Playground Session

Frontal Substructures – 27 October 2016

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

What are frontal substructures?

Frontal substructures are formations/developments within fronts (usually CF) which are not included in the CM of the CF, WF or Occlusion.

The Manual of Synoptic Satellite Meteorology lists the most common frontal sub-structures:

- Front Decay
- Front Intensification by Jet Crossing
- Rapid Cyclogenesis
- Secondary Low Centers in Occlusions Cloud Bands
- Upper Wave
- Wave

Why are they important?

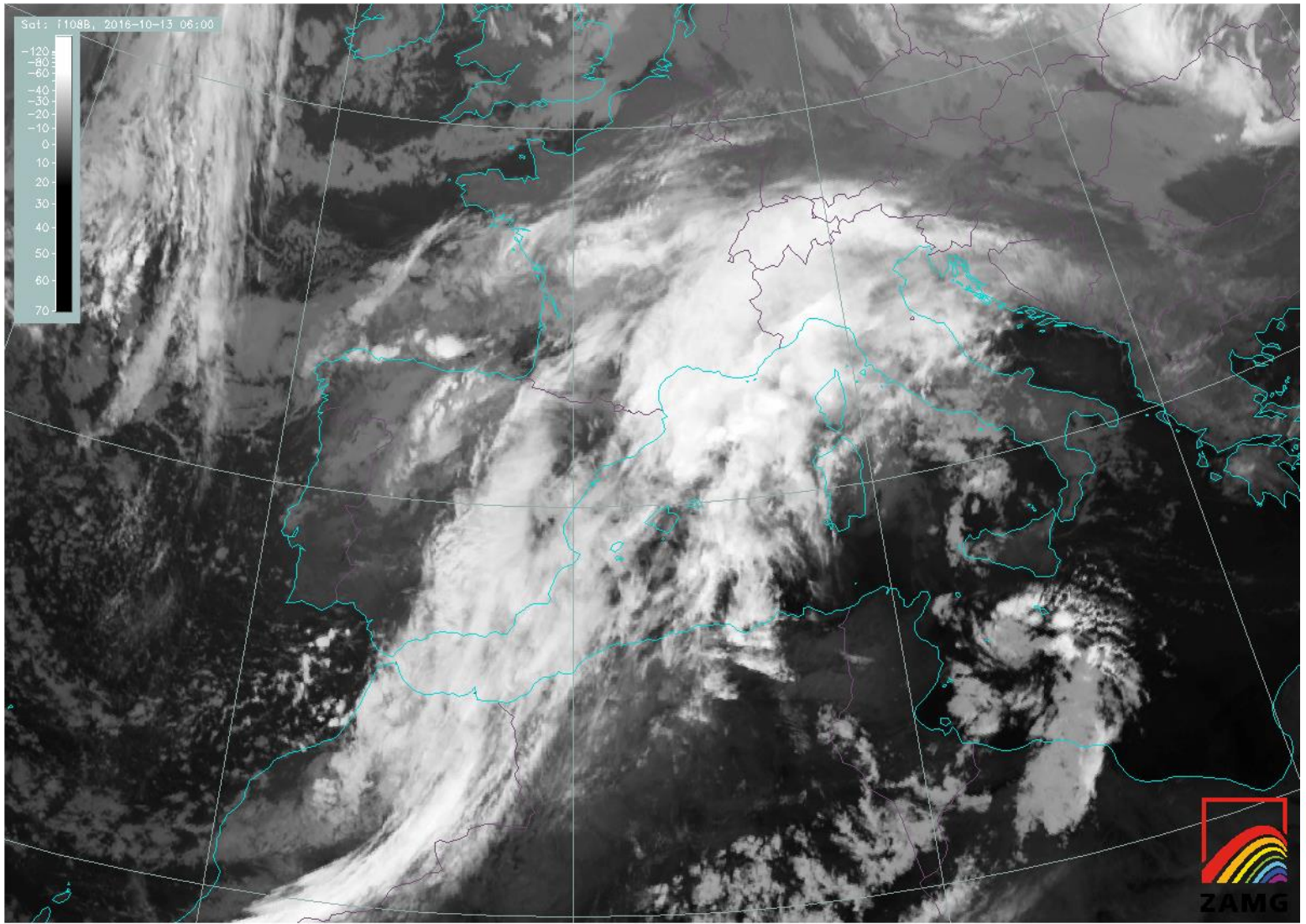
Frontal substructures often show new developments within fronts which might (or might not) lead to structural changes of frontal systems.

They are often the first signs for ongoing physical processes within the fronts even before they are reflected in model fields.

It is important to check the satellite images in the perspective of such new developments.

Front Decay: 13 October 2016, 06:00 UTC

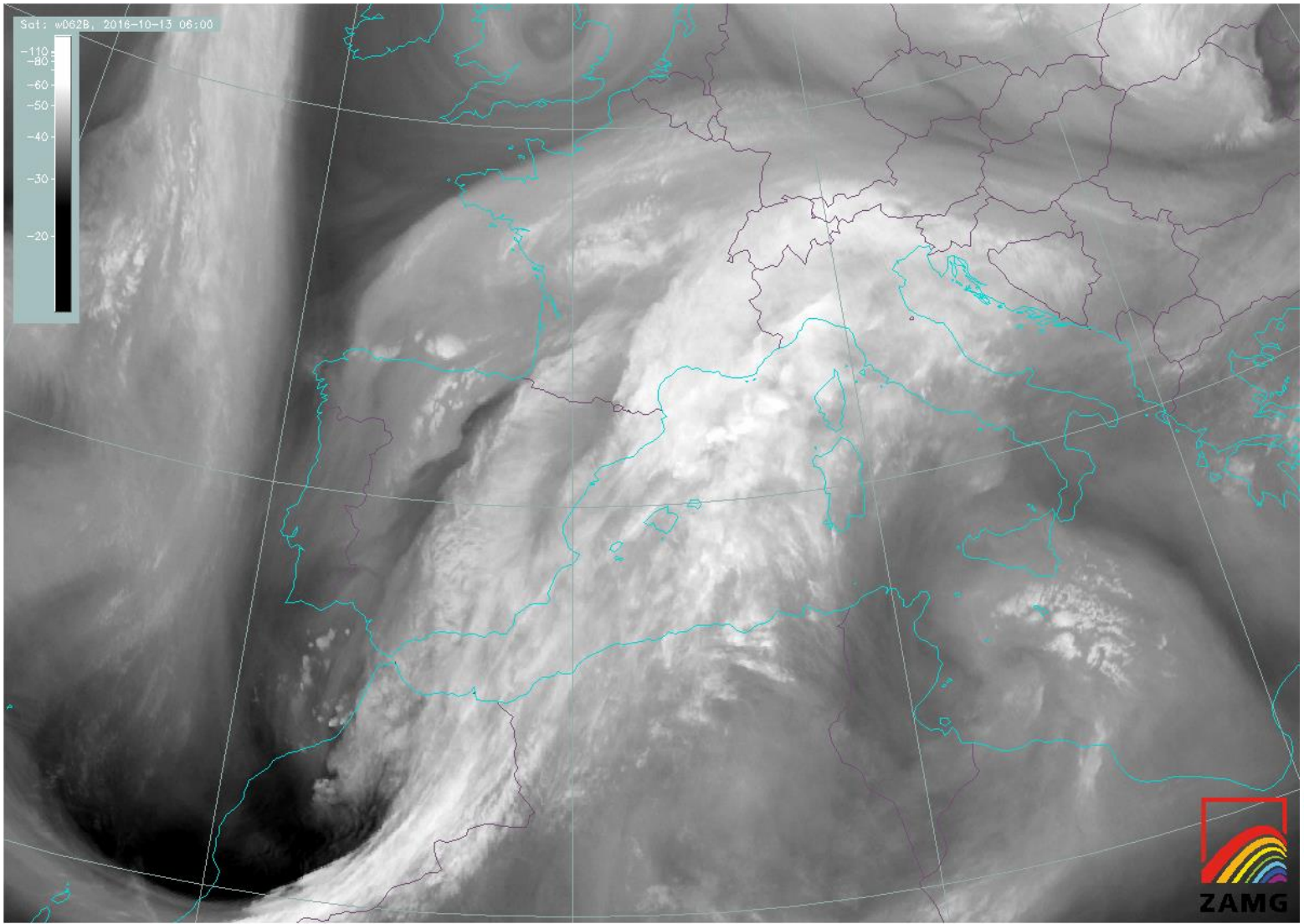
Front decays are usually easy to detect in the IR satellite image.



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Decay: 13 October 2016, 06:00 UTC

Front decay in WV imagery:

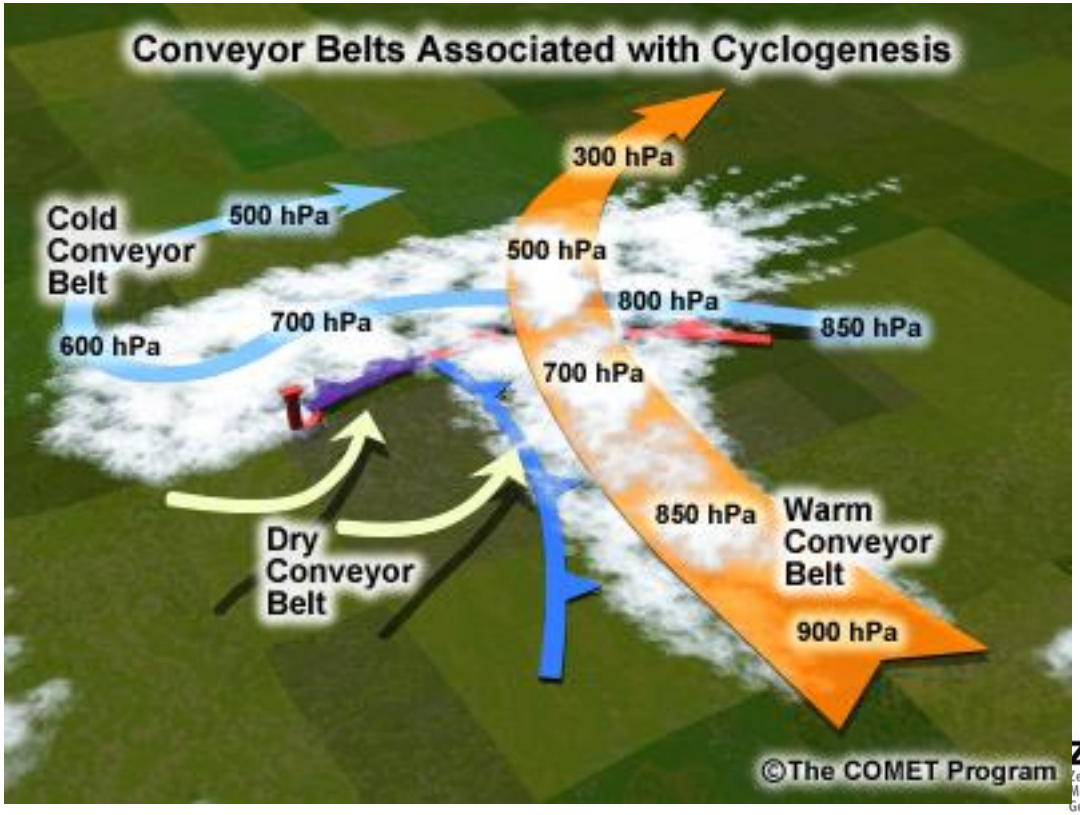


ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Decay – Meteorological Physical Background

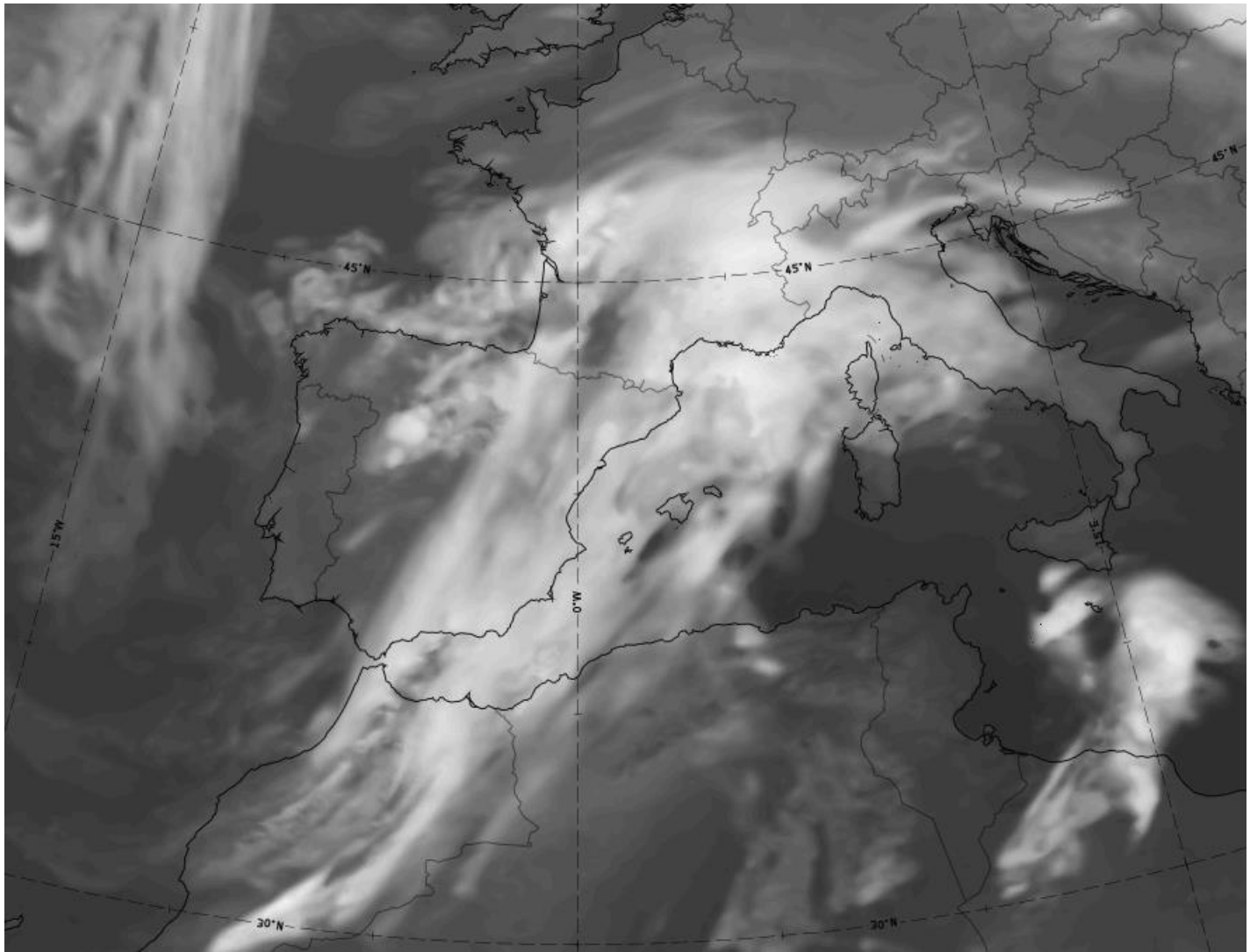
The conveyor belt concept provides a good explanation for frontal cloud dissolution. 3 possible reasons are mentioned in the Manual:

- Dry intrusion
- Sinking of the warm conveyor belt
- Approach of a secondary CF



Front Decay

Does the ECMWF model correctly reflect the synoptic situation?



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Decay – Key Parameters

Excerpt from the Manual:

- Height contours at 1000 hPa and 500 hPa
- Thermal front parameter (TFP) and equivalent thickness
- Temperature advection (TA) at 700 hPa:

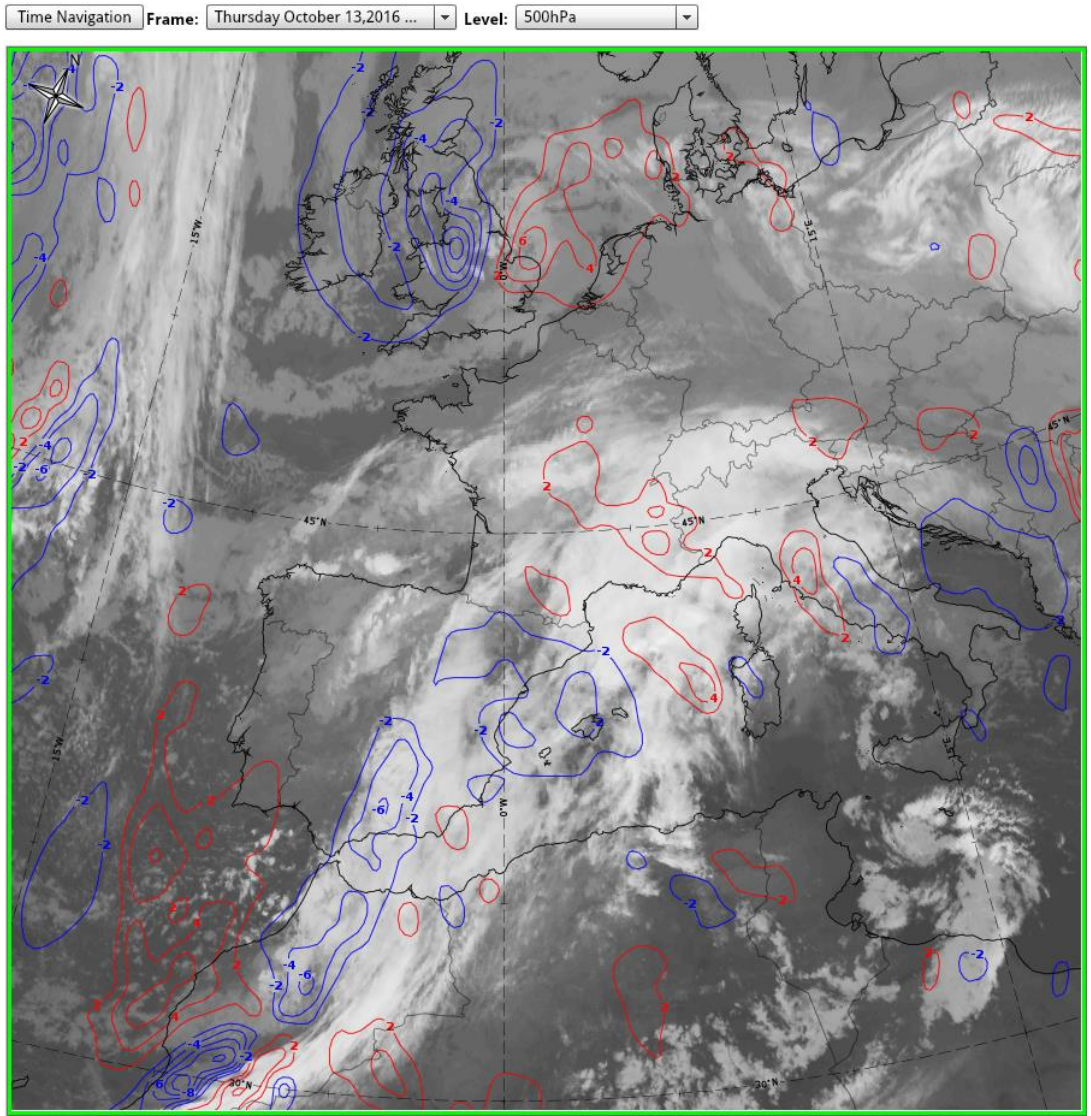
  Very distinct maximum of CA over the dissipation zone within the frontal cloud band
- Isotachs at 300 hPa:

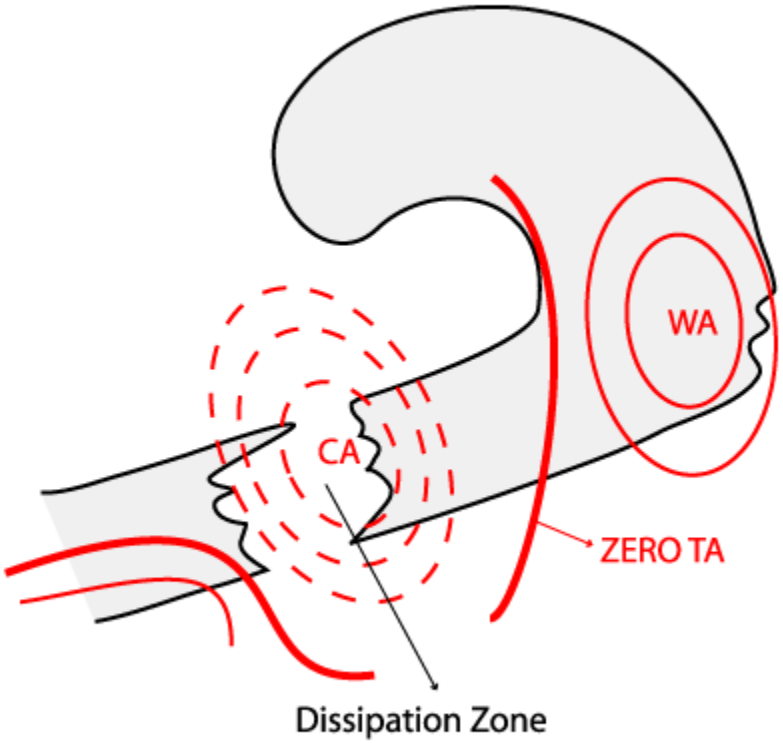
  The cloud gap of the Front Decay is always located on the anticyclonic side of the jet axis
- Vorticity advection at 500 and 300 hPa:

  Field of vorticity advection shows an NVA at 500 as well as at 300 hPa

Front Decay: 13 October 2016, 06:00 UTC

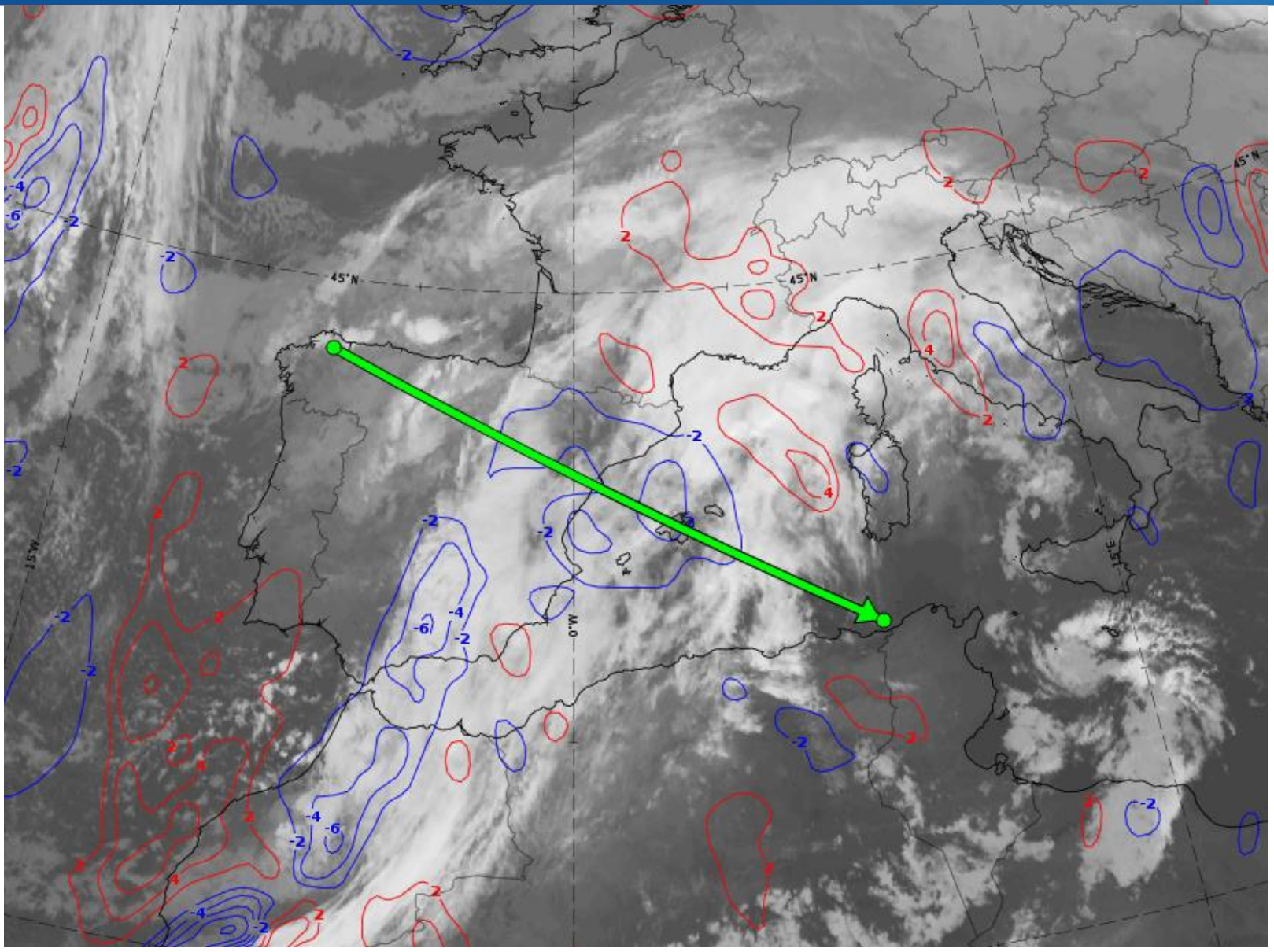
Temperature Advection:





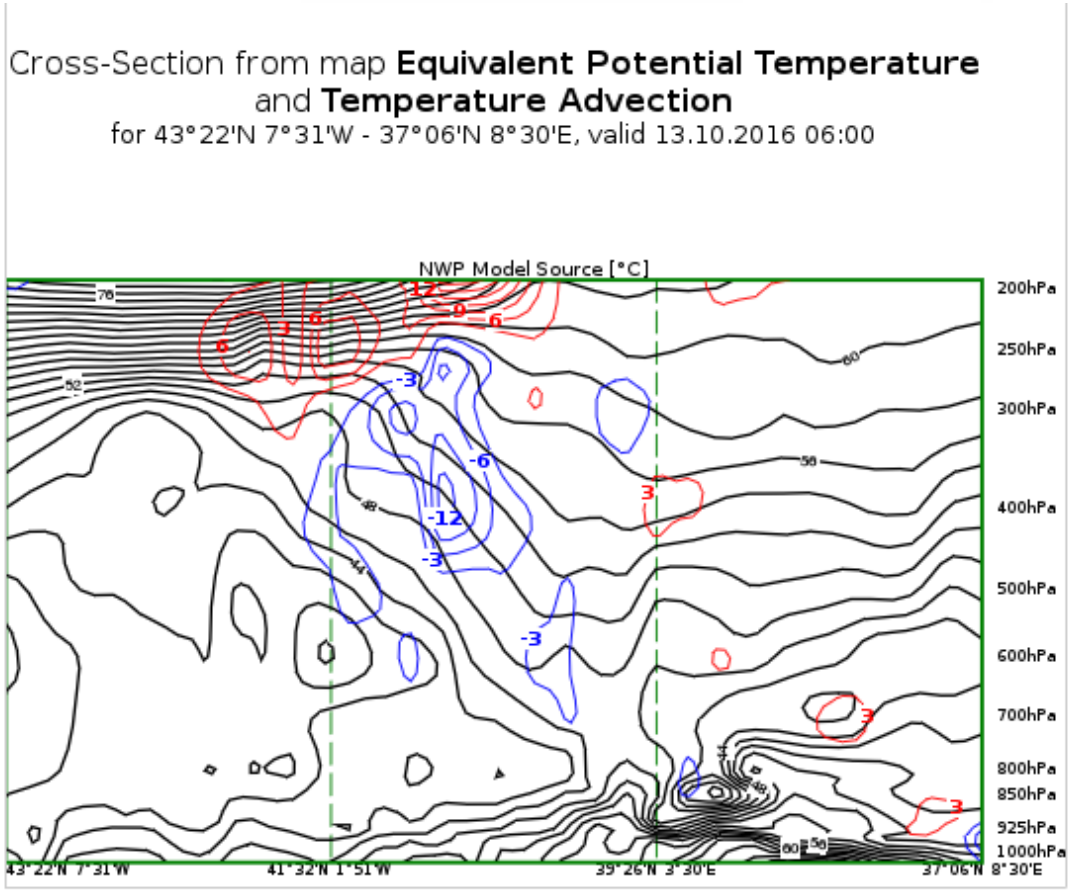
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Decay: 13 October 2016, 06:00 UTC



