

Zentralanstalt für Meteorologie und Geodynamik



Frontal Substructures

Synoptic and Mesoscale Analysis
Satellite Meteorology

9. October 2014

MAIN INDEX

BASICS

CONCEPTUAL
MODELS

SHORT
VERSIONS

EXERCISES

CASE STUDIES

CATASTROPHIC
WEATHER
EVENTS

GLOSSARY

ABBREVIATIONS

UNITS OF KEY
PARAMETERS

PRACTICAL
INFORMATION

- Instant Occlusion
- Occlusion: Cold Conveyor Belt Type
- Occlusion: Warm Conveyor Belt Type
- **BAROCLINIC BOUNDARY**
 - Baroclinic Boundary
- **SUBSTRUCTURES IN FRONTS AND INITIAL STAGES OF CYCLOGENESIS**
 - Front Decay
 - Front Intensification by Jet Crossing
 - Rapid Cyclogenesis
 - Secondary Low Centres in Occlusion Cloud Bands
 - Upper Wave
 - Wave
- **NON-FRONTAL SYNOPTIC SCALE PHENOMENA**
 - Deformation Band
 - Thickness Ridge Cloudiness
 - Upper Level Low
 - Warm Conveyor Belt



MAIN INDEX

BASICS

CONCEPTUAL
MODELS

SHORT
VERSIONS

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CASE STUDIES

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 - Wave
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CONCEPTUAL
MODELS

SHORT
VERSIONS

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 - Front Decay
 - Front Intensification by Jet Crossing
 - Rapid Cyclogenesis → 14 and 16 October
 - Secondary Low Centres in Occlusion Cloud Bands
 - Upper Wave
 - Wave
- **NON-FRONTAL SYNOPTIC SCALE PHENOMENA**
 - Deformation Band
 - Thickness Ridge Cloudiness
 - Upper Level Low
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MAIN INDEX

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CONCEPTUAL
MODELS

SHORT
VERSIONS

EXERCISES

CASE STUDIES

CATASTROPHIC
WEATHER
EVENTS

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 - Front Decay
 - Front Intensification by Jet Crossing
 - **Rapid Cyclogenesis** → 14 and 16 October
 - Secondary Low Centres in Occlusion Cloud Bands
 - Upper Wave
 - **Wave**
- **NON-FRONTAL SYNOPTIC SCALE PHENOMENA**
 - Deformation Band
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MAIN INDEX

BASICS

CONCEPTUAL
MODELS

SHORT
VERSIONS

EXERCISES

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WEATHER
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 - Front Decay
 - Front Intensification by Jet Crossing
 - Rapid Cyclogenesis
 - Secondary Low Centres in Occlusion Cloud Bands
 - Upper Wave
 - Wave
- **NON-FRONTAL SYNOPTIC SCALE PHENOMENA**
 - Deformation Band
 - Thickness Ridge Cloudiness
 - Upper Level Low
 - Warm Conveyor Belt



MAIN INDEX

BASICS

CONCEPTUAL
MODELS

SHORT
VERSIONS

EXERCISES

CASE STUDIES

CATASTROPHIC
WEATHER
EVENTS

GLOSSARY

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Front Intensification by crossing Jet Streak (a.k.a. FI by Jet)

(Präsentation)
12.11.2014 Folie 8

- What are we looking for in satellite imagery?
- Impact on weather events
- Meteorological Physical Background

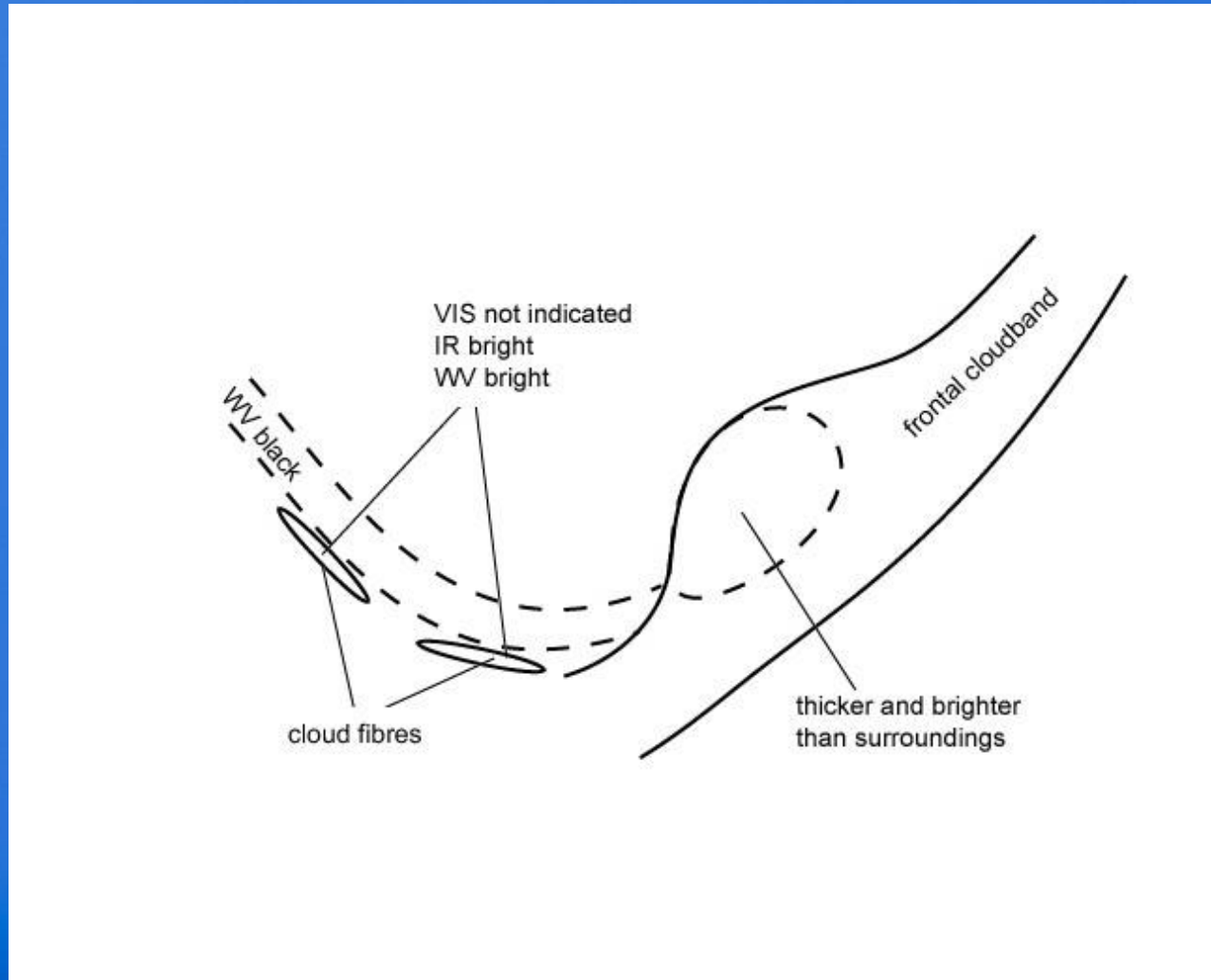


Key Parameters



Appearance in IR imagery

(Präsentation)
12.11.2014 Folie 9



FI by Jet - Appearance in IR imagery

(Präsentation)
12.11.2014 Folie 10

Front Intensifications can be found:

- at the rear side of a cold front
- near the occlusion point (most common place)



Often left exit regions lead to cloud formation in trough regions.

