Representation of cloud and TOA radiative flux diurnal cycles in the CanAM4

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CERES Science Team Meeting
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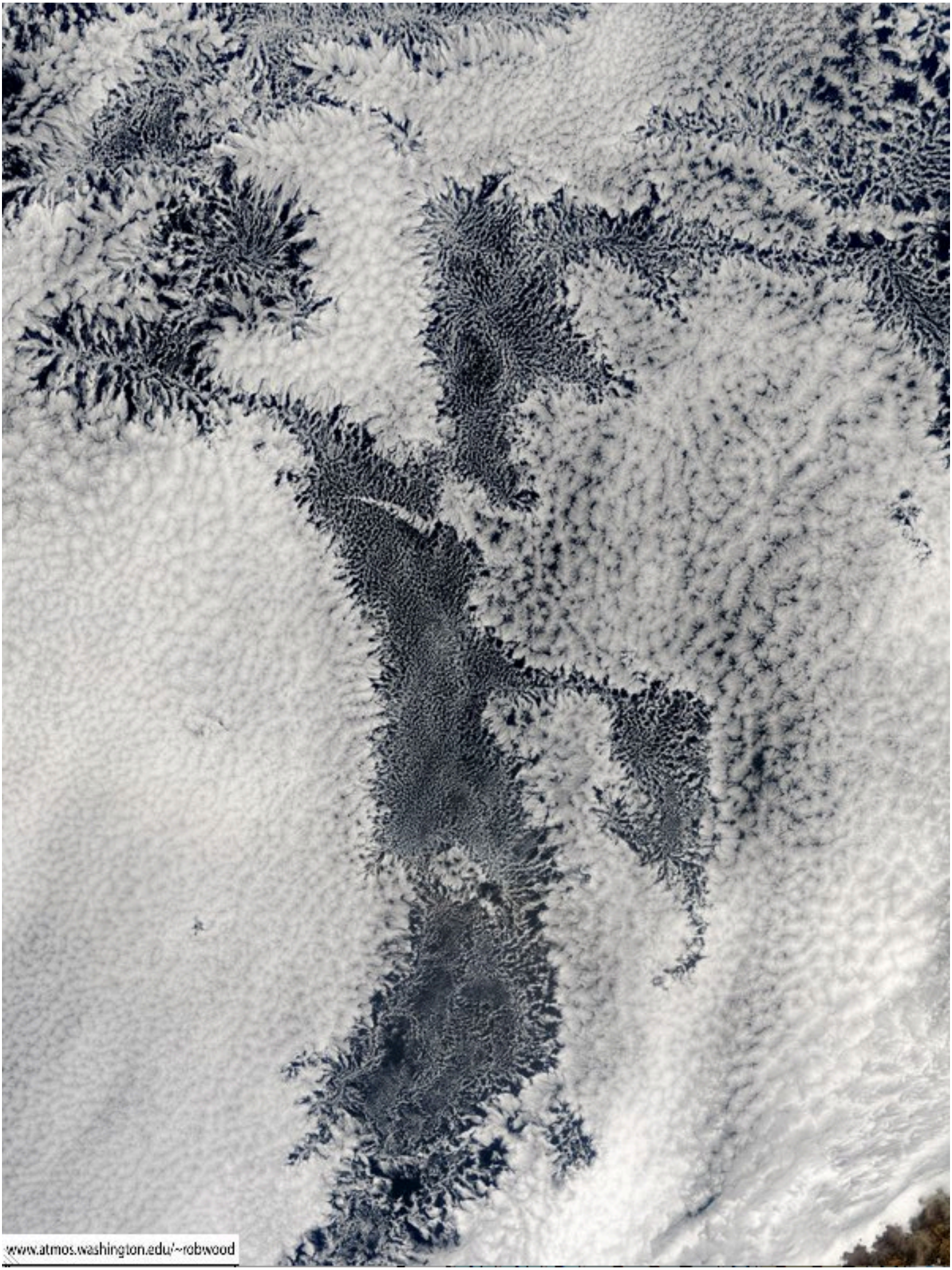
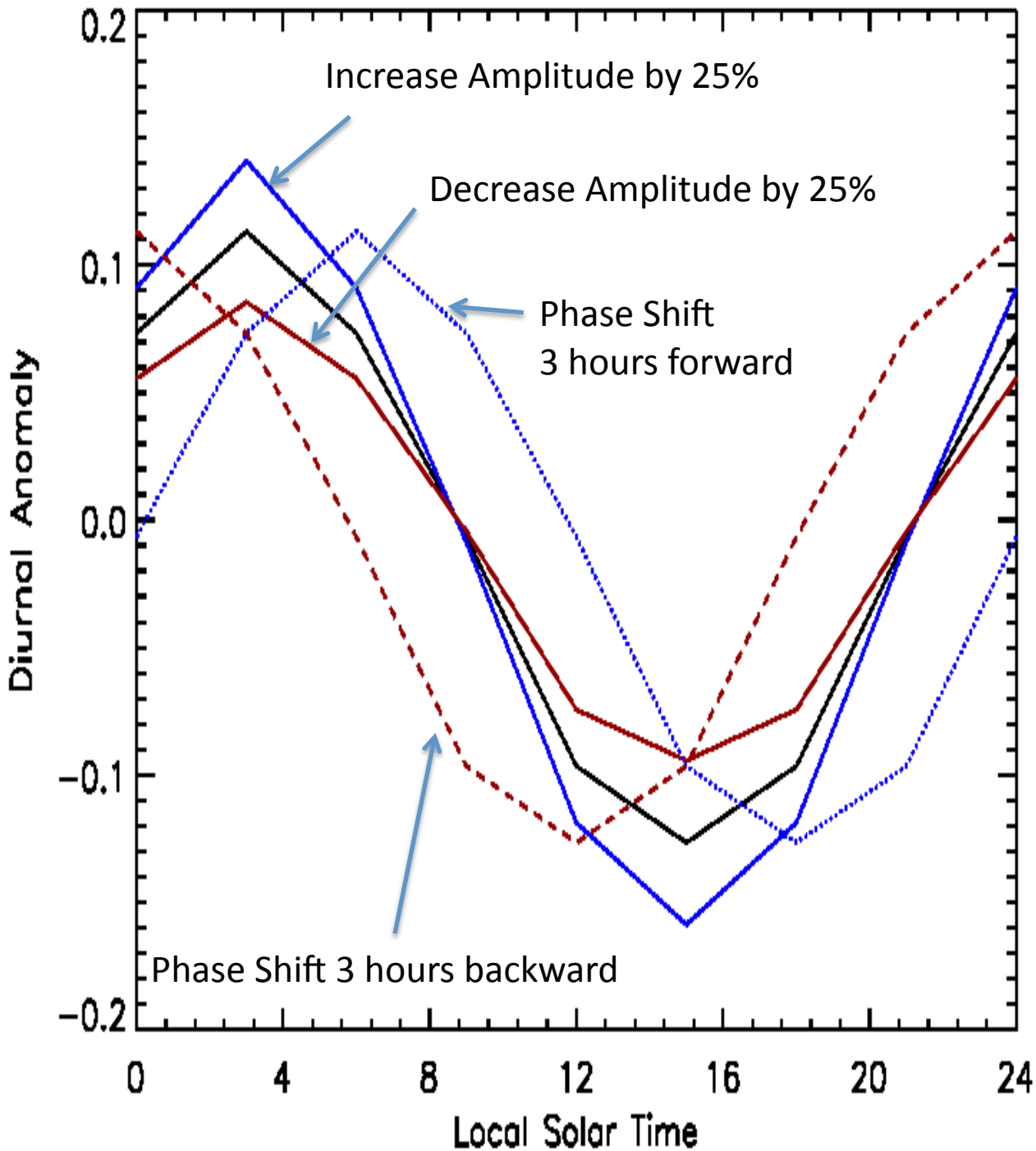

