Impact of the MJO on the Gulf of Carpentaria during the monsoon

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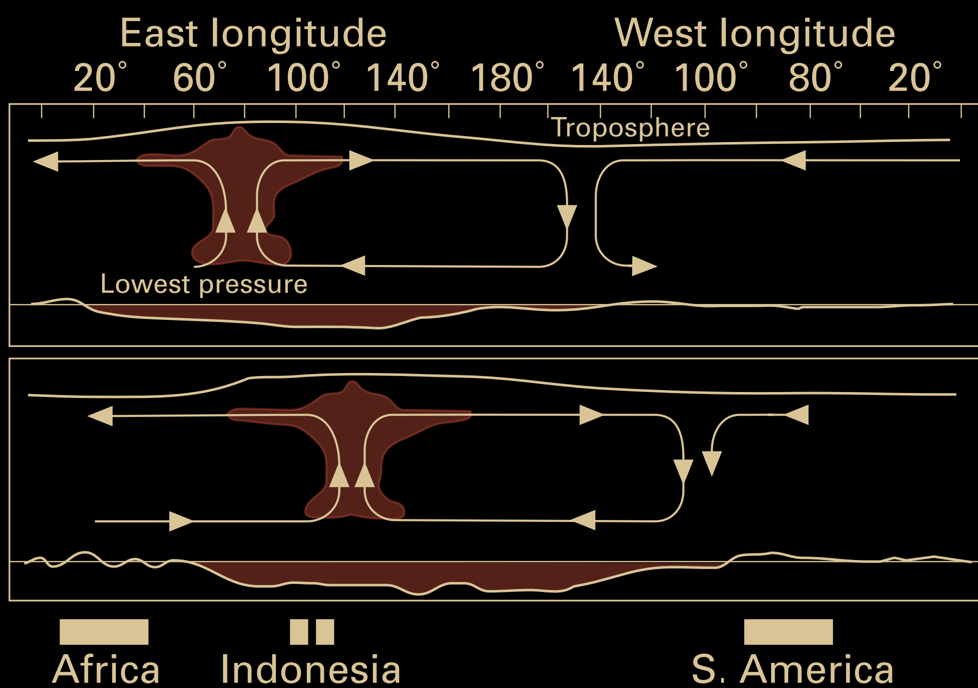
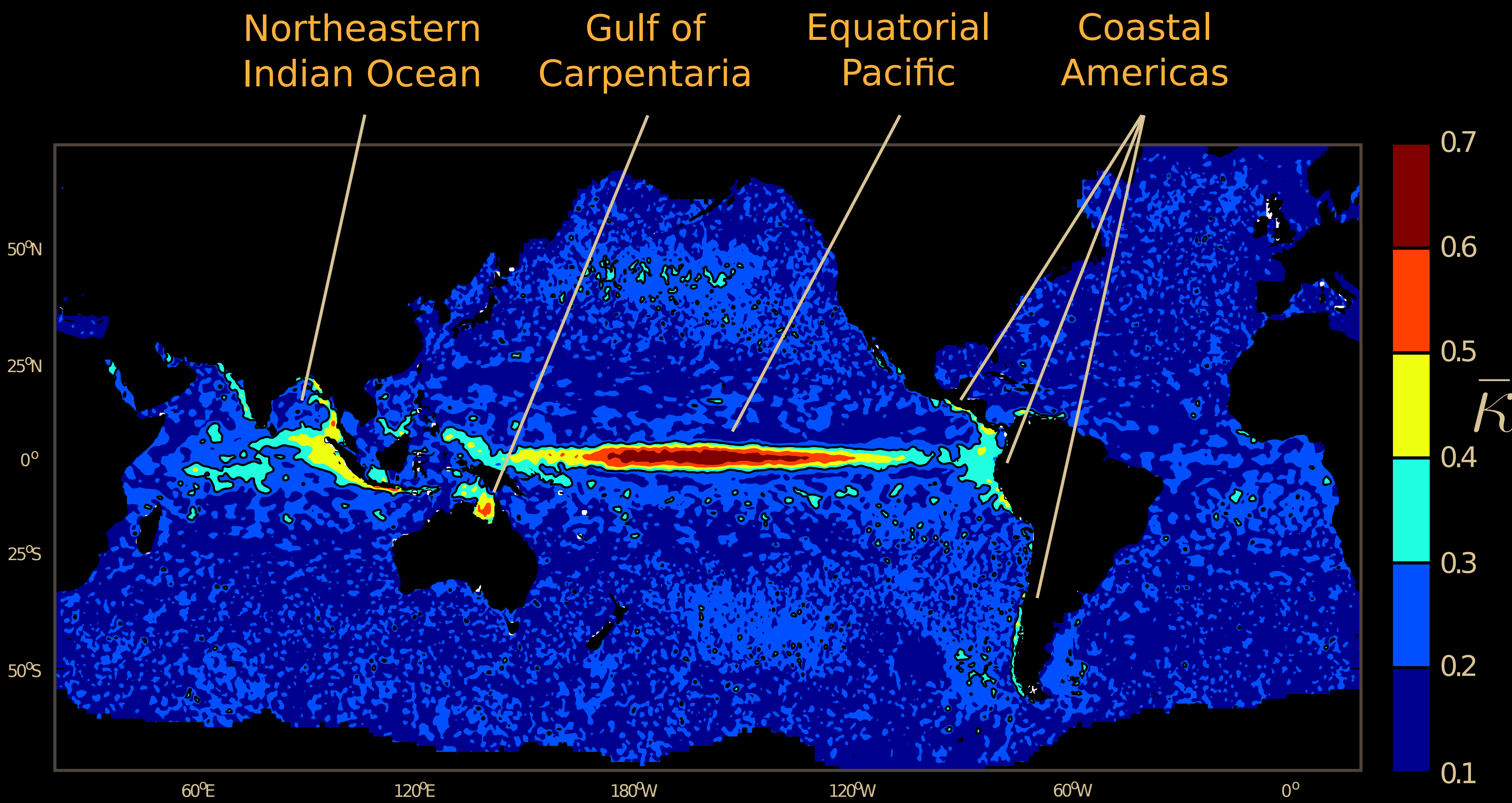
The Madden-Julian Oscillation

- The Madden-Julian Oscillation (MJO) is an intraseasonal (30-90 day period) phenomenon that originates over the equatorial Indian Ocean and propagates eastward
- Associated with deep convection and zonal wind anomalies at both low and high levels in the tropics
- Characterized by bivariate index [Wheeler and Hendon, 2004]



