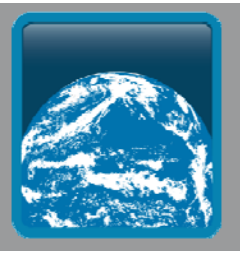
ESA Cloud cci



RAL Space

Freie Universität Berlin

VNIVERSITAT DE VALÈNCIA

Royal Netherlands Meteorological Institute
Ministry of Transport, Public Works and Water Management

SMHI

Universität Bremen

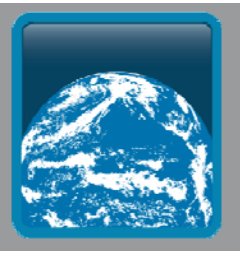
LMD/CNRS

DLR

Jürgen Fischer
Free University Berlin

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Consortium: Cloud cci



Deutscher Wetterdienst (DWD), Lead
Rutherford Appleton Laboratory (RAL)
University of Oxford (UO)
Free University of Berlin – Institute for Space Sciences (FUB) with University of Valencia
Swedish Meteorological and Hydrological Institute (SMHI)
Koninklijk Nederlands Meteorologisch Instituut (KNMI)
Laboratoire Météorologie Dynamique (LMD)
German Aerospace Centre (DLR)
University of Bremen (UB)

Clouds in the climate System

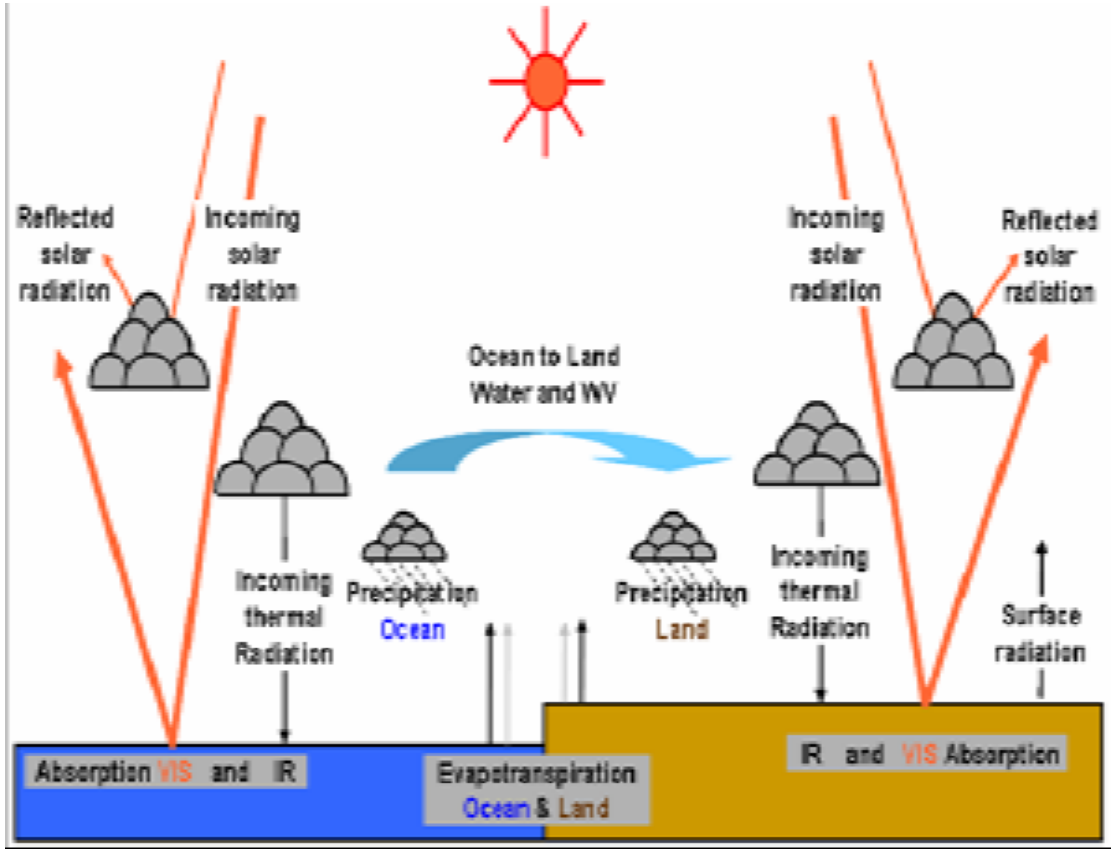


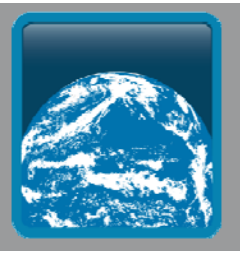
Image:
Courtesy R. Roebeling

Clouds are …

- affecting the energy budget
- a coupling mechanism to hydrological cycle
- highly variable in space and time
- easy to observe??

… but not fully understood nor modelled

Primary Objectives of Cloud CCI (I)

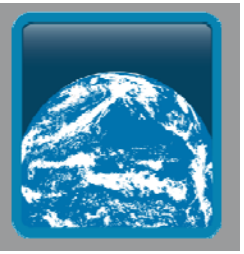


- Development of inter calibrated radiance data sets for ESA and non ESA instruments in an international collaboration

- Development of a coherent physical retrieval framework for the GCOS cloud property ECVs cloud cover, cloud top height and temperature, liquid and ice water path that can be considered as an open community retrieval framework that will be publicly available and usable by all scientists.

- Development and processing of two multi-annual global data sets for the GCOS cloud property ECVs including uncertainty estimates.
    - (A)ATSR – AVHRR – MODIS – MERIS (lowest common approach)
    - (A)ATSR and MERIS. (synergy retrieval)

Primary Objectives of Cloud CCI (II)



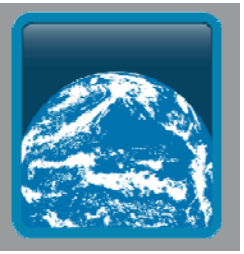
- Validation of the cloud property products against ground based and other satellite based measurements taking into account the individual error structures of the individual observations as far as possible.

- Providing a common data base and the necessary assessment of cloud data sets in the framework of GEWEX.

- Development of a complete processing system distributed over Europe that can further strengthen operational production of cloud property data sets.

