CM SAF Global temperature and moisture products from ATOVS

Nathalie Courcoux

TPW / kg m^{-2}

0 10 20 30 40 50 60 70
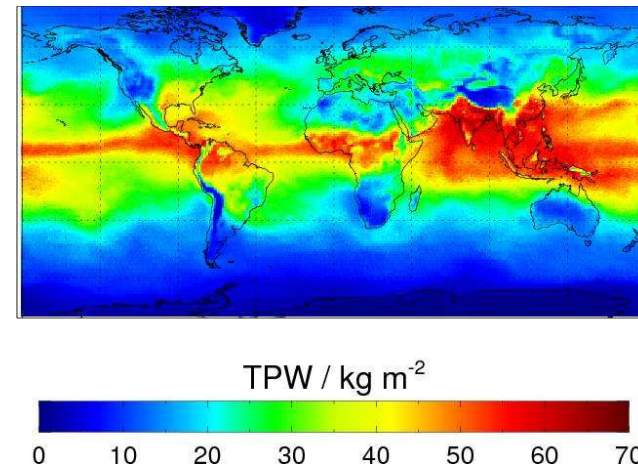
Deutscher Wetterdienst
www.cmsaf.eu

Outline

- Which CM SAF products are we talking about

- Description of the instruments and satellites

- Satellite remote sensing and inverse theory

- Algorithm description of the processing chain

- Description of the final products
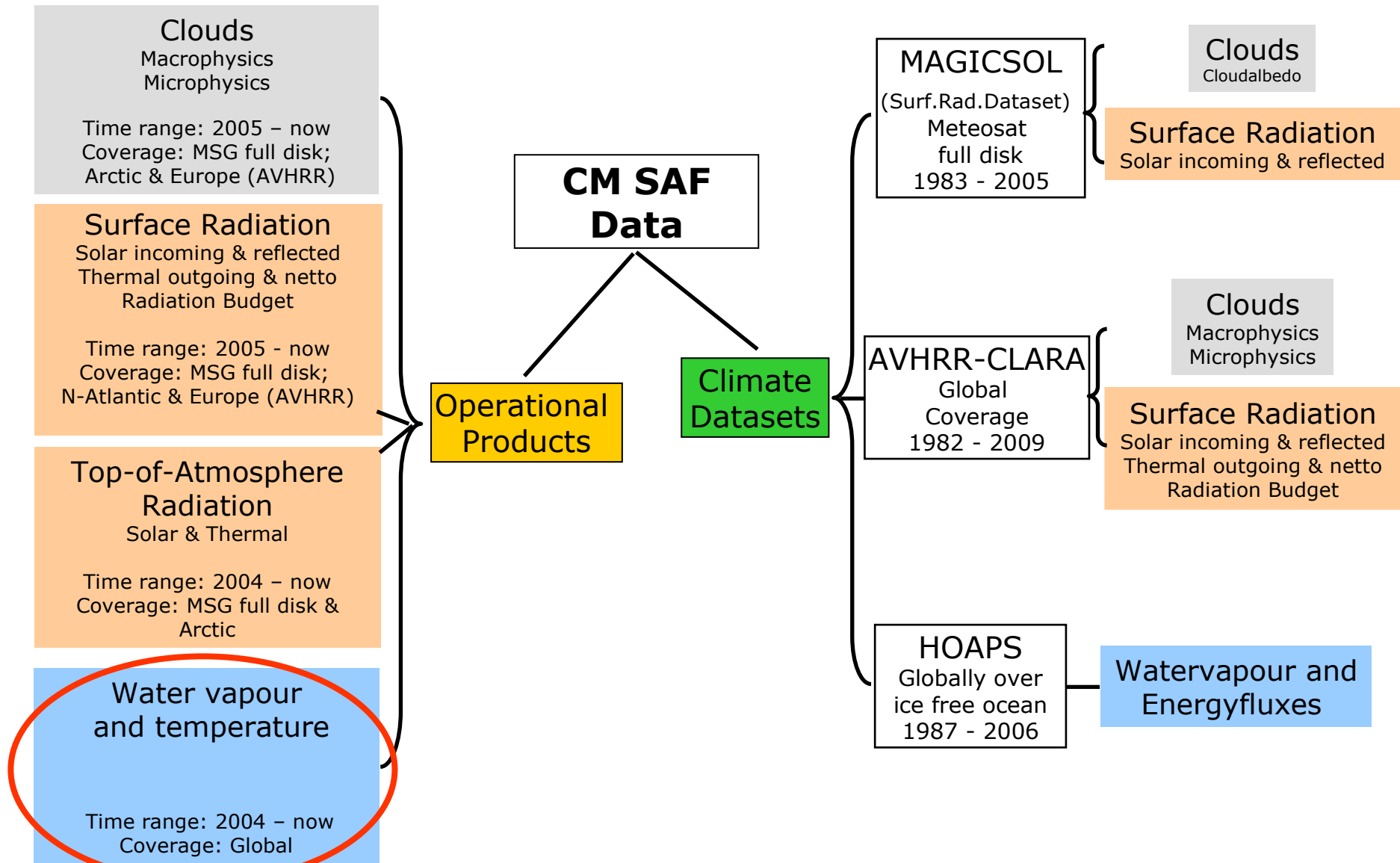
- Validation

