# Surface EBAF Edition4 Plans and Prototype Results

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CERES Science Team Meeting

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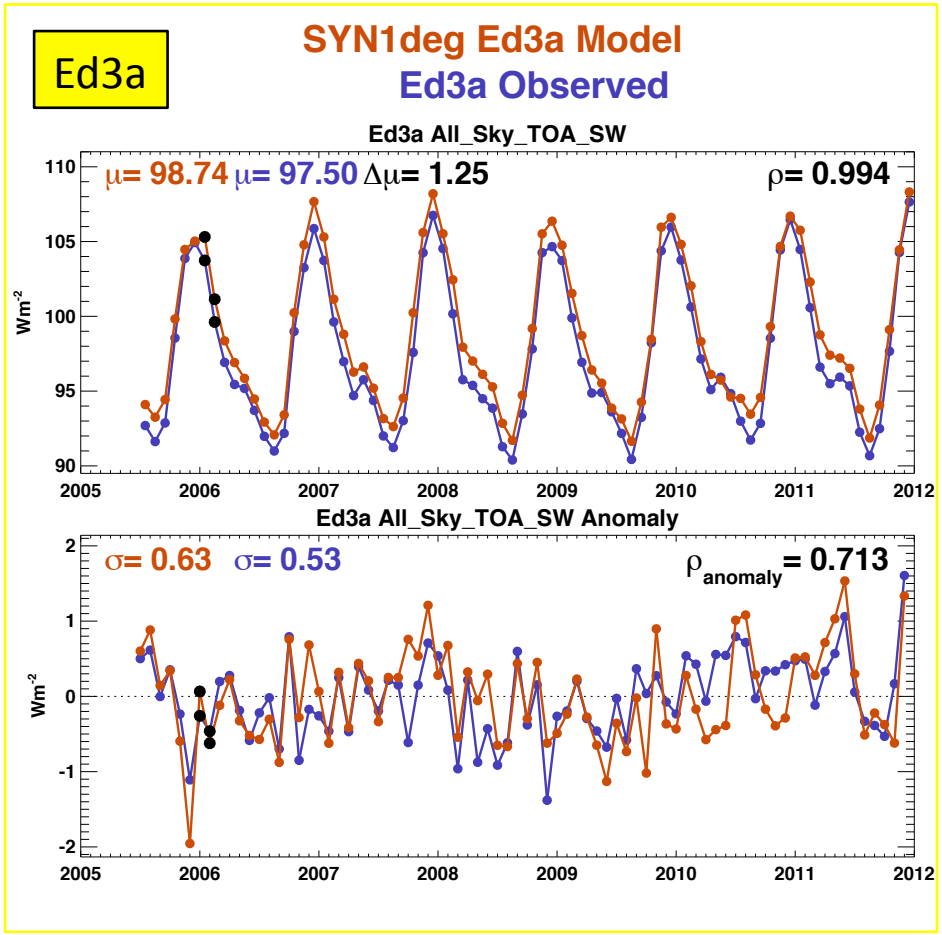
# Outline

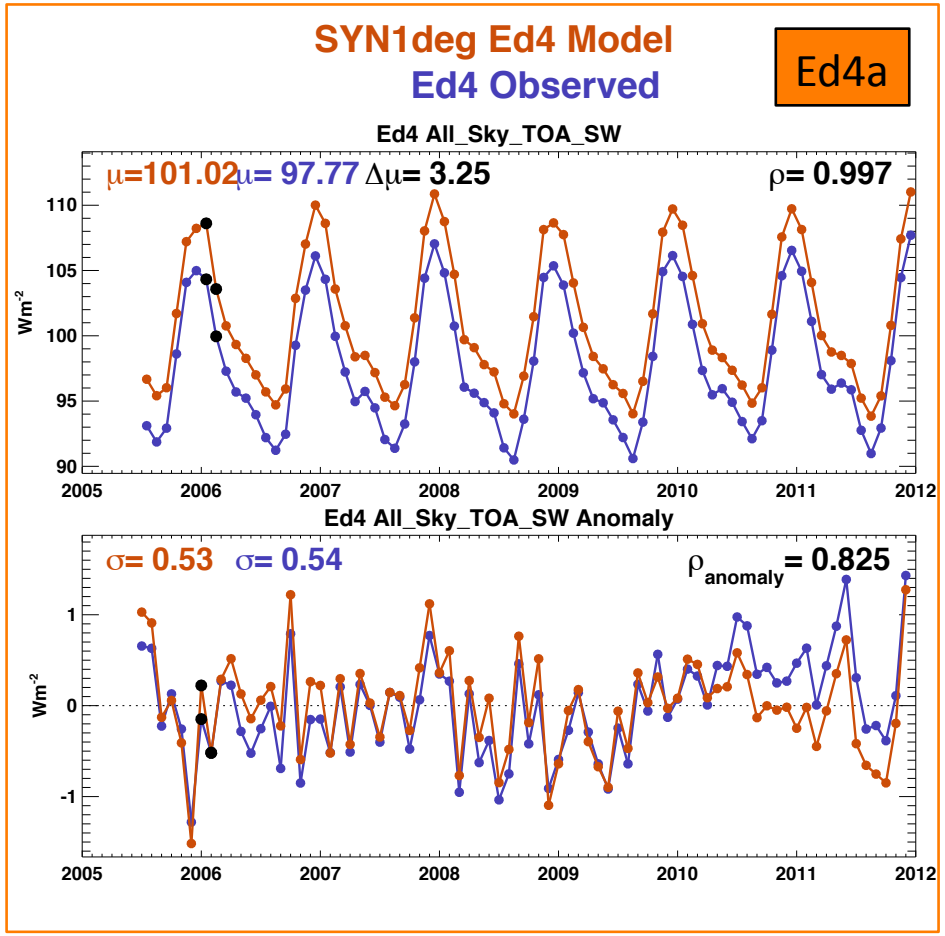
- Ed4a SARB SYN_1deg
  - Ed4a vs. Ed3a comparisons
- Planed changes to Ed4 Surface Ebaf
  - What is Surface Ebaf
  - Changes / New Inputs
    - Airs Spectral Flux (All Sky)
    - Modified tolerances
  - Prototype results ( 48 month 2007-2011)
    - Still using Ed2.8 TOA_EBAF
  - UTRH details

# Ed4a vs. Ed3a Comparisons (July 2005 - Dec 2011) 6 ½ years

- Global Mean and Anomaly
- Zonal Mean and Anomaly correlations
- No Jan & Feb 2007

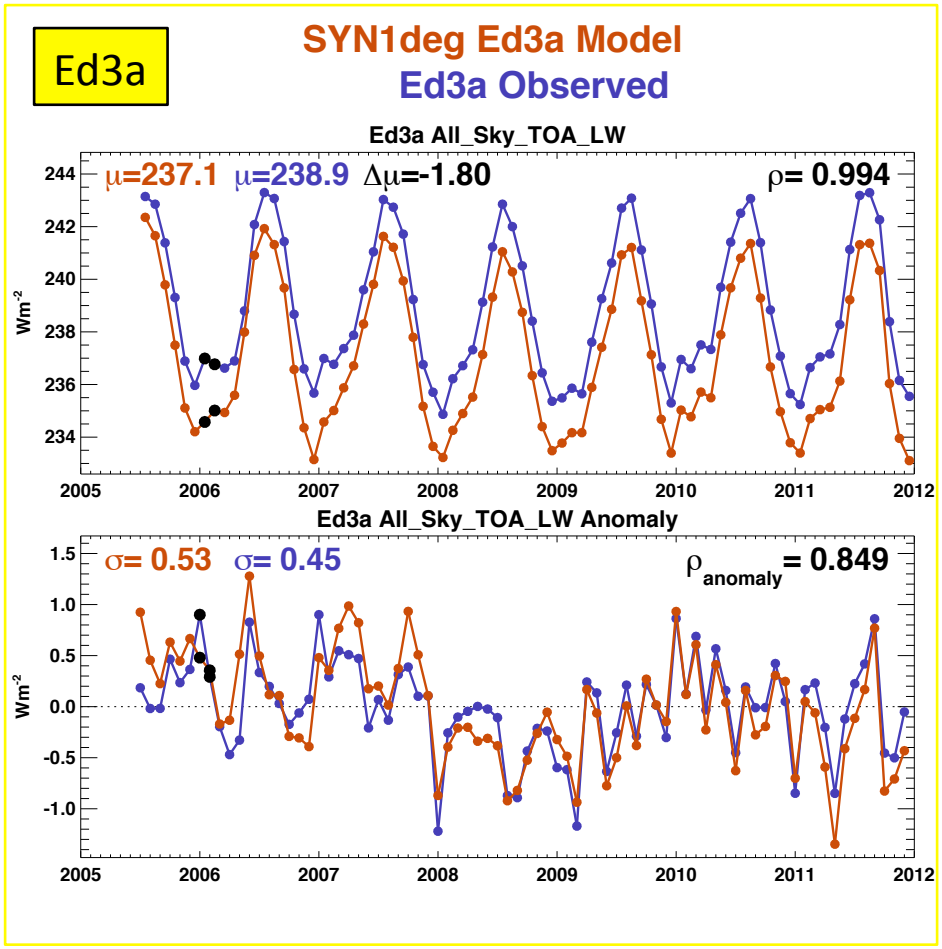
# TOA Shortwave: Model Vs Observed

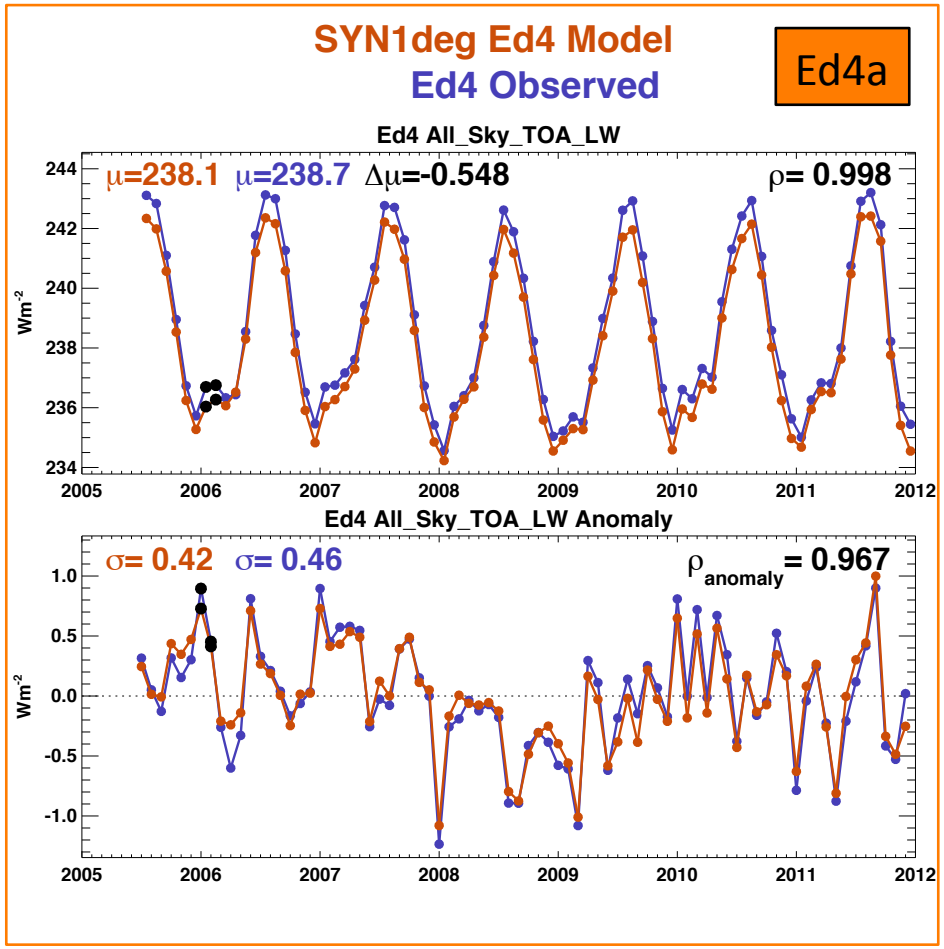



- Ed4 is significantly brighter than Syn1degMth Observed (more clouds)
- Anomaly correlation much improved.

