Investigating the Spin-Up of NCEP Climate Forecast Systems with CERES EBAF Products

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Climate Forecast Systems

"Climatologies" *"Anomalies"*

CFSR Re-Forecast (CFSRR)
45-day/9-month

CFSv2 Forecast
9-month

Changes

CFS Reanalysis (CFSR)
1979-2010

CFSv2 Analysis
2011-Present

	CFS Reanalysis	CFSv2 Analysis
Grid Resolution (Atmosphere)	T382L64	T574L64
Sub-grid Cloud & Overlapping	None max-random	McICA max-random
Radiation Transfer Models	RRTM_SW RRTM_LW	RRTMG_SW RRTMG_LW
Marine Stratus Enhancement	With	Without
Cloud microphysics		Same schemes, but parameters may be changed via tuning

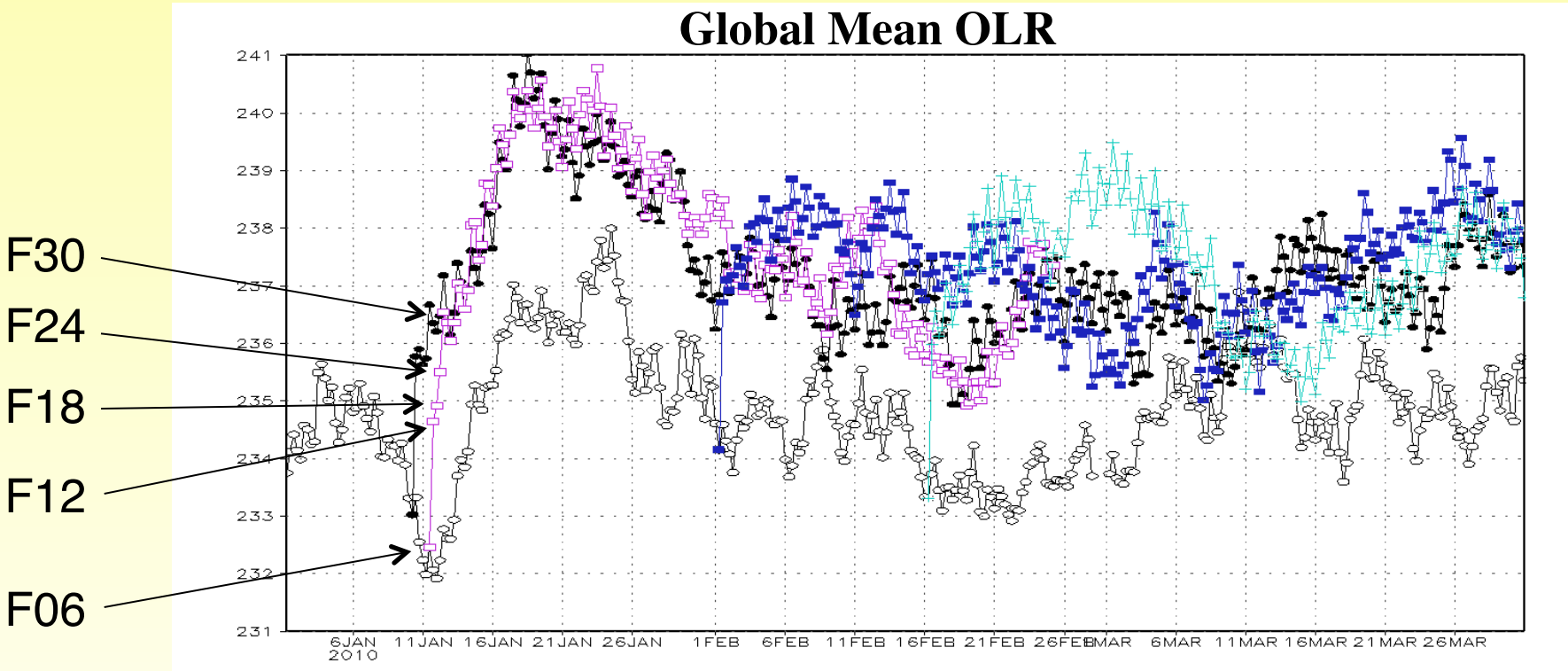
Forecast	T126L64 GFS with half-hourly coupling to the ocean analysis (Ocean model MOM4 at 0.25 degree equatorial, 0.5 degree global)

What is "Analysis" for Radiation

- Consider "radiation analysis" the best representation of radiation fields from the model.
- Radiation is a temporally accumulative quantity integrated through forecast increments.
- Typically, the integral of radiative fluxes in the first 6-hour of forecasts is the "best" representation, denoted as **F06**.
- We found this untrue for CFS.