www.atmos.washington.edu/~robwood



Control

$$\left(\frac{\partial SW_{NET}}{\partial CLD}\right)_{Control} = -0.93\, W\, m^{-2}\, \%^{-1}$$

$$\left(\frac{\partial SW_{NET}}{\partial LWP}\right)_{Control} = -0.26\, W\, m^{-2}\left(g\, m^{-2}\right)^{-1}$$

Decrease Amplitude:

$$\left(\frac{\partial SW_{NET}}{\partial LWP}\right)_{ACLD=9\%} = -0.35\, W\, m^{-2}\left(g\, m^{-2}\right)^{-1}$$

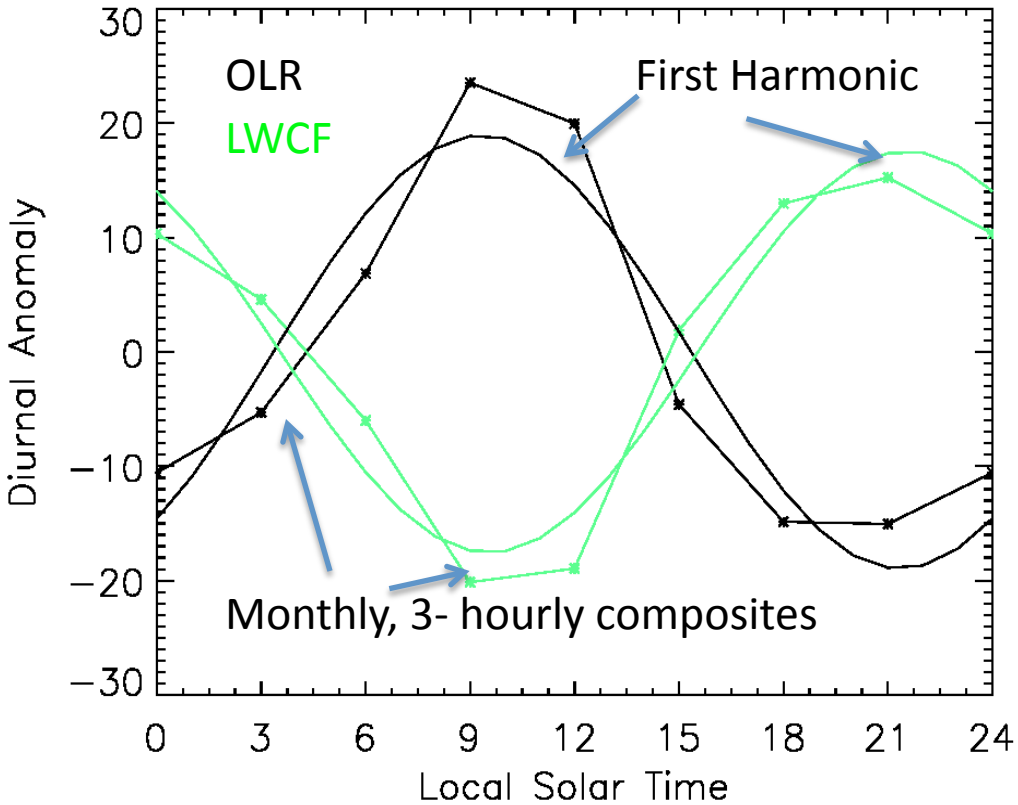
$$\left(\frac{\partial SW_{NET}}{\partial CLD}\right)_{ALWP=25} = -0.96\, W\, m^{-2}\, \%^{-1}$$

Phase Shift: 3 hours backward

$$\left(\frac{\partial SW_{NET}}{\partial LWP}\right)_{\phi\, \min us 3} = -0.34\, W\, m^{-2}\left(g\, m^{-2}\right)^{-1}$$

$$\left(\frac{\partial SW_{NET}}{\partial CLD}\right)_{\phi\, \min us 3} = -0.91\, W\, m^{-2}\, \%^{-1}$$