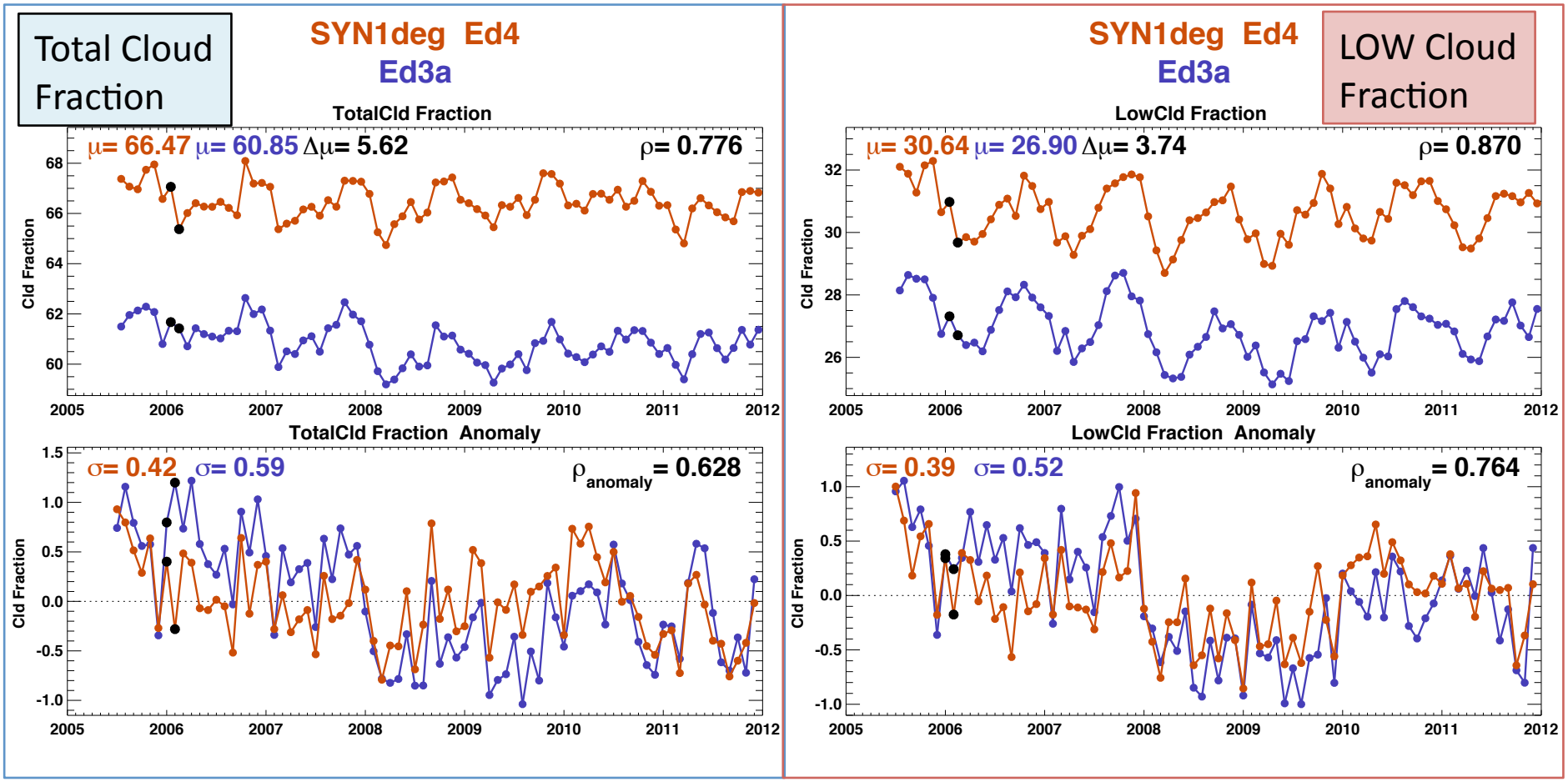
# TOA Longwave: Model Vs Observed



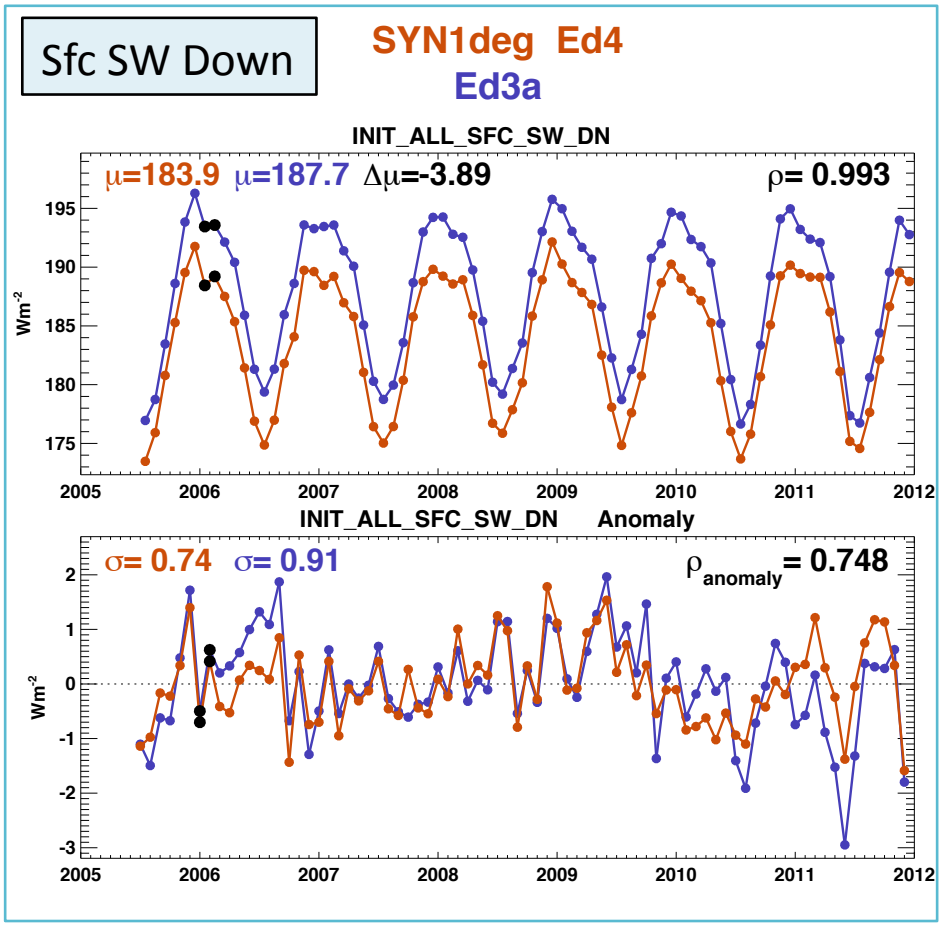



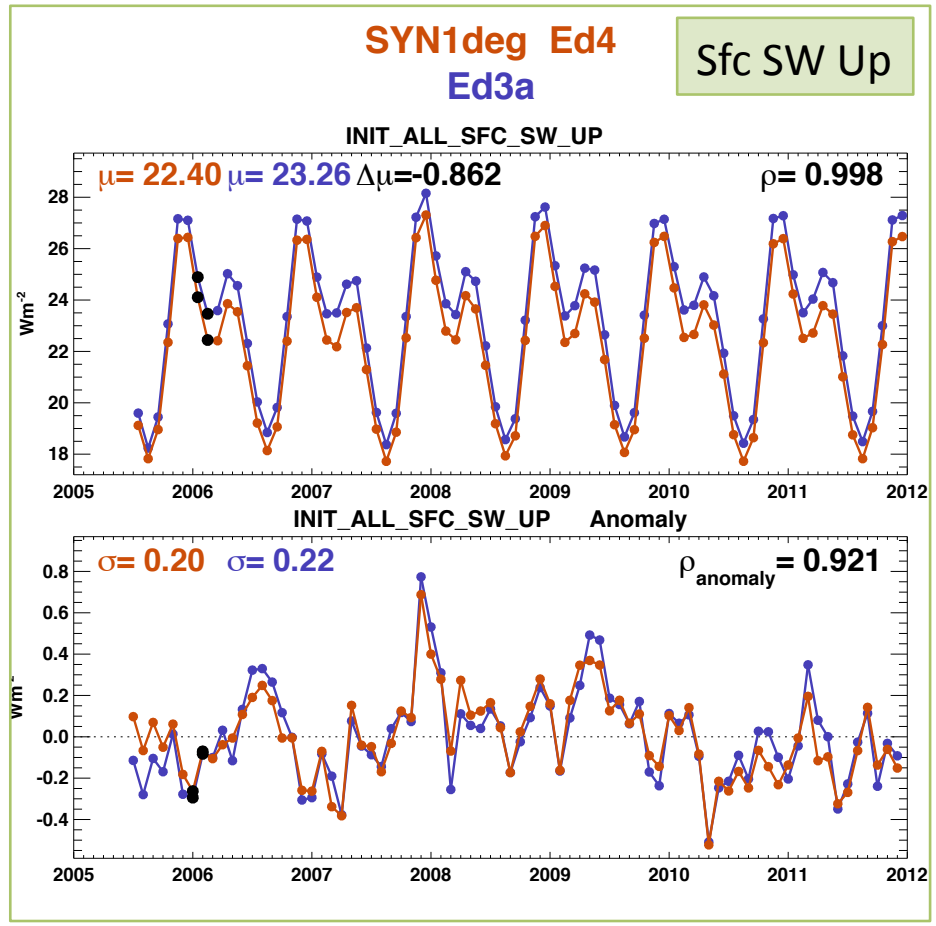

- Ed4 bias to Syn1degMth Observed smaller than Ed3a
- Anomaly correlation improved slightly.

