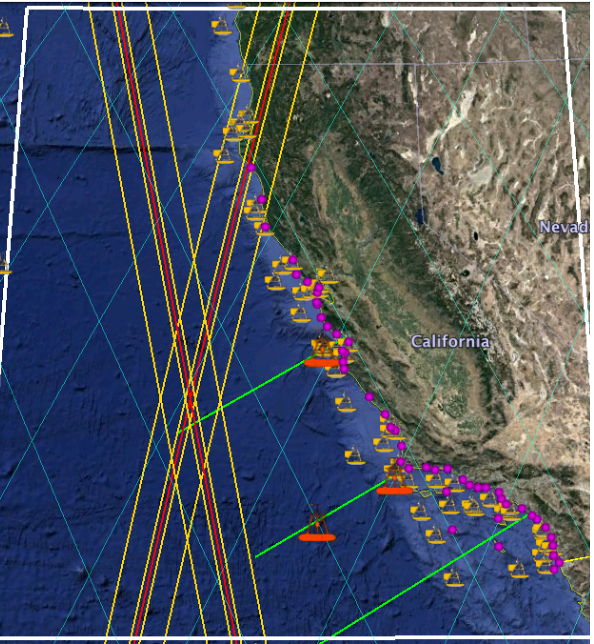
High-wavenumber variability in the California Current: Evaluating sub-100 km scales with high-resolution altimetry, ADCP, and model output



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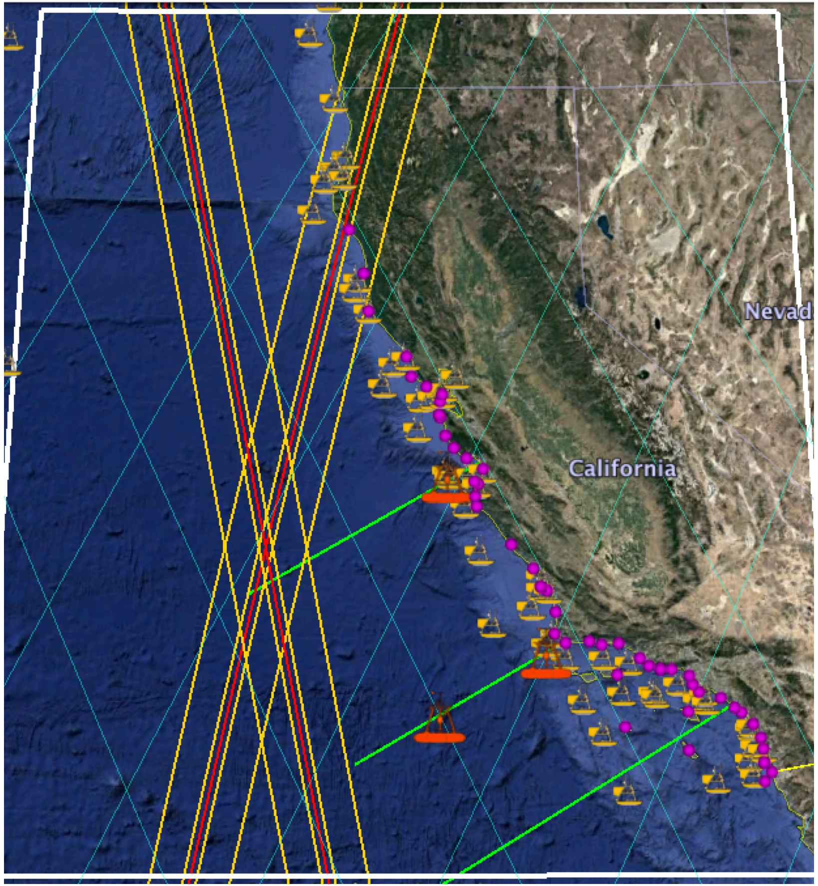
California Current: Test bed for SWOT

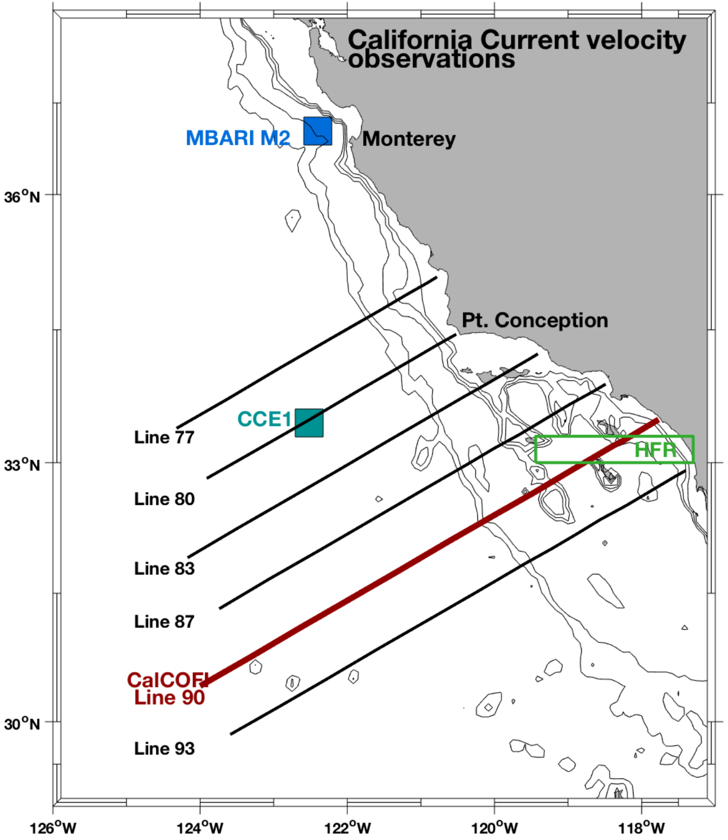


Goal: Develop regional version of MITgcm to assimilate SWOT's high-wavenumber measurements

