Lagrangian filtering for removing waves from modeled ocean surface velocities

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The problem

- Eventually, we would like to be able to infer vertical tracer transport from SSH observations
- This is a really hard problem, partly because the surface field includes inertia-gravity waves, which do not transport tracers
- As an intermediate step, we want to remove these waves from the surface velocity field

Filtering methods

- Inertia-gravity waves have frequencies higher than f in a reference frame that follows the flow

Eulerian filtering
(traditional frequency filtering)

Find velocity time series at each x, y, z point in Eulerian space

↓

Apply a low-pass filter to the velocities measured at each x, y, z point

Lagrangian filtering

Advect particles in horizontal flow field

↓

Record velocities at regular intervals along the particle trajectory

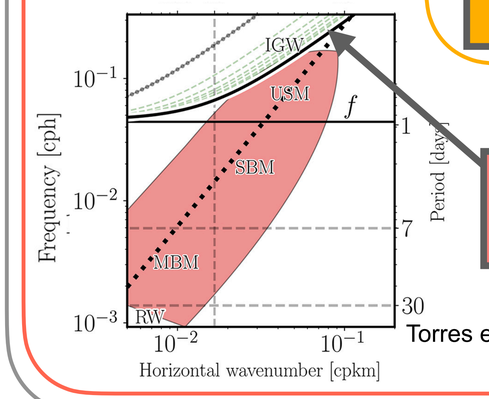
↓

Apply a low-pass filter to the velocities measured by each particle

↓

Interpolate the velocity back onto a regular grid

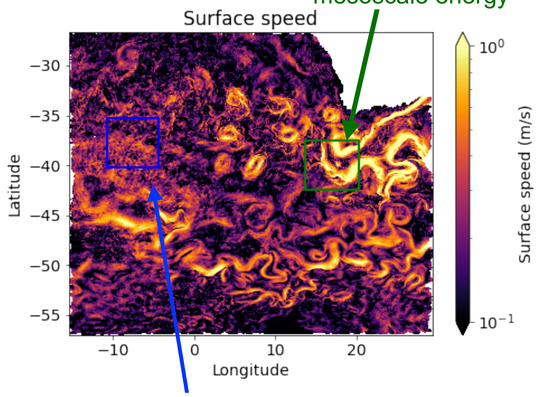
Frequency-wavenumber filtering



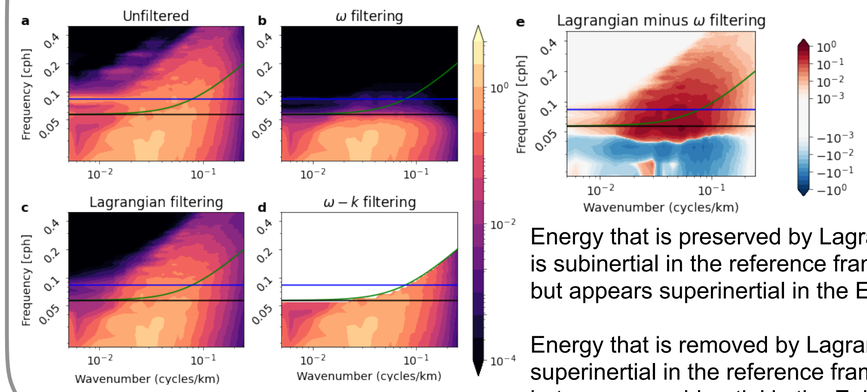
Remove motions that appear above the black line (10th baroclinic mode)