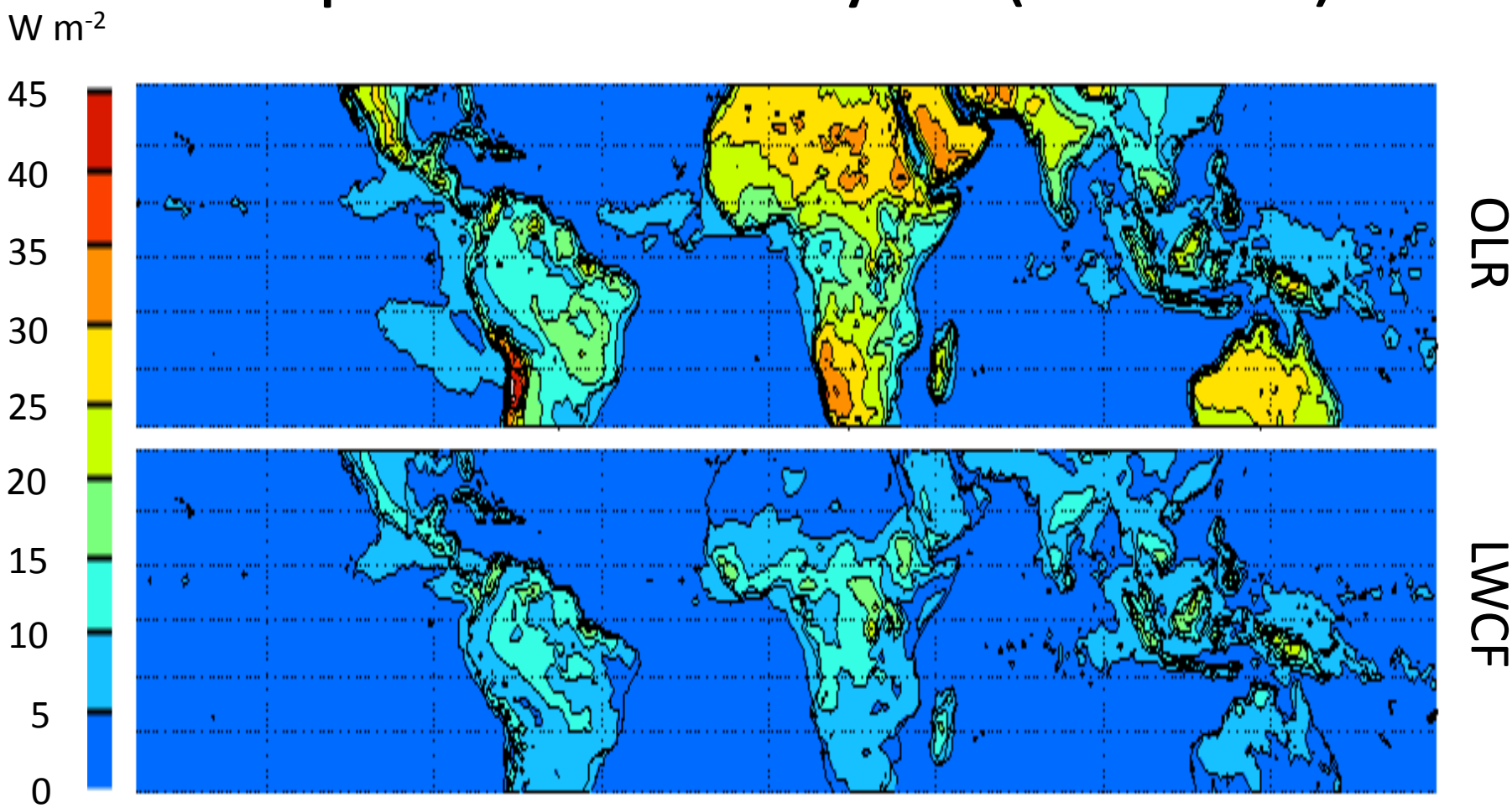
Methodology



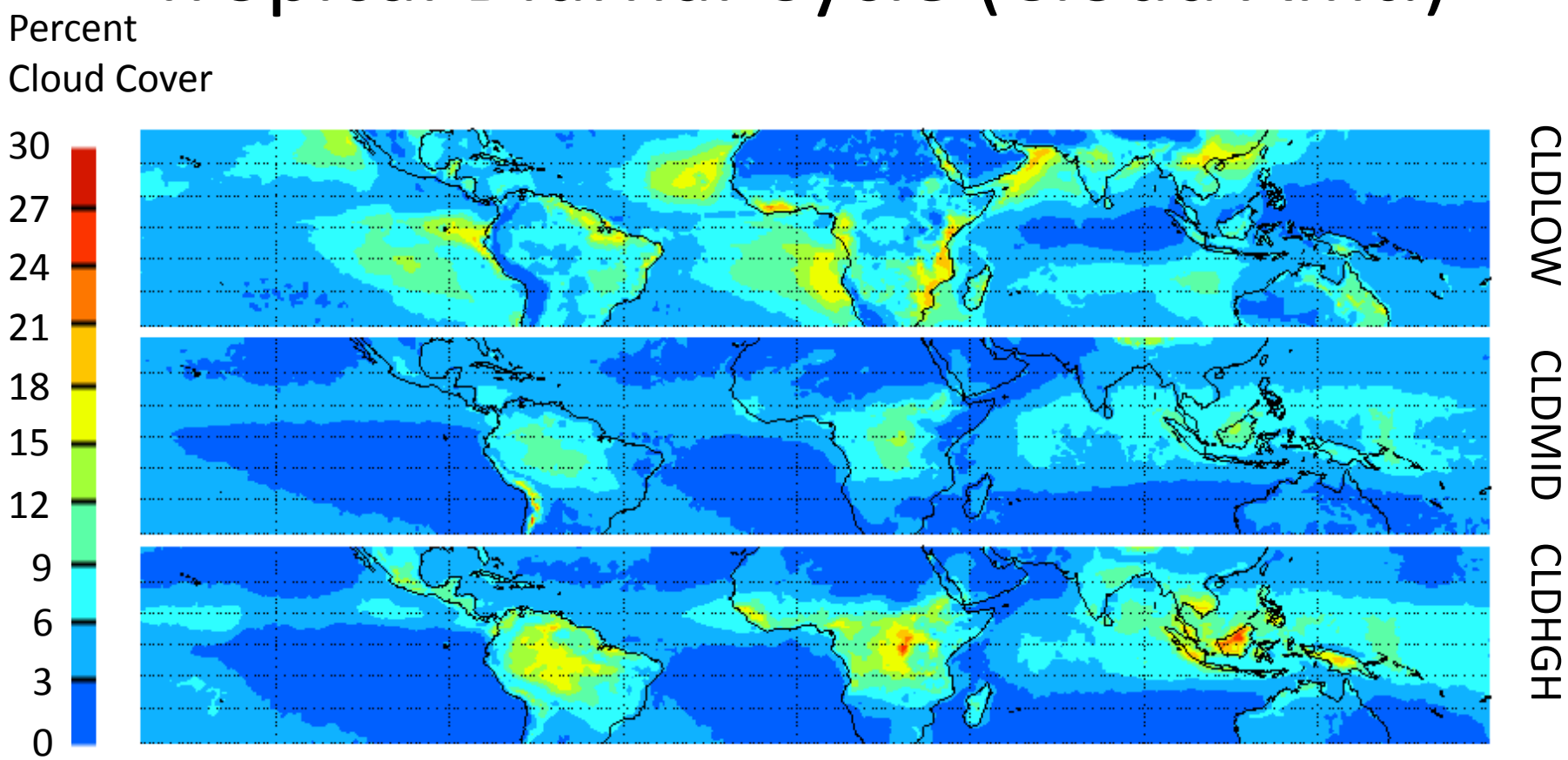
$$X'(t) = A\cos\left(\frac{2\pi t}{24\,hrs} - \phi\right)$$