- Perform a Round Robin Exercise to identify weaknesses of algorithms

Addressing the needs from GCOS: Requirements for clouds



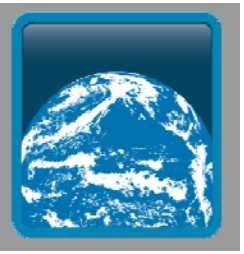
Requirements as stated in GCOS-107, product A-4; update 2011[1]

	Accuracy	Spatial resolution	Temporal resolution	Stability (target)	Justification Source
Cloud Cover	0.01-0.05	50 km	3 h	0.01/dec	CFMIP
Cloud pressure	15- 50 hPa	50 km	3 h	3-15 hPa/dec	NISTIR-7047
Cloud temperature	1 K	50 km	3 h	0.25 K/dec	NISTIR-7047
Cloud ice profile	25 %	50 km	3 h	5 %/dec	NISTIR-7047
Cloud water profile	25 %	50 km	3 h	5 %/dec	NISTIR-7047

[1] currently under discussion and in open review

y 2011

State of the art: Existing global Cloud Climatologies



Longterm cloud climatologies:

ISCCP *GEWEX cloud dataset* *1983-2006* *(Rossow et al. 1999)*

PATMOS-x *AVHRR* *1981-2006* *(NESDIS/ORA; Heidinger et al.)*

HIRS-NOAA *13h30/1h30* *1985-2001* *(Wylie et al. 2005)*

TOVS Path-B *7h30/19h30* *1987-1995* *(Stubenrauch et al. 2006)*

SAGE *limb solar occultation* *1984-1991,1993-2005* *(Wang et al. 1996, 2001)*

SOBS (Surface Observations): *1952-1996(sea), 1971-1996(land)* *(Hahn & Warren 1999; 2003)*

EOS cloud climatologies *(since 2000, 2002)*:

MODIS-ST *(Ackerman et al.)* **MODIS-CE** *(Minnis et al.)*

AIRS-LMD *(Stubenrauch et al. 2008)*

+ A-Train *(since 2006)*:

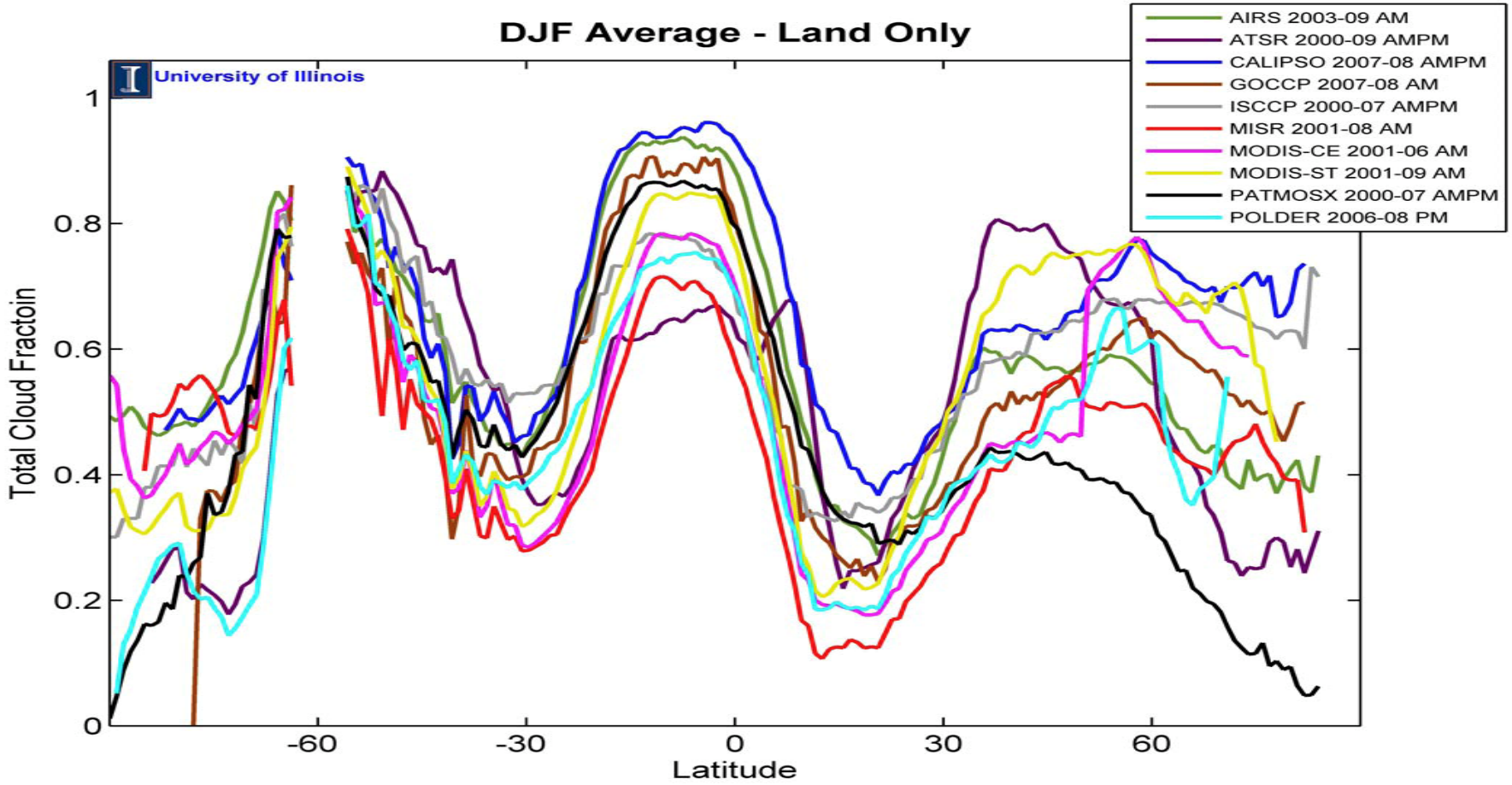
CALIPSO L2 data (V2) *(Winker et al. 2007)* ***active lidar***

CloudSat *(Mace)* **POLDER** *(Riedi)* **MISR** *(DiGirolamo)* **ATSR2** *(Poulsen)*

