Shallow Clouds and Related Weather Phenomena

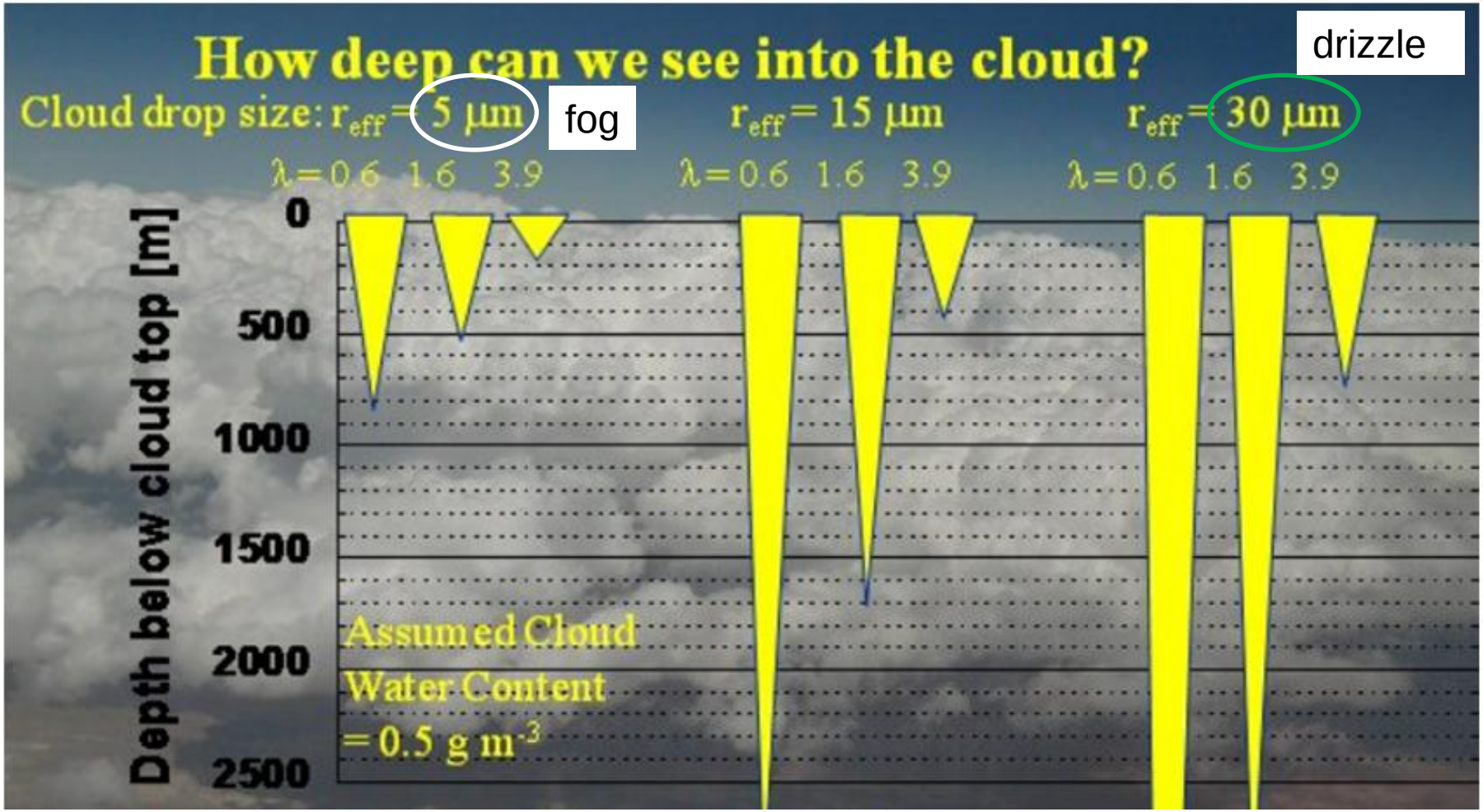
Wilfried Jacobs
Deutscher Wetterdienst
Meteorological Training and Conference Center
Email: wilfried.jacobs@dwd.de

1. Physical background
2. Fog and low stratus
   - Channels and products
   - Interpretation and examples
3. Precipitation and icing
   - Channels and products
   - Interpretation and examples
4. Summary
5. Homework

Fog – low stratus

Basic rules for some solar channels

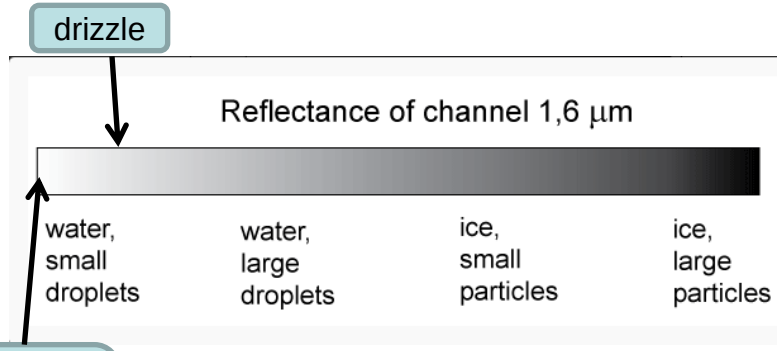
- Netto reflectance
  - 0.6 (and 0.8) µm higher with increasing thickness (more water, more icing (T<0° C))
  - 3.9ref µm (solar part)
    - Scattering (occurs at the drop surface) proportional to r^2
    - Absorption (occurs inside the drop) proportional to r^3
    - Netto reflectance: ($r^2/r^3 = 1/r$) proportional to 1/r
      - r = effective droplet radius

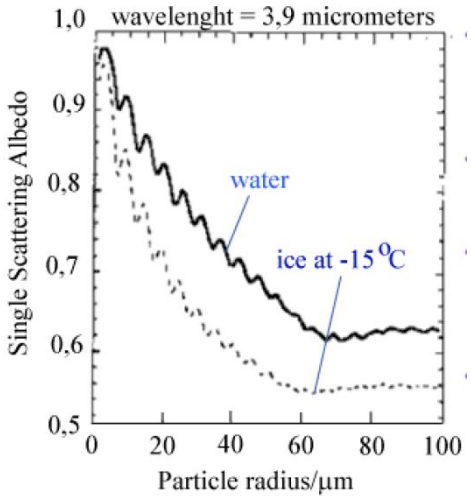


- 3.9 µm: Mainly near the cloud top or in the upper cloud‘s part
- 1.6 µm: Pennetrates deeper into the cloud
- 0.6 µm: Only for small droplets in the upper parts of the cloud. However, with increasing droplet size more and more to the ground, increasing influence by the soil.
- With decreasing drop size better identification, however, in any case cloud layer of less than 200 meters difficult (e.g., thin fog layers, especially radiation fog).

Reflectance of different solar channels

Source: EUMeTrain-CAL-Module: http://www.eumetrain.org/data/2/253/index.htm

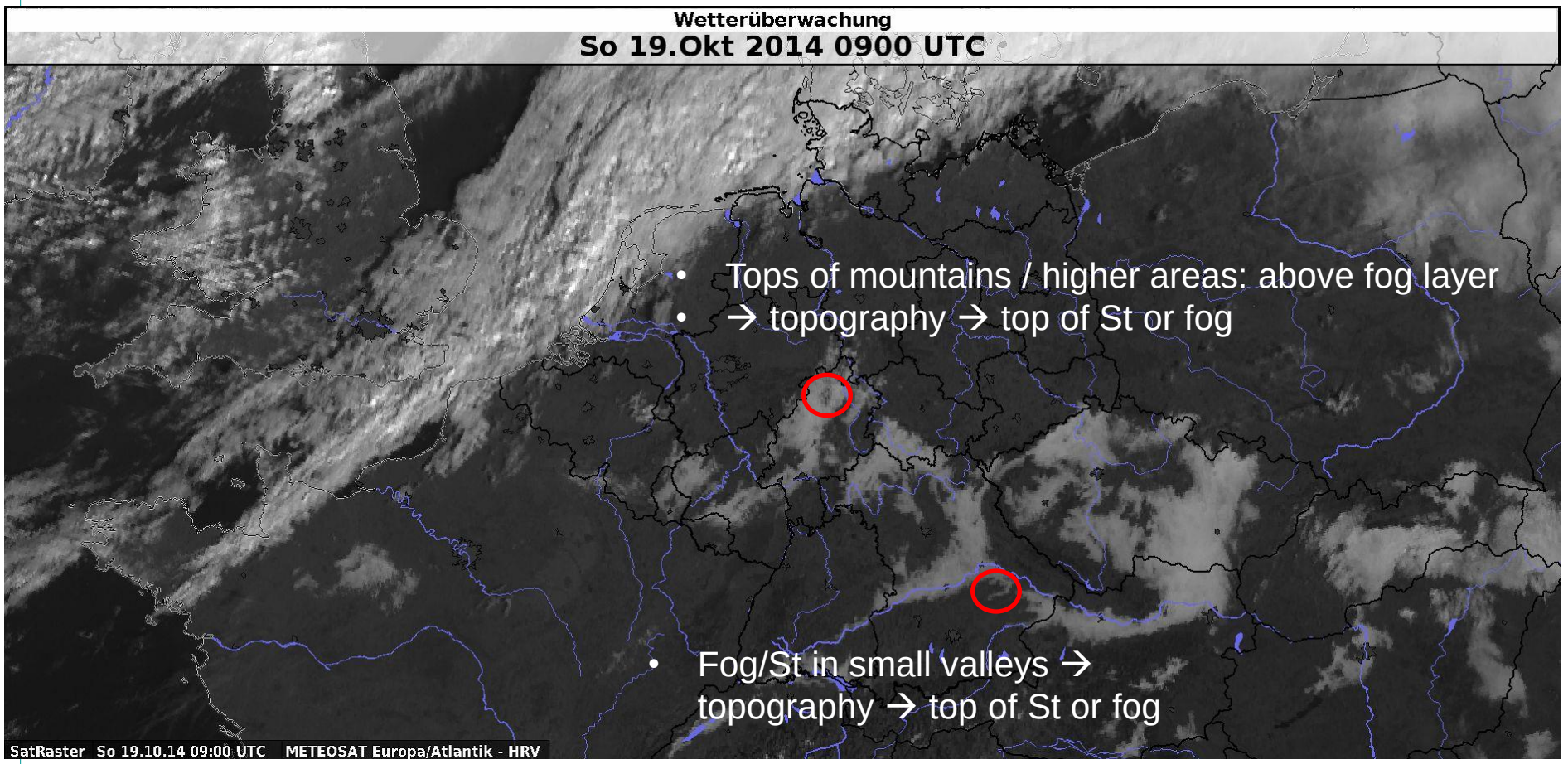




Cloud drops, fog

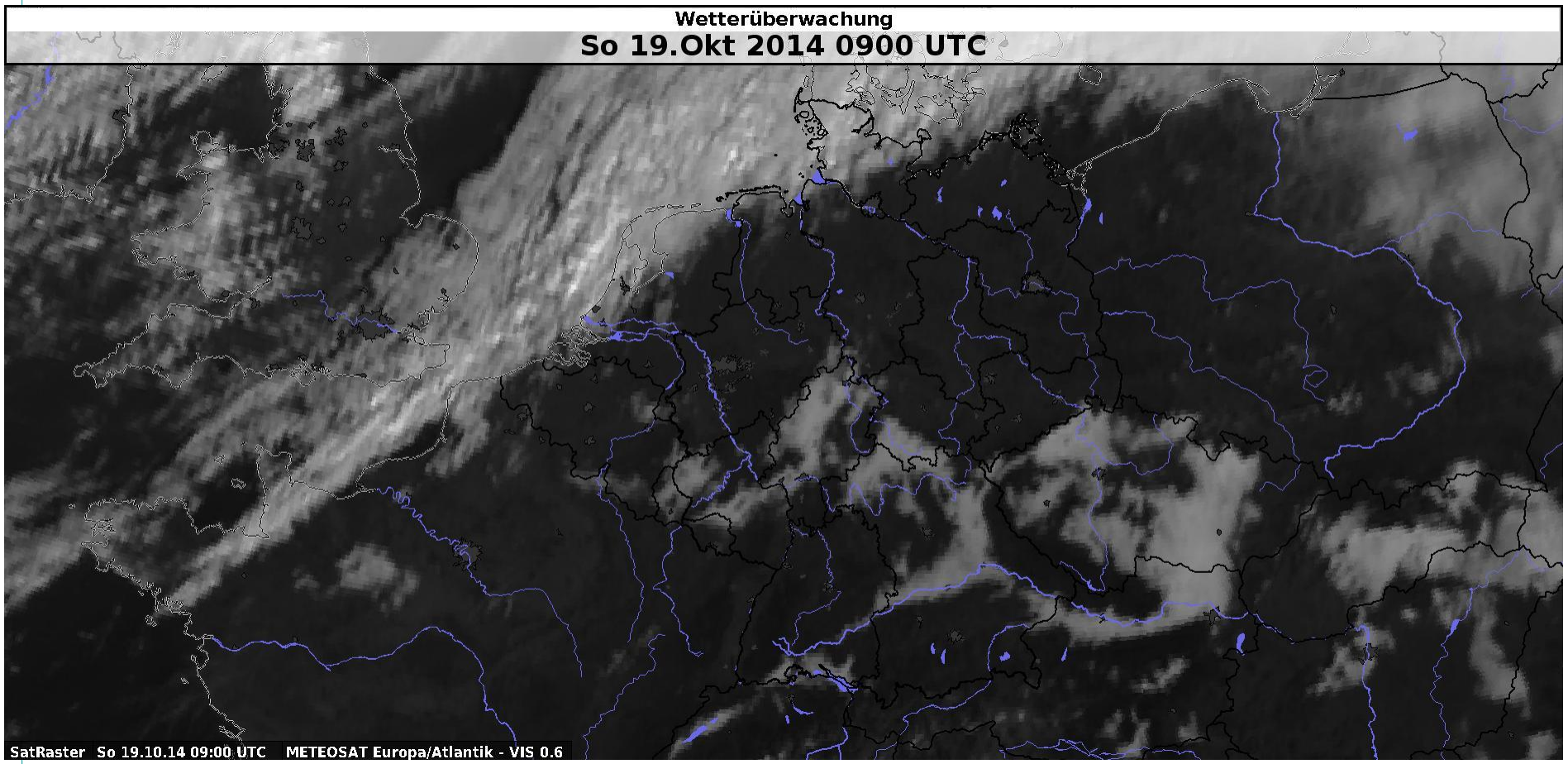
Moistening fog / drizzle

Fog/low stratus: HRV – 19/10/2014, 09 UTC (Most powerful for detailed considerations)



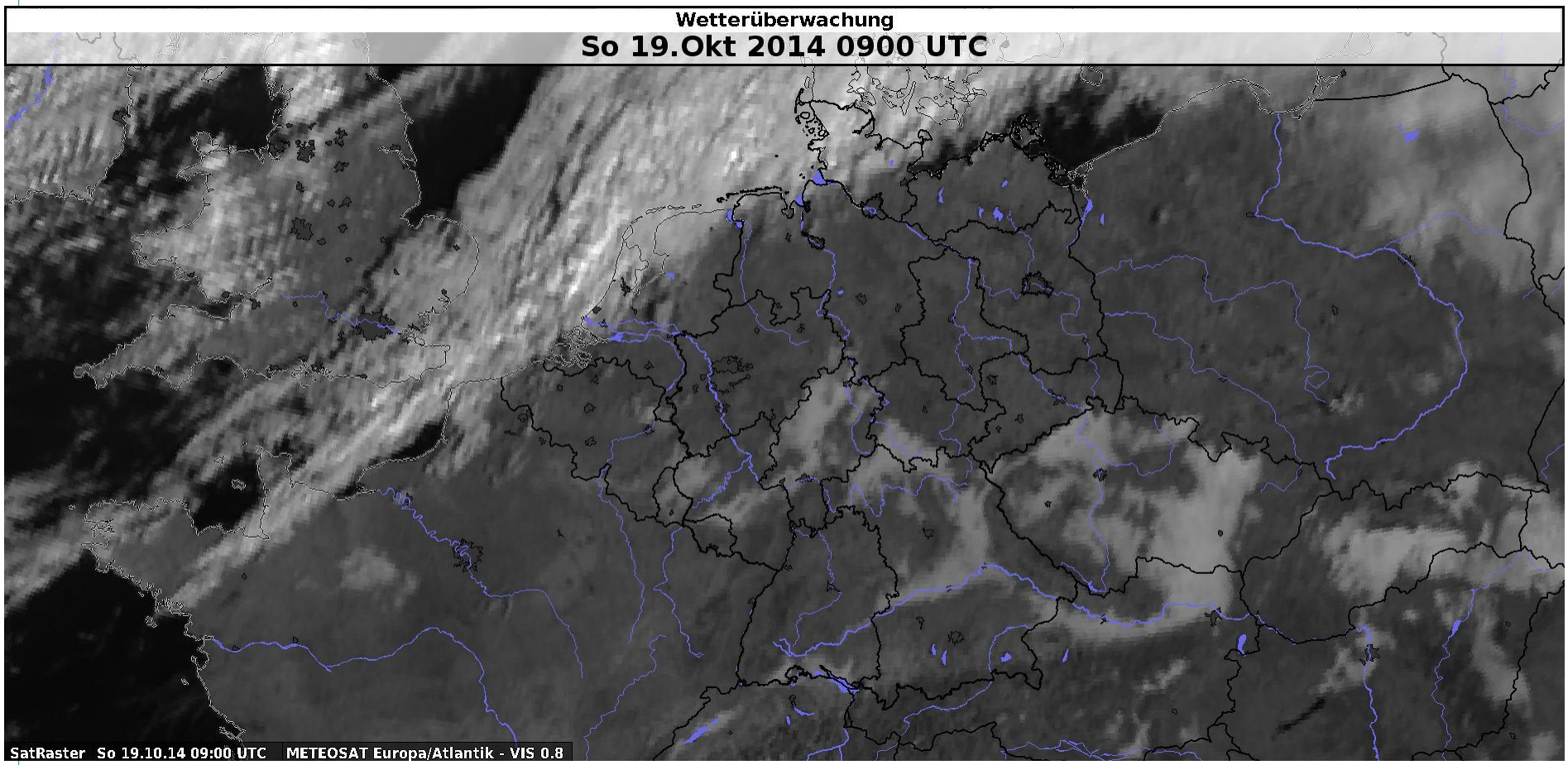
Fog/low stratus: 0.6µm – 19/10/2014, 09 UTC

(higher contrast, however, thinner fog/St-layers difficult to indentify)



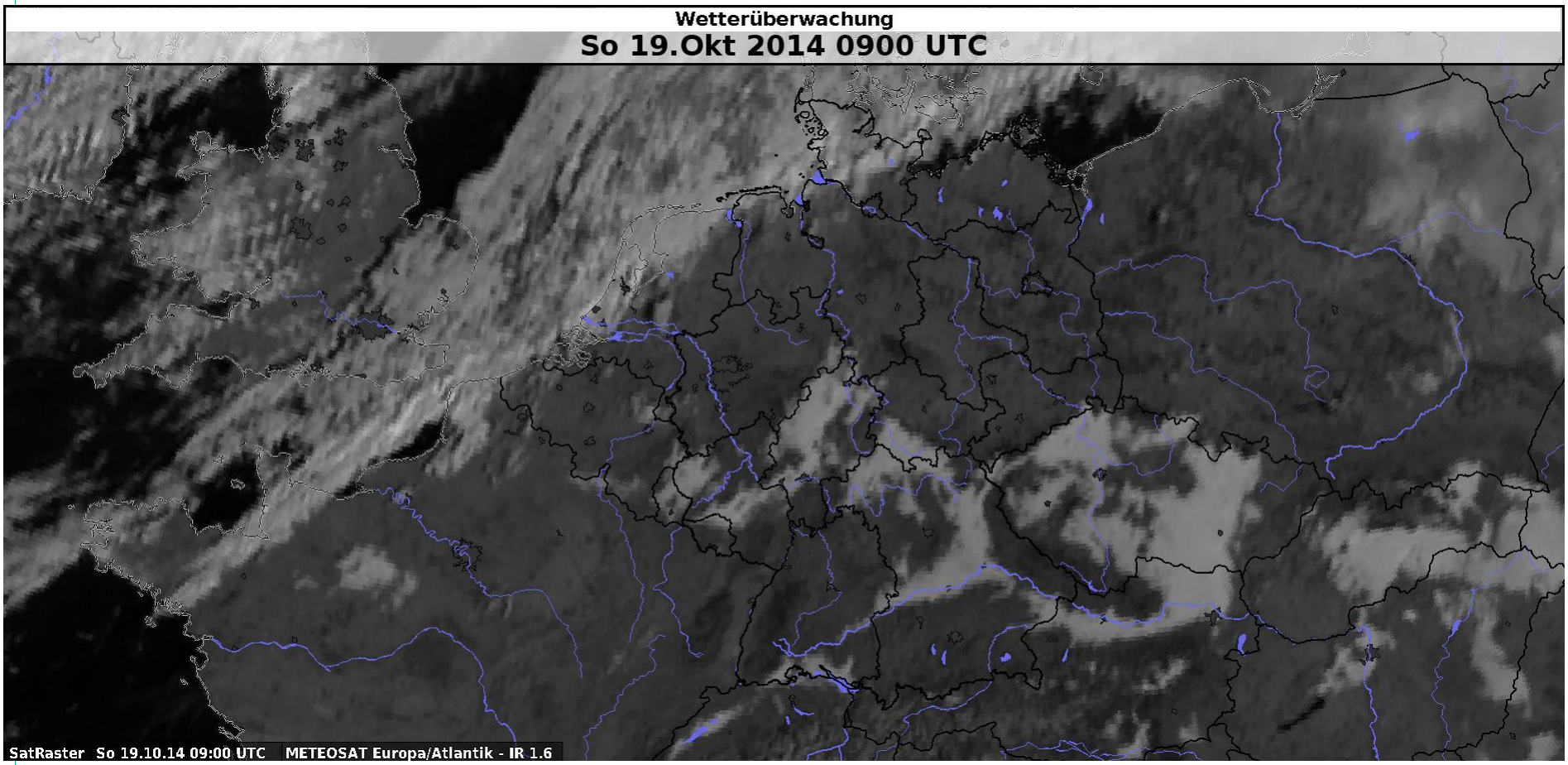
Fog/low stratus: 0.8µm – 19/10/2014, 09 UTC

(less contrast, however, thinner fog/St-layers easier to identify)



Fog/low stratus: 1.6µm – 19/10/2014, 09 UTC

(St, fog brighter, thinner fog/St-layers easier to identify than with 0.8µm)

