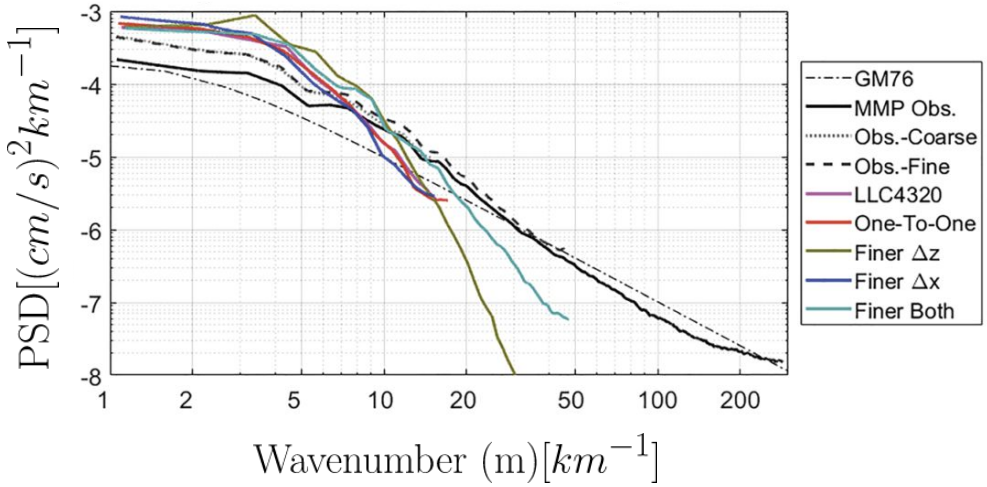
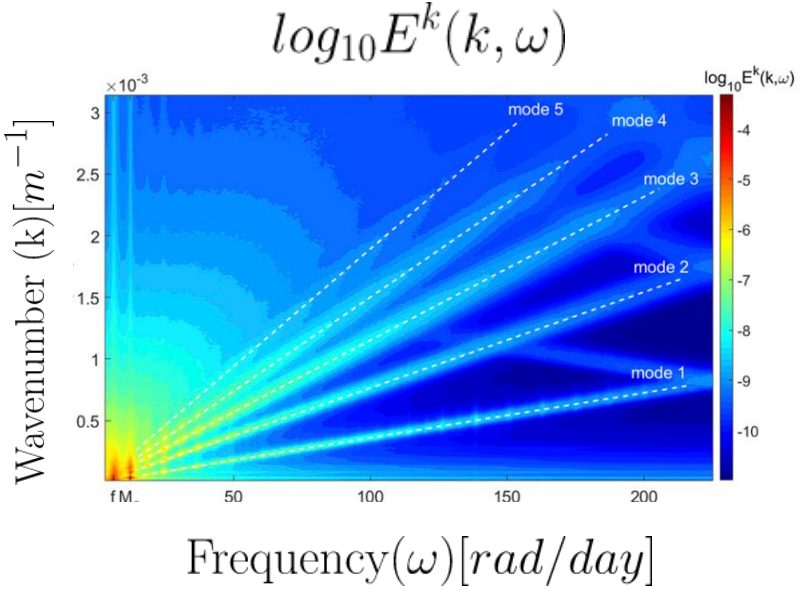
Impact of vertical mixing parameterizations on internal gravity wave spectra in regional ocean models

Ritabrata Thakur, Brian K Arbic

In collaboration with J Skitka, K Momeni,
Y Pan, D Menemenlis, W R Peltier, Y Ma, M H Alford

