Status of development of satellite application software for FCI and LI at SHMU in context of monitoring severe storms - Application demo

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Abstract

EUMETSAT provided first FCI and LI test data in 2020 and newer sets in 2021. This was good opportunity for those responsible for setup of operational chains, which will generate real-time output products to users. Traditionally, the approach at SHMI is to develop own software as it was in case of previous satellite missions and re-use the experience and functional modules that already exist and work on the same principle as in the past.

In the case of satellite storm monitoring, we have many years of experience that are worth continuing, and this experience is stored in existing software tools that only need to be adapted. For new LI data, there is a set of projection functions inside MTGProc, which we are using to localise and draw LI data to the background maps. This can be simply a clear map or satellite images/RGB products.

Currently active tools at SHMI to monitor severe storms we have developed for MSG data. In the frame of adaptation these tools, we are in progress with preparation of MTGProc version of processing software for FCI (and ABI) instrument. We are in progress of adaption auxiliary tools like ViewMSG (->ViewGEO), TRACK and AMV software, 3D-compositions, installation latest NWCSAF software and adapt our web-map based applications for combined display of all remote sensing data together (radars, ground lightning detection networks, satellite RGBs, Nowcasting products, etc.).

About this software

This software is successor of previously developed MSGProc for processing of image data from Meteosat Second Generation. MTGProc cannot be considered as new version, as this new software is not devoted to process and visualize MSG SEVIRI data, but rather new FCI MTG and in addition to process ABI GOES data.

Set of standard RGB products in pre-defined cartographic projections is generated in effective fast-speed manner, without special requirements on third party software prerequisites. Only HDF5/NetCDF/FCI-decompression software is required to read input satellite image data delivered in NetCDF format. Please note that in case of necessity you can contact EUMETSAT Helpdesk to consult problems with installation of this software. The responsibility of this document is only to take care of MTGProc installation, configuration and usage.

Instructions how to install MTGProc software and manual for usage is also provided in the MTGProc package delivery.

New features in comparison to older MSGProc versions:

Two different ways of parallelization to speed-up calculations and make shorter processing time:

1. In Windows and in Linux using PTHREAD library in C-language for -

- Parallelization of calculation loops in processes
- Sun height calculations
- Reflectivity of 3.8µm channel
- Creation of RGB bitmap files

2. In Linux only using parallel C-shell running of commands with WAIT statement for -

- Parallel image compositor
- Parallel image projector

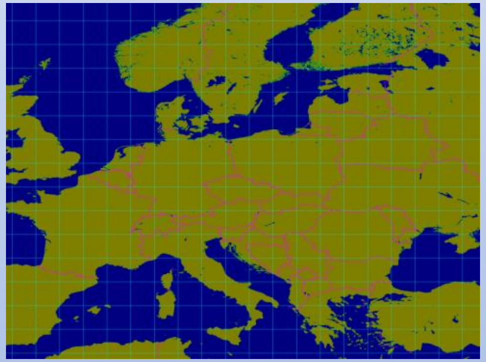
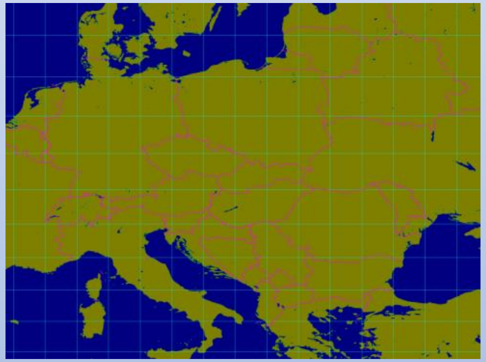
a) More domains can be generated in parallel using only one software installation.
b) Common format of domain definitions for both MTG/FCI and GOES/ABI instruments

These features were missing in old MSGProc, where for each domain it was necessary to make new installation of the software or run the processing repeatedly for different domains.

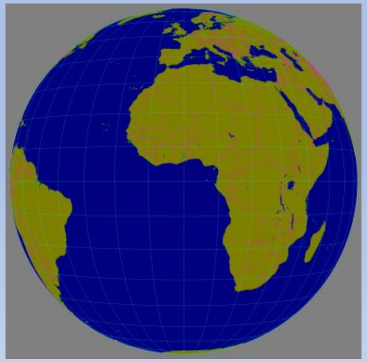
Definition of domain:

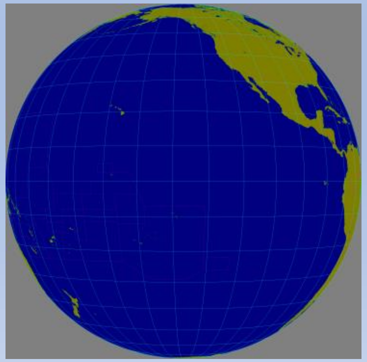
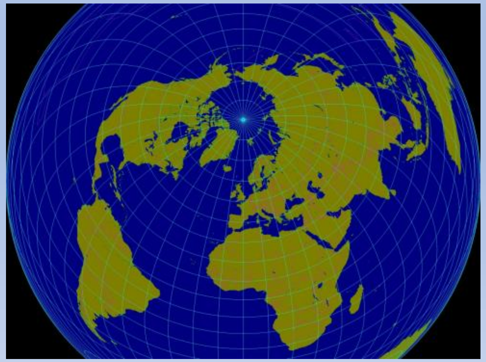
Instruments: ABI; FCI
Projections: Albers; Regular la, fi; Mercator, Geo-View, Lambert
Input image size: 5424x5424, 5568x5568, 11136x11136, 22272x22272 or **sub regions - new**
Sub regions offsets: optional
Central position: optional
Domain size: optional (previously 2000x1500 or 4000x3000)
Lat/lon grid: optional

Examples of domains:


Equal area
Versus
Regular grids



Equatorial
Versus
Polar views

New features in comparison to older MSGProc versions:

Domain definitions examples

GeoView for **FCI**

Proj_Domain-000.dat - SciTE

```
Domain code <d00,d01,d02,...>  Y: d000
Projection name          string Y: GeoView
Projection number <1,2,3,4,5>  Y: 4
Central longitude [deg] float  N:  0.0000
Central latitude  [deg] float  N:  0.0000
Scale factor                   N:  0.0000
Domain width      [deg] float  N:  0.0000
Domain height     [deg] float  N:  0.0000
Longitude grid    [deg] uint   Y: 10
Latitude grid     [deg] uint   Y: 10
Political border width <0,1,2> Y: 1
Column offset     [pixels]     Y: 0
Row offset        [pixels]     Y: 0
Domain pixel size [km]  float  Y: 2.0
Domain width      [pix] uint   Y: 5568
Domain height     [pix] uint   Y: 5568
Satellite position[deg] float  Y: 0.0
Scanner type      <FCI,ABI>    Y: FCI
```

Albers for **FCI**

Proj_Domain-001.dat - SciTE

```
Domain code <d00,d01,d02,...>  Y: d001
Projection name          string Y: Albers
Projection number <1,2,3,4,5>  Y: 1
Central longitude [deg] float  Y:  0.0000
Central latitude  [deg] float  Y: 48.0000
Scale factor                   Y:  1.3050
Domain width      [deg] float  N:  0.0000
Domain height     [deg] float  N:  0.0000
Longitude grid    [deg] uint   Y: 10
Latitude grid     [deg] uint   Y: 10
Political border width <0,1,2> Y: 1
Column offset     [pixels]     N: 0
Row offset        [pixels]     N: 0
Domain pixel size [km]  float  N: 0.0
Domain width      [pix] uint   Y: 4000
Domain height     [pix] uint   Y: 3000
Satellite position[deg] float  Y: 0.0
Scanner type      <FCI,ABI>    Y: FCI
```

GeoView for **ABI**

Proj_Domain-312.dat * SciTE

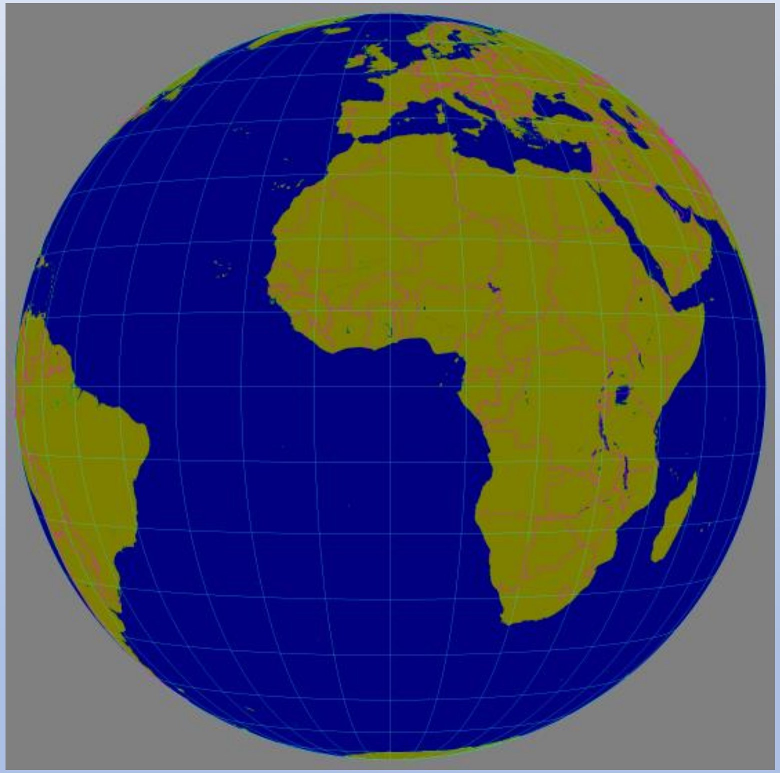
```
Domain code <d00,d01,d02,...>  Y: d312
Projection name          string Y: GeoView
Projection number <1,2,3,4,5>  Y: 4
Central longitude [deg] float  N: 0.0000
Central latitude  [deg] float  N: 0.0000
Scale factor                   N: 0.0000
Domain width      [deg] float  N: 0.0000
Domain height     [deg] float  N: 0.000
Longitude grid    [deg] uint   Y: 10
Latitude grid     [deg] uint   Y: 10
Political border width <0,1,2> Y: 0
Column offset     [pixels]     Y: 0
Row offset        [pixels]     Y: 0
Domain pixel size [km]  float  Y: 2.0
Domain width      [pix] uint   Y: 5568
Domain height     [pix] uint   Y: 5568
Satellite position[deg] float  Y: -75.0
Scanner type      <FCI,ABI>    Y: ABI
```

Columns: Description, unit, type, applicable, value

New features in comparison to older MSGProc versions:

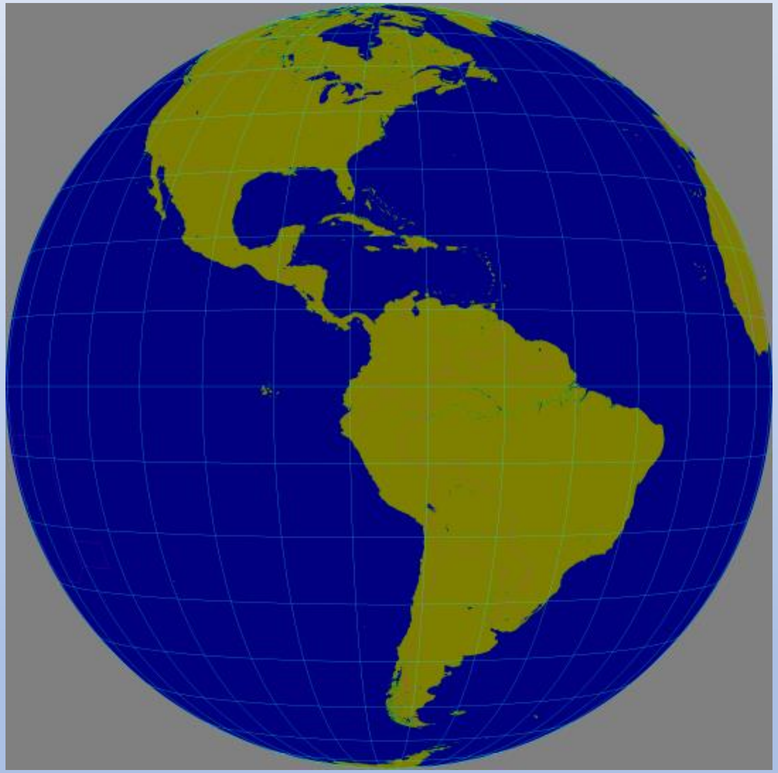
Another domain definitions examples

GeoView for FCI



Albers for FCI

GeoView for ABI



New features in comparison to older MSGProc versions:

RGB definitions examples

Airmass

MTG_rgb_configuration-Airmass.dat - SciTE

```
RGB name ...............:Airmass

Red channel parameters
inpR....................:wv_63_-wv_73_
R minimum ..............: -2500
R maximum ..............:     0
R slope ................:     1
R gamma ................:   100

Green channel parameters
inpG....................:ir_97_-ir_105
G minimum ..............: -4300
G maximum ..............:   200
G slope ................:     1
G gamma ................:   100

Blue channel parameters
inpB....................:wv_63_
B minimum ..............: -5900
B maximum ..............: -2900
B slope ................:    -1
B gamma ................:   100

Land and sea delimiter...:     0
Maximum zenith angle ....:   860

Lookup table............:linear.pal
Draw configuration ......:draw_config1.txt

R latitude concavity.....: -1200
G latitude concavity.....: -1200
G latitude concavity.....:  2400

Remove cyan from NatCols.: 0
```

24h Microphysics

MTG_rgb_configuration-24hMicrophysics.dat - SciTE

```
RGB name ...............:24hMicrophysics

Red channel parameters
inpR....................:ir_123-ir_105
R minimum ..............:  -950
R maximum ..............:  -350
R slope ................:     1
R gamma ................:   100

Green channel parameters
inpG....................:ir_105-ir_87_
G minimum ..............:   300
G maximum ..............:   900
G slope ................:     1
G gamma ................:   120

Blue channel parameters
inpB....................:ir_105
B minimum ..............: -2500
B maximum ..............:  3000
B slope ................:     1
B gamma ................:   100

Land and sea delimiter...:     0
Maximum zenith angle ....:   860

Lookup table............:linear.pal
Draw configuration ......:draw_config1.txt

R latitude concavity.....: 0
G latitude concavity.....: 0
G latitude concavity.....: 0

Remove cyan from NatCols.: 0
```

Daily Cloud Phase Distinction

MTG_rgb_configuration-DailyCloudPhaseDistinction.dat - SciTE

```
RGB name ...............:Daily_Cloud_Phase_Distinction

Red channel parameters
inpR....................:ir_105
R minimum ..............: -5350
R maximum ..............:   750
R slope ................:    -1
R gamma ................:   100

Green channel parameters
inpG....................:vis_06
G minimum ..............:     0
G maximum ..............:  7800
G slope ................:     1
G gamma ................:   100

Blue channel parameters
inpB....................:nir_16
B minimum ..............:     0
B maximum ..............:  5900
B slope ................:     1
B gamma ................:   100

Land and sea delimiter...:     0
Maximum zenith angle ....:   860

Lookup table............:linear.pal
Draw configuration ......:draw_config1.txt

R latitude concavity.....: 0
G latitude concavity.....: 0
G latitude concavity.....: 0

Remove cyan from NatCols.: 0
```

RGB definitions list

MTG	G16	G17
24hMicrophysics	24hMicrophysics	24hMicrophysics
Airmass	Airmass	Airmass
CloudTypes	CloudePhase	CloudePhase
ColorizedColdCloudTops	CloudTypes	CloudTypes
ConvectiveStorms	DailyCloudPhaseDistinction	DailyCloudPhaseDistinction
DailyCloudPhaseDistinction	DayMicrophysical	DayMicrophysical
DayMicrophysical	DaySolar	DaySolar
DaySolar	Dust	Dust
Dust	FireTemperature	FireTemperature
IR_105	NaturalColors	NaturalColors
IR_123	NaturalColorsWhite	NaturalColorsWhite
IR_123-IR_105	NaturalTrueColors	NaturalTrueColors
IR-WV	Night	Night
NaturalColors	NightLowClouds	NightLowClouds
NaturalColorsWhite	NightMicrophysical	NightMicrophysical
Night	VIS-IR	VIS-IR
NightLowClouds	VolcanicAsh	VolcanicAsh
NightMicrophysical		
SunHeight		
TrueColors		
VIS-IR		
VolcanicAsh		
[illegible]		

RGB definitions – adding new RGB - Example, how to do it:

1. Create new definition rgb file copying existing:

```
./config/rgb> cp MTG_rgb_configuration-WV6.3-enhanced.dat MTG_rgb_configuration-WV6.3-bw.dat
```

2. Edit `./config/rgb/MTG_rgb_configuration-WV6.3-bw.dat` according your needs

3. Edit `./MTG_LIST_channels.sh`
As an example, see parts denoted by comment:
`# 11.5.2022 add new RGB`
Note that there is more lines modified!

