The spatial structure of Near-Inertial oscillations in the presence of submesoscale flow

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1. Introduction

A NIO observed both from HFR (High-Frequency doppler Radars) and an assimilative ROMS surface currents off the south shore of Oahu, Hawaii (f=0.7 cpd, 33.4 h) is described. The spatial and temporal variability of the NIO amplitude and frequency its correlated with the background flow at a sub-mesoscale resolution.

2. Methodology

- HFR and ROMS hourly surface currents were demodulated at f to extract NI currents
- The phase-slope of the demodulated currents was used to extract the NIO frequency
- 3-day low-passed surface currents were used to calculate vorticity, divergence and effective frequency (f_{eff}) of NIO $f_{eff} = \sqrt{f^2 + f\left(\frac{\partial V}{\partial x} - \frac{\partial U}{\partial y}\right) - \frac{\partial V}{\partial x}\frac{\partial U}{\partial y} + \frac{\partial U}{\partial x}\frac{\partial V}{\partial y}}$
- The slab-layer model currents were calculated from using mixed-layer depth and wind from ROMS and a WRF wind model

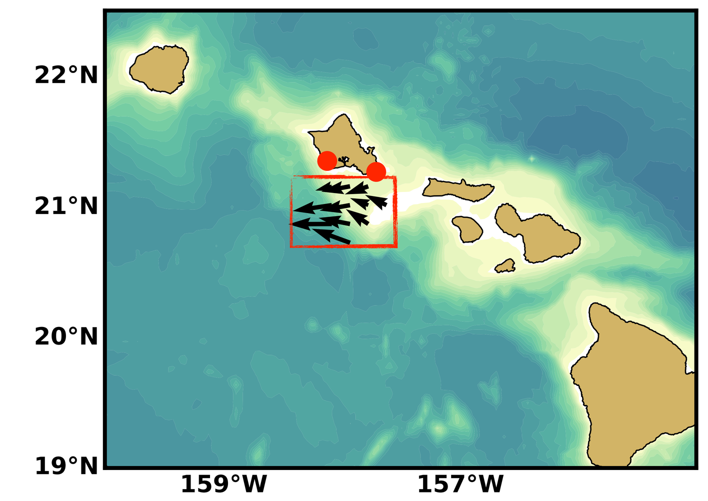

Figure 1. Red dots indicate the two HFR

3. Results

The amplitude of an NIO from March 6 to March 11 has spatial variability at scales down to ~20 km (HFR) and ~40 km (ROMS) in amplitude and frequency.

Phase contours are correlated to the vorticity and to the gradient of vorticity.

