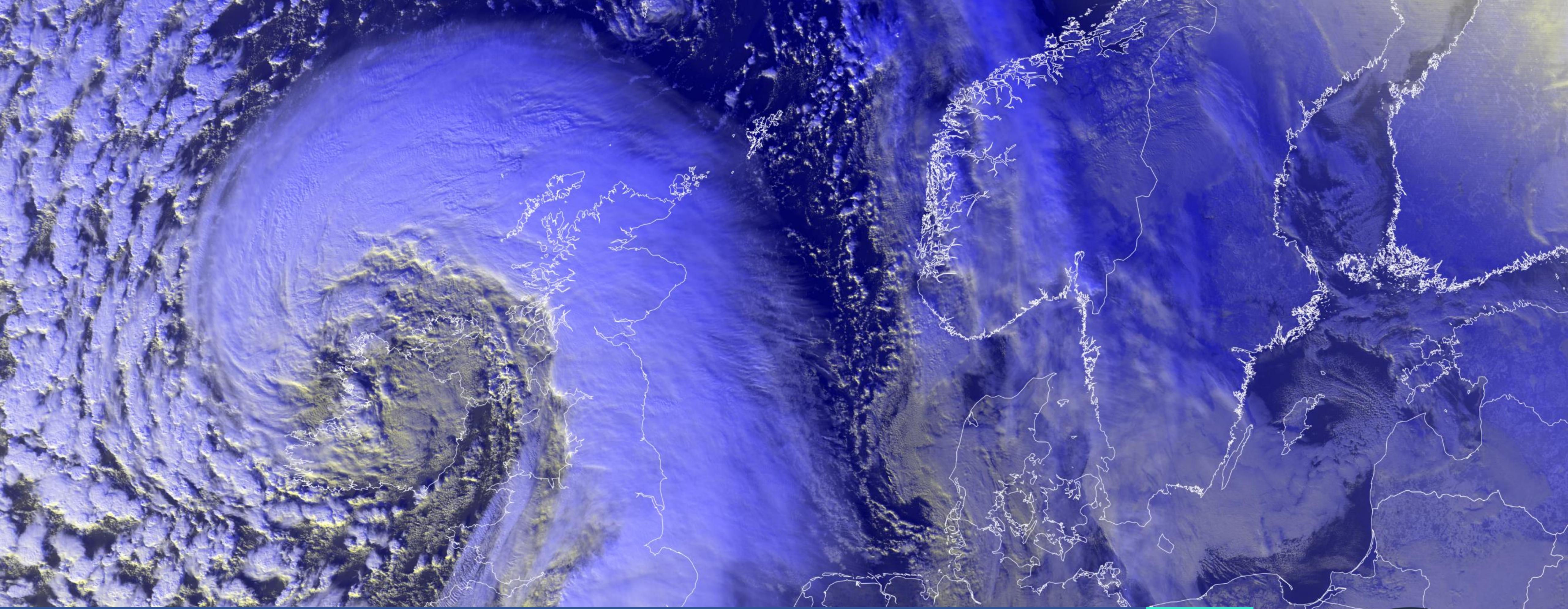


Satellite Imagery and Products for Extratropical Cyclones.

Bożena Łapeta[1], Piotr Struzik[2]

[1] Satellite Remote Sensing Department, IMGW-PIB
[2] Specialized Forecast Team, IMGW-PIB

Outline

Review of satellite images and products for:

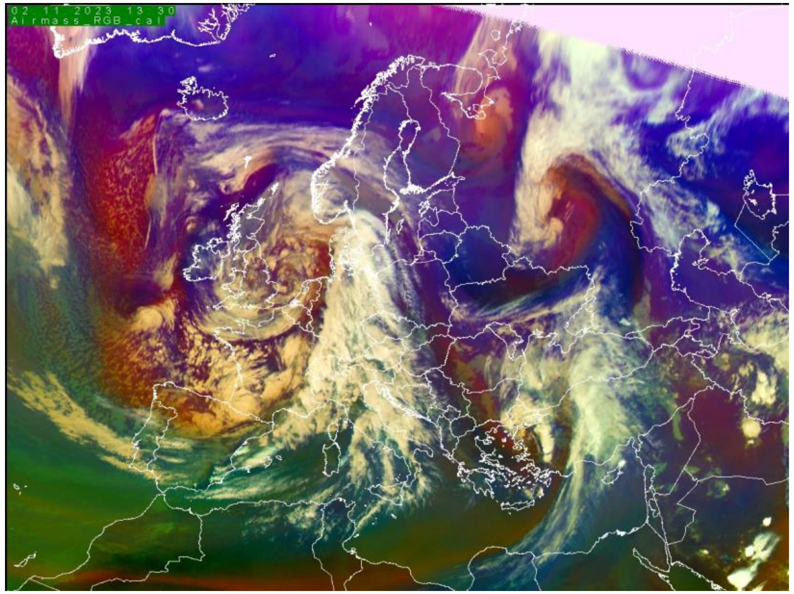
- ETC detection in monitoring:
  - RGBs from GEO and LEO satellites and MTG/FCI data
  - polar satellites specifics
  - microwave data
- ETC effects detection and monitoring:
  - wind
  - sea altimetry
  - precipitation

Exercises

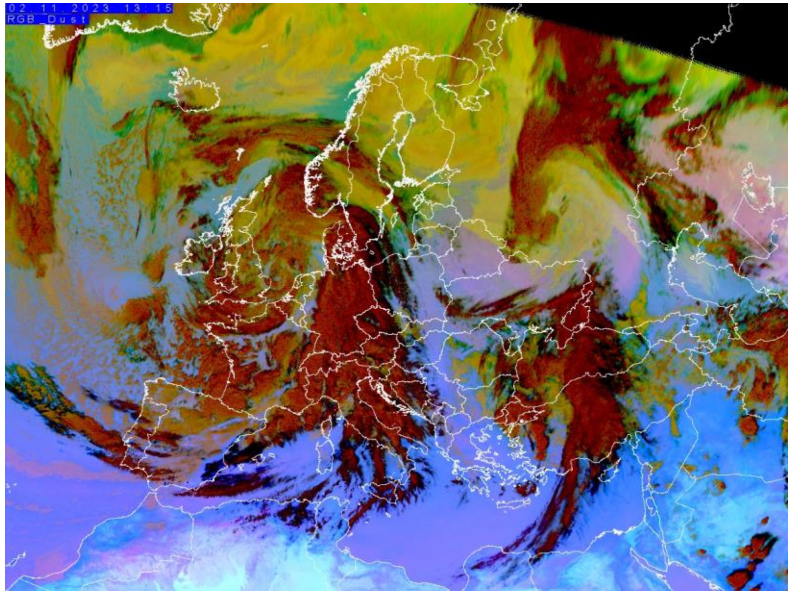
Images

Useful images

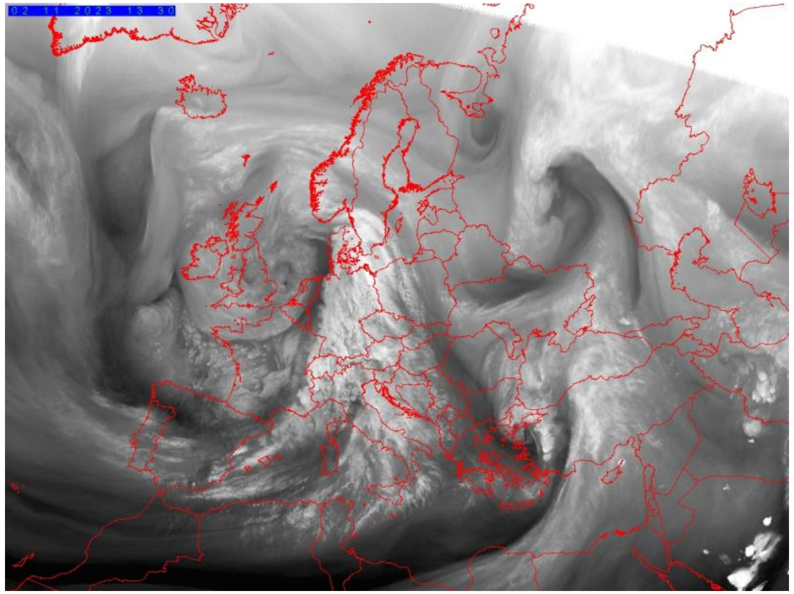
Airmass

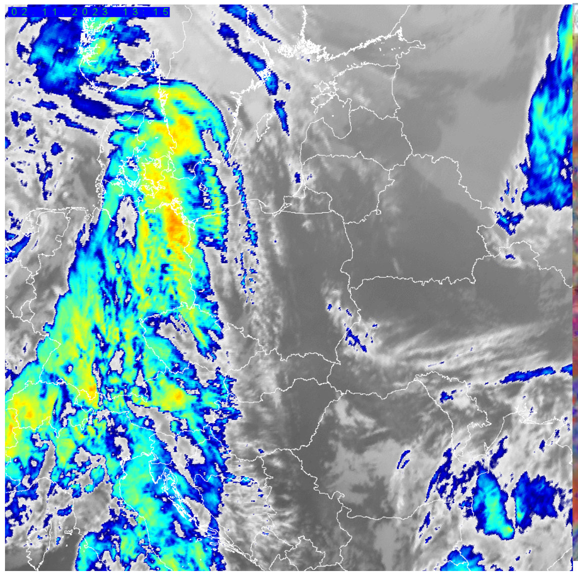


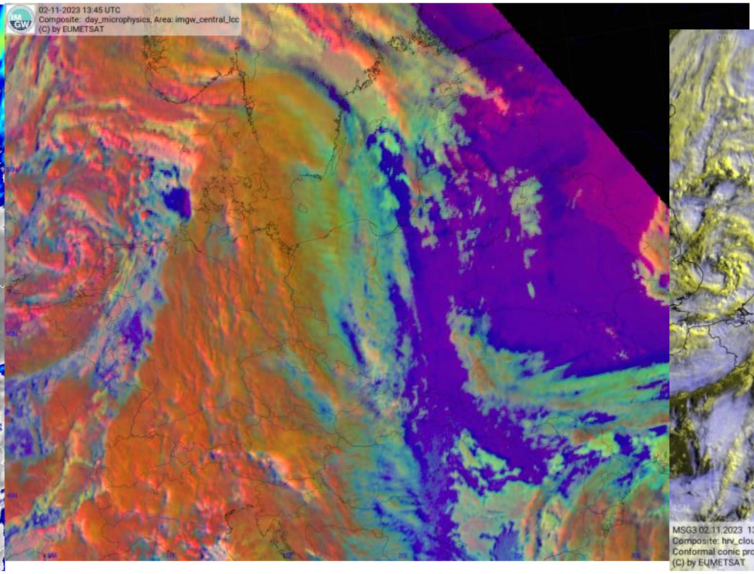
Dust

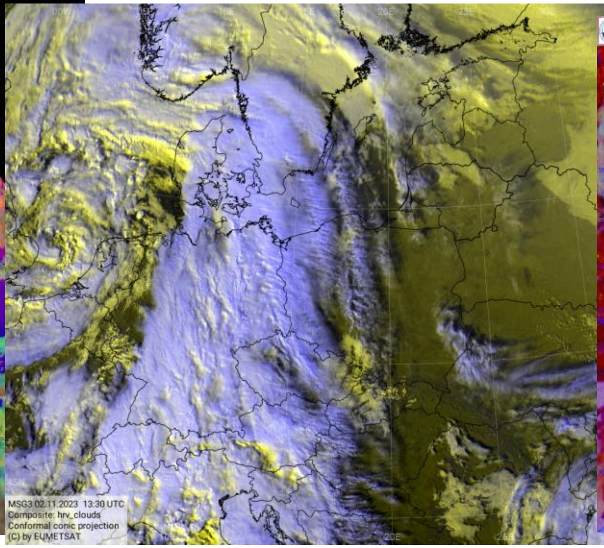


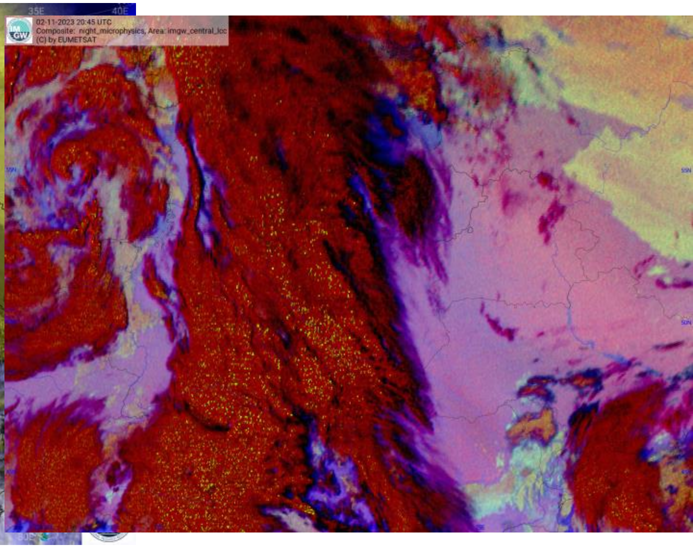
WV



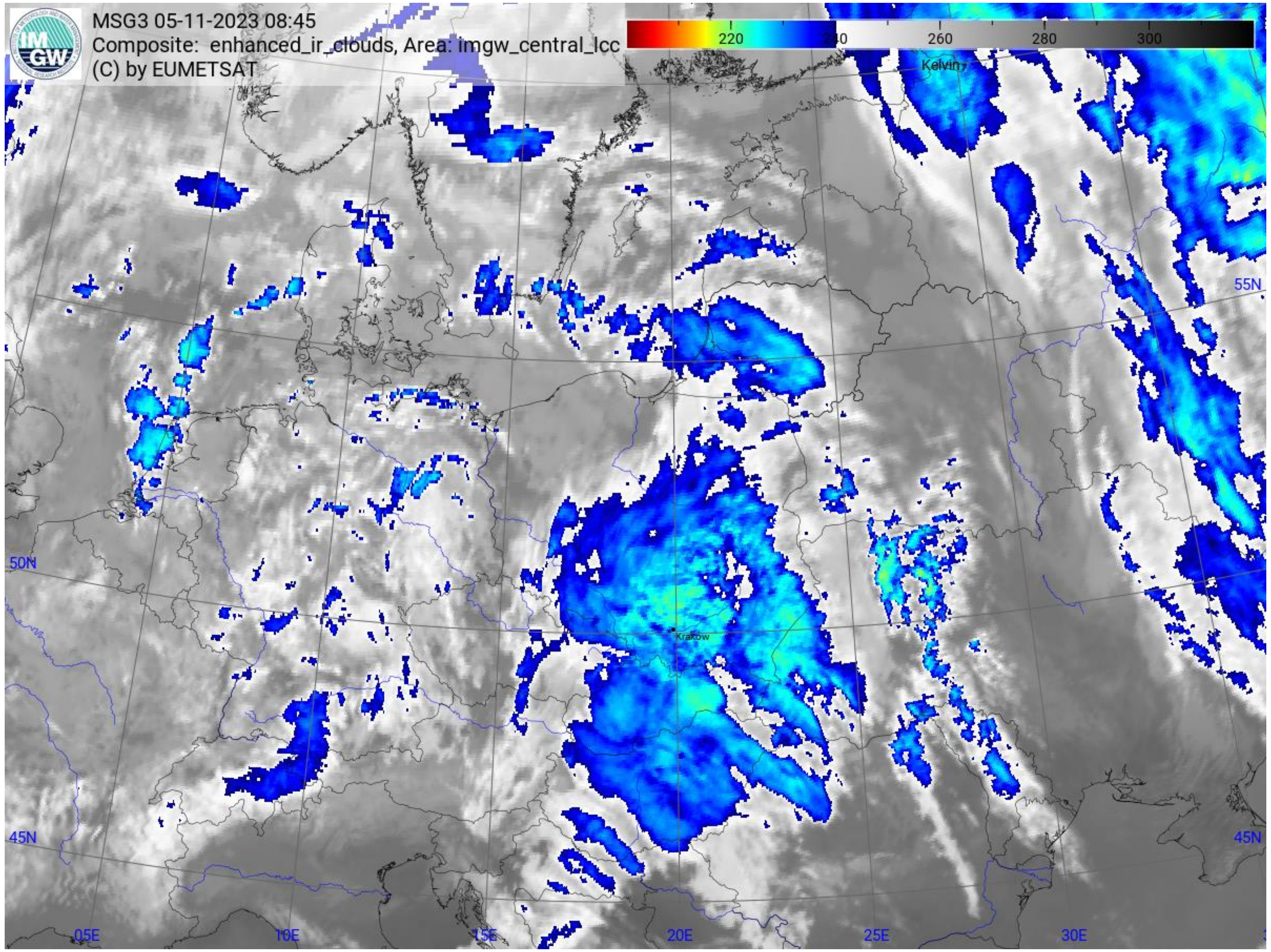






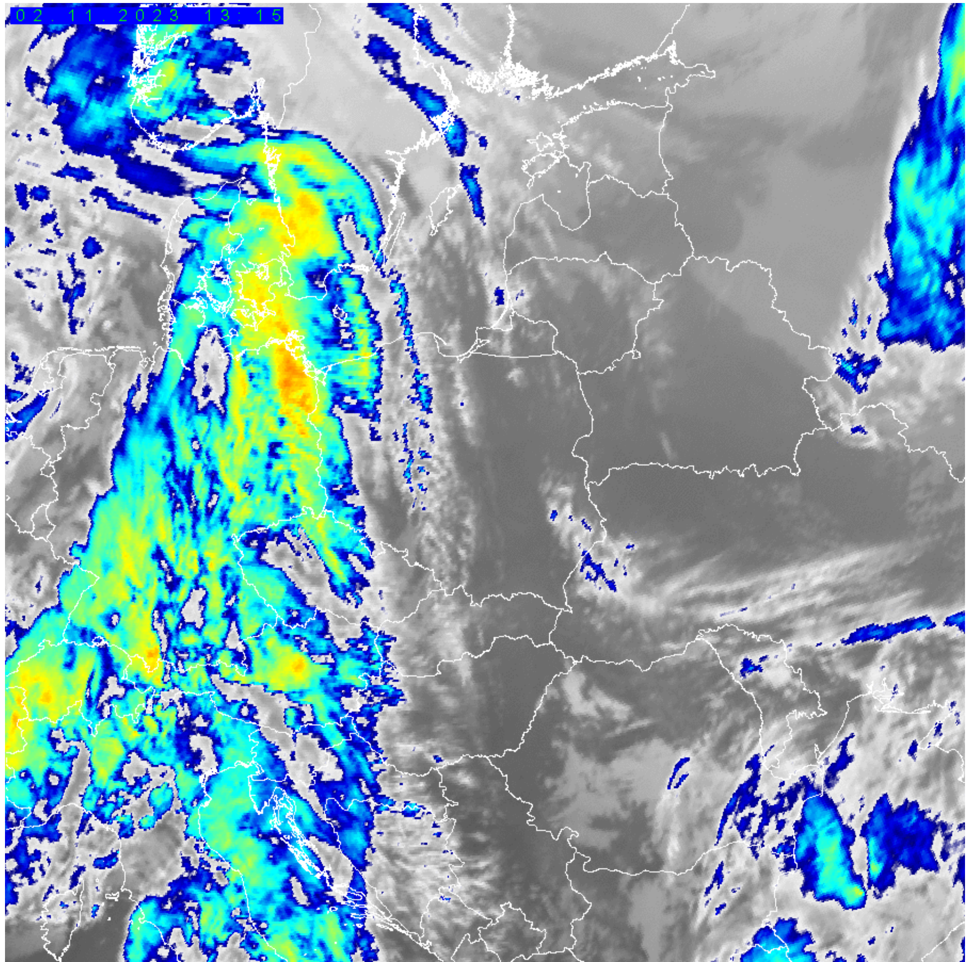


Useful images – IR enhanced/IR clouds



IR image with color scale applied for the pixels colder than -33°C.

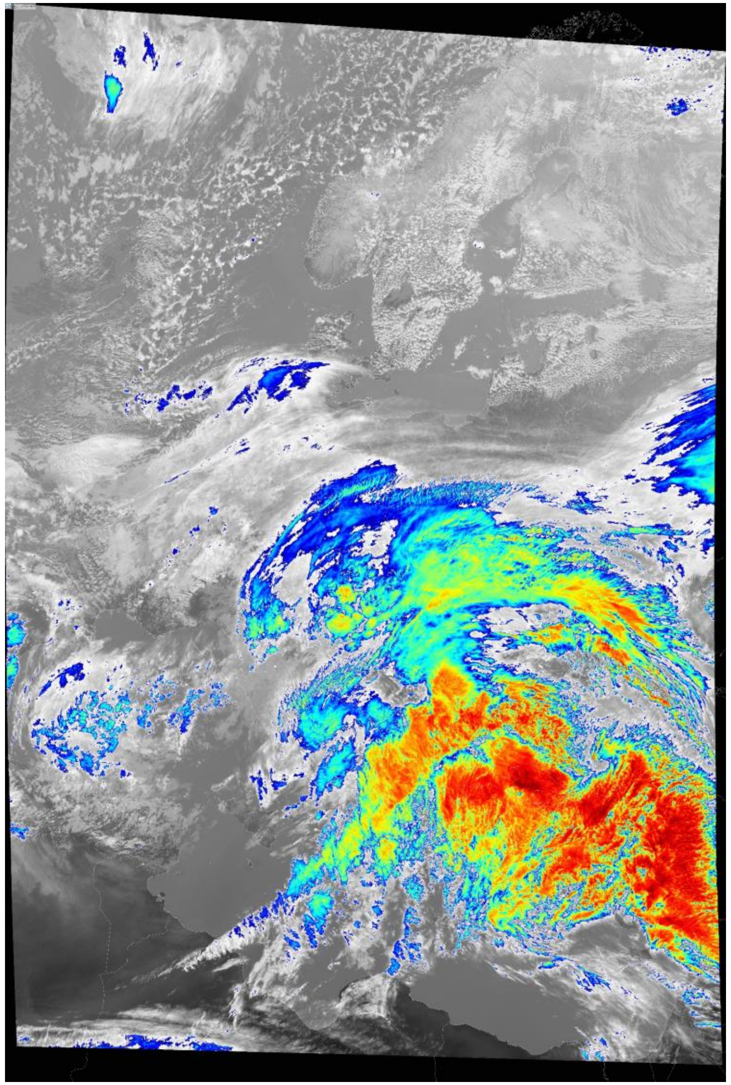
Useful for convective clouds detection but can be also used for monitoring the frontal clouds .



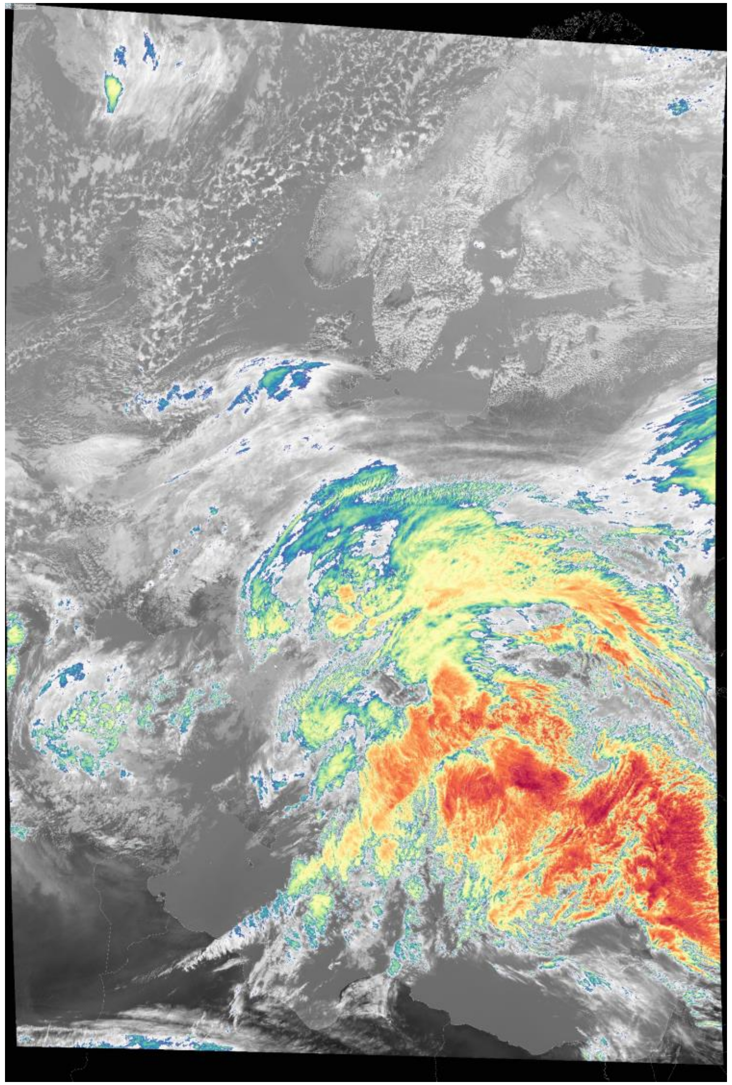
Useful images – IR enhanced/IR clouds

METEO IMGW-PIB meteo.imgw.pl

Color scale - rainbow



Color scale - spectral



Two different color scales.

Useful images – Natural Color

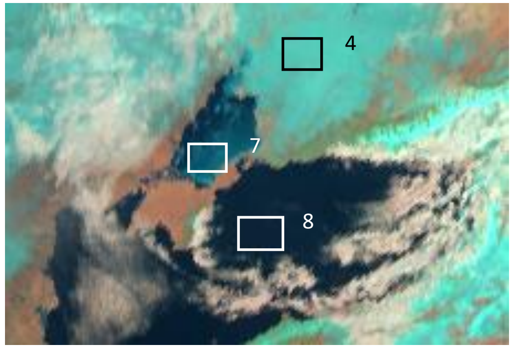
METEO
IMGW-PIB
meteo.imgw.pl

Vegetation detection, dust, smoke, fog, snow, water surface, water and ice clouds.
Available during the day.

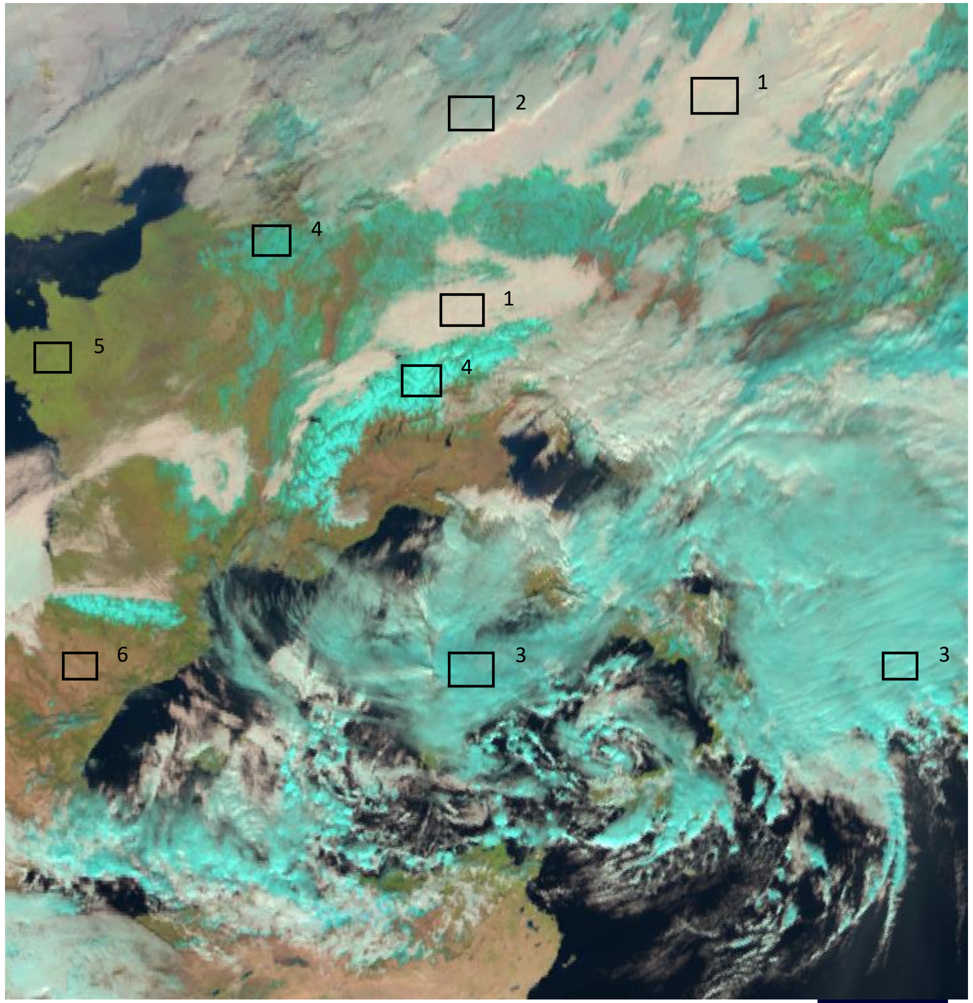
R – cloudy phase	**R = NIR 1.6**	**0...100%**	**Γ=1**
G and **B** – reflectivity from different surfaces (optical thickness, water content)	**G = VIS 0.8**	**0...100%**	**Γ=1**
	B = VIS 0.6	**0...100%**	**Γ=1**

1	Water clouds (fog or stratus)
2	Mixed phase clouds or clouds with a cirrus veil on top
3	Thick ice clouds with large ice crystals in higher levels
4	Snow and ice on the ground
5	Ground covered by photo-synthetically active vegetation
6	Sandy deserts, bare soils or arid vegetation
7	Sea ice not covered by snow
8	Oceans and lakes.

Natural Colour RGB, 17 luty 2017, 12:00 UTC



SEVIRI Natural Colour RGB, 18 styczeń 2017, 12:00 UTC

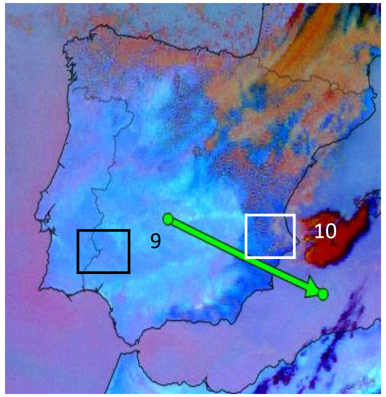


EUMETRAIN

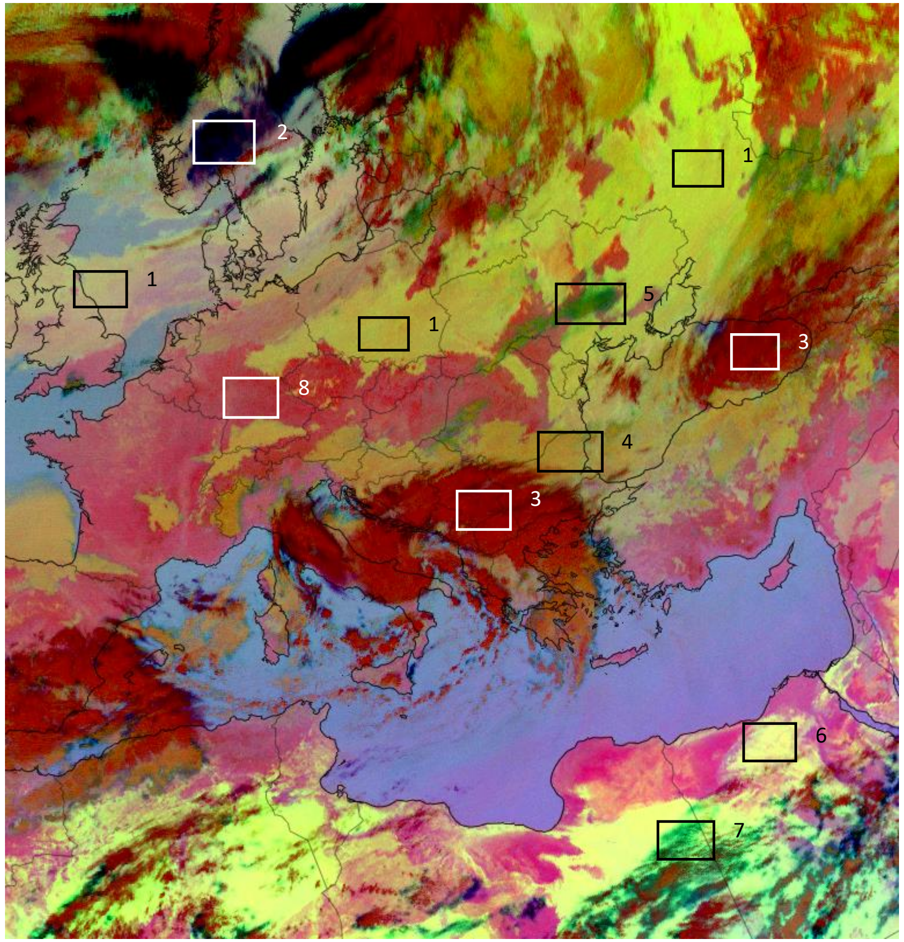
Round-the-clock cloud analysis: Distinguish between ice clouds and water clouds and detect high-level cirrus clouds.

R – optical thickness of the cloud,	**R = IR12.0 – IR10.8**	**-4K...2K**	**Γ=1**
G – cloud phase,	**G = IR10.8 – IR8.7**	**0...6K**	**Γ=1.2**
B – temperature of the vertices	**B = IR 10.8**	**248K...303K**	**Γ=1**

1	Low level water clouds (fog or stratus), pinkish for larger drops
2	Cirrus clouds with no clouds below, dark blue for the thinner parts
3	Thick, high and cold ice clouds
4	Thick mid-level water or mixed phase clouds
5	Semi-transparent mid-level clouds
6	Cold sandy Deserts
9	Hot land, dry bound. layer
7	Cirrus clouds over deserts (same colour as item 5)
8	Cold land
10	Hot land, moist bound. layer



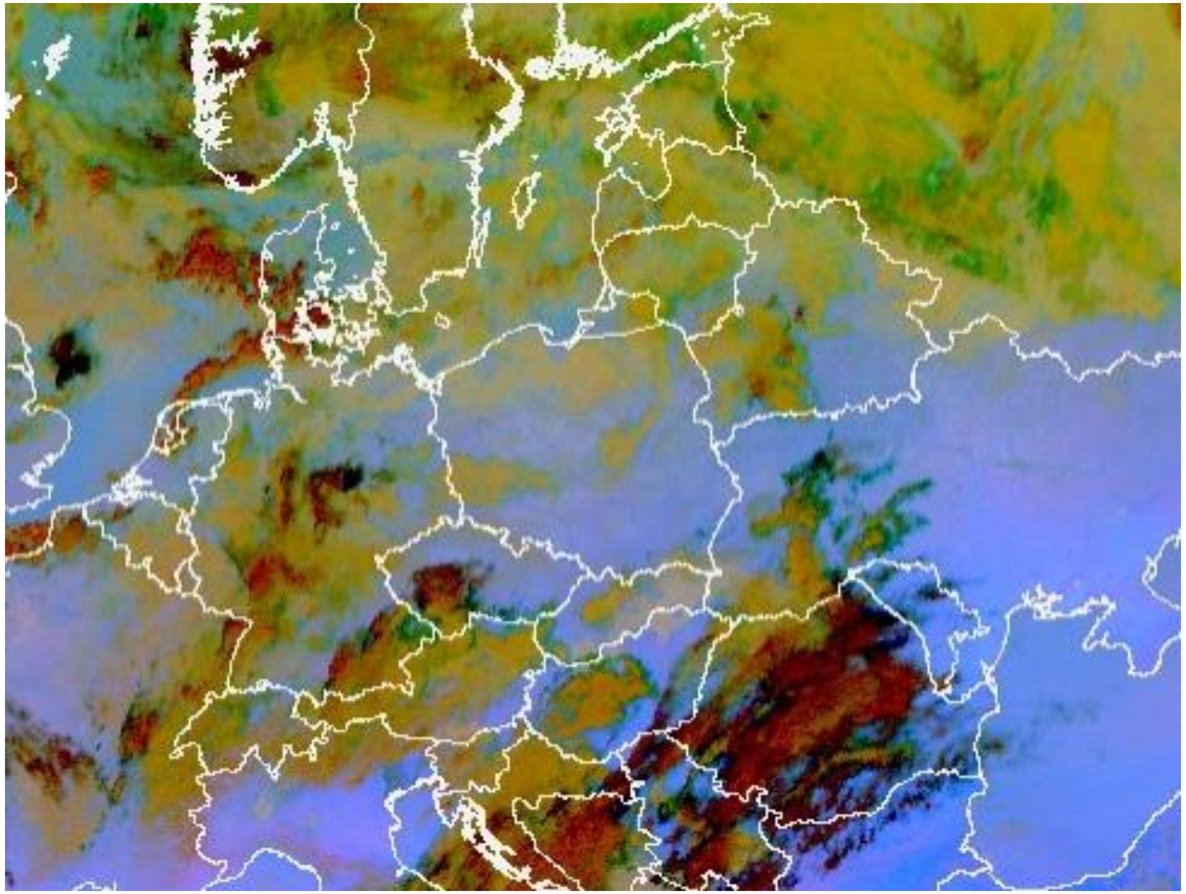
SEVIRI Całodobowa Mikrofizyka RGB, 19 Styczeń 2017, 00:00 UTC



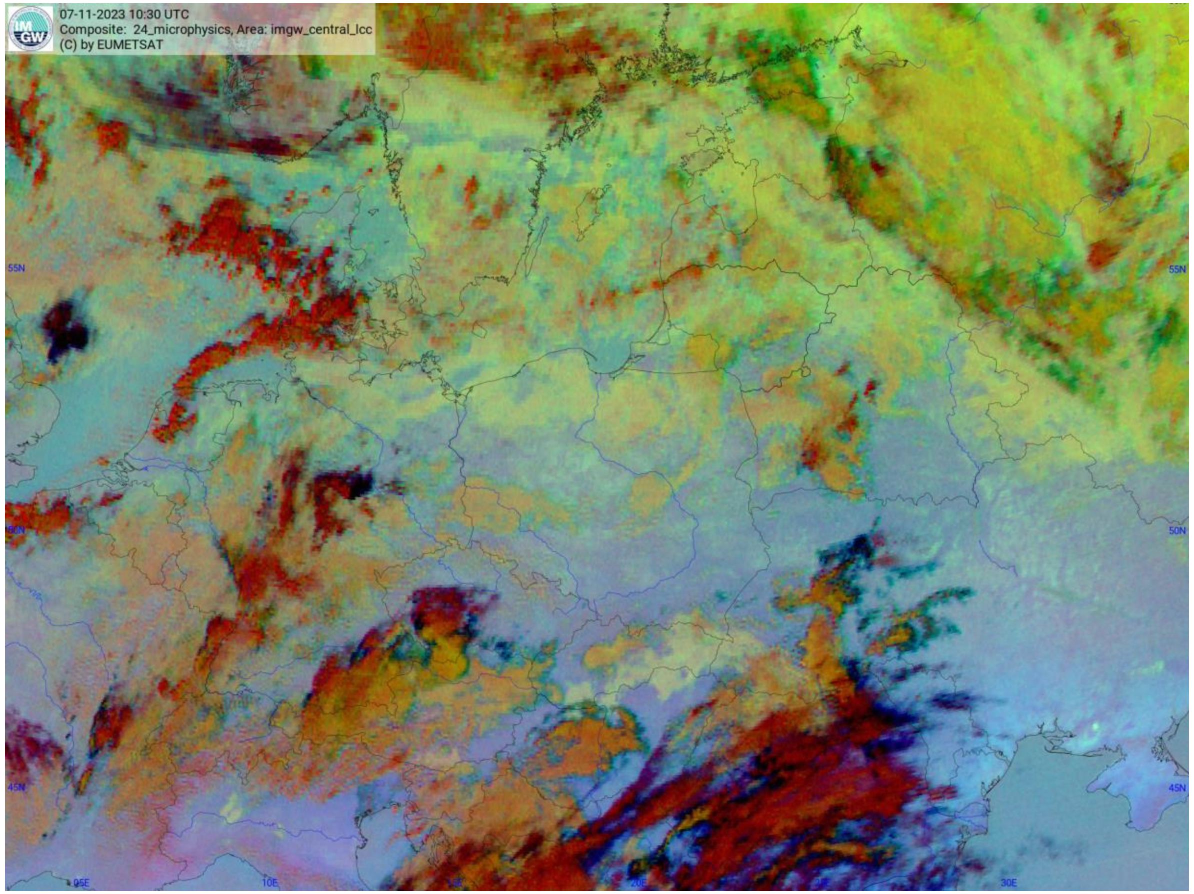
Useful images – 24h Microphysics

METEO
IMGW-PIB
meteo.imgw.pl

RGB Dust



RGB 24h Microphysics



Useful images – Day Microphysics

Analysis of clouds, convection, fog, snow, fires. Available during daylight hours.

