Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Verkeer en Waterstaat

Application of polar orbiter products in weather forecasting Using open source tools and standards

ADAGUC & PyTROLL

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Many thanks to :

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[2]SMHI Swedish Meteorological and Hydrological Institute

Application of polar orbiters for weather forecasting?

Till 2011, KNMI operated a satellite receiving station for polar orbiters, but use of polar satellite data in the weather office was limited:

- Data availability was too irregular in space and time
- Some orbits were missed due to simultaneous reception of other satellite data
- Accessibility and usability was difficult
- Alternatives like Meteosat 9 were easier to use in an operational environment.

Use of polar orbiter data in weather office is still limited!

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EUMETCAST, open standards and open tools

- Nowadays, polar orbiter data is available via EUMETCAST on regular basis

- Polar orbiter products have improved
  - Higher resolution, more spectral bands (e.g. Suomi NPP VIIRS)

- Open tools and standards are available and have improved
  - Pytroll can help reading data, create meteorological products and predict orbit locations
  - ADAGUC can help serving geographical data on the web in an accessible way

Time to explore the possibility to enhance the usage of polar satellite data for weather forecasting

Plan: Read satellite data with Pytroll, convert to gridded NetCDF for ADAGUC

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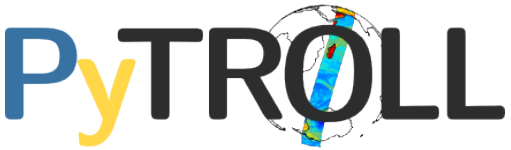
PyTROLL



http://pytroll.org

- A community driven FOSS project
  initiated by DMI and SMHI in 2009
- Free and open source python modules for the reading, interpretation, and writing of weather satellite data
  - **pyresample for resampling satellite data**
  - mipp for reading weather satellite data
  - **mpop for processing weather satellite data**
  - python-bufr for reading bufr files
  - pycoast for putting coastlines, borders and rivers on an image
  - **pyorbital for computing satellite orbital parameters and reading TLE's**

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ADAGUC Server and Viewer

Geographical information system to visualize netCDF files via the web

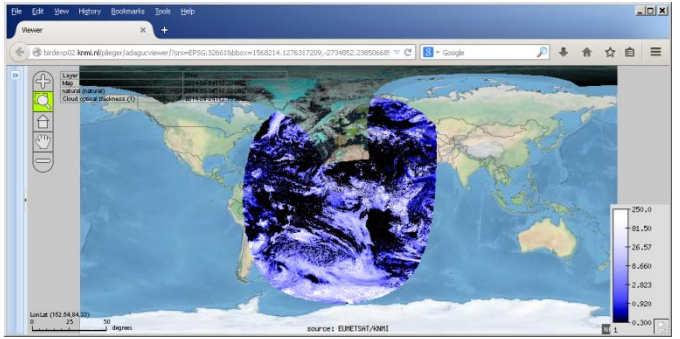
- Web Map Service and Web Coverage Service
- Developed at KNMI (2009 till present)
- Server: C++ application
- Viewer/Client: JavaScript application
- NetCDF4, HDF5 and OpenDAP
- Multi dimensional data supported!
- Can serve true color data (1 byte per channel, RGBA)
- Very fast nearest neighbour reprojection (C++)

ADAGUC

Atmospheric Data Access

for the

Geospatial User Community



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ADAGUC: Web Map and Web Coverage server

DATA

WMS/WCS

Fast rendering, resizing, reprojection & styling

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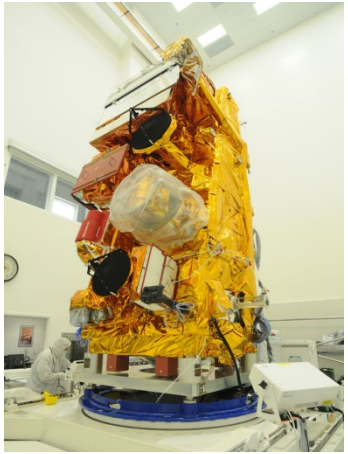
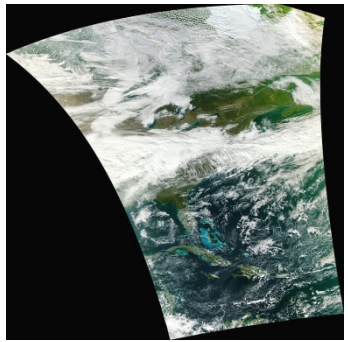
Data from VIIRS instrument on the Suomi NPP Satellite

- Suomi NPP Satellite

  Suomi: Named after meteorologist Verner E. Suomi
  - NPP: National Polar-orbiting Partnership (NASA, NOAA, Defense)
  - Sun-synchronous orbit, 824 km height, 14 orbits per day
  - Launched at 28 October 2011
  - Instruments: ATMS, CrIS, OMPS, CERES and VIIRS

- VIIRS instrument
  - Visible Infrared Imaging Radiometer Suite (VIIRS)
  - 22 spectral band scanning radiometer
    - visible and infrared bands
  - 750 meter resolution, ~3000 km swath width, covers earth in 2 days