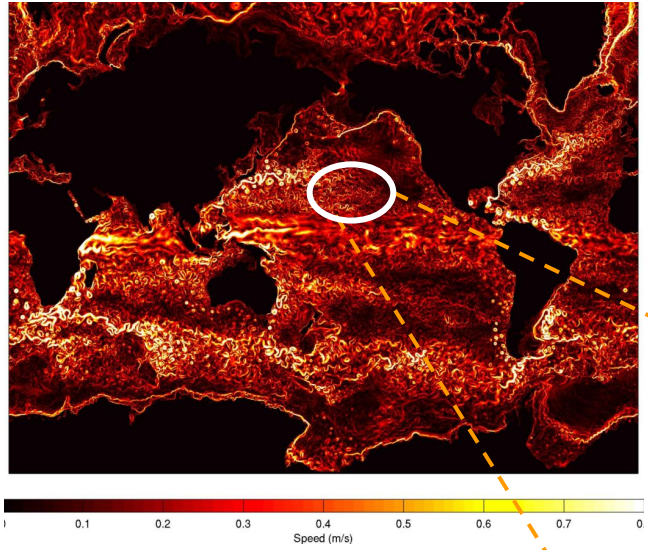
IW spectra in regional models





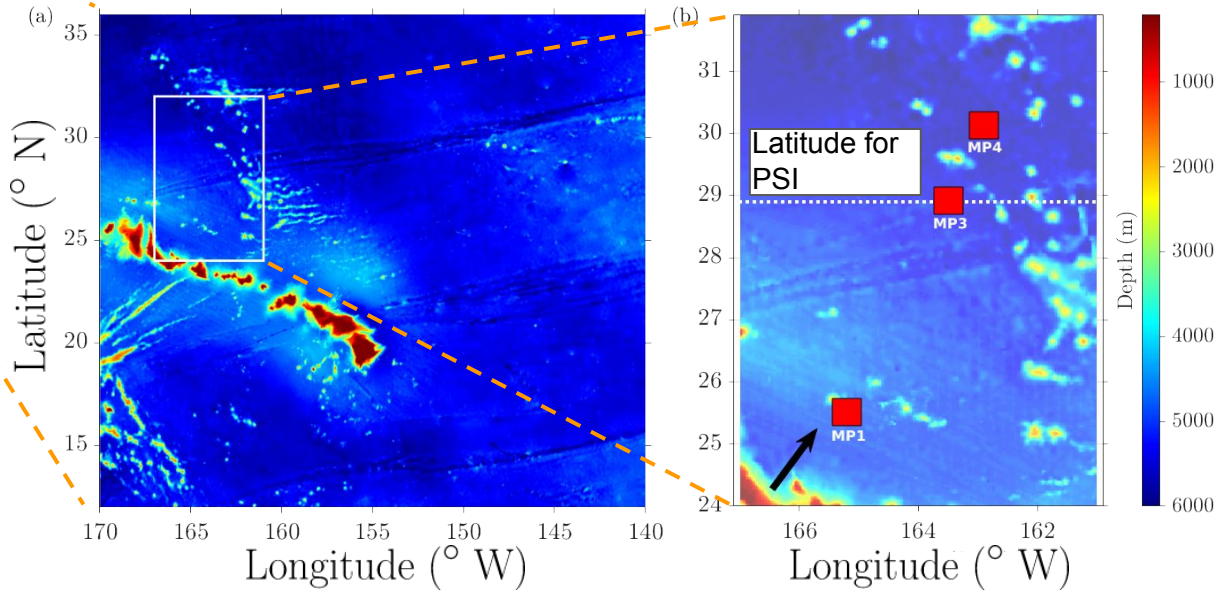
Pan et al, *J. of Phys. Oceanography* 2020
Nelson et al, Mazloff et al, *JGR:Oceans* 2020

Regional simulation domain -- North of Hawaii

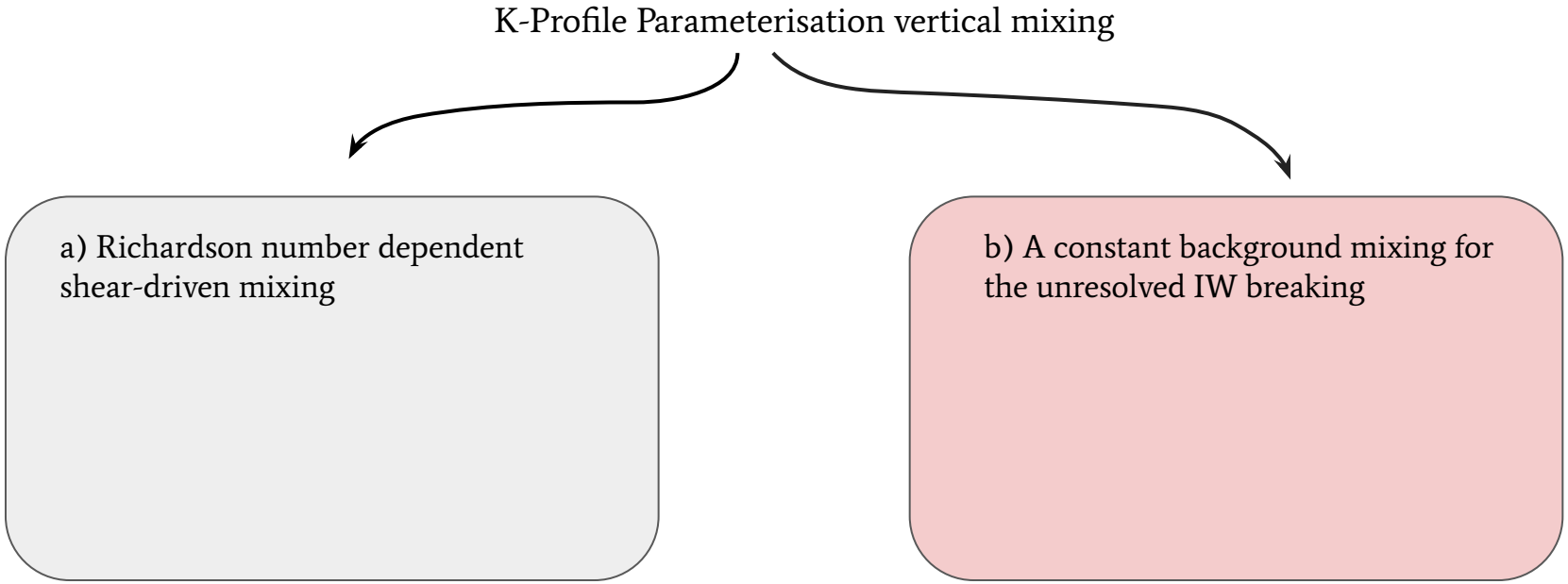


Global simulation of MITgcm
(Dimitris Menemenlis)

