The EUMETSAT Network of Satellite Application Facilities

NWC SAF

Support to Nowcasting and Very Short Range Forecasting

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# Nowcasting - PPS algorithms and products

Adam Dybbroe

NDRC-9: NASA Direct Readout Conference, Valladolid, Spain, 21-24 June, 2016

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# Outline

- The Nowcasting SAF
- PPS overview
- Algorithms, products and validation
- Use in Nowcasting - examples
- Running PPS locally
- Summary & Outlook

# Questions - Nowcasting

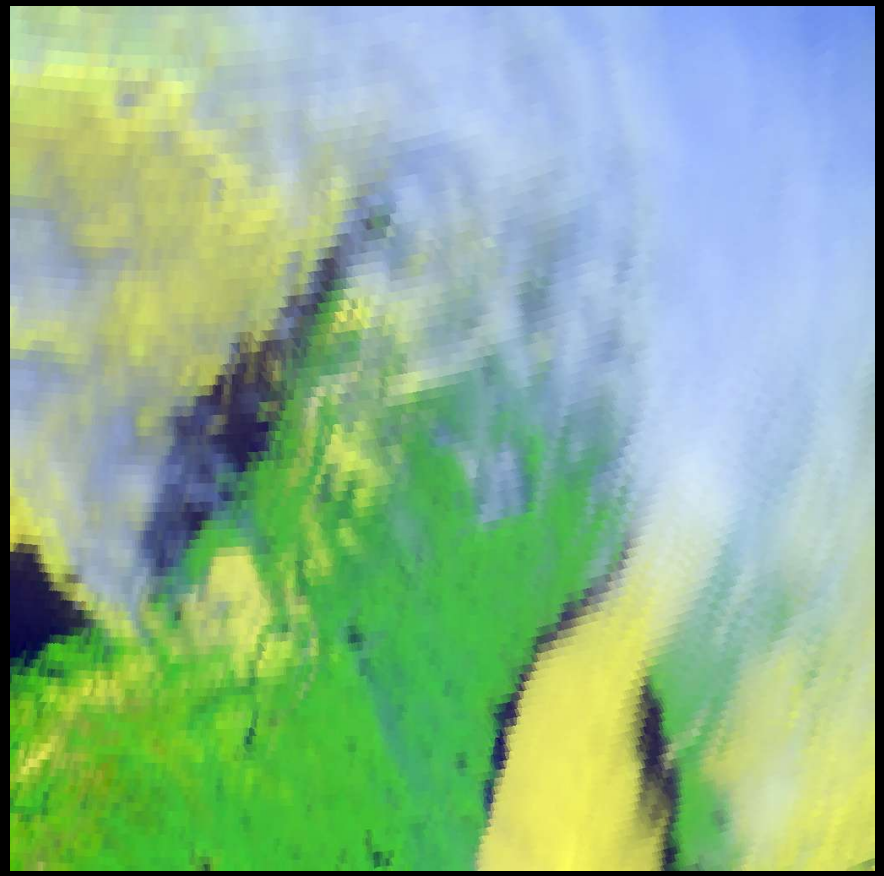
- Where is the scope for direct readout and polar orbiters?
  - Now, 10 and 20 years from now?

# Nowcasting

- Geo versus Polar (and/or HEO!?)
- Spatial resolution & coverage
- Spectral resolution
- Timeliness
- Local reception or regional
- etc

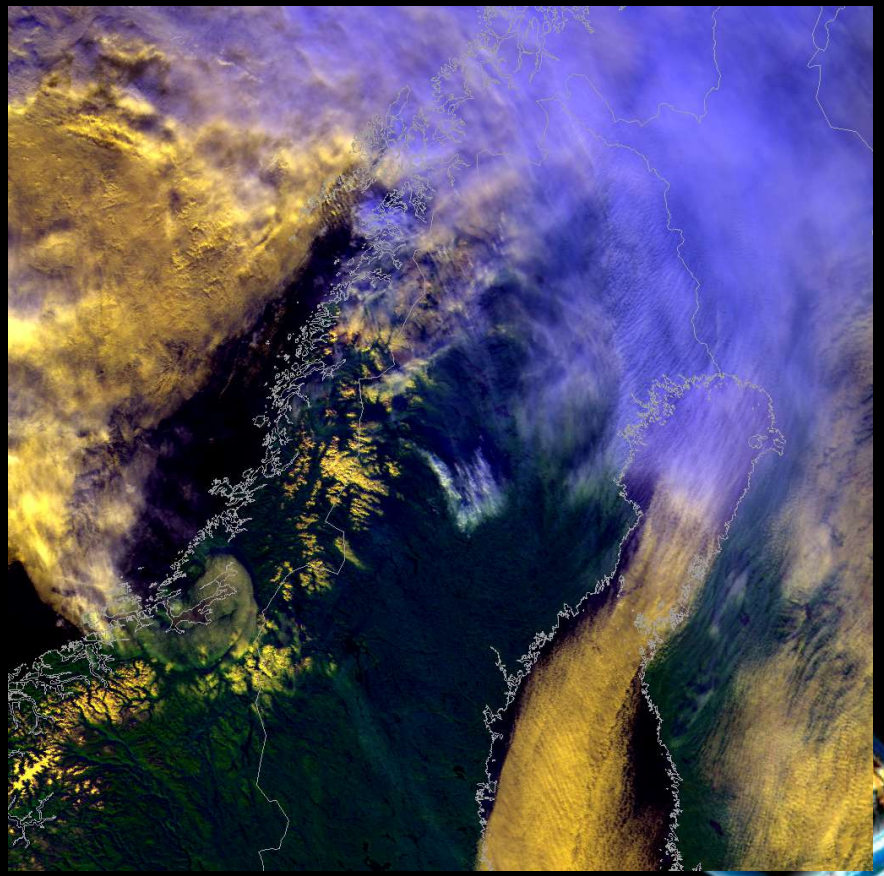
# Resolution and coverage differ

SEVIRI RGB ch 1,2,9



Met08 2005-10-16 11:30 UTC

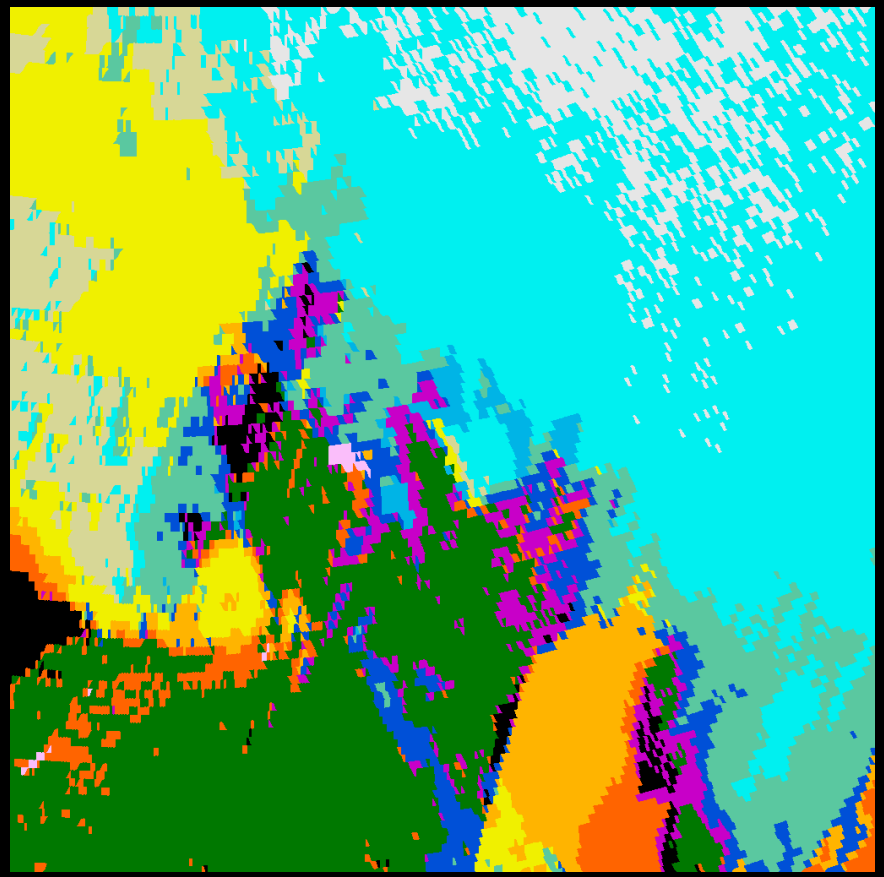
AVHRR RGB ch 1,2,4



NOAA 18 #2102 2005-10-16 11:31 UTC

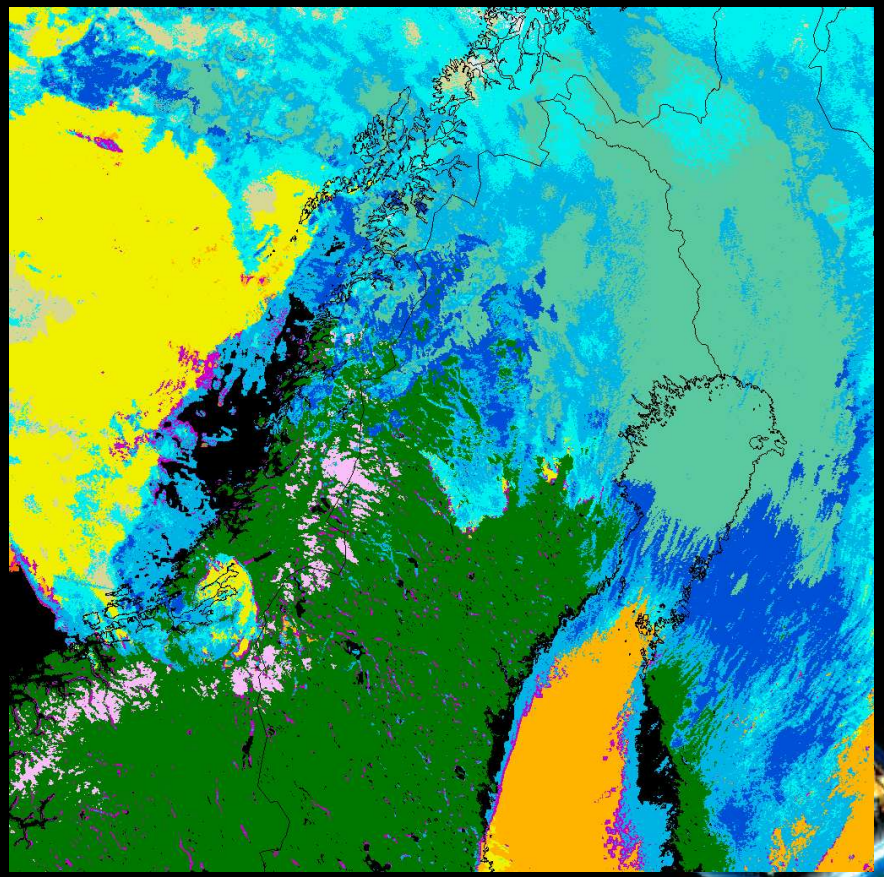
# Resolution and coverage differ

SEVIRI Cloud Type



Met08 2005-10-16 11:30 UTC

AVHRR Cloud Type



NOAA 18 #2102 2005-10-16 11:31 UTC

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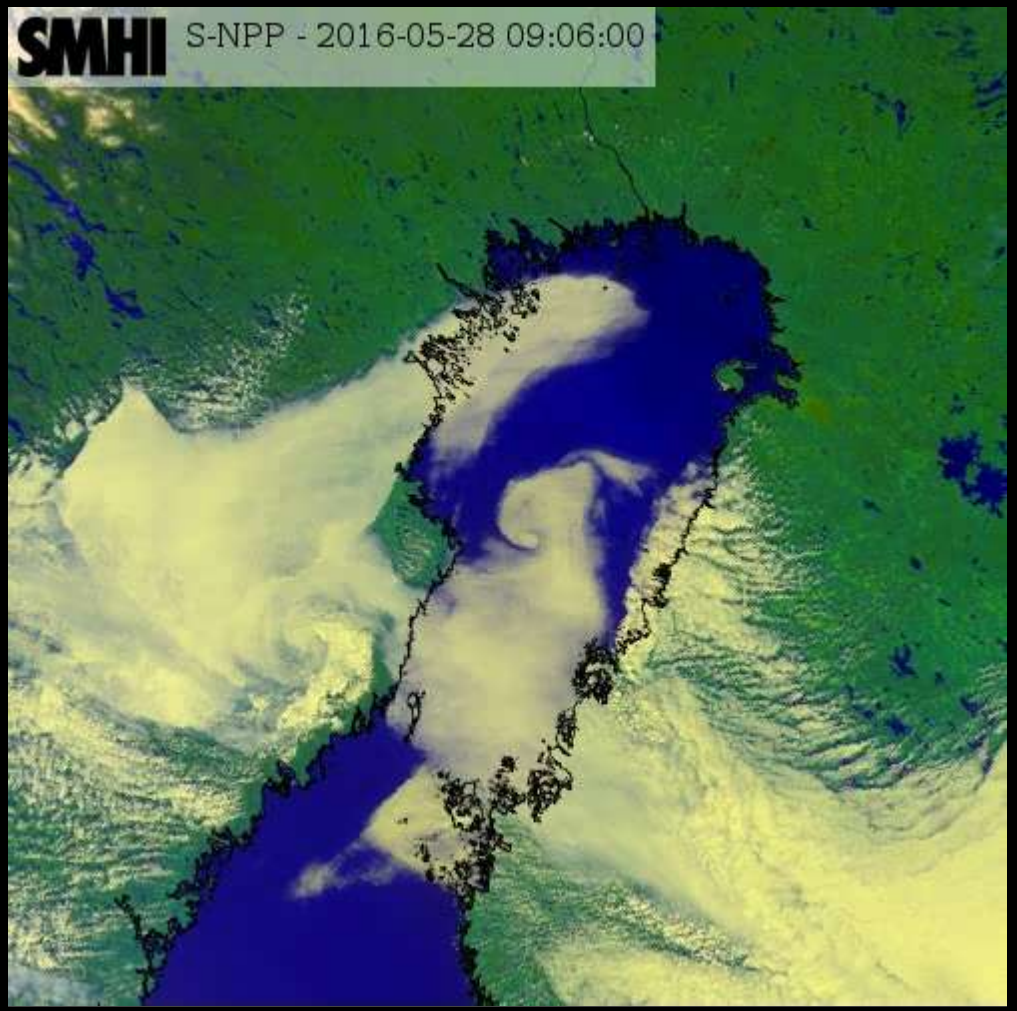


https://dl.dropboxusercontent.com/u/37482654/mesoscale_vortex_2016may28.avi

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# The Nowcasting SAF

- Established 1996 between EUMETSAT and Spanish National Weather Service (AEMET)
- Under the leadership of AEMET the NWCSAF is developed by a project team involving France (Météo-France) Sweden (SMHI) and Austria (ZAMG)

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# The Nowcasting SAF

- The main goal is the derivation of Nowcasting products from both MSG and EPS satellite systems in the form of SW packages
- The NWCSAF is responsible for the development and maintenance of the appropriate SW packages, as well as related User's support tasks
- User support is facilitated through a dedicated Help Desk (www.nwcsaf.org)

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# PPS Overview

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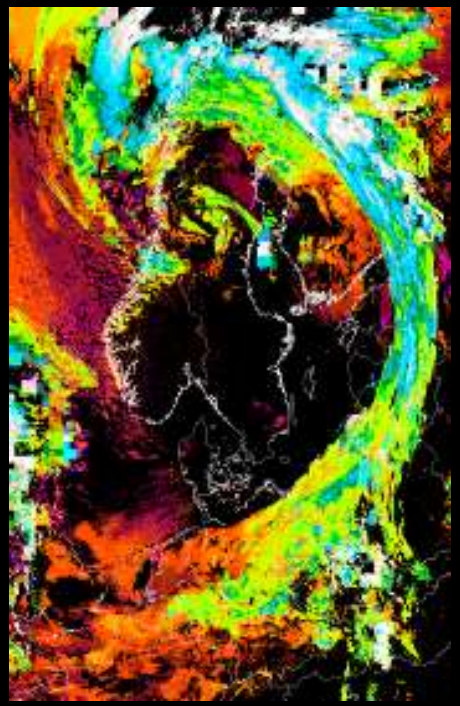
# Polar Platform System Package

- Retrieval of cloud and precipitation parameters from polar orbiters

# SMHI team

- Sara Hörnquist
- Nina Håkansson
- Anke Thoss
- Ronald Scheirer
- Karl-Göran Karlsson
- Adam Dybbroe
- Salomon Eliasson
- Abhay Devasthale
- Josef Sedler
- Martin Raspaud

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## SMHI team

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- Adam Dybbroe
- Abhay Devasthale
- Martin Raspaud

## KNMI team

- Jan Fokke Meirink
- Gerd-Jan van Zadelhoff

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# What is PPS?

- AVHRR (+AMSU/MHS), VIIRS and MODIS
- Direct Readout
- Global Metop
- EARS=European Advanced Re-transmission Service
- GAC=Global Area Coverage format

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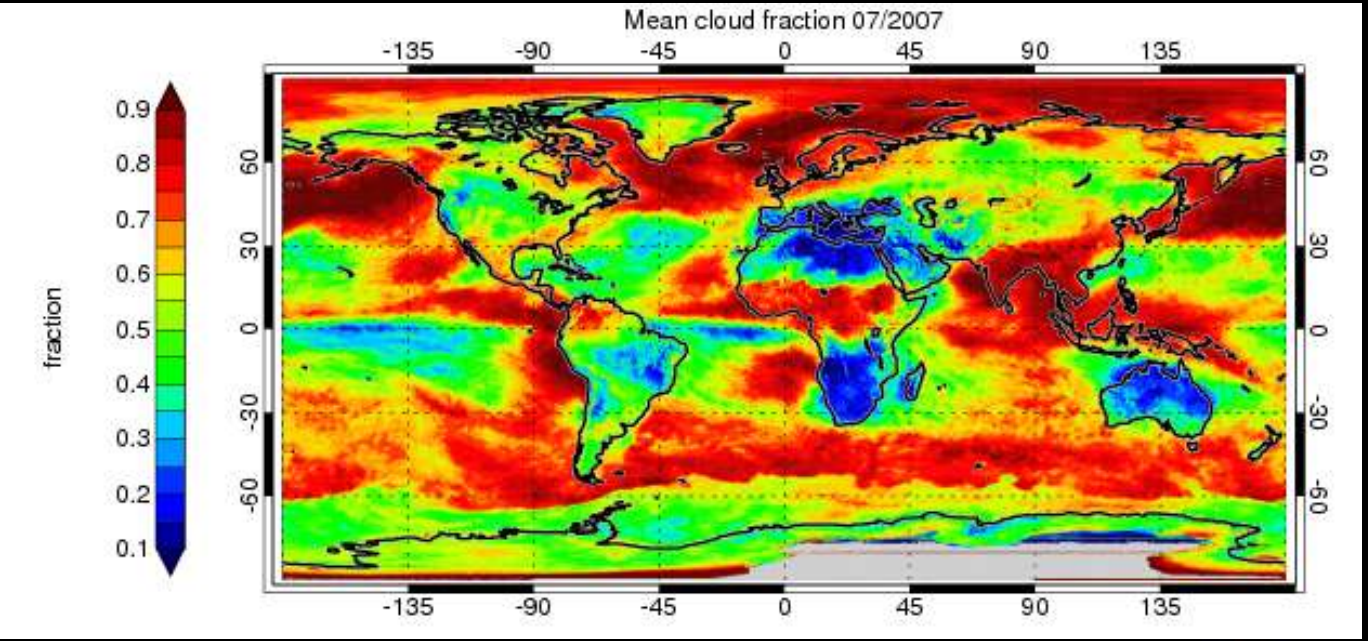
# What is PPS?

