The Satellite Application Facility on Climate Monitoring

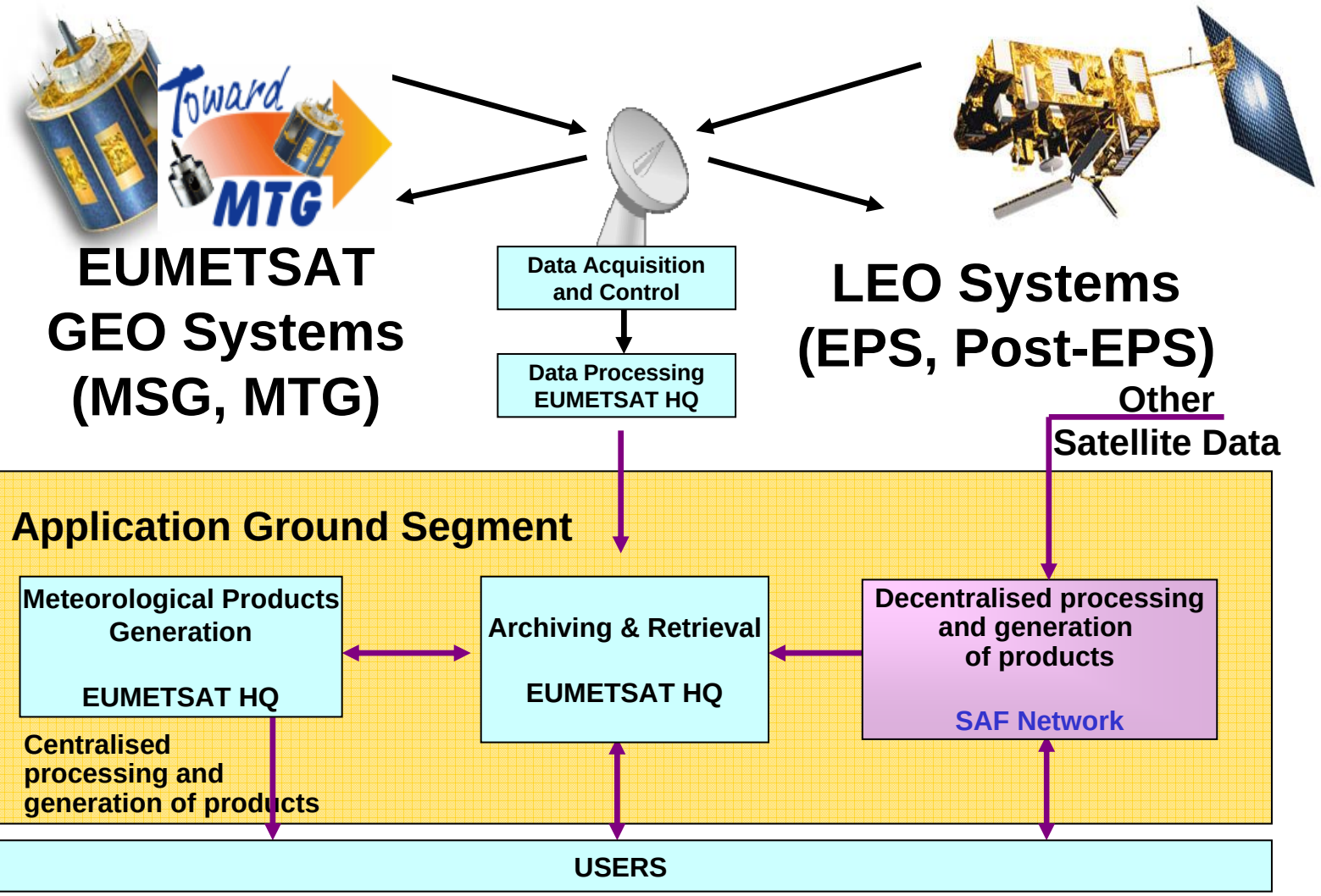
Achievements and Future Plans

Jörg Schulz
on behalf of the CMSAF consortium

Outline

- The network of Satellite Application Facilities and the CMSAF
- CMSAF cloud – radiation – water vapour products
- Continues Development and Operations Phase (2007-2012) – Goals and planned activities
- Conclusions

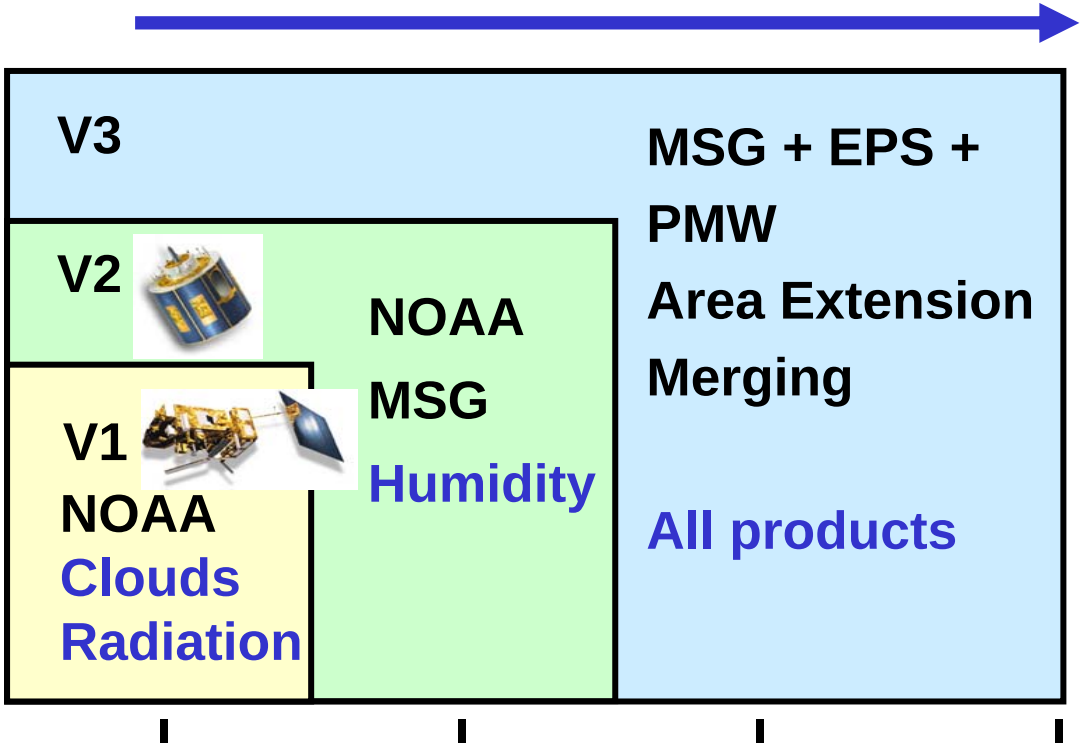
EUMETSAT Distributed Application Ground Segment

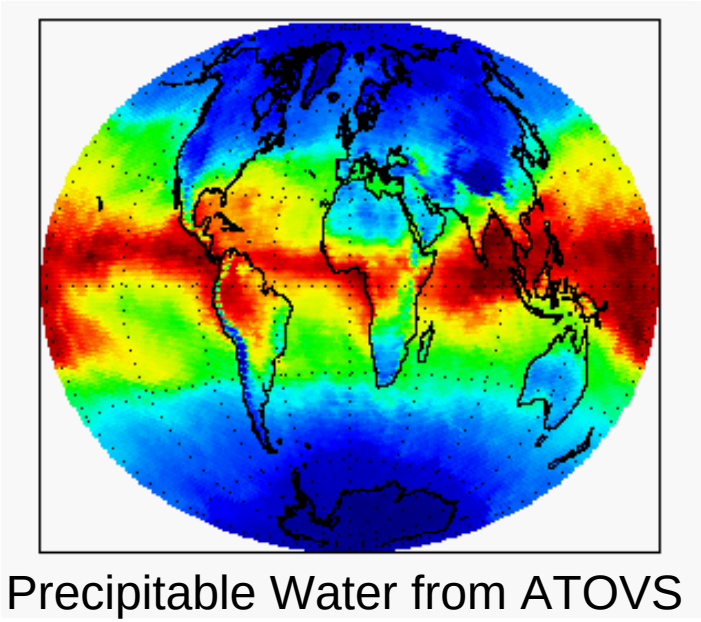


Courtesy of Lothar Schüller, EUMETSAT

CM-SAF: Schedule & Versioning

CM-SAF has the mandate to generate thematic climate data records in an operational off - line environment. It requires calibrated and cross calibrated radiance data sets from different satellite operators.





