Cloud Assessment

a review

Claudia Stubenrauch*
+
S. Kinne, W. B. Rossow, C. Pearl, A. Heidinger, A. Walther, A. Guignard, S. Ackerman, S. Platnick, B. Maddux, P. Minnis, S. Sun-Mack, L. DiGirolamo, A. Menzies, P. Menzel, E. Olsen, J. Riedi, S. Zeng, D. Winker, B. Getzewich, H. Chepfer, G. Cesana, C. Poulsen, A. Sayer

*Laboratoire de Météorologie Dynamique, IPSL/CNRS
Ecole Polytechnique, France

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

Cloud Assessment

co-chairs: C. Stubenrauch, S. Kinne

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

initiated in 2005 by GEWEX Radiation panel (GRP)

Assessments essential for climate studies & model evaluation

2005-2010: 4 workshops *(Madison, New York, Berlin)*

2009-2011: Preparation of common data base *(monthly statistics in netCDF format)*

2011: WCRP report, BAMS article & opening of data base to public

- Homogenized documentation on
  - *sensor, calibration*
  - *retrieval method, ancillary data*
  - *sampling*
  - *evaluation*
- state strength & limitations & suitable applications for each dataset
- make clear statements for each of the cloud properties
  (global averages & distributions, regional variability, seasonal cycles, interannual variations, longterm anomalies)

Cloud Assessment common data base

to facilitate assessments, climate studies & model evaluation

properties:	(GCOS ECV's)	
• cloud amount	CA	+ rel. cloud type amount
• pressure/ height	CP/CZ	
• temperature	CT	
• IR emissivity	CEM	
• eff cloud amount	CAE	*(= cloud amount weighted by emissivity)*
• VIS optical depth	COD	
• Water path	CLWP/CIWP	
• eff part. radius	CRE	

1° x 1° monthly statistics per obs time:

• **averages,** • **monthly variability,** • **histograms**

distinguish : tot, High, Mid, Low Water, Ice

CP< 440 hPa, CP>680hPa CT>260K, CT<260 / 230K

Participating cloud climate records:

ISCCP *GEWEX cloud dataset*	*1984-2007*	*(Rossow et al.)*
TOVS Path-B	*1987-1994*	*(Stubenrauch et al.)*
AIRS-LMD	*2003-2009*	*(Stubenrauch et al.)*
MODIS-ScienceTeam	*2001/3-2009*	*(Ackerman et al.; Platnick et al.)*
MODIS-CERES	*2001/3-2006*	*(Minnis et al.)*

relatively new retrieval versions:

PATMOS-x (*AVHRR*)	*1982-2009*	*(Heidinger et al.)*
ATSR-GRAPE	*1999/2003-2009*	*(Poulsen et al.)*

only CA or CAE & CT:

HIRS-NOAA	*1982-2008*	*(Wylie et al., Menzel et al.)*
CALIPSO-ScienceTeam	*2007-2008*	*(Winker et al.)*
CALIPSO-GOCCP	*2007-2008*	*(Chepfer et al.)*

complementary cloud information:

MISR	*2001-2007*	*(DiGirolamo et al.)*
POLDER (*O_2 & Rayleigh*)	*2006-2008*	*(Riedi et al.)*

Cloud properties from space:

IR-NIR-VIS radiometers

good spat res (1-5km), 1 to 5 radiometric channels: depending on day-night

1) COD,CT *(assumption on microphys)* 2) spectral diff (VIS-NIR) -> CRE, CWP

IR Sounders

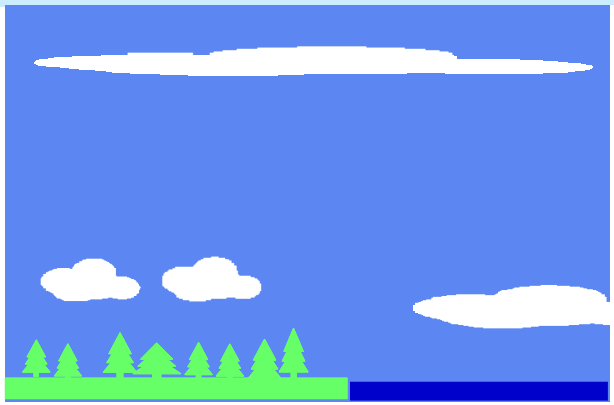
15km res, sounding CO_2 abs band (5-8 channels): sensitive to thin Ci (COD>0.1), day&night

