cloud cci

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Clouds in the climate System

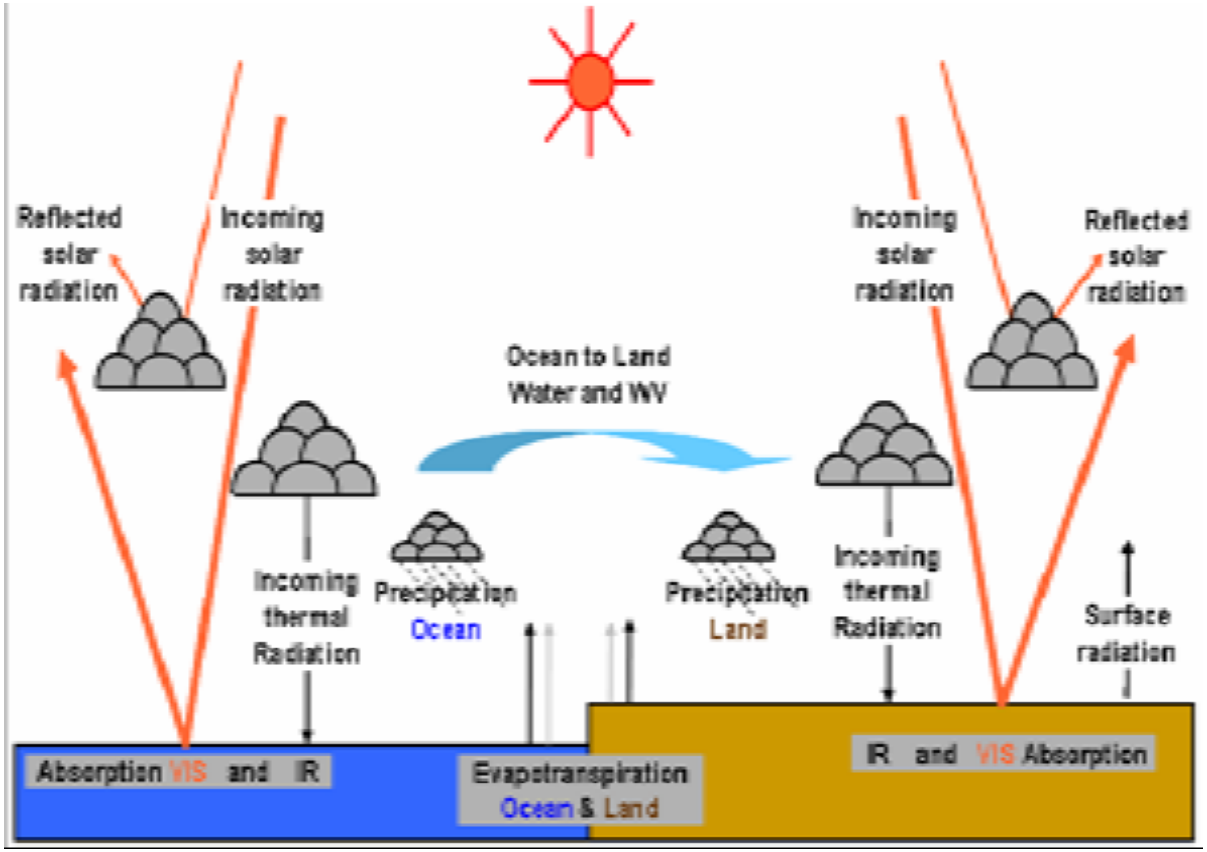


Image:
Courtesy R. Roebeling

Clouds are …

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

… but not fully understood nor modelled

GCOS requirements for clouds

Requirements as stated in GCOS-107, product A-4:

	Accuracy	Spatial resolution	Temporal resolution
Cloud Cover	10 %	100 km	3 h
Cloud top height	500 m	100 km	3 h
Cloud top temperature	0.3 K	100 km	3 h
Cloud ice profile	n/a	100 km	3 h
Cloud water profile	n/a	100 km	3 h

State of the art: Existing global Cloud Climatologies

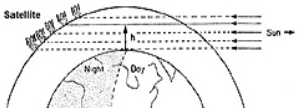
Longterm cloud climatologies:

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)* **ATSR** *(Poulsen)*

MODIS Terra 9 year mean cloud fraction

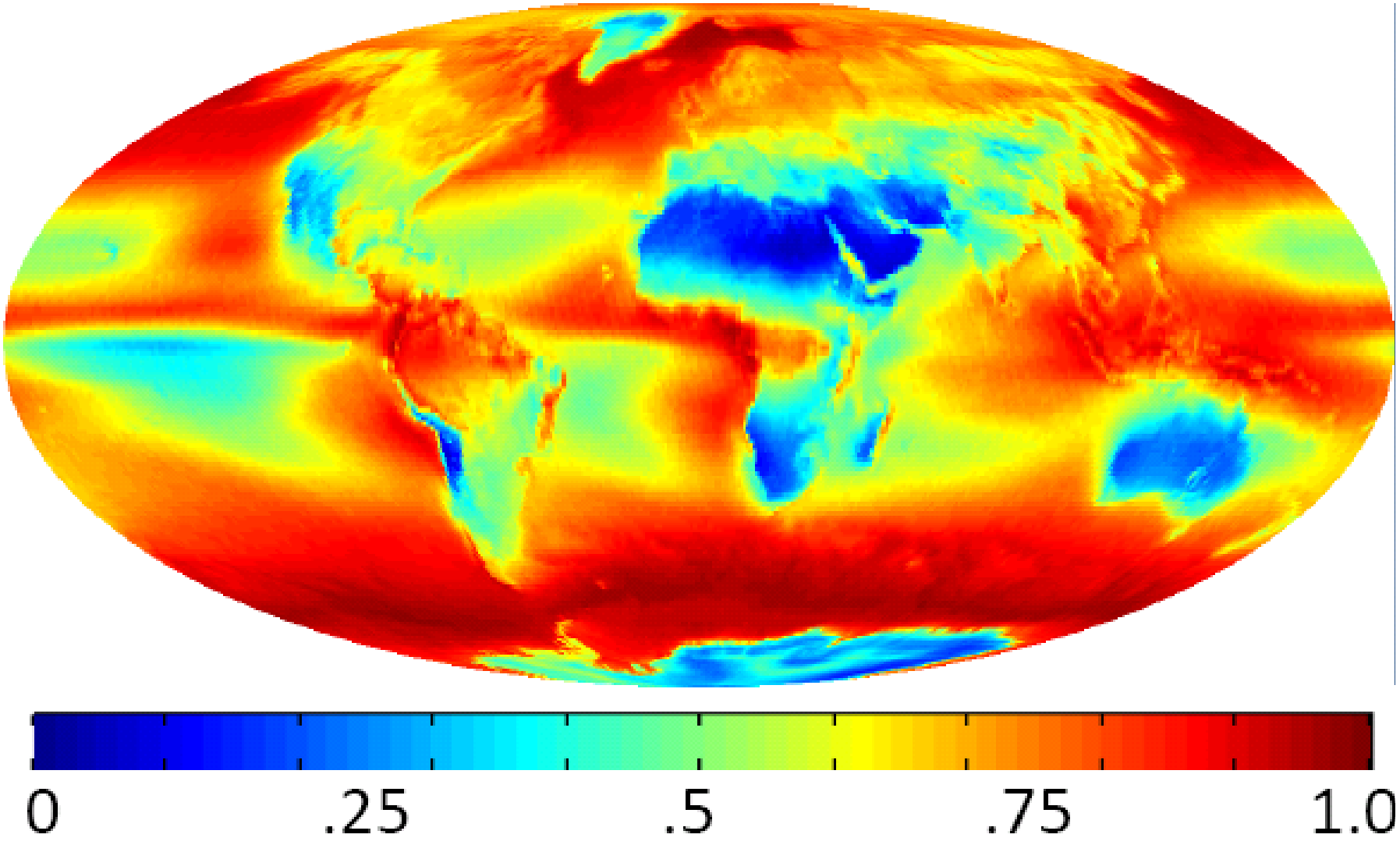
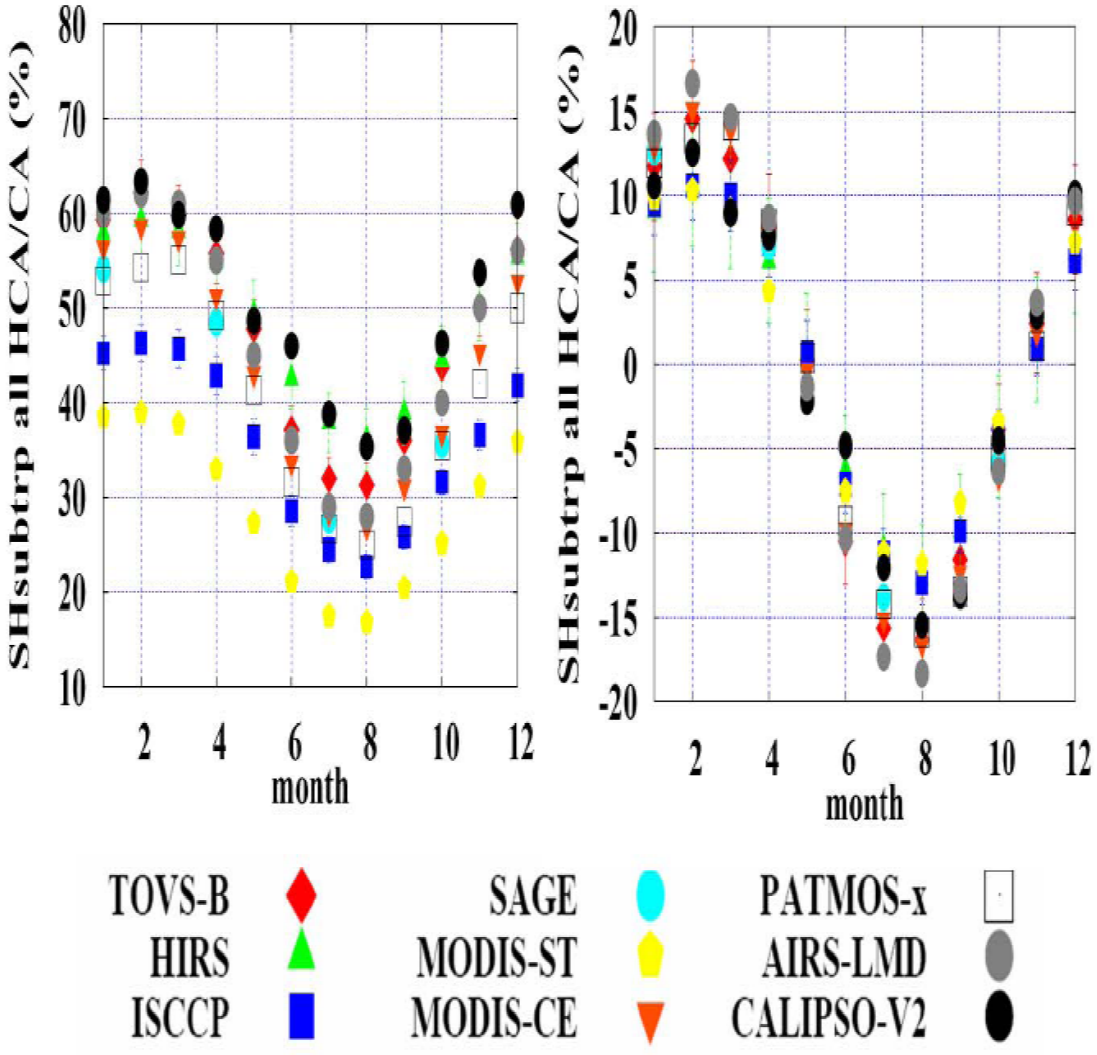