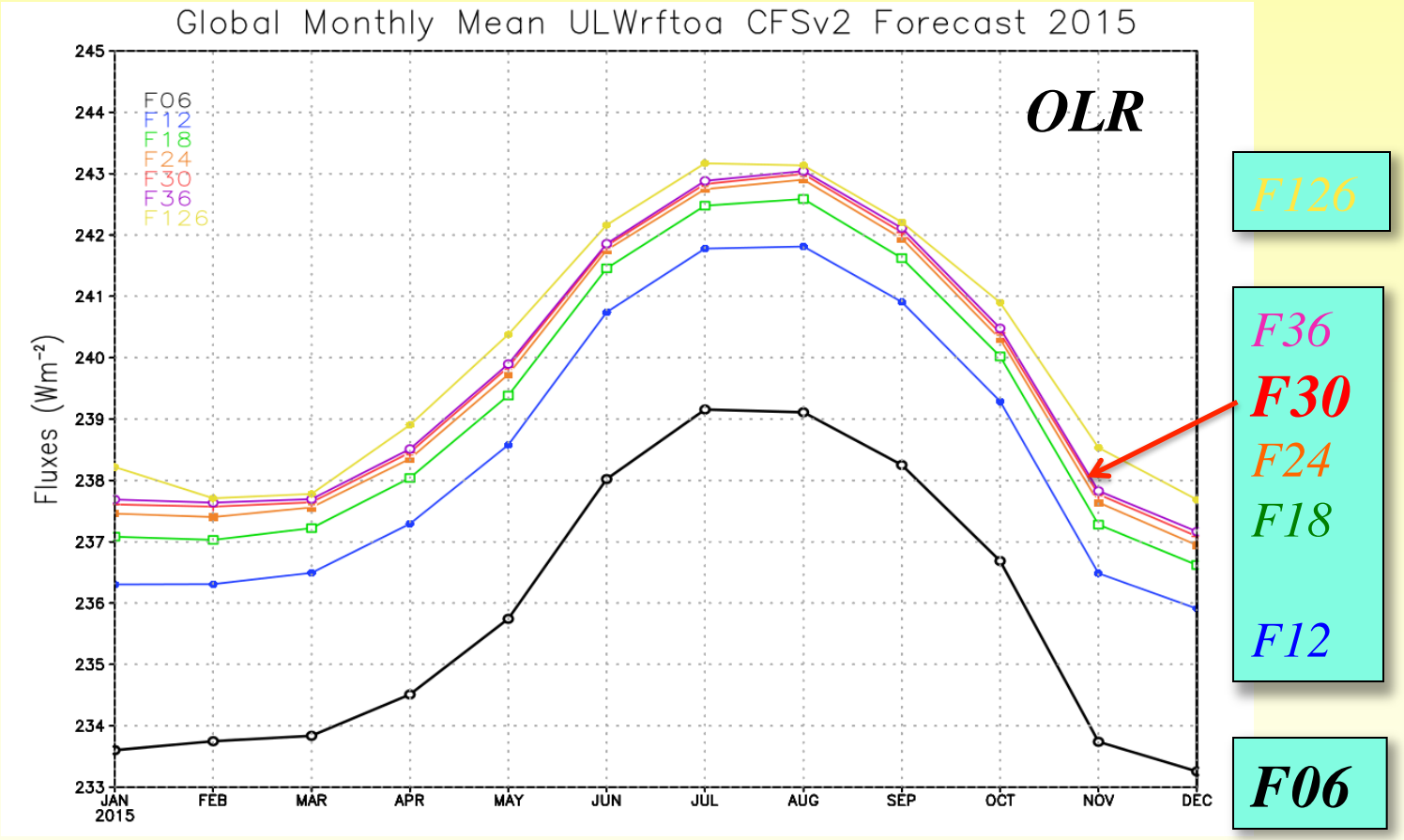
Detecting Spin-ups

Spin-up Signatures

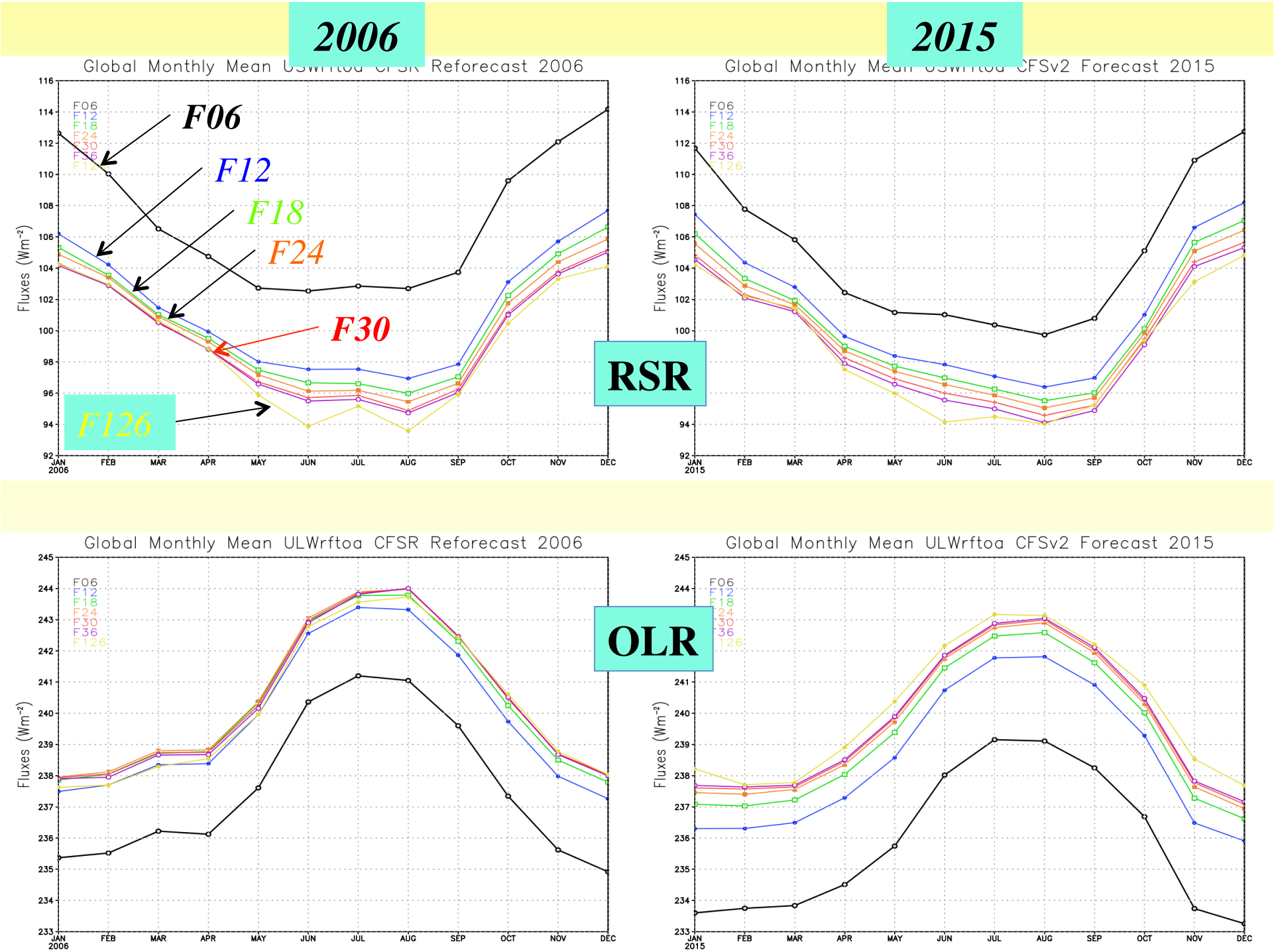


F06 *= 6-hourly integral from 00-06 hours of forecasts*
F12 = 6-hourly integral from 06-12 hours of forecasts
…
F30 *= 6-hourly integral from 24-30 hours of forecasts*

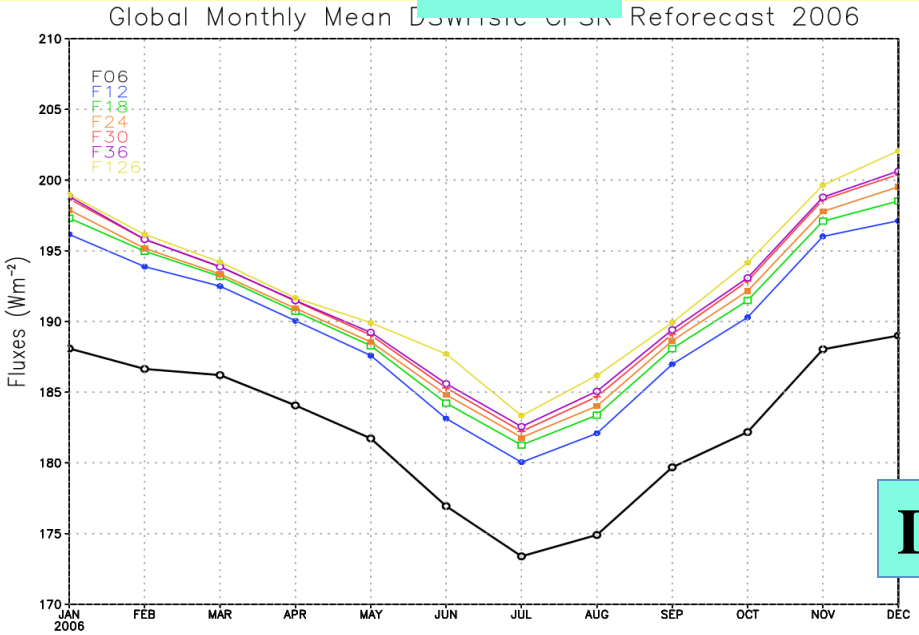
Spin-Up of Radiation Fields in CFSv2 Forecast

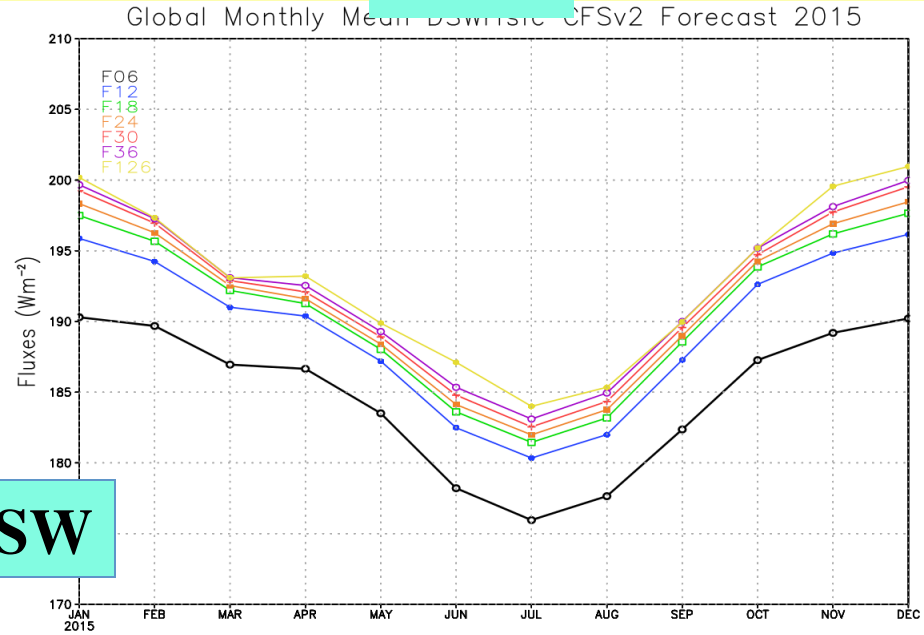


CFSv2 Forecast model takes about 24 hours to "stabilize" for TOA OLR radiation field.