1) CP,CEM *(**no** assumption on microphys)* 2) spectral diff (8-12μm) -> CRE, CWP (only Ci)

multi-angle VIS radiometers

1/20km res, only day, only sensitive to clouds with COD>2: Ci over low cld -> low cld

multi-angle scattering -> cld top polarization -> CT independent phase

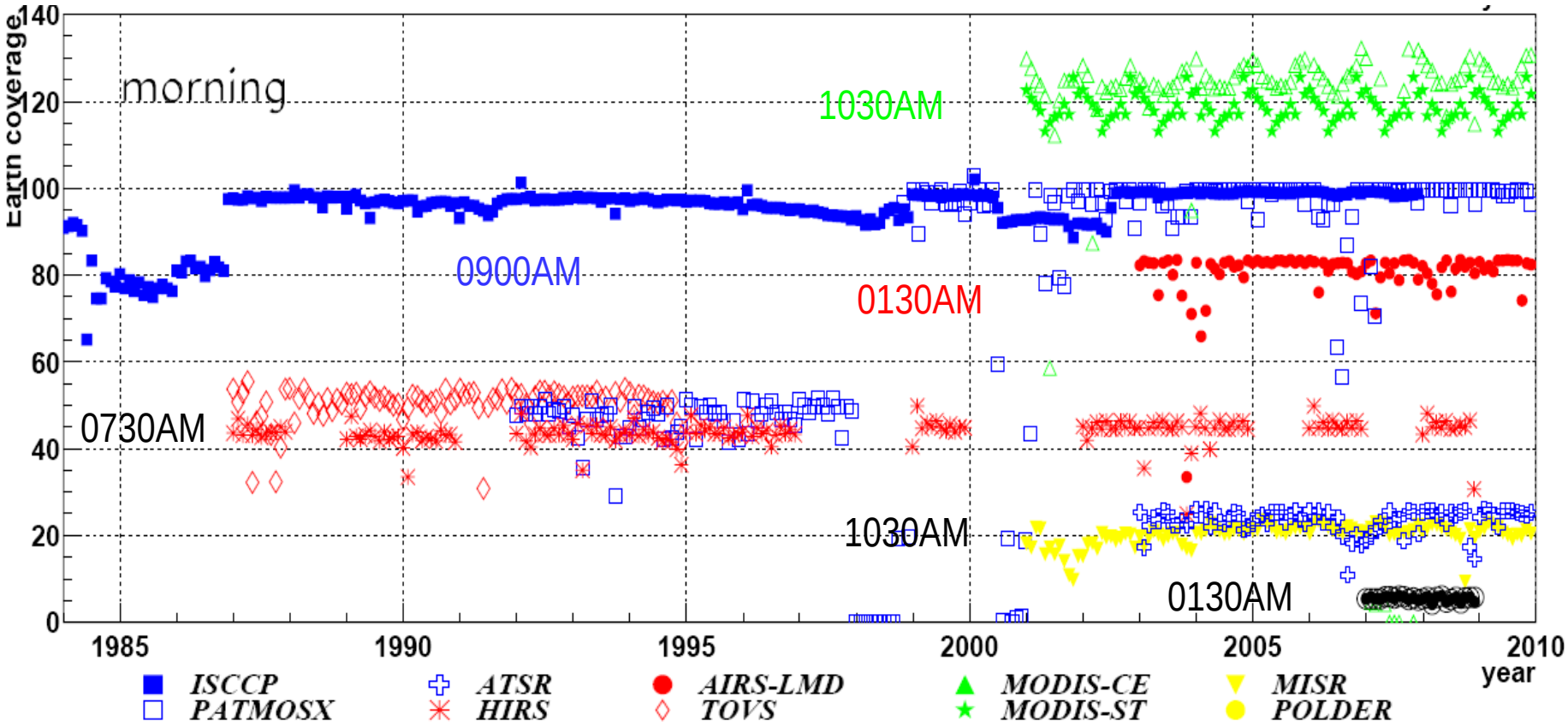


CALIPSO, HIRS,TOVS,AIRS, MODIS

ISCCP, ATSR

MISR, POLDER

Monitoring of Earth coverage



➢**climate change studies**: be aware of temporal changes in coverage!

