# Three years of dual MSG image data from operational, user and scientific perspective: possibilities and limitations

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# Introduction

- Stereoscopic images are produced operationally and archived at SHMÚ since December 2017 over three regions: Central Europe, Europe and Central Africa
- Imagery is based on HRV and Airmass image products
- Mutual parallax shifts of clouds are calculated and archived since February 2018
- Because of HRV window shifts, Sun elevation and mutual satellite constellation observations of meteorological events are limited to:
  - specific time slots during the day and
  - to specific regions only
- Archived products are used for case studies locally and can be used as quick look and offered to anyone who is interested in detailed 3D studies of cloudiness development, mainly in case of severe convection.
- Presentation describes the image library of currently available dual satellite constellations of MSG satellites and examples prepared using data received by our local EUMETCast station

## Part 1: Products available for the period December 2017 – September 2018

| Database: | e:\C\MSGIODC\stereoscopic_imagery\yyyymmdd\ | Availability dates: | | Period of day: | | Data | Product |
|---|---|---|---|---|---|---|---|
| Code: | File naming: Maxtor 20171126 | START | END | Start | End | format | Composite |
| M3D | M3D-amv-YYYYmmddHHMM.bin | 29.1.2018 | 30.9.2018 | 0:00 | 23:45 | bin | vectors |
| M3R | M3R-amv-YYYYmmddHHMM.bin | 29.1.2018 | 30.9.2018 | 0:00 | 23:45 | bin | vectors |
| A-012 | MSG-d00-012-YYYYmmddHHMM-A.jpg | 1.12.2017 | 30.9.2018 | 0:00 | 23:45 | jpg | HRV |
| A-021 | MSG-d00-021-YYYYmmddHHMM-A.jpg | 25.1.2018 | 30.9.2018 | 0:00 | 23:45 | jpg | Airmass |
| A-045 | MSG-d00-045-YYYYmmddHHMM-A.jpg | 1.12.2017 | 30.9.2018 | 0:00 | 23:45 | jpg | HRV+IR+NIR |
| L-045 | MSG-d00-045-YYYYmmddHHMM-L.jpg | 1.12.2017 | 30.9.2018 | 0:00 | 23:45 | jpg | HRV+IR+NIR |
| R-045 | MSG-d00-045-YYYYmmddHHMM-R.jpg | 1.12.2017 | 30.9.2018 | 12:00 | 16:45 | jpg | HRV+IR+NIR |
| A-Africa | MSG-d17-012-YYYYmmddHHMM-A.jpg | 1.12.2017 | 30.9.2018 | 12:00 | 16:45 | jpg | HRV |
| L-Africa | MSG-d17-012-YYYYmmddHHMM-L.jpg | 1.12.2017 | 30.9.2018 | 0:00 | 23:45 | jpg | HRV |
| R-Africa | MSG-d17-012-YYYYmmddHHMM-R.jpg | 1.12.2017 | 30.9.2018 | 0:00 | 23:45 | jpg | HRV |

28800 frames for M3D and M3R binary files
28800 frames for Airmass North hemisphere product
14400 frames for HRV Europe (48 frames per day in average)
6000 frames for HRV Central Africa region

## Part 2: Products available for the period October 2018 – June 2019

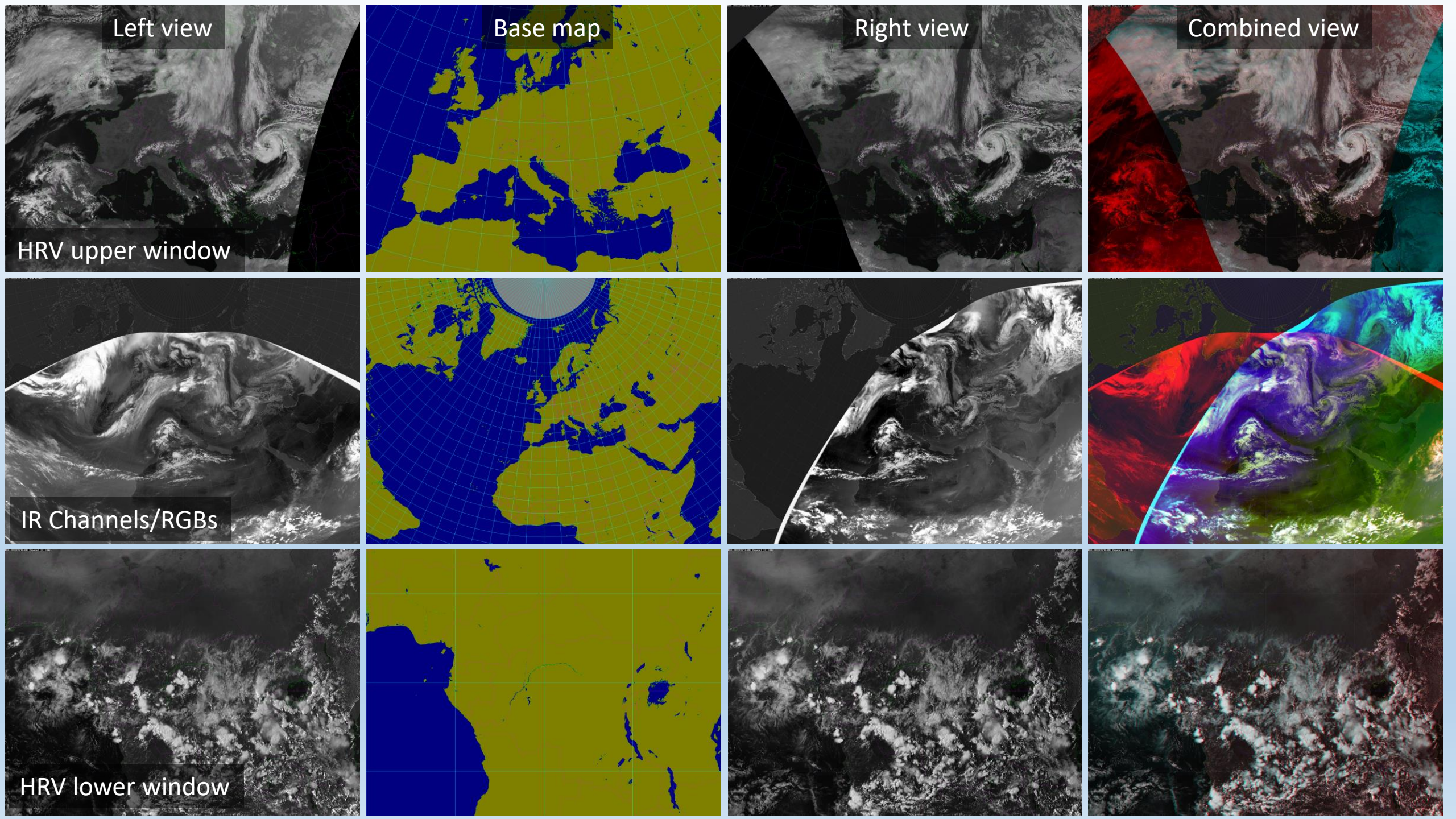
| Database: | e:\C\MSGIODC\stereoscopic_imagery\yyyymmdd\ | Availability dates: | | Period of day: | | Data | Product |
|---|---|---|---|---|---|---|---|
| Code: | File naming: Maxtor 20191130 | START | END | Start | End | format | Composite |
| M3D | M3D-amv-YYYYmmddHHMM.bin | 1.10.2018 | 30.6.2019 | 0:00 | 23:45 | bin | vectors |
| M3R | M3R-amv-YYYYmmddHHMM.bin | 1.10.2018 | 30.6.2019 | 0:00 | 23:45 | bin | vectors |
| A-012 | MSG-d00-012-YYYYmmddHHMM-A.jpg | 1.10.2018 | 30.6.2019 | 0:00 | 23:45 | jpg | HRV |
| A-021 | MSG-d00-021-YYYYmmddHHMM-A.jpg | 1.10.2018 | 30.6.2019 | 0:00 | 23:45 | jpg | Airmass |
| A-045 | MSG-d00-045-YYYYmmddHHMM-A.jpg | 1.10.2018 | 30.6.2019 | 0:00 | 23:45 | jpg | HRV+IR+NIR |
| L-045 | MSG-d00-045-YYYYmmddHHMM-L.jpg | 1.10.2018 | 30.6.2019 | 0:00 | 23:45 | jpg | HRV+IR+NIR |
| R-045 | MSG-d00-045-YYYYmmddHHMM-R.jpg | 1.10.2018 | 30.6.2019 | 12:00 | 16:45 | jpg | HRV+IR+NIR |
| A-Africa | MSG-d17-012-YYYYmmddHHMM-A.jpg | 1.10.2018 | 30.6.2019 | 12:00 | 16:45 | jpg | HRV |
| L-Africa | MSG-d17-012-YYYYmmddHHMM-L.jpg | 1.10.2018 | 30.6.2019 | 0:00 | 23:45 | jpg | HRV |
| R-Africa | MSG-d17-012-YYYYmmddHHMM-R.jpg | 1.10.2018 | 30.6.2019 | 0:00 | 23:45 | jpg | HRV |