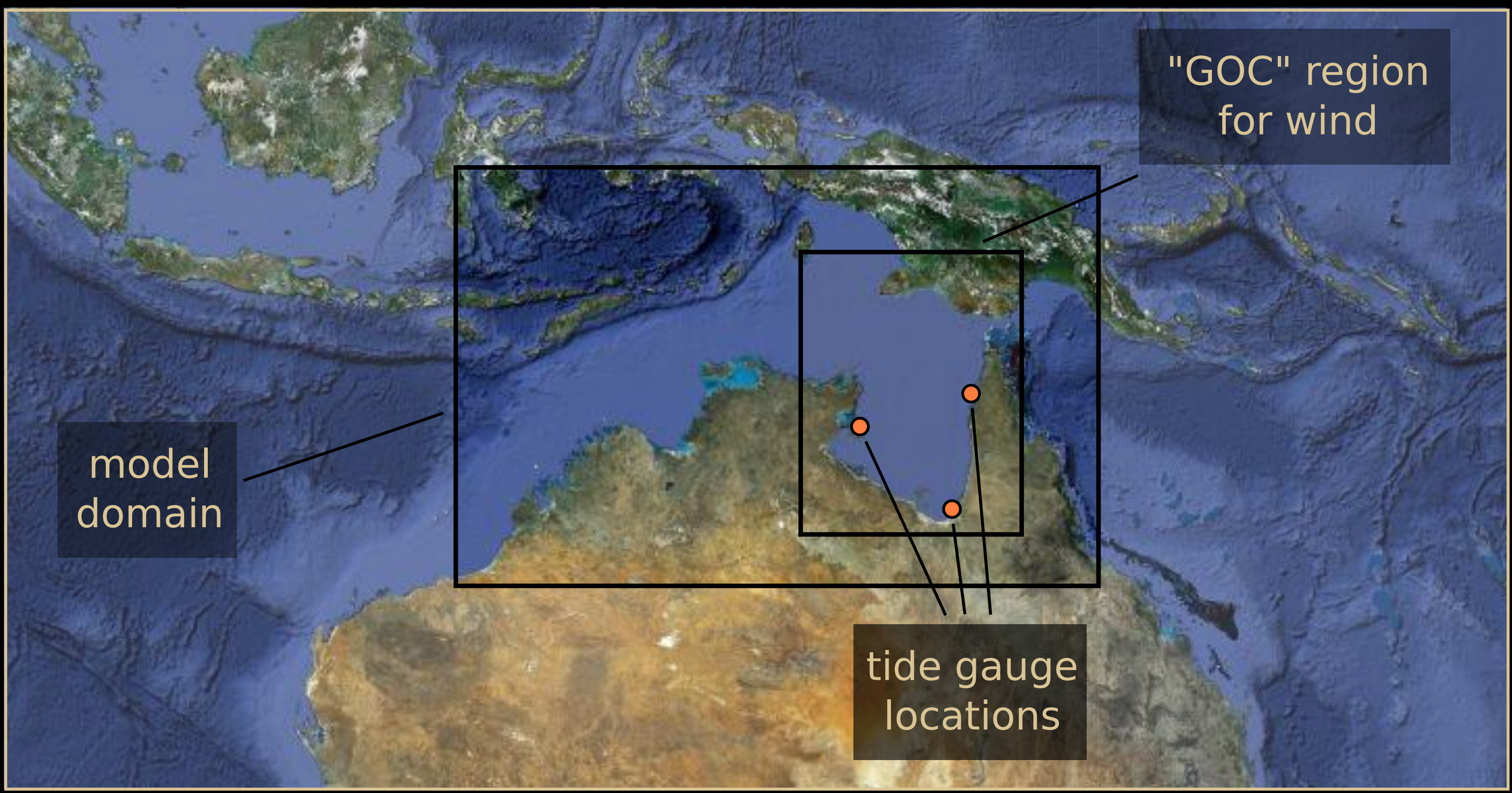
The MJO and Global Sea Level

- Oliver and Thompson [JGR, 2010] calculated statistical connections between the MJO and global sea level using a coherence-based metric