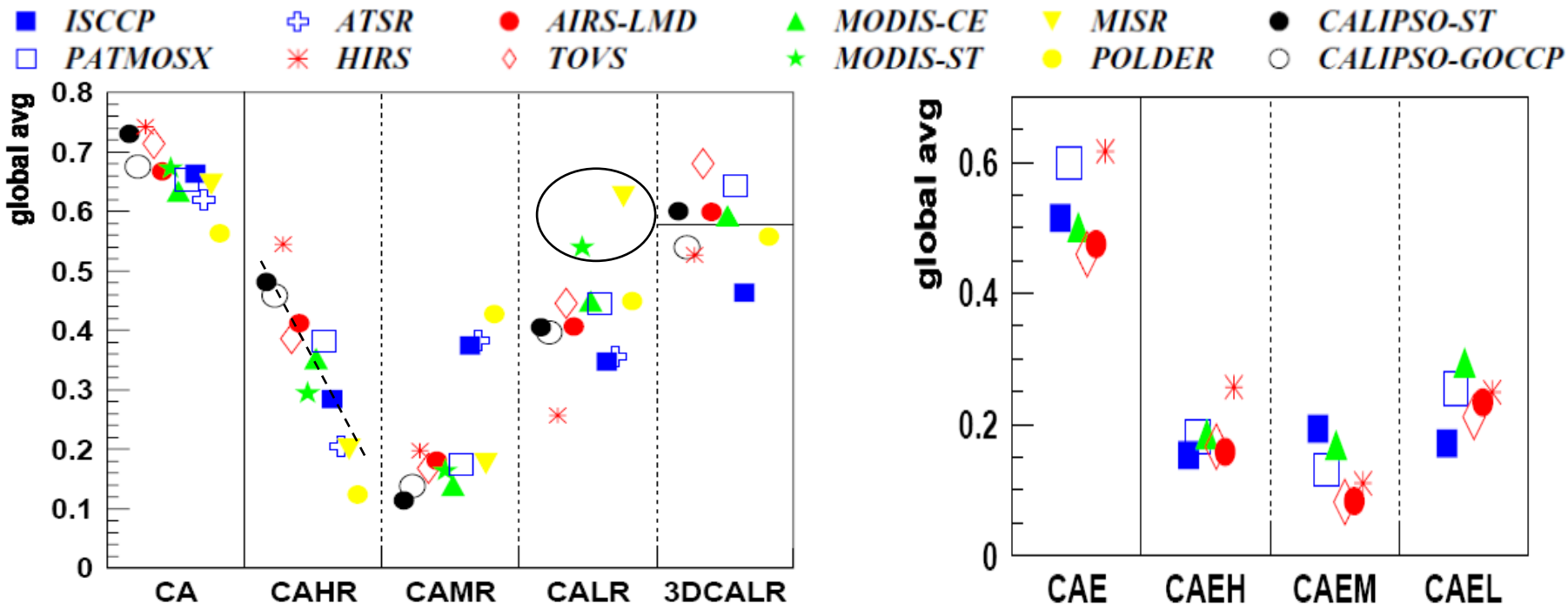
MODIS at high latitudes more than 1 orbit passages, all others have kept only 1 passage

ISCCP nearly 100% coverage – MISR / ATSR 20% - CALIPSO 5%

➢**Interannual variability increases with decreasing Earth coverage!**

Amount, Height, Temperature, Emissivity

Interpretation of cloud properties from satellite observations



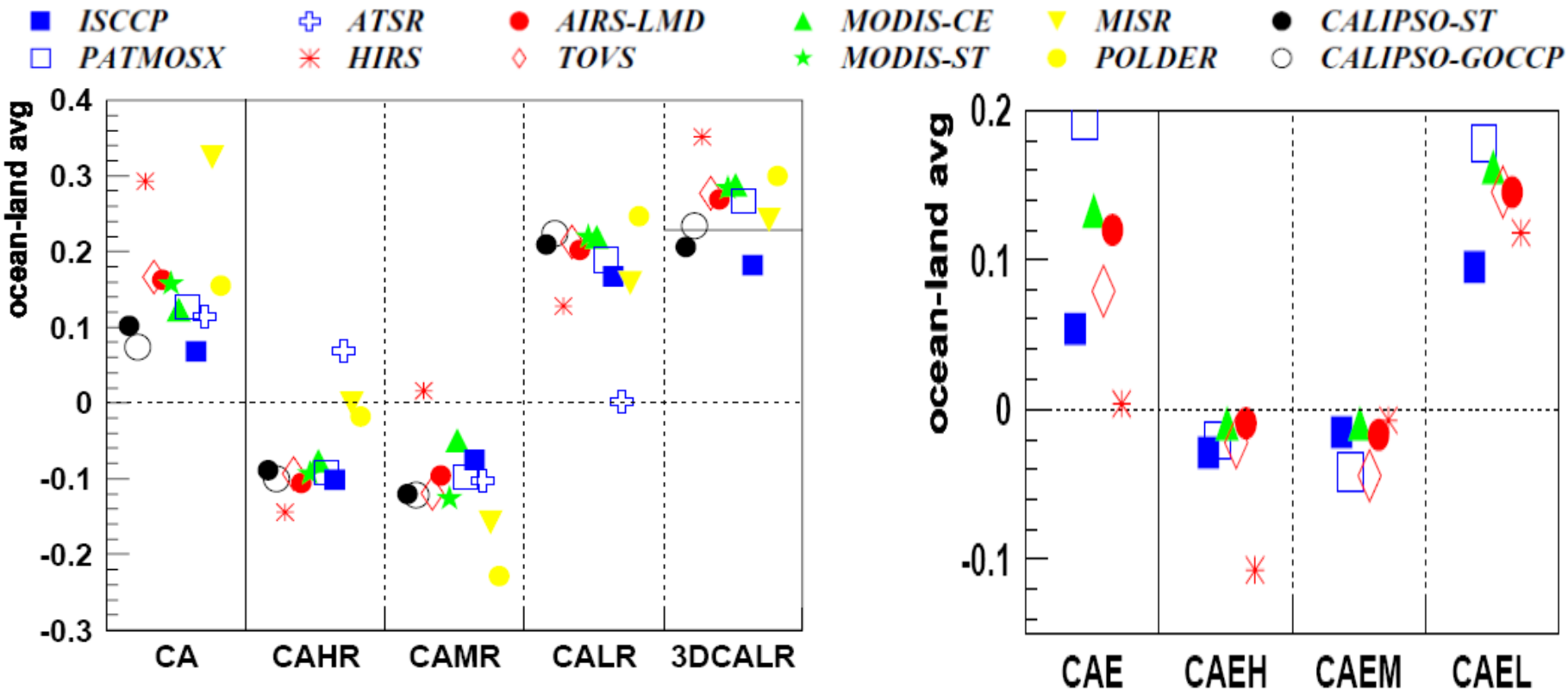
global CA 65-70% (+ 5% subvisible Ci) : 40% high , 40% single layer low
CALIPSO-GOCCP: + 1/3 low clouds underneath higher clouds
in agreement with random overlap