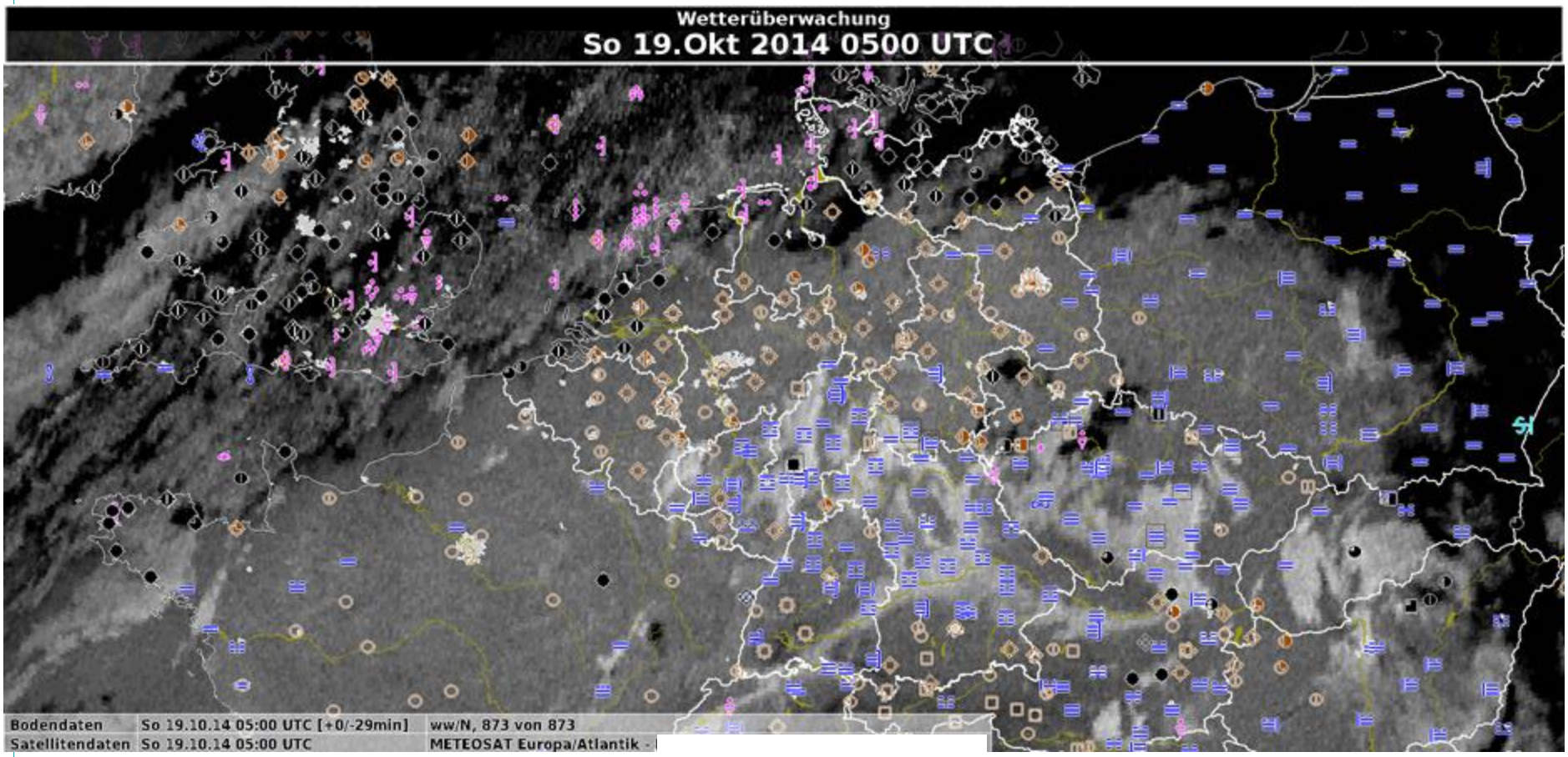


FOG/low stratus: (10.8 – 3.9) µm

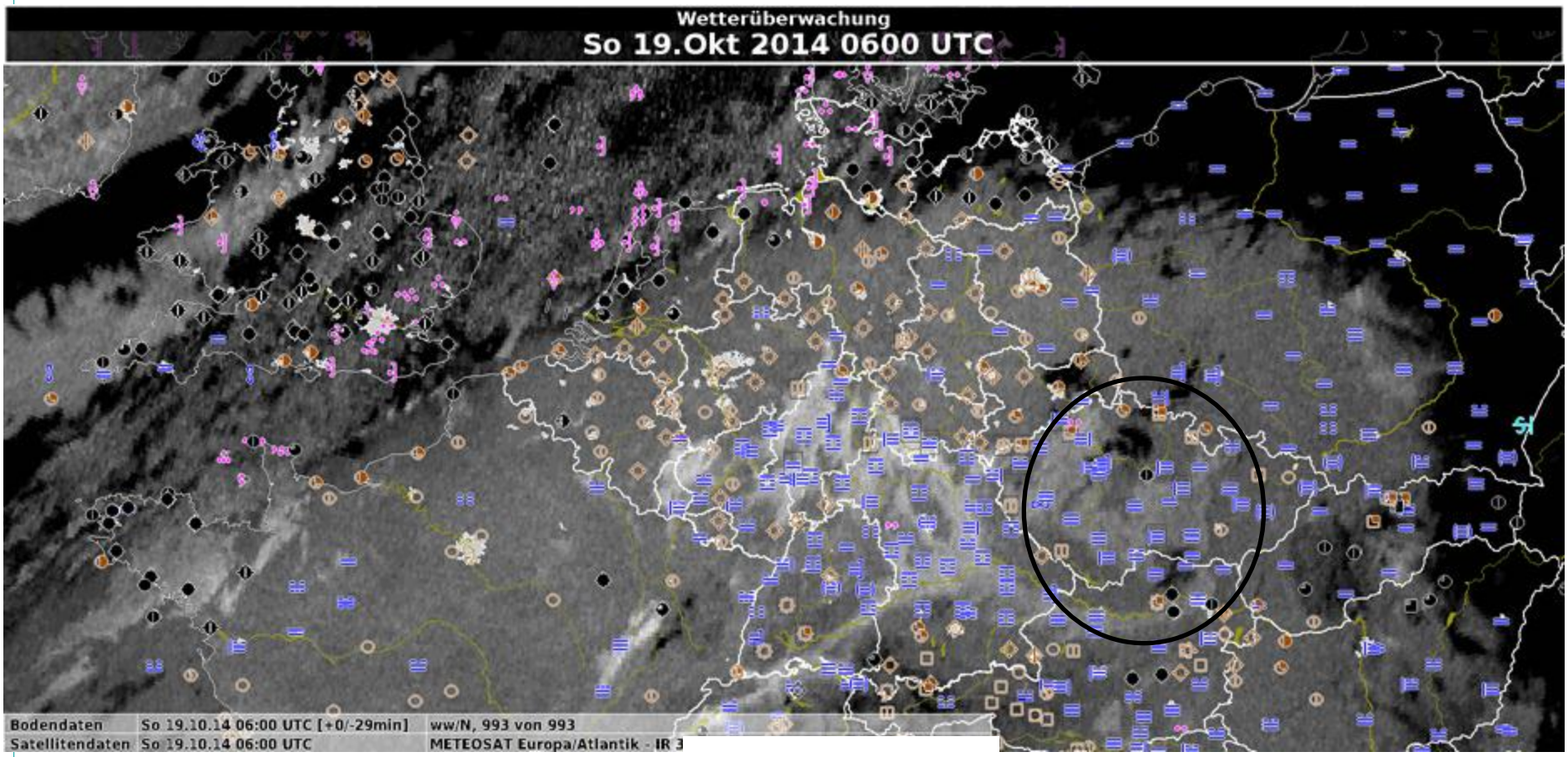
- Small water droplets (fog, low stratus) exhibit a lower emissivity in the 3.9 µm channel than in the 10.8 µm channel.
- Night: Differences (10.8 – 3.9) µm show positive values (normally up to plus 10 K)
- This will be used for the detection of fog and and low stratus during night time.
- Recommended for fog/low St-detection during the night

- Hint for practical work: During the night cloud top temperature about -10 degrees and no clouds above → drizzle possible, may be freezing

(10.8 – 3.9) µm 0 to 10 K, 19/10/2014, 05 UTC
(low level water clouds (St, fog): relatively bright (night time))

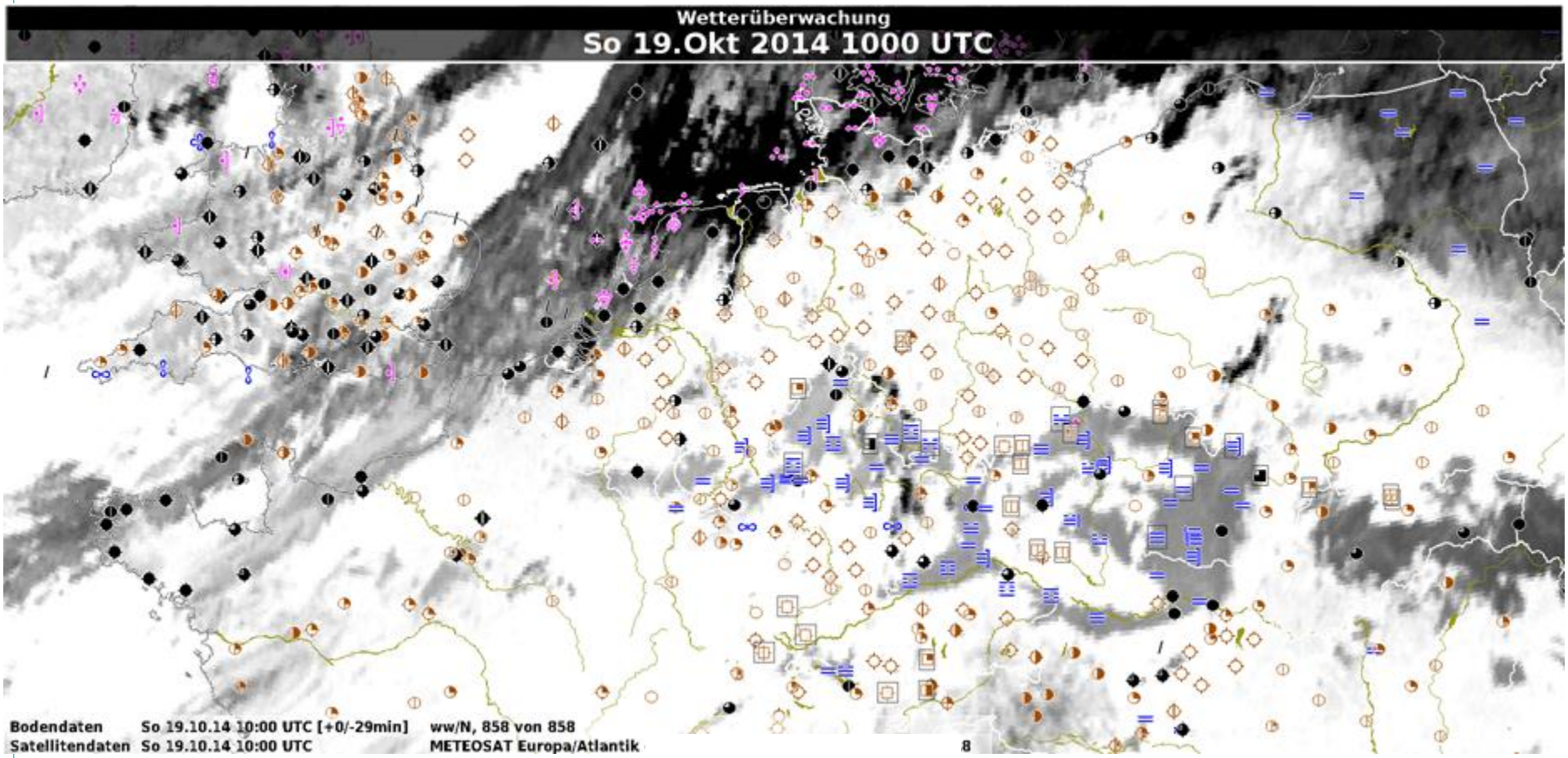


(10.8-3.9) µm (0 to 10 K) 19/10/2014, 06 UTC
(low level water clouds (St, fog)
bright (night time) / around sunrise (difficult to identify)



(10.8-3.9) µm, -30 to 0K) 19/10/2014, 10 UTC

(low level water clouds (St, fog),
after sunrise grey to almost black, HRV or RGB “day microphysik better

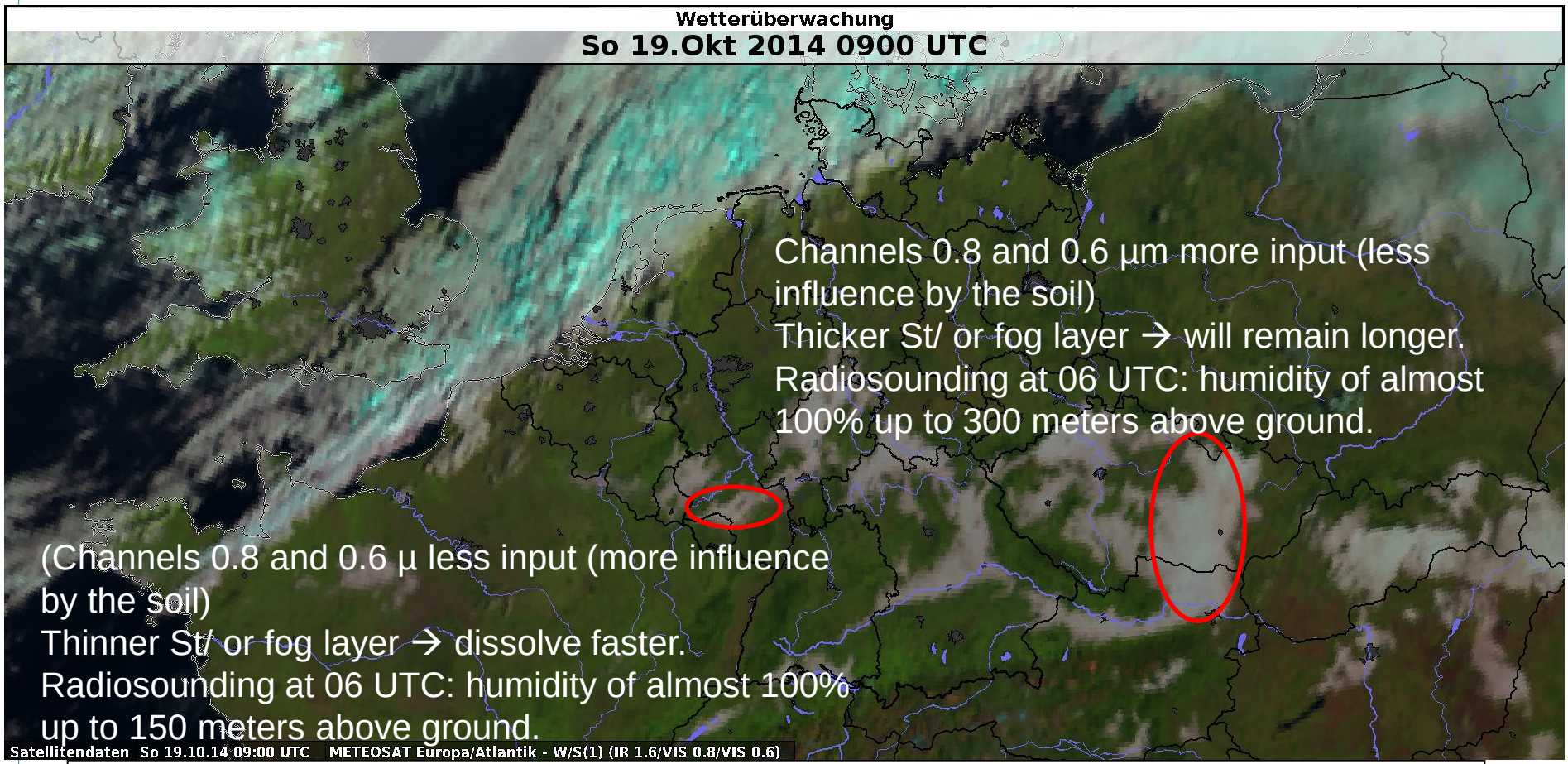


FOG / St: RGBs (during the day)

RGB (Day Natural Colours)

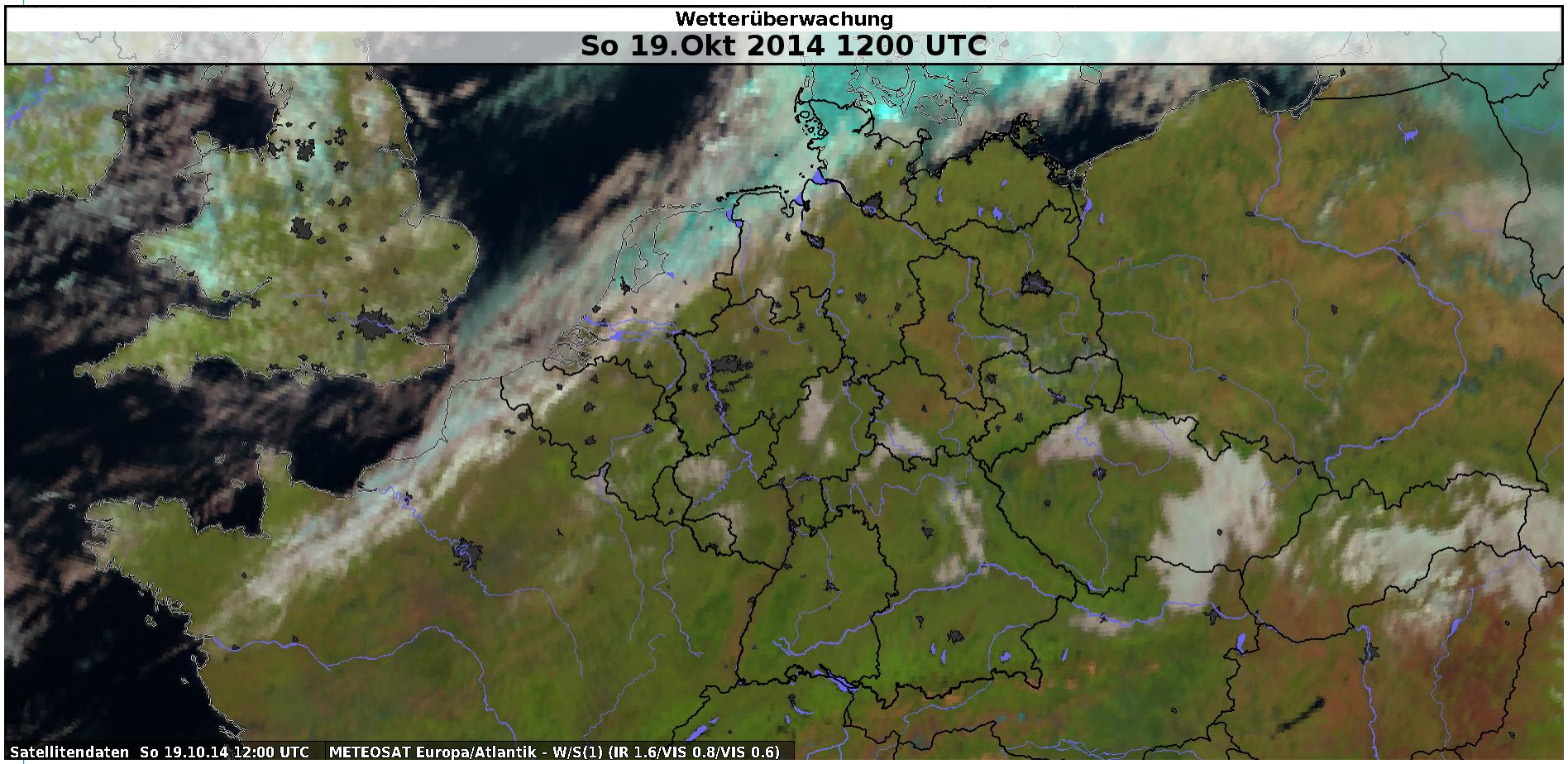
R = NIR1.6
G = VIS0.8
B = VIS0.6

RGB (Day Natural Colours, 1.6/0.8/0.6) – 19.10.2014, 09 UTC (low level water clouds (St, fog)



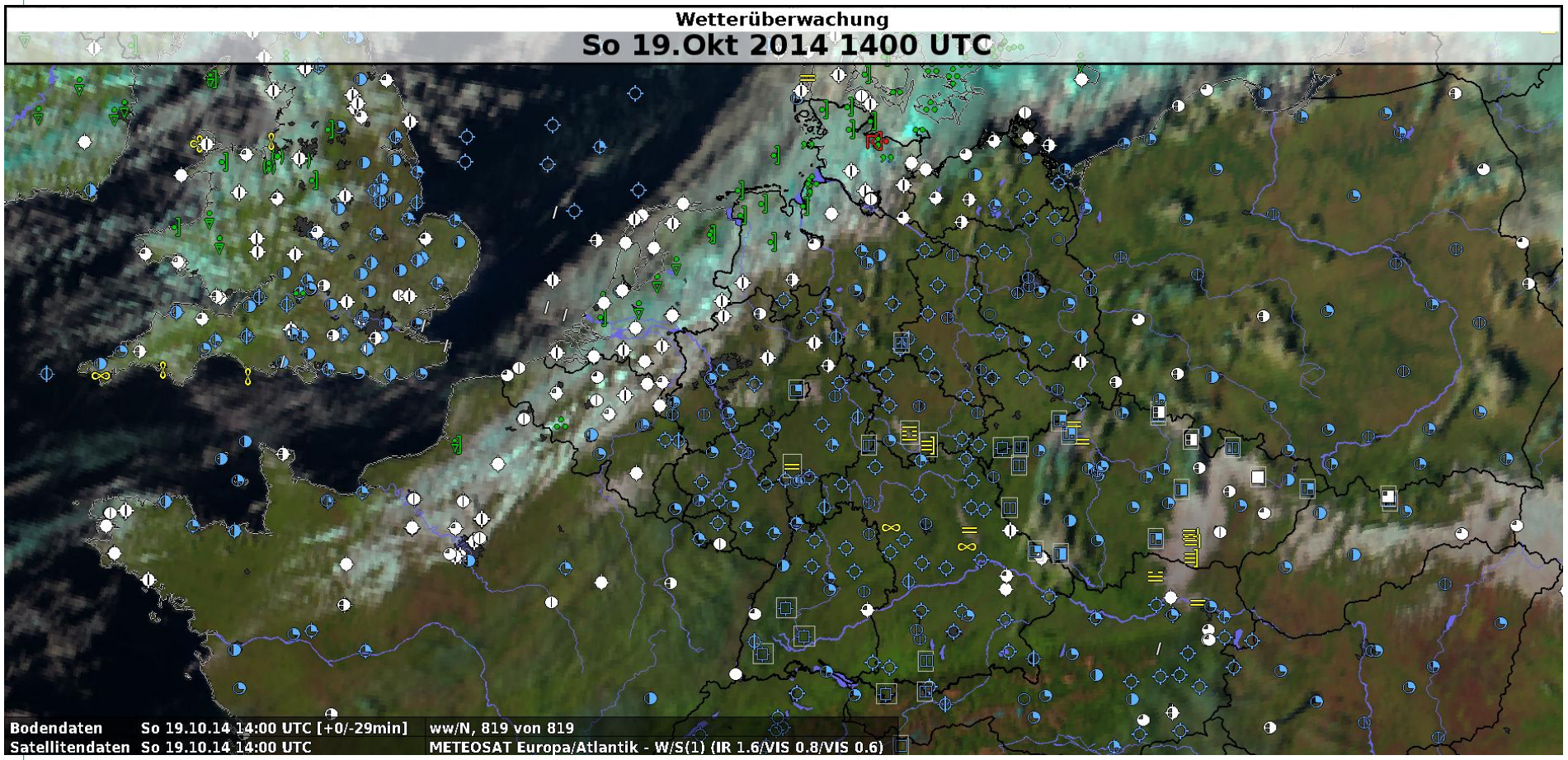
Low St / fog (thinner layer) appear in pinkish-whitish
Low St / fog (thicker layer) appear in whitish-greenish