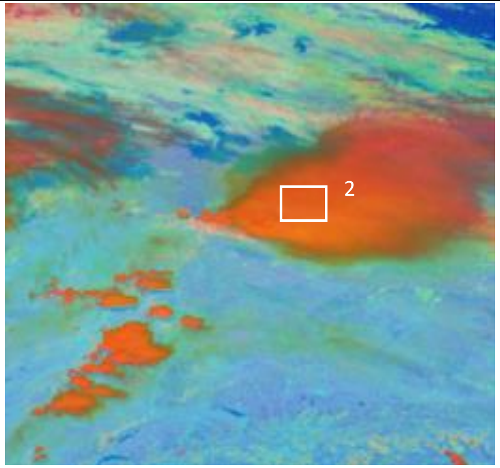
R – reflectivity,	R = VIS 0.8	0...100%	Γ=1
G – phase and size of particles,	G = IR 3.9r	0...60%	Γ=2.5
B – temperature of the vertices	B = IR 10.8	203...323	Γ=1

Colour Interpretation

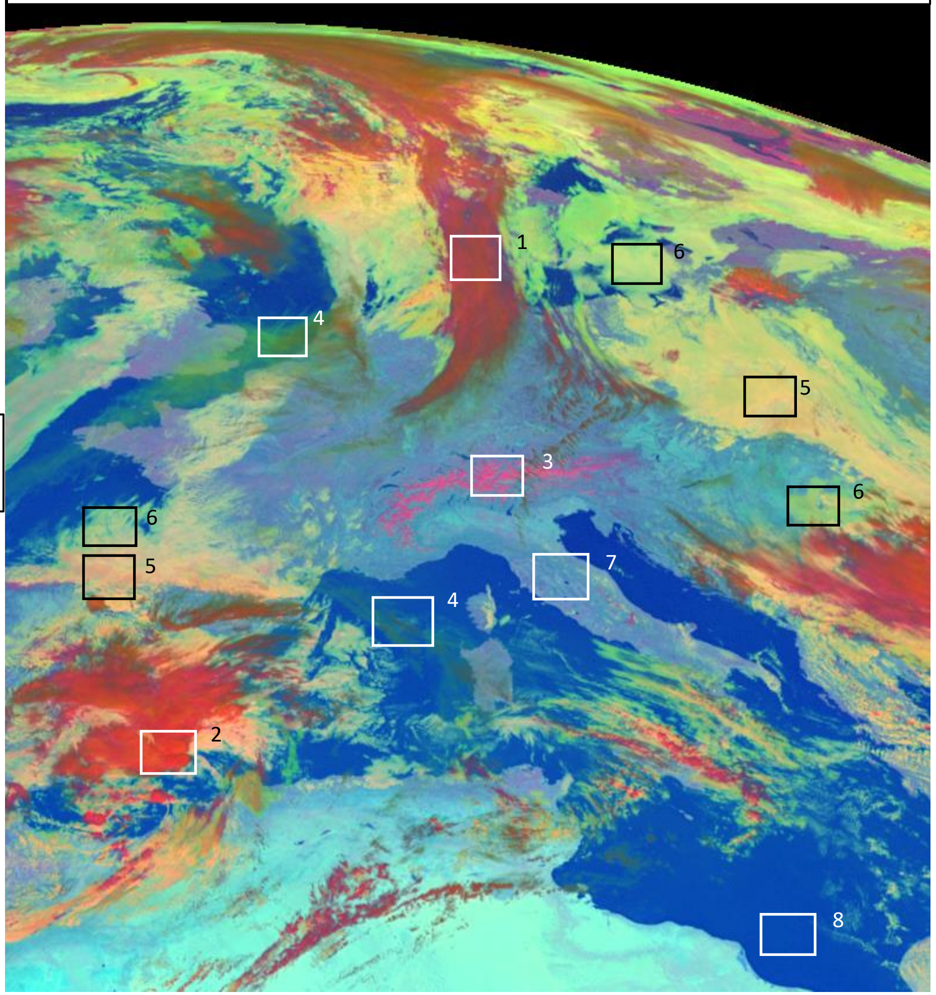
1	Thick ice clouds with large ice particles.
2	Thick ice clouds with small ice crystals on top.
3	Snow and ice on the ground.
4	Semi-transparent ice clouds. *
5	Low to mid-level **thick** water clouds with large particles.
6	Low to mid-level **thick** water clouds with smaller particles.
7	Cloud-free land.
8	Oceans and lakes.

* The colour shade may depend on the typeof the underlaying surface.

Day Microphysics RGB, 22 June 2017, 12:00 UTC



SEVIRI Day Microphysics RGB, 13 March 2017, 12:00 UTC



Useful images – Night Microphysics/Fog

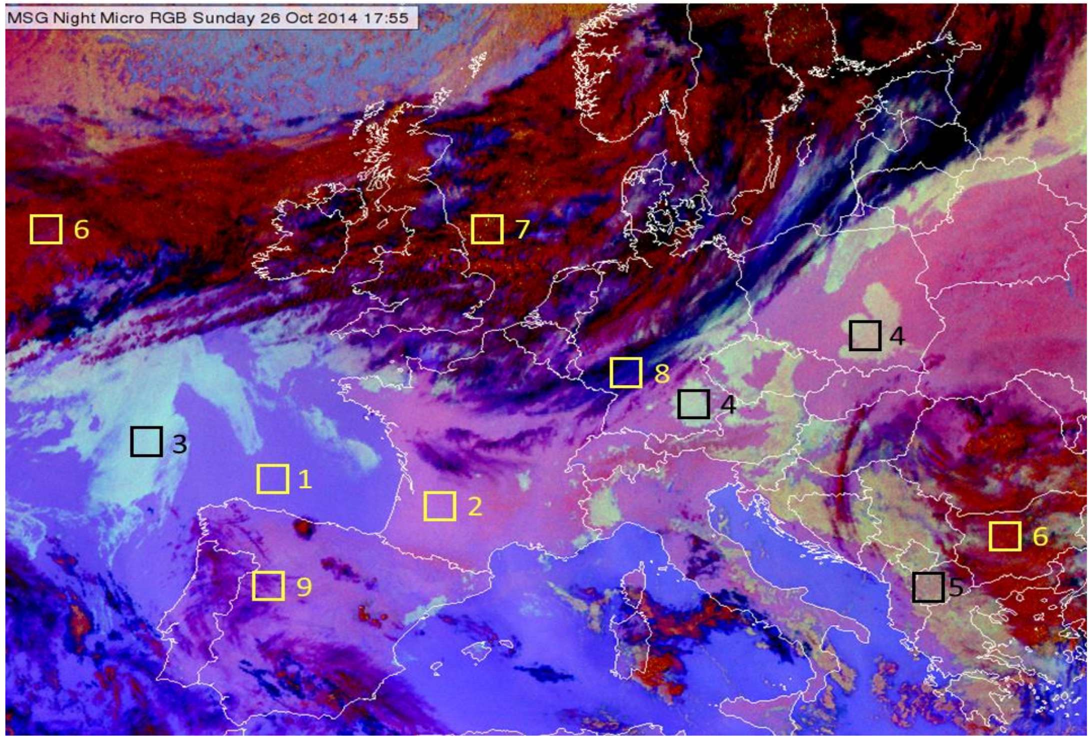
METEO
IMGW-PIB
meteo.imgw.pl

Night cloud cover analysis, clearly visible contrails, fog;

Useful for snow, fog and fire detection.

R – optical thickness	R = IR 12.0 – IR 10.8	-4K...2K	Γ=1
G – phase and particle size	G = IR 10.8 - IR 3.9	0...10K	Γ=1
B – cloud tops temperature	B = IR 10.8	243...293	Γ=1

SEVIRI Night Microphysics RGB for 26 October 2014 17:55 UTC



EUMETRAIN

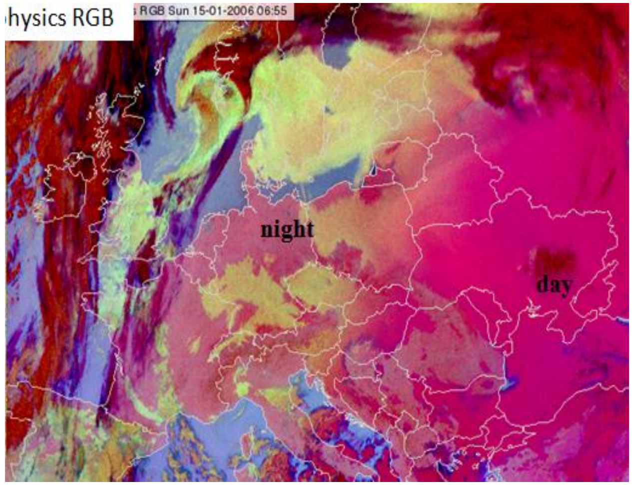
Interpretation

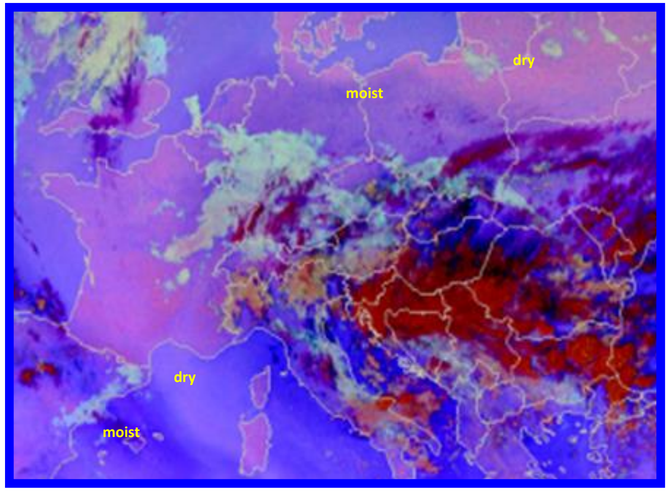
Colours may depend on viewing angles.

1, 2	Cloud free sea and land (Shades of blue or pink depending on temperature and water vapour content, see the panel to the right)
3	Warm, thick fog/low cloud, with small droplets (Shades of aqua)
4	Cold, thick fog/low cloud (Greenish in case of small droplets; pinkish grey in case of large droplets or thin cloud)
5	Thick mid-level cloud (Shades of tan)
6	Thick ice cloud (Reddish brown)
7	Very cold thick ice cloud (Reddish brown with green dots)
8	Thin cirrus (Shades of dark blue depending on the transparency)
9	Very thin cirrus (Shades of magenta depending on the transparency and the type of the underlying surface)
10	Clouds during daytime (Shades of magenta, red, blue depending on the temperature)

Useful images – Night Microphysics/Fog

03.09.2014, 20:40 UTC — 15.09.2006, 08:55 UTC





Interpretation

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1, 2	Cloud free sea and land (Shades of blue or pink depending on temperature and water vapour content, see the panel to the right)
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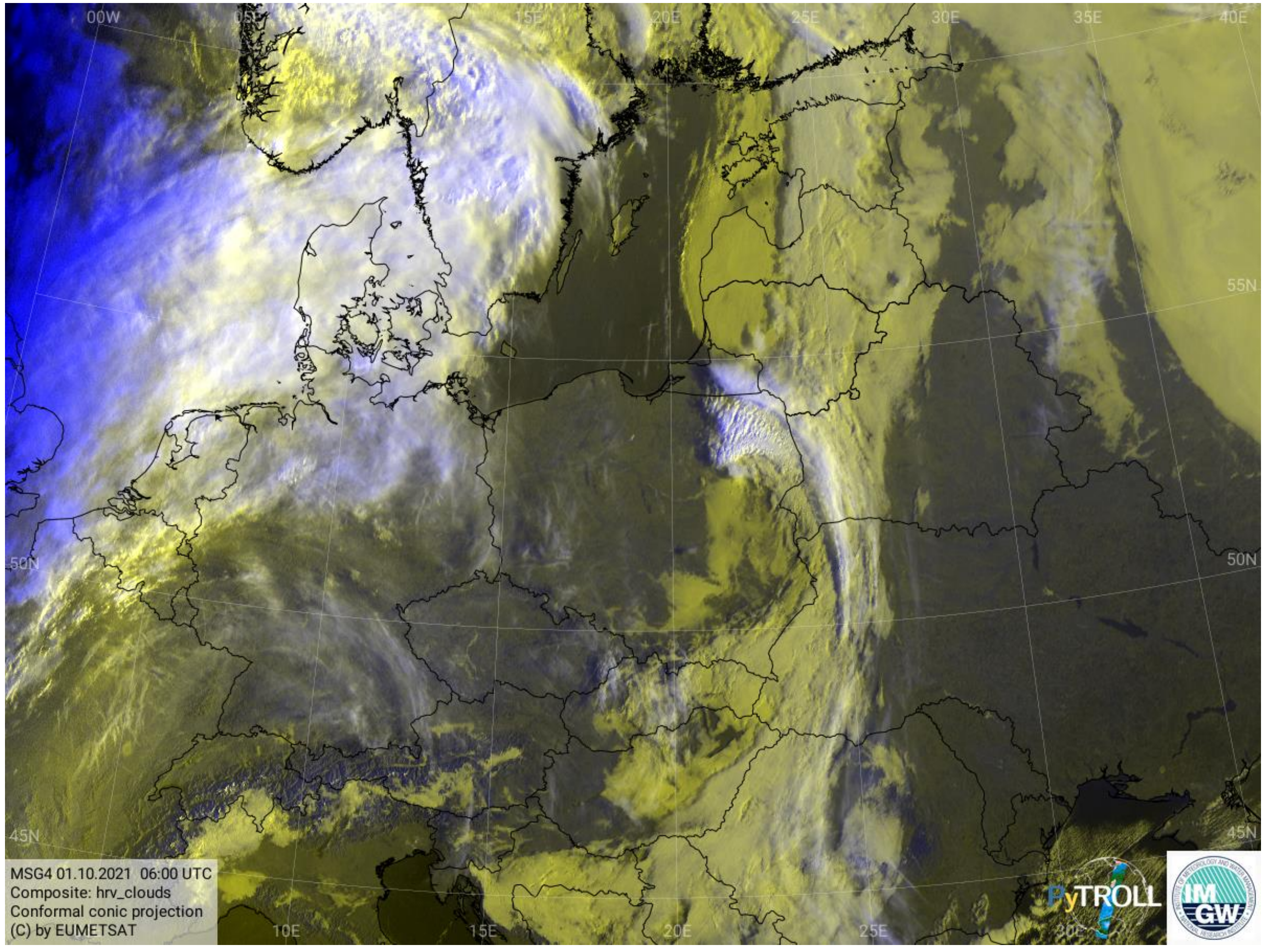
9	Very thin cirrus (Shades of magenta depending on the transparency and the type of the underlying surface)
10	Clouds during daytime (Shades of magenta, red, blue depending on the temperature)

METEO IMGW-PIB
meteo.imgw.pl

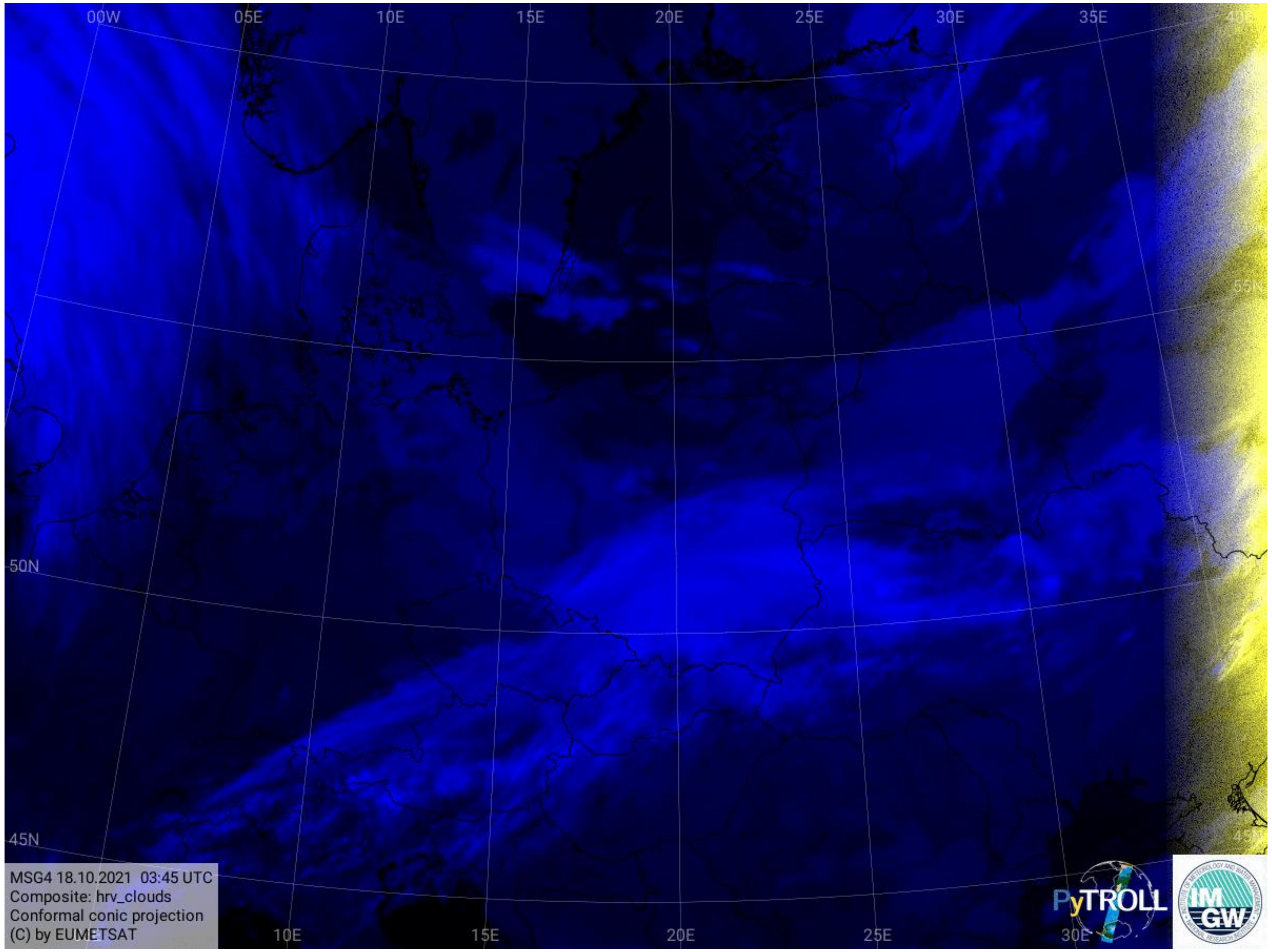
Overview/Clouds: detection of low and high level clouds, snow over land.
During night only blue component (IR 10.8µm) is available



R optical thickness of the cloud	**VIS 0.7**	**0...100%**	**Γ=1**
G optical thickness of the cloud	**VIS 0.7**	**0...100%**	**Γ=1**
B temperature	**IR 10.8**	**0...100%**	**Γ=1**

1	Thick high clouds (Bright greyish, whitish shades with shadows)
2	Thin high level clouds (Bluish shades depending on the transparency and the type of the underlying surface)
3	Fog, low- and mid-level clouds or snow covered land (Shades of yellow depending on the cloud top temperature, cloud thickness; temperature and state of the snow)
4	Snow-free land (Shades of grey with some bluish or yellowish tones depending on the temperature and surface reflectivity)
5	Ice-free sea (Shades of dark blue)

EUMETRAIN



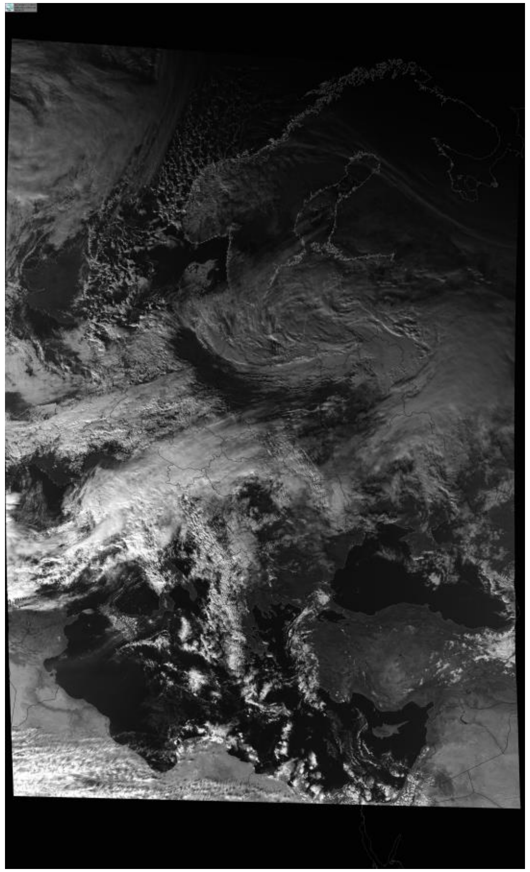
At night, only channel 10.8 is available – the picture in shades of blue.

Night overview (from VIIRS data only)

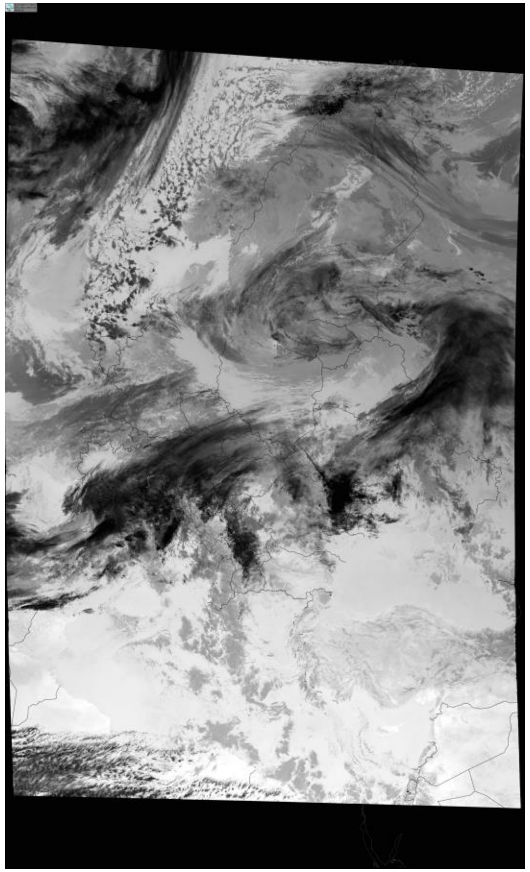
R – optical thickness of the cloud,
G – optical thickness of the cloud,
B – cloud tops temperature

R = DNB (0.7 µm)
G = DNB (0.7 µm)
B = M15 (10.8 µm)

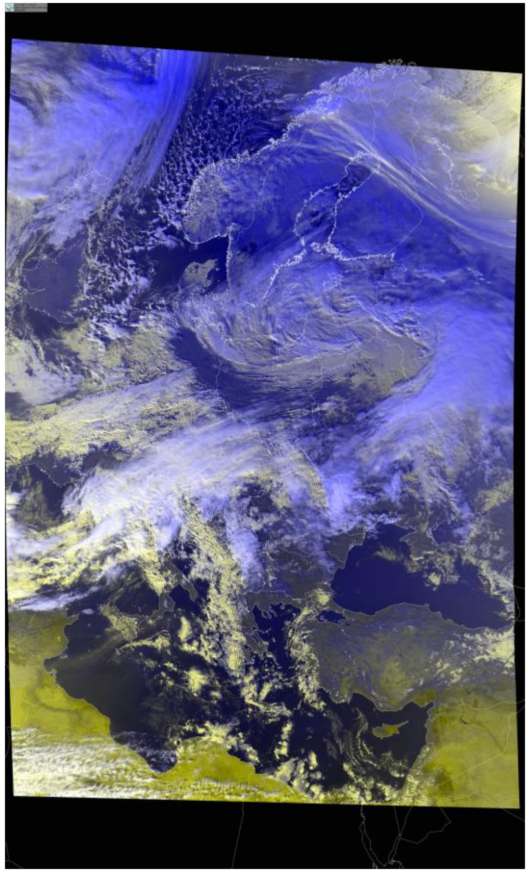
DNB



M15

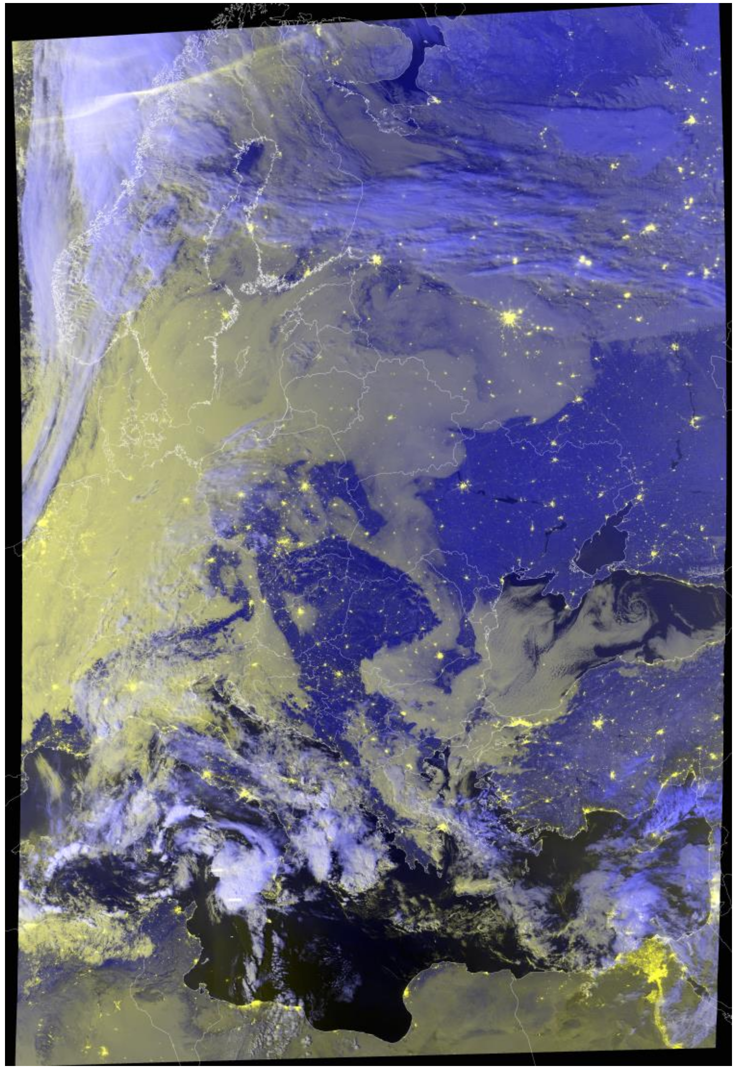


Night overview



At night during the Full Moon – clouds are visible, including low clouds and fog as well as snow on the ground and ice on the sea.

- Low, warm clouds – yellow,
- Cold, high clouds – white, white-blue,
- Snow – pale yellow, shade of yellow depending on the temperature,
- Land – dark blue or rotten green (e.g. deserts).
- Water – black,
- Northern Lights – yellow bands in the north,
- City and road lights - bright yellow.

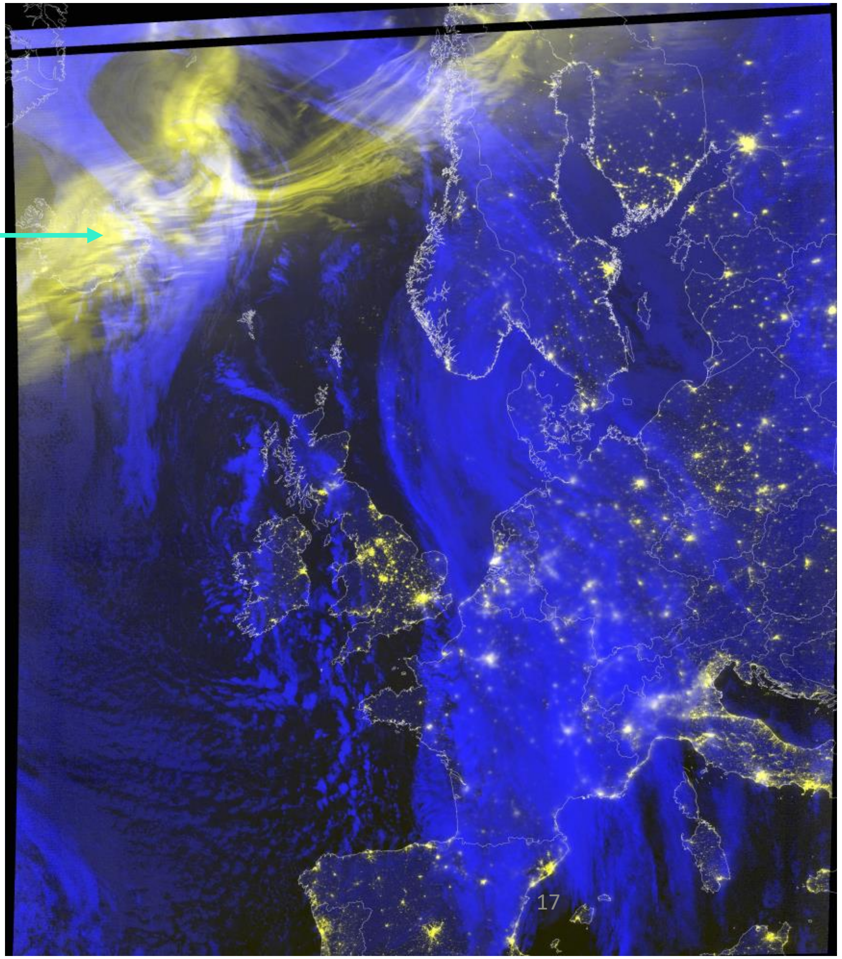


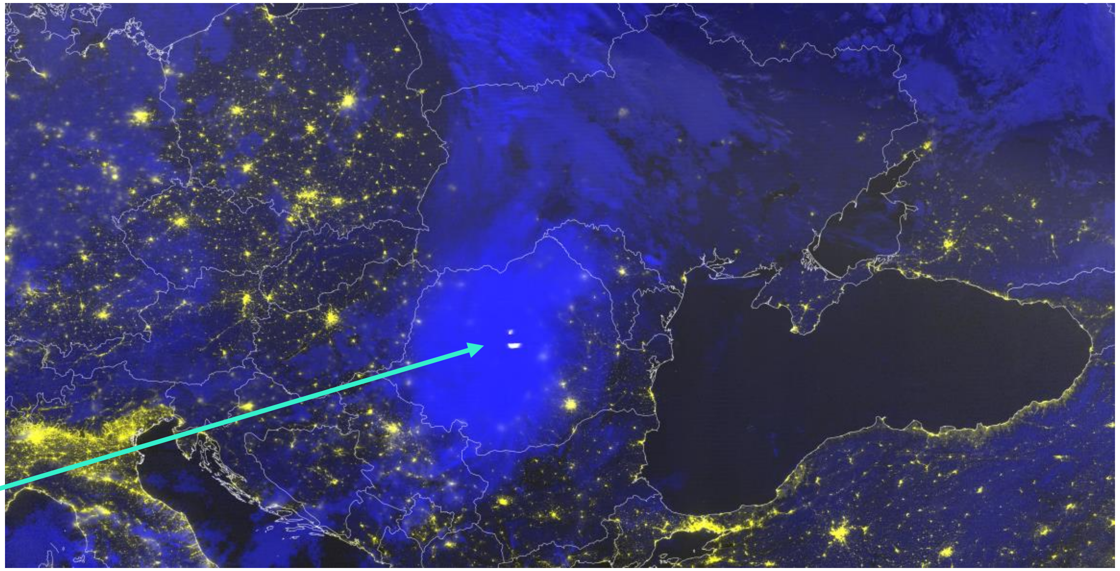
At night, during the New Moon – image in shades of blue. Cold, optically thick clouds are well visible.

- Low, warm clouds – barely visible, their existence is evidenced by the blurring of the lights of cities and roads
- High, cold clouds – blue: the colder the cloud, the brighter the blue
- Snow – invisible,
- Land – navy blue
- Aurora– yellow bands in the north
- City and road lights bright yellow.
- Lightnings – white.

NOAA-20, 28.11.2022, 02:03 UTC

Aurora





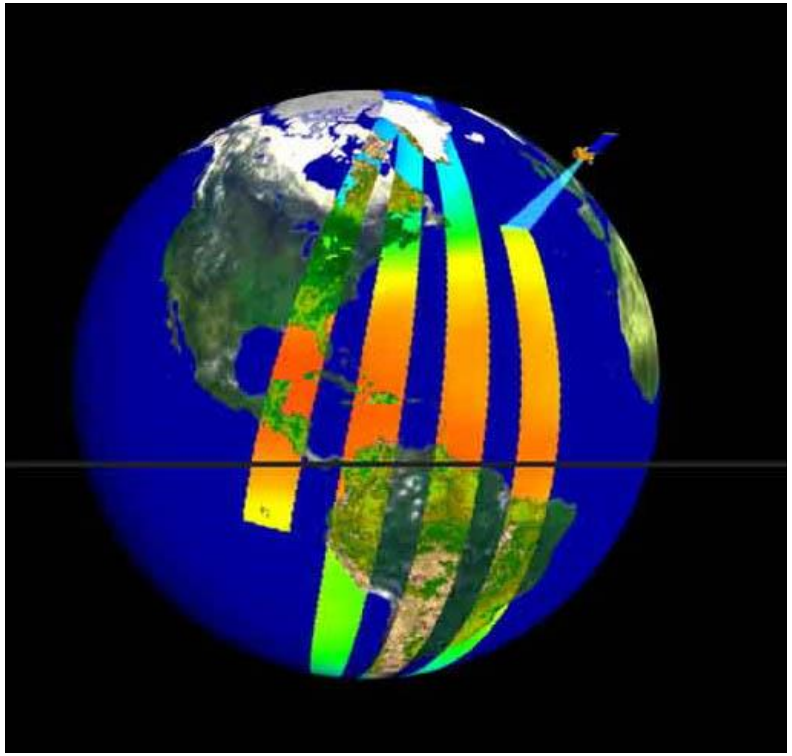
Lightnings

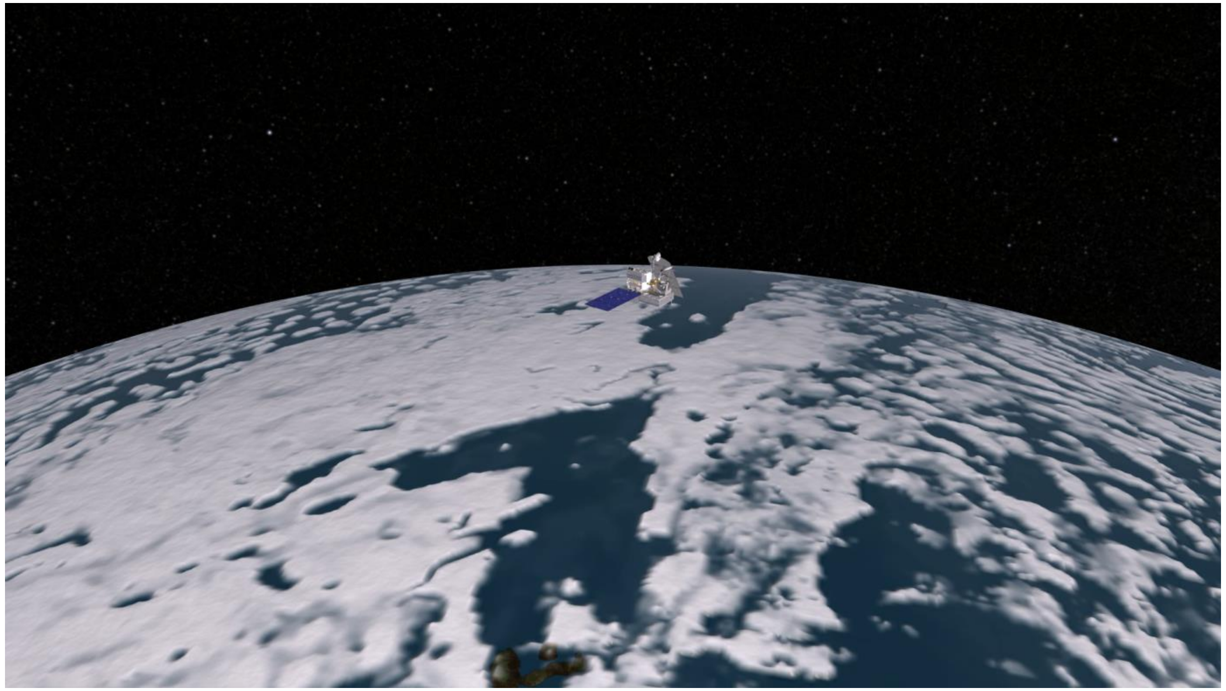
Polar satellites specifics

Polar satellites (LEO) - moving in "low" orbits(c.a. 800 km above the Earth), inclined to the plane of the Earth's equator at an angle close to 90°. Their position relative to a point on Earth changes.

