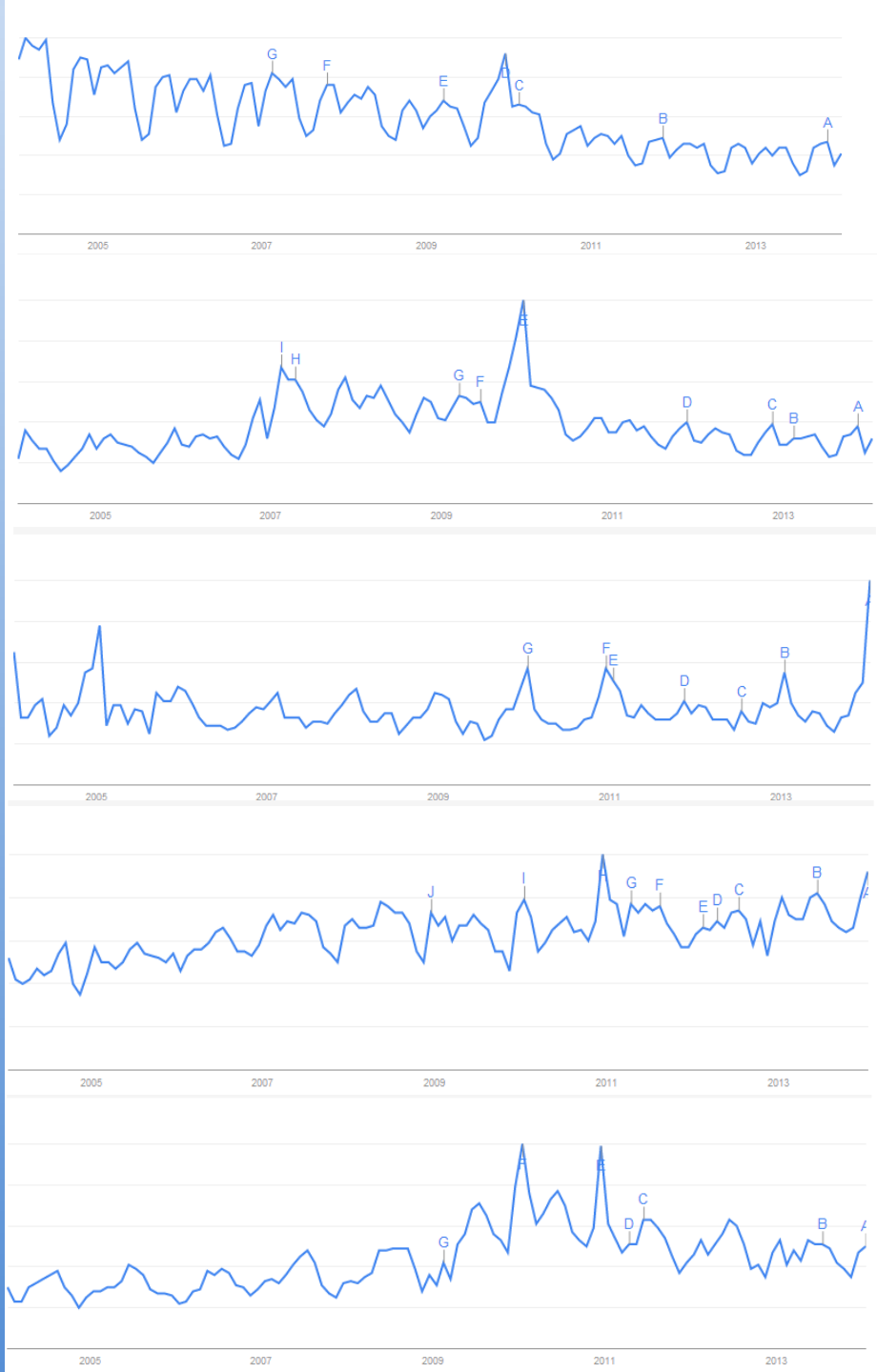
Use of Satellite Data for Climate Applications
- CM SAF -

Zanita Avotniece

Latvian Environment, Geology and Meteorology Centre

- Climate
- Climate change
- Extreme weather
- Weather
- Weather forecast



*Trends from Google search

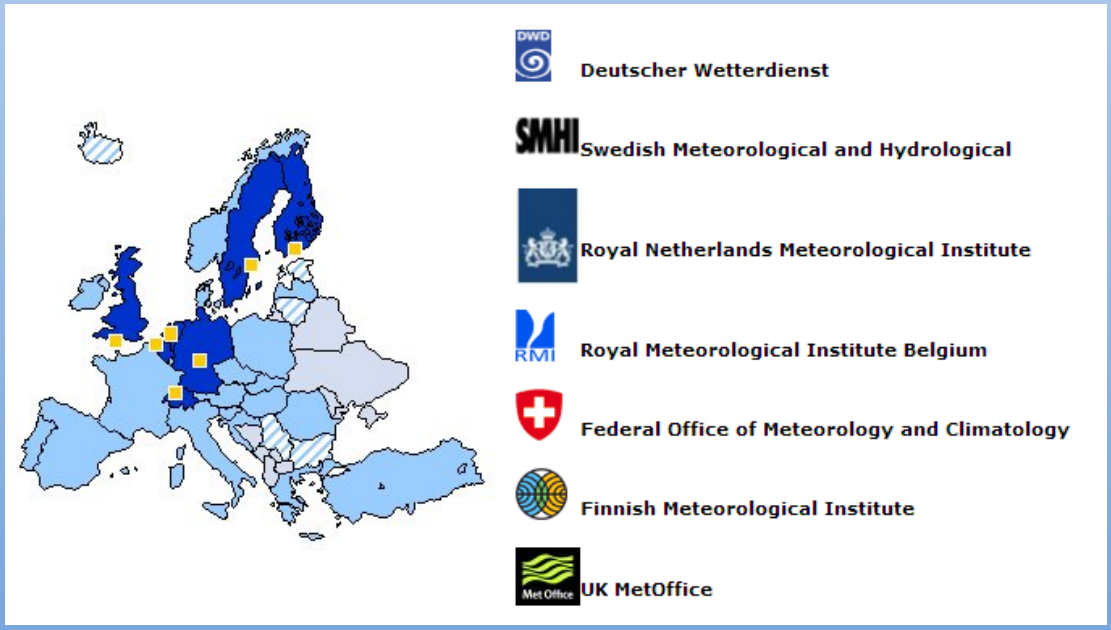
What is Climate?

Status of the atmosphere at a certain point in time and space

Status of the atmosphere over a reasonably long period of time

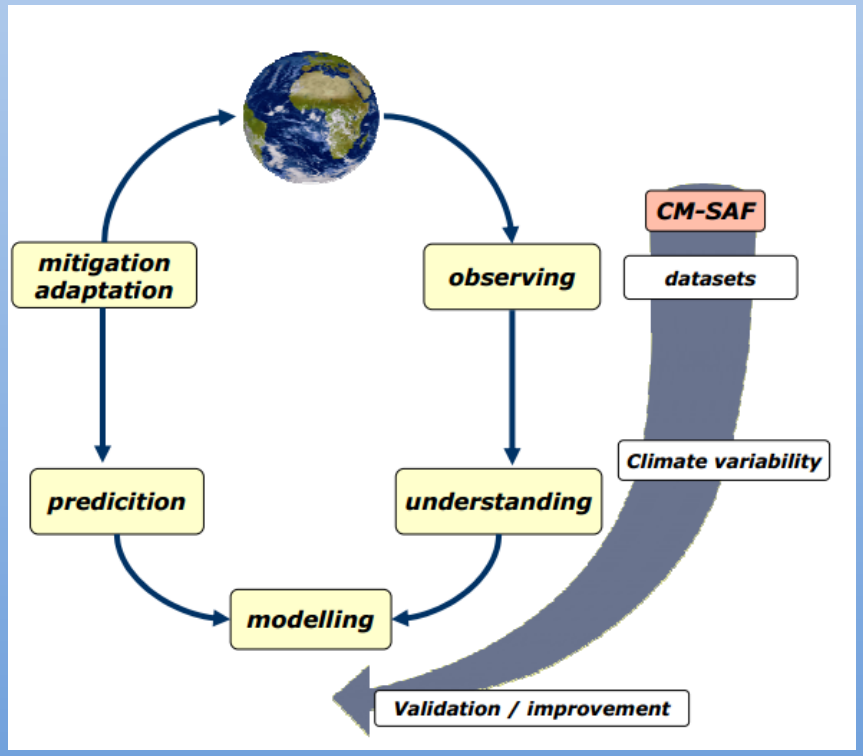
CM SAF – Satellite Application Facility on Climate Monitoring

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



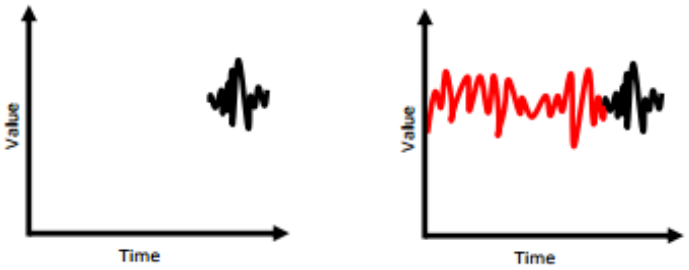
The CM SAF is part of the EUMETSAT Satellite Application Network and is a joint effort of six European National Meteorological and Hydrological Services, led by Deutscher Wetterdienst

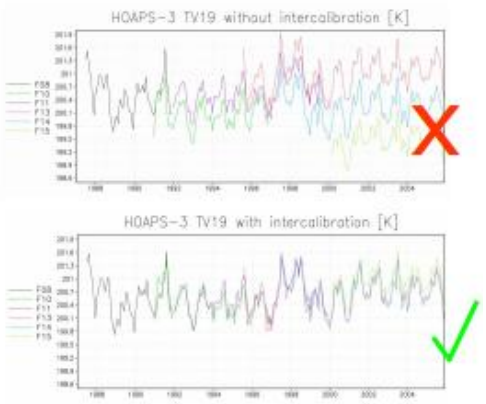
- Assess past and current climate to
  - Understand the climate system
  - Assess possible trends and changes
- Support the development of climate models
- Assess climate impacts
- Provide a basis for political decisions and infrastructure planning

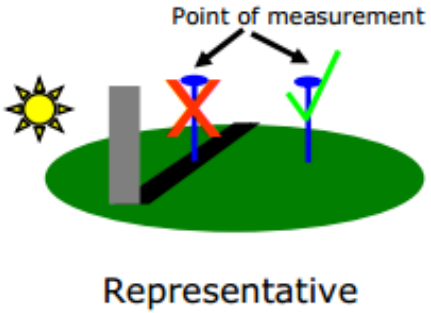


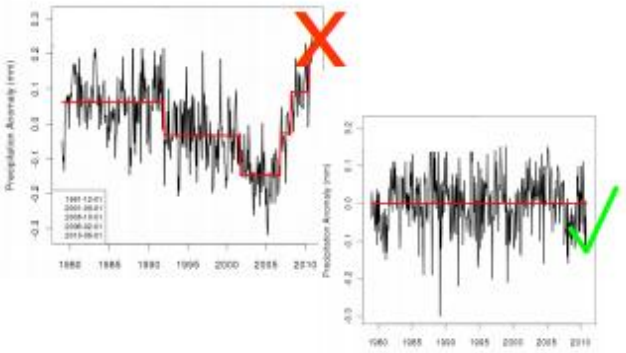
Requirements for Climate Data Records

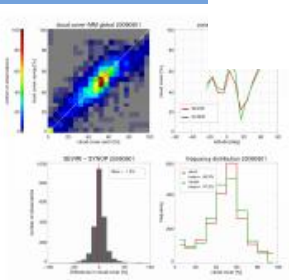
- Sufficiently long time series
- Calibrated and homogeneous data series
- Representative measurements
- Quality controlled datasets

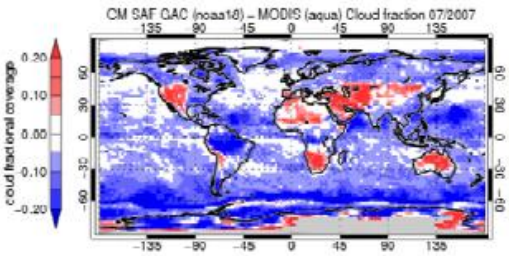




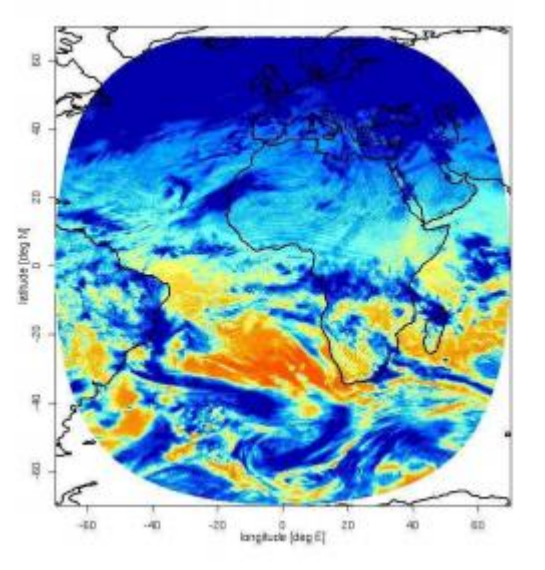


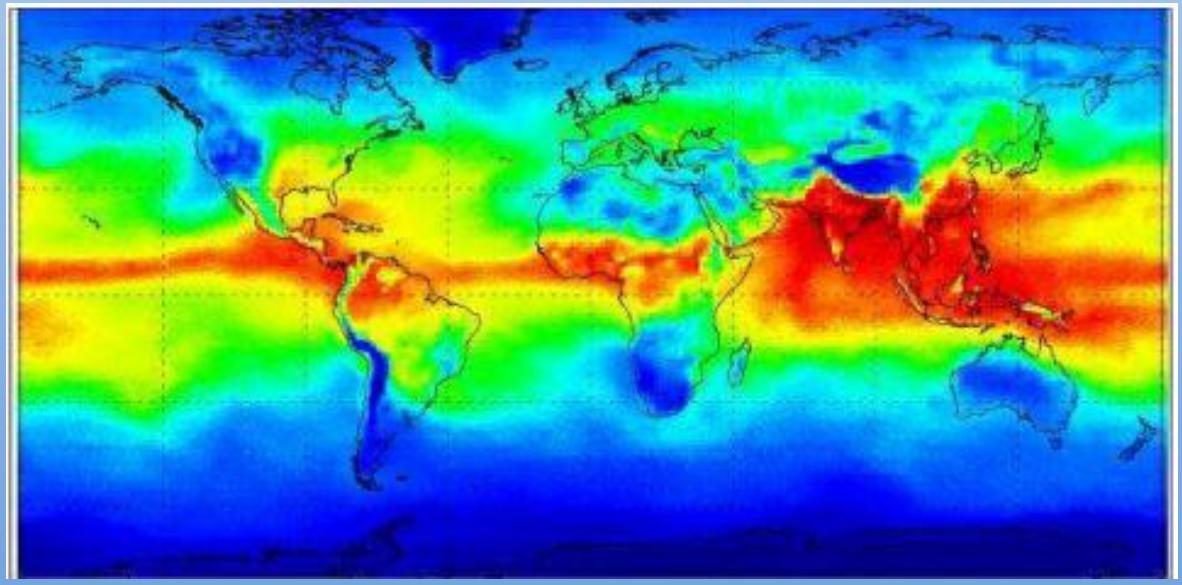






Geostationary or Polar-orbiting Satellite?





