Surface Atmospheric Radiation Budget (SARB) working group update

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[3]Tech-X

SARB working group meeting (75 min)

- David Fillmore
  - Ed4 MATCH black carbon evaluation
  - AERONET AAOD, BC surface and aircraft observations
  - Edd2 AeroCom black carbon study
- Fred Rose: Status of Ed4 SYNI development
  - Cloud top height (Peff vs. Ptop)
  - Effect of the CO2 channel to cloud retrieval
  - LWC vertical profile
  - Ice crystal size consistency
- David Rutan
  - Ed4 surface validation (emphasis on diurnal cycle)
- Alexander Radkevich
  - Status of model-CERES comparison over Dome-C
  - Modeled surface albedo comparison
  - Snow surface albedo table

Outline

- Ed4 SYN
  - Ed2 MODIS vs. Ed4 MODIS
  - 5 channel code vs. 2 channel code
  - Entropy production
- CRS
  - Ed4
  - NPP

SYNI Ed4 (in progress)

- Cloud
  - Use 4 significant cloud vertical profiles (combination of 4 cloud types)
  - Include cloud overlap (random overlap)
  - Incorporate cloud group's lapse rate and consistent phase function.
  - Include vertical IWC profile derived from CloudSat
  - Ice particle size definition consistent with the definition of the cloud group
- Aerosols
  - Hourly MATCH (file size ~700 Mb/day) (test data month July 2010)
  - Include tropospheric SO4, stratospheric SO4, Ammonium sulfate, and volcanic ash in addition to small dust, large dust, sulfate, sea salt, black carbon, soluble, and insoluble.
  - MODIS aerosols (collection 5)
  - Surface type dependent uncertainty
  - Anthropogenic source fraction/flag
- Surface albedo
  - Ed4 surface history map (include partly clear-sky albedo derived from MODIS radiances)
  - new spectral shape (using MODIS MCD43C product) over land and snow
  - Solar zenith angle dependent surface albedo look-up table
- Radiative transfer code
  - 18 SW bands
  - SW, GWTSA (inhomogeneous scenes) /4-stream (homogeneous scenes) hybrid; homogeneous cloud SF >= 10 4-stream, inhomogeneous cloud (SF< 10, GWTSA), clear-sky 4-stream.
- Tuning
  - Regional, seasonal, scene (cloud/clear) and surface type (land and ocean) dependent tuning
- TSI
  - 5-channel GEO cloud properties (test data month Jan. 2010, July 2004 Terra only + 4GEO, April 2008 Terra+Aqua+4GEO)
  - Including MODIS and GEO retrieved skin temperature
  - Improved NB-BB LW irradiance
  - Include lapse rate retrieved by the cloud group (at least two heights of temperature and pressure)
- Snow/Ice map
  - Use 1/16 mesh of EICE and ESNOW maps.
- New variables
  - Aerosol radiative effect product from SYN pristine, clear-sky, all-sky, and all-sky no aerosol fluxes (proposed)
  - Entropy computations

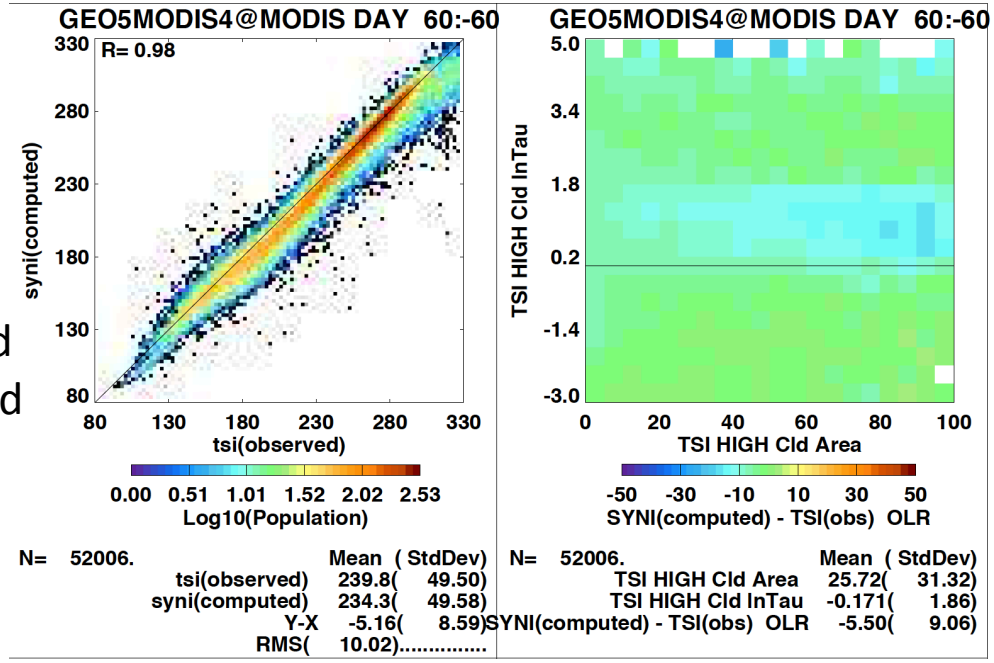
Computed and Modeled OLR comparison

- A large difference of modeled and CERES-derived OLR from very early SYNI test runs leads us to investigate further

OLR Computed with cloud top pressure (MODIS)

ED4 MODIS
Aqua only

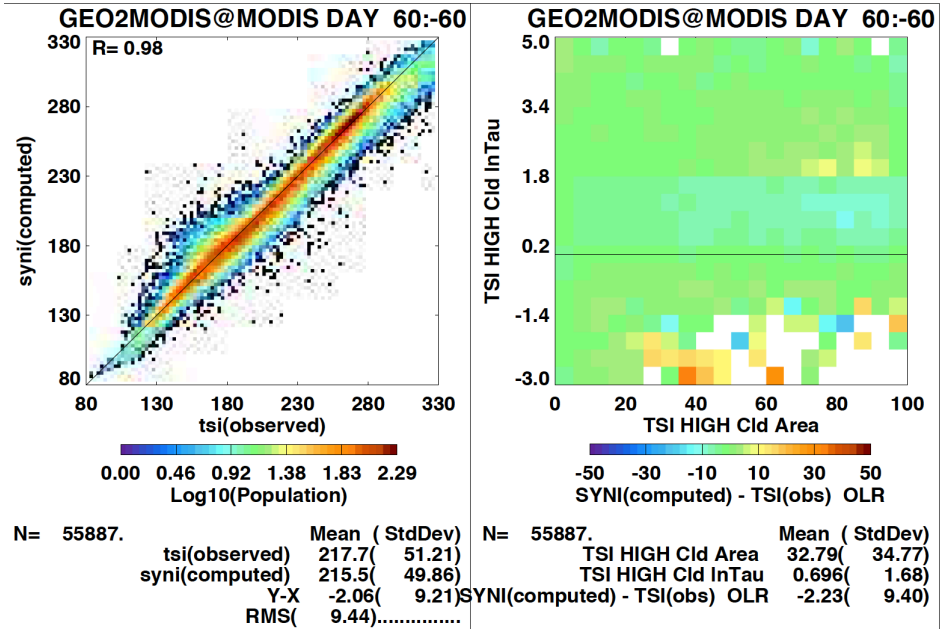
X-axis: Observed
Y-axis: computed



X-axis: high cloud area
Y-axis: high cloud ln(τ)

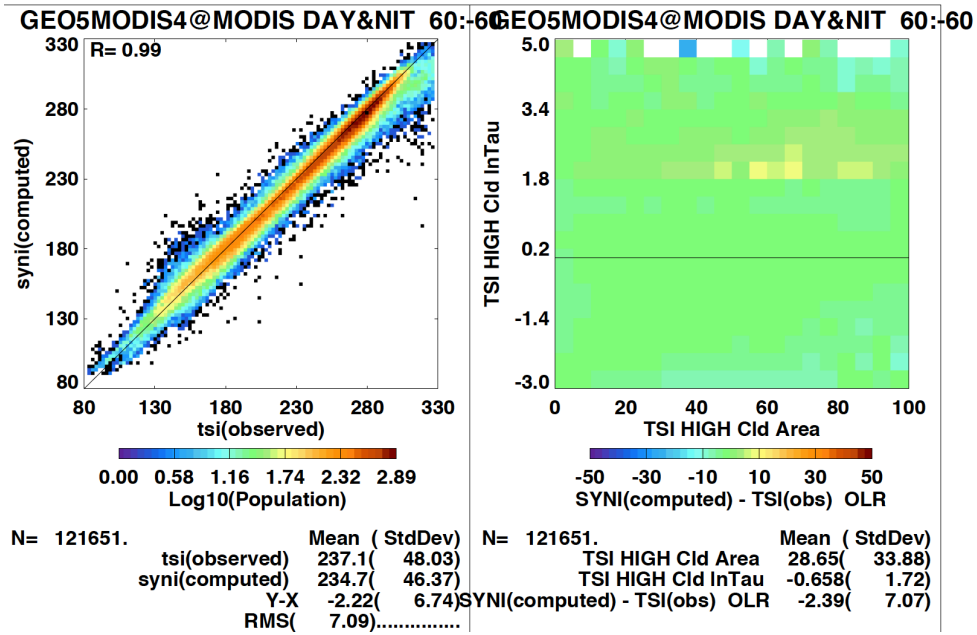
Computed - modeled

ED2
MODIS
Terra
+Aqua



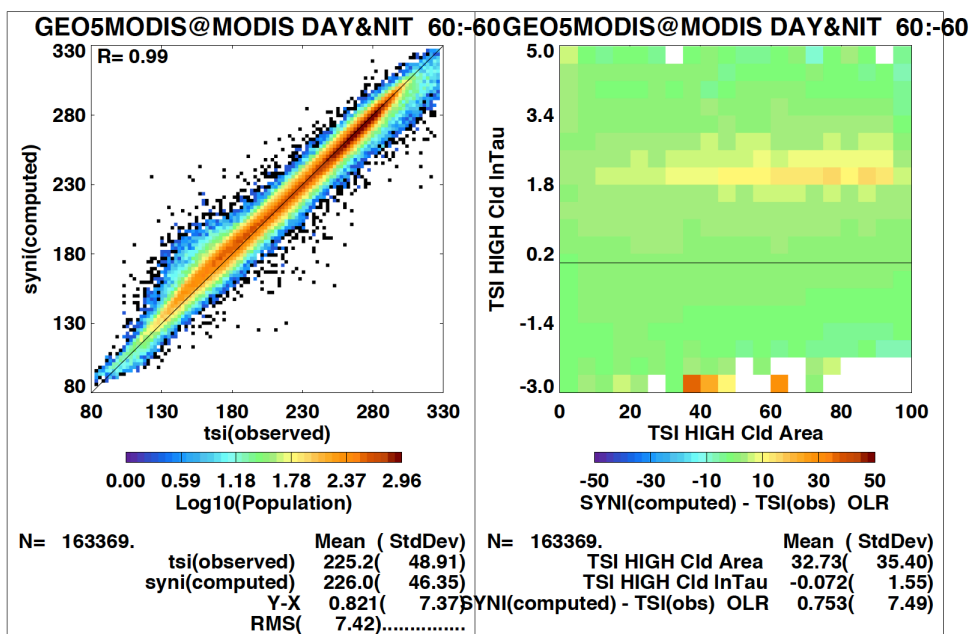
OLR computed with effective cloud top pressure (MODIS)

ED4
MODIS
Aqua
only



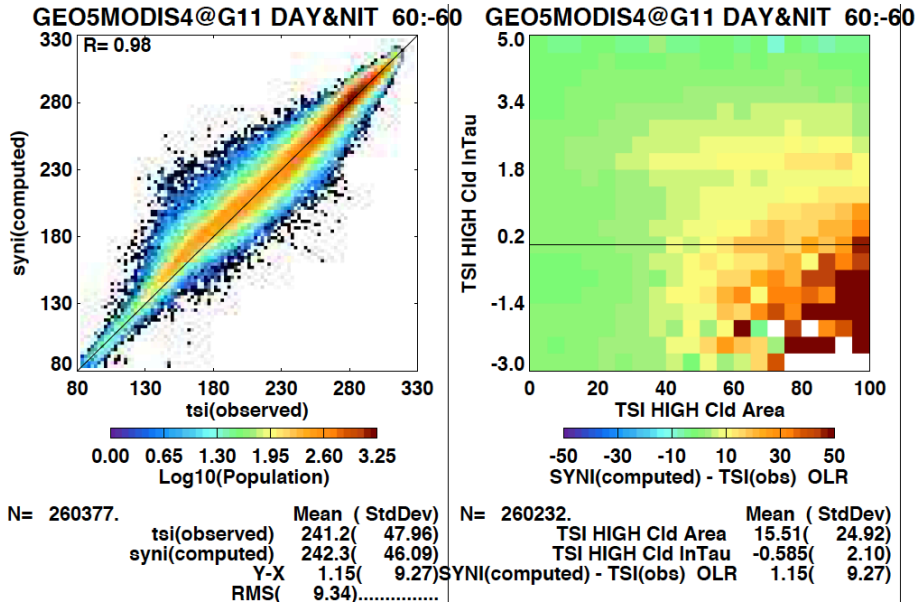
Using the effective cloud top pressure as the cloud top makes a better agreement.

ED2
MODIS
Terra
+Aqua

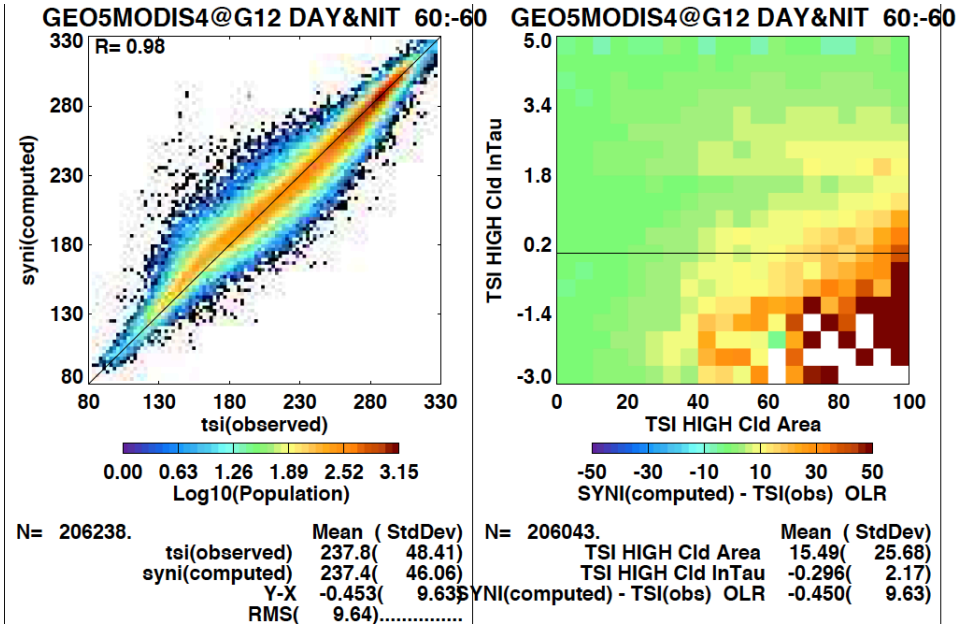


Ed4 shows a better agreement for thick clouds but shows a slightly cold bias for thin clouds

OLR computed with effective cloud top pressure (GEO)



Using the effective cloud top pressure improves the agreement for G11

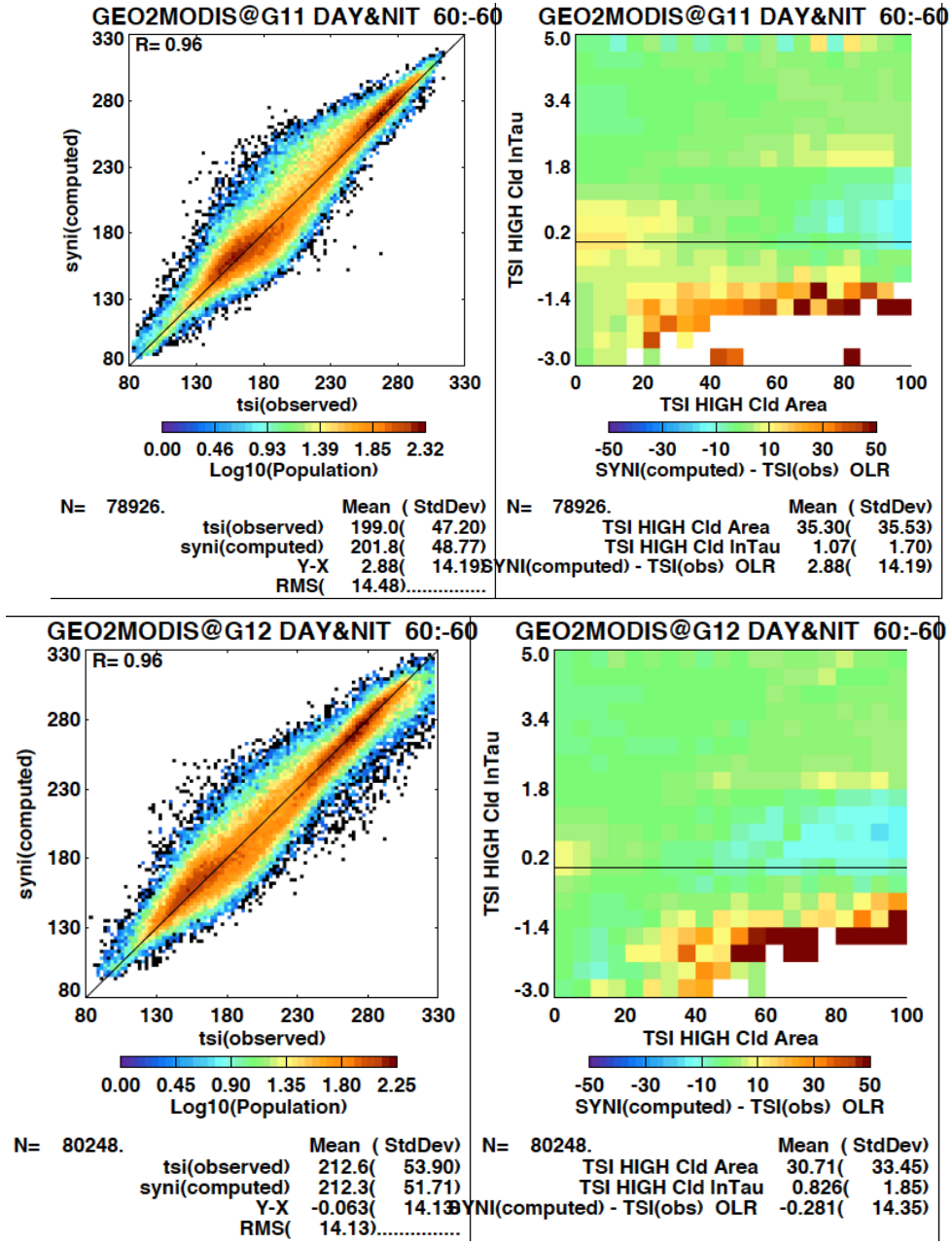


G12

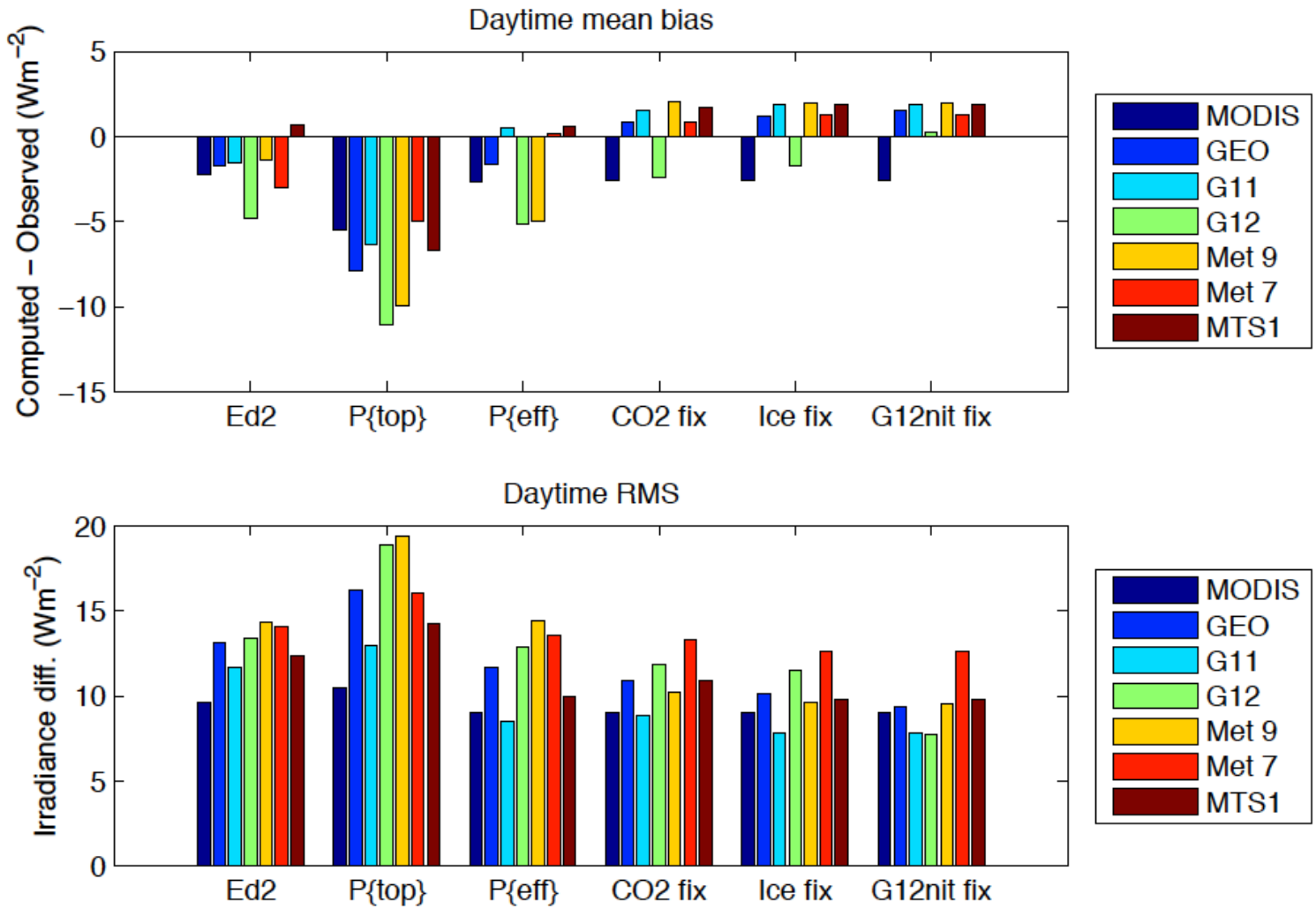
No cloud retrieval from CO_2 channel for day time

Two channel only for nighttime

Hourly 2-channel retrieval

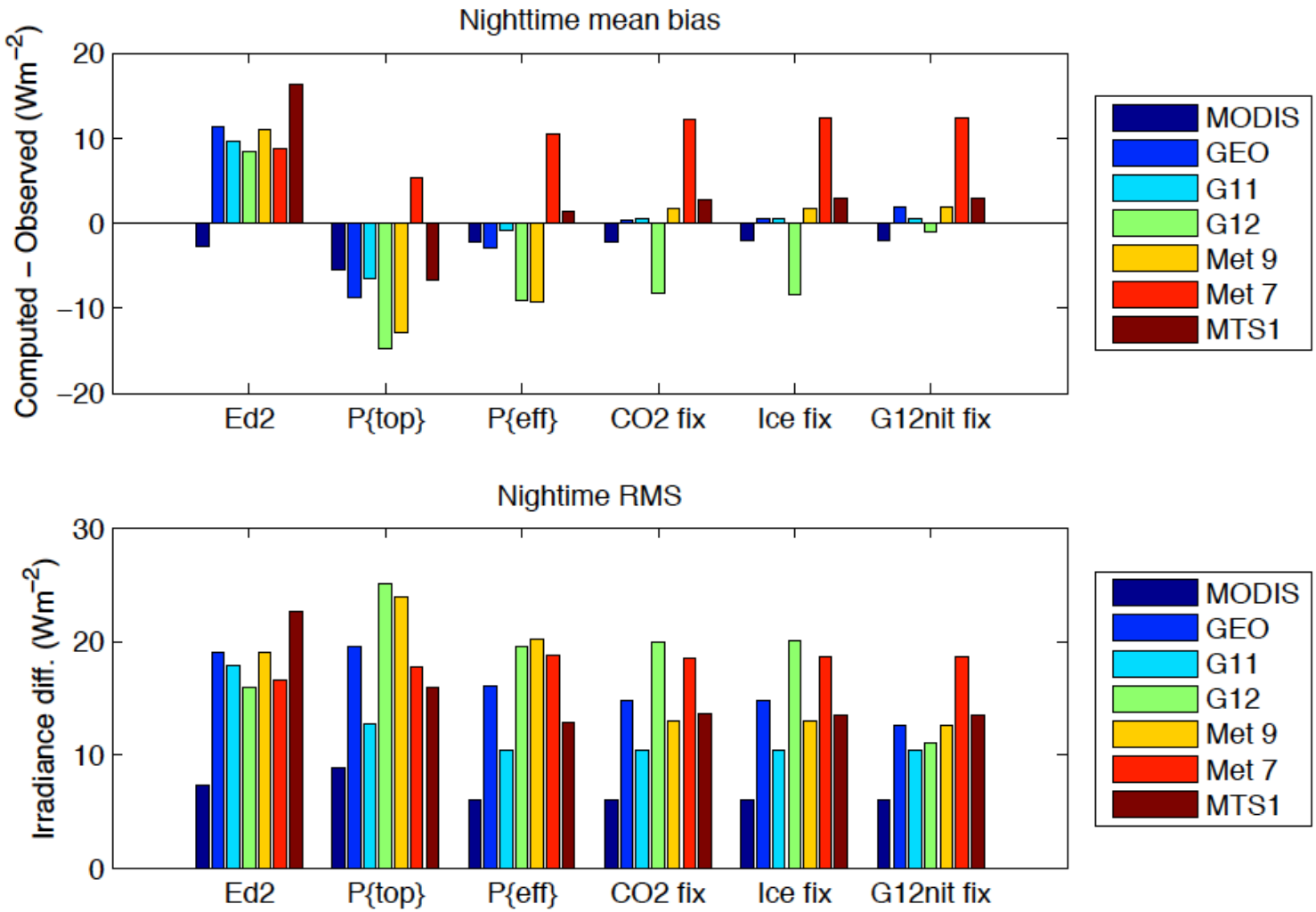


OLR comparison summary (Daytime)



F. Rose presentation for details

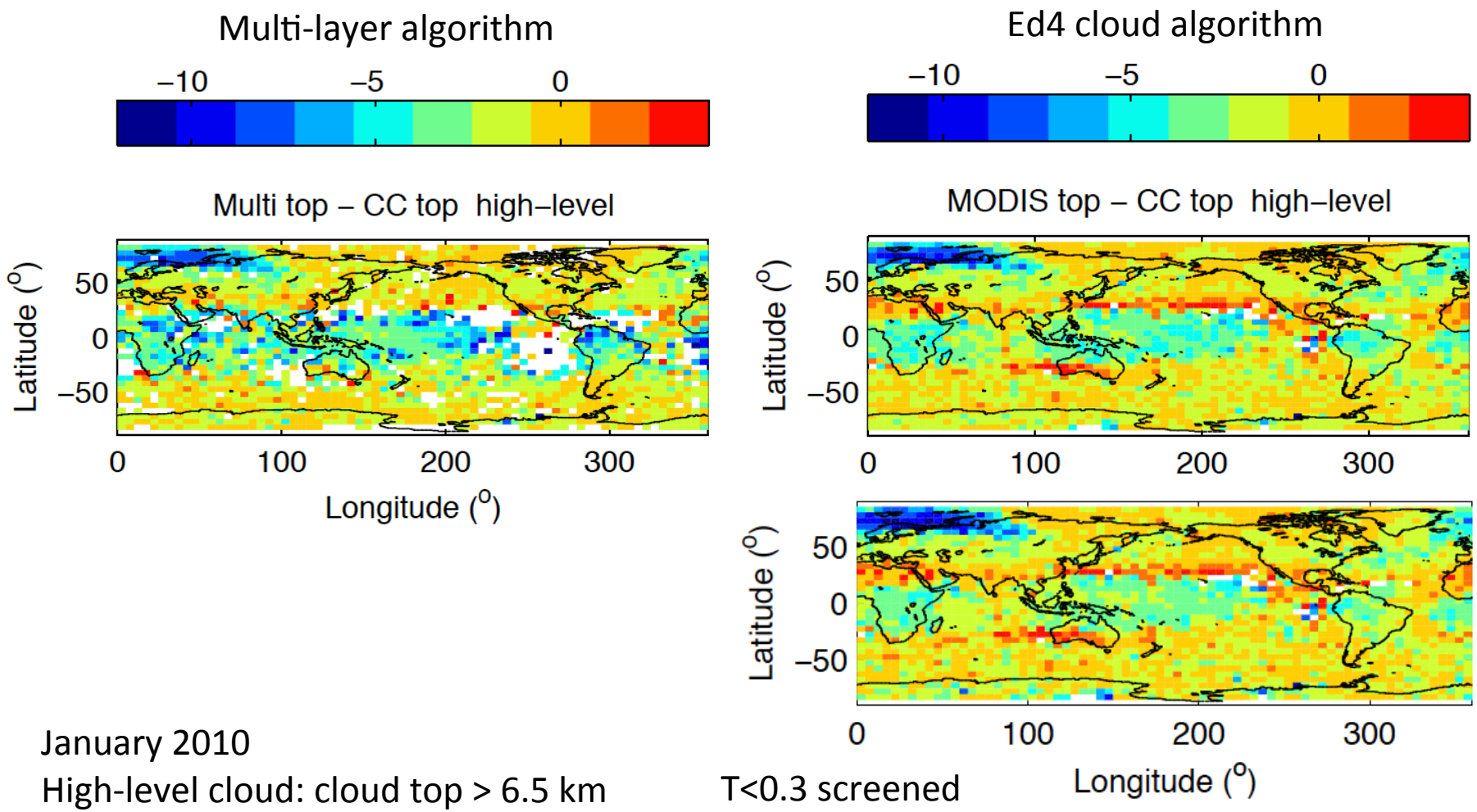
OLR comparison summary (nighttime)



Multi-layer clouds

cloud top height comparison with CALIPSO/CloudSat

High-level Cloud top height difference (km)

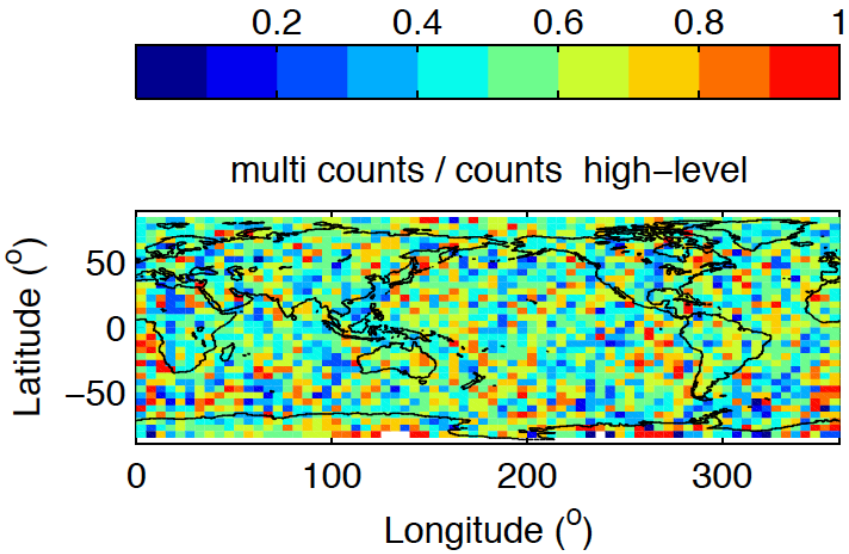


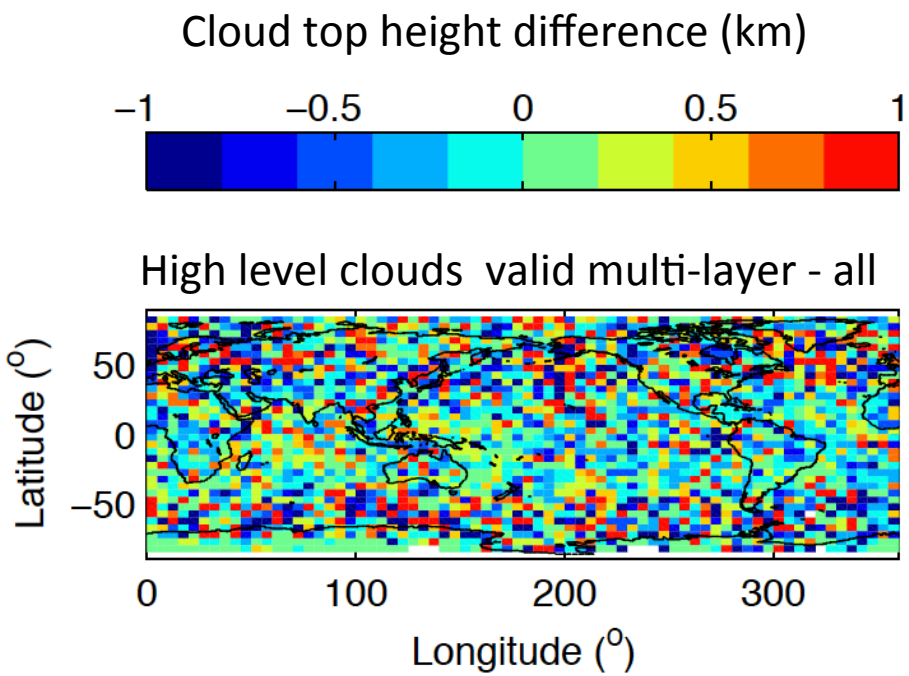
January 2010

High-level cloud: cloud top > 6.5 km

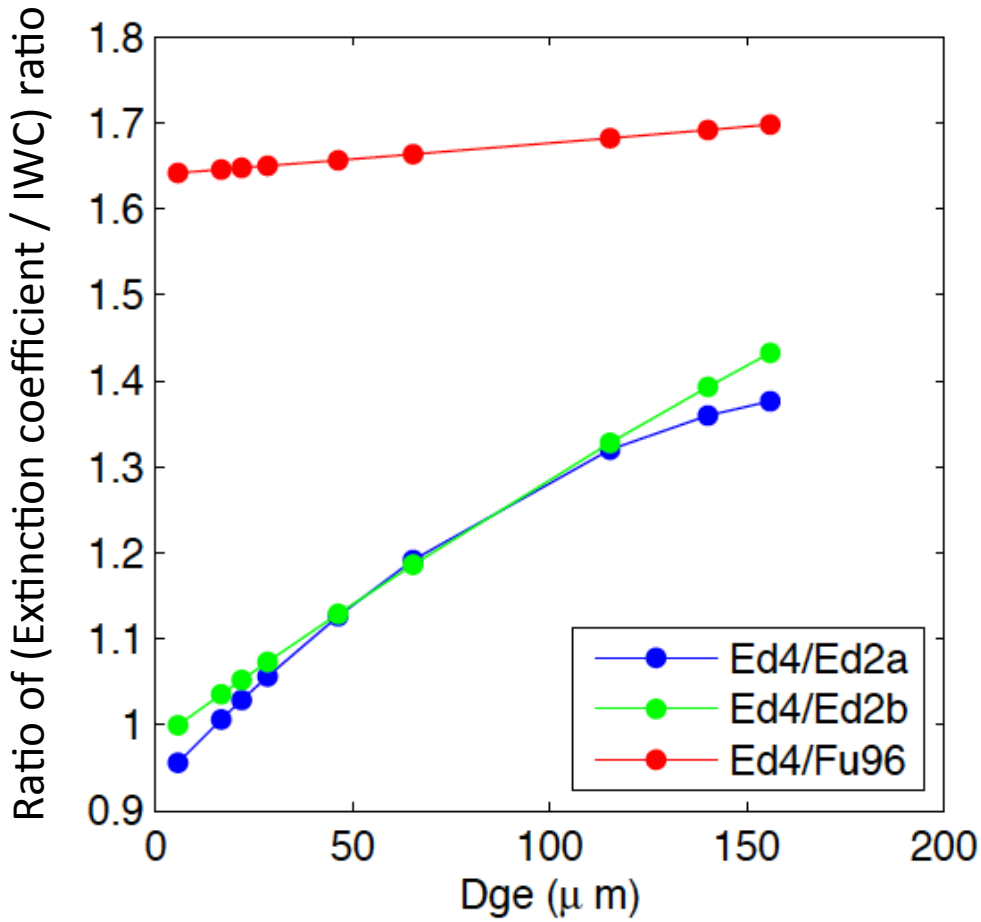
T<0.3 screened

Effective cloud top height





Ice particle size (De and Dge)



$$IWC = \frac{3\sqrt{3}}{8}\rho\int D^2 Ln(L)\,dL = Const\rho\int D^2 Ln(L)\,dL$$

$$\beta = \int \sigma n(L)\,dL = \overline{Q}\int An(L)\,dL$$

then

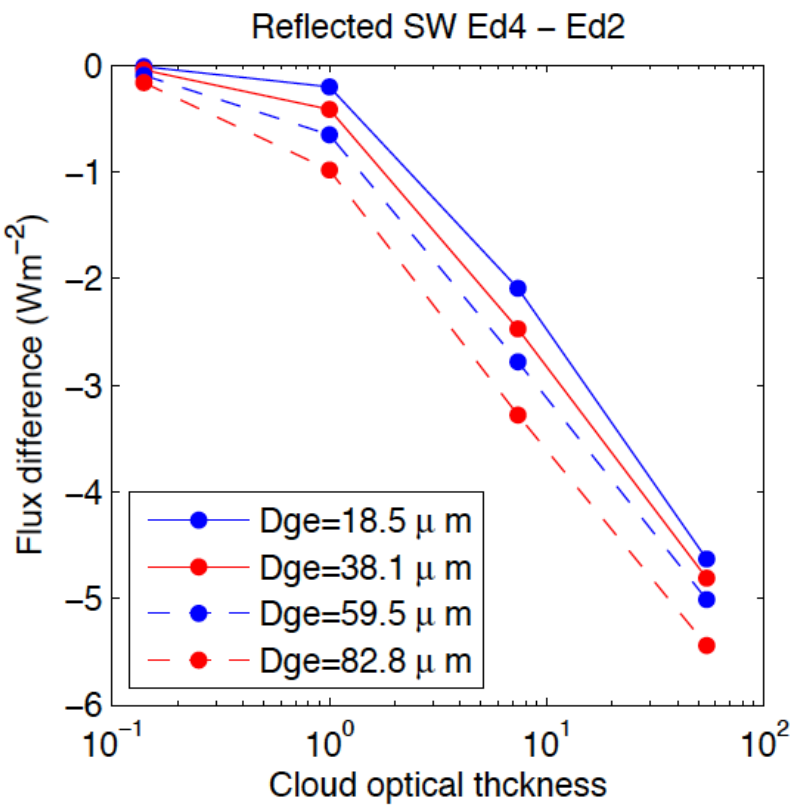
$$\frac{\beta}{IWC} = \frac{\overline{Q}}{Const\rho_{ice}D_{ge}}$$

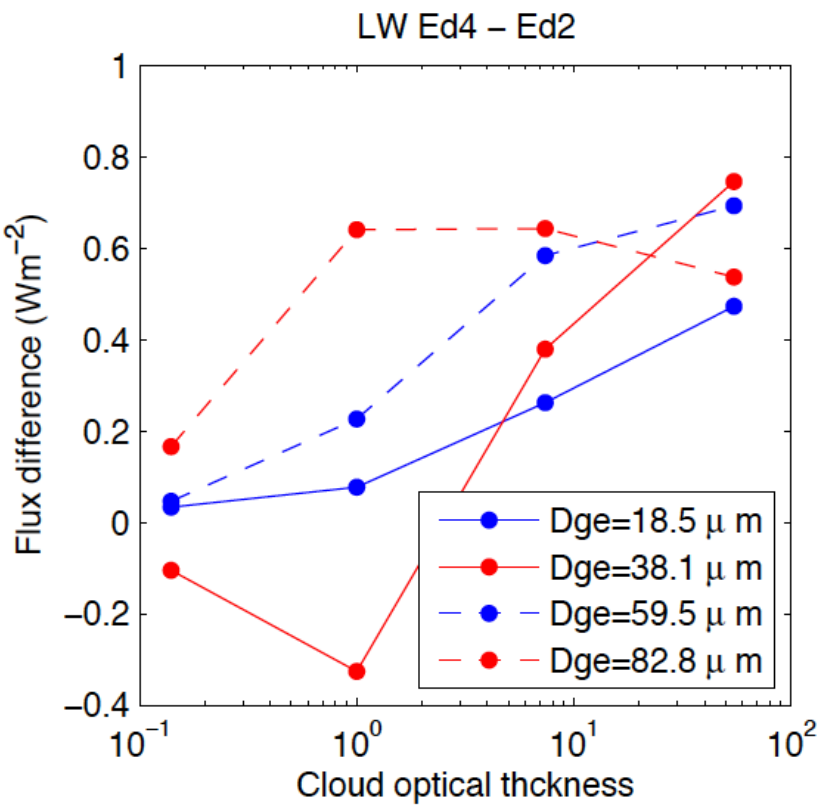
Q and Const depend on crystal shape
But more than 60% different from hexagonal ice crystal and ~20% difference (@60 micron) from Ed2

Physical reason??

Larger β/IWC ratio gives less IWP for a given τ

Ed2 Ed4 flux differences

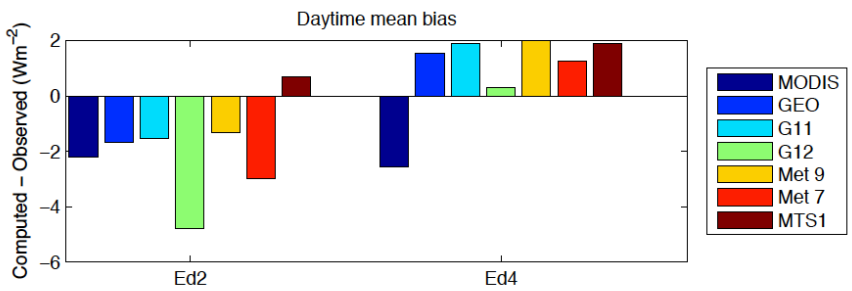


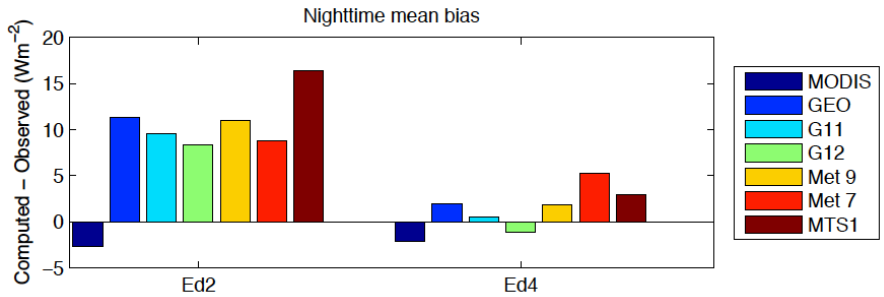


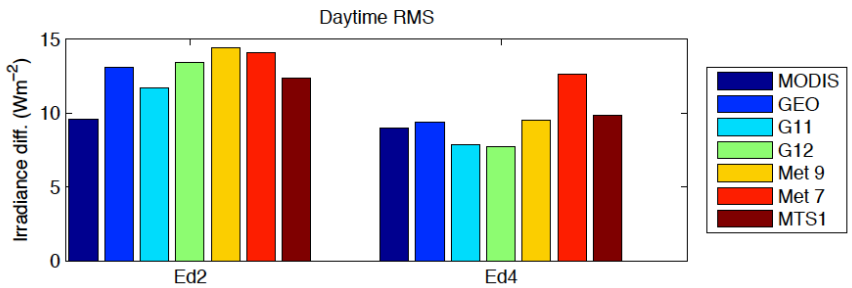
Summary of 5 Channel GEO algorithm for January 2010

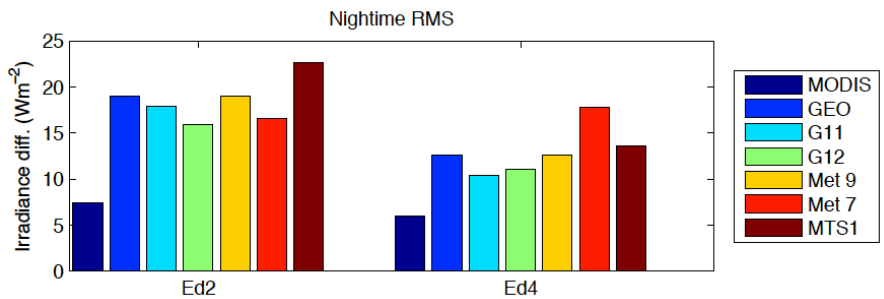
- Use effective cloud top pressure (Peff) for MODIS and all GEOs (G11, G12, Met-9, MTS1) except for nighttime Met-7. Use cloud top pressure (Ptop) for nighttime Met-7.
- CO2 turned off for daytime and 2-channel for nighttime for G12
- CO2 turned off for both daytime and nighttime for Met-9
- New extinction coefficient to ice water content relationship for MODIS and all GEOs (See F. Rose presentation)

Current Ed4 (with 5 channel) versus Ed2 (LW) Jan. 2010

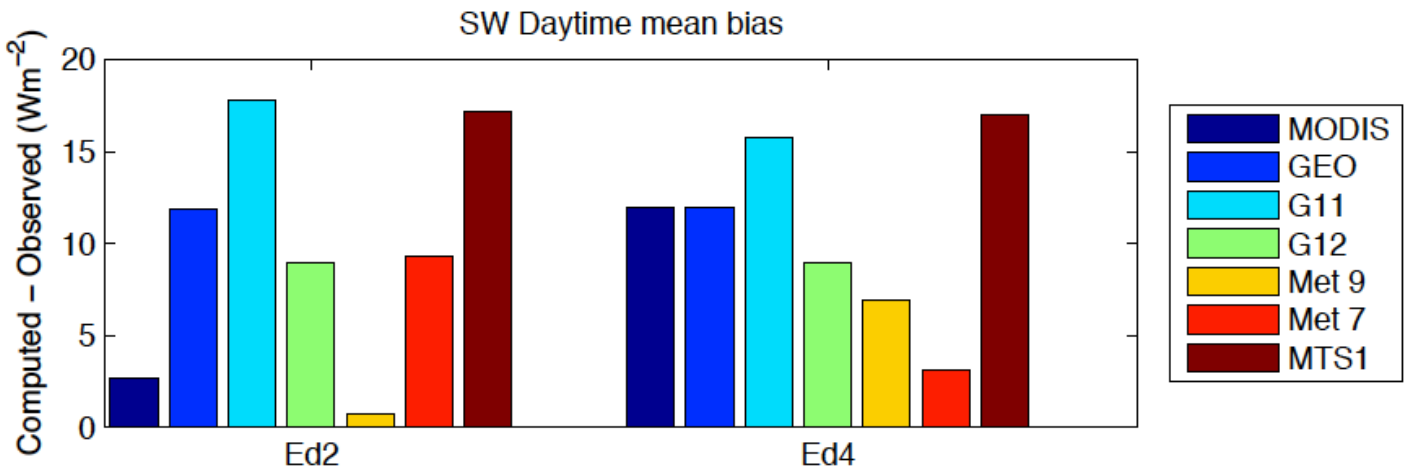


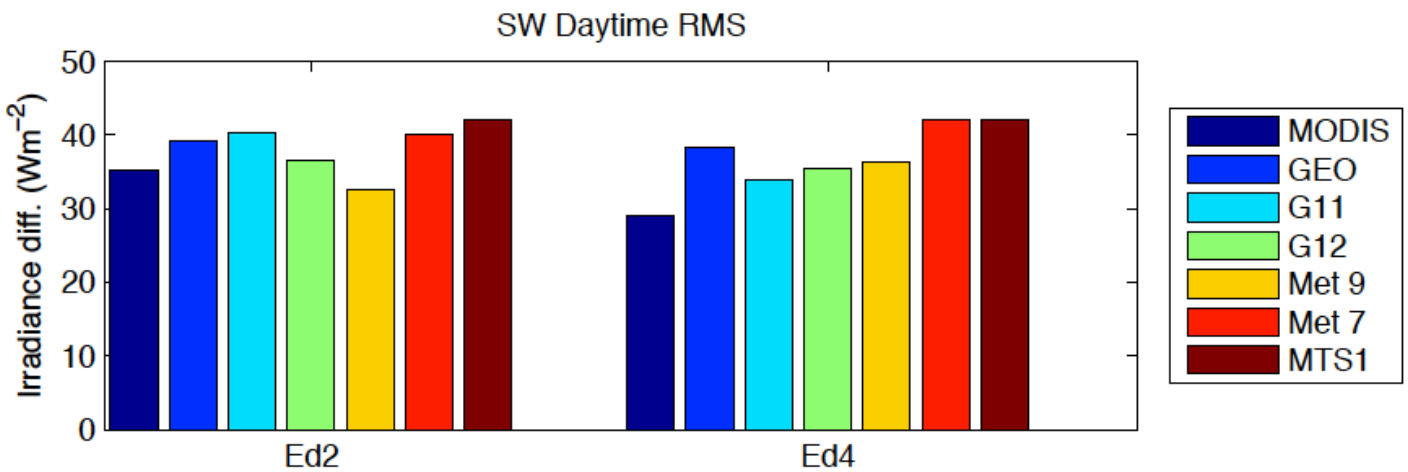






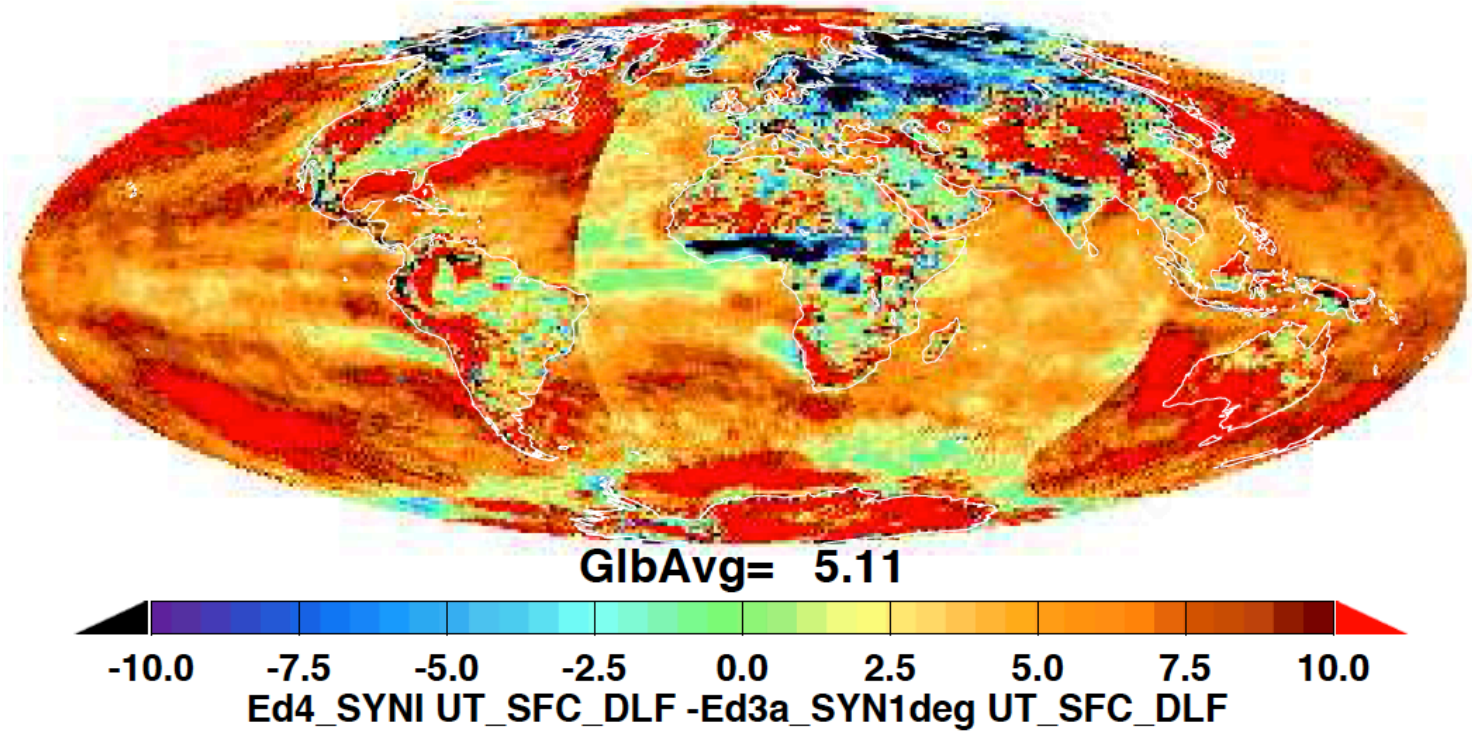
Current Ed4 (with 5 channel) versus Ed2 (SW) Jan. 2010





Ed4 MODIS gives a larger bias than Ed2

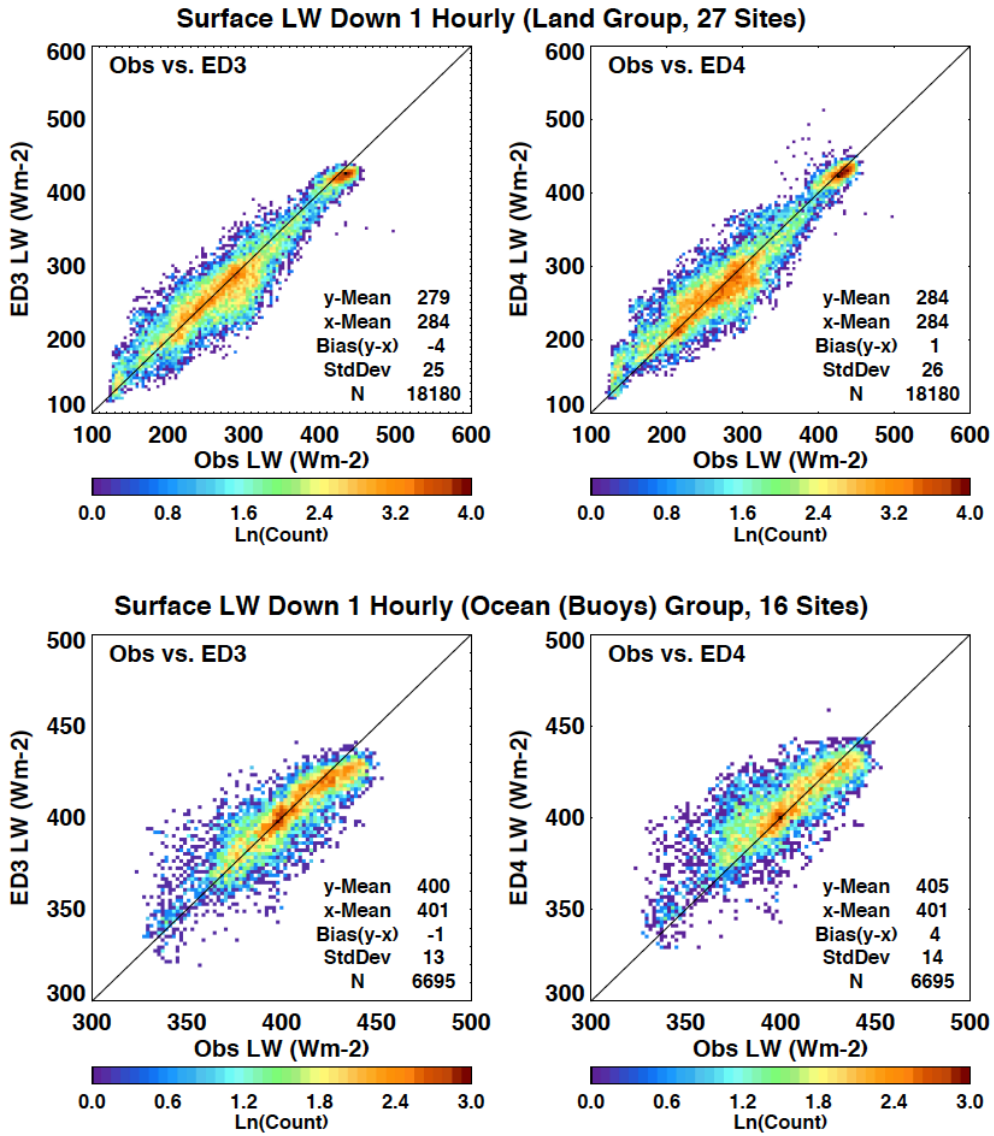
Surface downward longwave irradiance



Ed4 downward longwave is larger than Ed3 downward longwave because

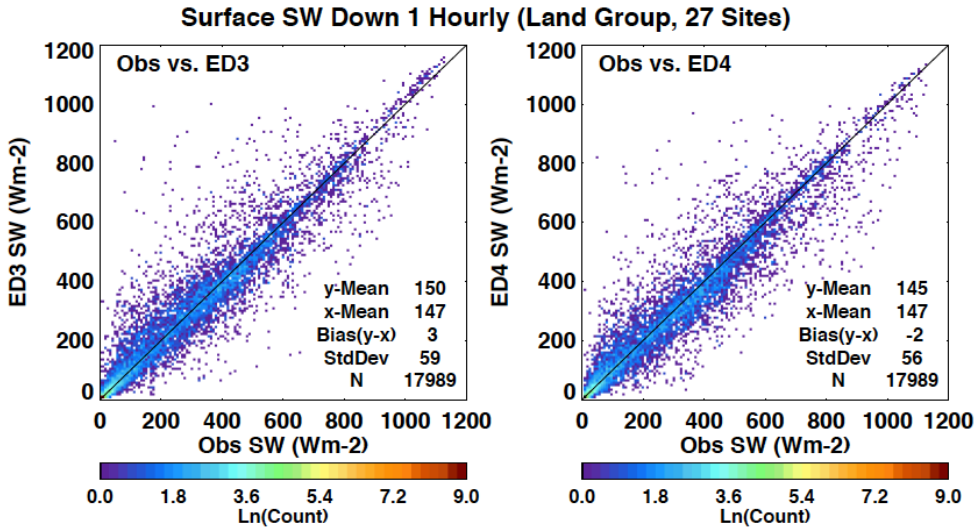
1) Ed4 include random cloud overlap (~3 Wm^{-2}, consistent with a 3.4 Wm-2 difference DLF computed with and without CALIPSO and CoudSat, Kato et al. 2011)
2) Using effective cloud top pressure instead of cloud top pressure (~2 Wm^{-2})

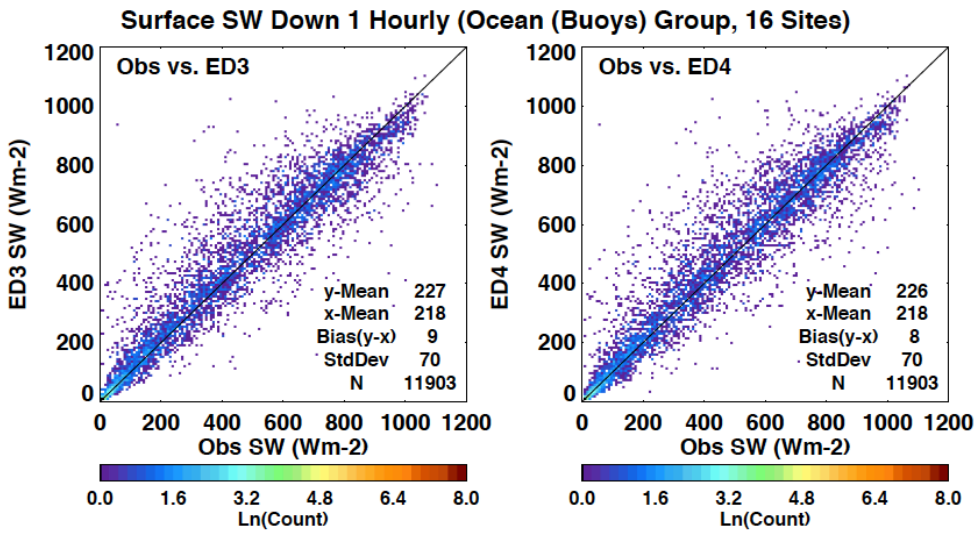
Comparison with surface observations (LW)
Jan. 2010



D. Rutan's presentation for detail

Comparison with surface observations (SW) Jan. 2010





D. Rutan's presentation for detail

Next step before deliver the SYN code

- Process GEO clouds, TSI and SYN, for three more test months (April 2008, July 2004, October 2002).
- Develop cloud top fix for GEOs with 2 channels (e.g. Met-7; the correction is a function of optical thickness).
- Develop cloud top fix (remove CO2 slicing effects) for MODIS and ignore thin clouds (?).
- Use MOA instead of GEOS-5 for GEO code (?)
- Deliver the SYNI code at the end of June

Satellite	Oct. 2002	July 2004	April 2008	Jan. 2010	April 2013	GEO type
GOES-8	X					4
GOES-12		X	X	X		5
GOES-13					X	5
GOES-10	X	X				4
GOES-11			X	X		4
GOES-15					X	5
Met-7 0°E	X					3
Met-8		X				6
Met-9			X	X		6
Met-10					X	6
Met-5	X	X				3
Met-7 60°E			X	X	X	3
GMS-5	X					3
GOES-9		X				4
MTSAT-1			X	X		4
MTSAT-2					X	4
Terra MODIS	Ed4-ASDC	Ed4-ASDC		?	?	1
Aqua MODIS	Ed4-ASDC	Ed4-ASDC		Ed4-offline	?	2
GERB		X		X		

3: 3 channels
4: 5 channels with 12 micron channel GEO
5: 5 channels with 12 micron channel is replaced by 13.2 channel
6: 5 channels with both 12 and 13 channels

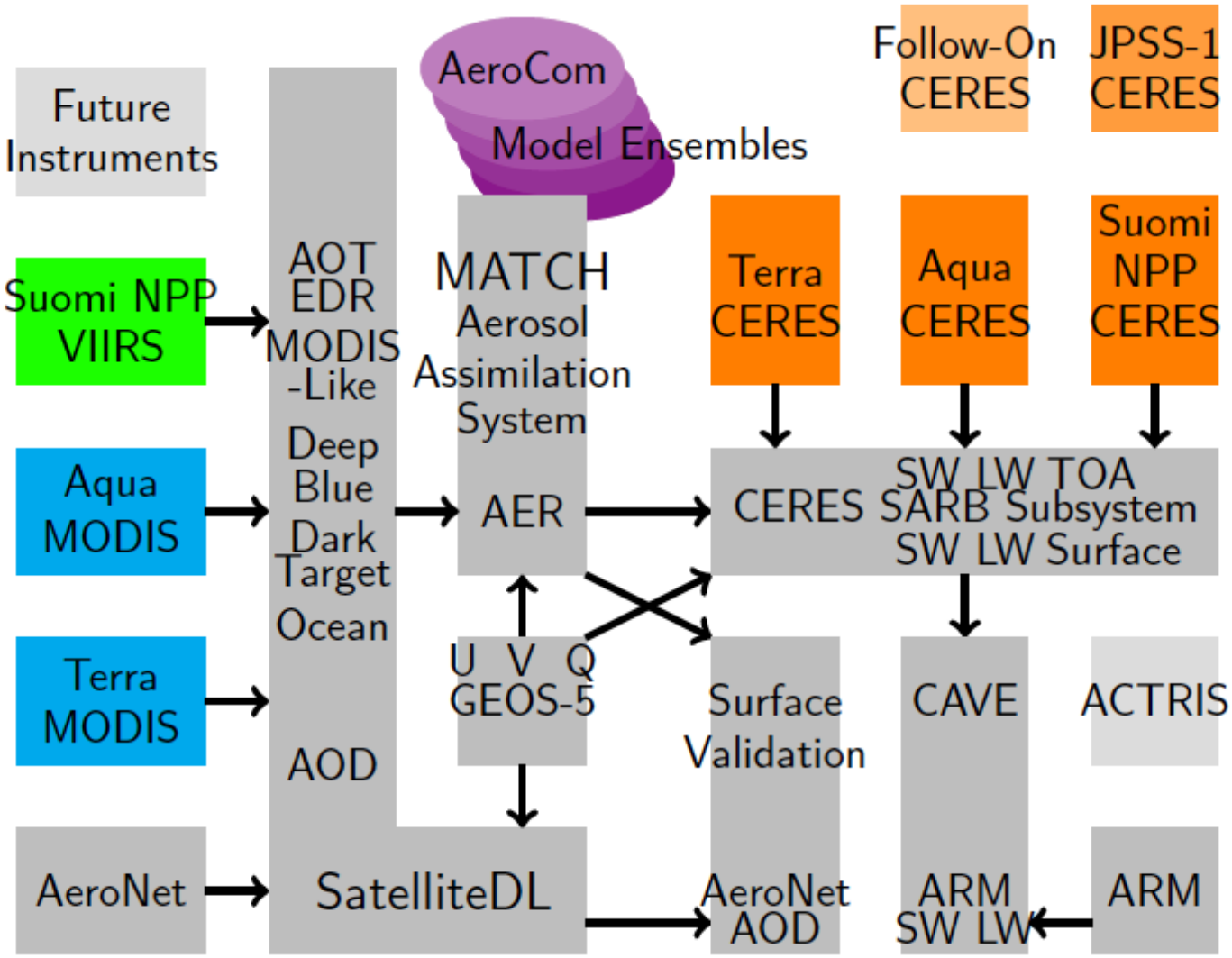
MATCH

MATCH Edition 4 Update

Final MATCH changes before June 1 code delivery:

- MODIS AOD uncertainty estimation by CERES surface types from Petrenko and Ichoku 2013 based on GIOVANNI [1] coincident Terra/Aqua MODIS and AERONET statistics
- will improve assimilation observation error covariance matrices
- anthropogenic emissions of SO2, SO4, OC, BC
  from *AeroCom*, based on GEIA (Global Emissions InitiAtive) [2]
  new MATCH types SO4, OC, BC $\rightarrow$
  SO4A, OCA, BCA (anthro) and SO4N, OCN, BCN (natural)

MATCH process flow diagram

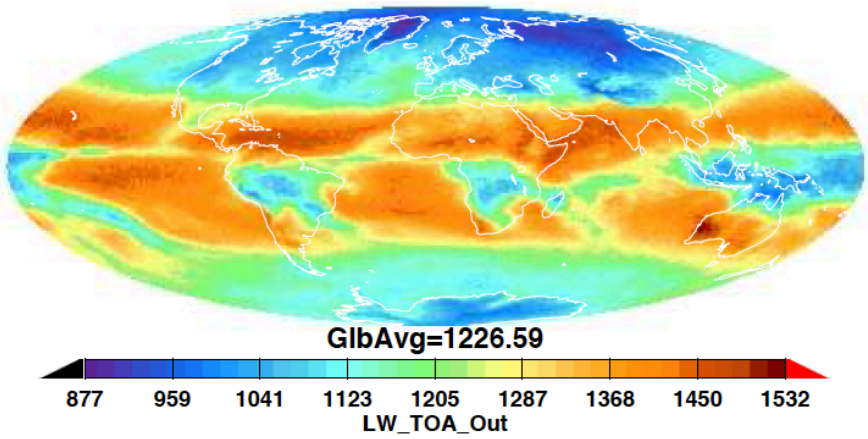


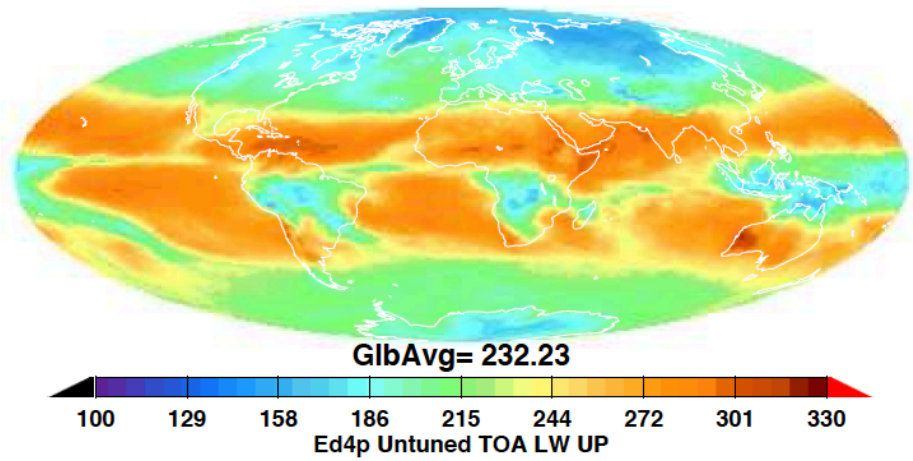
Entropy production

Entropy production by OLR

Jan. 2010

OLR





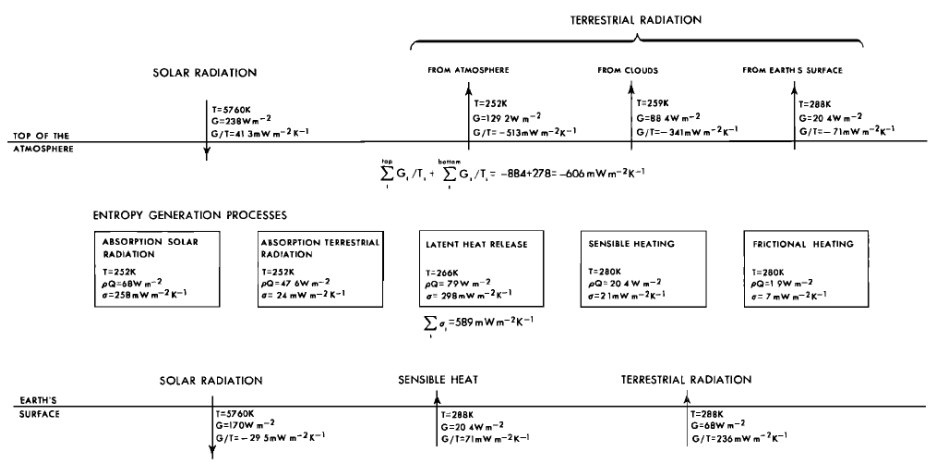


Fig. 2. Entropy budget of the global atmosphere estimated for annual mean conditions. Shown are the equivalent temperature T* in K, the energy flux G in W m^{-2}, and the entropy flux G/T^* in units of mW m^{-2} K^{-1} for each energy component at the top of the atmosphere and at the Earth's surface. A positive (negative) sign is used when the atmosphere gains (loses) entropy. The boxes in the middle of the figure contain estimates for each component of the atmospheric temperature where the absorption takes place in K, the rate at which energy is absorbed, ρQ, in W m^{-2}, and the rate of entropy production σ in units of mW m^{-2} K^{-1}.

Entropy production by radiation published by Peixoto et al. in 1991 is not correct

Peixoto et al. 1991

CRS

- NPP CRS
  - Ed2 code with Ed4 SSF format. Need to check ice particle size is radius or diameter.
- Ed4 CRS (4+ months after SYN?)

Ed4 CRS

- 18 band SW code
- New ice cloud properties (consistent with cloud group)
- Time varying CO2, CH4, N2O
- Boundary layer temperature profile consistent with cloud group
- Surface albedo history map including retrieval from partly cloudy CERES footprints
- Snow spectral albedo is modeled by snow grain size as a parameter
- Use MODIS derived surface albedo spectral shape
- Solar zenith angle dependent all-sky surface albedo
- Revised tuning algorithm

Publications and documentations

- Ham, S.-H., S. Kato, H. W. Barker, F. G. Rose, and S. Sun-Mack (2014), Effects of 3-D clouds on atmospheric transmission of solar radiation: Cloud type dependencies inferred from A-train satellite data, *J. Geophys. Res. Atmos*., 119, doi: 10.1002/2013JD020683.
- D. Rutan, D. Doelling, N. Loeb, L. Nguyen, T. Caldwell, and S. Kato, (2014), CERES synoptic (SYN) data product: Methodology and validation, in preparation.

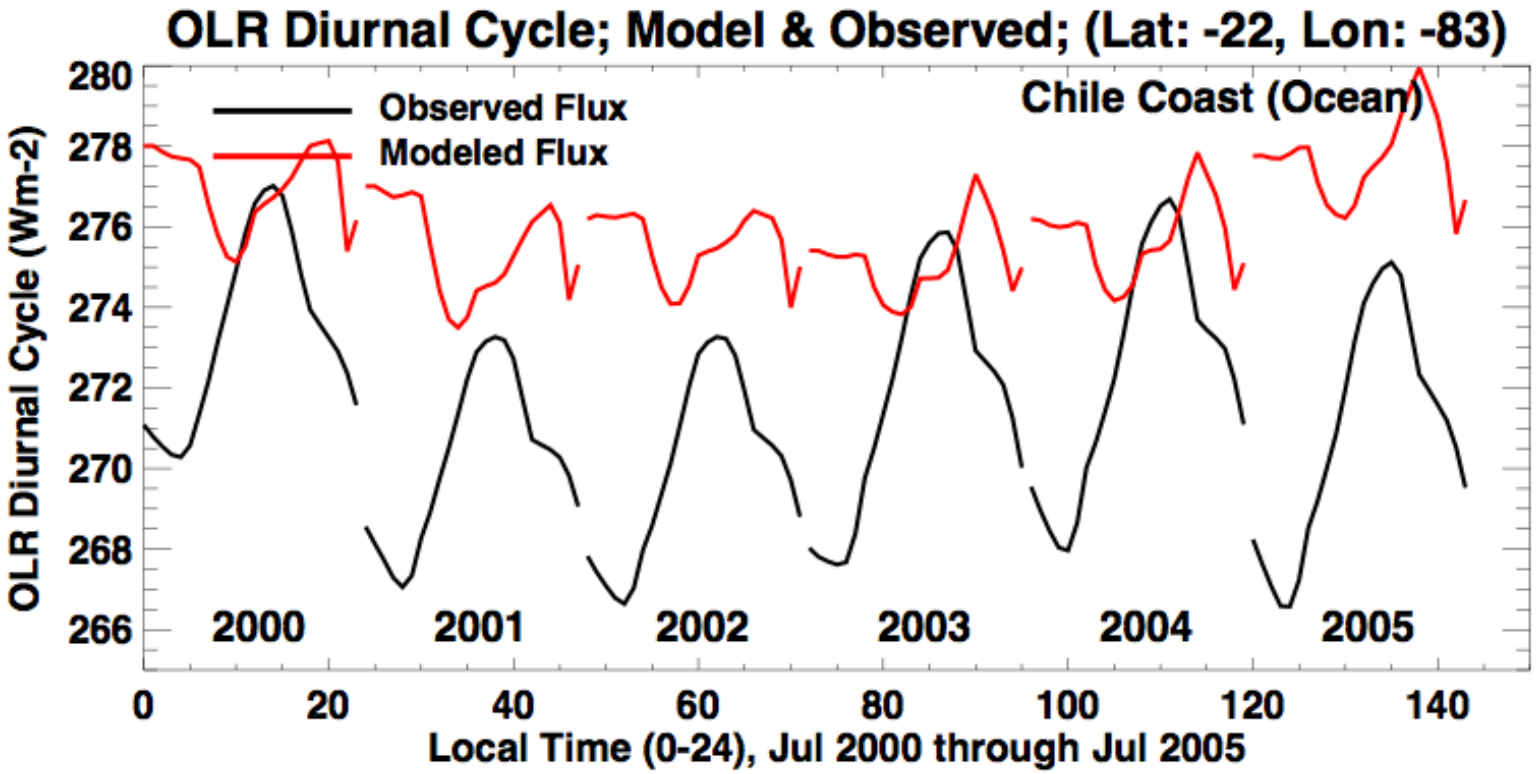
Back ups

OLR comparison
Model – Obs (RMS)

	MODIS	GEO	G11	G12	Met 9	Met 7	MTS1
Ed2 (Ptop)							
Day	-2.06 (9.44)	-6.14 (25.36)	-6.46 (24.58)	10.52 (28.01)	-6.78 (26.82)	-8.55 (25.58)	-1.98 (23.43)
Night	-2.66 (7.39)	2.33 (23.65)	0.50 (23.50)	-0.47 (23.20)	2.10 (23.32)	-0.52 (22.51)	7.14 (24.87)
Ed4 (Peff)							
Day	-2.25 (8.31)	-1.64 (11.65)	0.53 (8.46)	-5.17 (12.84)	-5.12 (14.42)	0.25 (13.53)	0.59 (9.95)
Night	2.20 (6.04)	-2.84 (16.15)	-0.80 (10.38)	-9.01 (19.59)	-9.22 (20.24)	10.46 (18.79)	1.41 (12.82)

SYN Ed4

- TOA SW and LW comparison with CERES
  - MODIS Ed3a, MODIS Ed4
  - GEO 2ch (hourly), GEO 5ch
  - Comparison by GEO (5ch)
  - Cloud property comparison with CALISPO/CloudSat (fraction, cloud top height), Arctic? Regional?
- Surface SW and LW comparison
  - Ed2 versus Ed4
  - Comparison by GEO (5ch)
  - Arctic?
- Surface SW and LW validation with surface data
  - Ed3a versus Ed4 monthly mean
- TOA and surface SW and LW diurnal cycle
  - Ed3a versus Ed4


OLR Diurnal Cycle; Model & Observed; (Lat: -22, Lon: -83)
Observed Flux
Modeled Flux
Chile Coast (Ocean)
OLR Diurnal Cycle (Wm-2)
280
278
276
274
272
270
268
266
2000
2001
2002
2003
2004
2005
0
20
40
60
80
100
120
140
Local Time (0-24), Jul 2000 through Jul 2005