Sensors onboard polar satellites do not 'see' the entire Earth's disk, but a certain belt the width of which depends on the type of sensor and the scanning mode.

Satellite orbit period – c.a. 102 minutes

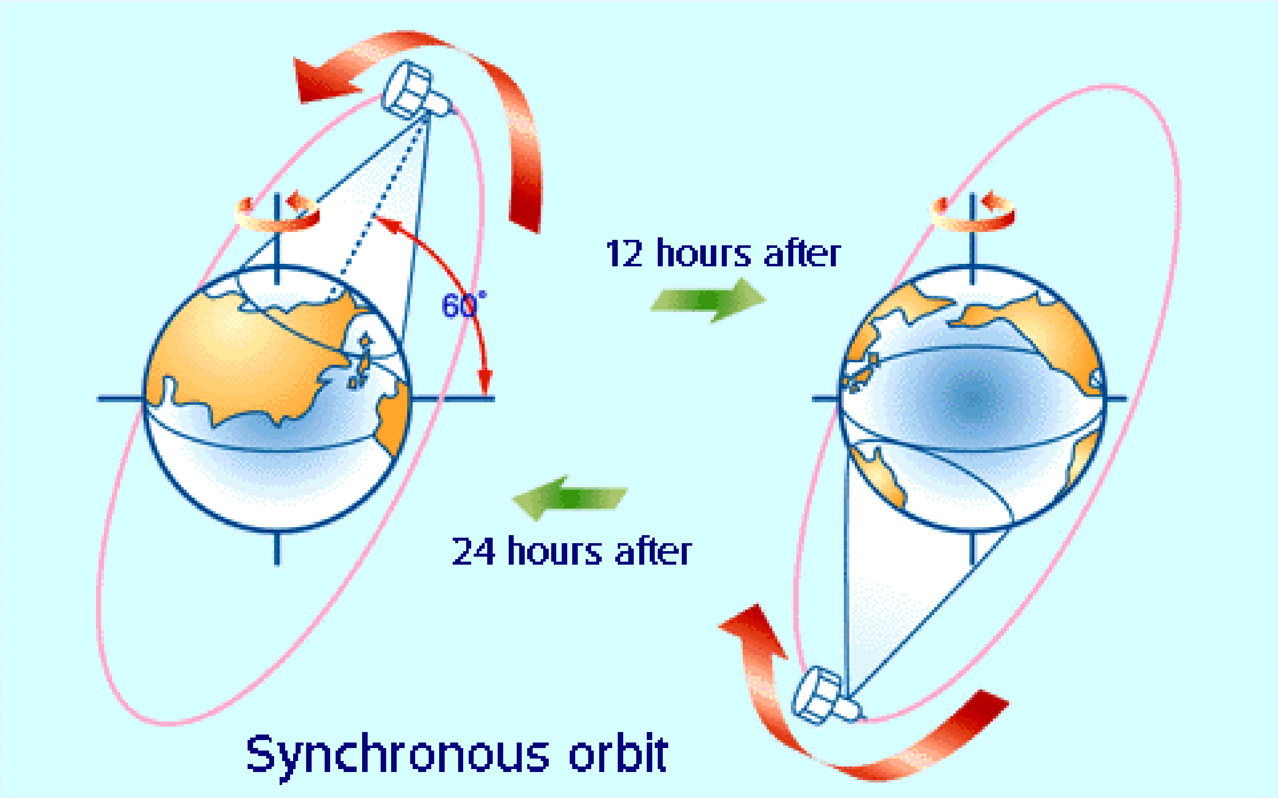




Properties of polar orbits

Most polar satellites orbits are synchronized with the Sun, i.e. the satellite appears over a given area at about the same local time – important for climate change research;

Transmissions from the first half of the day are descending (the satellite flies from N to S) and from the second half of the day – ascending ones (the satellite flies from S to N).



Properties of polar orbits

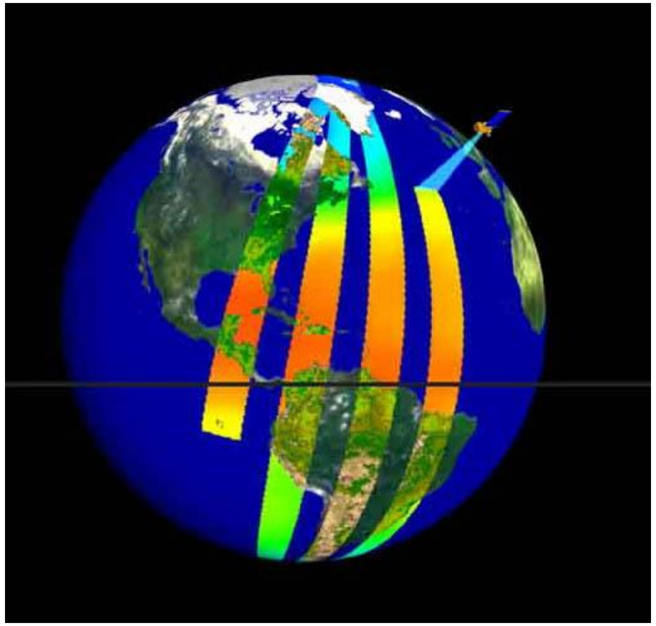
The timing of the flights of polar satellites is consulted among satellite agencies in order to:

- Ensure continuity of observation at a given time of day;
- Ensure that overpass times are distributed as evenly as possible throughout the day.

The frequency of the appearance of one polar satellite over a given place depends on its latitude: from the lowest above the equator to the highest over the Earth's poles.

The frequency of observations increases with the number of satellites in orbit.

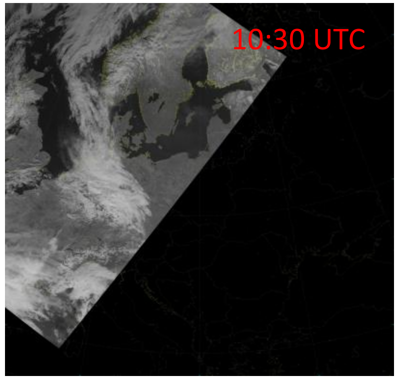
In the case of Poland, data from one satellite is available from 4-6 times a day*. For the higher latitudes this number increases.

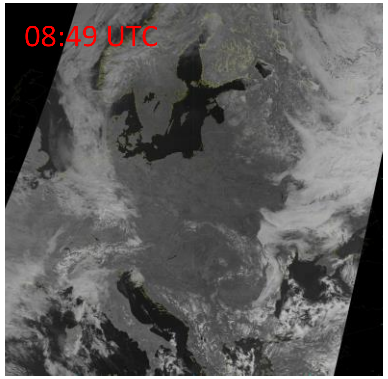


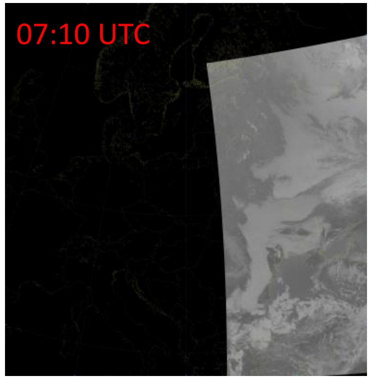
*not every overpass will cover the whole of Poland.

Właściwości orbit okołobiegunowych

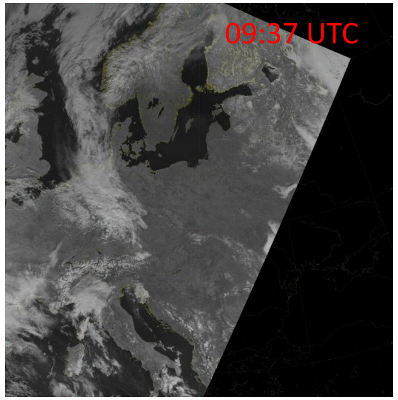
- W odróżnieniu od satelitów geostacjonarnych, położenie danego punktu w obrębie transmisji (zdjęcia satelitarnego) nie jest stałe i zmienia się od przelotu do przelotu.
- Najczęściej zdarzające się sytuacje (kolejność dla pierwszej połowy doby):
  - 1 -3 transmisji: bardzo wschodnia (Polska poza obrazem lub jej Wschód z lewej strony obrazu), zenitalna (Polska w centrum) i bardzo zachodnia (Polska poza obrazem lub jej Zachód z prawej strony obrazu),

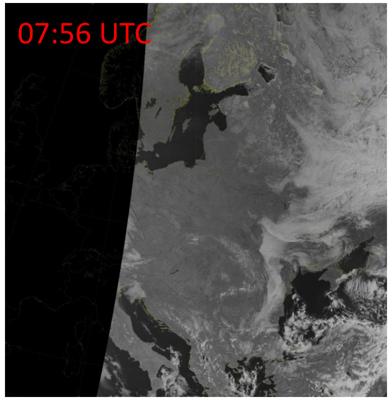






  - 2 transmisje: wschodnia (Polska w lewym poł wie obrazu) i zachodnia (Polska w prawej połowie obrazu).

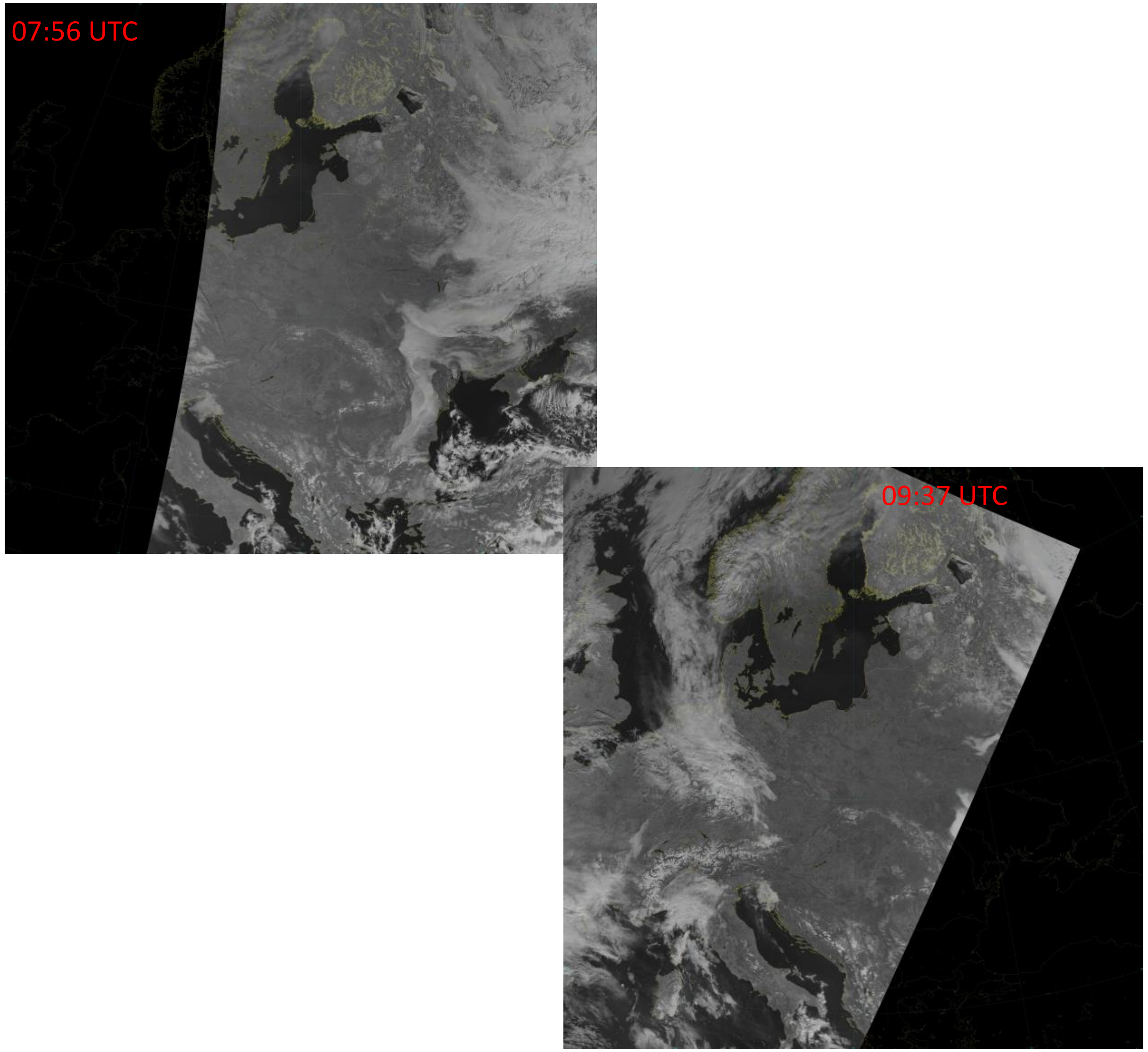




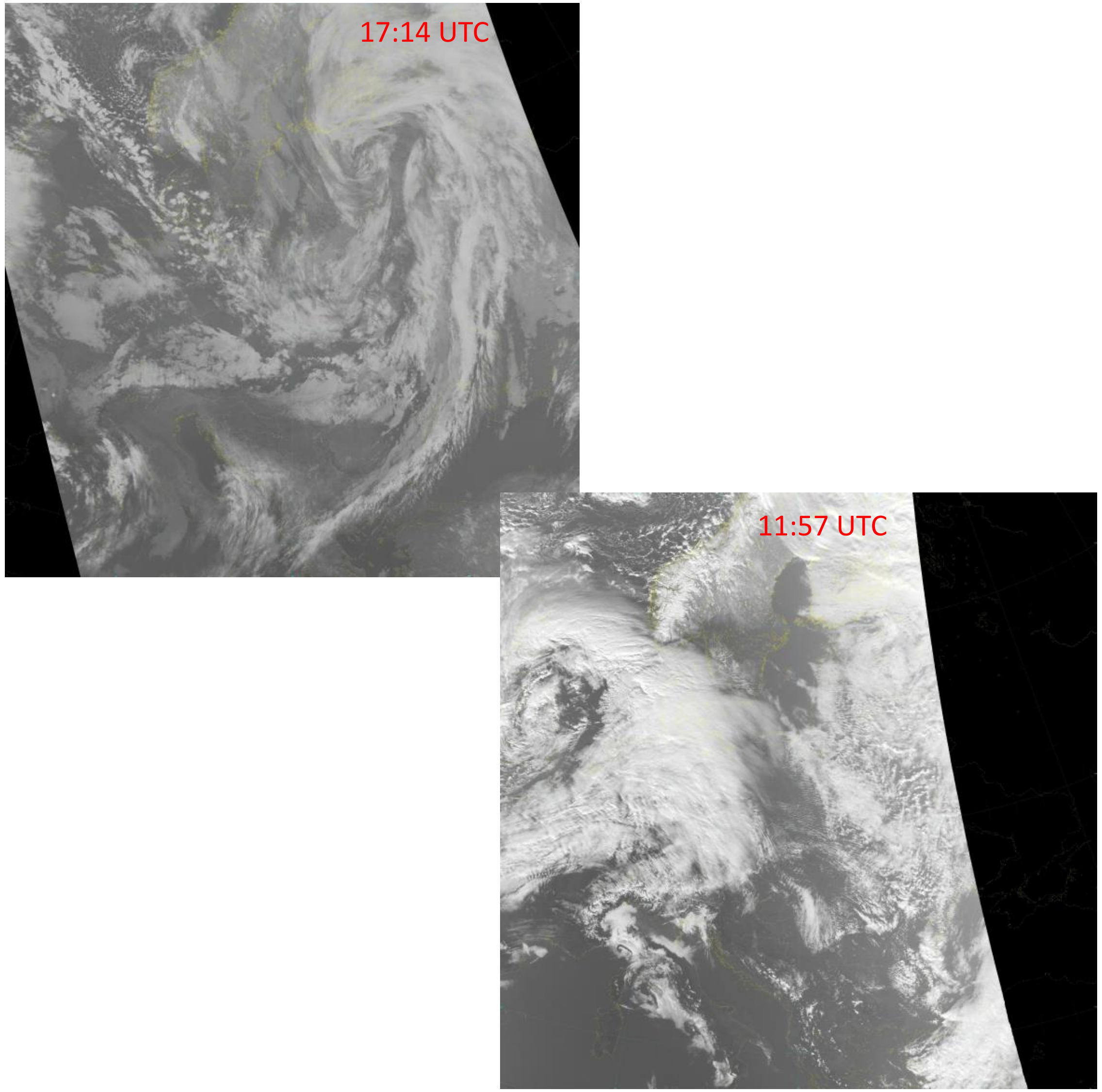
Właściwości orbit okołobiegunowych

METEO IMGW-PIB meteo.imgw.pl

- Descending orbits (midnight, morning)



- Ascending orbits (noon, afternoon)



LEO:

EUMETSAT: **METOP-B** i **-C**

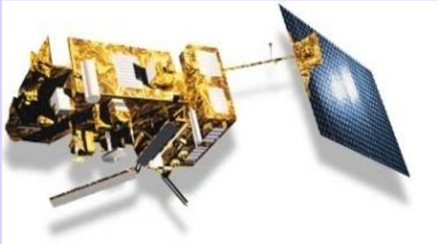
NOAA: **NOAA-15**, **NOAA-18** i **NOAA-19**

NOAA JPSS: **Suomi NPP** i **NOAA-20** (NOAA-21 at commissioning phase)

Environmental: **TERRA, AQUA**

Copernicus: **Sentinel-1, Sentinel-2, Sentinel-3 and Sentinel-5P**

Chinese: **FY-3D, FY-3E**



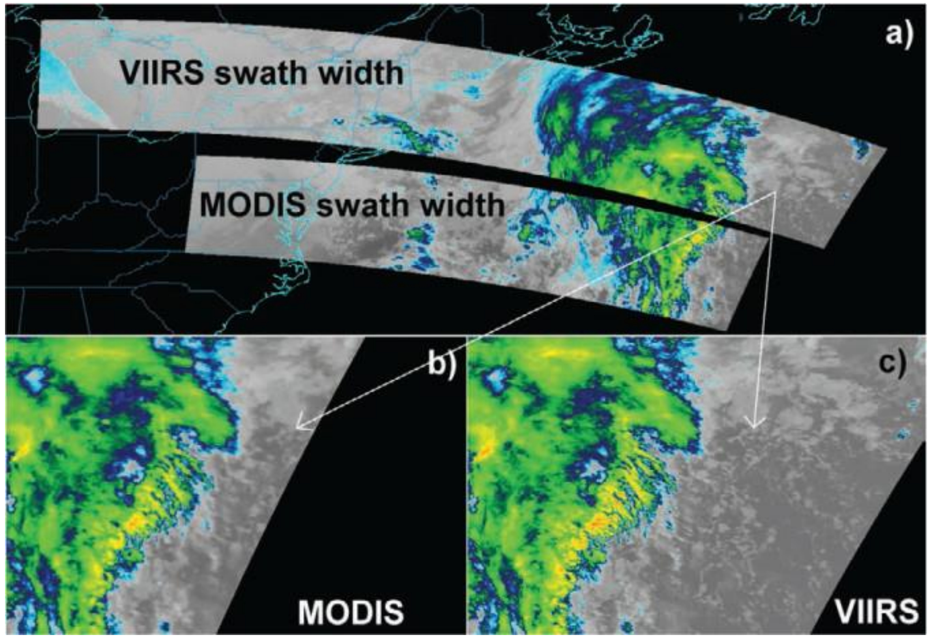
Imagers:

- Metop: Metop-B i Metop-C (AVHRR)
- NOAA-18 and NOAA-19 (AVHRR)
- NPP (NPOESS Preparatory Program) : Suomi NPP, NOAA-20, *NOAA-21* (VIIRS)
- Terra i Aqua (MODIS)
- Sentinel-2 (MSI)
- Sentinel-3 (OLCI, SLSTR)

The spatial scope of the data is always dependent on:

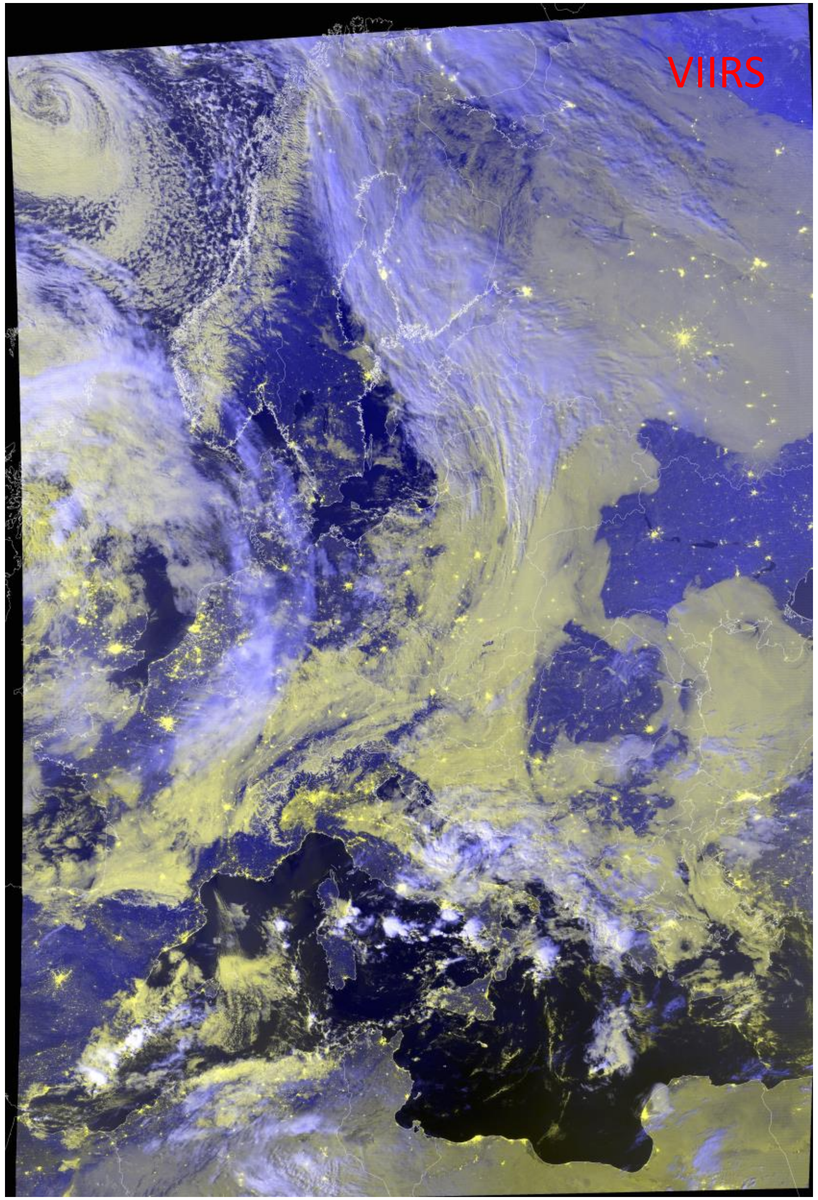
- sensor characteristics – scanning or 'fixed',
- orbital parameters – very eastern and western transmissions their length will be shorter than zenital one,
- geographical location of the receiving antenna: maximum range N-S and E-W.

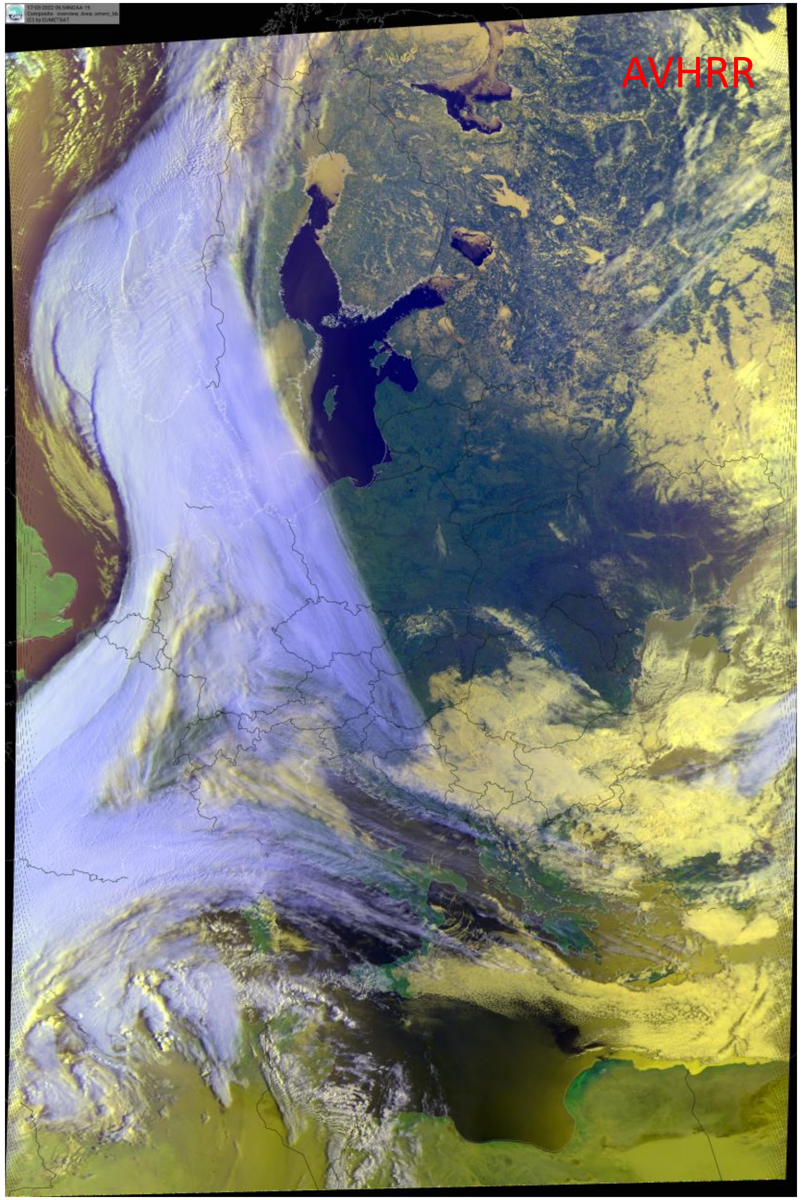
In the case of imaging sensors, the transmission width ranges from c.a. 2 300 km to 3 000 km.

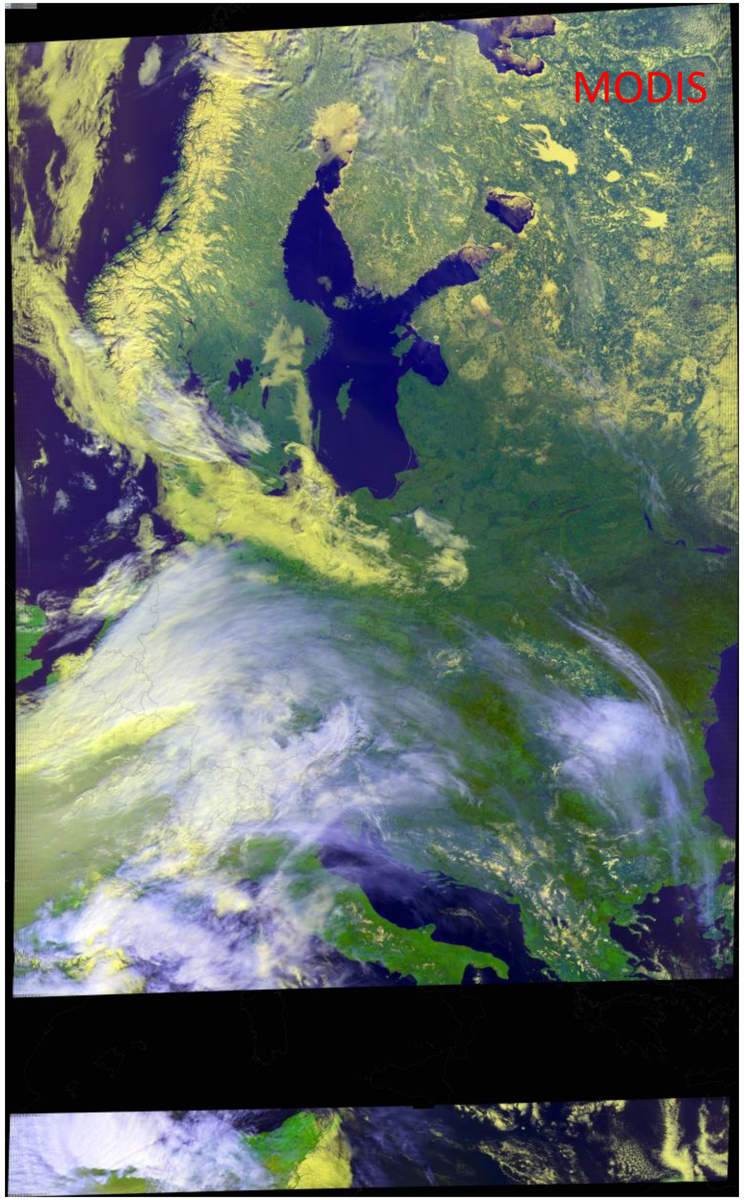


Transmission width

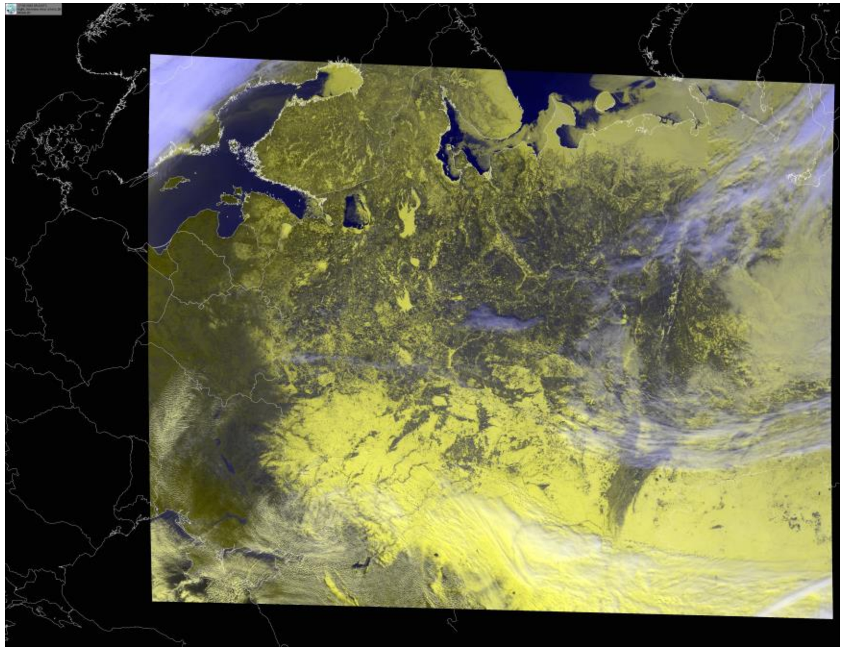
METEO
IMGW-PIB
meteo.imgw.pl

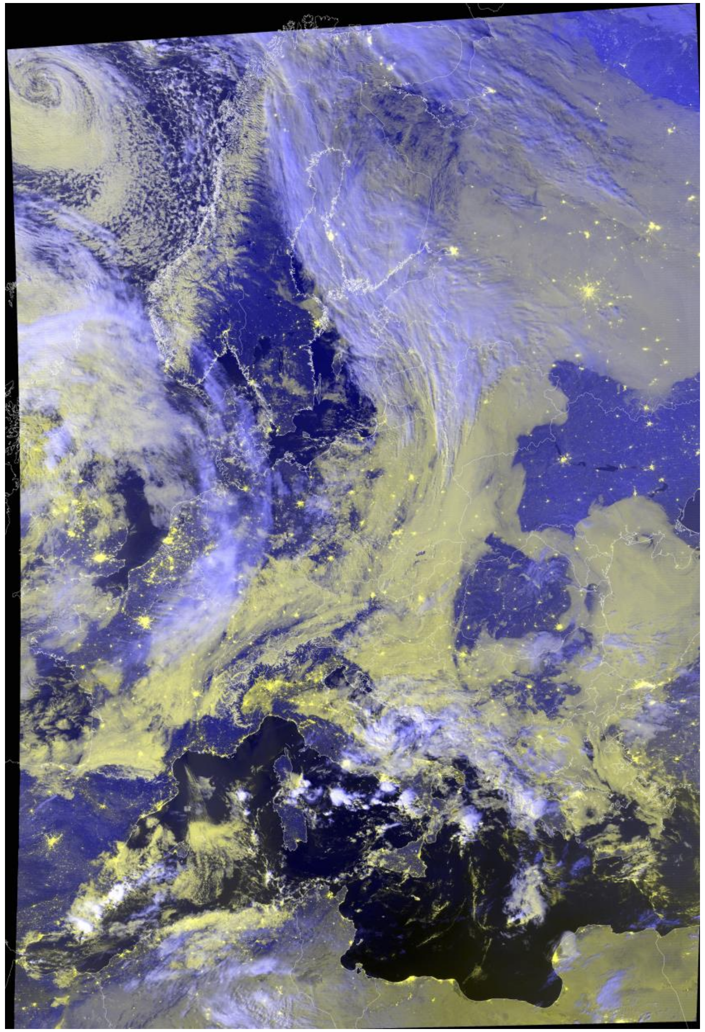


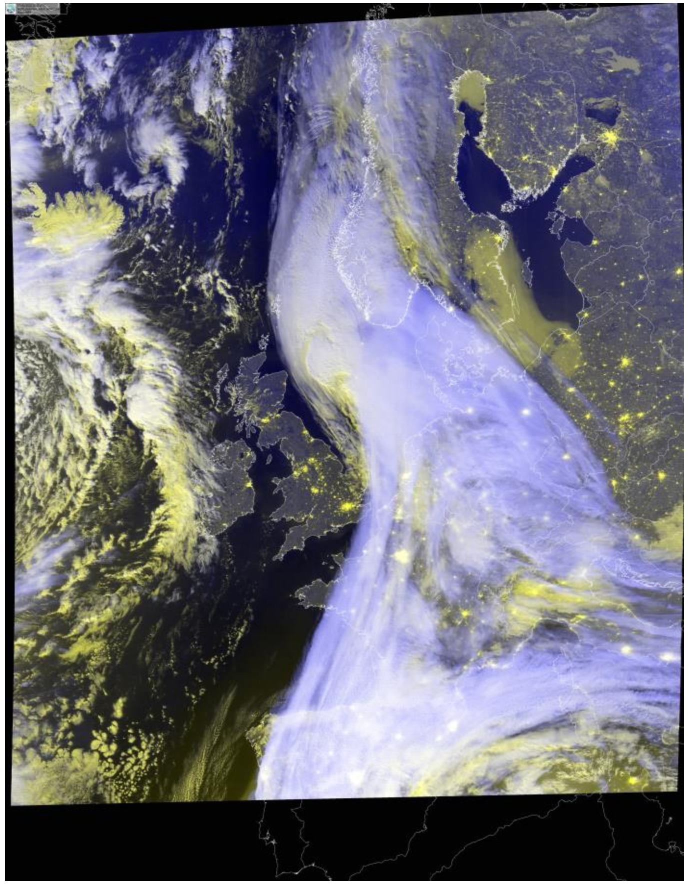




W przypadku naszej stacji odbieramy transmisje od północnych wybrzeży Afryki po Północną Skandynawię (dane dla transmisji zenitalnych).

