Ed4 SURFACE_EBAF
Part1) Algorithm and Flux Differences from Ed2.8

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Surface EBAF :: What is it.

Surface Energy Balanced & Filled ED4_SFC_EBAF is a monthly , 1°x1^{o} deg surface broadband flux product that is made consistent with CERES (TOA_EBAF) SW and LW fluxes, MODIS and Geostationary based cloud properties, GMAO GEOS 5.4.1 assimilation, MATCH aerosols, using uncertainty estimates of input properties (clouds, atmosphere and surface) and TOA and surface fluxes within a 1d radiative transfer (Fu-Liou) framework.

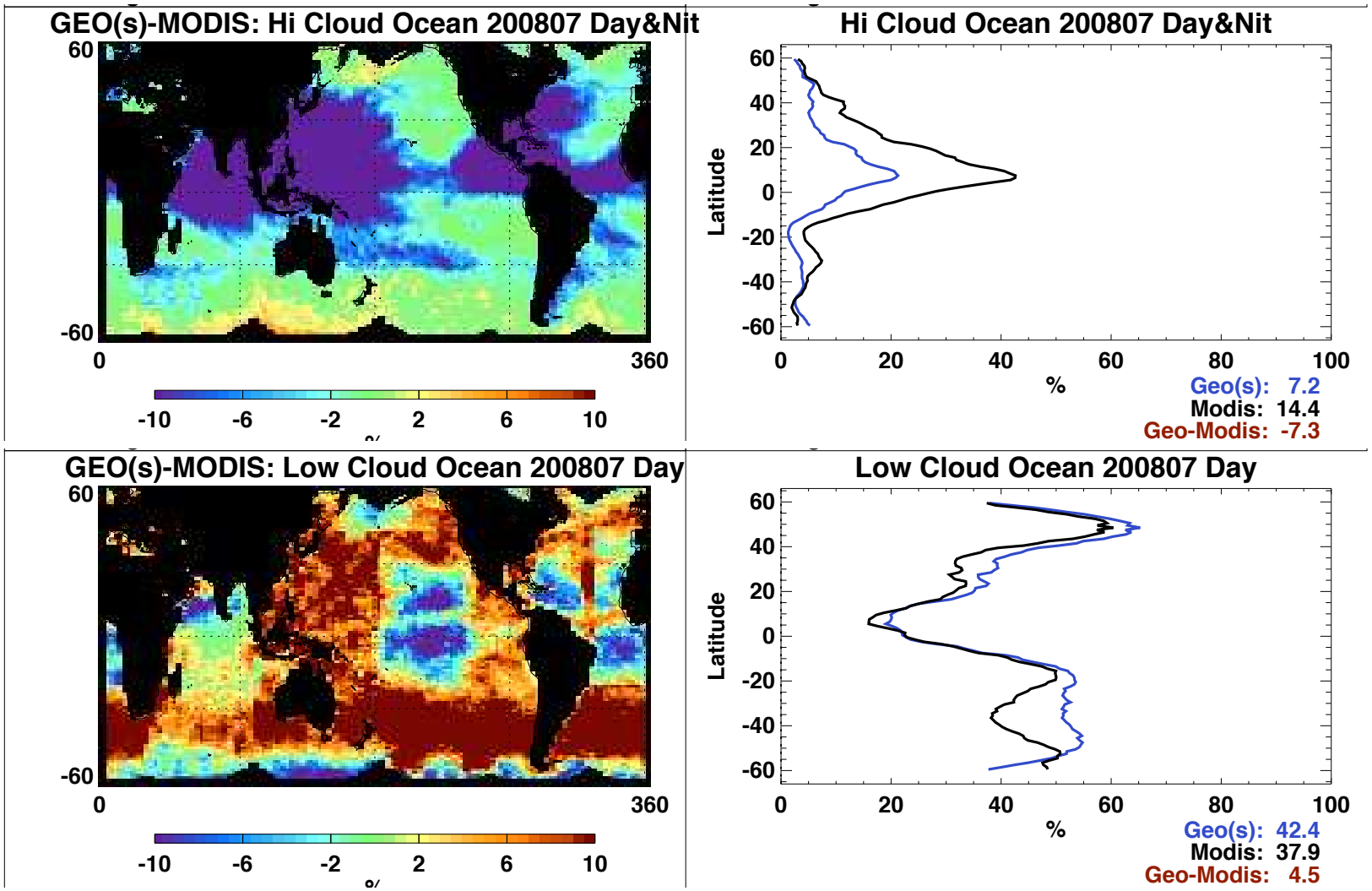
Surface EBAF:: What new for Ed4 Inputs

- Use of Ed4 CERES product throughout.
- Geos5.4.1 replaces mix of Geos4 & Geos5.2
  - No discontinuity in 2008.
- MATCH Ed4 MODIS col5 based aerosol.
- Modified bias adjustments prior to Lagrange Multiplier.
- Surface Flux uncertainties bootstrapped from unadjusted model Ed4-Ed3 differences

Input to SFC_EBAF :Ed4 Differences

- Ed4 TOA_EBAF
  - SW All Sky 0.39 Wm-2 Darker than Ed2.8
  - LW All Sky 0.54 Wm-2 Warmer ..
  - SW Clear Sky 0.91 Wm-2 Brighter…
  - LW Clear Sky 2.54 Wm-2 Warmer….
- Ed4 has larger cloud fraction
  - GEOs have more Low cloud fraction
  - MODIS has better thin ice cloud detection
  - Less Clear sky sampling
    - Increases Observed Clear Sky OLR

