



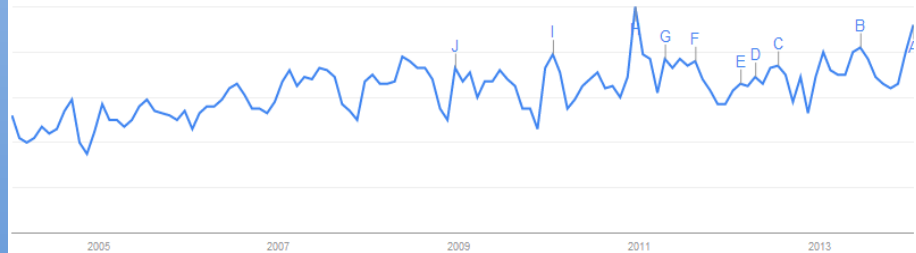
Use of Satellite Data for Climate Applications - CM SAF -

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

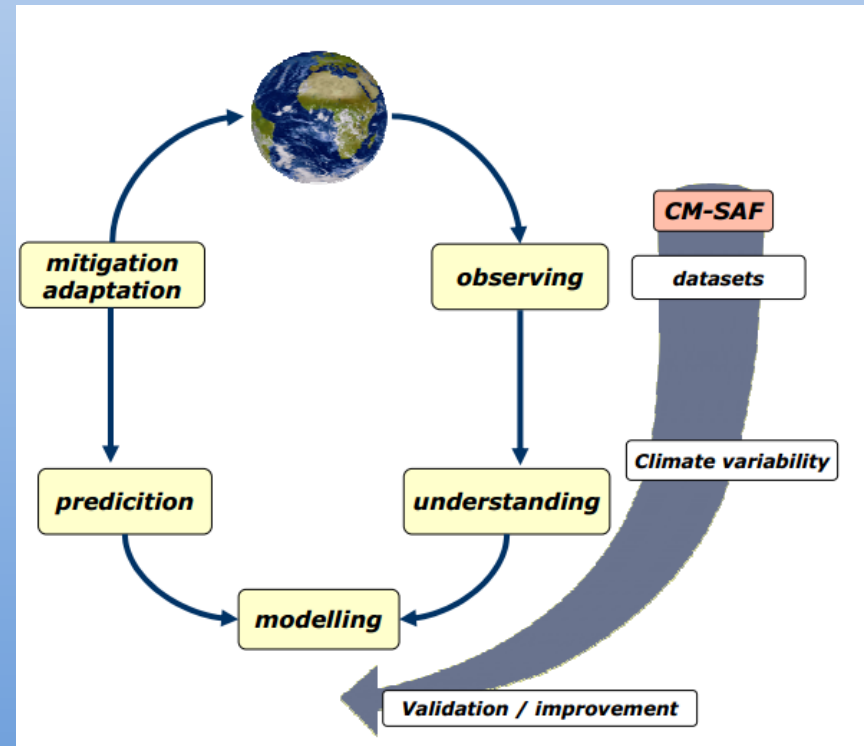
CM SAF – Satellite Application Facility on Climate Monitoring

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.



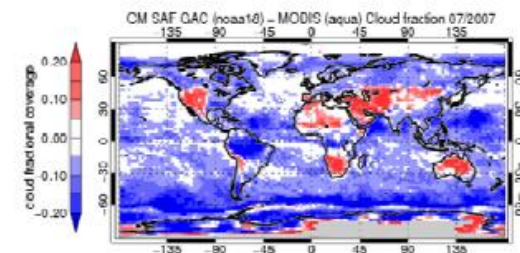
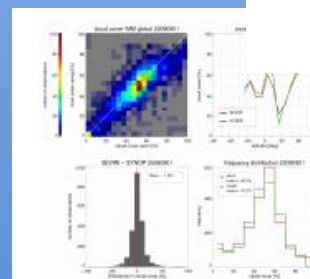
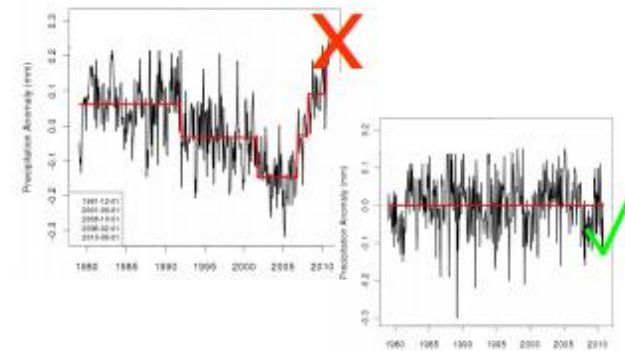
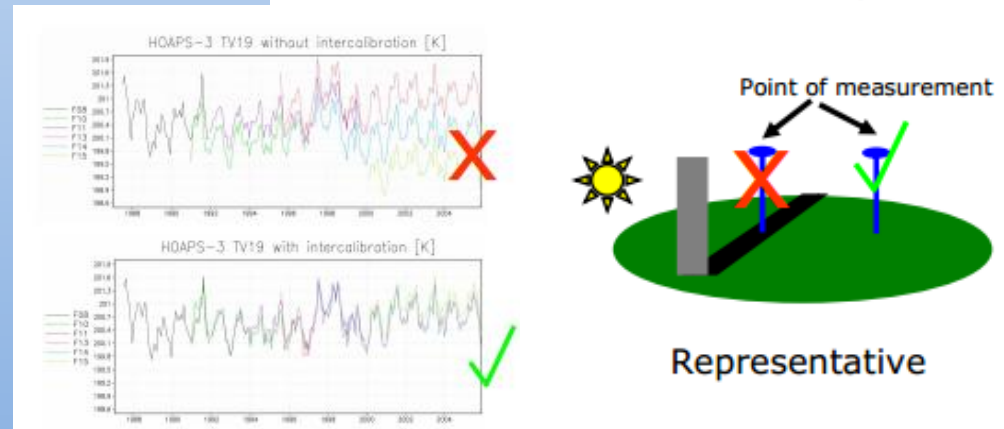
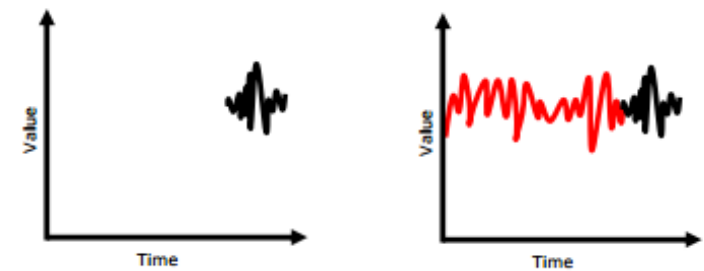
The CM SAF is part of the EUMETSAT Satellite Application Network and is a joint effort of six European National Meteorological and Hydrological Services, led by Deutscher Wetterdienst

- 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

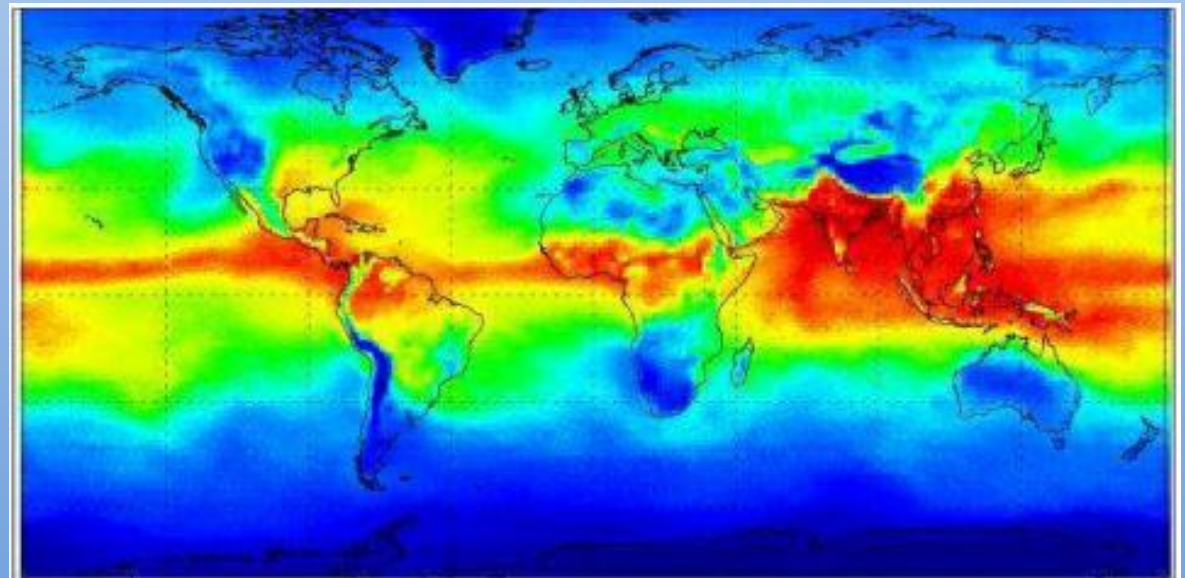
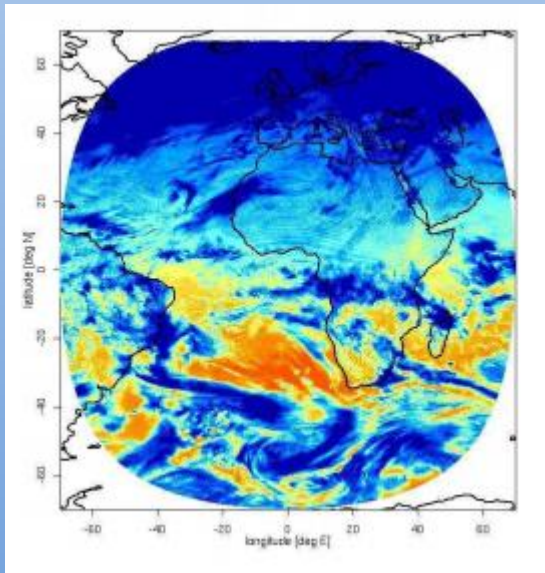


Requirements for Climate Data Records

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



Geostationary or Polar-orbiting Satellite?



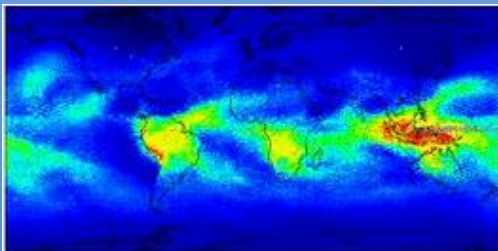
CM SAF Climate Datasets

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)

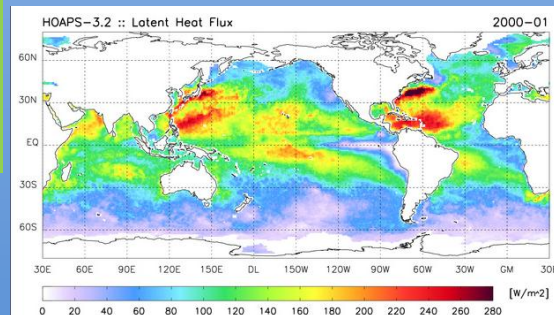
ATOVS (1999-2011)

- 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

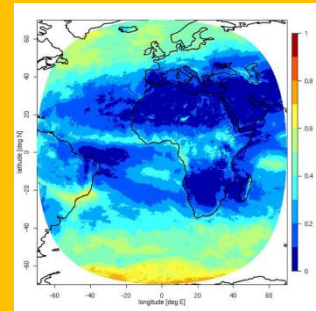


MFG/MVIRI (1983-2005)

- 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



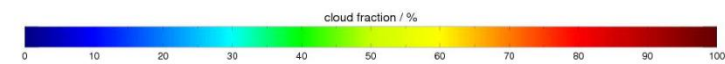
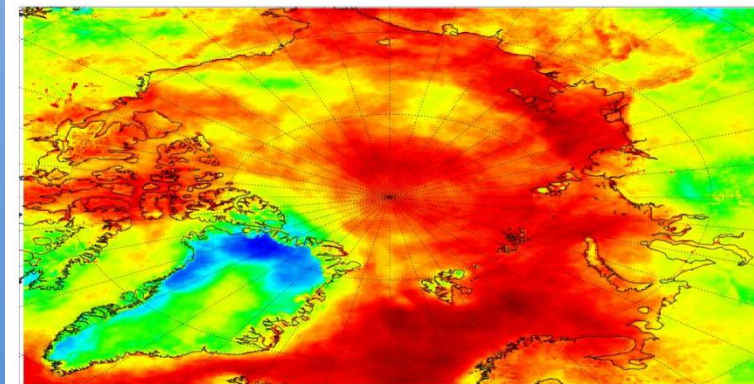
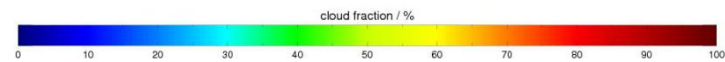
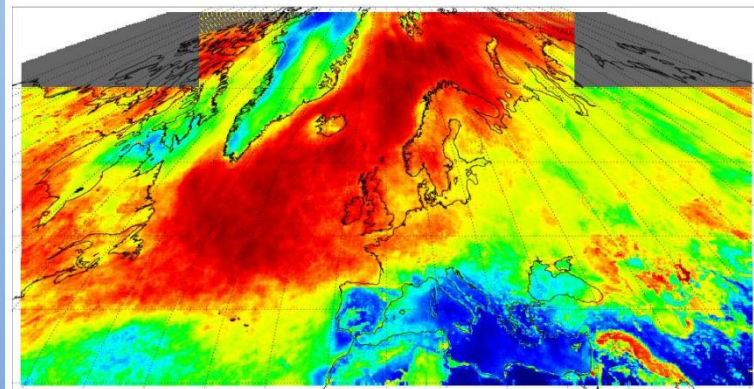
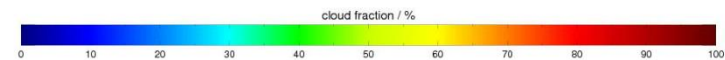
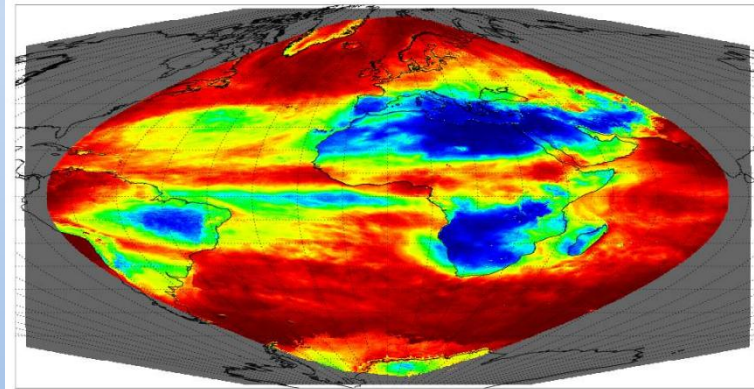
MFG/MVIRI and MSG/SEVIRI (1983-2009)

