

Robustness and sensitivities of Central U.S. summer convection in SP-CAM: Multi-model intercomparison with a new regional EOF index

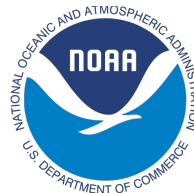
Kooperman et al. 2013
GRL

Gabriel J. Kooperman

Michael S. Pritchard

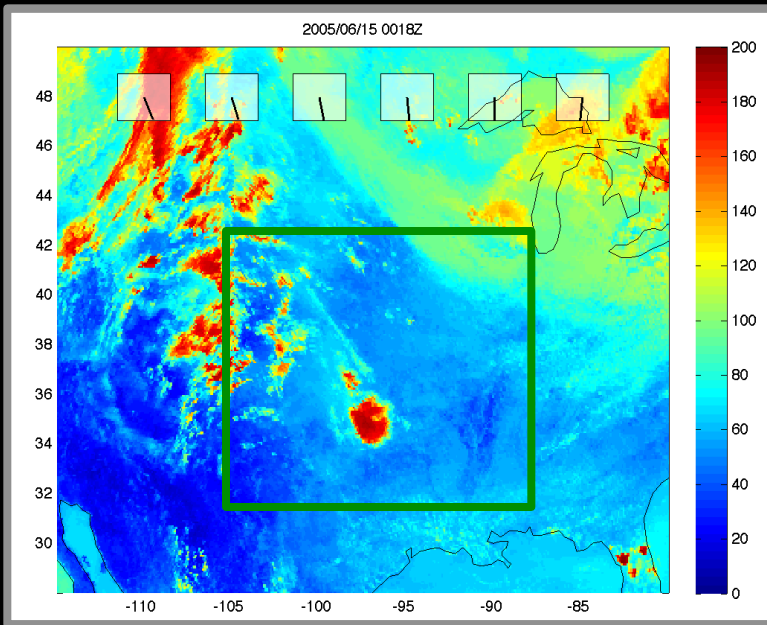
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August 7, 2013



Propagating mesoscale convective systems in the Central US shift diurnal timing of rainfall

GOES 11 micron IR

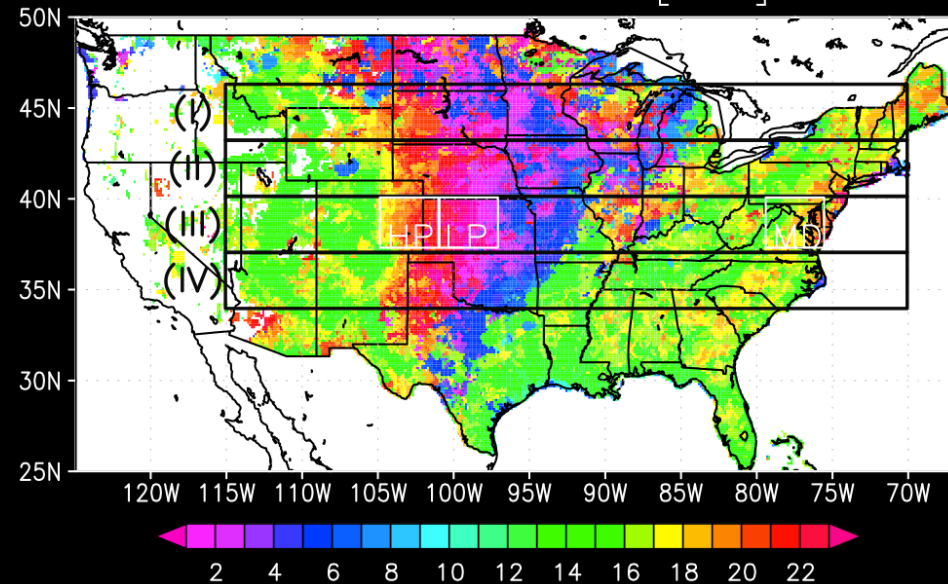


- MCSs generate up to 60% of summer rainfall.
- Overall diurnal rainfall is dominated by MCS signal.
- The MCS rainfall maximum occurs over night.

- Large organized storm systems propagate east across the Central US and grow over night.