- Processing in original swath projection
- Entire swath, orbit, or granule

# What is PPS?

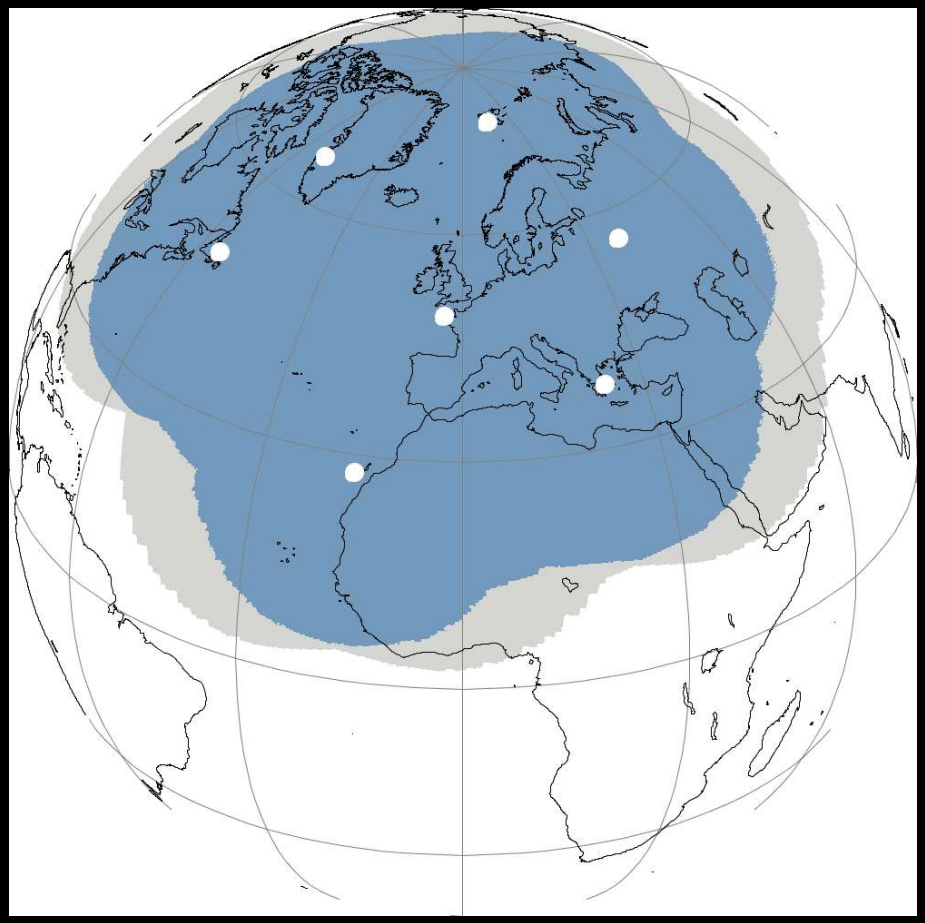
- Used not only for Nowcasting, but also by Climate Monitoring SAF, Ocean and Sea Ice SAF and Land SAF

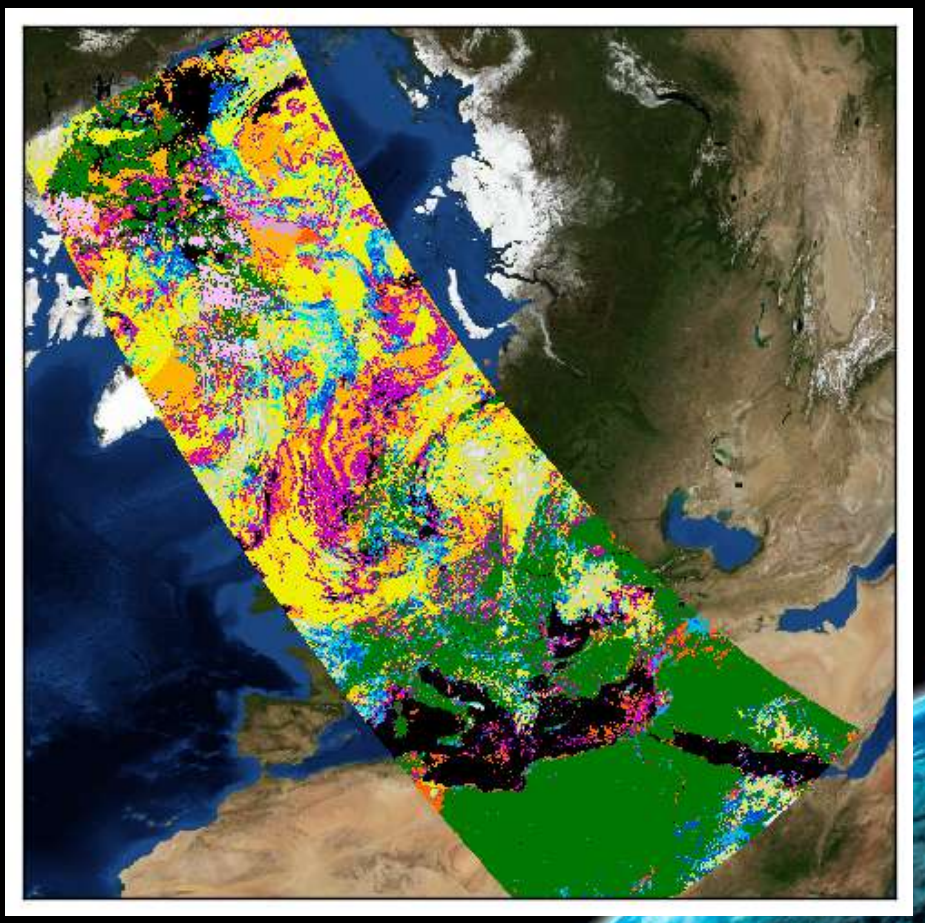



Mean cloud fractional coverage for July 2007, derived from NOAA 15, 16, 17 and 18:

# What is PPS?

- Also used for processing cloud products in the EARS-NWC service





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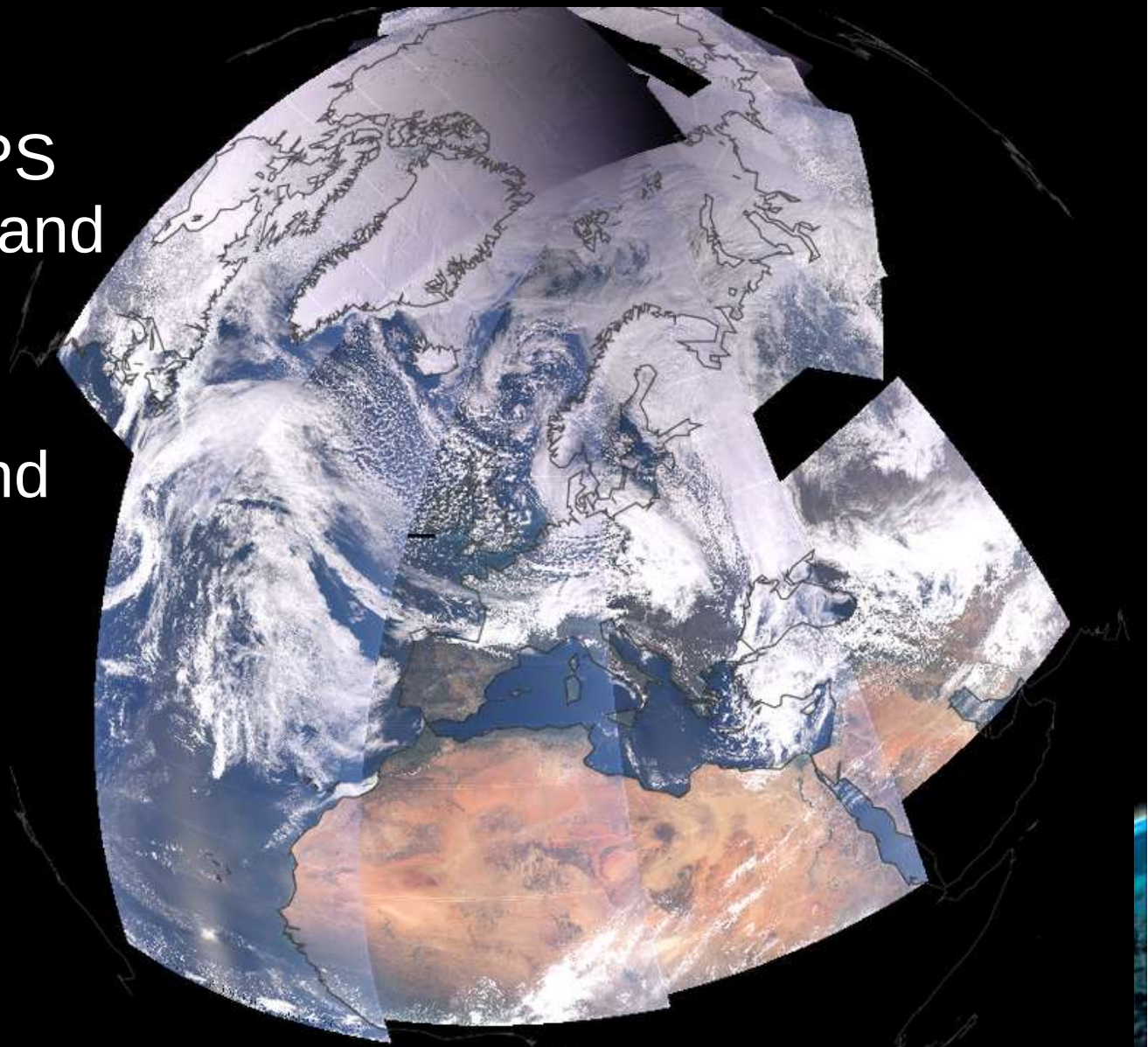
# EARS-NWC extended to VIIRS

- Currently EARS-NWC provides PPS cloud mask, type and CTTH on AVHRR
- EARS team is preparing to extend this to VIIRS



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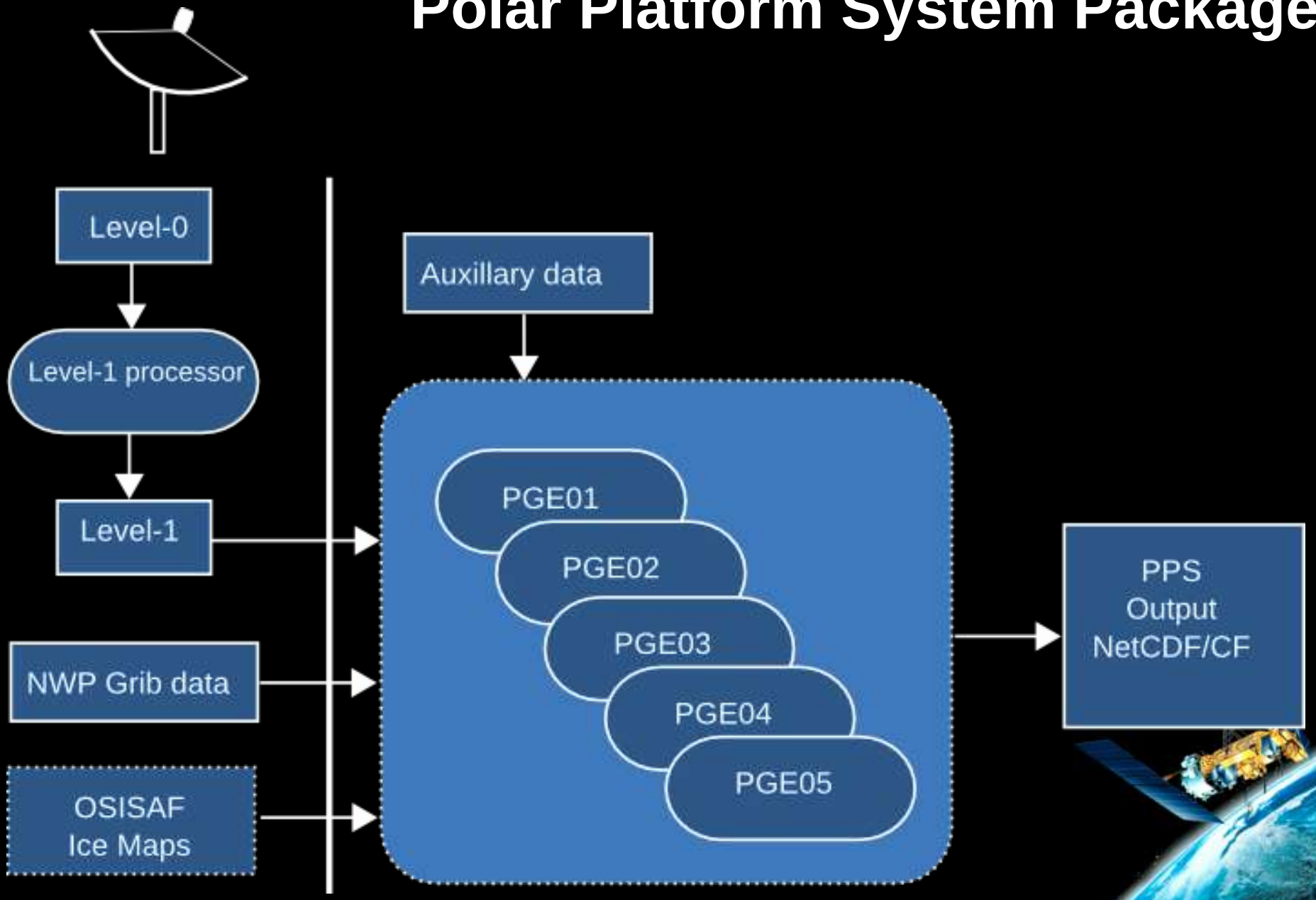
# Polar Platform System Package



# What is PPS?

- C/Python (+Fortran interfaces)

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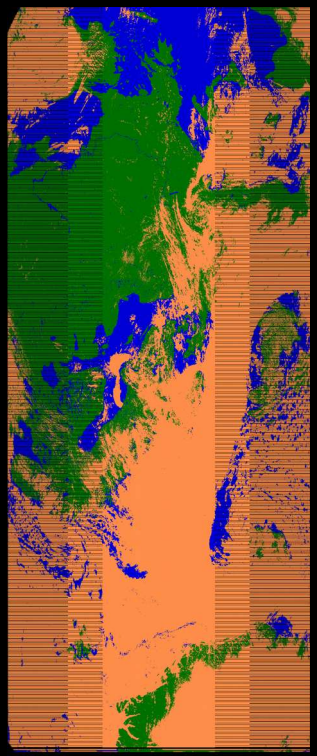
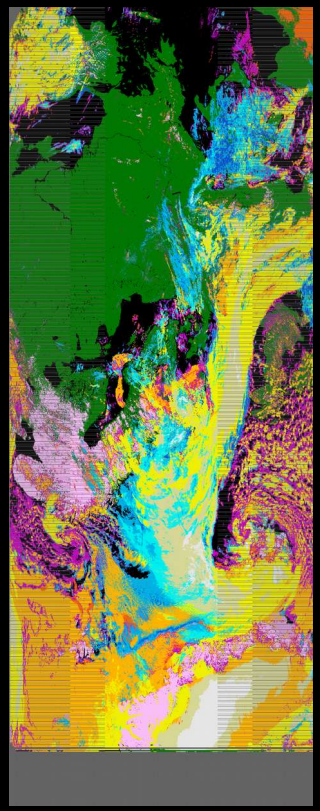
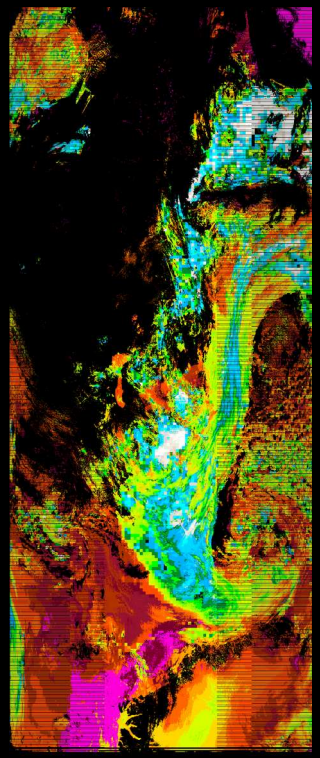
# Parameters



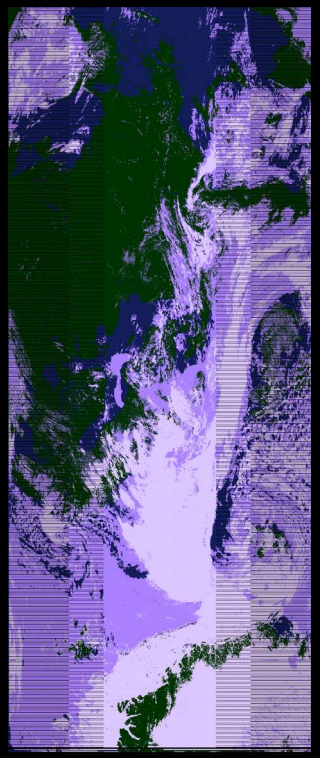
Cloud Mask



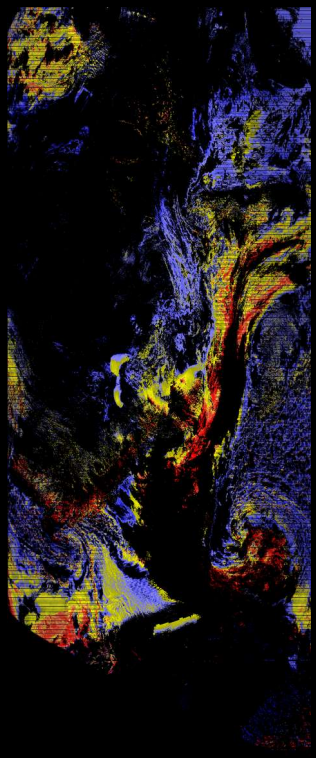
Cloud Type



Cloud Temperature and Height

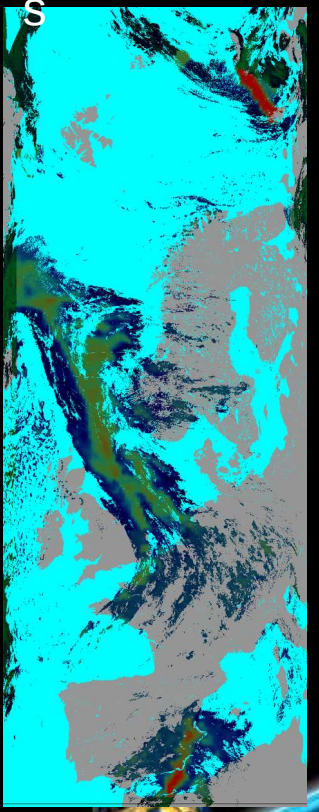


Cloud Phase



LWP

Likelihood for light, moderate and intense precipitation s



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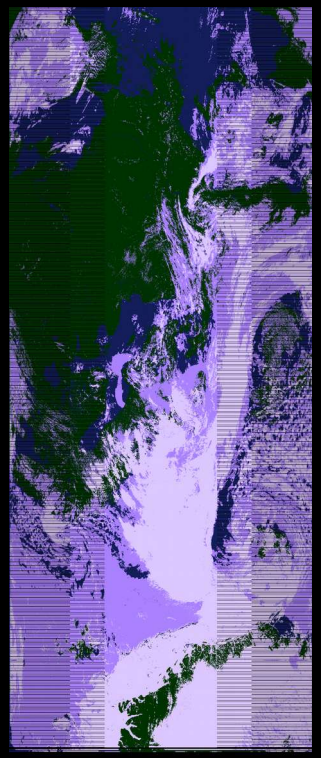
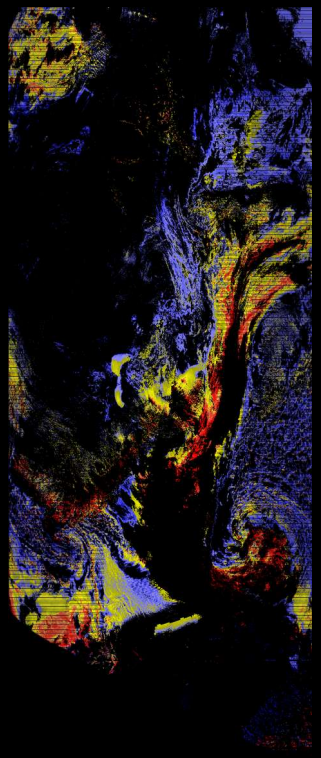
# Cloud Microphysical Parameters