- Comma cloud formation
- Enhanced cumuli

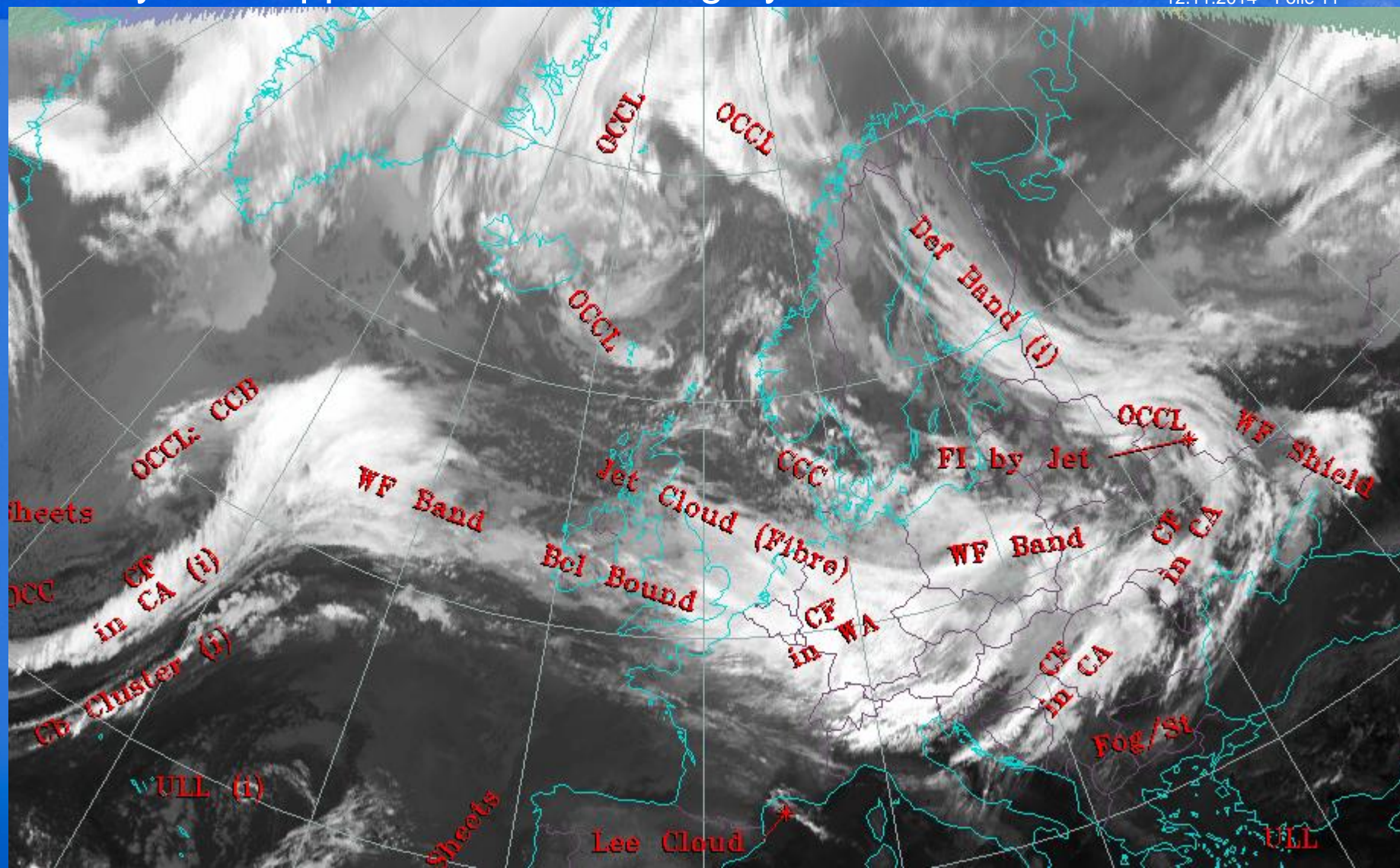


The conceptual model FI by Jet is always linked to interaction of jets with fronts.