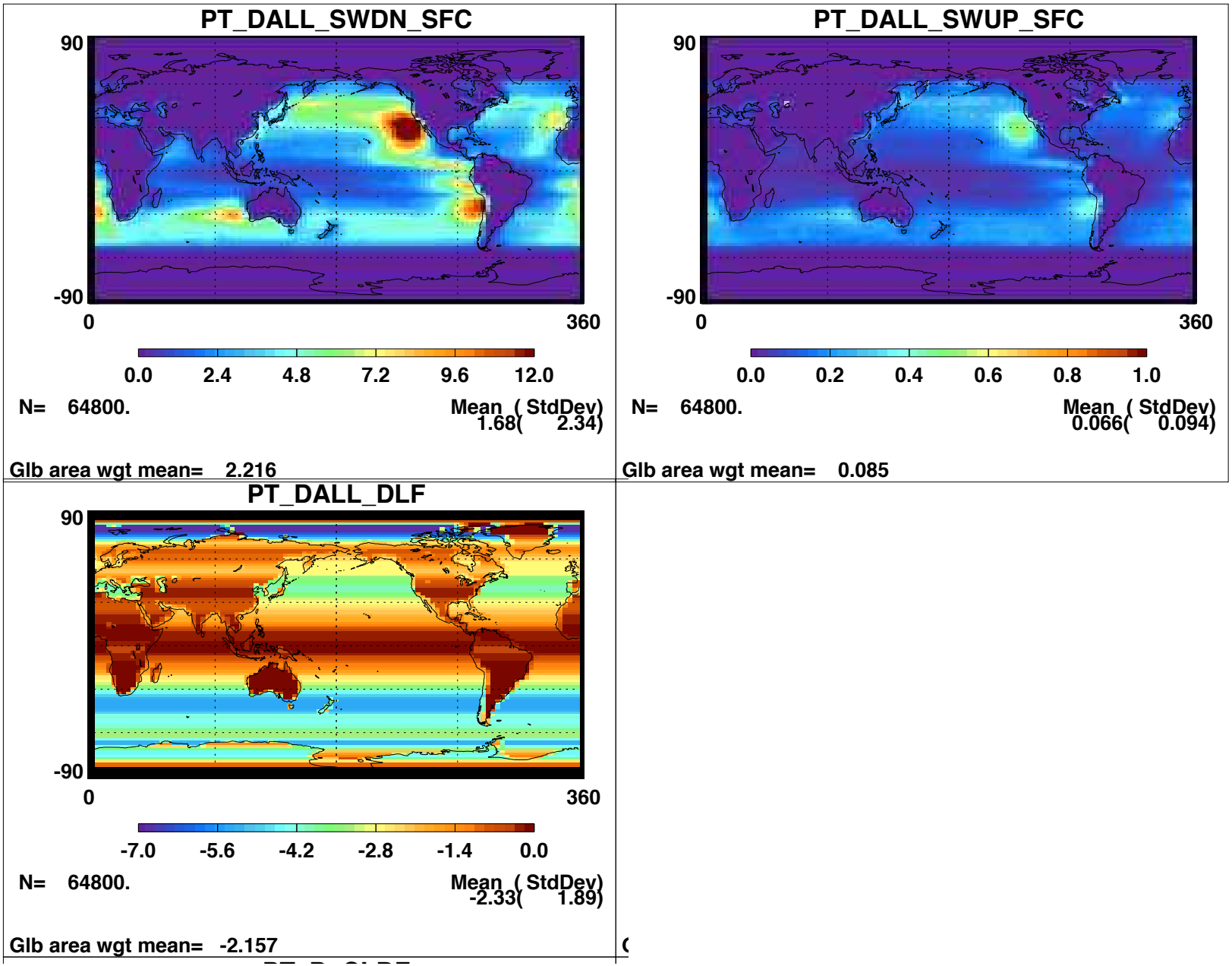
Geo vs Modis Cloud Amount Biases



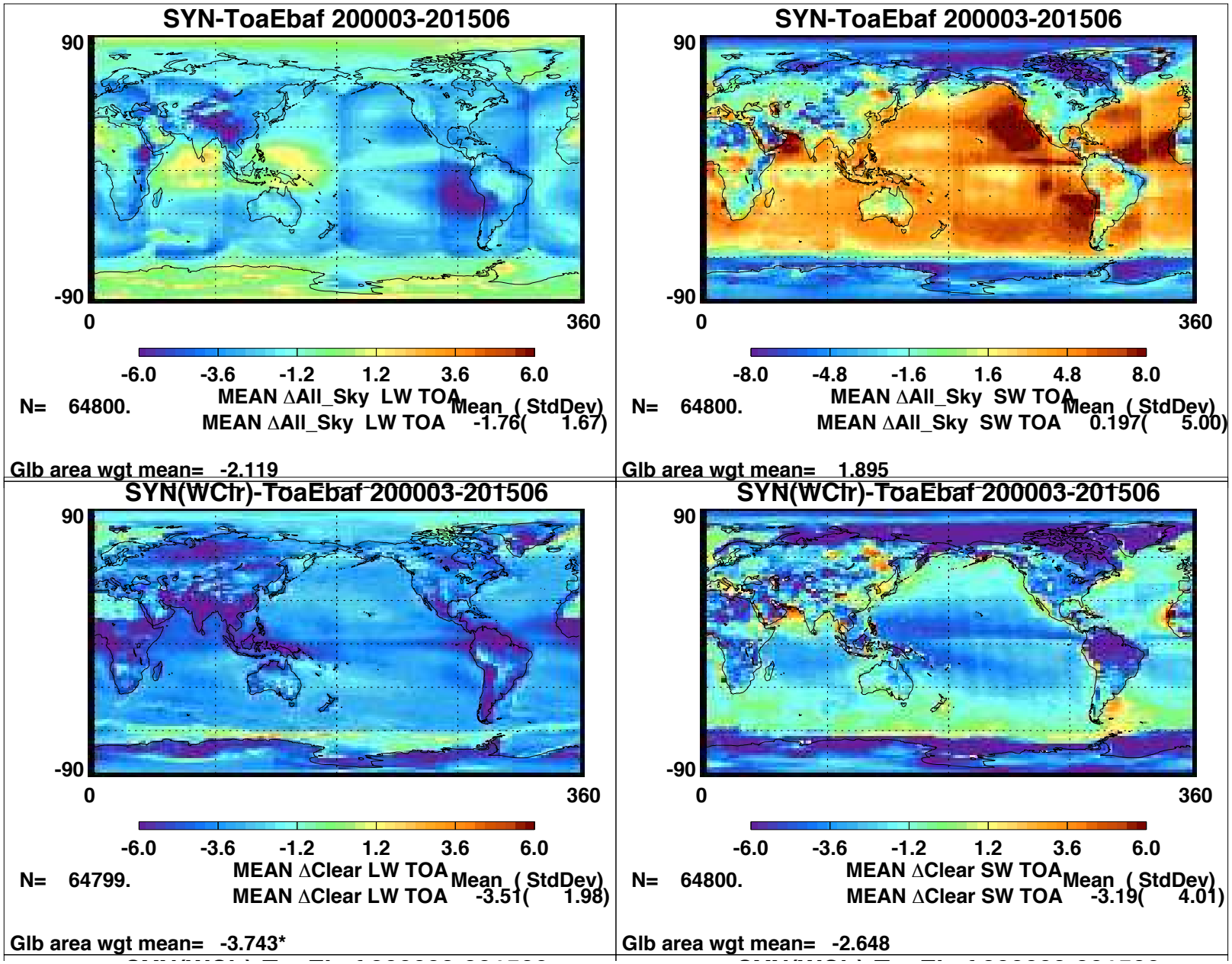
Surface EBAF:: Ed4 Process

- Surface EBAF consists of two basic processes
  1. Bias Corrections
  2. Lagrange Multiplier Adjustments
- Ed4 has Enhanced Bias correction adjustments
  - Replaced Bulk Upper Troposphere Humidity adj.
    - dOLR/dT(z) and dOLR/dQ(z) adj. to AIRX3STM.006
    - Clear and All Sky
  - Correction of GEO/MODIS *bottom* view cloud fraction and base to a Calipso/CldSat zonal monthly climatology
    - dSFC_LWdn /dCF(bottom view)
    - dSFC_LWdn /dCloud_Base
  - Use of a GEO/Modis *vs* Calipso/CldSat *top* view cloud low cloud fraction over ocean as a zonal relative percentage adj. applied on the monthly grid scale to bias correct
    - dSW_TOA/dCF, dSFC_SWdn/dCF , dOLR/dCF

Bias Adjustments to Surface Fluxes



Unadjusted Model – TOA_EBAF(OBS)



SFC EBAF Basic Concept
SW TOA Albedo vs SFC Transmission

- Shown here by Bob Cess (1995)
- Reflectance + Transmittance + Absorptance = 1
- In SFC EBAF we adjust primarily clouds to match TOA_EBAF albedo resulting in a modified SFC transmission
- TOA fluxes have less influence on SFC LW Down

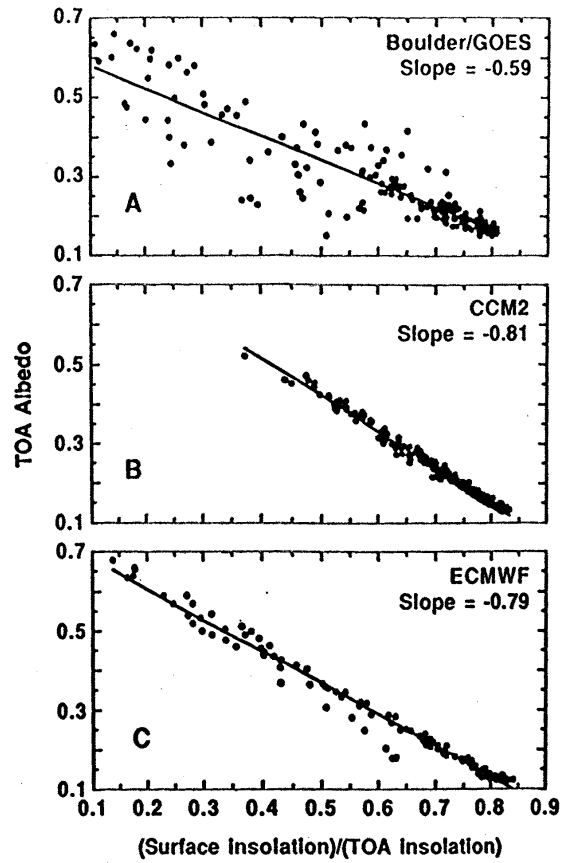


Fig. 2. (A) Scatter plot of the GOES TOA albedo as a function of surface insolation (measured at the BAO tower) divided by the TOA insolation. (B) The same as (A) but for CCM2. (C) The same as (A) but for the ECMWF GCM.