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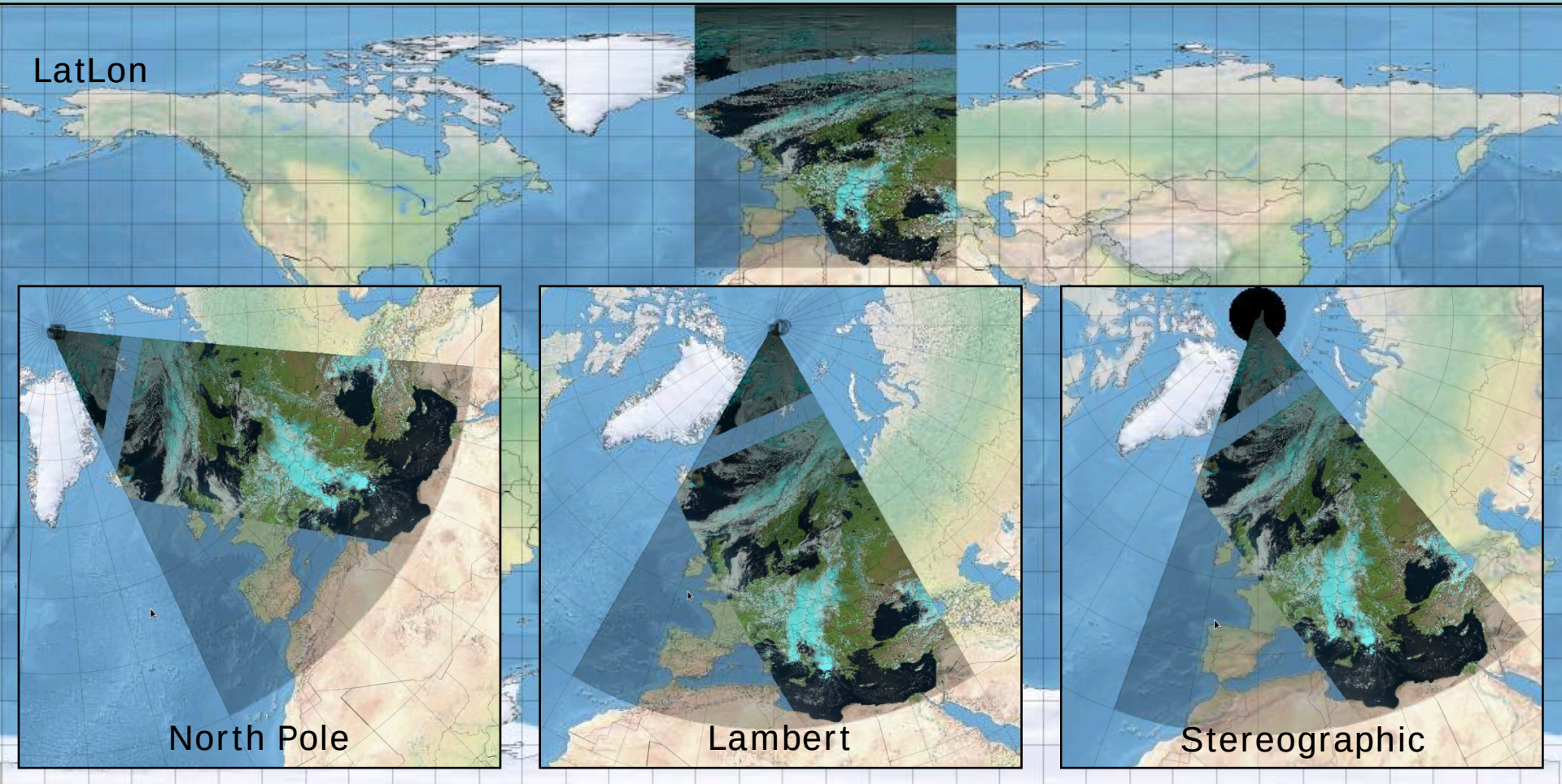
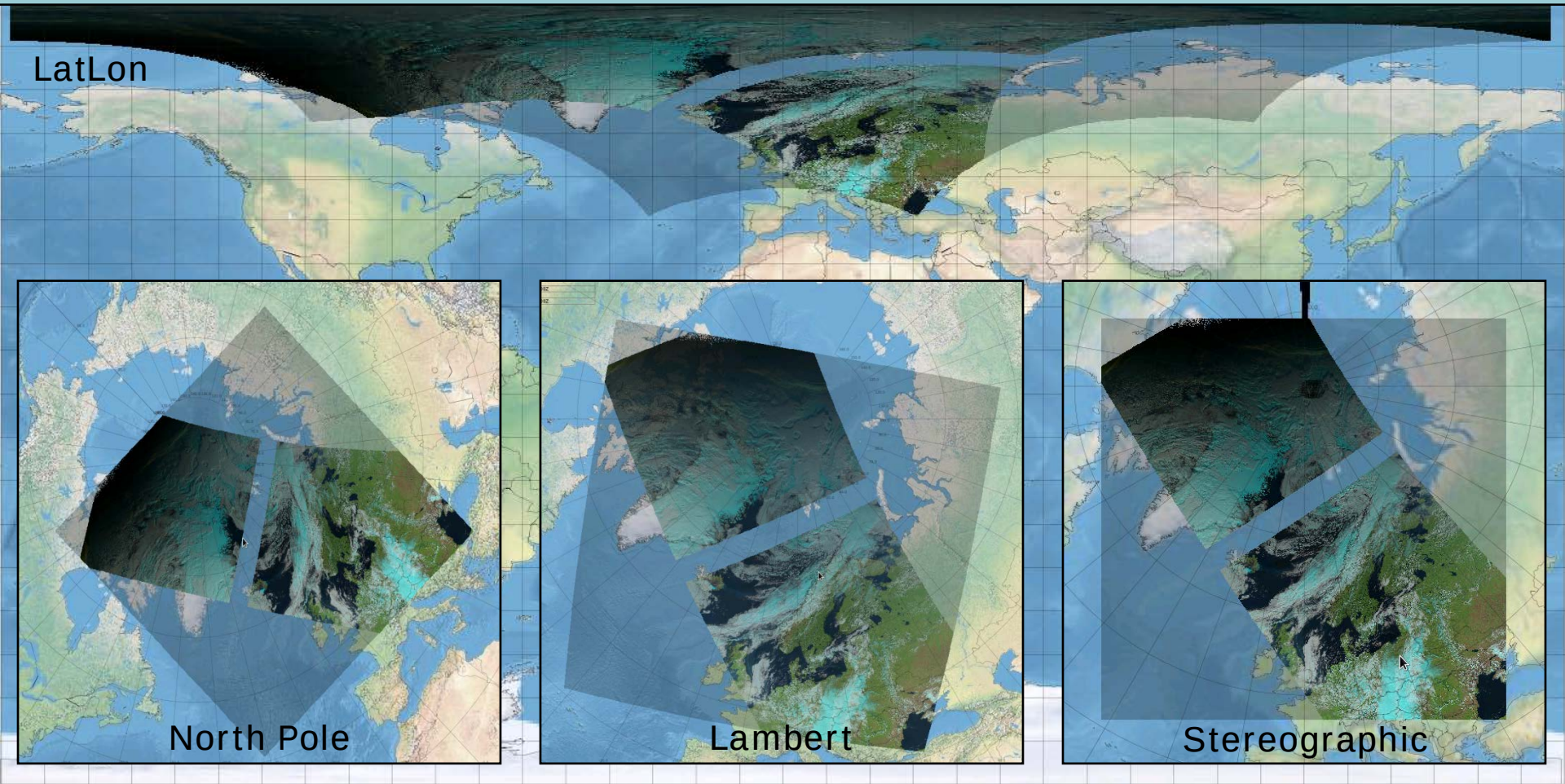
Effects of geographic projections (from latlon)