25920 frames for M3D and M3R binary files
25920 frames for Airmass North hemisphere product
12960 frames for HRV Europe (48 frames per day in average)
5400 frames for HRV Central Africa region

## Part 3: Products available for the period July 2019 – December 2020 and continuing …

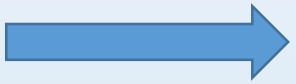
| Database: | e:\C\MSGIODC\stereoscopic_imagery\yyyymmdd\ | Availability dates: | | Period of day: | | Data | Product |
|---|---|---|---|---|---|---|---|
| Code: | File naming: WD Elements 20200902 | START | END | Start | End | format | Composite |
| M3D | M3D-amv-YYYYmmddHHMM.bin | 1.7.2019 | 31.12.2020 | 0:00 | 23:45 | bin | vectors |
| M3R | M3R-amv-YYYYmmddHHMM.bin | 1.7.2019 | 31.12.2020 | 0:00 | 23:45 | bin | vectors |
| A-012 | MSG-d00-012-YYYYmmddHHMM-A.jpg | 1.7.2019 | 31.12.2020 | 0:00 | 23:45 | jpg | HRV |
| A-021 | MSG-d00-021-YYYYmmddHHMM-A.jpg | 1.7.2019 | 31.12.2020 | 0:00 | 23:45 | jpg | Airmass |
| A-045 | MSG-d00-045-YYYYmmddHHMM-A.jpg | 1.7.2019 | 31.12.2020 | 0:00 | 23:45 | jpg | HRV+IR+NIR |
| L-045 | MSG-d00-045-YYYYmmddHHMM-L.jpg | 1.7.2019 | 31.12.2020 | 0:00 | 23:45 | jpg | HRV+IR+NIR |
| R-045 | MSG-d00-045-YYYYmmddHHMM-R.jpg | 1.7.2019 | 31.12.2020 | 12:00 | 16:45 | jpg | HRV+IR+NIR |
| A-Africa | MSG-d17-012-YYYYmmddHHMM-A.jpg | 1.7.2019 | 31.12.2020 | 12:00 | 16:45 | jpg | HRV |
| L-Africa | MSG-d17-012-YYYYmmddHHMM-L.jpg | 1.7.2019 | 31.12.2020 | 0:00 | 23:45 | jpg | HRV |
| R-Africa | MSG-d17-012-YYYYmmddHHMM-R.jpg | 1.7.2019 | 31.12.2020 | 0:00 | 23:45 | jpg | HRV |

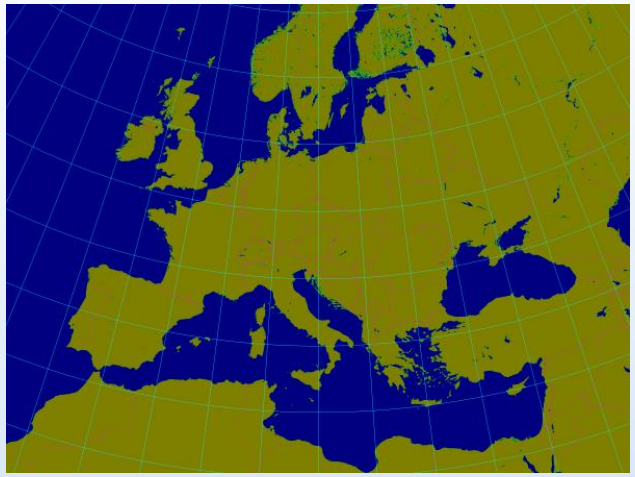
17280 frames for M3D and M3R binary files
17280 frames for Airmass North hemisphere product
8640 frames for HRV Europe (48 frames per day in average)
3600 frames for HRV Central Africa region

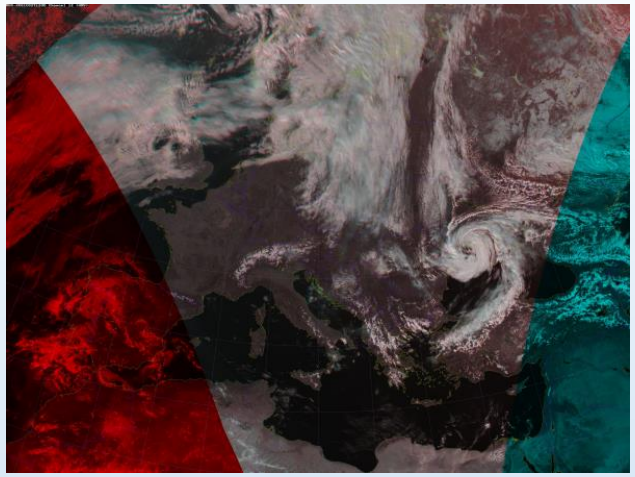

Left view
Base map
Right view
Combined view
HRV upper window
IR Channels/RGBs
HRV lower window

# Details of base maps definitions:

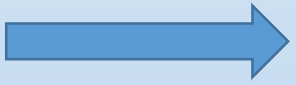
Albers projection 4000x3000 pixels
Map central lon=15˚ lat=48˚
Resolution 1.305 km

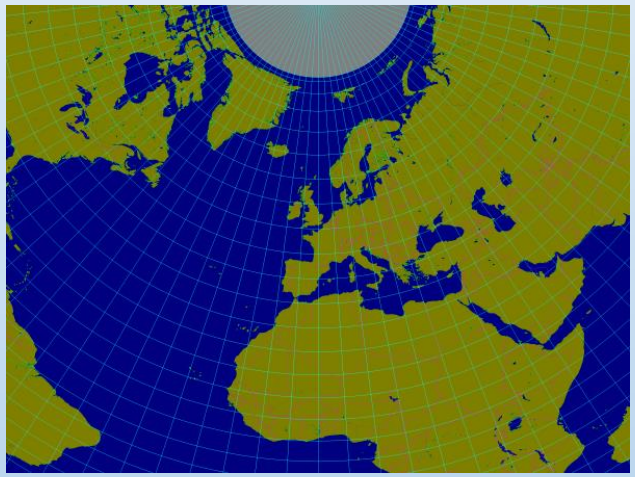


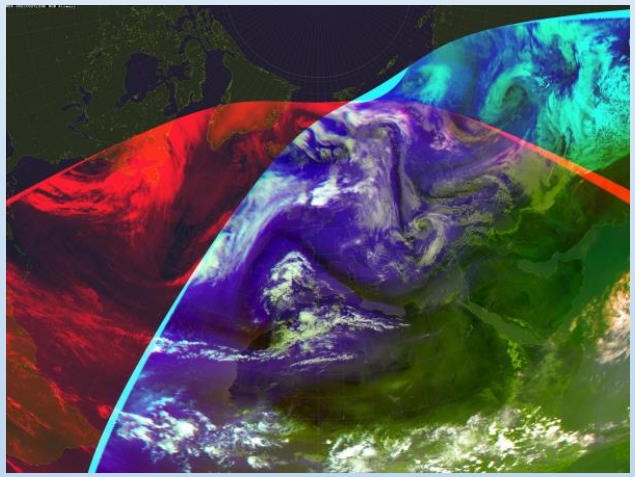




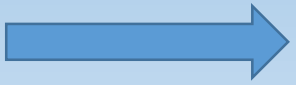
Albers projection 4000x3000 pixels
Map central lon=0˚ lat=48˚
Resolution 3.500 km

