Spatial and temporal characteristics of the errors in Jason-2 and Jason-1 sea surface height measurements

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Motivating questions

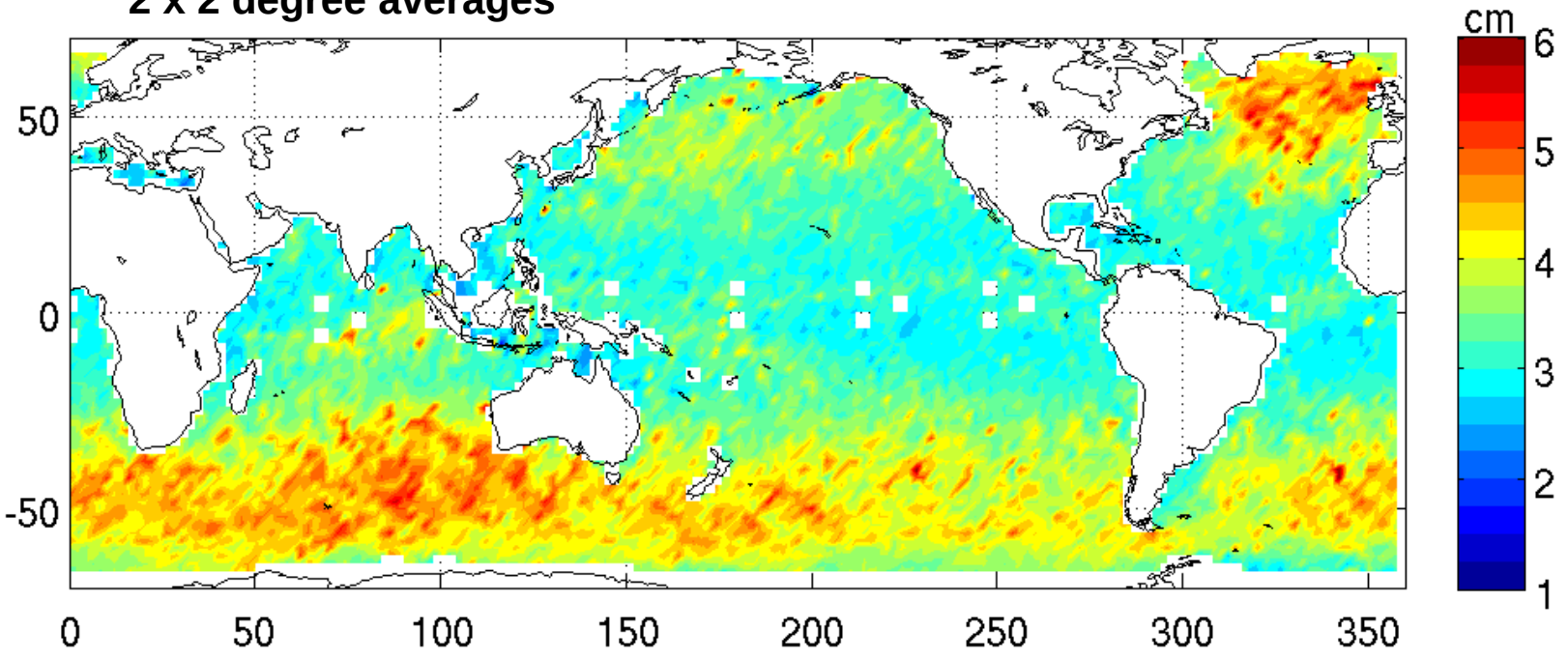
- Can we go beyond a global mean error estimate?
- What are the spatial and temporal characteristics of altimeter errors?
- Do we understand the main sources of error and can we improve the error budget?
- What can we say about signal-to-noise ratios and the spatial scales that are well resolved in the data?

T/P and Jason-1 comparison

Standard deviations of the difference T/P − J1 during overlap period

Ponte, Wunsch & Stammer (2007, JAOT)

