# Significance of ISCCP to Realistic Estimates of Global Radiation Profiles


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# OUTLINE

I. Possibilities opened by ISCCP
(related to radiative transfer profile modeling)

II. ISCCP-based radiative profile product: FD

III. Global, long-term ERB

IV. Global, long-term SRB

V. Clouds/AOD vs Diffuse/Direct fluxes

VI. Meridional energy transports

VII. Summary

# I. Possibilities opened by ISCCP
## (Related to radiative transfer profile modeling)

**(Then-)Unique Features of ISCCP Products:**
1. Long-term, continuous global coverage with mesoscale resolution (280 km)
2. Resolved diurnal variation (3-hourly, barely though)
3. Essentially radiance-only-dependent cloud-detection methodology
4. Retrieval of most important cloud optical property: $\tau$(or liquid/ice path)
5. Consistent retrievals for atmospheric-surface physical properties

**that make the following realistic or to be realistic:**
1. Deepening understanding on key roles of clouds in global energy and water circulations (and regional climate/weather variations)
2. Estimates of radiative transfer fluxes for Earth-atmosphere system, Surface and (with knowledge of cloud vertical structure) whole atmospheric profile
3. Producing consistent, long-term and continuous, global-covered ERB and SRB datasets (ISCCP-FD and GEWEX-SRB)
4. And these lead to studying all possible general energy circulations (transports) of Earth-atmosphere, atmosphere and ocean
5. Monitoring climate variations

# II. ISCCP-based radiative profile product: FD

## 1. Main Features of ISCCP-FD (Version: 0.00, But 0.10 for 2004)

► **FD** is a self-consistent, physically-integrated, TOA-to-SRF profile flux product, including all up & down, SW (*diffuse/direct and VIS/NIR*) and LW for full-, clear- and (100%) overcast sky

- Spatial resolution: horizontal: 280-km equal-area (2.5° on equator)
  vertical: 5 levels (SRF-680mb-440mb-100mb-TOA)
- Temporal resolution: Nominal 3-houly (UTC = 0, 3, … 21)
- Spatial coverage: fully global (on 280-km equal-area map)
- Temporal coverage: July 1983 → Dec. 2006 → …

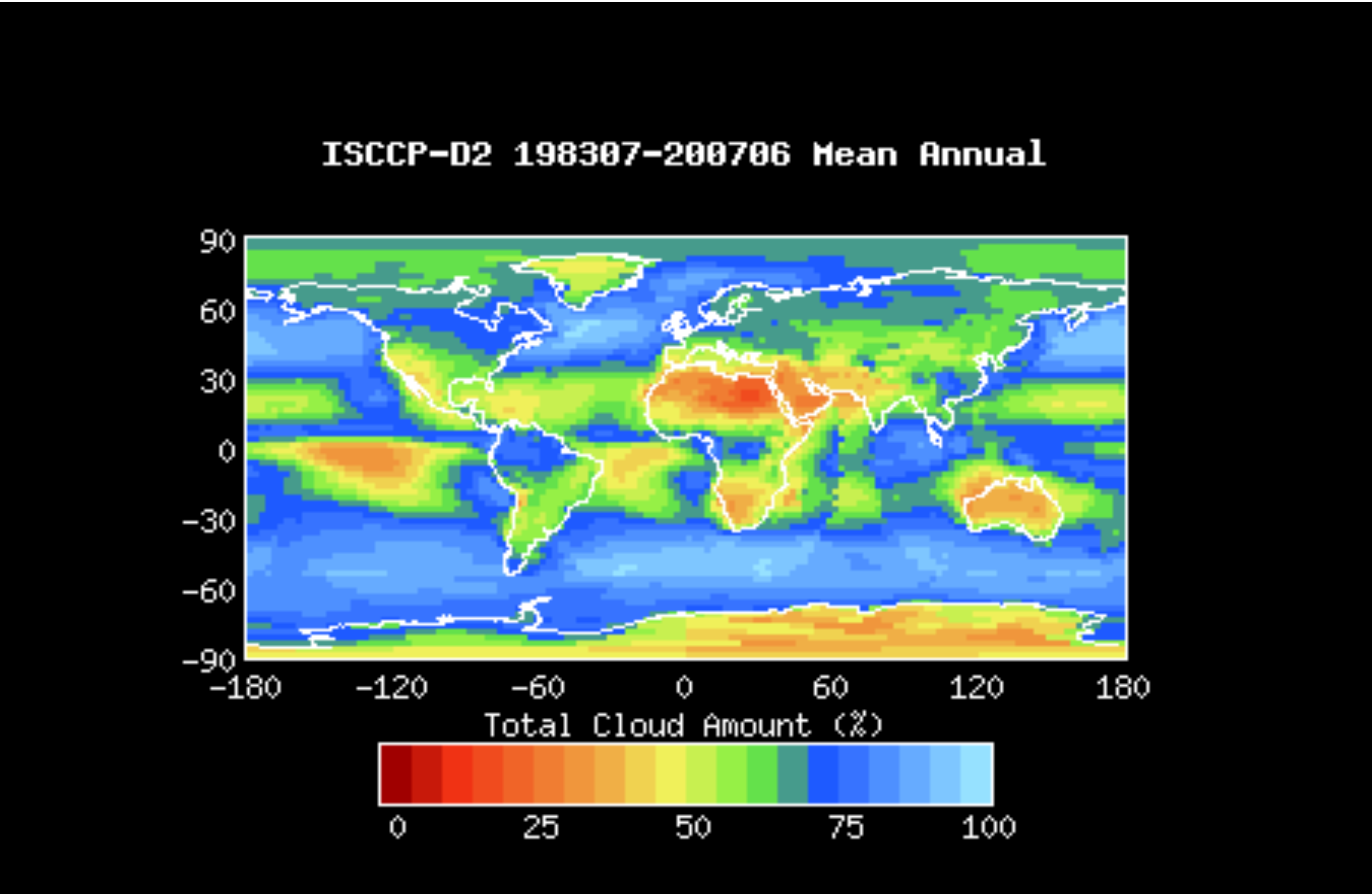
► Radiative Model: (modified) NASA GISS model using **mainly ISCCP-D1**

- **Cloud inputs**: Cloud Fraction (CF), Optical thickness (τ) and its macro-inhomogeneous variability factor (ε), Statistical vertical structure, phases and particle size climatology
- Albedo: Land: VIS -- based on ISCCP-D1 visible reflectance
  NIR -- modified model ratio of VIS/NIR over 8 Vege types
  Ocean: from NASA GISS model
- AOD: GISS' 1950-2000 evolutional monthly climatology (18 sizes/compositions)

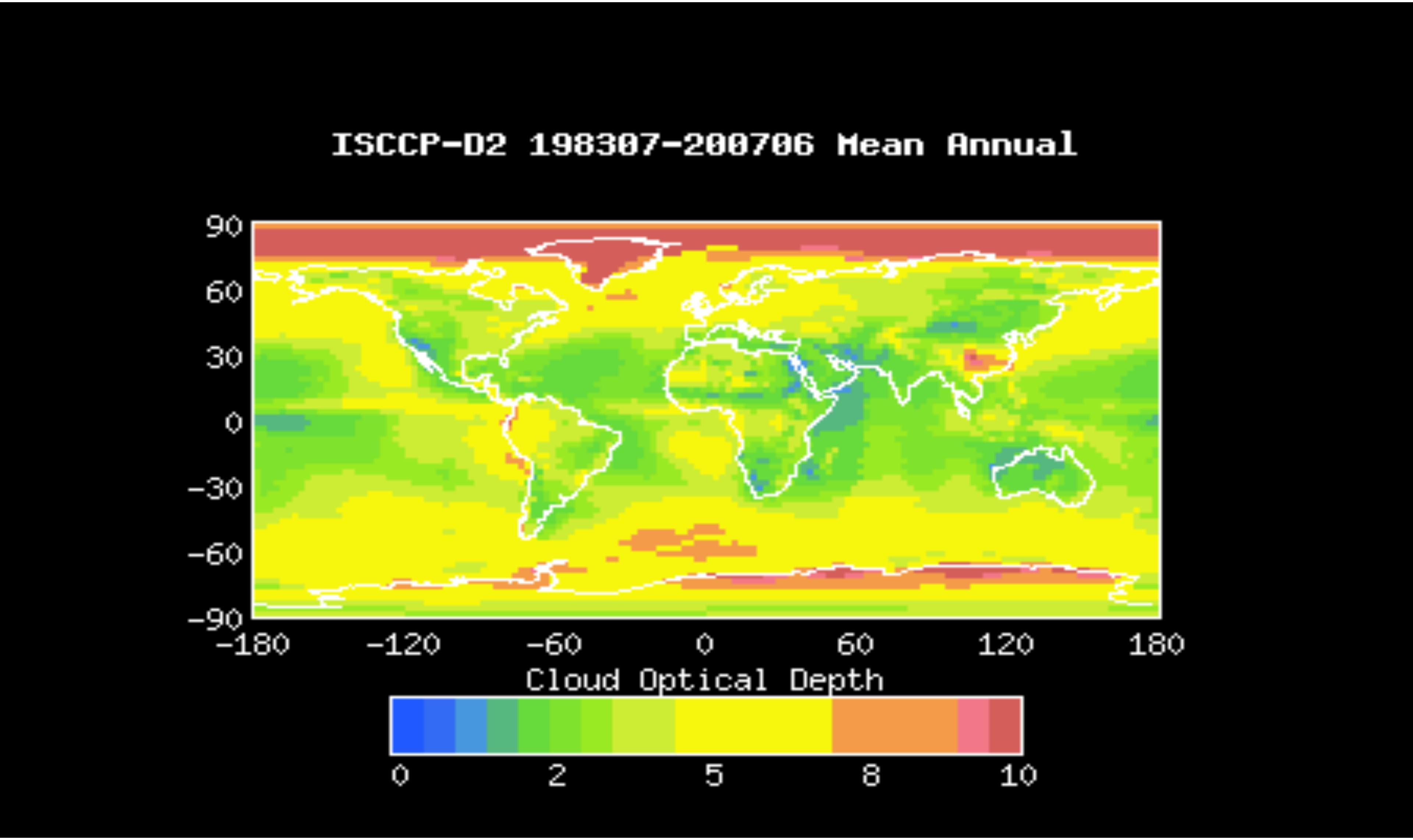
► 23.5-year, 3-hourly and global FD-product:
(1) **FD-TOA**, (2) **FD-SRF, (3) FD-PRF,** (4) **FD-INP &** (5) **FD-MPF**

● **Allow Evaluation on Radiative Fluxes through Input Physical Variables**

..II..FD: 2. Clouds: (1) Multiyear Annual Mean Cloud Fraction (CF) (%)

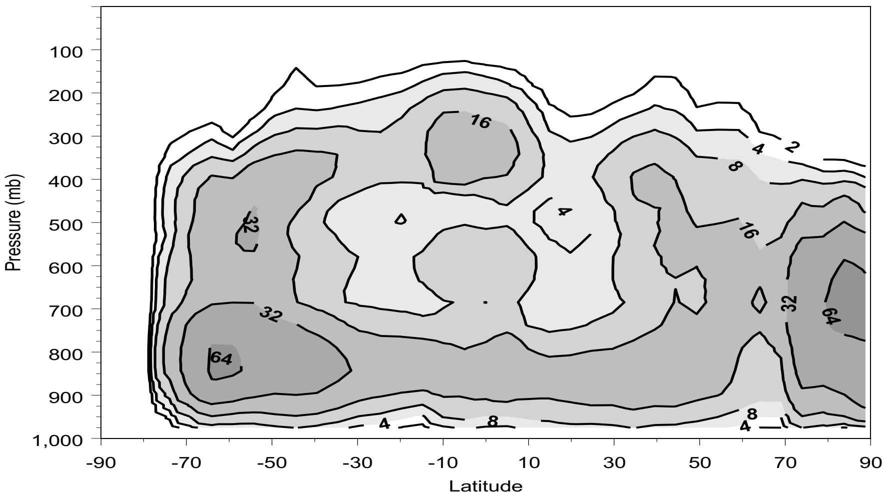


## ..II..FD: 2. Clouds: (2) Multiyear Annual Mean Cloud Optical Depth (τ)

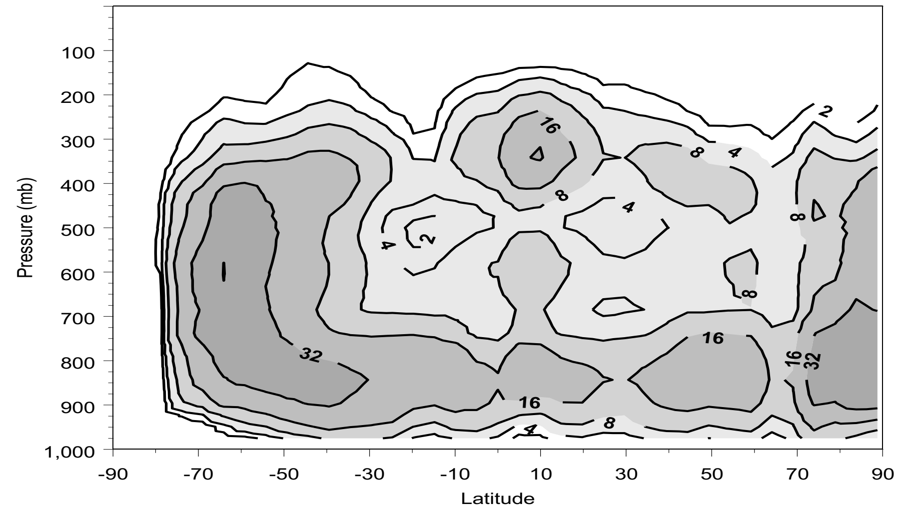


# ..II..FD: 2. Clouds: (3) Vertical Structure (CVS): CF (%) of 90-92 FD

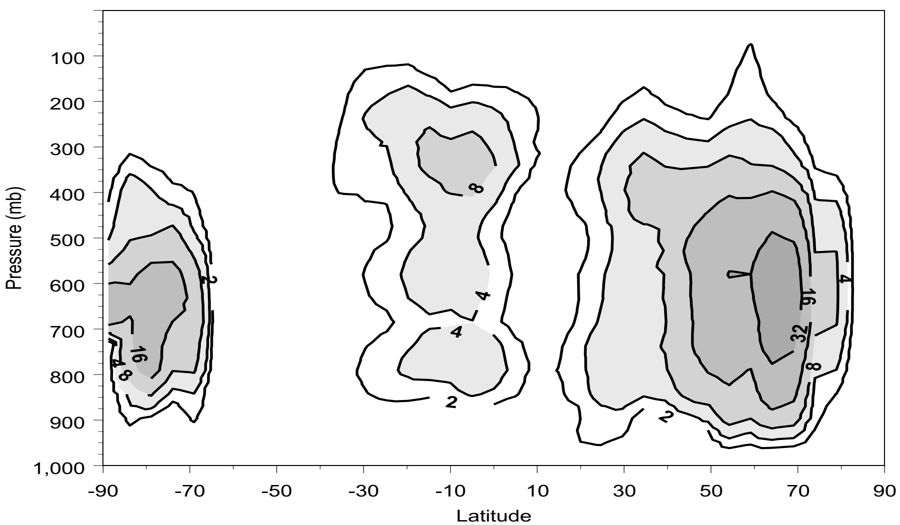
Model-B: Zonal-mean Cloud Fraction for Ocean of 90-92 January



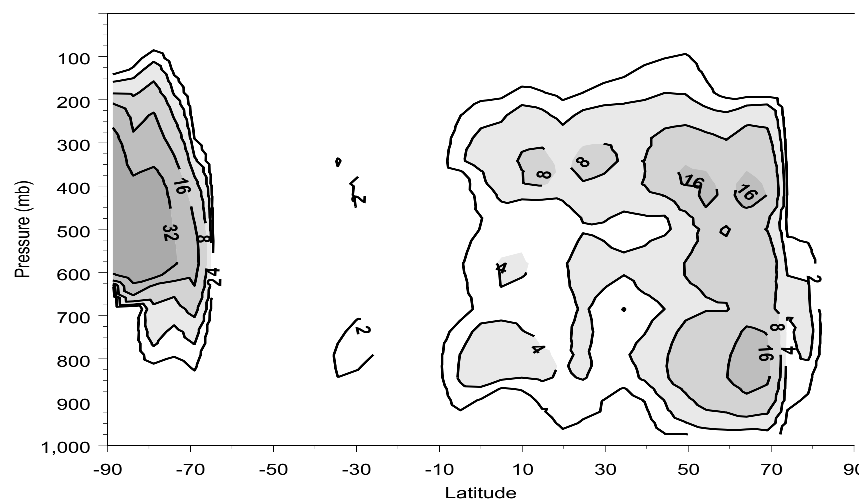

Model-B: Zonal-mean Cloud Fraction for Ocean of 90-92 July



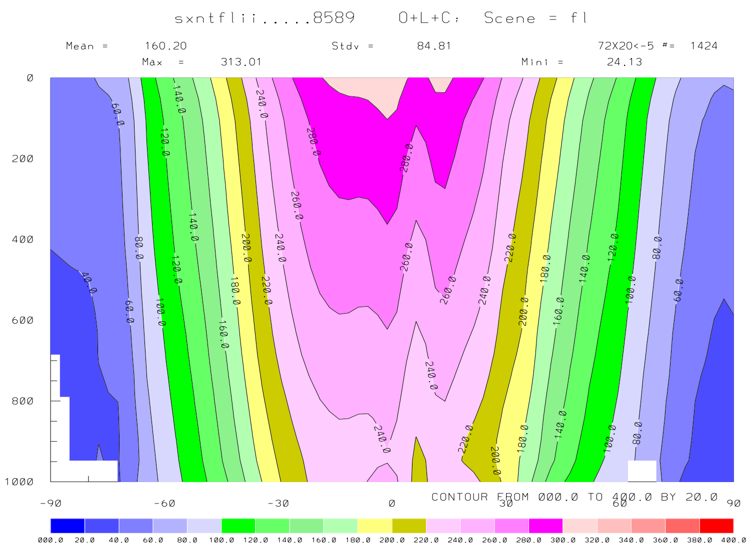

Model-B: Zonal-mean Cloud Fraction for Land of 90-92 January

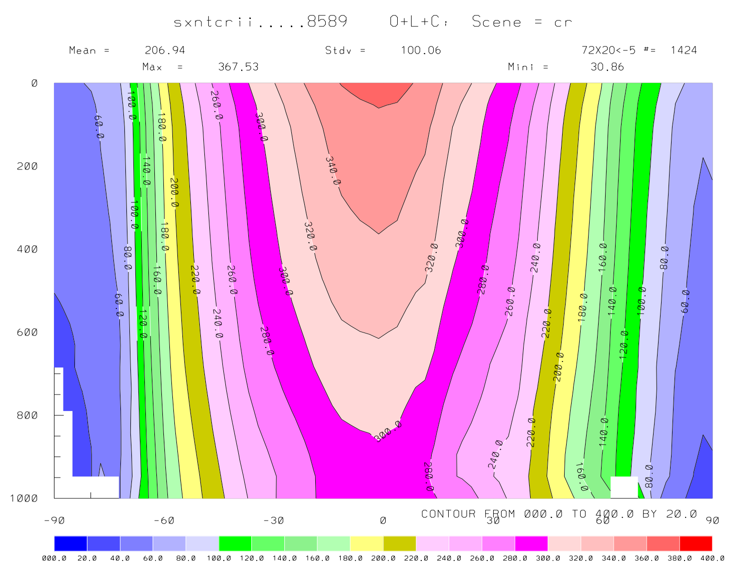


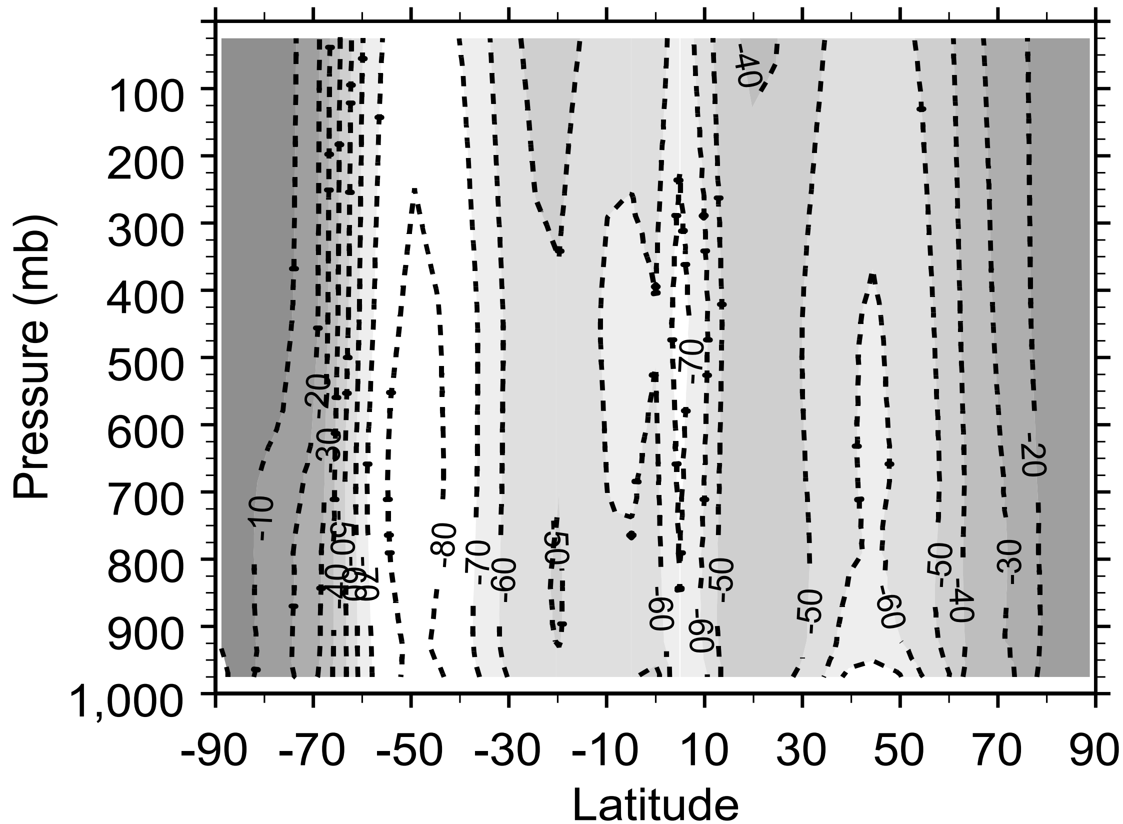

Model-B: Zonal-mean Cloud Fraction for Land of 90-92 July



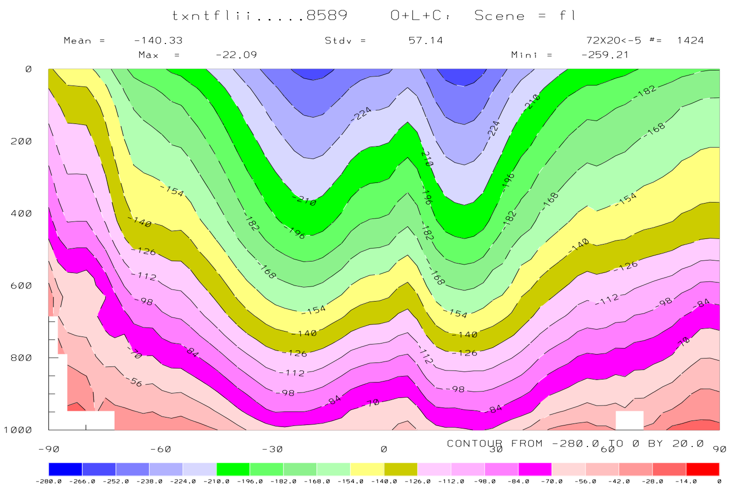
# ..II..FD: 3. FD-PRF: (1) 85-89 SW Net Profile for Full/Clr sky & CE (W/m²)

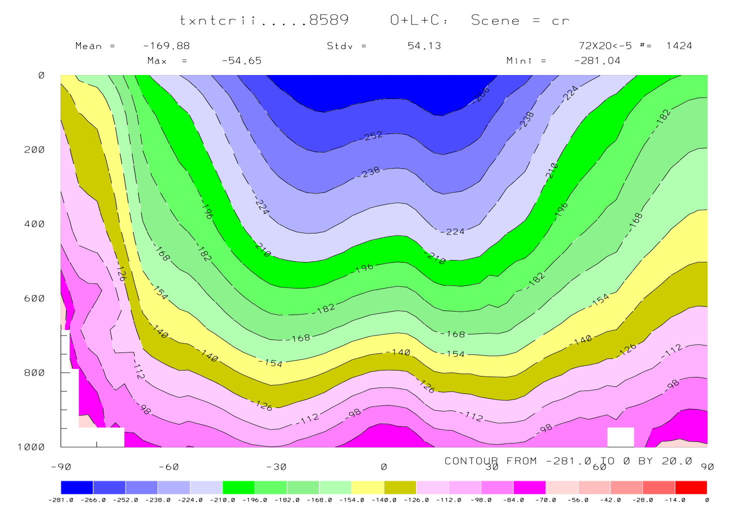


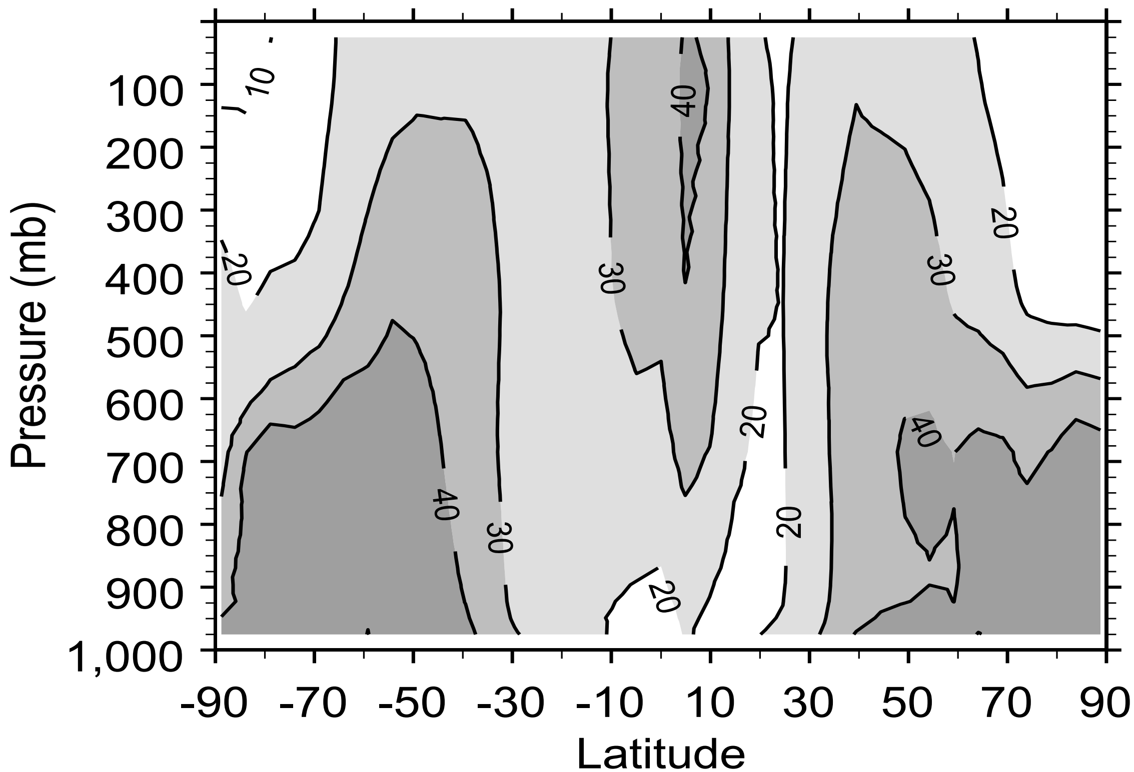



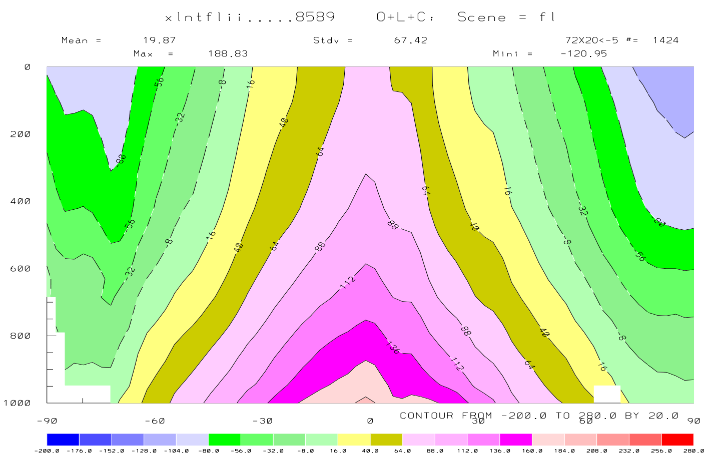
## ..II..FD: 3. FD-PRF: (2) 85-89 LW Net Profile for Full/Clr sky & CE (W/m²)