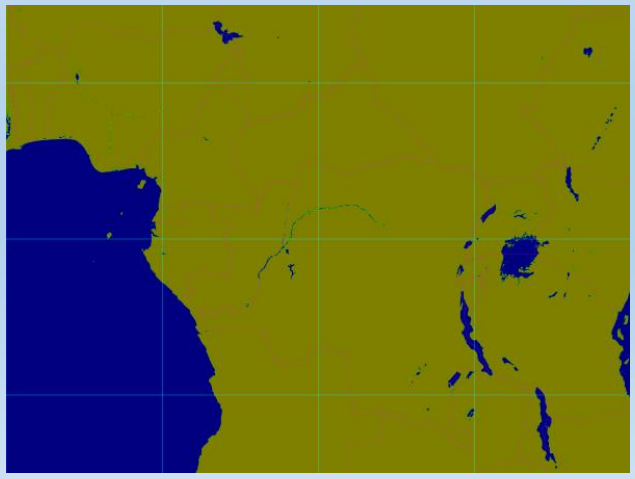


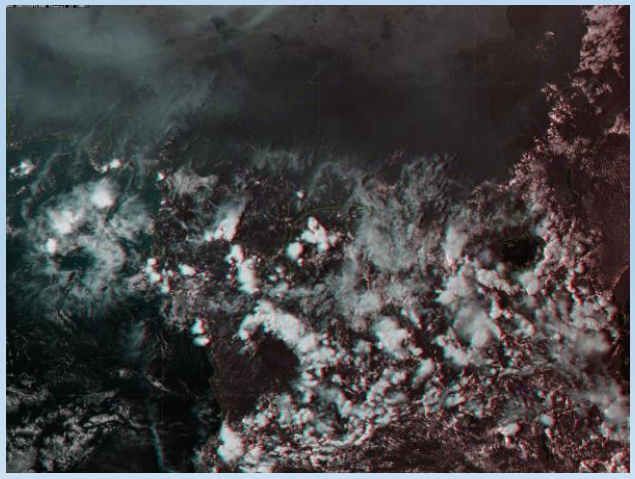




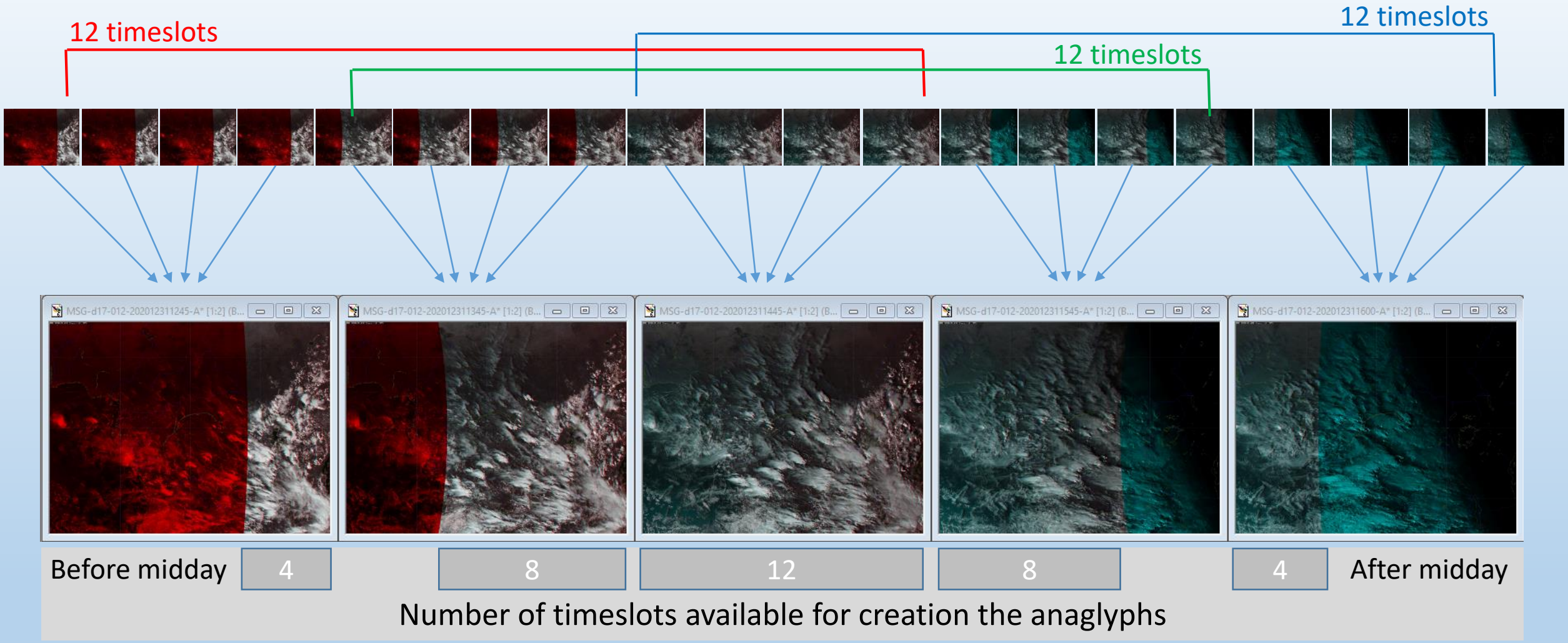
Regular longitude-latitude grid 4000x3000 pixels
Map central lat=0˚ lon=20˚
Region 40˚x30˚
Resolution 1.113 km







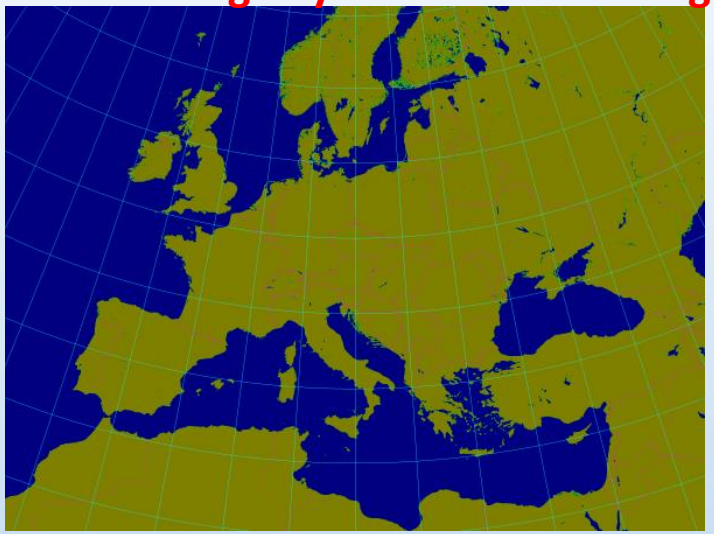
# Limitation of the Central African region during day time 12 timeslots = 3 hours:




For MSG HRV lower window (African region) totally 20 15-minutes timeframes,
but regions covered only by 4, 8 or maximum 12 frames (3 hour of cloud development)

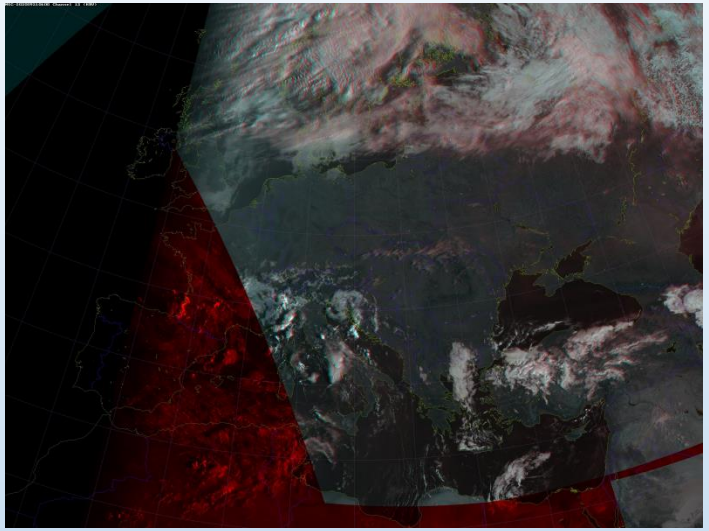
# Areas over Europe during the day covered by dual MSG observations:

**EUMETSAT changes in timing of upper HRV window during day decreased coverage !!!**

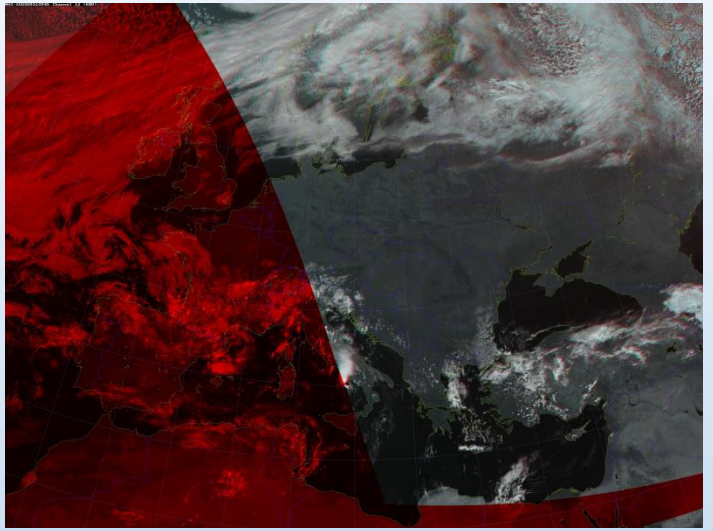


Movement of upper HRV window during the day limits the regions covered by dual satellite observations:

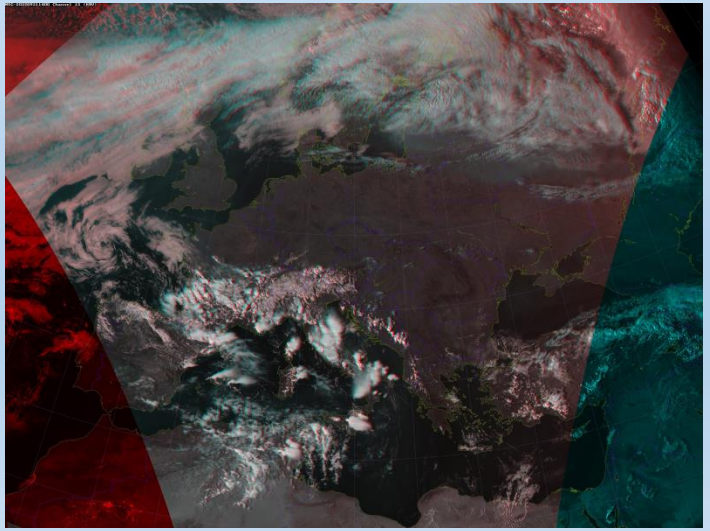
From 06:00 To 09:30



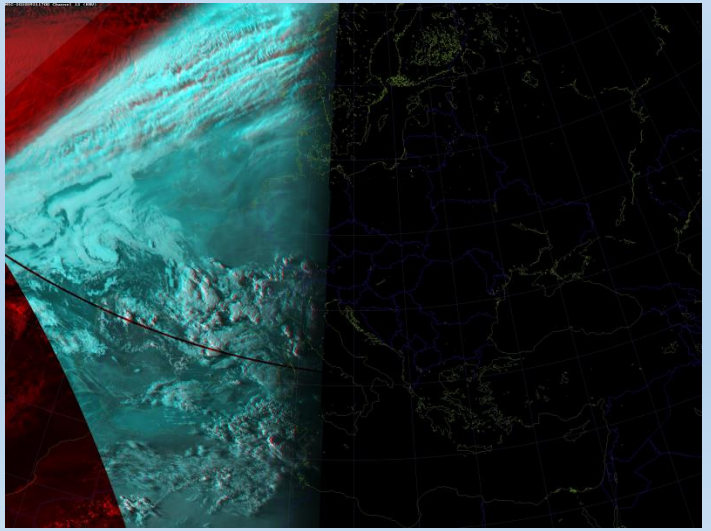
From 09:45 To 13:45



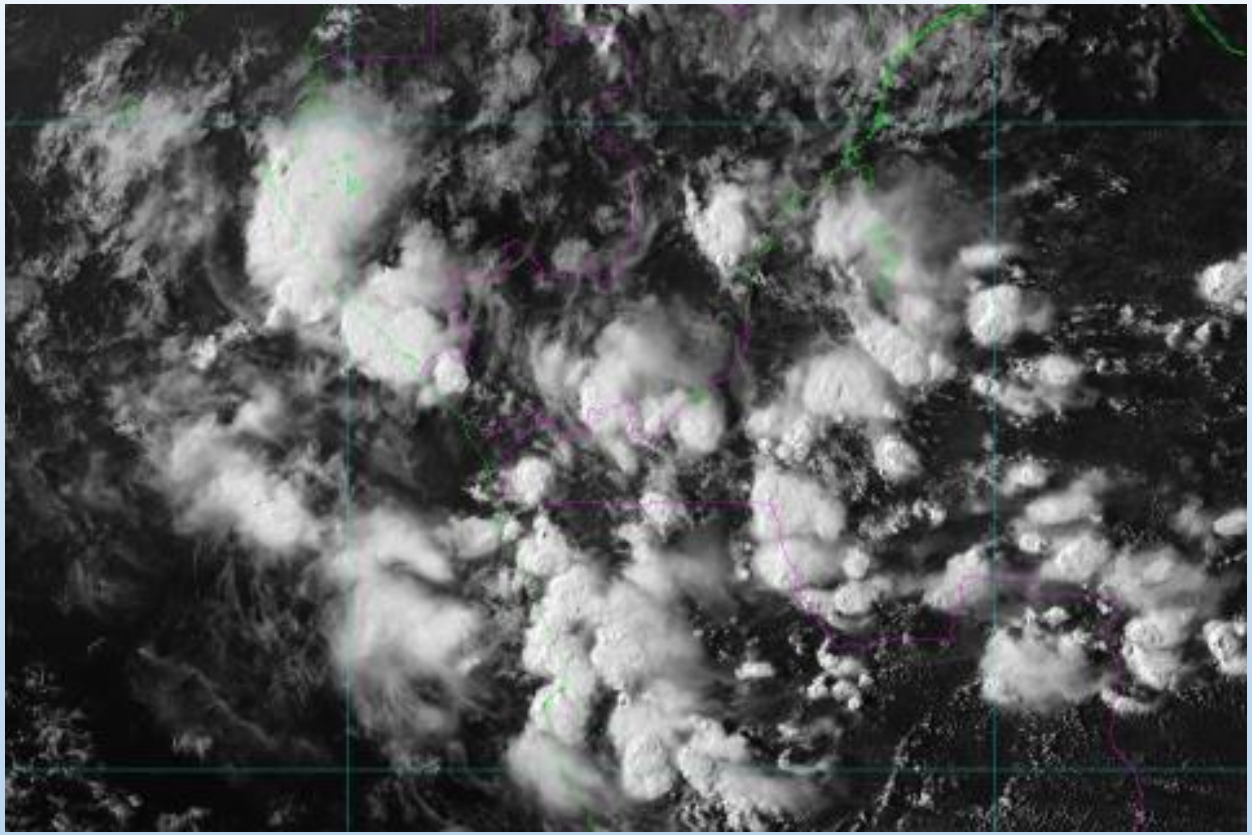
From 14:00 To 16:45

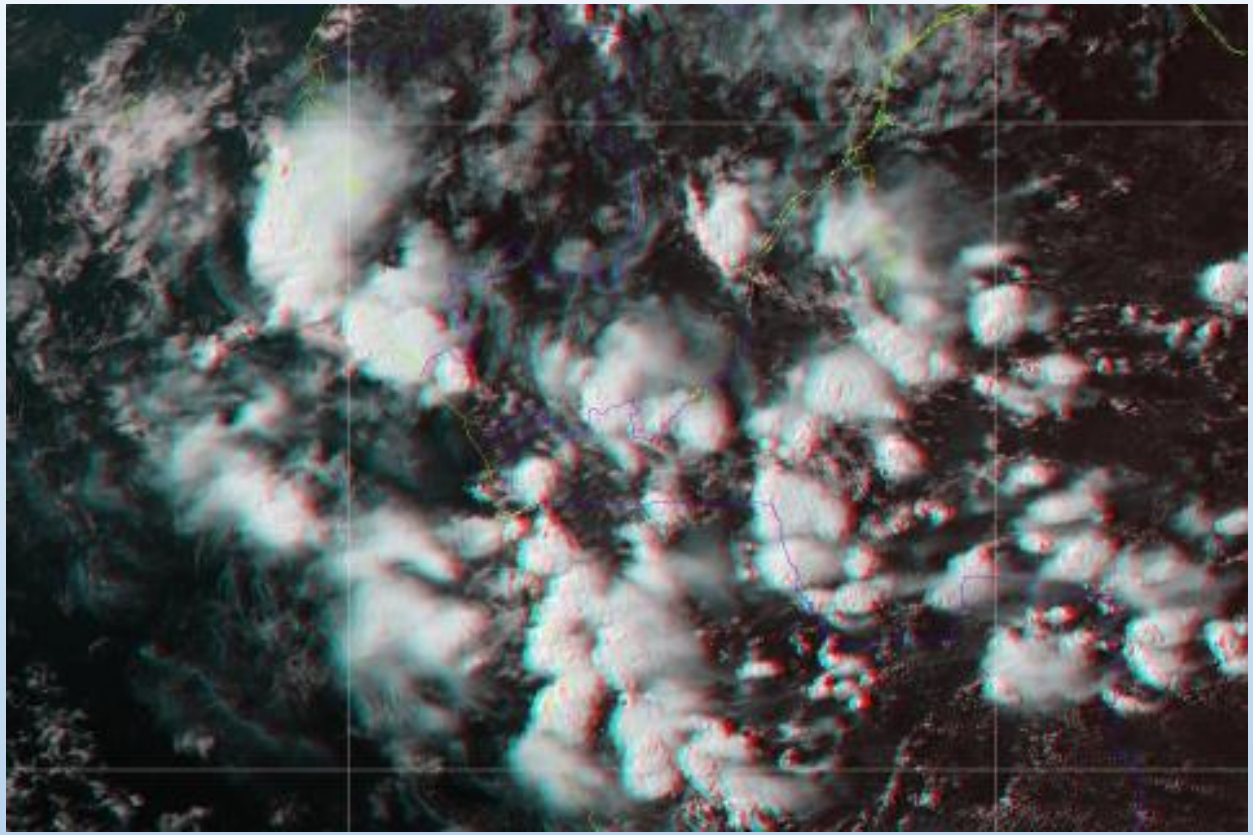


From 17:00 To 18:00

