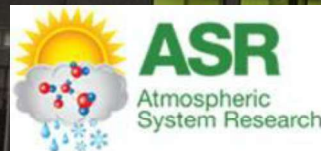




Attribution of Surface Radiation Biases in NWP and Climate Models near the US Southern Great Plains

Kwinten Van Weverberg, Cyril Morcrette, Hsi-Yen Ma,

J. Petch, S.A. Klein, C. Zhang, S. Xie, Q. Tang, W.I. Gustafson Jr., Y. Qian, L.K. Berg, Y. Liu, M. Huang, M. Ahlgrimm, R. Forbes, E. Bazile, R. Roehrig, J. Cole, W. Merryfield, W.-S. Lee, F. Cheruy, L. Mellul, Y.-C. Wang, K. Johnson, M. Khaiyer

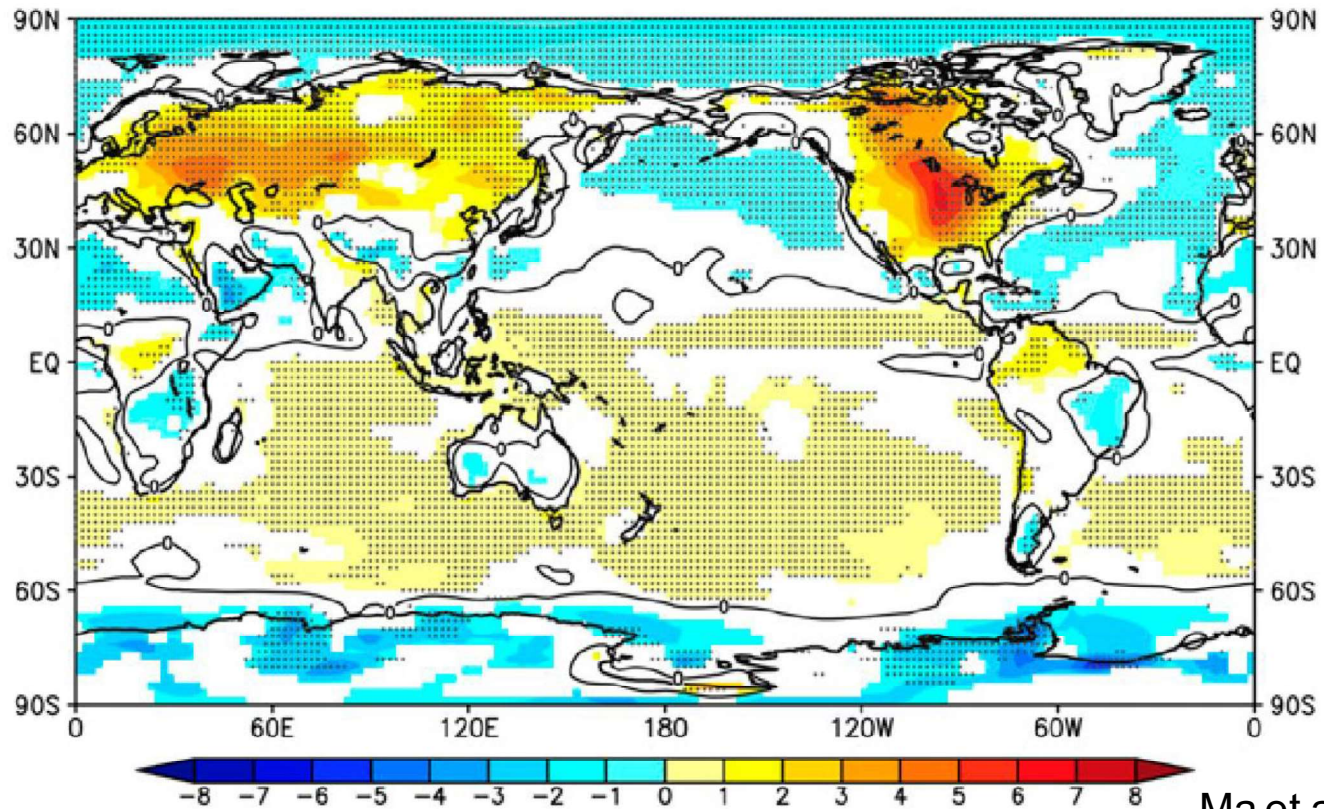


5th WGNE Workshop on Systematic Errors

19 June 2017, Montreal



Midlatitude Continental Warm Bias



Ma et al. JC 2014

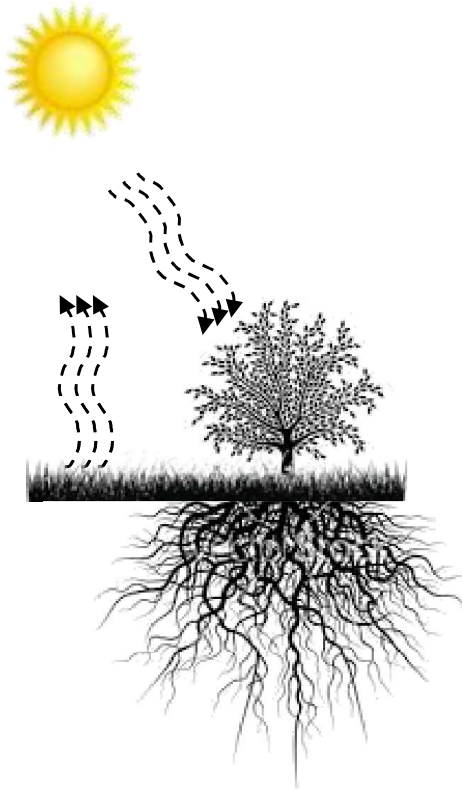
2m-Temperature Bias
(K)

Colours: CMIP5 ensemble for 20 years
Dots: Day 5 forecast using same GCMs

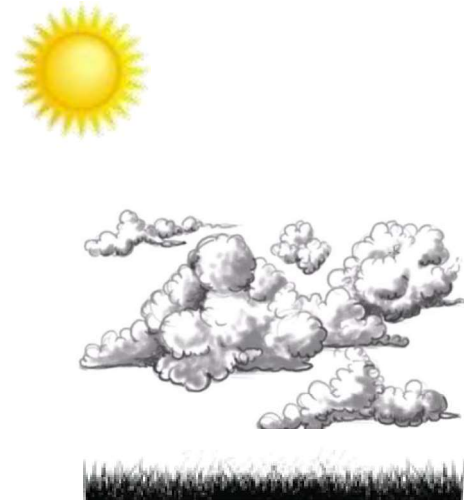
Midlatitude Continental Warm Bias

Hypotheses:

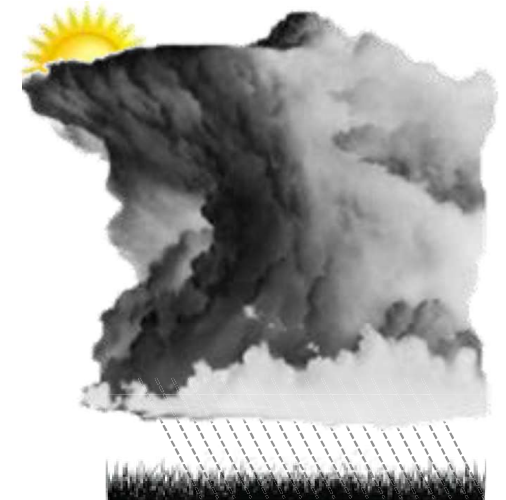
Soil-vegetation-atmosphere



Boundary-layer clouds



Convective storms



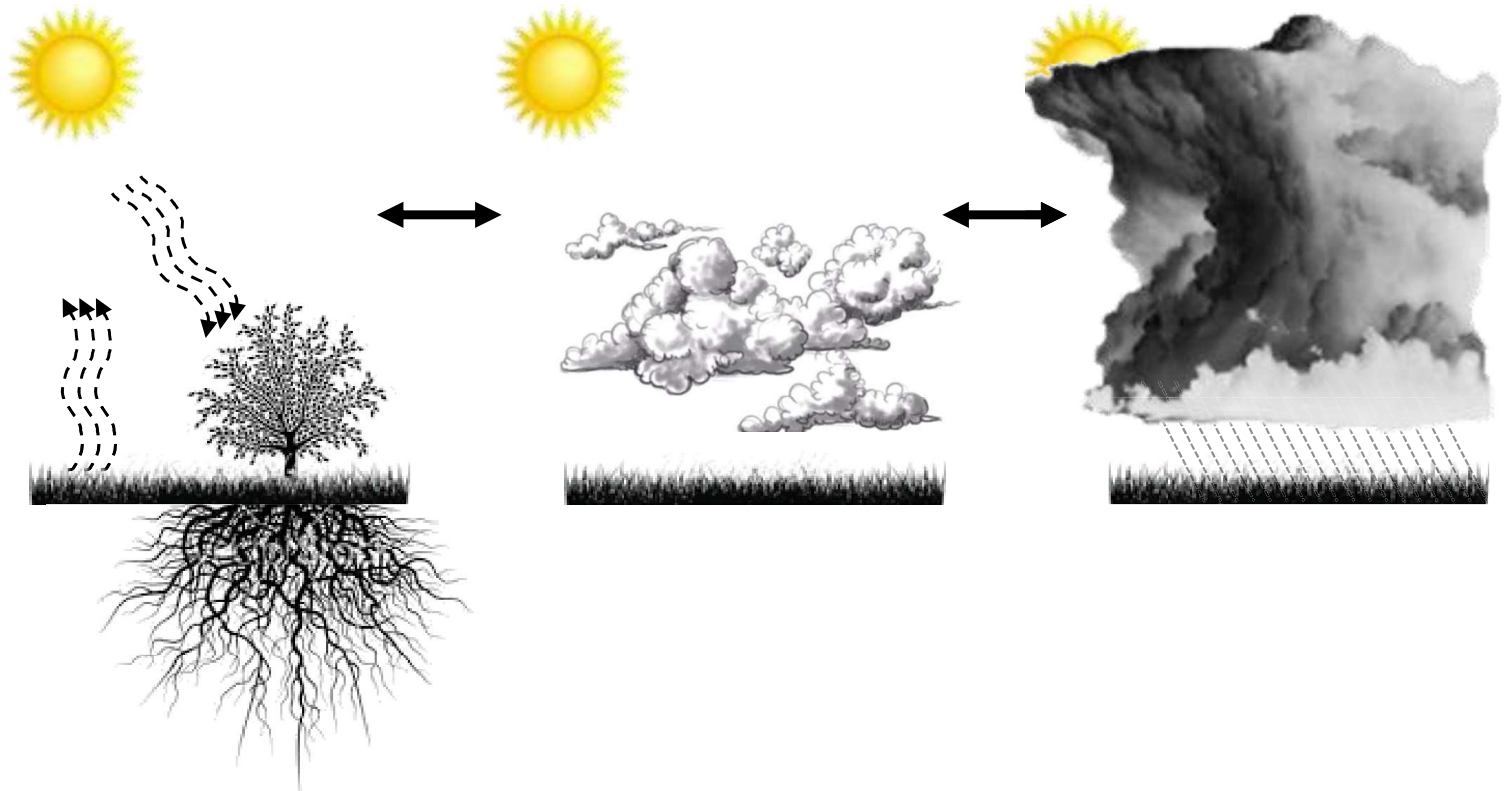
Midlatitude Continental Warm Bias

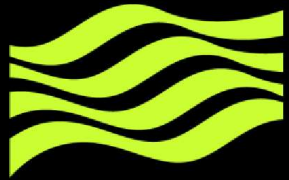
Hypotheses:

Soil-vegetation-atmosphere

Boundary-layer clouds

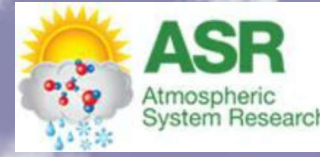
Convective storms





Met Office

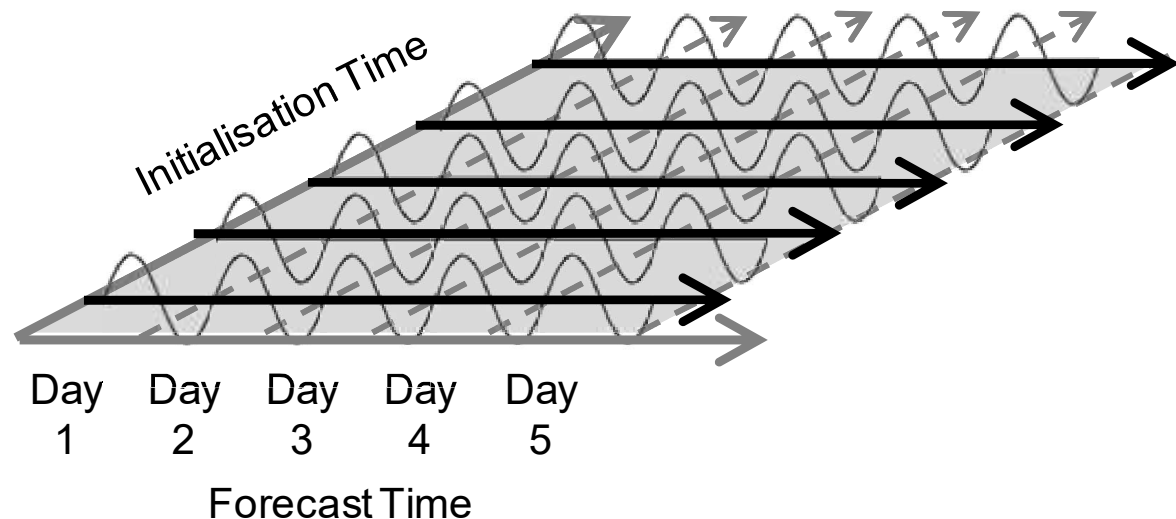
CAUSES



Clouds Above the US and Errors at the Surface

Research Foci

- Radiation errors – particularly due to clouds
 - Led by U.K. Met Office
- Precipitation and surface energy budget errors
 - Led by U.S. Department of energy, LLNL

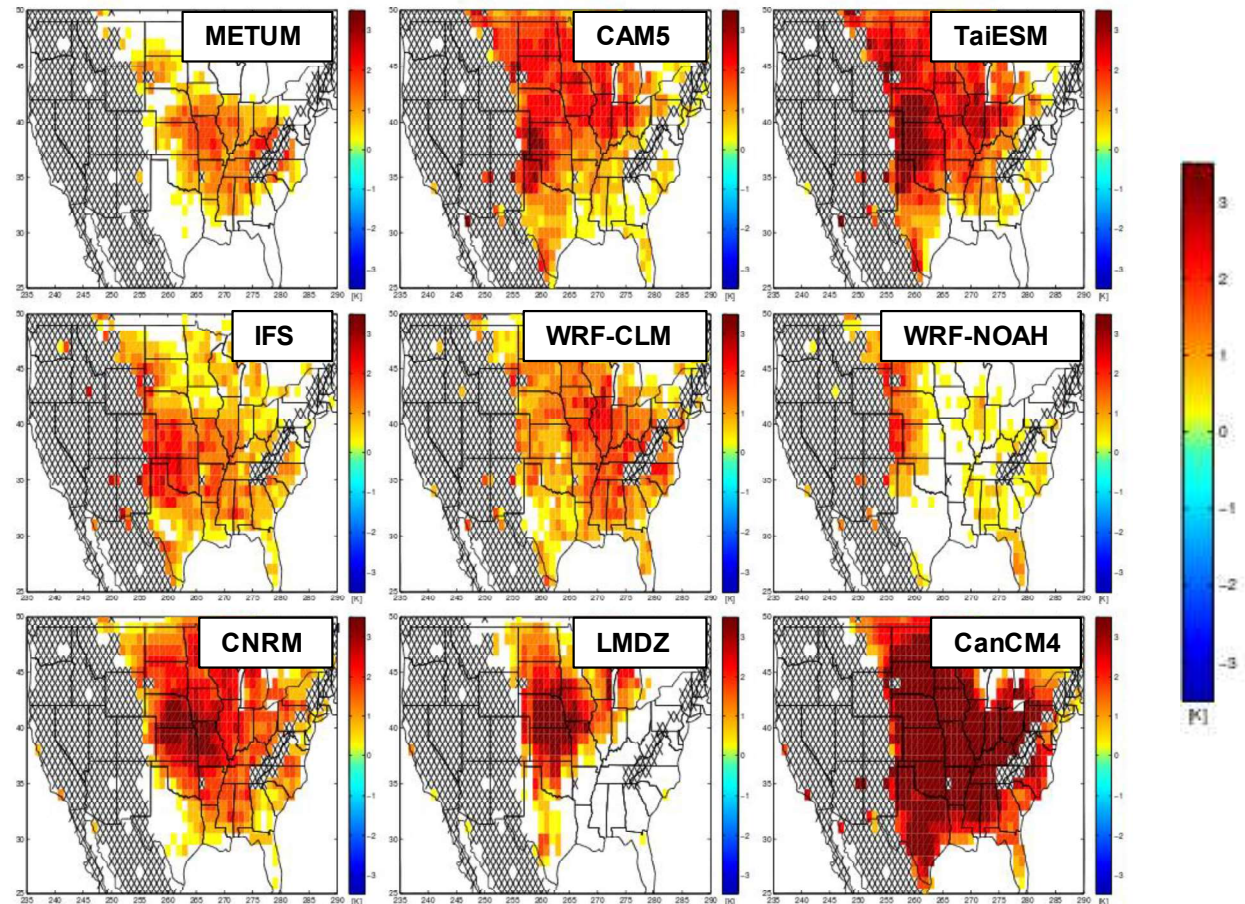


5-day hindcasts for every day 1 April – 31 August 2011

<http://portal.nerdc.gov/project/capt/CAUSES/>

CAUSES: Temperature Bias

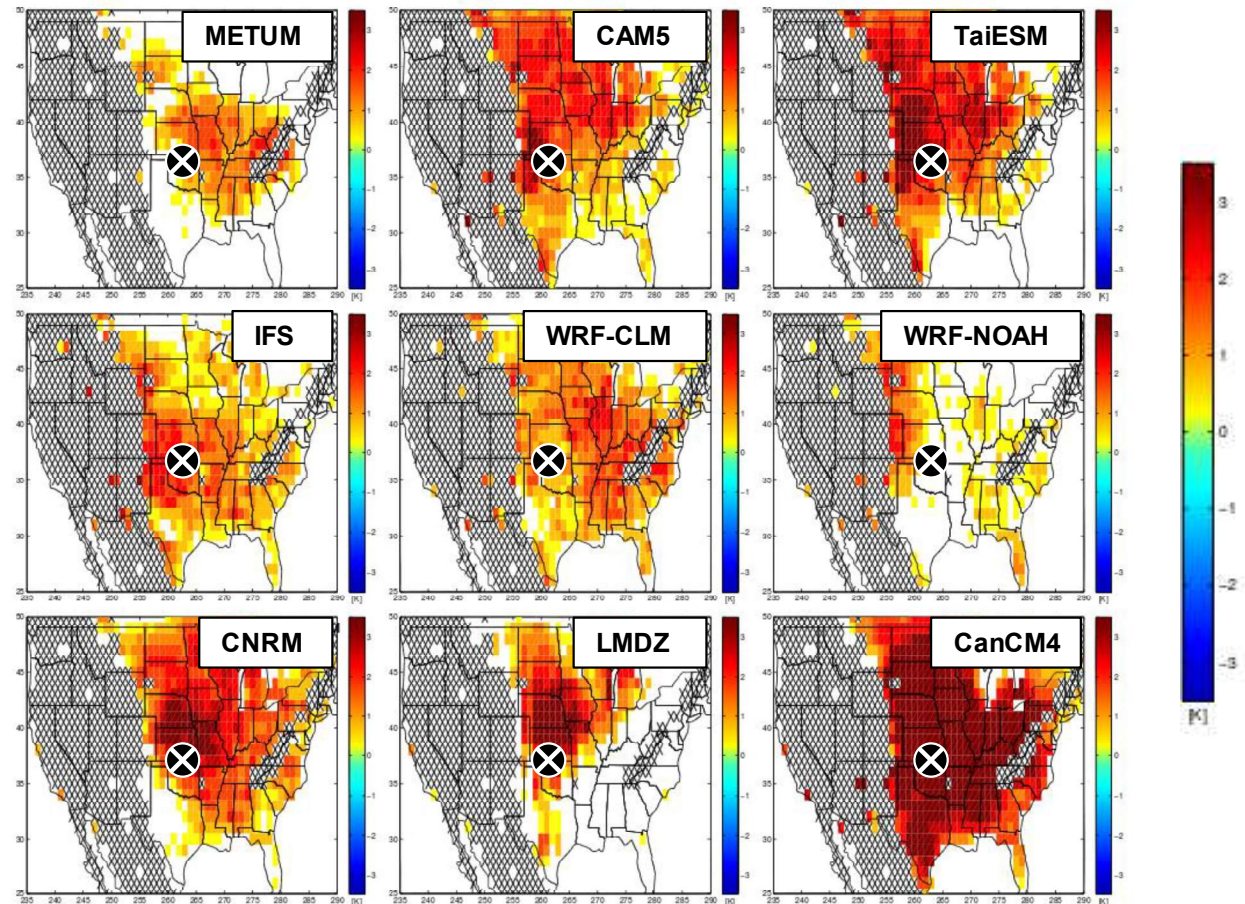
Clouds Above the US and Errors at the Surface



