Status of GOT5 tides and associated prediction software

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GOT5 empirical tides

GOT5.0 – used same prior as used in FES2014 development.

GOT5.1 – used FES2014 as prior (similar to EOT20).

GOT5.2 – in progress.

All altimetry from RADS — thanks to Remko, Eric, & Co!

GOT5 empirical tides

Main region (between ±66°)

- Solved for: σ1, Q1, O1, P1, S1, K1, J1, OO1, 2N2, μ2, N2, M2, S2, K2, M4, MS4
- Exact repeat data, with datums estimated at every normal point
- Deep water: Topex + Jason only
- Shallow water: Topex + Jason + Envisat, ERS-2, SARAL, GFO, Sentinel-3A
- Data NOT corrected by DAC because of leakage. Daily mean IB.
- Data corrected for "mesoscale" (DUACS21 SSH) – leakage errors?
- Data corrected for internal tides (HRET8.1) – leakage errors?

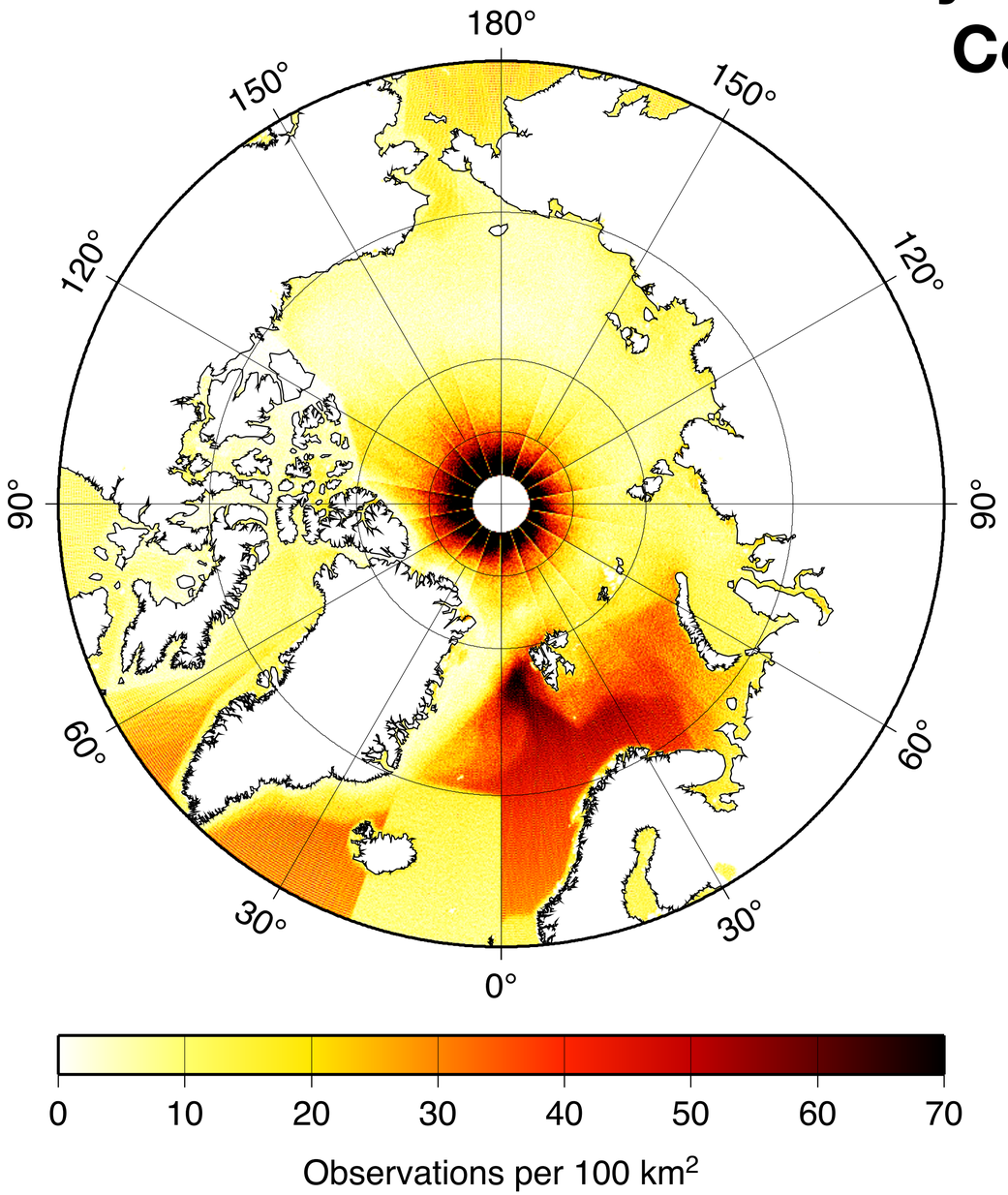
Polar regions

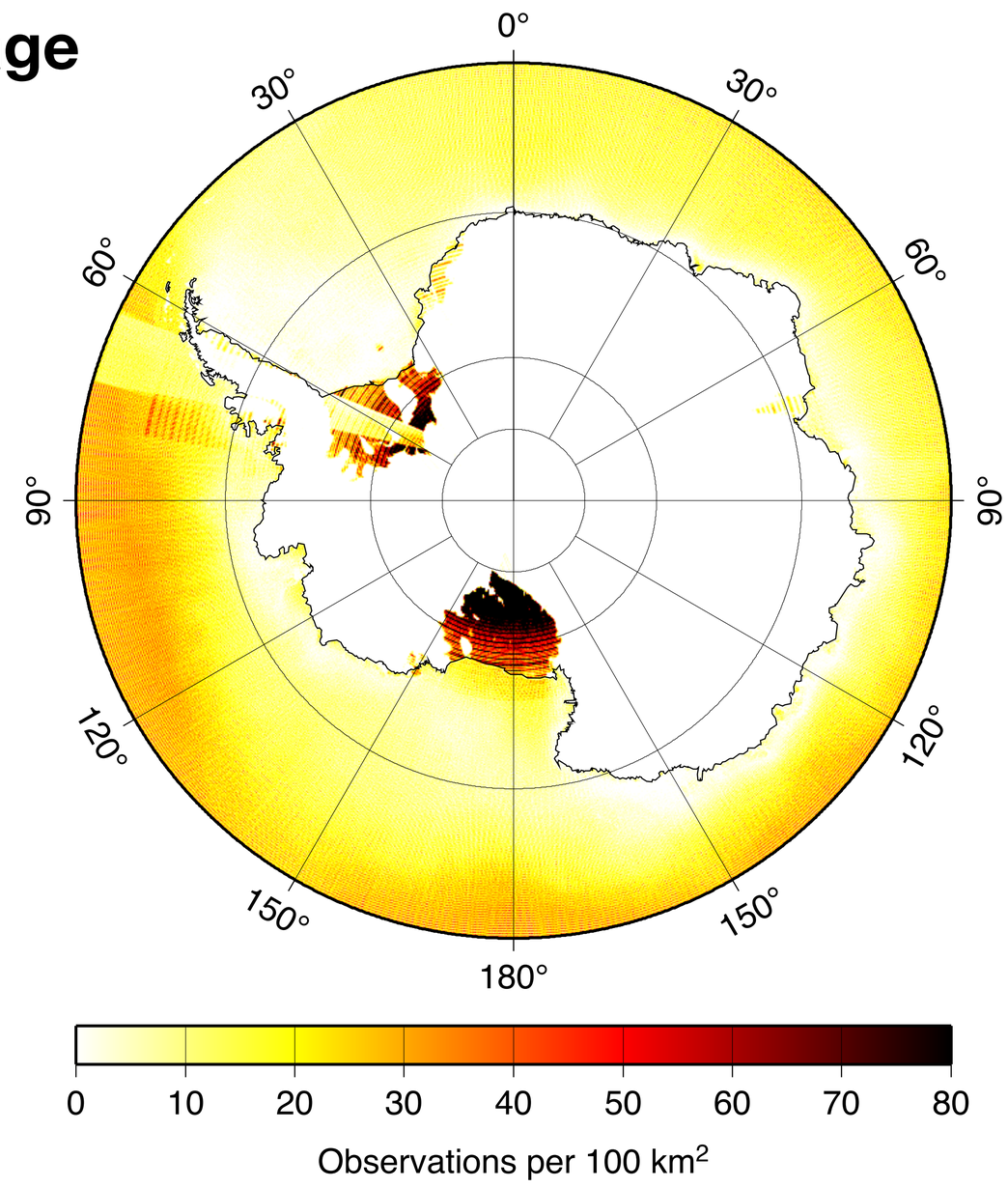
- Solved for Q1, O1, S1, K1, N2, M2, S2; others inferred (if possible).
- Non-exact repeat data, with datums estimated only by satellite.
- Depends critically on DTU21 mean sea surface.
- Data from Cryosat-2, Envisat, SARAL, GFO — C-2 most important.

