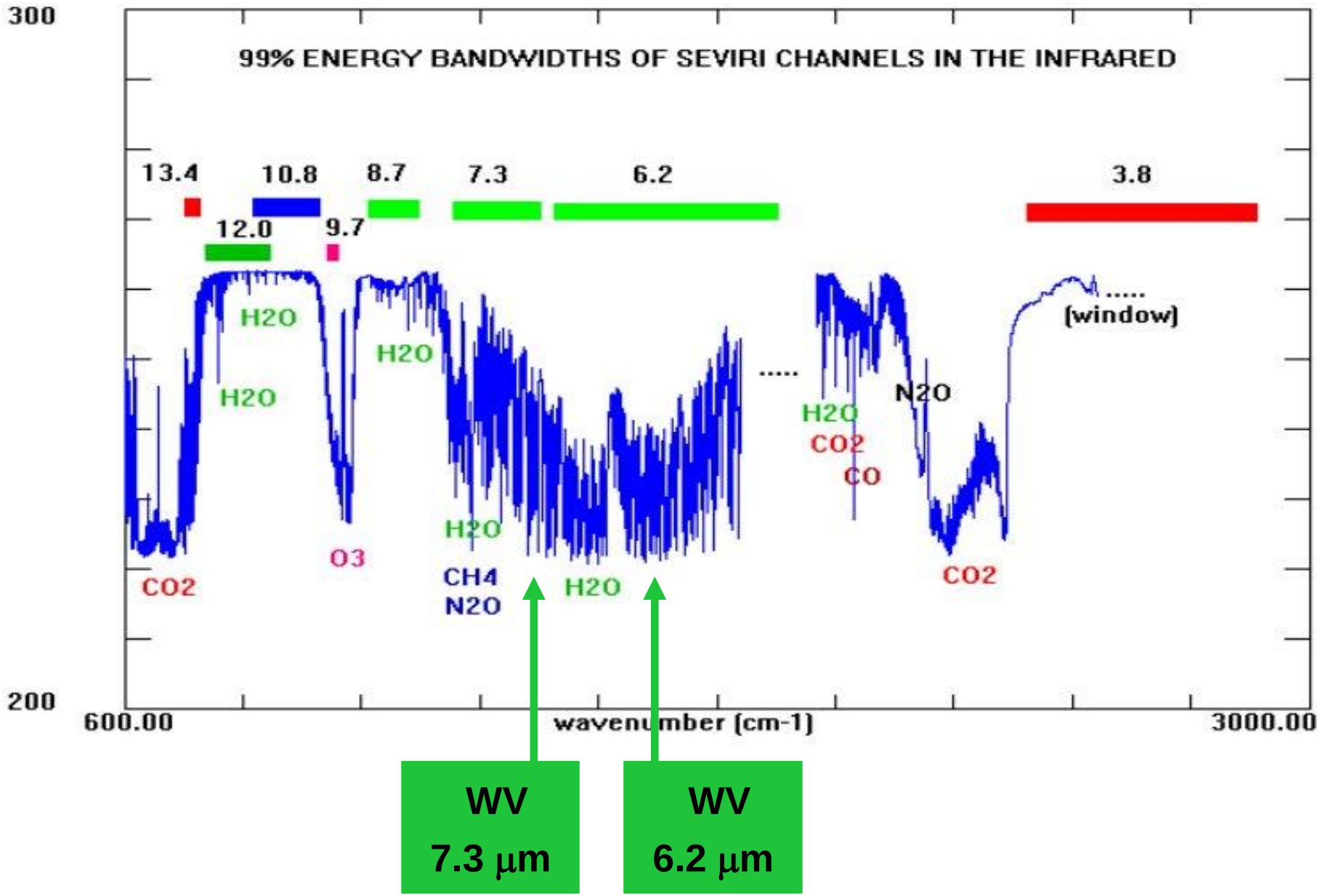
WV signatures in mid/high atmosphere – dark stripes, WV eyes, dry intrusion, waves/turbulence.....

Natasa Strelec Mahovic
User Training Officer, EUMETSAT

EUMeTrain WV Event Week / 12-15 December 2022 / Online

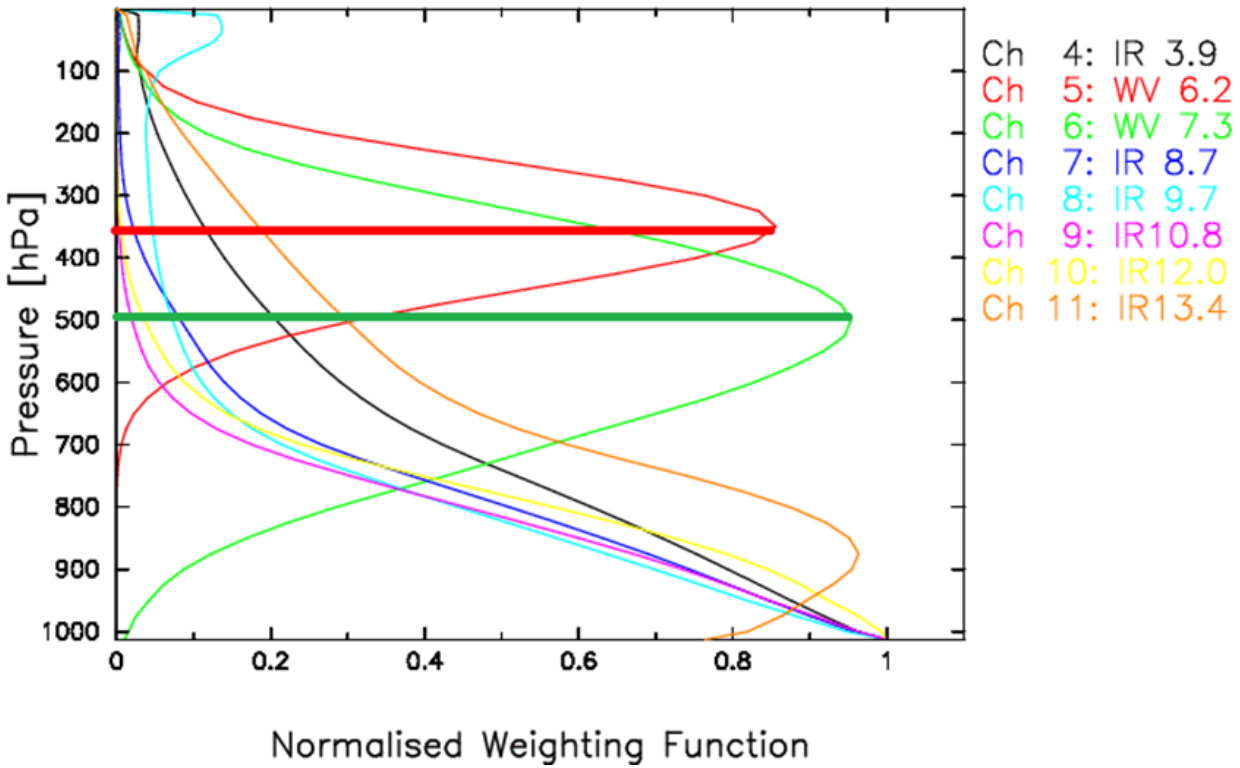
SEVIRI channels in WV absorption band

Strong absorption by water vapour, stronger for 6.2 µm



6.2 µm channel

- Level of the largest sensitivity range 350 - 400 hPa
- 6.2 µm band is very sensitive to differences in humidity of middle - and upper-tropospheric layers
- Differences in humidity content below 700 hPa are not seen in 6.2 µm channel
- The WV channels serve as tools for observing humidity content in different layers of the troposphere.

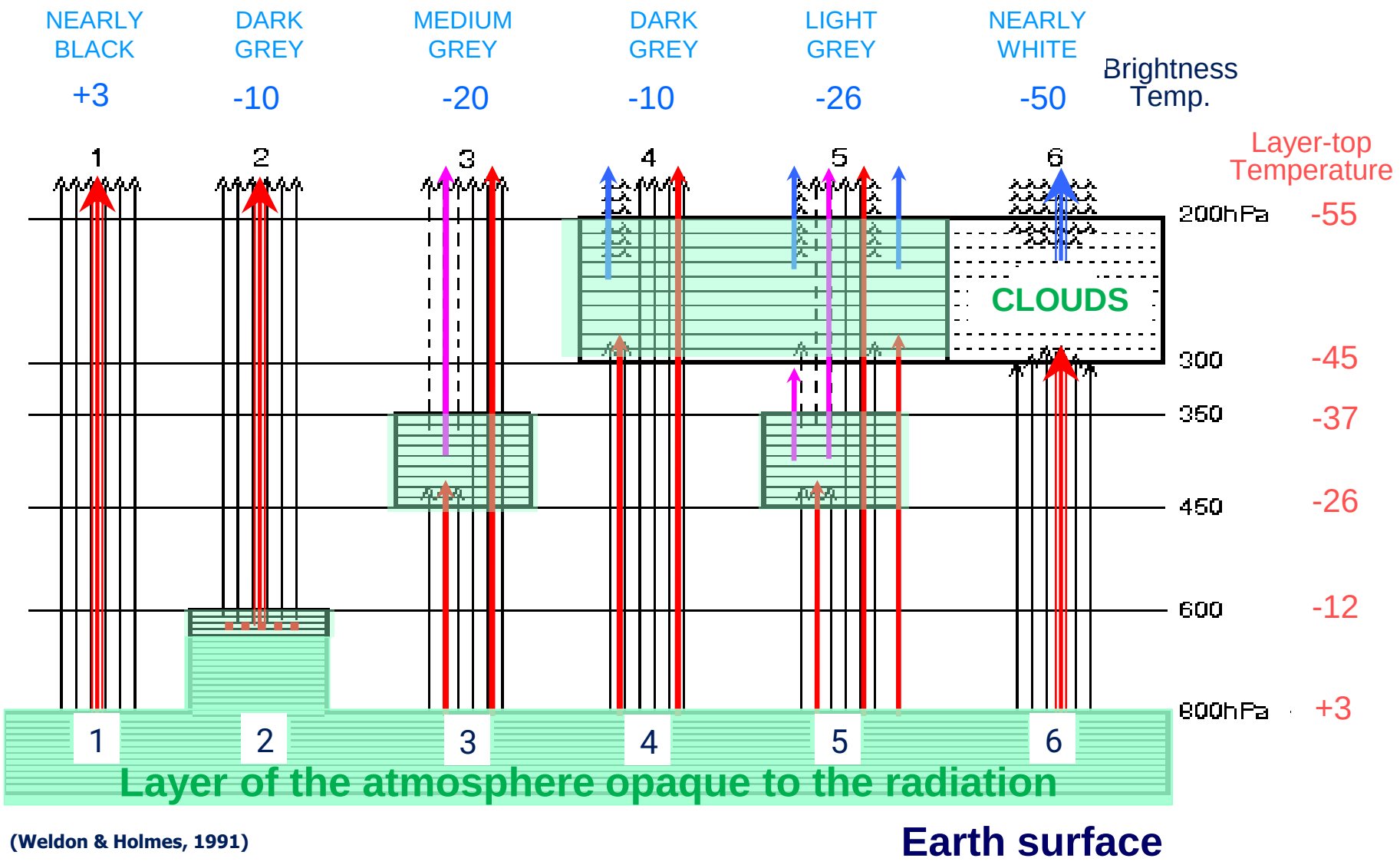


6.2 µm radiance from moisture at different levels

Brightness temperature in WV channels:

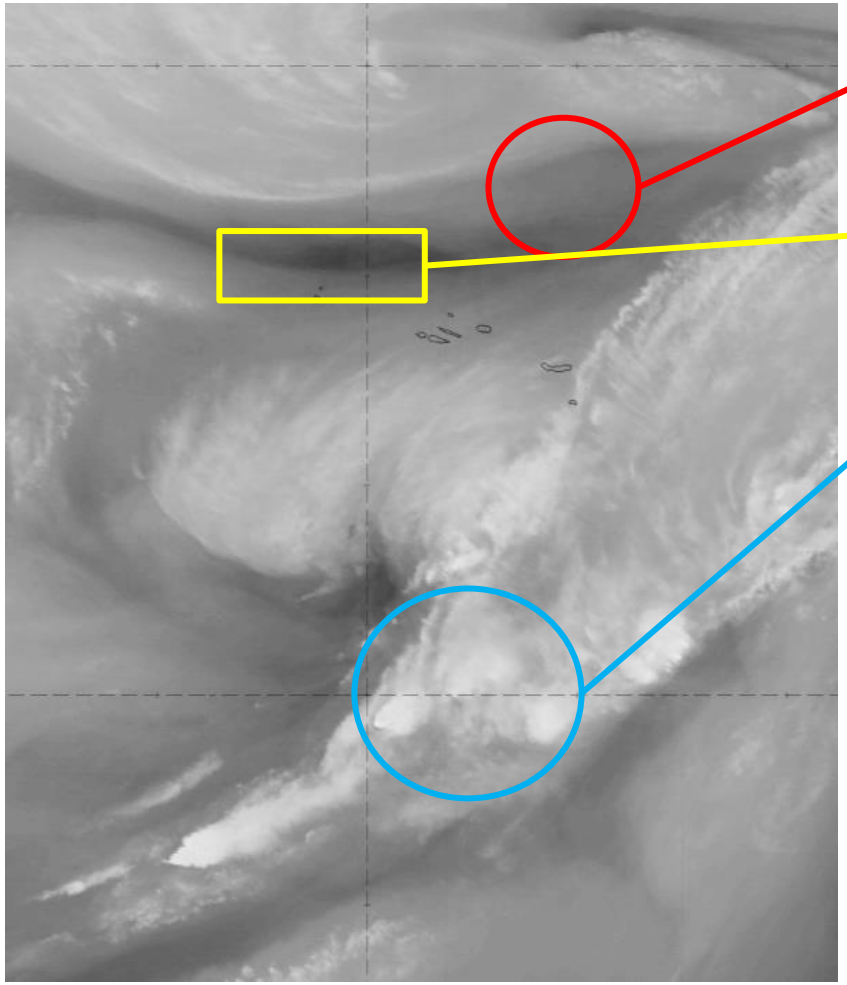
- Different from physical temperature of the object
- Depends on the vertical distribution of humidity

Water vapour absorbs some portion of the upcoming radiation and re-radiates. Since it is usually colder than the earth's surface or the cloud tops radiating from bellow, water vapour radiates at a lower energy level



(Weldon & Holmes, 1991)

