Atmospheric and Environmental Research

How well do we know the seasonal cycle in ocean bottom pressure?

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ECCO Team Meeting (UT Austin, TX)

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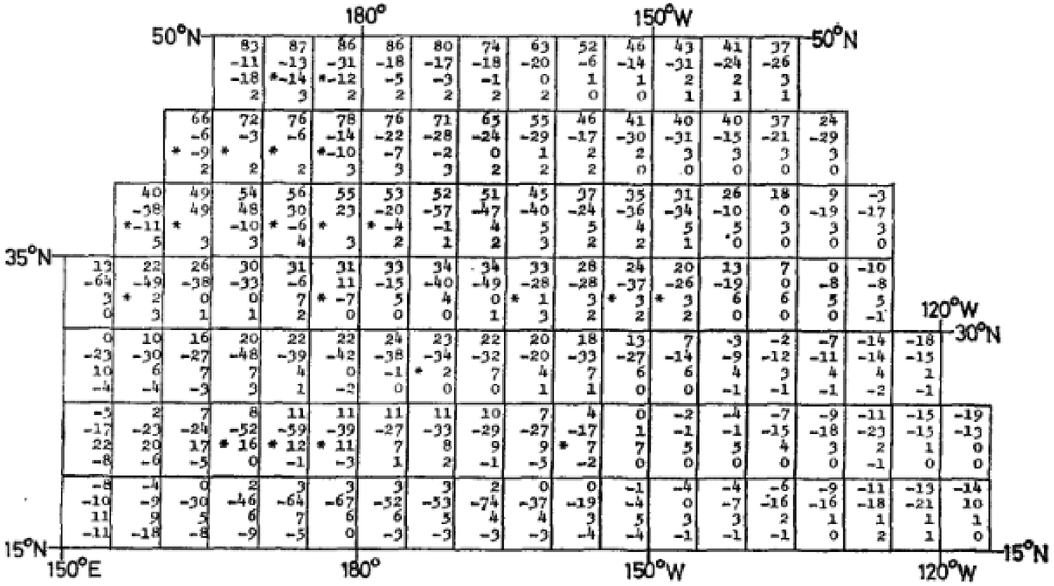
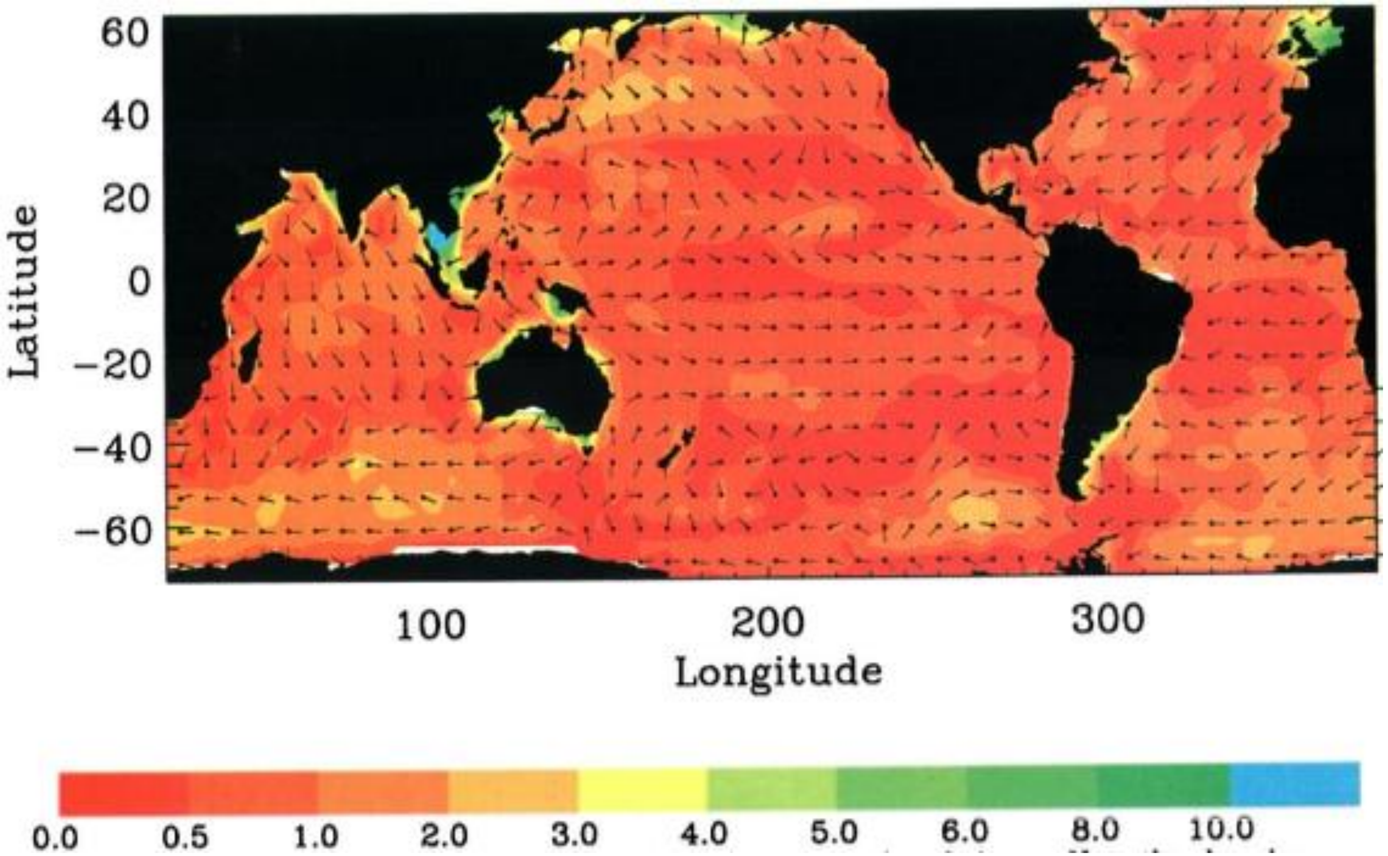
Old stories



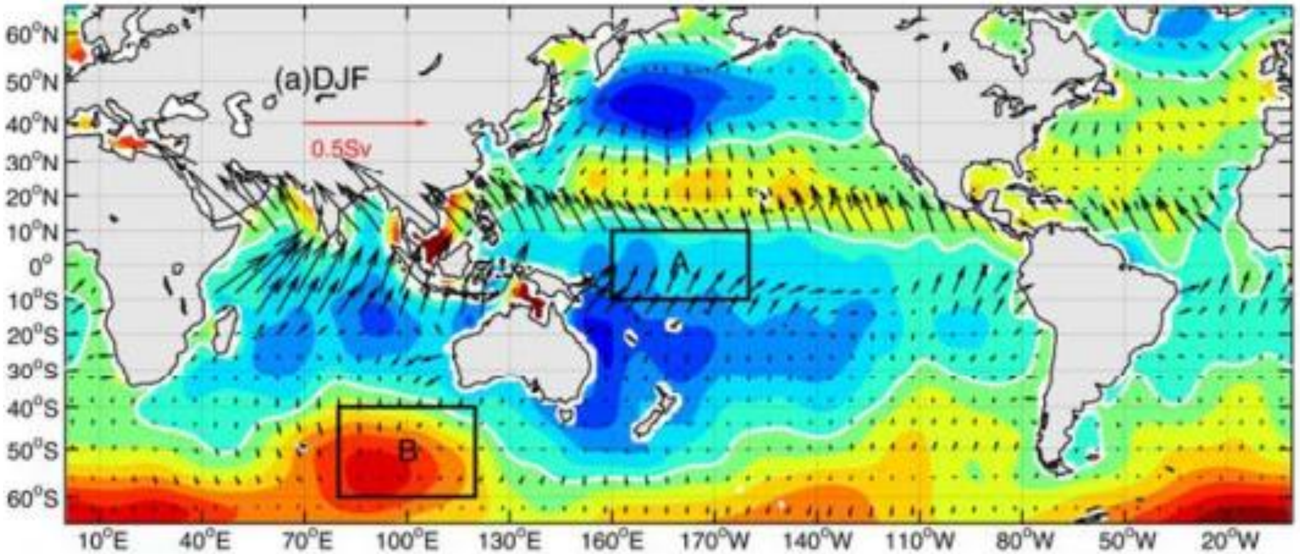
Gill and Niiler (1973, Deep-Sea Research)