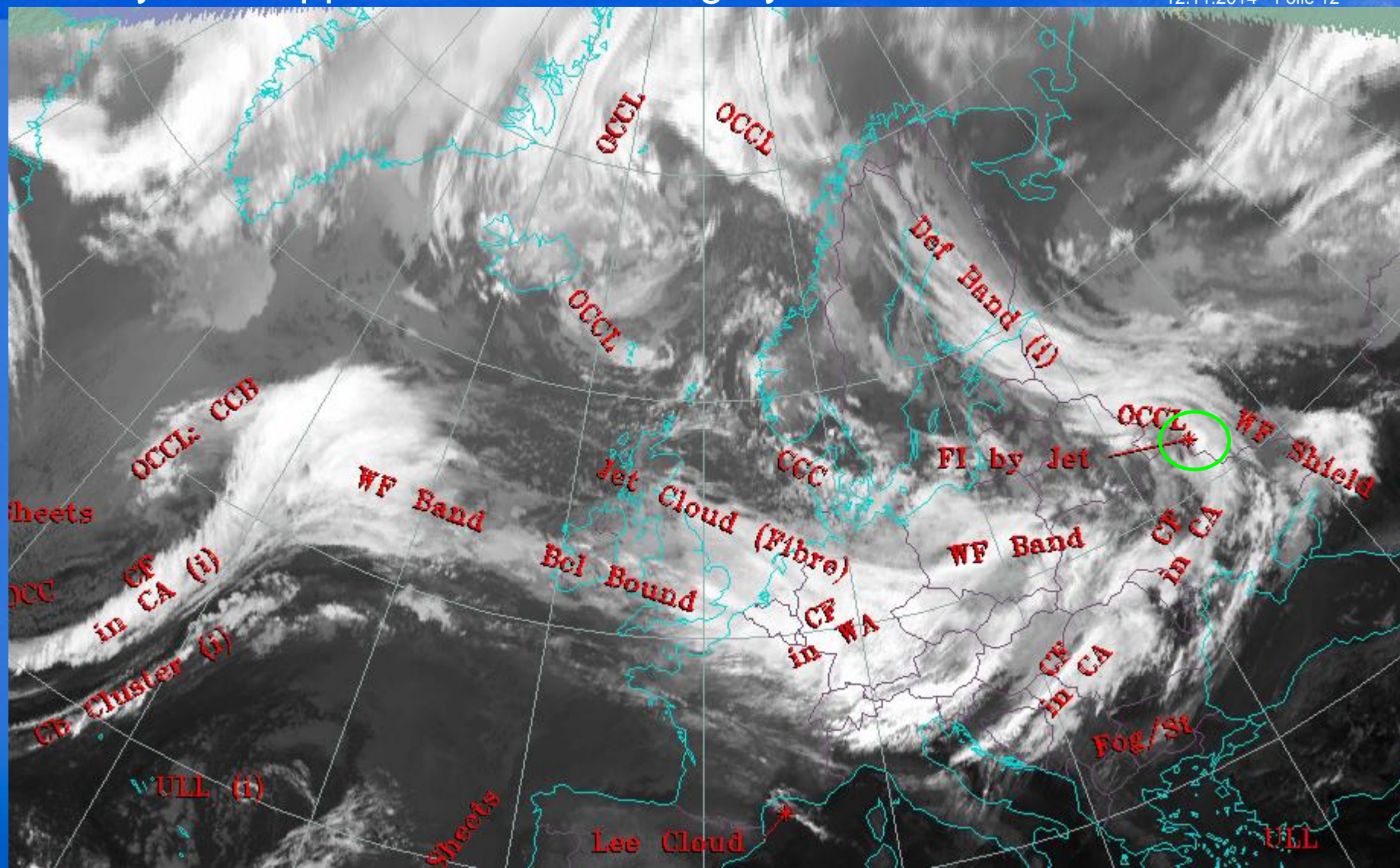
FI by Jet - Appearance in IR imagery

(Präsentation)
12.11.2014 Folie 11



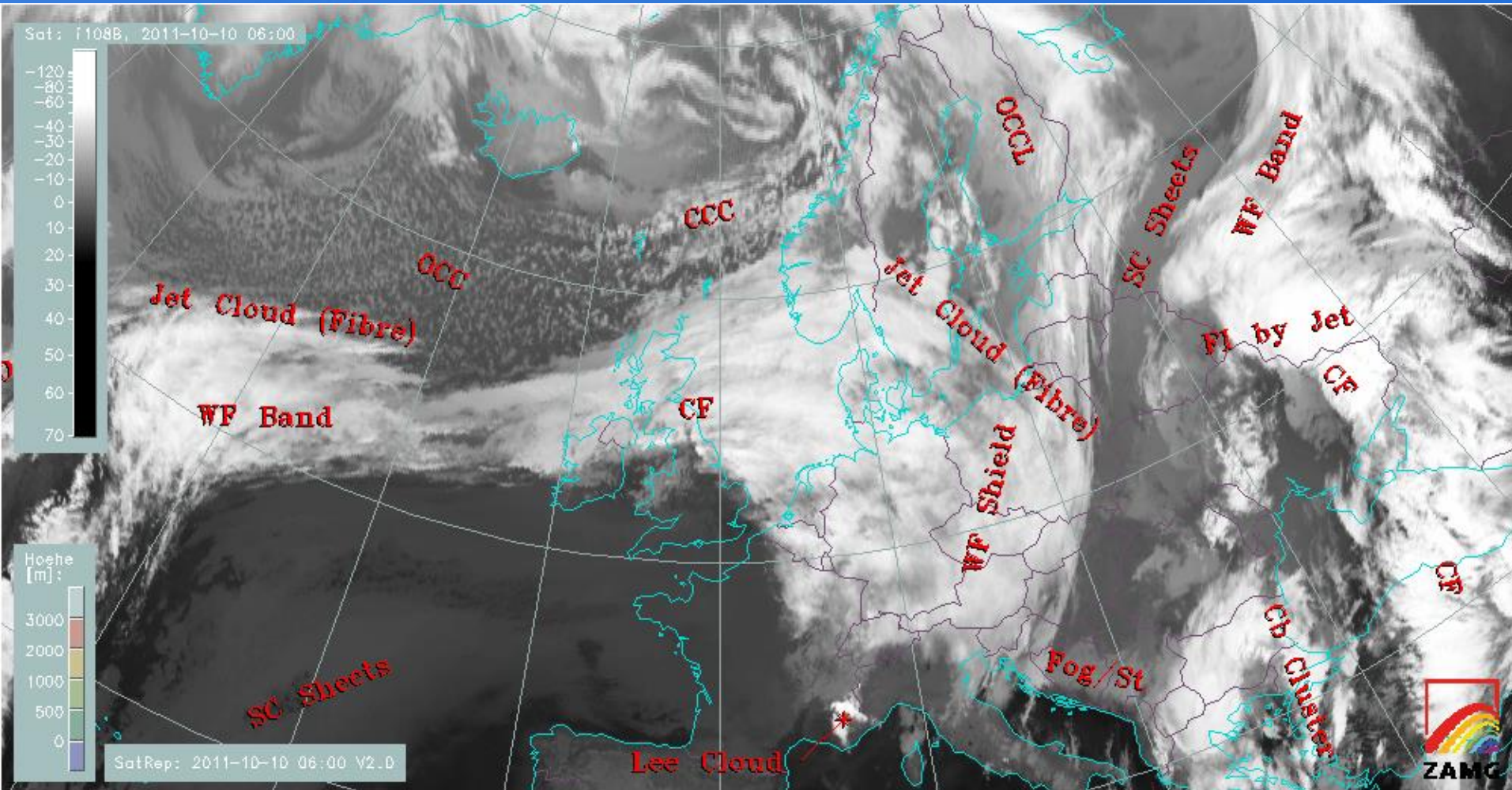
FI by Jet - Appearance in IR imagery

(Präsentation)
12.11.2014 Folie 12



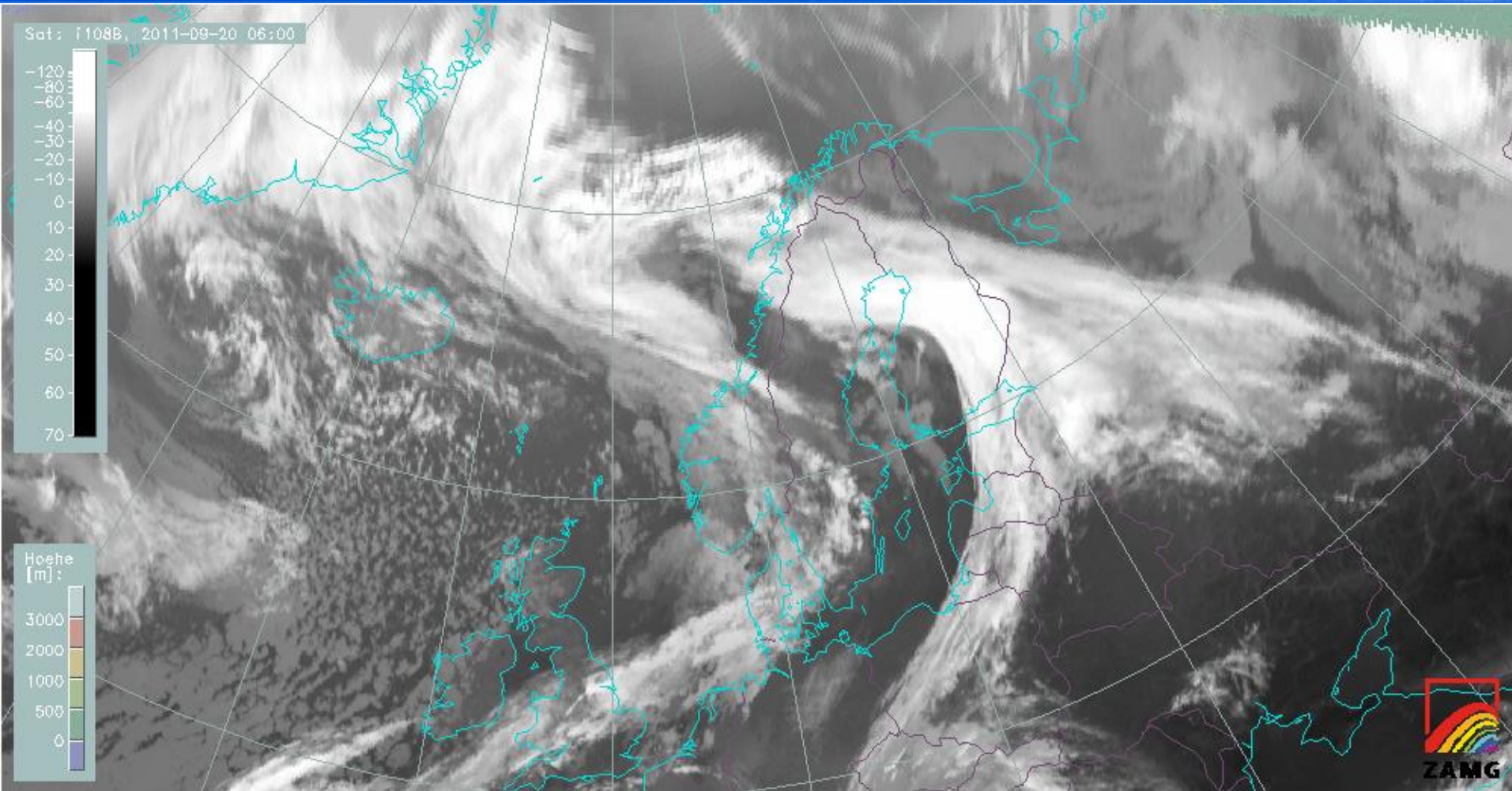
FI by Jet - Appearance in IR imagery

(Präsentation)
12.11.2014 Folie 13



FI by Jet - Appearance in IR imagery

(Präsentation)
12.11.2014 Folie 14

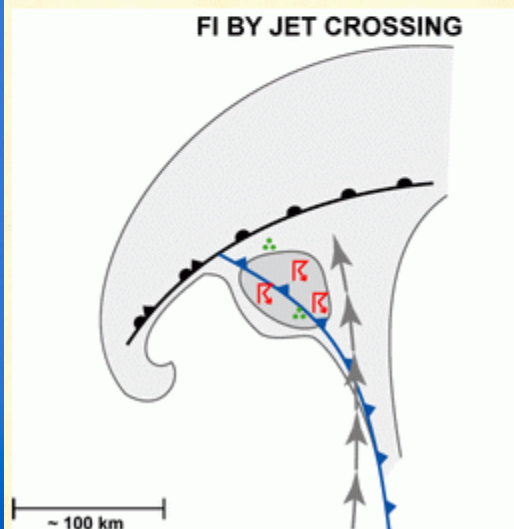


FI by Jet - Impact on weather events

(Präsentation)
12.11.2014 Folie 16

Where there is no orography, cloudiness in middle and high levels dominates with slight to moderate rain or drizzle.

Parameter	Description
Precipitation	<ul style="list-style-type: none">• Intensifying precipitation, embedded Cbs and thunderstorms.• May prolong the rainy period after the passage of the actual frontal precipitation area.
Temperature	<ul style="list-style-type: none">• No significant change.
Wind (incl. gusts)	<ul style="list-style-type: none">• No significant change.
Other relevant information	

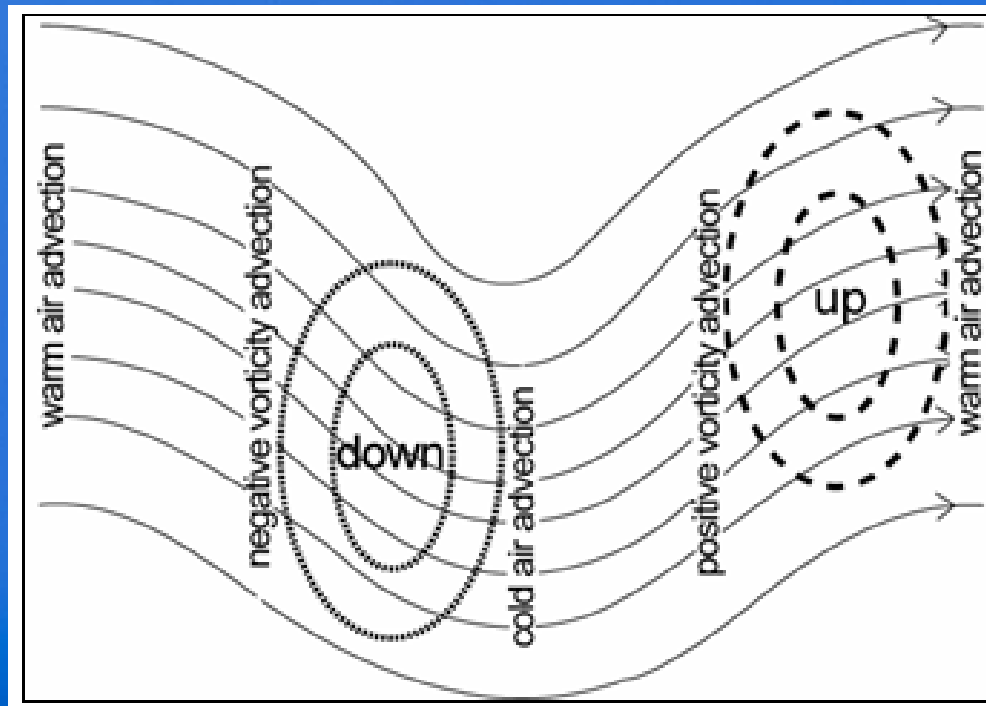


Meteorological Physical Background

(Präsentation)
12.11.2014 Folie 17

Quasi-geostrophic theory ($-\Omega = DVA + TA$) states that vertical motion is primarily forced by:

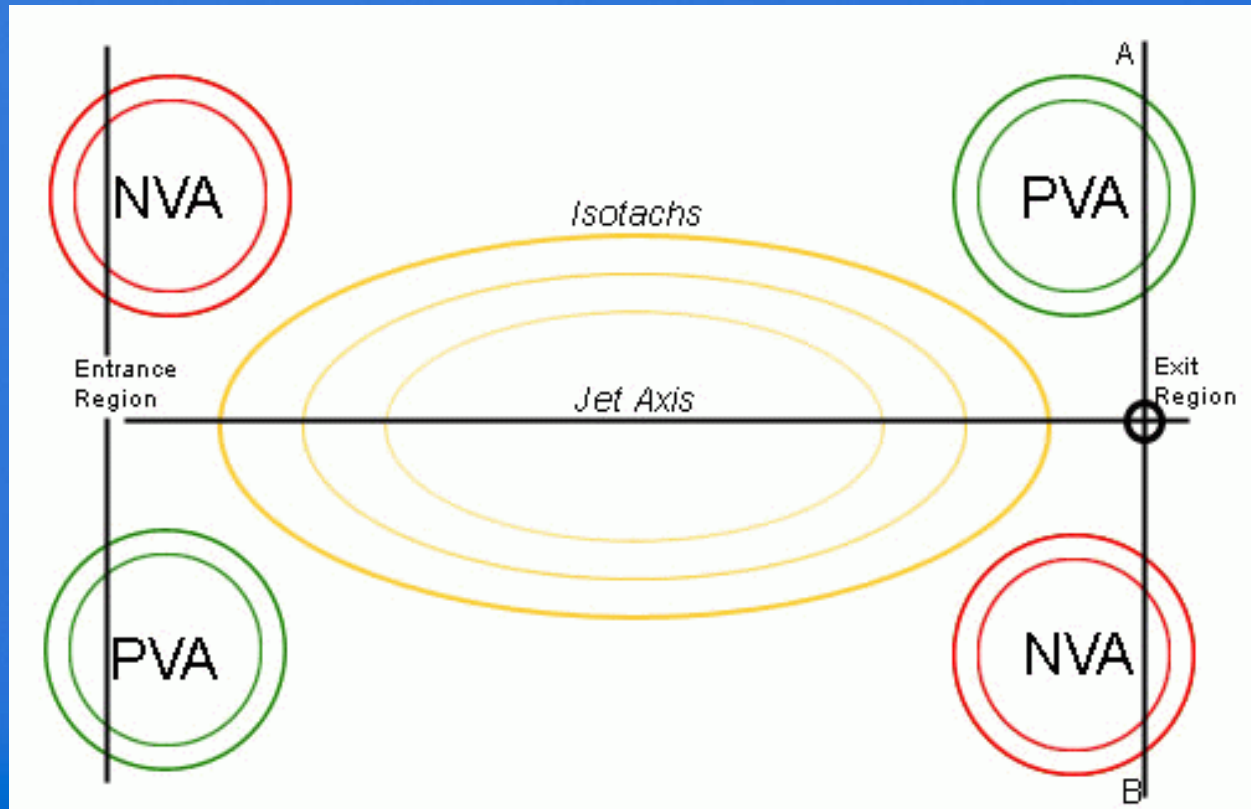
- an increase of vorticity advection with height, and
- warm air advection.