ABSORPRION vs. WINDOW channels

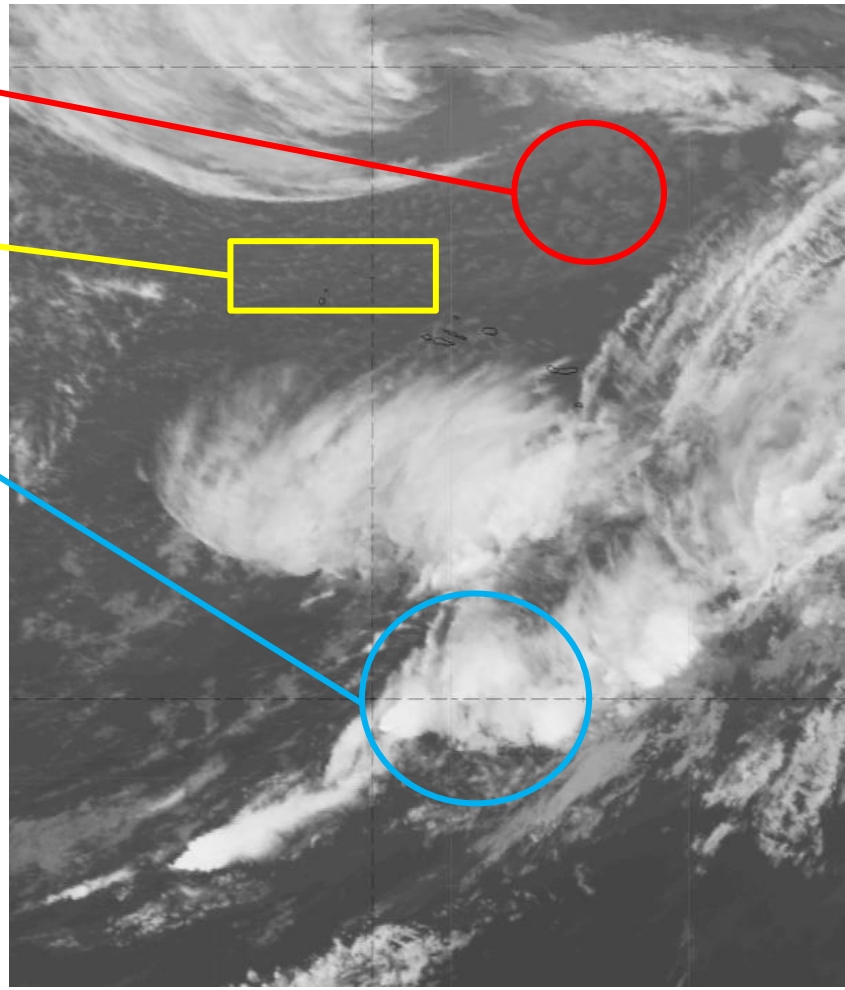


Lower cloud masked by water vapour absorption above

In a dry atmosphere – also contribution from lower levels

High clouds (Cb, anvils, high cirrus) appear similar in WV and IR images

No depiction of low atmosphere or ground in 6.2 µm channel



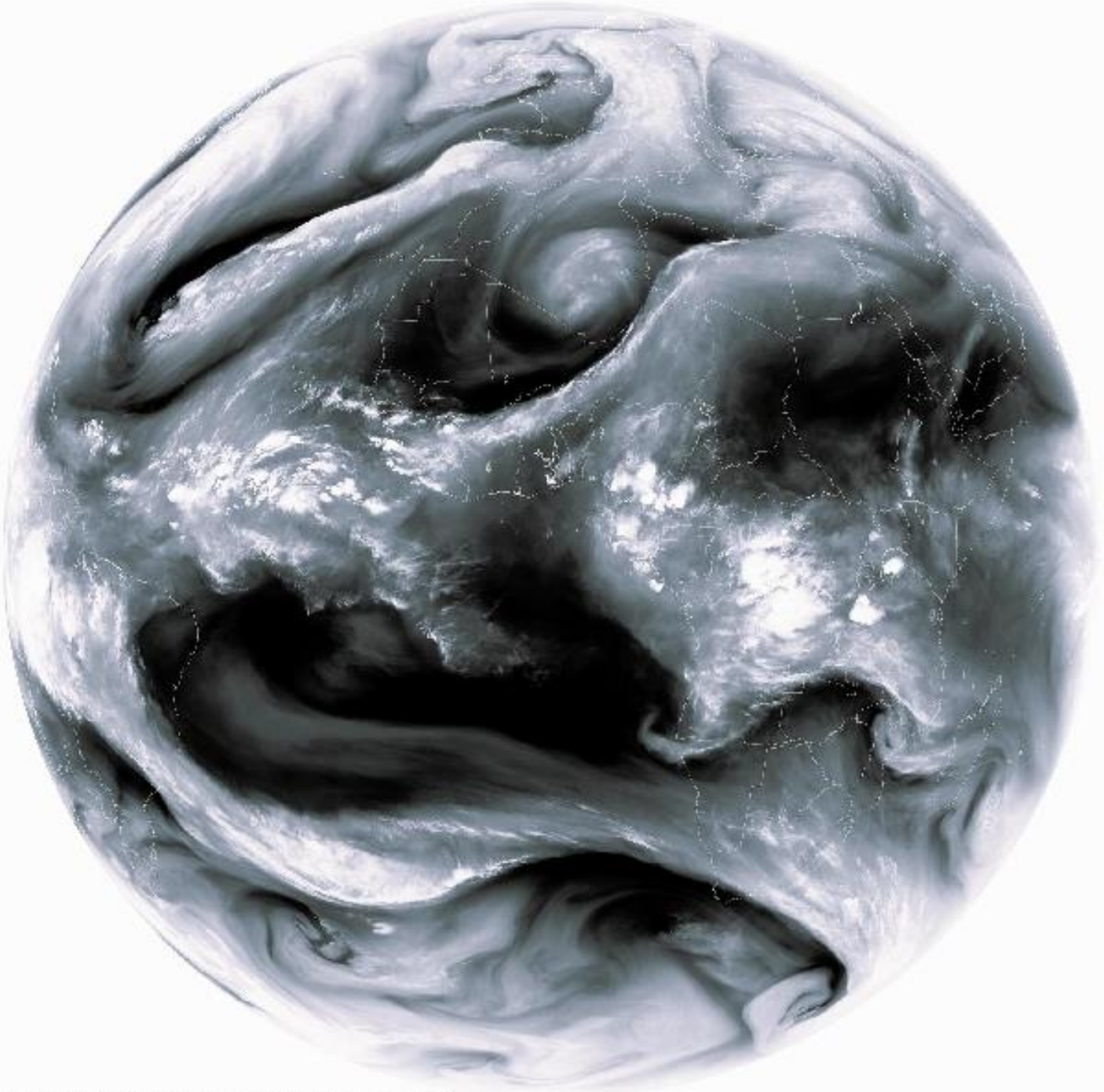
WV 6.2

IR 10.8

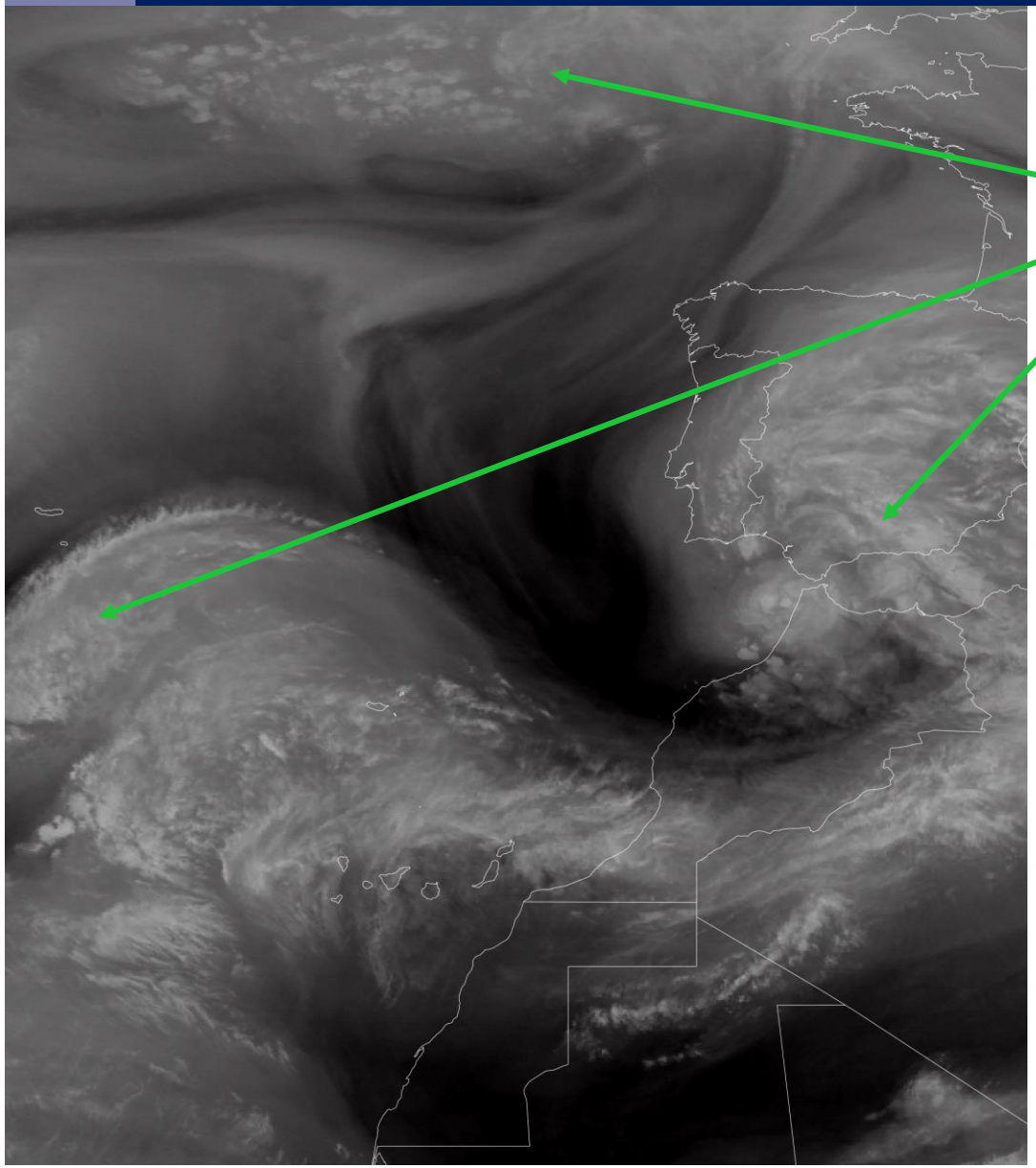
6.2 µm channel imagery

"3 D" view of the upper troposphere

- Mid- and upper-level moisture regime
- Jet stream
- Ascent regions – convection
- Upper-air turbulence
- Dry intrusions
- Vorticity centres
- Wedges and troughs
- Deformation zones
- Mountain waves, Lee clouds



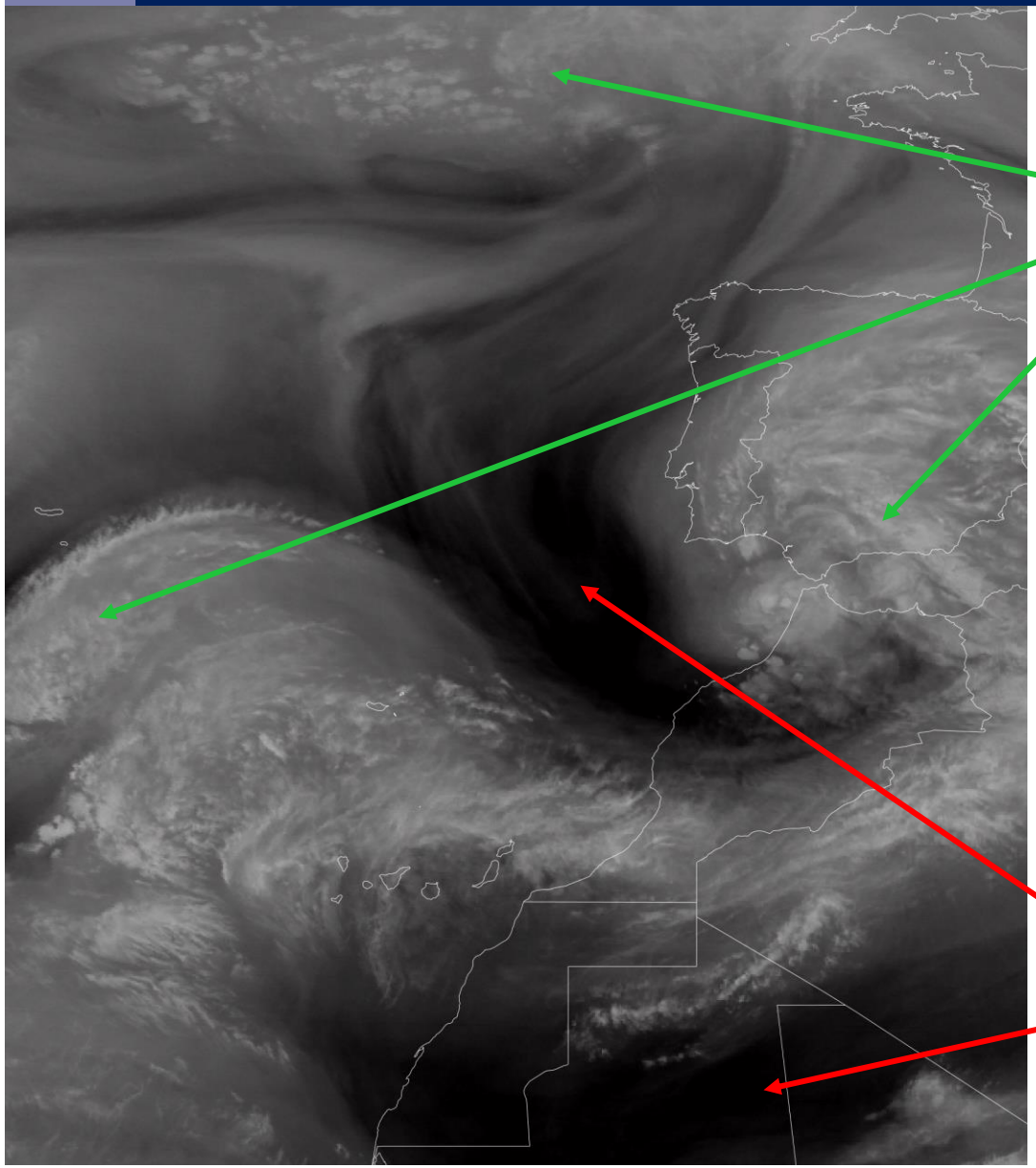
Mid-/upper-level moisture regime



Light grey shades indicate MOIST cloud free or CLOUDY air at mid- to upper level.

WV channel - tool for observing moisture regimes in the mid/upper troposphere

Mid-/upper-level moisture regime

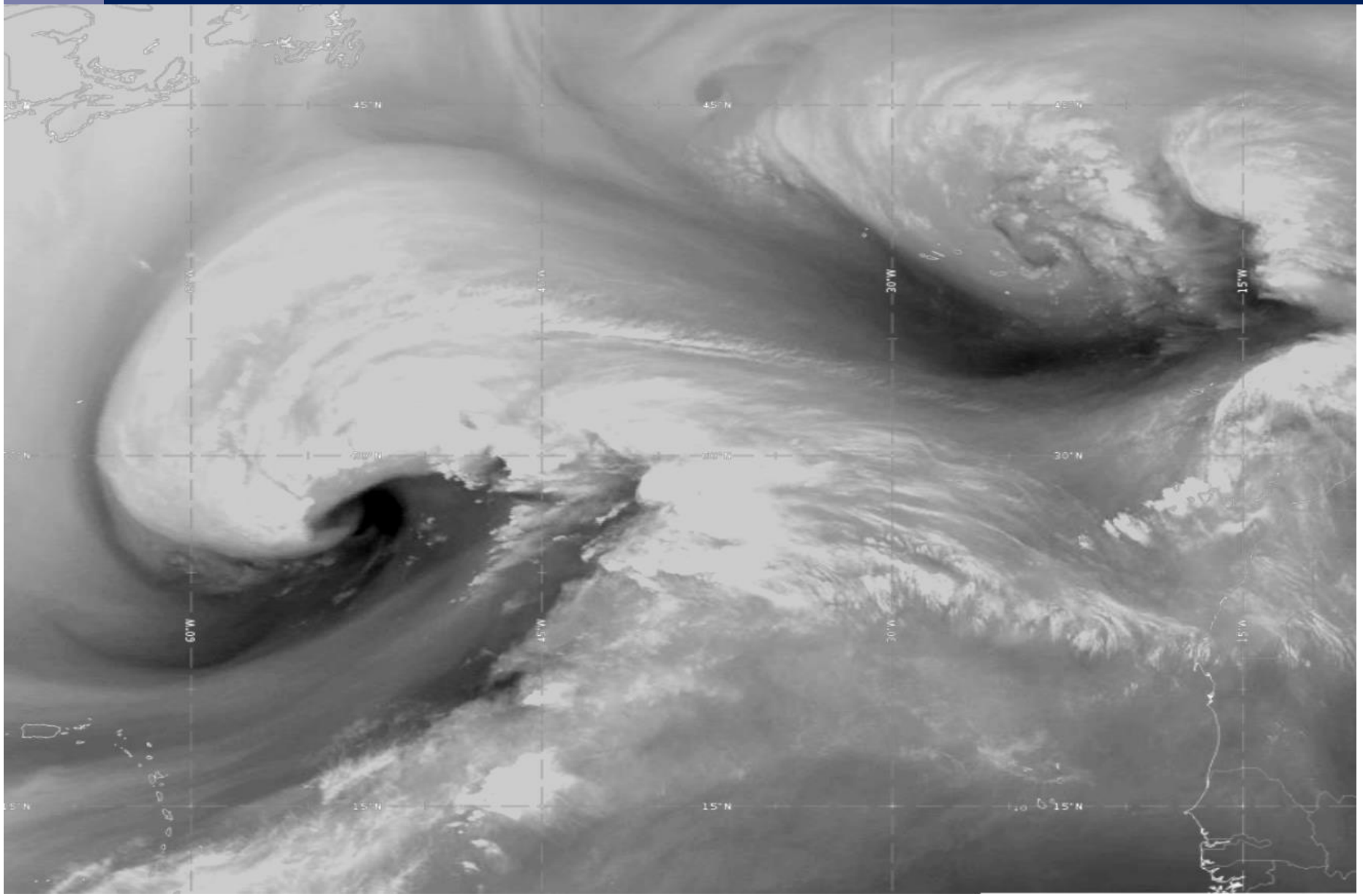


Light grey shades indicate MOIST cloud free or CLOUDY air at mid- to upper level.

WV channel - tool for observing moisture regimes in the mid/upper troposphere

Dark grey shades indicate DRY AIR at mid- to upper level.

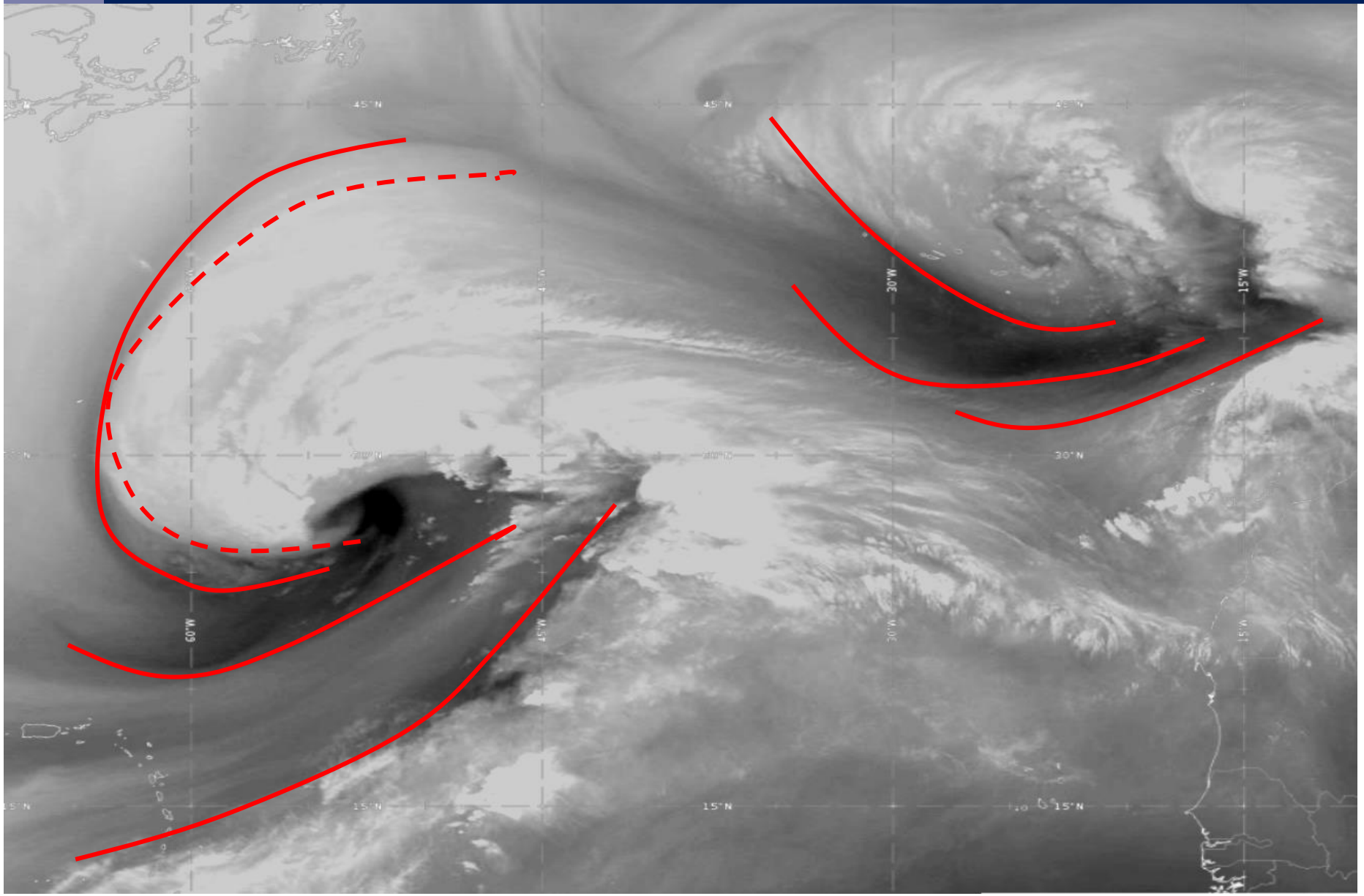
WV boundaries



The boundaries between dark and light grey shades

WV6.2
07 December 2022, 09 UTC

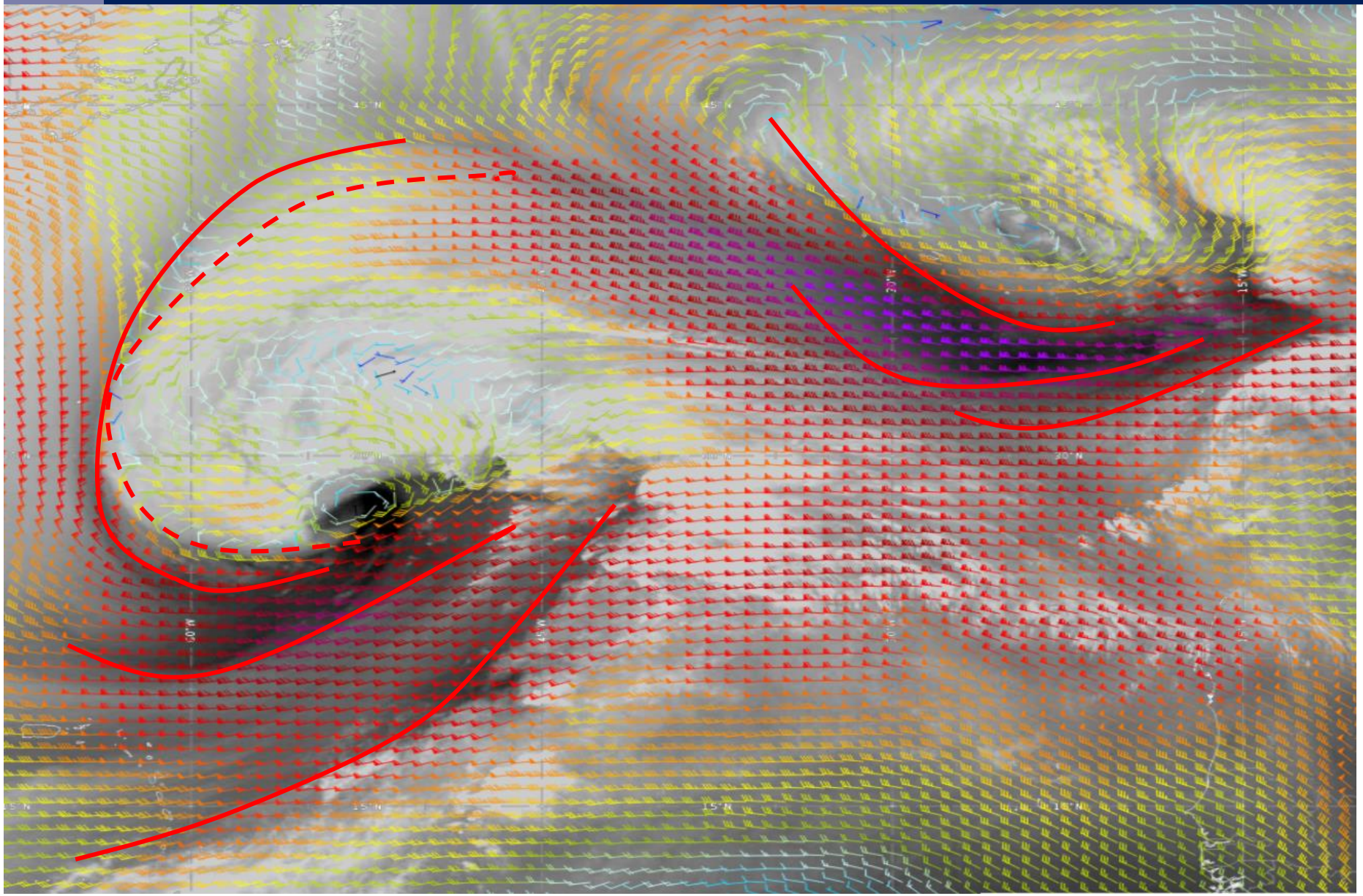
WV boundaries



The boundaries between dark and light grey shades indicate transition between different moisture contents or cloud regimes