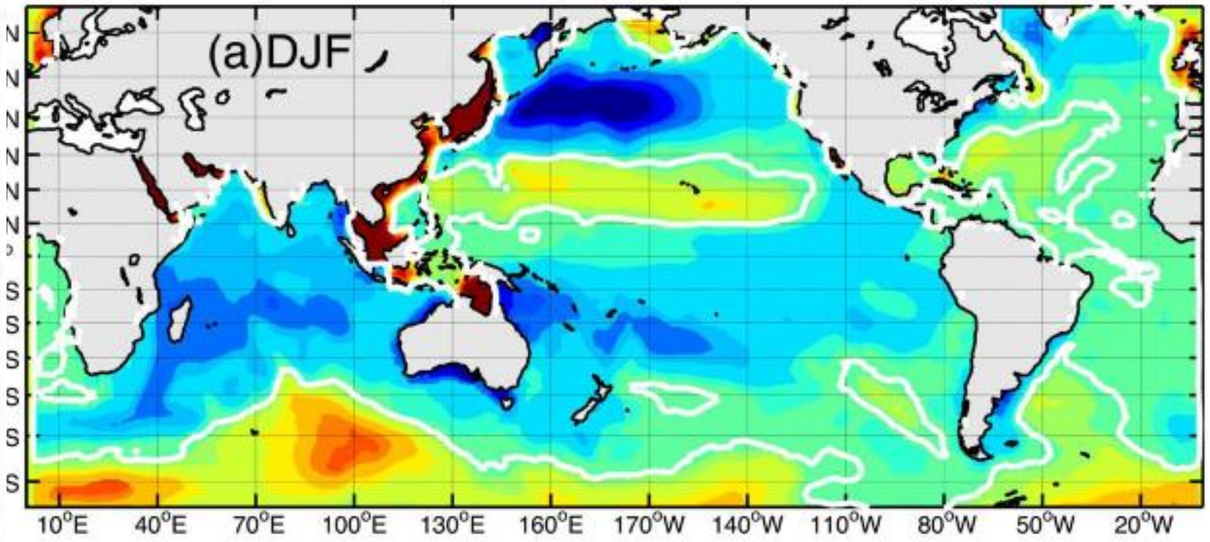
Ponte (1999, Journal of Geophysical Research)



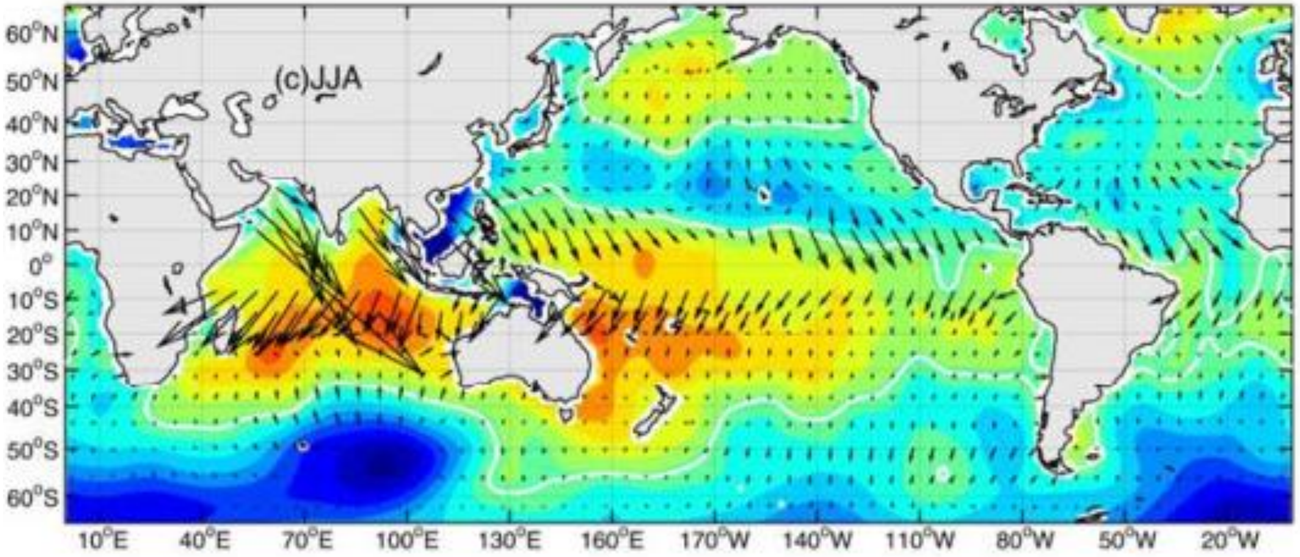
cm (equivalent water thickness)

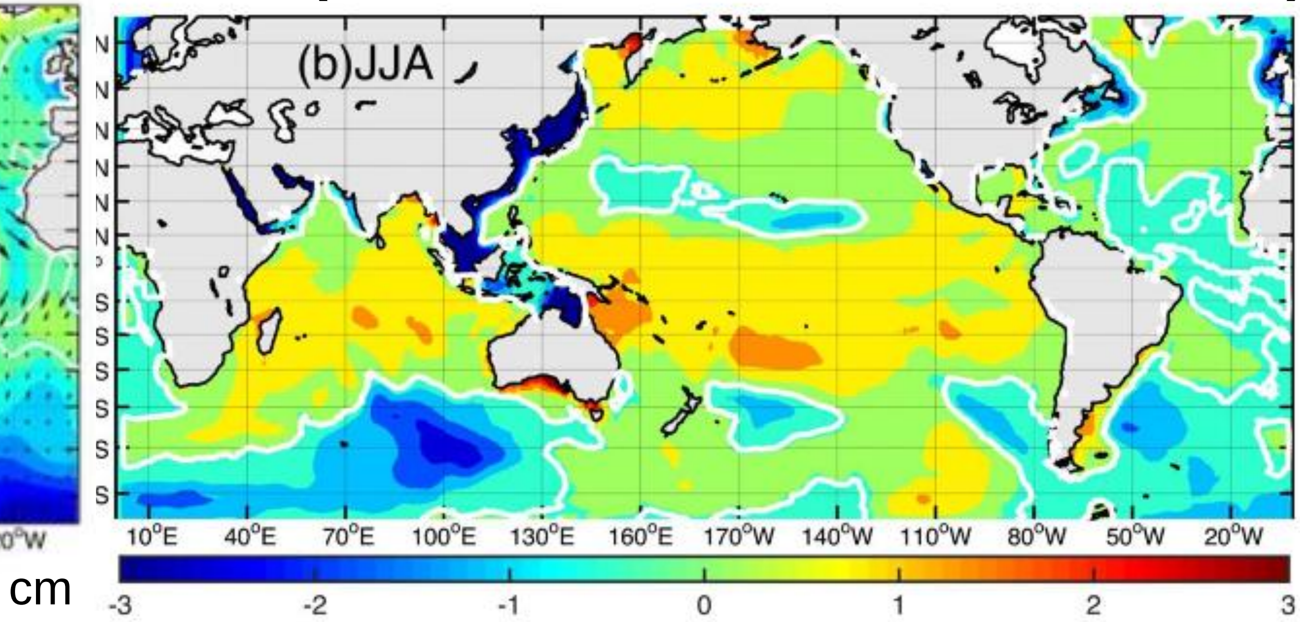
More recent stories (Cheng et al. 2021)