# Ed4 Vs Ed3
# Global Mean Cloud Fraction



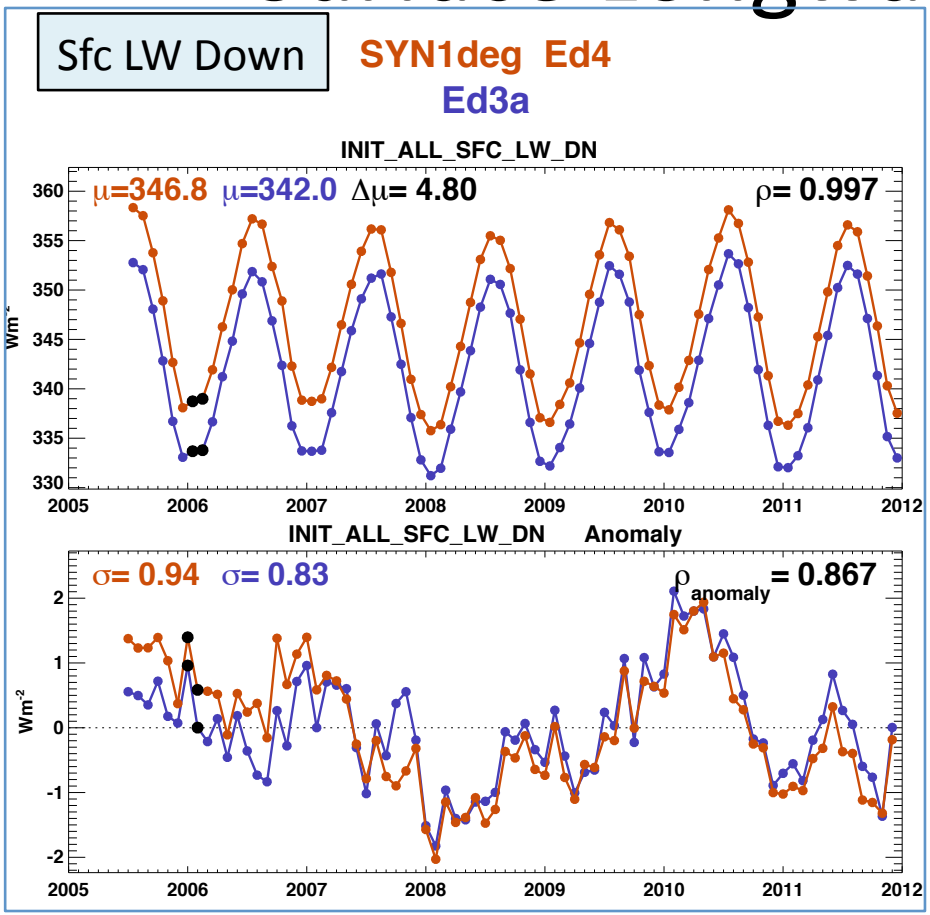
# Surface Shortwave : Ed4a vs Ed3a

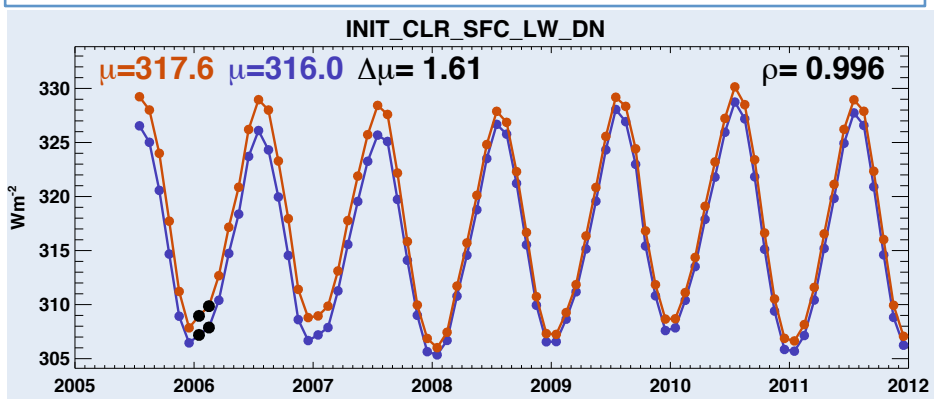


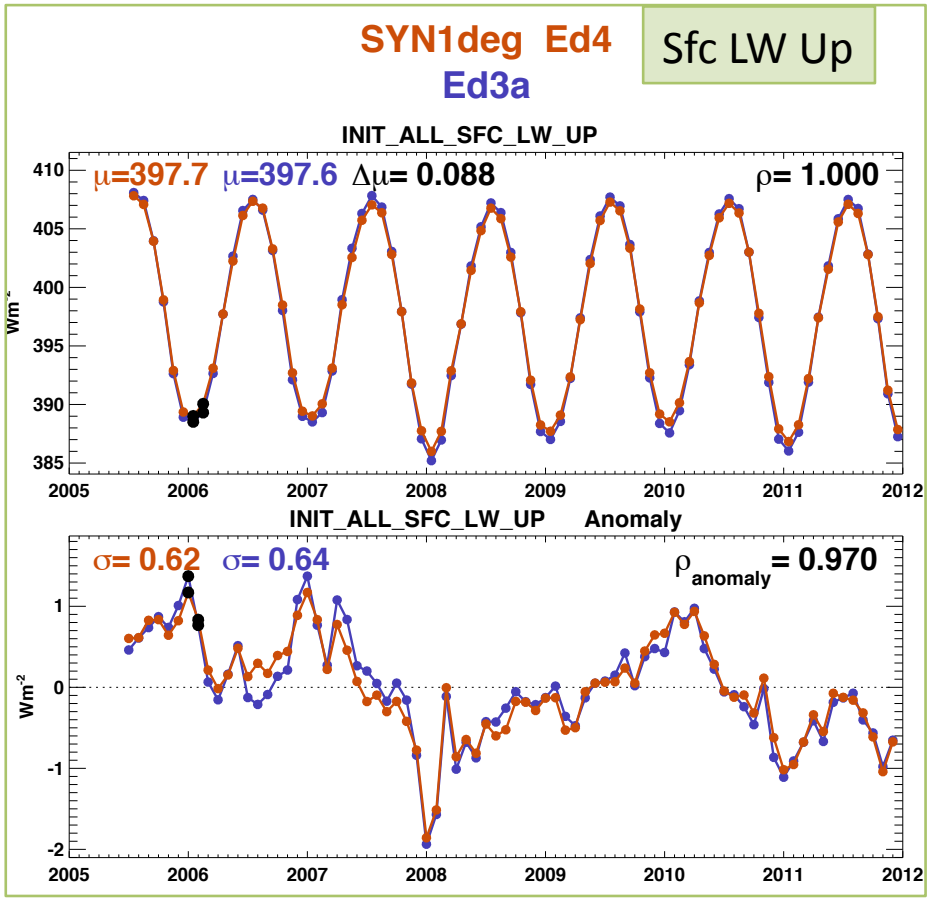




- Ed4 has less SW Surface Down than Ed3a (more clouds)
- Anomaly variance has become smaller in Ed4a.
- Anomaly correlation of Ed3a and Ed4a shows differences.

# Surface Longwave: Ed4a vs Ed3a



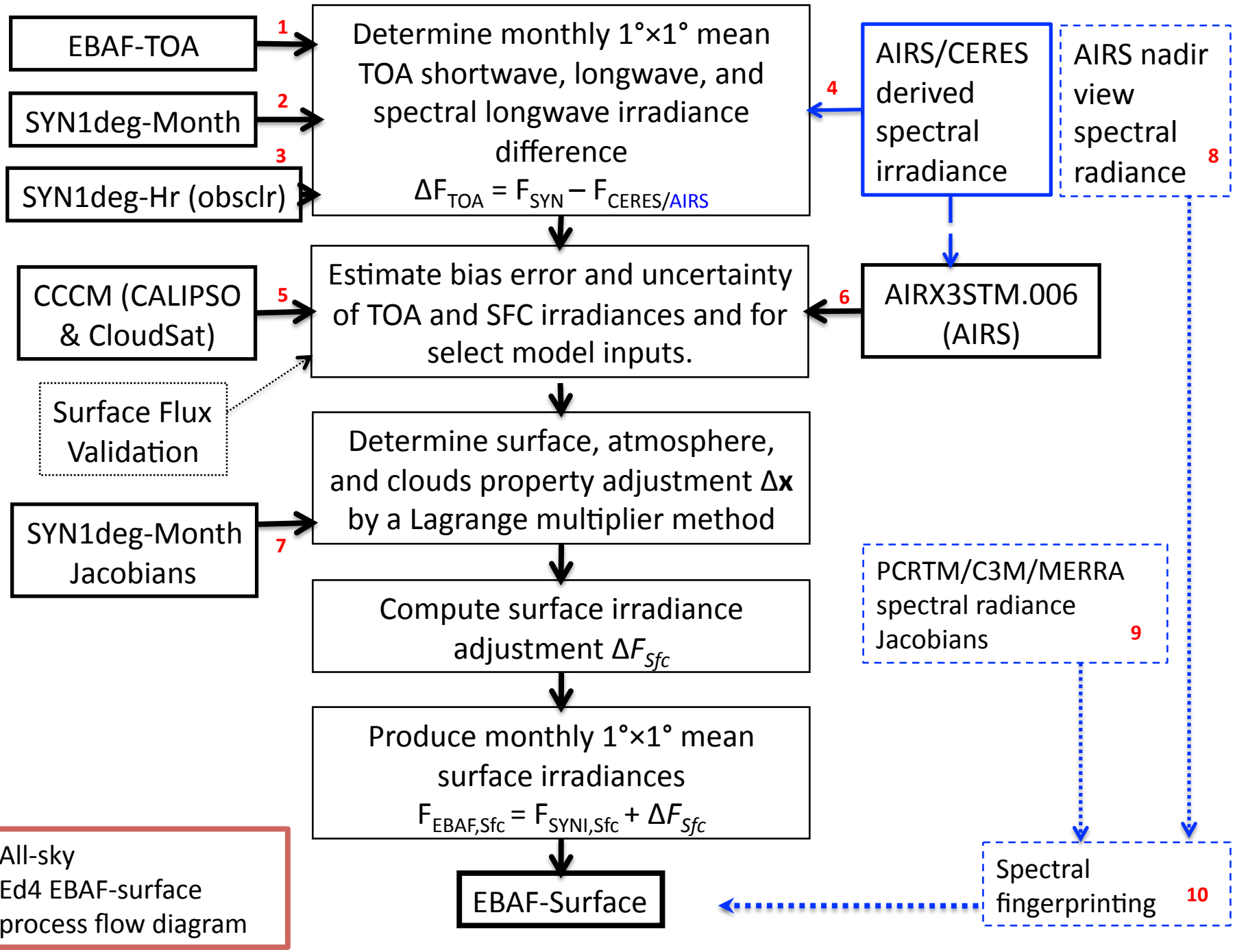




- Ed4 has more LW Surface Down than Ed3a (more clouds)
- Anomaly variance and correlation very similar between Ed3a & Ed4a.
- Clear Sky DLF also increases ( Geos5.4.1)

# What is “Surface Ebaf”

- Surface Energy Balanced & Filled is a monthly 1x1 deg surface broadband flux product that is made consistent with CERES (TOA_EBAF) &AIRS(ed4) fluxes, Modis and Geo based cloud properties, GMAO assimilation, Match aerosols, using uncertainty estimates of input properties (clouds, atmosphere and surface) and TOA and surface fluxes in a 1d radiative transfer (Fu-Liou) framework.


EBAF-TOA
1
SYN1deg-Month
2
SYN1deg-Hr (obsclr)
3
Determine monthly 1°×1° mean TOA shortwave, longwave, and spectral longwave irradiance difference
$\Delta F_{TOA} = F_{SYN} - F_{CERES/AIRS}$
4
AIRS/CERES derived spectral irradiance
AIRS nadir view spectral radiance
8
CCCM (CALIPSO & CloudSat)
5
Estimate bias error and uncertainty of TOA and SFC irradiances and for select model inputs.
6
AIRX3STM.006 (AIRS)
Surface Flux Validation
Determine surface, atmosphere, and clouds property adjustment Δ**x** by a Lagrange multiplier method
SYN1deg-Month Jacobians
7
PCRTM/C3M/MERRA spectral radiance Jacobians
9
Compute surface irradiance adjustment $\Delta F_{Sfc}$
Produce monthly 1°×1° mean surface irradiances
$F_{EBAF,Sfc} = F_{SYNI,Sfc} + \Delta F_{Sfc}$
EBAF-Surface
Spectral fingerprinting
10
All-sky
Ed4 EBAF-surface
process flow diagram

# Changes for Ed4 SFC_EBAF

- **Inclusion of  All-sky Airs spectral fluxes (X.Huang Michigan)**

- **Inclusion of Ceres window flux for clear sky**

- **Modification of uncertainties especially cloud fraction to account for:**
  **Different Ed4 All-Sky TOA SW and LW biases.**
  **Use of Airs Spectral Fluxes.**

- **Upper-Troposphere Humidity (options).**
  **A) Adjust to Model-AIRS error spectral flux (5 bands) in LMT.**
  **B) Modify Airs Lev3 UTRH Product using correlation of**
  **AIRS-Model 5band spectral flux error vs AIRSL3-MOA UTRH.**