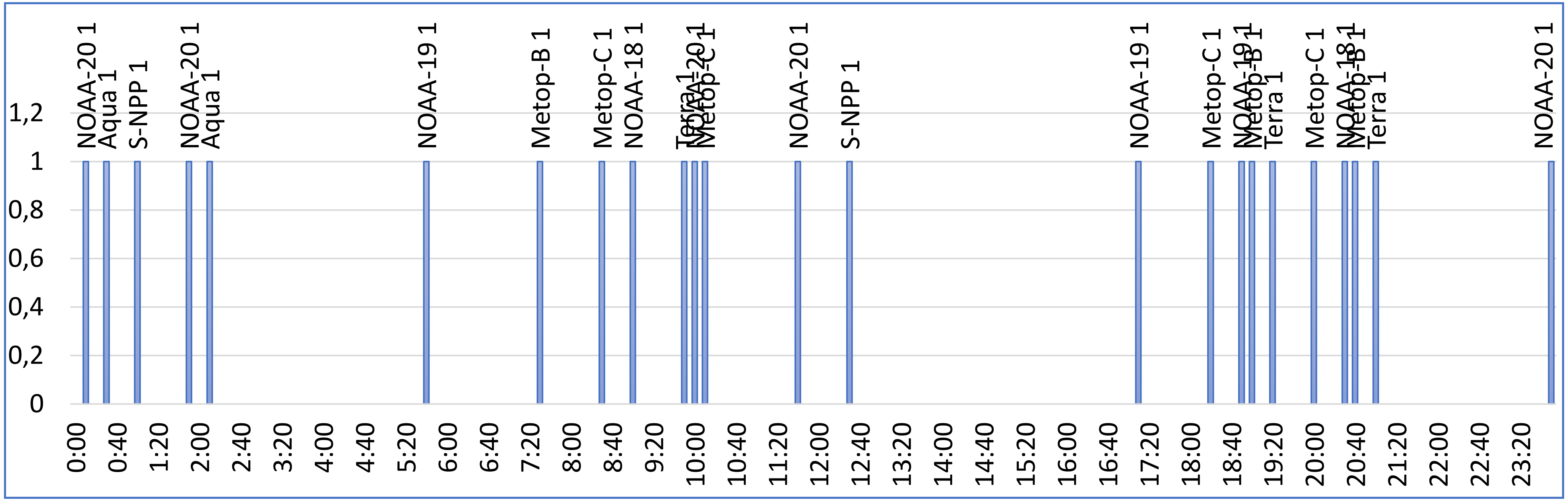






Imaging Sensors on Circumpolar Satellites – Temporal Resolution

An example of the distribution of flight times of circumpolar satellites with the antenna located at Kraków:



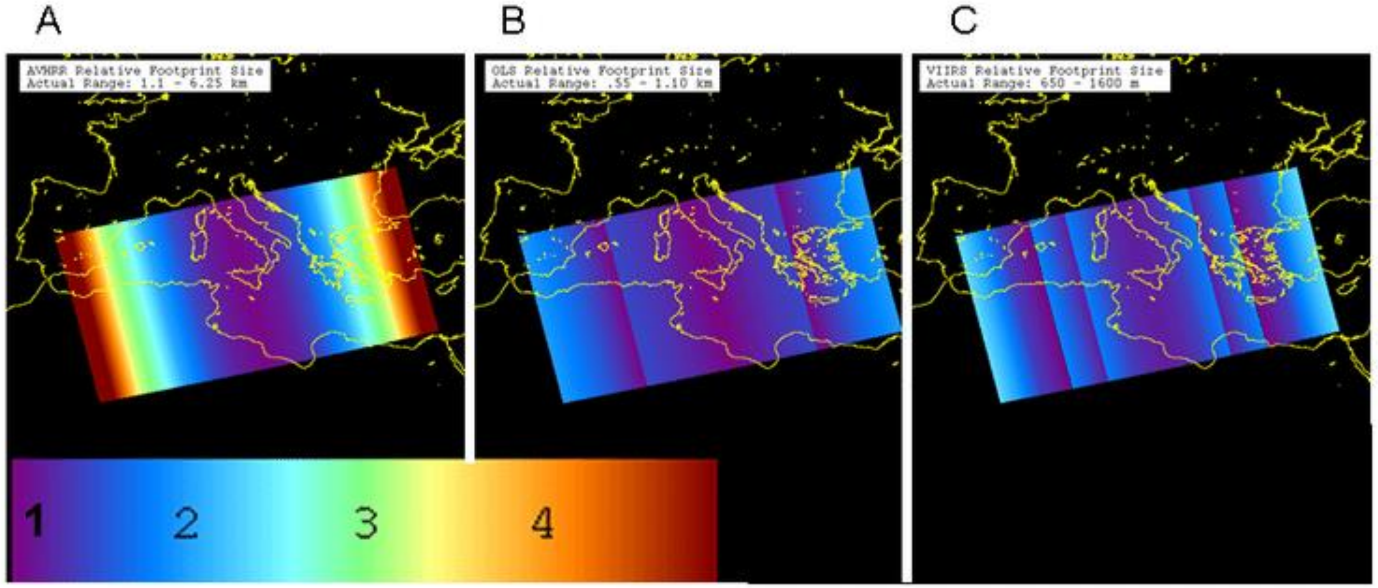
- c.a. 24 flights a day grouped around midnight, morning, noon and evening,
- deficiencies in the early morning and afternoon,
- different spatial ranges of each transmission,
- various sets of RGB compositions.

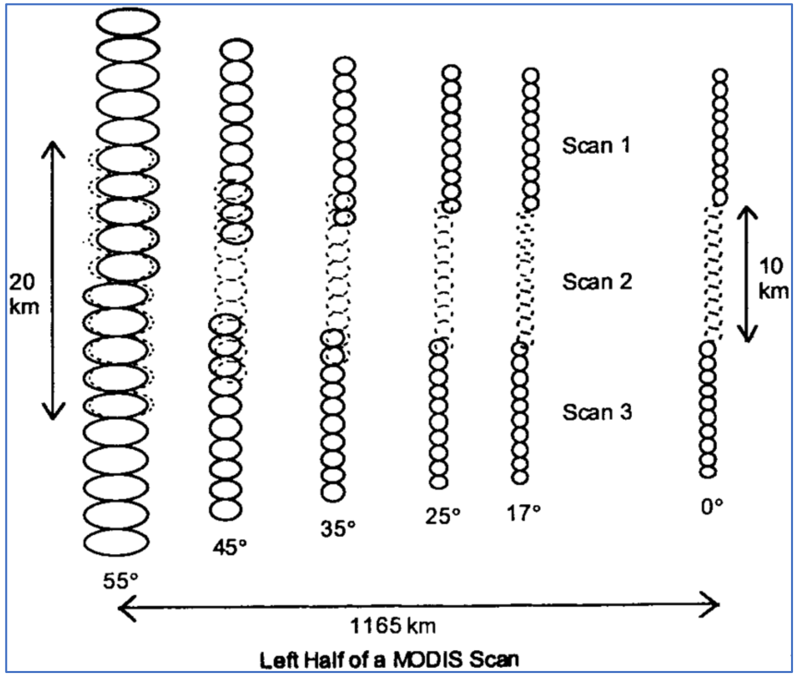
Imaging sensors on polar satellites – spectral resolution

METEOSAT		NOAA & METOP			TERRA & AQUA						SUOMI-NPP					
SEVIRI		AVHRR			MODIS						VIIRS					
kanał	pasmo	kanał	pasmo	Piksel [m]	kanał		pasmo		piksel [m]		kanał		pasmo		piksel [m]	
1	VIS 0.6	1	VIS 0.63	1090	1	13	VIS 0.64	VIS 0.66	250	1000	I1	M5	VIS 0.64	VIS 0.67	375	750
2	VIS 0.8	2	VIS 0.87	1090	2	16	VIS 0.86	VIS 0.87	250	1000	I2	M7	VIS 0.86	VIS 0.86	375	750
					3	9	VIS 0.47	VIS 0.44	500	1000		M2		VIS 0.45		750
					4	12	VIS 0.55	VIS 0.55	500	1000		M4		VIS 0.55		750
					5		NIR 1.24		500			M8		NIR 1.24		750
3	NIR 1.6	3A	NIR 1.61	1090	6		NIR 1.63		500		I3	M10	NIR 1.61	NIR 1.61	375	750
					7		NIR 2.1		500							
												M11		NIR 2.25		750
					8		VIS 0.41		1000			M1		VIS 0.44		750
					10		VIS 0.49		1000			M3		VIS 0.49		750
					11		VIS 0.53		1000							
					14		VIS 0.68		1000							
					15		VIS 0.75		1000			M6		VIS 0.75		750
					17		VIS 0.9		1000							
					18		VIS 0.94		1000							
					19		VIS 0.93		1000							
4	IR 3.9	3B	IR 3.74	1090	20		IR 3.78		1000		I4	M12	IR 3.74	IR 3.7	375	750
					21		IR 3.96		1000			M13		IR 4.05		750
					22		IR 3.96		1000							
					23		IR 4.06		1000							
					24		IR 4.47		1000							
					25		IR 4.54		1000							
					26		NIR 1.38		1000			M9		IR 1.38		750
5	WV 6.2				27		IR 6.75		1000							
6	WV 7.3				28		IR 7.33		1000							
7	IR 8.7				29		IR 8.52		1000			M14		IR 8.55		750
8	IR 9.7				30		IR 9.74		1000							
9	IR 10.8	4	IR 10.8	1090	31		IR 11.0		1000		I5	M15	IR 11.4	IR 10.8	375	750
10	IR 12.0	5	IR 12.0	1090	32		IR 12.0		1000			M16		IR 12.0	375	750
11	**IR 13.4**				**33**		**IR 13.4**		**1000**							
					34		IR 13.6		1000							
					35		IR 13.9		1000							
					36		IR 14.2		1000							
12	HRV										DNB	DNB		0.5 - 0.9		750

The pixel size listed in the Table is for subsatellite pixels. Their size depends on the position in the satellite scan (distance from the subsatellite point).

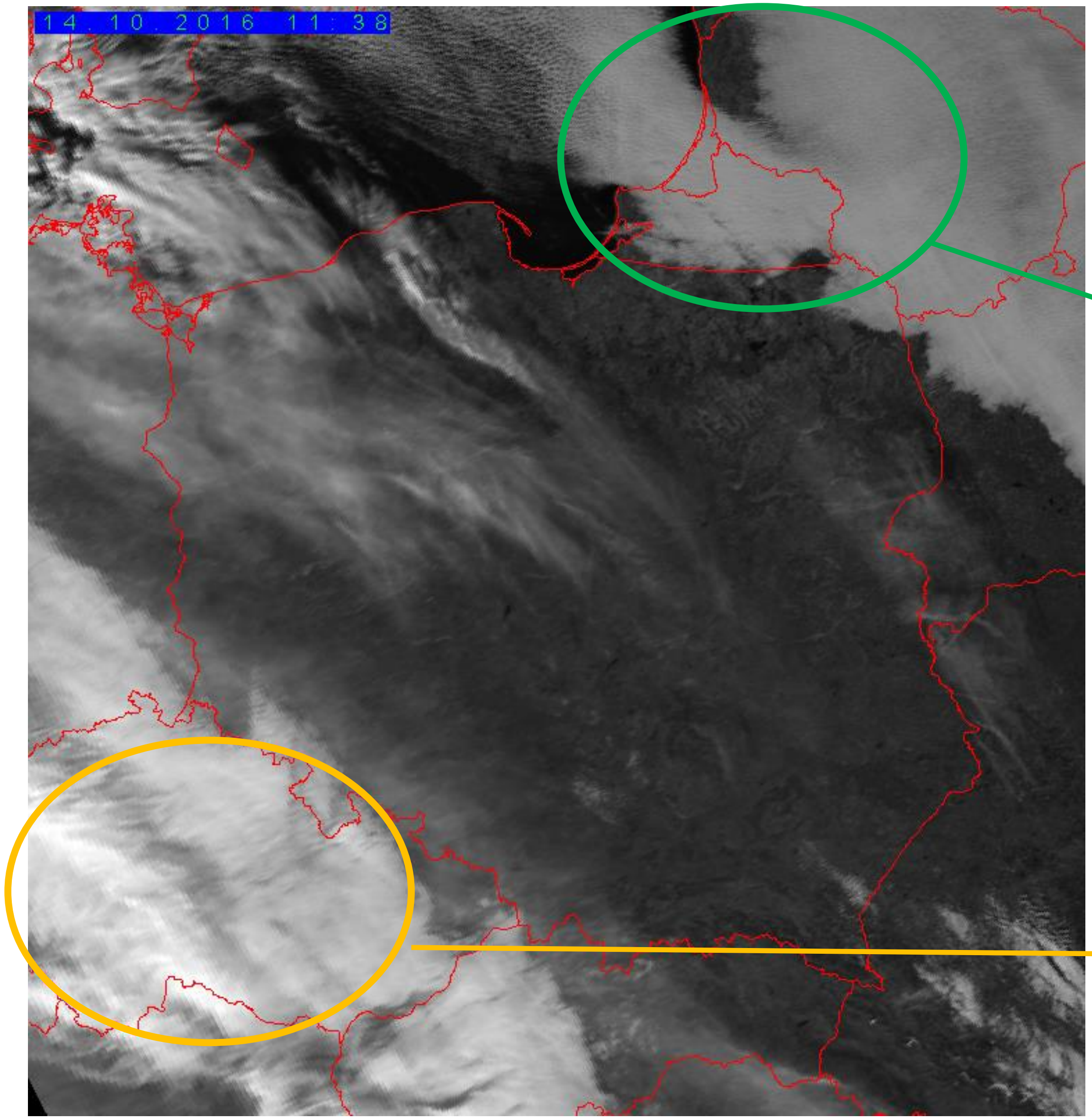
Change in pixel size (spatial resolution) depending on distance from the subsatellite point for AVHRR (A), VIIRS (C) and MODIS (B).





After Thomas F. Lee, et all. , Applications of the NPOESS Visible/Infrared and Microwave Imagers , https://www.researchgate.net/publication/253051713

Source: https://www.researchgate.net/figure/Pixel-growth-and-overlap-between-adjacent-MODIS-scans-is-illustrated-At-55-the-first_fig4_3201885



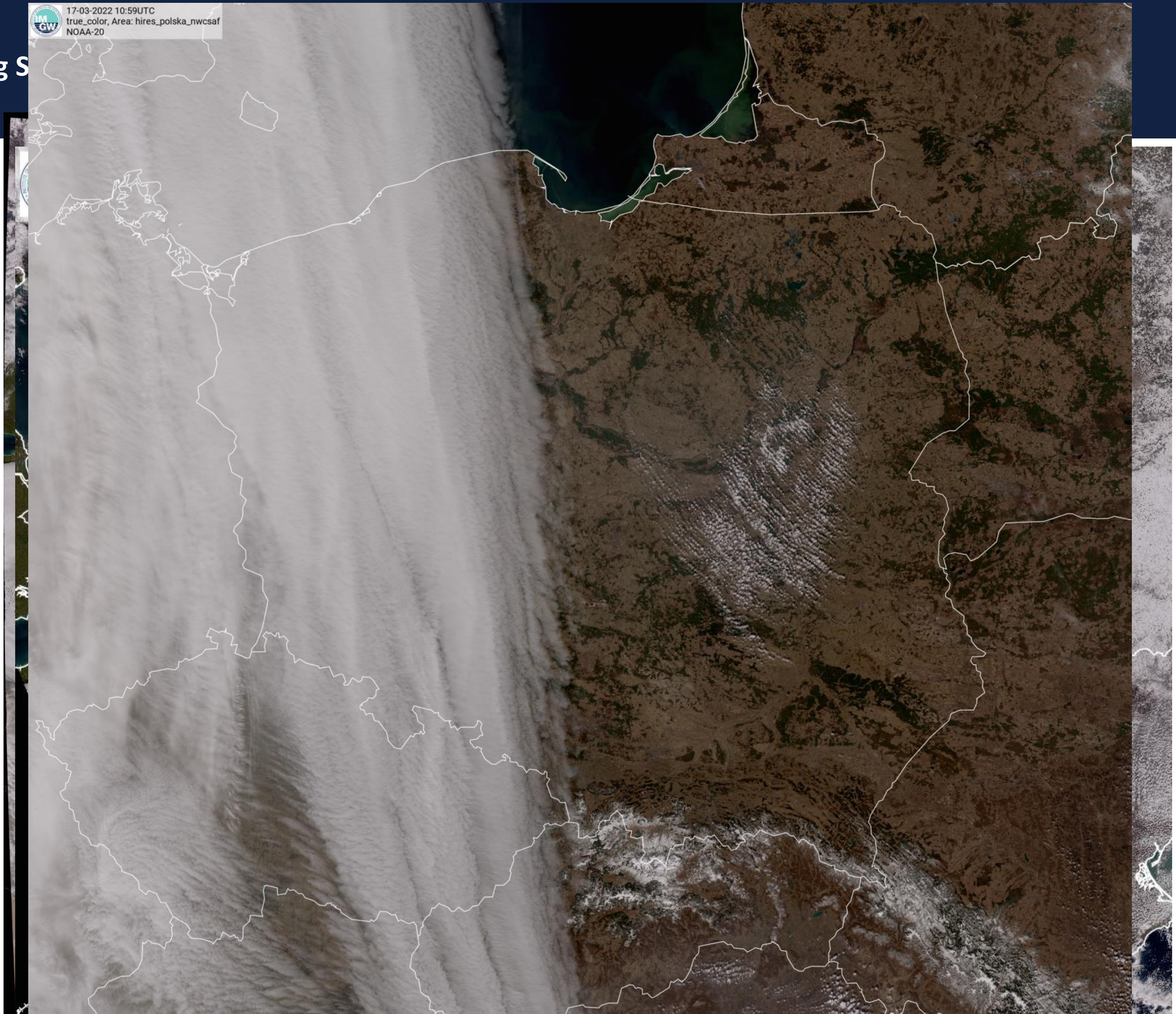
AVHRR kanał 0.8µm,

14.10.2016, 11:38 UTC

High Resolution

Low Resolution

Imaging S



METEO
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RGB compositions and images generated from polar satellites

Compositions generated from Meteosat/SEVIRI and polar satellites data - the colors may be slightly different because the spectra ranges, and sensitivity functions of individual channels are different.

Kompozycja	AVHRR	VIIRS	MODIS
IR_enhanced	x	x	x
Sandwich	x	x	x
OST	-	-	x
Natural Colors	x (only Metop)	x	x
Overview	x	X	x
24-micro	-	x	x
Day-micro	X (only NOAA)	x	x
Night-micro	x	x	x
Dust	-	x	x
Airmass	-	-	x
Convection	-	-	x
False colors	x	x	x

Examples of other RGB compositions.

Kompozycja	AVHRR	VIIRS	MODIS
True colors	-	x	x
Ocean colors	-	x	x
Cloud phase		x	x
Cloud type		x	x
Snow	x (tylko Metop	x	x
Green snow	-	-	x
Snow age	x (tylko Metop)	x	x
Cloud top	-	x	x
Night overview		x	

RGB compositions and images generated from polar satellites

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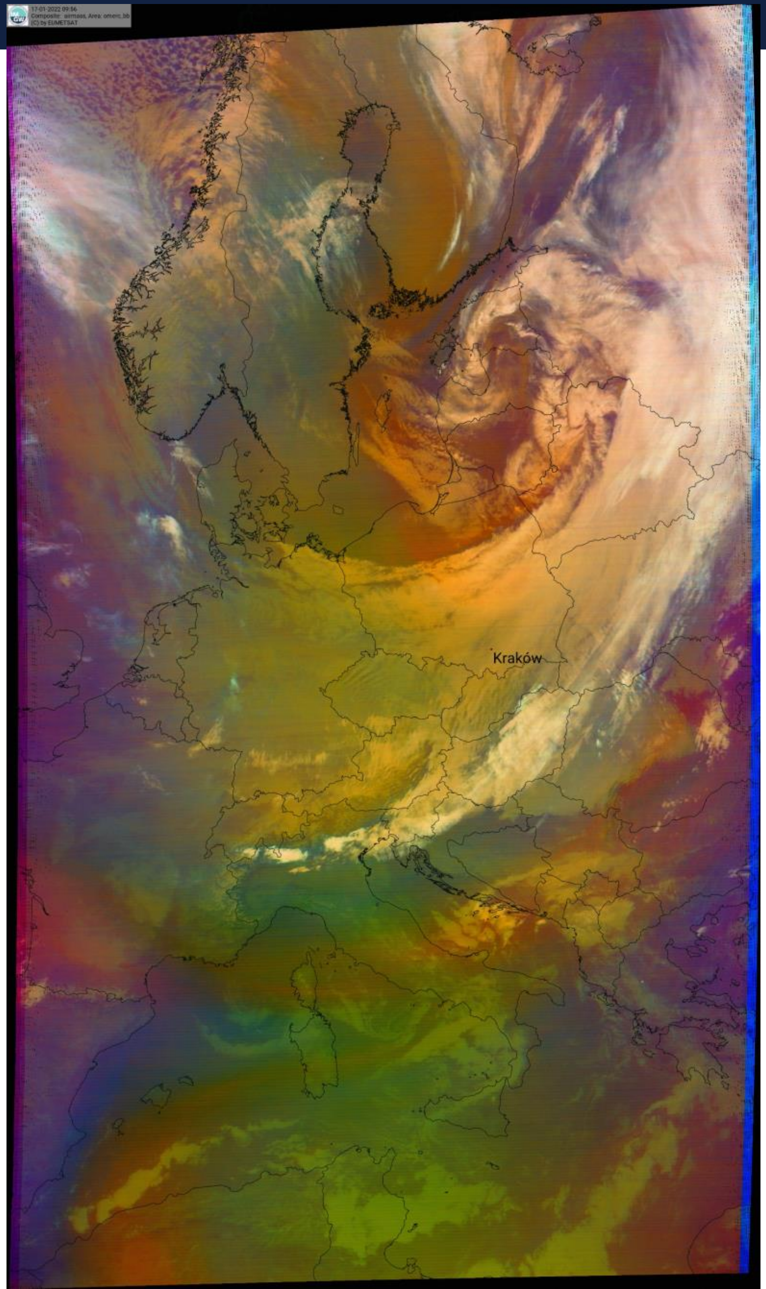
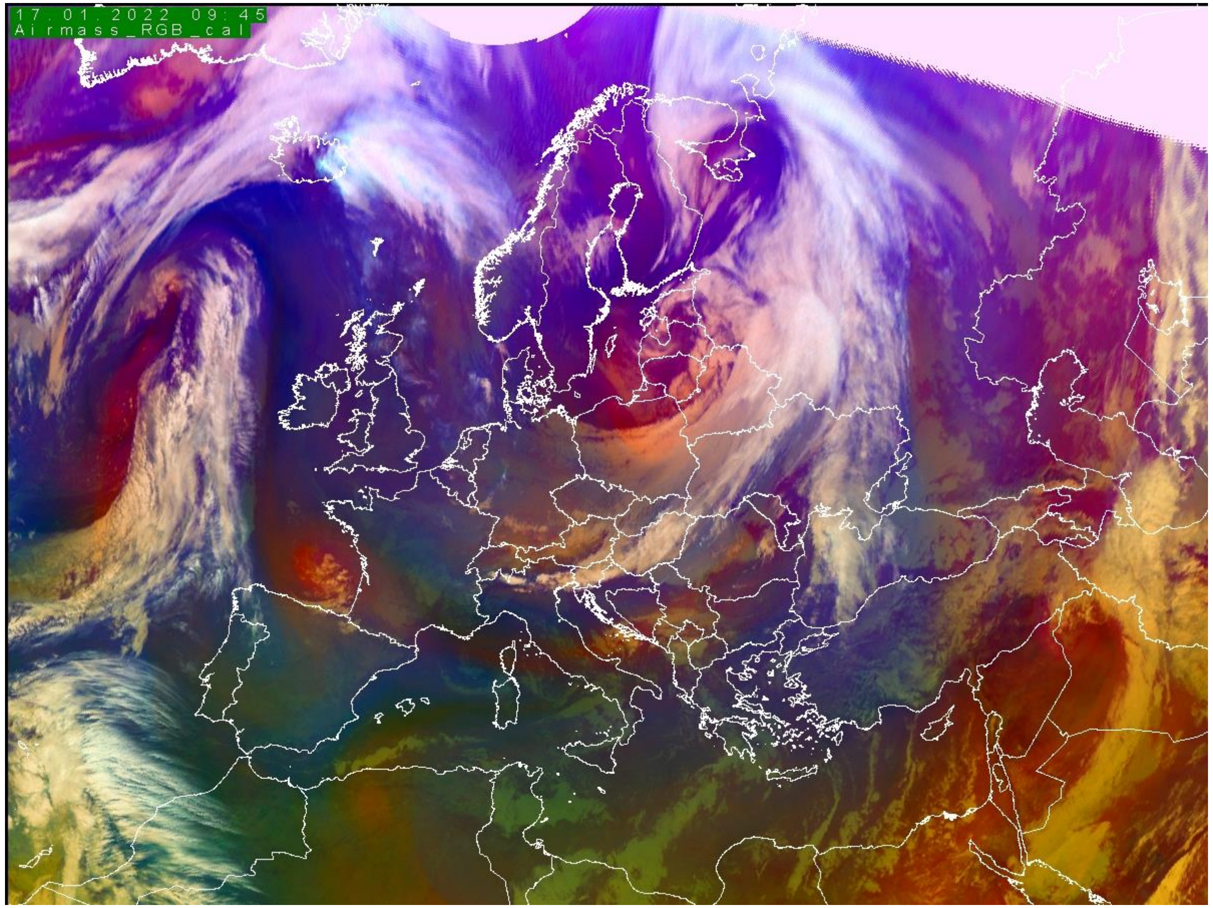
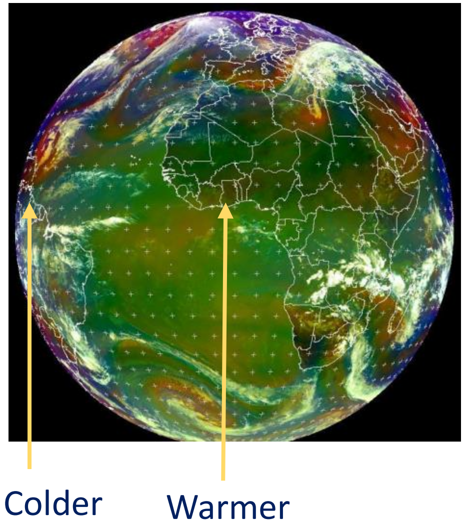


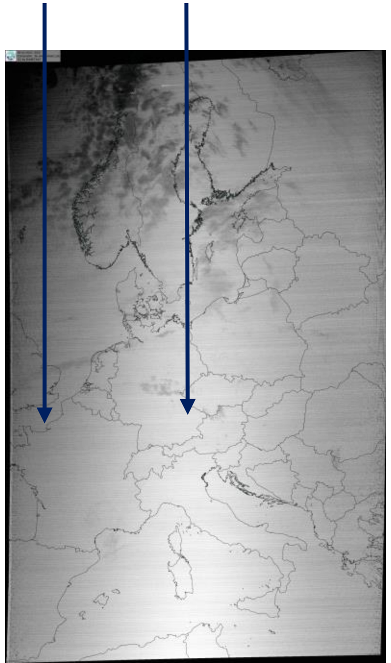
Airmass, MODIS,
17.01.2022, 09:56

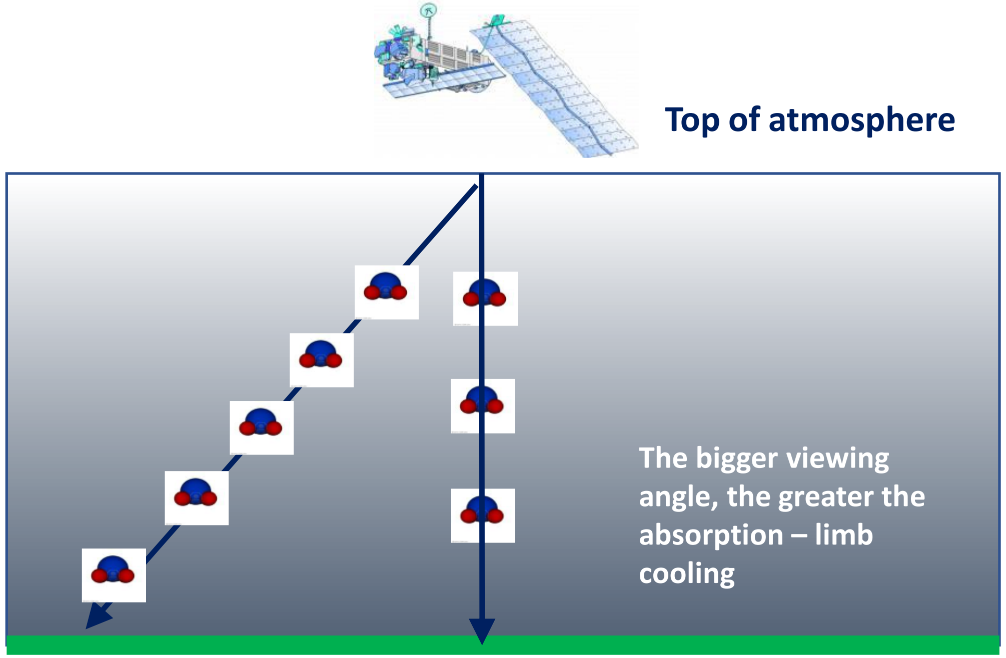
Airmass, SEVIRI,
17.01.2022, 09:45



Limb cooling effect on RGBs derived from polar satellite data



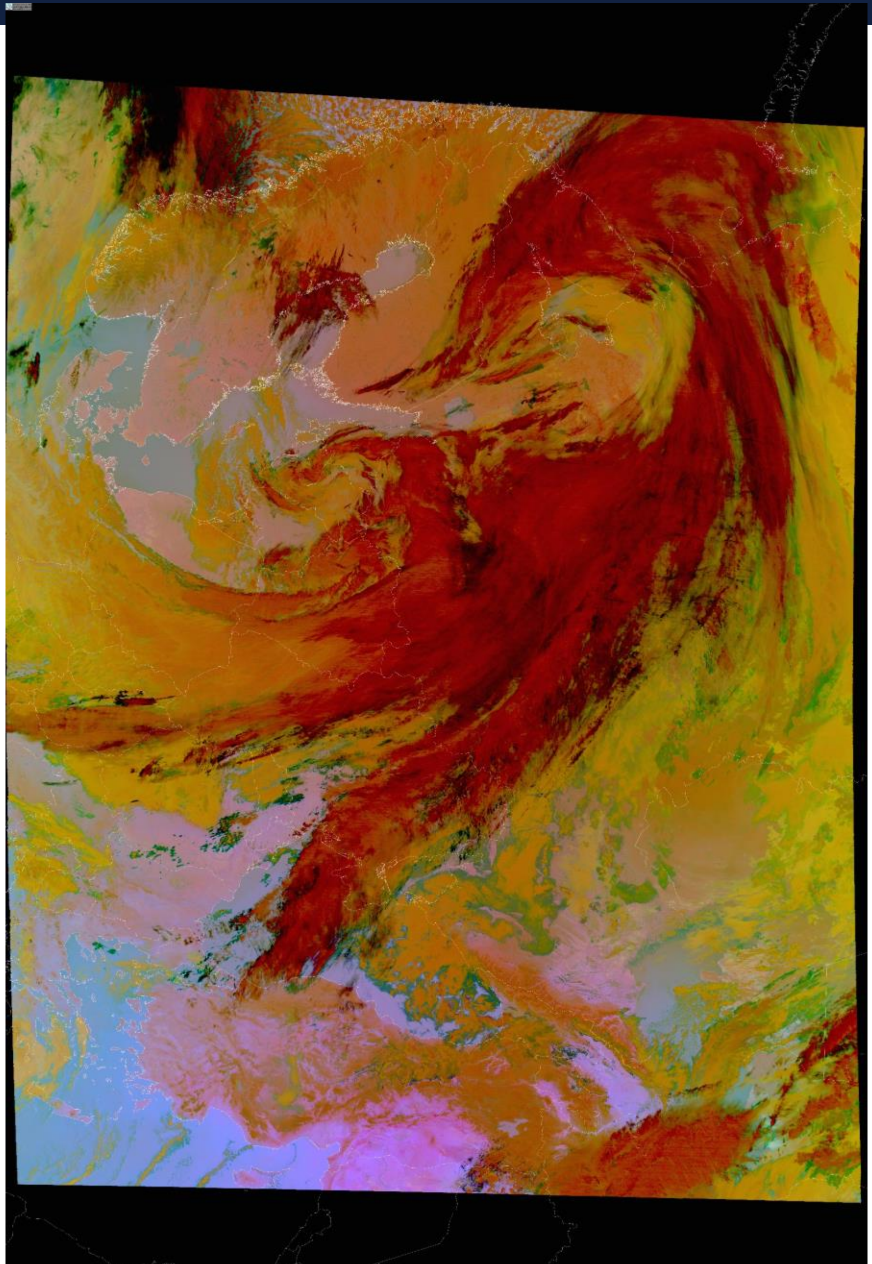




CO_2 14.2µm image, Terra/MODIS

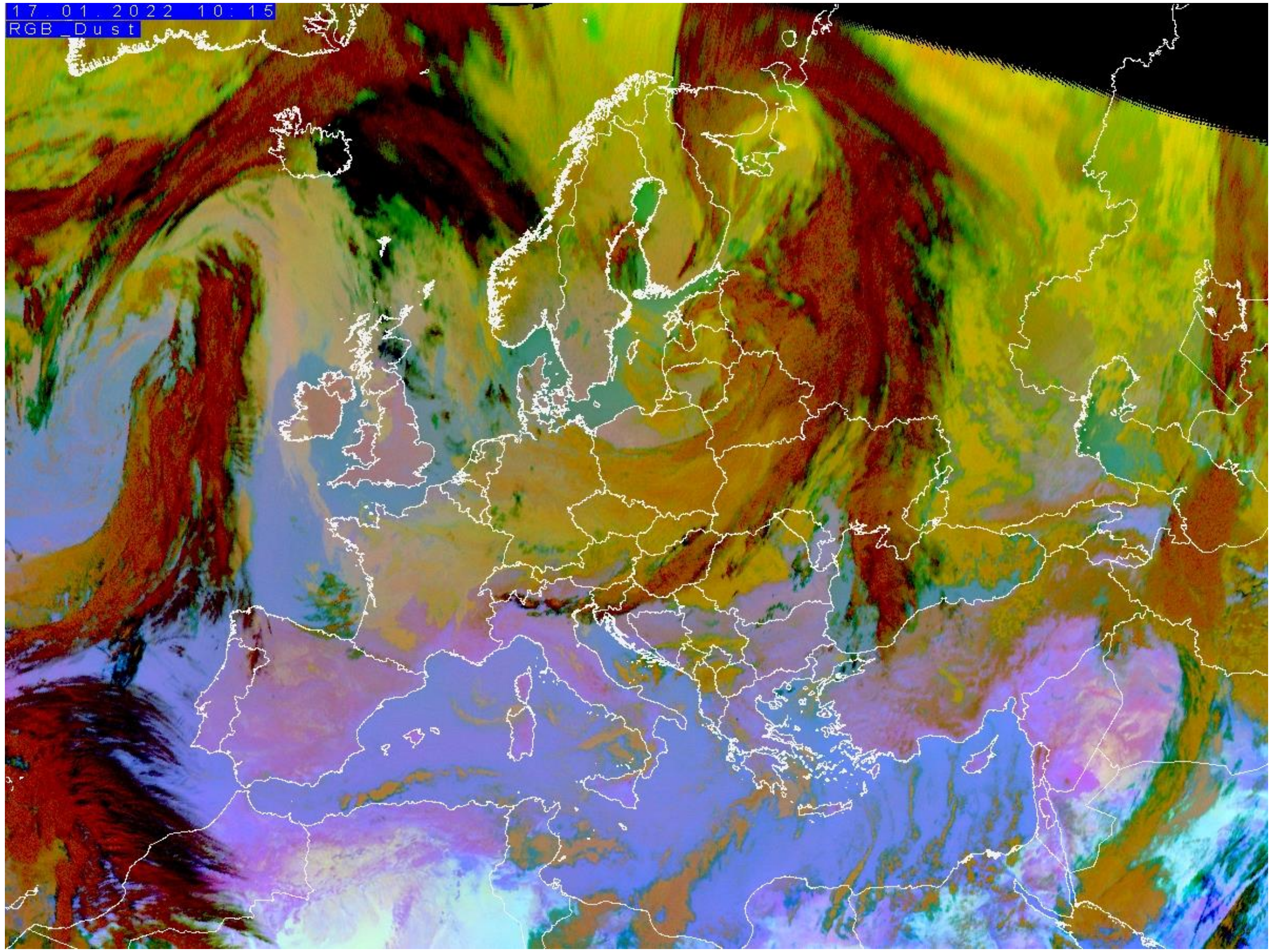
The 'limb cooling' effect will be visible only in images in channels located in absorption bands and in RGB compositions created using them, e.g. 24 hour microphysics, Airmass, Dust, Ash.