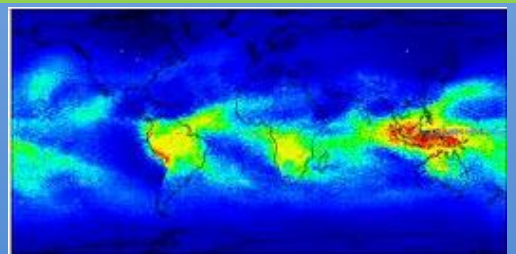
CM SAF Climate Datasets

AVHRR (1982-2009)

- Fractional cloud cover
- Joint cloud histogram
- Cloud top parameters
- Cloud optical thickness
- Cloud phase
- Liquid water path
- Ice water path
- Surface albedo
- Surface incoming shortwave radiation
- Surface net shortwave radiation
- Surface outgoing shortwave radiation
- Surface downward longwave radiation
- Surface net longwave radiation
- Surface radiation budget
- Cloud radiative effect (SW and LW)

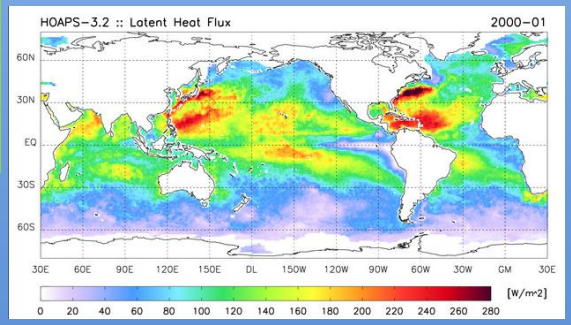
ATOVS (1999-2011)

- Vertically integrated water vapour
- Water vapour, humidity and temperature at layers
- Temperature and specific humidity at 6 pressure levels



SSM/HOAPS (1987-2008)

- Vertically integrated water vapour
- Evaporation – Precipitation
- Evaporation
- Latent heat fluxes
- Near surface specific humidity
- Precipitation
- Near surface wind speed
- Latent heat transfer coefficient
- Vertically integrated liquid water
- Difference in humidity
- Sensible heat flux at sea surface
- Surface net longwave radiation
- Sea surface saturation specific humidity
- Sea surface temperature
- Vertically integrated total (ice + liquid) water
- Microwave radiance FCDR

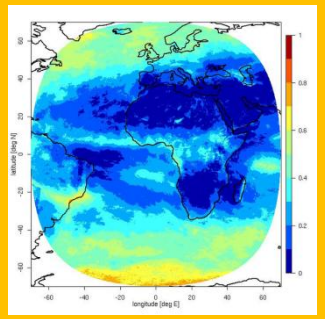


MFG/MVIRI (1983-2005)

- Effective cloud albedo
- Surface incoming direct radiation
- Surface incoming shortwave radiation
- Surface net shortwave radiation
- Daylight intensity

MSG/SEVIRI (2006-2011)

- Fractional cloud cover
- Joint cloud histogram
- Cloud top parameters
- Cloud optical thickness
- Cloud Radiative Effect (SW and LW)
- Cloud phase
- Liquid water path
- Ice water path
- Surface albedo
- Surface net shortwave radiation
- Surface Outgoing Longwave Radiation
- Surface Downward Longwave Radiation
- Surface Net Longwave Radiation
- Surface radiation budget
- Surface Incoming Shortwave Radiation
- Surface Incoming Direct Radiation
- Spectral Resolved Irradiance
- Emitted thermal radiative flux at top of atmosphere
- Reflected solar radiative flux at top of atmosphere
- Daylight intensity



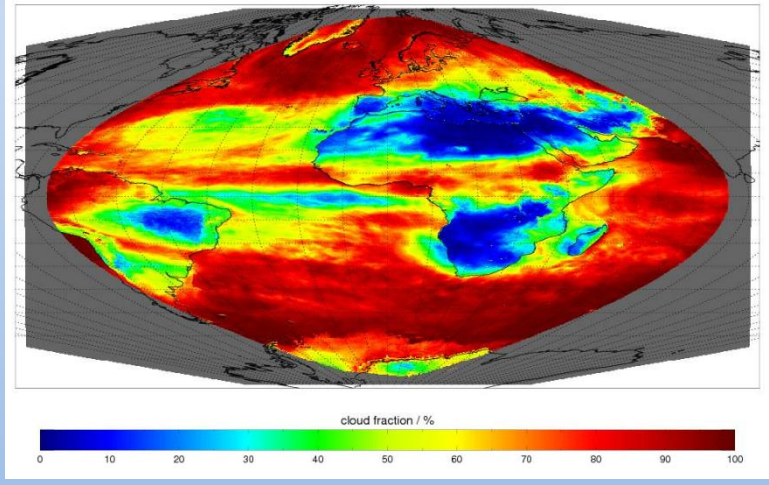
MFG/MVIRI and MSG/SEVIRI (1983-2009)

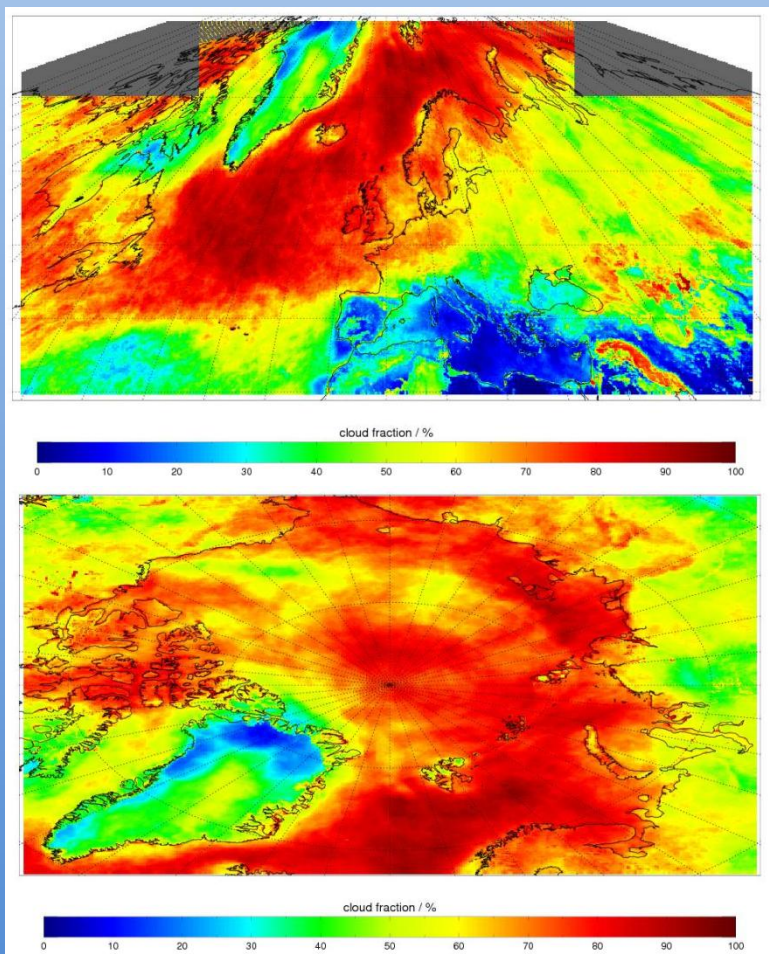
- Free tropospheric humidity

CM SAF Operational Products

AVHRR, SEVIRI, ATOVS (2004-...)

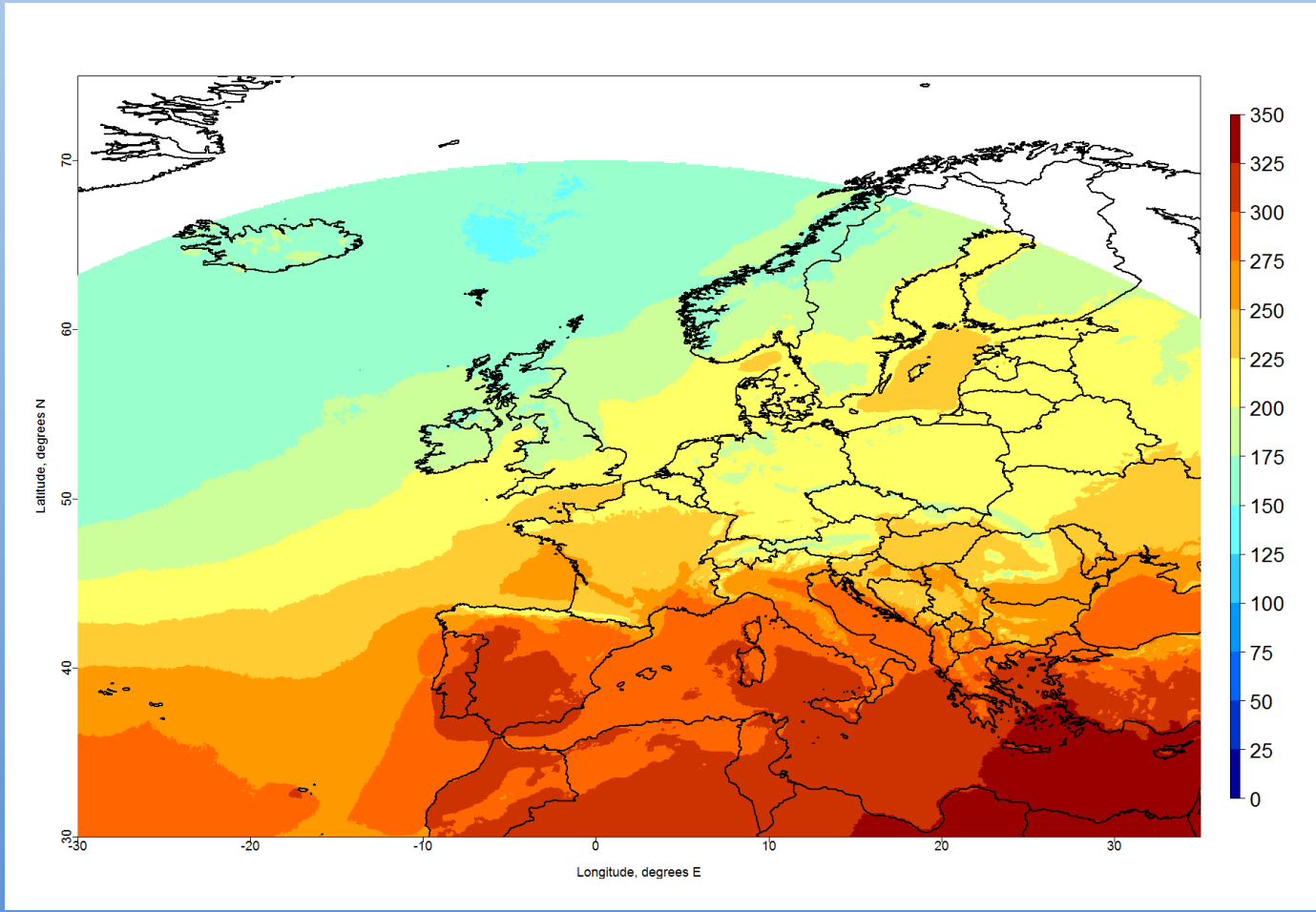
- Fractional cloud cover
- Cloud type (low clouds, middle level clouds, high opaque clouds, high semitransparent clouds, fractional clouds)
- Cloud top temperature
- Cloud top height
- Cloud top pressure
- Cloud optical thickness
- Cloud phase (ice, water, mixed)
- Cloud water path
- Surface incoming shortwave radiation
- Surface incoming direct radiation
- Surface albedo
- Surface net shortwave radiation
- Surface outgoing longwave radiation
- Surface downward longwave radiation
- Surface net longwave radiation
- Surface radiation budget
- Incoming solar radiative flux at the top of the atmosphere
- Reflected solar radiative flux at the top of the atmosphere
- Emitted thermal radiative flux at the top of the atmosphere
- Vertically integrated water vapour
- Layered vertically integrated water vapour and layer mean temperature and relative humidity for 5 layers
- Temperature and mixing ratio at 6 pressure levels



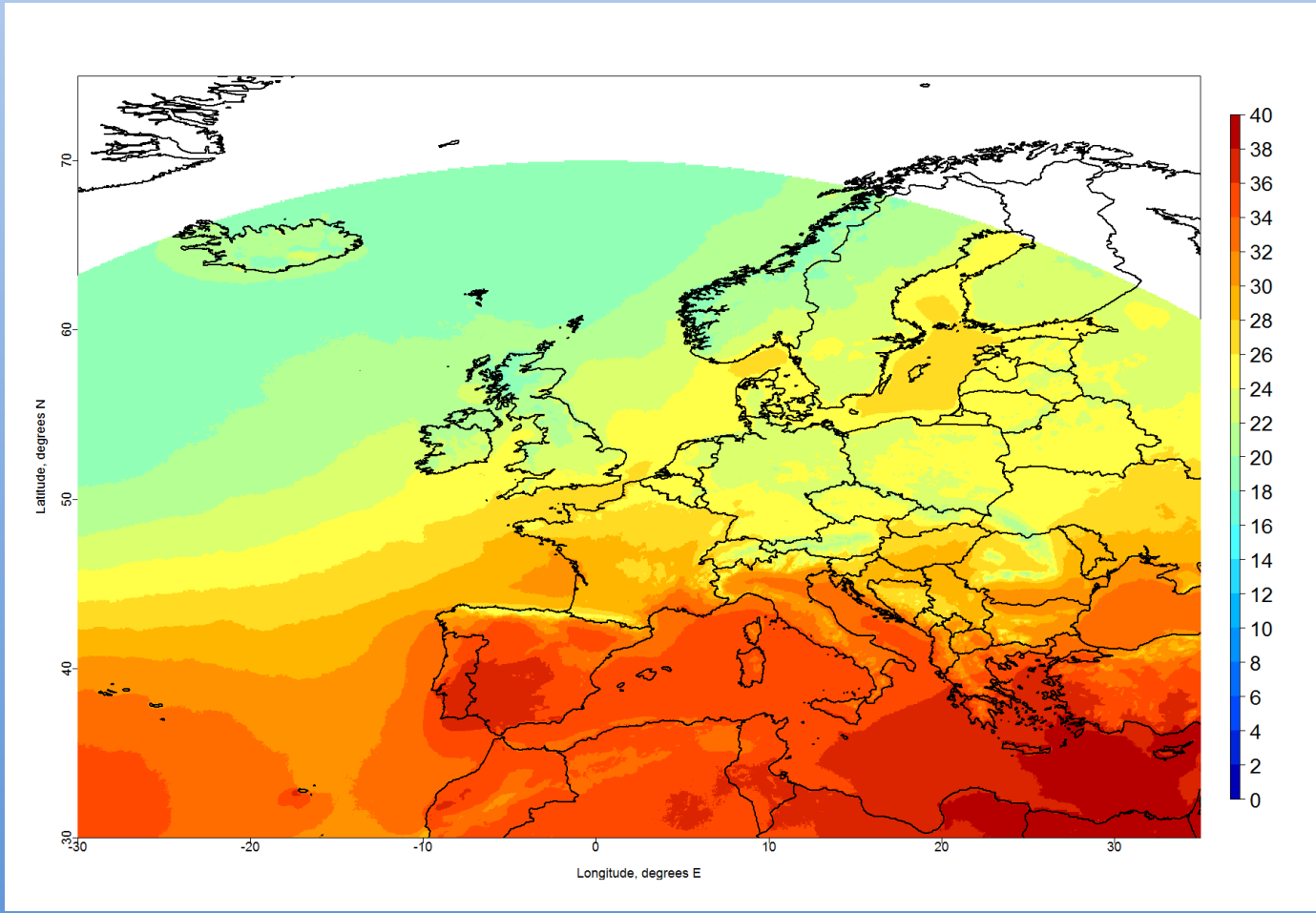


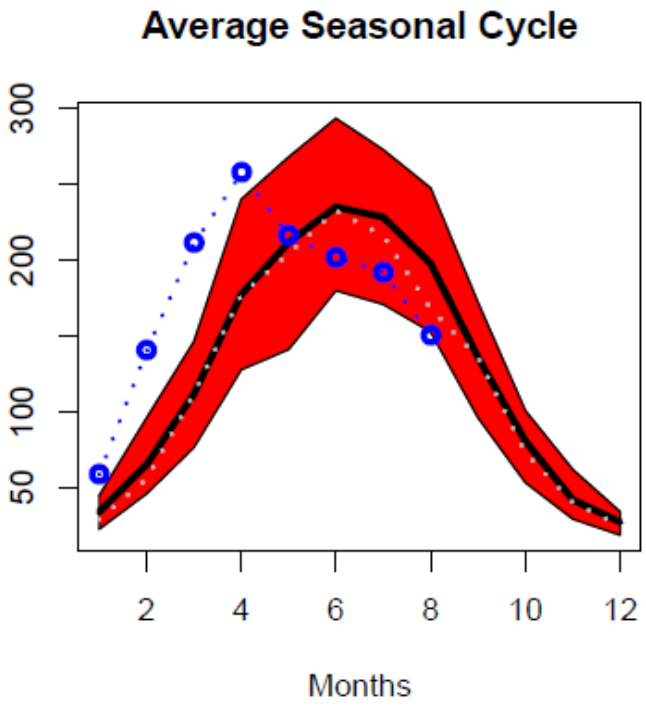
Applications of CM SAF Data

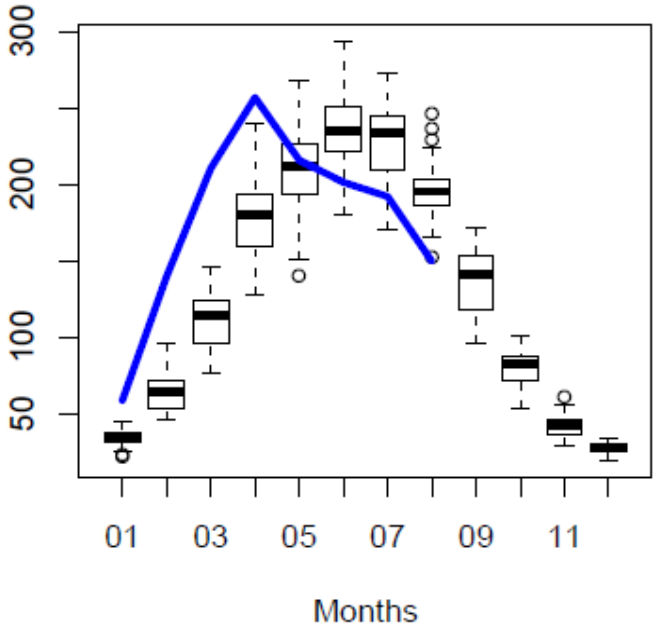
Mean Surface Incoming Shortwave Radiation in Summer (1990-2005)



Mean Daylight Intensity in Summer (1990-2005)







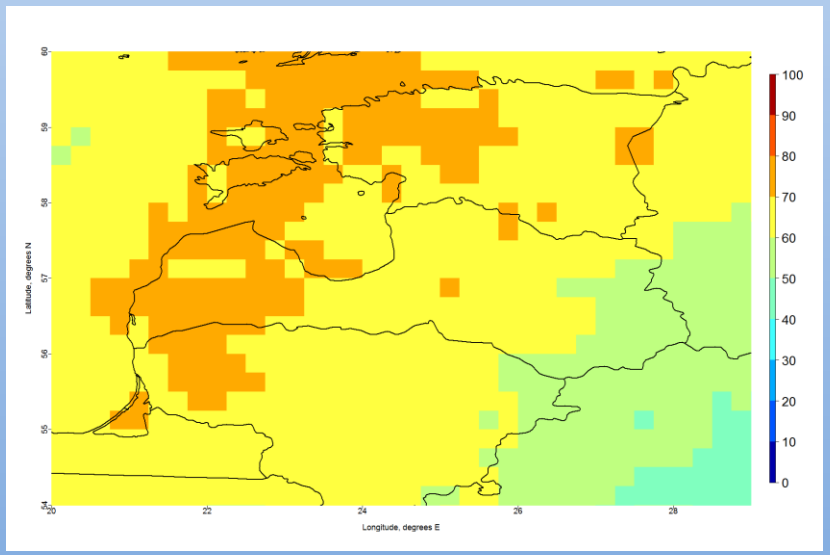
Normal or Not?

