An Ocean-Atmosphere Simulation for Studying Air-Sea Interactions

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1. Background:

Analysis of coarse-resolution, observation-based products generally finds negative correlation between Sea Surface Temperature (SST) and surface wind speed. This ocean-atmosphere interaction is interpreted as the ocean passively responding to wind-induced latent and sensible heat fluxes. For oceanic mesoscales, however, observations show that wind speed is stronger over warmer ocean and weaker over cooler ocean. The explanation for this is one-way feedback between SST anomalies and Planetary Boundary Layer (PBL) instability. Positive SST anomalies increase PBL instability, which results in transfer of momentum from the upper levels to the surface.

Is there a governing two-way feedback mechanism between the atmosphere and the ocean?
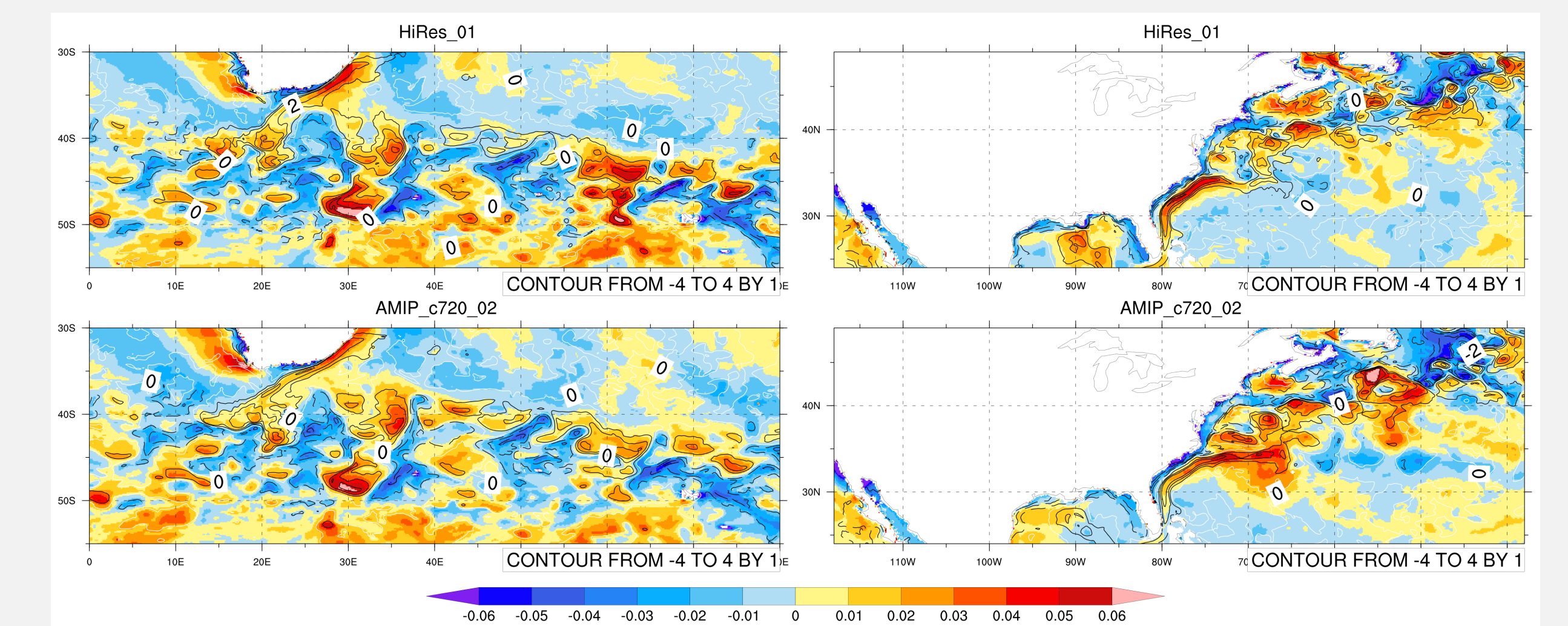
Two-month averages (Feb-Mar, 2012) of spatially high-pass-filtered sea surface temperature (SST) overlaid as contours on spatially high-pass-filtered wind stress