4. Edit `./MTG_LIST_rgb_generator.sh`
Also, see comments in this file:
`# 11.5.2022 add new RGB`
Note that there is more lines modified!

5. Edit `./GEO_000_MTG_list_domain-rgb.sh`
Also, see comments in this file:
`# 11.5.2022 add new RGB`
Note that there is more lines modified!

6. Run script `./GEO_000_MTG_list_domain-rgb.sh`
Output you will see on the screen:

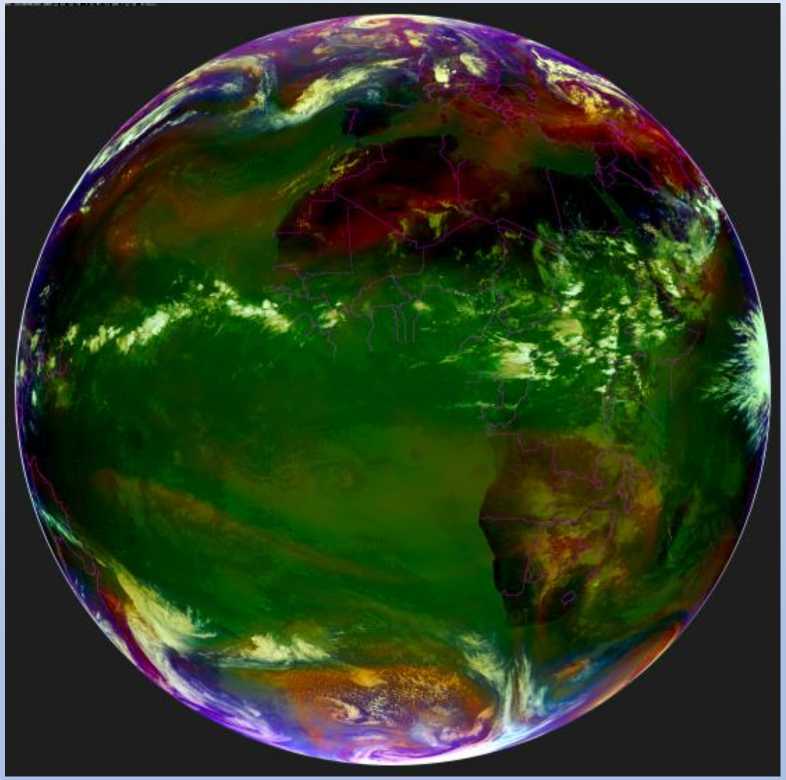
`004 NNNNNYNNNNNNNYNNNNNNNNYY`	- 004 is number of domains
`000 NNNNNNNNNNNNNYNNNNNNNNYY`	- 000 domain number 000
`001 NNNNNYNNNNNNNNNNNNNNNNNN`	- 001 domain number 001
`002 NNNNNNNNNNNNNNNNNNNNNNNN`	- 002 domain number 002
`003 NNNNNNNNNNNNNNNNNNNNNNNN`	- 003 domain number 003

And also in file `./config/runtime/GEO_MTG_list_domain-rgb.dat`

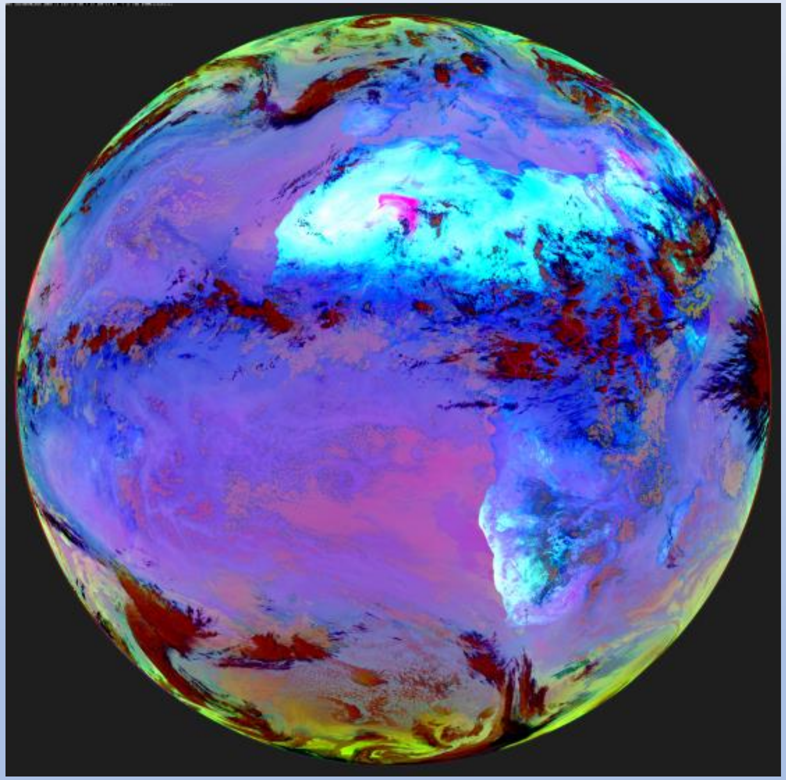
New features in comparison to older MSGProc versions:

RGB examples

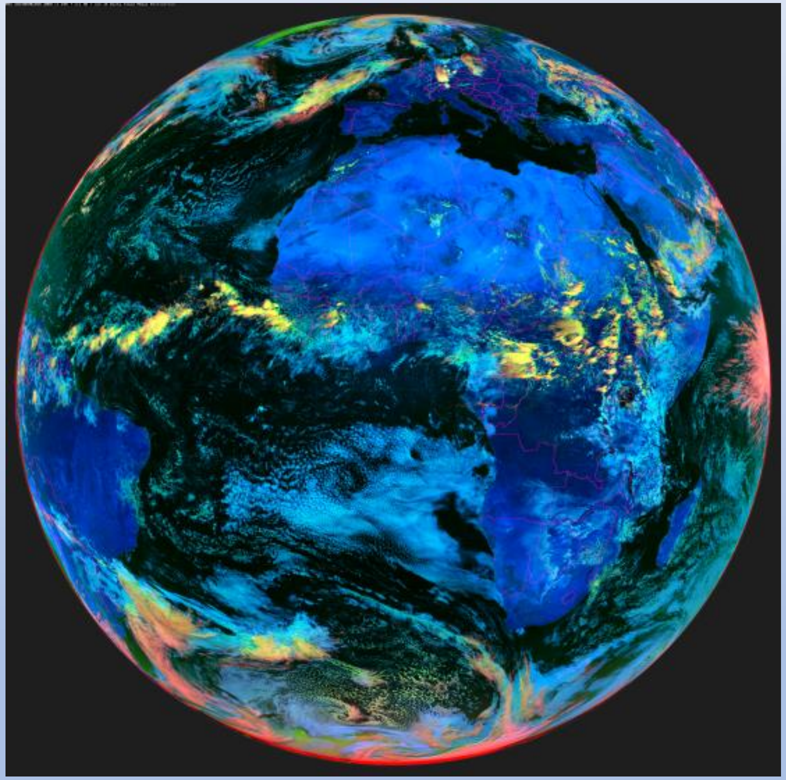
Airmass



24h Microphysics



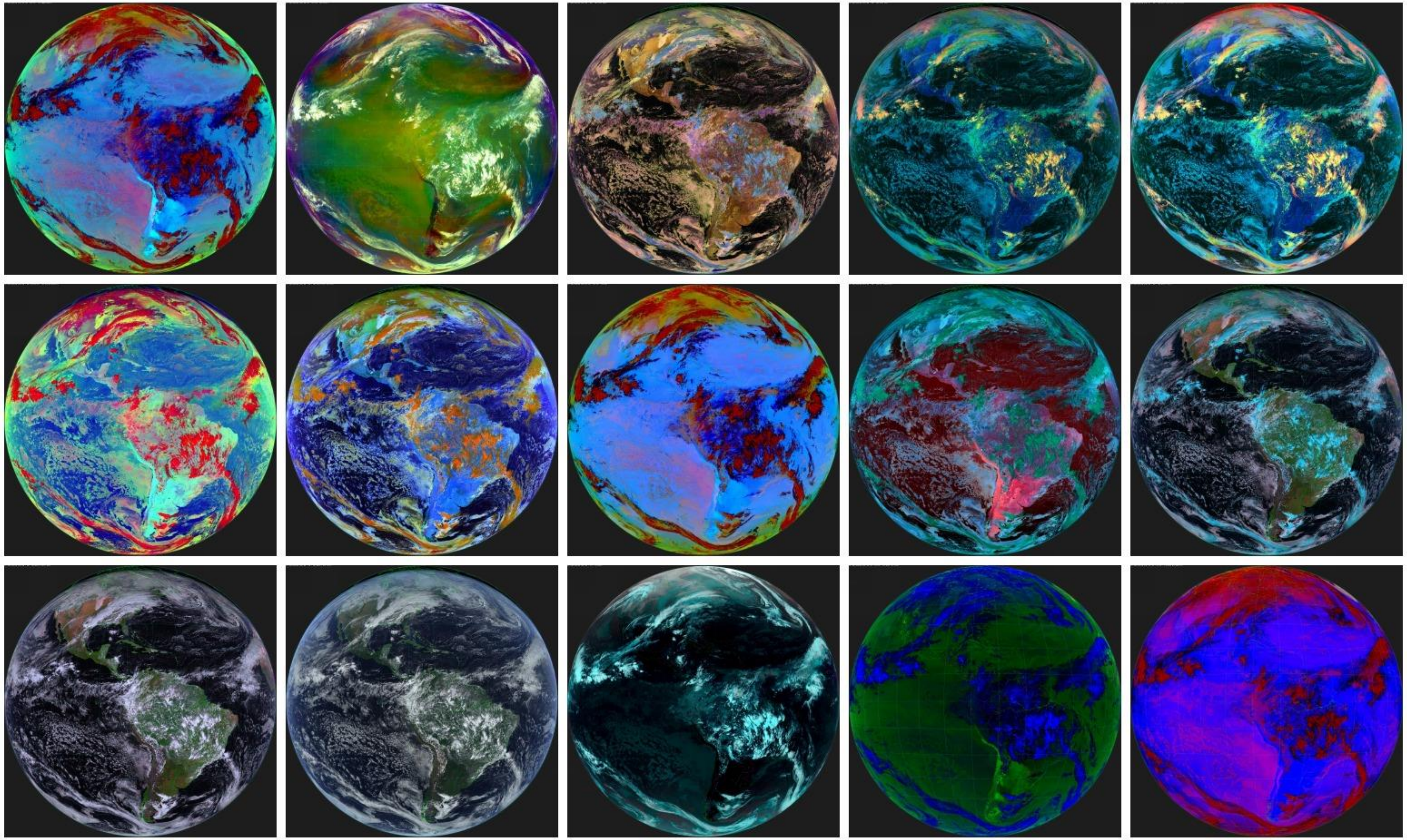
Daily Cloud Phase Distinction

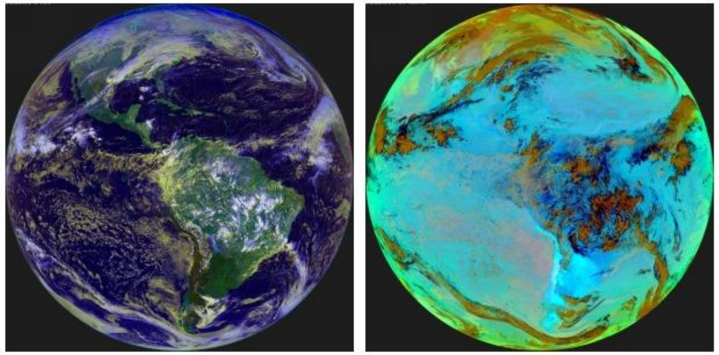


MTGProc/GEOProc C/C-shell software:

GOES-16 Full disk RGB set of products available in latest software version:

G16_202112181700_d312_24hMicrophiscs.jpg
G16_202112181700_d312_Airmass.jpg
G16_202112181700_d312_Cloud_Phase.jpg
G16_202112181700_d312_Cloud_Types.jpg
G16_202112181700_d312_Daily_Cloud_Phase_Distinction.jpg
G16_202112181700_d312_Day_Microphysical.jpg
G16_202112181700_d312_Day_Solar.jpg
G16_202112181700_d312_Dust.jpg
G16_202112181700_d312_Fire_Temperature.jpg
G16_202112181700_d312_Natural_Colors.jpg
G16_202112181700_d312_Natural_Colors_White.jpg
G16_202112181700_d312_Natural_True_Colors.jpg
G16_202112181700_d312_Night.jpg
G16_202112181700_d312_Night_low_clouds.jpg
G16_202112181700_d312_Night_Microphysical.jpg
G16_202112181700_d312_VIS-IR.jpg
G16_202112181700_d312_Volcanic_Ash.jpg





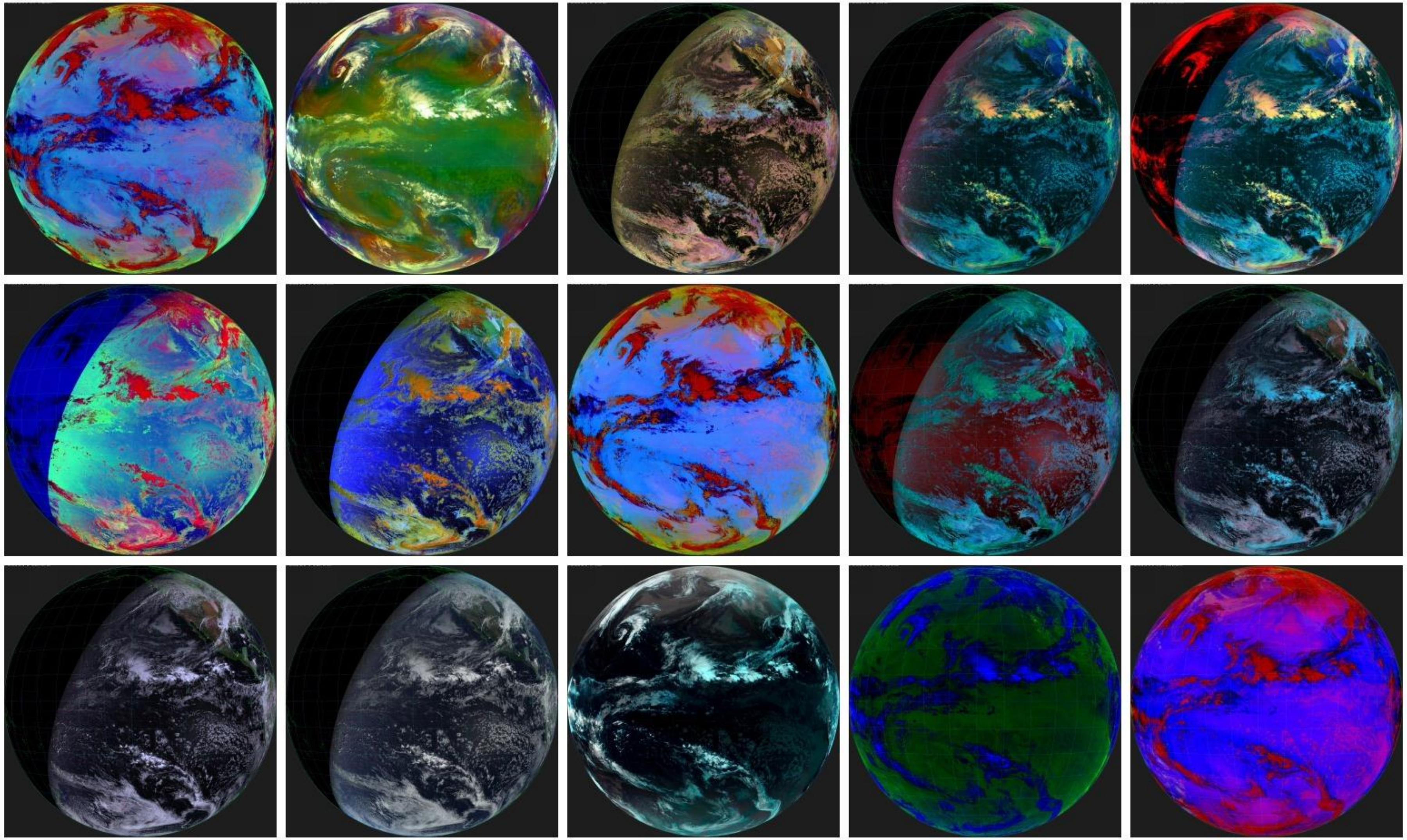
Tested processing time in two platforms:

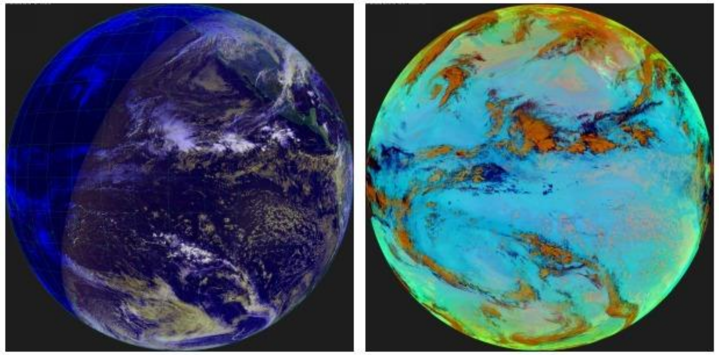
Windows (laptop 6 cores, 12 logical) 70 seconds
Linux (32 physical cores processor) 20/25 seconds

MTGProc/GEOProc C/C-shell software:

GOES-17 Full disk RGB set of products available in latest software version:

G17_202112181700_d312_24hMicrophiscs.jpg
G17_202112181700_d312_Airmass.jpg
G17_202112181700_d312_Cloud_Phase.jpg
G17_202112181700_d312_Cloud_Types.jpg
G17_202112181700_d312_Daily_Cloud_Phase_Distinction.jpg
G17_202112181700_d312_Day_Microphysical.jpg
G17_202112181700_d312_Day_Solar.jpg
G17_202112181700_d312_Dust.jpg
G17_202112181700_d312_Fire_Temperature.jpg
G17_202112181700_d312_Natural_Colors.jpg
G17_202112181700_d312_Natural_Colors_White.jpg
G17_202112181700_d312_Natural_True_Colors.jpg
G17_202112181700_d312_Night.jpg
G17_202112181700_d312_Night_low_clouds.jpg
G17_202112181700_d312_Night_Microphysical.jpg
G17_202112181700_d312_VIS-IR.jpg
G17_202112181700_d312_Volcanic_Ash.jpg





Tested processing time in two platforms:

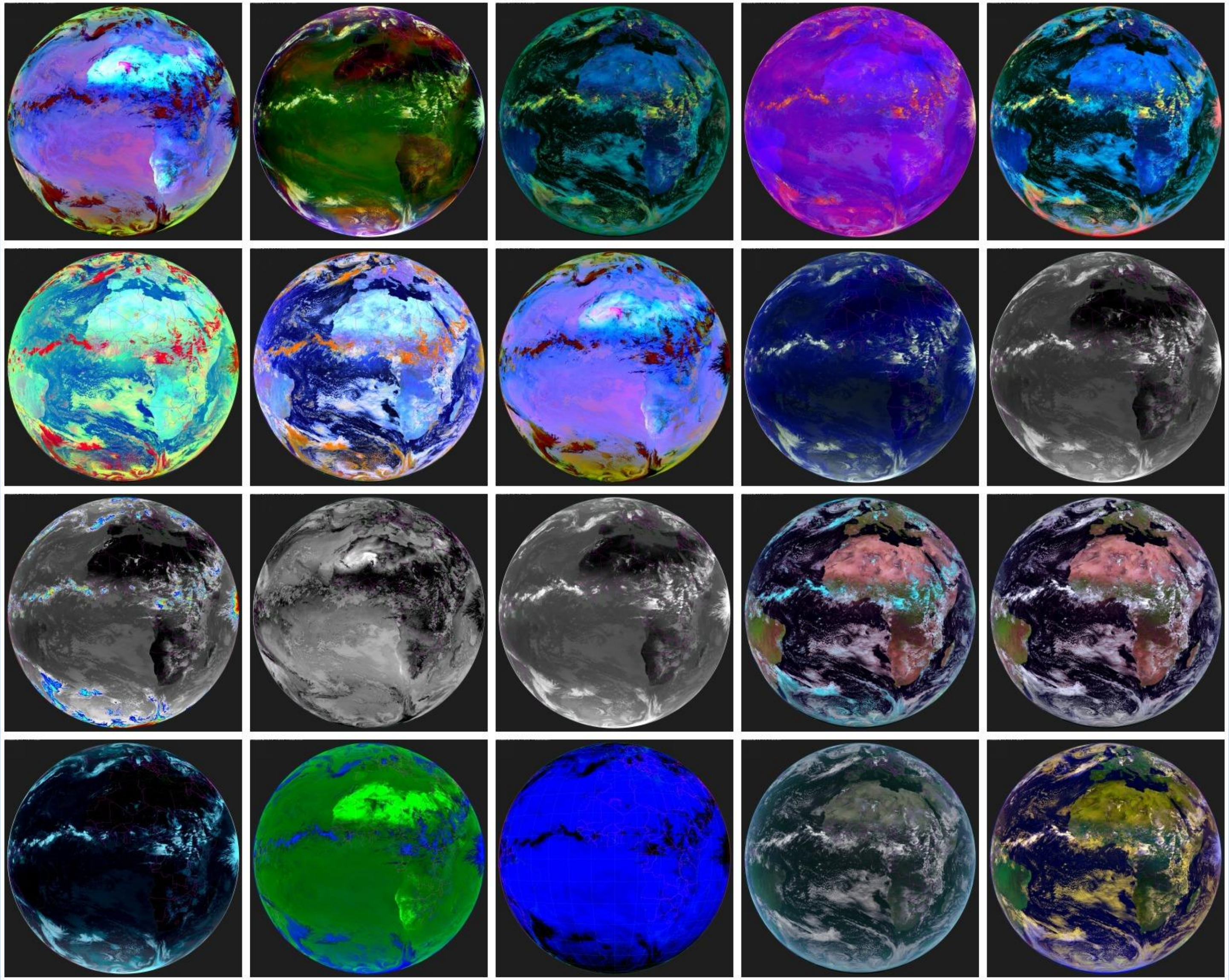
Windows (laptop 6 cores, 12 logical) 70 seconds
Linux (32 physical cores processor) 20/25 seconds

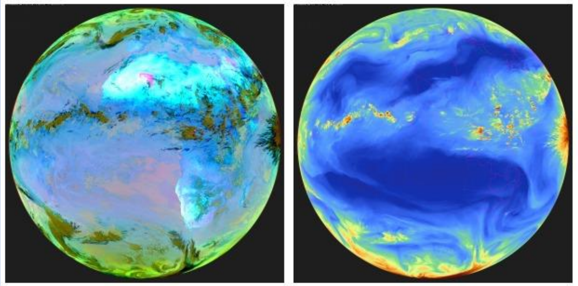
MTGProc/GEOProc C/C-shell software:

MTG-test data Full disk RGB set of products available in latest software version:

MTG_201308041200_d000_24hMicrophiscs.jpg
MTG_201308041200_d000_Airmass.jpg
MTG_201308041200_d000_Cloud_Types.jpg
MTG_201308041200_d000_Convective_storms.jpg
MTG_201308041200_d000_Daily_Cloud_Phase_Disti nction.jpg
MTG_201308041200_d000_Day_Microphysical.jpg
MTG_201308041200_d000_Day_Solar.jpg
MTG_201308041200_d000_Dust.jpg
MTG_201308041200_d000_IR-WV.jpg
MTG_201308041200_d000_IR105.jpg
MTG_201308041200_d000_IR105_Colorized_cold_cl oud_tops.jpg
MTG_201308041200_d000_IR123-IR105.jpg
MTG_201308041200_d000_IR123.jpg
MTG_201308041200_d000_Natural_Colors.jpg
MTG_201308041200_d000_Natural_Colors_White.jpg
MTG_201308041200_d000_Night.jpg
MTG_201308041200_d000_Night_low_clouds.jpg
MTG_201308041200_d000_Night_Microphysical.jpg
MTG_201308041200_d000_True_Colors.jpg
MTG_201308041200_d000_VIS-IR.jpg
MTG_201308041200_d000_Volcanic_Ash.jpg
MTG_201308041200_d000_WV6.3-enhanced.jpg

Problem: EUMETSAT not providing FCI/decompression for Windows
Only for Linux





Tested processing time in two platforms:

Windows (laptop 6 cores, 12 logical) 90/110 seconds
Linux (32 physical cores processor) 30/40 seconds

Visualization functionalities planned to continue with FCI imagery

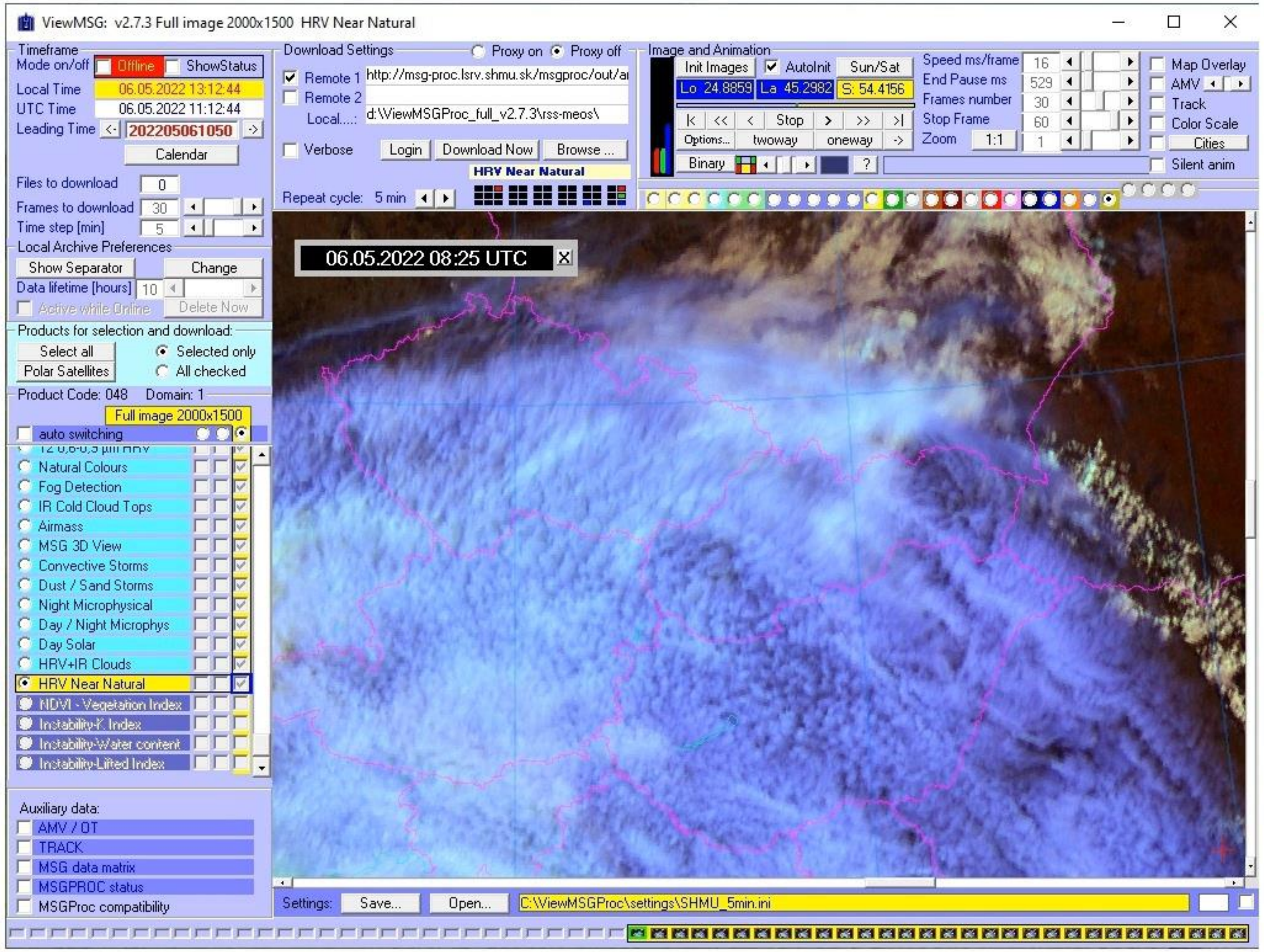
- **High flexible animation, mainly of rapid scan imagery with:**
  - Continuous zoom and scroll of the image
  - Single switch between RGB products for image comparison
  - the ability to quickly change the time period of the animation
- **Use mouse properties to quickly read position and values in the image**
  - λ, ϕ, BT, albedo, classified values (cloud type, cloud top height, CTT, …)
  - Detection of OT including calculations of OT height, OT BT
- **Overlay additional vector products like:**
  - AMV (motion vectors)
  - Track (tracking storms)

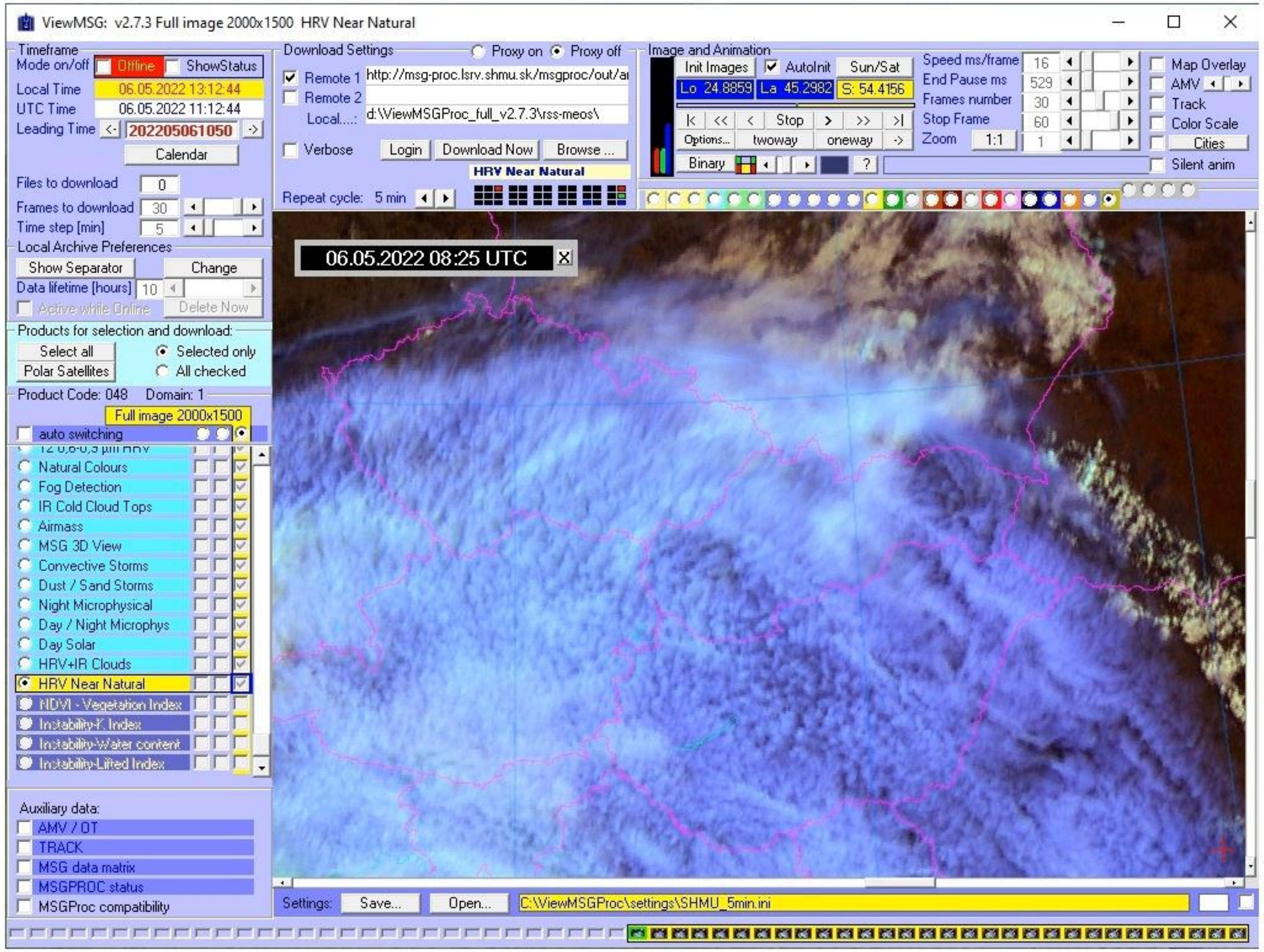
All these functionalities were developed and are available at SHMÚ.