- Simulation region: 660 km x 880 km
- 2km horizontal resolution
- Max vertical thickness: 25m
- Boundary conditions from a global simulation



Model vertical mixing scheme



Regional simulations are ideal for understanding and improving model mixing parameters

Model vertical mixing scheme

K-Profile Parameterisation vertical mixing

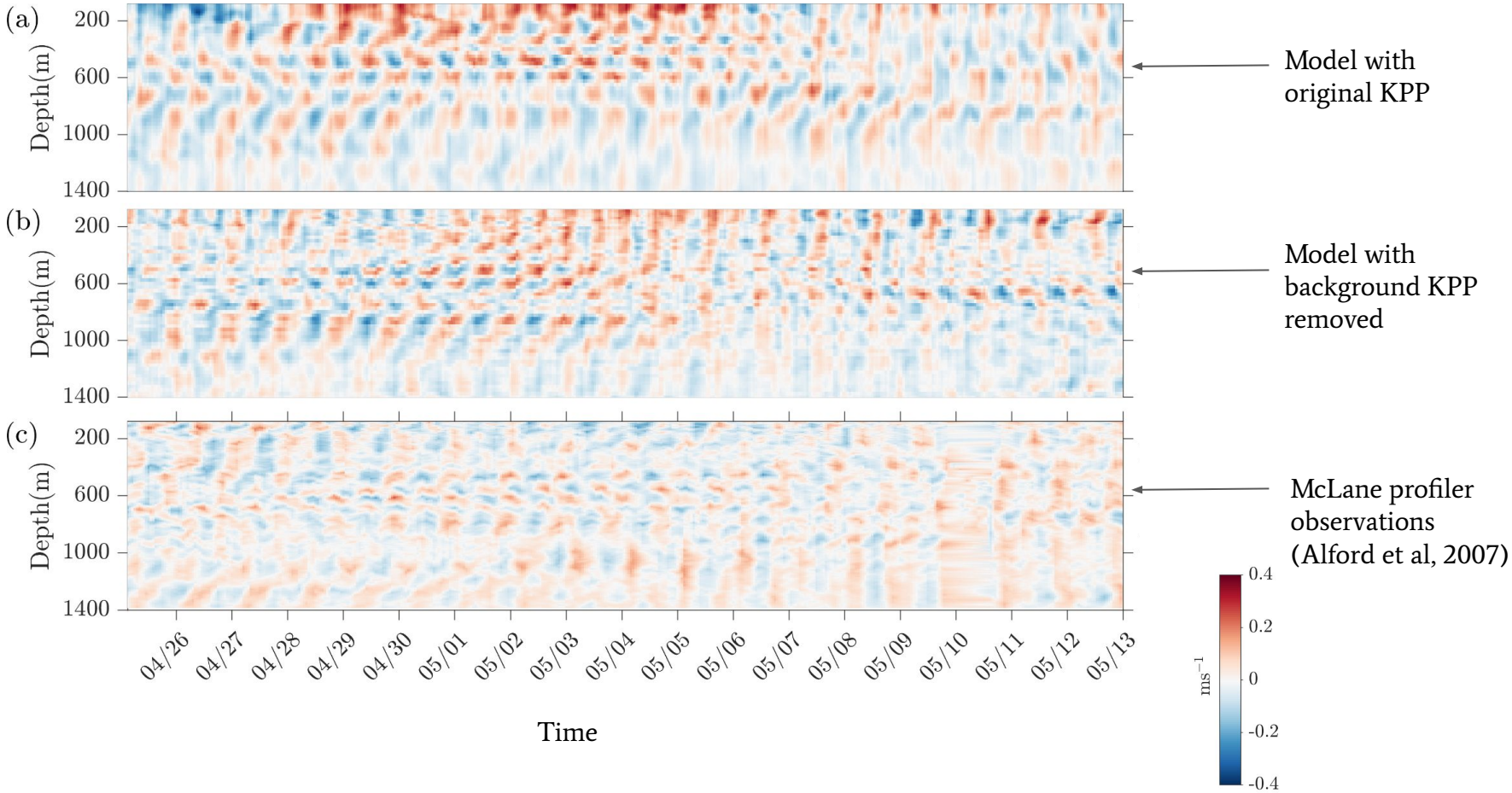
a) Richardson number dependent shear-driven mixing