Meteorological Physical Background

(Präsentation)
12.11.2014 Folie 18

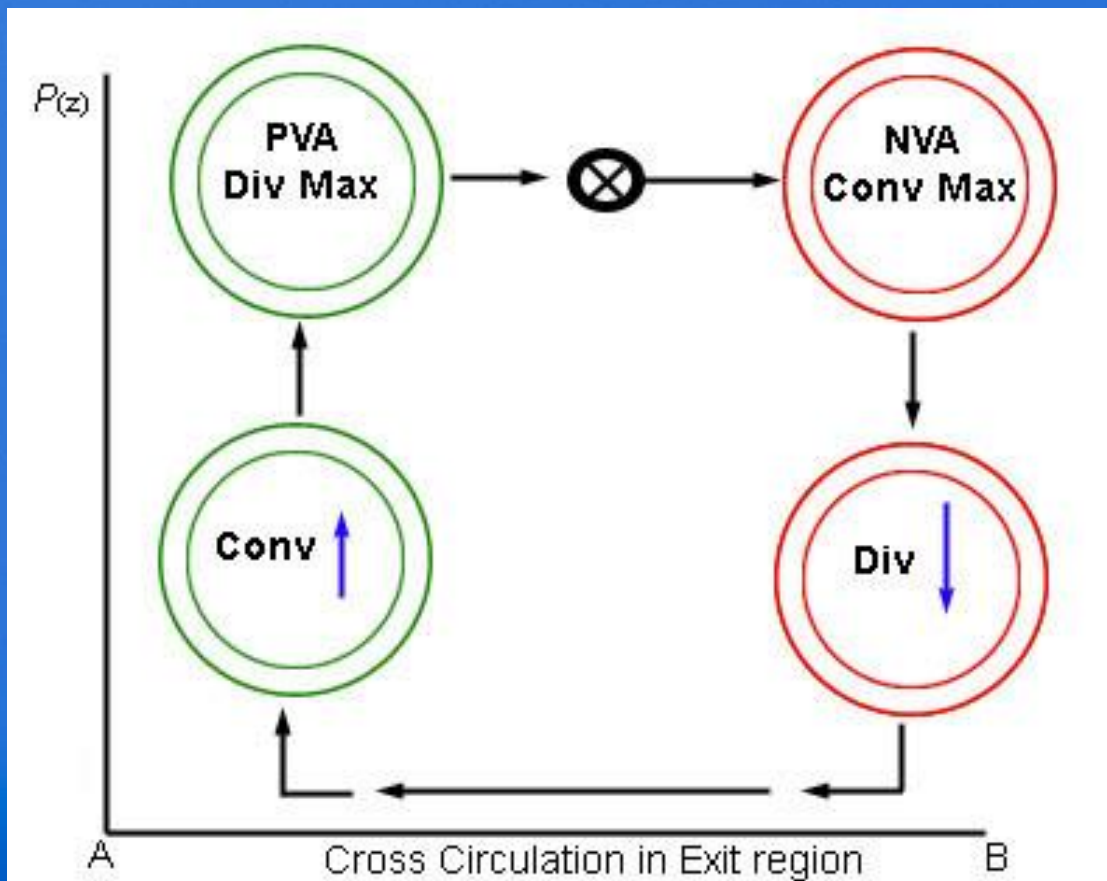
The displacement of the jet streak from west to east leads to the formation of PVA/NVA fields at 300 hPa.



Meteorological Physical Background

(Präsentation)
12.11.2014 Folie 19

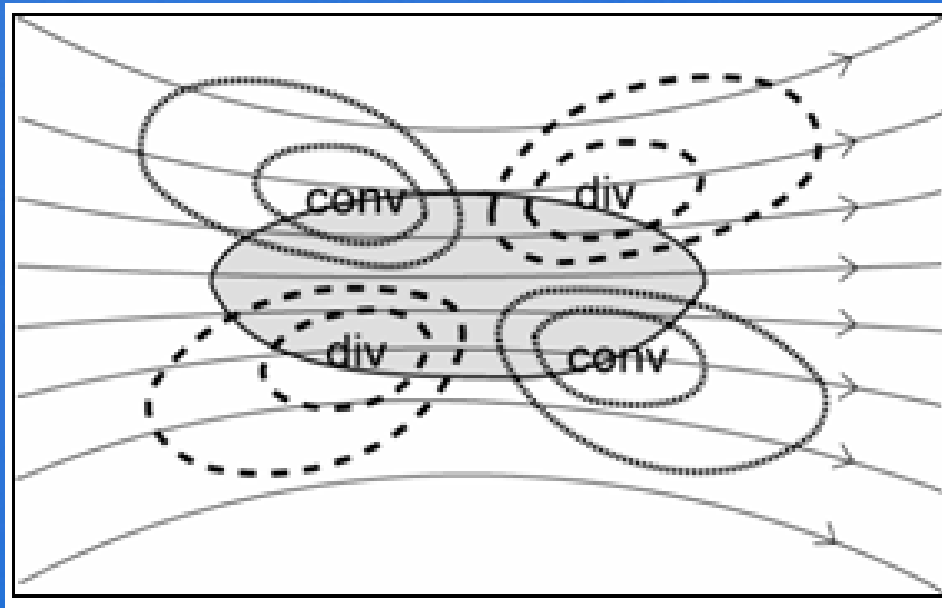
The upper level dynamics induce **divergence** and **convergence** in lower levels.



Meteorological Physical Background

(Präsentation)
12.11.2014 Folie 20

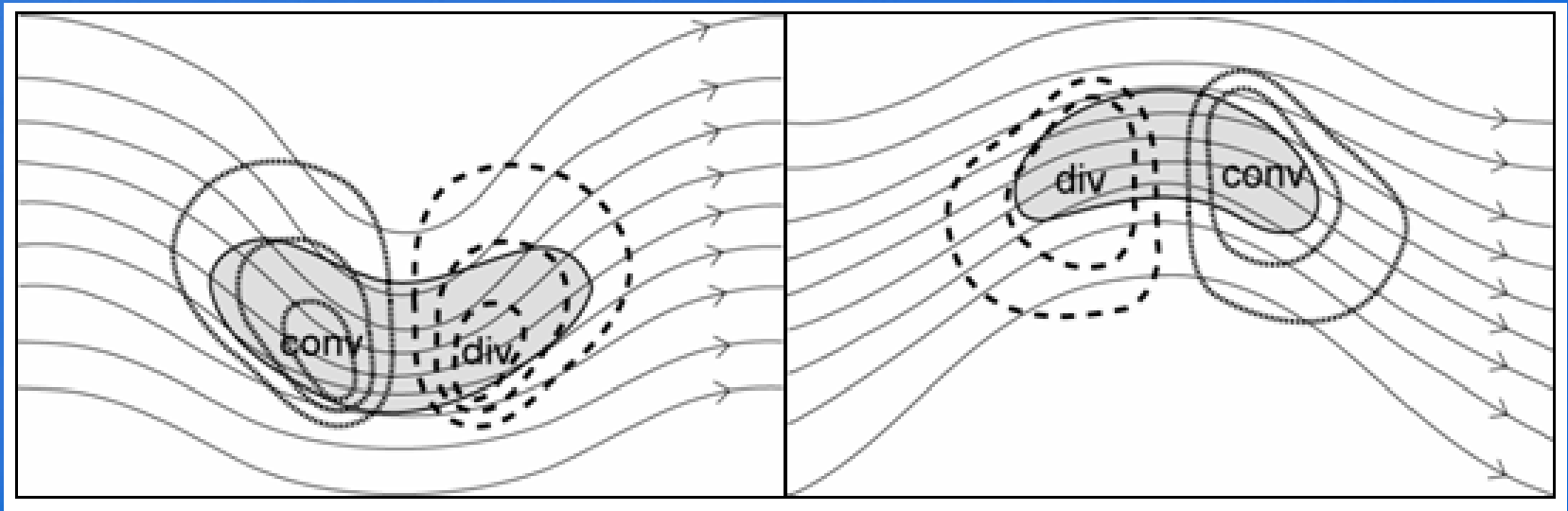
According to the omega equation which states that cyclonic vorticity advection combined with warm air advection fosters the rising of an air mass, we get:



Meteorological Physical Background

(Präsentation)
12.11.2014 Folie 21

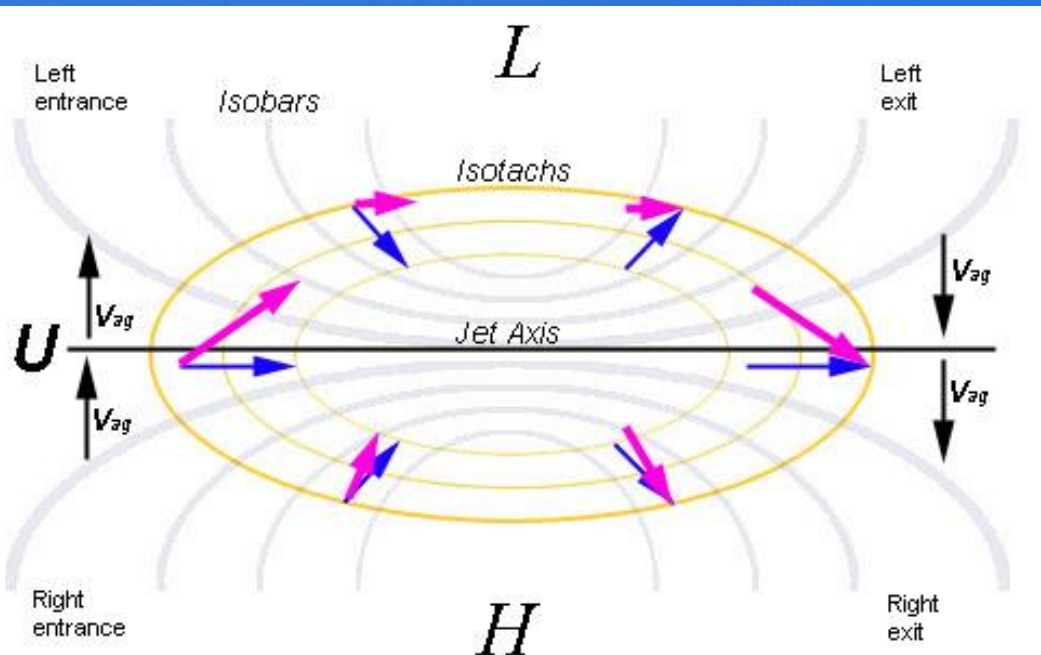
In reality jet streaks are often not straight but may be cyclonically or anticyclonically curved. In the case of a cyclonically-curved jet, divergence tends to be very strong across its entire exit region, while an anticyclonic jet is associated with divergence across its entrance region.



Meteorological Physical Background

(Präsentation)
12.11.2014 Folie 22

Air accelerates within the entrance region as it approaches the core of the jet streak and air decelerates within the exit region as it leaves the core of the jet streak. According to the momentum equations, the ageostrophic wind is perpendicular and to the left of the parcel acceleration vector (in the Northern Hemisphere):



$$\mathbf{V}_{ag} = \frac{1}{f_0} \mathbf{k} \times \frac{d\mathbf{V}}{dt}$$

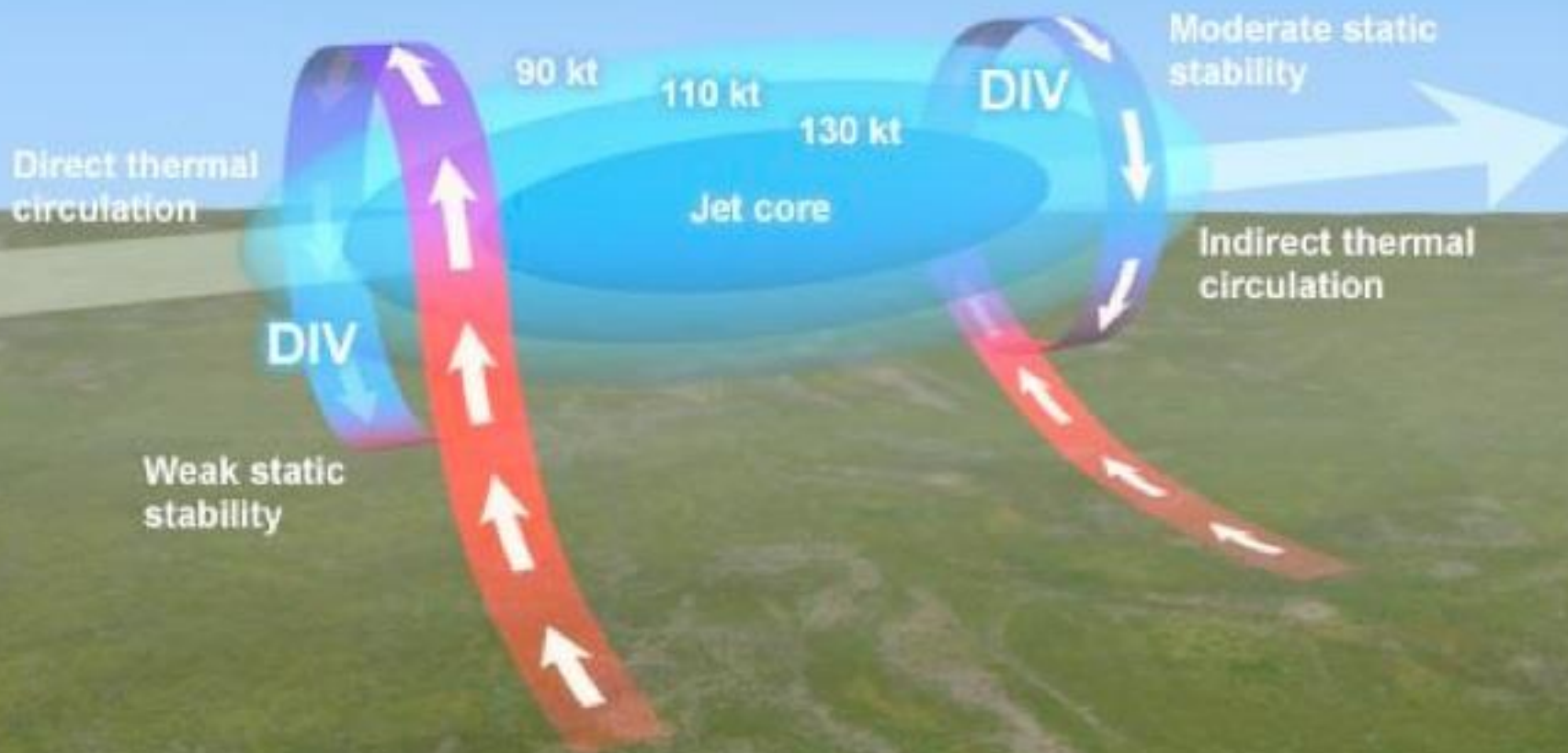
or in component form:

$$\frac{du}{dt} = f v_{ag}$$

$$\frac{dv}{dt} = -f u_{ag}$$



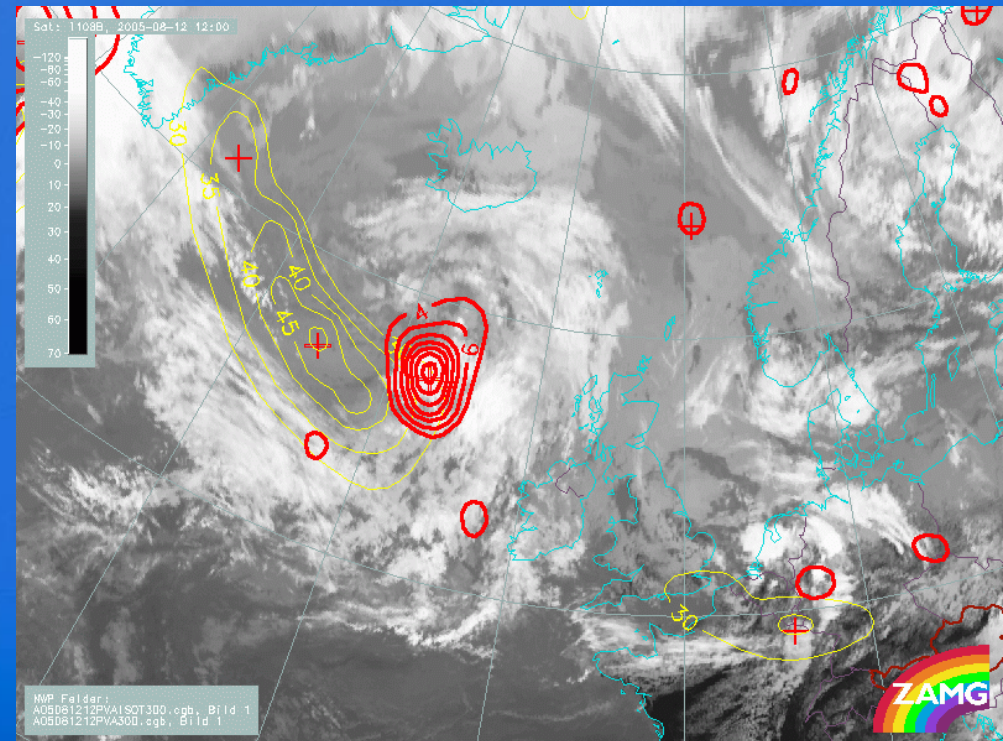
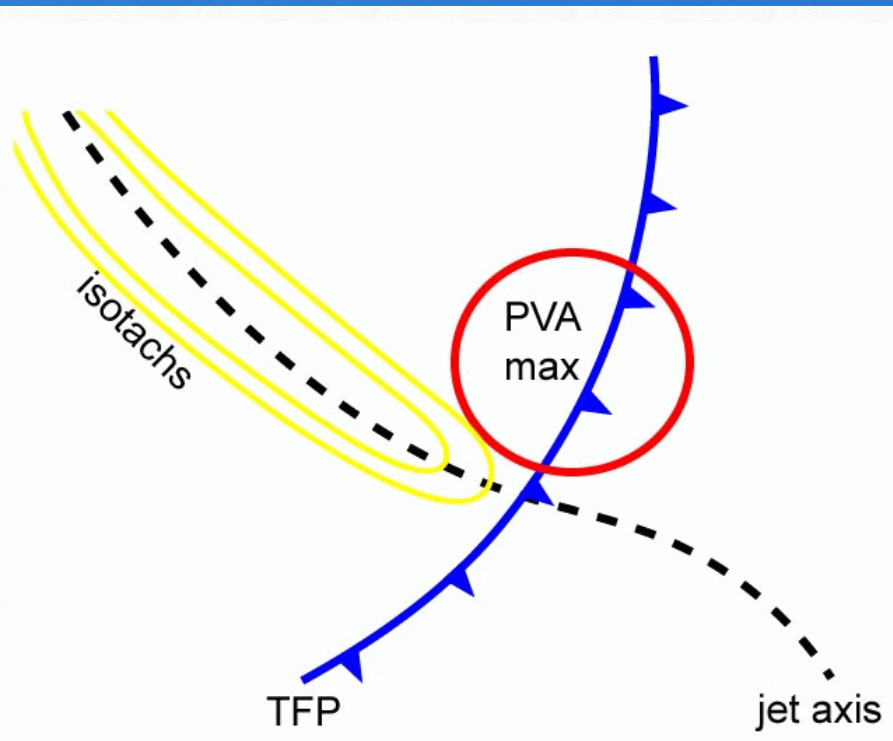
Circulations in the Exit and Entrance Regions of an Upper-Level Jet Streak