State of the art: Cloud fraction

Cloud Assessment

Heidinger et al, 2010

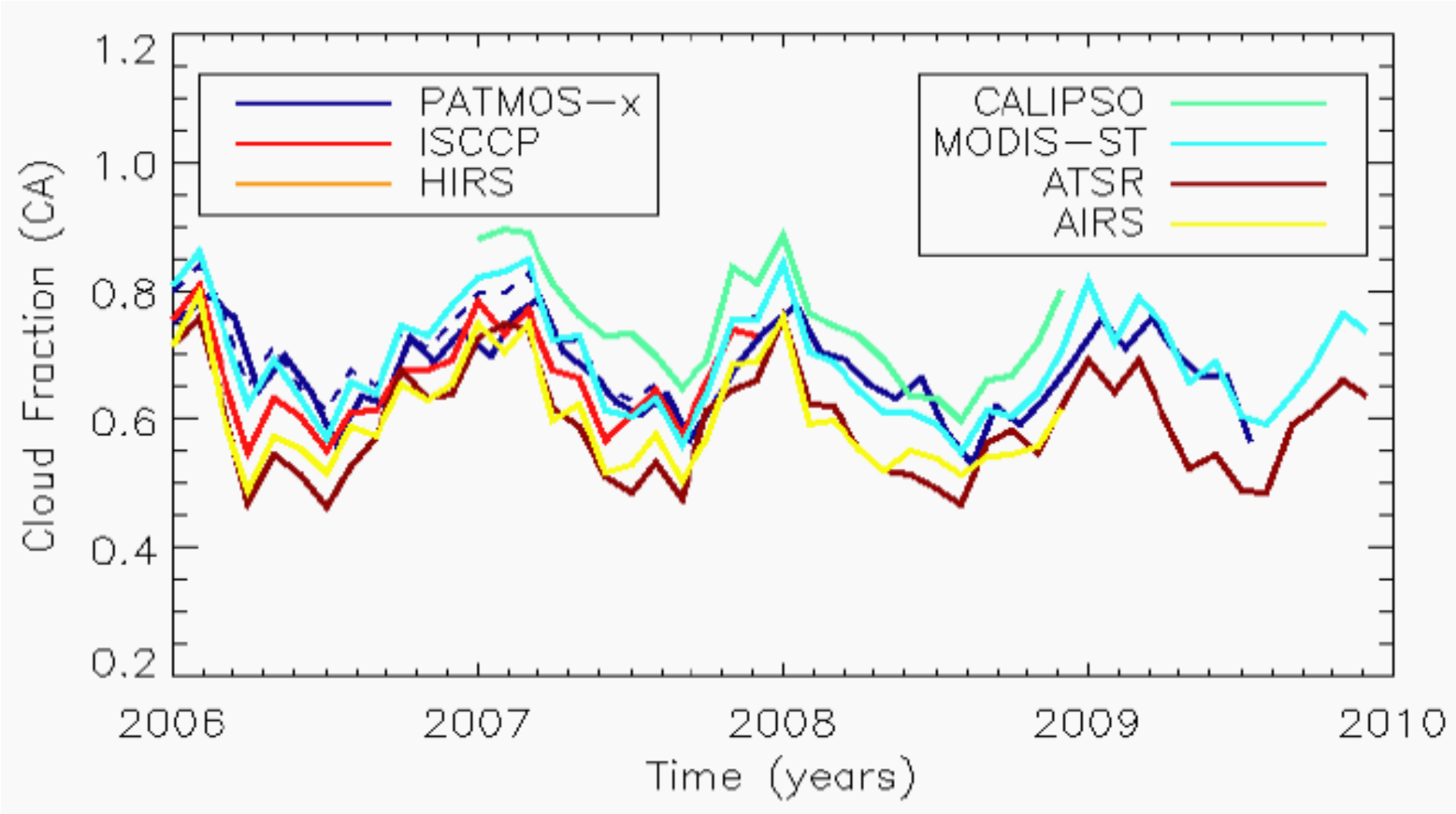


Previous GEWEX analysis showed that PATMOS-x cloud amounts over cold land ere too low, but the Bayesian mask appears to have brought PATMOS-x “back in line”

Cloud amount comparison

Cloud Assessment

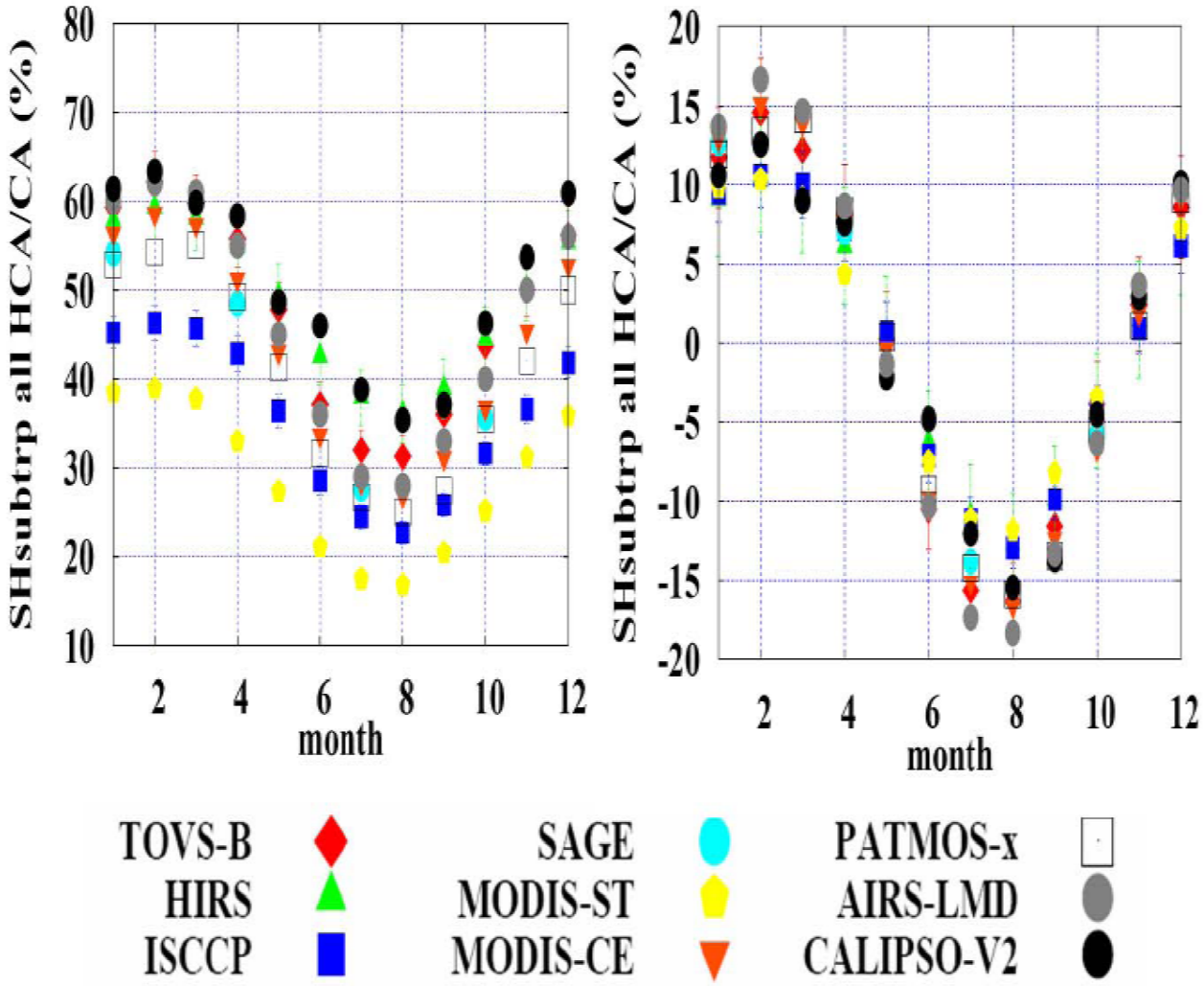
Heidinger et al, 2010



State of the art: Cloud fraction

Cloud Assessment

Co-lead C. Stubenrauch, S. Kinne



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

geographical cloud structures & seasonal cycles agree quite well

absolute values depend on instrument sensitivity (& retrieval method)

