What do errors between altimeters tell us about the length of the Jason-3/Jason-CS calibration phase?

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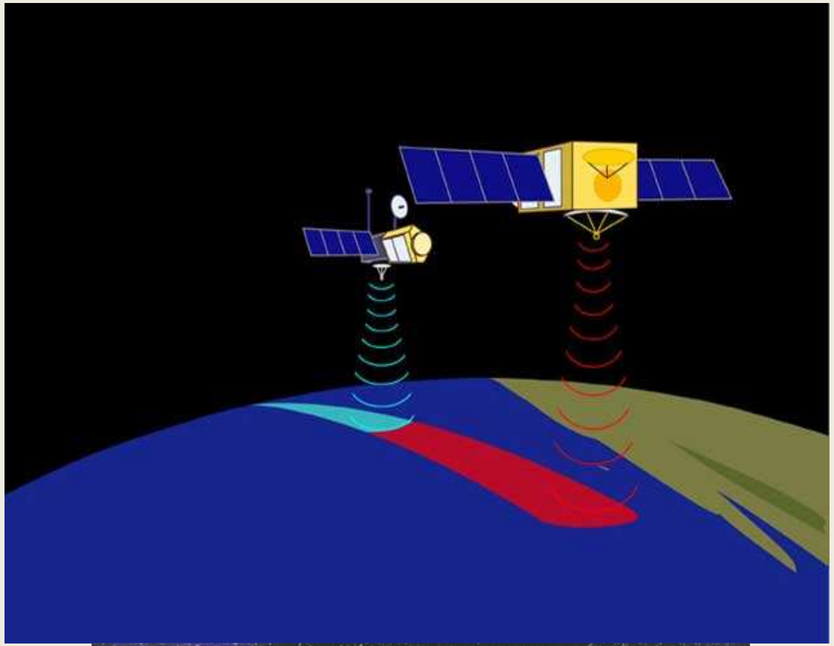
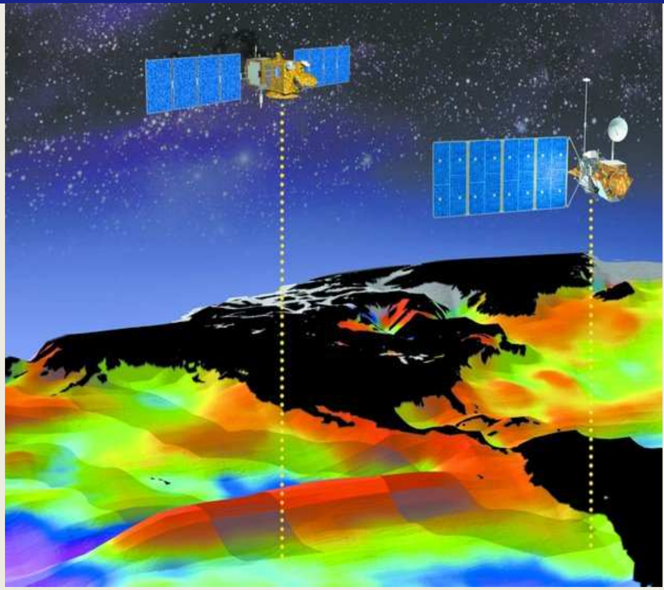
Outline

- Review what we can (and can't) compare during tandem cal/val phases
- Error as a function of time when determining the intermission biases
- Sampling of the sea state
- Specific Jason-3 to Jason-CS instrument differences

Tandem phases for reference missions

- TOPEX & Jason-1
  – January-June 2002
- Jason-1 & Jason-2
  – July 2008-January 2009
- Jason-2 & Jason-3
  – April-September 2015?
- Jason-3 & Jason-CS-A/Sentinel-6A
  – 2020?





Tandem mission length

The length of the Jason-1/Jason-2 tandem mission was debated at the 2008 OSTST (Nice), but no recommendation was made.

One of the recommendations of the CEOS Ocean Surface Topography Constellation Strategic Workshop 2008, Assmannshausen, Germany

– *"launch Jason-CS/Jason-4 in time to allow an appropriate overlap (9-12 months) due to the change in the series for cross calibration and system tuning."*

What does the tandem phase allow?

Tandem Differences Reveal

- Total sea level comparisons
- Measurement errors from instruments
  - Altimeter
    - range, SWH, sigma0
      - ionosphere path delay
      - wind speed
      - sea state
  - Radiometer
    - brightness temperatures
      - wet troposphere path delay
  - Orbit determination
    - DORIS, GPS, SLR
    - Solar forcing models, etc.