Radar-gauge Hourly Rainfall

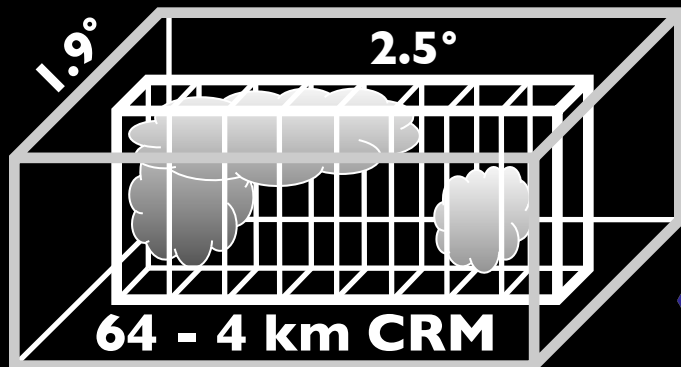
Diurnal-Maxima LST [hour]



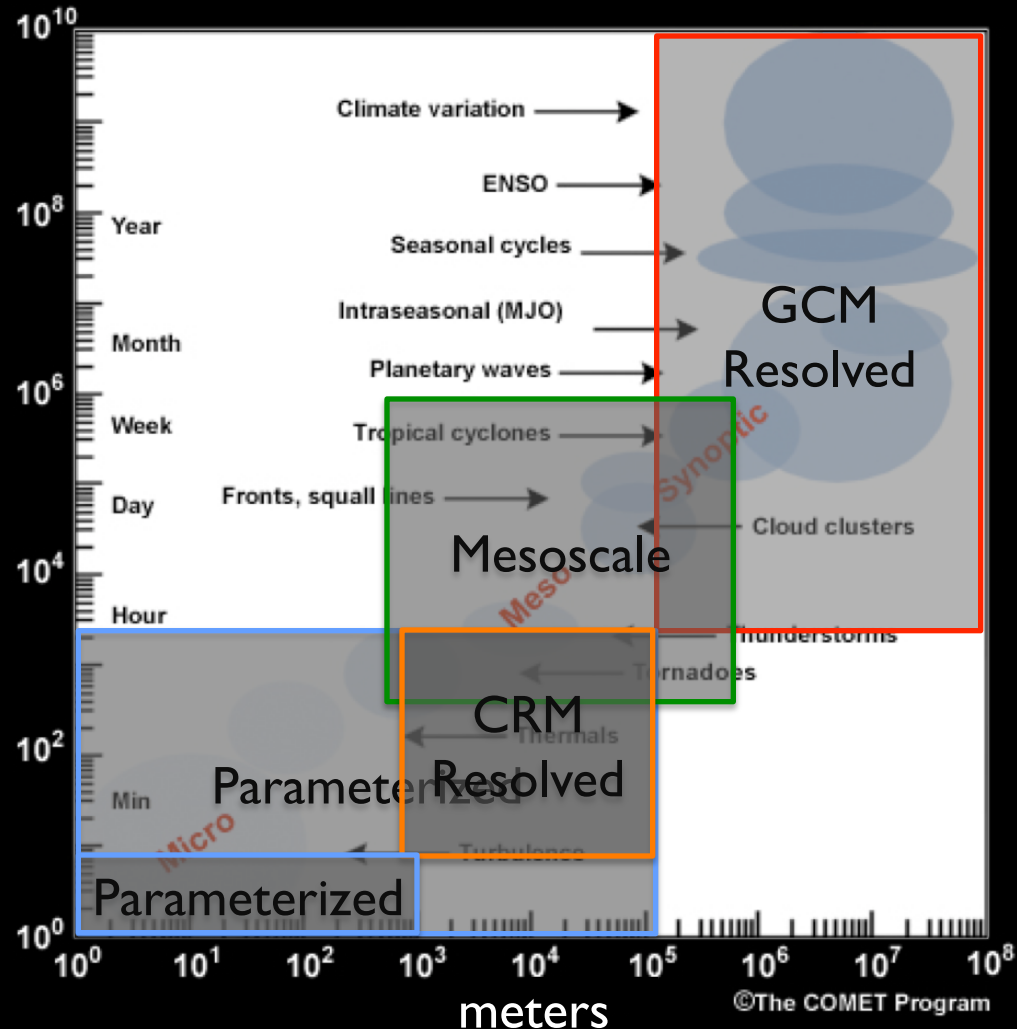
Matsui et al. 2010

The mesoscale straddles the divide between resolved and parameterized processes

- GCMs resolve large-scale atmospheric motion.
- Processes smaller than a grid box are parameterized.
- Mesoscale processes are not resolved or parameterized.
- A new GCM attempts to capture both by combining a GCM and CRM: **SP-CAM**