Build on existing regional ECCO machinery and network of observations

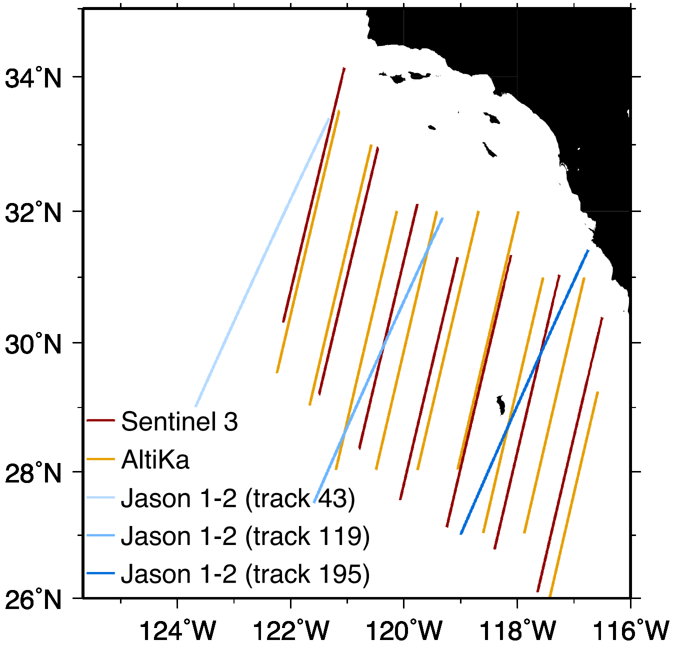
- SWOT (swath boundaries)
- Nadir altimetry (Jason)
- Moorings
- HF radar
- Buoys (NDBC)
- Glider lines

California Current: In Situ Observations



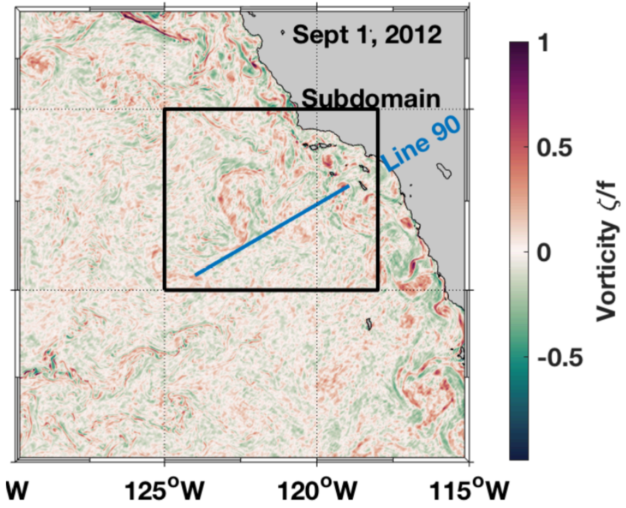
- MBARI M2: Steric height from temperature/salinity measurements in upper 300 m, June-Sep 2009
- CCE1: Steric height from temperature/salinity measurements in upper 300 m, June-Sep 2016 & 2017
- CalCOFI Line 90: Shipboard ADCP velocity transects, 39 cruises, October 1993 to October 2004
- HFR: High frequency radar (Kim et al., JGR-Oceans 2011)

California Current: Altimetry Products



- Sentinel 3: SAR mode altimeter, Jan 2017 to May 2018, 20 cycles, 7 ground tracks
- AltiKa: October 2013 to May 2016, 25 cycles 9 ground tracks
- Jason-1/2 ALES: January 2002-August 2016, 557 cycles, 3 ground tracks

KE spectra: global model & observations

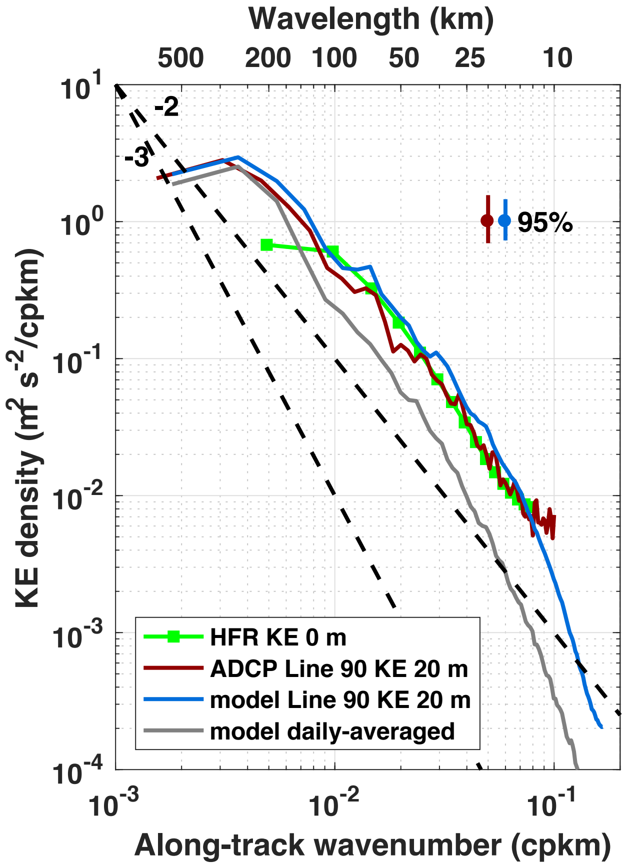


- global, 1 year simulation
- forced with tides & ECMWF
- 90 vertical levels
- 1/48° resolution