- **Improved Jacobian computations**

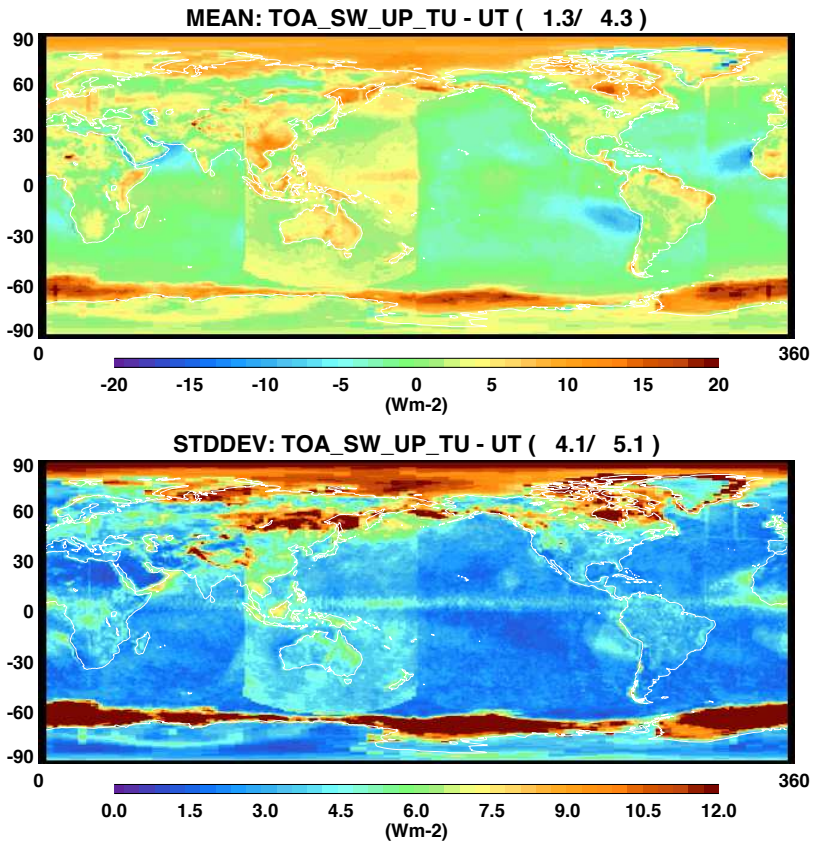
- **"cleaner" code / process flow**

# Prototype Ed4 SFC_EBAF Results

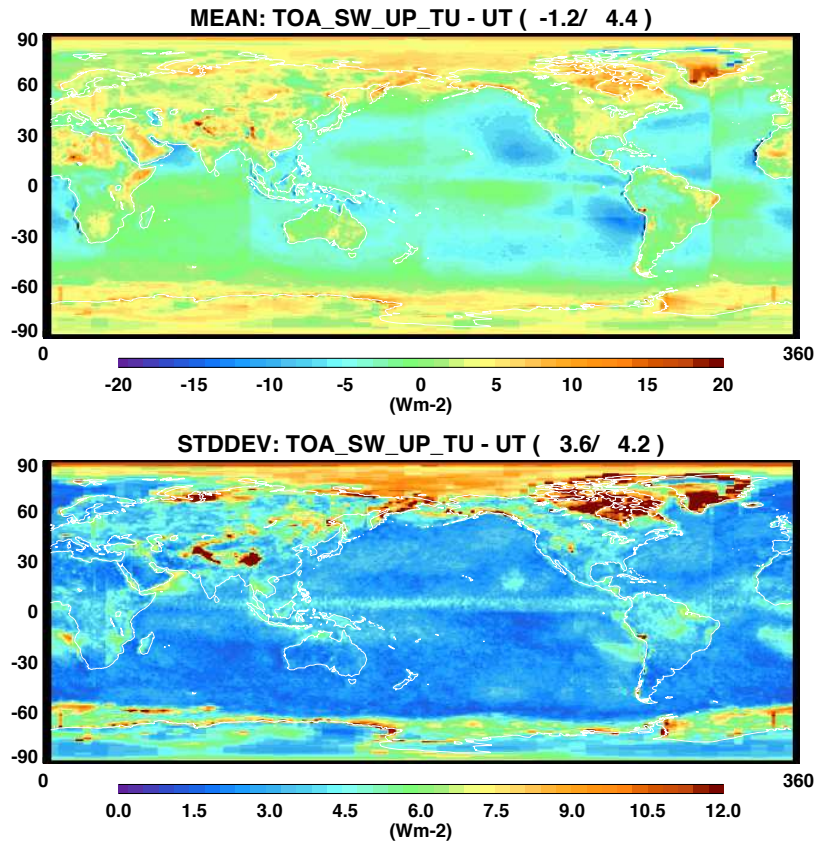
- Based on Ed4a Syn1deg-Month product
  - Ed4a has more (especially low cloud) fraction than Ed3a
- Still adjusting to Ed2.8 TOA EBAF SW and LW.
- Results shown are for Lagrange Multiplier only
  - NO UTRH pre-tuning to Airs Lev3 UTH
- Major points
  - Unadjusted TOA SW brighter than TOA_EBAF
  - Unadjusted TOA LW in closer agreement to TOA_EBAF
  - Unadjusted Sfc LW Down larger than Ed3
  - Decrease in cloud fraction necessary for TOA agreement.