Precipitable Water from ATOVS

Continued Development and Operations Phase (CDOP) 2007-2012

Available CM-SAF cloud products

Cloud parameters

CFC **Cloud Fractional Cover**

CTH **Cloud Top Height**

CTY **Cloud Type**

CTT **Cloud Top Temperature**

CPH **Cloud Phase**

COT **Cloud Optical Thickness**

CWP **Cloud Water Path**

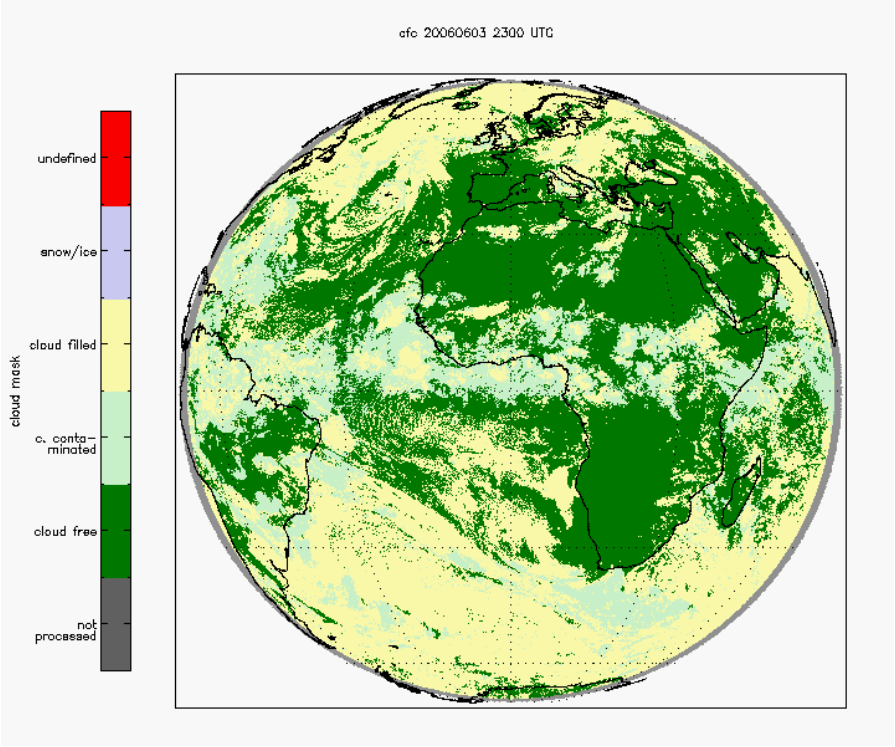
Time resolution

15min for SEVIRI, daily, monthly, monthly mean diurnal cycle

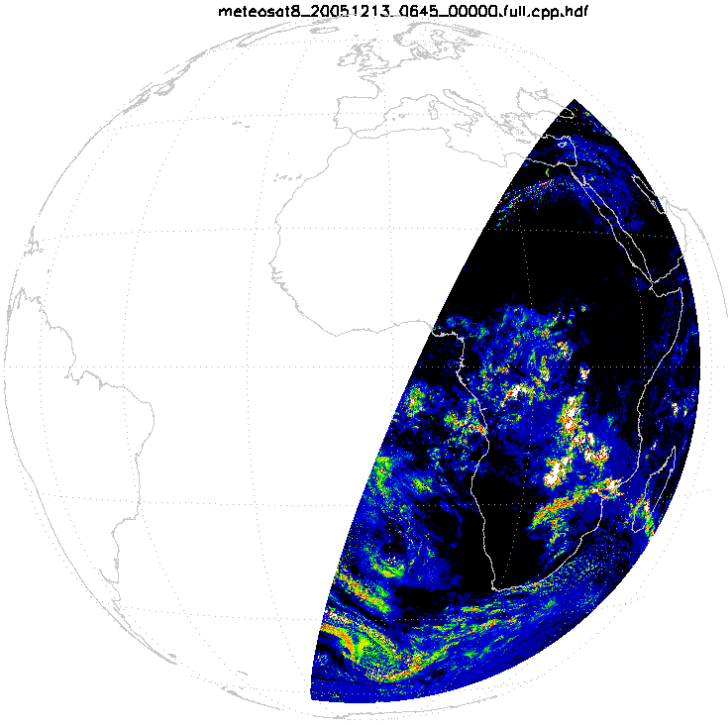
Spatial resolution

(Pixel), 15 km x 15 km

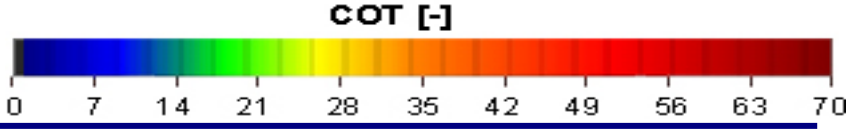
SEVIRI - Cloud Products



Fractional cloud cover



Cloud optical thickness



The use of CM-SAF cloud products for validation of ECMWF Re-Analysis results

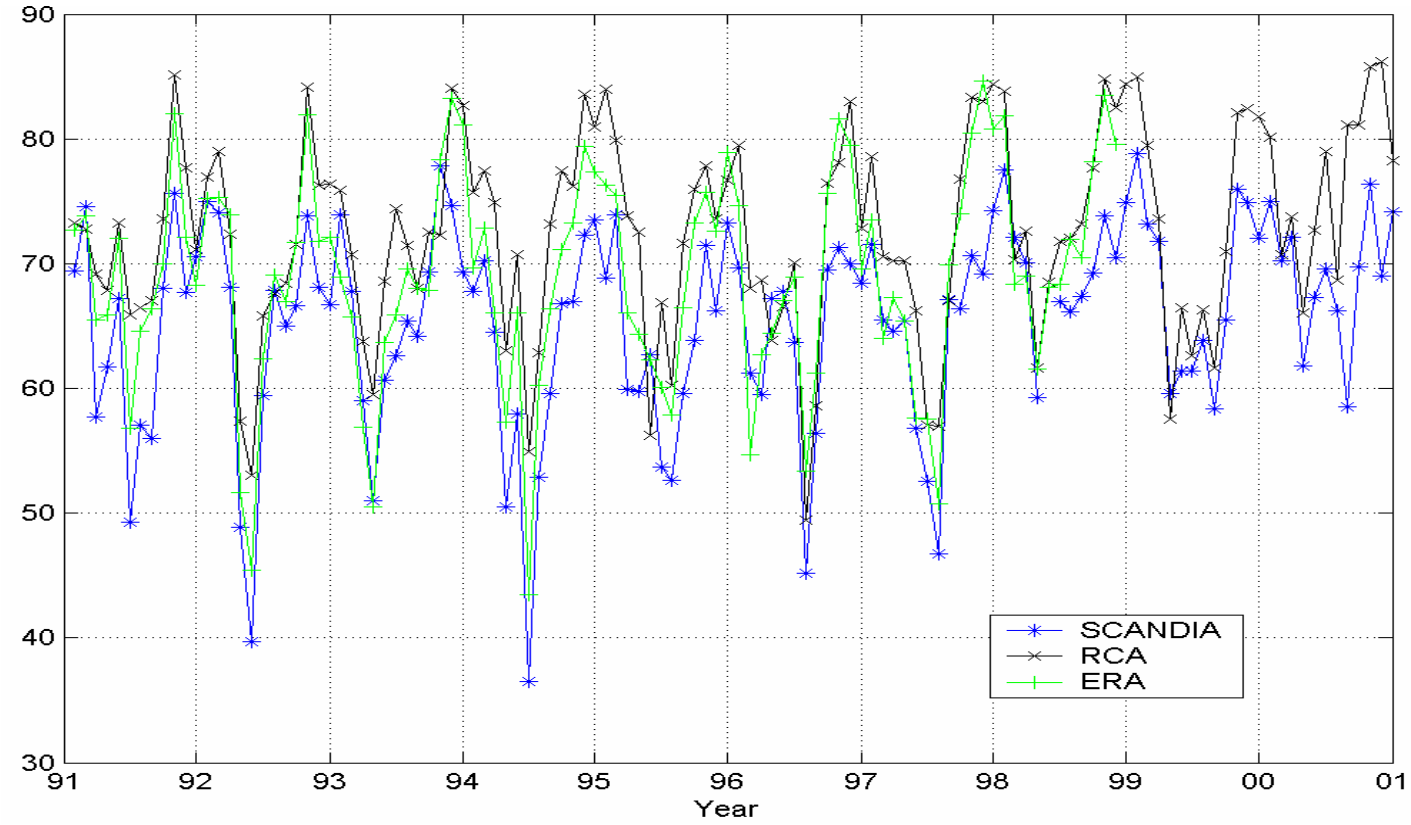
Idea: ECMWF cloud datasets (generated from short forecasts based on re-analyses) could be compared to monthly cloud climatologies from CM-SAF.

Motivation:

- Offers an independent observation dataset (not assimilated) with known quality characteristics;
- Provides an indirect evaluation of whether the re-analysed field humidity and temperature are consistent with observed cloud fields;
- Contributes to the validation of ECMWF cloud parameterization schemes and the achieved radiation budget components (the latter also estimated by CM-SAF).

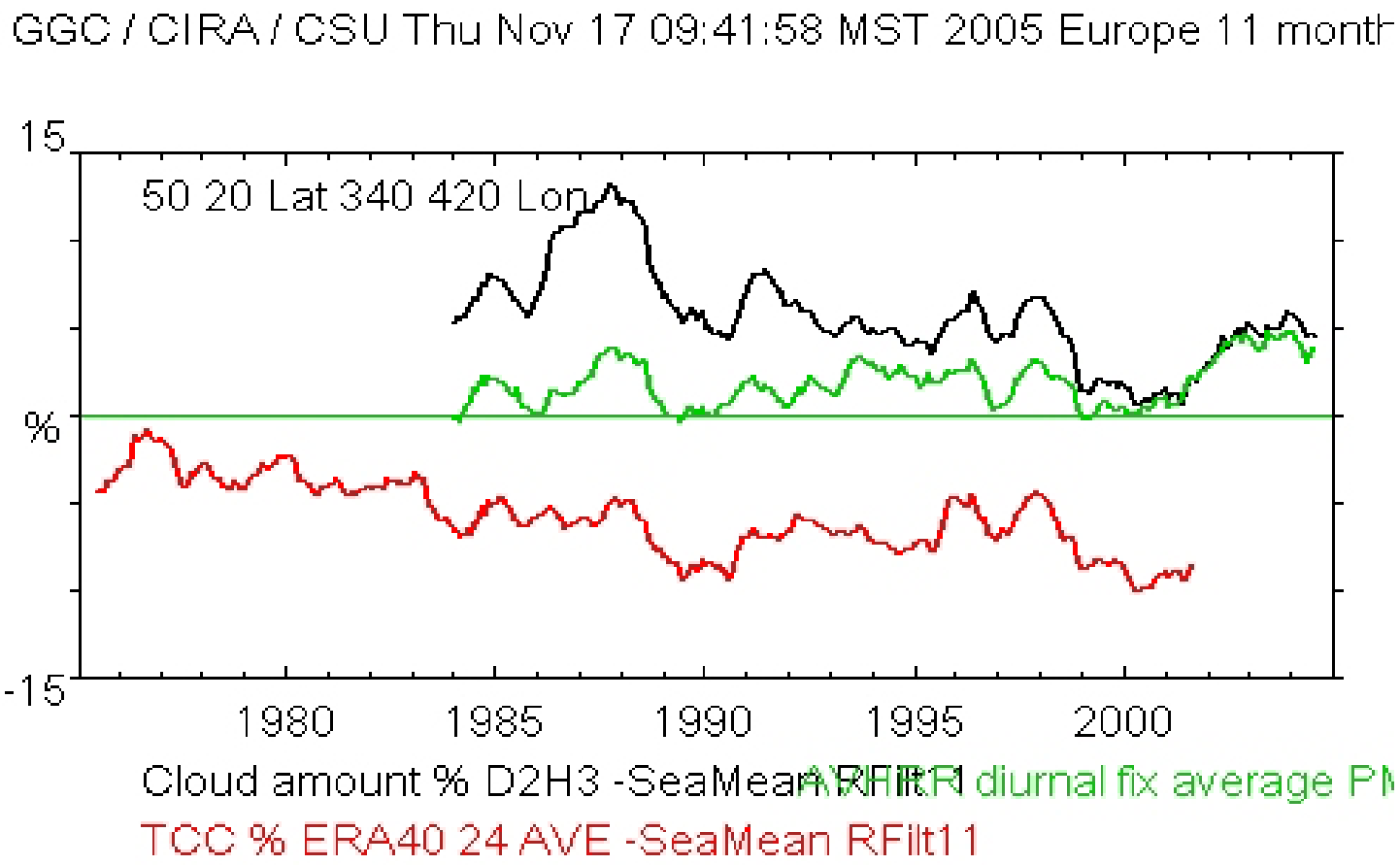
Previous evaluation of ERA-40 using NOAA AVHRR climatologies over Scandinavia