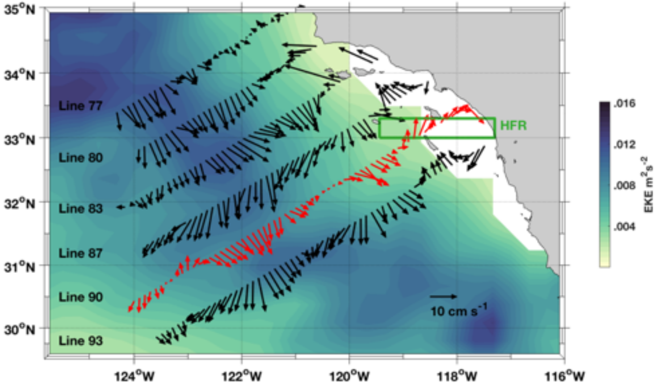
ADCP & model-hourly KE at 20 m & HFR KE at 0 m have similar shape, slope and energy levels

Model-daily KE has steeper slope, less energy at high wavenumber

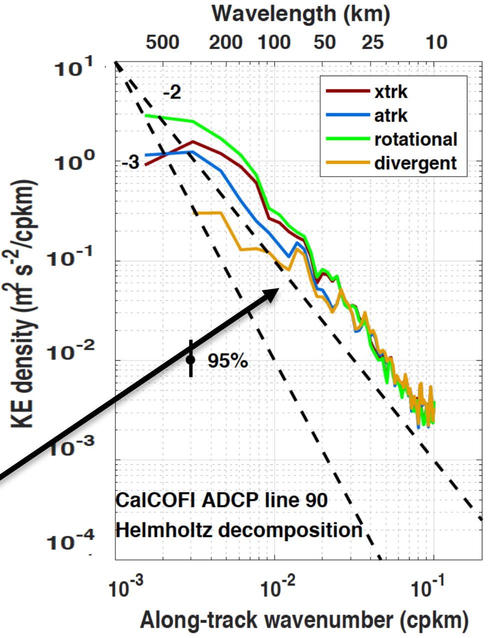
Chereskin et al., JGR-Oceans, 2019



Balanced flow regime: observations (& model)



Helmholtz decomposition to separate rotational & divergent components



ADCP Line 90

1993-2004, 39 cruises

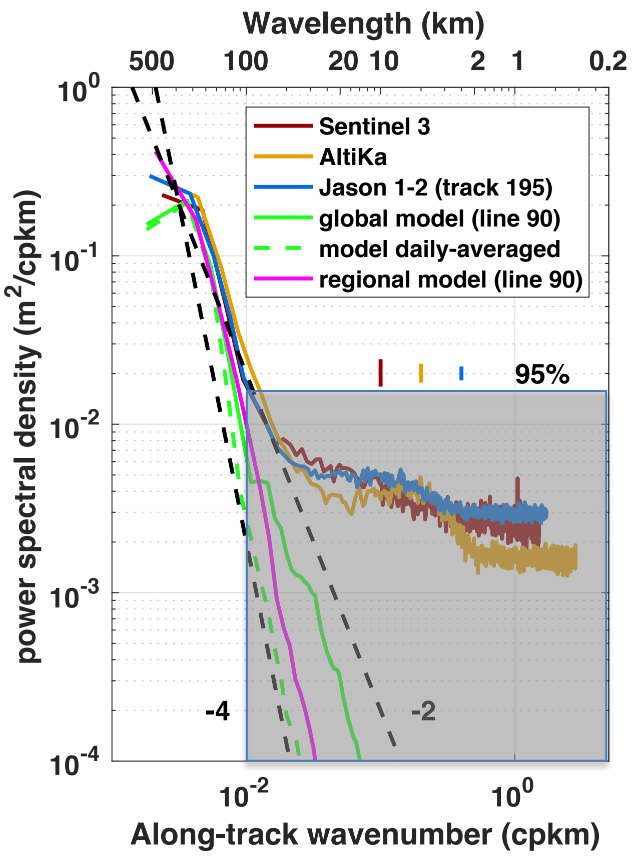
Transition from balanced regime observed in ADCP around 70 km

(Transition in model around 100 km (not shown))

Chereskin et al,, JGR-Oceans, 2019

Sea surface height wavenumber spectra

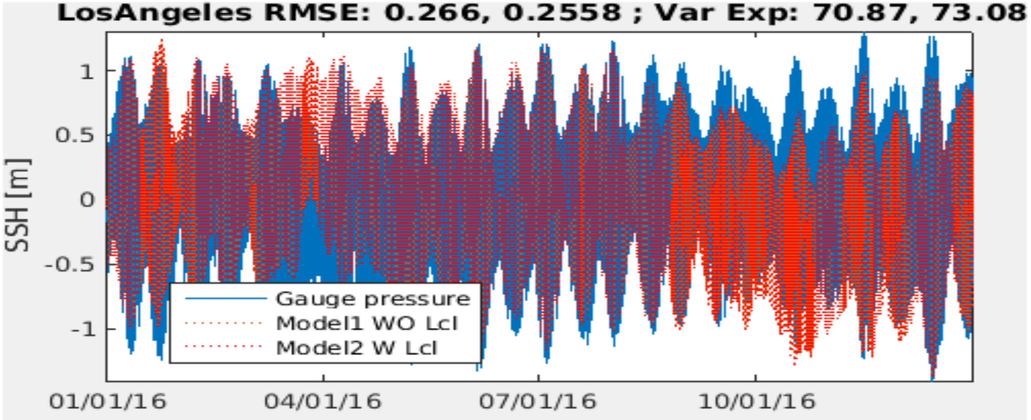
- Global model: spectra from hourly output vs daily averages
- Regional model: less energetic than global model at high wavenumbers---more like daily averages
- Altimeter spectra more energetic than models from 100-50 km and flatten out (implying "noise") for scales smaller than ~50 km.



