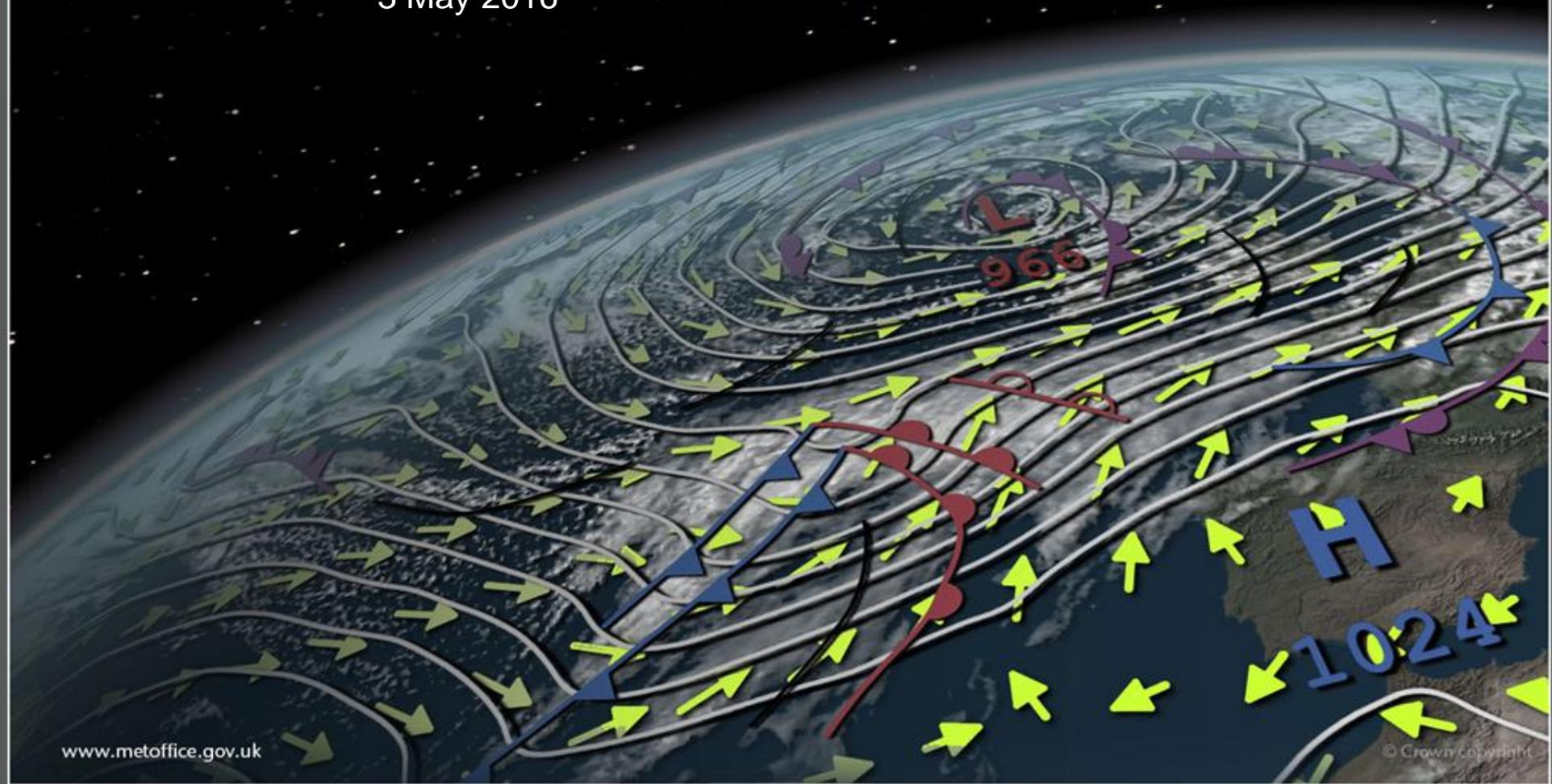


# Attribution Study of Surface Temperature Biases in GCMs

Kwinten Van Weverberg and all CAUSES-collaborators

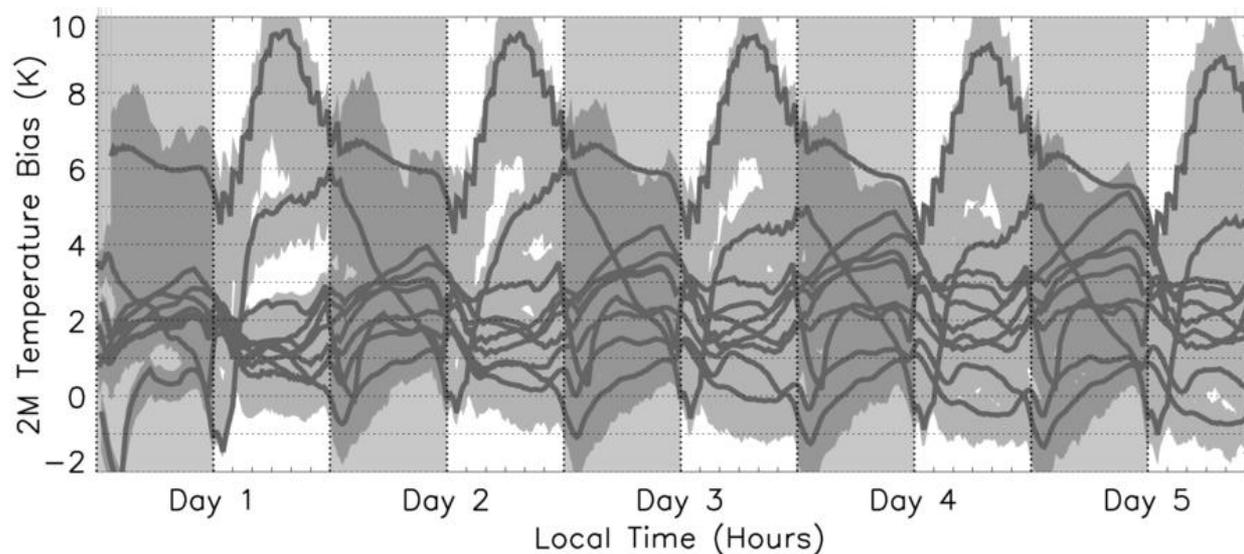
3 May 2016



# CAUSES Experiment 1A

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

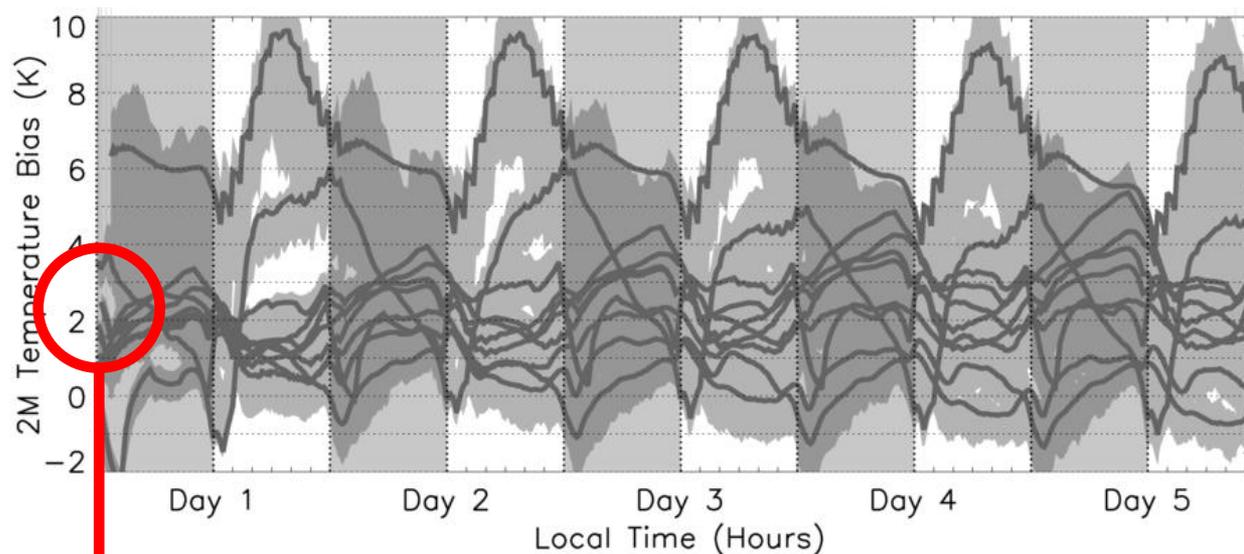
Data from 10 GCM-simulations



# CAUSES Experiment 1A

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

Data from 10 GCM-simulations

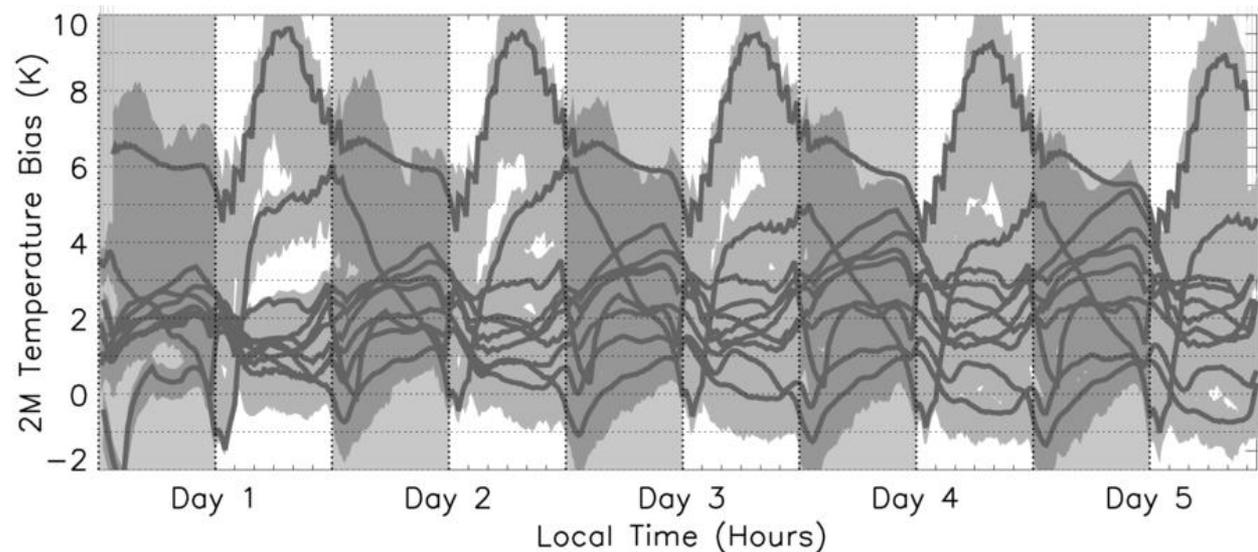


**Most GCMs start with a 1-2 K bias**

# CAUSES Experiment 1A

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

Data from 10 GCM-simulations



**Limited bias growth over the 5 days**

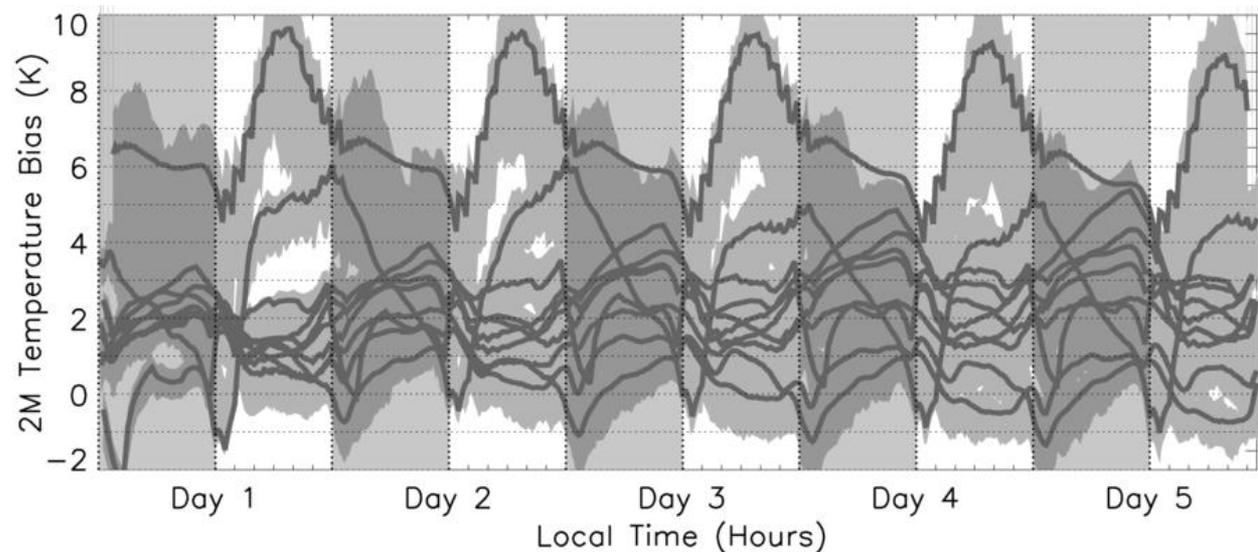


Met Office

# CAUSES Experiment 1A

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

Data from 10 GCM-simulations