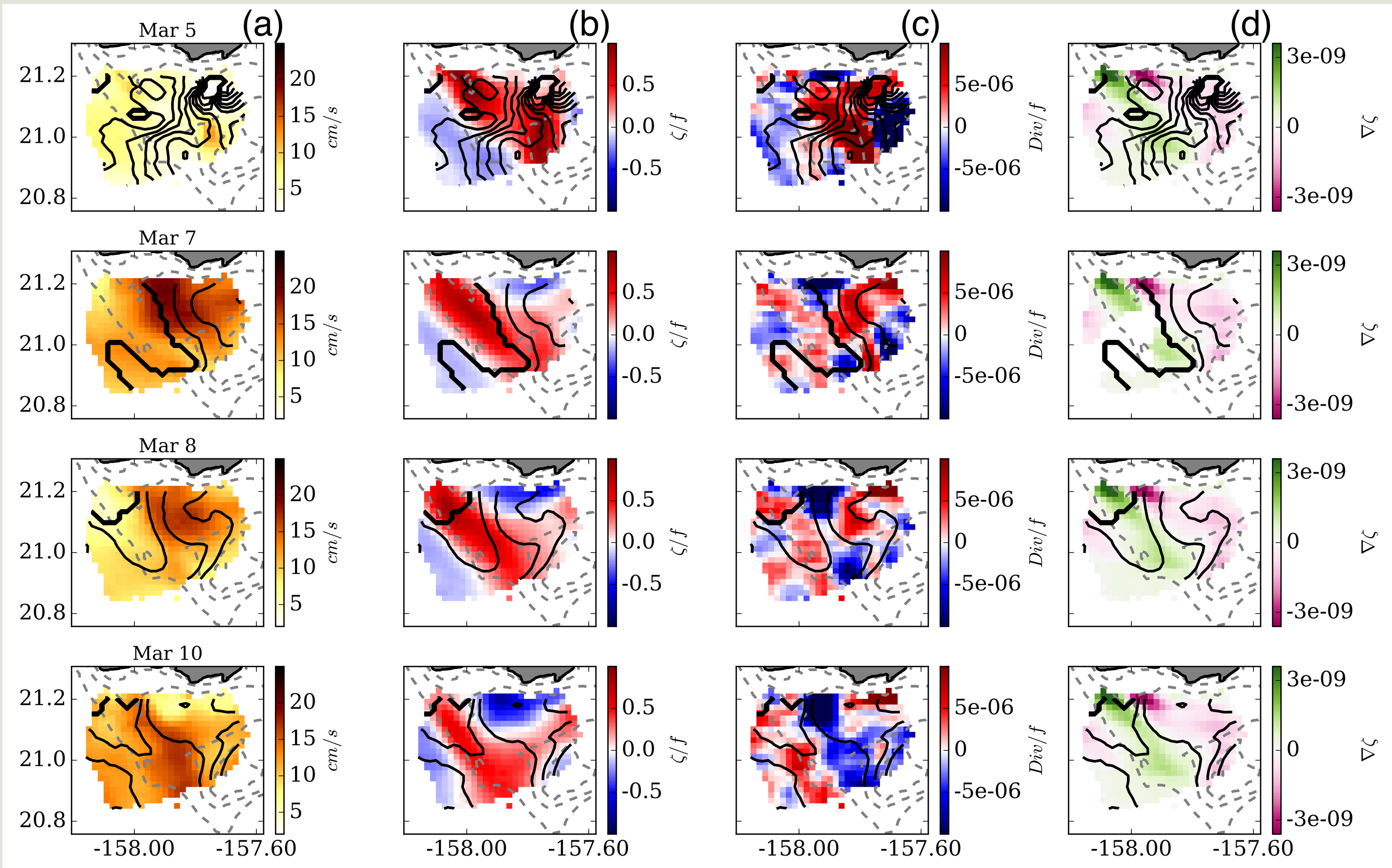

Figure 2. HFR surface currents spatial maps of daily average a)amplitude of demodulated currents at f, b)relative vorticity, c)divergence, d)$\nabla\zeta$ for the NIO in March 2012. Black solid lines indicate phase contours every 20 deg.