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

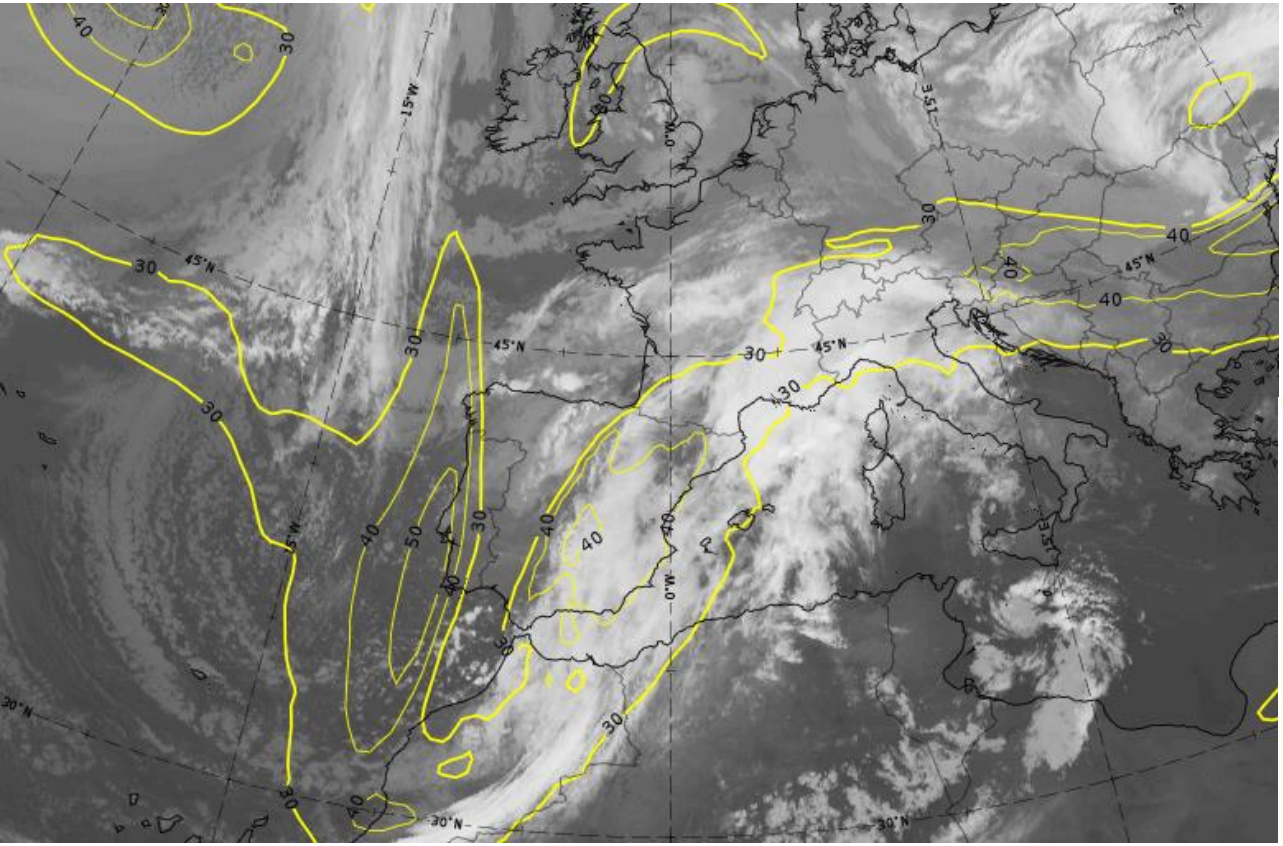
Front Decay: 13 October 2016, 06:00 UTC

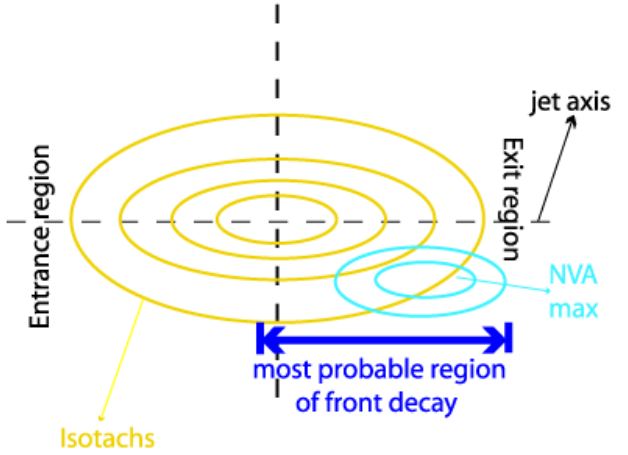


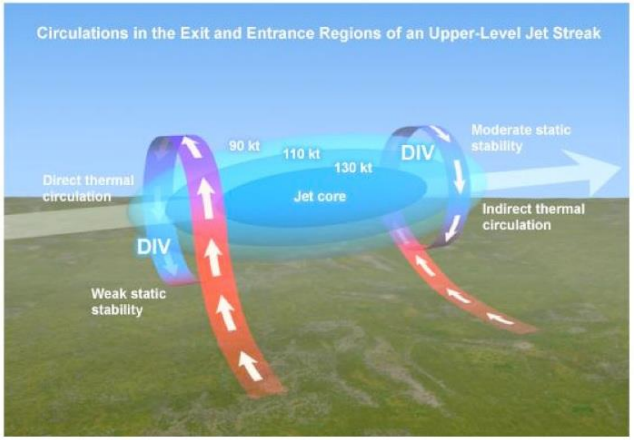
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Decay: 13 October 2016, 06:00 UTC

Isotachs and vorticity advection:

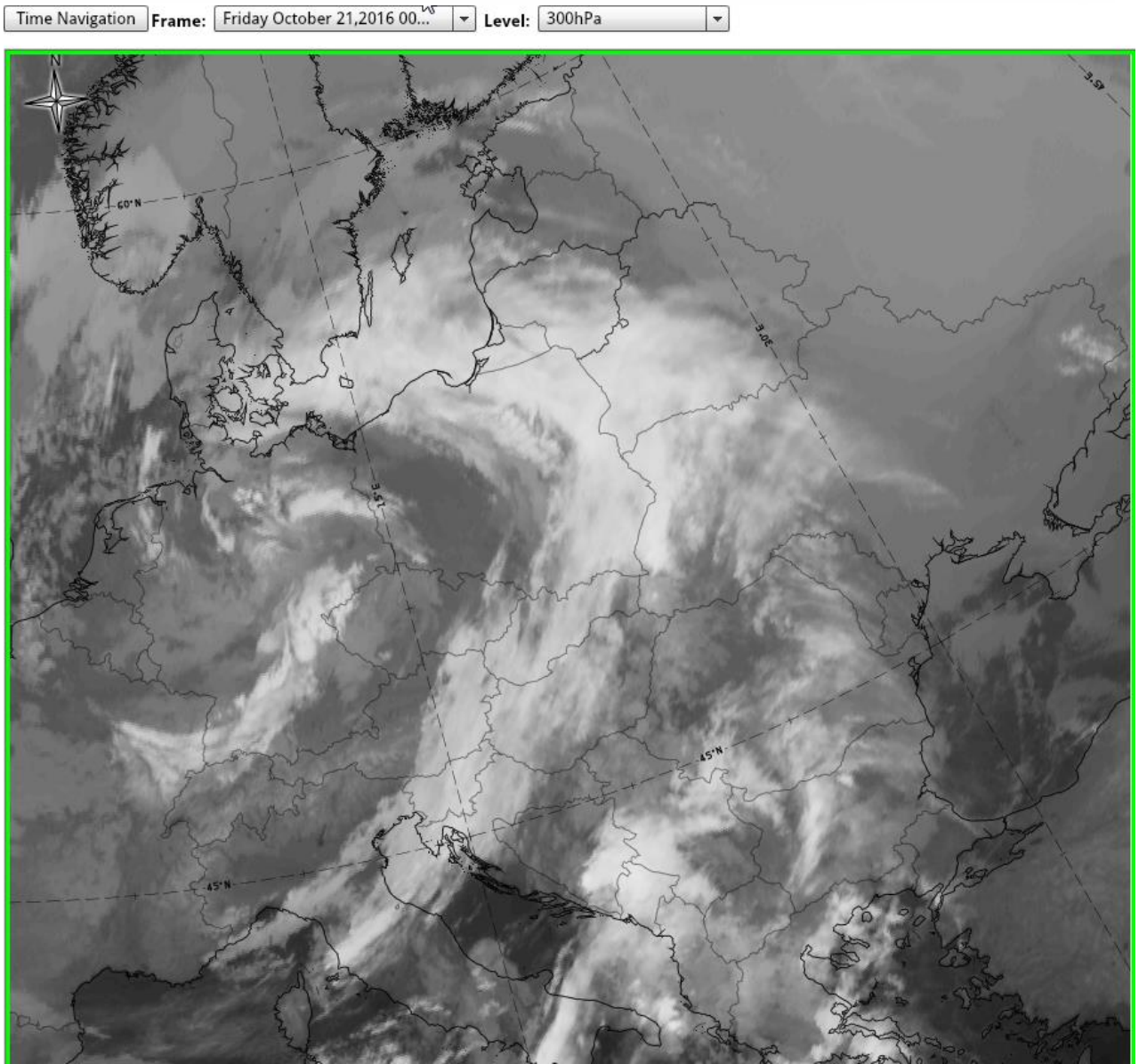






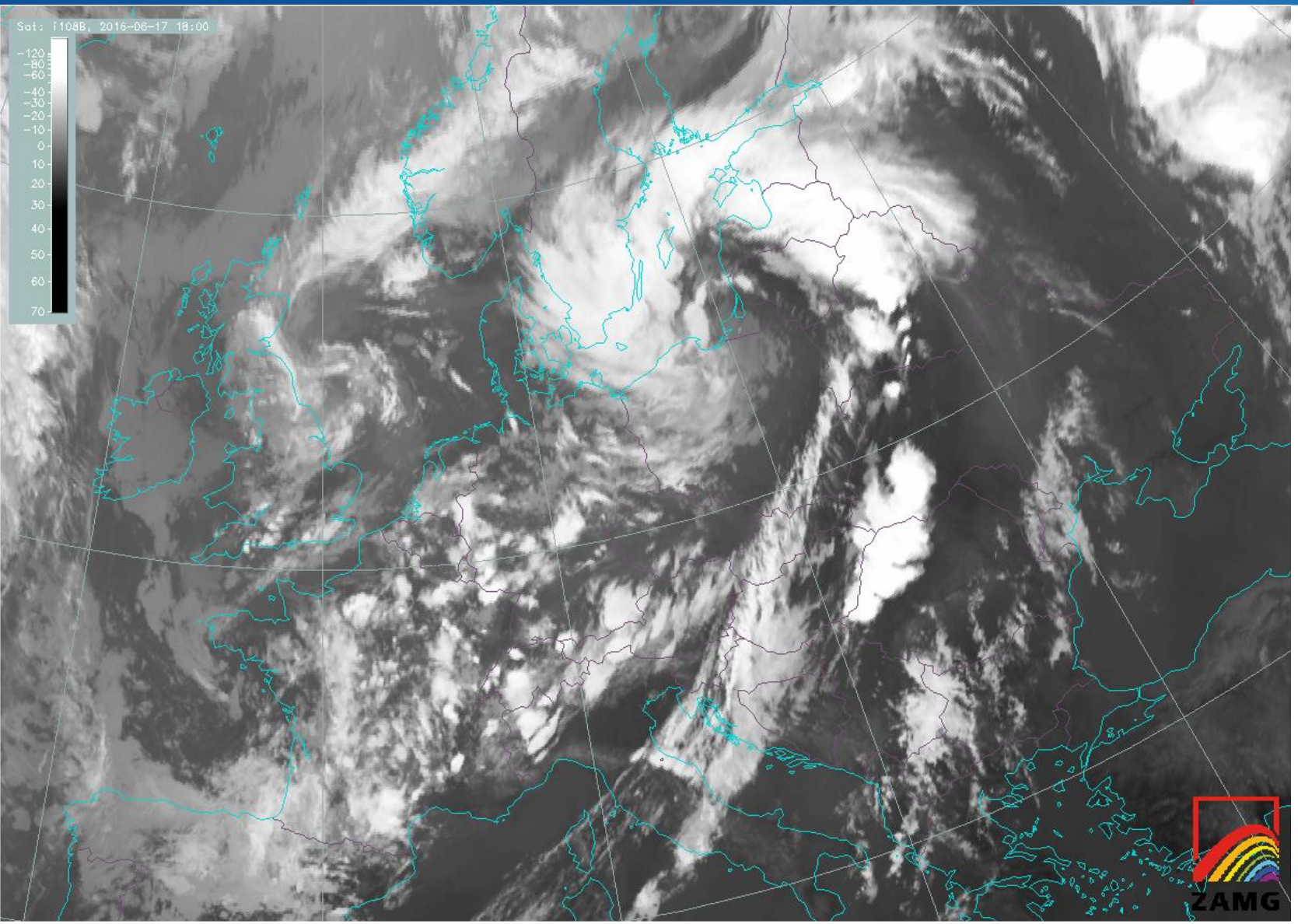
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Decay: Tricky Situations



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Decay: Tricky Situations



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Waves and Upper Waves

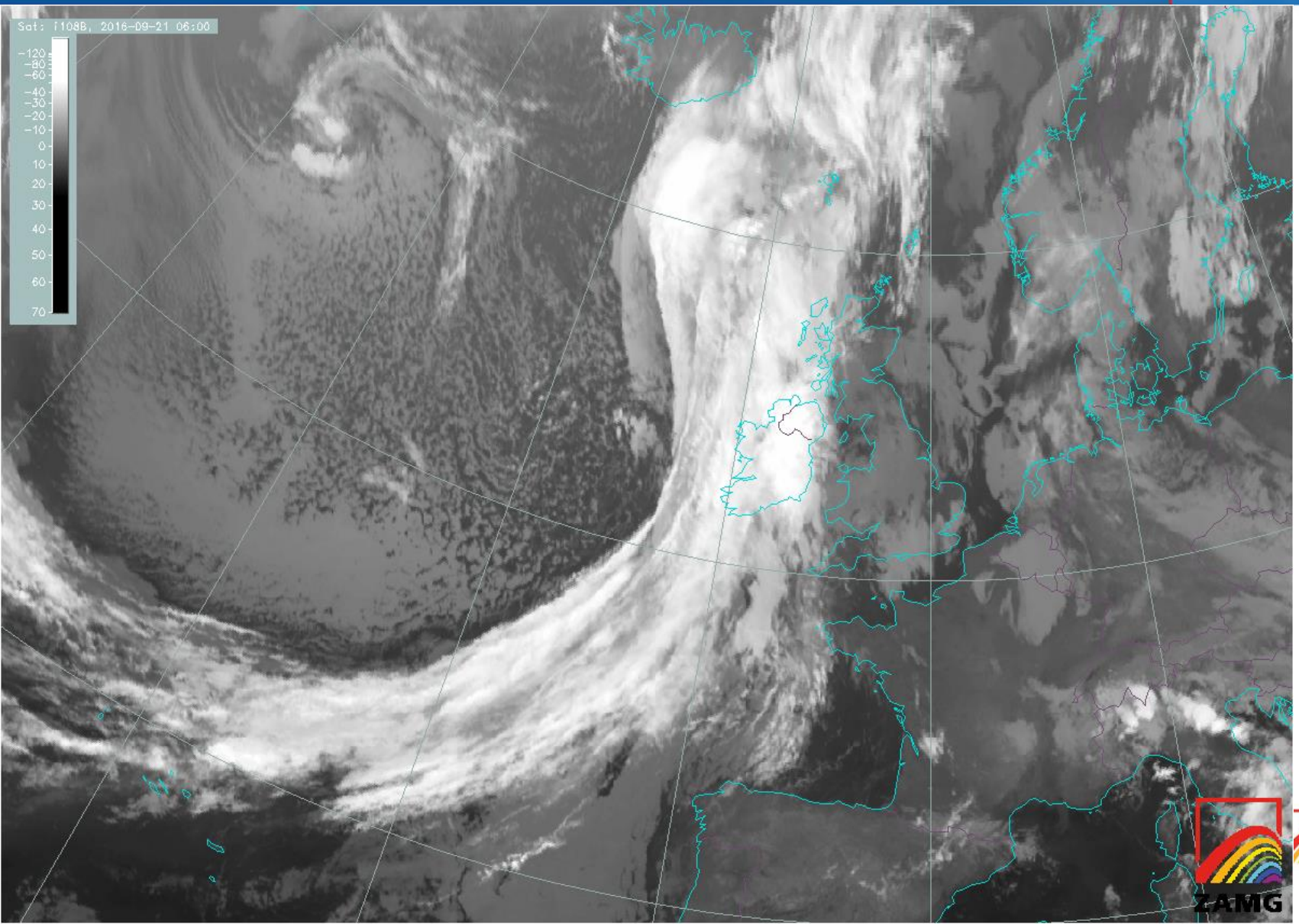
According to the Manual on Satellite meteorology:

- Upper Waves are cloud bulges at the rear edge of Cold Front cloud bands. They are associated with upper level processes and do not develop.

- Waves are cloud bulges at the rear edge of Cold Front cloud bands, indicating the initial stage of secondary cyclogenesis.

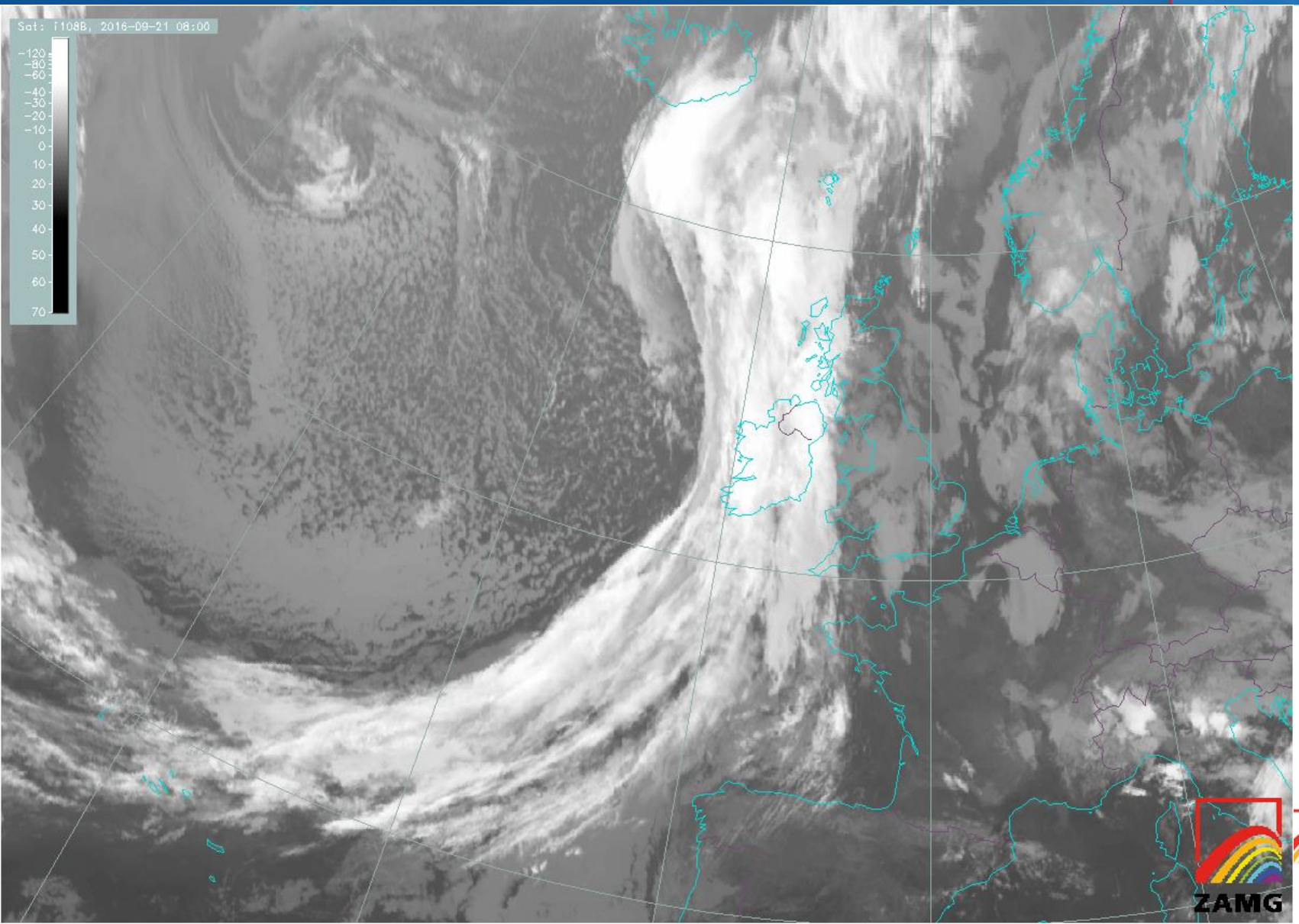
How can we differentiate between these 2 wave types?

How can we differentiate between these 2 wave types?



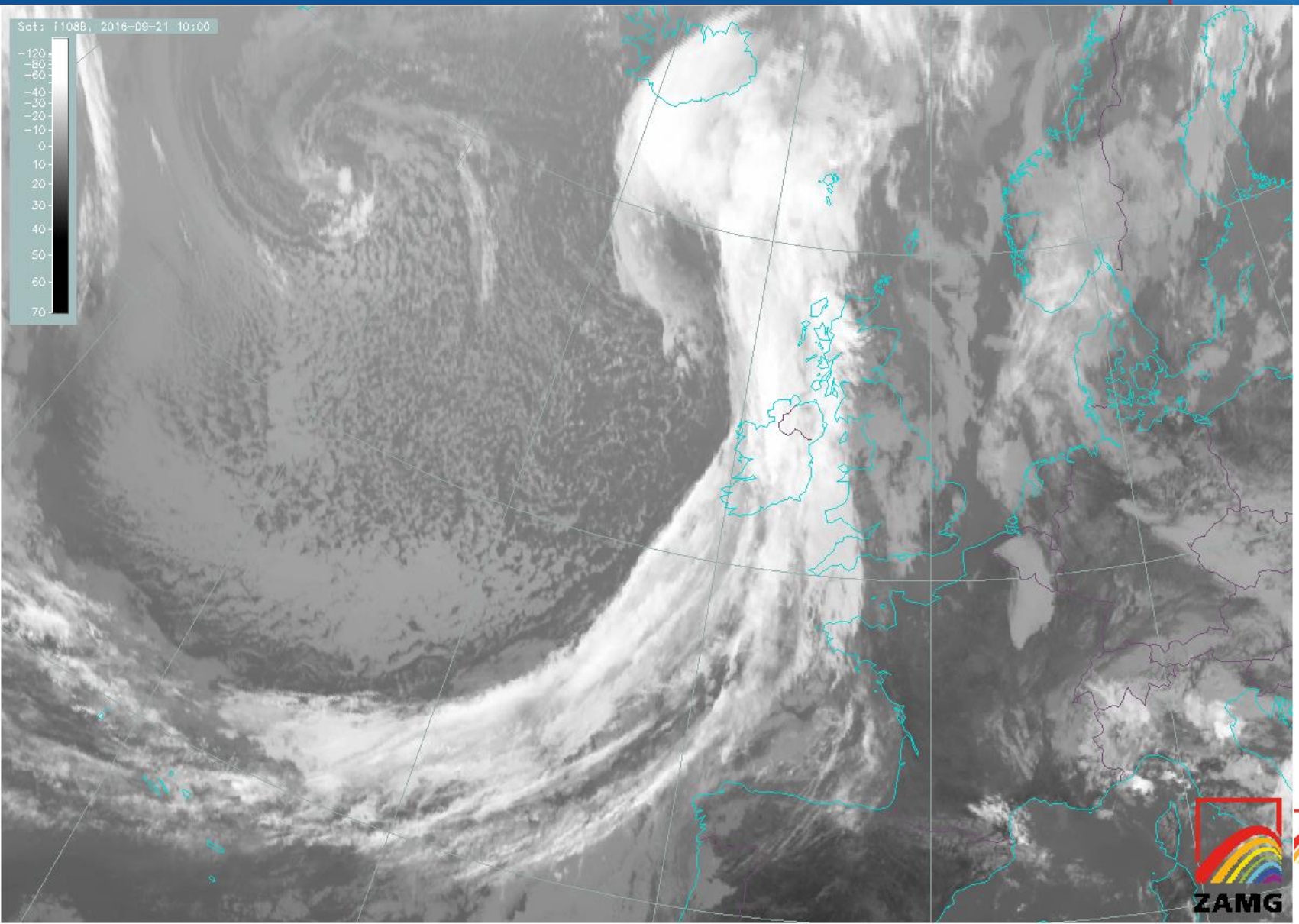
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

How can we differentiate between these 2 wave types?



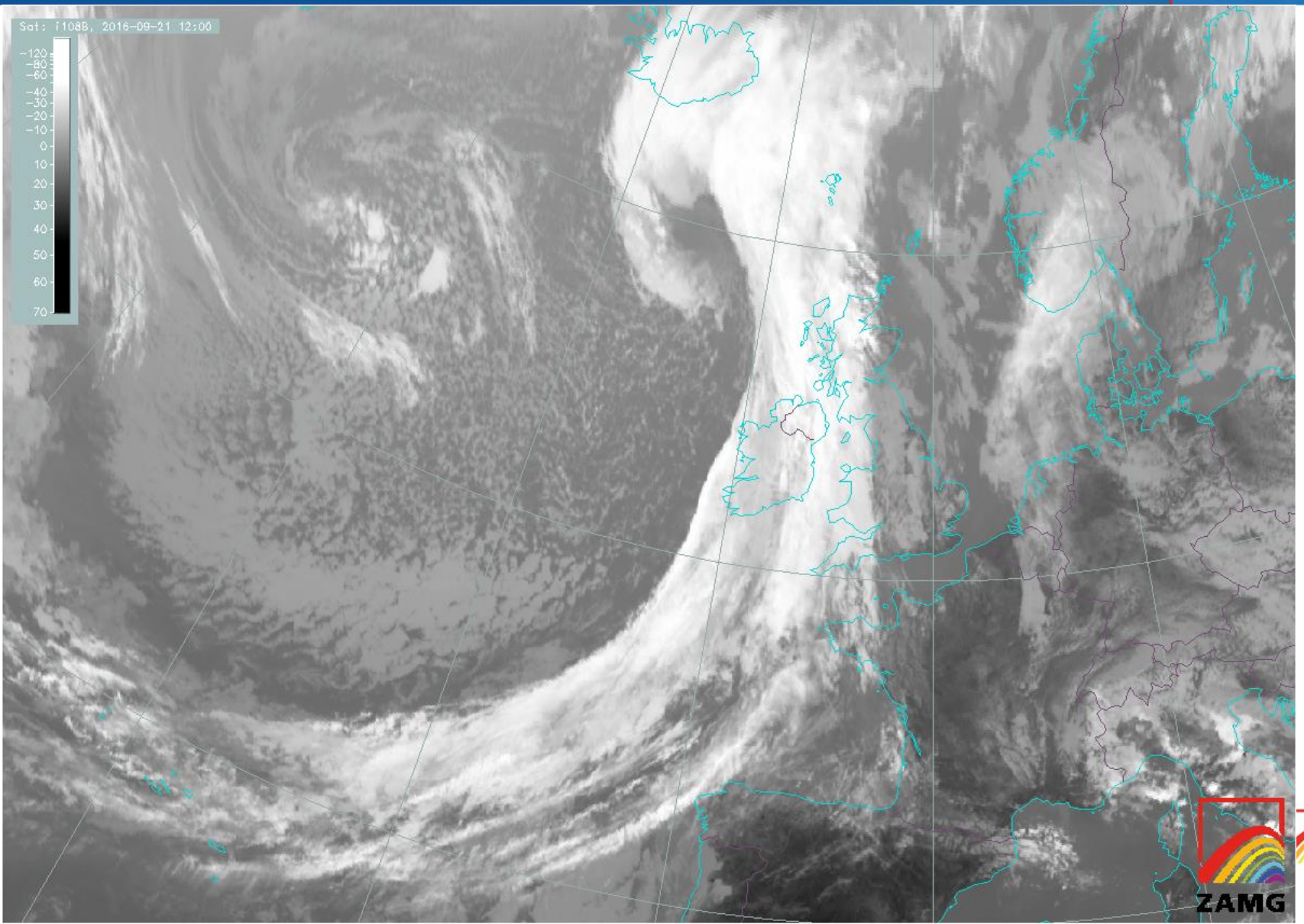
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

How can we differentiate between these 2 wave types?