b) A constant background mixing for the unresolved IW breaking

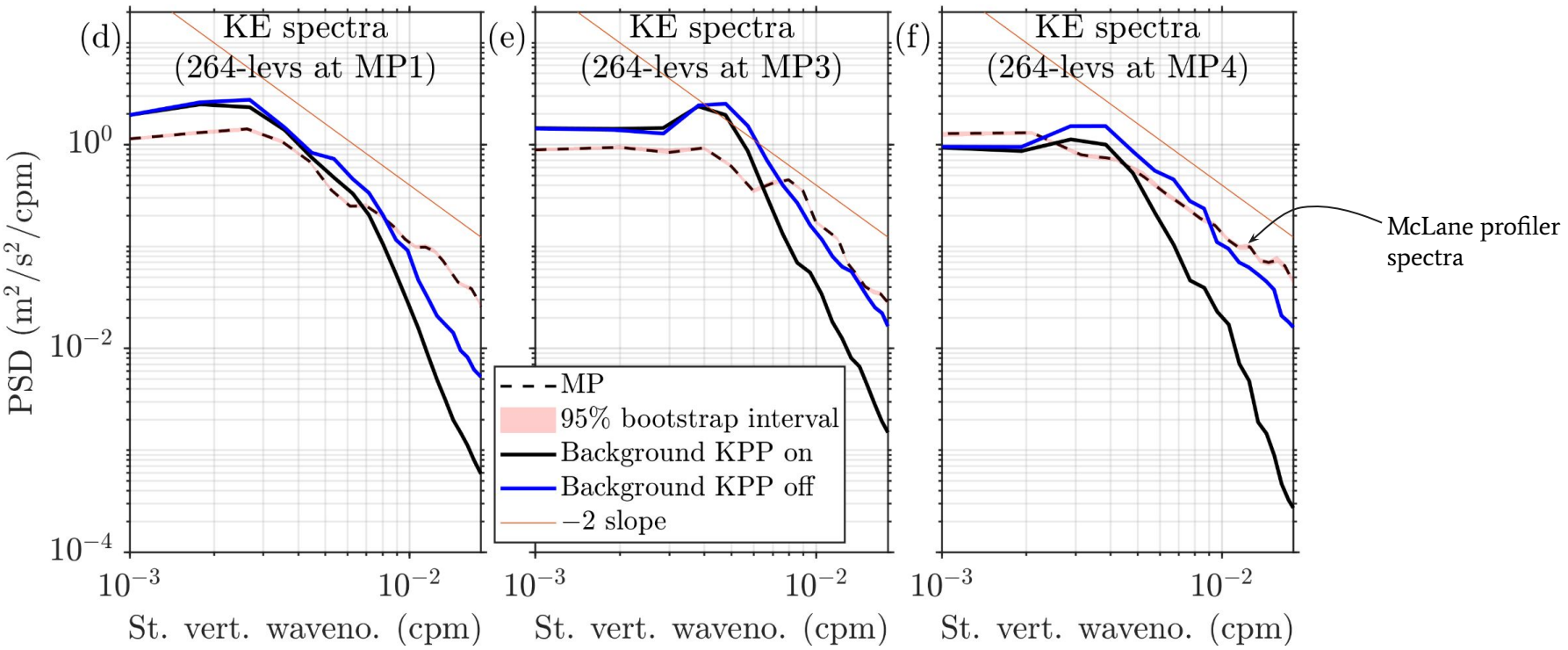
When models start resolving IWs, do we need this “background” KPP?

Regional simulations are ideal for understanding and improving model mixing parameters

Small-scale velocity structure (model vs data)