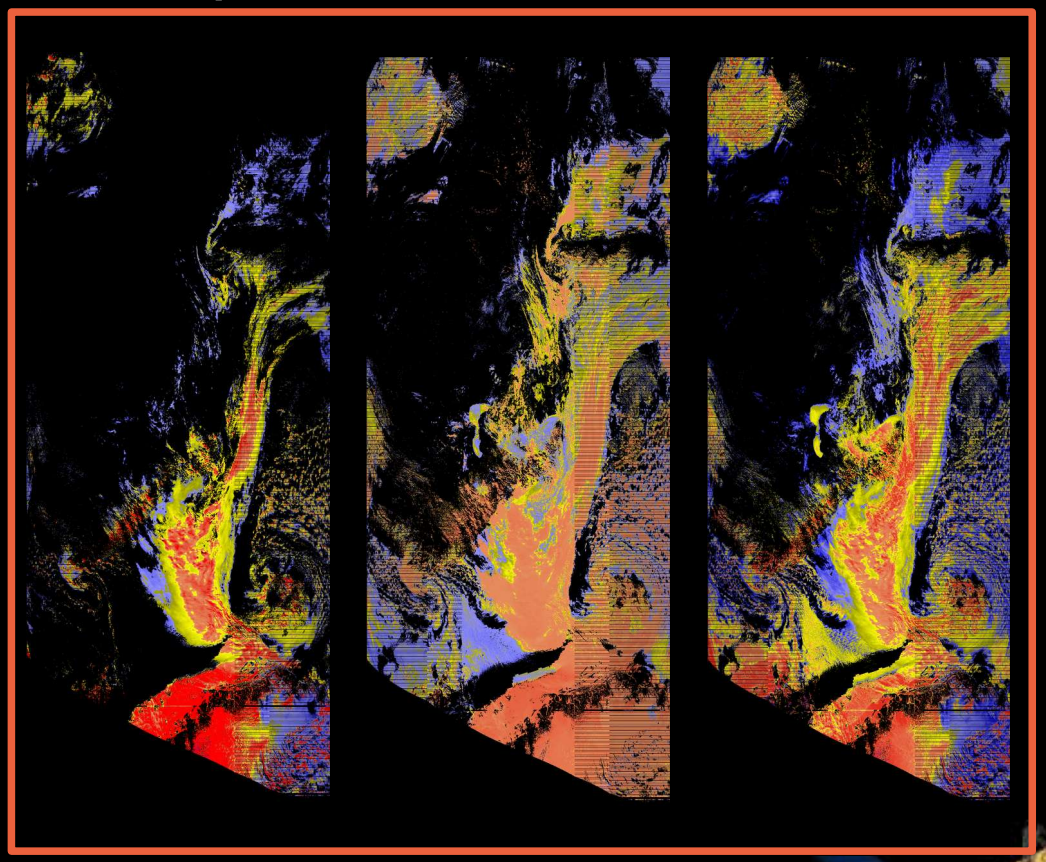


Cloud Phase



LWP

Extra products – not committed



IWP

Effective radius

Cloud Optical Thickness

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# PPS parameters

- Cloud Mask
- Cloud Type
- CTTH
- Precipitating Clouds
- Cloud Phase
- LWP
- IWP
- COT
- $r_{eff}$

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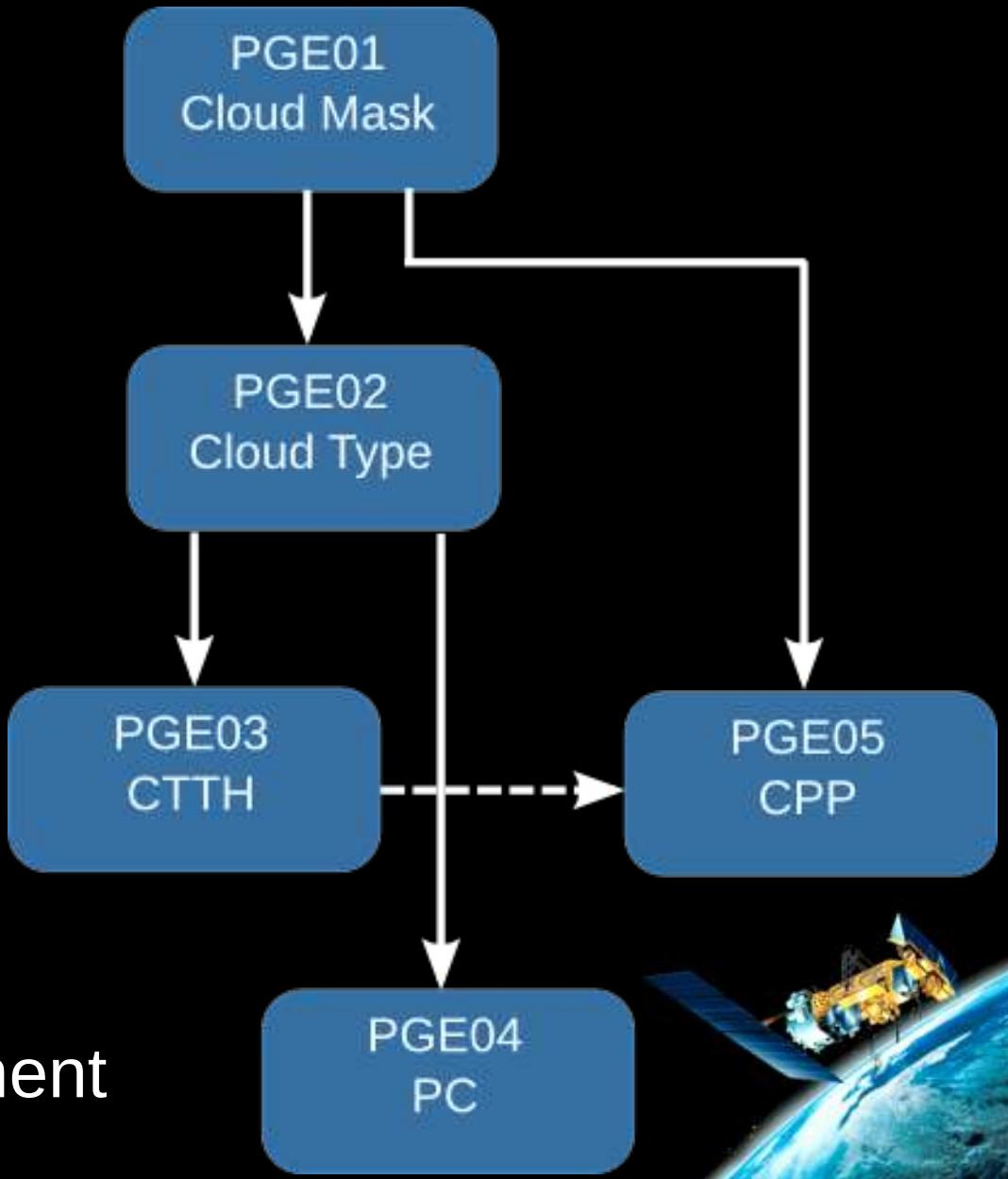
# PPS products

- Cloud Mask
- Cloud Type
- CTTH
- Precipitating Clouds
- Cloud Phase
- LWP
- IWP
- COT
- $r_{eff}$

**CPP algorithms/package**

# PGE dependencies




PGE =
Process Generation Element

# Support and release strategy

- Major releases every ~2-3 years
  - Subject to external reviews
  - Full validation
- Available via the Help Desk (www.nwcsaf.org)
  - Free registration

# Support and release strategy

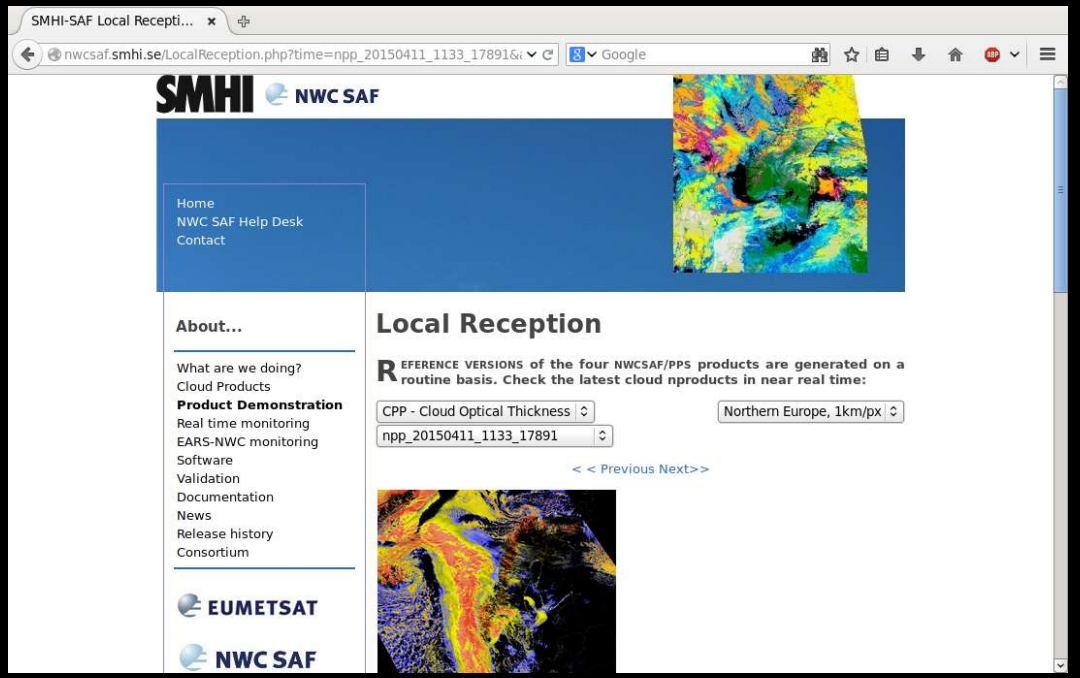
- Patches as necessary, e.g.
  - in case of bugs
  - new satellites
  - portability
- Bug reports and user support via mail-box on Help Desk
  - Usually answered within 24 hours

# Support and release strategy

- All releases contain full source code
- ...and ready built binaries for a few common Linux distributions:
  - CentOS-6/RHEL-6
  - Ubuntu Trusty
  - *...more depending on user needs*

# Reference system

- nwcsaf.smhi.se
- Real time images
- Norrköping DR station




# Products and Algorithms

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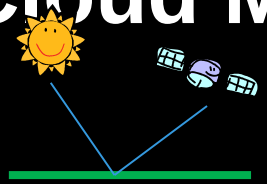
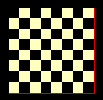
# Cloud Mask & Type

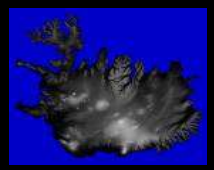


Sun-Satellite viewing



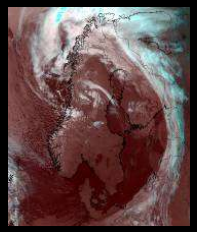
Surface emissivity/reflectivity

Land use

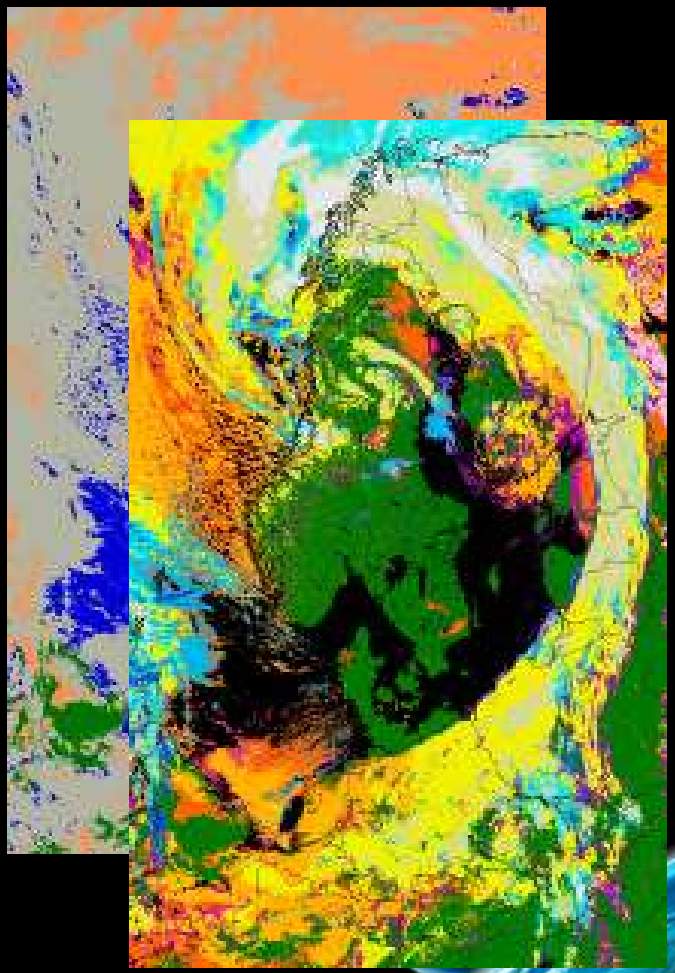


Topography

Humidity and emperature from NWP



Satellite data



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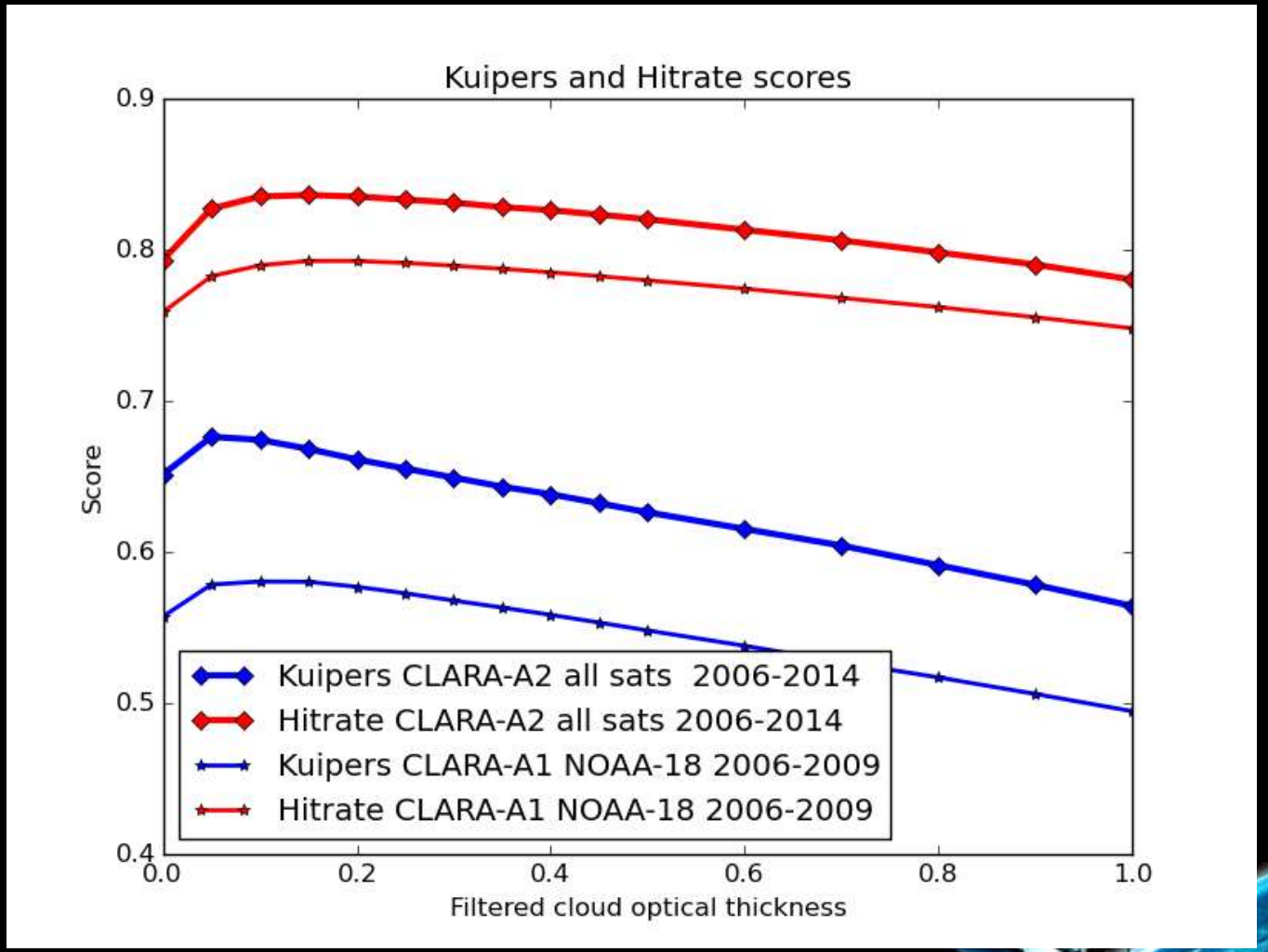
# Cloud Mask & Type - validation

- Co-location of AVHRR/VIIRS with Calipso/CALIOP
- 2006-2014
- > 8500 orbits
- Utilize both 1km and 5km CALIOP data

Kuipers and Hit rate as a function of optical thickness:

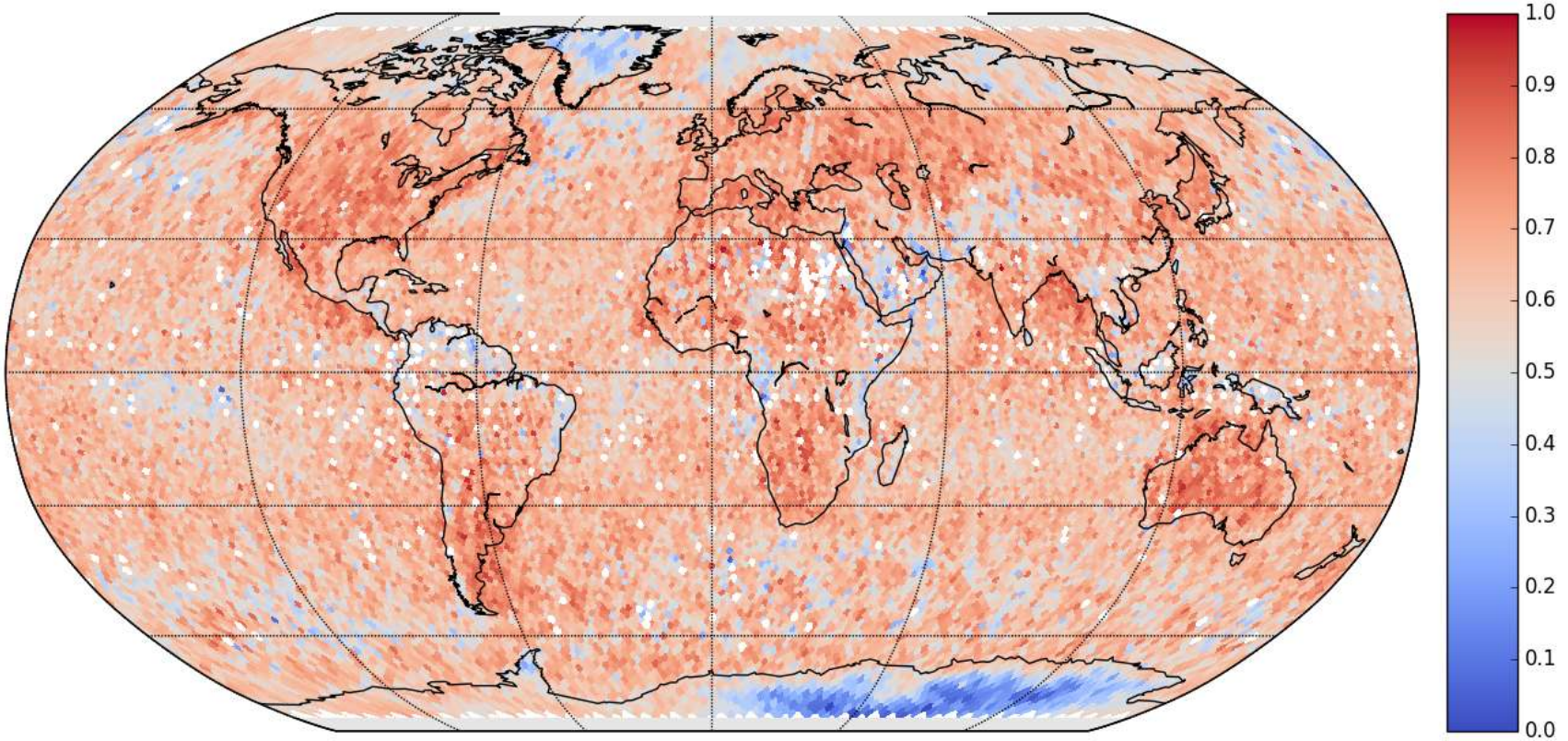
- Provides information on AVHRR Cloud detection limit




Peak hit rate for CLARA-A2 found for cloud optical thickness = 0.15!