2. The coupled Model

Atmosphere – GEOS:
- Horizontal grid type – Cubed sphere, $1/8°$ X $1/8°$
- Vertical grid type – hybrid sigma-pressure, 72 levels

Ocean – MITgcm
- Horizontal grid type – Lat-Lon-Cap, $1/12°$ X $1/12°$
- Vertical grid type – z* rescaled height vertical coordinate, 90 levels

3. Experiments

1. Atmosphere Only – GEOS (AGCM)
- Feb, 9 – Apr 9, 2012
- Forcing: SST and ice fraction from ocean only equivalent experiment.
- Initial conditions: MERRA-2
2. Coupled – GEOS-MITgcm (AOGCM)
- Feb, 9 – Apr 9, 2012
- Ocean initial conditions: from run 1
- Atmospheric initial conditions: MERRA-2 (same as the run 1)

4. Correlation between daily SST and wind speed tendencies

**Coupled**   **Atmosphere Only**   **MERRA-2**
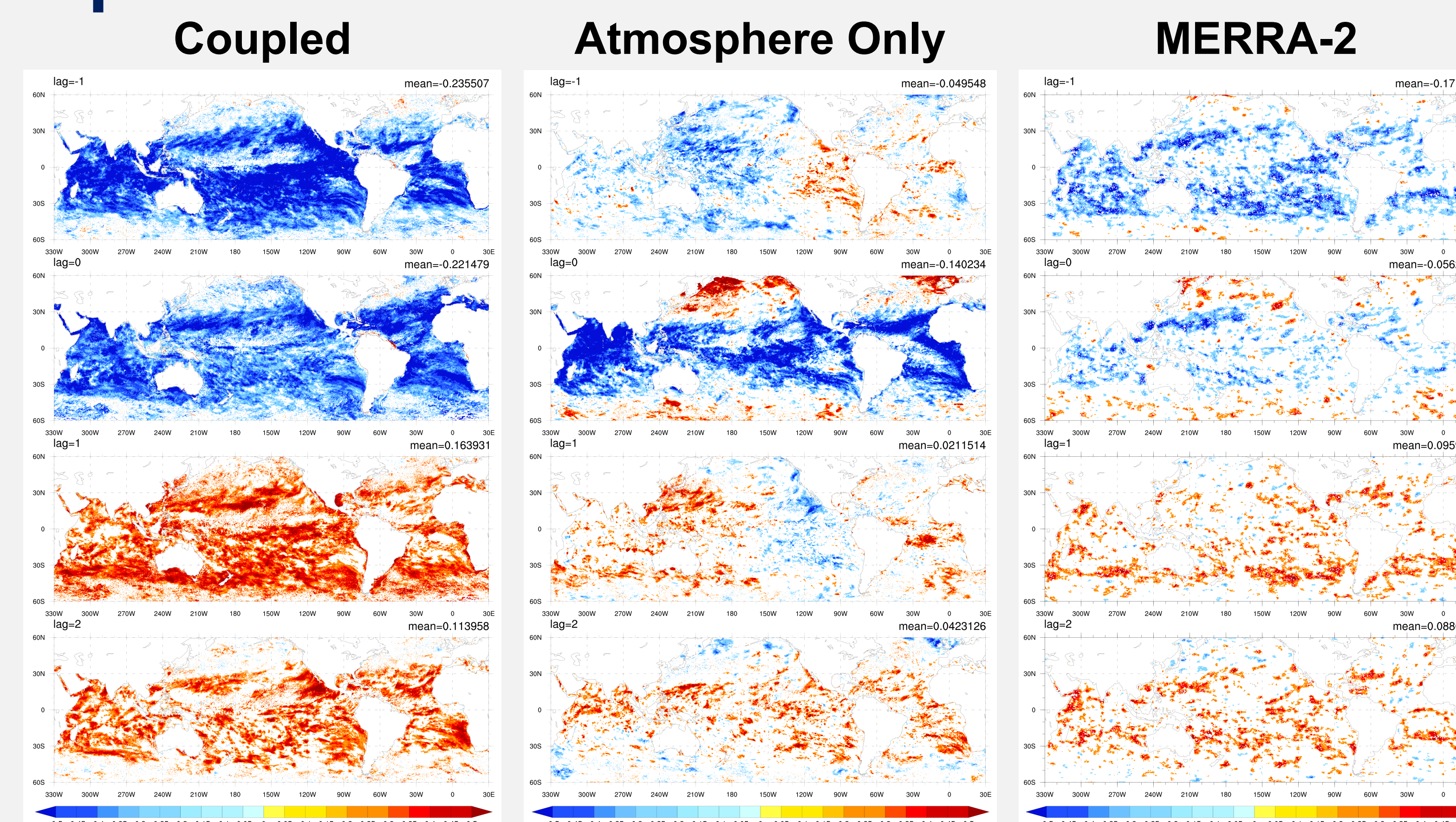
Lagged correlations between SST and wind speed for -1,0,1 and 2 days for the AOGCM (left), AGCM (middle) and MERRA-2 (right). Positive lag corresponds to SST leading the wind speed