2 x 2 degree averages

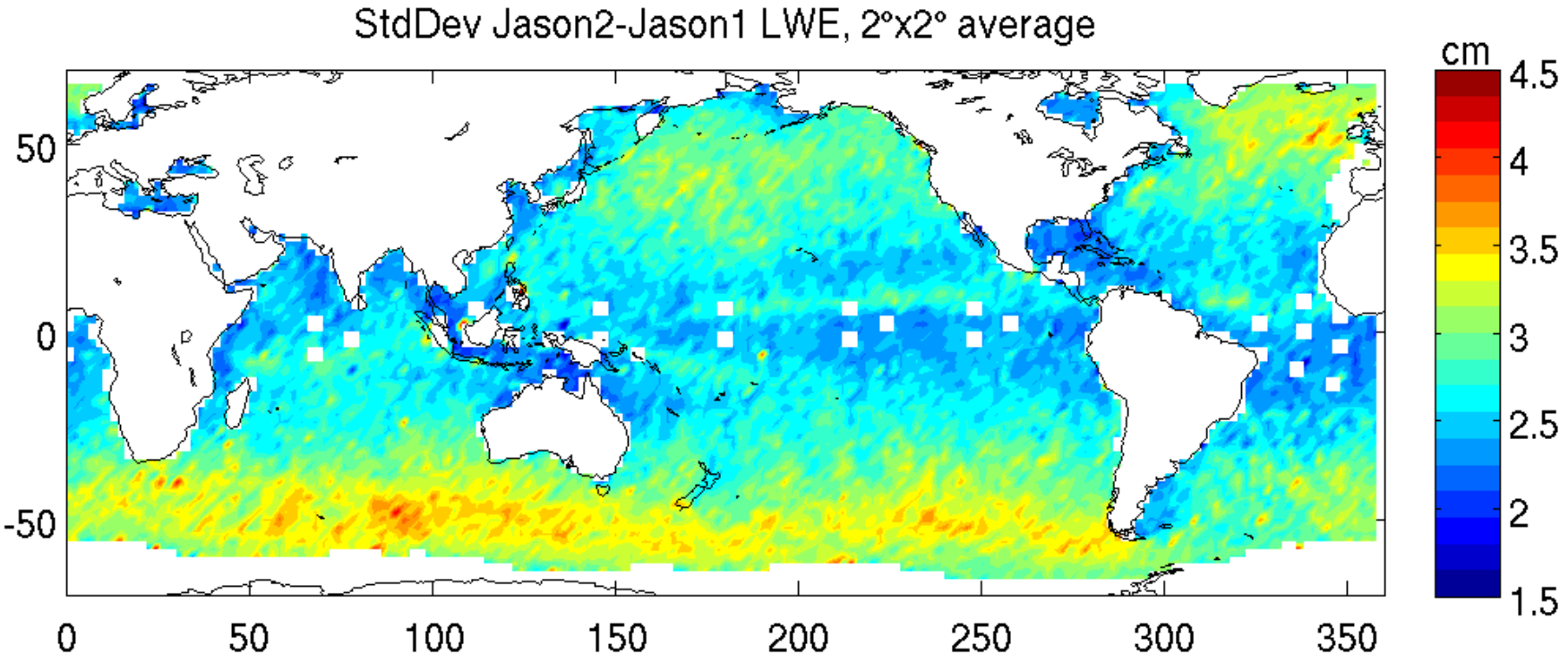


- **Values represent combined rms error in both missions resulting from radar noise, orbit error and other errors associated with sea-state bias, ionospheric, and wet tropospheric corrections**

Using Jason-1 and Jason-2

- **Tandem mission data over 20 cycles (July 12, 2008 – January 26, 2009) interpolated onto common reference tracks**
- **Data processing (RADS version 3.1)**
  - Orbit CNES EIGEN-GL04S (Jason-1) or CNES EIGEN-GL04C (Jason-2)
  - ECMWF dry tropospheric and inverse barometer correction
  - Enhanced JMR (Jason-1) or AMR (Jason-2) wet tropospheric correction
  - Smoothed dual-frequency ionosphere correction
  - Solid earth tide, ocean and load tide GOT 4.7, pole tide
  - CLS sea state bias
- **Local error estimates based on time series of differences J1−J2 calculated at every point along track**
- **Time mean differences removed (bias not included in results)**
- **Assume uncorrelated and equipartitioned errors: error variance in each mission is $\approx \frac{1}{2} < (J1-J2)^2 >$**