- Free tropospheric humidity

CM SAF Operational Products

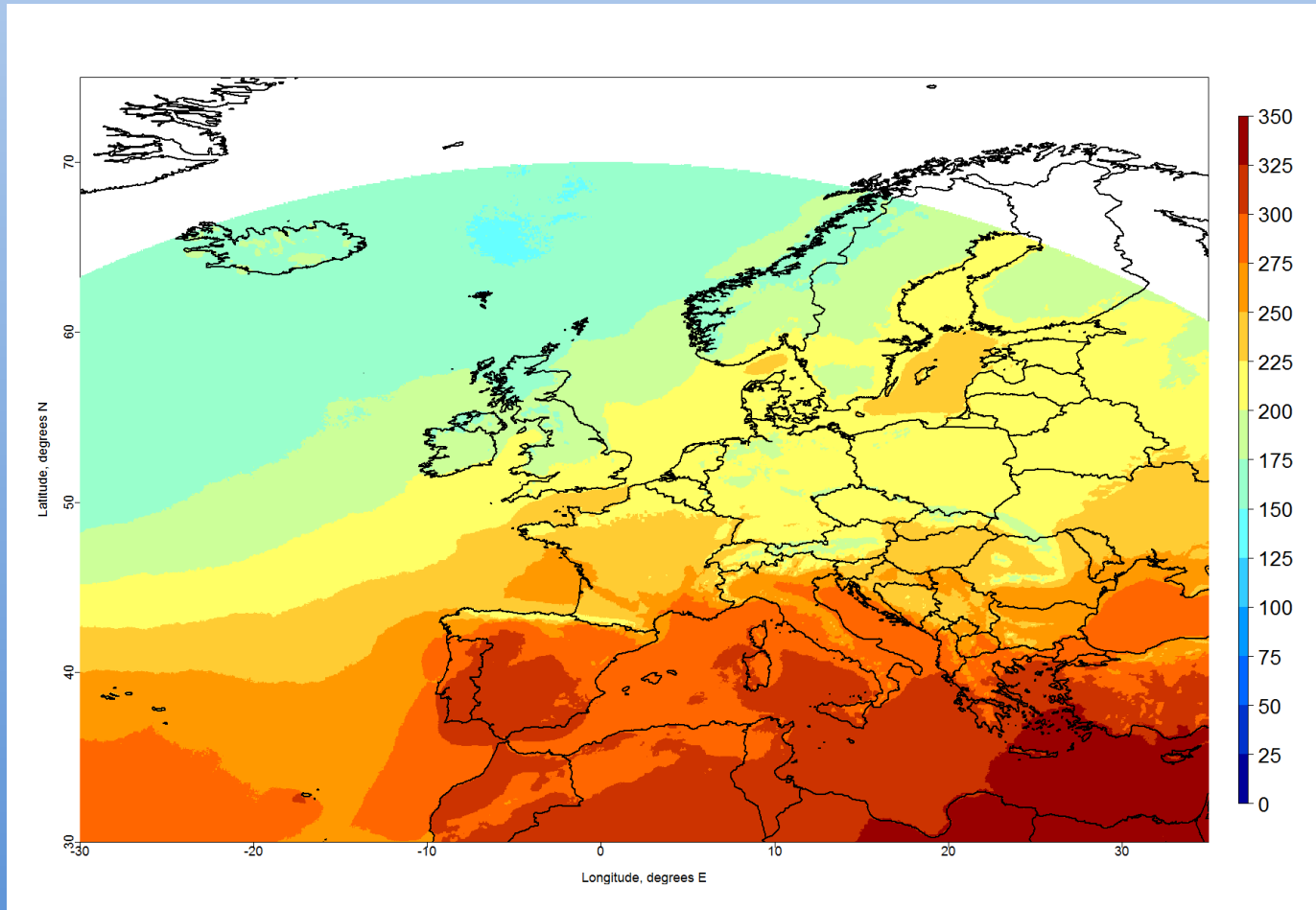
AVHRR, SEVIRI, ATOVS (2004-...)

- 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

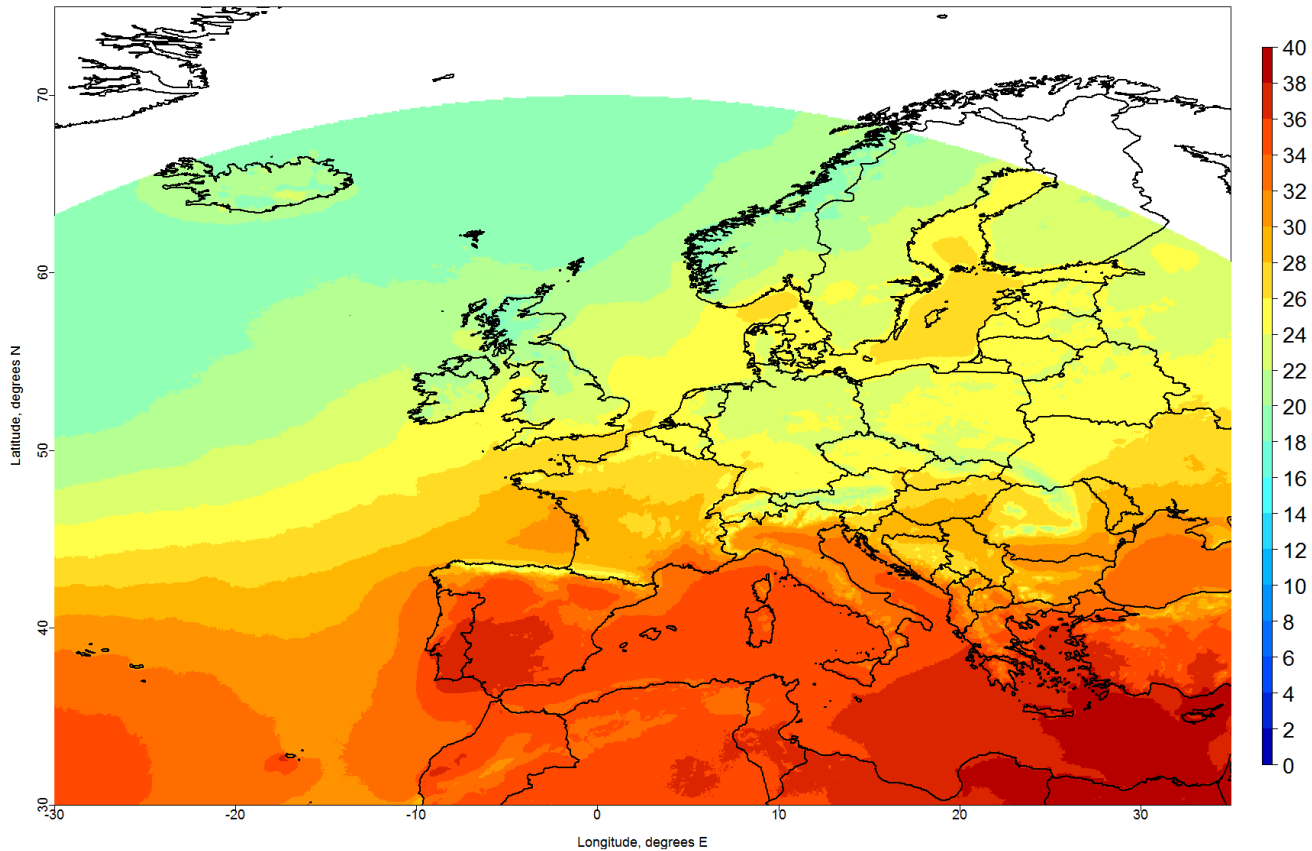


Applications of CM SAF Data

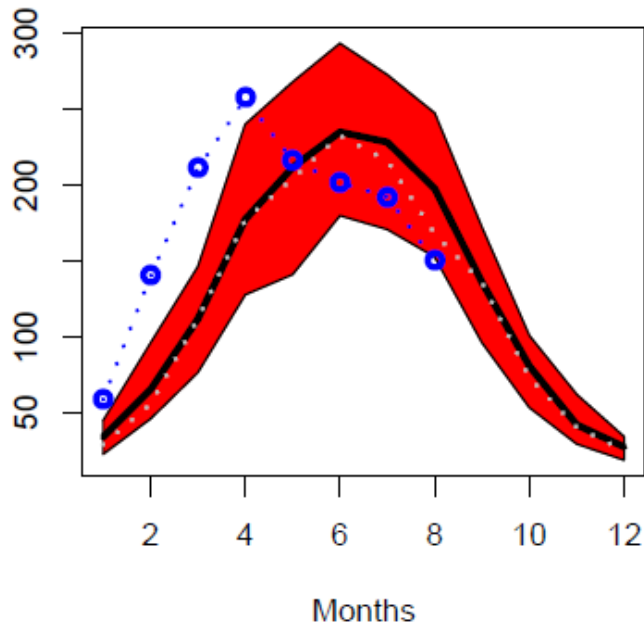
Mean Surface Incoming Shortwave Radiation in Summer (1990-2005)



Mean Daylight Intensity in Summer (1990-2005)



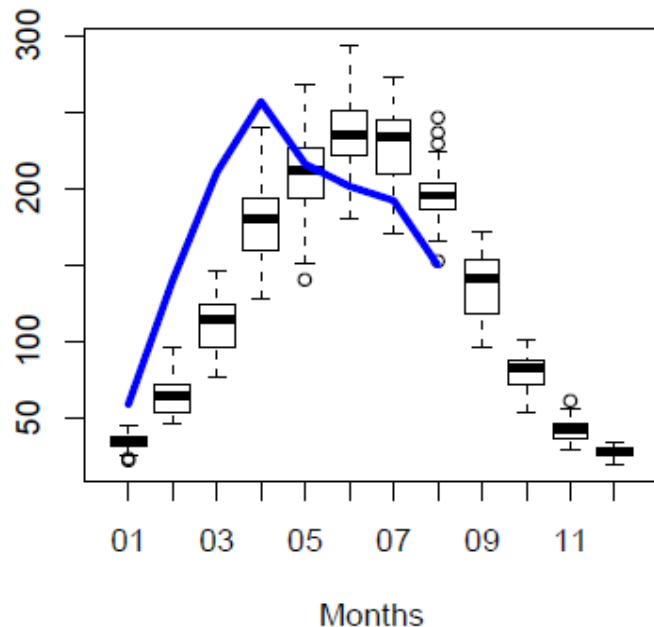
Average Seasonal Cycle



Normal or Not?

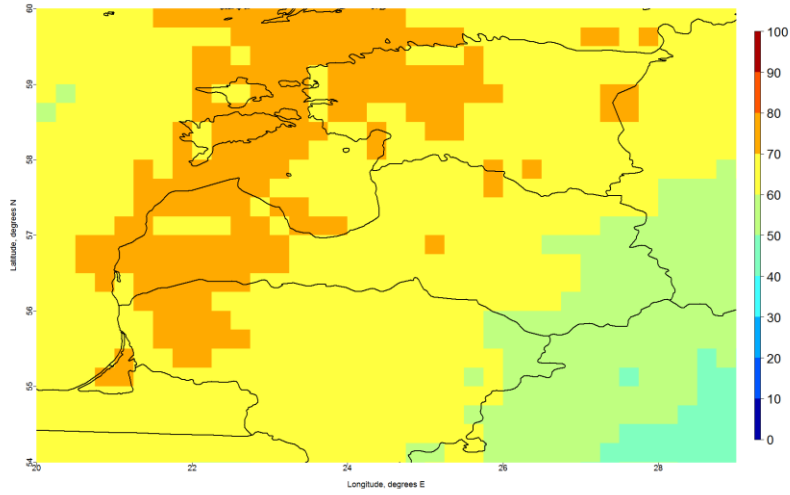
Comparison of the Solar radiation in the year 2010 and the long-term mean (1982-2009)

* Dr. Mark Higgins, EUMETSAT

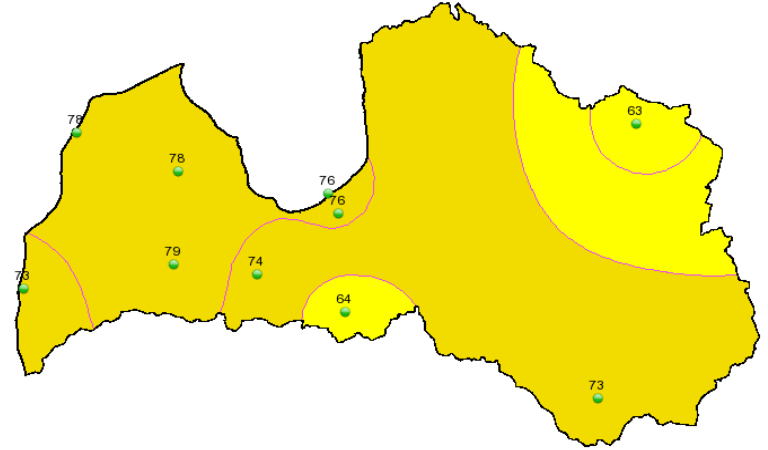


July 2004 Mean Cloud Cover

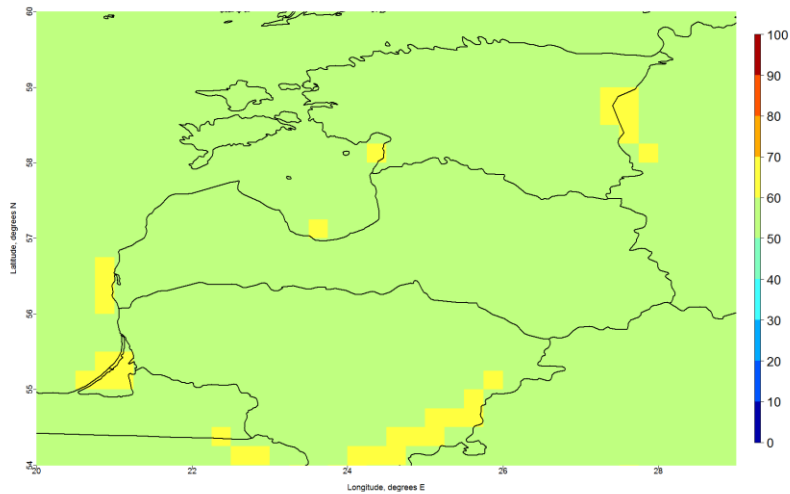
July 2004



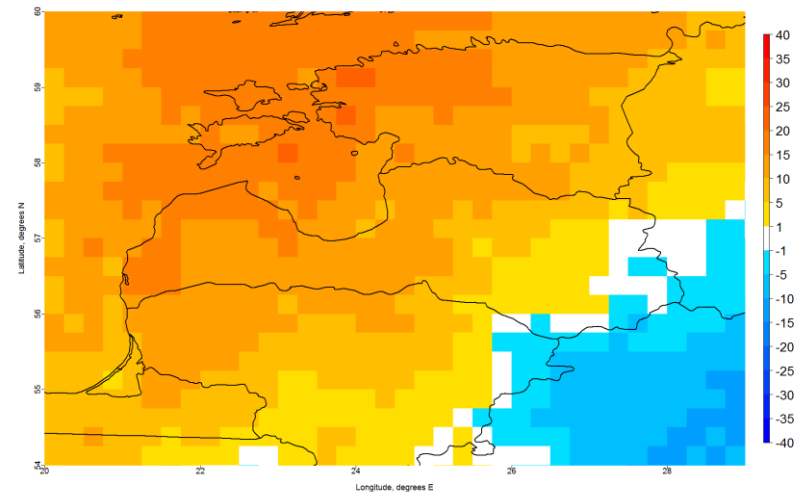
Surface Observations



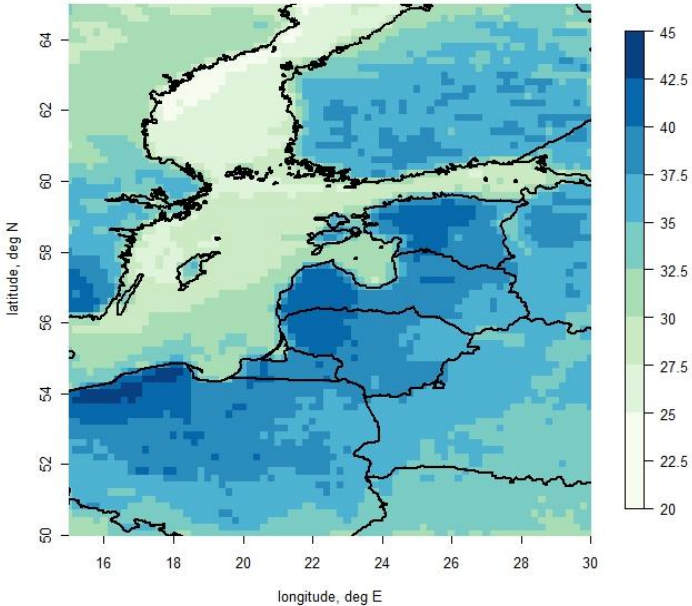
July Mean



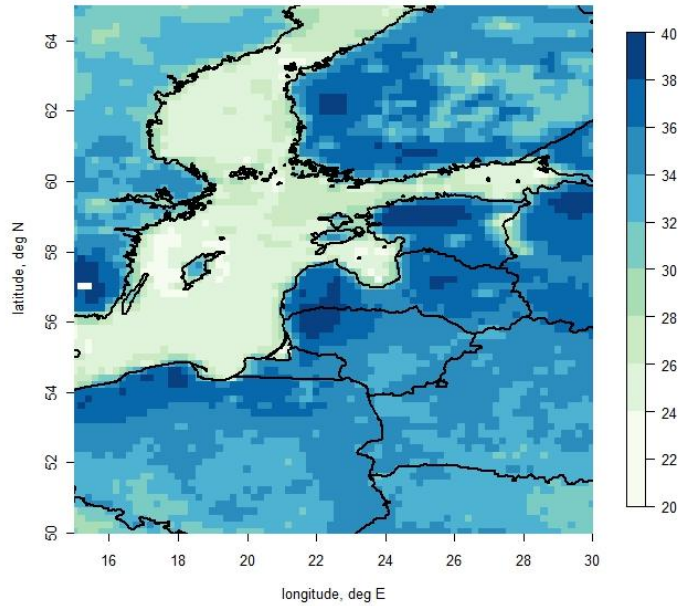
July 2004 Anomaly



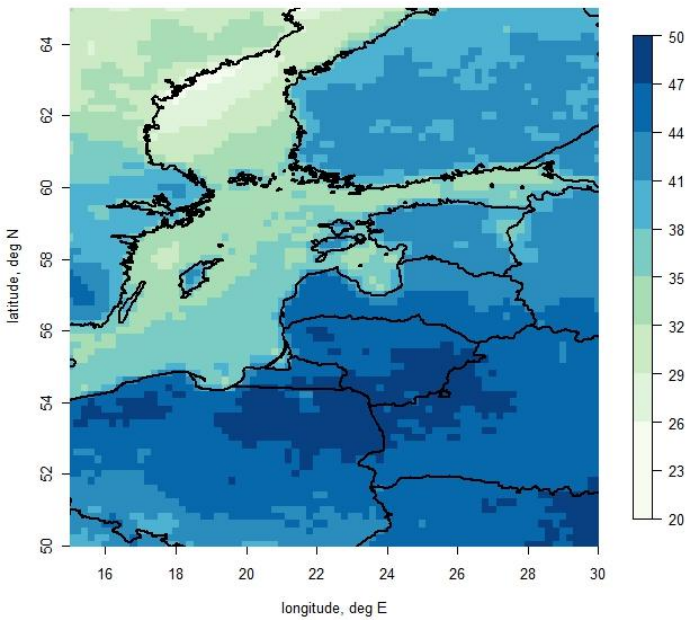
CTY-MM LOW CLOUDS (percent), Mean Seasonal Low Cloud Cover mai 2011