detection thresholds also affect average cloud opt. depth & T

trend analysis difficult, synergy of data sets & variables important

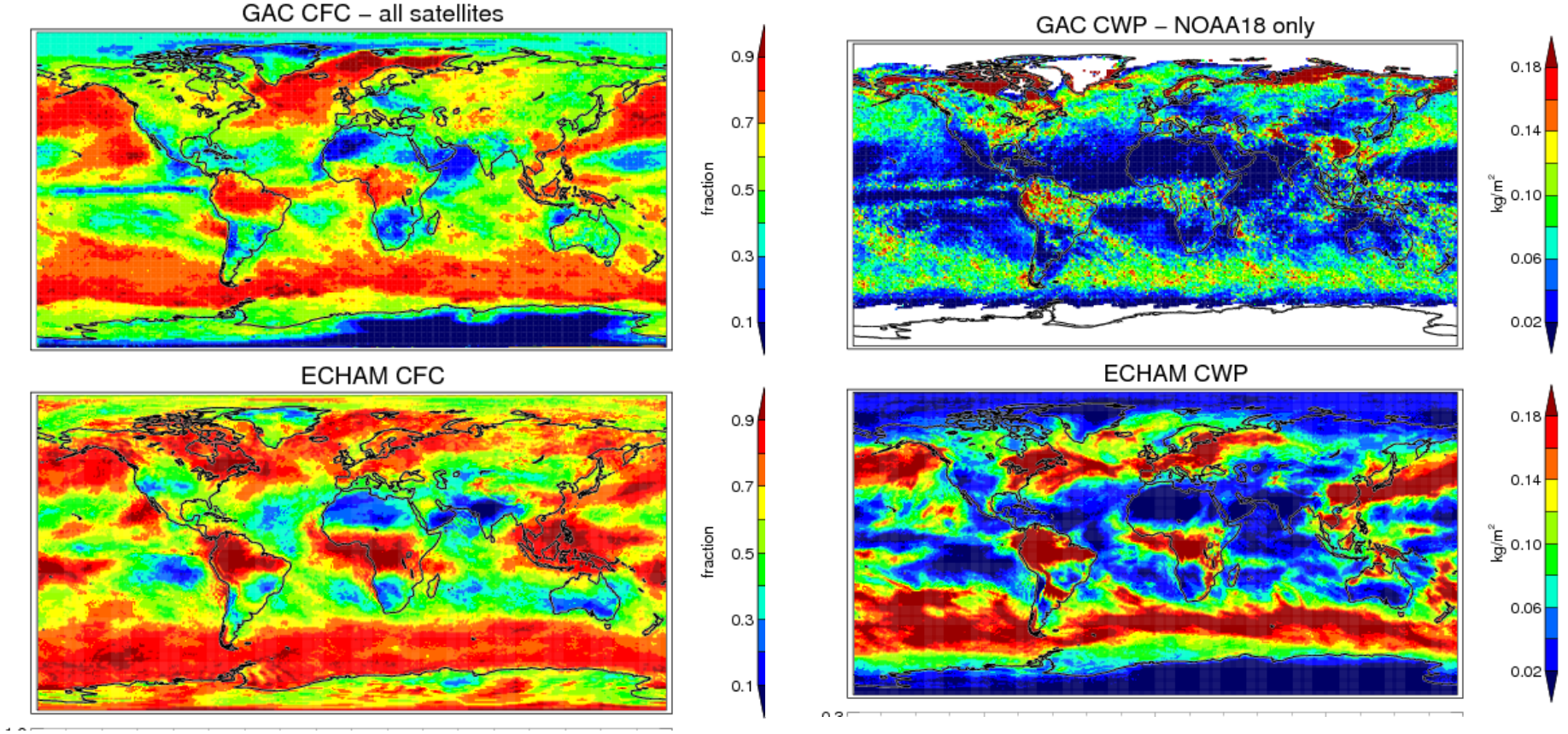
Current baseline: Specifications

Temporal resolution of final products
(based on local satellite equator crossing time)

- AATSR/MERIS (ENVISAT):
  10:00 am/pm
- AVHRR (N15, N16, N17, N18, N19, Metop):
  10.00 am/pm (drifting), 02:00 am/pm (drifting), 10:00 am/pm, 01.30 am/pm
- MODIS (AQUA,TERRA):
  01:30 am/pm, 10:30 am/pm

Providing the final products:
- Monthly means for each individual sensor
- Monthly means for each sensor group (e.g. all AVHRRs)
- Monthly means for all sensors on all satellites
  - AATSR-MODIS-AVHRR
  - AATSR-MERIS

Product application…



Example: Comparison of Cloud fraction (left) and liq. Water path (CWP) vs. ECHAM 5, April 2009