GRACE data **PCOM (Pressure Coordinate Ocean Model)**





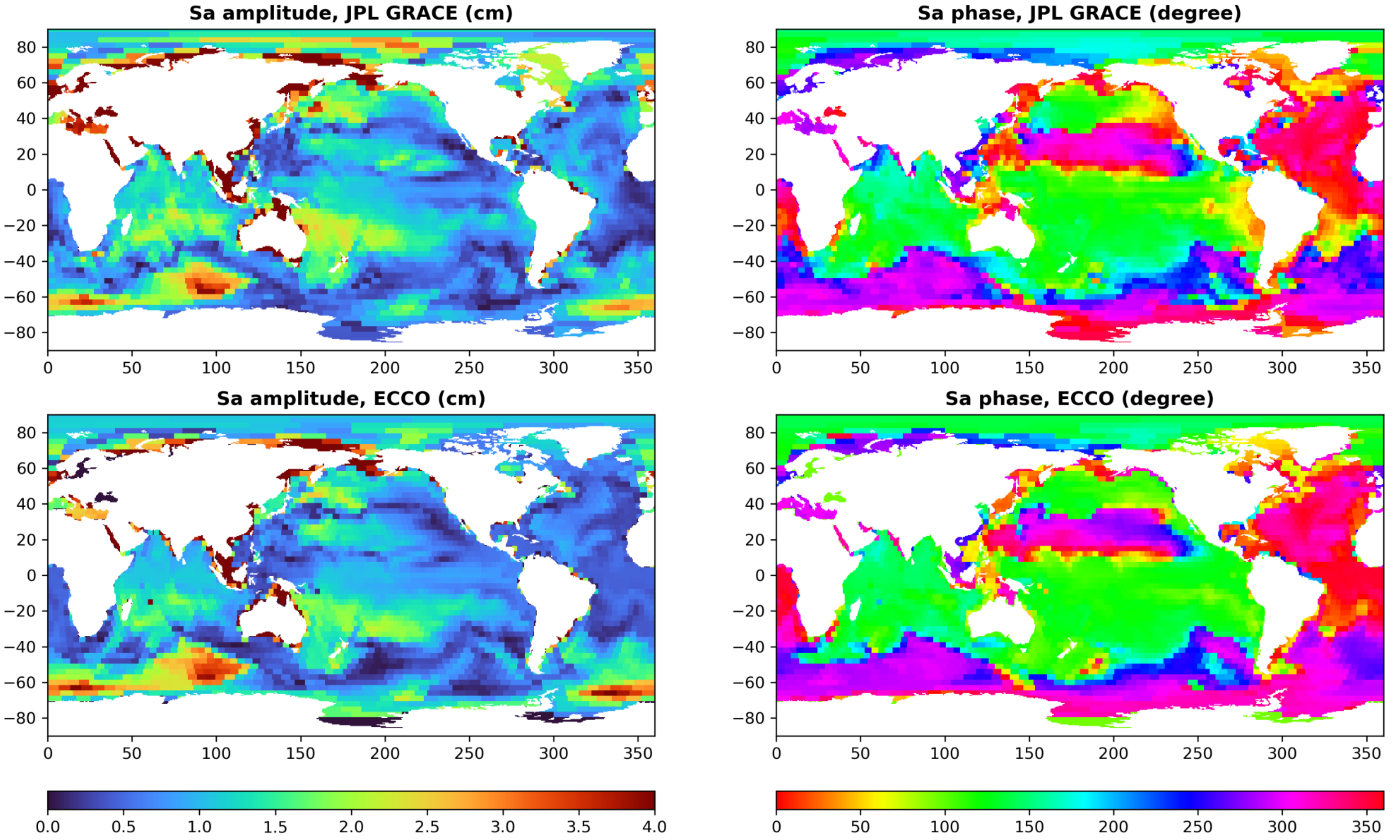
Data and Modeling Tools

- GRACE and GRACE Follow-On data (JPL and GSFC mascon solutions)
- State estimates from the ECCO Version 4 Release 5 for period 1992-2023

A few details:

- ECCO constrained by various data, including JPL mascons, for period 1992-2019
- Bottom pressure analyses confined to period of overlap between data and ECCO (2002-2022)
- Analyses done in terms of annual (Sa) and semi-annual (Ssa) harmonics
- Spatial means removed from all fields

GRACE and ECCO (annual cycle)



JPL mascons

(JPL_RL06.1_v03)