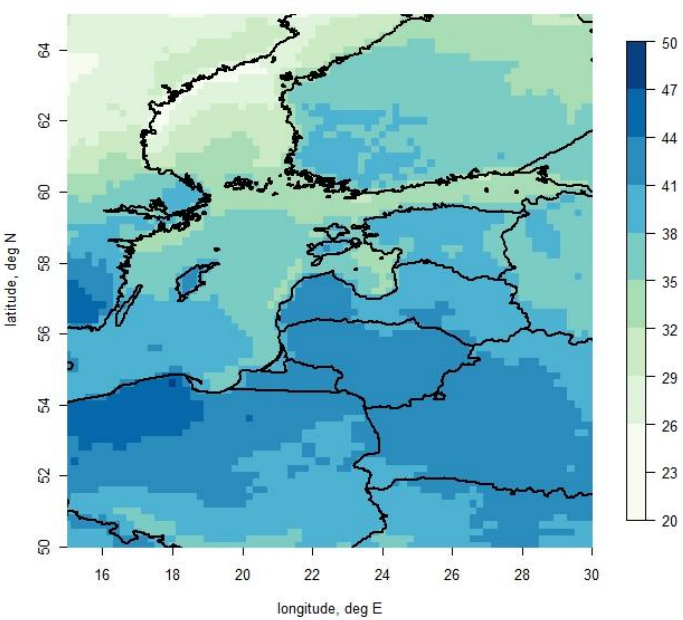
CTY-MM LOW CLOUDS (percent), Mean Seasonal Low Cloud Cover aug 2011



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



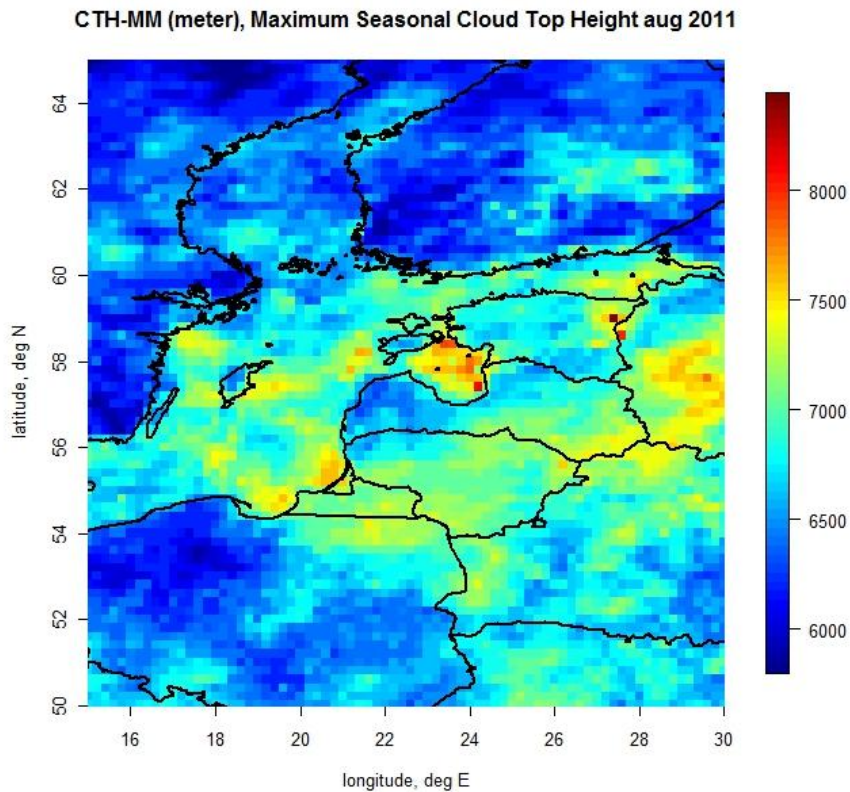
CTY-MM LOW CLOUDS (percent), Mean Seasonal Low Cloud Cover feb 2011



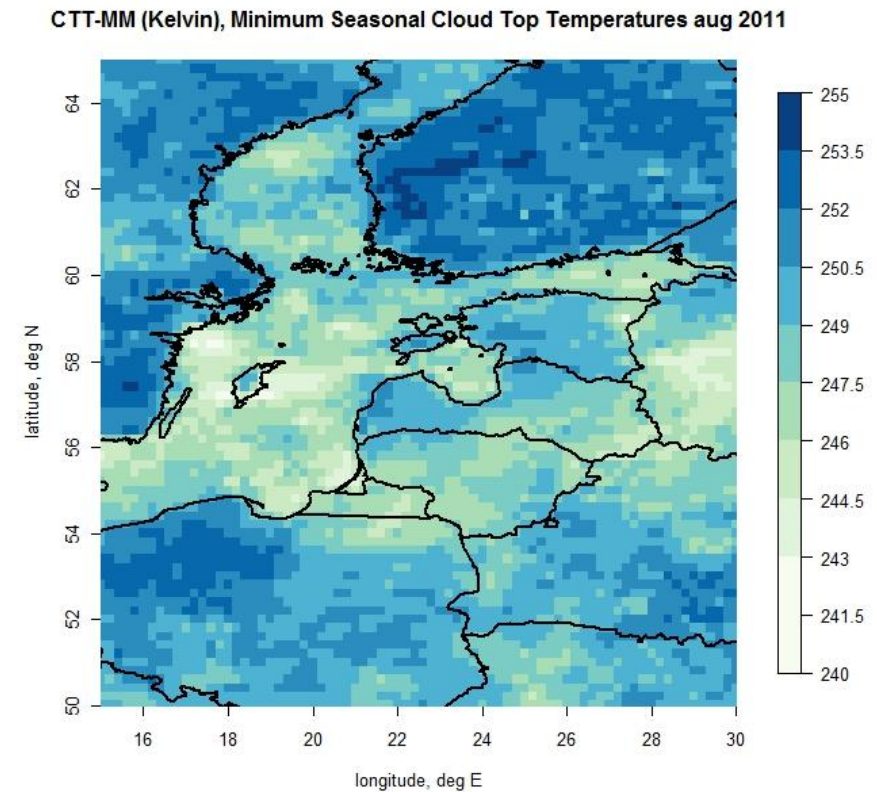
**Seasonal Mean
Low Cloud
Cover 2005-
2011**

