Temporal and spatial scale dependency of air-sea interactions over the Gulf Stream

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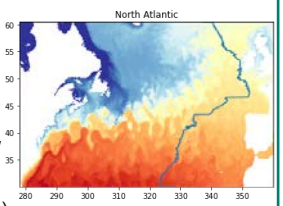
Motivation

- Air-sea coupling via the vertical mixing mechanism (VMM) and the pressure adjustment mechanism (PAM) rely on interactions between SST, wind(stress) and sea level pressure.
- When models resolve mesoscale eddies, they are able to capture these coupled ocean-atmosphere processes that are otherwise not seen in lower resolution models.
- However, the timescales and spatial scales of these air-sea interactions is less clear.
- What are the temporal and spatial scales of the following air-sea interactions?
  1) SST & surface wind speed
  2) VMM: downwind SST gradient & wind stress divergence
  3) PAM: Laplacian of SLP & wind stress convergence

Model & methodology

- ICON-A: ICOsahedral Nonhydrostatic Atmosphere
- ICON-O: ICOsahedral Hydrostatic Ocean
- ~1 year global coupled 5-km ICON run [NextGEMS]
- Daily surface variable output

- *Right:* Region over which cross spectra are computed. North Atlantic following coast and extending eastwards
- *Below:* Figures below show phase spectra (hue) & squared coherence (saturation)



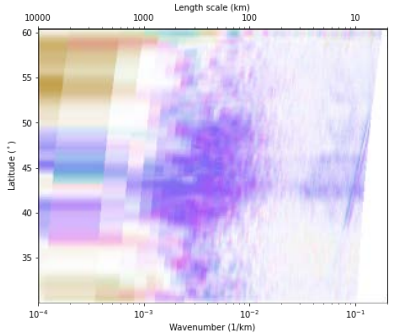
Conclusion

Air-sea coupling	Spatial scale	Timescale
SST-wind speed	**100-900 km**	**>= 30 days**
	> 500 km	*all*
Vertical mixing mechanism	10-60 km	*all*
	100-900 km	**>= 10 days**
Pressure adjustment mechanism	**60-100 km**	***all***
	>1000 km	*all*

- In bold are spatial scales where main power of in-phase air-sea coupling reside
- *all* indicates timescales between 2-60 days

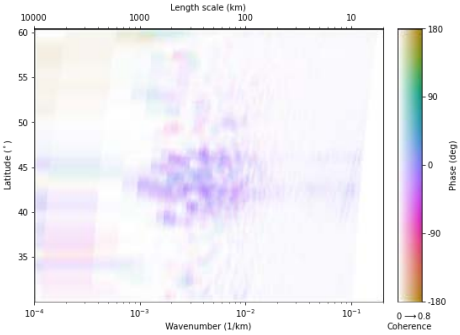
SST & surface wind speed

Spatial spectra (monthly fields)



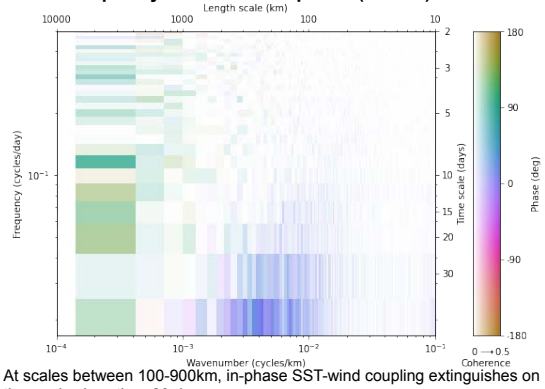
- On monthly timescales, power of in-phase SST-wind coupling, which suggest ocean-driven variability, reside at 10-60km and 100-900km

Spatial spectra (daily fields)



- Significance of SST-wind coupling diminishes when shortening timescales from monthly to daily

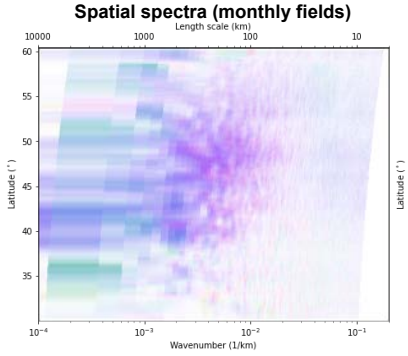
Frequency-wavenumber spectra (40-50N)