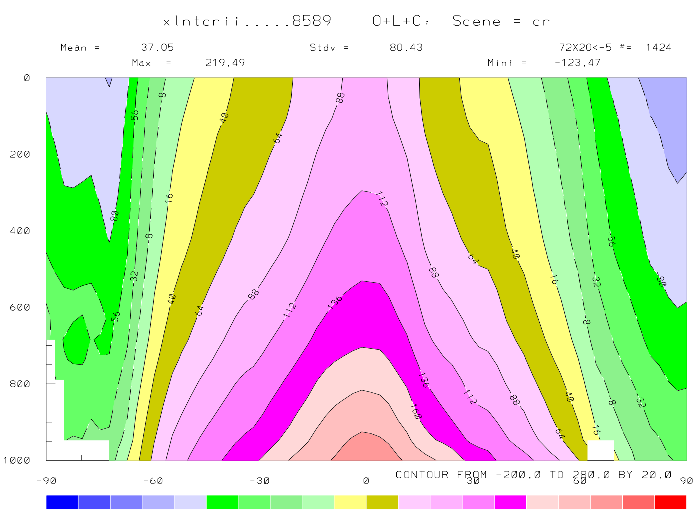


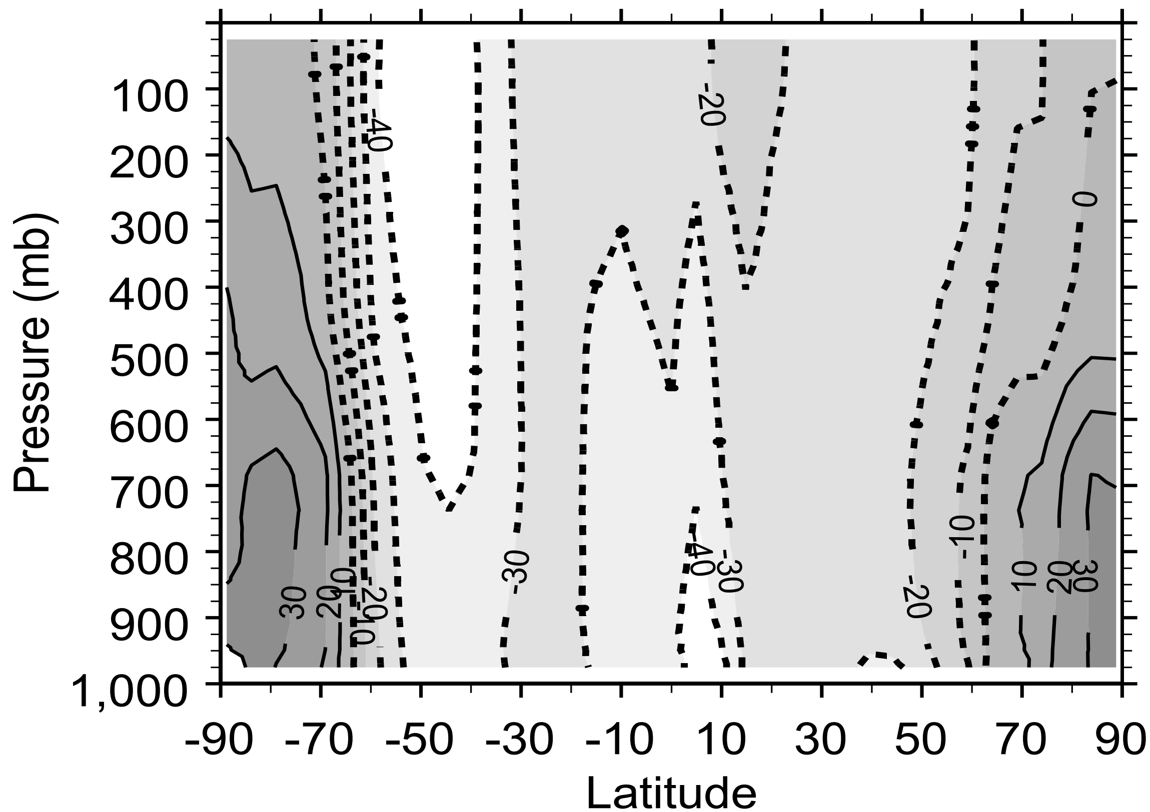



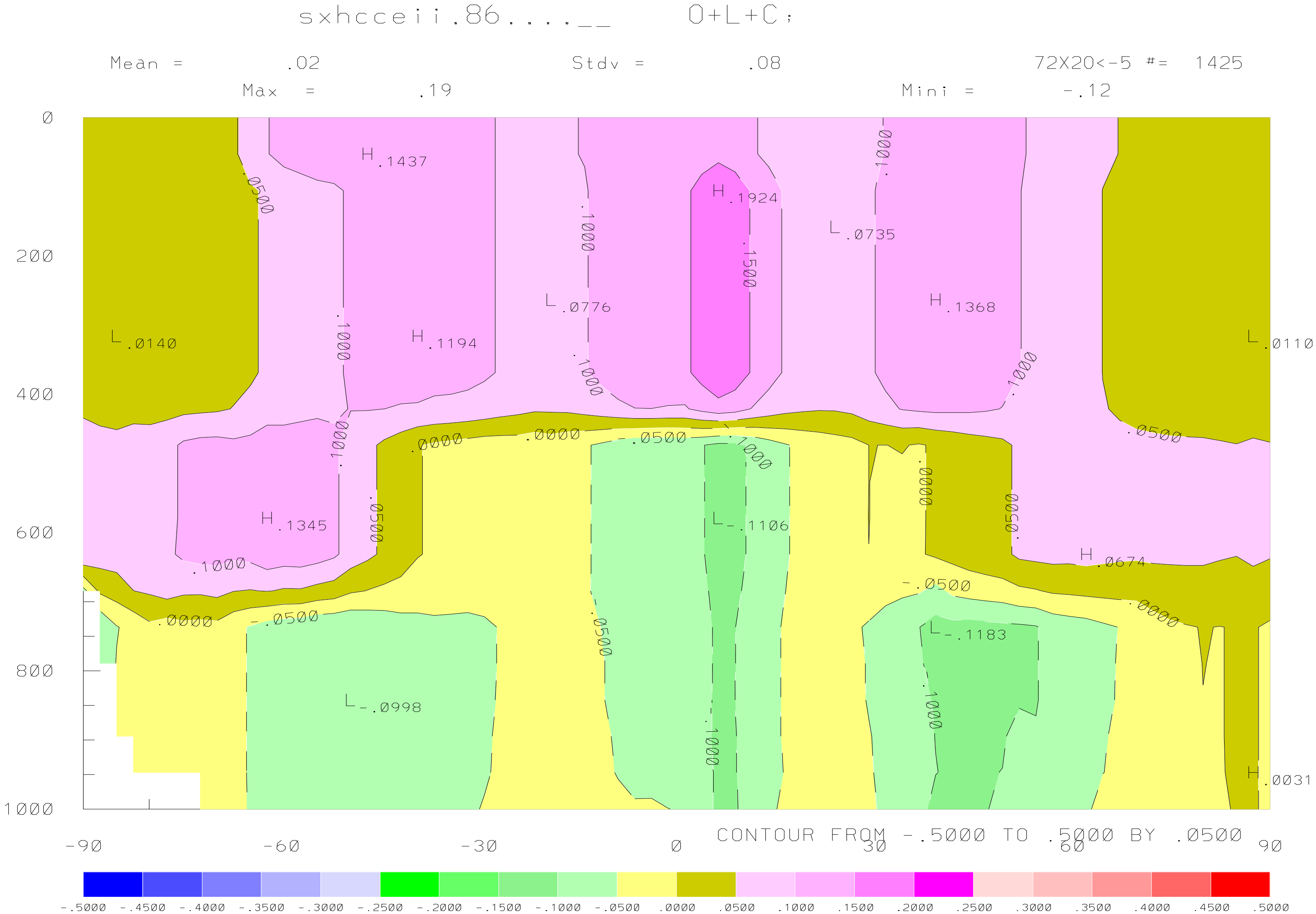
# ..II..FD: 3. FD-PRF: (3) 85-89 Total Net Profile for Full/Clr sky & CE ($W/m^2$)



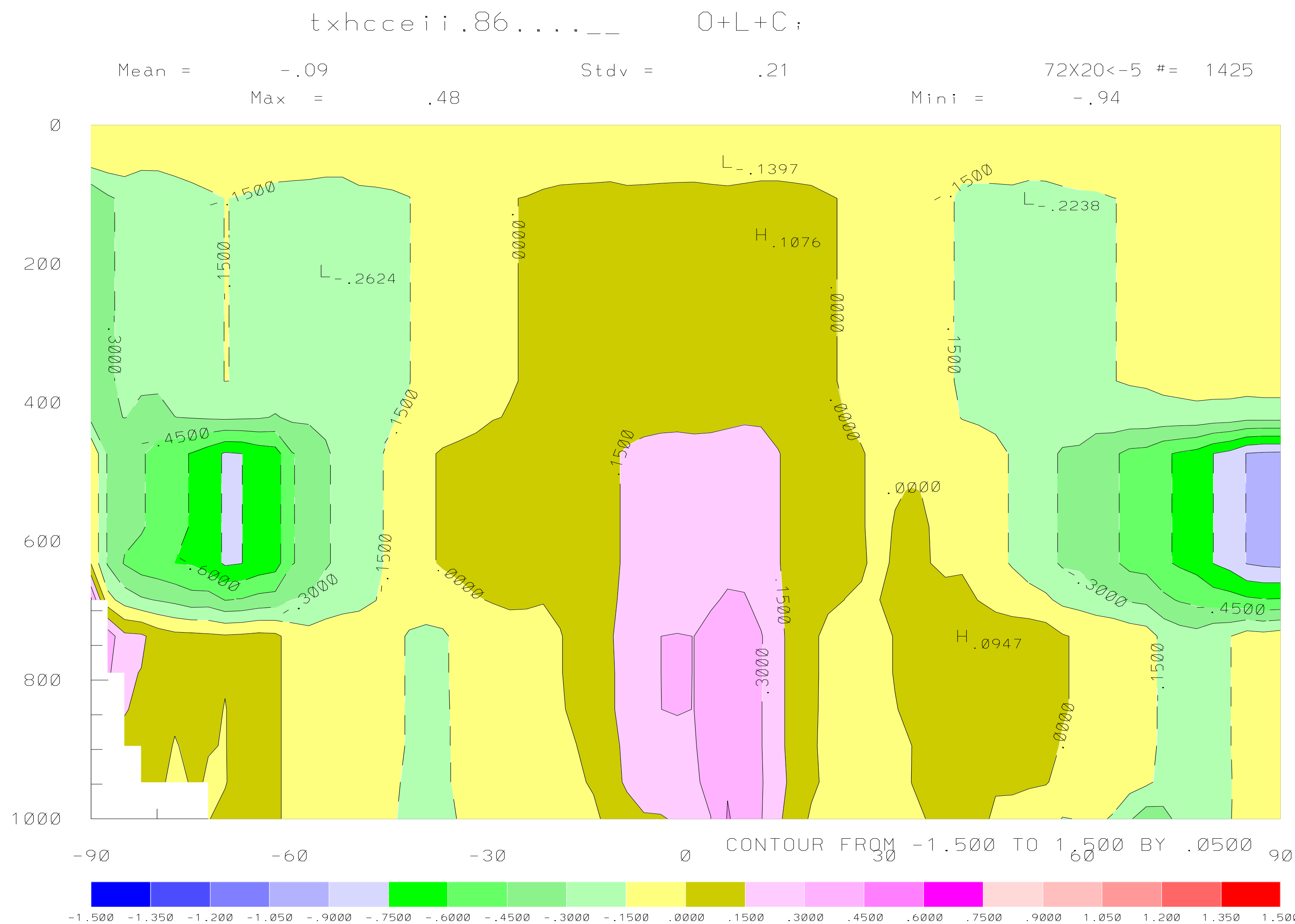



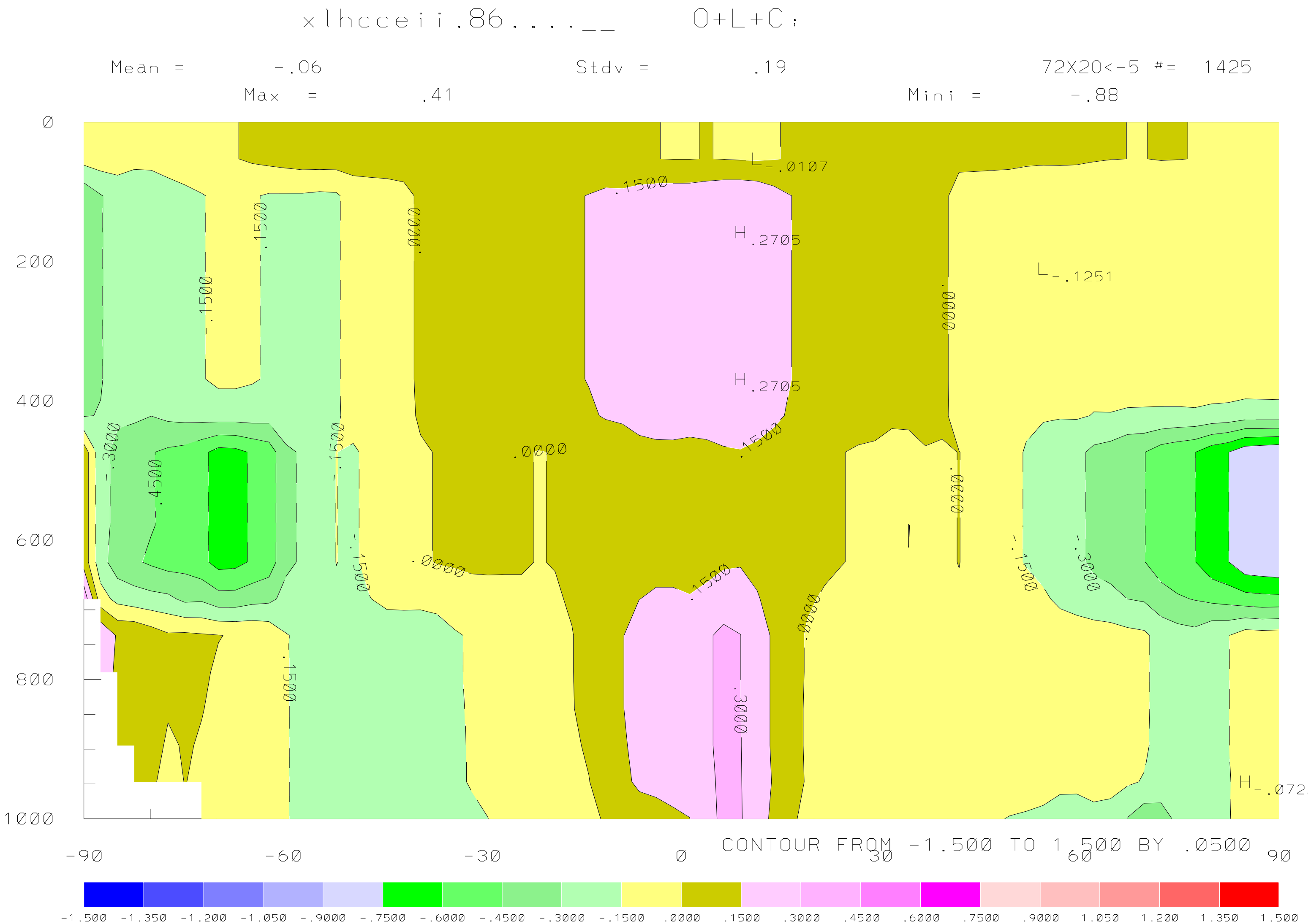
# ..II..FD: 3. FD-PRF: (4) 86-Annual Cloud Effects ("cloud forcing"): for SW Heating Profile (K/Day)



## ..II..FD: 3. FD-PRF: (5) 86-Annual Cloud Effects ("cloud forcing"): for LW Cooling Profile (K/Day)



## ..II..FD: 3. FD-PRF: (6) 86-Annual Cloud Effects ("cloud forcing"): for Total (SW+LW) Heating/Cooling Profile (K/Day)

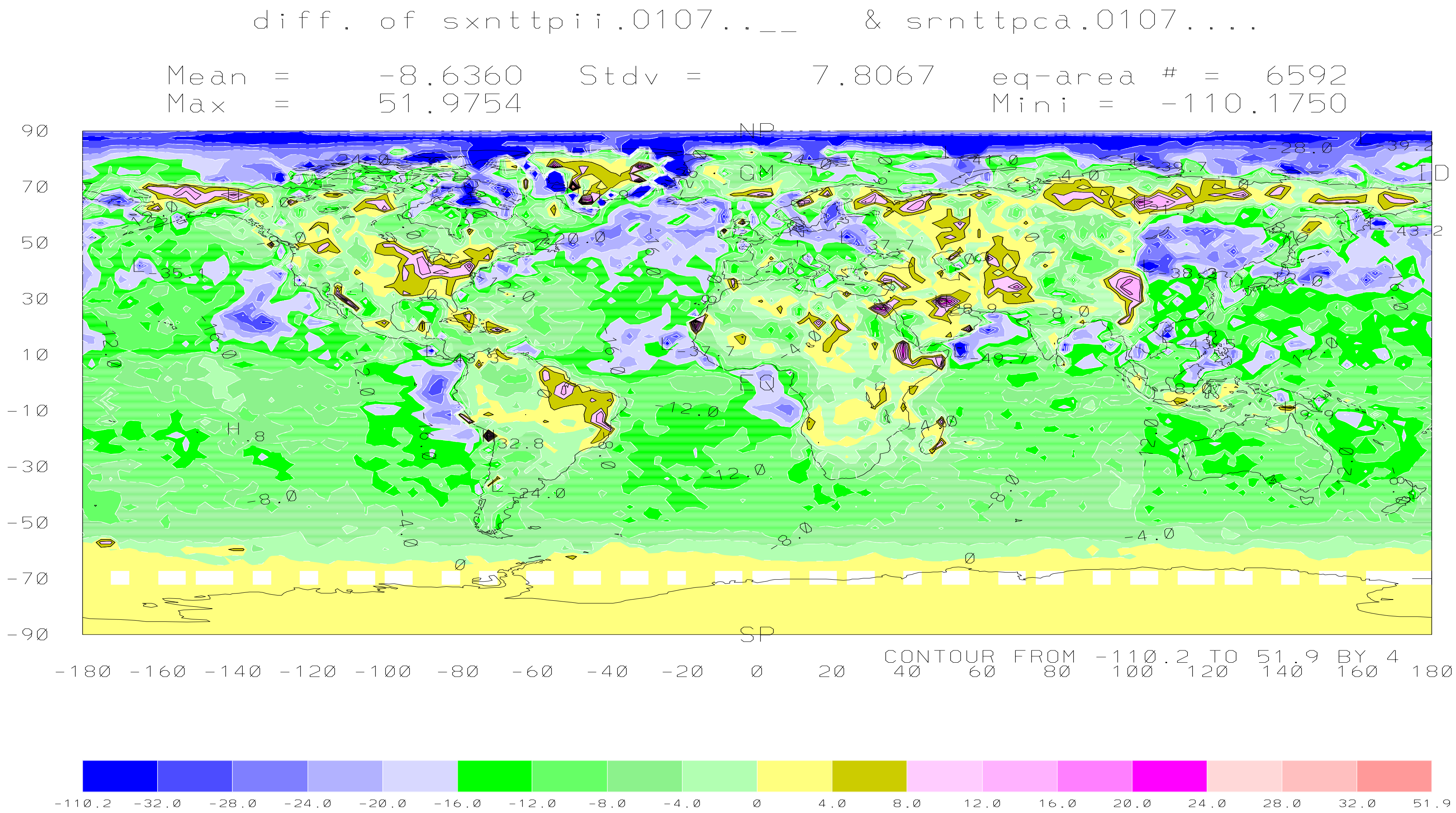


# III. Global, long-term ERB: 1. FD vs. CERES:

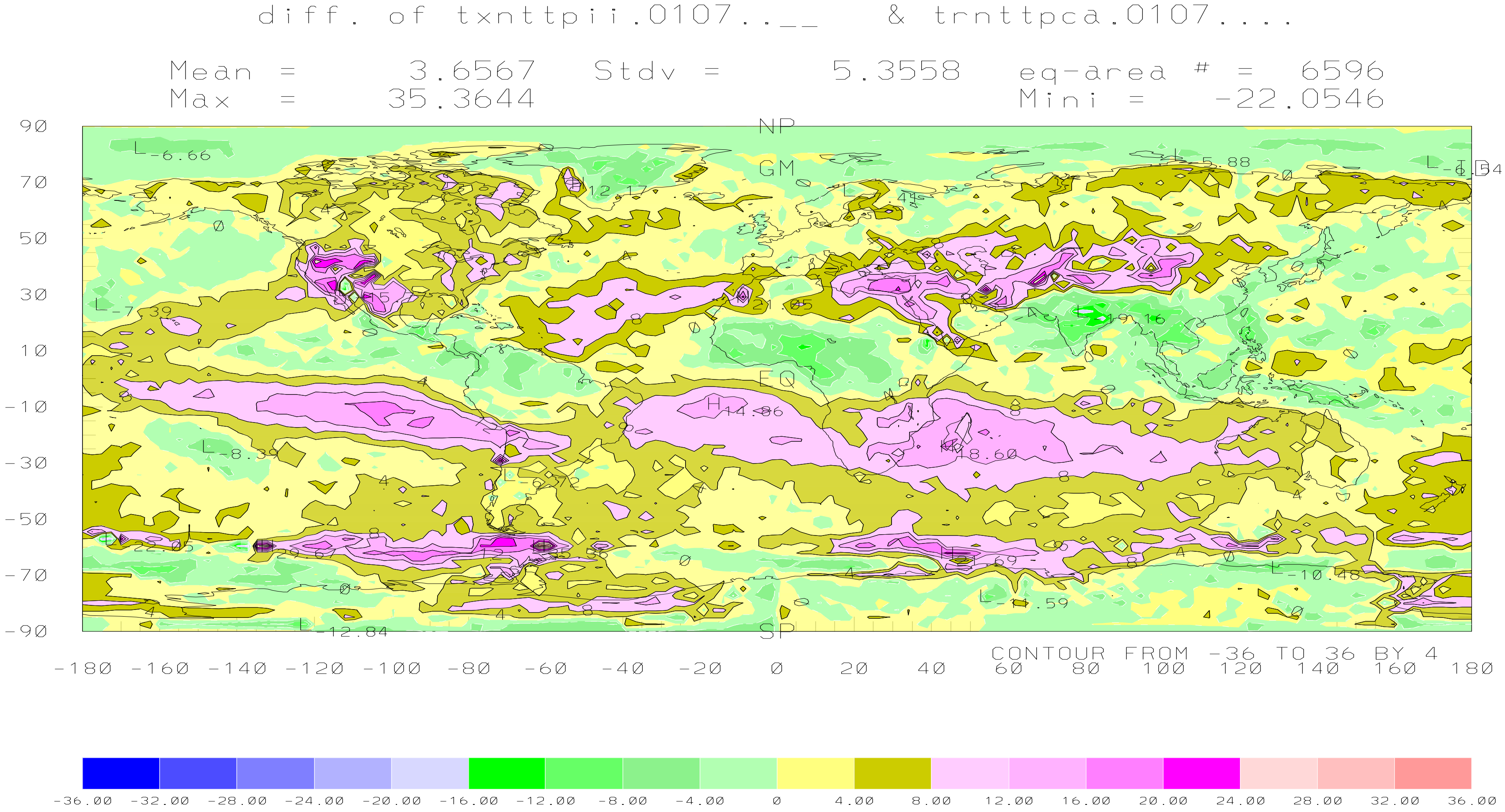
## (1) Overall Statistics based on 0003-0302 monthly means

| Var | FD | CERES | Mn Dif | Stdv | Cor Coef | Slope | Intcpt | N Dev |
|---|---|---|---|---|---|---|---|---|
| SWup | 105.59 | 98.14 | 7.448 | 8.211 | .9798 | .95 | -2.55 | 5.72 |
| LWup | 235.33 | 237.12 | -1.787 | 5.157 | .9886 | 1.03 | -3.36 | 3.48 |
| Clr_SWup | 55.26 | 51.53 | 3.732 | 8.687 | .9648 | .99 | -3.35 | 6.11 |
| Clr_LWup | 261.80 | 264.23 | -2.425 | 6.437 | .9813 | 1.03 | -.26 | 4.37 |
| SWdn | 341.85 | 341.37 | .485 | .907 | 1.0000 | 1.00 | .18 | .56 |
| ALB | 33.61 | 31.53 | 2.082 | 3.490 | .9654 | 1.01 | -2.33 | 2.44 |
| Clr_ALB | 18.27 | 17.04 | 1.236 | 3.388 | .9640 | 1.00 | -1.14 | 2.36 |
| NET | 1.81 | 6.96 | -4.885 | 9.150 | .9945 | 1.01 | 5.15 | 6.34 |
| Clr_Net | 29.57 | 30.42 | -.847 | 10.087 | .9945 | .99 | 1.13 | 7.00 |
| NET_SW | 237.35 | 244.31 | -6.897 | 8.081 | .9972 | 1.01 | 4.31 | 5.61 |
| NET_LW | -9.00 | -9.00 | 1.787 | 5.157 | .9886 | 1.03 | 5.49 | 3.48 |
| Clr_NT_SW | 292.05 | 295.28 | -3.232 | 8.732 | .9973 | 1.00 | 3.73 | 6.14 |
| Clr_NT_LW | -9.00 | -9.00 | 2.425 | 6.437 | .9813 | 1.03 | 5.85 | 4.37 |
| CE_SW | -9.00 | -9.00 | -3.878 | 8.306 | .9680 | .95 | 1.31 | 5.82 |
| CE_LW | 26.17 | 26.81 | -.647 | 5.317 | .9485 | .99 | .93 | 3.76 |
| CE | -9.00 | -9.00 | -4.502 | 9.226 | .9393 | .90 | 1.95 | 6.45 |
| CE_SWup | 14.86 | 13.87 | .981 | 2.830 | .9377 | .96 | -.33 | 2.02 |