Antarctic ice shelves

- Solved for Q1, O1, K1, N2, M2, S2; others inferred (if possible).
- X-over data from Cryosat-2

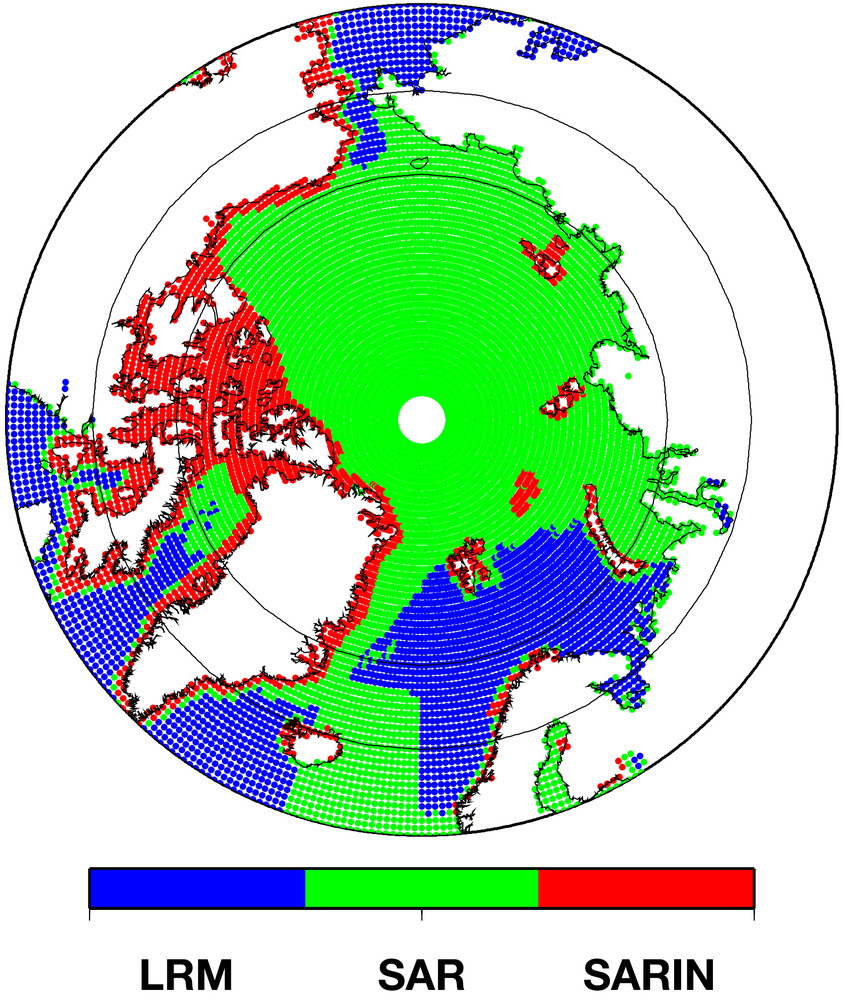
CryoSat-2 Data Coverage



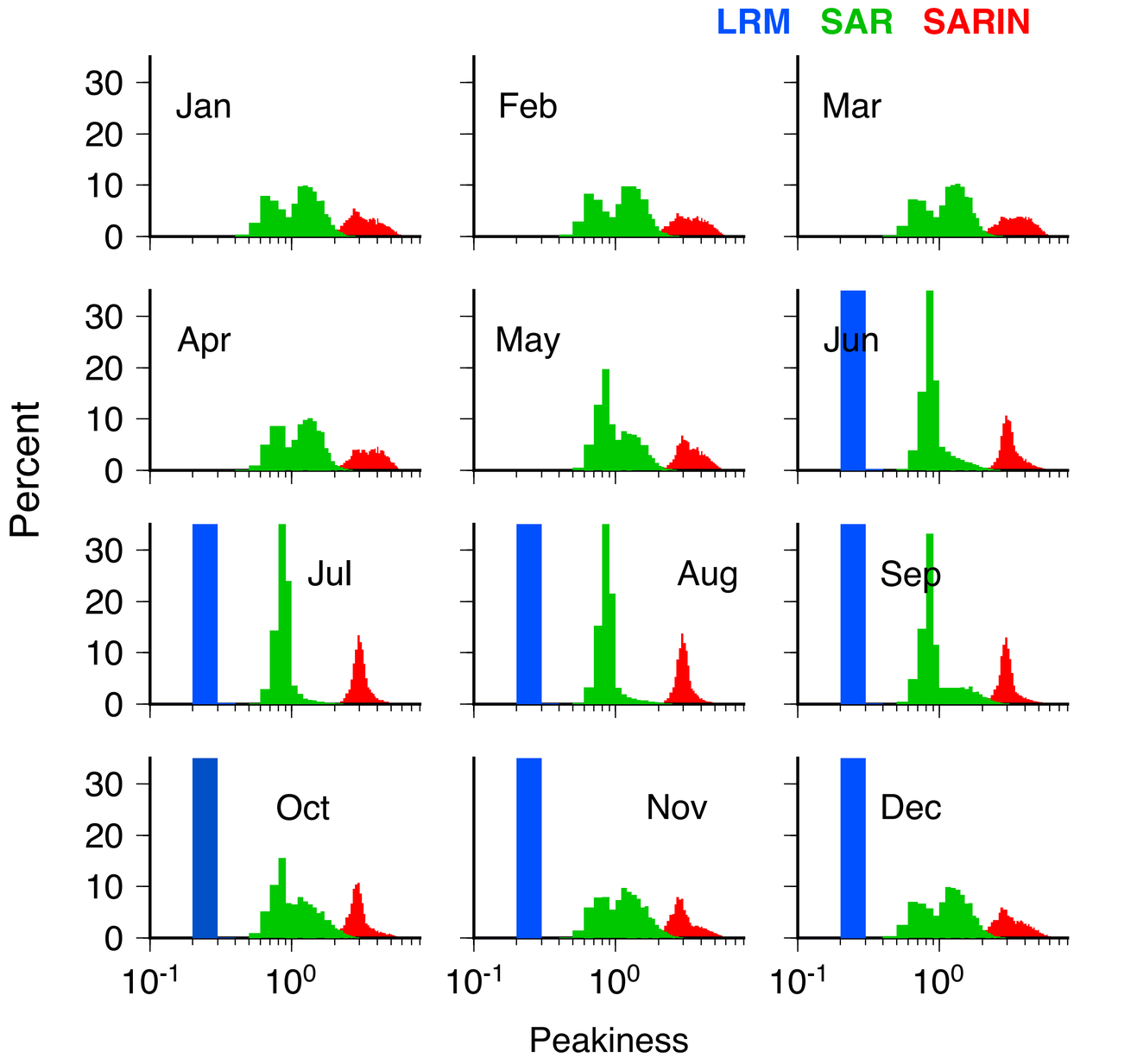


CryoSat-2 modes

(2020)