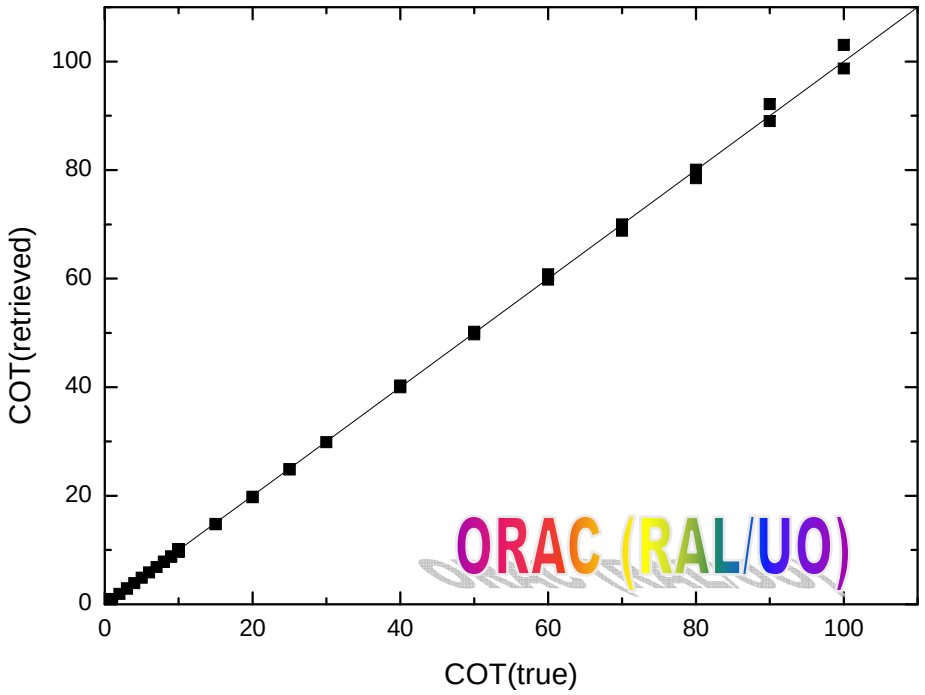
Synthetic datasets for Round Robin

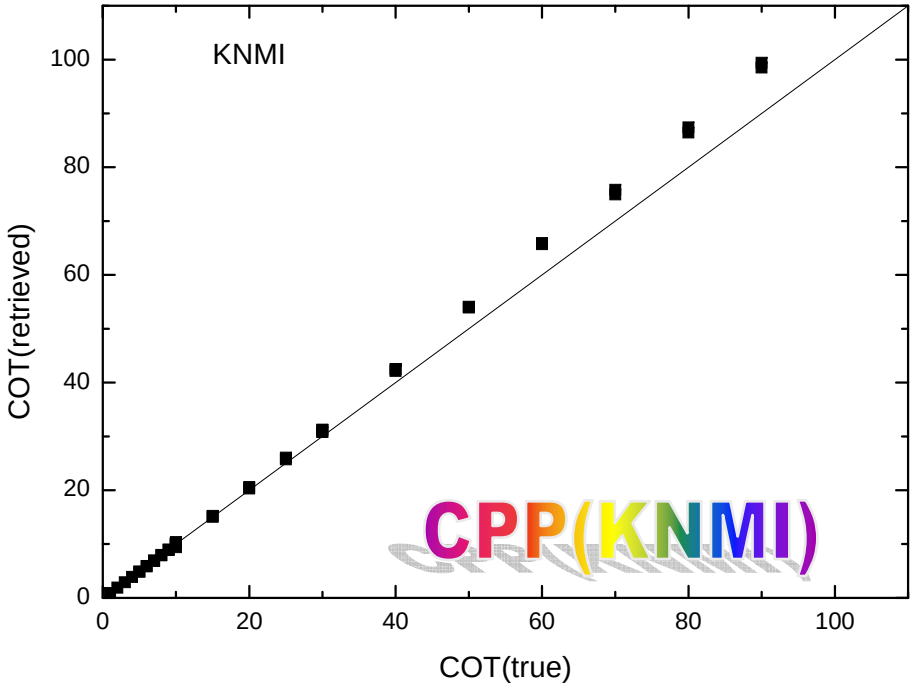
- Droplet size distribution
- Temperature, pressure and gaseous absorbers profiles (no aerosol) were specified and distributed
- Aerosol scattering was neglected
- Multiple light scattering by water droplets was considered in the framework of discrete ordinates method with single scattering correction term (SCIATRAN 3.1)
- Polarization effects were neglected
- Rayleigh scattering, Absorption by oxygen, ozone, and water vapor

  - Channels: 0.555, 0.658, 0.753, 0.76175(SRF was supplied by FUB), 0.860, 1.242, 1.585, 2.114, 3.7, 11, 12 micrometers
  - SZA=60 degrees
  - VZA=0, 20, 40, 55, 75 degrees
  - RAA=0, 30, 60, 90, 120, 150, 180 degrees
  - Surface albedo: 0.0, 0.4

Courtesy of A. Kokhanovsky

Prelim. results (nadir view only)





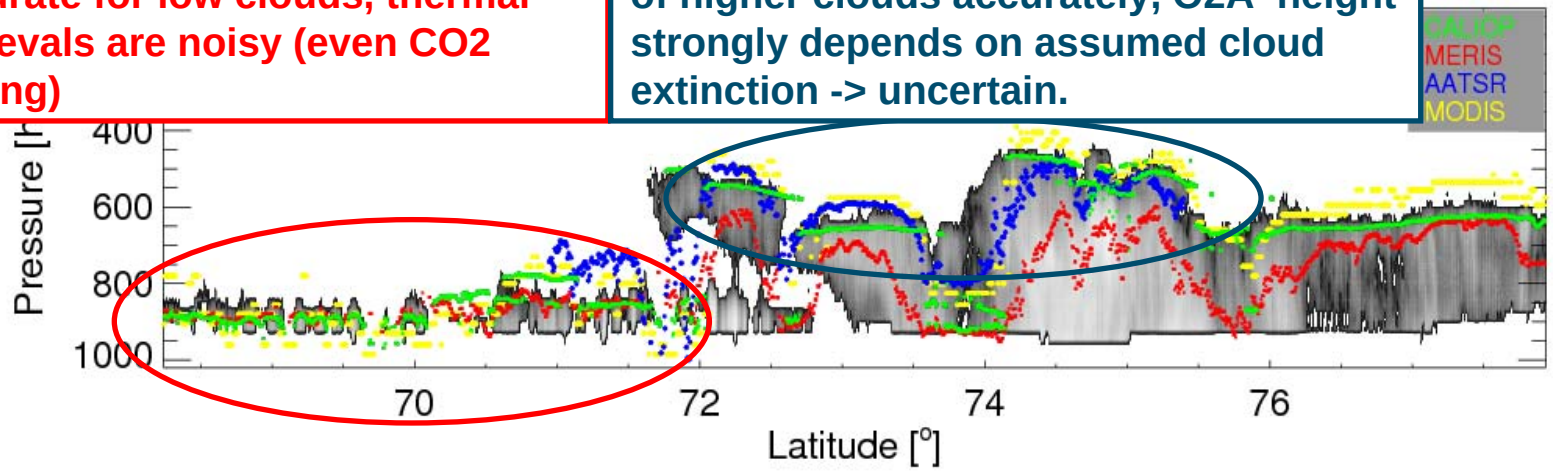
- ORAC/AATSR(0.55, 0.66, 0.87, 1.6, 11 µm)
- CPP/AVHRR(0.6, 1.6 µm)

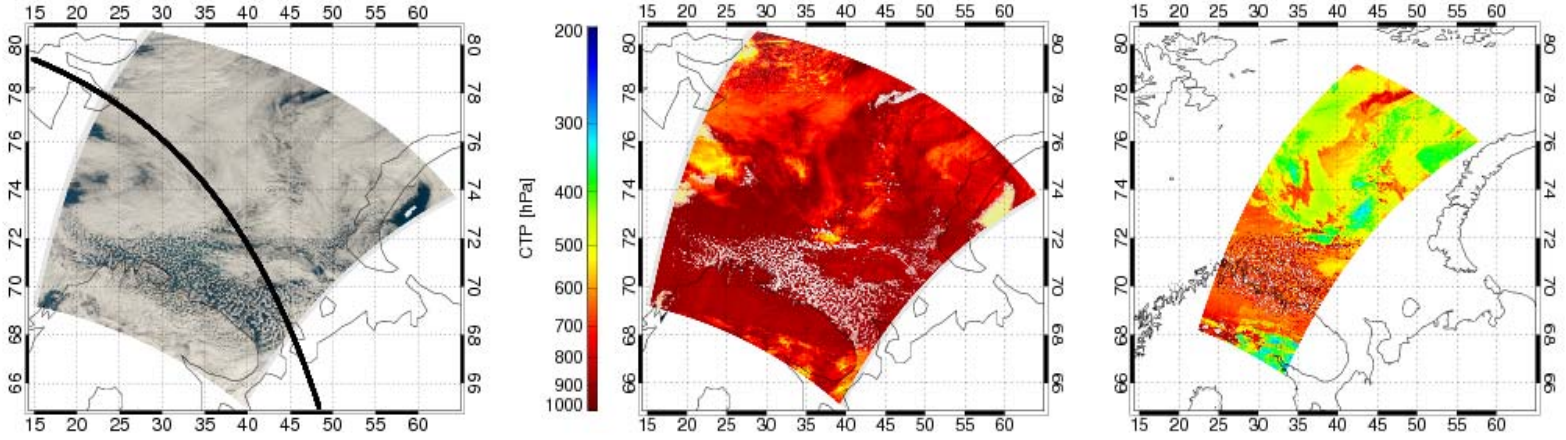
Courtesy of A. Kokhanovsky

CTP: Thermal vs. O_2 *A* band measurements

O_2 *A* cloud height is accurate for low clouds, thermal retrievals are noisy (even CO2 Slicing)

Thermal techniques detect cloud height of higher clouds accurately, O2A height strongly depends on assumed cloud extinction -> uncertain.