Lagrange Multiplier Concept

$$\sum_{i=0}^{n} (Fki\ \Delta Ci\ ) + \sum_{i=0}^{n} Ci \sum_{j=1}^{m} ((\delta Fki/\delta \nu j)\Delta \nu j\ ) - \Delta Fk = \varepsilon Fk$$

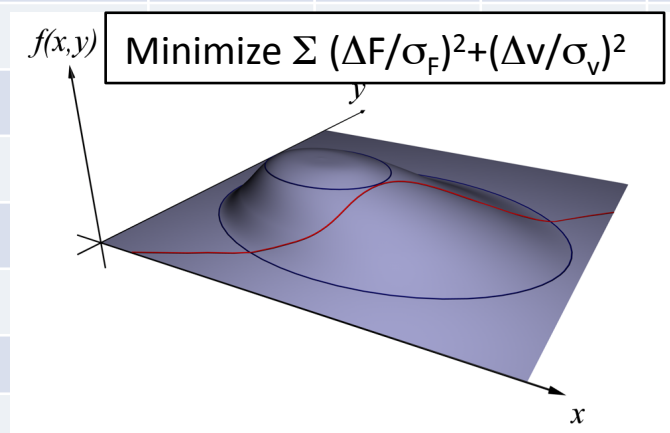
$\Delta F k$ are the TOA Model – Observed *bias corrected* Flux differences

Surface differences assigned to zero after bias correction.

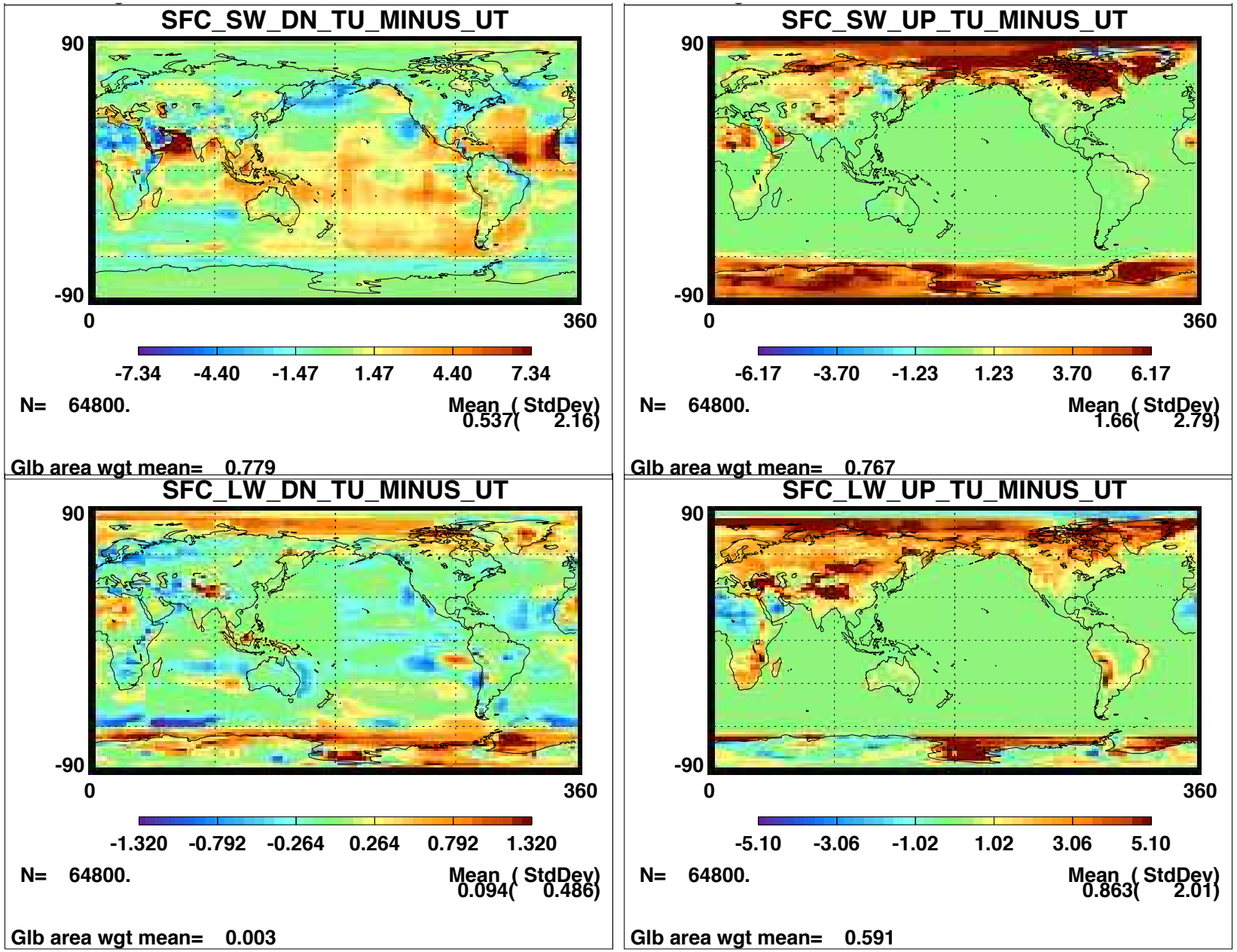
$\varepsilon F k$ are the 1sigma uncertainties assigned to flux component.

Resulting variable adj. $\Delta \nu j$ forces TOA agreement causing SFC flux modifications

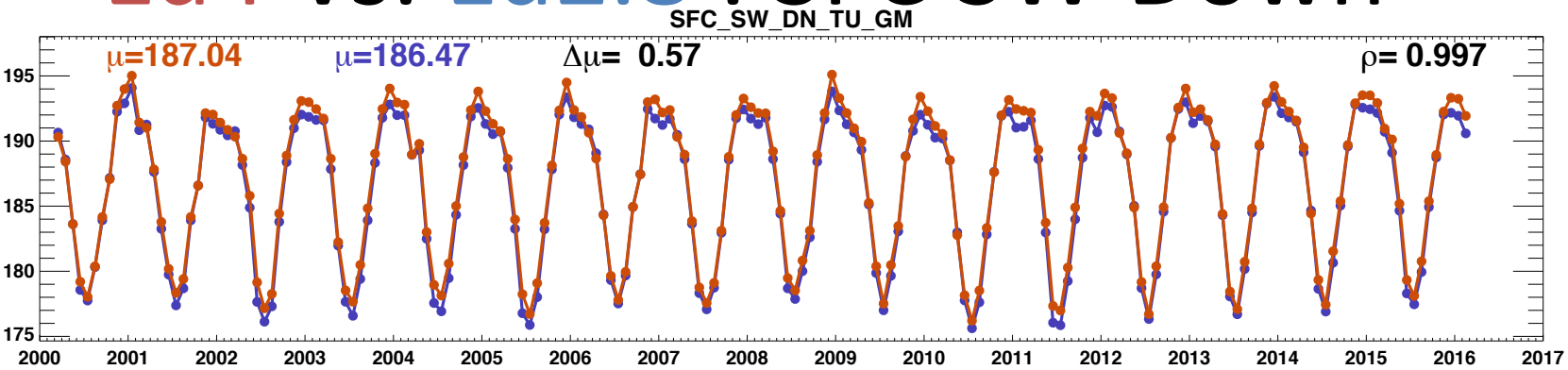
Fluxes / Variables	SW TOA	LW TOA	SW Sfc Dn	SW Sfc Up	LW Sfc Dn	LW Sfc Up
SkinT	df/dv*δv*Δv					
SfcAirT						
PW(sfc:500)						
PW(200:500)						
AOT						
SfcAlbedo						
Cld Optical Depth						
Cld Top						
Cld Base						
Cld Fraction	Method uses a set of Overcast-Sky and Clear-Sky Partial Derivatives					