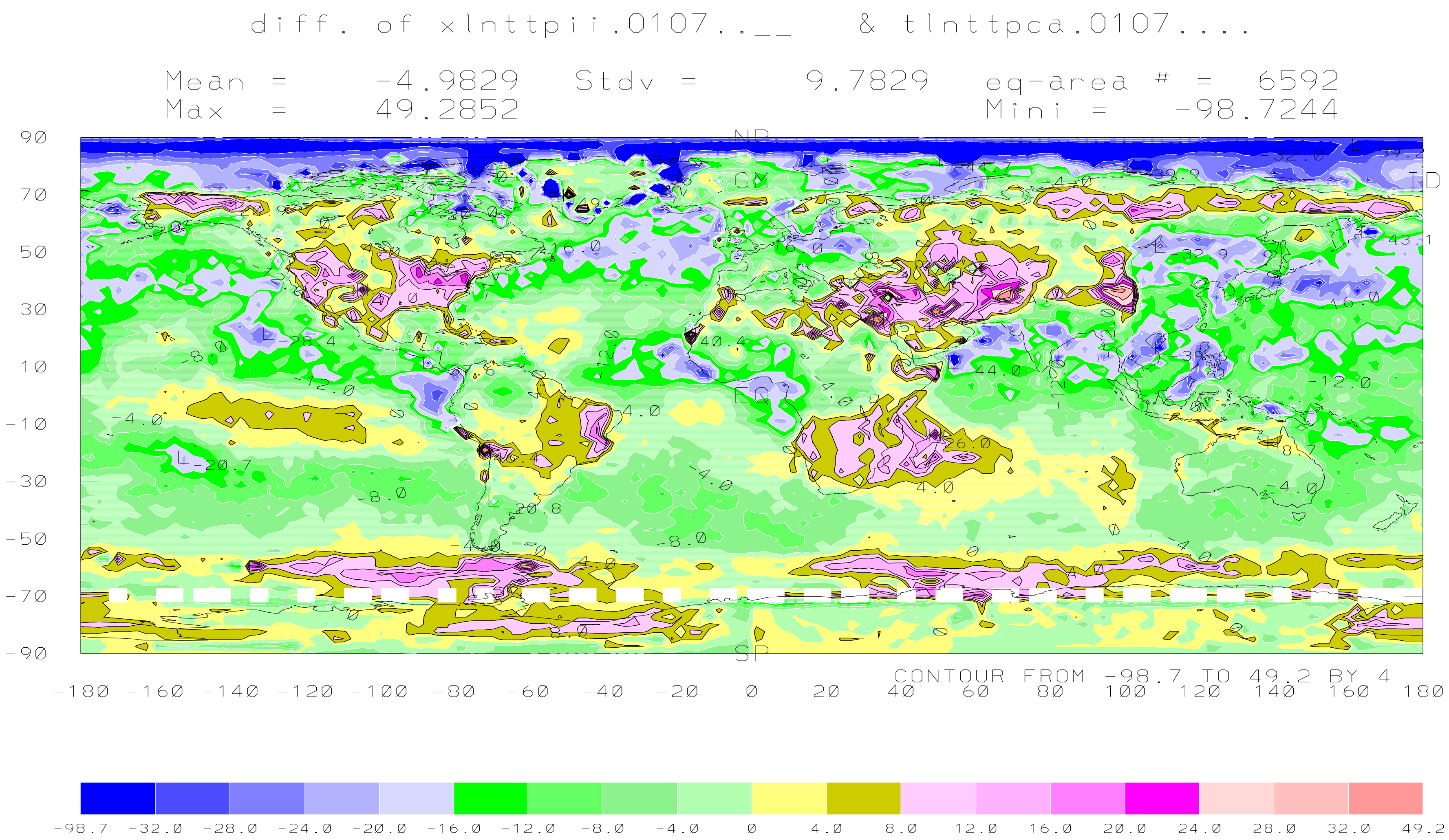
# ..III. ERB: 1. FD vs. CERES: (2) TOA SW Net for 0107



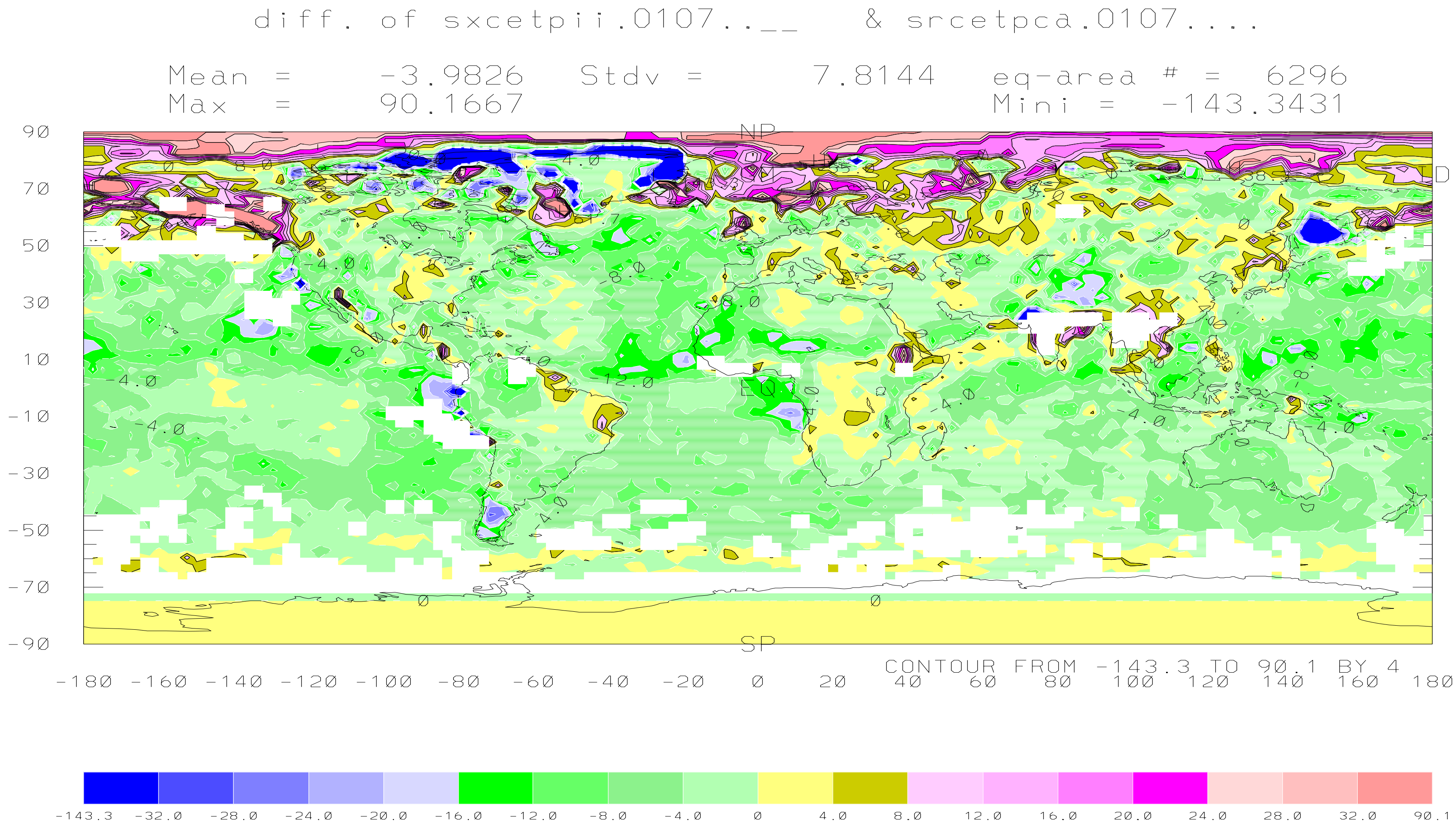
# ..III. ERB: 1. FD vs. CERES: (3) TOA LW Net for 0107



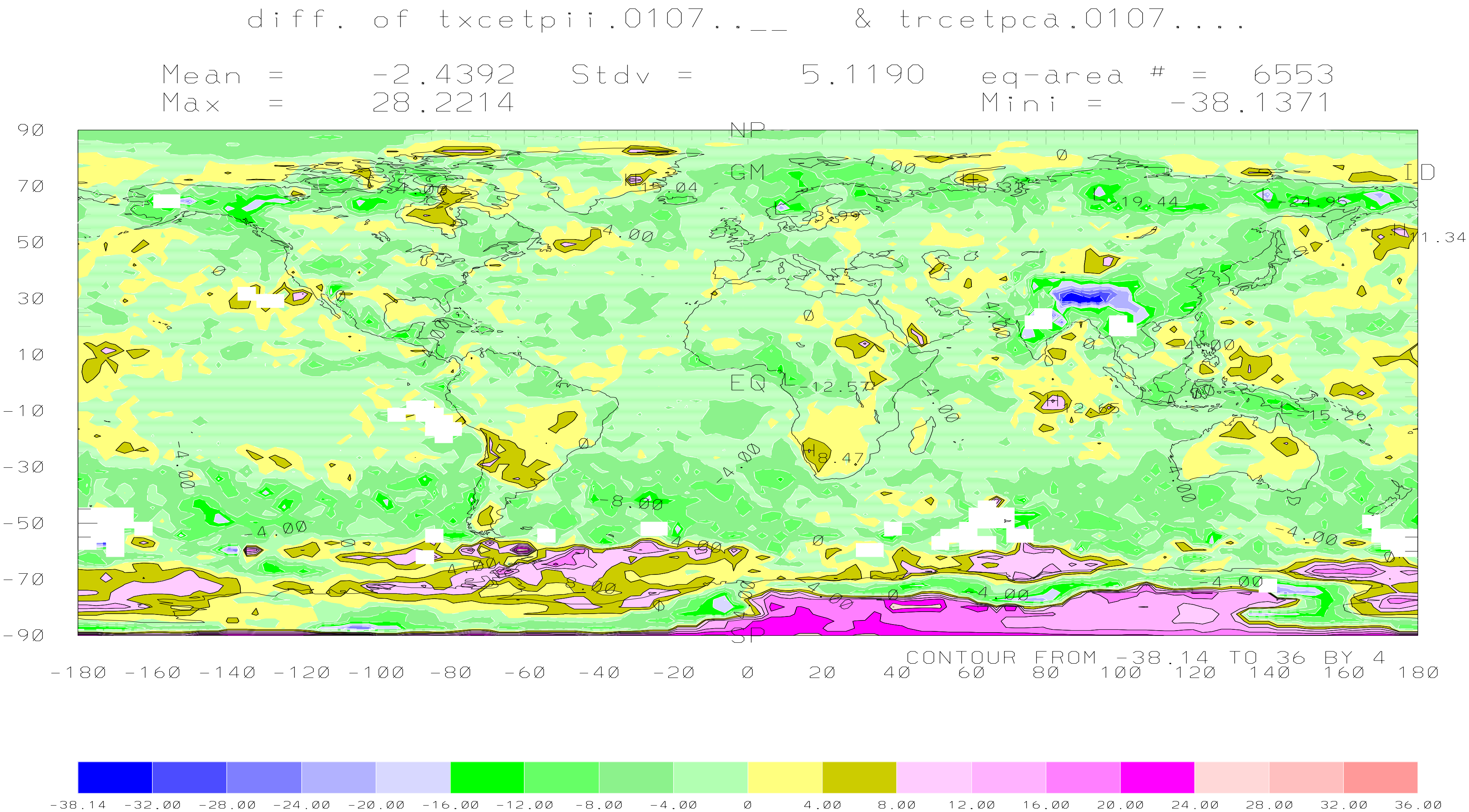
# ..III. ERB: 1. FD vs. CERES: (4) TOA Total (SW+LW) Net for 0107



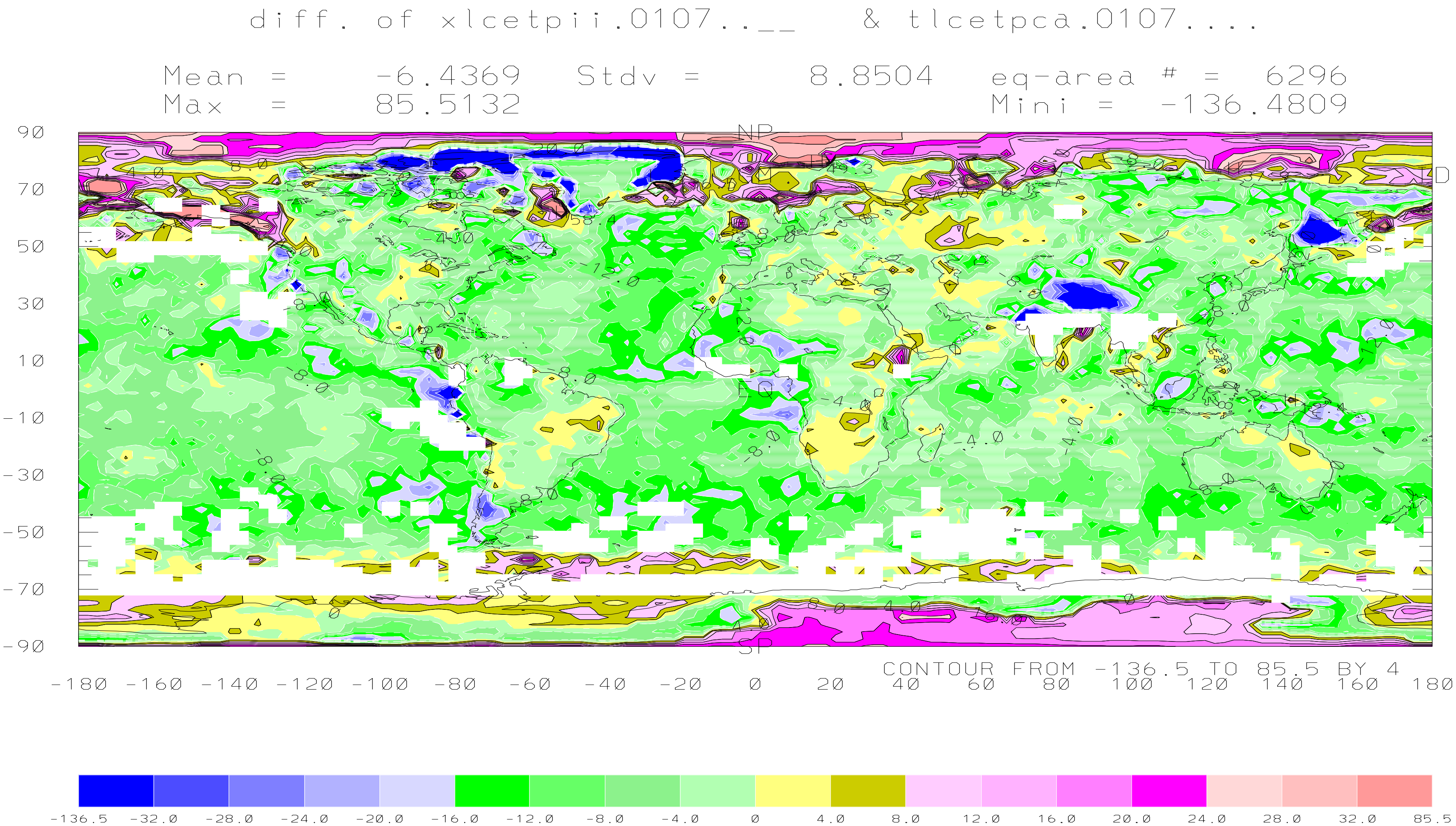
# ..III. ERB: 1. FD vs. CERES: (5) TOA SW Cloud Effects for 0107



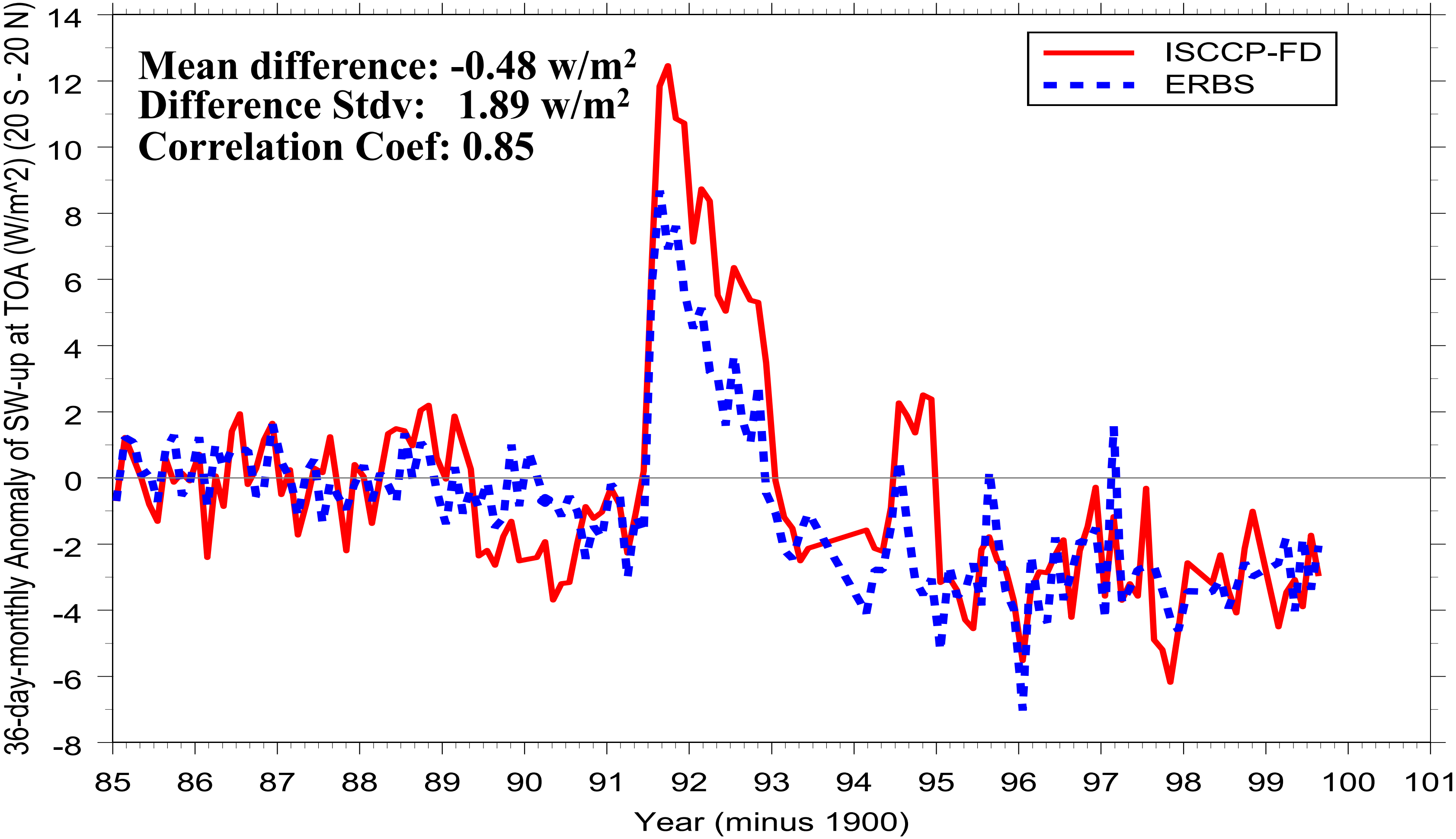
# ..III. ERB: 1. FD vs. CERES: (6) TOA LW Cloud Effects for 0107



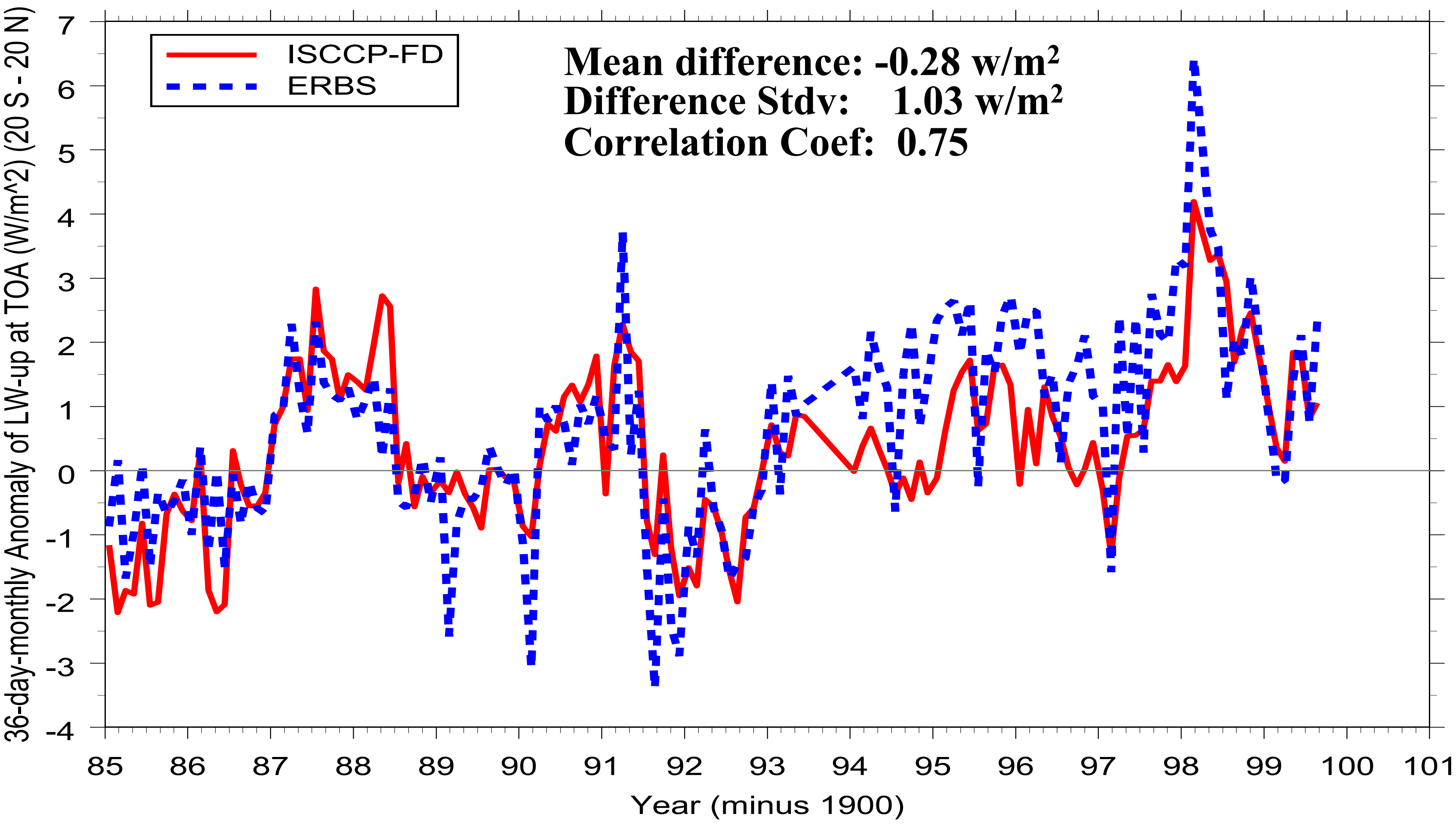
# ..III. ERB: 1. FD vs. CERES: (7) TOA Total Cloud Effects for 0107



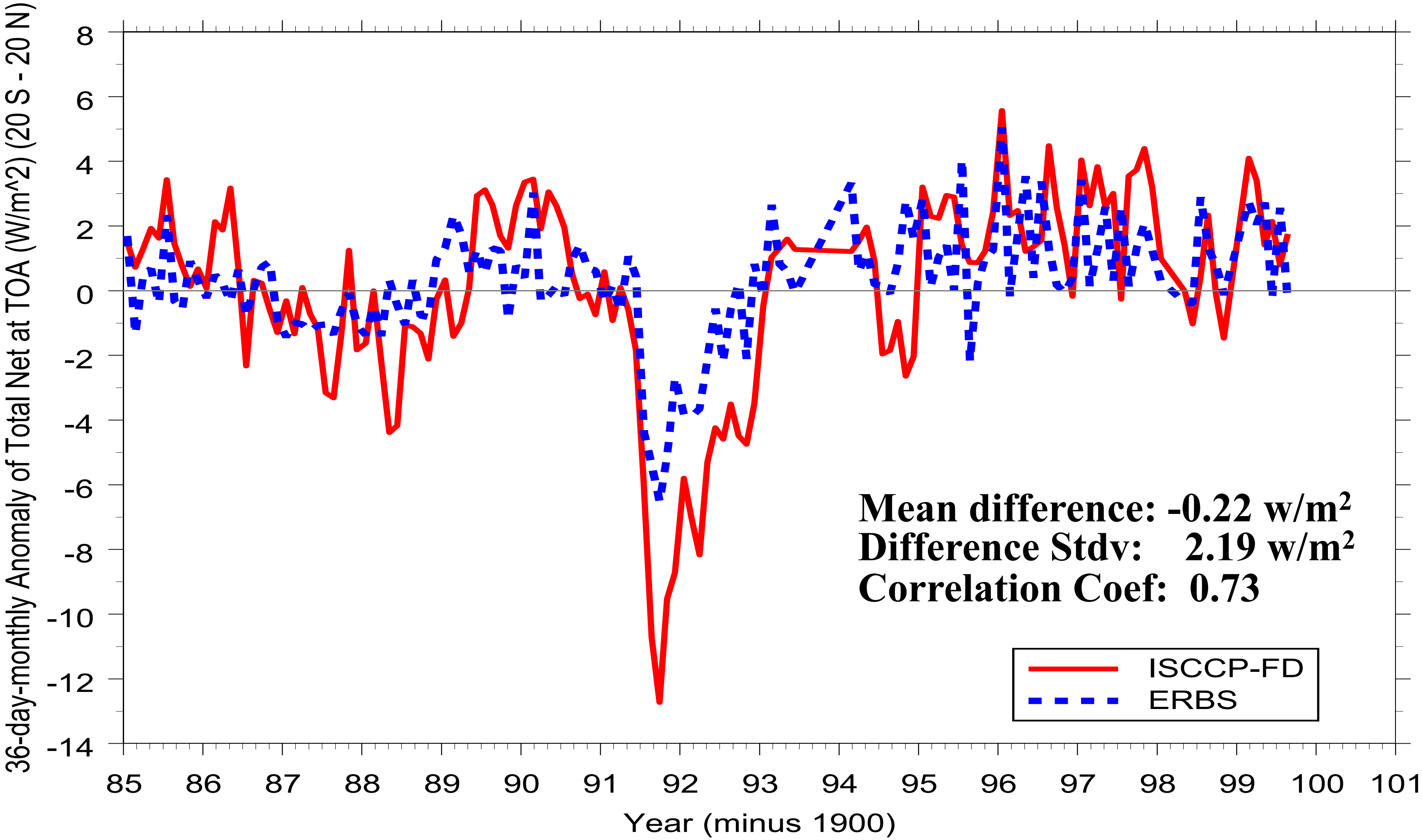
# ..III. ..ERB: 2. FD vs. ERBS: (1) SWup Tropical Anomaly