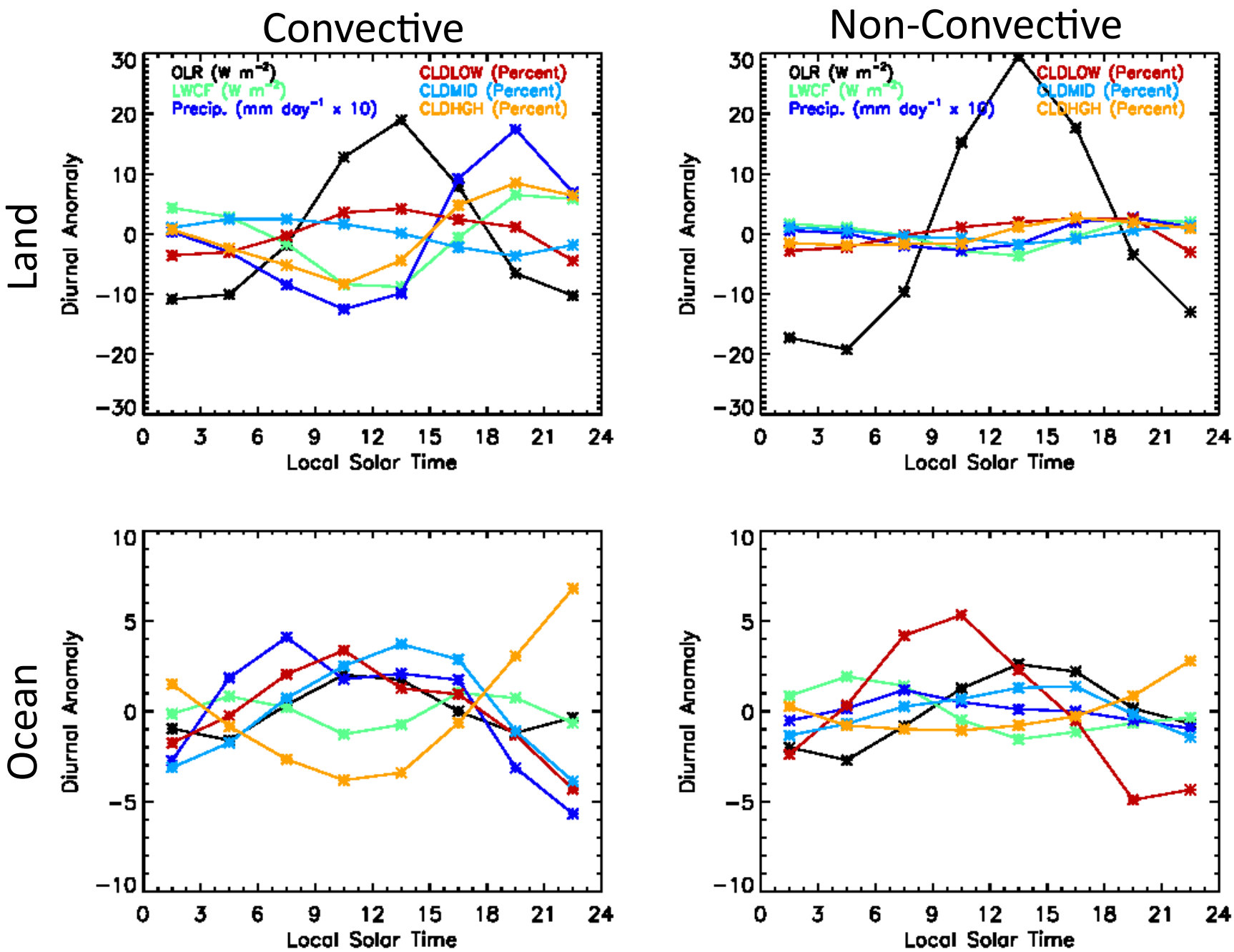
- CERES Synoptic Data
  - 3-hourly CERES-Geo merged data product.
- Fourier Analysis is used to compute diurnal harmonics.

Climatological
Tropical Diurnal Cycle (TOA LW)



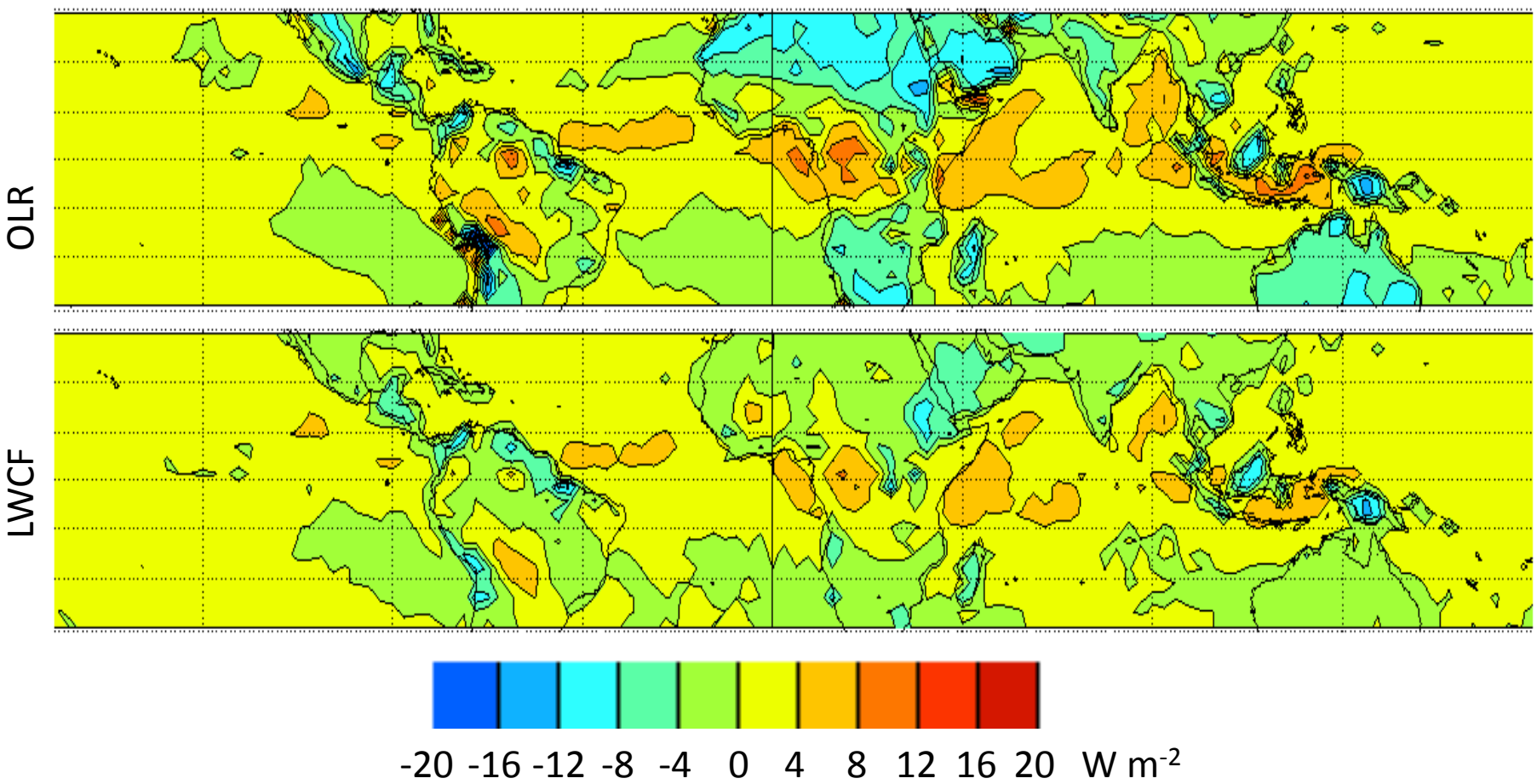
Climatological
Tropical Diurnal Cycle (Cloud Amt.)