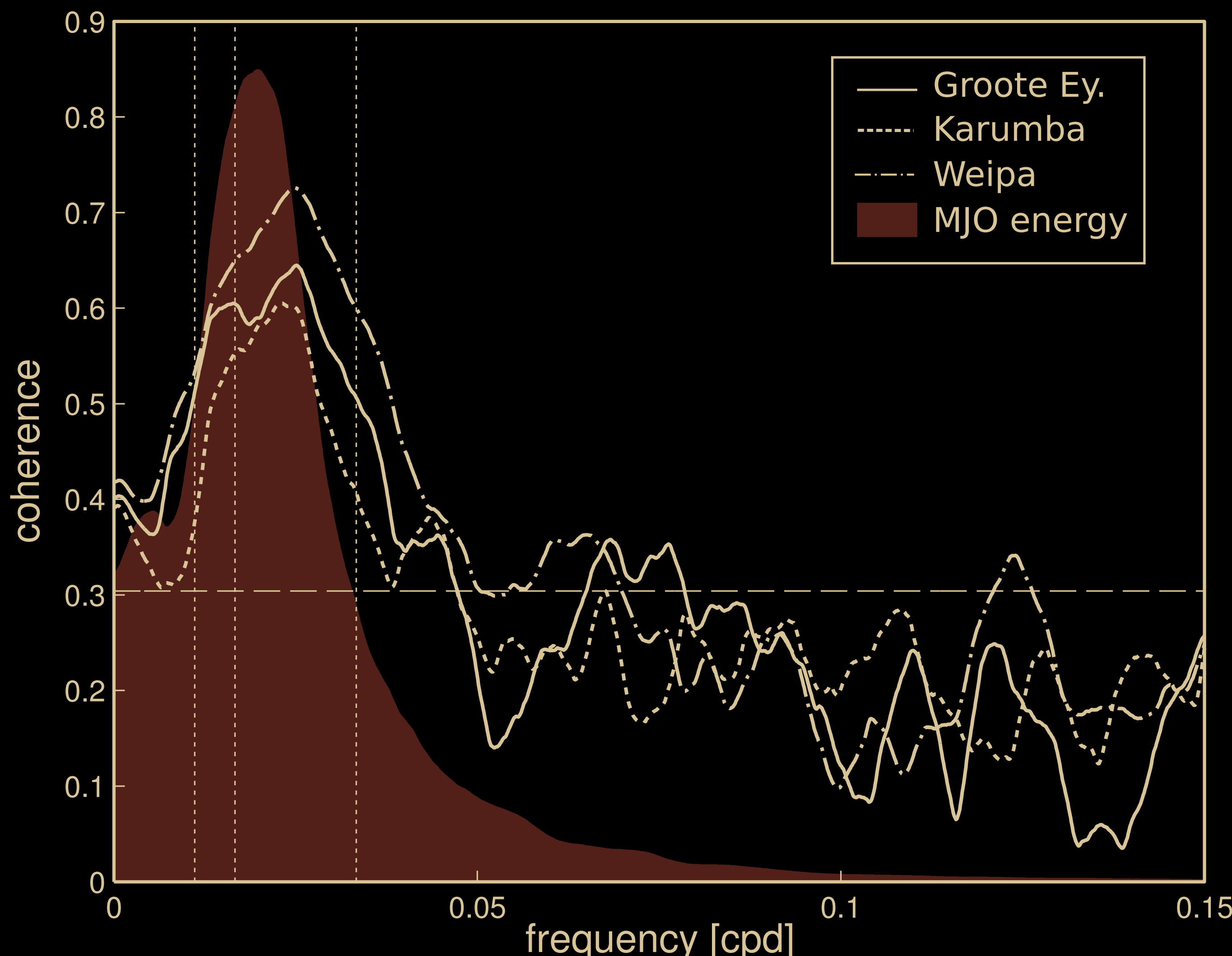
The Gulf of Carpentaria

- The Gulf of Carpentaria (GOC) is a shallow (~50 m avg.) sea north of Australia. It neighbours shallow Arafura and Timor Seas and the deep waters of the Indonesian Archipelago to the west as well as the deep waters of the Western Pacific to the East



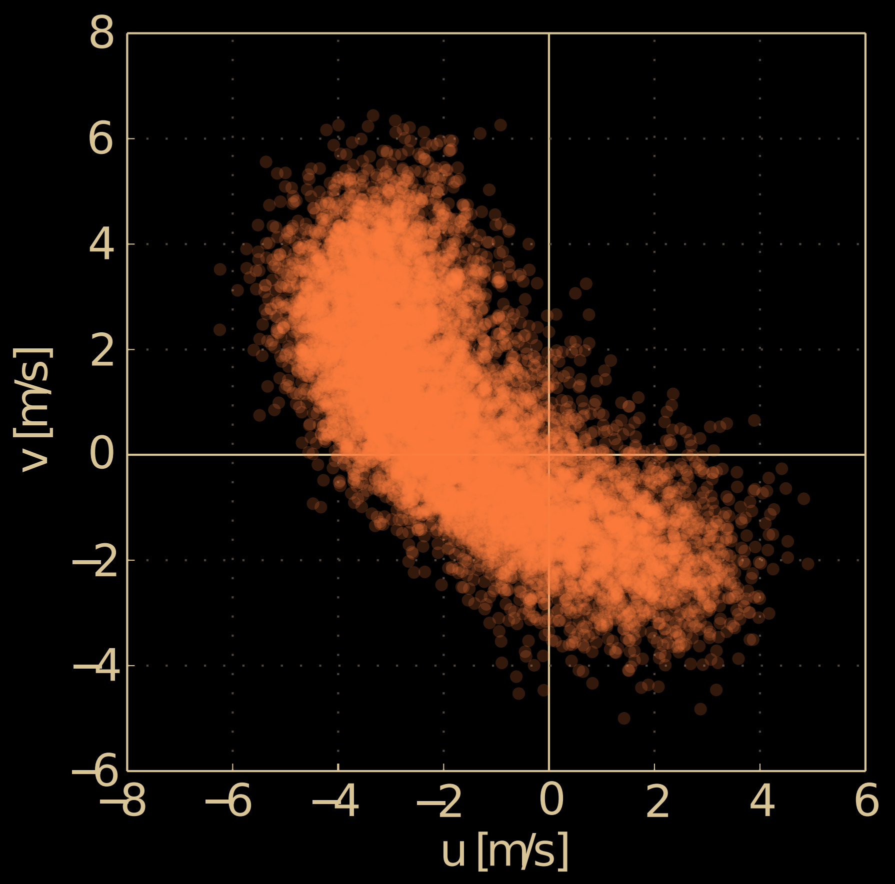
The MJO and Coastal Sea Level

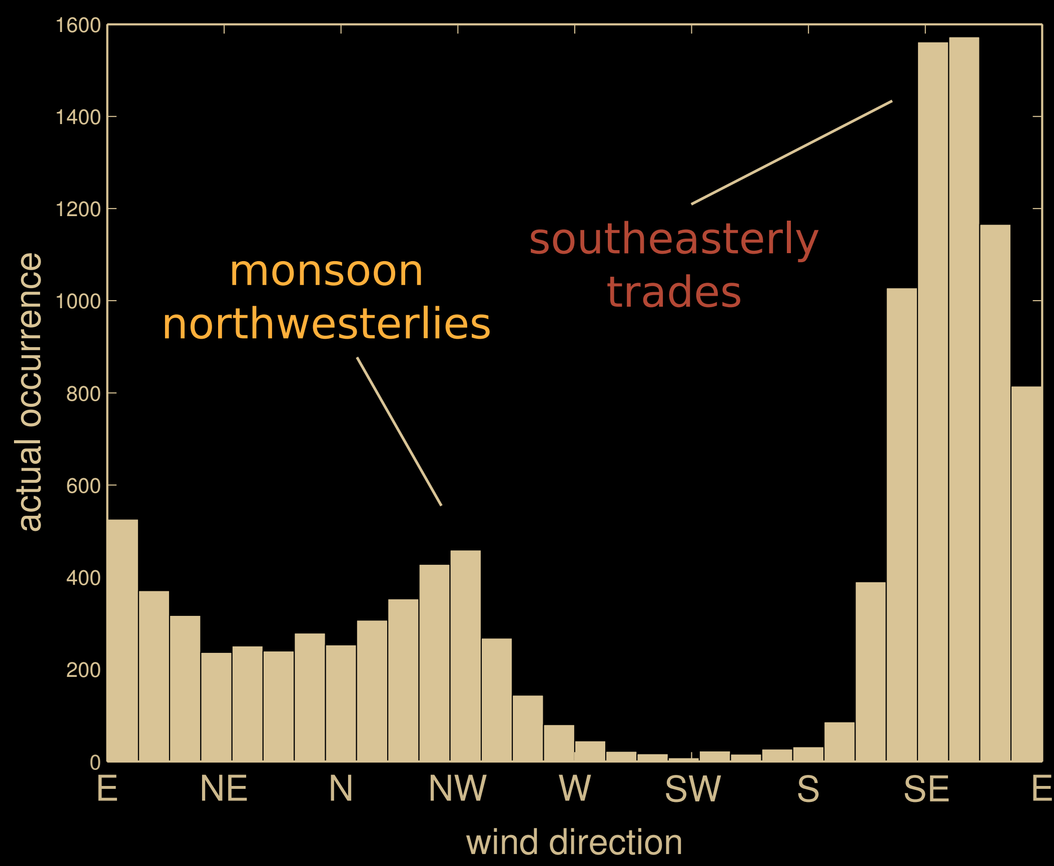
- Sea level from tide gauges also coherent with MJO over intraseasonal time scales:



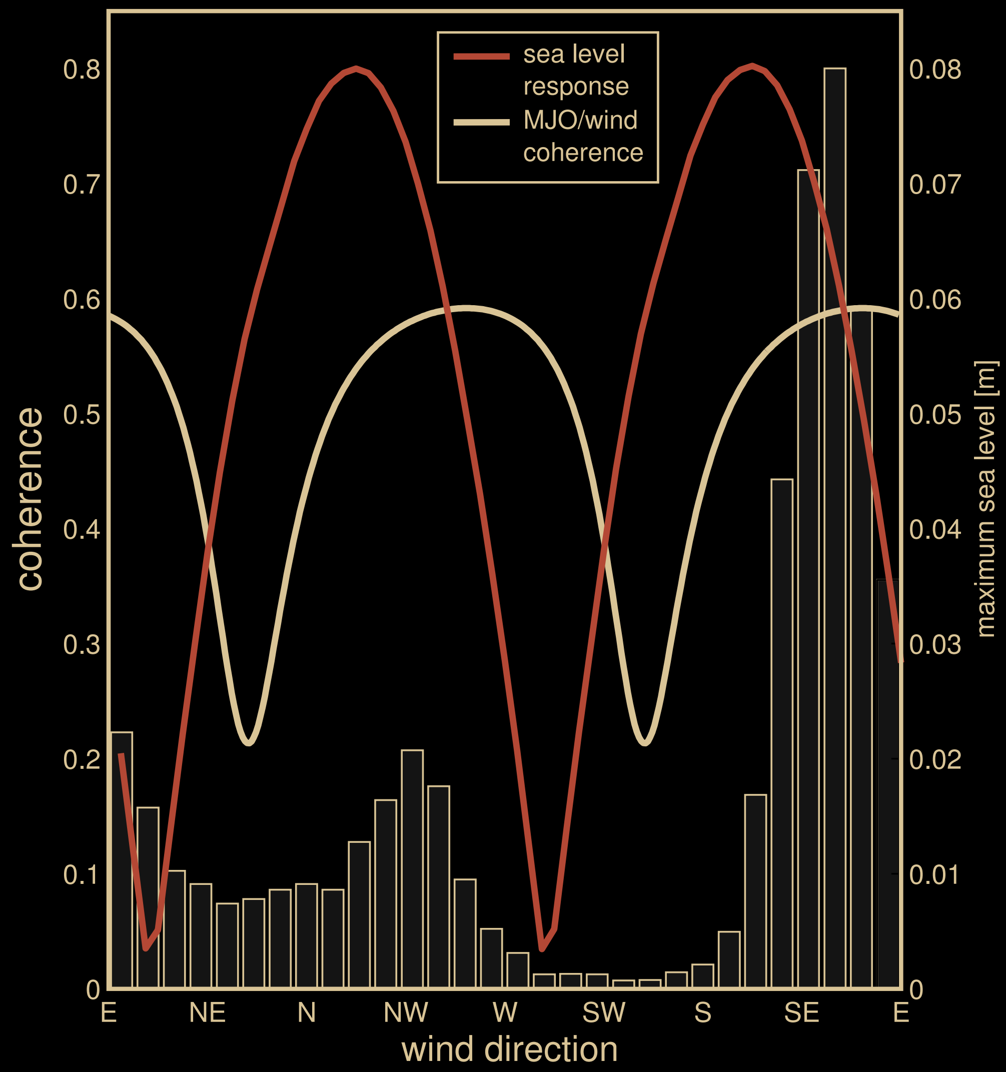
Observed Wind

- Surface wind (10m) over the GOC is predominantly northwesterly during monsoon season (peak in January) and the predominantly southeasterly trade winds peak six months later, in July