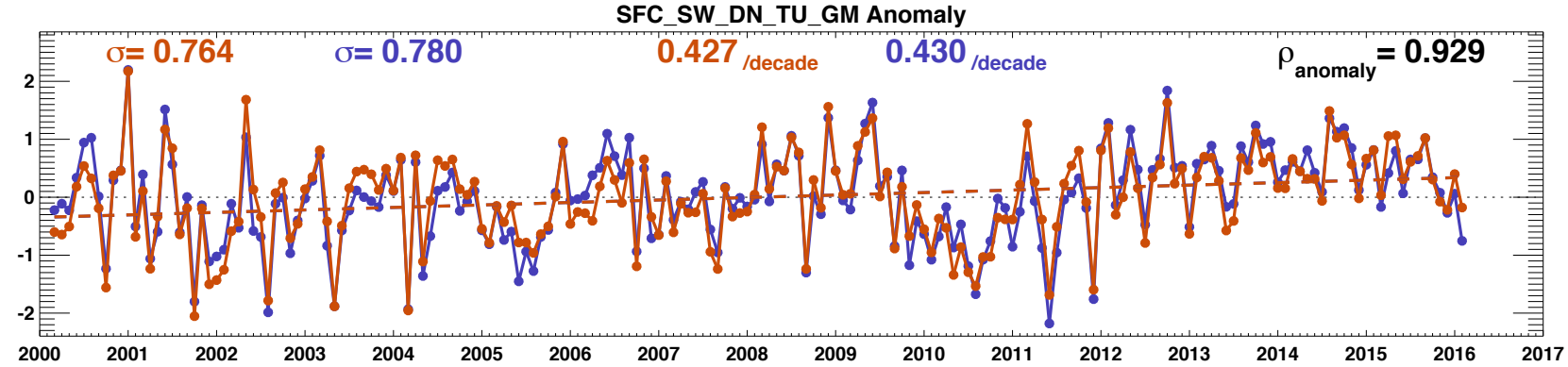


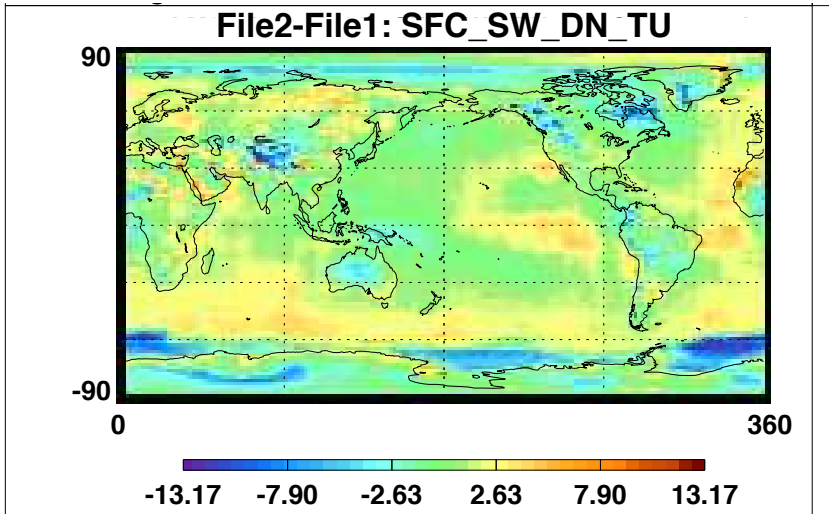
Lagrange Multiplier Adjustments to SFC



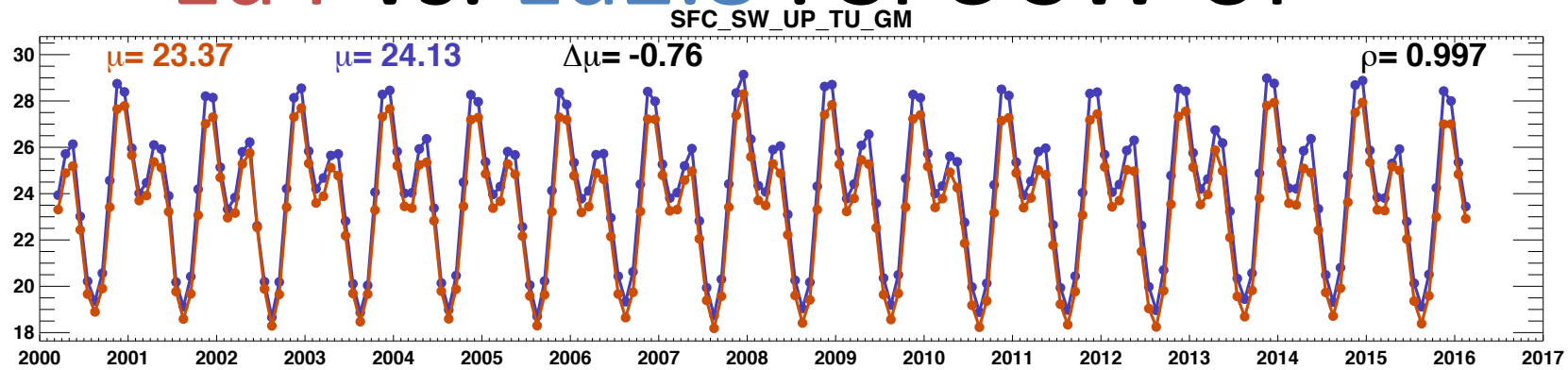
Ed4 Vs. Ed2.8 : SFC SW Down

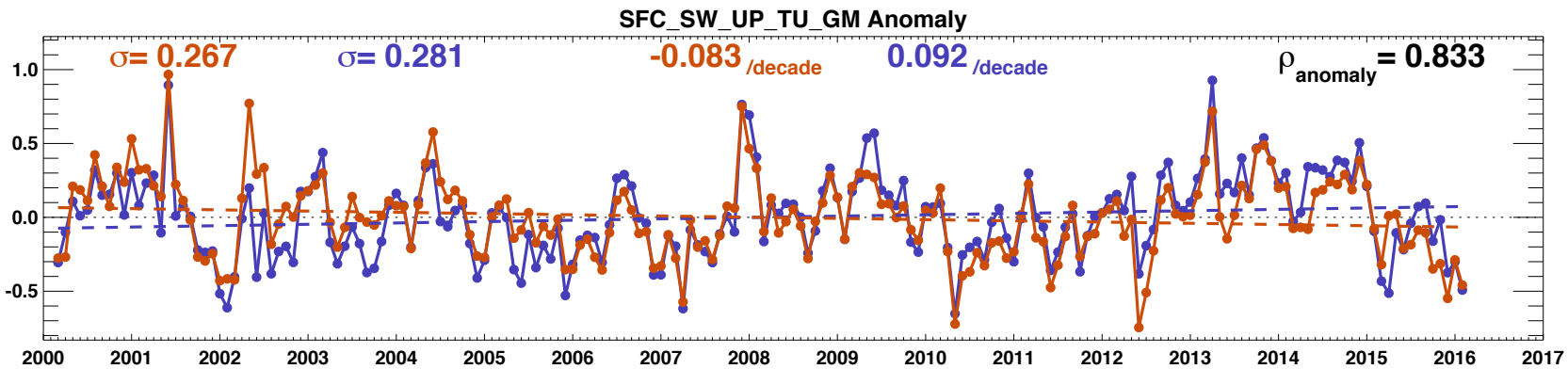


