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Tides and Near-inertial Oscillations from HF Radar

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SWOT SURFACE WATER AND OCEAN TOPOGRAPHY

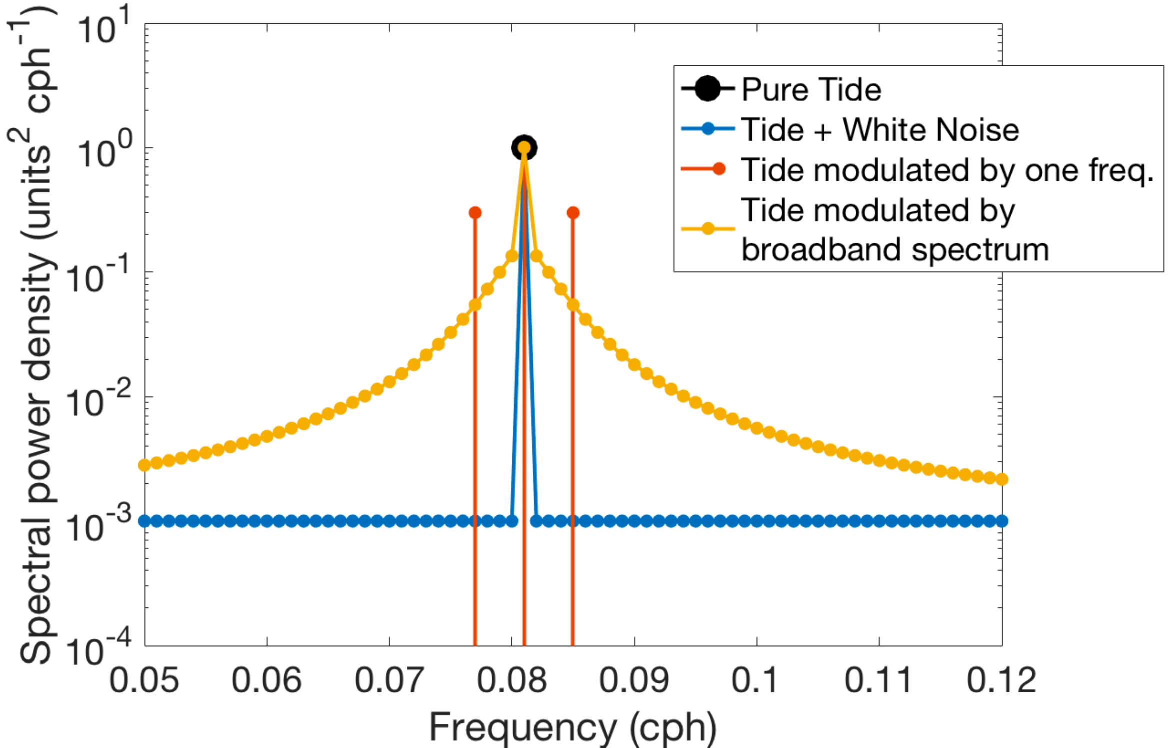
Small-scale processes and SWOT

- "*Retrieving small-scale SSH observations and performing relevant field reconstructions from the SWOT mission data can be limited to spatial scales longer than* [*70 to*] *85 km, based on a comparison of both spectra of SWOT-mapped SSHs and true SSHs, and may require more information on the vertical structure of the ocean (e.g., Gaultier et al., 2016, Wang et al., 2018).*" (Lee and Kim 2021)
- In that study, submesoscale ageostrophic currents contribute up to 50% of variance, mostly comprised of near-inertial currents and internal tides.
- We show results of harmonic analysis for tides and near-inertial currents from high-frequency radar (HFR) surface currents, to ascertain the non-phase-locked (non-stationary) fraction of tidal variance, and the distribution and length scales of tidal and NI signals

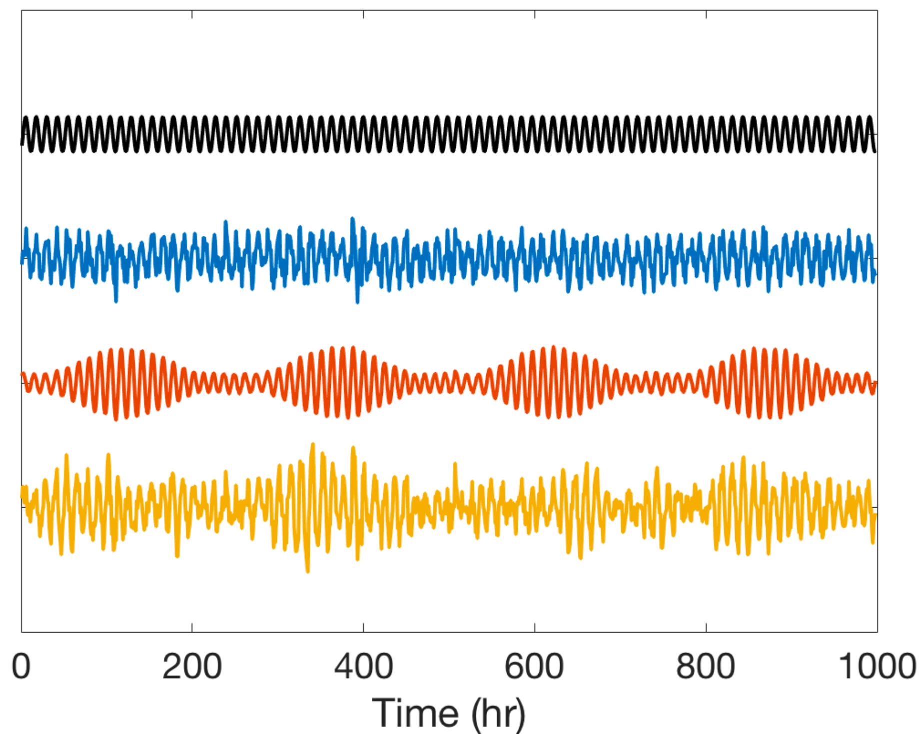
Predictability of the Internal Tide

- Characterizing the non-phase-locked tide (also *incoherent* or *non-stationary*) is an ongoing challenge for altimetry due to small spatial scales and long satellite repeats relative to tidal periods
- Schematically:

Frequency Domain

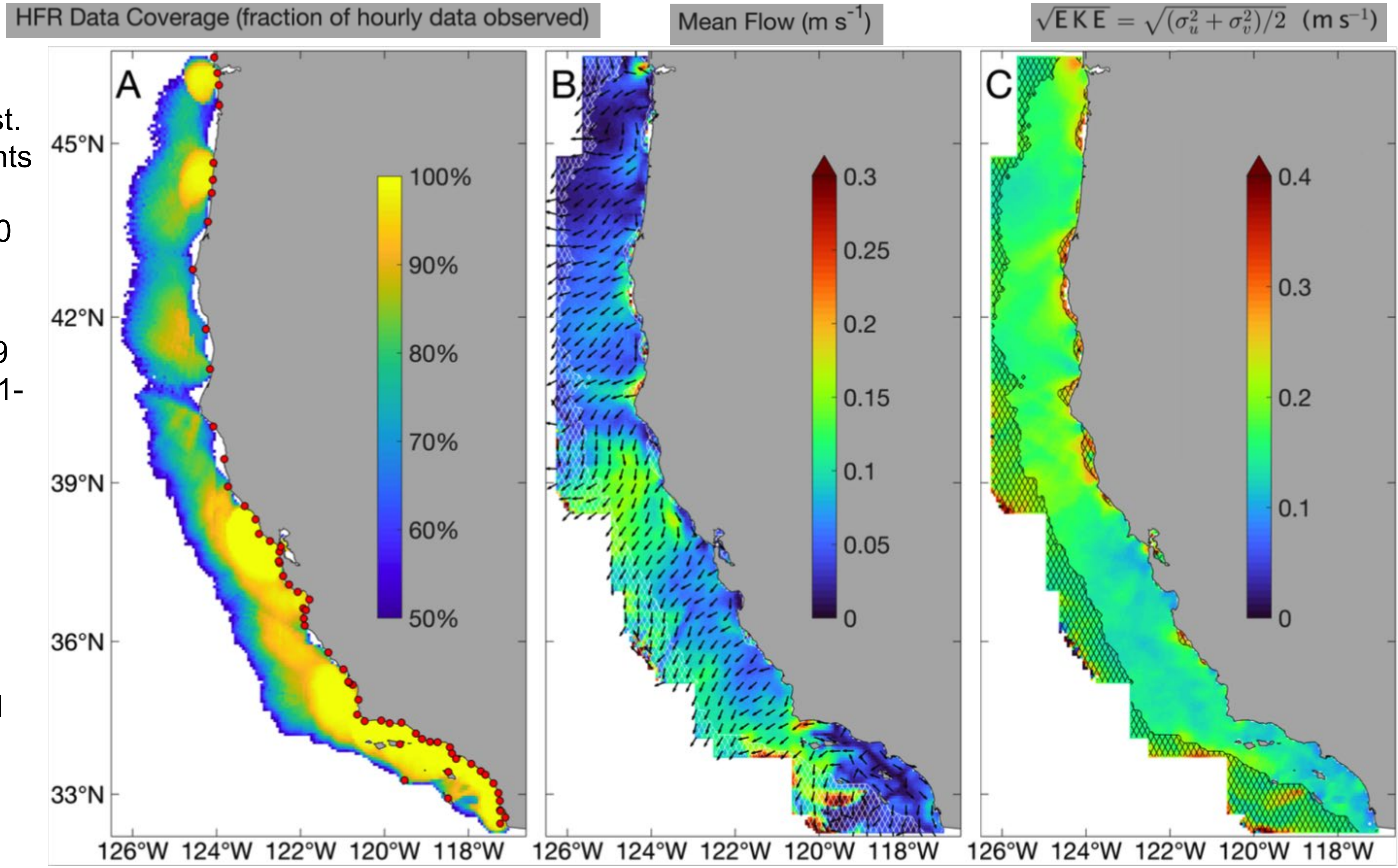


Time Domain



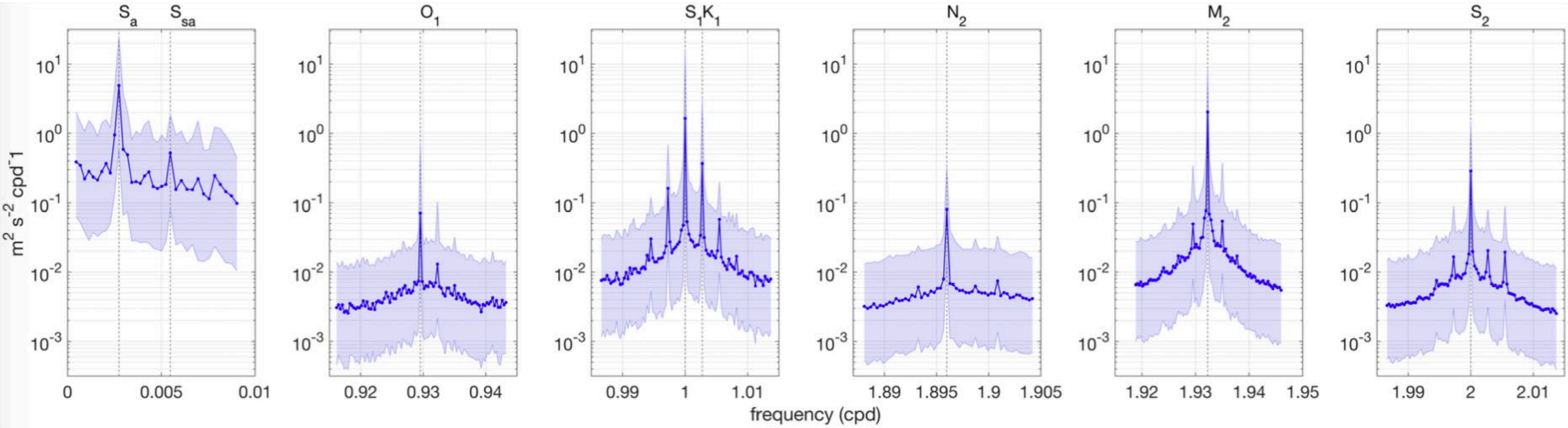
High-frequency Radar (HFR)