RGB (Day Natural Colours, 1.6/0.8/0.6), 19.10.2014, 12 UTC (low level water clouds (St, fog)

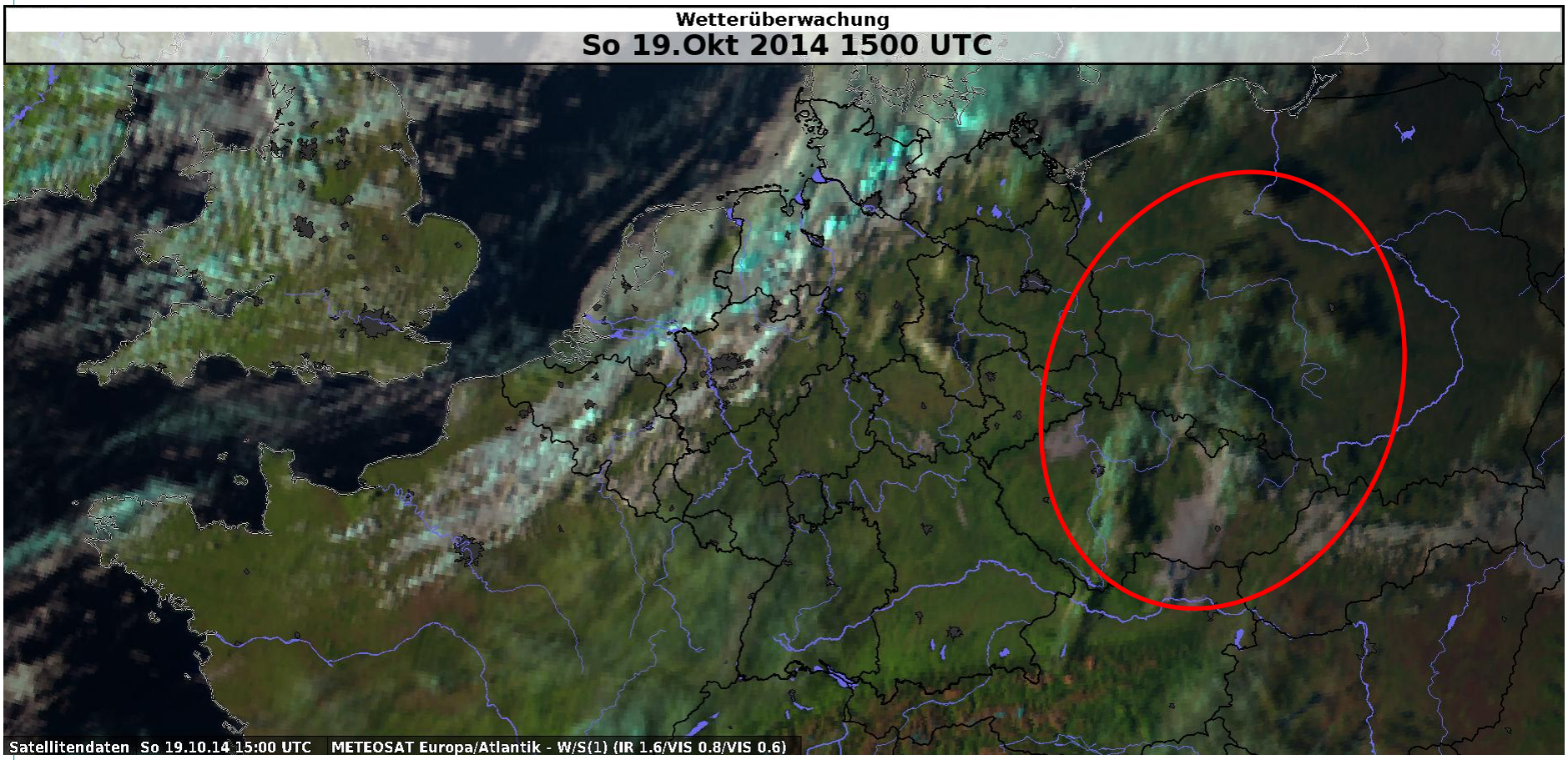


Which fog/St-areas will probably not dissolve? (Please use the yellow star.)

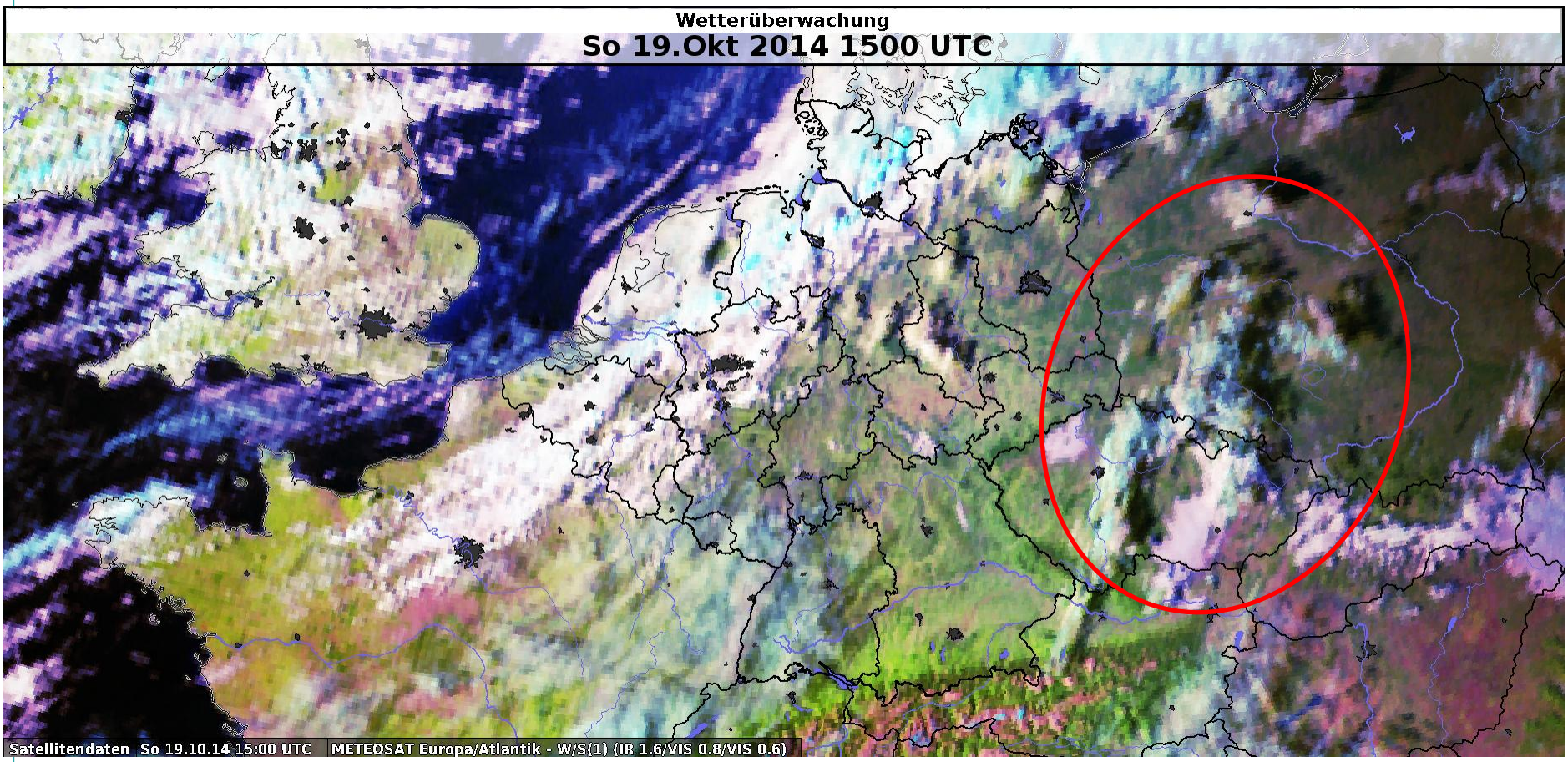
RGB (Day Natural Colours, 1.6/0.8/0.6), 19.10.2014, 14 UTC (low level water clouds (St, fog)



RGB (Day Natural Colours, 1.6/0.8/0.6), 19.10.2014, 15 UTC (low level water clouds (St, fog) – Shadow / no shadow



RGB (Day Natural Colours, 1.6/0.8/0.6) - enhanced, 19.10.2014, 15 UTC (low level water clouds (St, fog) – Shadow / no shadow



Water and ice clouds, snow: NIR/HRV/HRV (better spatial resolution)

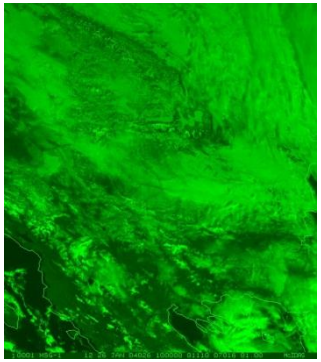
Colour	channel	values
red	NIR1.6	0 … +70%
green	HRV	0 … +100%
blue	HRV	0 … +100%

26-01-2004, 10 UTC: Snow, water clouds (St, fog over SE/E-Europe)

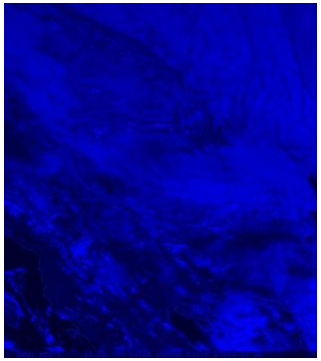
(J. Kerkmann, EUMETSAT)

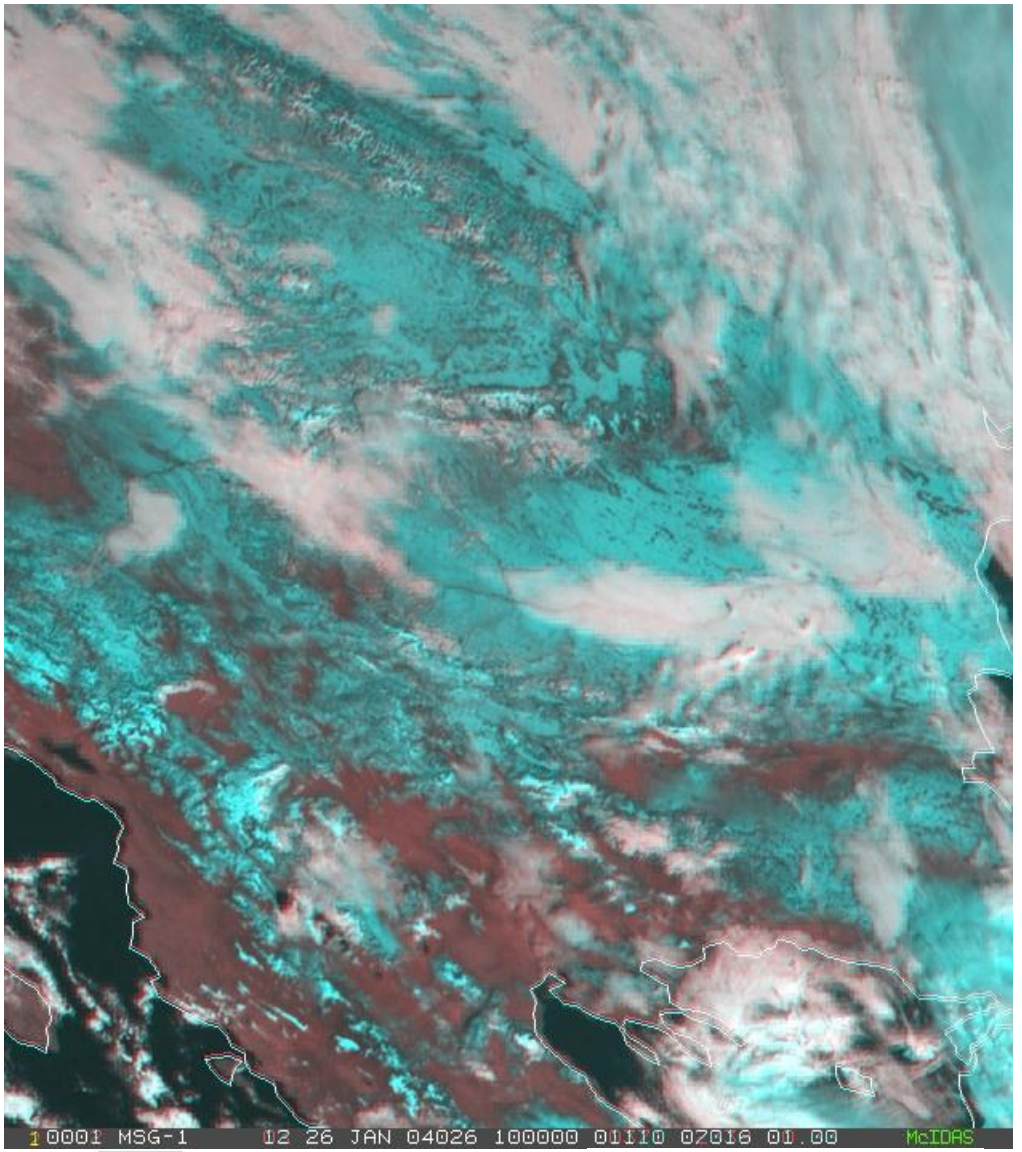
NIR1.6

HRV



HRV





EUMETRAIN

DWD

EUMETCAL

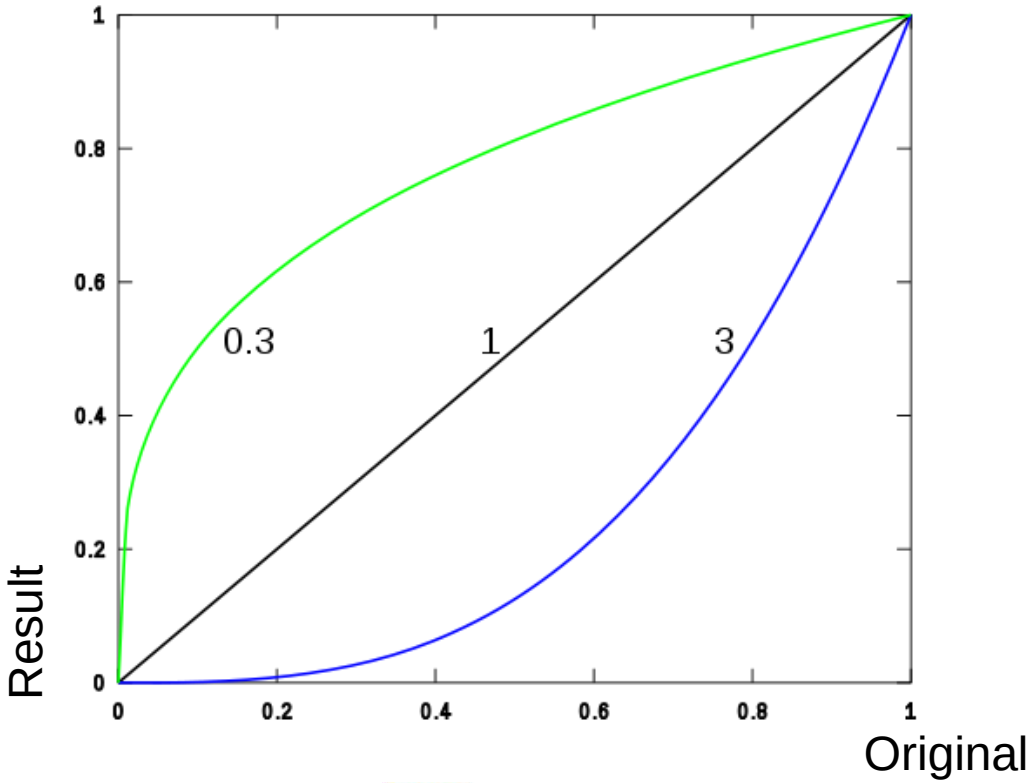
RGB (day solar, also for fog/St)

R = VIS0.8 (0-100%, Gamma=1.7)
G = NIR1.6 (0-70%, Gamma=1.7)
B = 3.9ref (0-30%, Gamma=1.7)

Image processing: Gamma – Principle

- Purpose: Increase amount of information from images
- Processing of brightnesses of pixel
  - Gamma>1: relative high input values expanded, low compressed
  - Gamma<1: Vice-versa

Source: Wikipedia (from 29th October 2014) http://de.wikipedia.org/wiki/Gammakorrektur



RGB (day solar, 0.8/1.6/3.9ref): Interpretation of Colours for Thick Ice and Water Clouds

(J. Kerkmann, EUMETSAT)

Deep precipitating cloud (precip. not necessarily reaching the ground)