Atmospheric Scales of Motion



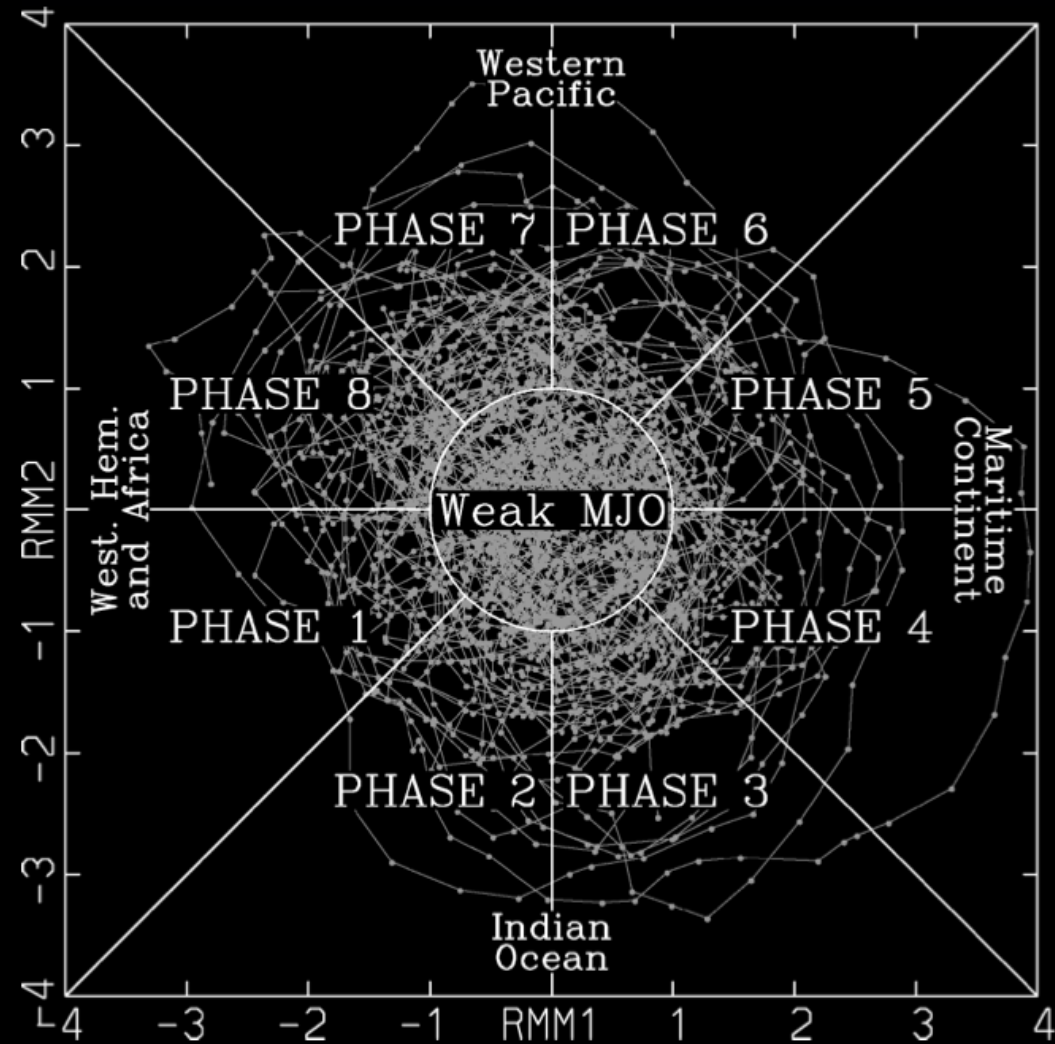
Questions:

1. How realistic is the SP MCS signal in the earlier version 3.5?
2. Can SP-CAM reproduce the timing, spatial structure, frequency, and intensity of observed events?
3. Does the signal exist and improve in other versions of SP-CAM (3.0 and 5.0)?