Day 2-5 mean temperature bias April – August 2011

CAUSES: Temperature Bias

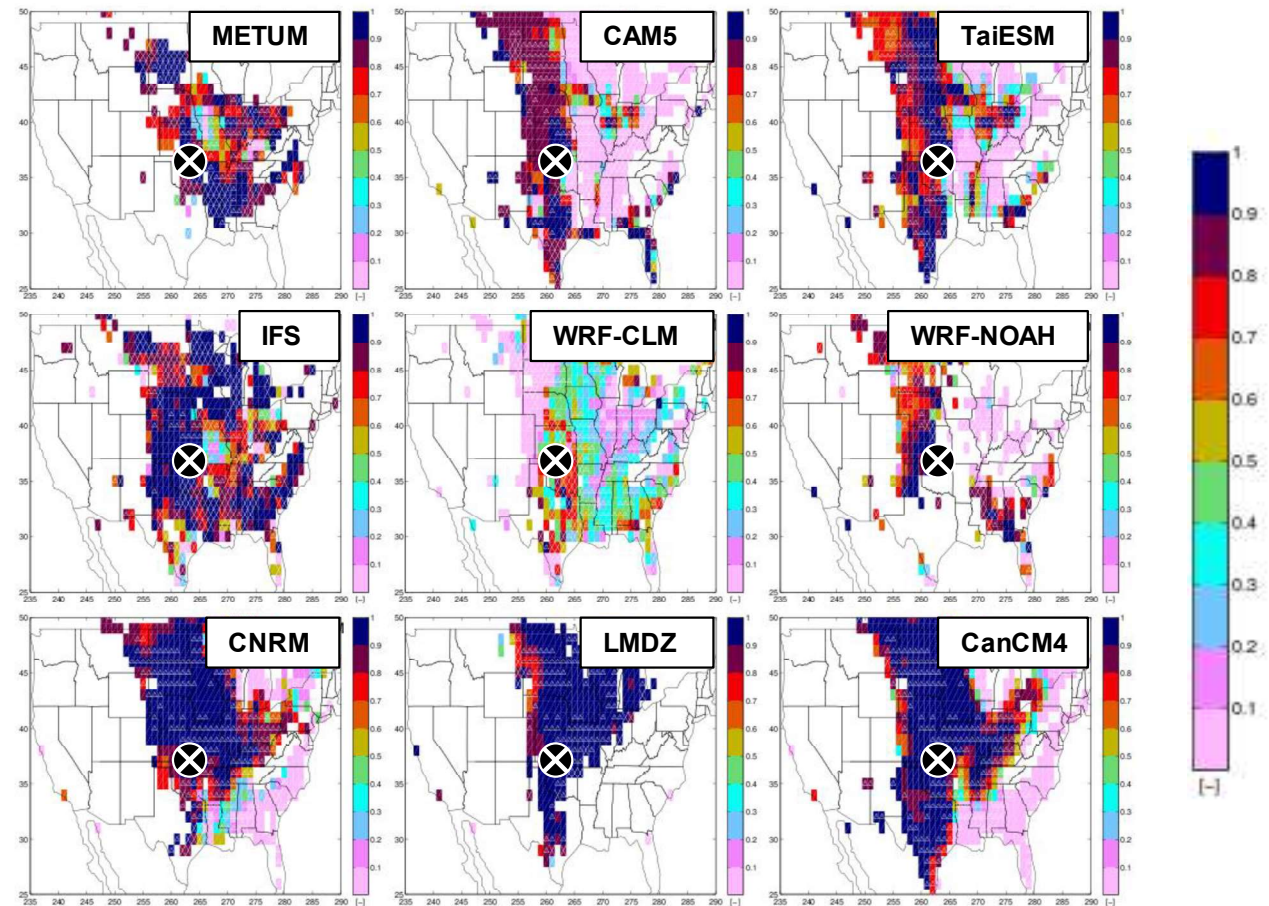
Clouds Above the US and Errors at the Surface



Is ARM Southern Great Plains site representative?

CAUSES: Temperature Bias

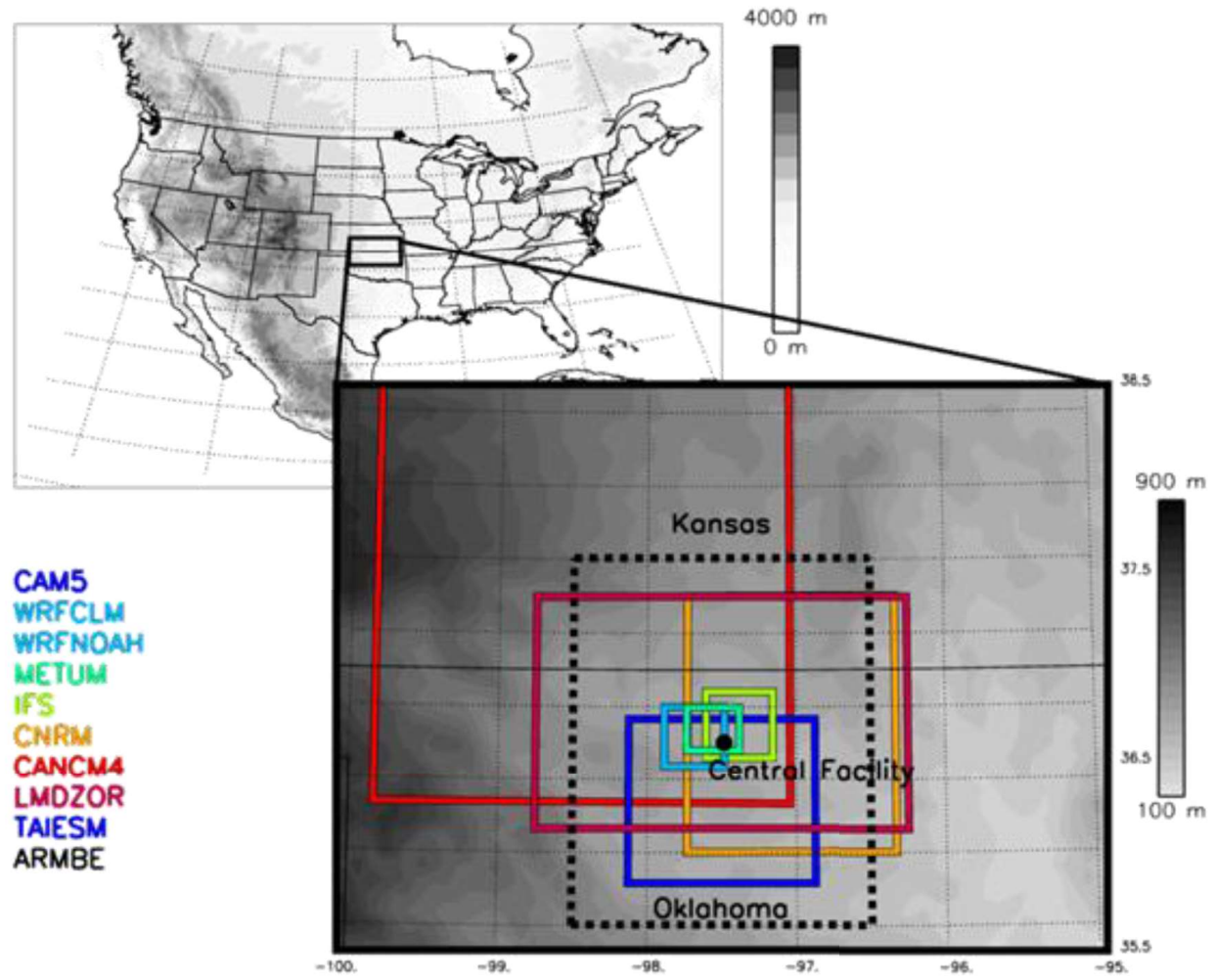
Clouds Above the US and Errors at the Surface