Adapted from Chereskin et al., JGR-Oceans, 2019

Regional MITgcm built to match MITgcm (llc4320) global model

- ~2 km resolution
- Tidal forcing on boundaries and surface
- 90 vertical levels allows internal waves to propagate

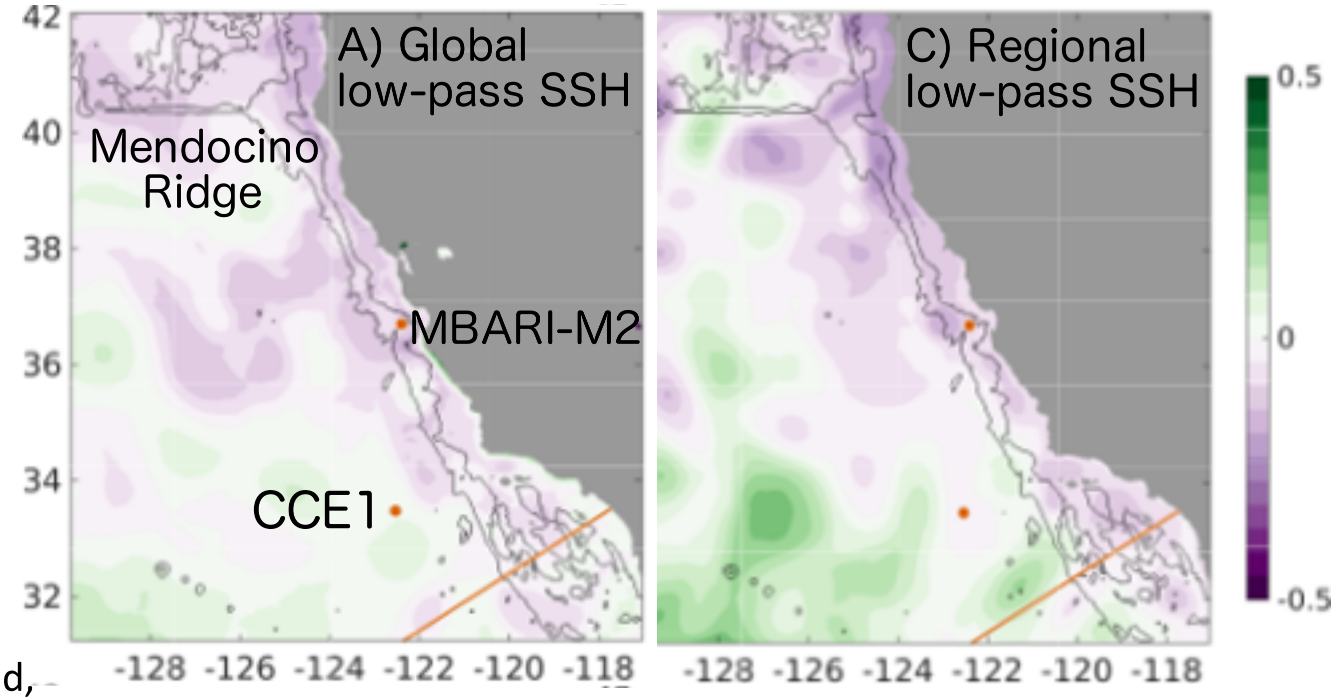


Tide in 2016 for Los Angeles replicates major features of tide gauge observations

Regional MITgcm built to match MITgcm (llc4320) global model

Global LLC4320 (left) vs a regional version with same numerics (right)