Tandem Differences Do Not Reveal

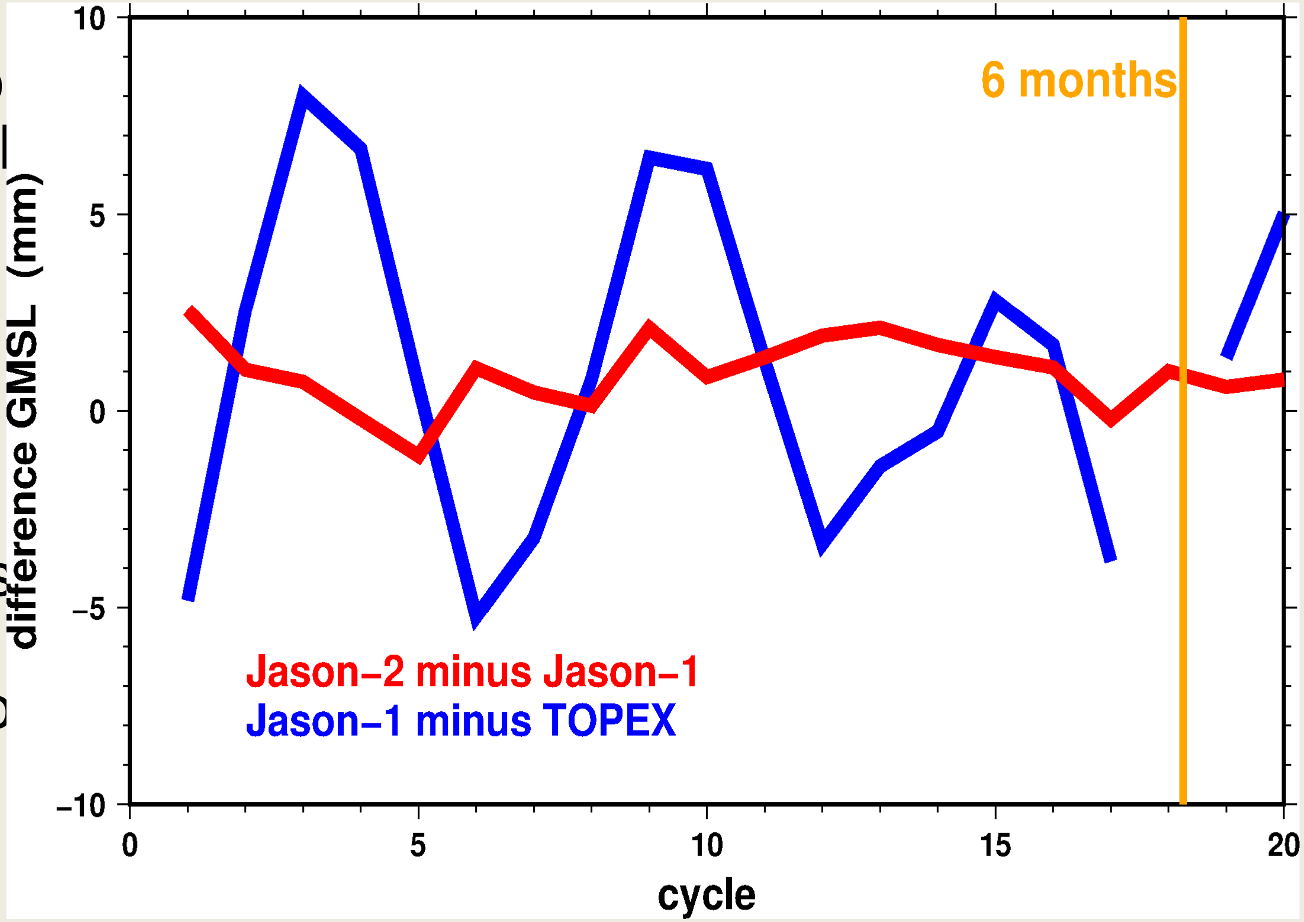
Common forcings (largely cancel)

- Reference frame
- Static and time-variable gravity (including geocenter)
- Solar radiation
- Geophysical corrections
  - dry troposphere,
  - tides
  - wet troposphere,
  - ionosphere
  - sea state

Variation of global mean intermission bias

The good stability observed between J-2 and J-1 is probably due to their being nearly identical instruments & buses.