- bright, thick
- large ice particles

Deep precipitating cloud*

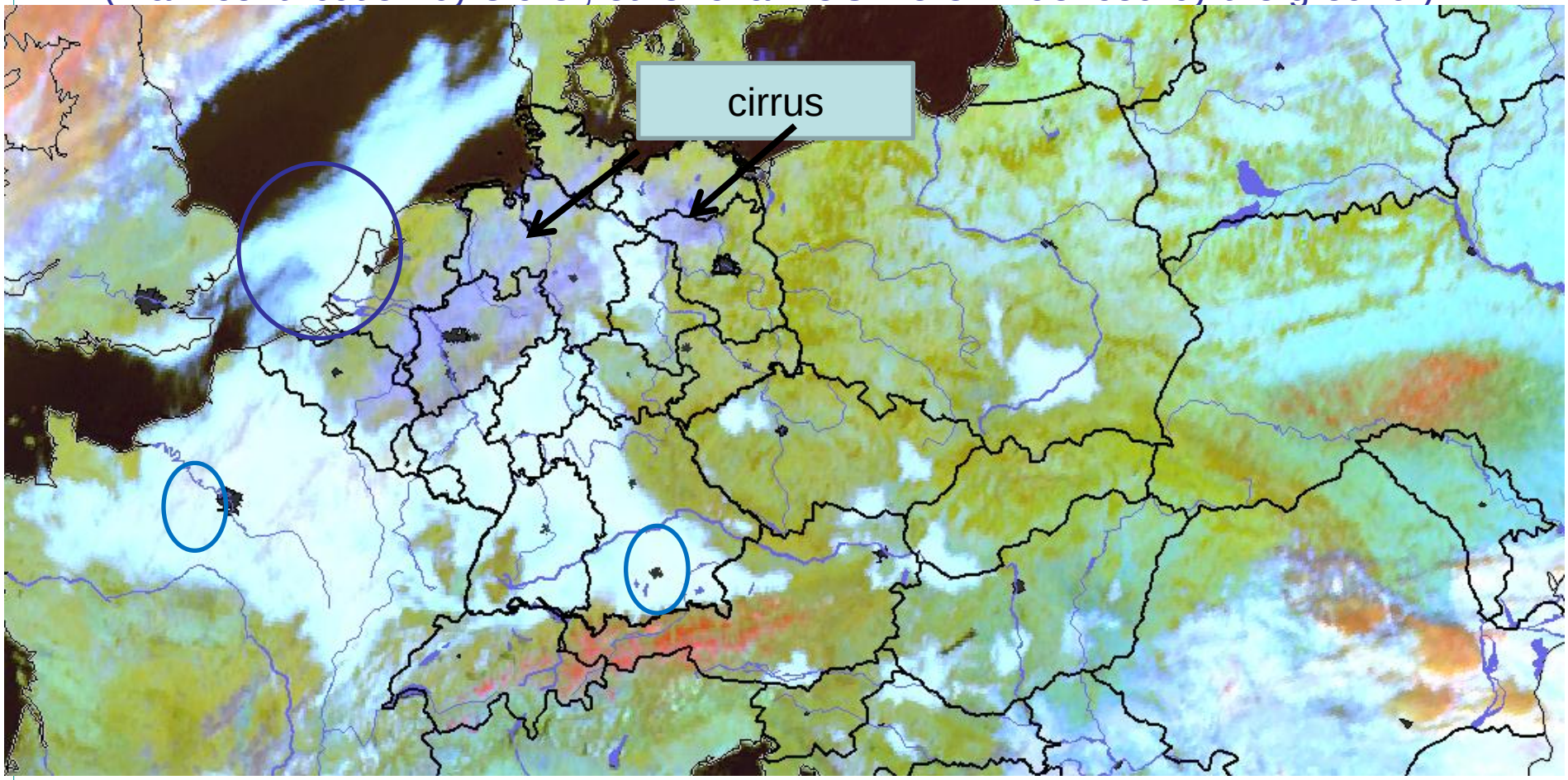
- bright, thick
- small ice particles

*or thick, high-level lee cloudiness with small ice particles

Thick water cloud with large droplets

Thick water cloud with small droplets

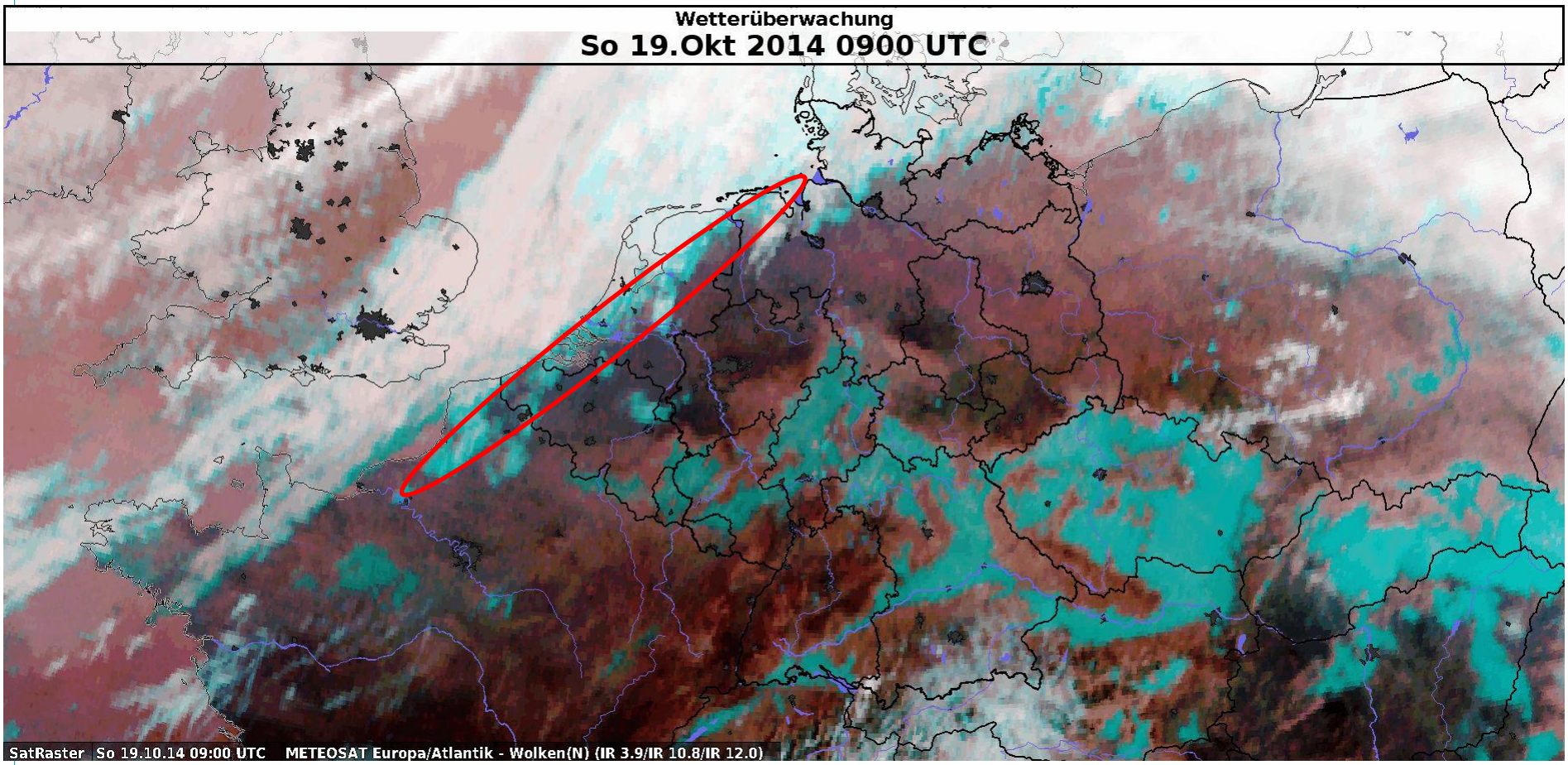
RGB (day solar, 0.8/1.6/3.9ref), 28.10.2014, 12 UTC
Munich: Thick layer (1000 meter, -1 Grad) of St, fog: whitish
Trappes: thinner layer (500 meter, 5 Grad) of St, fog, whitish-blueish
SW-North Sea: NE-part thicker St, fog
English channel thin St, fog → just about to dissolve
(main contribution by 3.9ref, other channels more influenced by the ground.)



RGB (Night-Composite, during daytime)

R = 3.9
G = 10.8
B = 12.0

RGB (night, 3.9/10.8/12.0), 19.10.2014, 09 UTC
St, fog: cyan



Question (marking): Please use the F2-buttom. Which technique do you use for answering the question: „Fog/stratus or low frontal clouds? (one word would be enough.)

RGB (Microphysik-day)

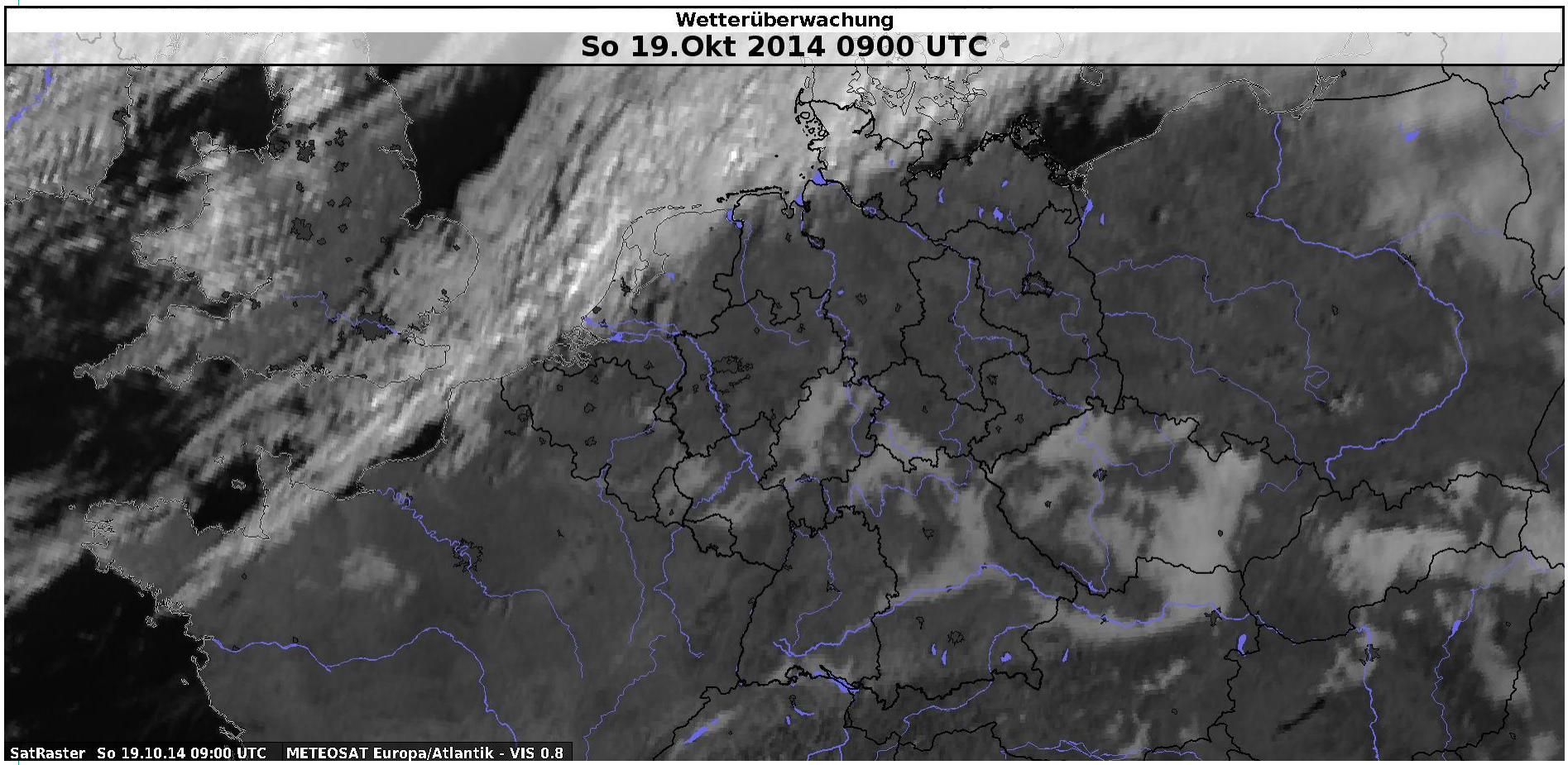
R = VIS 0.8

G = 3.9 ref (0 to 60%) Gamma = 2.5

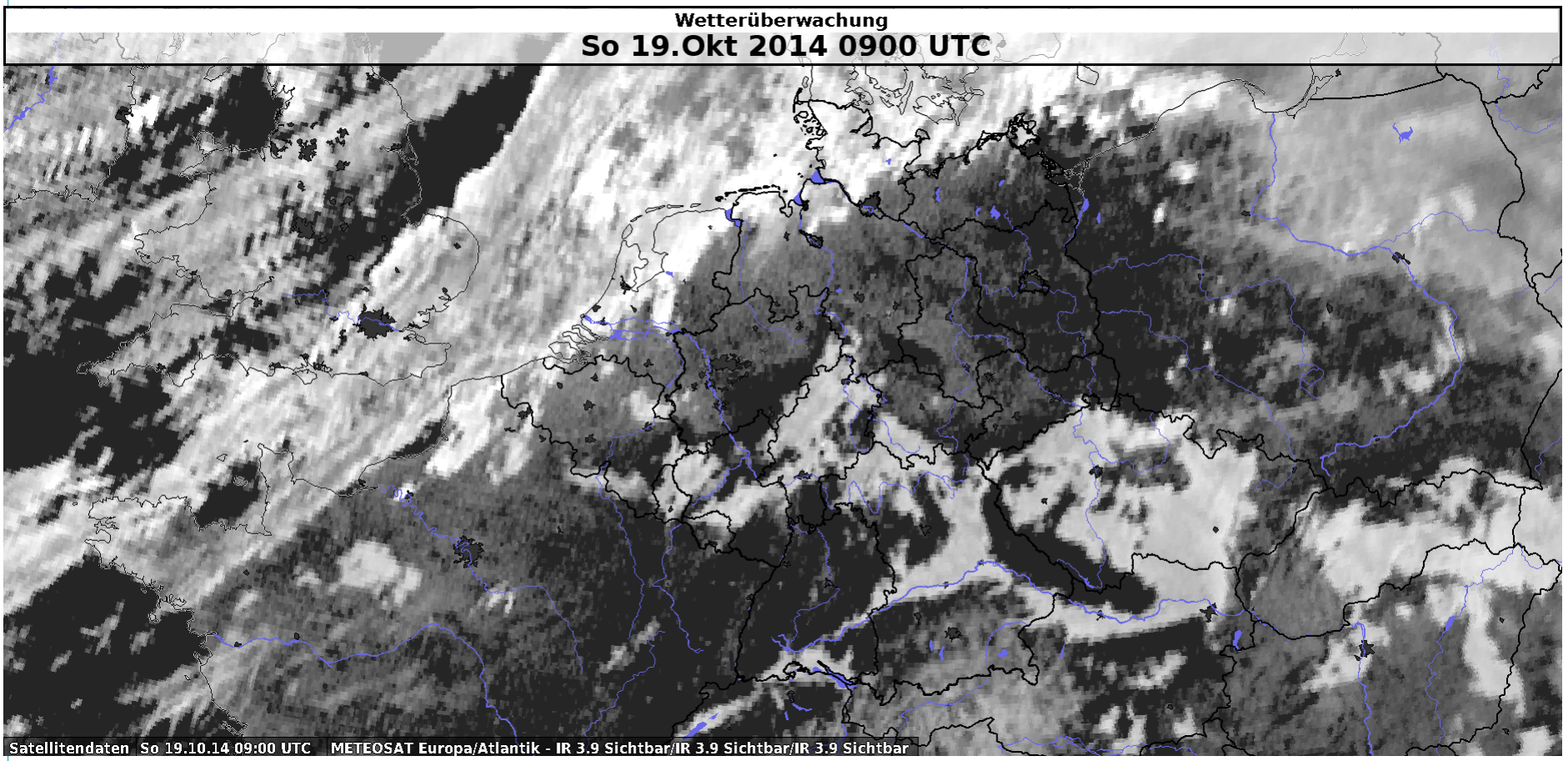
B = 10.8 (203 to 323 K) – fog / St: almost no contribution

Fog/low stratus: 0.8µm – 19/10/2014, 09 UTC

thinner St/fog layers more difficult to identify than with 3.9 ref

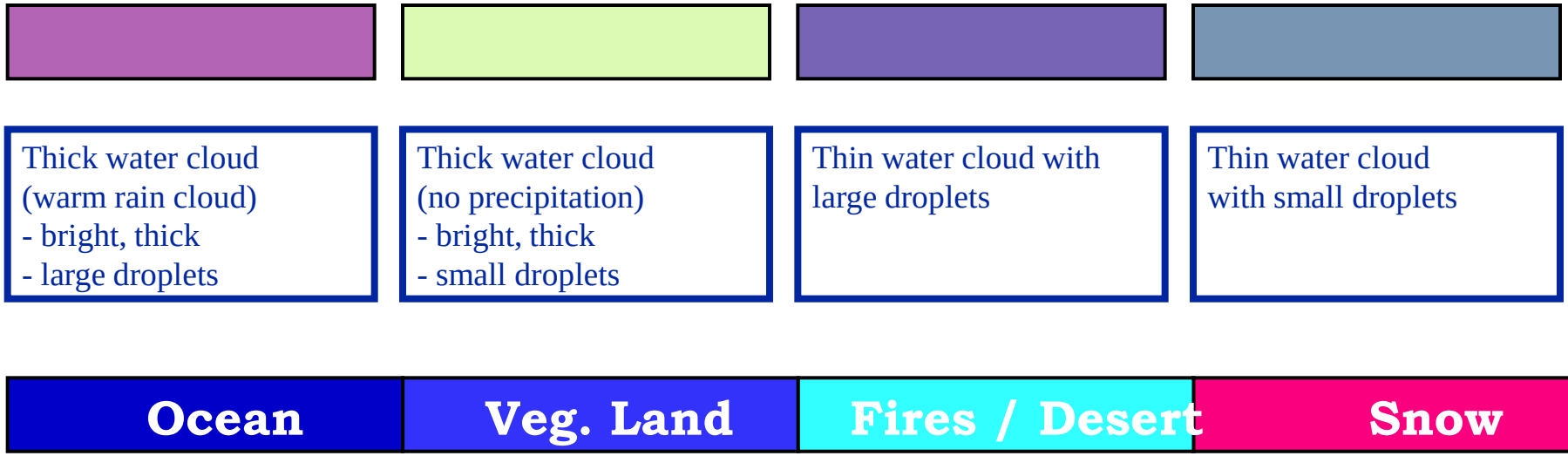


3.9 µm-ref (0 to 60%, Gamma = 2.5), 19.10.2014, 09 UTC
St, fog: light-grey to whitish, thinner fog layers (>100m) detecable

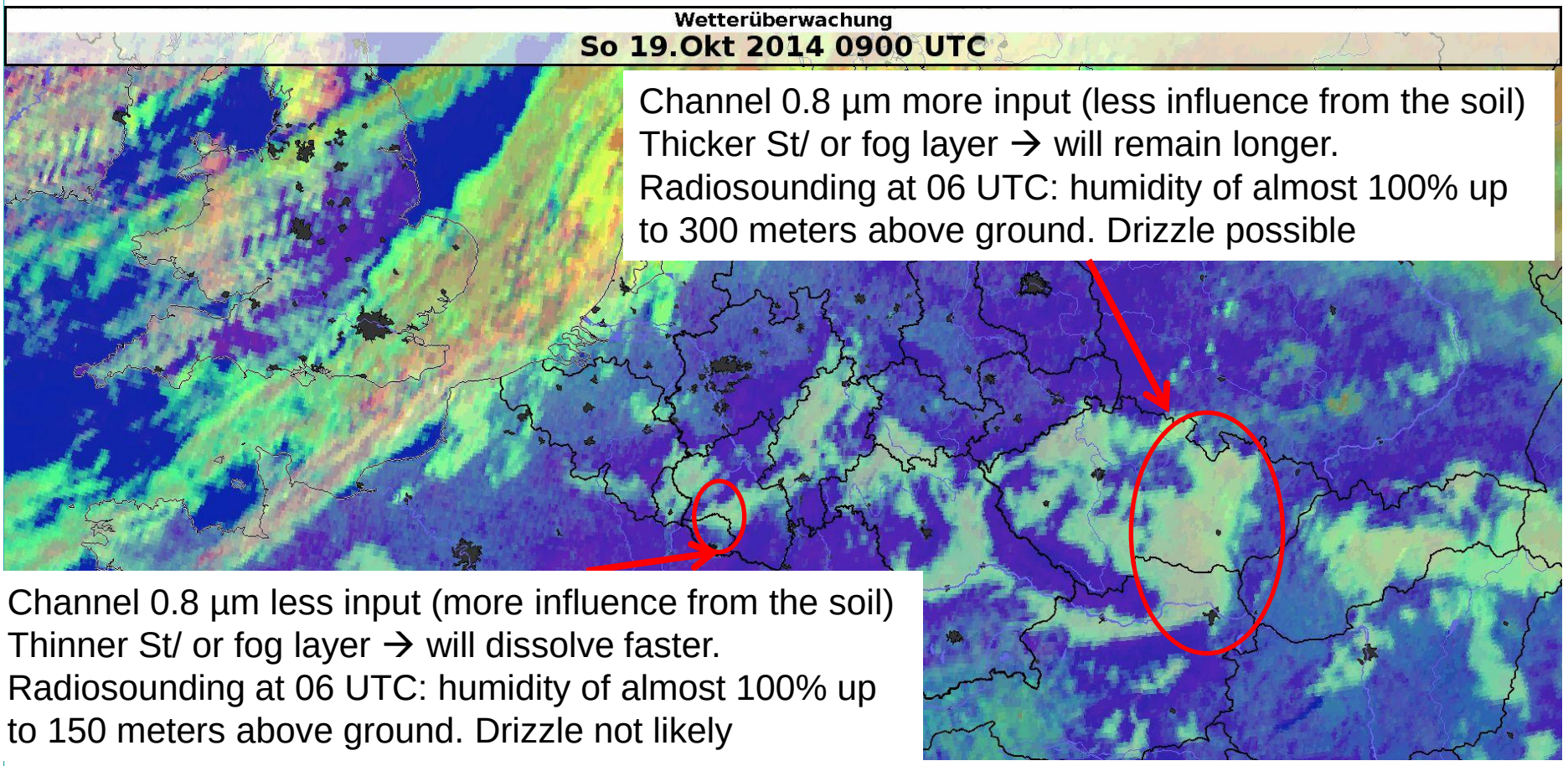


RGB Day Microphysik: Interpretation of Colours for Low-level Clouds

(J. Kerkmann, EUMETSAT)



RGB (Day Microphysik (0.8/3.9ref/10.8), 19.10.2014, 09 UTC St, fog: thinner layer: bright greenish / thicker layer: pinkish

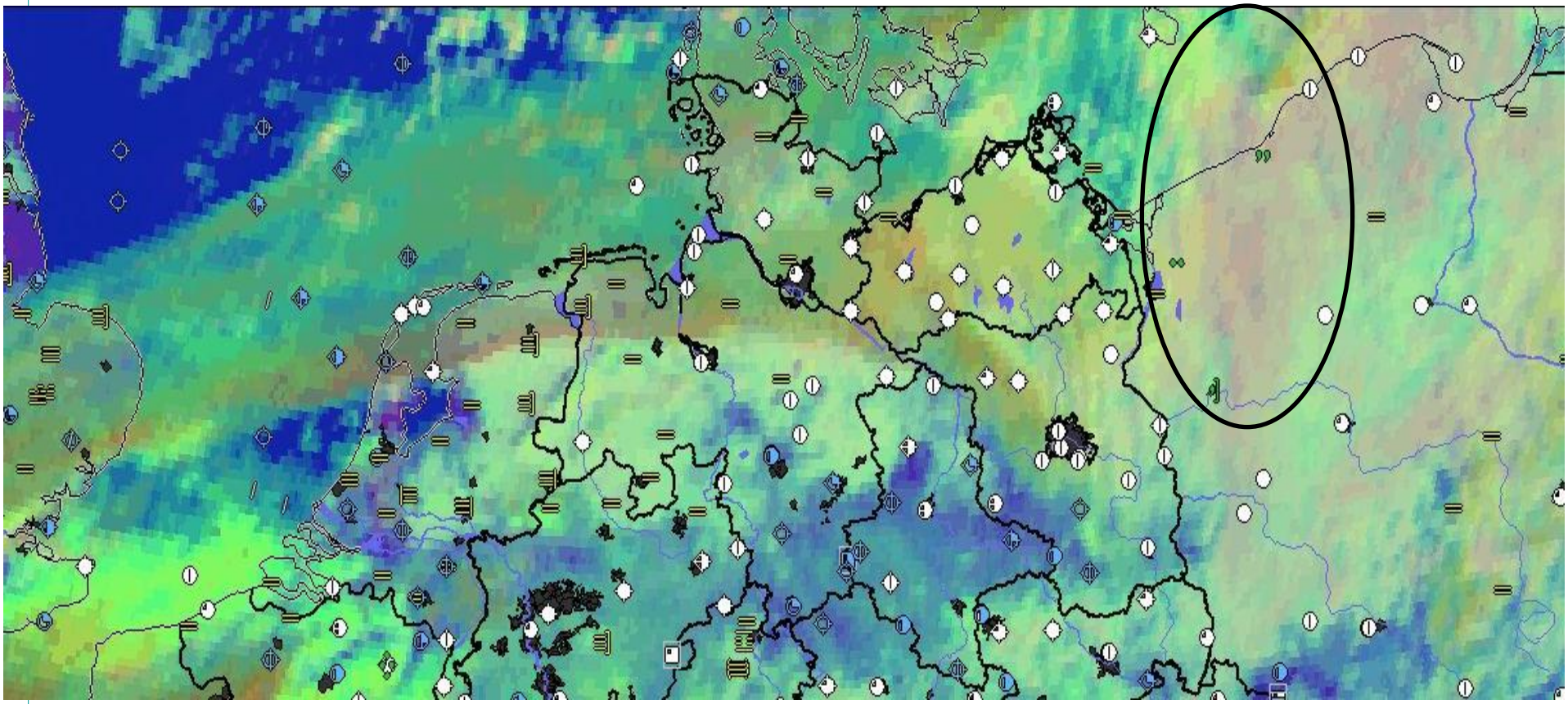


Channel 0.8 µm more input (less influence from the soil)
Thicker St/ or fog layer → will remain longer.
Radiosounding at 06 UTC: humidity of almost 100% up to 300 meters above ground. Drizzle possible