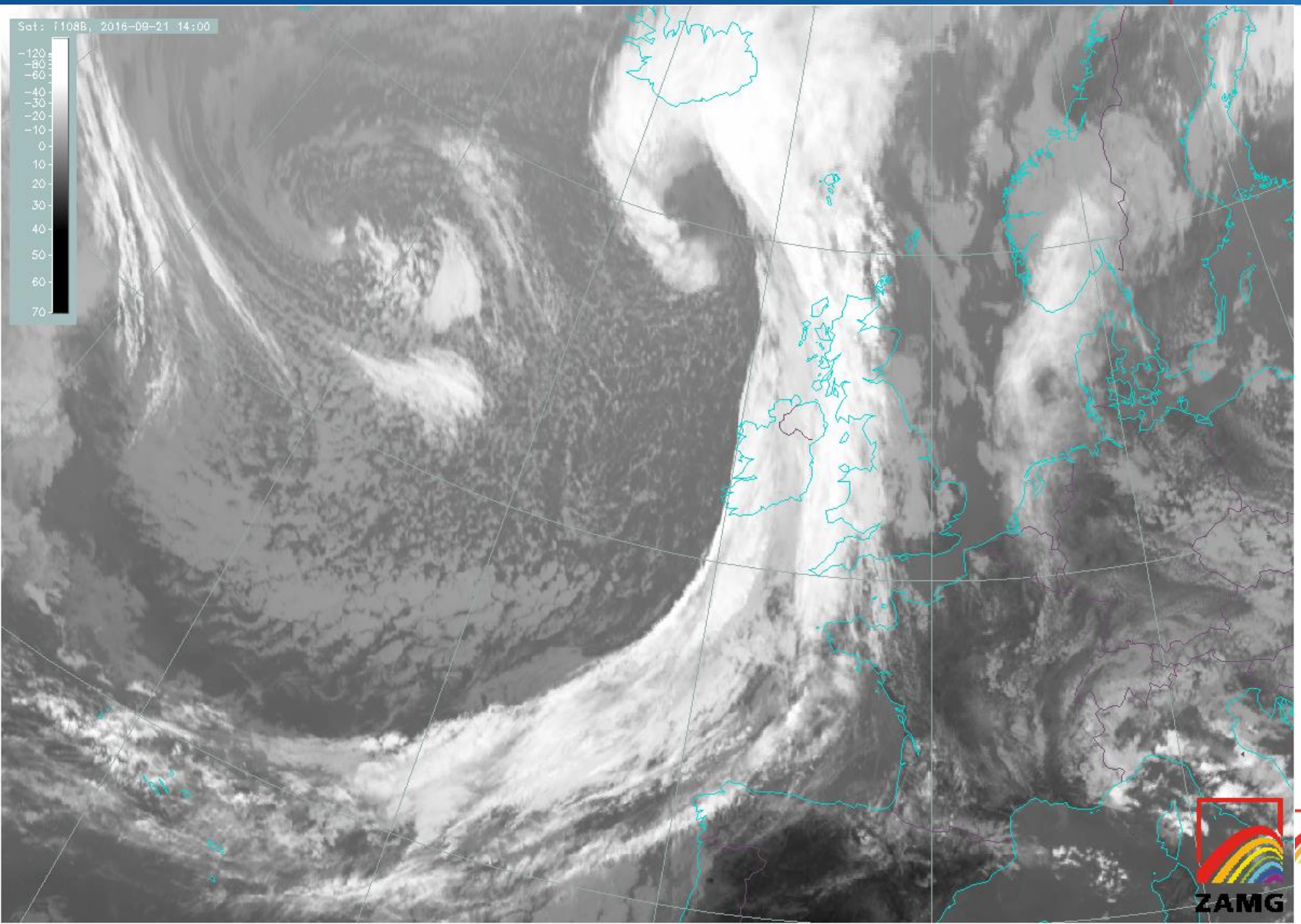
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

How can we differentiate between these 2 wave types?



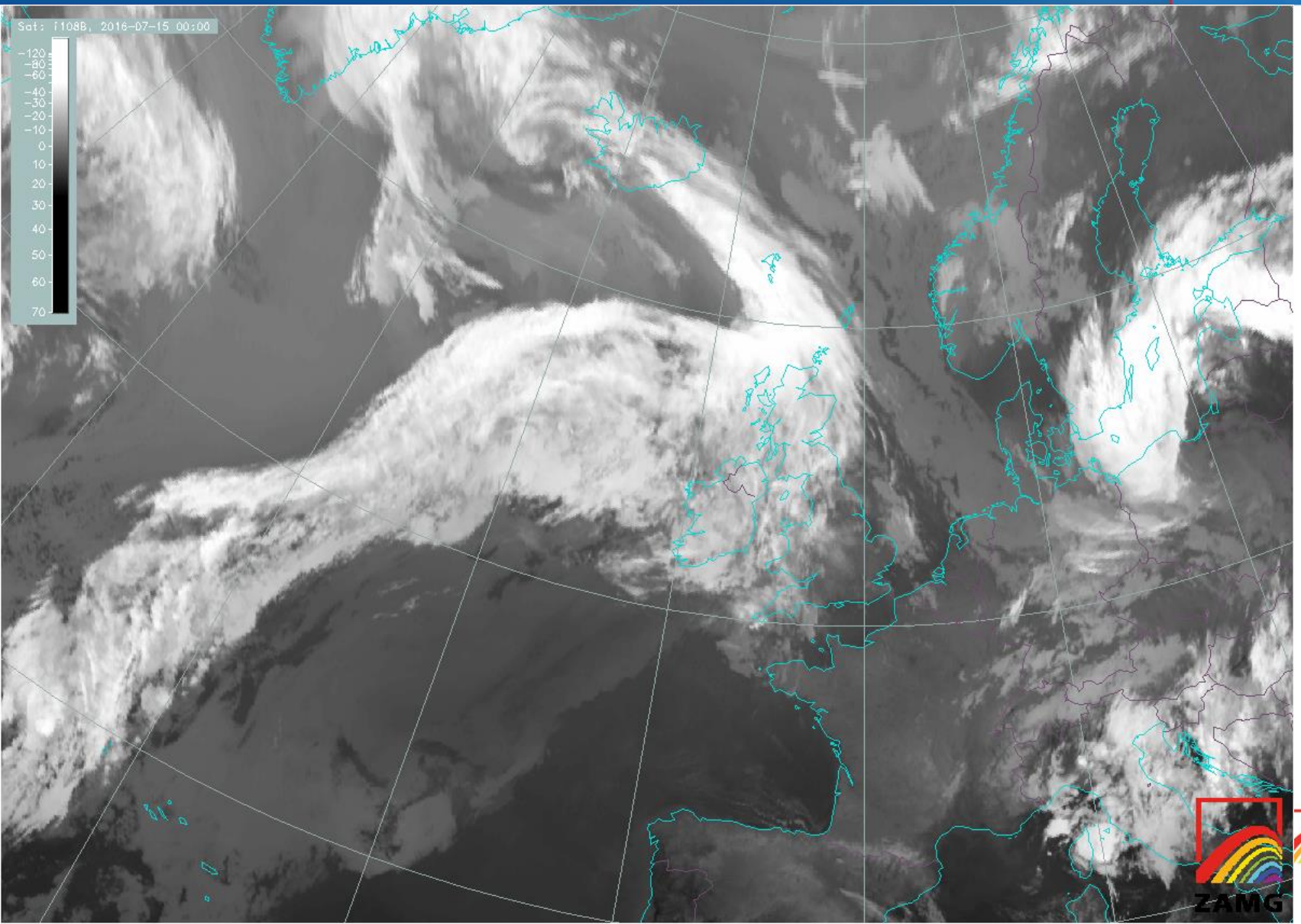
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

How can we differentiate between these 2 wave types?



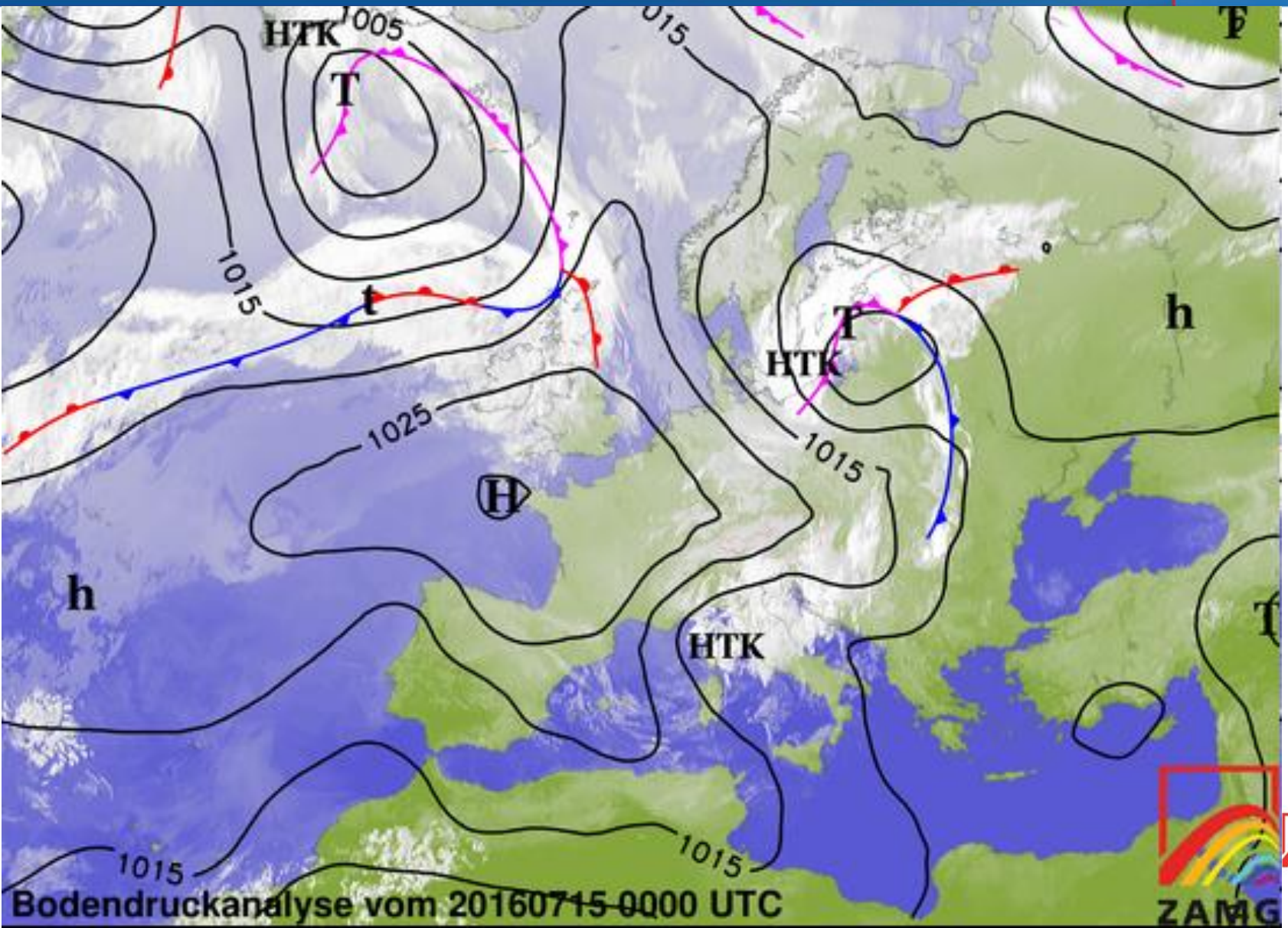
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

And now the Classical Wave (moving type)



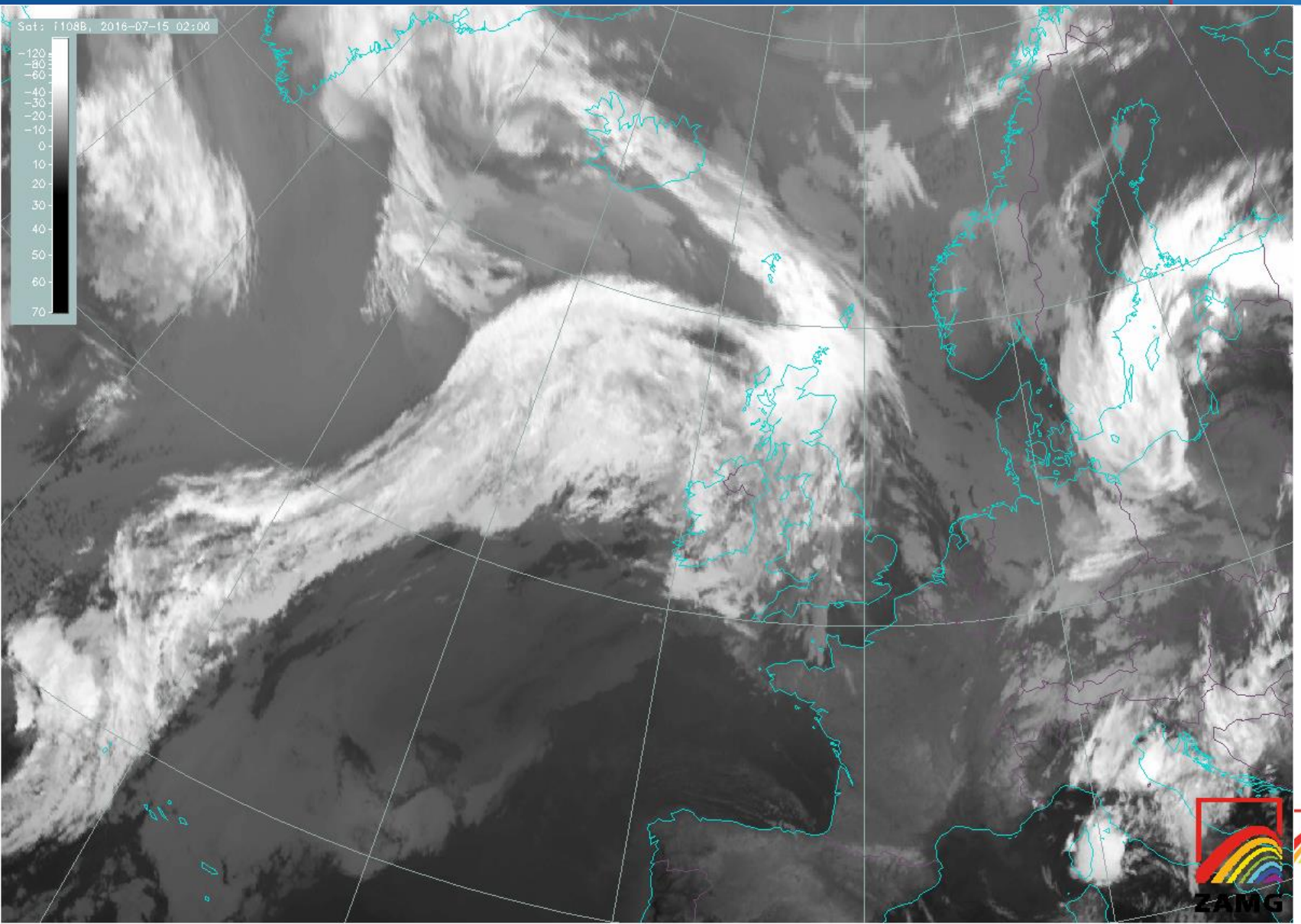
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

And now the Classical Wave (moving type)



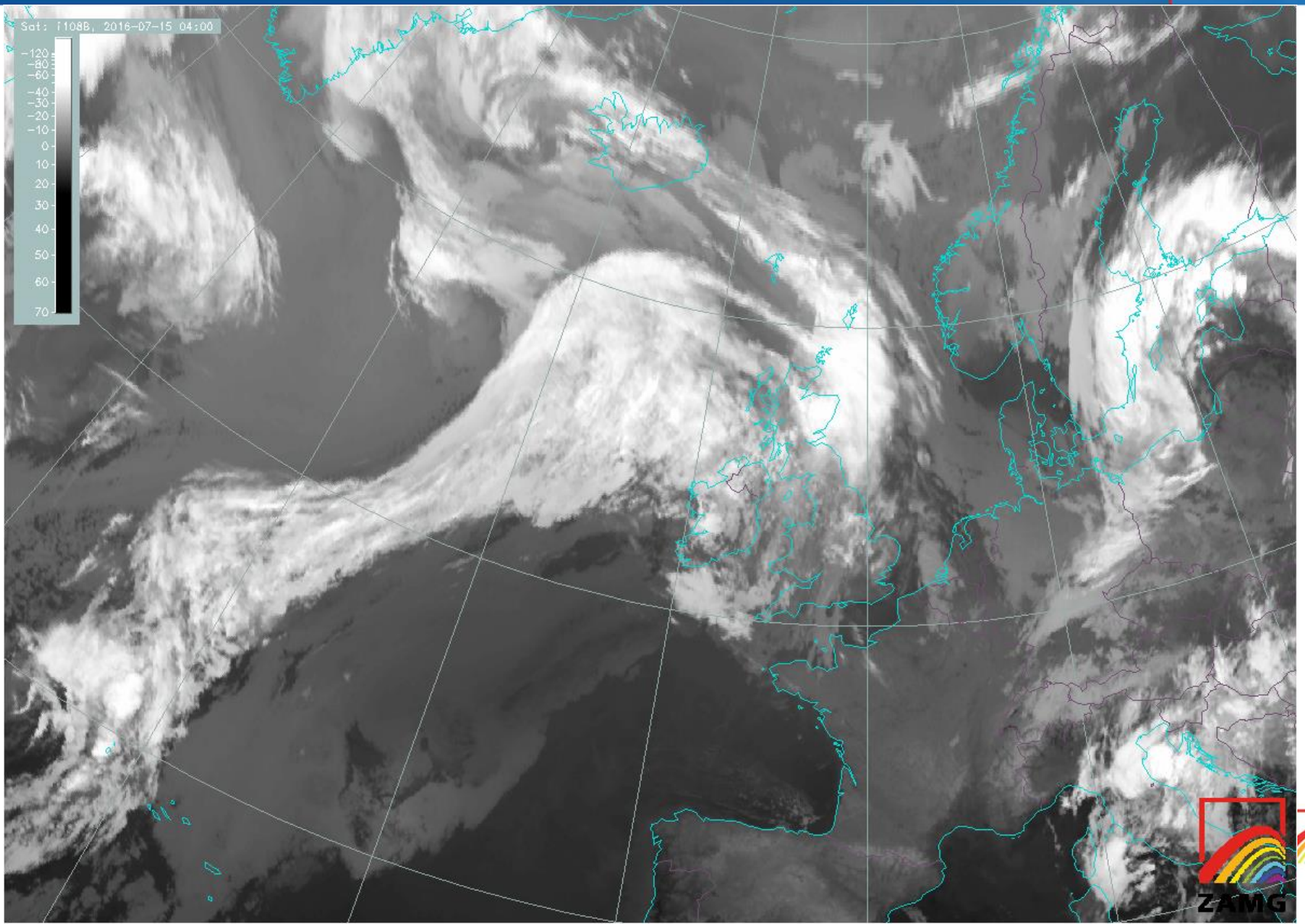
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

And now the Classical Wave (moving type)



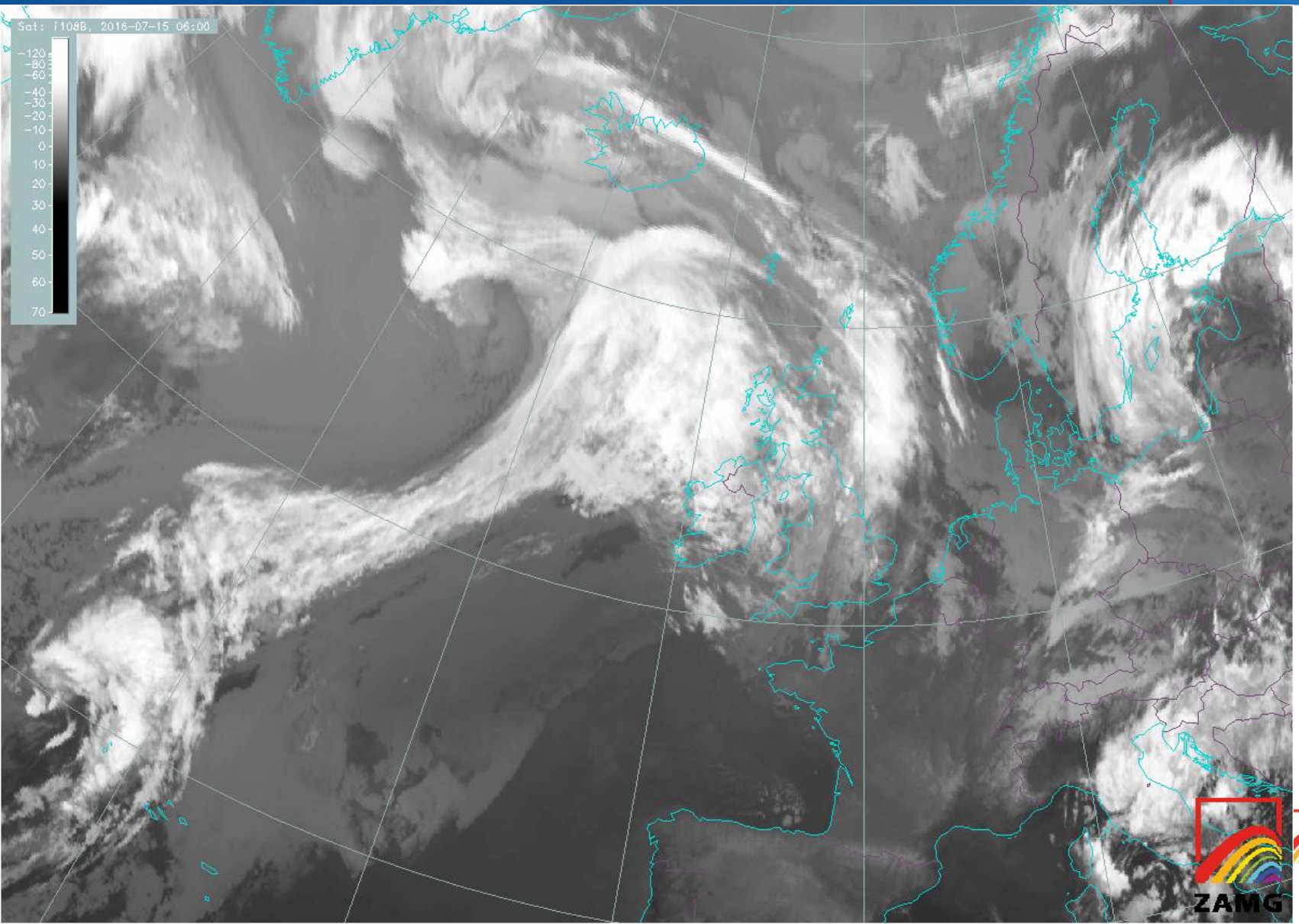
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

And now the Classical Wave (moving type)



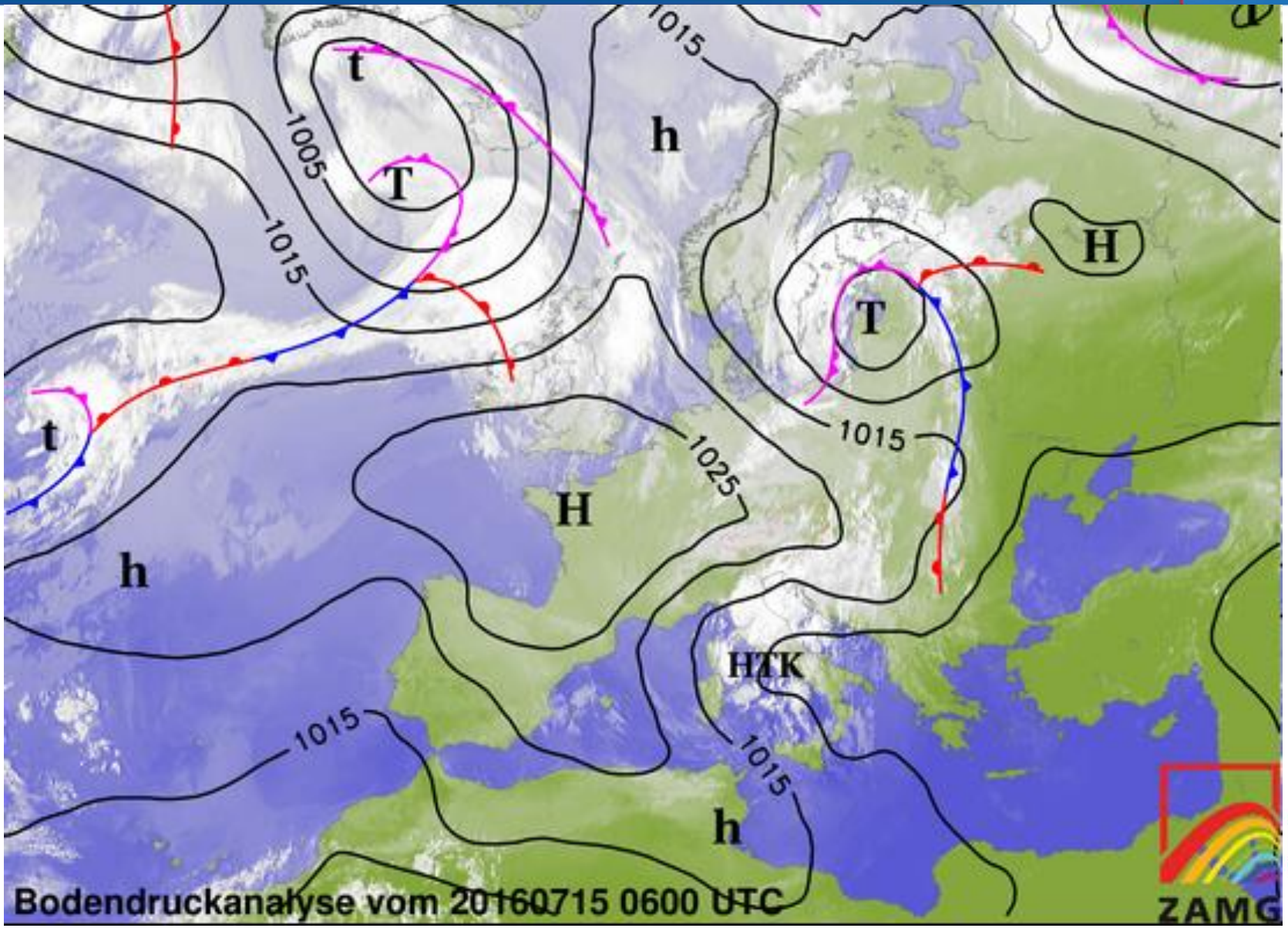
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

And now the Classical Wave (moving type)



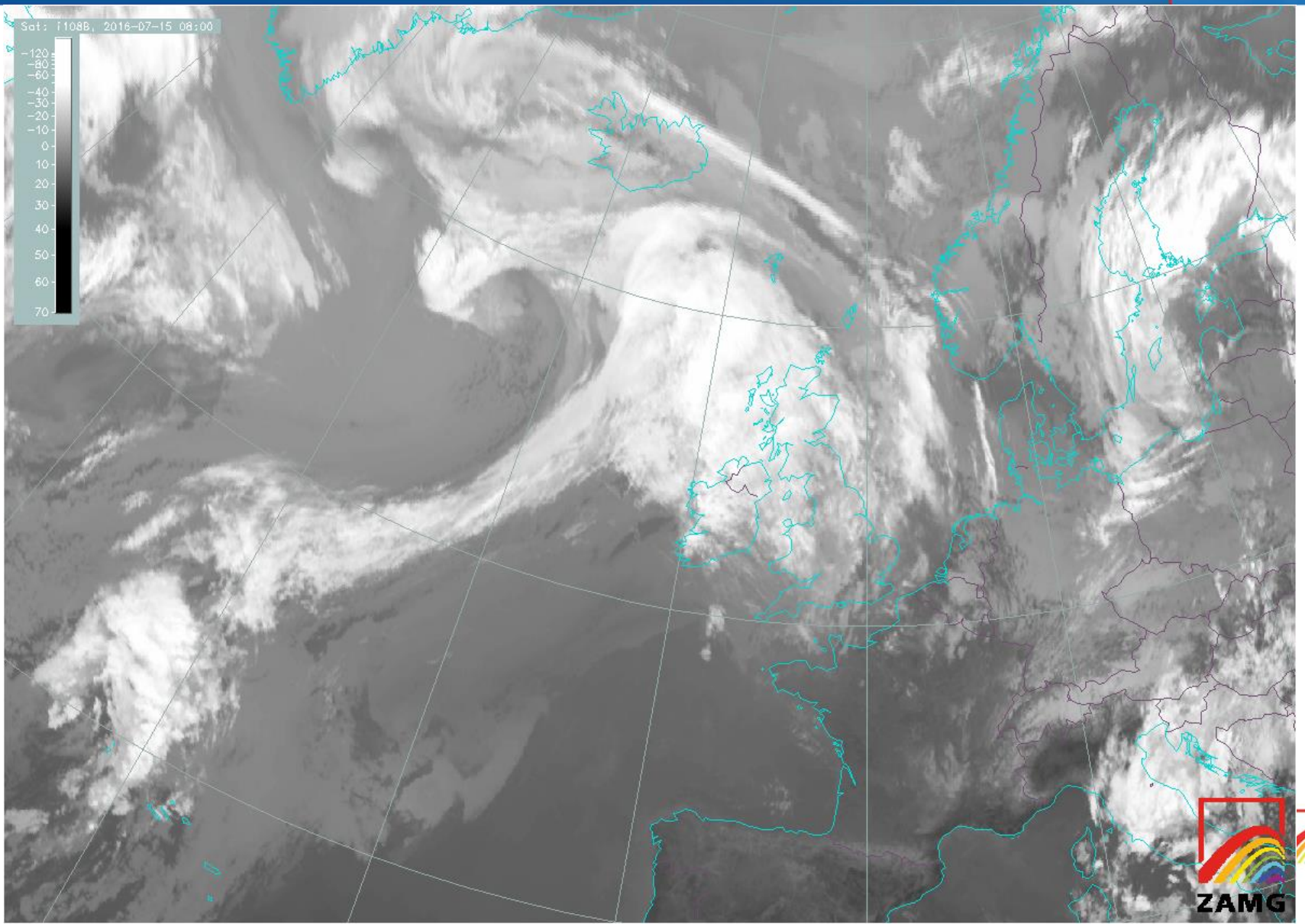
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

And now the Classical Wave (moving type)



