A Proposal Submitted to PACS/GAPP to Study the

Warm Season Diurnal Cycle over the US and Mexico in GCMs

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Motivation

The diurnal cycle is a fundamental component of the warm season climate of the continental United States and Northern Mexico.

Current (probably all) atmospheric/land general circulation models (AGCMs) do poorly in simulating the diurnal cycle and consequently do poorly in simulating the mean warm season climate over much of the United States and Mexico.

The AGCM deficiencies in the diurnal cycle are symptomatic of our lack of understanding of the relevant physical processes that, over the United States and Mexico, operate and interact on local, regional, as well as continental and larger scales.

Recognized as a key focus area by a collaborative diagnostics initiative to help global model development efforts within the United States (lead by GFDL)

NAME offers an important opportunity to establish a strong interaction between a regional/process-oriented observing program and targeted development in global models.

Some characteristics of the diurnal cycle

A complex phenomenon

late afternoon precipitation maximum over western and southeastern US, Rockies

also late afternoon over western slopes of the Sierra Madre Occidental, but early morning maximum off the coast

nocturnal maximum (east of Rockies and Great Plains)

timing also depends on intensity

Impact on monsoon

The diurnal cycle impacts the partitioning of precipitation between the land and ocean

Link to weather

Link to mesoscale convection/propagating systems

modulated on synoptic and longer time scales

Impact on interannual variability

evidence that summer flooding in the central United States is sensitive to the diurnal cycle

Long-term changes

U.S. summer afternoon precipitation frequency increased 30-60% in the southwest, while it decreased by about 15-30% in the southeast over the period 1963-1993 (link to increased cloudiness?)

Mechanisms

mountain-generated storm systems (including mesoscale convective systems) that tend to move eastward from the Rocky Mountains onto the Plains after sunset

GPLLJ contributes to nighttime boundary layer convergence that favors nocturnal convection in the Great Plains.

Over the Sierra Madre Occidental, monsoonal precipitation is associated with sea breezes that lead to heavy afternoon precipitation, and precipitation along and off the coast during the early morning

In the Gulf of California, the GCLLJ contributes to the flux of moisture into the southwest

Large-scale thermally driven atmospheric tides contribute to diurnal variations – appear to affect the timing of summer moist convective precipitation over the United States.

Other factors: interactions with clouds, interactions with the land surface, landscape changes, and radiative heating over deserts

Current model performance

There are a number of problems in the United States and northern Mexico that appear to be common to many AGCMs.

Climate models are typically run at resolutions that only marginally (if at all) resolves some of the regional phenomena discussed above.

little or no nocturnal precipitation over the Great Plains (despite simulating a reasonable GPLLJ),

too frequent precipitation and too much drizzle

too large of an amplitude in the diurnal cycle of precipitation over the central and eastern United States,

excessive afternoon precipitation over the western slopes of the Sierra Madre Occidental, and a poorly resolved GCLLJ

incorrect regional and larger-scale interactions that act to modulate the local convective processes (tides?)

many of these problems appear to be linked to the models convective parameterizations, and how the schemes interact with the land surface, the boundary layer, and clouds.

Goals of proposed Work

1) assess and analyze the diurnal cycle in three different AGCMs,

2) improve our understanding of the important physical processes that drive the diurnal cycle,

3) provide guidance for the development of physical parameterizations aimed at improving the simulation of the warm season hydrological cycle over the United States and northern Mexico.

Methodology

A three-pronged coordinated approach that recognizes the different scales of the diurnal cycle and capitalizes on the expertise and experience of three major modeling groups at GFDL, NCEP and NASA:

the GFDL group focuses on local convective processes (e.g. the development of convective available potential energy, interactions with the land surface, and the role of clouds),

the NCEP group focuses on regional controls (e.g. land/sea circulations, role of sloping/complex terrain, and the propagation of coherent convective systems)

the NASA group focuses on sub-continental and larger scale linkages (e.g. low level jets, thermally driven atmospheric tides, and the interaction of the diurnal cycle with the developing North American monsoon system).

Coordination between groups

The proposed work will be coordinated by carrying out a common set of experiments, by sharing verification data and model simulation results using a web interface, and through regular meetings to compare results, discuss progress, and address problems.

Several baseline simulations will be carried out aimed at documenting and assessing the simulated diurnal cycle at various resolutions, and gaining a first order assessment of the role of the diurnal cycle in the simulated warm season climate.

A second set of simulations will examine the impact of the diurnal cycle on the seasonal mean climate and on the development of the North American monsoon system. These runs are the same as above, except that the diurnal solar forcing is replaced by a daily mean radiative forcing.

A web site will be developed to help share verification data and the results (both figures and the data) from model simulations. A prototype version of the web site is available for viewing at:

ftp://nsipp/pub/atmos/diurnal_cycle_forum/front.html

Challenges

Strong coordination/interaction with NAME observing program

Link to regional modeling effort

Performance metrics