FI by Jet - Key Parameters

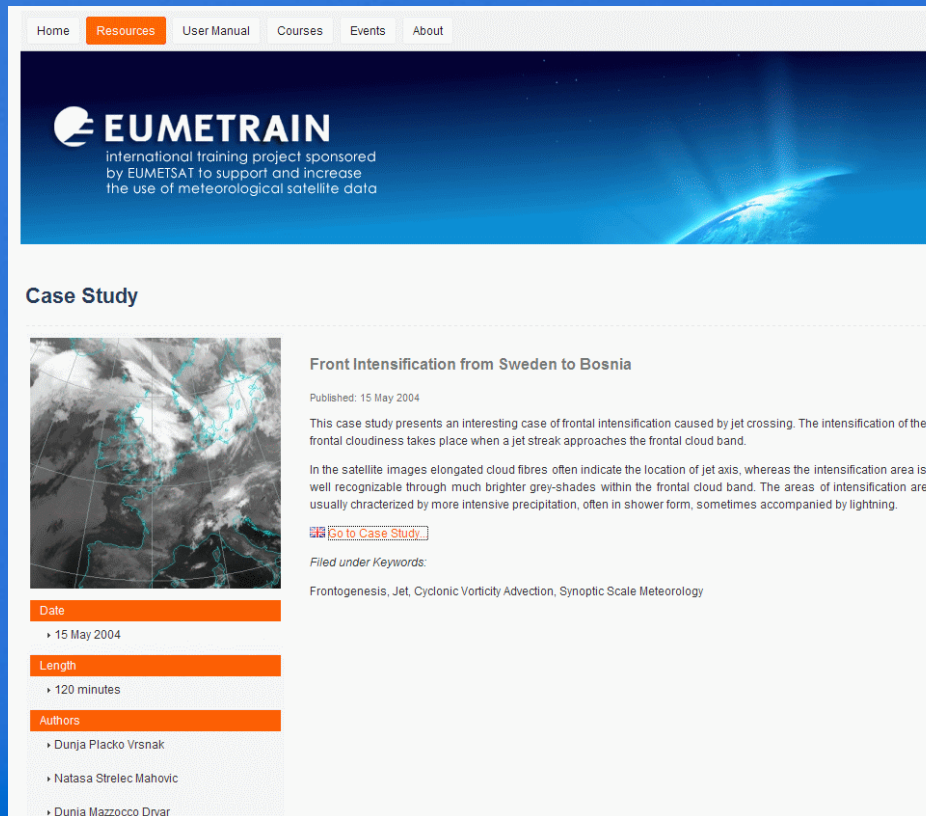
(Präsentation)
12.11.2014 Folie 24

- Isotachs (for the location of the jet streak)
- PVA maximum at jet level (left exit region)
- Shear vorticity



For further study:

http://www.eumetrain.org/resources/front_intensification.html

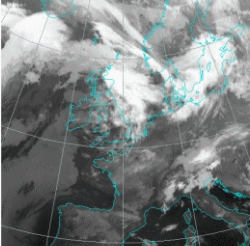


The screenshot shows the EUMETRAIN website interface. At the top, there is a navigation menu with links for Home, Resources (highlighted in orange), User Manual, Courses, Events, and About. Below the menu is a banner for EUMETRAIN, described as an international training project sponsored by EUMETSAT. The main content area features a 'Case Study' section with a satellite image of a weather system over Europe and the Mediterranean. The case study title is 'Front Intensification from Sweden to Bosnia', published on 15 May 2004. The text describes the intensification of frontal cloudiness caused by jet crossing. A 'Go to Case Study' button is provided. Below the text, there are sections for 'Filed under Keywords' (Frontogenesis, Jet, Cyclonic Vorticity Advection, Synoptic Scale Meteorology) and a list of authors: Dunja Placko Vrsnak, Natasa Strelec Mahovic, and Dunja Mazzocco Dvjar.

Home Resources User Manual Courses Events About

EUMETRAIN
international training project sponsored
by EUMETSAT to support and increase
the use of meteorological satellite data

Case Study



Front Intensification from Sweden to Bosnia

Published: 15 May 2004

This case study presents an interesting case of frontal intensification caused by jet crossing. The intensification of the frontal cloudiness takes place when a jet streak approaches the frontal cloud band.

In the satellite images elongated cloud fibres often indicate the location of jet axis, whereas the intensification area is well recognizable through much brighter grey-shades within the frontal cloud band. The areas of intensification are usually characterized by more intensive precipitation, often in shower form, sometimes accompanied by lightning.

[Go to Case Study](#)

Filed under Keywords:
Frontogenesis, Jet, Cyclonic Vorticity Advection, Synoptic Scale Meteorology

Date
› 15 May 2004

Length
› 120 minutes

Authors
› Dunja Placko Vrsnak
› Natasa Strelec Mahovic
› Dunja Mazzocco Dvjar



Front Decay

(Präsentation)
12.11.2014 Folie 26

- Appearance in satellite imagery
- Weather events
- Meteorological physical background