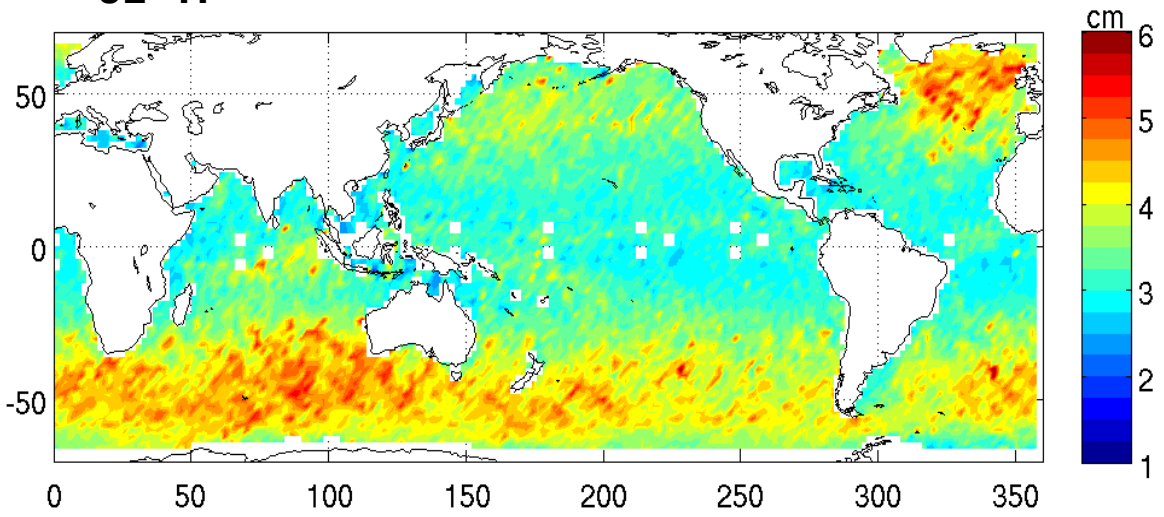
Estimated RMS error



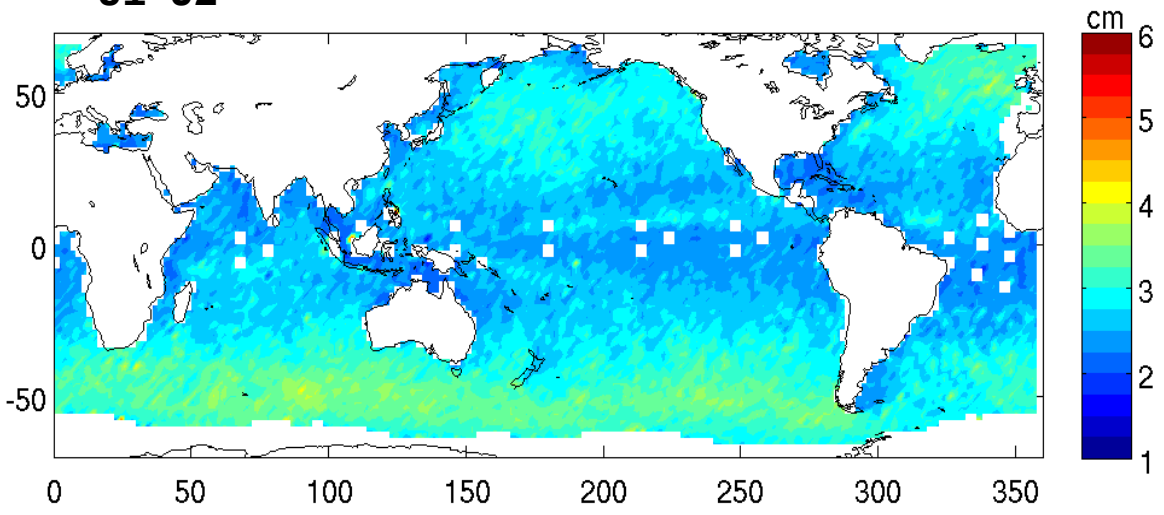
- Major dependences on latitude include effects of wave height and wet tropospheric corrections
- Global average value is ~ 2.9 cm (equipartition implies mean rms error of ~2.1 cm)