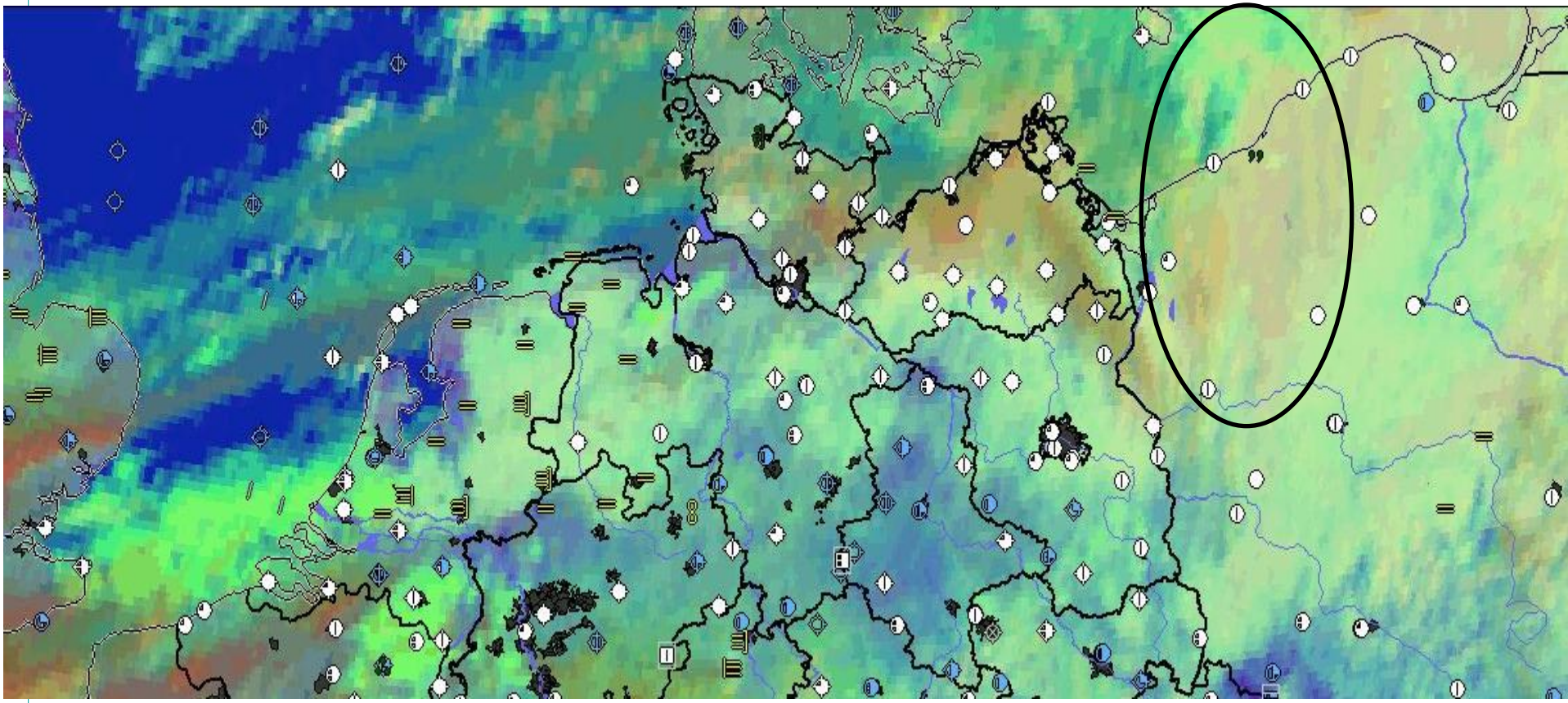
Channel 0.8 µm less input (more influence from the soil)
Thinner St/ or fog layer → will dissolve faster.
Radiosounding at 06 UTC: humidity of almost 100% up to 150 meters above ground. Drizzle not likely

Small differences possible due to different image processing or different hardware

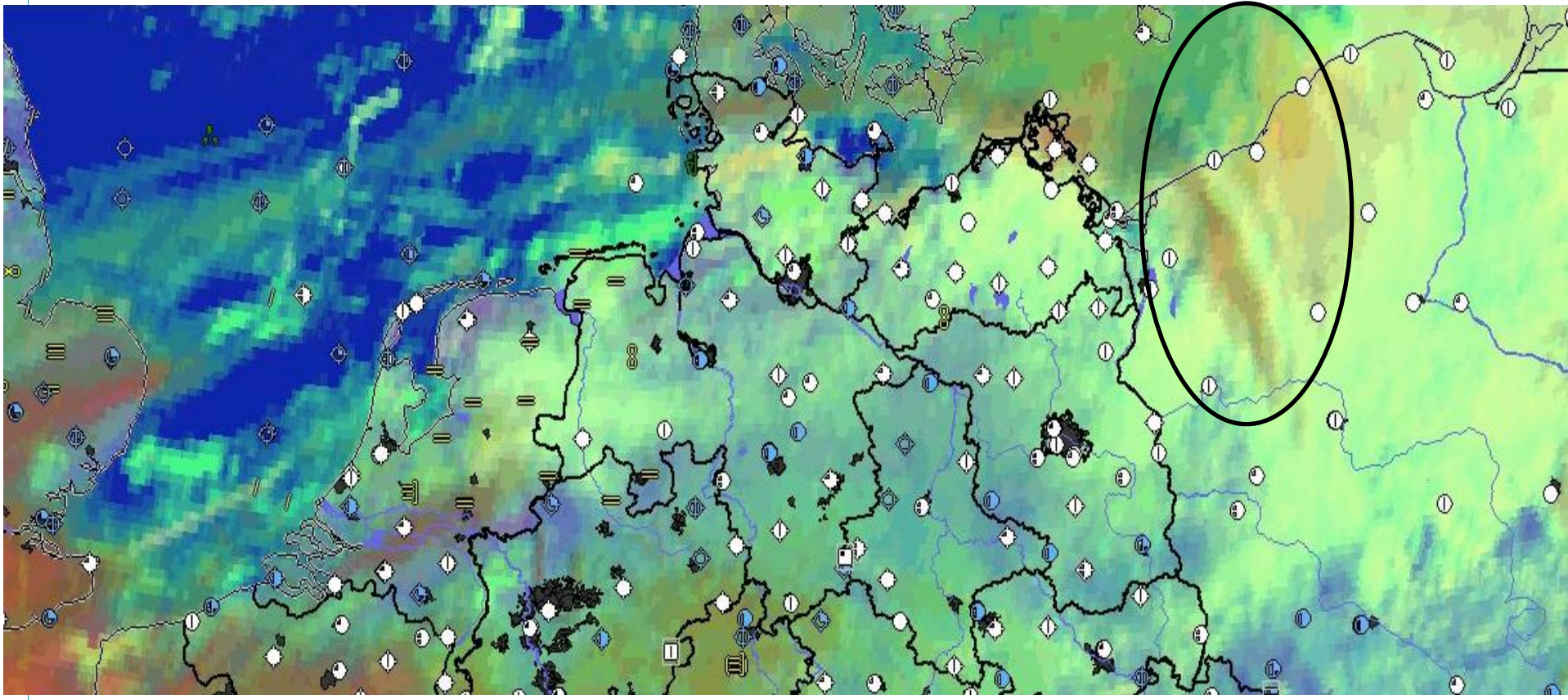
RGB (Day Microphysik (0.8/3.9ref/10.8), 12.10.2014, 09 UTC thicker layer: pinkish (some drizzle/light rain), will remain



RGB (Day Microphysik (0.8/3.9ref/10.8), 12.10.2014, 10 UTC thicker layer: pinkish (some drizzle/light rain), will remain

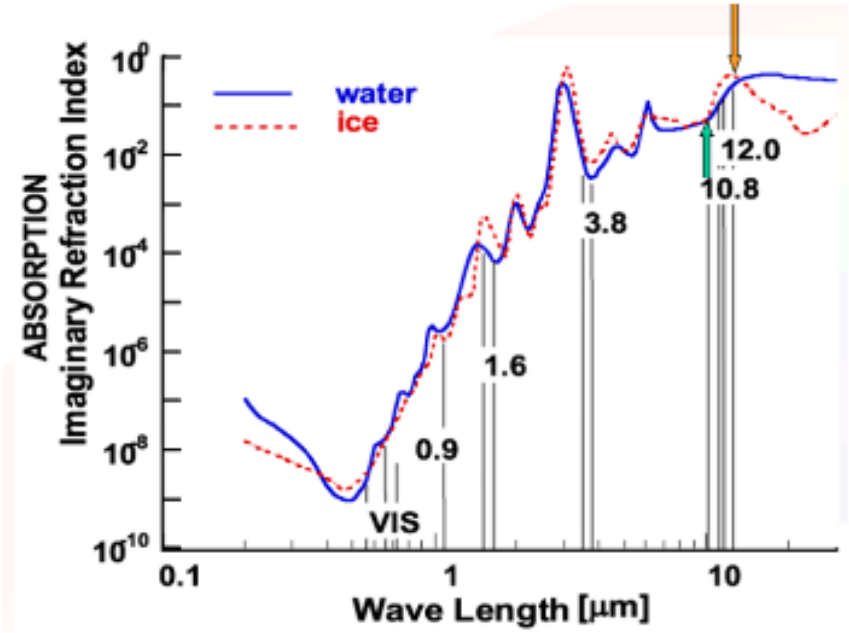


RGB (Day Microphysik (0.8/3.9ref/10.8), 12.10.2014, 11 UTC
thicker layer: superimposed by higher clouds



FOG / St: RGBs (day & night)

Cloud phase: Differences between (12.0 – 10.8) µm



The channel 12.0 µm absorbs slightly more for ice clouds than the channel 10.8 µm. Although the difference is small (-4 to +2 K) water clouds and ice clouds can be distinguished.

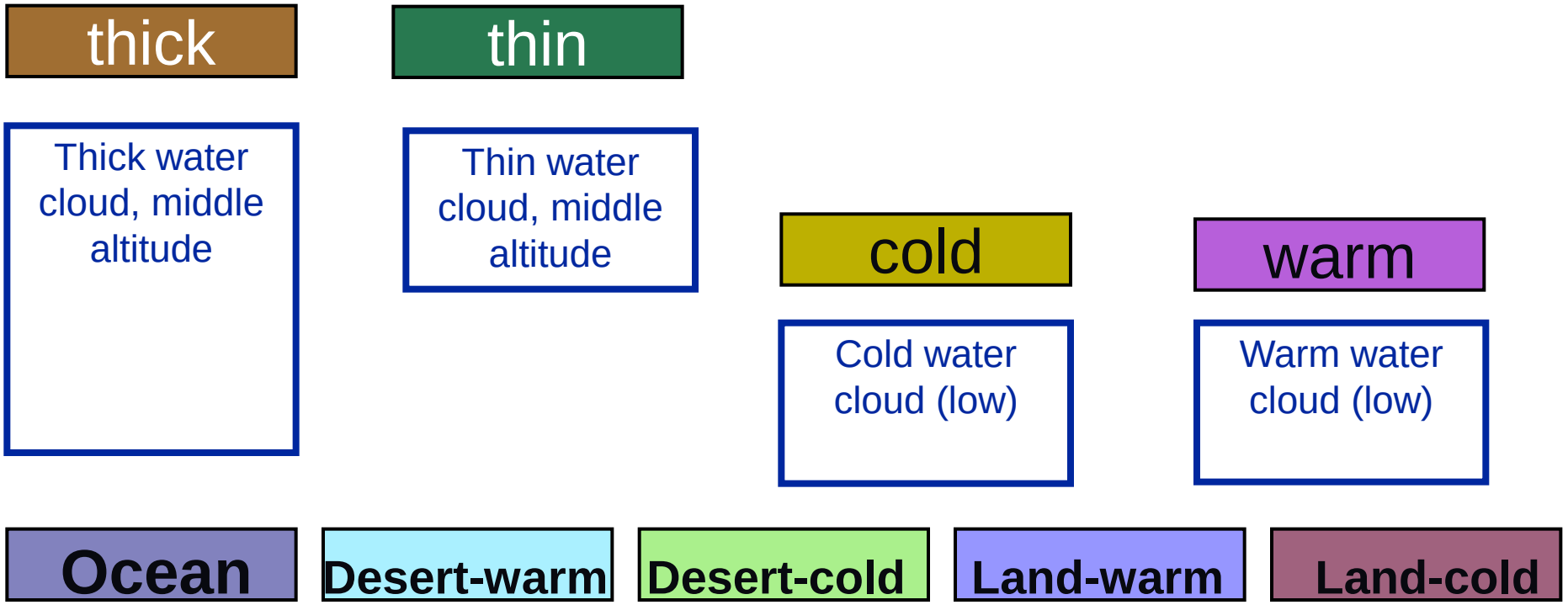
(Source: EUMeTrain: http://www.eumetrain.org/data/2/253/navmenu.php?tab=3&page=2.0.0)

RGB (Dust Microphysik– 24h)

R = 12.0-10.8 (-4 to +2 K) – phase and optical thickness
G = 10.8-8.7 (0 to +15 K, Gamma = 2.5) – phase and optical thickness
B = 10.8 (261 to 289 K) – cloud top temperature

RGB “Dust” (IR12.0-IR10.8/IR10.8-IR8.7/IR10.8) Interpretation for middle and low clouds

(J. Kerkmann, EUMETSAT)

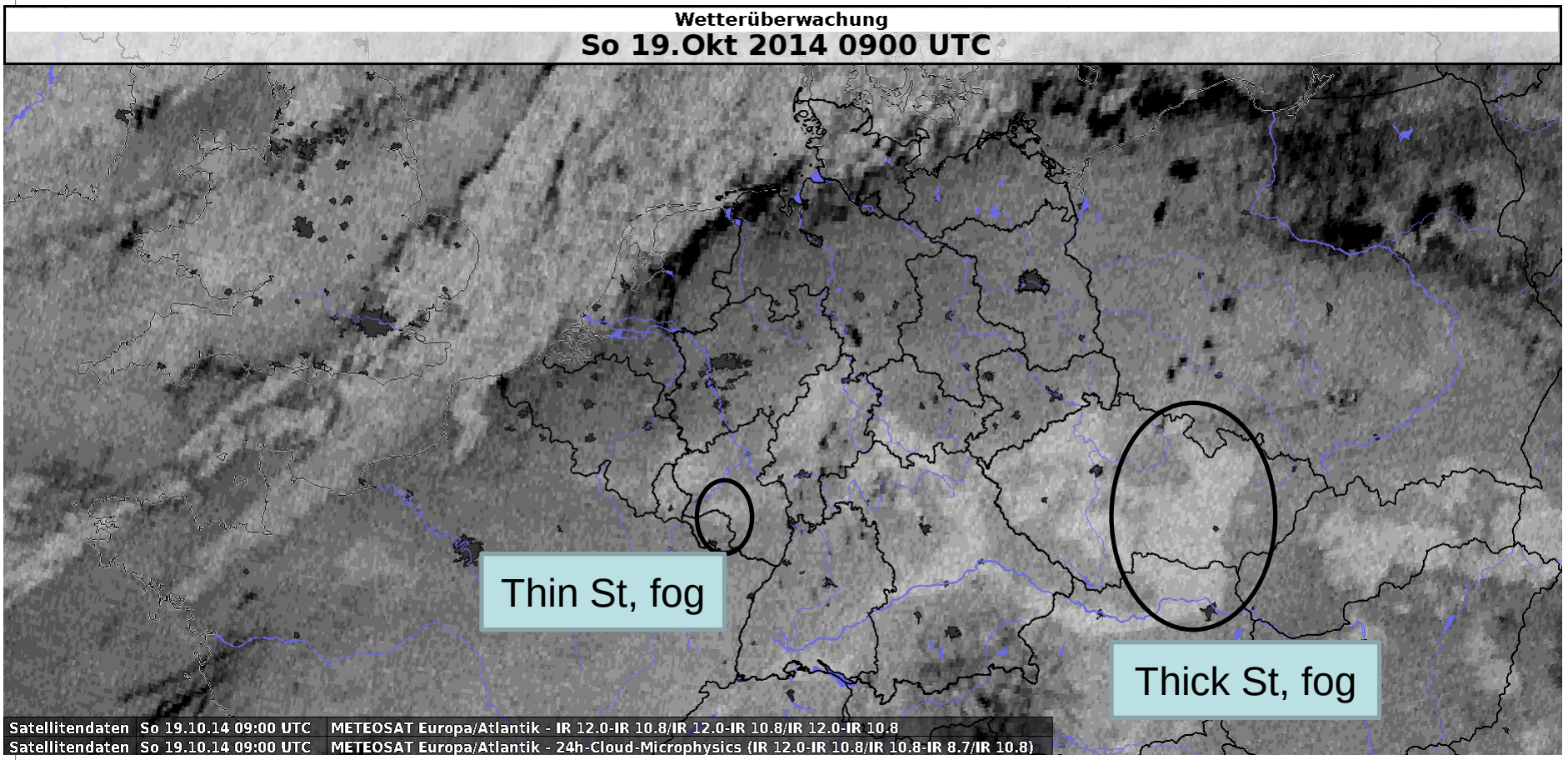


EUMETRAIN

DWD

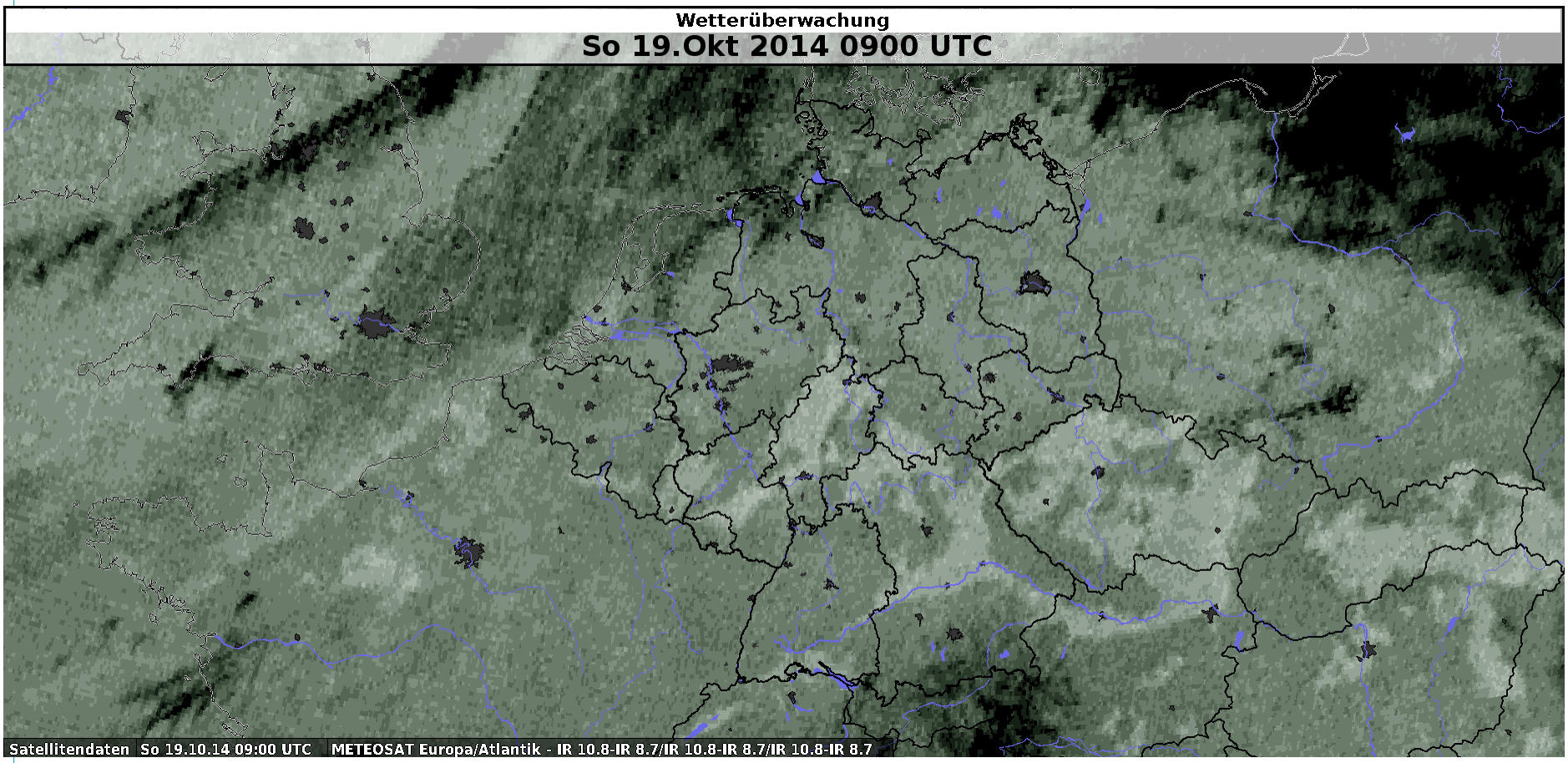
EUMETCAL

(12.0-10.8) µm,19.10.2014, 09 UTC (St, fog): brighter



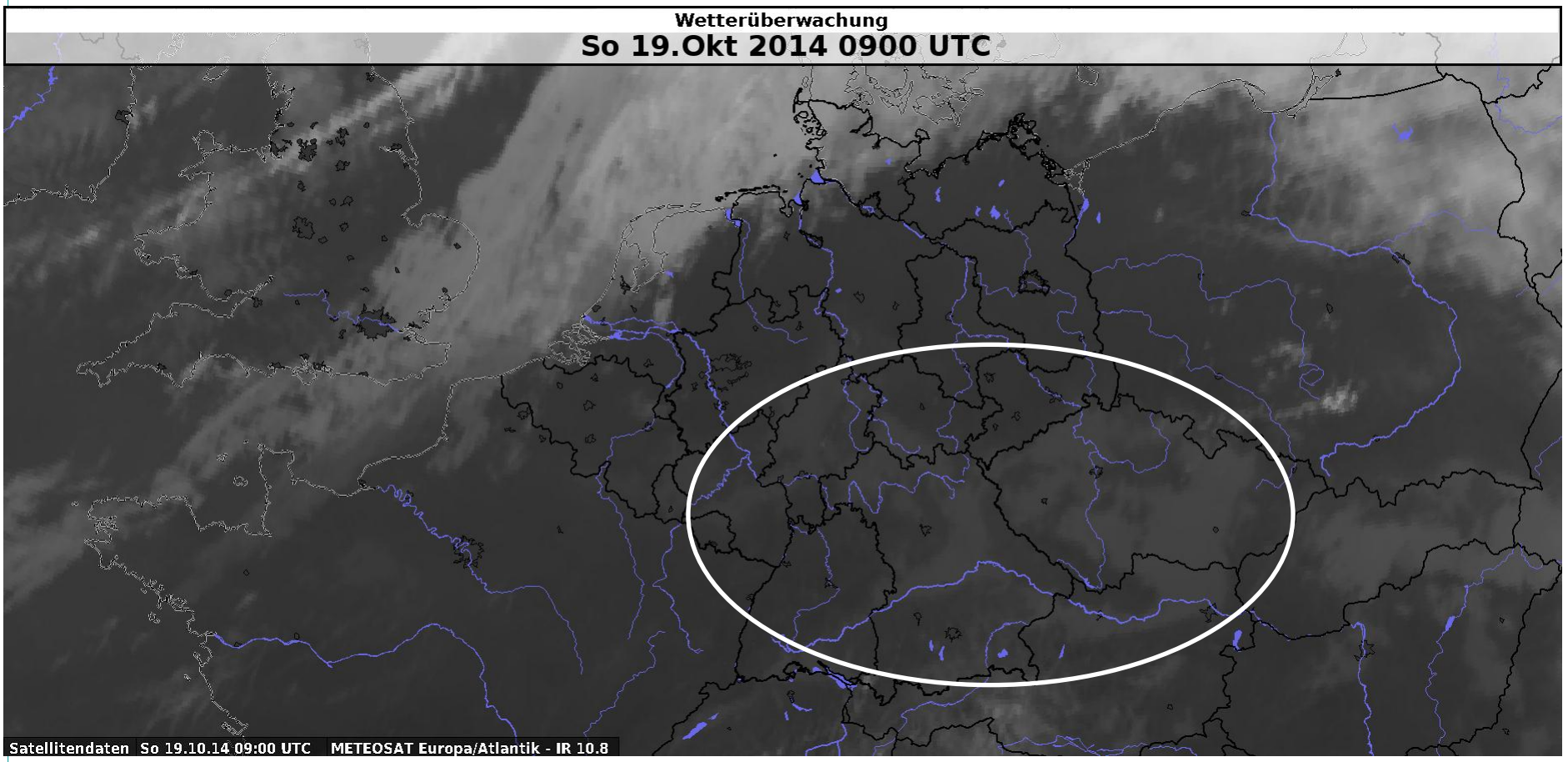
EUMETRAIN DWD EUMETCAL

(10.8-8.7) µm, Gamma = 2.5, 19.10.2014, 09 UTC (St, fog): brighter



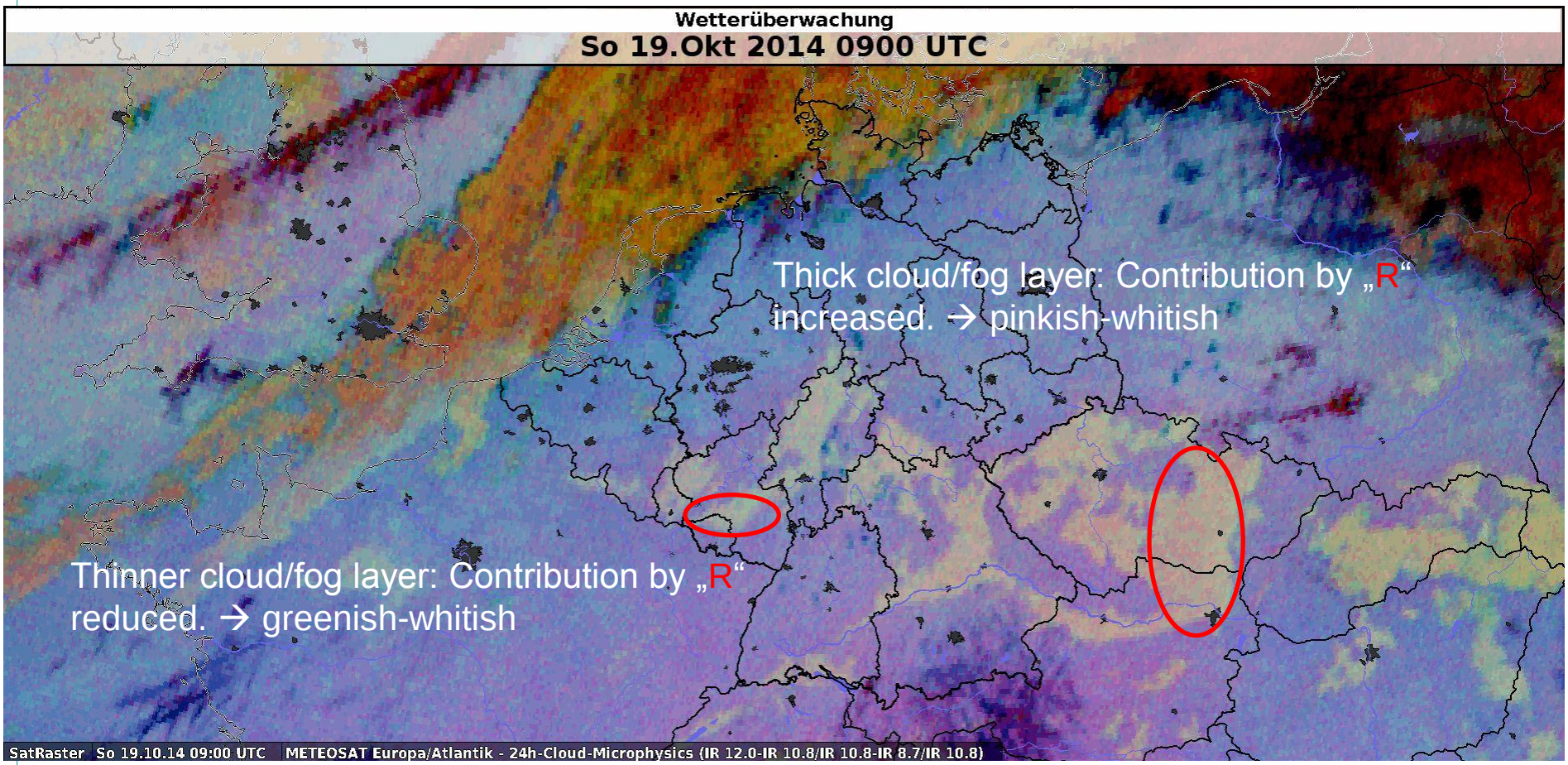
Thickness of fog and St difficult to distinguish

10.8 µm, 19.10.2014, 09 UTC (St, fog): a bit brighter (colder)

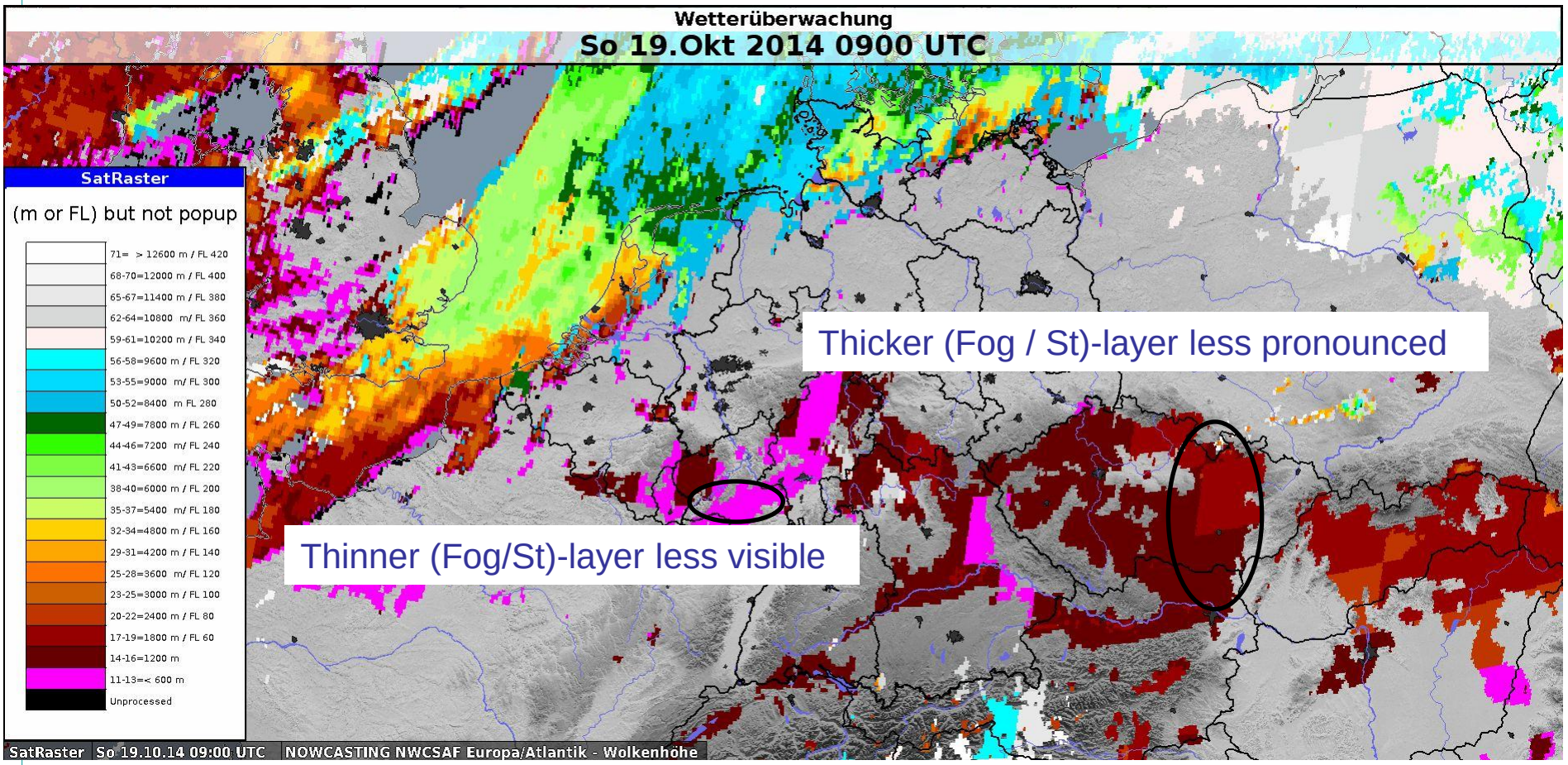


Fog, St difficult to indentify

RGB (24h-Cloud-Microphysik (12.0-10.8 / 10.8-8.7 / 10.8) µm 19.10.2014, 09 UTC



Cloud top (Nowcasting-SAF 19.10.2014, 09 UTC (St, fog): violet: < 600 m / dark brown: 600-1200 m red-brown: a few higher clouds superimposing



EUMETRAIN

DWD

EUMETCAL

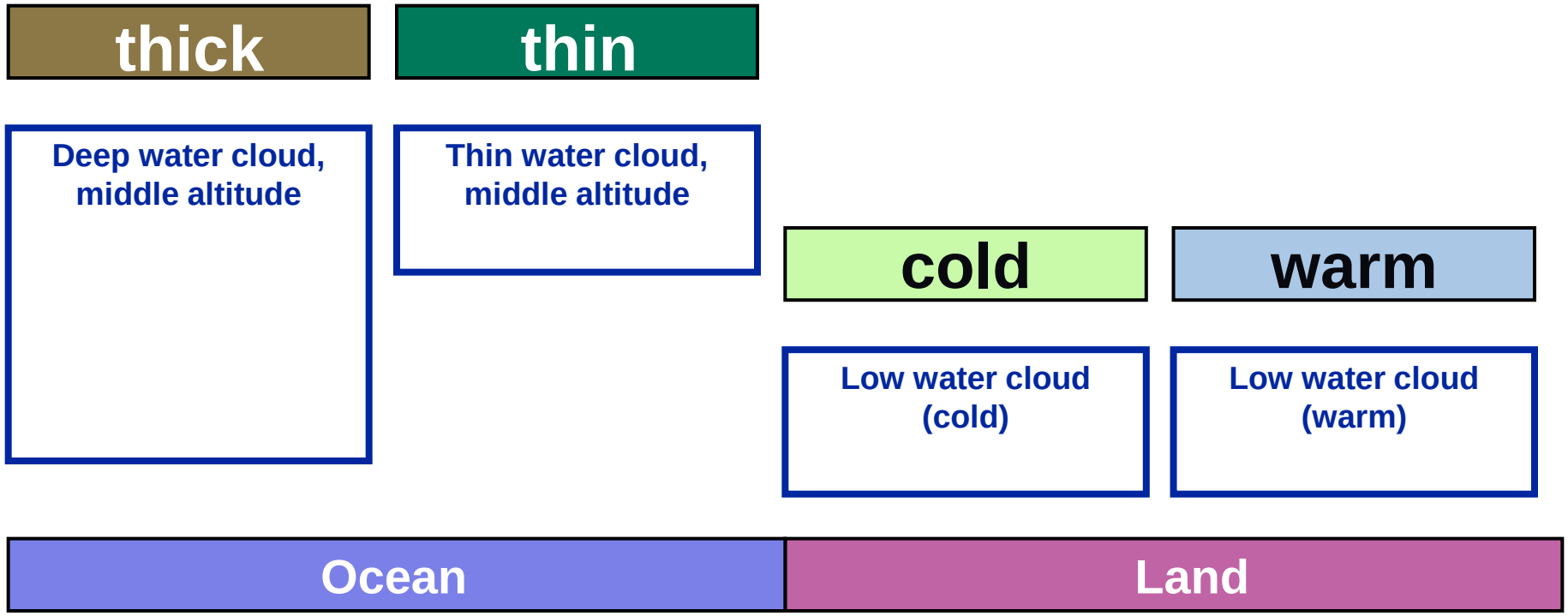
FOG / St: RGBs (during the night)

RGB (Cloud Microphysik – night)

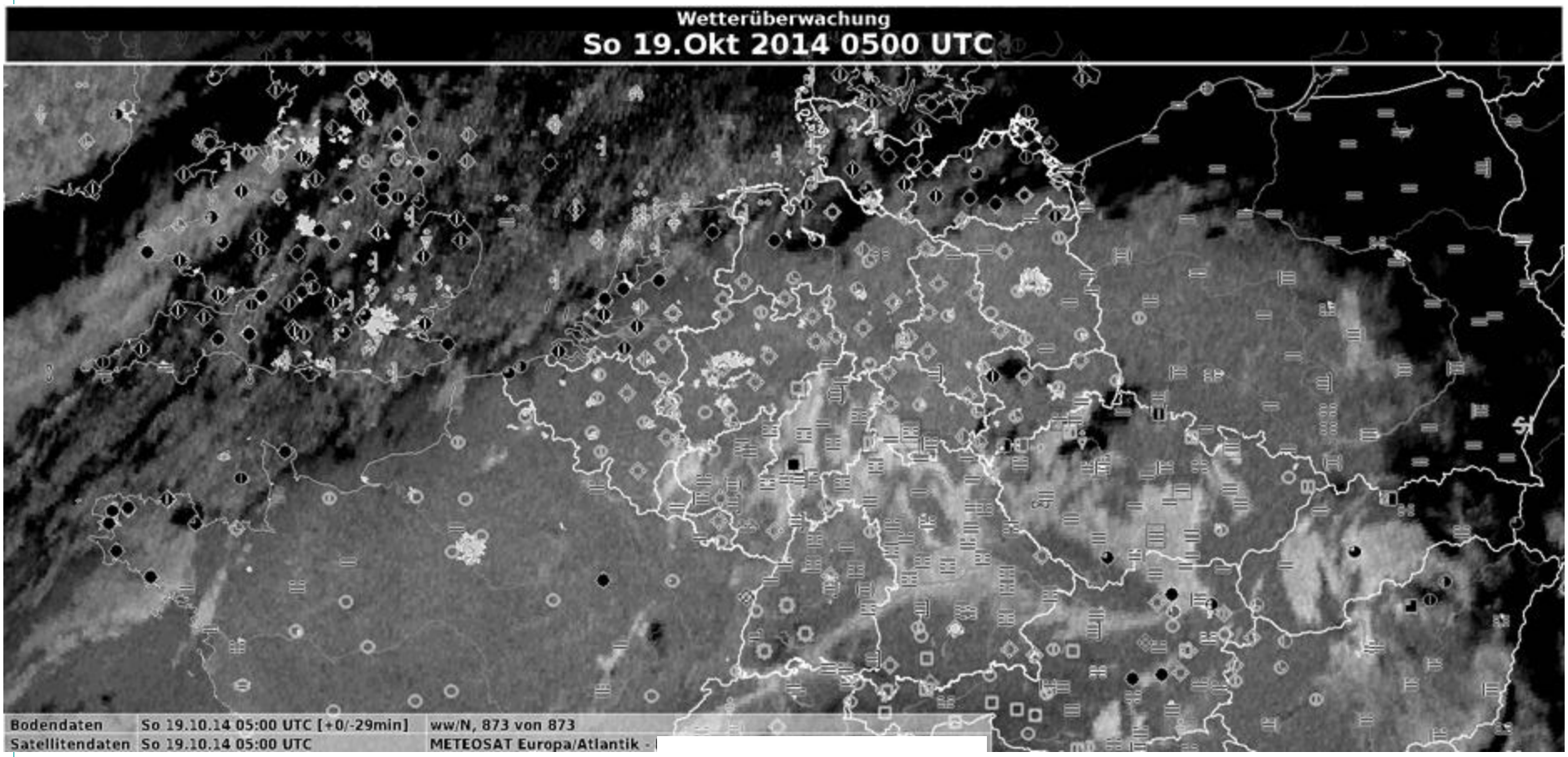
R = 12.0-10.8 (-4 to +2 K)
G = 10.8-3.9 (0 to +10 K) **Gamma = 0.5**
B = 10.8 (243 to 293 K)

RGB Night-Mikrophysik (IR12.0-IR10.8, IR10.8-IR3.9, IR10.8 Colour interpretation

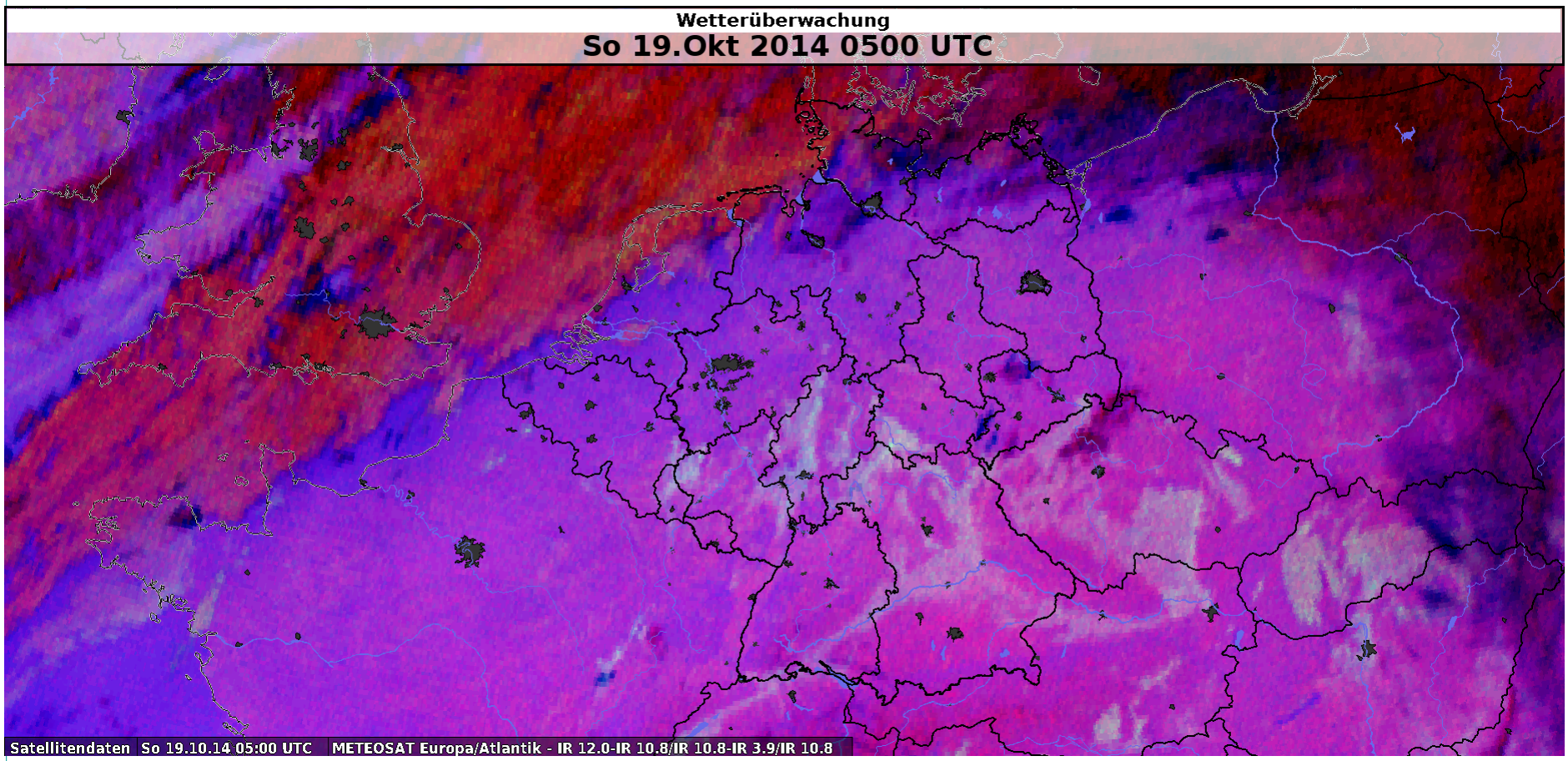
(J. Kerkmann, EUMETSAT)



(10.8 – 3.9) µm (0 to 10 K) 19/10/2014, 05 UTC (St, fog): bright (night time))



RGB (Night-Microphysik (12.0-10.8 / 10.8-3.9 / 10.8) µm
19.10.2014, 05 UTC
(fog/St: light green, small contributions from red and blue)



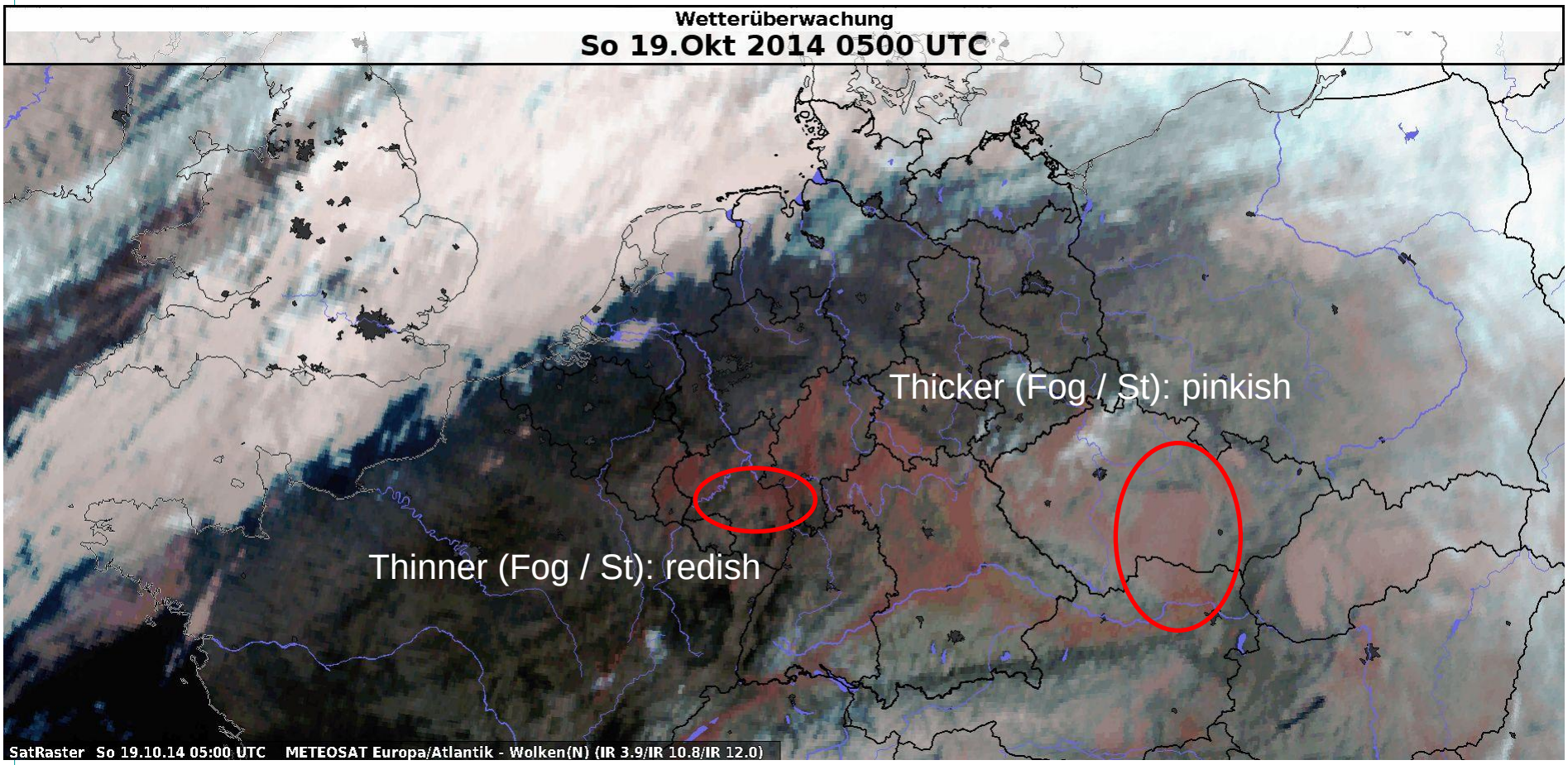
RGB (Night-Composite)

R = 3.9

G = 10.8

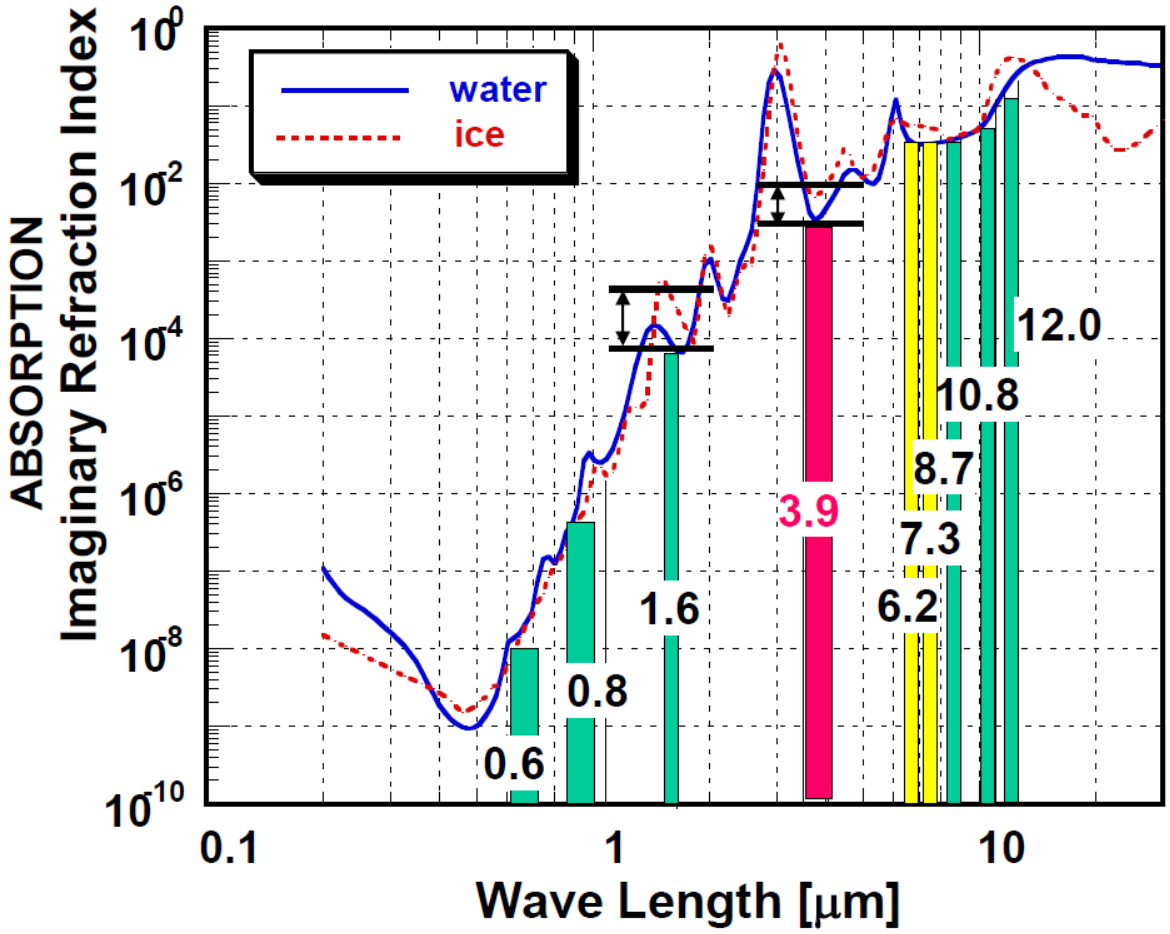
B = 12.0

RGB (night, 3.9/10.8/12.0), 19.10.2014, 05 UTC
St, fog: redish to pinkish



Shallow clouds and precipitation

How can we detect from space the size of microscopic cloud particles? (D. Rosenfeld)



Channel 4, 3.9 μm, absorbs even more solar radiation than Channel 3, 1.6 μm. Ice absorbs more strongly than water at 3.9 μm.

Components Day Microphysik (06 / 3.9ref / 10.8)

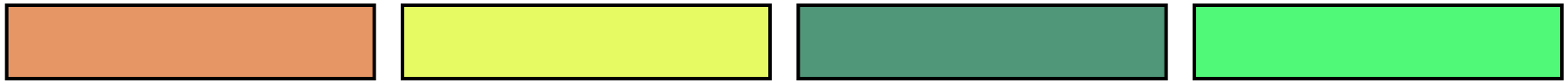
1. R = VIS 0.8: Visible brightness, reflecting more solar radiation for thicker clouds with more water and ice

2. G = 3.9 ref:
   - Cloud particle size and phase (water or ice), having larger drops for clouds with greater depth. Drops appear larger when freezing at temperatures that can range between 0 and -38ºC.
   - brighter with smaller particles

3. B = 10.8: Temperature, lower for higher tops (image not inverted!)

RGB Day Microphysik: Interpretation of Colours for Mid-level Clouds

(J. Kerkmann)

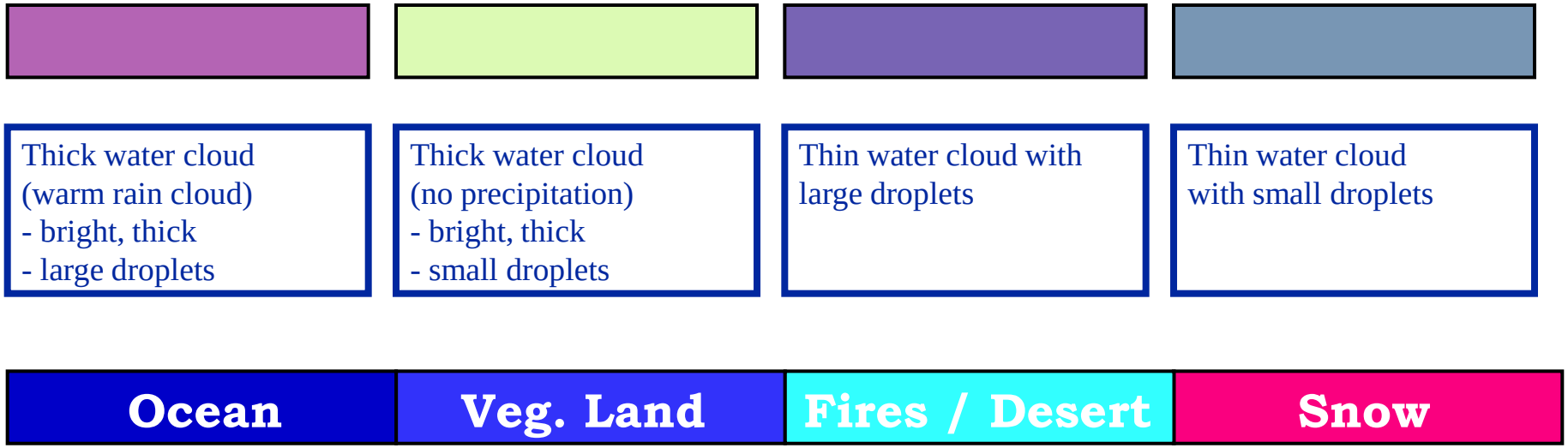


Supercooled, thick water cloud - bright, thick - large droplets	Supercooled, thick water cloud - bright, thick - small droplets	Supercooled thin water cloud with large droplets	Supercooled, thin water cloud with small droplets * * or, in rare occasions, thin Ci cloud with small ice particles

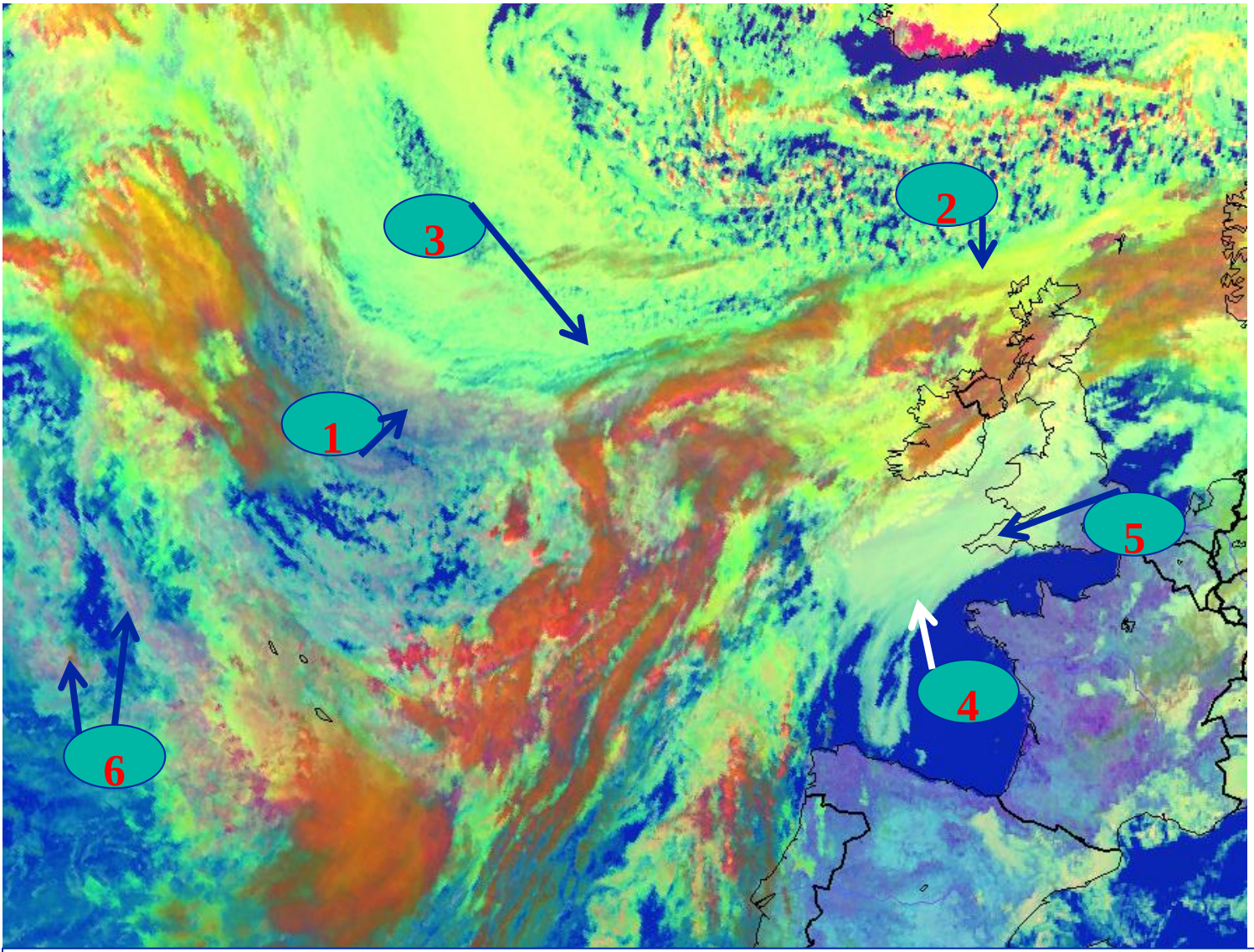
Ocean	Veg. Land	Fires / Desert	Snow

RGB Day Microphysik: Interpretation of Colours for Low-level Clouds

(J. Kerkmann)



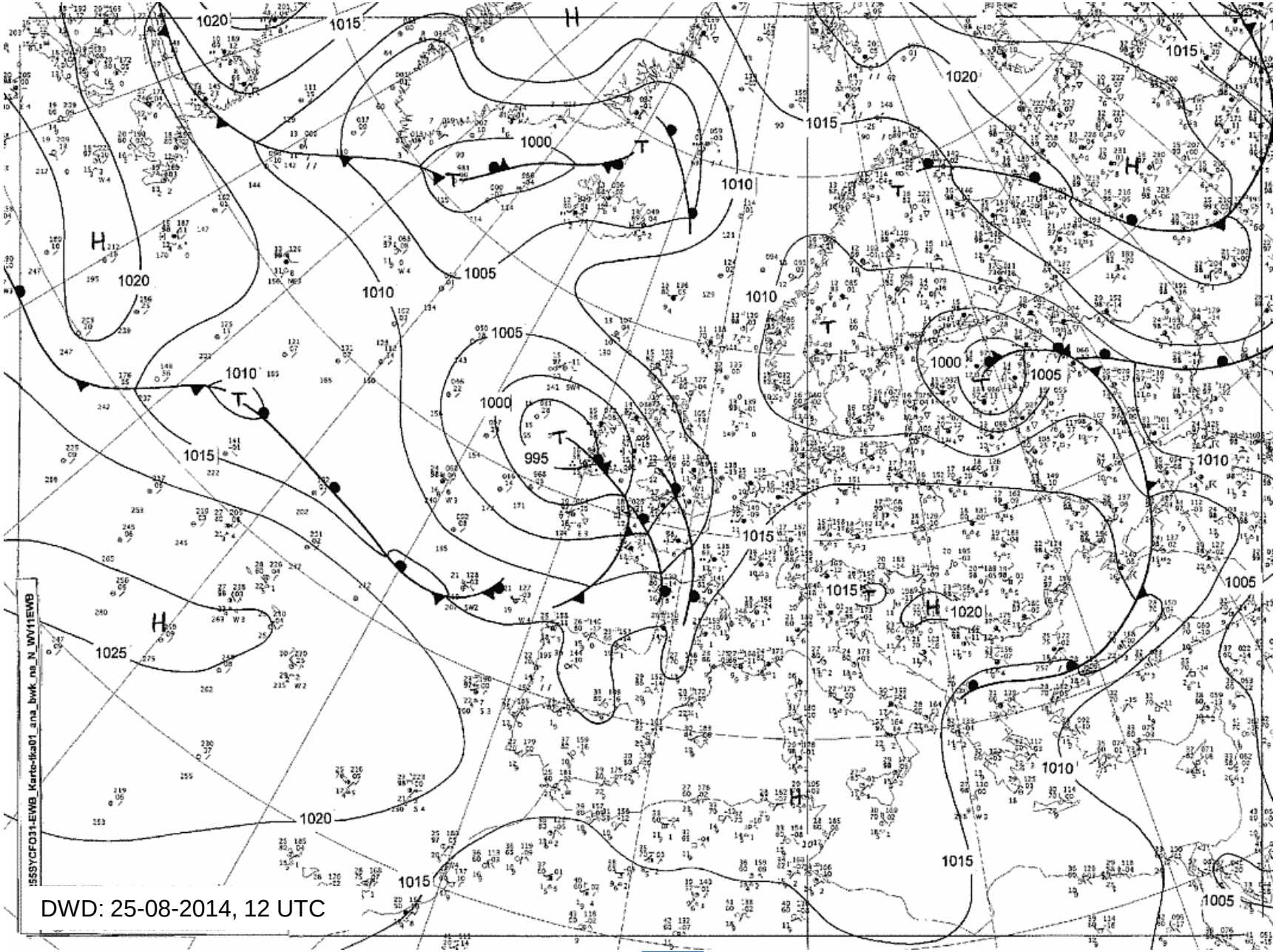
Example: 27-10-2014, 12 UTC (RGB “Day Microphysik”)



1. +8 degree Mixture (thin water clouds with small and large droplets, precipitation possible)
2. -20 degree: Supercooled thick water water cloud, small droplets → moderate icing
3. About -5 degree: Supercooled thin/thick water cloud with small and large droplets → precipitation possible and icing!
4. +10 degree: Water cloud, small droplets
5. +8 degree: Thick water cloud, small droplets fog/St-layer about 700 meters.. Near the English South coast light drizzle.
6. About +12 degree: Mixture (think/thick water clouds (warm rain cloud), large droplets). Partly precipitation.