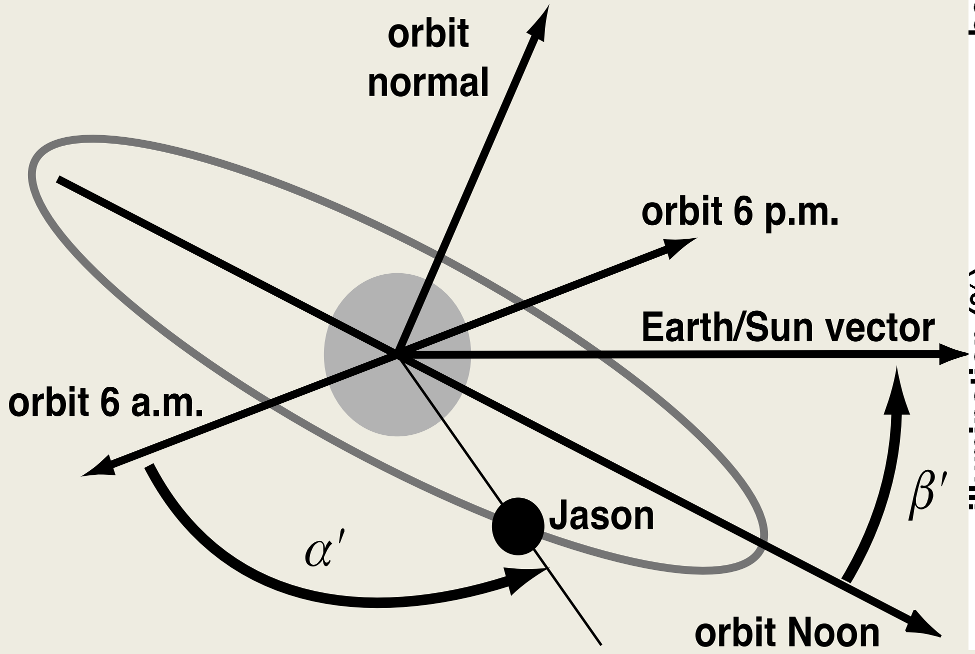
The J-1/TOPEX bias is correlated with the Beta angle (orbit plane to the Sun-Earth line), which has variability at 59 days and 6 months. The only way to observe the Beta dependence is to measure for at least 6 months.



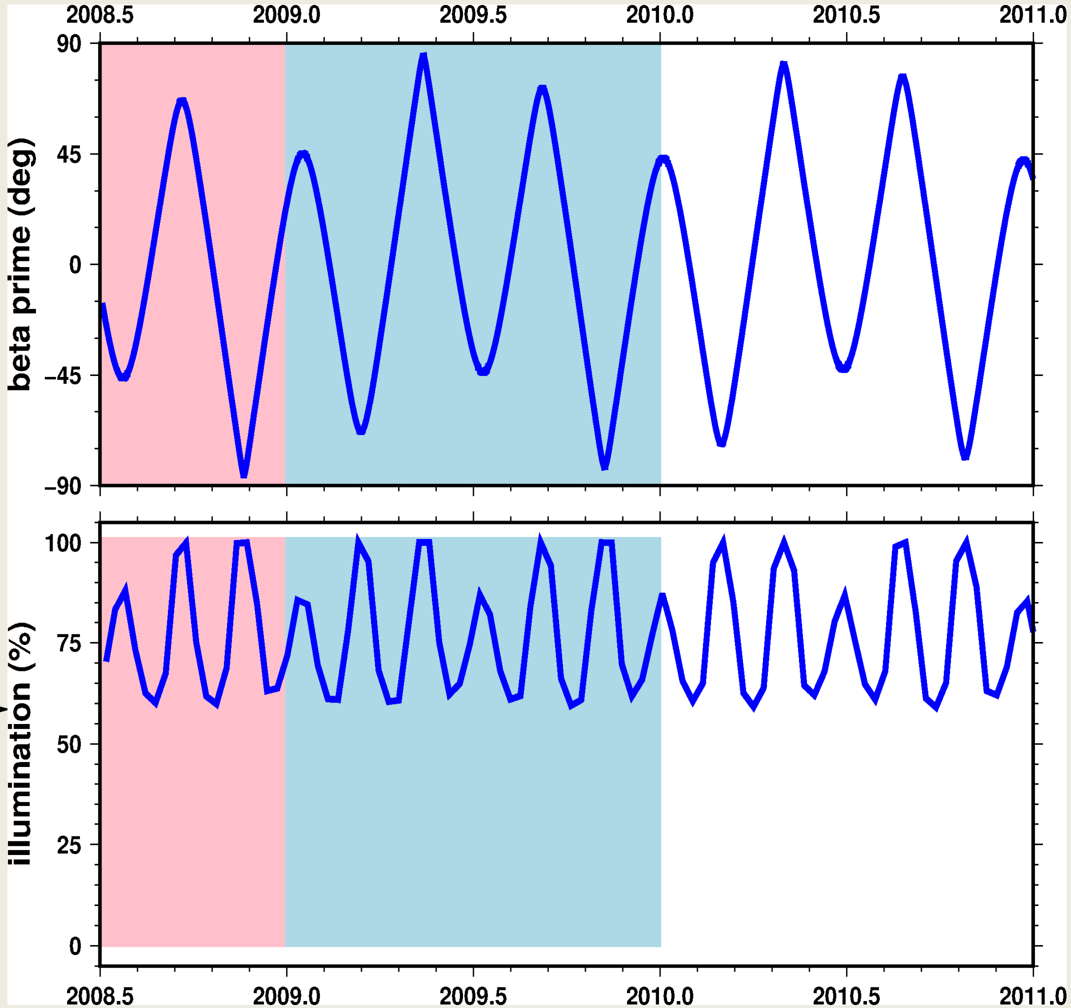
Beta prime and illumination

The beta prime, the angle between the Earth/Sun vector and the orbital plane, varies by ~59 days and 1 year.