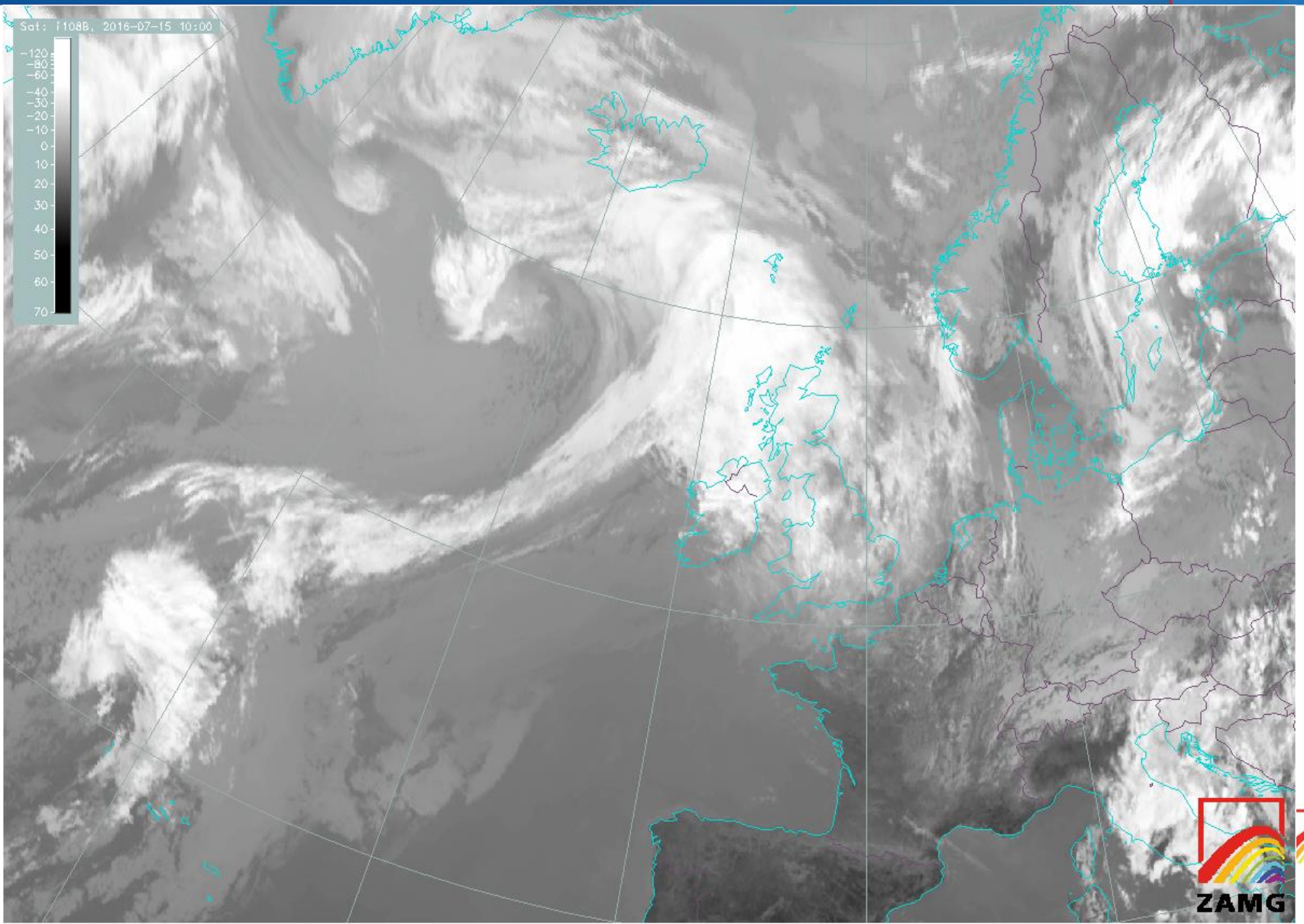
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

And now the Classical Wave (moving type)



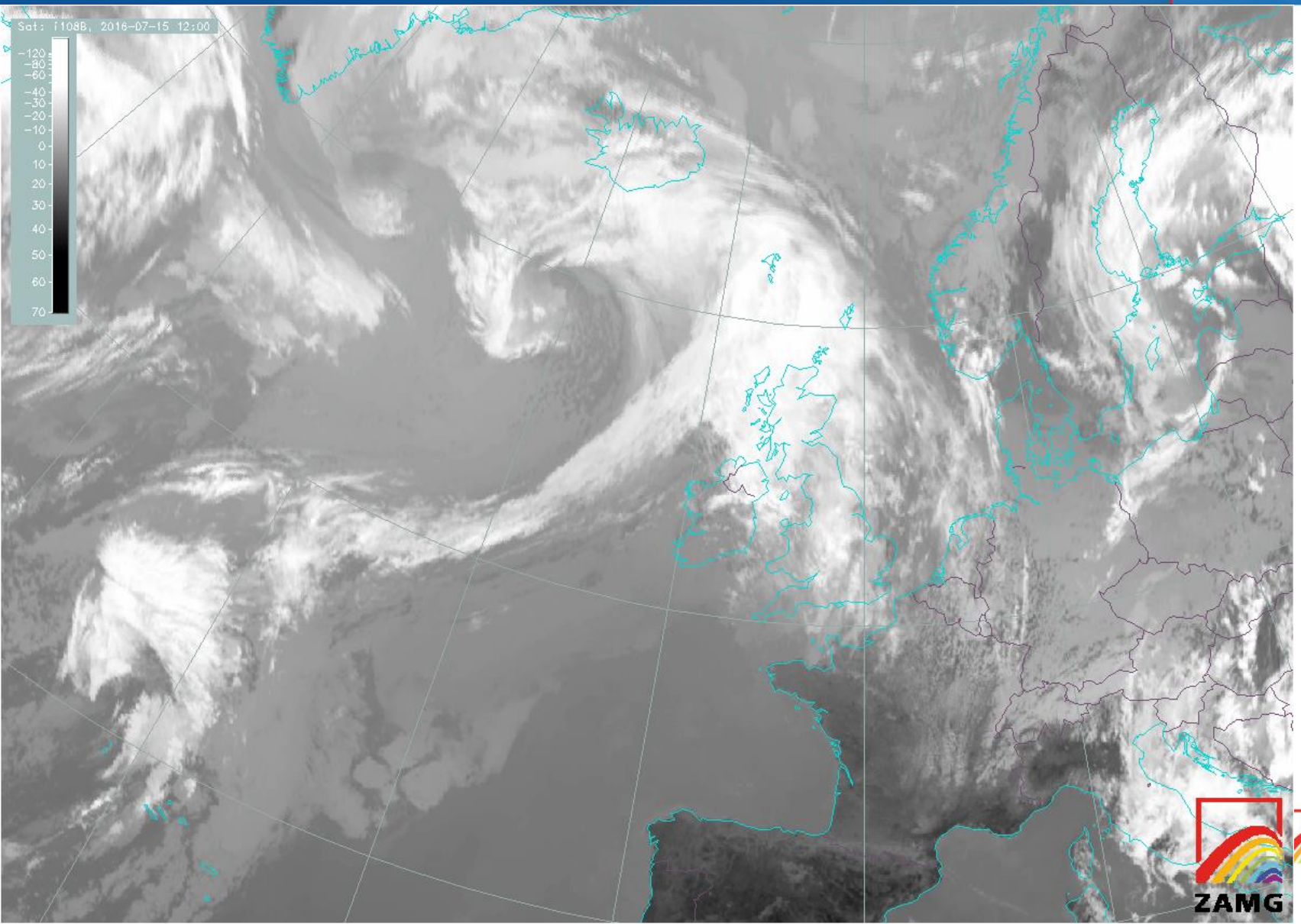
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

And now the Classical Wave (moving type)



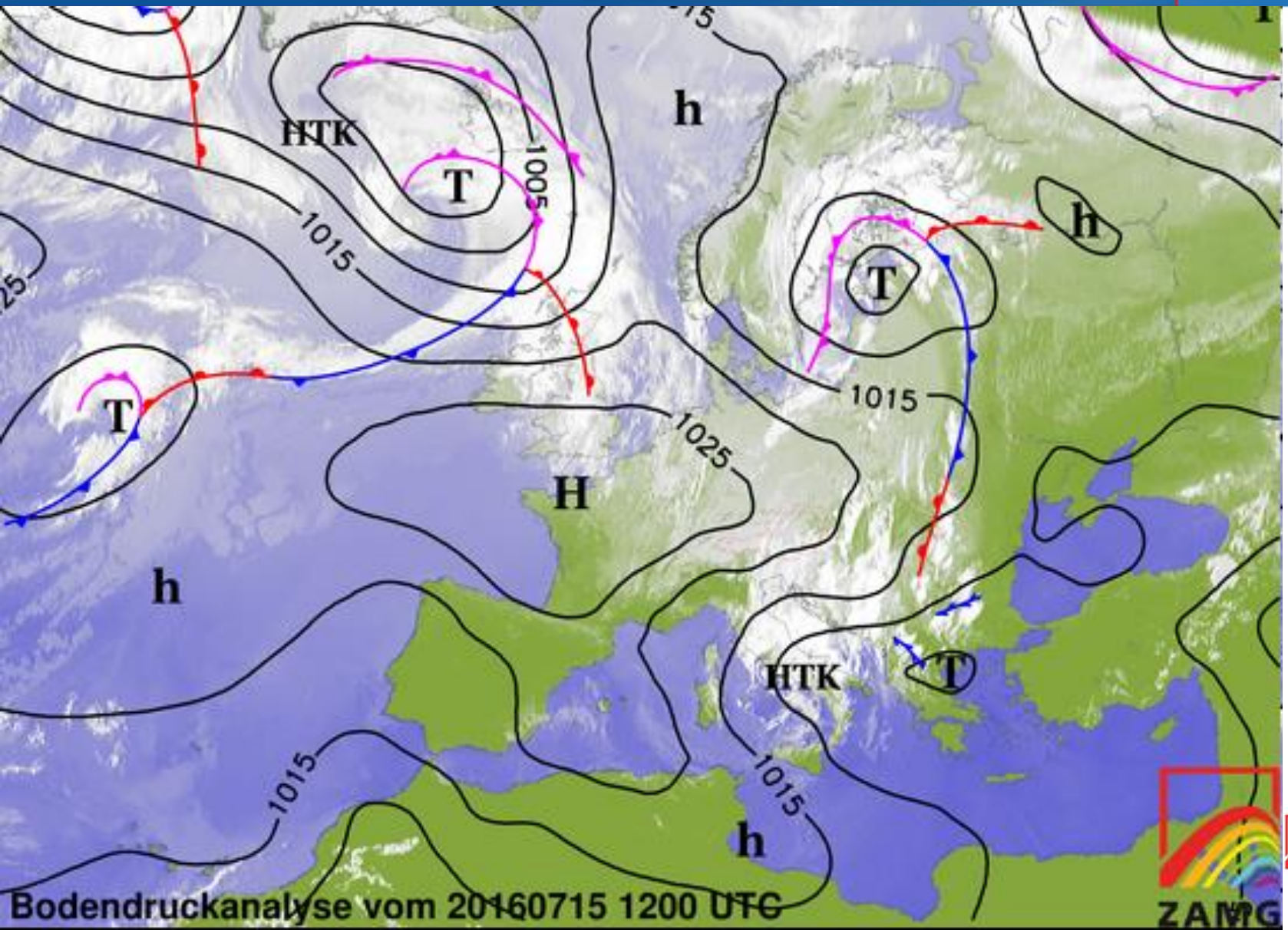
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

And now the Classical Wave (moving type)



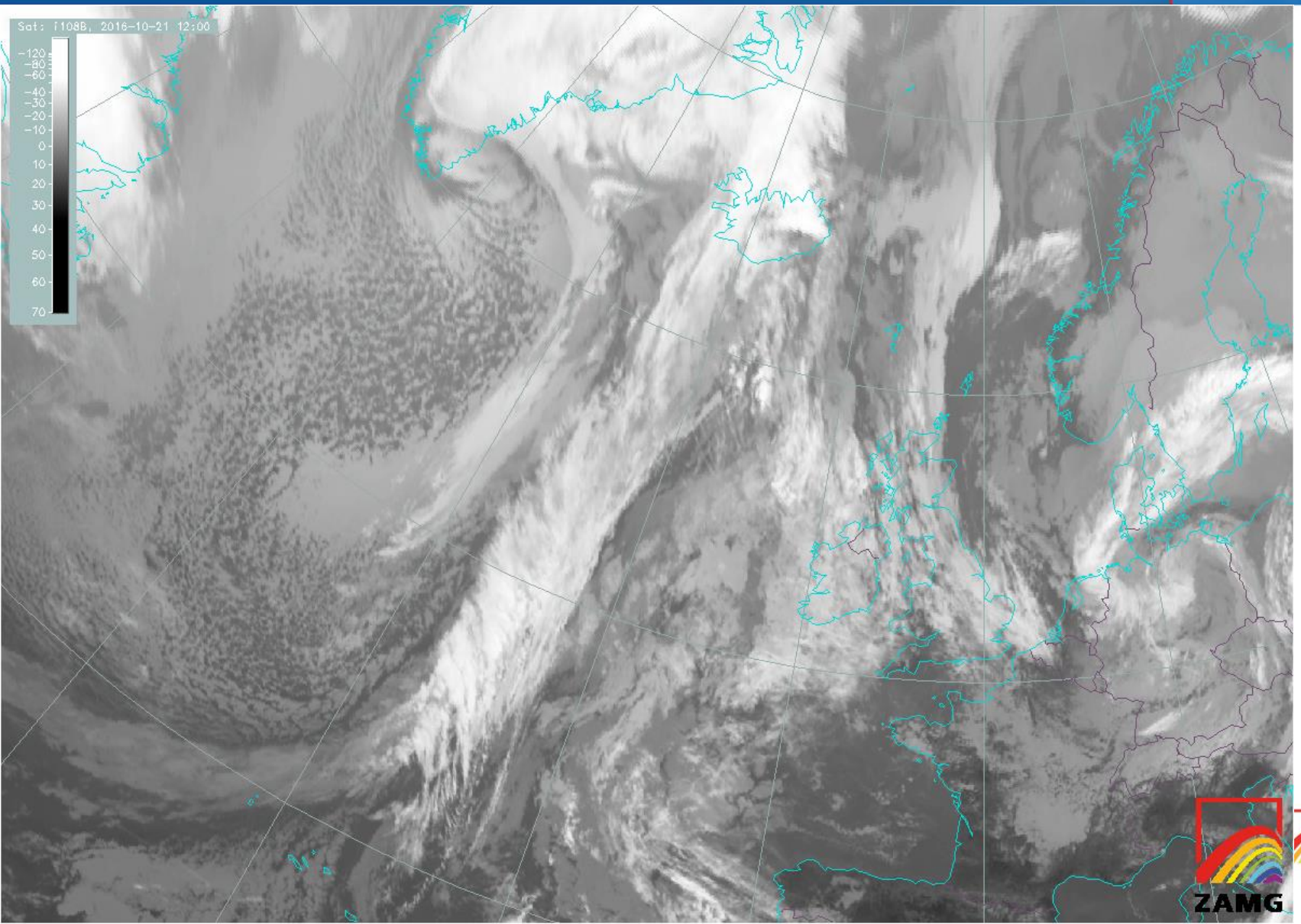
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

And now the Classical Wave (moving type)



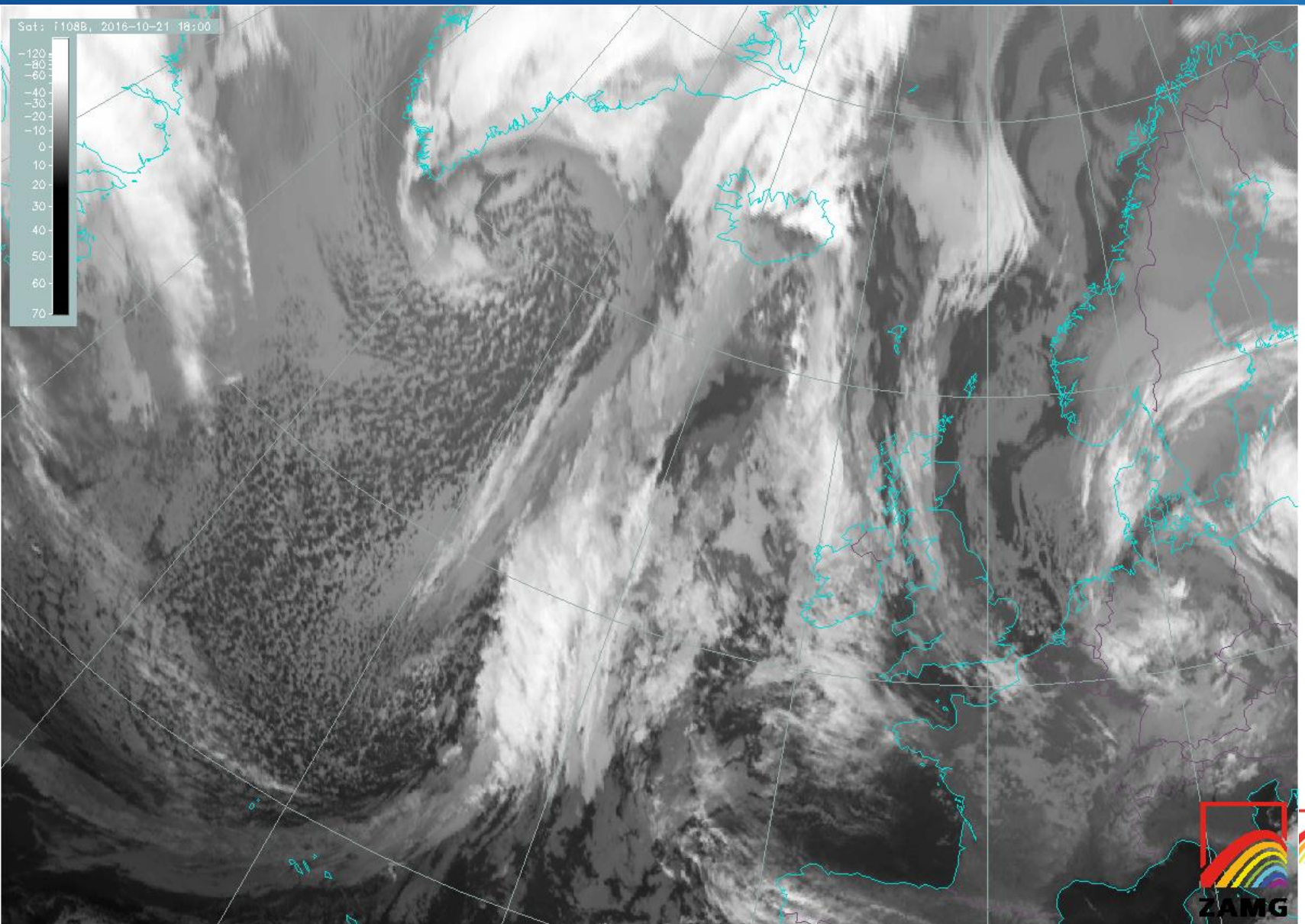
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

The Classical Wave (stationary type)



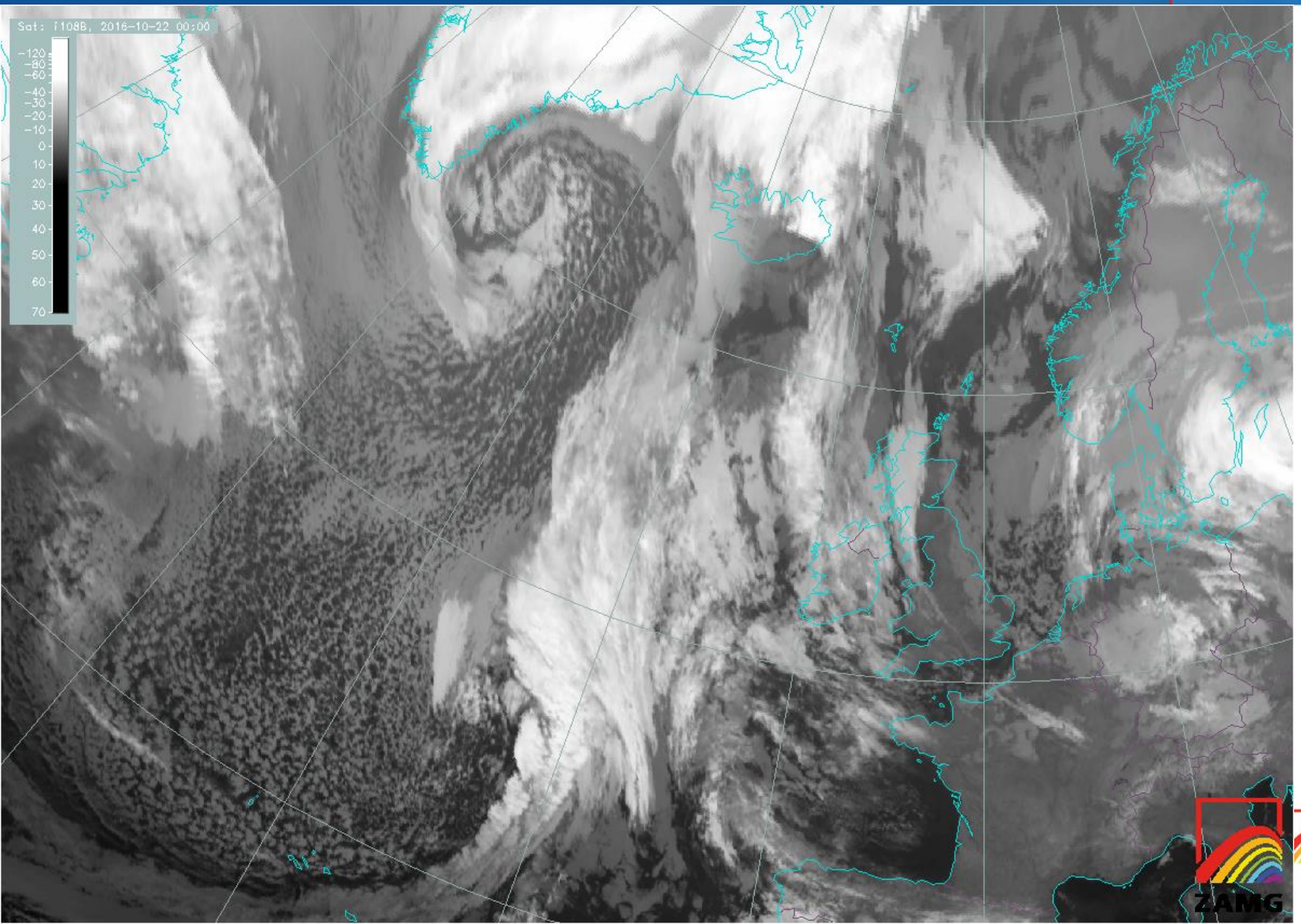
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

The Classical Wave (stationary type)



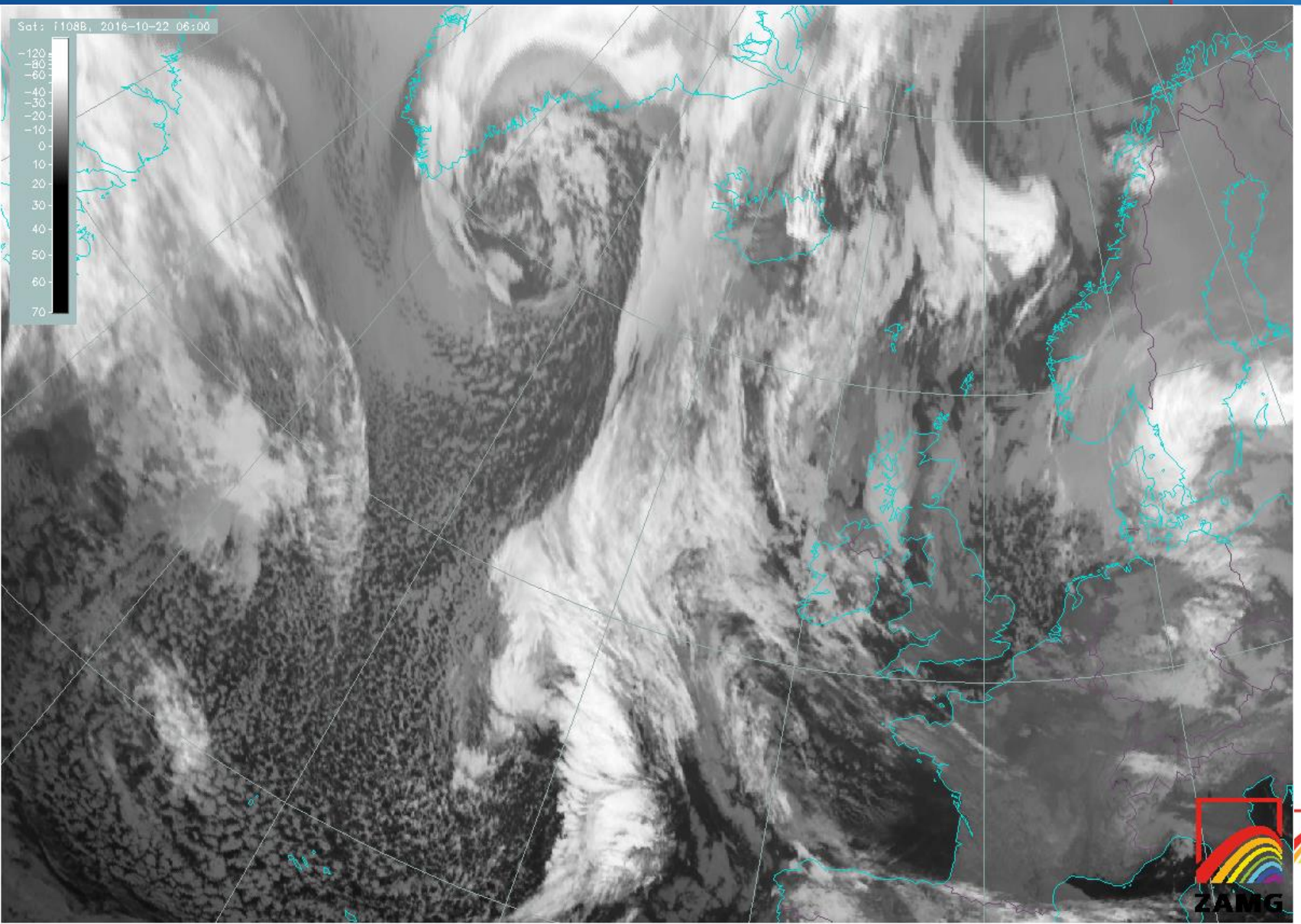
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

The Classical Wave (stationary type)



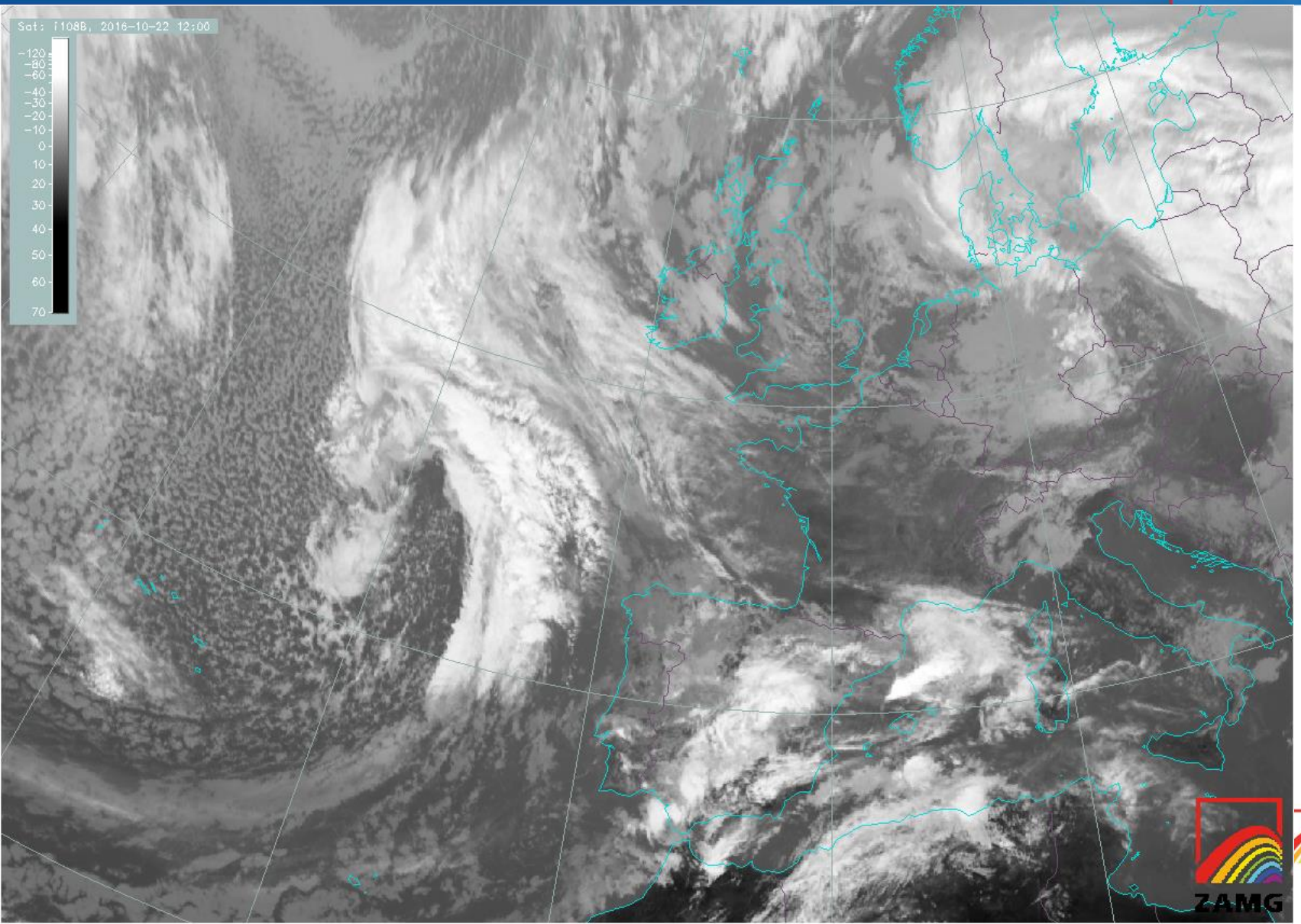
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