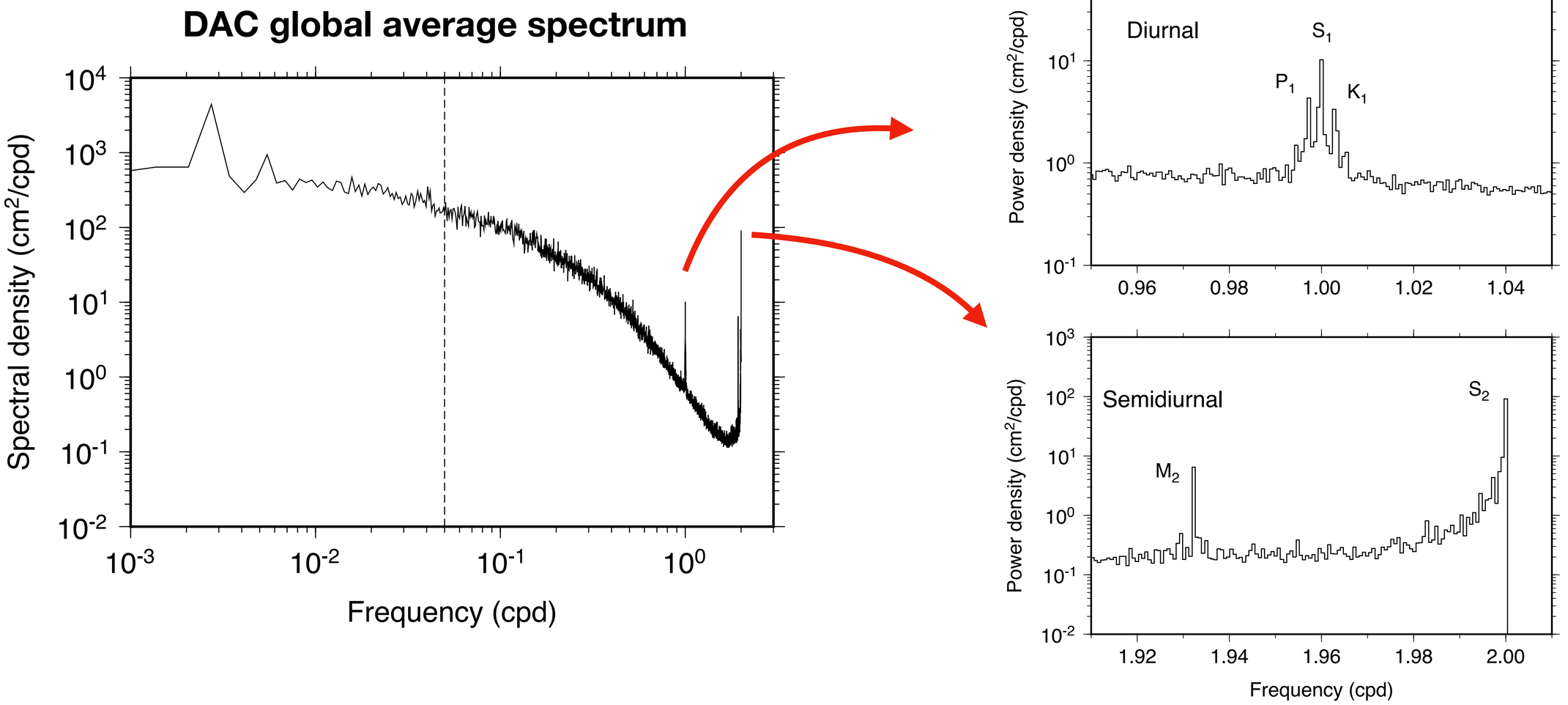


“Peakiness” parameter depends on tracking mode



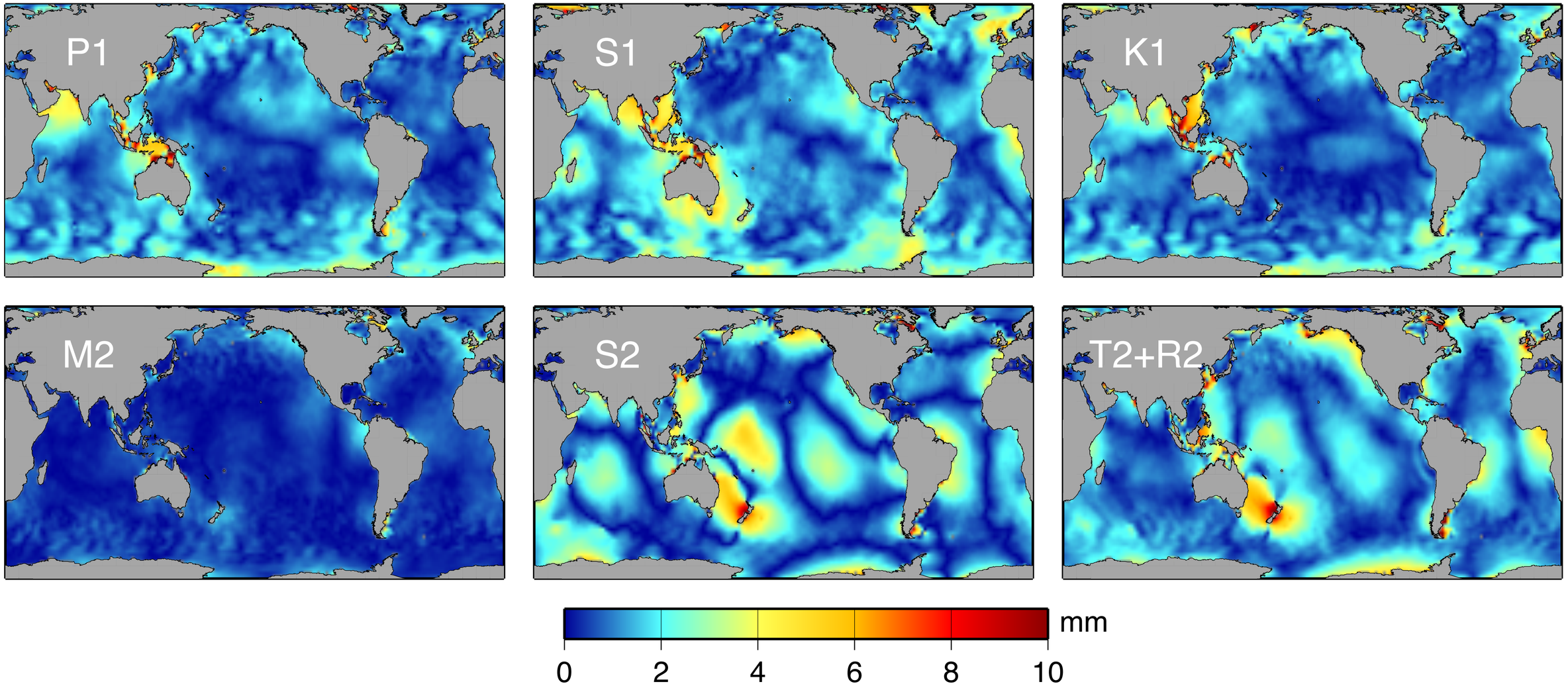
Tide Leakage in DAC

(DAC = dynamic atm. correction; Carrere et al.)