Low-pass SSH



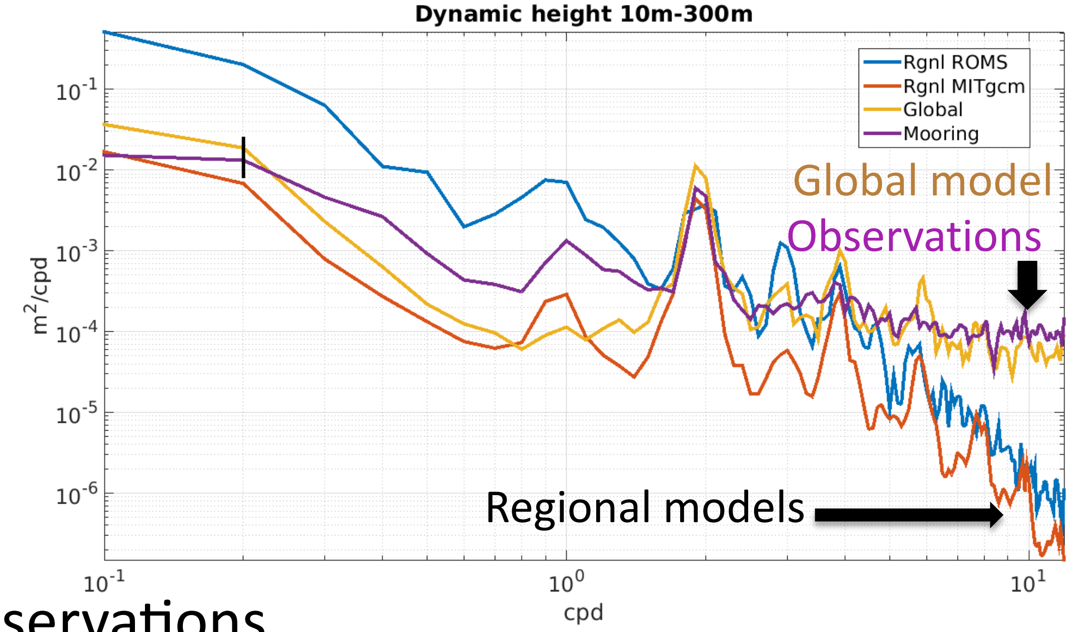
LLC4320 **MITgcm regional**

Mazloff et al., submitted, JGR-Oceans., 2019

Can a regional model generate enough internal wave energy?

Regional tests

- MBARI M2 Mooring has high-frequency energy
- Global model (llc4320 MITgcm) replicates mooring energy
- Regional MITgcm and ROMS missing high-frequency energy

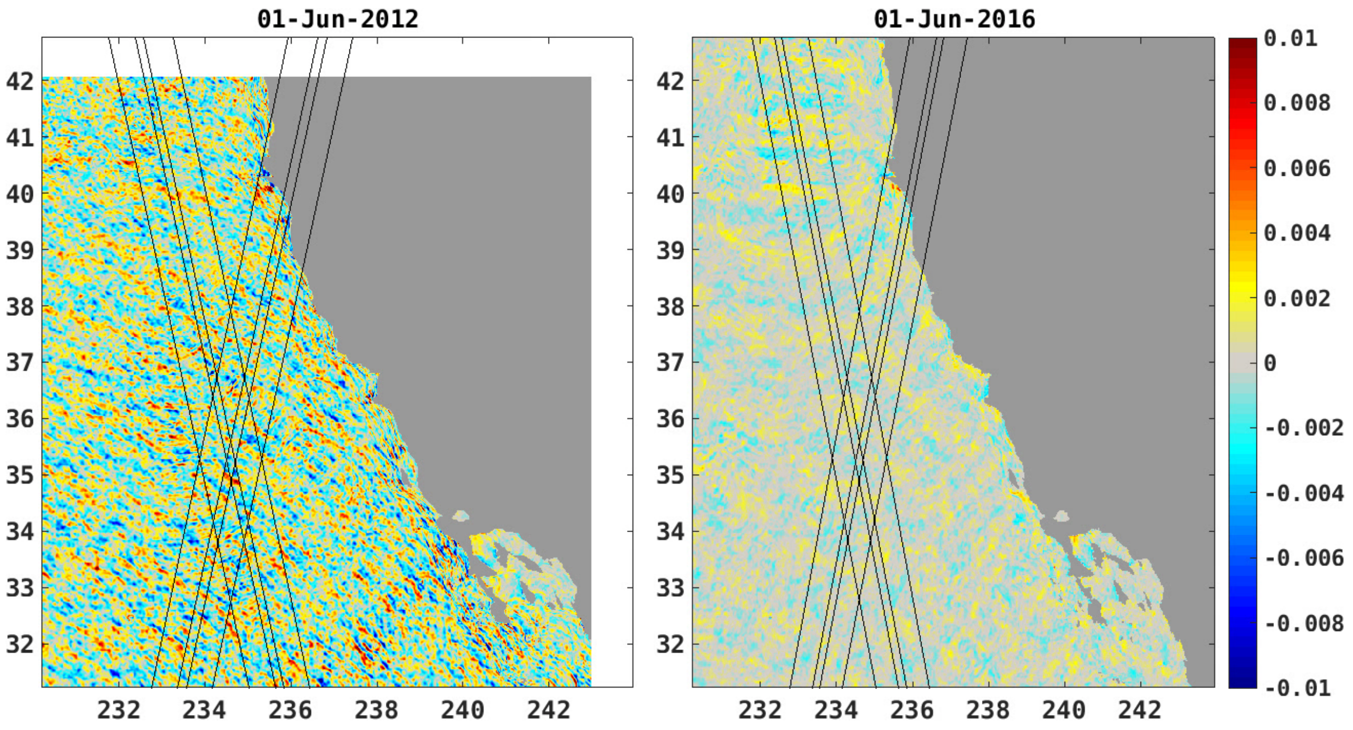


Hypotheses:

- Interannual variability in observations
- Open boundaries don't let in enough energy

