SLOVENSKÝ HYDROMETEOROLOGICKÝ ÚSTAV

EUMETSAT H SAF
SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

# Satellite observations of precipitation Drought management in Armenia: Webinar by Slovak Remote sensing department

**Ján Kaňák, Marian Jurašek**
**Remote Service Department**
**Slovak Hydrometeorological Institute**

**9th June 2023**

# Content:

1. EUMETSAT HSAF (introduction)
2. HSAF Products (rain, snow, soil moisture)
3. Case studies (rainfall estimation application for meteorology, hydrology and climatology)
4. Accuracy (10-years evaluation statistics)

SLOVENSKÝ HYDROMETEOROLOGICKÝ ÚSTAV

# EUMETSAT HSAF – introduction

HSAF started in September 2005 as last from 8 existing projects on satellite applications. The H SAF objectives are:

- to provide new satellite-derived products from existing and future satellites with sufficient time and space resolution to satisfy the needs of operational hydrology, by mean of the following identified products:
- precipitation (liquid, solid, rate, accumulated);
- soil moisture (at large-scale, at local-scale, at surface, in the roots region);
- snow parameters (detection, cover, melting conditions, water equivalent);
- to perform independent validation of the usefulness of the new products for fighting against floods, landslides, avalanches, and evaluating water resources;

**The activity includes:**

- downscaling/upscaling modelling from observed/predicted fields to basin level;
- fusion of satellite-derived measurements with data from radar and raingauge networks;
- assimilation of satellite-derived products in hydrological models;
- assessment of the impact of the new satellite-derived products on hydrological applications.
- Other SAFs: AC CM LSA OSI NWP ROM

SLOVENSKÝ HYDROMETEOROLOGICKÝ ÚSTAV

EUMETSAT H SAF SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

# HSAF Products:

## Three main groups of products are

- Precipitation — instantaneous and accumulated
- Soil moisture — surface and root zone
- Snow detection — cover and water equivalent

## Associated activities are

- Development of products — and operational generation **(start cycle)**
- Quality assessment — and preparation of reports
- Hydrological validation — and impact studies
- **Training activities** — **and workshops**
- **Operational usage** — **and user requirements (end cycle)**

# Precipitation products:

**Instantaneous precipitation from microwave measurements:**
current (AMSU- MHS, SSMIS, ATMS, AMSR-2, GMI) and future, (e.g., MWI, MWS) microwave radiometers on board a constellation of Low Earth Orbit (LEO) satellites – mainly EPS and EPS-SG.

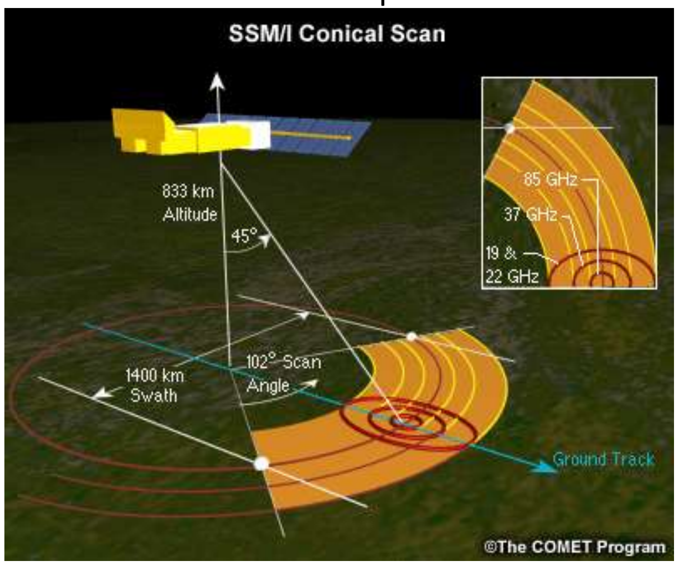
**Instantaneous precipitation merged MW and GEO/IR:**
precipitation estimation by merging higher quality, sparsely sampled precipitation estimates from LEO satellites with highly temporally and spatially sampled data from geostationary satellites – MSG & MTG.

**Accumulated precipitation:**
Integrated regular in time instantaneous precipitation fields from merged MW & IR into 1, 3, 6, 12 and 24-hours totals (10 min in near future from MTG satellite).

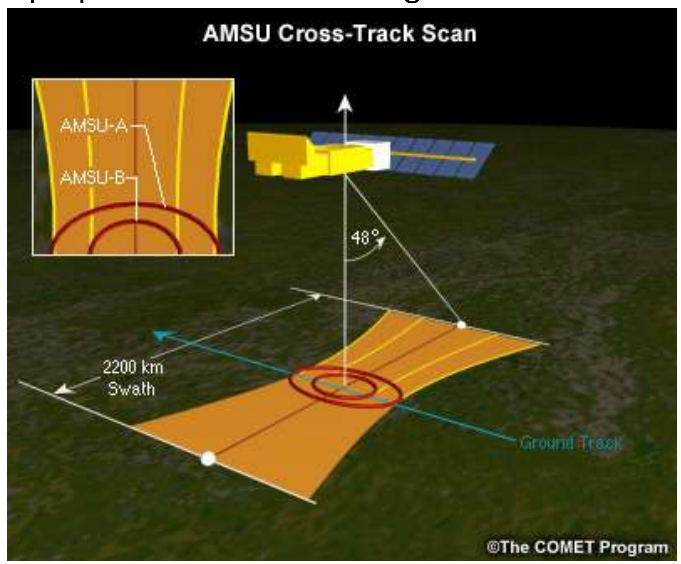
# Quality Assessment activities

- comparison to ground truth – Step 1: understand data

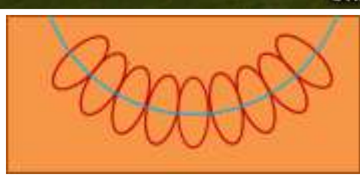
Conical scanner – constant FOV, ellipses oriented to sub satellite point



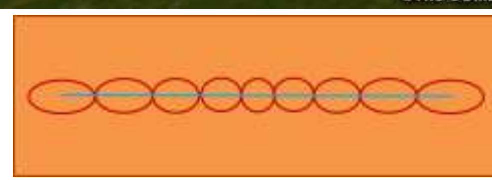

Cross-track scanner – variable FOV, ellipse perpendicular to satellite ground-track




H01

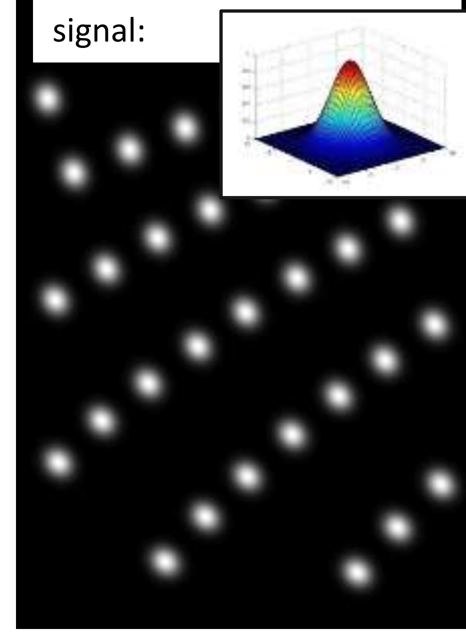


Size of FOV Depends on signal frequency



H02

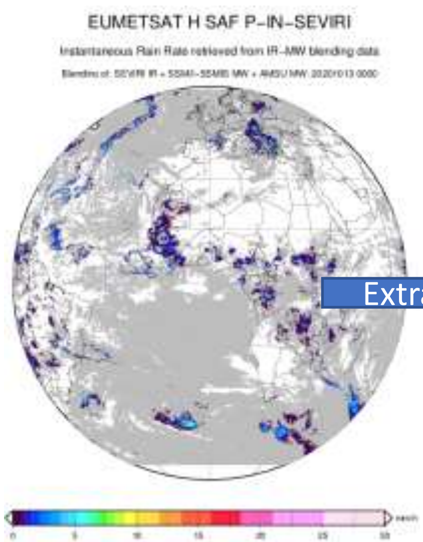
Radar (ground truth) FOV Must be weighted by Gaussian distribution of signal:



# Quality Assessment activities

## - comparison to ground truth – Step 1: understand data

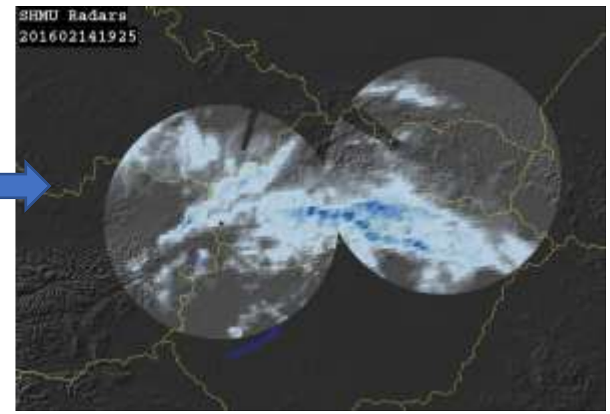
H01, H02 merged with MSG SEVIRI -> H03, H05 in regular or so called Meteosat view projection grid, ground truth data averaged directly over satellite FOV's pixels, or after re-projection to common grid:




Extract data

H03 and/or H05


???

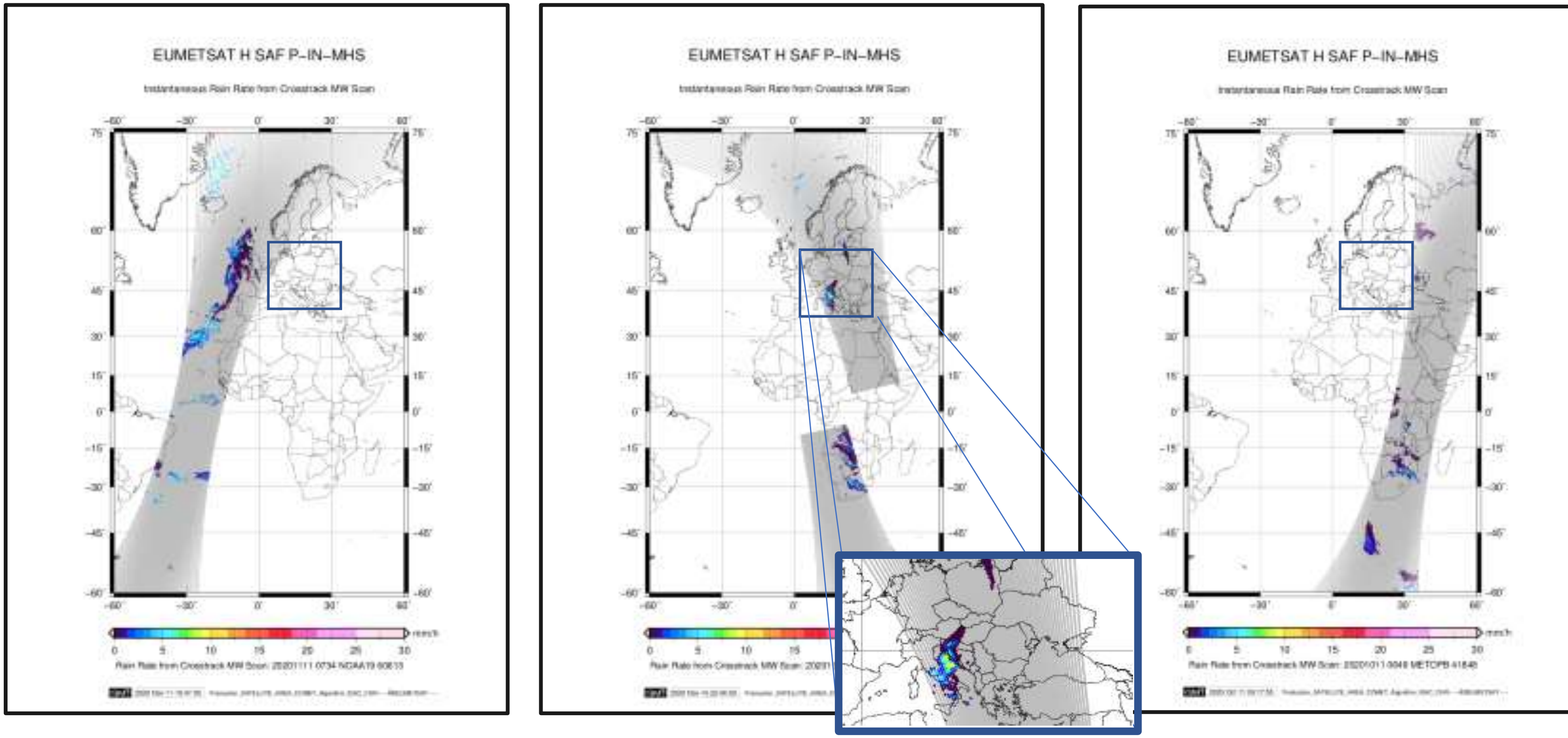


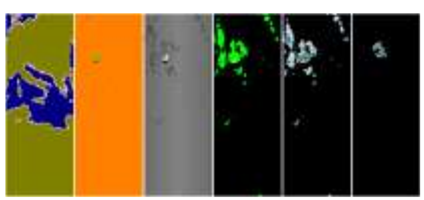

Comparison, statistics, evaluation

# Quality Assessment activities

## - comparison to ground truth - STEP 2: collect time/space data

Selection of proper satellite overpass and, extract date and time, extract geolocation and product data …



Satellite Precipitation
Quality index
Longitude Latitude
Scan time

↔

Ground Precipitation
Quality index
Longitude Latitude
Scan Time

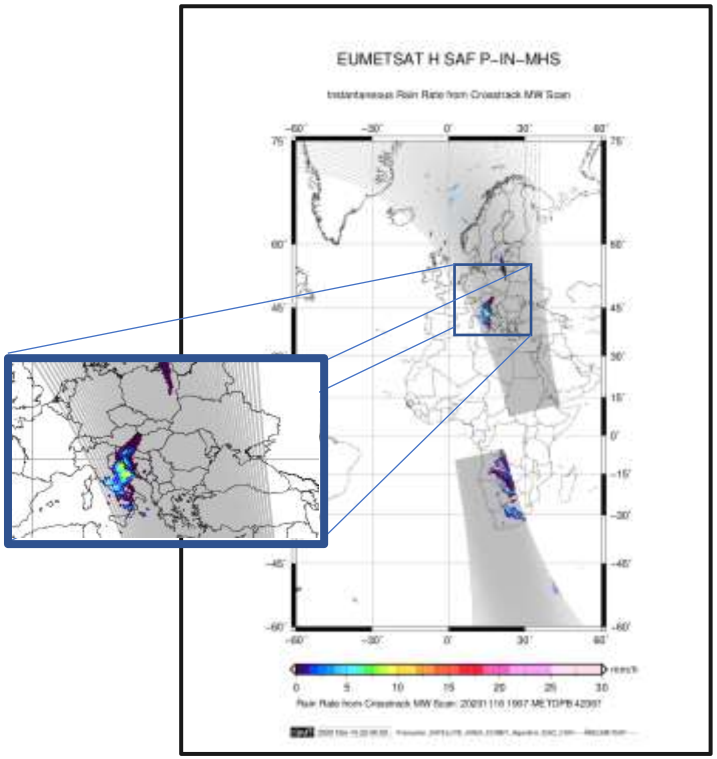
SLOVENSKÝ HYDROMETEOROLOGICKÝ ÚSTAV

EUMETSAT H SAF SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

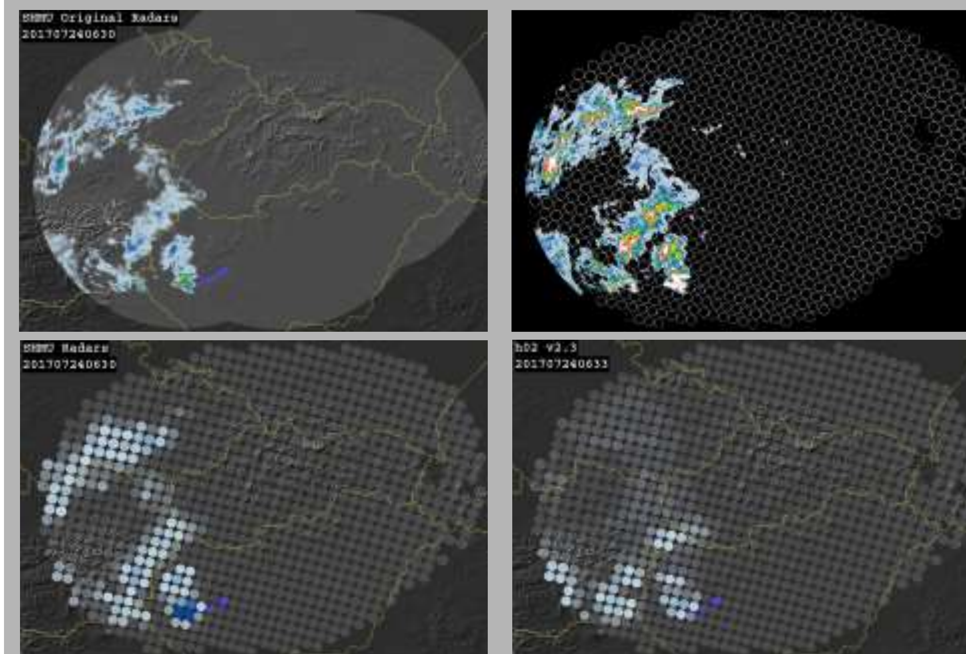
# Quality Assessment activities

## - comparison to ground truth - STEP 2: collect time/space data

Selection of proper satellite overpass and, extract date and time, extract geolocation and product data …