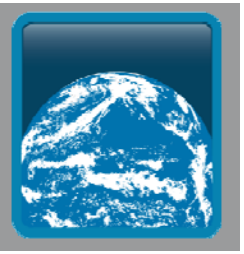




MERIS CTP

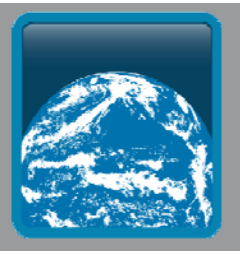
AATSR CTP

Cloud products from the combined AATSR-MERIS time series



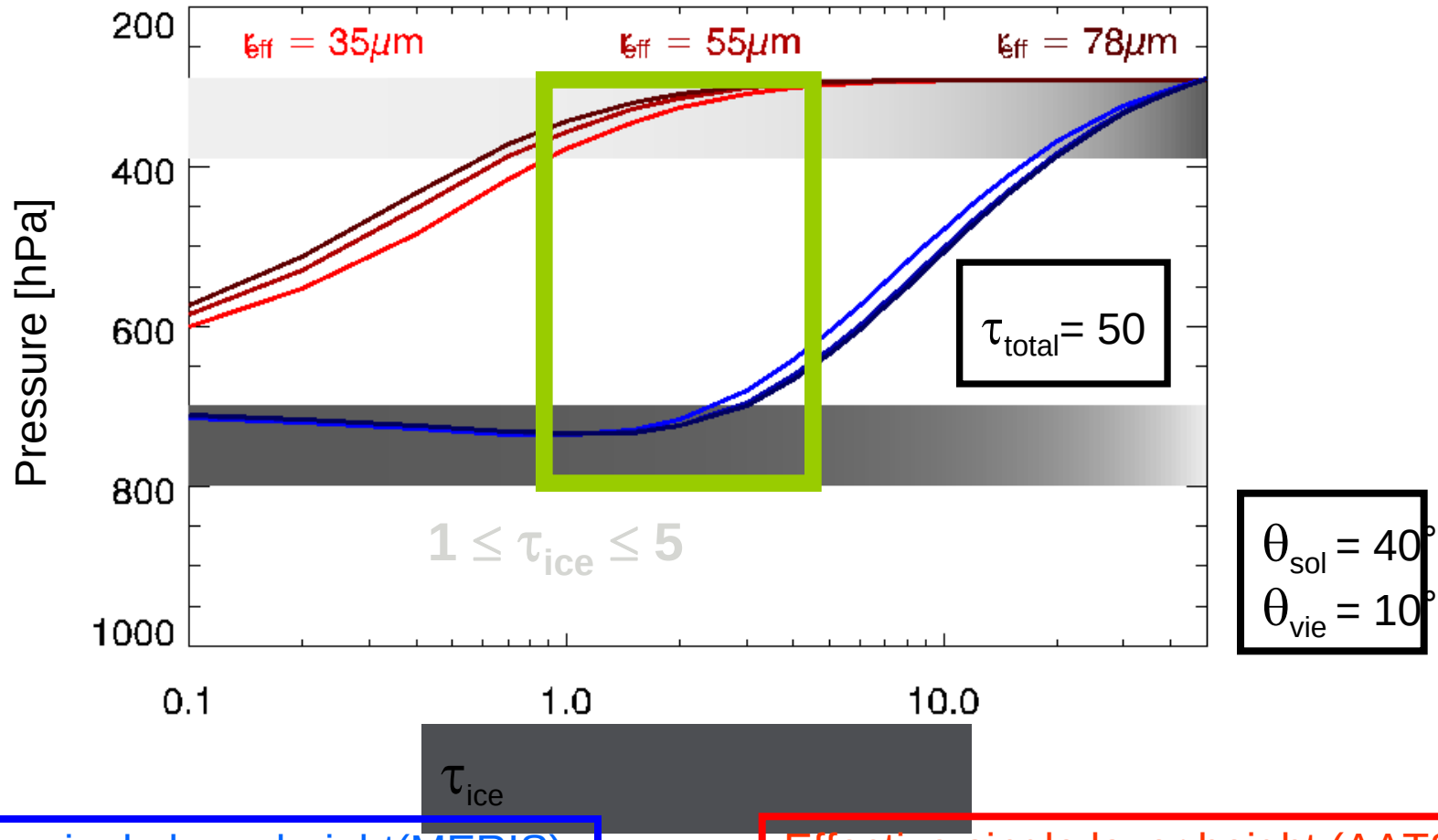
- **AATSR-MERIS-combination in orbit since 2002.**
- **MERIS was not primarily built for cloud retrievals (No SWIR, no TIR)**
- **So… why are we doing this?**

Motivation



- **So… why are we doing this?**
  - **MERIS provides O_2 *A* band measurements at high spatial resolution.**
  - **Combination with "classical" cloud retrieval bands from AATSR provides:**
    - Improved cloud detection from sensor synergy
    - Retrieval of cloud phase, CTH, COD, r_{eff}, (->LWP, IWP), cloud amount.
    - Improved cloud height detection from sensor synergy.
    - Improved multi-layer cloud flagging.
    - Multi-layer cloud height detection for cirrus-above water cloud (Advanced Retrieval Component)
  - **Combined observations to be continued by SLSTR+OLCI on Sentinel-3 for *several decades*.**