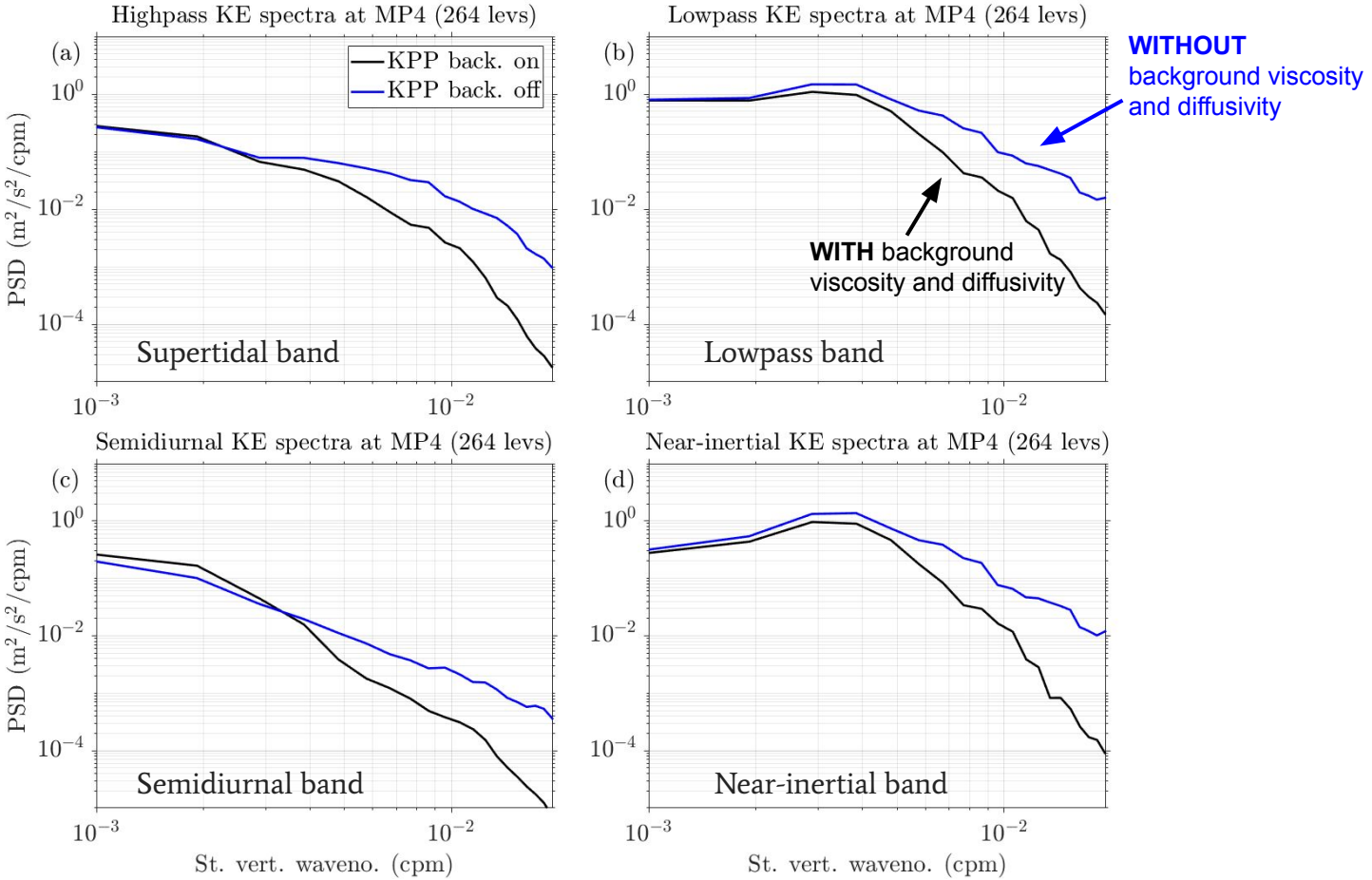


Improved IW spectra without KPP background



Garrett and Munk. *J of Geophys. Res.* 1975
Cairns and Williams. *J of Geophys. Res.* 1976
Thakur et al, in review

KE spectra in different frequency bands



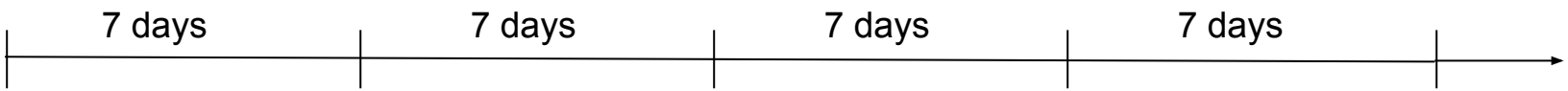
Project II

Mapping incoherent internal tides (ongoing)

Following Egbert and Erofeeva (2021),
Geophysical Research Letters, 48

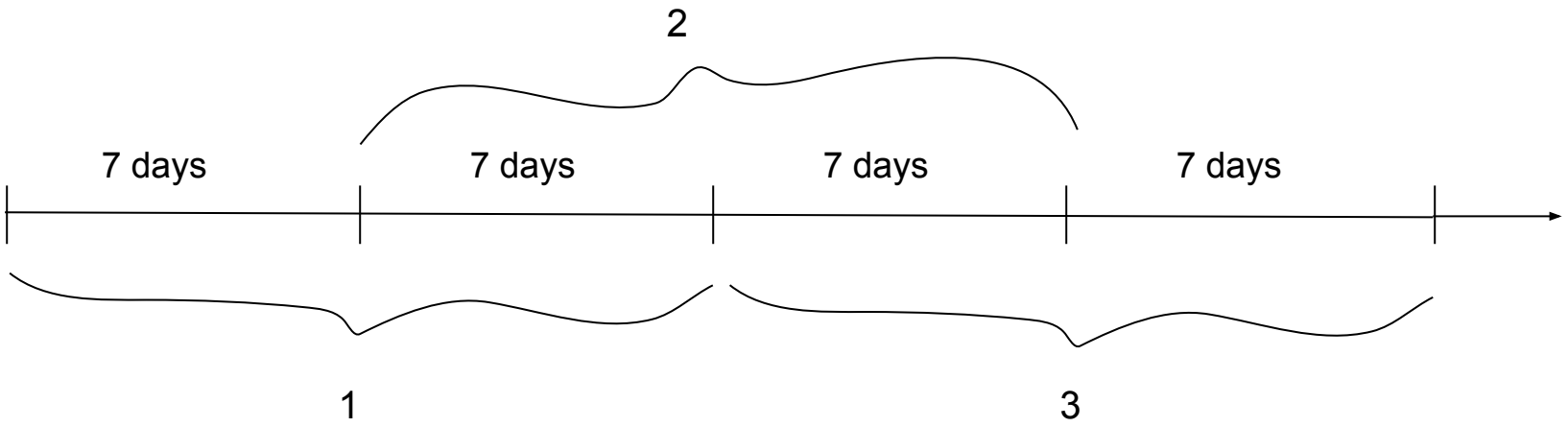
Non stationarity estimate

- Hourly samples of steric SSH
- Global non-assimilative HYCOM run for calendar year 2016
- Horizontal grid resolution was 1/25° with 41 hybrid levels
- Tidal forcing included the five largest constituents



