Cloud Assessment

a review

Claudia Stubenrauch*


presented by Anthony Guignard*

*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)

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

Assessments essential for climate studies & model evaluation

Heritage of GEWEX cloud assessment

- cooperation of 12 cloud teams
- statistical analysis of cloud properties
- global evaluation of retrieval methods
- insight of how clouds are perceived by different instruments
- combination of different instruments leads to additional information
**participating cloud climate records:**

**most complete data sets:**

<table>
<thead>
<tr>
<th>Cloud Dataset</th>
<th>Time Period</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISCCP GEWEX cloud dataset</td>
<td>1984-2007</td>
<td>(Rossow et al. 1983, 1999)</td>
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<tr>
<td>MODIS-ST</td>
<td>2001/3-2009</td>
<td>(Ackerman et al.; Platnick et al.)</td>
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<tr>
<td>MODIS-CE</td>
<td>2001/3-2006</td>
<td>(Minnis et al.)</td>
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**relatively new retrieval versions:**

<table>
<thead>
<tr>
<th>Cloud Dataset</th>
<th>Time Period</th>
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</thead>
<tbody>
<tr>
<td>PATMOS-x (AVHRR)</td>
<td>1982-2009 (histos 96-09)</td>
<td>(Heidinger et al.)</td>
</tr>
<tr>
<td>POLDER</td>
<td>(O₂ &amp; Rayleigh)</td>
<td>2006-2008</td>
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<tr>
<td>HIRS-NOAA</td>
<td>only av</td>
<td>1982-2008</td>
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<tr>
<td>CALIPSO-ST</td>
<td>av &amp; histos</td>
<td>2007-2008</td>
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<tr>
<td>CALIPSO-GOCCP</td>
<td></td>
<td>2007-2008</td>
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**only averages of CA's:**

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<tr>
<td>MISR</td>
<td>2001-2007</td>
<td>(DiGirolamo et al.)</td>
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GEWEX Cloud Assessment Common Data base

Monthly statistics per year & obs time, $1^\circ \times 1^\circ$

- average, monthly variability, histograms

**properties:**
- cloud amount $\text{CA}$ (tot, High, Midlevel, Low, Water, Ice)
- rel. cloud amount $\text{CAR}$ $\text{CP< 440 hPa, CP>680 hPa}$
- Pressure/ height $\text{CP/CZ}$ (tot)
- temperature $\text{CT}$ (tot, H, M, L, W, I)
- IR emissivity $\text{CEM}$ (tot, H, M, L, W, I)
- eff cloud amount $\text{CAE}$ (tot, H, M, L, W, I)
- VIS optical depth $\text{COD}$ (tot, H, M, L, W, I)
- Water path $\text{CLWP/CIWP}$ (W, I, IH)
- $r_{\text{eff}}$ $\text{CRE}$ (W, I, IH)
  - $\text{CT>260K, CT<260 / 230K}$

**separate statistics:**

**joint histograms**
- COD – CP, CEM – CP, COD – CRE
Interpretation of cloud properties from satellite observations

- Global CA 60-70% (+5% subvisible Ci): 40% high, 40% single layer low
- CAHR (high clouds out of all clouds) depends on sensitivity to thin Ci (misidentified as midlevel clouds by ISCCP, ATSR, POLDER)
- CAE (effective CA = CA weighted by cloud emissivity) agrees better
- Global monthly variability of CA: 20%-30% of CAE: 0.25-0.30

CALIPSO only considers uppermost layers to better compare with the other data sets

April 2011 EGU 2011
15% more clouds over ocean than over land (low clouds), whereas over land there are more high and midlevel clouds. The latter are optically thinner over land, so that effective cloud amount of those is similar.
Amount of uppermost cloud layers

Geographical distributions, latitudinal & seasonal variations similar

HCA depends on sensitivity to thin cirrus
CALIPSO > TOVS/AIRS > MODIS/PATMOS
> ISCCP > POLDER/MISR

Stubenrauch et al. 2009, GEWEX news
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

10° x 10° regions of typical climate regimes with increasing small scale variations:

(1 – <COD(rad)>/<COD(lin)>)

Strcum regions (1,2): average CAHR, but optically thin
Storm regions (3,4,5): largest CA
NAtlantic (5): smaller CAHR & 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

April 2011
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 / CREI(H) agree quite well with 15μm / 25μm.

IR sounders determine CREIH, CIWPH only for a subsample: semi-transparent ice clouds ⇒ CIWPH 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 ….
CREW distributions agree quite well, with a large peak around 11 μm, small peak at 42 μm from ISCCP (perhaps water cloud misidentification). CREIH: IR sounders, ISCCP: large peak at 32 μm, second peak of ISCCP at 18 μm (at top for opt thick clouds) peaks of MODIS-ST and ATSR-GRAPE at 27 μm.

CLWP: large peak at 80 gm⁻²
CIWPH: 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!
(see also poster 6346 in Session AS3.3)
climate change studies: be aware of temporal changes in coverage!
MODIS at high latitudes more orbit passages, all others have kept only one passage
ISCCP nearly 100% coverage, CALIPSO 5%
Global CA anomalies

- Global CA within ±2.5% (~ interannual & monthly mean variability)
- Possible origins of variability:
  - Changing average view angle (decreasing with nb of covering geo sat for ISCCP)
  - Satellite drift (for NOAA polar afternoon satellites (HIRS))
  - Change in Earth coverage, .....
Conclusions

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

However, once the data base is reliable,
it provides a wealth of information for climate studies & model evaluation

So far statistical analyses:
➢ geographical distributions, latitudinal & seasonal variations agree quite well
➢ differences can be mostly understood by different sensitivities to cirrus,
  *(problems in retrieval methods, misidentification water-ice clouds)*
➢ monitoring of cloud properties very difficult  *(need synergy of different variables)*

➢ Phase II of assessment *(next 3 months)*: review knowledge of stratocumulus, storms, cirrus
to contribute please contact: stubenrauch@lmd.polytechnique.fr, kinne@zmaw.de

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