Mazloff et al., submitted, JGR-Oceans, 2019

Vertical velocity (*W*) at 500 m

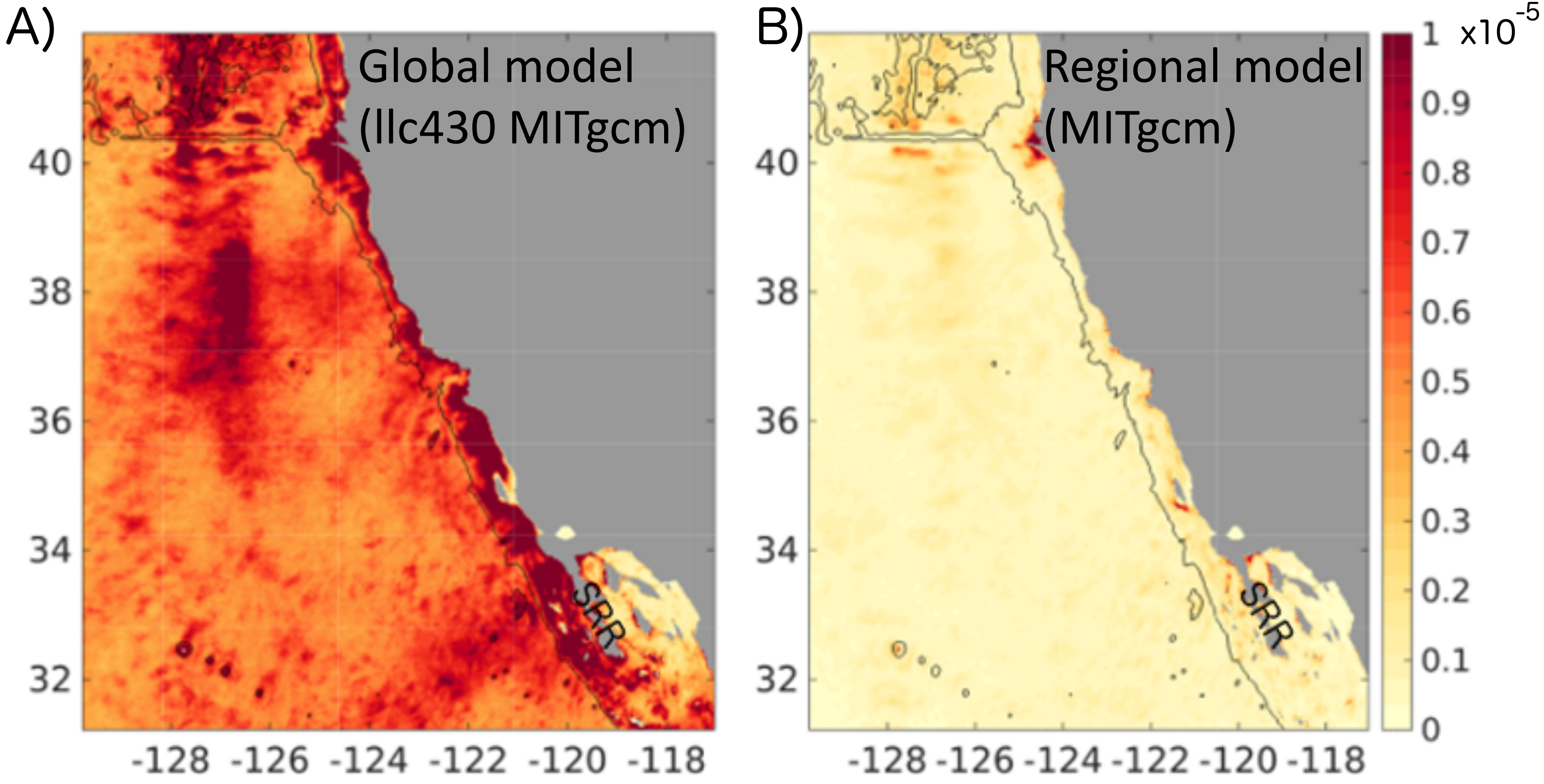


Mazloff et al., submitted,
JGR-Oceans, 2019

LLC4320

MITgcm regional

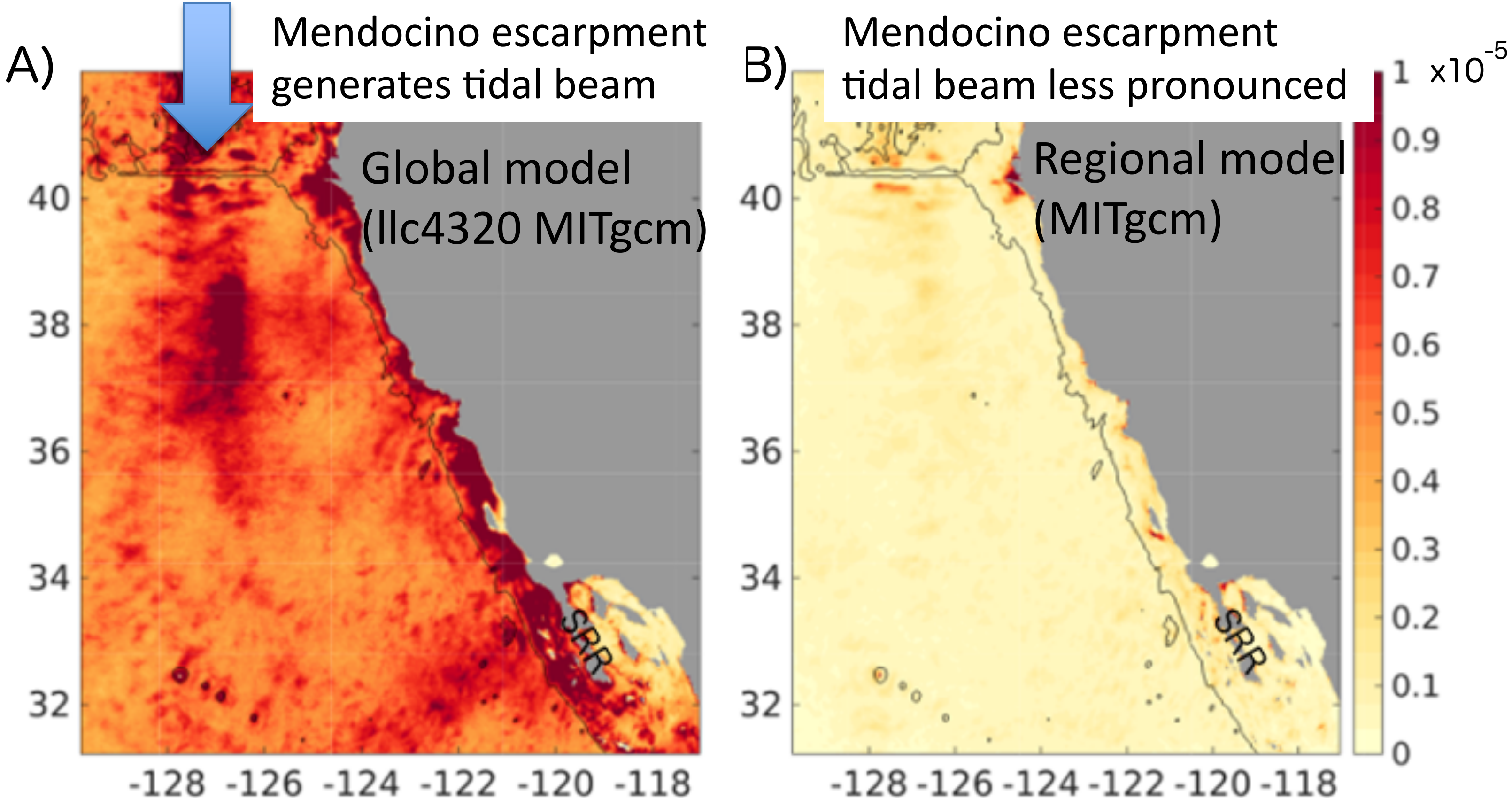
Larger vertical velocity variance in global model