The average time the spacecraft spends illuminated has periods at ~59 days and 6 months.



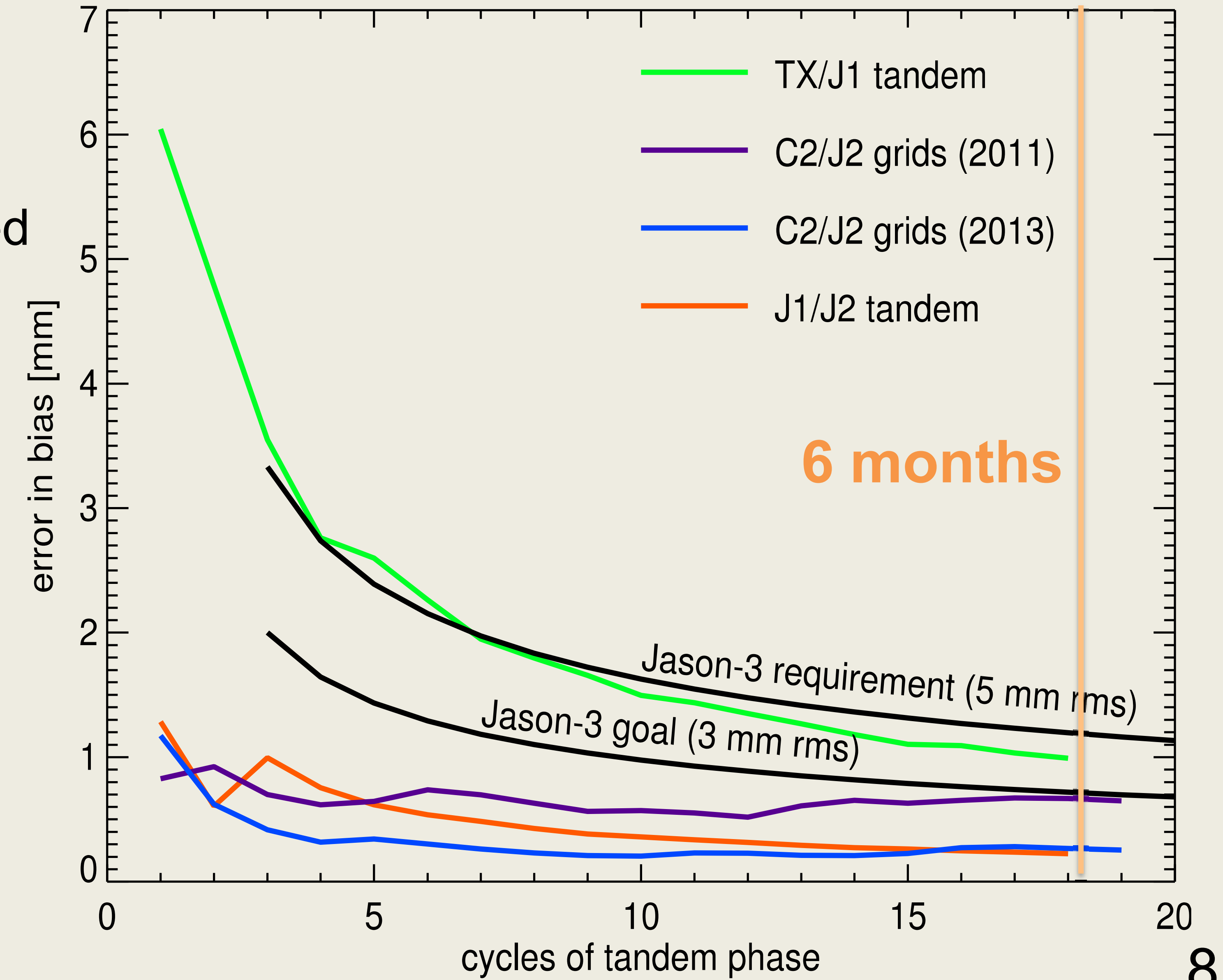
(pink-> 6 month; blue 12 months)



