R: Sea surface temperature and salinity south of Java as predictors of Indonesian precipitation

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Objective

Rainfall in the Indonesian Throughflow region is greatly influenced by coupled air-sea processses on a range of temporal scales: the Madden-Julian Oscillation on intraseasonal time scales, the seasonal monsoon, and the interannual Indian Ocean Dipole (IOD) and ENSO climate modes. The objective is to evaluate the predictability of Indonesian rainfall variability in the boreal fall, using the 90-year monthly output from the ACME v0.1 enhanced resolution fully coupled model. We found that, besides ENSO and IOD, sea surface salinity at the Java region in the boreal summer is an important predictor of the South Indonesian rainfall in the subsequent boreal fall.

Approach

We analyze both ACME v0.1 model output and observations.

Model: 90-year monthly output.
Observations:
(1) Salinity: EN4 (Good et al. 2013, JGR).
(2) Temperature: EN4 and Hadi (Rayner et al. 2003, JGR).
(3) Precipitation: Global Precipitation Climatology Project monthly precipitation (GPCP).

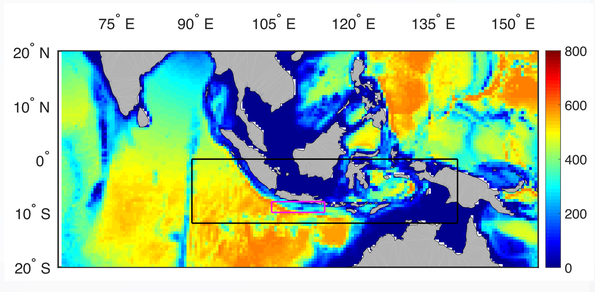
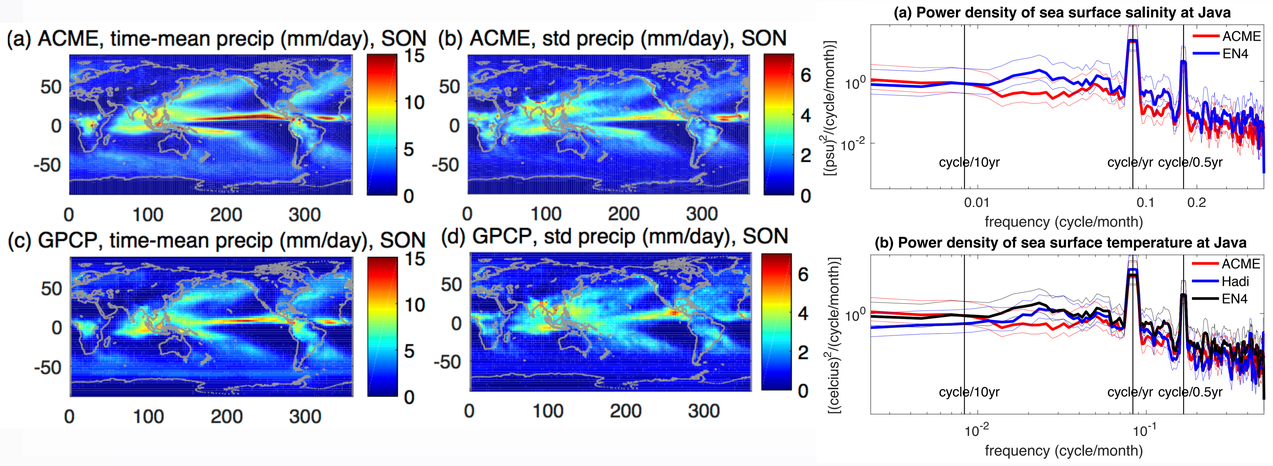