# Validation – global distribution

## Kuipers Score



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# Cloud Top Temperature & Height (CTTH)

- Simulating cloudy and cloudfree radiances
- Opaque clouds:
  - 11 micron Tb versus NWP temperature profile
- Semi-transparent and fractional clouds
  - 2D histogram method – curve fitting of Tb11-Tb12 versus Tb11

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# VIIRS Cloud Top Height

Validation with Collocated Calipso/CALIOP observations


Suomi NPP scene:
June 11 12:53 UTC, 2012

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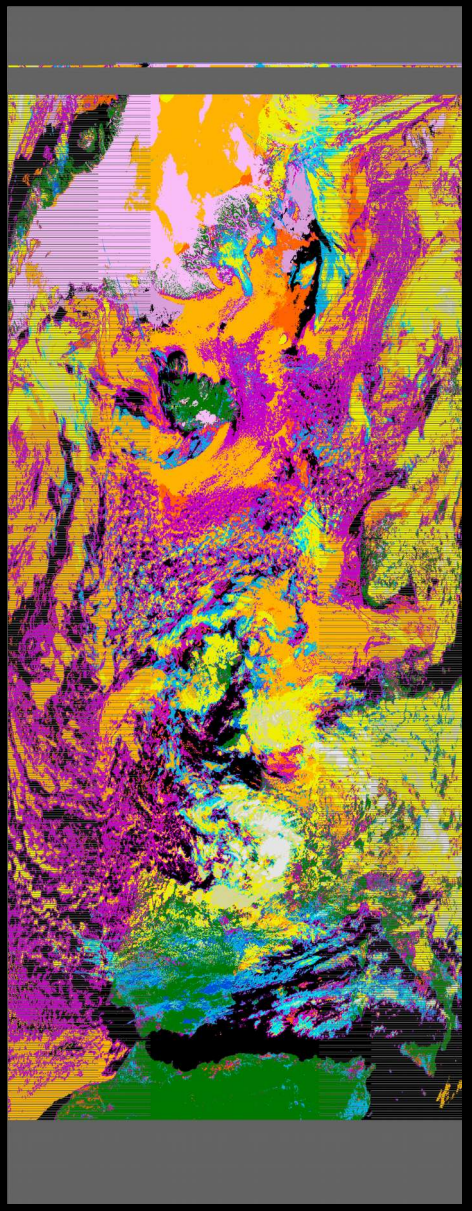
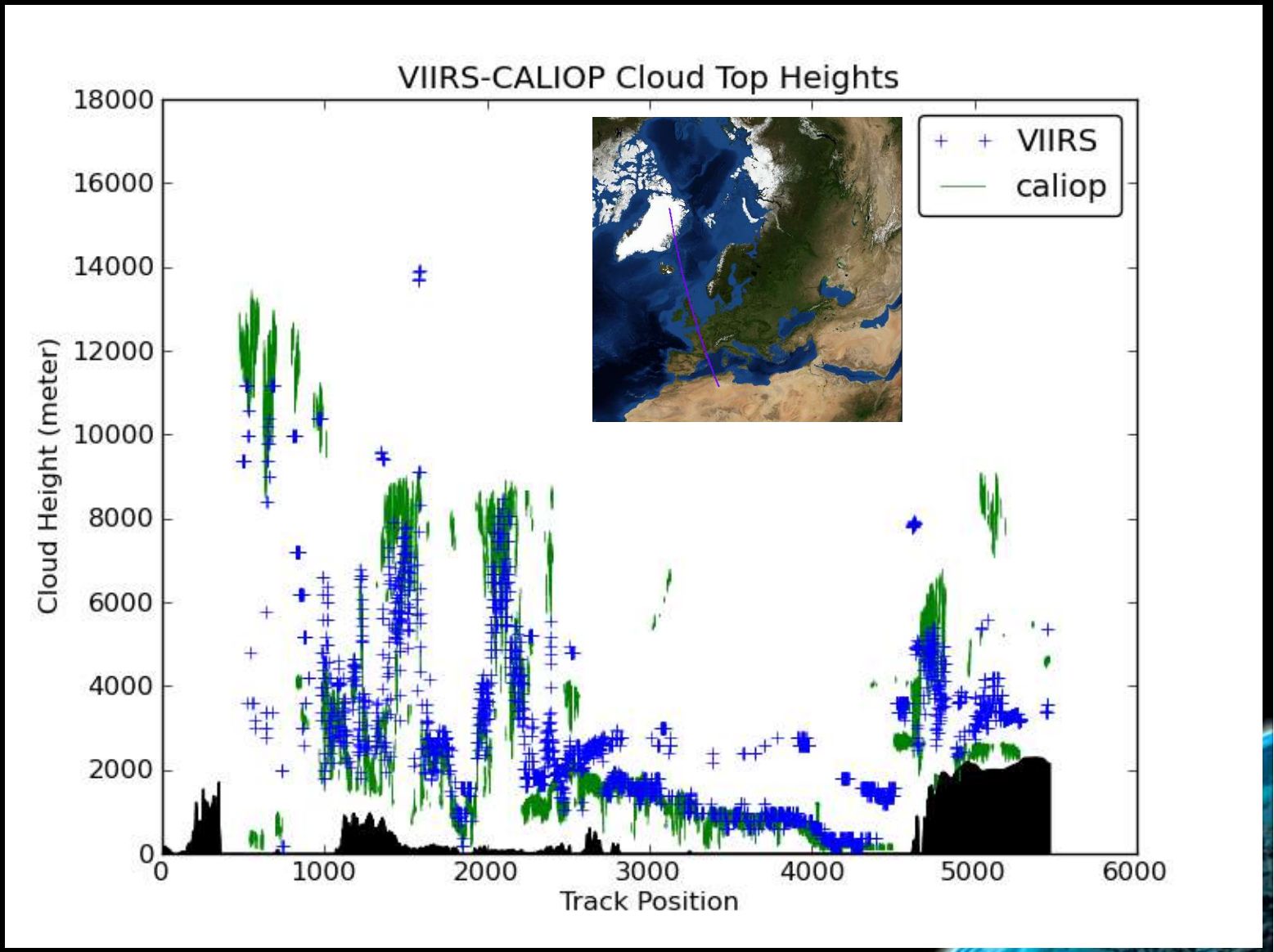
# VIIRS Cloud Top Height





# CTTH validation against CALIOP

Semi transparent clouds

| | All | Low | Medium | High |
|---|---|---|---|---|
| Bias (m) | 148 | 951 | 724 | -426 |
| RMS (m) | 1739 | 1532 | 1242 | 1977 |
| bc-RMS (m) | 1732 | 1201 | 1009 | 1931 |

Opaque clouds

| | All | Low | Medium | High |
|---|---|---|---|---|
| Bias (m) | -186 | 424 | -127 | -1313 |
| RMS (m) | 1445 | 870 | 943 | 2294 |
| bc-RMS (m) | 1433 | 760 | 934 | 1881 |

# Precipitating Clouds

- Probability of precipitation for intensity classes
- Likelihood supplied for classes
  - no precip (< 0.1mm/h)
  - Light/chance of precip (0.1mm/h – 0.5mm/h)
  - Moderate precip (>0.5mm/h – 5mm/h)
  - Heavy precip (>5mm/h)

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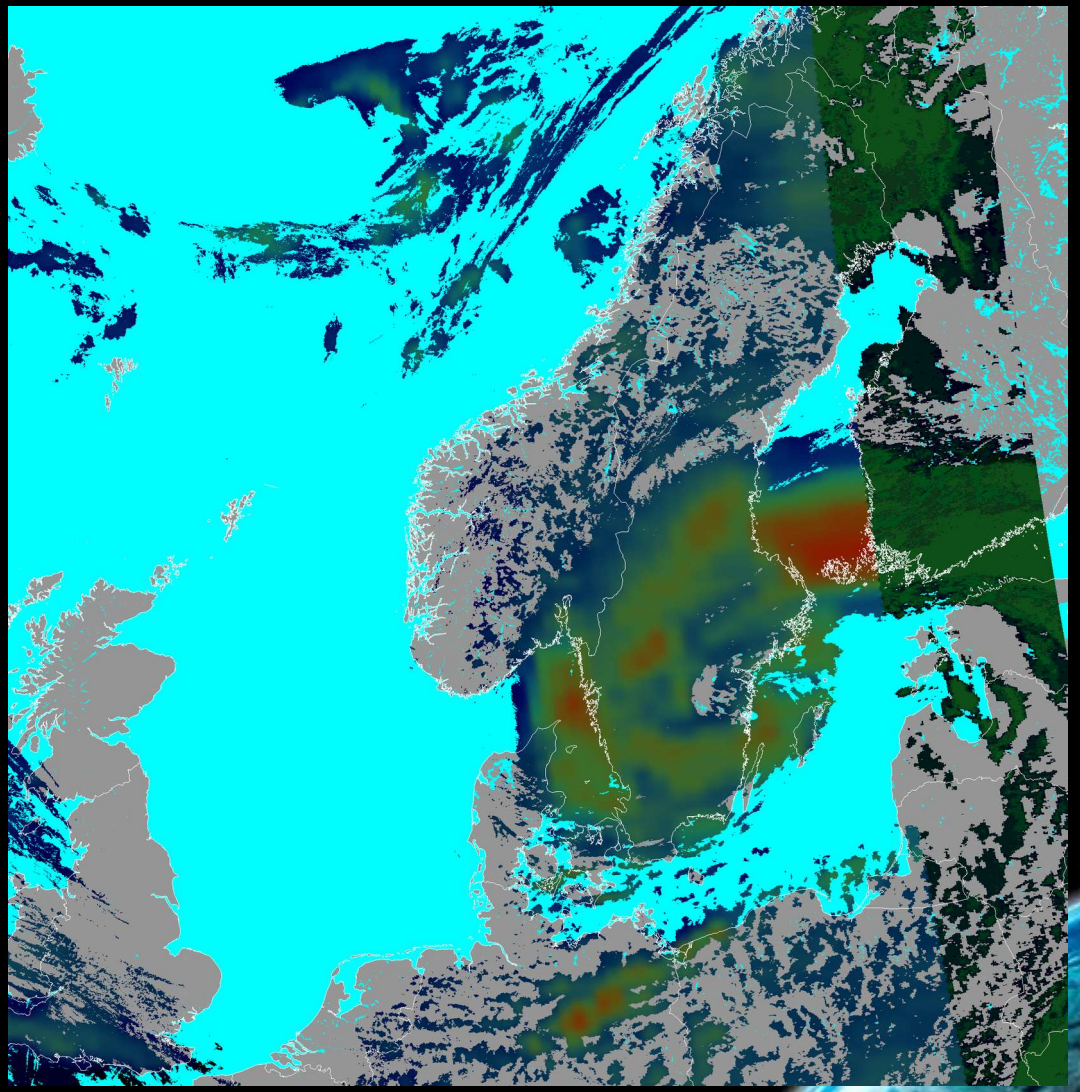
# Precipitating Clouds

- Light/chance of precip: 0.1mm/h – 0.5mm/h
- Moderate precip: >0.5mm/h – 5mm/h
- Heavy precip: >5mm/h



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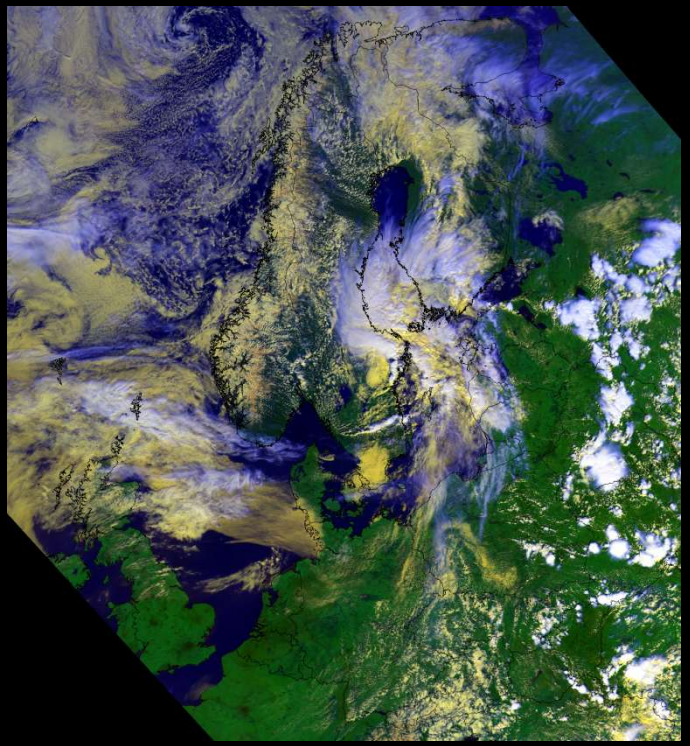
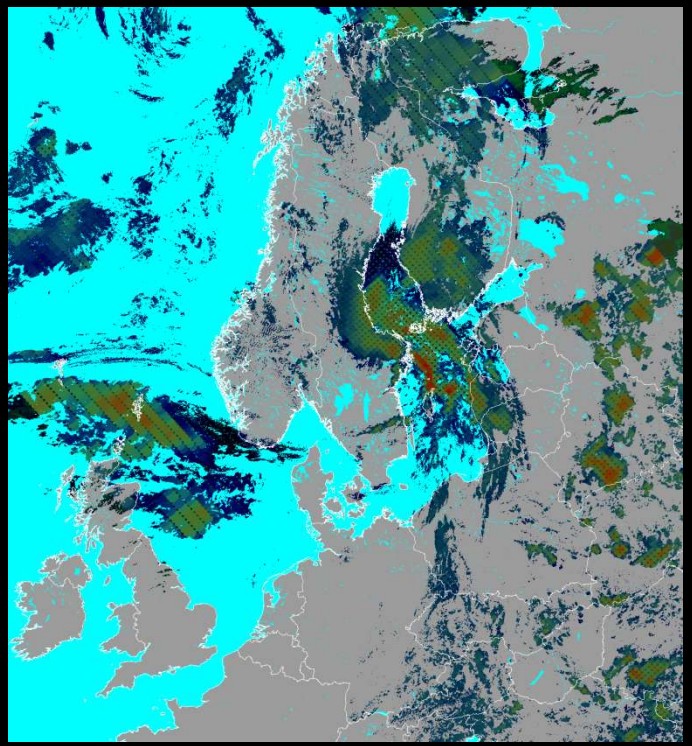
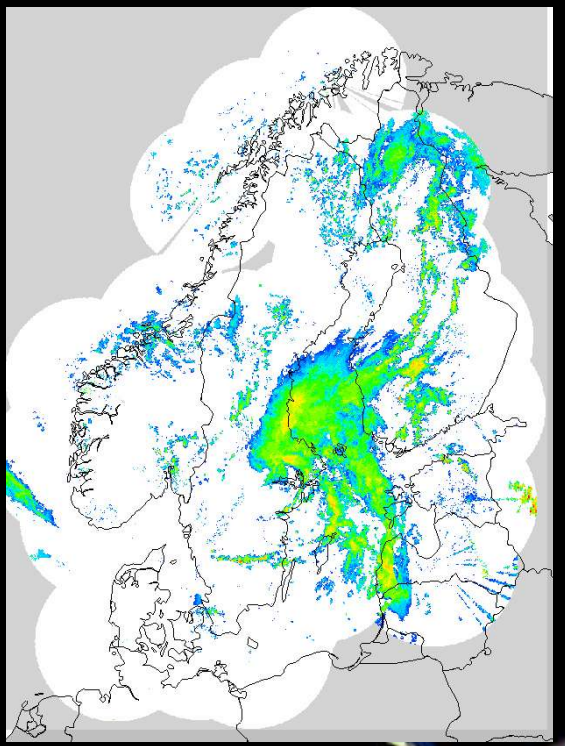
# Precipitating Clouds







# Precipitating Clouds

AMSU-B/MHS estimate of precipitation likelihood based on scattering signature

**SI=Tb89 - Tb150 – corrections(θ)**

For MHS (NOAA18… and METOP) the 157GHZ channel is corrected to simulate 150GHZ behaviour with help of RTM calculations. Correction factor applied: corr (Tb89,Tb183, θ)

Separate estimates over land and sea, in coastal areas blended estimate according to land/sea fraction

Likelihood of precipitation estimated in intensity classes is mapped to SI based on histograms of scattering index versus NORDRAD data.

Using AVHRR and NWCSAF Cloud type product to screen out non-precipitating areas (statistically verified with BALTRAD/NORDRAD data)

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# Cloud Physical Parameters

- Derived by KNMI
- A tool within CM SAF
- Main features:
  - Liquid Water Path (LWP)
  - Cloud Phase (CPH)

# Cloud Physical Parameters

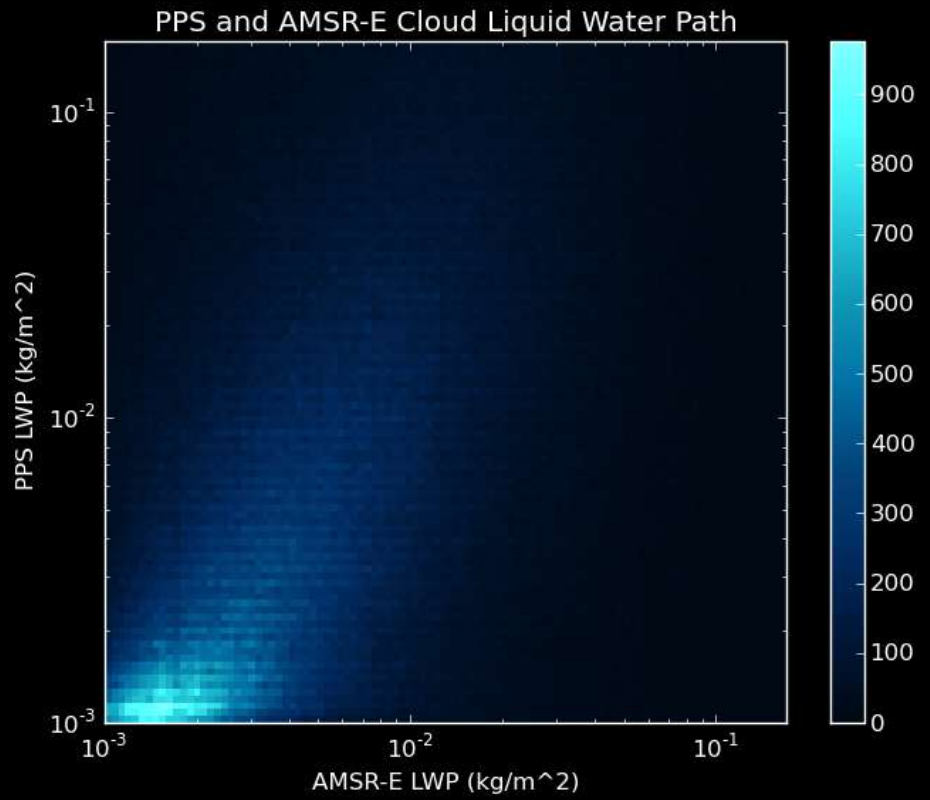
- Extensive use of RTM calculations (off line)
  - Doubling and Adding KNMI (DAK)
  - Simulating TOA radiances for varying optical thickness and particle size for water and ice clouds
- Surface reflectivity database
- LUT tables

# CPP validation

| Cloud Phase validation | |
|---|---|
| POD Liquid | 0.73 |
| POD Ice | 0.80 |
| FAR Liquid | 0.18 |
| FAR Ice | 0.30 |

CALIOP

## PPS LWP against AMSR-E over sea




RMS = 45.4 g/cm$^2$
BIAS = 3.4 g/cm$^2$

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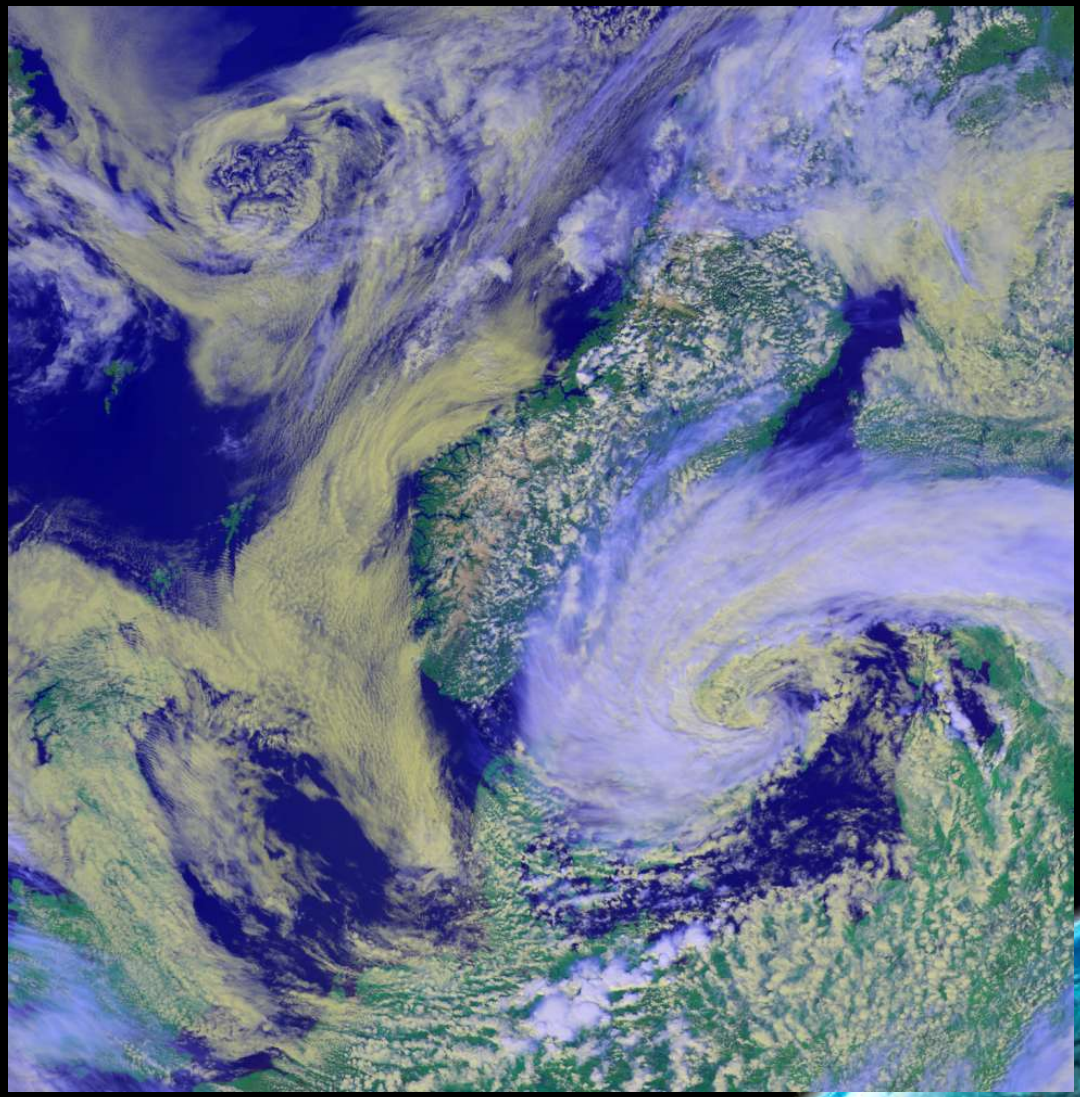
# Nowcasting

# Complement to Weather Radar

Midsummer storm

- June, 25 2012
- VIIRS
- 11:48 UTC



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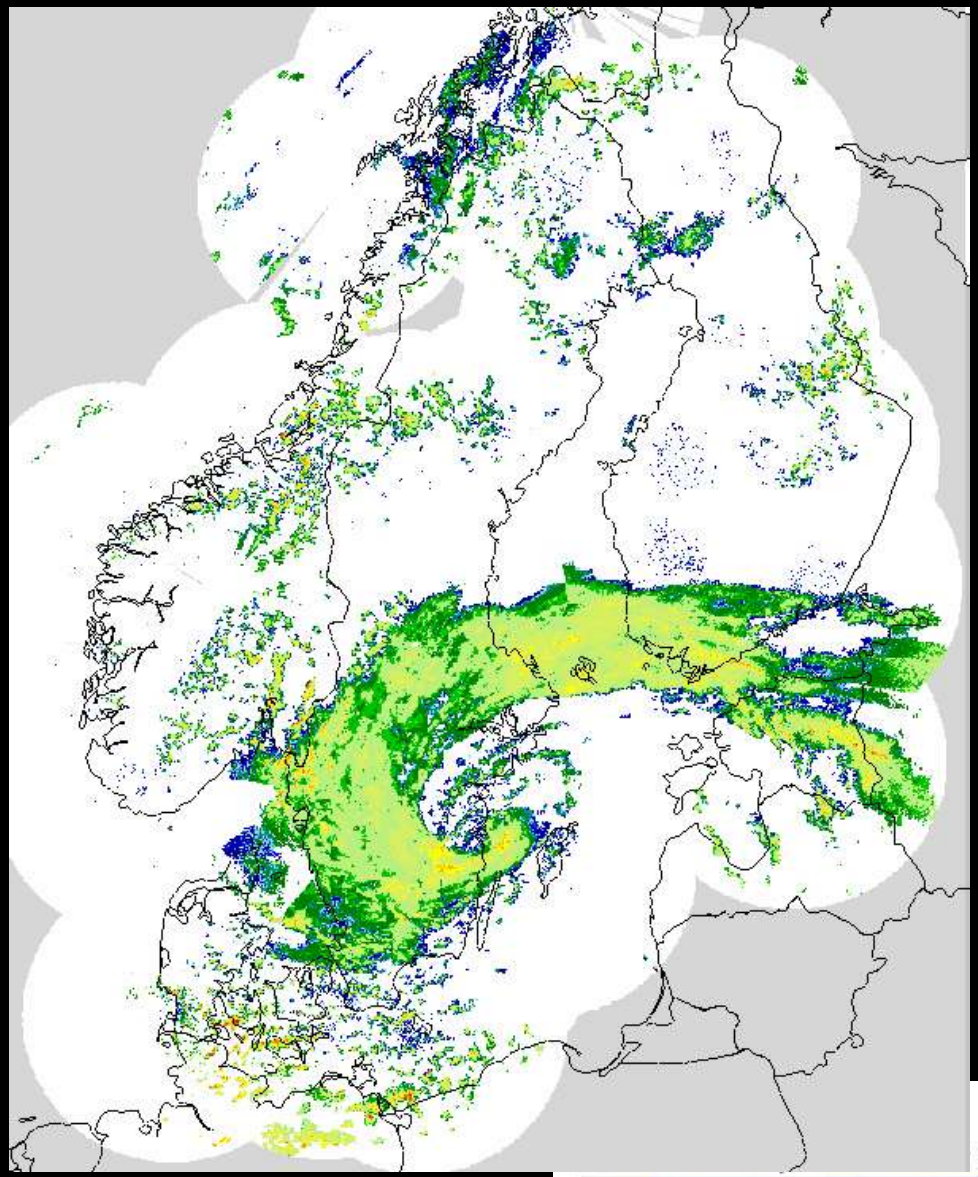
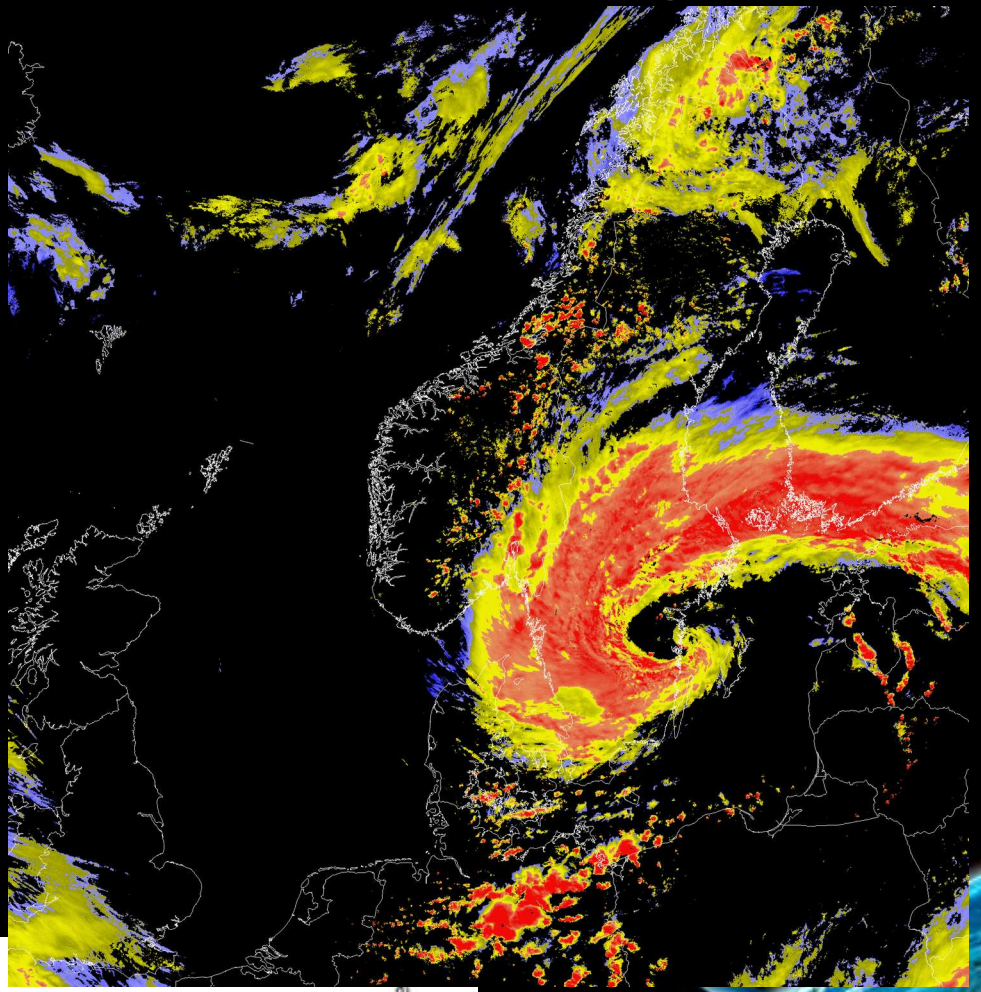
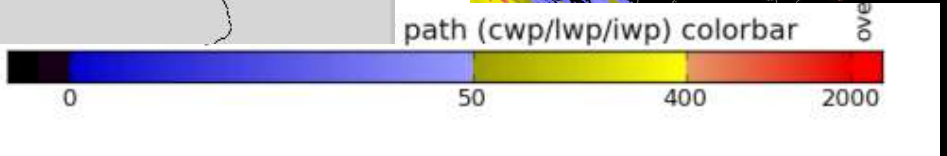
## Weather Radar



## Ice Water Path [kg/m2]





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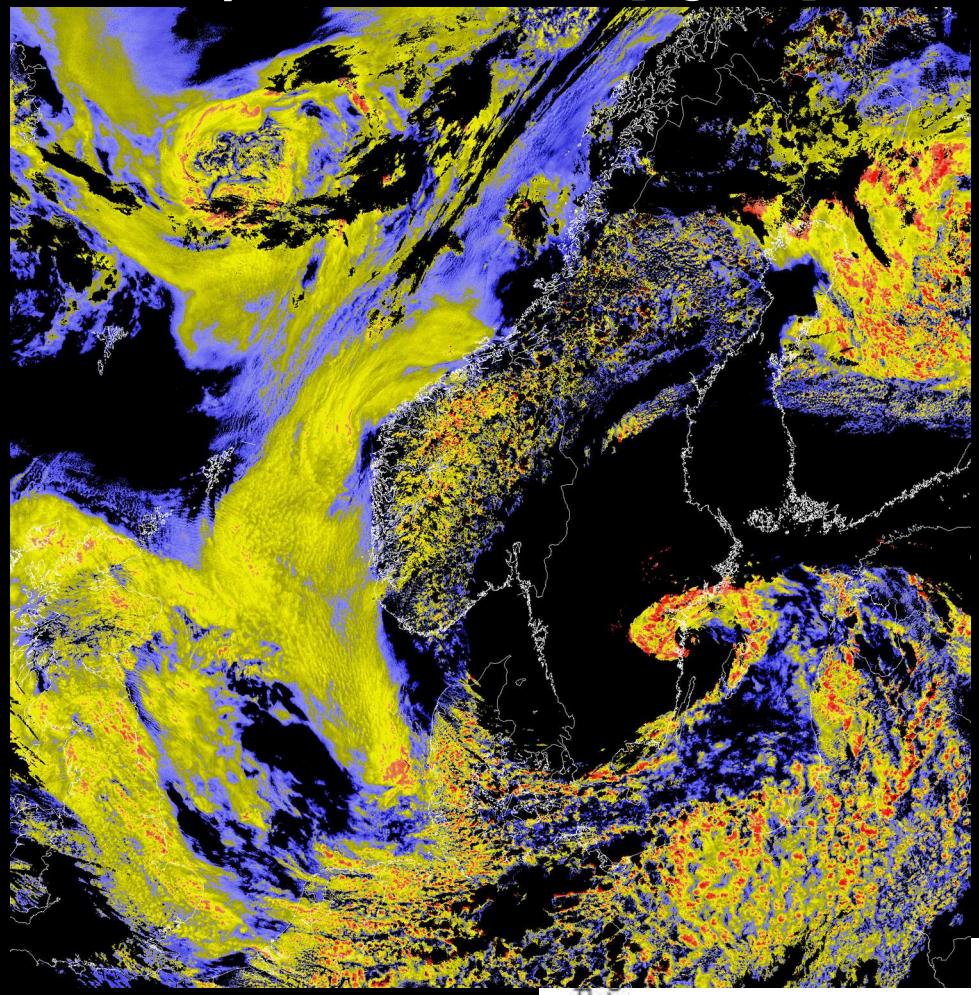
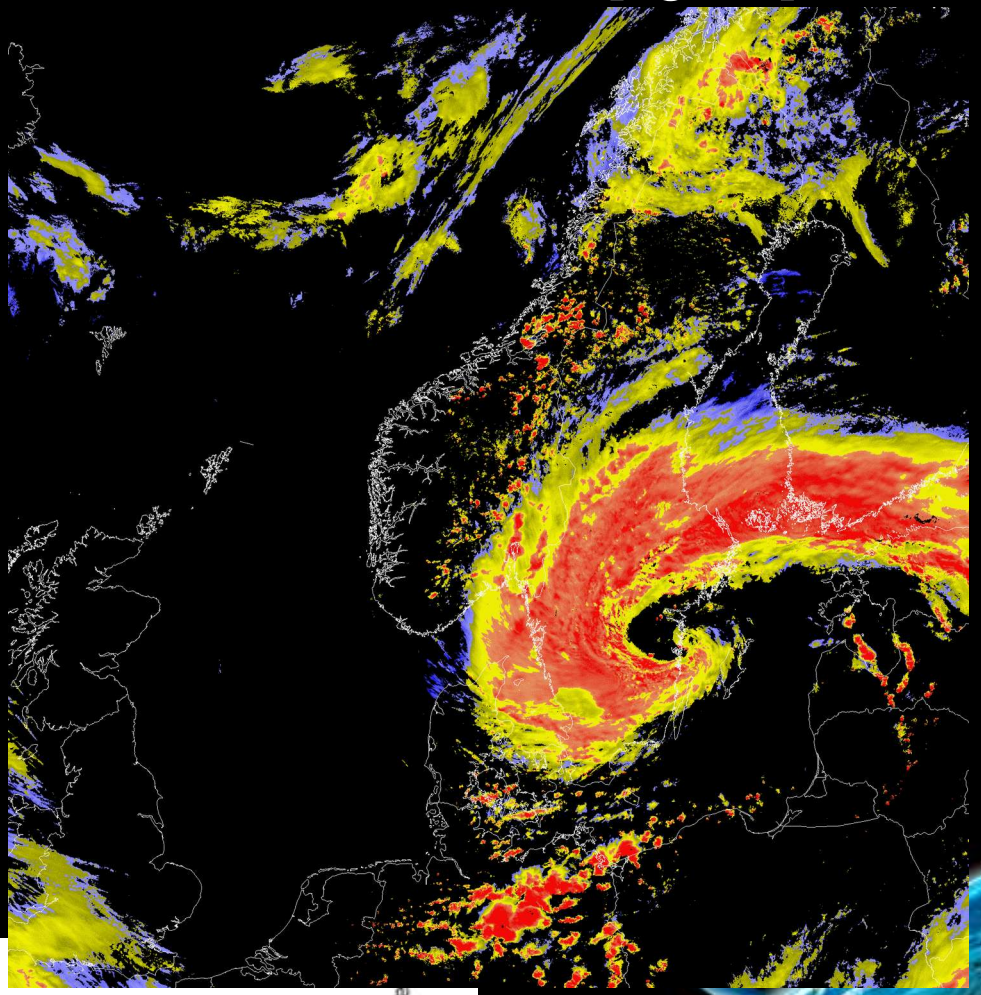
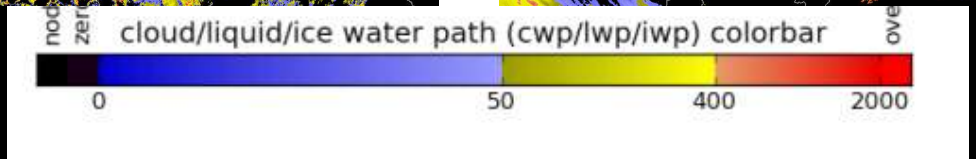
# CPP with VIIRS

## Liquid Water Path [kg/m2]



## Ice Water Path [kg/m2]





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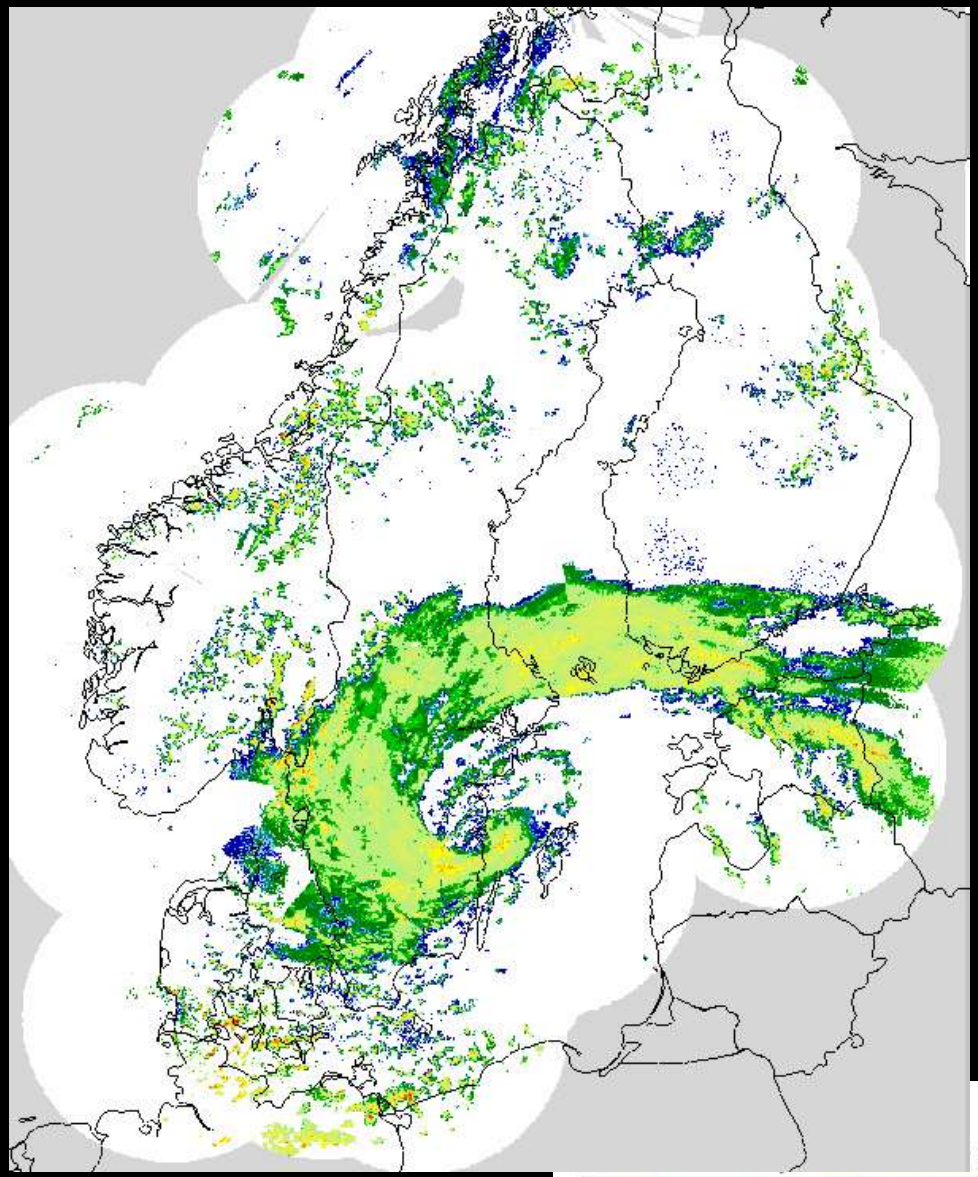
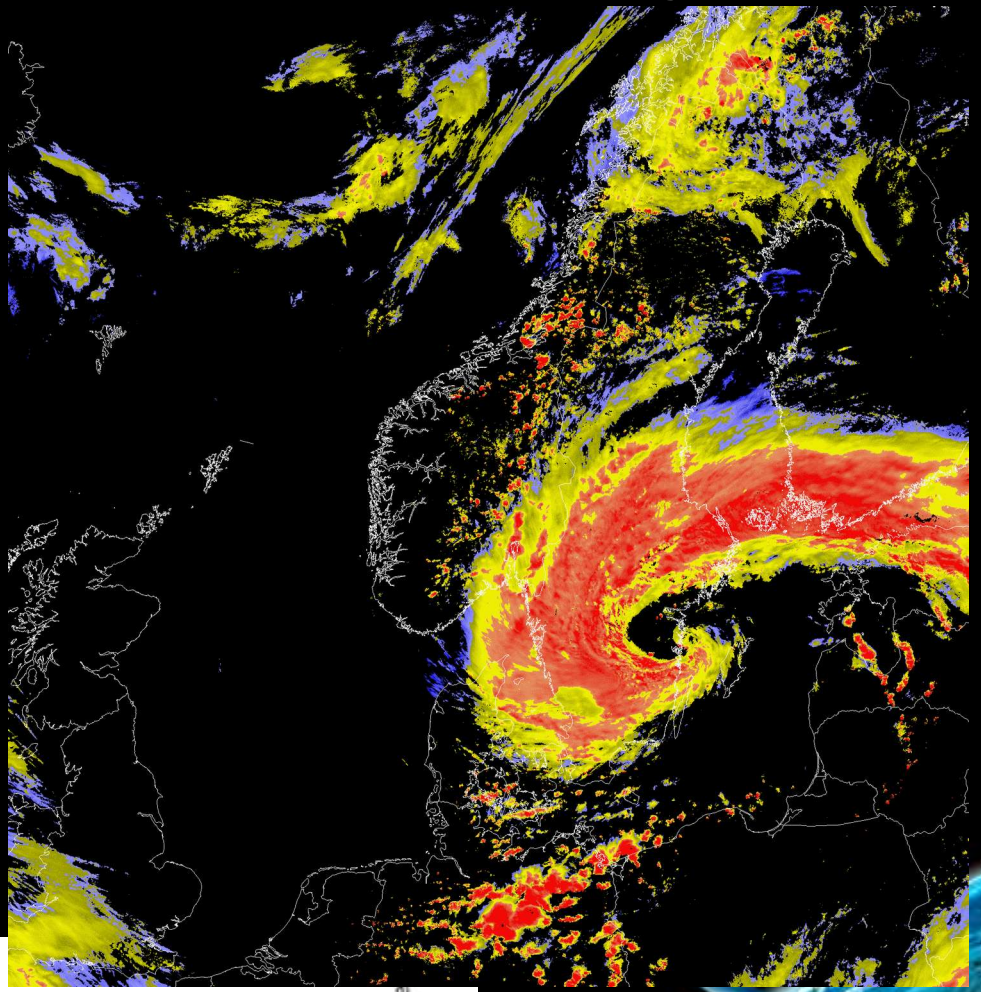
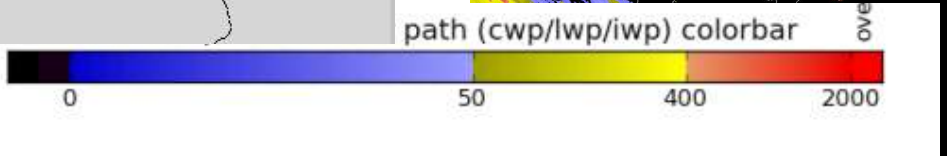
## Weather Radar



## Ice Water Path [kg/m2]



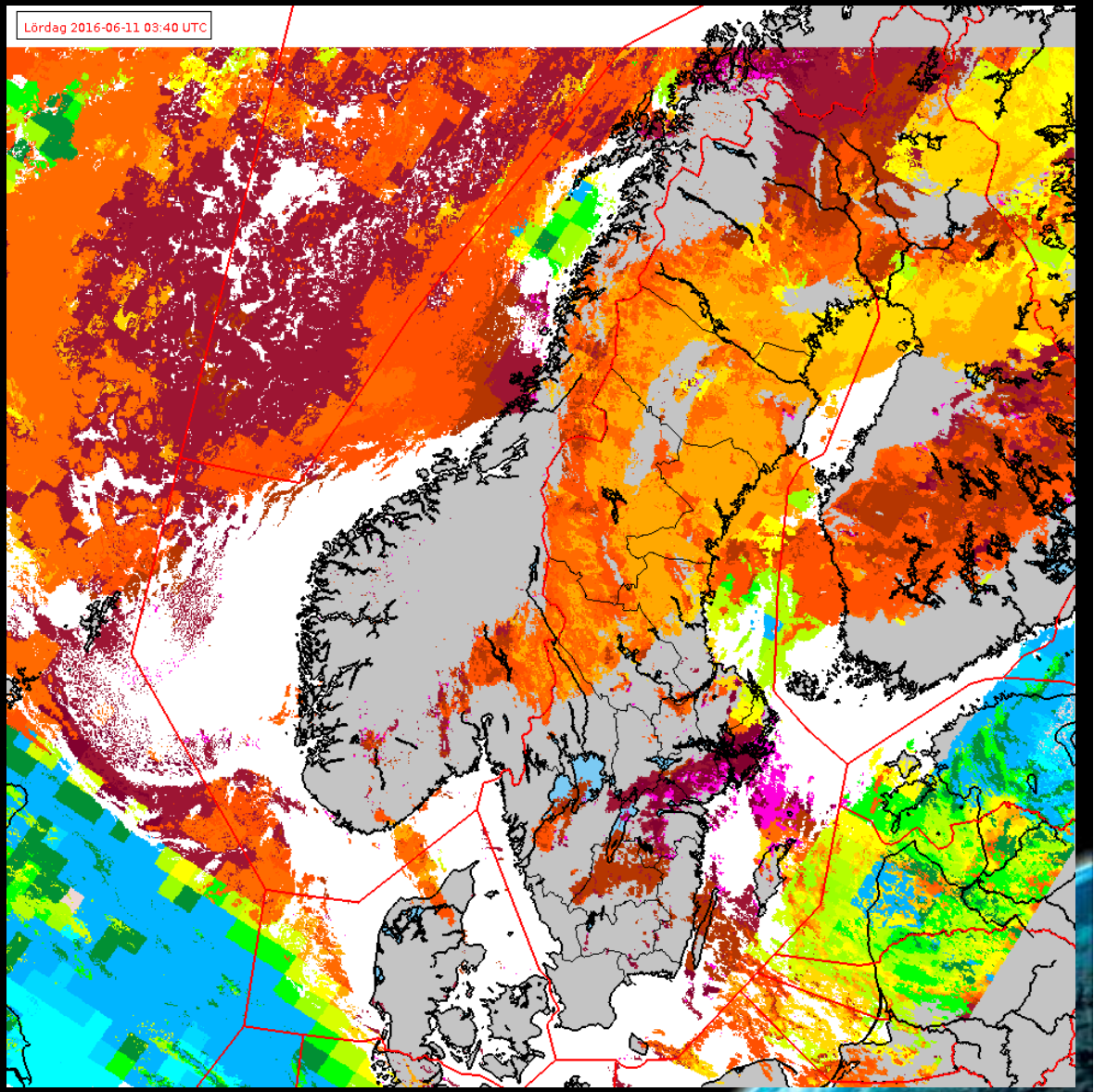


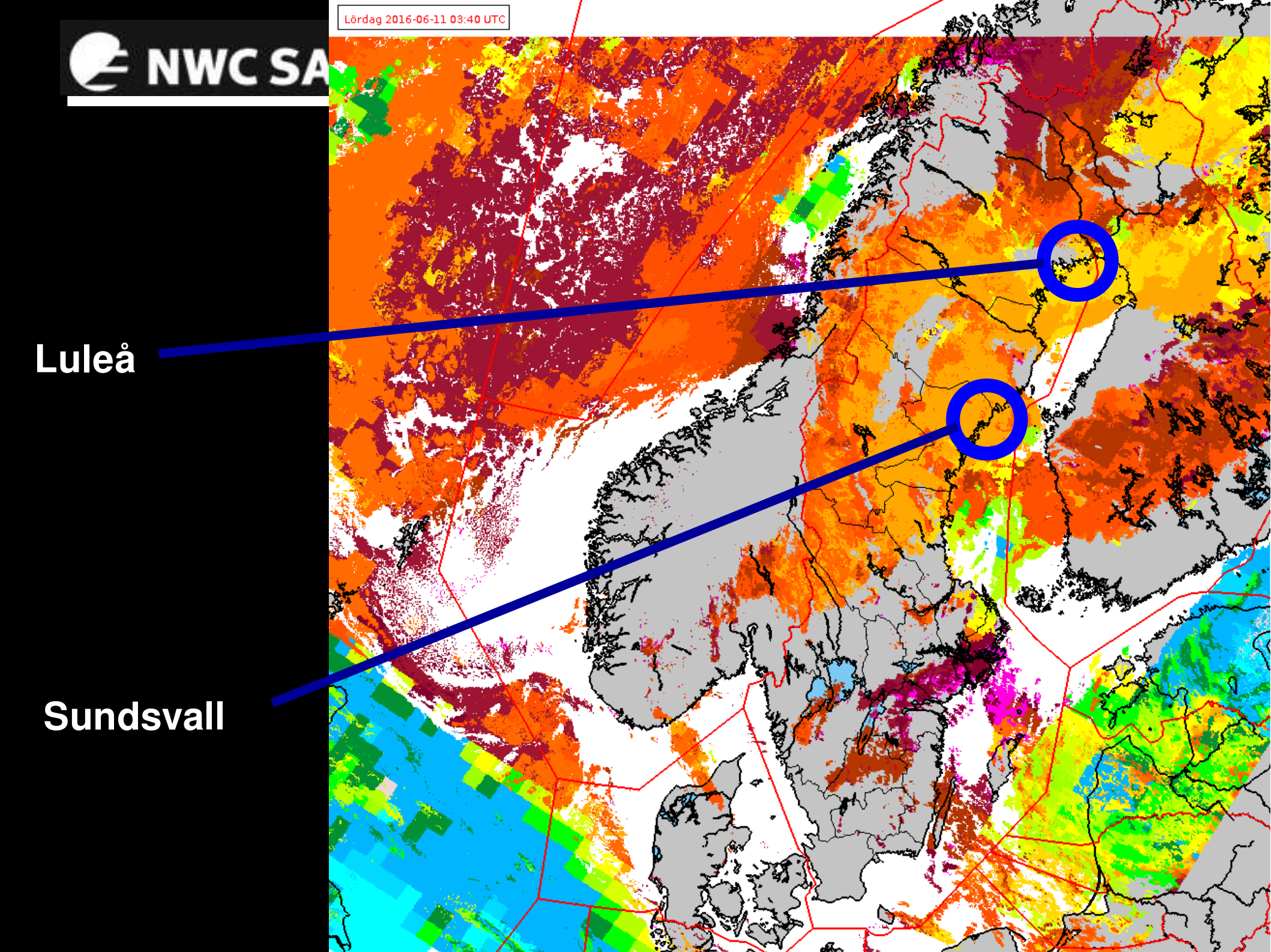
# Aviation applications

- Cloud height → CTH
- Icing conditions → CPH, CTT, $r_{eff}$

# Flight level analysis with CTTH

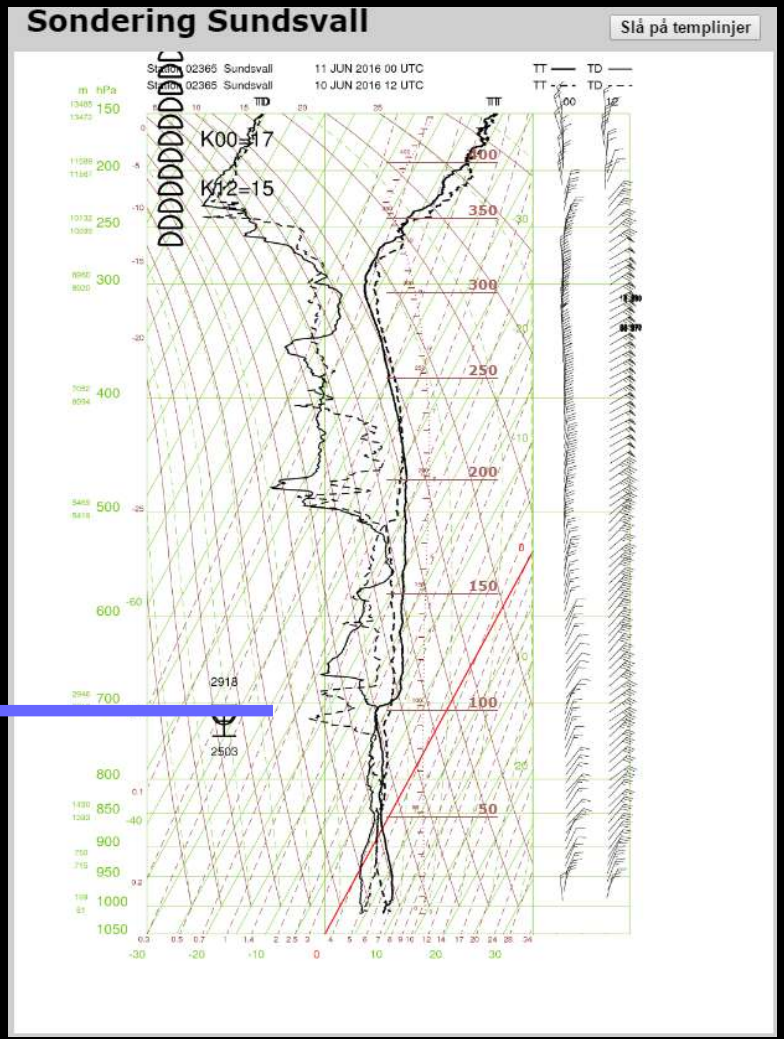
Cloud height from AVHRR comparing well with radiosonde data




NWC SA
Lördag 2016-06-11 03:40 UTC
Luleå
Sundsvall

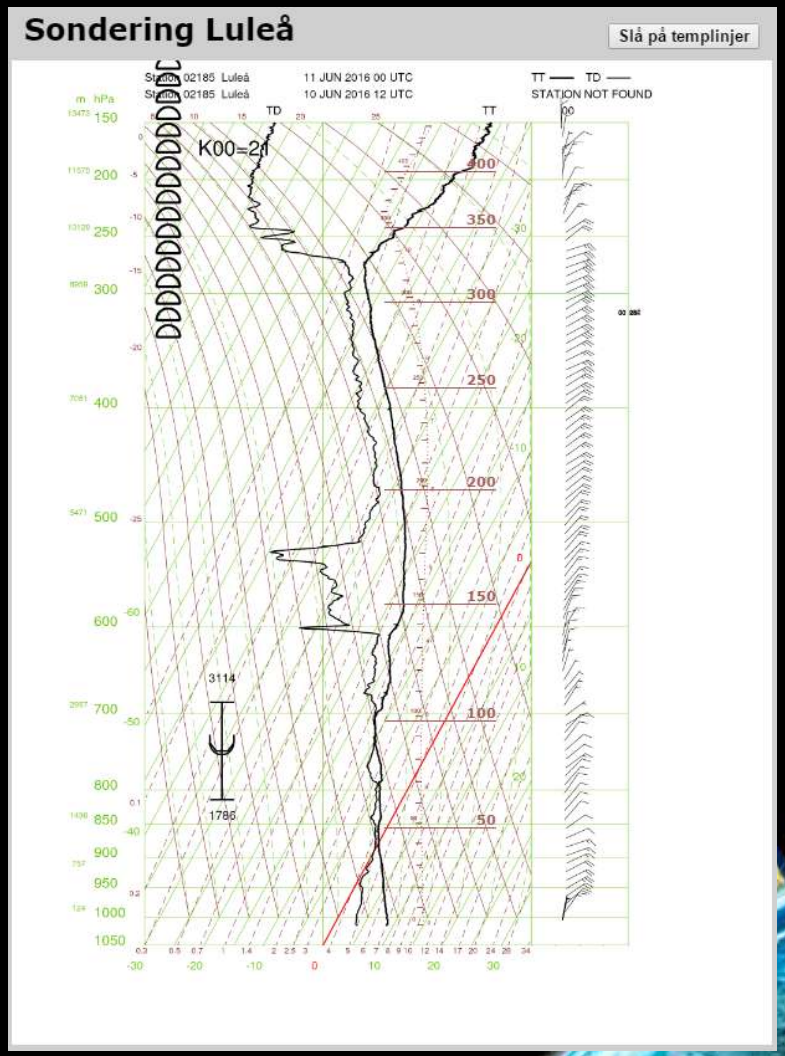
# Aviation applications

## Sundsvall




10,000 ft

## Luleå



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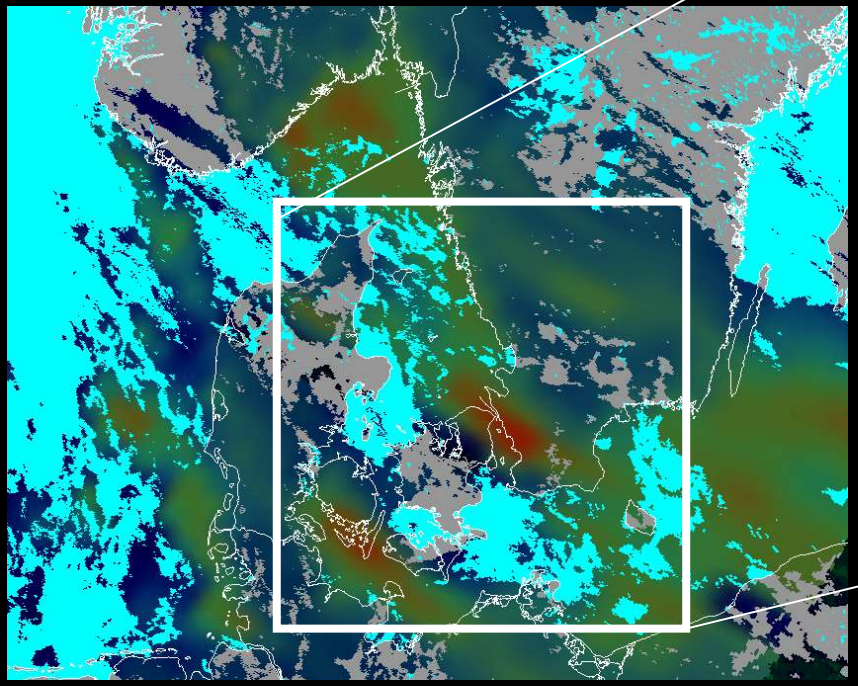
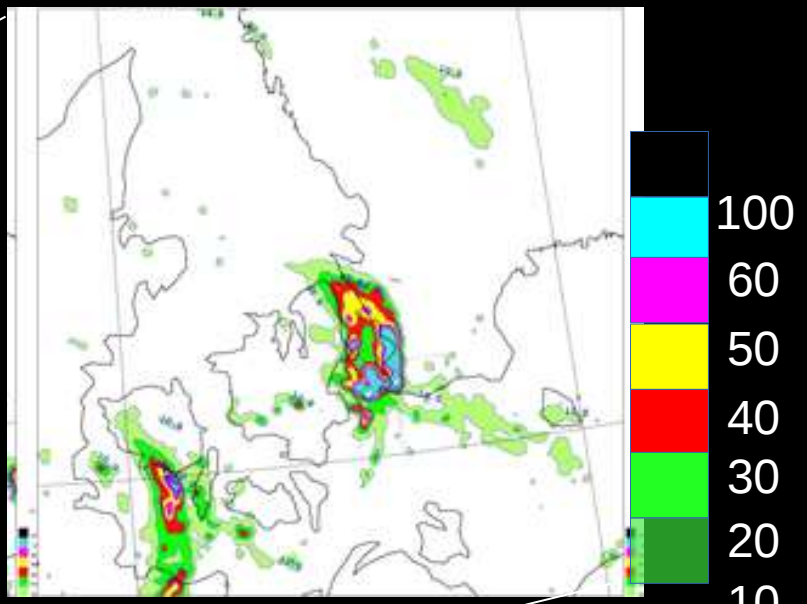
# ”Malmö” storm 2014-08-31, causing severe flooding in Malmö and Copenhagen of locally up to 100mm/12h

PC NOAA18 05:12Z






Radar

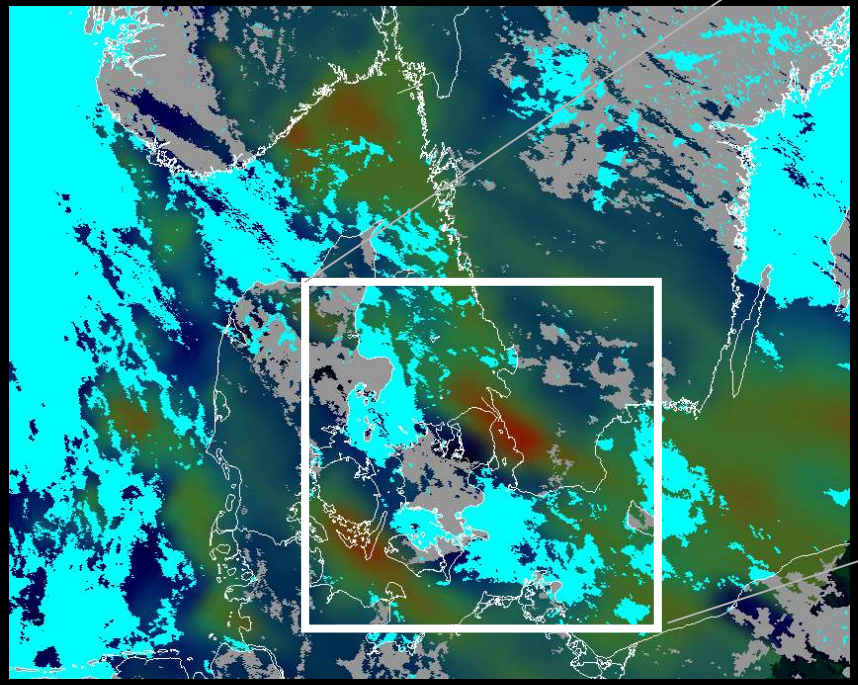
Accumulated precipitation
00Z – 12Z

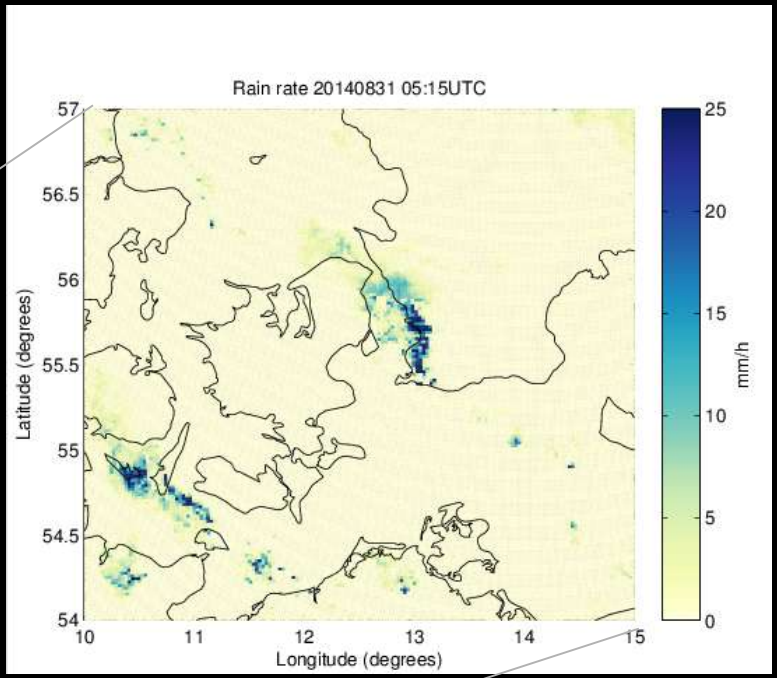
NWC SAF

SMHI

# ”Malmö” storm 2014-08-31, causing severe flooding in Malmö and Copenhagen of locally up to 100mm/12h

PC NOAA18 05:12Z






NORDRAD 05:15

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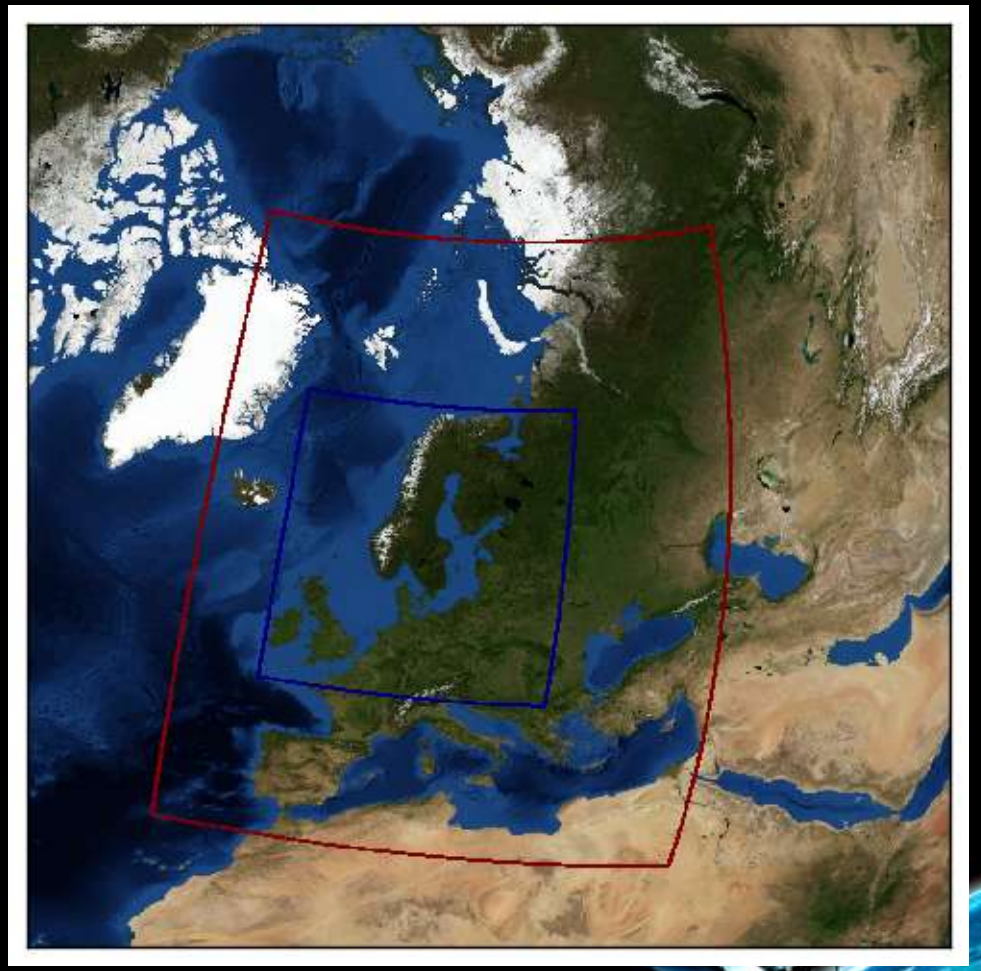
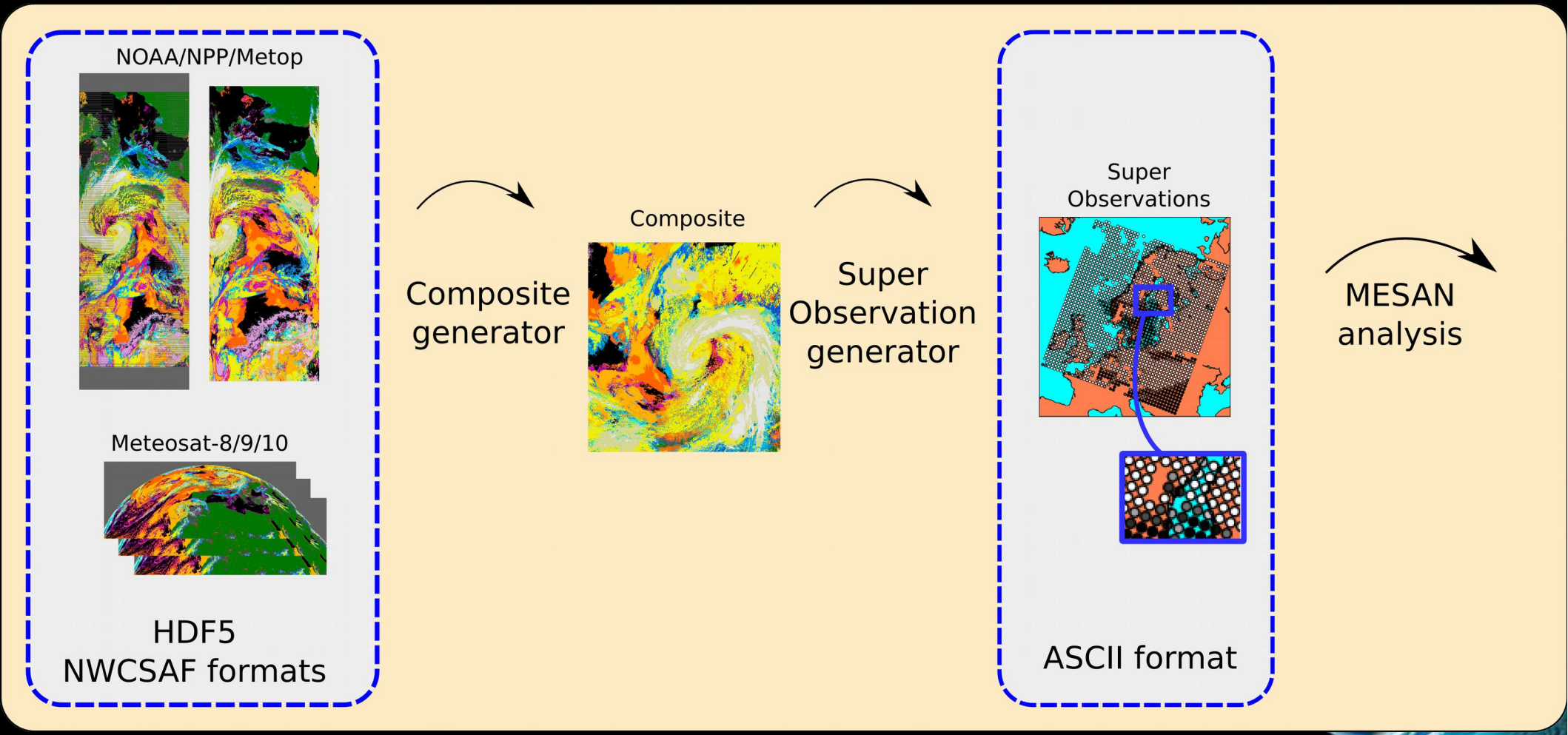
# MESAN - MESoscale ANalysis

- Resolution: 2.5*km every hour*
- Method: *Optimal Interpolation*
- Data:
  - *NWP first guess*
  - *Satellite and Radar*
  - *Synop, Climate, Metar, etc*
  - *Physiographic fields*



# Composite and SuperObs generation



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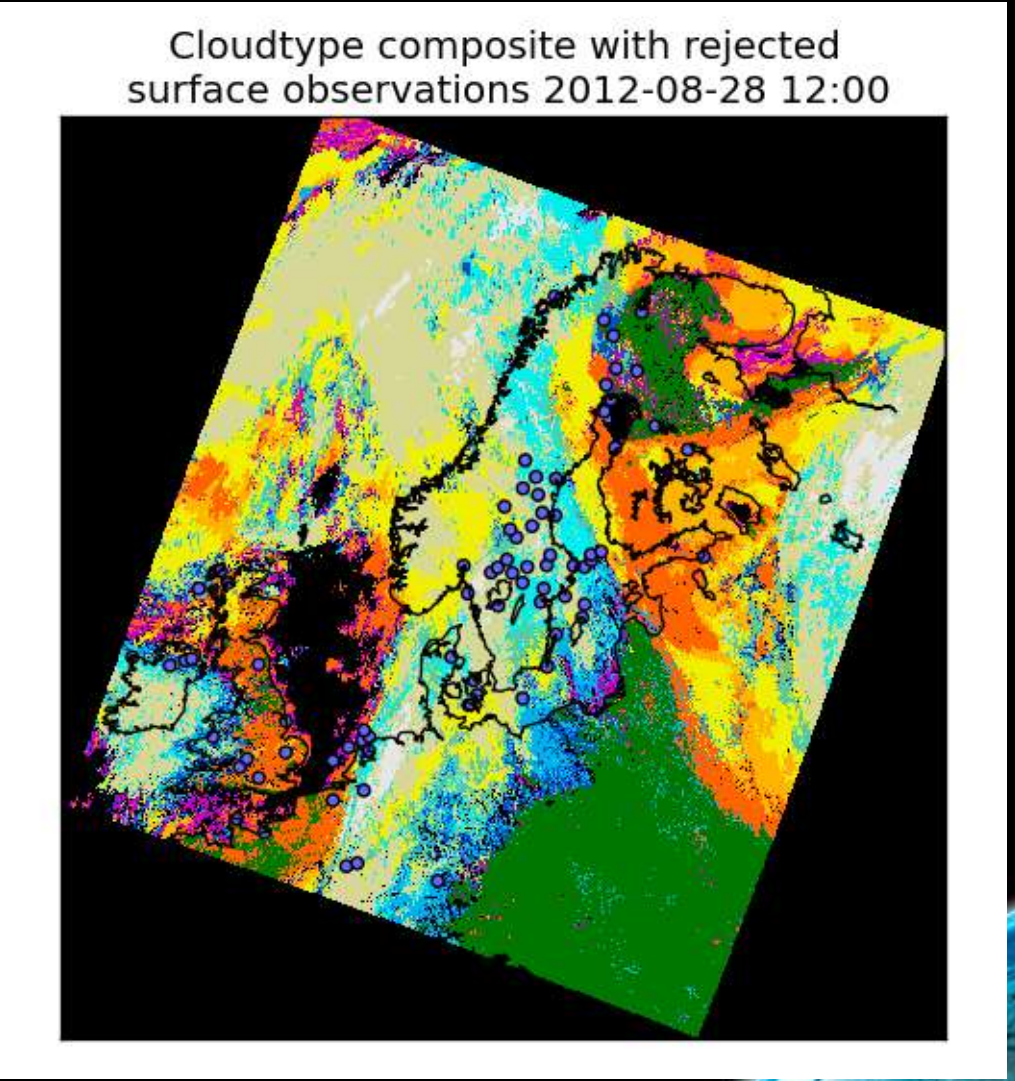
# Positive impact using Satellite data

Example:

- Blue dots: cloudfree reports from automatic stations have been rejected – satellite obs show high clouds with high confidence