- Conclusion

Survey 1

On this page put a survey:
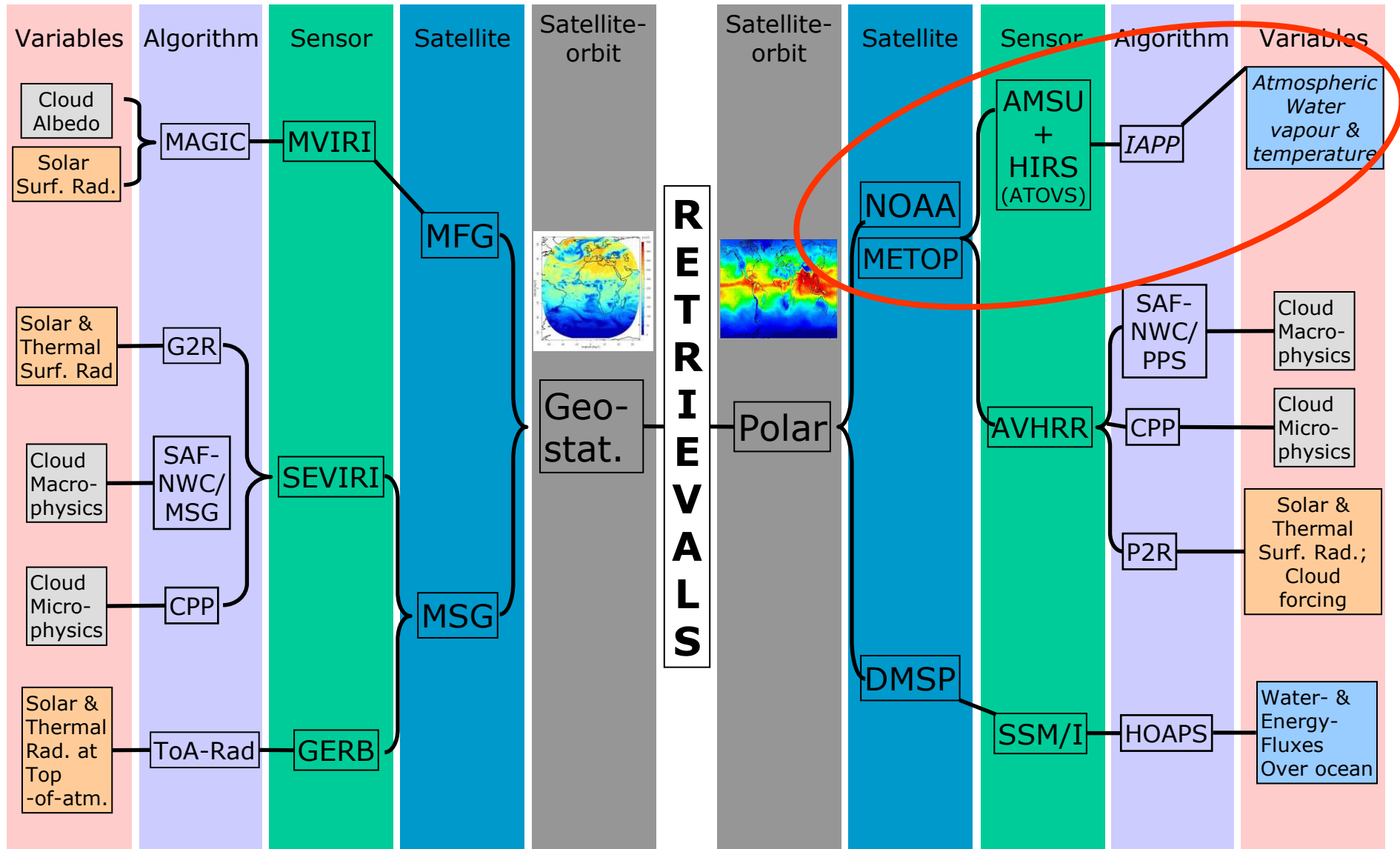Did you already worked with satellite products or satellite data?

Yes

No

CM SAF products

The EUMETSAT Network of Satellite Application Facilities

CM SAF
Climate Monitoring

DWD
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

CM SAF Data

Operational Products

Clouds
Macrophysics
Microphysics

Time range: 2005 – now
Coverage: MSG full disk;
Arctic & Europe (AVHRR)

Surface Radiation
Solar incoming & reflected
Thermal outgoing & netto
Radiation Budget

Time range: 2005 - now
Coverage: MSG full disk;
N-Atlantic & Europe (AVHRR)

Top-of-Atmosphere Radiation
Solar & Thermal

Time range: 2004 – now
Coverage: MSG full disk &
Arctic

Water vapour and temperature

Time range: 2004 – now
Coverage: Global

Climate Datasets

MAGICSOL
(Surf.Rad.Dataset)
Meteosat
full disk
1983 - 2005

Clouds
Cloudalbedo

Surface Radiation
Solar incoming & reflected

AVHRR-CLARA
Global
Coverage
1982 - 2009

Clouds
Macrophysics
Microphysics

Surface Radiation
Solar incoming & reflected
Thermal outgoing & netto
Radiation Budget

HOAPS
Globally over
ice free ocean
1987 - 2006

Watervapour and Energyfluxes

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CM SAF products

Variables	Algorithm	Sensor	Satellite	Satellite-orbit		Satellite-orbit	Satellite	Sensor	Algorithm	Variables
Cloud Albedo	MAGIC	MVIRI	MFG				NOAA	AMSU + HIRS (ATOVS)	IAPP	Atmospheric Water vapour & temperature
Solar Surf. Rad.							METOP			
Solar & Thermal Surf. Rad	G2R			Geo-stat.	RETRIEVALS	Polar		AVHRR	SAF-NWC/PPS	Cloud Macro-physics
Cloud Macro-physics	SAF-NWC/MSG	SEVIRI	MSG						CPP	Cloud Micro-physics
Cloud Micro-physics	CPP								P2R	Solar & Thermal Surf. Rad.; Cloud forcing
Solar & Thermal Rad. at Top-of-atm.	ToA-Rad	GERB					DMSP	SSM/I	HOAPS	Water- & Energy-Fluxes Over ocean

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Instruments

- Different types of instruments can fly onboard satellites
- Active/passive
- Imager/sounders (Infrared (IR)/Visible/Microwave (MW))
- Solar occultation, radio occultation
- Different geometries: nadir, limb
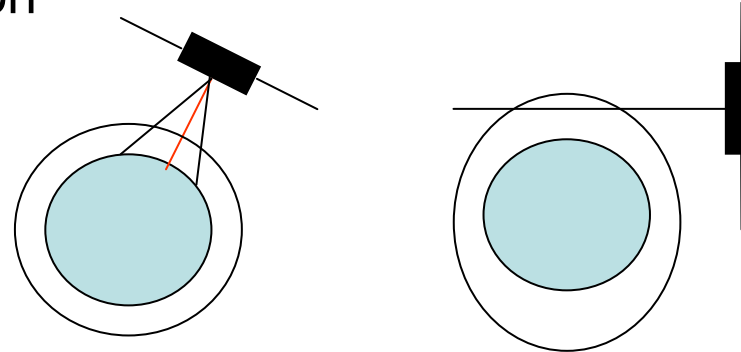
- ATOVS is a group of 3 instruments
- Passive/sounder
- 1 IR instrument HIRS (High resolution InfraRed Sounder)
- 2 MW instruments AMSU-A and AMSU-B (Advanced Microwave Sounding Unit-A and B) and later MHS (Microwave Humidity Sounder)

Instruments

- Cross track scanners
- Spatial resolution: HIRS: 18.9 km, AMSU-A: 48km and AMUS-B: 16 km

- HIRS has 20 channels :
  - ✓ For temperature and humidity profiles + cloud information (cloud cover, cloud top height and temperature, cloud phase)+ surface albedo

19 IR channel, 1 channel in the visible
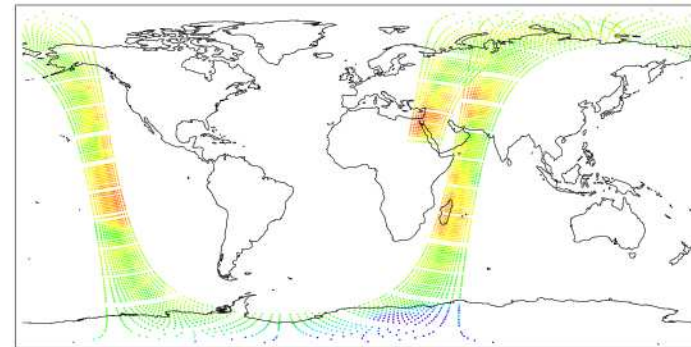
- AMSU-A has 15 channels:
  - ✓ For temperature sounding