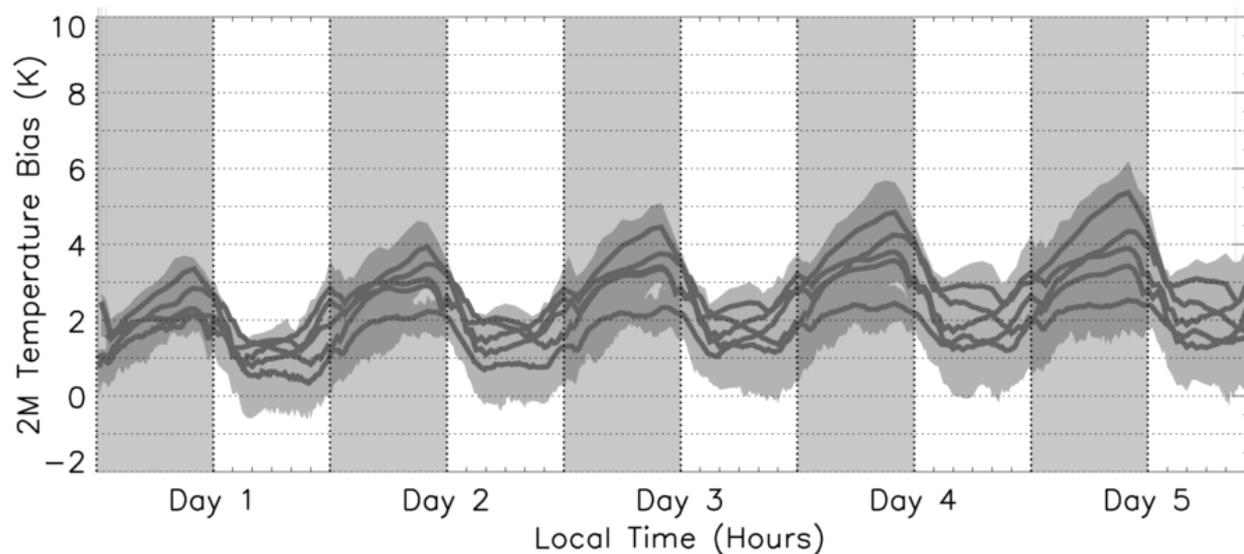


**Fairly distinct diurnal cycle in the bias**

# CAUSES Experiment 1A

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

Data from 5 GCM-simulations with similar behaviour

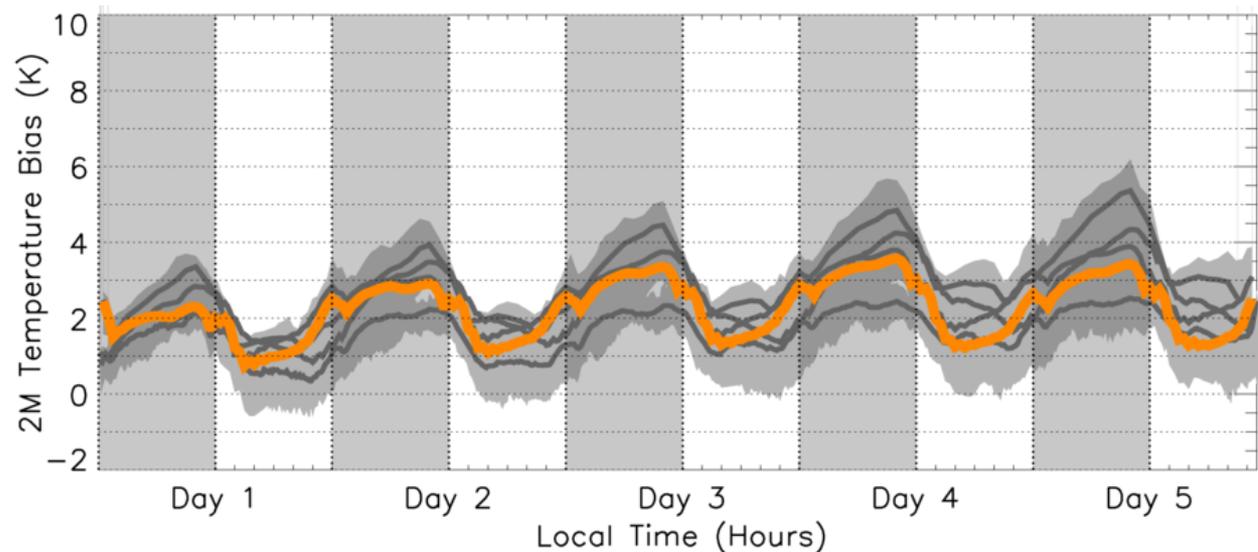


**Five GCMs that behave fairly similarly**

# CAUSES Experiment 1A

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

Data from 5 GCM-simulations → LLNL-CAM5



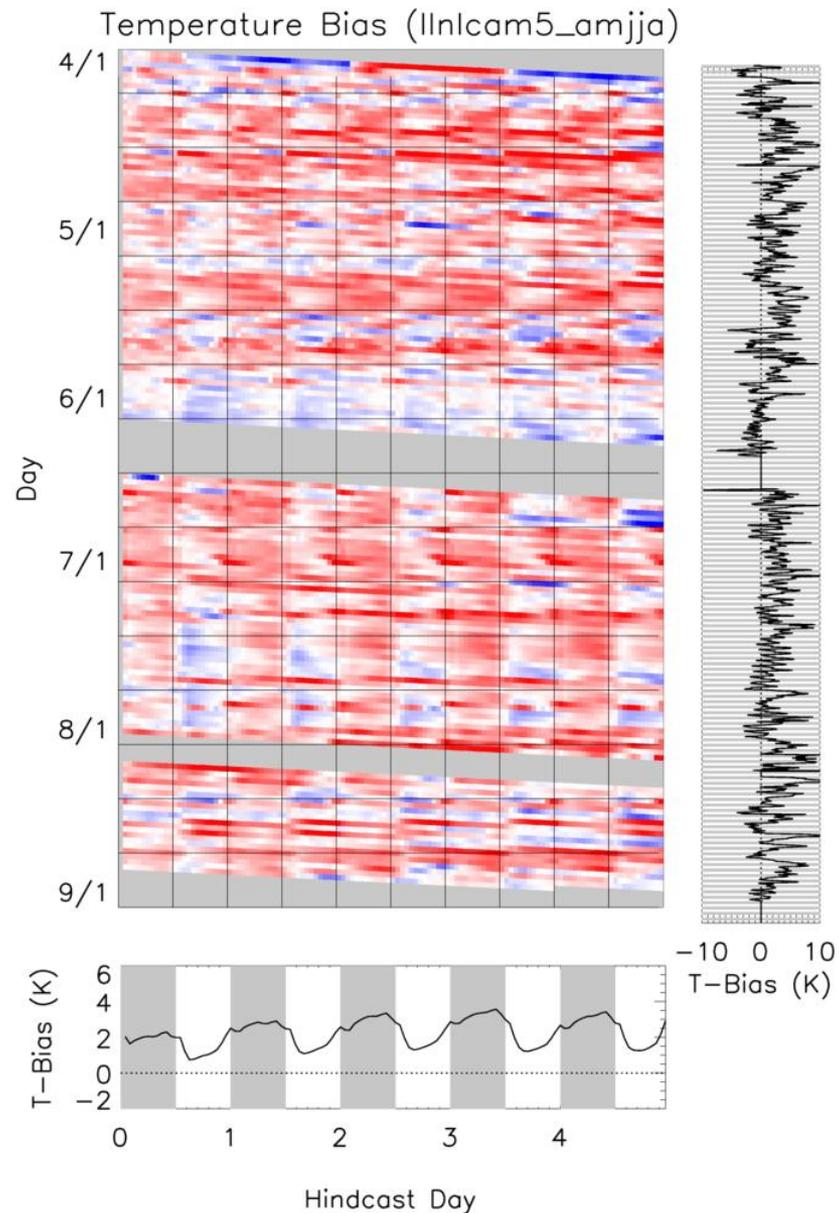
**CAM5 (LLNL)**

# CAUSES Experiment 1A

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

LLNL-CAM5

2m Temperature Bias



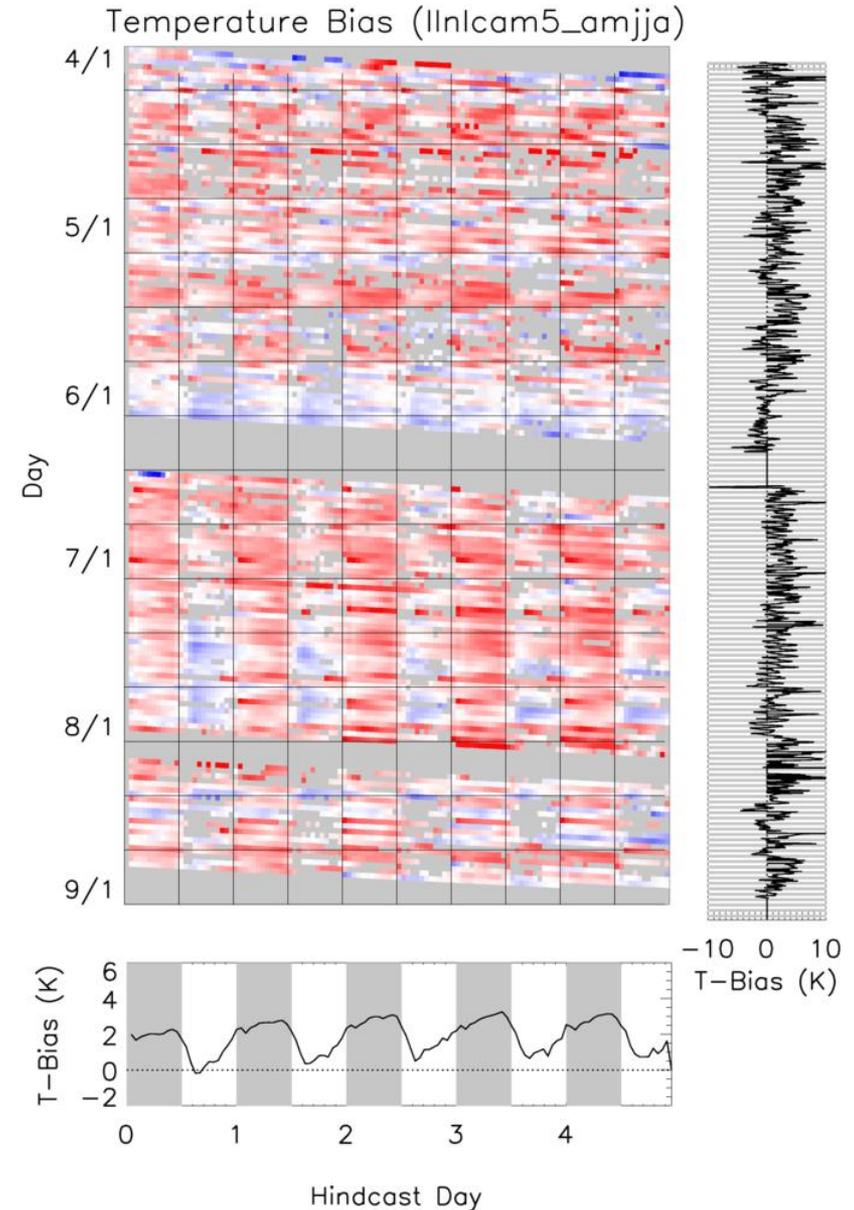
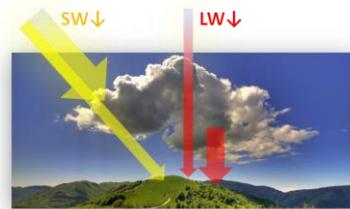
# CAUSES Experiment 1A

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

LLNL-CAM5

2m Temperature Bias

Time steps with correct downwelling radiation (GOODRAD)