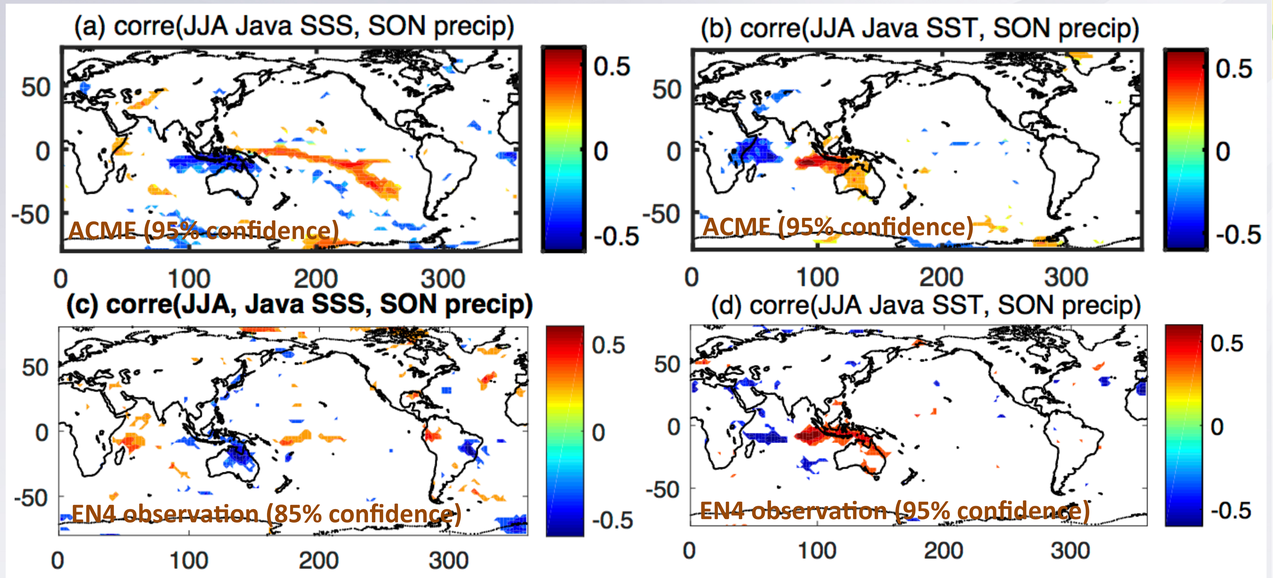
Fig1. Bathymetry (m) from the ACME model. Black box indicates the South Indonesian region, where the fall rainfall variability is assessed. We also examine the link between sea surface salinity and temperature in the Java region (magenta box) in the summer and the rainfall variability in the subsequent fall in the black box.

Results

(a) Model and data agree on time-mean, standard deviation and spectra of key variables.



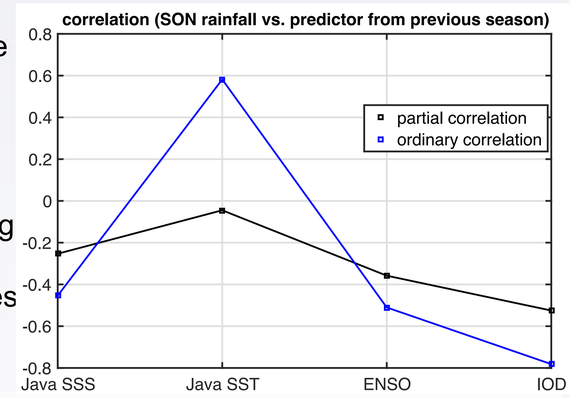
(b) Correlation between sea surface salinity (SSS) and sea surface temperature (SST) at June-August south of Java and the global precipitation at September-October.



In both model and observations, large Java SSS and small JAVA SST in the summer corresponds to less rainfall in the Southern Indonesian in the subsequent fall.

(c) Relative importance of four predictors of the Fall rainfall in the Southern Indonesian.

For the fall rainfall, the most important predictor is the IOD index in the summer, the ENSO index is the 2nd most important predictor, Java SSS has a noticeable contribution as well.
Hypothesis: the increase of JAVA SSS weakens the barrier layer thickness, leading to more vertical mixing and a lower SST. In consequence, atmosphere Convection is reduced and thus fall rainfall decreases The barrier layer and salinity variability probably also modulate IOD characteristics.



Impact

(1) Observations and model agree in the correlation, spectral analysis, as well as the time-mean and standard deviation of rainfall, temperature and salinity, suggesting that, despite the challenges of simulating tropical rainfall variability, ACME v0.1 is a reasonable tool to explore tropical rainfall dynamics.
(2) Both salinity and temperature at Java are important in modulating tropical rainfall variability.
(3) Future work:
a. to test the barrier layer hypothesis using ACME model.
b. to gain a deep understanding of tropical rainfall variability, its simulation and prediction.

References

(1) Rayner, N. A., et al. "Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century." *Journal of Geophysical Research: Atmospheres* 108.D14 (2003).
(2) Good, Simon A., Matthew J. Martin, and Nick A. Rayner. "EN4: Quality controlled ocean temperature and salinity profiles and monthly objective analyses with uncertainty estimates." *Journal of Geophysical Research: Oceans* 118.12 (2013): 6704-6716.

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