Results for the entire Nordic area



Time series 1991-2000 of mean monthly total cloud amount (%) from NOAA AVHRR (SCANDIA), Rossby Center climate simulation (RCA) and ERA-40 (ERA). Notice wintertime overestimation of cloudiness from models and the good ERA40-agreement for summer minimum cloudiness. (Karlsson, 2003, Int. J. Climatol., Vol. 23)

ERA40 vs. satellite cloud climatology



Courtesy of G.G. Campell

TOA and Surface radiation parameters

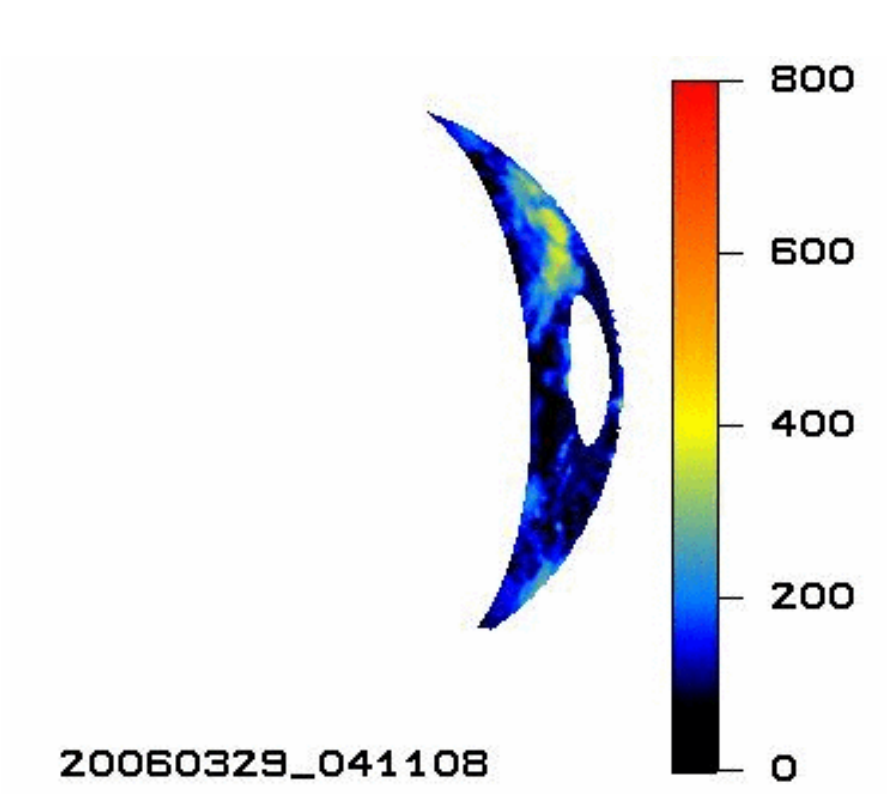
TET	Emitted Thermal Flux (Its OLR)
TRS	Reflected Solar Flux
TIS	Incoming Solar Flux
SIS	Surface Incoming Short Wave Radiation
SNS	Surface Net Short Wave Radiation
SDL	Surface Downward Long Wave Radiation
SOL	Surface Out going Long Wave Radiation
SNL	Surface Net Long Wave Radiation
SRB	Surface Radiation Budget
SAL	Surface Albedo

Time resolution: daily mean, monthly mean, monthly mean diurnal cycle (SAL: weekly, monthly)

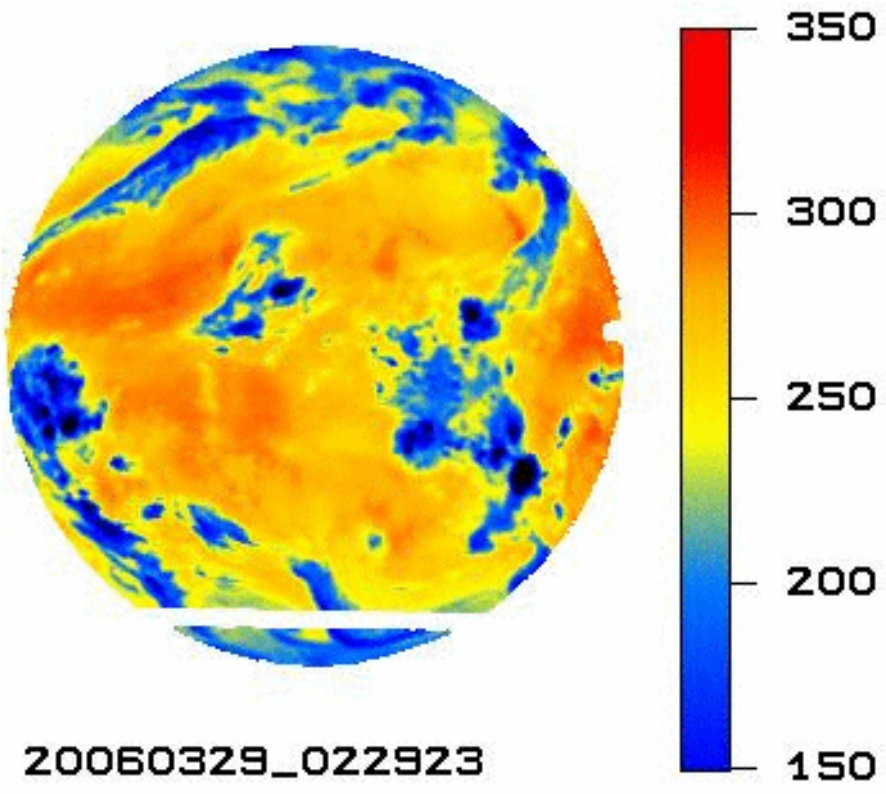
Spatial resolution
(Pixel), 15 km x 15 km, 50 km x 50 km for GERB

TOA products on full disc

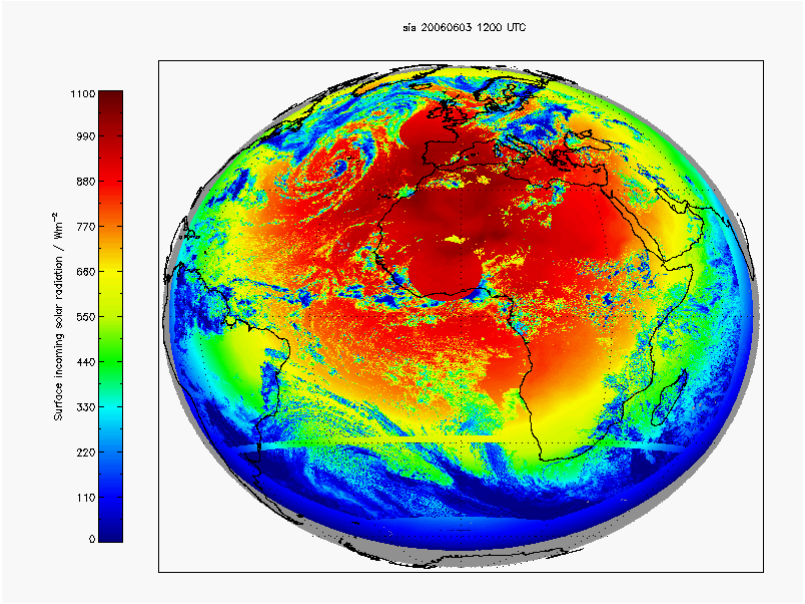
ARG Reflected solar flux (W/m^2)



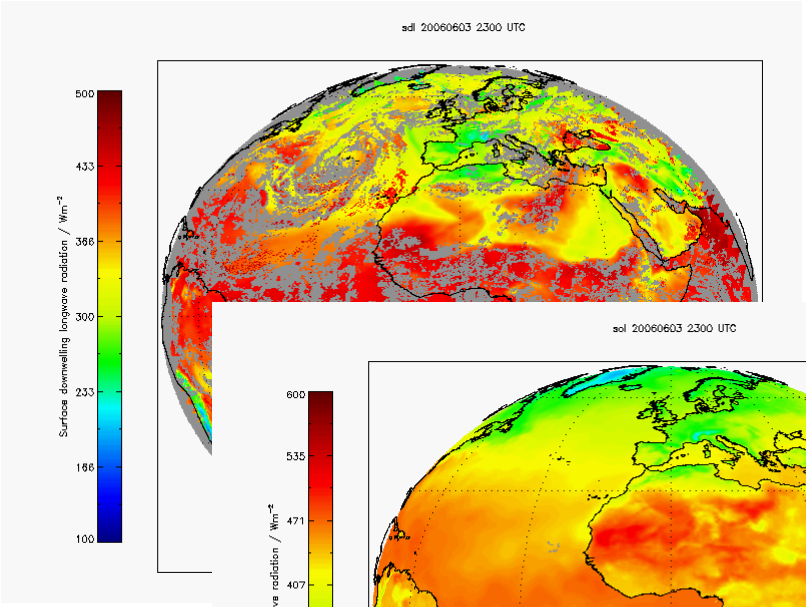
ARG Emitted thermal flux (W/m^2)