Example 25./26.08.2014, 12 UTC

RGB „Day Microphysik“ - precipitation



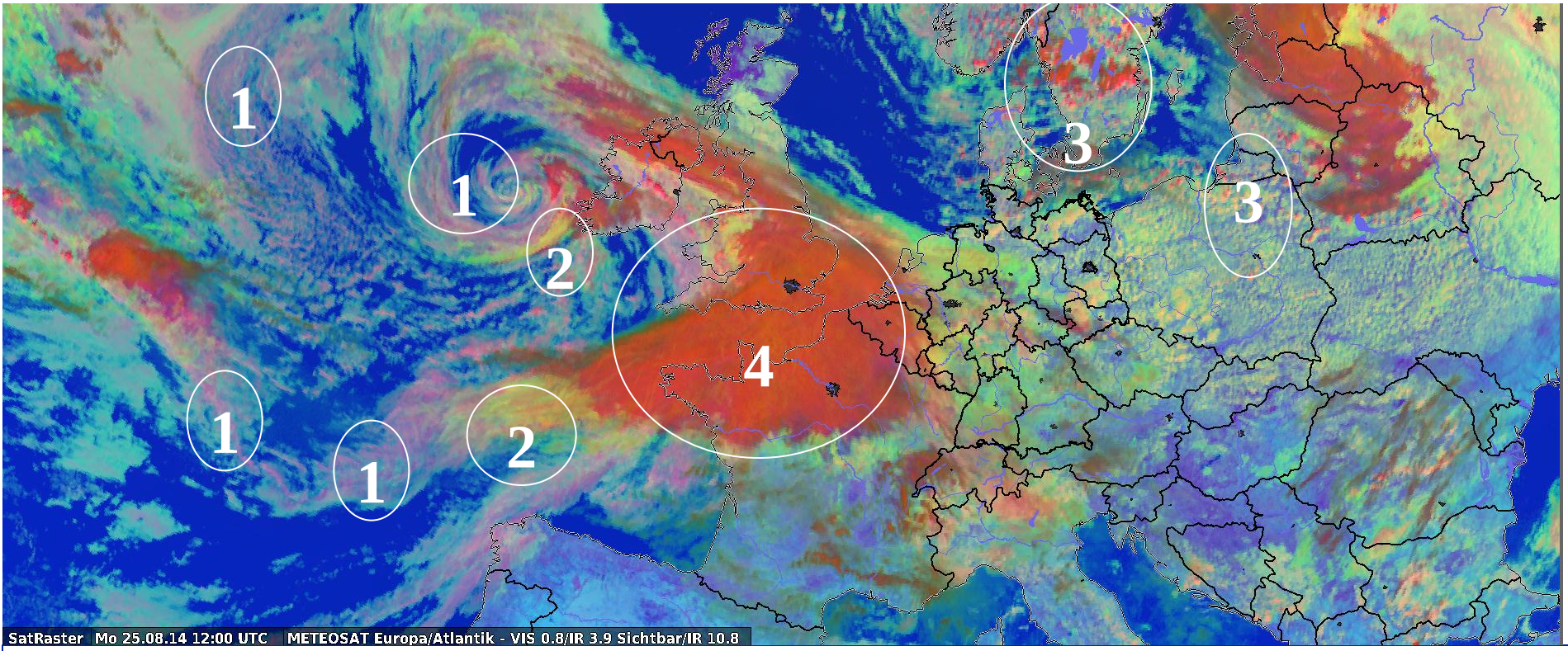
EUMETRAIN

DWD

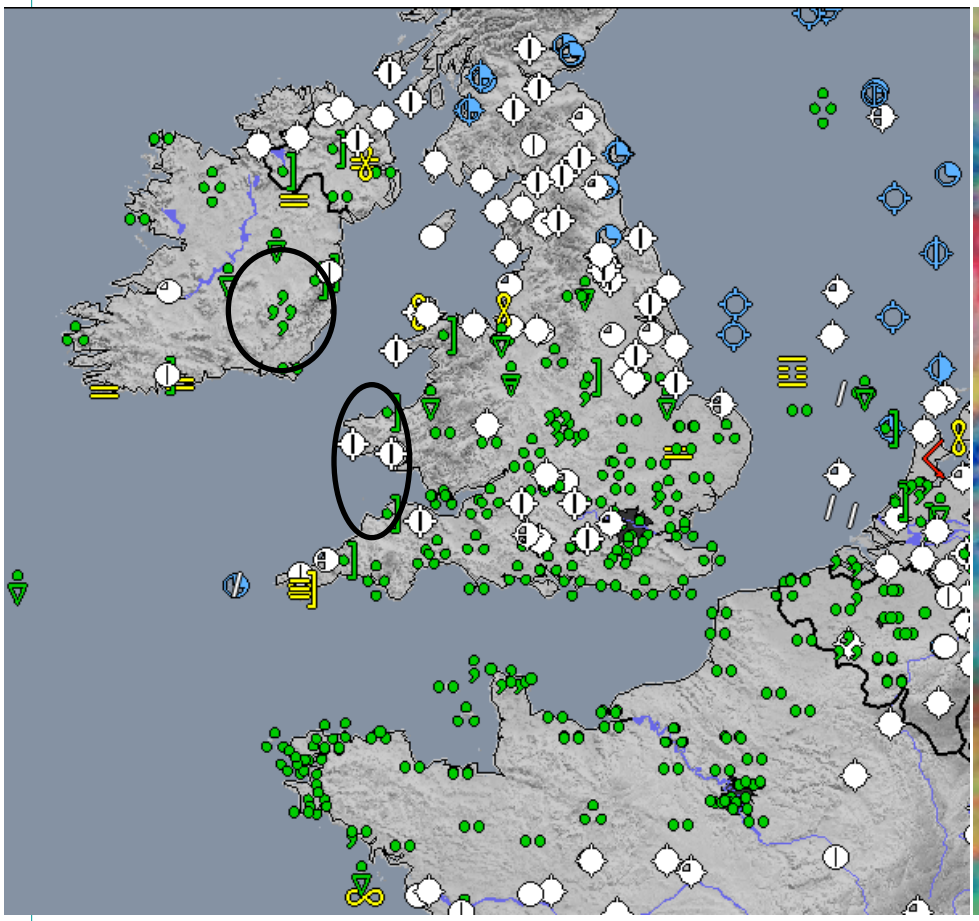
EUMETCAL

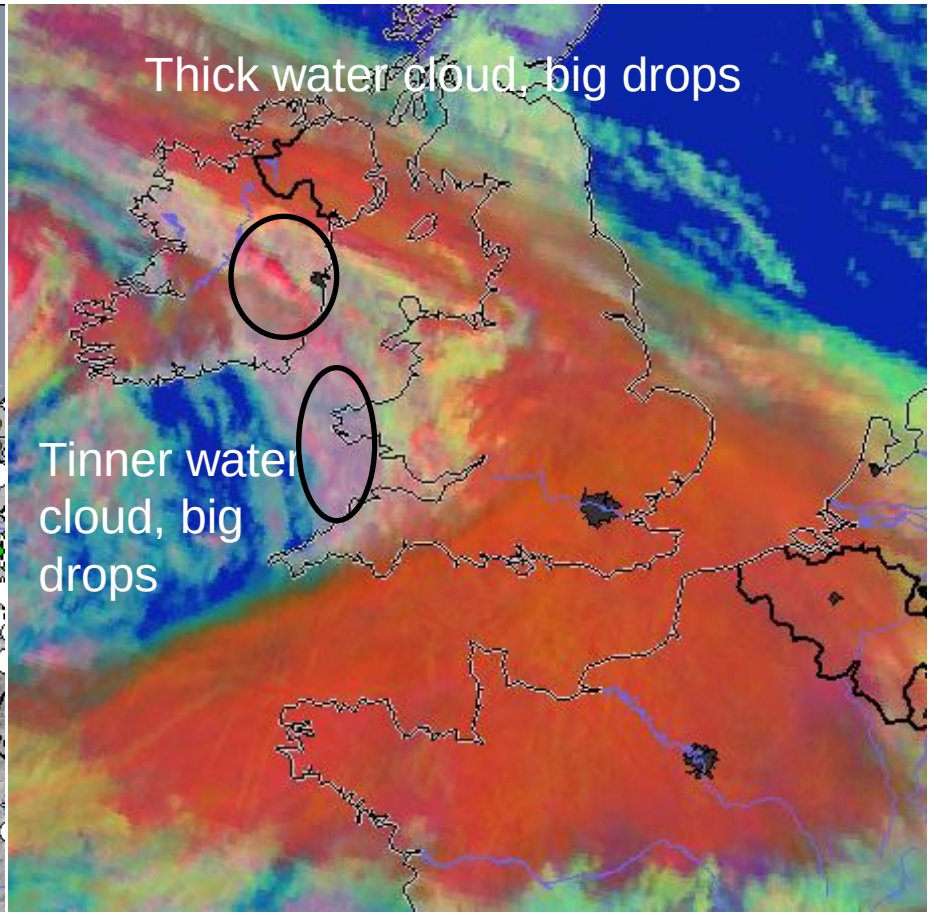
Overview: RGB “Day Microphysik”: 25-08-14, 12 UTC

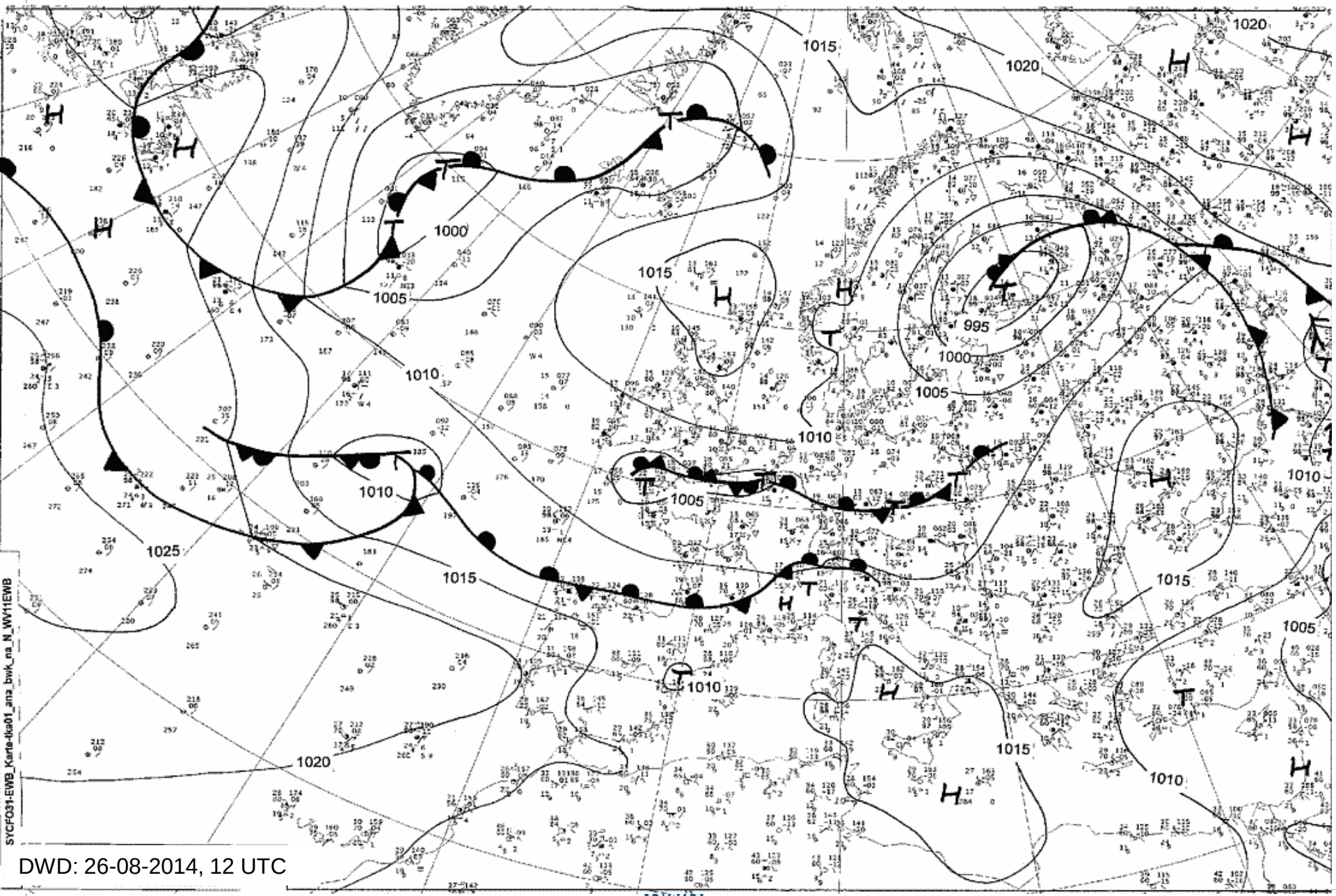
1. Thick low water cloud, big drops – precipitation likely, Temp between 0 and +10 degree
2. Supercooled water (-10 to -20 degree): Icing
3. High extending ice cloud, compact: Shower
4. High extending ice clouds (WCB): Partly heavy rain (No 65, over UK)



25-08-2014, 12 UTC: ww / Day Microphysik







DWD: 26-08-2014, 12 UTC

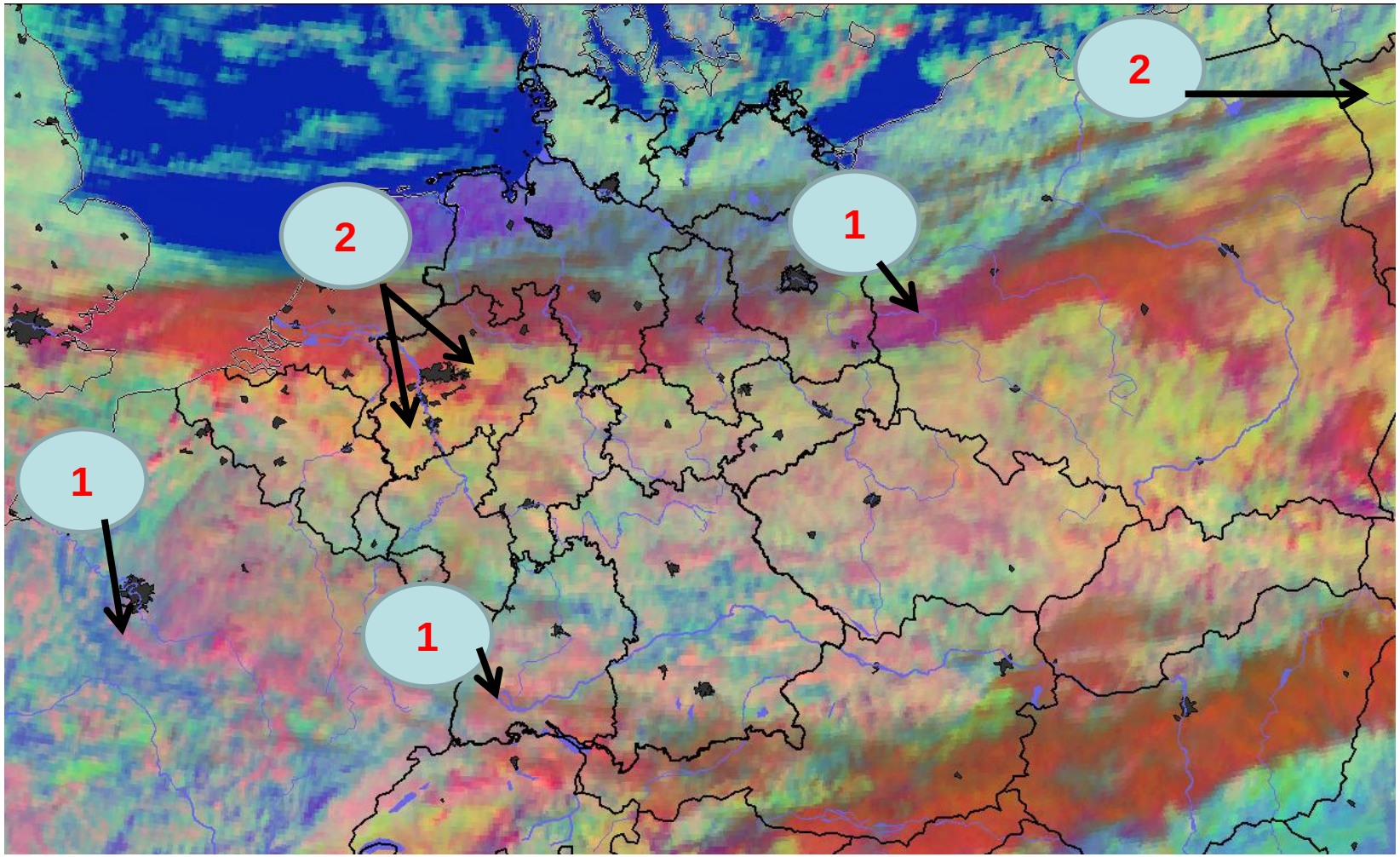
EUMETRAIN

DWD

EUMETCAL

26-08-2014, 12 UTC: Day-Microphysik

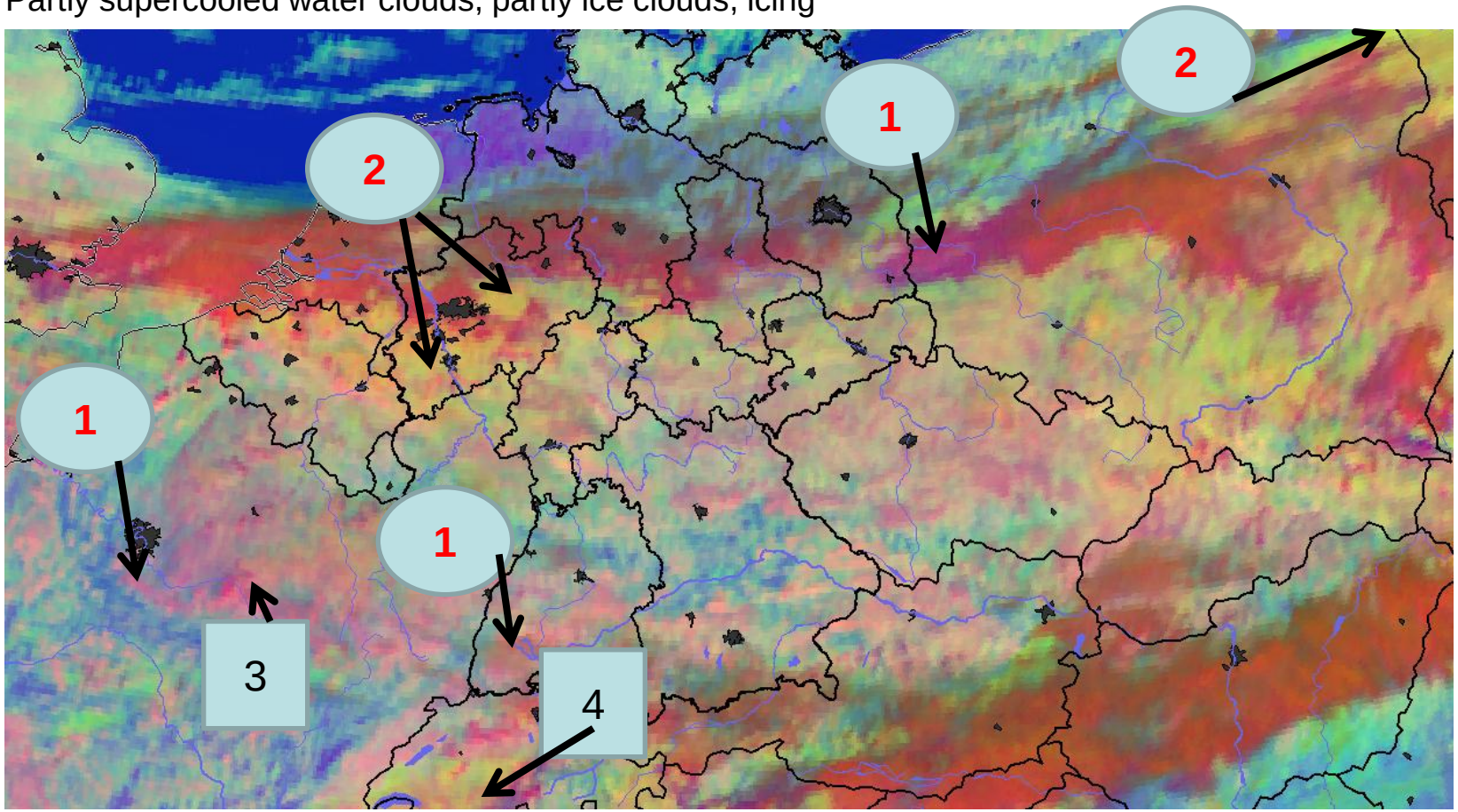
Please use the F2-Buttom (Chat) and tell us which cloud type and weather you expect for cloud category 1 and 2.



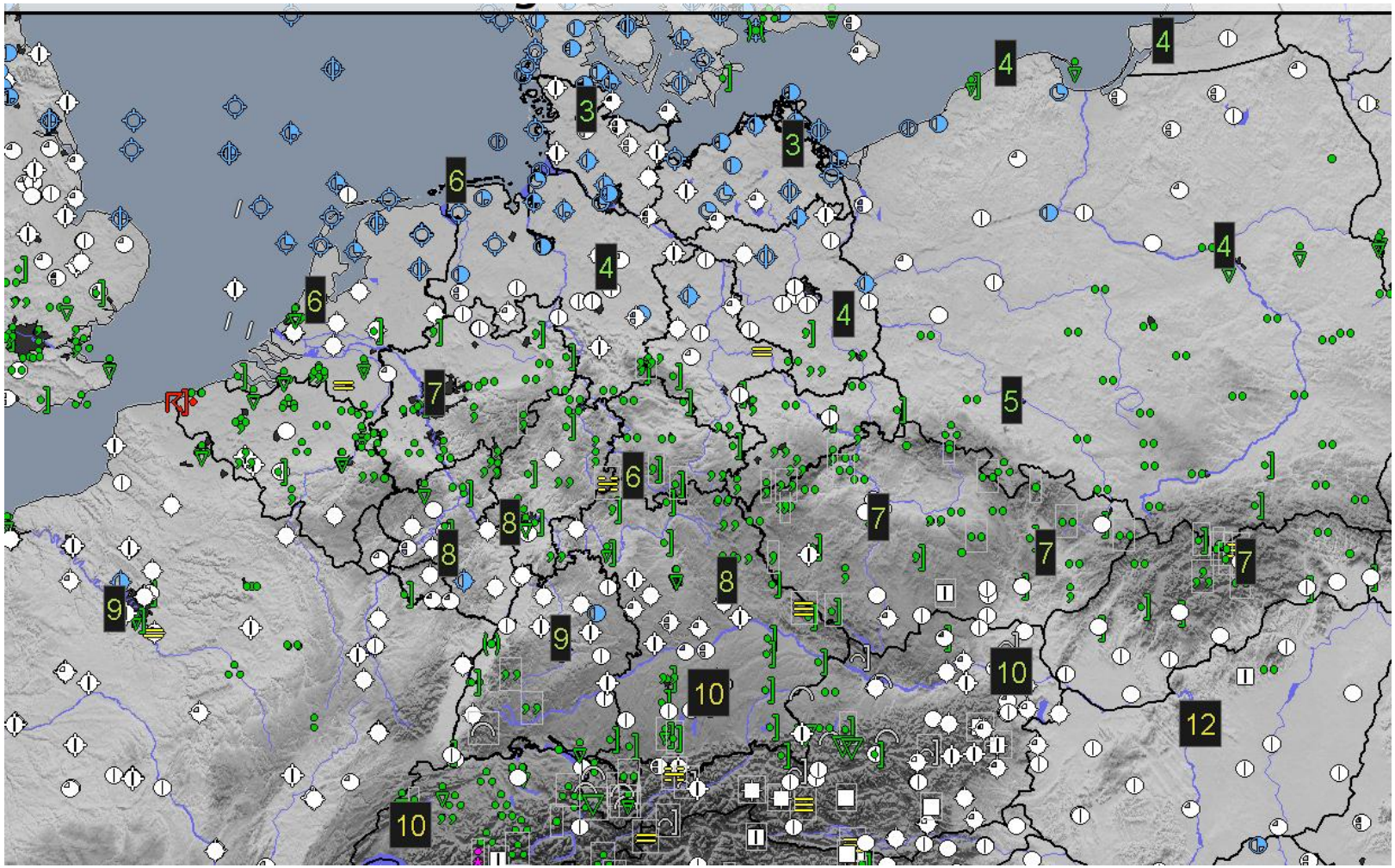
26-08-2014, 12 UTC: Day-Microphysik

1. Low water cloud, thick, precipitation (drizzle, partly light rain, about 0 degree)
2. Supercooled water cloud (-10 to -20 degree, some rain, icing!)

3. Thick water clouds, however, also partly ice clouds, icing
4. Partly supercooled water clouds, partly ice clouds, icing



26-08-2014, 12 UTC: ww + T in 850 hPa (front over Germany)



Summary

Recommended Schemes for RGB Image Composites (Interpretation: Corresponding colour schemes)

RGB	Applications	Time
1.6/0.8/0.6 (Day Natural Colour)	Vegetation, snow, fog (thickness) *whitish-pinkish: thicker fog/St* *whitish: thinner fog/St*	Day
1.6/HRV/HRV	Snow, fog (better spatial resolution) *similar to "Day Natural Colour"*	Day
0.8/3.9ref/10.8 (Day Microphysik)	Cloud diagnosis (ice, water clouds), thickness of clouds, icing, precipitation *yellow: thick cloud super cooled water (icing)* *green (bright/dark): thin cloud, super cooled water (icing)* *violet: warm water cloud (drizzle)* *whitish-greenish: thinner fog, St / pinkish-whitish: thicker fog/St*	Day
0.8/1.6/3.9ref (day solar)	Snow, fog *whitish: thicker fog, St / whitish-bluish: thinner fog, St*	Day
12.0-10.8/10.8-3.9/10.8 (Night Microphysik) 12.0-10.8/10.8-8.7/10.8 (Day Microphysik-24h)	Cloud diagnosis, fog *whitish: As brighter as thicker (better for fog, St during the night)* Dust, thin clouds *less suitable for fog/St*	Night Day&Night

Explanations to (homework / quizzes), next steps

1. Two images for interpretation – like we did here
2. One set of multiple choice questions (about basics)

3. Please consider to deliver your homework by 18th November

4. Certificates (online students) will be distributed by mid of December, at latest
   - Email attachment
   - If you need the original please tell me
     - Just for precaution: Address

Langen, 24-01-2013, after freezing rain, followed by snow (T = -10 degree)