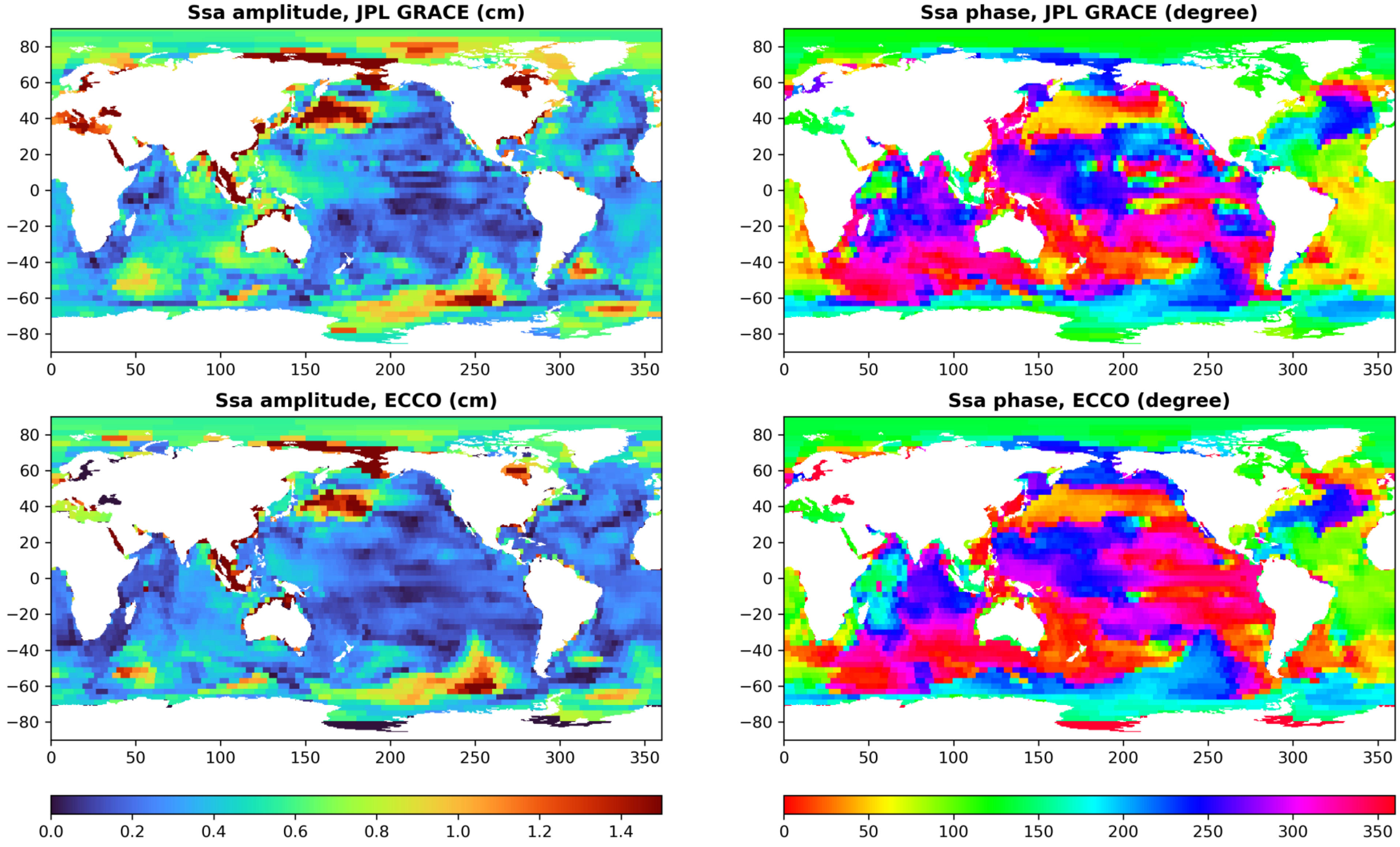
ECCO

(version 4 release 5)

Amplitude (cm)

Phase (degrees, referenced to the vernal equinox)

GRACE and ECCO (semi-annual cycle)



JPL mascons

(JPL_RL06.1_v03)

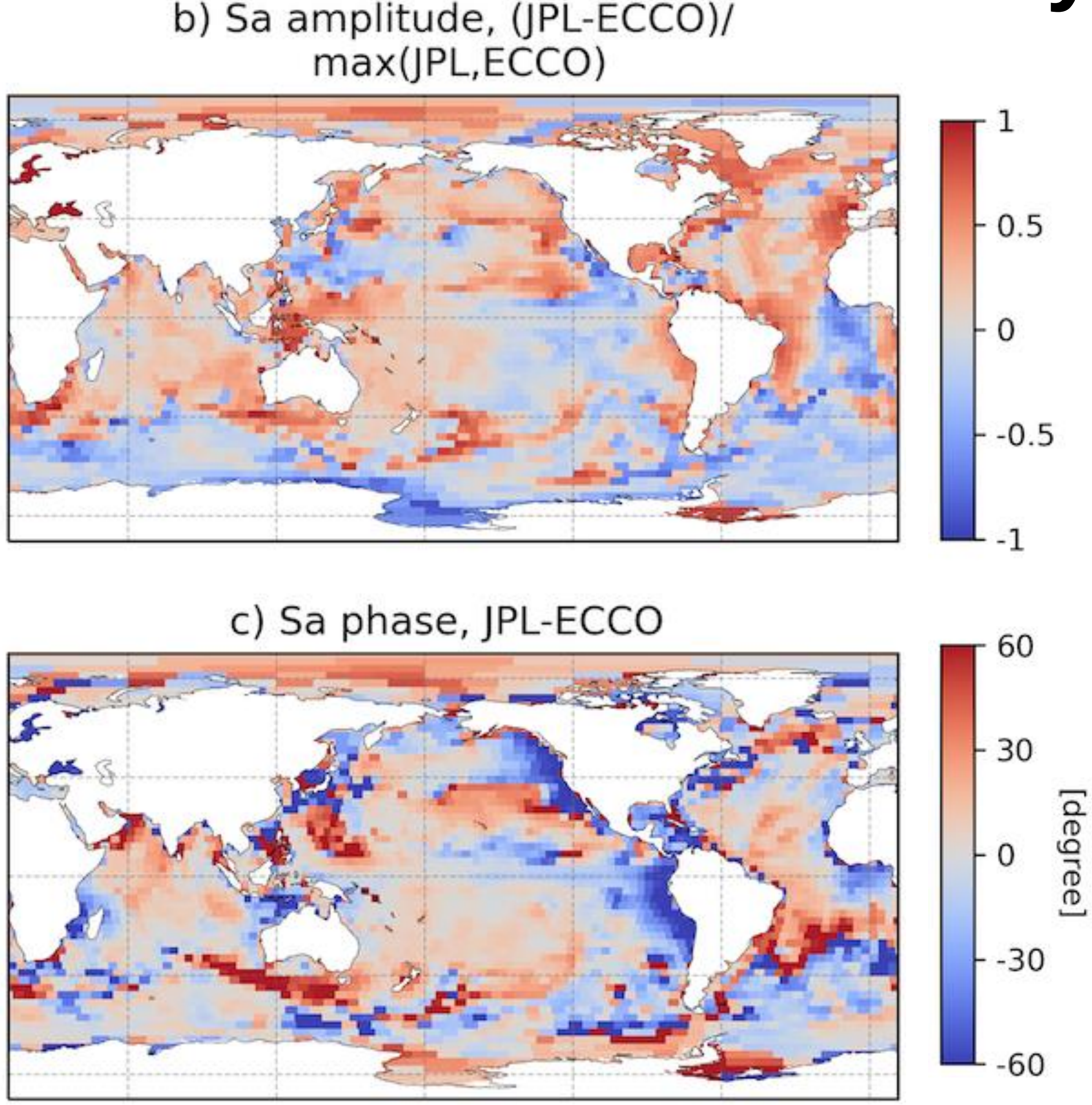
ECCO

(version 4 release 5)

Amplitude (cm)

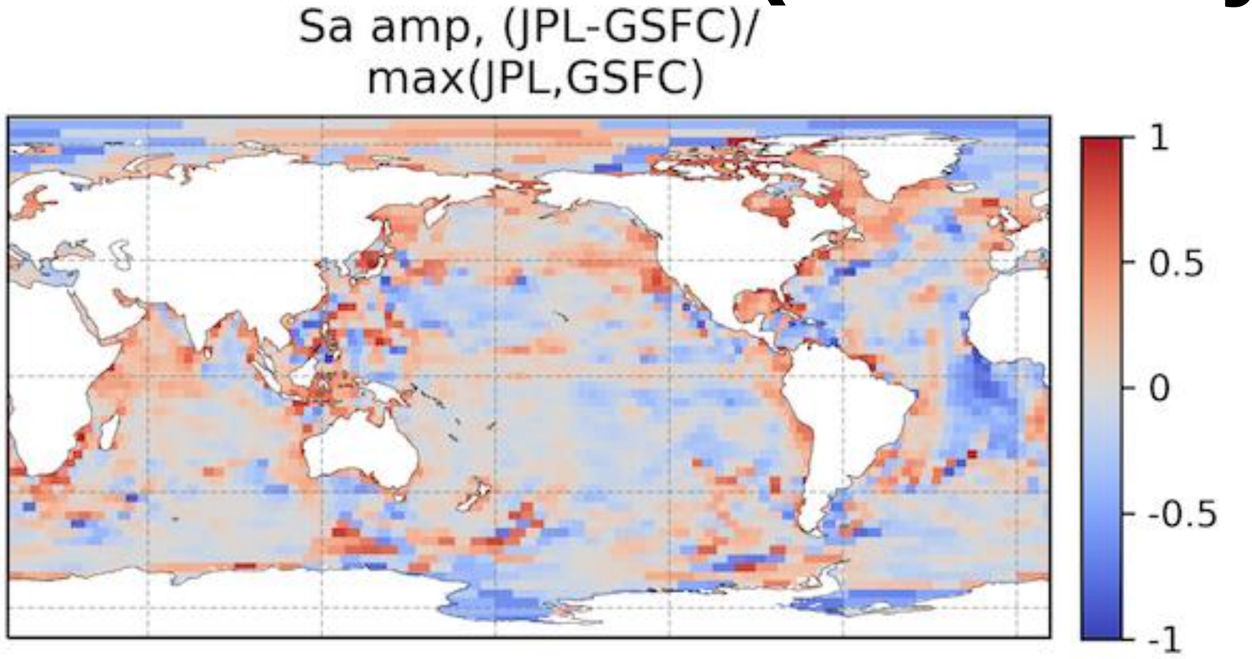
Phase (degrees, referenced to the vernal equinox)