Steric SSH with five stationary components removed

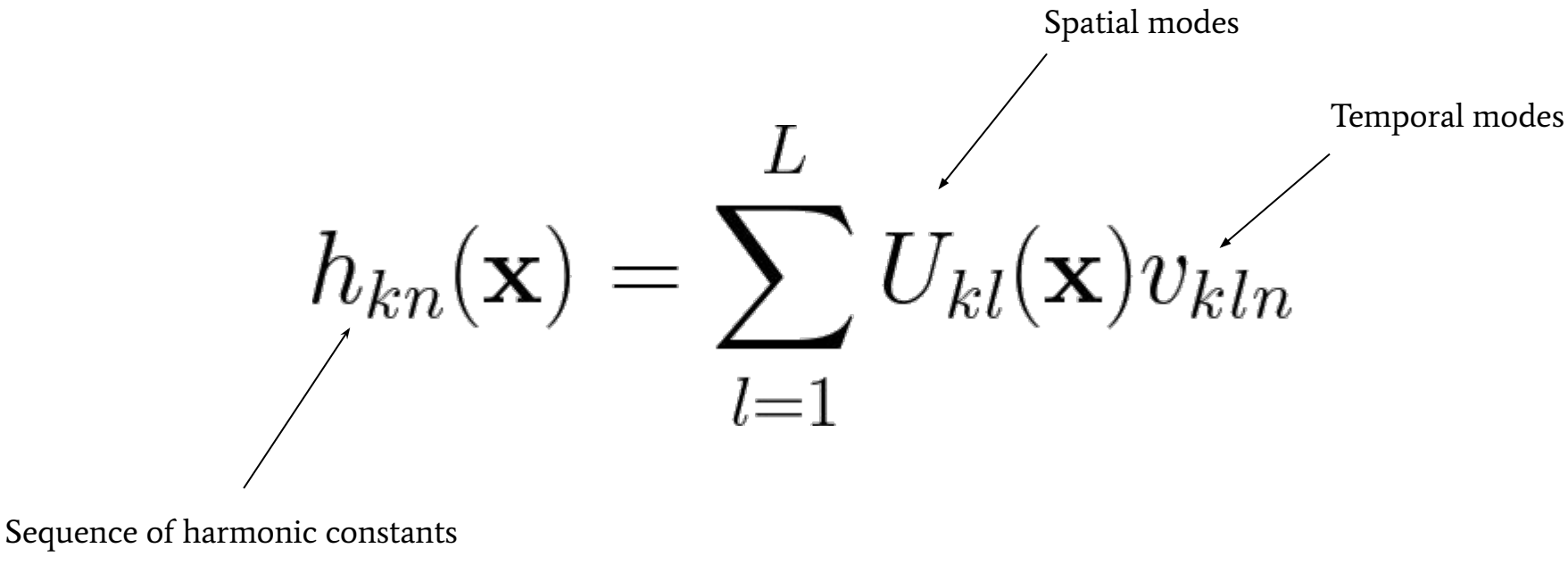
Non stationarity estimate



Degree of non-stationarity : Estimate harmonic constants in each of these 14-day periods

$$h_{kn}(\mathbf{x}) = \sum_{l=1}^{L} U_{kl}(\mathbf{x}) v_{kln}$$

Sequence of harmonic constants


Spatial modes
Temporal modes
$$h_{kn}(\mathbf{x}) = \sum_{l=1}^{L} U_{kl}(\mathbf{x}) v_{kln}$$
Sequence of harmonic constants