- Coastal HFR stations along the US West Coast. Measures surface currents using Bragg scattering, radar frequencies of 5-40 MHz.
- 6km gridded data, over 9 years hourly sampled (01-01-2012 to 01-04-2021)
- Coverage and precision depend on antennae geometry
- Useful to assess internal tide at O[10] km scale



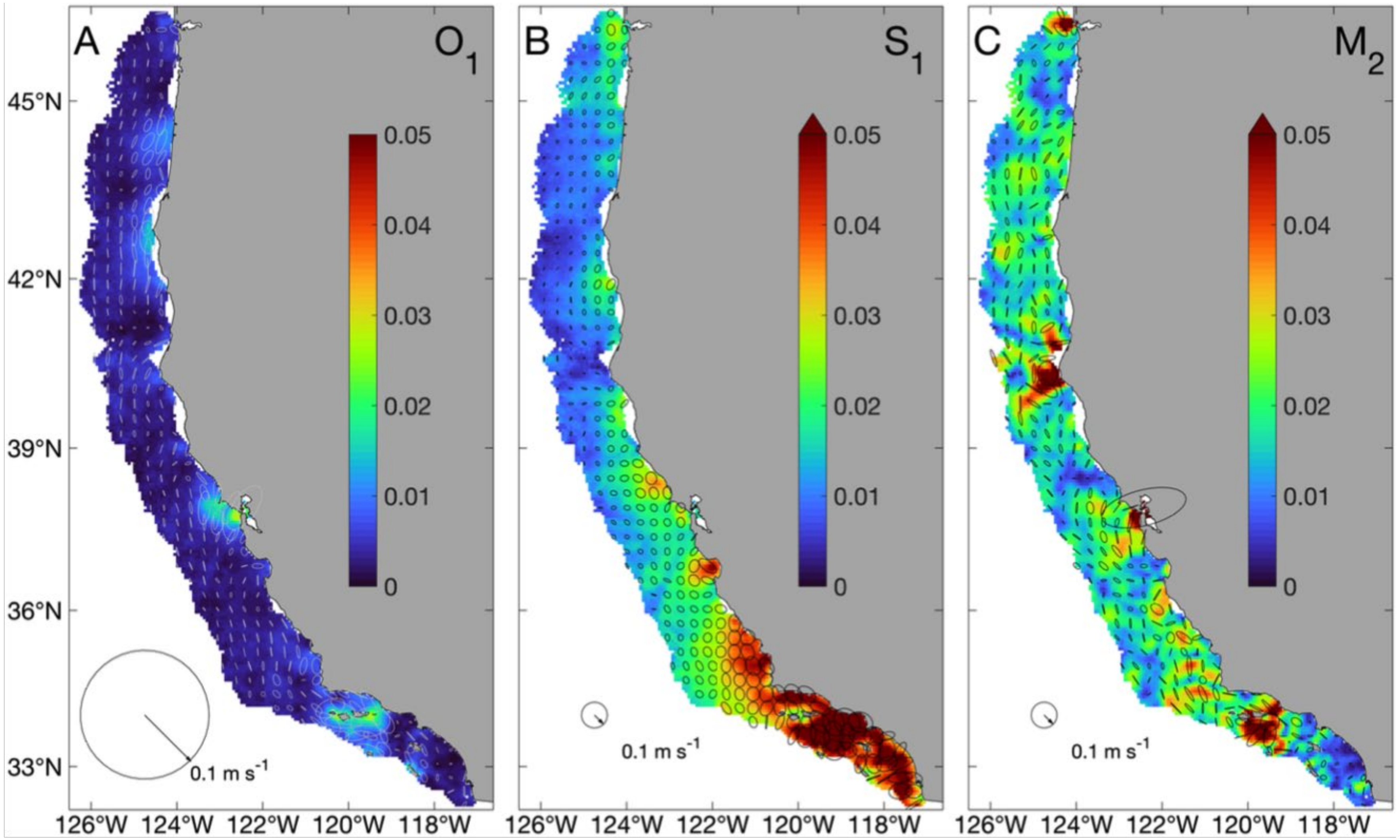
Tidal Constituents: Cusps and Phase-locked Energy

- Fitting to many close frequencies recovers information about tidal modulation



Phase-locked Currents: O_1, S_1, and M_2

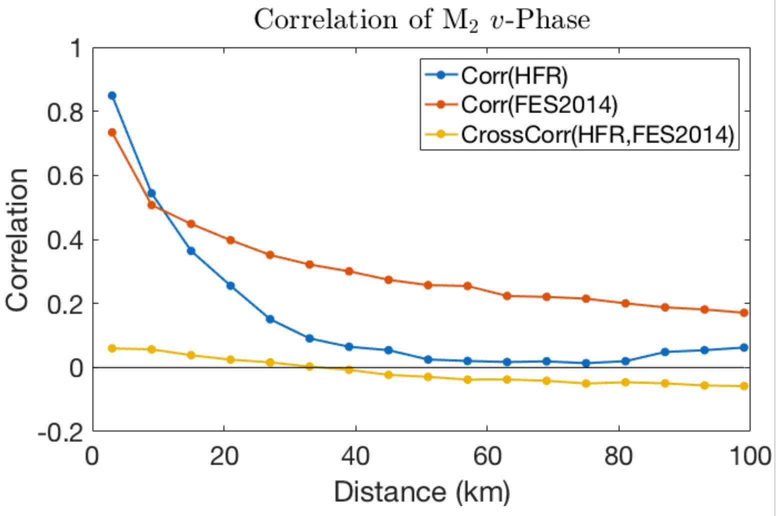
$$\sqrt{EKE} = \sqrt{(\sigma_u^2 + \sigma_v^2)/2} \quad (\mathrm{m\,s^{-1}})$$