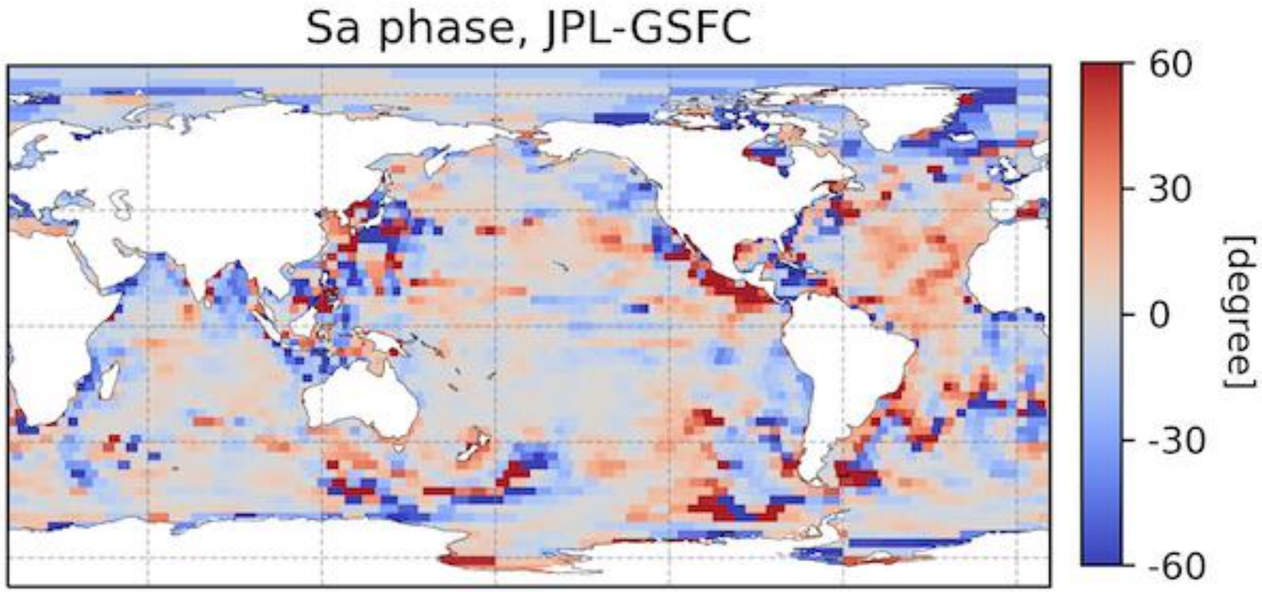
JPL vs. ECCO (annual cycle)



- Largest amplitude differences (> 50%) tend to exist around the boundaries, similar for phase differences
- Signs are fairly consistent over broad areas, with tendency for GRACE to have higher amplitudes than ECCO

JPL vs. GSFC (annual cycle)



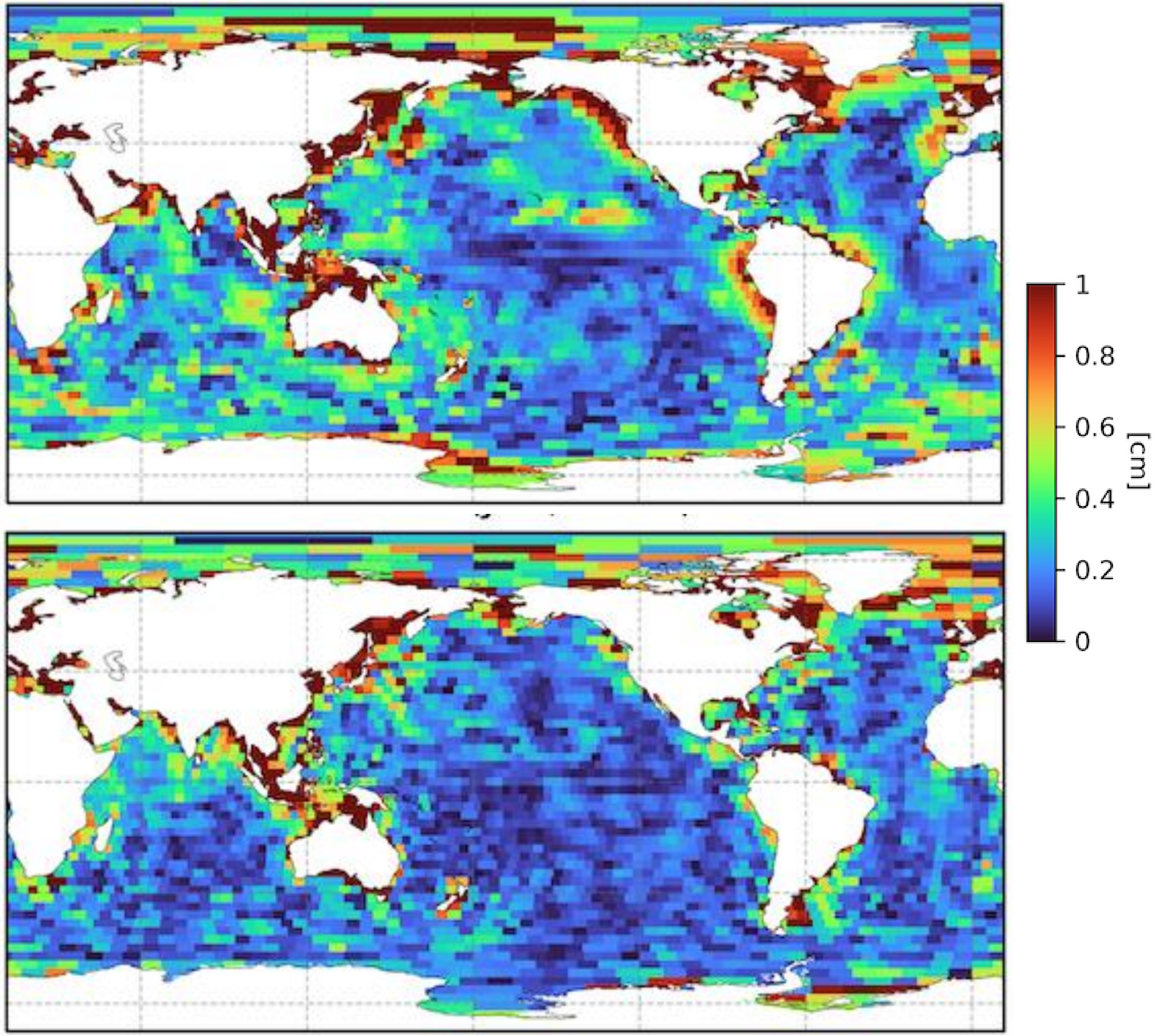


- Largest data differences tend to occur around boundaries (resolution and leakage issues)
- Similar spatial patterns but generally smaller differences than those between JPL and ECCO