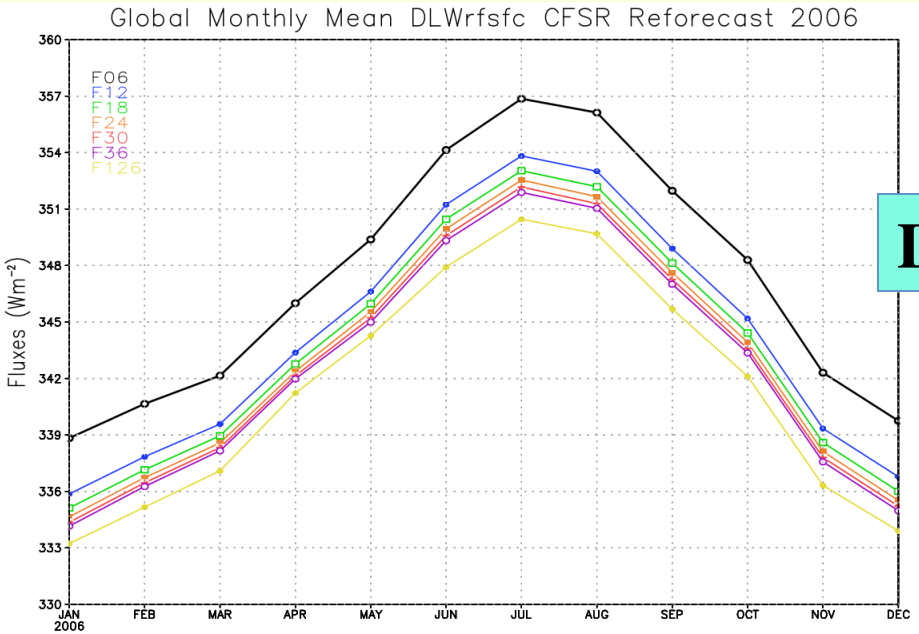

2006
2015
Global Monthly Mean USWrftoa CFSR Reforecast 2006
Global Monthly Mean USWrftoa CFSv2 Forecast 2015
F06
F12
F18
F24
F30
F36
F126
RSR
Global Monthly Mean ULWrftoa CFSR Reforecast 2006
Global Monthly Mean ULWrftoa CFSv2 Forecast 2015
OLR
Fluxes (Wm-2)
JAN 2006
JAN 2015
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