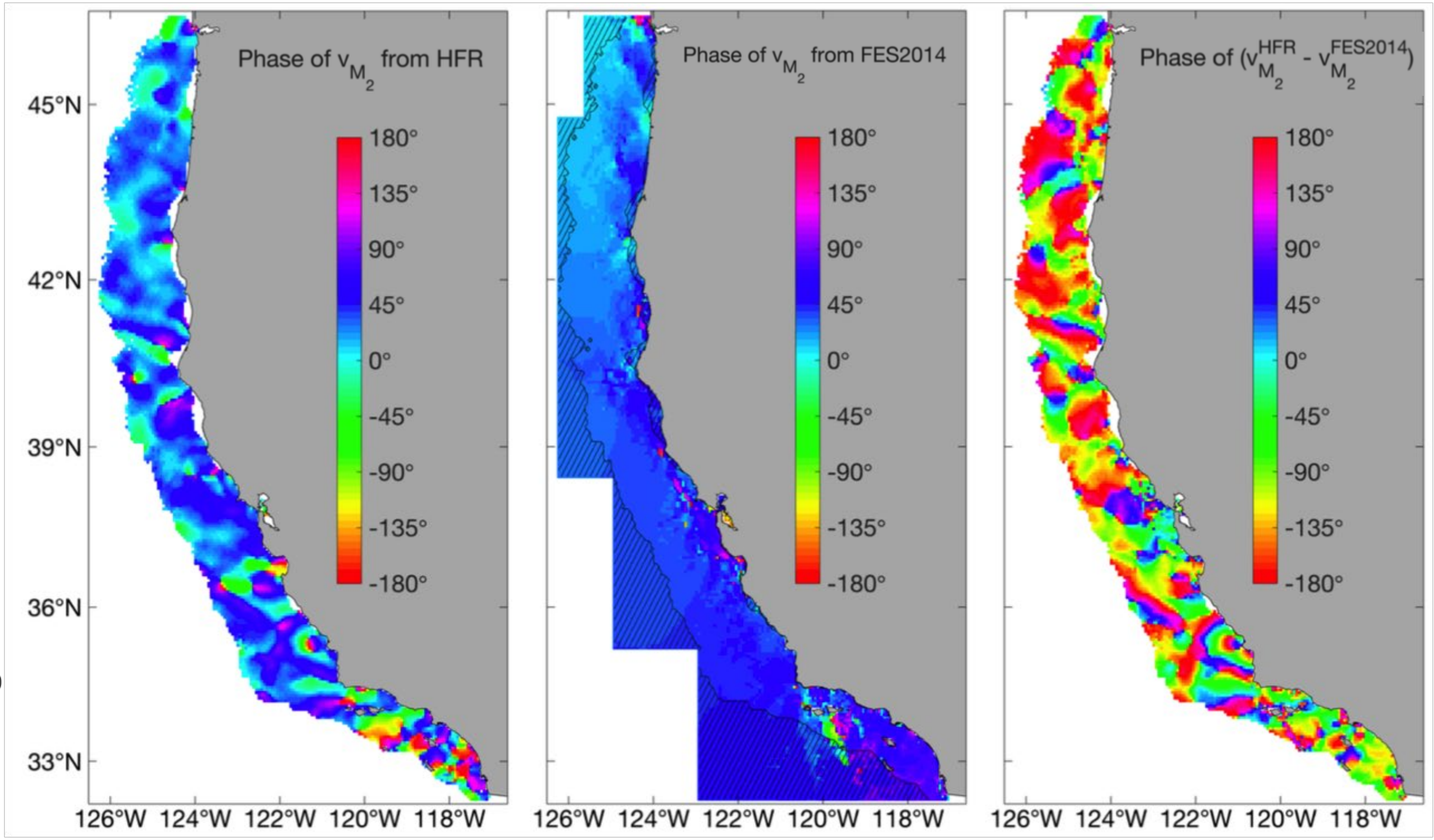


- O_1 (25.819 hr): non-propagating, weak. Only prominent near generation sites.
- S_1 (24 hr): Strong, wind-driven, polarized due to wind
- M_2 (12.421 hr): Strongest near generation sites, propagating frequency, complicated structure

Phase-locked M_2: Barotropic vs. Baroclinic

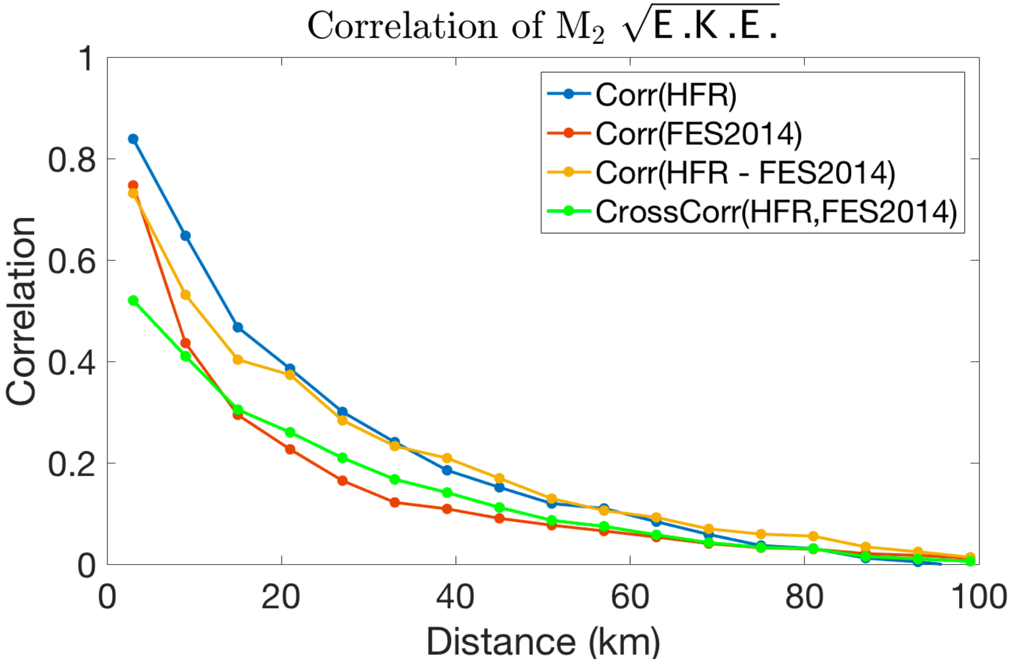
- *v*-component shown (*u* similar)
- Propagating structure recovered