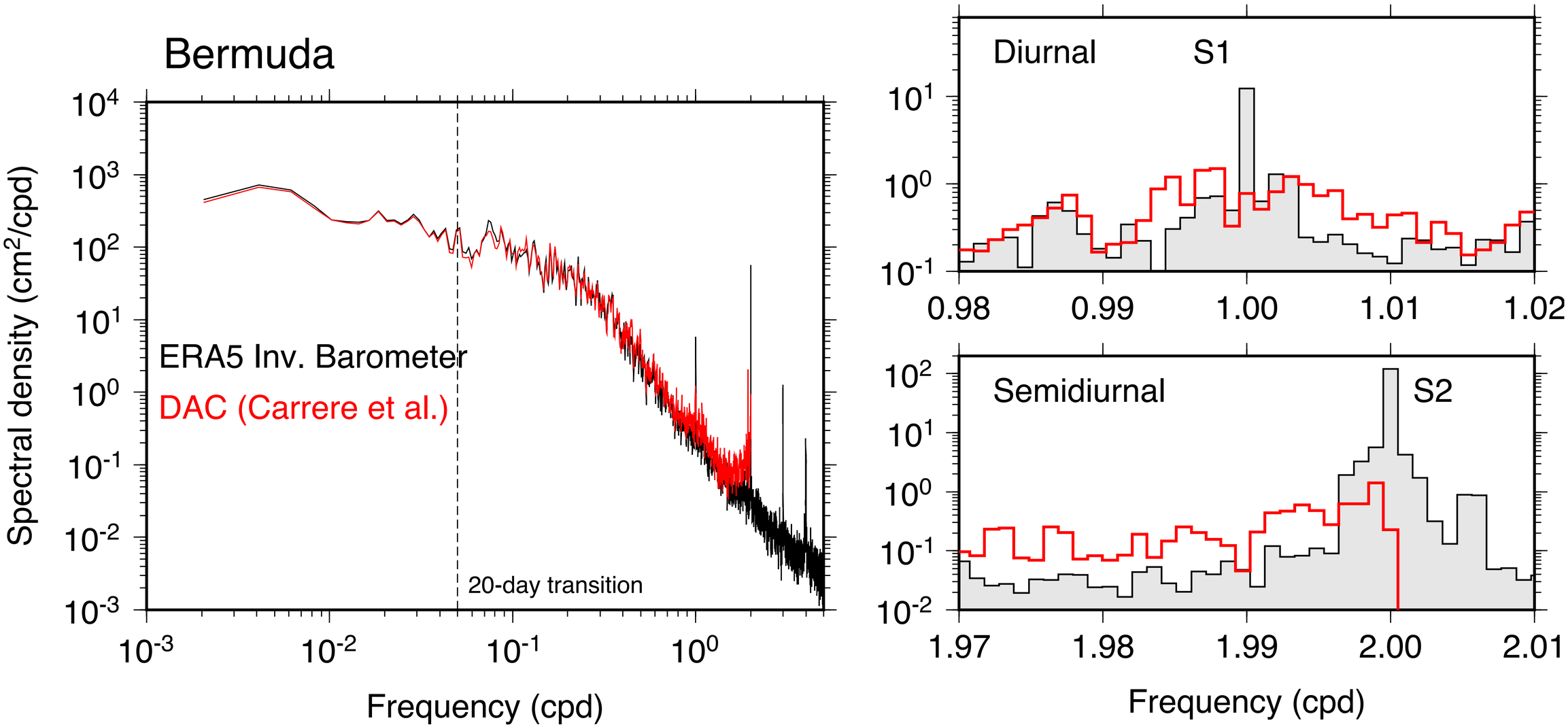


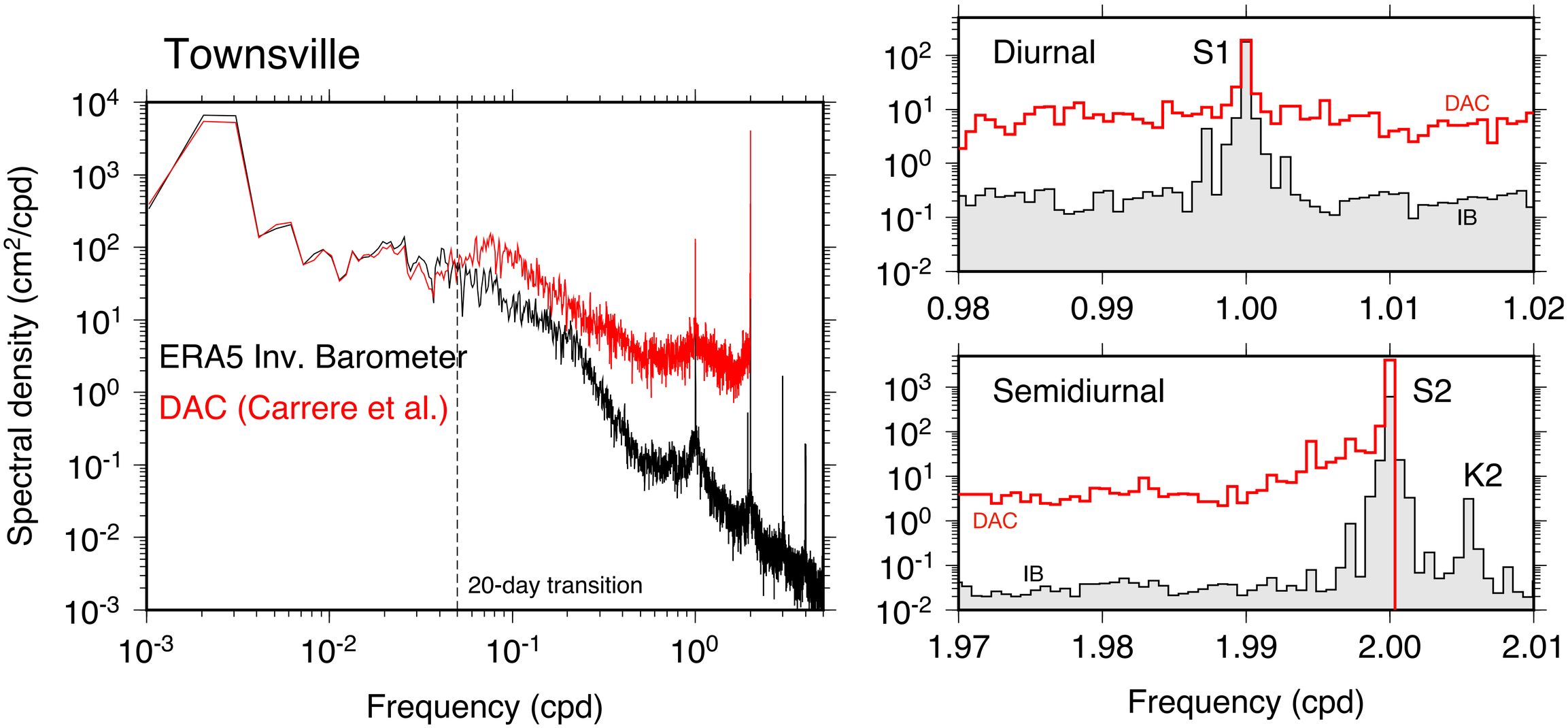
Tidal signals extracted from DAC grid time series