# ..III. ..ERB: 2. FD vs. ERBS: (2) LWup Tropical Anomaly

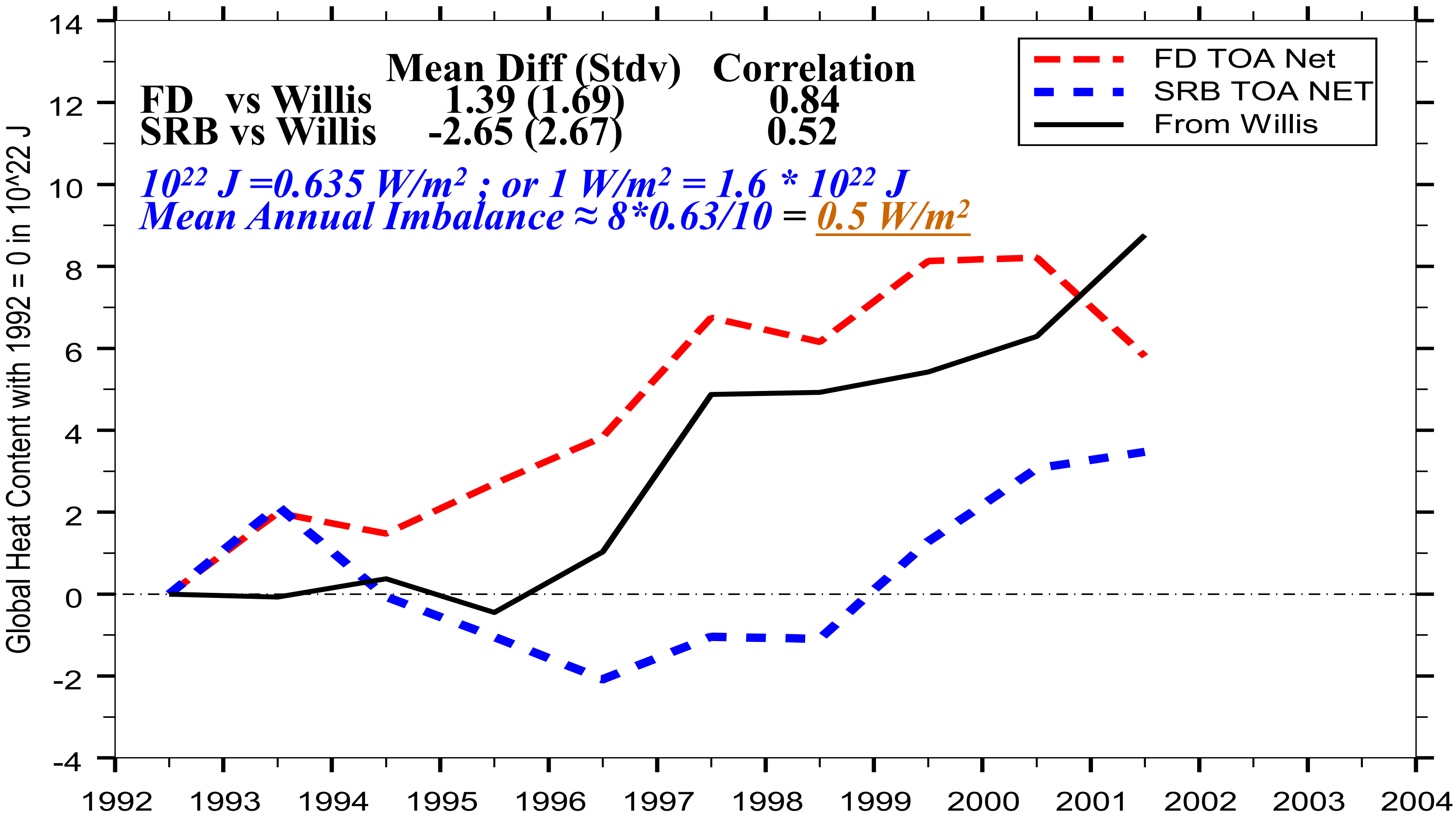


## ..III. ..ERB: 2. FD vs. ERBS: (3) NET Tropical Anomaly

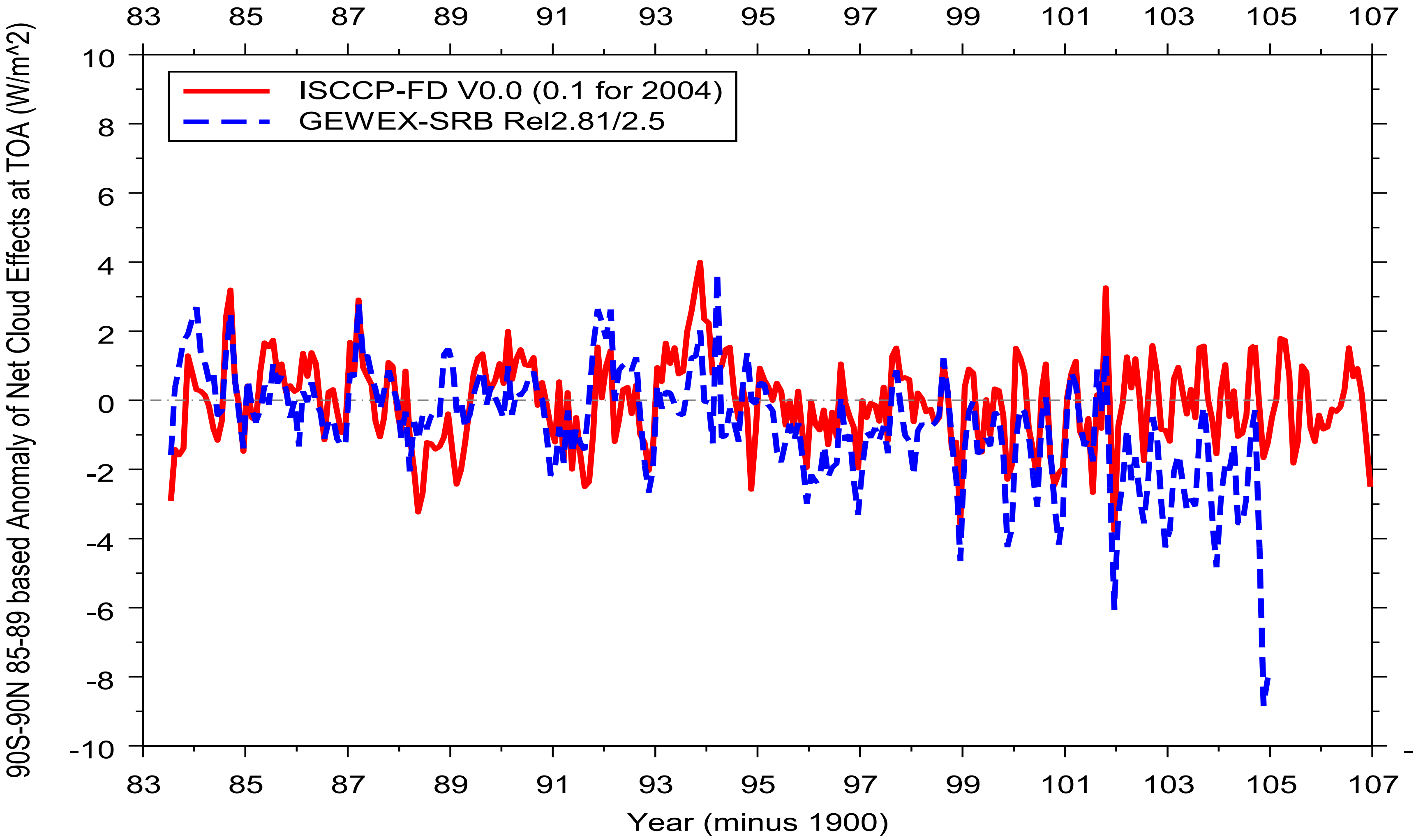


# ..III. ..ERB: 3. FD/GEWEX-SRB vs. Ocean Heat Content

[Correcting XBT (eXpendable Bathy Thermograph) is being processing]

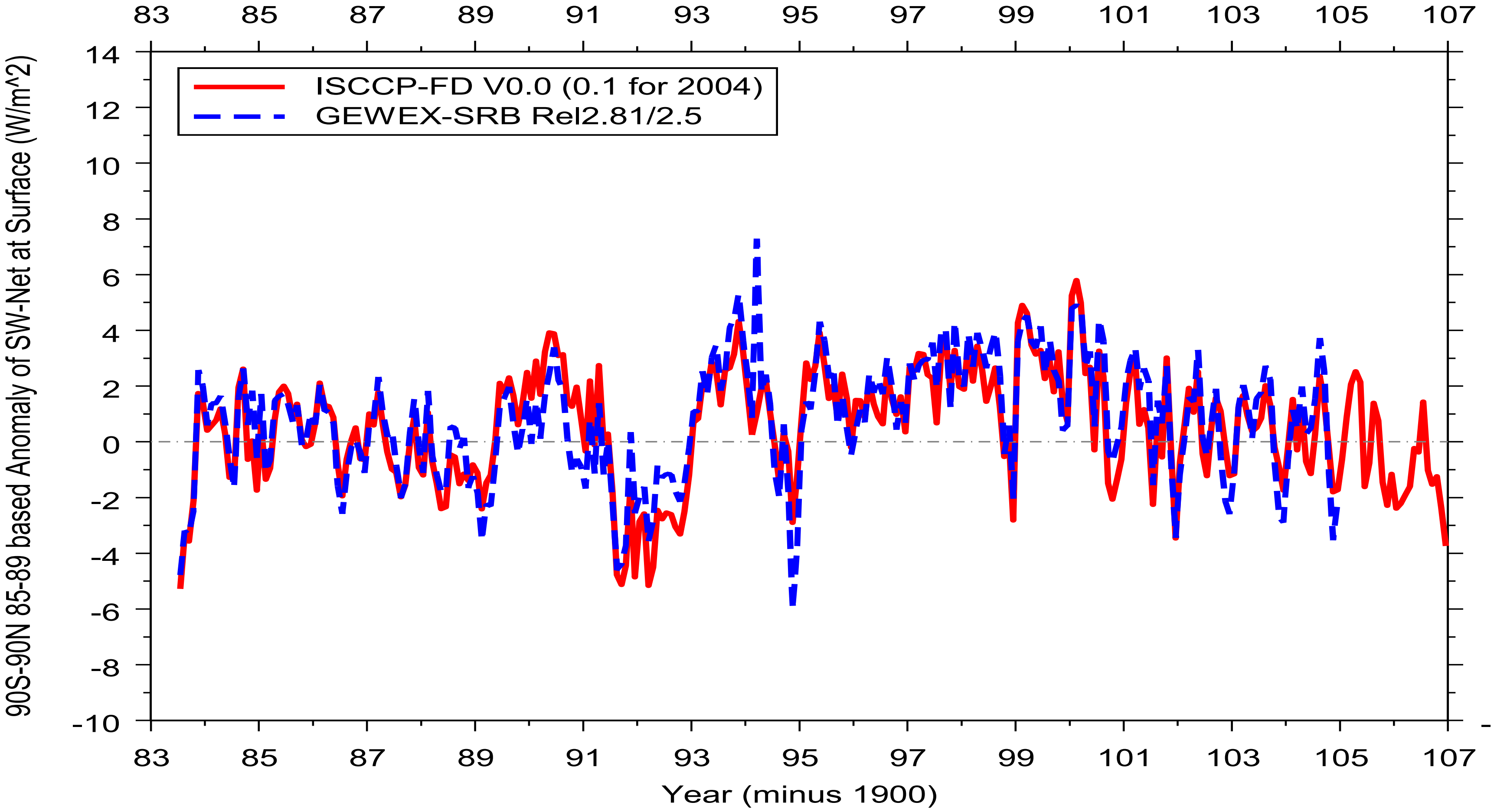


# ..III..ERB: 4. Total CE (cloud Effect) Anomaly: FD vs. GEWEX-SRB

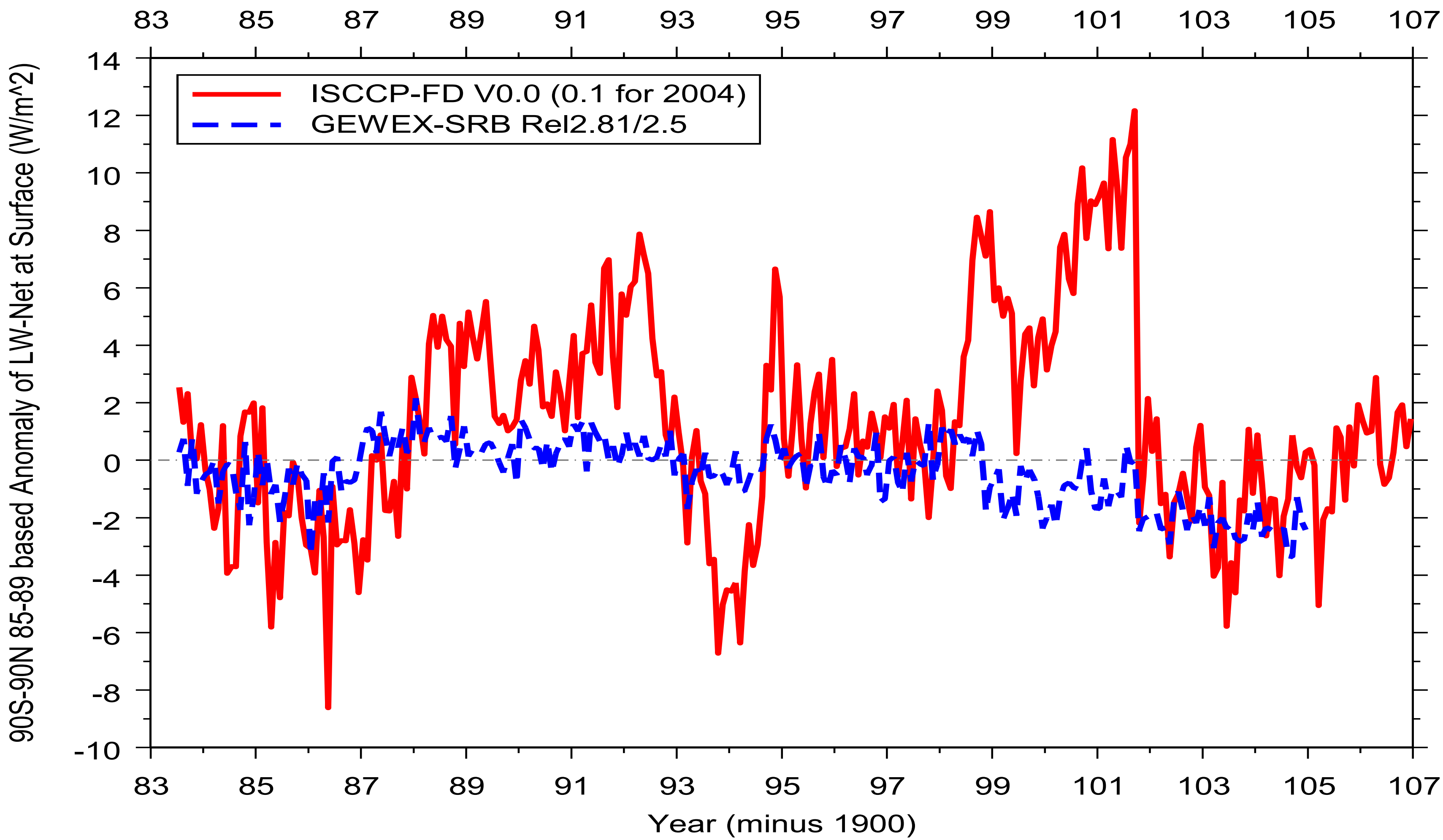


# IV. Global, long-term SRB:

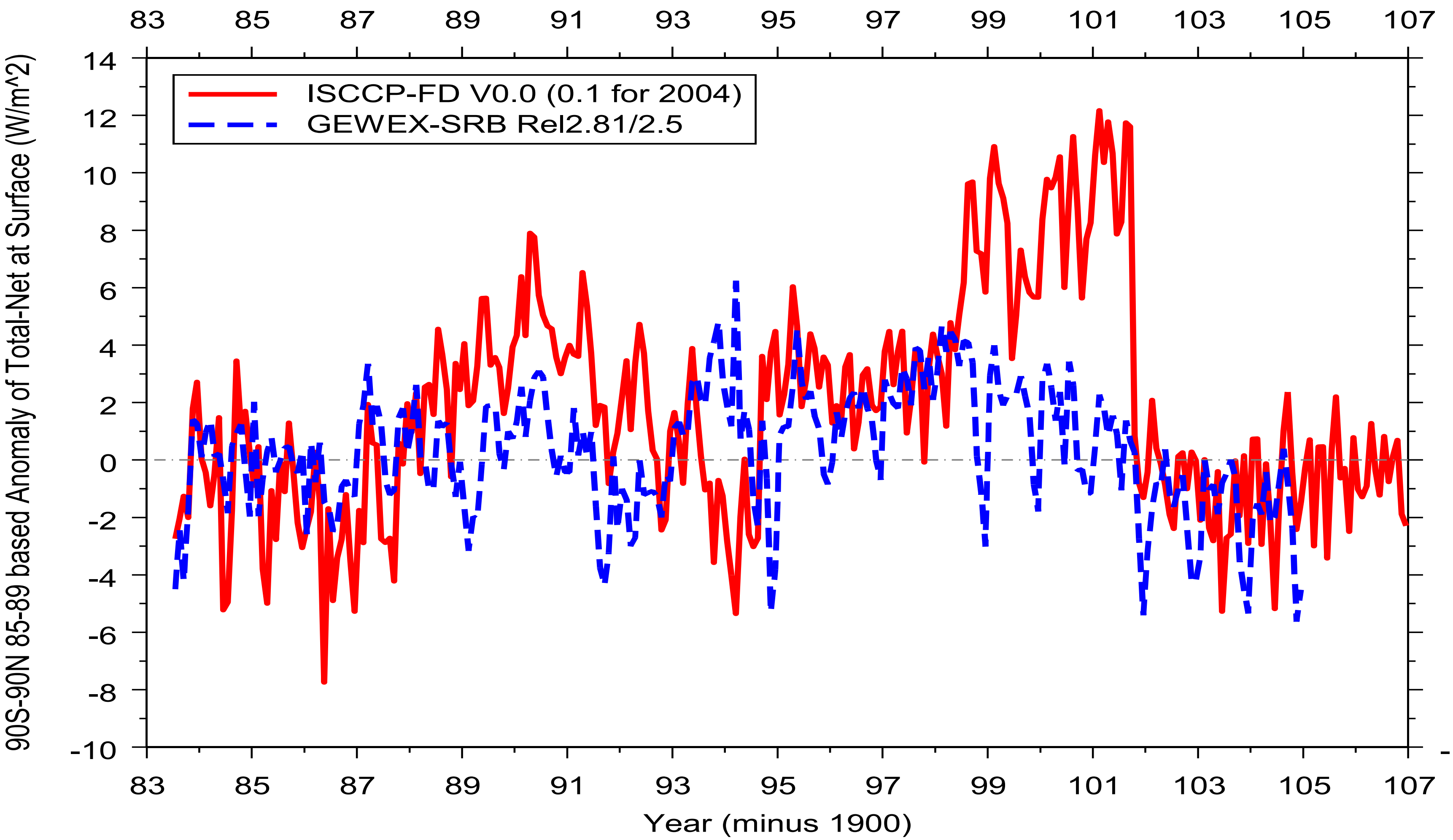
## 1. FD vs GEWEX-SRB: SW-Net Anomaly at Surface



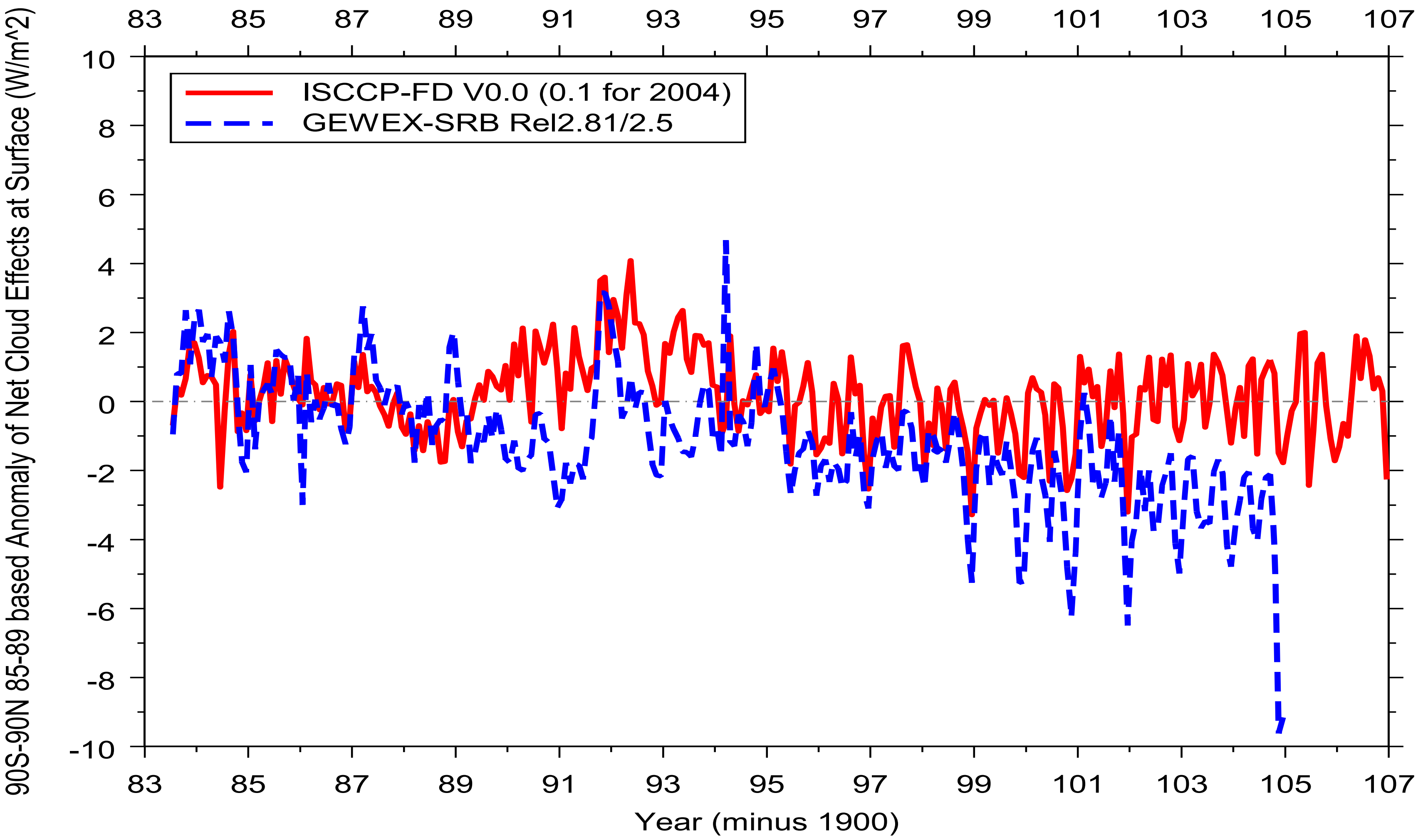
# ...IV. . SRB: 2. FD vs GEWEX-SRB: LW-Net anomaly at Surface



## ..IV. . SRB: 3. FD vs GEWEX-SRB: Total-Net anomaly at Surface

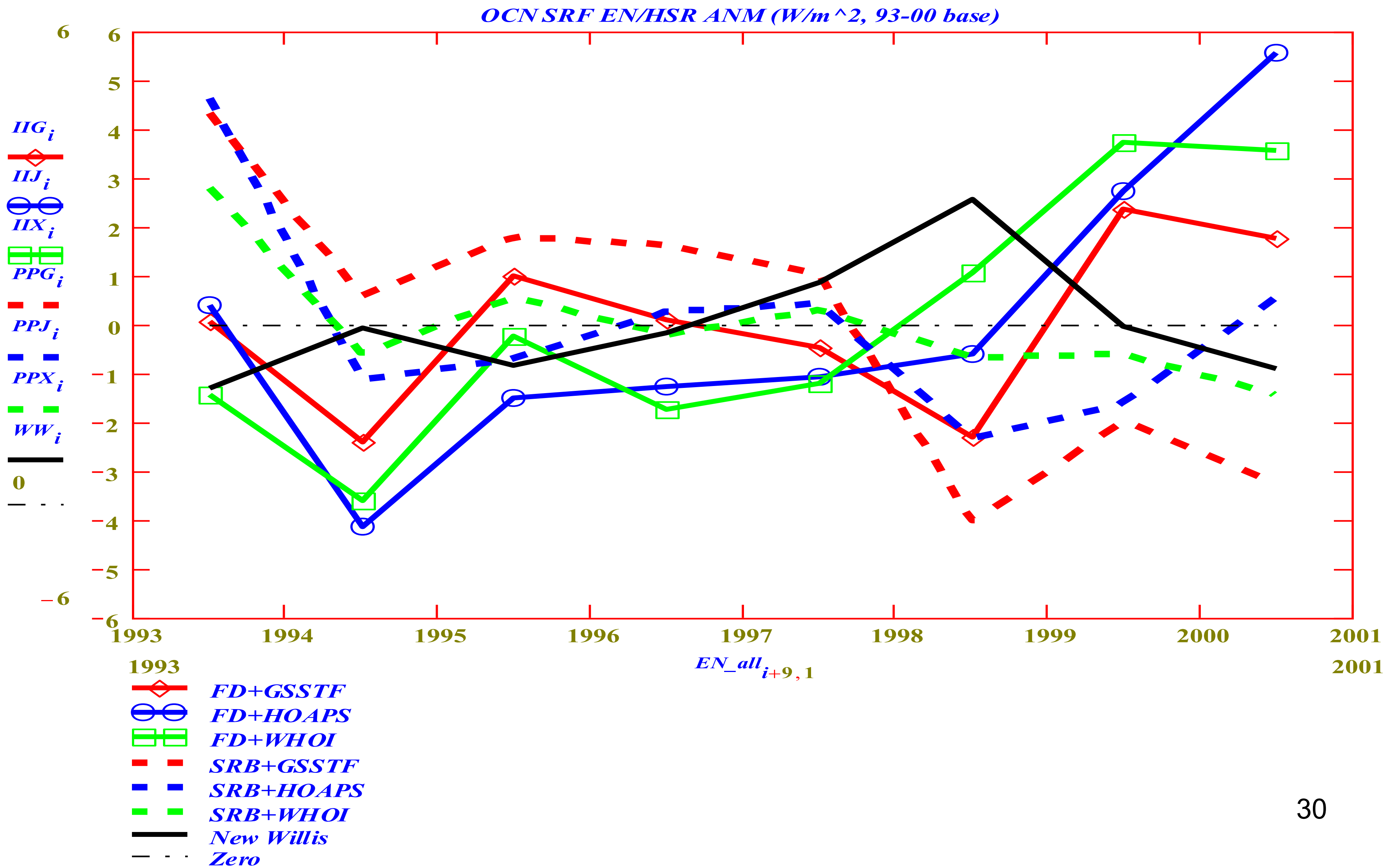


# …IV. . SRB: 4. FD vs GEWEX-SRB: Surface Total CE Anomaly



# …IV. . SRB: 5. Surface Net Energy Flux vs Ocean Heat Storage Rate:

FD/SRB with F2, H2 & WH vs. OHSR 7-yr Anomaly (W/m²)