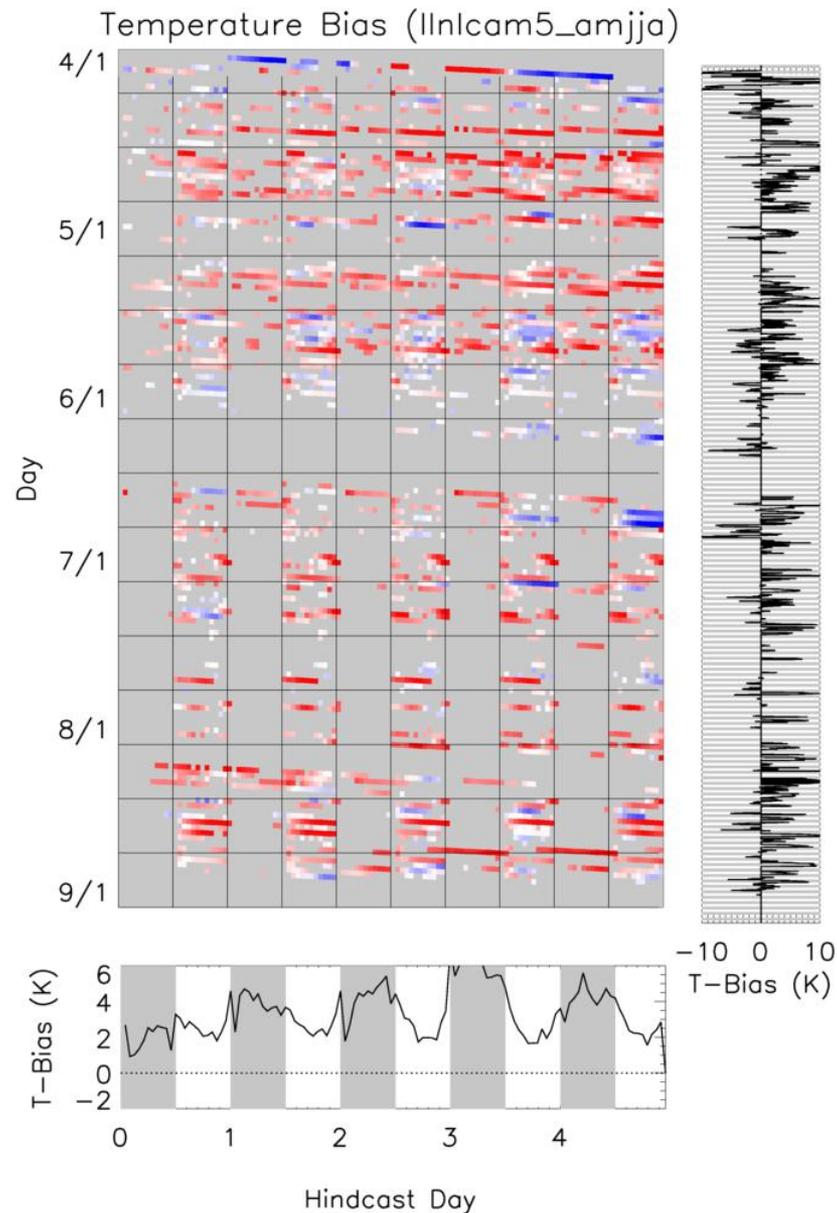
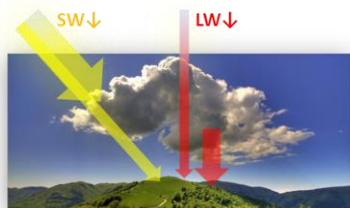
# CAUSES Experiment 1A

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

LLNL-CAM5

2m Temperature Bias

Time steps with biased downwelling radiation (BIASRAD)





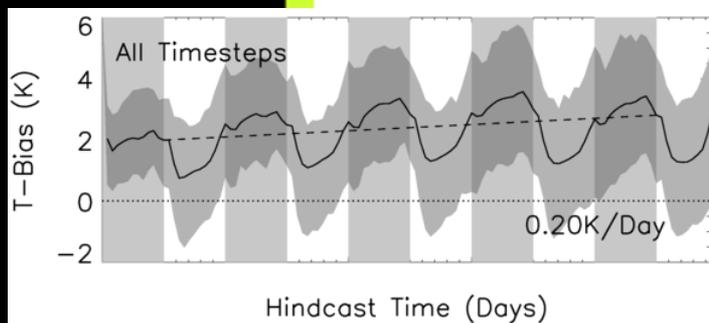
Met Office

# CAUSES Exp 1A

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

LLNL-CAM5

Attribution of the mean  
2m Temperature bias

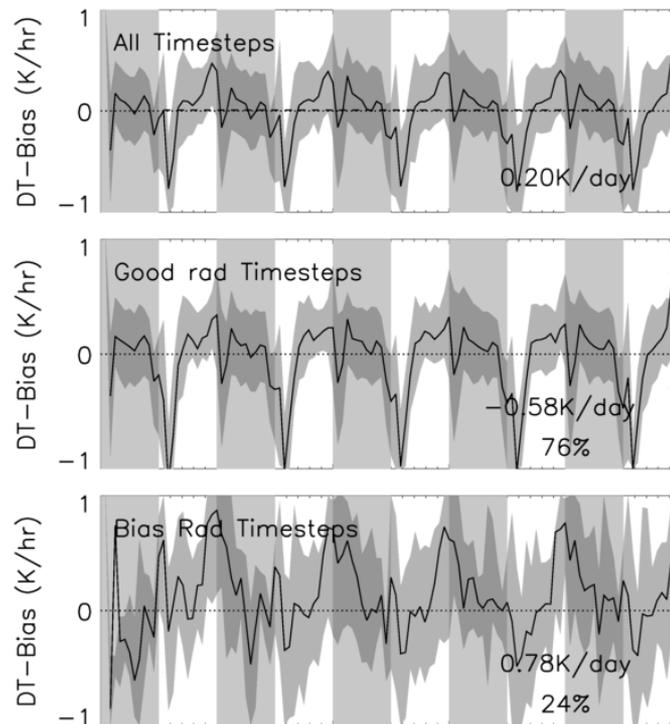
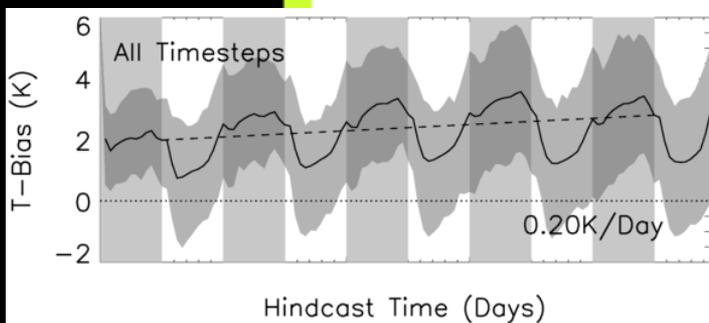


# CAUSES Exp 1A

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

LLNL-CAM5

Attribution of the mean 2m Temperature bias



$$\overline{\Delta T_{bias}} = f_{GR} \overline{\Delta T_{GRbias}} + f_{BR} \overline{\Delta T_{BRbias}}$$

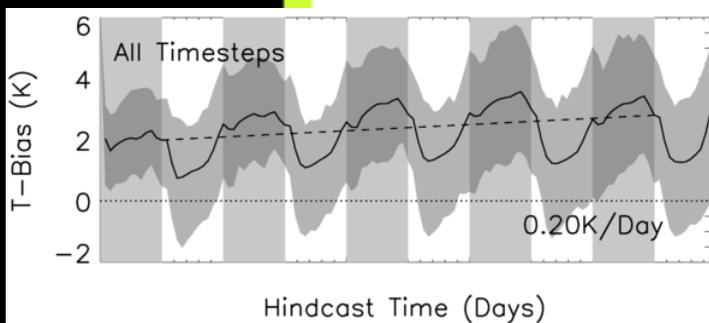
Hindcast Time (Days)

# CAUSES Exp 1A

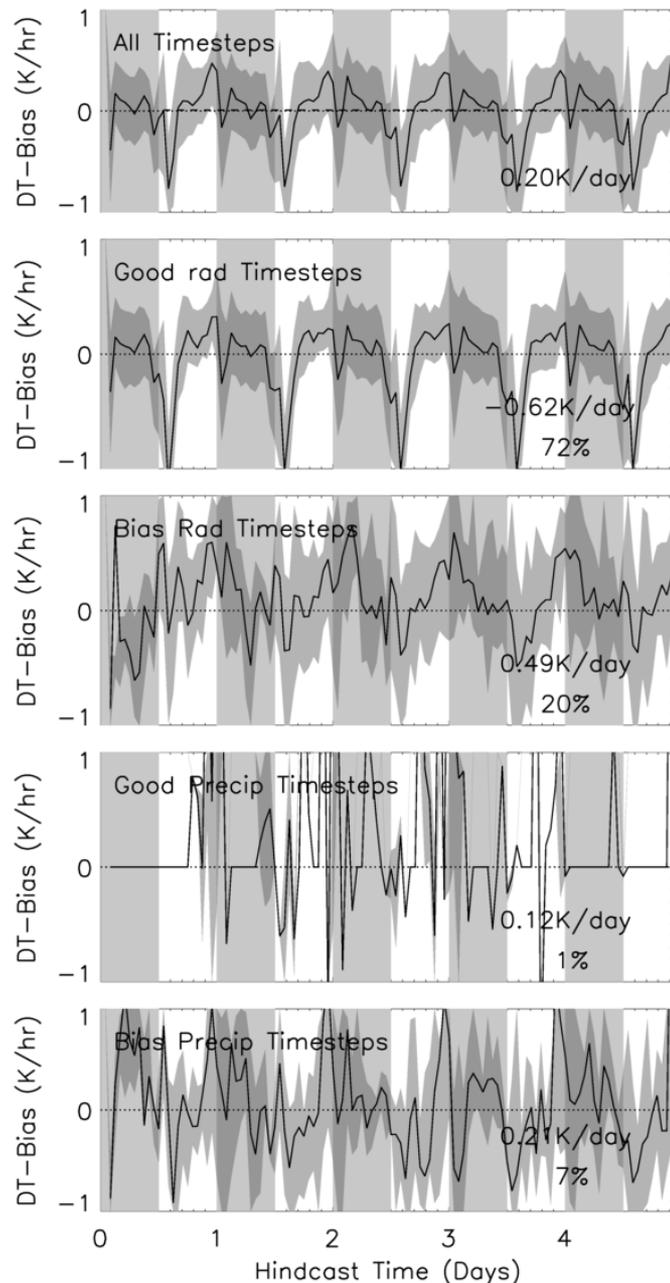
5-day hindcasts for every day 1 April – 31 August 2011

LLNL-CAM5

Attribution of the mean 2m Temperature bias



$$\overline{\Delta T_{bias}} = f_{GR} \overline{\Delta T_{GRbias}} + f_{BR} \overline{\Delta T_{BRbias}} + f_{GP} \overline{\Delta T_{GPbias}} + f_{BP} \overline{\Delta T_{BPbias}}$$

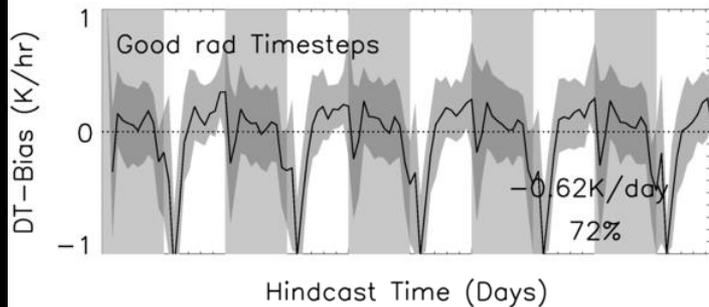




Met Office

# CAUSES Experiment 1A

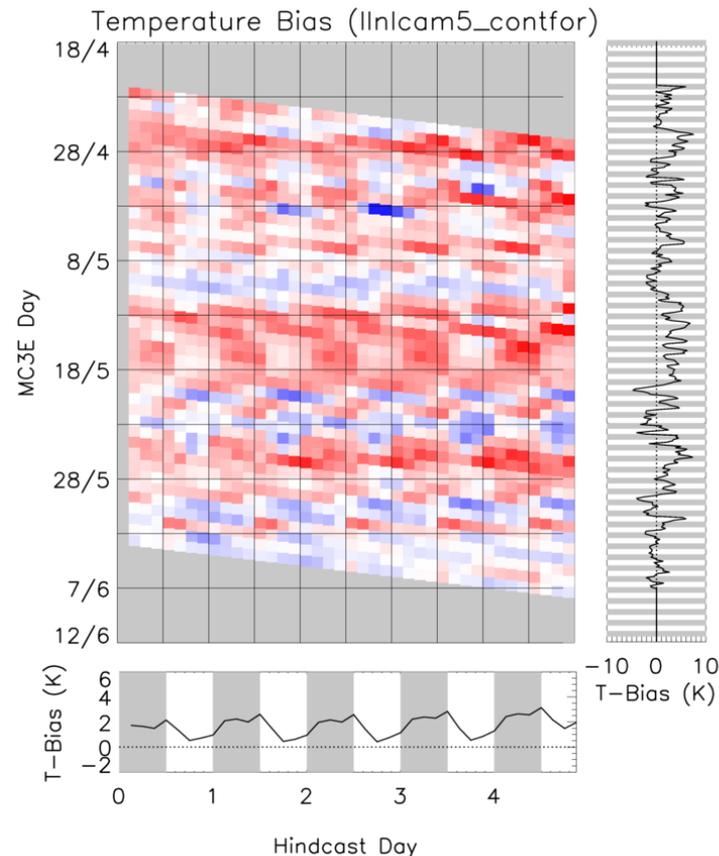
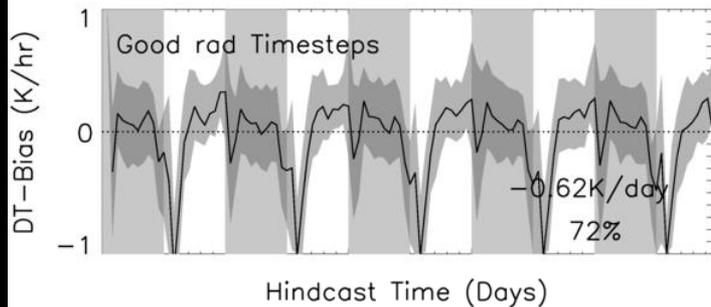
**What drives the diurnal cycle in the bias in the GOODRAD composite?**



# CAUSES Experiment 1A

What drives the diurnal cycle in the bias in the GOODRAD composite?