(1993-1994)

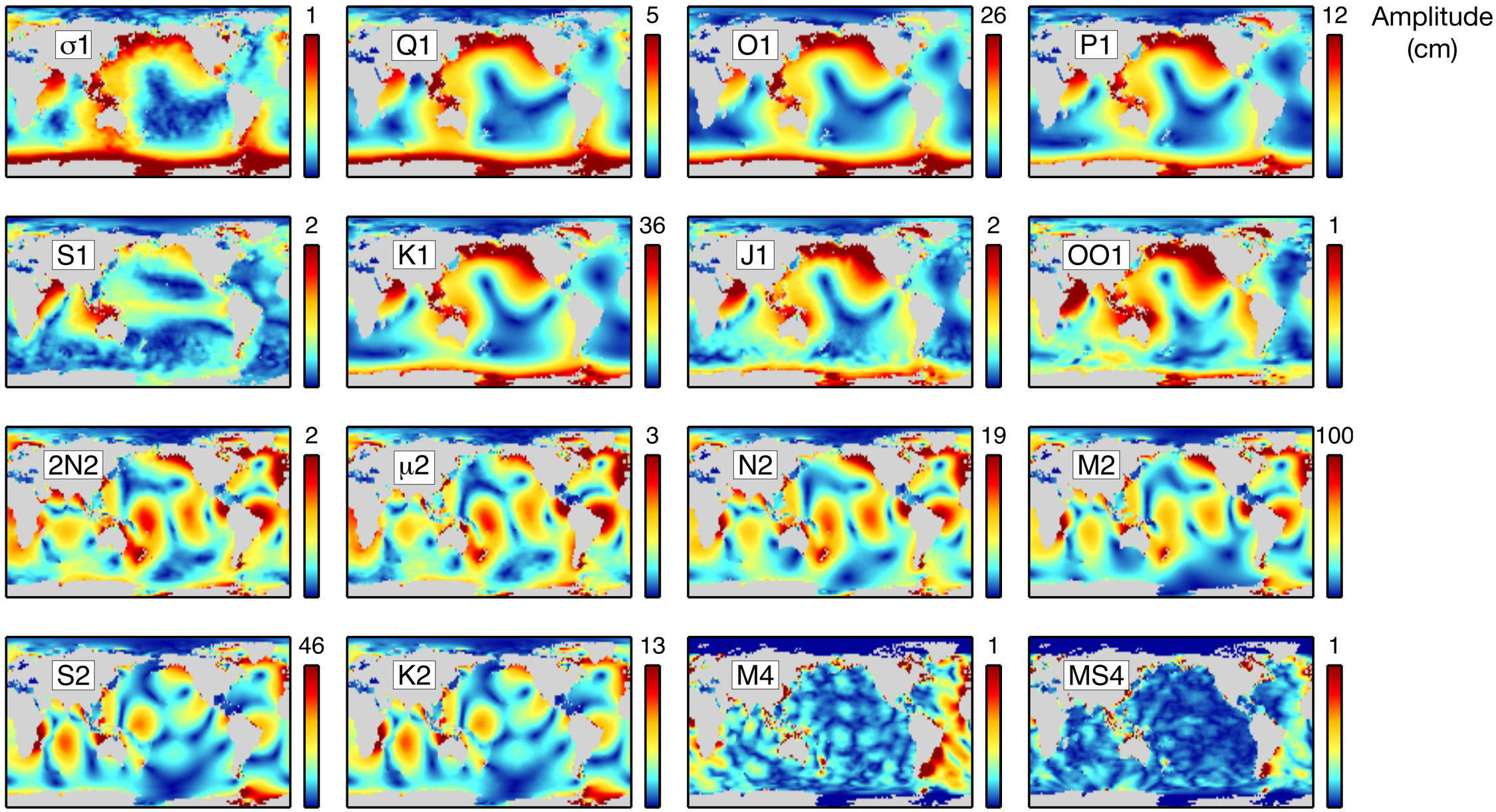


DAC = Dynamic Atm. Correction (Carrere et al., 2016)


Bermuda
Spectral density (cm²/cpd)
ERA5 Inv. Barometer
DAC (Carrere et al.)
20-day transition
Frequency (cpd)
Diurnal
S1
Semidiurnal
S2
Frequency (cpd)

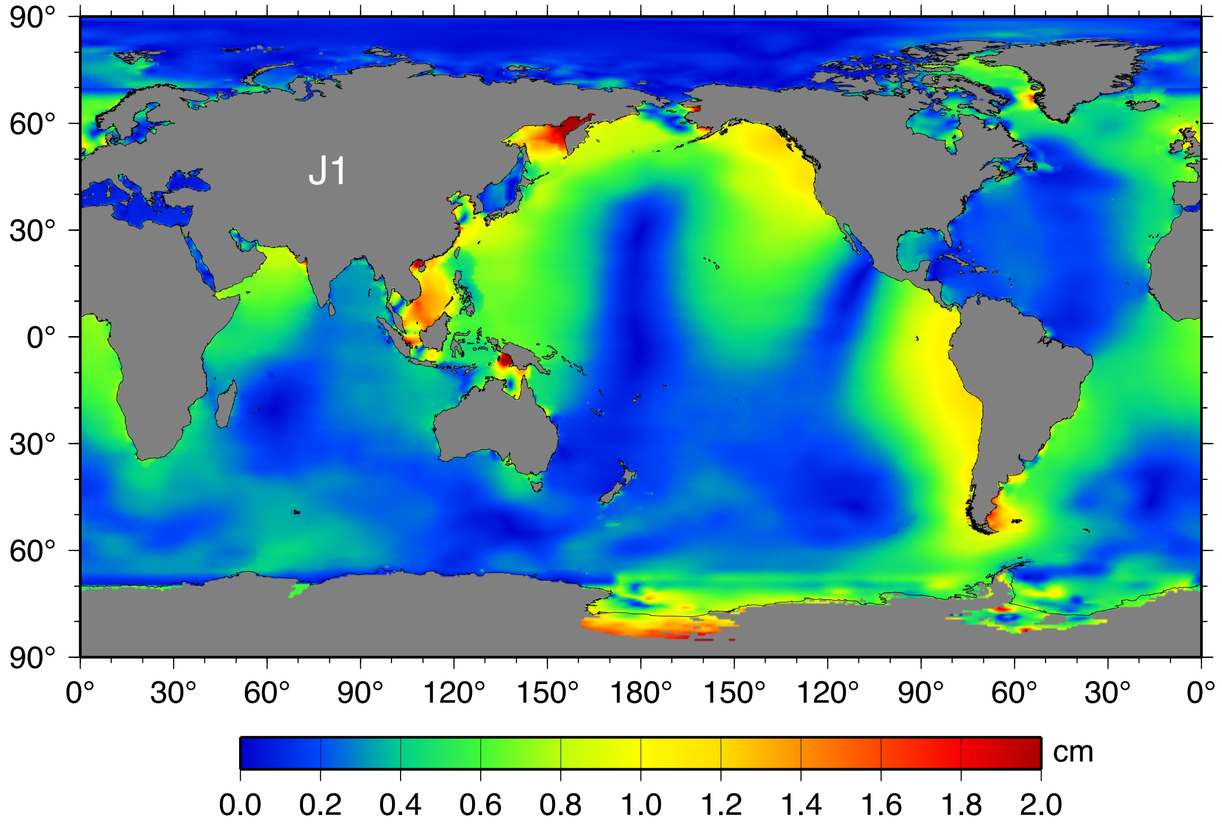

Townsville
Spectral density (cm²/cpd)
Frequency (cpd)
ERA5 Inv. Barometer
DAC (Carrere et al.)
20-day transition
Diurnal
S1
DAC
IB
Semidiurnal
S2
K2
DAC
IB
Frequency (cpd)