Coupled – SST and wind speed spectral analysis
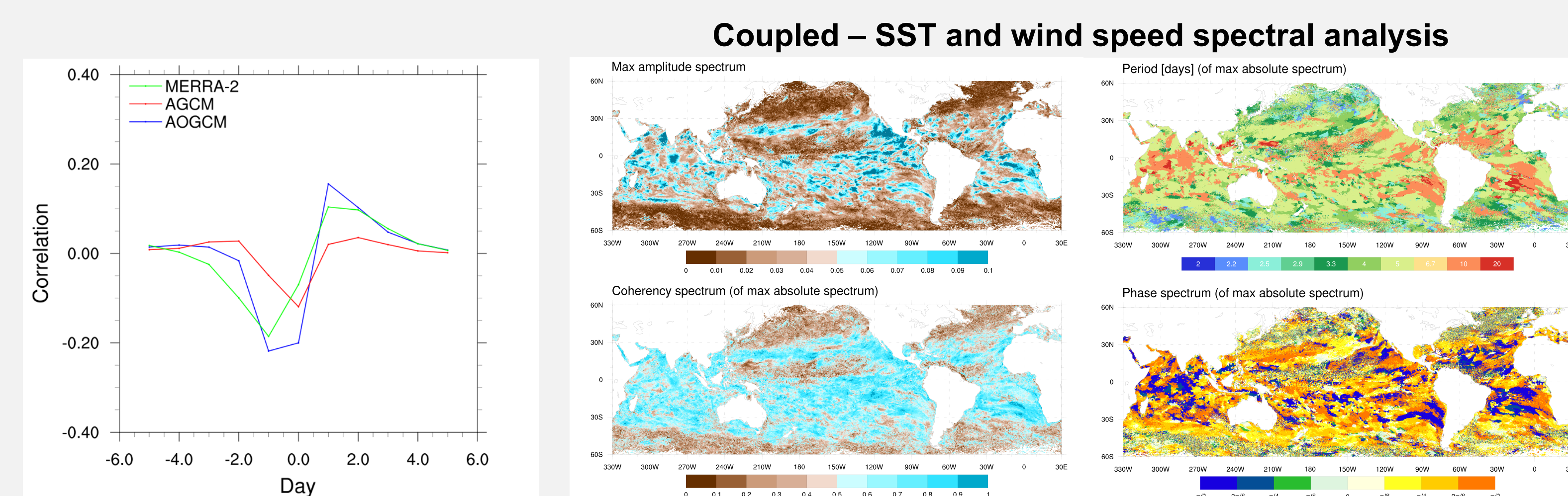
Global lagged correlations between SST and wind speed

Maximum absolute spectrum (top left) and the coherency (bottom right), Frequency (top right) and phase (bottom right) of the maximum absolute spectrum.