WV6.2
07 December 2022, 09 UTC

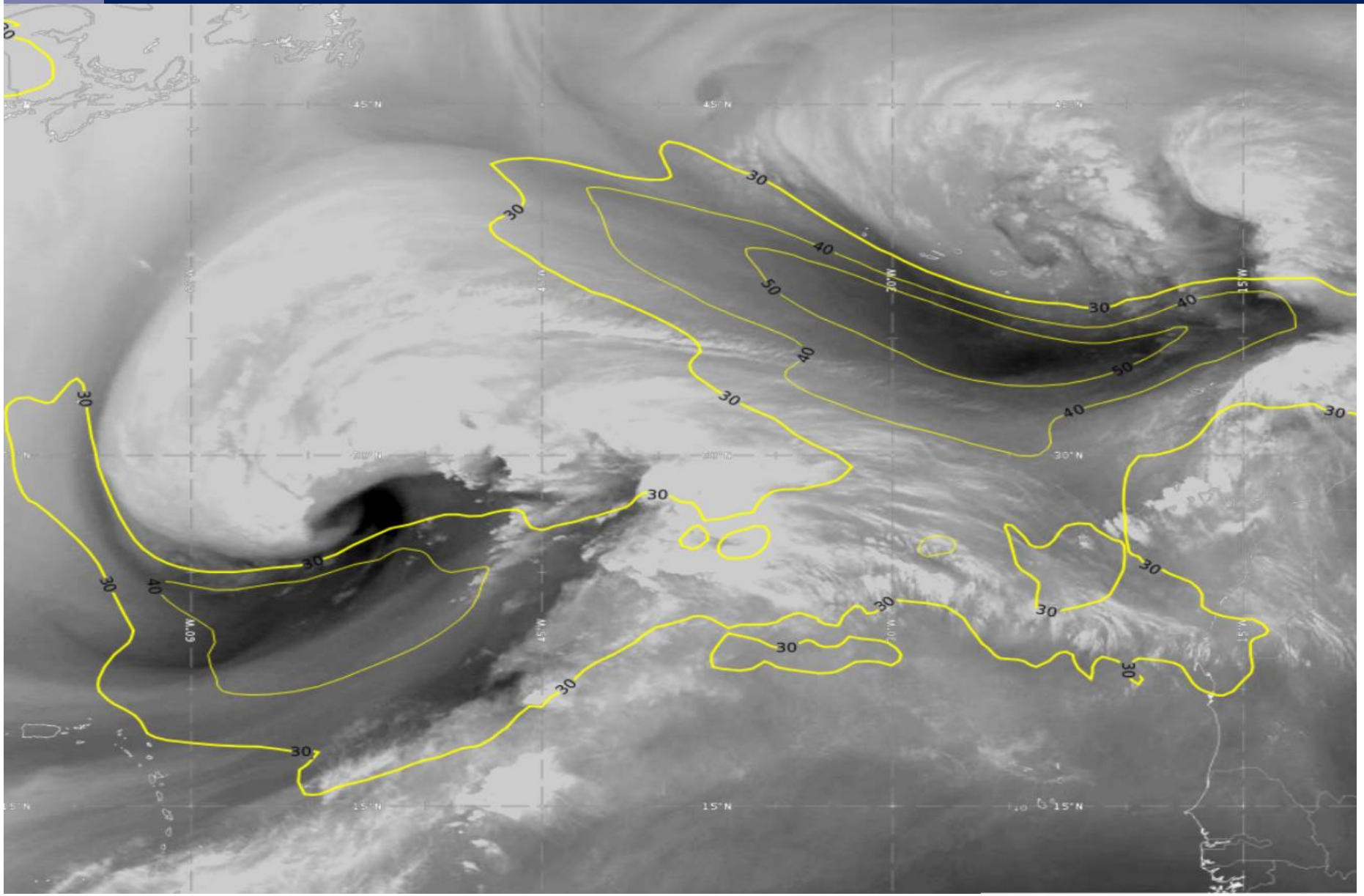
WV boundaries



…. and also transition between different upper level wind regimes

WV6.2
07 December 2022, 09 UTC

Dark stripes ⟷ Jet streak

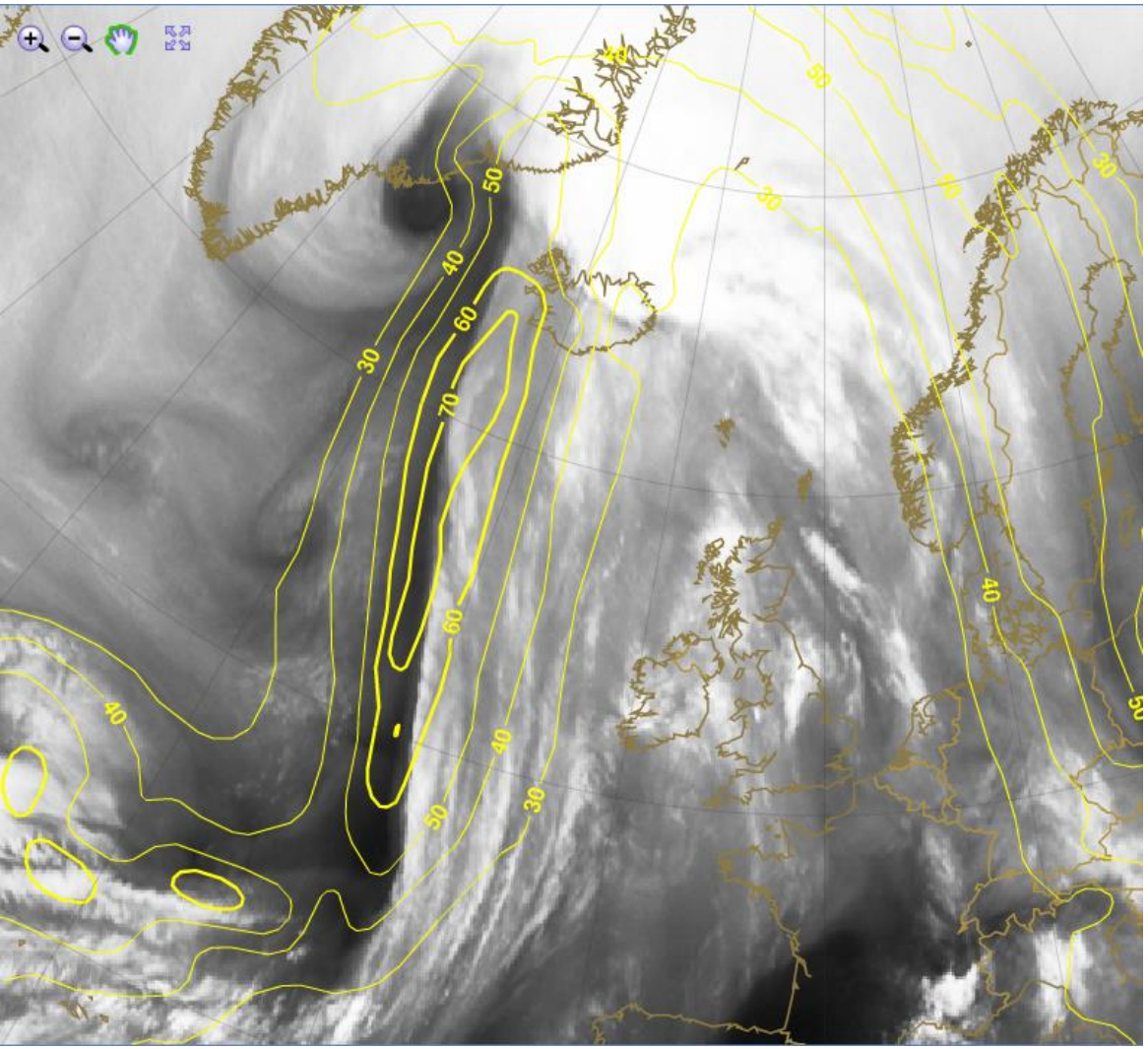


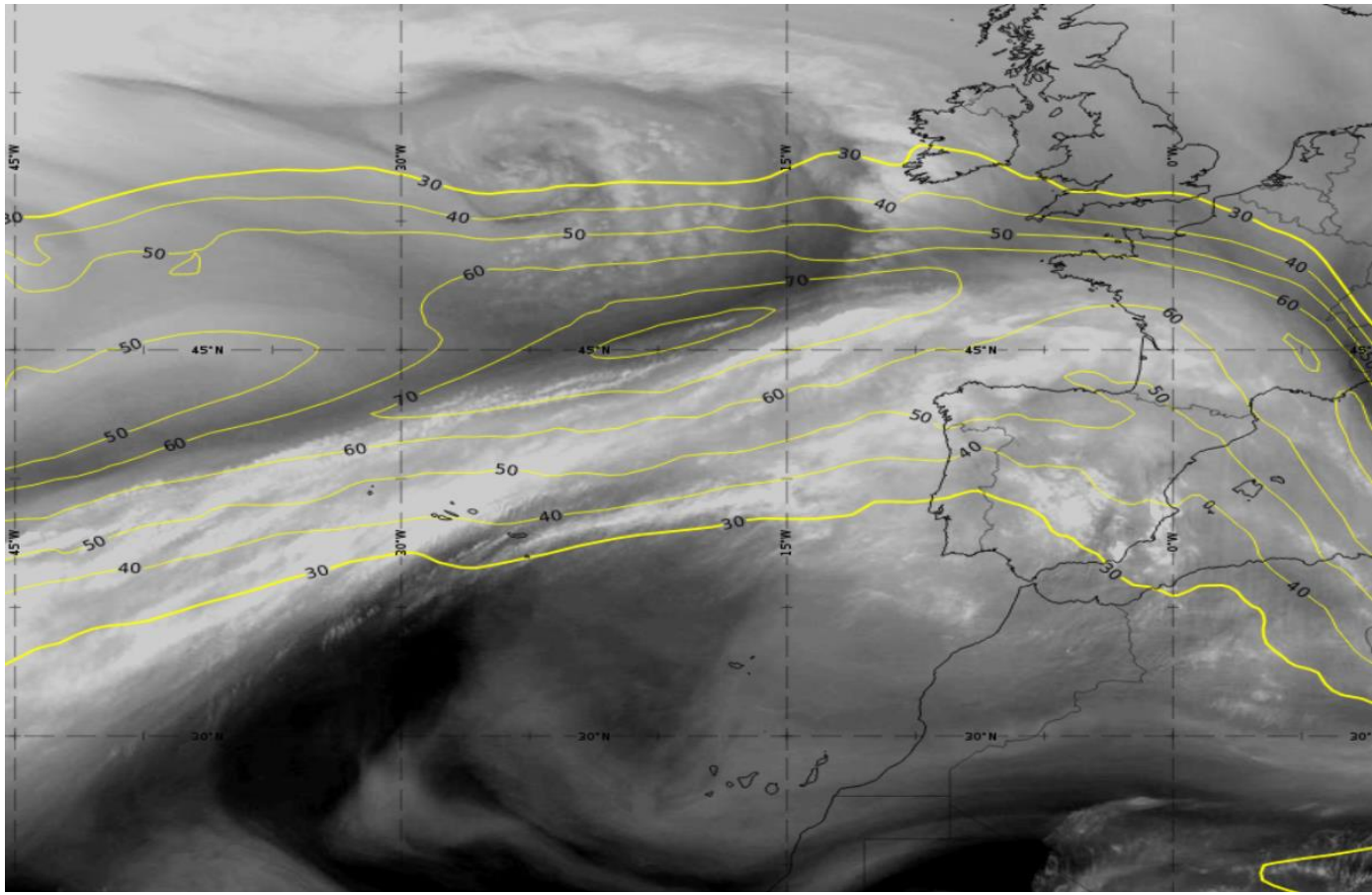
Dark stripes in WV images are often well correlated with maximum wind at 300 or 250 hPa level, i.e. JET STREAK