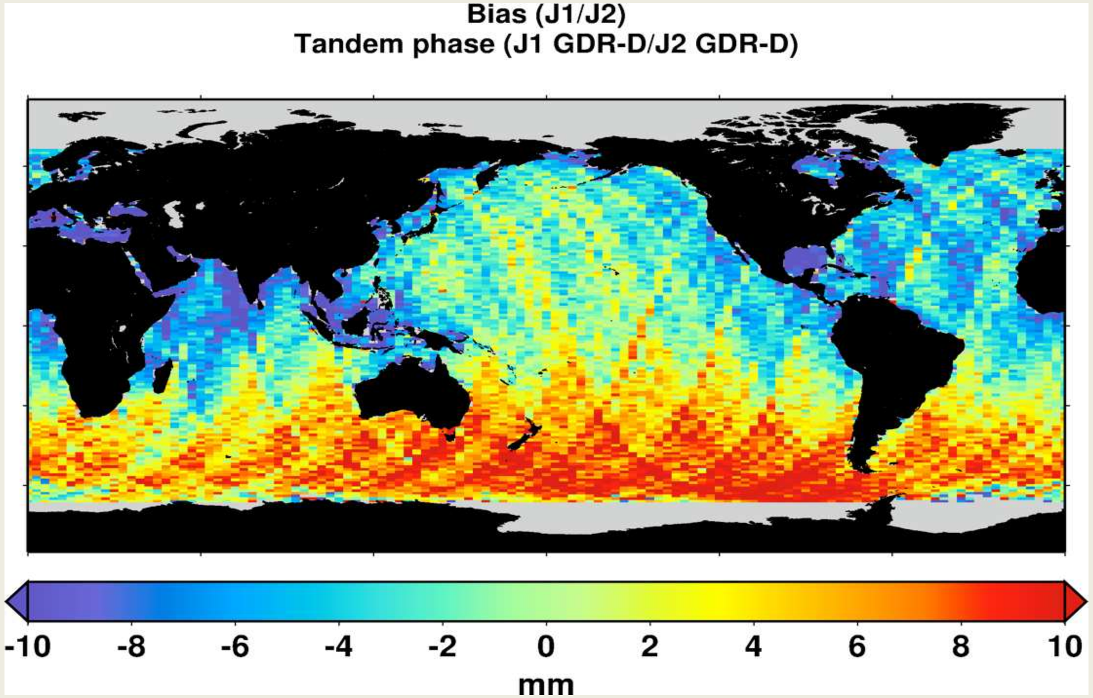
Error in intermission bias over time

For previous missions, the intermission bias could be determined to a few mm after only a few cycles.

Bias error = rms of cycle biases/sqrt(# cycles)



Mean bias map from J1/J2 tandem phase



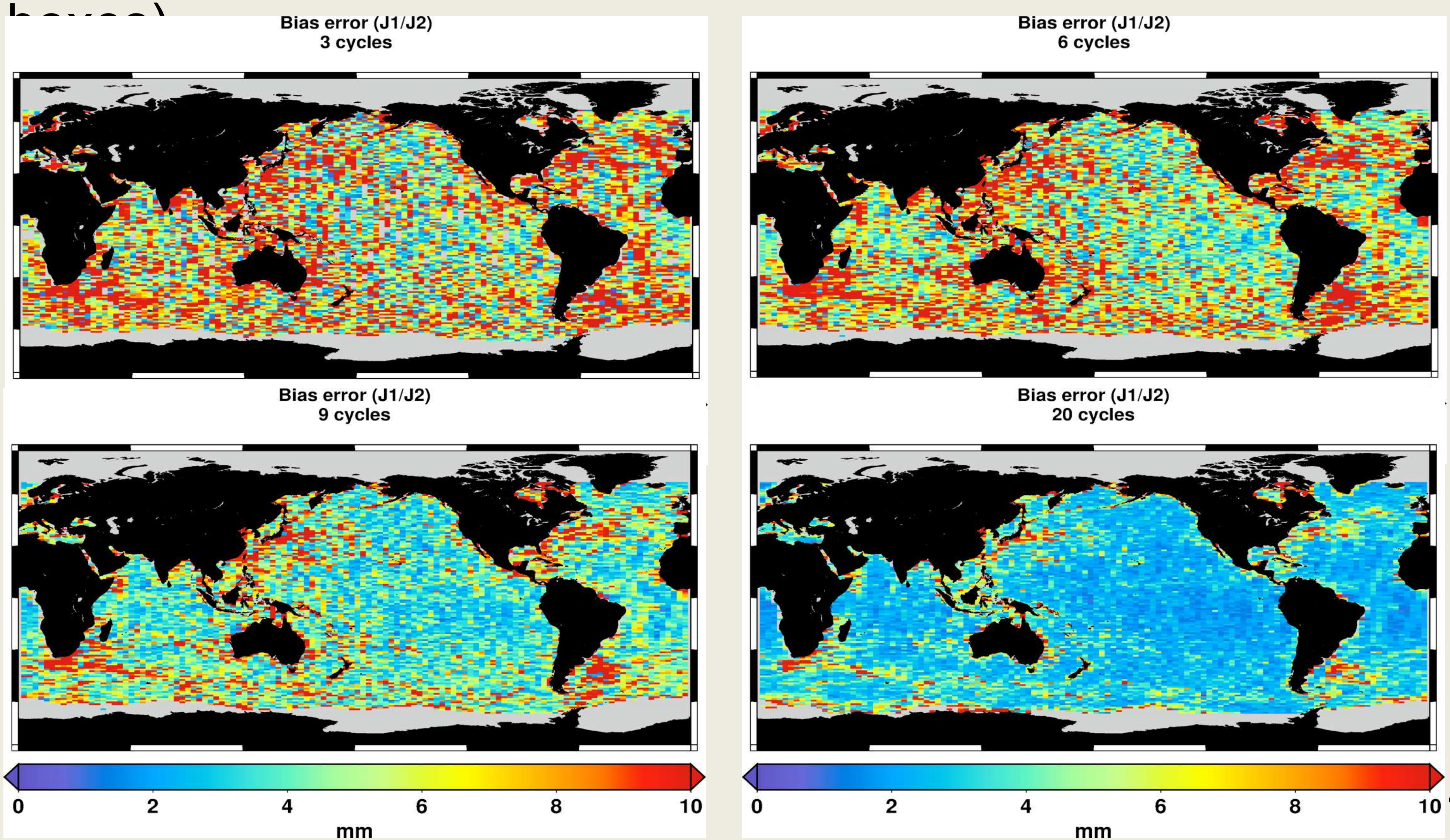
The Jason-1 and Jason-2 global bias was determined to be stable (1.1 mm rms) immediately after the cal/val phase (OSTST 2009, Seattle), but the regional bias (±8mm) was significant.