The Classical Wave (stationary type)



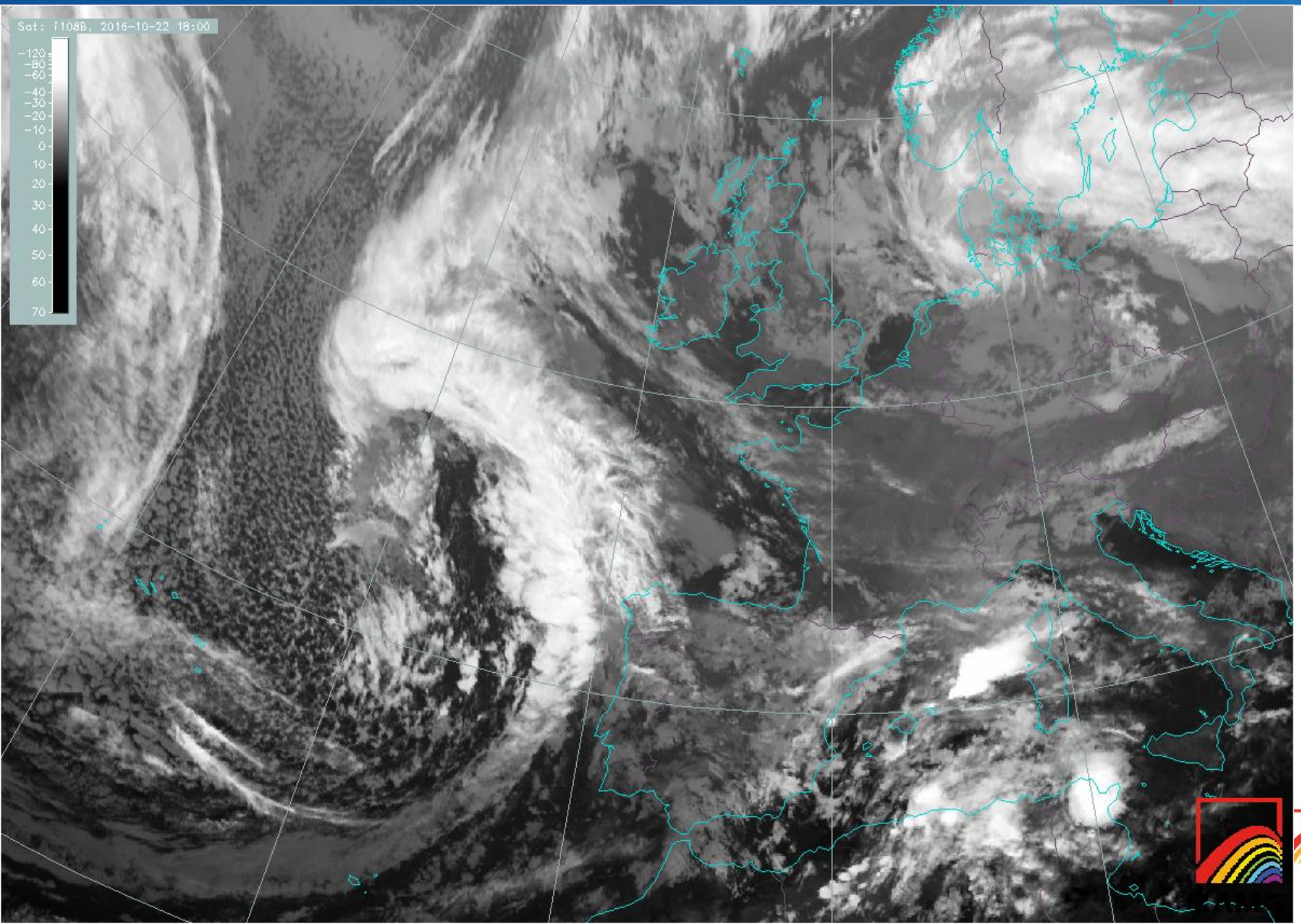
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

The Classical Wave (stationary type)



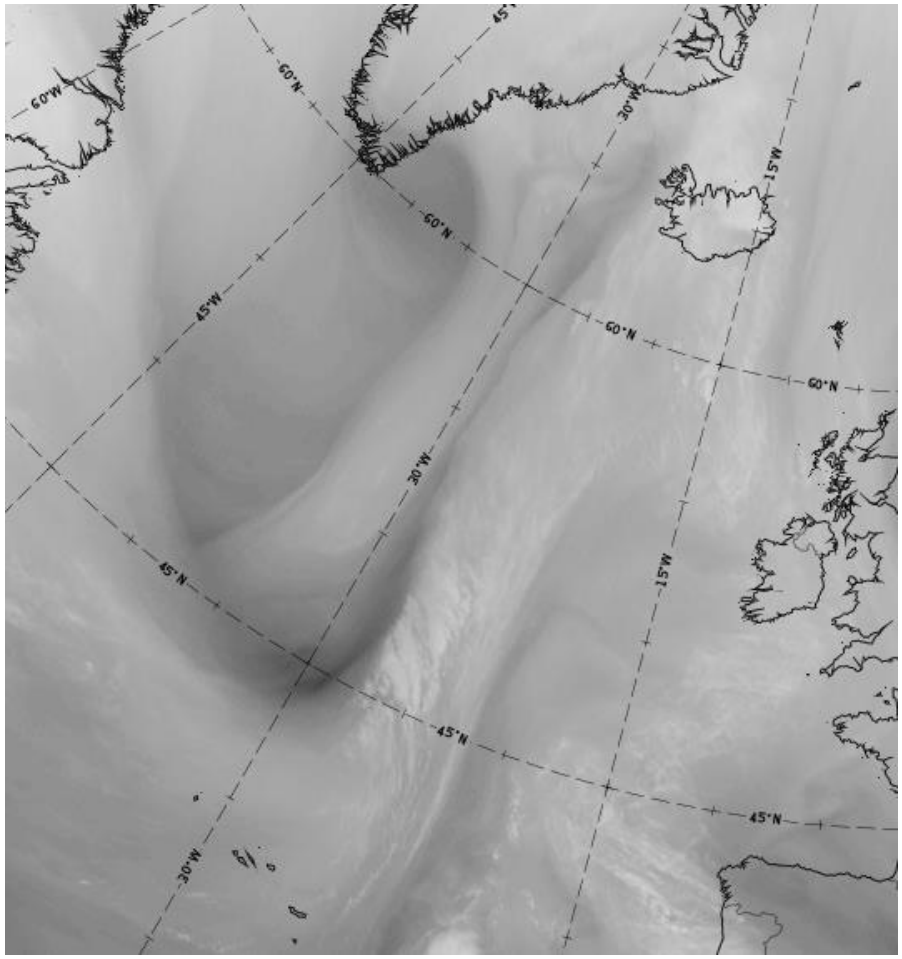
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

The Classical Wave (stationary type)

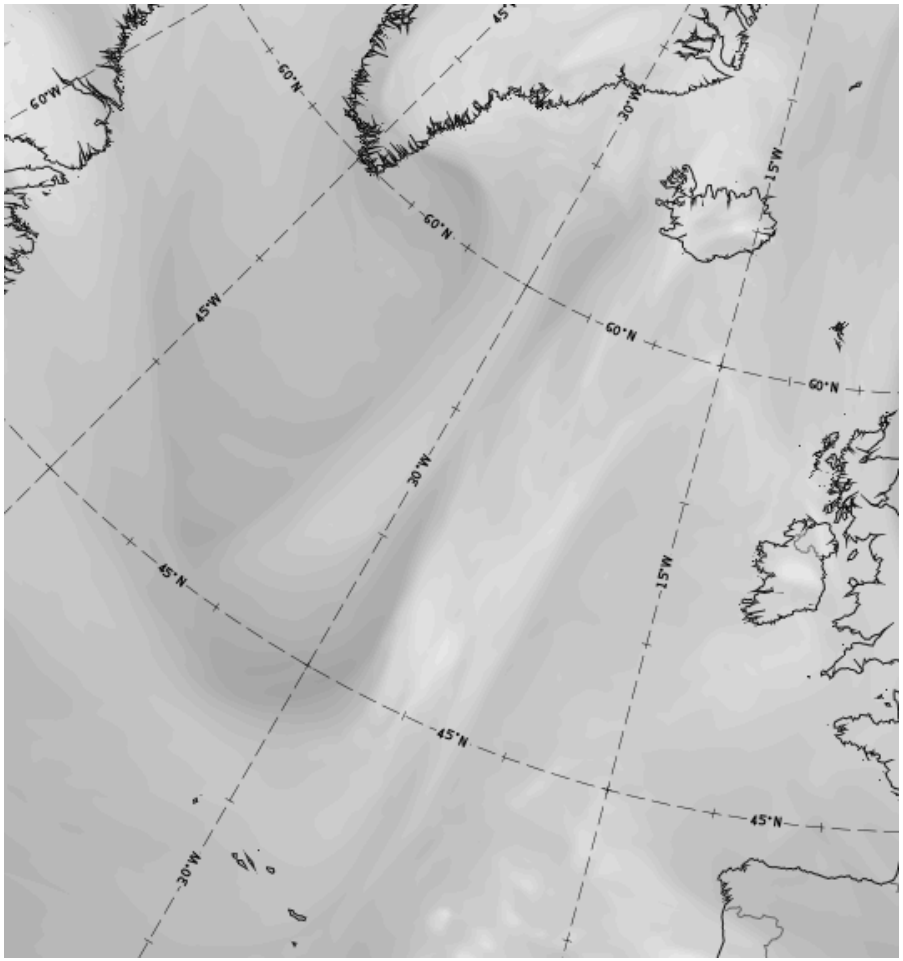


ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Is the wave reflected in the ECMWF model fields?



WV6.2 µm image

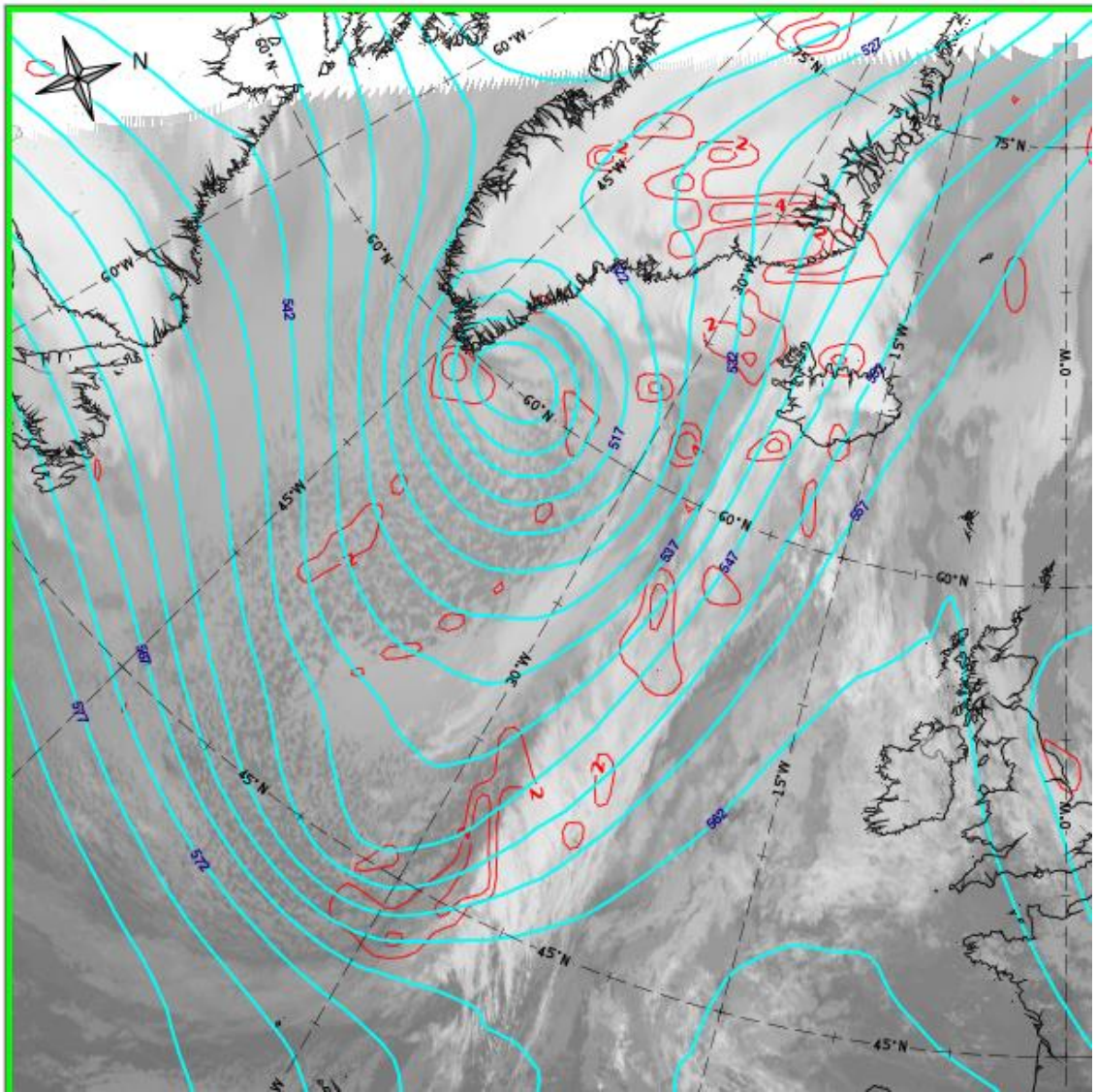


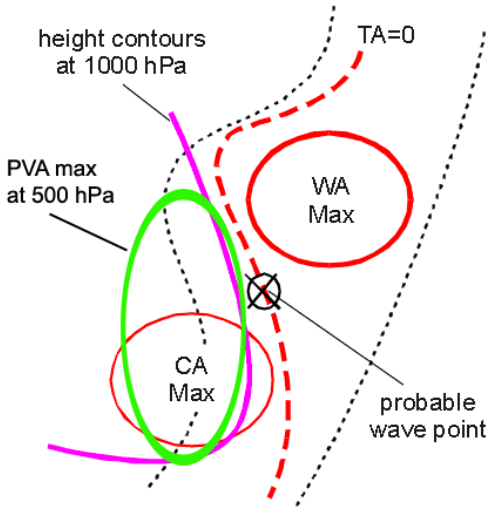
SimSat WV6.3 µm image

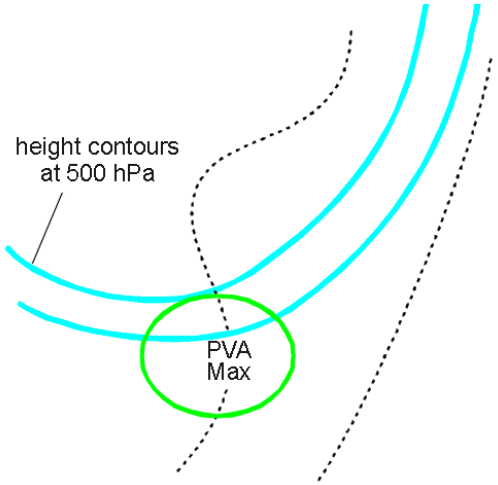
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

The wave key parameters: PVA 500 hPa

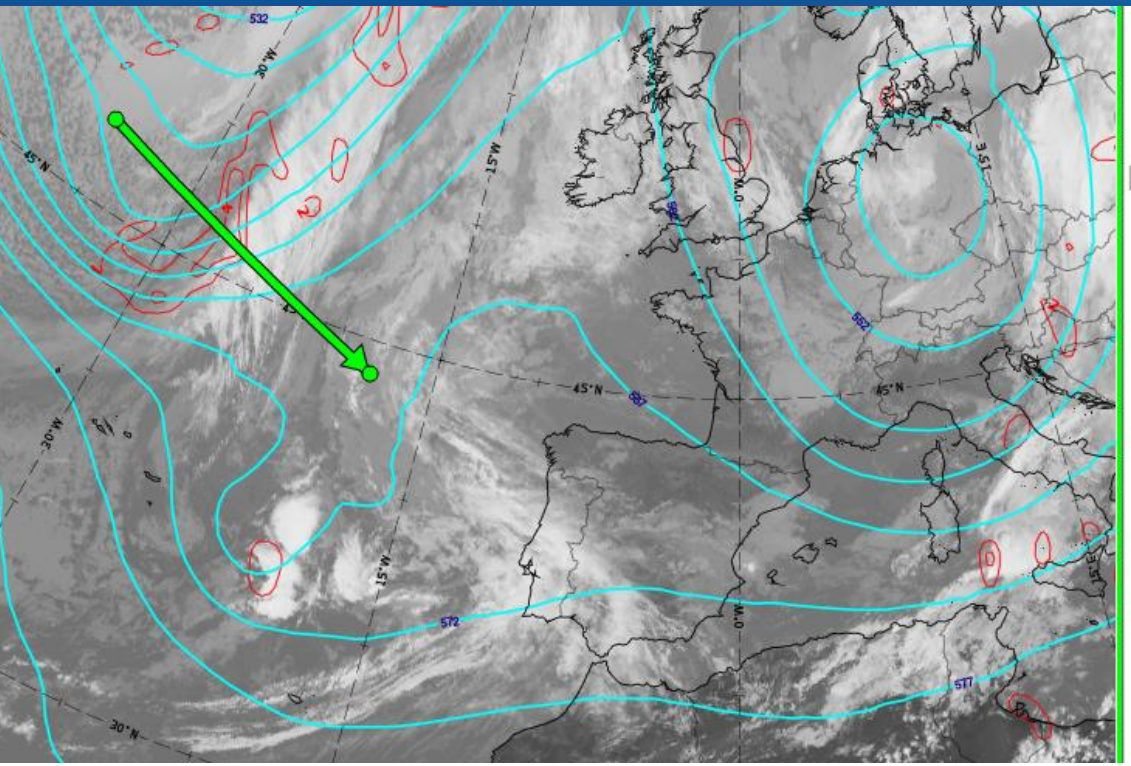
Time Navigation | Frame: Friday October 21,2016 12... | Level: 500hPa

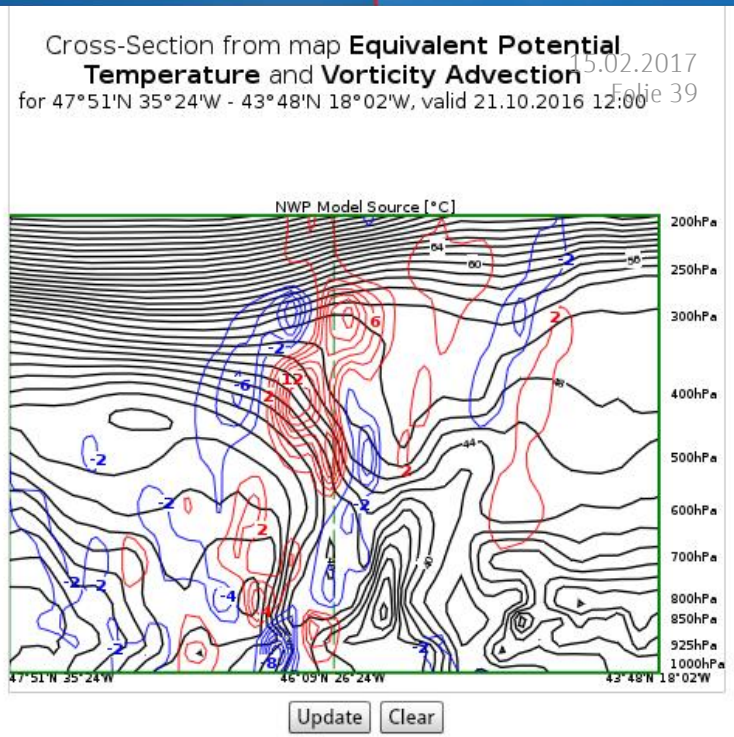






The wave key parameters: PVA 500 hPa

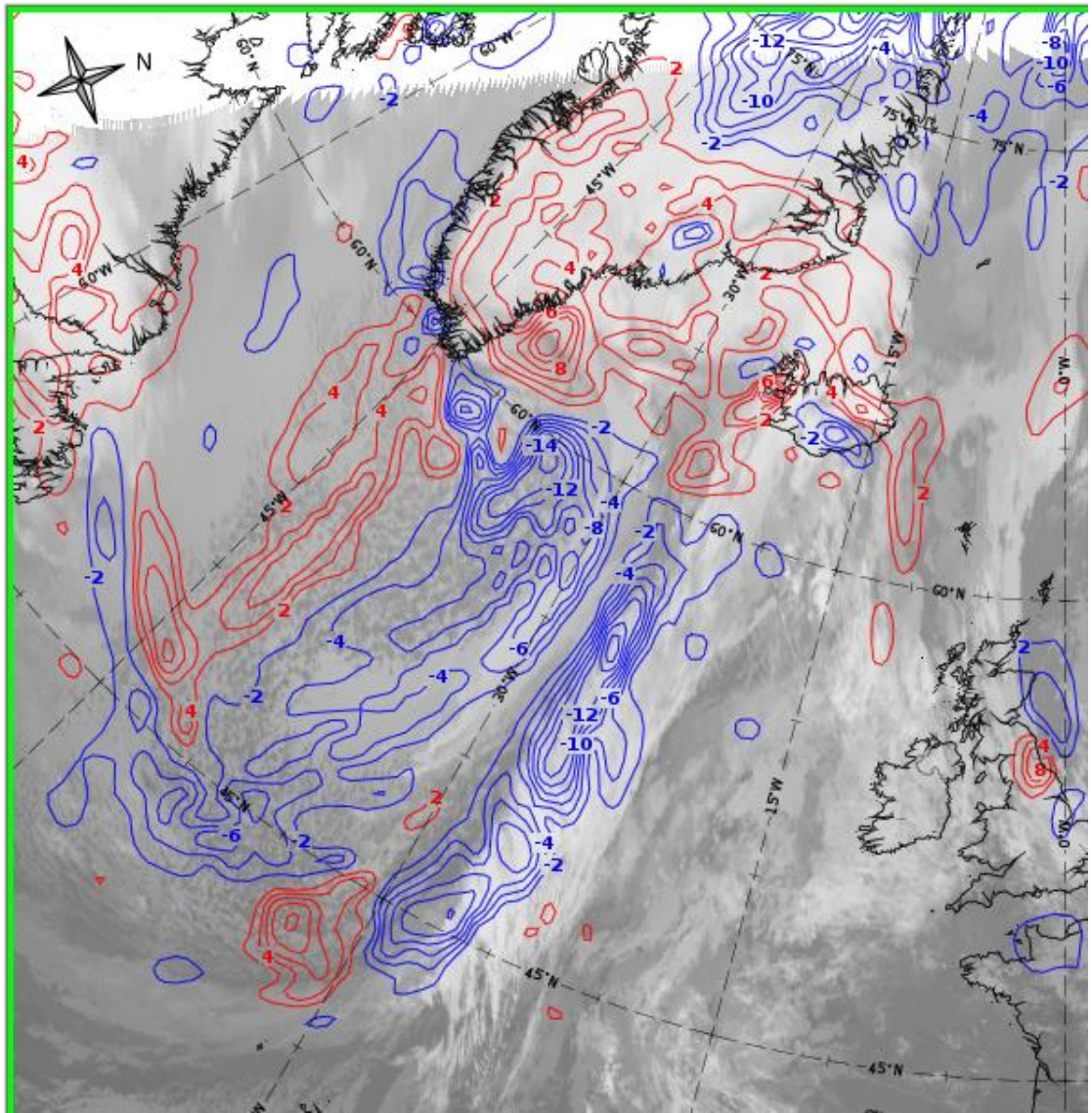


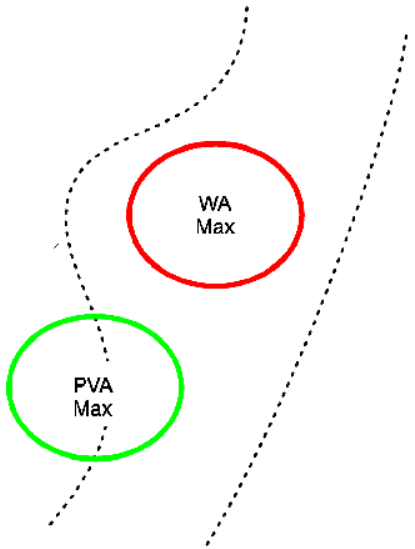


ZAMG
Zentralanstalt für Meteorologie und Geodynamik

The wave key parameters: Temperature Advection

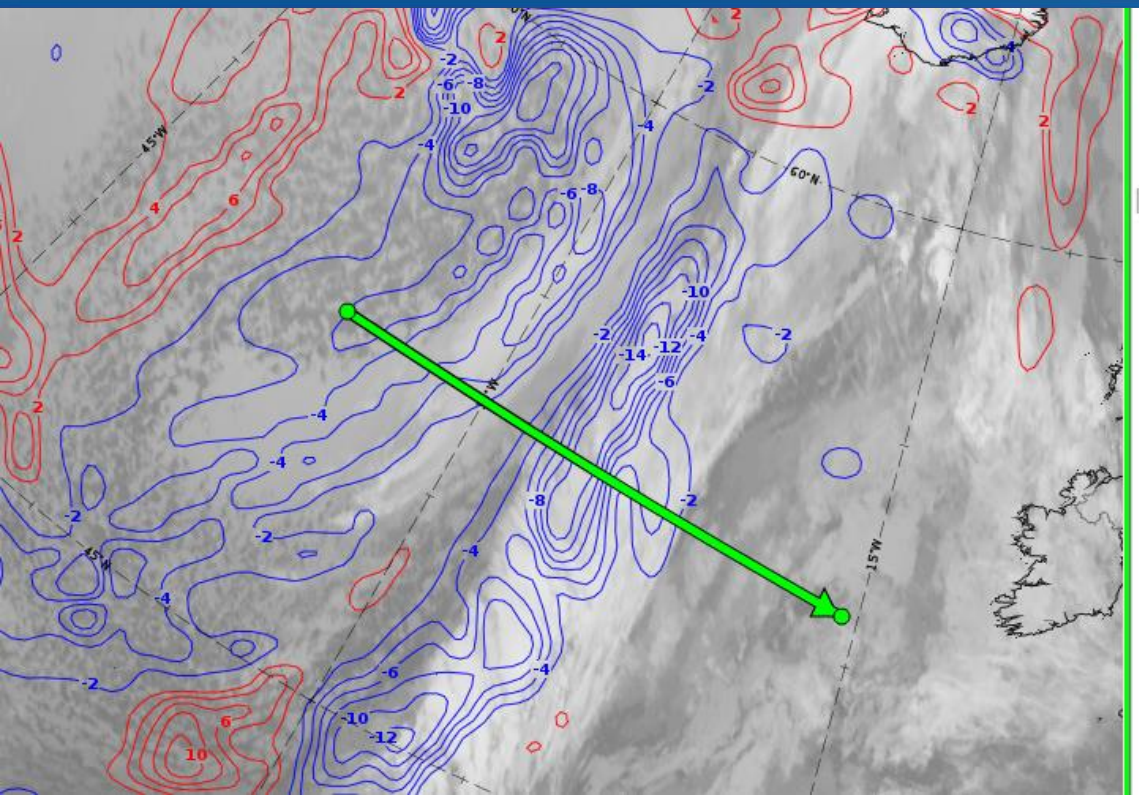
Time Navigation **Frame:** Friday October 21,2016 12... **Level:** 500hPa