Figure from B. Maddux MODIS-ST presentation GEWEX meeting Berlin 2010

State of the art: Cloud fraction



GEWEX WCRP 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

Primary Objectives of cloud cci (I)

- Develop a inter calibrated radiance data sets for ESA and non ESA instruments in an international collaboration (FCDRs)

- Develop 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.

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

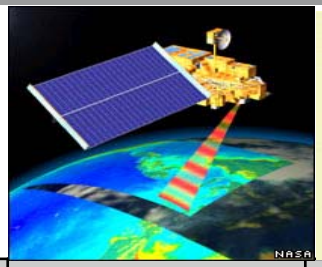
Primary Objectives of cloud cci (II)

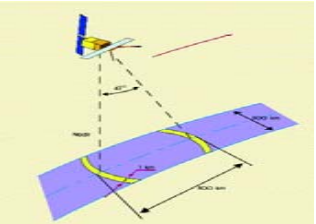
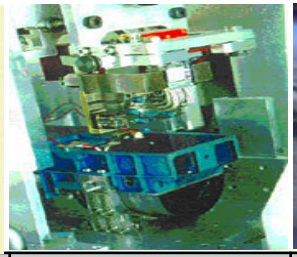
- Validation of the cloud property products against ground based and other satellite based measurements taking into account the individual error structures of the individual observations as far as possible.

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

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

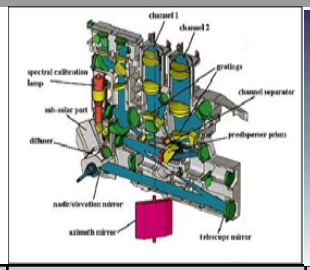
Capabilities of algorithms/instruments (I)

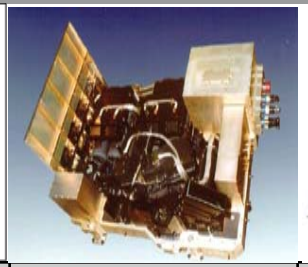


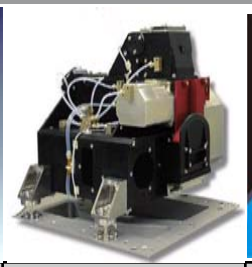



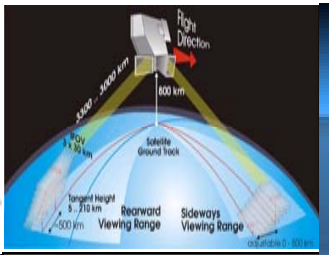
Cloud Properties	MODIS	AATSR	MERIS	AVHRR	(A)TOVS AIRS IASI
Cover	d/n	d/n*	d	d/n	d/n
Pressure	d/n	d/n*	d	d/n	d/n
Temperature	d/n	d/n*	d*	d/n	d/n
Height	d/n	d/n*	d*	d/n	d/n
VIS opt. depth	d	d	-	d	d
IR emissivity	d/n	d*/n*	-	*	d/n
LWP	d	d	-	d	
IWP	d	d	-	d	d/n

Capabilities of algorithms/instruments (II)









Cloud Properties	SCIA	GOME	OMI	MIPAS	SSM/I/ SSMIS AMSR-E
Cover	d	d	d	d	d/n
Pressure	d*	d*	-	-	-
Temperature	-	-	-	d	-
Height	d	d	d	d	-
VIS opt. depth	-	-		-	-
IR emissivity	-	-	-	-	-
LWP	-	-	-	d	d/n
IWP	-	-	-	d	d

Challenges (I)

Clouds in Mountainous and Polar Regions
Cloud Masking Over Snow and Ice

- Both issues are specifically addressed in Round robin exercise and in more detail in Option 7