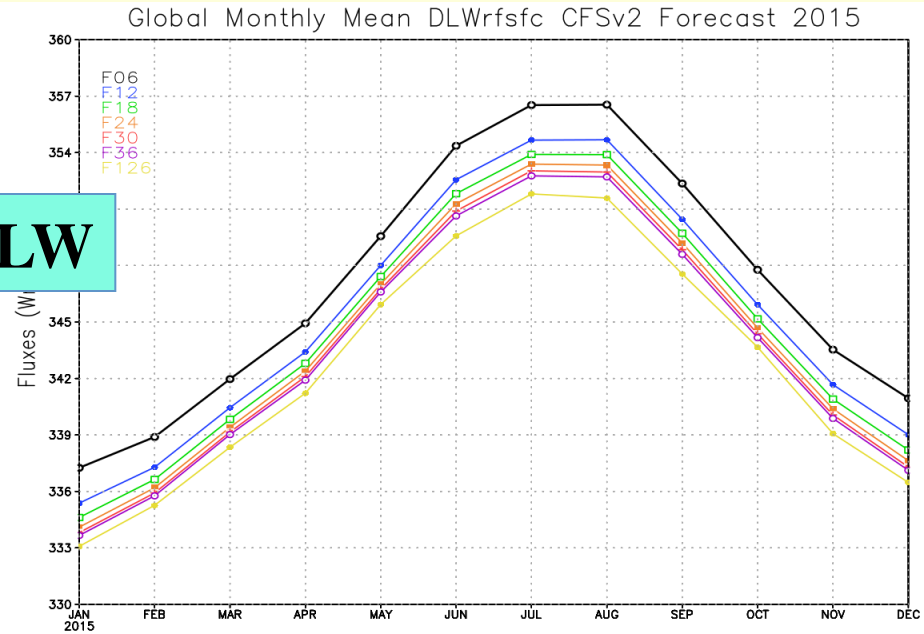
2006 **2015**





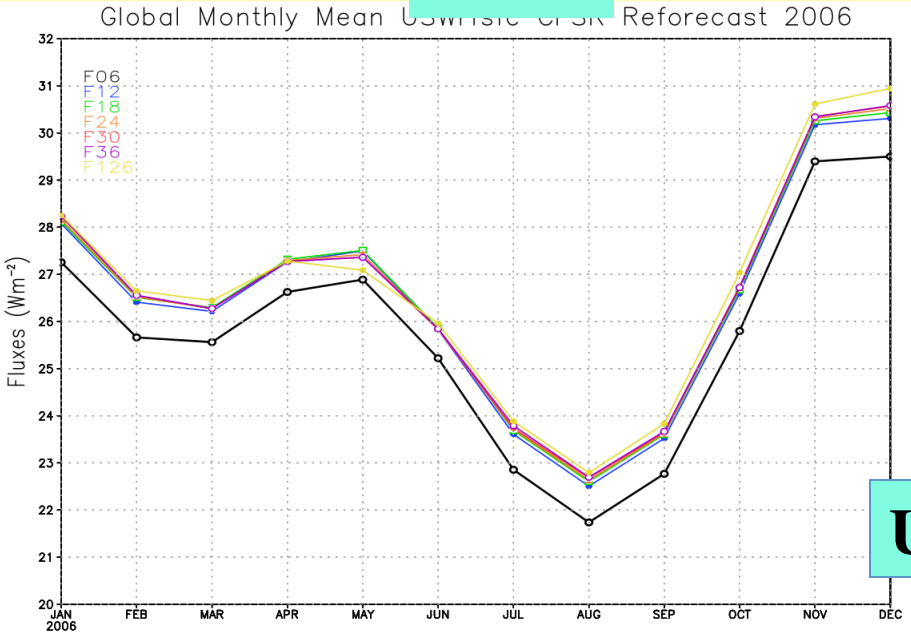
DSW

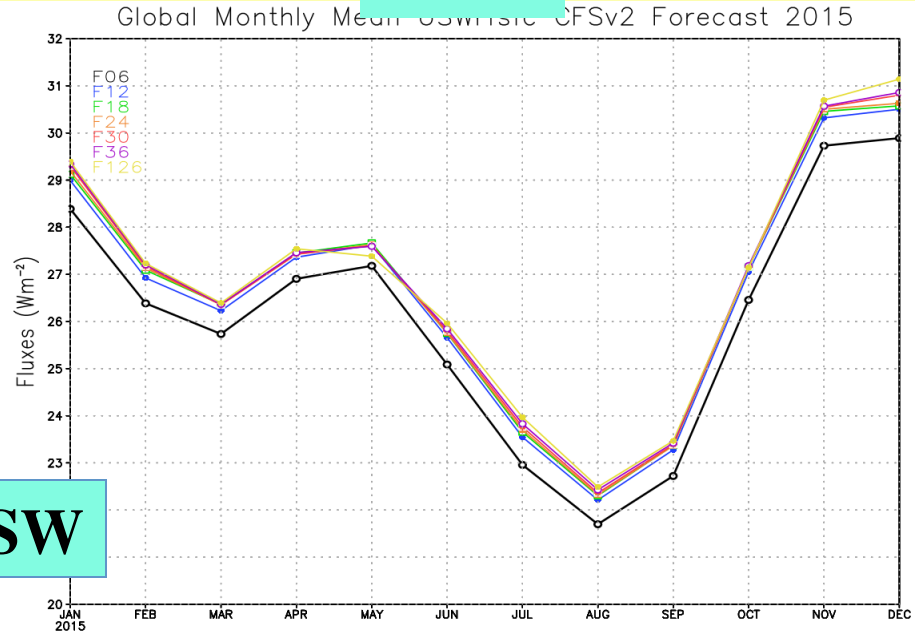




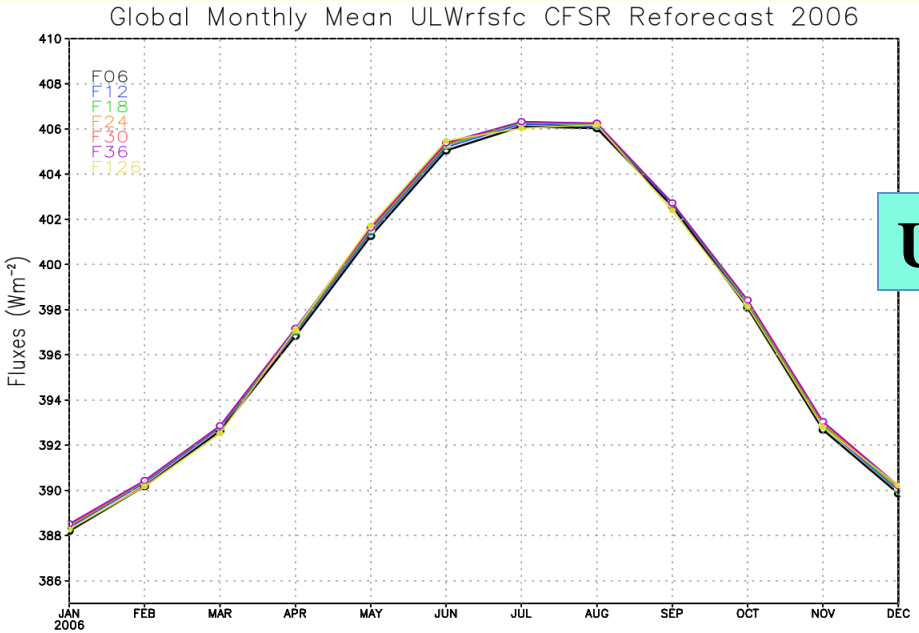
DLW

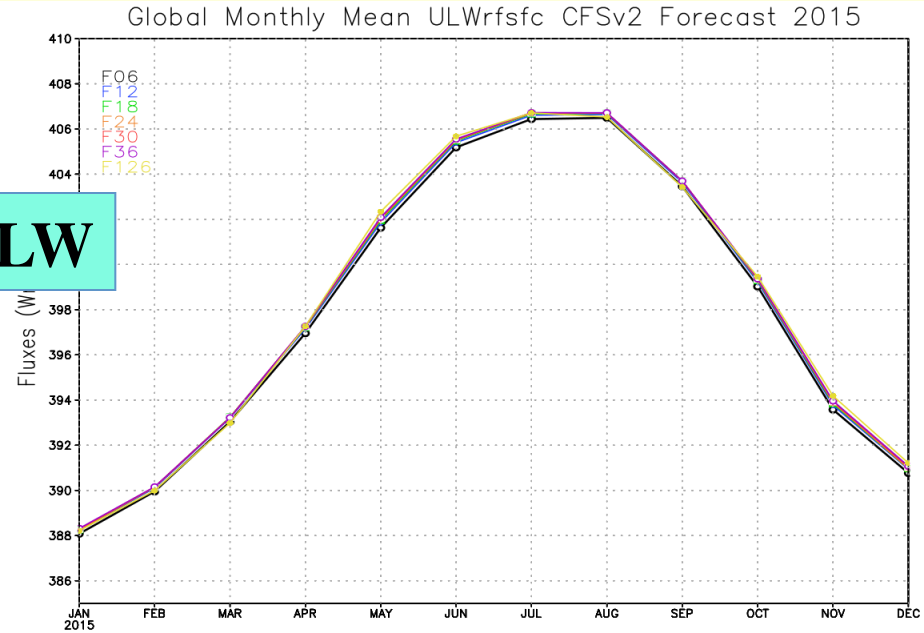
2006 **2015**





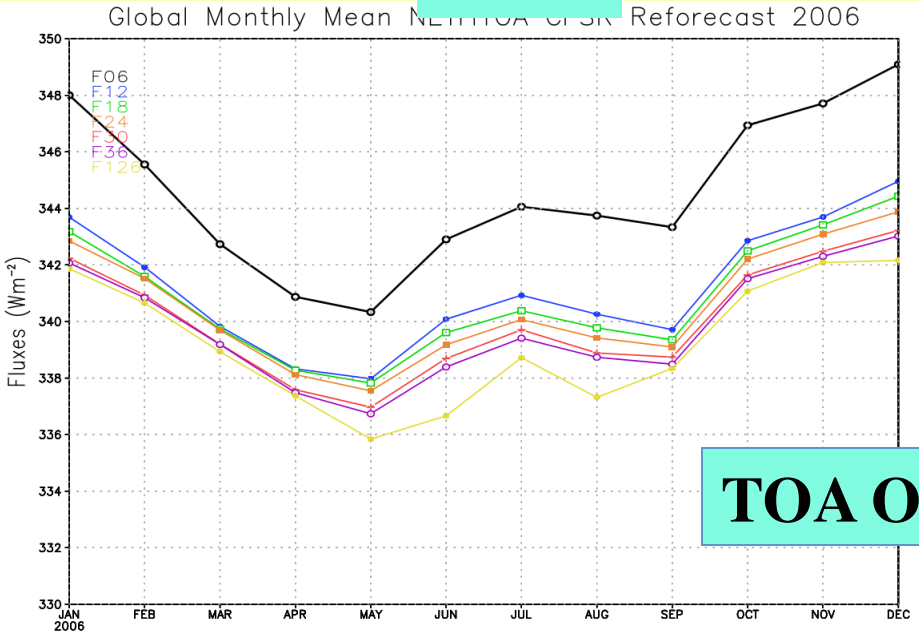
USW

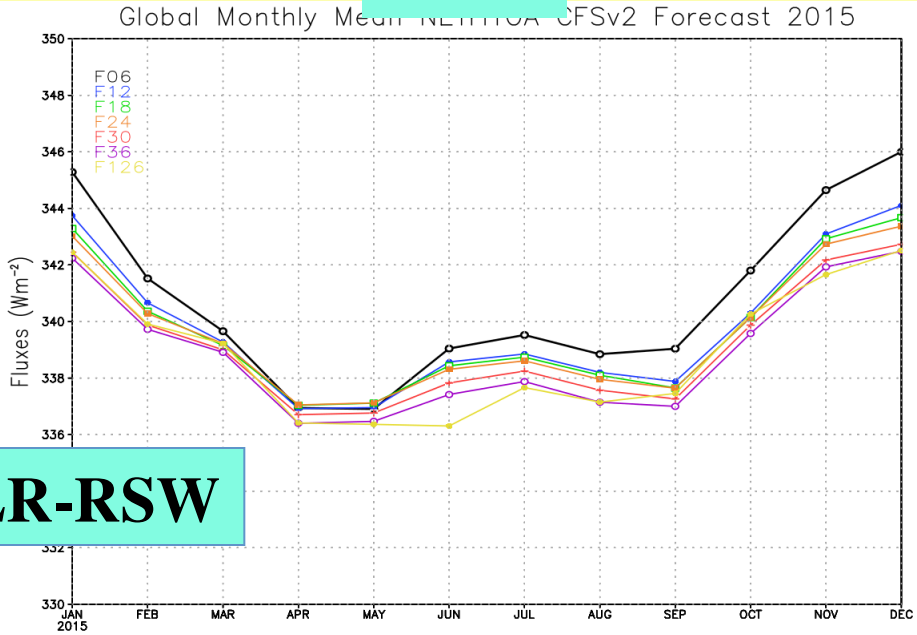




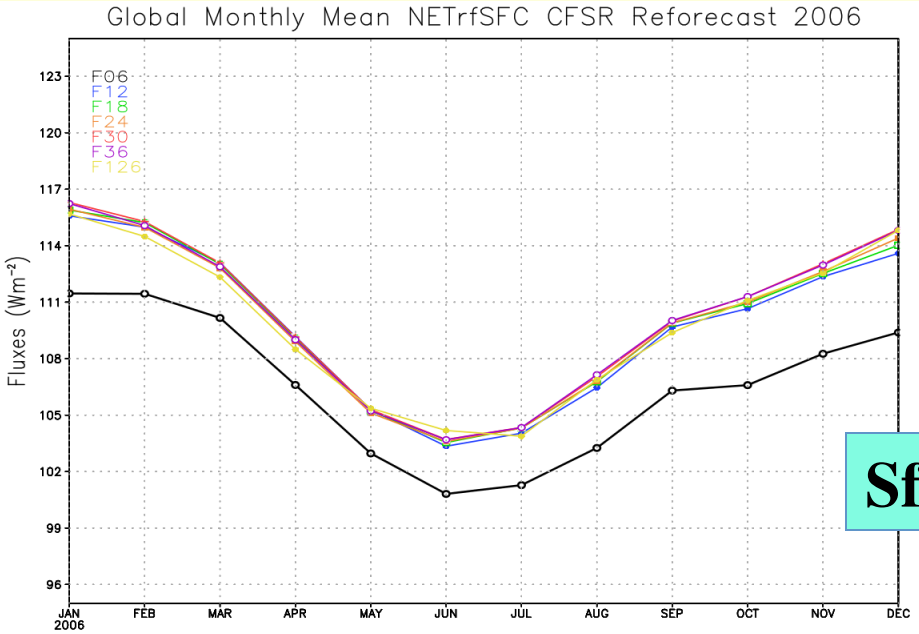
ULW

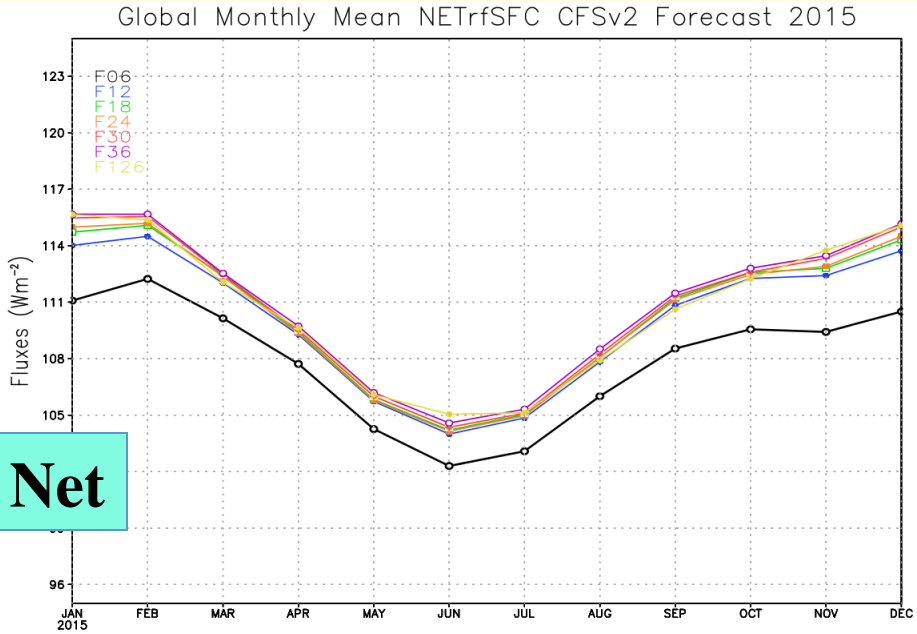
2006 **2015**