Comparison J1−TP vs. J1−J2

J1−TP

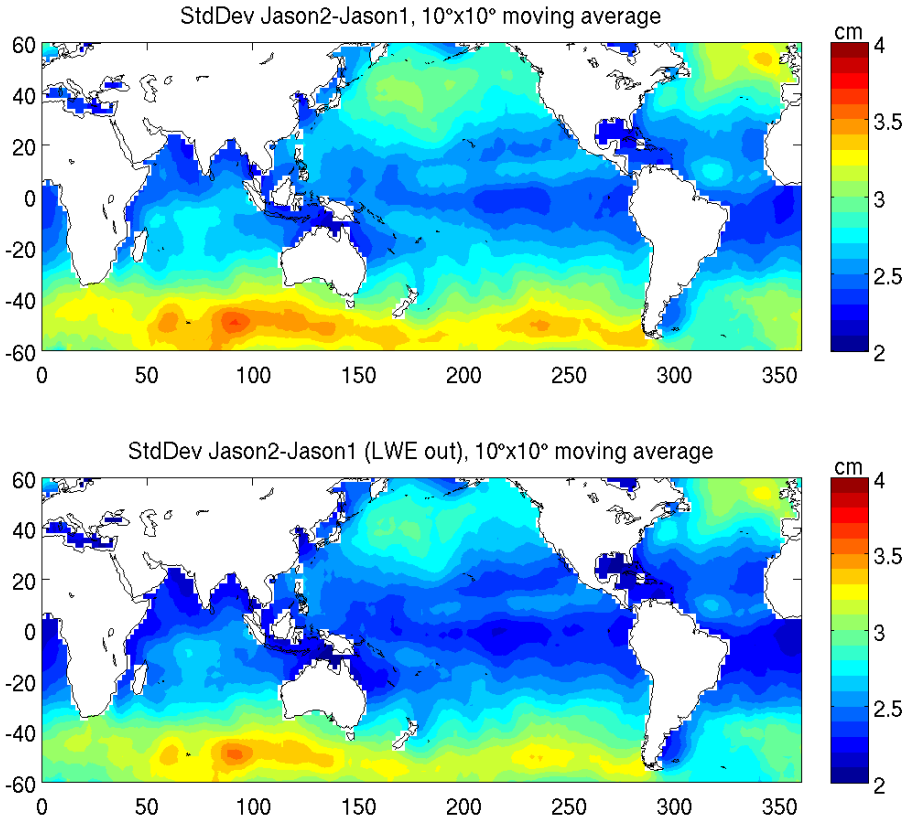


J1−J2

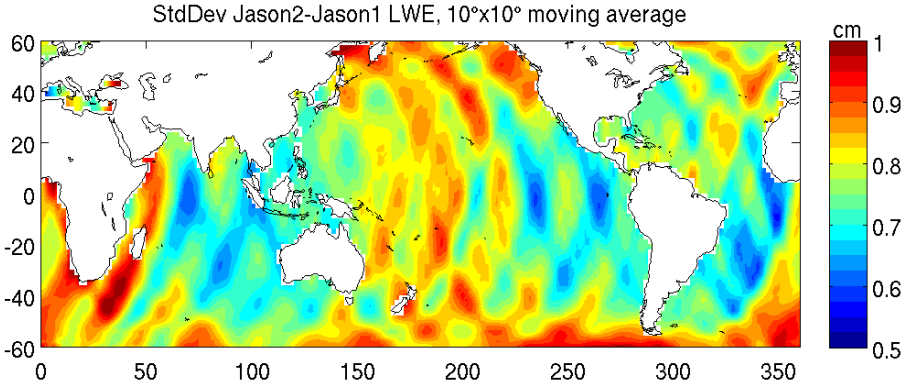


- Similar latitudinal patterns
- Effects of wave height, wet tropospheric errors apparent
- Smaller differences for J1−J2 than for J1−TP
- Possible effects of seasonality, GDR refinements, etc., in the differences between missions

Long wavelength errors (LWE)



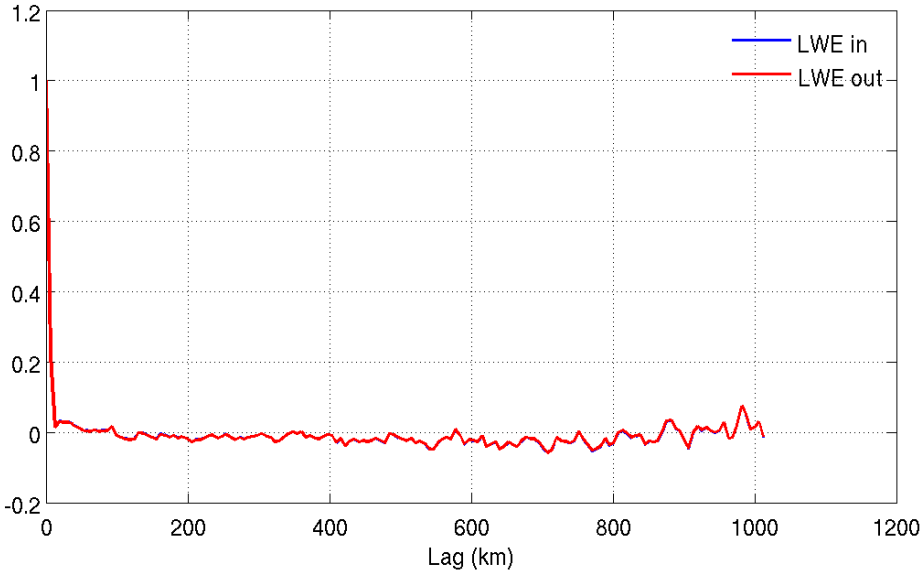
Removal of LWE based on low-order polynomial along-track filter