GOT5.1 tide solutions

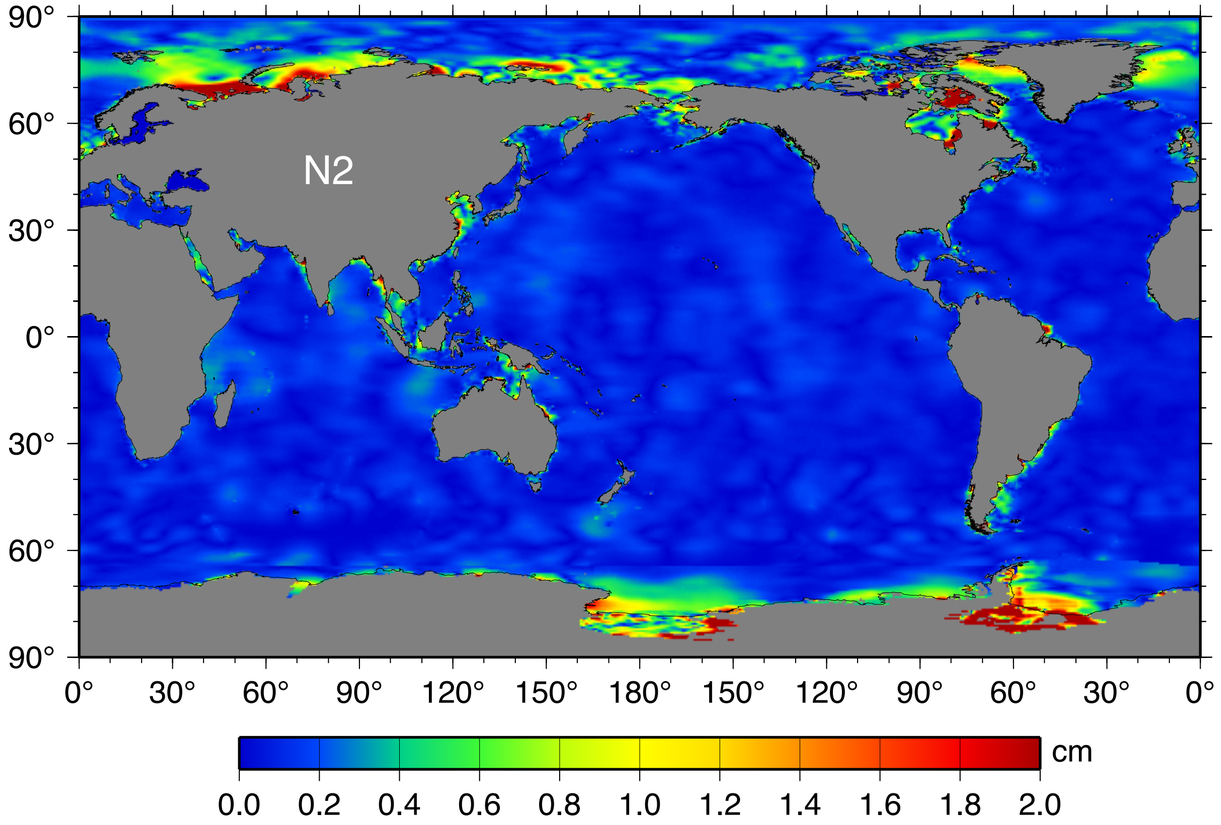


Two example constituents: | GOT5.1 minus FES2014 |

J1: Large-scale differences



N2: Small differences (exc. poles)



Colors saturate in polar regions
and a few shallow regions

“Ground Truth” Comparisons :: RMS (cm)

Deep (BPR) stations (151)

	Q1	O1	P1	S1	K1	J1	2N2	μ2	N2	M2	S2	K2	M4	MS4
FES14	0.136	0.181	0.138	0.296	0.227	0.450	0.095	0.096	0.192	0.300	0.266	0.148	0.120	0.128
EOT20	0.297	0.252	0.280	0.498	0.386	0.276	0.190		0.346	0.482	0.439	0.328	0.176	
GOT4.8	0.165	0.296	0.234	0.331	0.423				0.252	0.510	0.369	0.209	0.089	
GOT5.1	0.131	0.172	0.132	0.277	0.239	0.116	0.092	0.068	0.191	0.305	0.261	0.138	0.054	0.060

Shelf stations (195)

	Q1	O1	P1	S1	K1	J1	2N2	μ2	N2	M2	S2	K2	M4	MS4
FES14	0.79	0.92	0.66	0.88	1.29	0.97	0.54	1.53	1.48	3.47	2.18	0.91	0.65	1.71
EOT20	0.80	0.90	0.71	0.87	1.39	0.80	0.51		1.43	3.18	2.11	0.84	0.70	
GOT4.8	0.82	1.00	0.84	0.90	1.54				1.98	4.88	2.78	1.48	2.23	
GOT5.1	0.80	0.92	0.70	0.76	1.37	0.80	0.56	1.46	1.45	3.28	2.12	0.86	0.63	1.23

Coastal (no estuarine) stations (262)

	Q1	O1	P1	S1	K1	J1	2N2	μ2	N2	M2	S2	K2	M4	MS4
FES14	0.26	0.96	0.50	0.55	1.37	0.63	0.32	1.11	1.71	7.63	3.26	1.06	1.35	1.93
EOT20	0.35	0.94	0.54	0.80	1.29	0.34	0.36		1.57	7.03	3.10	0.92	1.26	
GOT4.8	0.58	1.80	0.92	0.82	2.52				3.61	16.25	9.50	2.47	2.63	
GOT5.1	0.34	0.94	0.54	0.43	1.37	0.30	0.38	1.10	1.68	7.26	3.17	1.01	1.30	1.57

“Ground Truth” Comparisons :: RMS (cm)