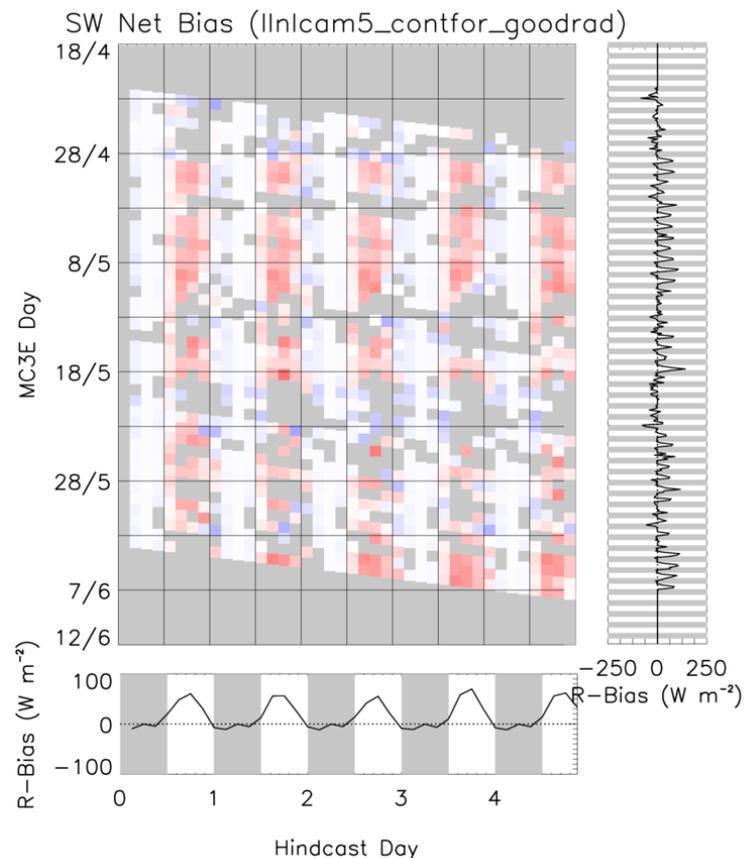
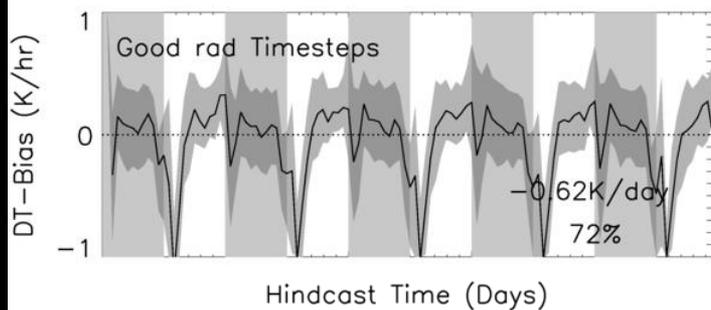
1.5 m Temperature



# CAUSES Experiment 1A

What drives the diurnal cycle in the bias in the **GOODRAD** composite?

## Net SW Radiation

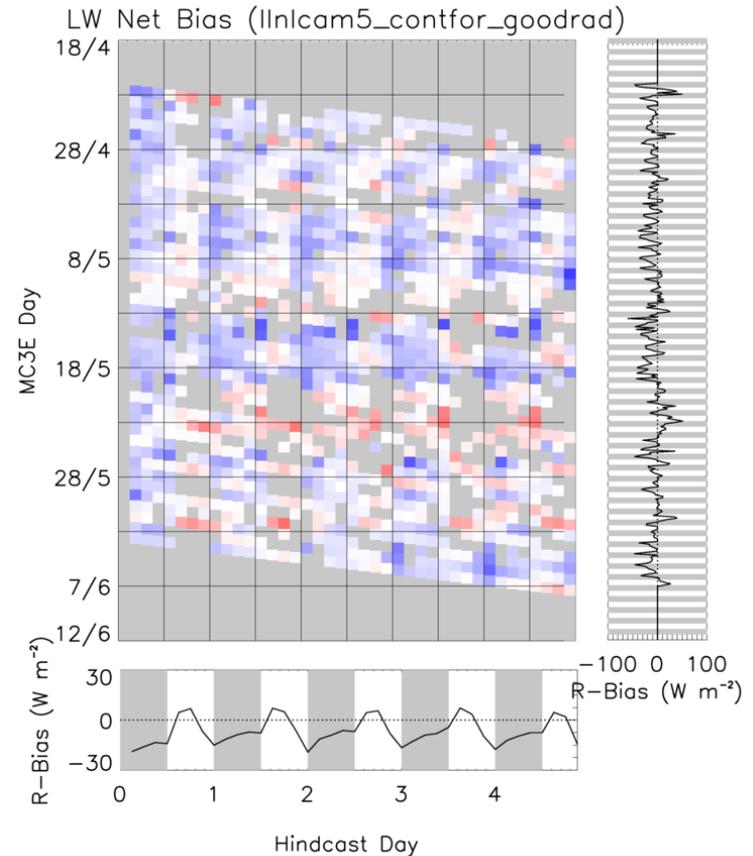
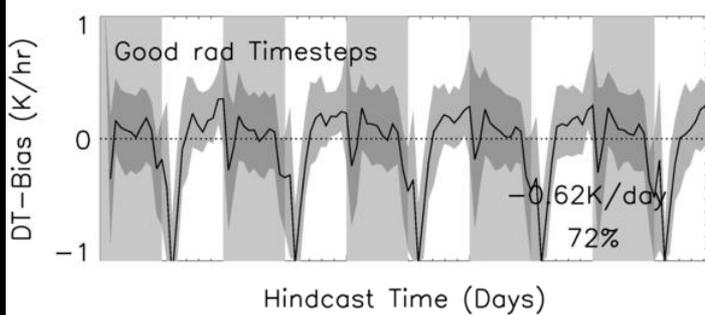


-250 250  $W m^{-2}$

# CAUSES Experiment 1A

What drives the diurnal cycle in the bias in the **GOODRAD** composite?

## Net LW Radiation

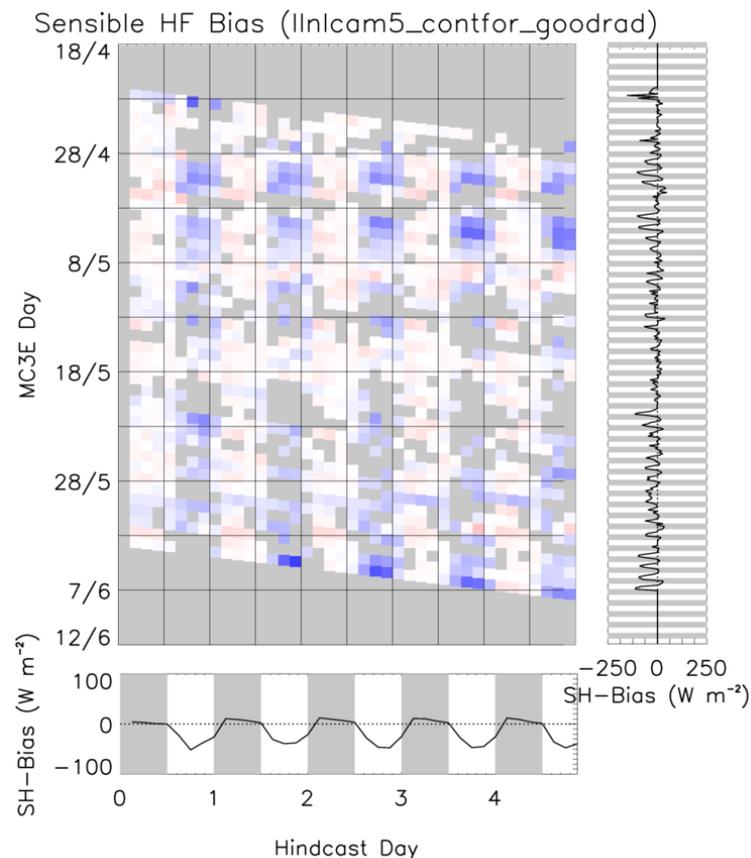
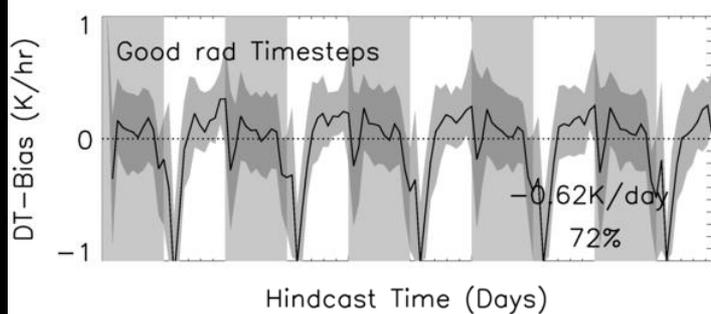


-100  100 W m<sup>-2</sup>

# CAUSES Experiment 1A

What drives the diurnal cycle in the bias in the **GOODRAD** composite?

## Sensible Heat Flux

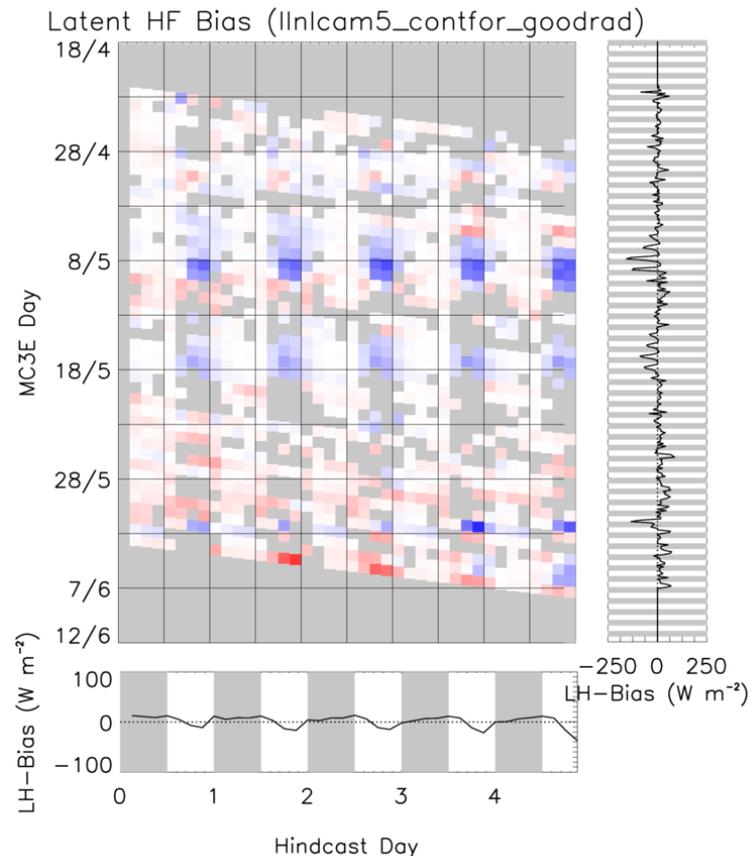
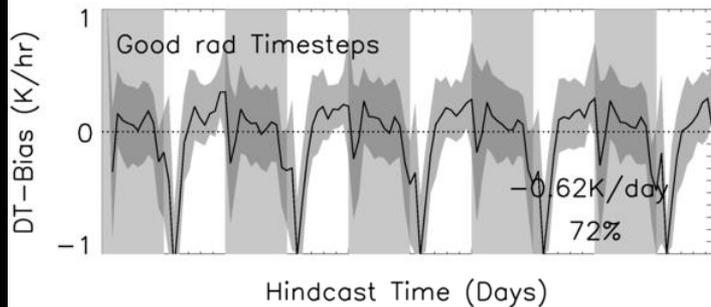


-250  250  $W m^{-2}$

# CAUSES Experiment 1A

What drives the diurnal cycle in the bias in the GOODRAD composite?