Observed Wind

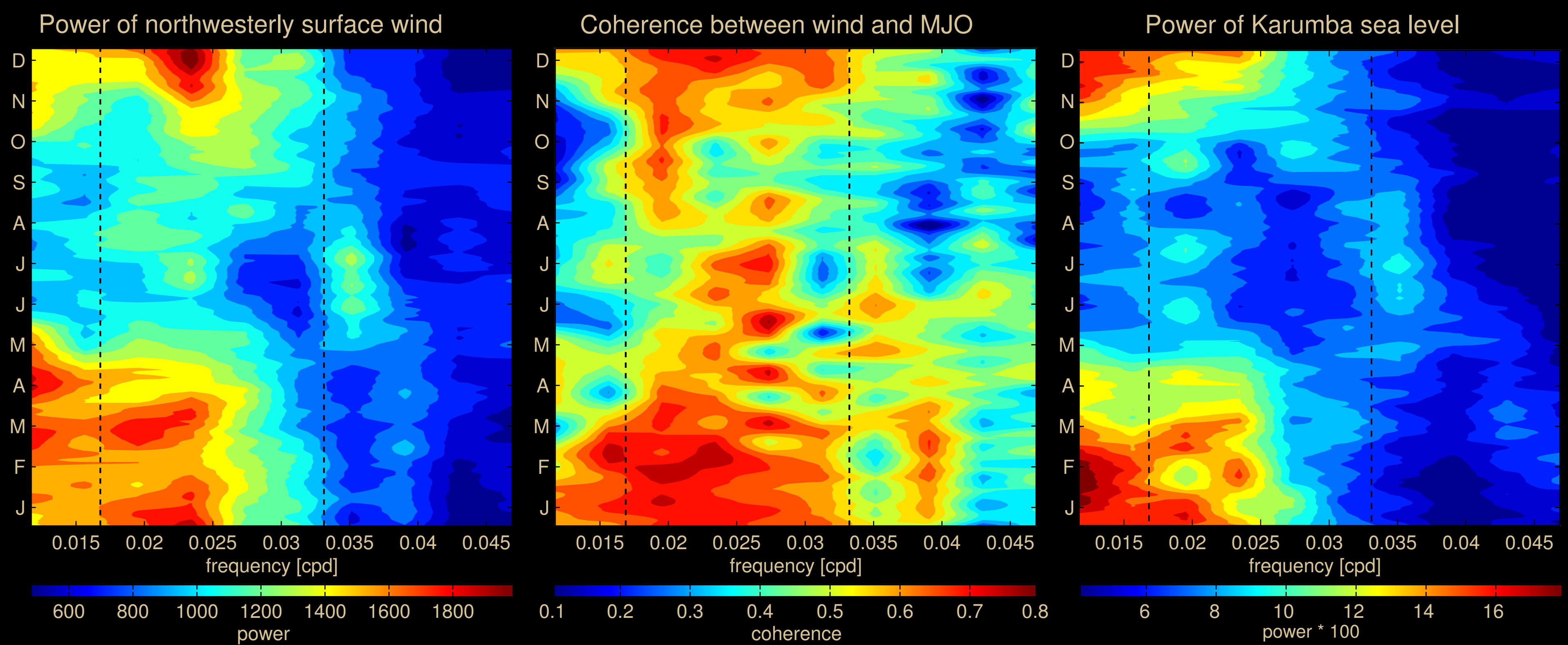


- Wind over the Gulf is predominantly northwesterly or southeasterly (▯ histogram bars)
- The coherence between the MJO and surface wind is highest for ESE and WNW winds (— line)
- Sea level in the Gulf responds preferentially to SSE and NNW winds (— line)

These factors combine to make sea level in the Gulf particularly responsive to the MJO

Seasonality of ISV

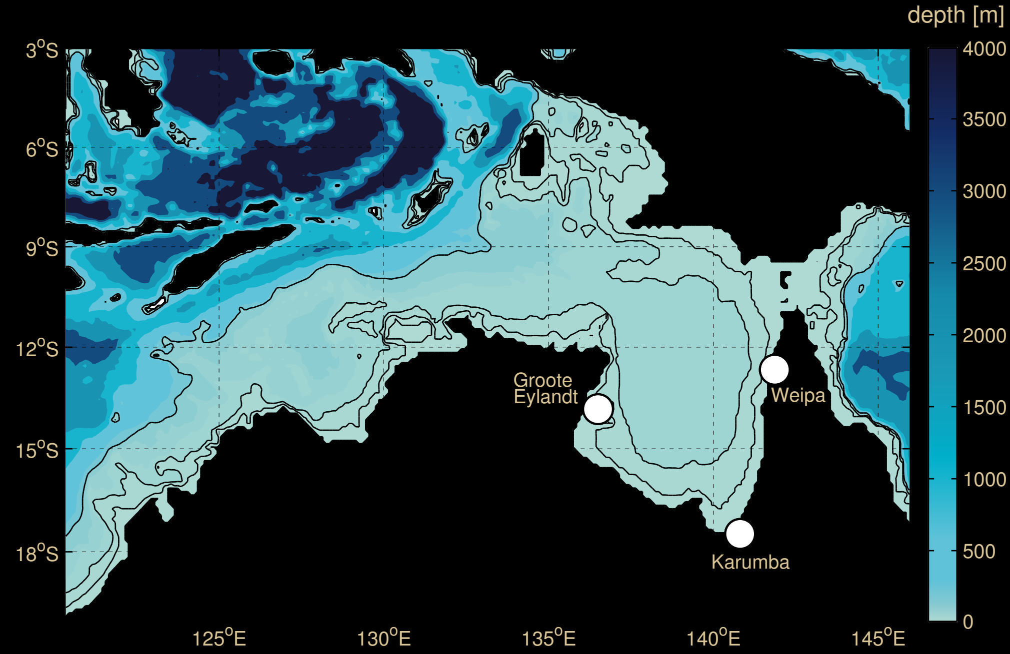
- Strong seasonality of wind, sea level, and MJO relationship over intraseasonal time scales.



- Northwesterly surface wind is strongly coherent with the MJO during the monsoon (Austral Summer) and this corresponds to season of maximum intraseasonal sea level variability .

Numerical Model

- Princeton Ocean Model (POM) [Blumberg and Mellor, 1987]
- Non-linear, two-dimensional barotropic
- Ten-minute spatial resolution (157 x 103 grid points)
- 12 s time step for CFL cond.
- Radiation conditions at open boundaries
- Sea level and both zonal and meridional currents output daily



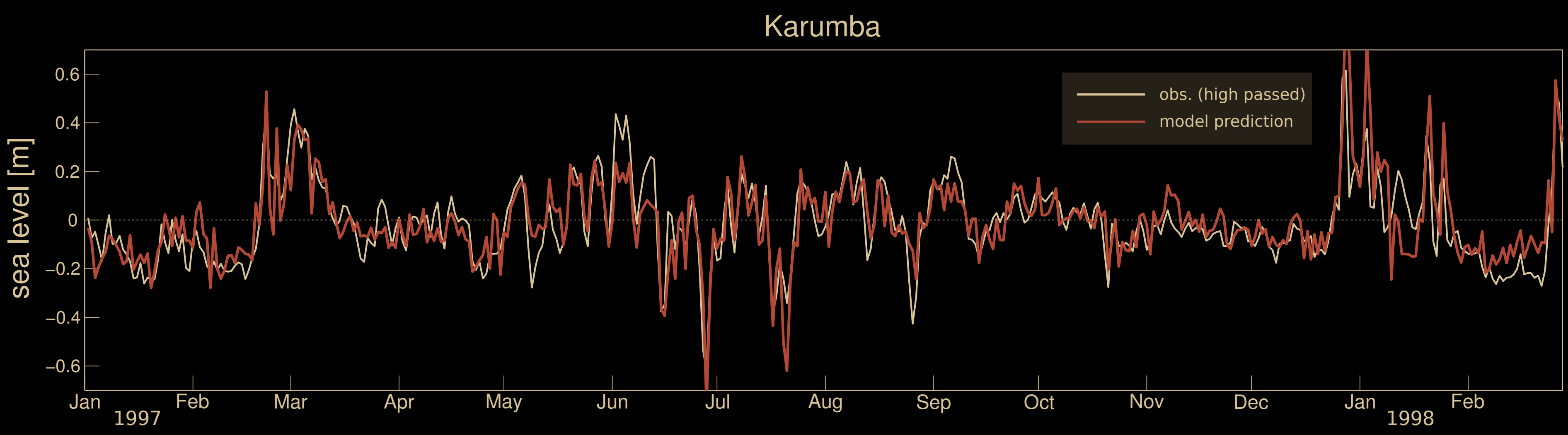
- Bathymetry from CSIRO, using Geoscience Australia (2009) data
- Forced by NCEP/NCAR Reanalysis 2 winds (6 hourly) and we are considering the POM results to be the wind-forced, barotropic component of sea level variability in the Gulf of Carpentaria