Torres et al. 2018

Study region



Lagrangian filtering preserves motions that other methods remove

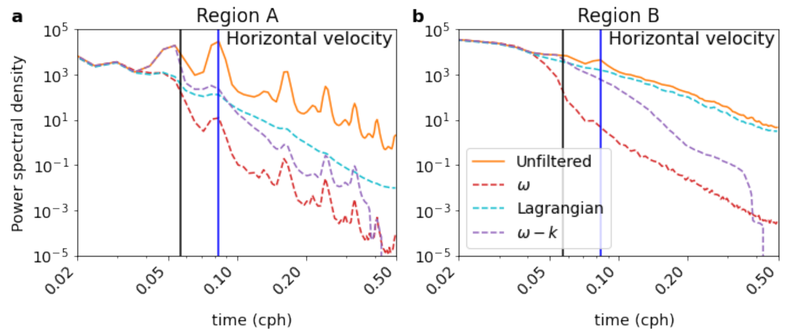


(These figures are for region B)

Energy that is preserved by Lagrangian filtering is subinertial in the reference frame of the flow but appears superinertial in the Eulerian frame

Energy that is removed by Lagrangian filtering is superinertial in the reference frame of the flow but appears subinertial in the Eulerian frame

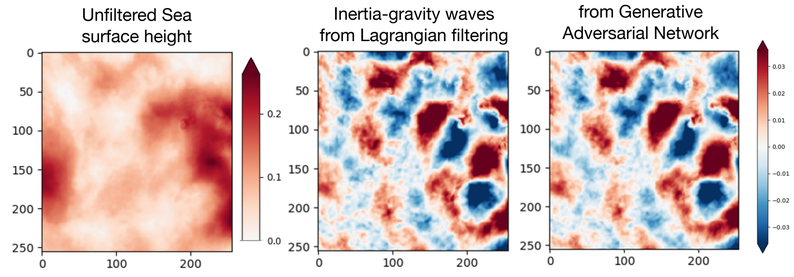
Energy spectra before and after filtering



- Lagrangian filtering removes less energy at superinertial frequencies when frequency is measured in the Eulerian frame
- In region B, strong background currents create more Doppler shift

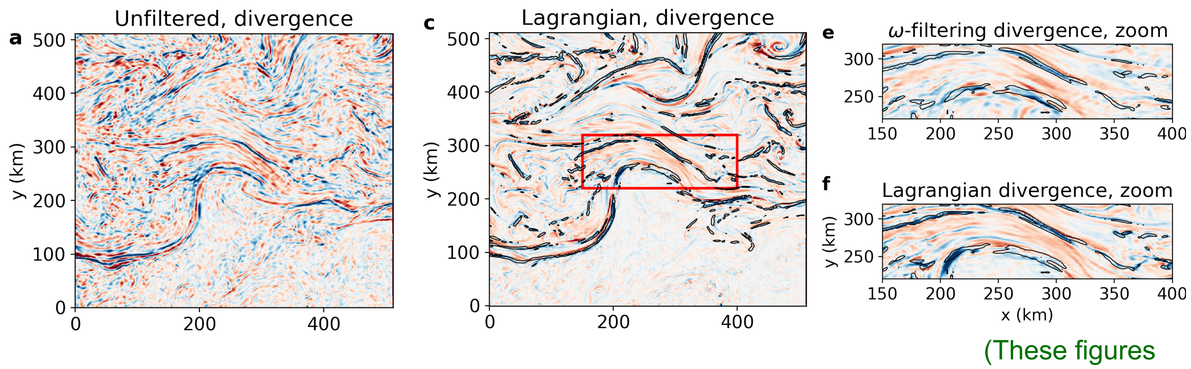
Next steps

- Unfiltered and Lagrangian filtered fields can be used as a training dataset for machine learning algorithms



- We plan to apply the machine learning algorithm to SWOT observations

Divergence before and after filtering



(These figures are for region B)

- Black outlined regions are regions with high frontogenesis function
- All filtering methods remove a lot of divergence away from these regions
- Lagrangian filtering preserves more divergence in high frontogenesis regions

Conclusions

- Lagrangian filtering preserves frontal divergence and other fast transport-relevant flows
- Lagrangian filtering is likely to be most helpful in regions with strong background velocities

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