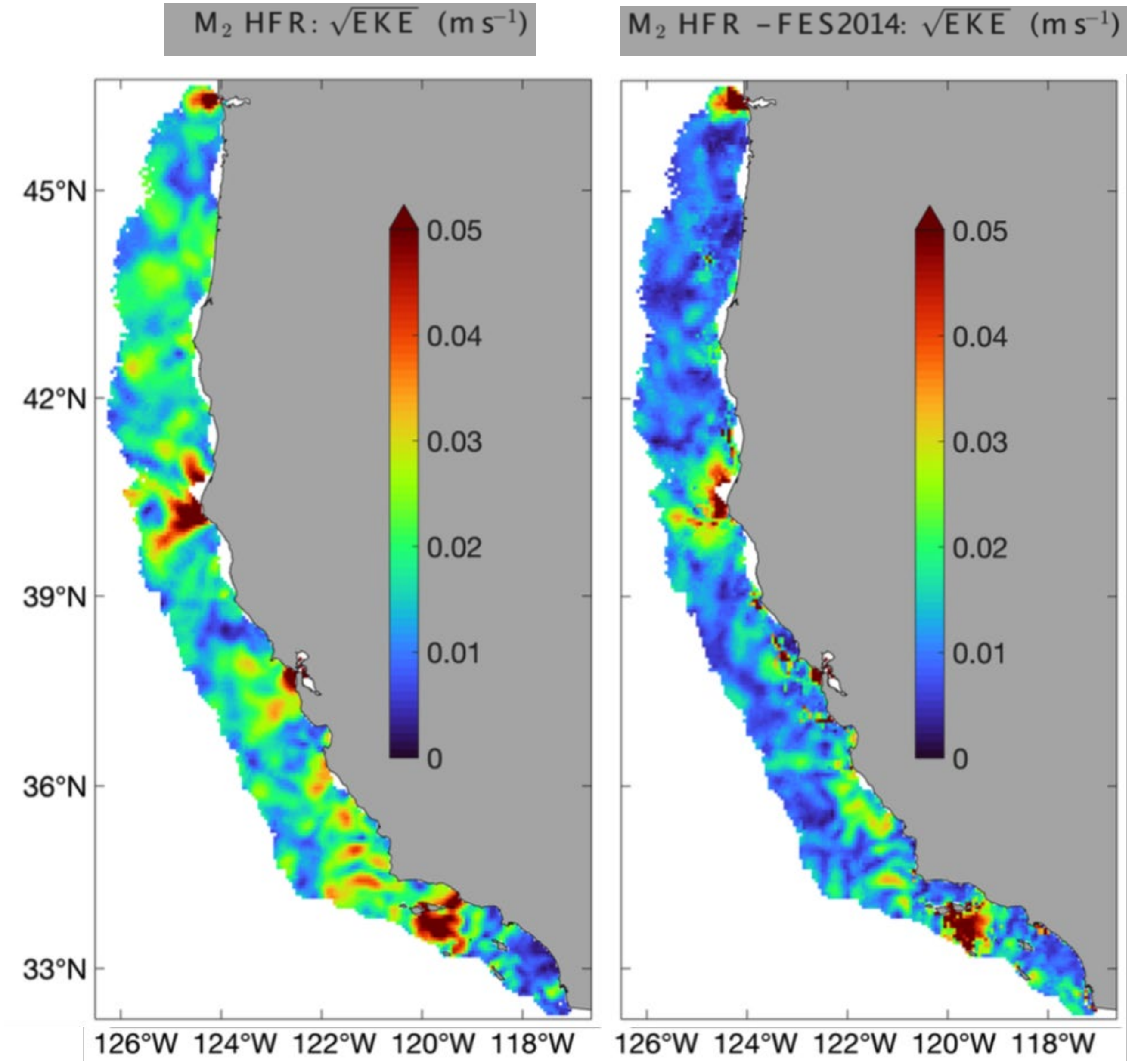




Phase-locked M_2: Barotropic vs. Baroclinic

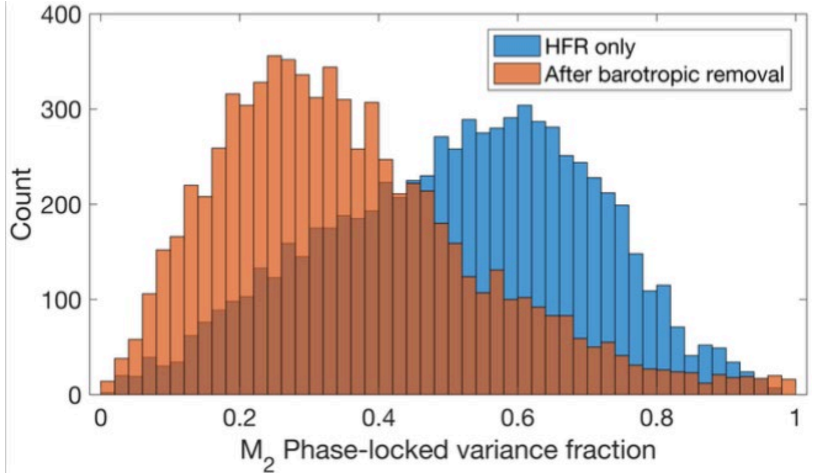
- Reduction in energy
- Minimal reduction in horizontal correlation length scale