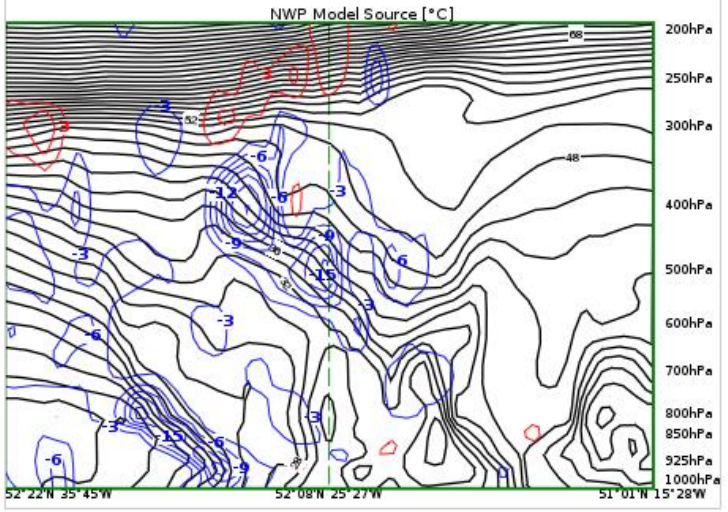


ZAMG
Zentralanstalt für Meteorologie und Geodynamik

The wave key parameters: Temperature Advection



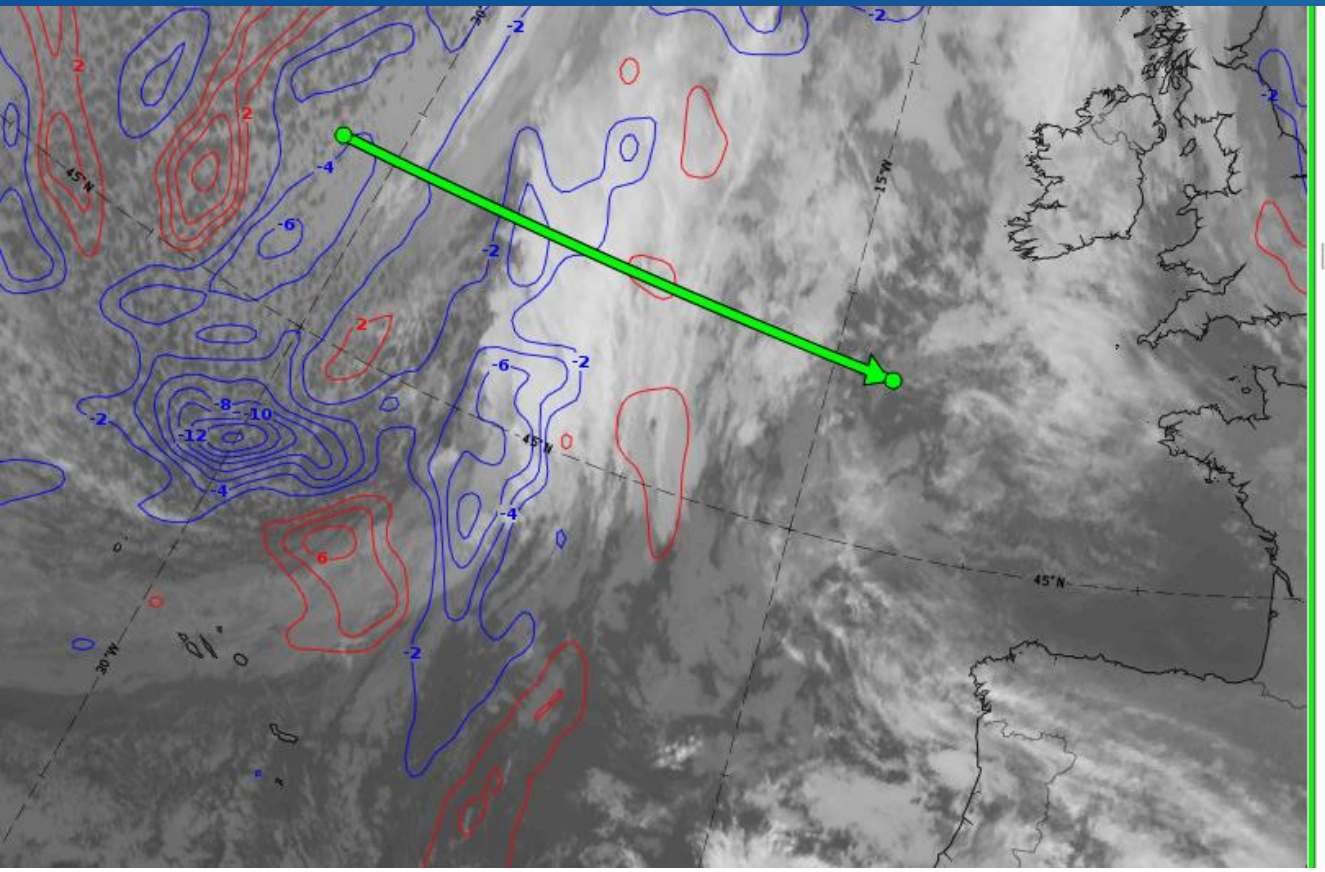
Cross-Section from map **Equivalent Potential Temperature** and **Temperature Advection**
for 52°22'N 35°45'W - 51°01'N 15°28'W, valid 21.10.2016 12:00



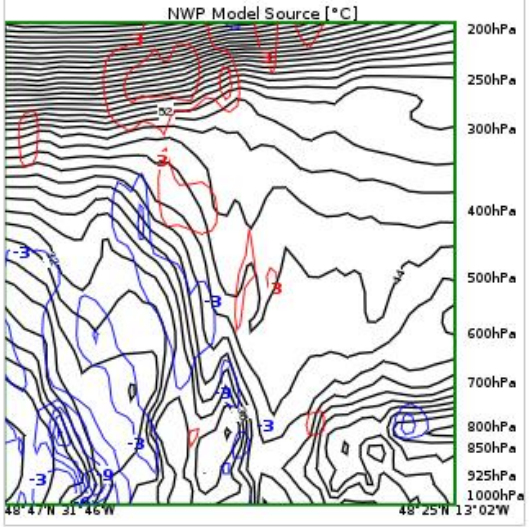
Update Clear

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

The wave key parameters: Temperature Advection (+6 hours)



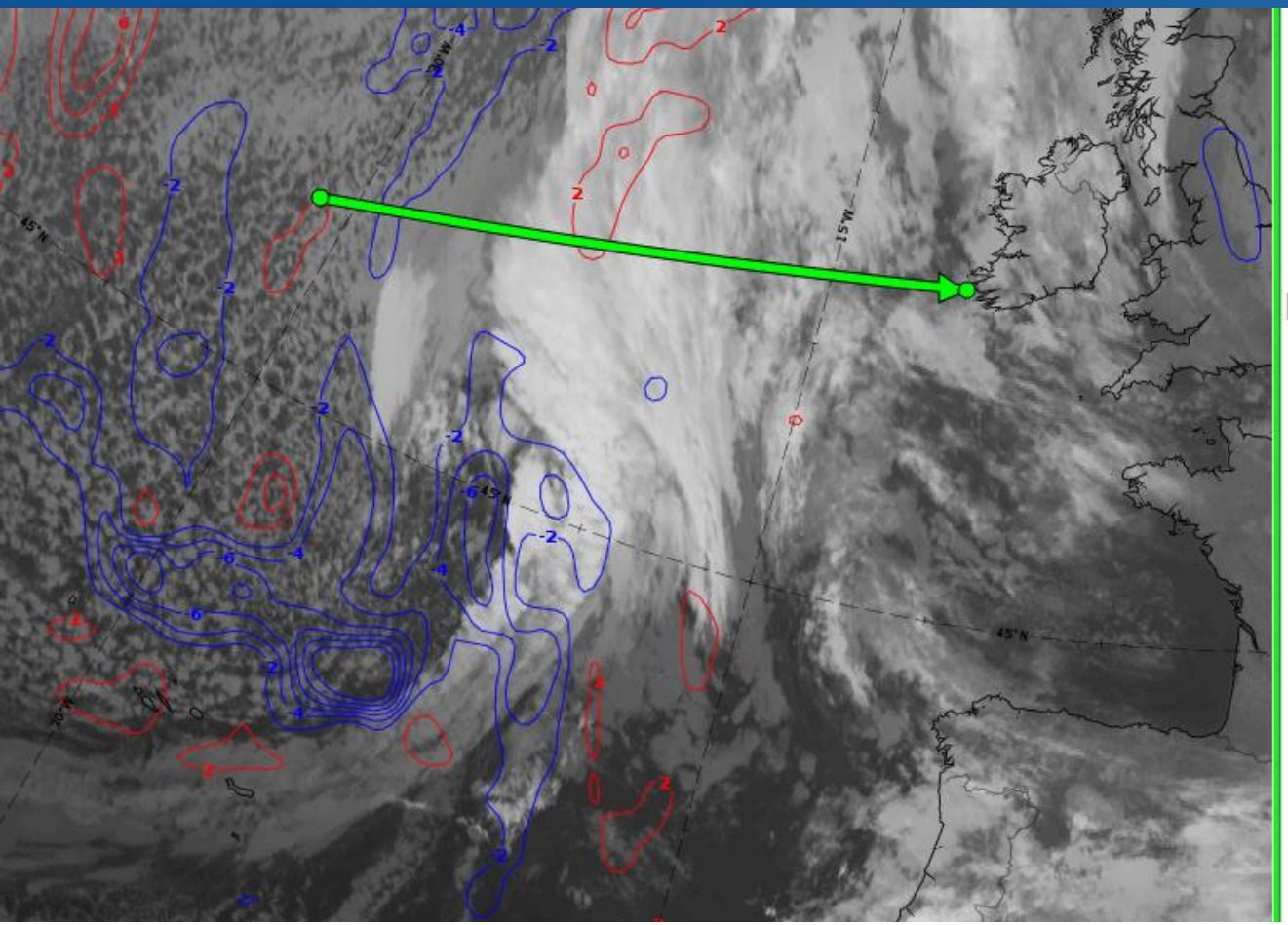
Cross-Section from map
Equivalent Potential Temperature and **Temperature Advection**
for 48°47'N 31°46'W - 48°25'N 13°02'W,
valid 21.10.2016 18:00



Update Clear

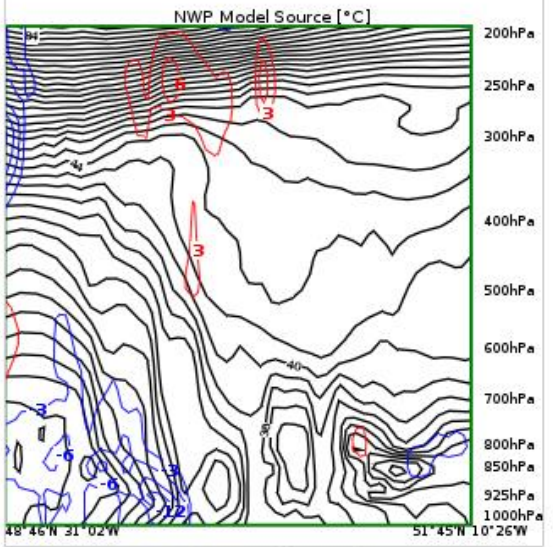
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

The wave key parameters: Temperature Advection (+12 hours)



Type: VCS EquiPT+TempAdv

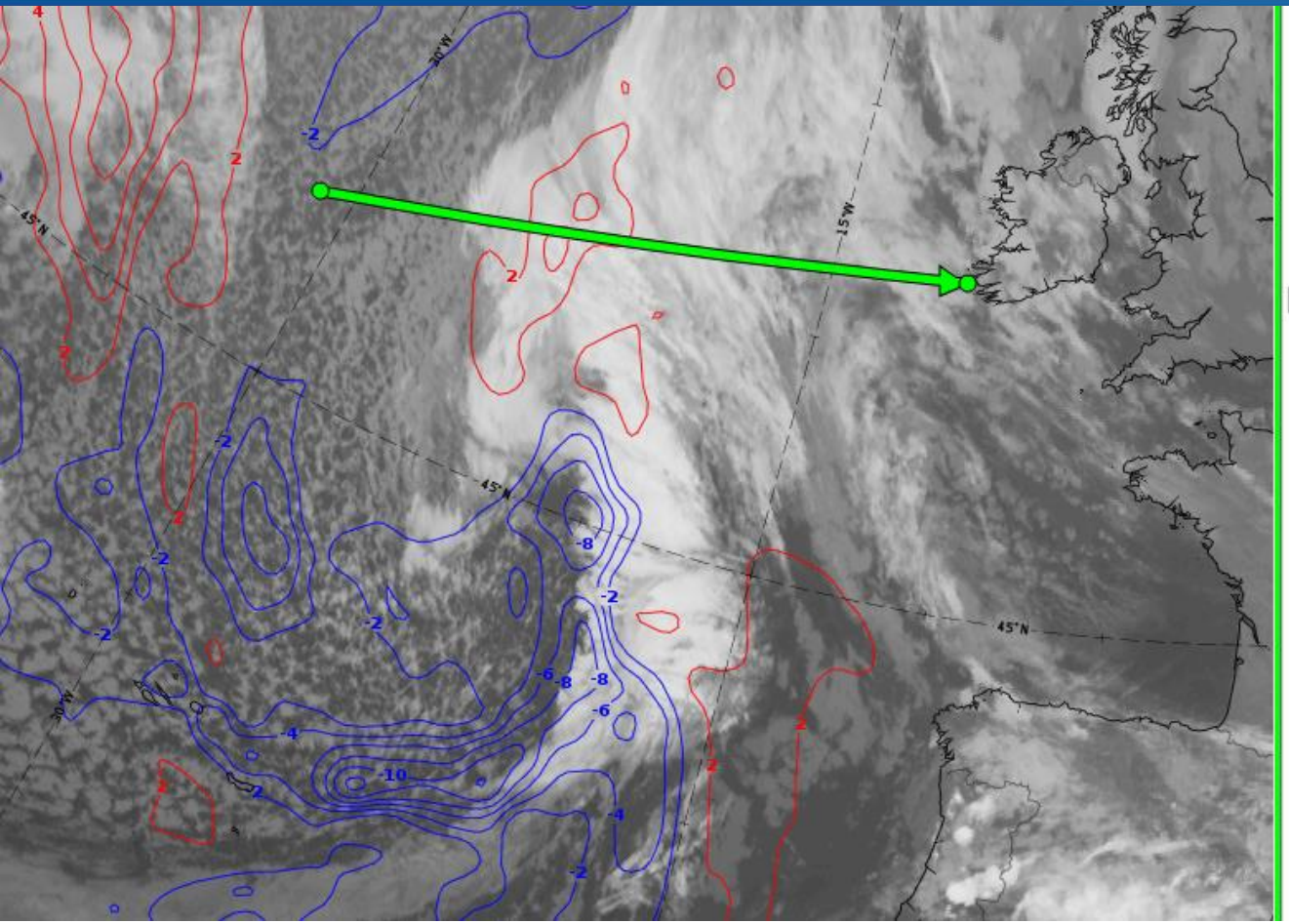
Cross-Section from map
Equivalent Potential Temperature and **Temperature Advection**
for 48°46'N 31°02'W - 51°45'N 10°26'W,
valid 22.10.2016 00:00

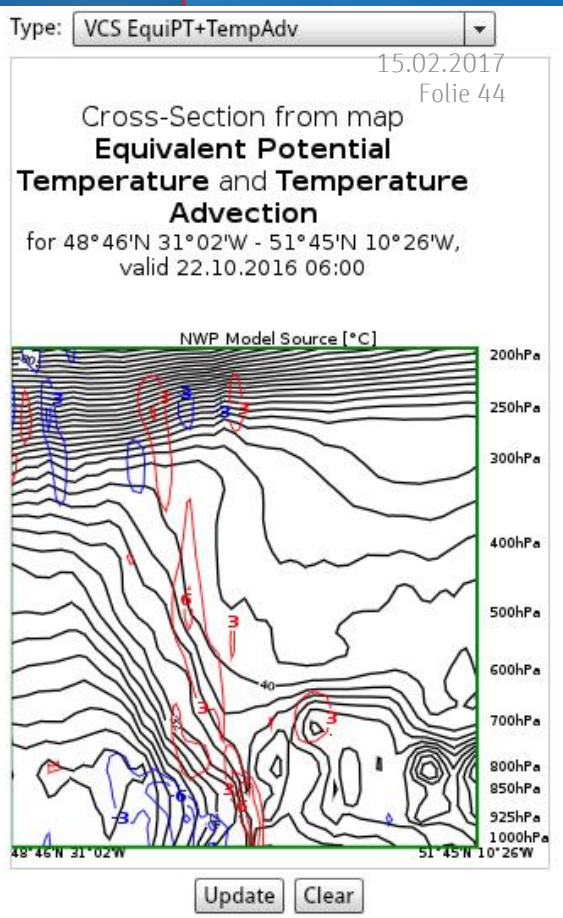


Update Clear

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

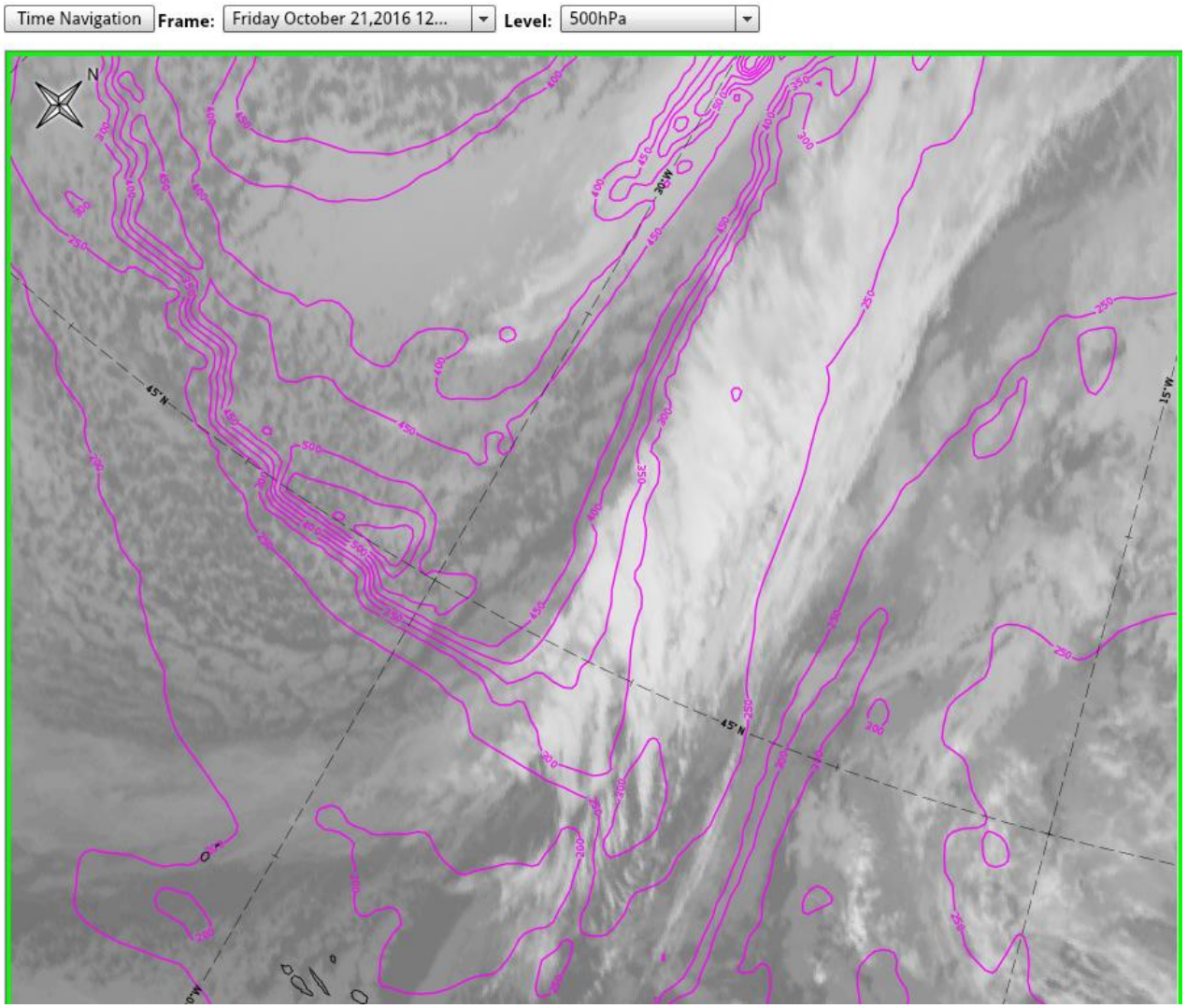
The wave key parameters: Temperature Advection (+12 hours)

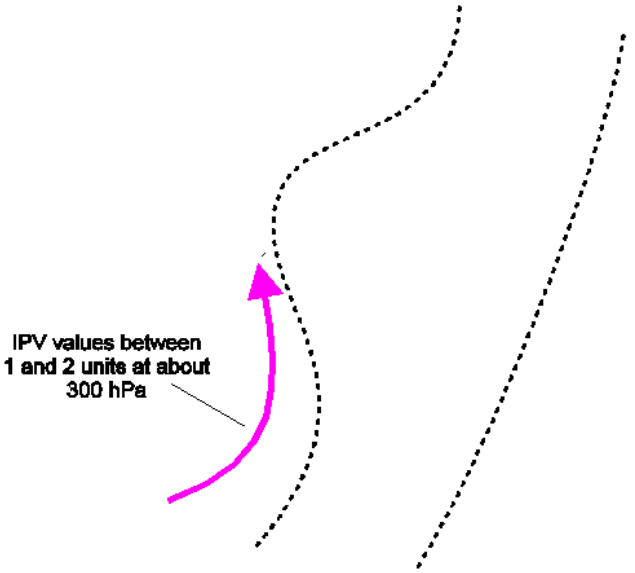




ZAMG
Zentralanstalt für Meteorologie und Geodynamik

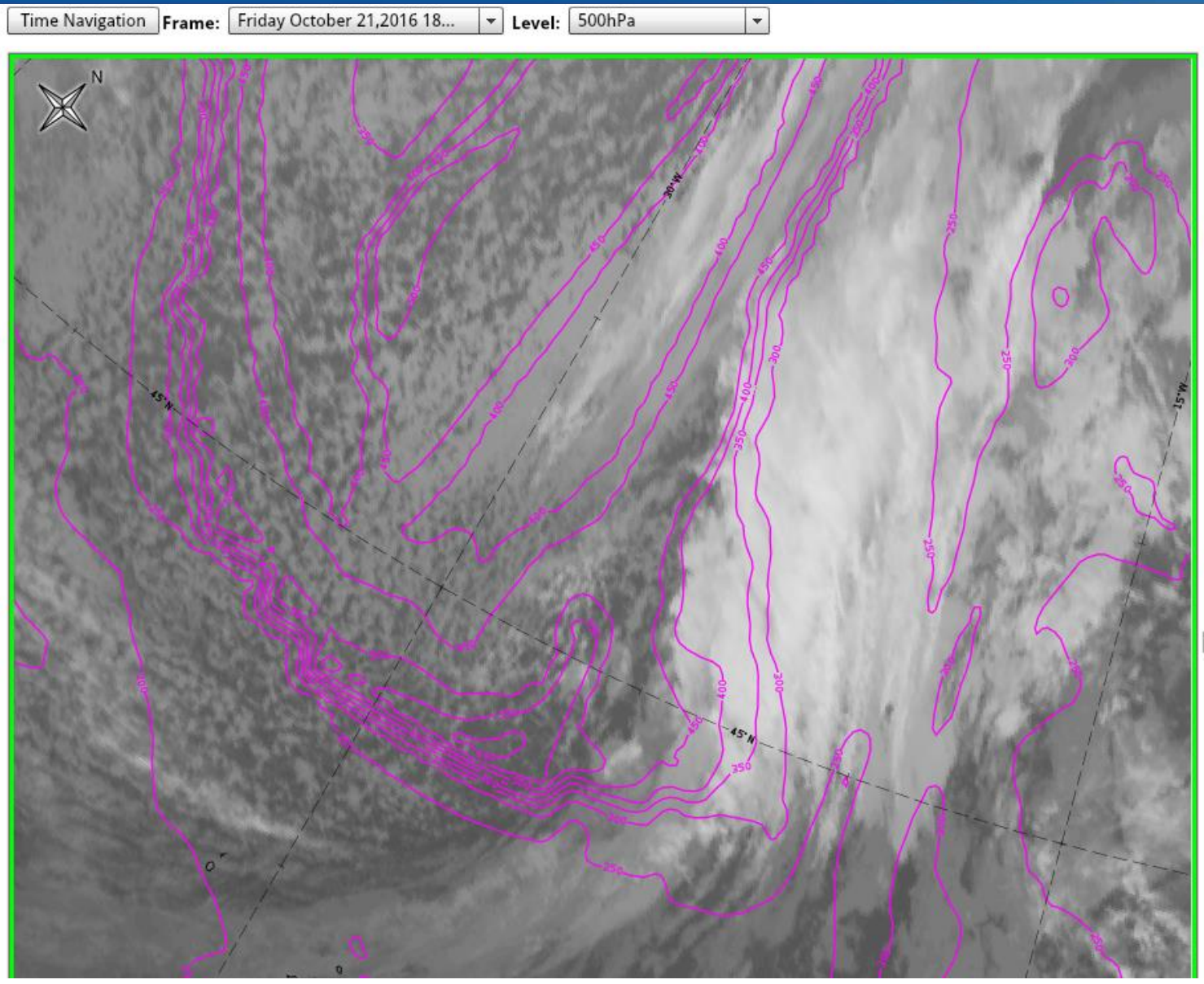
The wave key parameters: Potential Vorticity





ZAMG
Zentralanstalt für Meteorologie und Geodynamik

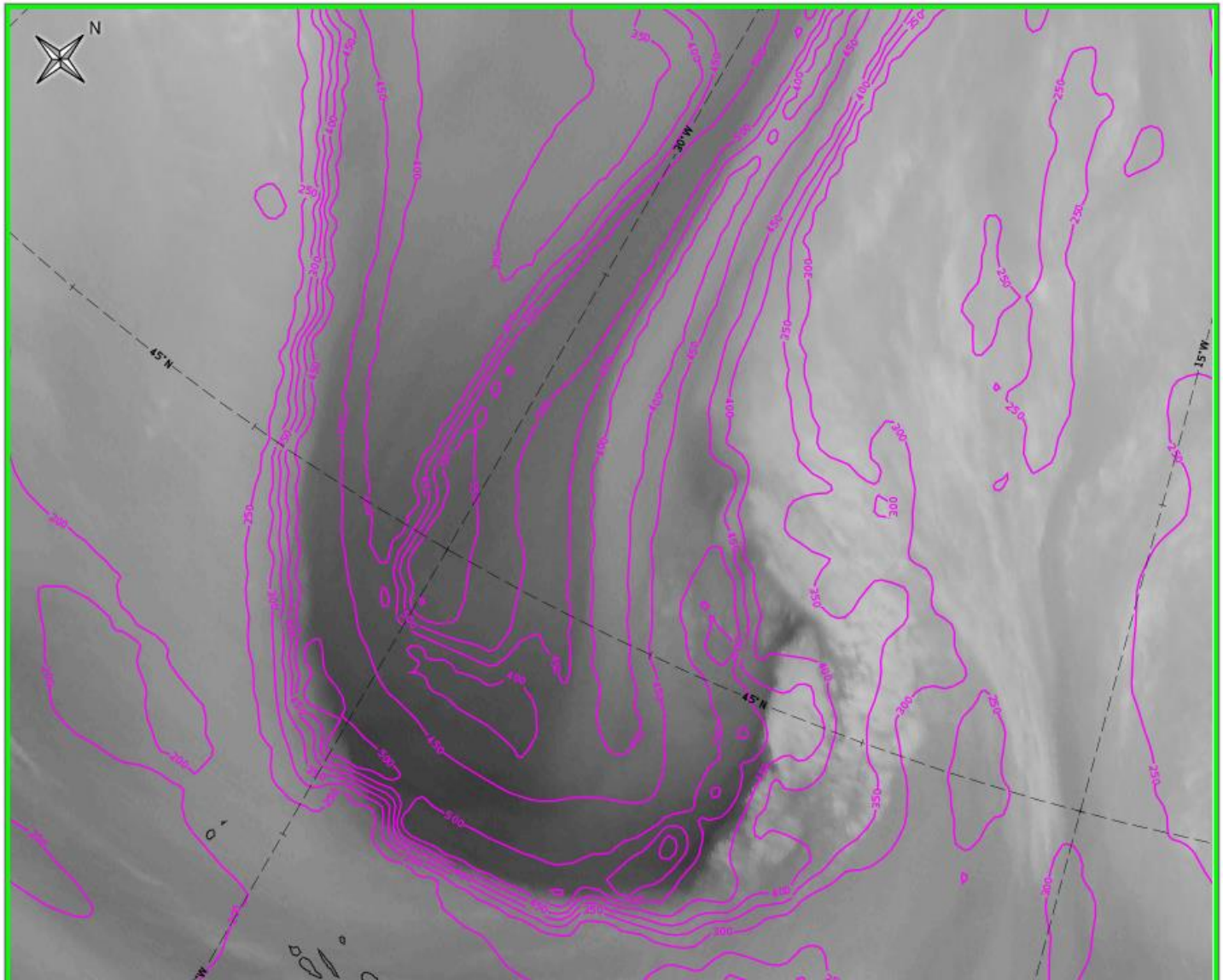
The wave key parameters: Potential Vorticity (+ 6 hours)



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

The wave key parameters: Potential Vorticity (+ 12 hours)

Time Navigation **Frame:** Saturday October 22,2016 ... **Level:** 500hPa



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Intensification by Jet Crossing – 5 W's

What?

⇒ developement of thicker and mostly more convective clouds

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Intensification by Jet Crossing – 5 W's

What?

$\Rightarrow$ developement of thicker and mostly more convective clouds

Who?

- warm front
- cold front
- occlusion

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Intensification by Jet Crossing – 5 W's

What?

⇒ developement of thicker and mostly more convective clouds

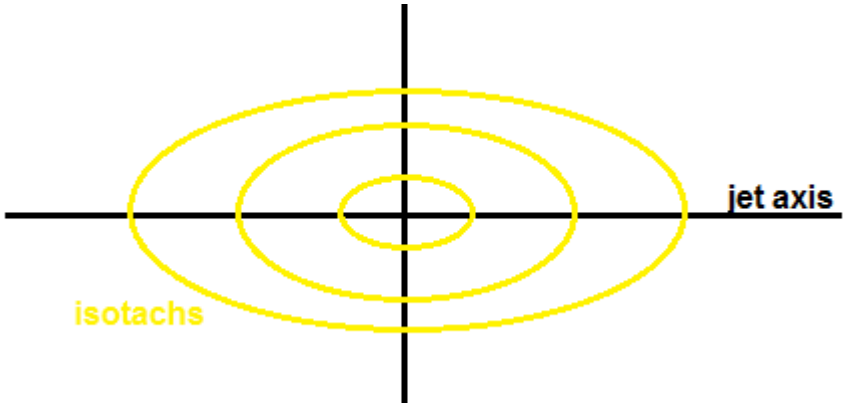
Who?

- warm front
- cold front
- occlusion

When?

⇒ anytime

Where?



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Intensification by Jet Crossing – 5 W's

What?

⇒ developement of thicker and mostly more convective clouds

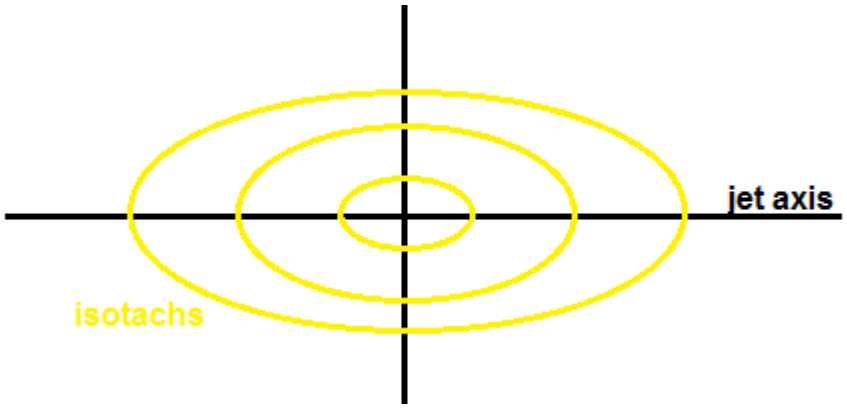
Who?

- warm front
- cold front
- occlusion

When?

⇒ anytime

Where?



Why?

convection

microphysics

PVA min

magic

NVA max

coincidence

dynamics

water vapour

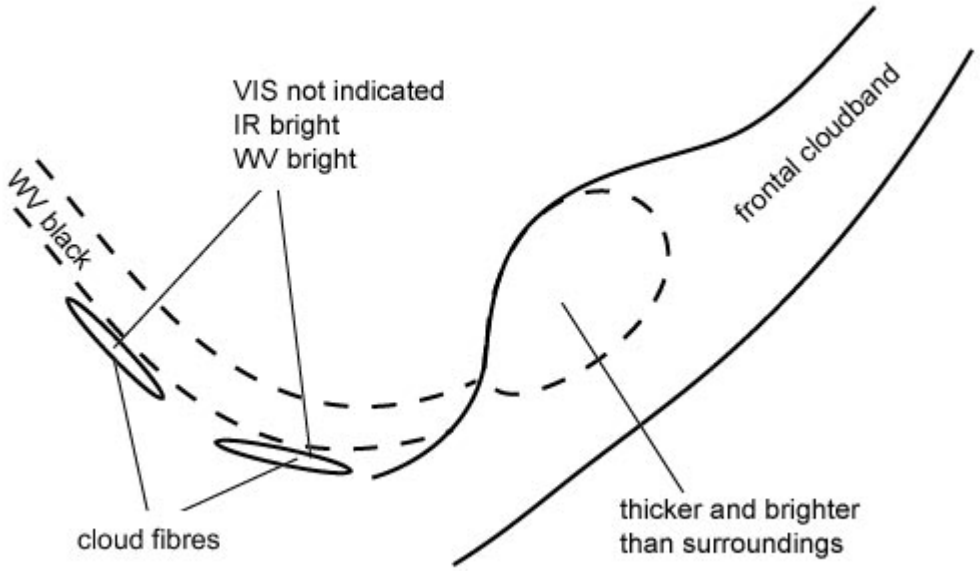
PVA max

turbulence

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

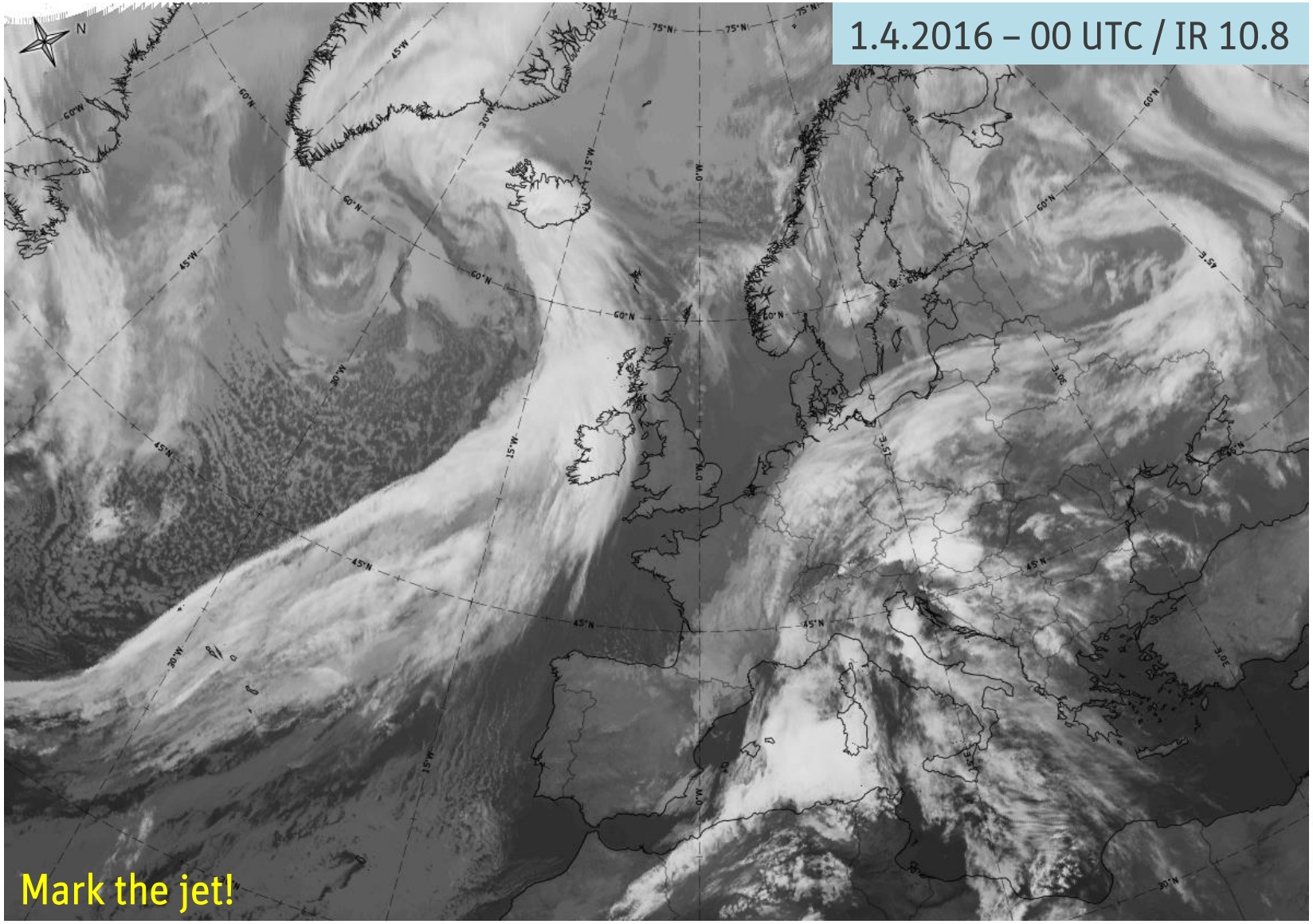
Front Intensification by Jet Crossing

Conceptual Model



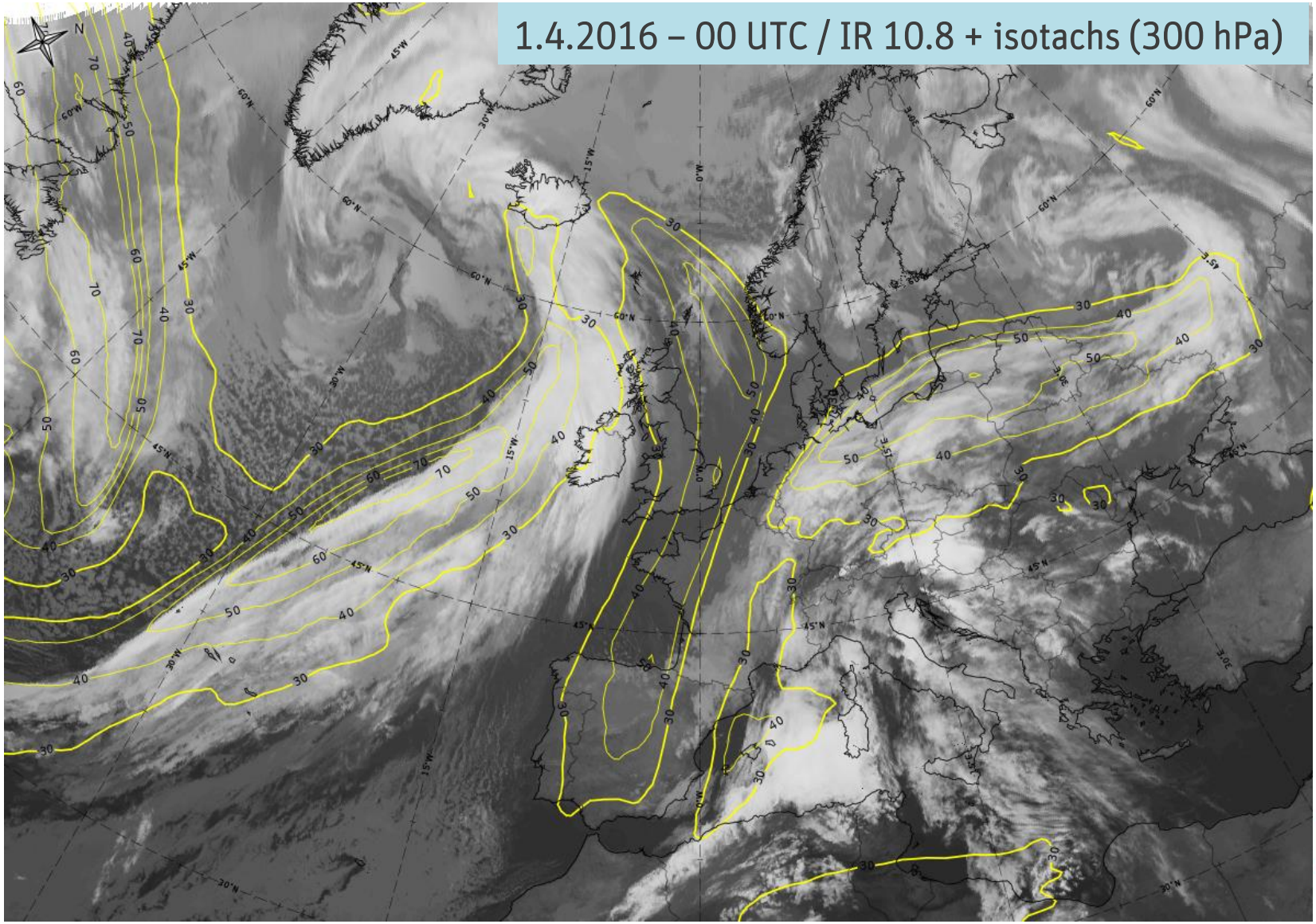
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Intensification by Jet Crossing



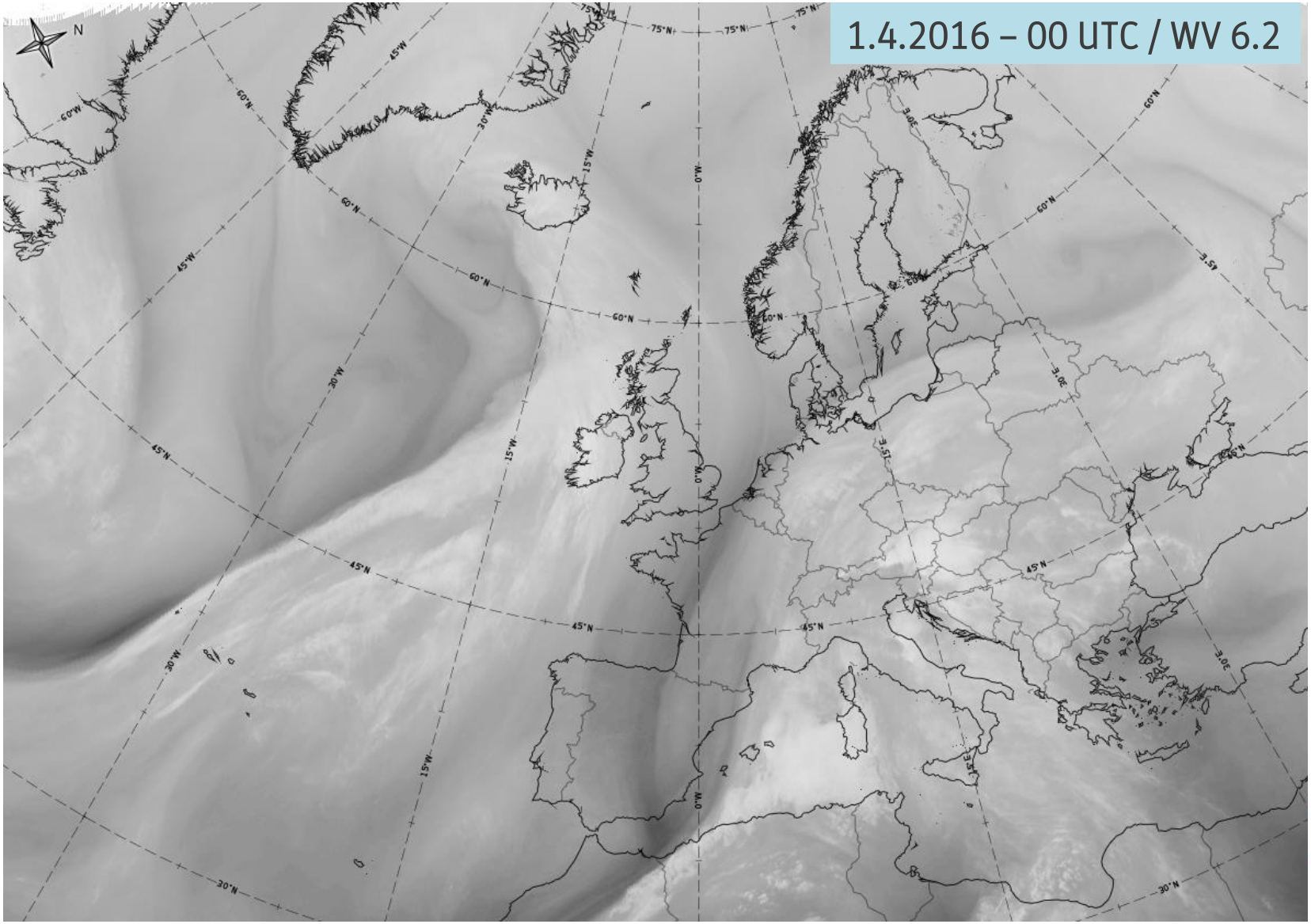
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Intensification by Jet Crossing



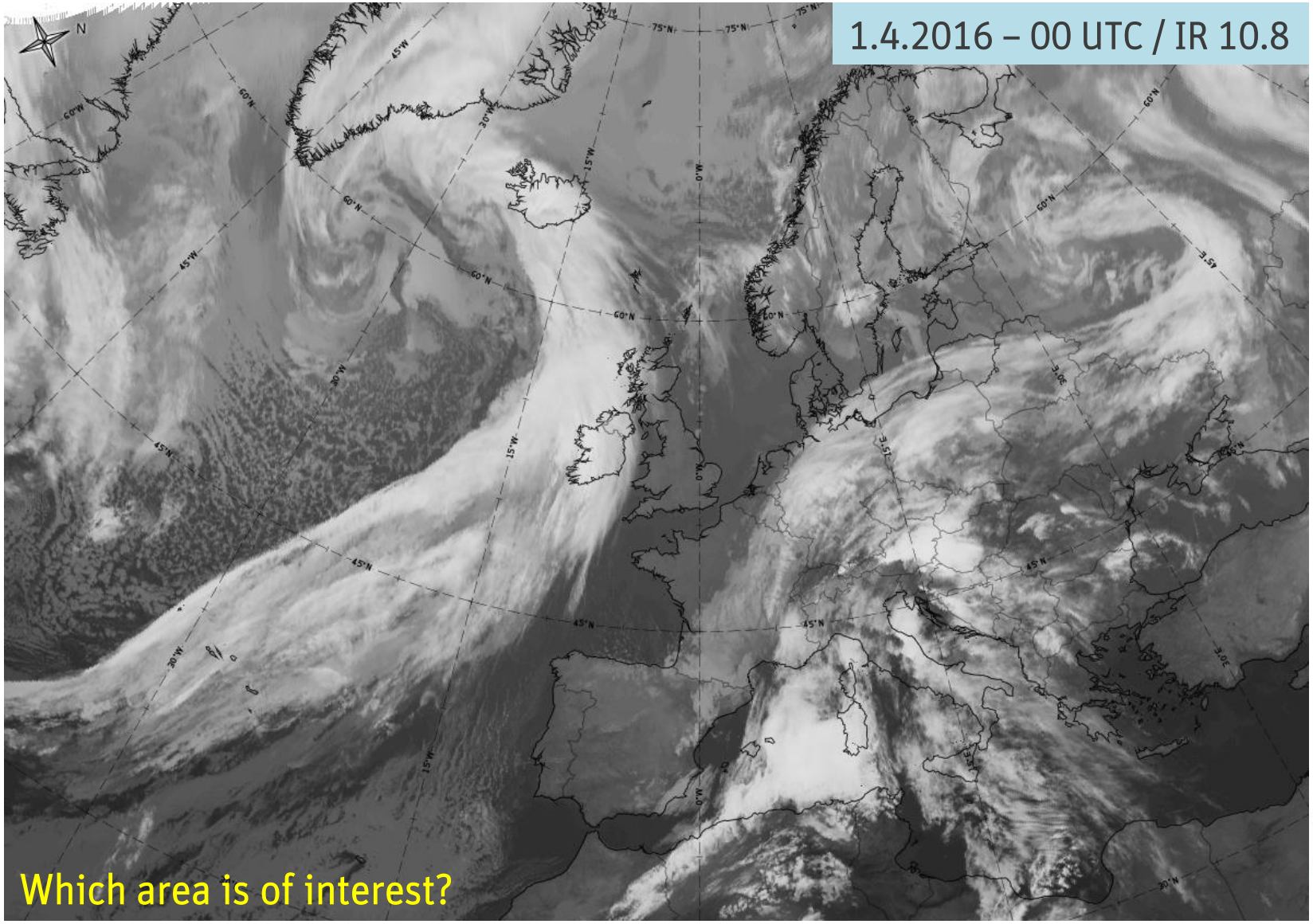
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Intensification by Jet Crossing



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

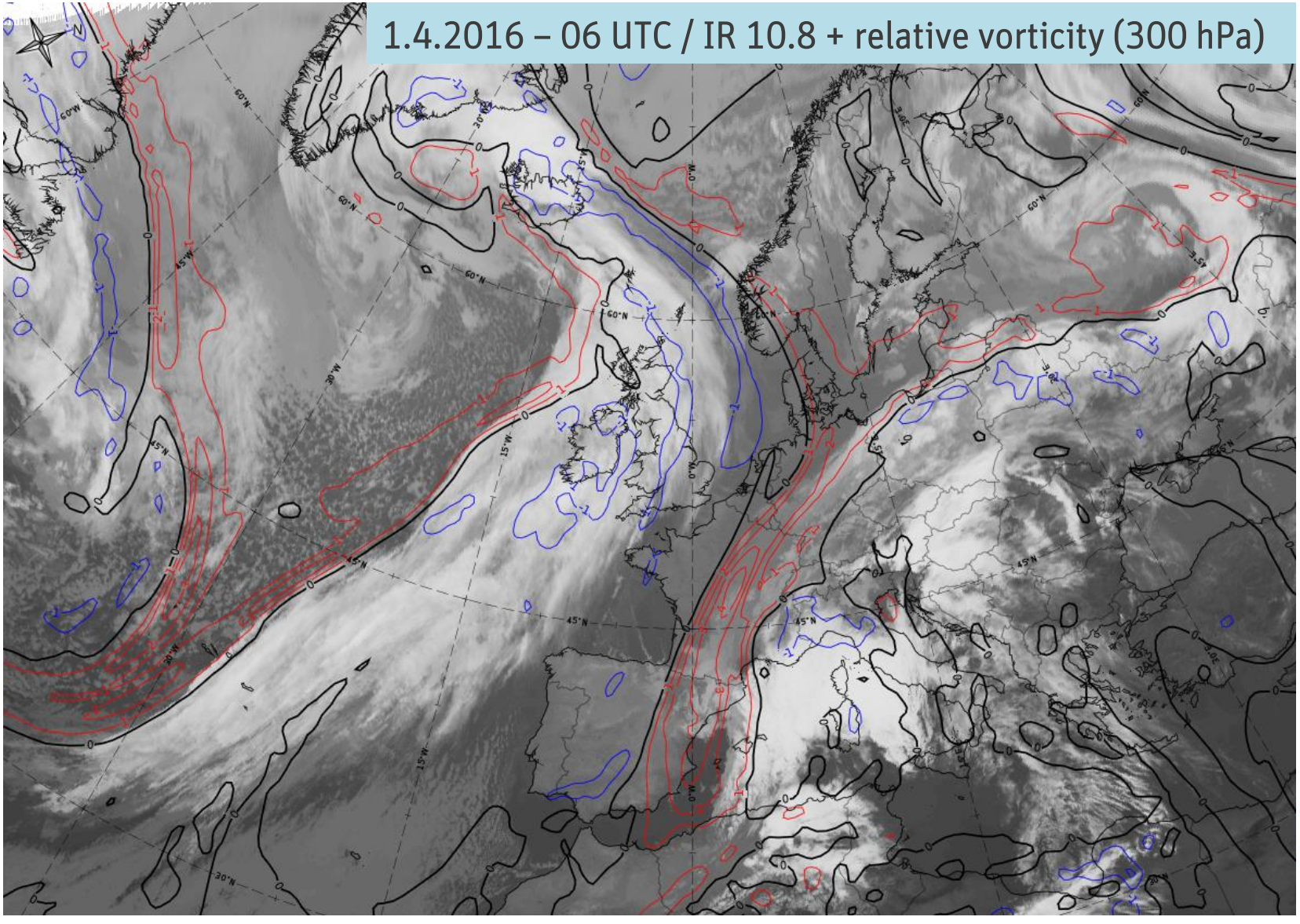
Front Intensification by Jet Crossing



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Intensification by Jet Crossing

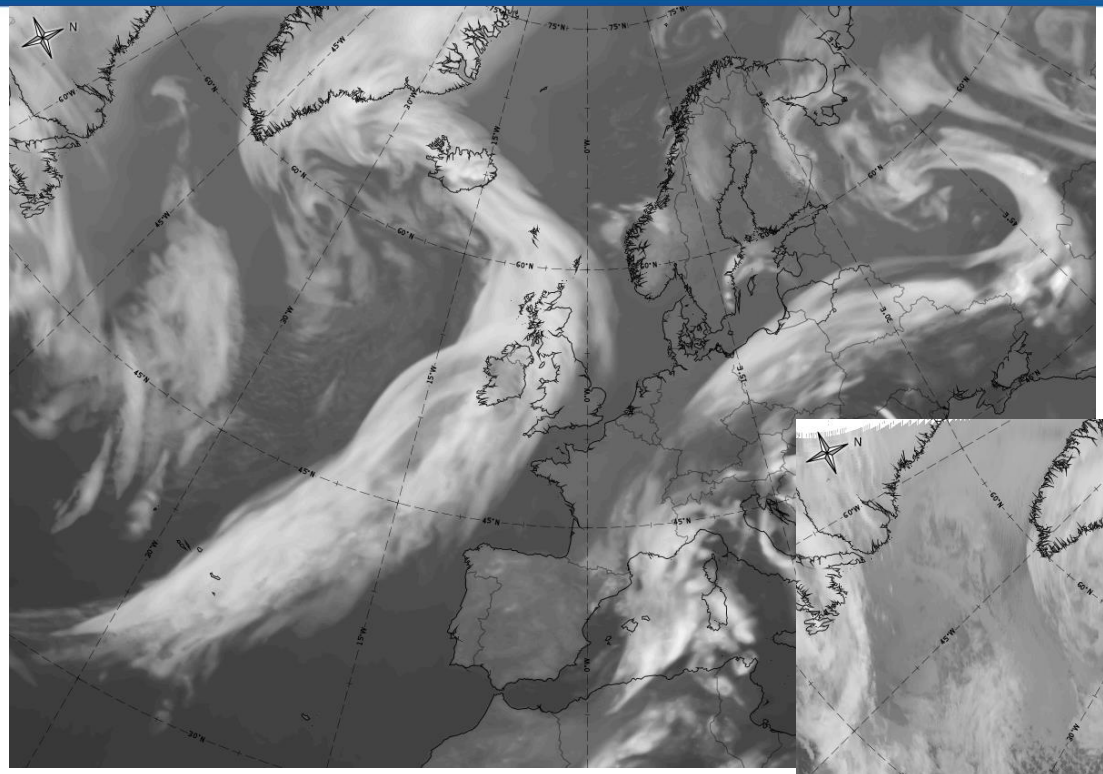
1.4.2016 – 06 UTC / IR 10.8 + relative vorticity (300 hPa)



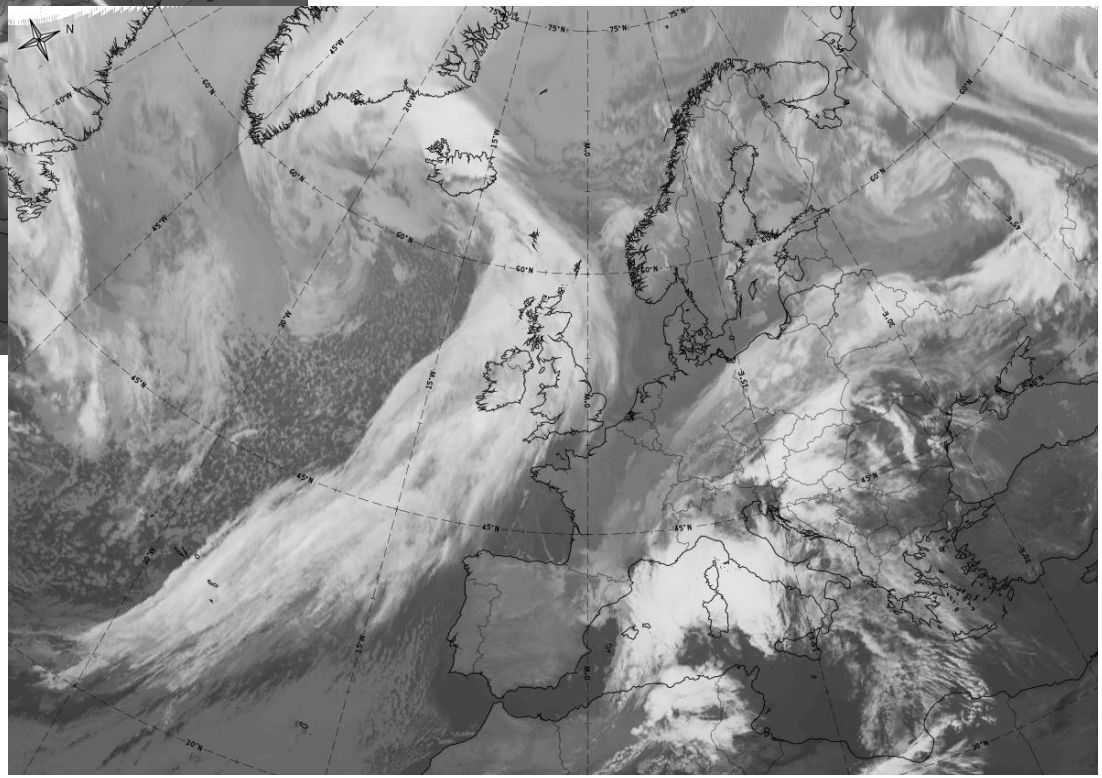
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Intensification by Jet Crossing