We would be happy to keep these functionalities for the future.

Not only to keep but to improve and adopt for better FCI space and time resolution as tools extremely useful for monitoring and investigation of severe events

Visualization functionalities planned to continue with FCI imagery





AMV (ATMOSPHERIC MOTION VECTORS) ALGORITHM:

Standard correlation algorithm applied to square region in satellite image:

$$\max\left\{ r = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}} \right\}$$

Algorithm description:
Define limited area in the first image and look for identical image structure in second image. Shift of structure between images corresponds to mutual parallax shift between left and right satellite observations.

- Originally used only WV channels smooth structures;
- standard cross-correlation technique is applied to rectangular targets;
- detecting optimal shift between target and matcher;
- applied to regular satellite image grid (step size optional from 10 to single image pixels)

Important note: Both images from left and right satellites must be projected to the common map!!!

Algorithm comes from CEI Nowcasting Project 2002-2004

AMV (ATMOSPHERIC MOTION VECTORS) ALGORITHM:

Standard correlation algorithm applied to square region in satellite image:

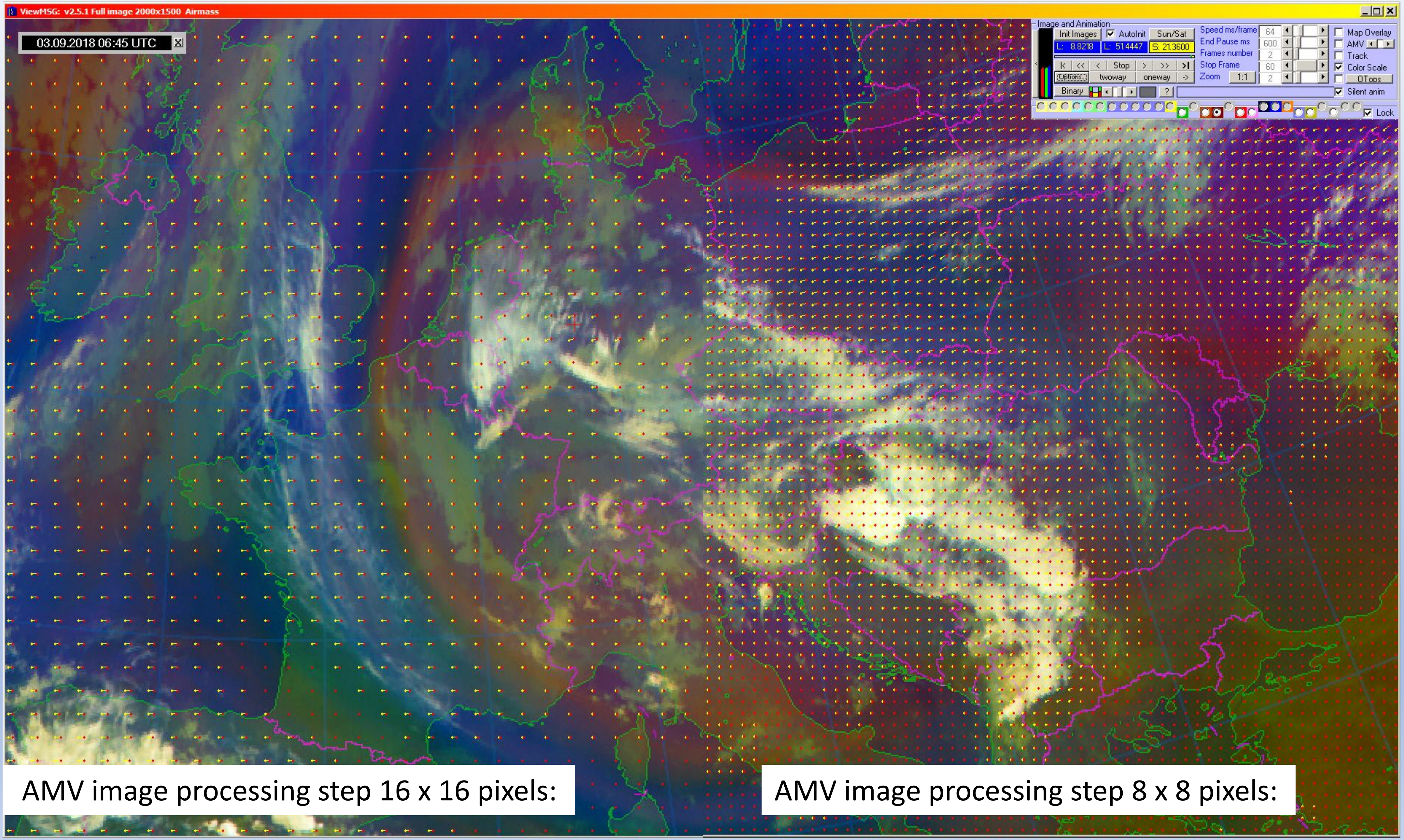
$$\max\left\{ r = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}} \right\}$$

Algorithm description:
Define limited area in the first image and look for identical image structure in second image. Shift of structure between images corresponds to mutual parallax shift between left and right satellite observations.

Parameter:	Step 16x16	Step 8x8
Correlation window size	33	33
Span of possible displacements	36	36
x-coordinate of first column	32	32
y-coordinate of first row	32	32
x-difference between vectors	16	8
y-difference between vectors	16	8
number of vectors in x-direction	122	244
number of vectors in y-direction	91	182
Gaussian pyramid iterations	2	2
number of smoothing cycles	3	3
Area zoom factor	1	1
Area X-offset	1400	1400
Area Y-offset	750	750
Time interval	15	15

Algorithm comes from CEI Nowcasting Project 2002-2004

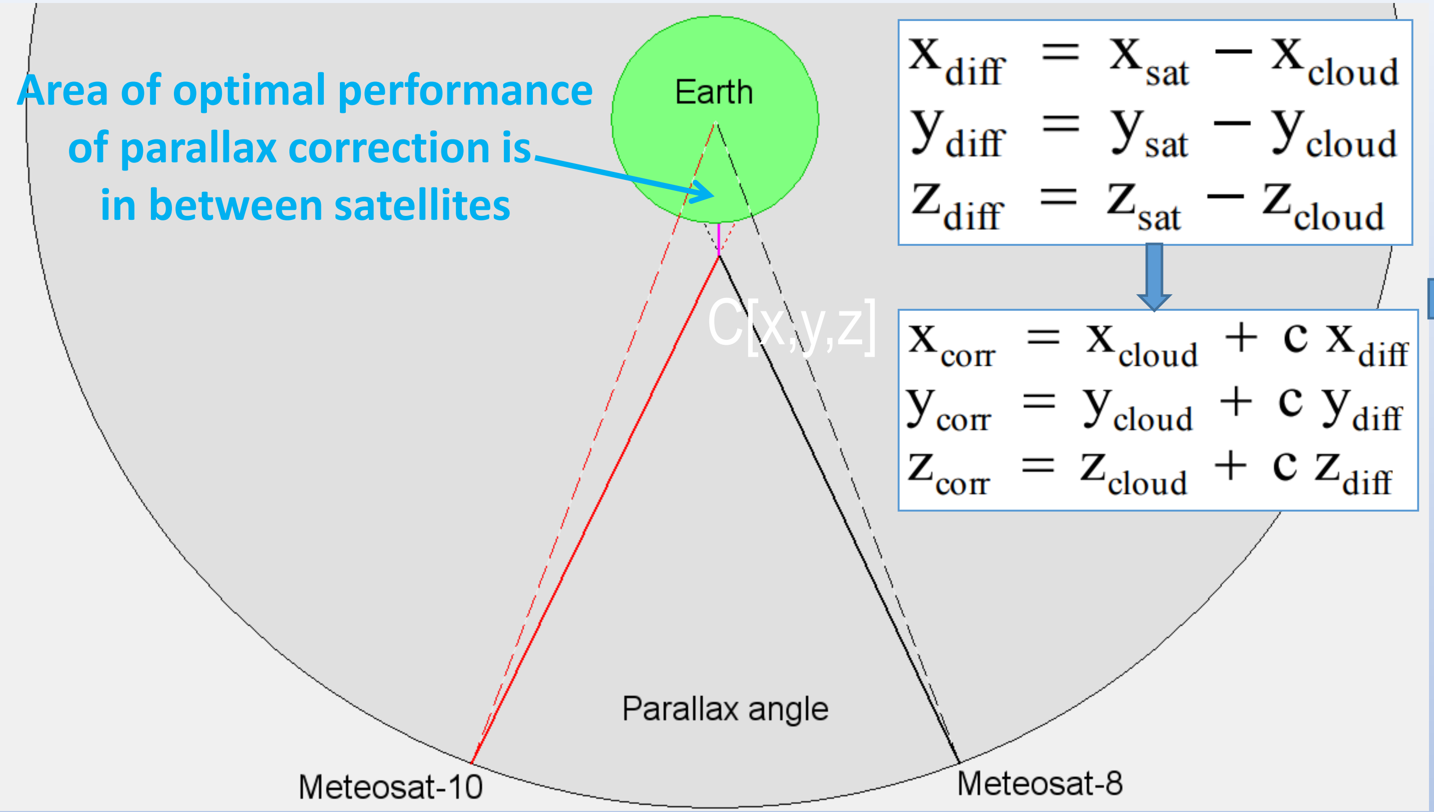
WAY TO THE FINAL PRODUCTS / AMV CASE:



AMV image processing step 16 x 16 pixels:

AMV image processing step 8 x 8 pixels:

DUAL SATELLITES PARALLAX – SIMPLIFIED SCHEME ABOVE EQUATOR VERSUS FULL-EARTH SOLUTION



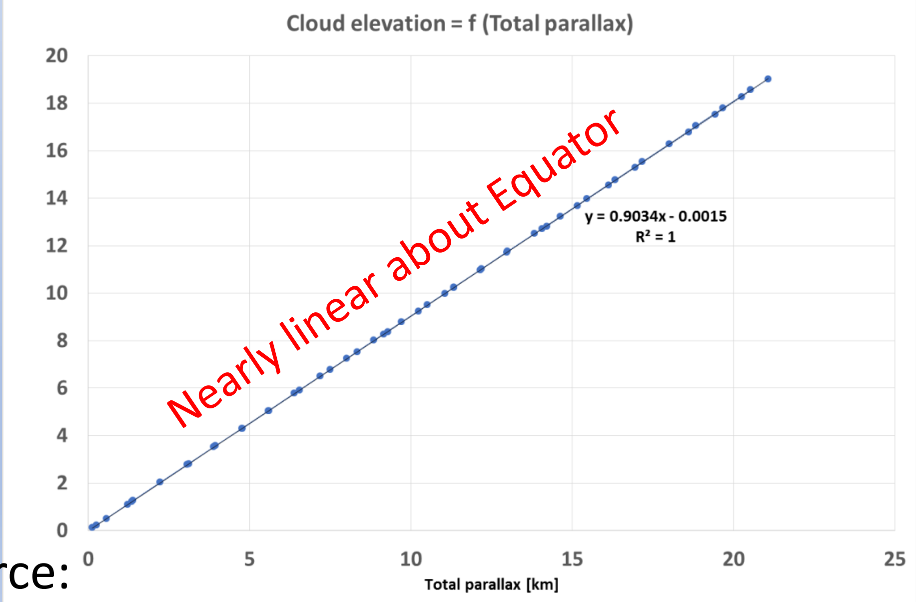
$$x_{diff} = x_{sat} - x_{cloud}$$
$$y_{diff} = y_{sat} - y_{cloud}$$
$$z_{diff} = z_{sat} - z_{cloud}$$

$$x_{corr} = x_{cloud} + c\, x_{diff}$$
$$y_{corr} = y_{cloud} + c\, y_{diff}$$
$$z_{corr} = z_{cloud} + c\, z_{diff}$$

$$\varphi_{cloudcorr} = \arctan\left[\frac{\tan\left(\arctan\frac{y_{corr}}{\sqrt{x_{corr}^2 + z_{corr}^2}}\right)}{R_{ratio}^2}\right]$$

$$\lambda_{cloudcorr} = \mathrm{ATAN2}(x_{corr}, y_{corr})$$
$$\tan(\lambda_{cloudcorr}) = \frac{x_{corr}}{z_{corr}}$$

General Full-Disk solution



Cloud top height in point “C” is calculated as its vertical coordinate. Point “C” is intercept between viewing directions from left and right satellite (black and red lines). Preconditions: To determine left and right cloud positions in both satellite images.