12 channels on the 57 GHz O_2 band
  - ✓ For tropospheric water vapour, precipitation over ocean, sea ice coverage or other surface characteristics

3 channels at 23.8, 31.4, and 89 GHz

- AMSU-B has 5 channels:
  - ✓ For tropospheric water vapour and precipitation

3 channels on the 183.31 GHz H_2O line
  - ✓ For surface characteristics

2 channels at 89 and 150 GHz
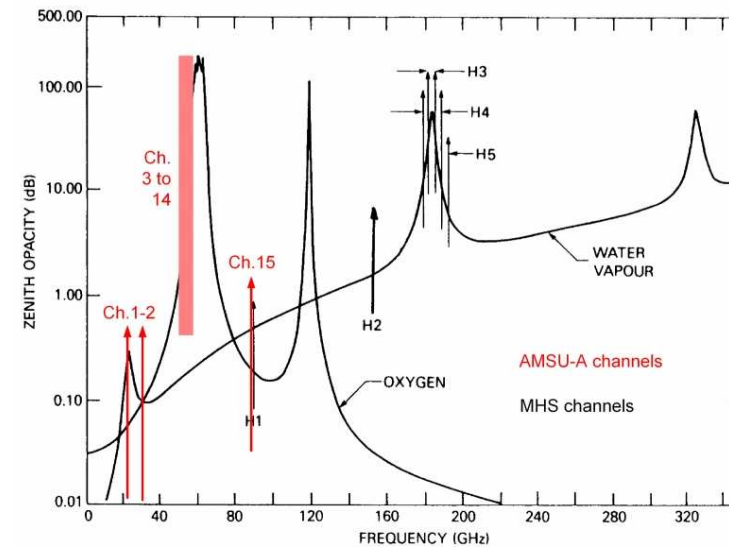
Image from EUMETSAT

Instruments

BT
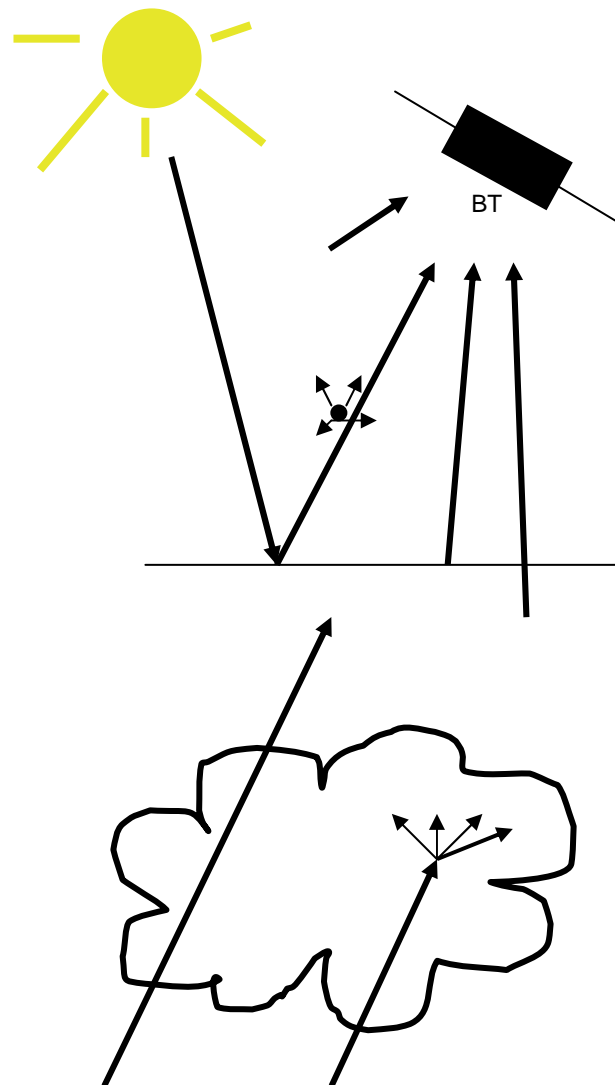
- Atmosphere and surface emit, transmit, reflect and scatter electromagnetic radiations

- The different type of radiations can be measured by dedicated sensors

- The radiation (emitted/reflected…) detected by the sensor can be related, depending on its wavelength, to the temperature or the moisture of the observed atmosphere or surface

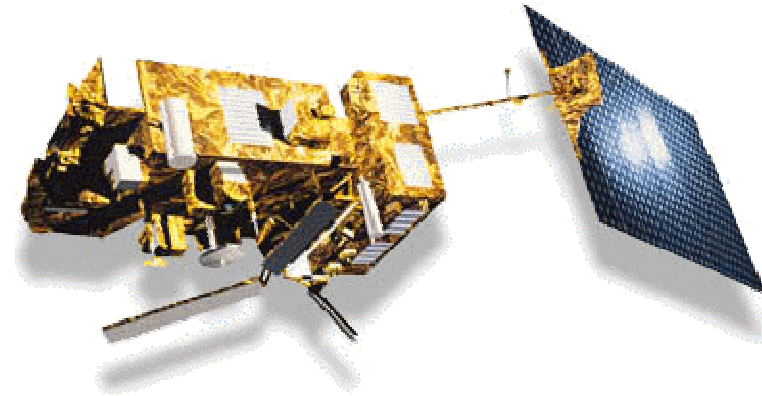- IR and MW remote sensing have different properties due to different wavelength
  - ➔ MW: humidity observations under all weather conditions
  - ➔ IR: cloud observations

Satellites

NOAA satellites:

NOAA-15, 16, 17, 18, 19
Launched in 1998,2000, 2002,
2005, and 2009

MetOp:

1 MetOp so far, launched in 2006
MetOp-B launched planned for 2012

Polar orbit /sun synchronous orbit
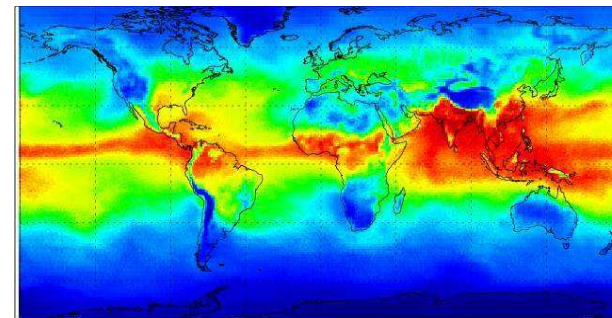
Images from http://www.dk3wn.info