Geographically-correlated errors produce regional variations in the bias (and trend).

There is no formal mission requirement on the size of regional intermission biases.

Bias error in maps

After 20 cycles, the regional bias errors < 2 mm (3° x1° boxes)

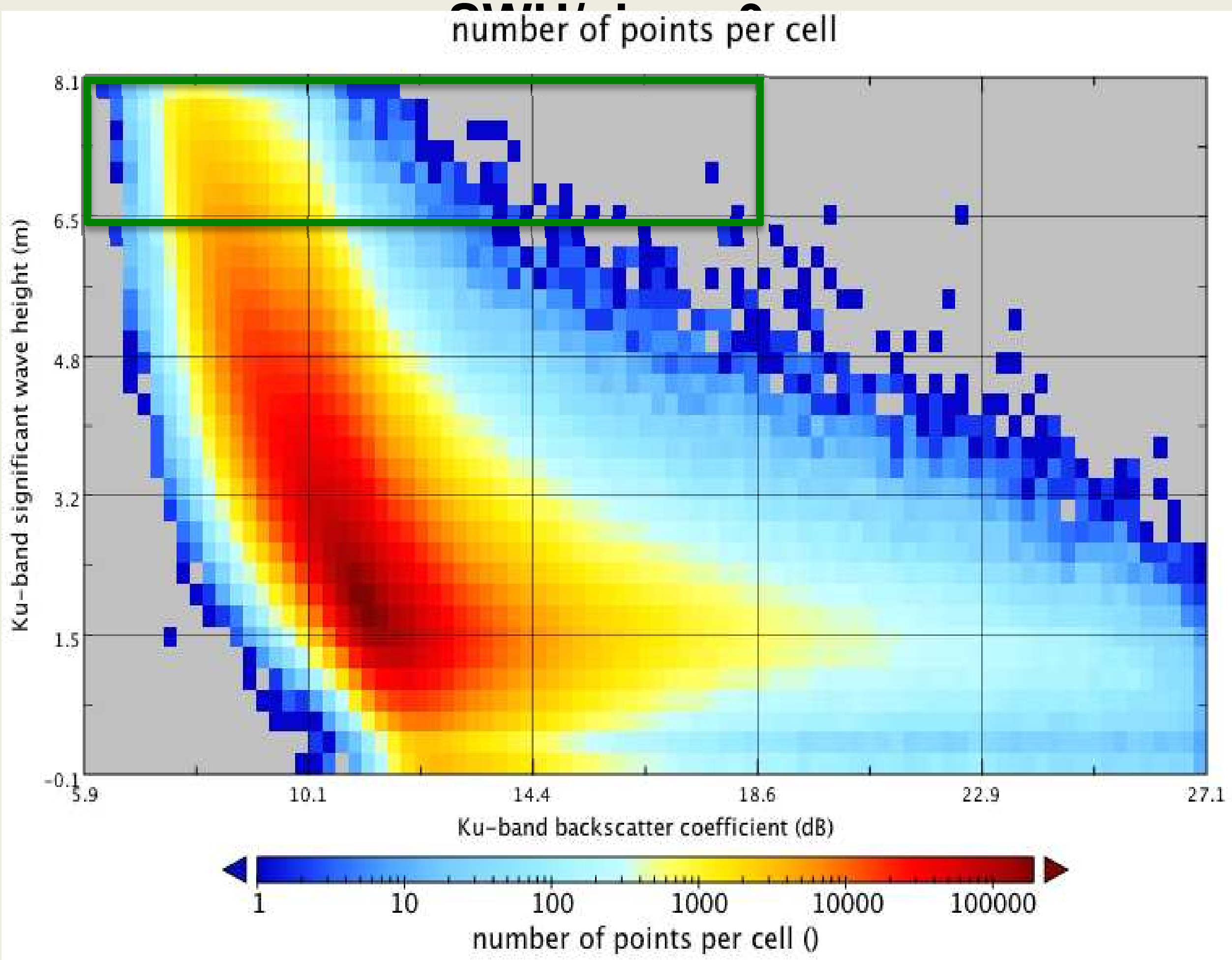


Sea state sampling