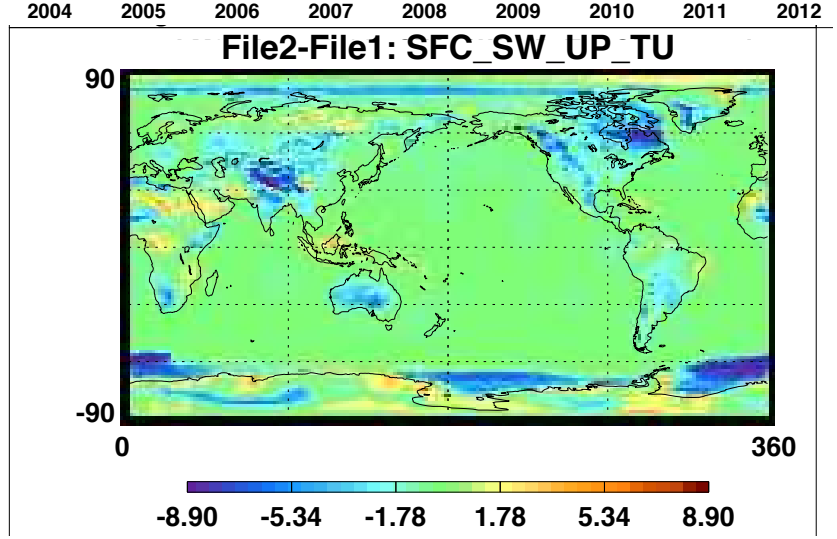




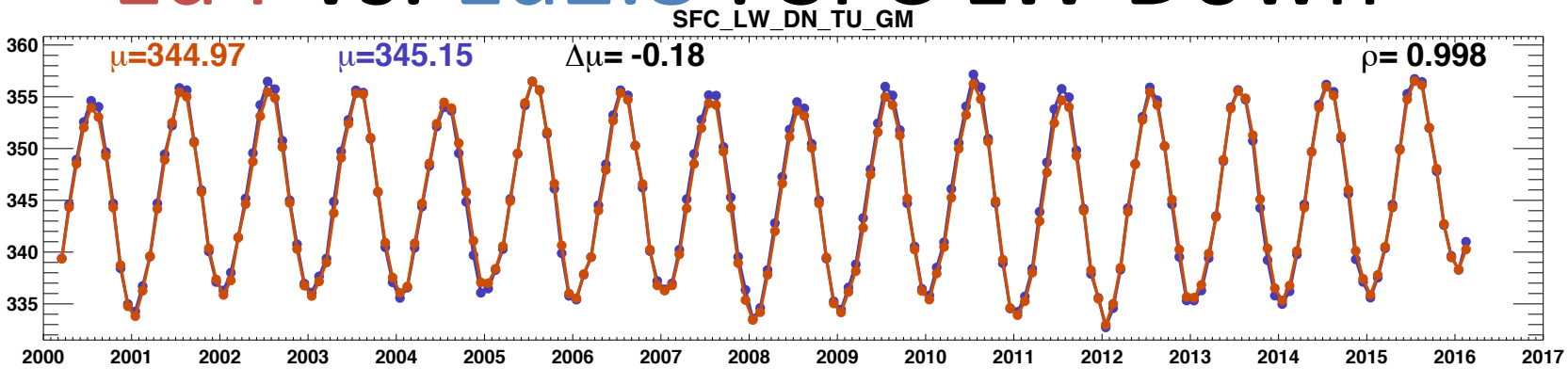
Ed4 Vs. Ed2.8 : SFC SW UP

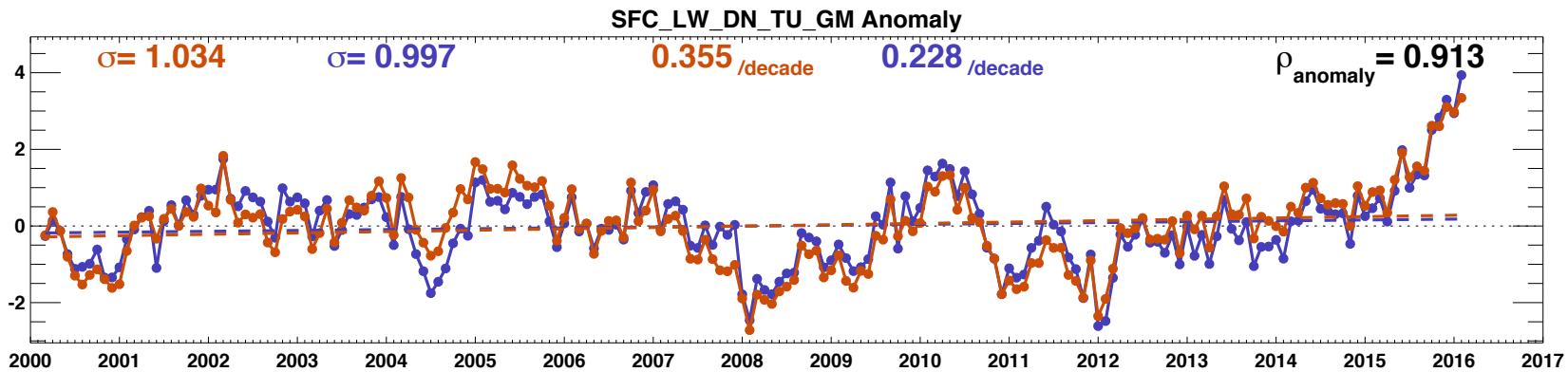


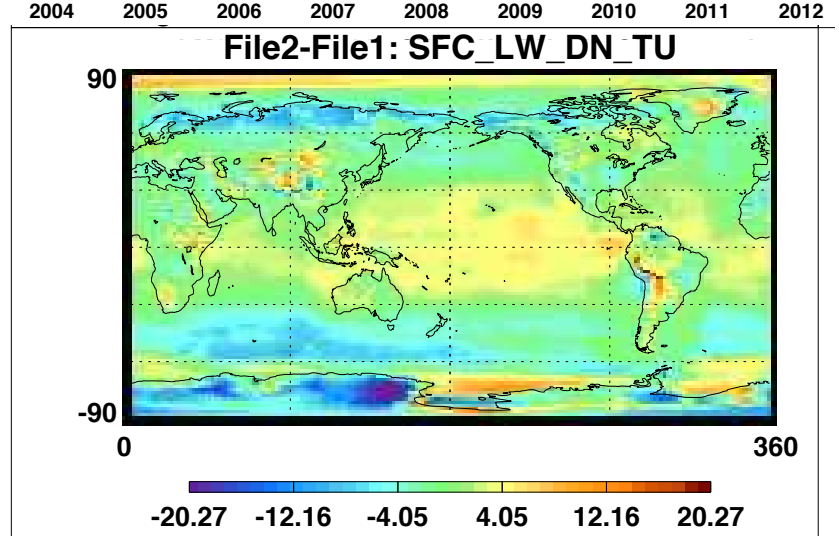




Ed4 Vs. Ed2.8 : SFC LW Down