RGB compositions and images generated from polar satellites



Dust, VIIRS, 17.01.2022, 10:16

Dust, SEVIRI, 17.01.2022, 10:15



RGB compositions and images generated from polar satellites

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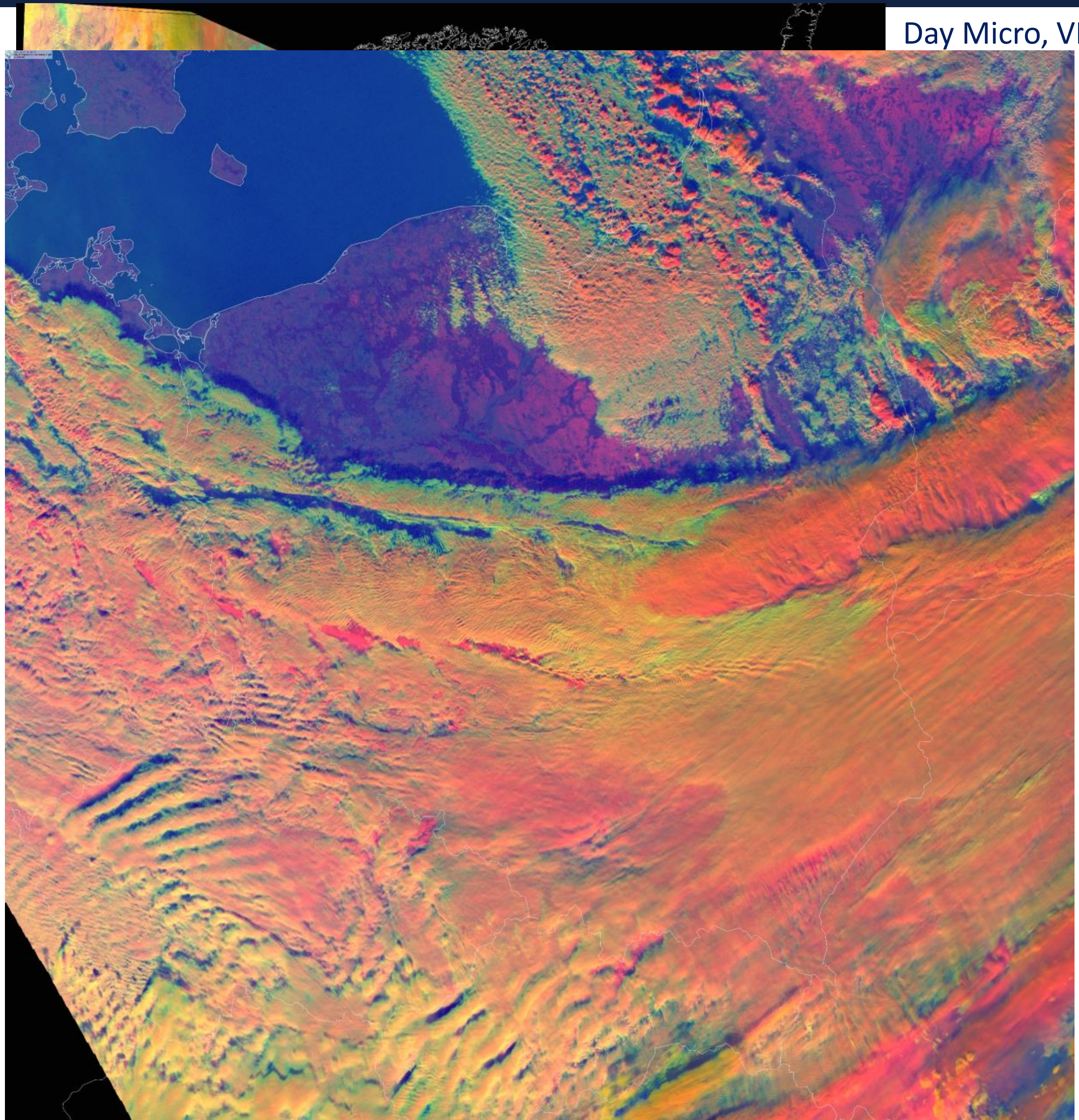
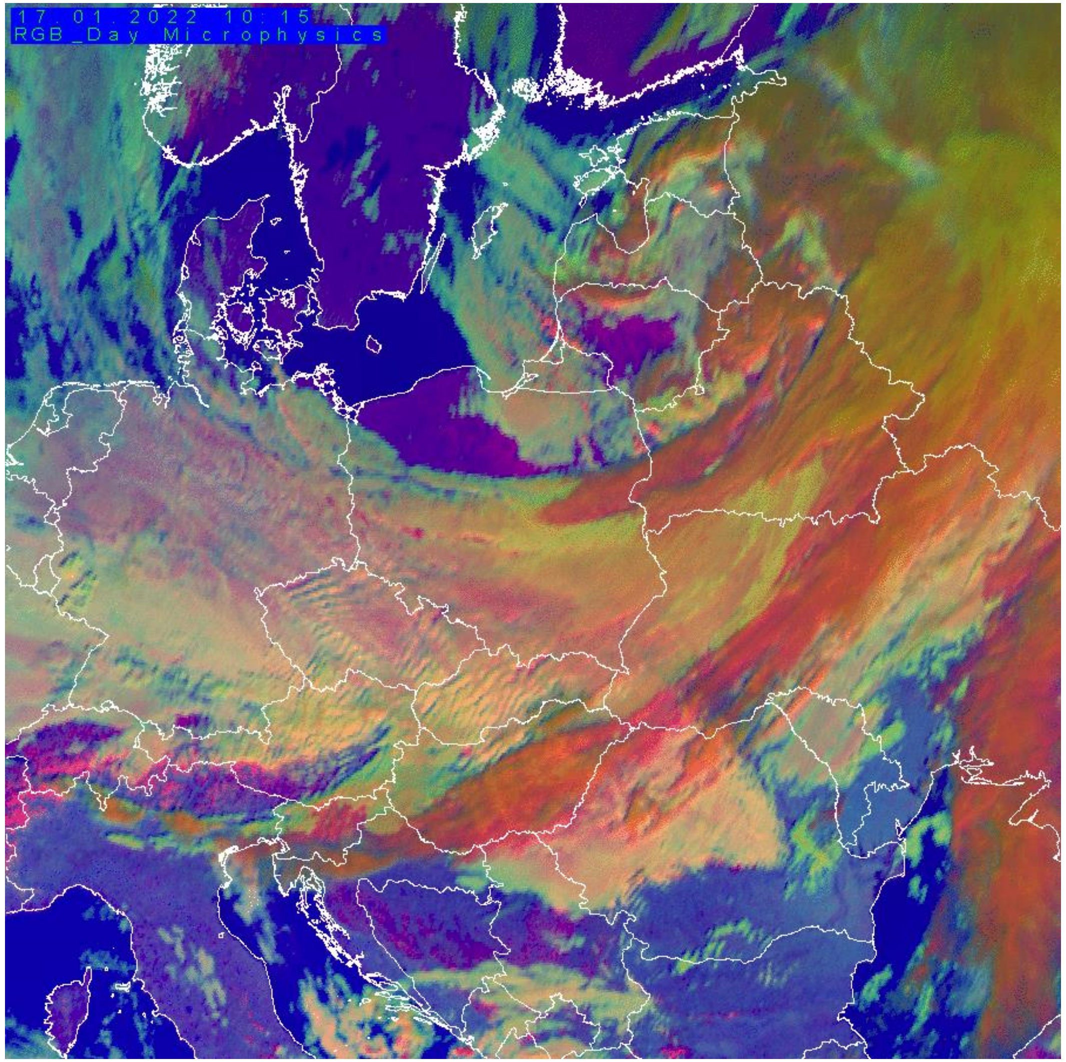


Day Micro, VIIRS, 17.01.2022,

Day Micro, SEVIRI, 17.01.2022, 10:15



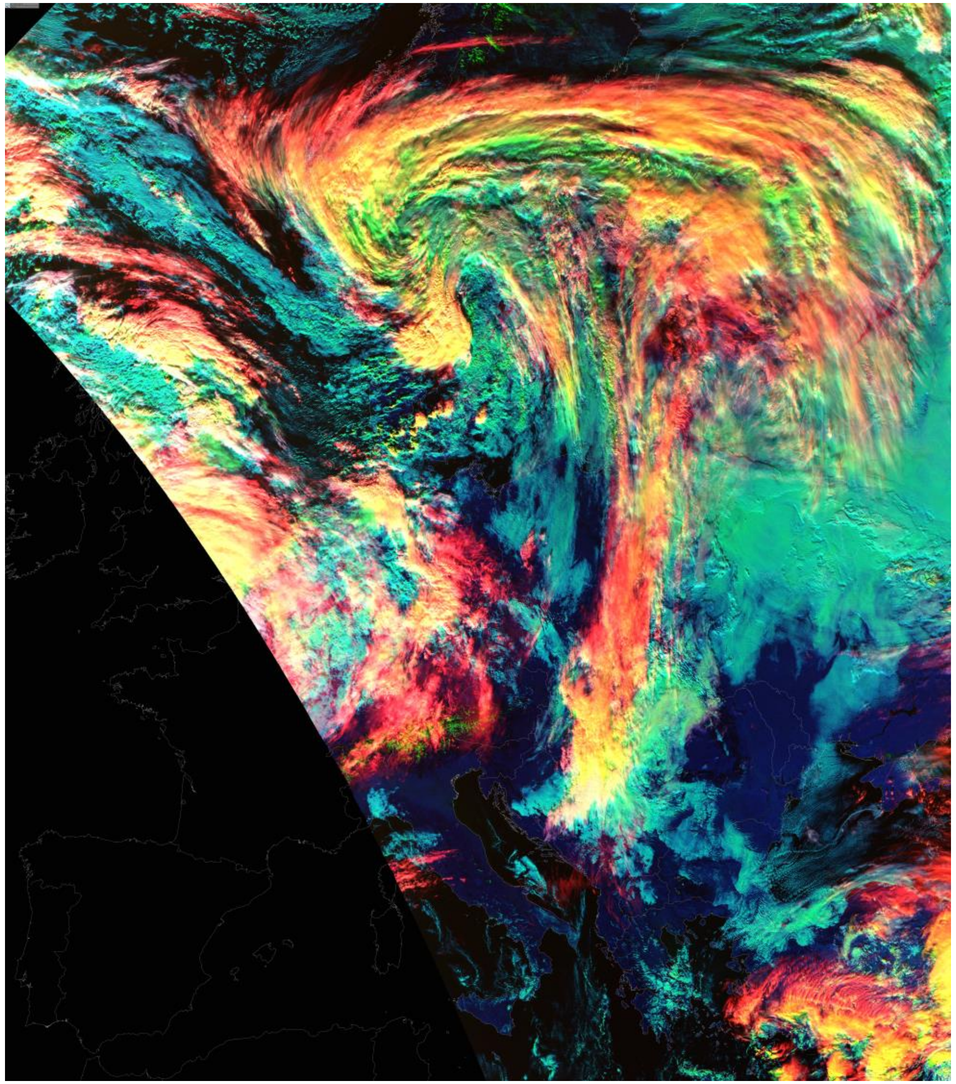
Cloud types recognition (low clouds and medium clouds, thin and thick high clouds, super-cool water clouds). Detection of thin Cirrus clouds. Available during daylight hours only.

R = NIR 1.3	0...10%	Γ=1.5
G = VIS 0.6	0...80%	Γ=0.75
B = NIR 1.6	0...80%	Γ=1

R – cloud height and optical thickness: Low clouds – **High clouds**

G – optical thickness of clouds: Thin clouds – **Thick clouds/land covered with snow/ice**

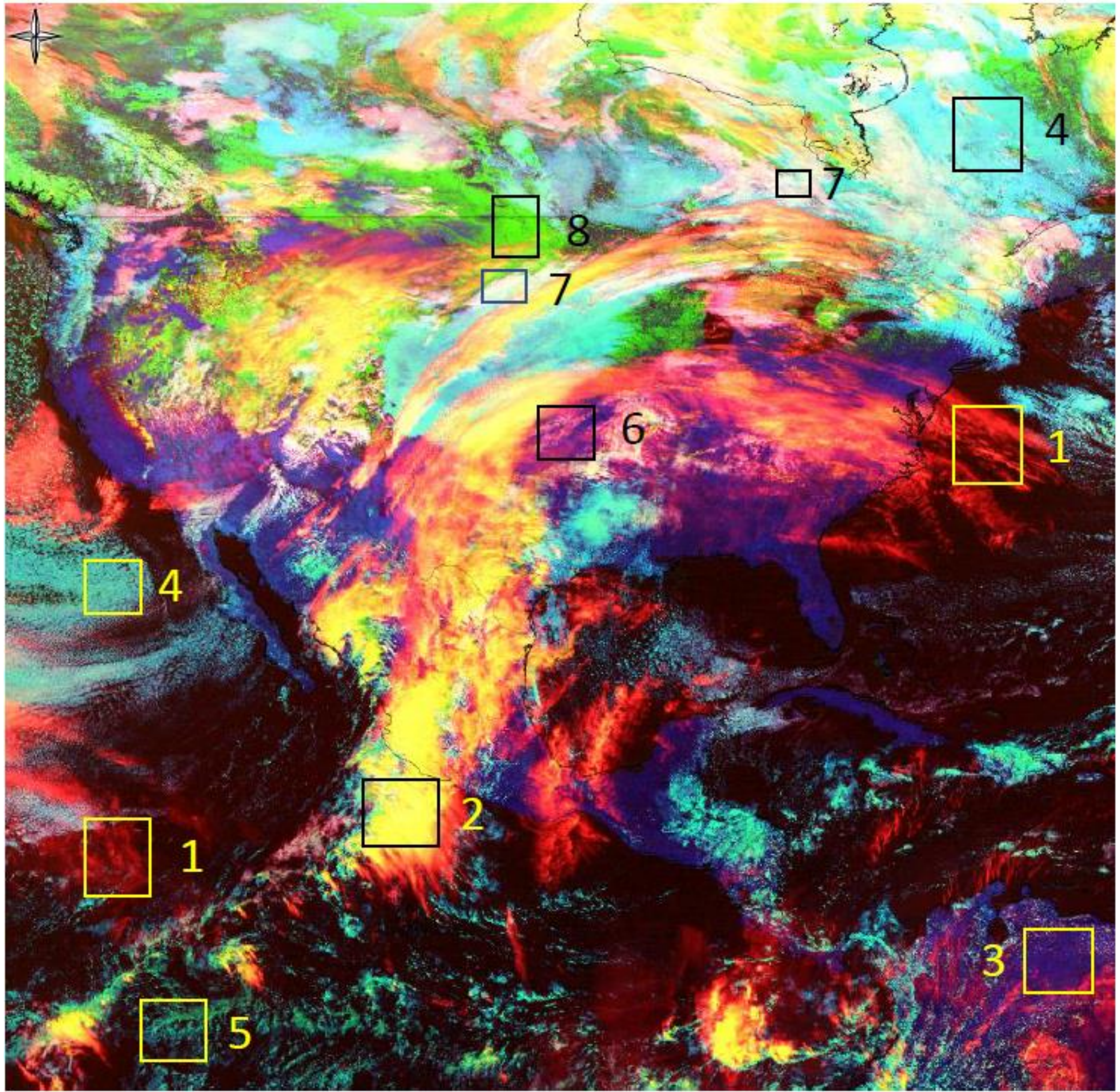
B – cloud phase: Thick ice clouds/snow over land– **Thick water clouds**



New RGBs generated from polar satellites and MTG/FCI – Cloud type

METEO
IMGW-PIB
meteo.imgw.pl

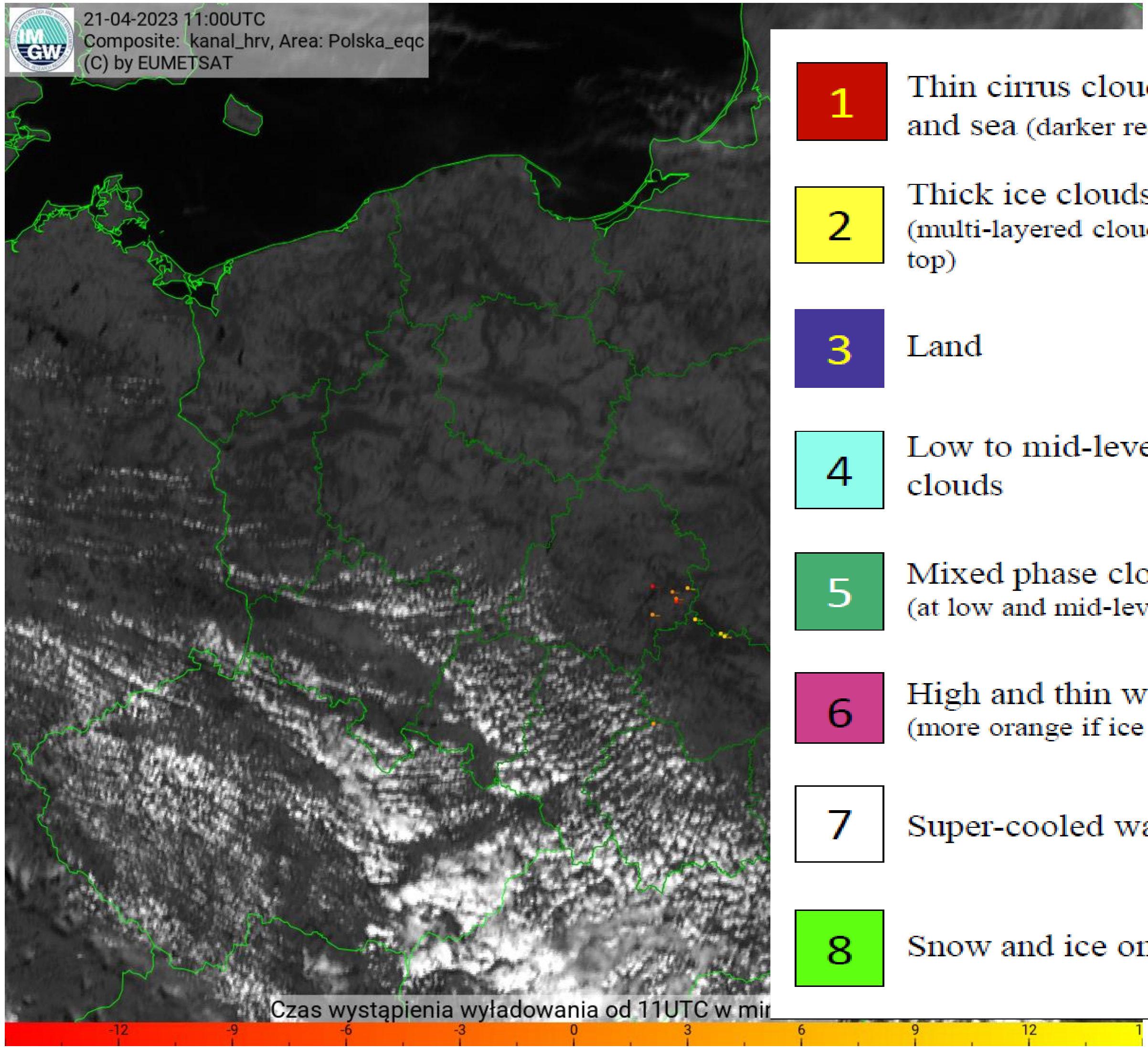
1	Thin cirrus clouds over land and sea (darker red over the seas)
2	Thick ice clouds (multi-layered clouds with ice on top)
3	Land
4	Low to mid-level water clouds
5	Mixed phase clouds (at low and mid-levels)
6	High and thin water clouds (more orange if ice is present)
7	Super-cooled water clouds
8	Snow and ice on the ground



New RGBs generated from polar satellites and MTG/FCI – Cloud type

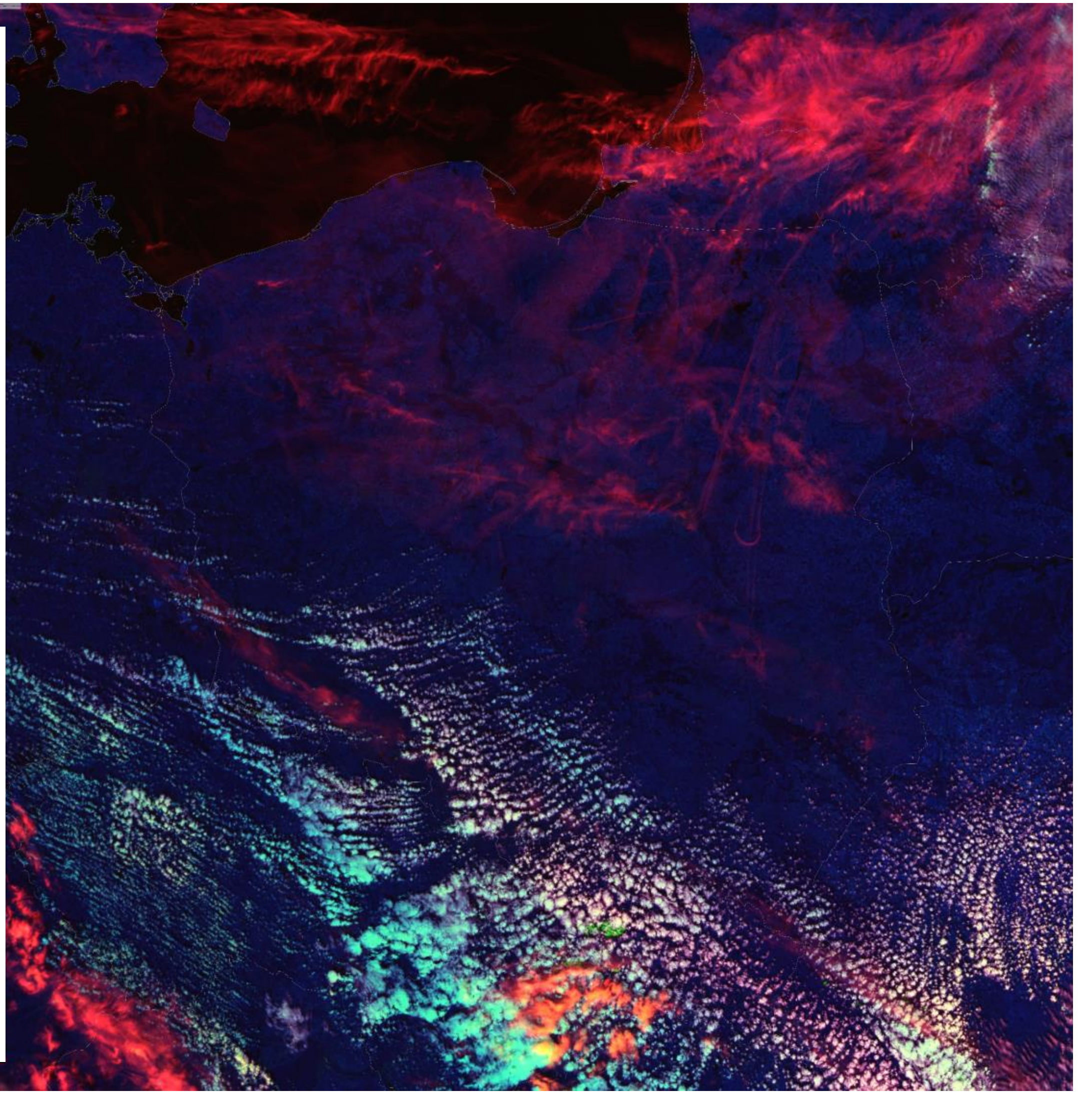
METEO IMGW-PIB
meteo.imgw.pl

21.04.2023, 11:00 SEVIRI/HRV



1	Thin cirrus clouds over land and sea (darker red over the seas)
2	Thick ice clouds (multi-layered clouds with ice on top)
3	Land
4	Low to mid-level water clouds
5	Mixed phase clouds (at low and mid-levels)
6	High and thin water clouds (more orange if ice is present)
7	Super-cooled water clouds
8	Snow and ice on the ground

11:00 VIIRS/Cloud type



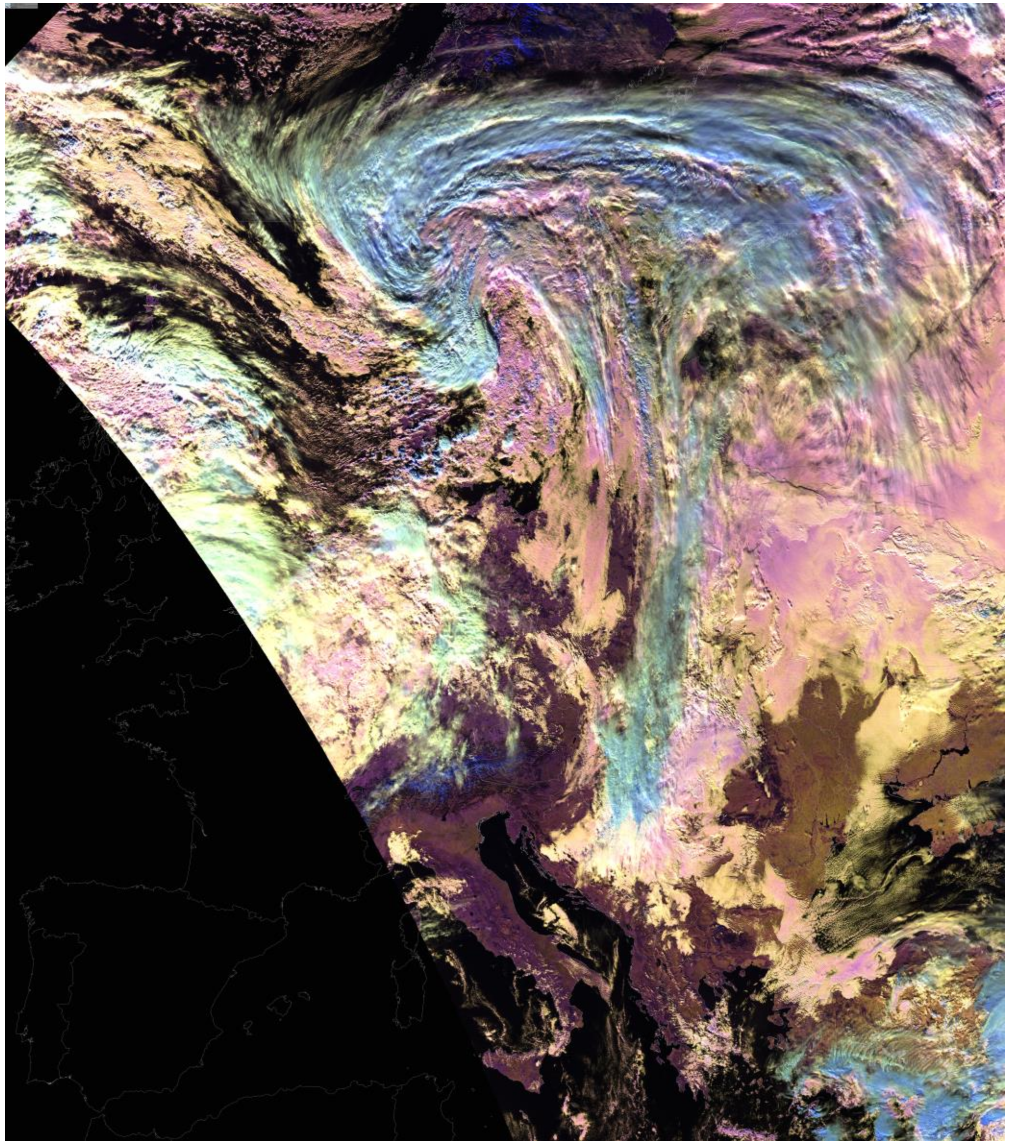
Differentiation between water clouds and ice clouds. Information about the particle size of the cloud top. Available during daylight hours only.

R = NIR 1.6	0...50%	Γ=1.0
G = NIR 2.25	0...50%	Γ=1.0
B = VIS 0.6	0…100%	Γ=1.0

R – cloud cover phase, size of particles at the tops: Thick ice clouds – **Thick water clouds**

G – size of particles at vertices (and phase): Thick clouds with large particles – **Thick clouds with small particles**

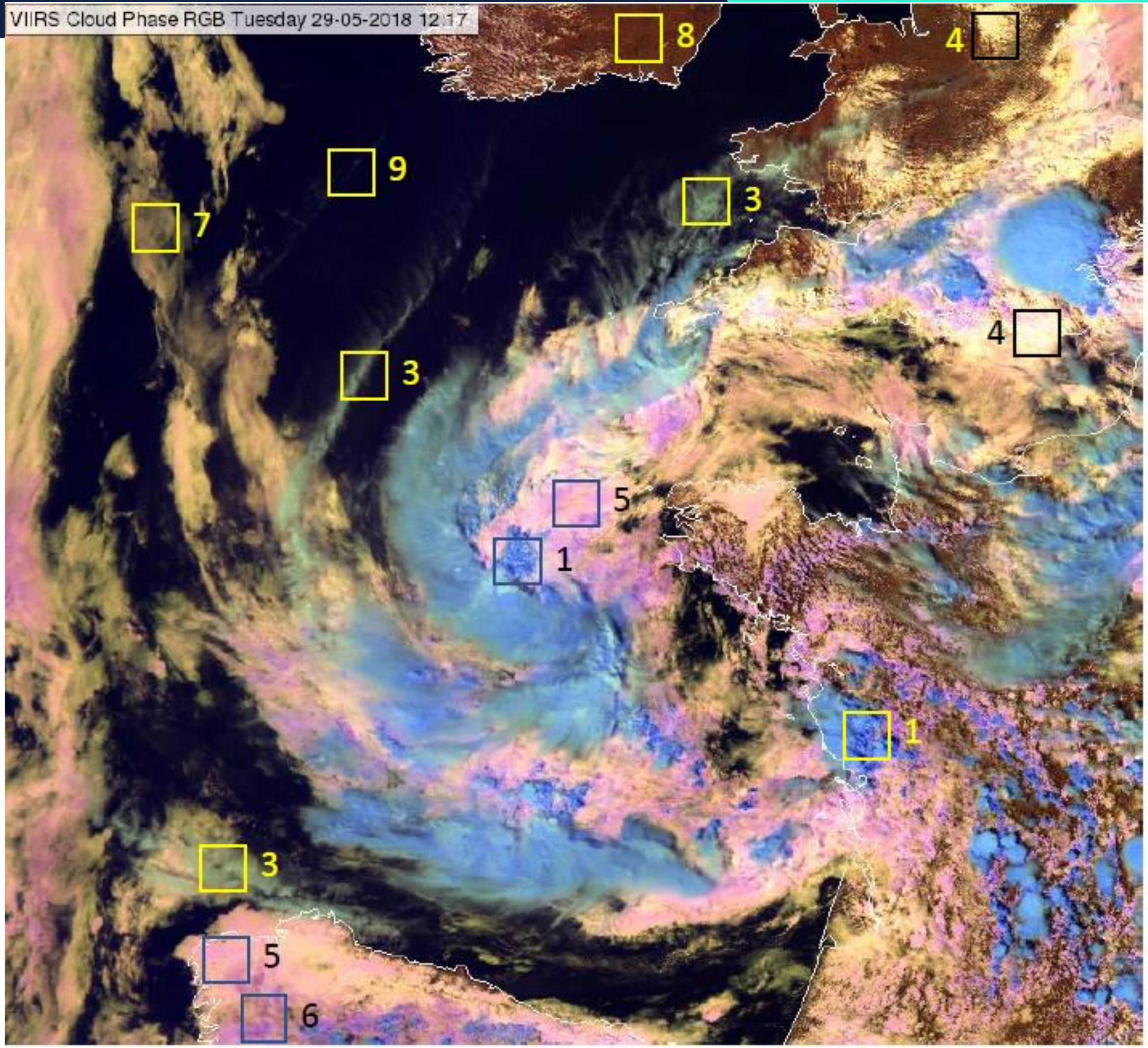
B – optical thickness of the cloud: Thin clouds – **Thick clouds**



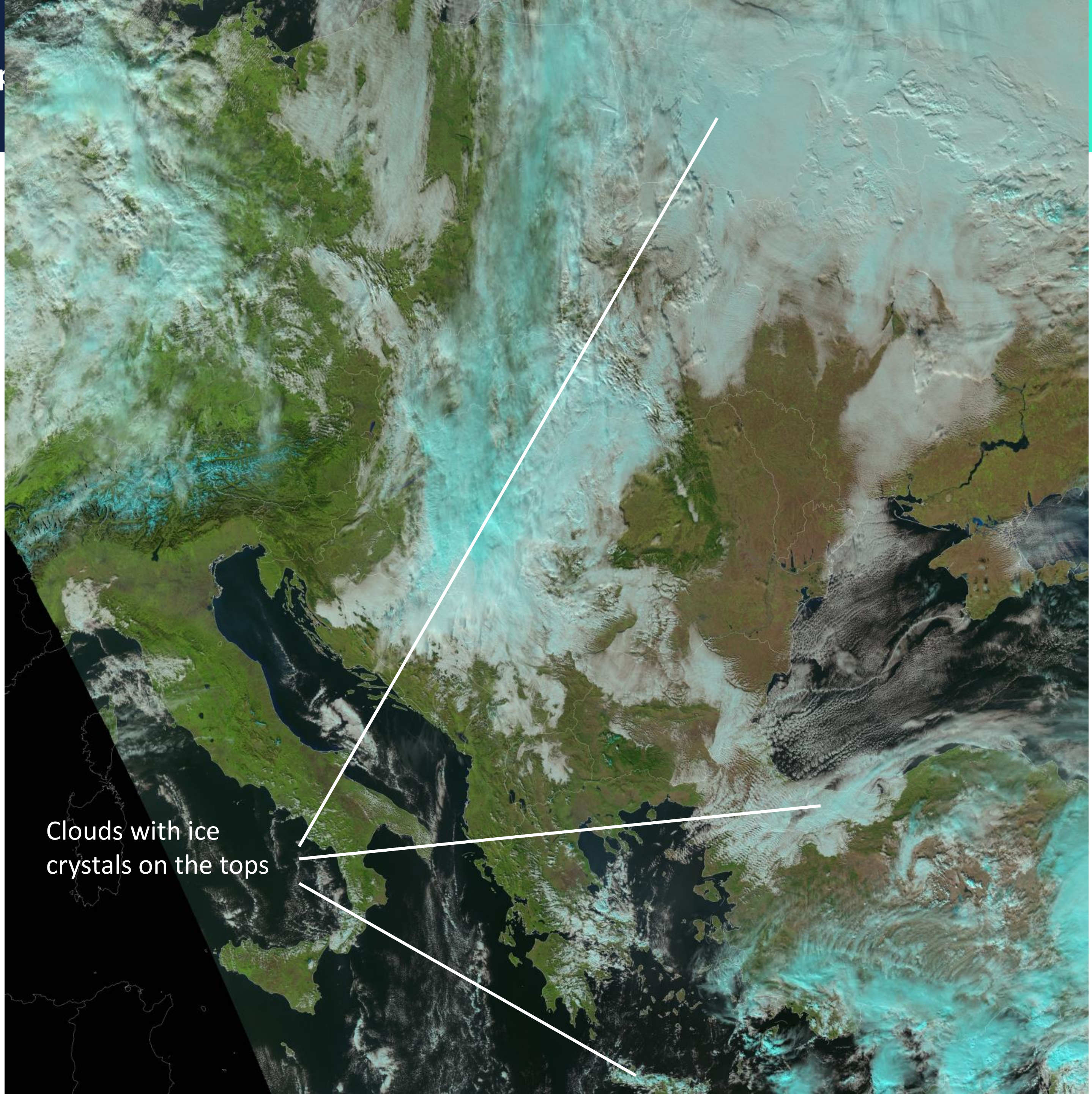
New RGBs generated from polar satellites and MTG/FCI – Cloud phase

METEO IMGW-PIB meteo.imgw.pl

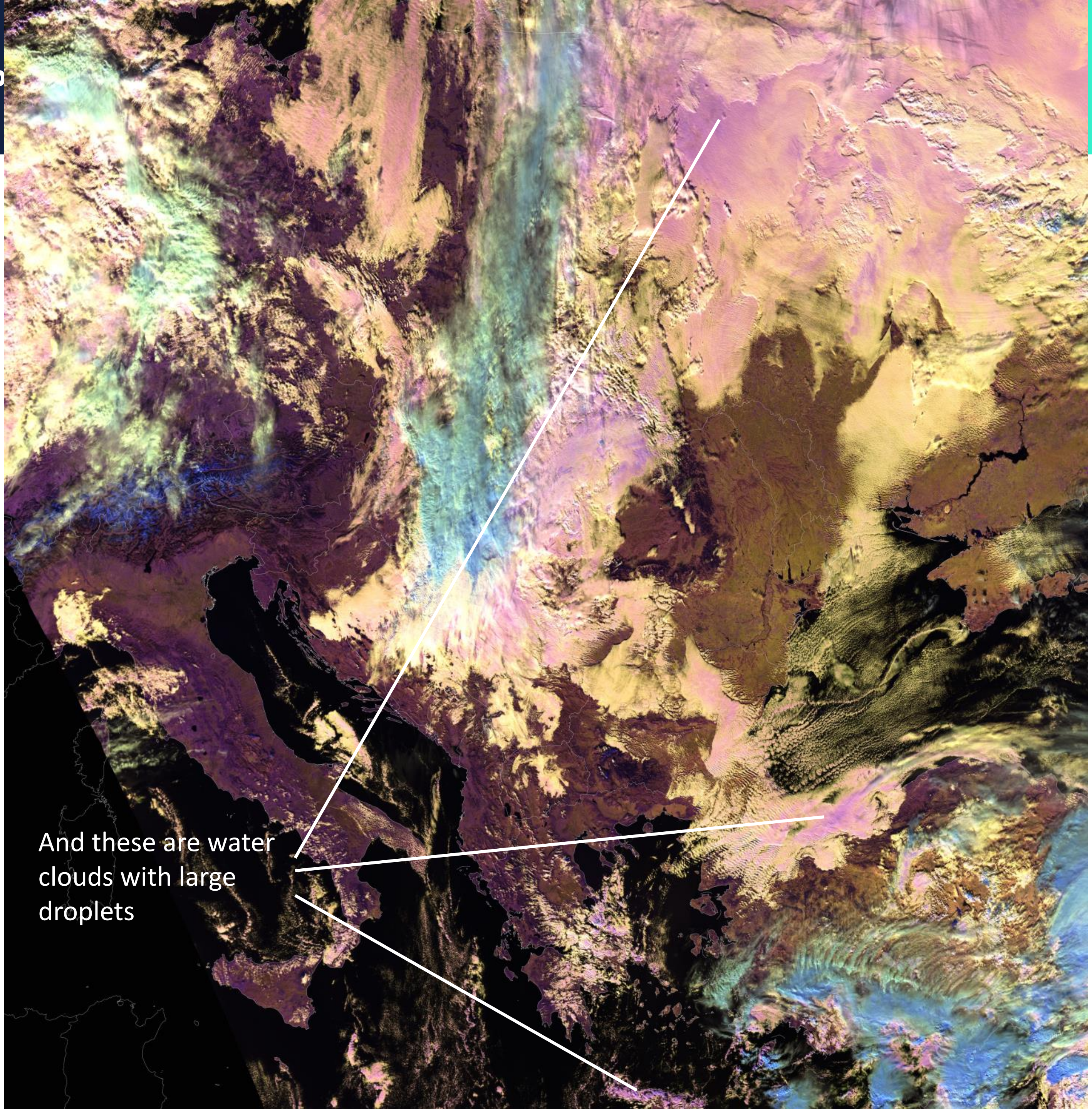
1	Thick ice clouds, large particles
2	Thick ice clouds, small particles
3	Thin ice clouds
4	Thick water clouds, small droplets
5	Thick water clouds, larger droplets (larger the droplets are darker pink)
6	Thick water clouds, extreme large droplets (or thick mixed phase clouds)
7	Thin water clouds over sea
8	Vegetated land (snow free)
9	Sea (ice free)
10	Desert
11	Snow on ground or sea ice



New RGBs generated from p



New RGBs generated from p

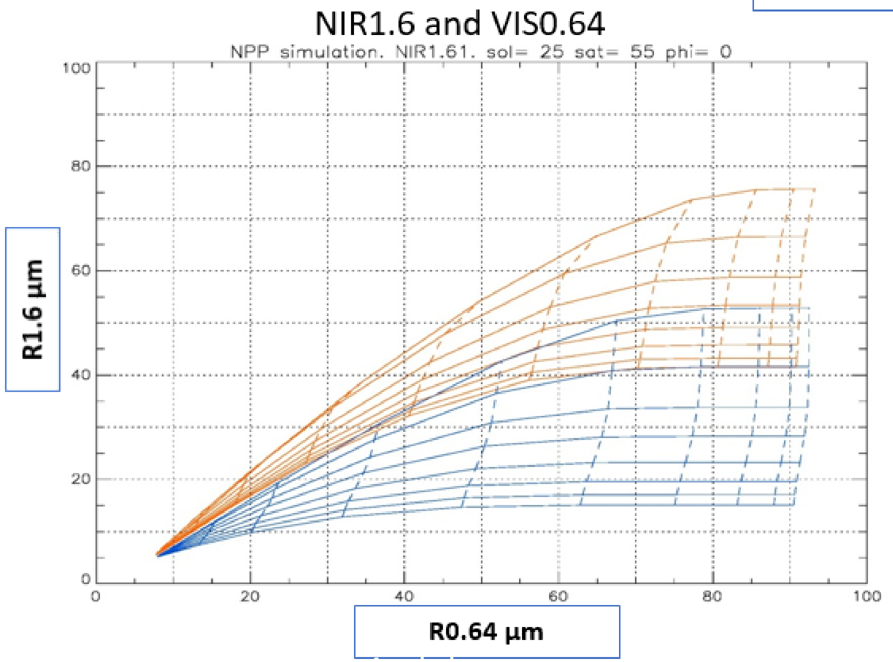


METEO IMGW-PIB meteo.imgw.pl

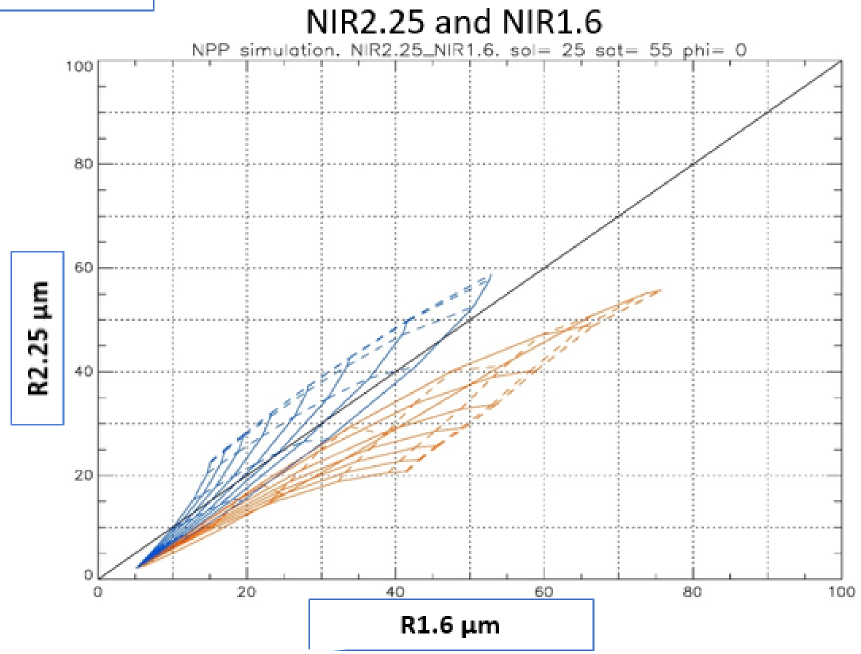
Common use of NIR1.6 and NIR2.25 channels