Evaluating the robustness and sensitivities of the signal using a new regional MCS index.

A Wheeler and Hendon type EOF index for Central US mesoscale convection

1. Organized convection in the tropics and mid-latitudes is a major source of variability.
2. And a major challenge for many GCMs.
3. The signal has a clear zonal propagation in both regions.
4. An EOF based index has been a useful tool for evaluating the MJO.



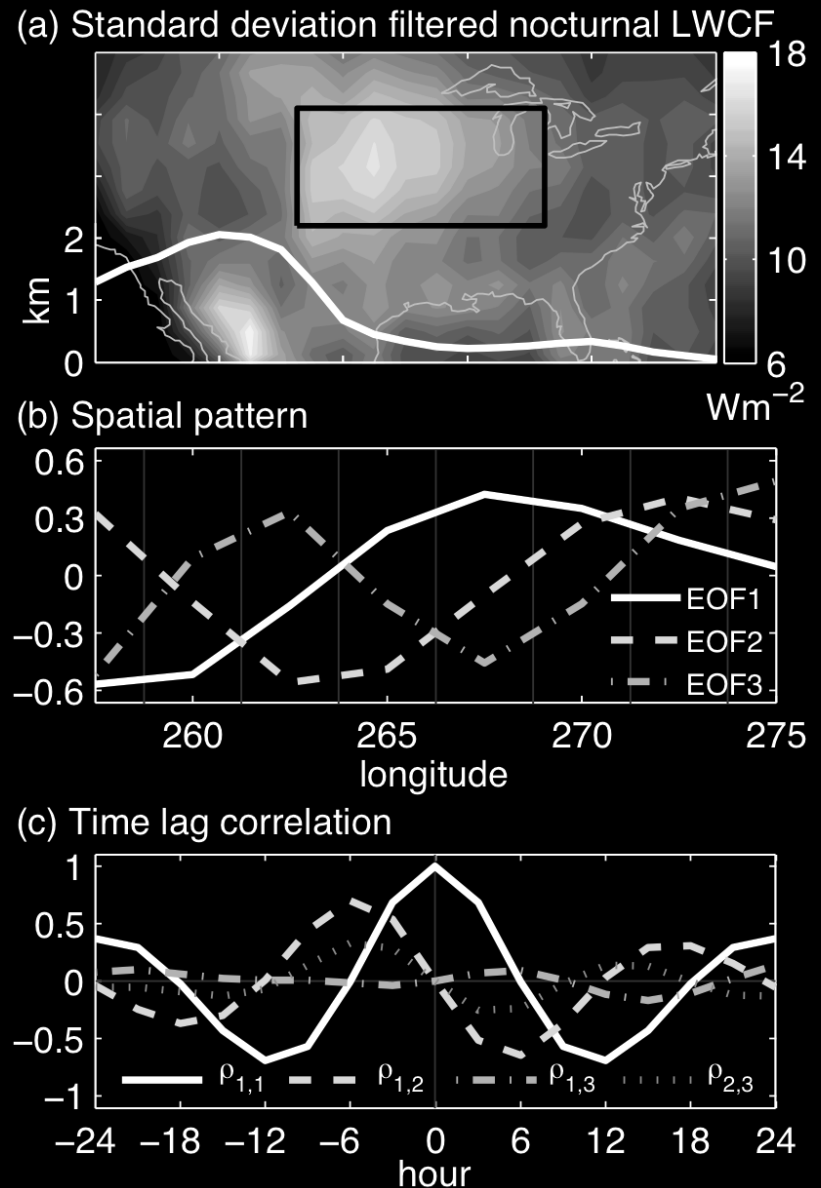
New MCS index to compare six conventional and super-parameterized versions of CAM

- 3 hourly MJJA longwave cloud forcing (LWCF) band-pass filtered for 12 to 48 hours from observations and six model versions.
- Observations are from 23 years (1984–2006) of the NASA GEWEX Surface Radiation Budget (SRB) TOA flux data.
- Hourly precipitation from the NCEP Climate Prediction Center.

