Assessing the diurnal cycle of precipitation in a multi-scale climate model

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Scientific Questions

- How does the mean daily cycle of JJA precipitation in the T42 Multiscale Modeling Framework (MMF) compare to the standard Community Atmosphere Model (CAM) and to satellite retrievals?
- Does the T42 MMF admit the propagating organized convective systems that in nature cause a nocturnal maximum in summer rainfall over the central U.S.?

Context

Inter-model differences at diurnal timescales must be interpreted in light of existing biases at the seasonal scale (Fig. 1).

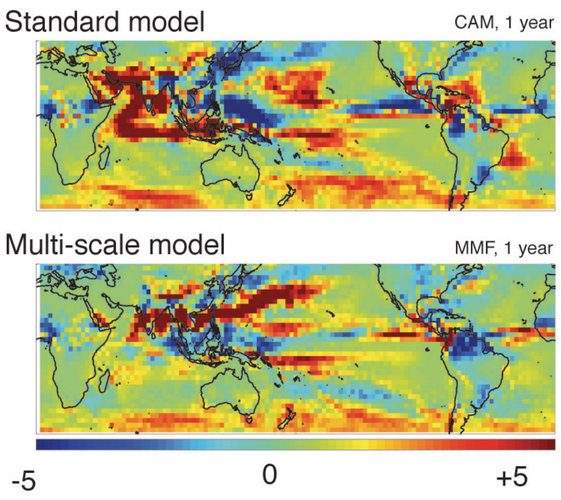

Fig. 1: JJA precipitation biases (mm/day) relative to TRMM 3B42 climatology).

24-hour diurnal harmonic

The percentage of total diurnal variance that can be explained by the best fit 24-hour mode (Fig. 2) is improved (i.e. reduced) in the MMF relative to CAM, particularly over Asia and Africa. However, significant biases remain over the global ocean (too much variance in this mode) and central North America (too little).

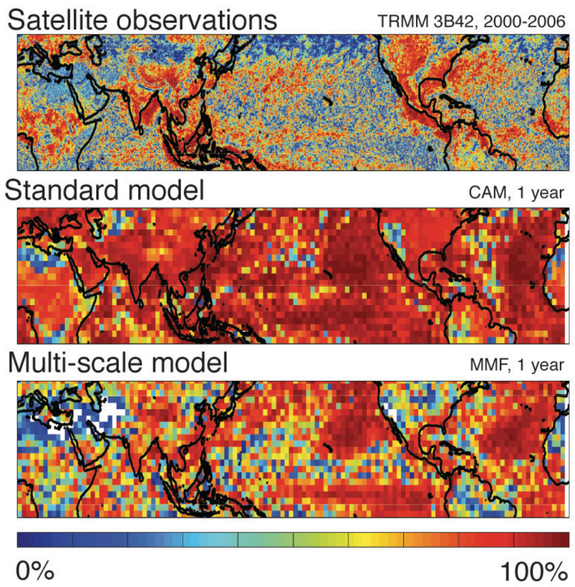

Fig. 2: % variance explained by the fitted 24-hour diurnal harmonic.

Phase of the 24-hr harmonic

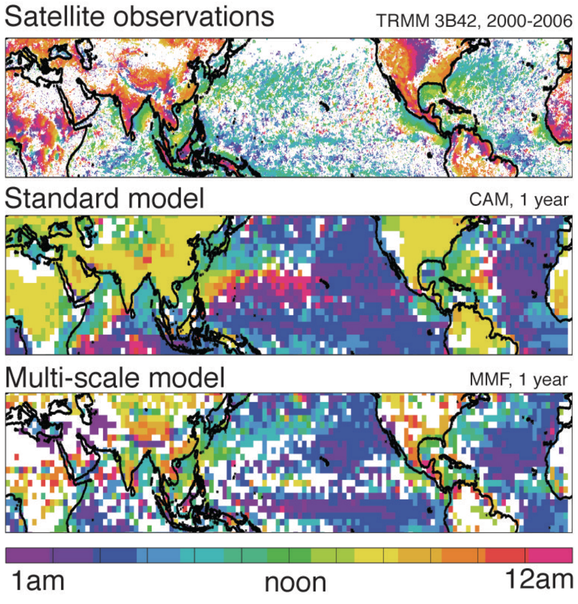

Fig. 3: Phase (LST) of the fitted 24-hour diurnal harmonic, where it accounts for more than 40% of the diurnal variance.