Mazloff et al., submitted, JGR-Oceans, 2019

W variance at 500 m; black contour = 3000 m bathymetry

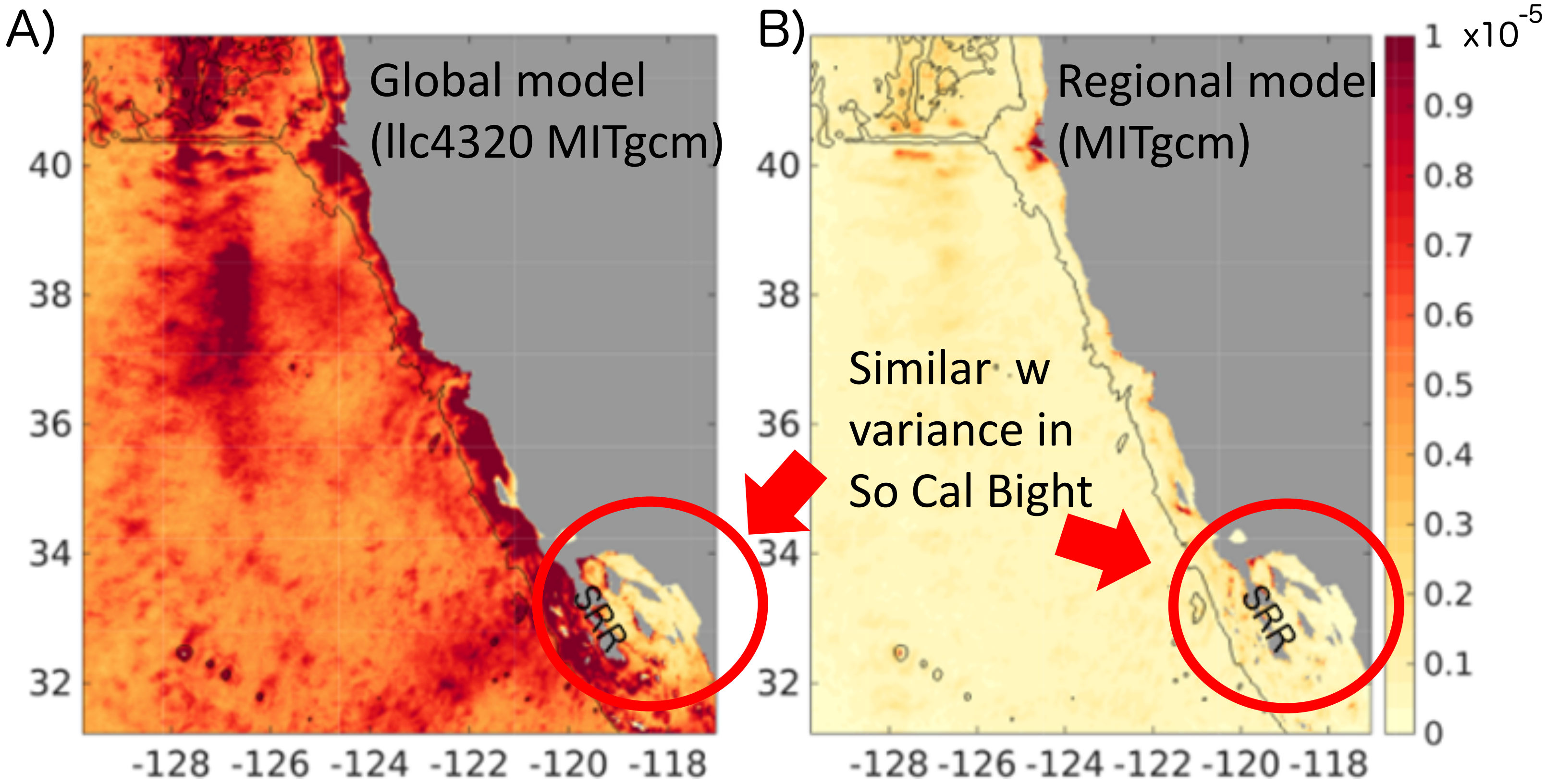
Larger vertical velocity variance in global model