Correlation of the temperature bias with the SGP-site

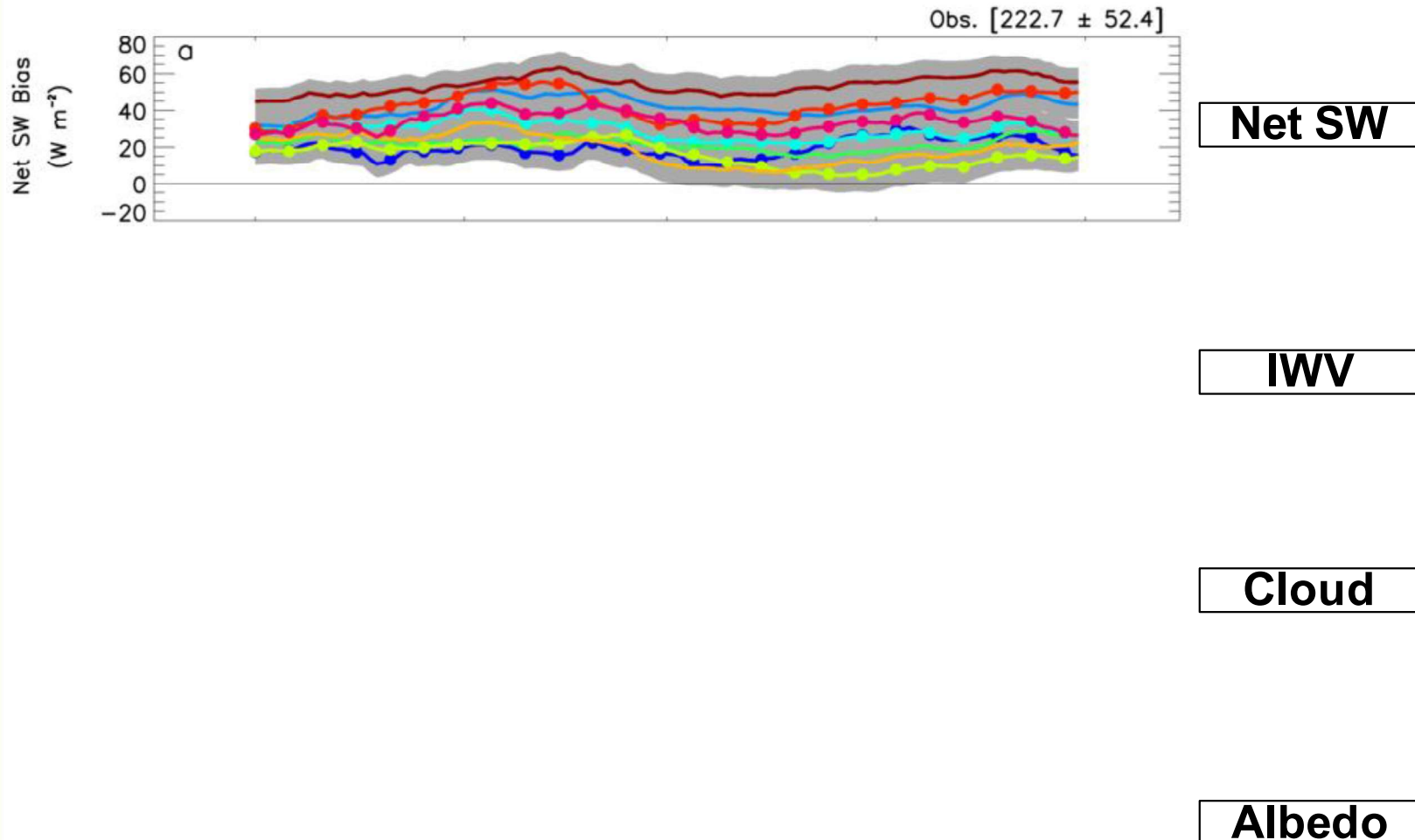
CAUSES: Radiation Attribution

Clouds Above the US and Errors at the Surface



CAUSES: Radiation Attribution

Clouds Above the US and Errors at the Surface

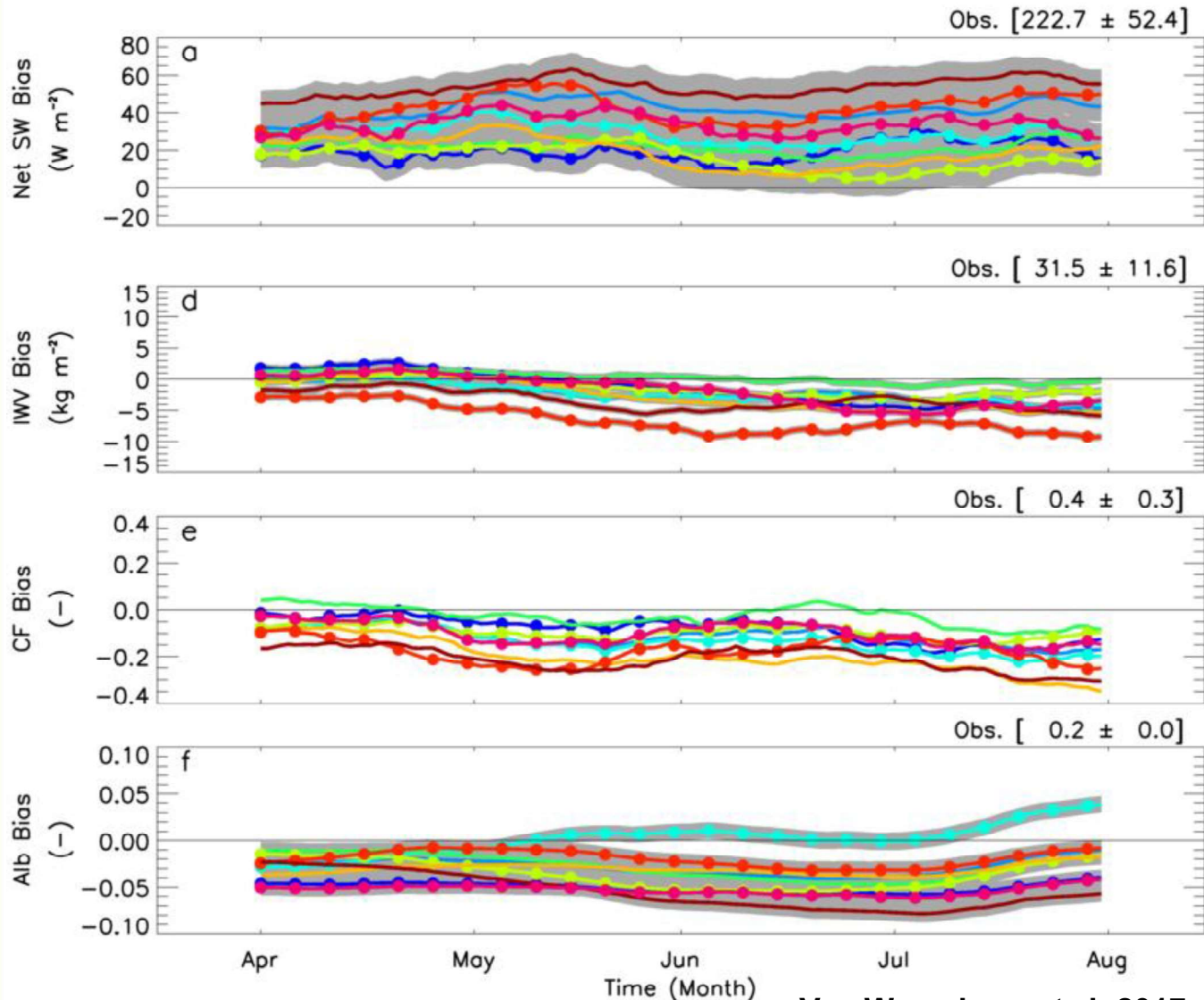
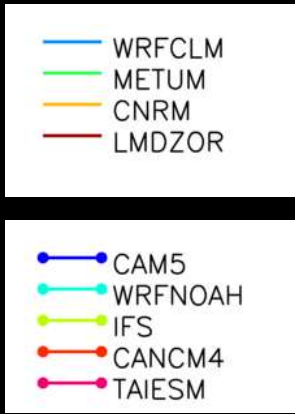