Simulated reflectivity values over dark background depending on optical depth and effective particle size as parameters

blue: ice clouds
brown: water clouds



Overlap between the curves of water and ice clouds



No overlap, using this channel pair the phase retrieval will be more perfect

The better separation was confirmed by
- NPP/VIIRS and Himawari simulations and
- **measurements**

NWC SAF METEO FRANCE

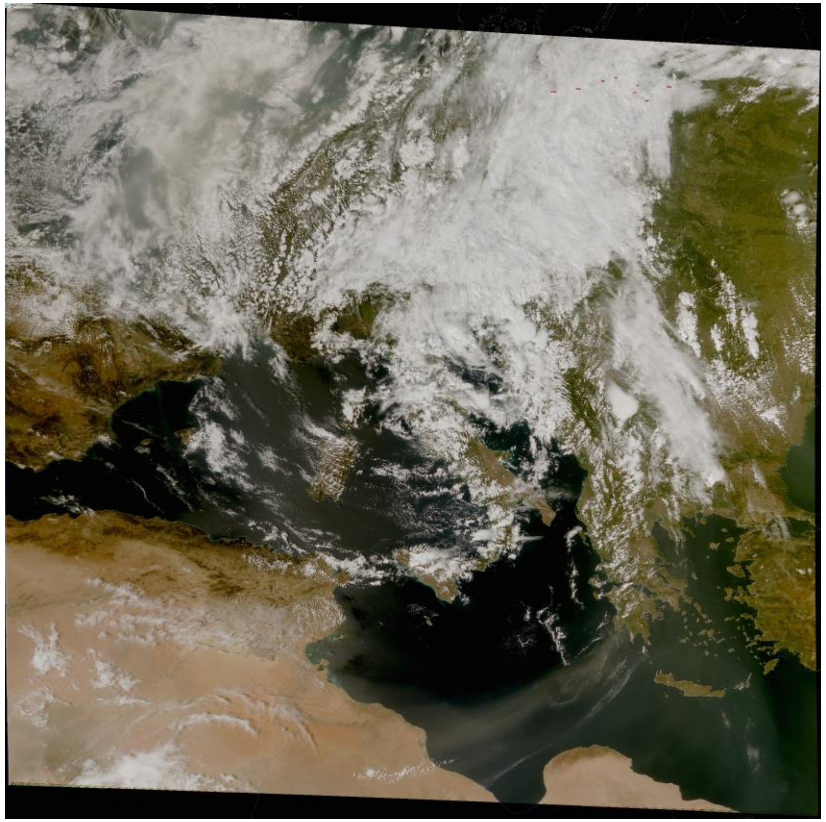
G.Kerdraon, H. Le Gléau, M.-P. Raoul
Météo-France, CMS, Lannion France

RGBs generated from polar satellites and MTG/FCI – True color

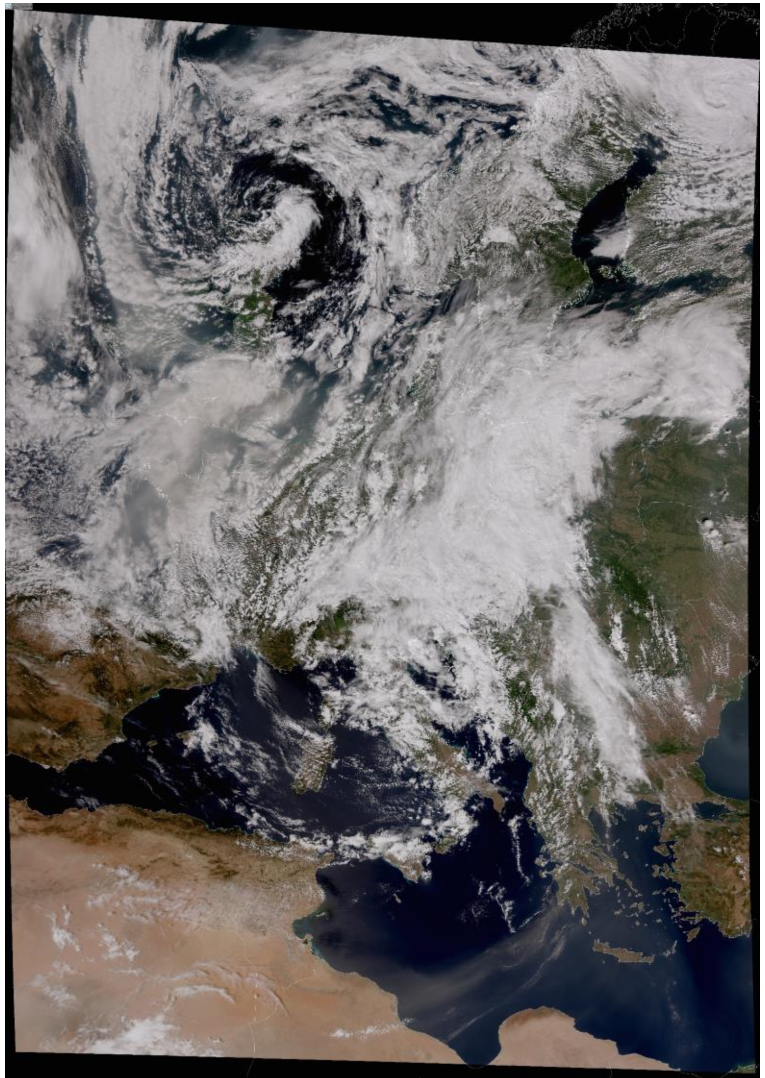
The RGB is excellent for identifying atmospheric aerosols (smoke, ash) and tracking seasonal changes in vegetation (greens, brown). Phytoplankton blooms and sediment will contrast against an otherwise deep blue ocean.

R, **G** and **B** – Cloud optical thickness, vegetation, aerosols, smoke, water, sediment

R = VIS 0.64	**0...100%**	**Γ=1**
G = VIS 0.56	**0...100%**	**Γ=1**
B = VIS 0.49	**0...100%**	**Γ=1**



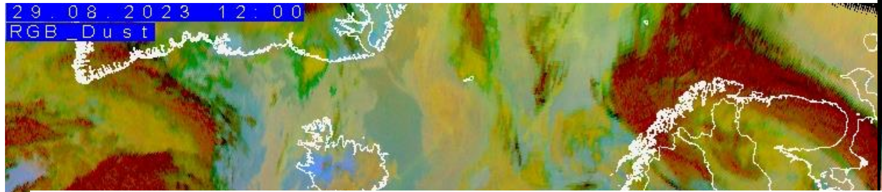
29.08.2023, 12:48, FY-3D/MERSI-2

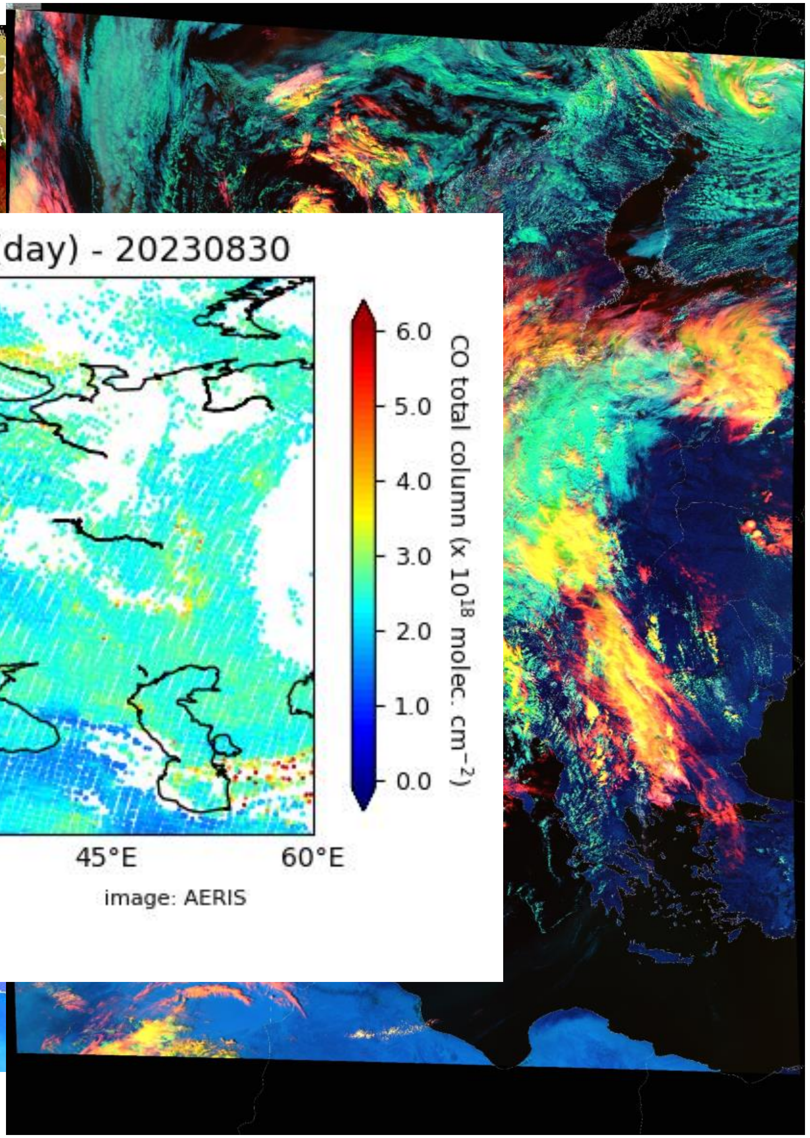


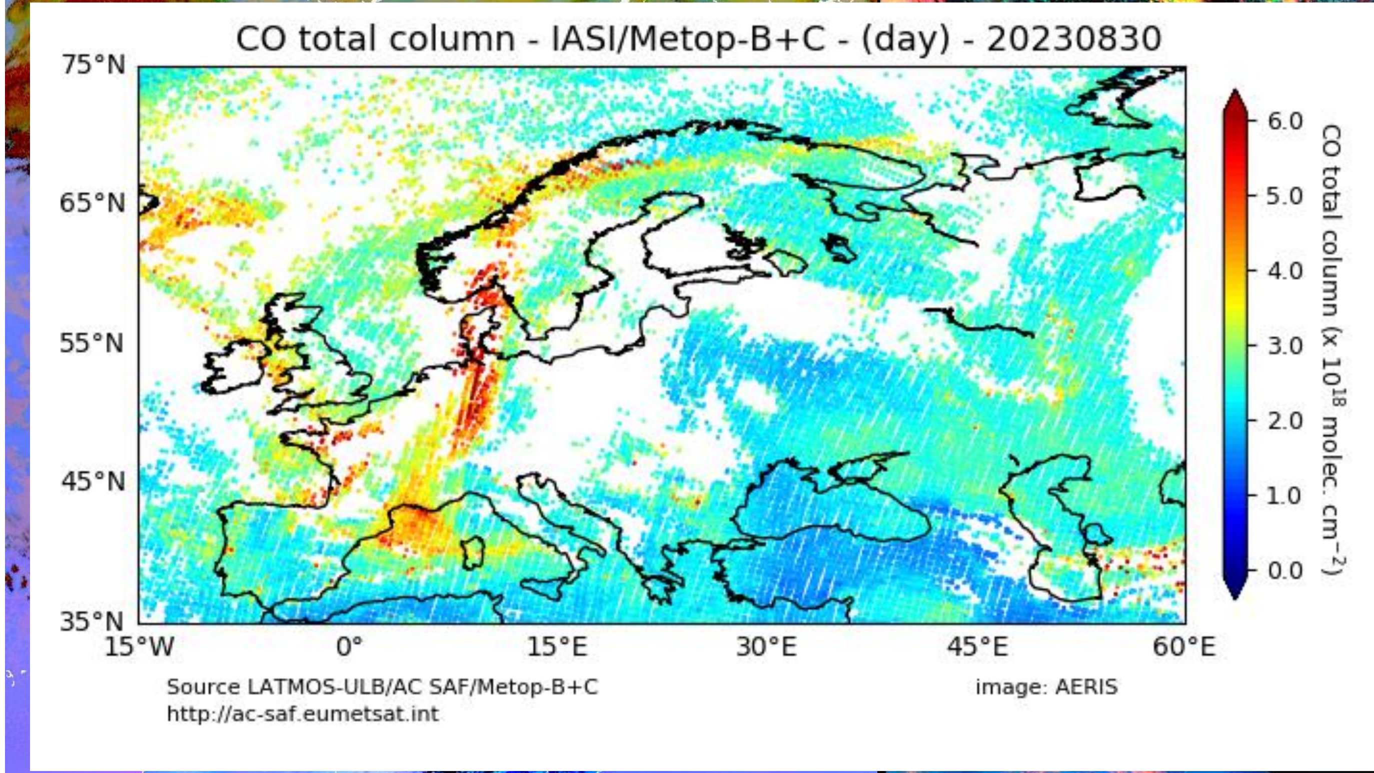
29.08.2023, 12:03, NOAA-20/VIIRS

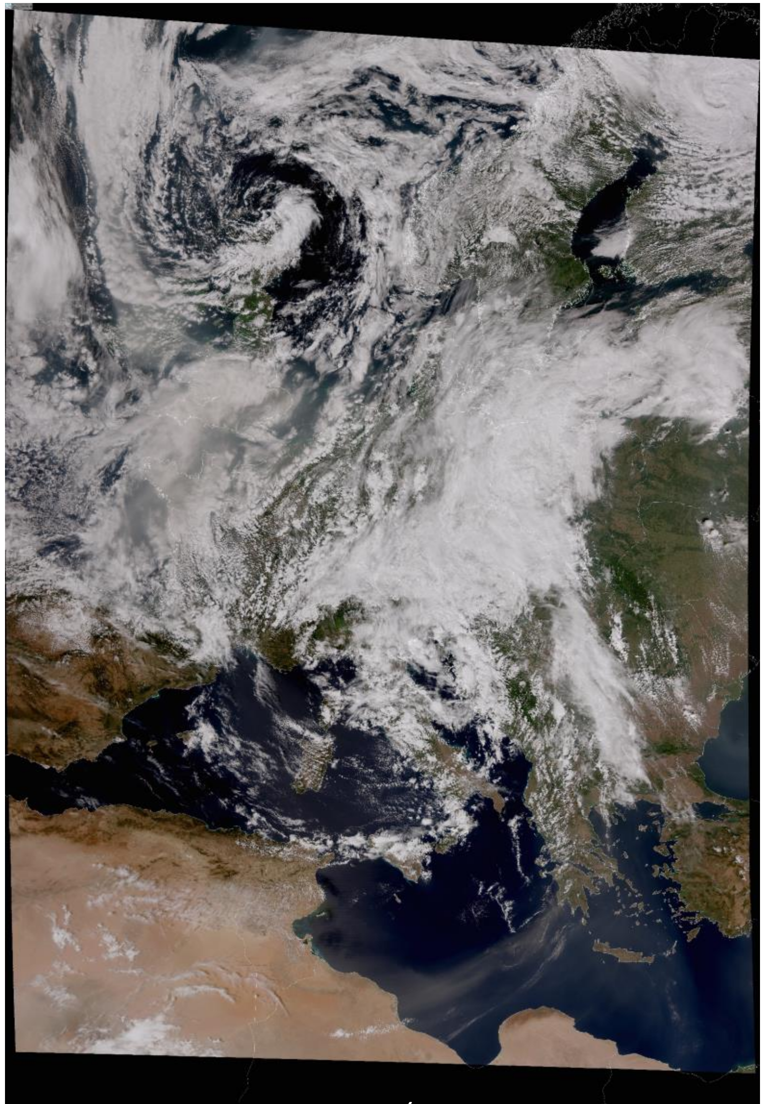
RGBs generated from polar satellites and MTG/FCI – True color

29.08.2023, 12:00, SEVIRI Dust RGB





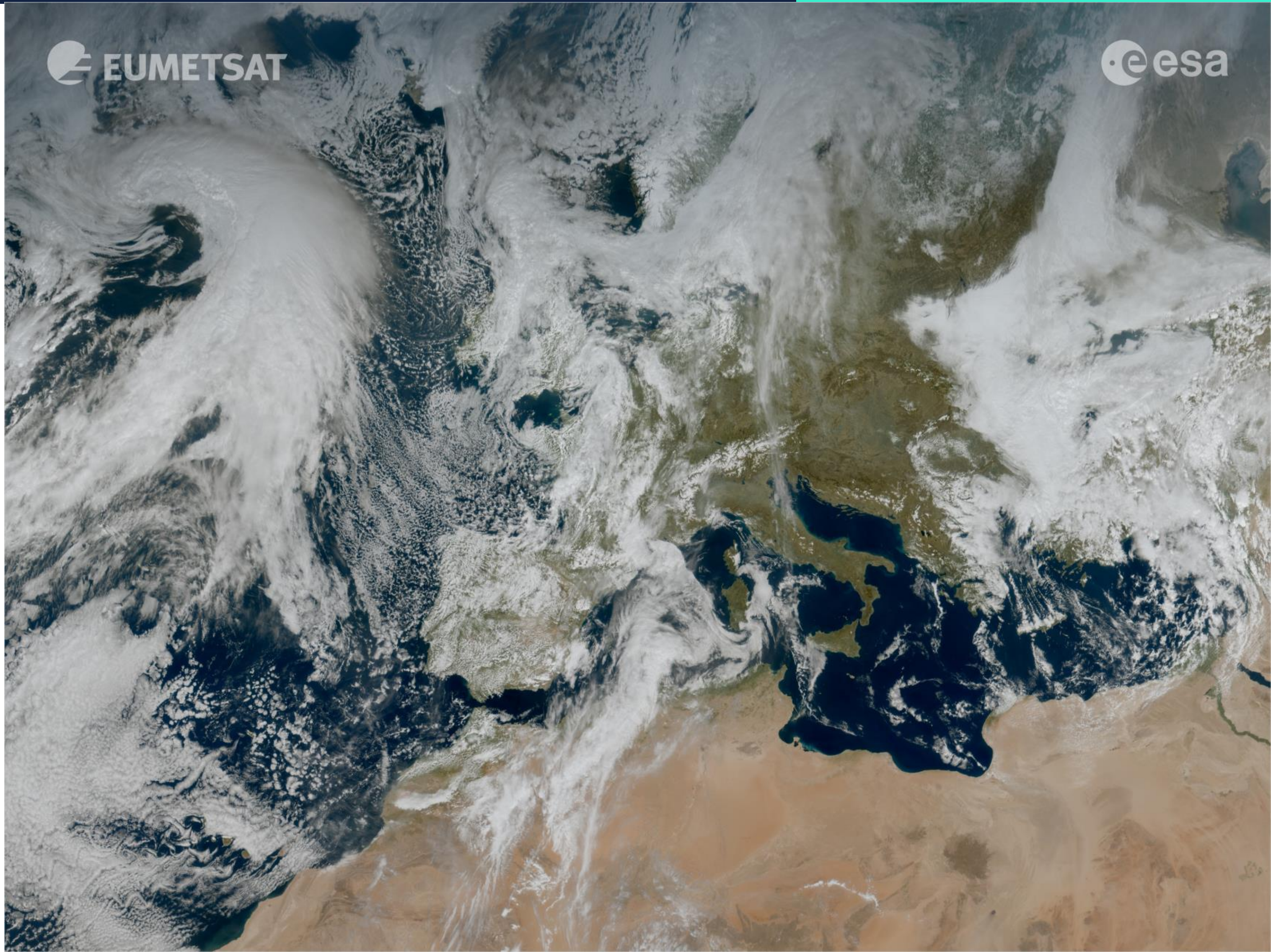




29.08.2023, 12:03, NOAA-20/VIIRS

RGBs generated from polar satellites and MTG/FCI – True color

Next year: MTG/FCI True Color



Polar satellites – other sensors

All polar satellites are equipped with the following passive sensors:

- imagers (AVHRR, MODIS, VIIRS) measuring radiation in visible, near-infrared and thermal infrared ranges,
- infrared radiation sensors: HIRS-4 (NOAA-18 and -19), IASI (Metop-B and –C) and CrIS (S-NPP and NOAA-20) and AIRS (Aqua),
- passive microwave sensors : MHS (NOAA-18 and -19, Metop-B and –C), AMSU-A (NOAA-18 and -19, Metop-B and –C, Aqua), ATMS (S-NPP, NOAA-20, and NOSAA-21), AMSRE (Aqua).

Some satellites are equipped with active microwave sensors:

- ASCAT (Metop-B and Metop-C) – sea wind, soil moisture
- SRAL (Senetinel3A and Sentinel-3B) – altimetry
- Poseidon-4 (Sentinel-6 Michael Freilich) - altimetry

Microwaves – absorption bands and atmospheric windows

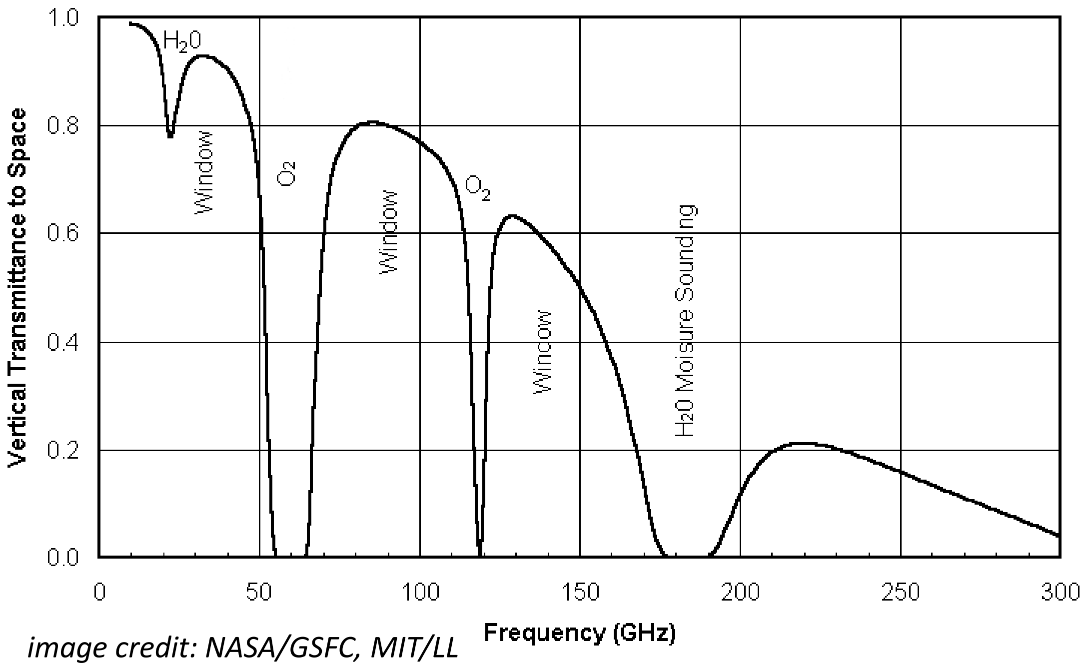
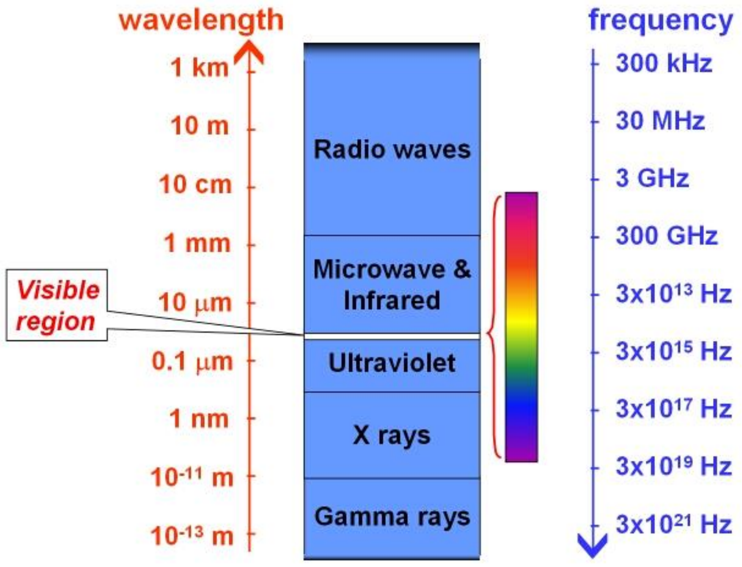


image credit: NASA/GSFC, MIT/LL



The advantage of microwave radiation is that it partially penetrates the cloud. Its absorption in the channels of the atmospheric window depends on the particle size of the cloud and the liquid water amount in the cloud.

Raindrops have the greatest impact on radiation with a frequency of less than 60 GHz.

At higher frequencies, scattering is the dominant process: clouds with large ice crystals at the top become clearly visible in the 89 GHz, 166 GHz or 183 GHz channels.

Important Features of Microwave Radiation

The radiative temperature (brightness temperature) depends on both the physical temperature of the object and the emissivity of the surface.

The emissivity of the water surface ranges from 0.4 to 0.5, which is why the seas and oceans in the microwave channels are 'cold' - the radiation temperature of the ocean calculated from satellite measurements is about 223 K (about -50 °C).

For comparison, in the infrared the emission coefficients ranges from 0.95 to 1.0 (for the desert surface about 0.85) and the radiation temperature determined from infrared satellite data is close to the real one. In the case of microwaves, these temperatures can vary greatly.

The emissivity of land is much more variable (from 0.5 to 0.9) and depends on the presence of snow/ice, type of vegetation, type and moisture of the soil. Therefore, the interpretation of measurements in the microwave range over the land surface is very difficult.

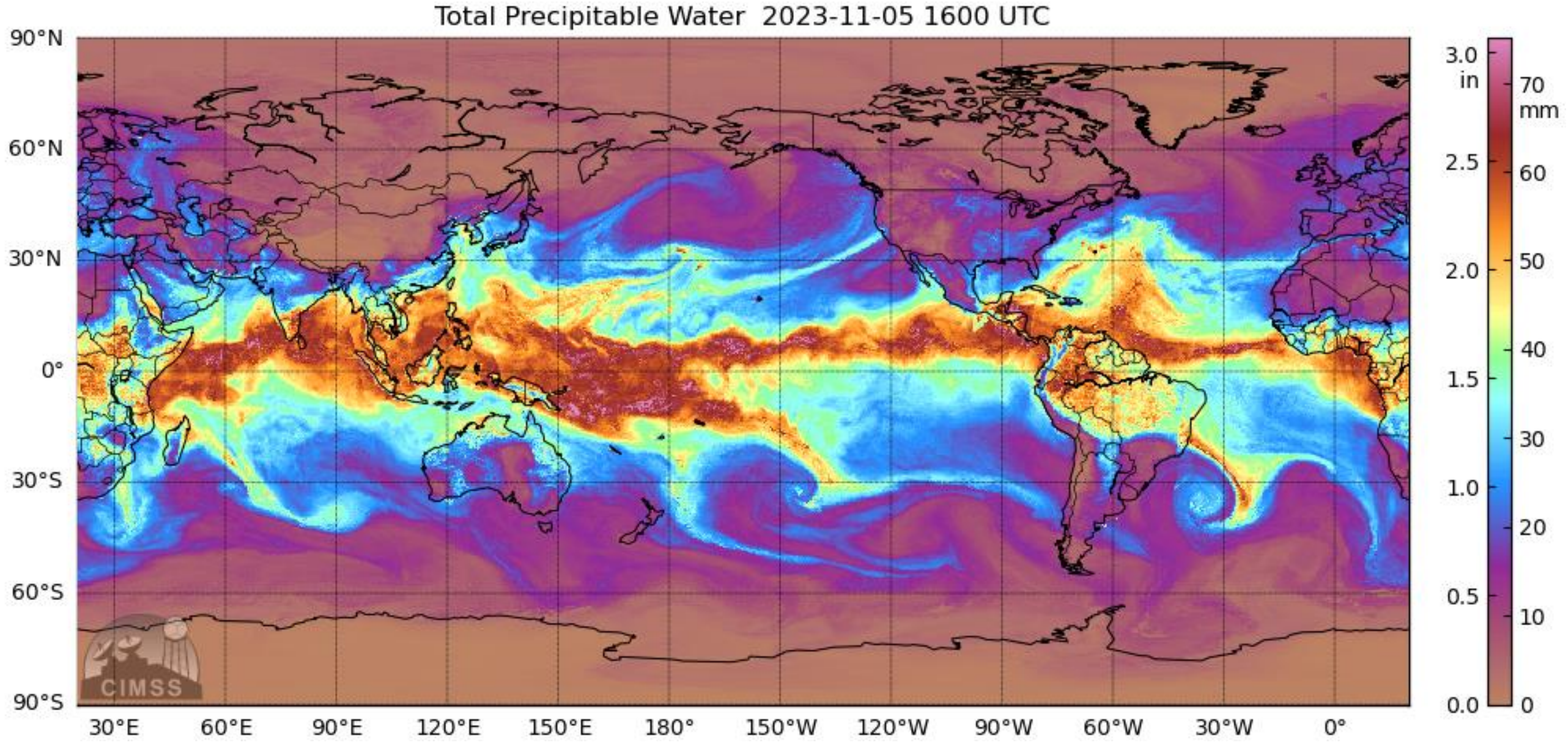
Depending on the wavelength, microwave radiation may or may not penetrate clouds. In the latter case, clouds above the water surface are very well visible and satellite measurements in the microwave range are used, among other things, to estimate the amount of precipitation or Total Precipitable Water to analyze the development of tropical cyclones over the oceans.

MIMIC-TPW2 is an experimental global product of total precipitable water (TPW), using morphological compositing of the MIRS retrieval from several available operational microwave-frequency sensors.

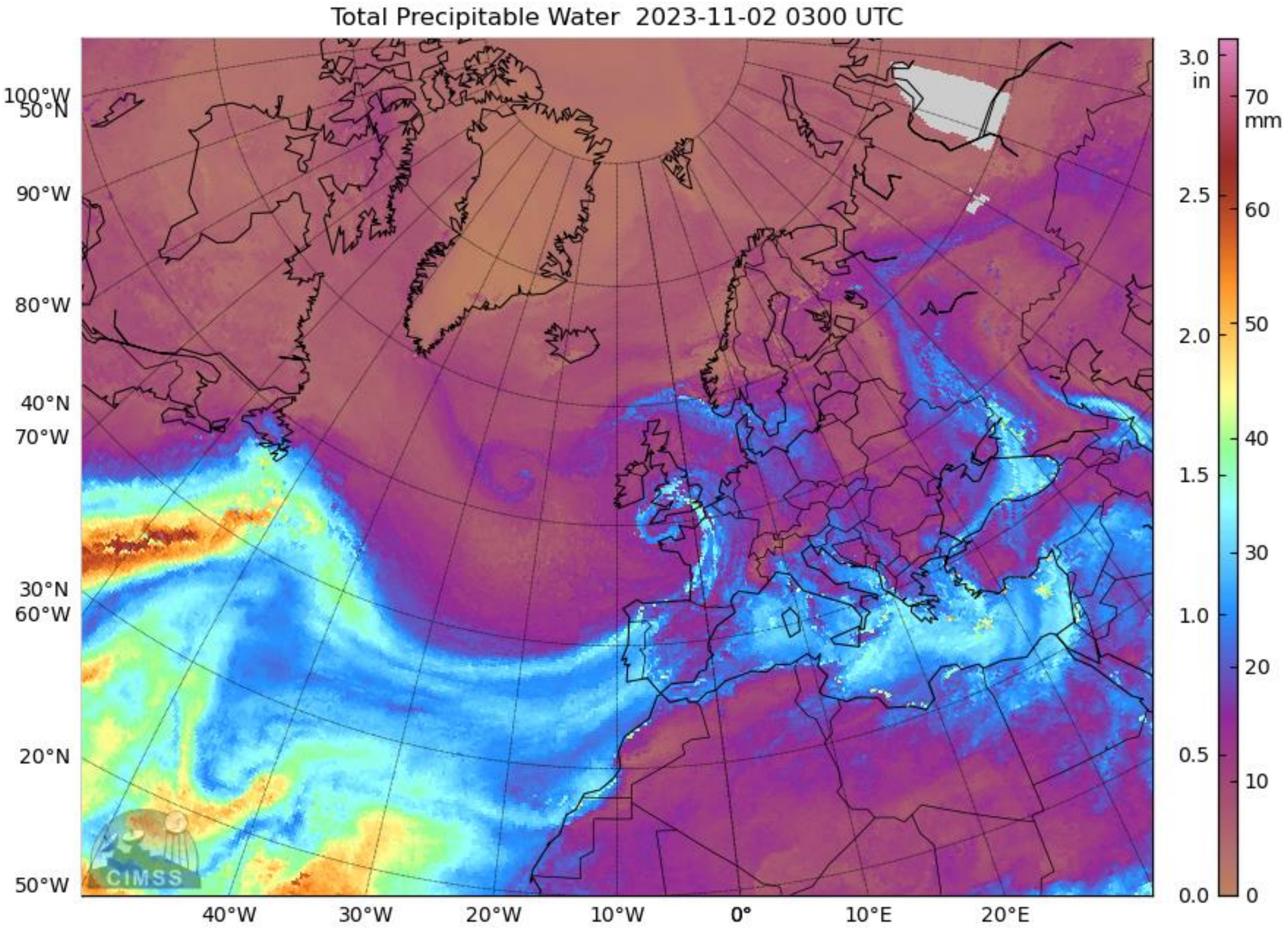
The composite product is made from retrievals using AMSU-B and MSU from NOAA-18, NOAA-19, Metop-A and Metop-B. It also uses the retrieval from ATMS of Suomi-NPP, NOAA-20 (and NOAA-21 in the future).

It was demonstrated that the morphological compositing process added a mean average error of only 1-2 mm TPW in a multi-satellite composite over the ocean, which is usually negligible. The error over land is assumed to be somewhat larger, but this will have to be investigated sometime later.

Development of the MIMIC-TPW2 product is supported by the JPSS Risk Reduction Program and the Office of Naval Research.



MW derived TPW



- Available with 1 hour temporal resolution.
- Useful for cyclones detection and monitoring.
- Information about atmospheric rivers.
- An atmospheric river (AR) is a narrow corridor or filament of concentrated moisture in the atmosphere.
- Atmospheric rivers have a central role in the global water cycle.
- They are also the major cause of extreme precipitation events that cause severe flooding in many mid-latitude, westerly coastal regions of the world, including the west coast of North America, Western Europe, the west coast of North Africa, the Iberian Peninsula, Iran and New Zealand.

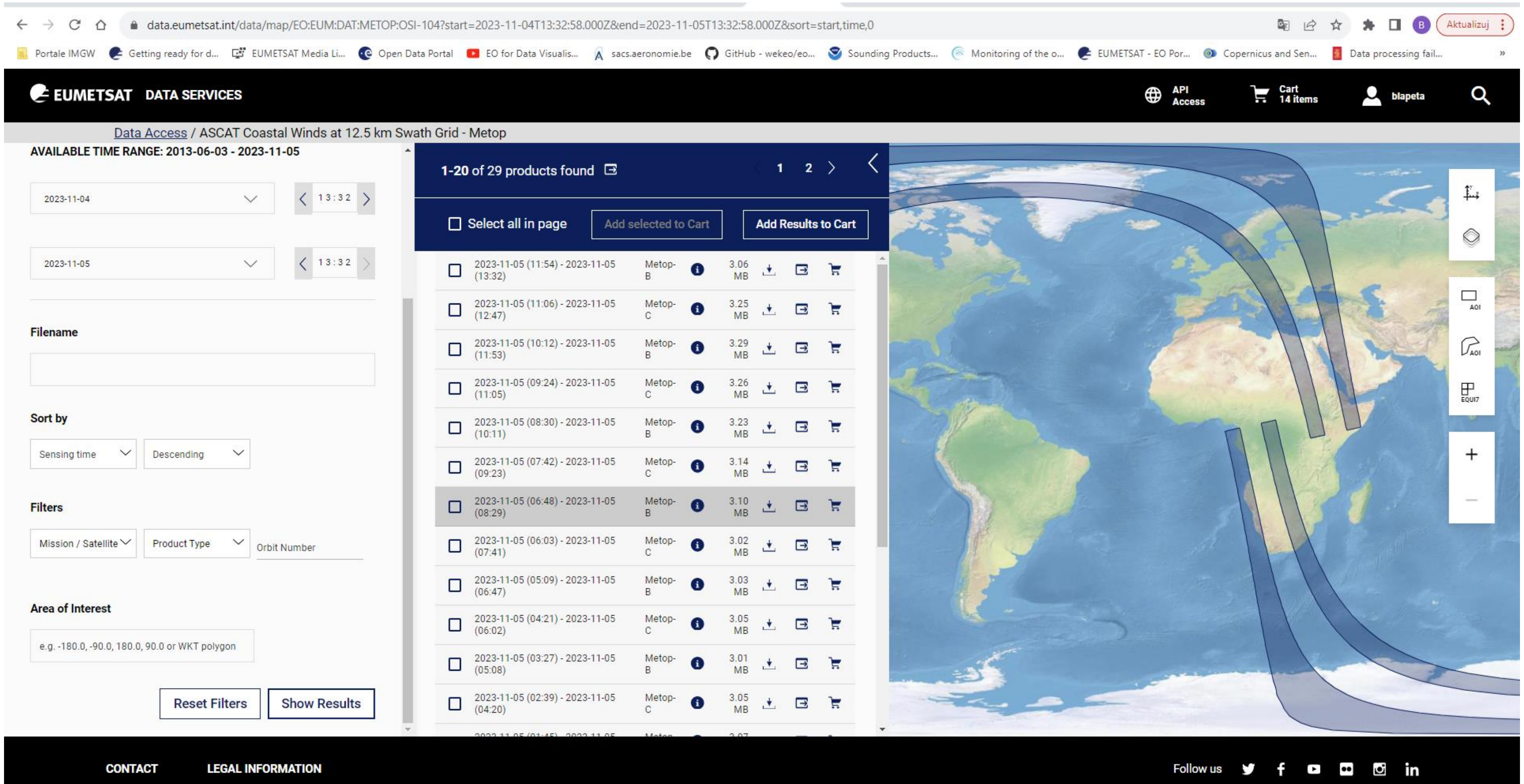
https://tropic.ssec.wisc.edu/real-time/mtpw2/product.php?color_type=tpw_nrl_colors&prod=europe&timespan=24hrs&anim=html5

Products

Sea wind

Derived from Metop/ASCAT data.