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EOT20	0.35	0.94	0.54	0.80	1.29	0.34	0.36		1.57	7.03	3.10	0.92	1.26	
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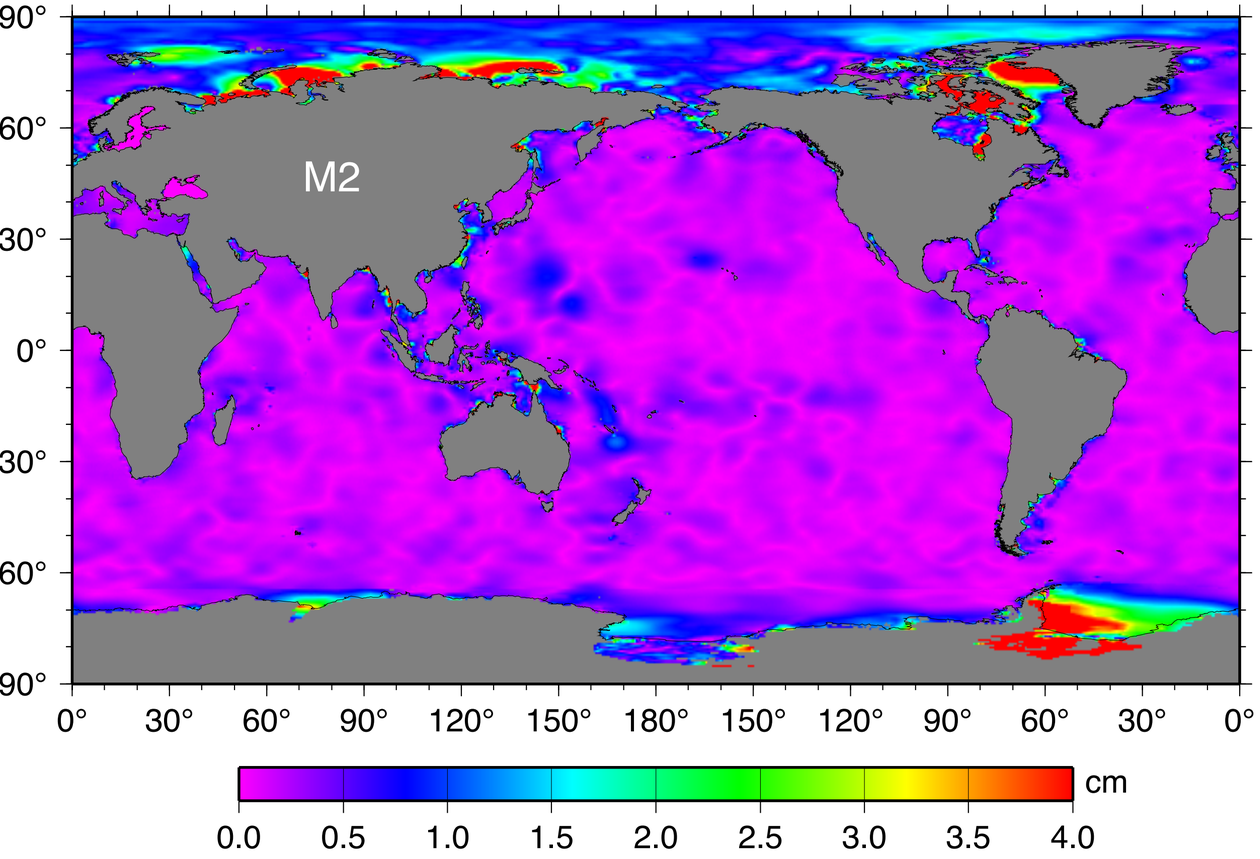
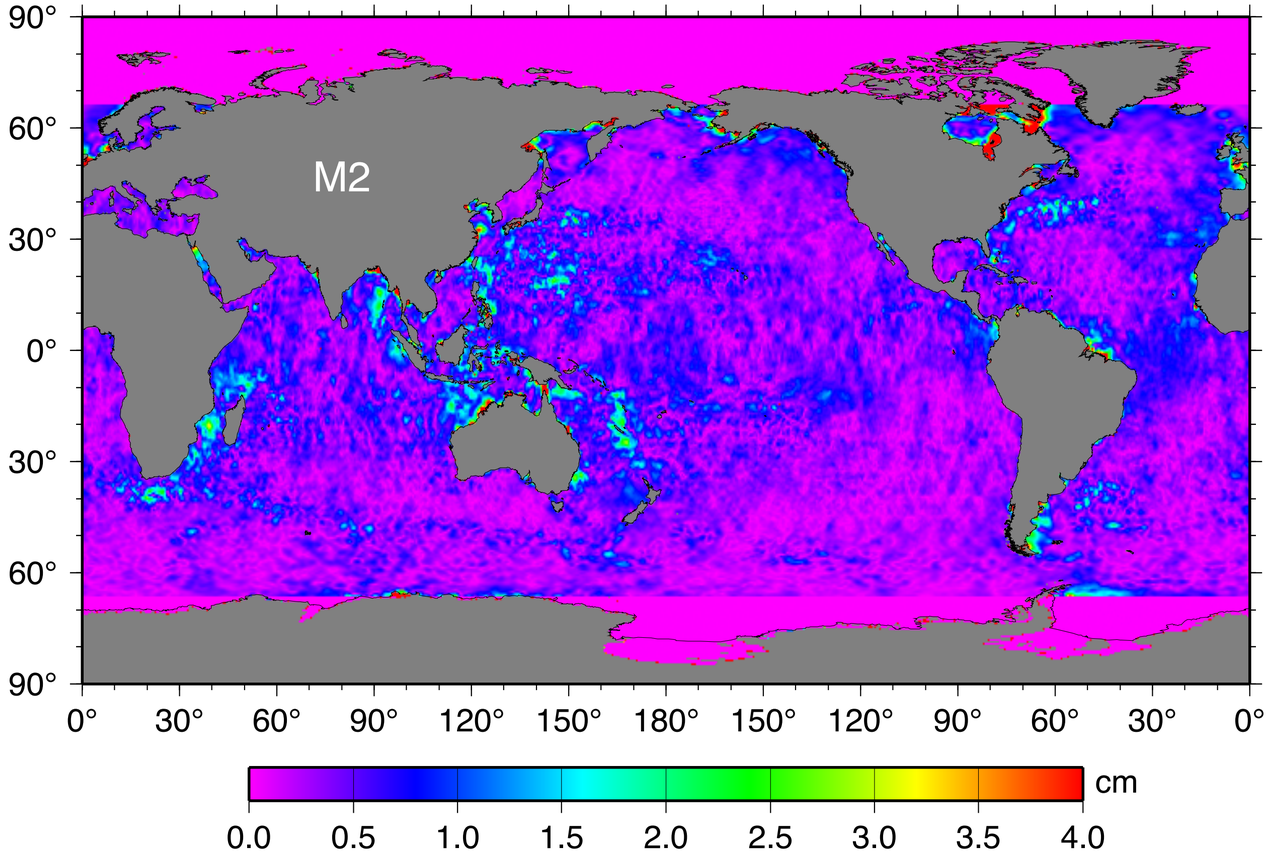
Comparison of GOT5 and EOT20 against FES14