- At scales between 100-900km, in-phase SST-wind coupling extinguishes on timescales less than 20 days
- At scales greater than 5000km, 90° phase-lag in SST-wind coupling suggests atmosphere-driven variability

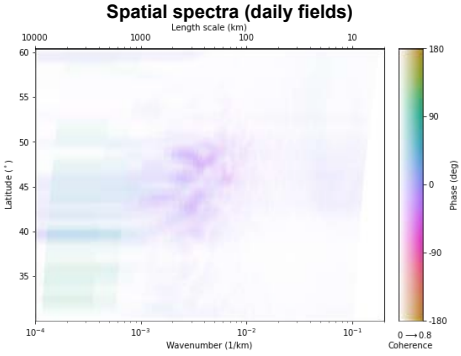
VMM: downwind SST gradient & wind stress divergence

Spatial spectra (monthly fields)



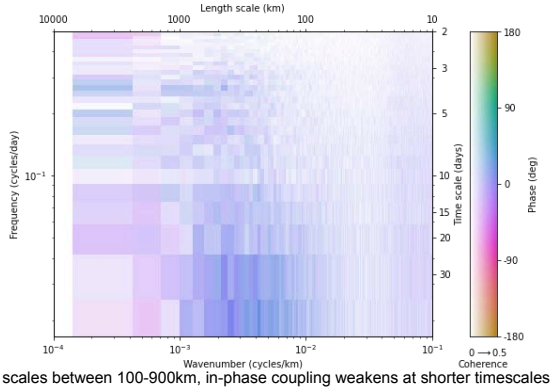
- Power of in-phase coupling resides at 90-1000km, and along the front (~42°N), up to ~8000km

Spatial spectra (daily fields)



- Significance of coupling weakens as timescale shortens from monthly to daily

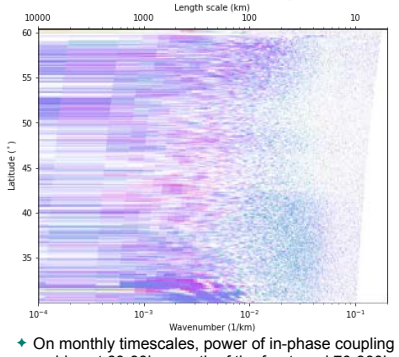
Frequency-wavenumber spectra (40-50N)



- At scales between 100-900km, in-phase coupling weakens at shorter timescales
- In-phase coupling also seen at scales between 10-60km

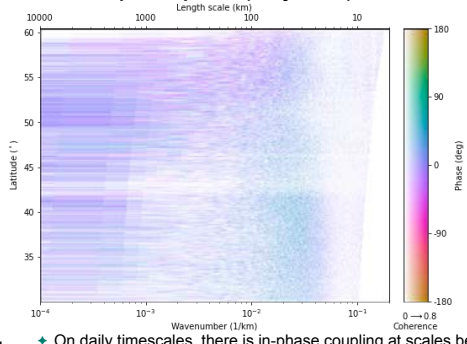
PAM: Laplacian of SLP & wind stress convergence

Spatial spectra (monthly fields)



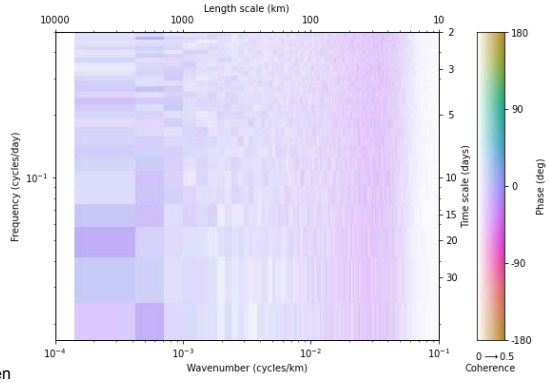
- On monthly timescales, power of in-phase coupling resides at 60-90km south of the front, and 70-900km north of the front.

Spatial spectra (daily fields)



- On daily timescales, there is in-phase coupling at scales between 60-100km and scales larger than 1000km south of the front
- North of the front, coupling at all scales larger than 70km

Frequency-wavenumber spectra (32-42N)



- At scales between 60-100km, in-phase coupling at all timescales

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