Because sea state conditions are concentrated in a narrow range of SWH/sigma0 values, extreme conditions benefit from additional measurements.

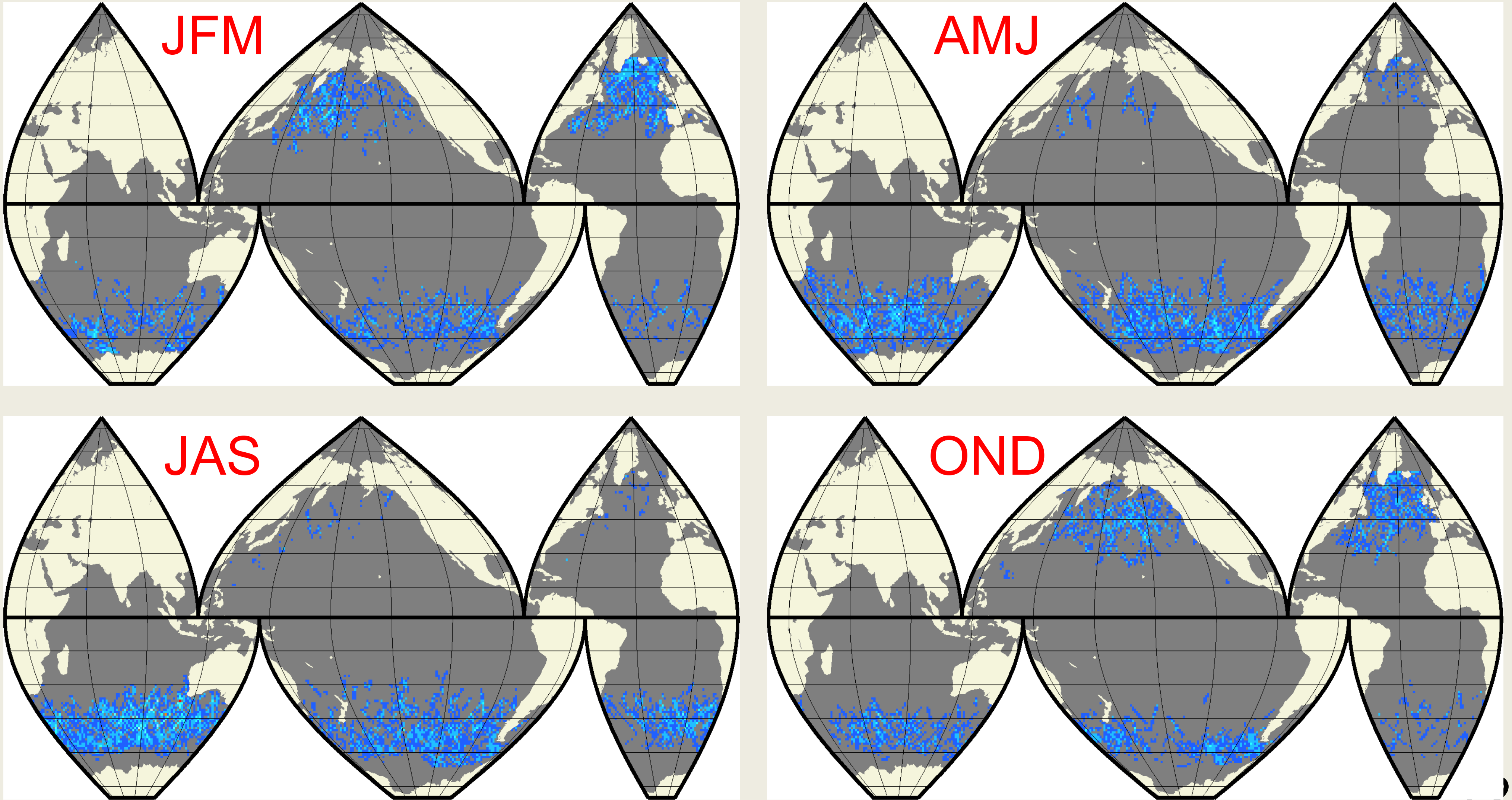
Increasing the observations from 20 cycles to 36 cycles roughly reduces the error in the average SSB by 25%, which can be accomplished without a tandem cal/val.