# Toa Shortwave Reflected Flux Sfc_Ebaf adjustment

Ed3



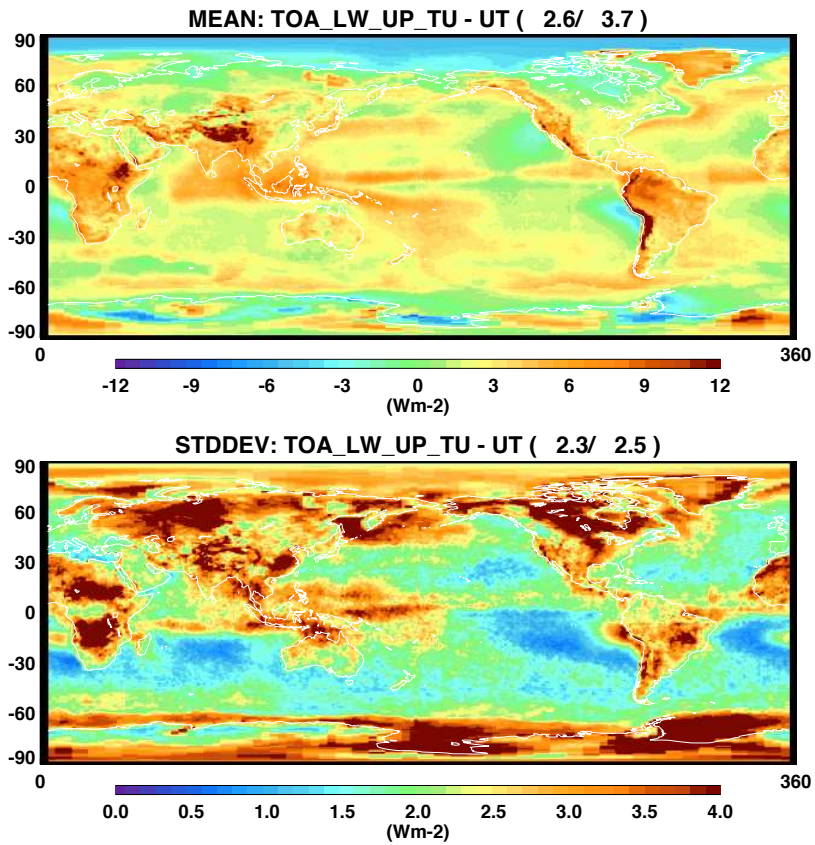

Ed4 prototype



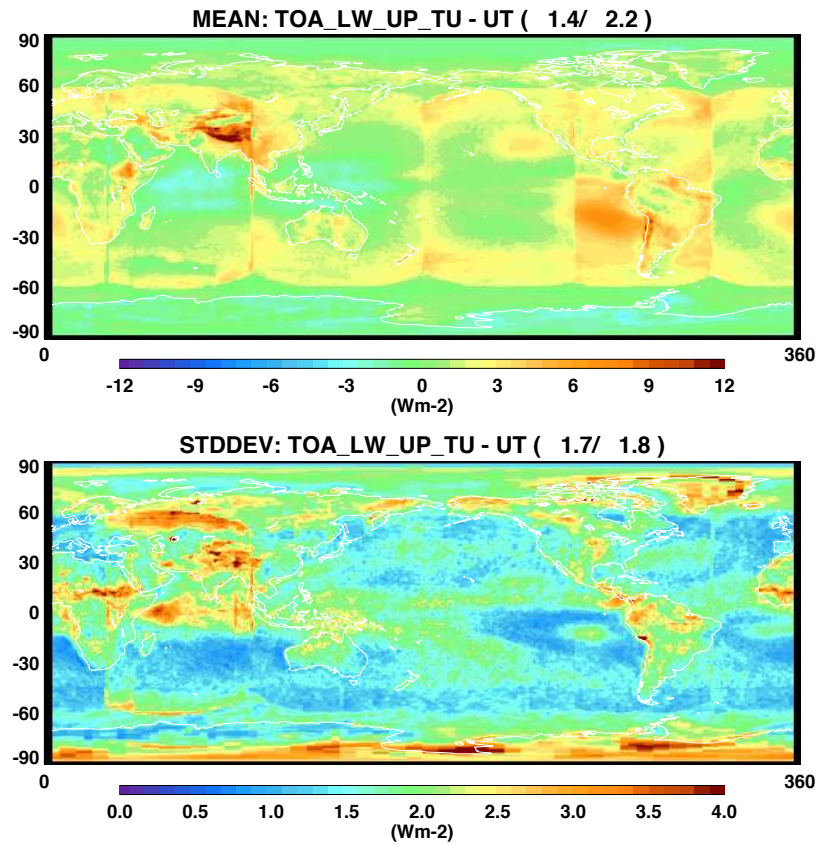

Ed4 Sfc_Ebaf needs to reduce SW TOA reflected to agree with Ed2.8 TOA EBAF

# Toa Longwave Flux
# Sfc_Ebaf Adjustment

Ed3



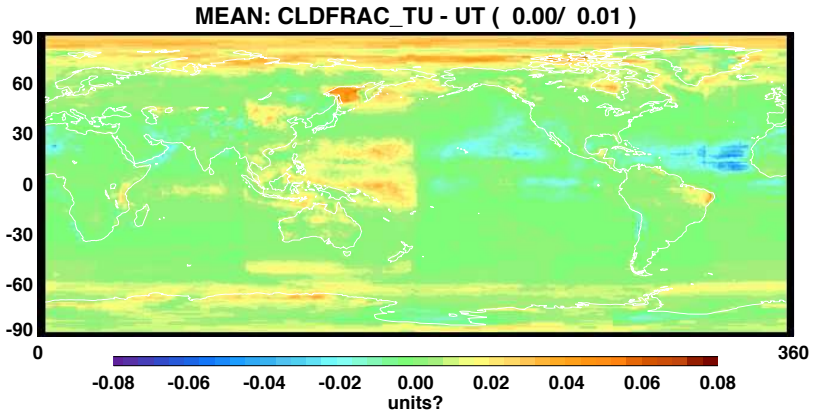

Ed4 prototype

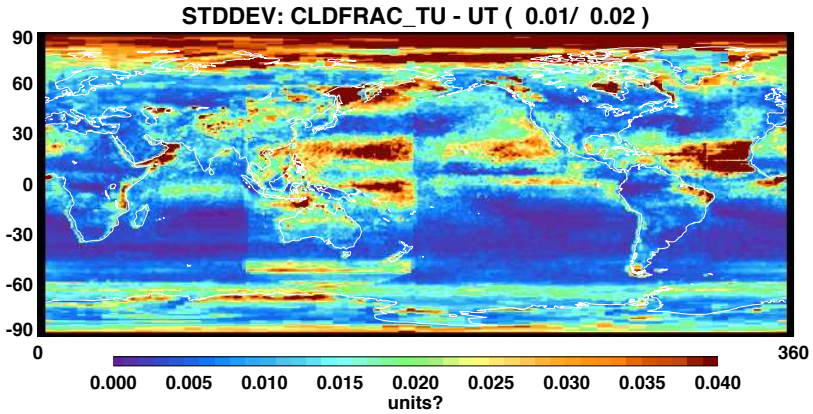



Ed4 Sfc_Ebaf needs to less LW TOA adjustment to agree with Ed2.8 TOA EBAF

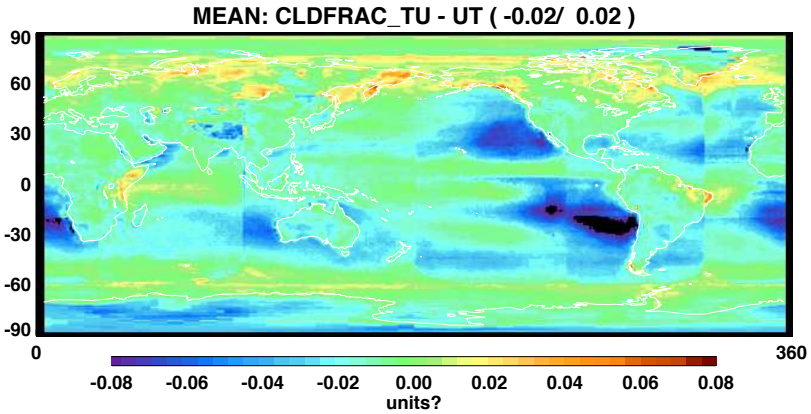
# Cloud Fraction
# Sfc_Ebaf Adjustment

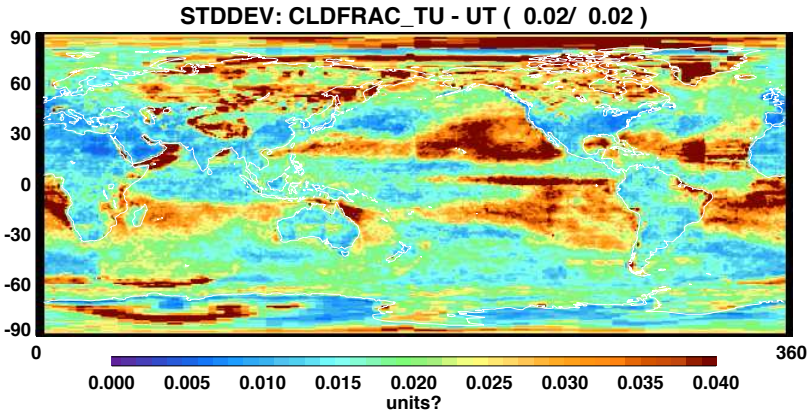
Ed3




Ed4 prototype

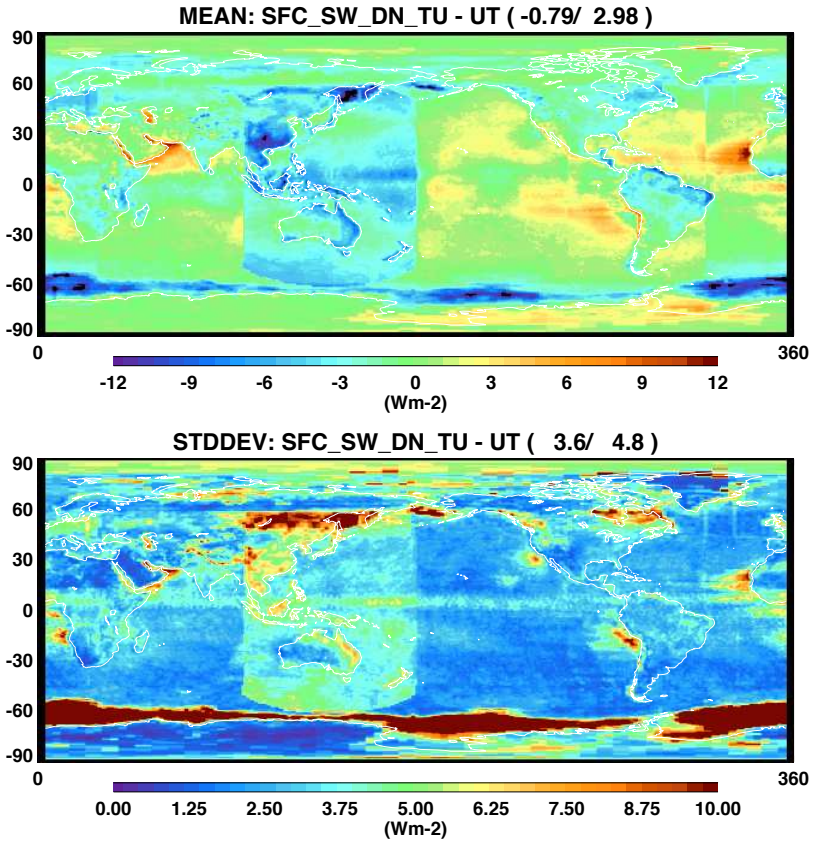


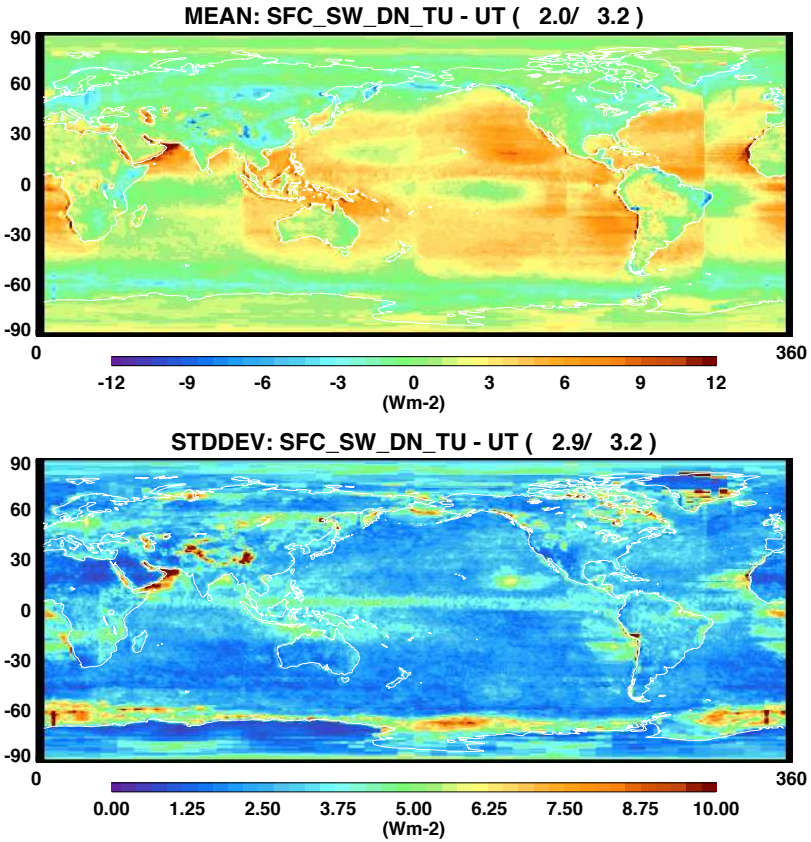

Ed4 Sfc_Ebaf reduces cloud fraction primarily to agree with Ed2.8 TOA EBAF SW

# Surface Shortwave Down Flux Sfc_Ebaf Adjustment

Ed3



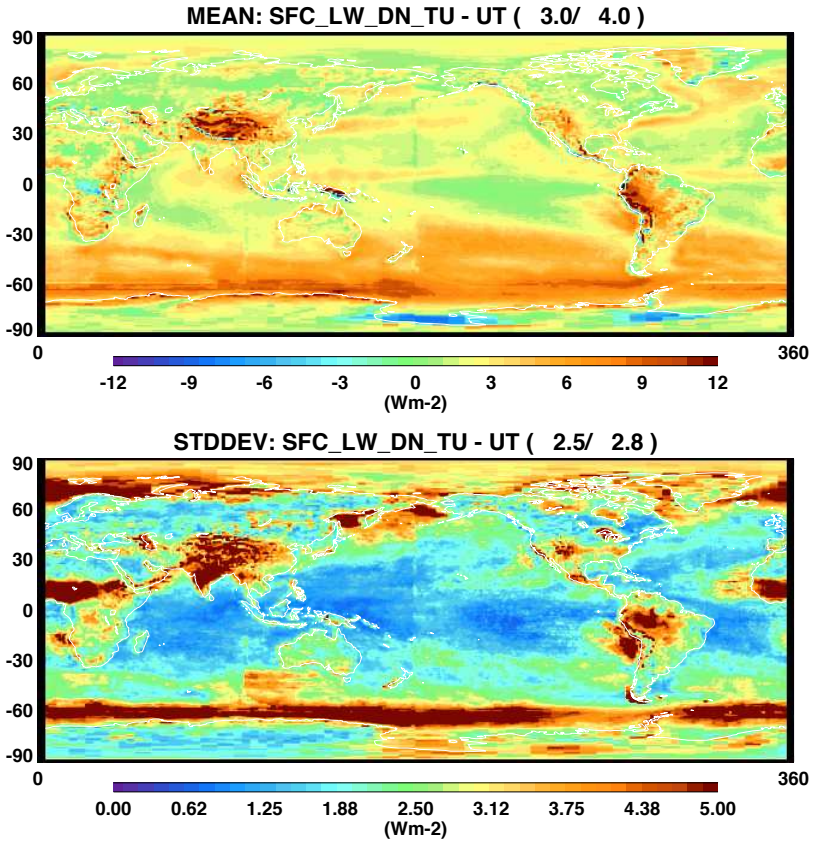

Ed4 prototype



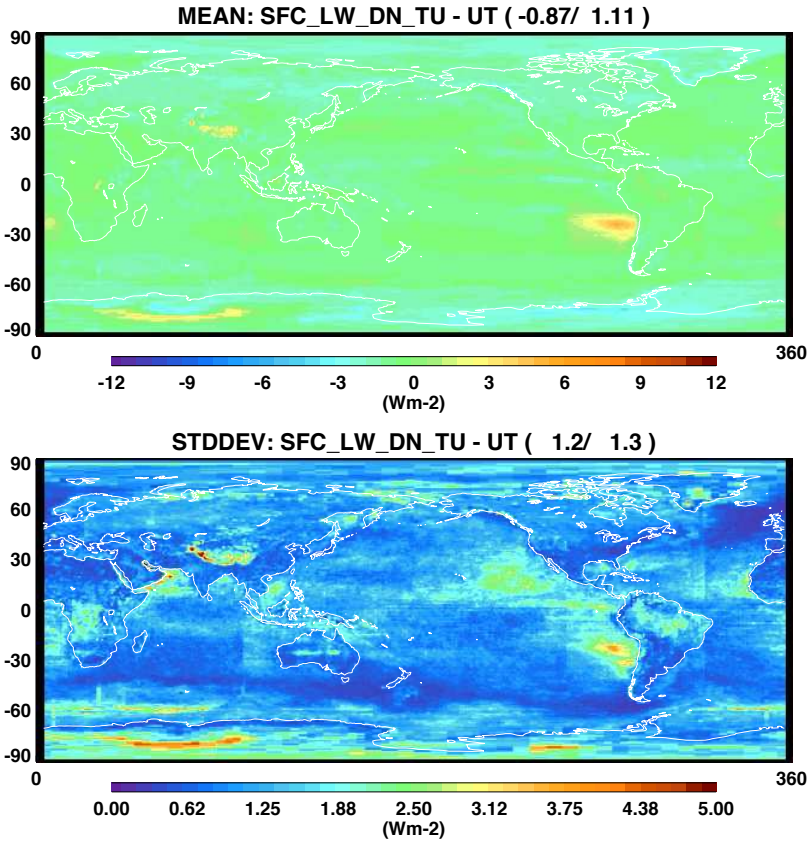

Reduction of cloud fraction in Ed4 Sfc_Ebaf increases Sfc. SW down.