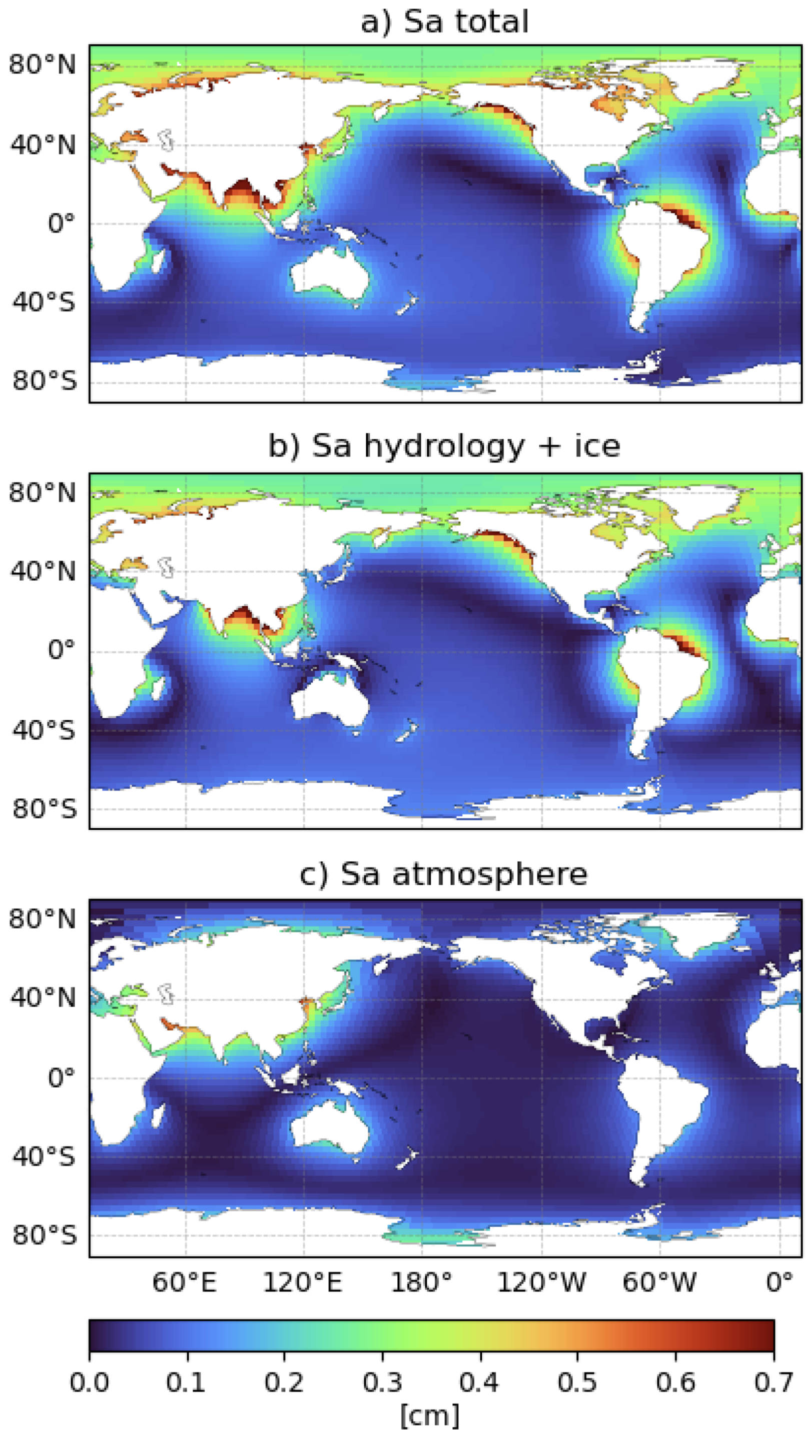
Annual cycle comparison (RMS differences)

JPL minus ECCO

JPL minus GSFC



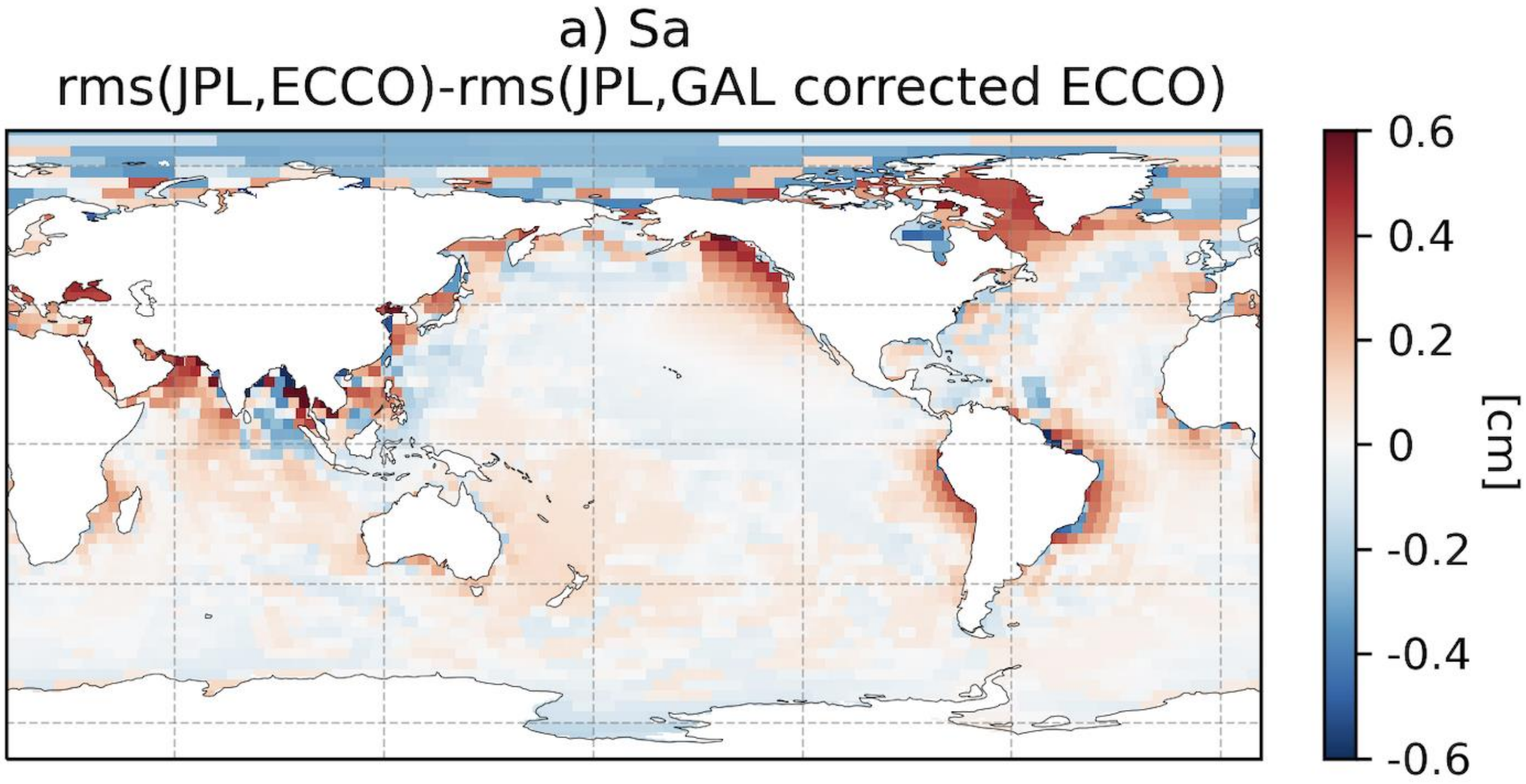
Gravitational attraction and loading effects