TOA OLR-RSW



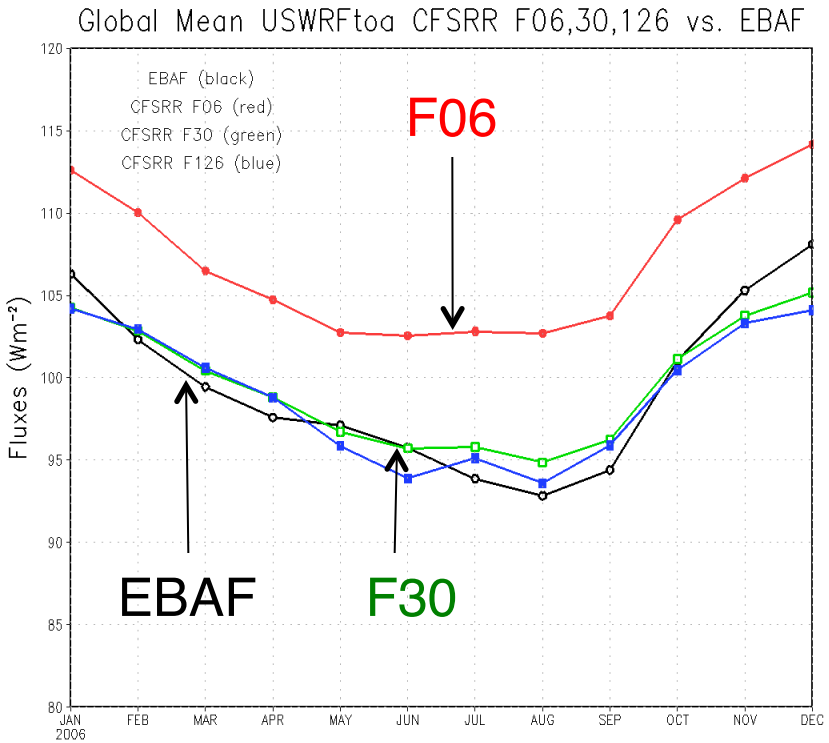


Sfc Net

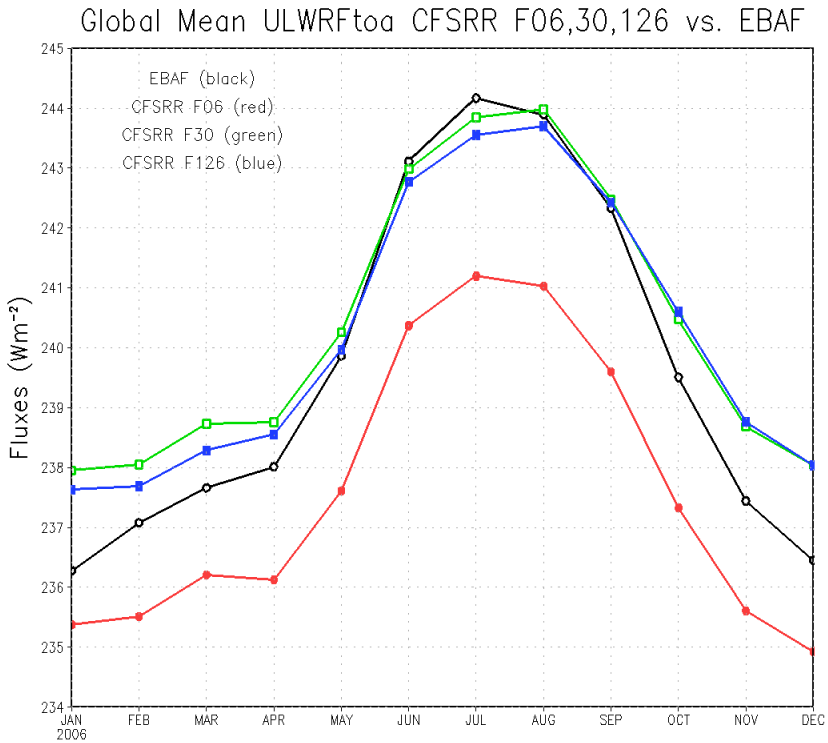
Accuracy Evaluation
with
EBAF Ed2.8

Global Monthly Mean (2006)

RSR



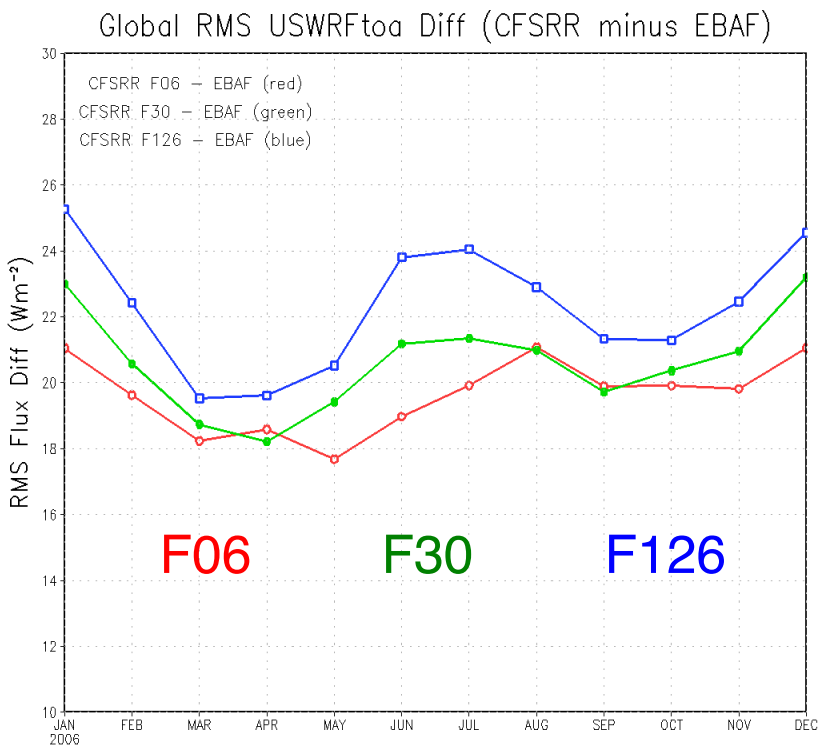
OLR



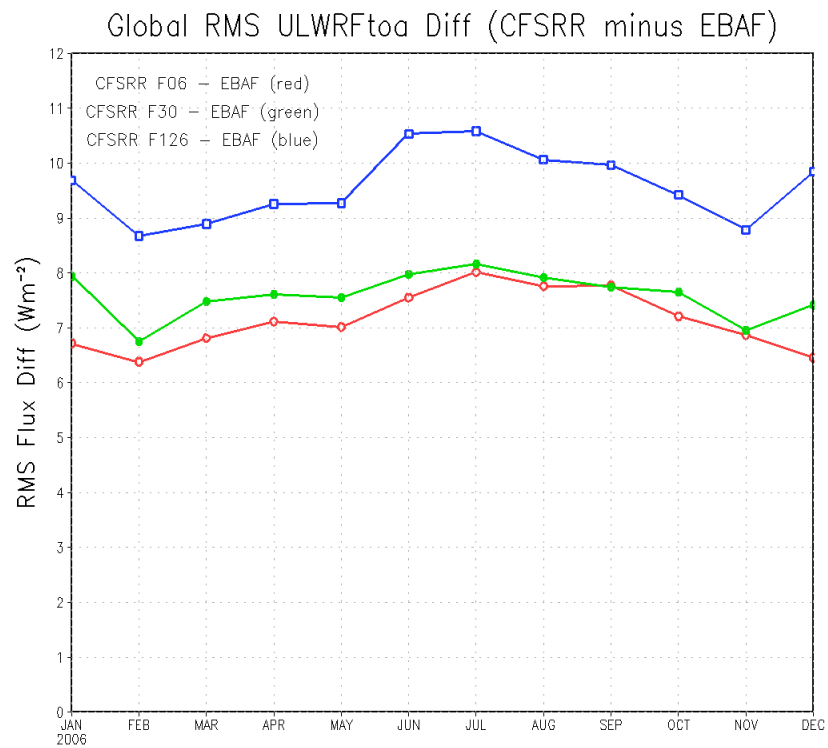
CFSRR uses 1366 Wm-2 for the incoming solar radiation, while CERES uses 1361 Wm-2.
This accounts for about +0.4 Wm-2 of CFSRR-CERES RSW differences, assuming at a 30% albedo.