# Surface Longwave Down Flux Sfc_Ebaf Adjustment

Ed3



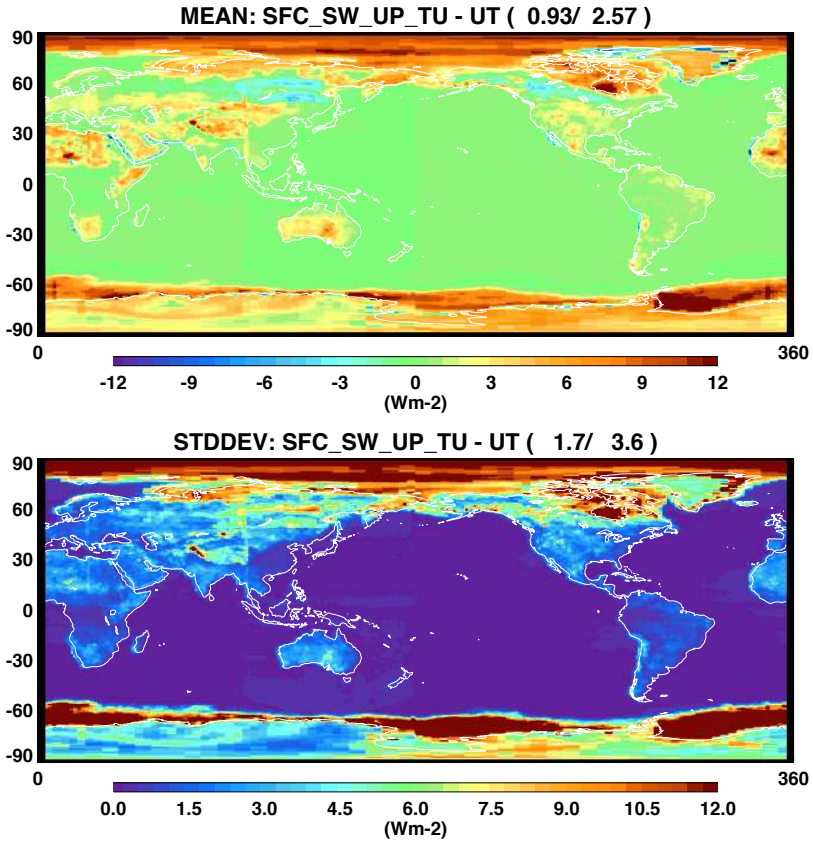

Ed4 prototype



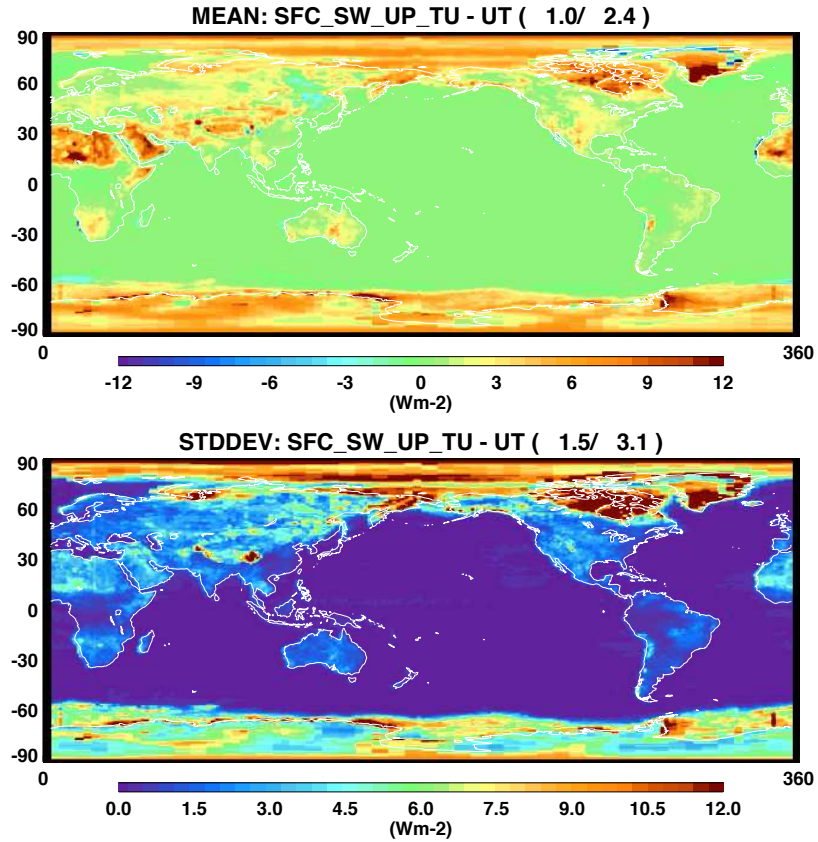

Less adjustment as Ed4 SYN has more cloud and has added a cloud overlap assumption on RT computation.