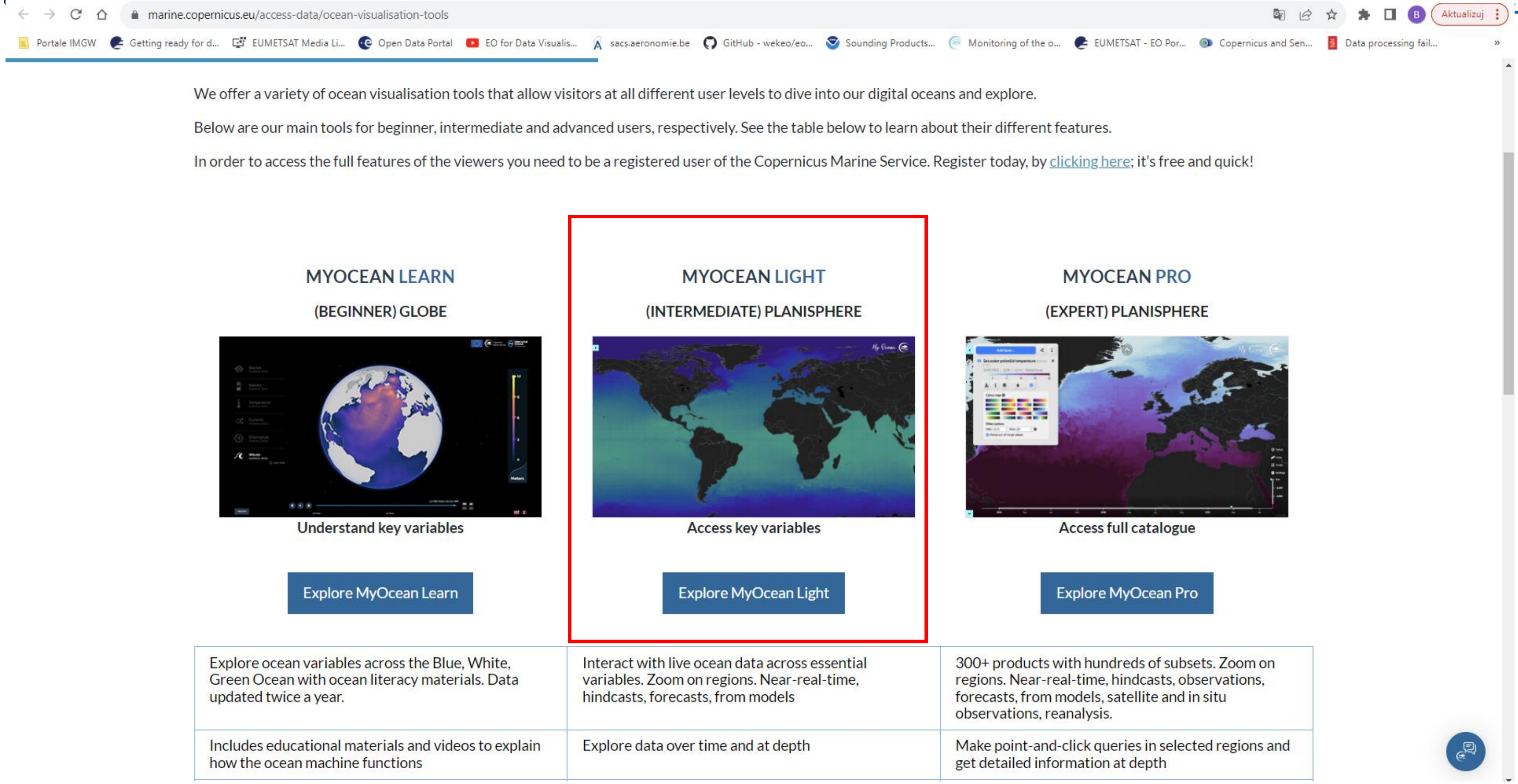
- EUMETCast i bufr format
- EUMETSAT Data store – NRT and archived products in NetCDF format (https://data.eumetsat.int/search?query=)



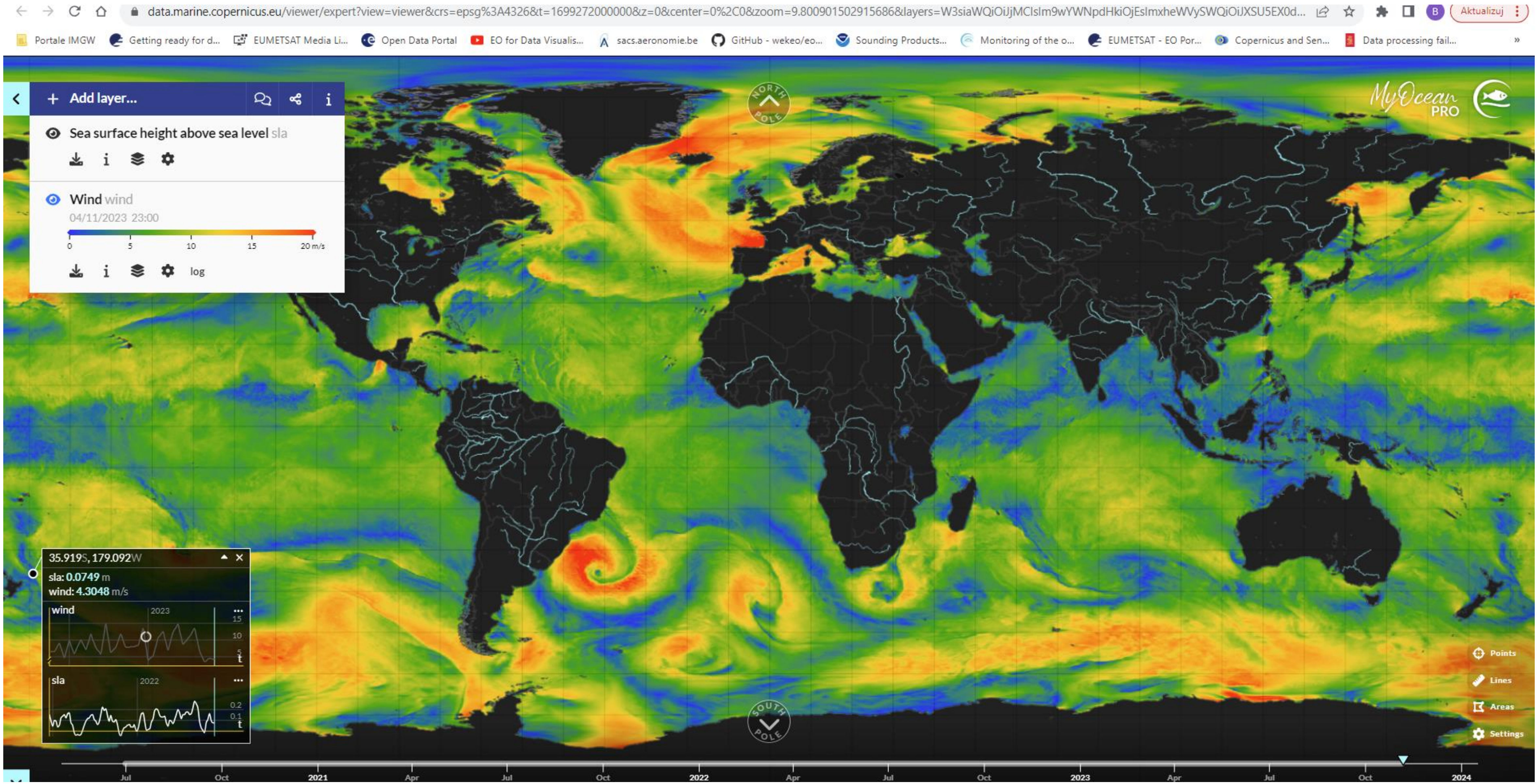
Sea wind

Derived from Metop/ASCAT data.

- EUMETSAT Data store – NRT and archived products
- OSI SAF - NRT and record data available (https://osi-saf.eumetsat.int/products/wind-products)
- Copernicus Marine Service – global products available with 1 day delay; data records :(https://marine.copernicus.eu/)



Sea wind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Add layer...
Sea surface height above sea level sla
Wind wind
04/11/2023 23:00
0
5
10
15
20 m/s
log
MyOcean PRO
35.919S, 179.092W
sla: 0.0749 m
wind: 4.3048 m/s
wind
2023
sla
2022
Points
Lines
Areas
Settings
2021
2022
2023
2024

Derived from Sentinel-6MF/Poseidon-4, Jason3, Sentinel-3A/SRAL and Sentinel-3B/SRAL data.

Data only from subsatellite track.

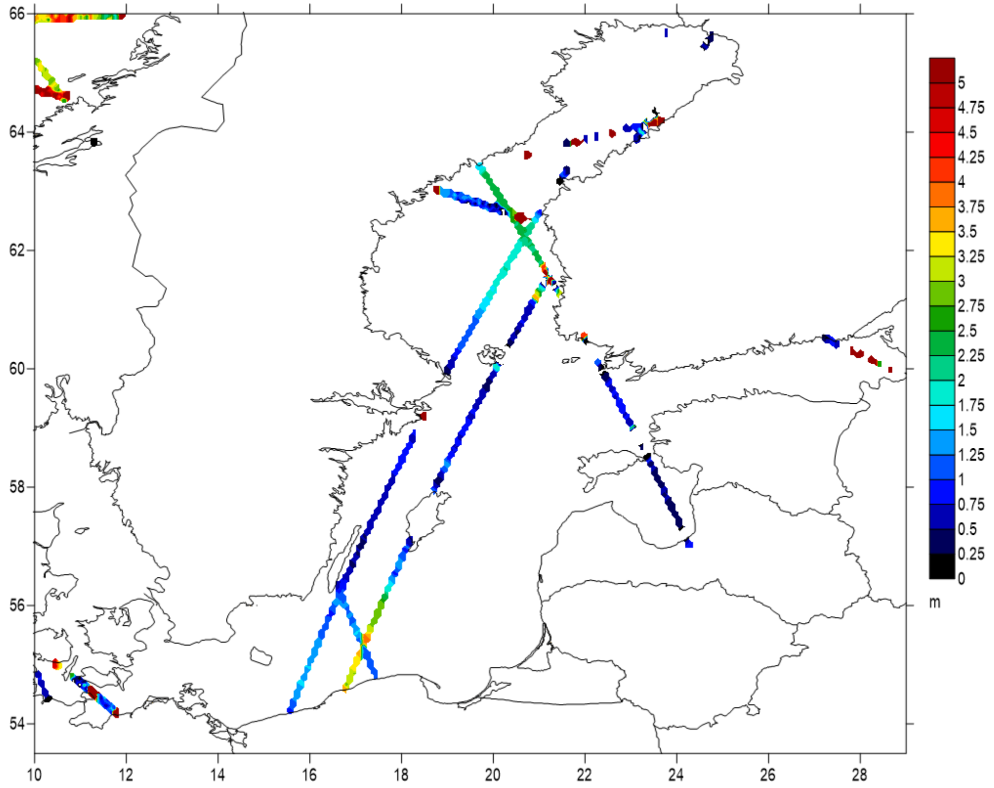
Data from Jason-3, SARAL/ALTIKA - service ftp-access.aviso.altimetry.fr folder geophysical-data-record

Data from Sentinel-3 – https://dataspace.copernicus.eu

Data from Sentinel-6 – EUMETSAT DataStore https://data.eumetsat.int

The latency of the altimeter data depends on the type of product:

- NRT (Near Real Time) - on the same day,
- Intermediate Data Record (also called NT – Non time critical) - after 2 days
- Geophysical Data Record – after 2 months.

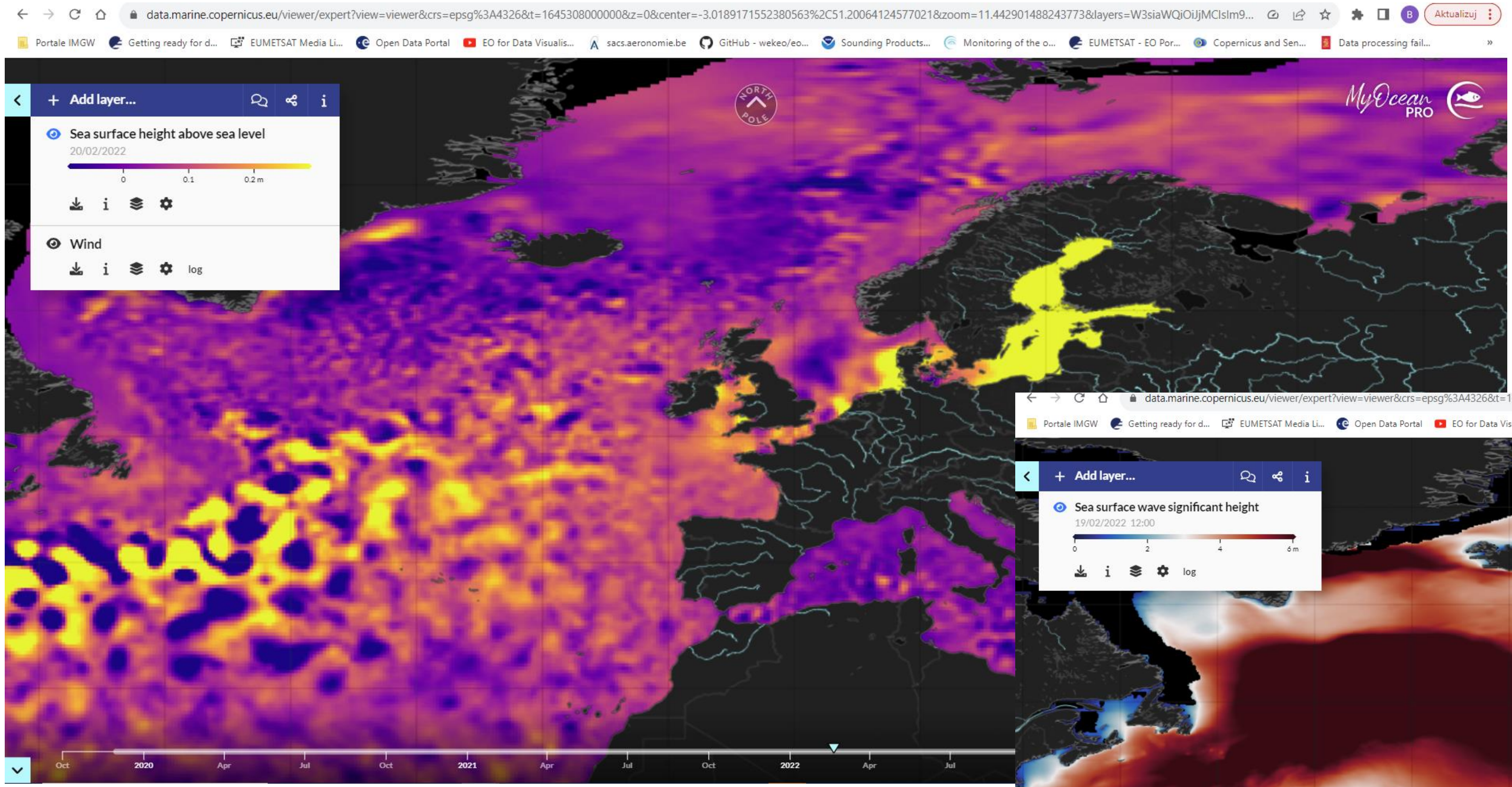


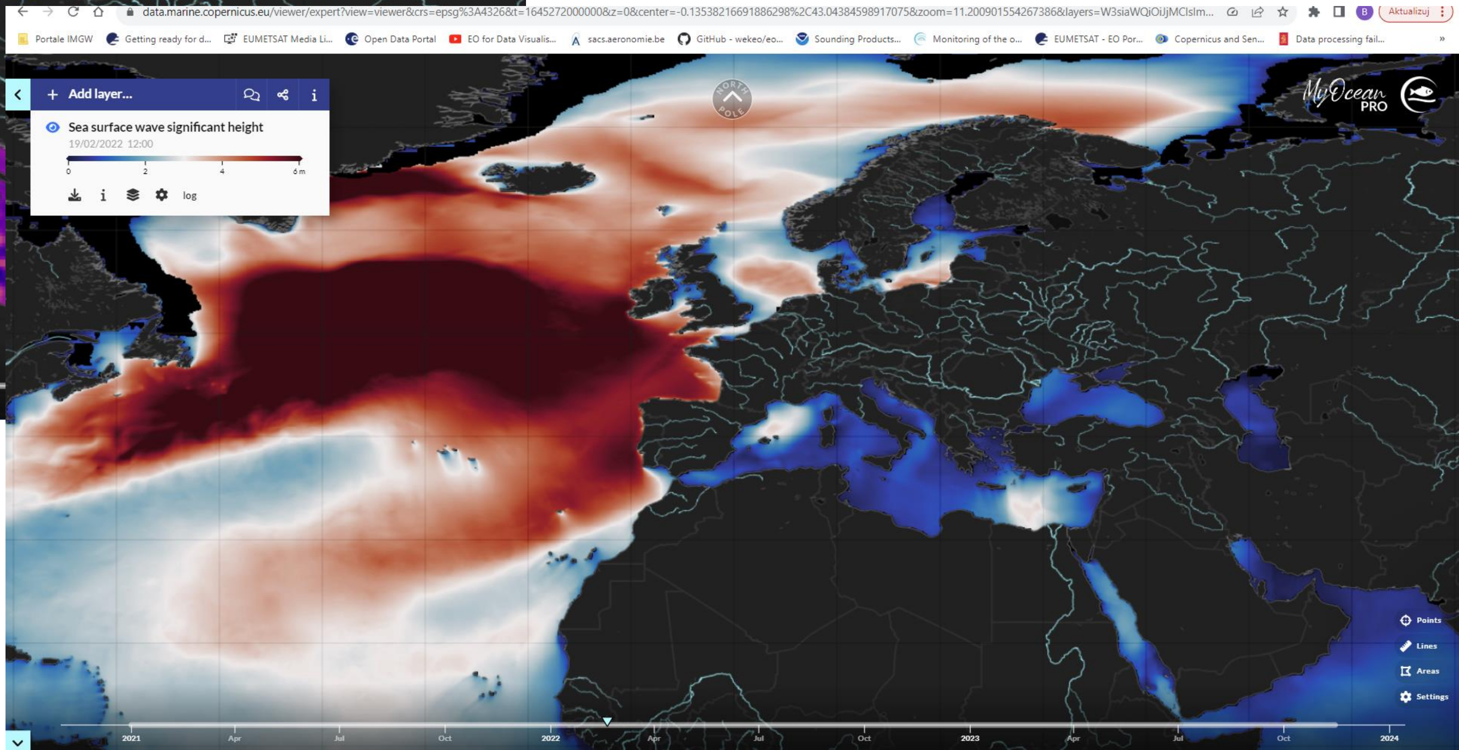
Significant waves height

Sea altimetry

METEO
IMGW-PIB
meteo.imgw.pl

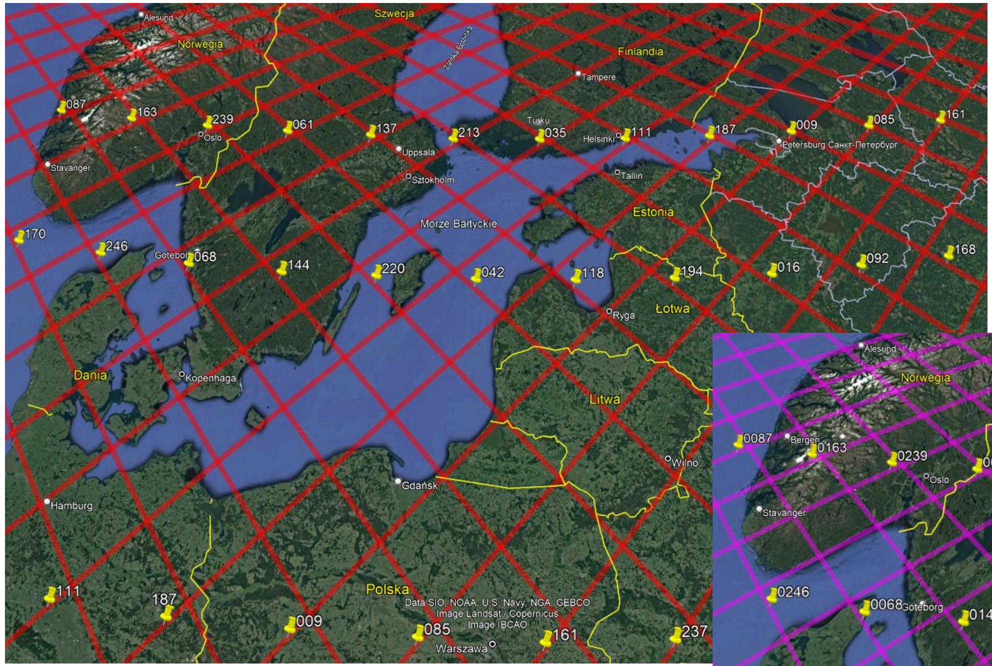
Copernicus Marine Service – global products available with 1 day delay; data records :(https://marine.copernicus.eu/)



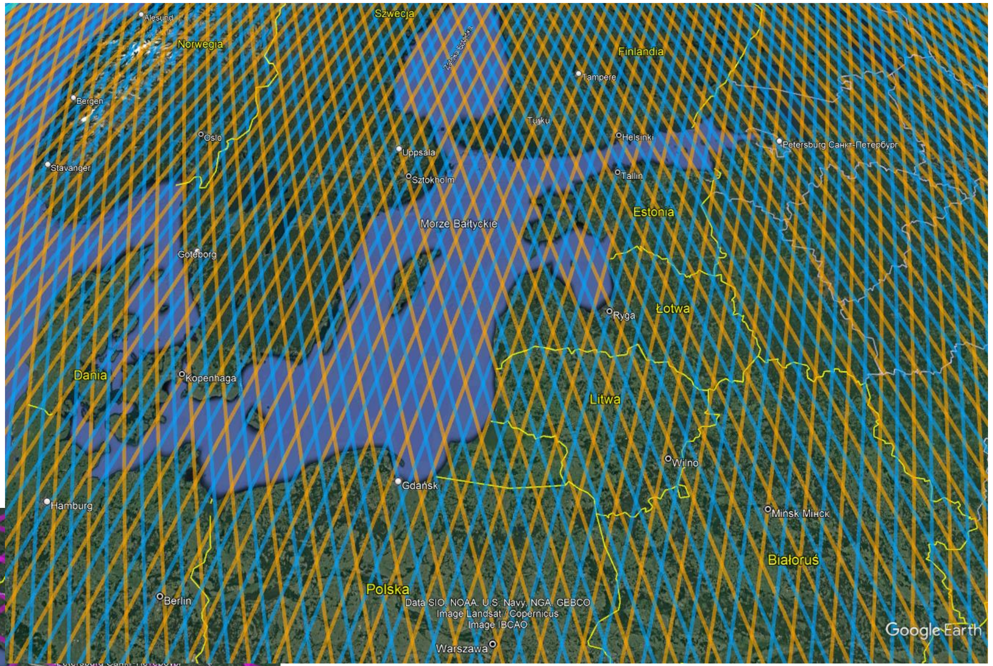


Overpass locator (https://www.aviso.altimetry.fr/en/data/tools/pass-locator.html)

Sentinel-6 MF



Jason-3



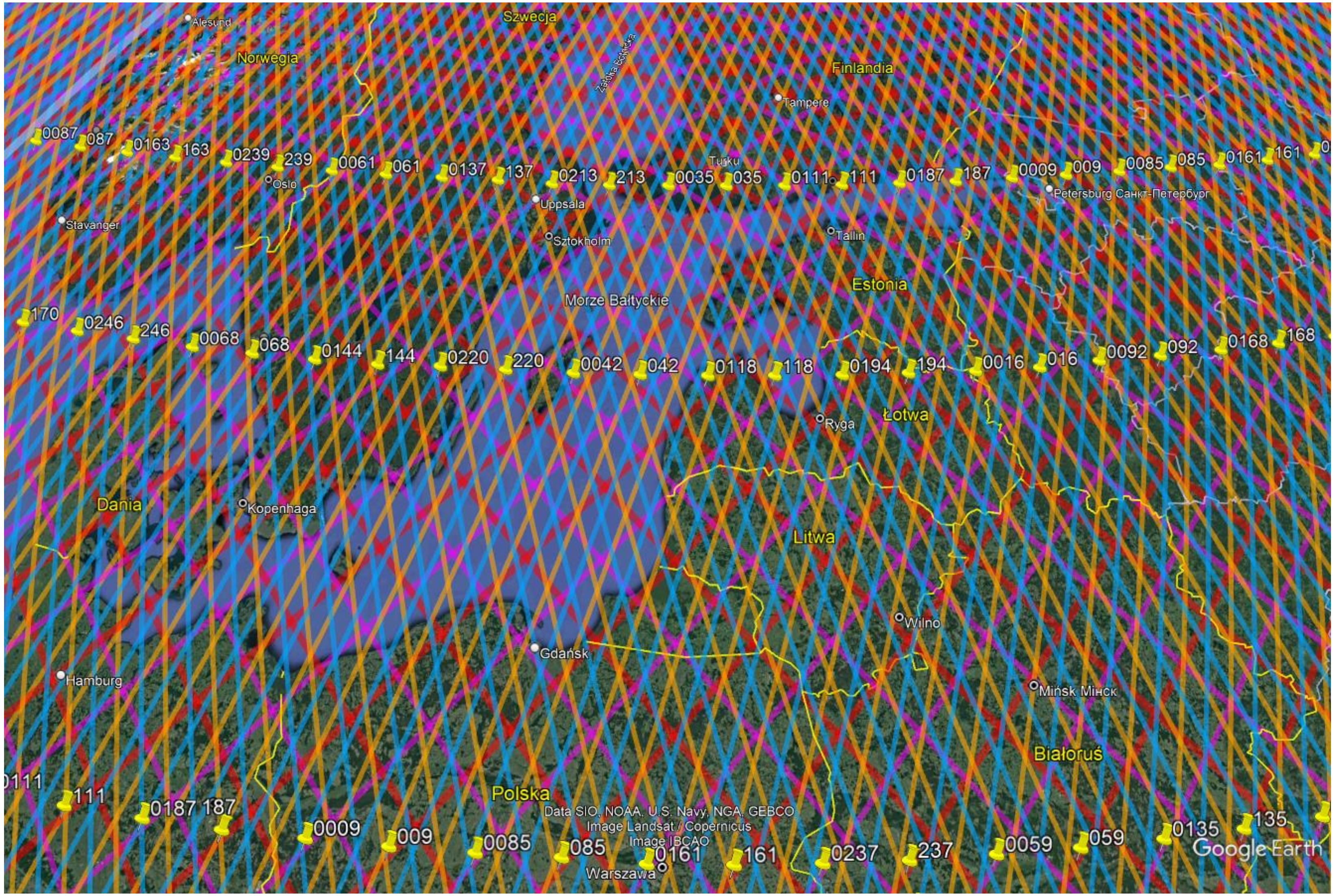
Sentinel-3A and *Sentinel-3B*

Overpass locator (https://www.aviso.altimetry.fr/en/data/tools/pass-locator.html)

Sentinel-6 MF

Jason-3

Sentinel-3A and Sentinel-3B



Precipitation

- Derived from passive microwave satellite data – reasonably good quality but poor temporal resolution (only from polar satellites)
- Derived from IR geostationary data – rather poor quality but good temporal resolution.
- Hybrid solution – reasonably quality and good temporal resolution:
  - Precipitation rate at ground by blended MW and IR (from H-SAF available at Eumetview along with Rapid Development Thunderstorm from NWC SAF))
- Precipitation parameters derived from satellite and NWP model data (NWC SAF)
  - Precipitation probability (stratiform type)
  - Convective rain rate

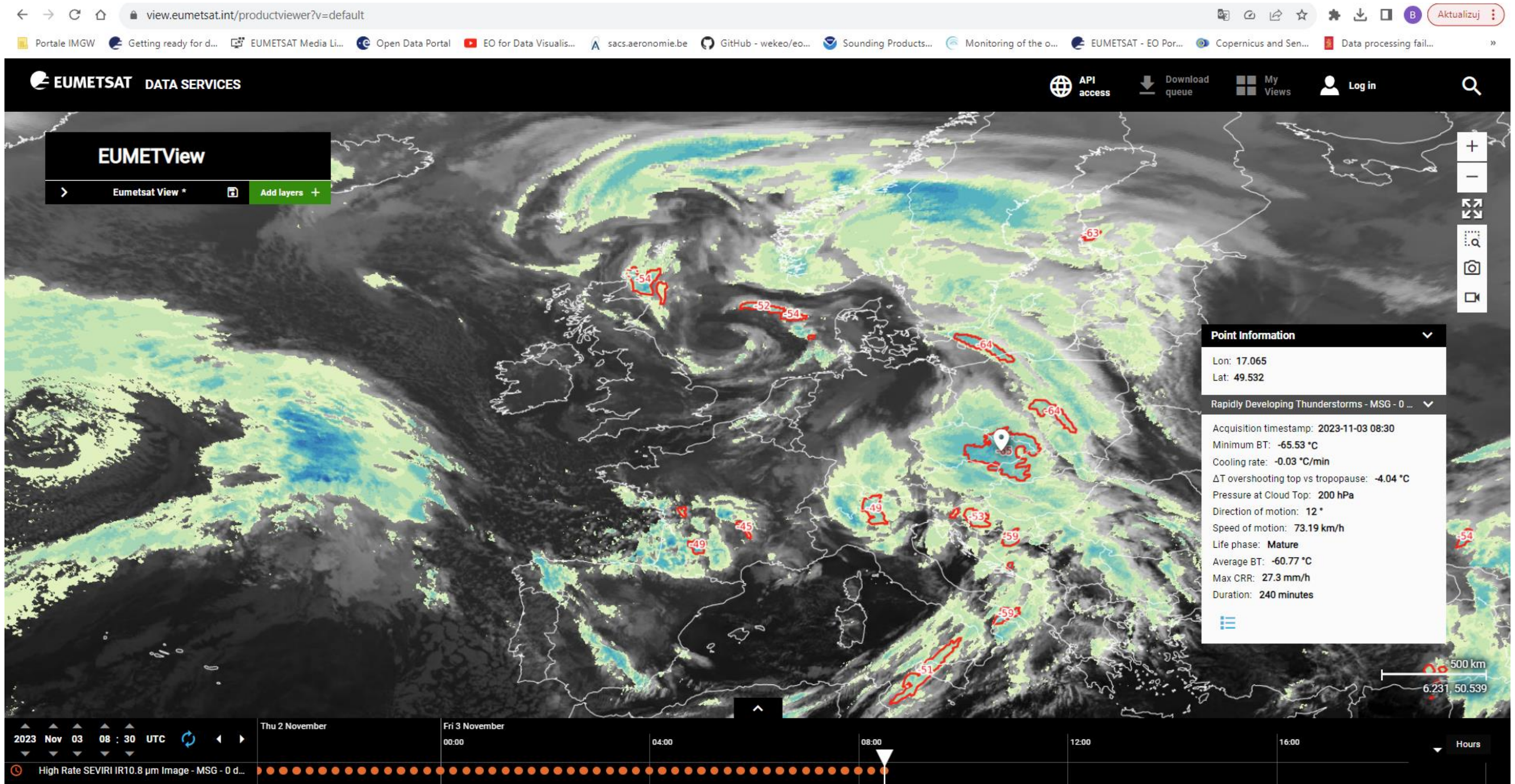
Precipitation

METEO
IMGW-PIB
meteo.imgw.pl

Instantaneous precipitation maps generated combining geostationary (GEO) IR images from operational geostationary satellites 'calibrated' by precipitation measurements from MW images on Low Earth Orbit (LEO) satellites, processed soon after each acquisition of a new image from GEO.

The blending algorithm ('Rapid Update’) generates precipitation estimates combining the equivalent blackbody temperatures (TBB) at 10.8 µm with rain rates from all available Passive MW measurements.

A separate treatment is performed for convective precipitation: the morphologic information and the enhancement of precipitation estimate is done by the use of NEFODINA software.