Jason-2 cycles 1-20: N=9168036



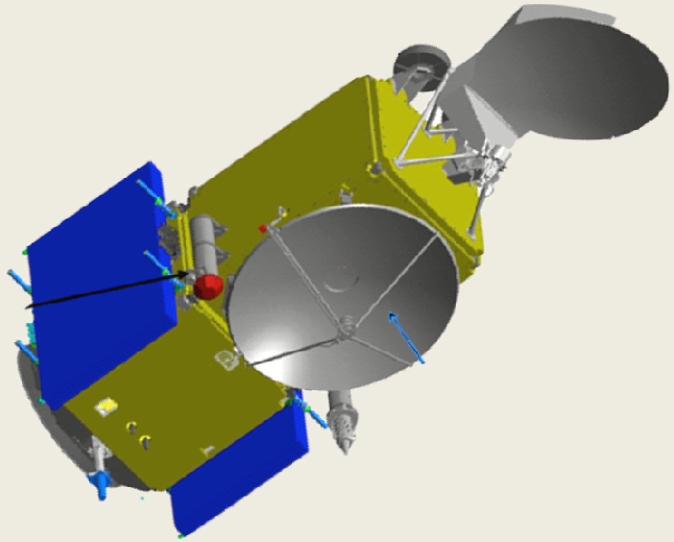
Sea state seasonal geographic-correlation

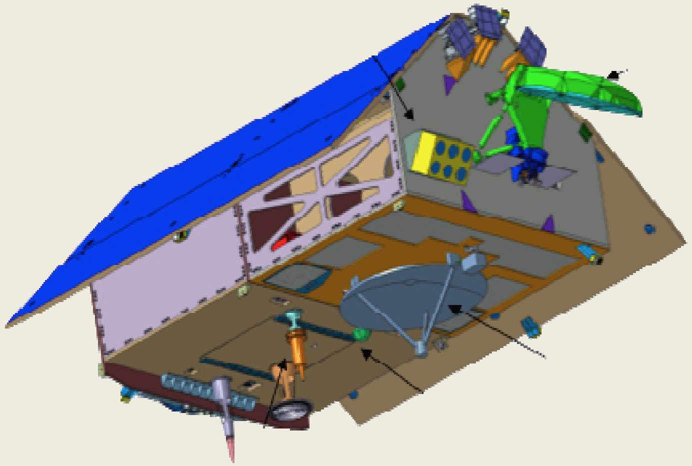
Seasonal variations in location of SWH > 6.5 m



Altimeter differences

- For the J3/J-CS Cal/Val phase, we'll be comparing Jason-3's 2kHz PRF Low-Rate Mode on Poseidon-3B to Sentinel-6/Jason-CS's 9kHz PRF Low-Rate Mode from Poseidon4's delay-Doppler/SAR.
- The higher PRF on J-CS should reduce the noise on range, SWH, and sigma0 compared to J3, but not as much as Sqrt[9/2].
- J-CS will have a digital chirp generator
  - different PTR characteristics, hence different bias look-up tables for the retracker, etc.





Jason-3 and Jason-CS Radiometer

- Jason-3 will carry an AMR similar to Jason-2 and will use cold-sky calibrations via pitch maneuvers.
- Jason-CS will carry an AMR-C that includes a secondary reflector to perform end-to-end calibration using stable blackbody calibration targets similar to SSM/I, AMSR-E, AMSU. Wet PD long term stability estimated to be better than 0.3 mm for any one year period.

Radiometer calibration benefits from calibration to a stable external reference. Stability of brightness temperatures must be continuously monitored.

The main benefit from the tandem calibration phase is to update the antenna pattern correction coefficients.

AMR calibration target

Conclusions

- Global and regional biases in sea level can be determined with a 6 month tandem phase.
  - Jason-2/CryoSat global biases are well determined after 6 months without tandem measurements.
- The radiometer calibration doesn't benefit significantly from an extended tandem phase.
- The seasonal, geographic variations of sea state make the SSB vulnerable to geographically-correlated errors.
  - If the geographically-correlated errors between J3 and S6/JCS were sufficiently small, 6 months would be sufficient to determine the SSB.
  - The Jason-2/Jason-3 cal/val (as scheduled) will poorly sample high waves in the Northern Hemisphere