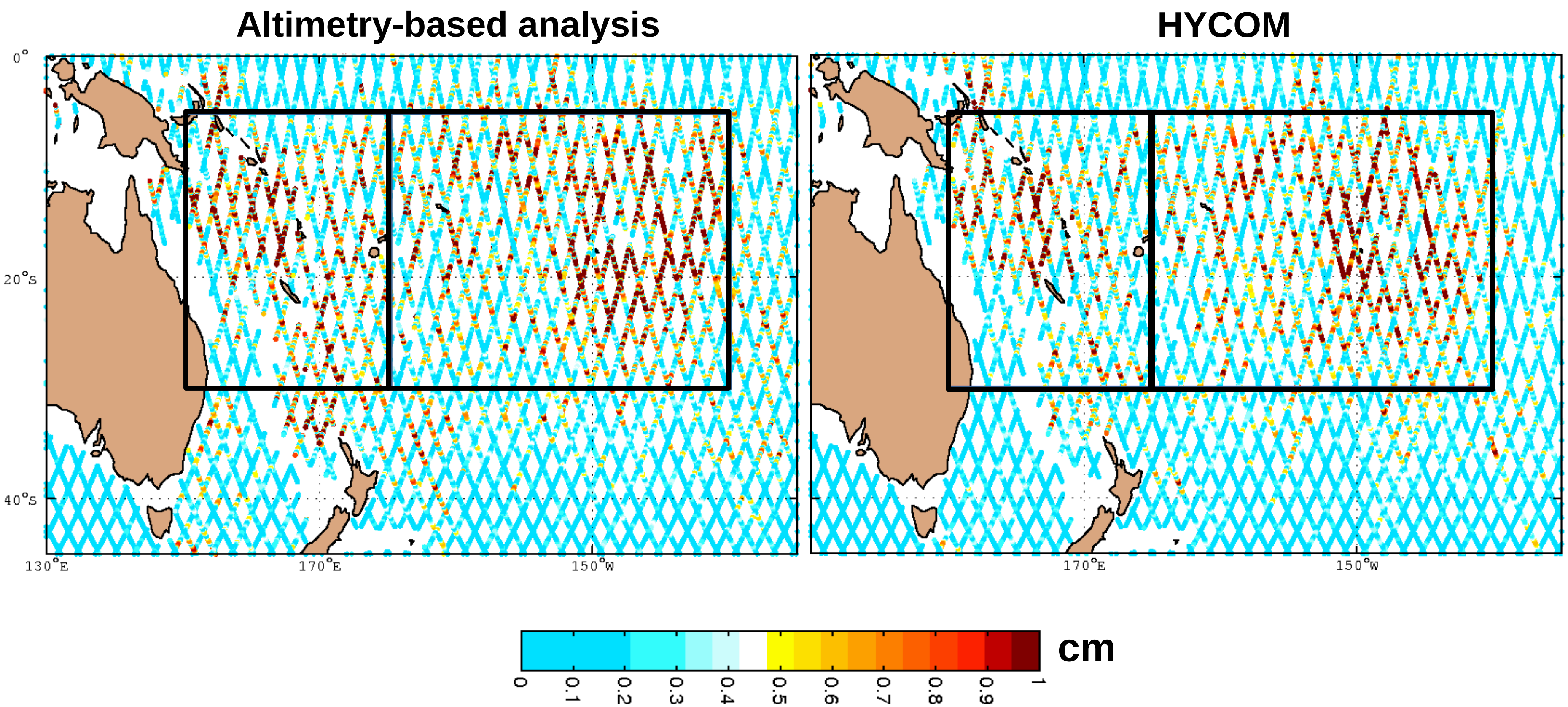


M_2 internal tide amplitude: along-track altimetry data vs 1/12° Global HYCOM

	Altimeter	HYCOM
M2	0.590	0.575
S2	0.291	0.312
N2	0.160	0.123
K2	0.089	0.115

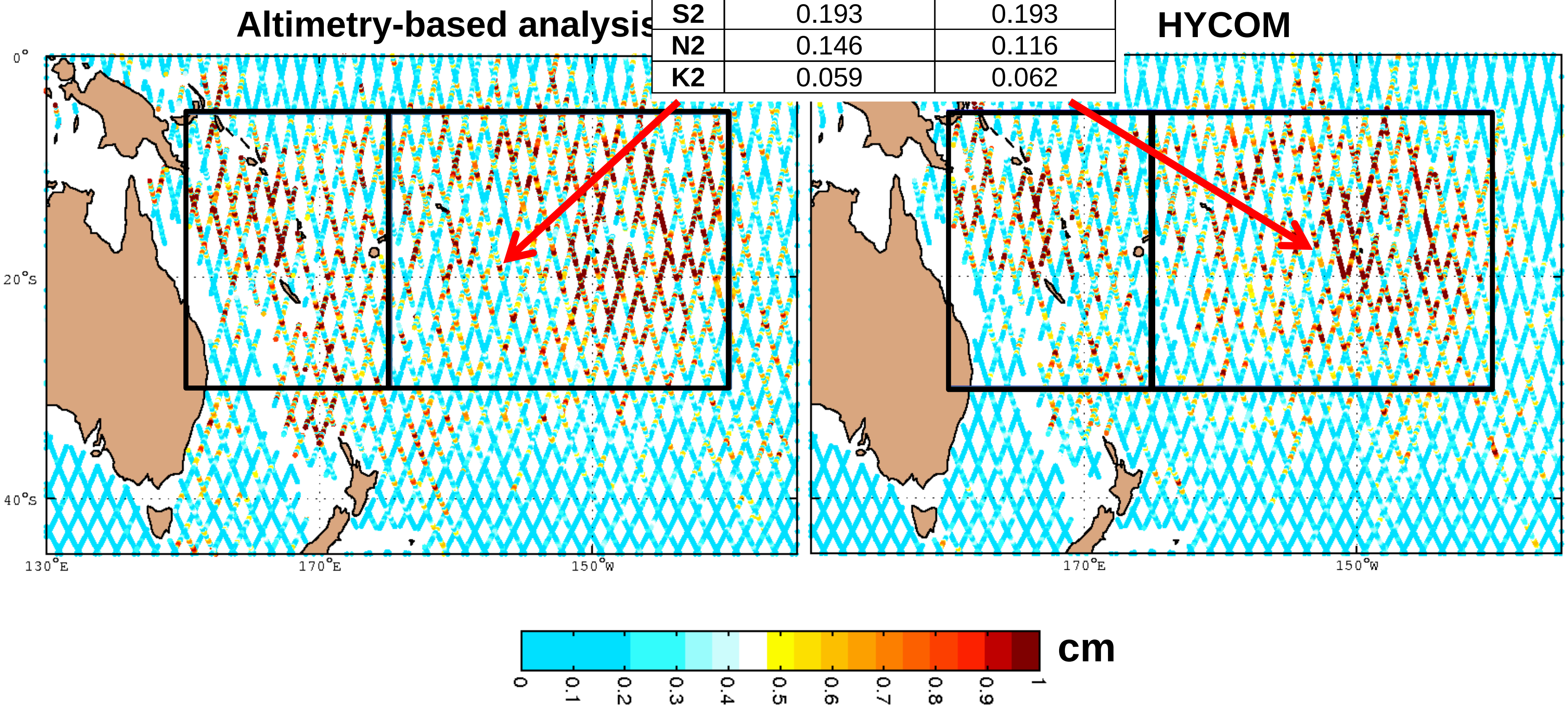


M_2 internal tide amplitude: along-track altimetry data vs 1/12° Global HYCOM



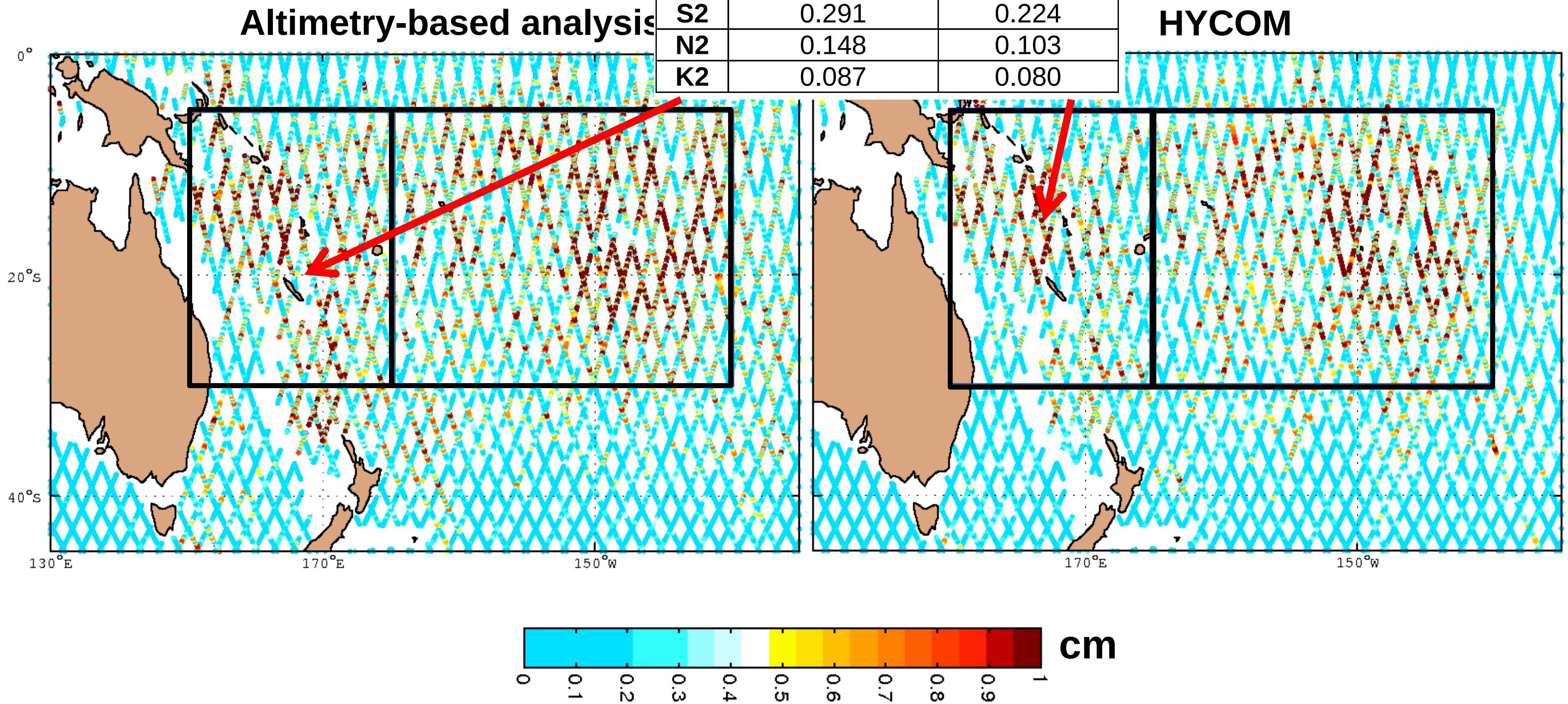
M_2 internal tide amplitude: along-track altimetry data vs 1/12° Global HYCOM

	Altimeter	HYCOM
M2	0.607	0.562
S2	0.193	0.193
N2	0.146	0.116
K2	0.059	0.062



M_2 internal tide amplitude: along-track altimetry data vs 1/12° Global HYCOM

	Altimeter	HYCOM
M2	0.527	0.449
S2	0.291	0.224
N2	0.148	0.103
K2	0.087	0.080



Area averaged amplitude over selected subregions

	M2	S2	N2	K2
Hawaii	0.548 0.631	0.292 0.337	0.144 0.116	0.089 0.106
East of Philippines	0.590 0.575	0.291 0.312	0.160 0.123	0.089 0.115
Tropical South Pacific	0.607 0.562	0.193 0.193	0.146 0.116	0.059 0.062
Tropical SW Pacific	0.527 0.449	0.291 0.224	0.148 0.103	0.087 0.080
Madagascar	0.518 0.472	0.294 0.258	0.139 0.091	0.088 0.089
Rest of world ocean	0.010 0.006	0.227 0.005	0.130 0.001	0.073 0.004