- WRFCLM
- METUM
- CNRM
- LMDZOR

- CAM5
- WRFNOAH
- IFS
- CANCM4
- TAIESM

CAUSES: Radiation Attribution

Clouds Above the US and Errors at the Surface



Net SW

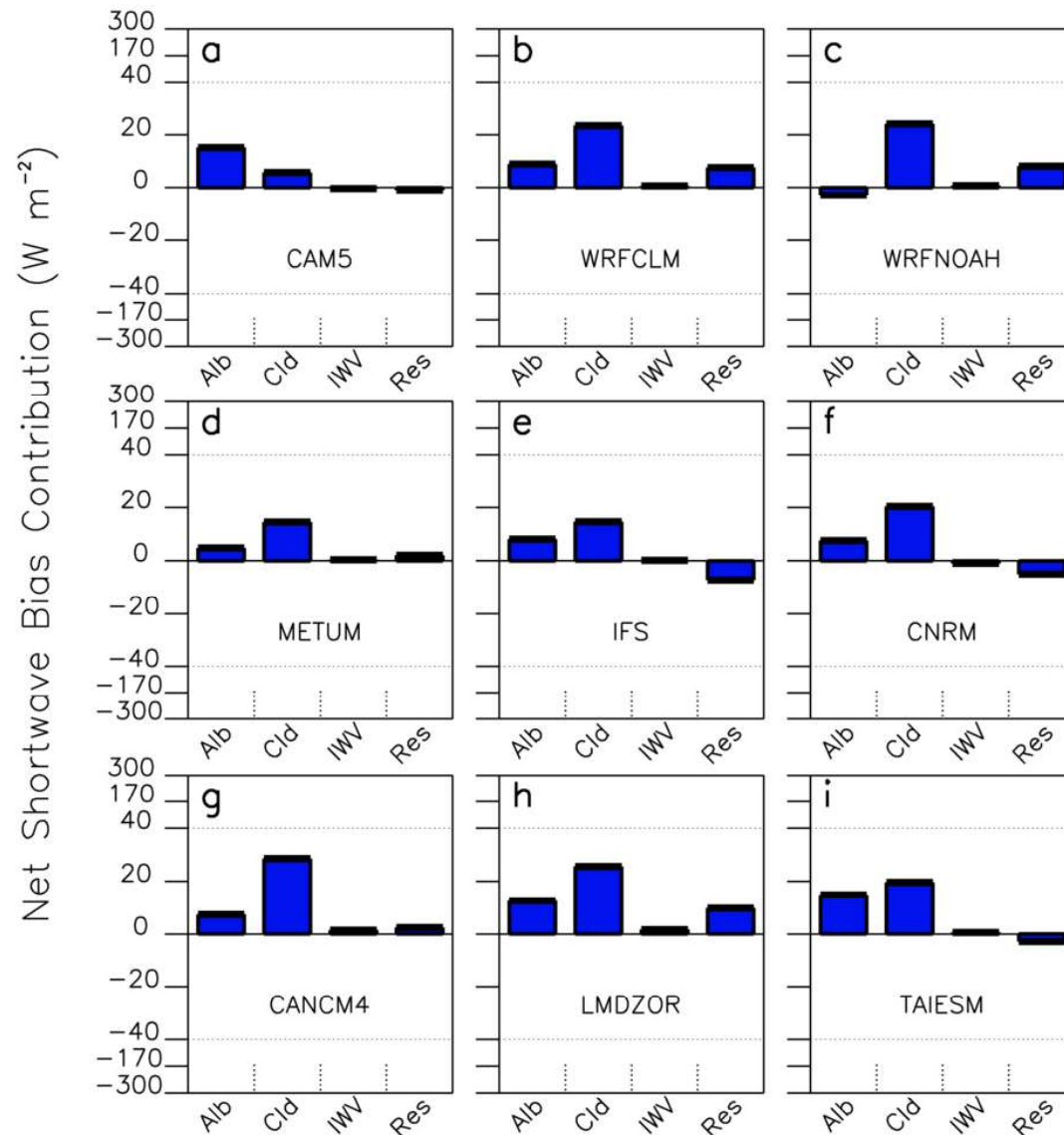
IWV

Cloud

Albedo

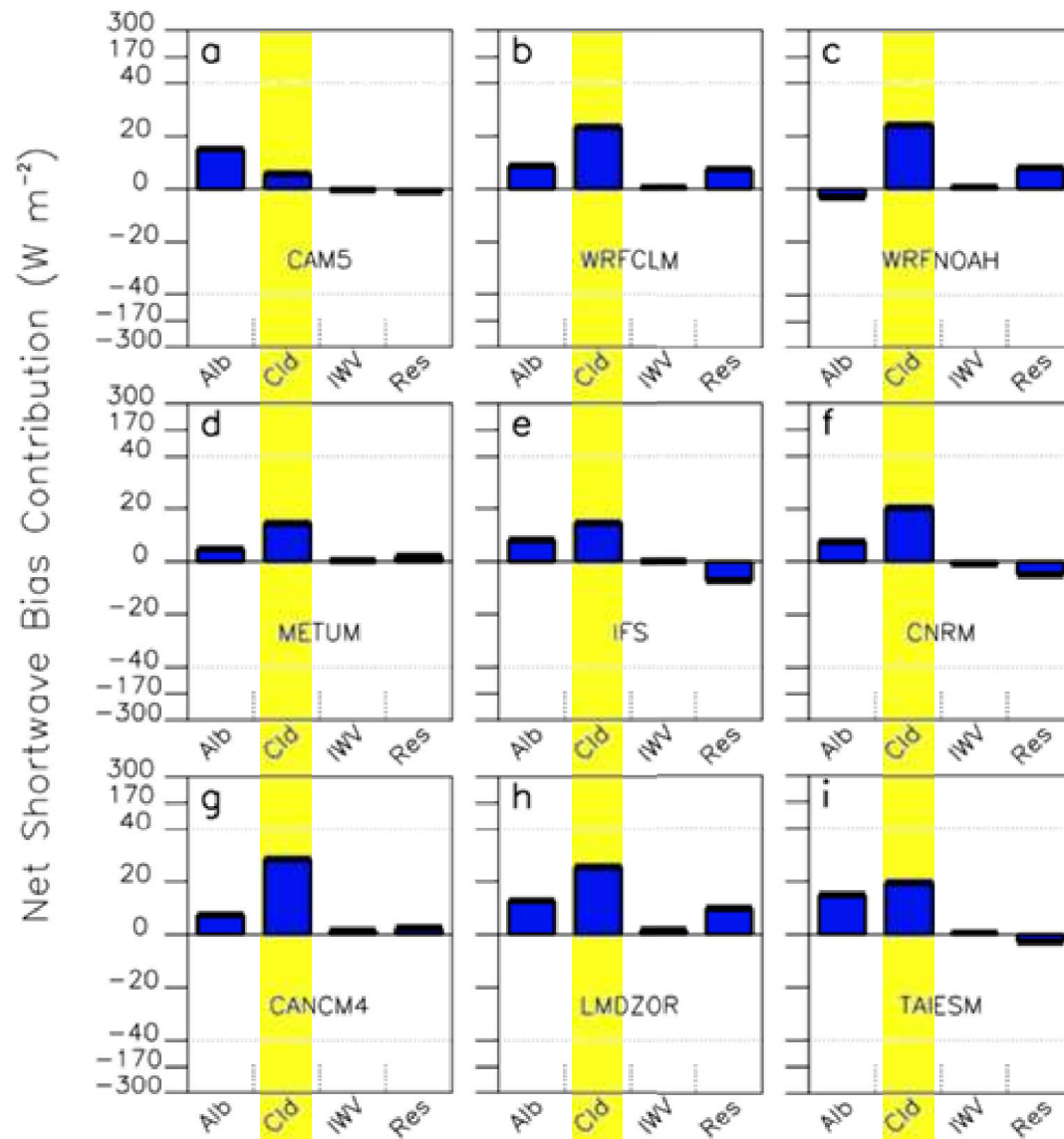
CAUSES: Radiation Attribution

Attribution of Shortwave bias to surf albedo, clouds and IWV



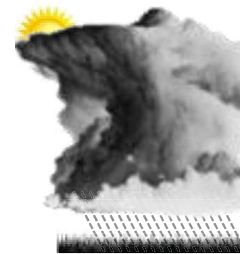
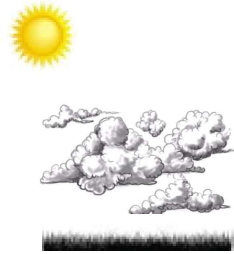
CAUSES: Radiation Attribution

Radiation Attribution: Clouds dominate



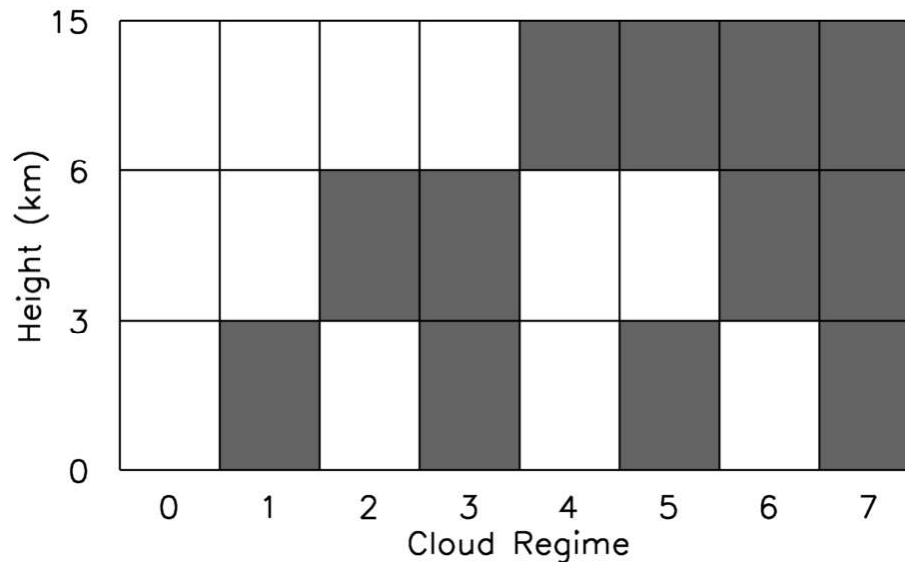
CAUSES: Cloud Regime Definition

Which cloud regimes are responsible for this bias?



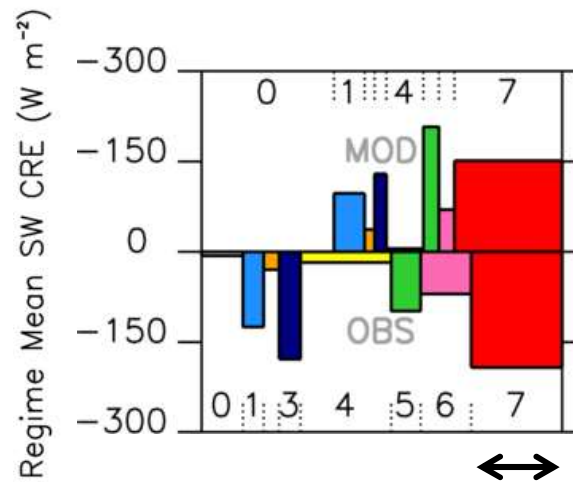
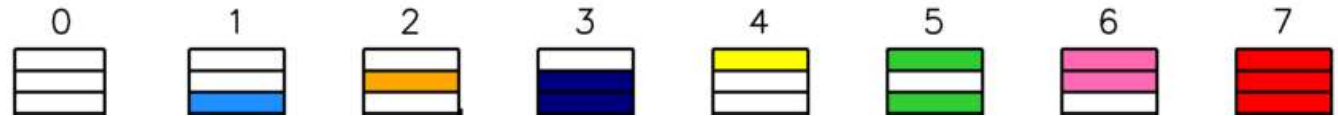
?

Cloud regimes, based on cloud occurrence at three levels of the atmosphere (Obs from ARSCL-Value Added Product)



CAUSES: Cloud Regime Analysis

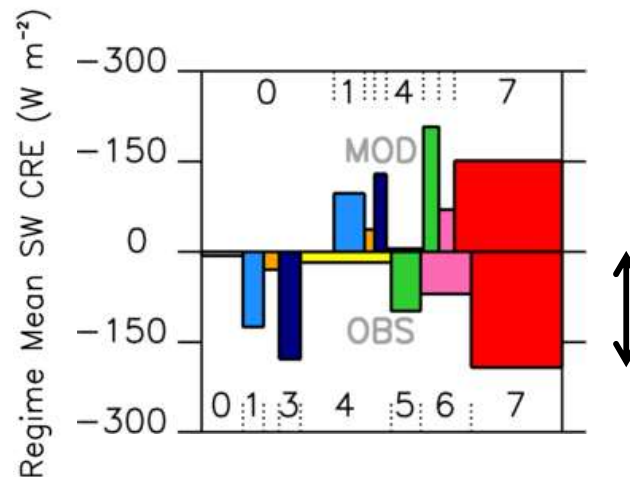
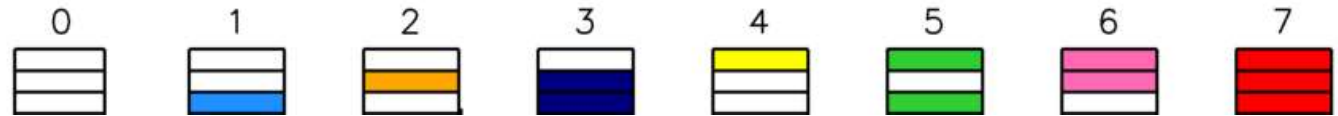
Composite cloud-related radiation bias into cloud regimes



Width of the bars: Frequency of occurrence of regime

CAUSES: Cloud Regime Analysis

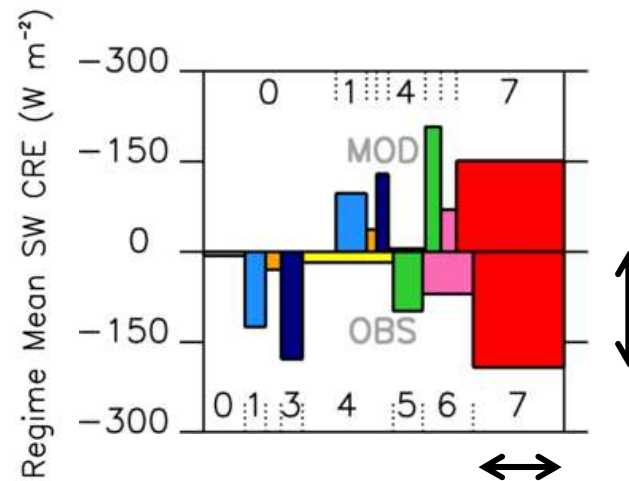
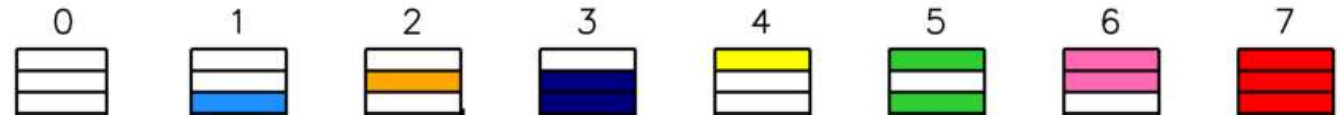
Composite cloud-related radiation bias into cloud regimes



Width of the bars: Frequency of occurrence of regime
 Height of the bars: Mean cloud radiative effect