Satellites

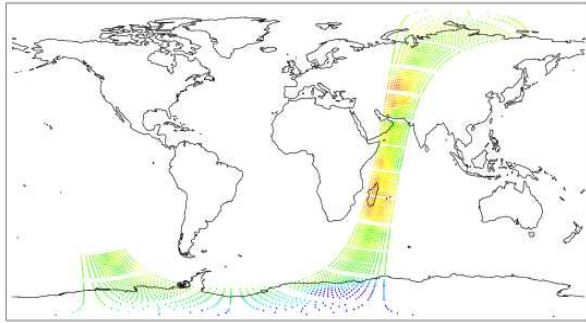Instruments flying onboard geostationary satellite don't provide global data
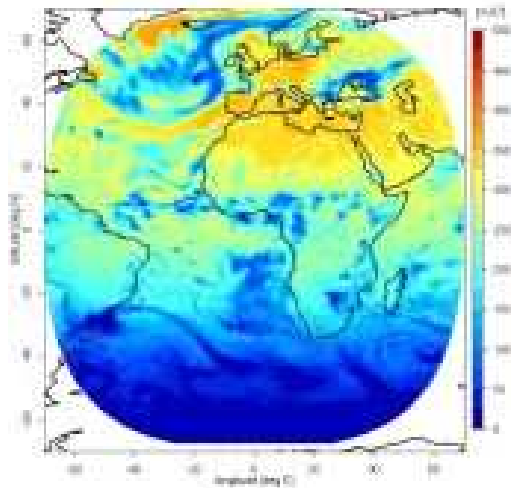
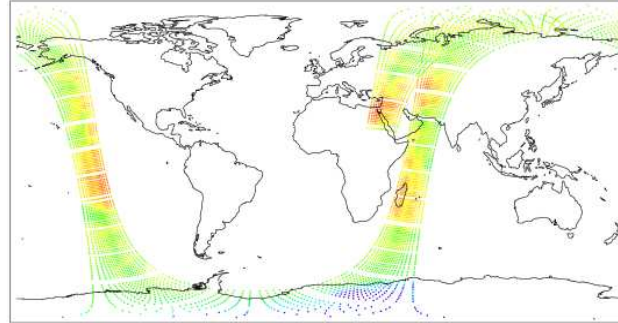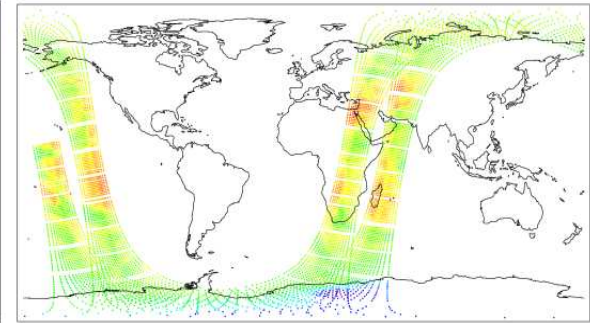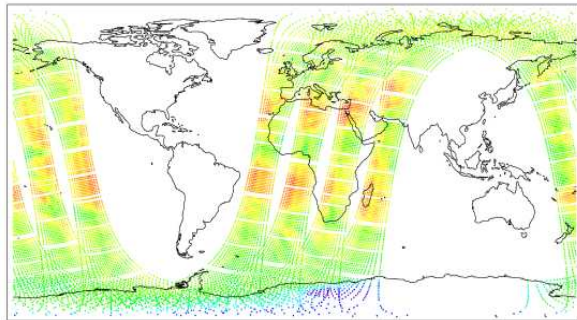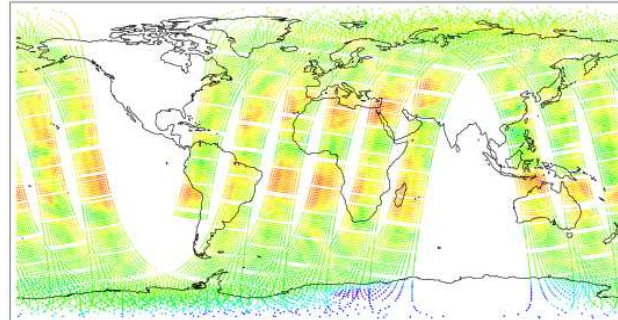Here I would like to insert the video showing the orbit of a polar orbiting satellite
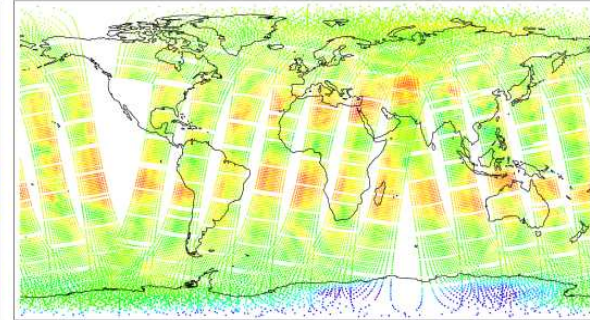
leo.swf

Satellites

1 hour

2 hours

3 hours

6 hours

9 hours

12 hours

18 hours

1 day

2 days
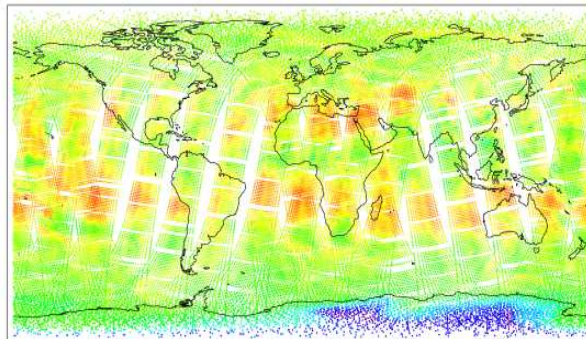
Nathalie Courcoux - Global temperature and moisture CM SAF products from ATOVS
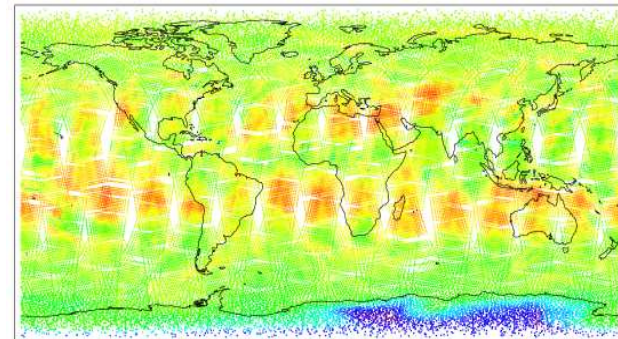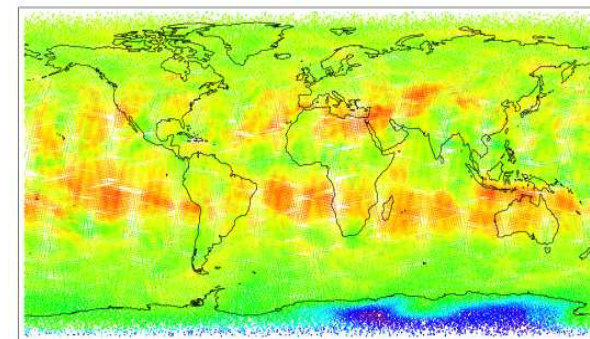
Survey 2

On this page put a survey:

Is the concept of retrieval of satellite data familiar to you?