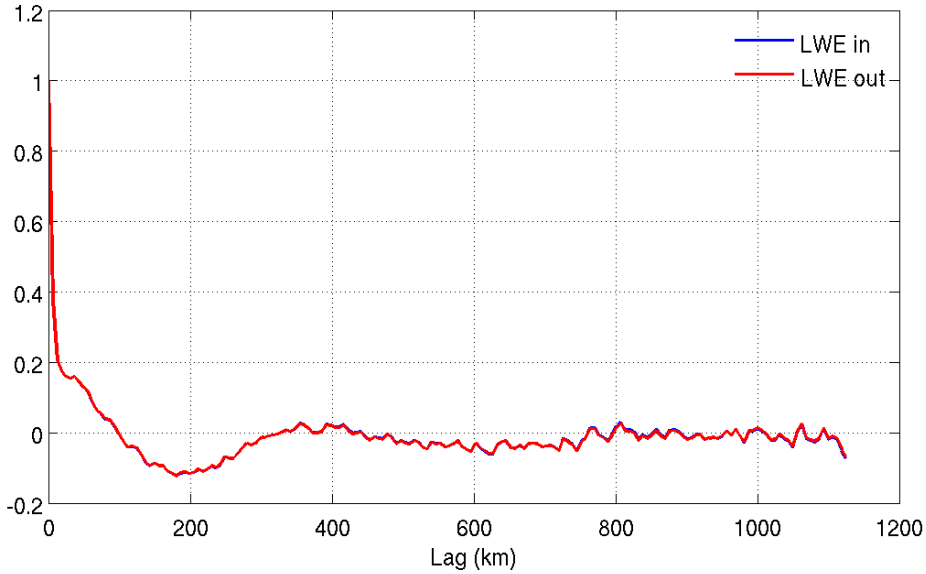
- Removal of LWE leads to reduction of rms error estimates by at most 10 %
- LWE consistent with typical orbit errors on the order of 1 cm, but possible correlations likely yield lower bound