# Running PPS locally

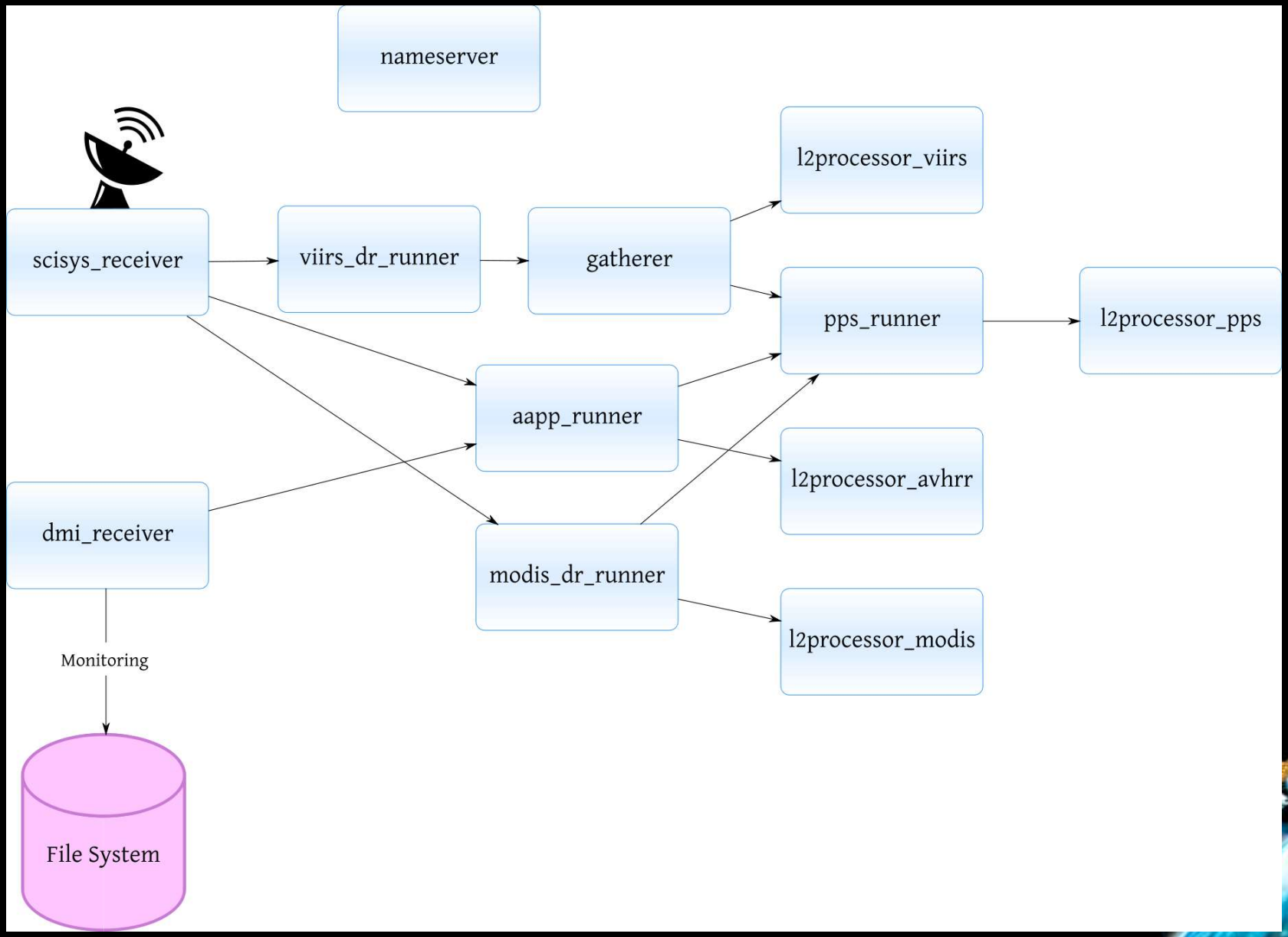
# The setup at SMHI

- Using messages to trigger processing
- Pytroll
- Supervisor

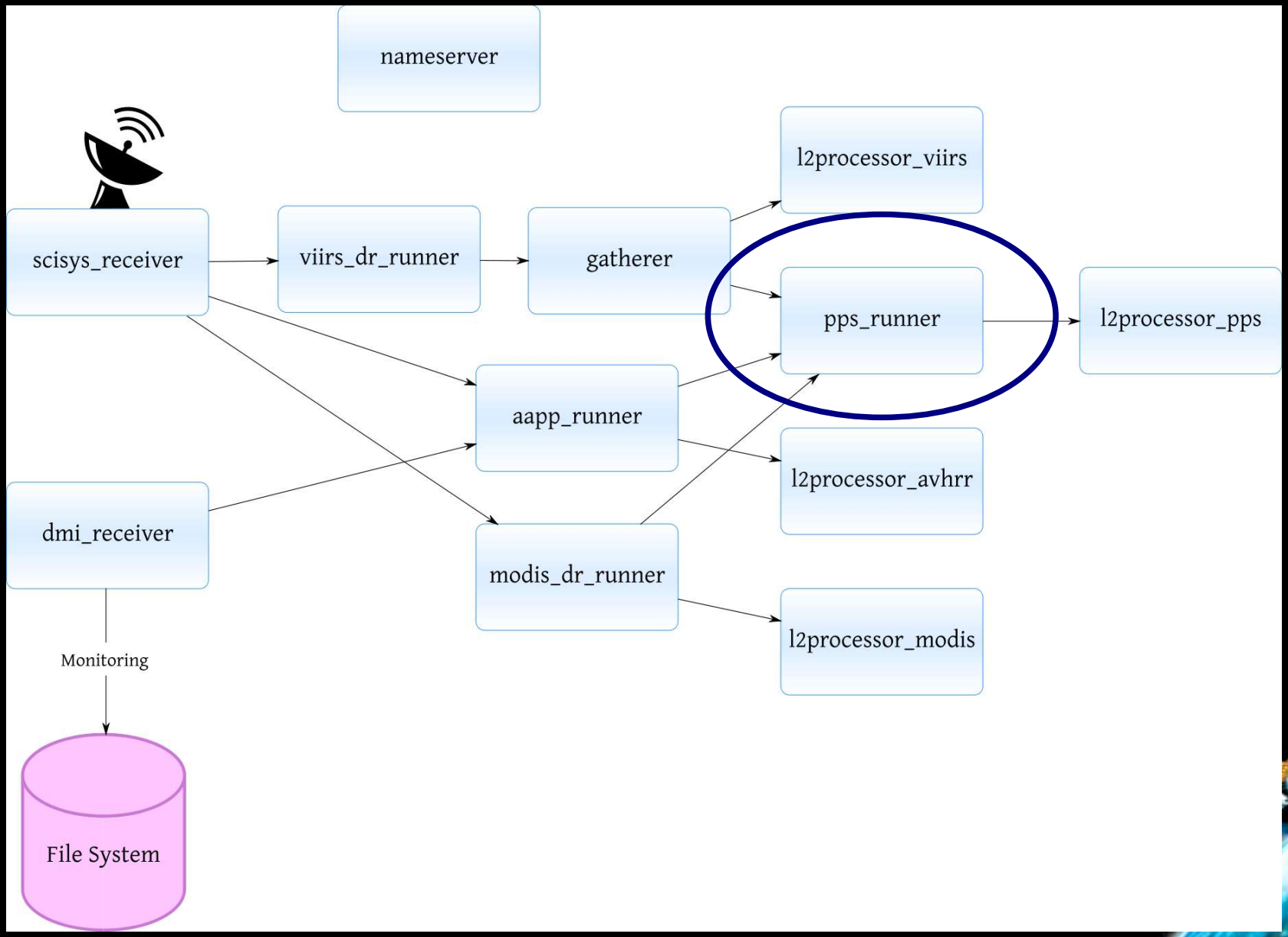
PyTROLL http://pytroll.org/

Supervisor: http://supervisord.org/

# The SMHI setup



# The SMHI setup



# The SMHI setup

## Supervisor status

Page refreshed at Tue Feb 24 08:34:03 2015

REFRESH | RESTART ALL | STOP ALL

| State | Description | Name | Action |
|---|---|---|---|
| running | pid 32416, uptime 4 days, 2:04:45 | aapp_runner | Restart Stop Clear Log Tail -f |
| running | pid 2868, uptime 11 days, 22:22:04 | crashmailbatch | Restart Stop Clear Log Tail -f |
| running | pid 2870, uptime 11 days, 22:22:04 | dmi_receiver | Restart Stop Clear Log Tail -f |
| running | pid 2869, uptime 11 days, 22:22:04 | fatalmailbatch | Restart Stop Clear Log Tail -f |
| running | pid 2881, uptime 11 days, 22:22:04 | gatherer | Restart Stop Clear Log Tail -f |
| running | pid 29207, uptime 19:10:26 | l2processor_avhrr | Restart Stop Clear Log Tail -f |
| running | pid 29256, uptime 19:10:10 | l2processor_modis | Restart Stop Clear Log Tail -f |
| running | pid 29296, uptime 19:09:57 | l2processor_pps | Restart Stop Clear Log Tail -f |
| running | pid 29338, uptime 19:09:45 | l2processor_viirs | Restart Stop Clear Log Tail -f |
| running | pid 2875, uptime 11 days, 22:22:04 | modis_dr_runner | Restart Stop Clear Log Tail -f |
| running | pid 2872, uptime 11 days, 22:22:04 | nameserver | Restart Stop Clear Log Tail -f |
| running | pid 7092, uptime 11 days, 20:51:23 | pps_runner | Restart Stop Clear Log Tail -f |
| running | pid 2871, uptime 11 days, 22:22:04 | scisys_receiver | Restart Stop Clear Log Tail -f |
| running | pid 26750, uptime 4 days, 2:47:16 | viirs_dr_runner | Restart Stop Clear Log Tail -f |

Supervisor

NWC SAF

SMHI

# Supervisor status

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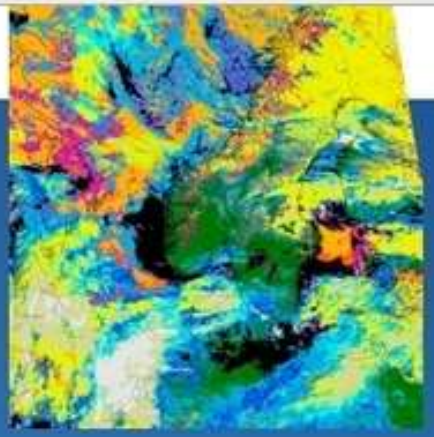
SMHI NWC SAF



**Home**
NWC SAF Help Desk
Contact

**About...**



EUMETSAT

NWC SAF

SMHI

The EUMETSAT Network of Satellite Application Facilities

NWC SAF
Support to Nowcasting and Very Short Range Forecasting

**THE SMHI REMOTE SENSING RESEARCH GROUP is involved in the Nowcasting Satellite Application Facilities (NWC SAF) initiated by EUMETSAT. The NWC SAF derive and develop products for nowcasting and very short range forecasting.**

The general objective of the NWC SAF is to provide operational services to ensure the optimum use of meteorological data in nowcasting and very short range forecasting. At SMHI we are responsible for the development and maintenance of the Polar Platform System package (the PPS-package) to process the products from data gathered from NOAA and Metop satellites.

**The NWC SAF products**

The NWC SAF products consist of four cloud and one precipitation product:

- Cloud Mask (CM)
- Cloud Type (CT)
- Cloud Top Temperature & Height (CTTH)
- Precipitation Clouds (PC)
- Cloud Physical Properties (CPP)

SMHI-SAF Local Recepti...

nwcsaf.smhi.se/LocalReception.php?time=npp

Google

**About...**

What are we doing?
Cloud Products
**Product Demonstration**
Real time monitoring
EARS-NWC monitoring
Software
Validation
Documentation
News
Release history
Consortium

EUMETSAT

NWC SAF

# Local Reception

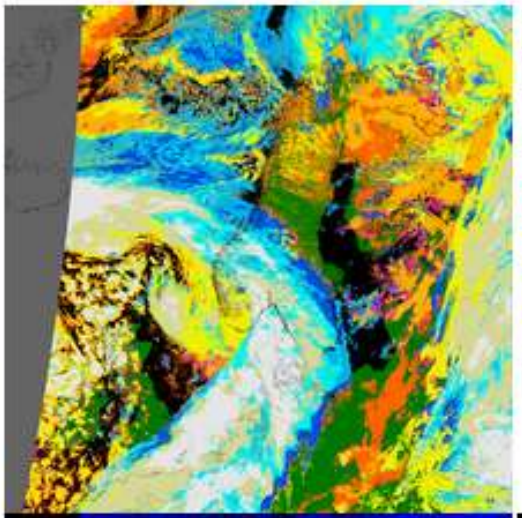
**REFERENCE VERSIONS of the four NWCSAF/PPS products are generated on a routine basis. Check the latest cloud nproducts in near real time:**

Cloud Type

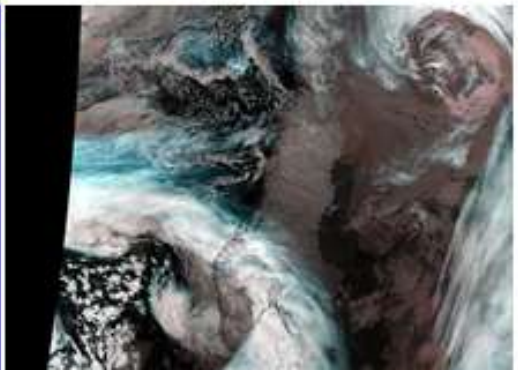
Northern Europe, 1km/px

npp_20150223_0123_17218

< < Previous Next>>



Cloud free
Cloud free
Snow
Snow/Ice
Very low
Low
Medium level
High
Very high
Very thin cirrus
Thin cirrus
Thick cirrus
Cirrus above
Fractional
Unclassified
Unprocessed



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# Summary & Outlook

# Outlook:

- v2018 (Q4)
  - Retrieval improvements
  - netCDF only
  - Continued focus to ease user site installations
    - Better encapsulation, e.g. Docker

# Outlook:

- New sensors:
  - MERSI-2 (FY3-D/E/F)
  - VII and MWI/ICI on EPS-SG
    - Current precipitation product development frozen. Instead prepare for precipitation, IWP and LWP products for release in CDOP4 (2023 TBC) based on MWI/ICI

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# Next cloudmask version (v2018)

- Additional probabilistic output (CM SAF)
- VIIRS-I bands
- Improve flag for heavy aerosol loads (dust, volcanic ash and smoke)
- Preparing for MERSI-2 - Prototyping with MODIS
- Use of 1.38 for improved thin cirrus detection
- OSISAF/GHRSST SST

# CTTH improvements for v2018

- Various activities improving cloud height
  - Emphasis on height assignment on low/mid level clouds
  - Machine learning
  - Improved uncertainty estimates

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## Summary

- PPS is a DR package providing cloud and precipitation parameters in near real time
- It is free and available for anyone
- A subset of PPS products are available in near-real time on EARS
- Products can be read and remapped by PyTROLL

http://www.nwcsaf.org

NWC SAF

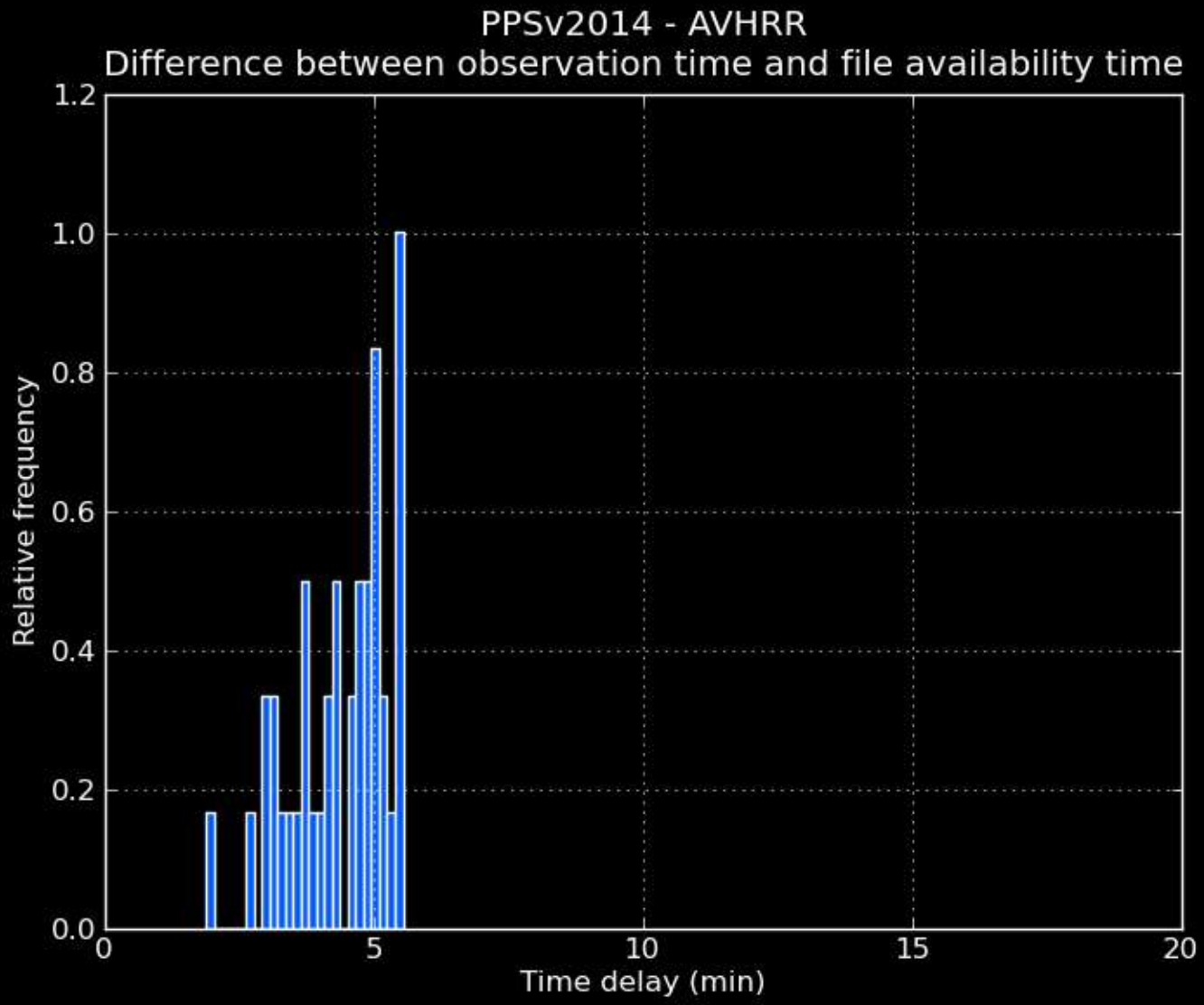
SMHI

# Thank you!

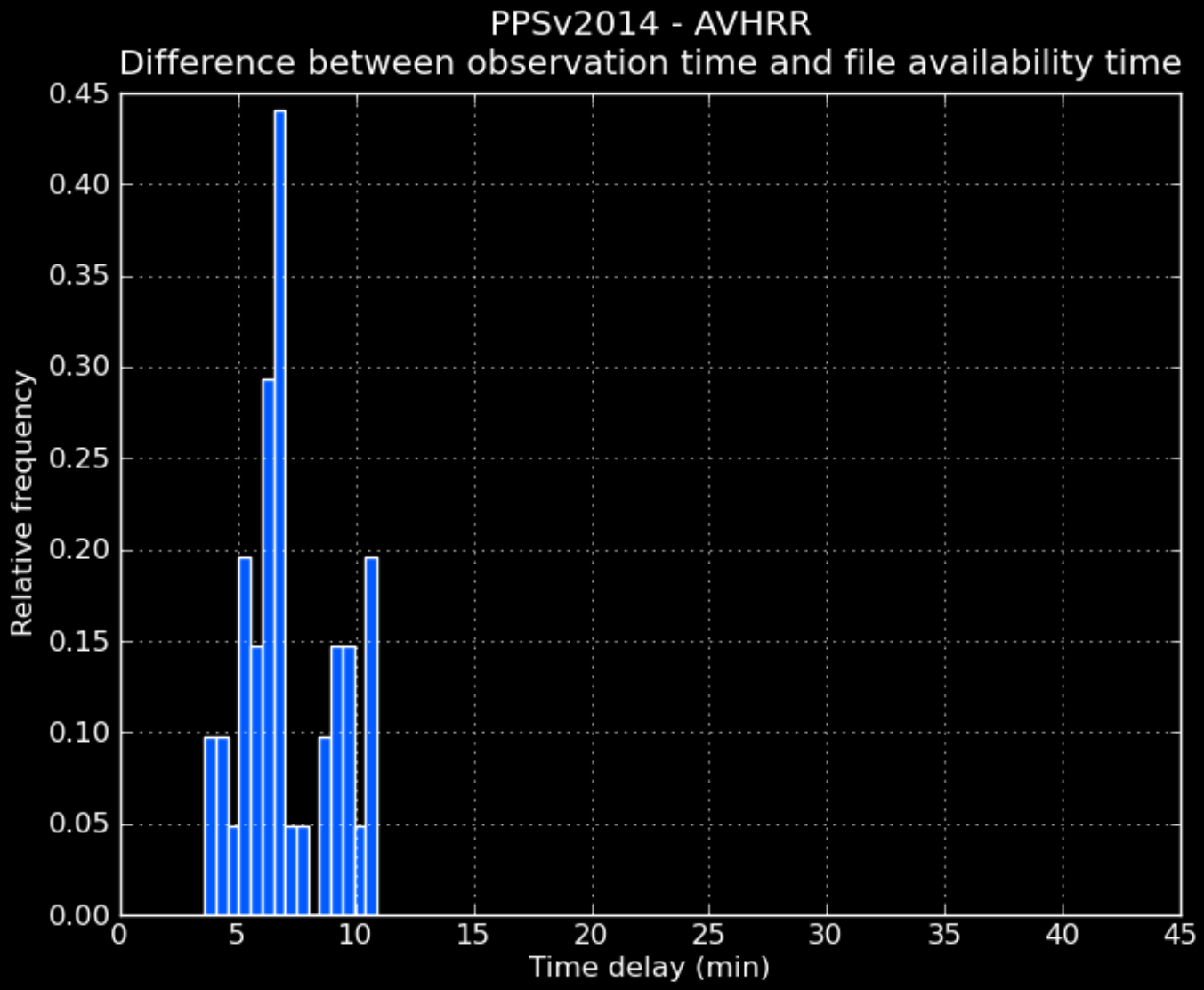
http://www.nwcsaf.org
http://nwcsaf.smhi.se
http://pytroll.org

# Performance - AVHRR

Cloud Mask

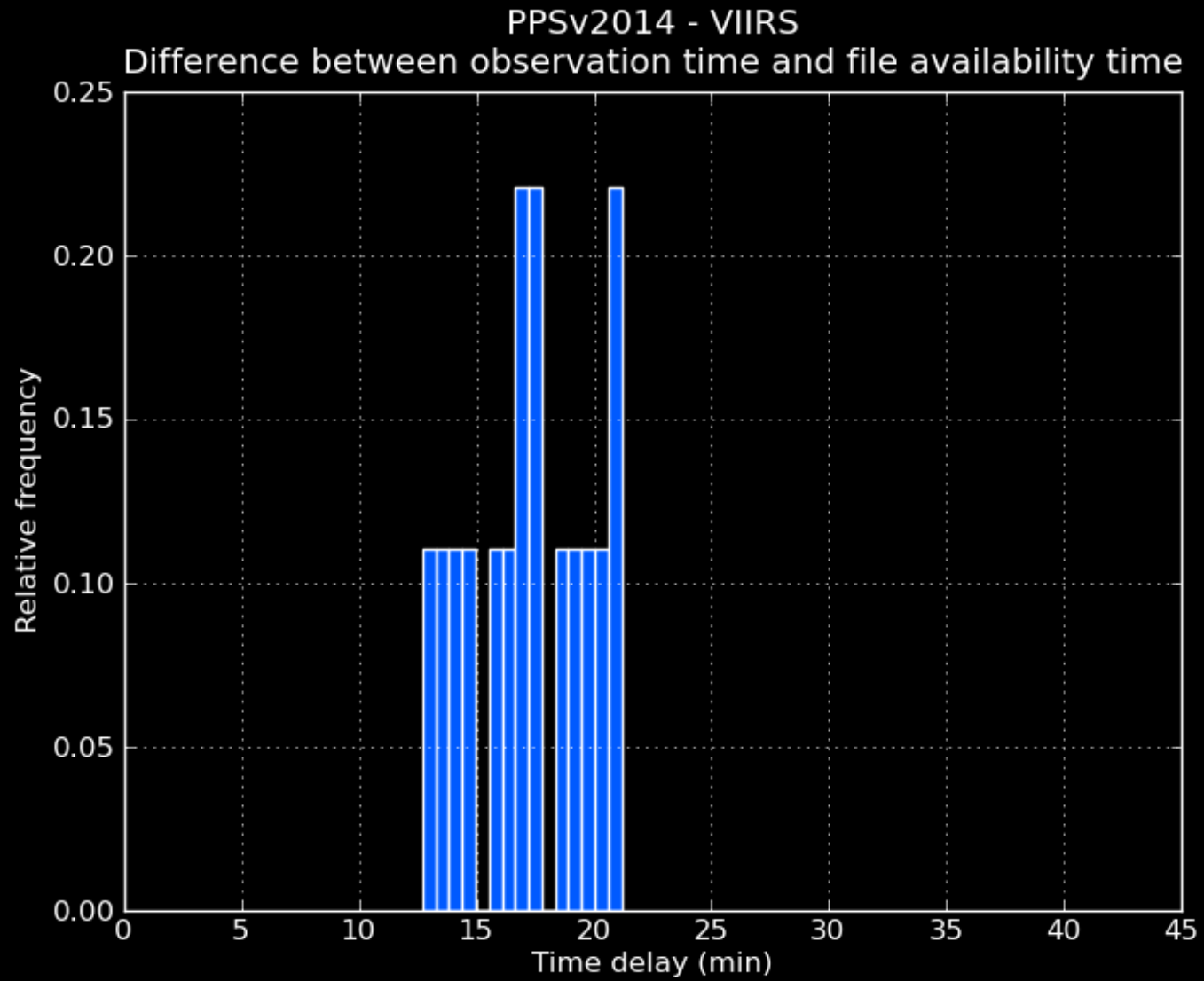


# Performance - AVHRR




CPP

# Performance - VIIRS




Cloud Mask

# Performance - VIIRS

CPP