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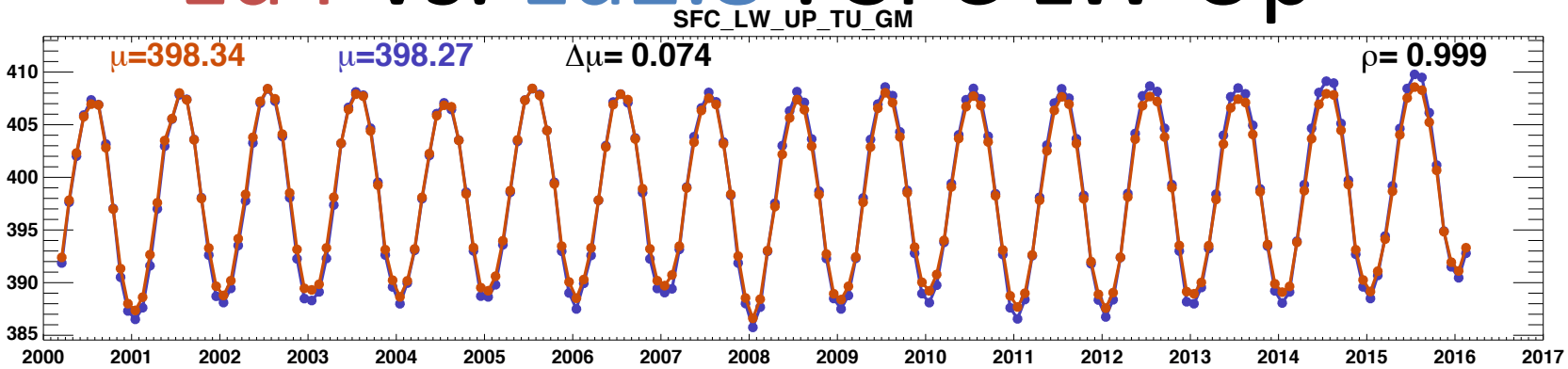
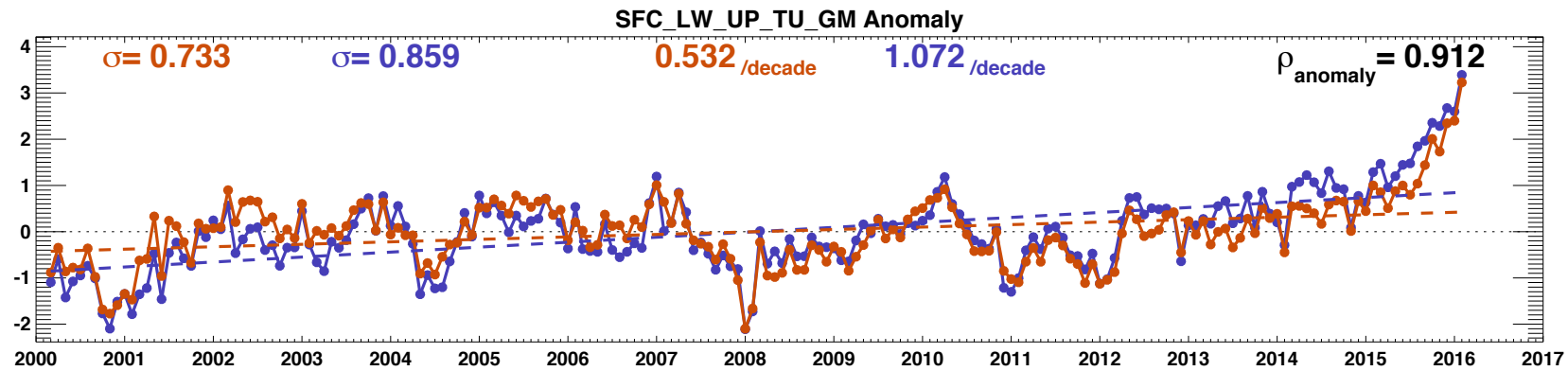
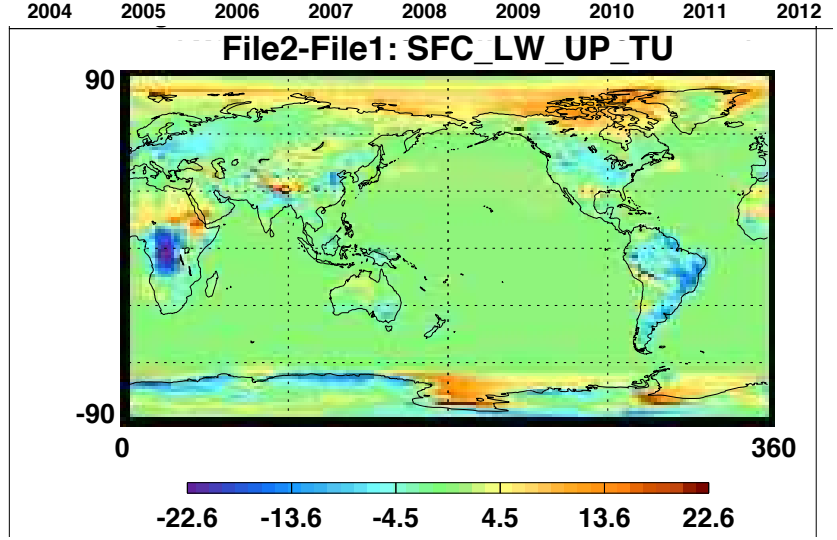
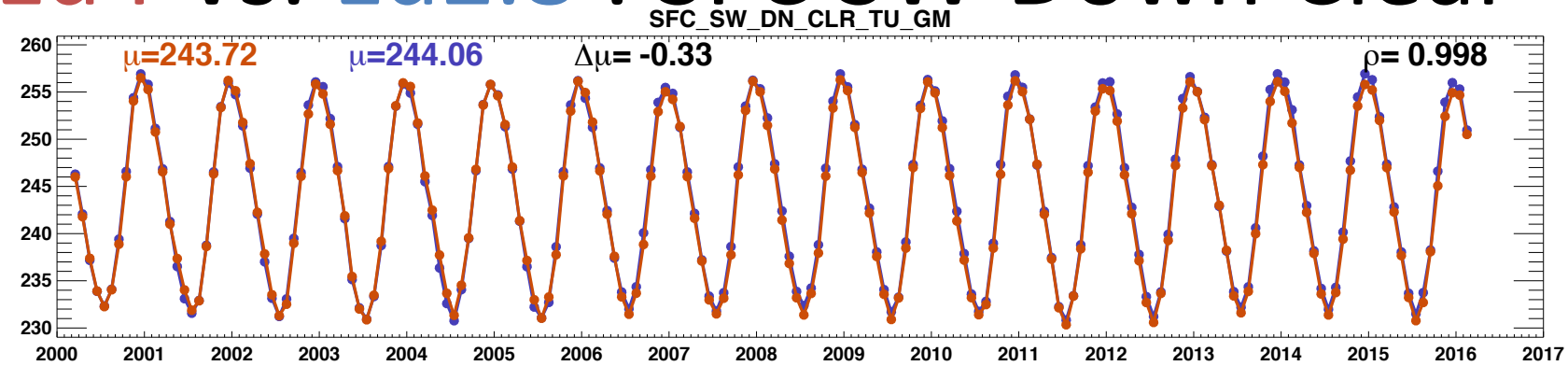
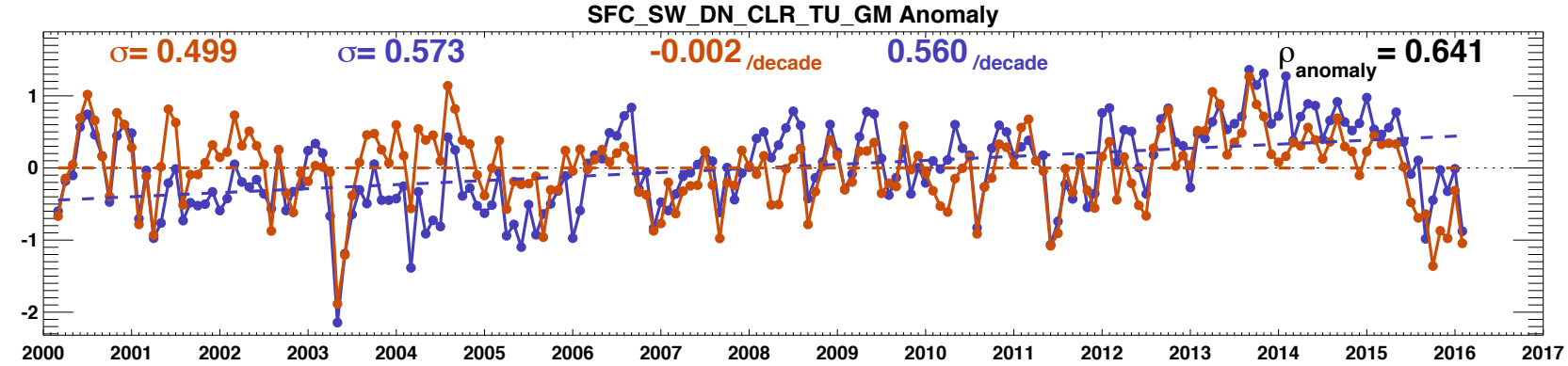