Spatial correlation functions

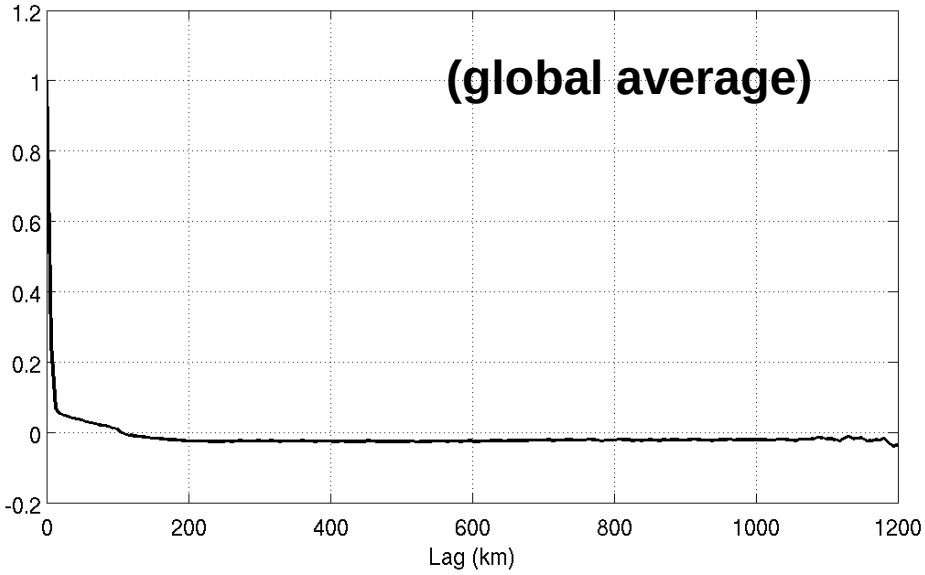
50S, 240E



10 x 10 degree boxes

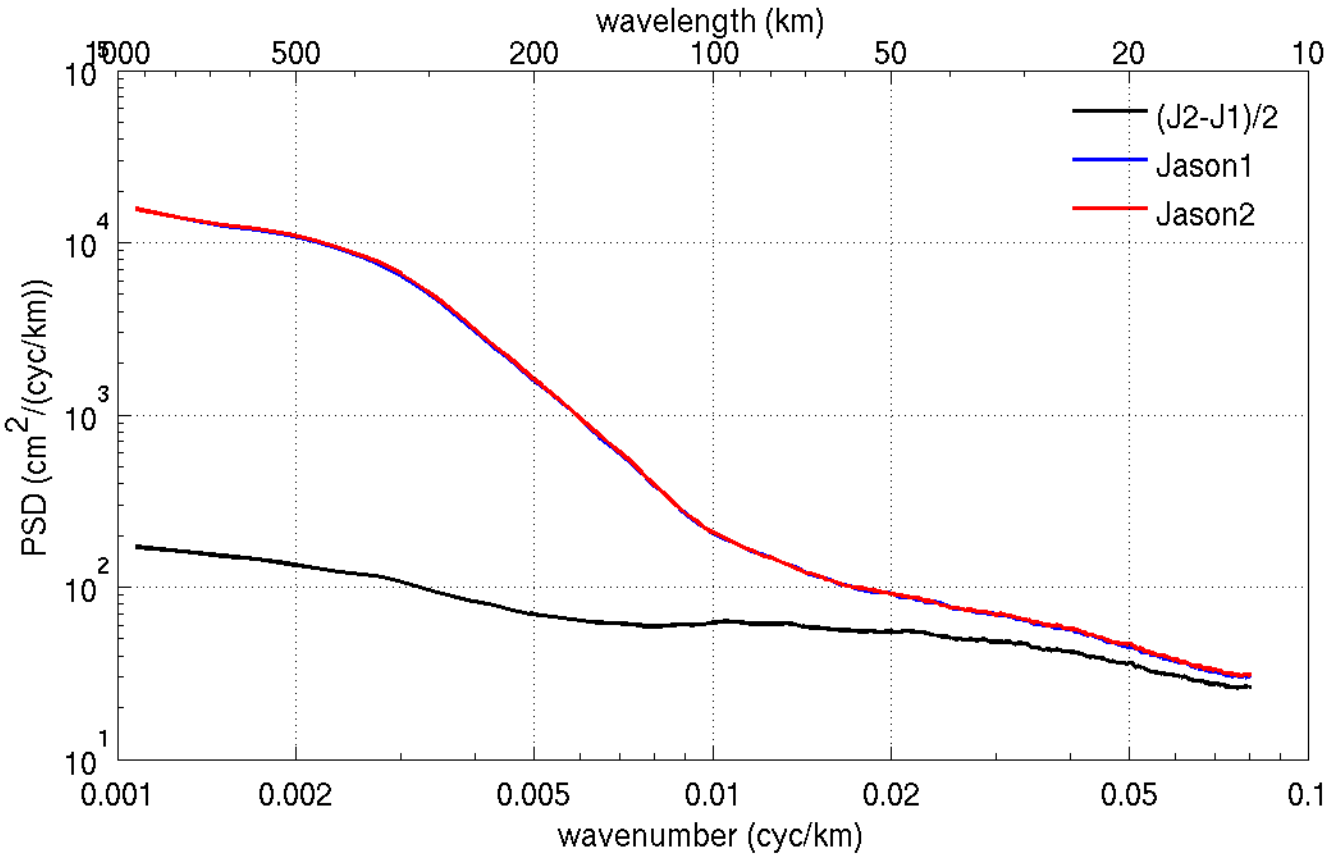


40N, 310E



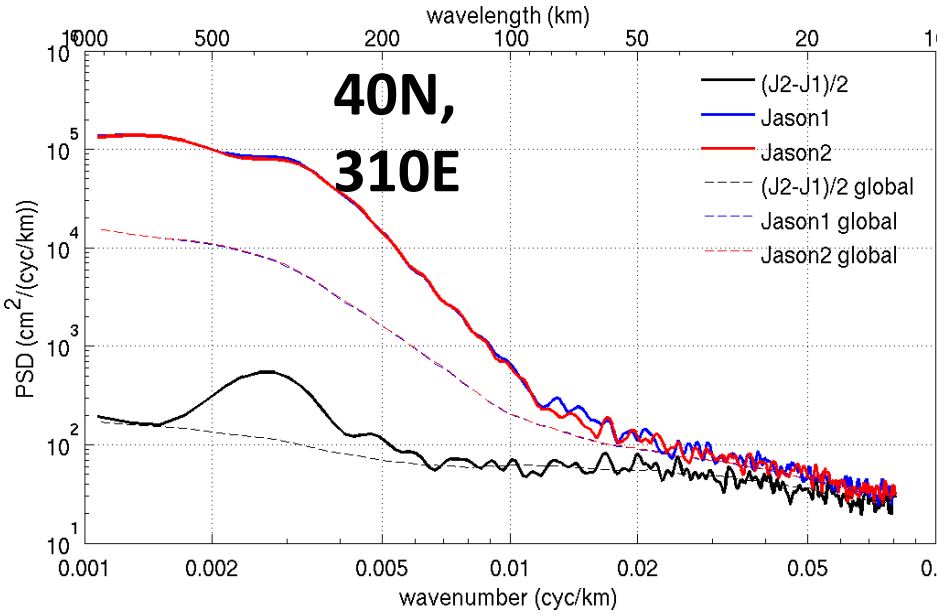
- **Correlations not affected by removal of LWE**
- **Sharply peaked at zero lag indicative of nearly white noise**
- **Similar results for time-lagged correlations (not shown)**