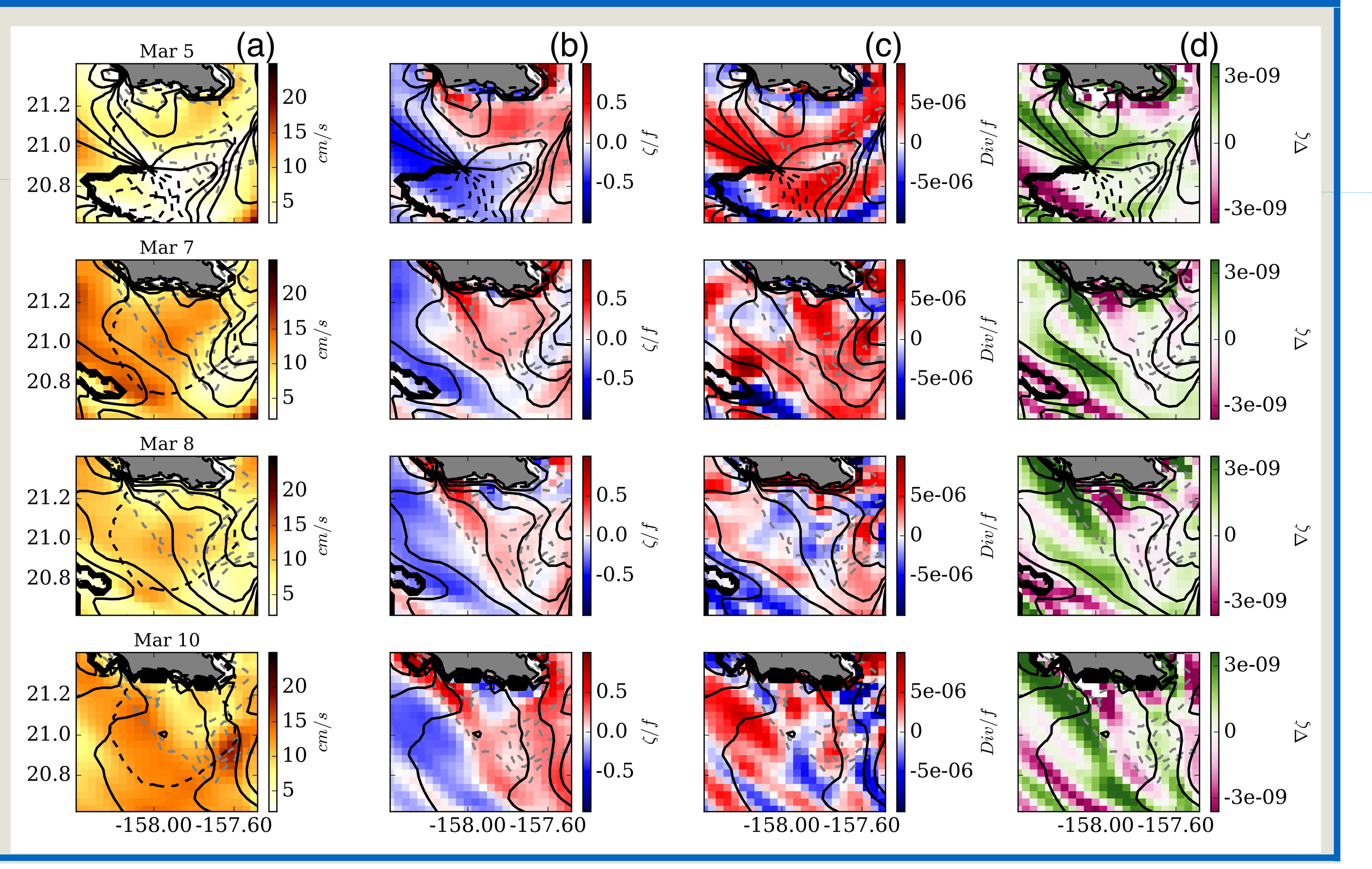

Figure 3. As with figure 2 but from ROMS surface currents. Dashed black lines in figure 3 indicate HFR spatial coverage when 50% of data is available.