Advanced Retrieval Components



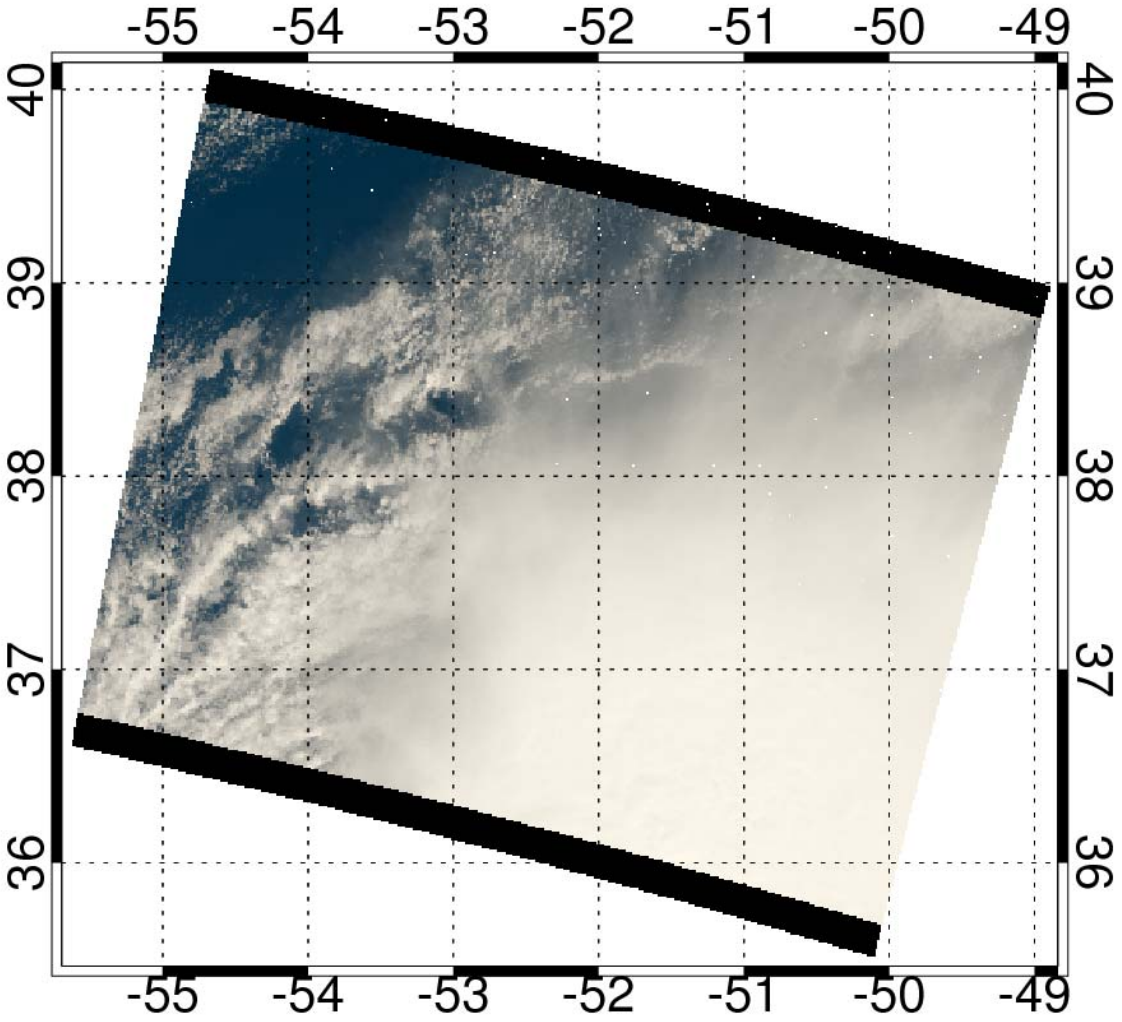
θ_{sol} = 40°
θ_{vie} = 10°

Effective single layer height(MERIS)

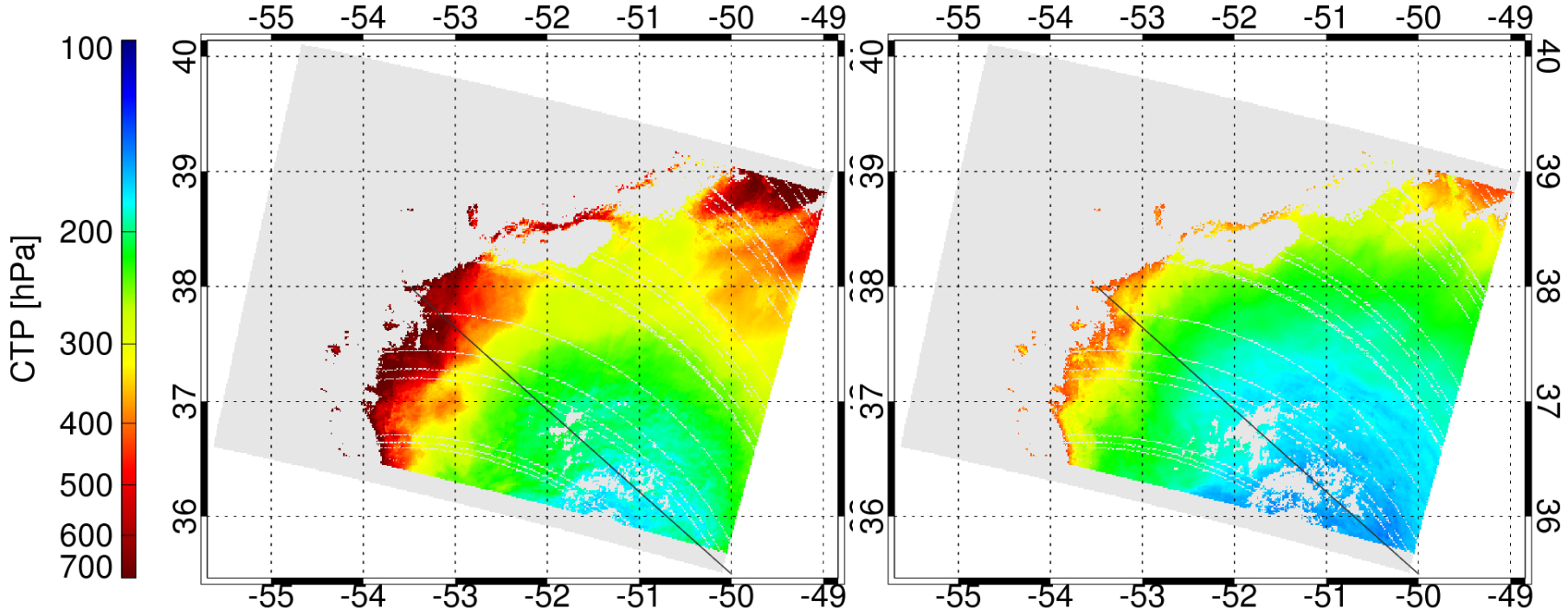
Effective single layer height (AATSR)