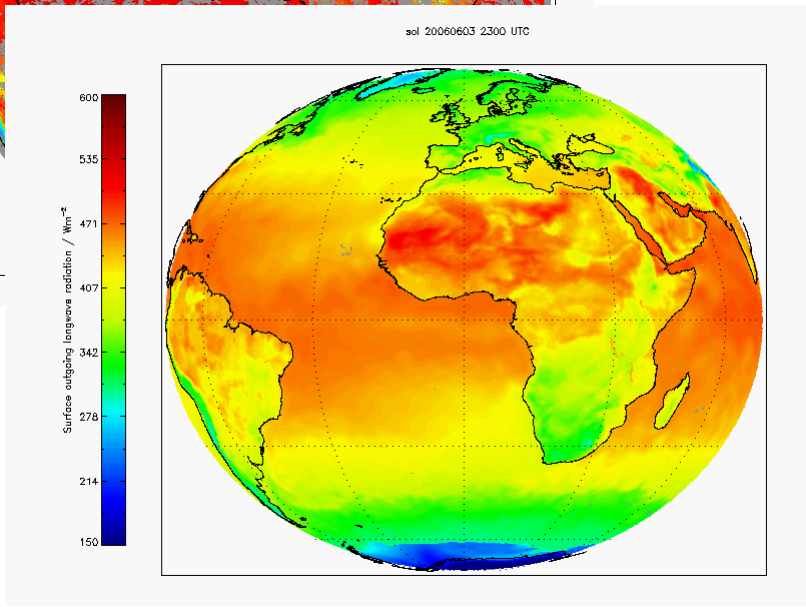
SEVIRI – Surface Radiation Products



Incoming Shortwave

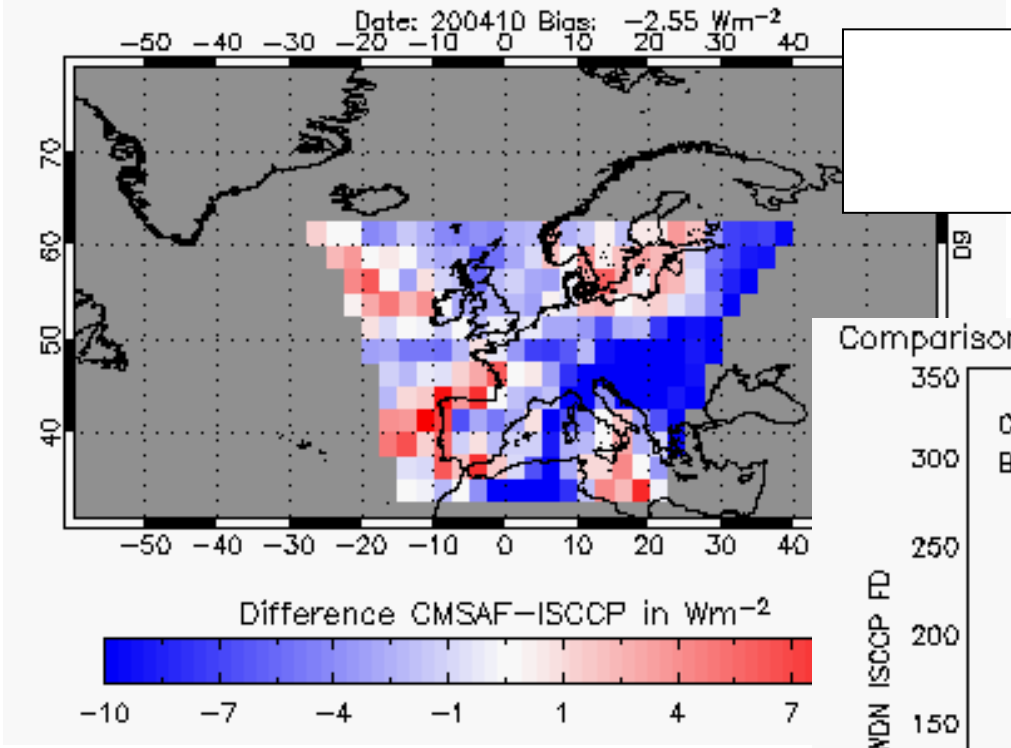


Downwelling Longwave

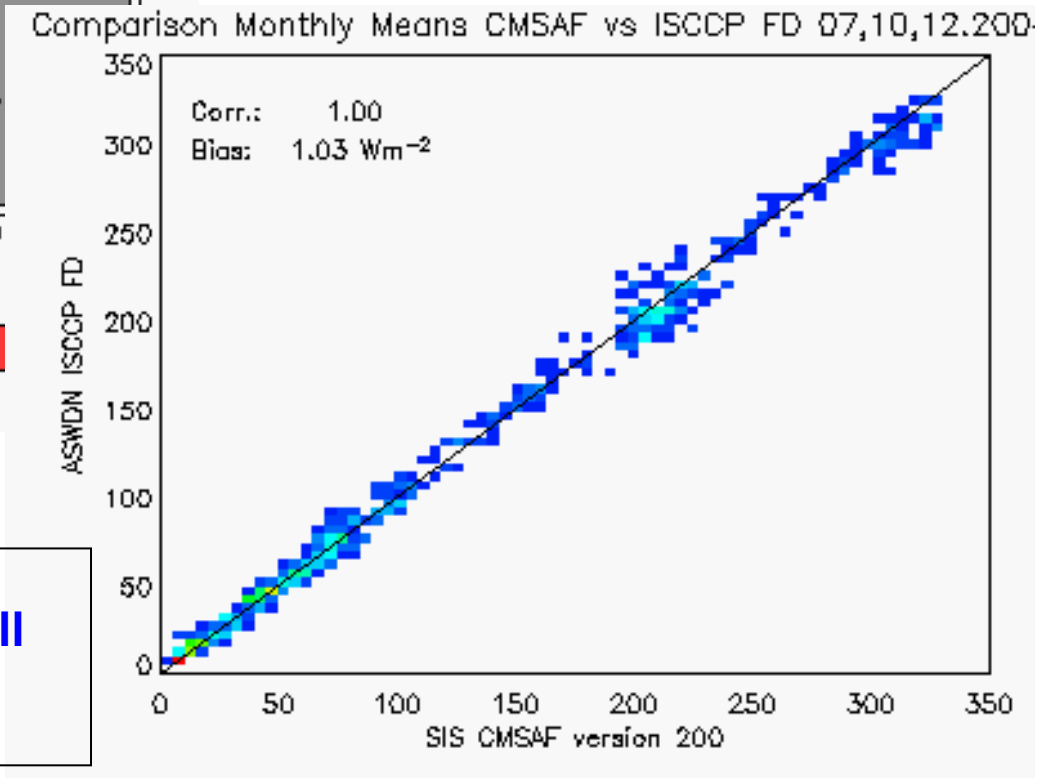


Upwelling Longwave

Comparison of ISCCP-FD vs CMSAF (V2)



Difference CMSAF-ISCCP, in W/m², October 2004



Scatter-plot all data, from all months

Comparison of RFA-data vs CMSAF (3)

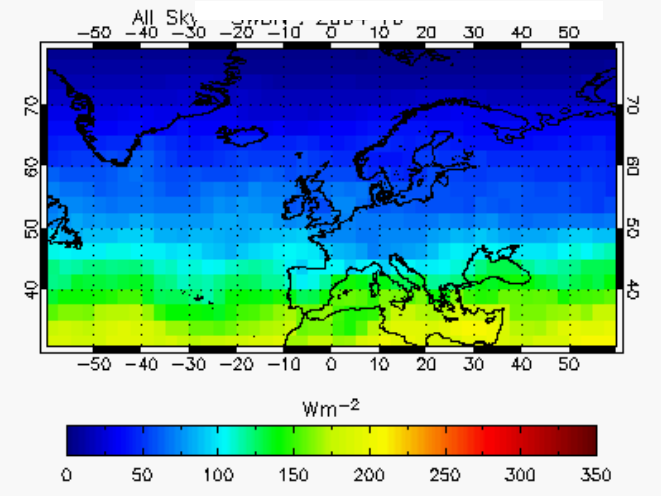
Statistics based on data from 3 months from 2004.

	Bias W/m²	R -	RMSE W/m²	N_data -
ISCCP-ASWDN	**1.0**	**1.0**	**7.6**	**711**
ISCCP-ALWDN	**3.7**	**0.91**	**13.9**	**711**
ISCCP-ALWUP	**6.9**	**0.95**	**16.1**	**711**
ISCCP-ALWNET	**-3.1**	**0.87**	**9.6**	**711**
ISCCP-ASWNET	**-2.2**	**0.99**	**16.1**	**711**
ISCCP-ATOTNET	**-3.8**	**0.99**	**12.3**	**711**
GEWEX-SRB-ASWDN	**-0.8**	**1.0**	**9.4**	**711**

Inter-comparison with GEWEX SRB: daily means (1)

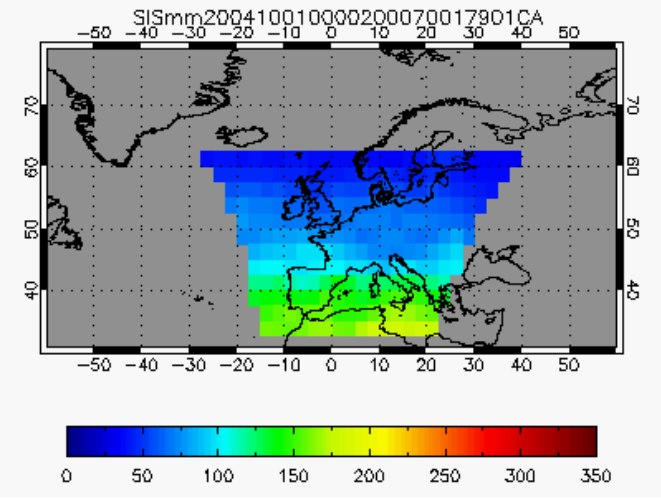
GEWEX SRB-Datasets:

- 1 x 1 deg
- daily means for May-December 2004
- solar & longwave surface radiation



CMSAF-Datasets:

- v200 (MSG – SEVIRI based products)
- 15 km x 15 km (aver. 1° x 1°)
- daily means for May- December 2004
- solar & longwave surface radiation



Surface-Measurements:

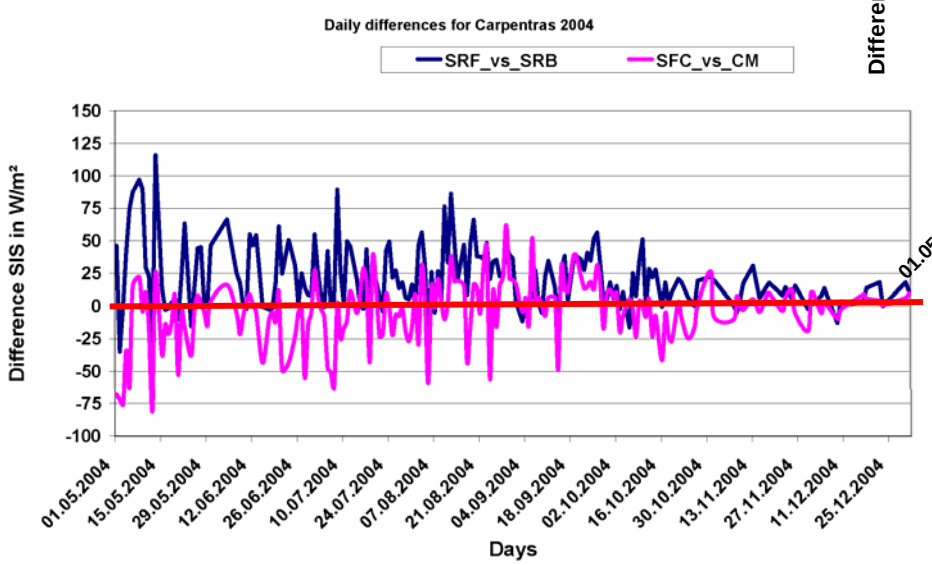
- 4 (BSRN) Stations in Europe
- daily means for May- December 2004
- solar & longwave surface radiation