Comparison of the Solar radiation in the year 2010 and the long-term mean (1982-2009)

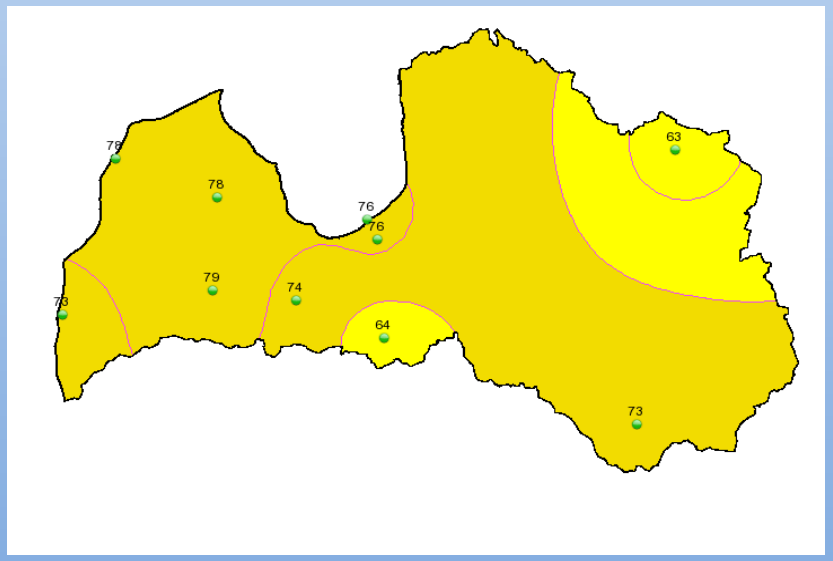
* Dr. Mark Higgins, EUMETSAT

July 2004 Mean Cloud Cover

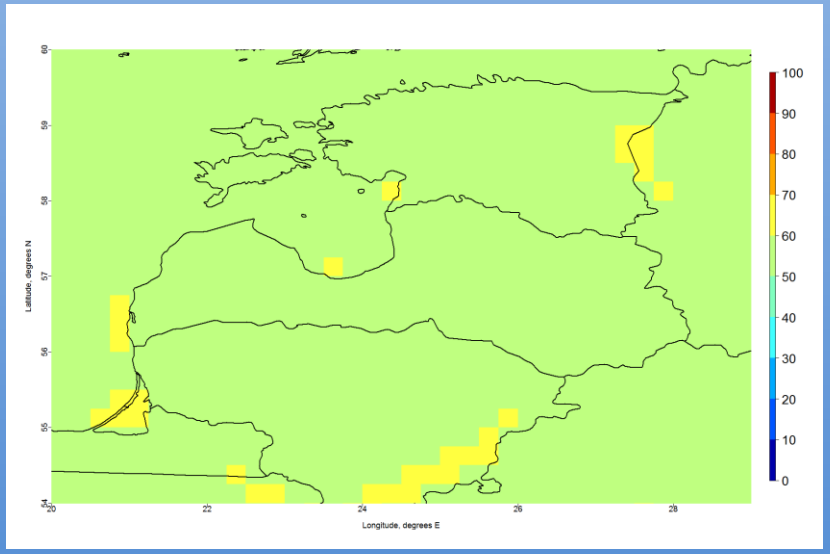
July 2004



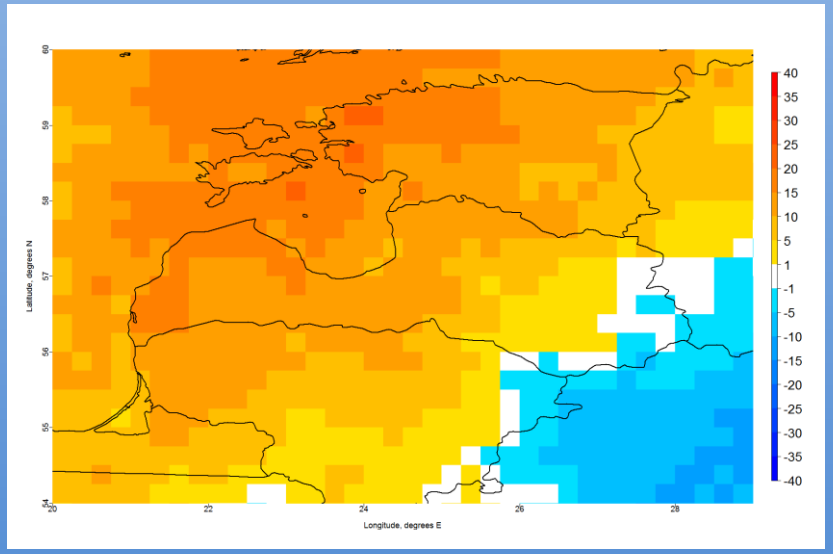
Surface Observations



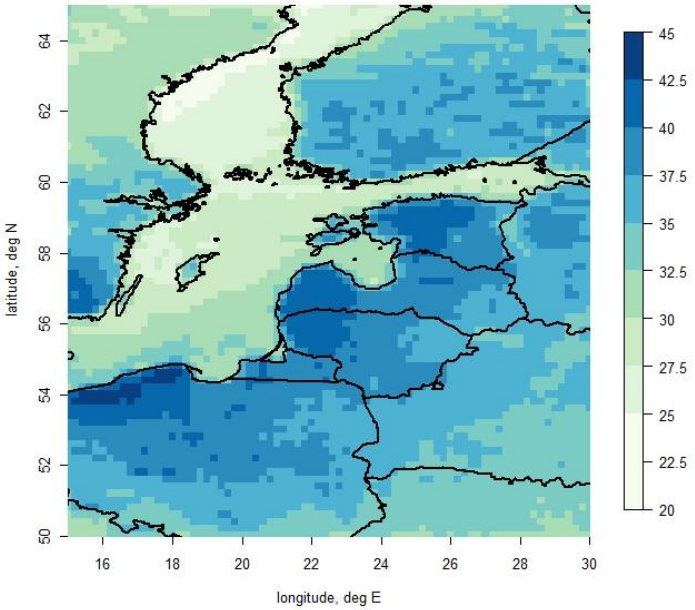
July Mean



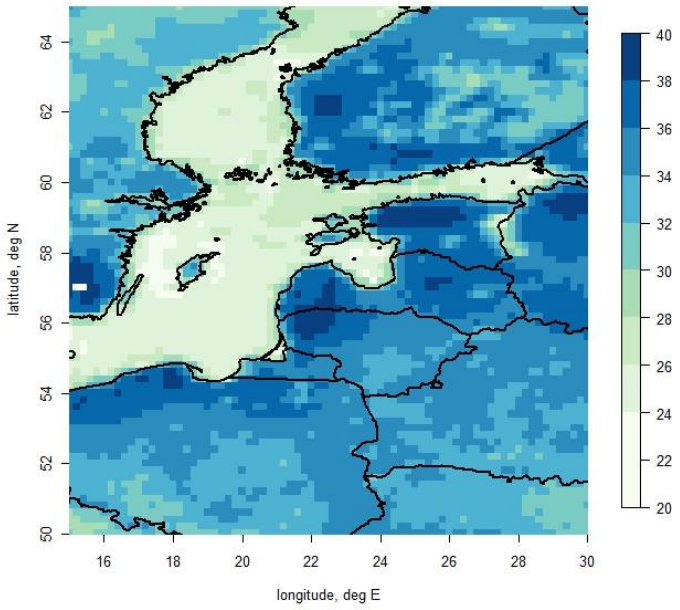
July 2004 Anomaly



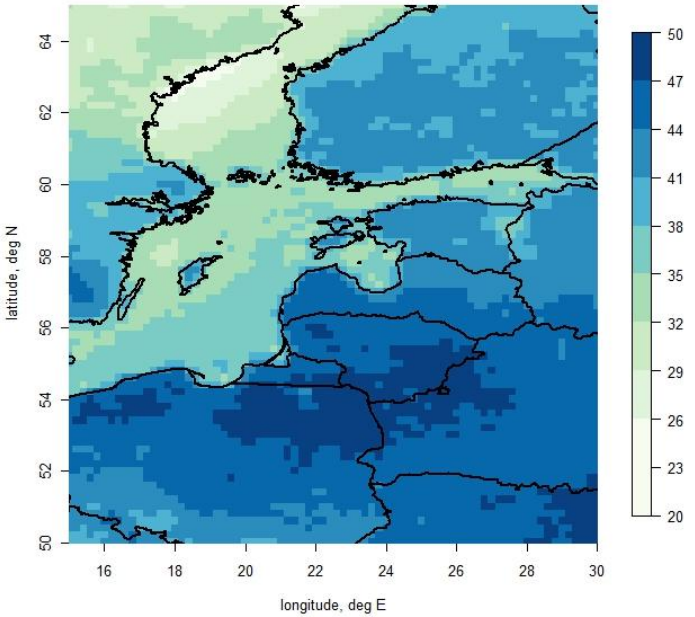
CTY-MM LOW CLOUDS (percent), Mean Seasonal Low Cloud Cover mai 2011



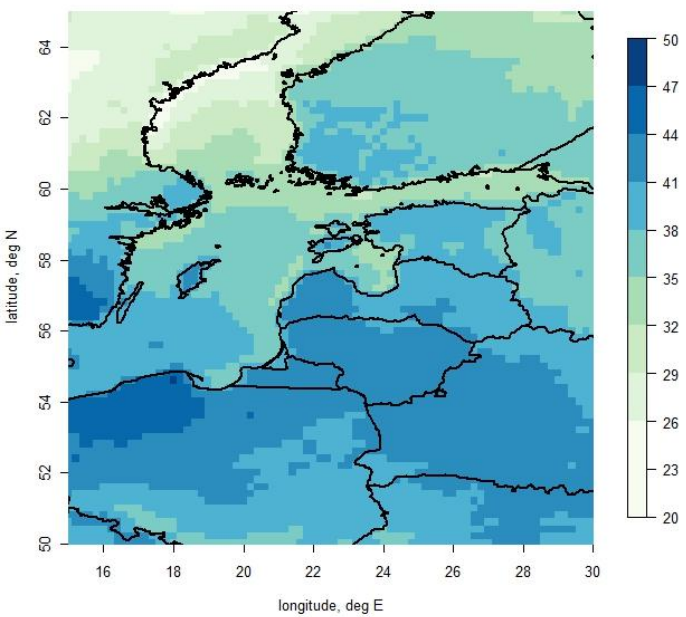
CTY-MM LOW CLOUDS (percent), Mean Seasonal Low Cloud Cover aug 2011



CTY-MM LOW CLOUDS (percent), Mean Seasonal Low Cloud Cover sep 2011



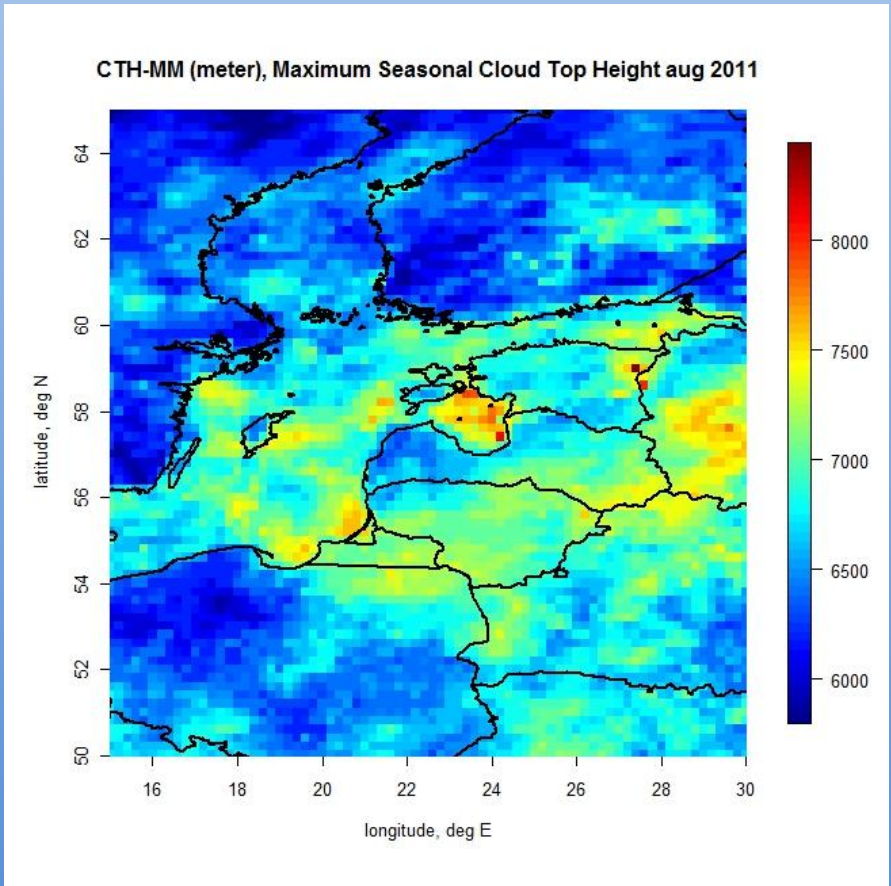
CTY-MM LOW CLOUDS (percent), Mean Seasonal Low Cloud Cover feb 2011



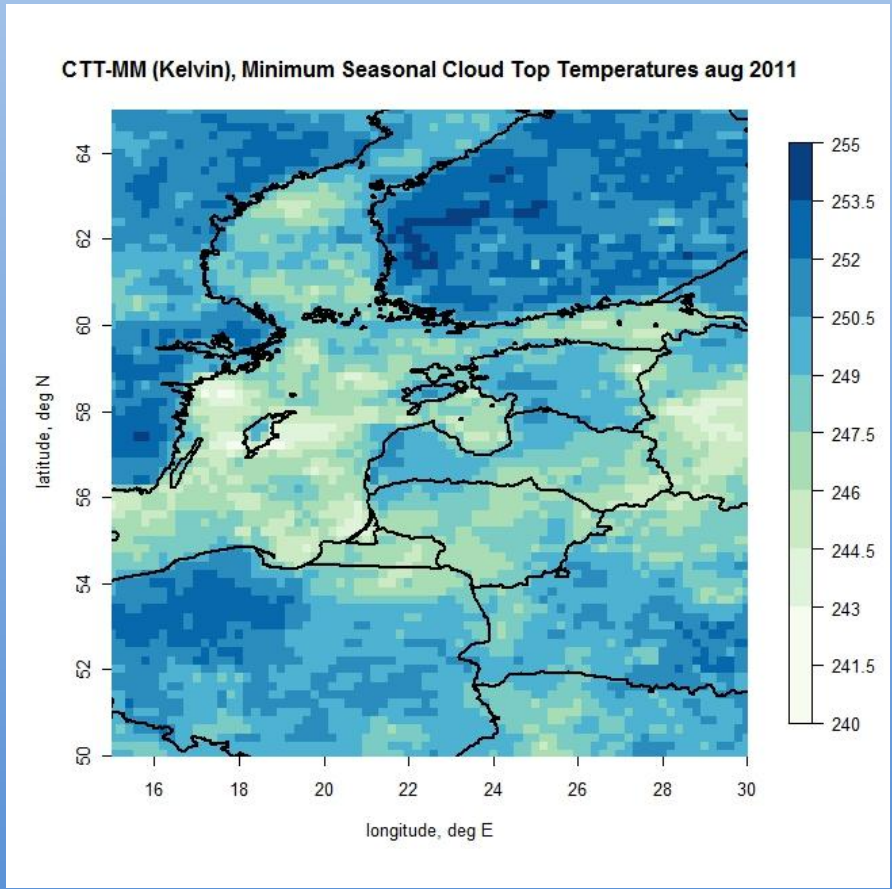
Seasonal Mean Low Cloud Cover 2005-2011

Maximum Cloud Top Height
vs
Minimum Cloud Top Temperature (Summer 2005-2011)