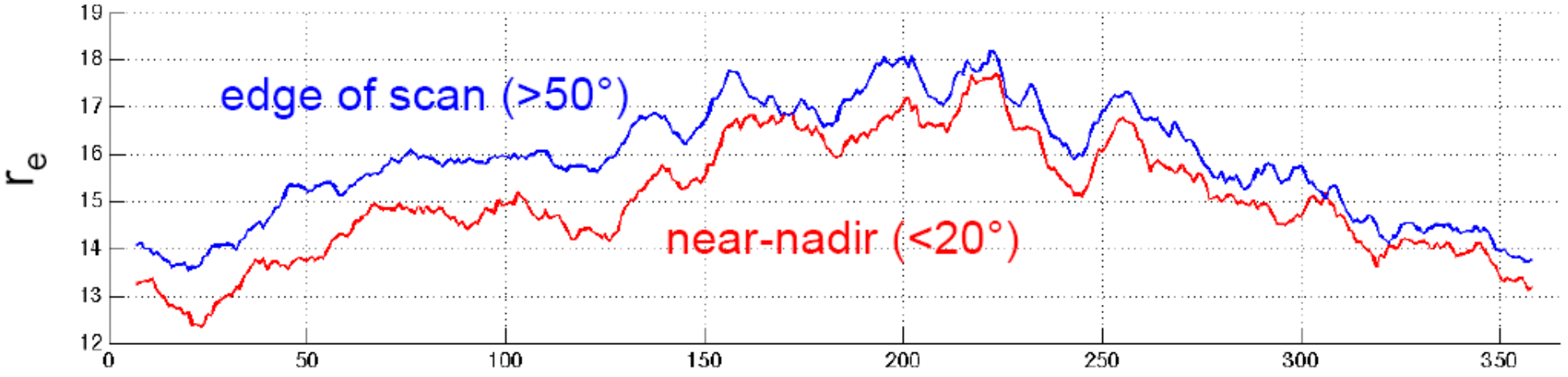
Multilayer clouds

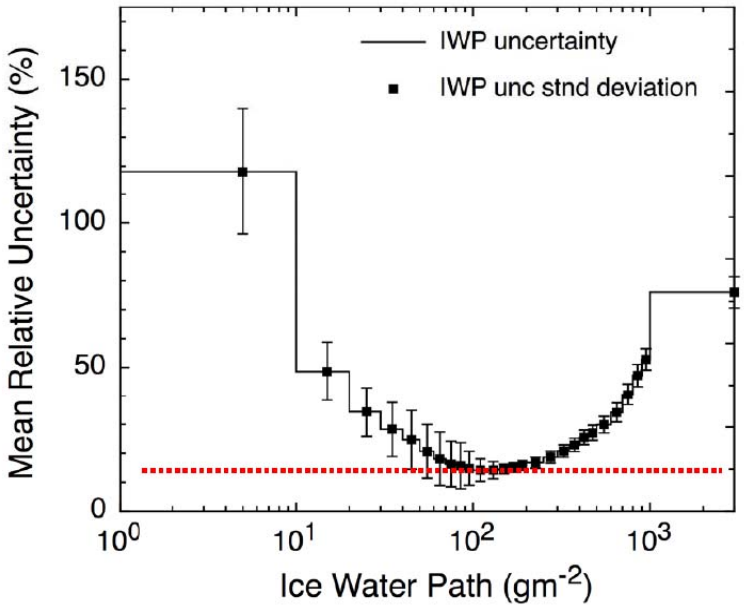
- MERIS utilizes measurements in the O2 A band around 0.76µm for the retrieval of cloud-top pressure
-Multilayer retrieval OE application (R. Siddans)

Uncertainty estimation

- intercomparing the different data sets for specific scenes, selected by using AIRS-CALIPSO-CloudSat will give insight into the vertical and horizontal structure

Examples of uncertainties in satellite cloud products





Figures from Platnick -Gewex Meeting Berlin 2010

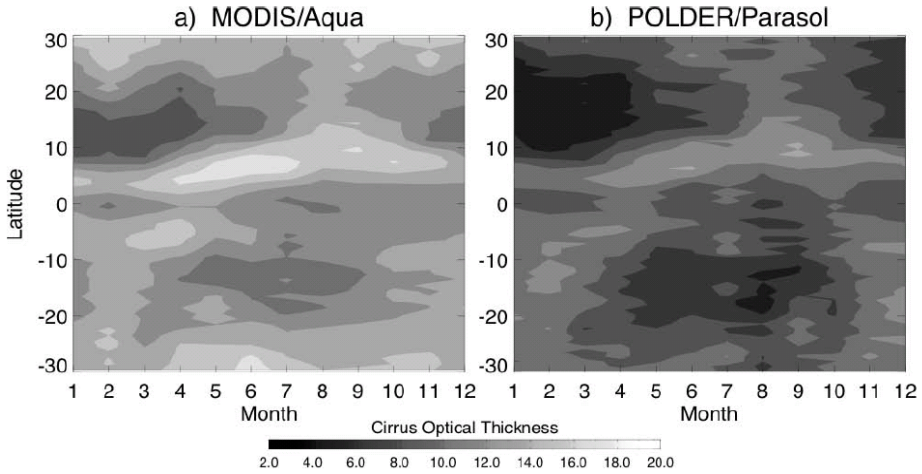


Fig. 5. Zonally-averaged monthly mean ice cloud optical thickness as function of latitude and month derived from **(a)** MODIS and **(b)** POLDER cloud products.