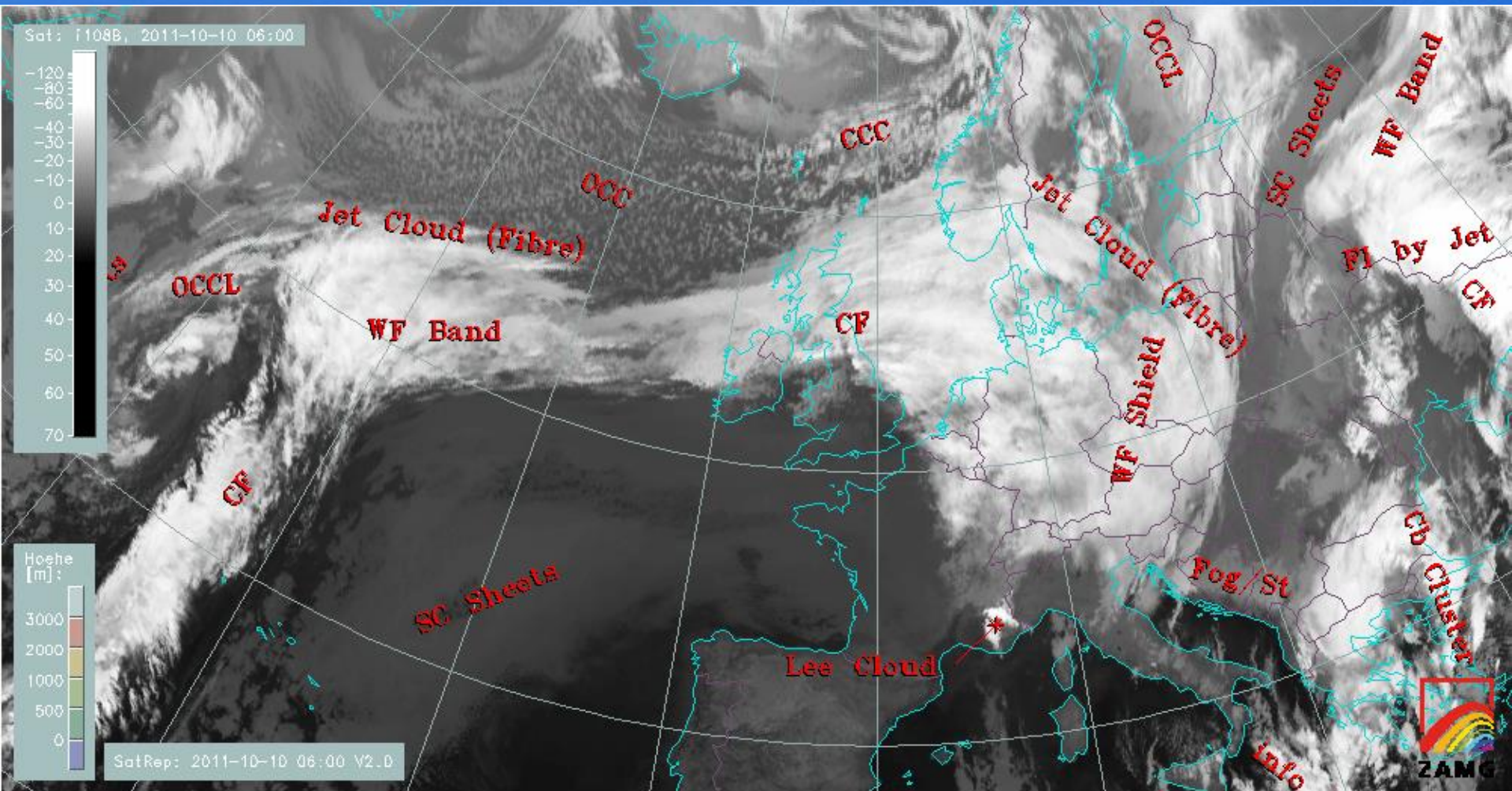


Key Parameters



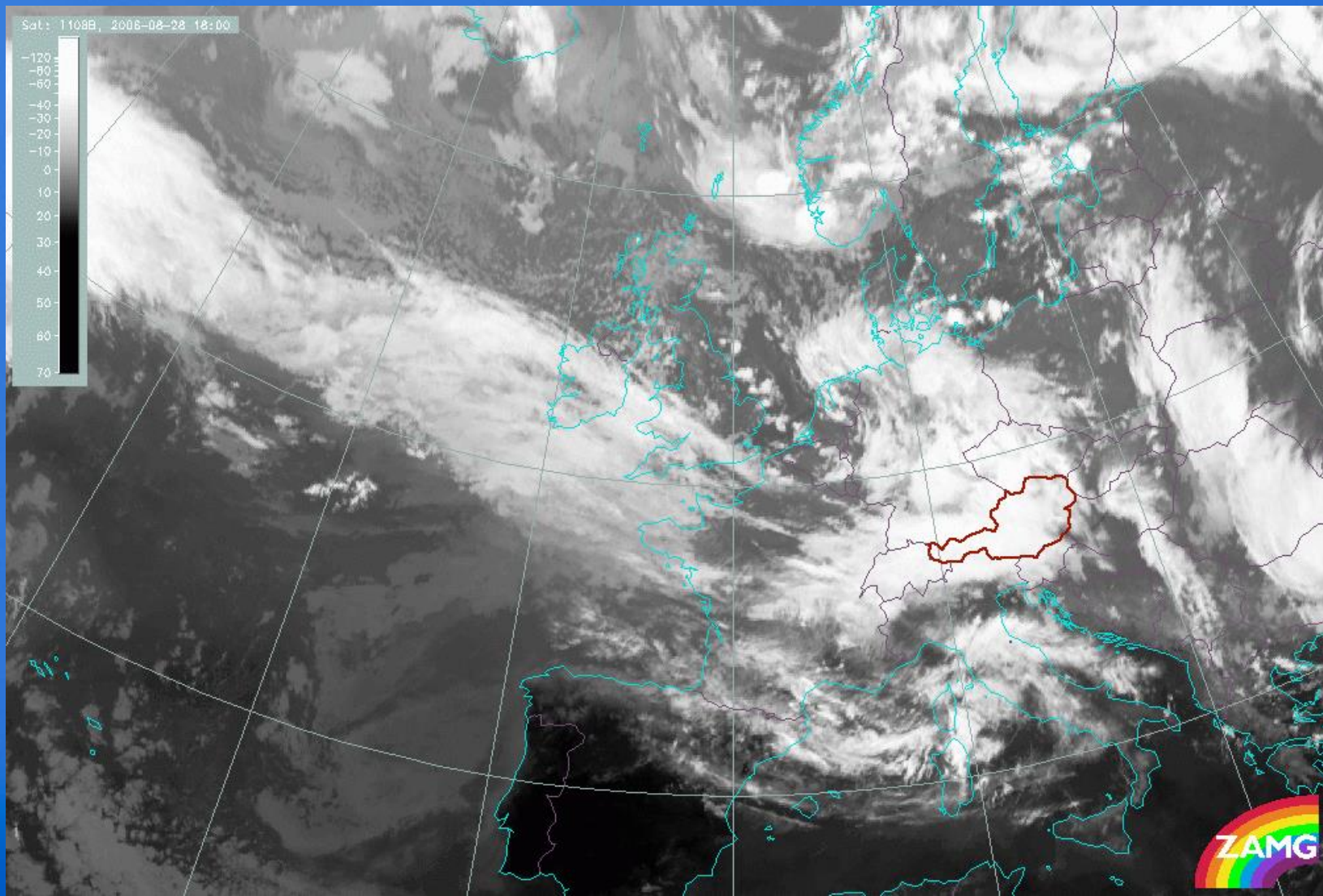
Front Decay - Appearance in satellite imagery

(Präsentation)
12.11.2014 Folie 27



Front Decay - Appearance in satellite imagery

(Präsentation)
12.11.2014 Folie 28



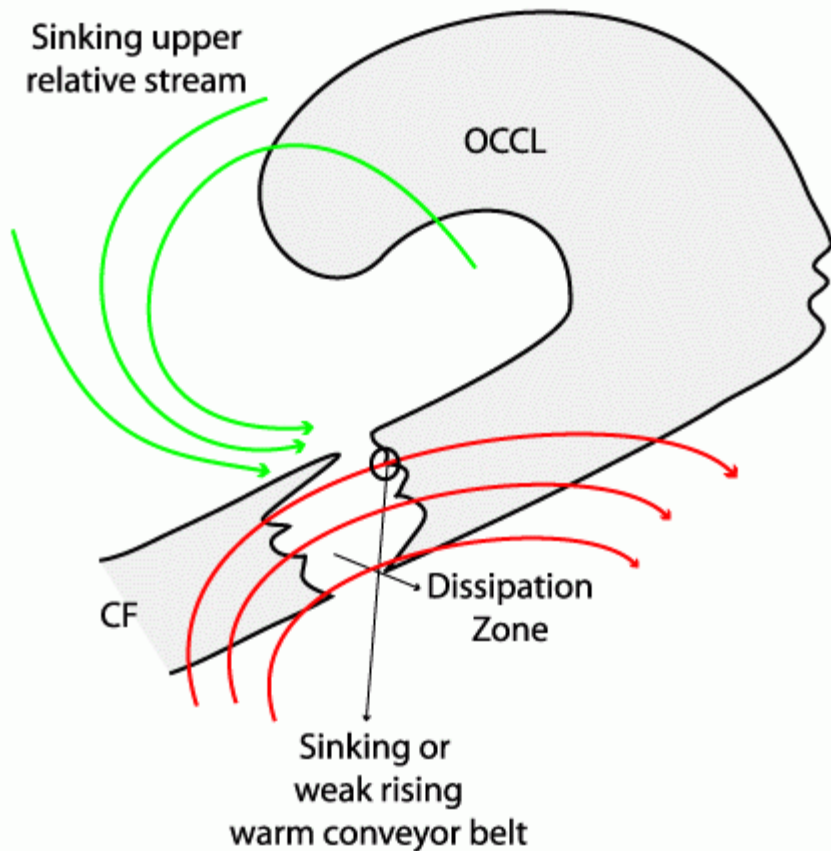
Front Decay - Weather Events

(Präsentation)
12.11.2014 Folie 29

Parameter	Description
Precipitation	<ul style="list-style-type: none">• The initial frontal system: precipitation in surface reports.• Front decay:<ul style="list-style-type: none">◦ Precipitation stops over the zone of cloud dissipation in connection with growth of cloud gap◦ development of dry area• Upstream or downstream of the dissipation zone the front is still very active (possible areas of front intensification)
Temperature	No connection to Front Decay
Wind	No connection to Front Decay
Cloud	<ul style="list-style-type: none">• The initial frontal system: multi layered cloudiness<ul style="list-style-type: none">◦ Front decay: dissipation of high and middle cloudiness;◦ Dissipation of low cloudiness only at mature stage◦ When cloud gap closes up again, no significant weather events can be seen
Other relevant information	

Front Decay – Meteorological Physical Background

(Präsentation)
12.11.2014 Folie 30



Front Decay is best explained relative streams:

Frontal cloud band dissolution from above by the **dry intrusion**. Weak or even sinking **warm conveyor** belt.

No embedded convective cells, stable stratification or only weak instability.

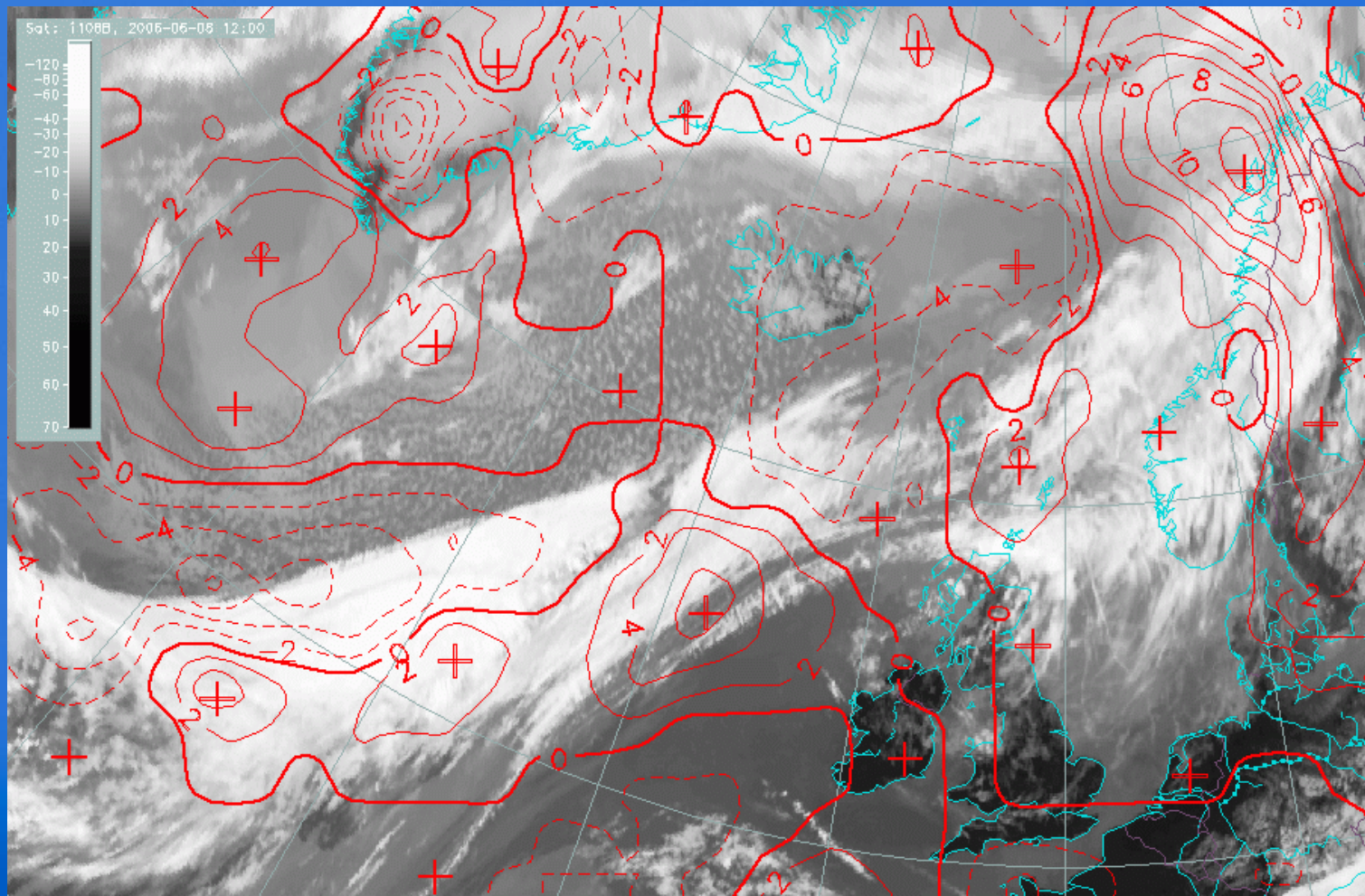
Cold air advection within the frontal cloud band is often observed.