Case study, 26 September 2005

Cumulonimbus above North Atlantic with cirrus anvil

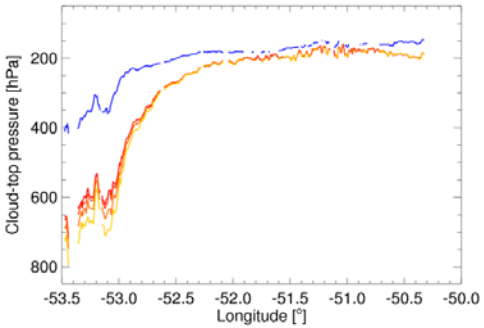


Case study, 26 September 2005

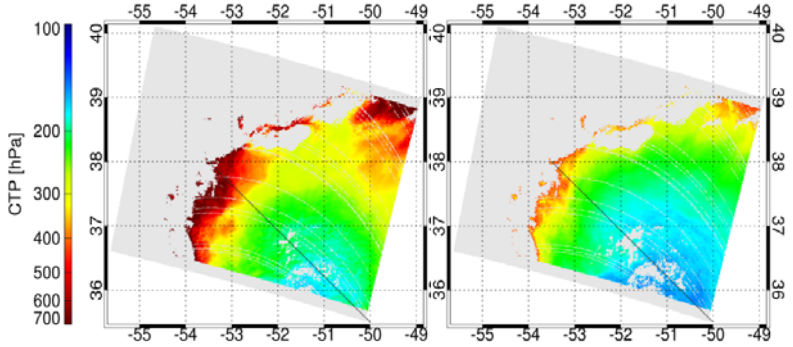


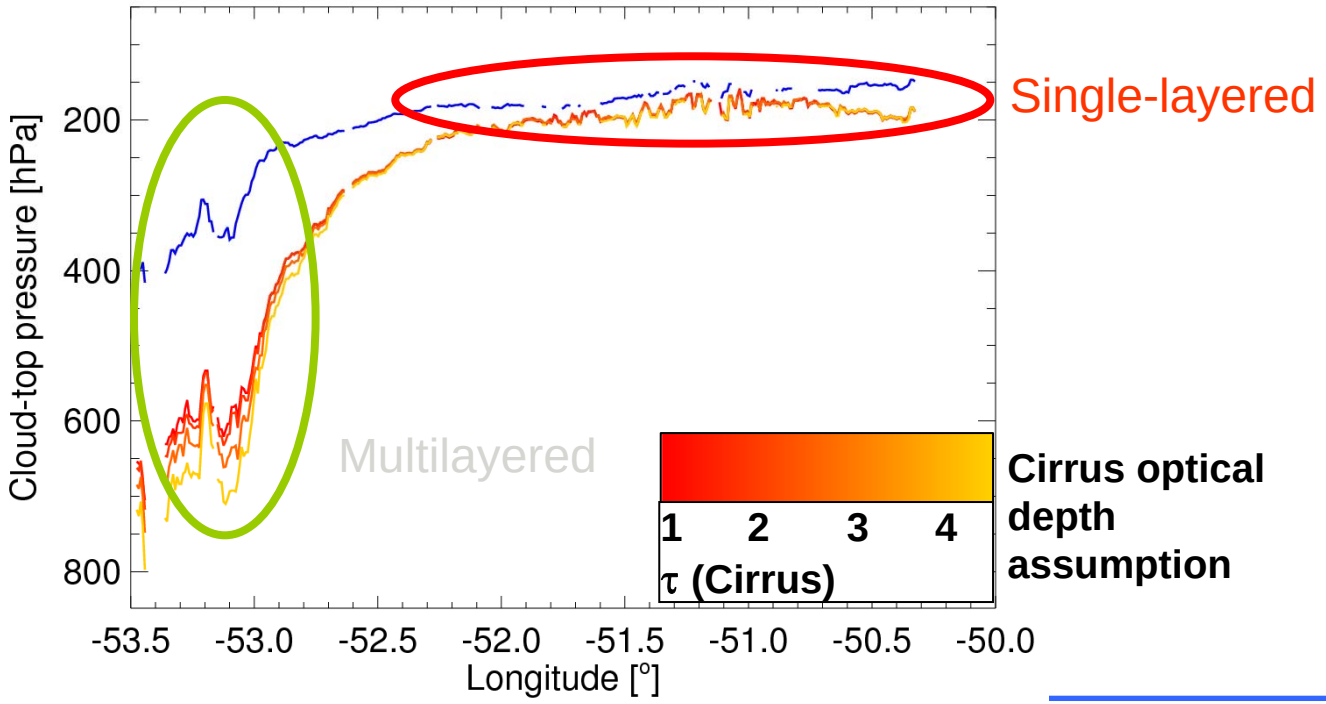
Low layer

Upper layer



Case study, 26 September 2005

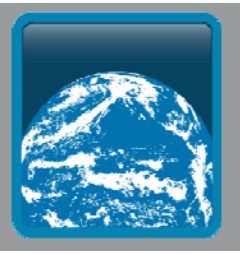




Single-layered

Cirrus optical depth assumption

Summary Cloud cci

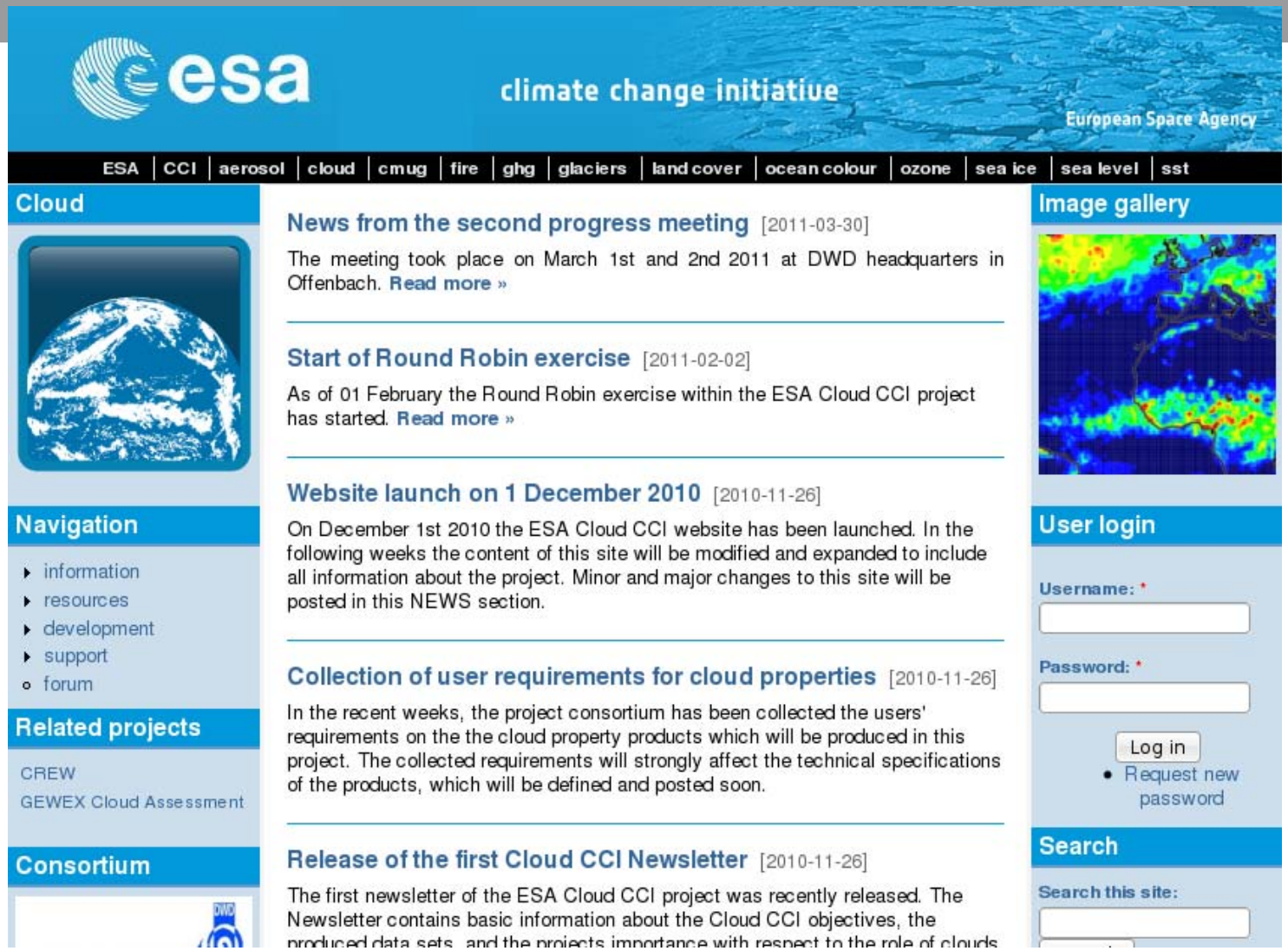


- A unique CDR of cloud properties based on a coherent physical retrieval framework from AVHRR-MODIS-(A)ATSR-MERIS
  - to allow for future and historical satellites instruments
  - with superior quality to single polar satellite products
  - with superior and improved error characterisation at pixel scale

- A unique CDR of cloud properties based on a synergetic physical retrieval framework from (A)ATSR-MERIS
  - to allow for future satellite instruments
  - with superior quality
  - with improved multi-layer cloud estimates

- Based on fully characterised and traceable FCDR's.
- a European component of an integrated assessment framework for GEWEX for cloud properties

Cloud CCI website



http://www.esa-cloud-cci.org