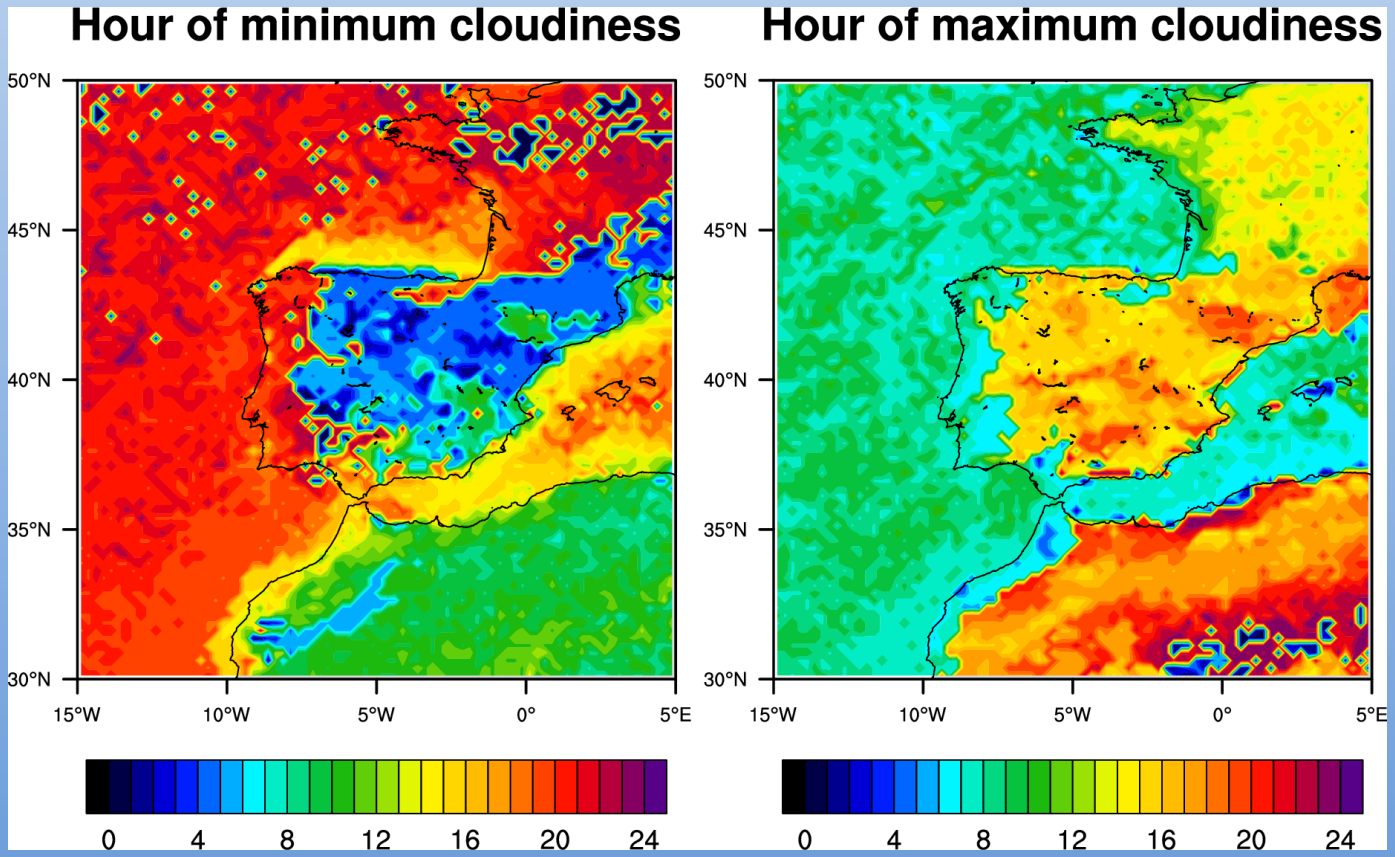
CTH



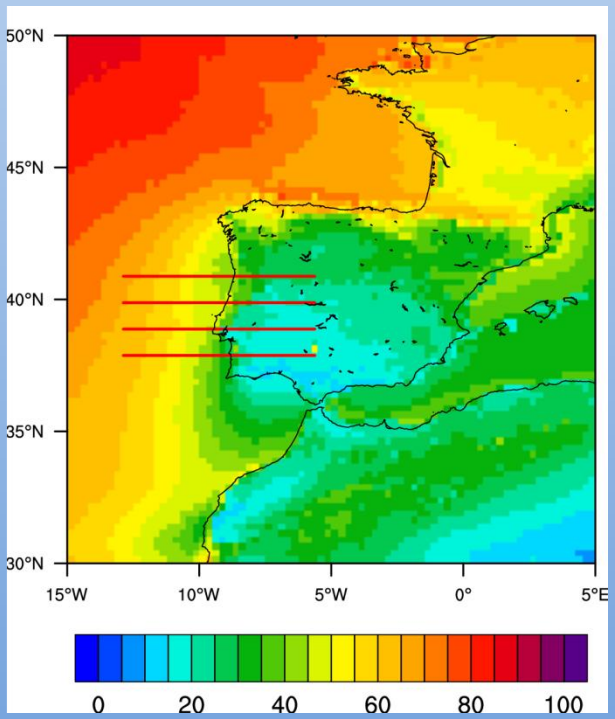
CTT

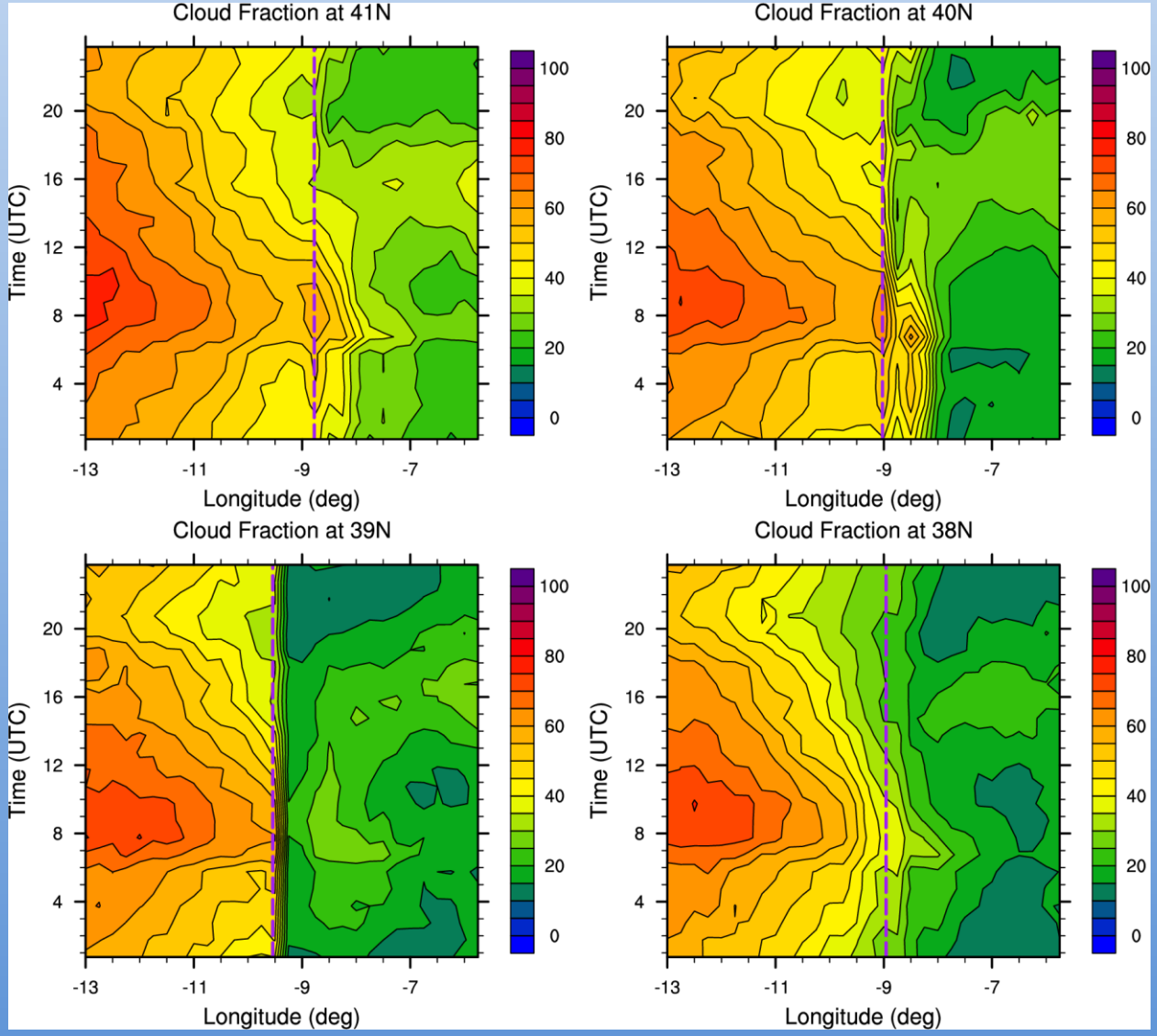


Characteristics of the Local Weather



* João Paulo Martins, IPMA


50°N
45°N
40°N
35°N
30°N
15°W
10°W
5°W
0°
5°E
0
20
40
60
80
100


Cloud Fraction at 41N
Cloud Fraction at 40N
Cloud Fraction at 39N
Cloud Fraction at 38N
Time (UTC)
Longitude (deg)
4
8
12
16
20
-13
-11
-9
-7
0
20
40
60
80
100

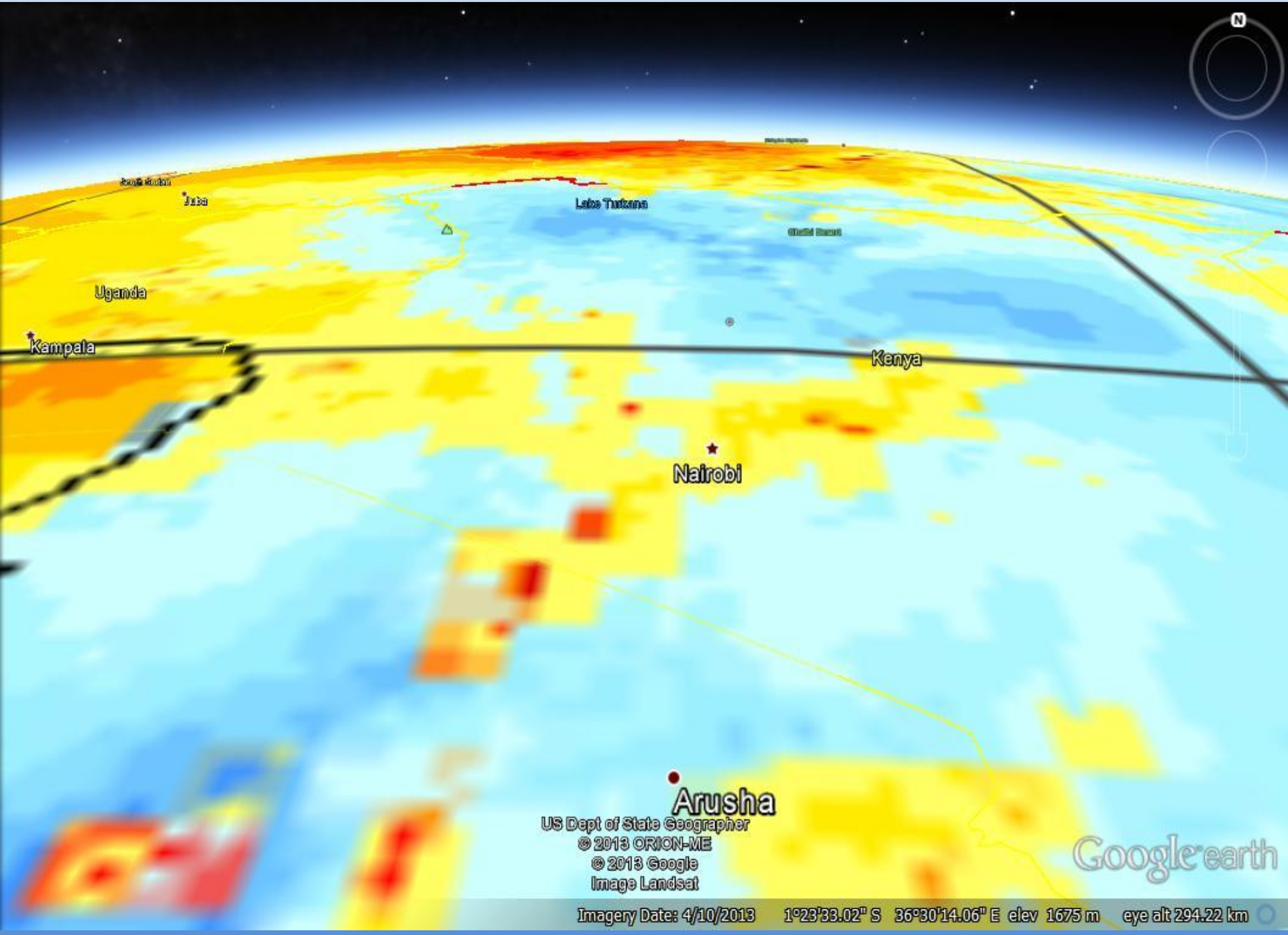

Juba
Lake Turkana
Uganda
Kampala
Kenya
Nairobi
Arusha
US Dept of State Geographer
© 2013 ORION-ME
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Image Landsat
Google earth
Imagery Date: 4/10/2013 1°23'33.02" S 36°30'14.06" E elev 1675 m eye alt 294.22 km

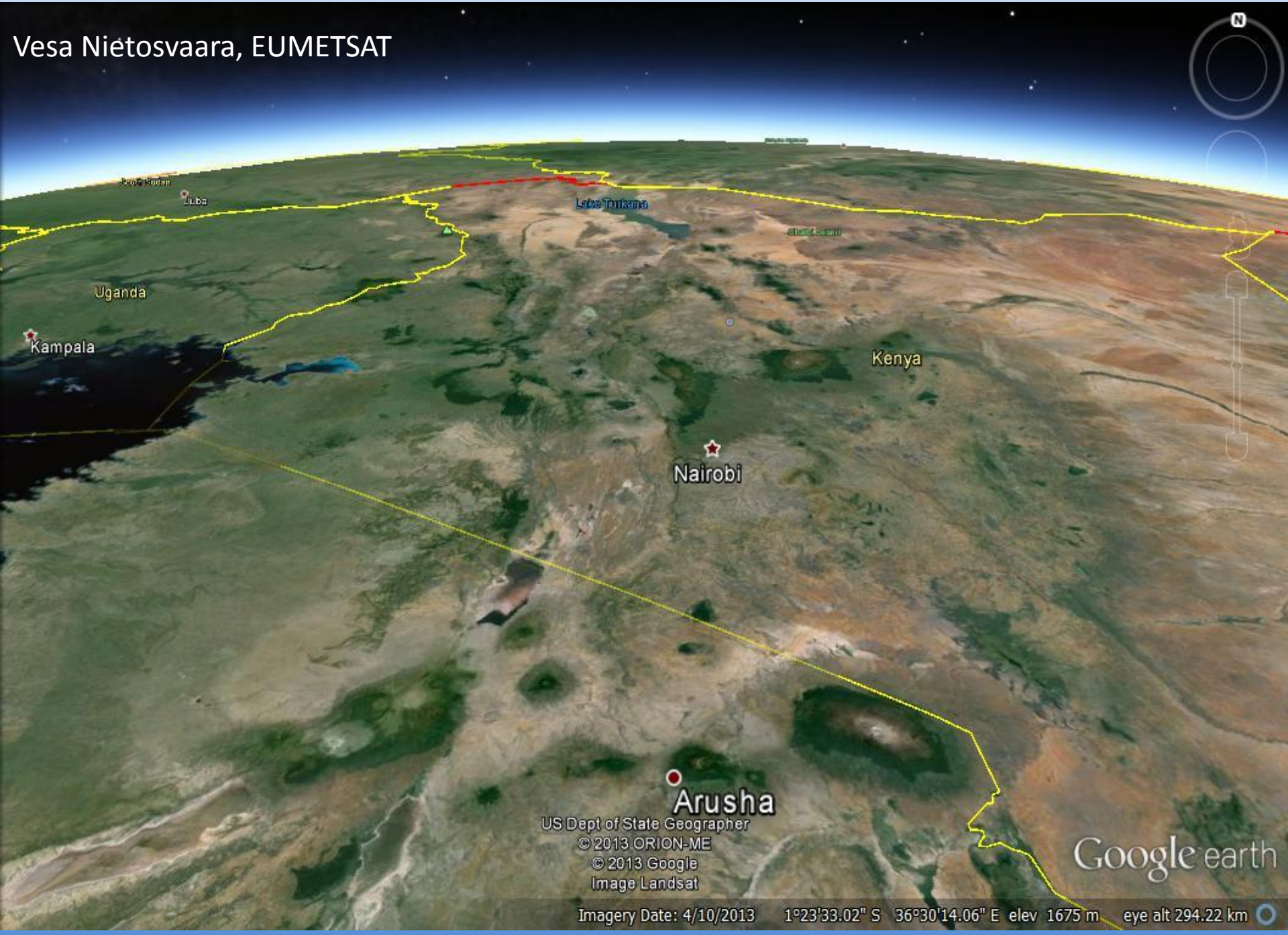
Vesa Nietosvaara, EUMETSAT
Lake Turkana
Uganda
Kampala
Kenya
Nairobi
Arusha
US Dept of State Geographer
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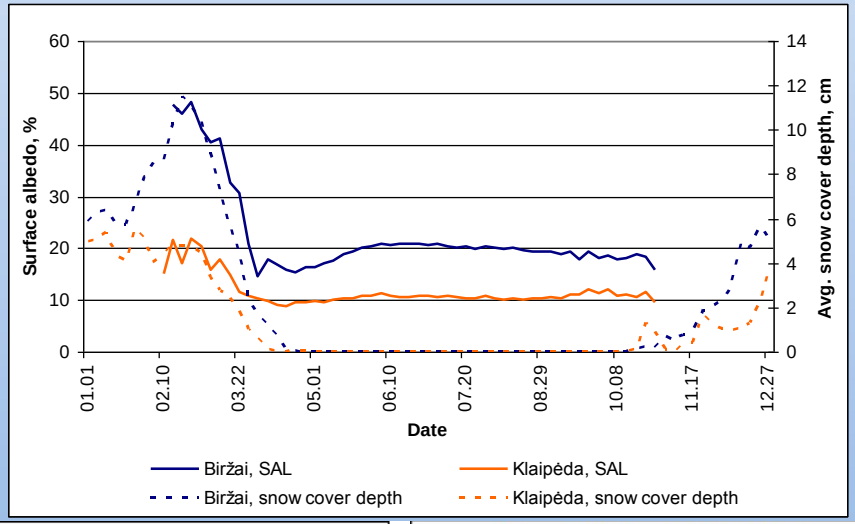
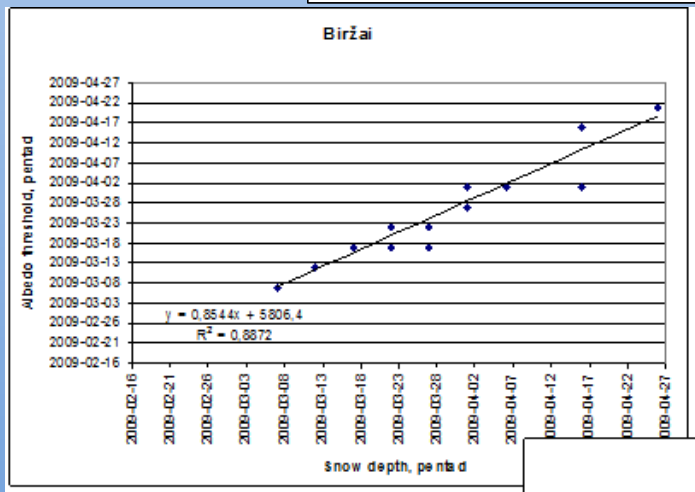
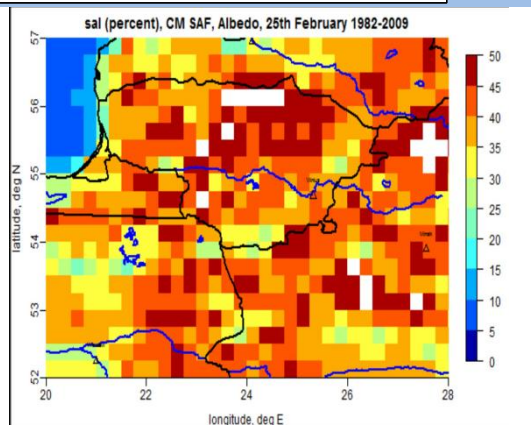
Image Landsat
Google earth
Imagery Date: 4/10/2013 1°23'33.02" S 36°30'14.06" E elev 1675 m eye alt 294.22 km