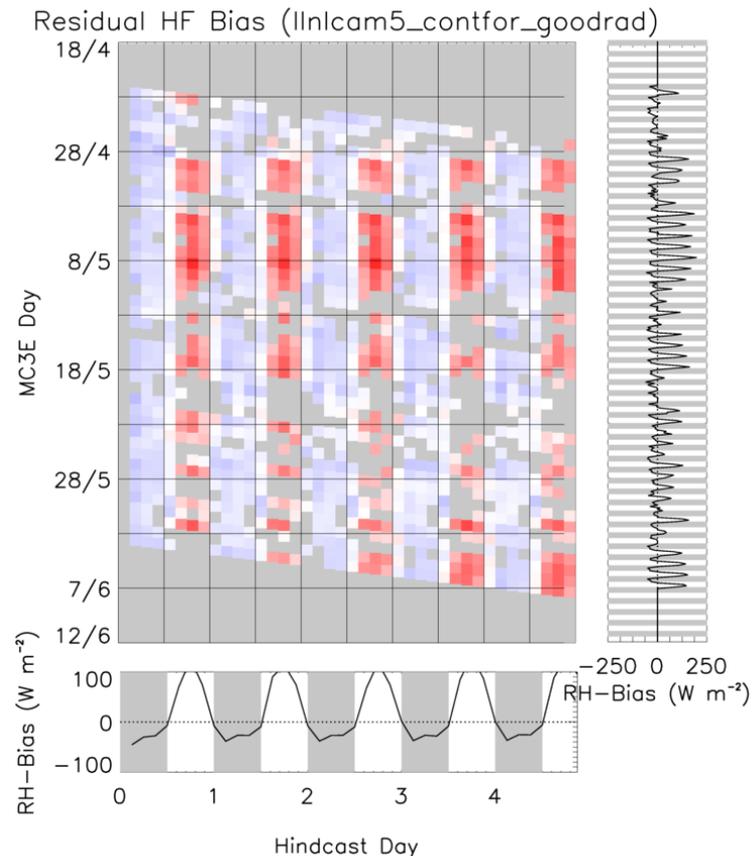
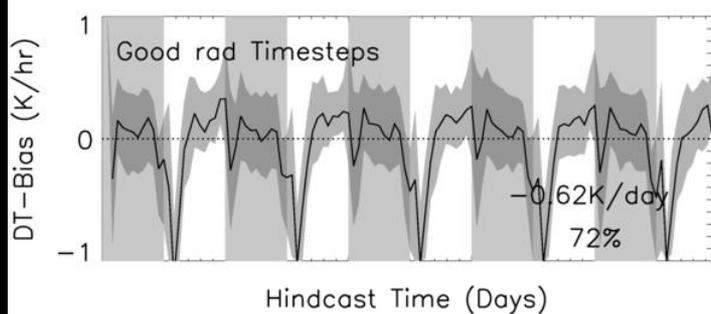
## Latent Heat Flux



# CAUSES Experiment 1A

What drives the diurnal cycle in the bias in the **GOODRAD** composite?

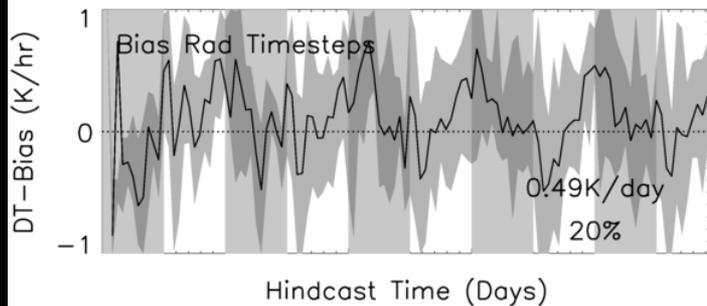
## Residual Heat Flux



-250  250  $W m^{-2}$

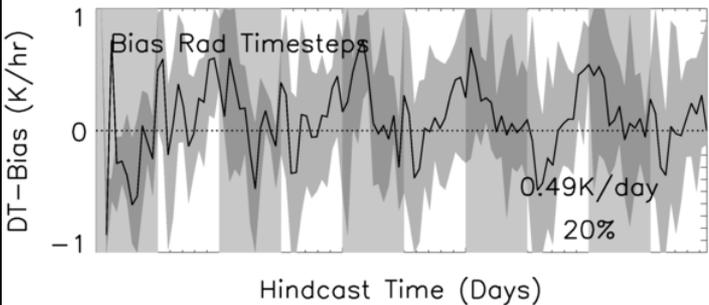
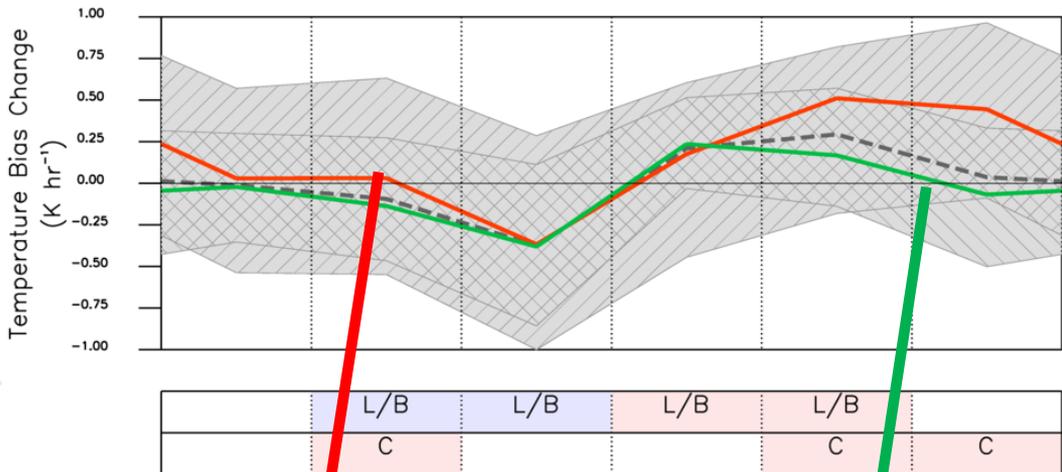
# CAUSES Experiment 1A

**What drives the temperature bias growth in the BIASRAD composite?**



# CAUSES Experiment 1A

What drives T bias growth in the BIASRAD composite?

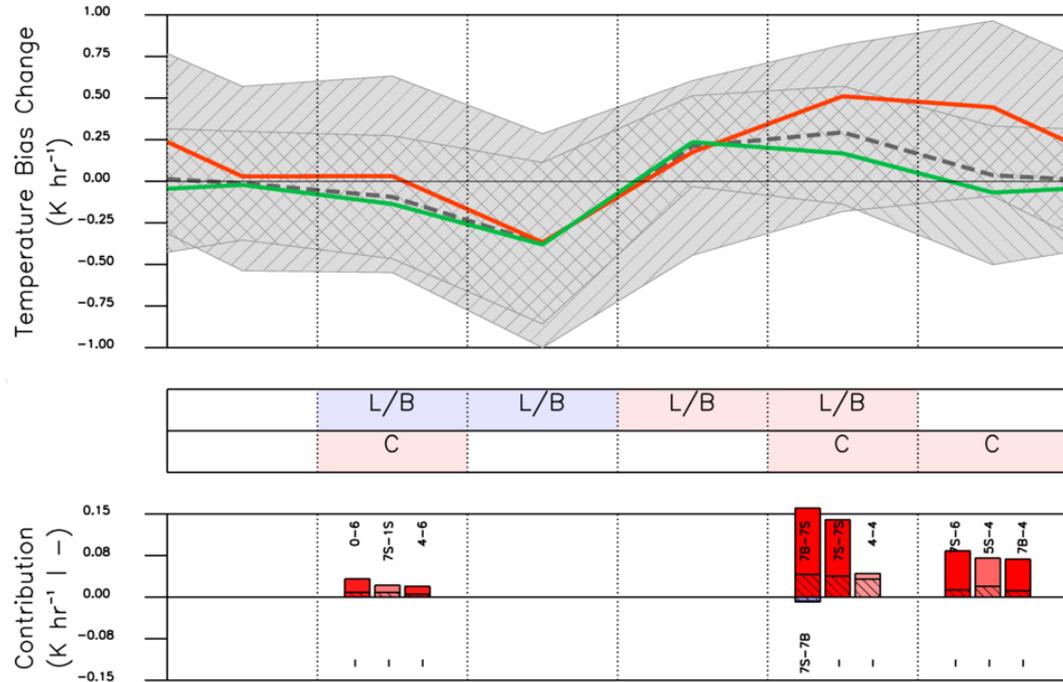
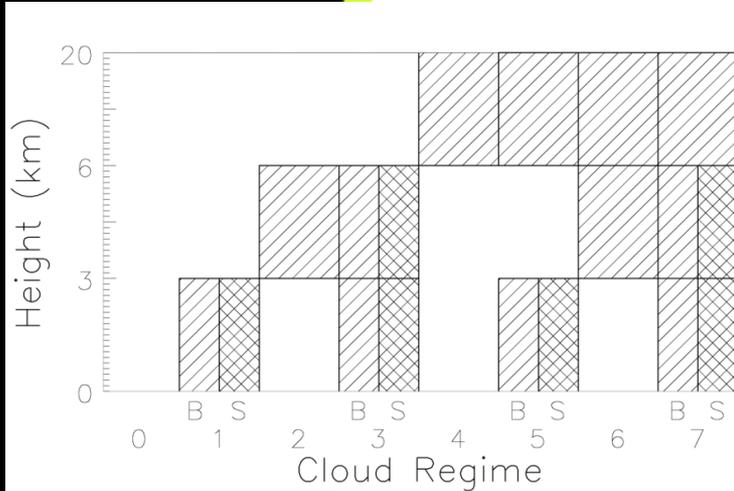


Temperature Bias Change in the BIASRAD Composite

Temperature Bias Change in the GOODRAD Composite

# CAUSES Experiment 1A

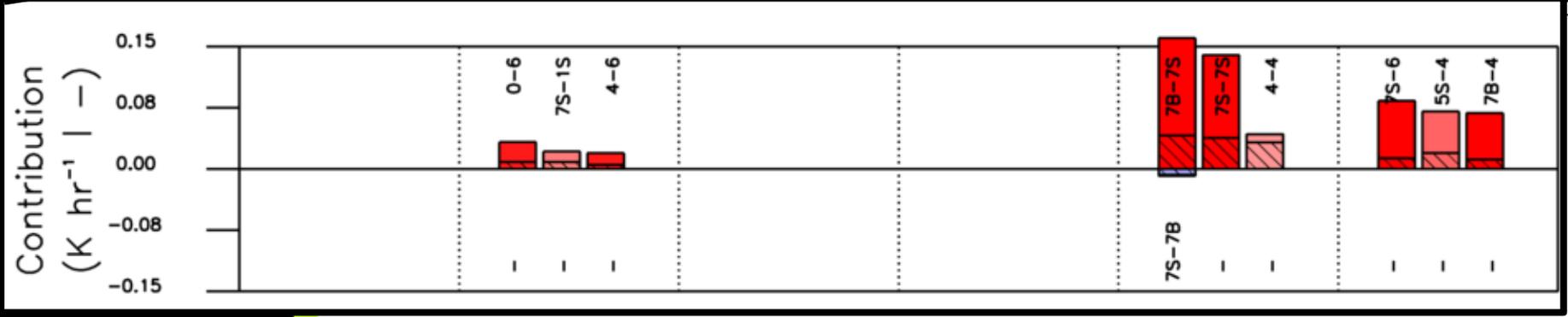
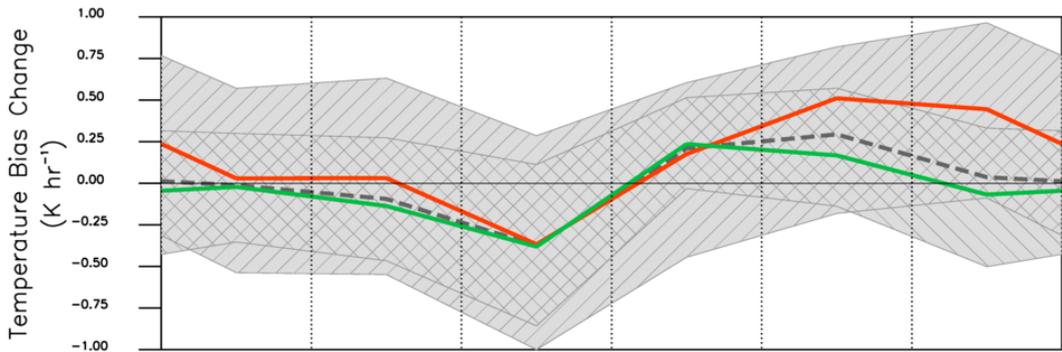
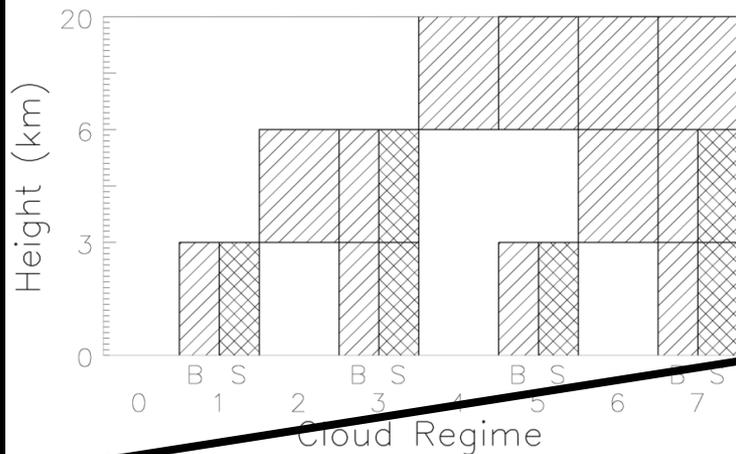
What drives T bias growth in the BIASRAD composite?