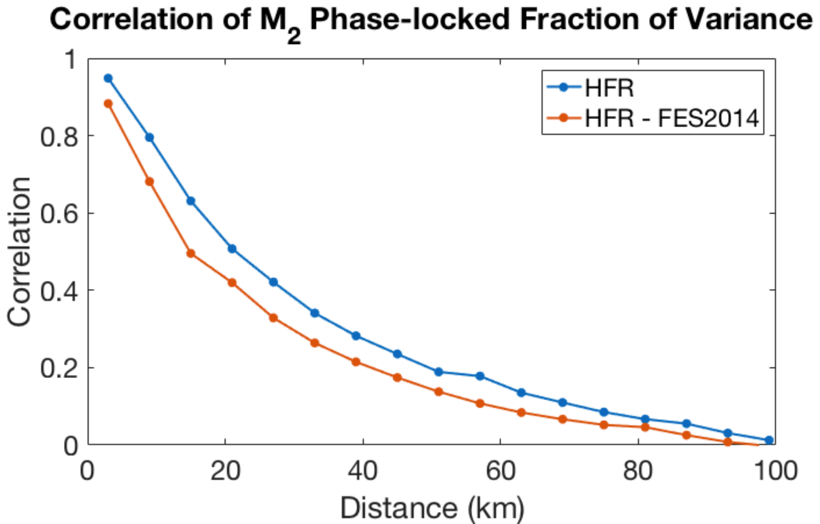


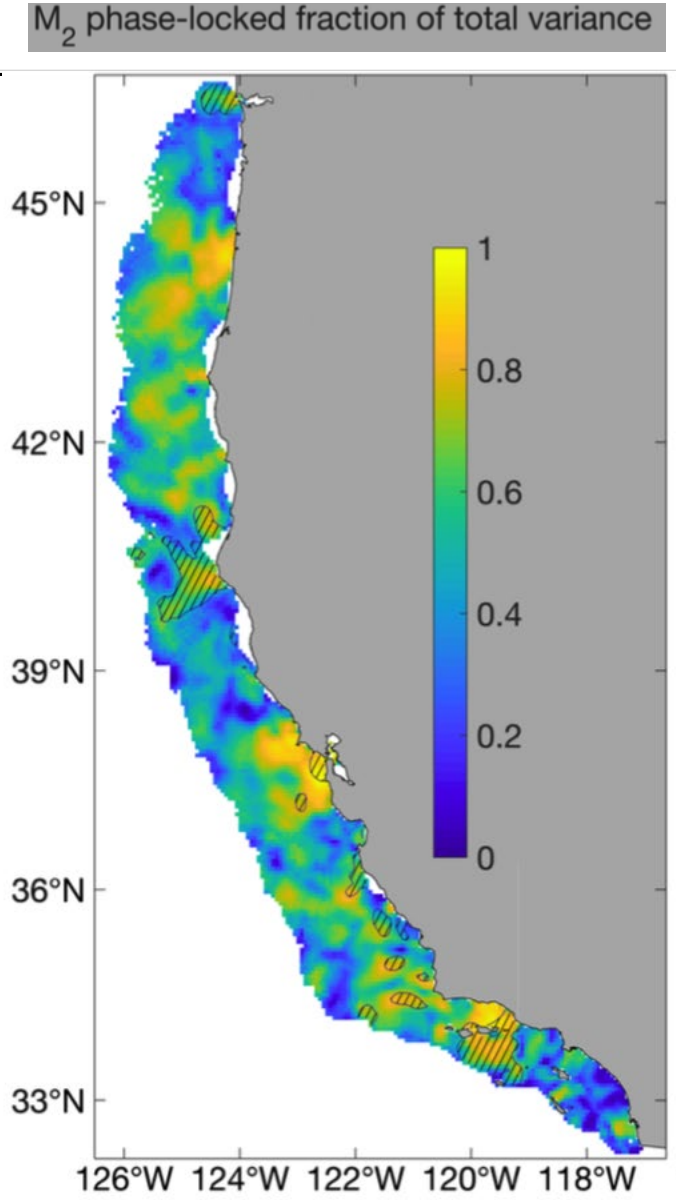


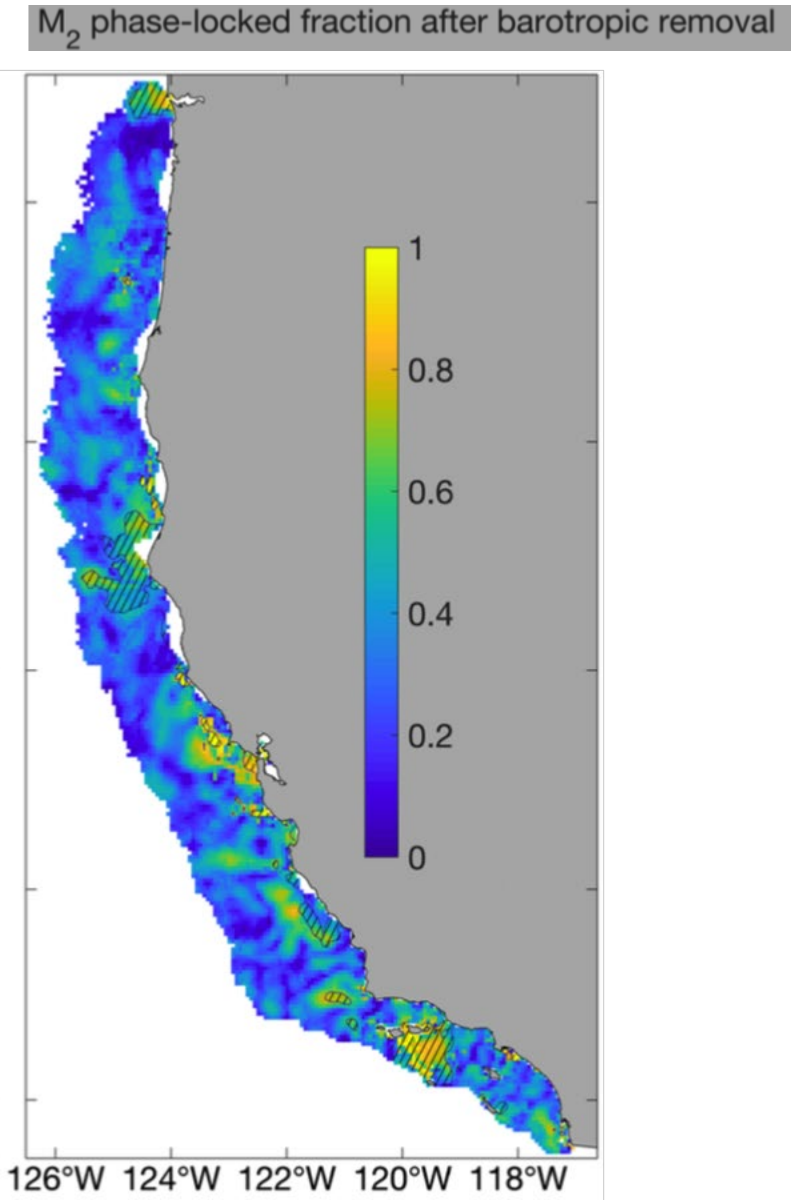
Fraction of Variance Phase-locked

$$\text{PL-fraction} = \frac{\text{variance at peak}}{\text{total variance in peak + cusp}}$$