Surface Albedo for Changes in Snow Cover

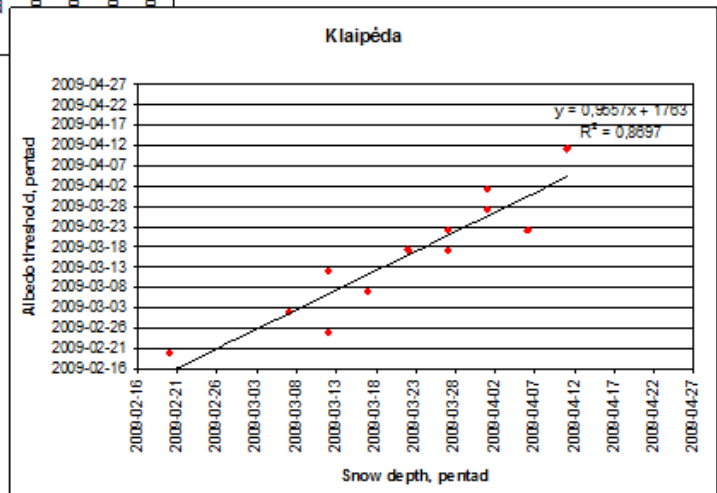






$$A_t = A_s + 2\sigma_{As}$$

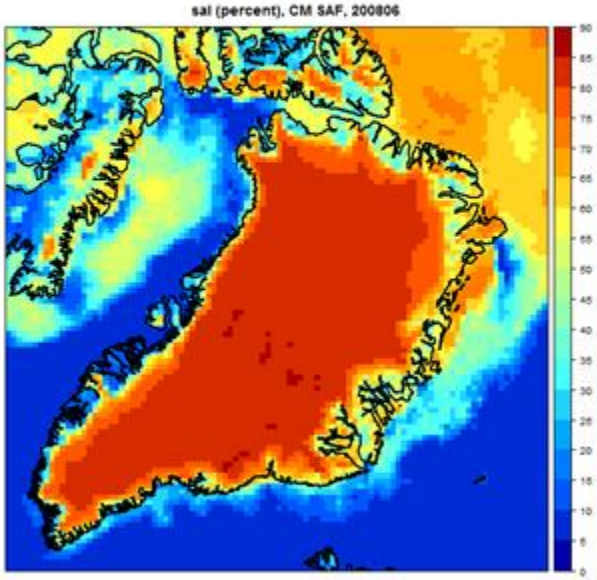
A_t – albedo threshold
A_s – summer time albedo value
σ_{As} - standard deviation of this value
(Hannuniemi H., J. Rinne, T. Manninen, 2007)



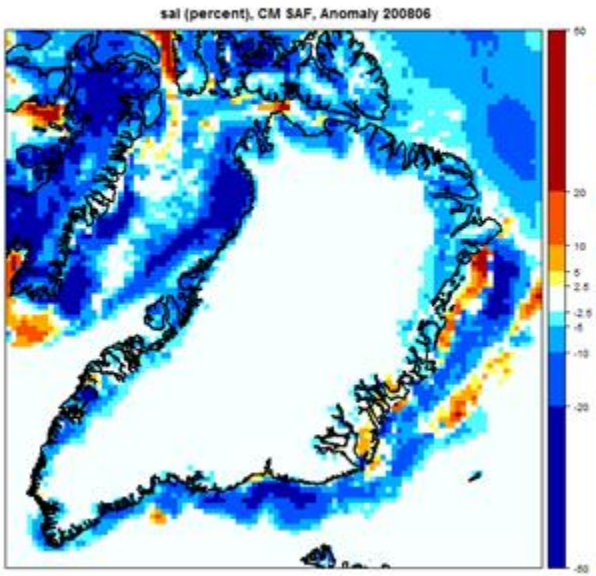
*Justinas Kilpys
Lithuanian Hydrometeorological Service

Surface Albedo for Sea-ice

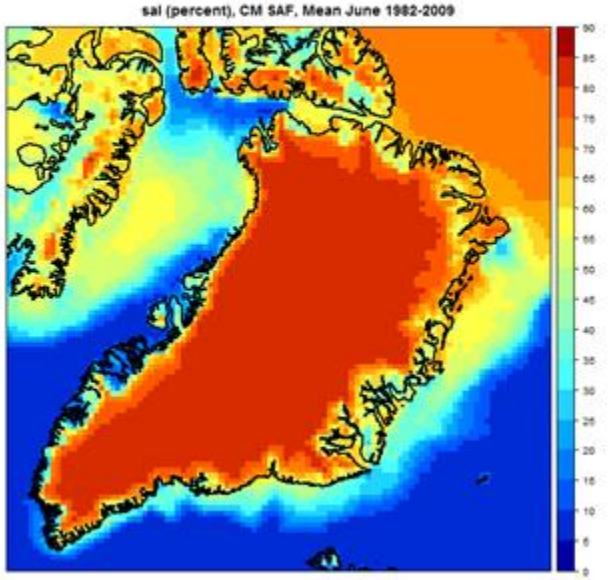
June mean 2008



June anomaly 2008

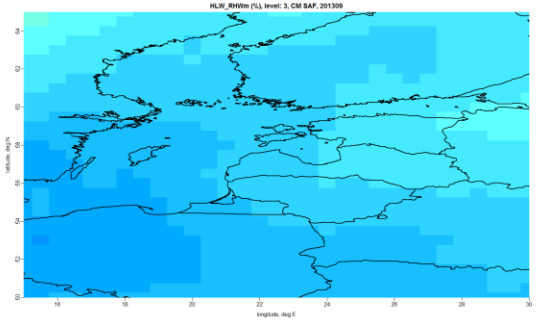
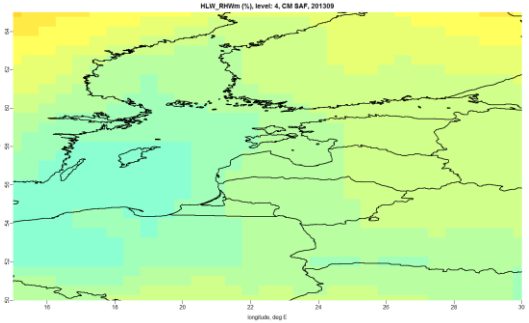
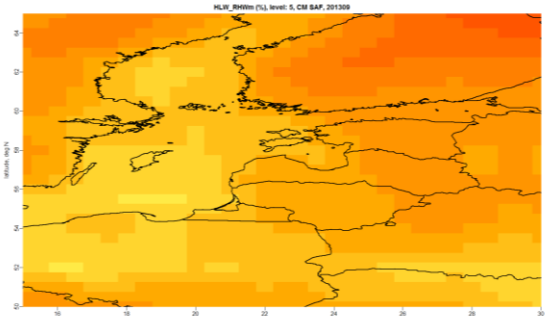
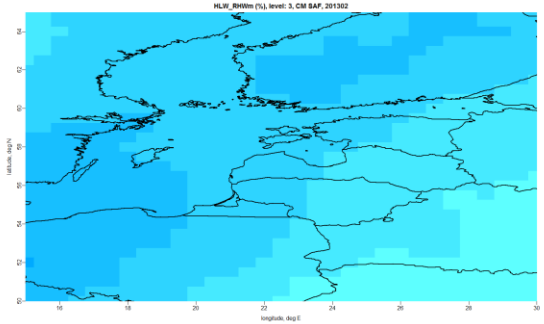
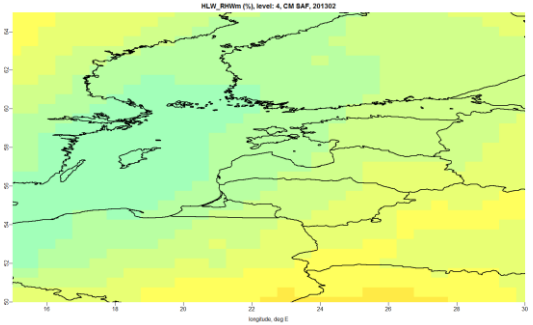
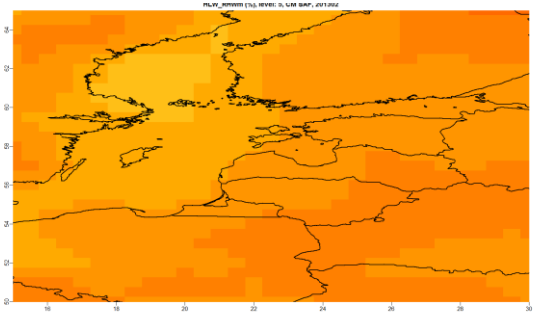
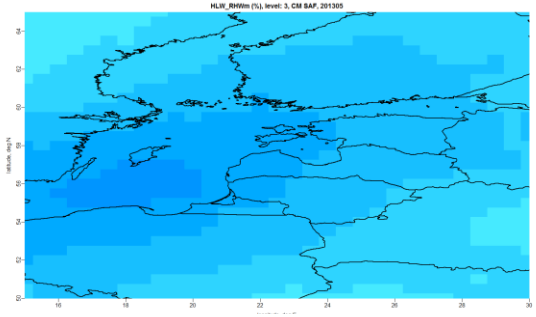
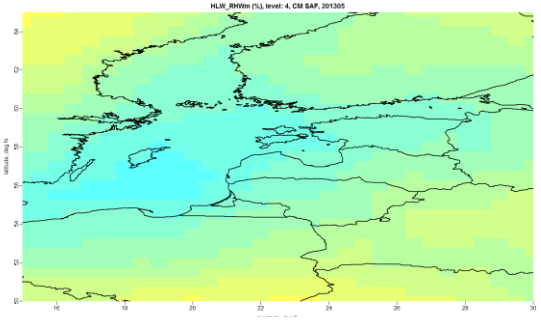
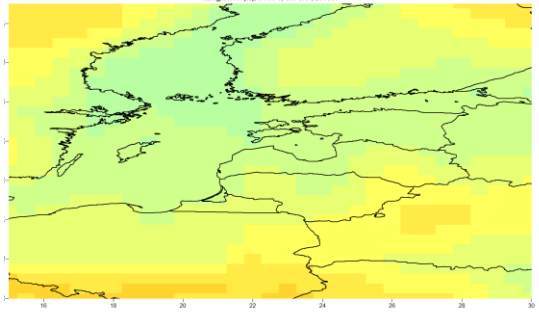
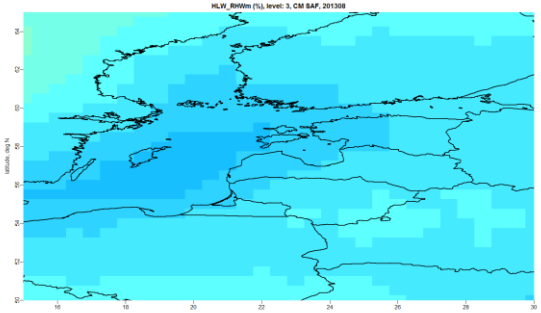
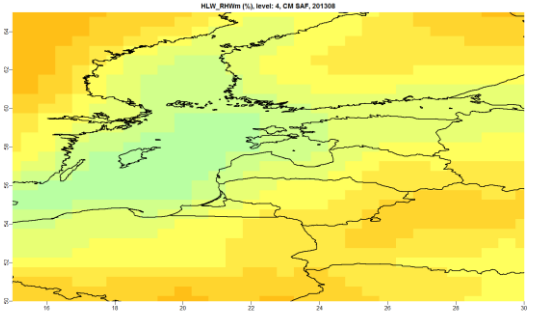
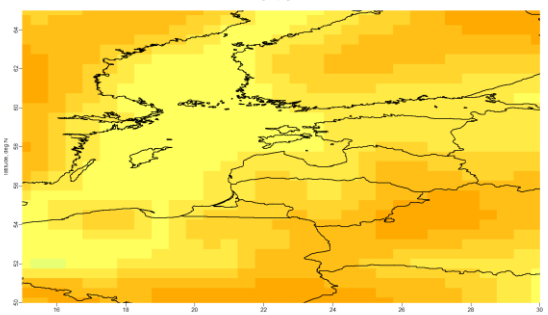


June mean 1982-2008

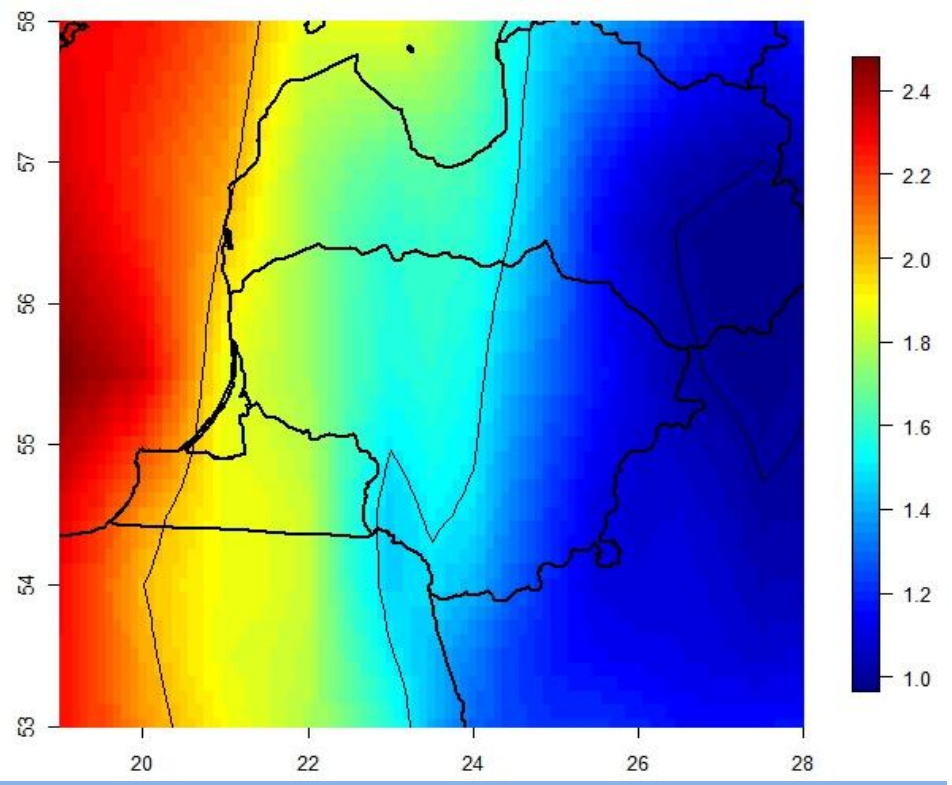


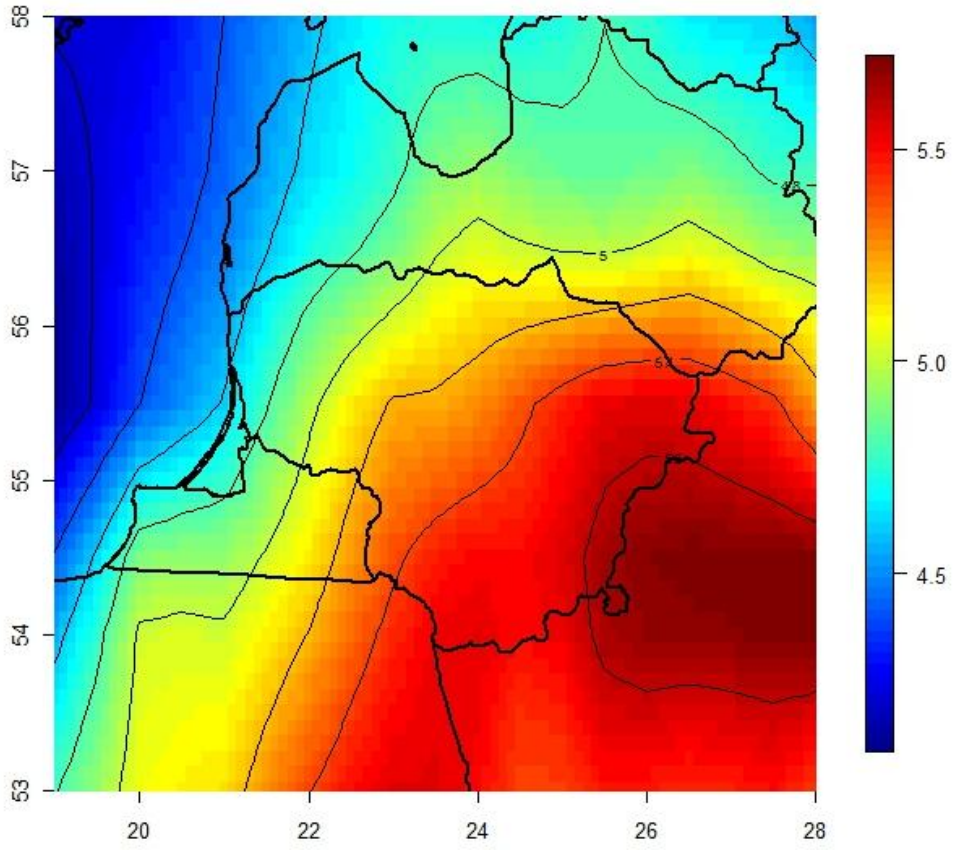
*Ilona Välisuo, FMI

HLW – Layer Mean RH, % (2004-2013)