Which cloud regimes contribute most to the bias growth in the BIASRAD?

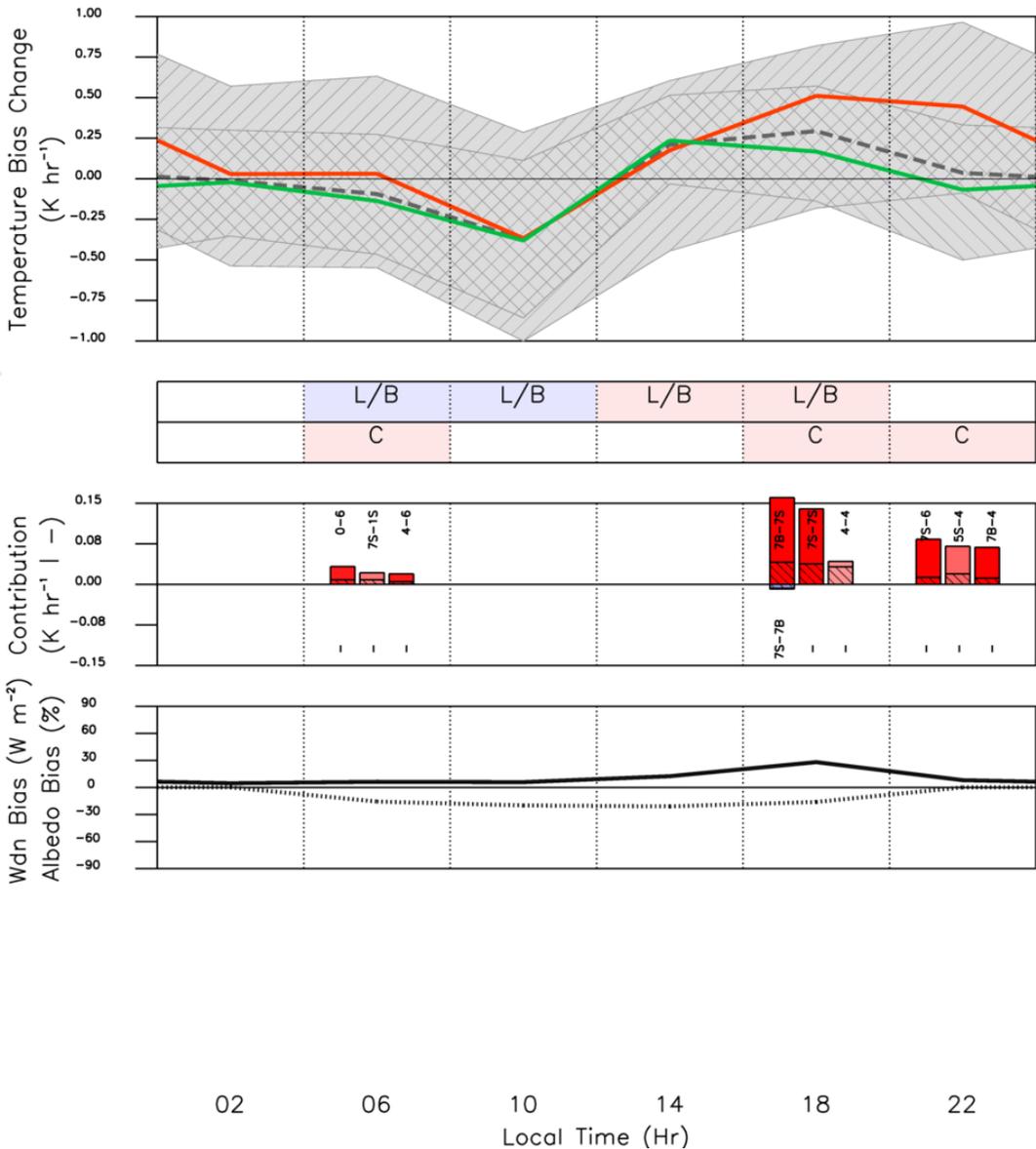
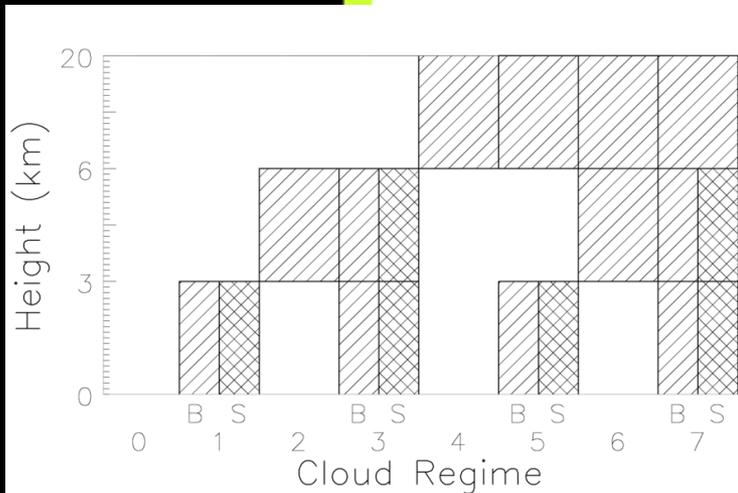
# CAUSES Experiment 1A

What drives T bias growth in the BIASRAD composite?



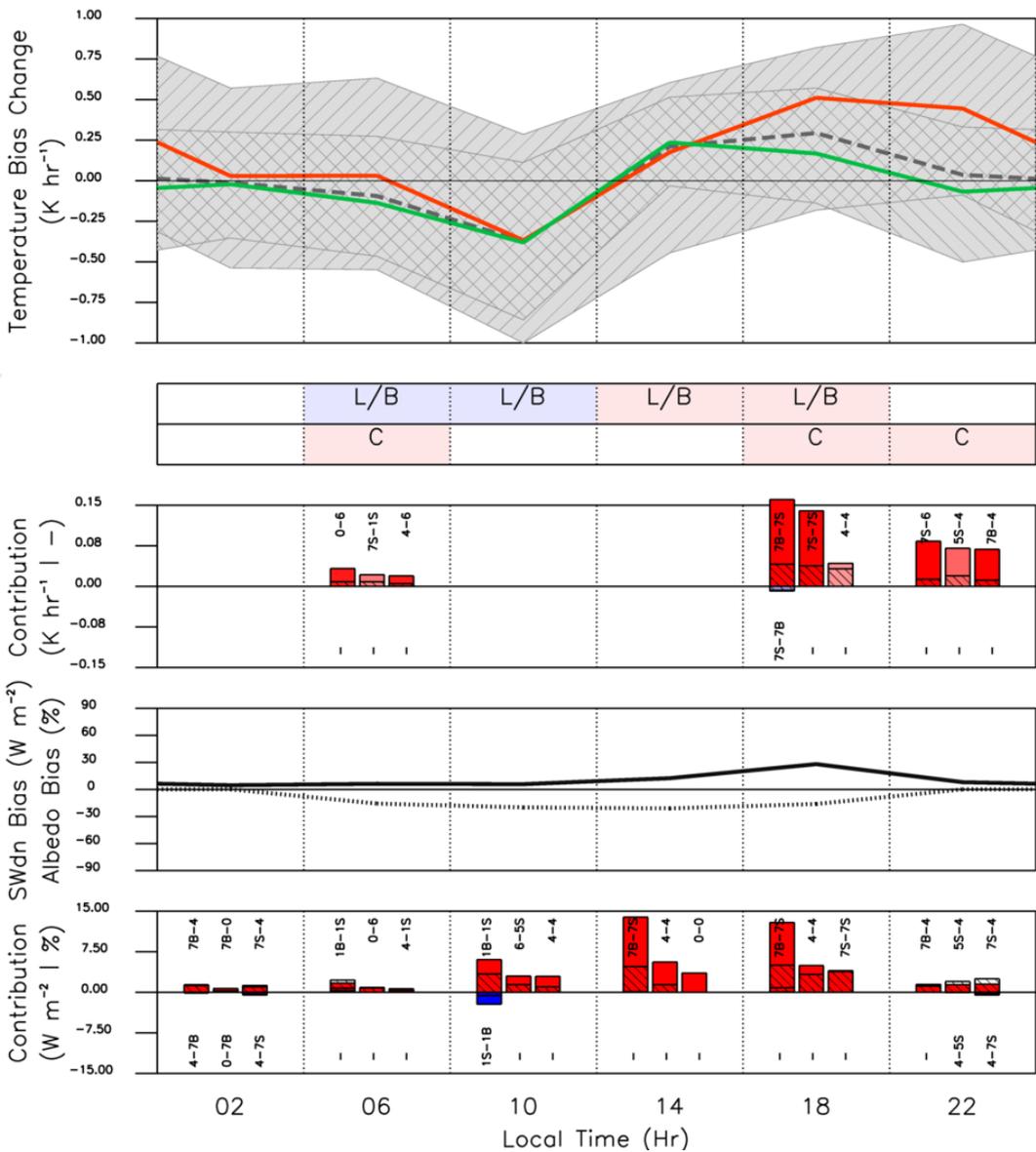
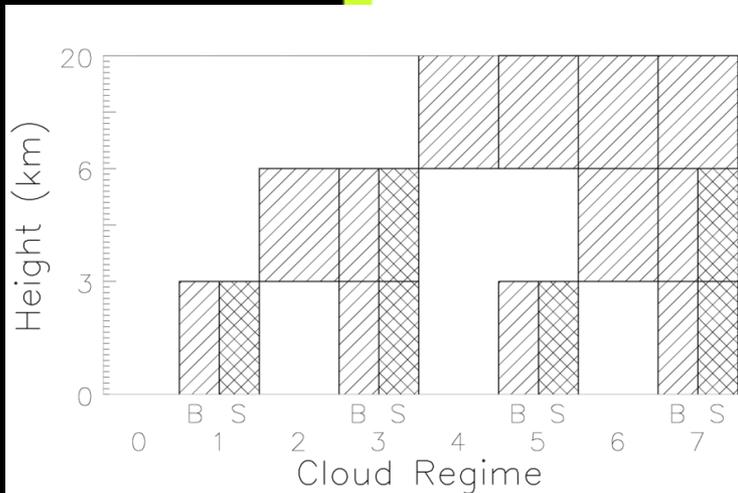
# CAUSES Experiment 1A

What drives T bias growth in the BIASRAD composite?