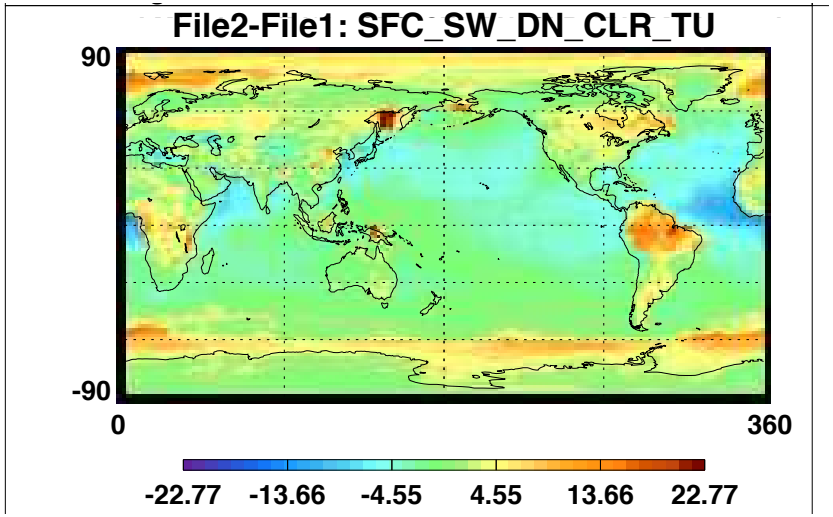




Ed4 Vs. Ed2.8 : SFC SW Down Clear







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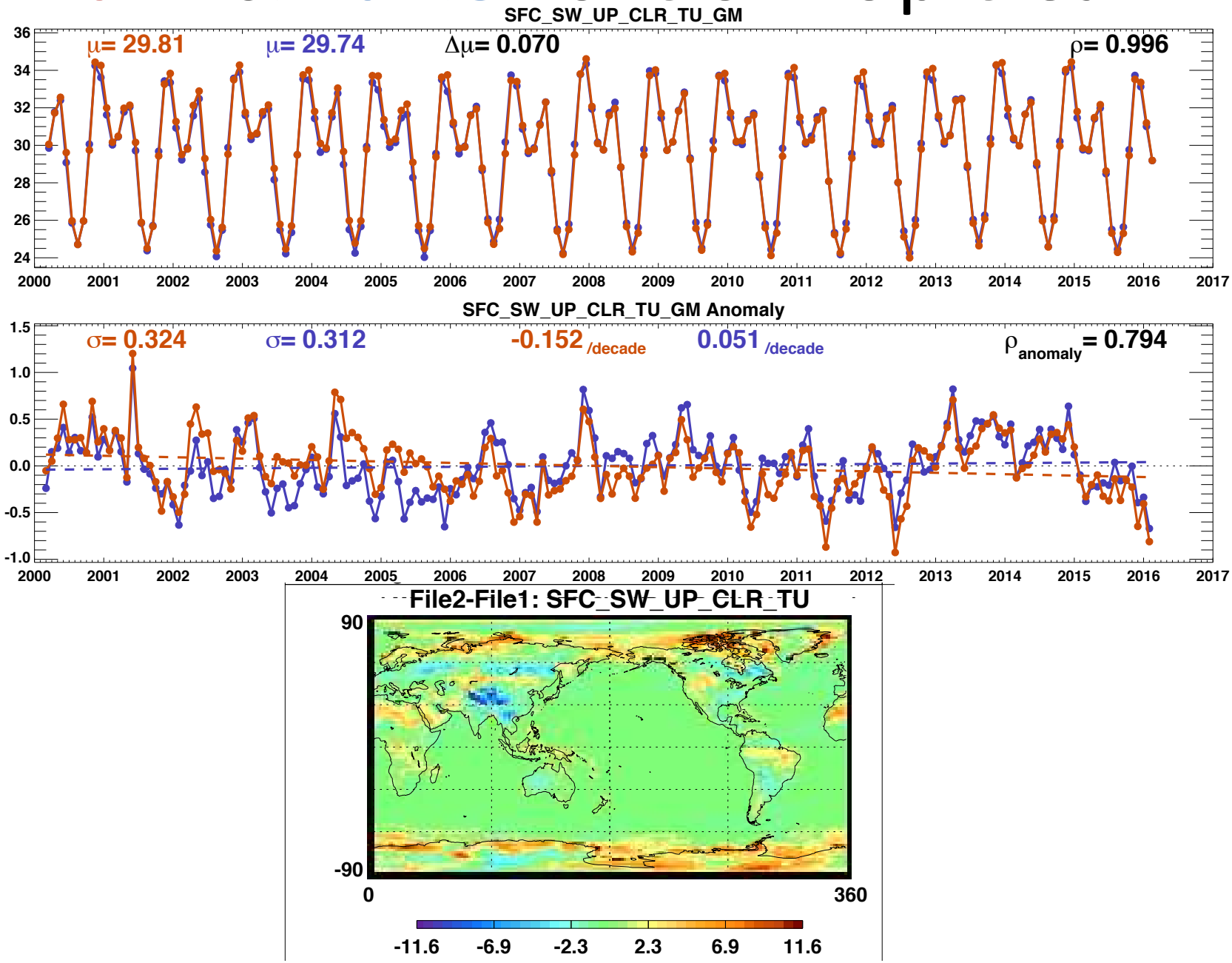
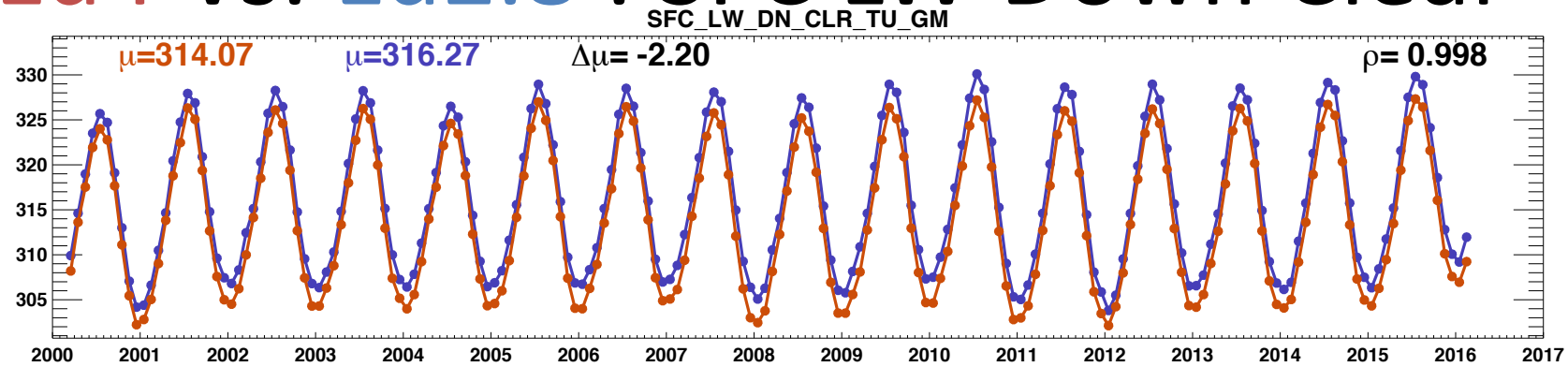
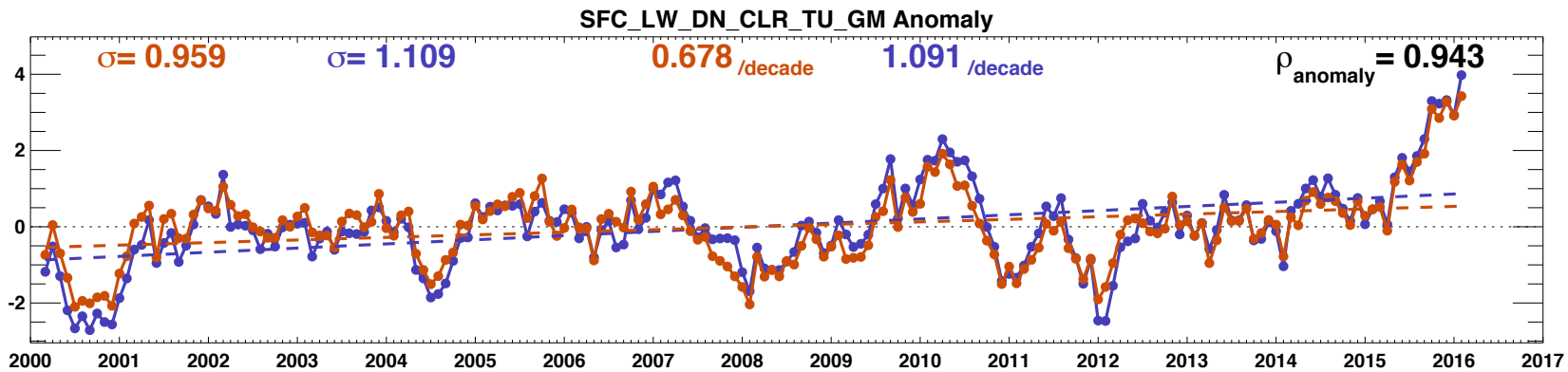
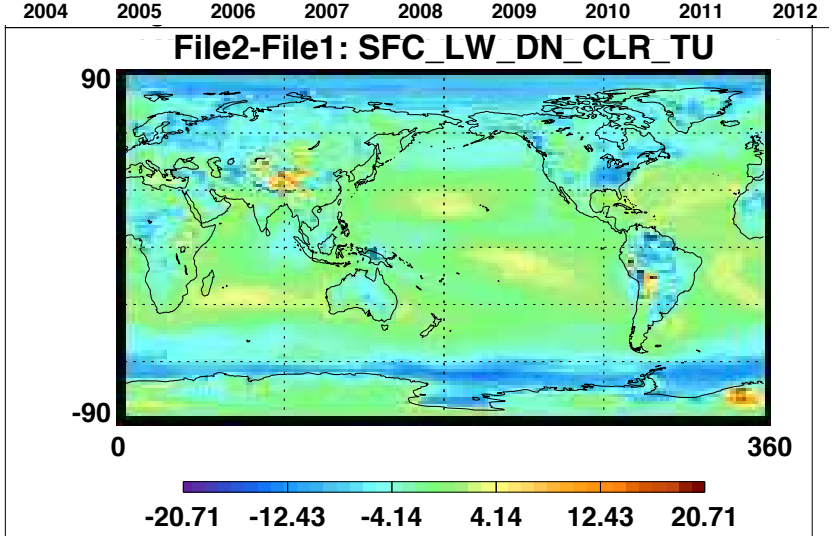