	700-500 hPa	850-700 hPa	850 hPa-surface
AUTUMN			
WINTER			
SPRING			
SUMMER			

HSH Specific Humidity Distribution at 850 hPa in a Cold February 2011 [←] and Hot and Wet July 2010 [↓]





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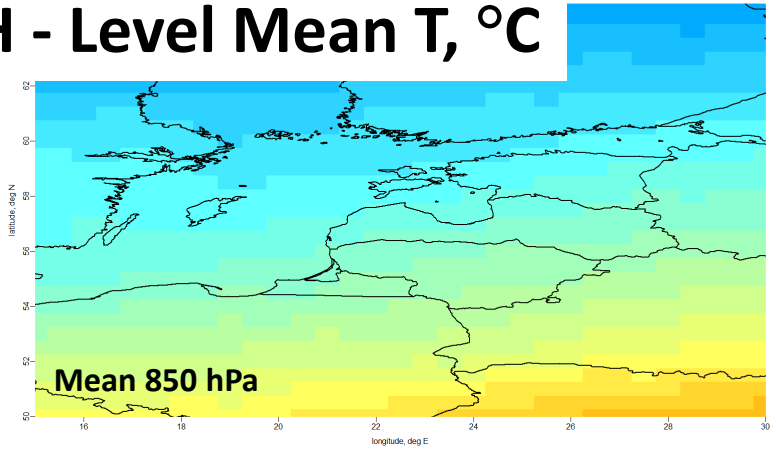
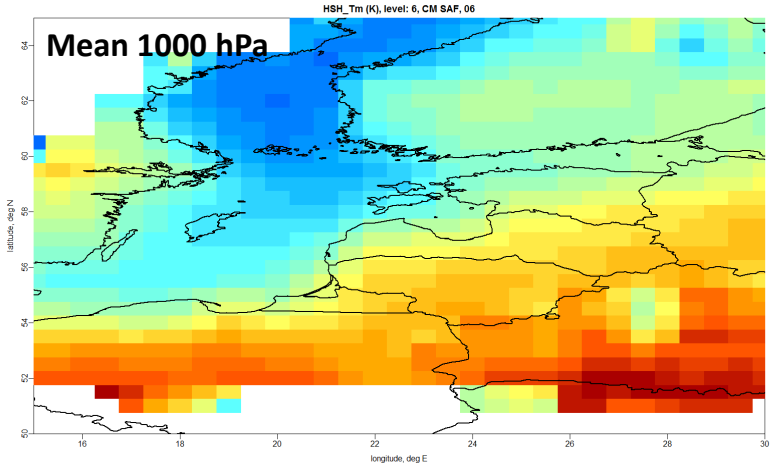
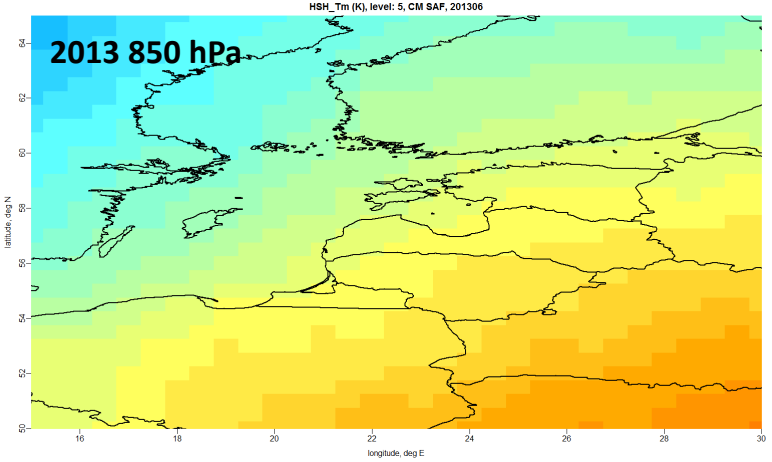
Vilnius university

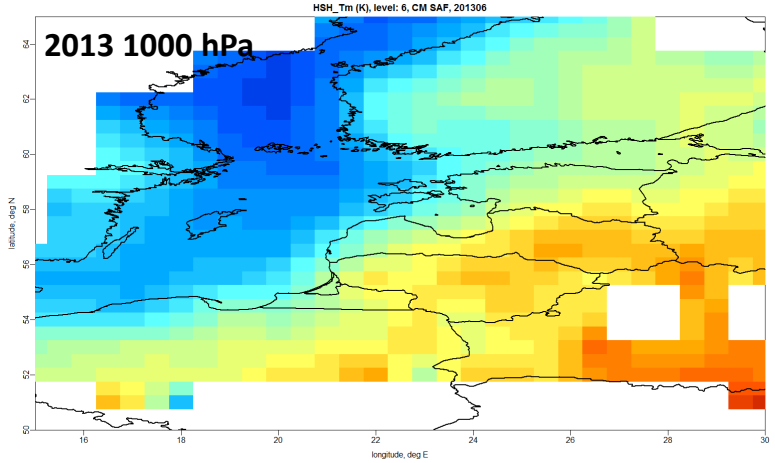
HSH - Level Mean T, °C

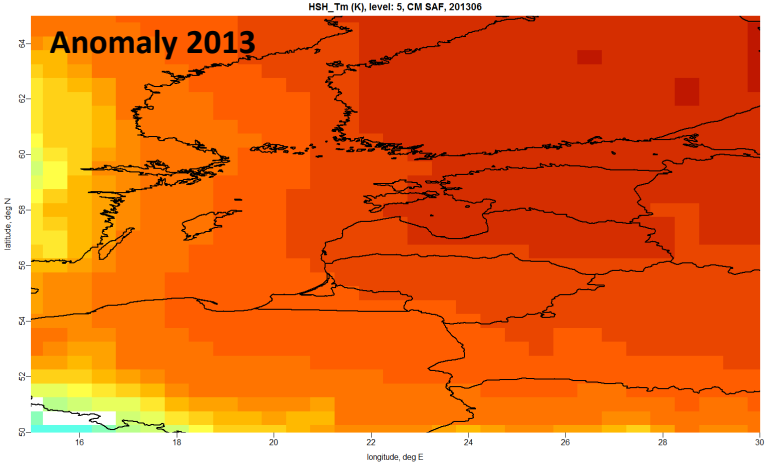
JUNE

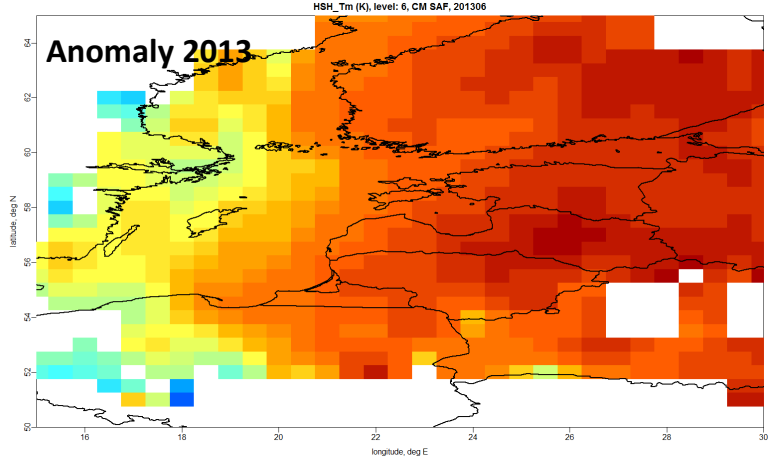




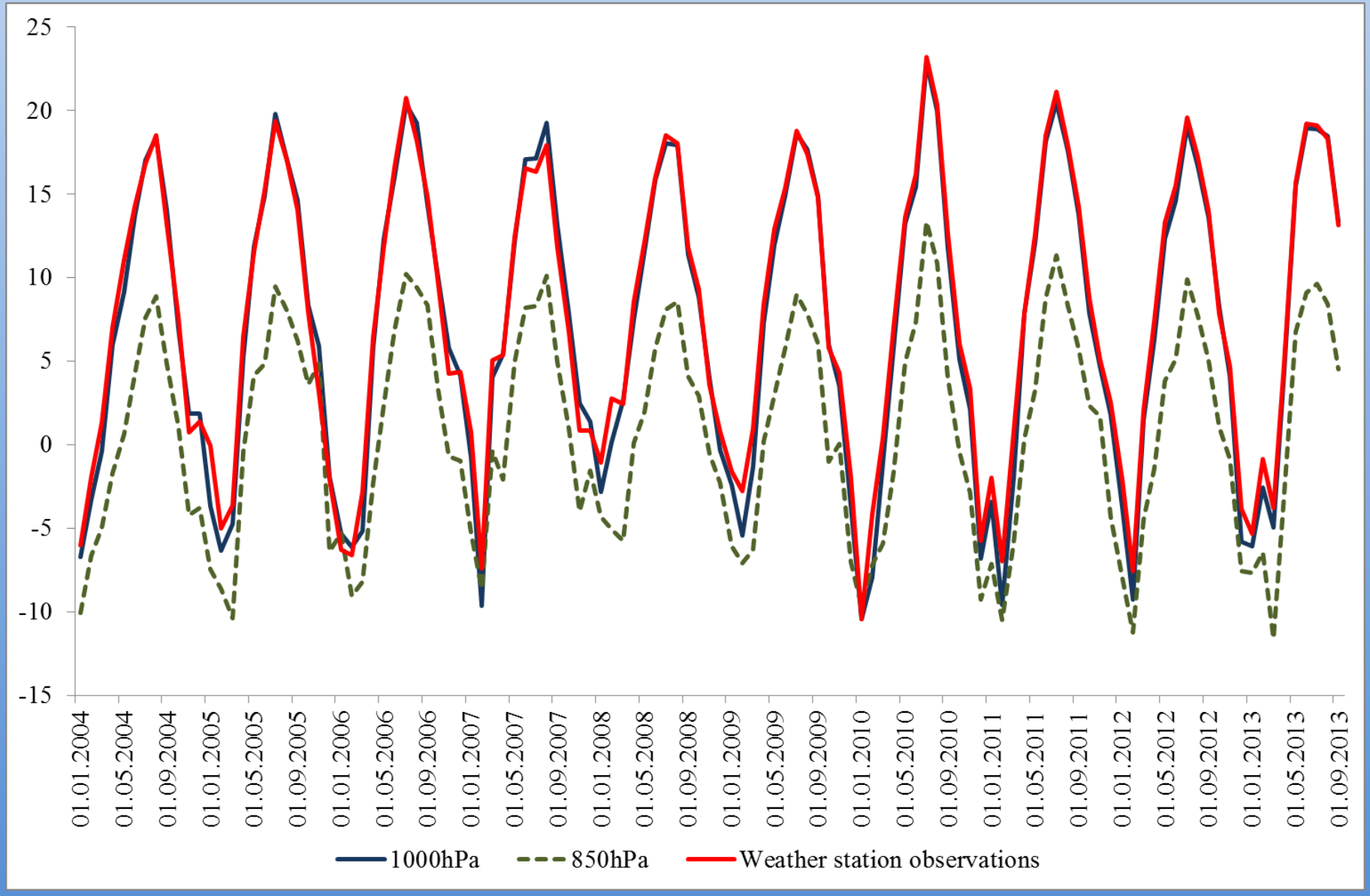




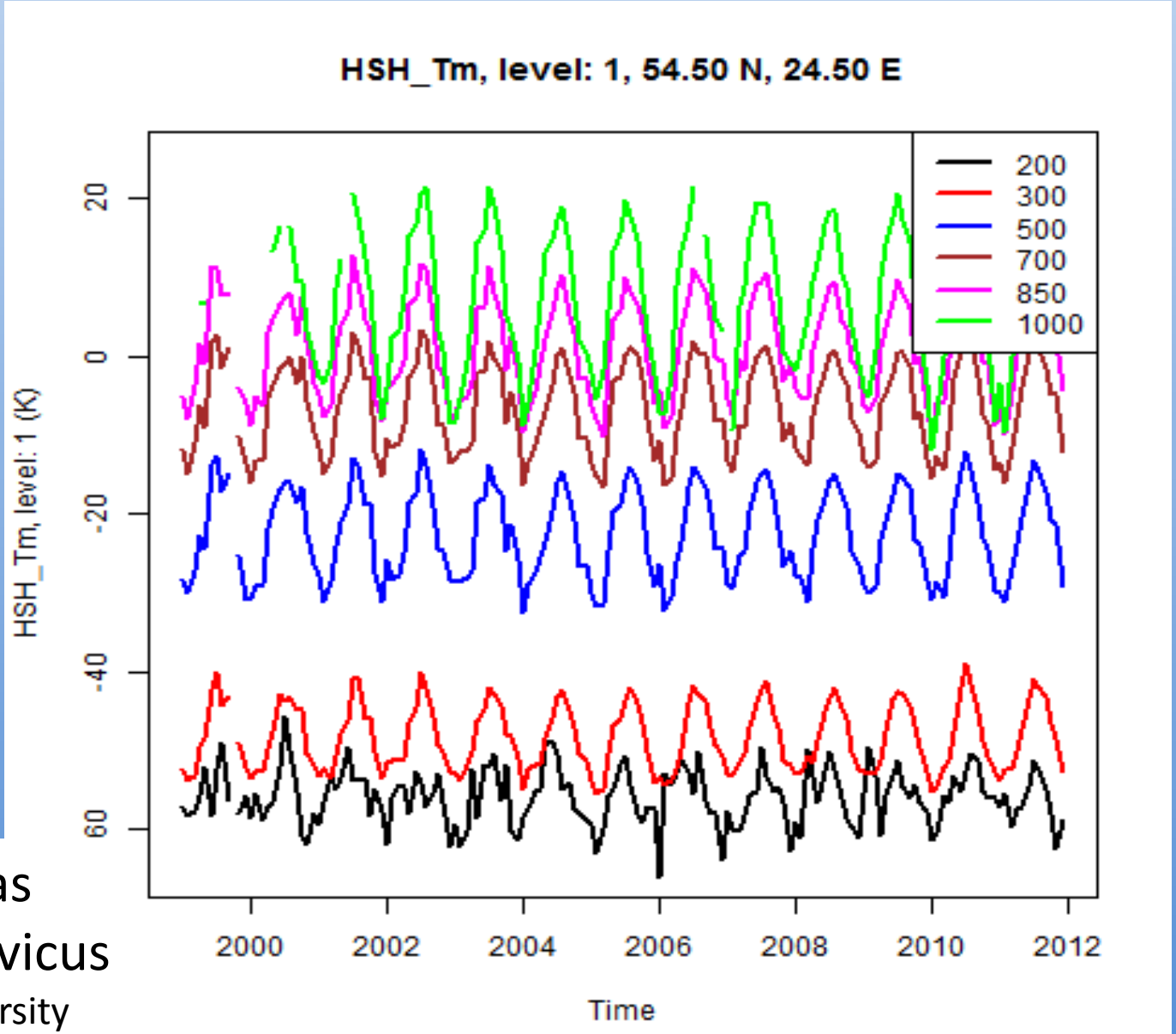




Comparison of Surface Observations and HSH Temperature at 850 and 1000 hPa in Riga