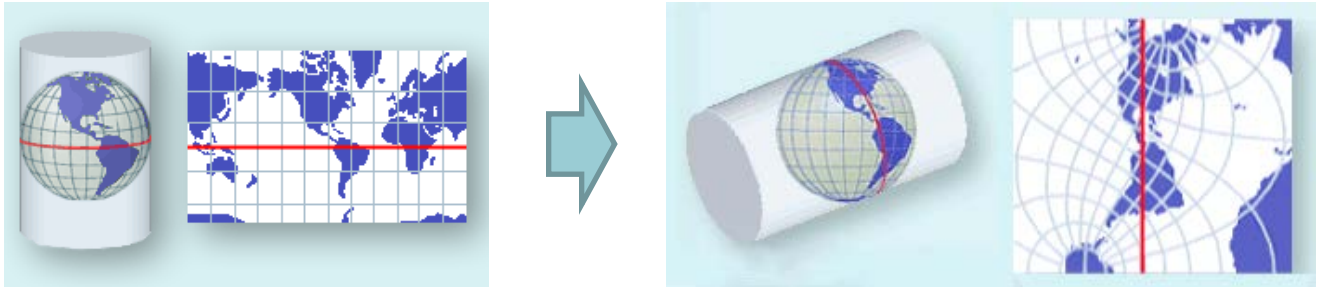


Effects of geographic projections (from stereographic)



Finding the optimal projection to store an orbit in a regular grid

- Requirements: retain instrument resolution of 750m and minimize the amount of overhead pixels on the edges (nodata)
- Use proj4 oblique Mercator projection (omerc)
  - Use brute force to find optimal projection parameters
  - Iterate longitude of origin, latitude of origin, alpha and gamma parameters



Like space oblique Mercator developed by John P. Snyder, Alden Partridge Colvocoresses and John L. Junkins in 1976

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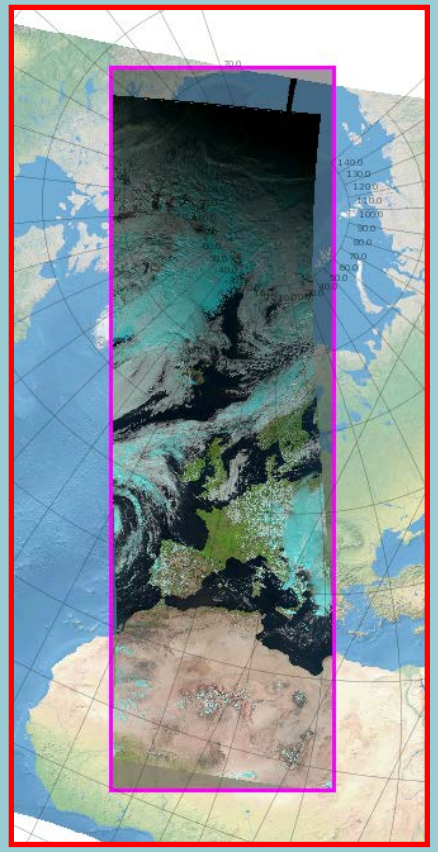
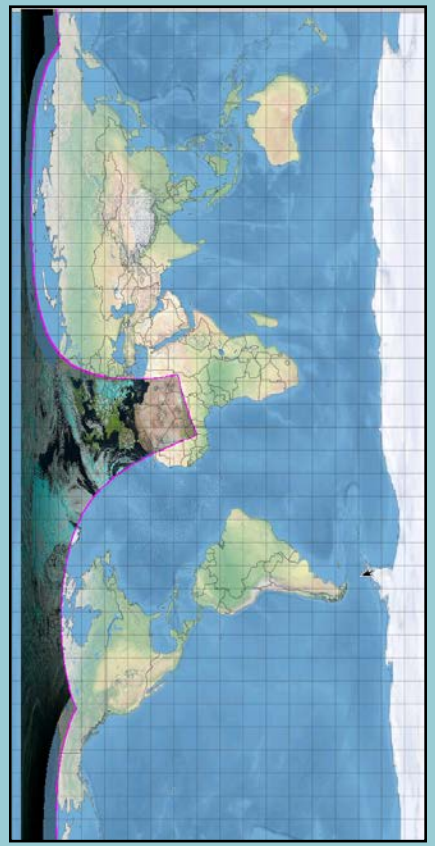
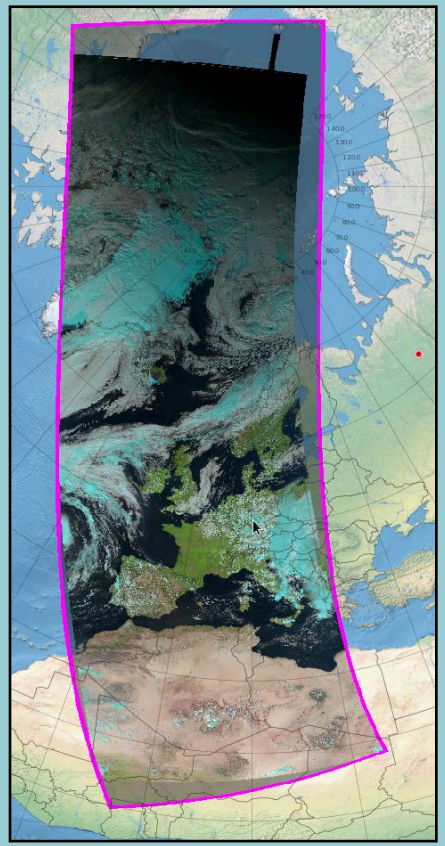
Oblique Mercator Projection



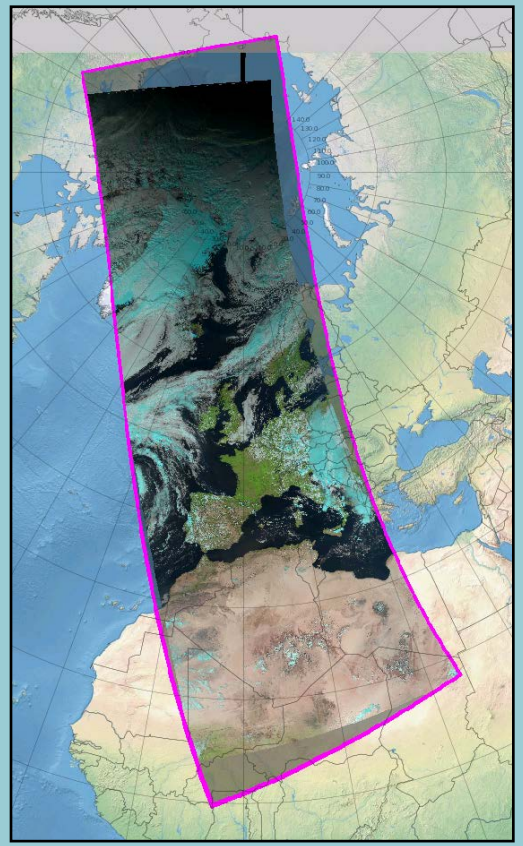
Oblique mercator



LatLon



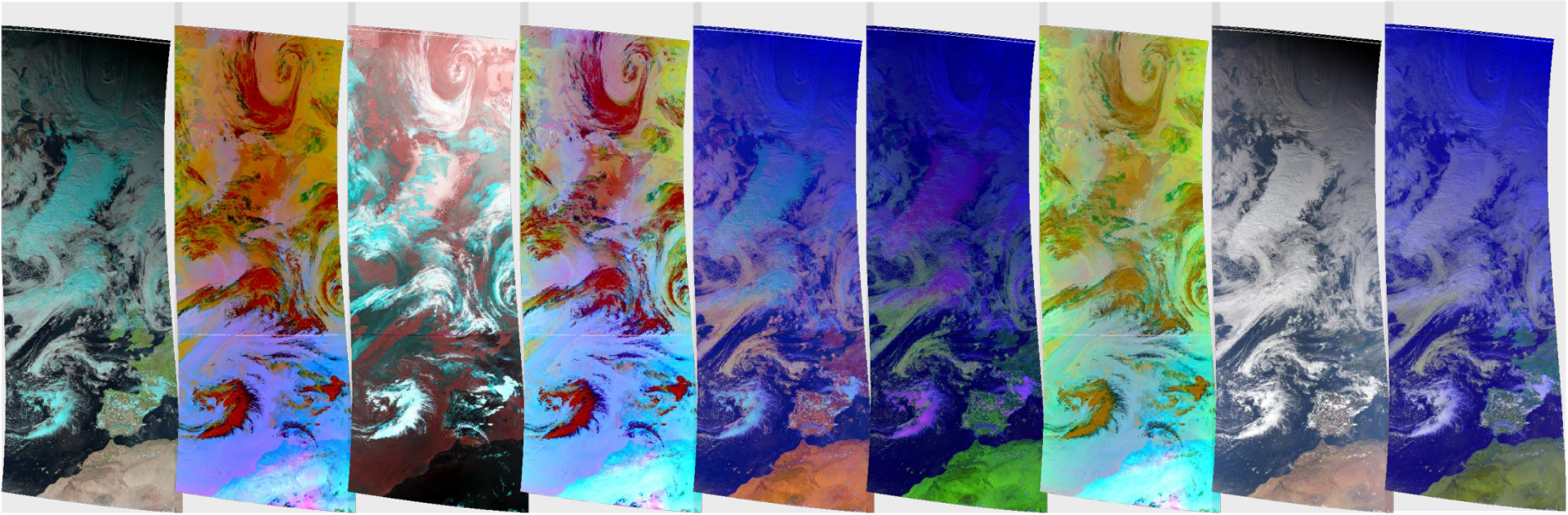
Lambert



Stereographic

+proj=omerc +y_0=0 +x_0=0 +k=1 +units=m +alpha=2.400000 +gamma=26.300000 +lonc=-15.000000 +lat_0=81.000000

Pytroll products from Suomi NPP VIIRS instruments



Natural | Dust | Night color | Fog | Green snow | Red snow | Ash | True color | Overview

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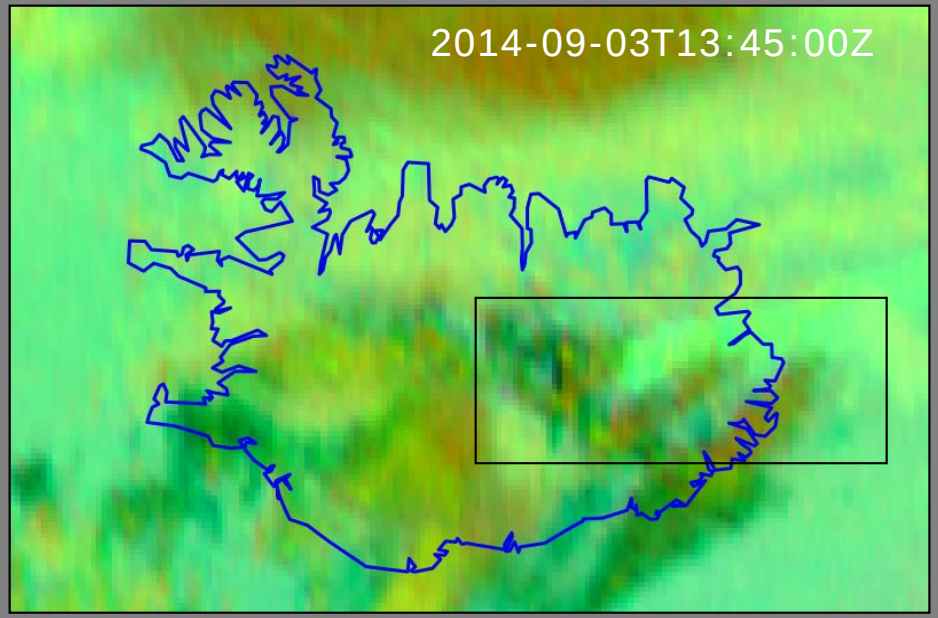
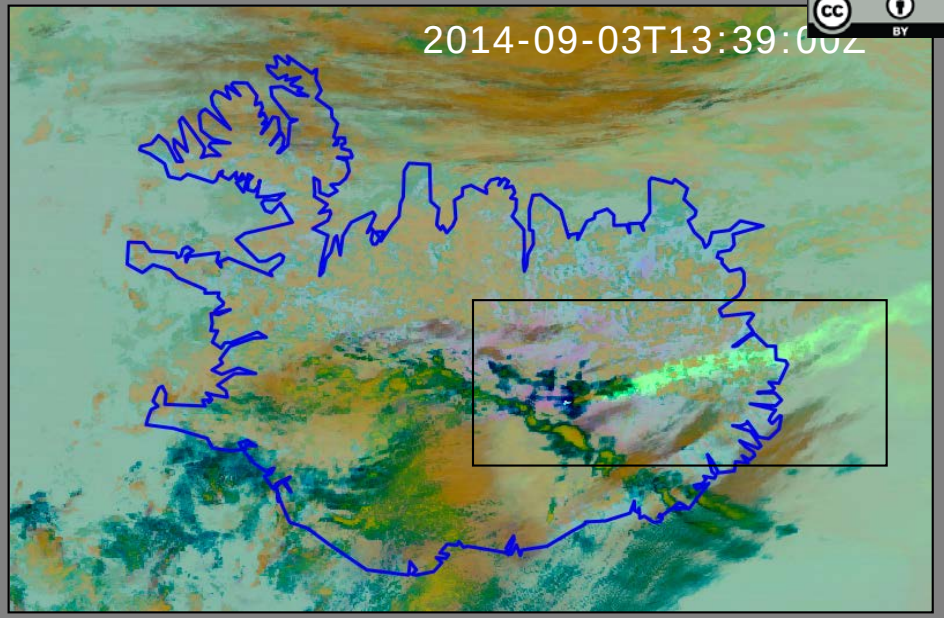
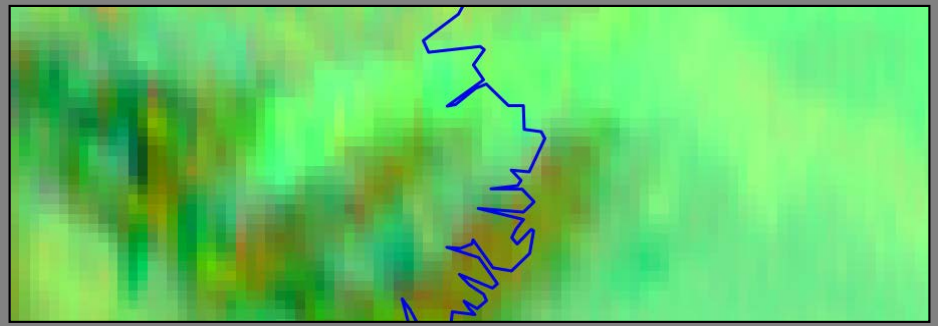
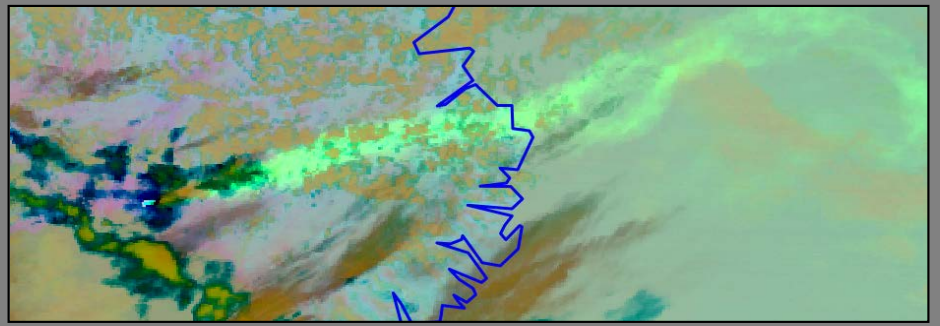






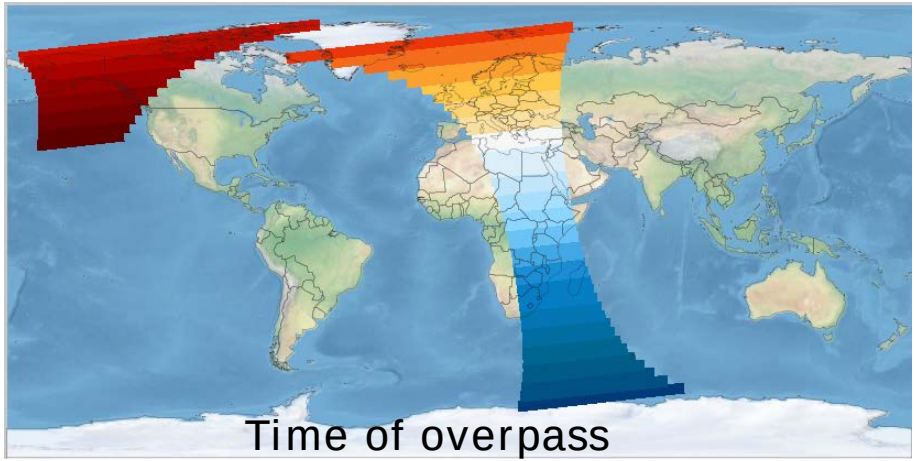


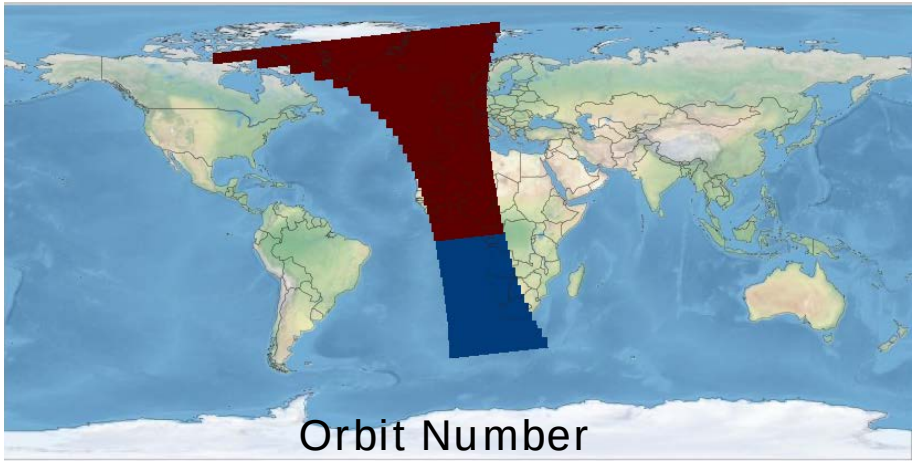
Meteosat 9 Cinesat Ash

Suomi NPP VIIRS Ash

Forecasting orbits with pyorbital

- Orbit trajectory can be calculated with PyTROLL's pyorbital based on time
- With known swath width and inclination the swath footprint can be calculated
- Time of overpass and orbit number is forecasted every hour, for 48 hr in advance





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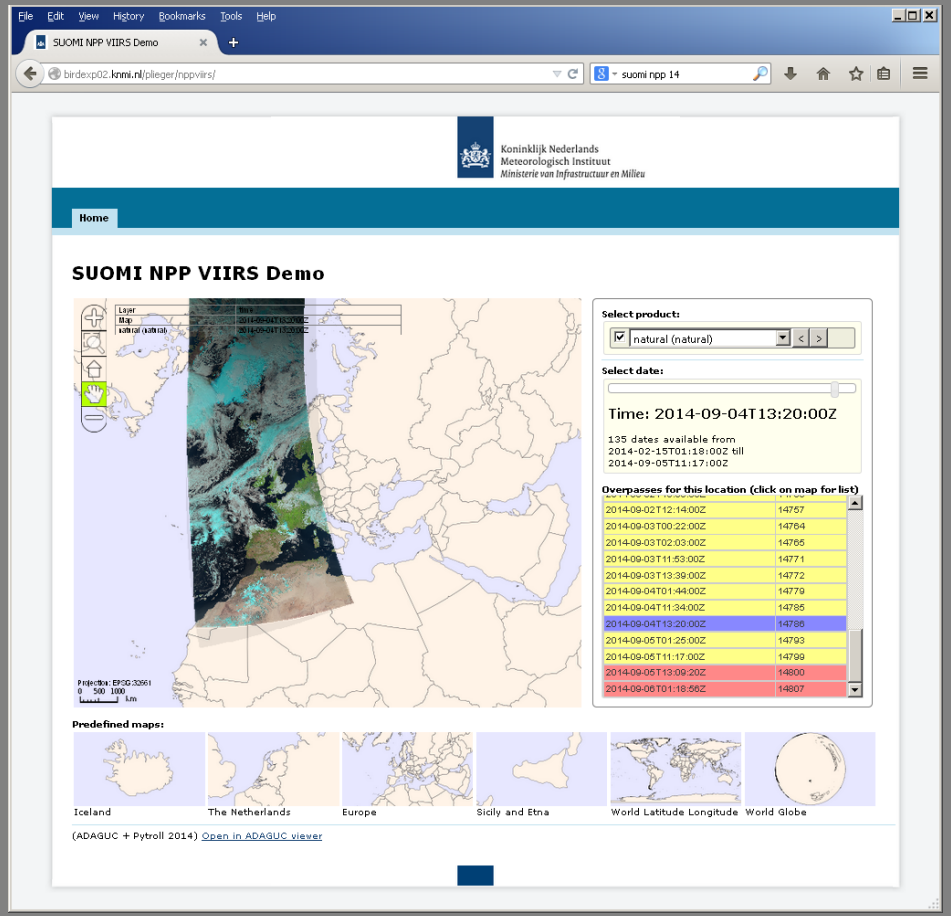