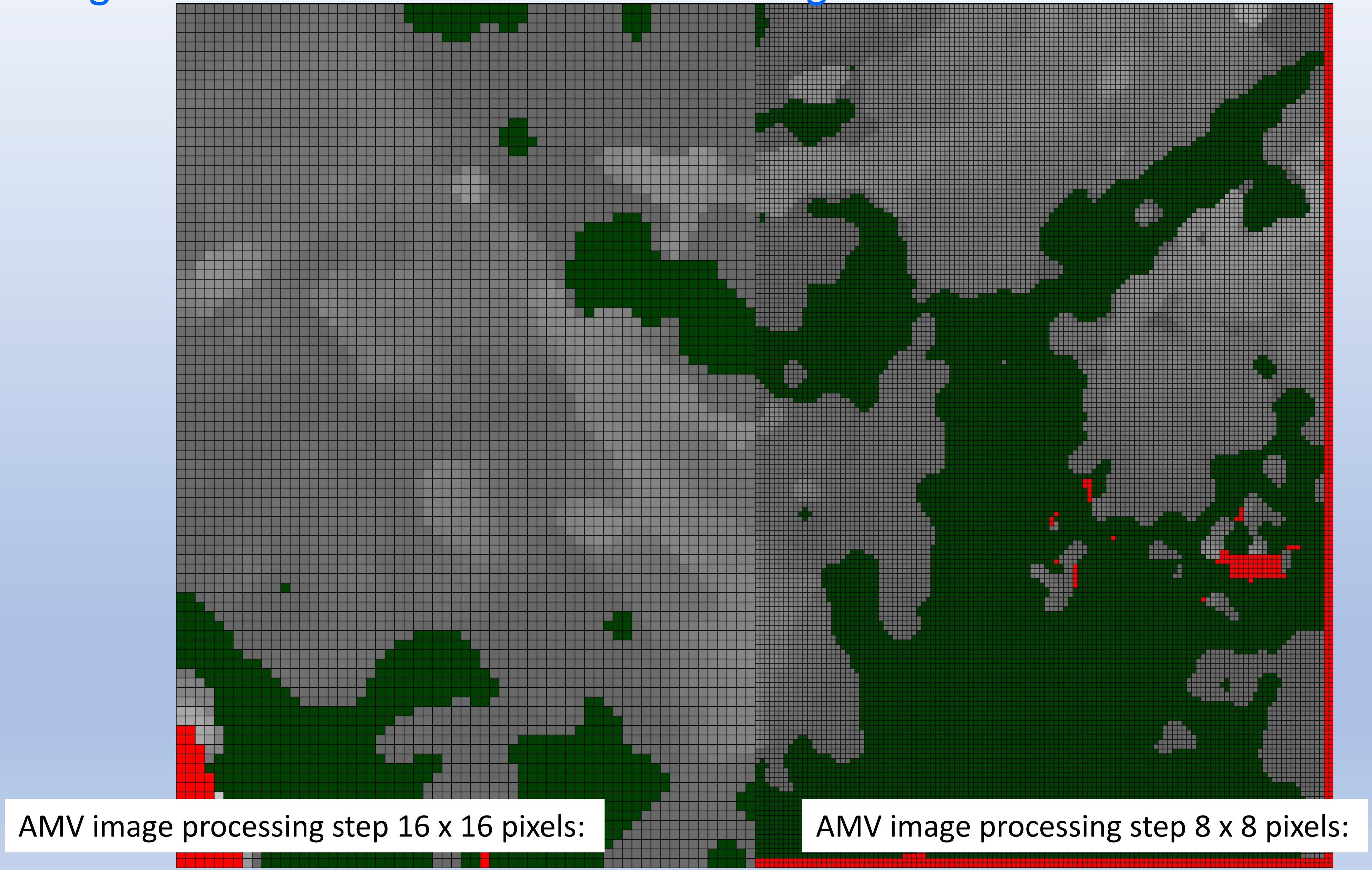
Parallax calculation algorithm source:
EUMETSAT and CWG, by Marianne Koenig
https://www.essl.org/cwg/res/parallax/DescriptionOfTheParallaxCorrectionFunctionality.pdf

To automatize this process we need:

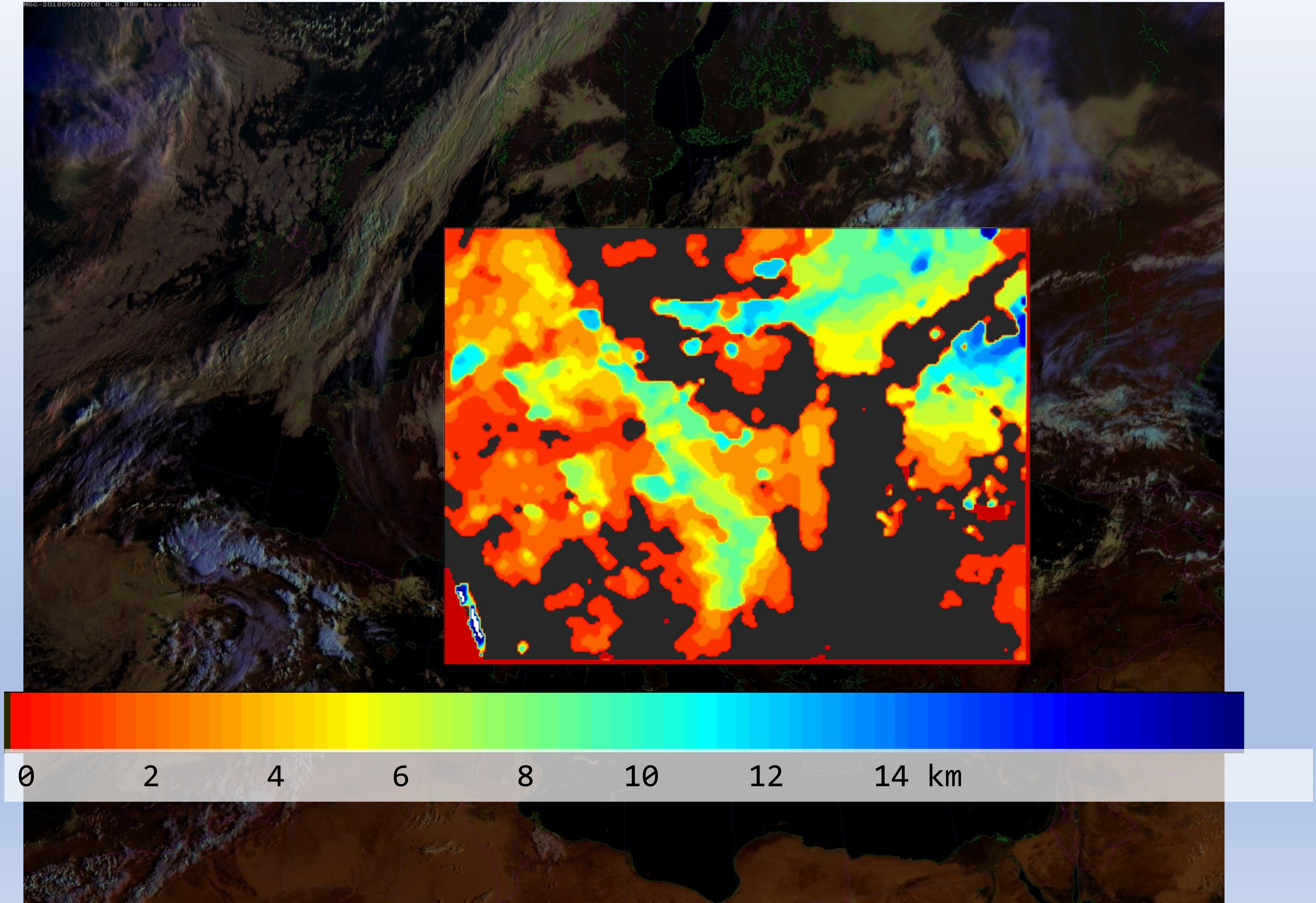
1. Identify cloud structures in the left and right satellite images using **AMV algorithm**
2. Couple cloud structures using dual set of Cartesian coordinates $[x_{left}, y_{left}]$ and $[x_{right}, y_{right}]$
3. Convert Cartesian to geographical coordinates $[\lambda_{left}, \phi_{left}]$ and $[\lambda_{right}, \phi_{right}]$
4. Calculate parallax corrected positions in left and right image $[\lambda_{left}, \phi_{left}]^{corr}$ and $[\lambda_{right}, \phi_{right}]^{corr}$
5. Calculate horizontal (surface) distance d between left and right corrected positions (note that for sea level elevation parallax correction is zero):
   - **d** = distance ($[\lambda_{left}, \phi_{left}]^{corr}$ - $[\lambda_{right}, \phi_{right}]^{corr}$)
6. Change elevation E in 100 meters steps up to 20 km atmosphere layer
7. Repeat calculation steps **3, 4, 5, 6** for each elevation E to look for minimal horizontal distance $\mathbf{d_{min}}$
8. Elevation $\mathbf{E(d_{min})}$ corresponding to the minimum distance $\mathbf{d_{min}}$ is the height of the cloud found!

WAY TO THE FINAL PRODUCTS AND IMPROVEMENT OF SATELLITE RESOLUTION

Higher satellite resolution – more dense grid for AMV calculations:



EXAMPLES OF FINAL PRODUCTS – DERIVED FROM HRV CHANNEL, OVER VIS/IR RGB:



EVALUATION OF PAIRED CTH MEASUREMENTS

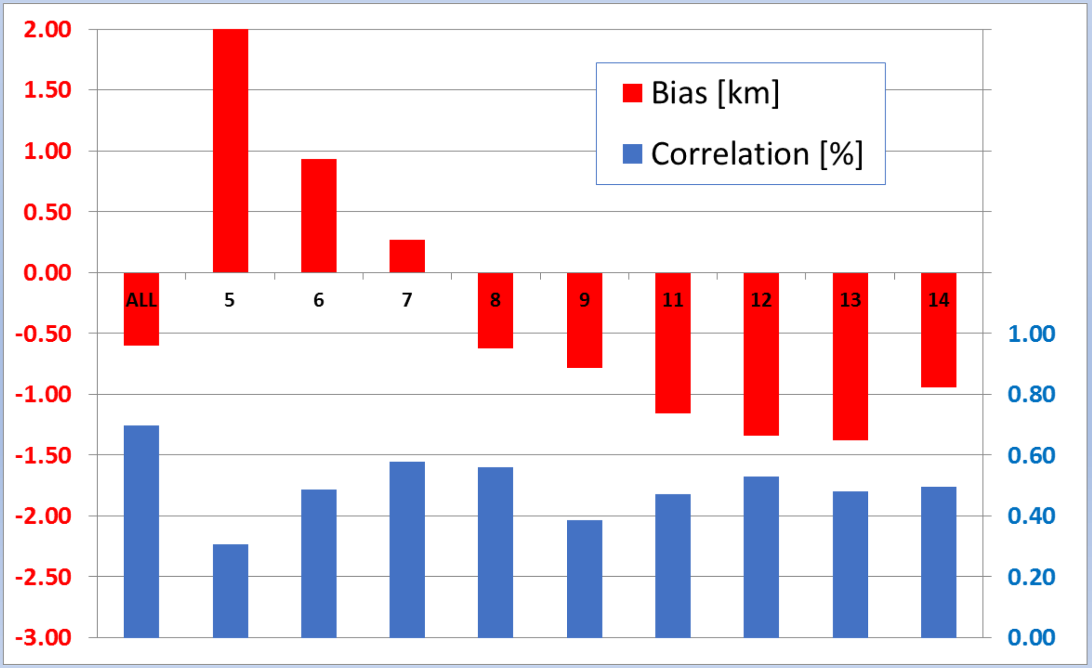
Precision factors of NWCSAF CTH:

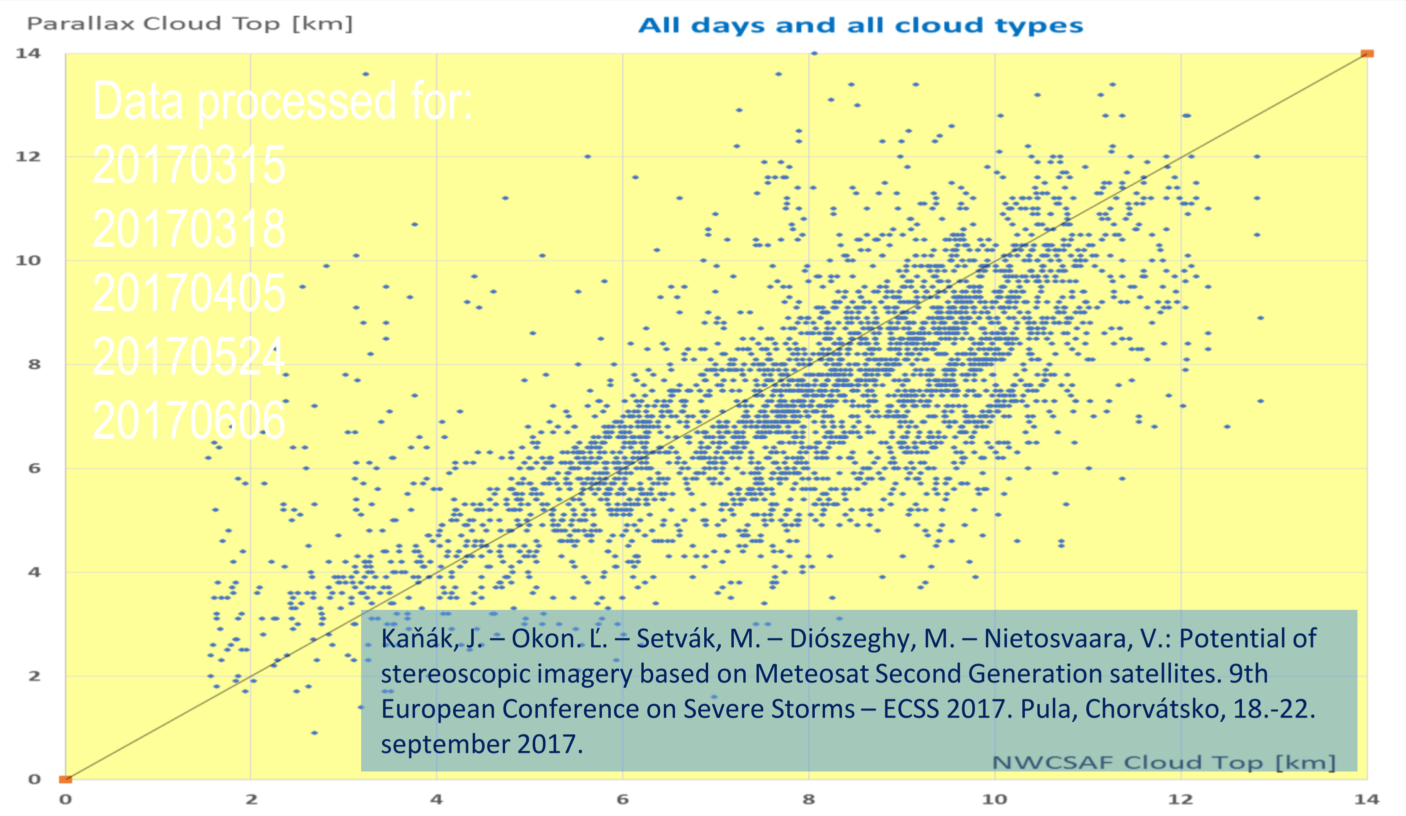
- Cloud mask & cloud types
- Cloud semi-transparency
- Radiances, BT and T,H-profiles

Precision factors of Parallax Cloud Top:

- Image resolution
- Optical cloud properties and shape

Bias and correlation of compared methods:

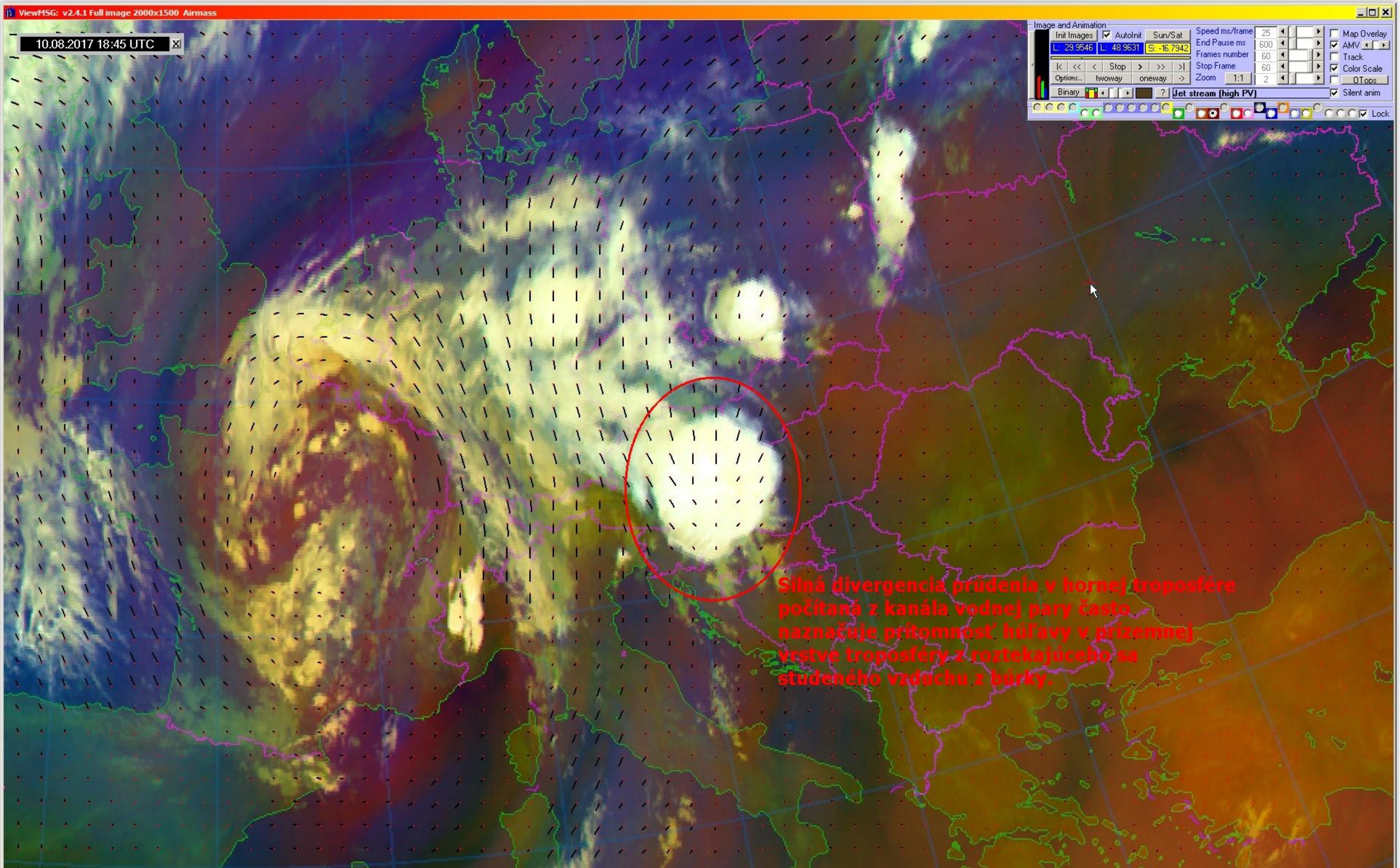




Kaňák, J. – Okon. Ľ. – Setvák, M. – Diószeghy, M. – Nietosvaara, V.: Potential of stereoscopic imagery based on Meteosat Second Generation satellites. 9th European Conference on Severe Storms – ECSS 2017. Pula, Chorvátsko, 18.-22. september 2017.