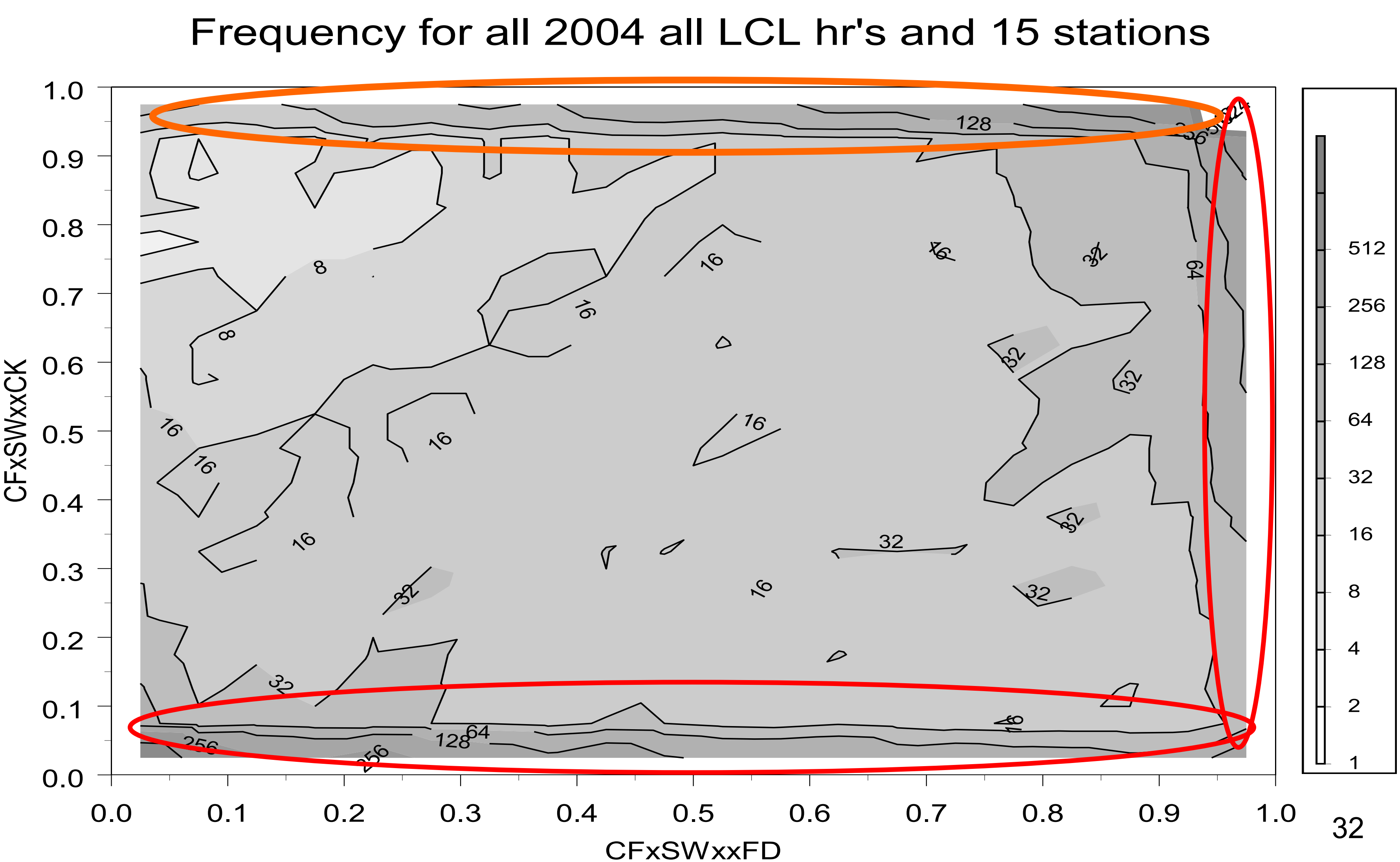
# V. Clouds/AOD vs Diffuse/Direct fluxes

## 1. SOB: 15 stations from BSRN, ARM and SURFRAD)

| Station | Station Name [Owner] | Network | Stat'n Lat/Lon | FD cell lat/lon | AOD |
|---|---|---|---|---|---|
| NYA | Ny Alesund, Spitsbergen [GM/NY] | BSRN | 78.9N/ 11.9E | 78.8N/ 6.4E | N |
| FPE | Fort Peck, MT [USA] | SURFRAD | 48.5N/254.8E | 48.8N/255.8E | Y |
| PAY | Paverne, [Switzerland] | BSRN | 46.8N/ 6.9E | 46.2N/ 5.4E | N |
| PSU | Rock Springs, PA [USA] | SURFRAD | 40.7N/282.1E | 41.2N/281.7E | Y |
| BOS | Boulder, CO [USA] | SURFRAD | 40.2N/254.6E | 41.2N/255.0E | Y |
| BON | Bondville, IL [USA] | SURFRAD | 40.1N/271.4E | 41.2N/271.7E | Y |
| DRA | Desert Rock, NV [USA] | SURFRAD | 36.6N/243.9E | 36.2N/243.6E | Y |
| BIL | Billings, OK [USA] | ARM | 36.6N/262.5E | 36.2N/262.2E | N |
| TAT | Tateno [Japan] | BSRN | 36.0N/140.1E | 36.2N/141.2E | N |
| GCR | Goodwin Creek, Mississippi [USA] | SURFRAD | 34.2N/270.1E | 33.8N/271.5E | Y |
| NAU | Nauru Island [USA] | ARM | 0.5S/166.9E | 1.2S/166.2E | Y |
| MAN | Momote, Manus Is., Papua New Guinea [USA] | ARM | 2.1S/147.7E | 1.2S/148.8E | Y |
| DAR | Darwin [Australia] | ARM | 12.5S/130.9E | 13.8S/129.9E | Y |
| GVN | George von Neumaver, Ant. [GM] | BSRN | 70.7S/351.8E | 71.2S/348.3E | N |
| SPO[7] | South Pole, Antarctica [USA] | BSRN | 89.8S/258.0E | 88.8S/300.0E | Y |

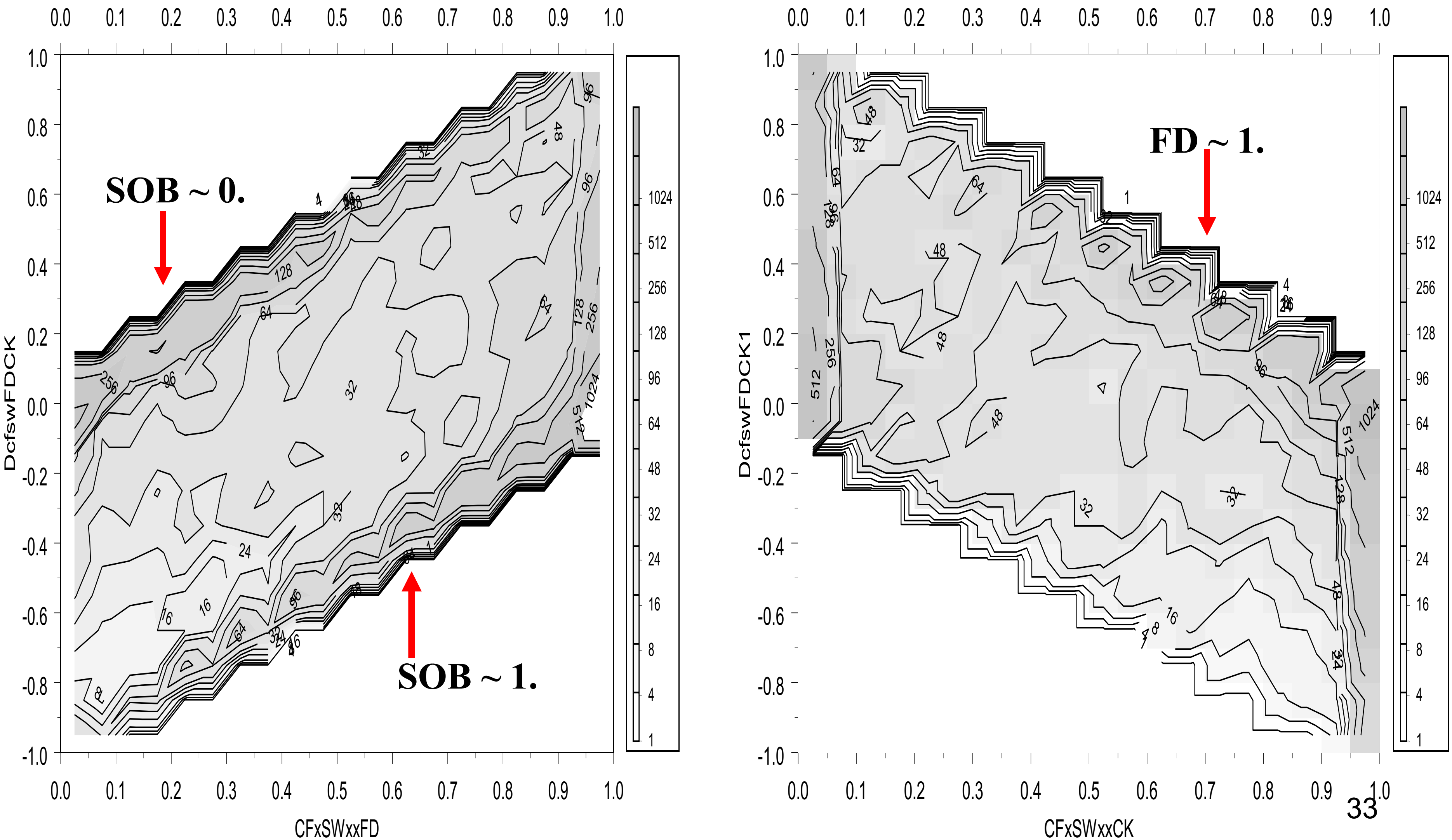
# .V.. Clouds/AOD vs Dif/Dir: 2. Cloud Fraction (CFsw):

## (1) 2-D frequency VS CFsw (X=FD and Y=SOB; scatter correlation = 0.588)



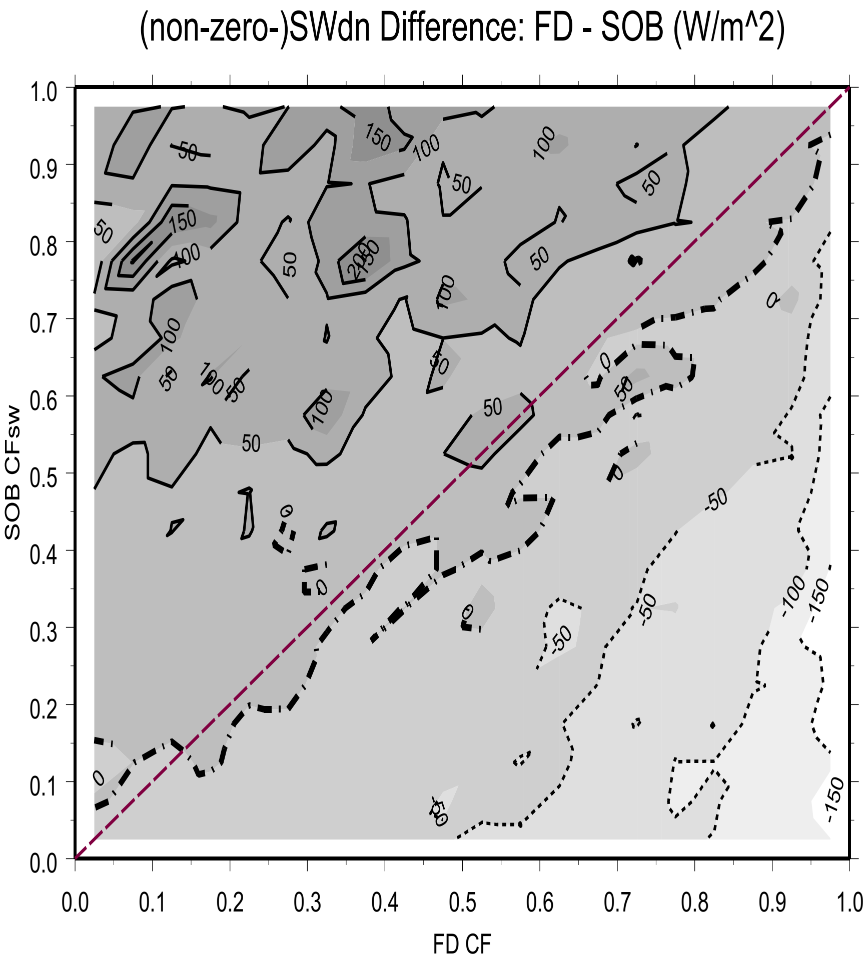
# .V.. Clouds/AOD vs Dif/Dir: 2. Cloud Fraction (CFsw):

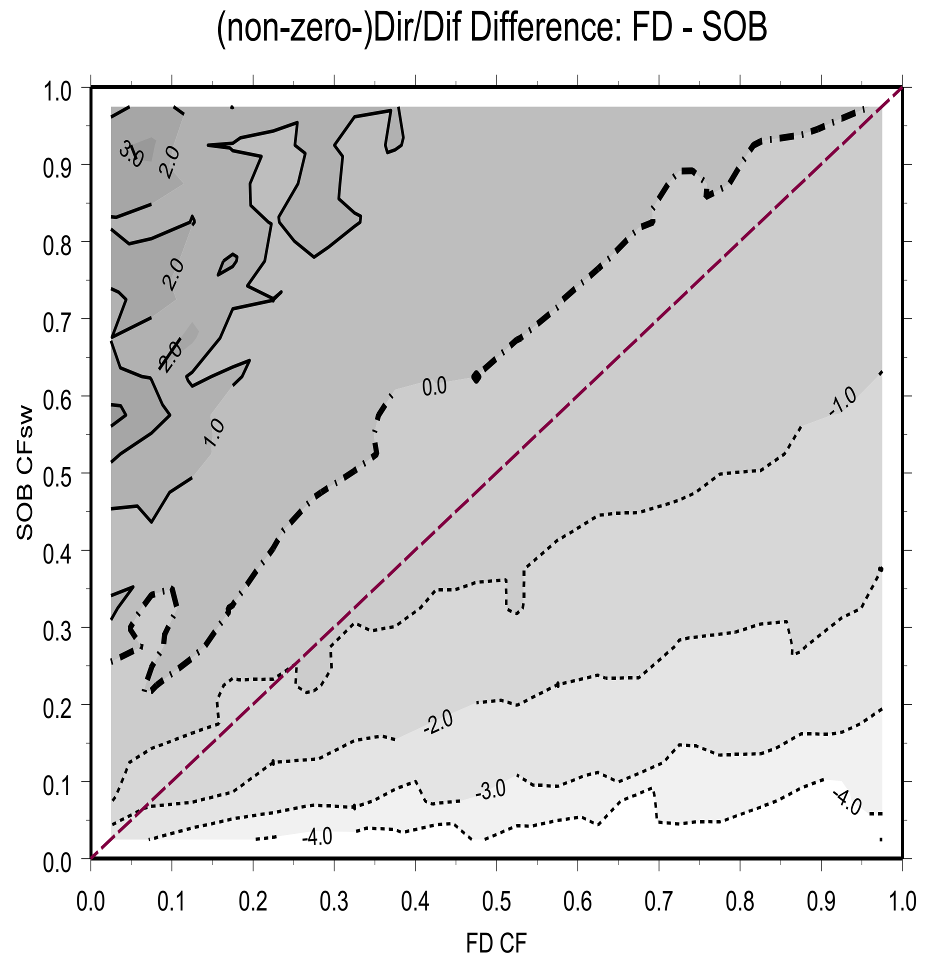
## (2) 2-D Frequency: X=CFsw of FD (L) and SOB (R); Y=CFsw difference (FD - SOB)



# ..V.. Clouds/AOD vs Dif/Dir: 2. Cloud Fraction (CFsw):

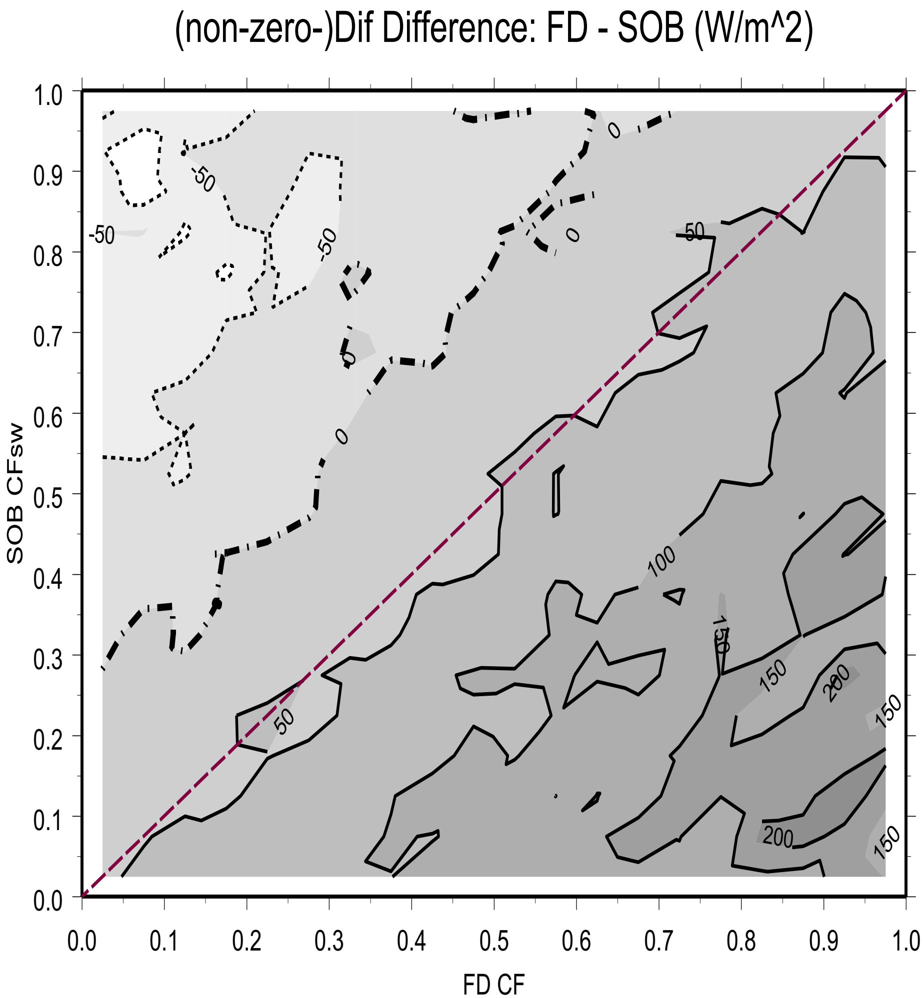
## (3) SWdn difference (L) and Dir/Dif difference (R) vs CFsw [X=FD; Y=SOB]

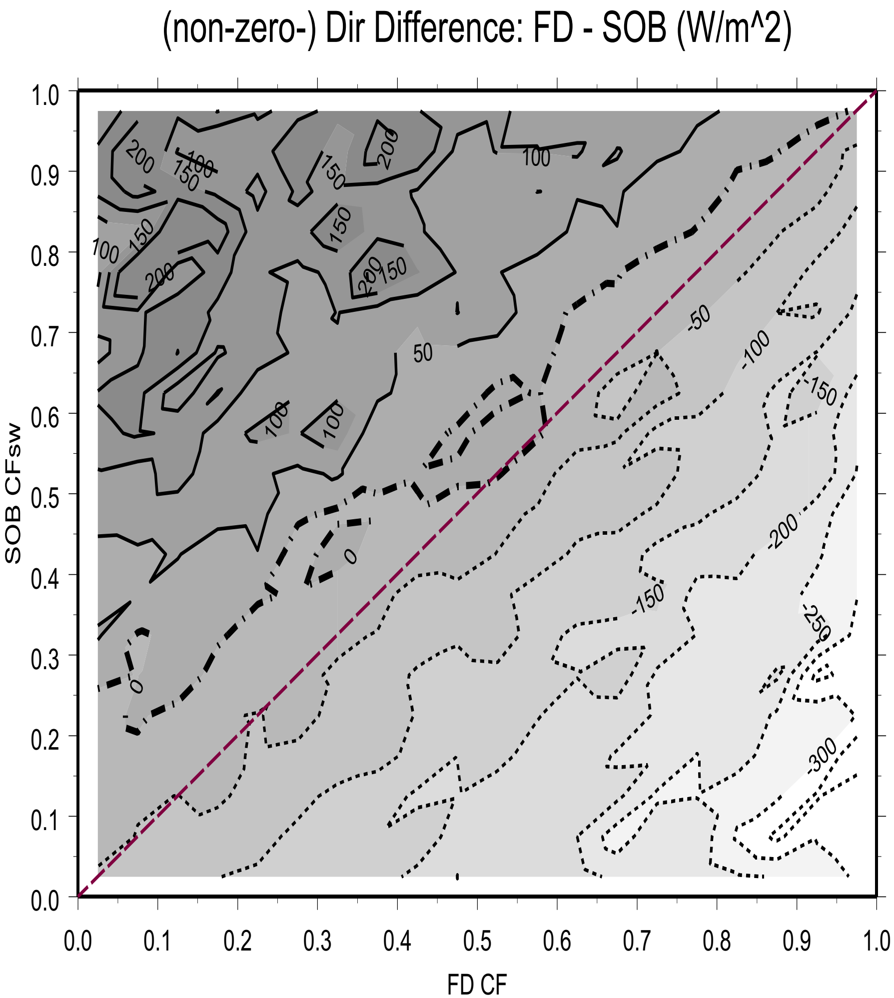


# .V.. Clouds/AOD vs Dif/Dir: 2. Cloud Fraction (CFsw):

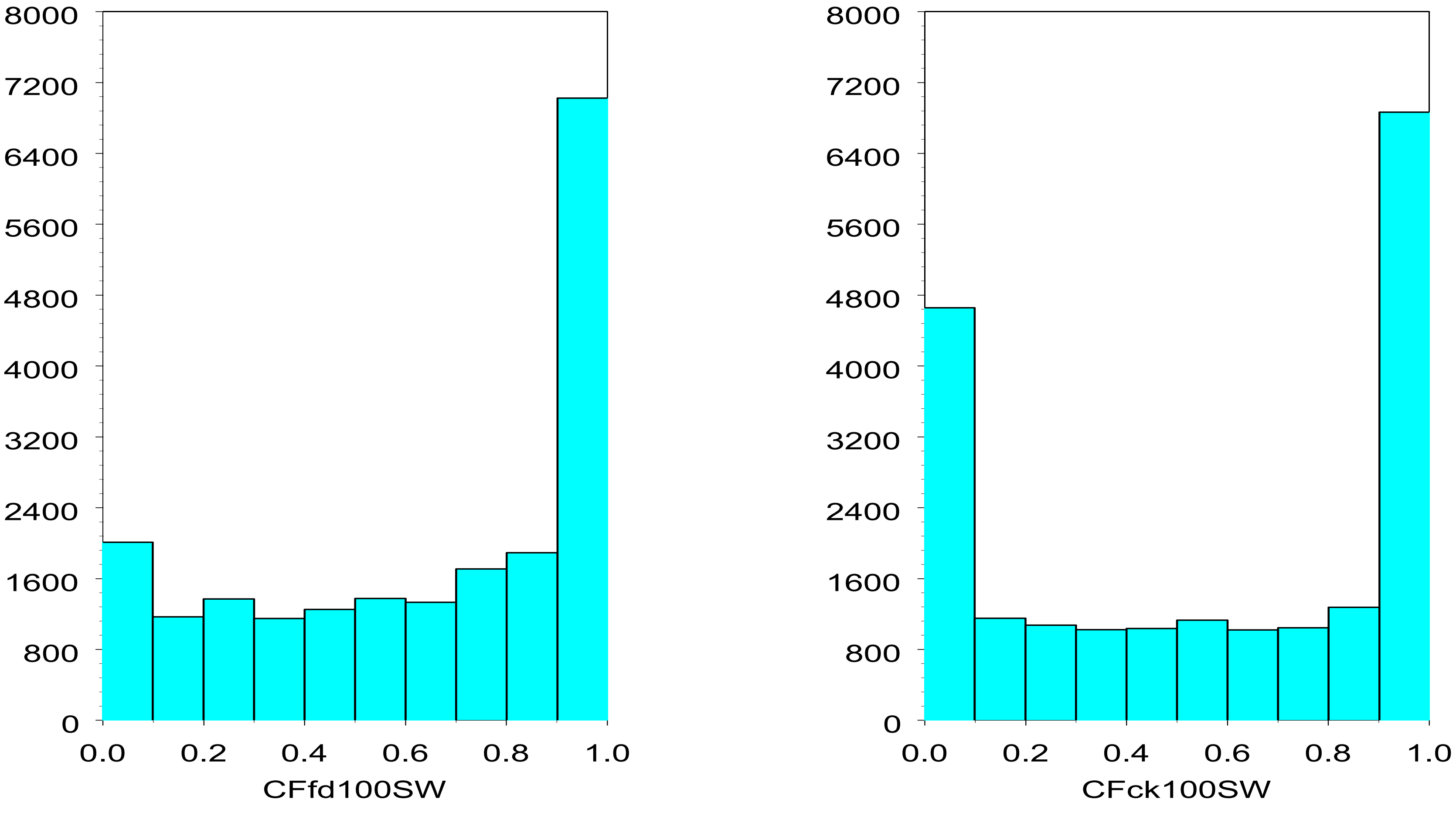
## (4) Dif difference (L) and Dir difference (R) vs CFsw [X=FD; Y=SOB]



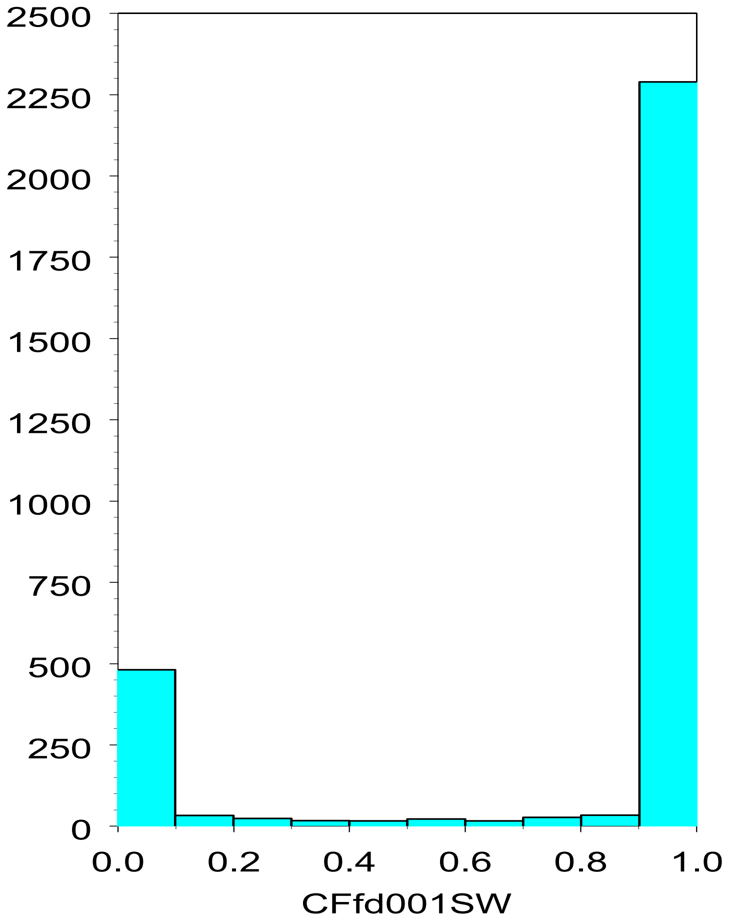
# ..V.. Clouds/AOD vs Dif/Dir: 2. Cloud Fraction (CFsw):