RMS Differences of Monthly Mean (2006) CFS minus EBAF

RSR



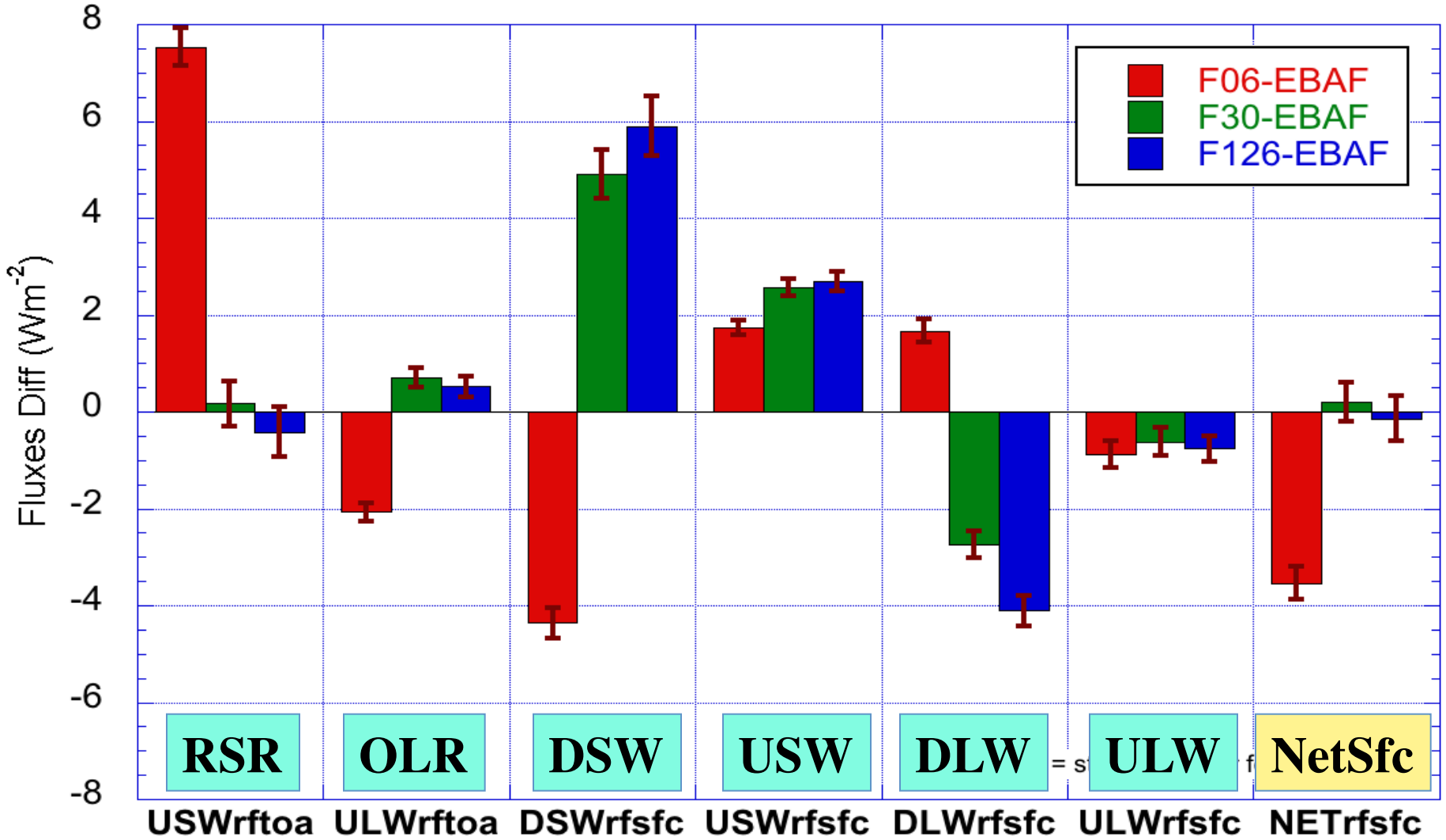
OLR



Longer forecasts lose spatial "fidelity", but overall performance of F30 does not degrade significantly compared to F06.