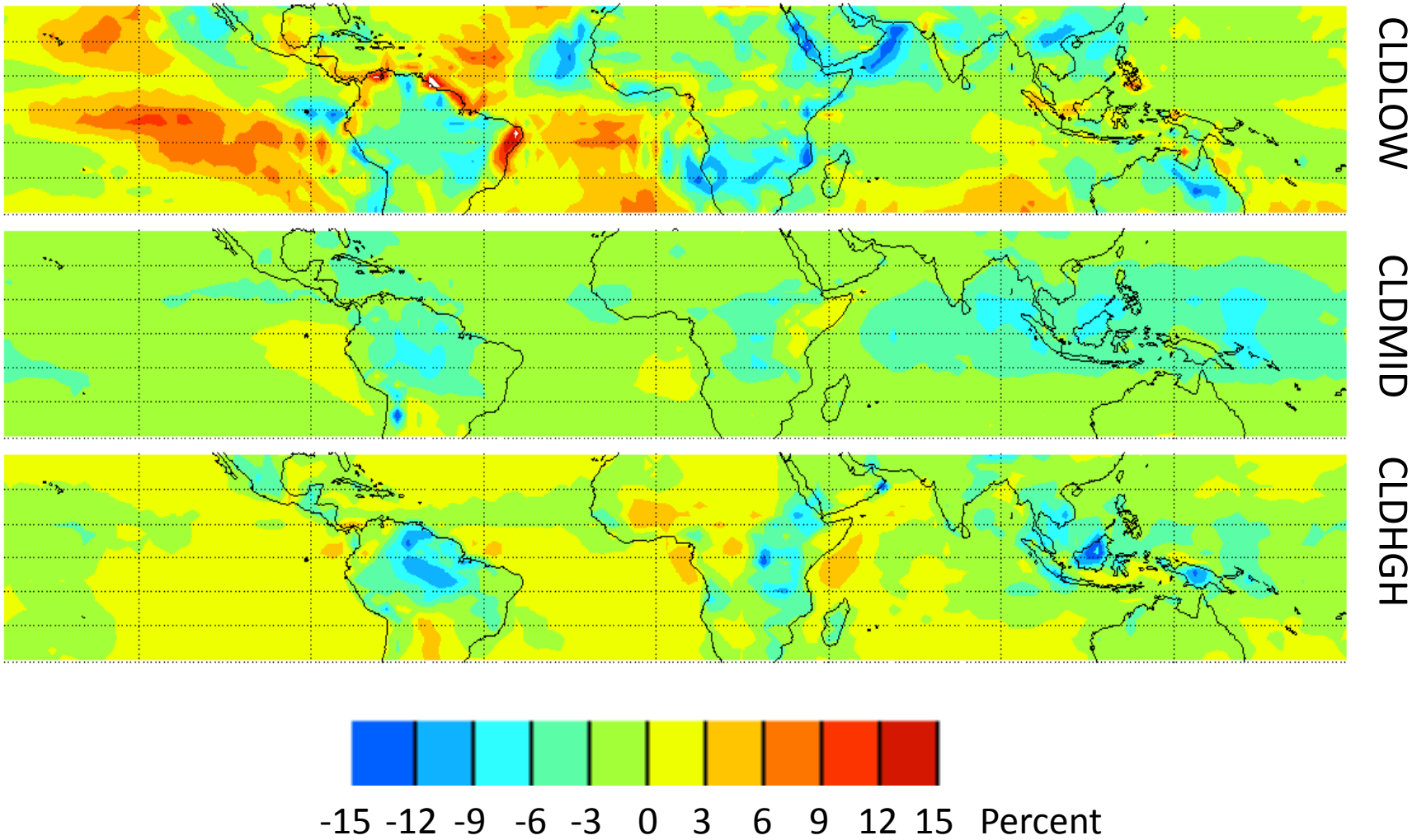

Convective
Non-Convective
Land
Ocean
OLR (W m^{-2})
LWCF (W m^{-2})
Precip. (mm day^{-1} x 10)
CLDLOW (Percent)
CLDMID (Percent)
CLDHGH (Percent)
Diurnal Anomaly
Local Solar Time

CanAM4.0 Results

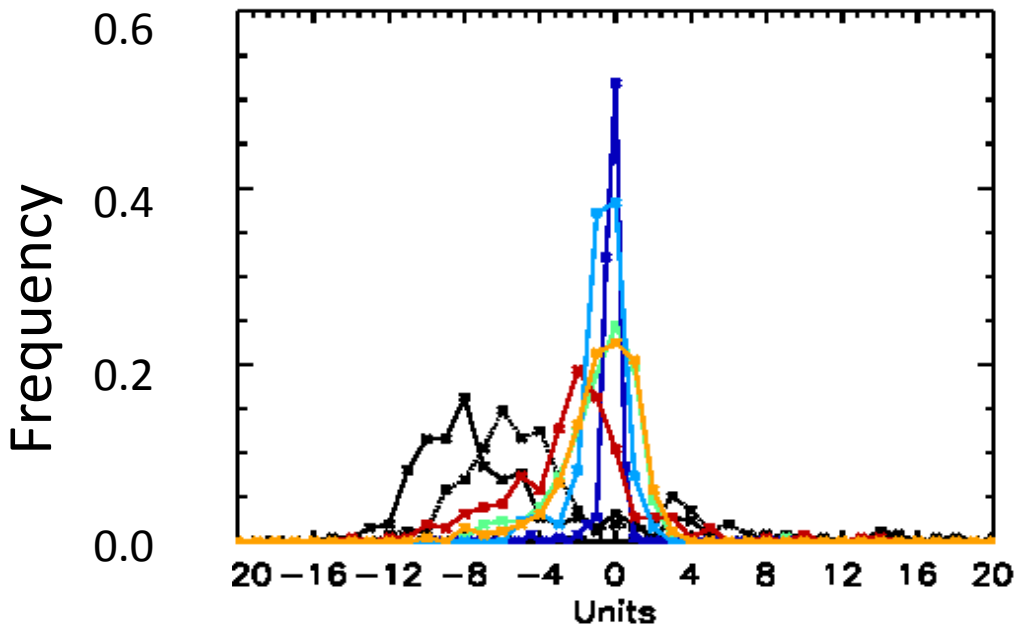
CanAM4.0 minus CERES diurnal amplitude differences