Spatial modes

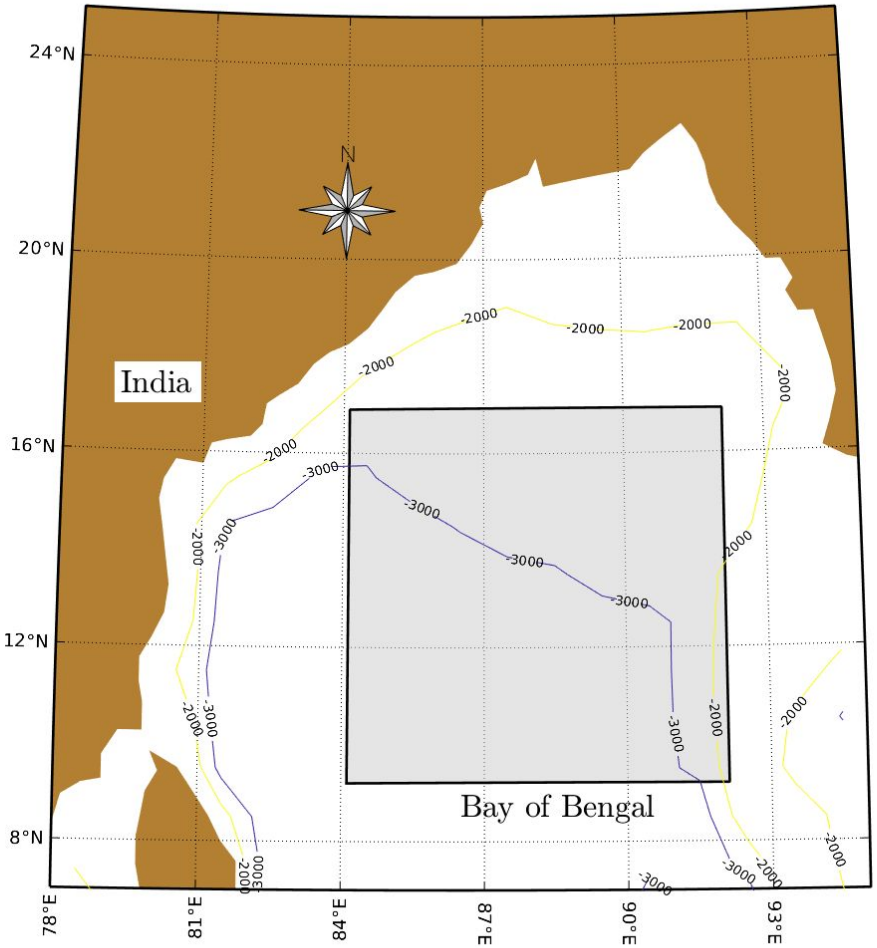
Temporal modes

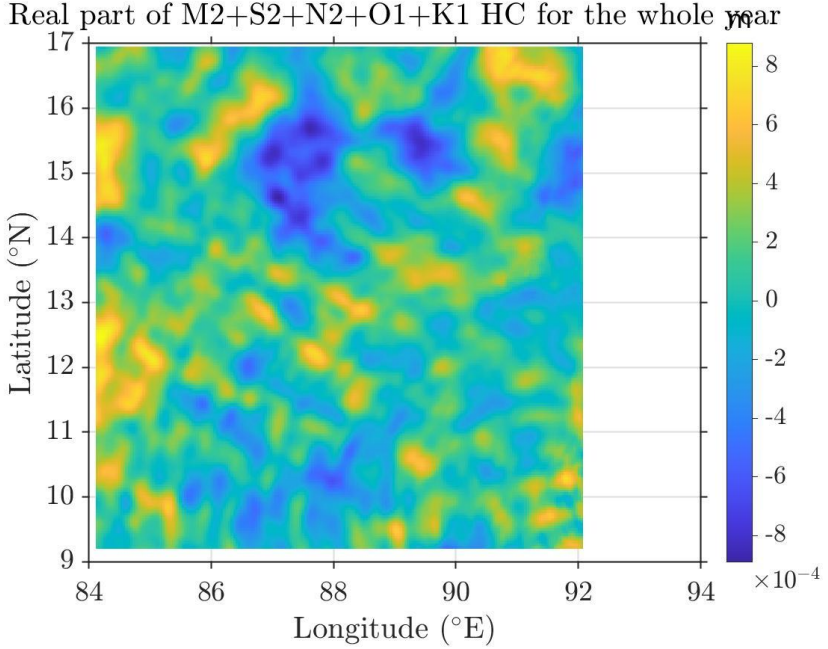
$$h_{kn}(\mathbf{x}) = \sum_{l=1}^{L} U_{kl}(\mathbf{x}) v_{kln}$$