WV6.2
07 December 2022, 09 UTC

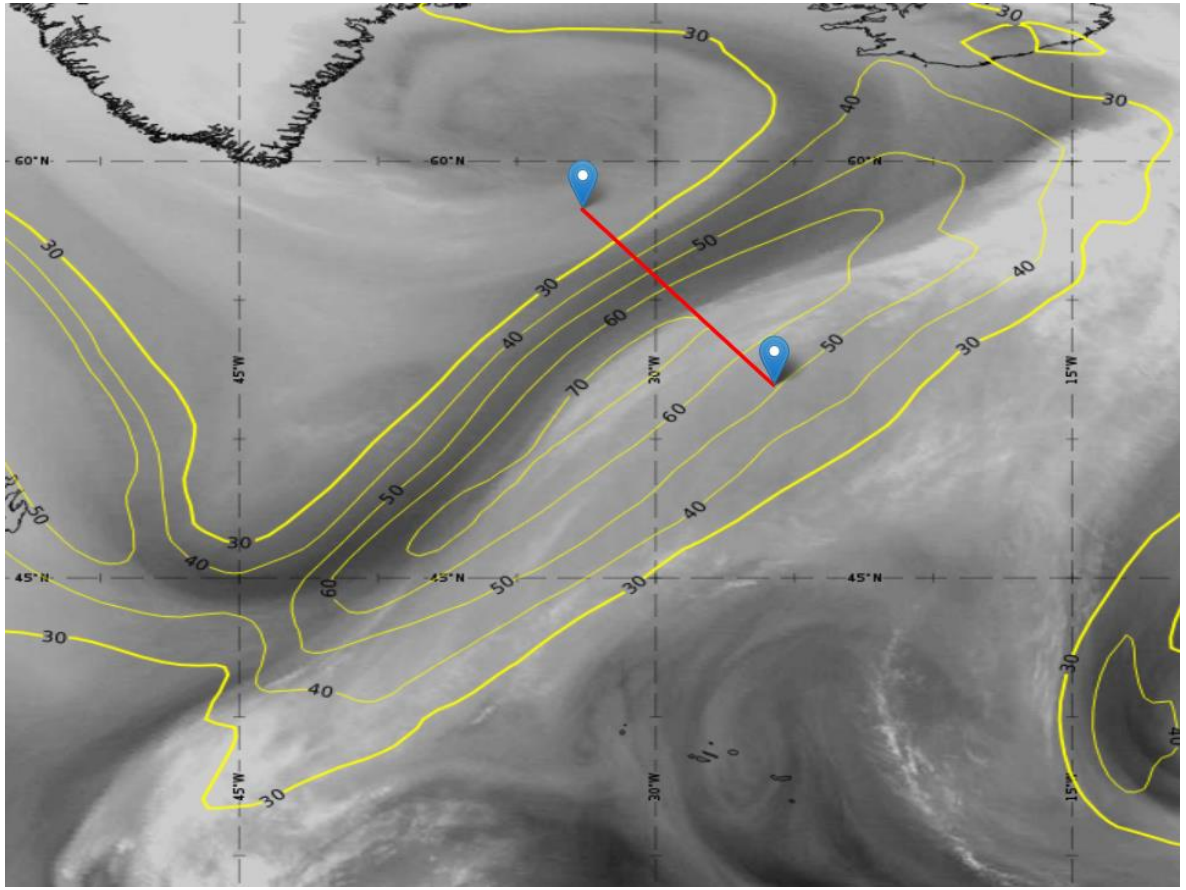
Dark stripes ⟷ Jet streak

www.eumetsat.int

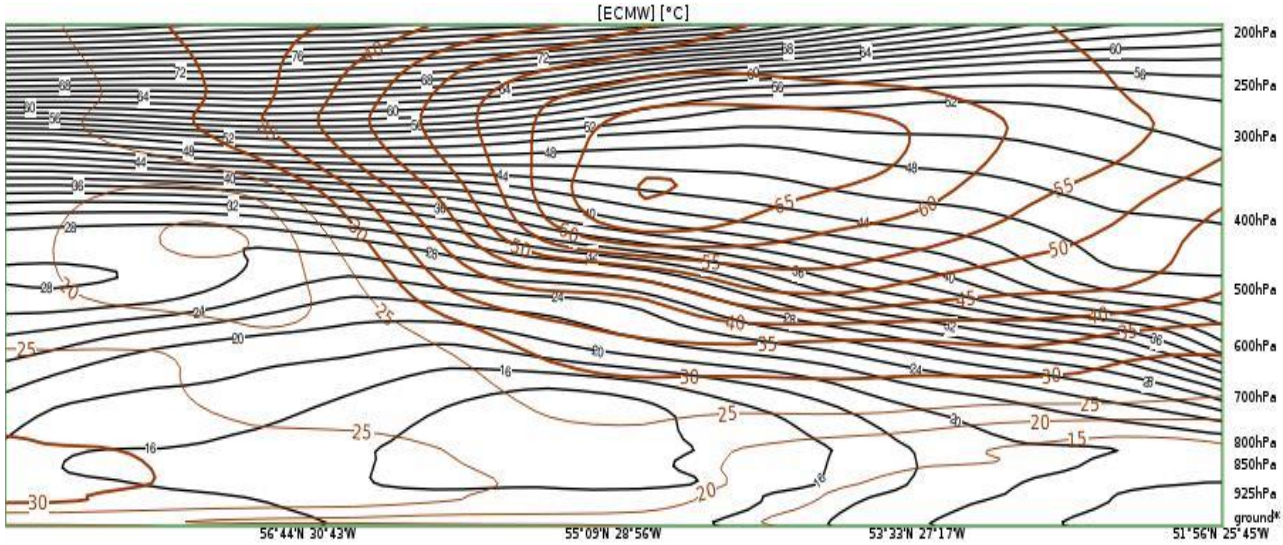




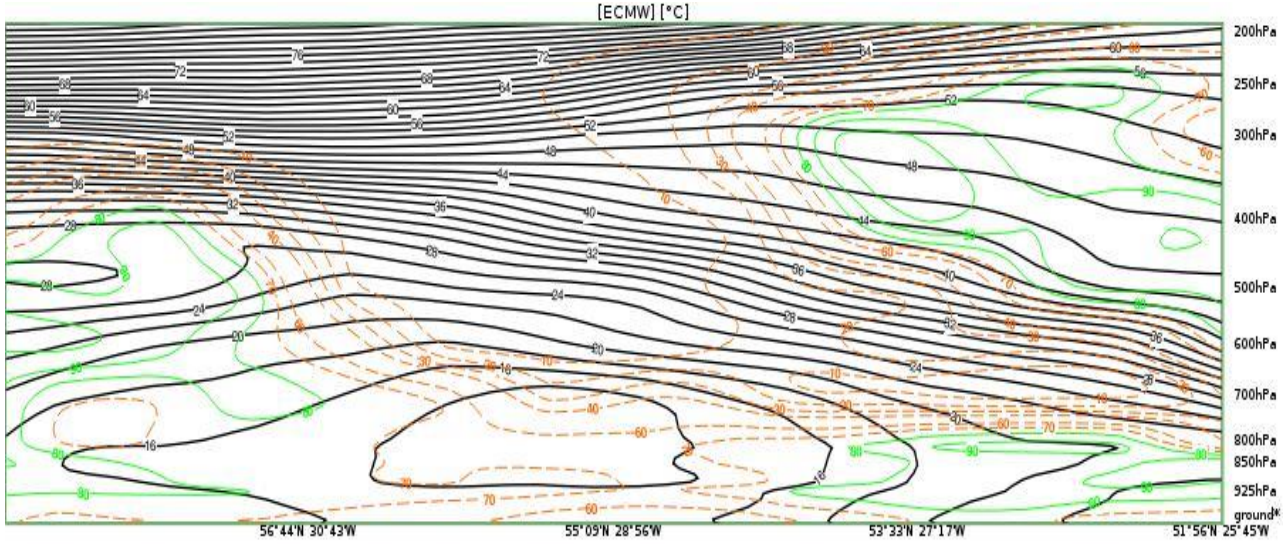
Cross section through a dark stripe



WV 6.2 + isotachs 300hPa
30 November 2022, 21 UTC

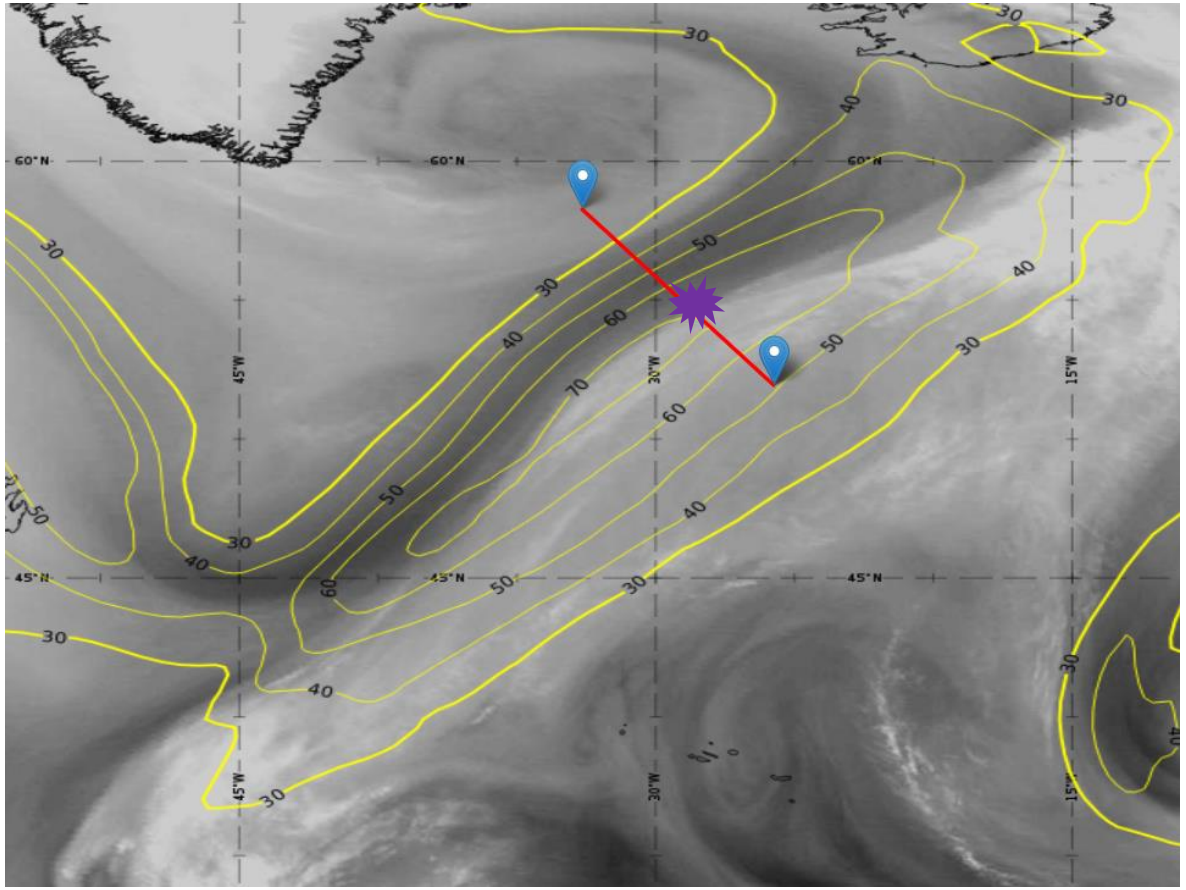


Isotachs

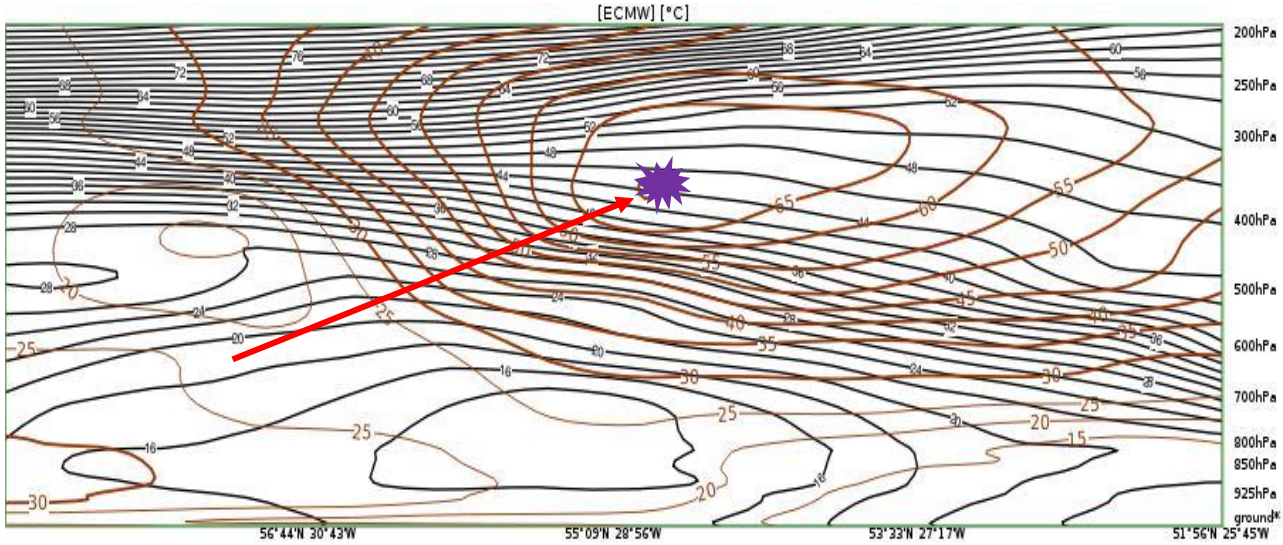


Relative humidity

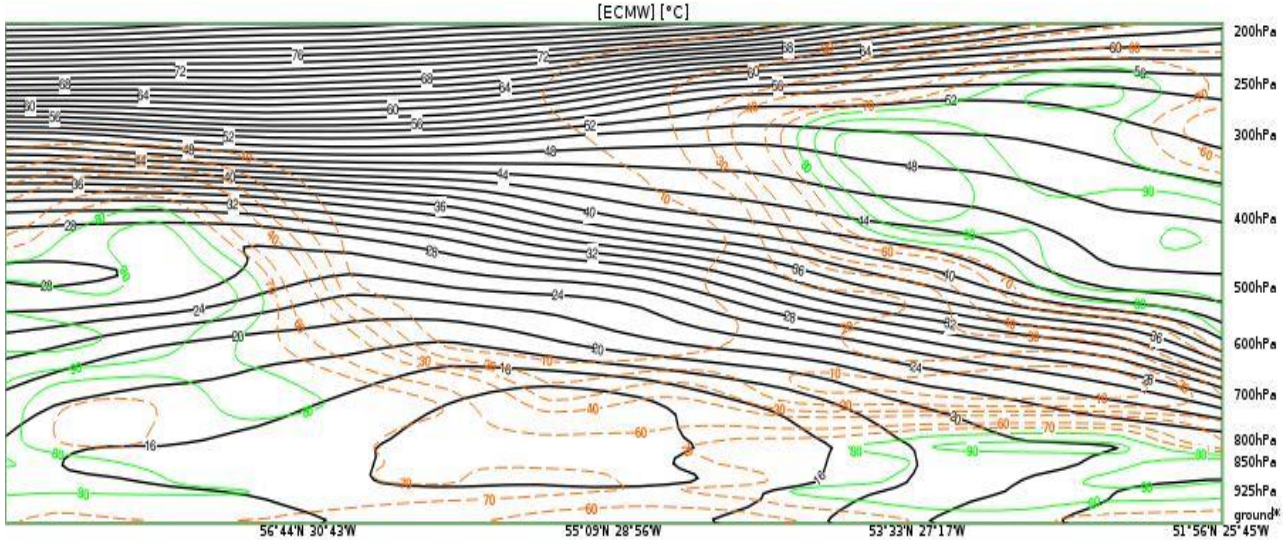
Cross section through a dark stripe



WV 6.2 + isotachs 300hPa
30 November 2022, 21 UTC

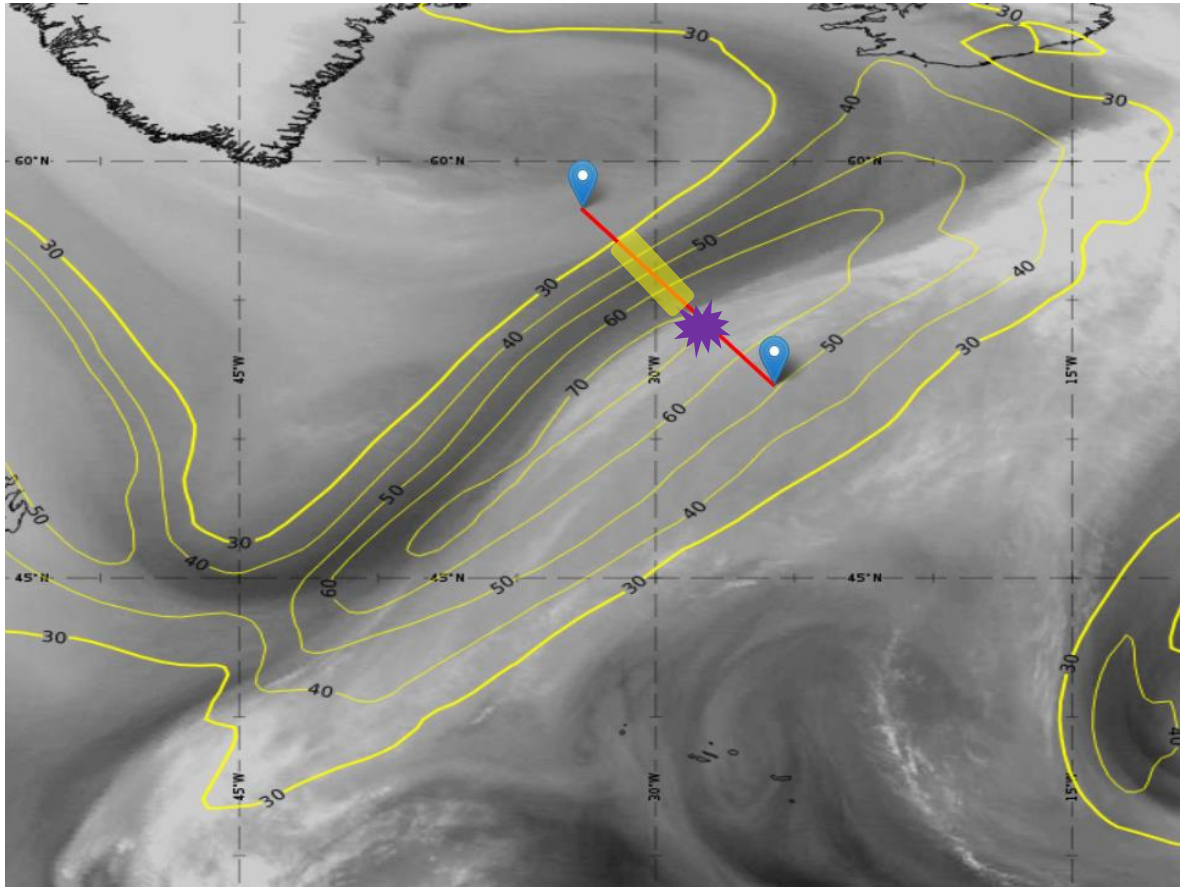


Isotachs

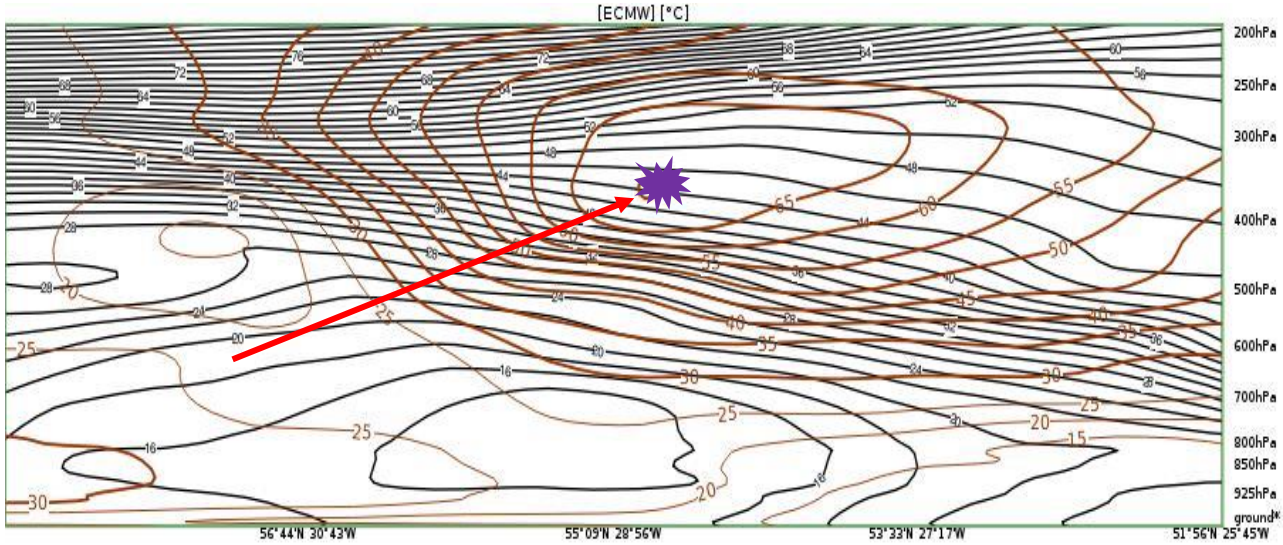


Relative humidity

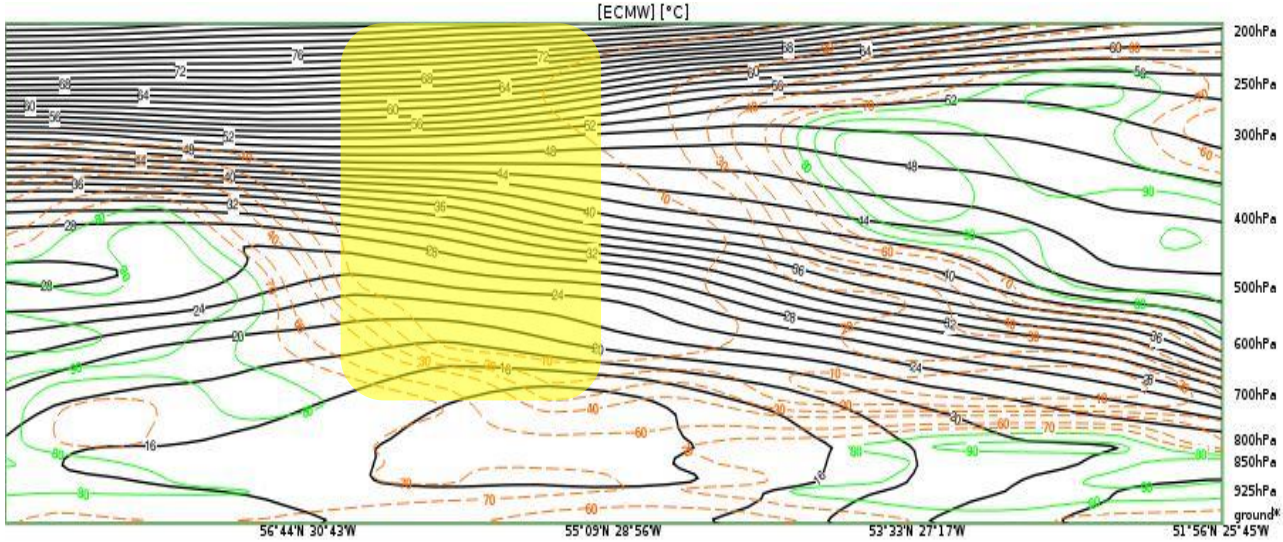