Annual Global Mean Difference
CFS Reforecasts minus EBAF Ed2.8

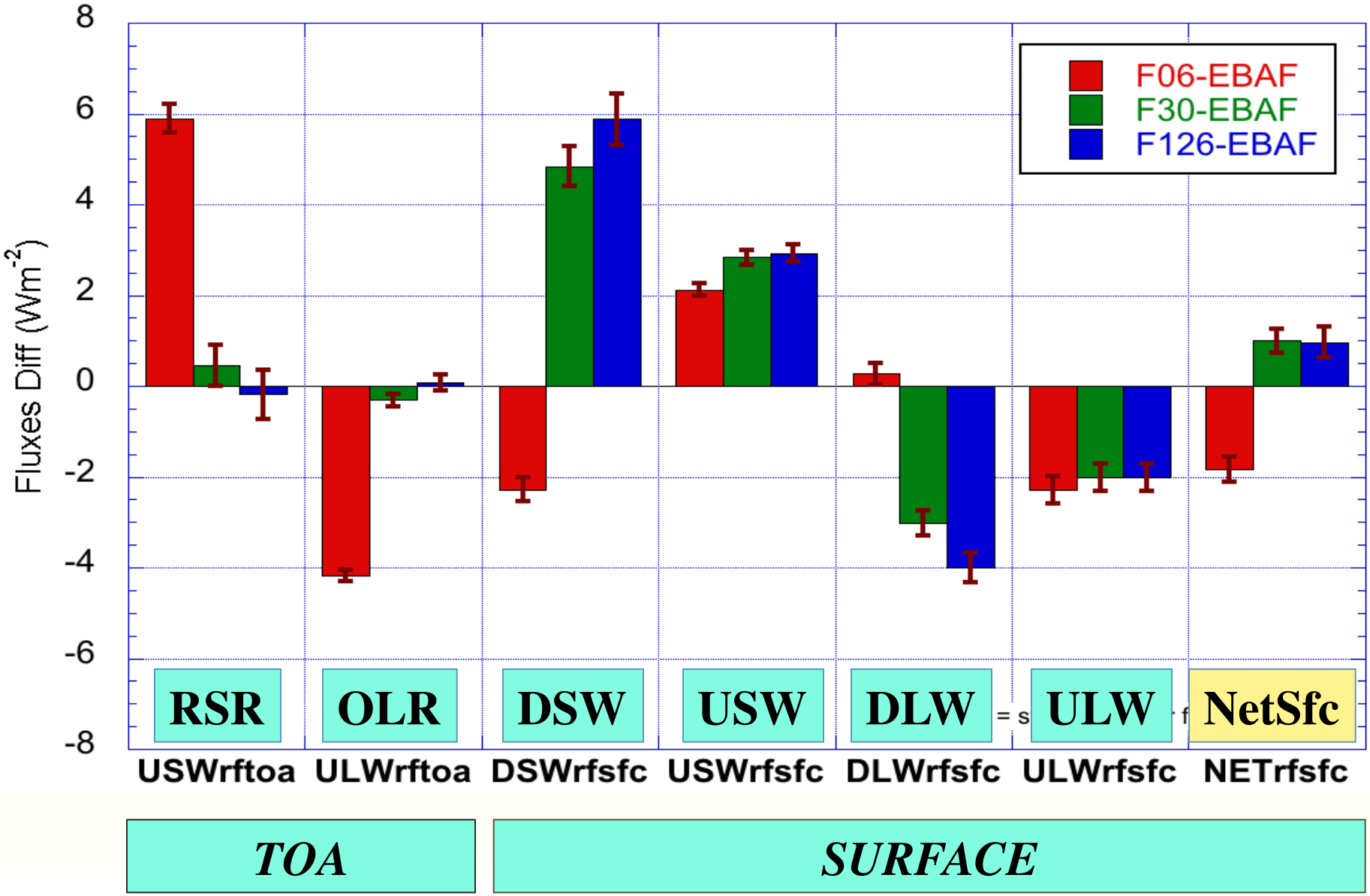
2006



TOA | *SURFACE*

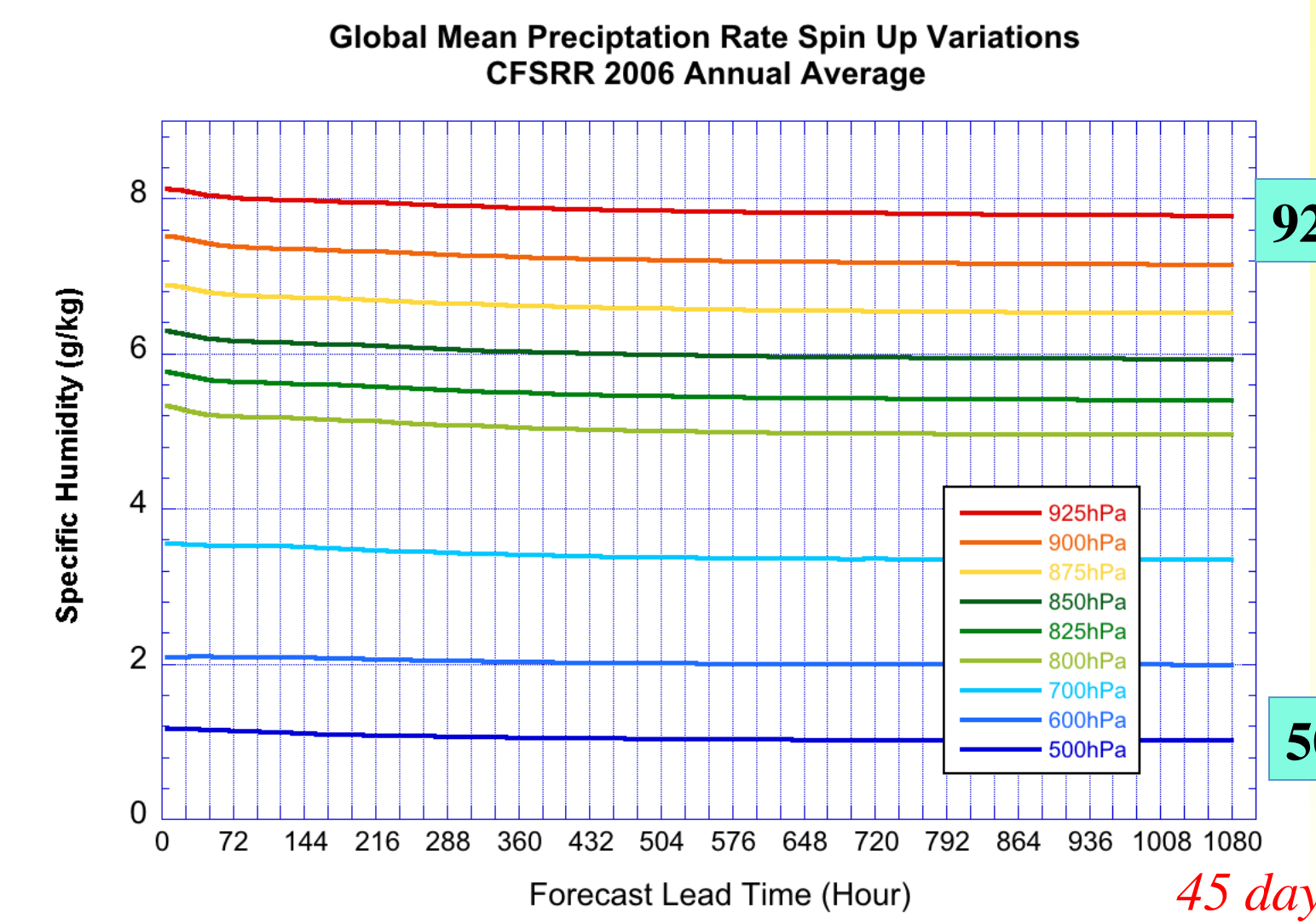
Annual Global Mean Difference
CFSv2 Forecasts minus EBAF Ed2.8