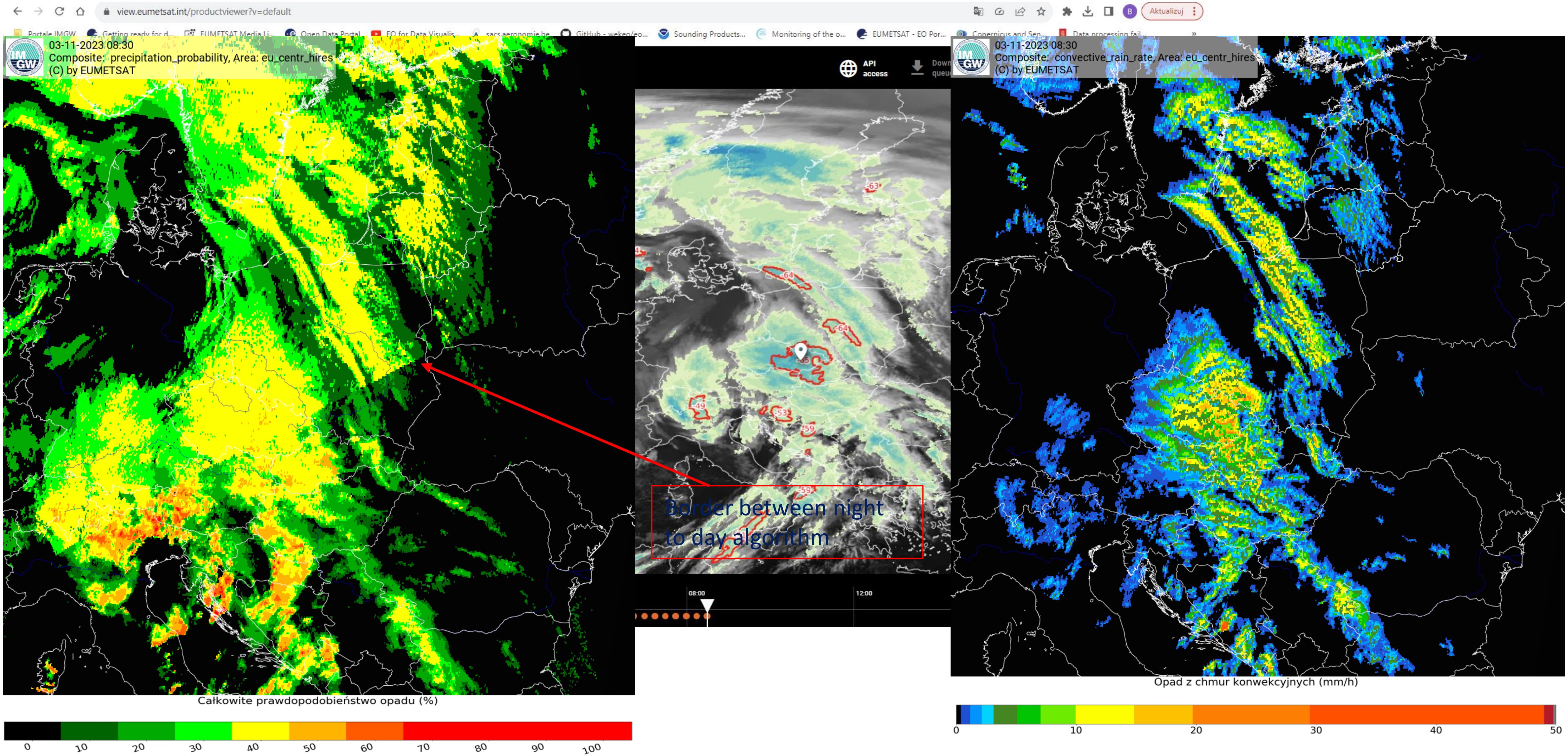


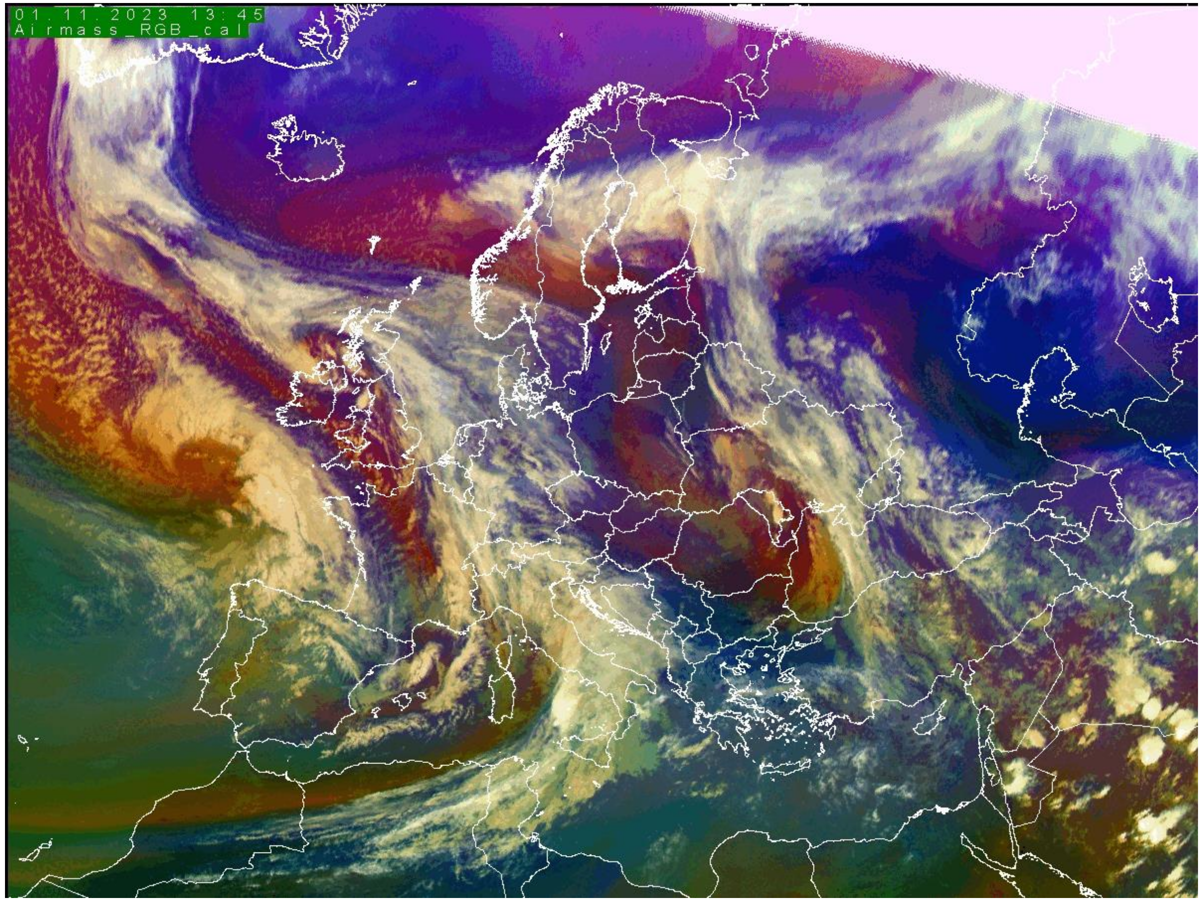
Precipitation

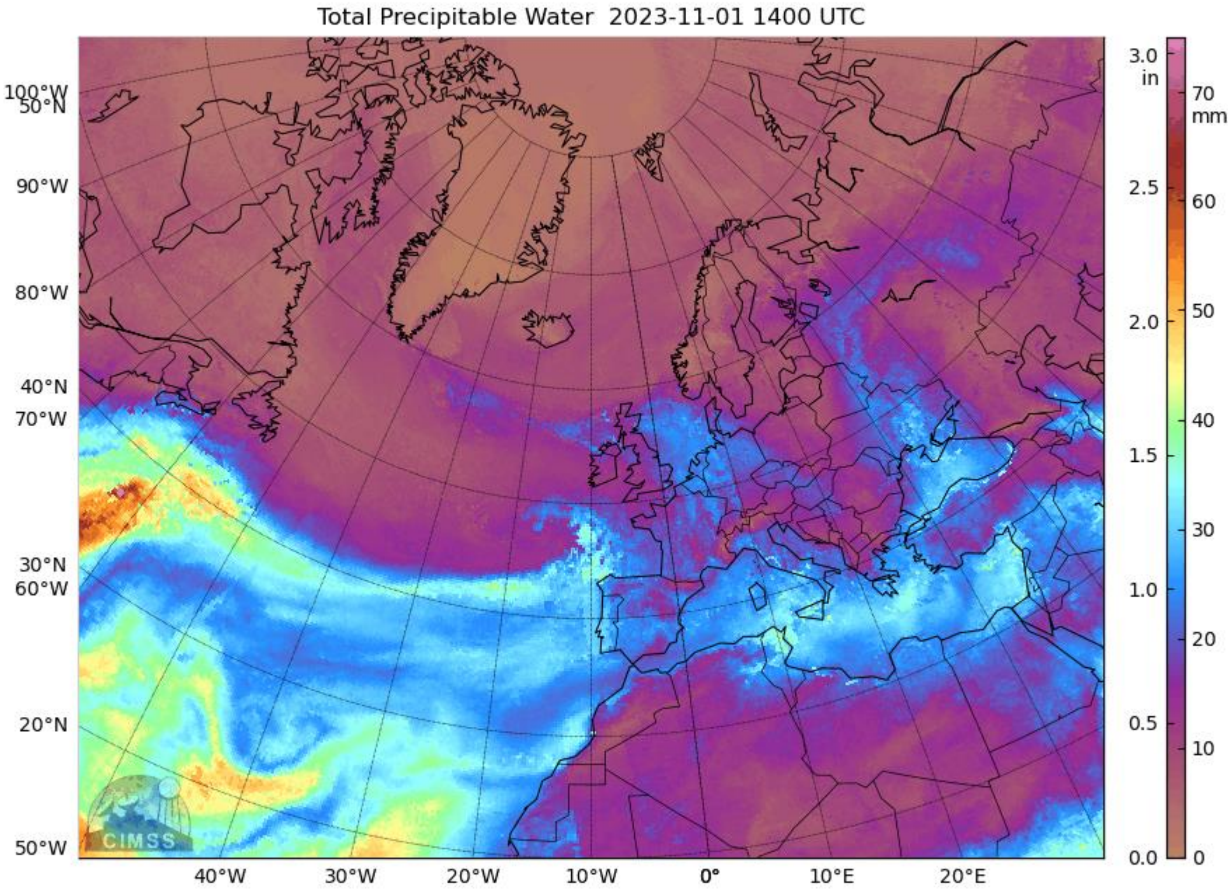
METEO
IMGW-PIB
meteo.imgw.pl

NWC SAF Precipitating Clouds (probability of precipitation)

Convective Rain Rate







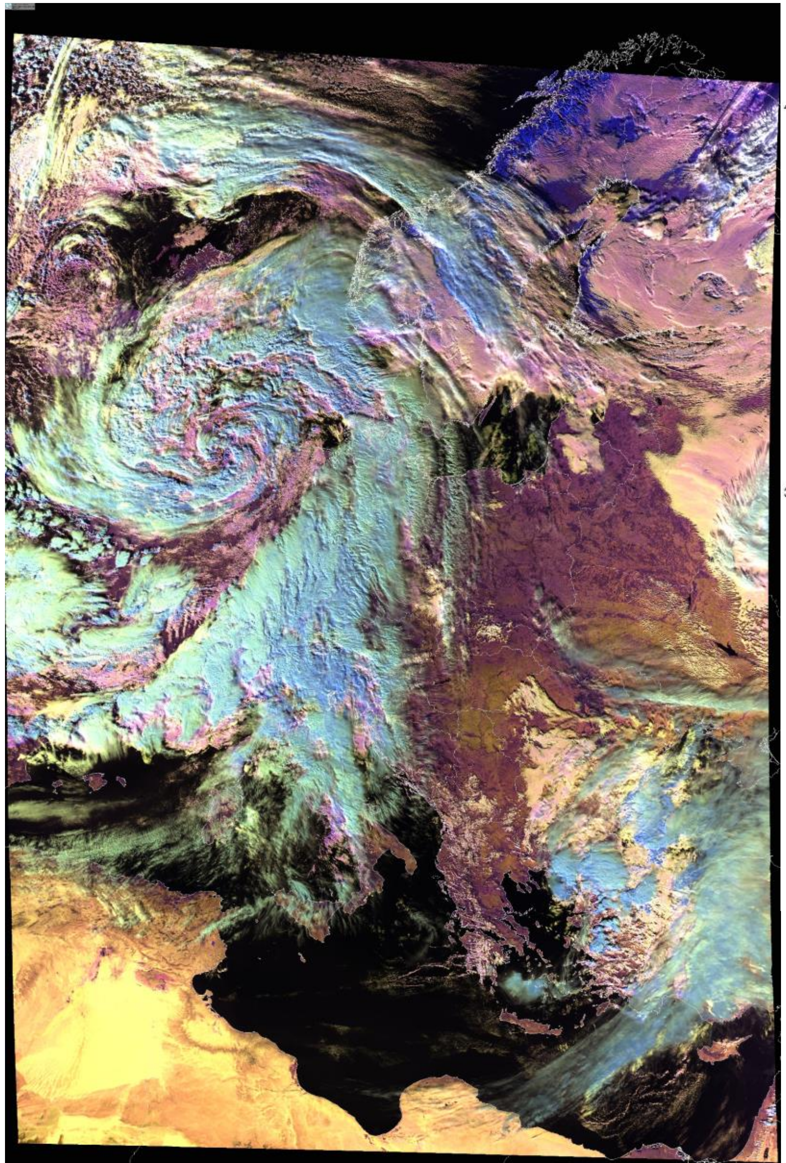
FROM SSEC web page:

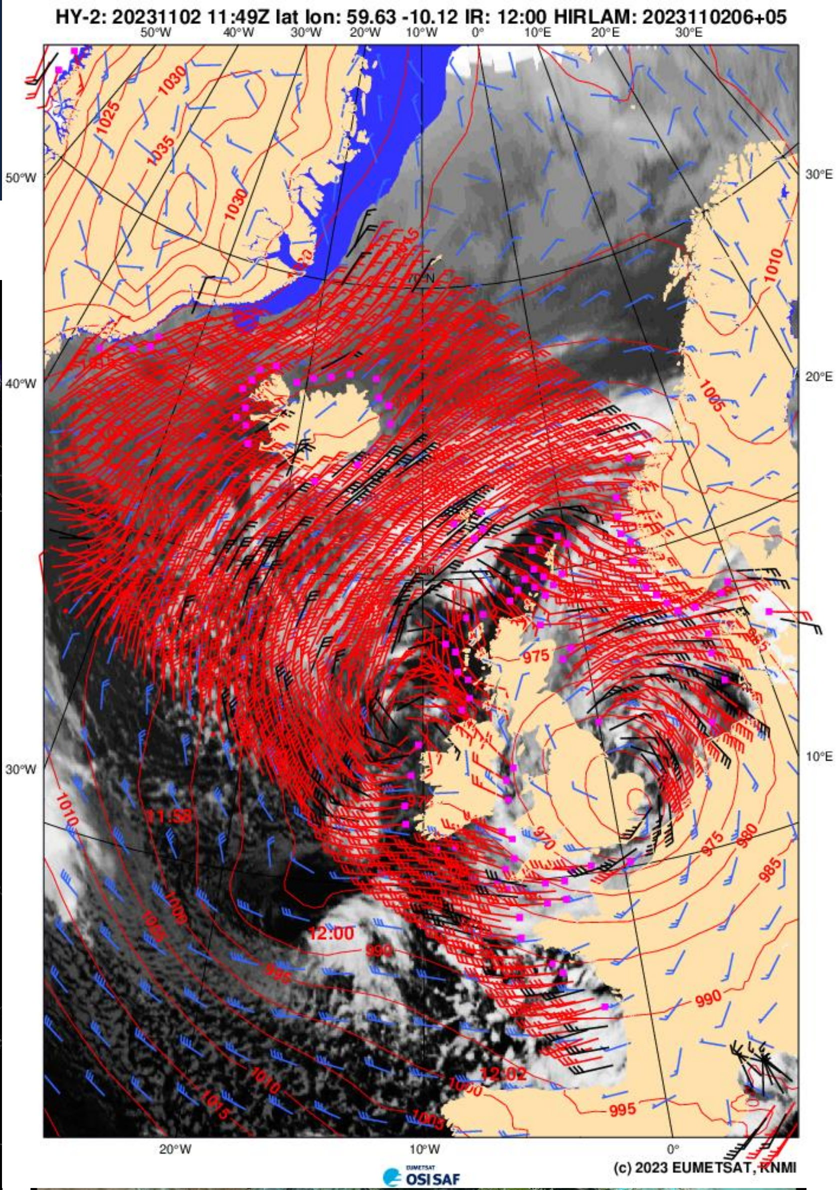
Use caution when interpreting the last 3 hours of the product near the coasts. We have noticed that the sudden change in TPW from land to water tends to persist over time, but when the MIMIC-TPW2 product uses only forward-advected data, it will tend to show the higher, over-water TPW moving over land and exaggerating the over-land TPW value.

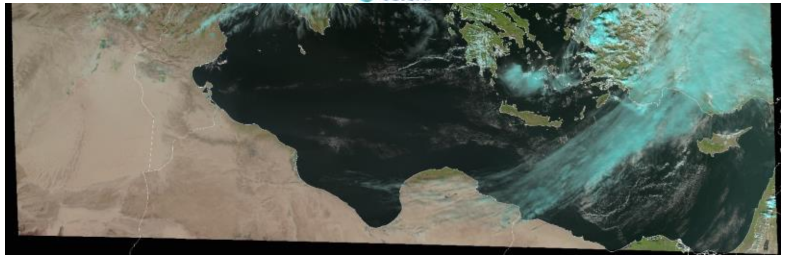
Orkan Cirian

METEO IMGW-PIB
meteo.imgw.pl

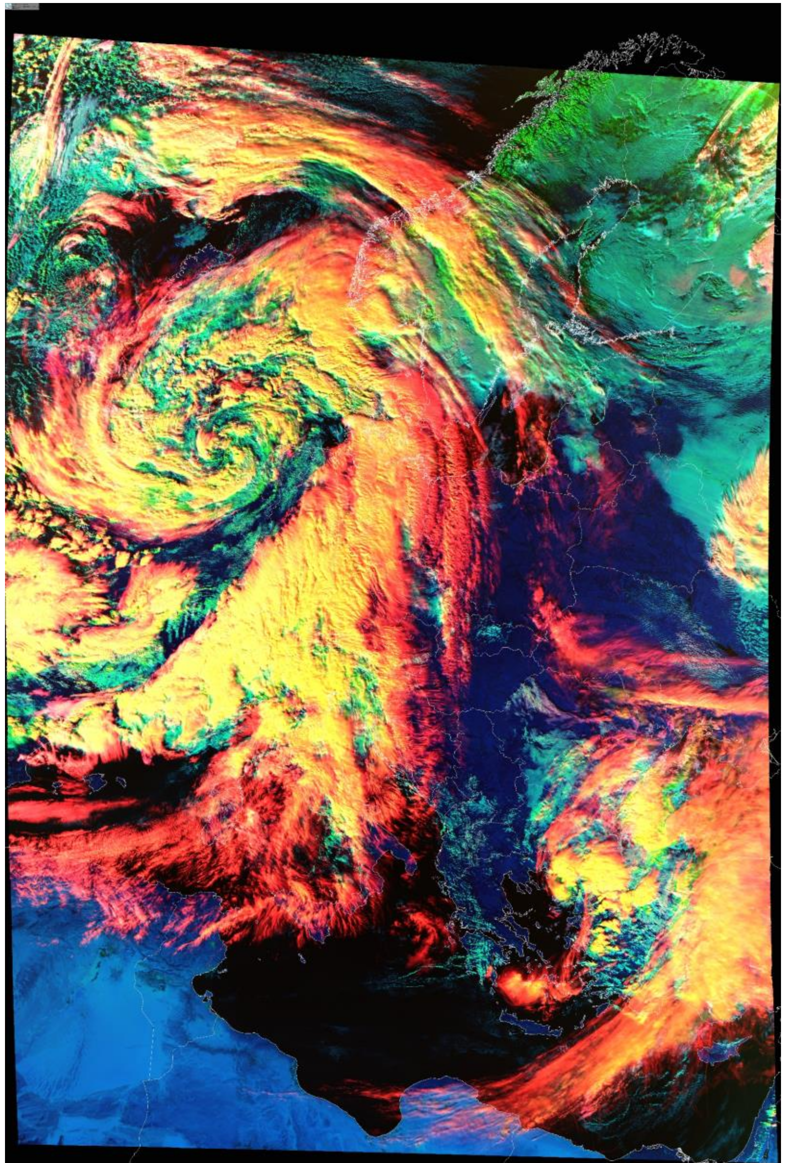
02.11.2023, 11:44UTC, Cloud phase,



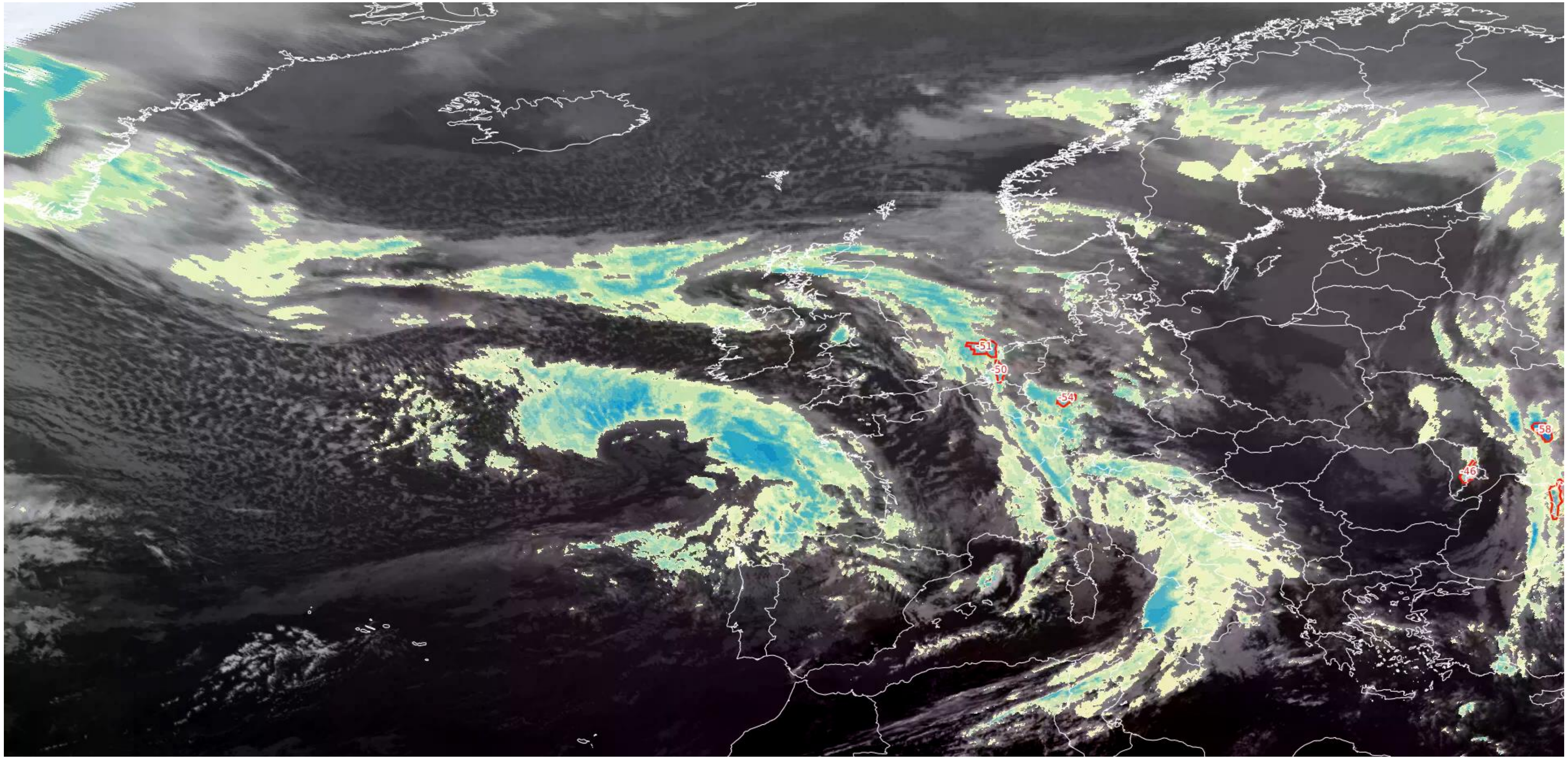




Cloud type

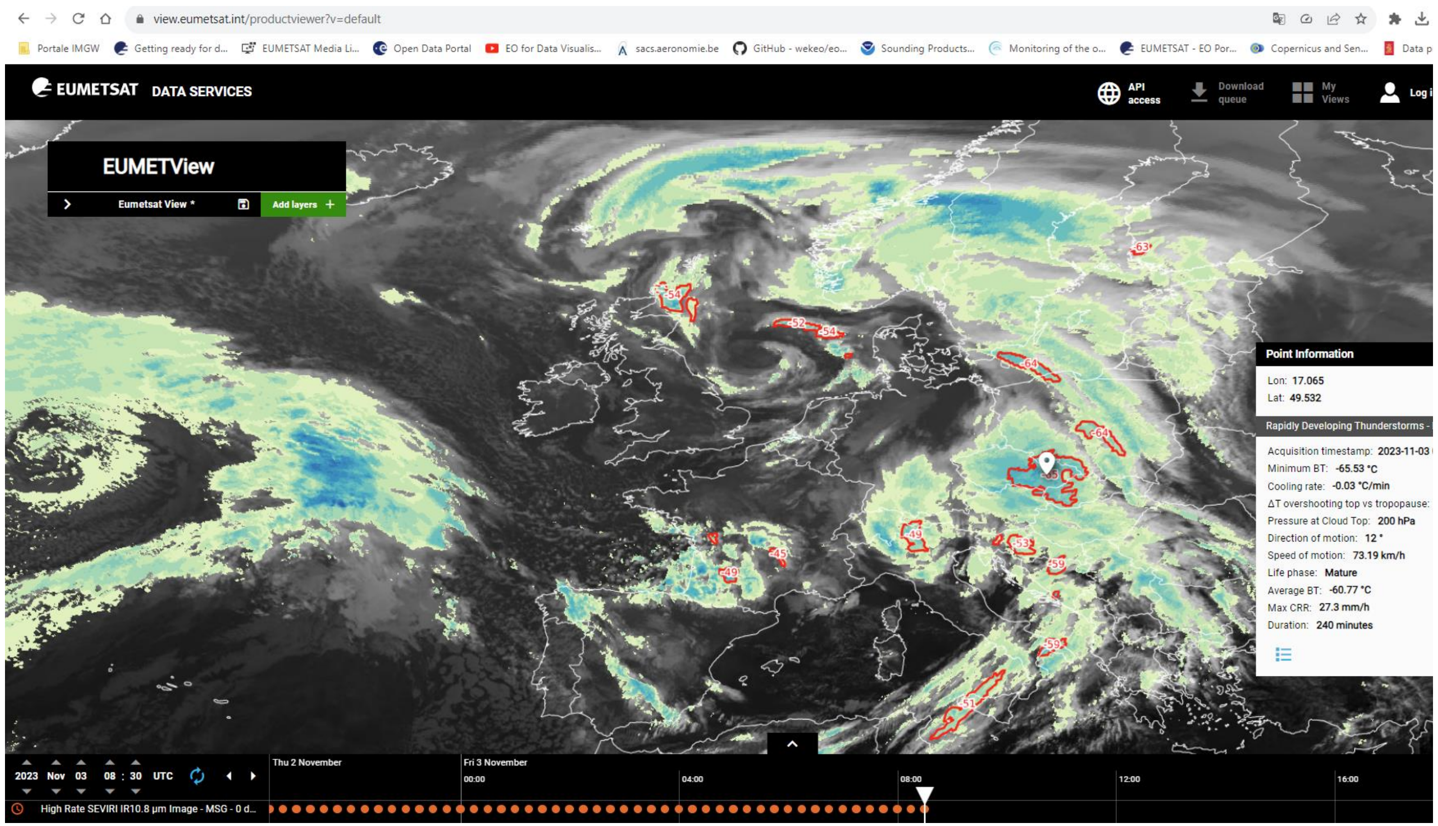


Orkan Cirian

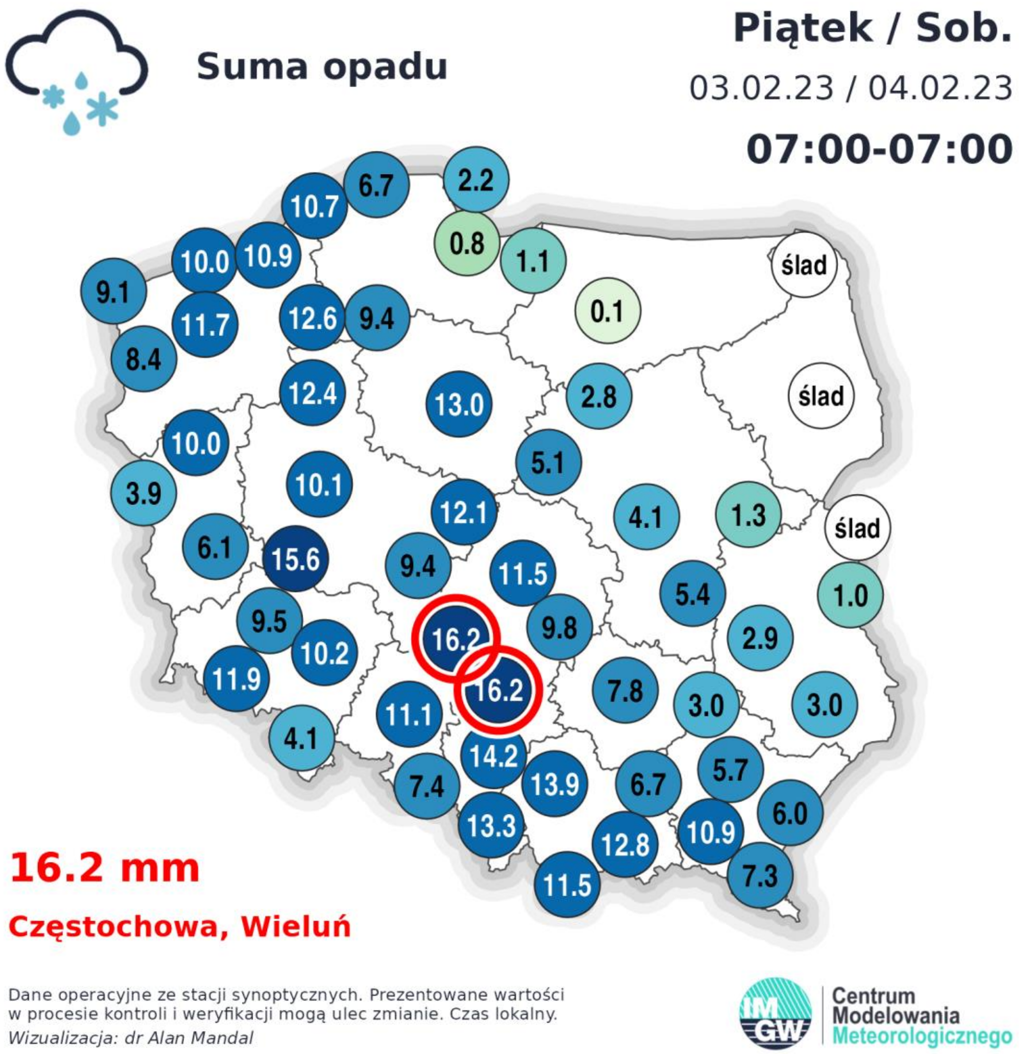


Source: Eumetview

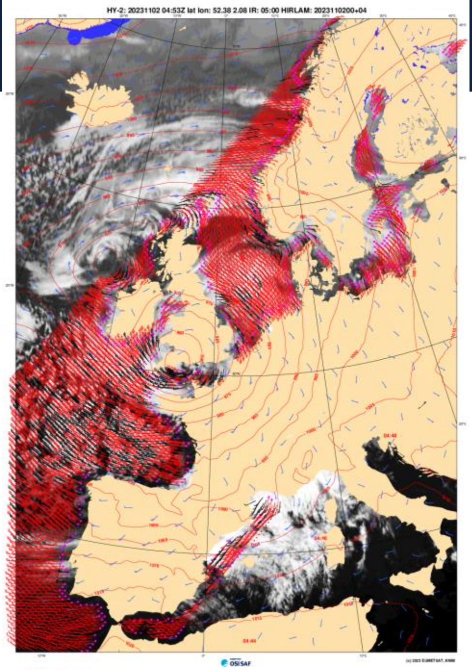
Orkan Cirian



Source: Eumetview



Orkan Ciran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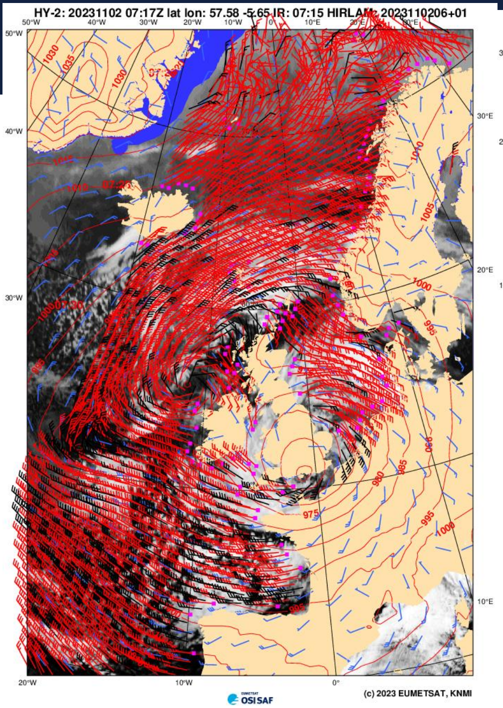
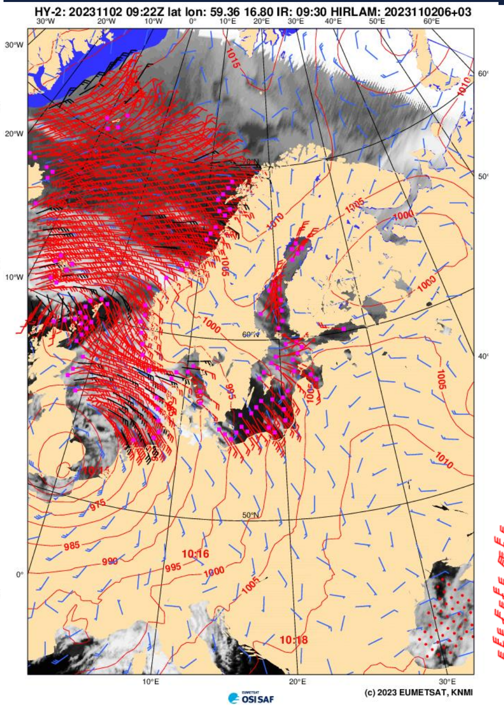
OSI SAF


HY-2: 20231102 07:17Z lat lon: 57.58 -5.65 IR: 07:15 HIRLAM: 2023110206+01
OSI SAF
(c) 2023 EUMETSAT, KNMI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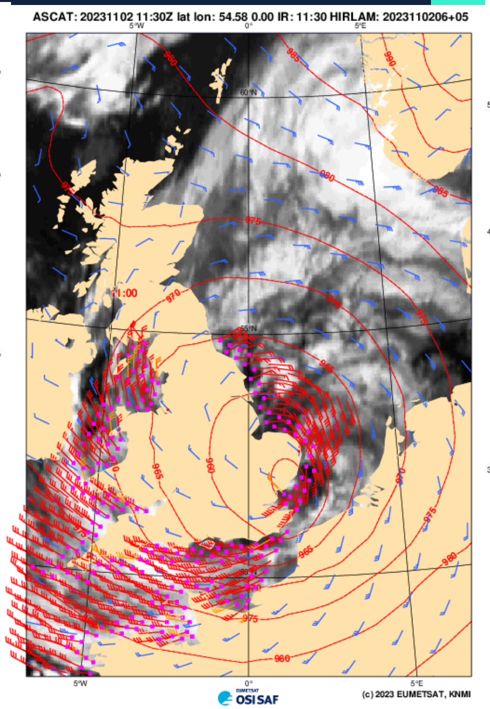
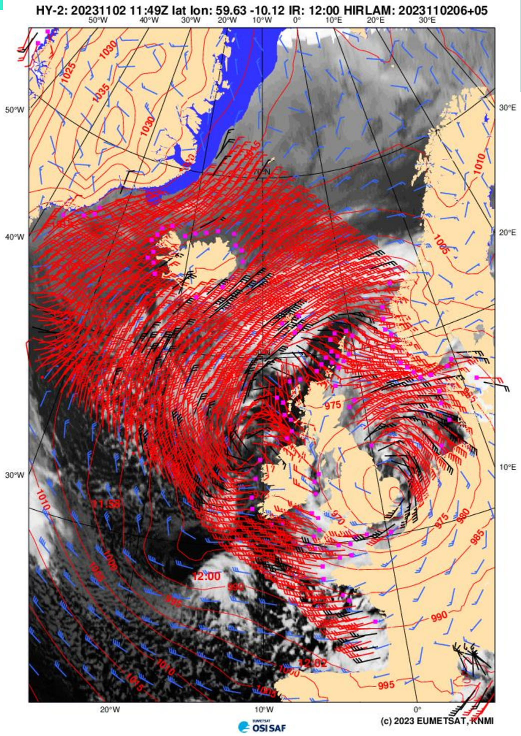
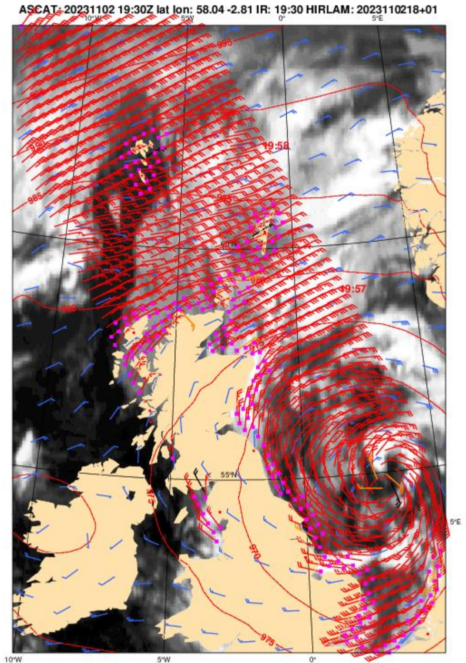
OSI SAF
(c) 2023 EUMETSAT, KNMI


ASCAT: 20231102 11:30Z lat lon: 54.58 0.00 IR: 11:30 HIRLAM: 2023110206+05
OSI SAF
(c) 2023 EUMETSAT, KNMI


HY-2: 20231102 11:49Z lat lon: 59.63 -10.12 IR: 12:00 HIRLAM: 2023110206+05
OSI SAF
(c) 2023 EUMETSAT, KNMI


ASCAT: 20231102 19:30Z lat lon: 58.04 -2.81 IR: 19:30 HIRLAM: 2023110218+01

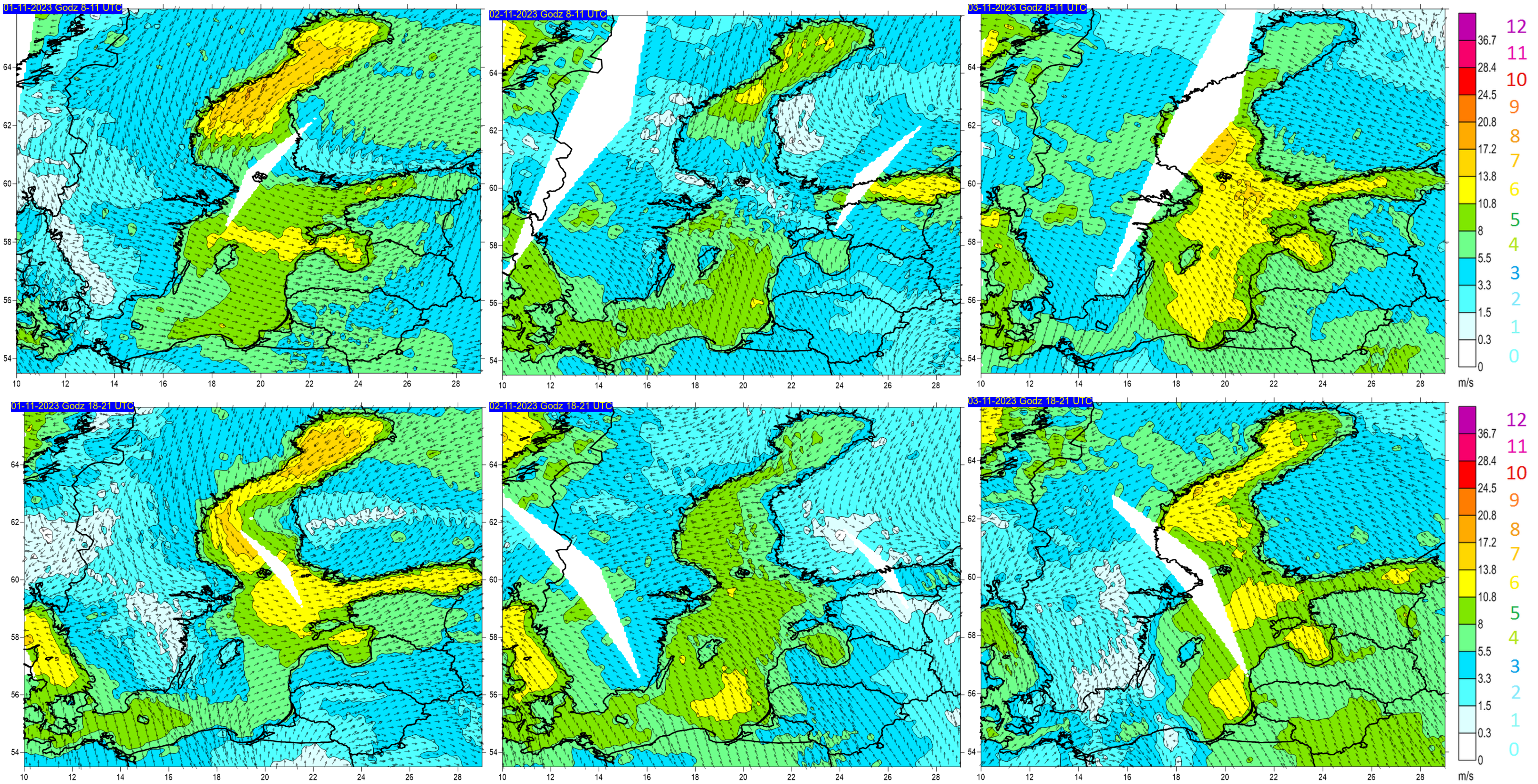
Orkan Cirian

METEO
IMGW-PIB
meteo.imgw.pl

01.11.2023 02.11.2023 03.11.2023

AM overpasses

PM overpasses



Useful links

NWC SAF GEO NRT products:

https://www.nwcsaf.org/web/guest/nwc/geo-geostationary-near-real-time-v2021

IASI Combined Sounding Products -Metop

https://eoportal.eumetsat.int/ registration required

Thank you for your attention

Bożena Łapeta/CMOK/ZTS
bozena.lapeta@imgw.pl

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IMGW-PIB
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