Predicted Sea Level

- Modeled sea level matches well with tide gauge records

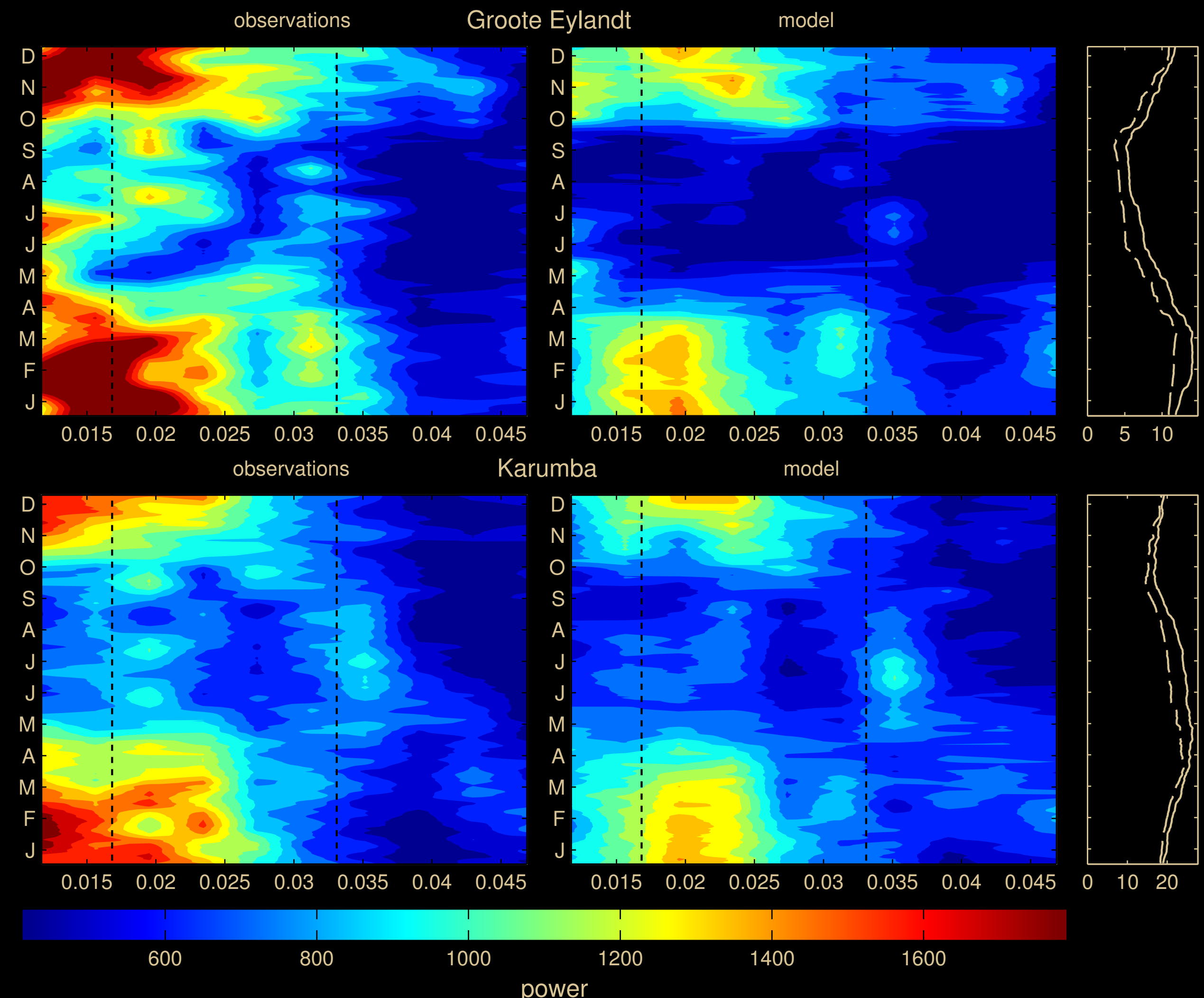
	Groote Eylandt	Karumba	Weipa
RMS error [cm]:	6.56	10.70	6.91
Correlation:	0.76	0.76	0.84
Gain	0.89	0.89	0.82

- Coherence is high (0.80-0.95) on intraseasonal frequencies (20-100 days) but drops for longer periods (>100 days) - model does not capture low frequency variability