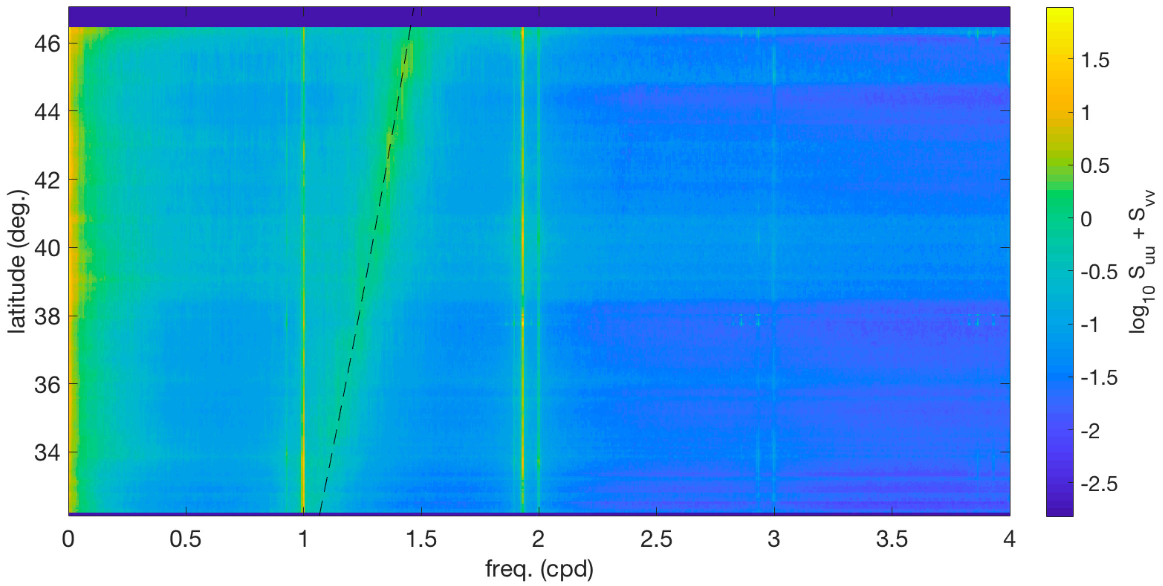


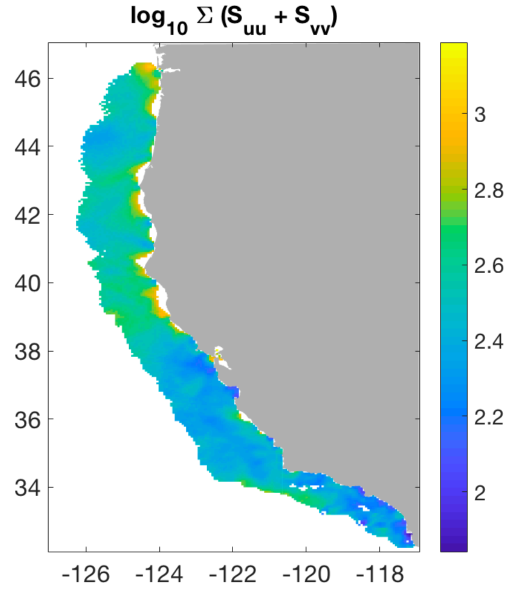


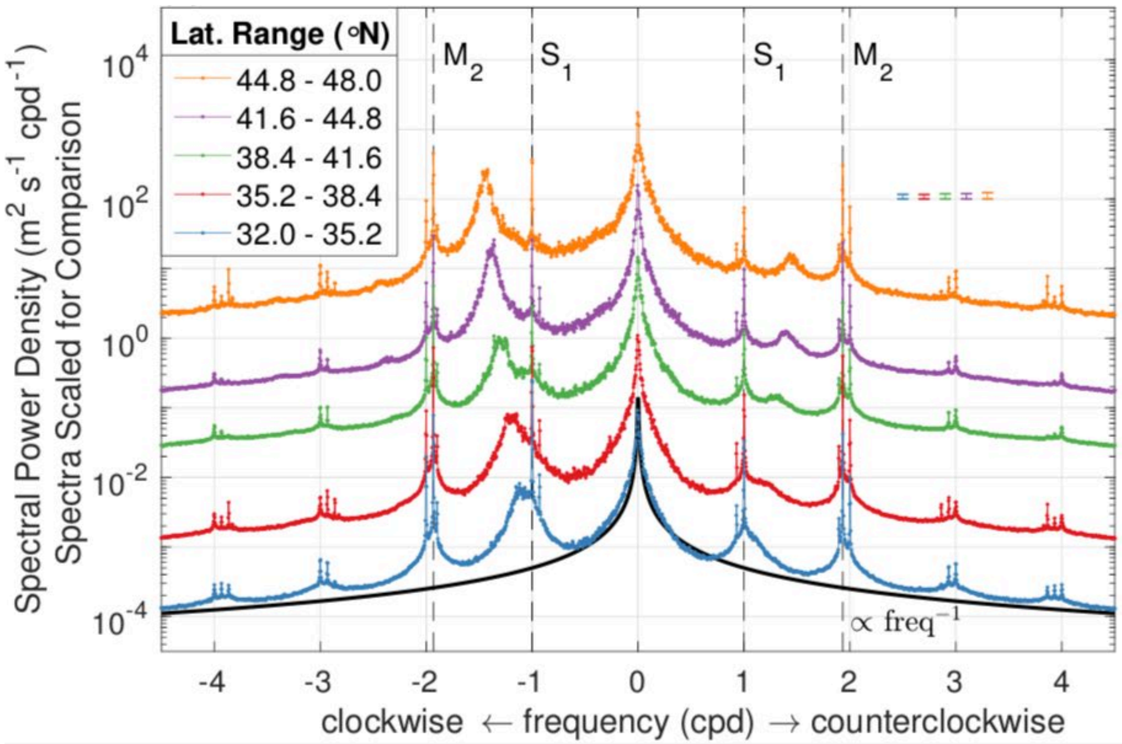


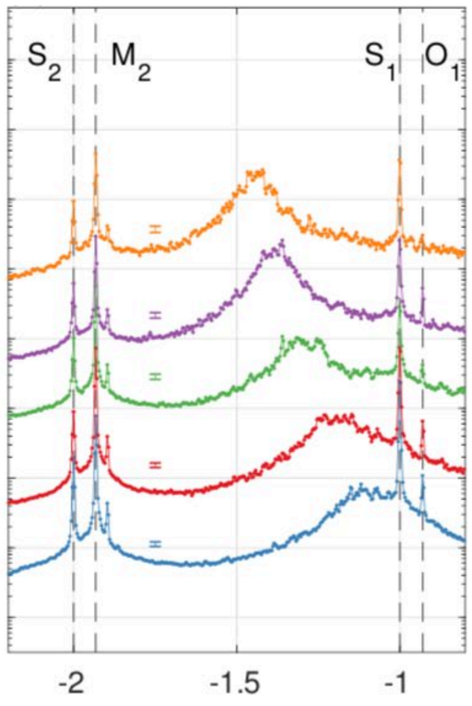
Near-inertial motions in HFR

- Broad peak shifting with latitude as expected
- Energetically comparable to tides



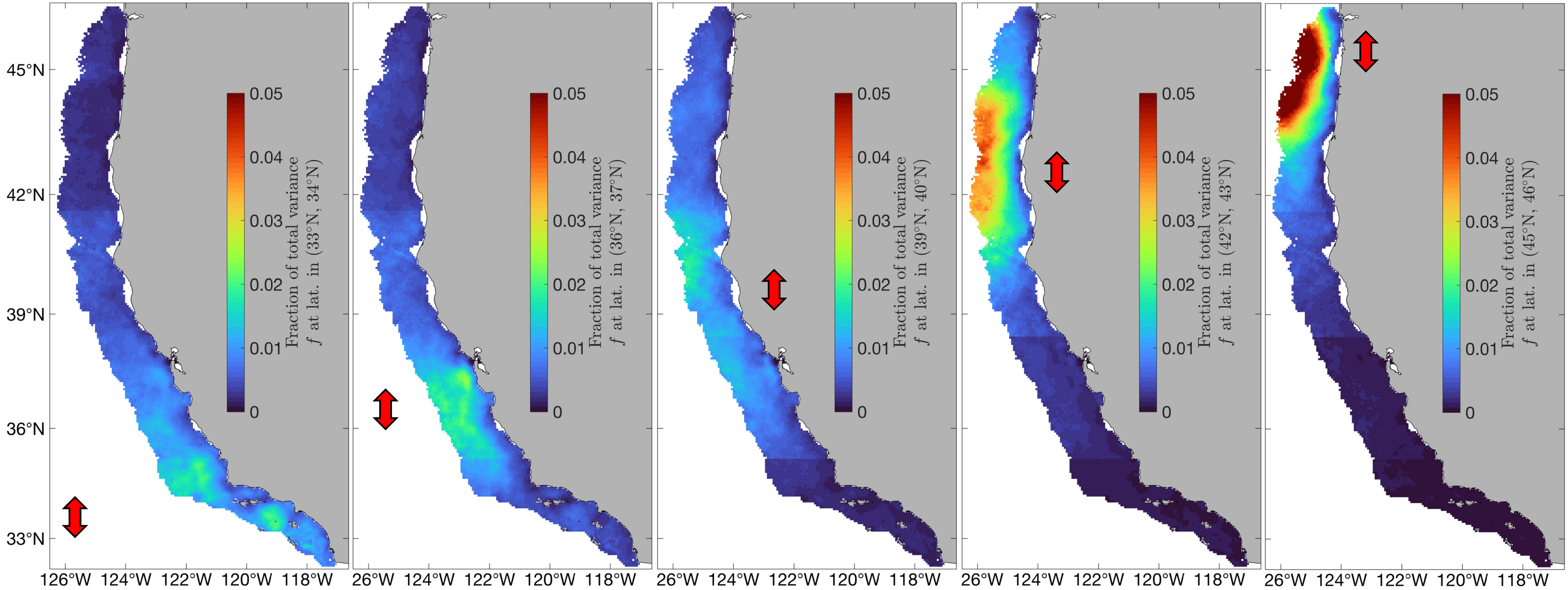






Near-inertial motions in HFR

- Northward and offshore intensification
- Minor methodological artifact (striping) to be removed shortly



Conclusions and Next Steps

- Our harmonic analysis of high-frequency radar recovers detailed information on tides and near-inertial currents
- Variance of both is substantial; spatial scale and distribution vary by constituent and inertial resonant latitude
- FES2014 accounts for some M_2 phase-locked variance, >50% of remaining is typically non-phase-locked
  - Before removal: PL fraction correlation length scale ~21 km
  - After removal: ~15 km
- Manuscript in preparation for tides results to address: *how much of the tides are phase-locked at scales that HFR can see, and what are the characteristic scales and locations at which phase-locked vs. non-phase-locked fraction varies?*
- Near-inertial currents study under way

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