Dynamical Decomposition of Multiscale Oceanic Motions

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INTRODUCTION

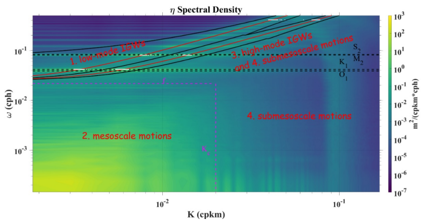
- A long-standing challenge in dynamical oceanography is to distinguish various dynamical regimes of multiscale oceanic motions
- Conventional approaches of the multi-regime disentanglement focus on time-scale or space-scale decompositions
- This study has established two *dynamical approaches* to disentangle vortical (PV-bearing) and wavy (PV-less) motions

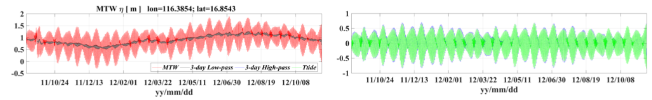
DYNAMICAL DECOMPOSITION #1

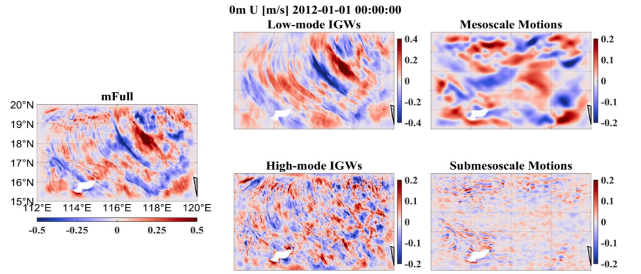
decomposing physical variables into six regimes

Dynamical properties

- Large-scale currents and barotropic tides have the largest horizontal scales but contrasting frequencies
- Low-mode IGWs are constrained by dispersion relations
- Mesoscale flows are of relatively low frequency and with horizontal scales above the first baroclinic deformation radius
- The intrinsic frequency of high-mode IGWs (submesoscale flows) is above (well below) the inertial frequency







DYNAMICAL DECOMPOSITION #2

decomposing variables & equations into vortical & wavy motions

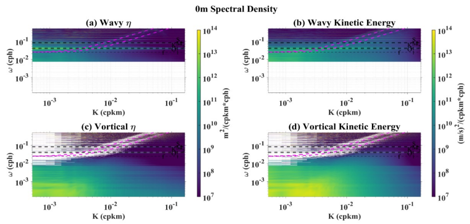
$$\frac{\partial \zeta}{\partial t} + U\frac{\partial \zeta}{\partial x} + V\frac{\partial \zeta}{\partial y} + f_{min}\frac{f\chi}{f_{min}} = 0$$

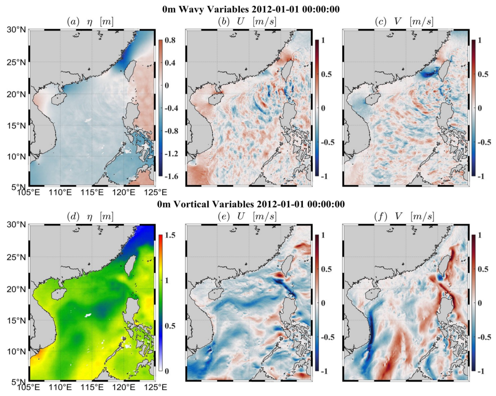
$$i\omega\hat{\zeta} + iUk\hat{\zeta} + iVl\hat{\zeta} + f_{min}\frac{\widehat{f\chi}}{f_{min}} = i\Omega\hat{\zeta} + f_{min}\frac{\widehat{f\chi}}{f_{min}} = 0$$

$$\begin{cases}\Omega = 0 & \text{vortical mode} \\ \Omega = \pm\sqrt{f_0^2 + c^2K^2} & \text{wavy mode}\end{cases}$$

$$\widehat{M_w}(k,l,\omega) = \begin{cases} 1, & \text{when } \left|\hat{\zeta}\right| < \left|\frac{\widehat{f\chi}}{f_{min}}\right| \text{ at } (k,l,\omega) \\ 0, & \text{when } \left|\hat{\zeta}\right| > \left|\frac{\widehat{f\chi}}{f_{min}}\right| \text{ at } (k,l,\omega) \end{cases}$$