Cloud type	Cloud index	Number of cases	Bias [km]	Correlation [%]
All clouds	ALL	3477	-0.60	0.70
Very low clouds	5	32	2.00	0.31
Low clouds	6	300	0.93	0.49
Mid level clouds	7	531	0.27	0.58
High opaque clouds	8	990	-0.62	0.56
Very high opaque clouds	9	154	-0.78	0.39
High semitransparent thin clouds	11	207	-1.16	0.47
High semitransparent meanly thick clouds	12	389	-1.34	0.53
High semitransparent thick clouds	13	565	-1.38	0.48
High semitransparent above low or medium clouds	14	309	-0.94	0.50

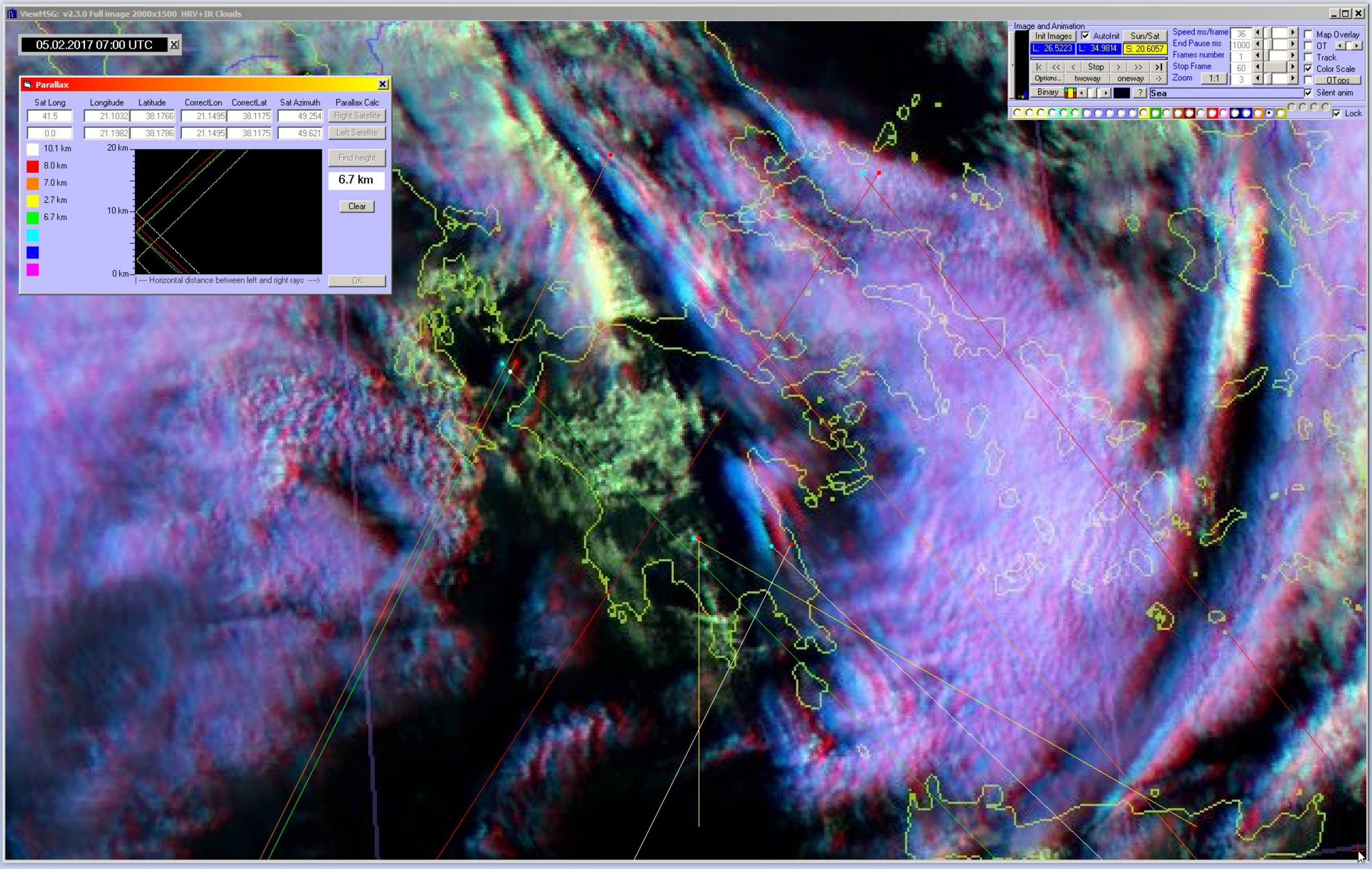
Storm August 10th, 2017 South-West of Slovakia usage of satellite AMVs


ViewMSG: v2.4.1 Full image 2000x1500 Airmass
10.08.2017 18:45 UTC
Image and Animation
Init Images
AutoInit
Sun/Sat
Speed ms/frame
End Pause ms
Frames number
Stop Frame
Zoom
Stop
twoway
oneway
Options...
Binary
Jet stream (high PV)
Map Overlay
AMV
Track
Color Scale
Silent anim
Lock
Silná divergencia prúdenia v hornej troposfére
počítaná z kanála vodnej pary často
naznačuje prítomnosť húľavy v prízemnej
vrstve troposféry z roztekajúceho sa
studeného vzduchu z búrky.

EXAMPLES OF REAL DATA OBTAINED BY PARALLAX MEASUREMENT TOOL:

Clouds over Greece 5.2.2017 07:00 UTC

Measured height values: 10.1, 8.0, 7.0, 2.7, 6.7 km



Higher cloud →

Bigger parallax →

Higher cloud top height

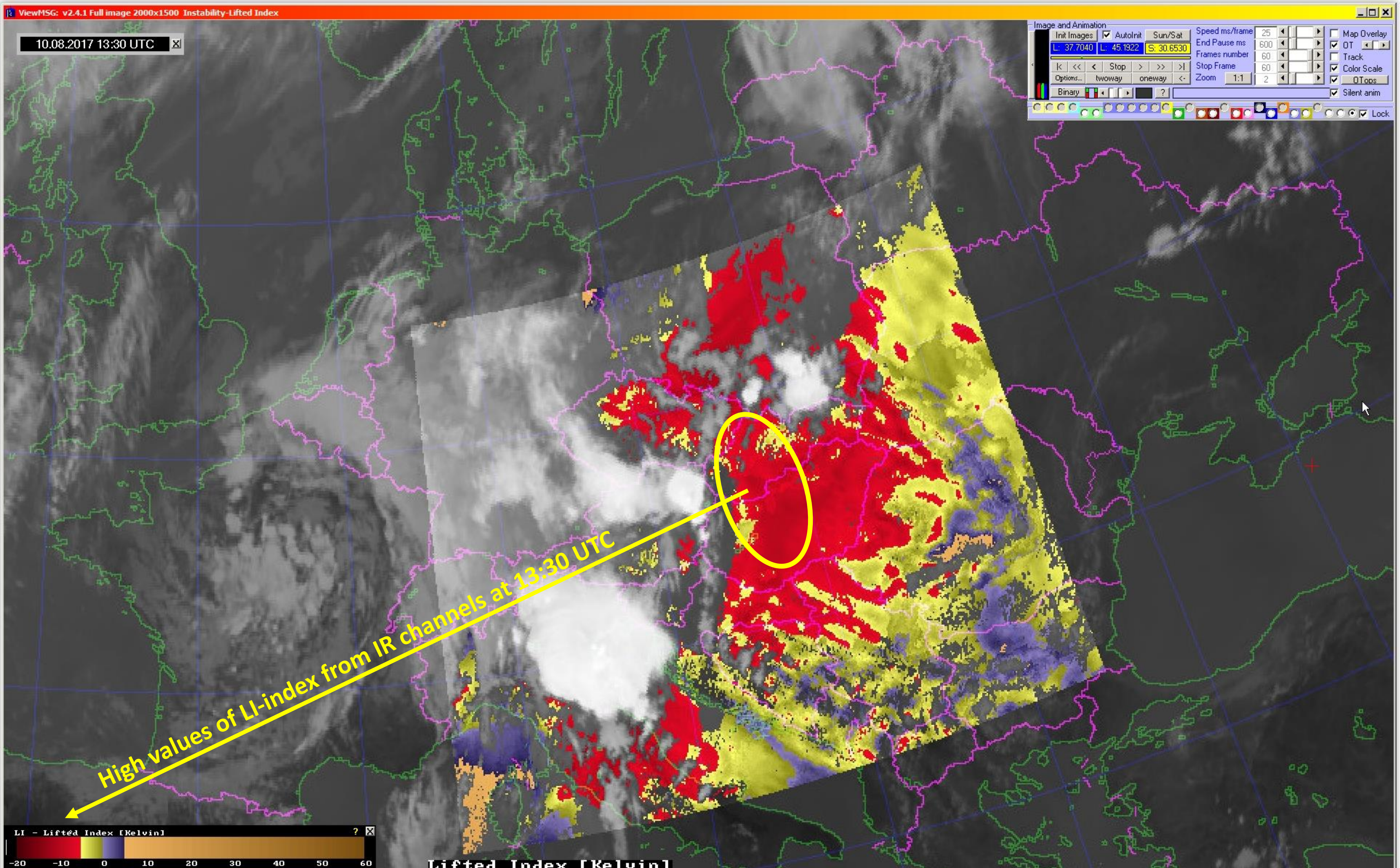
Visual method is inconvenient and subjective

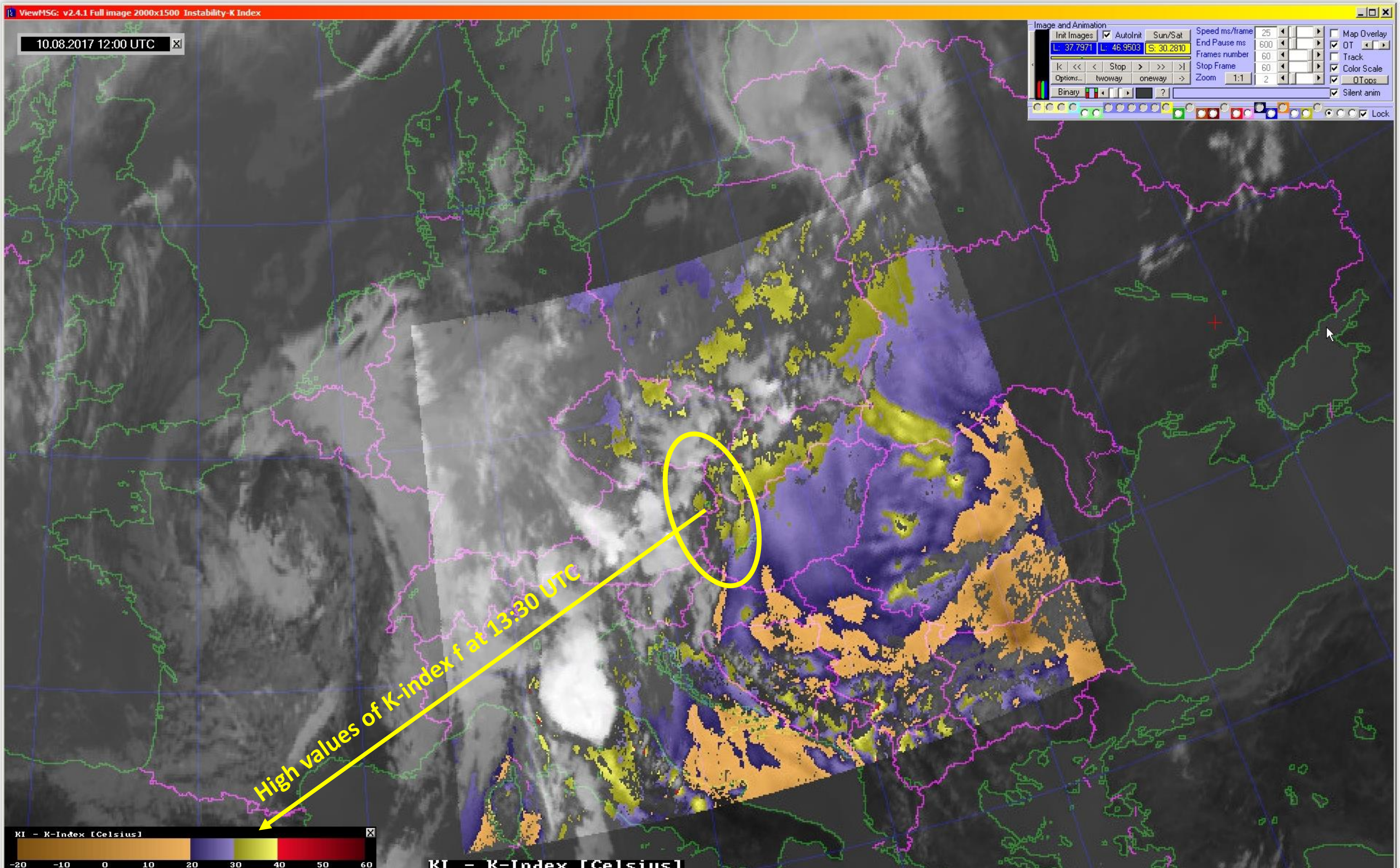
Instead automatic calculatio can be used:

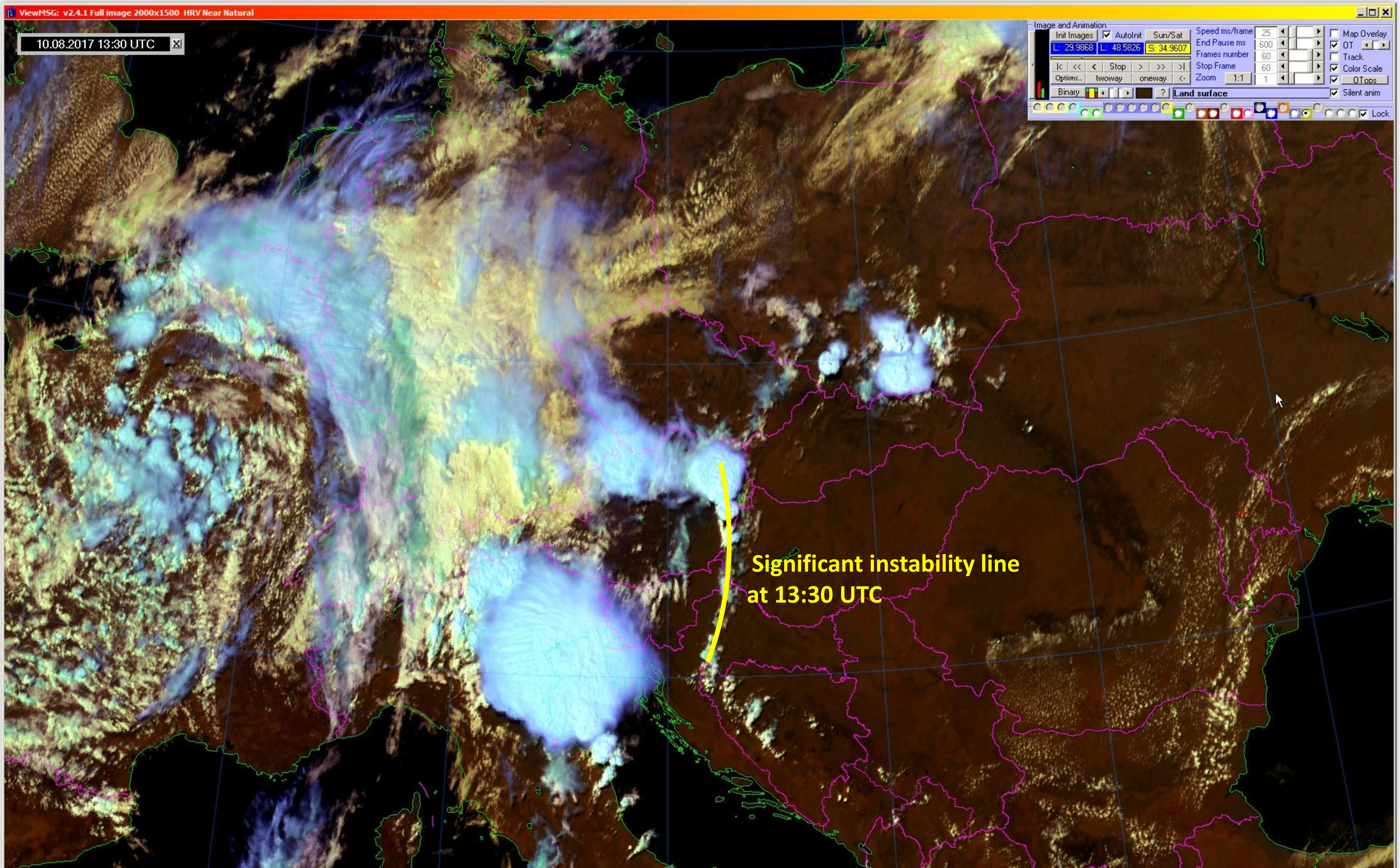
- To detect parallax shifts
- Calculate cloud top height

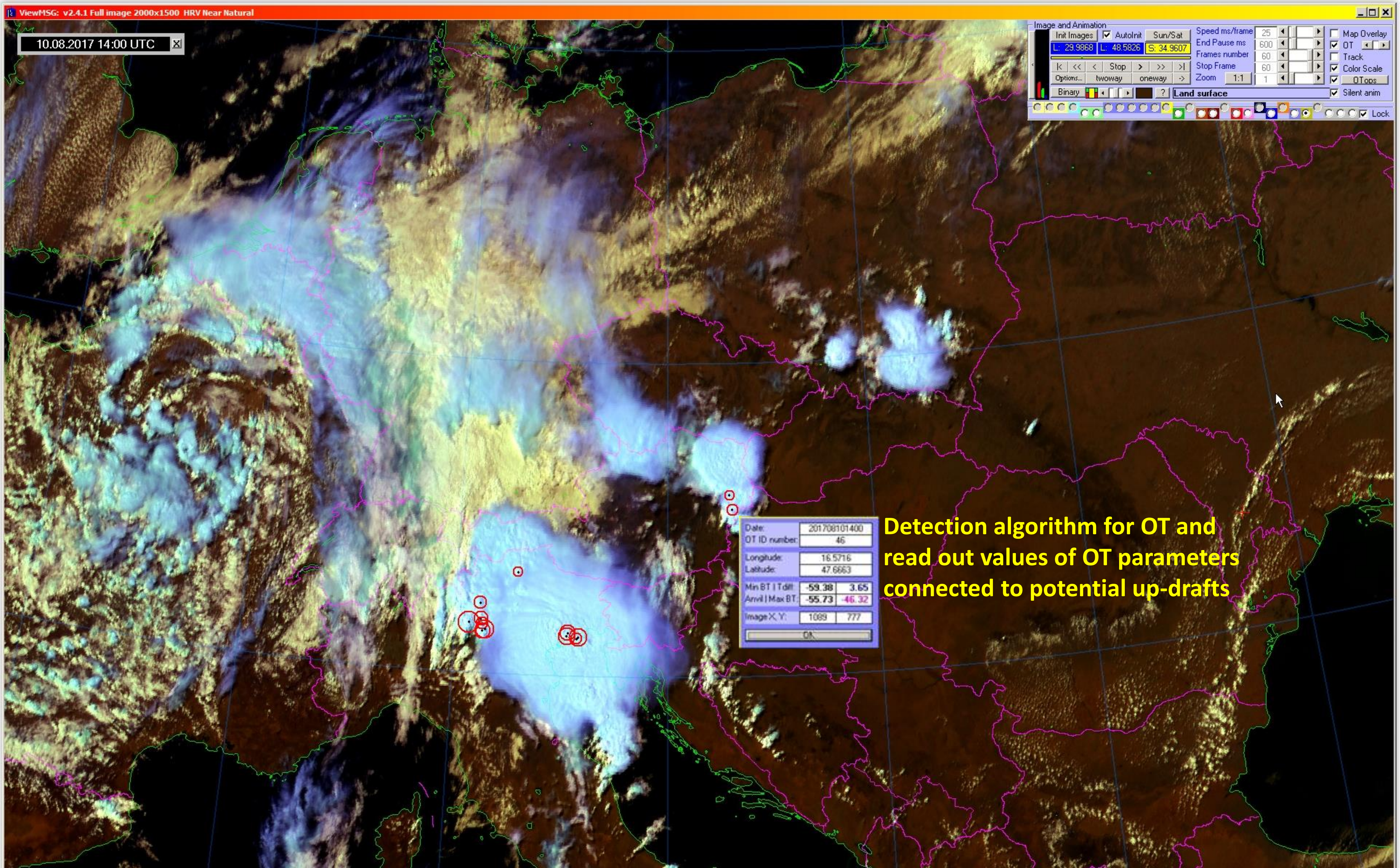
Required:

- Precise image geo-referencir
- Appropriate algorithms
- High computing resources

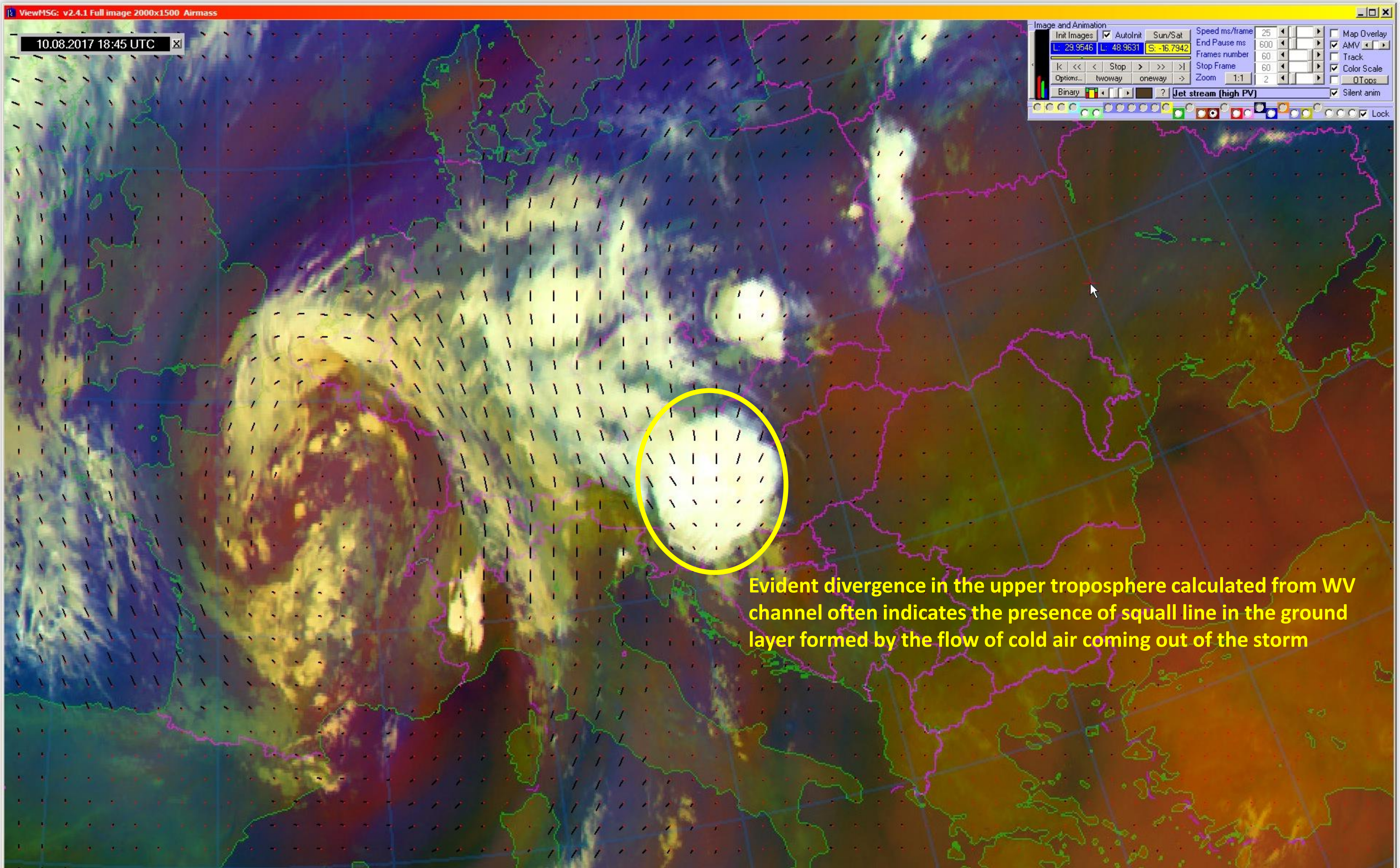

ViewMSG: v2.4.1 Full image 2000x1500 Instability-Lifted Index
10.08.2017 13:30 UTC
High values of LI-index from IR channels at 13:30 UTC
LI - Lifted Index [Kelvin]
-20 -10 0 10 20 30 40 50 60
Lifted Index [Kelvin]


ViewMSG: v2.4.1 Full image 2000x1500 Instability-K Index
10.08.2017 12:00 UTC
High values of K-index f at 13:30 UTC
KI - K-Index [Celsius]
-20 -10 0 10 20 30 40 50 60
KI - K-Index [Celsius]


ViewMSG: v2.4.1 Full image 2000x1500 HRV Near Natural
10.08.2017 13:30 UTC
Significant instability line
at 13:30 UTC



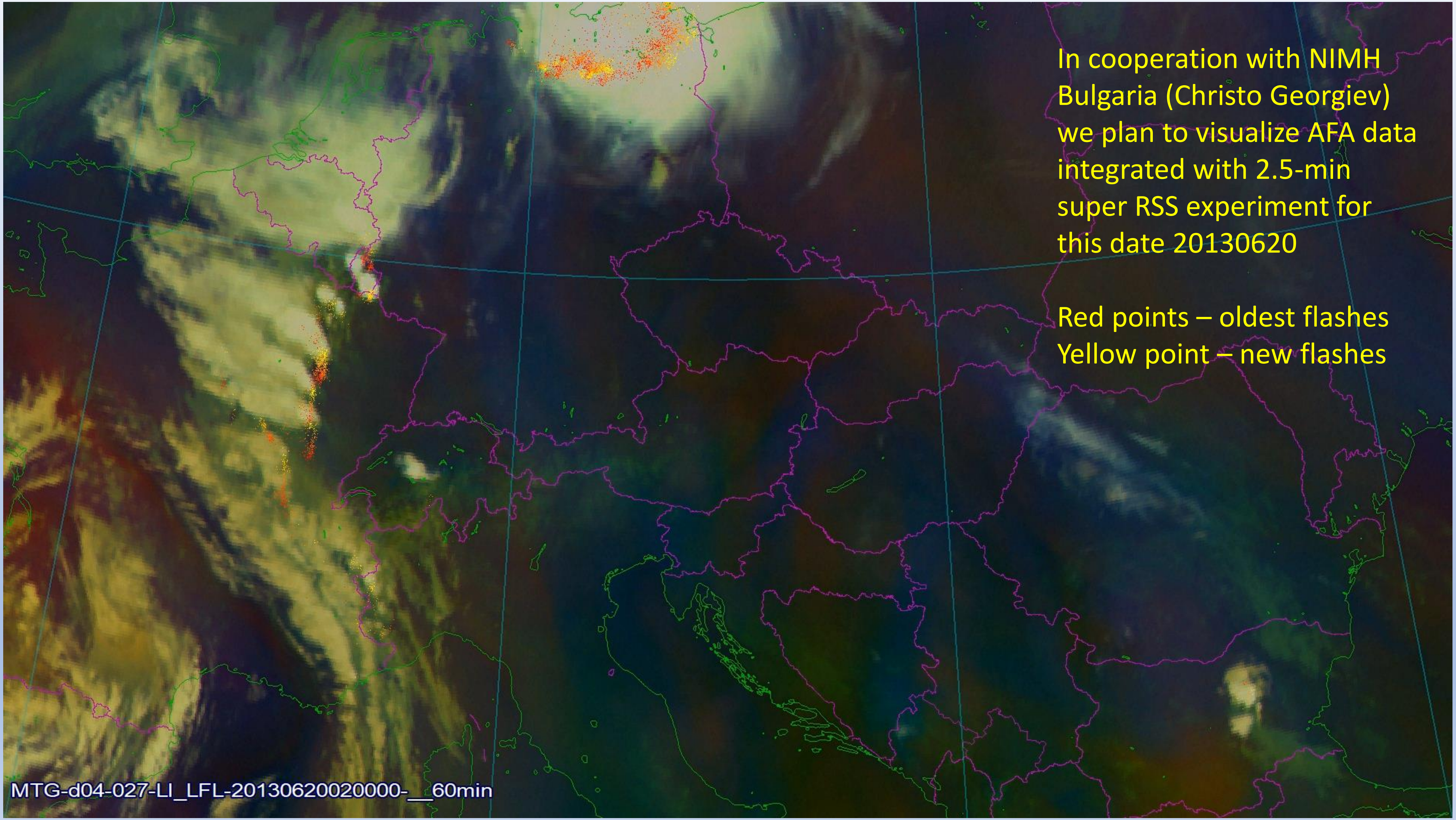
Detection algorithm for OT and read out values of OT parameters connected to potential up-drafts



Evident divergence in the upper troposphere calculated from WV channel often indicates the presence of squall line in the ground layer formed by the flow of cold air coming out of the storm