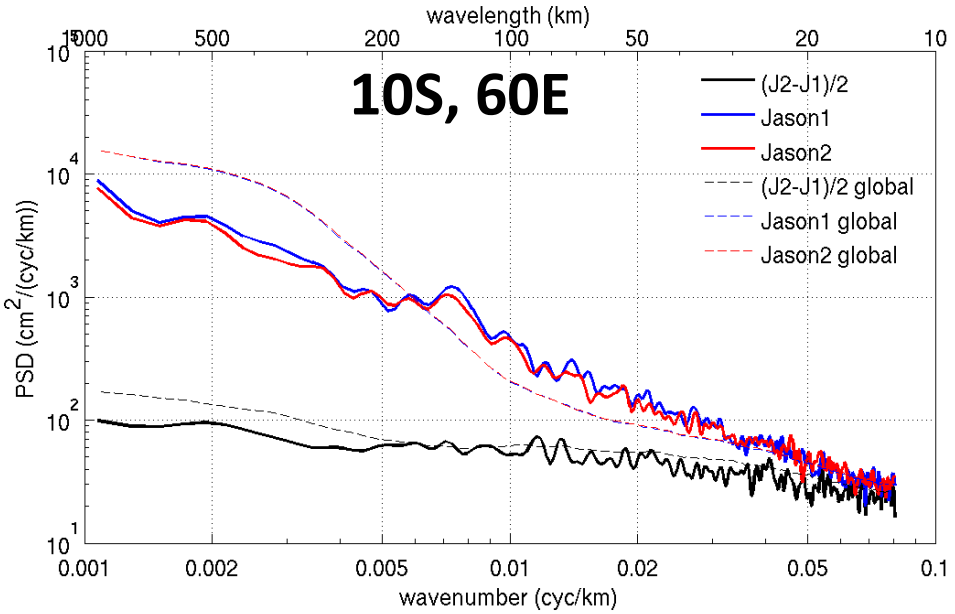
Average wavenumber spectra

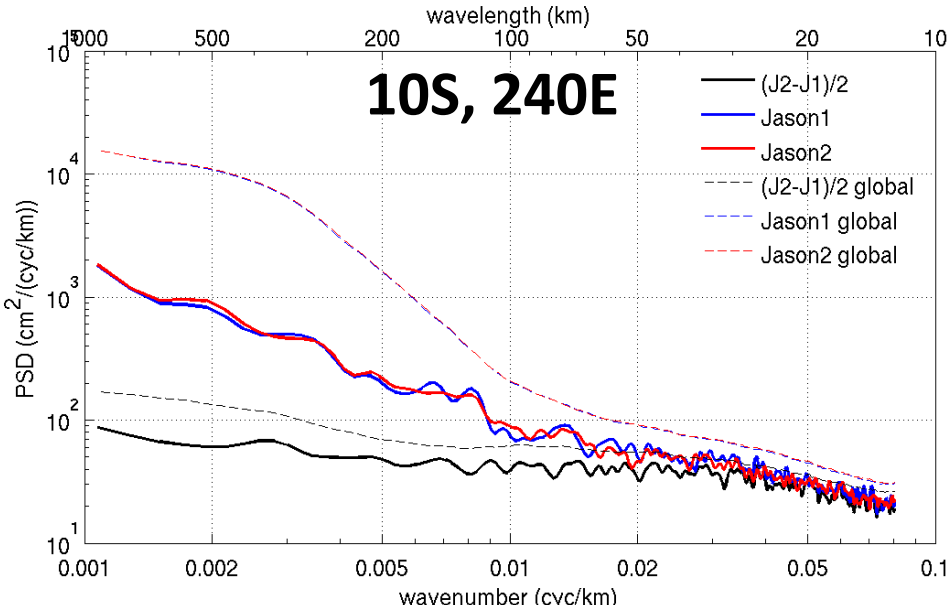


- J1, J2 spectra indistinguishable, variable slopes, one break at ~100 km
- Noise spectrum nearly flat (mean slope ≈ −0.4)
- S2N ≈ 10 at wavelengths of 150 km and longer
- Noise, signal spectra similar in slope+magnitude at wavelengths < 50 km