Cross section through a dark stripe



WV 6.2 + isotachs 300hPa
30 November 2022, 21 UTC

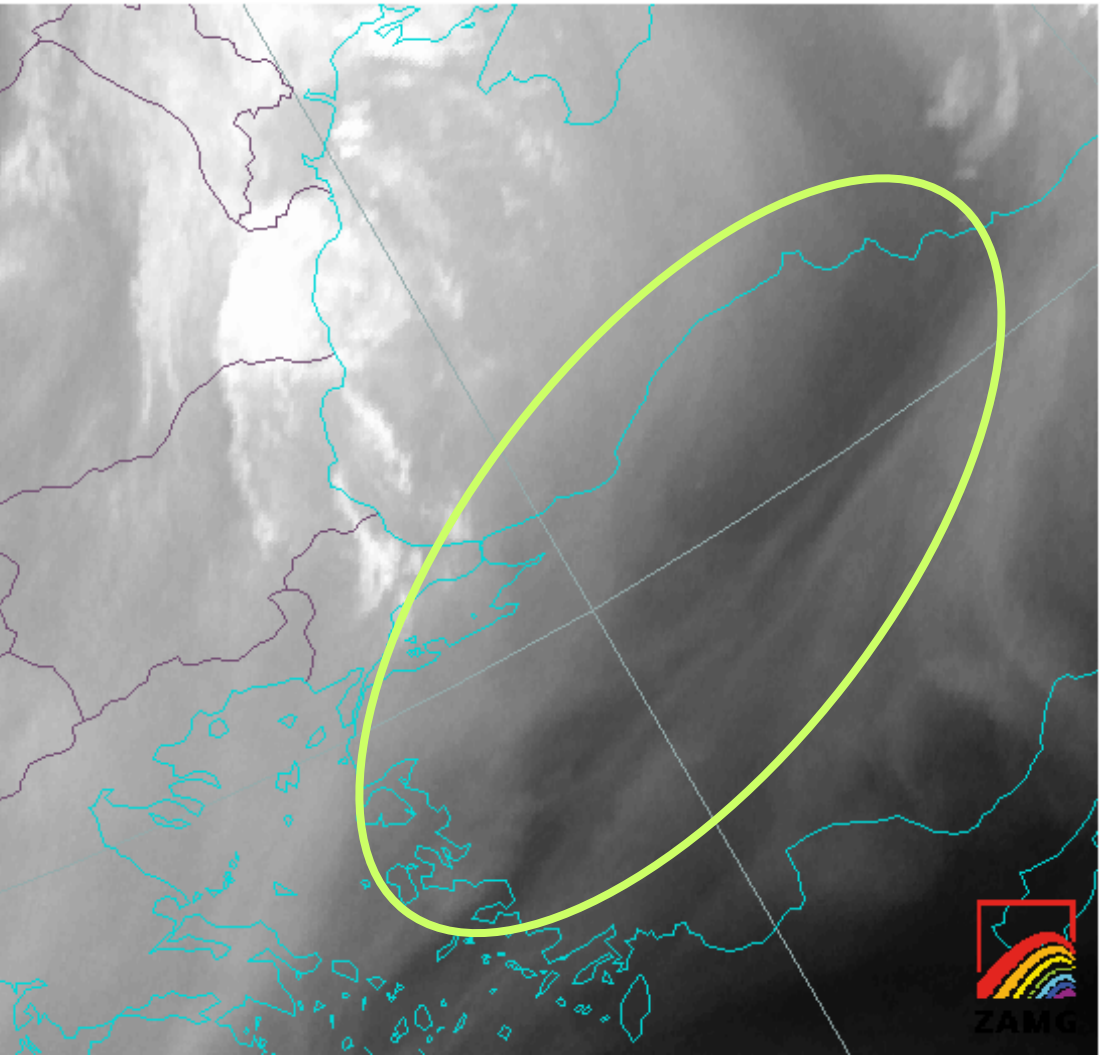


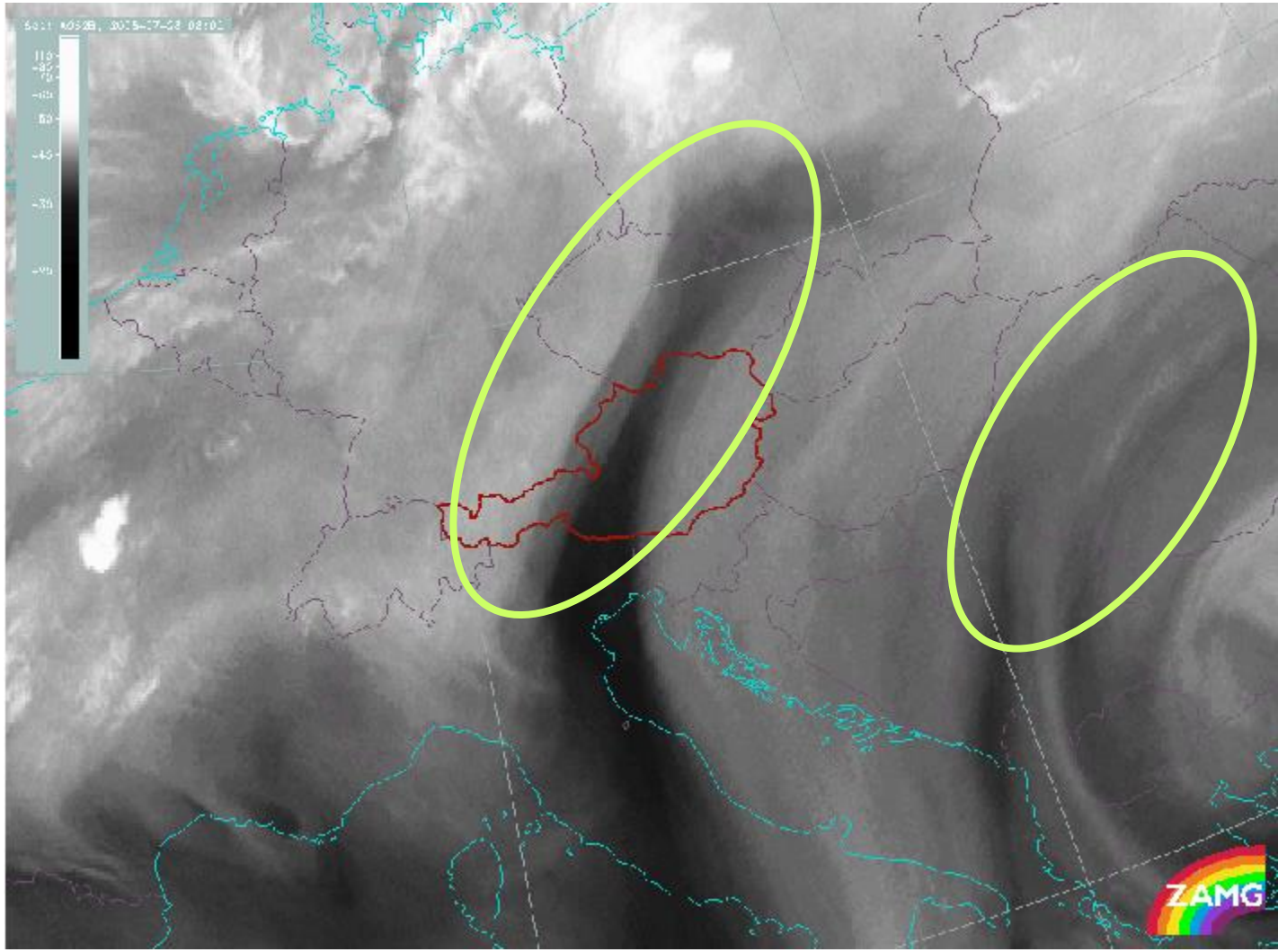
Isotachs



Relative humidity

Convection at the WV boundary

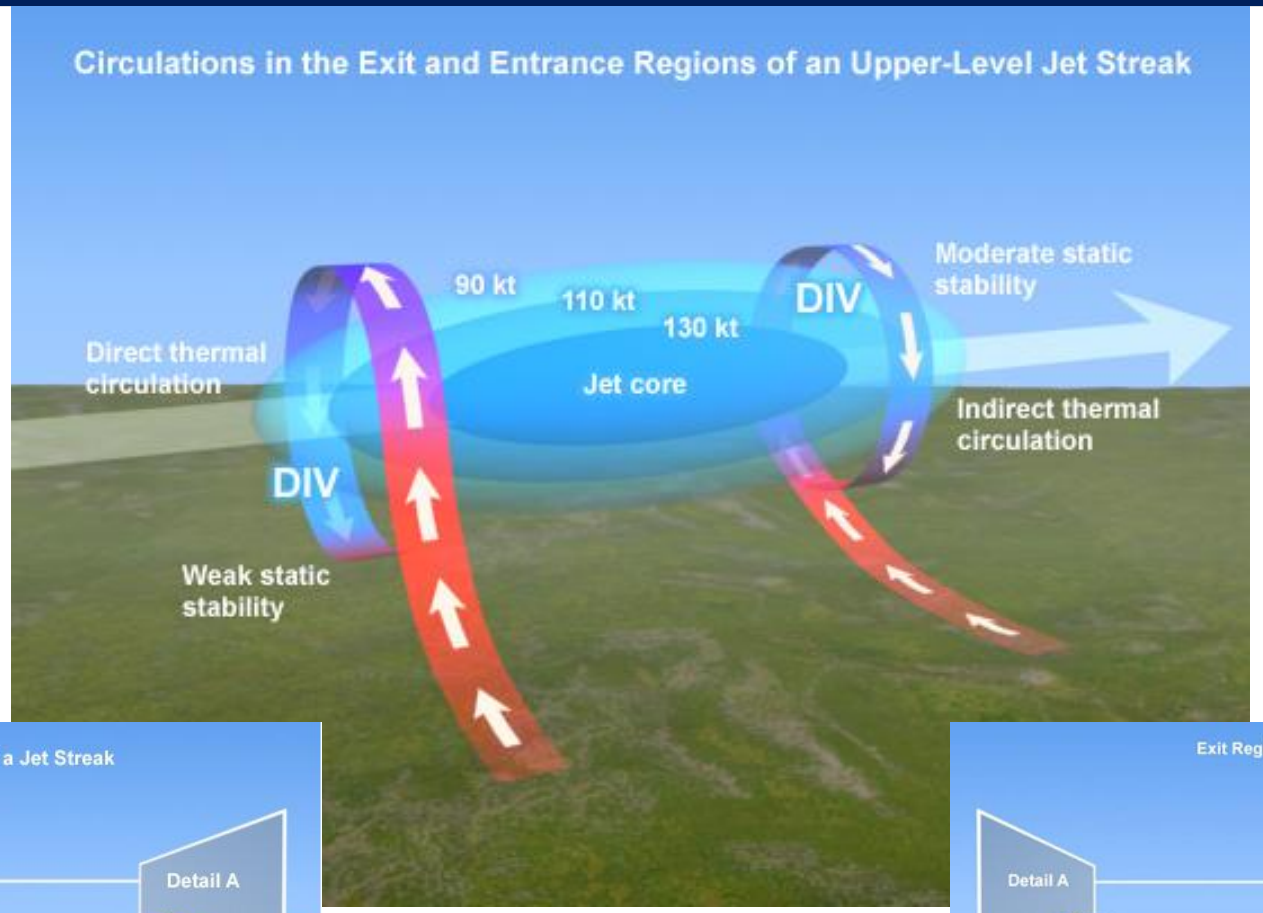


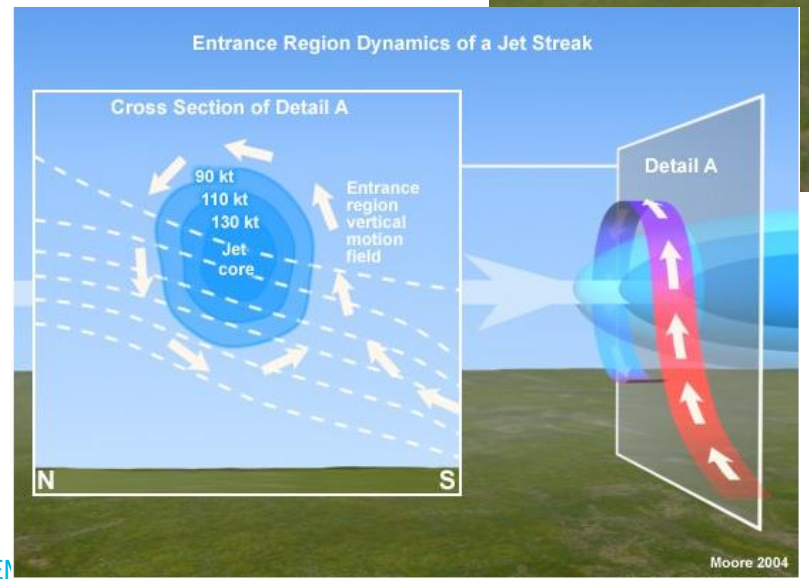


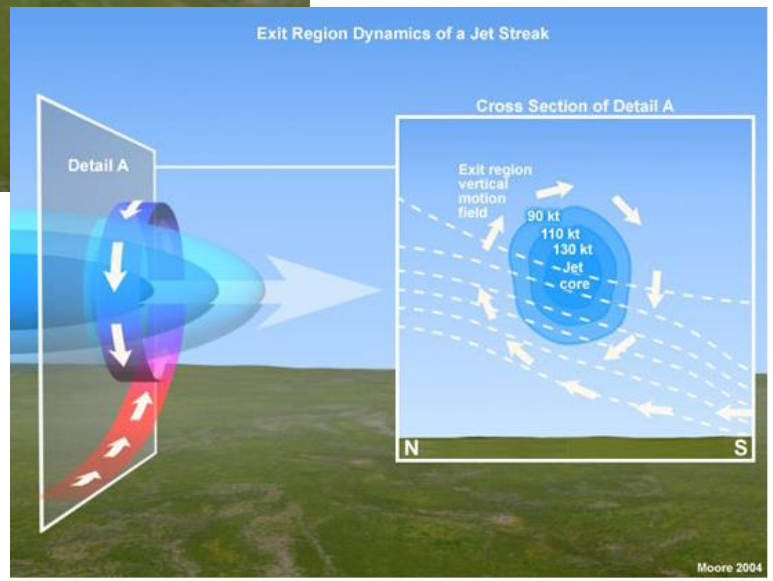
Ascent regions ⟷ Convection

Convection at the WV boundary

Ascent regions ⟷ Convection

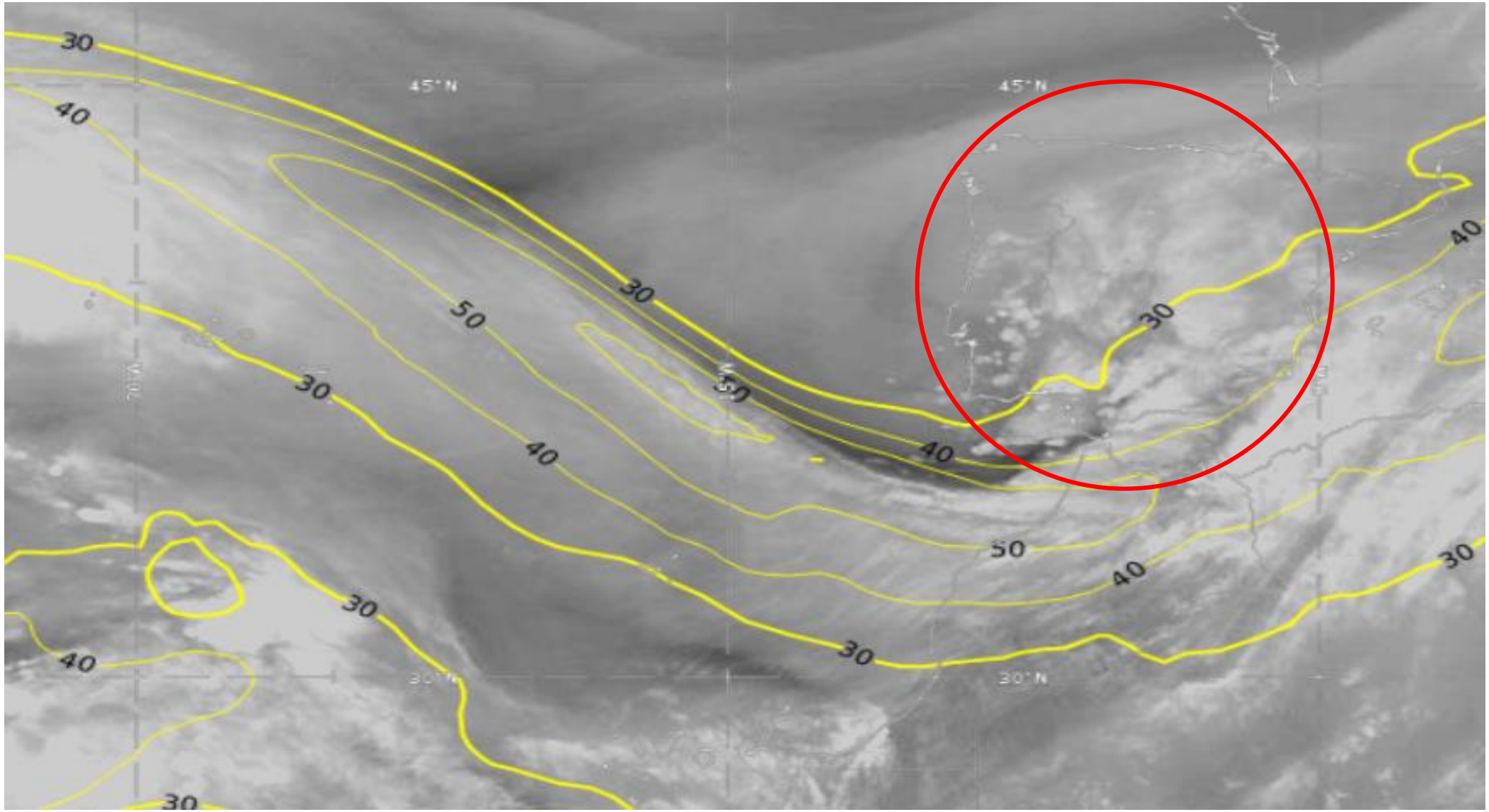




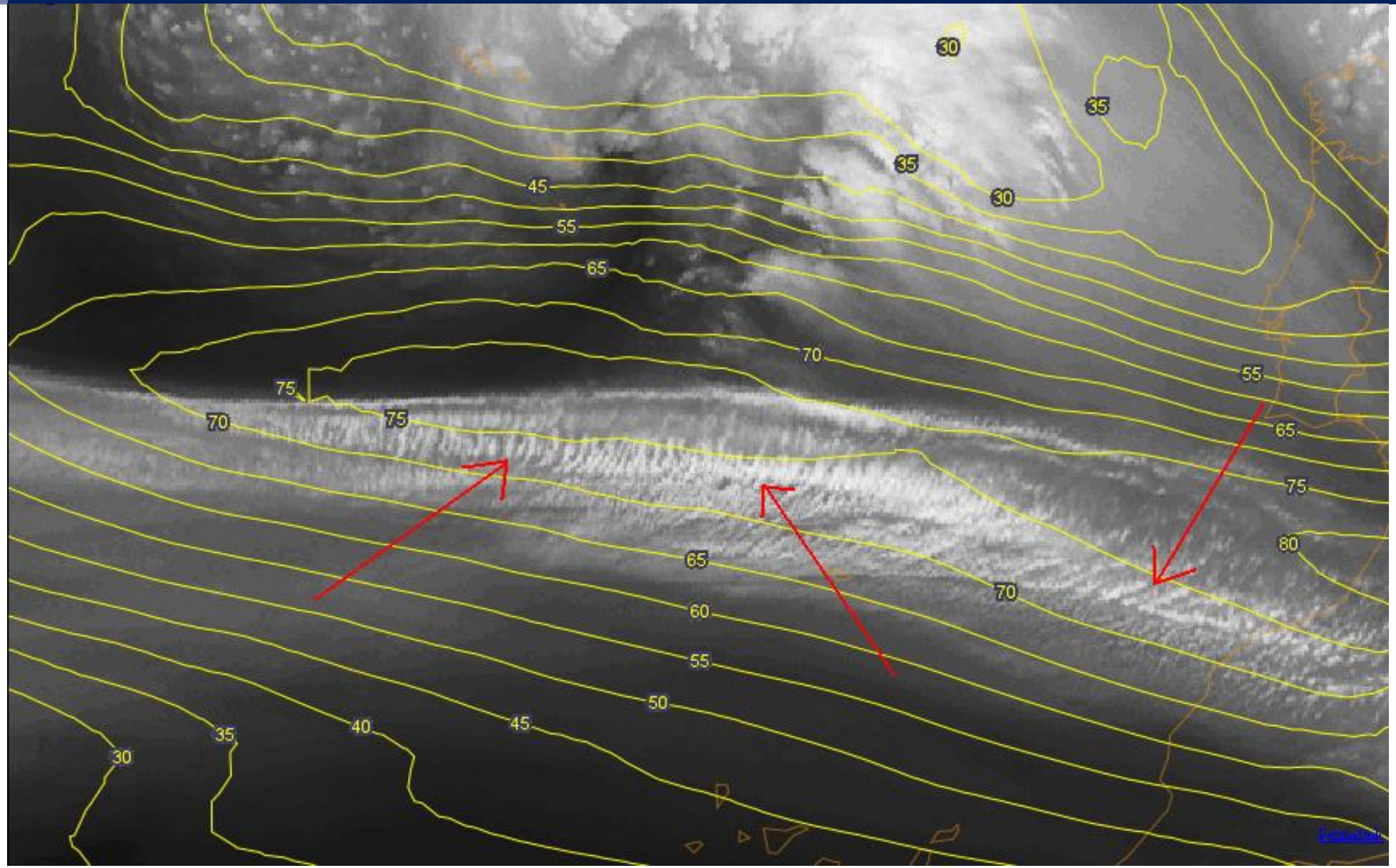


Ascent regions ⟷ Convection

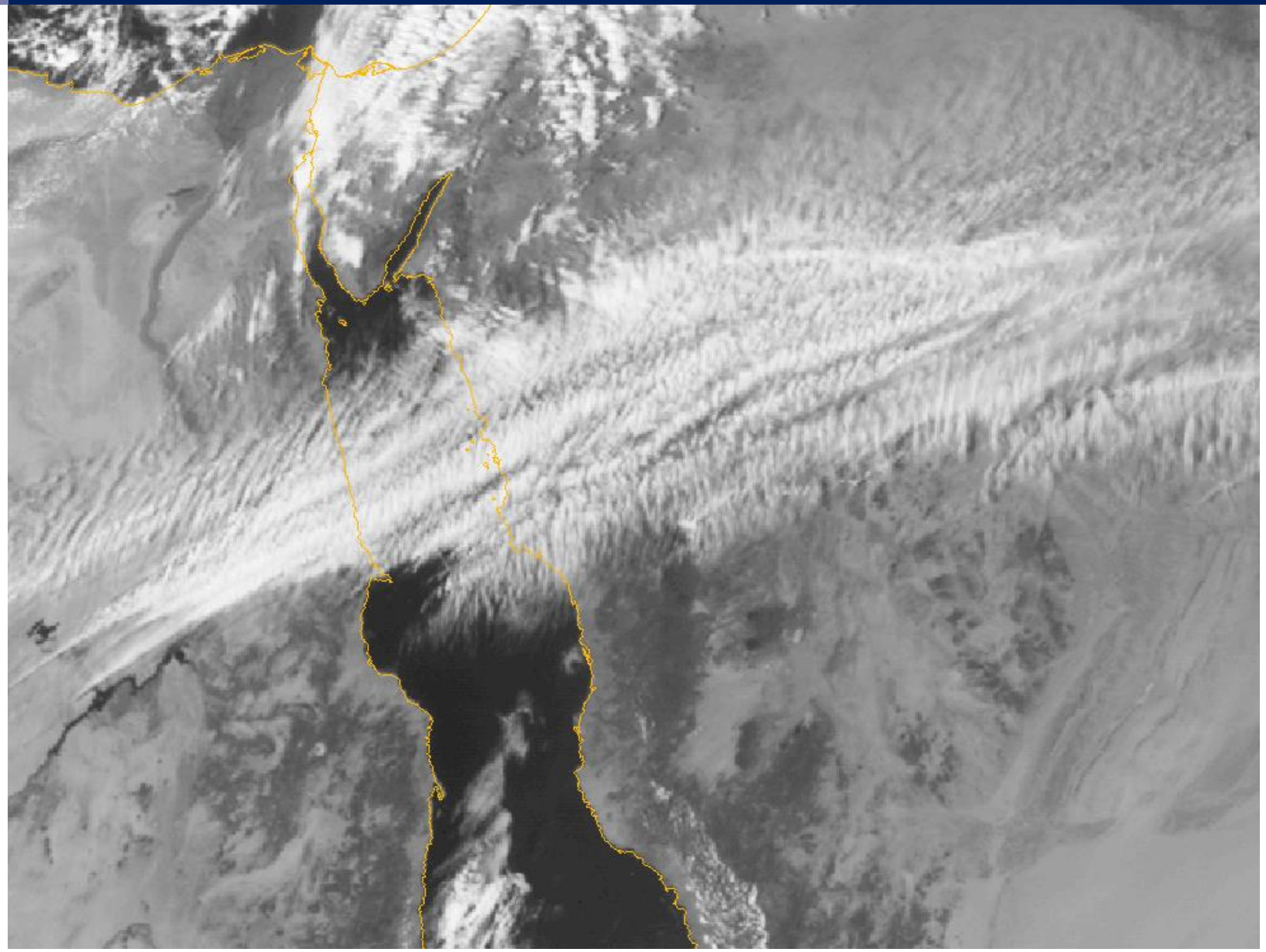
Convection in the left exit region of the jet streak