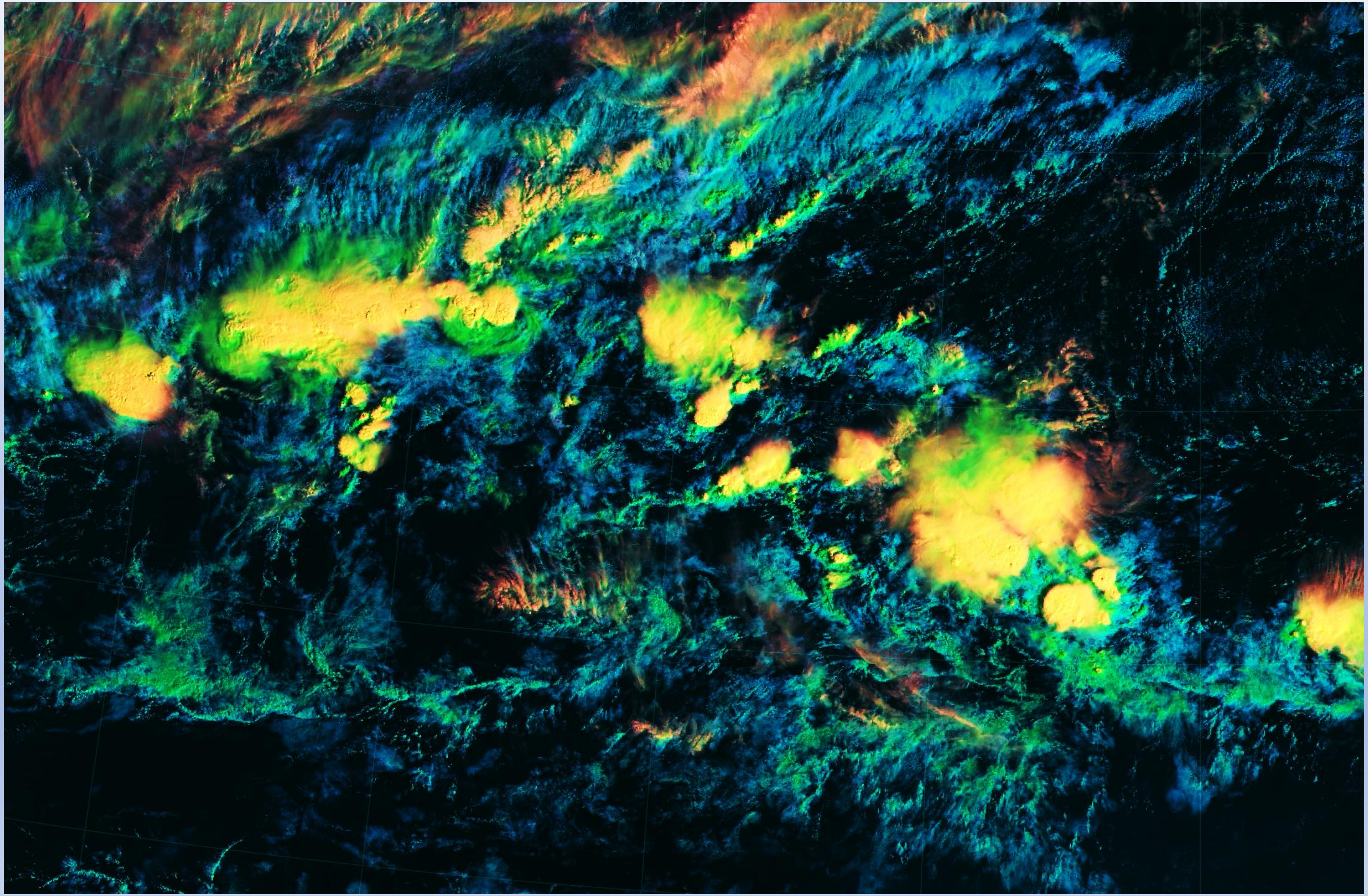
LI-2-LFL Data Visualisation Air Mass RGB, MSG RSS, flashes 60min_acumulations

Date: 20130620, start 02:00, end 23:55 UTC, 5-minutes MSG RSS, 60 min flash accumulations



2021-01-25 17:00 Cloud phase & Cloud types & phase distinction:

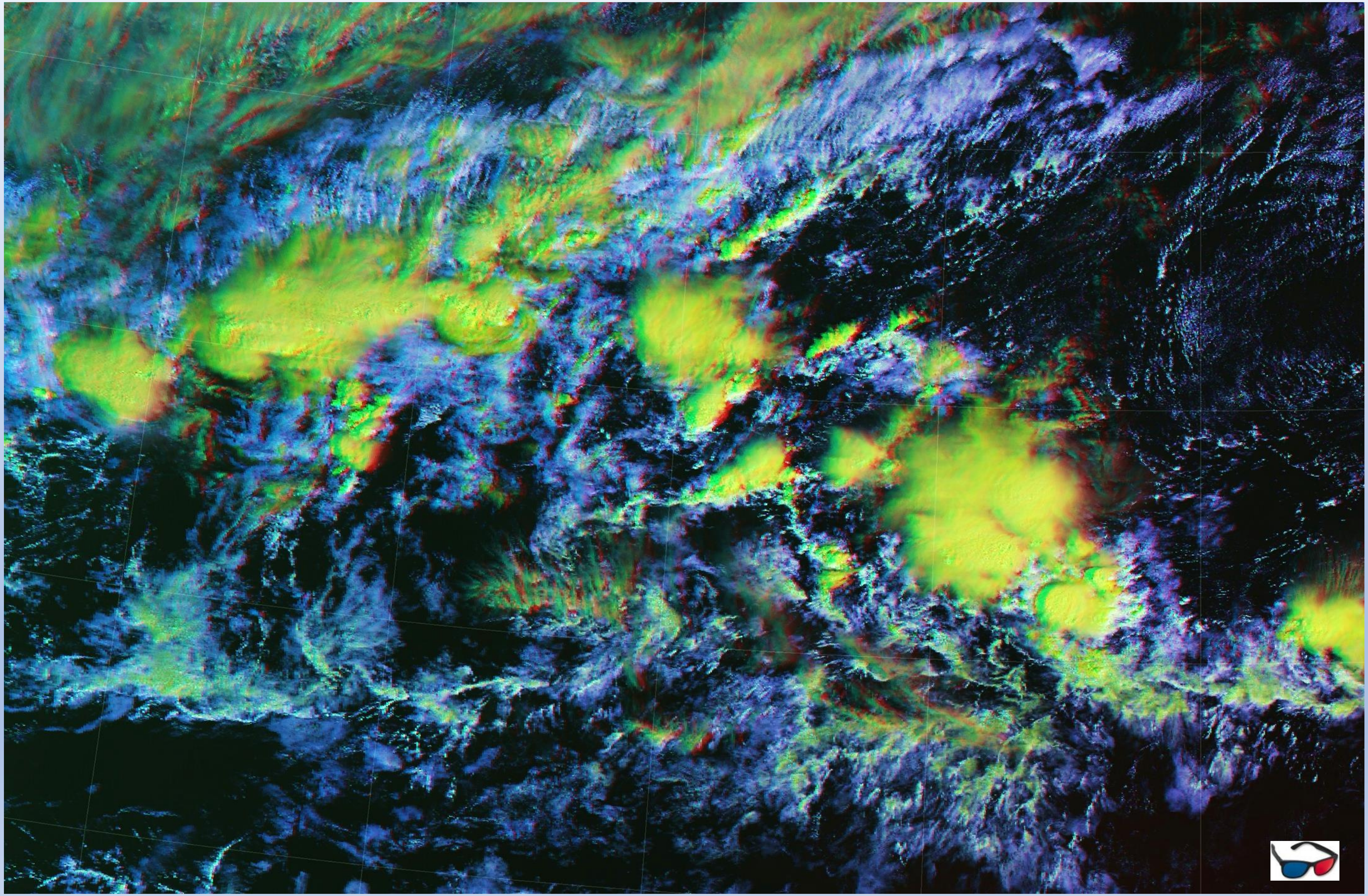
G17 Standard RGB



2021-01-25 17:00 Cloud phase & Cloud types & phase distinction:

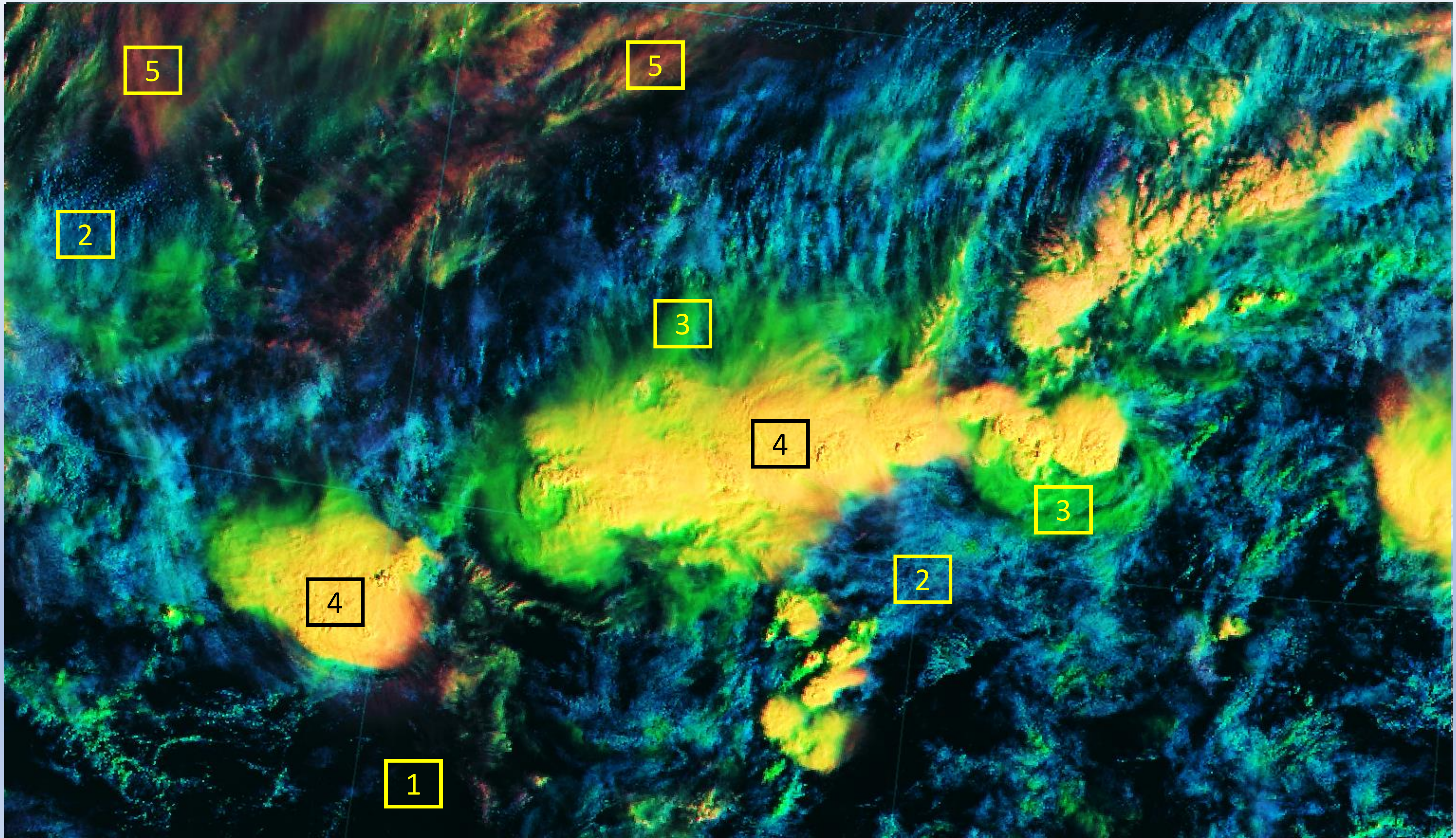
G16-G17 Anaglyph RGB:

137W <----- 62˚ -----> 75W



2021-01-25 17:00 Cloud phase & Cloud types & phase distinction:

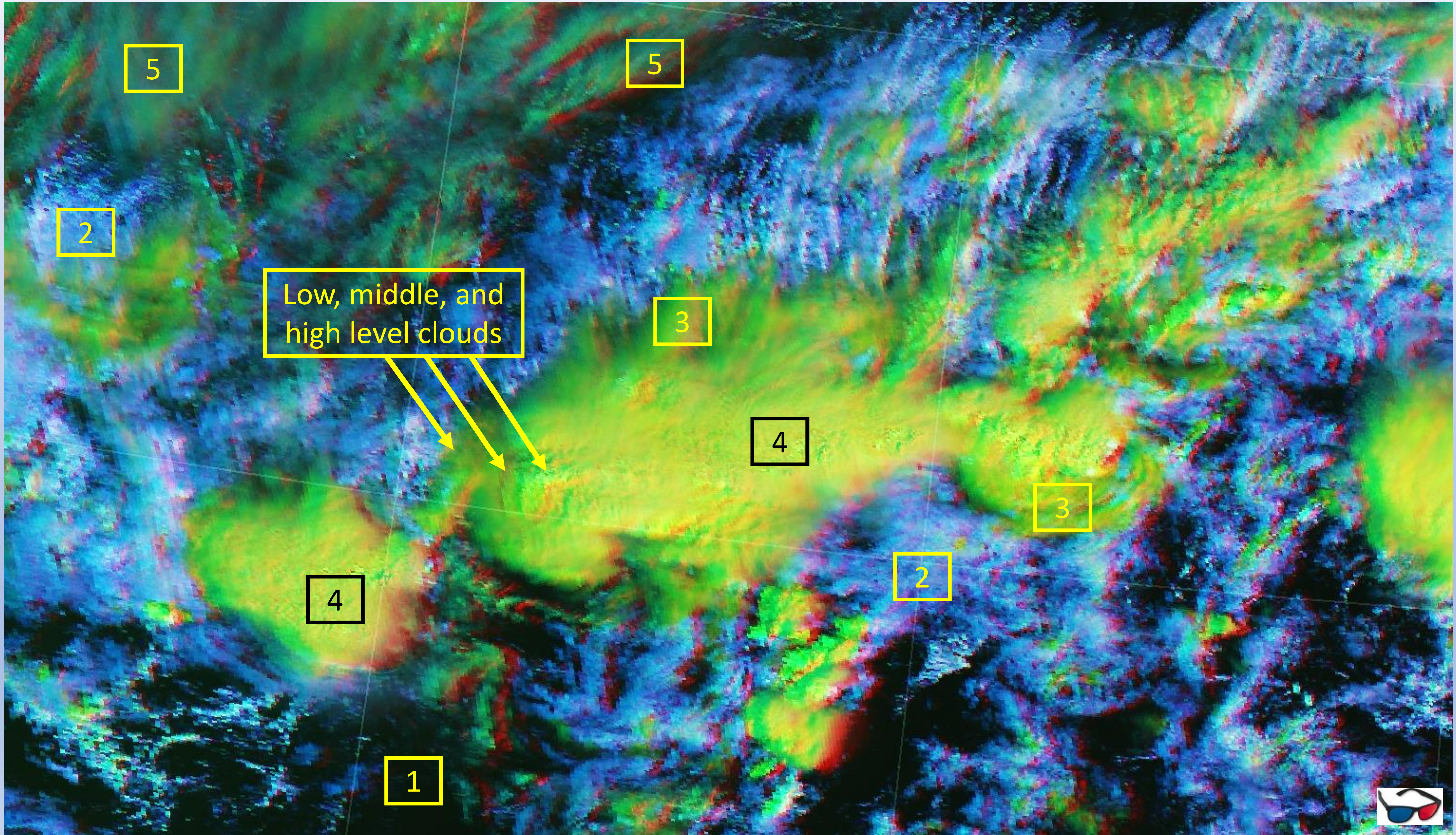
G17 Standard RGB Storms details:



2021-01-25 17:00 Cloud phase & Cloud types & phase distinction:

G16-G17 Anaglyph RGB storms details:

137W <----- 62˚ -----> 75W



2021-01-25 17:00 Cloud phase & Cloud types & phase distinction:

Legend:

1 **Sea surface**

2 **Low to mid-level water clouds**

3 **Mixed phase clouds at low and mid-levels**

4 **Thick ice clouds (multi-layered clouds with ice on top)**

5 **Thin cirrus clouds over land or sea (darker red over the seas)**

Conclusions

- Status of development of satellite application software for FCI and LI at SHMU
  - Maximize effectiveness of processing steps:
    - Avoid repeating of identical processing steps when generating different domains or different RGBs
    - Maximize processing speed using parallelization of calculations
  - What is missing and is planned to do:
    - Easy configure new domains and new RGBs
  - Installation of FCI Decompression software is not straight forward; at SHMI we have some knowhow how to install this software and prerequisites
  - Some parts of software are operational for MSG data at SHMI but available only as lab/test versions for future FCI data
    - We are prepared to adapt software parts as soon as possible when real-time FCI data will be available during or after commissioning phase of MTG-I1 satellite

Conclusions

- The preparation of this software took almost 2 years, so today's presentation does not bring too much added professional value, as it was in the past, for example:
  - OT detection
  - Monitoring areal and time distribution of storms
  - Both in higher time and space resolution

- I believe that also in case of this solution presented here the MTG era will bring new opportunities to deliver more research-oriented results and less time we will spend for technical data processing and preparation of our processing chains:
  - Operational for forecasters
  - Experimental for researchers

I am grateful to those who are willing to help me with testing and feedback for improvement: Christo Georgiev from Bulgaria and Humberto Barbosa from Brazil

Thank to all of you for attention!