Temperature Time-series for a Point at all Available Levels



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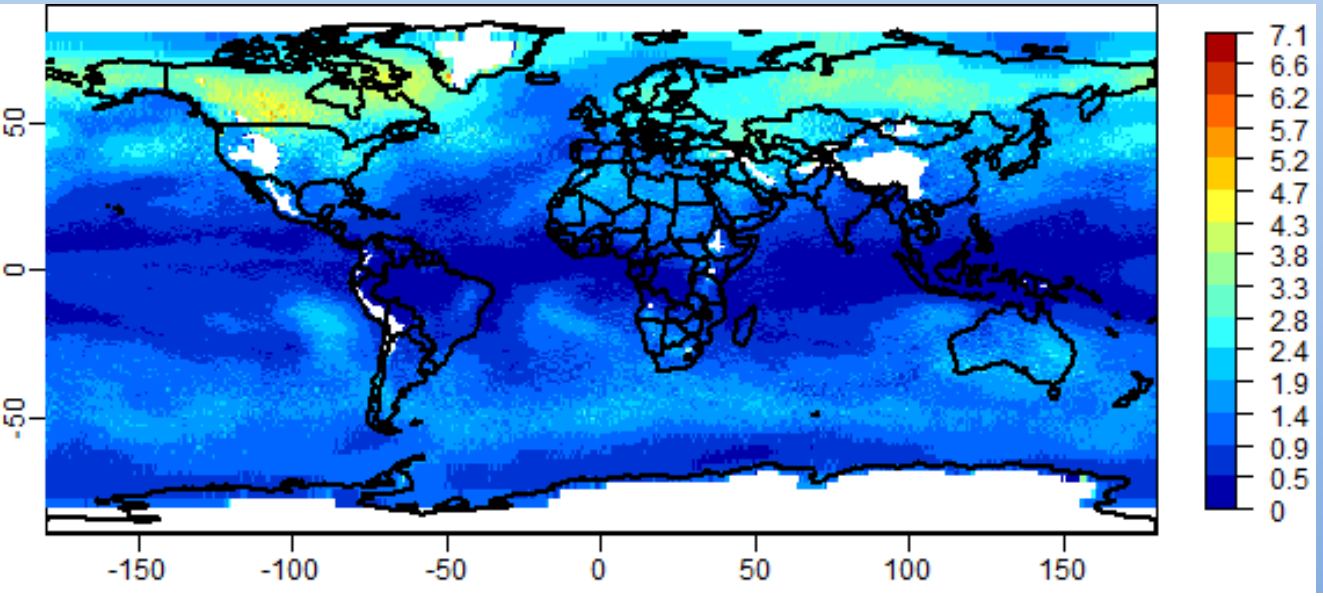
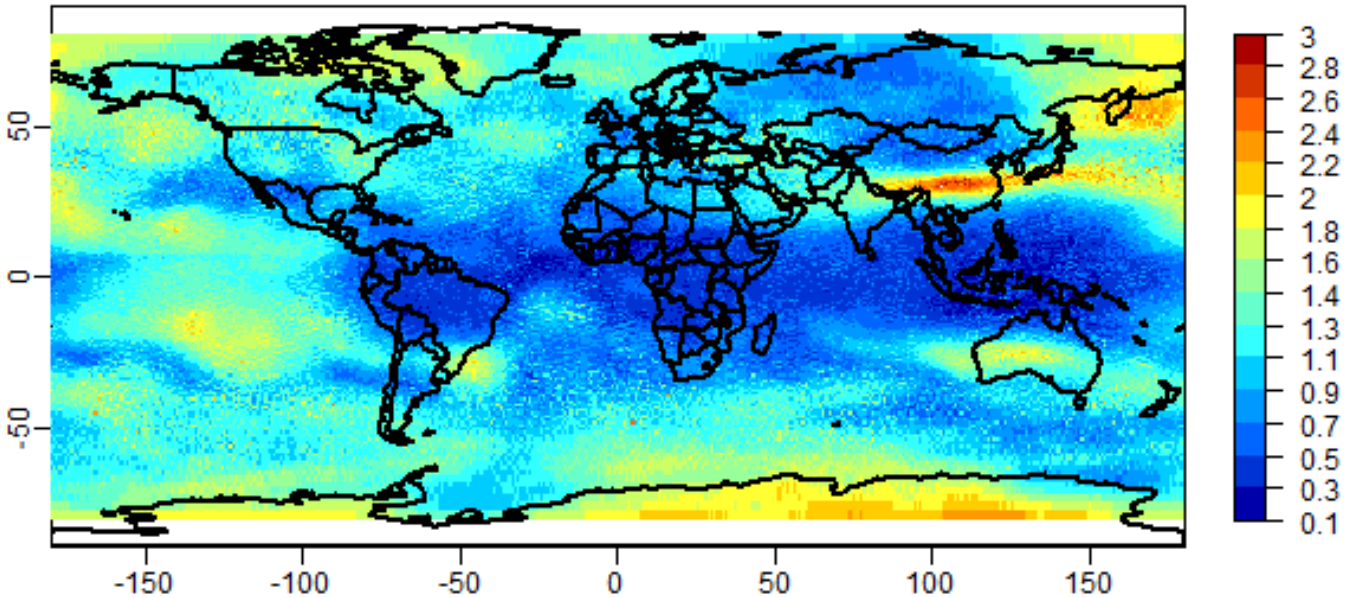
Vilnius University

Multi-year Temperature Variability (°C) in December at 850 and 300 hPa Level Height (1990-2011, expressed as STD)





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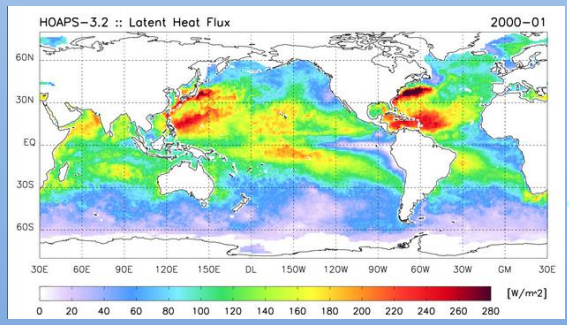
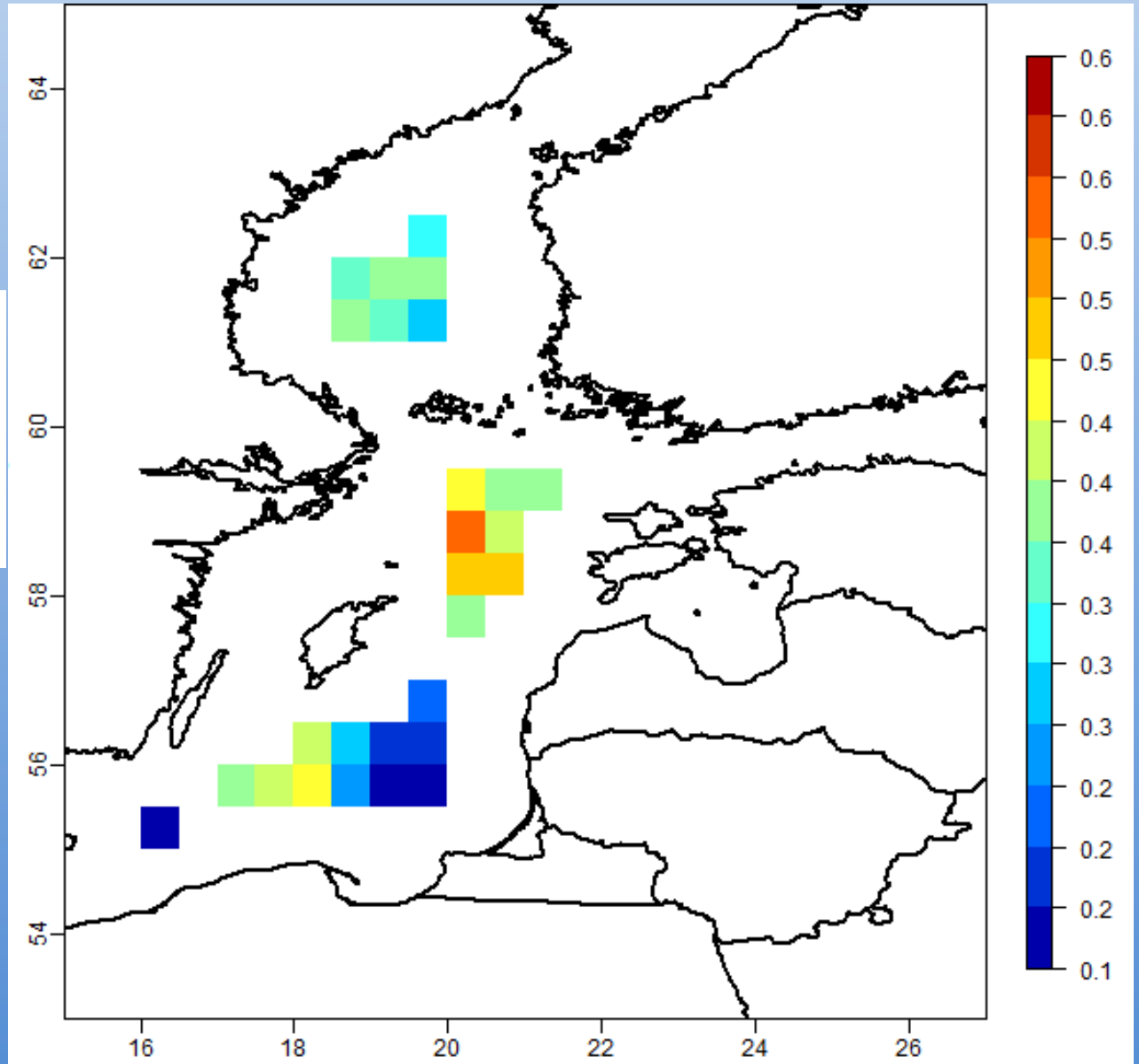
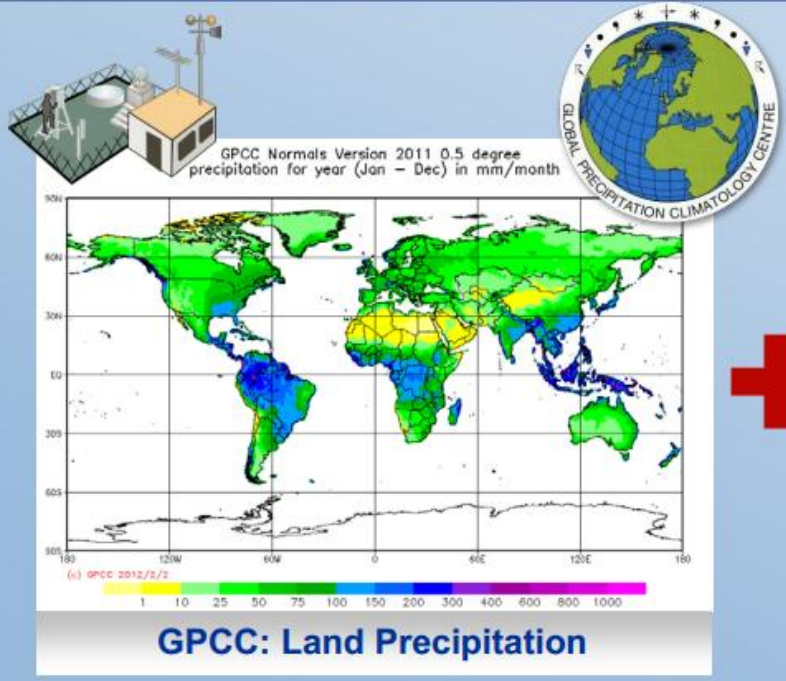
Vilnius university

The Variability of Rain Rate (mm/hour/month) in January 2008

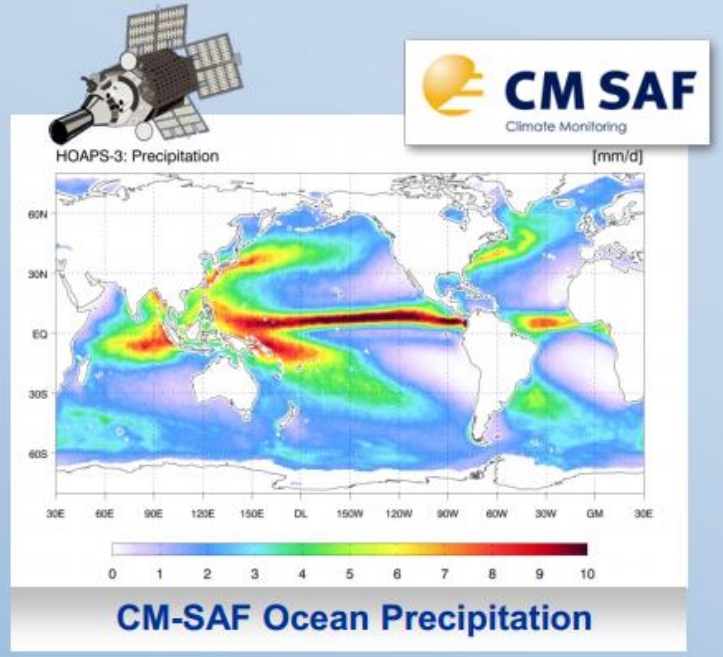


HOAPS

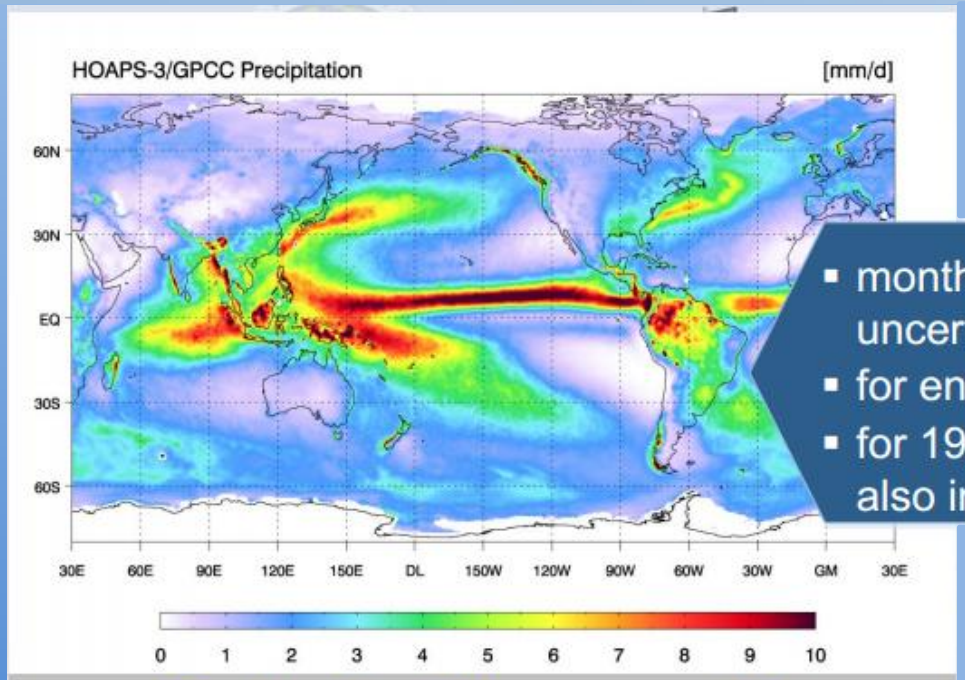




GPCC: Land Precipitation

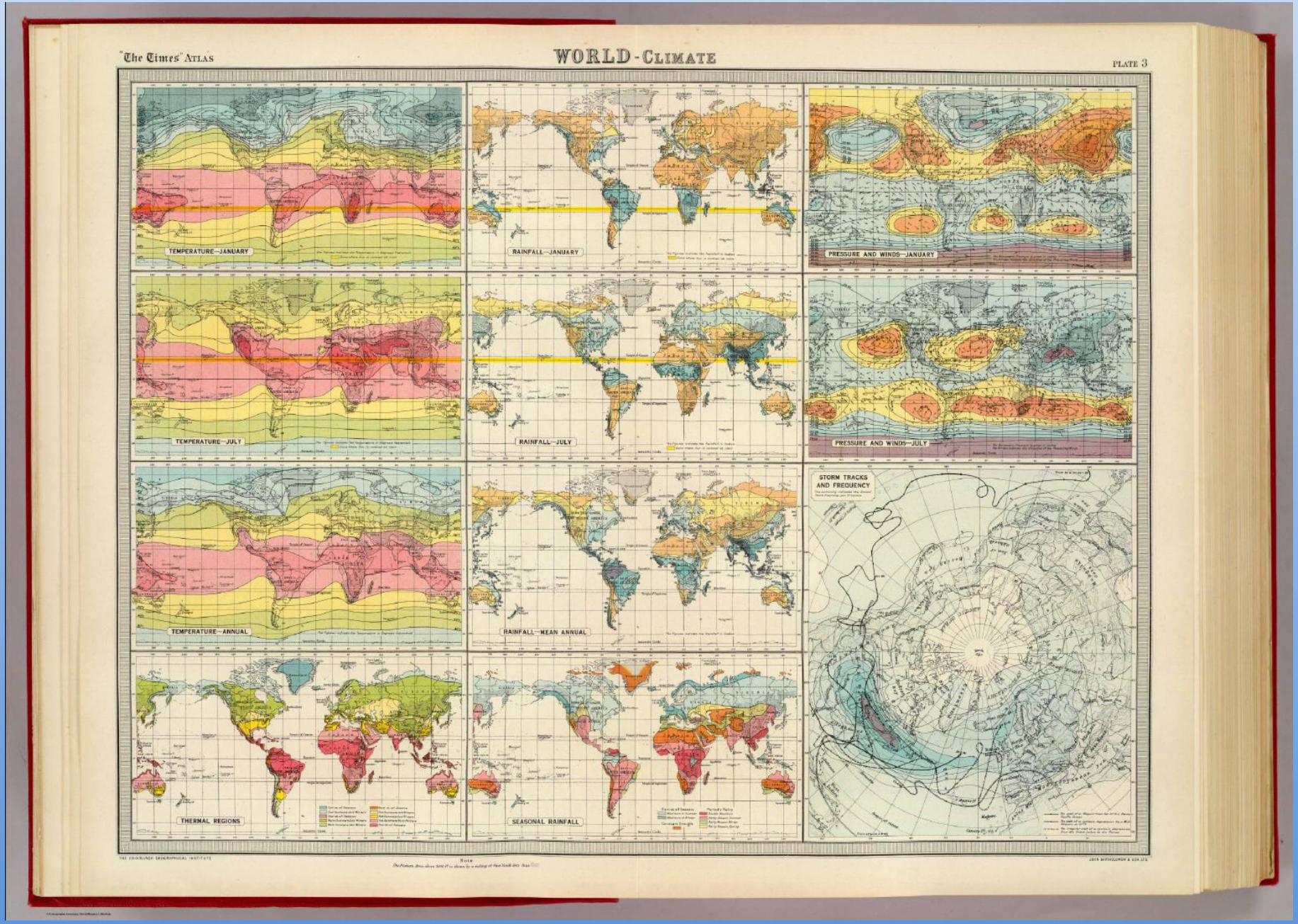


CM-SAF Ocean Precipitation



Combined satellite-gauge product

- monthly totals with uncertainty information
- for entire satellite era
- for 1988-2008 period also in daily resolution