The phase of the 24-hour harmonic (Fig. 3) is shifted later over the continents in the MMF, in closer agreement with observations. Topographic influences on the diurnal phase are evident over the Himalayas in the MMF but are absent over the Rockies.

Broadness of the diurnal peak

Over Africa and the Americas, observed spatial variability in the broadness of the mean daily cycle of JJA precipitation are more faithfully reproduced by the MMF than by standard CAM.

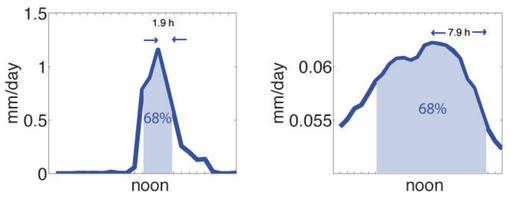

Fig. 4: A measure of the broadness of the diurnal maximum of precipitation.

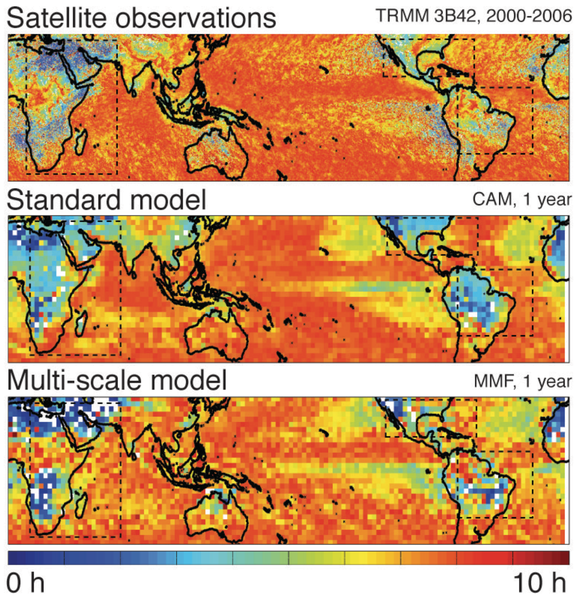

Fig. 5: Broadness of the mean summer day diurnal peak.

The U.S. mean summer day

Although eastward propagating organized convection over the central U.S. is not captured by the multi-scale model, improvements are evident in the diurnal cycle over the Gulf Stream (Fig. 6).

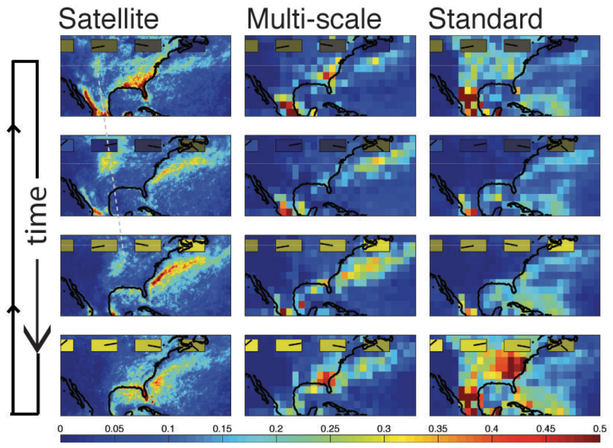

Fig. 6: Evolution of the mean summer day of precipitation (mm/hr) over the U.S.; snaphots for the 3-hour averaging intervals ending at 0300, 0900, 1500, and 2100 UTC.

Conclusions

Several features of the JJA diurnal cycle of precipitation in the multi-scale model are improved at T42 resolution, including:

- less variance in the 24-hour diurnal harmonic and improvement in its phase (including phase modulation associated with Himalayan topography).
- improved regional distributions of sharp vs. broad continental diurnal maxima

At T42 resolution, the MMF does not capture the eastward propagating organized convection responsible for the mid-U.S. nocturnal maximum, but is able to reproduce observed diurnal variability over the Gulf Stream.