Yes

No

Inverse theory
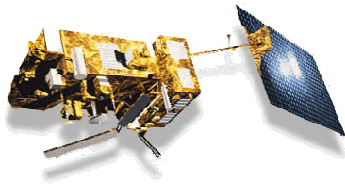
BT **?** ⟶ Atmospheric Temperature
Atmospheric Water vapour

Geophysical parameters

? **?**

Dog
Wolf
Cat
Elephant
Mouse

Inverse theory

$$\vec{y} = \vec{f}(\vec{x})$$

Measurements

(satellite radiance)

State vector

(Temperature, humidity, ozone)

The problem is ill-posed and the physics not straightforward

One needs to use statistical methods (linear regression, optimal estimation, neural network, statistical classification)

In our case optimal estimation is used, it implies the use of an "a priori"

The a priori will be the output of a NWP model

Algorithm

FindATOVS_Data.pl
FAD

Csobank-Call, gets level 1c ATOVS data in Bufr-Format for 3 days (incremental)

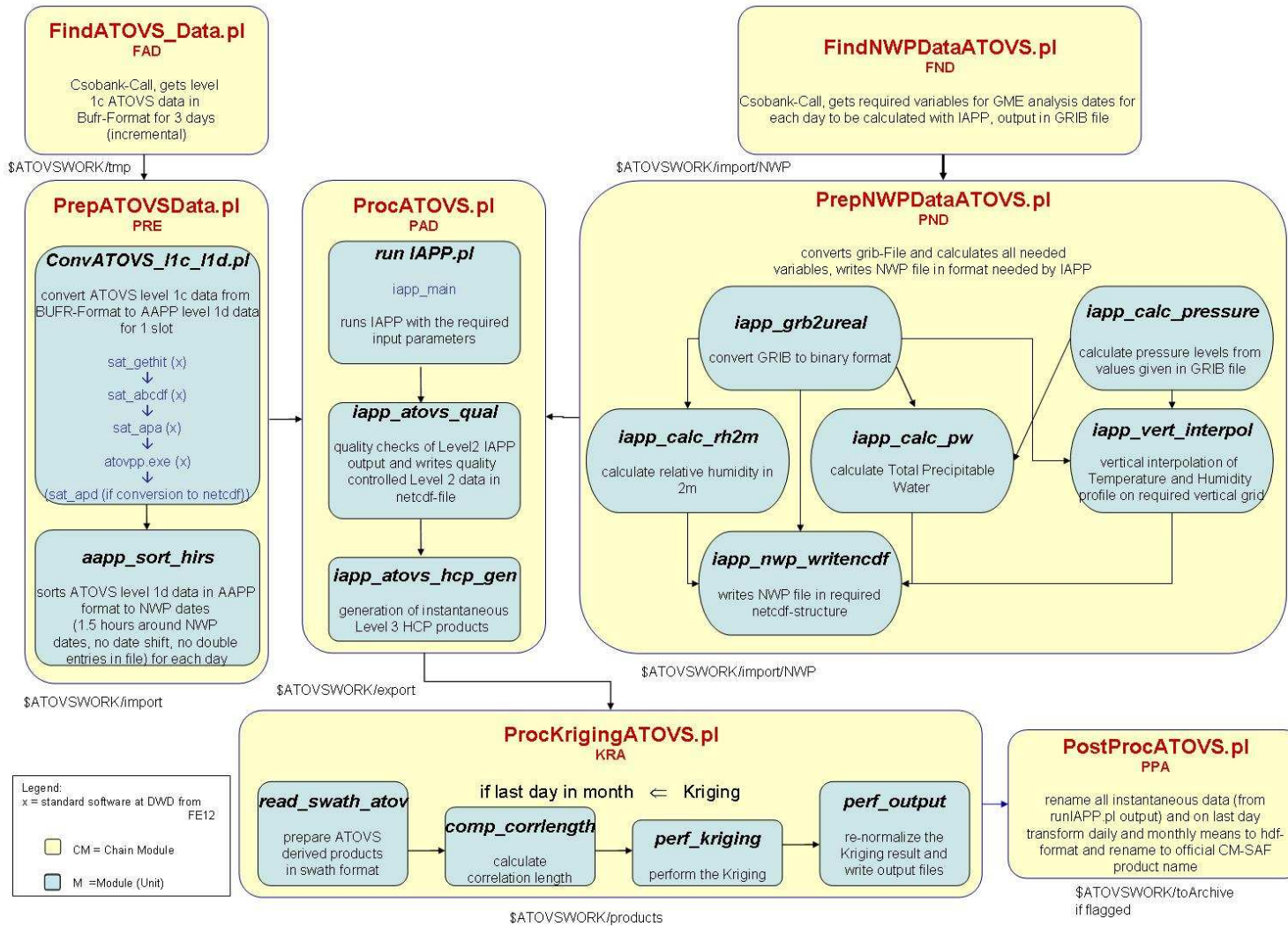$ATOVSWORK/tmp

FindNWPDataATOVS.pl
FND

Csobank-Call, gets required variables for GME analysis dates for each day to be calculated with IAPP, output in GRIB file

$ATOVSWORK/import/NWP

PrepATOVSData.pl
PRE

ConvATOVS_l1c_l1d.pl

convert ATOVS level 1c data from BUFR-Format to AAPP level 1d data for 1 slot

sat_gethit (x)
↓
sat_abcdf (x)
↓
sat_apa (x)
↓
atovpp.exe (x)
↓
sat_apd (if conversion to netcdf)

aapp_sort_hirs

sorts ATOVS level 1d data in AAPP format to NWP dates (1.5 hours around NWP dates, no date shift, no double entries in file) for each day

$ATOVSWORK/import

ProcATOVS.pl
PAD

run IAPP.pl

iapp_main

runs IAPP with the required input parameters

iapp_atovs_qual

quality checks of Level2 IAPP output and writes quality controlled Level 2 data in netcdf-file

iapp_atovs_hcp_gen

generation of instantaneous Level 3 HCP products

$ATOVSWORK/export

PrepNWPDataATOVS.pl
PND

converts grib-File and calculates all needed variables, writes NWP file in format needed by IAPP

iapp_grb2ureal

convert GRIB to binary format

iapp_calc_pressure

calculate pressure levels from values given in GRIB file

iapp_calc_rh2m

calculate relative humidity in 2m

iapp_calc_pw

calculate Total Precipitable Water

iapp_vert_interpol

vertical interpolation of Temperature and Humidity profile on required vertical grid

iapp_nwp_writencdf

writes NWP file in required netcdf-structure

$ATOVSWORK/import/NWP

ProcKrigingATOVS.pl
KRA

if last day in month ⇐ Kriging

read_swath_atov

prepare ATOVS derived products in swath format

comp_corrlength

calculate correlation length

perf_kriging

perform the Kriging

perf_output

re-normalize the Kriging result and write output files

$ATOVSWORK/products

PostProcATOVS.pl
PPA

rename all instantaneous data (from runIAPP.pl output) and on last day transform daily and monthly means to hdf-format and rename to official CM-SAF product name

$ATOVSWORK/toArchive
if flagged

Legend:
x = standard software at DWD from FE12

☐ CM = Chain Module

☐ M = Module (Unit)

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IAPP

- The IAPP is the retrieval software that CM SAF uses to process the ATOVS data
- It is the core of the processing chain
- IAPP stands for International ATOVS Processing Package
- It was developed by the University of Wisconsin in Madison

- It uses the optimal estimation method
- It retrieves :
  - Atmospheric temperature profile (on 42 levels)
  - Moisture profile (on 42 levels)
  - Atmospheric total ozone
  - Surface skin temperature
  - Microwave surface emissivity

- For more information about IAPP: "Global sounding of the atmosphere from ATOVS measurements: the algorithm and validation" by Jun Li *et al,* Journal of applied meteorology volume 39, 1999

On this page put a survey:

Did you ever work or had a look at the CM SAF ATOVS products?