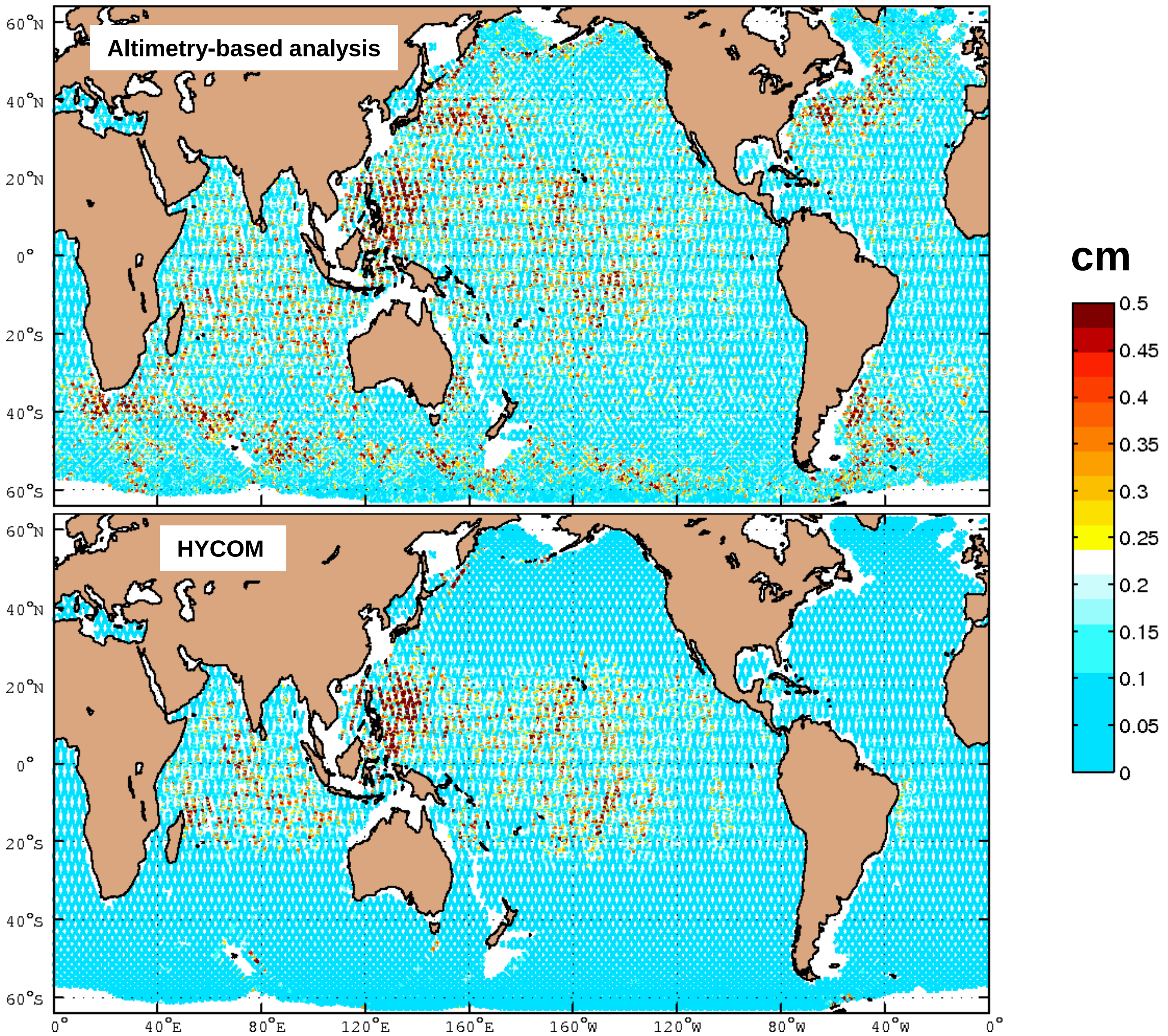
Black – altimetry based analysis Red – HYCOM

Area averaged amplitude over selected subregions

	M2	S2	N2	K2
Hawaii	0.548 0.631	0.292 0.337	0.144 0.116	0.089 0.106
East of Philippines	0.590 0.575	0.291 0.312	0.160 0.123	0.089 0.115
Tropical South Pacific	0.607 0.562	0.193 0.193	0.146 0.116	0.059 0.062
Tropical SW Pacific	0.527 0.449	0.291 0.224	0.148 0.103	0.087 0.080
Madagascar	0.518 0.472	0.294 0.258	0.139 0.091	0.088 0.089
Rest of world ocean	0.010 0.006	0.227 0.005	0.130 0.001	0.073 0.004