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

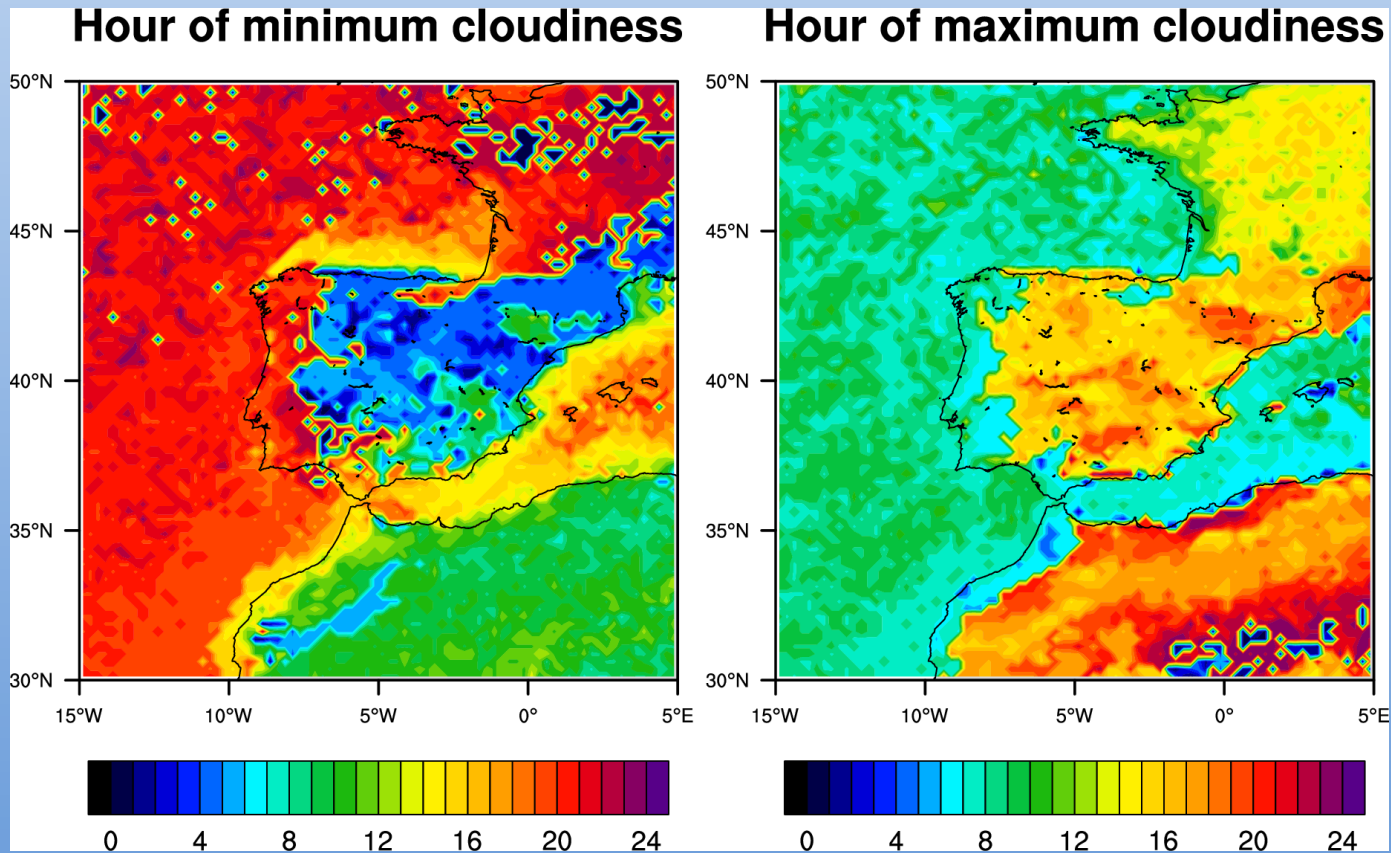
CTH



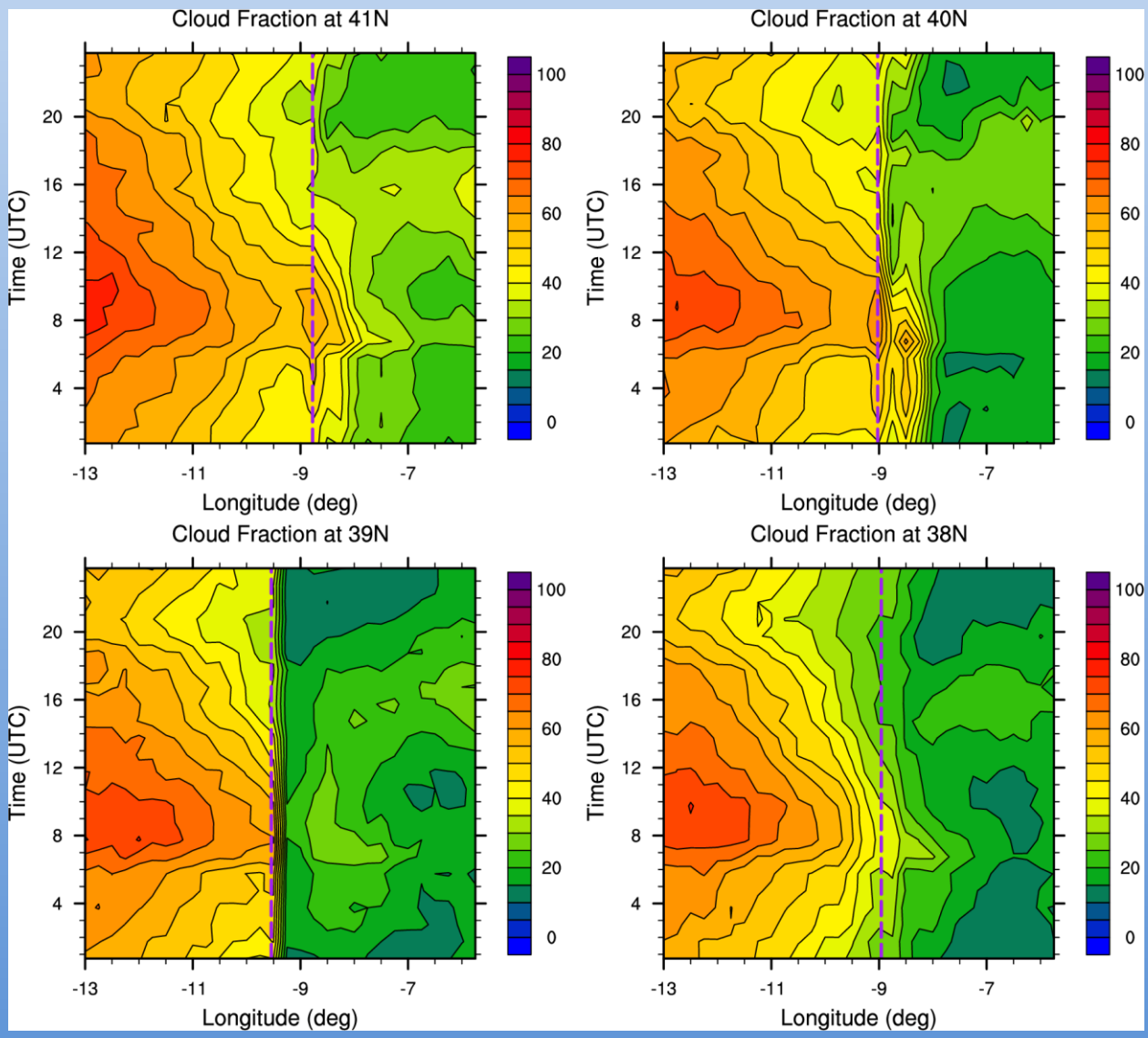
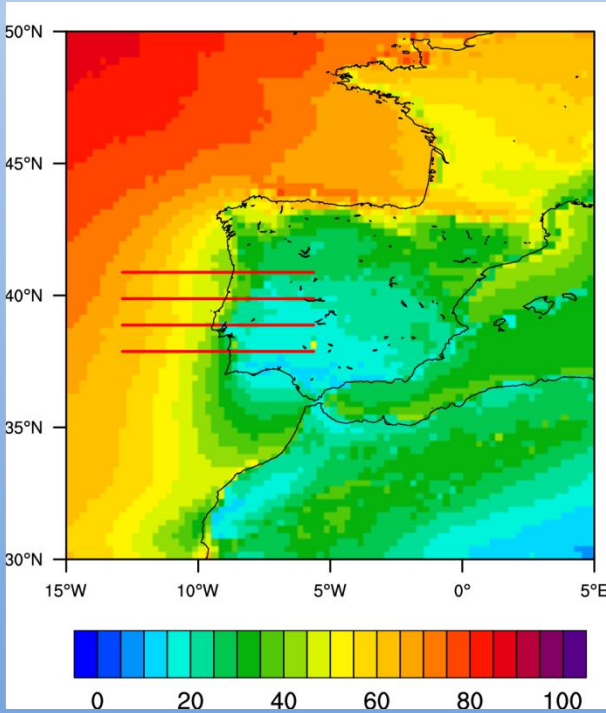
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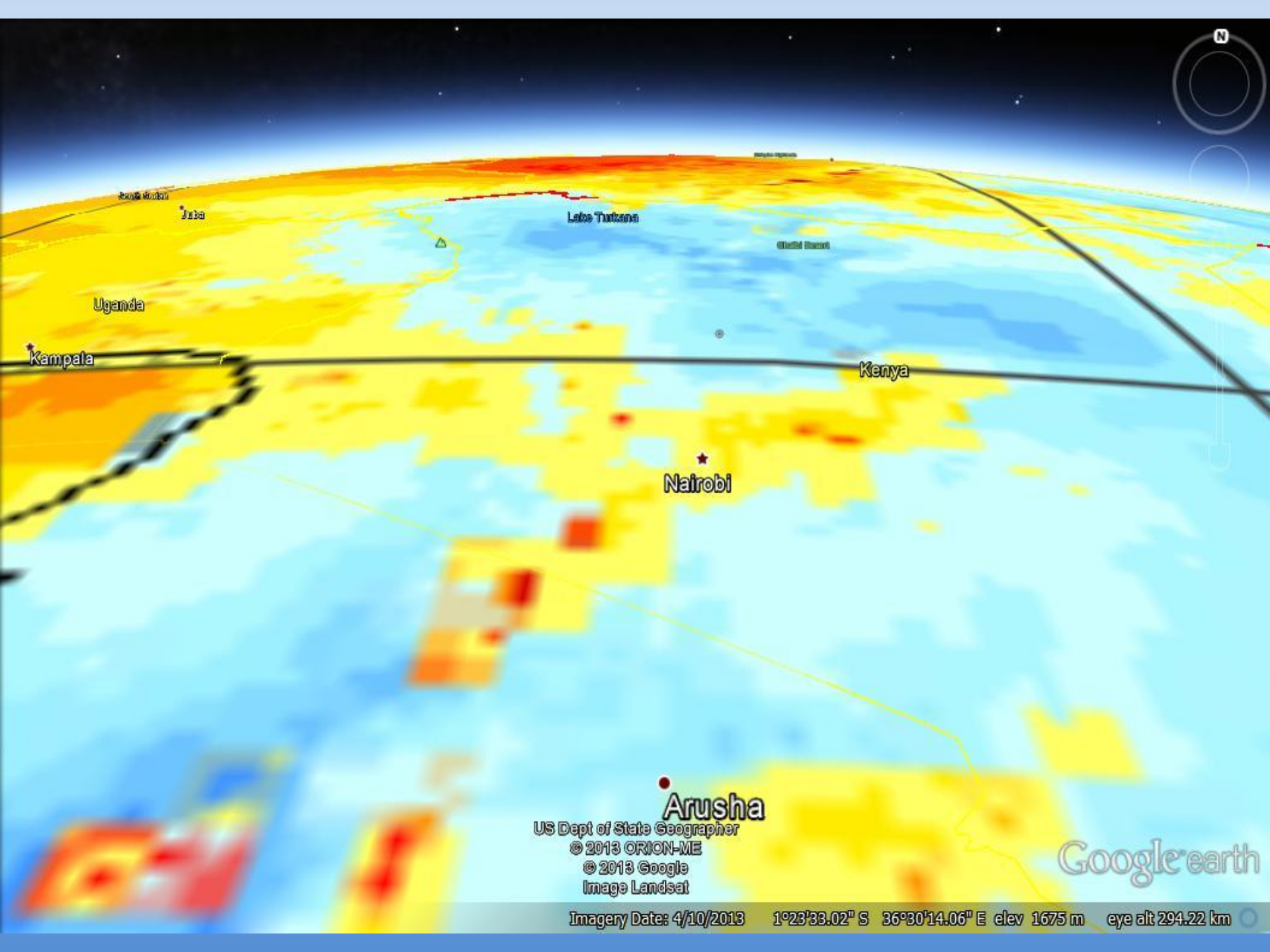


Characteristics of the Local Weather



* João Paulo Martins, IPMA



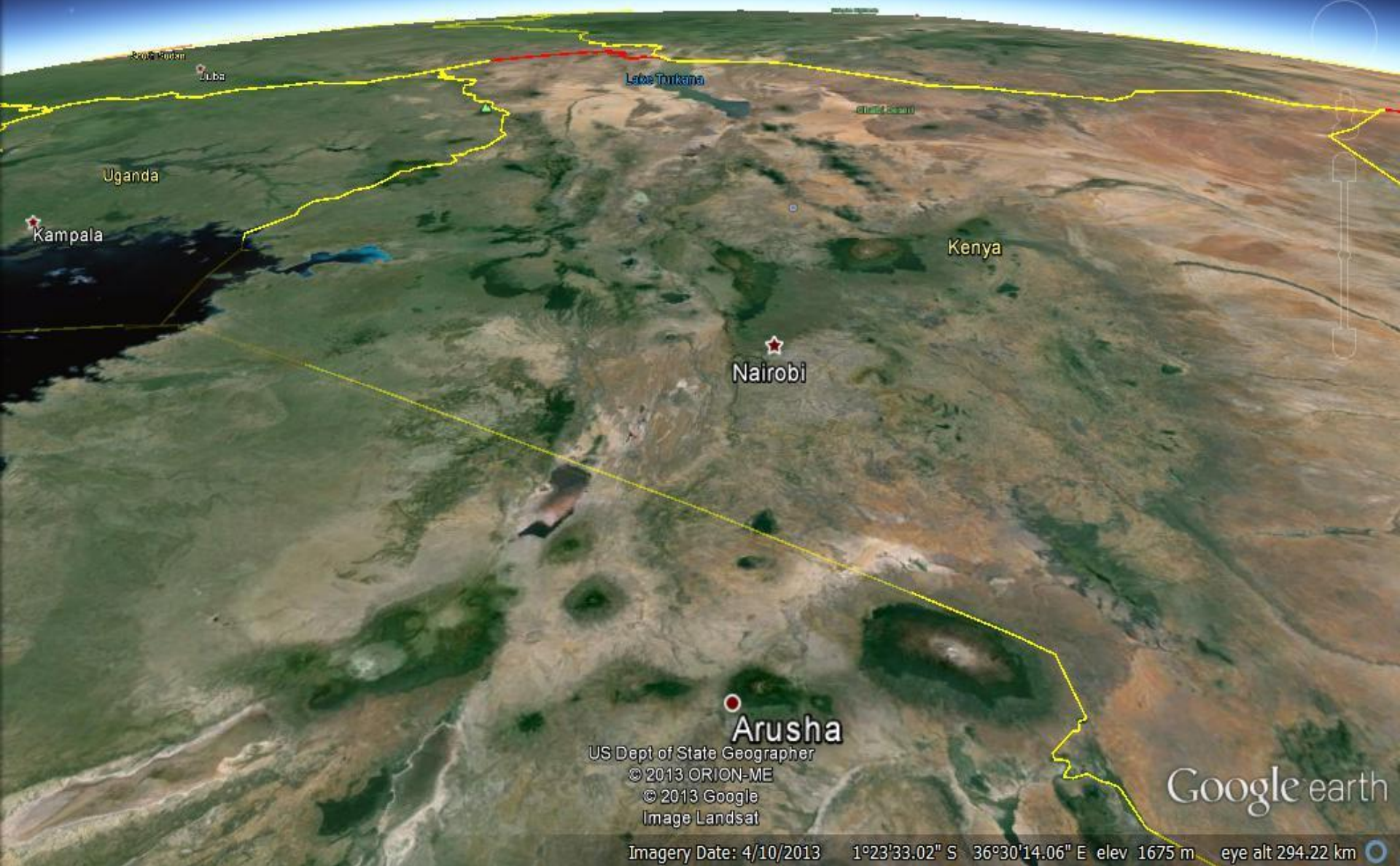


US Dept of State Geographer
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Image Landsat

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

Vesa Nietosvaara, EUMETSAT

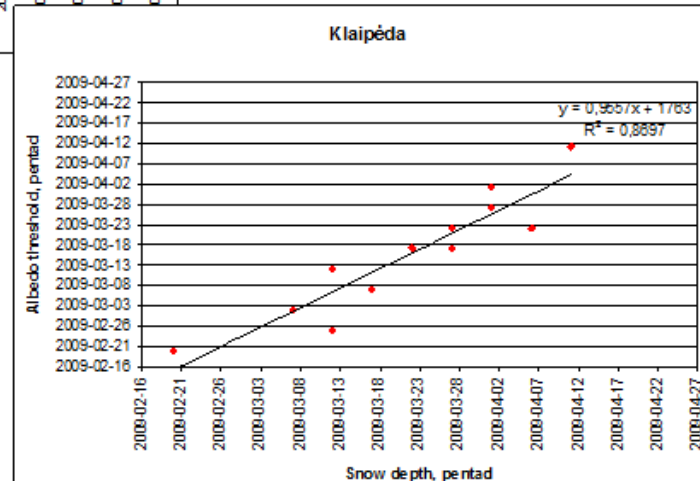
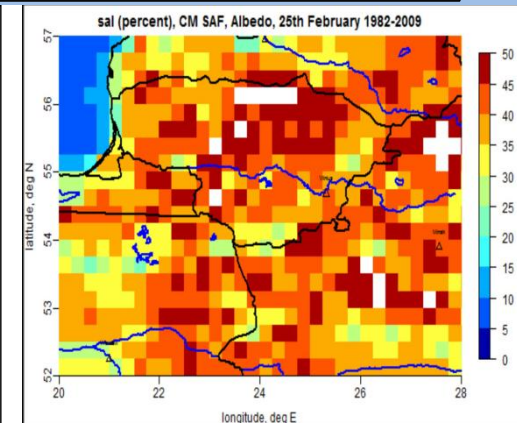
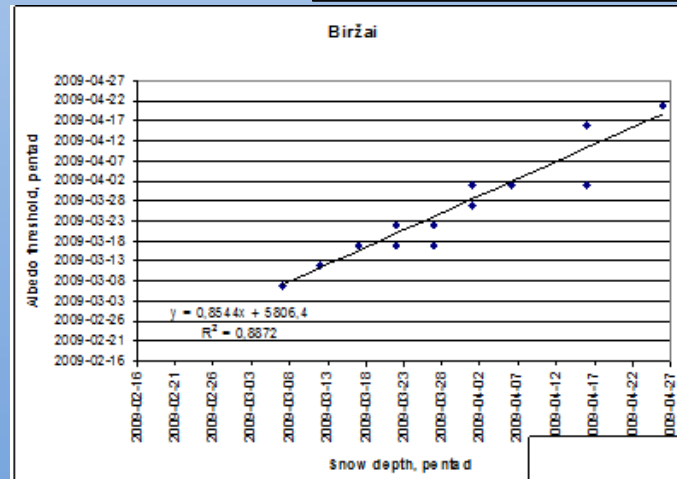
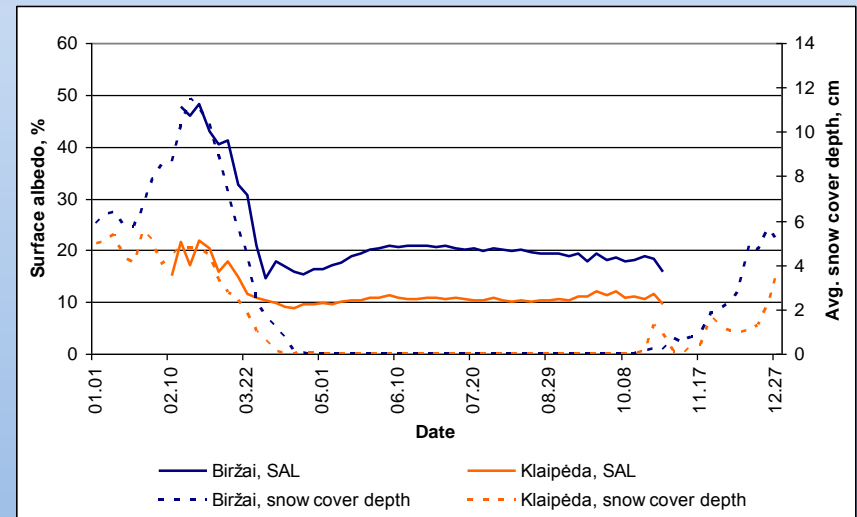


US Dept of State Geographer
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Image Landsat

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



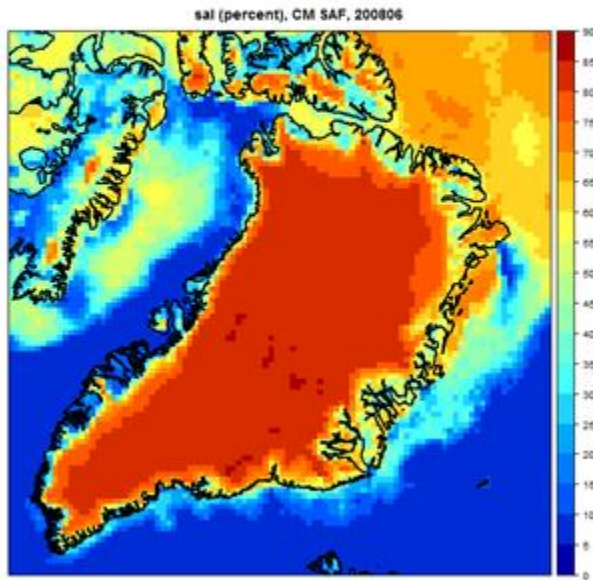
$$A_t = A_s + 2\sigma_{A_s}$$

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

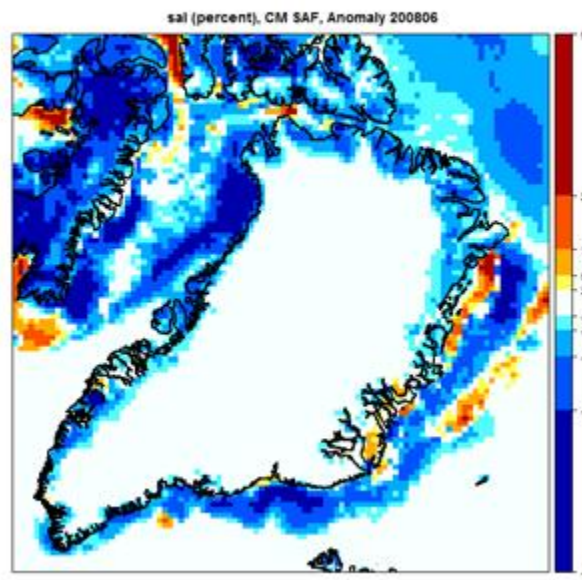
*Justinas Kilpys
 Lithuanian
 Hydrometeorological
 Service

Surface Albedo for Sea-ice

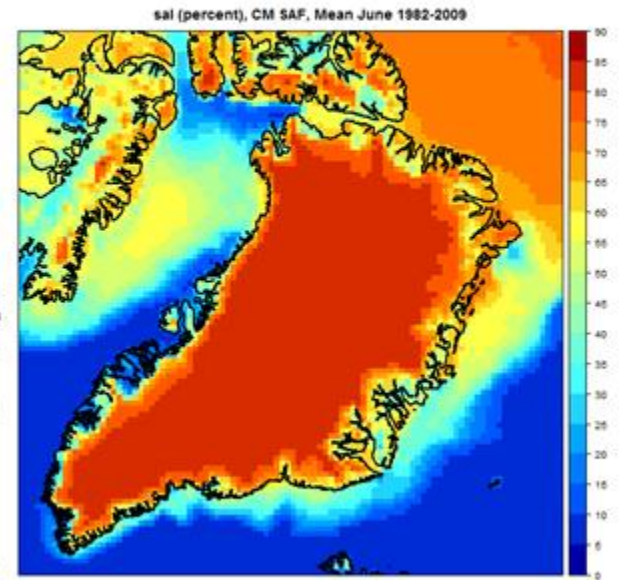
June mean 2008



June anomaly 2008



June mean 1982-2008



*Ilona Välisuo, FMI

HLW – Layer Mean RH, % (2004-2013)

700-500 hPa

850-700 hPa

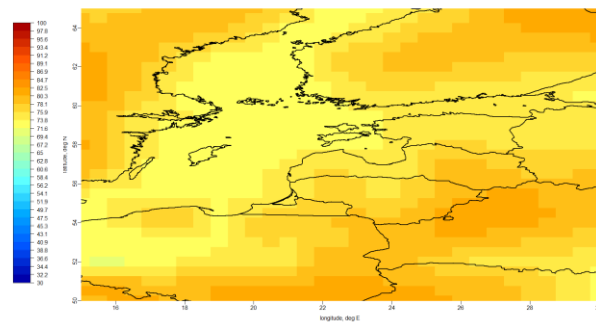
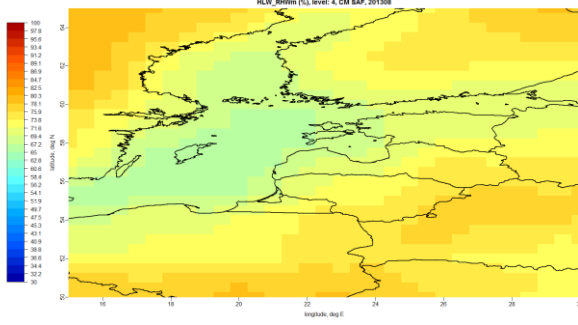
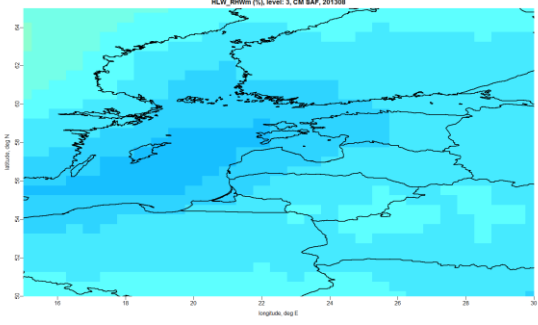
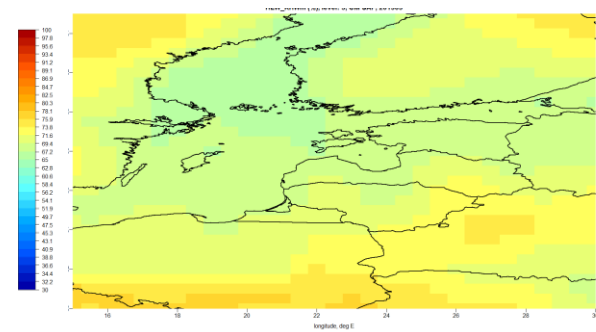
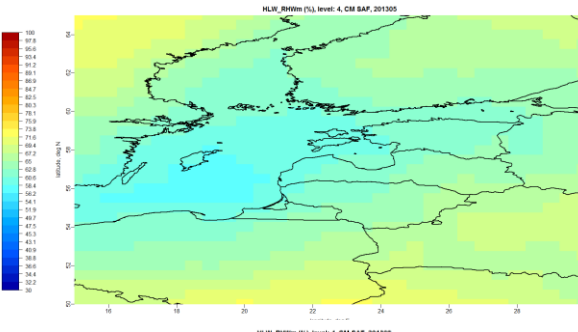
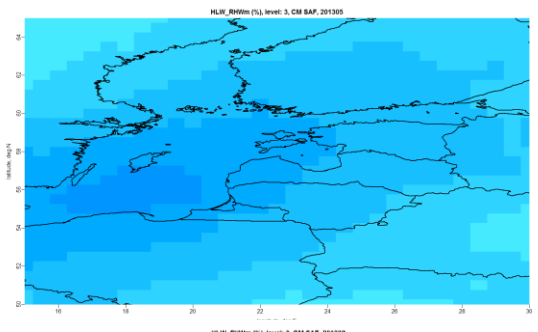
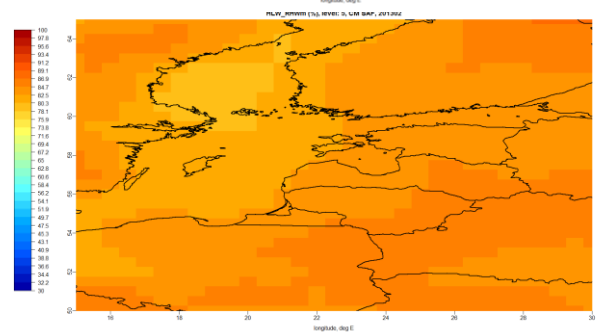
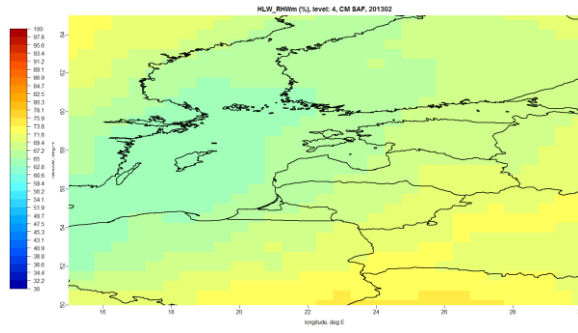
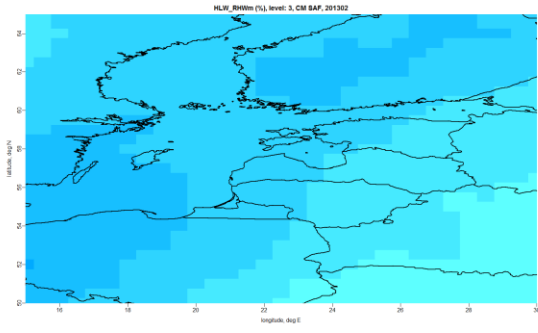
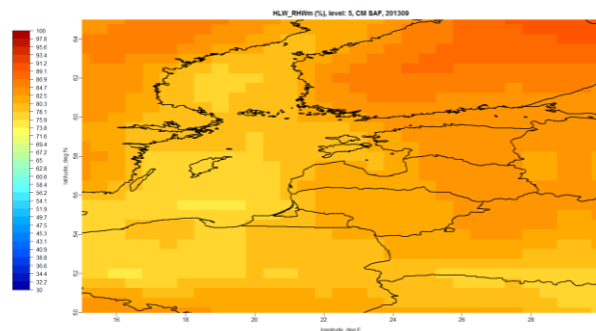
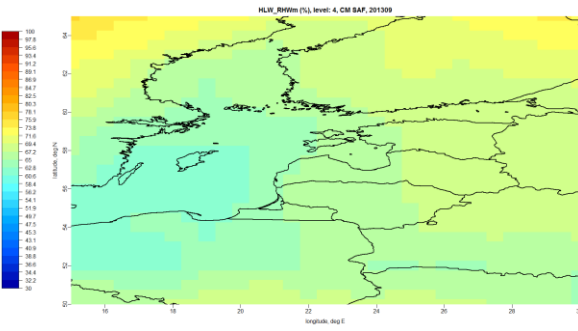
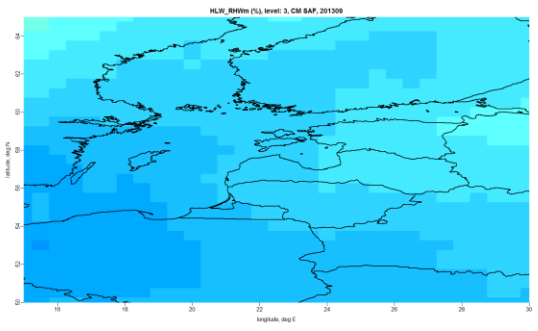
850 hPa-surface

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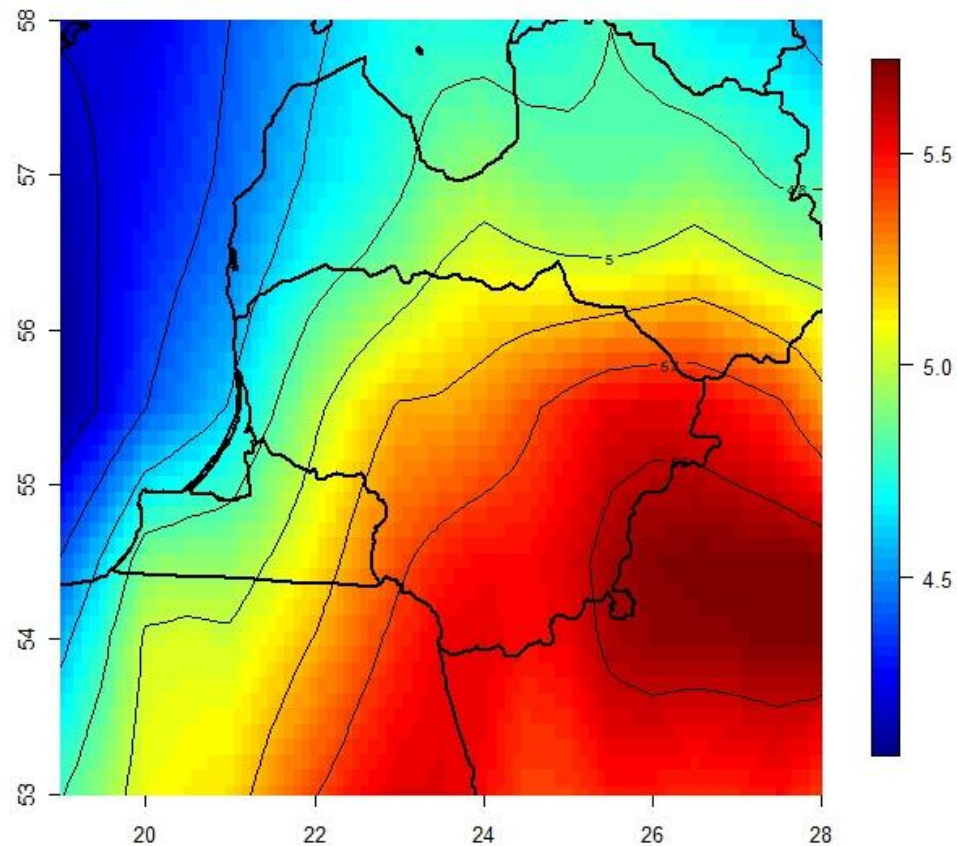
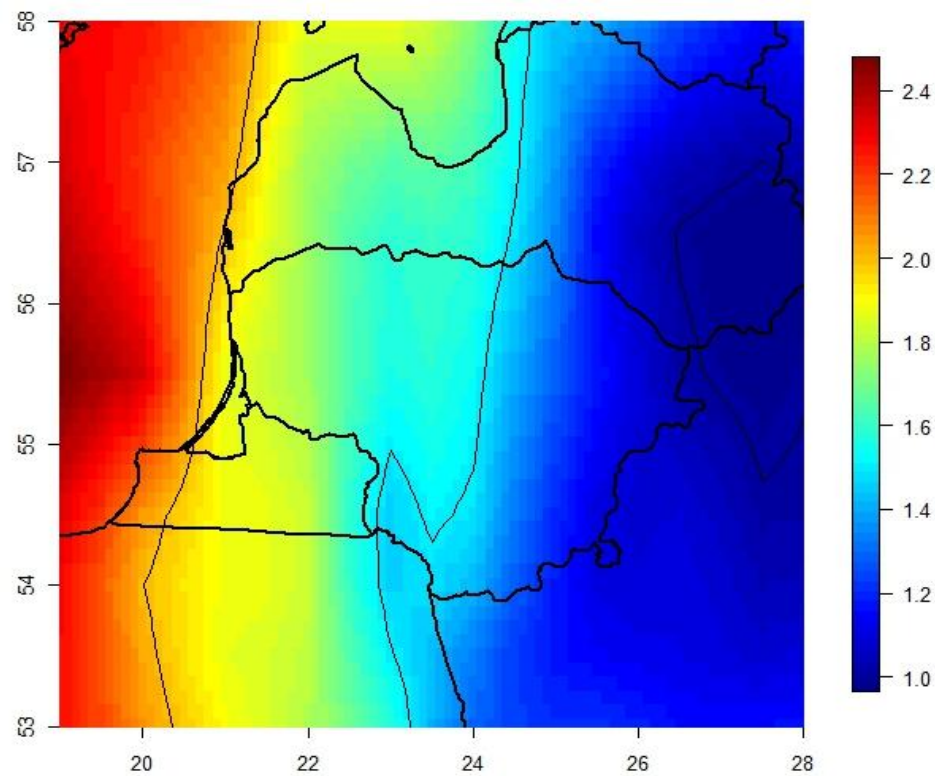
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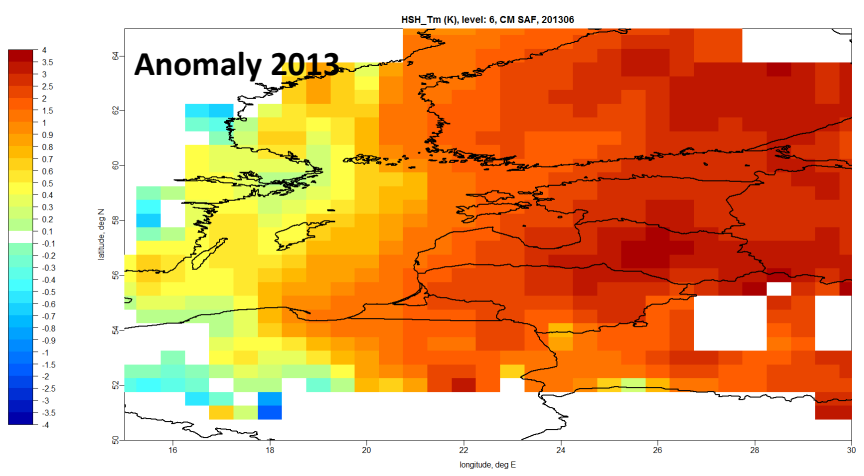
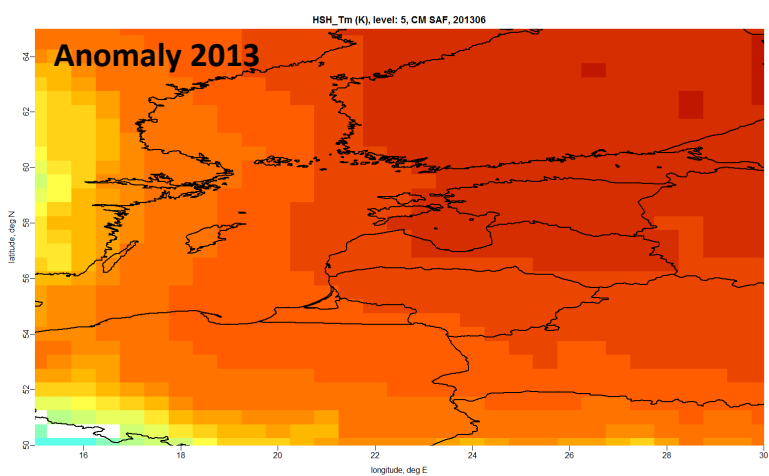
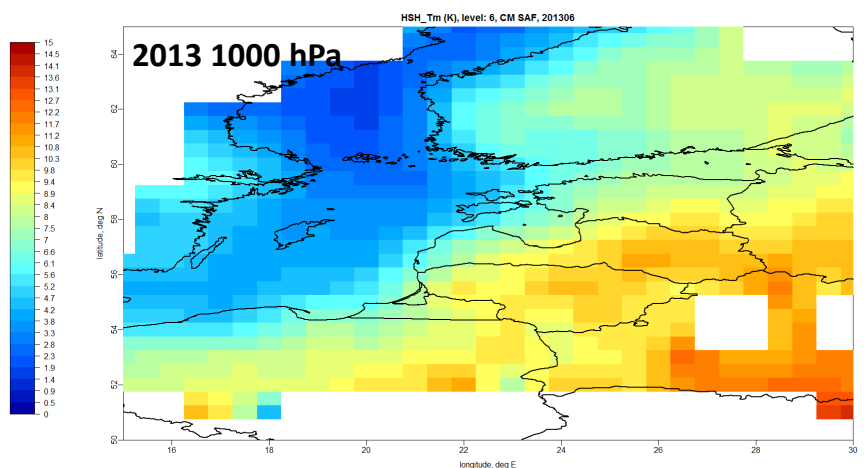
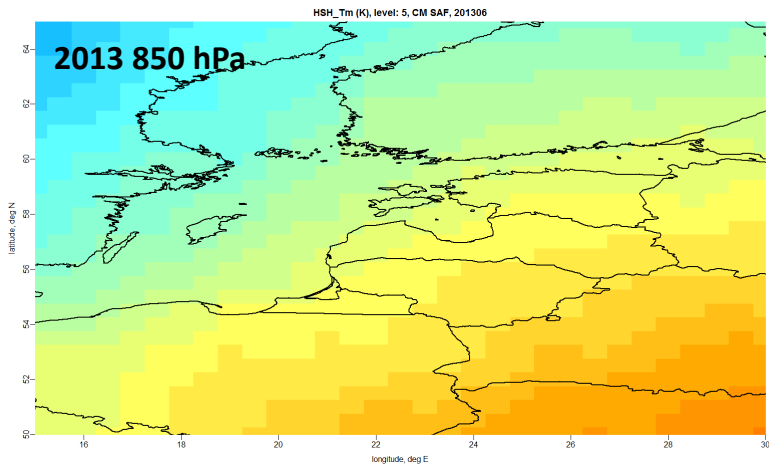
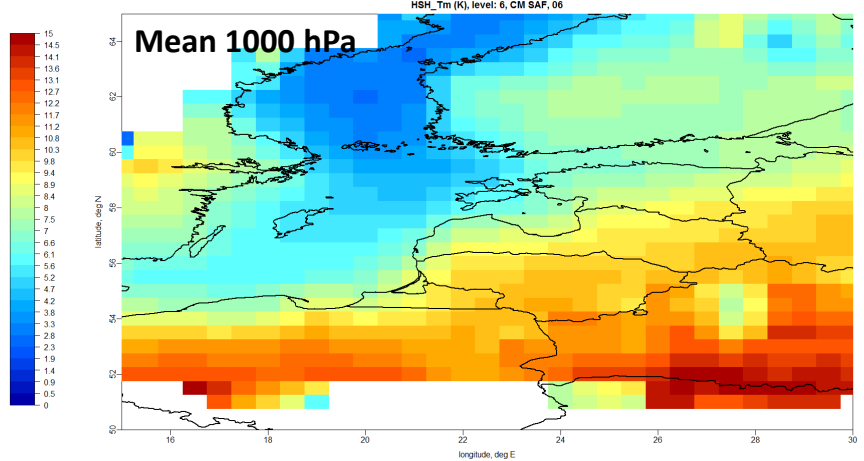
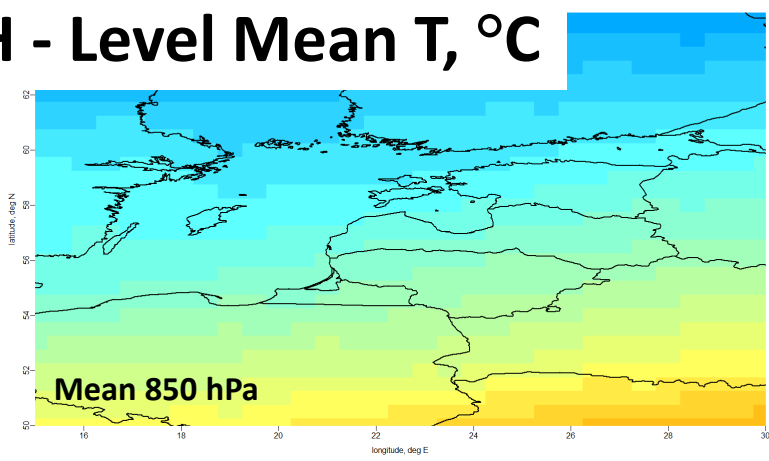
HSH Specific Humidity
Distribution at 850 hPa in a
Cold February 2011 [←]
and Hot and Wet July 2010
[↓]



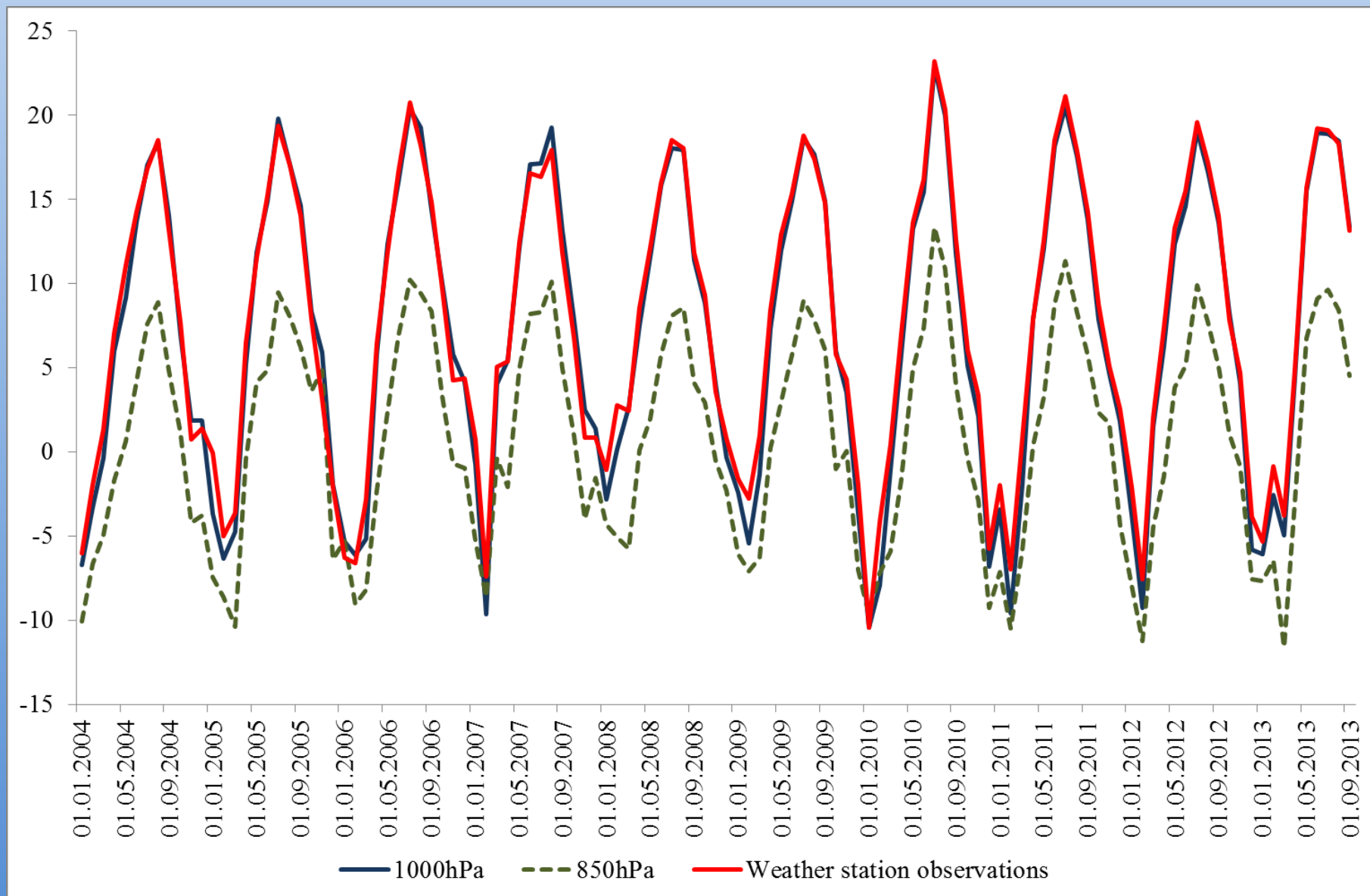
*Gintautas
Stankunavicius
Vilnius university

HSH - Level Mean T, °C

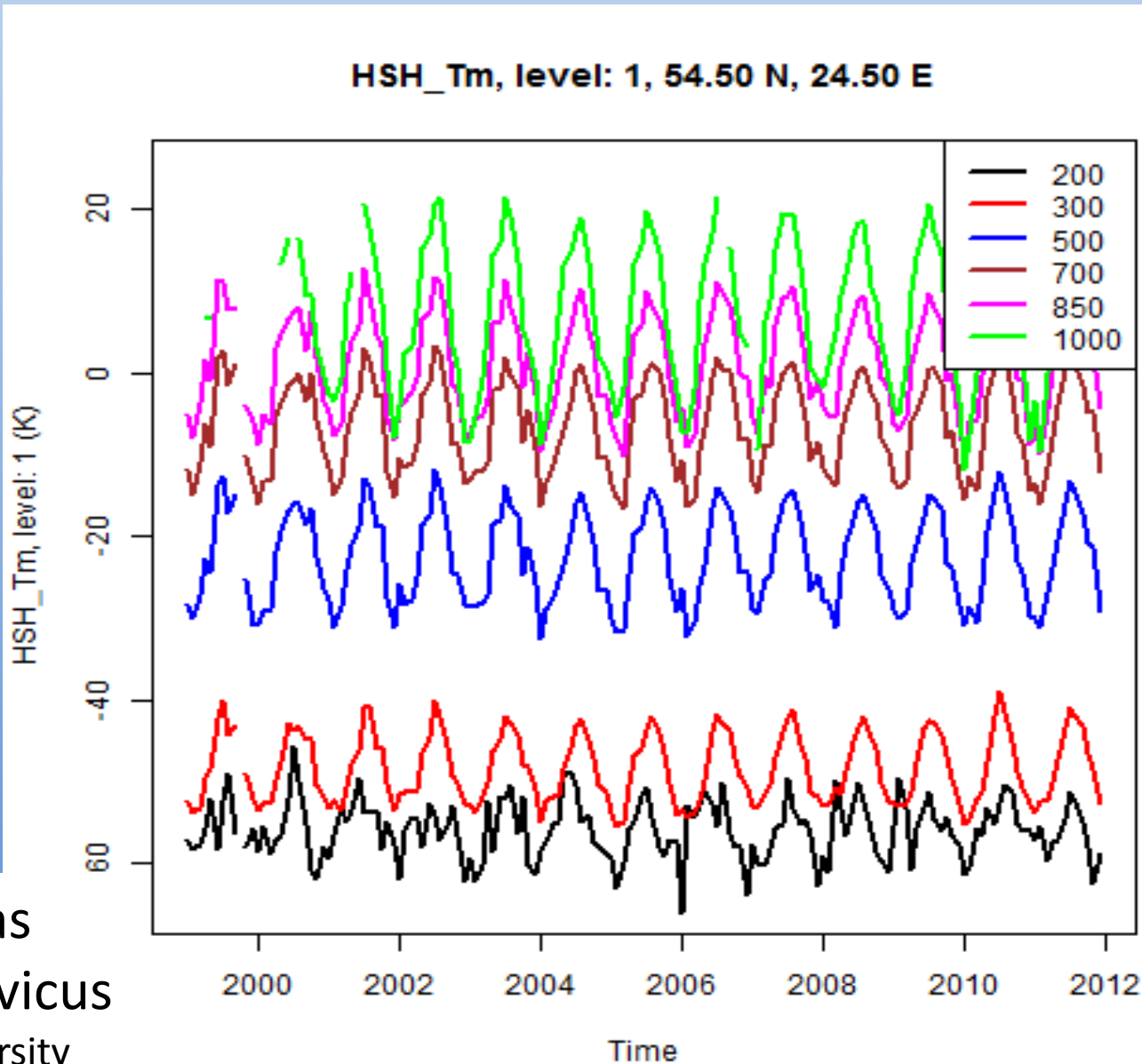
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Comparison of Surface Observations and HSH Temperature at 850 and 1000 hPa in Riga

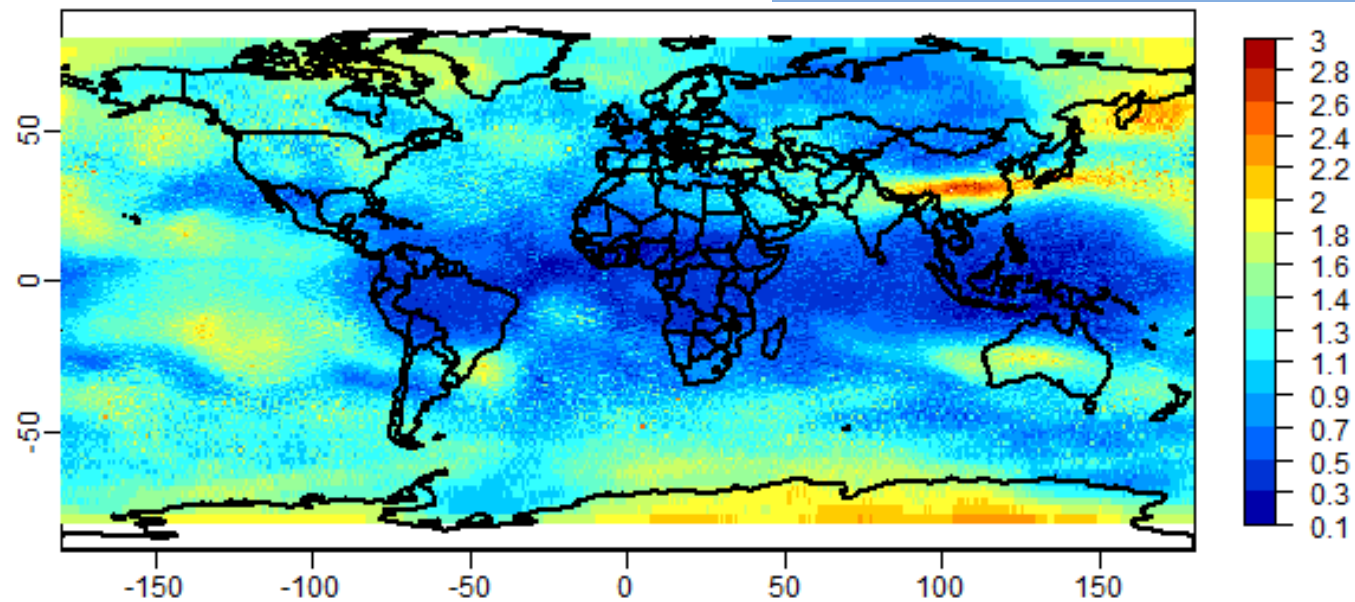
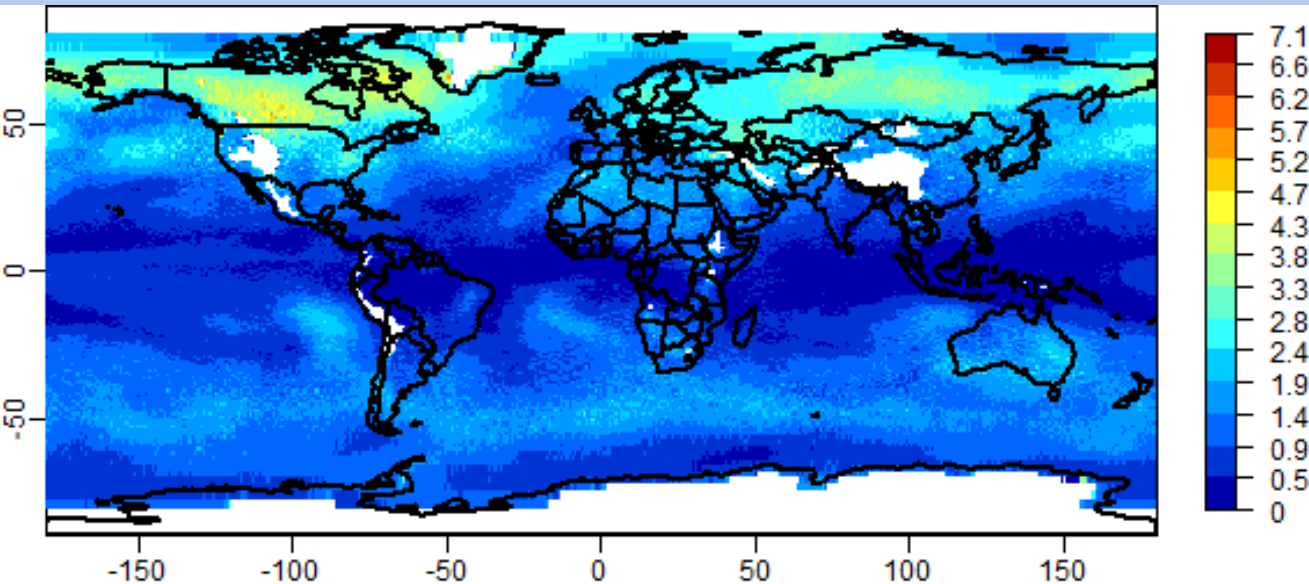