CanAM4.0 minus CERES diurnal amplitude differences



Diurnal cycle Amplitude Errors



μ_{OLR}=-5.65 W m^{-2}
μ_{LWCF}=-2.20 W m^{-2}
μ_{CLDLOW}=-2.84%
μ_{CLDMID}=-1.21%
μ_{CLDHGH}=-1.14%
μ_{PRECIP}=-0.91 mm day^{-1}

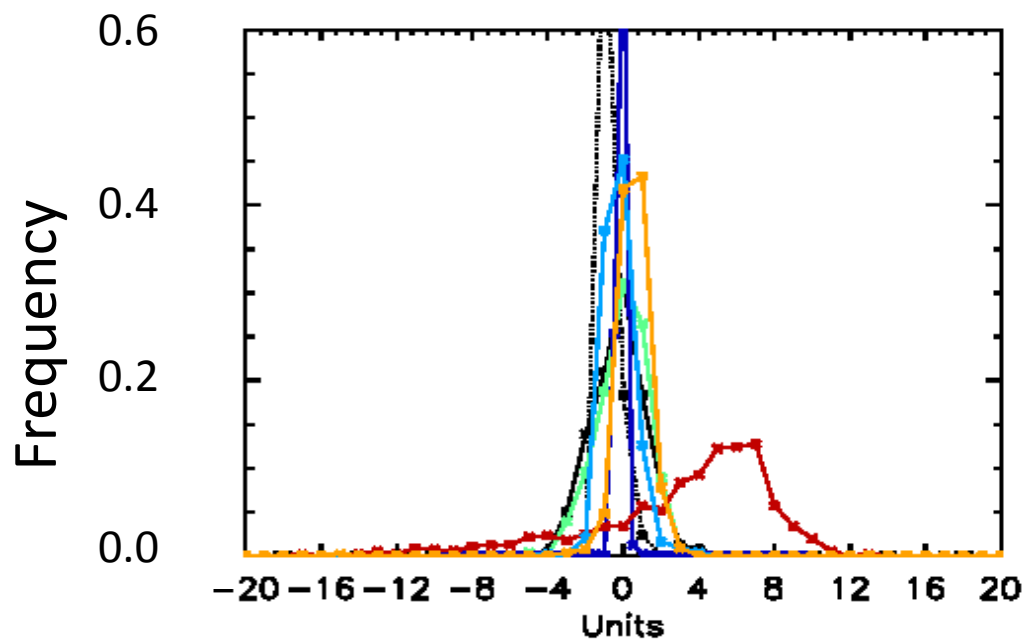
•Clear- and all-sky OLR exhibit the largest errors in diurnal cycle amplitude