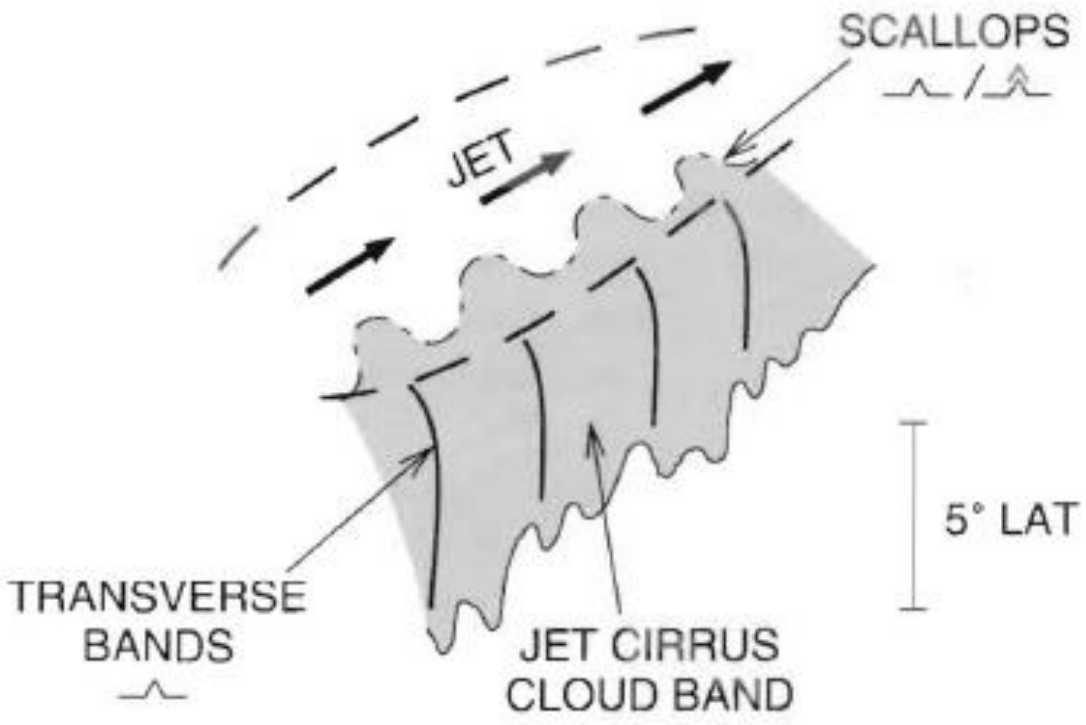
Transverse cloud bands - turbulence

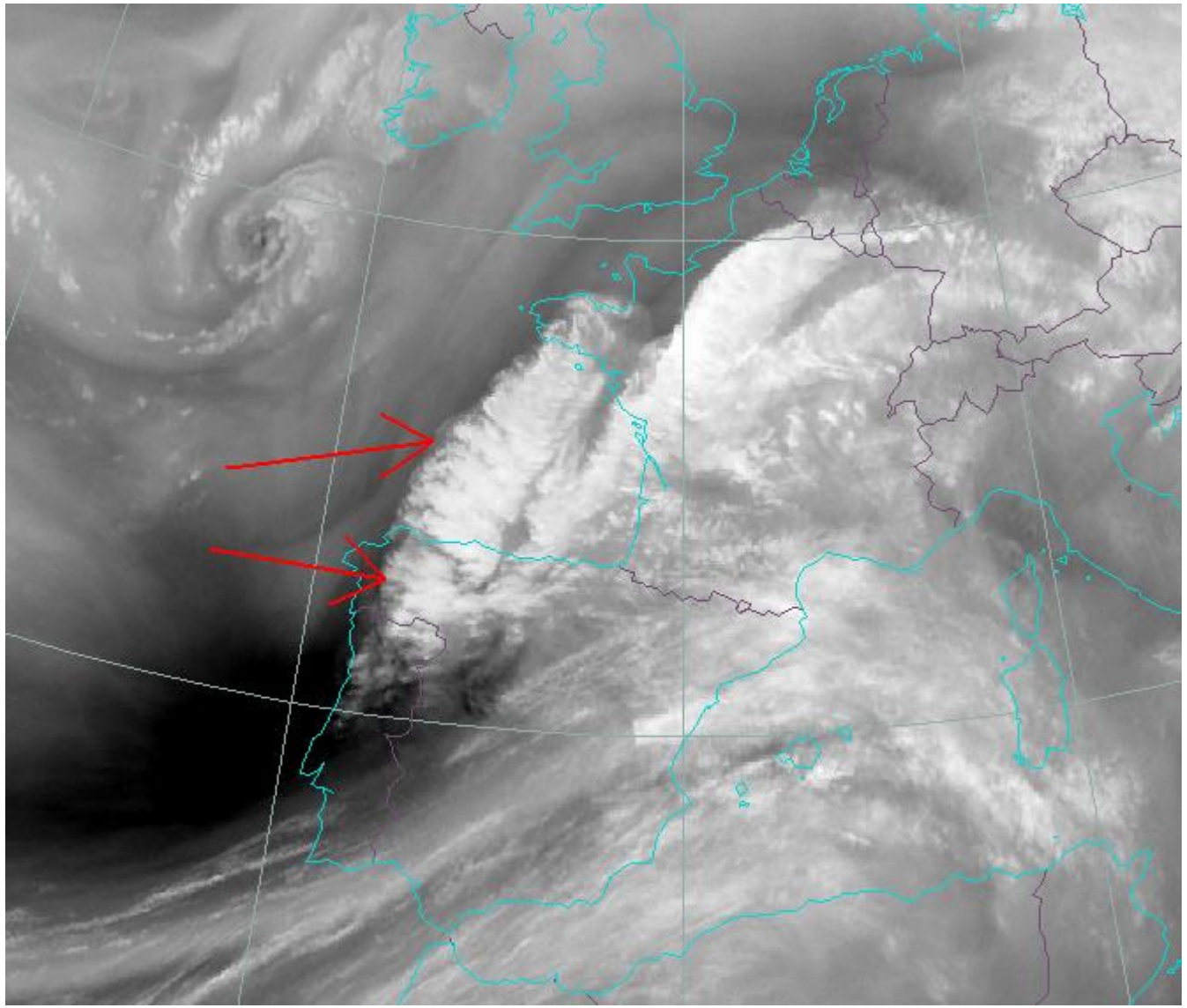


Transverse cloud bands - turbulence



Transverse cloud bands - turbulence

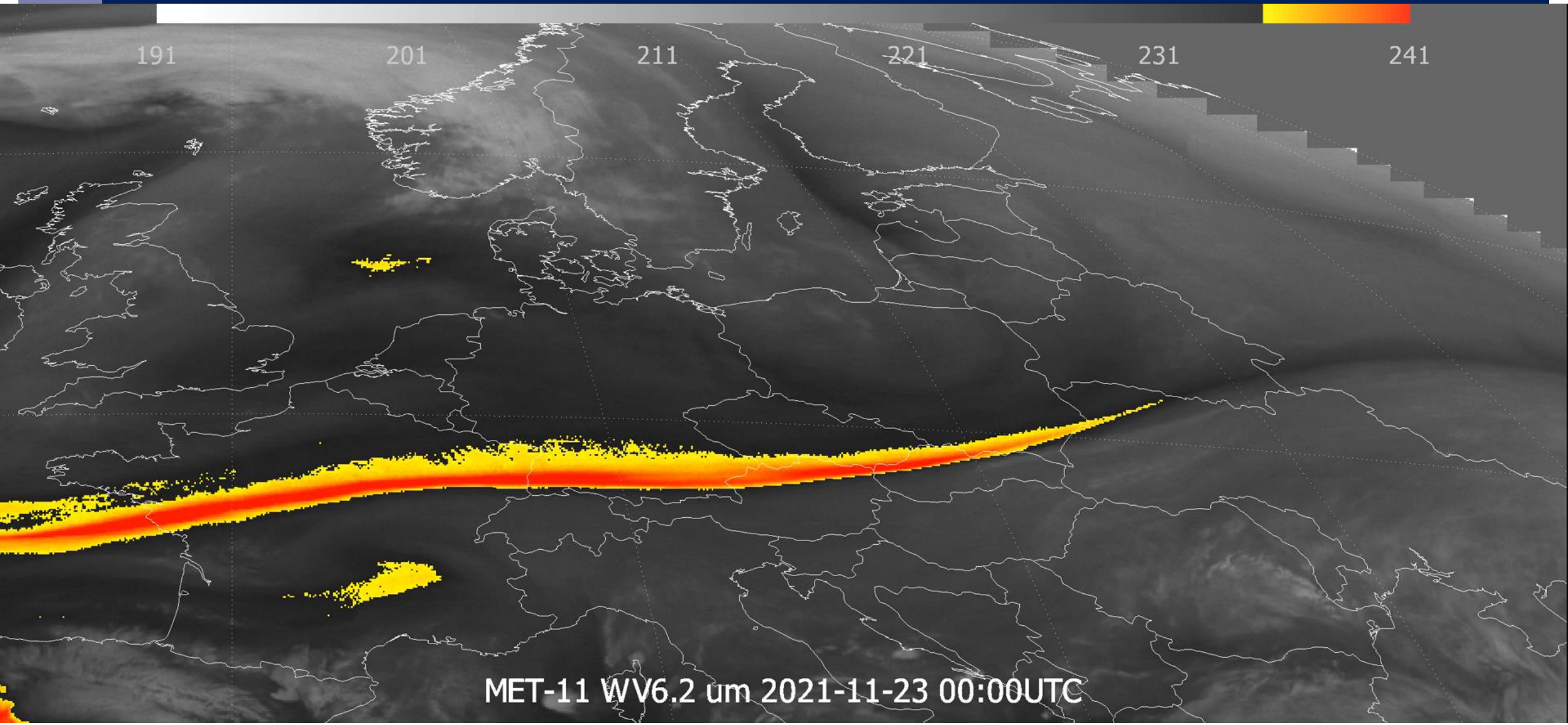




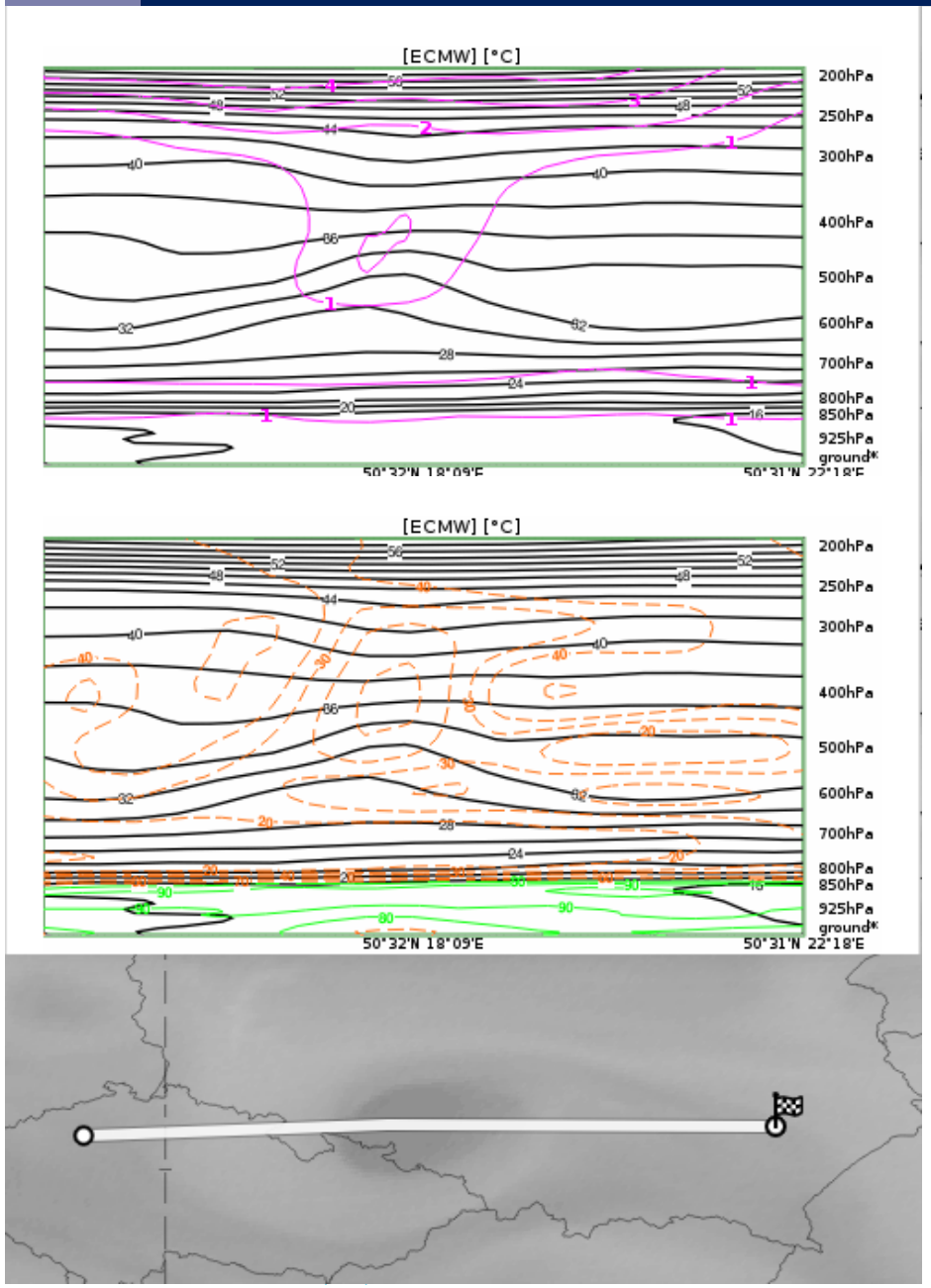
WV “Eyes”

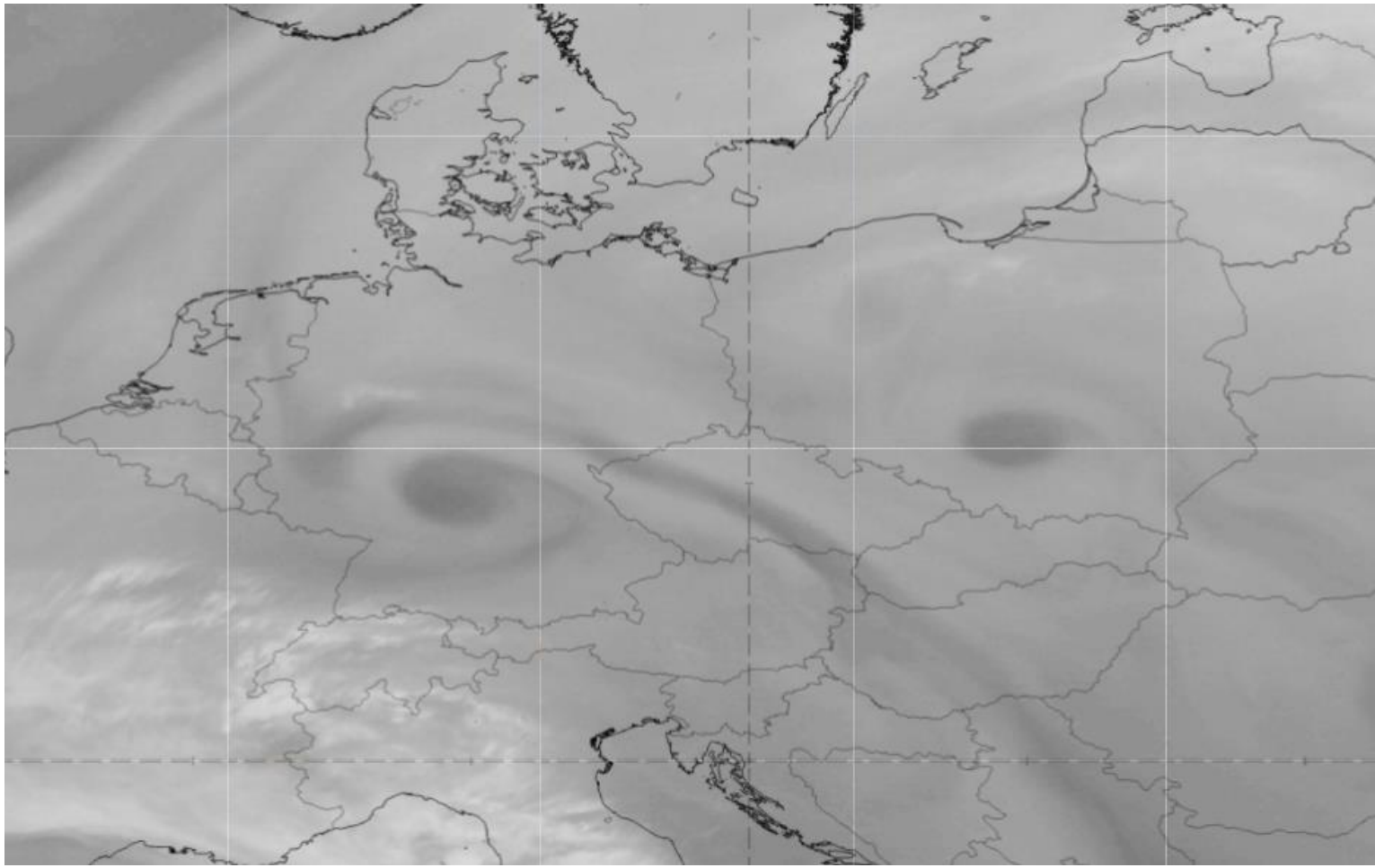
- Round “eye”-like structures are often seen in WV 6.2

WV "Eyes"



WV "Eyes"


[ECMW] [°C]
200hPa
250hPa
300hPa
400hPa
500hPa
600hPa
700hPa
800hPa
850hPa
925hPa
ground*
50°32'N 18°09'E
50°31'N 22°18'E
[ECMW] [°C]
200hPa
250hPa
300hPa
400hPa
500hPa
600hPa
700hPa
800hPa
850hPa
925hPa
ground*
50°32'N 18°09'E
50°31'N 22°18'E

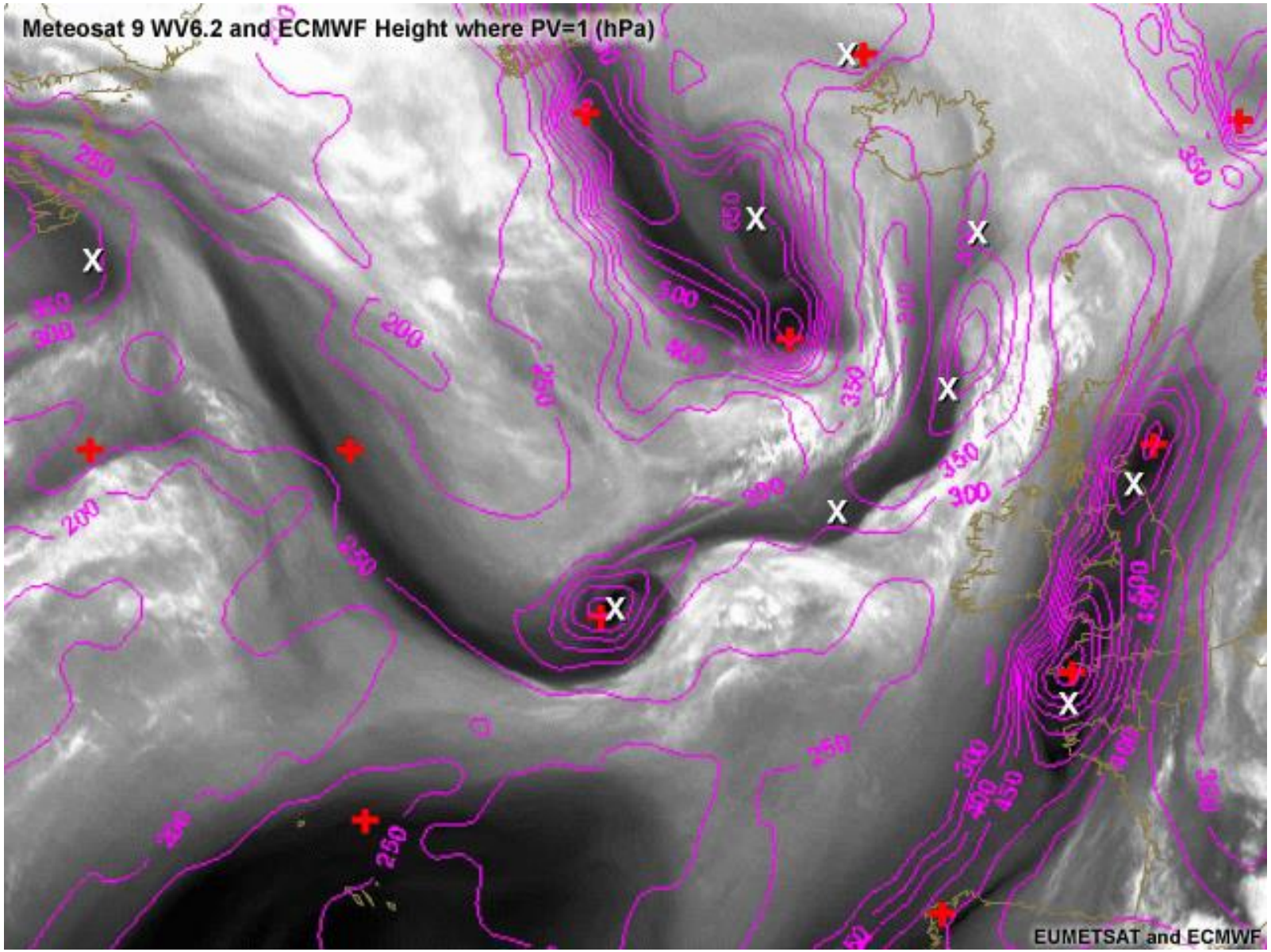


Dark spots

Dark spots in 6.2 µm images - often connected to isentropic potential vorticity (IPV) maxima, signaling vorticity rich stratospheric air subsiding to mid or lower troposphere

Moisture regime in WV 6.2 imagery reflects the tropopause height field

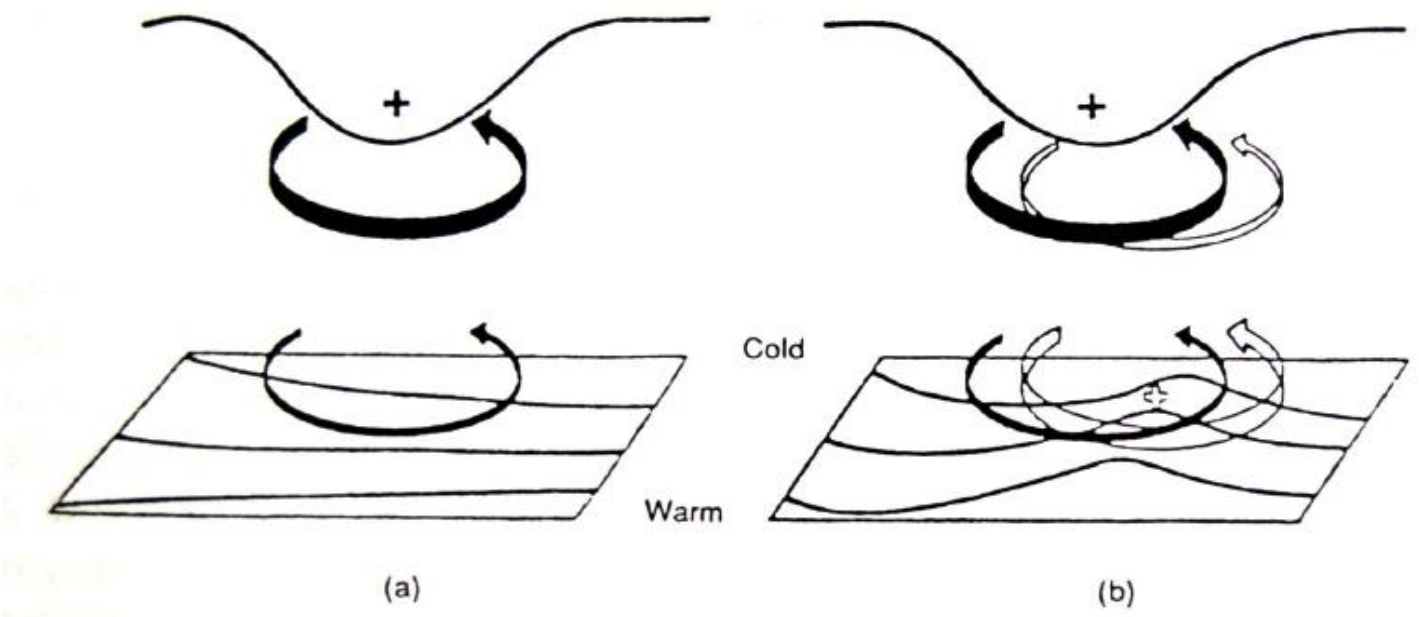
The boundaries between dark (dry) and light (moist) features represent sloping areas of the tropopause and strong gradient areas of height of the surface of constant potential vorticity equal to 1.5 (or 1) PVU



Cyclogenesis

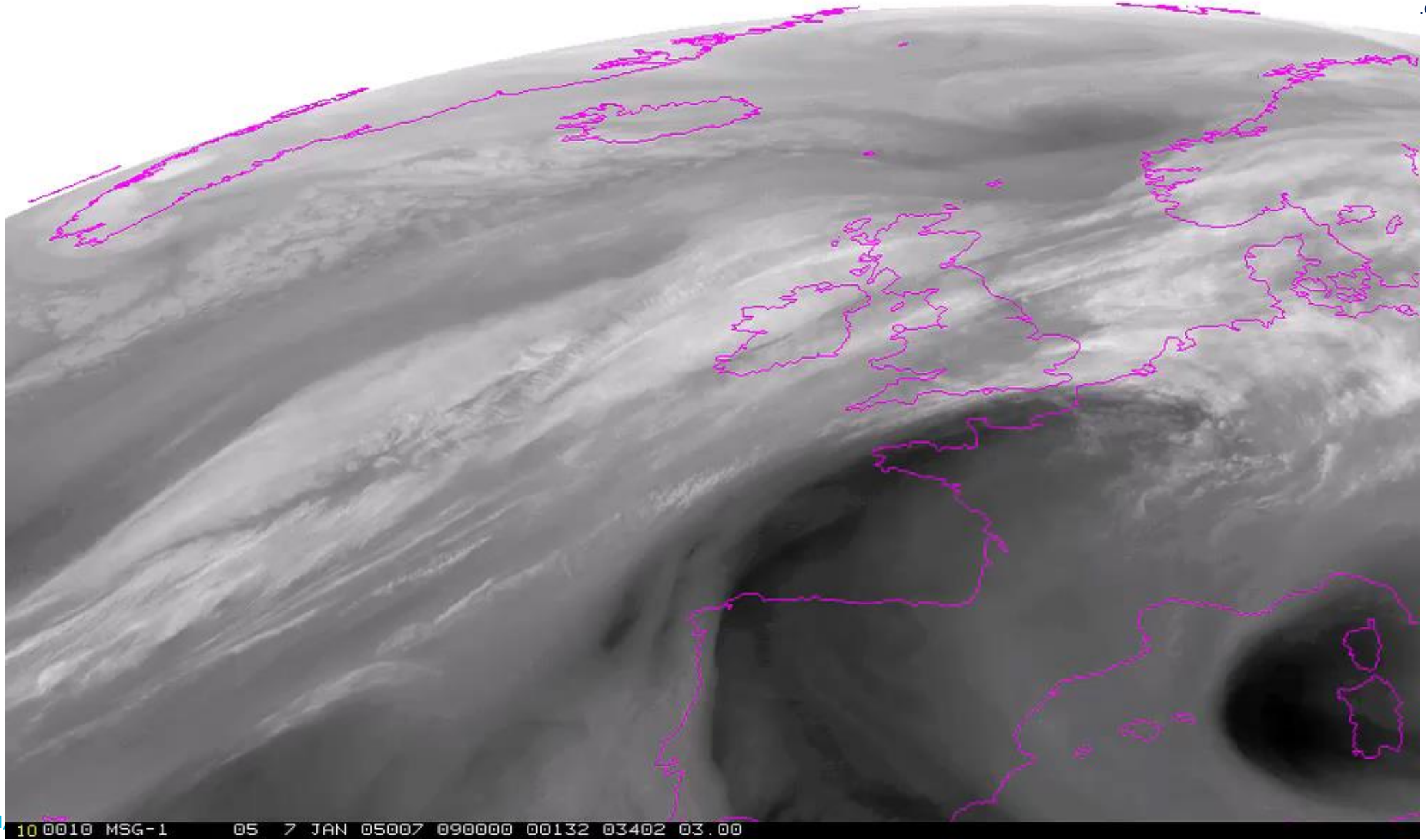
- Cyclogenesis at lower levels is induced by air masses with high values of PV being advected from the tropopause over a region with a pre-existing meridional temperature gradient

- the circulation induced by the upper-level PV anomaly leads to a temperature advection near the surface and upper-level PV - anomalies can become locked in phase, so that the induced circulations produce a rapid amplification of the anomaly pattern.

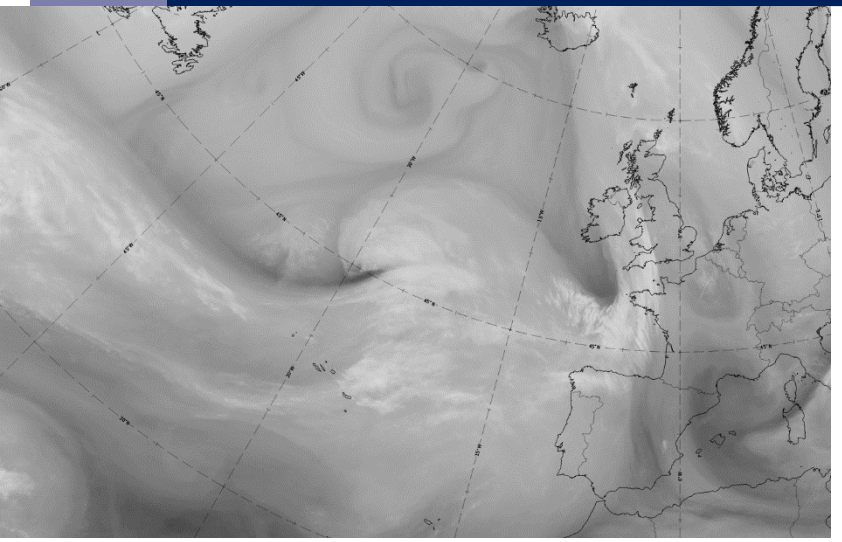


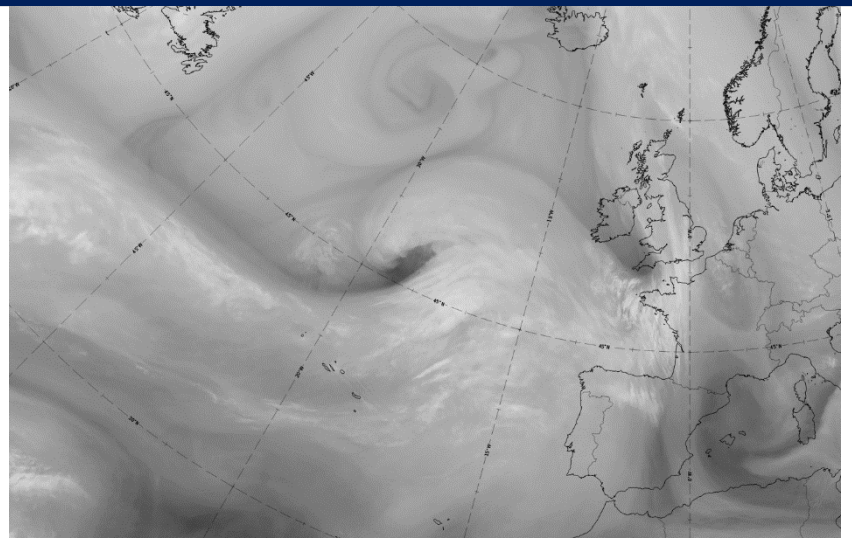
Cyclogenesis associated with the arrival of an upper-level vorticity anomaly.

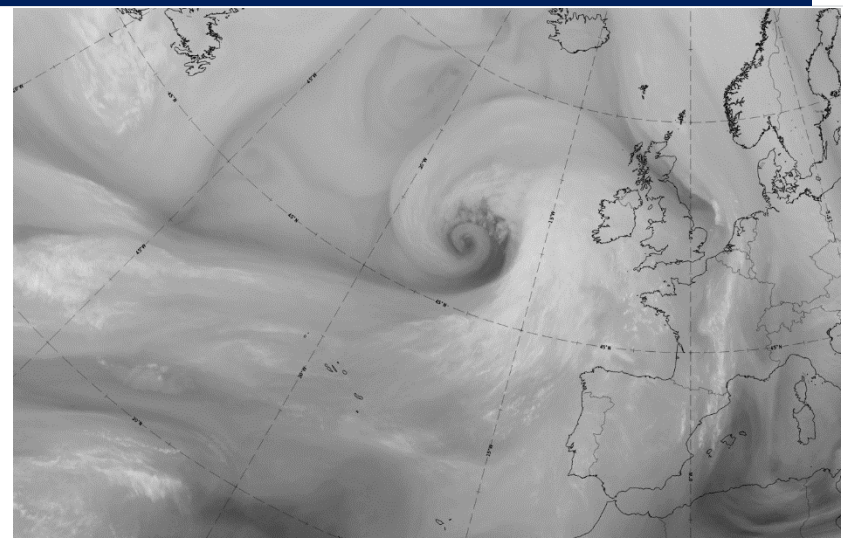
Rapid Cyclogenesis



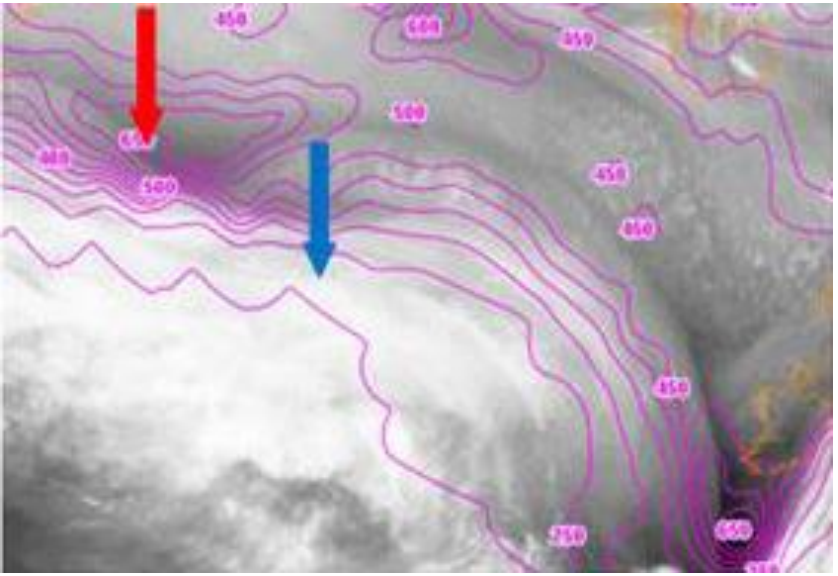
Rapid Cyclogenesis

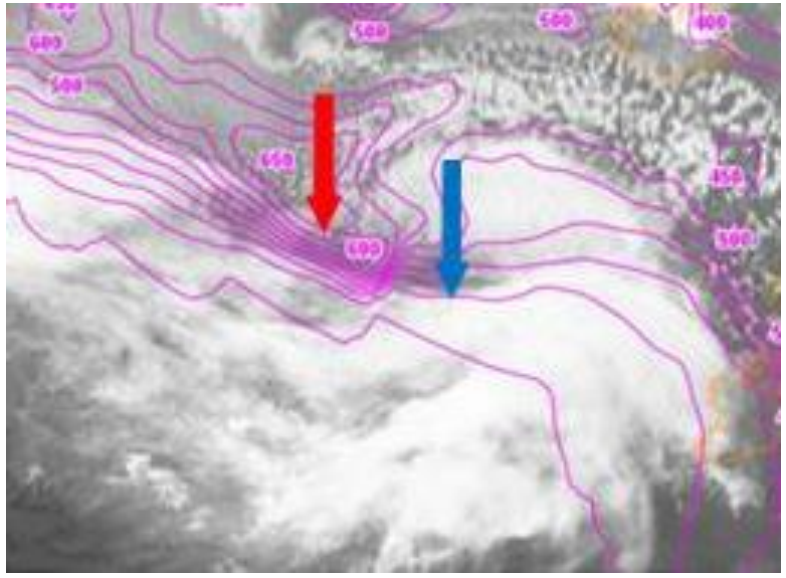


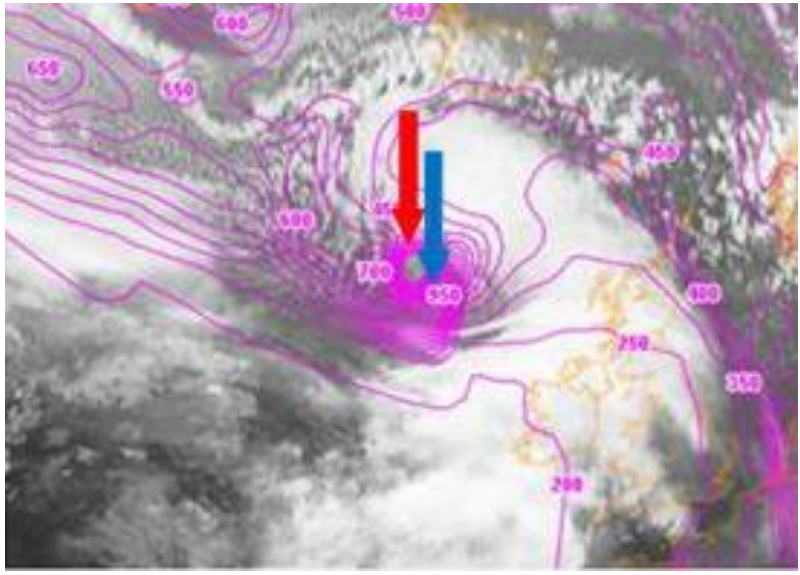




PV anomalies play a major role in the rapid or even explosive development of the cyclones

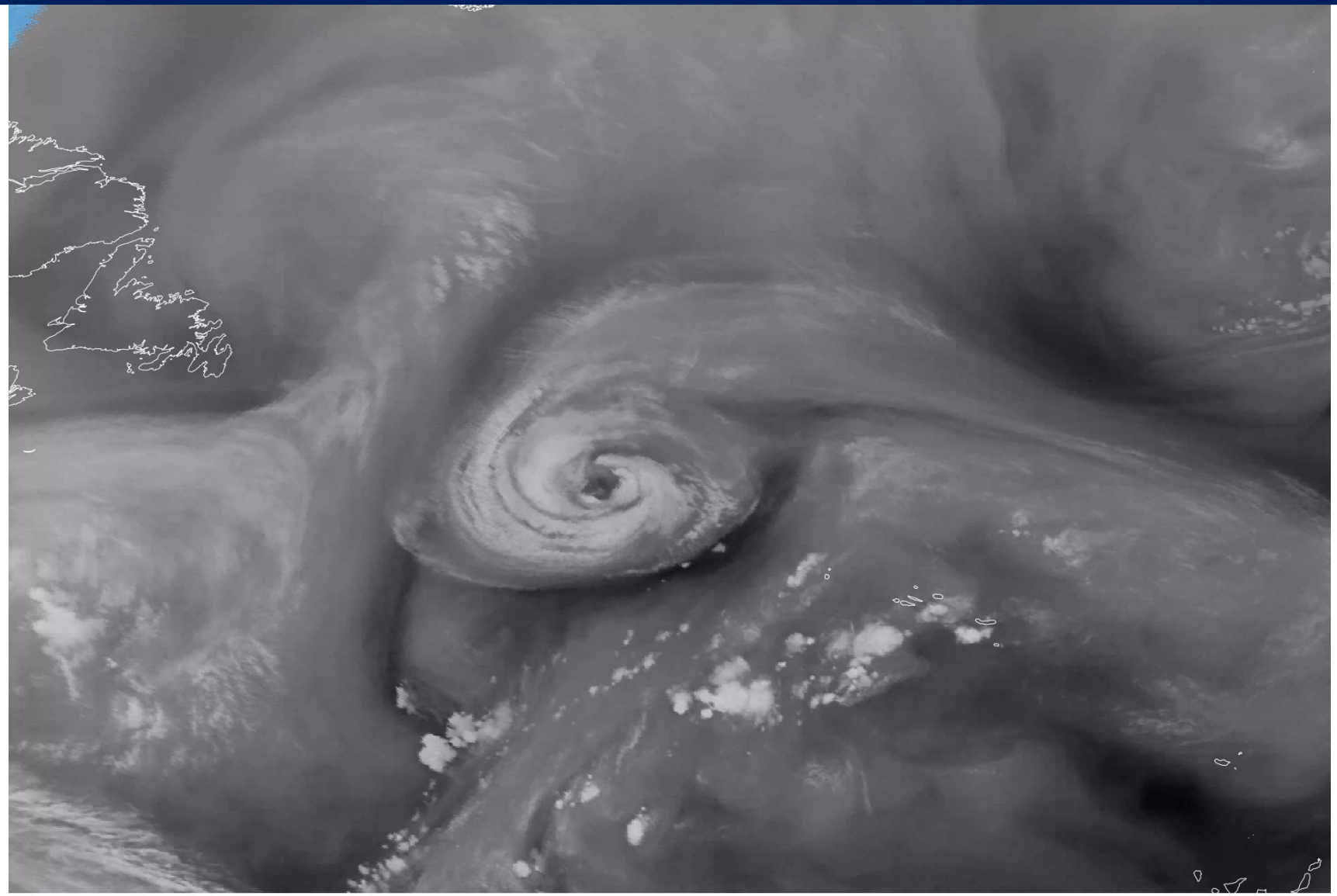






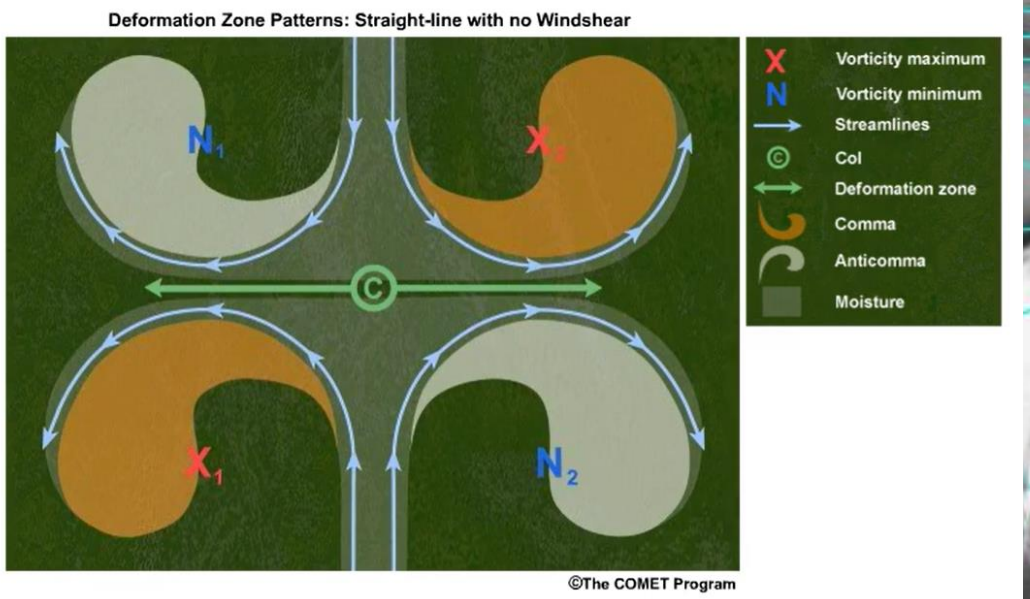
Cyclogenesis, cyclones

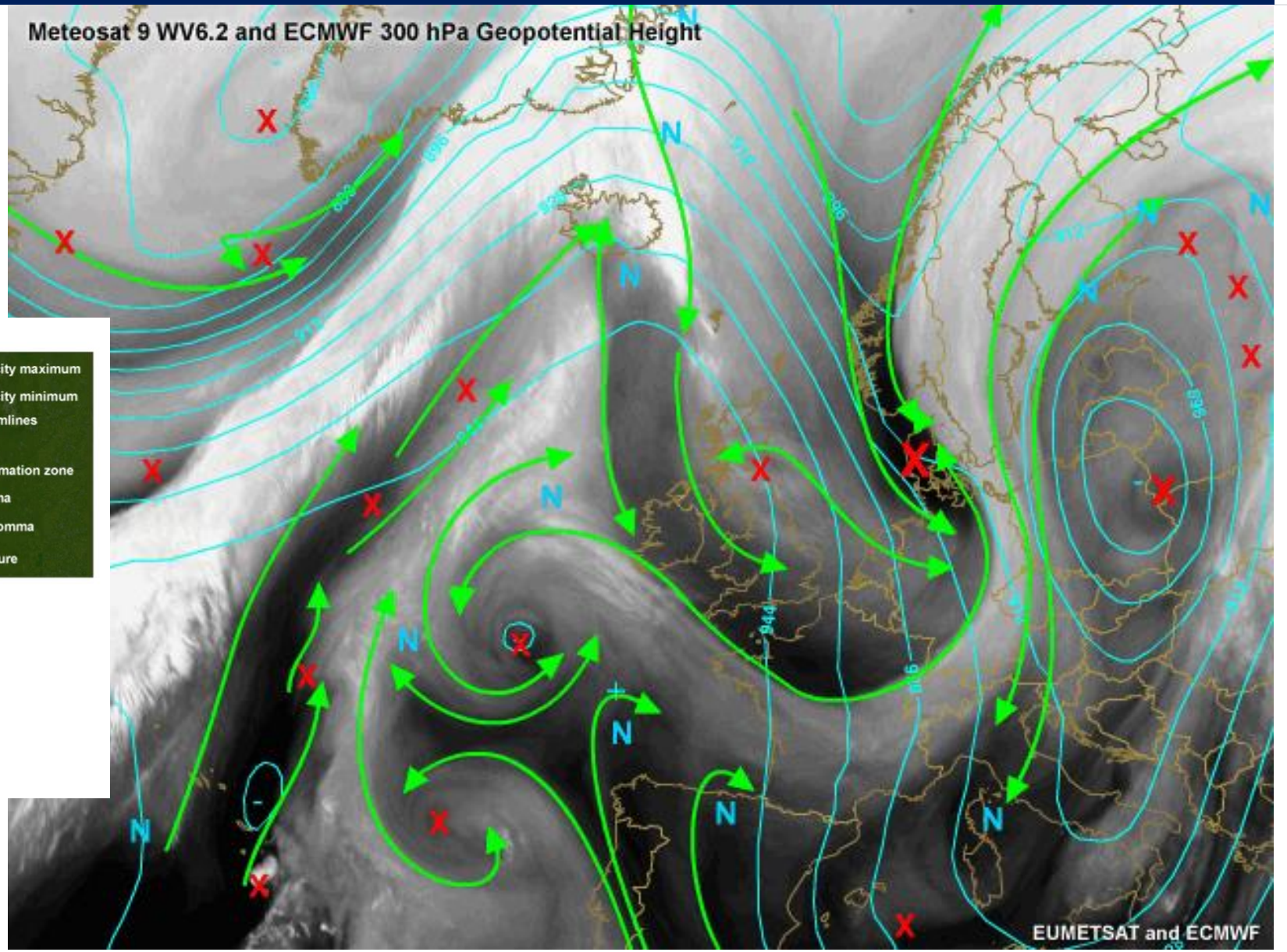
Cyclogenesis, cyclones



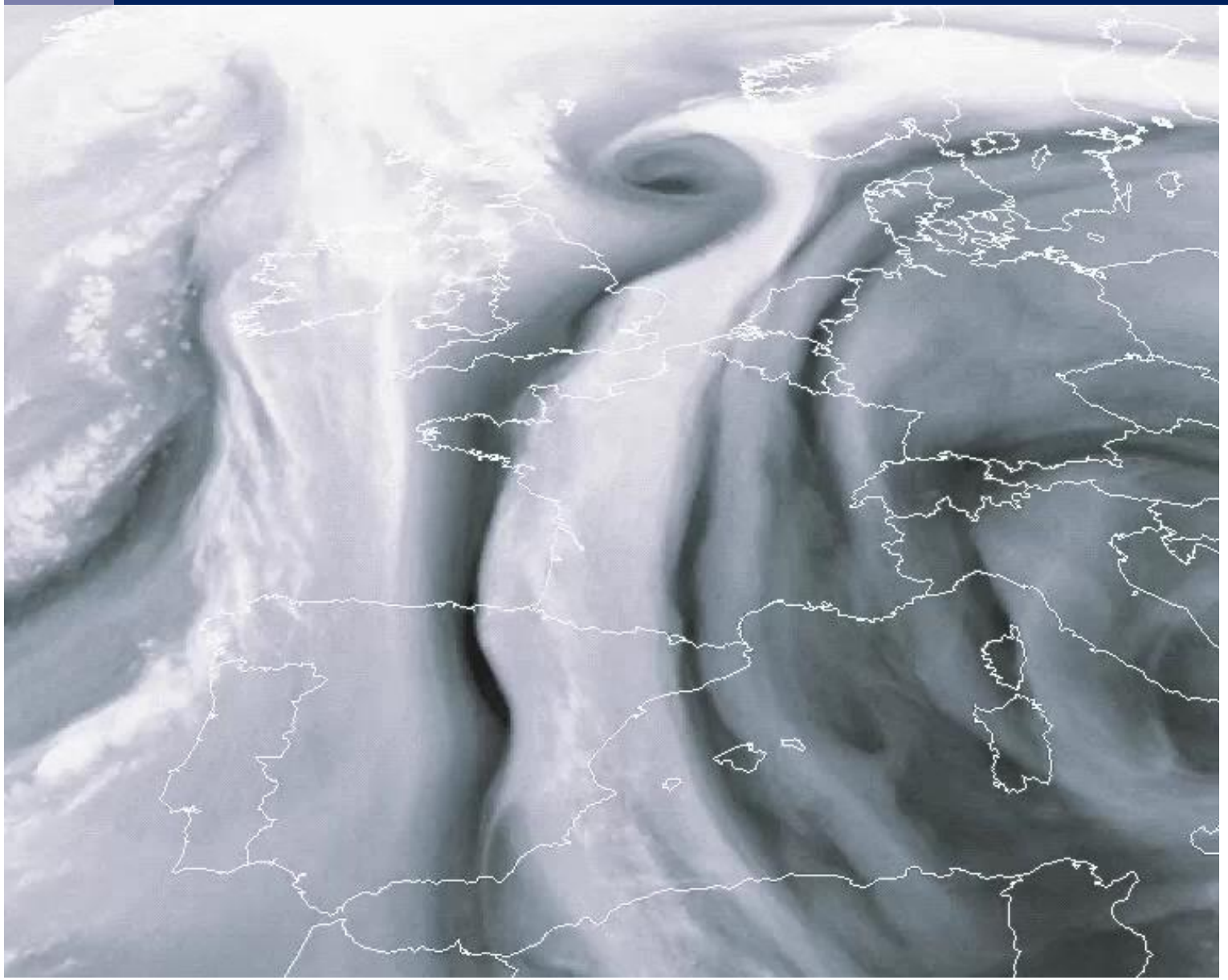
Deformation

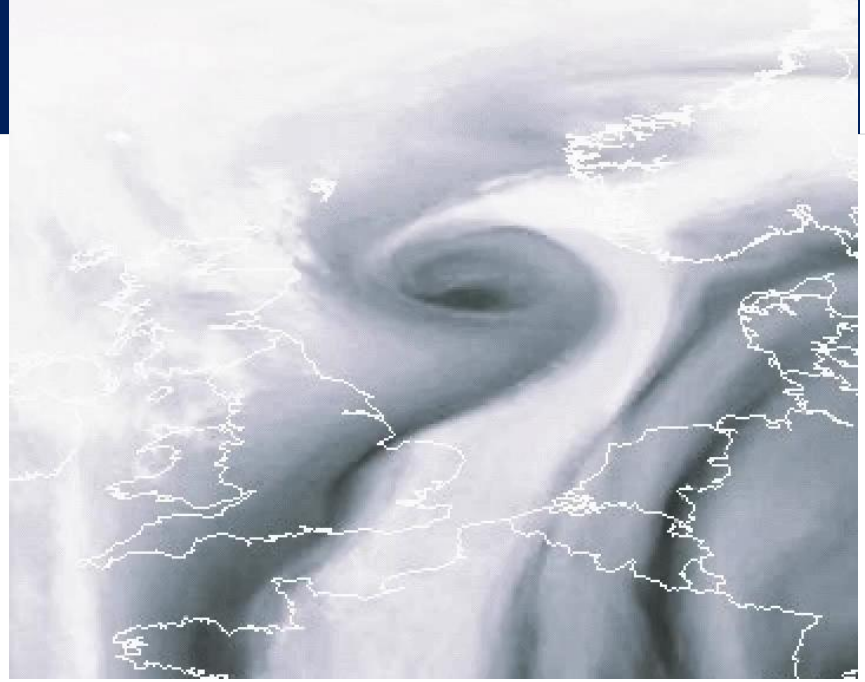
- deformation is a primary factor in the processes of frontogenesis and frontolysis.

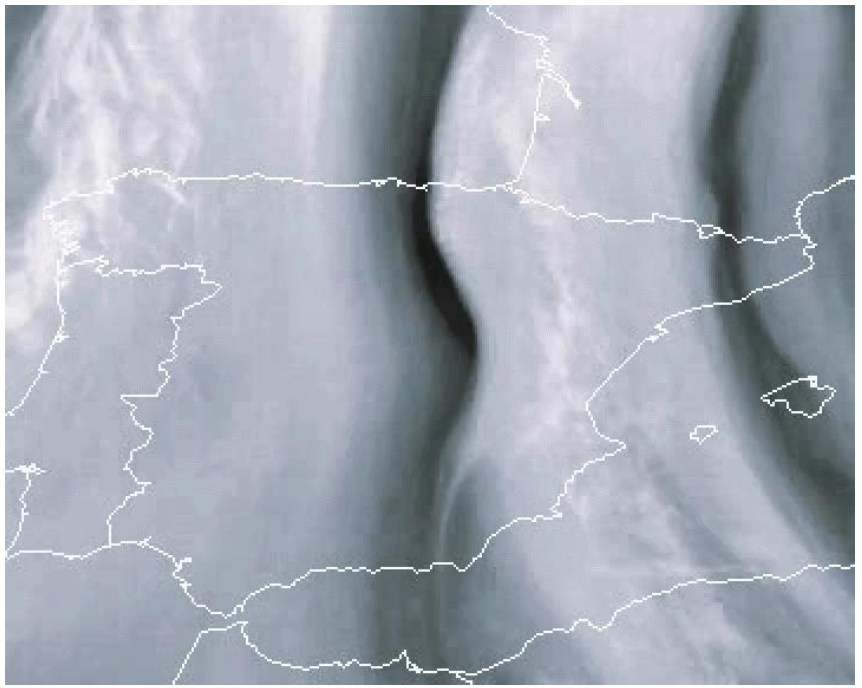




Deformation

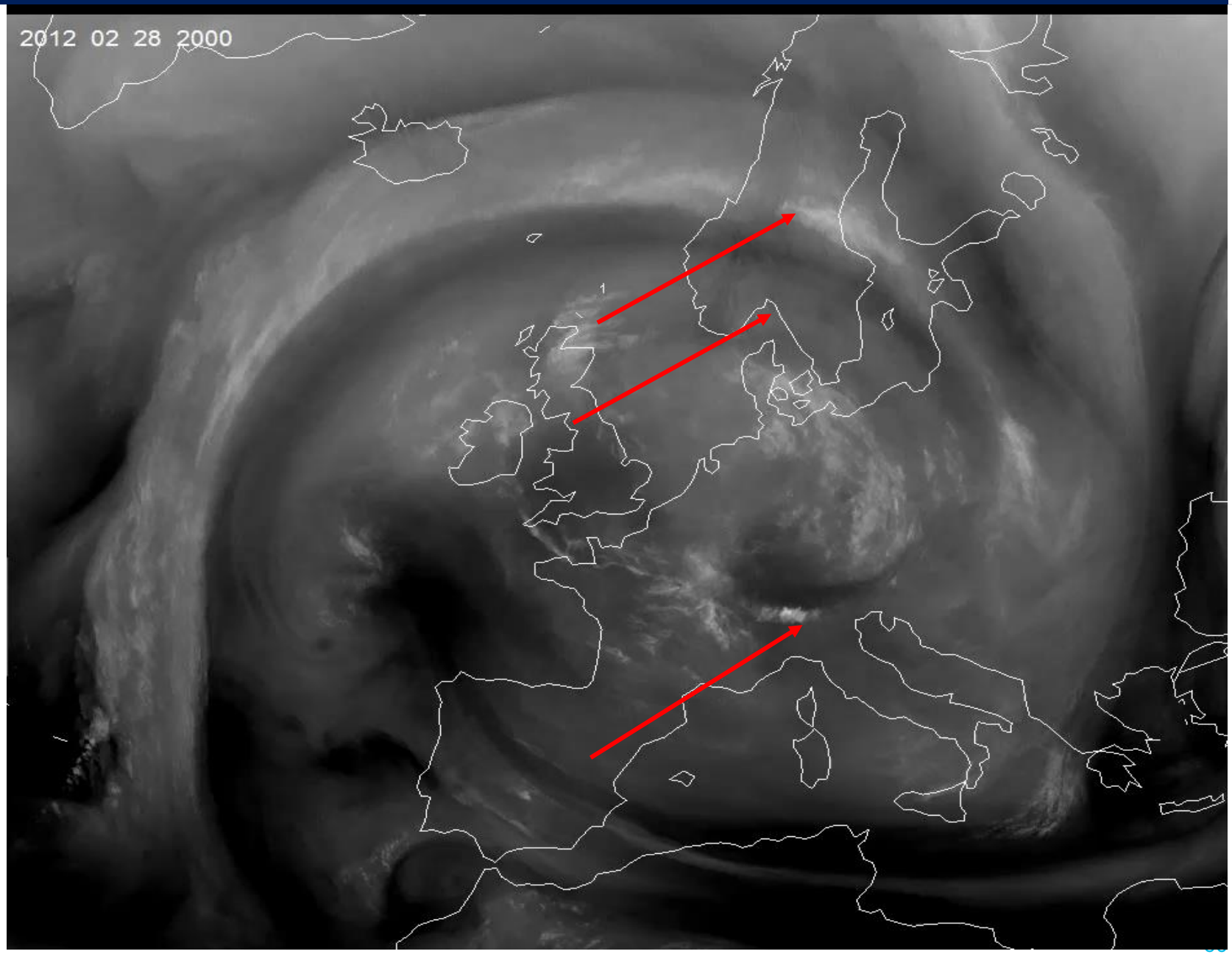




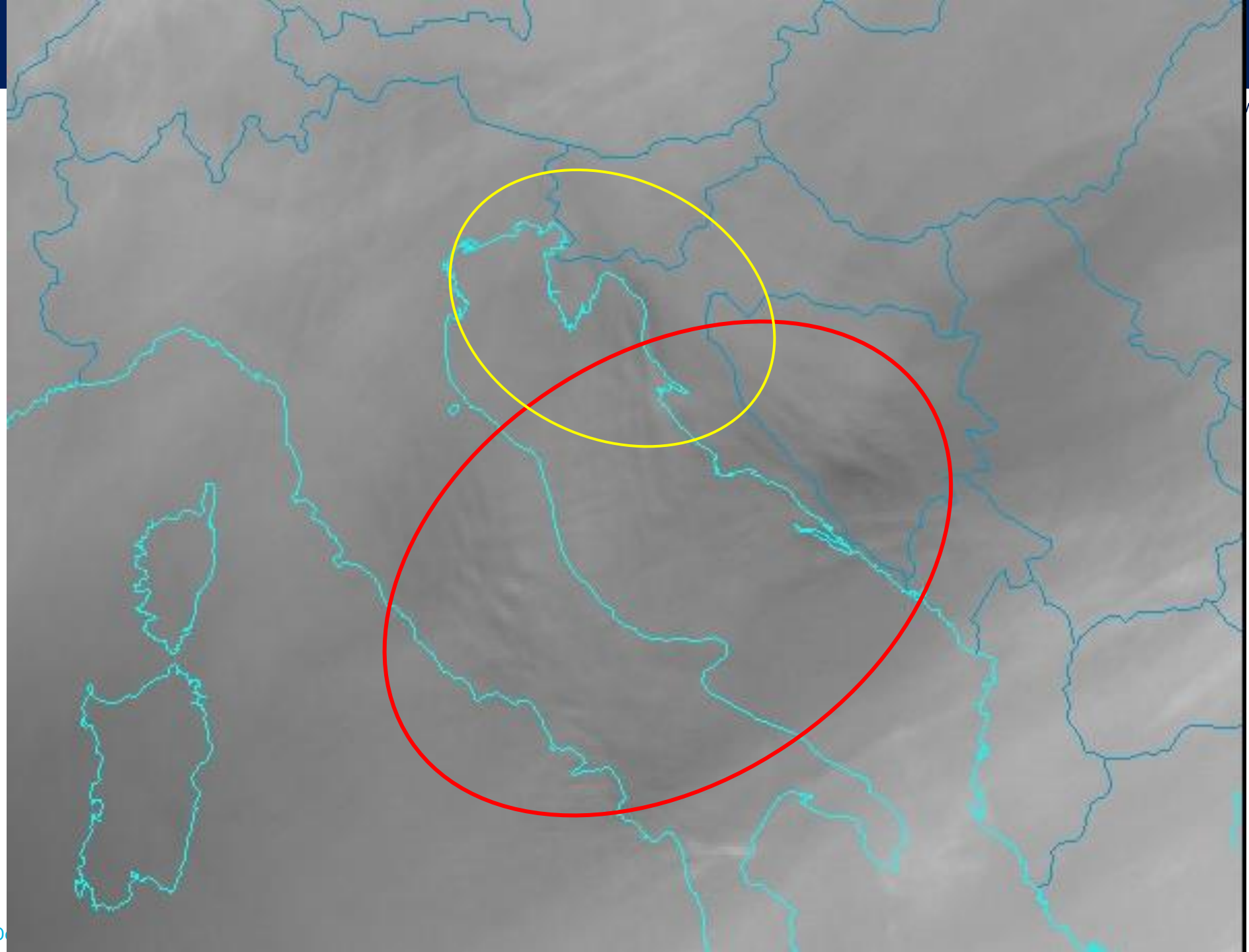


Lee clouds

Humidity patterns indicating wind regimes can be found in 6.2 µm images

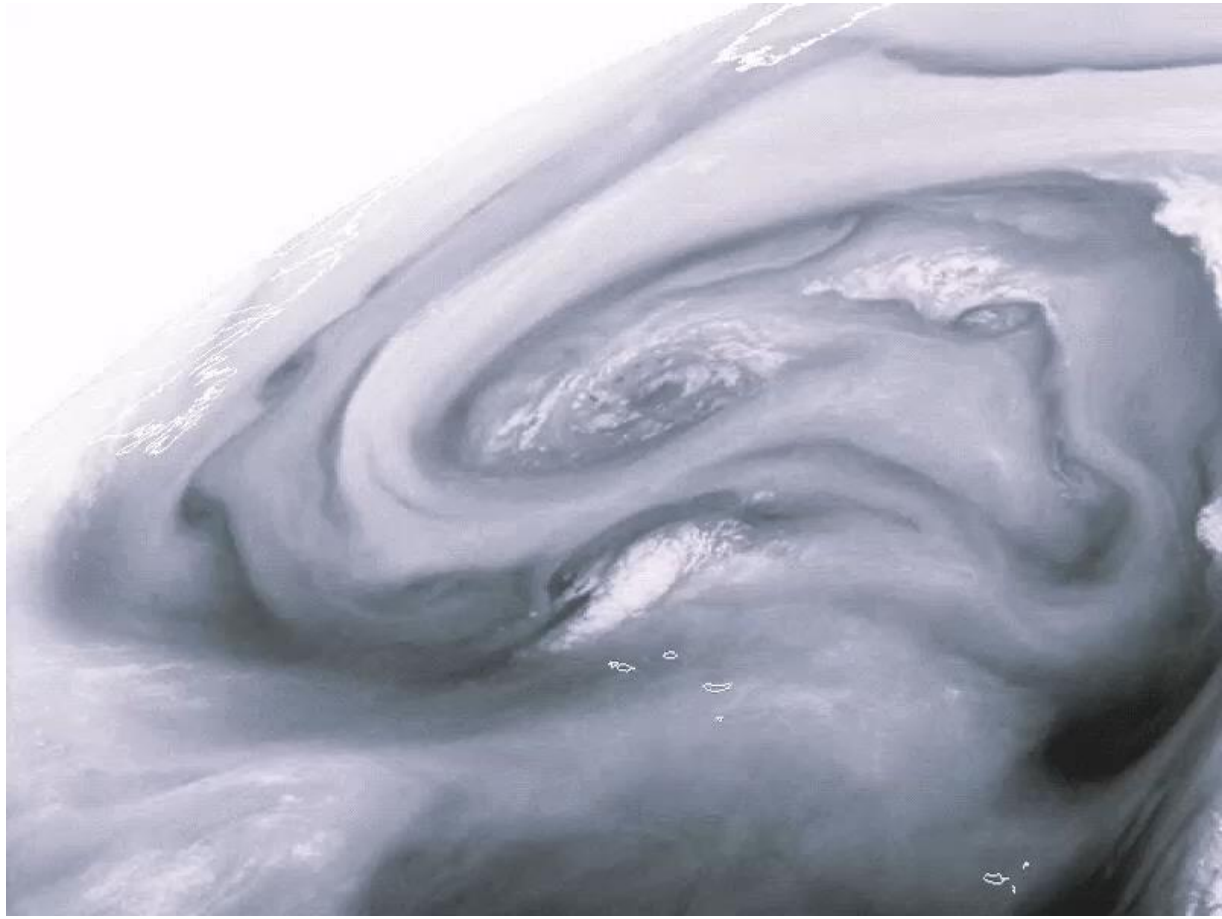


23 Feb 2019
00-24 UTC



Summary

- The radiation in 6.2 μm band is highly absorbed by water vapour
- 6.2 μm channel data is useful to be displayed and applied in image format for operational purposes
- 6.2 μm radiation is sensitive to the water vapour content in mid and upper troposphere, therefore useful for synoptic scale upper-level diagnosis.
- Water vapor imagery allows seeing a complete atmospheric motion, pointing out troughs and ridges and the areas where vertical motions are rising and sinking.
- Water vapor imagery can be used to pick out the exact position of upper level lows – validation of NWP
- Even mesoscale wind-related features – lee clouds, mountain waves - can sometimes be seen



Thank you!

Questions are welcome.