1.4.2016 – 00 UTC

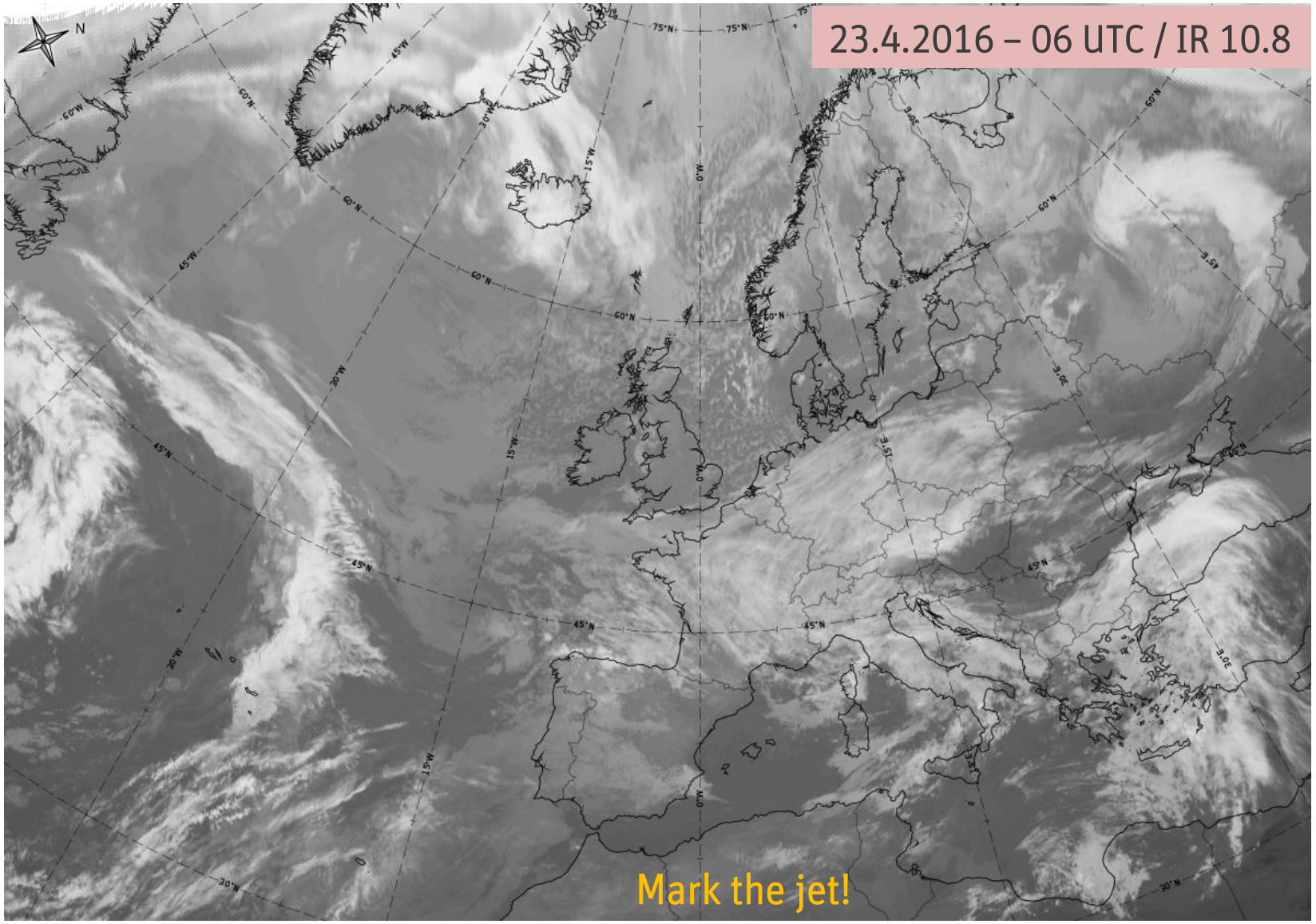


← simulated IR 10.8



real IR 10.8 →

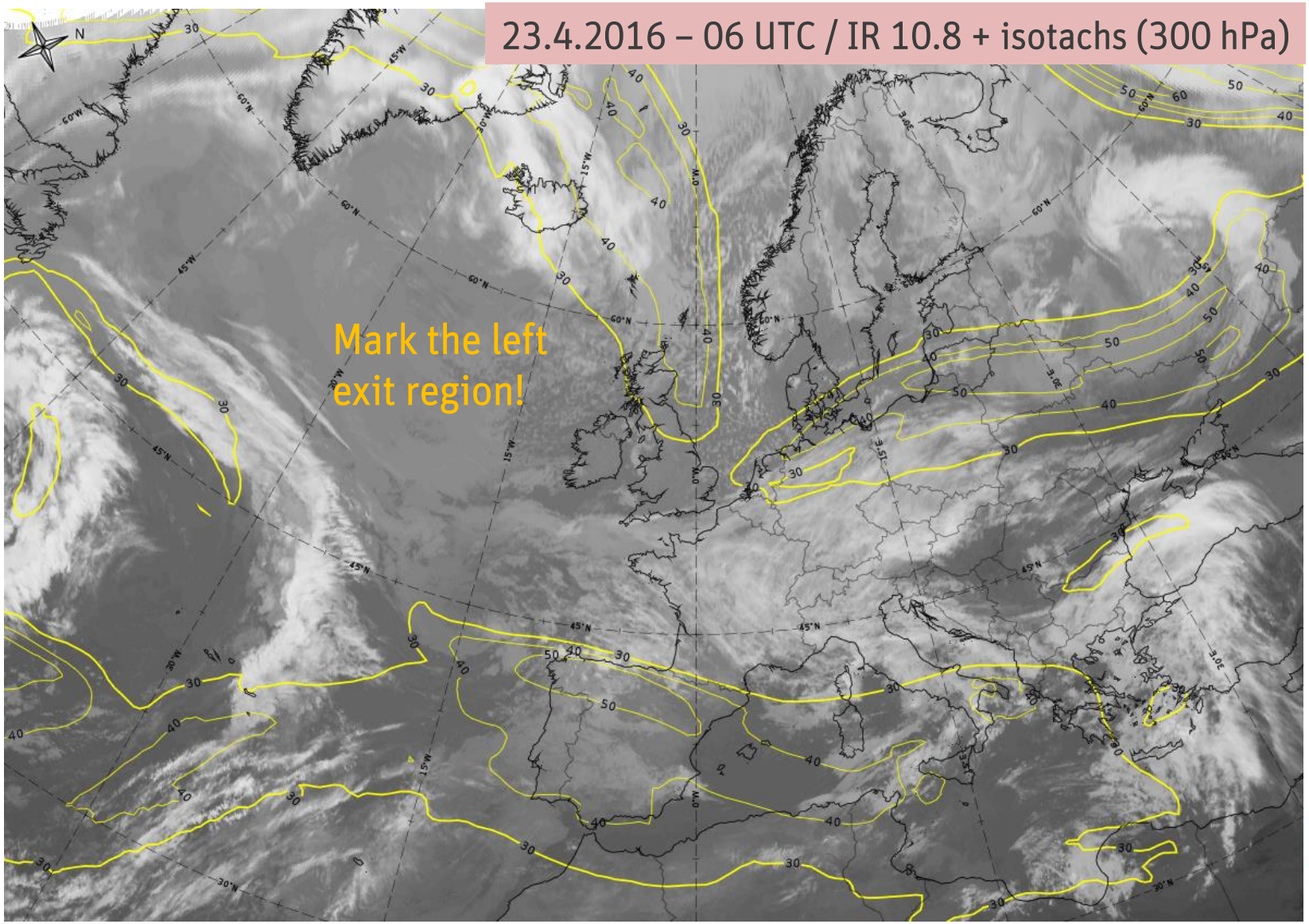
Front Intensification by Jet Crossing



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

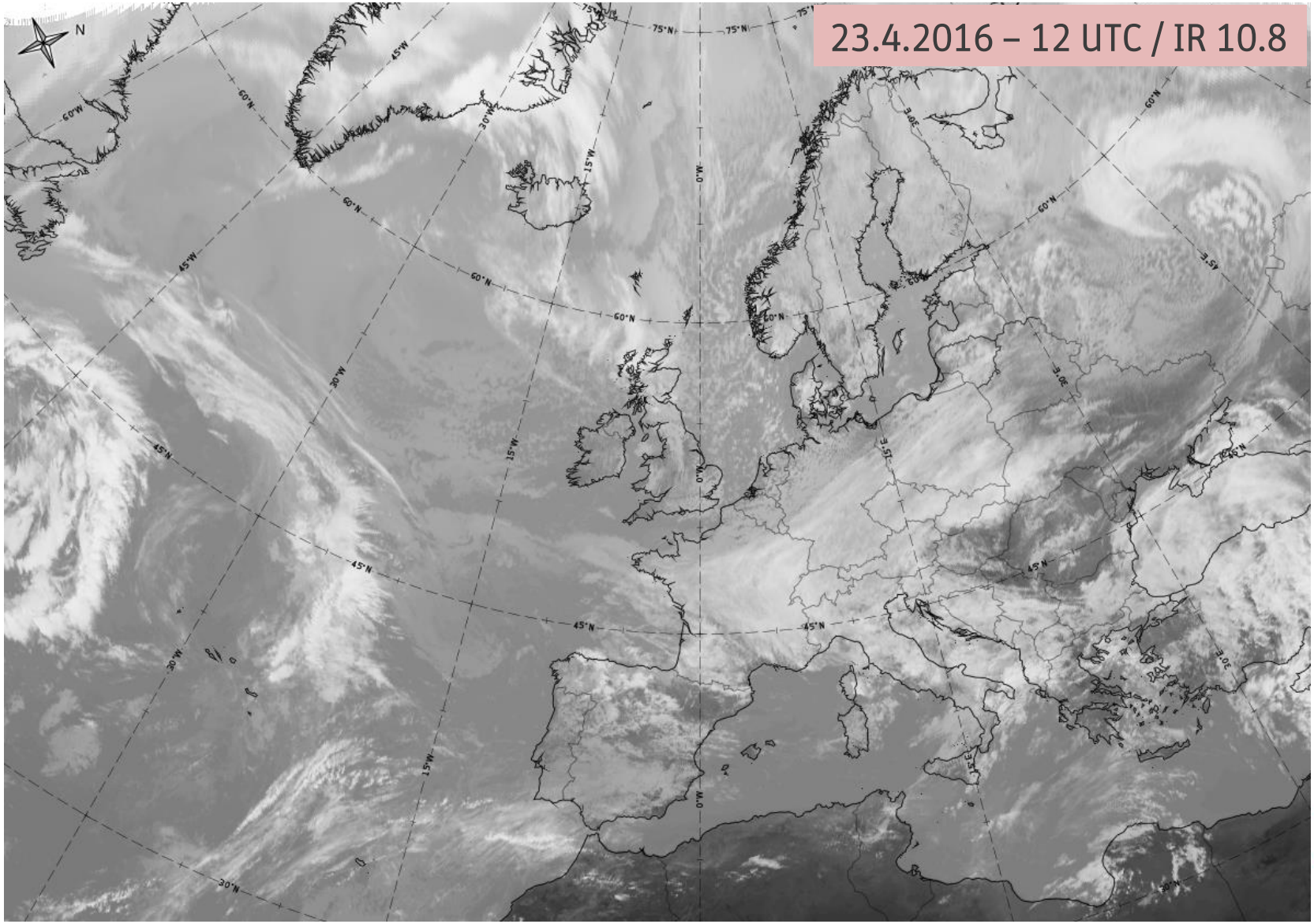
Front Intensification by Jet Crossing

23.4.2016 – 06 UTC / IR 10.8 + isotachs (300 hPa)



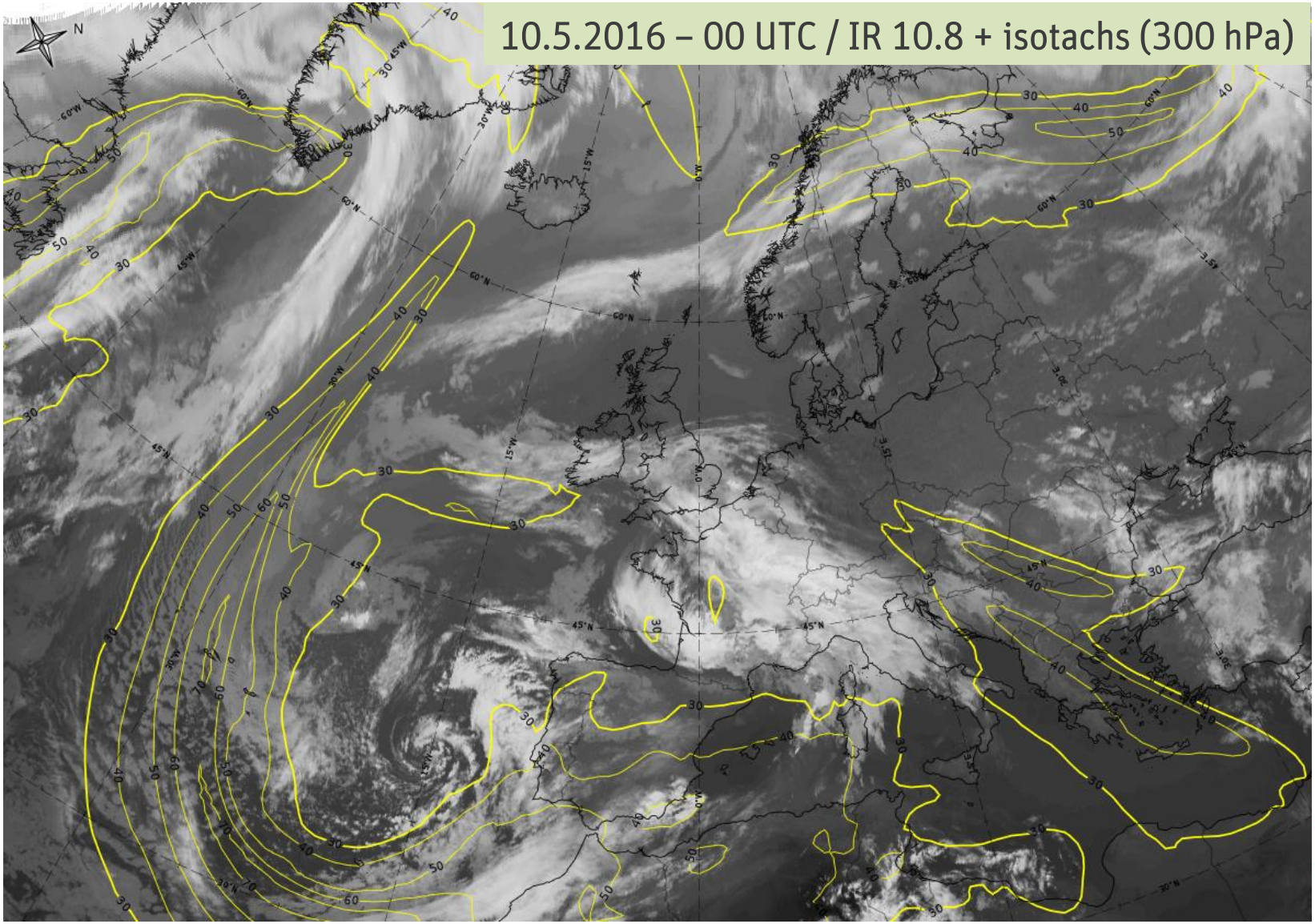
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Intensification by Jet Crossing



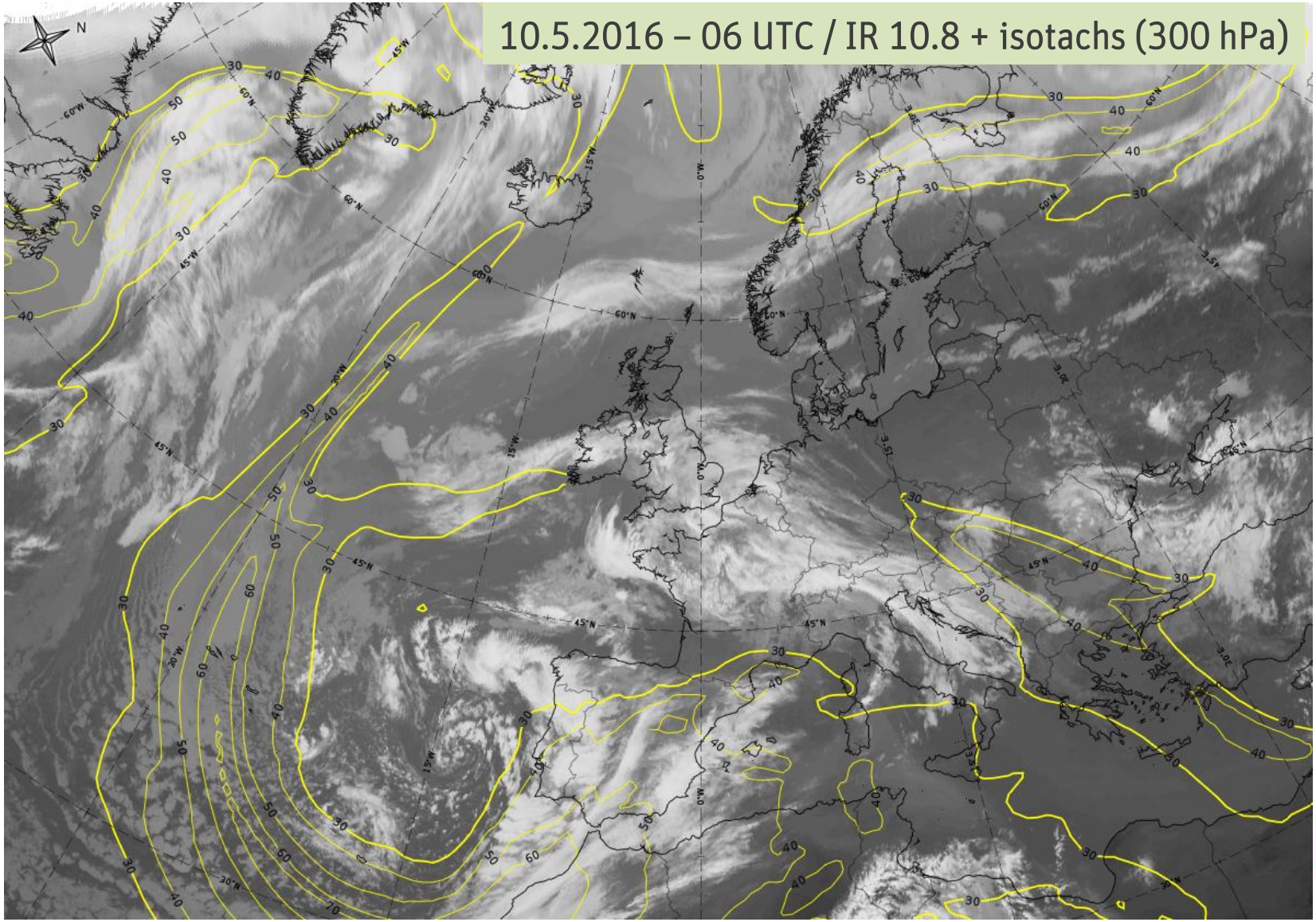
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Intensification by Jet Crossing



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Intensification by Jet Crossing

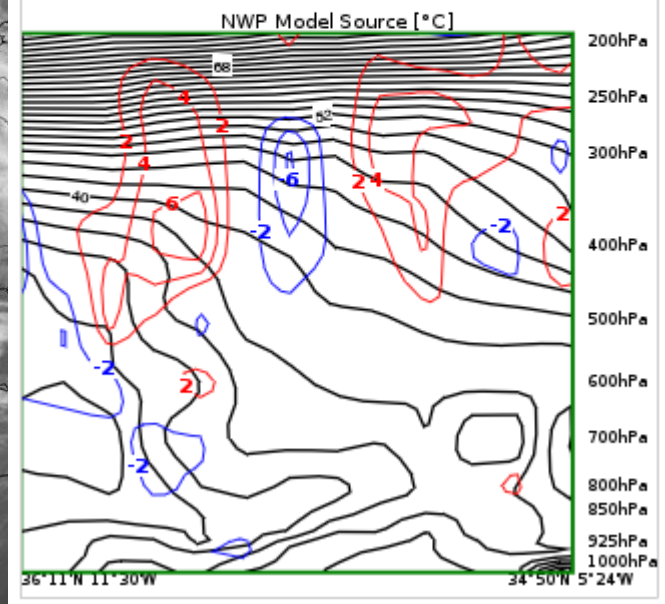


ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Intensification by Jet Crossing

10.5.2016 – 06 UTC / IR 10.8

What parameter can you see here apart from the potential temperature?



?

Omega

temp.-advection

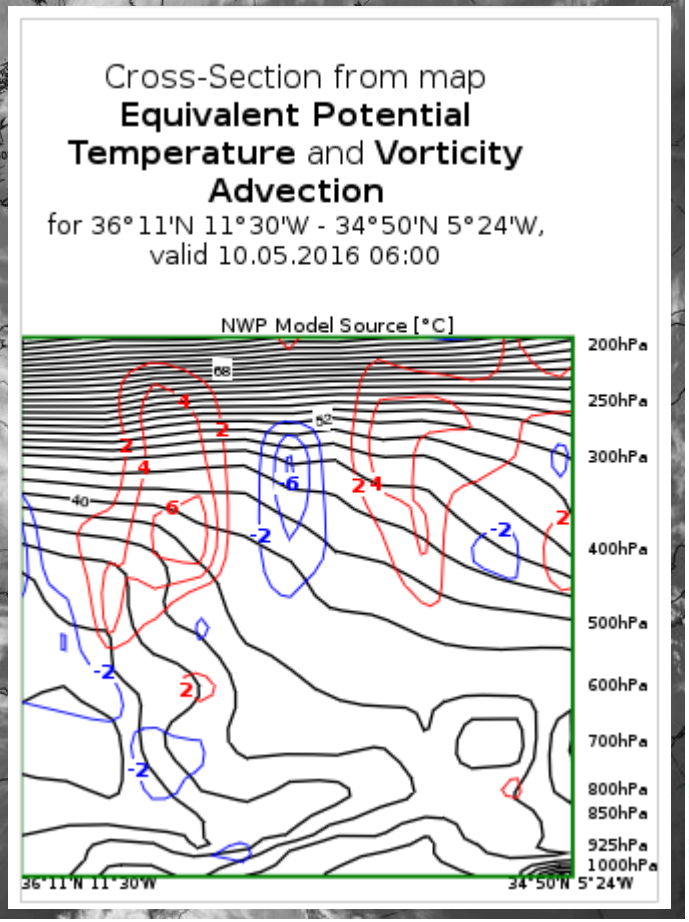
vorticity-advection

convergence/divergence

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

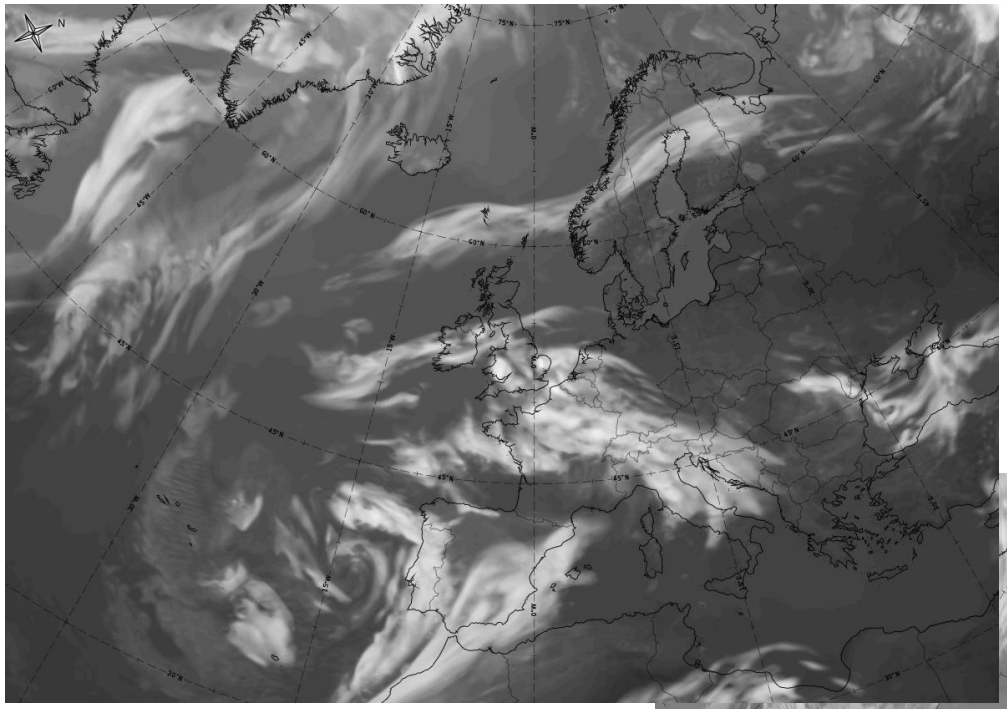
Front Intensification by Jet Crossing

10.5.2016 – 06 UTC / IR 10.8



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

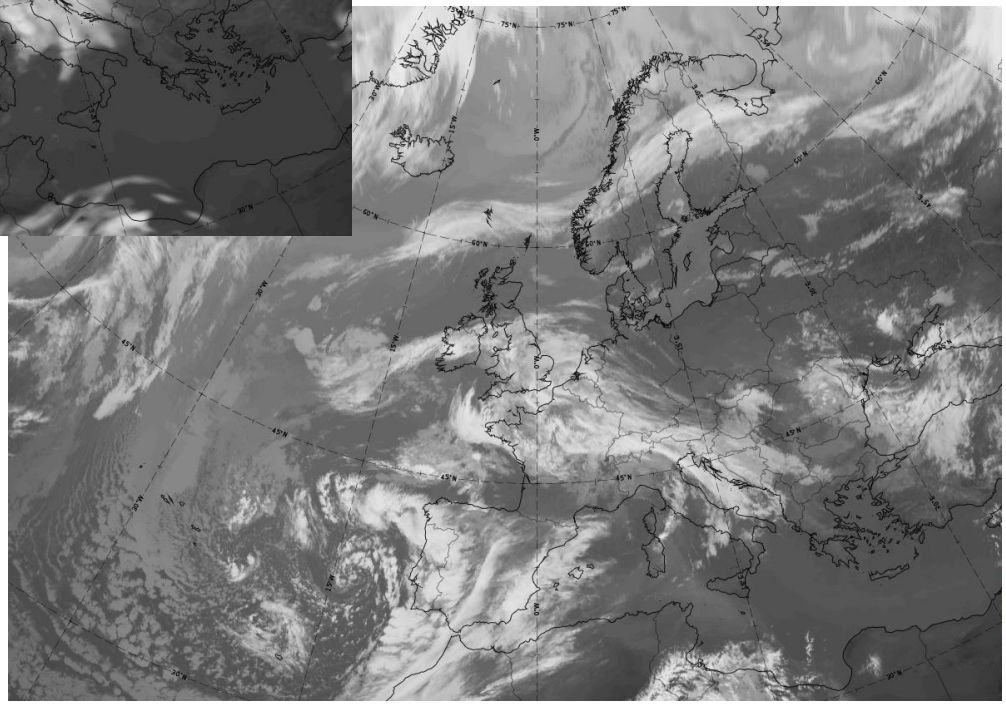
Front Intensification by Jet Crossing



10.5.2016 – 06 UTC

← simulated IR 10.8

real IR 10.8 →



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Front Intensification by Jet Crossing

Summary:

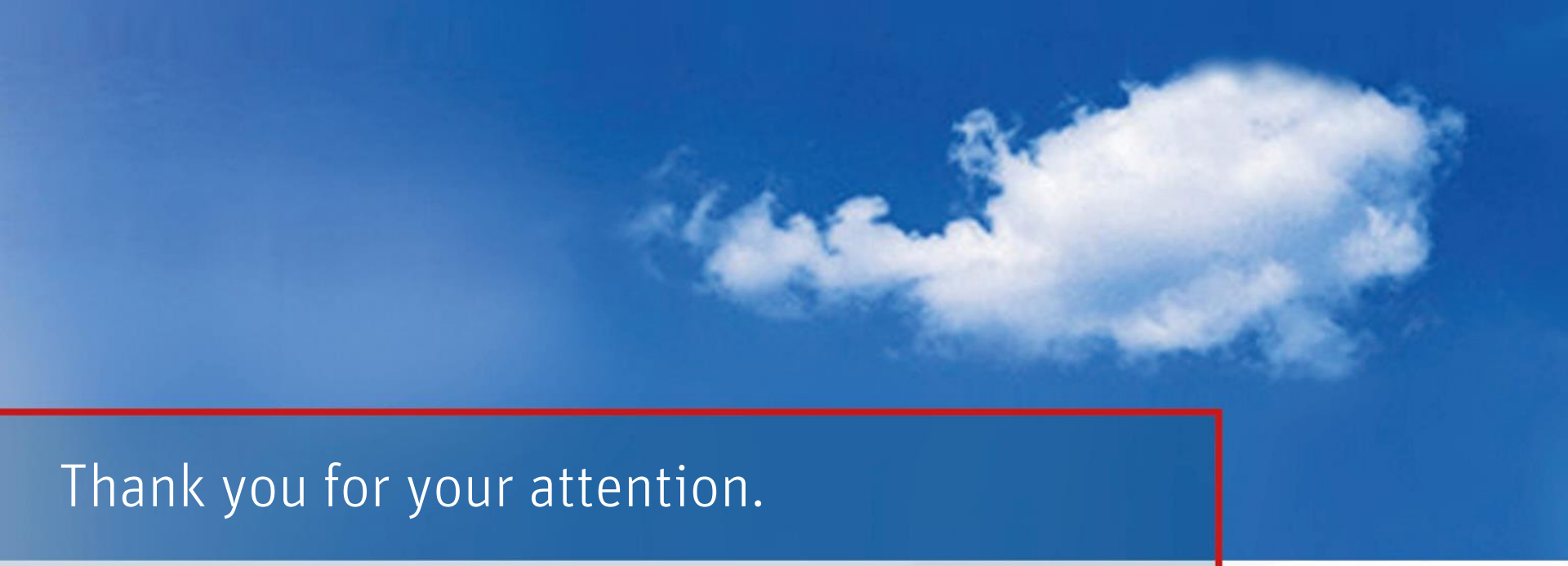
- (cold) frontal cloudiness in the left exit region gets thicker and/or more convective due to positive vorticity advection

- also waves, enhanced cumuli or comma features can develop

- models might not always predict these developements correctly

- Watch out for:
  left exit regions / pva

ZAMG
Zentralanstalt für Meteorologie und Geodynamik



Thank you for your attention.

Any questions?

ZAMG
Zentralanstalt für
Meteorologie und
Geodynamik