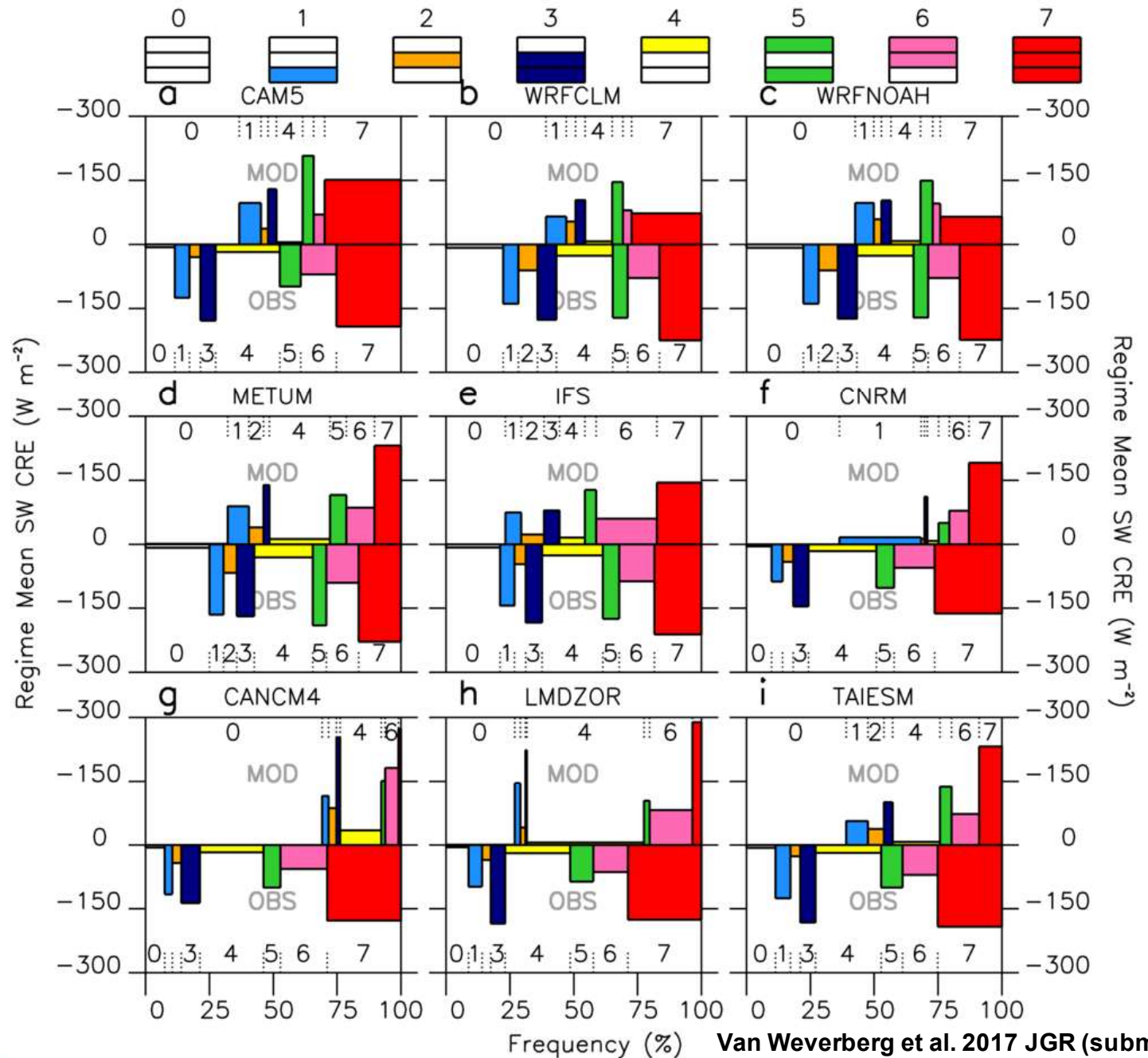
CAUSES: Cloud Regime Analysis

Composite cloud-related radiation bias into cloud regimes

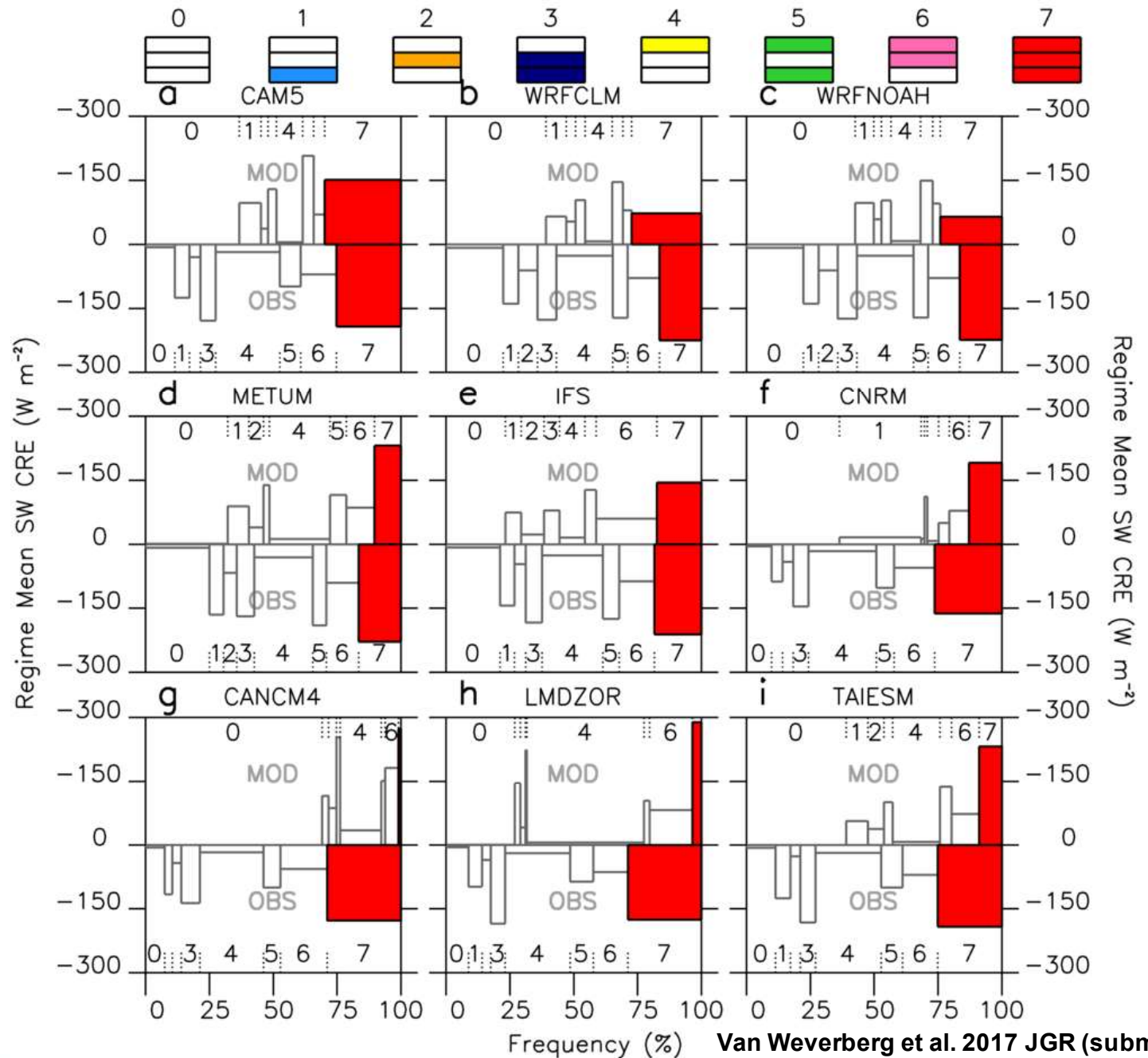


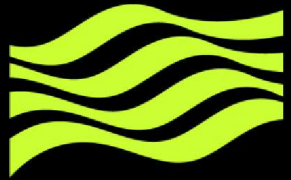
Width of the bars: Frequency of occurrence of regime
 Height of the bars: Mean cloud radiative effect of regime
 Surface area: Total cloud radiative effect of regime

CAUSES: Cloud Regime Analysis



CAUSES: Cloud Regime Analysis



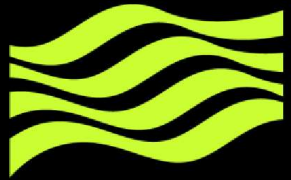


Met Office

CAUSES: Cloud Regime Analysis

→ Deep cloud regime problematic in most models, due to:

- Too small SW cloud radiative effect or
- Too small frequency



Met Office

CAUSES: Cloud Regime Analysis

→ Deep cloud regime problematic in most models, due to:

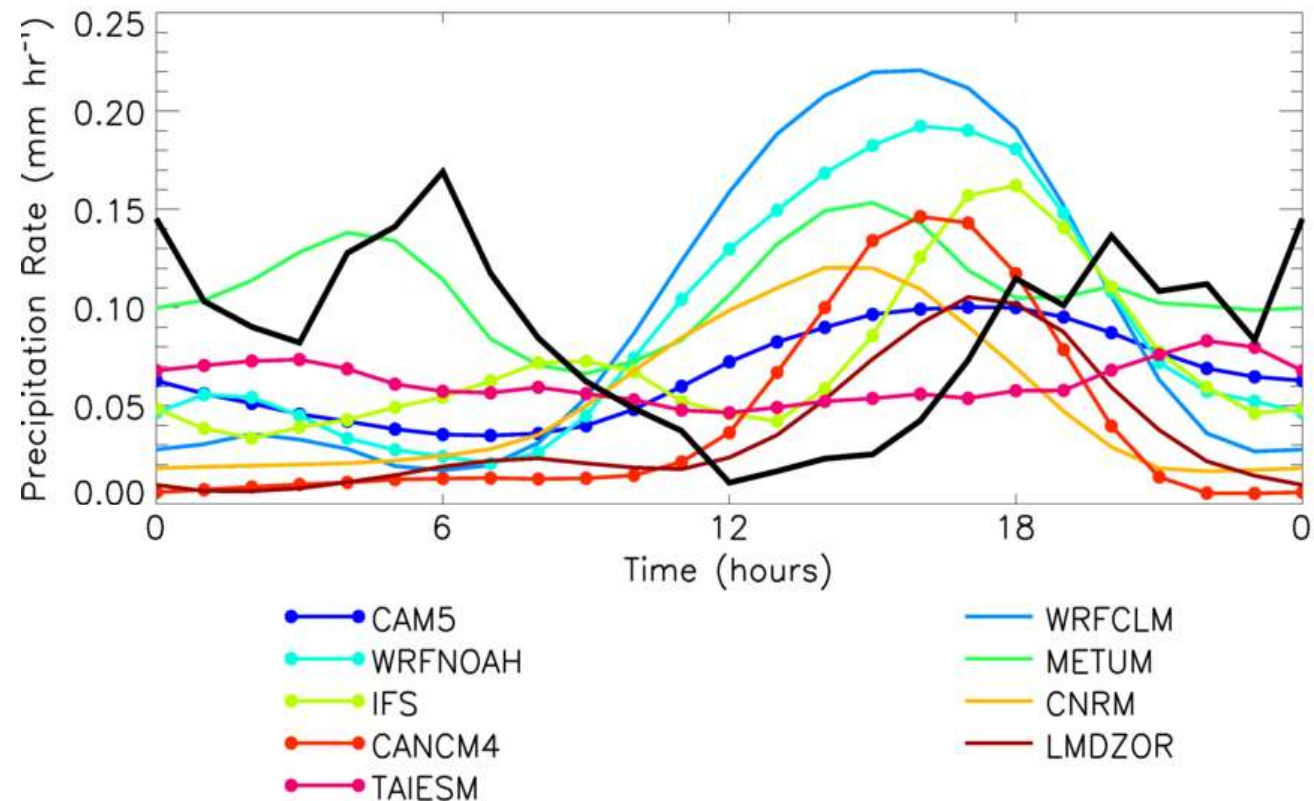
- Too small SW cloud radiative effect or
- Too small frequency

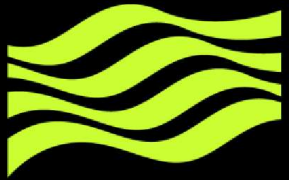
→ Suppressed convective activity during daytime?

