Investigation of surface flux feedbacks for coupled atmosphere-ocean anomalies

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Outline

- Overview of dynamical coupling rules
- Data sets used for classification and compositing
- Statistics of coupling events
- Composite analyses
- Conclusions and further work
Coupled or Uncoupled?

- Difficult to determine directly from observations
- Statistical, Cross-Correlation Method (Czaja et al. 2003)
- Use dynamical rules for determining atmosphere vs. ocean forcing (Pena et al. 2004)
Data Sets

- Data Period: 1985-2007 (23 years)
- MERRA 850mb U,V winds
- Reynolds OISST AVHRR-only V2
- OAFlux v3.0 Turbulent Fluxes
- GEWEX-SRB Shortwave and Longwave Radiation Fluxes

Methodology

- Interpolated all data onto 2.5 degree, pentad grids
- Removed mean annual cycle from each grid point
- Used dynamical rule for classifying coupled anomalies
- Coupled events longer than 3 pentads (15 days) were used for compositing surface heat budget terms
Largest absolute number of coupled “events” found in the tropics.

- Coupling in the extratropics: atmosphere-driving
- Coupling in the tropics: ocean-driving
Duration of “Events”

- The number of longer lasting anomalies in the tropics are same-sign -- OCEAN DRIVING
- The extratropics show opposite sign anomalies are longer lasting -- ATMOSPHERE DRIVING
Latent Heat Flux (about -25 to 25 W/m^2)

- Magnitudes appear to be stronger outside of the tropics.
- The extratropical LHF appears to be "in-phase" with regards to the sign of the SST anomaly.
- The tropical response appears to suggest a stronger connection to SST.
Sensible Heat Flux (about -10 to 10 W/m^2)

SHF magnitudes only about half the size of the LHF; tropical response particularly muted.

Extratropical Response appears connected mostly to wind speed.
Increase in QS-QA for SST>0 means QA does not increase as fast as QS. This also means that higher LHF is expected which would act to dampen the anomaly.

Since Qa is normally lower than QS, a decrease in QS-QA as QS decreases is expected. An increase in QS-QA results if QA decreases faster than QS.

How much can we trust Qa (or Ta) in the Southern Ocean ... ??
Wind Speed (about -1.5 to 1.5 m/s)

- Extratropics: Positive correlation between vorticity and wind speed; relationship less straightforward in the tropics.
- The wind speed response shows a positive feedback for parts of the tropical Pacific.
- Strongest wind speed response appears to be in the Southern ocean.
- Relationship in tropics perhaps related to differential changes in vorticity/pressure across the basin.
Net Shortwave response is on par with the changes in LHF overall but stronger than LHF in the deep tropics.

Positive feedbacks are seen for Ocean forcing cases in the stratus deck regions.

Extratropics show the expected dynamical relationship: Cyclonic => More Clouds => Less Radiation
Net Longwave Down (about -5 to 5 W/m$^2$)

- Longwave response is more muted, mostly from a cancellation of the upwelling and downwelling components (not shown).
- Large region of positive feedback by LWR forcing in central Pacific, but remember this weak.
- Negative feedback in the extratropics of atmospheric forcing cases.
Cloud Fraction (about -10 to 35 W/m\(^2\))

Cloud fractions are as expected of the dynamical coupling rules in the extratropics but less so in the tropics.

The tropics generally show a much stronger coupling to the SST, regardless of the sign of the vorticity anomaly.
Summary

- The use of “dynamical coupling” rules allows for identifying coupled vs. uncoupled anomalies and one-way interaction.

- Results of this study are consistent with those of Pena et al. (2003, 2004) although using a more recent reanalysis at higher resolution.

- Find more atmosphere-forcing coupled anomalies in the extratropics and ocean-forcing anomalies in the tropics.

- The LHF and SWR show the largest magnitude anomalies in the composite analysis.

- The turbulent flux responses are due to interactions between the differing responses in wind speed and near-surface gradients.

- The radiative fluxes responses are primarily tied to changes in cloud fraction, as expected, though longwave response can be tied more to changes in the upwelling component.
Future Work

- Perform similar composite analysis to MERRA turbulent and radiative fluxes.
- Use the CFSR to examine changes on the ocean side.
- Examine composite analysis using satellite-only based turbulent flux products.

References