Yes

No

- Time period: 2004 - now
- In total 28 products are available as global daily and monthly means on a cylindrical equal area projection of 90kmx90km

  - HTW:
  - vertically integrated water vapour of the atmospheric column from the surface to 100 hPa

  - HLW:
  - layered vertically integrated water vapour
  - layered mean temperature
  - layered relative humidity
  - 5 layers
  - 300 to 200 hPa, 500 to 300 hPa, 700 to 500 hPa, 850 to 700 hPa, and surface to 850 hPa

  - HSH:
  - temperature
  - water vapour mixing ratio
  - 6 pressure levels
  - 200 hPa, 300 hPa, 500 hPa, 700 hPa, 850 hPa, and 1000 hPa).

ATOVS products
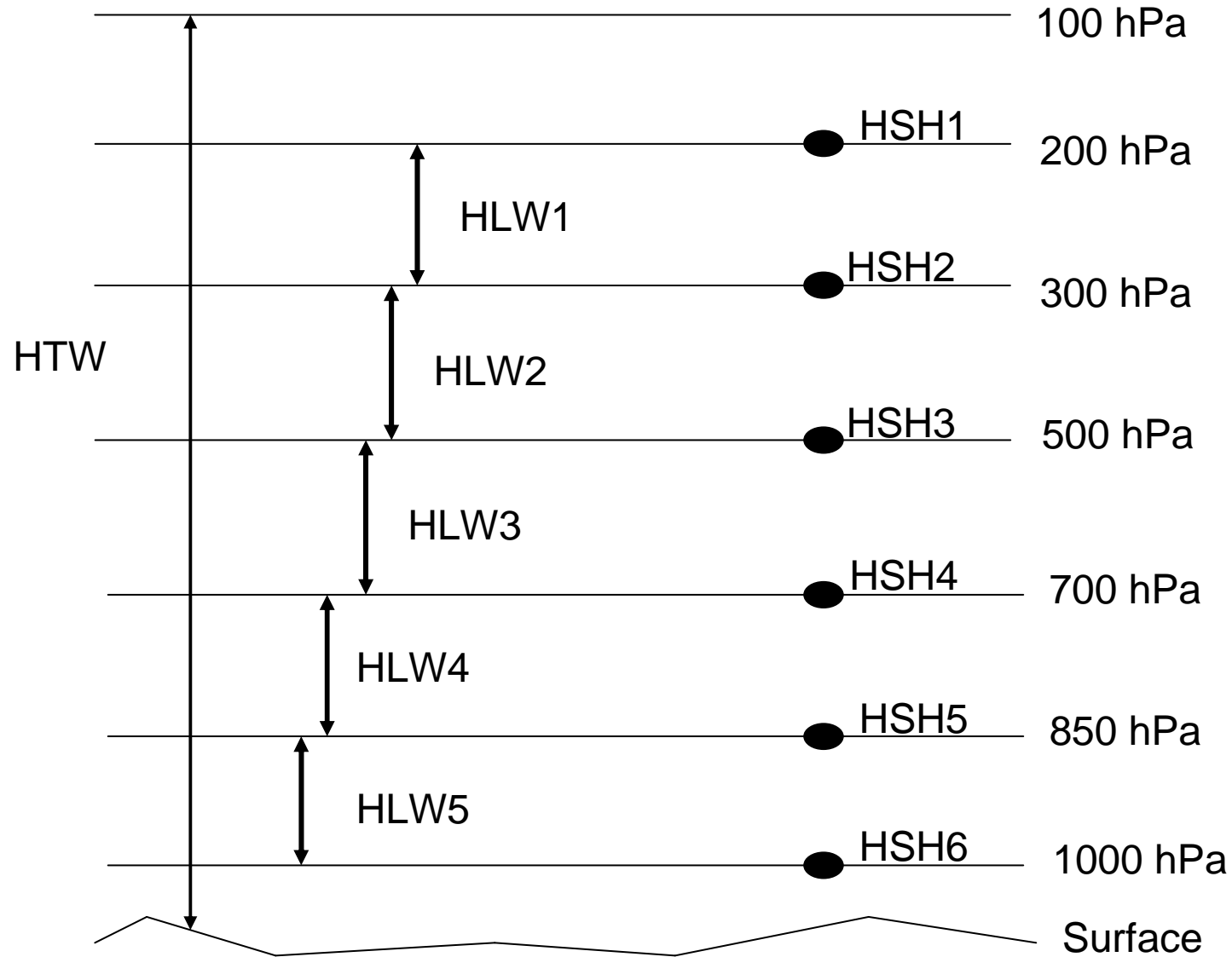
ATOVS products

• Different satellite combinations are used during the time period because some new satellites were launched and some others were out of order:

01.01.04 - 31.07.05: NOAA-15, NOAA-16
01.08.05 - 29.02.08: NOAA-15, NOAA-16, NOAA-18
01.03.08 - 31.05.09: NOAA-15, NOAA-18
01.06.09 - 30.11.09: NOAA-19, MetOp
01.12.09 - 31.01.10: NOAA-16,NOAA-19
01.02.10 - now: NOAA-16, NOAA-19, MetOp

• No radiance intercalibration between the different satellite
• GME outputs are used as first guess inputs and GME is regularly updates so the first guess is not produced in the same way for the entire time period

• Updates have been made in the processing chain and particularly in the IAPP software, so frozen set up was used