Ed4 Vs. Ed2.8 : SFC LW Down Clear







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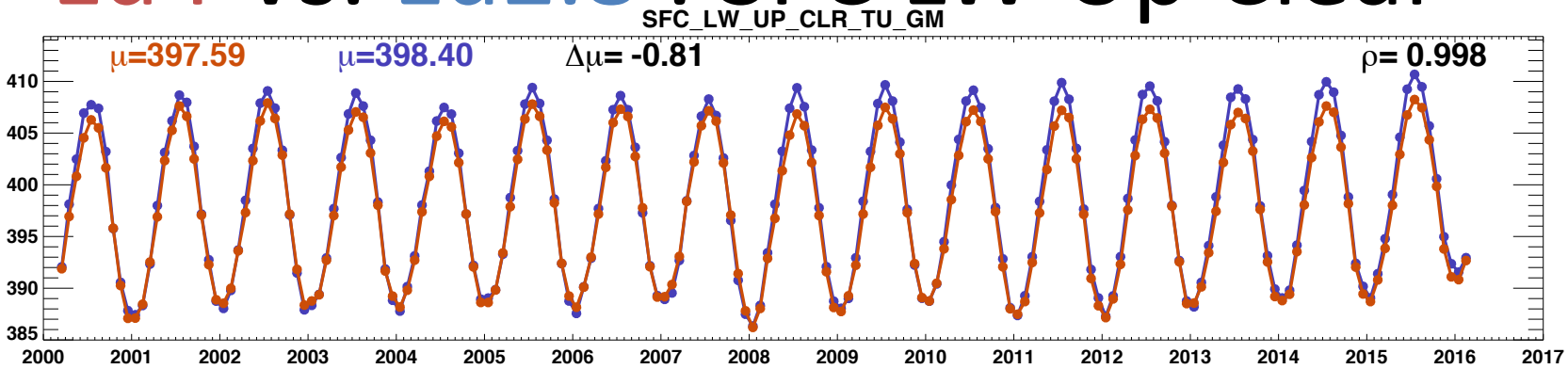

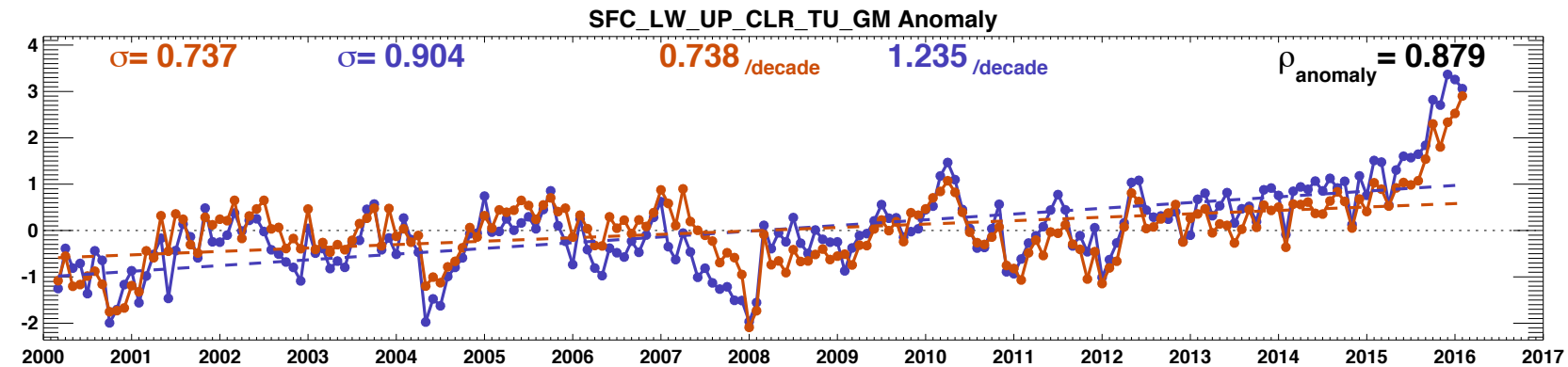

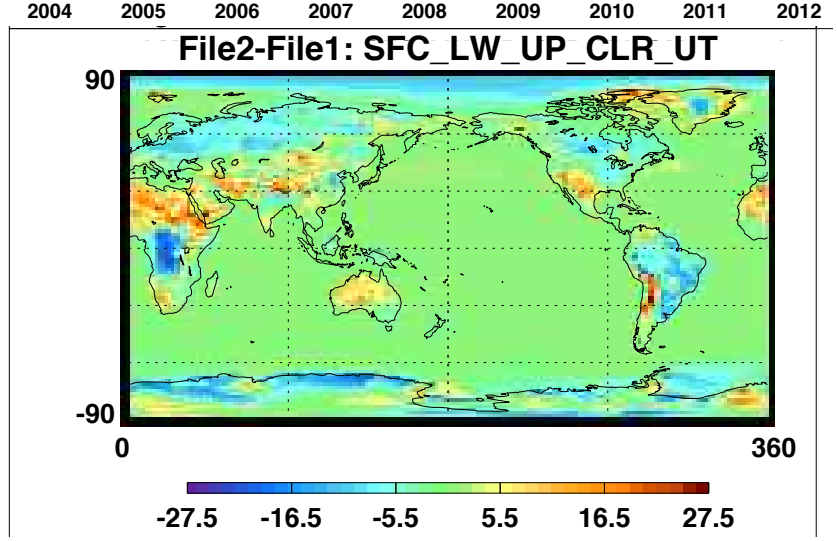

Global Means(Mar2000-Feb2016)

All Sky	Ed4	Ed2.8	Ed4 –Ed2.8
TOA SW Insolation	340.04	339.87	0.17
TOA SW Up	*99.23*	*99.62*	*-0.39*
TOA LW Up	*240.14*	*239.60*	*0.54*
SFC SW Down	187.04	186.47	0.57
SFC SW Up	23.37	24.13	-0.76 (3.1%)
SFC LW Down	344.97	345.15	-0.18
SFC LW Up	398.34	398.27	0.07

Clear Sky	Ed4	Ed2.8	Ed4 –Ed2.8
TOA SW Insolation	340.04	339.87	0.17
TOA SW Up	*53.41*	*52.50*	*0.91 (1.73%)*
TOA LW Up	*268.13*	*265.59*	*2.54*
SFC SW Down	243.72	244.06	-0.33
SFC SW Up	29.81	29.74	0.07
SFC LW Down	314.07	316.27	-2.20
SFC LW Up	397.59	398.40	-0.81

Conclusions

- Ed4 SFC EBAF is more stable and consistent due to use of Geos 5.4.1 throughout.
  - Ed4 Global anomaly trend and variance generally smaller.
- Large differences in unadjusted SW sfc down from increased Ed4 cloud amount have been largely removed through bias correction and constraint to TOA EBAF SW.
- All sky Global means similar to Ed2.8
- Clear Sky mean differences consistent with less clear sky sampling due to increased Ed4 cloud amount.
- Clear SW DN over ocean difference consistent with Ed4 TOA EBAF fix.