2015



Attributions

Spin-ups in Specific Humidity



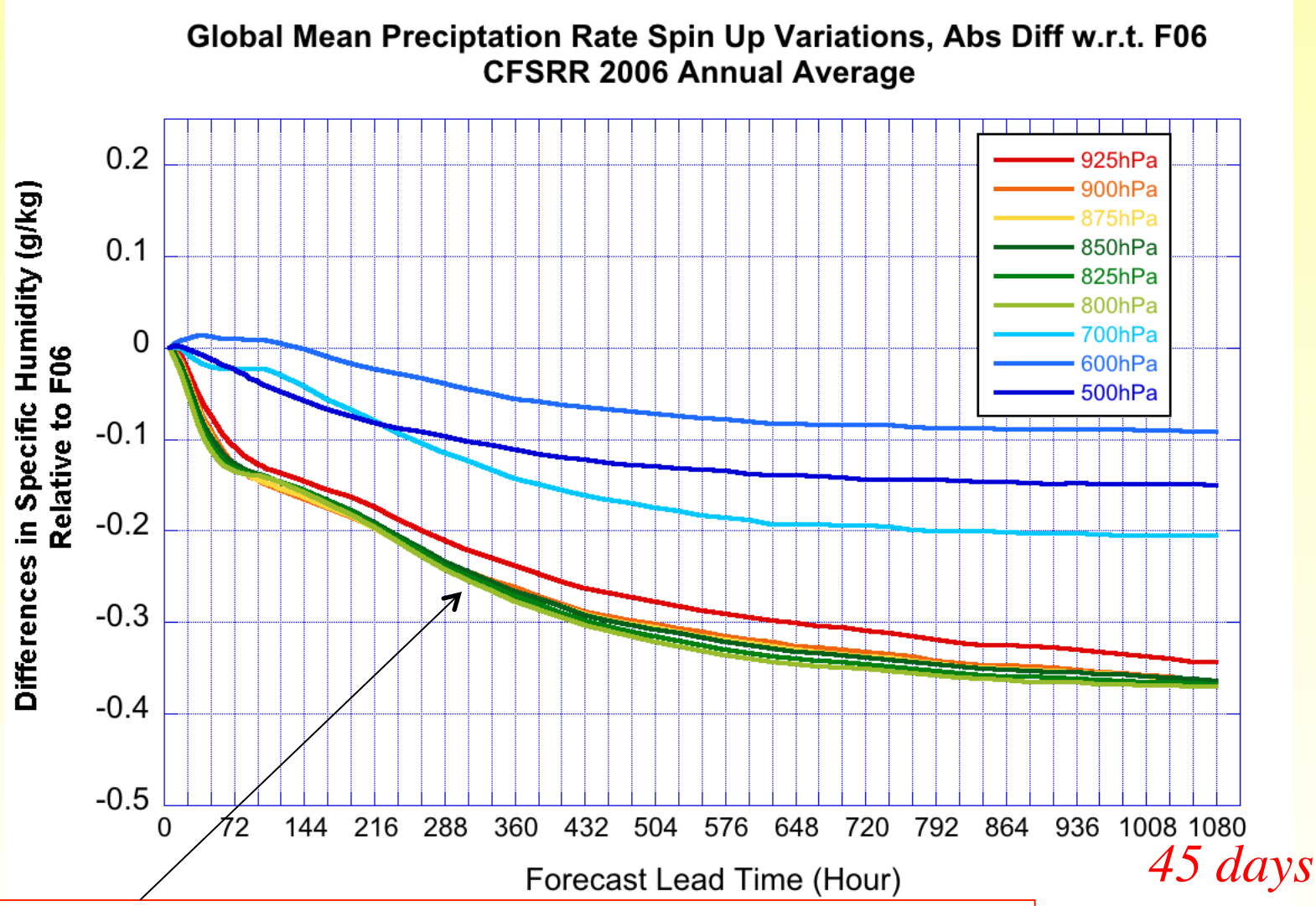
925 hPa

500 hPa

45 days

Spin-ups in Specific Humidity

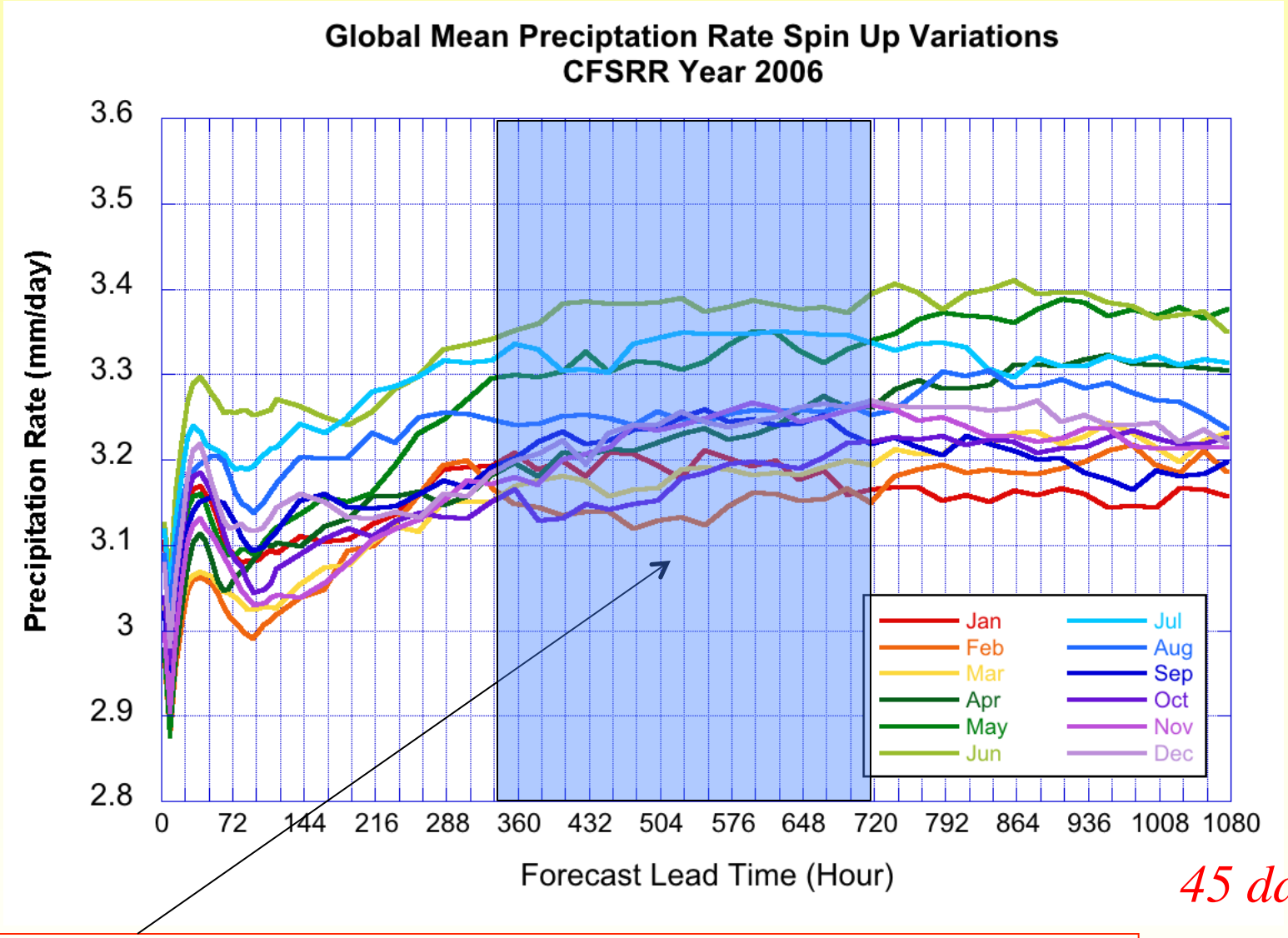
Absolute Difference Relative to F06



45 days

Drying reduces cloudiness (in lower troposphere)

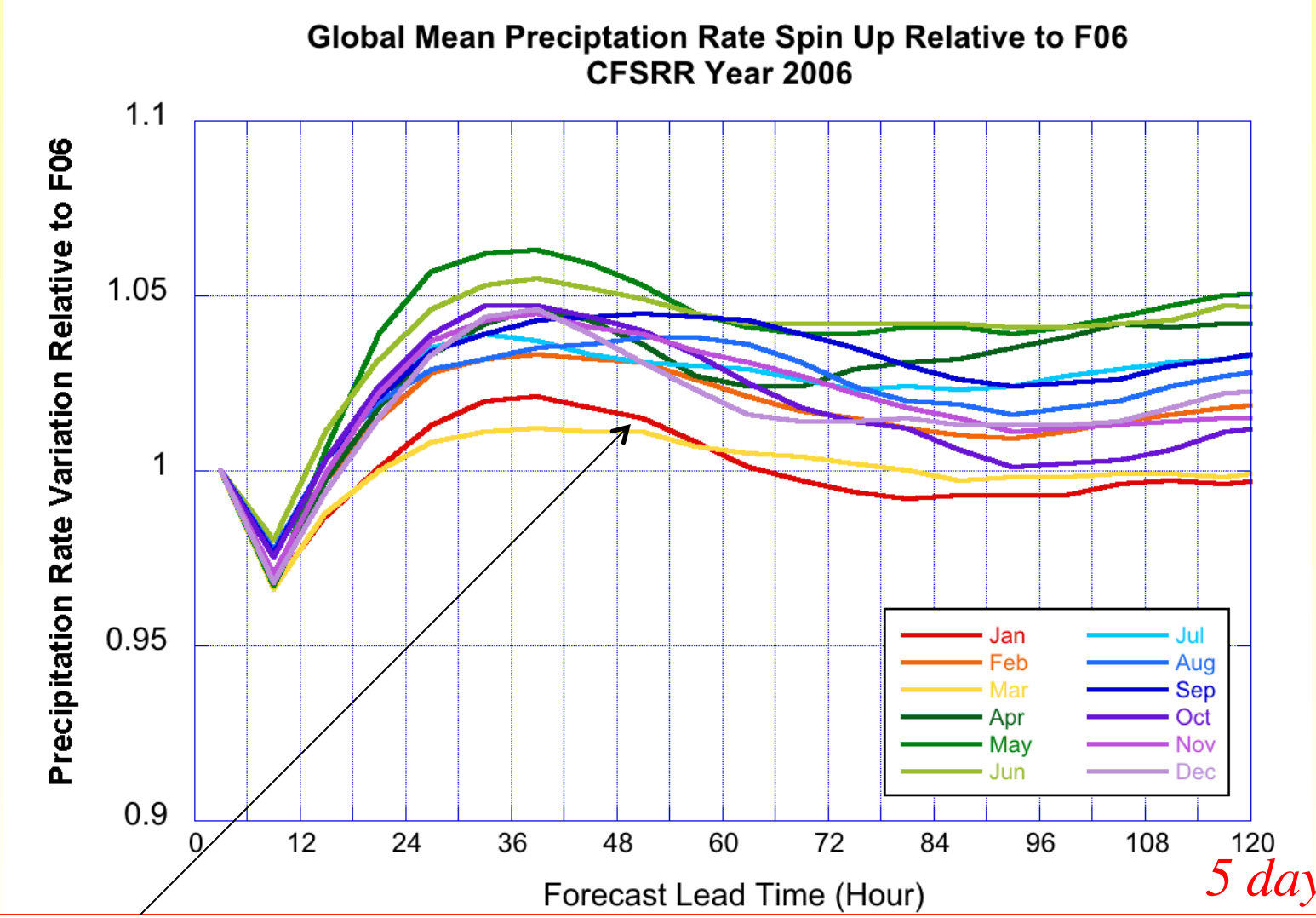
Spin-ups in Precipitation Rate



45 days

Tuning priority: Week 3-4, Precip. over North America

Spin-ups in Precipitation Rate Relative to F06



5 days

Assumption: "Changes in PRATE ←→ reallocate H2O between Atmos/Surface"

Summary

- CFSv2 Forecasts spin-up signatures found in Radiation, Specific humidity, and Precipitation rate – suggested a spin-up period of at least 24 hours

- For CFSR, the 6-hrly integral from **F30** (ie., 24-30 hours of forecasts) agrees better with CERES EBAF products, opposed to the **F06** output - the one we usually considered the best estimate.

- Working Assumption: "Tuning applied to Precipitation made the post spin-up radiation states more agreeable with EBAF." – a side benefit.

Who are affected?

- Inter-comparison of radiation among models and satellites
- Using global model radiation to drive regional model, or for land/ocean data assimilation.
- Using model state (T, q) to perform radiation calculations or for cloud retrieval purposes.

Acknowledgment

- NASA CERES Science Team and Data Center
- CPC CFSv2 Data Archives (Mingyue Chen, Li Zhang)
- Huug van den Dool, Wanqiu Wang, Shrinivas Moorthi, Fanglin Yang, Pingping Xie
- wgrib2 by Wesley Ebisuzaki.

Backup Slides

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  - Oreopoulos and Barker (1999)
  - http://rtweb.aer.com/rrtmg_sw_description.html
- **RRTMG_LW** (uses reduced set of g-intervals (140) for integration over absorption in each band, while RRTM_LW uses full set of g-intervals (256))
  - http://rtweb.aer.com/rrtmg_lw_description.html