# Attribution of Surface Radiation Errors near the Southern Great Plains in NWP and Climate Models


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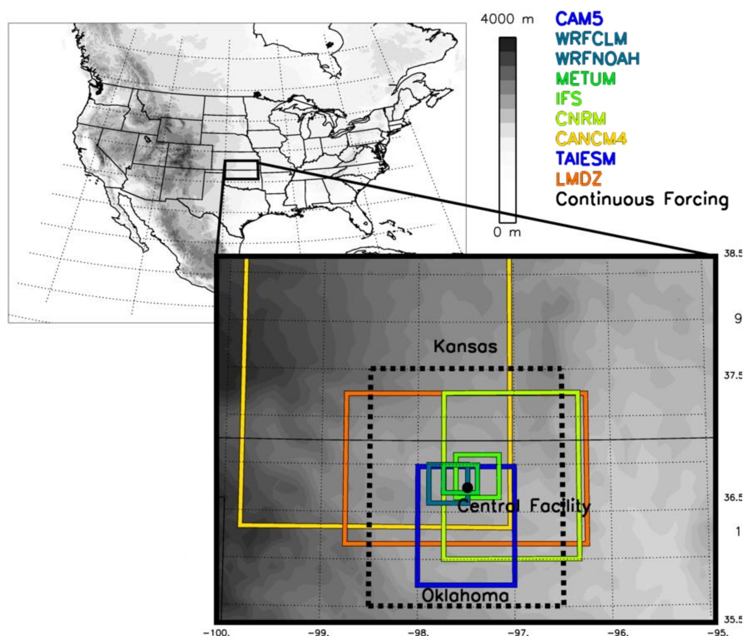
## Motivation CAUSES

- Many NWP and climate models suffer from large **temperature biases** in the mid-latitude continents (see poster **Morcrette et al**.).
- The origin of this bias is subject to **debate**, but likely involves cloud and land-surface deficiencies.
- **CAUSES** project (Clouds Above the US and Errors at the Surface) aimed at understanding the bias by running models in hindcast mode from April – August 2011, with particular focus on Southern Great Plains.
- This poster discusses origin of **radiation** biases present in 9 models analyzed in the CAUSES-project

## Attribution of Radiation Biases

### Methods

Attribution of net SW/LW radiation biases to albedo (α), cloud, integrated water vapor (IWV) and residual (res), using Continuous Forcing[a]




$$\overline{\Delta SW_{net}} = C_{\alpha} + C_{cloud} + C_{IWV} + C_{res}$$

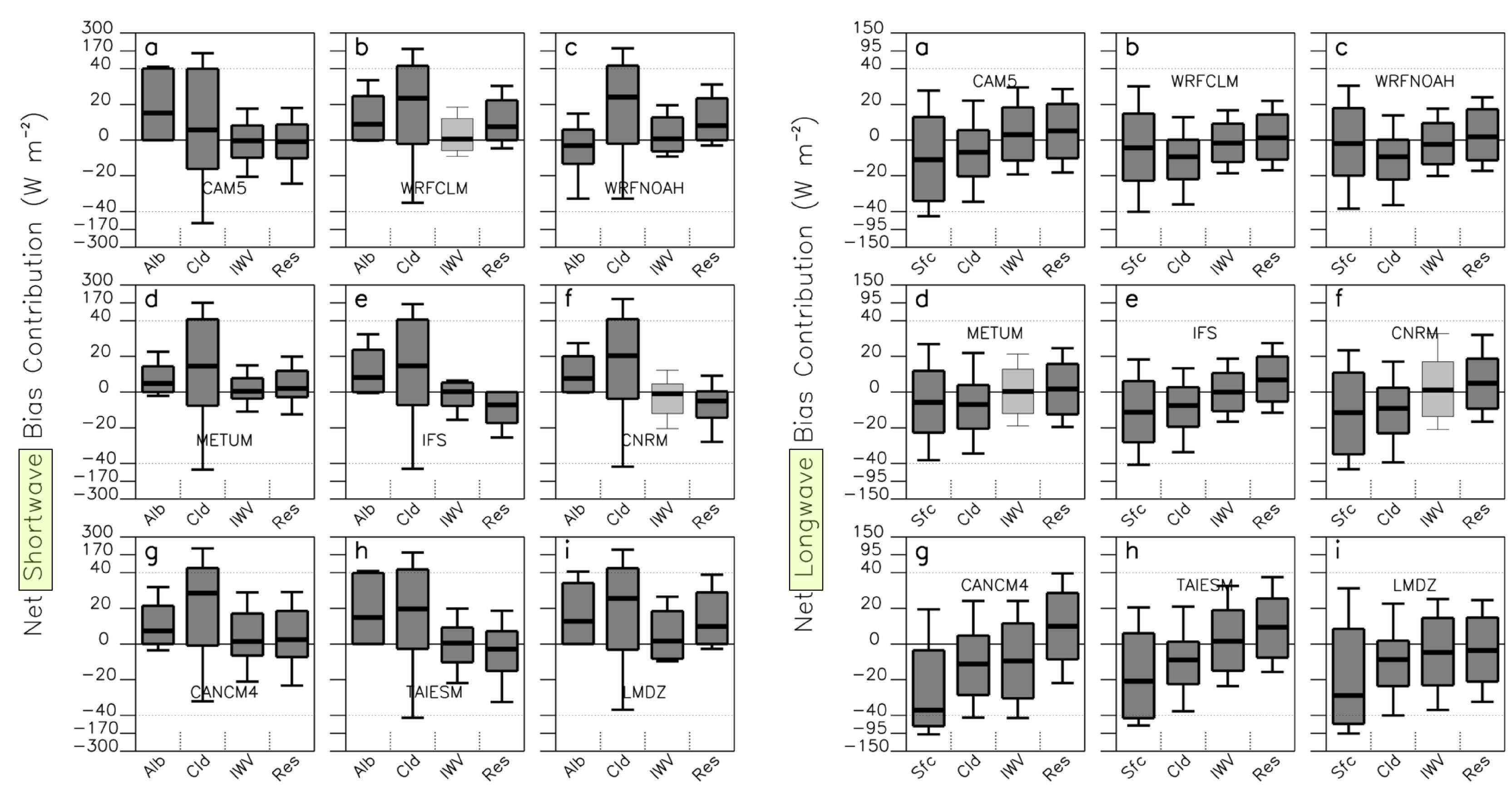
$$C_{\alpha} = \overline{(\alpha_M - \alpha_o) SW_{OD}}$$

$$C_{cloud} = \overline{(1-\alpha_o)((SW_{MD} - SW_{OD}) - (SWcs_{MD} - SWcs_{OD}))}$$

$$C_{IWV} = \overline{(1-\alpha_O)}\left(\Delta SWcs_{(Biased\ IWV)} - \Delta SWcs_{(Unbiased\ IWV)}\right) freq_{(Biased\ IWV)}$$

$$C_{res} = \overline{(1-\alpha_O)}\ \Delta SWcs_{(Unbiased\ IWV)}$$

### Attribution in 9 CAUSES models




**Large** SW and LW biases in all models.

Most of the SW bias originates from **cloud issues** in all models, apart from CAM5 which has a dominant **albedo** contribution

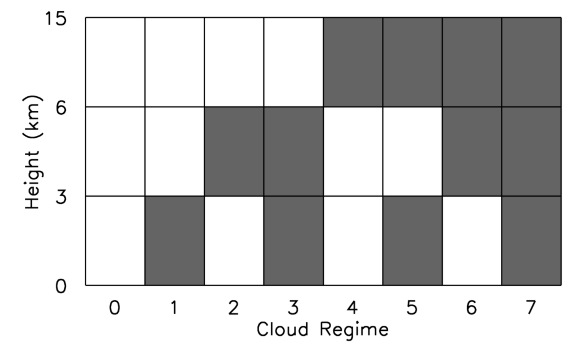
Small contribution from **IWV** for all models, apart from LW radiation in CanCM4

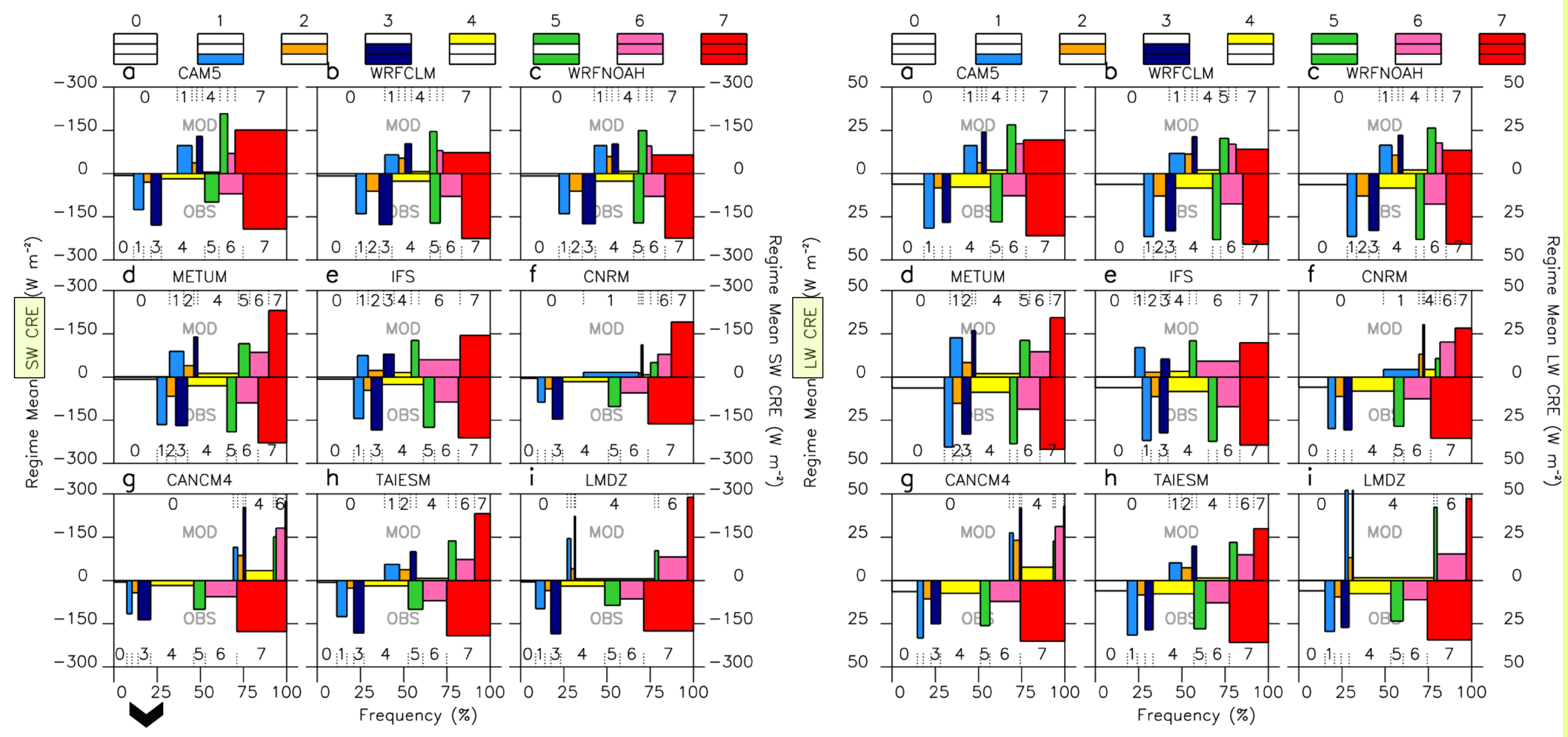
Small contributions from **residual term** for most models, but non-negligible for IFS, CNRM, CanCM4 and LMDZ

## AMJJA Cloud Regime-Radiation Analysis

Cloud regime analysis to further disentangle $C_{cloud}$

Cloud regimes based on cloud occurrence at 3 levels of the atmosphere, using ARSCL[b] and RADFLUXANAL[c]



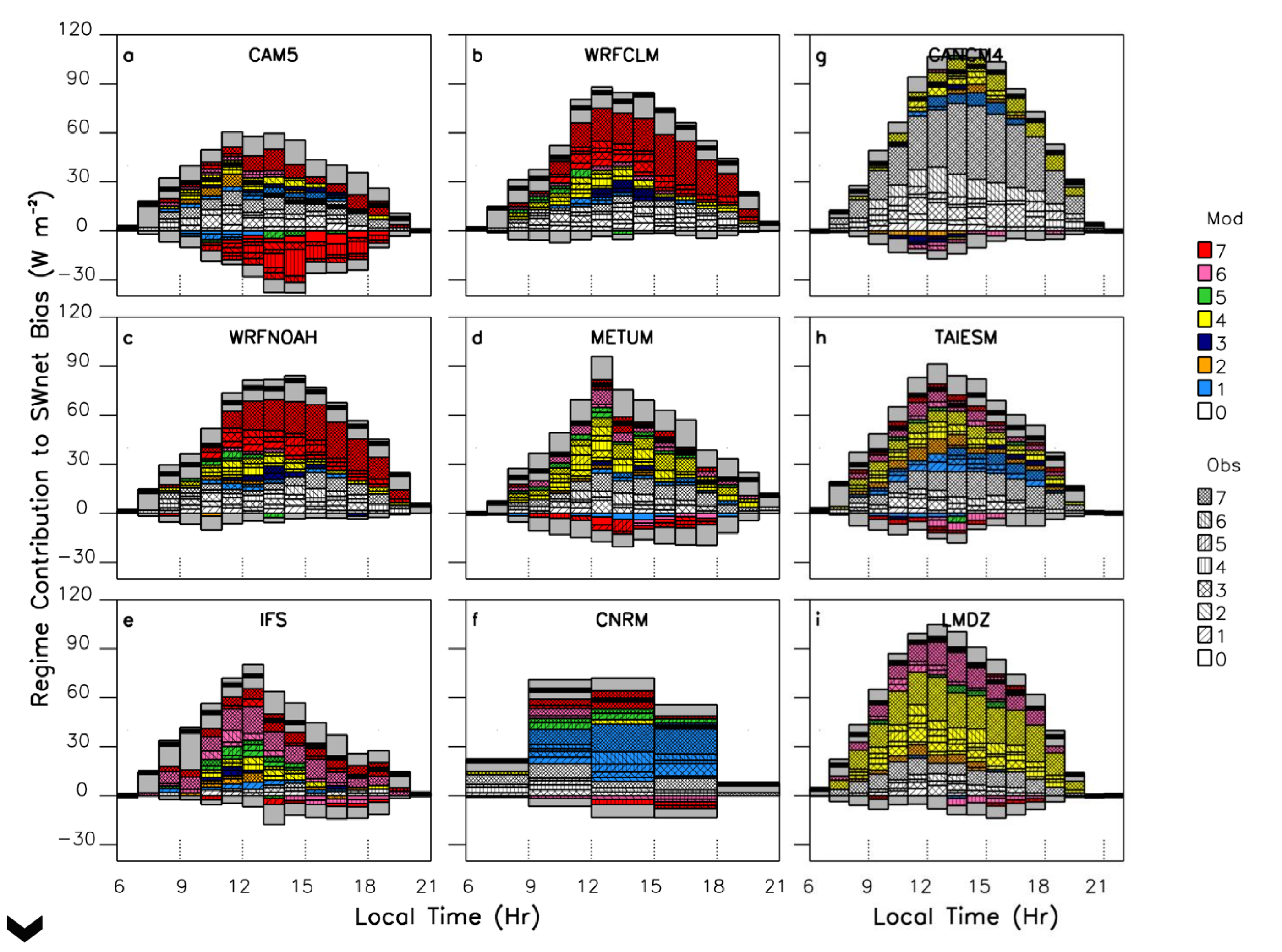




**Width** of bars = frequency of regime **Height** of bars = mean Cloud Radiative Effect
**Surface area** (width x height) = total Cloud Radiative effect
(Mod above 0-line, Obs below 0-line for each model)

Many models struggle to reproduce radiatively important **deep regime** (7). Some models fail to trigger enough of this regime (METUM, CNRM, CanCM4, TAIESM, LMDZ), while other models fail to reproduce its radiative impact (CAM5, WRF, IFS).

## Diurnal Cloud Regime-Radiation Analysis

Diurnal cycle of $C_{cloud}$, attributed to observed-simulated cloud regime pairs




While the main deficiency in all models in terms of radiative impact is under-representing the frequency and/or CRE of regime 7, all models seem to have a different issue in terms of why they fail to produce the characteristics of this regime.

## Conclusions

- **Warm bias in all CAUSES models associated with large biases in SW and LW radiation.**
- **This bias mainly originates from mis-representing cloud properties in all models, apart from the CAM5.**
- **All models fail to correctly represent the frequency and/or cloud radiative effect of the deep cloud regime, but all for different reasons.**


[a] Xie, S., Cederwall, R. T., Zhang, M.H. (2004). Developing long-term single-column model/cloud system-resolving model forcing using numerical weather prediction products constrained by surface and top of the atmosphere observations. Journal of Geophysical Research, 109, D01104.

[b] Johnson, K., Toto, T., Giangrande. S. (2016). Atmospheric Radiation Measurement (ARM)Climate Research Facility. 2011, updated hourly. Active Remote Sensing of CLouds(ARSCL) product using Ka-band ARM Zenith Radars (ARSCLKAZRBND1KOLLIAS).2011-03-31 to 2011-08-31, 36.605 N 97.485 W: Southern Great Plains (SGP) Central Facility, Lamont, OK (C1). Atmospheric Radiation Measurement (ARM) Climate Research Facility Data Archive: Oak Ridge, Tennessee, USA. Data set accessed 2017-01-20 at http://dx.doi.org/.

[c] Gaustad, K. L.,Riihimaki, L., Long, C. (2016). Atmospheric Radiation Measurement (ARM) Climate Research Facility. 1994, updated hourly. Radiative Flux Analysis(RADFLUX1LONG). 2011-03-30 to 2011-09-01, 36.605 N 97.485 W: Southern Great Plains (SGP) Central Facility, Lamont, OK (C1). Atmospheric Radiation Measurement (ARM) Climate Research Facility Data Archive: Oak Ridge, Tennessee, USA. Data set accessed 2016-09-14 at http://dx.doi.org/10.5439/1179822.

[d] Van Weverberg, K., C. J. Morcrette, J. Petch, S. A. Klein, H.-Y. Ma, C. Zhang, S. Xie, Q. Tang, W. Gustafson, Y. Qian, L. Berg, M. Wang, Y. Liu, M. Ahlgrimm, R. Forbes, E. Bazile, R. Roehrig, J. Cole, W. Merryfield, W.-S. Lee, F. Cheruy, L. Mellul, Y.-C.Wang, K. Johnson (2017). Attribution of Surface Radiation Errors near the Southern Great Plains in Numerical Weather Prediction and Climate Models. Journal of Geophysical Research, in preparation.



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The “CAUSES” project is a collaboration between GASS and ASR, led by staff at the Met Office and PCMDI.

Please get in touch if you would like to participate.