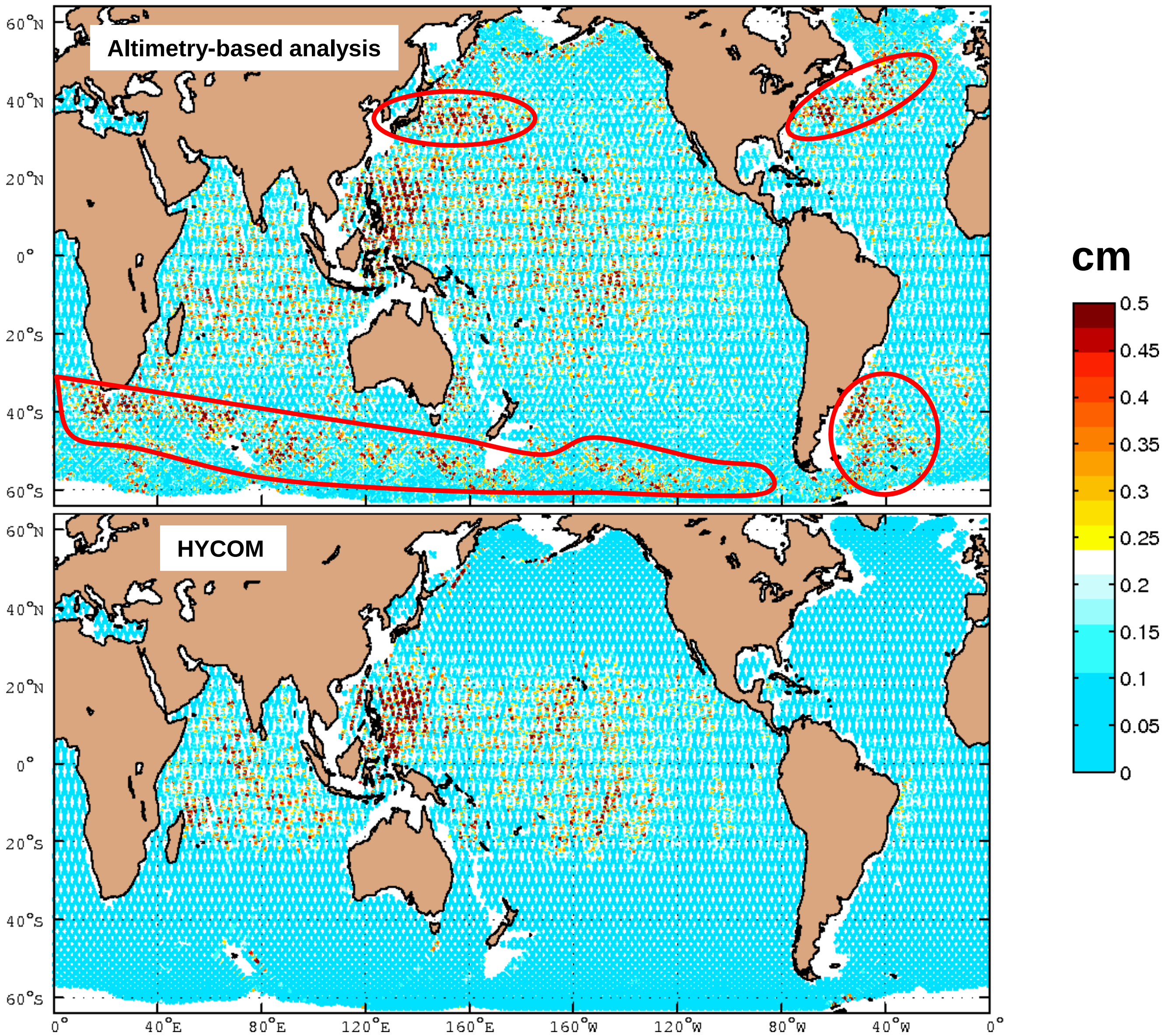
Black – altimetry based analysis Red – HYCOM

K_1 internal tide amplitude: areas of mesoscale leakage in altimetry-based tidal analysis