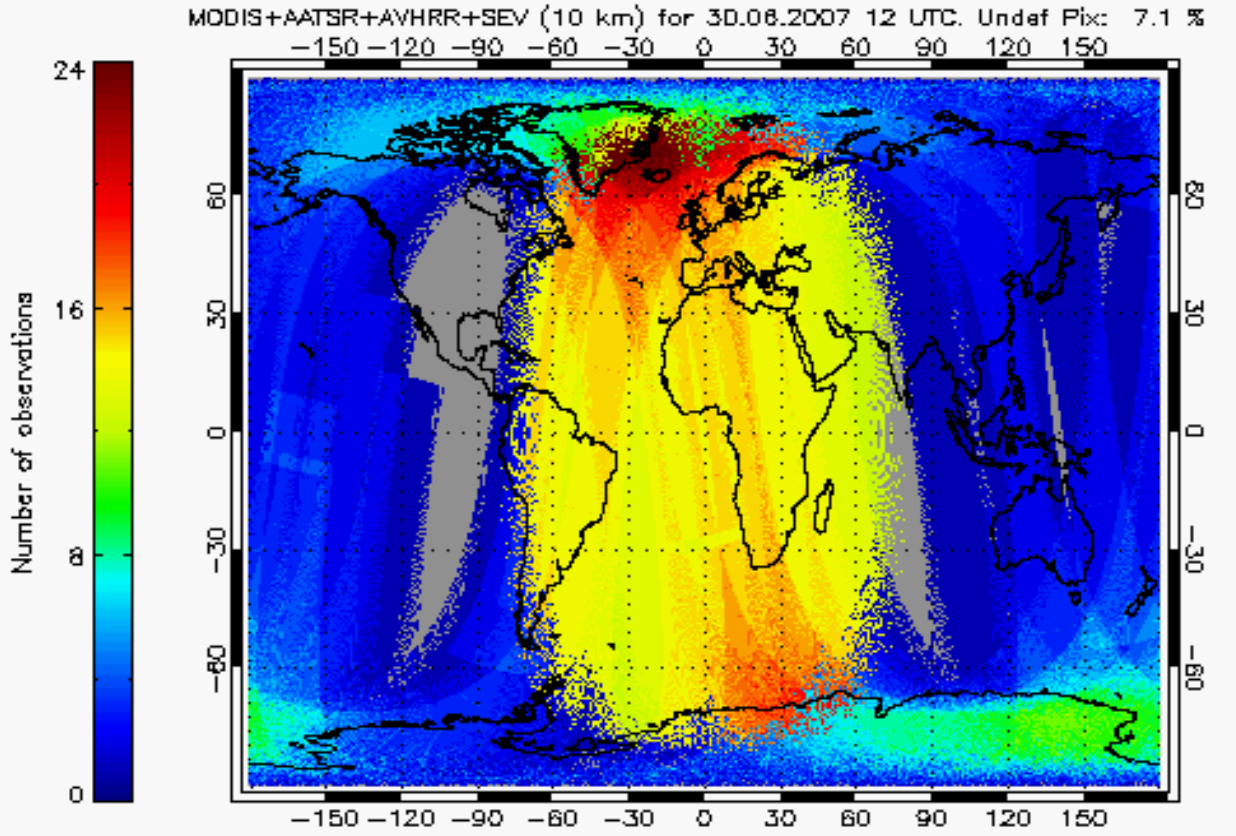
Figure from Zhang et al. 2009

Challenges (II)

Temporal sampling

- polar satellites will not give a true global 3 hourly coverage

- diurnal variation can be assessed via geostationary satellites (e.g. SEVIRI)



Global map of number of observations for 12-15 UTC 30.06.2007 based on available satellites.

Calibration and Inter-calibration (I)

- Homogenize MODIS – AVHRR – ATSR – MERIS

- Focus on common channels (lowest common denominator approach)

- Taking full benefit of GSICS results (e.g. SNO-overpass technology, MODIS – ATSR inter-calibration, NOAA-GAC inter-calibration)

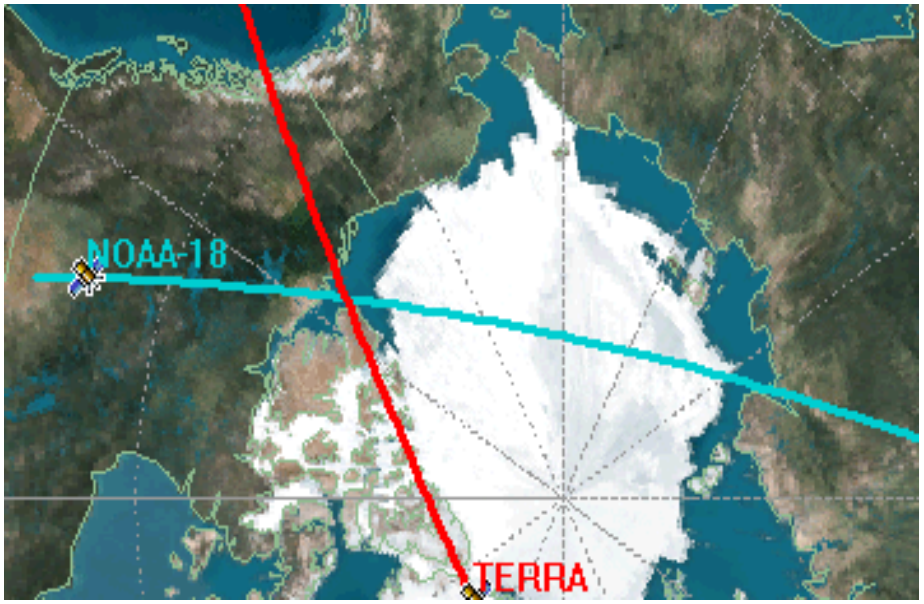
- Adding complementary methodologies where necessary enhancing GSICS capabilities

- establish or use existing calibration feedback-loops
- -> include expertise from US: Platnick (MODIS), Heidinger (NOAA), Bennartz (UWisc)
- -> combined with EU expertise (ATSR calibration scientist RAL, SMHI SNO expertise, MERIS expertise FU-Berlin, EUMETSAT)

Calibration and Inter-calibration (II)

A need for Level-1 radiances (FCDR):