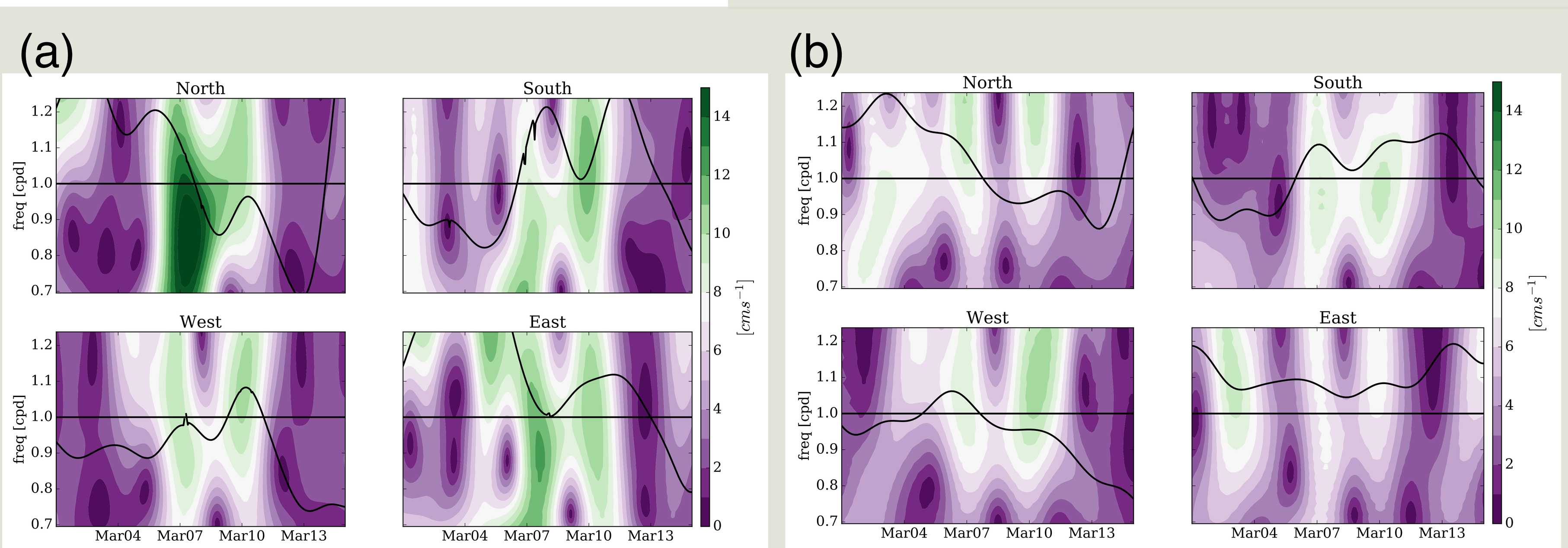

Figure 4. Demodulated currents at trial frequencies (±0.3f) around the inertial period from a) HFR and b) ROMS surface currents for the 4 different regions in Figure 1. Black line indicates f_{eff} from 3-day low passed surface current gradients.

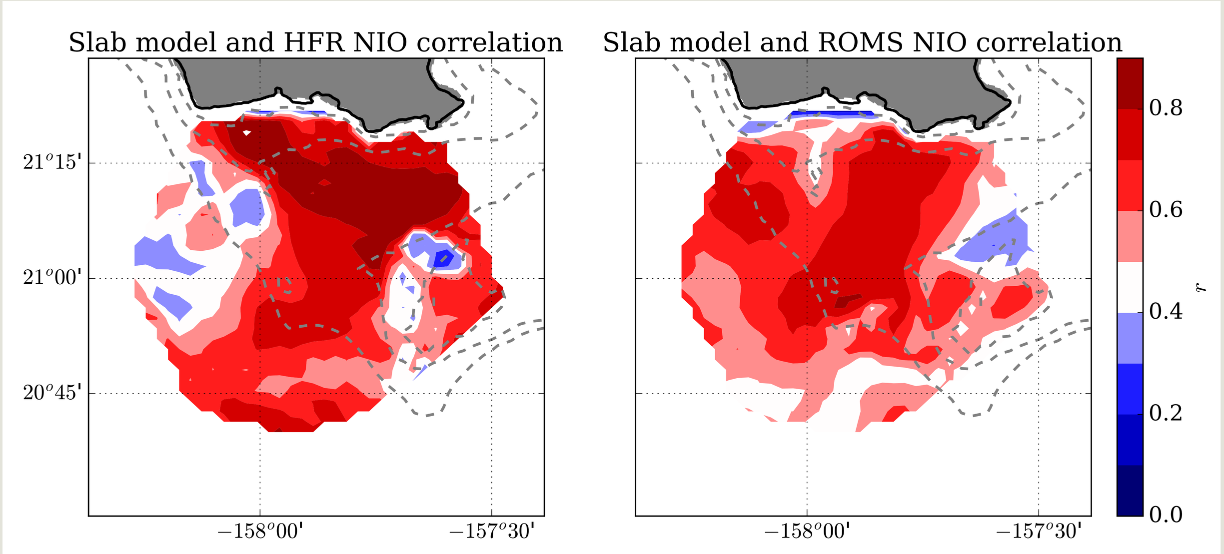

Figure 5. Correlation between the slab-layer model currents using a WRF wind model and a)HFR and b)ROMS demodulated currents at f over the NIO. Larger values are found in the north and east of the HFR spatial domain where largest NI amplitude is found in Figure 4a .