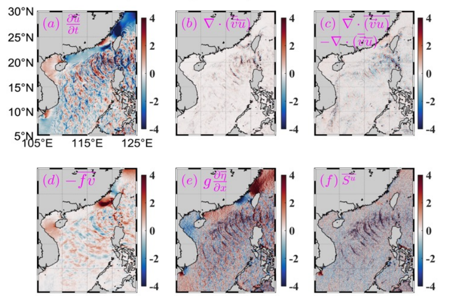
$$\begin{cases} A_w = M_w * A \\ A_v = M_v * A \end{cases}$$

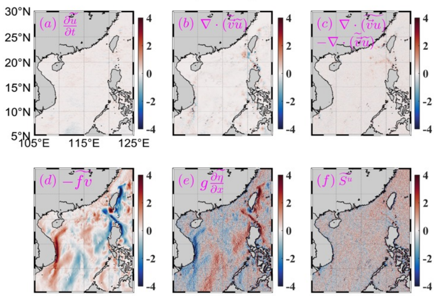




$$\frac{\partial \tilde{u}}{\partial t} + \frac{\partial \widetilde{uu}}{\partial x} + \frac{\partial \widetilde{vu}}{\partial y} + \frac{\partial \widetilde{wu}}{\partial z} - \tilde{fv} = -g\frac{\partial \tilde{\eta}}{\partial x} + \widetilde{res_x}$$

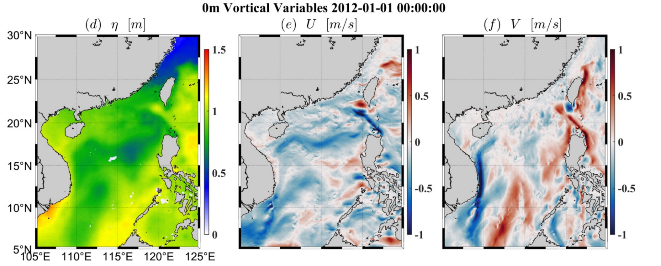
$$\frac{\partial \bar{u}}{\partial t} + \frac{\partial \overline{uu}}{\partial x} + \frac{\partial \overline{vu}}{\partial y} + \frac{\partial \overline{wu}}{\partial z} - \overline{fv} = -g\frac{\partial \bar{\eta}}{\partial x} + \overline{res_x}$$



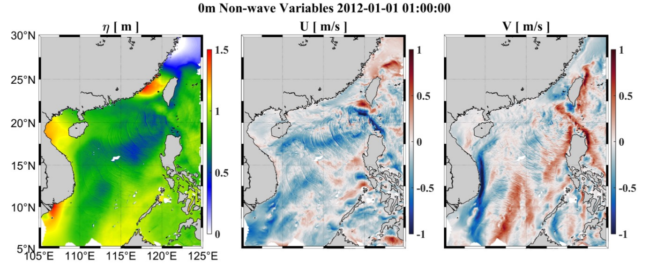


COMPARISON WITH LAGRANGIAN FILTERING

this study



Lagrangian filtering



REFERENCE FOR DETAILS (& CODES)

- Wang C., Liu Z.*, and Lin H. (2023), **On dynamical decomposition of multiscale oceanic motions**, *Journal of Advances in Modeling Earth Systems*, 15(3), e2022MS003556.
- Wang C., Liu Z.*, and Lin H. (2023), **A simple approach for disentangling vortical and wavy motions of oceanic flows**, *Journal of Physical Oceanography*, 53(5), 1237–1249.

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