- **Homogeneous**
- **Representative**
- **Quality-controlled**

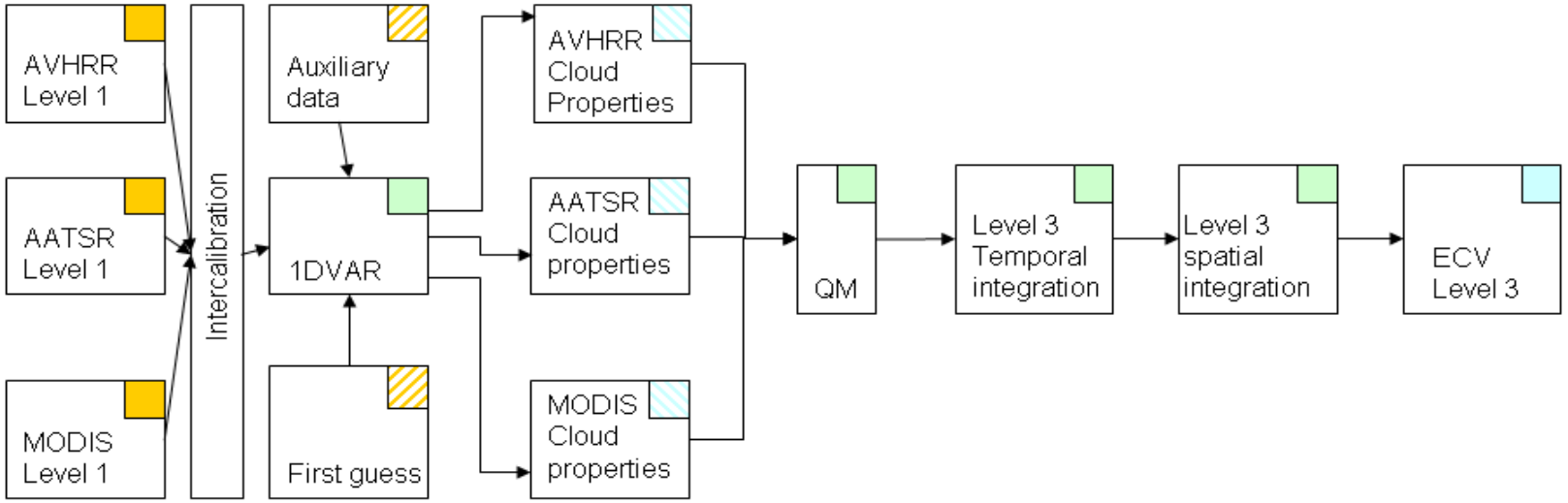


Simultaneous Nadir Overpass (SNO)

Improved calibrated radiances using SNO
->improved differences between sensors by order of magnitude.

Retrieval and processor development

- Develop a coherent physical retrieval framework for cloud cover, cloud top height and temperature, liquid and ice water path
- in an open community retrieval framework
- publicly available and usable by all interested scientists.
- round robin of algorithms will provide list of needed improvements
- for level-3 achieve radiative consistency with cloud properties



Validation and Assessment (I)

- Validation of the cloud property products against ground based measurements (ARM-sites, European sites e.g. Lindenberg, Cabauw)

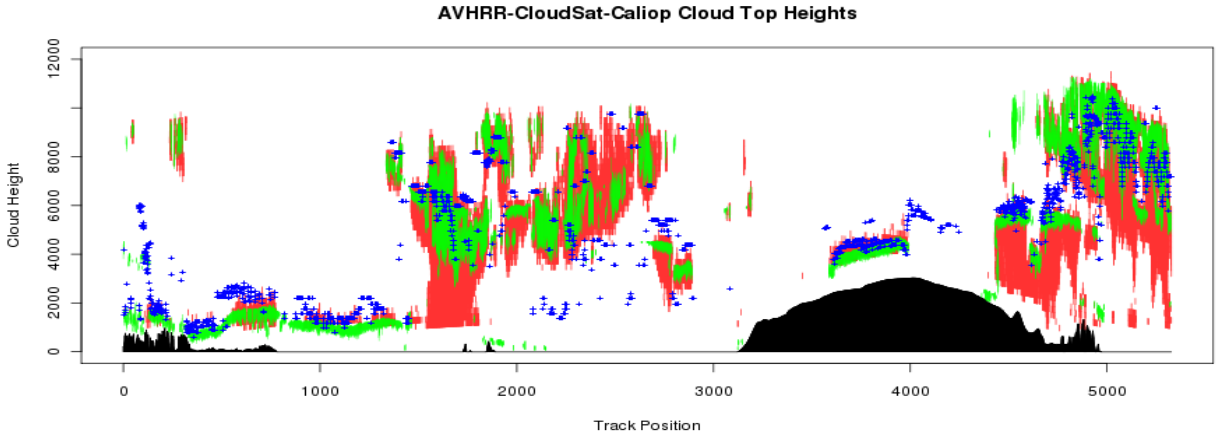
- Inter-comparison with other collocated satellite based measurements e.g. active instruments (CPR, Caliop from A-Train)

- taking into account the individual error structures of the individual observations as far as possible

- using GEWEX cloud assessment methods for continuous assessment of developed data sets throughout the three years

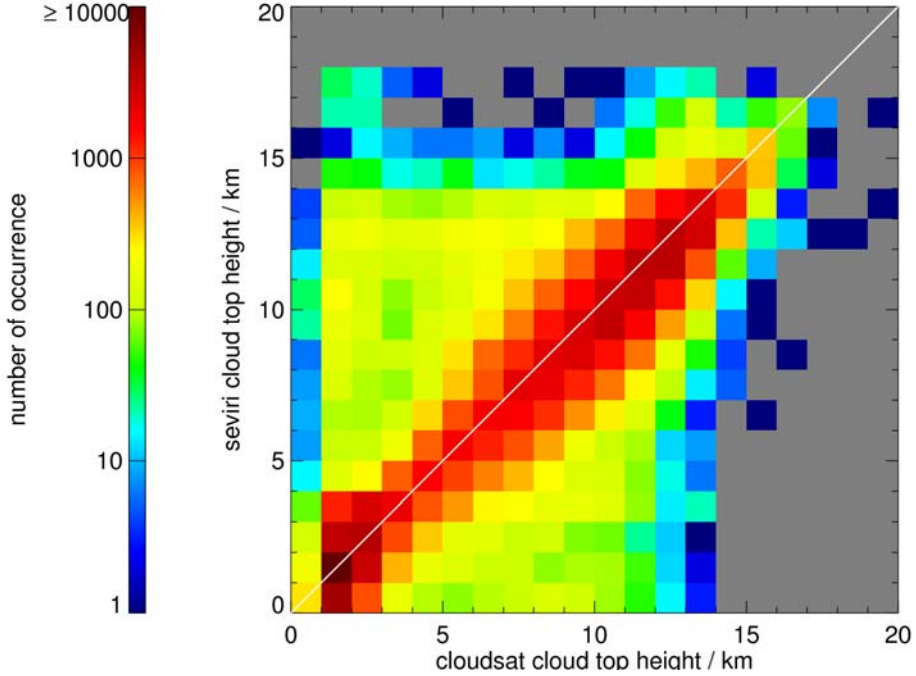
- Final evaluation from modelling user community included in the team (C. Jones (Rossby centre)) as well as via CMUG and externally (e.g. A. Will (COSMO-CLM), F. Kaspar (Miklip).