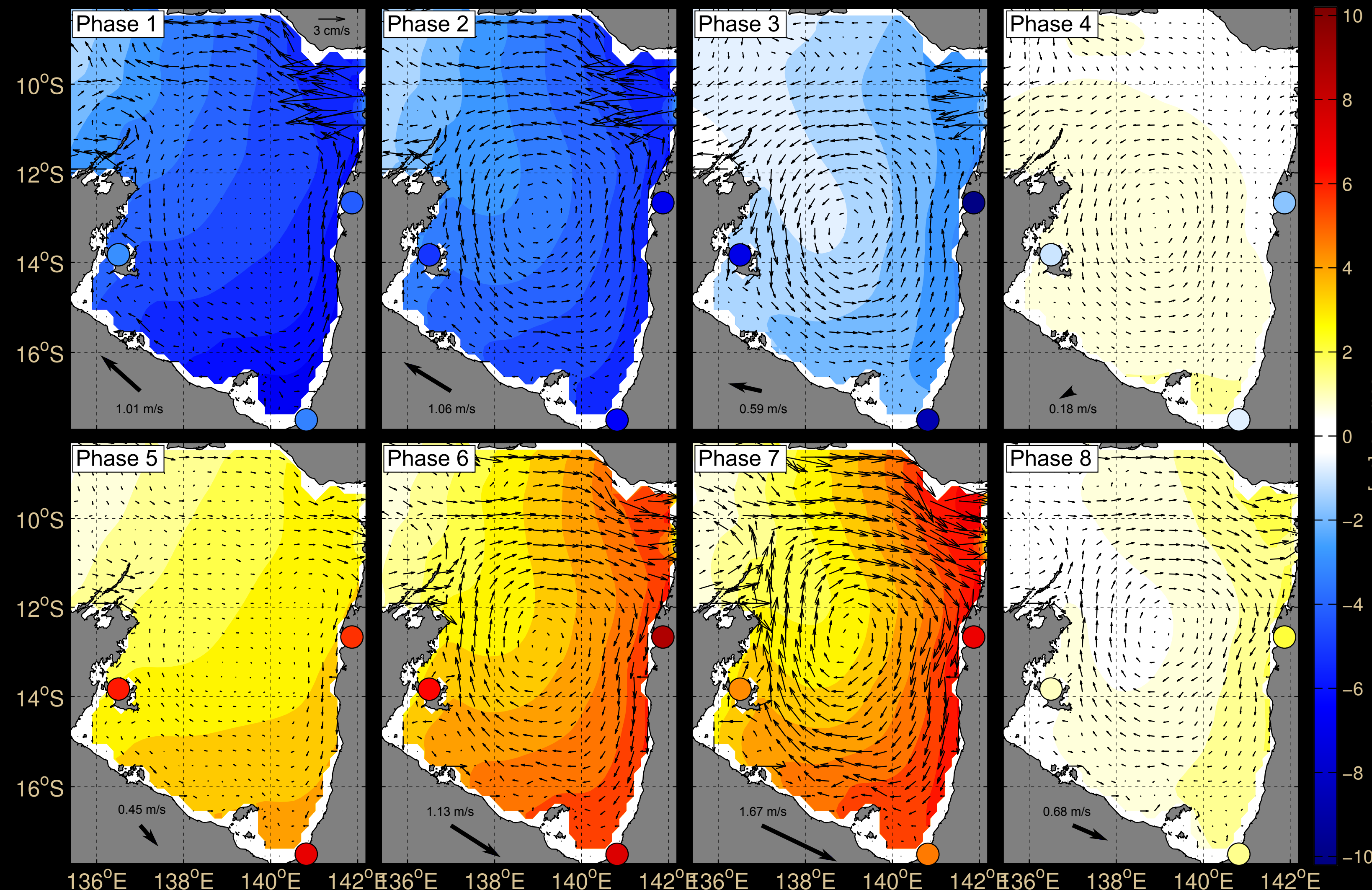
Predicted Seasonality of ISV

- Numerical model reproduces the seasonal cycle of intraseasonal variability, although with reduced amplitude



Canonical Response to MJO

- Composites of obs. wind, modeled sea level and circulation with the MJO: canonical response of Gulf of Carpentaria to MJO

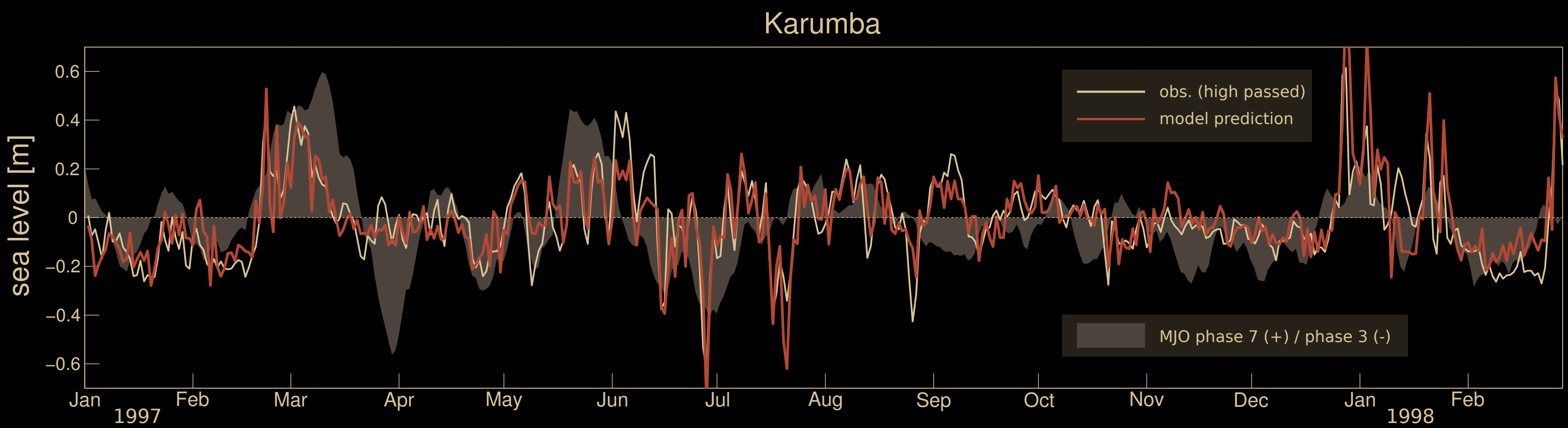


Setdown during phases 1-3

Setup during phases 5-7

Predictability: Role of the MJO

- The MJO index (projected on to phase 7/3) shows remarkable correlation with intraseasonal sea level in the Gulf of Carpentaria.



- The MJO index can be used as an indicator for set-up or set-down favourable conditions . . . the MJO can give predictability to the system

Predictability

- Potential predictability of MJO-related sea level variability quantified using a simple statistical prediction model

- Statistical model is a lagged linear regression model of sea level onto the MJO index at lags from 0 to D days.

$$\eta_{t+k} = \sum_{d=0}^{D} \beta_{1,d} I_{1,t-d} + \beta_{2,d} I_{2,t-d} + \epsilon_t$$