**Comparison pixel by pixel -> statistics, evaluation -> Final validation**



Satellite Precipitation Quality index Longitude Latitude Scan time

↔

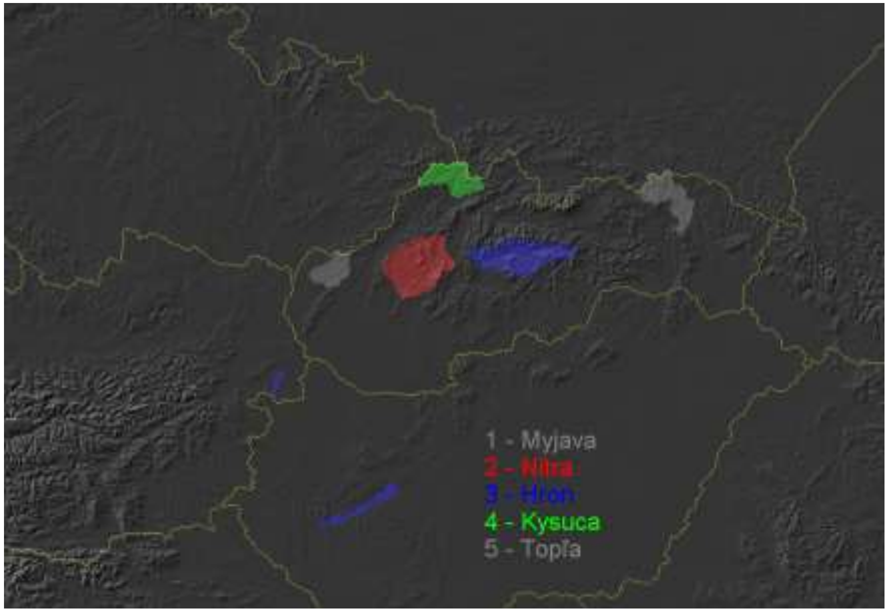
Ground Precipitation Quality index Longitude Latitude Scan Time

# Quality Assessment activities

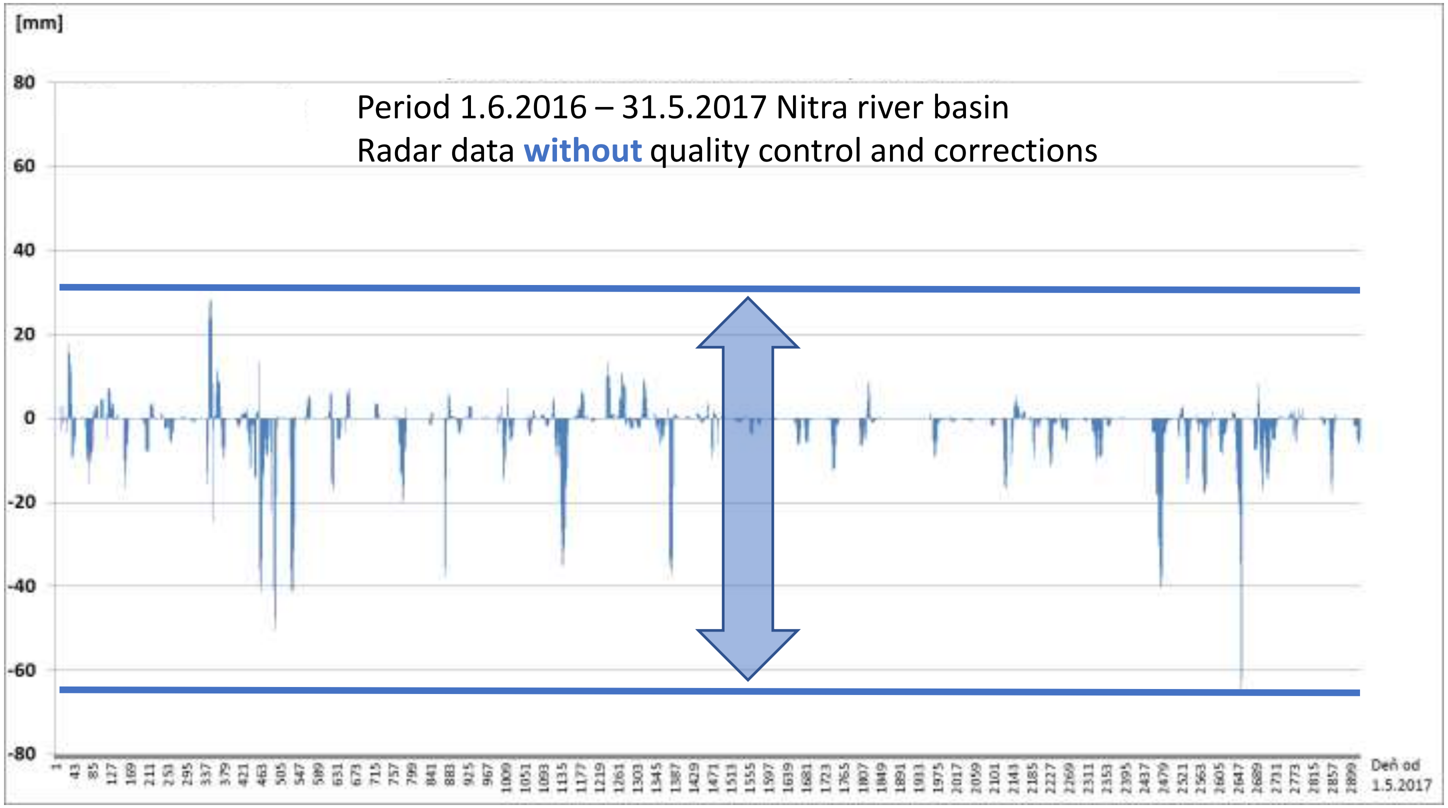
- comparison to ground truth - STEP 2: collect time/space data

More then areal comparison pixel by pixel for hydrologically useful products is:

Instantaneous precipitation sumed into accumulated values and used as «Long time series» processing and fitting satellite versus radar/gauge integrated data:

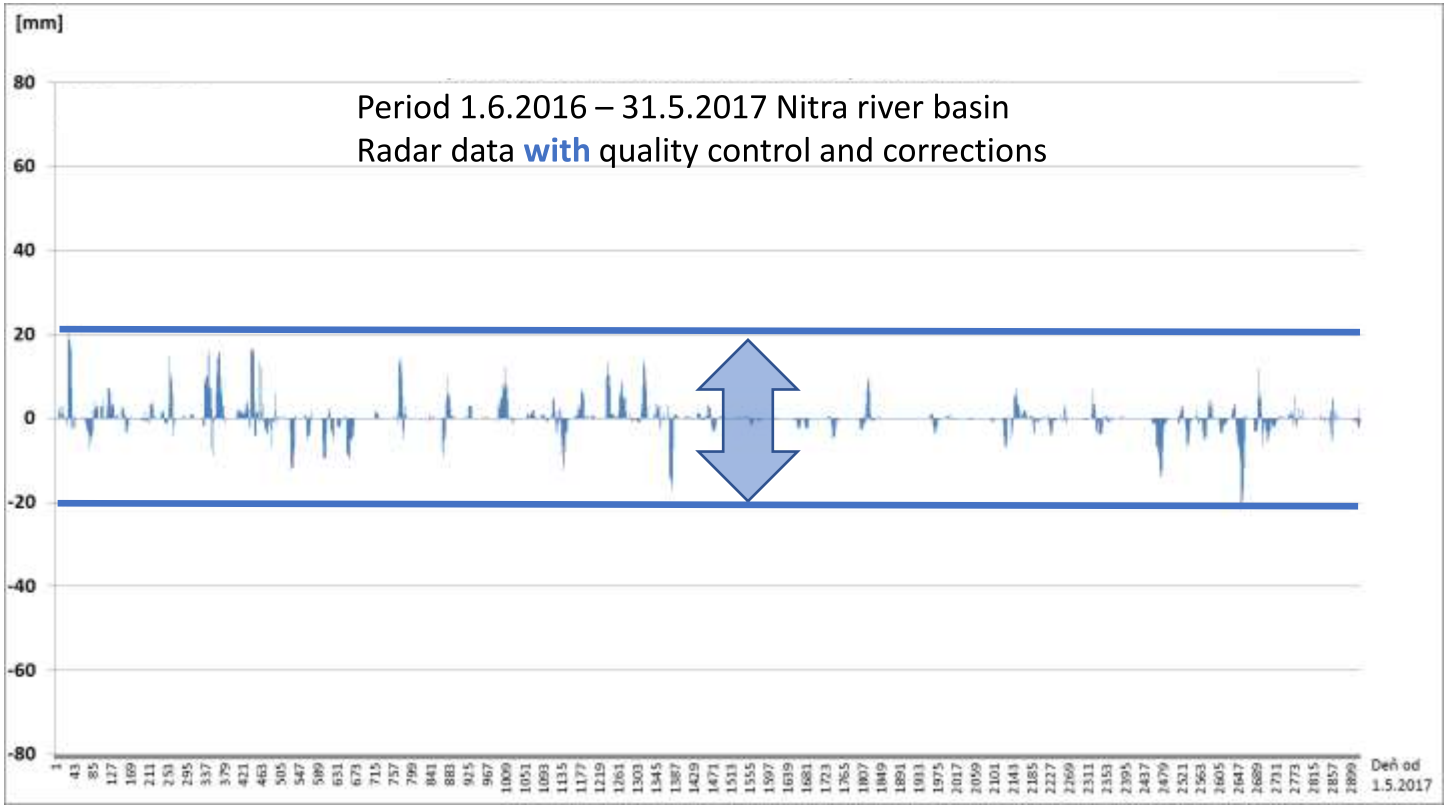


## Work with accumulated precipitation from satellite: How to see the difference between satellite and groud data?



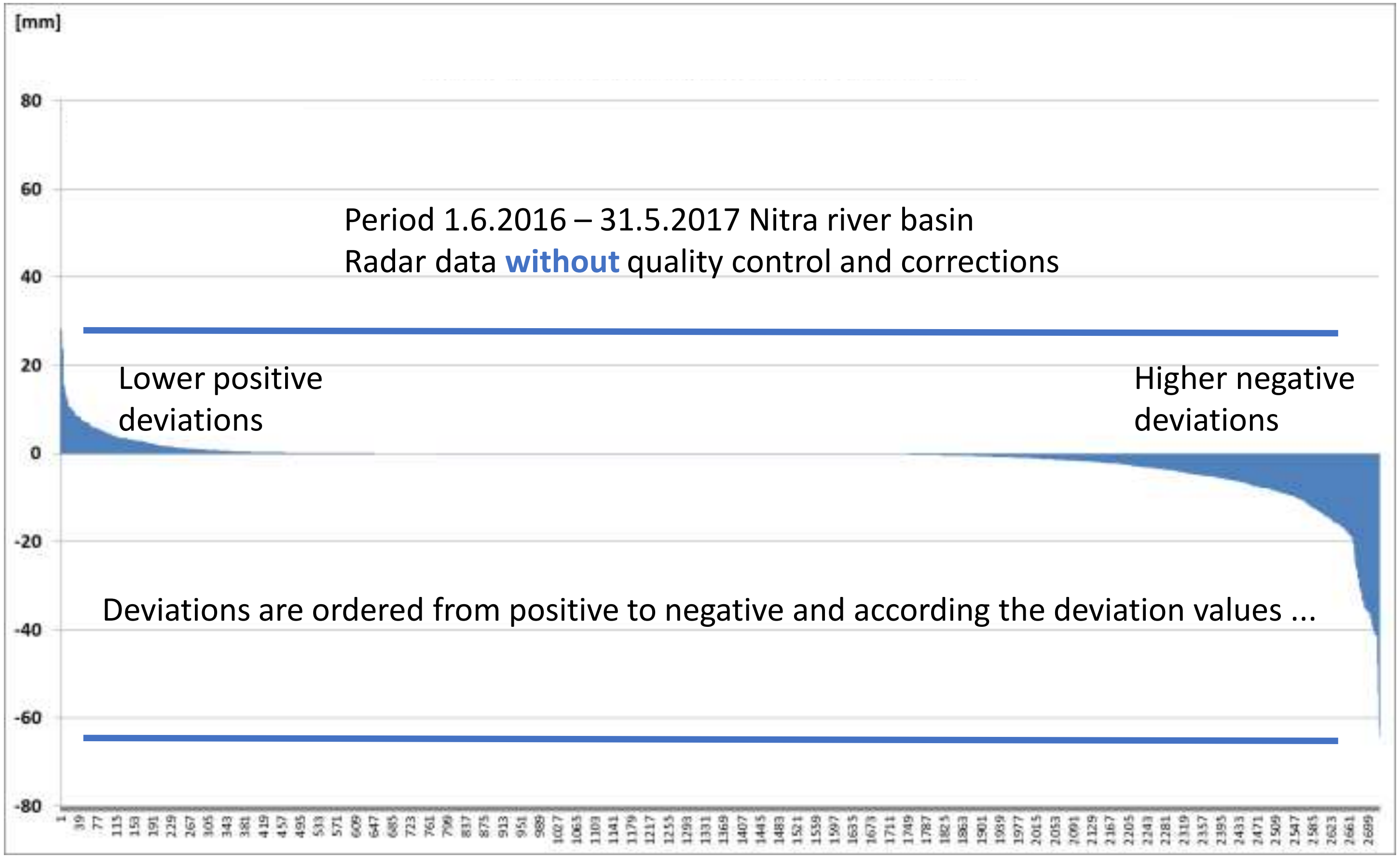

Over versus under – estimation of precipitation by satellite product is shown in this plot for H05 24-hours accumulated precipitation: We observe high under estimation up to -40 to -60 mm per day in few days in 2017 summer season.

## Work with accumulated precipitation from satellite:
## How to see the difference between satellite and groud data?




Over versus under – good agreement between over and under estimation deviations
After the quality control and correction of radar data.

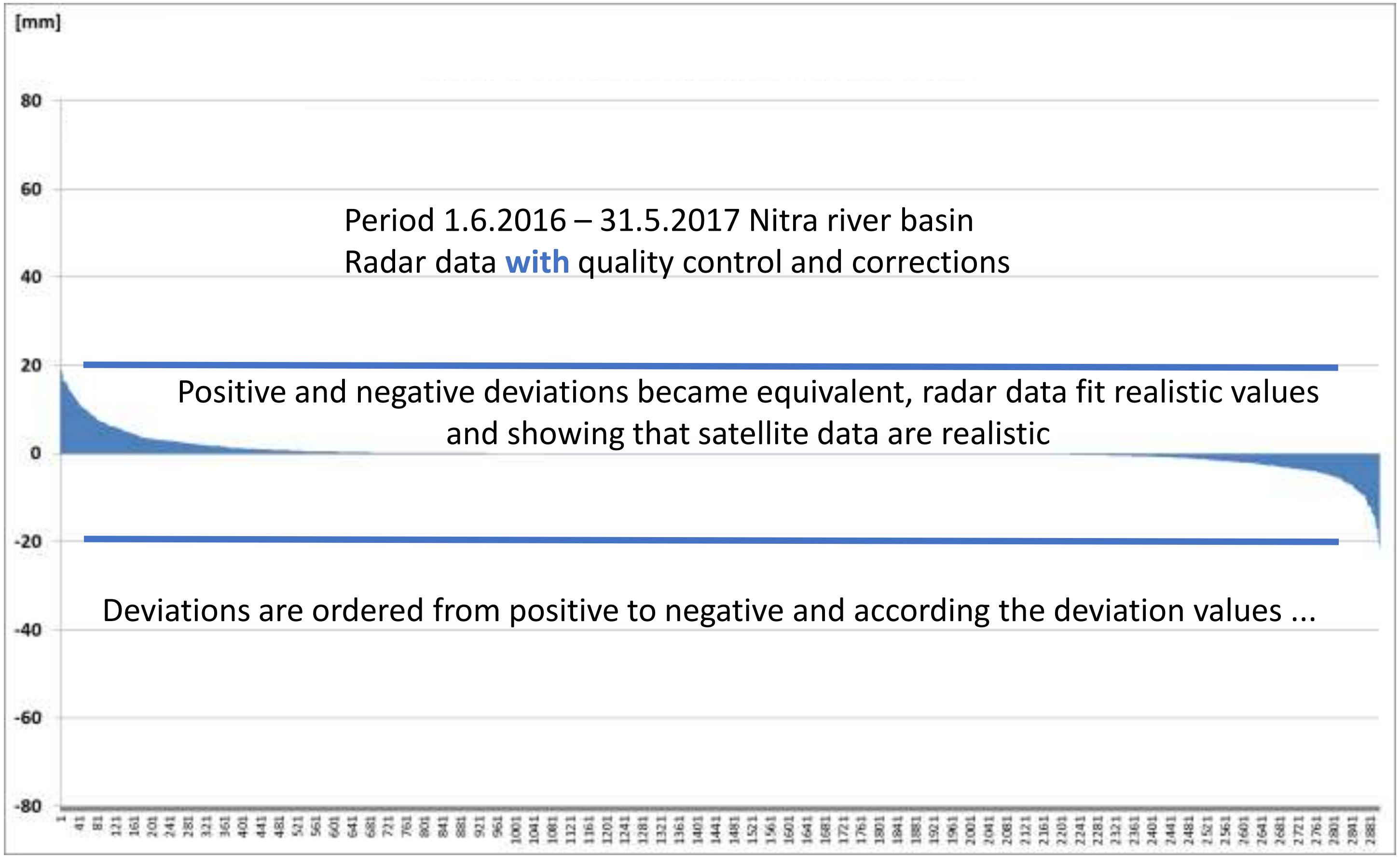
## Work with accumulated precipitation from satellite:
## How to see the difference between satellite and groud data?



SLOVENSKÝ HYDROMETEOROLOGICKÝ ÚSTAV

EUMETSAT H SAF
SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

## Work with accumulated precipitation from satellite:
## How to see the difference between satellite and groud data?

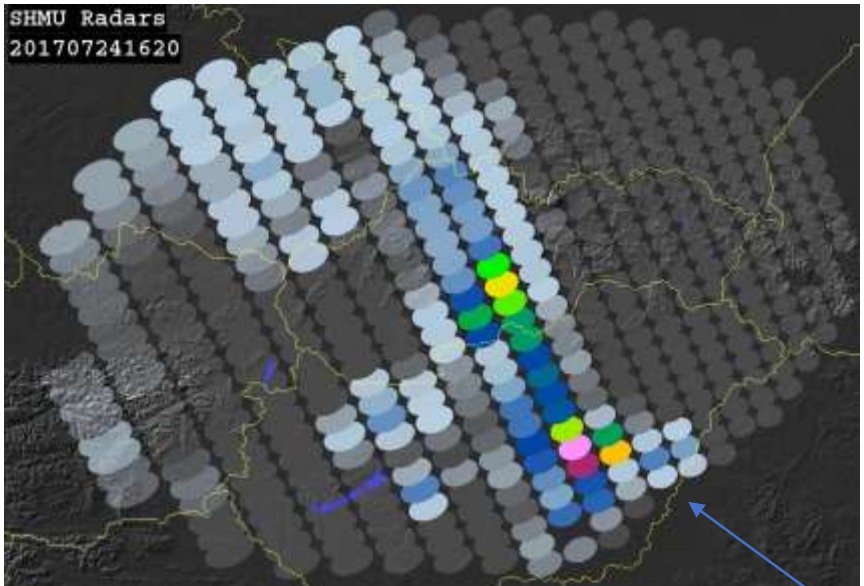


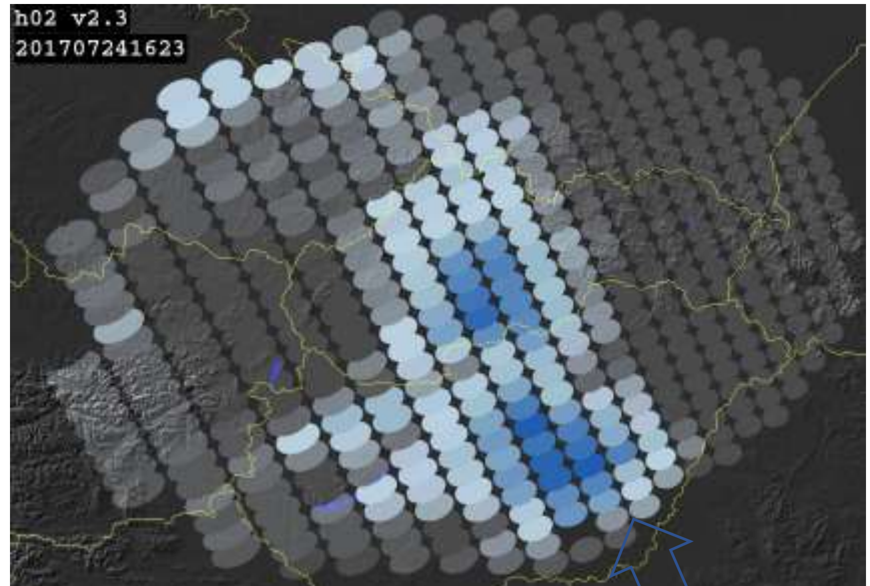
# Quality Assessment activities

- comparison to ground truth - STEP 2: collect time/space data

Using data from the **QRAD Software Package (SHMÚ, created by Ladislav Méri)** for validation we should get more reliable results on the quality of H05 than in the past, when we used radar data from simple merging software that essentially maximized precipitation values at each point where data from more than one radar was available.

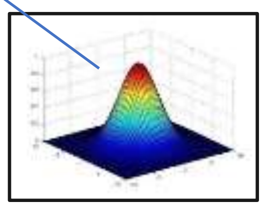
# How to properly overlay satellite and radar data?
## - different resolution, different coverage, different sensitivity of rain signal in FOV

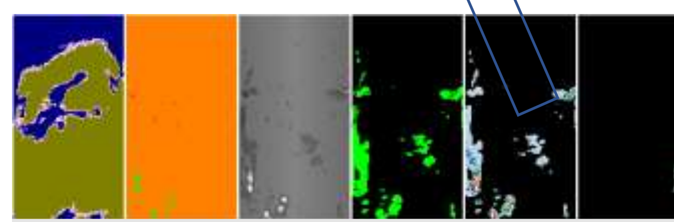



Weighted values of radar pixels

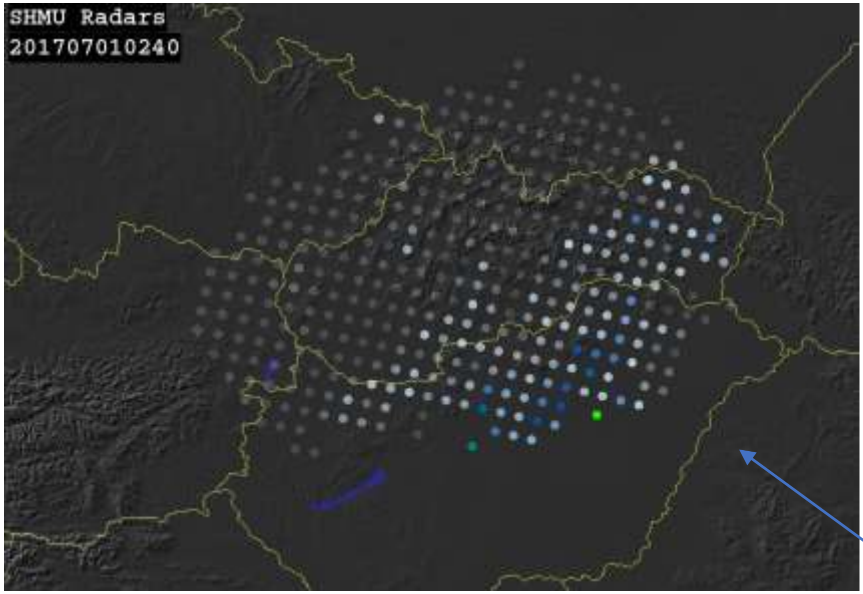
Radar data must be up-scaled to the resolution of satellite grid including signal distribution inside FOV:

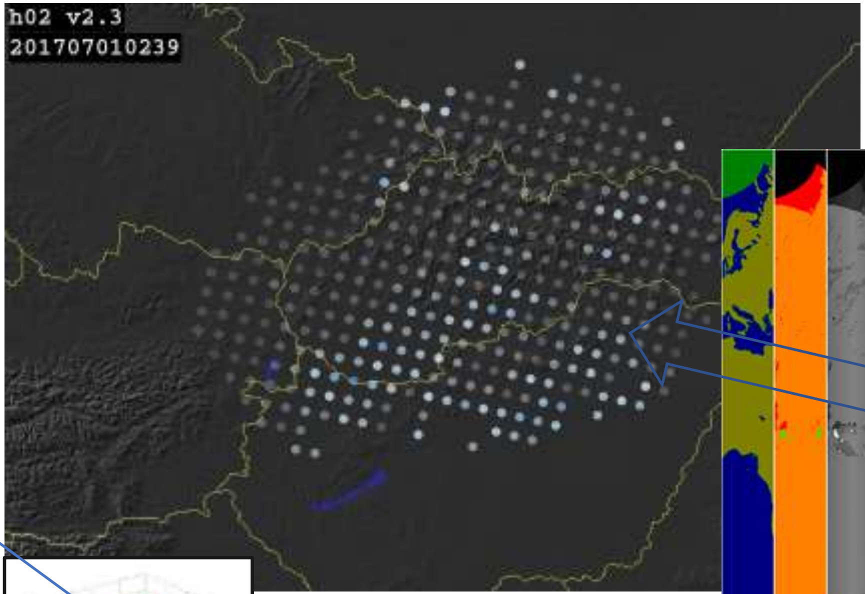


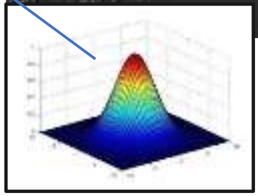


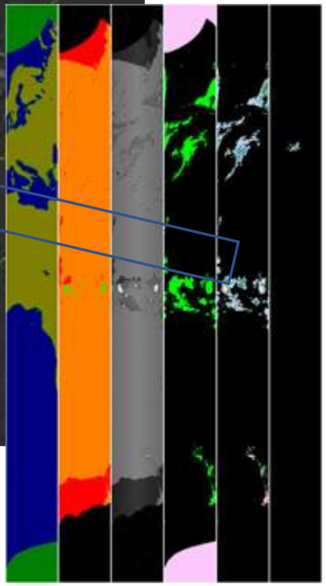
Mask/QI/Conf/Phase/PCP/radar data and QI

# How to properly overlay satellite and radar data?
- different resolution, different coverage, different sensitivity of rain signal in FOV





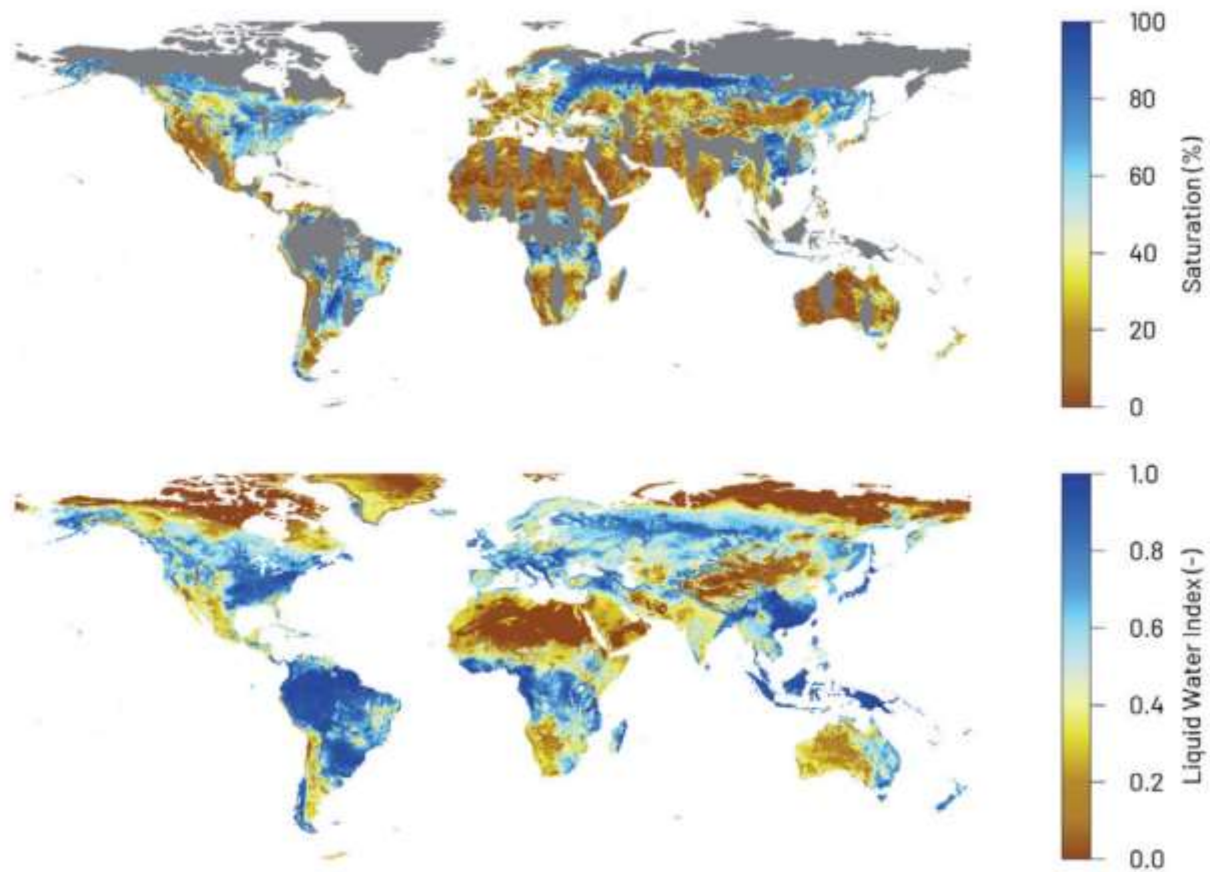
Weighted values of radar pixels

Radar data must be up-scaled to the resolution of Satellite grid including signal distribution inside FOV

Mask/QI/Conf/Phase/PCP/radar data and QI

SLOVENSKÝ HYDROMETEOROLOGICKÝ ÚSTAV

# Soil moisture products: Saturation (upper ) and water index (lower)

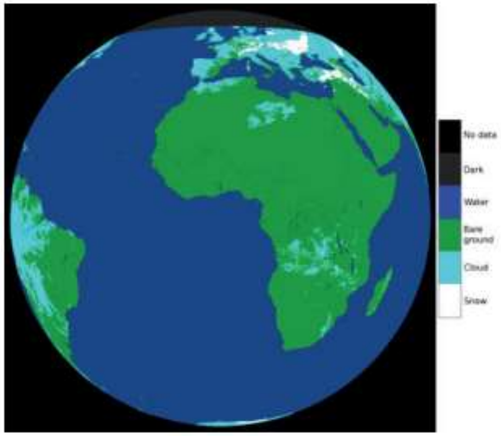



*Example of H16/H101 (top) and H14 (bottom) on 7 May 2019*

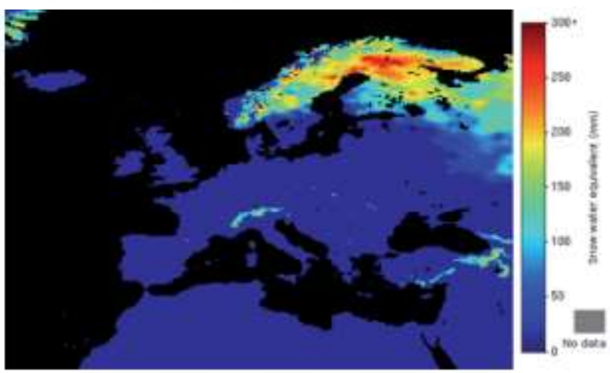
SLOVENSKÝ HYDROMETEOROLOGICKÝ ÚSTAV

EUMETSAT H SAF SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

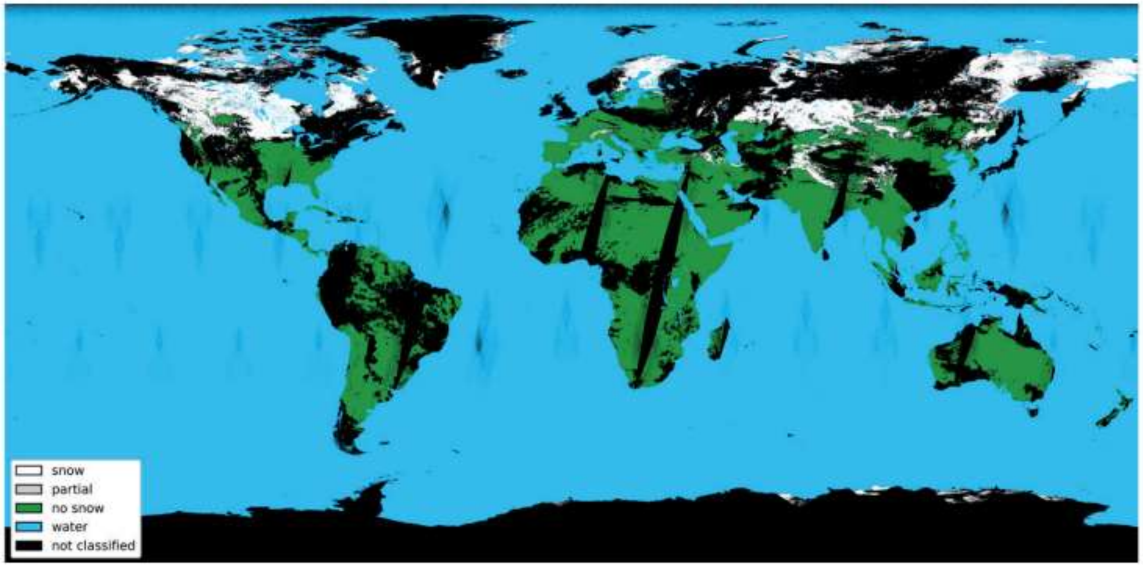
# Snow products: Snow masks (cover) or water content




*H34 product for January 19, 2019*




*H13 product for March 26, 2019*




*H32 product for March 22, 2019*

- Snow mask – visible imagery from GEO satellites
- Water content – microwave signal from land surface

# Case study:

## H05-RG 10 years of data for estimation dry/wet periods over Slovakia and central Europe (July 2012 - June 2022)

Definition of monthly rain characteristics
Processing and preparation of H05A/B (full disk) data
Processing and preparation of SHMÚ/other region raingauge data
Monthly precipitation totals in [mm/month] from H05
Monthly precipitation totals in [mm/month] from Raingauge network
Monthly precipitation 10-years normals in [mm/month] for H05
Monthly precipitation 10-years normals in [mm/month] for RAINGAUGES
Monthly precipitation anomalies according H05: Absolute differences
Monthly precipitation anomalies according RG: Absolute differences
Monthly precipitation anomalies according H05: Relative differences
Monthly precipitation anomalies according RG: Relative differences
Comparison of H05 vs RG: March 2021 Example of dry month
Comparison of H05 vs RG: July 2019 Example of dry month
Comparison of H05 vs RG: June 2022 Example of normal month at west
Comparison of H05 vs RG: April 2022 Example of normal month
Comparison of H05 vs RG: October 2016 Example of wet month
Comparison of H05 vs RG: February 2016 Example of wet month
Evaluation of dry/normal/wet months in 2012-2022 period from H05
Evaluation of dry/normal/wet months in 2012-2022 period from RG
Evaluation of differences between H05 and RG for each month in 2012-2022 period

# Case study background

In the frame of HSAF validation cluster the evaluation of precipitation products is very important task. Validation is based on comparison of satellite data against ground truth (raingauge or radar measurements).

Mainly statistical comparisons of instantaneous precipitation or 24 hour accumulations were performed until nowadays to evaluate HSAF precipitation products quality and performance.

**Aim of this case study is to use long-term accumulated data on monthly basis.**

Maximum 10 years of H05A/B HSAF products is available for this kind of work – operationally generated and archived data are covering the period from July 2012 until nowadays.

**What we need to estimate is DRY/NORMAL/WET period in following way:**

- Monthly accumulated precipitation (monthly totals) in mm per month (120 months)
- Monthly long-term normals, e.g. 10-years averaged accumulated precipitation for each month of the year
- Calculation of monthly anomalies (difference between monthly accumulated precipitation and monthly long-term normal
- Evaluation of monthly anomalies according DRY/NORMAL/WET classification table

# Definition of monthly rain characteristics

We re-used the table routinely used by the Climatological Service of SHMÚ.
This table defines 7 classes of rain characteristics:

| Definition: | *for month* | *for the season* |
|---|---|---|
| EXTREMELY DRY | below 10 % | below 60 % |
| VERY DRY | 10 - 49 % | 60 - 79 % |
| DRY | 50 - 79 % | 80 - 89 % |
| NORMAL | 80 - 120 % | 90 - 110 % |
| WET | 121 - 150 % | 111 - 120 % |
| VERY MOIST | 151 - 190 % | 121 - 140 % |
| EXTREMELY MOIST | above 190 % | above 140 % |

For our purposes in final evaluation we reduced number of classes to simplify our results:

DRY (includes EXTREMELY DRY and VERY DRY classes)
NORMAL (includes DRY, NORMAL and WET classes)
WET (includes VERY MOIST and EXTREMELY MOIST classes)

**NOTE: In this case study we evaluate rain characteristics only on monthly basis. For evaluation of the seasons we need to prepare more general processing software and we plan to do it in near future.**

# Processing and preparation of H05A/B data

H05A/B data we downloaded from HSAF FTP-server, where all precipitation products are archived:

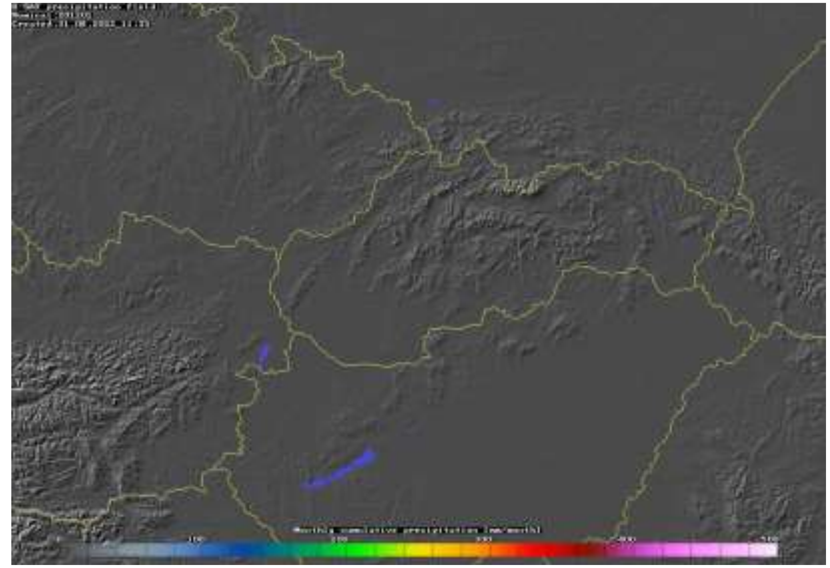
- H05A is covering the period from July 2012 to May 2015
- H05B is covering the period from June 2015 to July 2022

**In overlapping period after May 2015 we used merging principle of H05A/B with priority set to B product.**
**In this way we reached availability of data 100% for 102 months from overall 120 months and averaged availability 96.75% for this 2012-2022 10-years period.**

This availability is in compliance with EUMETSAT standards of overall satellite data availability.

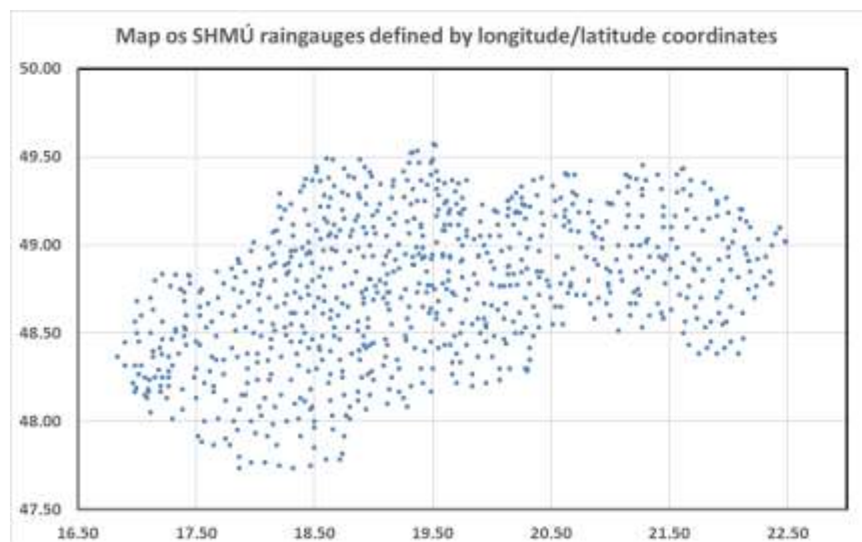
# Processing and preparation of SHMÚ raingauge data

Raingauge data are collected at SHMÚ and controlled by our Climatological department on monthly basis. We received and worked with quality checked and interpolated raingauge data over Slovak territory as monthly totals in mm/month.
Interpolation method includes the influence of 500m orography to rain distribution.
**NOTE: H05 product does not contain such kind of correction.**



Orography of Slovakia: lowlands and mountains

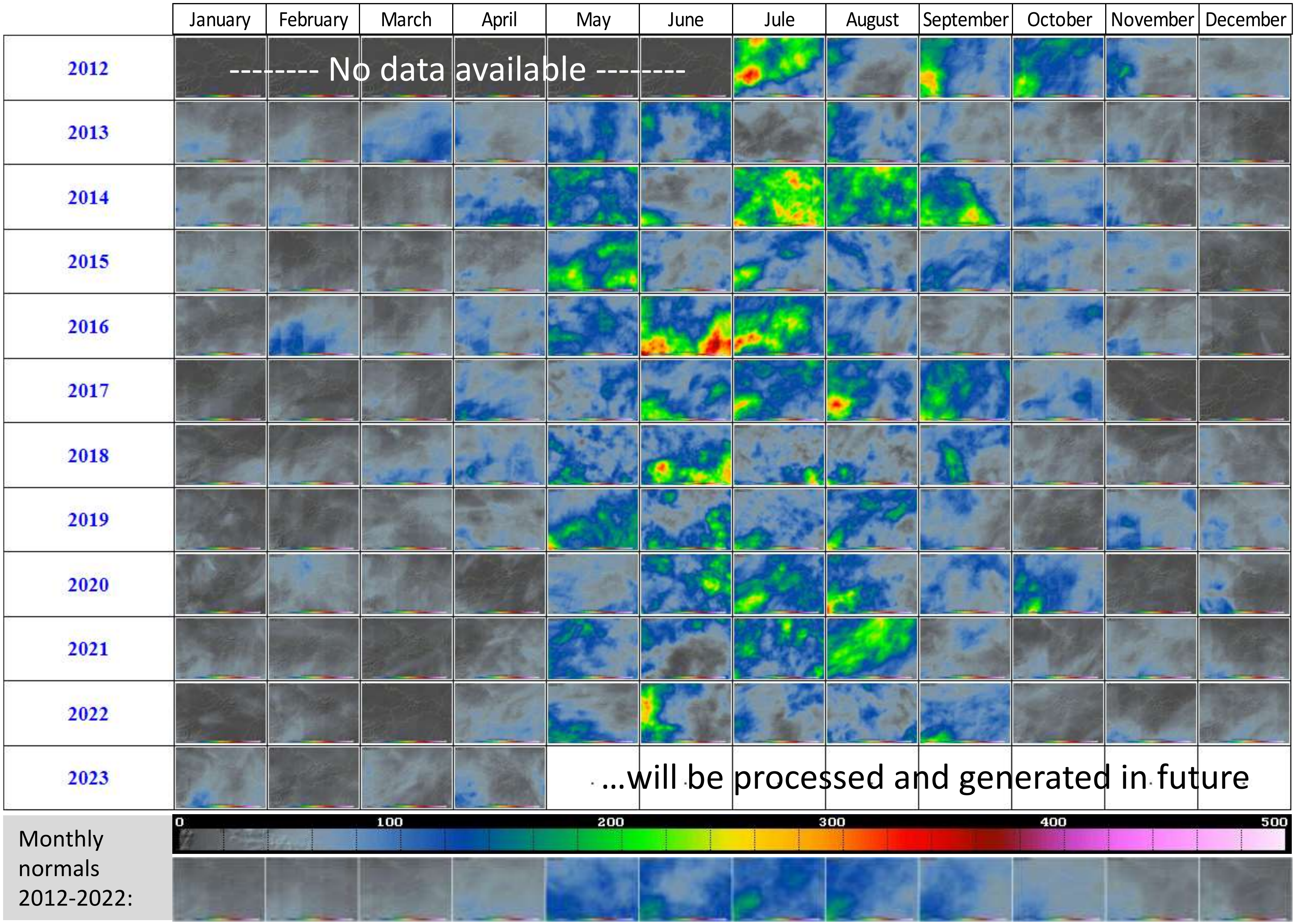
Raingauge data stored in GIS system were extracted together with lat/lon coordinates and re-projected/upscaled to common grid (Mercator projection) with satellite and raingauge data in resolution of 1x1km$^2$.




Database of SHMÚ raingauge data contains 830 single measurement points.

# Monthly precipitation totals in [mm/month] H05:

Summing 24h H05 accumulations to obtain monthly sums; summing single months 2012+…+2022 and calculating the average we received monthly normals (last line):



# Monthly precipitation 10-years normals in [mm/month] for H05:

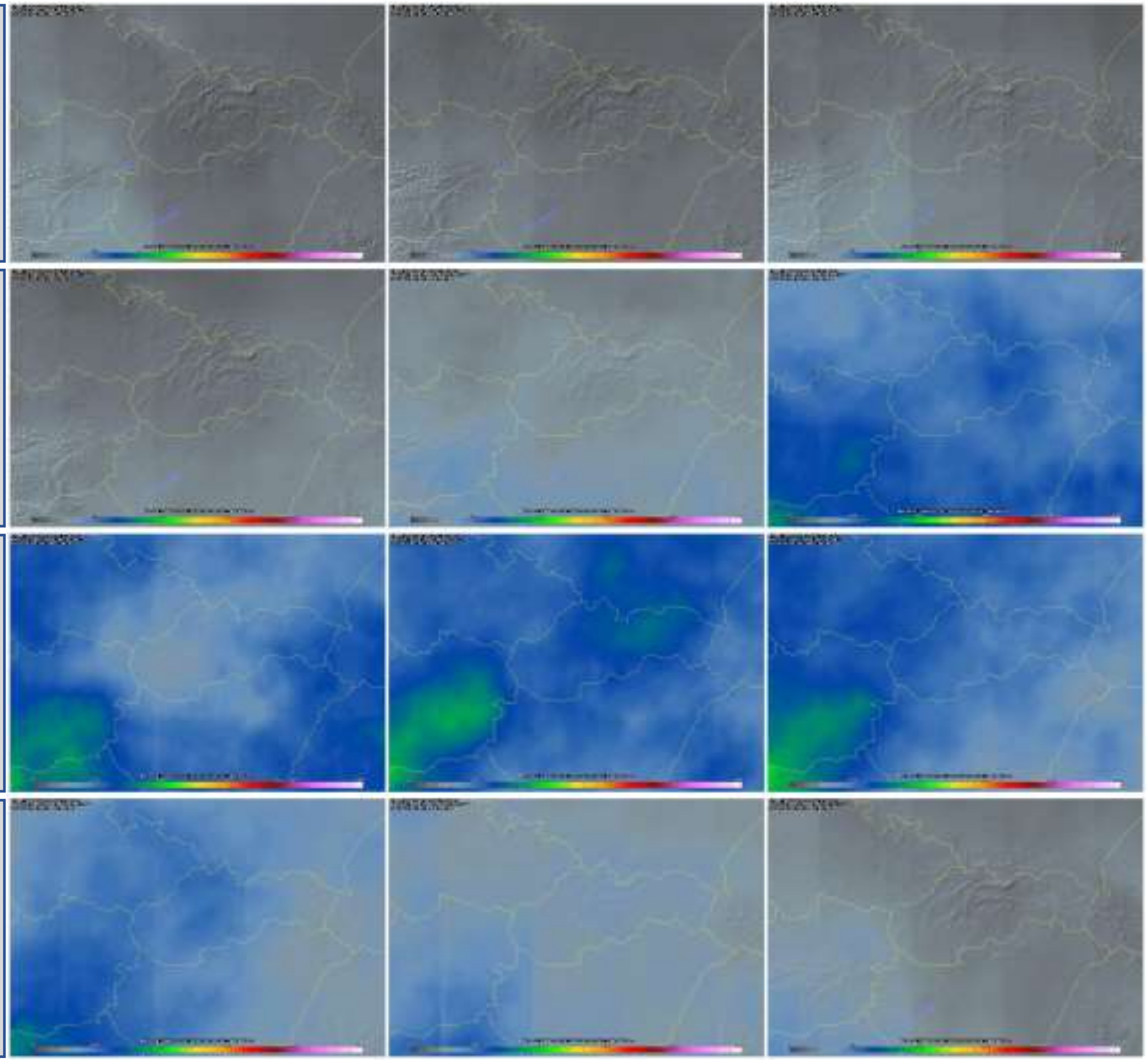
EUMETSAT H SAF
SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

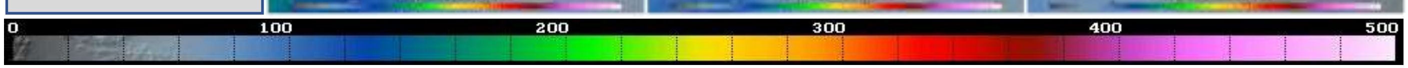
Winter: December January February

Spring: March April May

Summer: June July August

Autumn: September October November

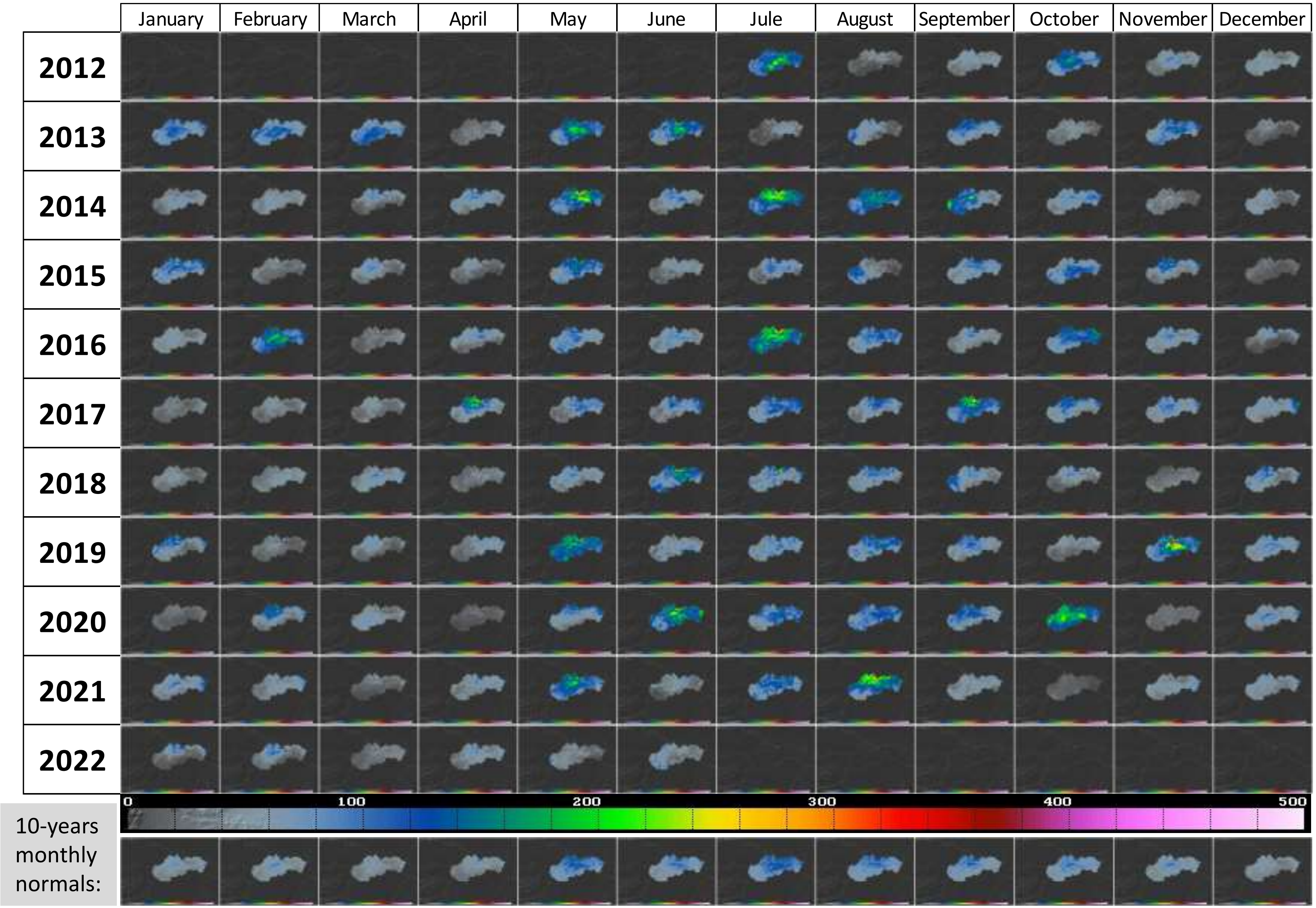





Summing single months 2012+…+2022 and calculating the average we received 10-years monthly normals. **NOTE: All area is covered by satellite data.**

# Monthly precipitation totals in [mm/month] RG:

Summing 24h RG accumulations to obtain monthly sums; summing single months 2012+…+2022 and calculating the average we received similar monthly normals:



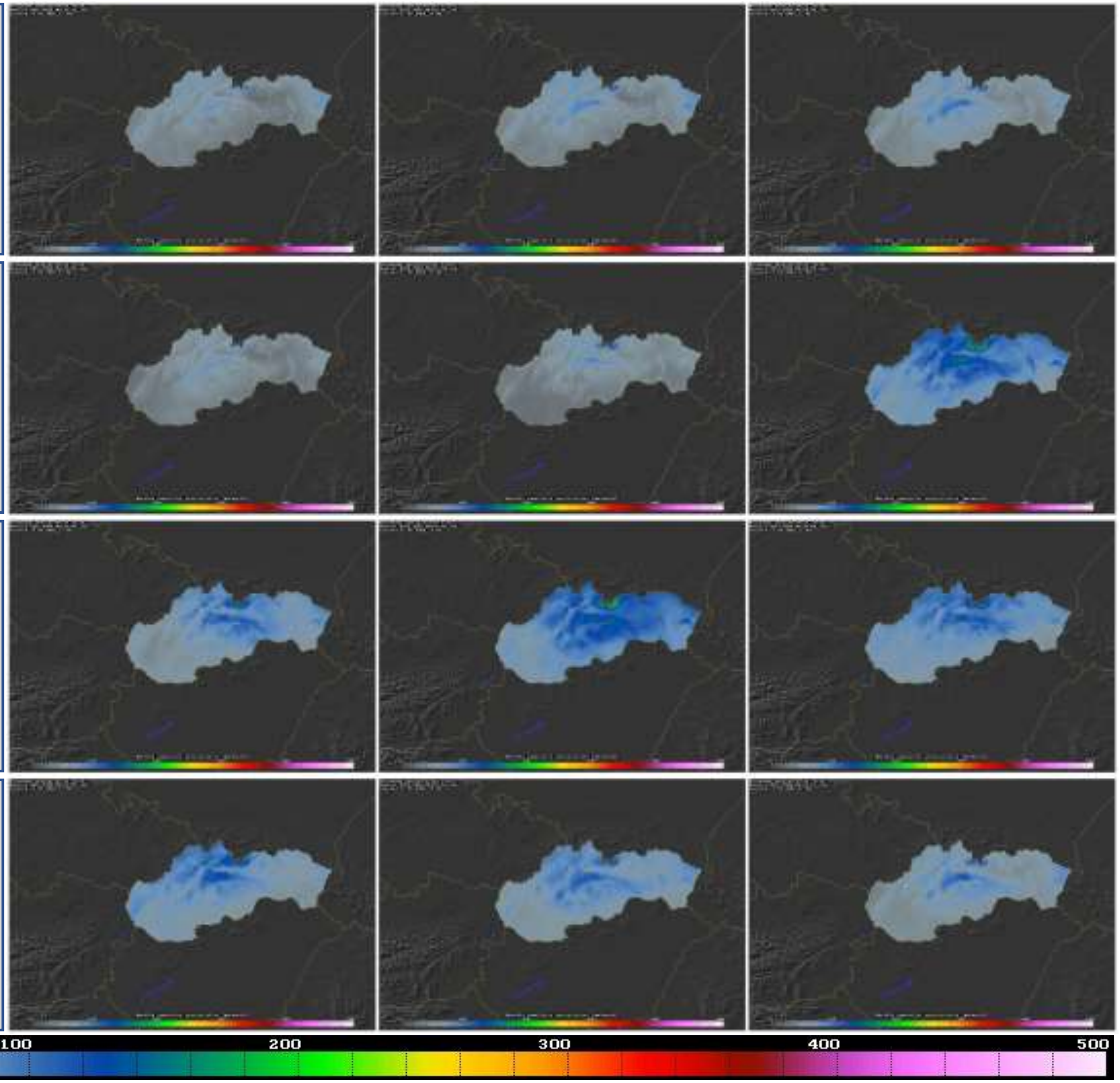
# Monthly precipitation 10-years normals in [mm/month] for RAINGAUGES:

Winter:
December
January
February

Spring:
March
April
May

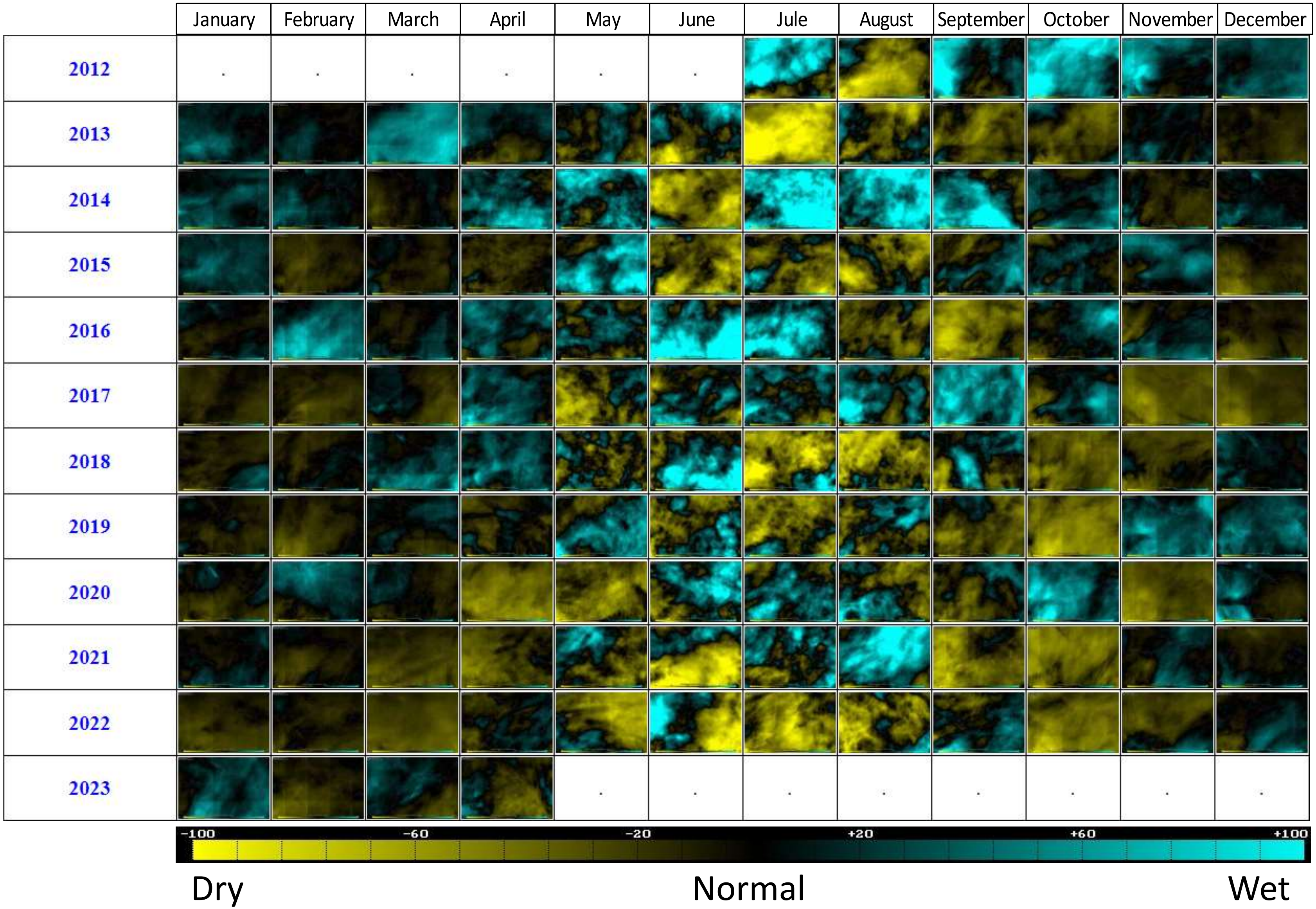
Summer:
June
July
August

Autumn:
September
October
November

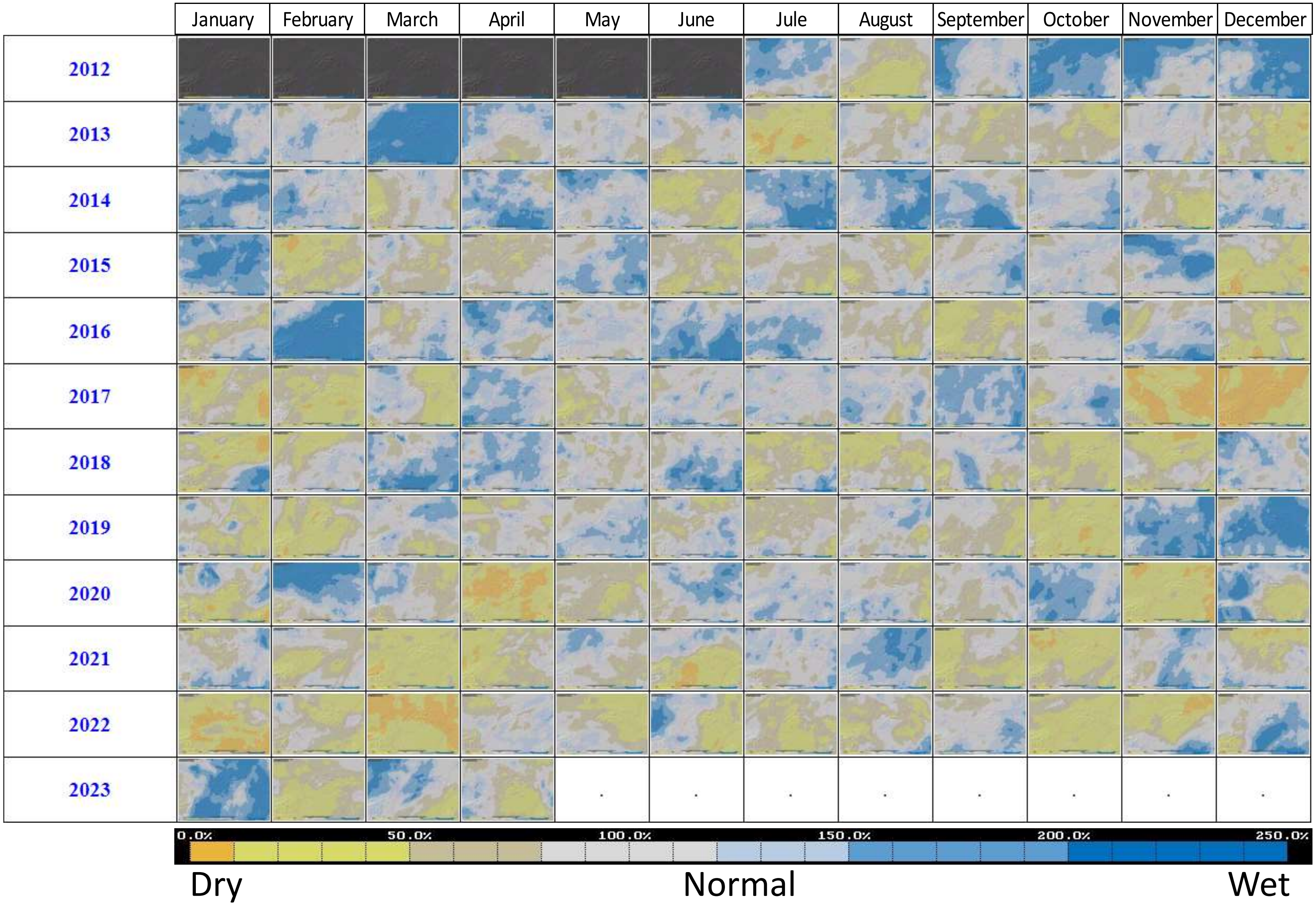



Summing single months 2012+…+2022 and calculating the average we received 10-years monthly normals. **NOTE: Only area of Slovakia is covered by RG data.**

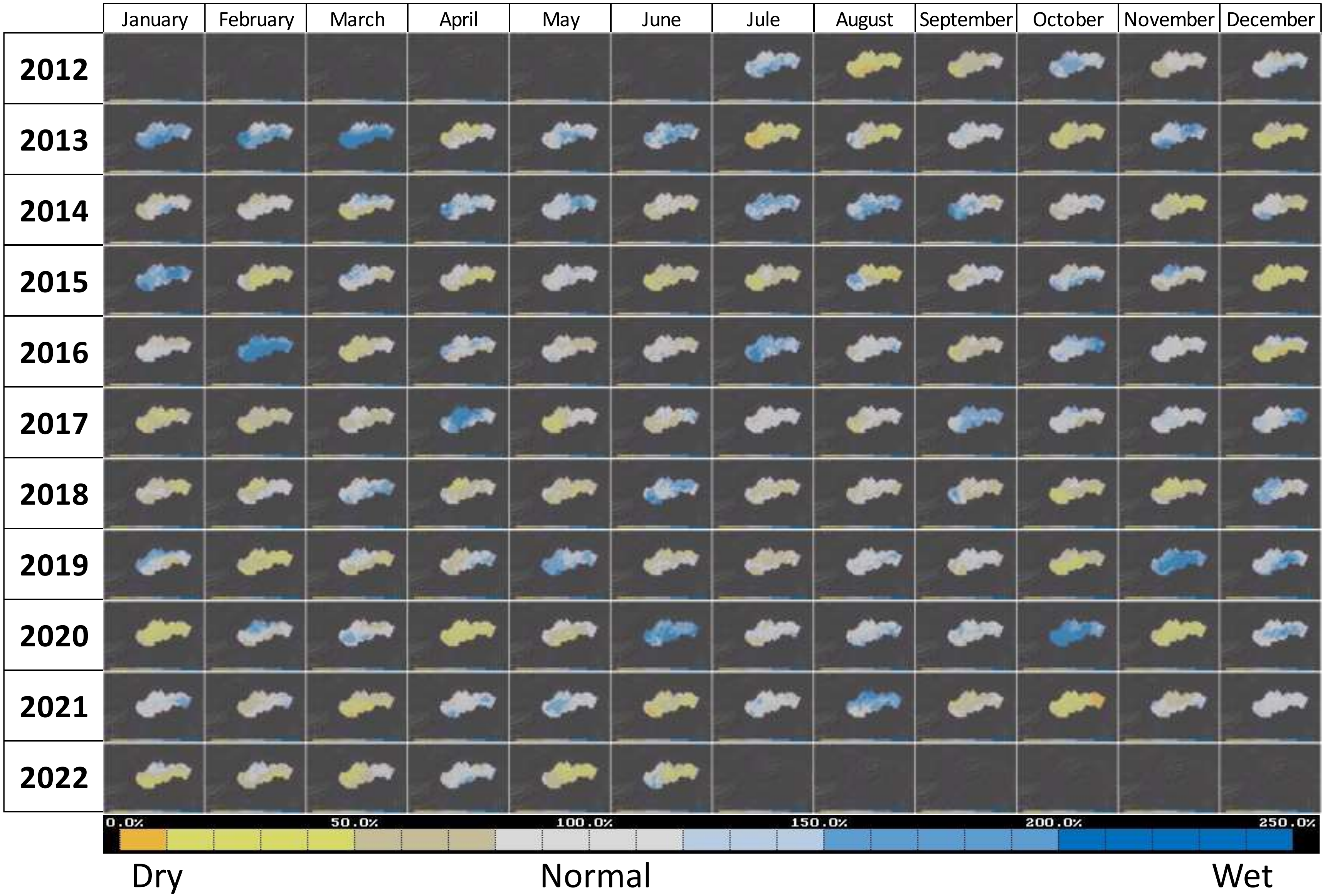
# Monthly precipitation anomalies according H05:
## Absolute differences in [mm/month] of monthly sums



# Monthly precipitation anomalies according H05: Relative differences in [%] of monthly sums

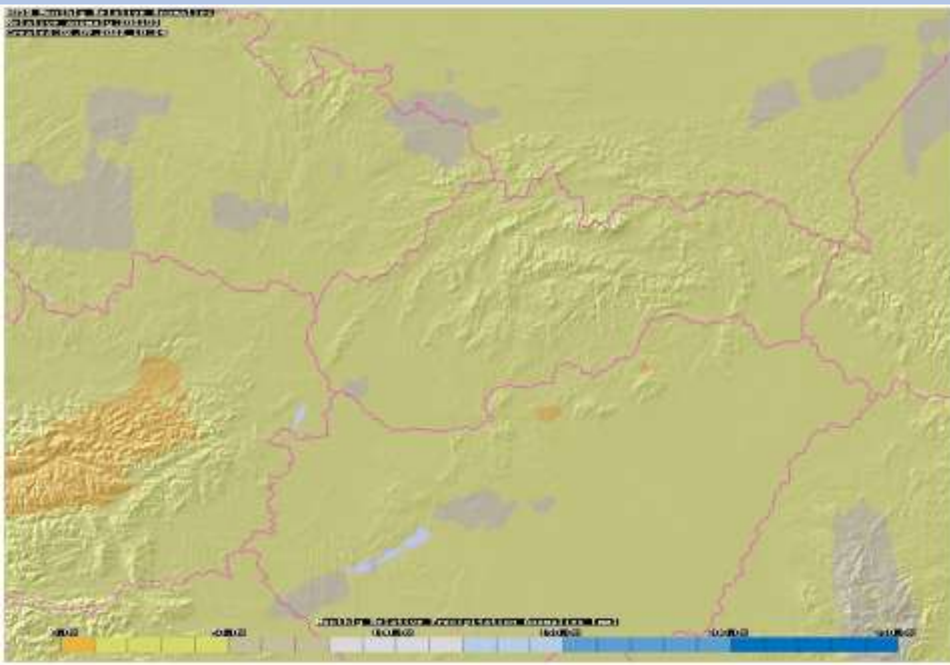


# Monthly precipitation anomalies according RG: Relative differences in [%] of monthly sums

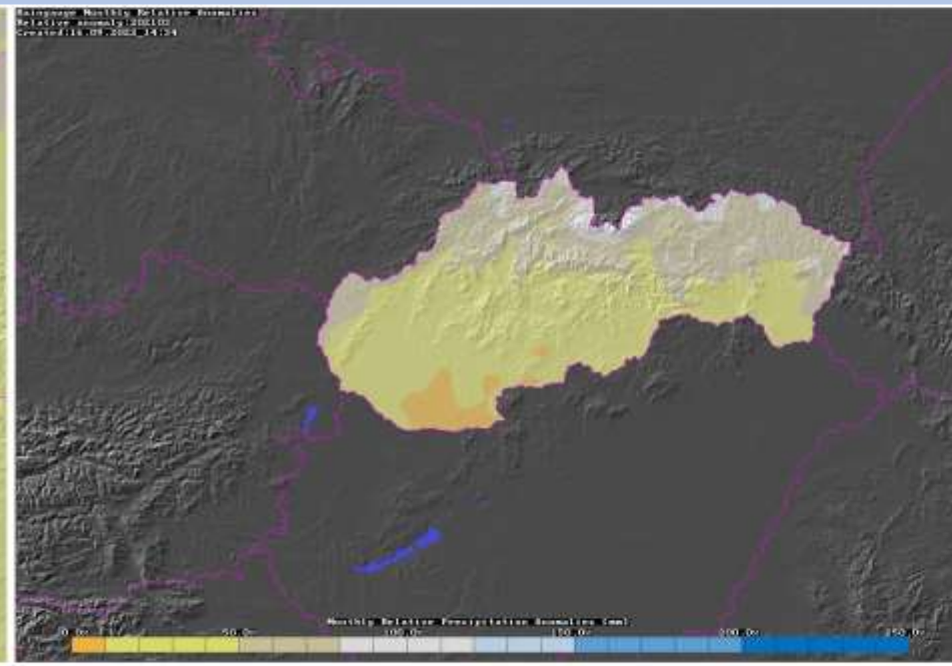


# Comparison of H05 vs RG:
# March 2021 Example of dry month

Anomalies derived from H05 product:



Anomalies derived from Raingauge network:



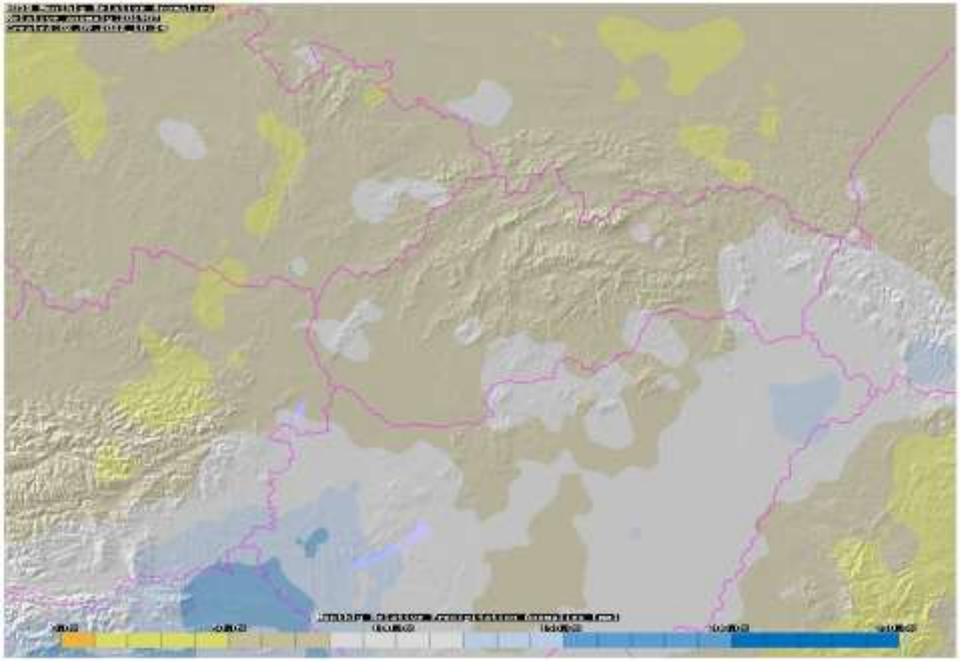
Results of comparison:

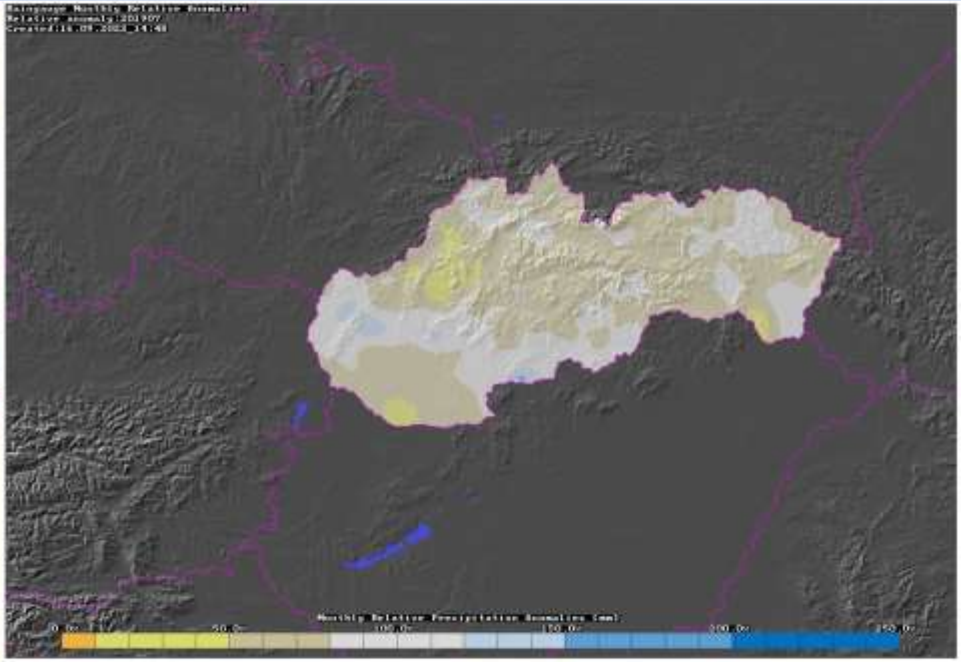
| Month | Source | DRY | NORMAL | WET |
|---|---|---|---|---|
| 202103 | H05 | 99.4% | 0.6% | 0.0% |
| | RG | 60.5% | 39.5% | 0.0% |

Table shows the percentage of DRY, NORMAL and WET pixels over Slovak territory

# Comparison of H05 vs RG:
# July 2019 Example of normal month

| Anomalies derived from H05 product: | Anomalies derived from Raingauge network: |
|---|---|





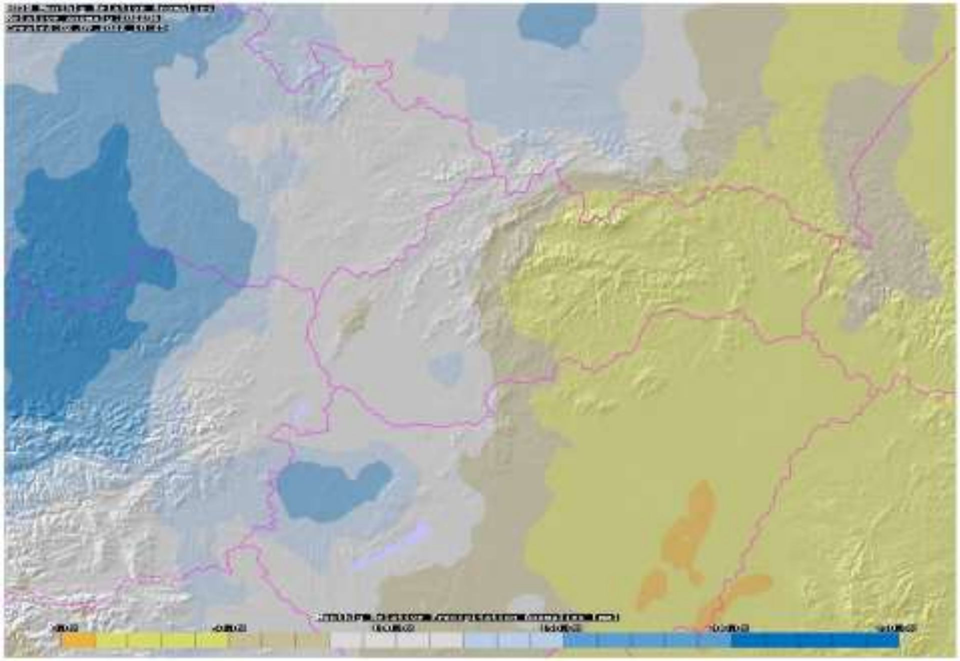
Results of comparison:

| Month | Source | DRY | NORMAL | WET |
|---|---|---|---|---|
| 201907 | H05 | 0.0% | 100.0% | 0.0% |
| | RG | 4.4% | 95.5% | 0.0% |

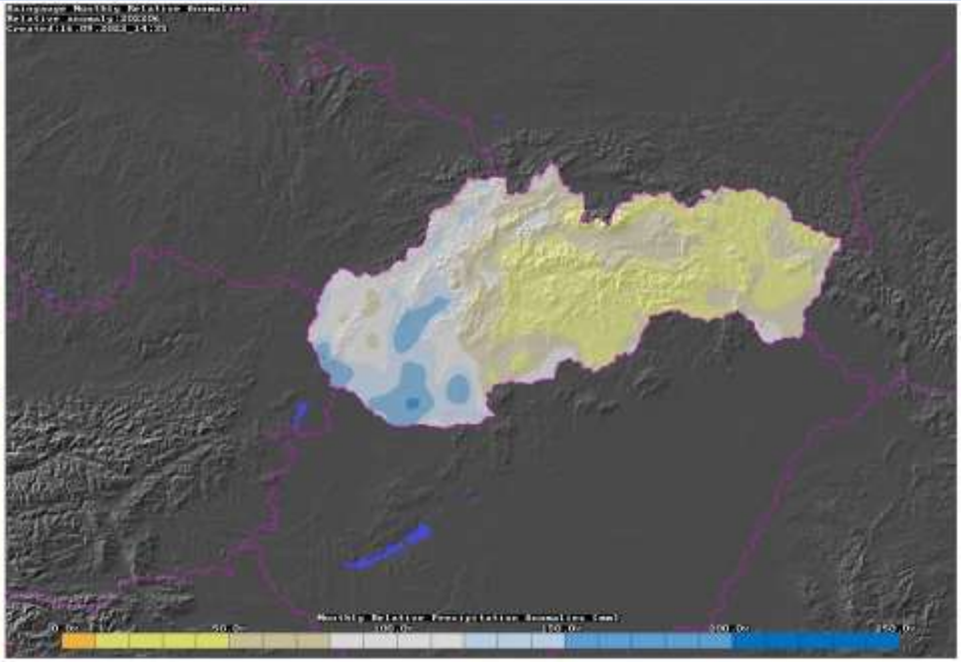
Table shows the percentage of DRY, NORMAL and WET pixels over Slovak territory

# Comparison of H05 vs RG:
# June 2022 Example of dry month
# (normal in west, dry in east Slovakia

Anomalies derived from H05 product:



Anomalies derived from Raingauge network:



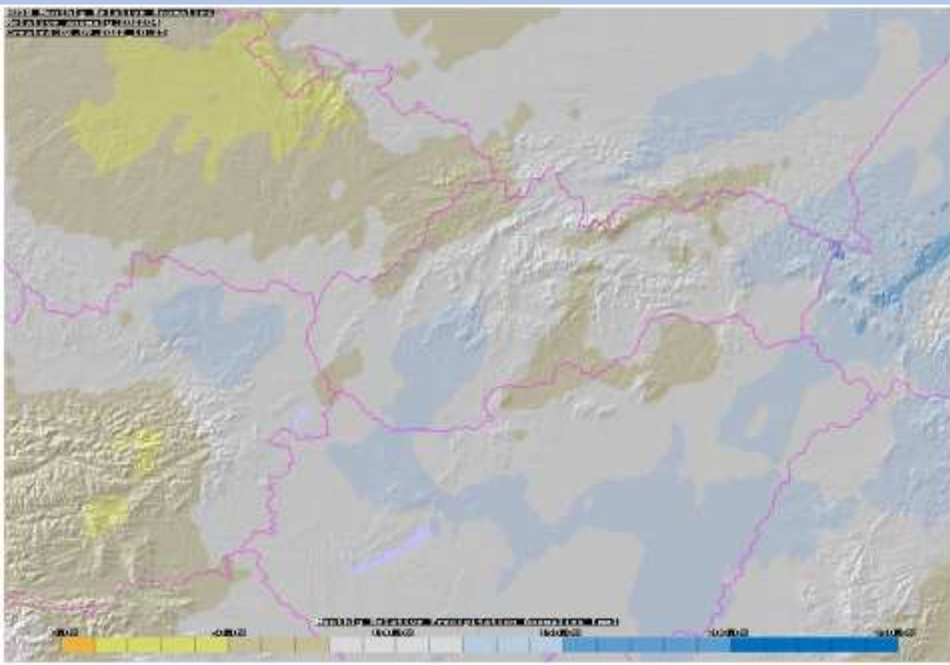
Results of comparison:

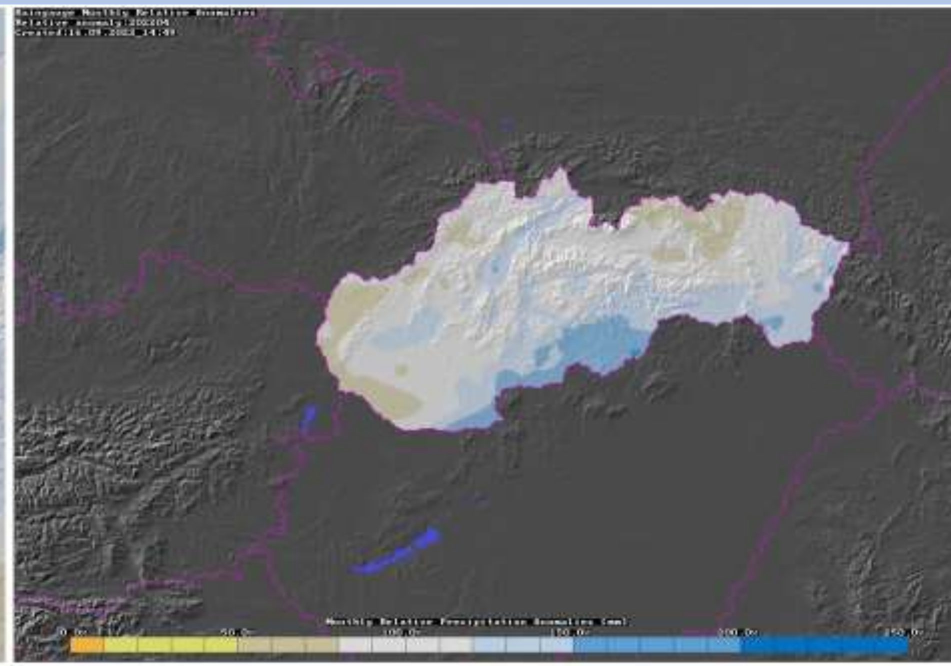
| Month | Source | DRY | NORMAL | WET |
|---|---|---|---|---|
| 202206 | H05 | 50.2% | 49.8% | 0.0% |
| | RG | 74.9% | 25.1% | 0.0% |

Table shows the percentage of DRY, NORMAL and WET pixels over Slovak territory

# Comparison of H05 vs RG:
# April 2022 Example of normal month

Anomalies derived from H05 product: Anomalies derived from Raingauge network:





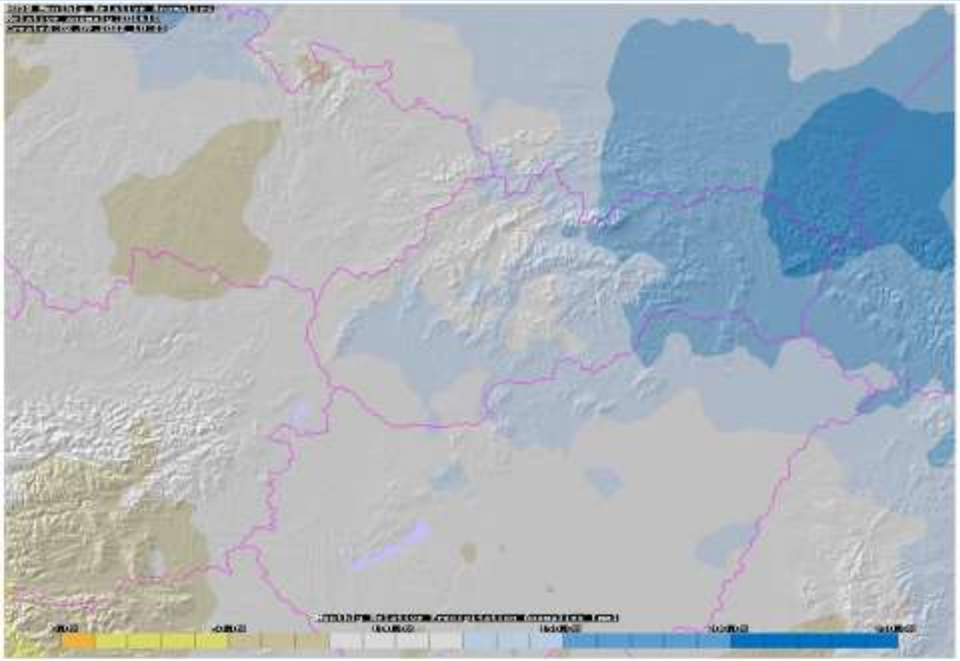
Results of comparison:

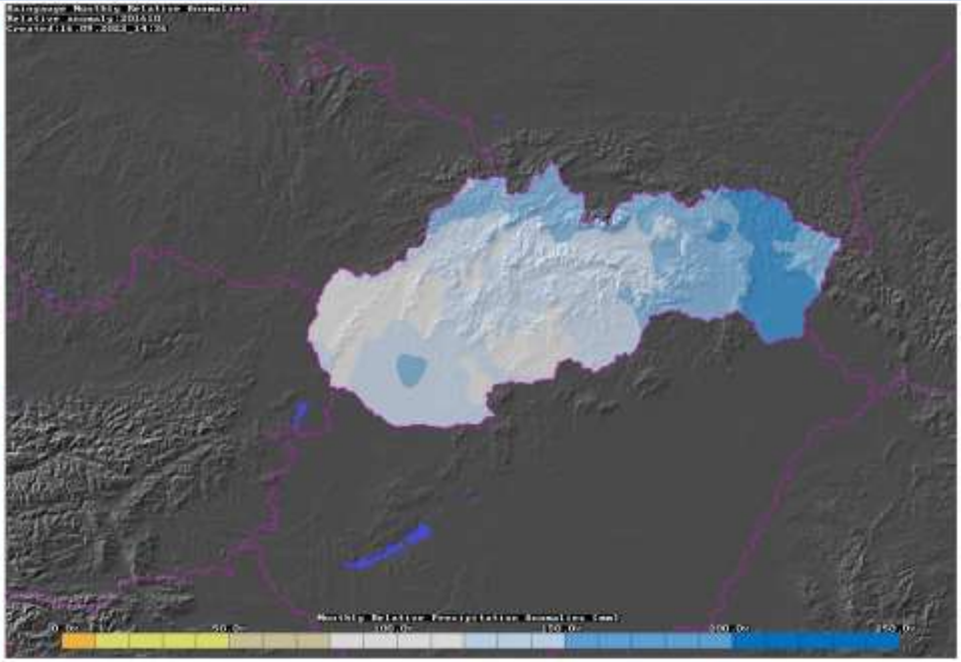
| Month | Source | DRY | NORMAL | WET |
|---|---|---|---|---|
| 202204 | H05 | 0.0% | 99.9% | 0.1% |
| | RG | 0.0% | 92.1% | 7.9% |

Table shows the percentage of DRY, NORMAL and WET pixels over Slovak territory

# Comparison of H05 vs RG:
# October 2016 Example of wet month

Anomalies derived from H05 product: Anomalies derived from Raingauge network:





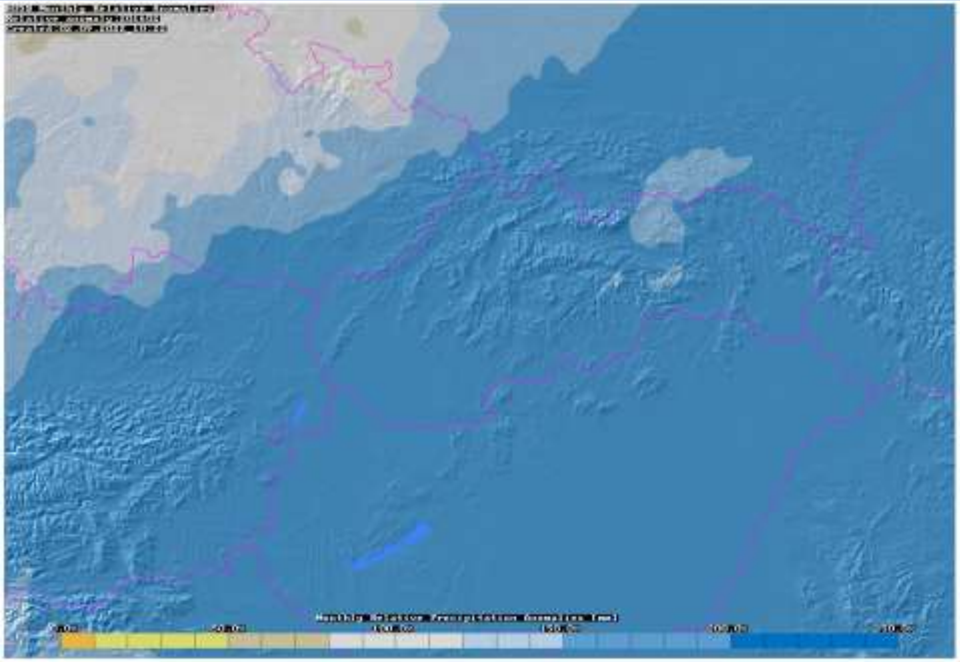
Results of comparison:

| Month | Source | DRY | NORMAL | WET |
|---|---|---|---|---|
| 201610 | H05 | 0.0% | 68.9% | 31.1% |
| | RG | 0.0% | 63.8% | 36.2% |

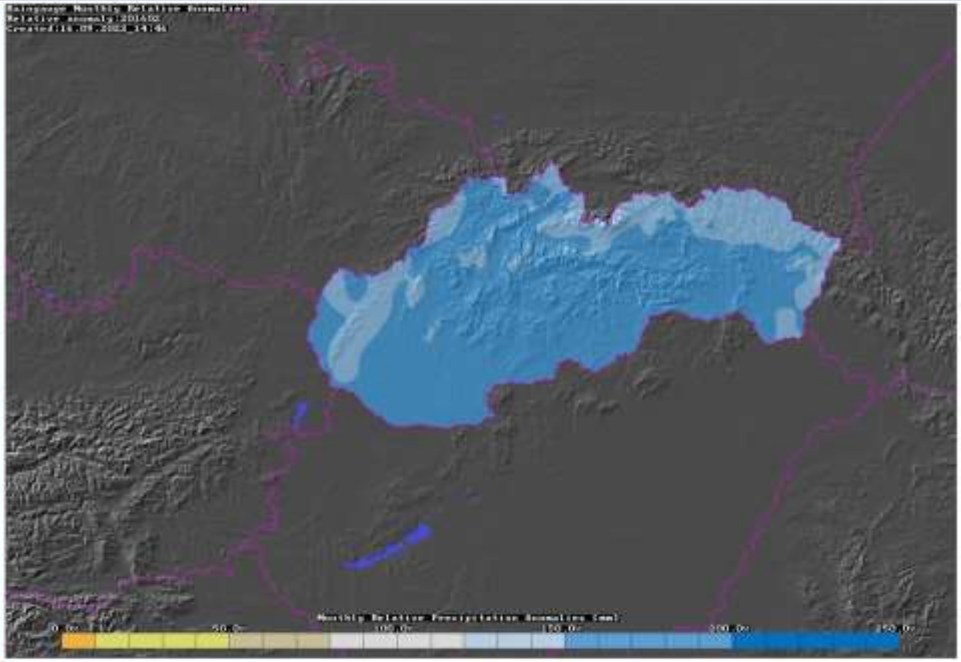
Table shows the percentage of DRY, NORMAL and WET pixels over Slovak territory

# Comparison of H05 vs RG:
# February 2016 Example of wet month

Anomalies derived from H05 product:



Anomalies derived from Raingauge network:



Results of comparison:

| Month | Source | DRY | NORMAL | WET |
|---|---|---|---|---|
| 201602 | H05 | 0.0% | 0.0% | 100.0% |
| | RG | 0.0% | 0.0% | 100.0% |

Table shows the percentage of DRY, NORMAL and WET pixels over Slovak territory

# Evaluation of dry/normal/wet months in 2012-2022 period

Evaluation according H05 processed data:

| Month/Year | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | nodata | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 1 |
| February | nodata | 2 | 2 | 2 | 3 | 1 | 2 | 1 | 3 | 2 | 1 |
| March | nodata | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 |
| April | nodata | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 1 | 2 | 2 |
| May | nodata | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 |
| June | | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 3 | 1 | 1 |
| July | 3 | 1 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 |
| August | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | nodata |
| September | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | nodata |
| October | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 3 | 1 | nodata |
| November | 2 | 2 | 2 | 3 | 2 | 1 | 1 | 3 | 1 | 2 | nodata |
| December | 3 | 1 | 2 | 2 | 2 | 1 | 2 | 3 | 2 | 2 | nodata |

Legend:

| | | |
|---|---|---|
| DRY | 1 | 0 to 50% |
| NORMAL | 2 | 50 to 150% |
| WET | 3 | Above 150% |

Table shows DRY, NORMAL or WET rain character according H05 data for each month in 2012-2022 period.

# Evaluation of dry/normal/wet months in 2012-2022 period

Evaluation according RAINGAUGE processed data:

| Month/Year | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | nodata | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 1 | 2 | 1 |
| February | nodata | 3 | 2 | 2 | 3 | 2 | 2 | 1 | 2 | 2 | 2 |
| March | nodata | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 |
| April | nodata | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 1 | 2 | 2 |
| May | nodata | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 1 |
| June | nodata | 3 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | 1 | 2 |
| July | 2 | 1 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | nodata |
| August | 1 | 2 | 3 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | nodata |
| September | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | nodata |
| October | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 1 | nodata |
| November | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 1 | 2 | nodata |
| December | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | nodata |

Legend:

| | | |
|---|---|---|
| DRY | 1 | 0 to 50% |
| NORMAL | 2 | 50 to 150% |
| WET | 3 | Above 150% |

Table shows DRY, NORMAL or WET rain character according RG data for each month in 2012-2022 period.

# Evaluation of differences between H05 and RG for each month in 2012-2022 period

Comparison table for H05 versus RG estimation of rain characteristics:

| Month/Year | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | nodata | 0 | 1 | 0 | 0 | 0 | -1 | 0 | 1 | 0 | 0 |
| February | nodata | -1 | 0 | 0 | 0 | -1 | 0 | 0 | 1 | 0 | -1 |
| March | nodata | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 |
| April | nodata | 0 | 0 | 0 | 0 | -1 | 1 | 0 | 0 | 0 | 0 |
| May | nodata | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | 0 |
| June | nodata | -1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | -1 |
| July | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | nodata |
| August | 0 | 0 | -1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | nodata |
| September | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | nodata |
| October | 1 | 1 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | 0 | nodata |
| November | 0 | 0 | 0 | 1 | 0 | -1 | 0 | 0 | 0 | 0 | nodata |
| December | 1 | 0 | 0 | 1 | 1 | -1 | 0 | 1 | 0 | 0 | nodata |

Legend:

| | |
|---|---|
| Under estimation | -1 |
| Agreement | 0 |
| Overestimation | 1 |

**Table shows underestimation (yellow) and overestimation (light red) of rain for H05 against RG measurements for each month in 2012-2022 period.**

# Case study summary

**From 120 evaluated months we found out**:

- 13 months with underestimated precipitation monthly totals by H05 against RG
- 93 months with agreement of precipitation monthly totals by H05 against RG
- 14 months with overestimated precipitation monthly totals by H05 against RG

While coverage of raingauge data is limited only to the territory of Slovakia, HSAF H05 products cover much bigger areas.

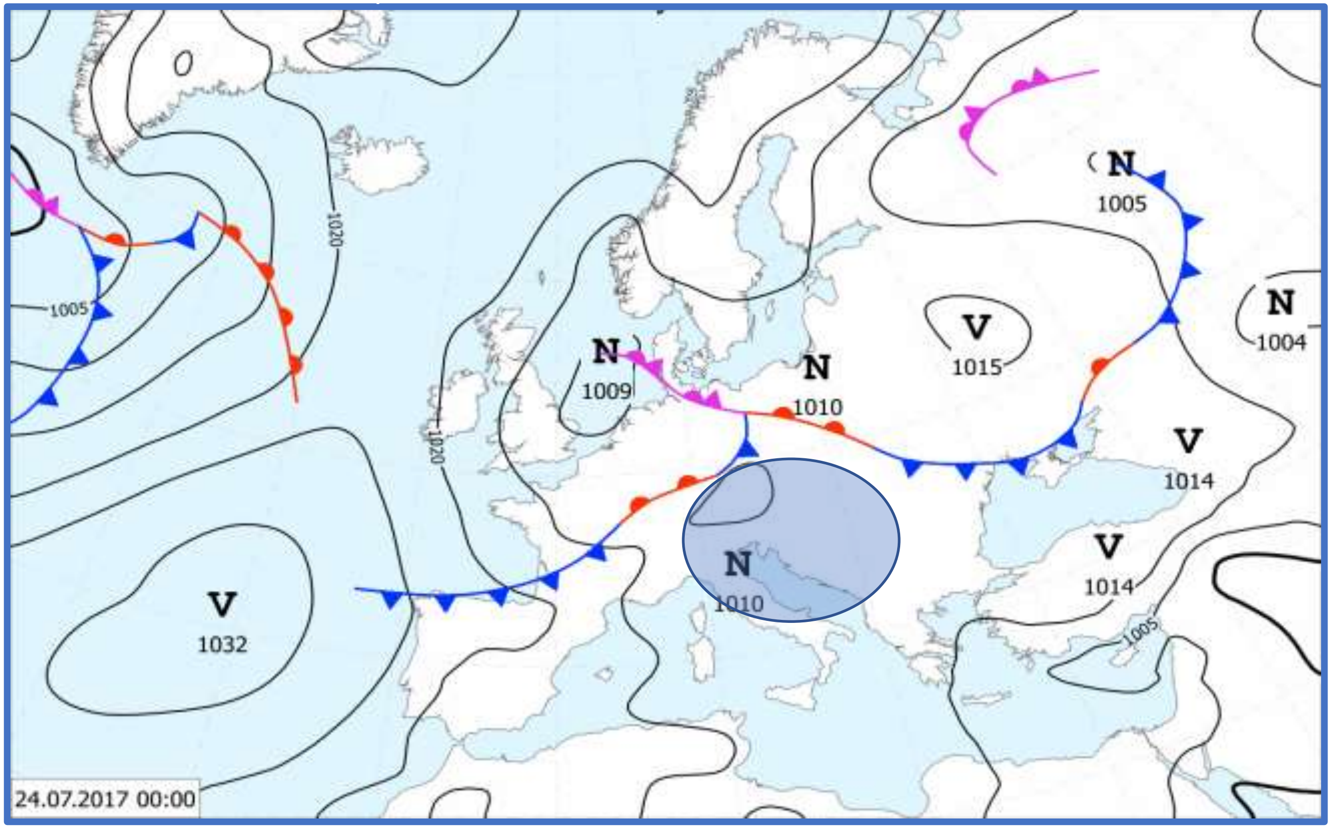
HSAF H05 product can be therefore used to evaluate long-term rain characteristics over non-limited regions in Europe and Africa, if we consider not only European H05A domain, but also H05B (full disk) product coverage.

For regions outside H05A domain we have not data available for 10 years , as production of the product H05B started only from June 2015. Therefore in such case we can calculate maximum 8-years long-term normals until now.
**For future developments during CDOP-4 phase this is promising vision.**

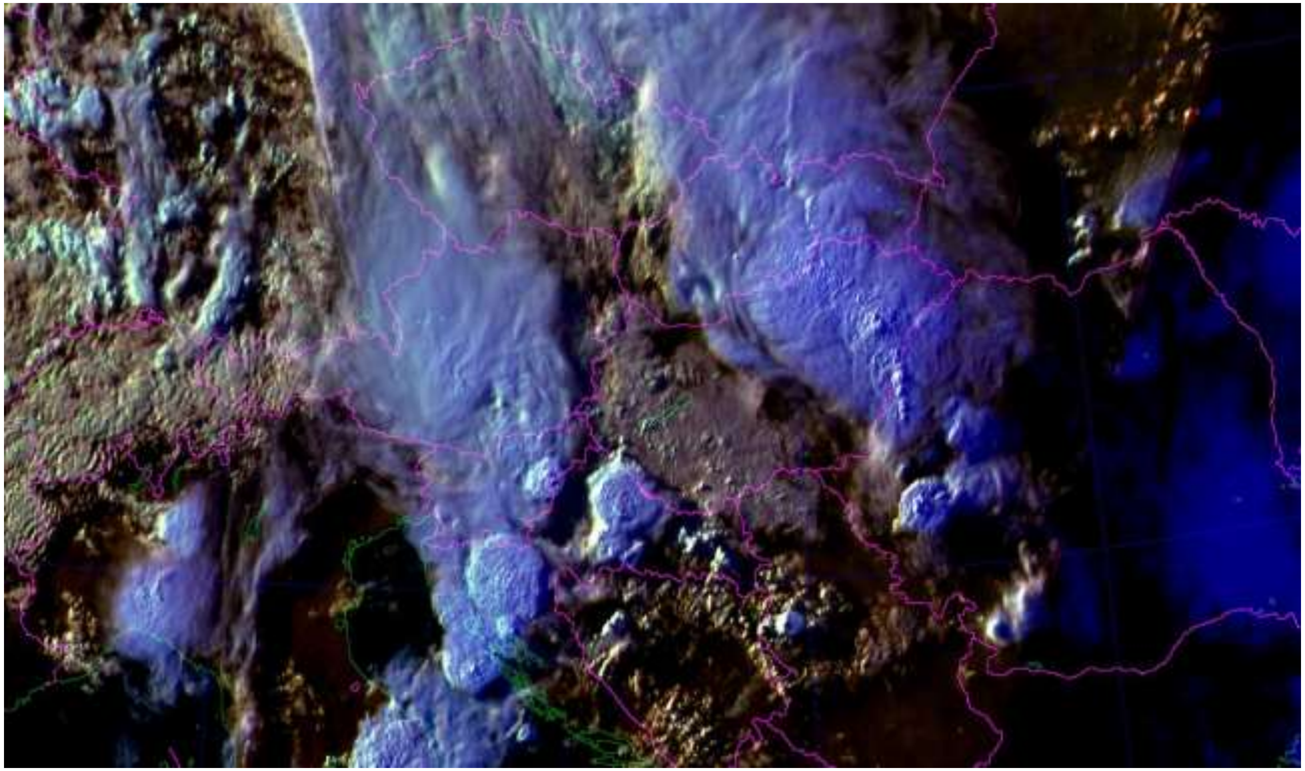
SLOVENSKÝ HYDROMETEOROLOGICKÝ ÚSTAV

EUMETSAT H SAF SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

# Case study: Slovakia 24th of July 2017



# Case study: Slovakia 24th of July 2017

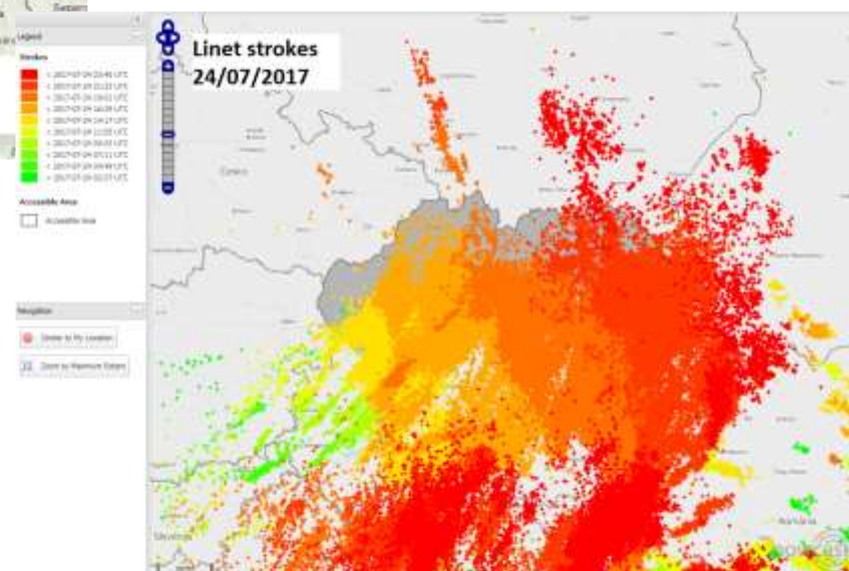


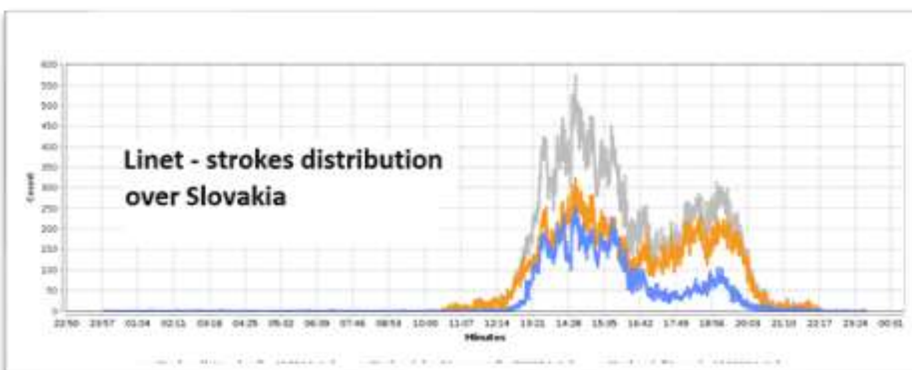
SLOVENSKÝ HYDROMETEOROLOGICKÝ ÚSTAV

EUMETSAT H SAF SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

# Case study: Slovakia 24th of July 2017

Data from raingauge & lightning detection network:

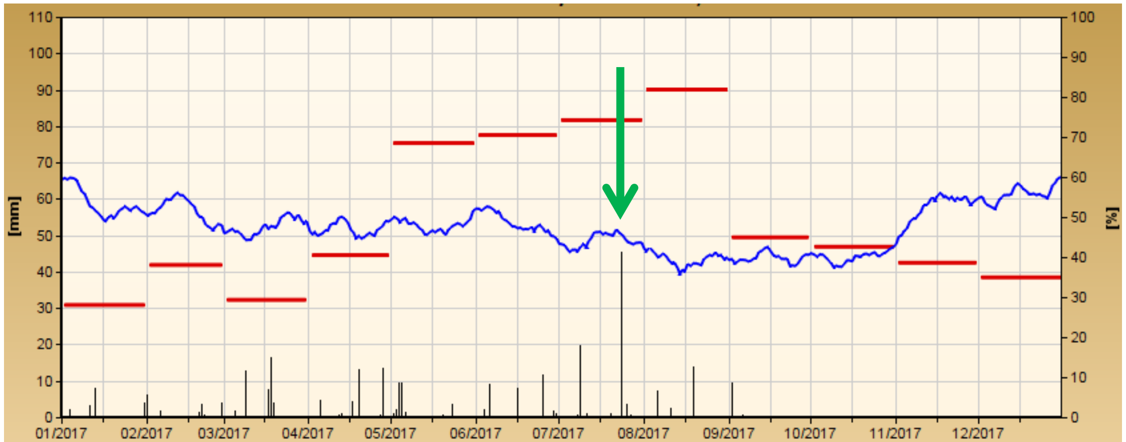



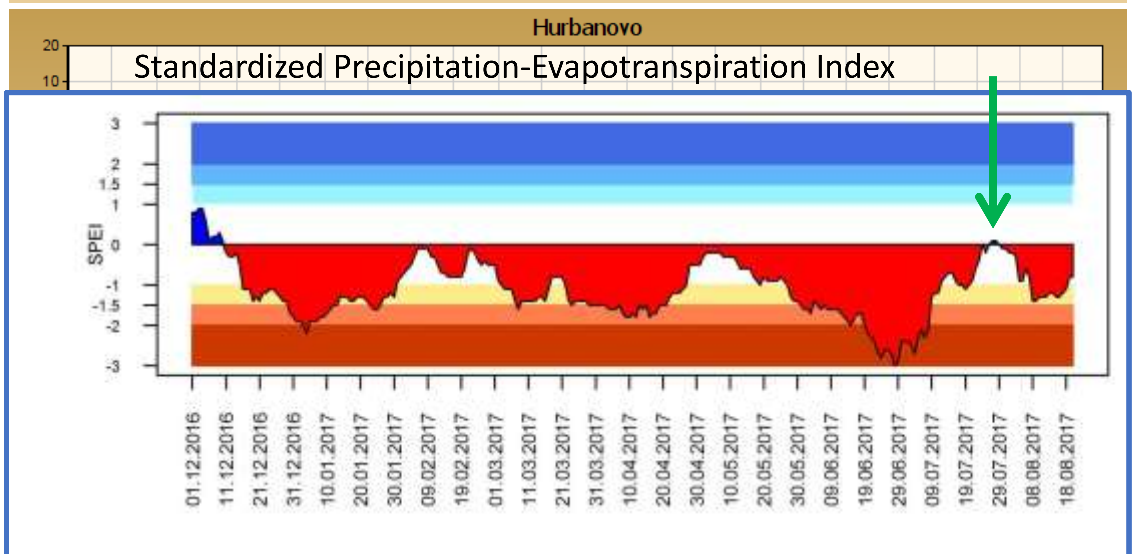



SLOVENSKÝ HYDROMETEOROLOGICKÝ ÚSTAV

EUMETSAT H SAF SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

# Case study: Slovakia 24th of July 2017



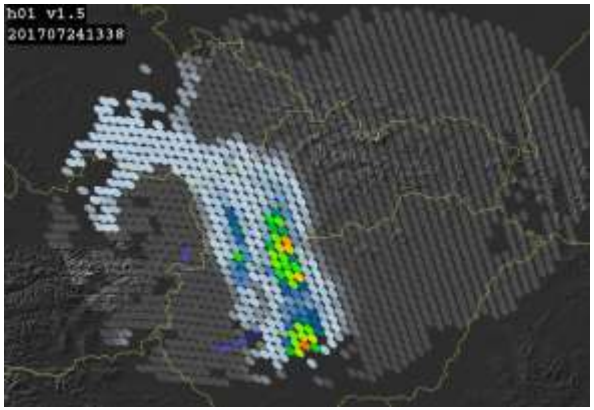

Similar even stronger event October 2020!

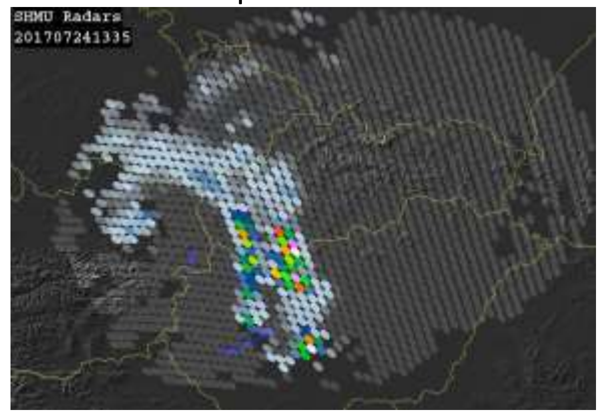
Green arrow shows the same event which reduced long duration drought in Southern Slovakia. Deficit of precipitation was decreased from -80 mm to -40 mm.

**Total duration of drought in this region is just more than 230 days.**

# Case study: Slovakia 24th of July 2017

Product **H01A** and SK-radar network rain intensities comparison: 13:35 UTC

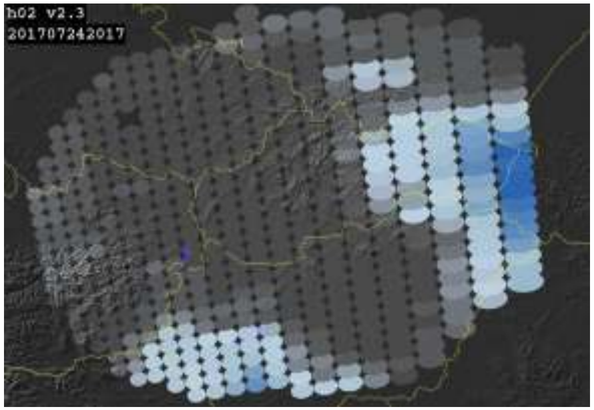


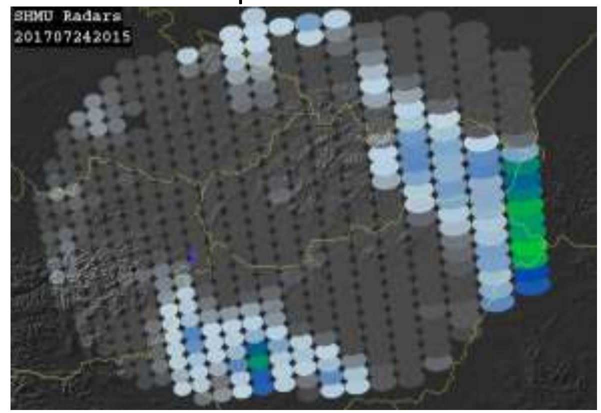



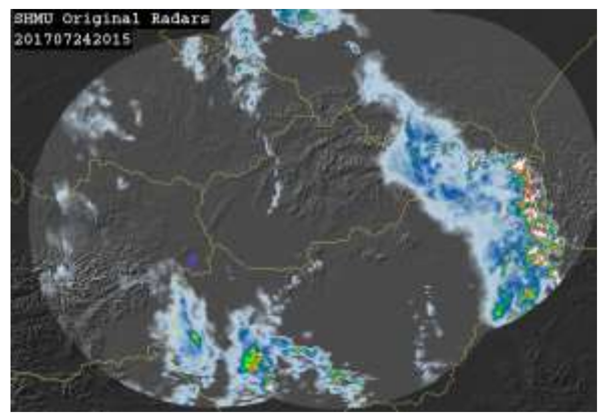

| | ≥ 0.25 mm/h | ≥ 1 mm/h |
|---|---|---|
| POD | 1.000 | 0.995 |
| FAR | 0.341 | 0.322 |
| CSI | 0.659 | 0.676 |

# Case study: Slovakia 24th of July 2017

Product **H02A** and SK-radar network rain intensities comparison: **20:15 UTC**




| | ≥ 0.25 mm/h | ≥ 1 mm/h |
|---|---|---|
| POD | 1.000 | 0.647 |
| FAR | 0.339 | 0.326 |
| CSI | 0.661 | 0.493 |

# Case study: Slovakia 24th of July 2017

Product **H03A** and SK-radar network rain intensities comparison: [illegible] UTC



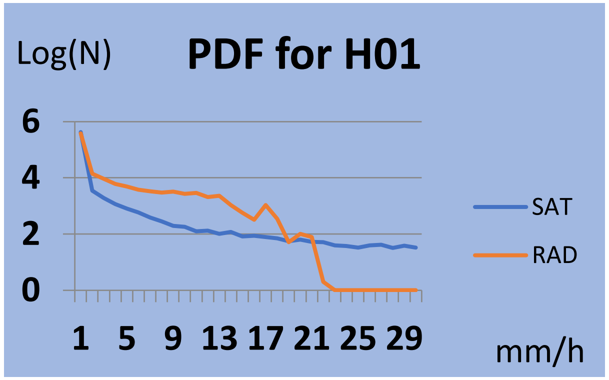

| | ≥ 0.25 mm/h | ≥ 1 mm/h |
|---|---|---|
| POD | 0.795 | 0.705 |
| FAR | 0.838 | 0.875 |
| CSI | 0.156 | 0.119 |

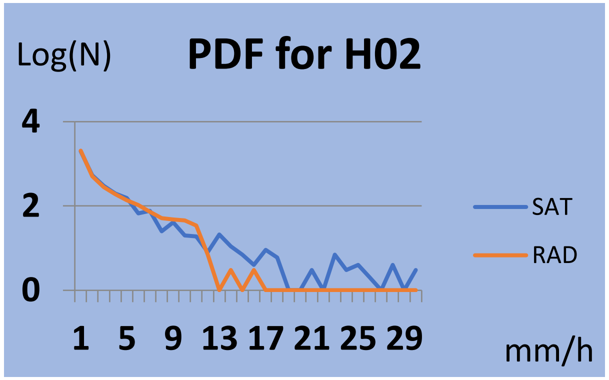
SLOVENSKÝ HYDROMETEOROLOGICKÝ ÚSTAV

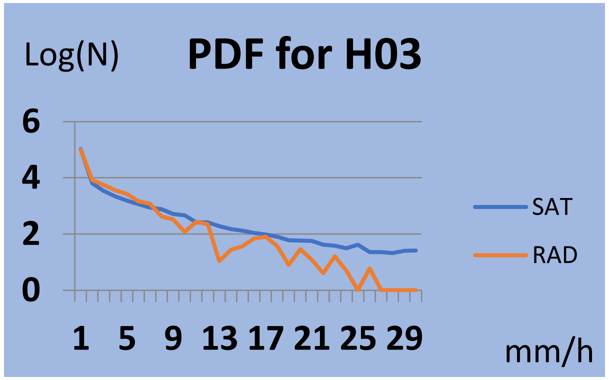
EUMETSAT H SAF SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

# Case study: Slovakia 24th of July 2017

## Probability Density Functions for H01, H02 and H03:



# Case study: Slovakia 24th of July 2017

## Results of continuous statistics for **H01**:

| Precipitation (mm/h) | 0.25 – 1 | 1 – 10 | ≥ 10 | ≥ 0.25 |
|---|---|---|---|---|
| No. of satellite obs. | 179 | 559 | 62 | 800 |
| No. of radar obs. | 104 | 378 | 45 | 527 |
| Mean Error (mm/h) | 1.769 | 1.320 | -5.141 | 0.857 |
| Multiplicative bias | 3.781 | 1.391 | 0.753 | 1.198 |
| Correlation coefficient | **0.144** | **0.456** | **0.587** | **0.739** |
| URD-RMSE (%) | 665.8 | 125.8 | 48.1 | 314.7 |
| Fract. Stand. Error (%) | 410.4 | 102.2 | 50.9 | 102.0 |
| Nash-Sutcliffe Coeff. | -149.15 | -1.50 | 0.12 | 0.524 |

# Case study: Slovakia 24th of July 2017

## Results of continuous statistics for **H02**:

| Precipitation (mm/h) | 0.25 – 1 | 1 – 10 | ≥ 10 | ≥ 0.25 |
|---|---|---|---|---|
| No. of satellite obs. | 2030 | 1424 | 47 | 3501 |
| No. of radar obs. | 784 | 1410 | 121 | 2315 |
| Mean Error (mm/h) | 0.680 | -0.671 | -10.056 | -0.704 |
| Multiplicative bias | 2.237 | 0.787 | 0.425 | 0.767 |
| Correlation coefficient | **0.055** | **0.402** | **0.447** | **0.580** |
| URD-RMSE (%) | 402.1 | 113.3 | 57.8 | 250.5 |
| Fract. Stand. Error (%) | 317.2 | 81.5 | 70.1 | 118.9 |
| Nash-Sutcliffe Coeff. | -66.67 | -0.632 | -1.477 | 0.309 |

# Case study: Slovakia 24th of July 2017

## Results of continuous statistics for **H03**:

| Precipitation (mm/h) | 0.25 – 1 | 1 – 10 | ≥ 10 | ≥ 0.25 |
|---|---|---|---|---|
| No. of satellite obs. | 13039 | 23514 | 833 | 37386 |
| No. of radar obs. | 10129 | 17236 | 2138 | 29503 |
| Mean Error (mm/h) | 0.430 | -1.426 | -19.450 | -2.095 |
| Multiplicative bias | 1.749 | 0.578 | 0.182 | 0.462 |
| Correlation coefficient | **0.053** | **0.196** | **0.215** | **0.290** |
| URD-RMSE (%) | 406.2 | 125.0 | 80.0 | 257.4 |
| Fract. Stand. Error (%) | 323.2 | 101.9 | 123.6 | 215.9 |
| Nash-Sutcliffe Coeff. | -73.03 | -1.352 | -0.70 | 0.023 |

Because of convective event MW products better reflect PCP then IR SEVIRI, which are too smooth over the region catching cloud tops only!