Standard deviation of annual cycle

- Estimates based on GSFC fields for ice+hydrology and surface atmospheric pressure from a reanalysis product
- Largest around landmasses and extensive ice bodies
- Atmospheric mass changes also important particularly around Eurasia
- Values comparable to bottom pressure amplitudes and similar in magnitude to the rms differences between JPL and ECCO

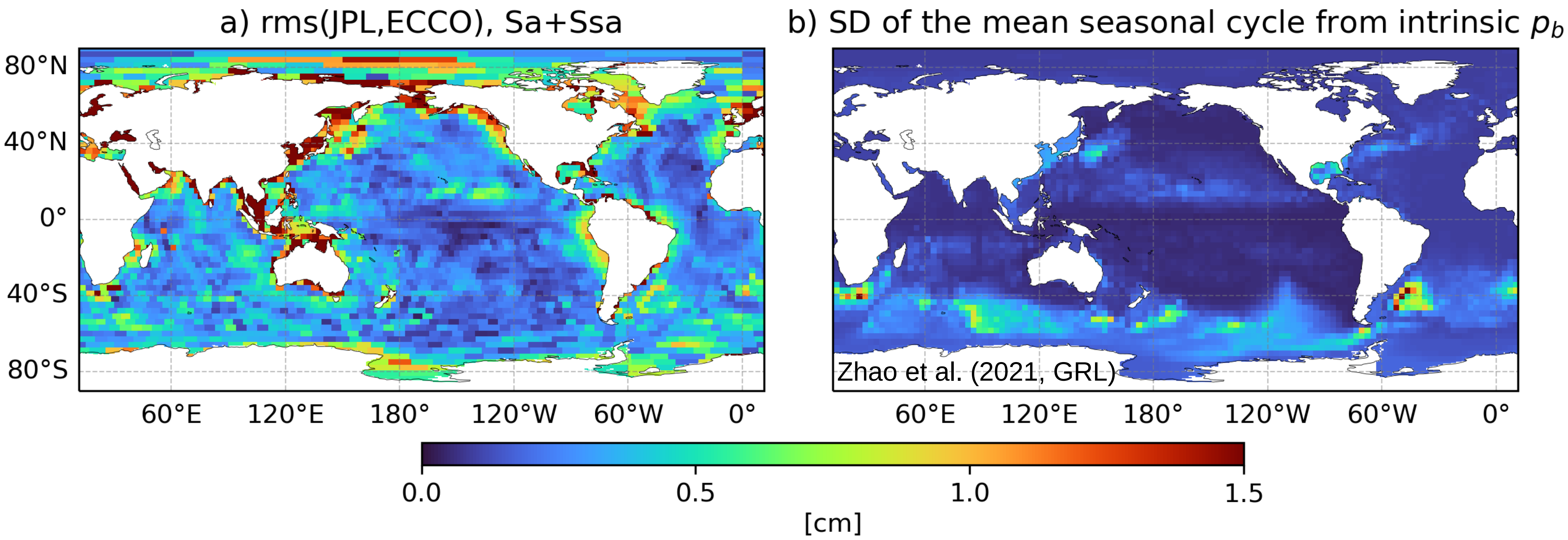
Gravitational and loading effects



[values > 0 imply adding gravitational/loading effects to ECCO fields reduces the differences to the data]

- Largest reductions can be seen around landmasses in areas with important gravitational/loading effects (e.g. around Greenland, around Amazon, near Alaska/British Columbia)