CAHR (hgh clds out of all clds) depends on sensitivity to thin Ci (30% spread)
(misidentified as midlevel clouds by ISCCP, ATSR, POLDER)

CAE (effective CA=CA weighted by cld emissivity) agrees better : 50%

global monthly variability of CA: 20%-30% of CAE: 0.25-0.30

Differences ocean - land

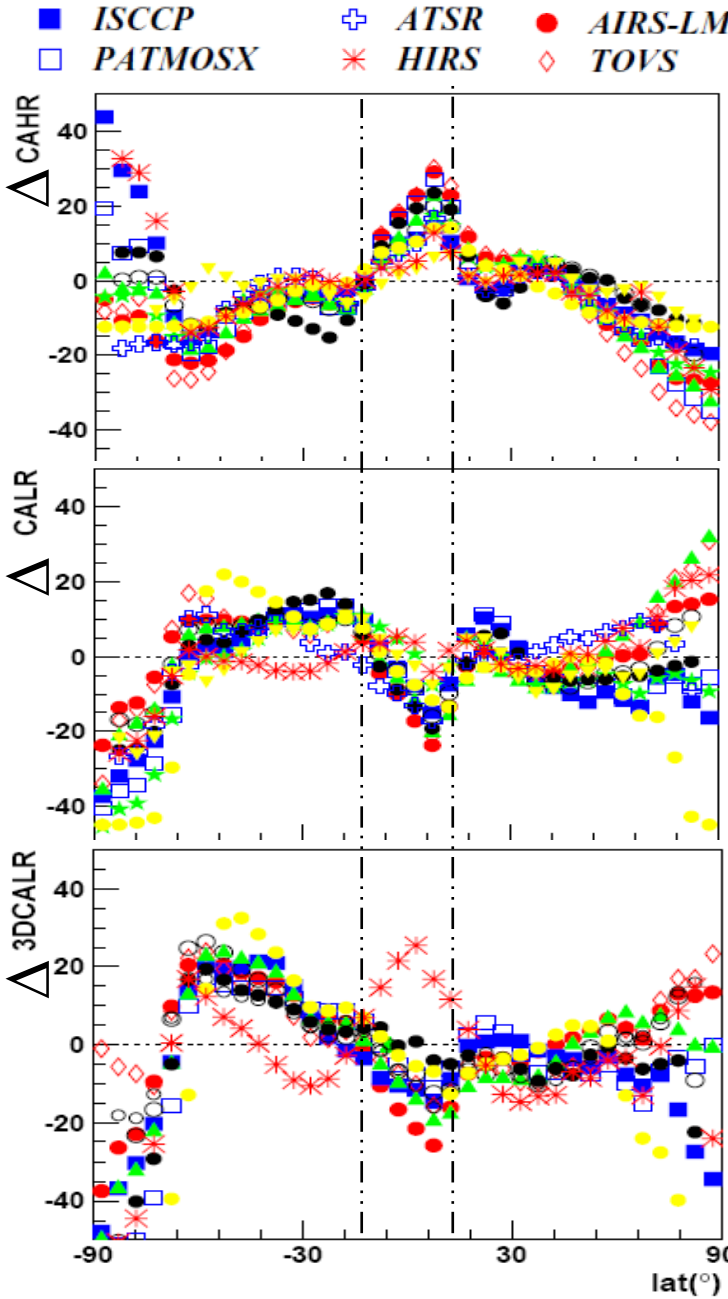


15% more clouds over ocean than over land (low clouds)

whereas over land there are more high and midlevel clouds

these are optically thinner over land, so that effective cloud amount of those is similar