Mazloff et al., submitted, JGR-Oceans, 2019

W variance at 500 m; black contour = 3000 m bathymetry

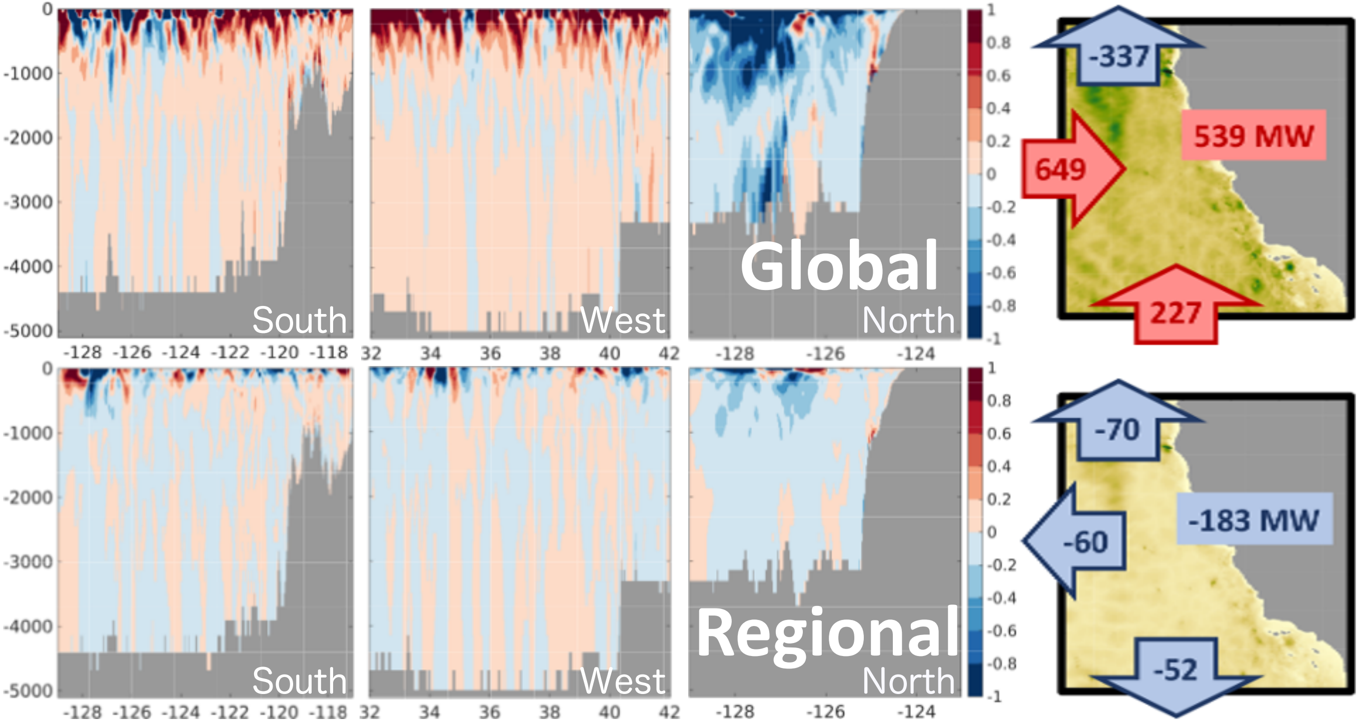
Larger vertical velocity variance in global model



Mazloff et al., submitted, JGR-Oceans, 2019

W variance at 500 m; black contour = 3000 m bathymetry

Internal Wave Energy Flux (u'p')



- Global has baroclinic KE 0.39 PJ greater than barotropic KE
- Integrated boundary fluxes: +539 MW global -183 MW regional
- Excess 0.39 PJ and boundary flux difference of 722 MW implies baroclinic wave energy residence time of 6.3 days

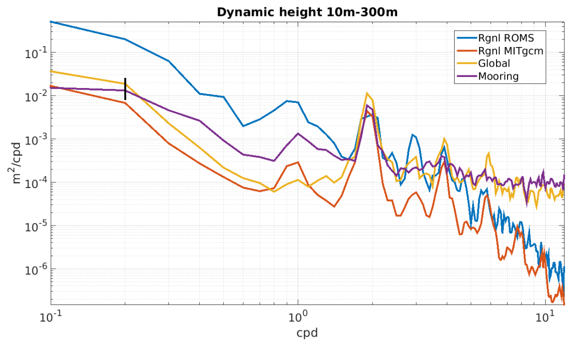
Positive: energy into the domain.

Negative: energy out of the domain.

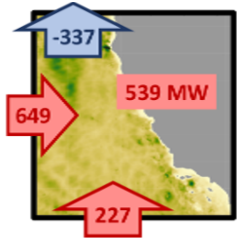
Mazloff et al., submitted, JGR-Oceans, 2019

Summary and Conclusions

- Small-scale and high-frequency processes occur in the California Current region in observations and global model, but not in regional model.
- Energy originates outside of regional domain (e.g. Hawaii and western Pacific).
- Tidally generated IGWs need time to exchange energy and fill the continuum in a regional domain.
- Future work: Regional models that represent internal waves will need a new strategy to input energy at open boundaries (e.g. prescribe internal wave flux at the open boundaries).



Global



Regional