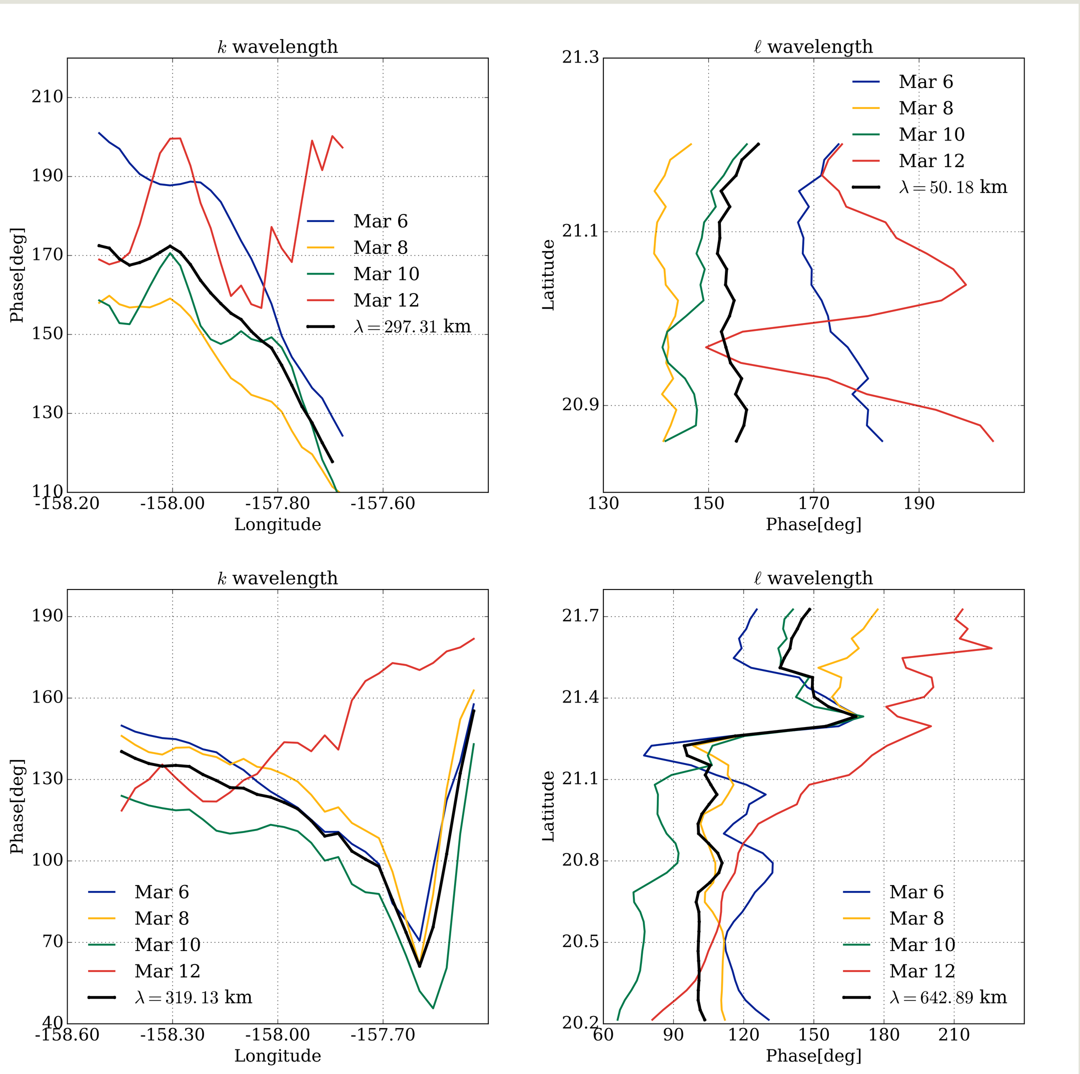

Figure 6. Daily averaged phase lines from demodulated currents at f for HFR (top row) and ROMS (bottom row) over longitude (first column) and latitude (second column) for the NIO. Black line is the temporal-average over the NI event. Wavelengths are calculated by least-square fitting the temporal-average slope over latitude and longitude. Note the different axis values between HFR and ROMS figures.

4. Key Points

- Maximum NI amplitudes in the North region (Figure 4a) are due to resonance between wind frequency and feff (Figure 5).
- Phase contours variability is highly dependent in the sub-mesoscale flow. In particular is dependent on vorticity and gradient of vorticity (Figures 2 and 3).
- Zonal and meridional NIO wavelengths are calculated by least-square fitting the phase-slope over longitude and latitude. ℓ = 300 km (both HFR and ROMS) and k= 50 km (due to HFR noise) and 640 km (ROMS).

References:

Kunze, E. (1985). Near-inertial wave propagation in geostrophic shear. Journal of Physical Oceanography, 15(5), 544-565.

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Acknowledgements: