Assessment of Global Cloud Climatologies

project of GEWEX Radiation Panel / WCRP

basic cloud properties I:

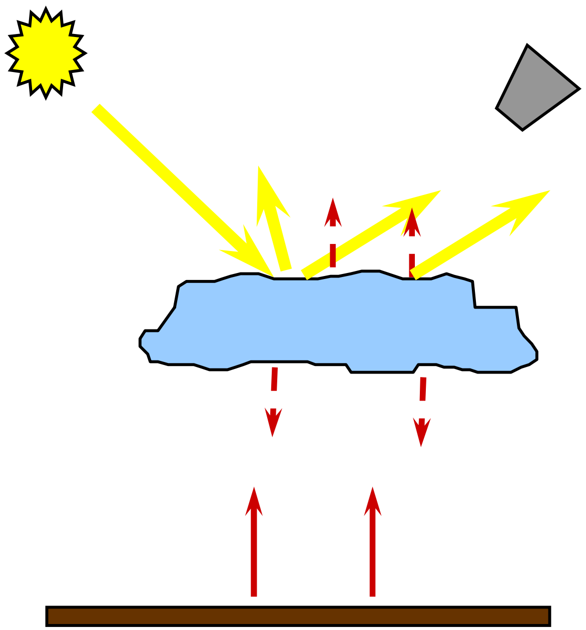
Cloud amount: total, high, mid & lowlevel (cloud pressure)

Cloud temperature: total, high, mid & lowlevel

Claudia Stubenrauch
+
GEWEX cloud assessment group

http://climserv.ipsl.polytechnique.fr/gewexca

cloud properties from satellite



Satellite radiometers measure:

emitted, reflected, scattered

radiation

cloud detection
inverse radiative transfer

cloud properties

best temporal & good spatial resolution

GEO (3hrs) *+polar*

polar satellites (12/6 hrs) **best spectral resolution**

ISCCP

IR, VIS

PATMOS-x

IR, NIR, VIS

HIRS-NOAA, TOVS Path-B

IR Vertical Sounder: CO_2-band

polarization

POLDER, MISR

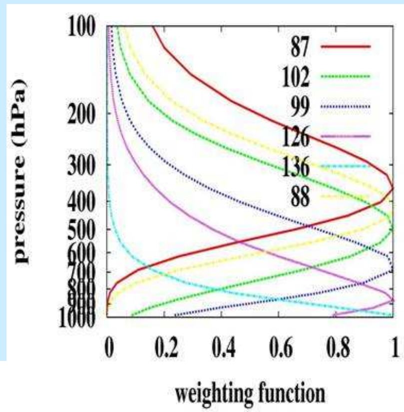
multi-angle scattering

best spatial resolution

MODIS

ATSR

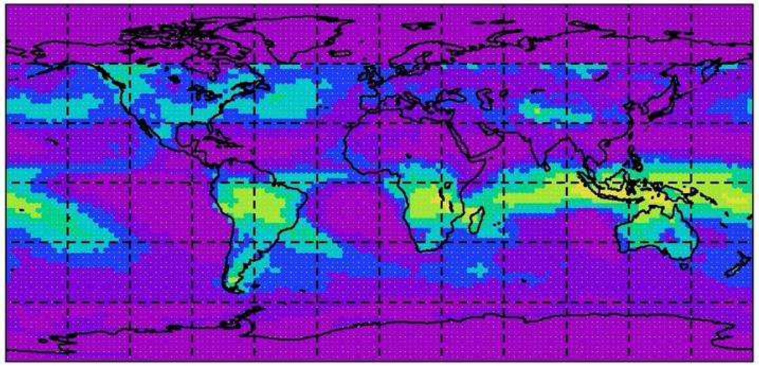
AIRS

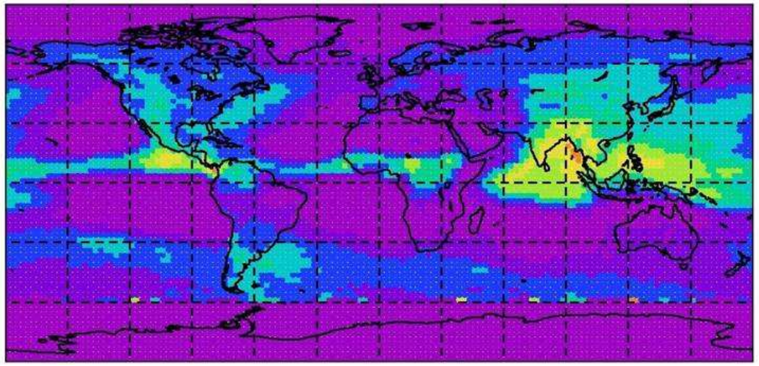


active instruments: CALIPSO, CloudSat

HCA geographical distributions

January **ISCCP** *July*

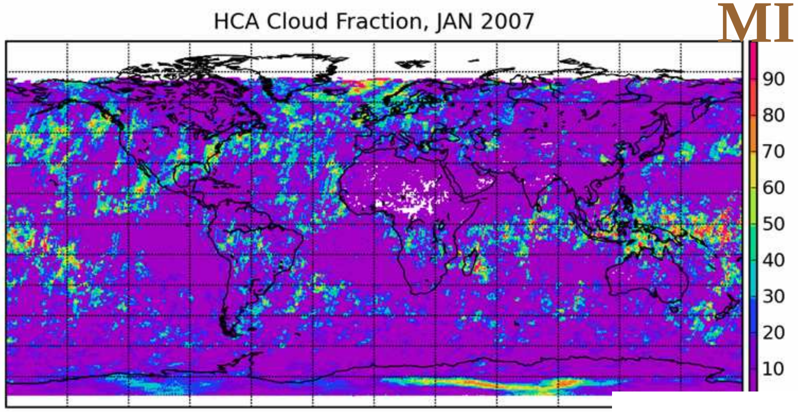


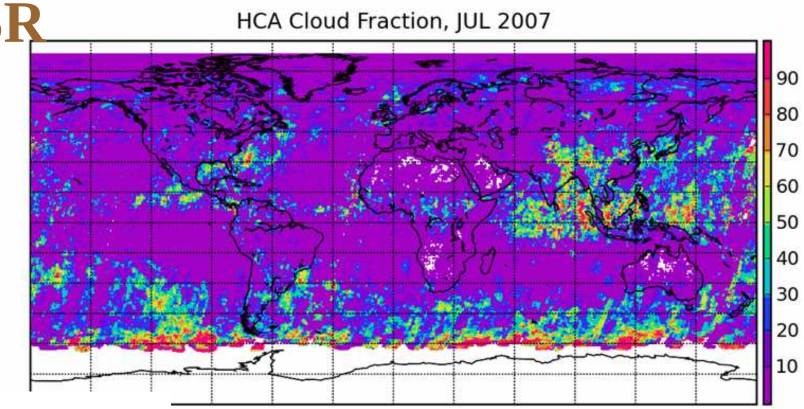


MISR

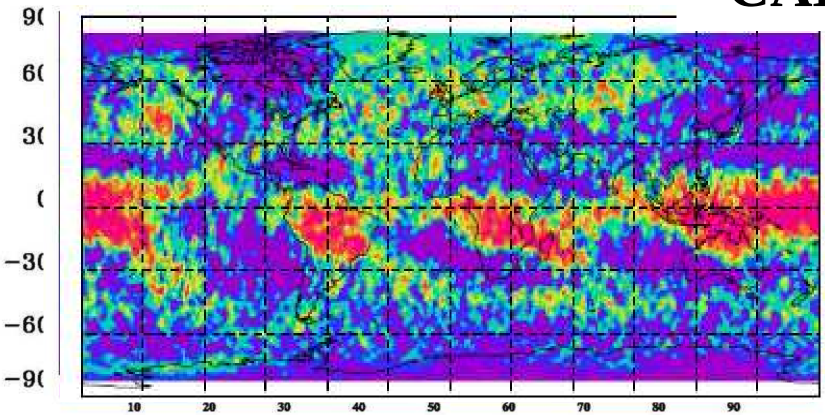
winter
strom tr

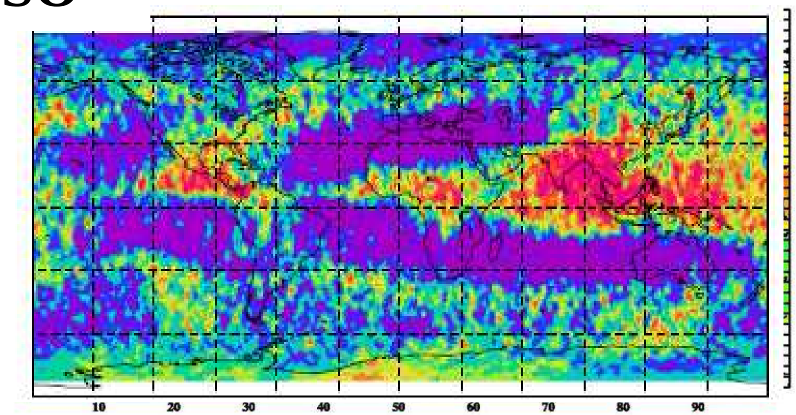
ITCZ

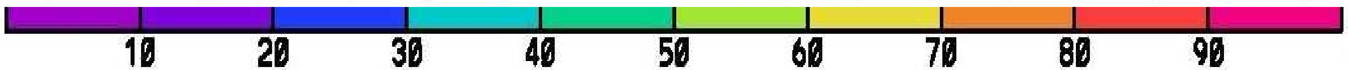


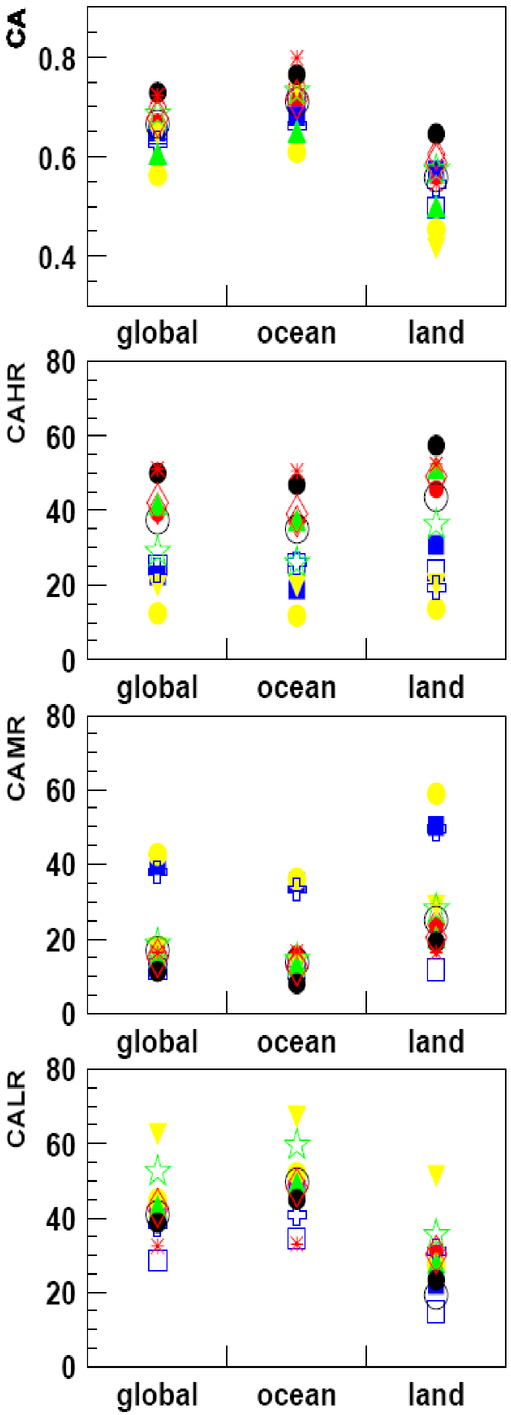


CALIPSO









<u>Average CA & monthly variability</u>

retrieved cloud amount depends on:
sensitivity to thin cirrus & partially covered footprints

max CA : 75%, 5-15% *more over ocean than over land*
(min CA: 57% POLDER, 60% MODIS-CE)

CAH, CAM & CAL scaled by CA: more useful for comparisons

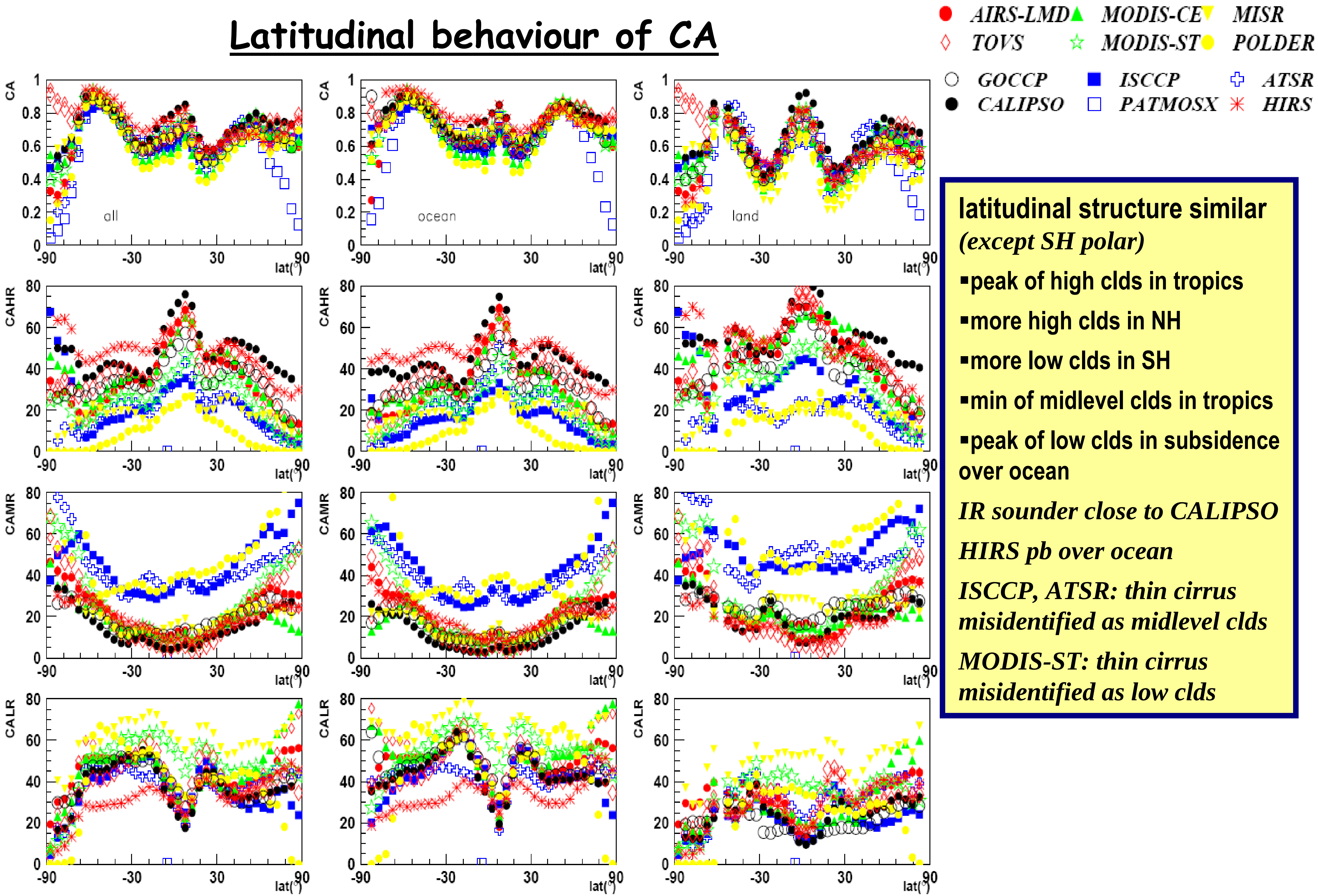
distribution of uppermost cloud layers:

50% / 10% / 40% high / midlevel / lowlevel	**CALIPSO**
42.5% / 15% / 42.5%	**IR sounders, MODIS-CE**
30% / 15% / 55%	**MODIS-ST**
25% / 40% / 35%	**ISCCP, ATSR**

POLDER O_2 band cloud height << radiative cloud height

more high clouds over land / more low clouds over ocean

Latitudinal behaviour of CA



latitudinal structure similar
(except SH polar)

- **peak of high clds in tropics**
- **more high clds in NH**
- **more low clds in SH**
- **min of midlevel clds in tropics**
- **peak of low clds in subsidence over ocean**

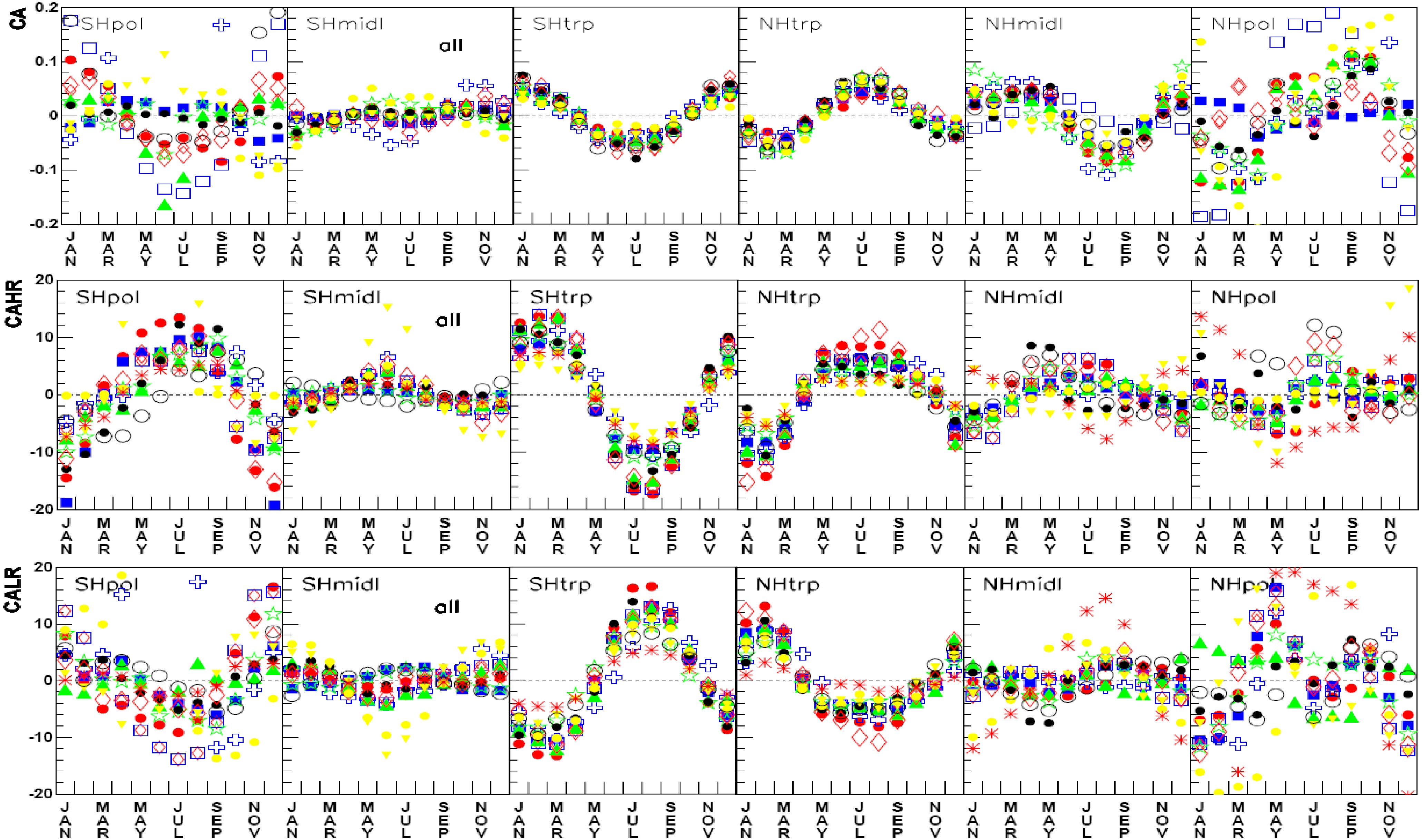
IR sounder close to CALIPSO

HIRS pb over ocean

ISCCP, ATSR: thin cirrus misidentified as midlevel clds

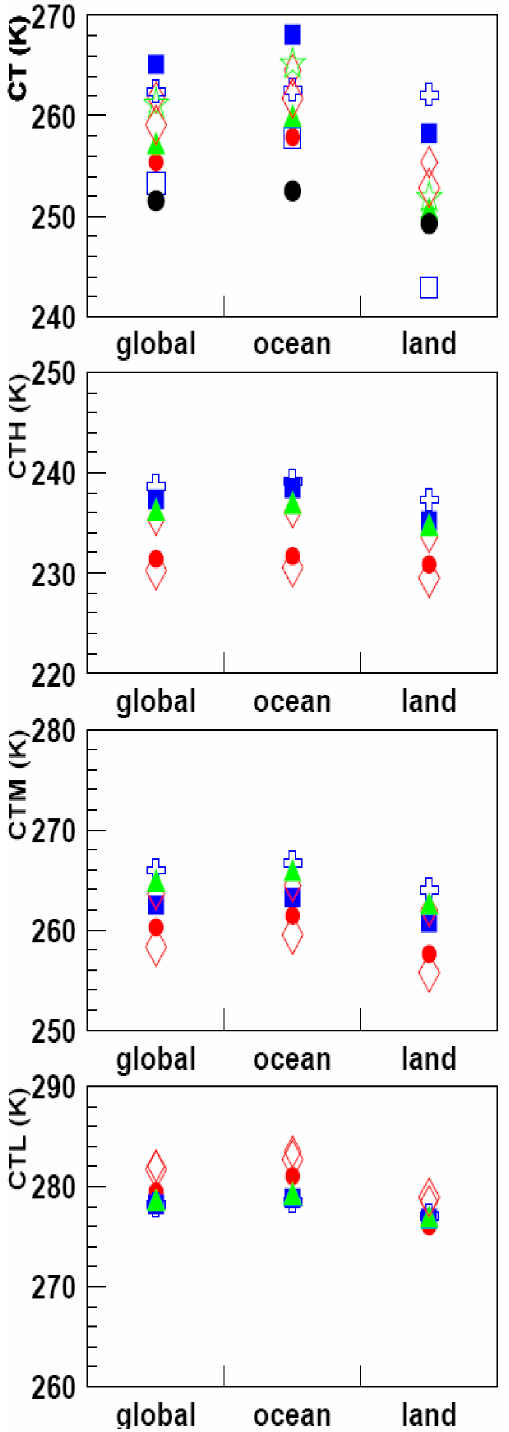
MODIS-ST: thin cirrus misidentified as low clds

Seasonal cycle of CA

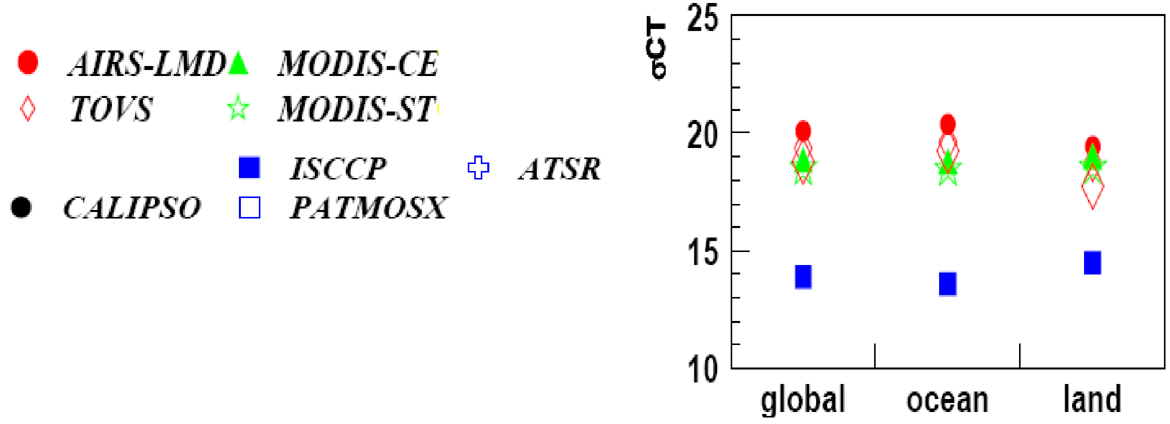


seasonal cycles agree quite well (*except polar latitudes & NH land*): largest in 0-30S, smallest in 30S-60S

AIRS-LMD *MODIS-CE* *MISR* *TOVS* *MODIS-ST* *POLDER* *GOCCP* *ISCCP* *ATSR* *CALIPSO* *PATMOSX* *HIRS*



Average CT & monthly variability



T variability may indicate sensitivity:

TOVS/AIRS & MODIS similar, ISCCP lower

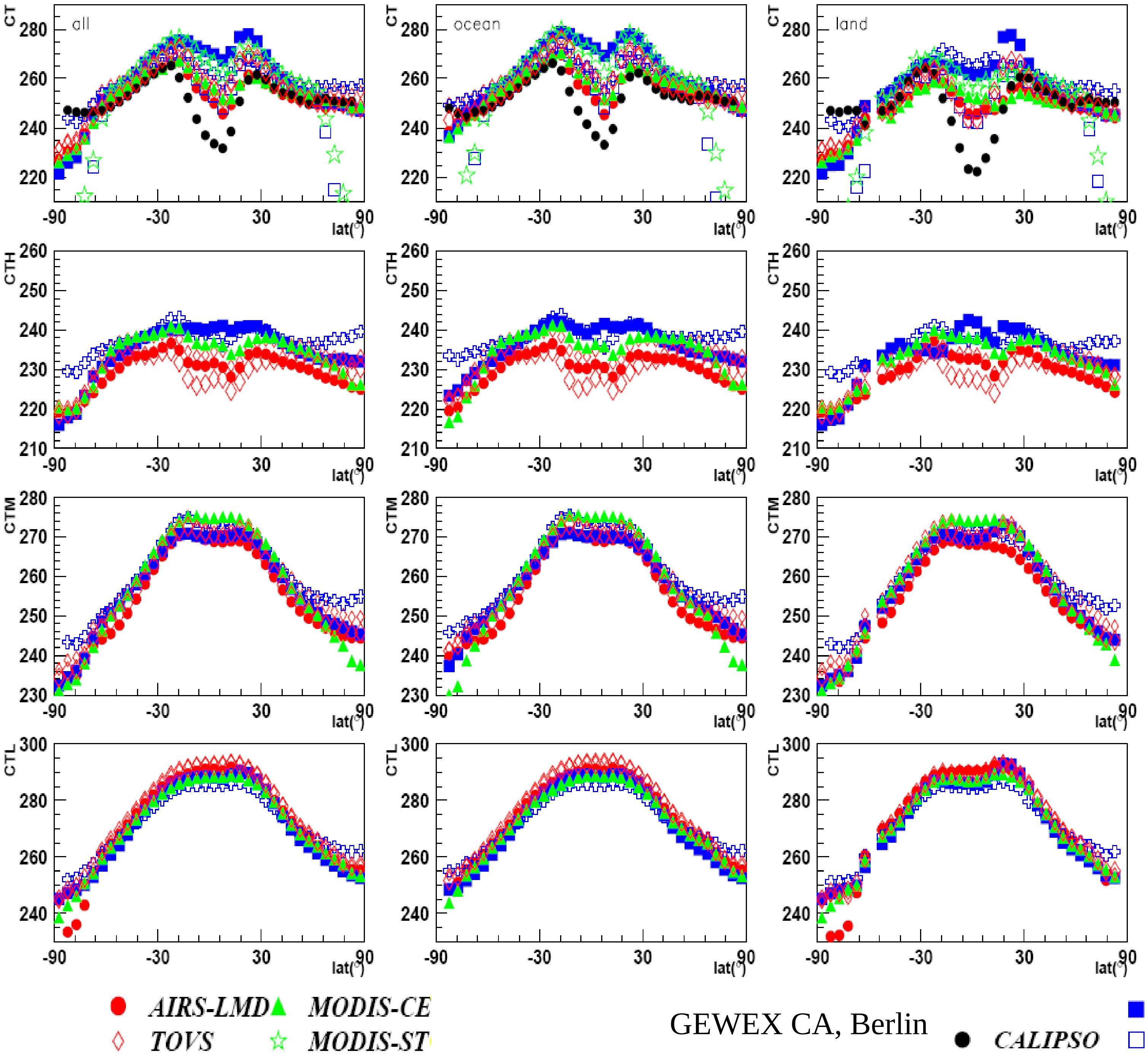
CALIPSO most sensitive to thin Ci => coldest T

$\mathbf{T_{CALIPSO} - T_{ISCCP} \cong 13\ K}$

larger spread for high clds than for low clds

(due to thin Ci sensitivity)

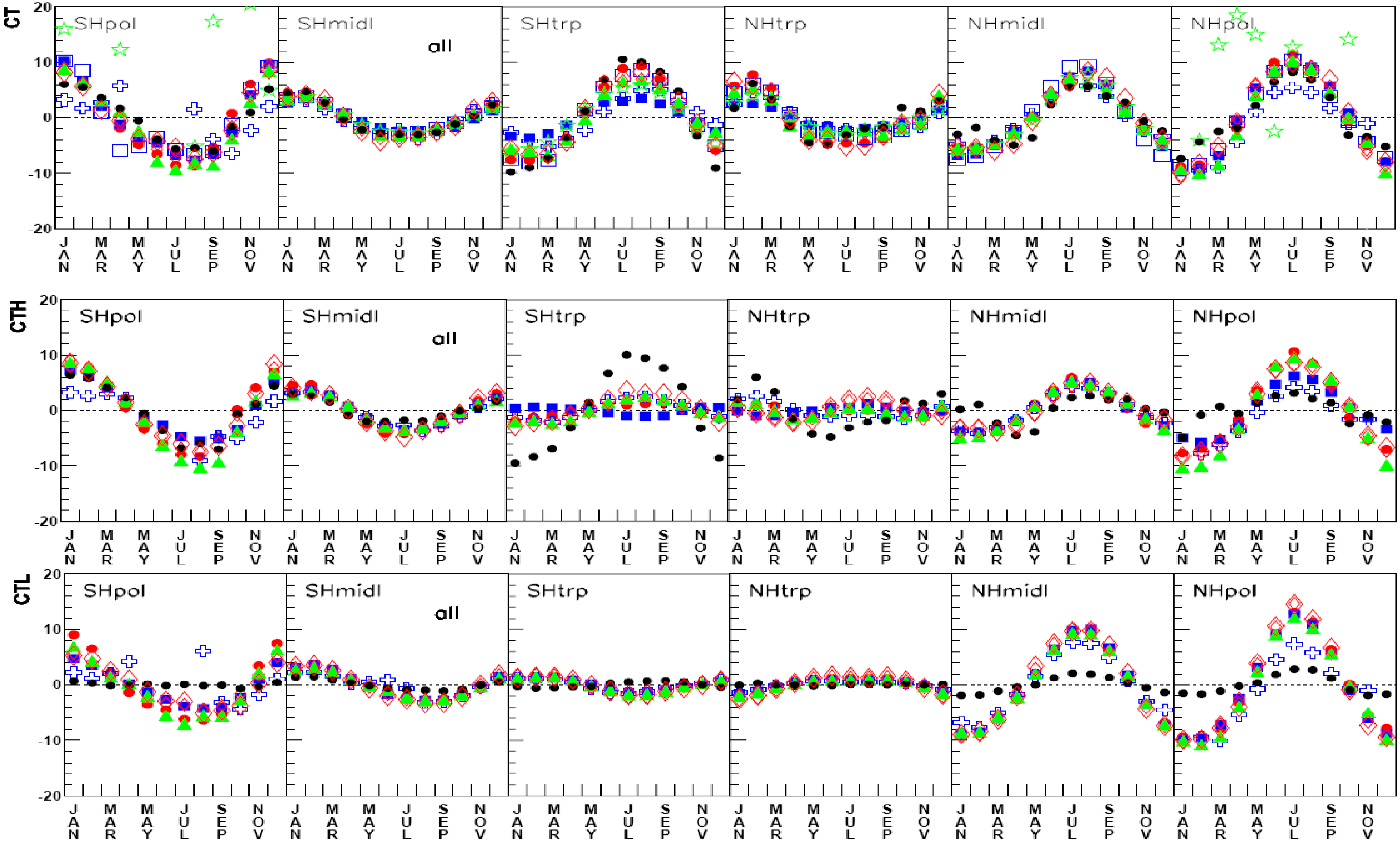
Latitudinal behaviour of CT



latitudinal structure similar ***(except SH polar)***

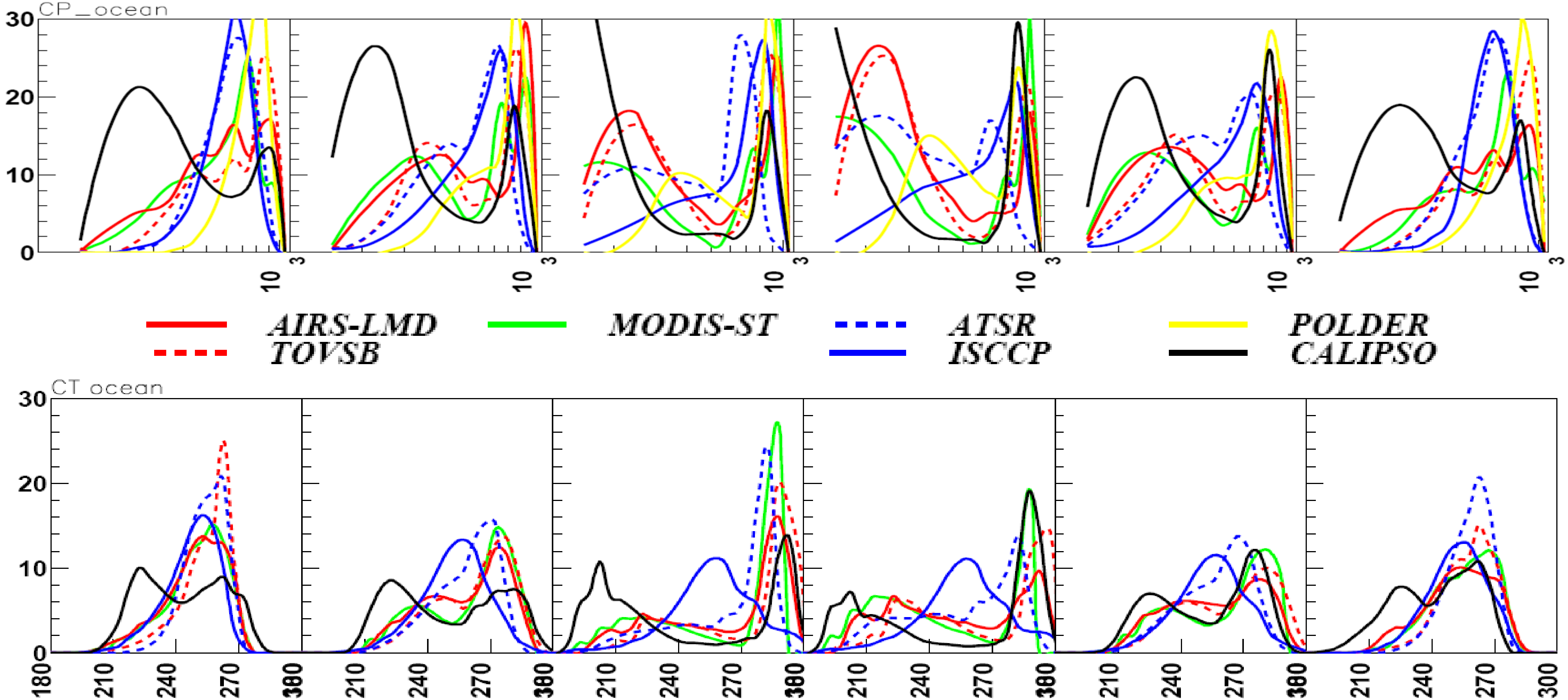
- **largest difference in tropics** **(linked to thin Ci)**
- **stronger latitudinal dependence for low clouds than for high clouds**
- **spread larger for high clouds than for low clouds** **(high clouds more diffuse)**

Seasonal cycle of CT



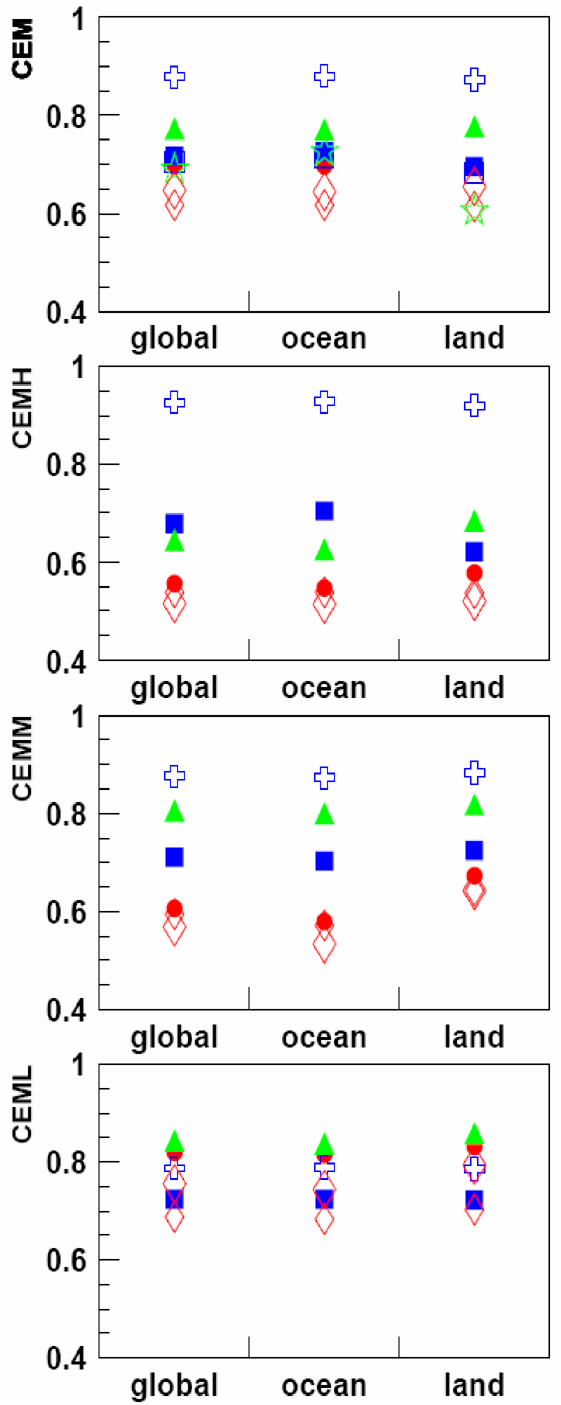
CT seasonal amplitude 20K; CTH/CTL seasonal cycle increases from tropics towards poles; ***pb CALIPSO?***

Distributions of CP & CT in latitude bands

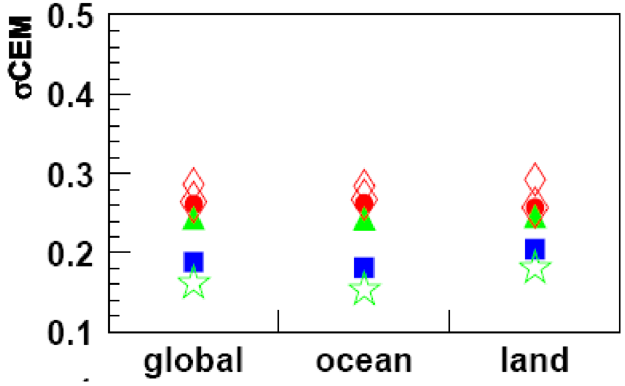


CALIPSO: highest cloud layer (no subvisible clouds, det. 5km)

largest CT spread in tropics, spread largest with CALIPSO, ISCCP misplaces thin Ci at midlevel



Average CEM & monthly variability

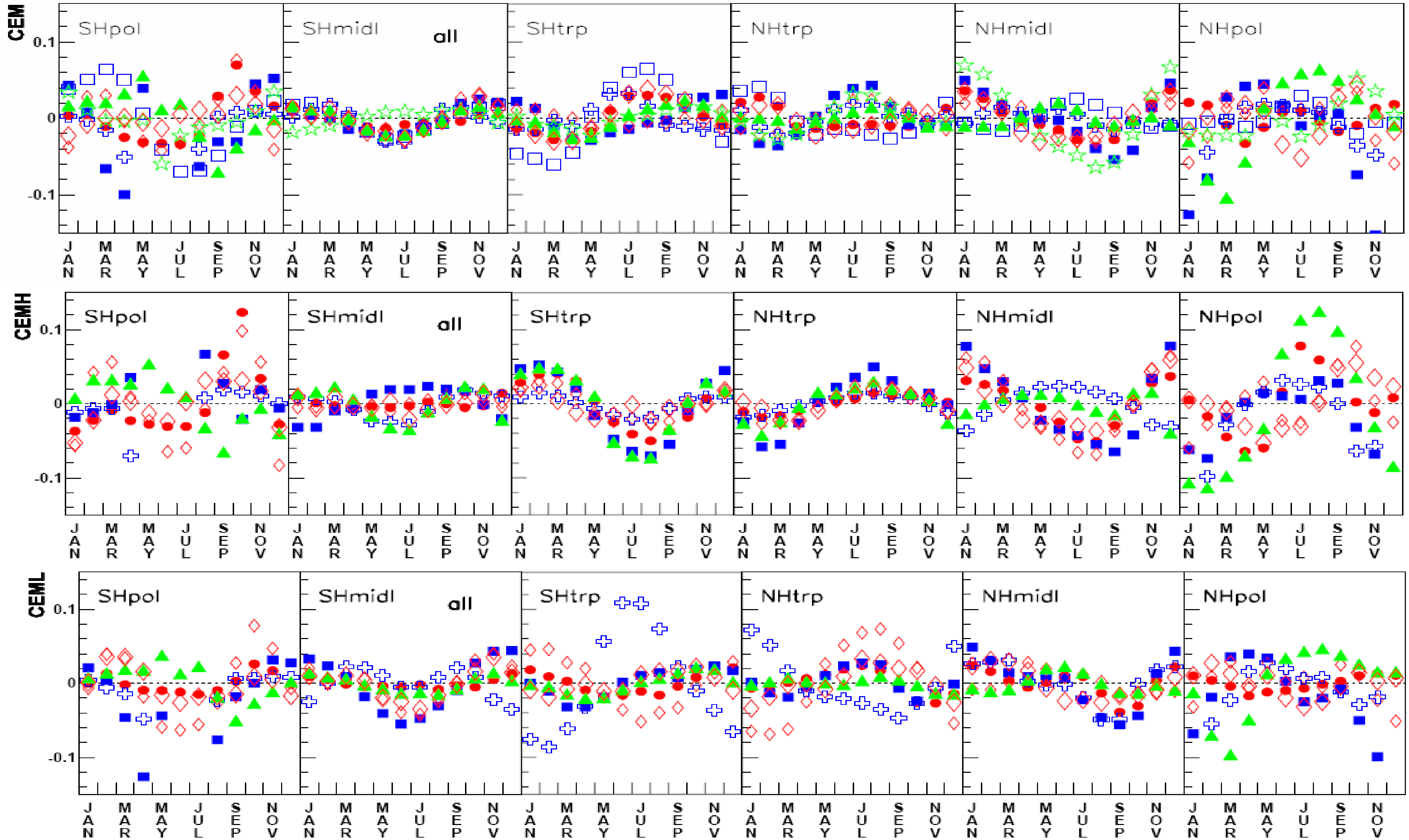


~0.7

monthly variability and average CEMH indicate again sensitivity to thin Ci

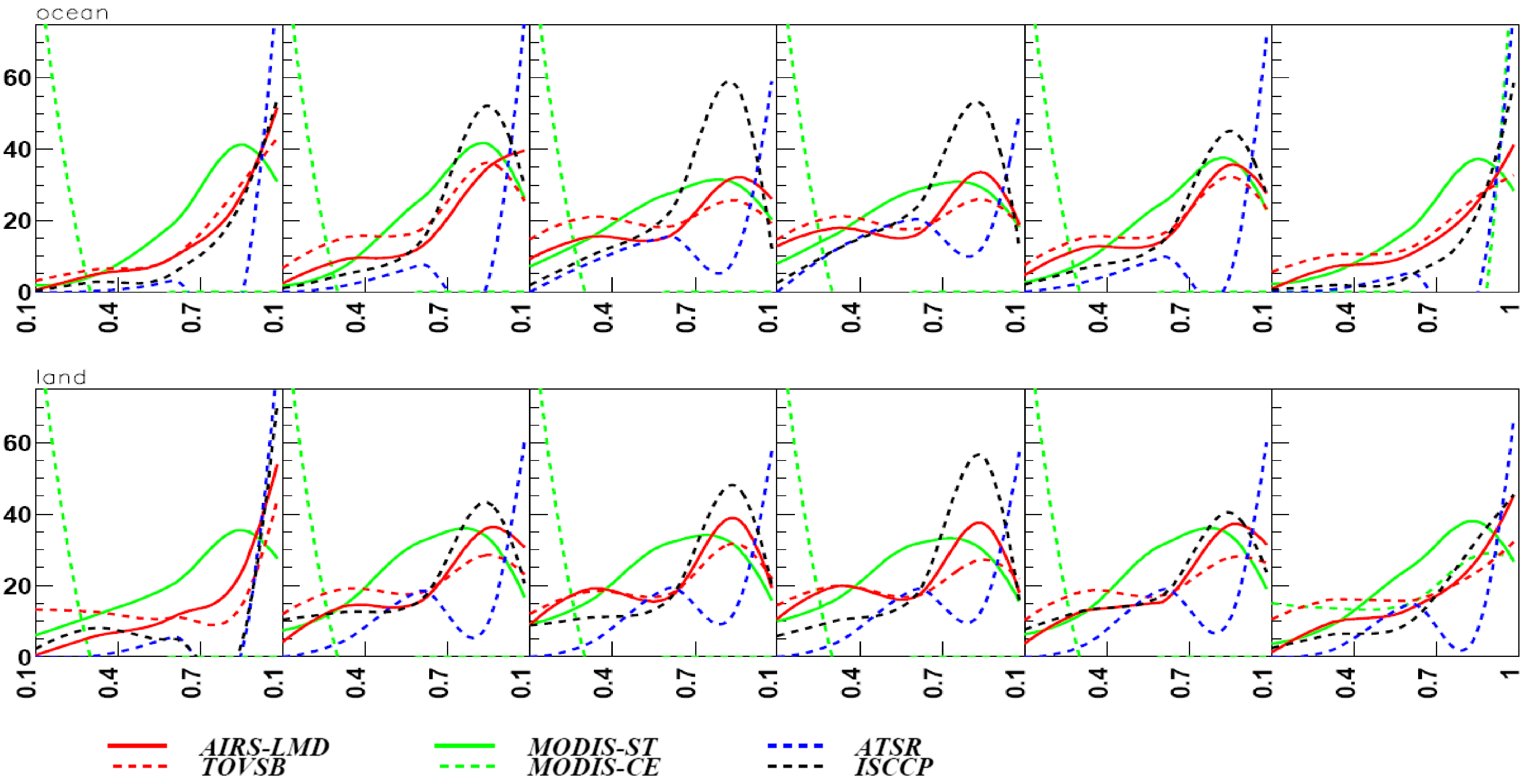
ATSR much too large!!

Seasonal cycle of CEM



Small seasonal cycle; AIRS & ISCCP seasonal cycle in NH midlatitudes agree well! MODIS-CE, ATSR diff. no agreement in polar latitudes

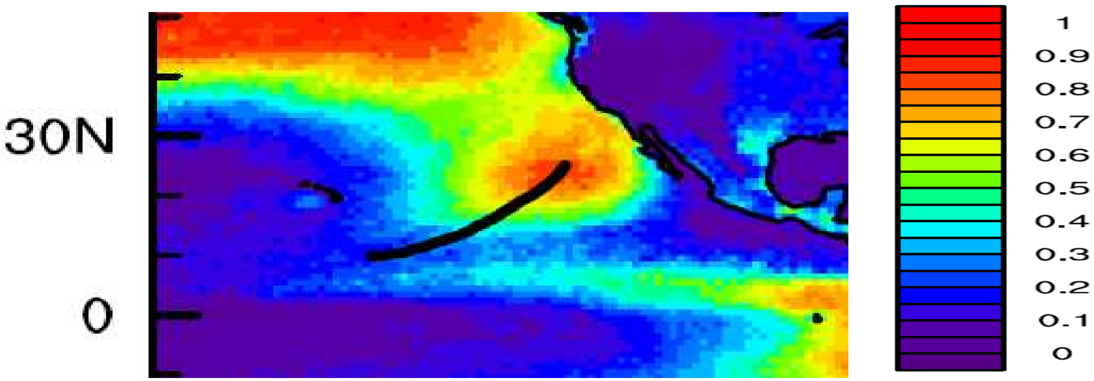
Distributions of CEM in latitude bands



Pacific Cross-section Intercomparison of GEWEX Cloud System Study
stratocumulus-> shallow cumulus

Analysis by Irina Sandu, MPI-M

MODIS CALW

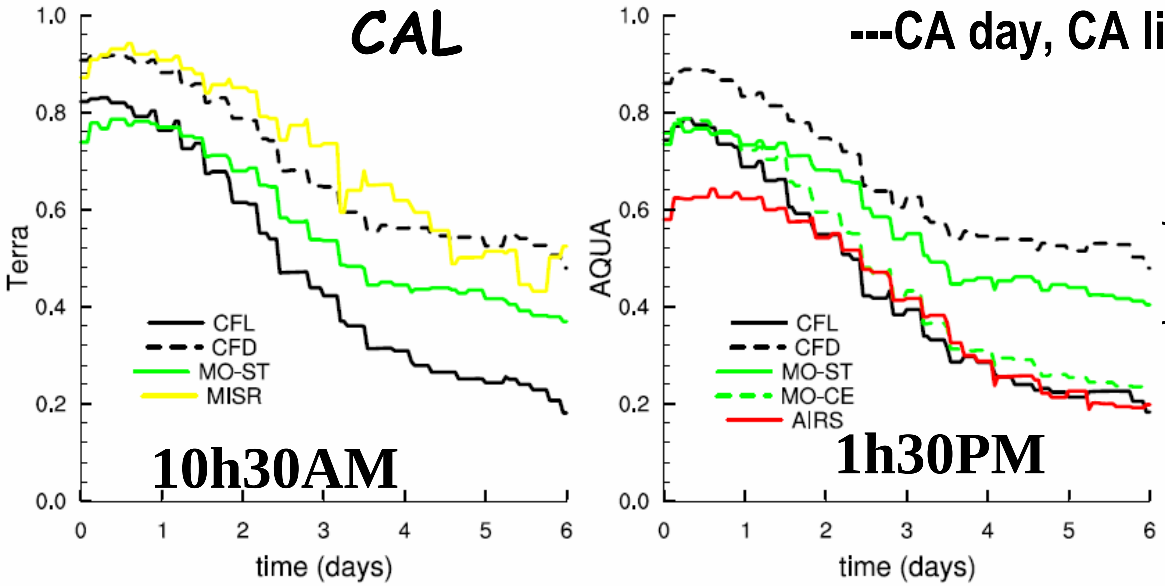


Trajectory analysis JJA 2006

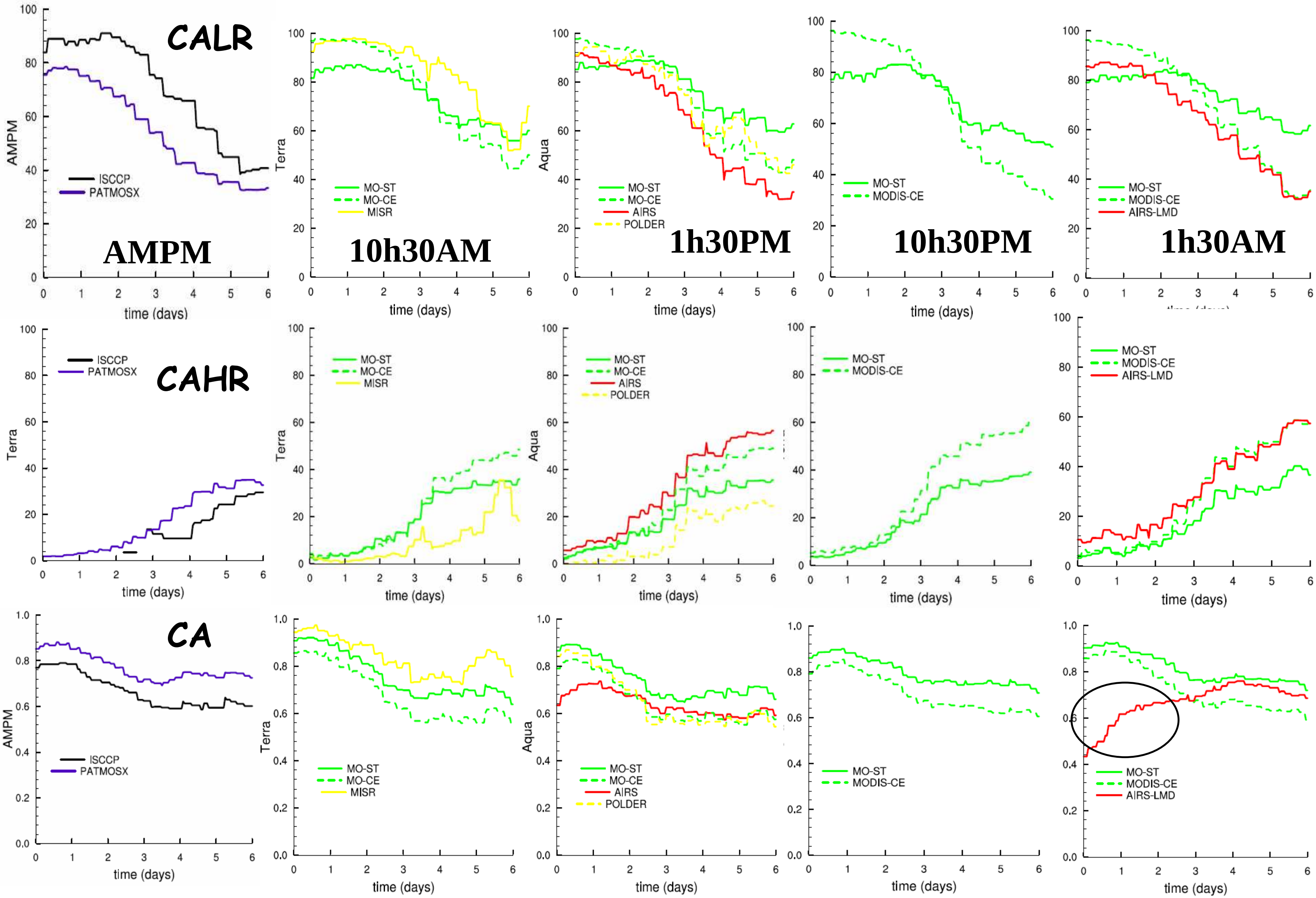
method decribed in (*Sandu et al. ACP 2009)*

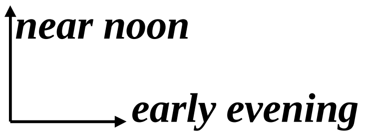
MODIS-ST:

---CA day, CA liquid, GEWEX netcdf



should be identical !!!


CALR
AMPM
10h30AM
1h30PM
10h30PM
1h30AM
CAHR
CA
ISCCP
PATMOSX
MO-ST
MO-CE
MISR
AIRS
POLDER
MODIS-CE
AIRS-LMD
time (days)
AMPM
Terra
Aqua



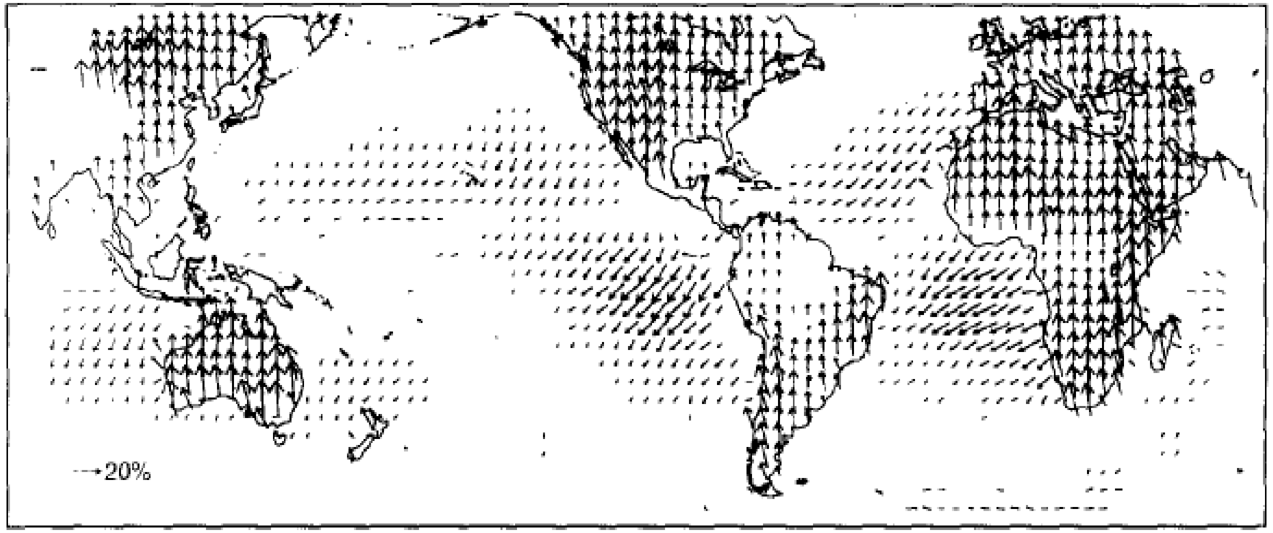
diurnal cycle of clouds

Cairns, Atm. Res. 1995

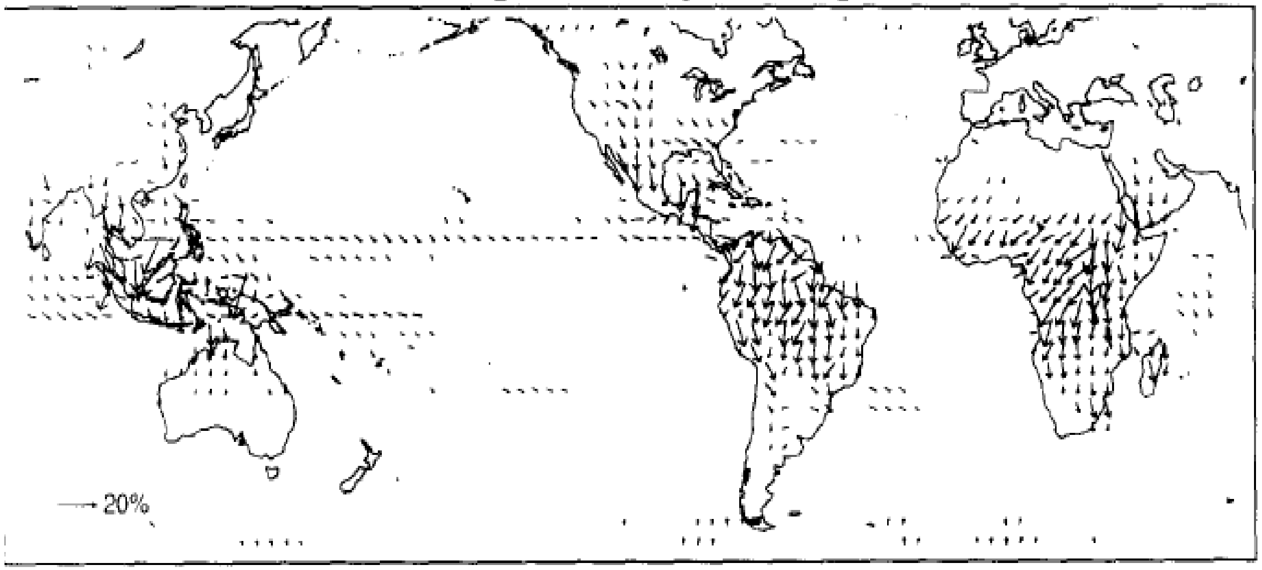
ISCCP C2, Complex Empirical Orthogonal Functions,

project. on distorted diurnal harmonics

Annual Average Diurnal Cycle for Low Cloud

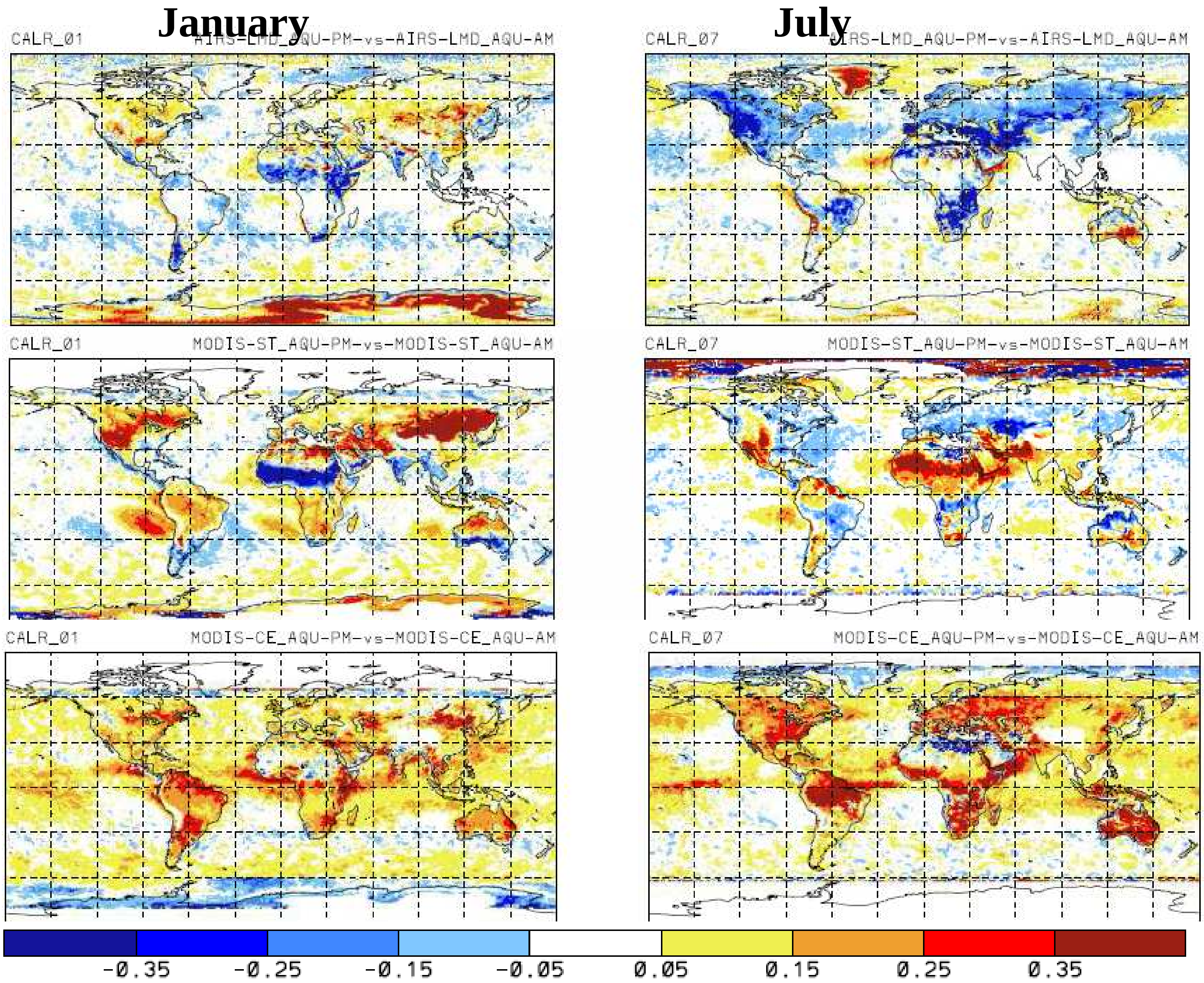


Annual Average Diurnal Cycle for High Cloud



- **Low clouds over land:** significant diurnal cycle, *max early afternoon*
- **Low clouds over ocean:** *max in early morning*
- **High clouds:** *max in evening*
- **Mid clouds:** *max in early morning or late at night (cirrus -> TOVS)*

Difference in low clouds between 1h30PM and 1h30AM



AIRS-LMD

max over land in early afternoon

only in winter !

