Evaporation-Precipitation Feedback in Reanalysis and Model Data: North America and Beyond

Alexis Berg
Geophysical Fluid Dynamics Laboratory, NOAA

Kirsten Findell
Geophysical Fluid Dynamics Laboratory, NOAA

Pierre Gentine
Department of Applied Physics and Applied Mathematics, Columbia University

Benjamin Lintner
Department of Environmental Sciences, Rutgers The State University of New Jersey

Land-atmosphere interactions are recognized as a major component of the physical climate system. One of the key features of these interactions is the feedback of soil moisture on precipitation, which reflects the coupling between soil moisture and evapotranspiration on the one hand, and between evapotranspiration and precipitation on the other hand.

Here, a new methodology for assessing the strength of the latter, the atmospheric branch, is applied to the North American Regional Reanalysis (NARR) database and the Geophysical Fluid Dynamics Laboratory's model AM2.1. The method assesses the sensitivity of afternoon rainfall frequency and intensity to late-morning fluxes of heat and moisture from the land surface. Over the common North American domain, the reanalysis and model both show that land surface fluxes can influence convective rainfall triggering but do not appreciably influence rainfall amounts. To leading order, the model reflects a comparable spatial pattern and seasonality of the sensitivity of afternoon rainfall probability to evaporative fraction (EF) to what is seen in NARR, namely rainfall probability increases with higher EF over the Eastern US and Mexico, and peaks in summer (JJA). However, AM2.1 shows an additional pattern of strong rainfall-precipitation sensitivity in the Northern part of the domain, which is not present in the NARR results. Sources of disagreement lie partly in model rainfall biases (cumulative amounts, "drizzle" intraseasonal distribution), which propagate to the subsequent surface fluxes partitioning. We note that the values and patterns of EF mean and variability differ markedly between reanalysis and model data, with EF much lower in the NARR data.

Beyond spatial patterns, functional relationships between the triggering metric and mean evaporative fraction suggest that in both the model and reanalysis, stronger coupling occurs when mean EF is in the range of 0.6 to 0.8 Similar plots with the rainfall amplification metric reveal a model tendency for convective rainfall only when mean evaporative fraction is greater than 0.5. Analysis of model results from the rest of the globe show that results from North America extend to the rest of mid-high northern latitudes. Results over the Tropics, in AM2.1, show even stronger connections between EF and afternoon rainfall probability, albeit with much more spatial variability. In particular, strong positive regions neighbor regions with a negative signal. Analysis shows that afternoon rainfall probability peaks at EF values around 0.8, and that negative regions are regions with a large percentage of days with EF values higher than this ~0.8 threshold. This suggests that some minimal amount of sensible heat flux is required for optimal convective conditions in the Tropics.

Corresponding Author:

Name: Alexis Berg
Affiliation: Geophysical Fluid Dynamics Laboratory
Address: Princeton University Forrestal Campus
201 Forrestal Road
Princeton, NJ 08540-6649