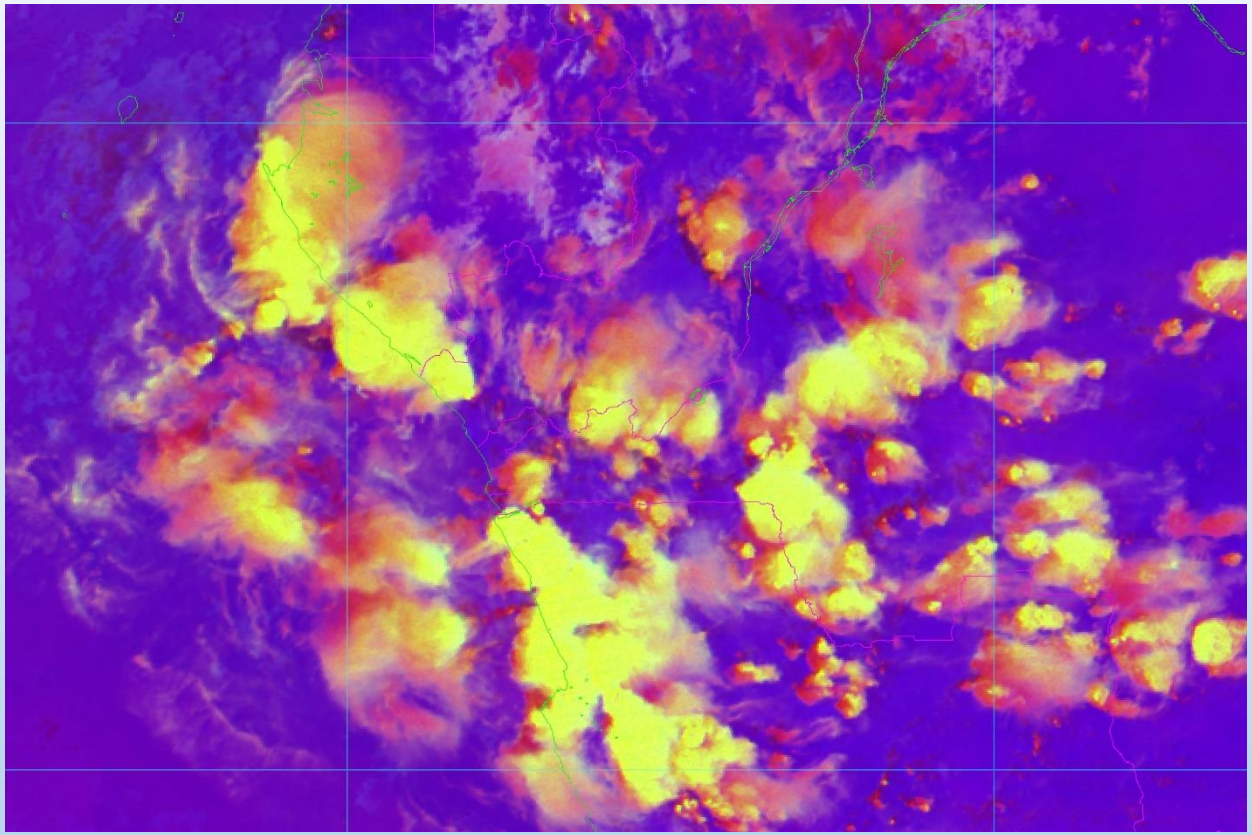


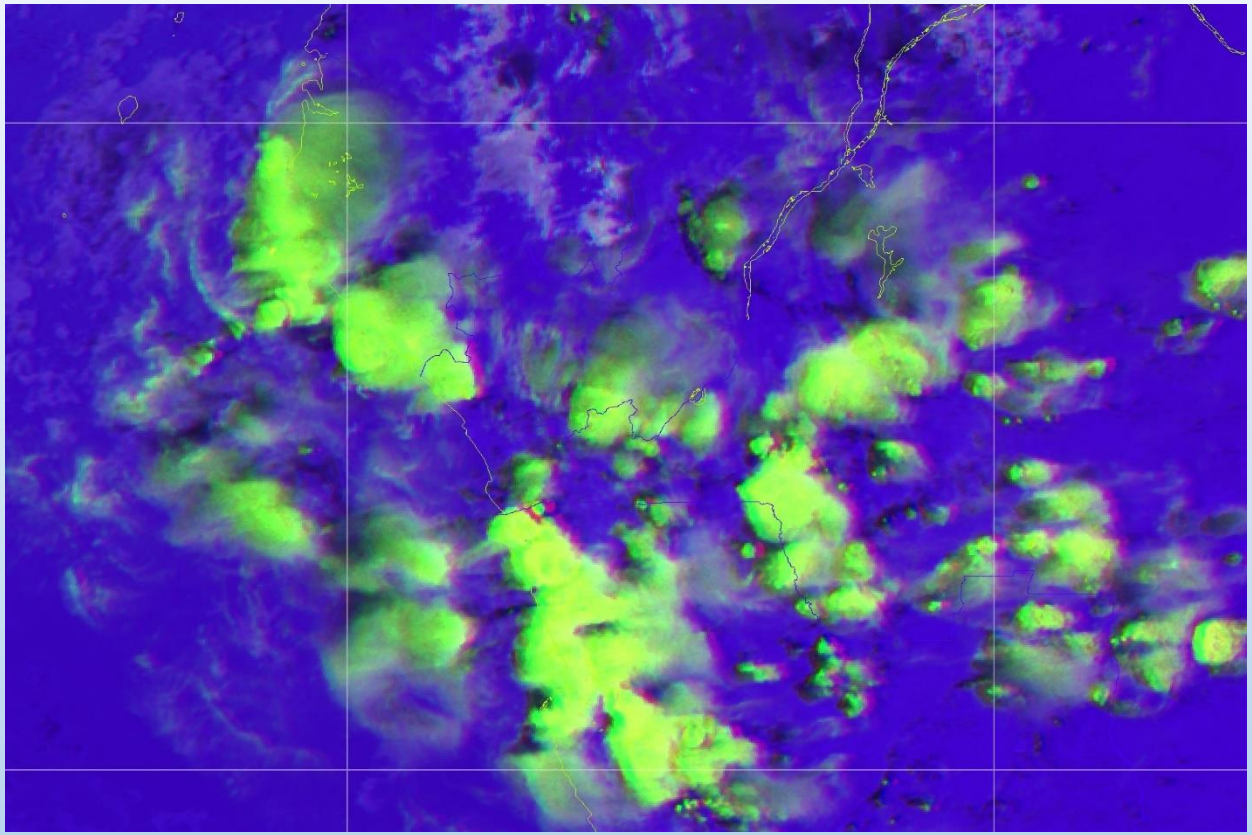
# Case 20210403 Central Africa different RGBs versus anaglyphs





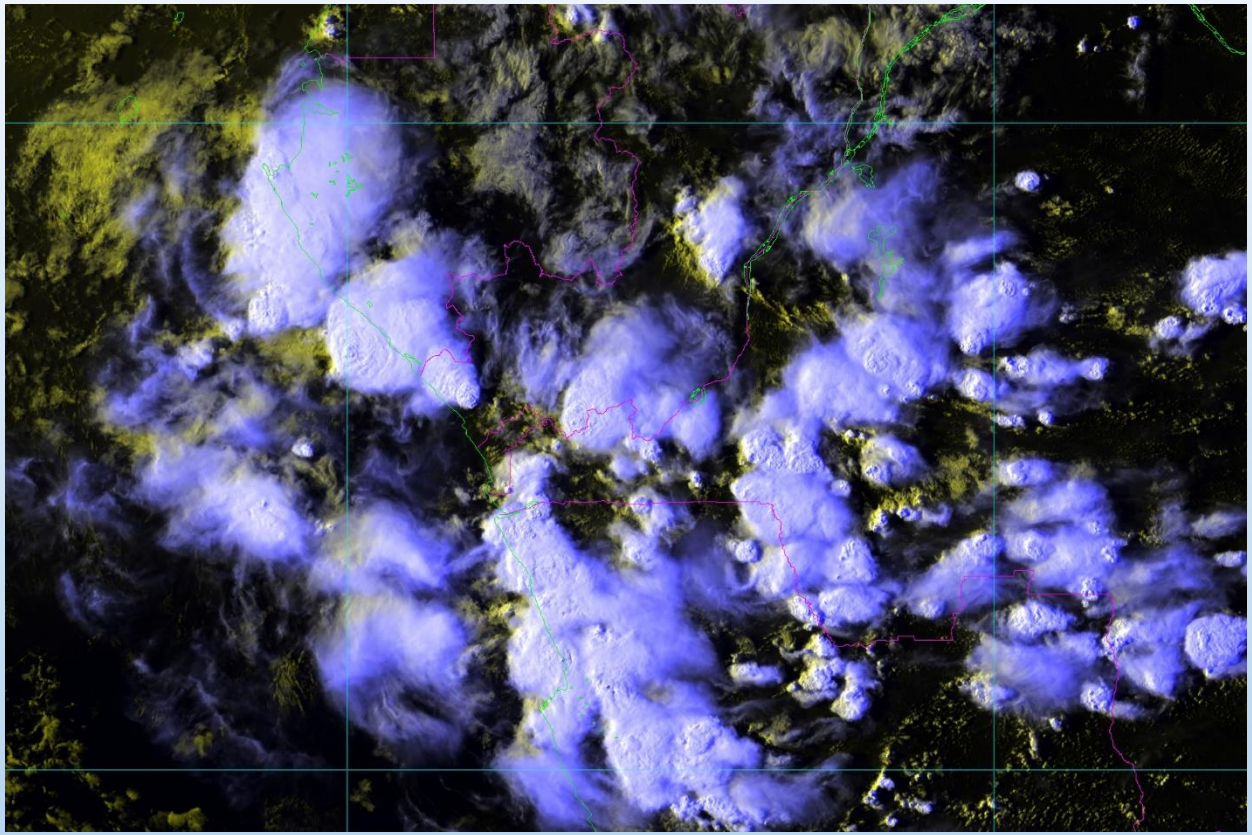
# Case 20210403 Central Africa different RGBs versus anaglyphs