Temperature Time-series for a Point at all Available Levels



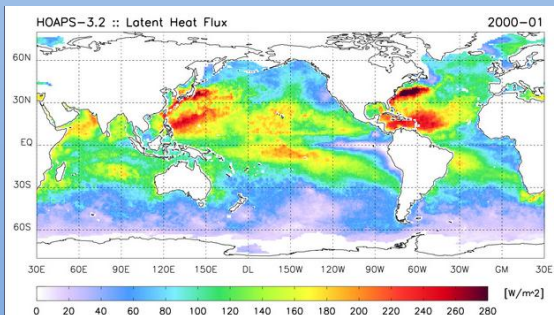
*Gintautas
Stankunavicus
Vilnius University

**Multi-year Temperature Variability ($^{\circ}\text{C}$) in December
at 850 and 300 hPa Level Height
(1990-2011, expressed as STD)**

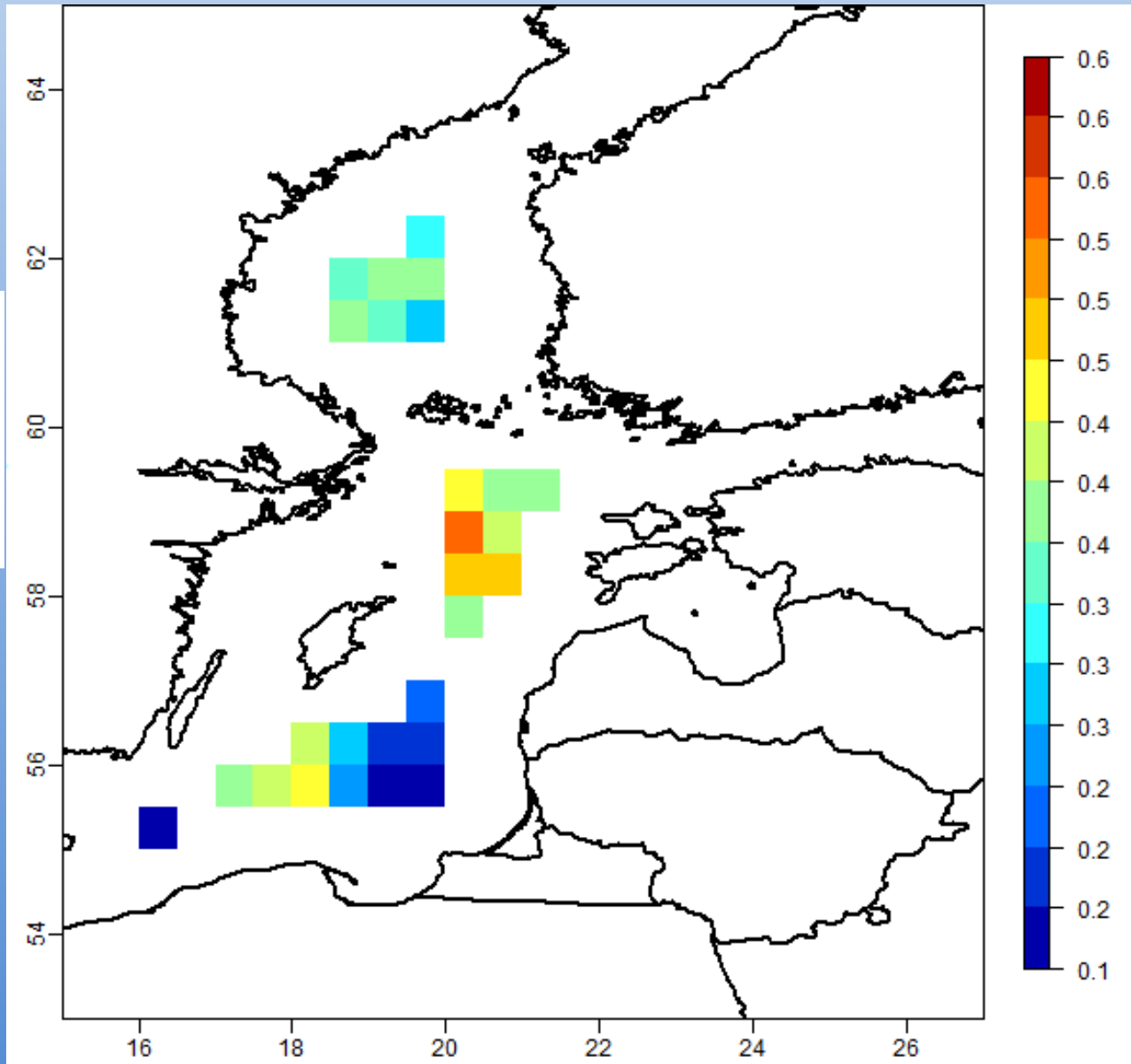


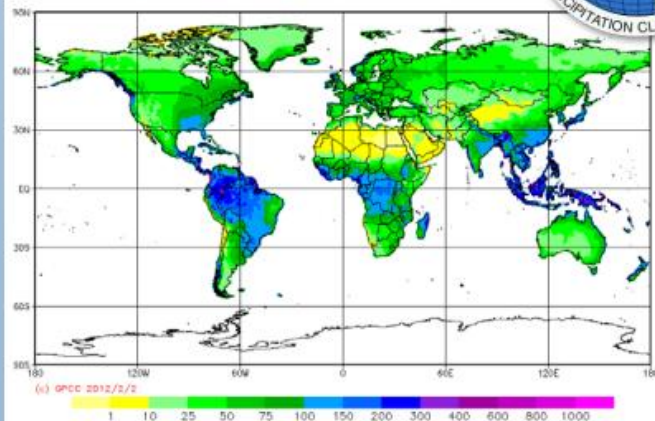
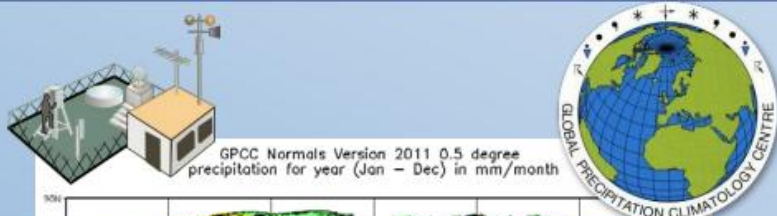
*Gintautas
Stankunavicius
Vilnius university

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

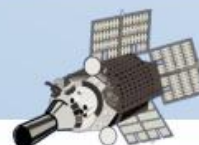


HOAPS

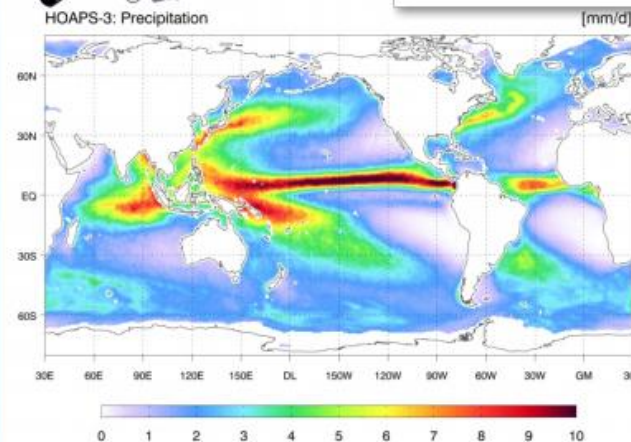




GPCC: Land Precipitation

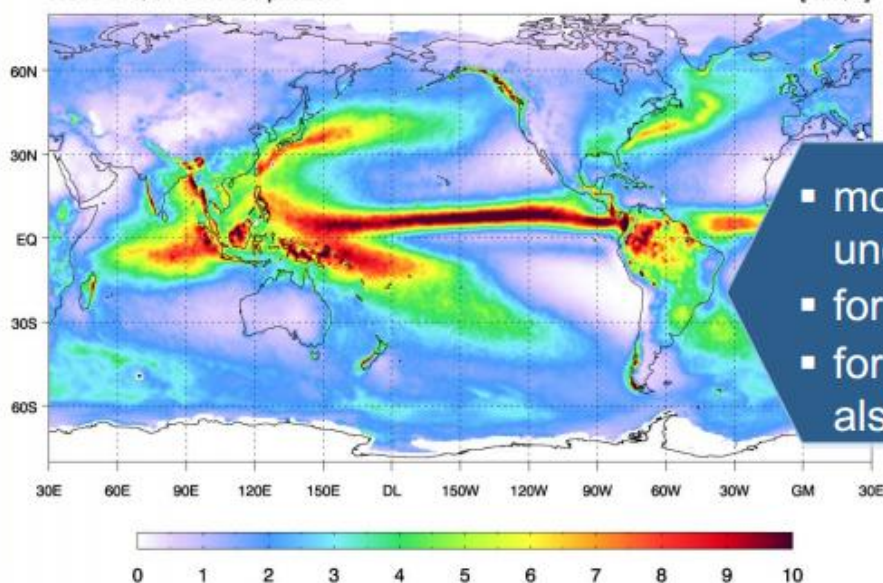


HOAPS-3: Precipitation



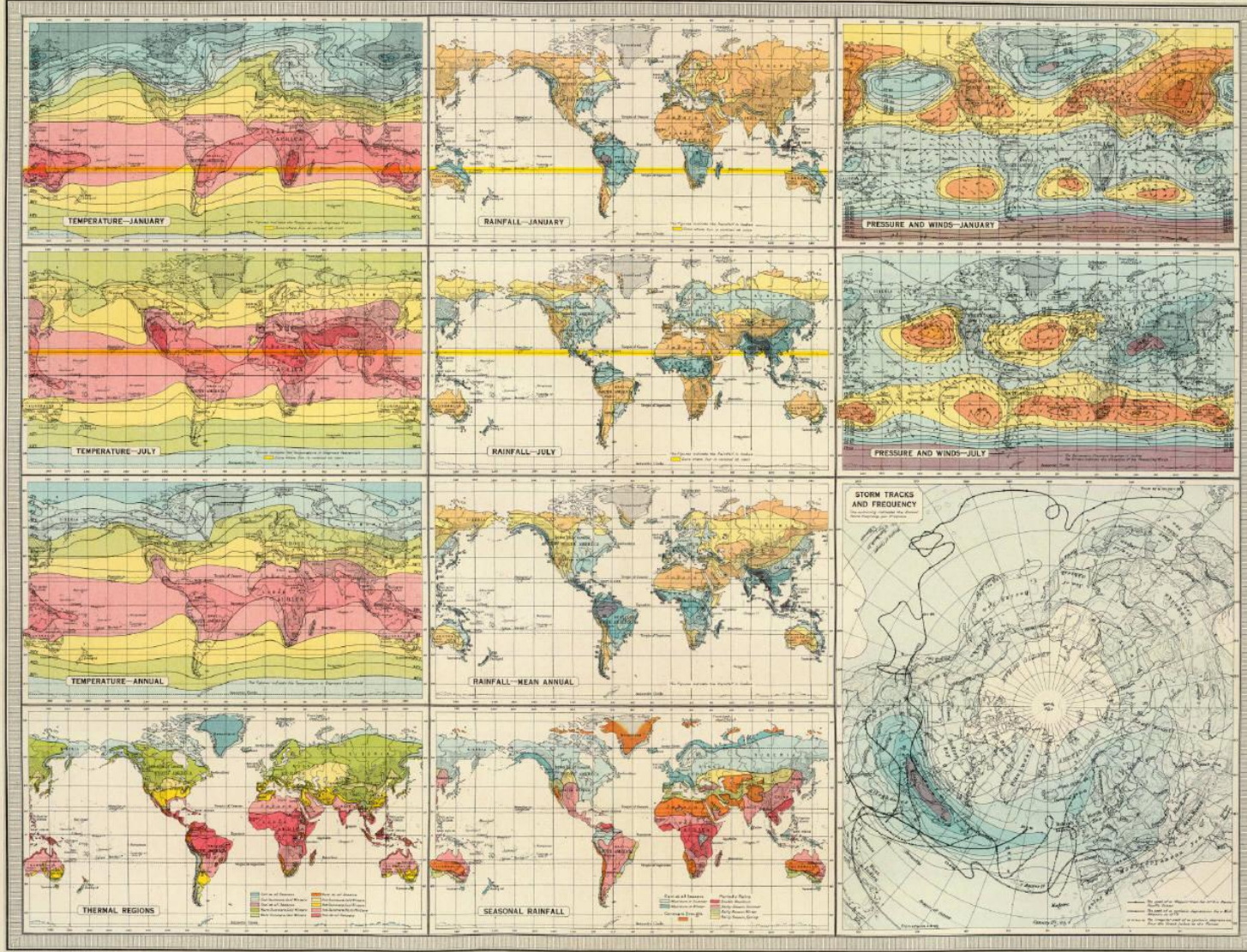
CM-SAF Ocean Precipitation

HOAPS-3/GPCC Precipitation



Combined satellite-gauge product

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



THE EDINBURGH GEOGRAPHICAL INSTITUTE

Scale
The figures show 1000 ft. or more in a height of 1000 ft. or more

JOHN BARTHOLOMEW & SON LTD.

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 strengths and weaknesses
- To provide instructions for creating a satellite climatology atlas and beginning to work with satellite datasets in general