• To overtake those problems, a reprocessing of the ATOVS CM SAF products took place and a ATOVS dataset with climate quality will be available soon for the time period 1999-2011 (with a frozen set up for the entire period, with ERA-40 as first guess, and with intercalibration at least for some of the instruments)
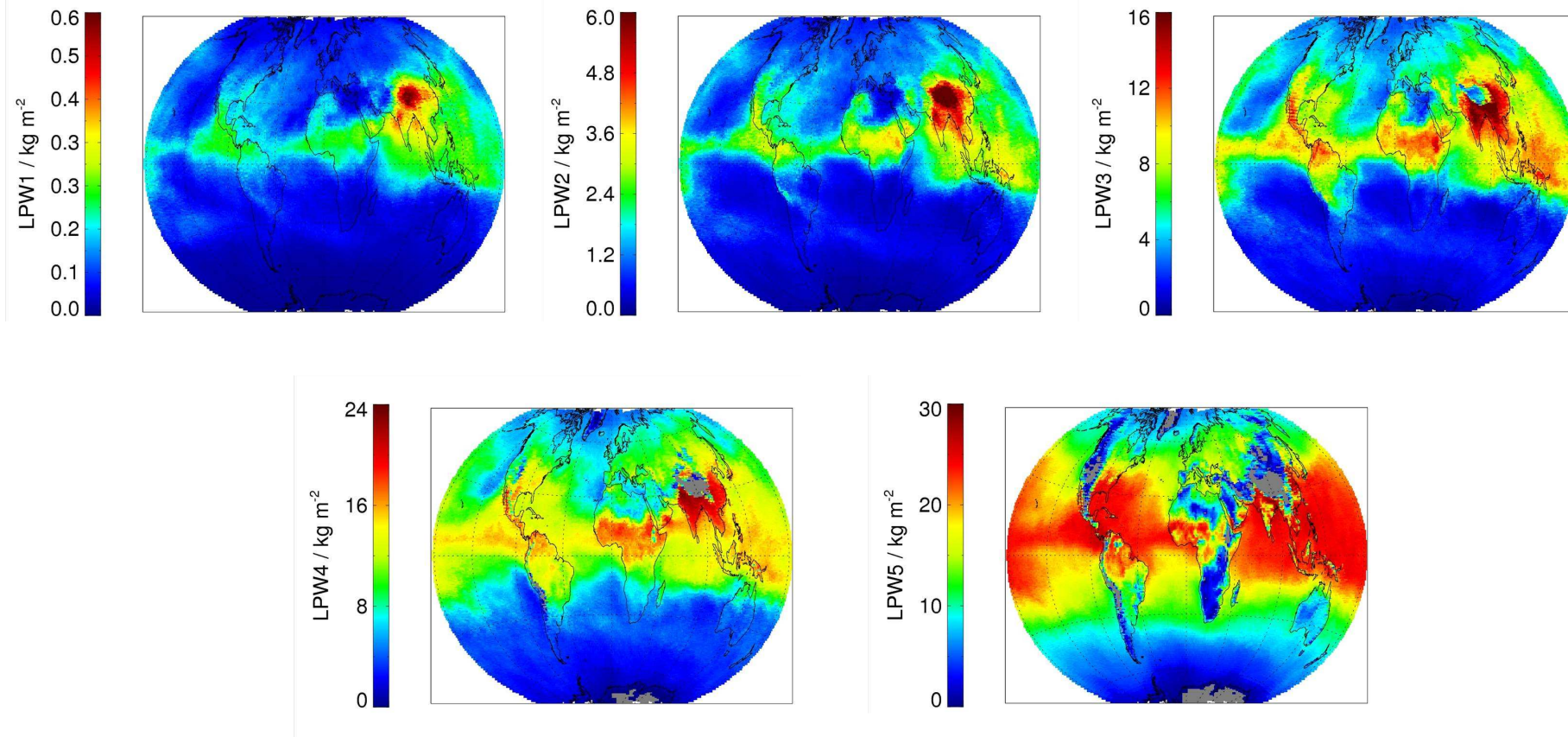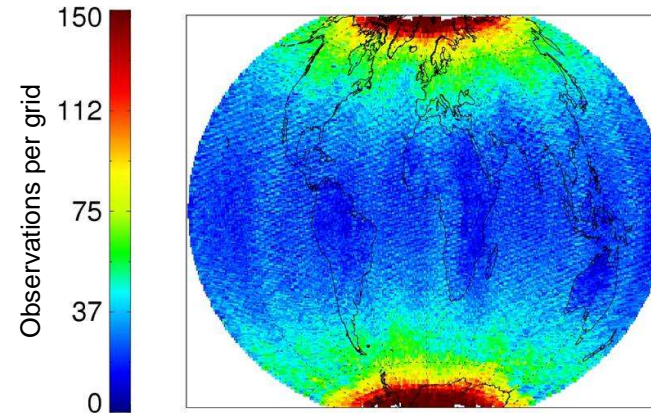
Layered vertically integrated water vapour for the 5 layers
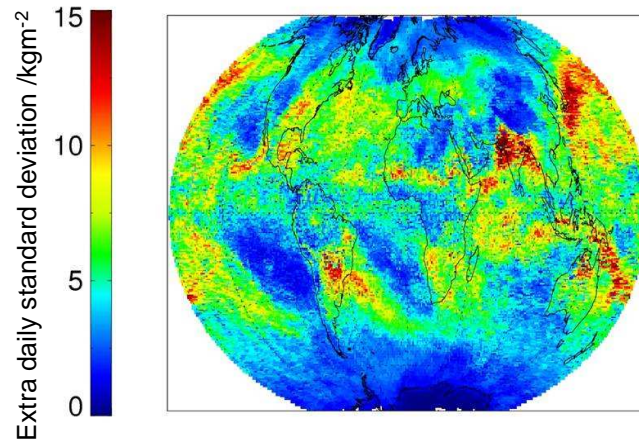
Monthly means for July 2005

ATOVS products
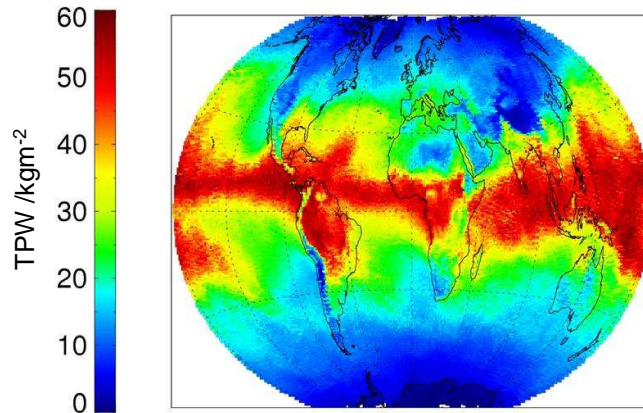
Vertically integrated water vapour


Number of observations per grid points


Extra daily standard deviation

October 2004

Validation

Validation of the ATOVS products:

• Against GUAN radiosondes

• GUAN: GCOS Upper air network

• Global radiosonde station network with some specific quality standard

• The bias and bias corrected RMSE between the products and the radiosondes are calculated and compared to the service specifications