Land Non-convective

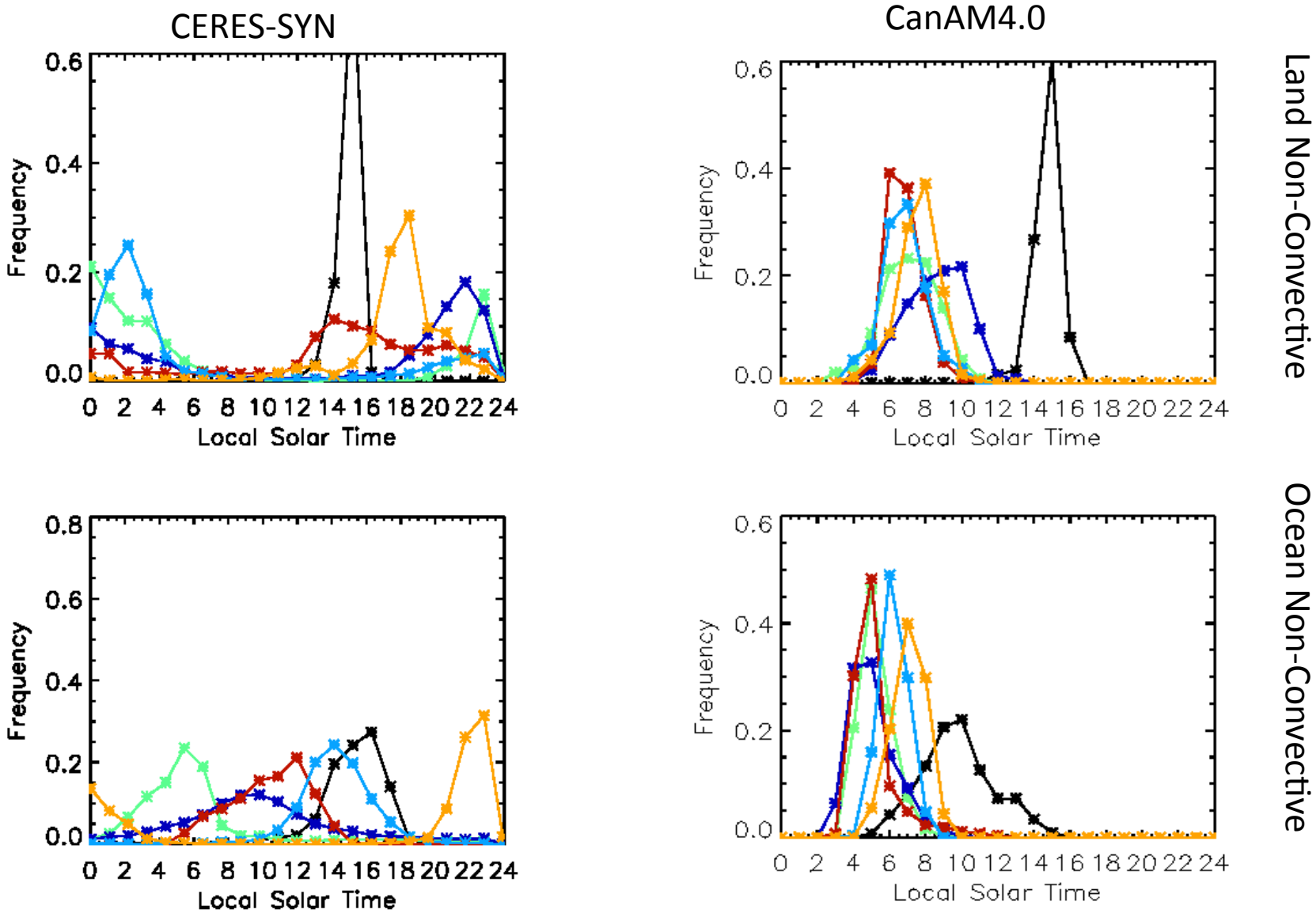
Ocean Non-convective

•Largest errors are found in the low cloud fraction diurnal cycle amplitude

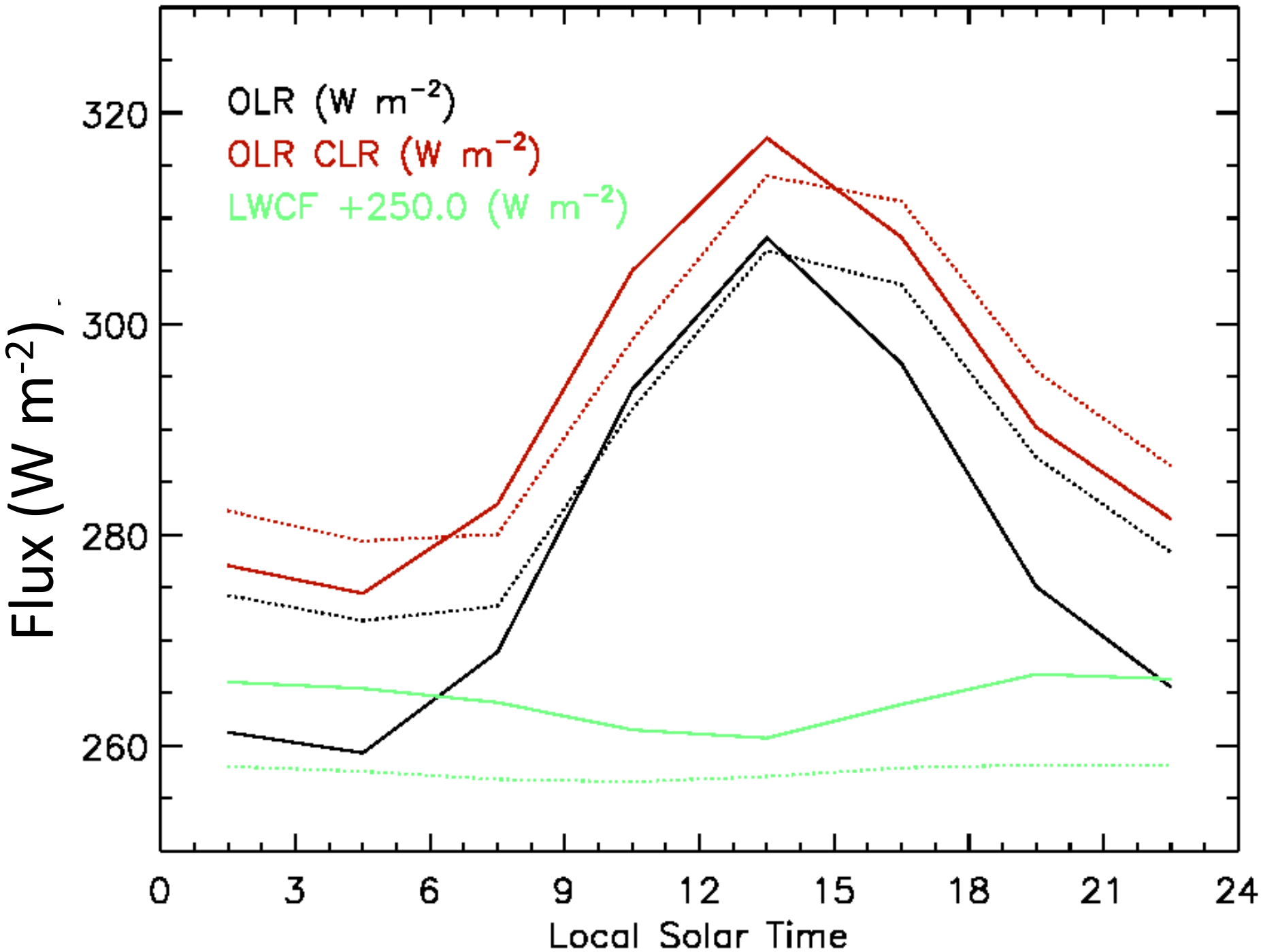
μ_{OLR}=-0.33 W m^{-2}
μ_{LWCF}=0.16 W m^{-2}
μ_{CLDLOW}=2.28%
μ_{CLDMID}=-0.64%
μ_{CLDHGH}=0.62%
μ_{PRECIP}=-0.01 mm day^{-1}