MODIS-ST

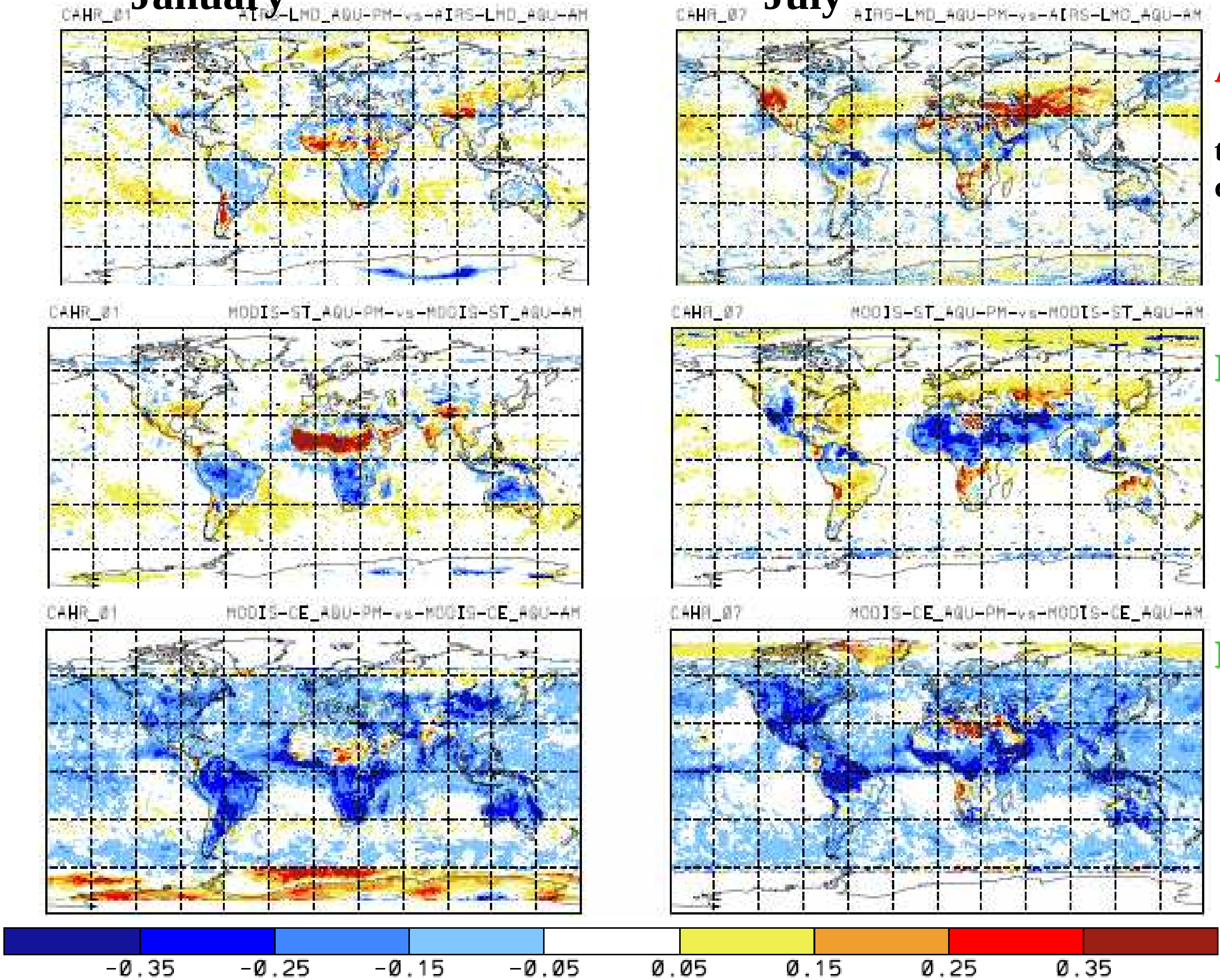
similar to AIRS over land

MODIS-CE

difference probably linked to VIS channel during day (PM)

Difference in high clouds between 1h30PM and 1h30AM

January July



AIRS-LMD

trop. land: more high clds during night

MODIS-ST

similar to AIRS

MODIS-CE

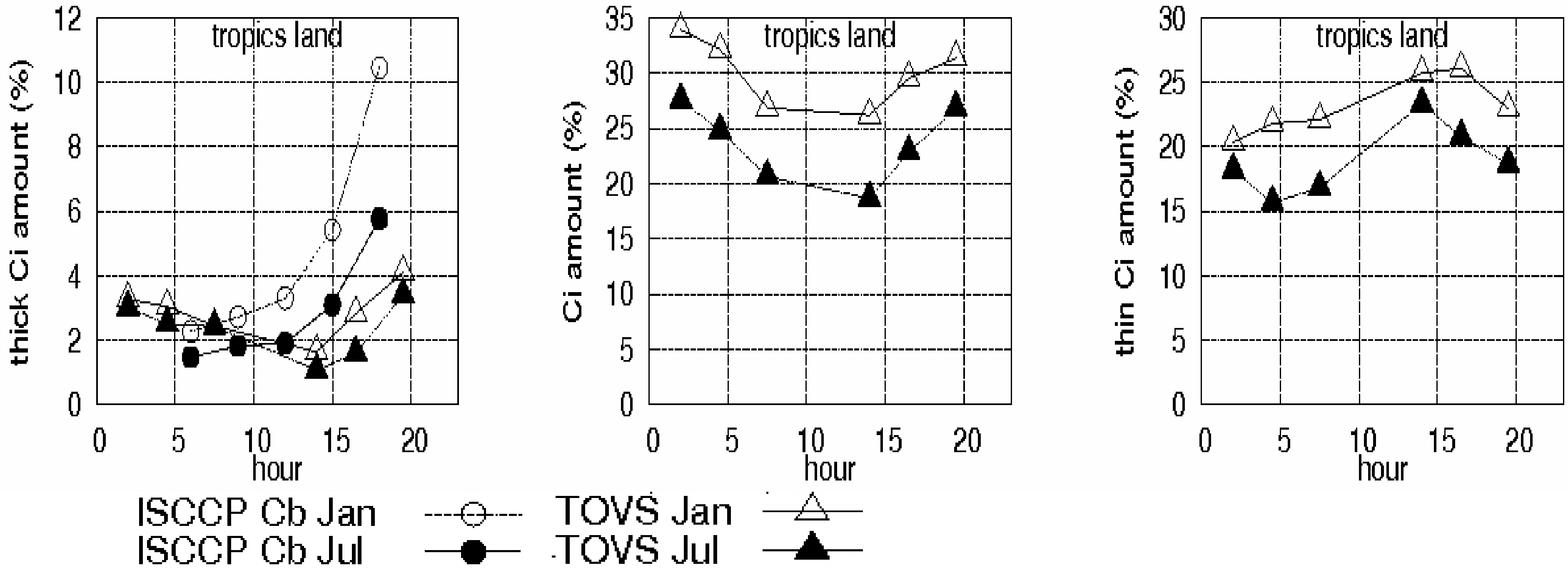
pb day-night treatment?

TOVS-B diurnal cycle of high clouds

Stubenrauch et al. J. Climate 2006

NOAA10/12 7h30 AM&PM, NOAA11 2h00 AM&PM(1989-90) NOAA11 4h30 AM&PM(1994-95)

strongest diurnal cycles over land, in tropics (& in midlat summer)



- max Cb (ISCCP) in early evening
- max. thick (large-scale) cirrus & cirrus in evening
- cirrus occurrence continues during night & decreases during day
- max. thin cirrus in early afternoon

Satellite observations:

❖ unique possibility to study cloud properties over long period
-> climatological values of CA, HCA, MCA & LCA
(also variabilities, T_{cld}, ε, τ, D_{eff}, WP) to help evaluate climate models

❖70% (±5%) clouds: ~ 40% high clouds & ~40% single-layer low clouds

❖**in general geographical cloud structures agree quite well:**
max of high clouds in ITCZ (up to 60%),
few single-layer midlevel clouds in tropics (5%), most in NH midlat winter (15%)
low clouds over ocean: seasonal cycle in Stratocum regions in good agreement
❖Seasonal cycle of LCA from SOBS smaller and abs value 20% higher
-> multilevel clouds

❖**CALIPSO L2 analysis confirms:**
IR sounders are the passive instruments most sensitive to cirrus
They only miss 10%/5% subvisible cirrus in tropics/midlat
(These are caught by limbsounding SAGE & active CALIPSO)

ISCCP miss 15%/10% in tropics/midlat compared to IR sounder, (included in MCA)

❖ **diurnal cycle**: well determined by ISCCP (midlevel clds –cirrus -> TOVS)

Be careful of systematic biases in diurnal differences

monthly mean values depend mainly on sensitivities

distributions

Uncertainties: only provided by TOVSB, AIRS-LMD

Histograms should be provided by all participating data sets

what to do with outliers?