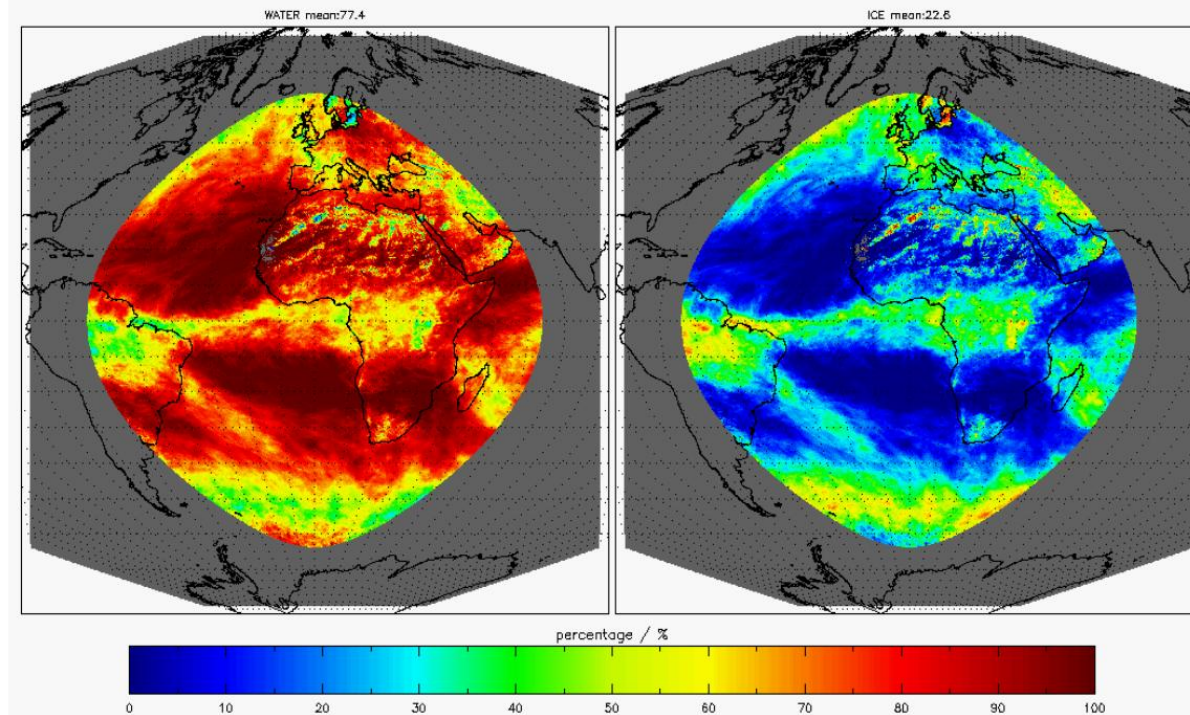
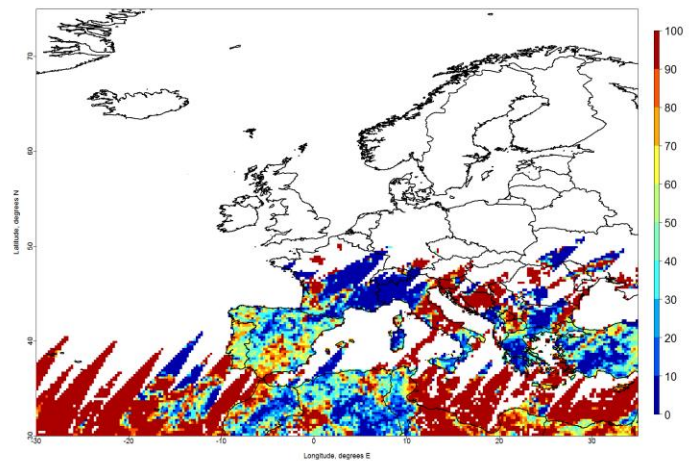
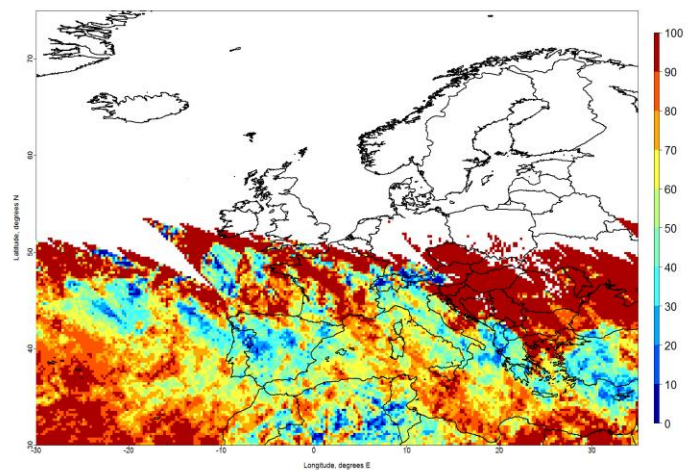
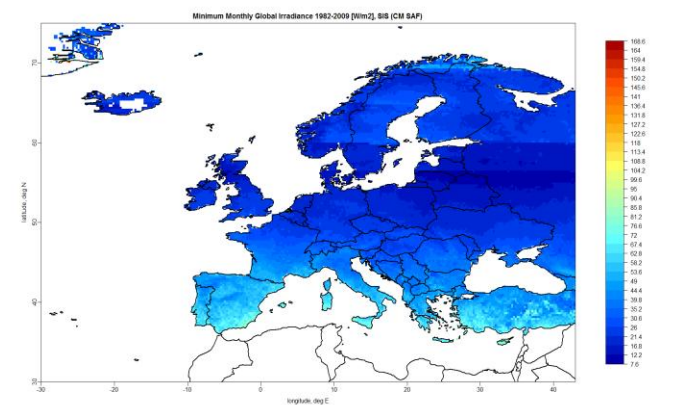
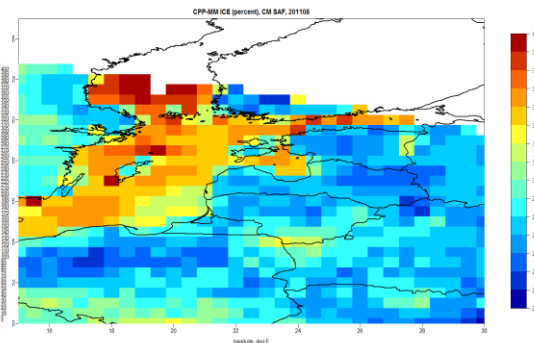
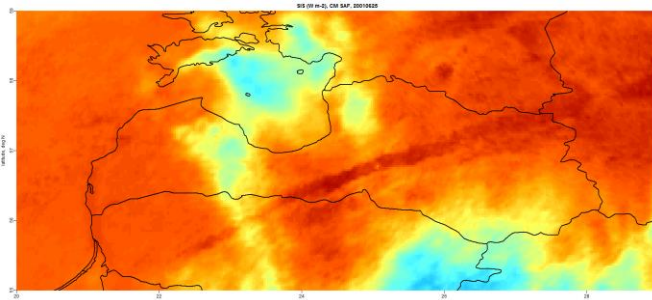
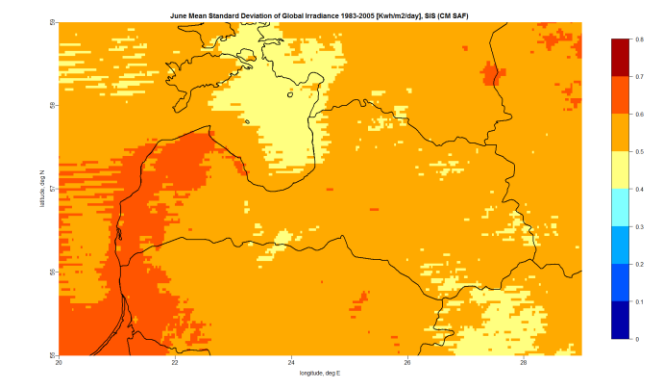
Showing the advantages of satellite data for climate studies

- 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

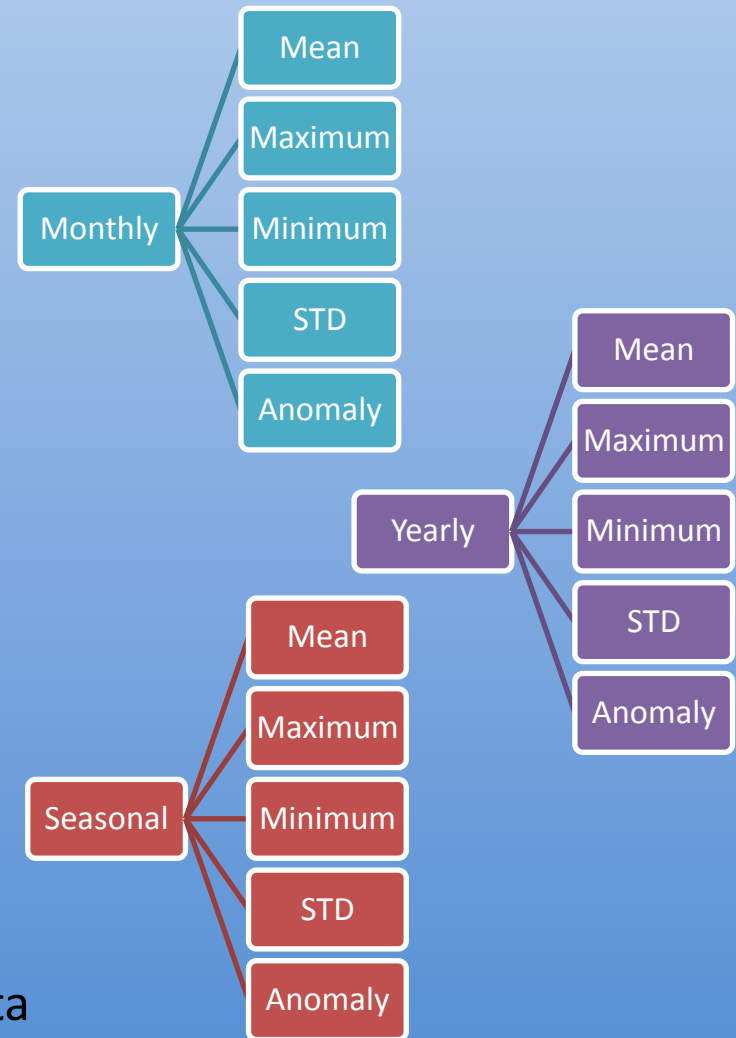


Data Used

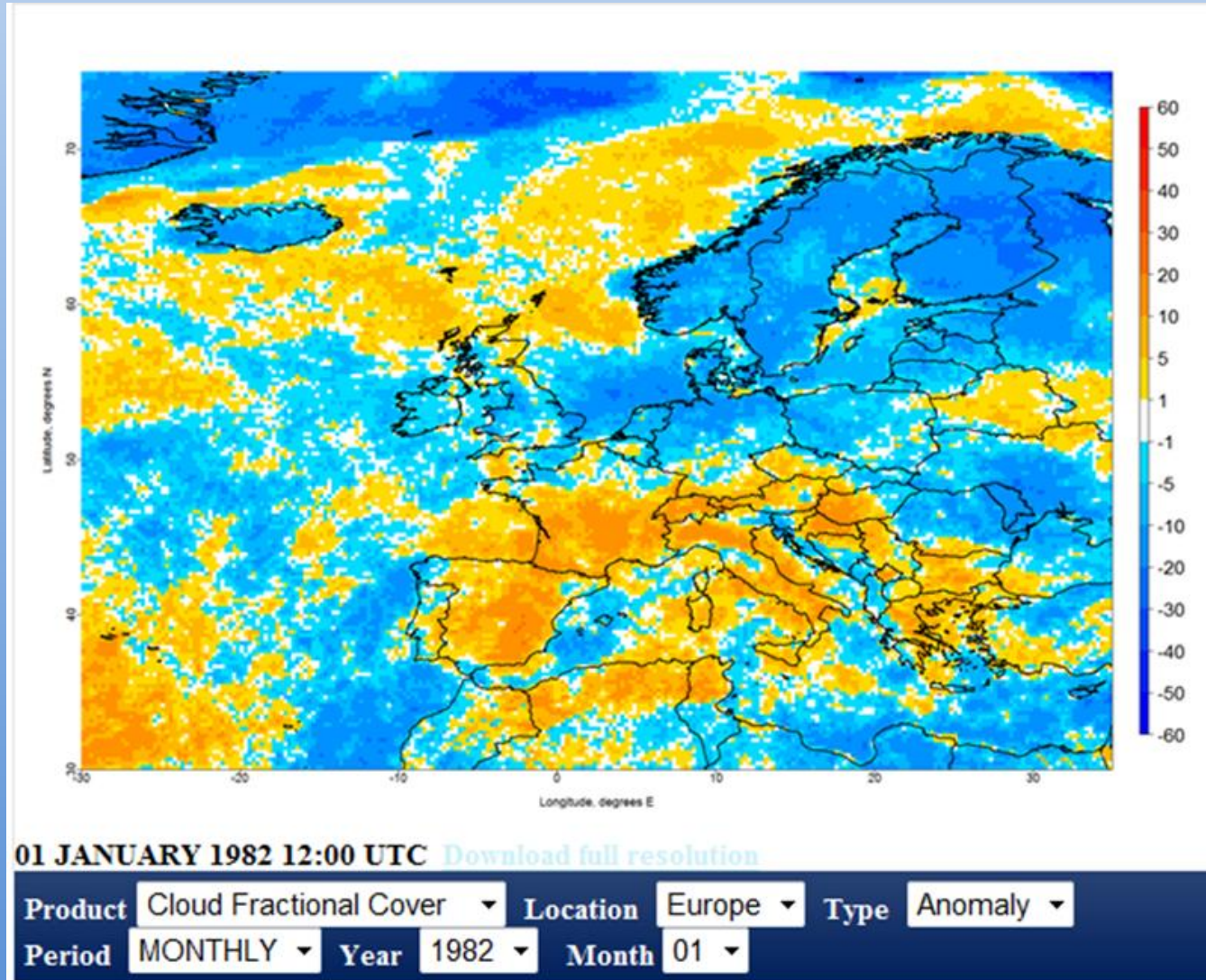
Parameter	Dataset	Variable	Period
Cloudiness	CLARA-A1	Monthly mean cloud fractional cover (CFC)	1982-2009
Cloud Phase	CLARA-A1	<ul style="list-style-type: none">- Monthly mean fraction of liquid water clouds (CPH)- Monthly mean cloud ice water path (IWP)- Monthly mean cloud liquid water path (LWP)	1982-2009
Cloud Top Parameters	CLARA-A1	<p>Monthly mean cloud top parameters (CTO)</p> <ul style="list-style-type: none">- Cloud top height- Cloud top pressure- Cloud top temperature	1982-2009
Cloud Optical Thickness	CLARA-A1	<p>Monthly mean cloud optical thickness (COT)</p> <ul style="list-style-type: none">- All clouds- Ice clouds- Liquid clouds	1982-2009
Solar Radiation	MVIRI dataset	<ul style="list-style-type: none">- 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



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*

The climate atlas is a tool to help visualise climate datasets for Europe and Latvia.

Date & Time: 1992-2009
Satellite: METEOSAT, Metop, NOAA

The F-SAR on Climate Monitoring (CM-SAR) provides satellite-based climate information on a variety of parameters, which can help people find out something more about atmosphere and climate.

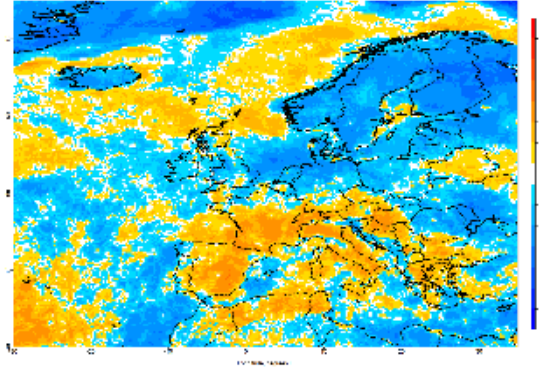
The climate atlas is a tool to help visualise climate datasets for Europe and Latvia. It is also a guide for working with satellite data in climatology.

More information and detailed analysis of the tool can be found in the In-Depth section.

IN DEPTH

by Zenta Avotniece (Latvian Environment, Geology and Meteorology Centre)

Monthly Anomaly of Cloud Fraction (%) in January 1992



PRODUCT: CPC Cloud Fraction REGION: Europe
TIME PERIOD: Monthly STATISTIC: Anomaly YEAR: 1992 MONTH: 01

The atlas is based on the climate datasets provided by the CM-SAR. It consists of maps providing climatological information of different meteorological parameters.

These include:

- general climatic characteristics of meteorological parameters over Europe and Latvia;
- information on satellite data suitable for climatological studies, particularly datasets provided by the CM-SAR;
- an example of the strengths and weaknesses of satellite data for climate applications;
- instructions for creating a satellite climatology atlas and beginning to work with satellite datasets in general.

The tool should be used for viewing example data from different CM-SAR climate datasets. The complete instructions provided here will enable users to create their own atlas with only minor additional support in processing or climatological theory.

In order to start creating your own atlas (or other product of your own choice), you should:

1. Decide what you want to achieve.
2. No, really decide what you want to achieve. In order to do this, you may want to consult the description files provided here and to visit the FCM-SAR web page and the FWeb User Interface.
3. Order and download the data of interest by using the instructions for data ordering.
4. Install the software and get an idea of how it works; get acquainted with the scripts. Use the instruction files provided here for a basic overview and guidance.
5. Get acquainted with the work package (folder structure) and start working.
6. Pay attention to the results you get. Is there something suspicious or artificial in the data? You may need to decide if you are looking at something geophysical (real) or something from the data and data processing.

Additional sources to help you:

- FClimate Atlas User Manual
- For additional information on the atlas please contact: Zenta Avotniece from the Latvian Environment, Geology and Meteorology Centre (zenta@vgoic.lv)
- For any additional support on the use of CM-SAR data please contact the CM-SAR.
- FCM-SAR Community Site will provide you with tutorial videos and useful scientific discussions of the current users of the data
- FCM-SAR Event week, webcasts (FClimate Monitoring SAR and FCM-SAR Future Plans) and Training Modules (FSatellite Data in Climate Monitoring) on the use of satellite data for climate monitoring
- Online courses on computing and data analysis. You can find such courses on, for example, Coursera and Future School

Work package used to create the atlas:

FToolbox containing the folder structure, example scripts and data (9 Gb). It contains the required folder structure, scripts and example NetCDF files for each product. Important – these are not the raw data as ordered and downloaded from the CM-SAR archive, but the result files acquired through manipulation of the raw data.

All intellectual property rights of the CM-SAR products belong to EUMETSAT. The use of these products is granted to every interested user, free of charge. If you wish to use these products, EUMETSAT's copyright credit must be shown by displaying the words "copyright (year) EUMETSAT" on each of the products used.

... 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! 😊