World - Climate. The Edinburgh Geographical Institute, John Bartholomew & Son, Ltd. "The Times" atlas. (London: The Times, 1922)

Satellite Climatology Atlas for Europe and Latvia

For climatologists, young scientists and general public who

- need information on Europe's climatology
- are just *maybe* thinking about starting with satellite data
- need inspiration for the further work

Objectives

- To provide general information on the climatic characteristics of meteorological parameters over Europe and Latvia
- To provide information on satellite data suitable for climatological studies, their strenghths and weaknesses
- To provide instructions for creating a satellite climatology atlas and beginning to work with satellite datasets in general

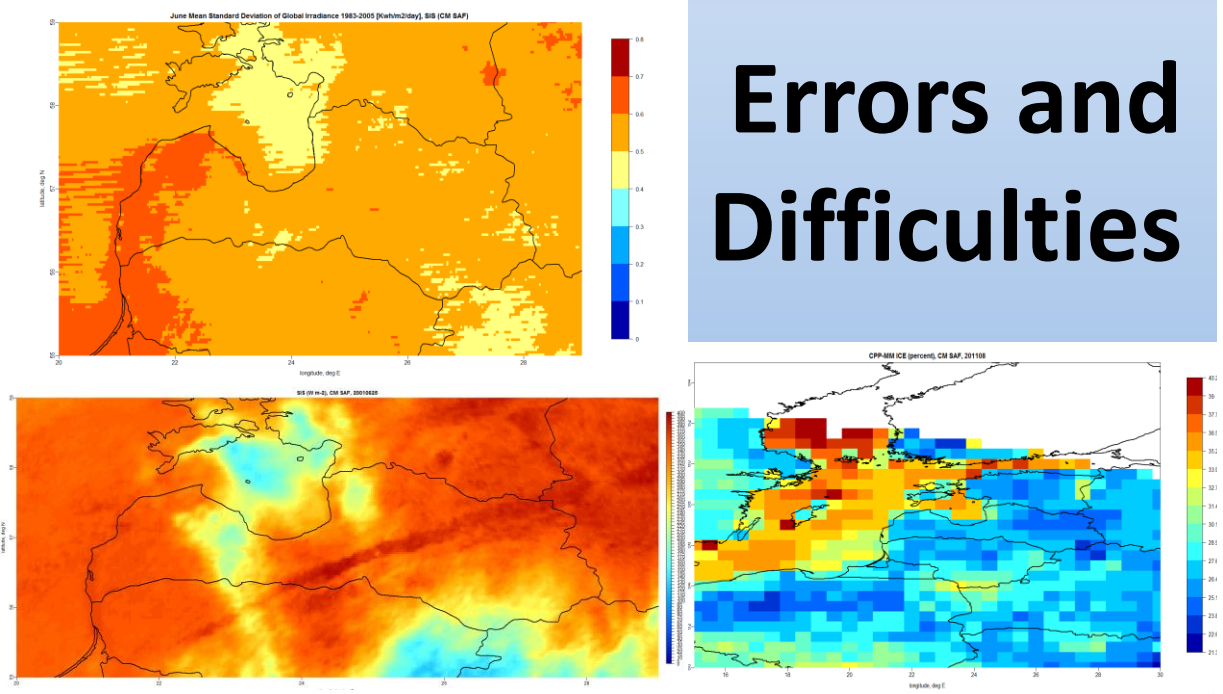
Showing the advantages of satellite data for climate studies

- Coverage, spatial and temporal resolution → GEO vs. LEO
- Information on parameters that can not be measured by the surface observation stations
- *Almost* 30-year period

Discussing things to pay special attention to

- Not measuring the exact parameter – result depends on the retrieval method
- Retrieval methods, limitations for the use of data
- Known errors and imperfections in the datasets:
  - ✓ Missing scan-lines
  - ✓ Effect of snow cover
  - ✓ Effect of SZA thresholds
  - ✓ Unnatural features in the data (line over Latvia)

Errors and Difficulties



Data Used

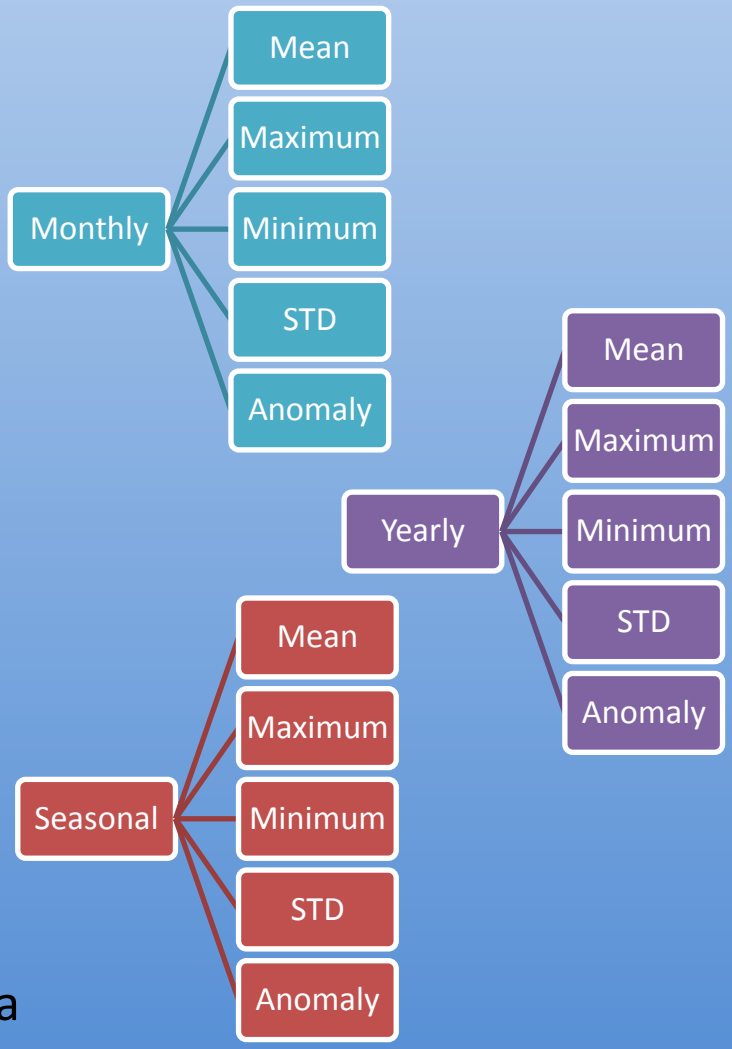
Parameter	Dataset	Variable	Period
Cloudiness	CLARA-A1	Monthly mean cloud fractional cover (CFC)	1982-2009
Cloud Phase	CLARA-A1	- Monthly mean fraction of liquid water clouds (CPH) - Monthly mean cloud ice water path (IWP) - Monthly mean cloud liquid water path (LWP)	1982-2009
Cloud Top Parameters	CLARA-A1	Monthly mean cloud top parameters (CTO) - Cloud top height - Cloud top pressure - Cloud top temperature	1982-2009
Cloud Optical Thickness	CLARA-A1	Monthly mean cloud optical thickness (COT) - All clouds - Ice clouds - Liquid clouds	1982-2009
Solar Radiation	MVIRI dataset	- Monthly mean solar surface irradiance (SIS) - Monthly mean direct radiance at surface (SID)*	1990-2005
Daylight	Daylight dataset	Daylight intensity (DAL)	1990-2005
Surface Albedo	CLARA-A1	Surface albedo (SAL)	1982-2009

Structure of the Atlas

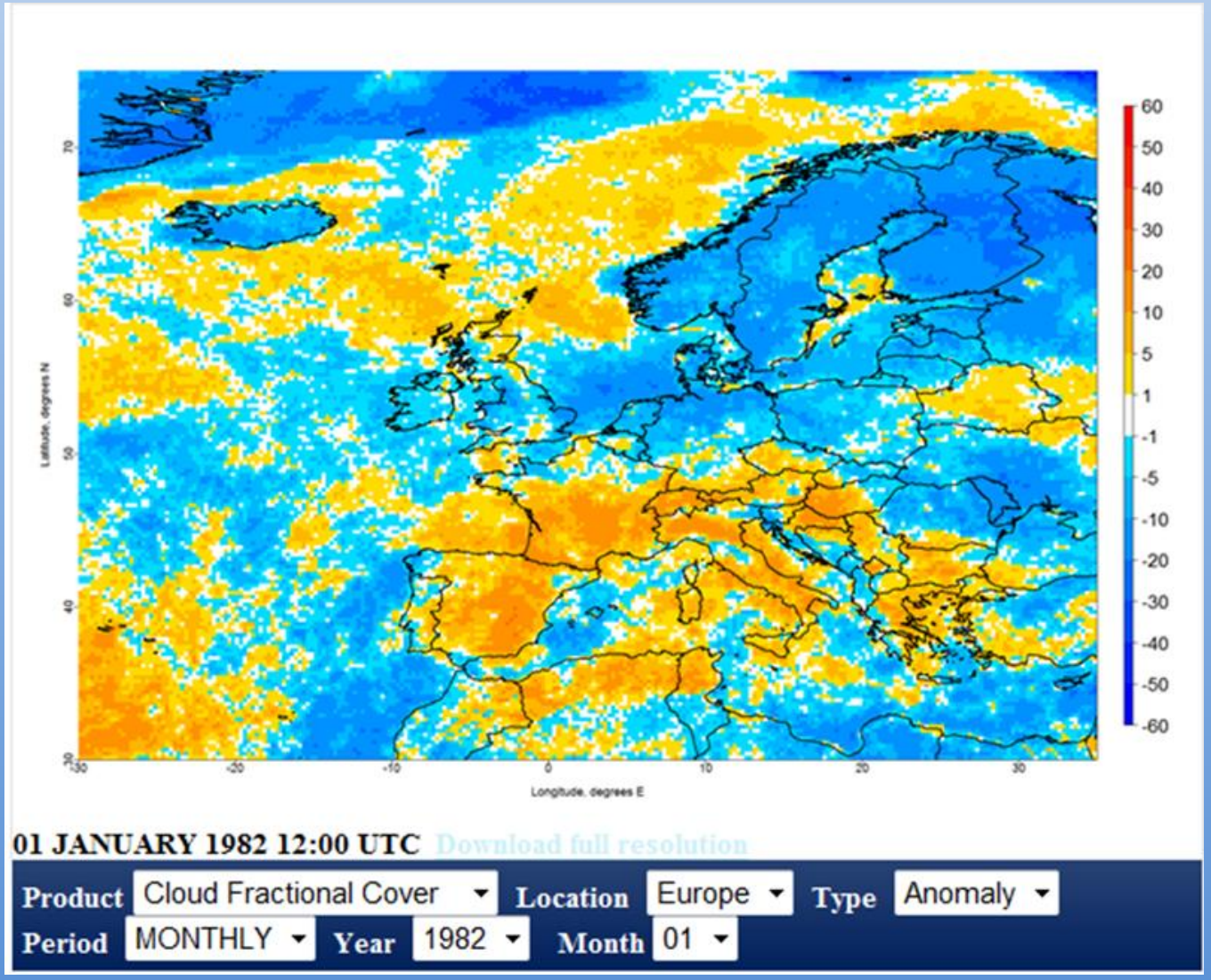
- Java script

- Spatial maps
- 2 domains – Europe and Latvia
- Possible to view means for each year/month/season , the multi-year yearly/monthly/seasonal means etc. and the anomalies
- Consistent colour scales

+ Instructions
  - Short descriptions of the variables, including the choices made while working with each variable
  - Description of the data sources, ordering, software tools and the use of scripts
  - Example scripts and data, auxiliary data



Java Script


Latitude, degrees N
70
60
50
40
30
-30
-20
-10
0
10
20
30
Longitude, degrees E
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5
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-5
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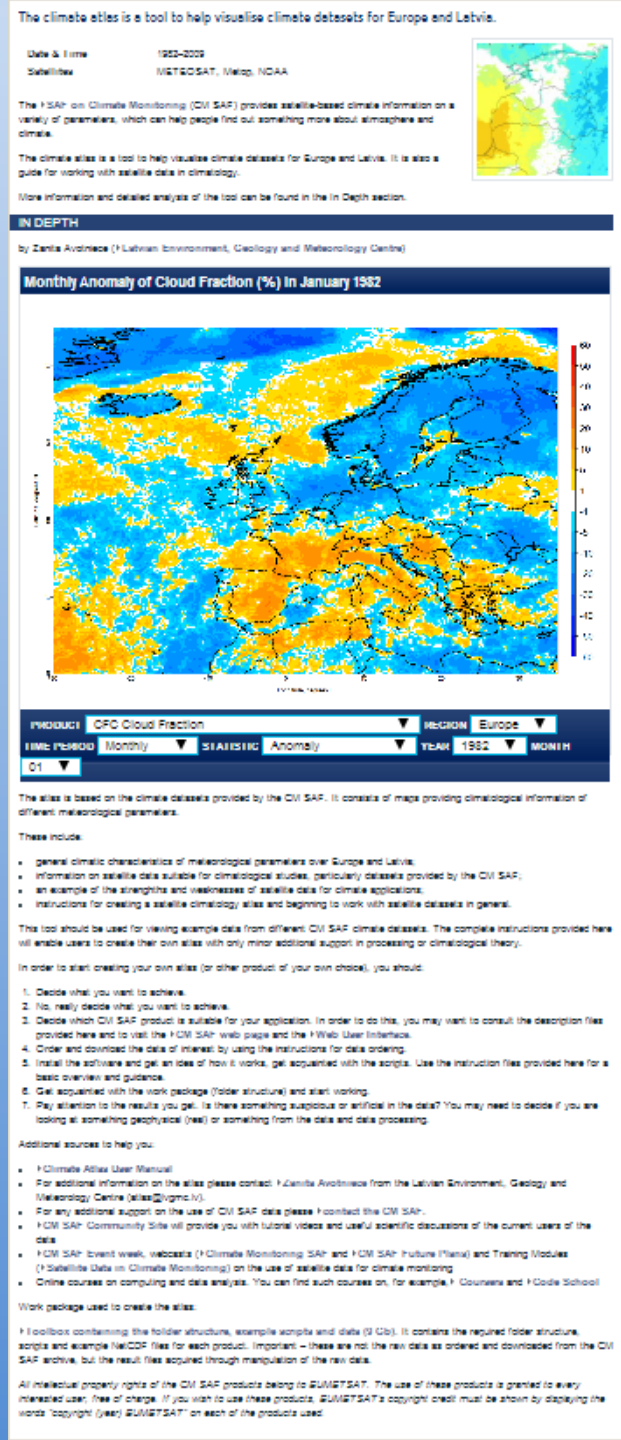
01 JANUARY 1982 12:00 UTC
Download full resolution
Product
Cloud Fractional Cover
Location
Europe
Type
Anomaly
Period
MONTHLY
Year
1982
Month
01

Access the Atlas

- http://www.eumetsat.int/website/home/Images/ImageLibrary/DAT_2266050.html

- www.eumetsat.int → Images → Image Library and search by *Feature: Climate Monitoring*



... And your task is

- Work in pairs
- (~15 minutes) Look at all the information you can find for the given country or parameter and discuss:

- What can you say about the climatology?
- What can you say about the data?

... And your task is

- Make bigger groups according to the country/parameter
- (~10 minutes) How do the seasons differ (in terms of both climatology and data)?

What did you find out about the environment?

What did you find out about the data?

What would you use this data for?

- What is the temperature at 850 hPa for different phases of precipitation? First snow?
- What are the temperatures at different pressure heights during extreme heat/cold episodes?
- Patterns representing unusually wet and dry periods?

+++

Useful Sites:

- CM SAF web site www.cmsaf.eu
- CM SAF Web User Interface http://wui.cmsaf.eu
- CM SAF community site http://training.eumetsat.int/mod/page/view.php?id=4511

Other Datasets Suitable for Climate Applications

- AVISO - Sea level http://www.aviso.oceanobs.com/en/
- MyOcean – Sea surface temperature, Sea ice http://www.myocean.eu/
- OSI SAF – Sea ice http://www.osi-saf.org/
- GPCP – Precipitation http://www.gewex.org/gpcp.html

Thank you for cooperation! ☺