# SW Up Surface Flux
# Sfc_Ebaf Adjustment

Ed3



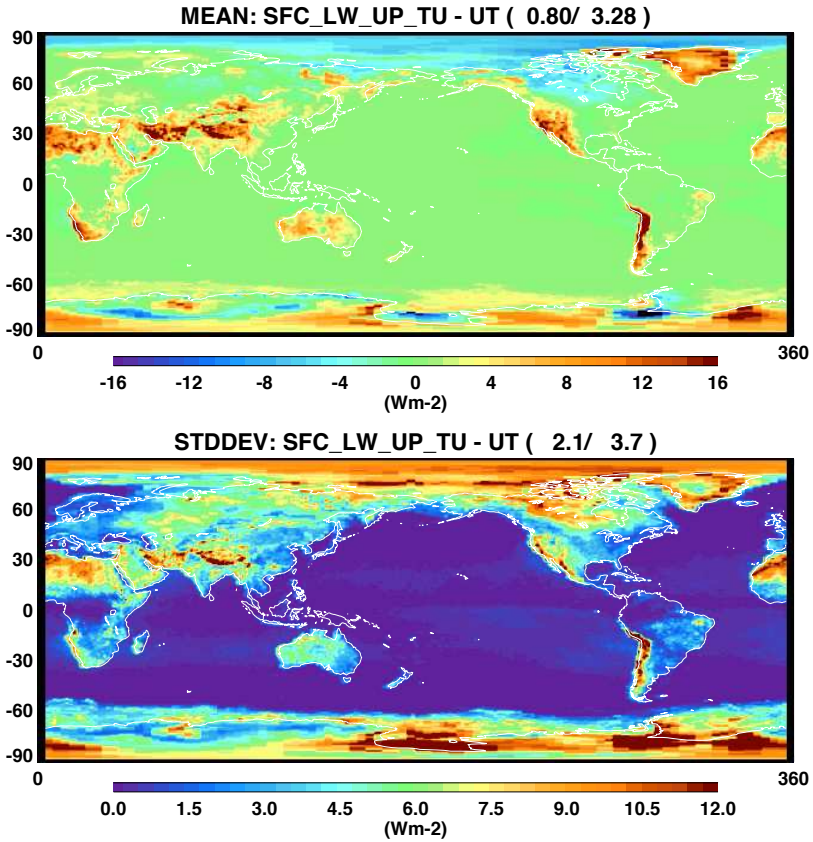

Ed4 prototype



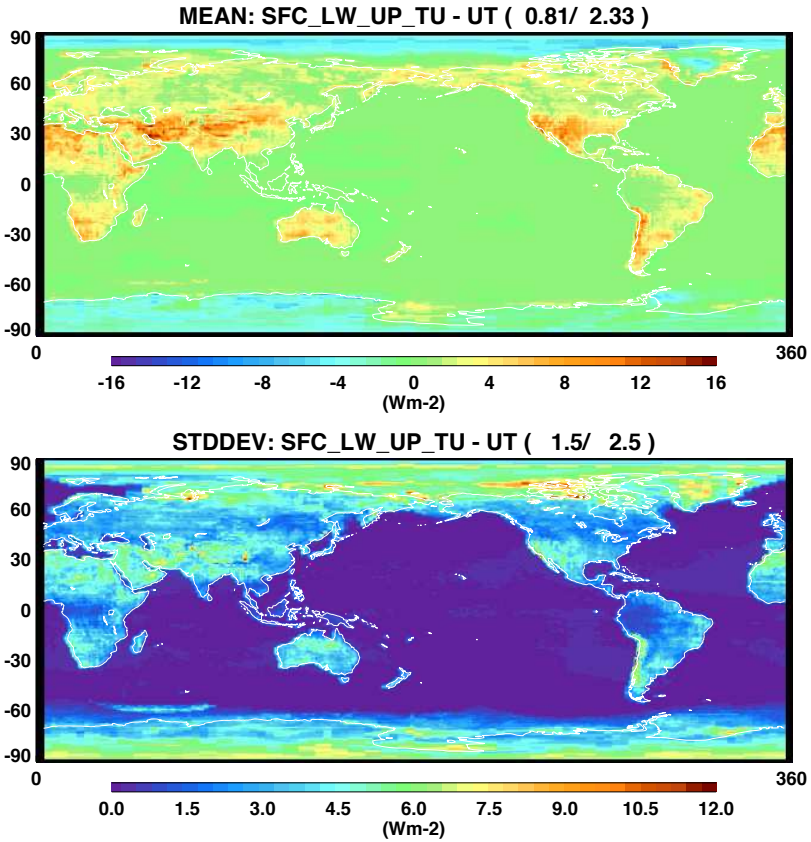

Better consistency in sea ice regions

# Surface Longwave Up
# Sfc_Ebaf Flux Adjustment

Ed3




Ed4 prototype




Ed3 had used GMAO Skint

Ed4 largely uses Modis/GEO Skint

# Global Mean:Syn1deg_Month & SFC_Ebaf (2008-2011)

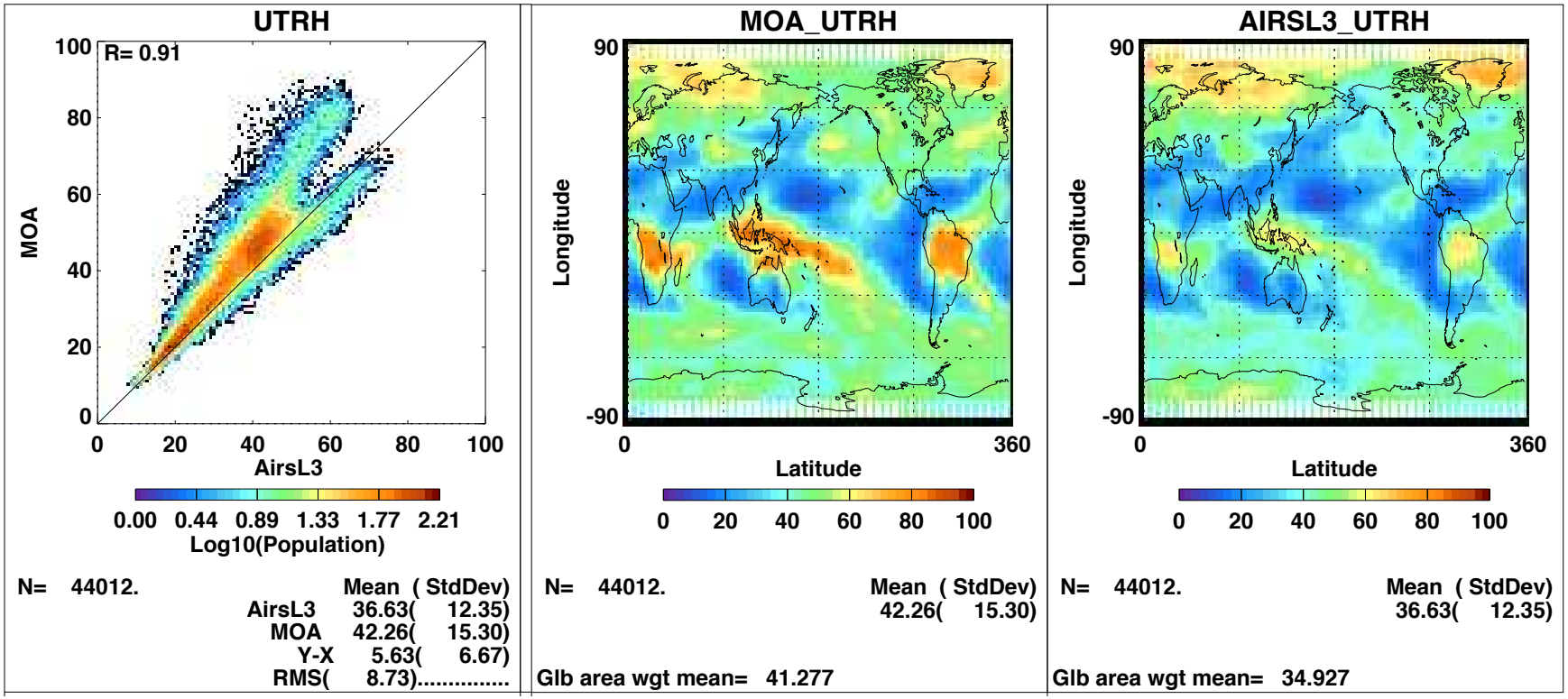
| SYN1Deg_Month | Ed3a | Ed4a | Ed4a –Ed3a |
|---|---|---|---|
| TOA SW Insolation | 341.0 | 339.9 | -1.1 |
| TOA SW Reflected | 98.4 | 100.9 | **2.5** |
| TOA LW | 236.8 | 237.9 | 1.1 |
| Surface SW Down | 187.1 | 184.0 | **-3.1** |
| Surface SW Up | 23.2 | 22.5 | -0.7 |
| Surface LW Down | 341.8 | 346.4 | **4.6** |
| Surface LW Up | 397.3 | 397.4 | 0.1 |

| SURFACE EBAF | Ed3 | Ed4_prototype | Ed4proto –Ed3 |
|---|---|---|---|
| TOA SW Insolation | 339.8 | 339.8 | 0.0 |
| TOA SW Reflected | 99.7 | 99.8 | 0.1 |
| TOA LW | 239.4 | 239.3 | -0.1 |
| Surface SW Down | 186.3 | 185.9 | -0.4 |
| Surface SW Up | 24.1 | 23.5 | -0.6 |
| Surface LW Down | 344.7 | 345.5 | **0.8** |
| Surface LW Up | 398.0 | 398.2 | 0.2 |

# Upper Troposphere Humidity Adjustment

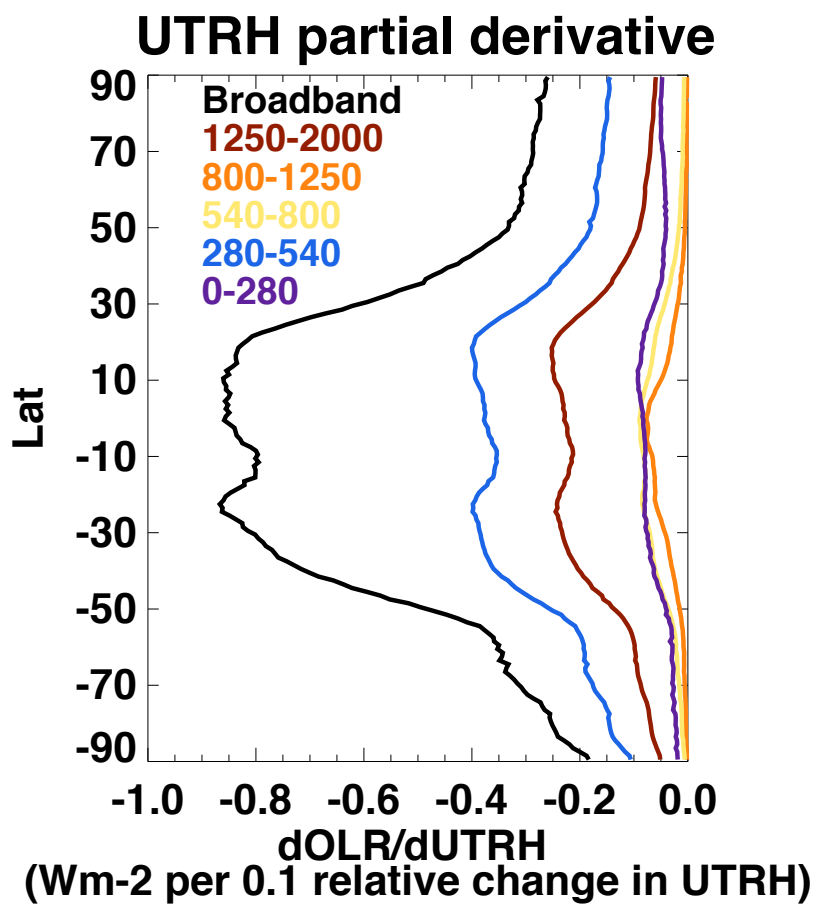
- MOA/Geos 5.4.1 Vs AIRX3STM.006 product
- UTRH adjustment:
  - A) AIRX3STM.006 UTRH ( used in Ed3 SFC_EBAF)
  - B AIRX3STM.006 UTRH modified using a correlation method to Airs spectral flux (X.Huang) minus SYN1deg (Fu-liou,Geos5.4.1)
  - C) Lagrange Multiplier result using Airs-Syn1deg spectral flux errors.
  - D) *Fingerprinting to Airs spectral nadir radiance*
    - *Consistency check*