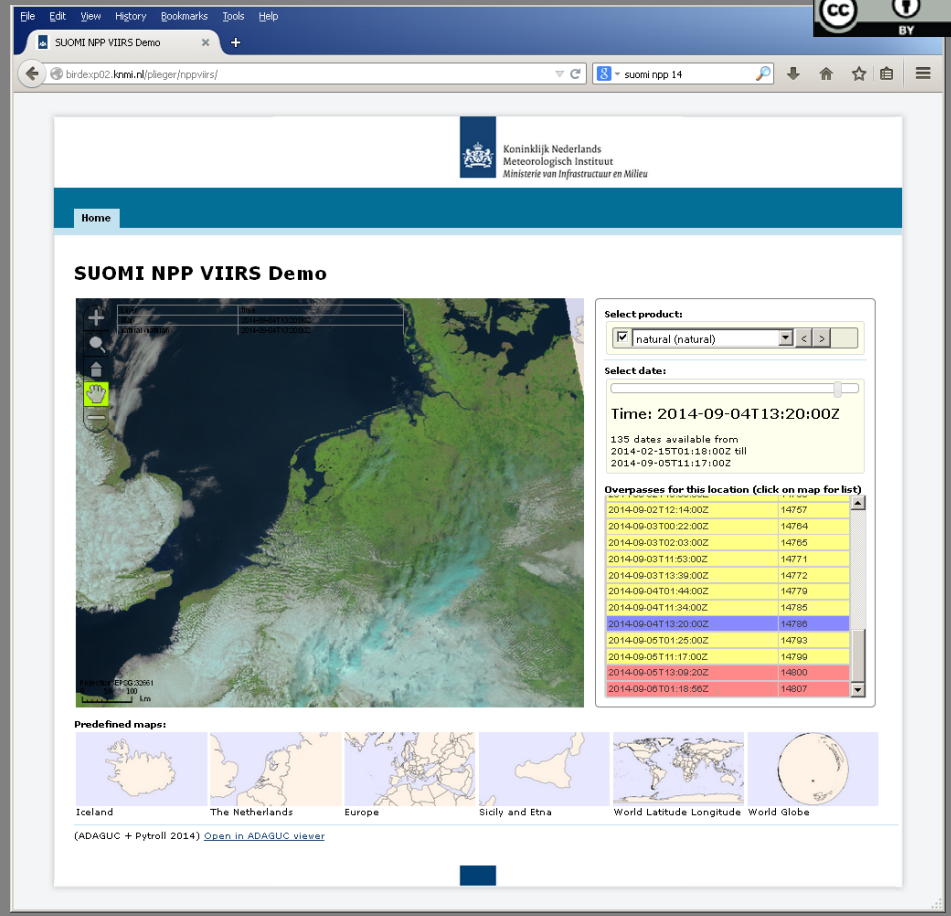

http://geoservices.knmi.nl/nppviirs/

Conclusions

- Pytroll is suited to read and resample polar orbiter satellite data and create derived products
- NetCDF with true color RGBA is suited to store true color satellite products
- Proj4 Oblique Mercator projection is suited to store swaths in regular grids
  - Still to check how space Mercator (+proj=lsat) performs…
- List of current and future overpasses is useful
- ADAGUC is able to render large true color NetCDF files on the web as OGC WMS service
  - Open tools and Open standards become mature

- Suomi NPP VIIRS are now available to the Weather office !
  - Provides added value over Meteosat 9 in polar regions like Iceland