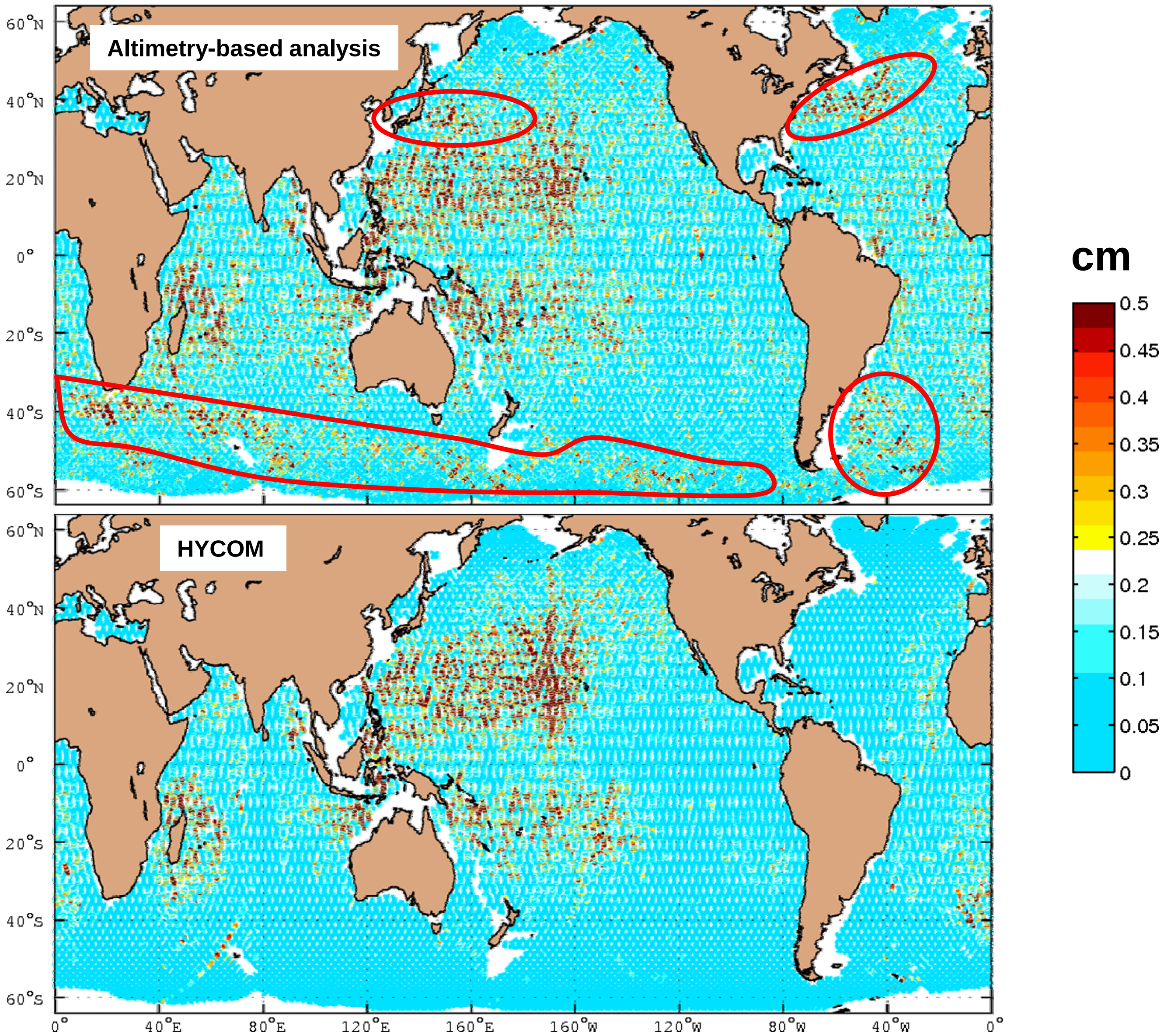
Diurnal internal waves are bound between +/- 30 by the dispersion relation (Gill, 1982)

K_1 internal tide amplitude: areas of mesoscale leakage in altimetry-based tidal analysis