Model	GCM resolution	CRM resolution	Microphysics	Aerosol Physics
CAM3.0	T42, 26 levels	N.A.	1 moment	N.A.
SP-CAM3.0	T42, 26 levels	1x32, 4 km, NS	1 moment	N.A.
CAM3.5	1.9x2.5°, 30 levels	N.A.	1 moment	N.A.
SP-CAM3.5	1.9x2.5°, 30 levels	1x64, 1 km, EW	1 moment	N.A.
CAM5.0	1.9x2.5°, 30 levels	N.A.	2 moment	3 mode, 2 mom
SP-CAM5.0	1.9x2.5°, 30 levels	1x32, 4 km, NS	2 moment	3 mode, 2 mom

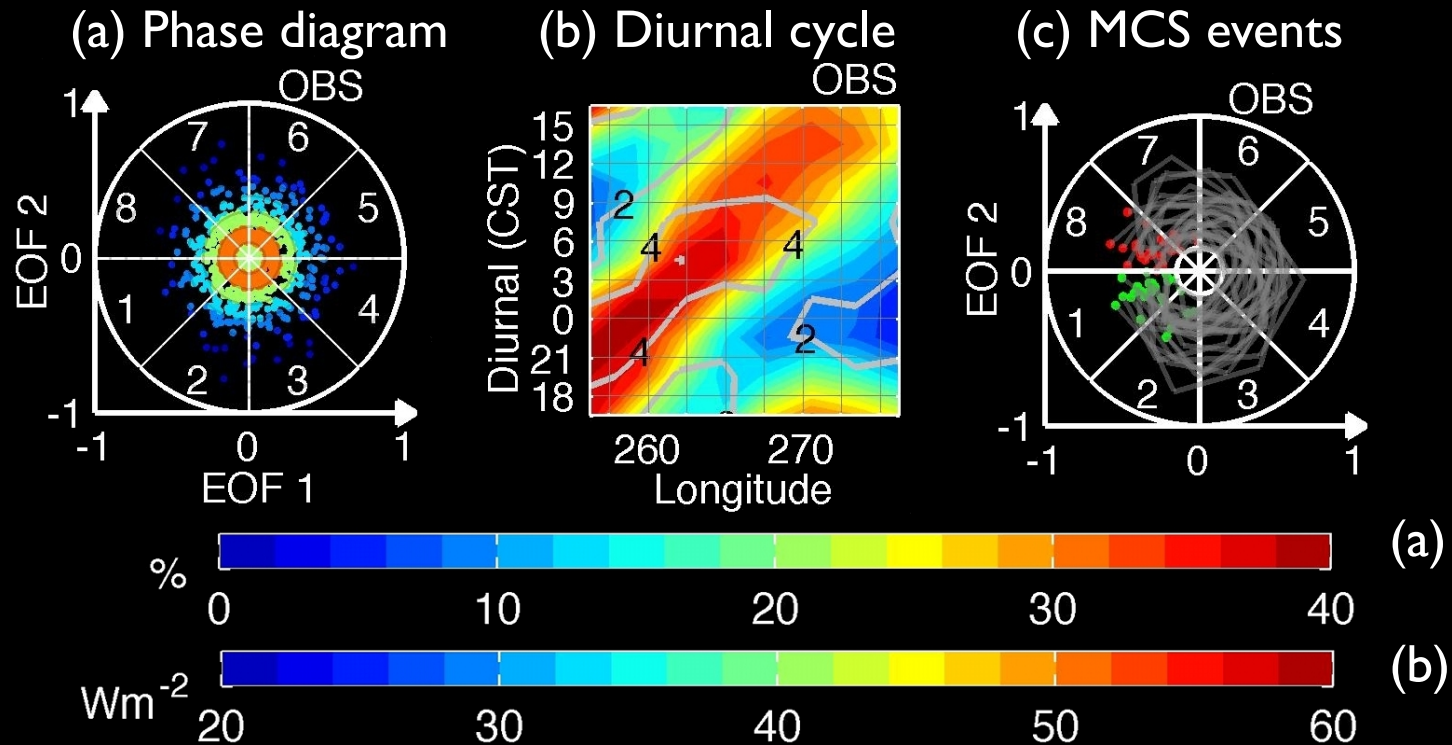
A regional LWCF leading EOF pair represents eastward propagating nocturnal convection