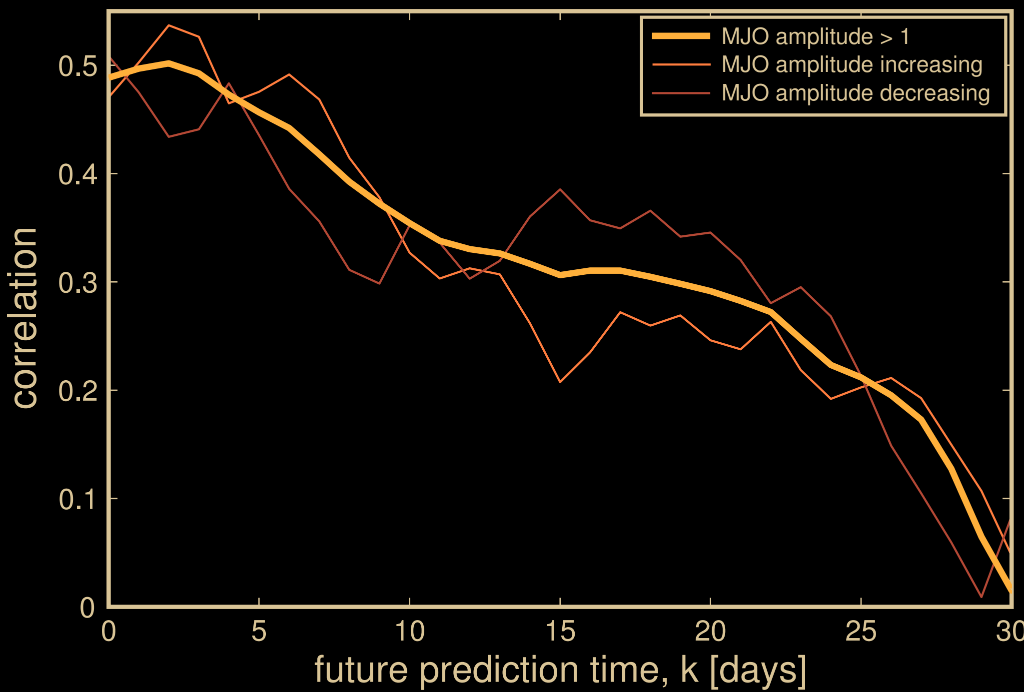
MJO index

regression coefficients

sea level at future time k

Predictability

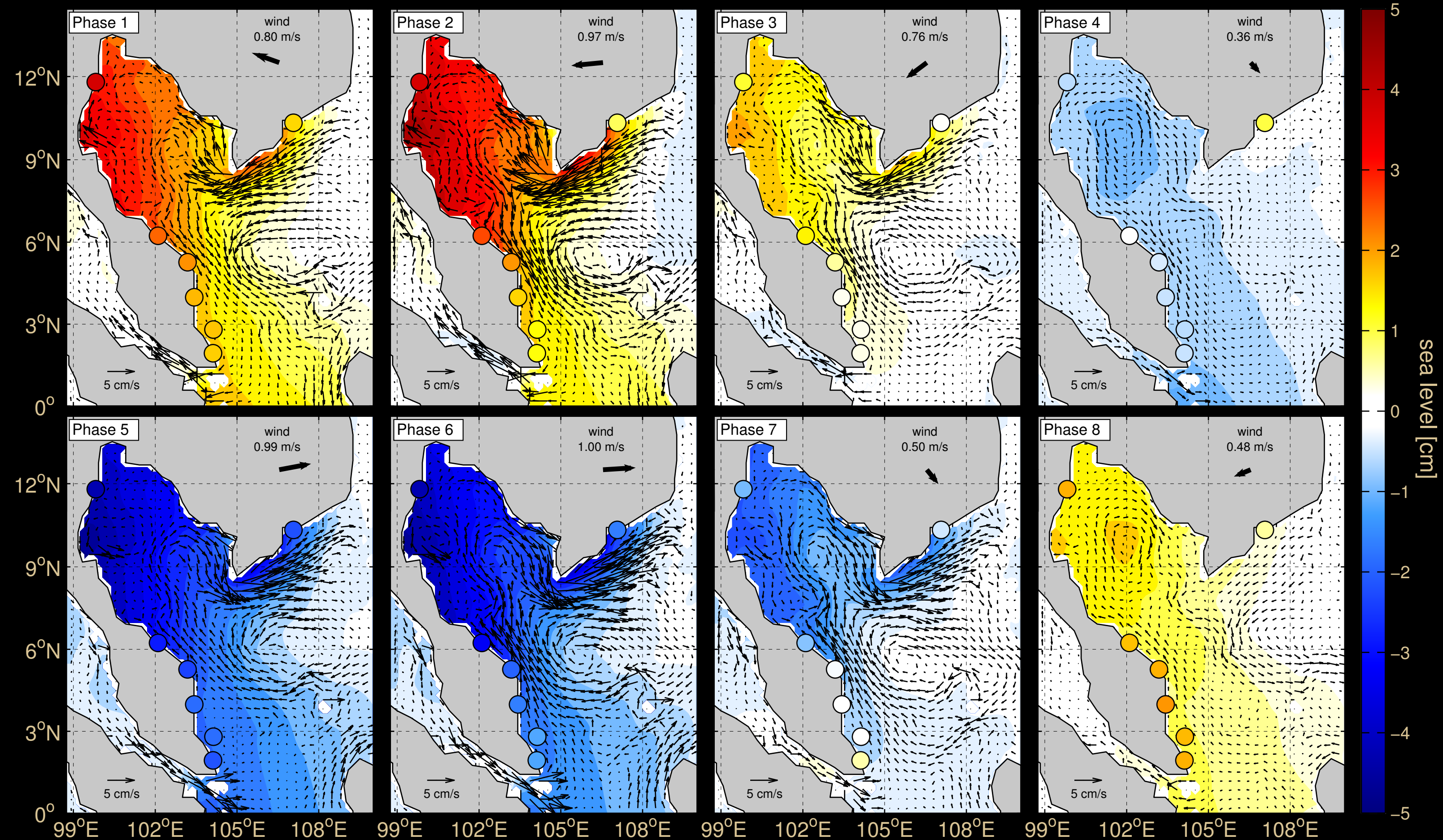
- Model only includes lags 0 and 8 days. Trained over March-November for 1979-1994 and validated for March-November 1995-2009:



- Statistical model can account for at 10-25% of the variance with leads times up to 20 days
- Can be supplemented with forecasts of the MJO index...

The Gulf of Thailand

- Similar study in Gulf of Thailand shows a very similar phenomenon: MJO-related wind-driven sea level and circulation variability during the monsoon season (July-January)



Setup during phases 8, 1-3

Setdown during phases 4-7

Oliver, E.C.J., Intraseasonal variability of sea level and circulation in the Gulf of Thailand: The role of the Madden-Julian Oscillation, accepted for publication in Climate Dynamics

Conclusions

- Madden-Julian Oscillation, an intraseasonal tropical phenomenon, is connected to global patterns of variability in sea level.
- Surface wind over the Gulf of Carpentaria is highly correlated to the MJO and is also well suited for setting up sea level.
- Numerical model confirms that observations are mainly wind-driven sea level set up during the Australian-Indonesian Monsoon
- Winds that lead to sea level set-up are part of a global system related to the MJO: there is potential for predictability and this is demonstrated using a simple real-time prediction model

Related publications:

i) Oliver and Thomspon, 2010, J. Geophys. Res.
ii) Oliver and Thompson, 2011, J. Geophys. Res
iii) Oliver, accepted for publication in Clim. Dyn.

Thank you!