Latitudinal & seasonal variation of cloud layers



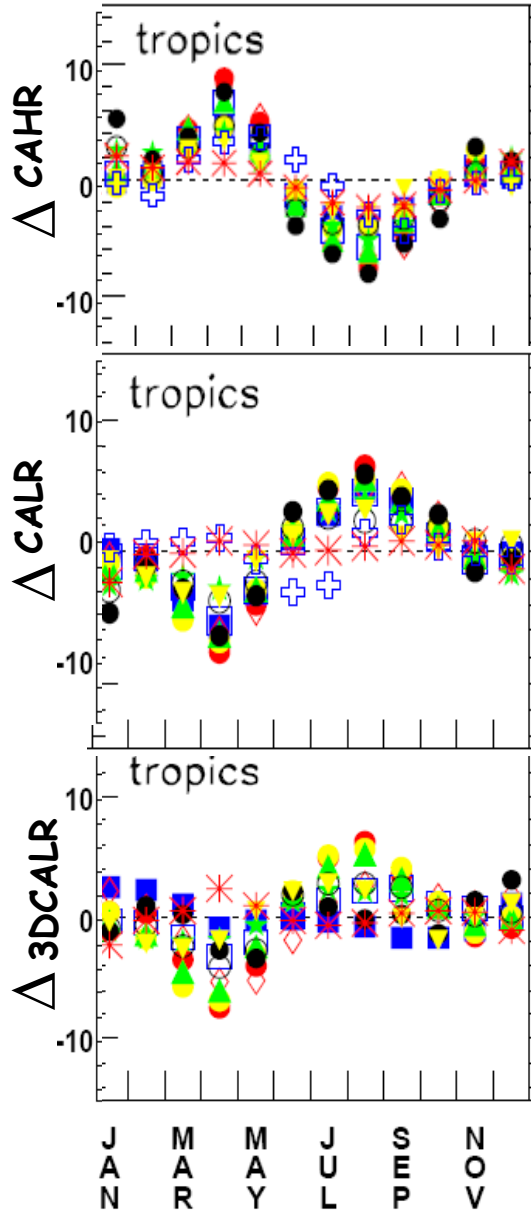
high clouds

single layer low clouds

latitudinal & seasonal variations similar

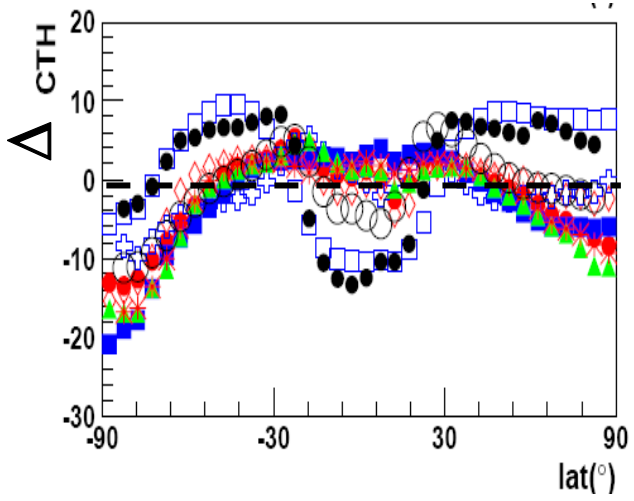
(except polar regions & HIRS CALR)

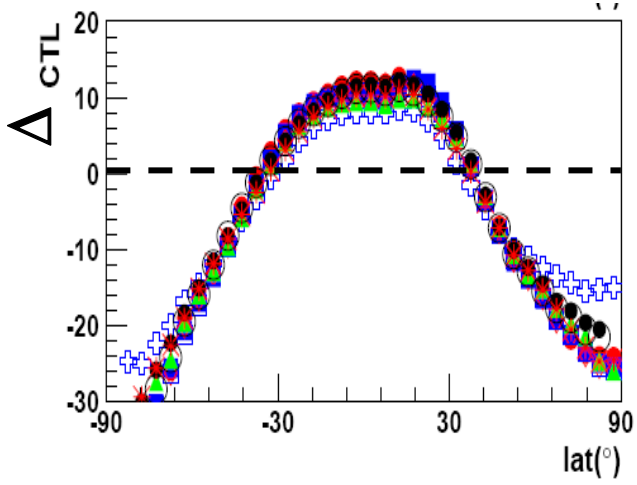
low clouds
(random overlap assumed)



Cloud temperature:

latitudinal variation & distributions

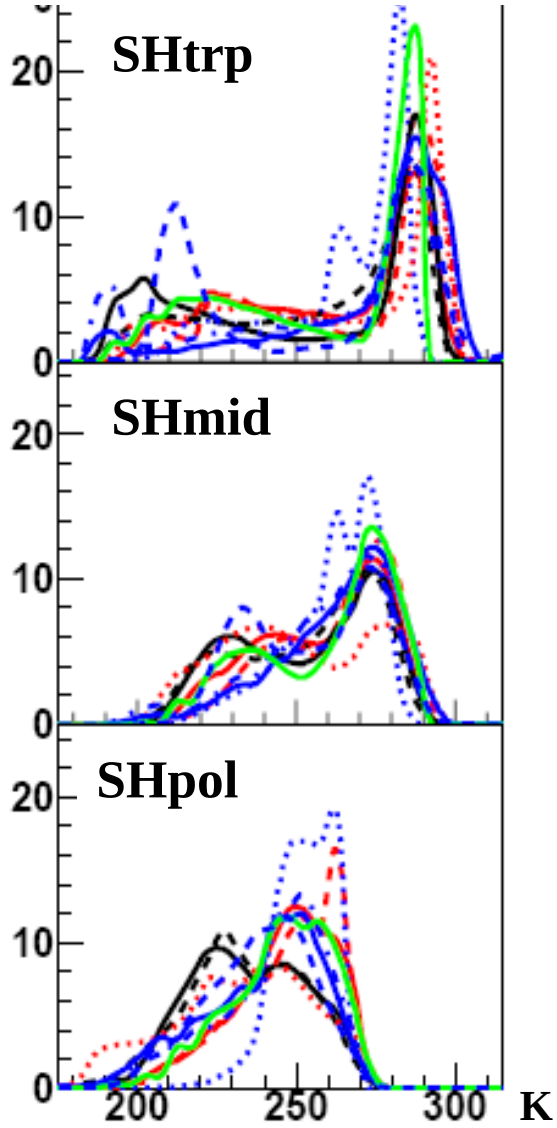




CALIPSO:
including subvis Ci, T(cld top)
passive remote sensing:
T(rad. cld height)

=> CTH(CALIPSO) should be lowest & nearest to tropopause, largest latitudinal variability
(PATMOSX should not be like CALIPSO for high clouds)

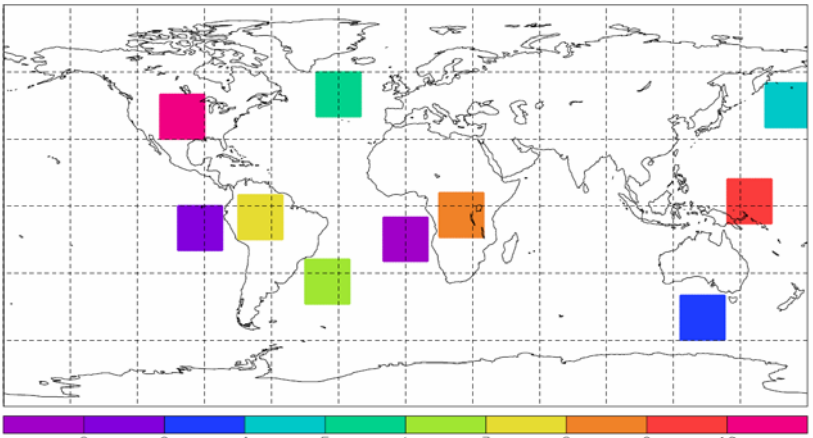
CT distributions reflect decrease of vertical extent of troposphere from tropics to poles



Specific regions, compared to globe

Rossow et al. J. Clim. 2002

20° x 20° regions of typical climate regimes with increasing small scale variations:
(1 – <COD(rad)>/<COD(lin)>)