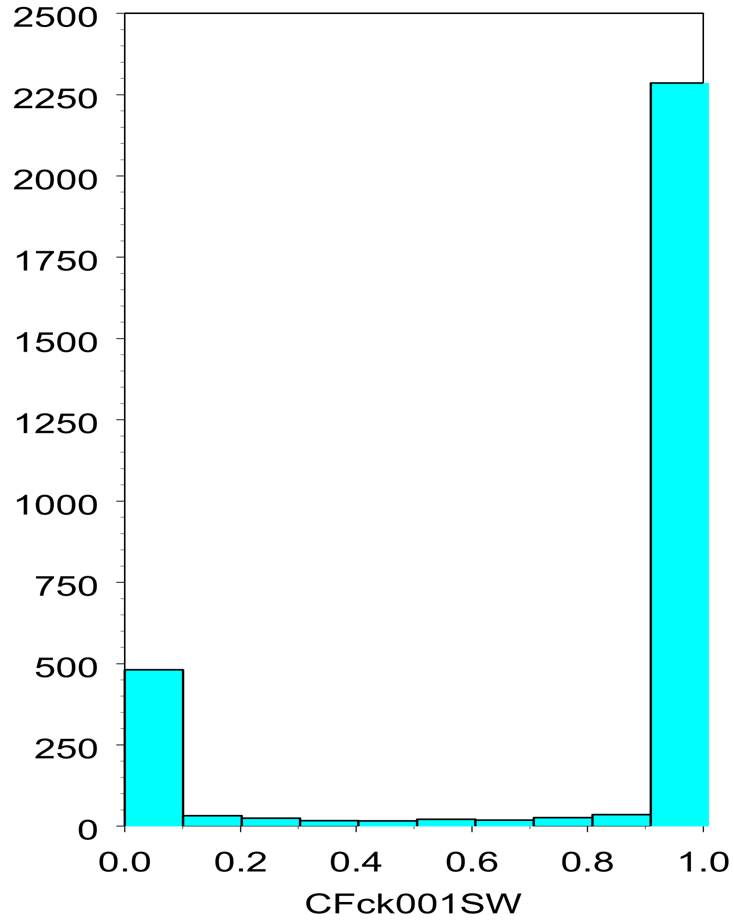
## (5) CFsw Histogram when |CFsw difference| ≤ 1(No restriction; total 20280's): FD (L) and SOB (R)



## ..V.. Clouds/AOD vs Dif/Dir: 2. Cloud Fraction (CFsw):

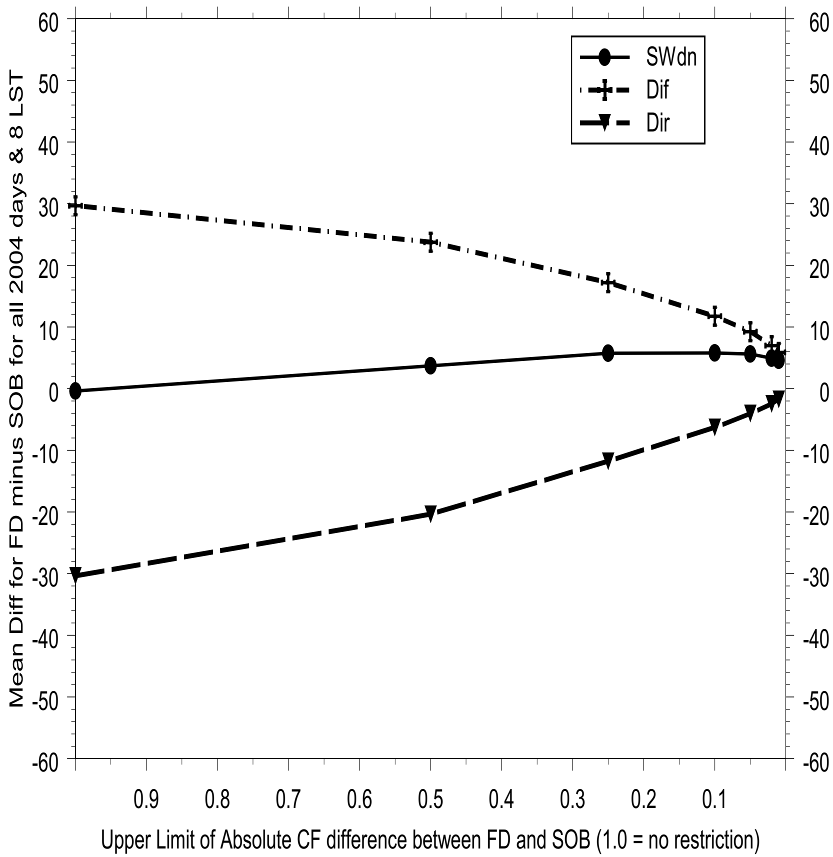
### (6) CFsw Histogram when |CFsw difference| ≤ 0.01 (total 2959's): FD (L) and SOB (R)

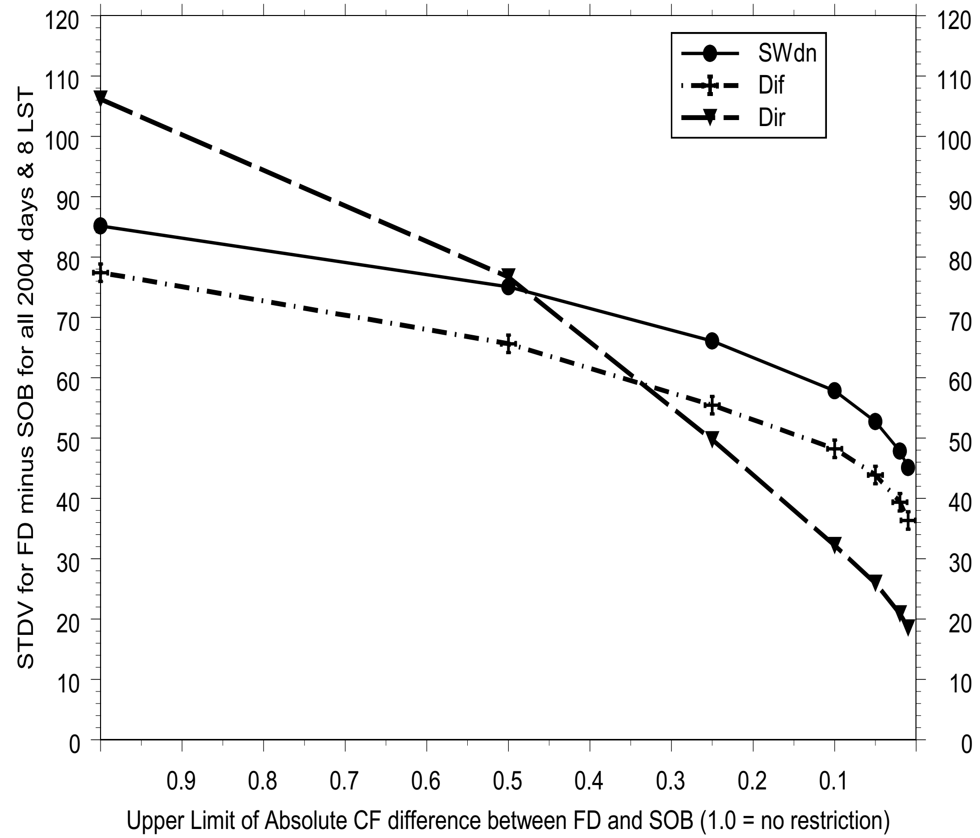


# ..V.. Clouds/AOD vs Dif/Dir: 2. Cloud Fraction (CFsw):

## (7) Mean difference (L) and Stdv (R) vs |CFsw difference|
## (no-CF-fluxes included: total 41005's for X=1.0) for 2004 3-hourly & 15 Sites

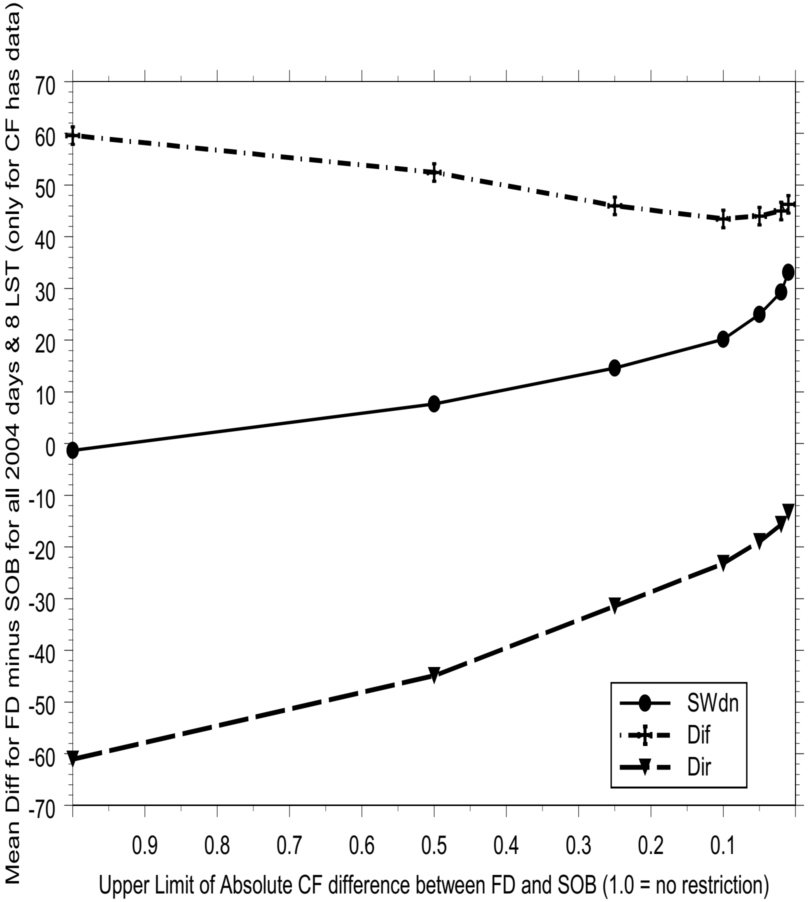


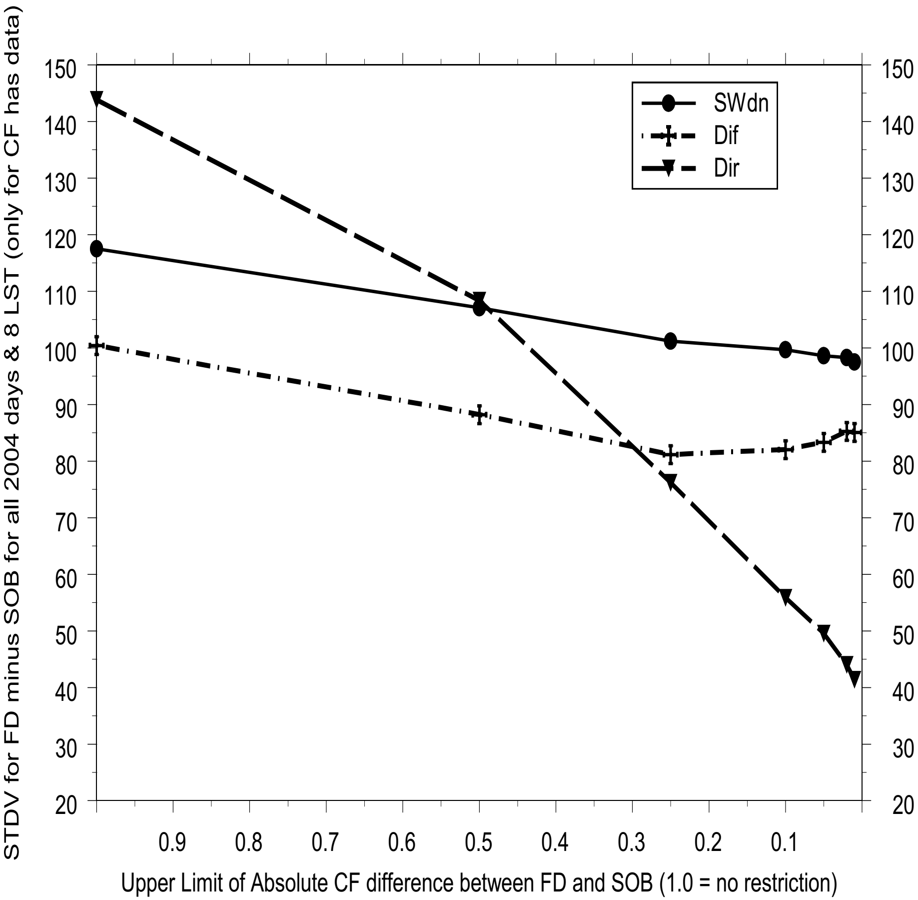



# ..V.. Clouds/AOD vs Dif/Dir: 2. Cloud Fraction (CFsw):

## (8) Mean difference (L) and Stdv (R) vs |CFsw difference|

## (All have CF, i.e., excluding no-CF flux values: total = 20280 for X=1.0)

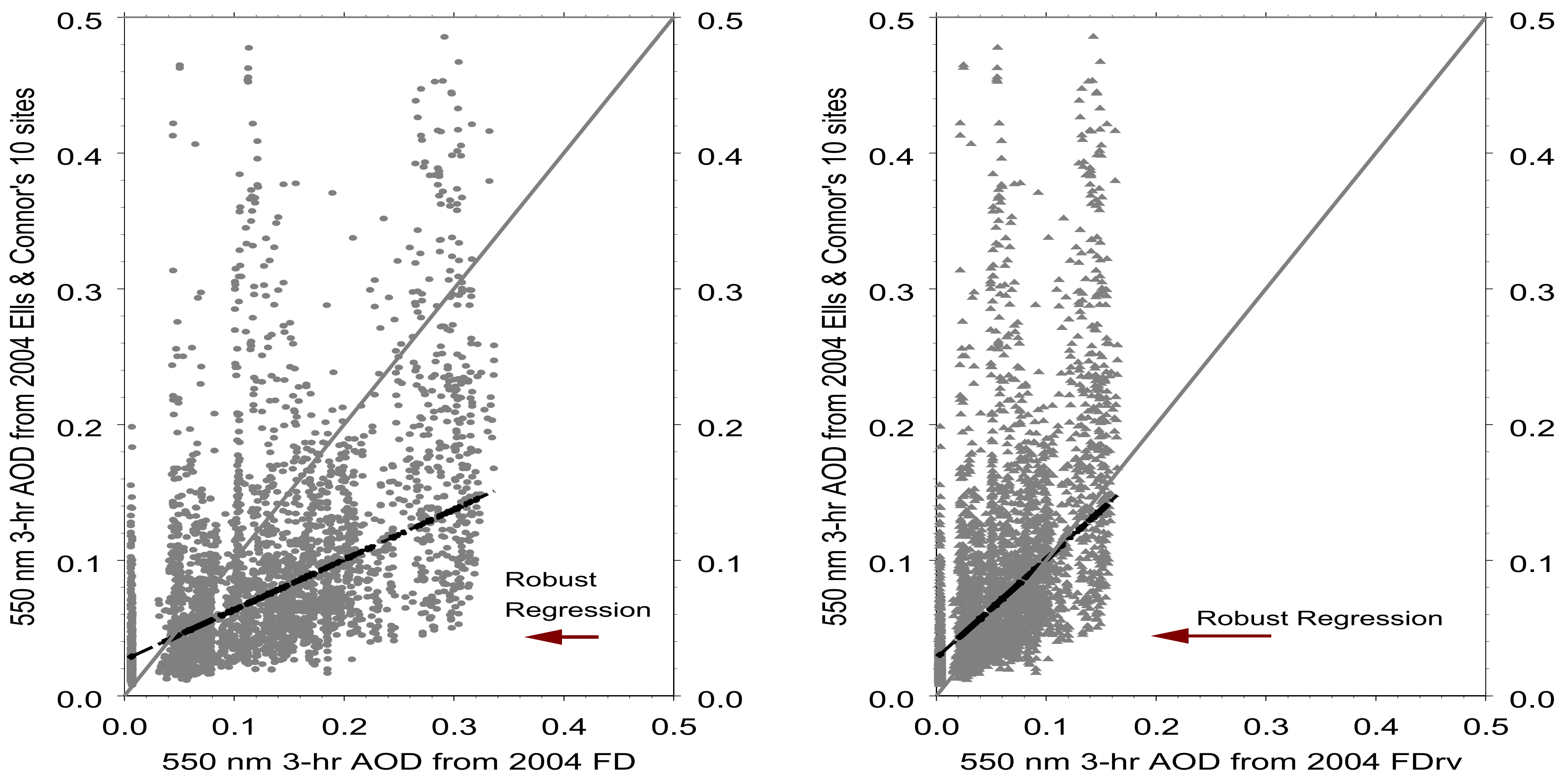


## ..V.. Clouds/AOD vs Dif/Dir: 3. AOD:

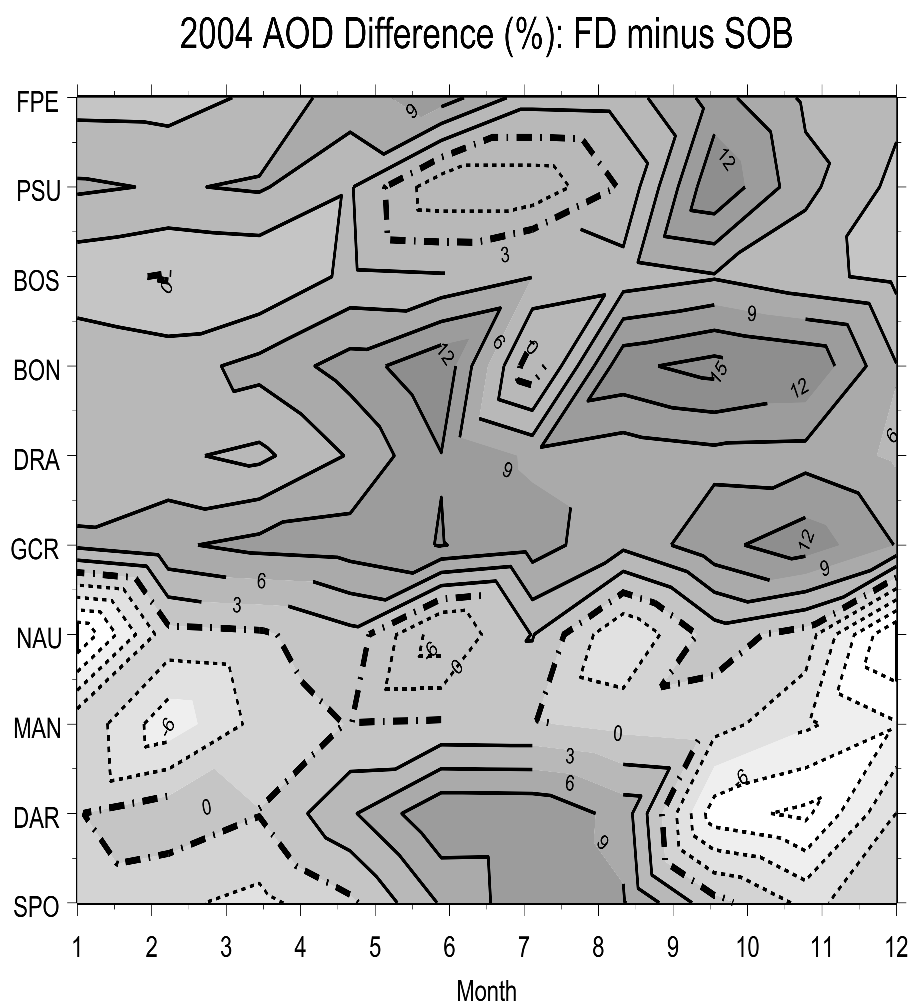
### (1) AOD for all 2004 local hr's from 10 Stations:

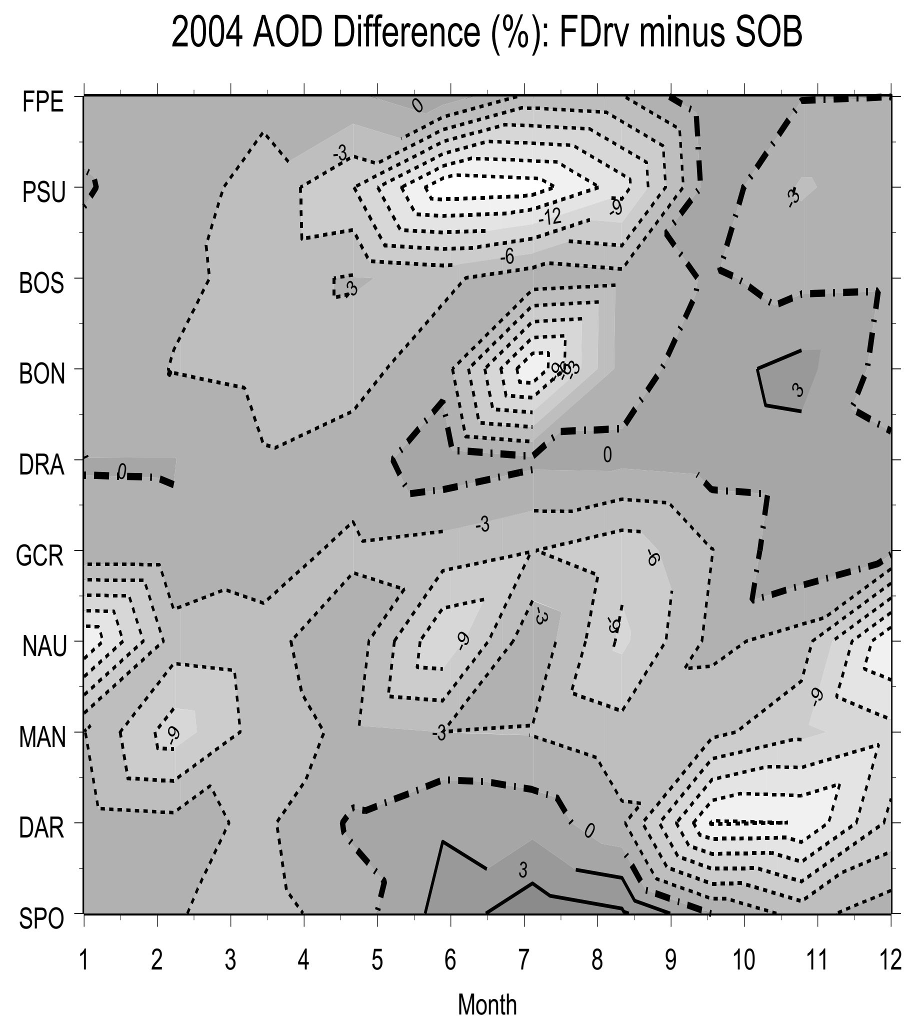
### Original (L) and FDrv=50% of original (R) [X=FD; Y=SOB]



# ..V.. Clouds/AOD vs Dif/Dir: 3. AOD:

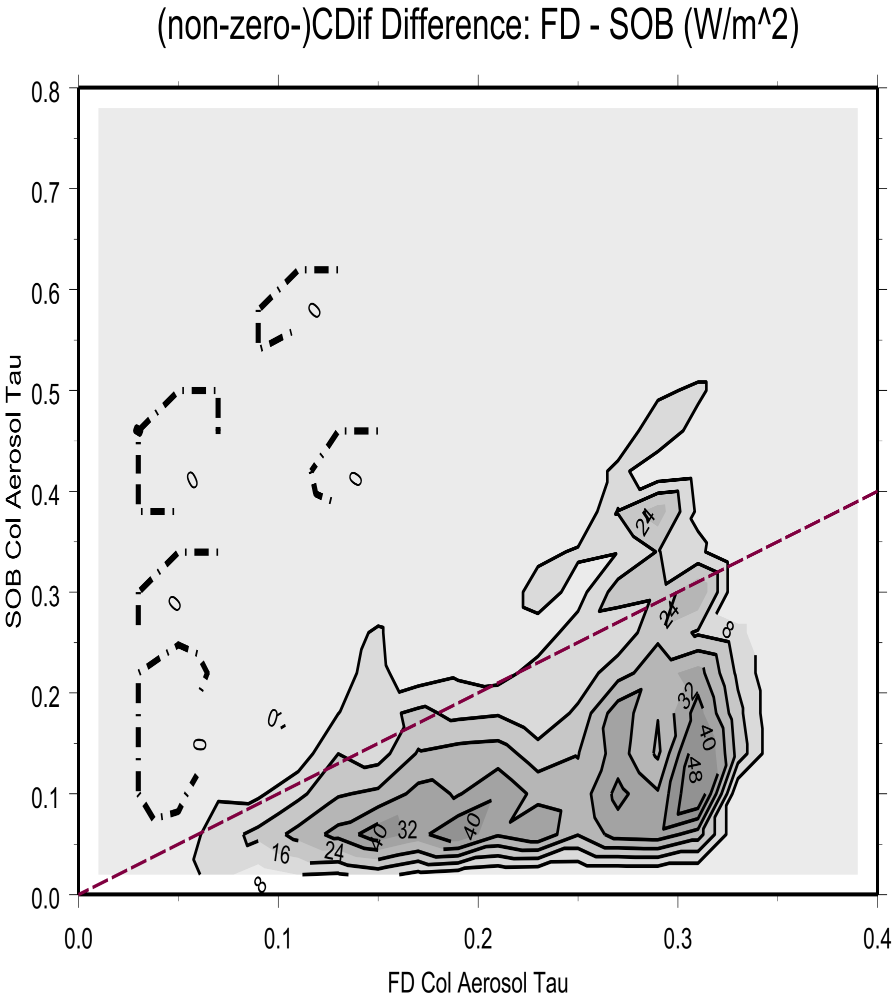
## (2) Seasonal/Site AOD difference (FD or FDrv minus SOB): Original (L) and FDrv=50% of original (R)