Validation and Assessment (II)



Example of a cross section of NOAA-18, with CPR, Caliop on 27th July 2007, 06:12 UTC. Cloud Height in m. (Karlsson et al. 2009)

CTH derived from MSG SEVIRI (CM-SAF product) with collocated Cloudsat-CPR CTH for January 2009 (Fig. courtesy of M. Lockhoff, DWD).
Accuracy (bias): 150 m.
Precision (bc-rms): 1000 m



AVHRR-(A)ATSR-MODIS-MERIS cloud properties

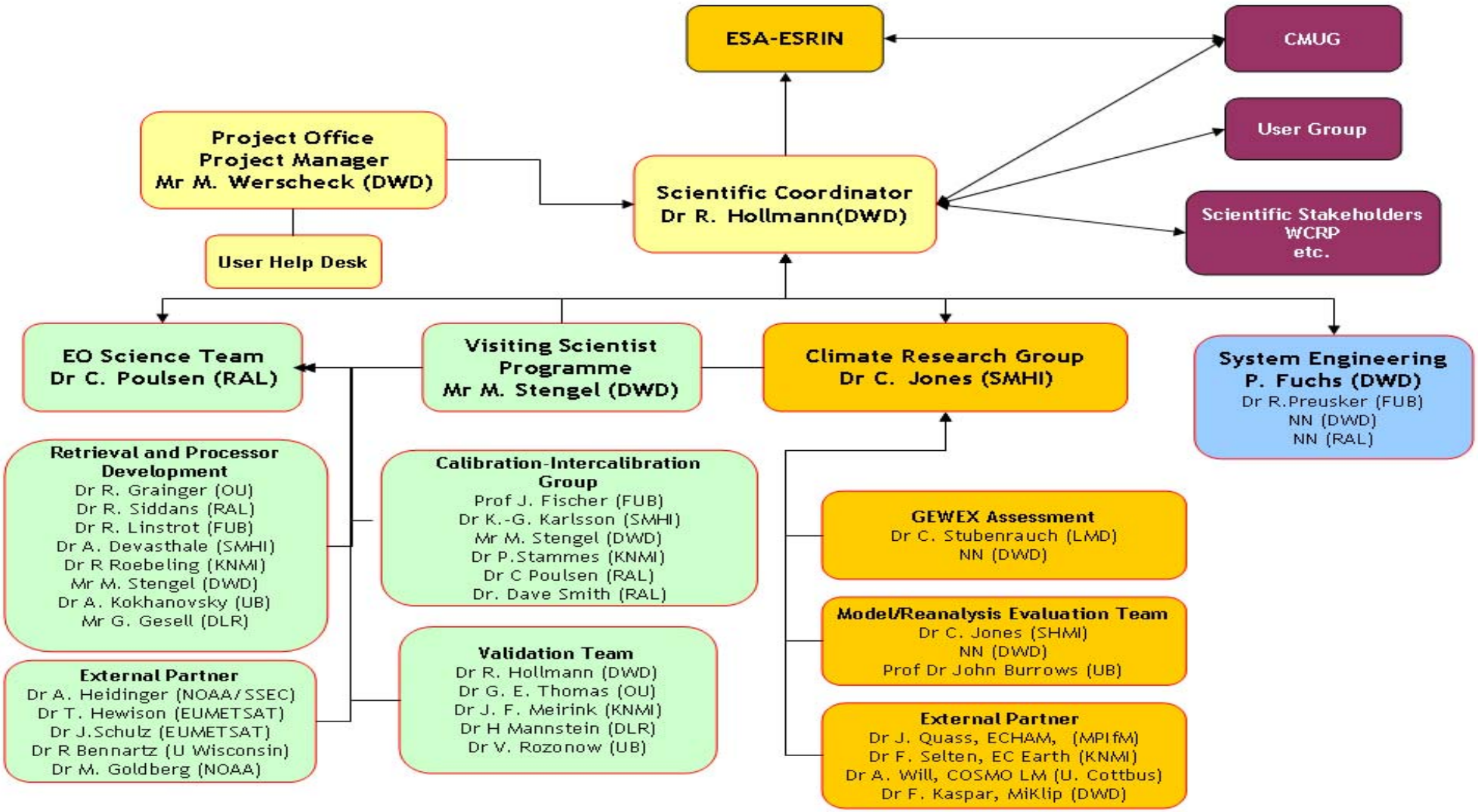
Expected product specification of cloud data set. For the column flags in the table the following abbreviations are used: U (Uncertainty), t (time of measurement), q (quality indicator), n (number of measurement), g (surface type), a (additional flags defined by users).