SST-wind correlation indicates a 3-5 day cycle

5. Buoys
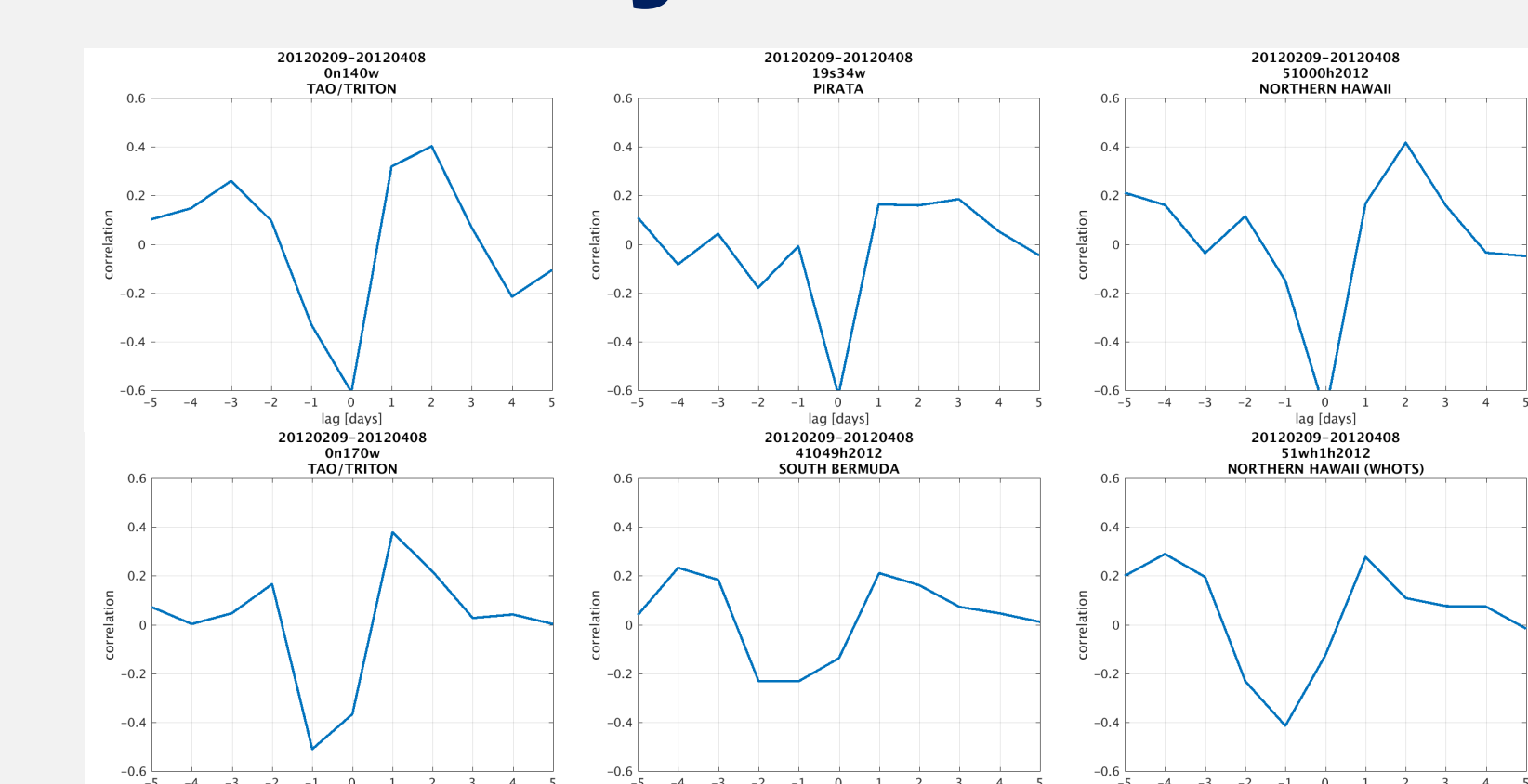
Lagged correlations between observed daily SST and wind speed tendencies for 6 boys

A 3-5 days cycle is also found in buoys

6. Suggested mechanism

Positive SST anomaly

Reduce upward latent and sensible heat flux

Increase instability and draw horizontal momentum from upper levels

Negative wind anomaly

Positive wind anomaly

Increase stability

Increase upward latent and sensible heat fluxes

Negative SST anomaly