- The nocturnal (00-06 CST) variance of LWCF shows the well known Central US MCS activity zone.
- EOF analysis of meridionally averaged LWCF in black box.
- Leading EOF-pair explains ~ 65% of the variance with 35% from EOF 1 and 30% from EOF 2.
- EOFs 1 and 2 have spatial patterns in phase quadrature and high time-lag correlation.



The new EOF index compactly isolates the mid-latitude MCS signal in observations

- High index amplitudes.
- Nocturnal-east slant.
- Co-located precipitation.
- Events span phases.

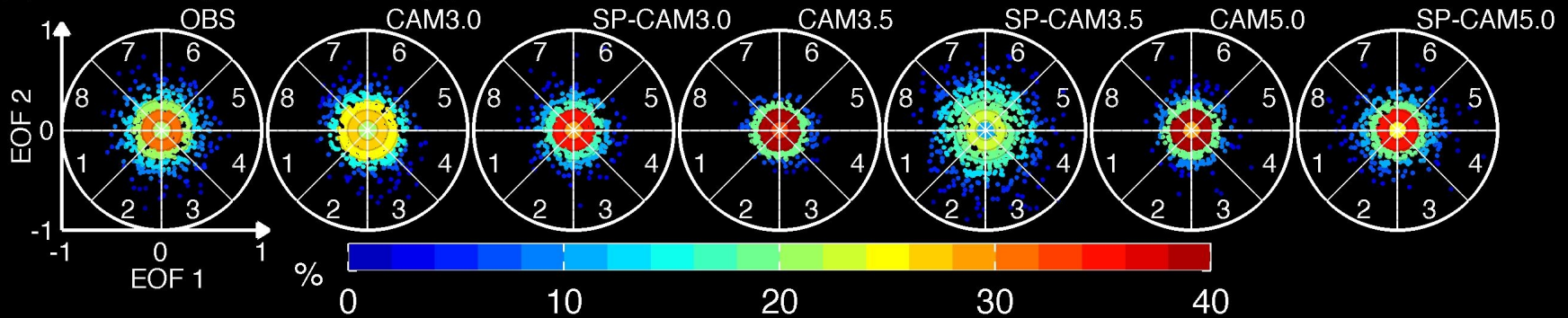


Event selection criteria:

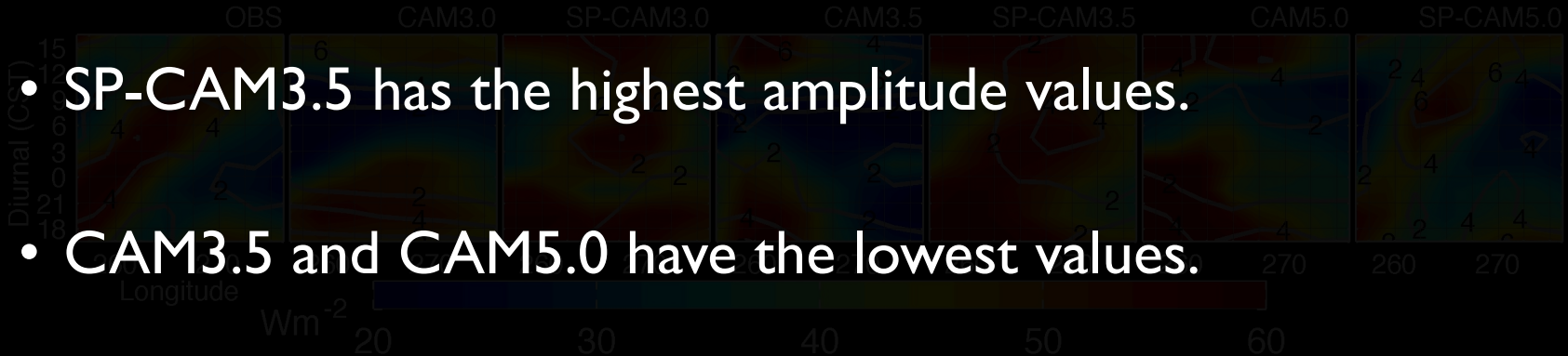
1. At least three (9 hours) consecutive index amplitudes greater than 0.15 propagating forward (east) in phase space,
2. spanning at least 70% of the domain (~ 1200 km), and
3. starting between 18 and 03 local (CST) time.