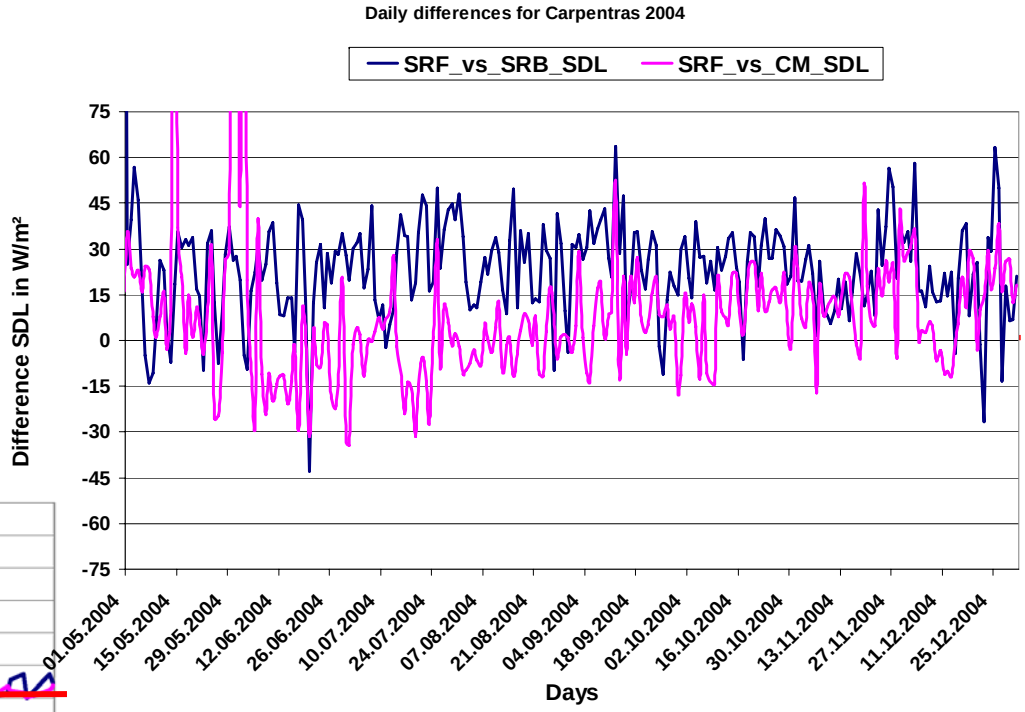
Comparison of GEWEX vs CMSAF: daily means (3)

Differences…

Shortwave:

	SRB	CM-SAF
Bias [W/m²]:	21.8	-4.2
MAB [W/m²]:	24.4	17.7



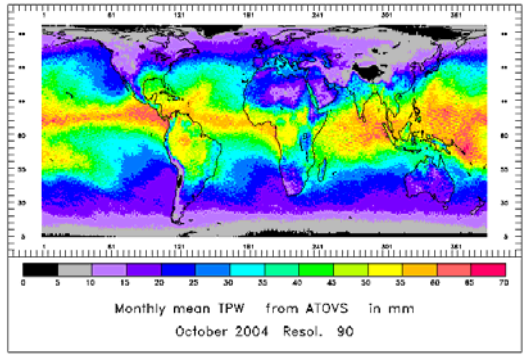


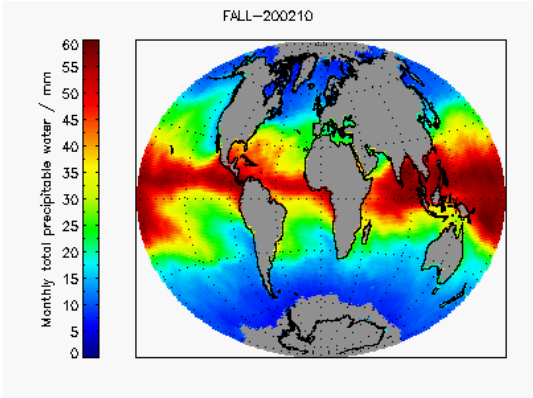
Longwave:

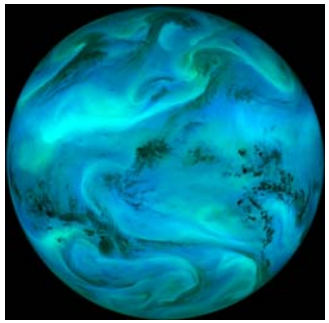
	SRB	CM-SAF
Bias [W/m²]:	23.2	5.9
MAB [W/m²]:	24.8	13.6

CM-SAF version 3 water vapour products

- Instantaneous temperature and mixing ratio profiles (all sounding instruments);
- Total precipitable water (ATOVS, SSM/I and SEVIRI) [individual instrument + family blended];
- Layered precipitable water (ATOVS (5 layers), SEVIRI (3 layers))
- Vertically averaged temperature and relative humidity for the same layers;
- Coverage: global for ATOVS and SSM/I, full disc for SEVIRI (gridding done with OI);
- Temporal resolution: Instantaneous, daily and monthly (diurnal cycle for SEVIRI possible);
- Spatial resolution: Instrument pixel for instantaneous, ~(15km)^2 for SEVIRI, ~(45km)^2 for SSM/I , ~(90km)^2 for ATOVS.





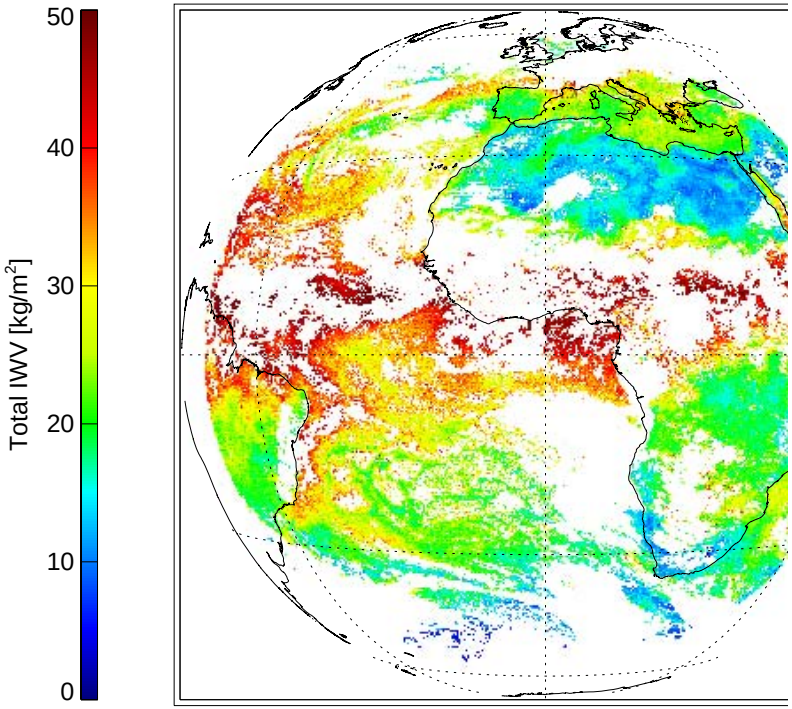


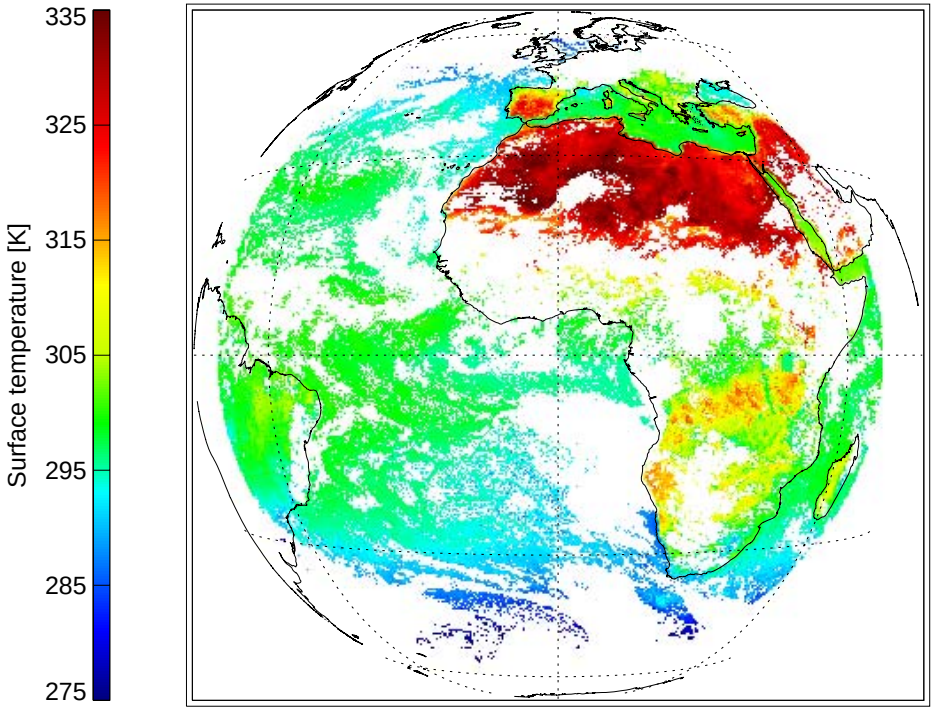
HCP – SEVIRI Retrieval

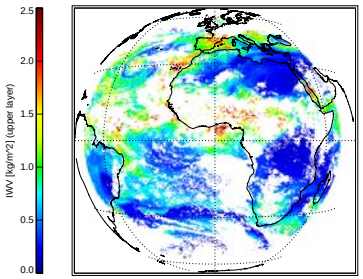
- New retrieval is optimum estimation retrieval employing RTTOV-8.5 for radiative transfer uses 6.2, 7.3, 8.7, 10.8, 12.0, 13.4 μm chan.;
- Surface emissivity derived from MODIS for 2003 (Borbas et al., 2005), Potential later improvement by constructing emissivity from IASI;
- Cloud mask can be either NWC-SAF or FUB. Implementation of others is straight forward. Will try to investigate influence of cloud mask on cut off of WV distribution;
- First guess is climatology from 10.000 radiosondes for the first pixel in image. After one successful solution first guess is neighbouring pixel;
- Needs medium compute power: 3 min for full disk taking every 5th pixel on IBM power 5, i.e. its suitable for real-time applications!
- First validation vs. AMSR: ~no bias, rms~3.5 kgm^{-2} for total col.