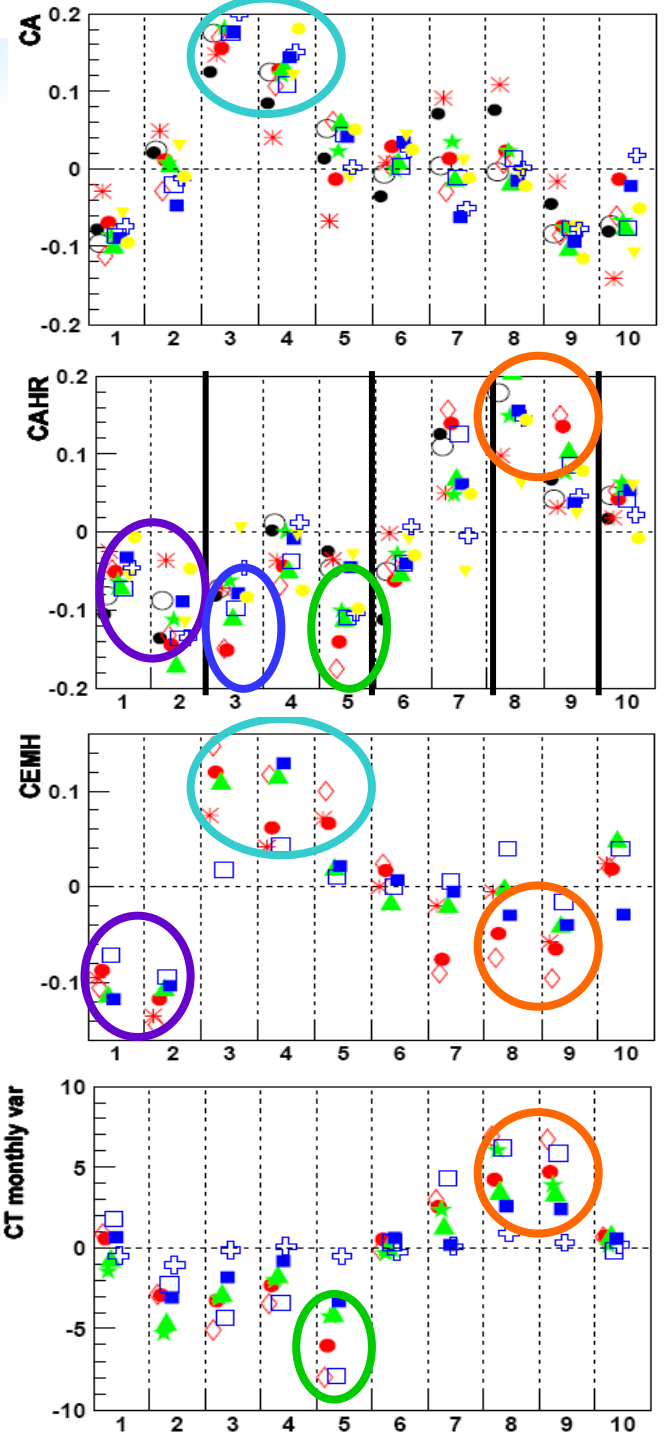


Strcum regions (1,2): smaller CAHR & optically thin

Storm regions (3,4,5): largest CA, opt thick
NAtlantic (5): smaller monthly CT variability

ITCZ (8,9): largest CAHR *(small CEMH, linked to Ci)* & largest monthly CT variability

1: SH Str Africa 2: SH Str America
3: SH midlat 4: NH EPacific 5: NAtlantic storms
6: SH Ci off America 7: SH Ci Amazon
8: SH Cb Africa 9: NH Cb Indonesia
10: ARM Southern Great Plain



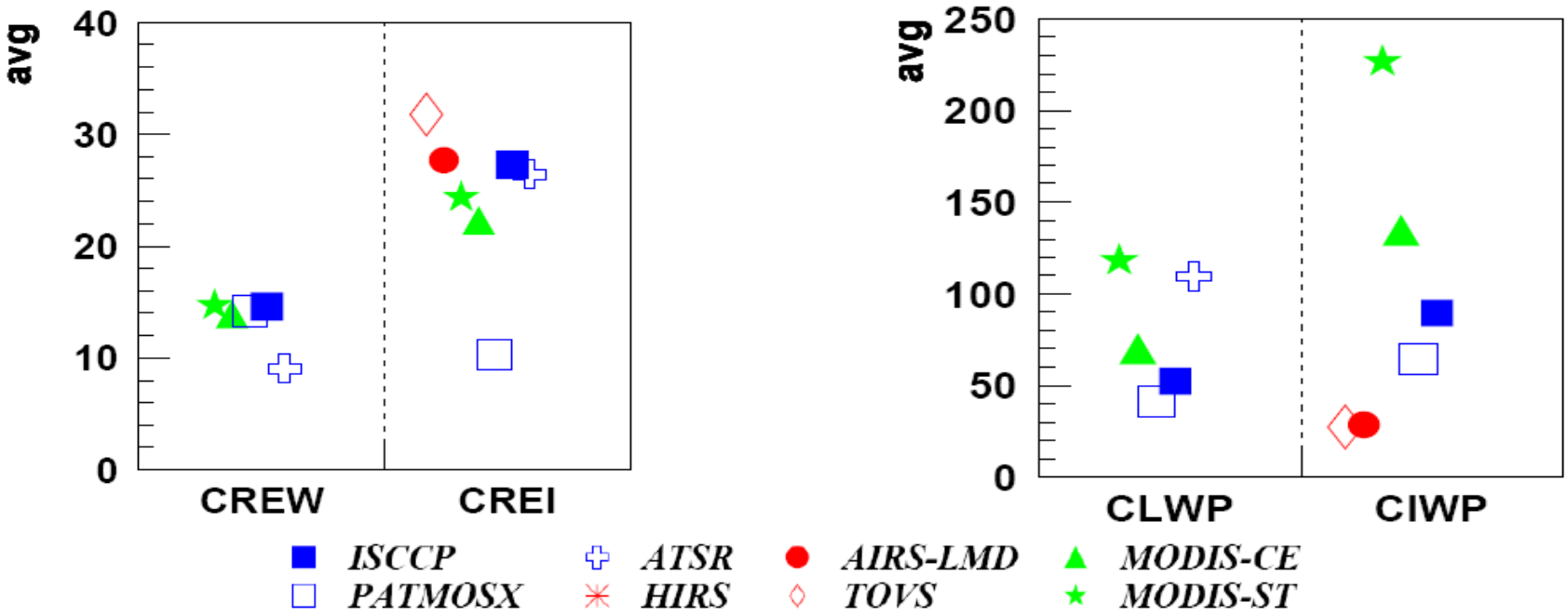
CALIPSO-ST
CALIPSO-GOCCP

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

Bulk microphysical properties

Bulk microphysical properties:

eff. liquid / ice particle radius & liquid / ice water path



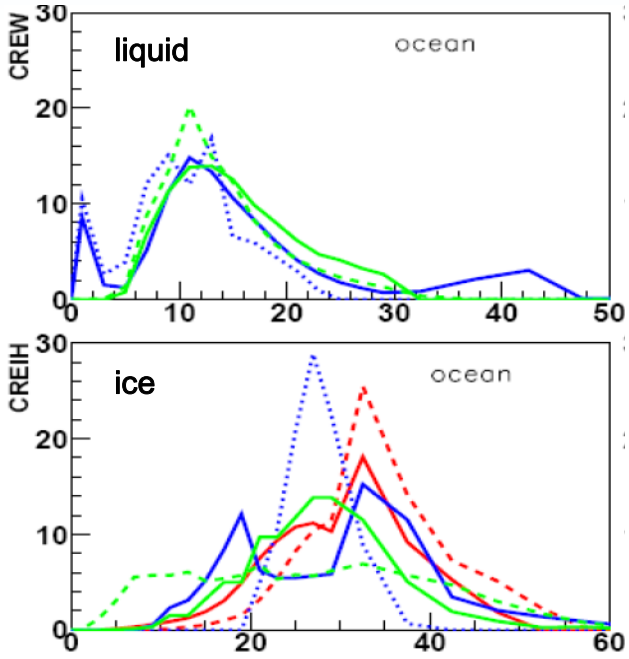
Whereas CA, CEM,CT, CP of the data base are well understood,
differences in CRE and CWP have still to be further explored

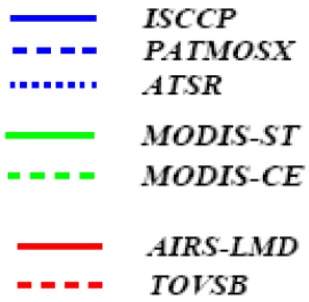
Global averages of CREW (15μm) / CREI (25μm) agree quite well

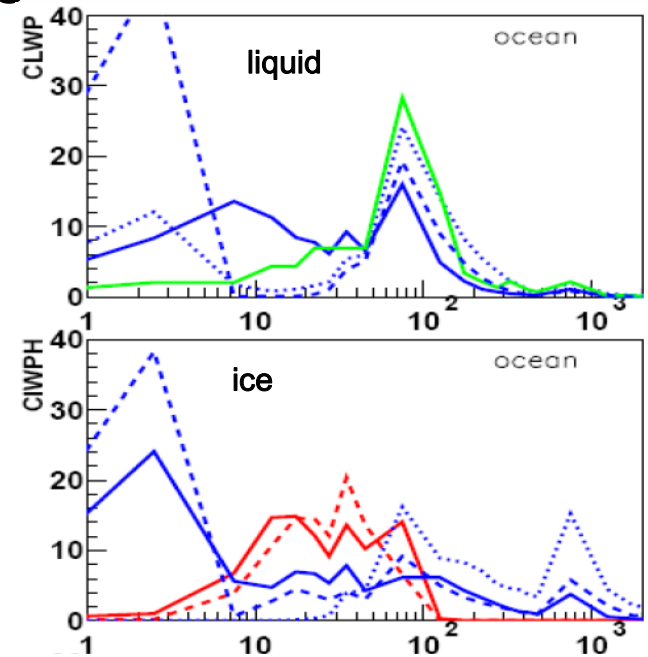
IR sounders determine CREI, CIWP only for a subsample: semi-transparent ice clouds
⇒CIWP is much smaller (25 gm^{-2}) than averaged over all ice clouds (~100gm^{-2})
VIS-IR methods: MODIS-ST / ATSR-GRAPE much larger values than ISCCP / MODIS-CE / PATMOSX

distributions are not Gaussian ….

eff. particle radius & water path distributions







CREW distributions agree quite well,
with a large peak around 11μm,
small peak at 42 μm from ISCCP (W-I misidentification)
CREI: IR sounders, ISCCP: large peak at 32 μm,
second peak of ISCCP at 18 μm (misidentified I-W?)
peaks of MODIS-ST & ATSR-GRAPE at 27 μm
(3.7 / 2.1 / 1.6 μm)

CLWP: large peak at 80 gm^{-2}

CIWP: AIRS, TOVS compact distribution between 5 & 100 gm^{-2};
ISCCP, PATMOSx large peak at 4 gm^{-2}
(regions with low clouds clouds?)

further investigations necessary

Conclusions

➢To produce a common data base is challenging *(GEWEX Cloud Assessment activity not funded)*

However, once the data base is reliable and guidance is provided,
it provides a wealth of information for climate studies

So far statistical analyses:

❖geographical distributions, latitudinal & seasonal variations agree quite well

❖differences can be mostly understood by different sensitivities to cirrus,

❖datasets of different maturity, differences day-night, land-ocean, multi-layer clds

-> one should not build an average over all datasets,
but choose most appropriates for a specific study

➢cloud products adequate for model evaluation & monitoring regional variability

➢ESA Cloud_CCI project (CIimate Change Initiative) includes assessment activities
& another cloud assessment workshop is foreseen at the end of the project (2013)

➢*to be updated on data base -> stubenrauch@lmd.polytechnique.fr*