Nocturnal eastward propagating MCS signal is captured in all versions of SP-CAM

(a) Phase diagram colored by percent index value occurrence



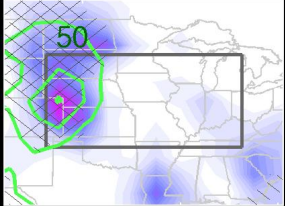
(b) Longwave cloud forcing (colors) and precipitation (contours) diurnal cycles



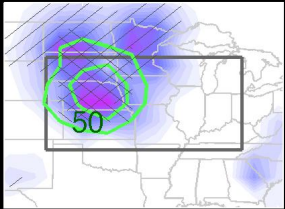
- SP-CAM3.5 has the highest amplitude values.
- CAM3.5 and CAM5.0 have the lowest values.
- Eastward slant in shows nocturnal propagating convection in observations and all versions of SP-CAM.
- SP-CAM5.0 agrees the best with the observed width and co-located precipitation, although LWCF is too weak.

MCS physics is a robust effect of SP and most realistic in 5.0 with two-moment microphysics

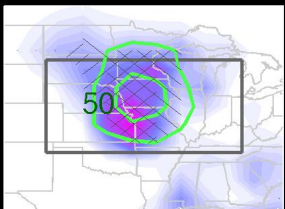
(a) Phase 1/2 OBS



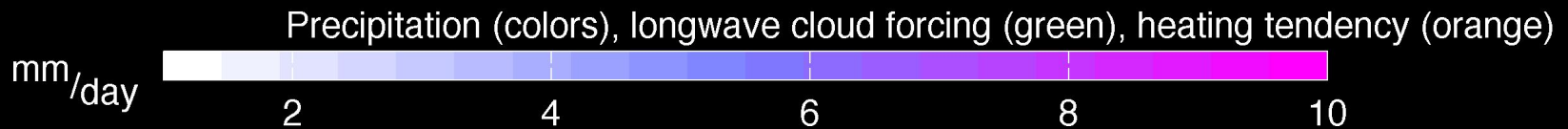
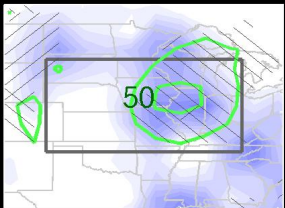
(b) Phase 3/4 OBS



(c) Phase 5/6 OBS

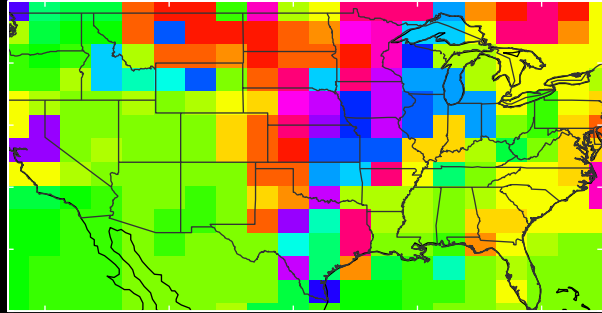


(d) Phase 7/8 OBS



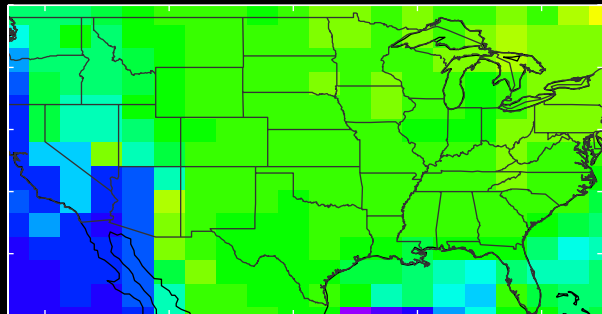
Capturing MCS physics improves the diurnal timing of peak precipitation in SP-CAM