Precipitable Water and Surface Temperature

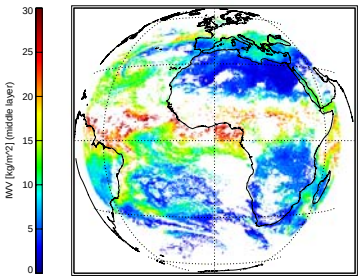
1 July 2004, 12:00 UTC





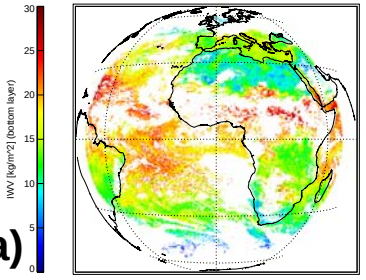


LPW (<500 hPa)

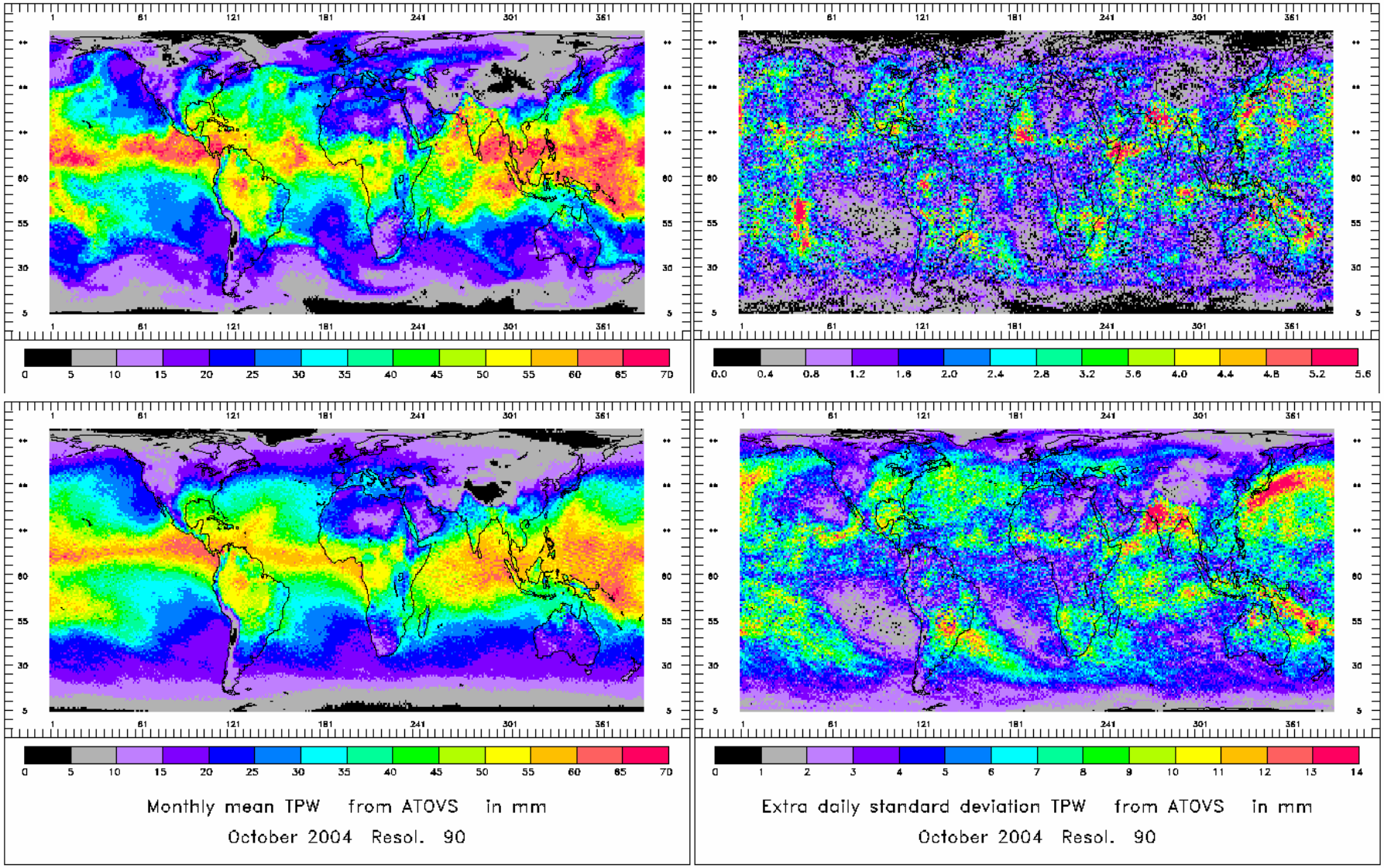


LPW (850-500 hPa)

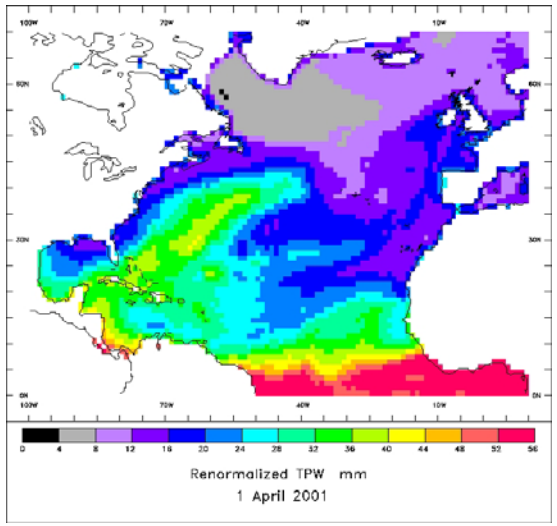
LPW (1000-850 hPa)



ATOVS global TPW October 2004

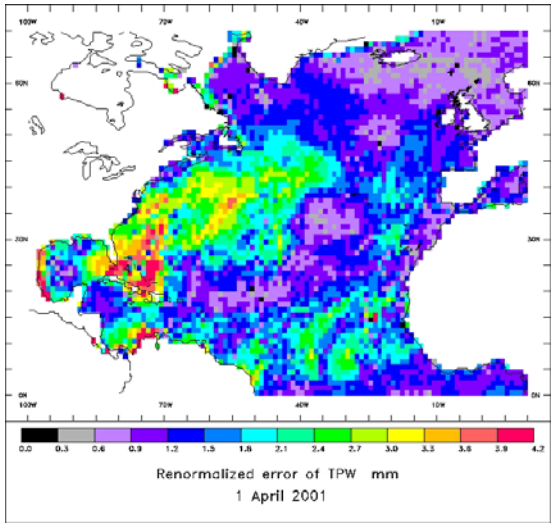


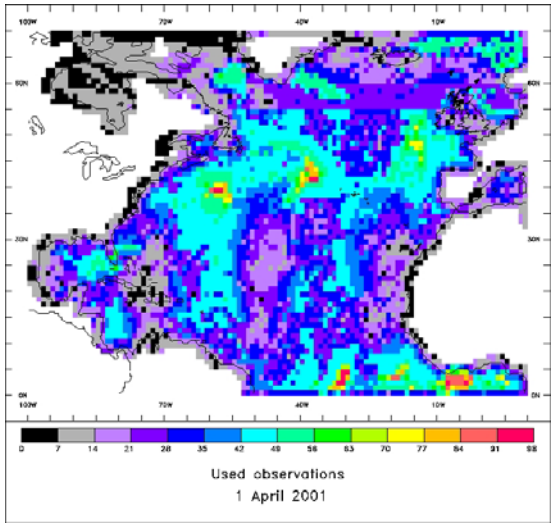
Product example SSM/I

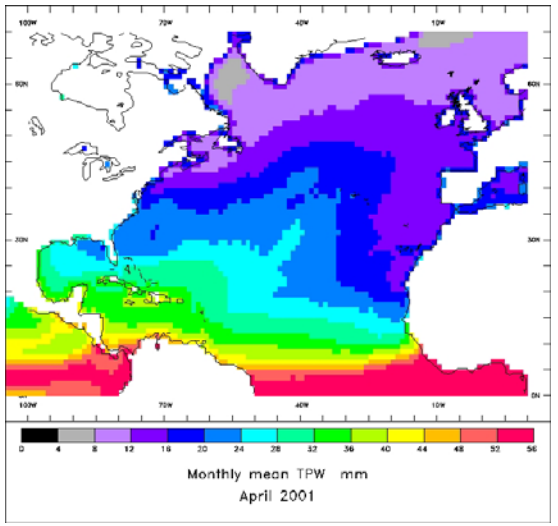


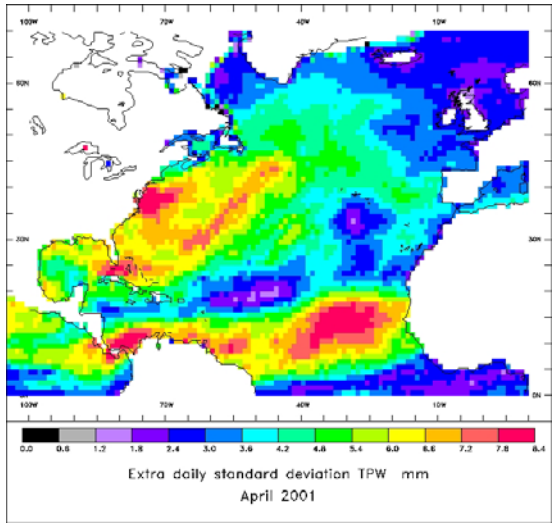
Monthly mean, and extra daily std. (variability) for April.

Daily mean, error, and number of measurements on 1 April.