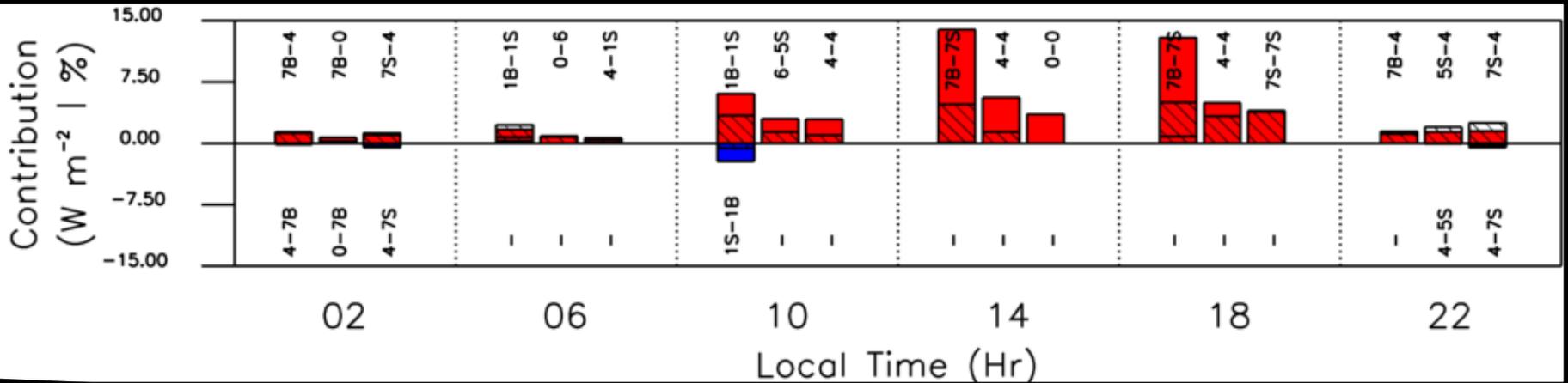
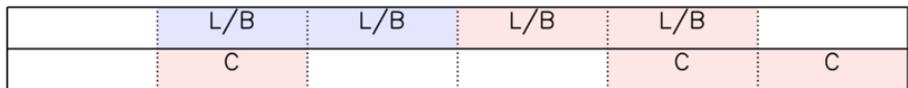
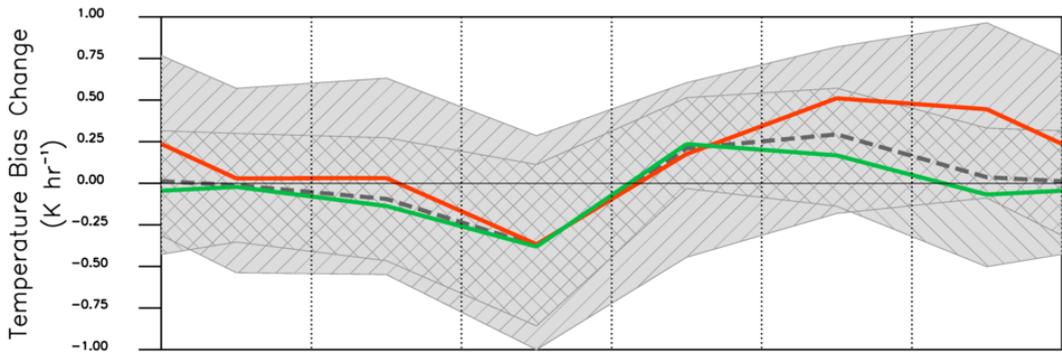
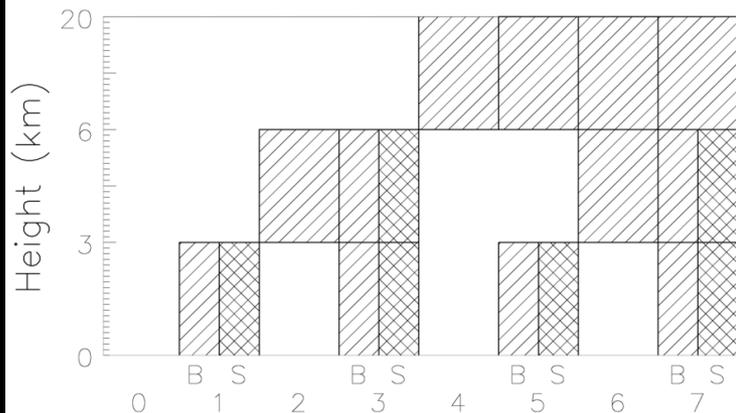
# CAUSES Experiment 1A

What drives T bias growth in the BIASRAD composite?



# CAUSES Experiment 1A

What drives T bias growth in the BIASRAD composite?



# CAUSES Experiment 1A

What about the other GCMs?

	llnlcam5	pnnlwrflm	pnnlwrfoah	metum	ecmwf	cnrm	cancm4	larccam5	arpege	Imdz
$T_{ST}$ (K)	<u>2.44</u>	<u>1.87</u>	<u>1.57</u>	<u>1.10</u>	<u>0.76</u>	-0.41	<u>6.33</u>	<u>2.48</u>	<u>1.53</u>	<u>3.56</u>
$dT_{ALL}$ (K day <sup>-1</sup> )	0.20	<u>-0.30</u>	<u>-0.36</u>	0.05	0.31	<u>0.28</u>	-0.17	0.36	0.44	0.13
$dT_{GR}$ (K day <sup>-1</sup> )	<u>-0.62</u>	<u>0.50</u>	<u>-0.55</u>	<u>-0.68</u>	-0.03	-0.27	<u>-1.38</u>	<u>-0.69</u>	0.16	<u>-0.68</u>
$dT_{BR}$ (K day <sup>-1</sup> )	<u>0.49</u>	<u>0.41</u>	<u>0.52</u>	<u>0.97</u>	<u>0.60</u>	<u>0.53</u>	<u>1.62</u>	<u>0.70</u>	<u>0.51</u>	<u>0.77</u>
$dT_{GP}$ (K day <sup>-1</sup> )	<u>0.12</u>	<u>0.25</u>	<u>0.27</u>	0.01	0.01	0.01	0.02	<u>0.14</u>	<u>0.08</u>	-0.03
$dT_{BP}$ (K day <sup>-1</sup> )	<u>0.21</u>	<u>-1.45</u>	<u>-0.60</u>	<u>-0.25</u>	<u>-0.27</u>	0.01	<u>-0.43</u>	<u>0.21</u>	<u>-0.31</u>	0.07

# Conclusions

- Most GCMs are too warm right from the start of the run
- Some models show further modest Tbias growth over 5 days
- Most models have distinct diurnal cycle in the Tbias
- Diurnal cycle of the Tbias seems modulated by land surface/boundary layer issues
- Most models have positive bias in downwelling shortwave radiation associated with lack of clouds
- When correct downwelling radiation, the Tbias seems to decrease
- When incorrect downwelling radiation or mislocated precipitation, the Tbias seems to increase



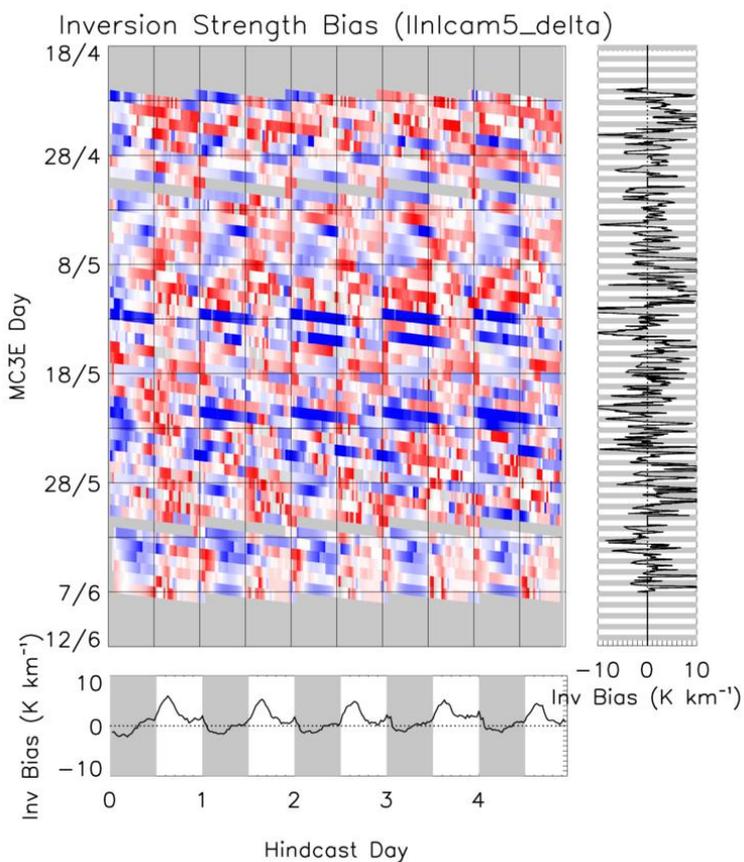
Met Office

Thanks!

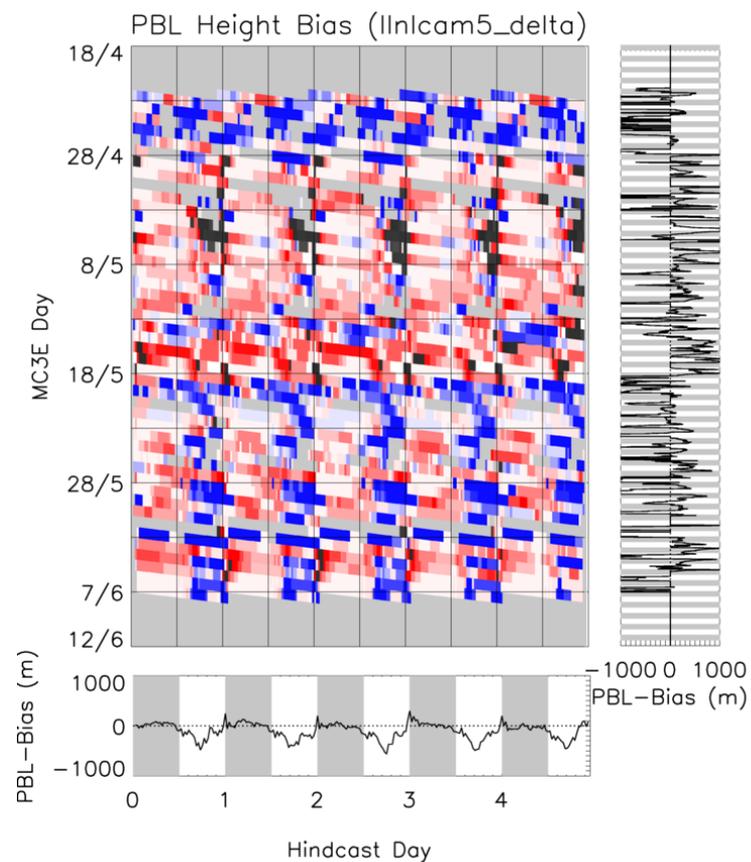


# EXTRA SLIDES

## PBL characteristics



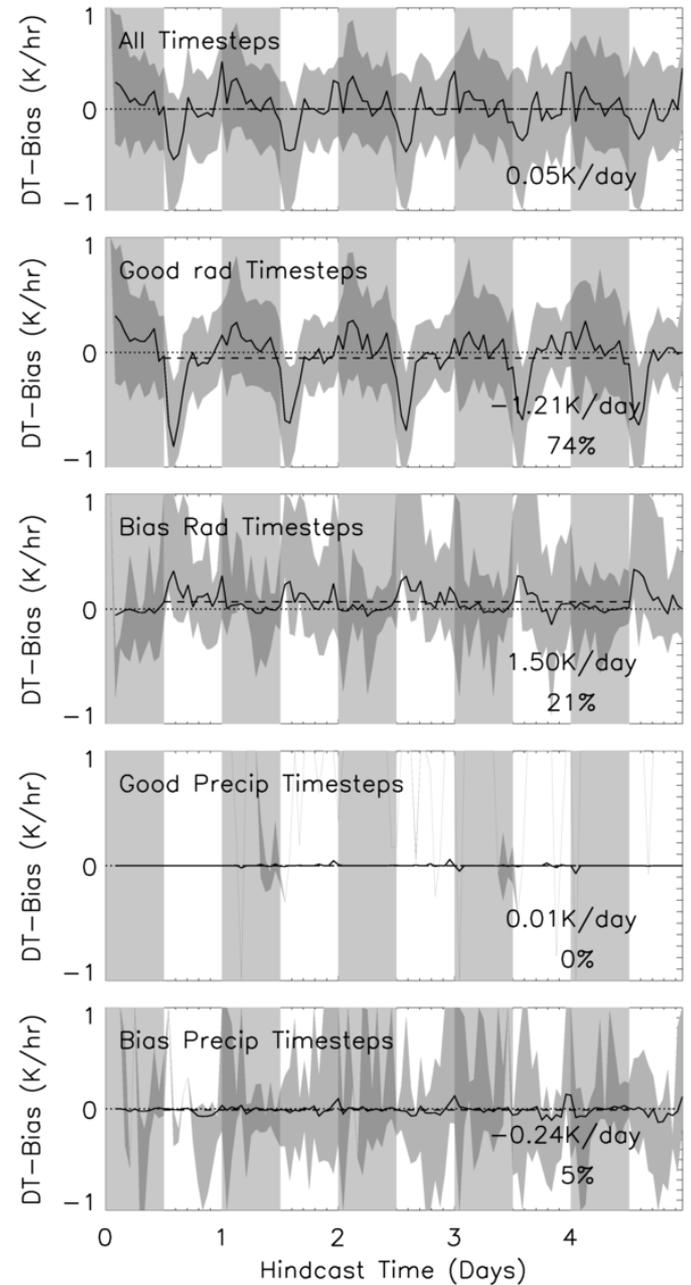
-10  10( $K km^{-1}$ )



-1000  1000(m)