OBS

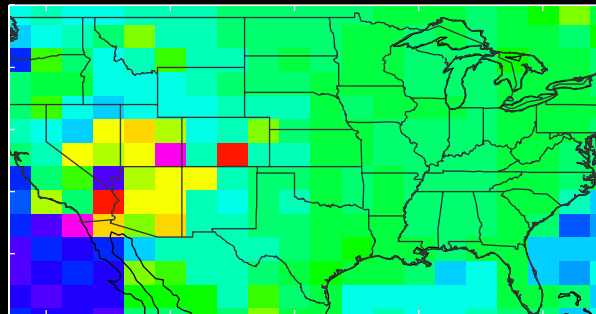


- Each version of SP-CAM has a somewhat better representation rainfall timing.
- CAM continues to rain in the afternoon.

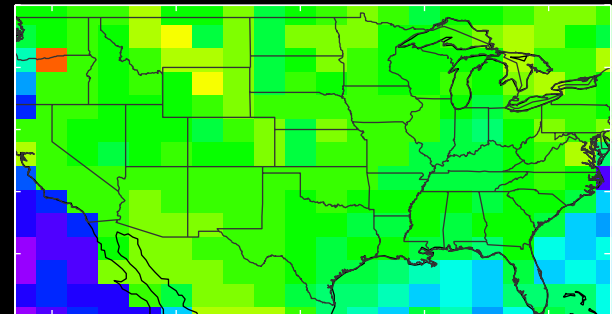
CAM3.0



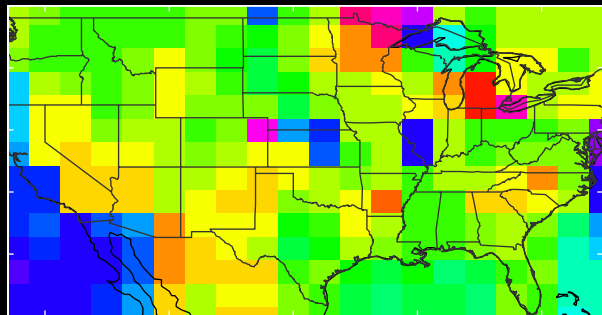
CAM3.5



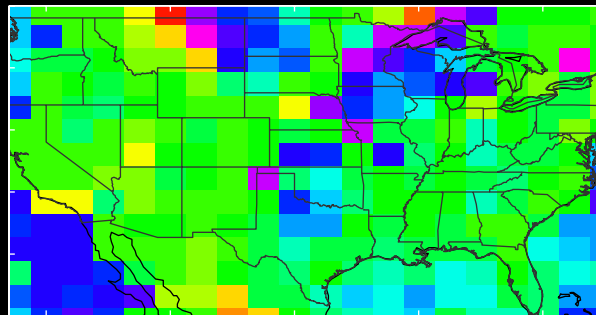
CAM5.0



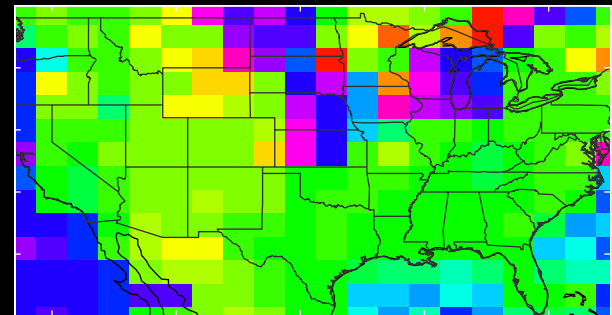
SP-CAM3.0



SP-CAM3.5



SP-CAM5.0



Hour (LST)



Conclusions: SP is a useful analog to nature

- A new EOF based index compactly evaluates the mid-latitude MCS signal in conventional and super-parameterized GCMs.
- US MCS physics is a robust effect of super-parameterization.
- The signal is most realistic in 5.0 with two-mom microphysics.

Future work investigating the virtual MCS signal using the new regional MCS index

- Detailed analysis of MCS climate change response.
- Investigate two-way aerosol-cloud (MCS) interactions.
- Model parameter/configuration sensitivity studies.