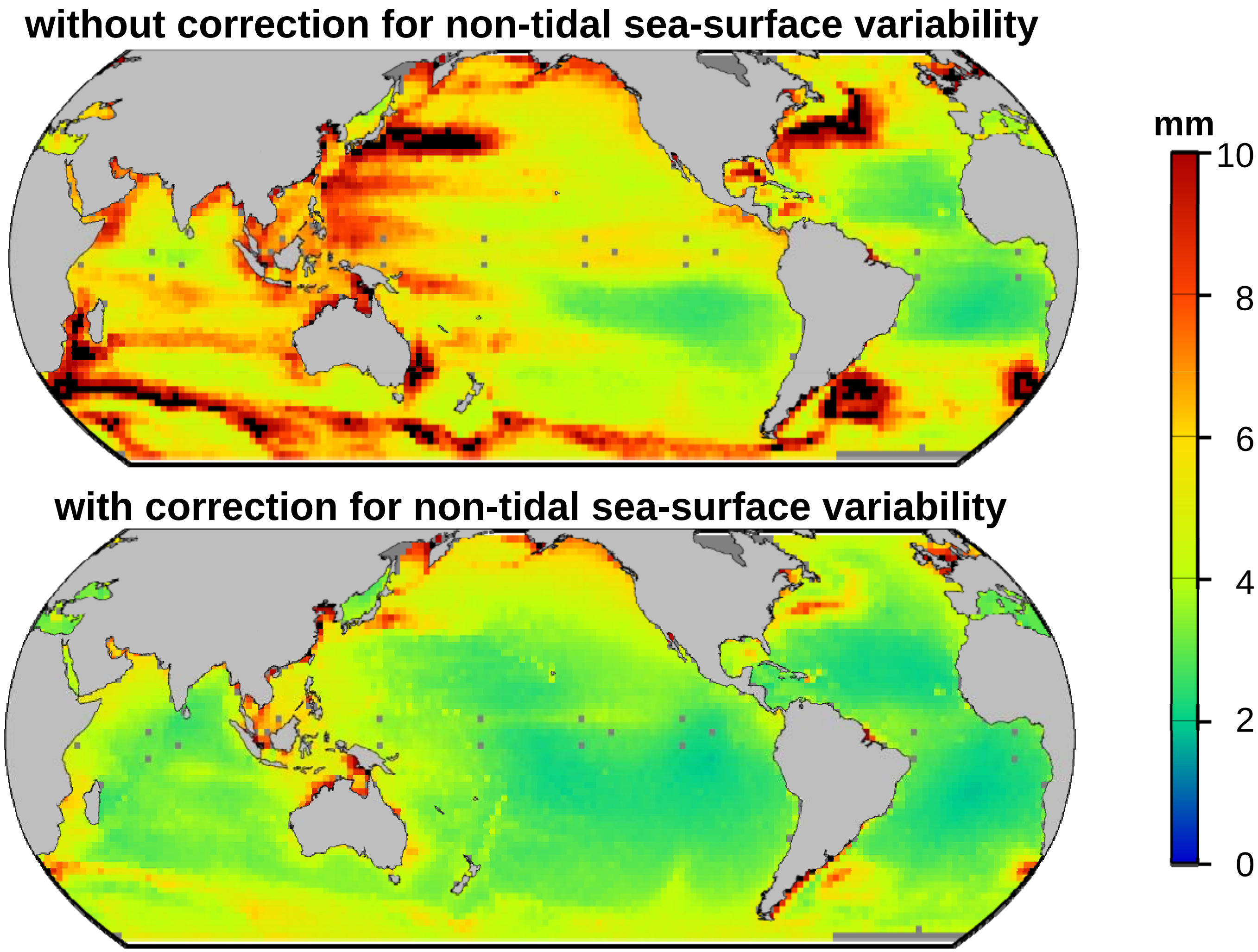


Diurnal internal waves are bound between +/- 30 by the dispersion relation (Gill, 1982)

S_2 internal tide amplitude: areas of mesoscale leakage in altimetry-based tidal analysis