Effects of ocean intrinsic variability

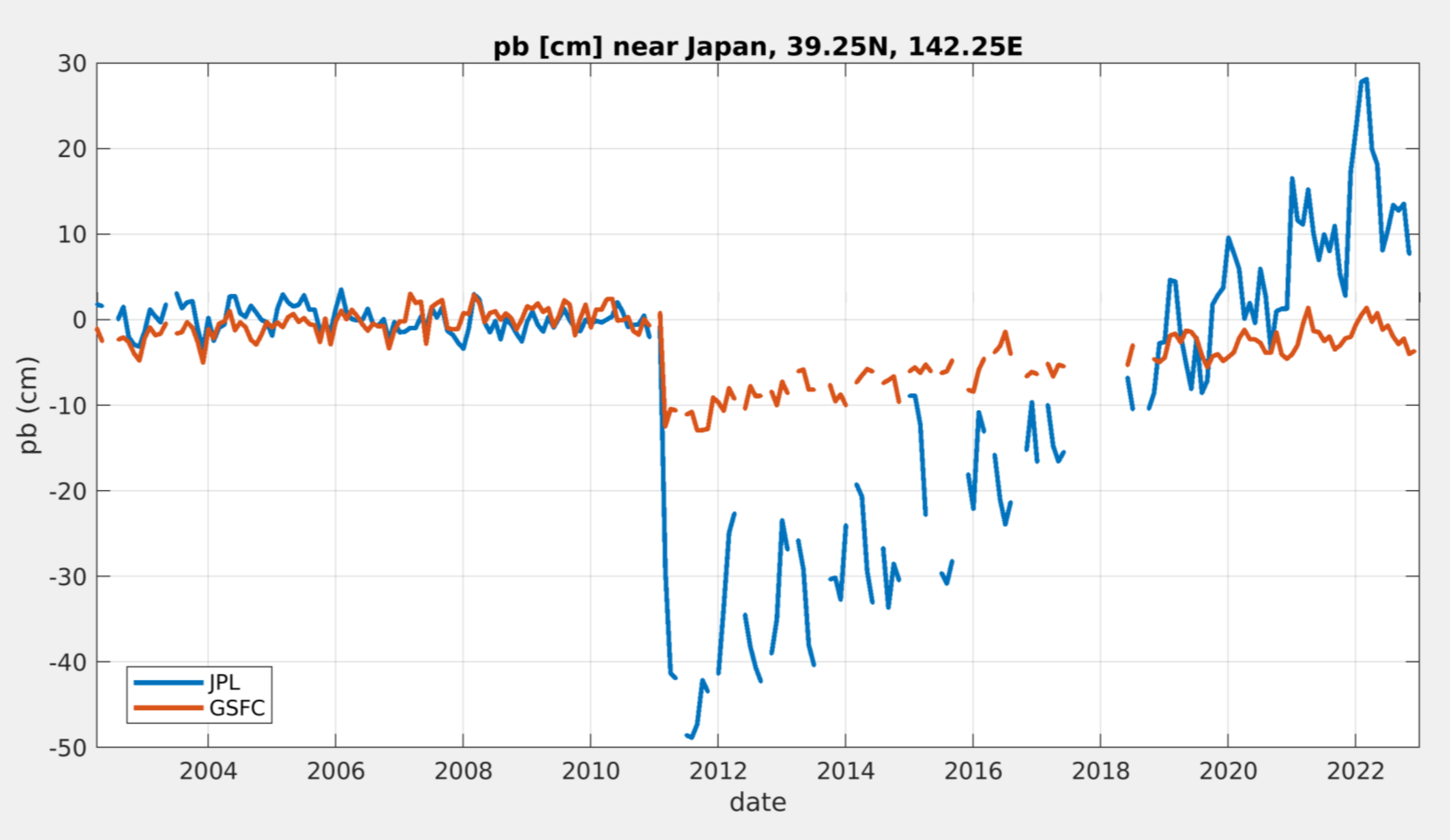


- Boundary current regions and Southern Ocean can involve important contributions of intrinsic variability to the seasonal cycle
- Possible contributions of intrinsic effects to JPL and ECCO differences (e.g., Kuroshio and Agulhas regions, Argentine Basin, parts of Southern Ocean)

Generic takeaways

- Seasonal cycle is a main climate signal in ocean bottom pressure variability and a key metric to assess how well we can observe and model ocean bottom pressure
- Estimates of the seasonal cycle, with a large annual component, can differ substantially between observations and model-based products, even when constraining to bottom pressure data
- Examining differences in estimates can elucidate remaining uncertainty in observations and missing physics in the models (e.g., lack of intrinsic variability due to coarse resolution, no accounting of gravitational attraction and loading effects)
- Advances in both observations and models will be both helpful for advancing quality of bottom pressure estimates and understanding underlying dynamics

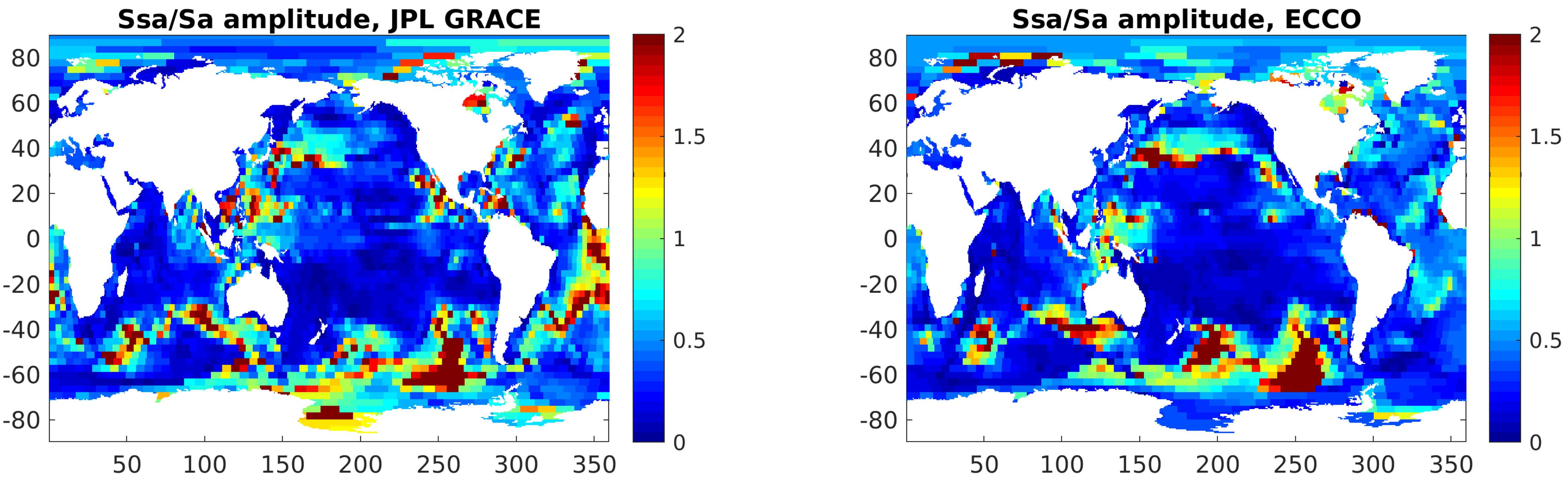
An example of data issues



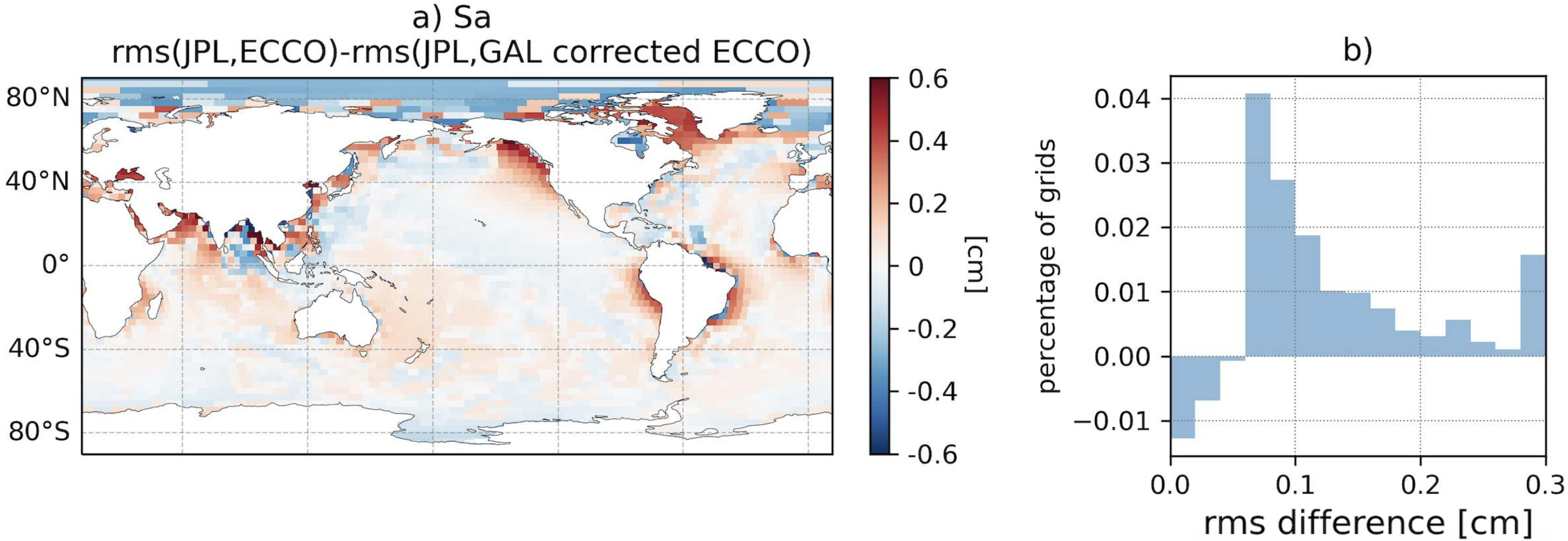
JPL (blue) and GSFC (red) series near Japan showing different representation of 2011 earthquake

- Aside from different trends across the earthquake event, there is an apparent jump in variability about the trend in the JPL series (not seen in GSFC series), which implies a substantially larger seasonal cycle after the earthquake

Semi-annual/annual amplitude ratio



Gravitational and loading effects



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