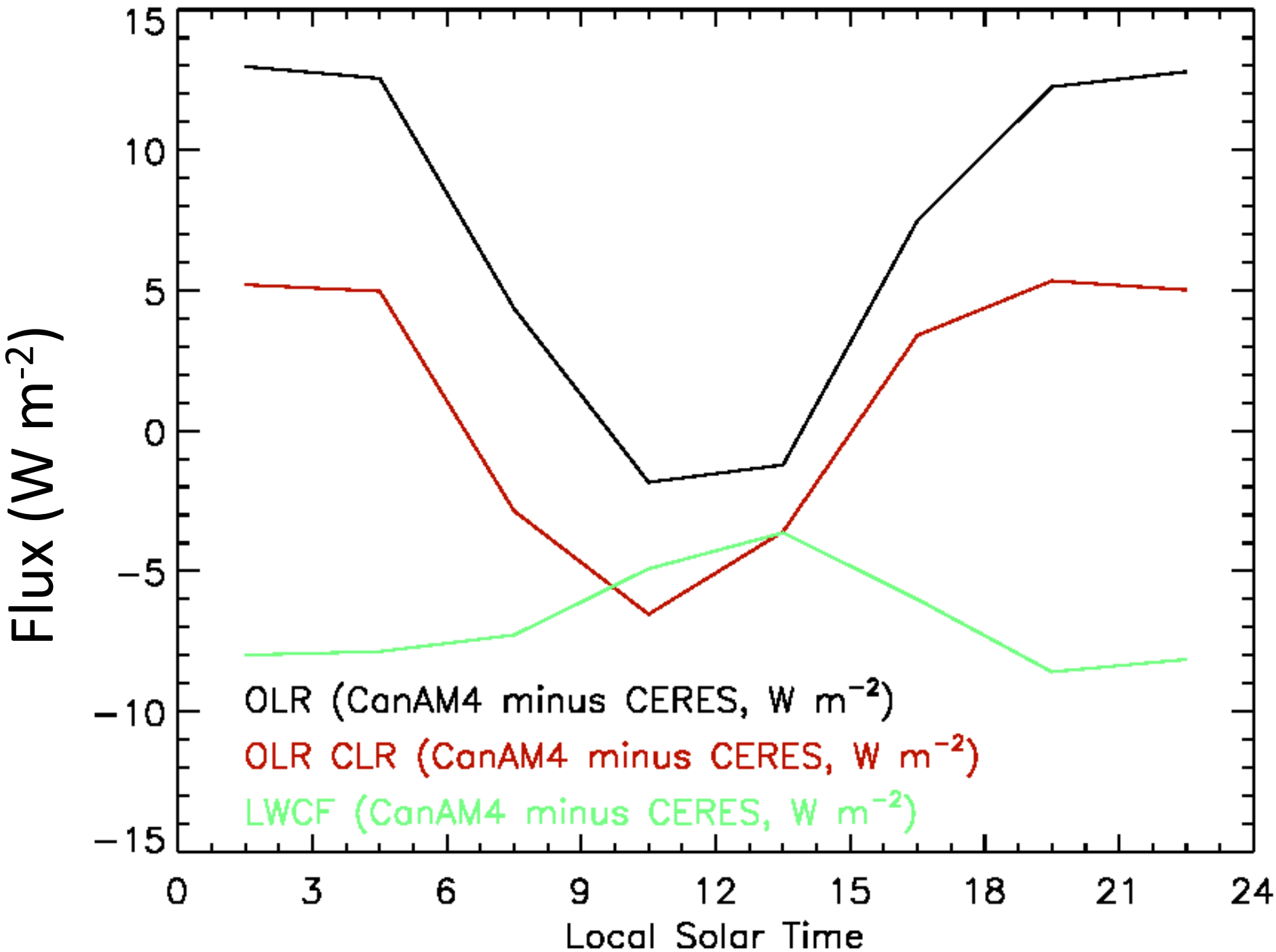


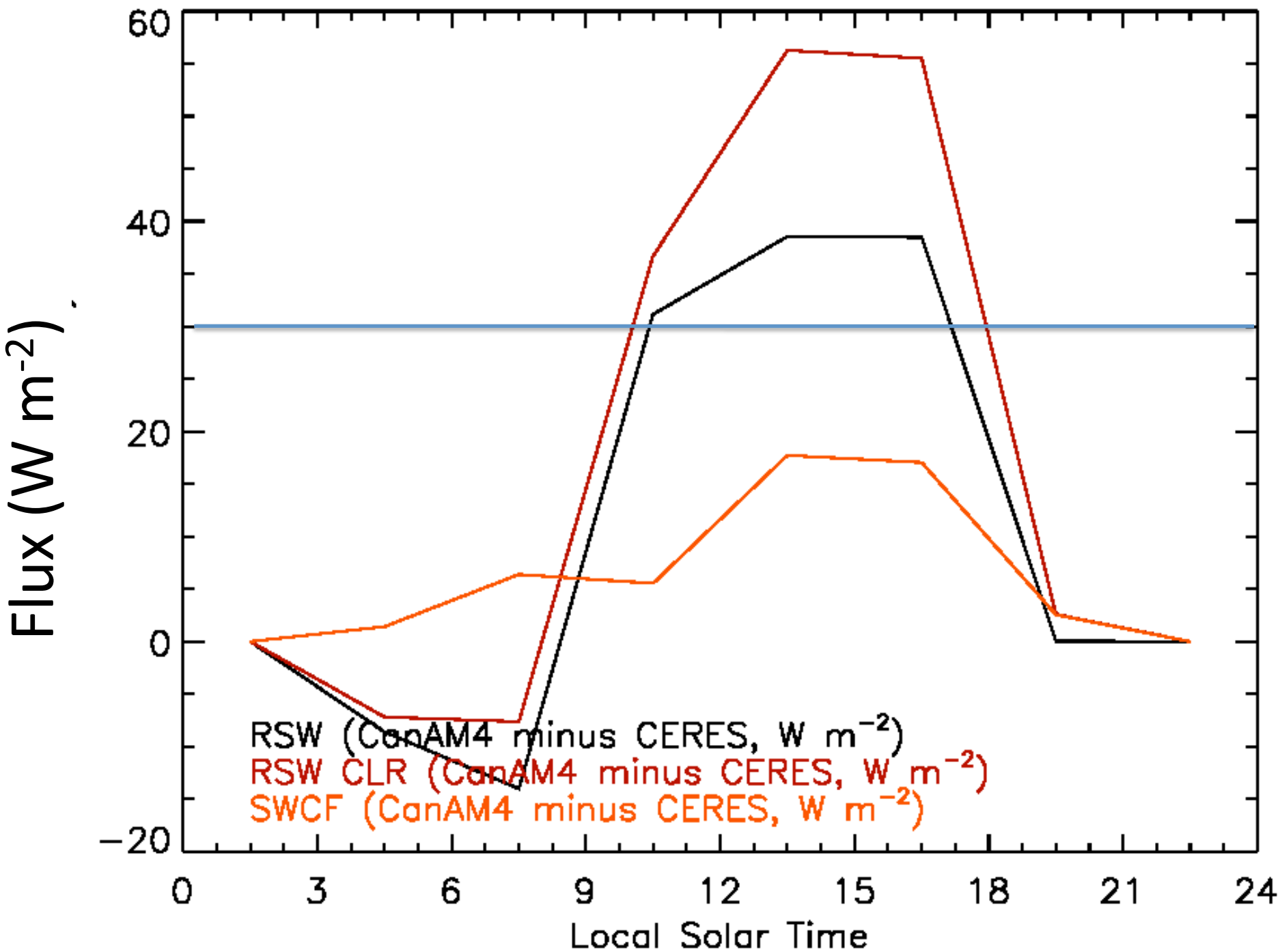
Diurnal Cycle Phase



What is causing errors in the land non-convective OLR diurnal cycle?


OLR (W m^{-2})
OLR CLR (W m^{-2})
LWCF +250.0 (W m^{-2})
320
300
280
260
Flux (W m^{-2})
0
3
6
9
12
15
18
21
24
Local Solar Time


Flux (W m-2)
15
10
5
0
−5
−10
−15
0
3
6
9
12
15
18
21
24
Local Solar Time
OLR (CanAM4 minus CERES, W m−2)
OLR CLR (CanAM4 minus CERES, W m−2)
LWCF (CanAM4 minus CERES, W m−2)


60
40
20
0
−20
Flux (W m-2)
0
3
6
9
12
15
18
21
24
Local Solar Time
RSW (CanAM4 minus CERES, W m−2)
RSW CLR (CanAM4 minus CERES, W m−2)
SWCF (CanAM4 minus CERES, W m−2)

Conclusions

- The CanAM4.0 reproduces general aspects of the TOA radiation, clouds, and precipitation diurnal cycles.
- However, large errors are found in the ocean non-convective low cloud diurnal cycle amplitude as well as in clear- and all-sky OLR in land non-convective regions.
- Model inconsistencies are found in the diurnal phasing of cloud types in all diurnal cycle regimes.
- The -6 W m^{-2} land non-convective regime OLR diurnal cycle amplitude bias is consistent with a -1.5 K bias in the surface temperature diurnal cycle driven by the model ~30 W m^{-2} midday errors in RSW.