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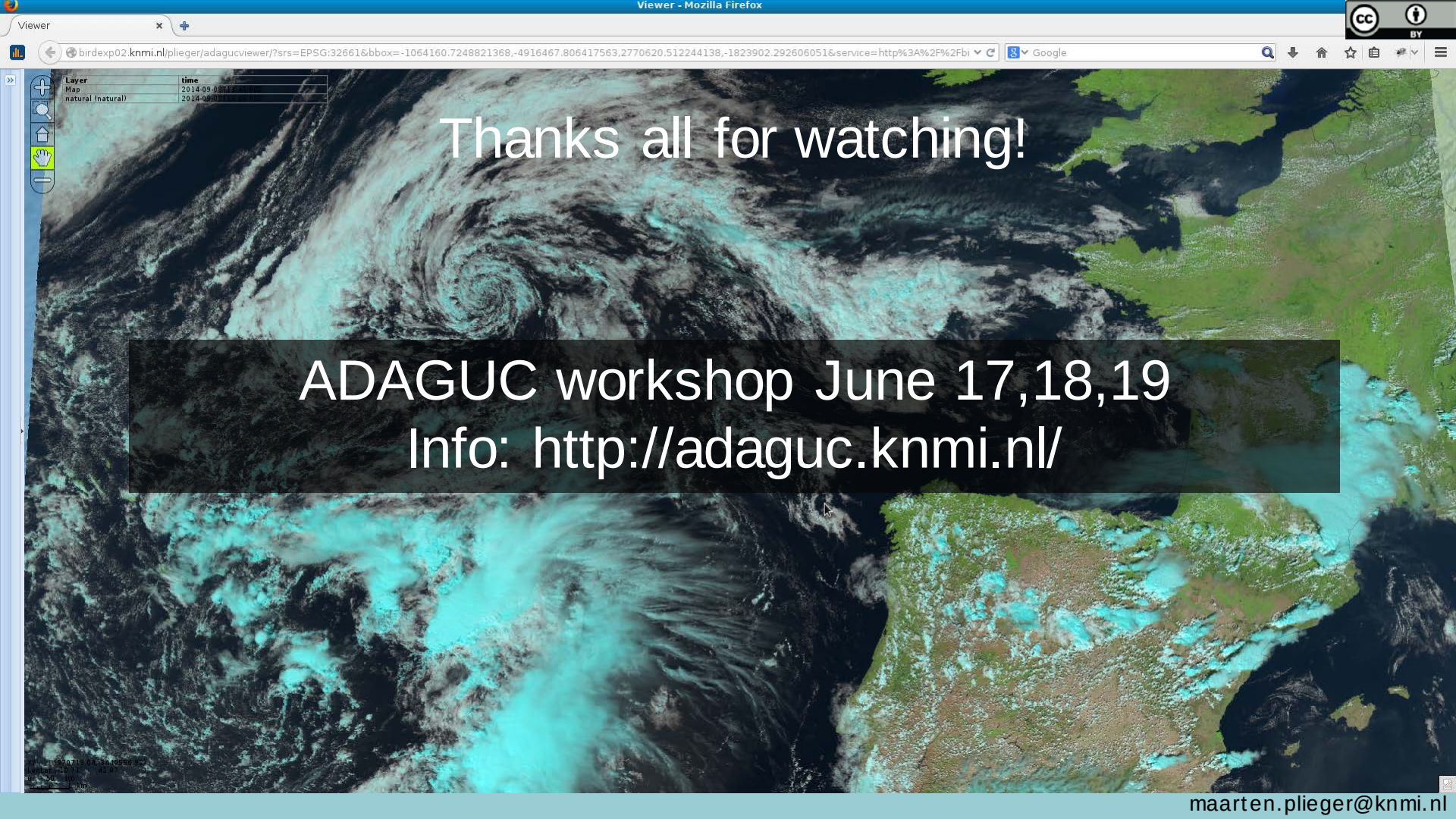

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The next slides are detail slides

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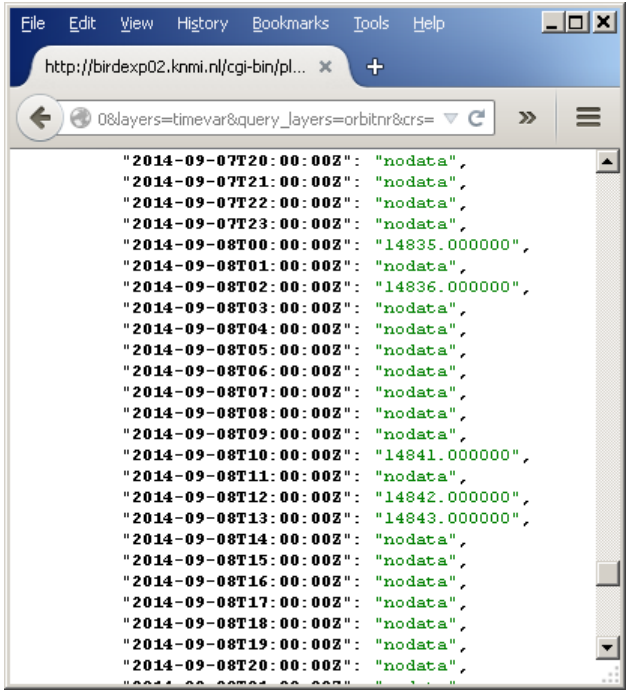
Forecasting orbits with pyorbital

- Forecasted swath data is stored per hour as multiple polygons in NetCDF files
- Data is served with ADAGUC WMS Server
- Data extraction for a certain point in time can be done with GetFeatureInfo
- ADAGUC can return a timeseries JSON file with all overpass hits for a location.
- Results are presented to the user in a table which is clickable



JSON timeseries showing overpasses for a location

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Converting VIIRS products to NetCDF4

- Extract EUMETCAST bzip2 files, the HDF5 files can be used in PyTROLL
  - Using the “npp compact” reader
  - Estimate best geographic projection, so orbit fits in a regular grid
  - Resample each orbit to this regular grid with its own custom projection.
    - Regular grids can be drawn in ADAGUC very fast
  - Create products, like ash, dust, fog, natural, truecolor, nightcolor, green snow, red snow, etc…
  - Store products as regular grid using true color rgba in a NetCDF file
    - Using unsigned integer, 4 bytes wide for R, G, B and A
  - Serve files with ADAGUC server
  - View Web Map Service in ADAGUC viewer

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