ECV Parameter	Format	Spatial Sampling	Temporal Sampling*	Flags
Cloud Cover	**Netcdf, Netcdf CF data and metadata convention will be implemented**	**(a) Global equal area grid with a resolution of 10 km x 10 km (b) Global equal angle grid with a resolution of 0.05 or 0.1 degree**	**Monthly mean at four local observation times: 0, 6, 12 and 18. Level 2 data set with the same 6-hourly resolution.**	**U, q, t, n, g, a**
Cloud Top Height, Temperature and Pressure				
Optical Depth (VIS), Effective Radius				
LWP (computed)				

Consortium: Cloud cci

Deutscher Wetterdienst (DWD), Lead
Rutherford Appleton Laboratory (RAL)
University of Oxford (UO)
Free University of Berlin – Institute for Space Sciences (FUB) – 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)

Cloud cci management overview



International cooperation

- Include expertise from US: Platnick (MODIS), Heidinger (NOAA), Bennartz (UWisc) via a visiting scientist program.
- Links to GSICS and CEOS IVOS work shops
- Lots of calibration expertise in house (SHMI…)
- Cloud parameter retrieval WorkShop of EUMETSAT (CWS)
- GEWEX WCRP / Gewex Radiation Panel (i.e. cloud Assessment)–last meeting Berlin 2010
- EUMETSATs CM-SAF
- SCOPE-CM (Sustained Co-ordinated Processing of Environmental Data for Climate Monitoring)
- Rossby centre and CMUG modelling group
  KNMI,DWD,UB U Cottbus

- Much more international collaboration is welcome!!!

Summary Cloud cci

Cloud cci will deliver

- Fully characterised and traceable FCDR's.

- 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

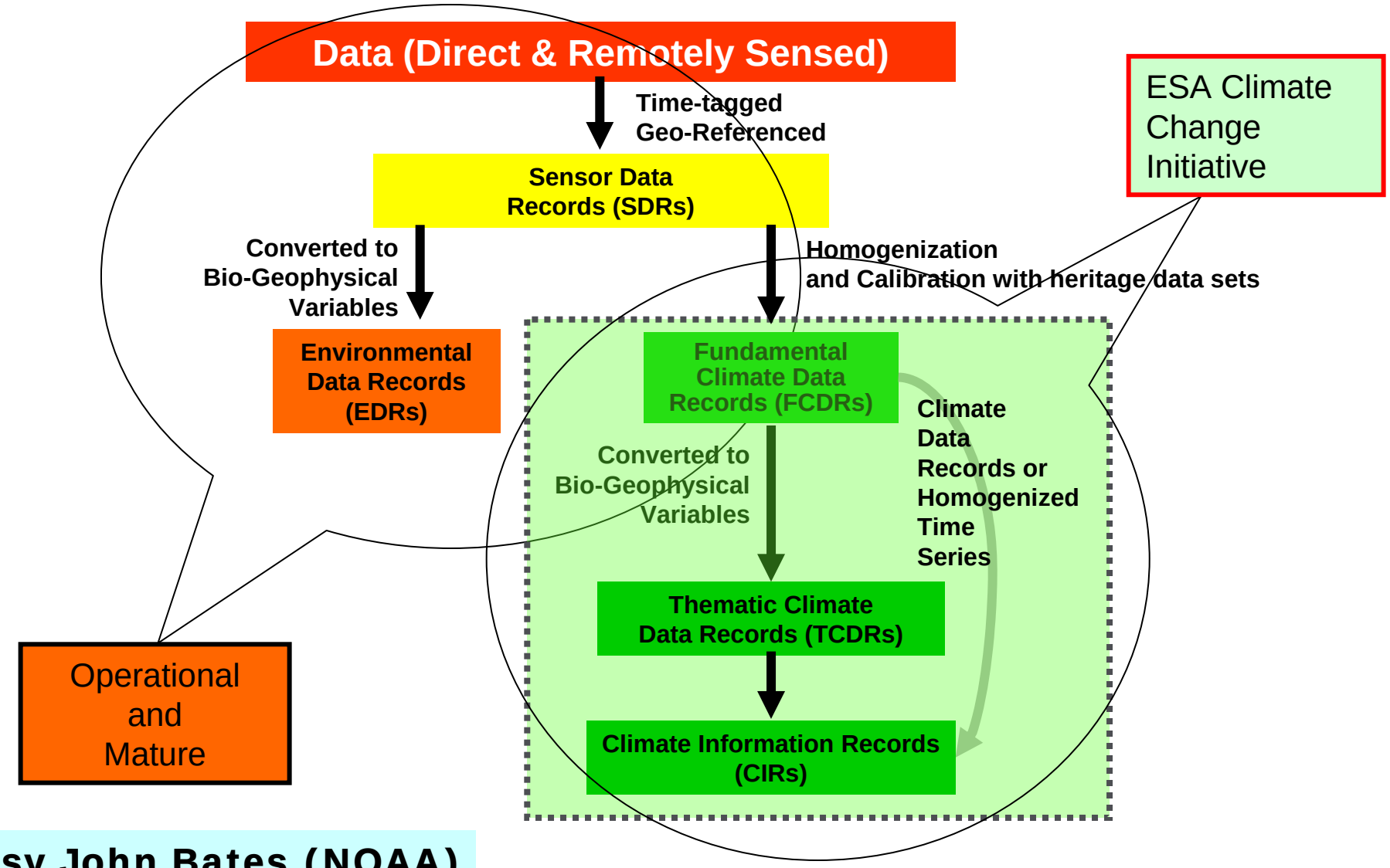
- A unique CDR of cloud properties based on a synergetic physical retrieval framework from (A)ATSR-MERIS
  - to allow for future satellite instruments
  - with superior quality
  - with improved multi-layer cloud estimates

- A European component of the GEWEX assessment of cloud properties

- **The end**

State of art: Weather vs. Climate Processing

Distinct Paths, Technologies, and Timelines



courtesy John Bates (NOAA)