GOT5.1 minus FES14



EOT20 minus FES14



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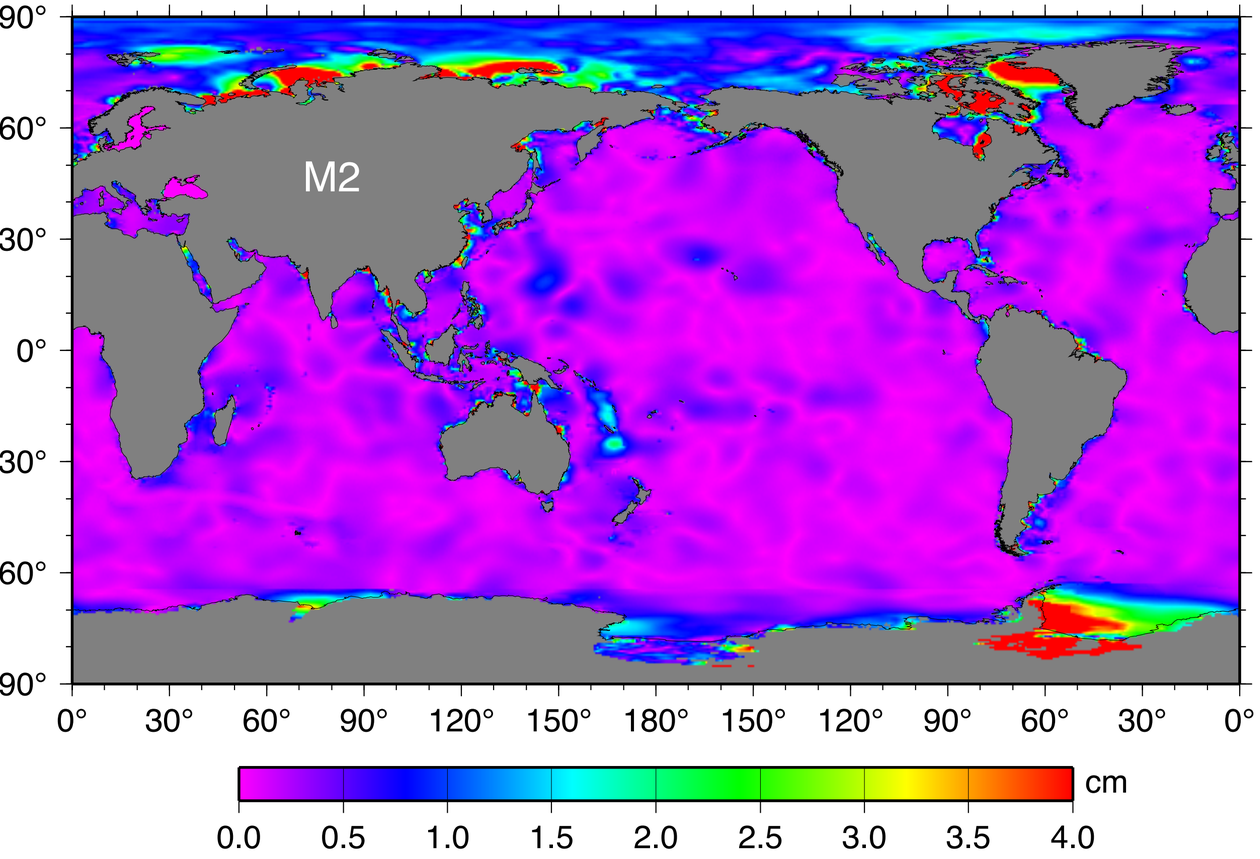
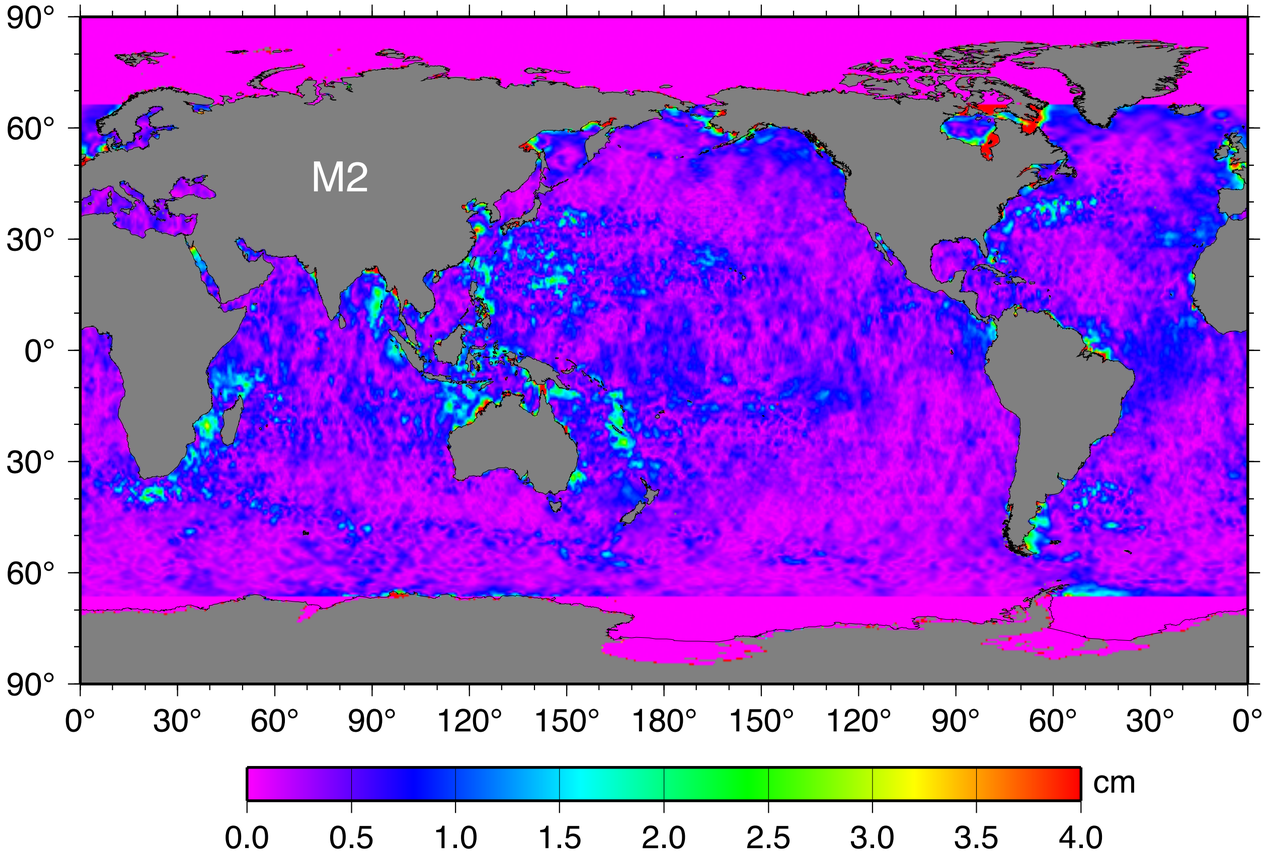
Comparison of GOT5 and EOT20 against FES14

preliminary GOT5.2 minus FES14



EOT20 minus FES14



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Conclusions

GOT4 series is obsolete in shallow water — but that was always the case!

GOT5.1 can be used now, but further solutions are in progress.

For empirical tide solutions, more work should explore deep/shallow tradeoff
– how to improve shallow-water tides without degrading deep-water tides
– loss of tidal signal versus enhancement of non-tidal noise

Must address tide leakage in DAC modeling. Important for non-altimeter uses.

Empirical methods are handicapped by coarse track spacing in shallow water.
A large SWOT dataset will resolve that.

perth5: A rewritten package for tidal prediction from gridded data

Call sequence compatible with old routine:

```
call perth5( lat, lon, time, tidal_height, is_data )
```

An initialization sets options (with defaults):

```
call perth5_initialize(  list_of_filenames,  number_of_files,
            [ format_type ],  [ verbose ],
            [ nodal_correction_flag ],
            [ inference_flag ]    )
```

Highlights

Fortran-2003 module

Handles multiple types of input grids
- **netCDF (for current popular models)**
- **ascii GOT4 grids**
- **native OTIS binary**
- **a simple list of tidal constants for one location**

Any number of constituents, input in any order
- **automatic name recognition**

Nodal modulations on/off – and more accurate

Tidal inference on/off
- **piecewise linear interpolation of admittances**
- **Munk-Cartwright Fourier interpolation**

Inference turns on 36 standard constituents if they are missing from input.