CAUSES: Surface Rain Analysis

→ Deep cloud regime problematic in most models.

→ Suppressed convective activity during daytime?



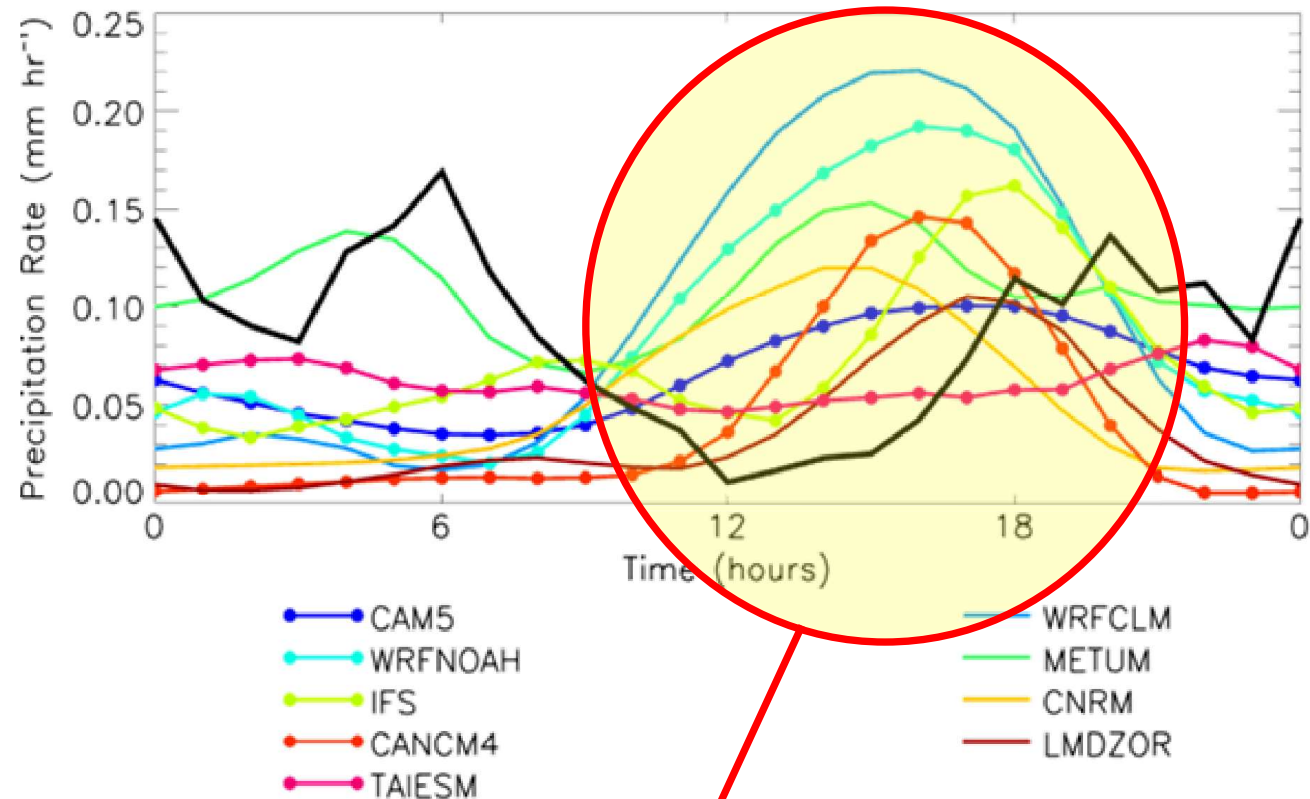


Met Office

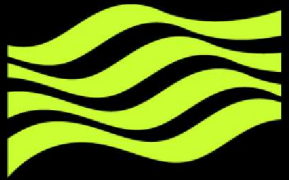
CAUSES: Surface Rain Analysis

→ Deep cloud regime problematic in most models.

→ Suppressed convective activity during daytime?



Most models are actually too wet in the afternoon!

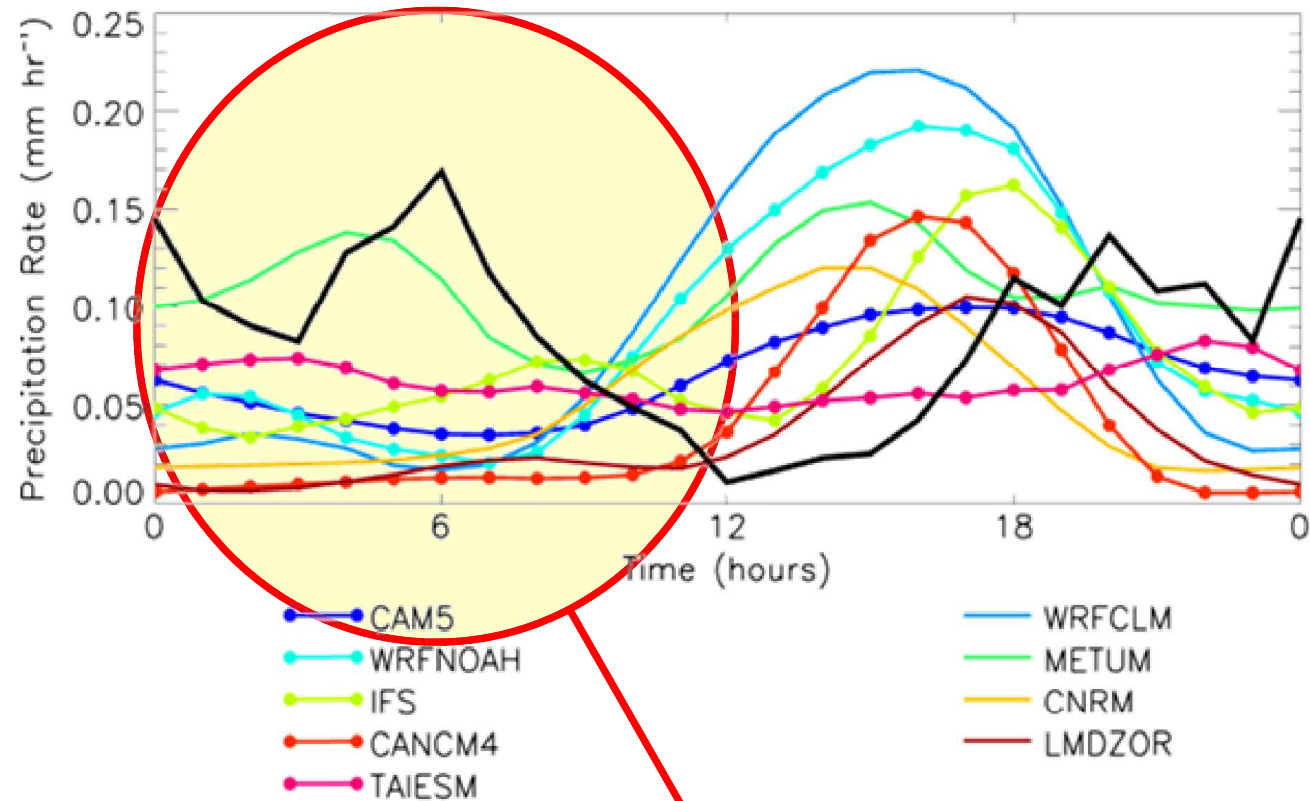


Met Office

CAUSES: Surface Rain Analysis

→ Deep cloud regime problematic in most models.

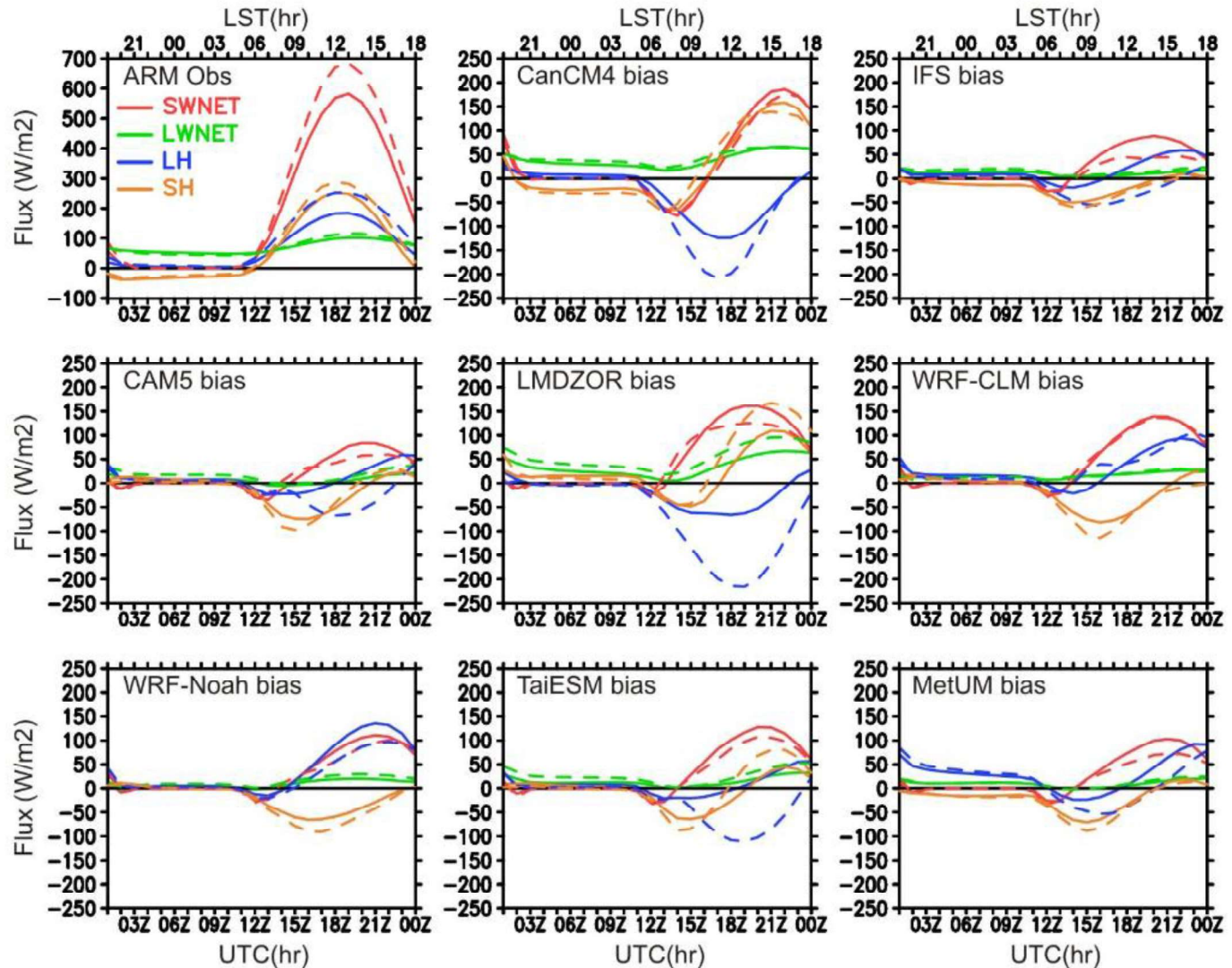
→ Suppressed convective activity during daytime?