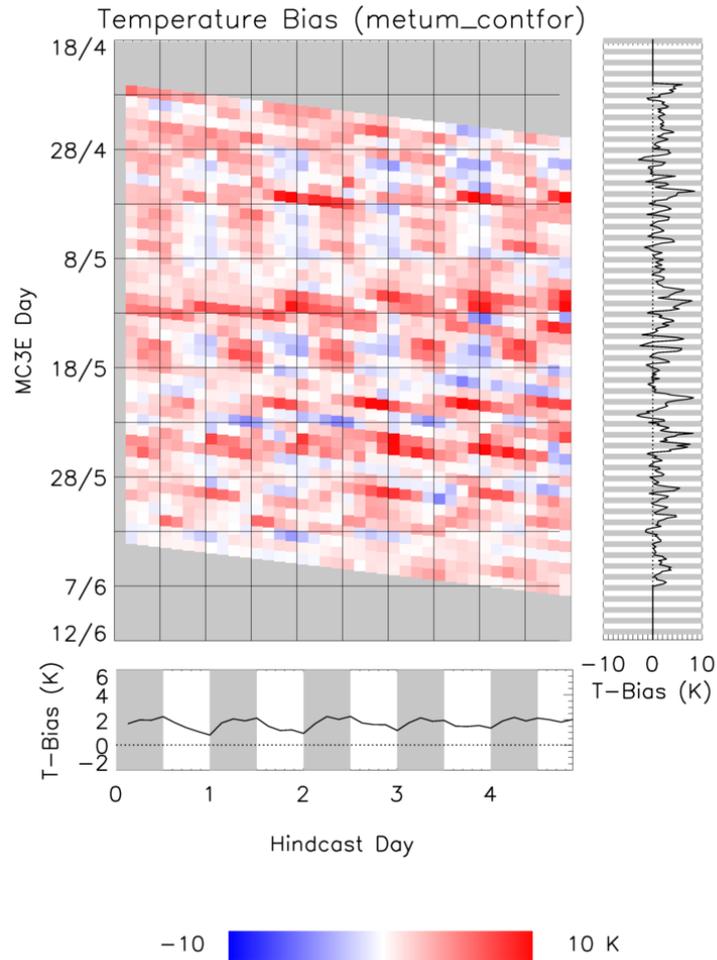
# EXTRA SLIDES

## METUM



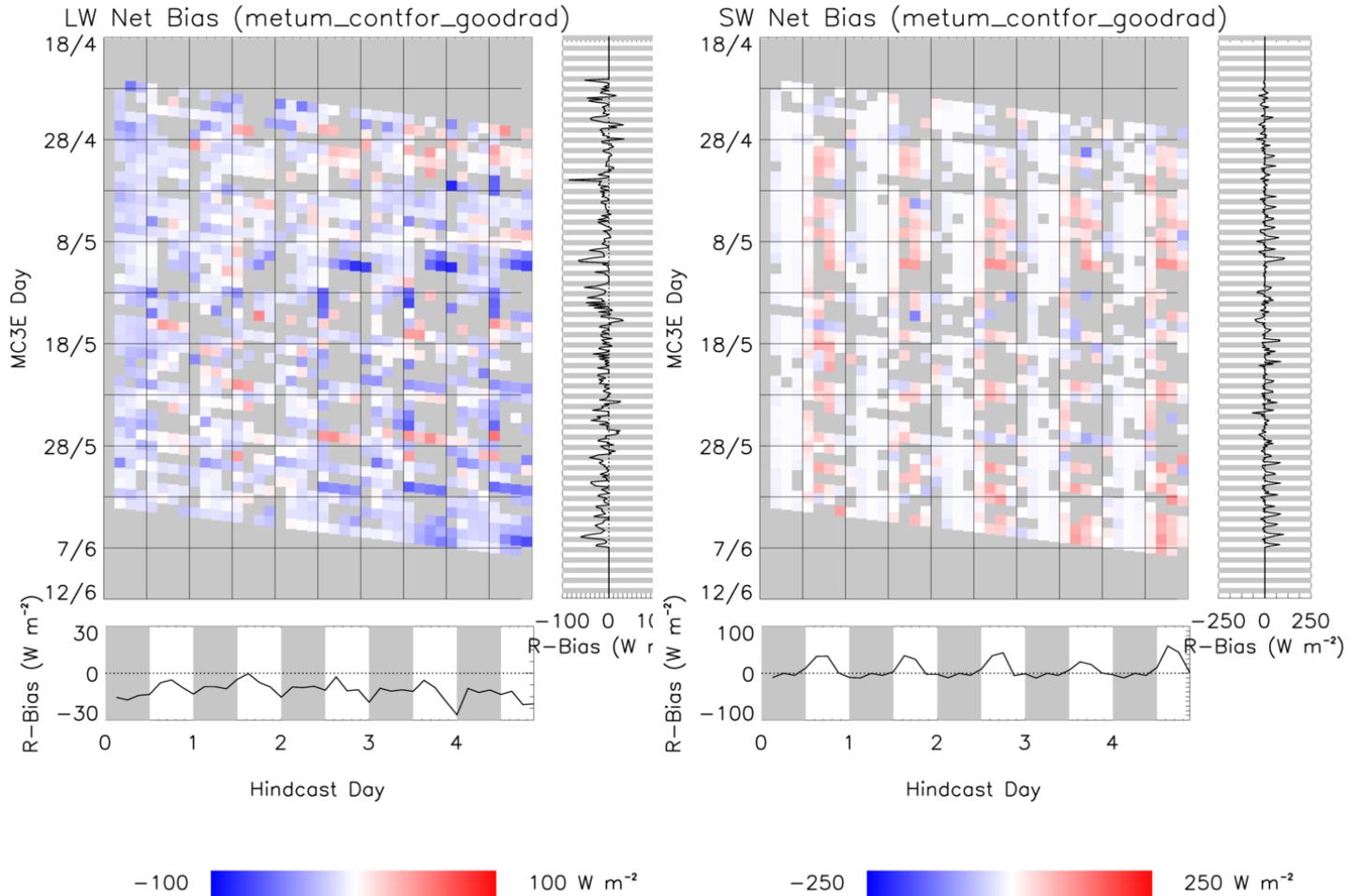
# EXTRA SLIDES

## METUM



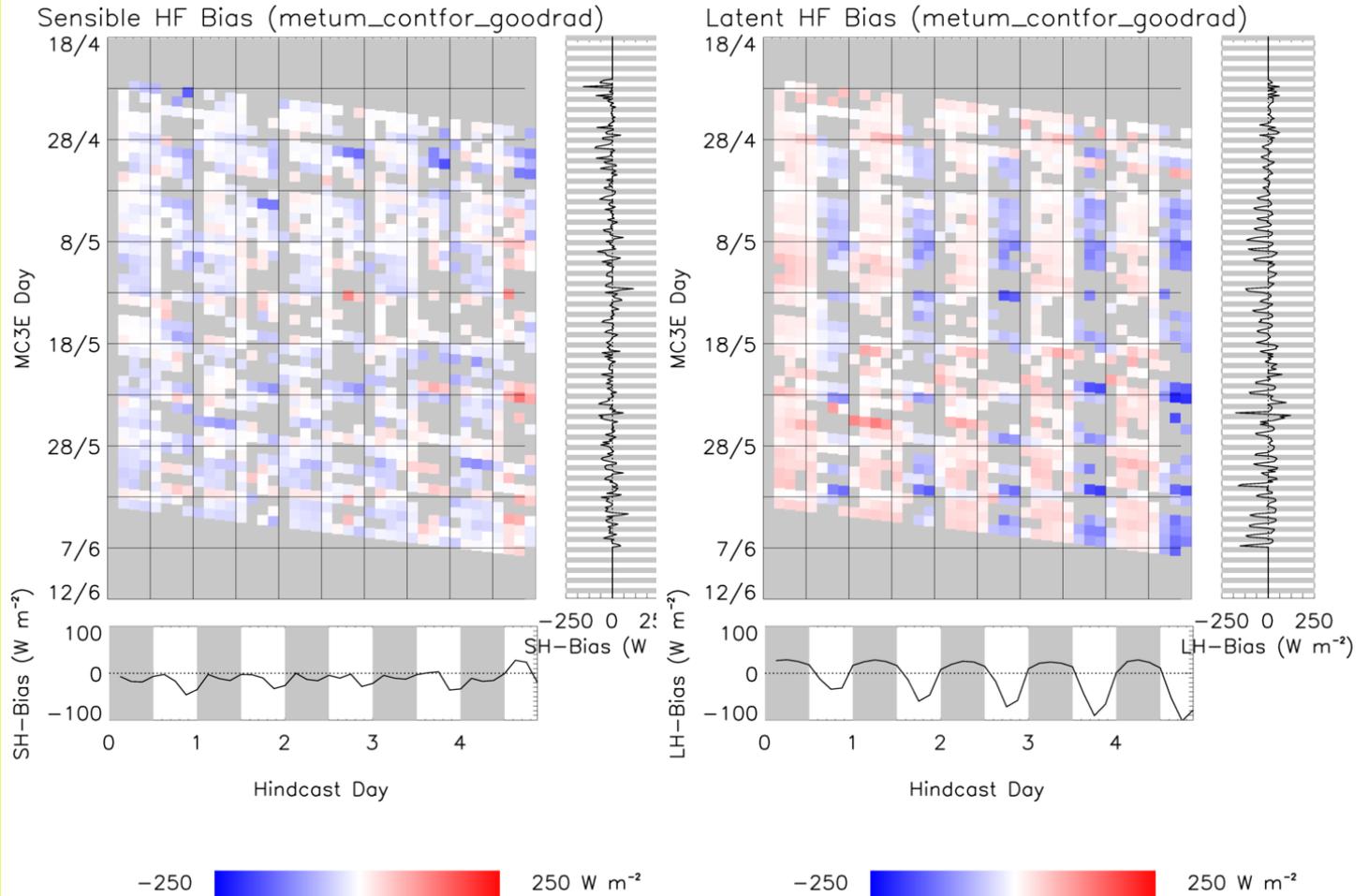
# EXTRA SLIDES

## METUM



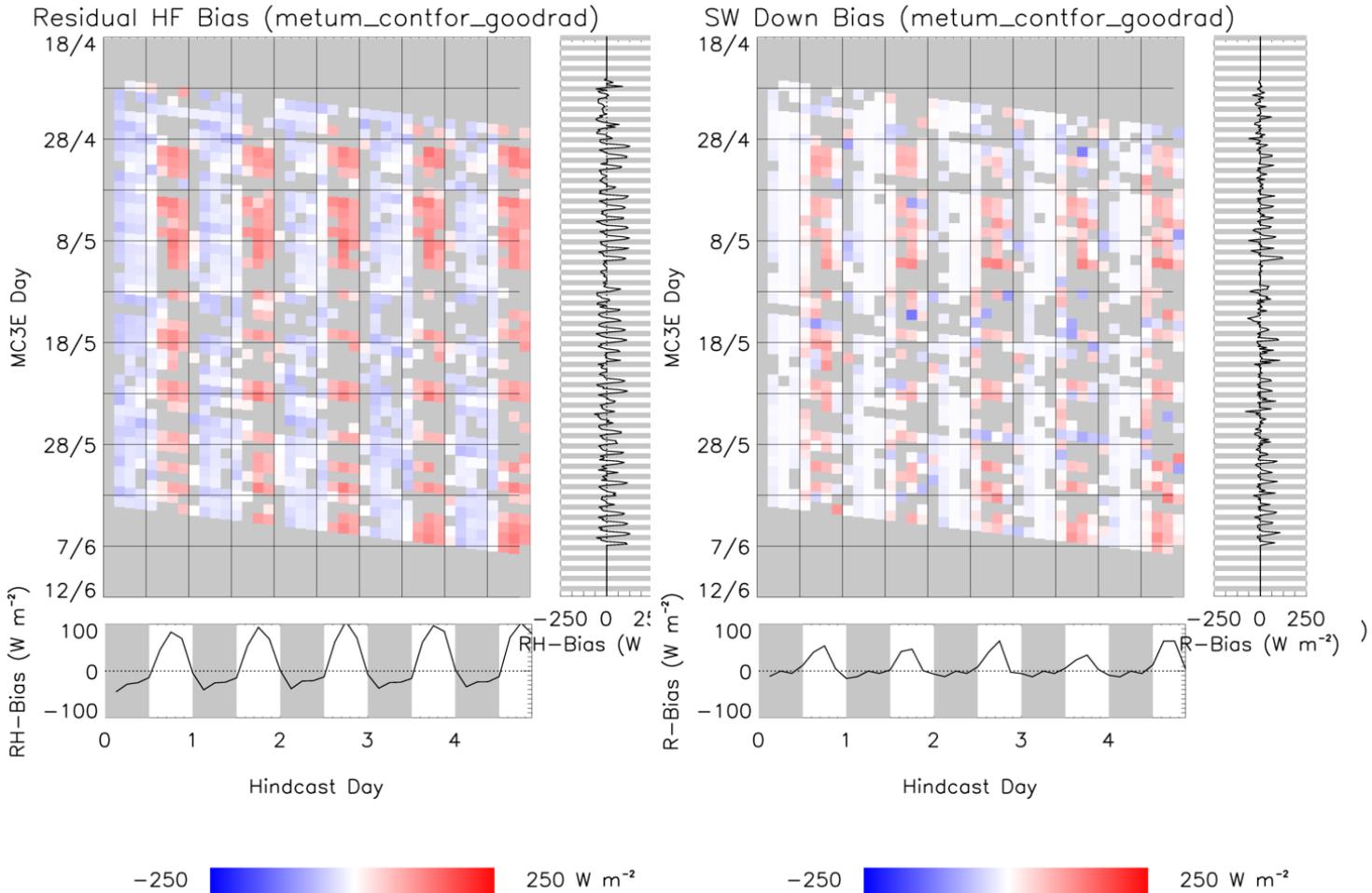
# EXTRA SLIDES

## METUM



# EXTRA SLIDES

## METUM



# EXTRA SLIDES

## METUM