Sequence of harmonic constants

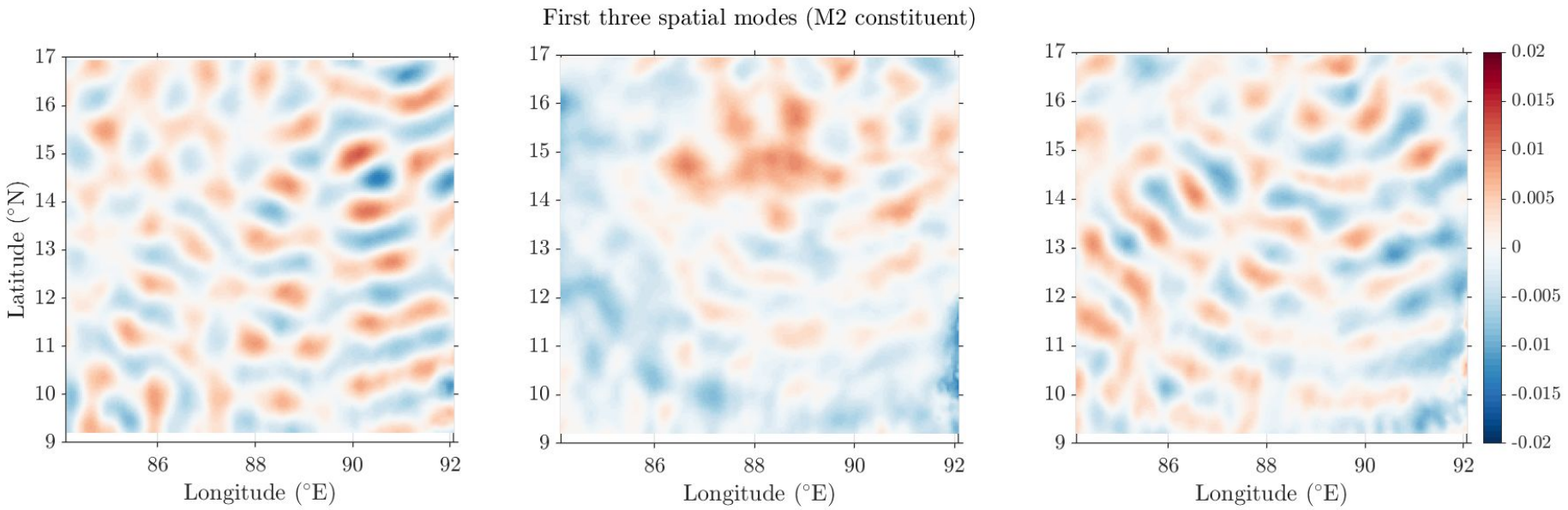
Obtained from the SVD of the full matrix of harmonic constants

A sample region of study: Bay of Bengal

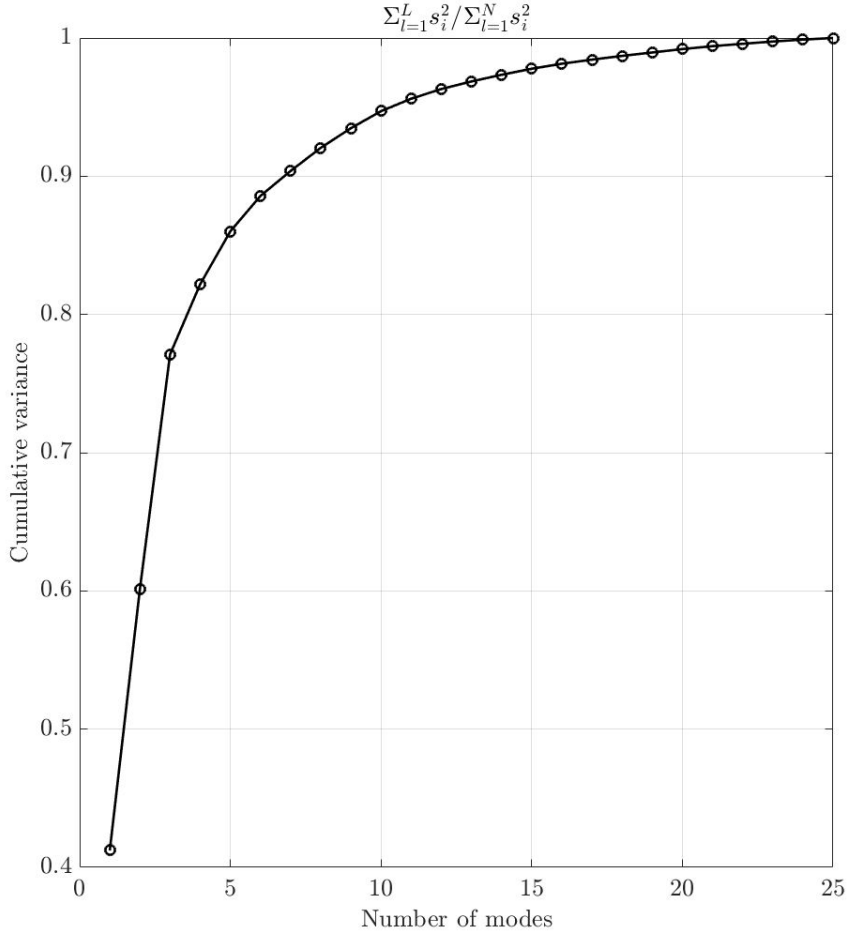




Spatial modes of non-stationarity



Cumulative variance and fitting satellite data



Satellite SSH

Spatio-temporal basis function from HyCOM

$$d_i = \left[\sum_{l=1}^{L} \sum_{k=1}^{K} c_{kl} F_{kl}(\mathbf{x_i}, t_i) \right] + \epsilon_i$$

For each location within a patch, a least squares fit gives values of c.

Summary and Future Work

- High-resolution numerical models have improved IW spectra with the KPP background turned off
- Consequences to modelling near-inertial and improving ocean mixing estimates

❑ Using HyCOM modes to extract non-stationary tides from altimeter data

❑ Estimate the sensitivity to changes in patch size and time window

❑ A global map of non-stationary internal tides