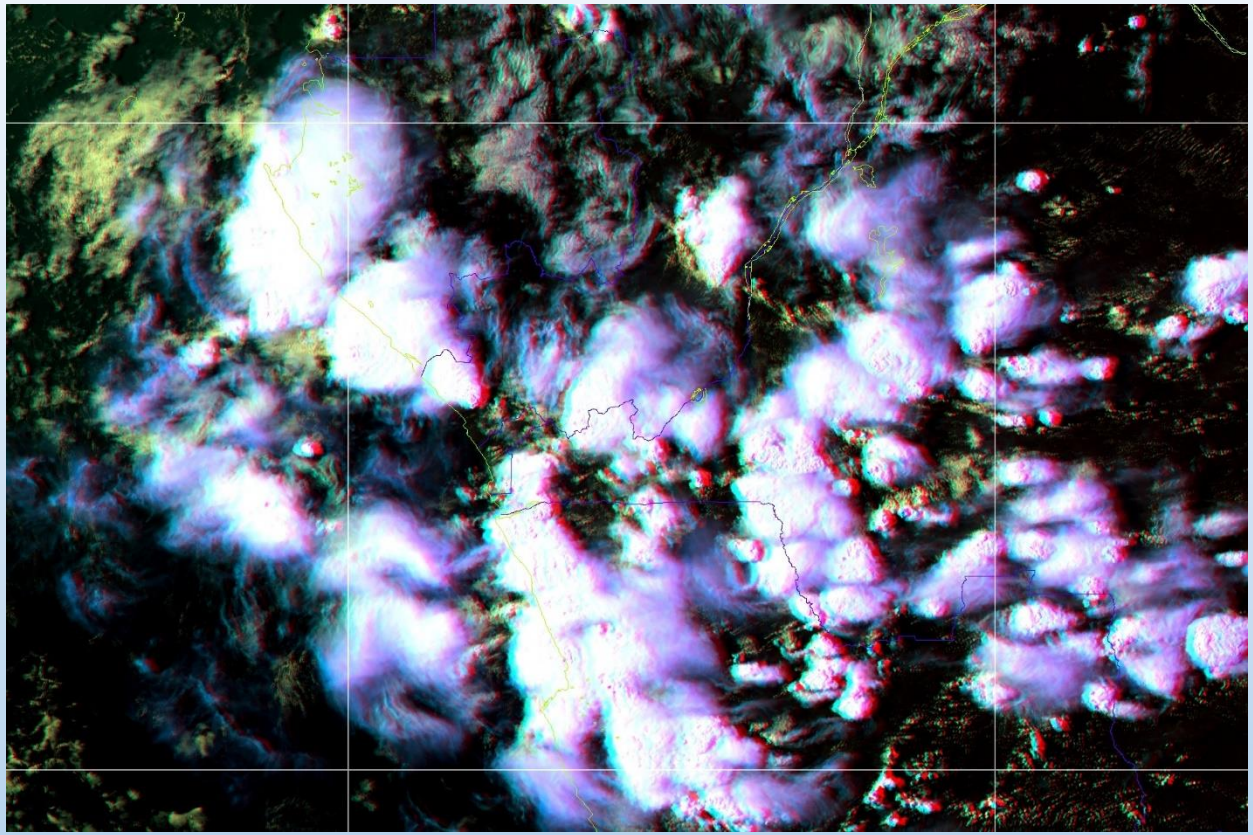




Microphysical information from RGBs as Day Microphysics, Convective Storms RGB, … is limited in anaglyphs or practically disappear because of the application of anaglyph method!

# Case 20210403 Central Africa different RGBs versus anaglyphs





Features:

- Overshooting tops in high resolution
- High cirrus arc (gravity wave) in the top-left corner westerly from the biggest storm
- Gust front in the upper-central part of this image sequence

**Technical possibilities how to observe 3D stereoscopic imagery:** **LEFT RIGHT**

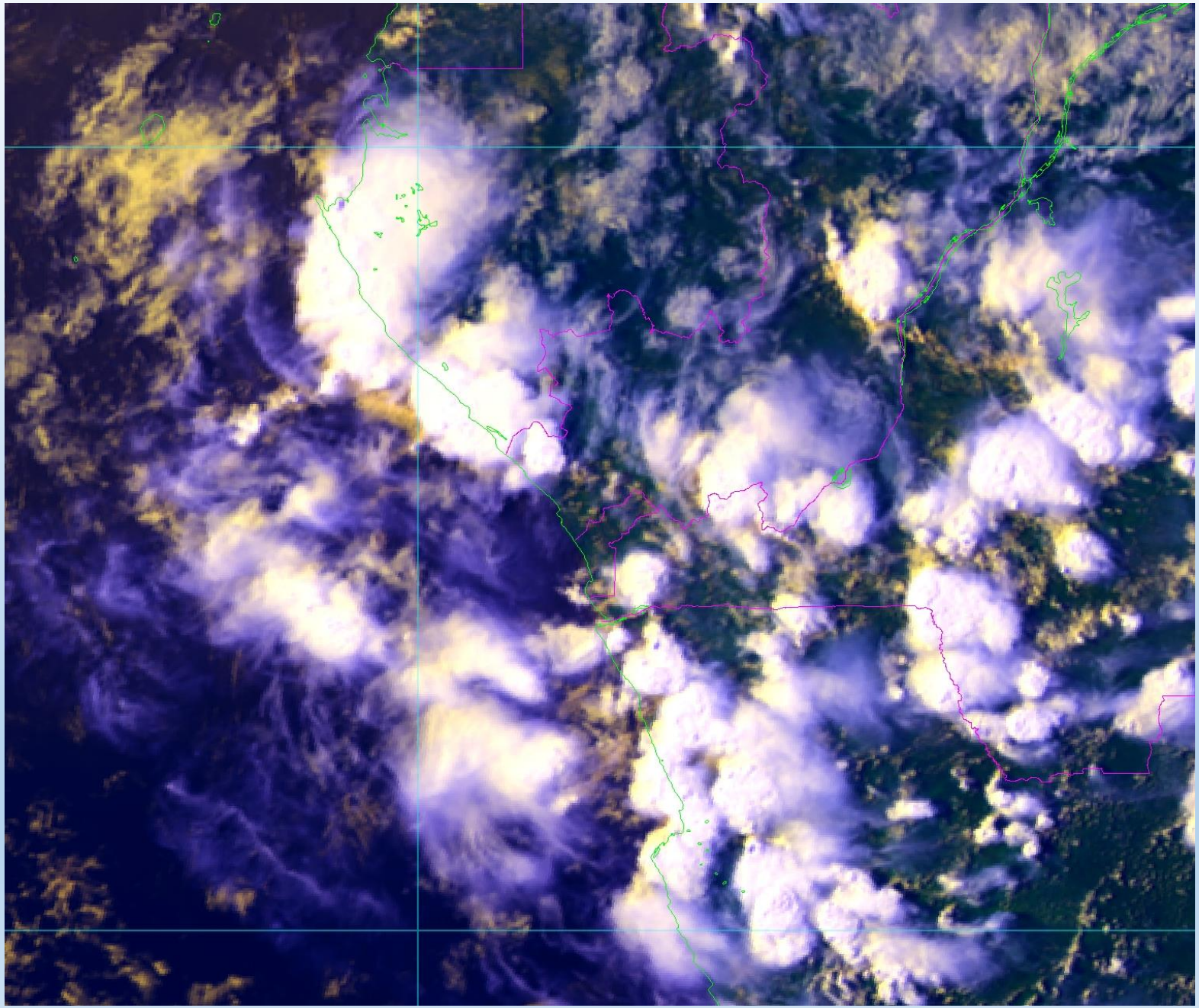
- Single switching between images:

We can observe the effects of parallax shifts for very high level clouds

Exact estimation of parallax shifts
Is possible numerically, e.g. by methods
Already presented in CWG or
At EUMETSAT conferences:

EUMETSAT Meteorological Satellite Conference 2018, Tallinn:

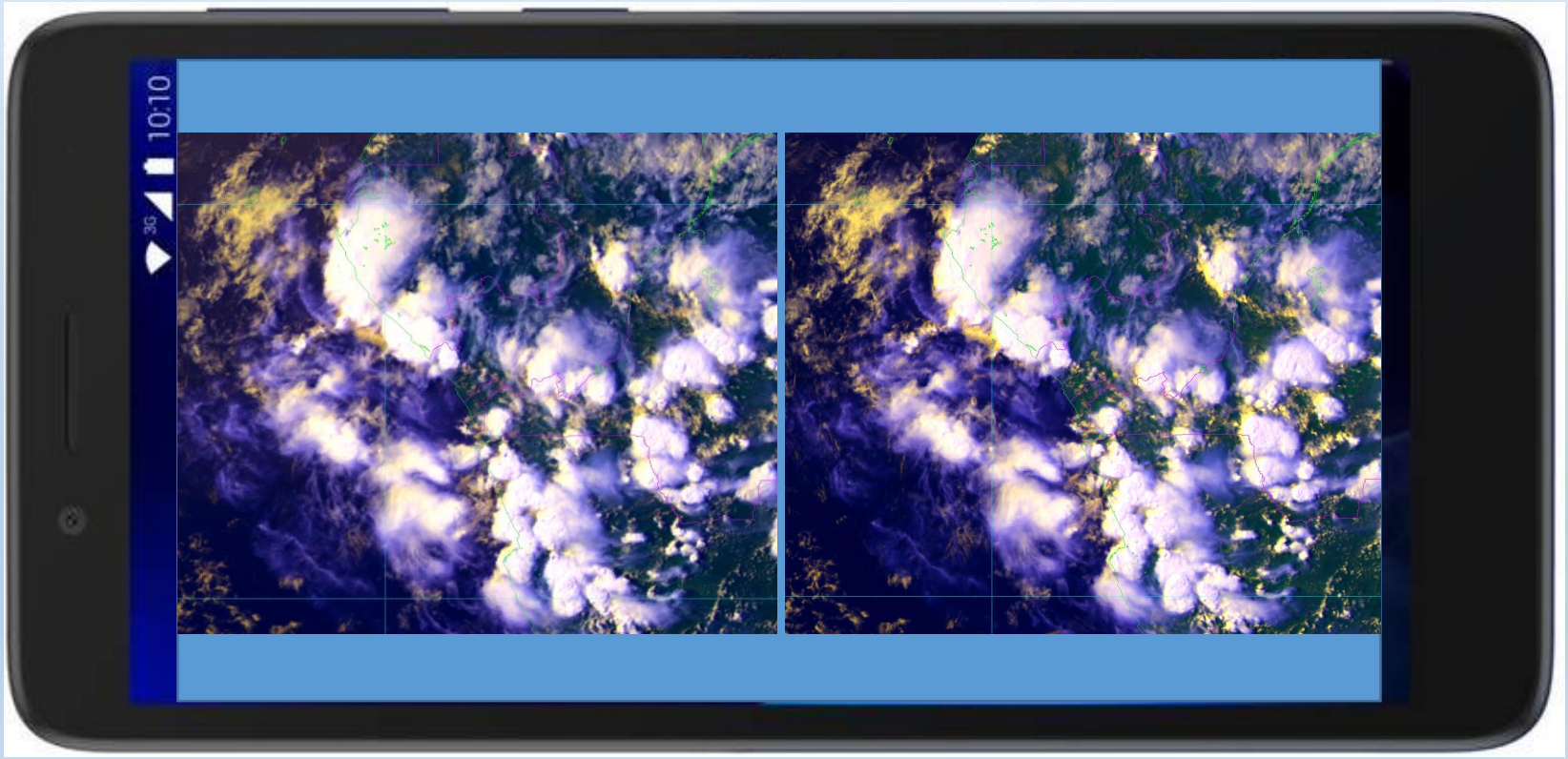
FULLY AUTOMATED QUANTITATIVE ESTIMATION OF CLOUD TOP HEIGHT USING STEREOSCOPIC METEOSAT SATELLITE OBSERVATIONS



## Technical possibilities how to observe 3D stereoscopic imagery:

- Professional 3D monitors or
- Quite simple and cheap Virtual Reality viewers base on smartphones:

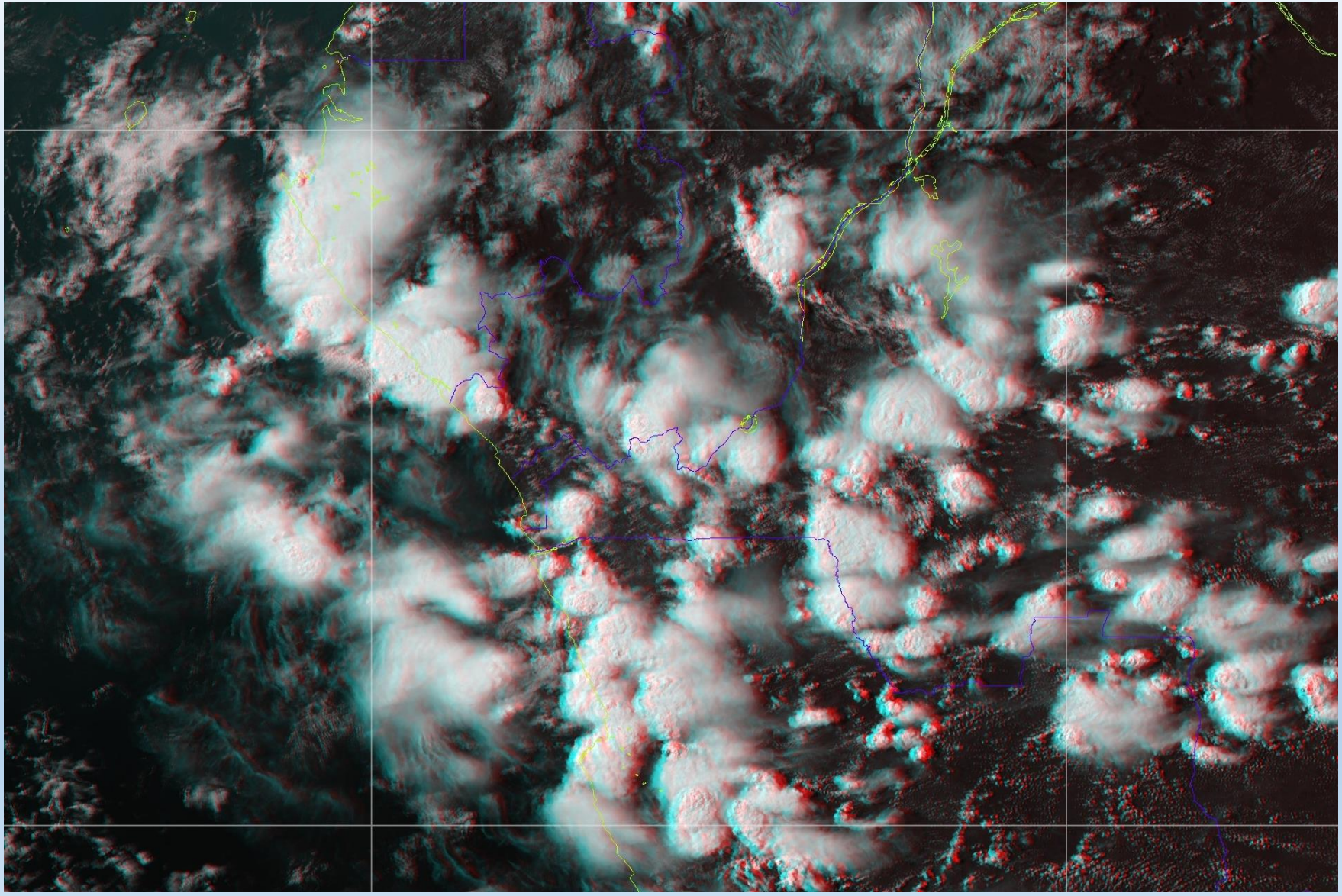
Advantage:
Full color perception in case of RGB products!!!

## Technical possibilities how to observe 3D stereoscopic imagery:

- Anaglyph images and red/blue glasses:

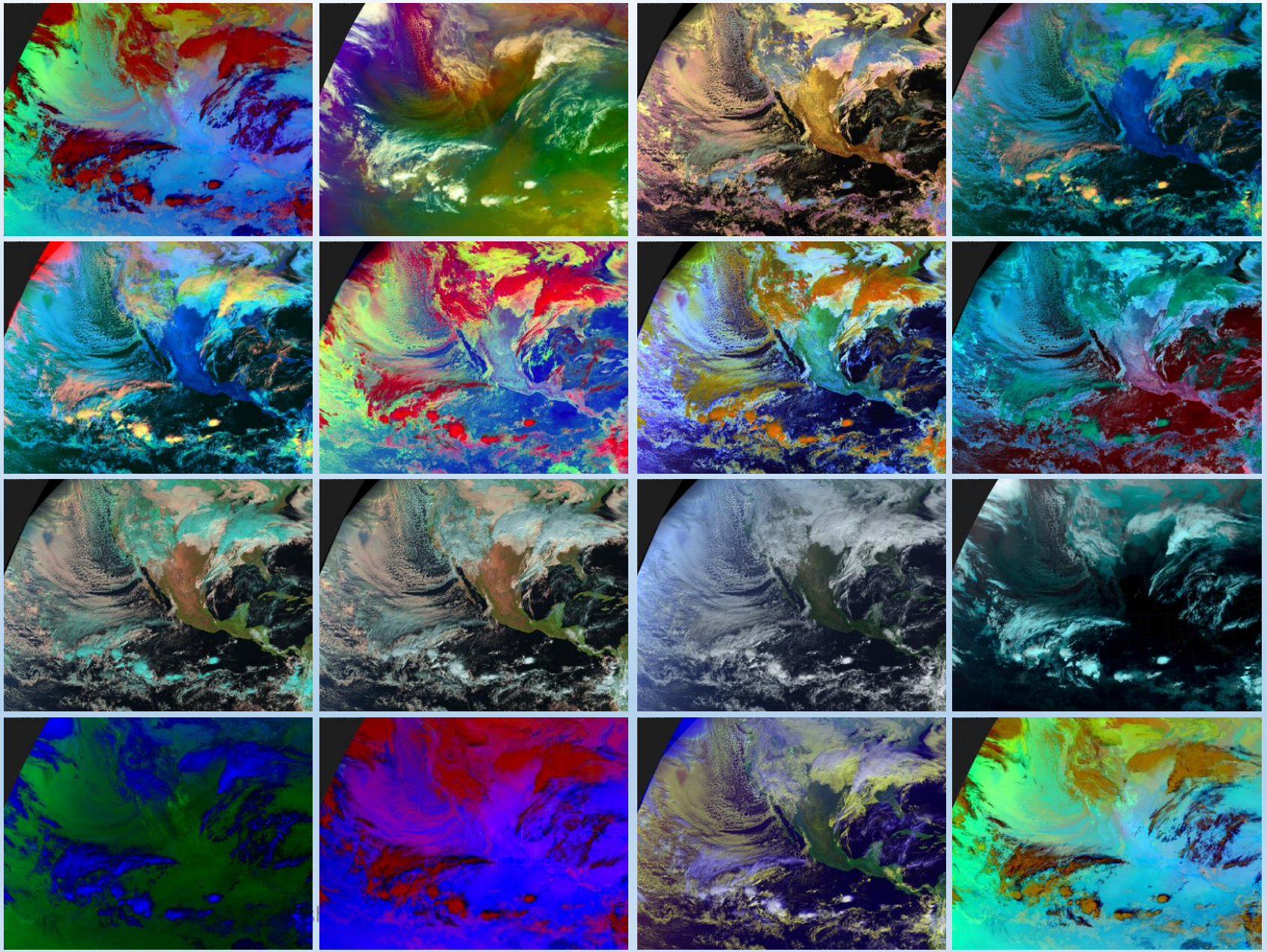
Problem:
Missing full color perception
in case of RGB products



# Different RBGs and their usability as anaglyphs

**Standard RGB images:**

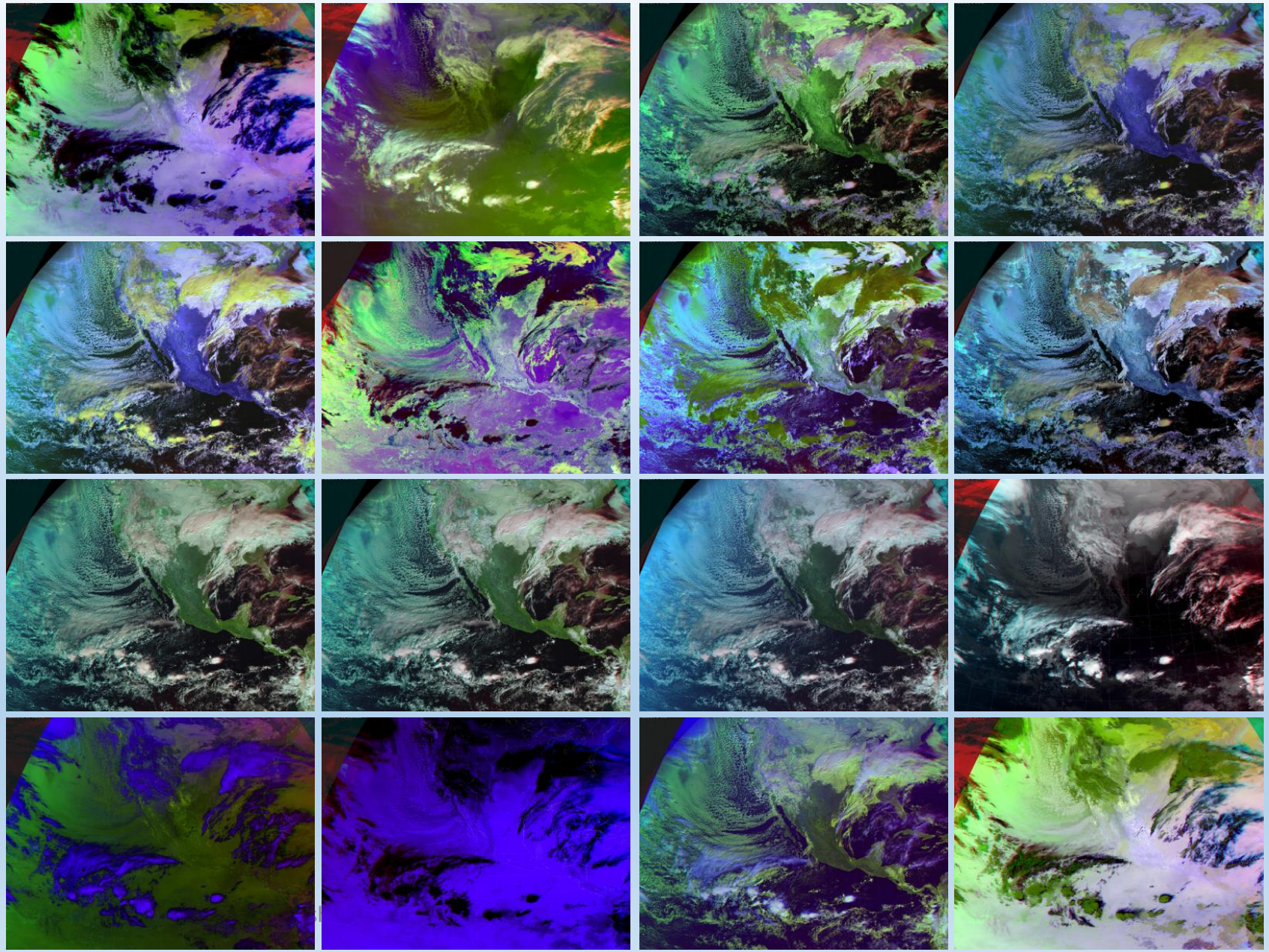
1. 24hMicrophiscs
2. Airmass
3. Cloud Phase
4. Cloud Types
5. Daily Cloud Phase Distinction
6. Day Microphysical
7. Day Solar
8. Fire Temperature
9. Natural Colors
10. Natural Colors White
11. Natural True Colors
12. Night
13. Night Low Clouds
14. Night Microphysical
15. VIS-IR
16. Volcanic Ash



# Different RBGs and their usability as anaglyphs

## Anaglyph RGB images:

1. 24hMicrophiscs
2. Airmass
3. Cloud Phase
4. Cloud Types
5. Daily Cloud Phase Distinction
6. Day Microphysical
7. Day Solar
8. Fire Temperature
9. Natural Colors
10. Natural Colors White
11. Natural True Colors
12. Night
13. Night Low Clouds
14. Night Microphysical
15. VIS-IR
16. Volcanic Ash



Problem:
Missing full color perception in case of RGB products

# Different RBGs and their usability as anaglyphs

**List of RGB images:**

1. 24hMicrophiscs
2. Airmass
3. Cloud Phase
4. Cloud Types
5. Daily Cloud Phase Distinction
6. Day Microphysical
7. Day Solar
8. Fire Temperature
9. Natural Colors
10. Natural Colors White
11. Natural True Colors
12. Night
13. Night Low Clouds
14. Night Microphysical
15. VIS-IR
16. Volcanic Ash

**What can we learn from the comparison of standard an anaglyph RGB images:**

1. Red color is reduced significantly because of anaglyph's algorithm, therefore clouds displaying at standard RGB in red, appear black in anaglyph
2. Some RGBs appear similar in anaglyphs
   a. Natural colors, Natural white, True colors ⟸ **OK**
   b. Cloud phase, Day solar, VIS-IR, Volcanic ash
3. 3D cloud height perception helps user to recognize more clearly between snow, low level clouds, fog in contrast with high thick cirrus clouds
4. 3D cloud height perception helps to recognize storm top features and better localize anvil cirrus clouds extension

# Final remarks

If imagery is properly georeferenced, then:

we can automatically

- estimate lower cloud tops in convection initiation phase
- and estimate CTH trends in time
- we can obtain anvil layer height in convection mature phase

we can manually

- detect overshooting tops
- make parallax-corrected location of OT
- measure absolute OT height

**Image library available at SHMÚ since 2017 can be freely provided to anyone who want to do the first quick look into 3D images. On the base of this SHMU offers reprocessing of any MSG1/MSG4 HRIT data for selected region in the maximum space and time resolution and to provide any RGBs which have to be studied with the aim of cloud top structures in 3D interpretation. Also SHMU can reprocess calculations of mutual parallax shifts for requested cases.**

# Final remarks

**Technical problems are the biggest limitation in exploitation of dual satellite observations.**

**The main goal:**

**To watch full-color RGB images in high resolution in smooth animation without loss of color, without the need for restrictive aids such as heavy and uncomfortable glasses.**

**Lot of colleagues in their presentations provided excellent methods of preparation the perfect RGB products with brilliant colors, but:**
**Still a persistent problem:**
**Can be solvable 3D displaying by virtual reality devices for convenient user utilization?**