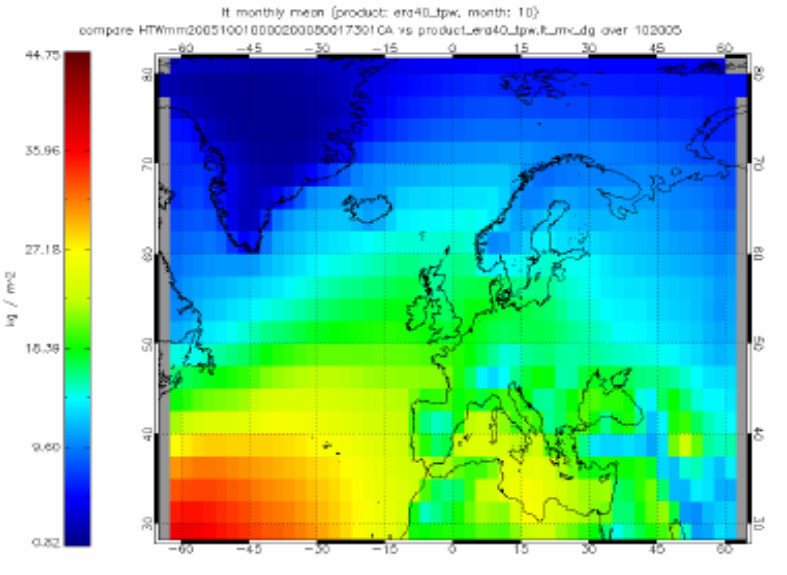
Major Objectives in CDOP (2007-2012)

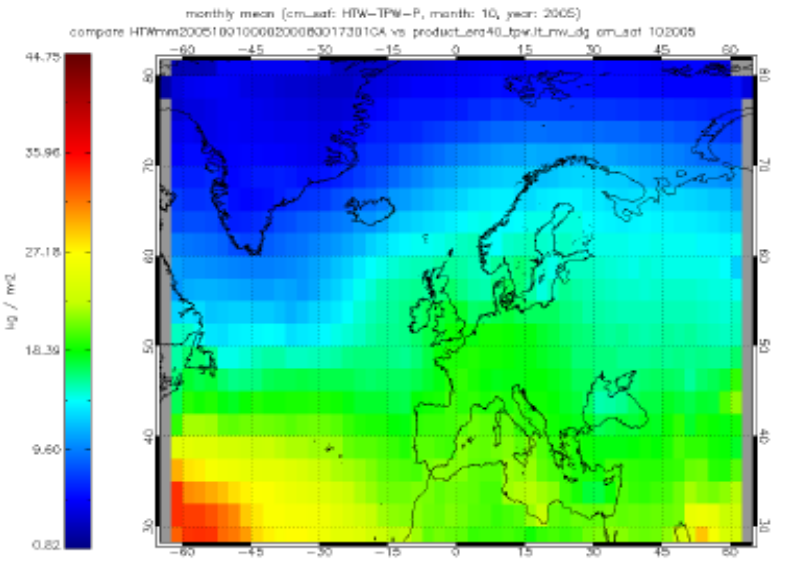
- Improved quality monitoring and assessment of (inter)calibration employing reference site data and radiative transfer modelling;
- Production of long homogeneous thematic climate data records (TCDR) for a couple of parameters based on fundamental climate radiance records (FCDR);
- Extension of spatial coverage from regional to global where appropriate;
- Addition of products to facilitate an improved understanding of the energy and water cycle;
- Enhance the support for the user community using the products for climate monitoring and climate research.

Improved Quality Monitoring

Toolbox for automatic quality control of CM-SAF products versus other datasets, e.g., ERA-40, NCEP-2 reanalysis and NVAP.

CM-SAF monthly mean



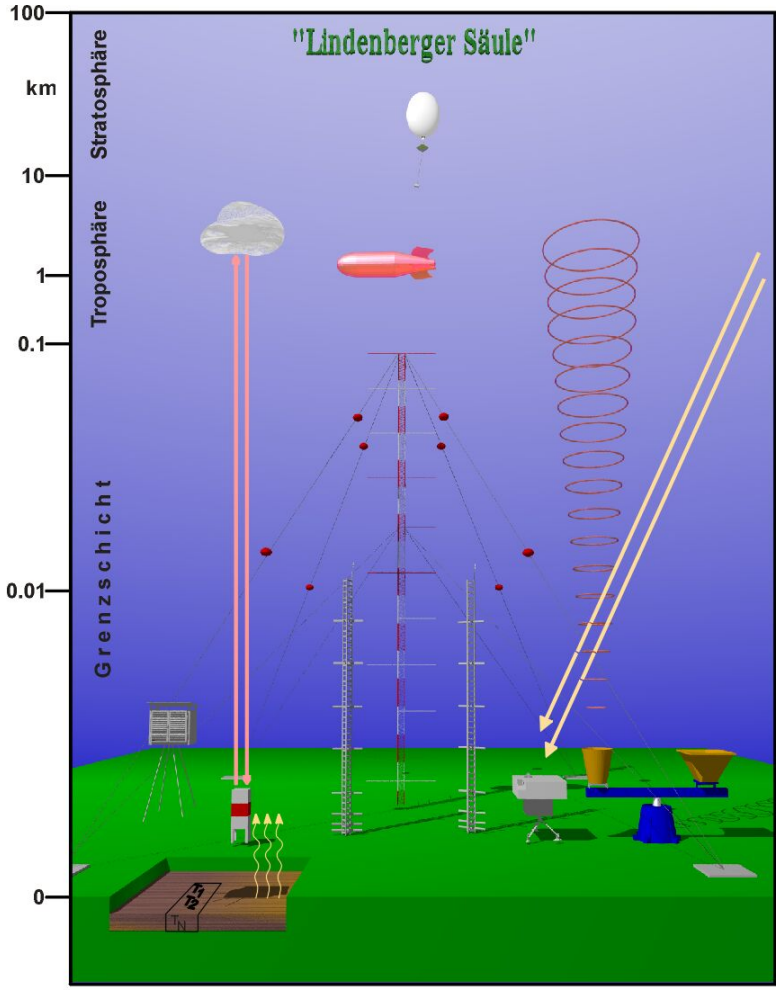


TPW: ERA 40 Oct mean

TPW: CM-SAF V2 product for Oct 2005 from NOAA library search algorithm

TPW: Total Precipitable Water

3D/4D Lindenberg Column



Lindenberger Säule - Meßsystem

bestehend aus : Bodenbeobachtungen, aerologischen Messungen, aktiven und passiven Fernerkundungsmethoden

Planned: Web-based monitoring of CM-SAF products and radiances at high quality reference stations belonging to the CM-SAF consortium (Lindenberg, Cabauw, Sodankylä and Payerne).

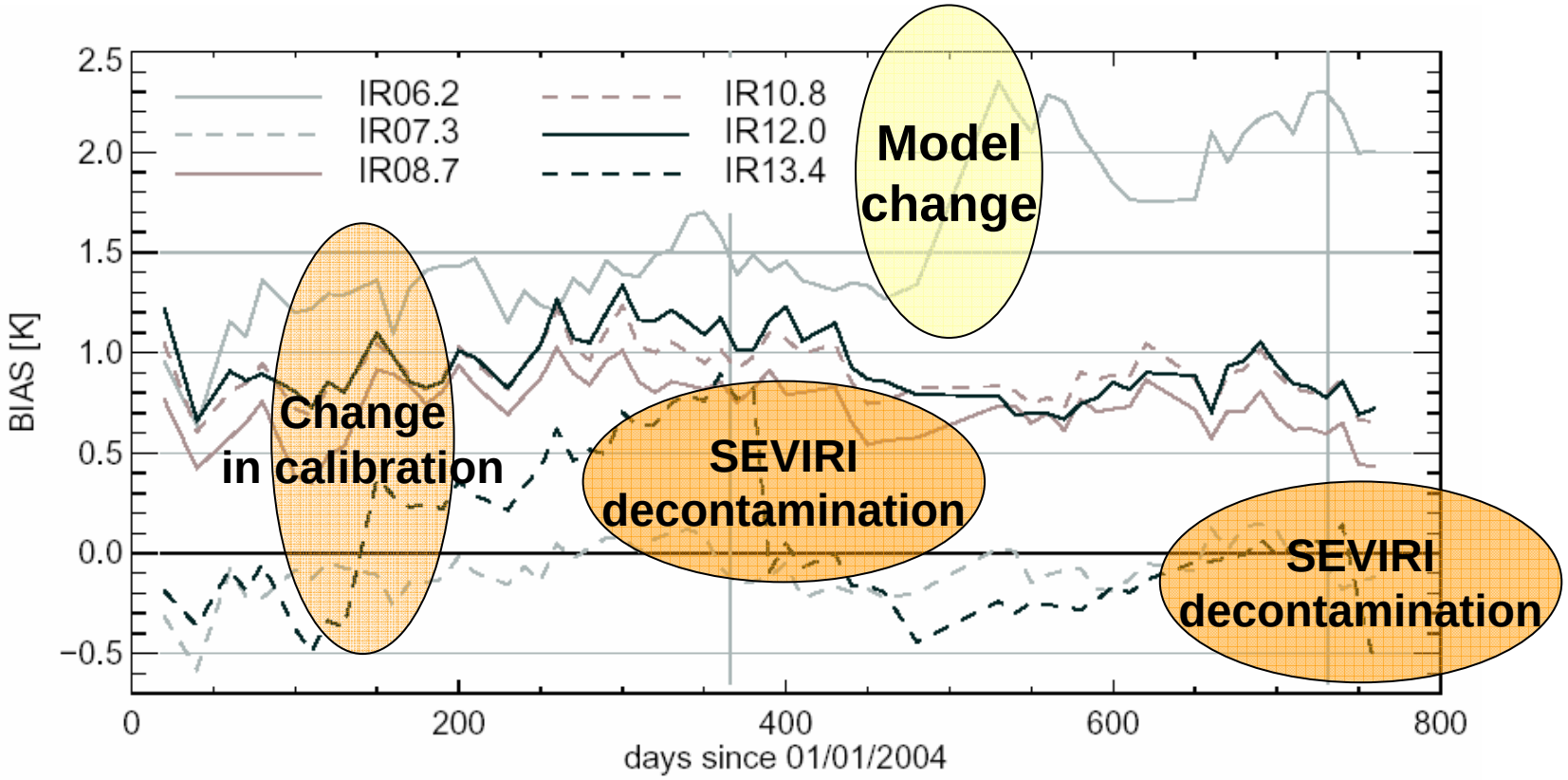
For global products the same will be done for ARM sites.

GABLS reference site

- routinely operating radiosounding (every 6 hours, incl. humidity calibration) – GUAN reference site
- surface broadband and spectral radiance & flux measurements – BSRN reference site

Reprocessing is important !