Some regional spectra

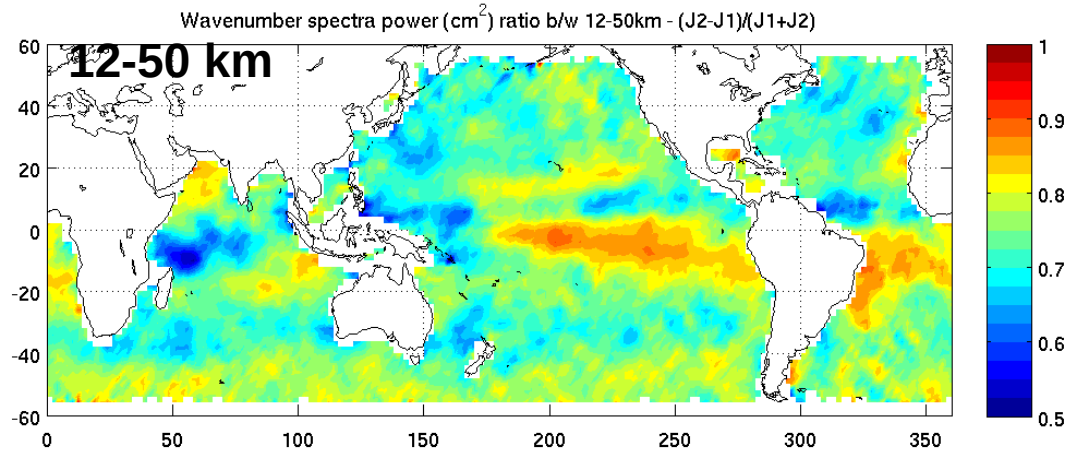


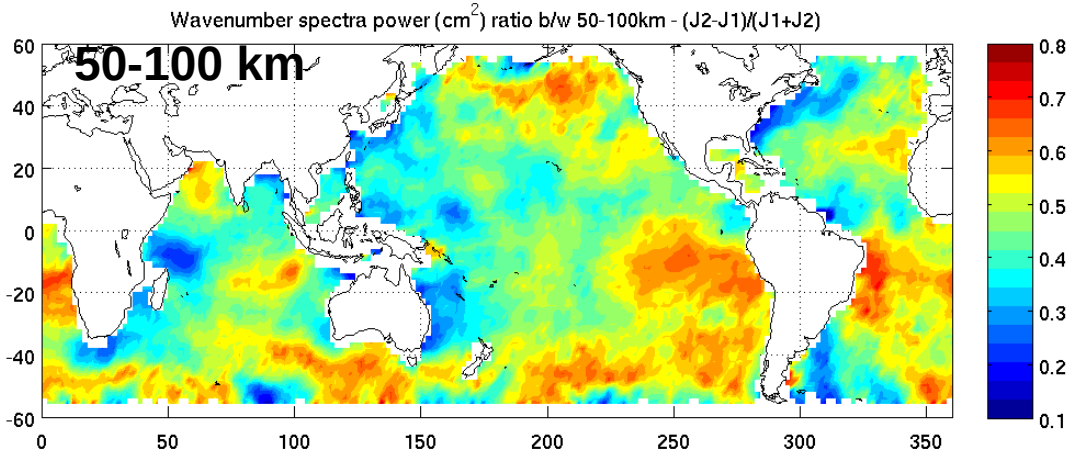




- Signal variance much more regionally dependent than noise
- Signal-to-noise ratios can vary with region

Noise vs. Signal





Noise-to-signal ratio:

Var(J1 − J2) / Var(J1) + Var(J2)

- **Altimeter measurements for wavelengths < 50 km at the noise level**
- Tendency for better noise-to-signal ratios in western basins, where signals can be stronger

Summary remarks

- Global average errors ≈ 2 cm, smaller in the tropics, larger at higher latitudes…possible lower bounds in case of possible correlated errors
- Comparison J1−J2, J1−TP suggest higher errors for TP…need to reanalyze J1−TP based on most recent GDR versions
- Long wavelength errors typically small and consistent with orbit error budgets…possibility of correlated errors
- Errors indistinguishable from white noise in time, nearly white in space
- Error spectra similar in slope and magnitude to J1, J2 spectra at wavelengths < 50 km
- Signal-to-noise statistics dependent on region, analyses at wavelengths < 100 km possible in some areas (e.g. western basins)
- Local robust statistics difficult to attain given only 20 cycles of overlap data, but patterns show considerable large-scale structure