... but miss the nocturnal elevated storms

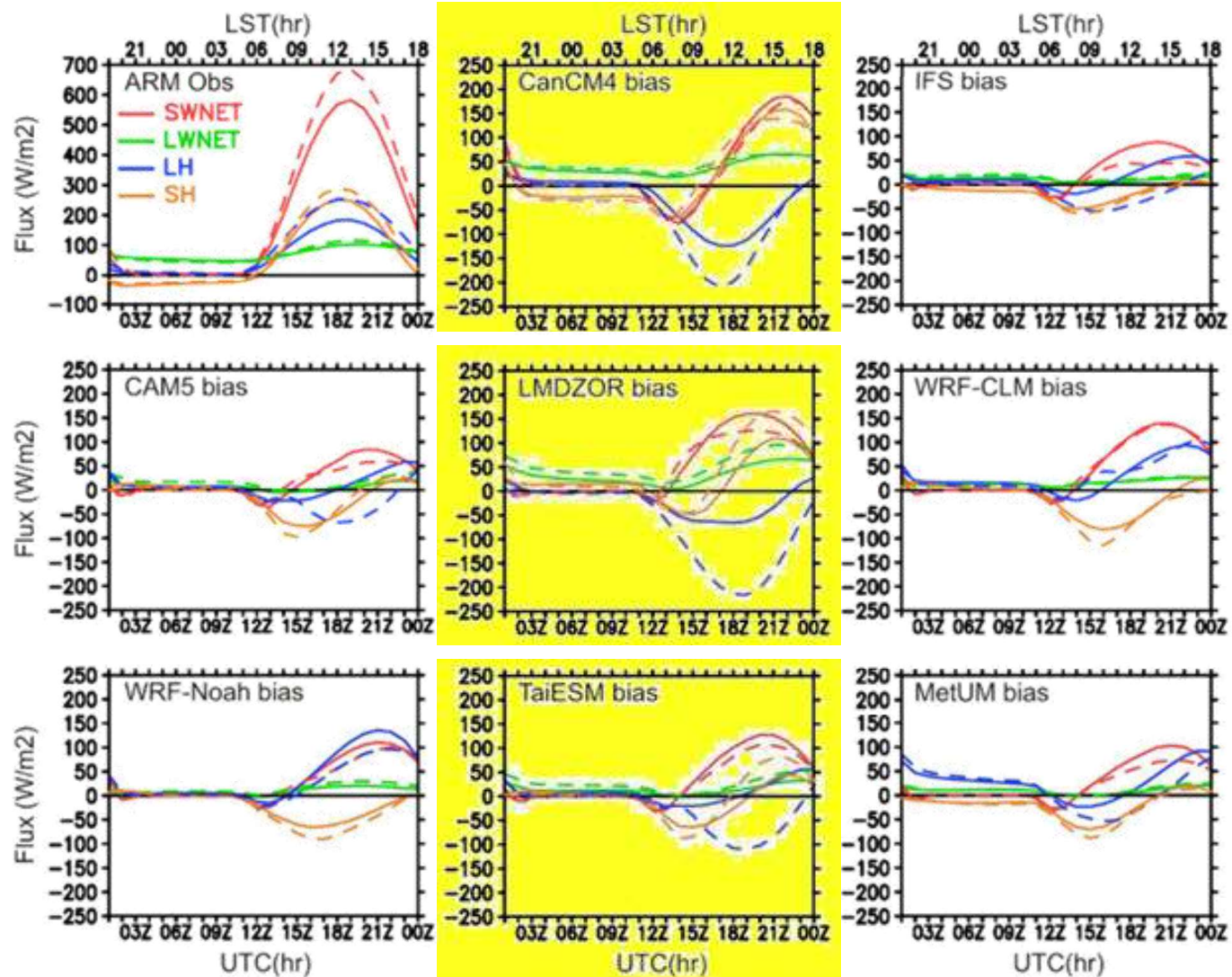
CAUSES: Relation to Warm Bias?

→ Energy balance, given too much SW:



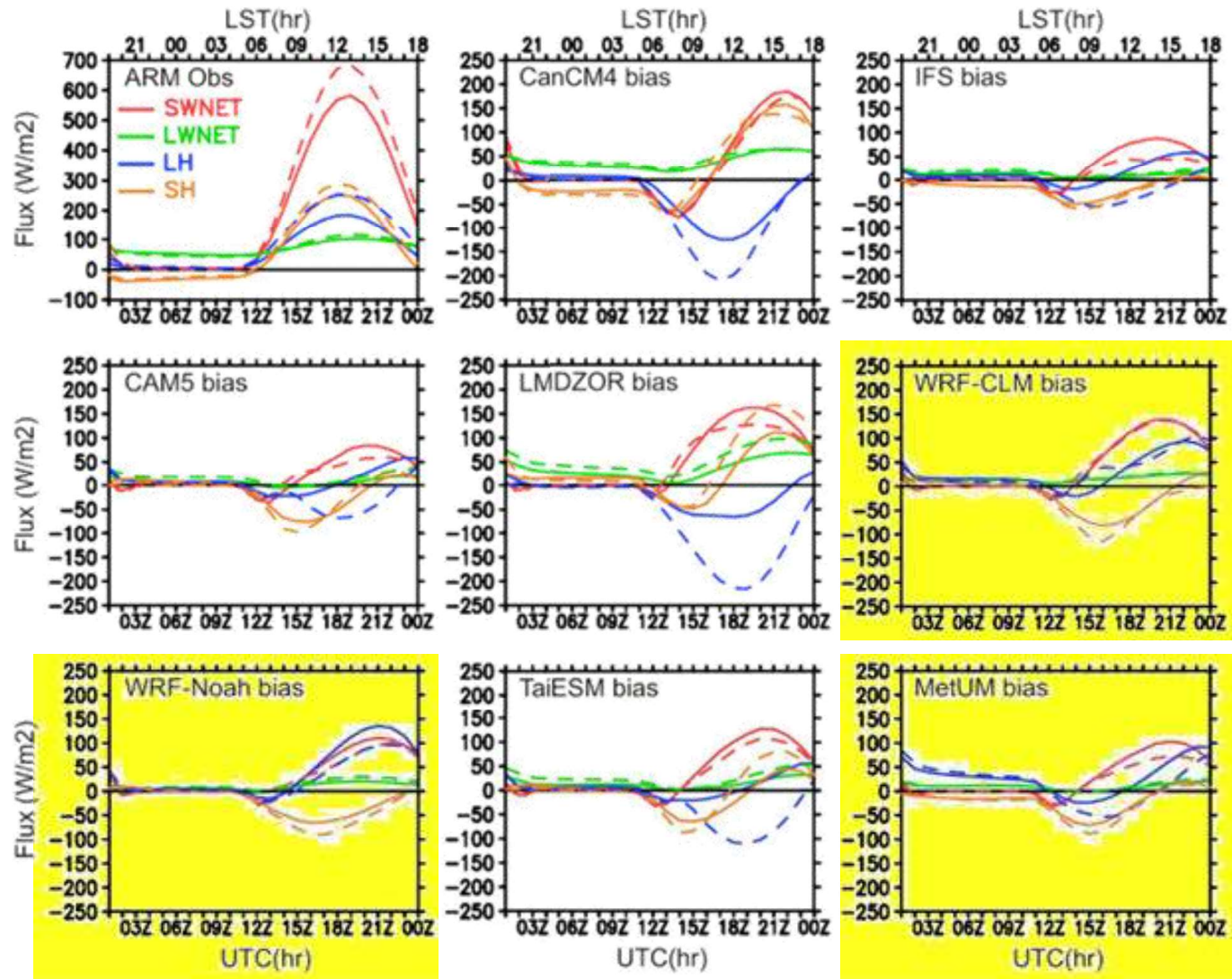
CAUSES: Relation to Warm Bias?

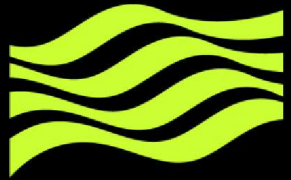
→ Warmest models energy balance: too dry → too small evaporative fraction



CAUSES: Relation to Warm Bias?

→ Cooler models energy balance: too wet → too large evaporative fraction





Met Office

Recommendations to developers

- All models suffer from excess shortwave at the surface
- Mainly because of too infrequent or too transparent deep cloud
- Daytime precipitation rates/frequency actually overestimated, so not an issue of insufficient convective triggering!

Recommendations to developers

- All models suffer from excess shortwave at the surface
- Mainly because of too infrequent or too transparent deep cloud
- Daytime precipitation rates/frequency actually overestimated, so not an issue of insufficient convective triggering!
- Possibly need to tune down precipitation efficiencies in midlatitudes to retain more cloud aloft and reduce rain rates
- Needs to be concerted with better captured elevated nocturnal convection, otherwise too dry overall, leading to too small evaporative fraction and maintaining the warm bias

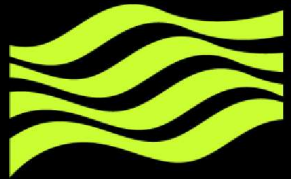
CAUSES

4 CAUSES papers submitted:

- 1) **Morcrette et al.** (Near-surface temperature errors in NWP and climate model 5-day hindcasts near the Southern Great Plains)
- 2) **Van Weverberg et al.** (Attribution of surface radiation biases in NWP and climate models near the U.S. Southern Great Plains)
- 3) **Ma et al.** (On the role of surface energy budget errors to the warm surface air temperature error over the central U.S.)
- 4) **Zhang et al.** (Diagnosis of the Summertime warm bias in CMIP5 climate models at the ARM Southern Great Plains site)

More info and data:

<http://portal.nersc.gov/project/capt/CAUSES/>



Met Office

Questions?