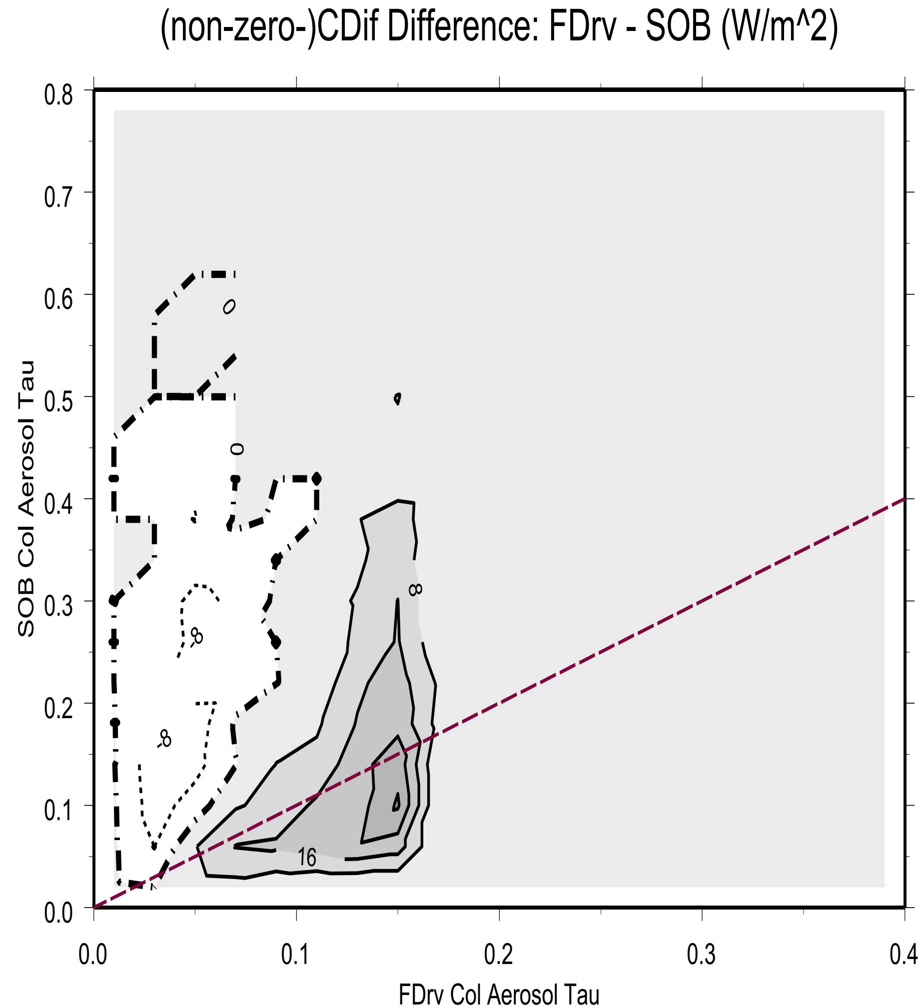


# ..V.. Clouds/AOD vs Dif/Dir: 3. AOD:

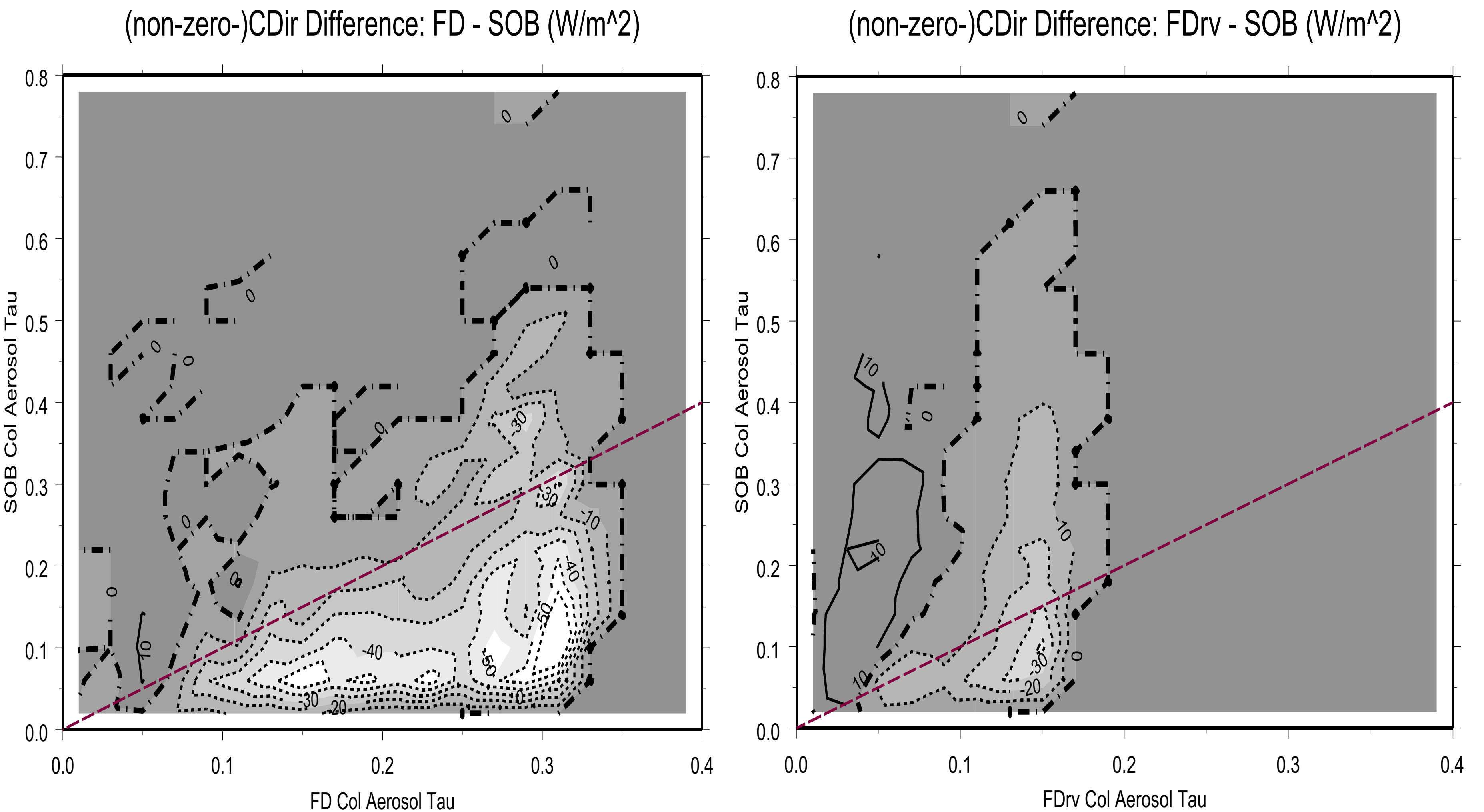
**(3) CDif (2004 local hr's) Difference (FD minus SOB) VS AOD [X=FD; Y=SOB]: Original (L) and FDrv=50% org (R)**



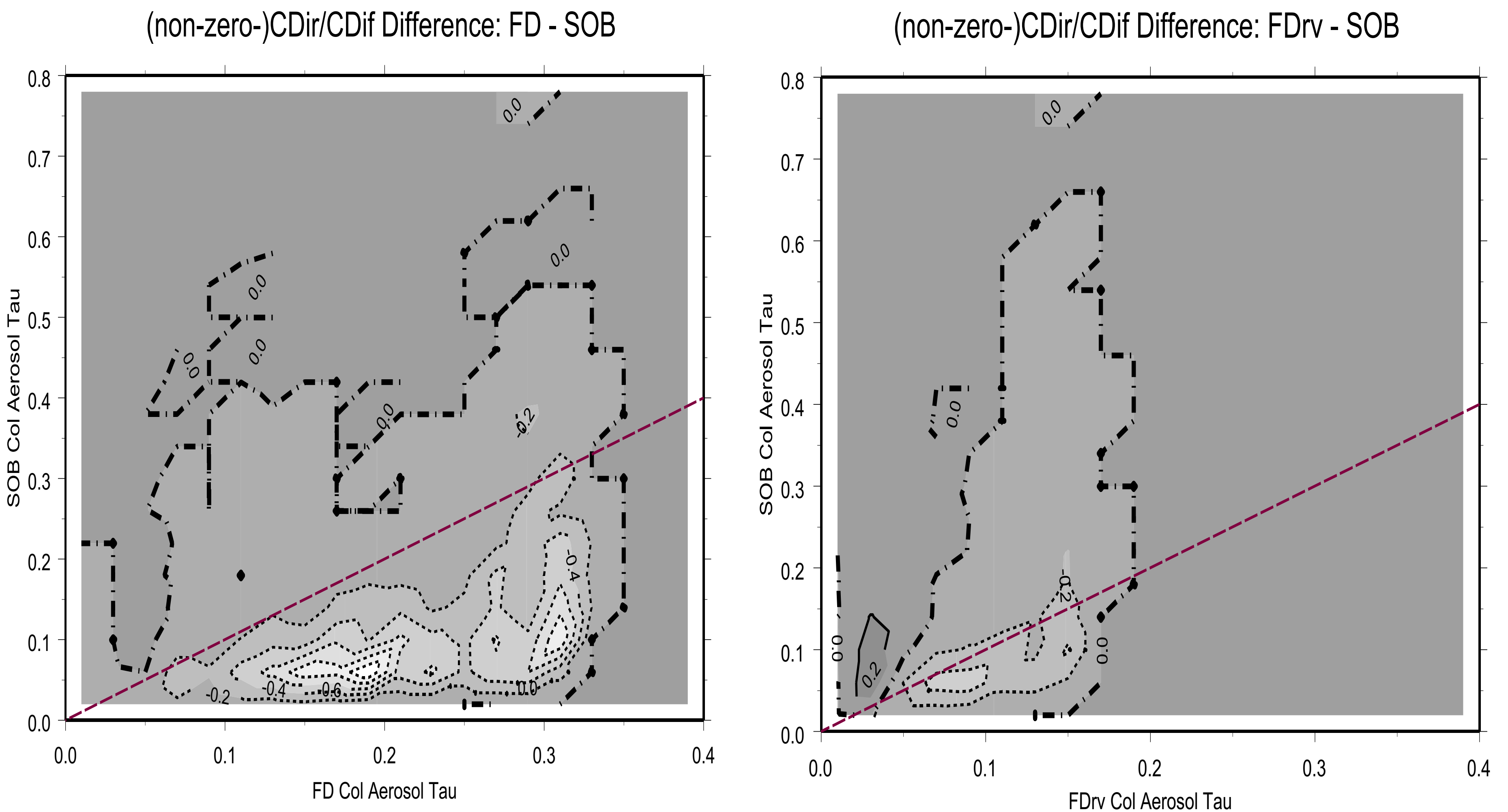
# ..V.. Clouds/AOD vs Dif/Dir: 3. AOD:

## (4) CDir (2004 local hr's) Difference (FD minus SOB) VS AOD [X=FD; Y=SOB]: Original (L) and FDrv=50% org (R)



# ..V.. Clouds/AOD vs Dif/Dir: 3. AOD:

## (5) CDir/CDif (2004 local hr's) Difference (FD minus SOB) VS AOD [X=FD; Y=SOB]: Original (L) and FDrv=50% org (R)



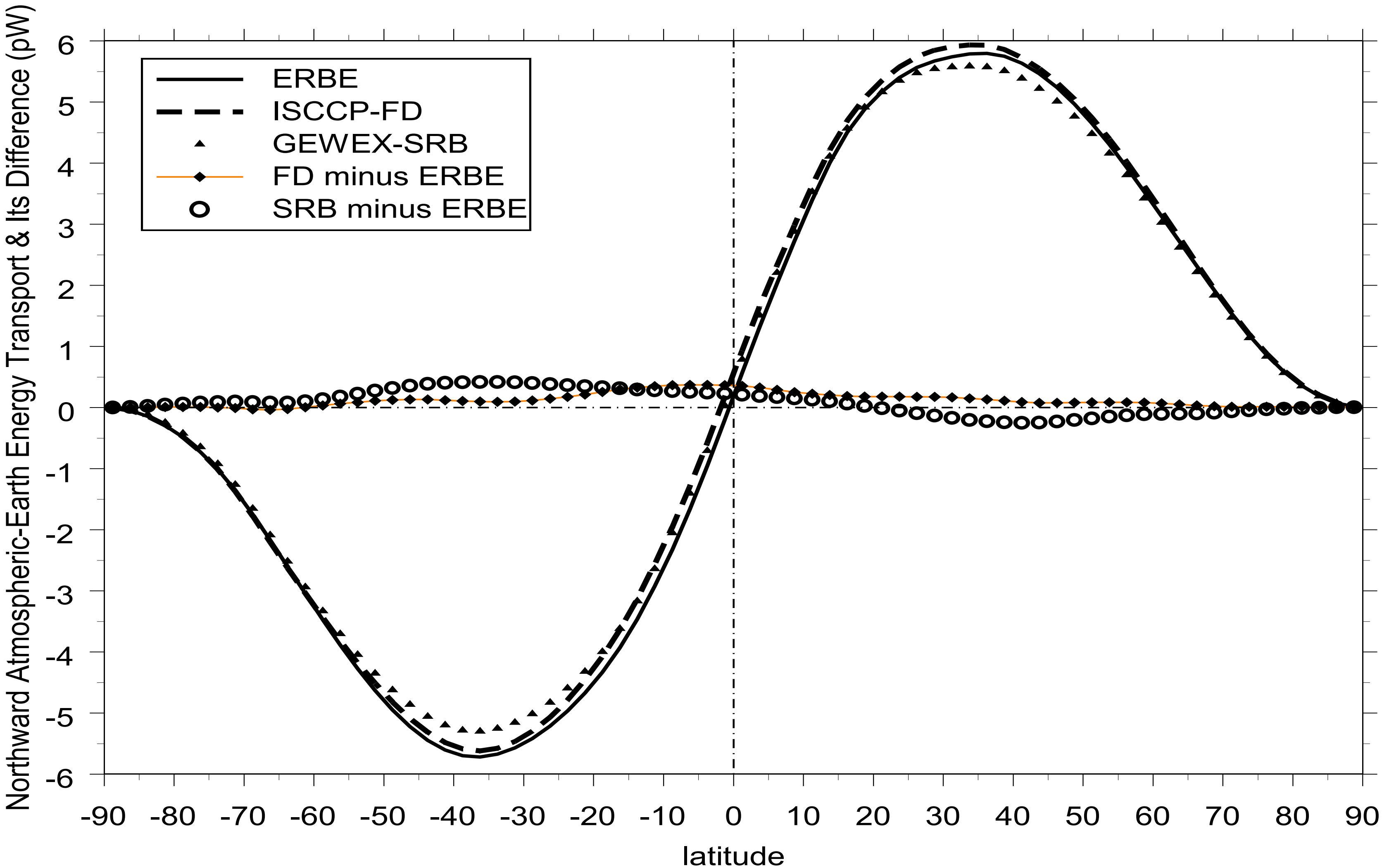
# ..V.. Clouds/AOD vs Dif/Dir:

## 4. Monthly-mean Statistical Comparison: FD/FDrv vs SOB

| Var Name | FD (X) | SOB (Y) | mean difference | Stdv | cor coef | slope | inter-cept | Nmdv |
|---|---|---|---|---|---|---|---|---|
| SWdn | 173.78 | 174.92 | -1.135 | 20.865 | 0.9733 | 0.94 | 10.93 | 14.71 |
| CSWdn (FDrv) | 231.45 (223.35) | 238.84 (224.25) | -7.394 (-0.897) | 11.442 (8.752) | 0.9945 (0.9976) | 0.99 (0.98) | 10.45 (5.65) | 8.08 (5.97) |
| Dif | 101.55 | 71.72 | 29.832 | 24.152 | 0.8769 | 0.67 | 3.19 | 15.04 |
| CDif (FDrv) | 58.98 (39.93) | 35.73 (33.55) | 23.251 (6.378) | 21.014 (11.223) | 0.7910 (0.8716) | 0.40 (0.68) | 12.16 (6.49) | 8.93 (7. 09) |
| Dir | 71.90 | 102.32 | -30.423 | 24.828 | 0.9234 | 1.08 | 24.87 | 16.65 |
| CDir (FDrv) | 172.47 (183.42) | 203.10 (190.69) | -30.634 (-7.266) | 30.175 (17.509) | 0.9473 (0.9859) | 0.98 (0.97) | 34.26 (12.43) | 21.52 (12.38) |
| ColAsl (FDrv) | 0.136 (0.067) | 0.104 (0.104) | 0.032 (-0.038) | 0.063 (0.052) | 0.6972 (0.6972) | 0.58 (1.19) | 0.03 (0.03) | 0.04 (0.03) |
| CFsw | 0.65 | 0.56 | 0.094 | 0.108 | 0.8016 | 0.95 | -0.06 | 0.08 |
| CldTau | 5.31 | 41.75 | -36.446 | 20.624 | -0.0050 | -0.03 | 41.89 | 20.20 |
| Dir/Dif | 0.53 | 1.12 | -0.582 | 0.573 | 0.6119 | 1.01 | 0.58 | 0.40 |
| Cdir/Cdif | 2.38 (3.26) | 4.16 (3.72) | -1.779 (-0.465) | 1.286 (1.378) | 0.5453 (0.7388) | 0.43 (0.62) | 3.13 (1.72) | 0.90 (0.97) |

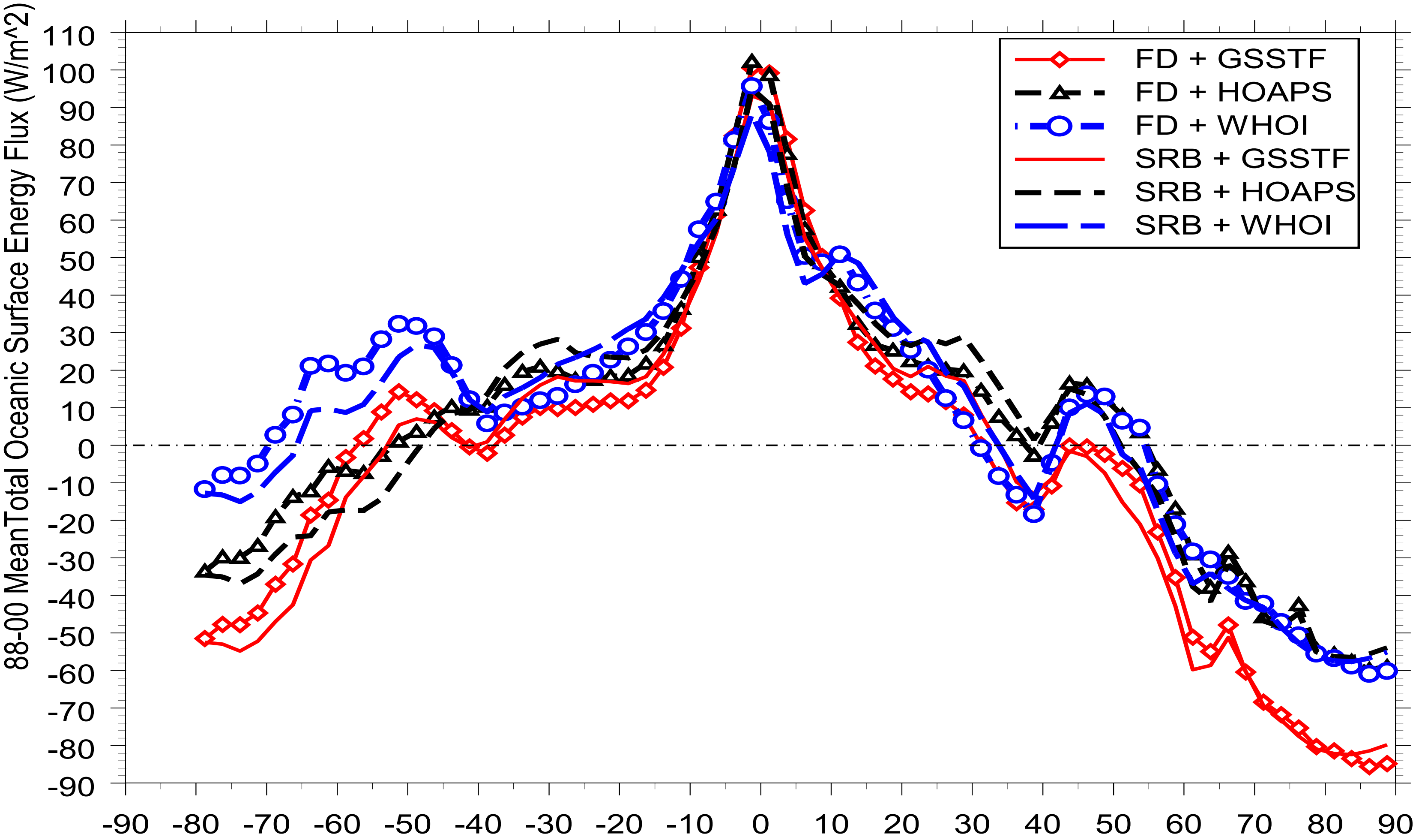
# VI. Meridional energy transports 1. Earth-atmosphere:

ERBE, FD & SRB Transports and Differences with ERBE (pW)



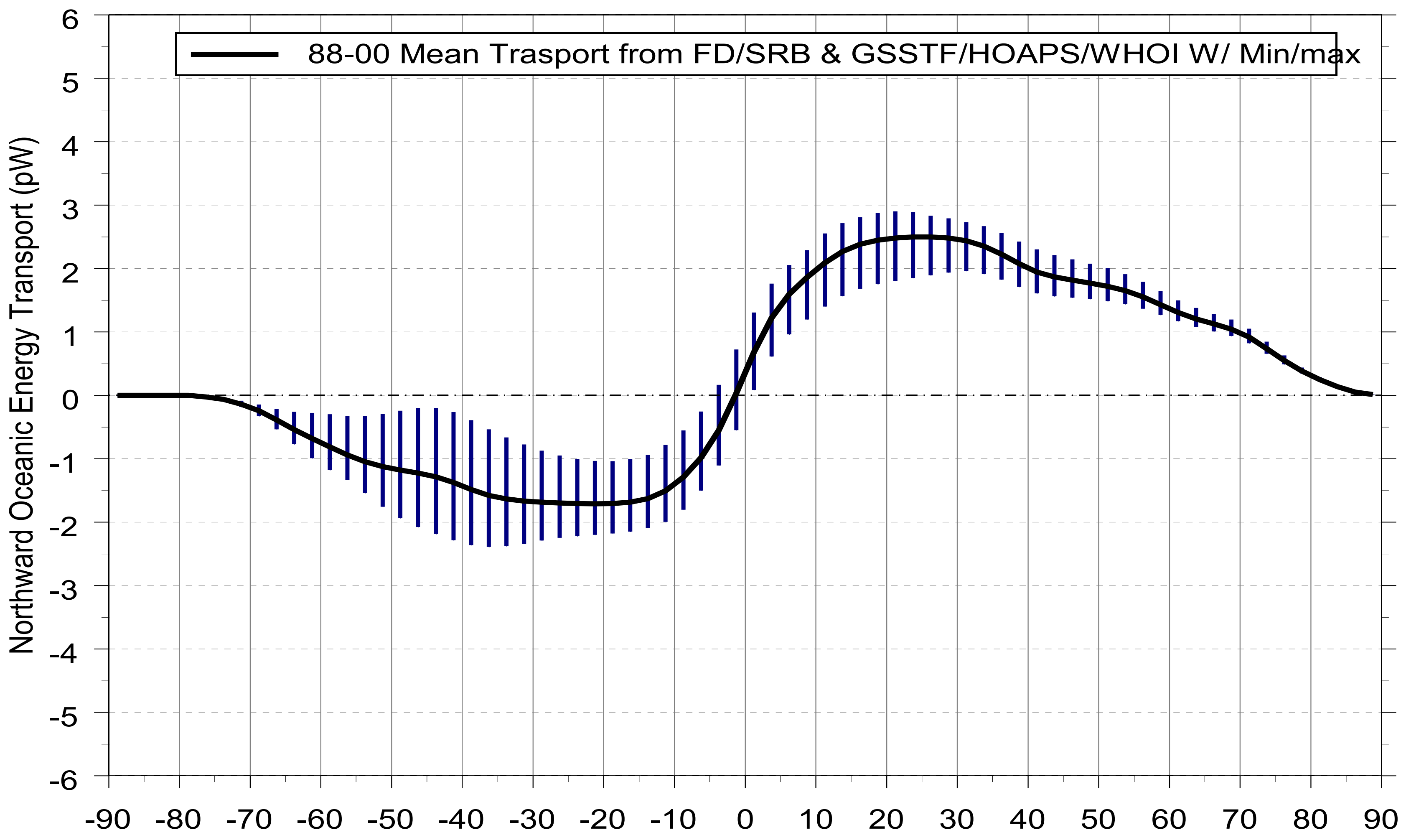
# ..VI. Transports: 2. Total Ocean Surface Energy Flux:

## Zonal Total SRF Energy from FD/SRB with F2, H2 & WH (W/m²)



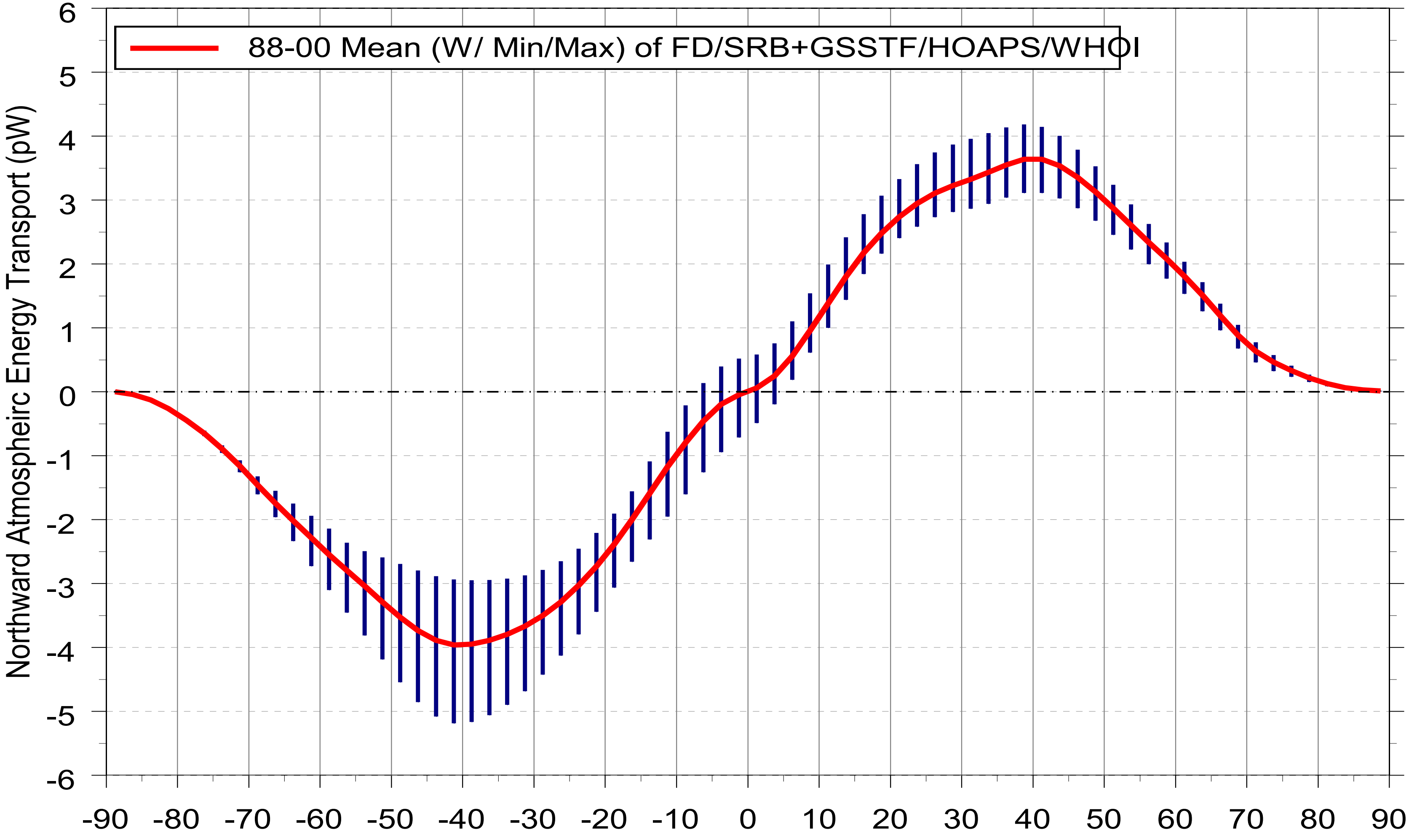
# ..VI. Transports: 3. Ocean Transport:

88-00 mean from FD/SRB with F2, H2 & WH (pW)



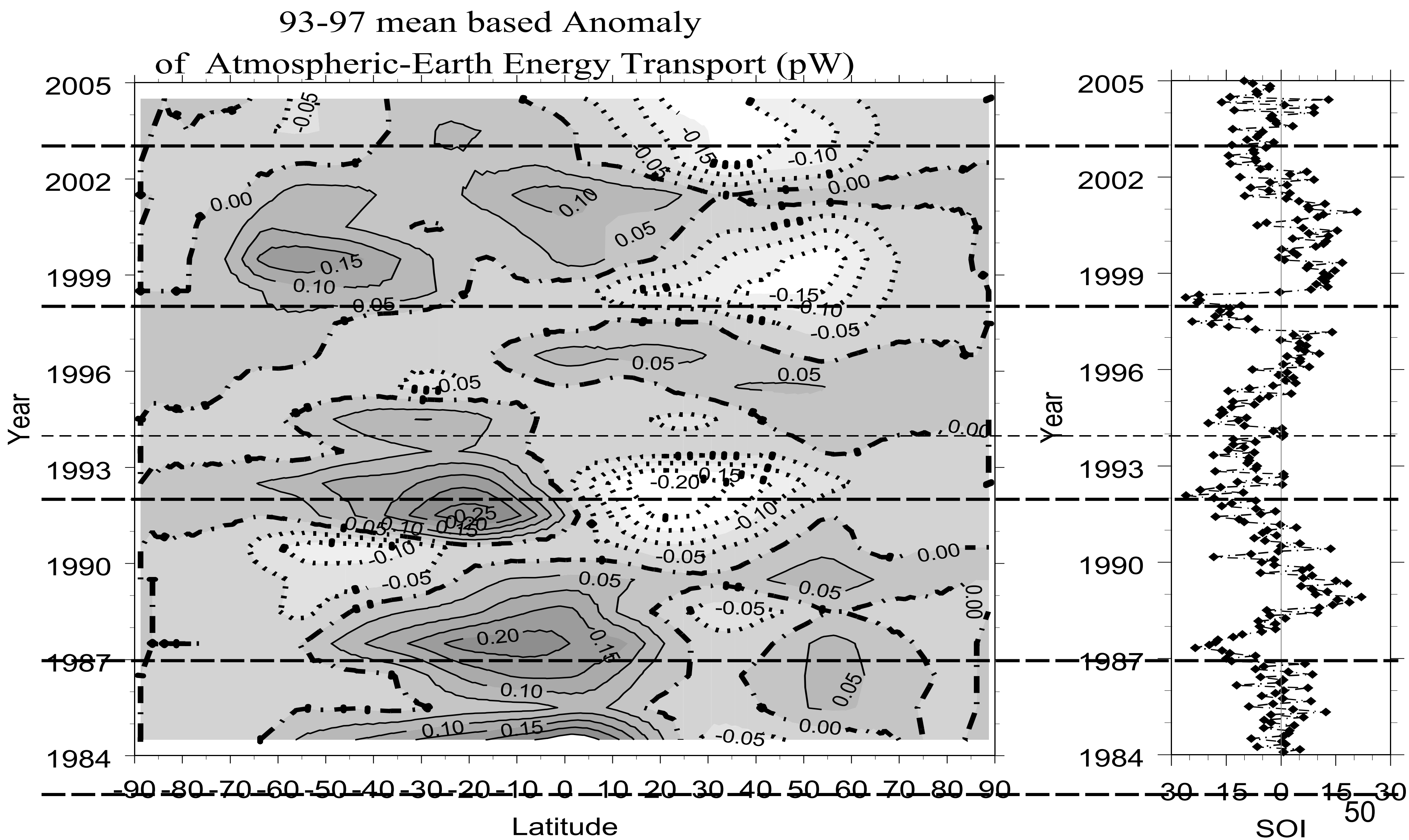
## ..VI. Transports: 4. Atmospheric Transport:

88-00 from FD/SRB with F2, H2 & WH (pW)



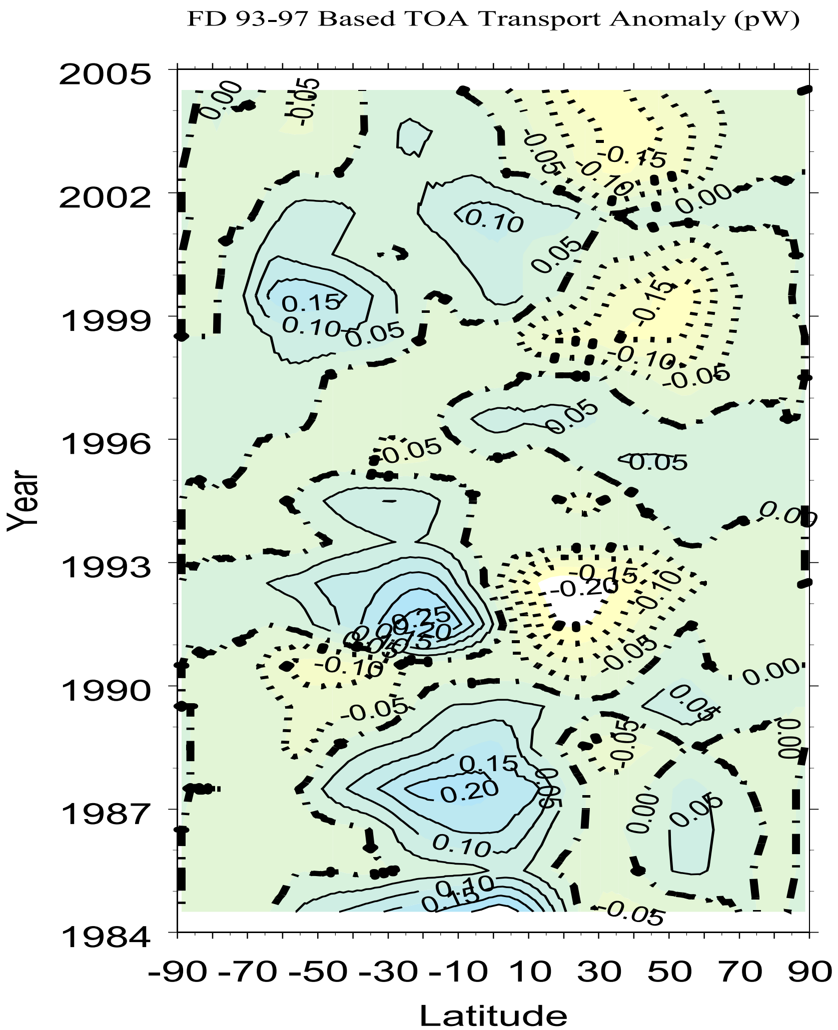
# ..VI. Transports:

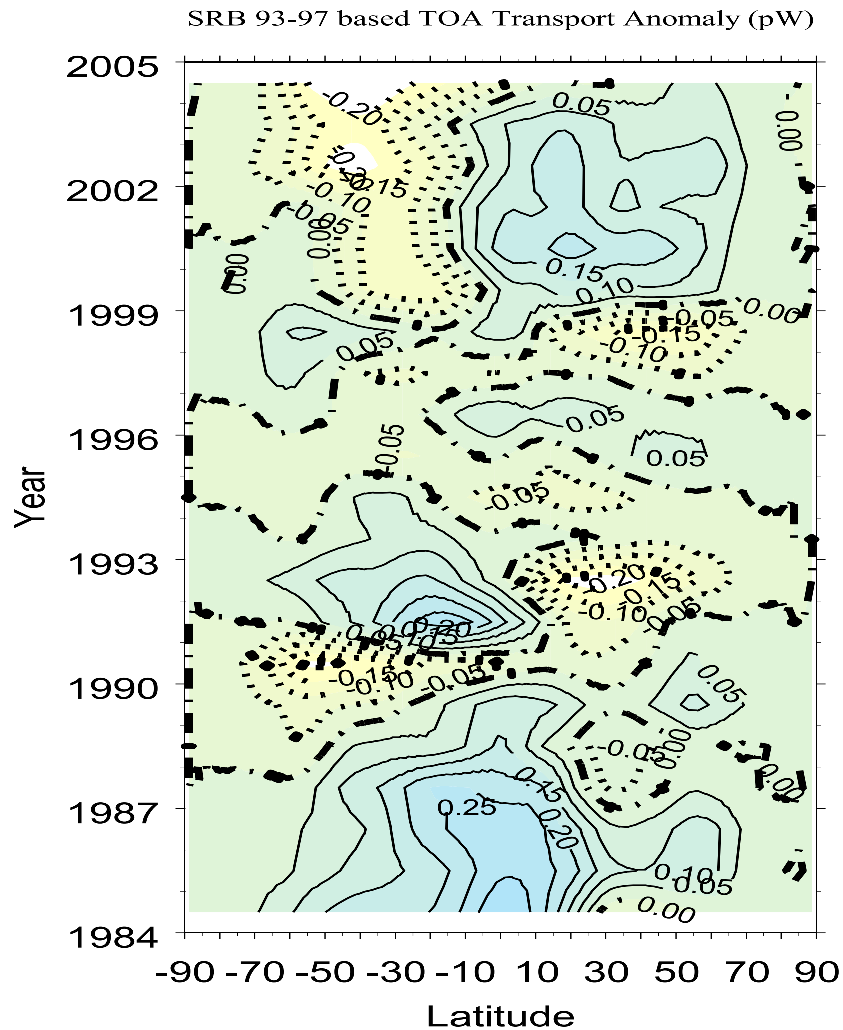
## 5. Anomaly of Atmosphere-ocean Transport: (1) ISCCP-FD



# ..VI. Transports:

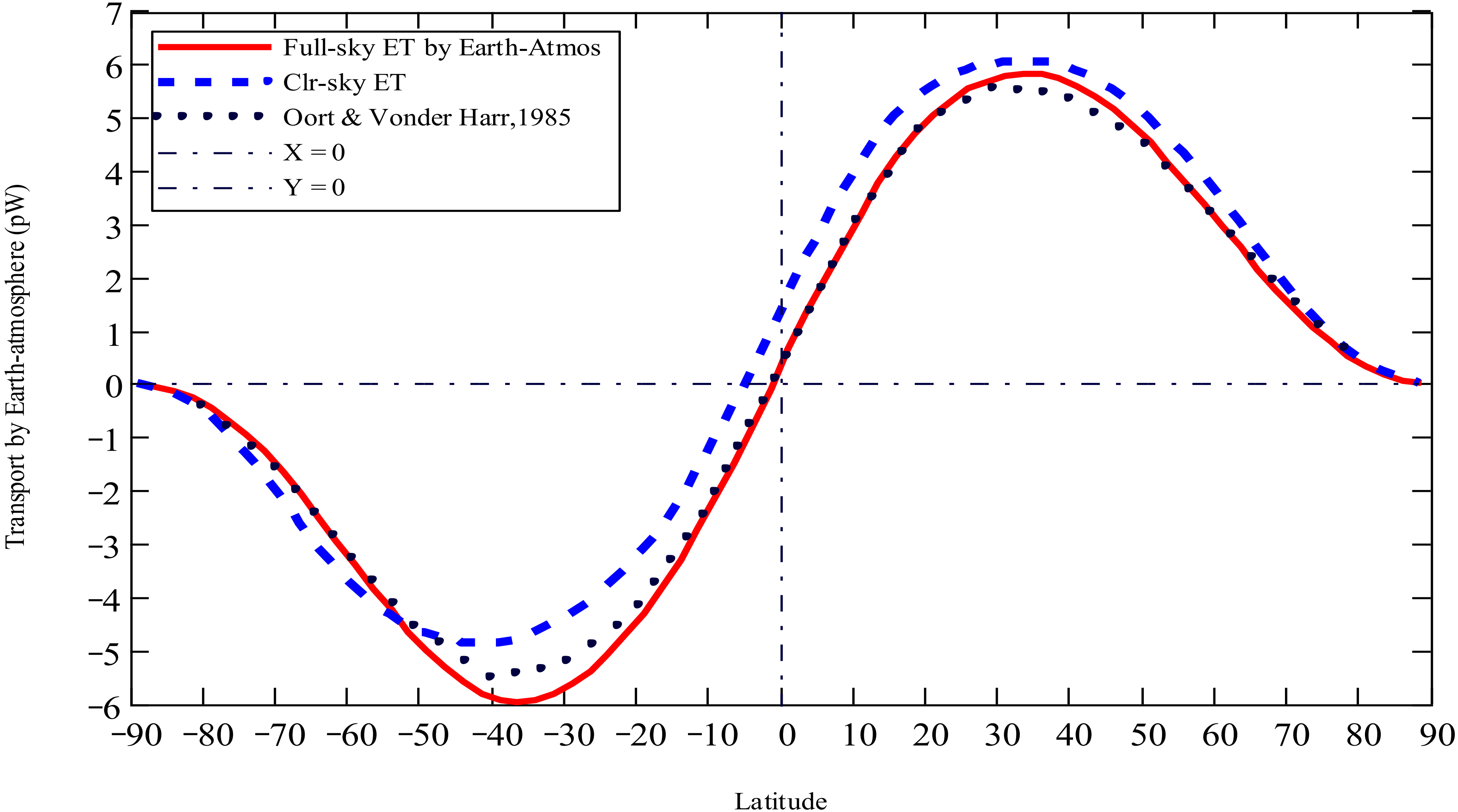
## 5. Anomaly of Atmosphere-ocean Transport: (2) FD & SRB



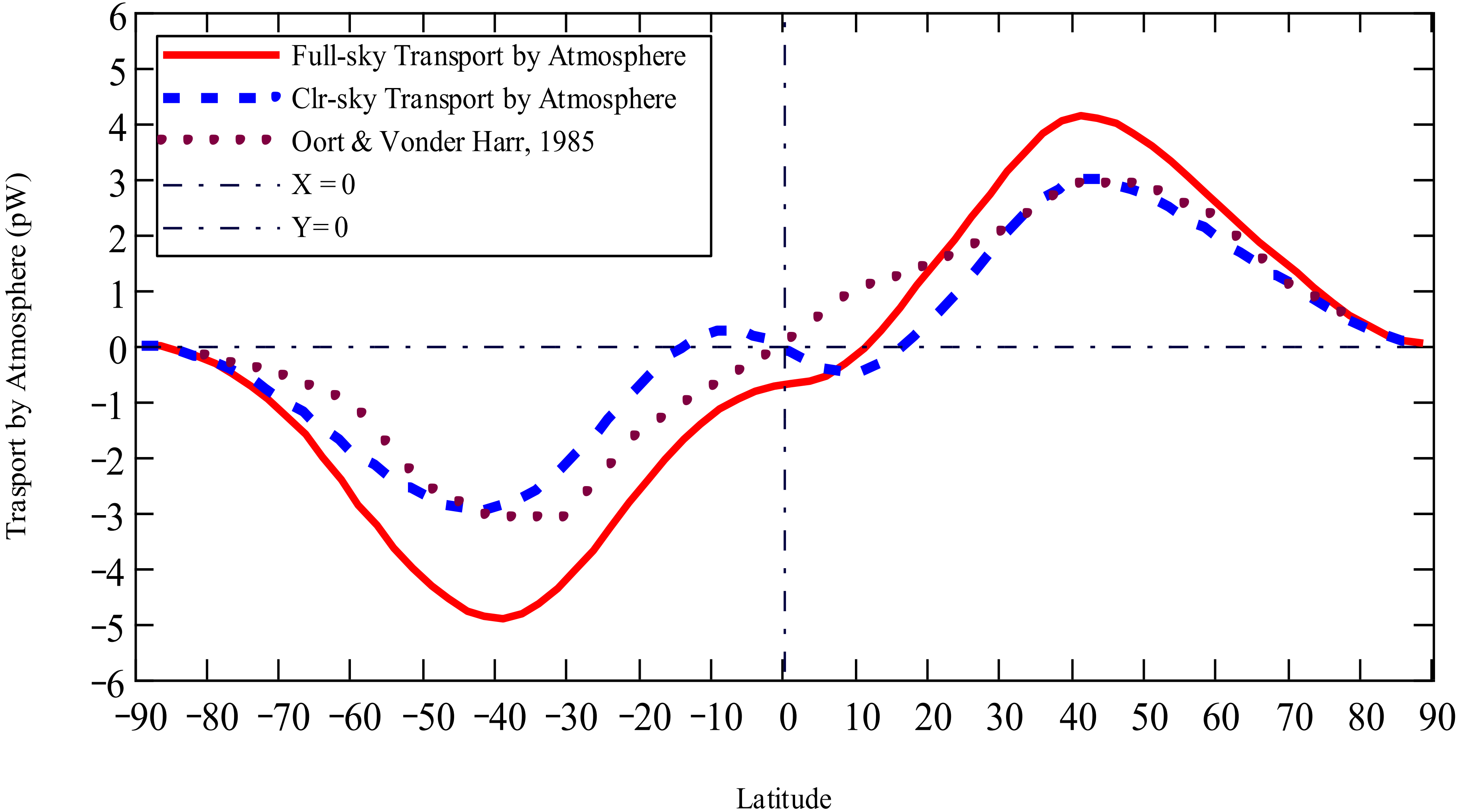
## ..VI. Transports: 6. CE on Transports: ISCCP-FC (precursor of FD)

### (1) 85-88 Full- and Clear-sky Transport by Earth-atmosphere System



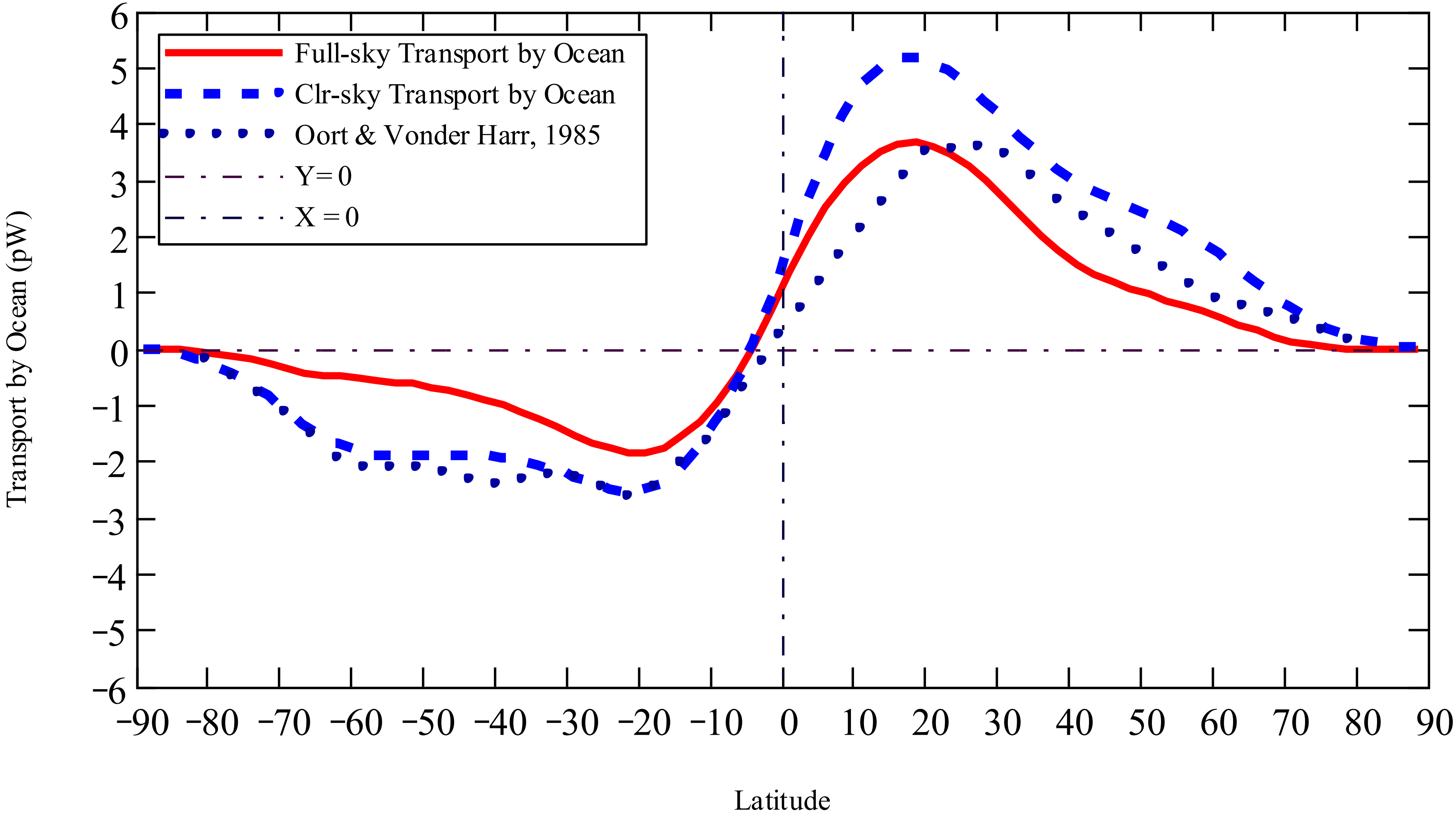
# ..VI. Transports: 6. CE on Transports: ISCCP-FC

## (2) 85-88 Full- and Clear-sky Transport by Atmosphere



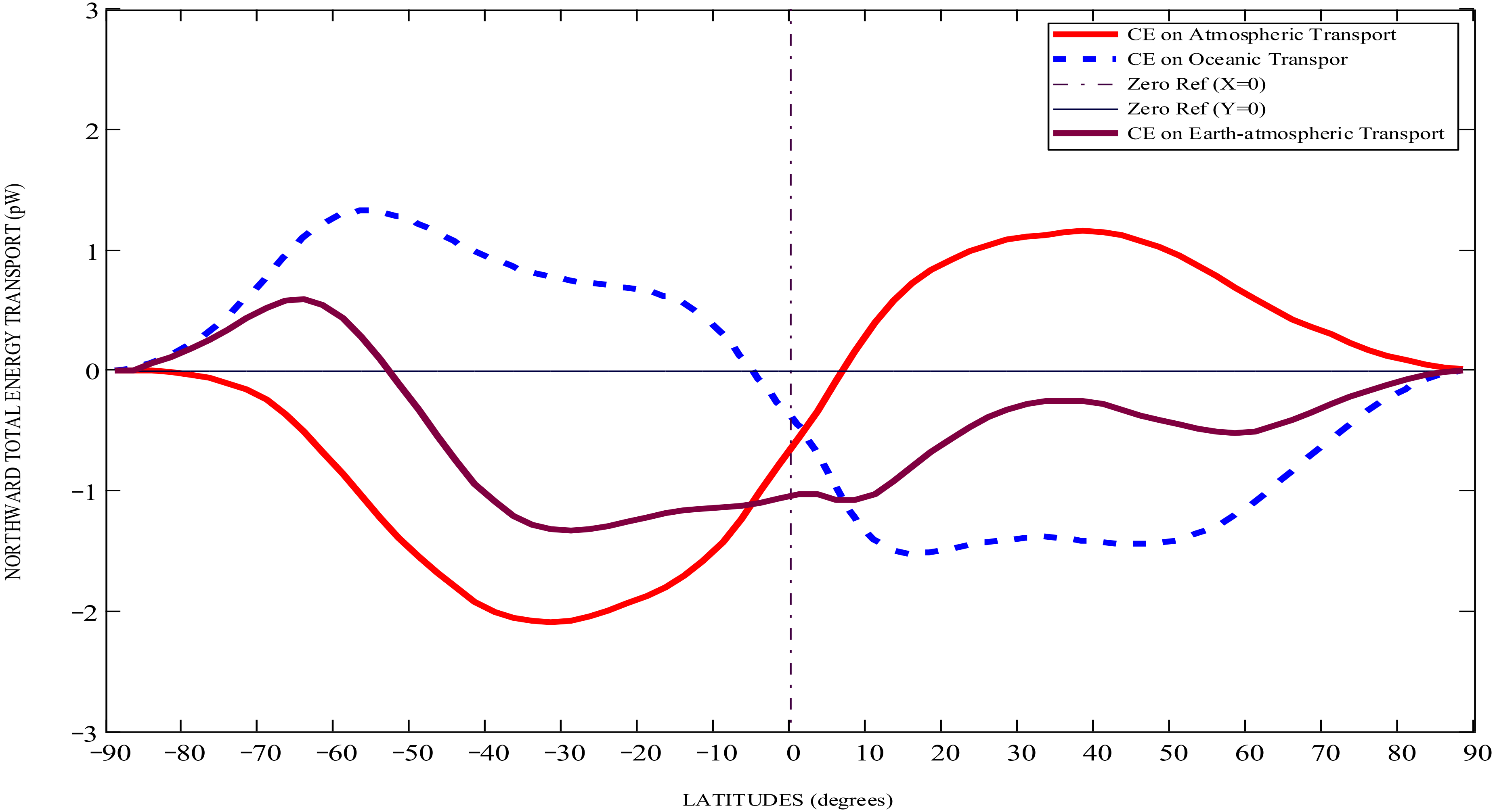
## ..VI. Transports: 6. CE on Transports: ISCCP-FC

### (3) 85-88 Full- and Clear-sky Transport by Ocean



# ..VI. Transports: 6. CE on Transports: ISCCP-FC

## (4) CE on Transports by Atmosphere, Ocean & Earth-atmosphere



# VII. Summary

1. ISCCP sets up **a kind of milestone for cloud climatological research** as it supplies decades-long, global, historically reasonably accurate and near-maximal parameter retrievals.
2. Such a **valuable and unique** data product **has opened unprecedented possibilities** for various cloud-related research fields.
3. In particular, we have produced **radiative transfer profiles, ISCCP-FD** based on ISCCP product (and some ancillary datasets).
4. As we can't yet validate the profiles because of lacking of observations, we have been validating their TOA and Surface components that shows we have reached realistically accurate levels as this presentation does – But still **not** the levels for accurately monitoring climate changes!
5. Even so, such a profile product has brought about a variety of applications in studying cloud-radiation interaction, Earth and surface (and profile) radiation budgets and global general energy circulations, etc.
6. Eventually we need **real CVS** to have more realistic radiative profile, and combine it with **to-be-produced latent and sensible heat profile** to have **a complete, real 3-D general energy circulation** that can **realistically monitor our planetary climate!**