- BIAS Monitoring, ocean (Simulation(NCEP-GFS) - Observation)



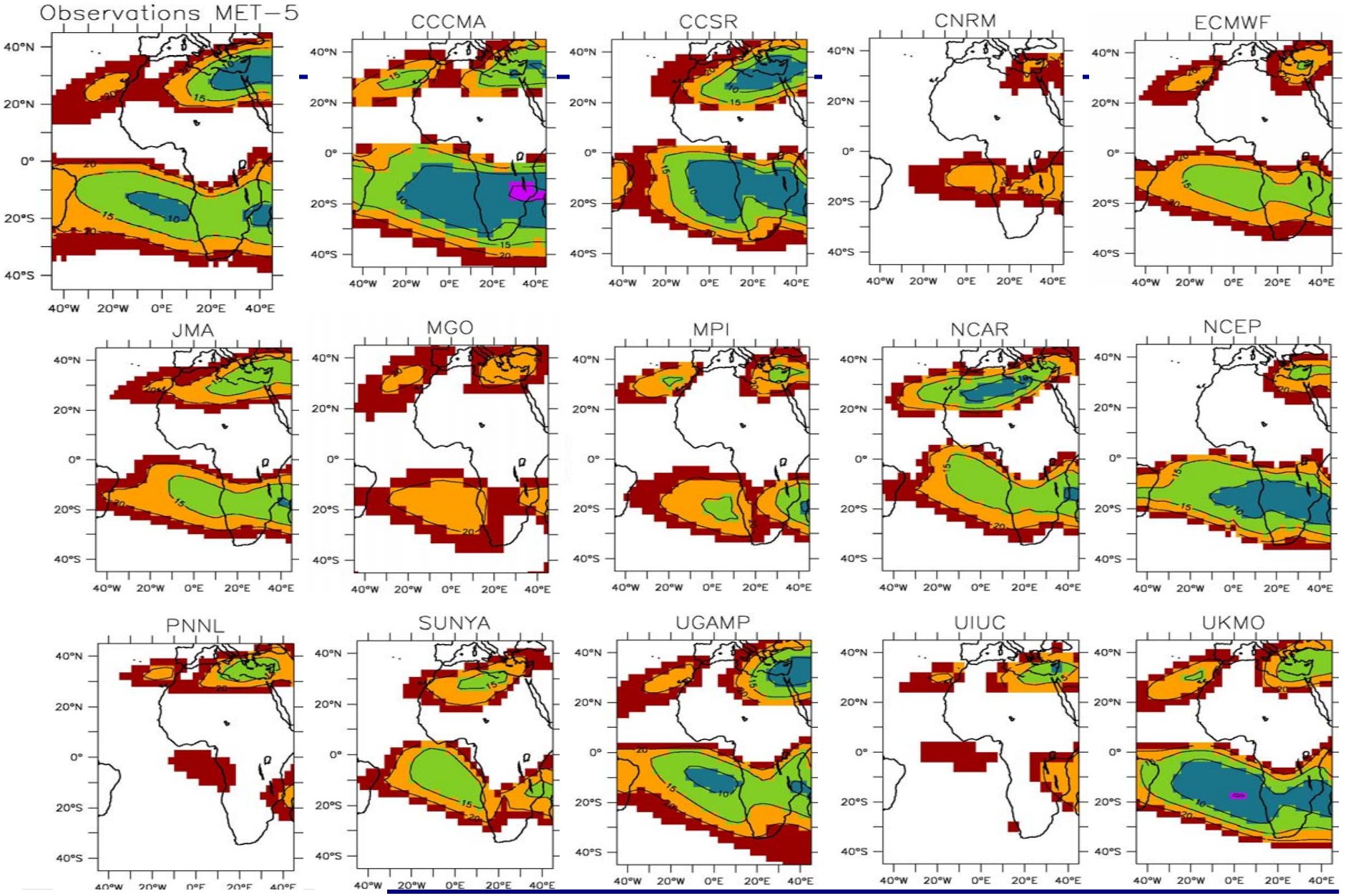
Courtesy of M. Stengel, SMHI

Production of Long Time Series (TCDRs)

- Global AVHRR cloud and surface radiation products based on Patmos-X GAC starting 1982 (partnership with NOAA and U. Wisc.);
- Water vapour and temperature products from polar orbiters including ATOVS, IASI, PMW plus inclusion of GOME (1 and 2) and GRAS (CHAMP, COSMIC) via federation activity of CM-GRAS-O3M SAF (several periods, shortest for EPS);
- SEVIRI+GERB cloud, radiation (top + surface), and vertical resolved water vapour products (2004-2010);
- Import and continuation of mature research products:
  - UTH from MFG and MSG (1983 – 2010), collaborative effort with LMD, Paris, France.
  - Turbulent heat flux + precipitation data set HOAPS (1987 – 2010), collaborative effort with Max-Planck Institute for Meteorology, Hamburg, Germany.

Perspectives AMIP2: Comparing summer 1984-1995

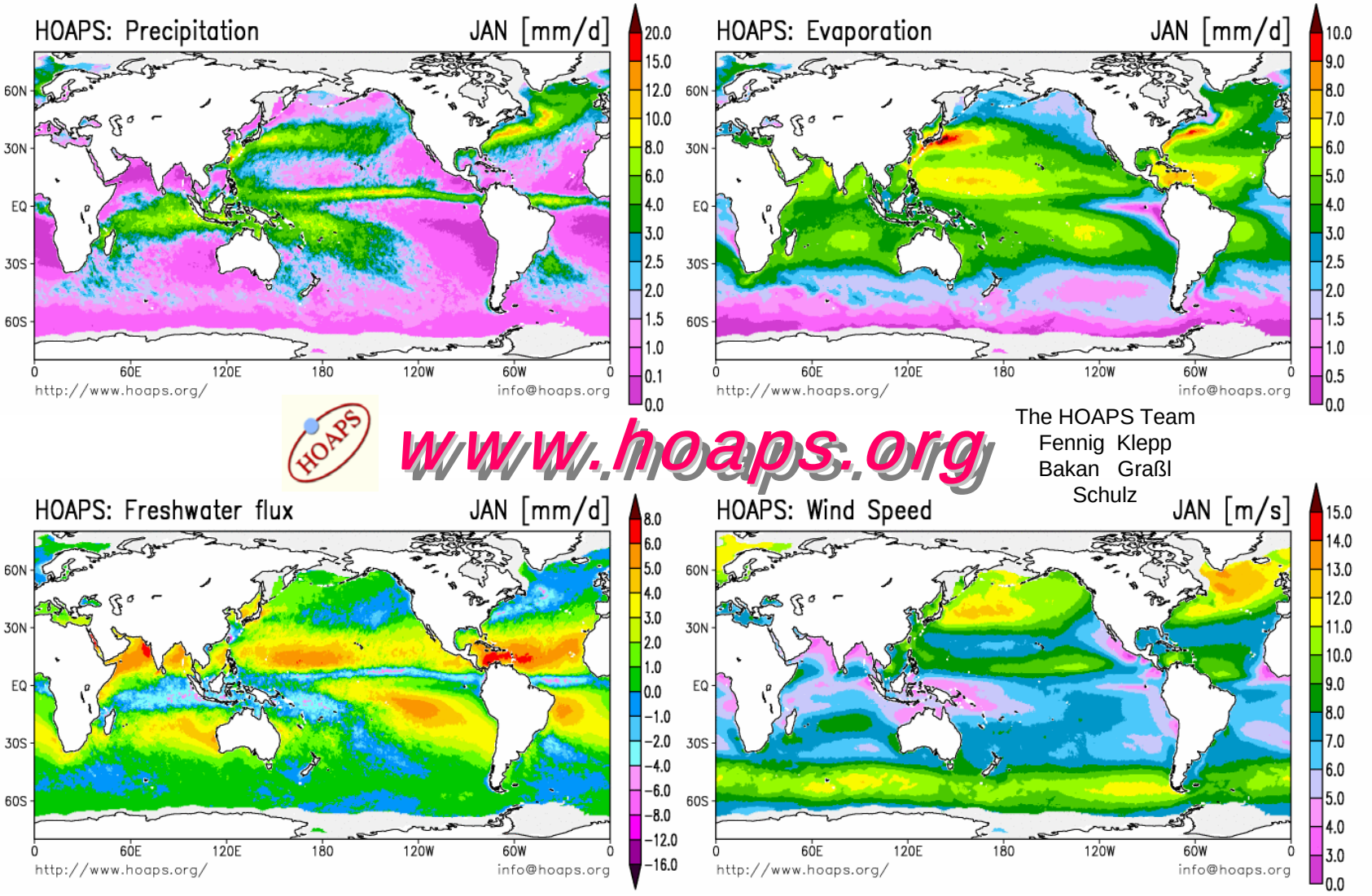
Brogniez et al., 2005, GRL



Courtesy of Rémy Roca

The HOAPS-II Data Set

Courtesy of Christian Klepp



Conclusions I

- CM-SAF has build data processing system for water vapour – cloud – radiation products using several polar and geostationary instruments that allows for reprocessing of large data volumes;
- Version 3 GERB and SEVIRI products will be on full disc (water vapour utilises an improved retrieval scheme);
- Version 3 water vapour products from polar orbiting instruments are global and provide error information (will be further improved in CDOP);
- Automated comparison tools for evaluating CM-SAF versus re-analysis are in place;
- Within CDOP product monitoring will be established ranging from radiance to gridded product employing reference site data (For EPS radiosondes matching overpasses will be launched with federated activity on H2O).

Conclusions II

- Usefulness of near real time integrated products depends largely on the stability of the calibration, some are only usable for sub-seasonal analysis, e.g. SEVIRI, others like SSM/I are already inter-calibrated;
- CDOP will see integration of long time series for core products based on inter- and recalibrated radiances, e.g. Patmos-X AVHRR and UTH Meteosat exercises;
- Multi sensor approach for water vapour allows for the analysis of differences between observing systems (4 independent systems from UV/VIS, IR, MW, and RO are used);
- High spatial resolution products are useful for validation of future regional re-analysis and may have value for statistical downscaling and validation of dynamical downscaling;

Conclusions III

- Addition of turbulent heat fluxes and precipitation over oceans in the frame of GRP SEAFLUX have potential for net energy flux estimates (currently experimental work at NASA GISS combining ISCCP and HOAPS is underway) and provides an alternative E-P field;
- The CDOP (2007-2012) of EUMETSAT Satellite Application Facilities will run in parallel to the new ERA and possible EURRA projects, i.e. a structural frame to support both is existing;
- CM-SAF took lead on most EUMETSAT SAF-network federation activities so will somehow lead the integration of SAF network products related to climate, e.g. assure same grid representations.