# Modified UTRH
# using AIRS-SYN Spectral Flux Errors
# and AIRX3STM.006

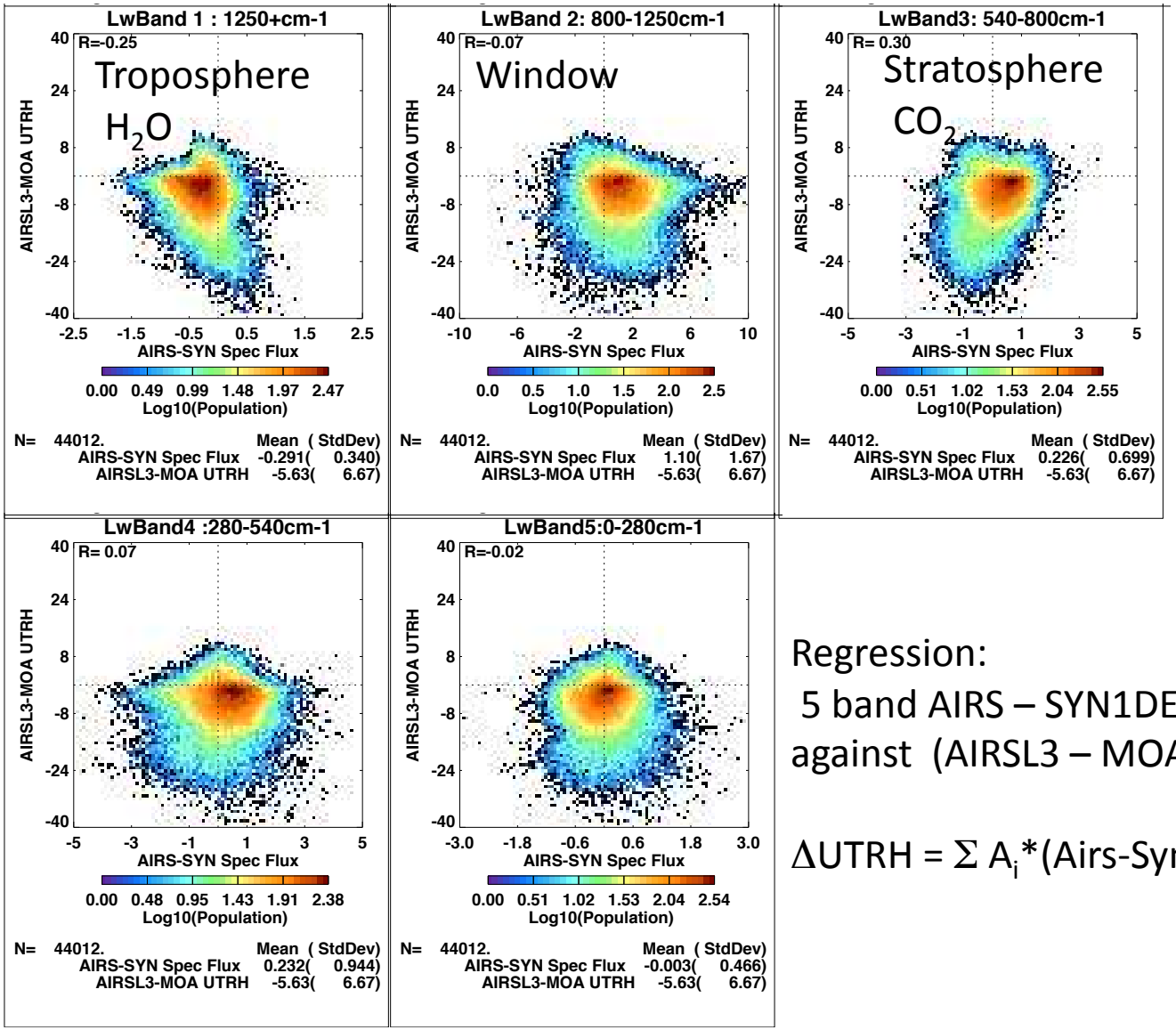


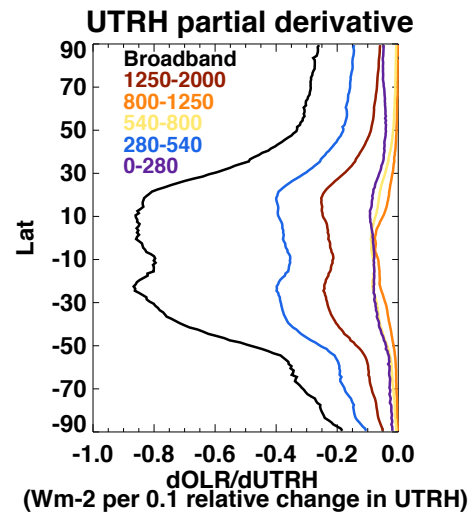

January 2008

# UTRH Sensitivity Fu-Liou Based Broadband and 5 LW Bands



# AIRS vs. G5.4.1 UTRH
# and Airs vs. Syn1deg All Sky Spectral Flux Differences



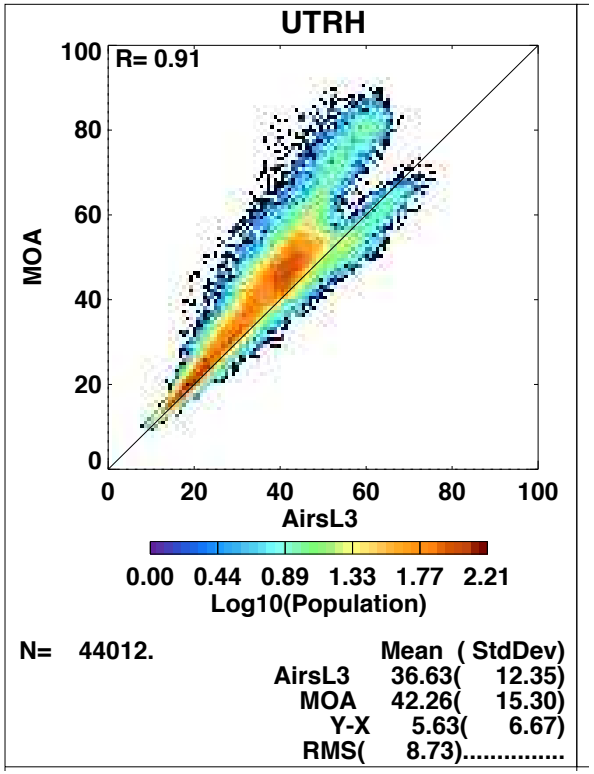



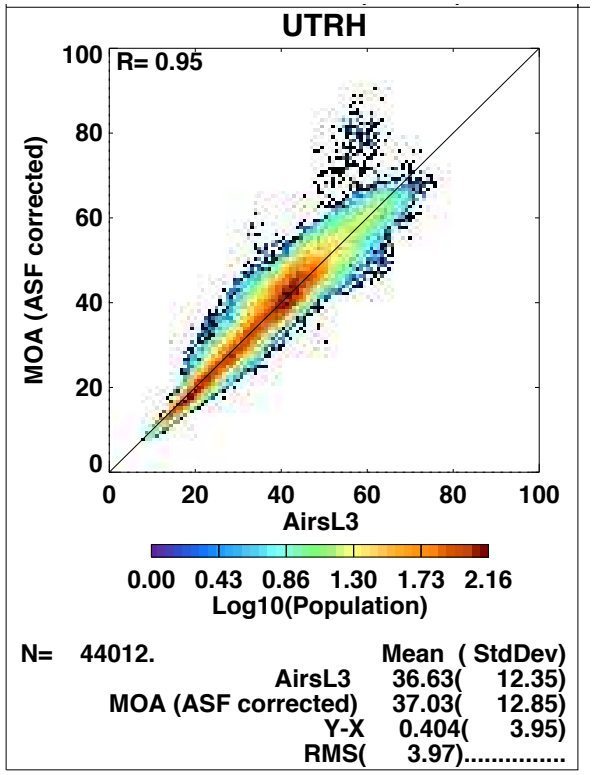

Regression:

5 band AIRS – SYN1DEG LW Δspectral flux against (AIRSL3 – MOA) UTRH

$$\Delta UTRH = \Sigma A_i*(Airs\text{-}Syn)_i + \Sigma B_i*(Airs\text{-}Syn)^2_i$$

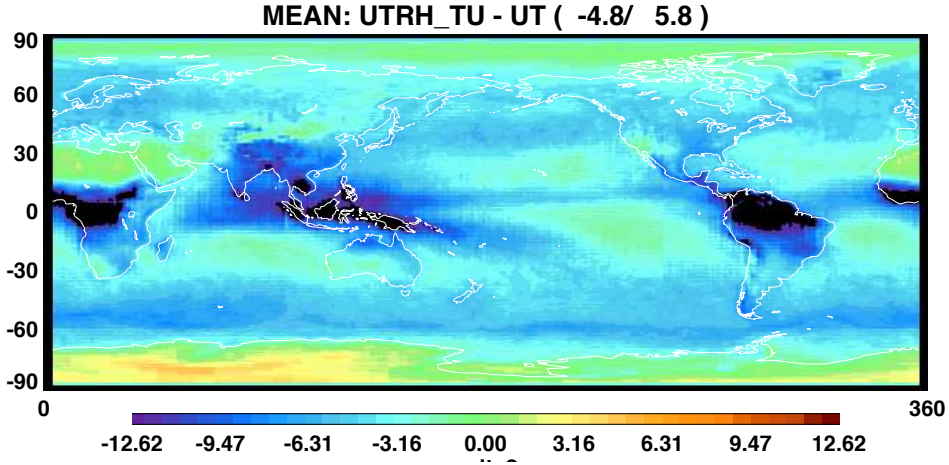
# Modified AIRS UTRH



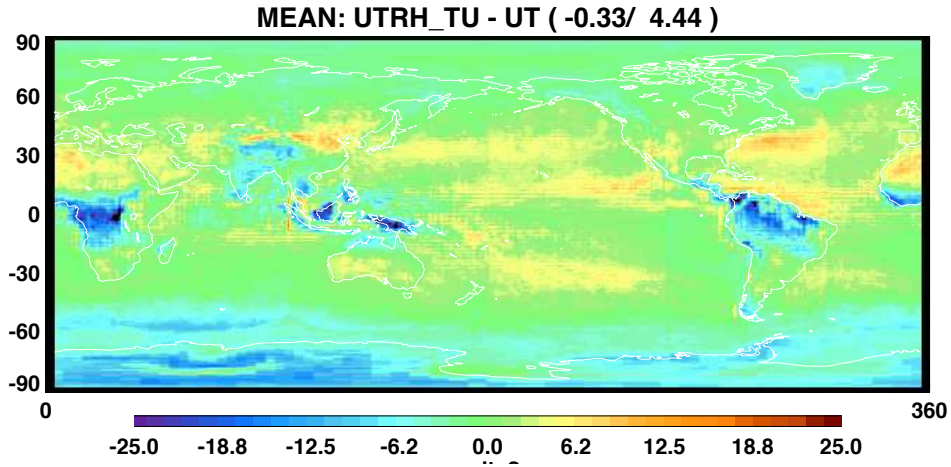



# UTRH Adjustment

Modified AIRSL3

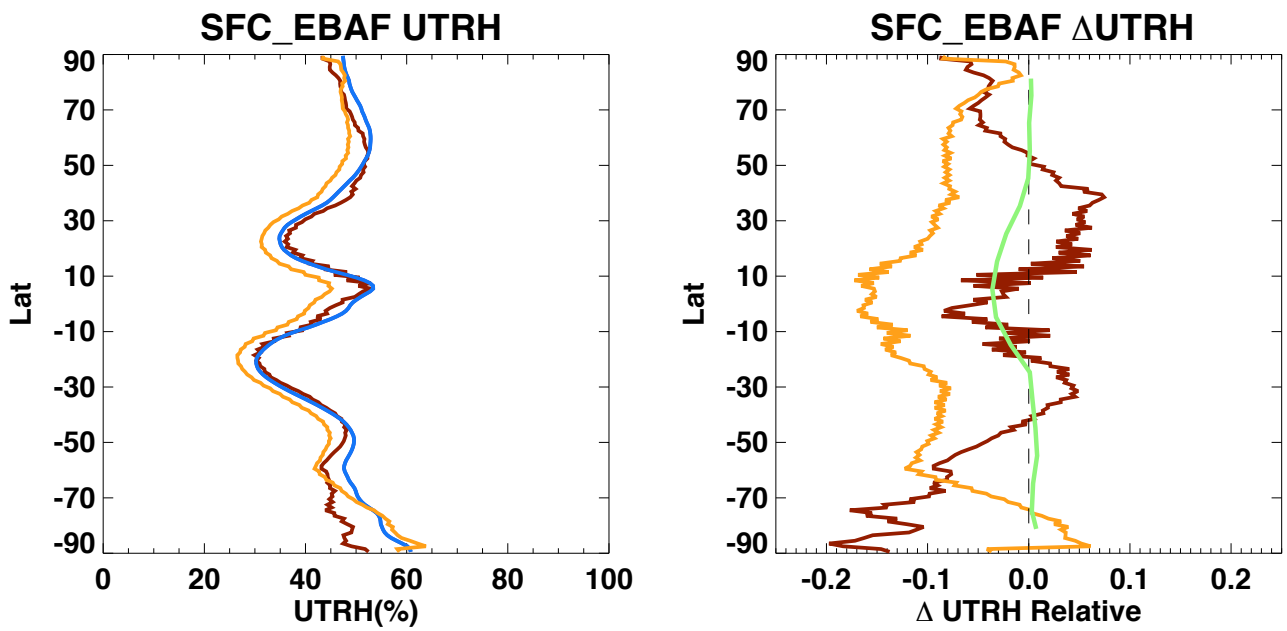



Lagrange Mult. to AIRS Spectral Shape ( 5 band)



# UTRH Adjustment

- Unadjusted MOA Geos5.4.1
- Pre-tuning to Modified AIRSL3 Product UTRH
- Lagrange Multiplier solution Airs Spectral Flux
- Fingerprinting to AIRS Radiances using PCRTM spectral model &C3M data



# Summary

- Ed4 Syn1Deg-Month
  - Better anomaly correlation of model and observed fluxes
  - More cloud fraction in Ed4
    - Larger bias against TOA EBAF SW
    - Less Surface SW Dn / More Sfc LW Dn
- Sfc Ebaf prototype
  - Uses Airs Spectral Flux primarily for UTRH adjustment
  - Reduces Cloud fraction to achieve TOA SW consistency
    - Similar Global Mean Surface Fluxes to Ed3

# Backup Slides

# SFC EBAF Processing Overview

1. Monthly average :
   MOA , MATCH , Syn1deg_Month, TOA_EBAF , AIRSL3V6, Airs Spectral Flux (X.Huang)
2. Create Jacobians using monthly mean grid-box data
   Cloud (Fraction, Top & Base Pressure, Optical depth)
   Surface( Skin & Near surface Temperature, Albedo)
   Atmosphere( Precipitable Water, Upper Troposphere RH, Aerosol Tau)

3. Compute monthly mean "clear sky" when observed from theoretical clear
Syn1deg Hourly for Fluxes & input variables?

4. Merge and verify data from TOA_EBAF, SYN1DEG, AIRS Spectral Flux, Observed Clr Flux

5. Option: A ) Pre-tune OLR to Airs Lev3 UTRH ( as in Ed3 SFCEBAF)
   B ) Pre-tune OLR to AIRS Lev3 UTRH Product using correlation of
   AIRS-Model 5band spectral flux error vs AIRSL3-MOA UTRH
   C ) No UTRH Pretune

6. Lagrange multiplier adjustment to:
   TOA_EBAF SW ,LW & AIRS Spec Flux "Shape" normalized to TOA EBAF LW
   Surface bias adjustment. ( C3M DLF, Surface Sites??)

# Notes on the flow diagram

1. All-sky irradiances from Ed4 EBAF-TOA
2. Monthly 1x1deg All-sky untune computed irradiance from Ed4 SYN1deg
3. Monthly 1x1deg Clear Sky when observed clear (toa& sfc untuned model) from Syn1deg-Hr
4. The bias correction is derived by regressing the difference of UTRH from GEOS (MOA) and AIRS level 3 with the difference of AIRS and SYN1deg spectral irradiances. This process might not be needed because IR spectral irradiance can be directly used in Lagrange Multiplier solution.
5. C3M Surface downward longwave irradiance **bias** correction is derived for Ed3. But use Ed4 and Ed3 downward longwave irradiance difference to adjust the downward longwave bias correction for Ed4. C3M data also used for Cloud (fraction, height,tau) **uncertainty.**
6. Upper tropospheric relative humidity **bias** correction using Level 3 AIRS data. AIRX3STM.V006 also used for skin and sfc air temperature **uncertainty**
7. Compute Toa and Surface flux Jacobians from SYN1deg-Month , MOA, Match for each grid box.
8. AIRS nadir spectral radiance data (X.Huang / U Mich.)
9. PCRTM longwave spectral radiance model using C3M clouds and MERRA atmosphere inputs to compute spectral radiance and Jacobians..
10. Retrieval of skin temperature, air temperature, and water vapor mixing ratio biases in GEOS using IR spectral radiance difference between computed with GEOS thermodynamic variables and CALIPSO/CloudSat clouds (C3M) and observed nadir view AIRS spectral radiances. Provides a consistency check between skin temperature, air temperature, and humidity adjustments and those derived from the Lagrange Multiplier process .