Institute of Meteorology and Water Management
National Research Institute

Deep convection processes analysed by MSG Optimal Cloud Analysis (OCA) products

Piotr Struzik, Monika Pajek

IMWM-NRI – Poland, Kraków
Satellite Remote Sensing Department

POGODYNKA PL

Presentation outline:

- Optimal Cloud Analysis (OCA) Product – overview.
- Components of OCA in deep convective clouds analysis.
- Limitations of OCA product – analysis of two storm seasons.
- Nighttime – nightmare !
- RGB from OCA subproducts ?
- Conclusions.

OCA Product overview

Inputs:

- Reflectances from the SEVIRI Level 1.5 image data for the VIS0.6 µm, the VIS0.8 µm and the VIS1.6 µm channels;
- Radiances from the SEVIRI Level 1.5 image data for these channels: IR3.9 µm, IR6.2 µm, IR7.3 µm, IR8.7 µm, IR9.6 µm, IR10.8 µm, IR12.0 µm and IR13.4 µm. ***Note: The IR3.9 µm and the IR12.0 µm channels are currently used only passively.***
- Future: Radiances from the SEVIRI Level 1.5 image data for the IR3.9 µm and IR9.6 µm channels to be made active;
- Auxiliary input: ECMWF forecast, CIMSS IR land emissivity, CRM (surface reflectance maps), CLM (cloud mask product),

Outputs:

- Cloud Top Pressure (CTP).
- Cloud Optical Thickness (COT),
- Cloud Particle Size – Effective Radius (CER),
- additional information: ice cloud / water cloud/ 2 cloud layers.

If exist upper layer and is transparent, additional information about the lower layer:

- Cloud Top Pressure (CTP),
- Cloud Optical Thickness (COT),

OCA Product overview

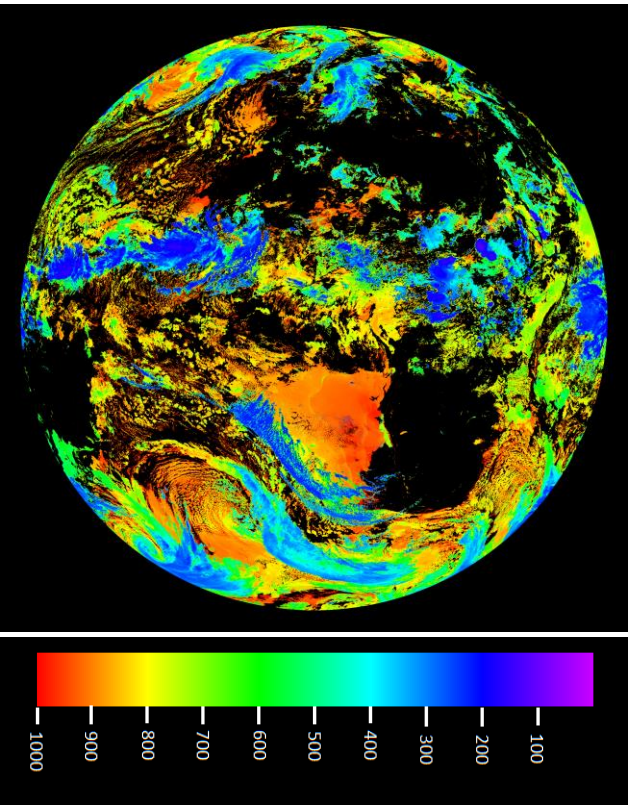
- **Global coverage, SEVIRI grid,**
- **Distrubuted via EUMETCast since Aug. 2013 in GRIB format with 1 hour time step,**
- **actual status „operational”**
- **Since 08.10.2015 (morning) - 15 min products available at Eumetsat Data Centre but not distributed operationally !**

Please note the difference between MODIS OCA product and SEVIRI one !

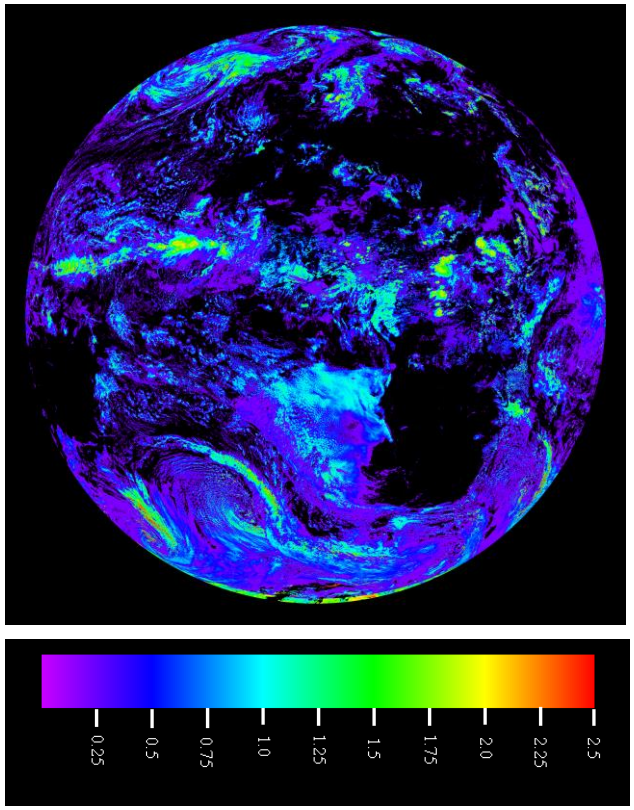
- Cloud Optical Thickness in **SEVIRI product represent $\log_{10}$ from Cloud Optical Depth**,
- Additionally values of SEVIRI Product are limited to the range **-1.7 to 2.41**, which corresponds to Cloud Optical Depth (MODIS like) respectively **0.05 to 256**.

Three components of upper level clouds

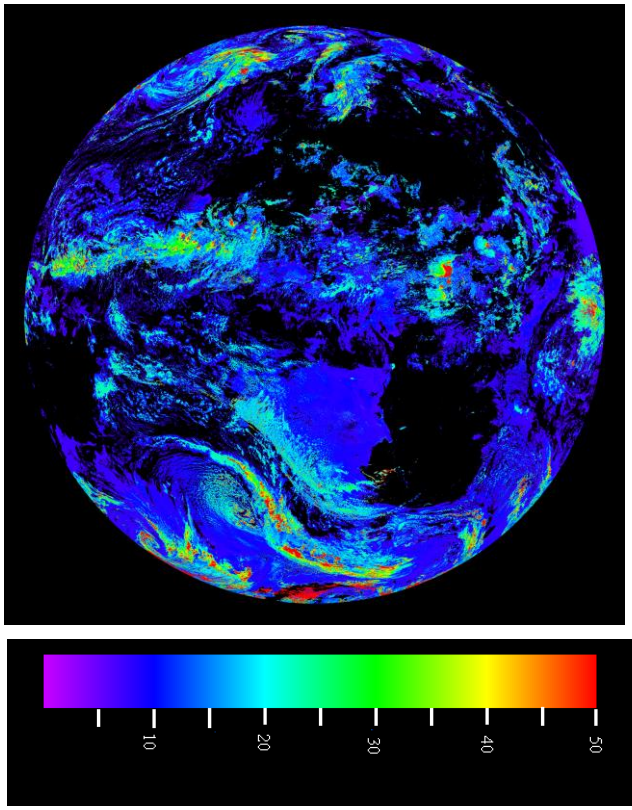
Cloud Top Pressure



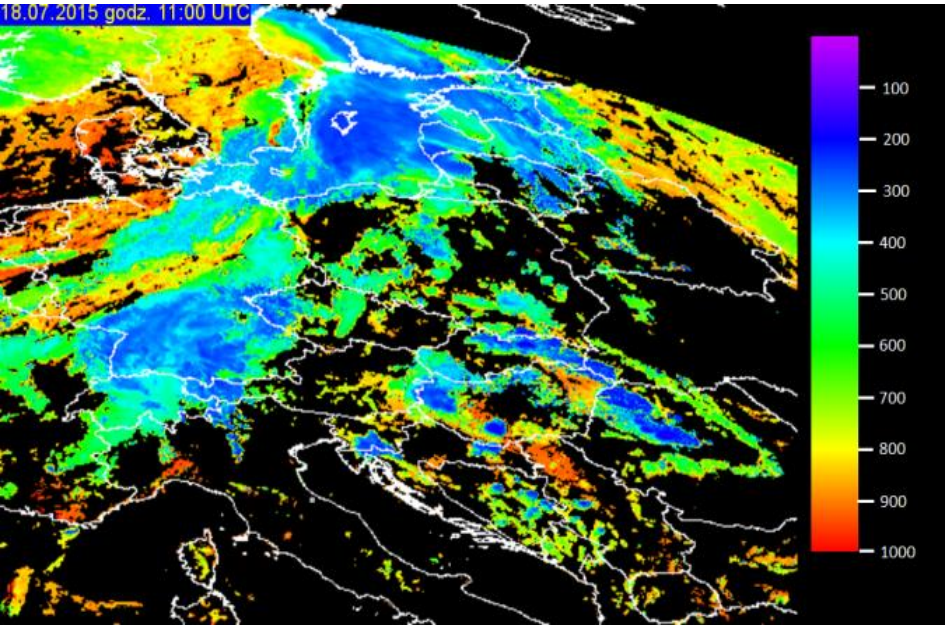
Cloud Optical Thickness



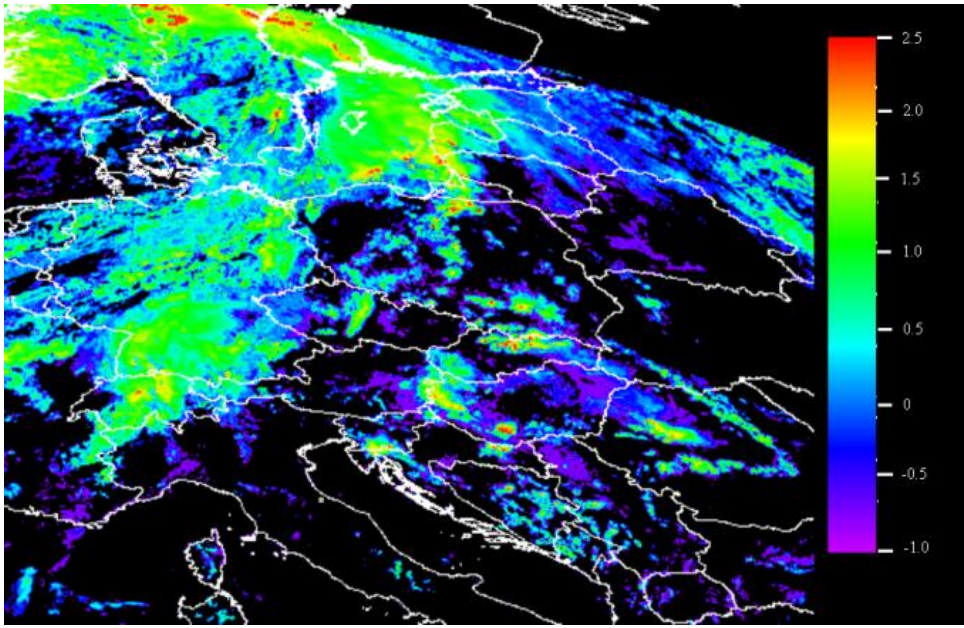
Cloud Effective Radius



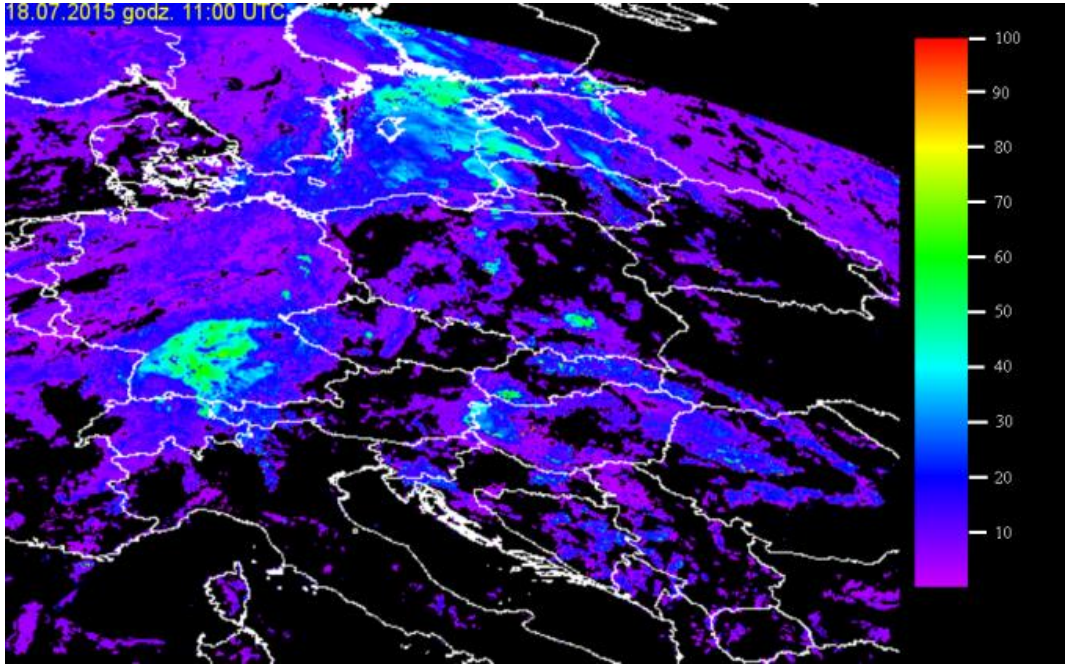
Upper Level OCA components for Central Europe:



Cloud Top Pressure [hPa]

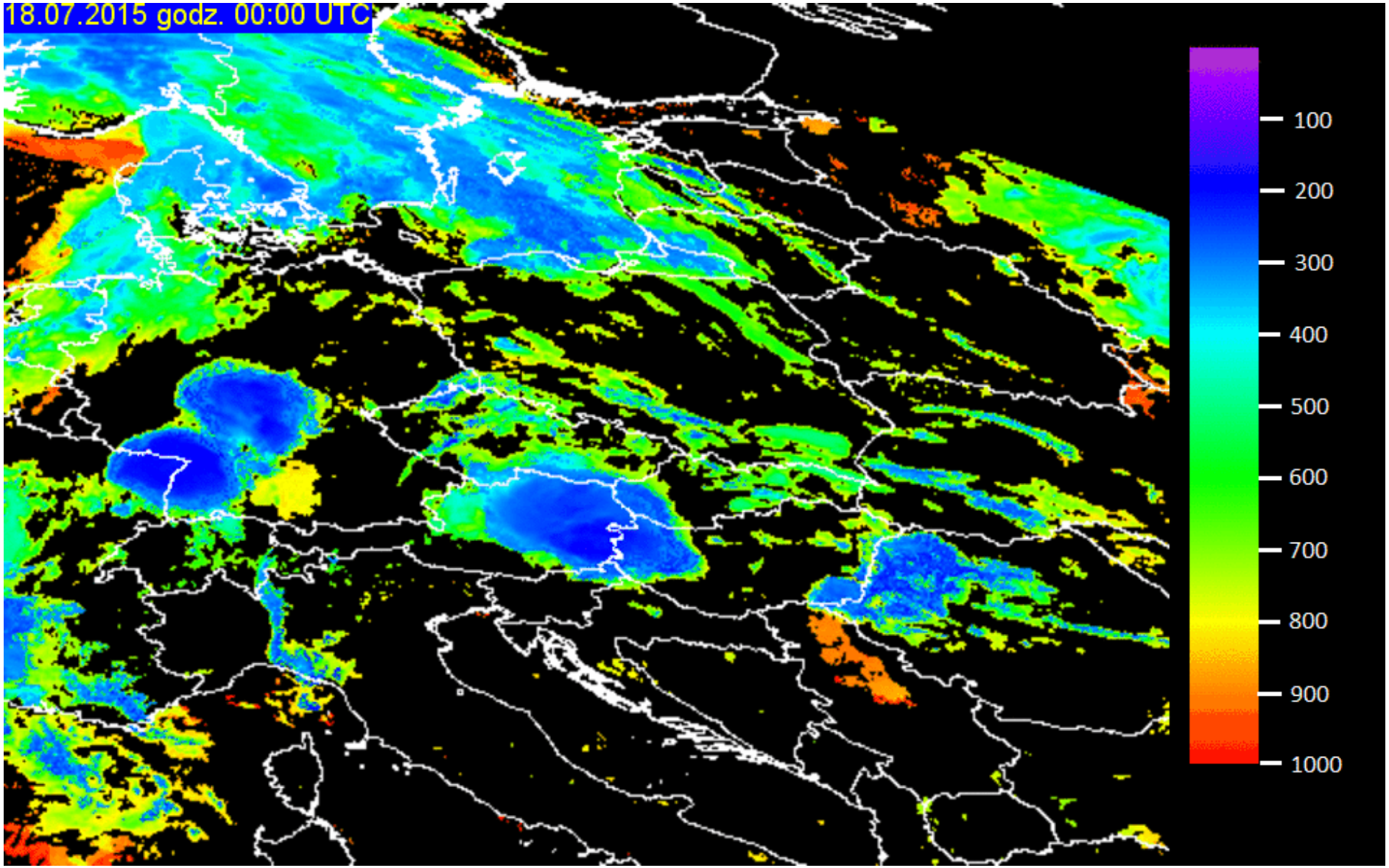


Cloud Optical Thickness



Cloud droplets Effective Radius [um]

OCA Cloud Top Pressure for Central Europe – two stormy days 18-19.07.2015



Processed OCA products for convective cases of 2014 and the most part of 2015 storm season (1.04-31.08).

All OCA products were **corrected for parallax effect** using Cloud Top Pressure as indicator of cloud top height.
Conversion from pressure (hPa) to height (km) was performed using **barometric formula** with certain simplifications concerning surface pressure and temperature:

$$A=-Rg*T/(M*g) \qquad h=A*\log(P/P_0);$$

Where: h – cloud top height

Rg - universal gas constant for air: 8.31432 N·m /(mol·K)

M - molar mass of Earth's air (0.0289644 kg/mol)

T – **surface temperature=293.0 K**

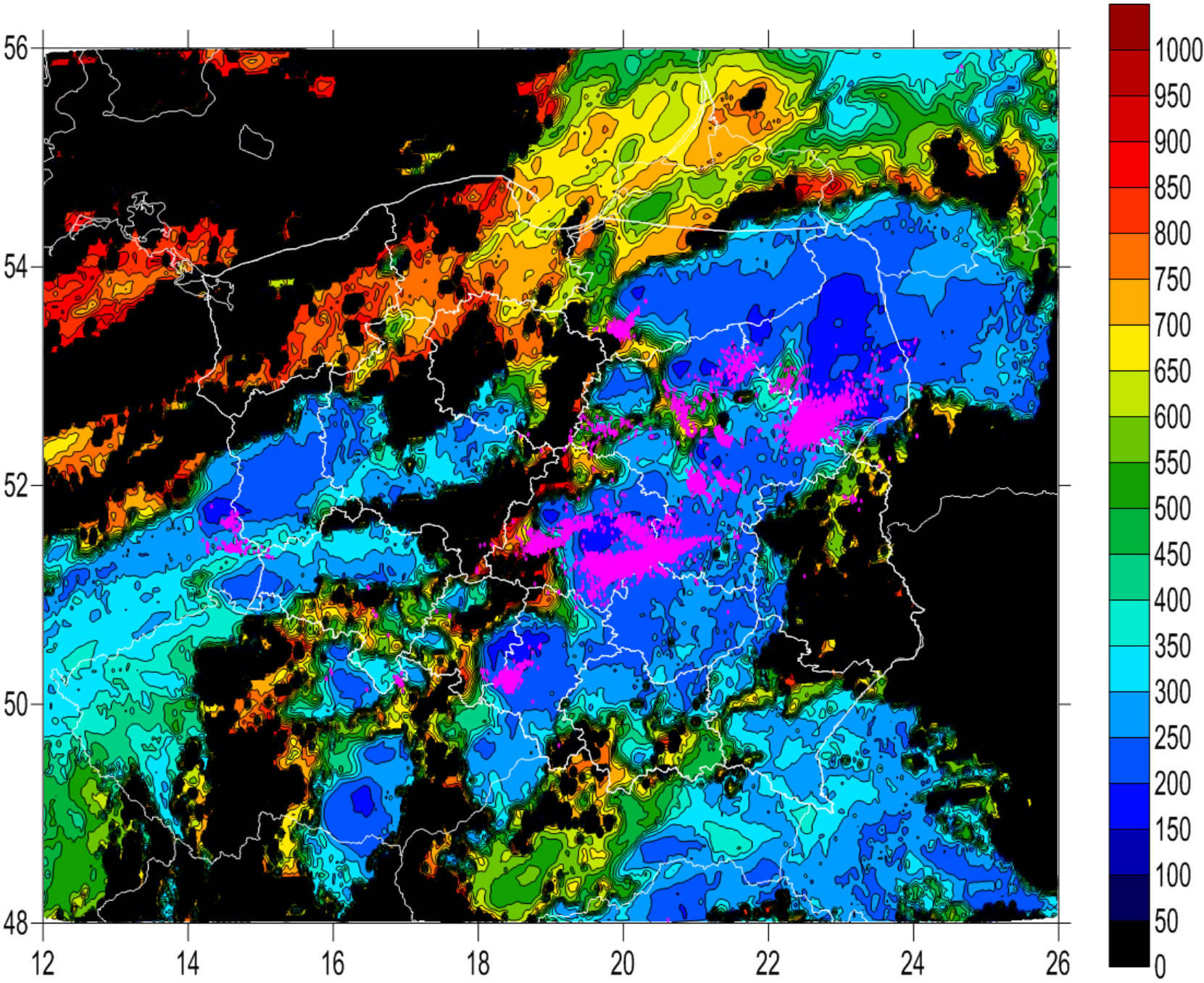
g - gravitational acceleration (9.80665 m/s^2)

P_0 – **surface pressure=1013.25 hPa**

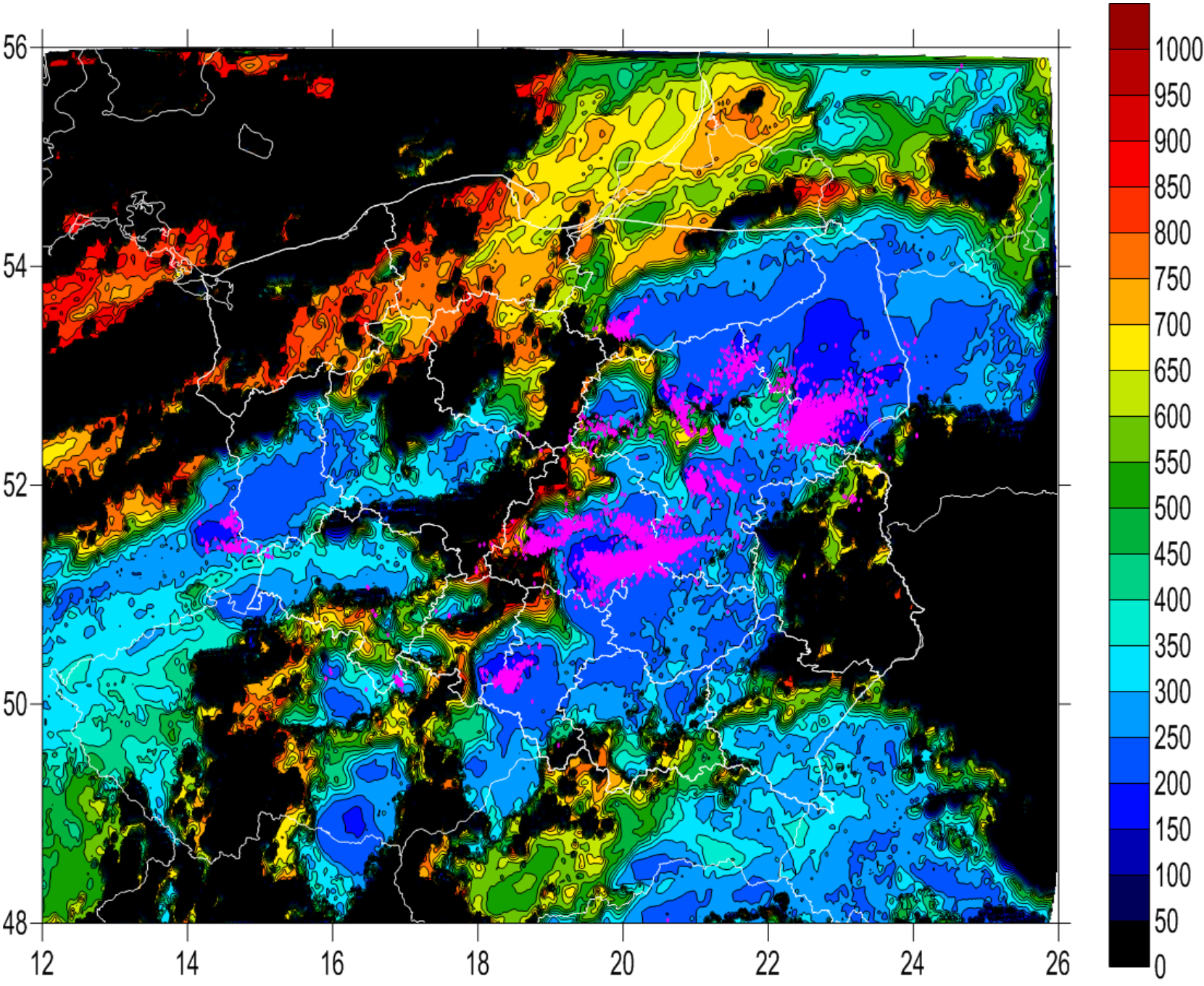
P – cloud top pressure (from OCA CTP product) [hPa]

Correction of each pixel geographical position was done with use of algorithm specified in software recommended by Convection Working Group (http://www.essl.org/cwg/res/parallax/parallax.f90).

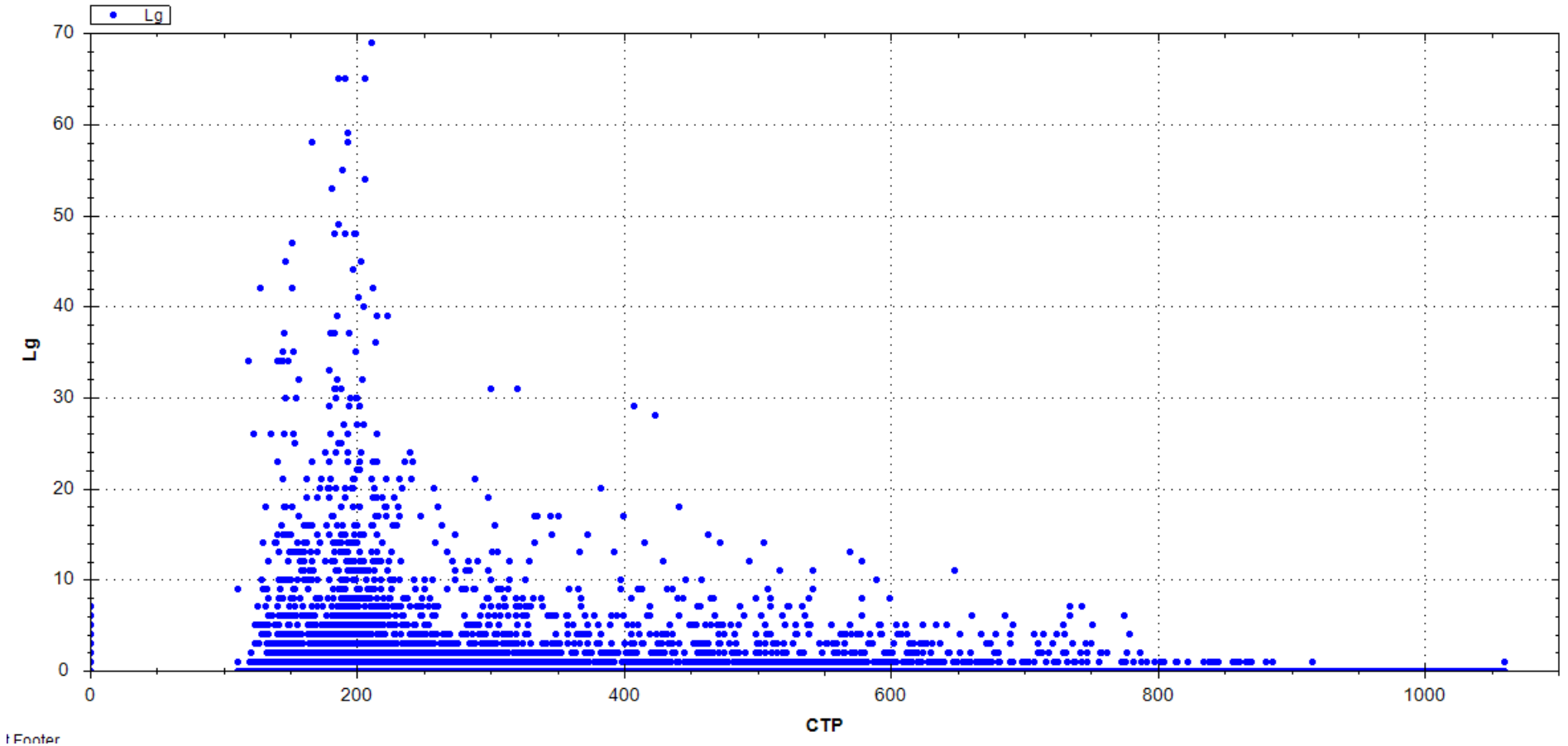
OCA Cloud Top Height with overlaid lightnings (magenta) – before Paralax Correction



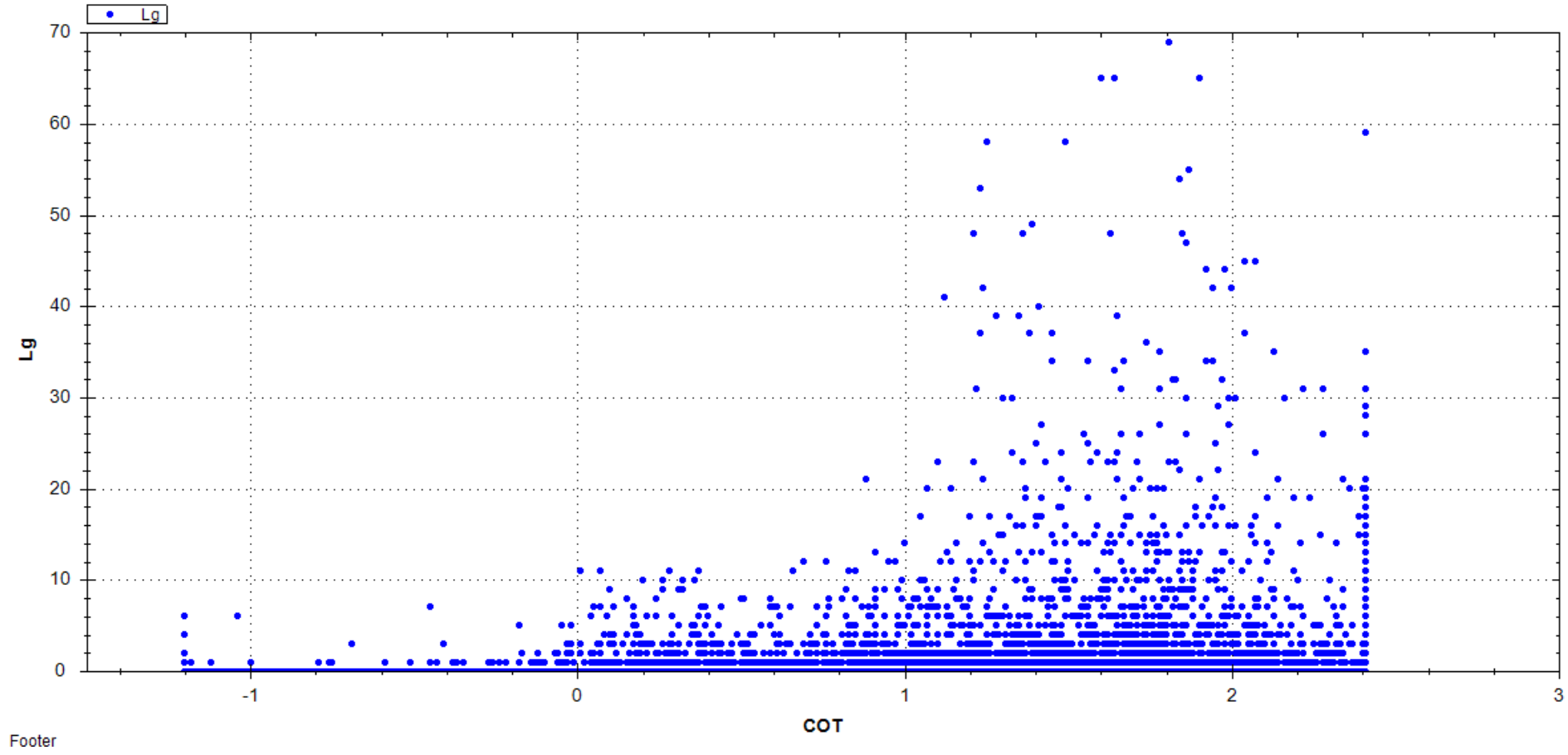
OCA Cloud Top Height with overlaid lightnings (magenta) – after Paralax Correction



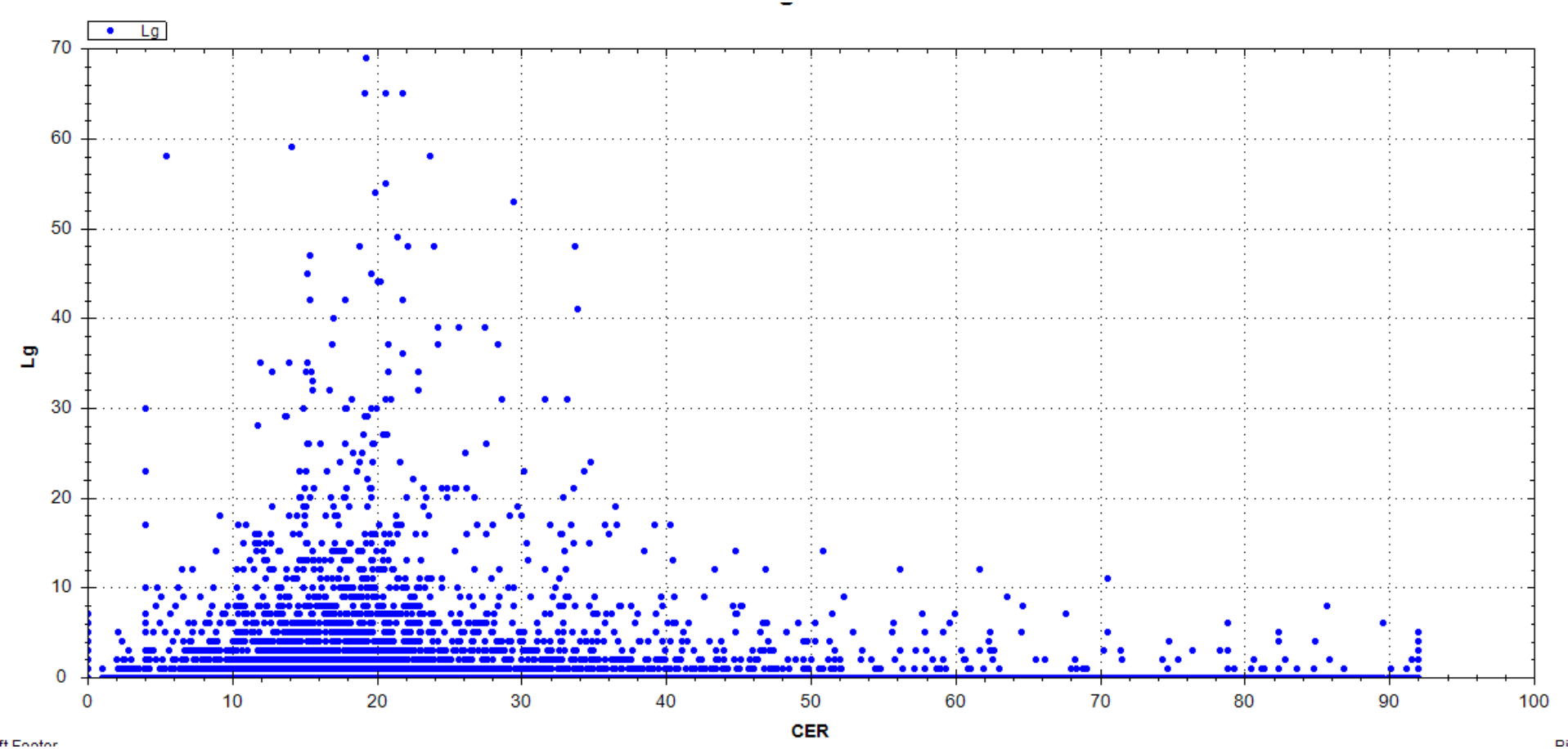
Scatterplot for relation between **CTP (Cloud Top Pressure)** and number of **Cloud to Ground lightnings** (Day)



Scatterplot for relation between **COT (Cloud Optical Thickness)** and number of **Cloud to Ground lightnings** (Day)



Scatterplot for relation between **CER (Cloud Effective Radius)** and number of **Cloud to Ground lightnings** (Day)



[um]

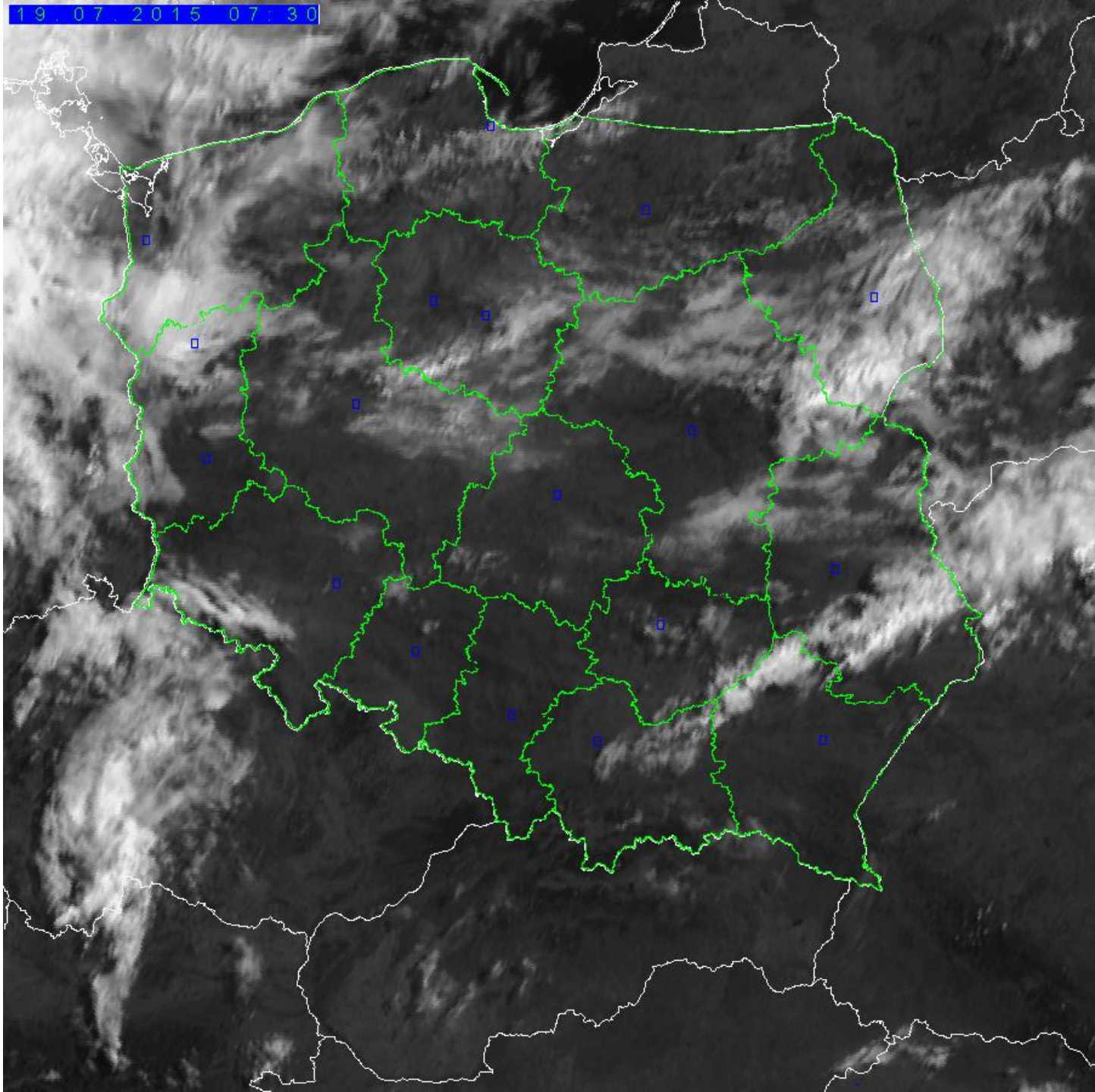
19.07.2015

Meteosat HRV channel with overlaid lightnings from Perun system

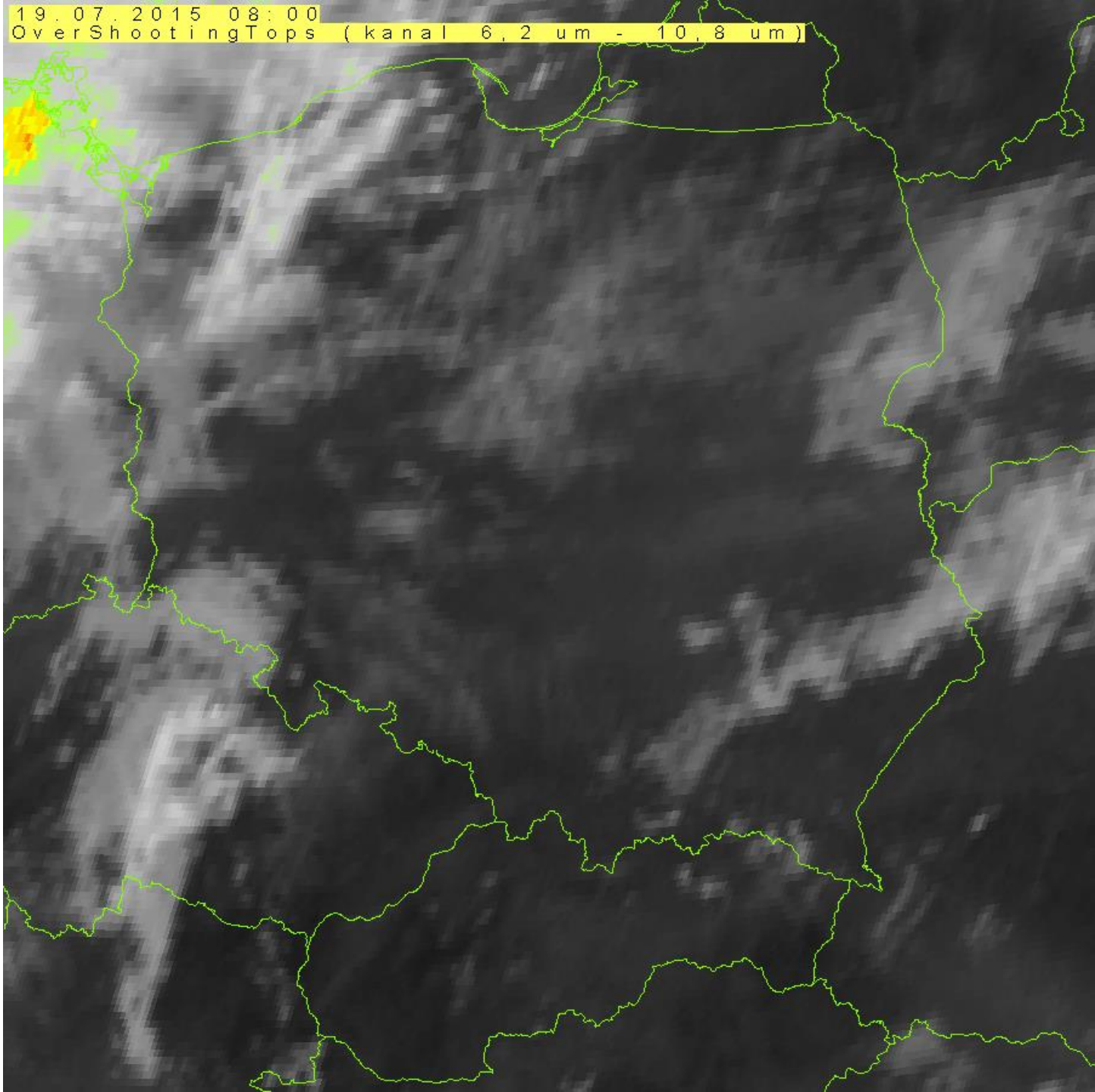
CG+ Lighnings

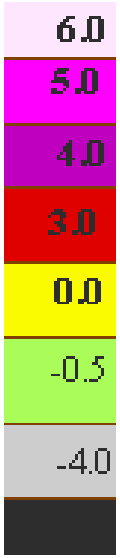
CG- Lightnings

CC Lightnings

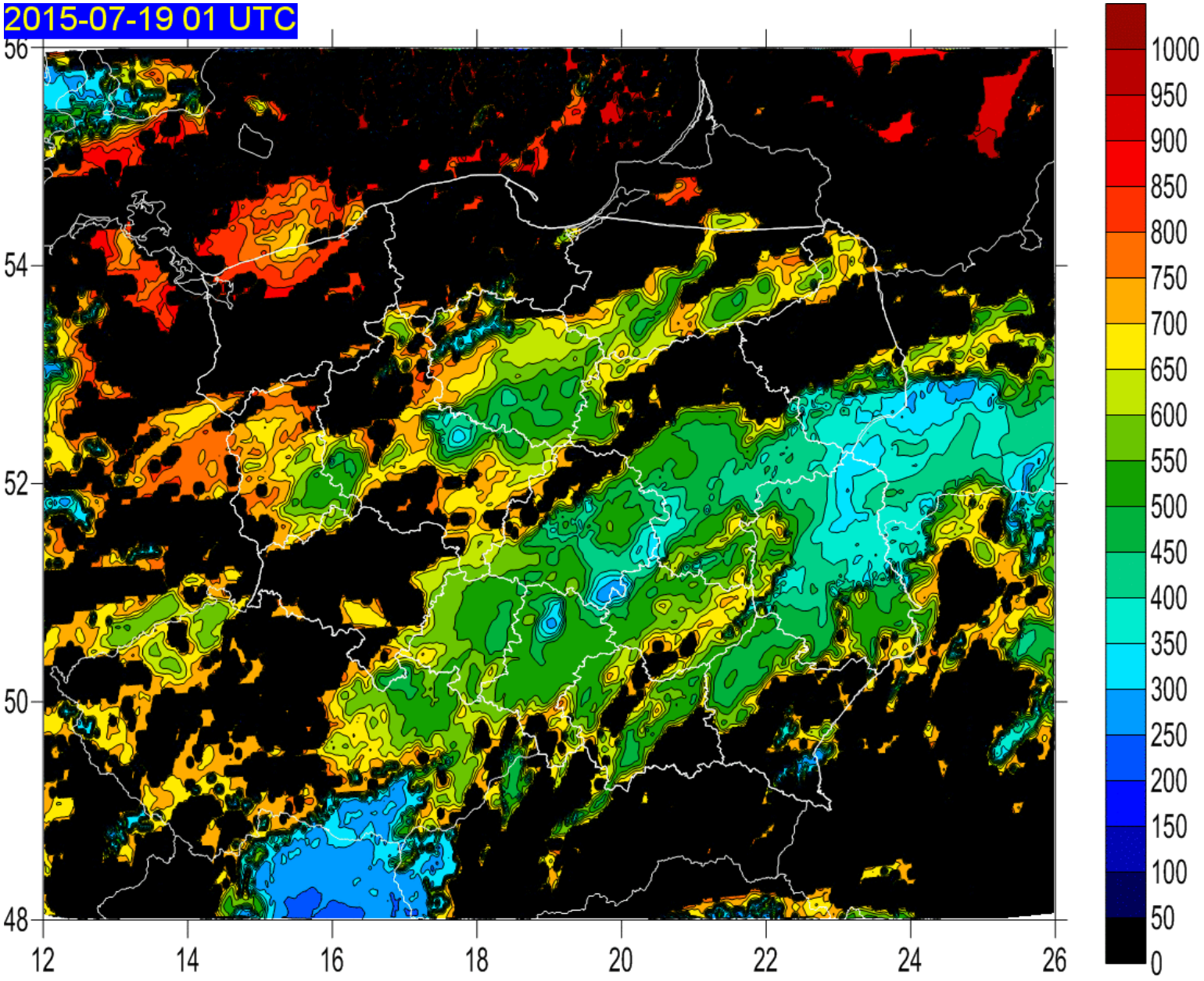


Meteosat WV 6.2 um – IR 10.8 um

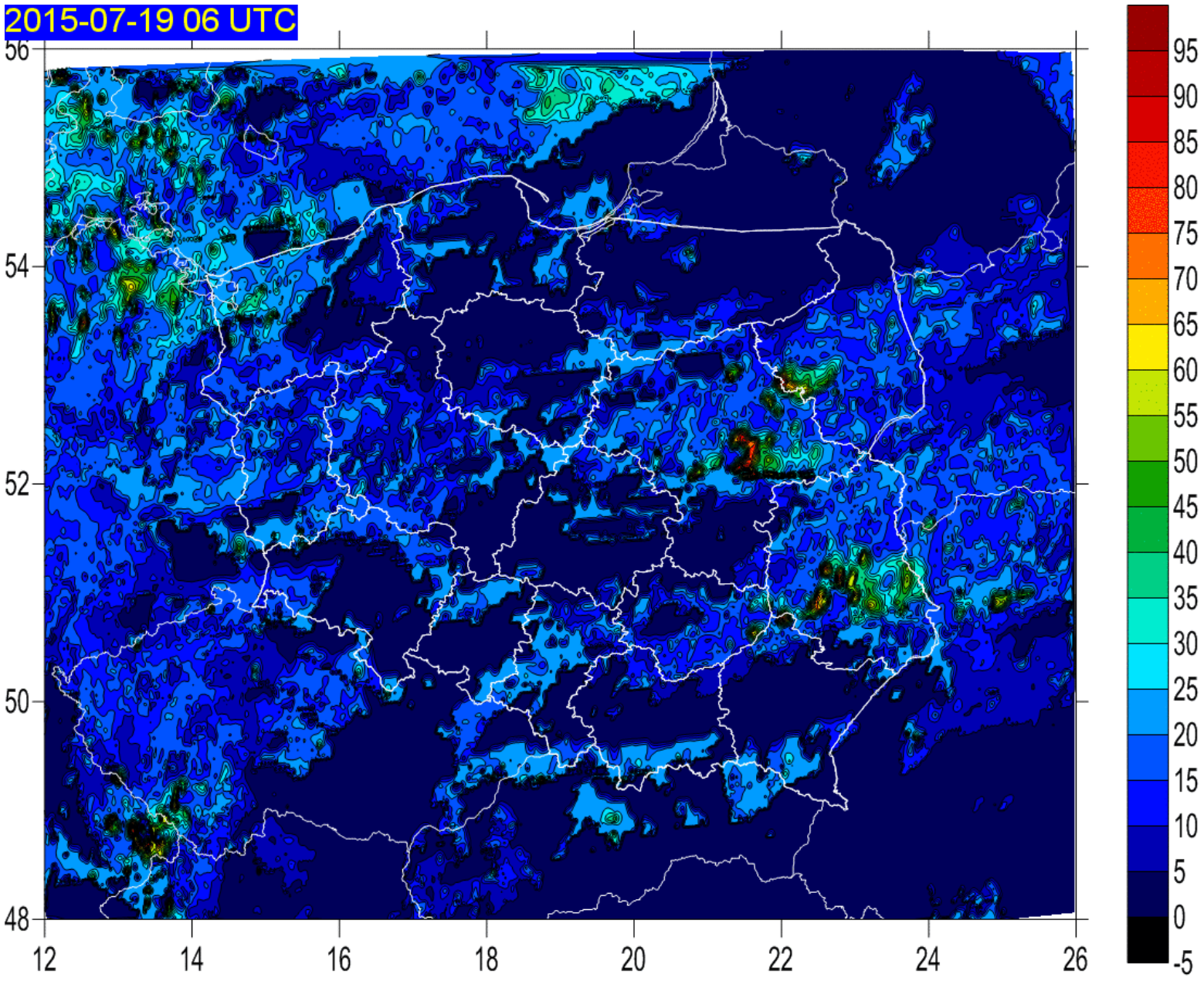




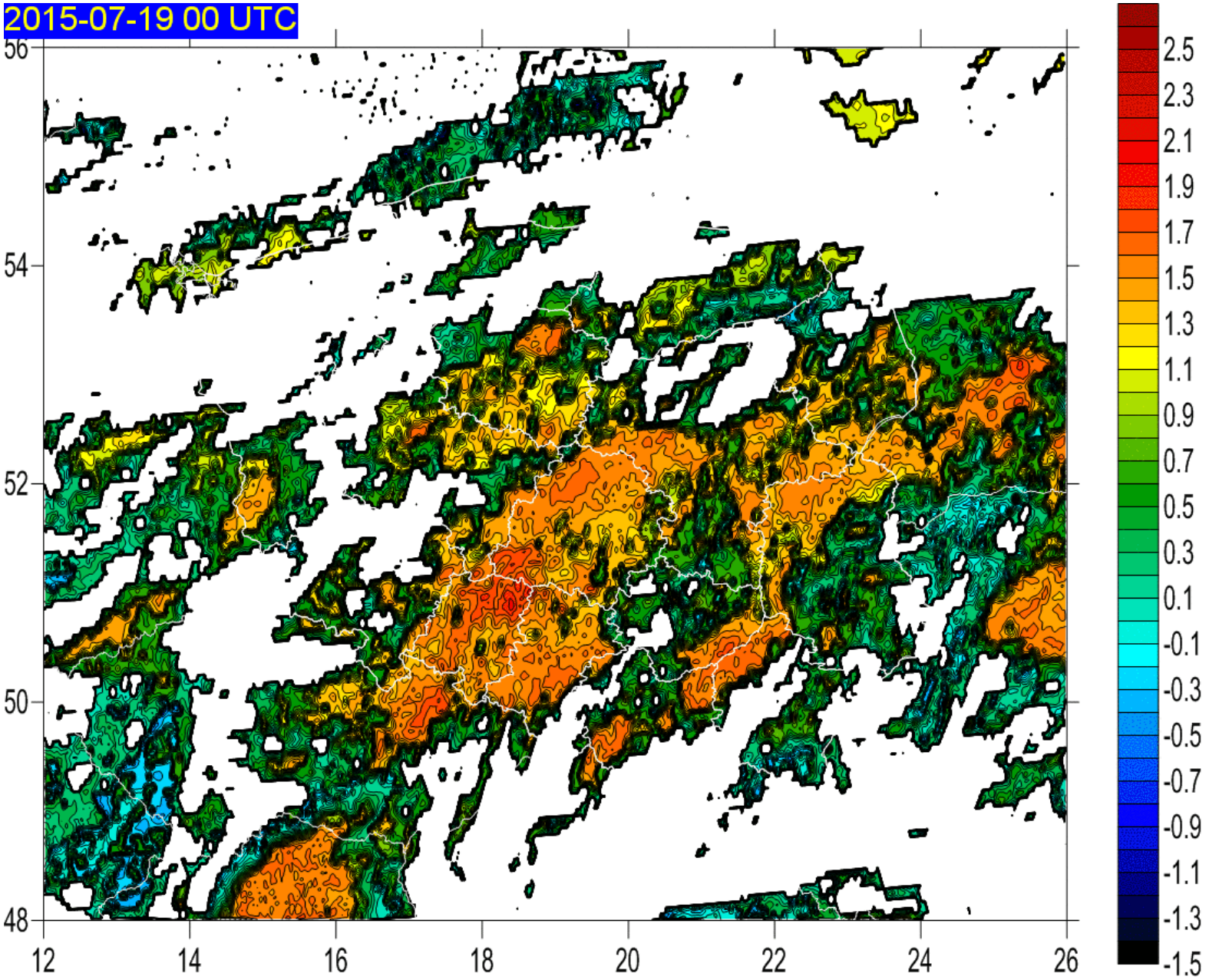
OCA - Cloud Top Pressure product



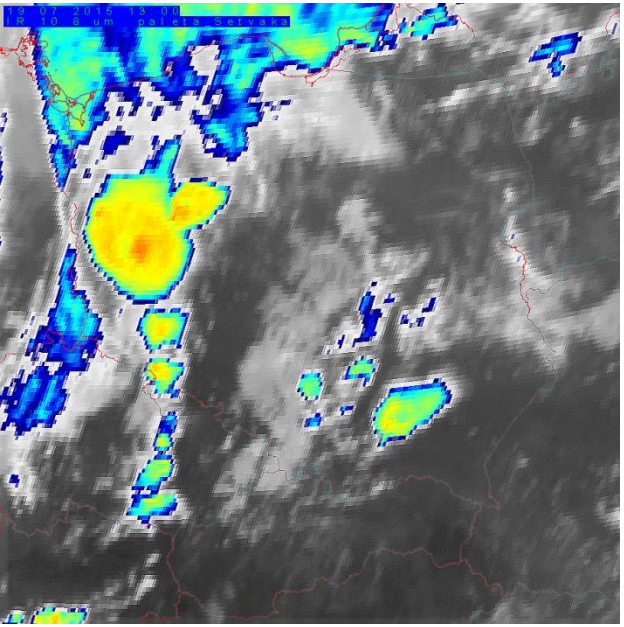
OCA - Cloud Droplets Effective Radius product



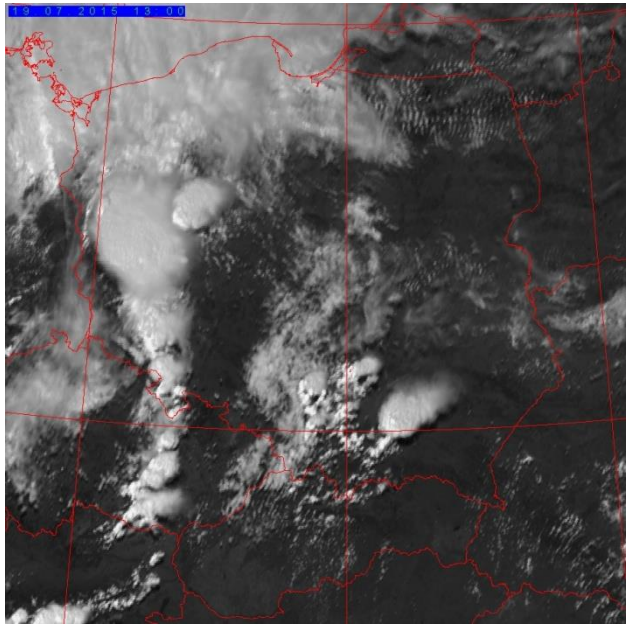
OCA - Cloud Optical Depth product



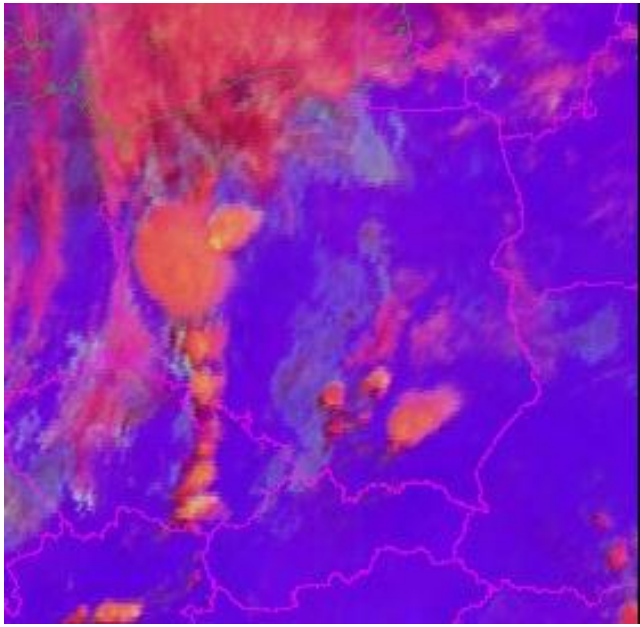
Case on 19.07.2015 13:00 UTC seen on three Meteosat10 satellite products



IR 10.8 (colour enhanced)

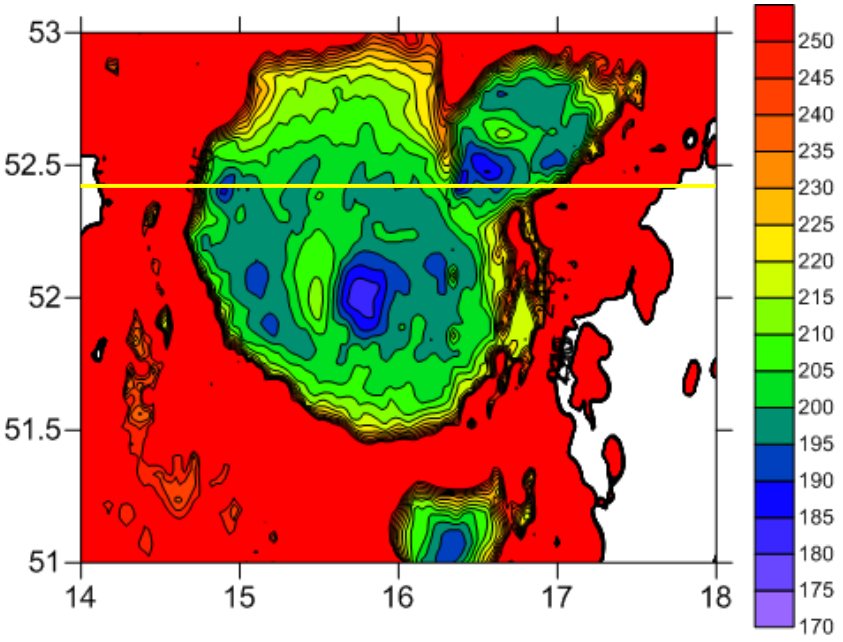


HRV channel

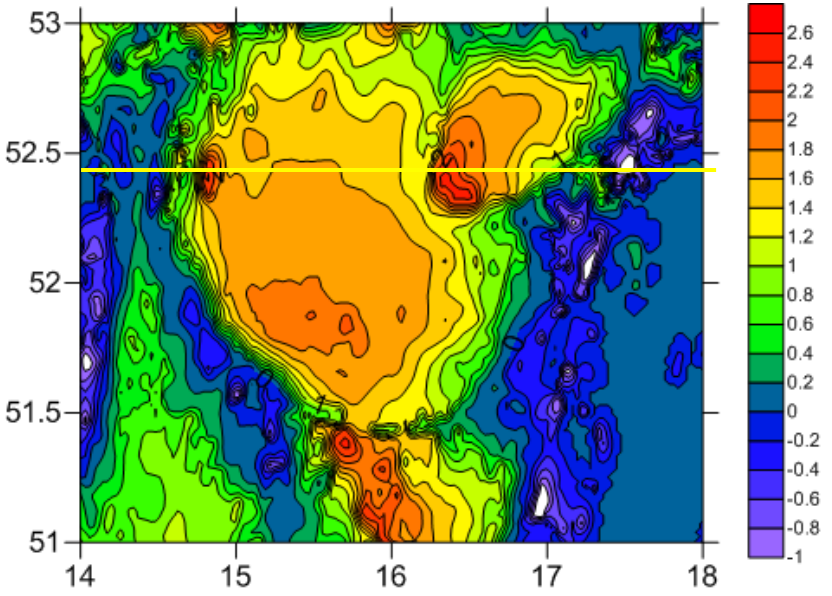


RGB Convection

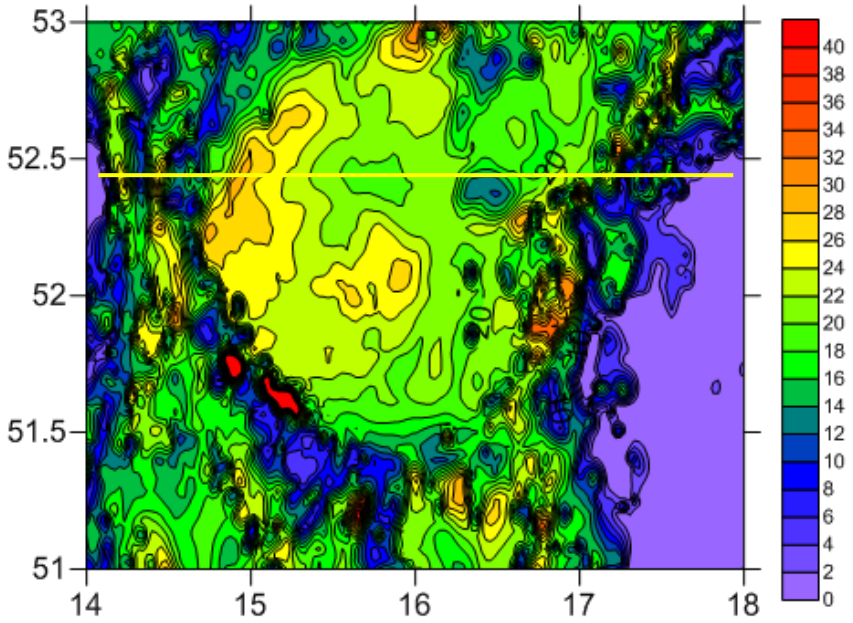
19.07.2015 13:00 UTC – large convection cell in 3 OCA parameters (color enhancement):



CTP



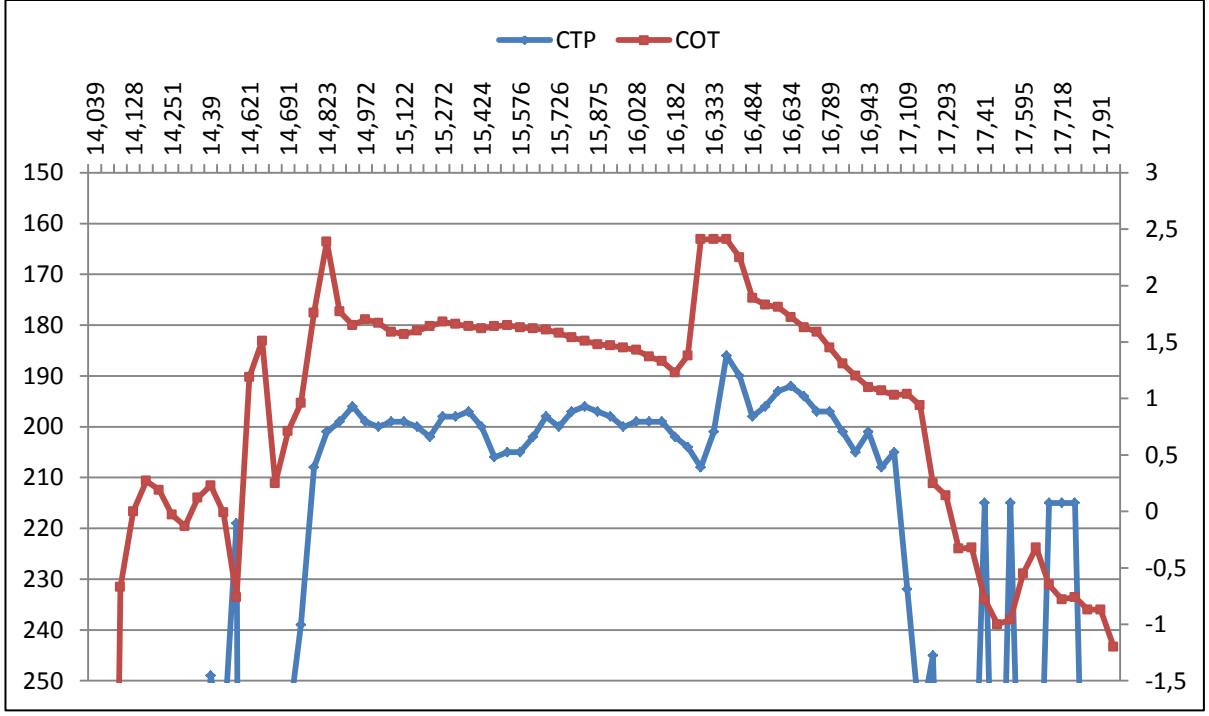
COT



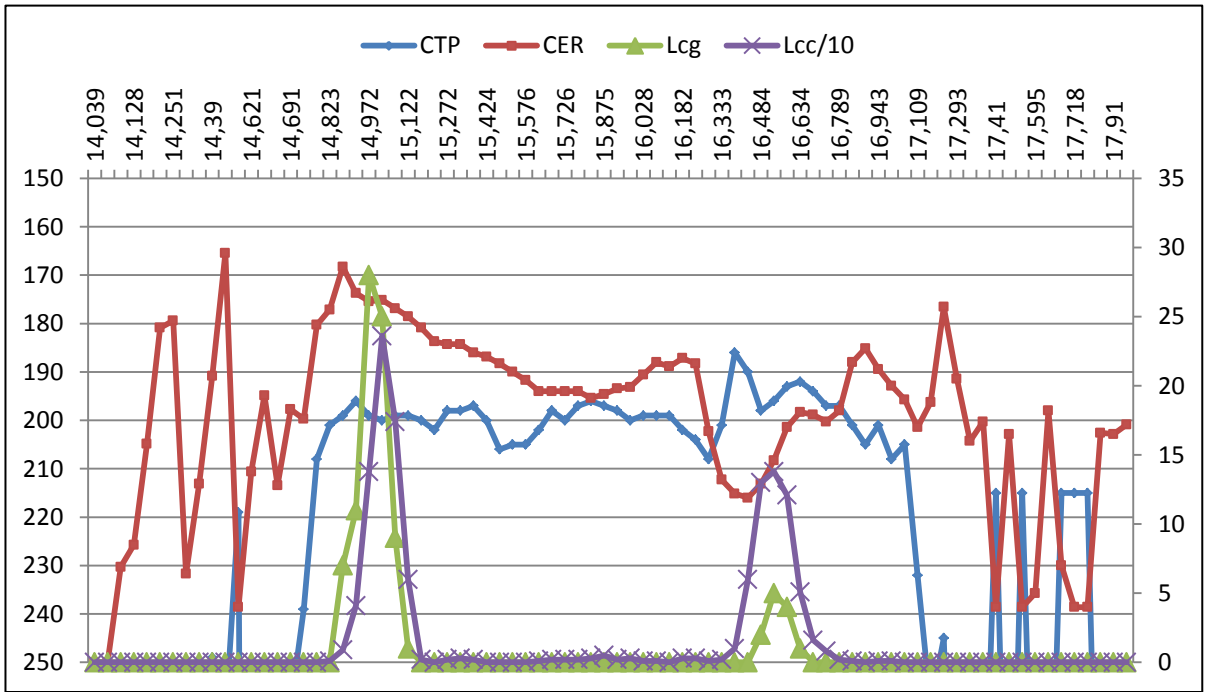
CER

Crossection:
14-18E; 52.4 N

Cloud Top Pressure
and
Cloud Optical Thickness



Cloud Top Pressure,
Cloud Droplets Effective Radius,
Lightnings Cloud to Ground,
Lightnings Cloud to Cloud



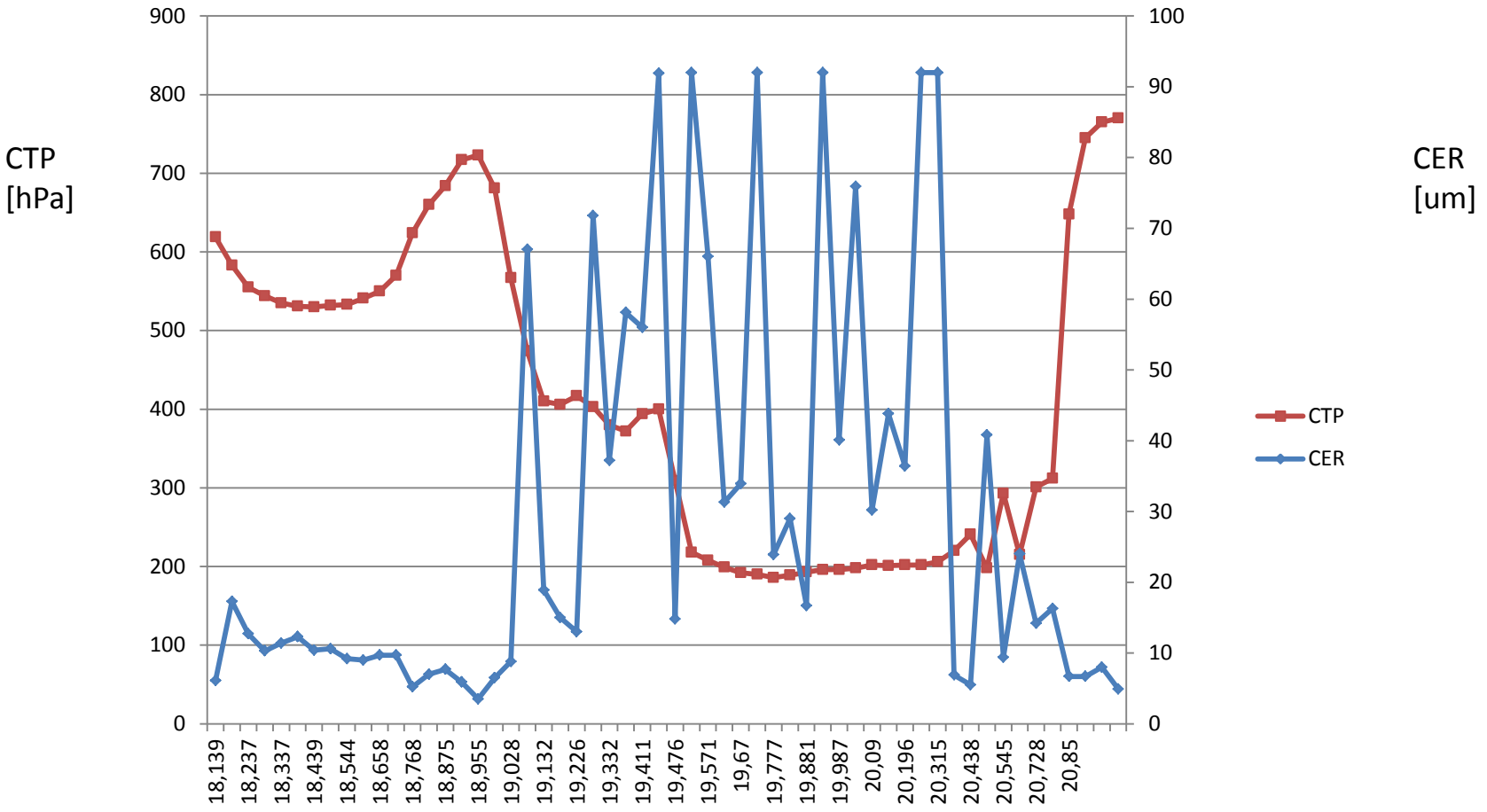
Nighttime problems:

CTP – not affected.

COT – Unusual high Optical Thickness at the sunrise and sunset conditions, suppressed by maximum value 2.41. At night smaller values of COT but tendency for two likely optical depth around 0.5 and 1.5, separated from each other.

CER – convective cloud with ice crystals contains both normal size particles and doubled and tripled size particles up to the limit of 92 um. Cloud appears scattered.

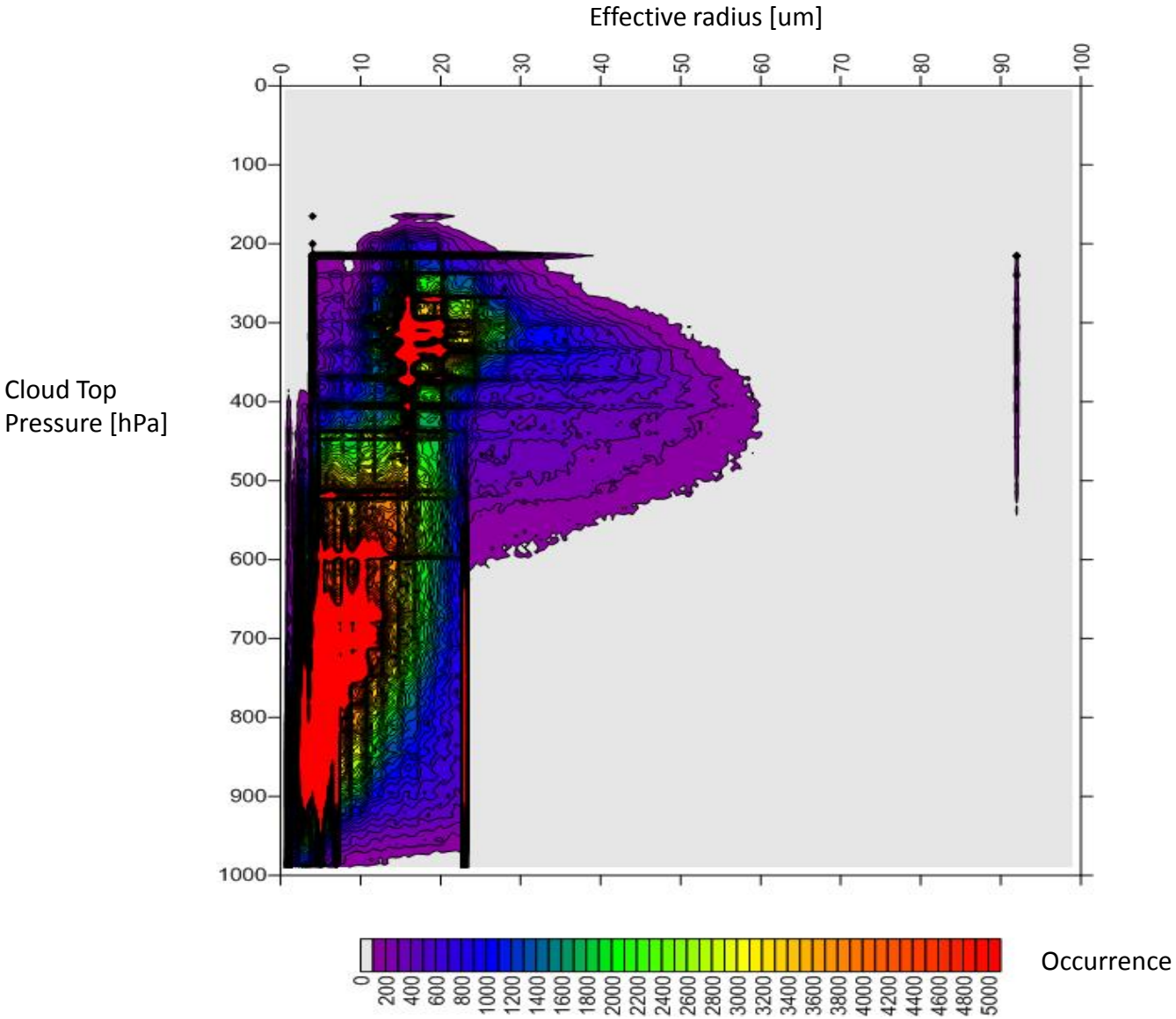
Cross section through the high cloud - **Nighttime**



OCA Product at the Daytime

Scatterprot for CTP (Cloud Top Pressure) and CER (Cloud Effective Radius)

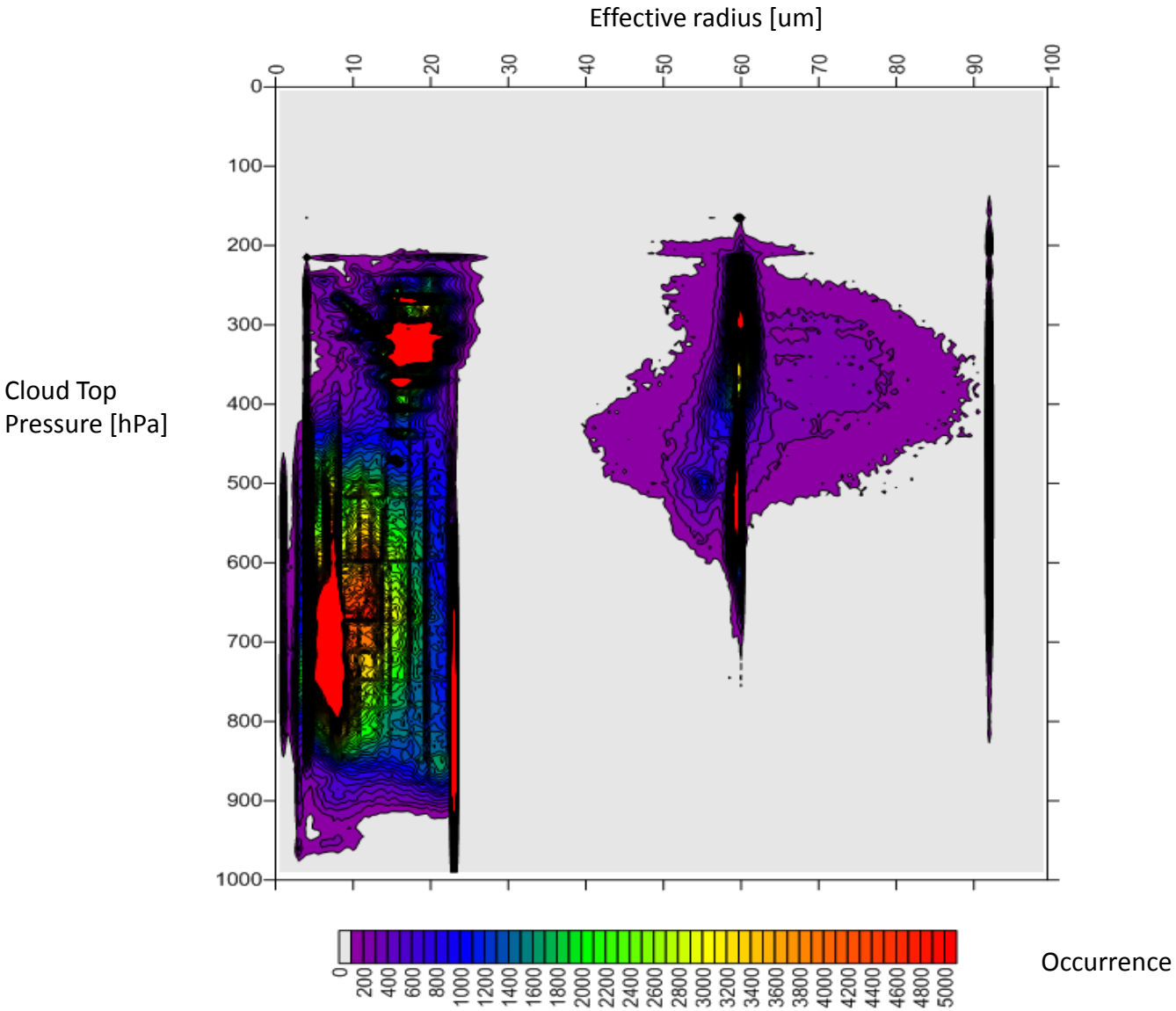
Processed 3800 OCA products from Apr-Aug 2014 and 2015



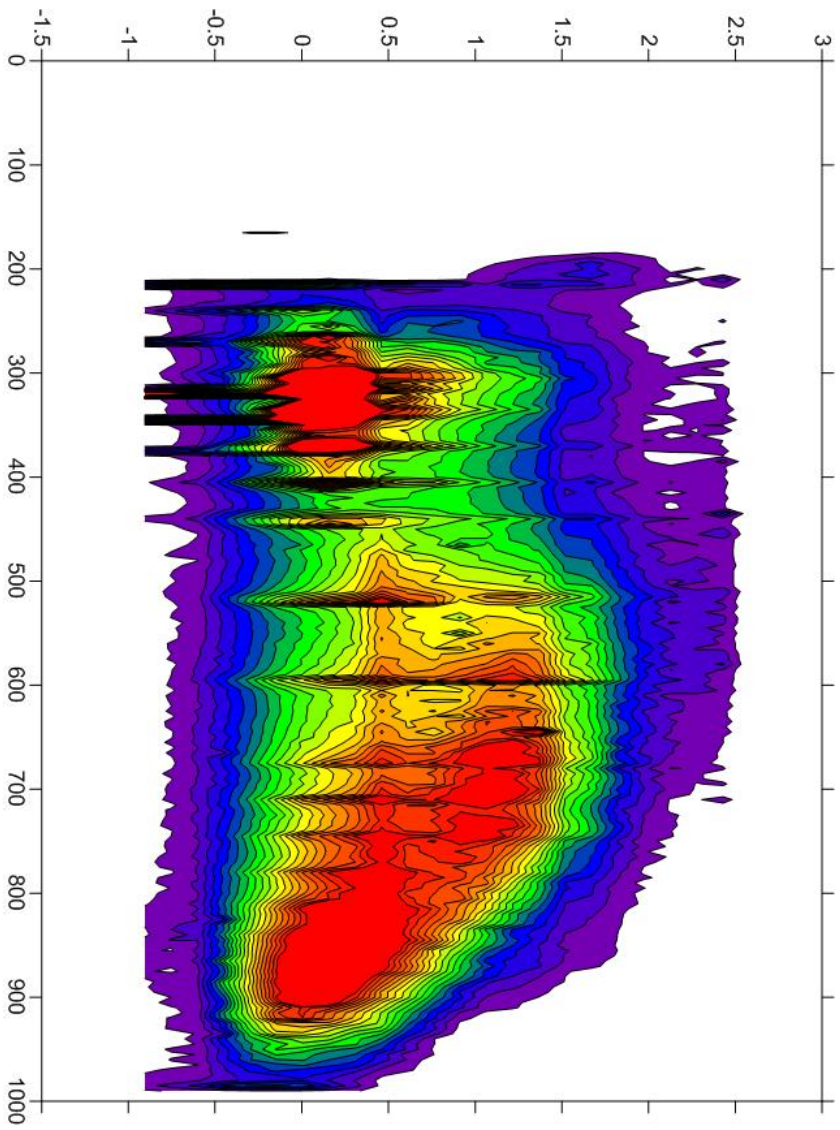
OCA Product at the Nighttime

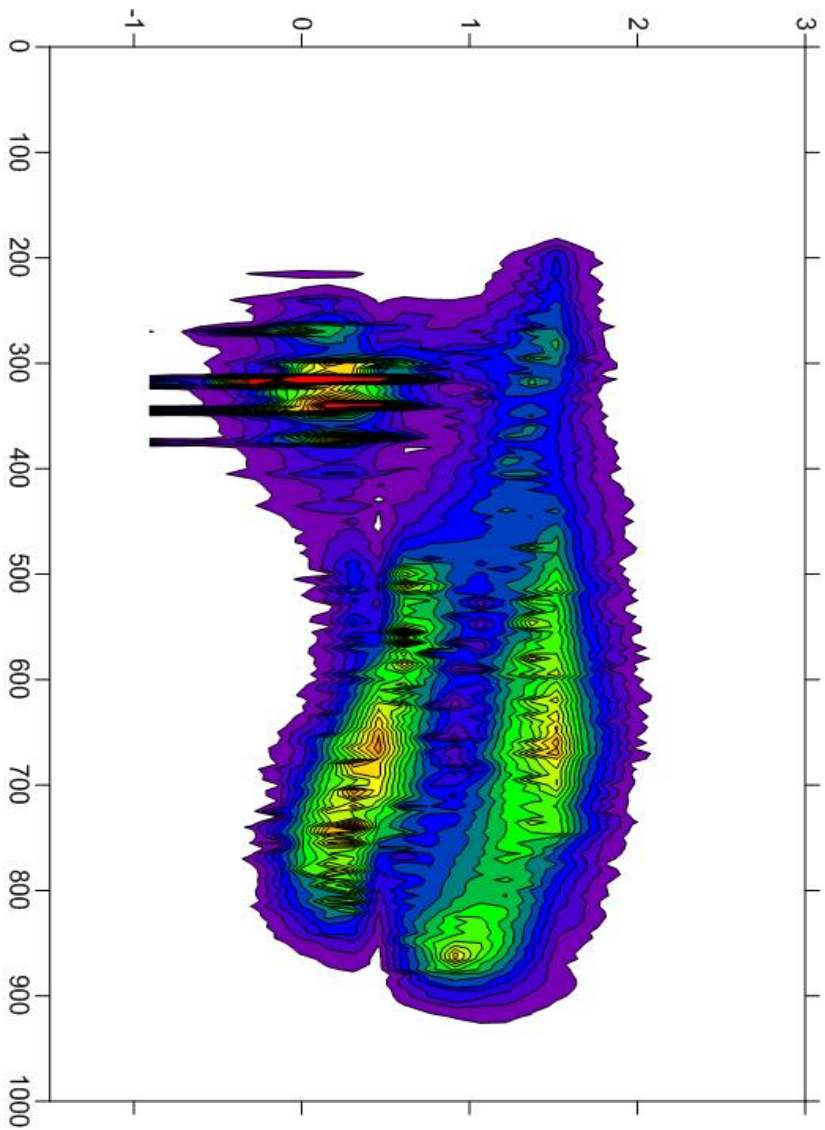
Scatterprot for CTP (Cloud Top Pressure) and CER (Cloud Effective Radius)

Processed 3800 OCA products from Apr-Aug 2014 and 2015



OCA Product at the Daytime and Nightime
Scatterplot for CTP (Cloud Top Pressure) and COT (Cloud Optical Thickness)

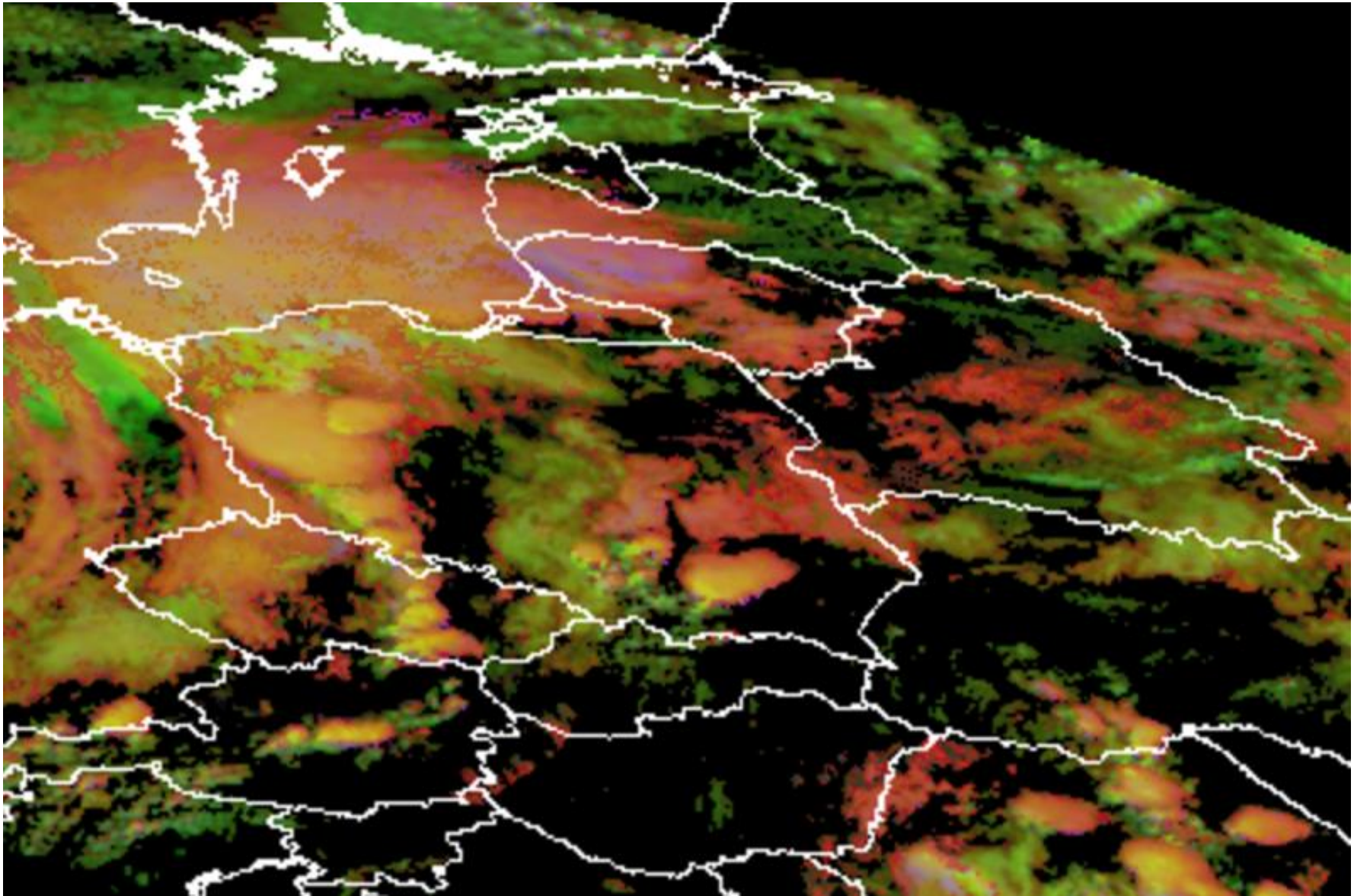




RGB composition based on 3 components of OCA:

R-CTP reversed; G-COT; B-CER

similar features to Convection RGB were found



Conclusions:

1. OCA is interesting product presenting real physical values.
2. Deep convective clouds are well presented – possible interpretation of processes inside convetive cloud.
3. Product Cloud Top Pressure allow for good interpretation both at Day and Night.
4. Products: Cloud Effective Radius and Cloud Optical Depth significantly differs for Day and Night, interpretation at Night difficult. Sharp jumps between day and night images.
5. **Product required operationally available, with 15 min time step, instead of 1h as now.**

6. Very ineresting product for Fog/Low Stratus recognition, even under upper layer of transparent clouds !

Announced future development of OCA product:

- A-Train data for cloud properties is to be used to validate the OCA products.
- Full implementation of 2-layer model - – extension of the state vector to two layers and development of the shortwave and longwave 2-layer radiative transfer model - Visiting Scientist from JMA.
- The use of the OCA product to set the AMV height, important improvements for low clouds.
- Any operational use of OCA needs the availability of the OCA product for every repeat cycle !

Thank you
for your attention

Piotr Struzik
Monika Pajek
Institute of Meteorology and Water Management
- National Research Institute
Satellite Remote Sensing Department
30-215 Kraków, ul. P. Borowego 14
Poland