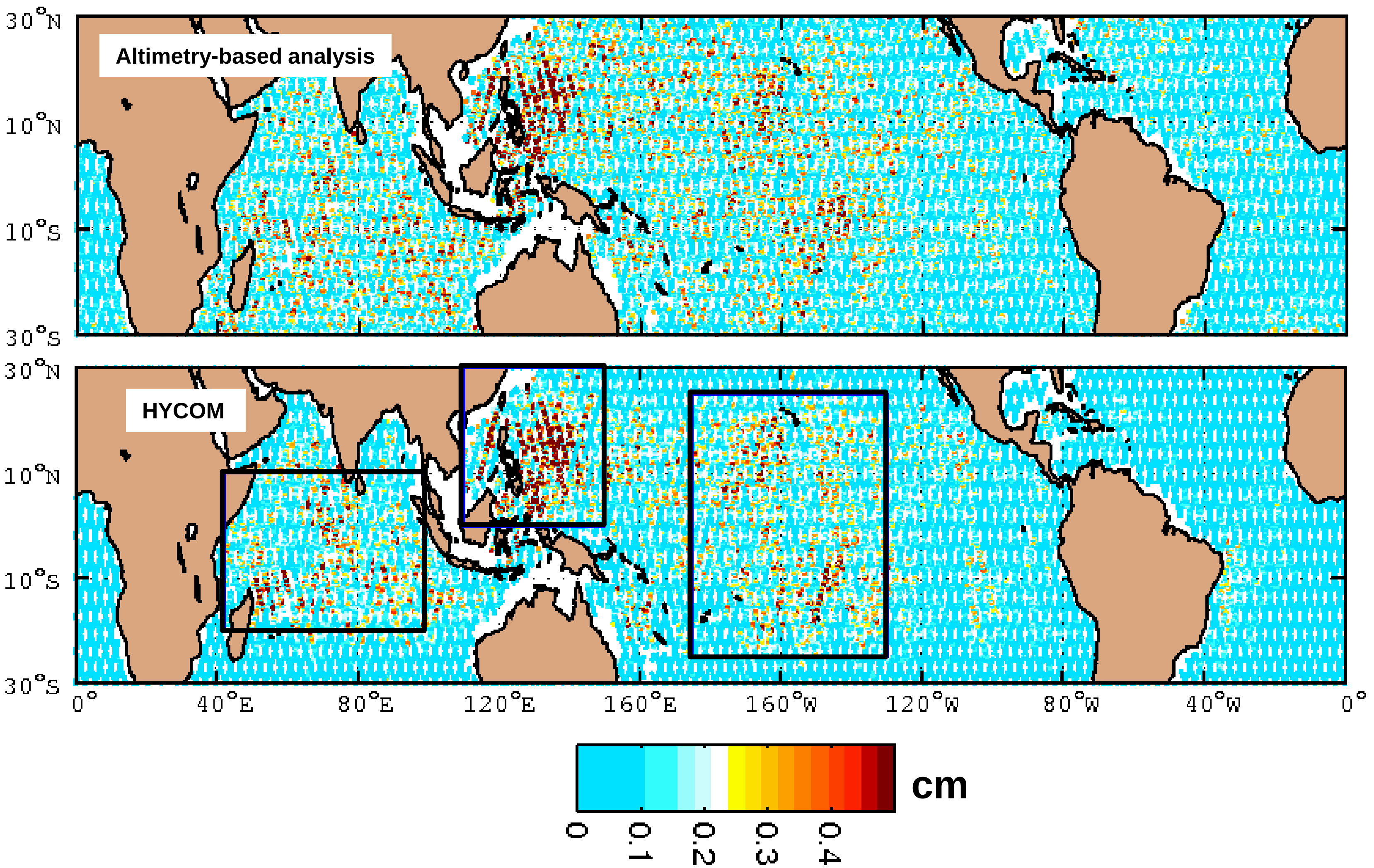
Standard errors of altimeter-based along-track estimates of the O1 tide



Non-tidal SSH correction uses weekly gridded sea-level anomalies derived from a multi-satellite analysis [*Pascual et al.*, 2006] for the nontidal variability

(Ray and Byrne, 2010)

K_1 internal tide amplitude: along-track altimetry data vs 1/12° Global HYCOM



Area averaged amplitude over selected subregions

	Central Tropical Pacific	Philippines	Central Indian Ocean	Rest of world ocean
K1	.180/.174	.276/.272	.193/.181	.128/.089
O1	.129/.131	.222/.233	.130/.104	.104/.064
P1	.058/.084	.086/.111	.062/.067	.043/.040
Q1	.077/.032	.102/.052	.078/.028	.071/.020

Black – altimetry based analysis Red – HYCOM

Summary and Conclusions

- HYCOM, forced only by atmospheric forcing and the astronomical tidal potential, is able to generate internal waves statistically consistent with observations without the benefit of data assimilation.
  - averaged internal tide amplitudes globally are found to be quite similar to that observed in satellite altimeter data for 7 of the 8 tidal constituents in HYCOM.

- Leakage of mesoscale variability into the altimetric-based tidal analysis affects all constituents and is probably unavoidable, owing to limitations in time sampling and that low mode internal tides have the same spatial scales as mesoscale variability.