• The service specifications are given to the user as a minimum data quality
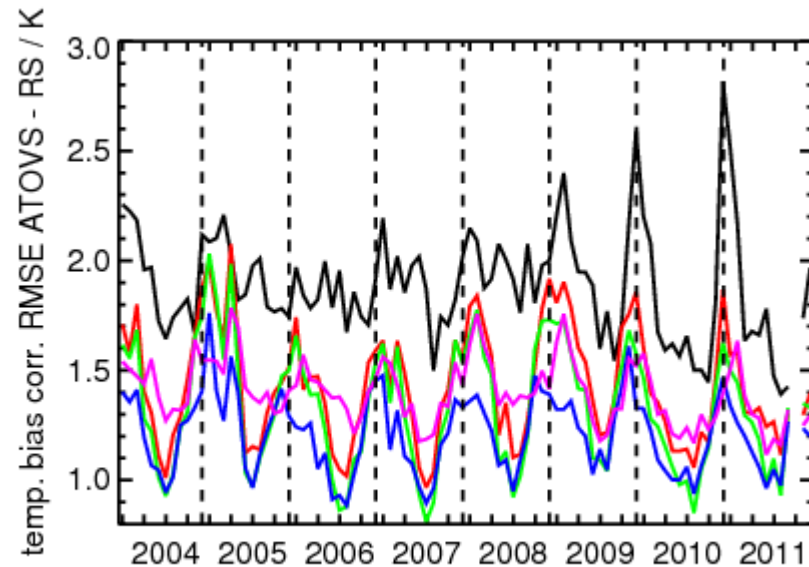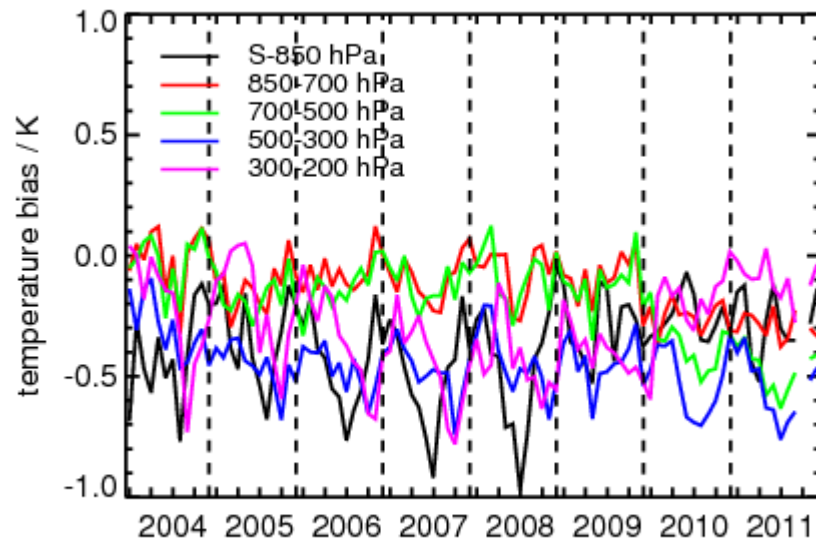
Total precipitable water vapour
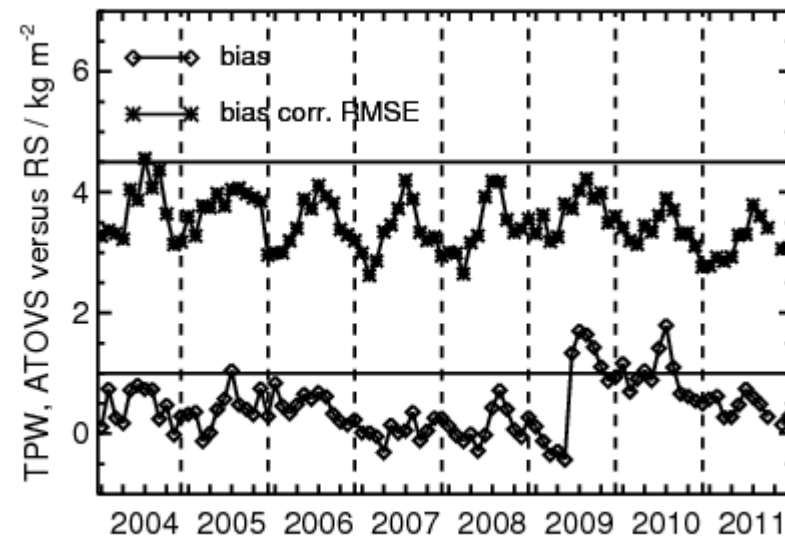
Layered precipitable water vapour
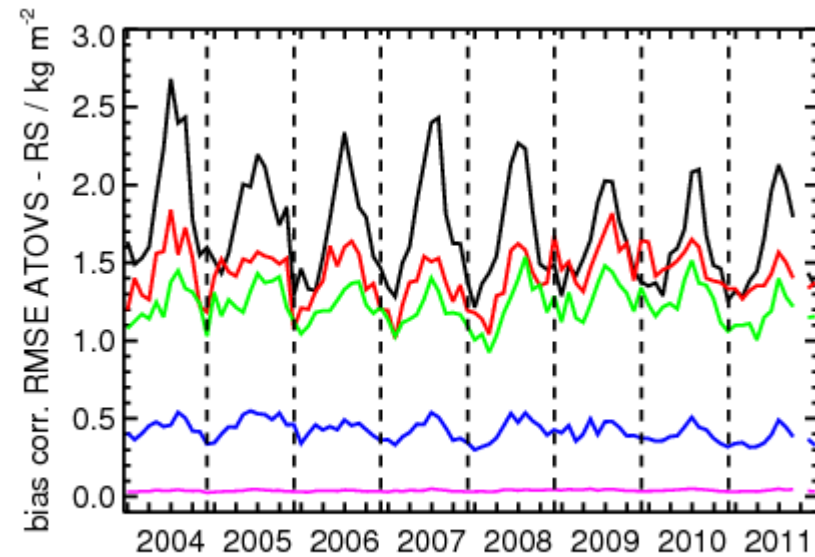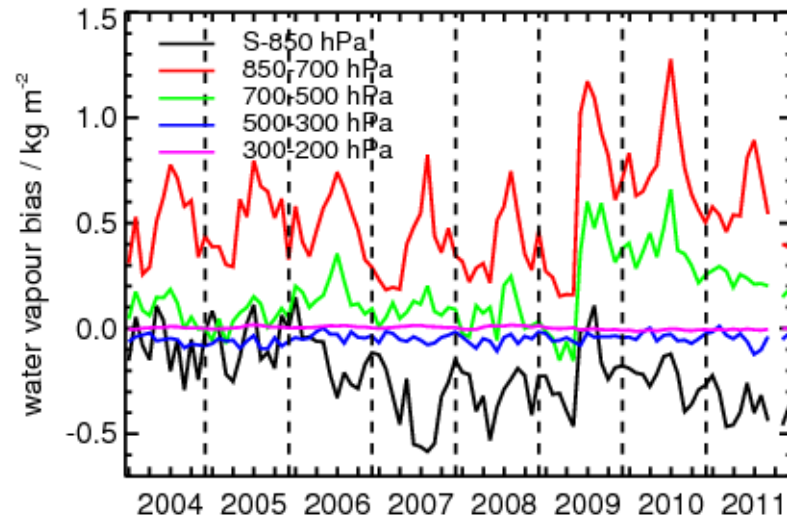
Layered temperature

Conclusion and outlook

- CM SAF produces operationally humidity and temperature products from ATOVS

- There are in total 28 products available globally on a cylindrical equal area projection of 90kmx90km

- In addition to the products themselves, the extra daily standard deviation and the number of observation per grid point are available for each products

- The products are validated against GUAN radiosondes

- The products show a good quality however because they are produced operationally they are not of climate quality, but they can be used for some other applications, for example for the monitoring of anomalies or extreme events

- A reprocessing took place, the dataset of climate quality will be soon available

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Network of
Satellite Application
Facilities

CM SAF
Climate Monitoring

DWD

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Thank you for your attention

Questions?