Front Decay – Key Parameters

(Präsentation)
12.11.2014 Folie 31

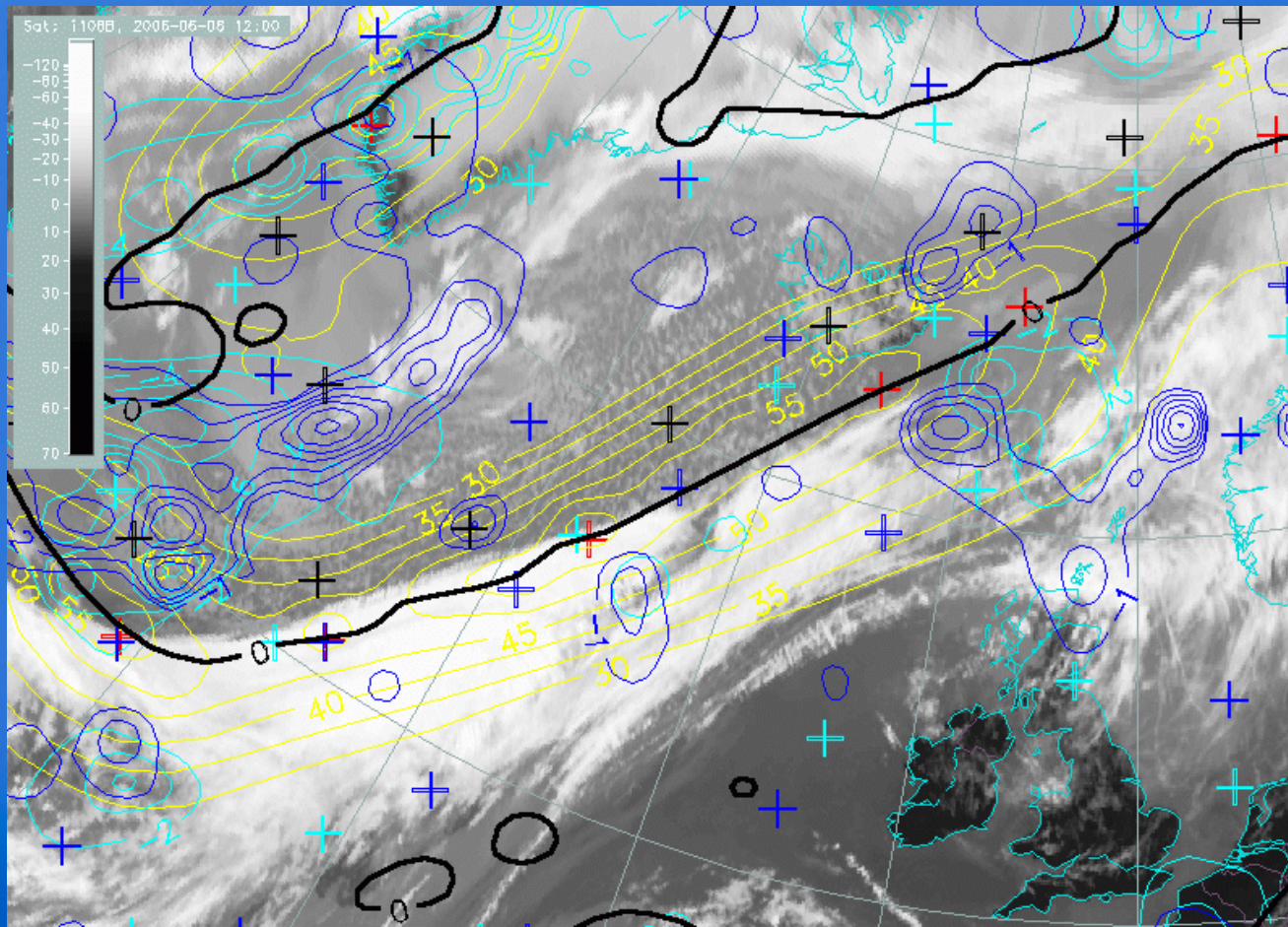
Cold air advection mainly in higher levels, often down to 700 hPa.



Front Decay – Key Parameters

(Präsentation)
12.11.2014 Folie 32

Negative vorticity advection may play a role, but is seldom observed in the model fields (right exit region).

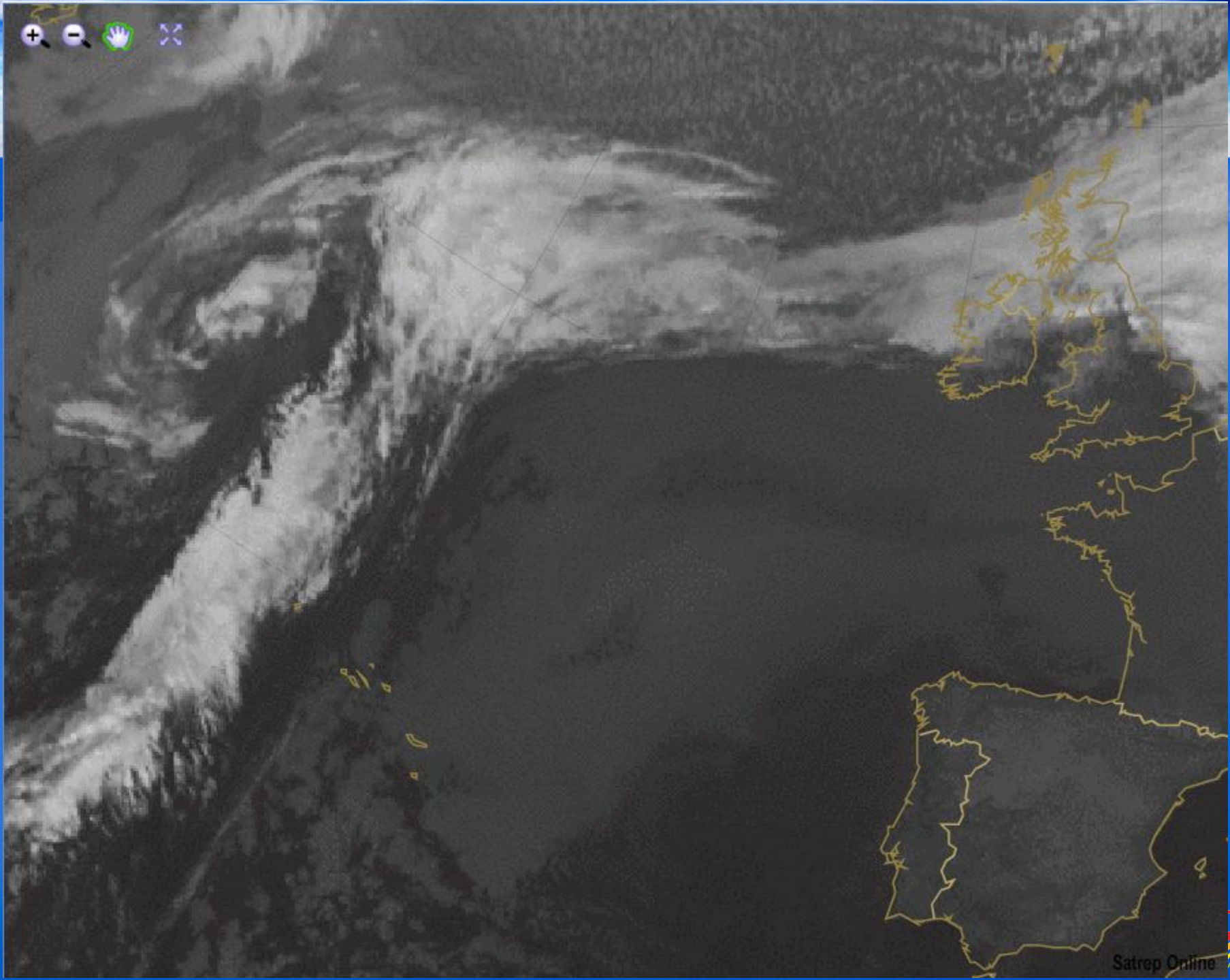


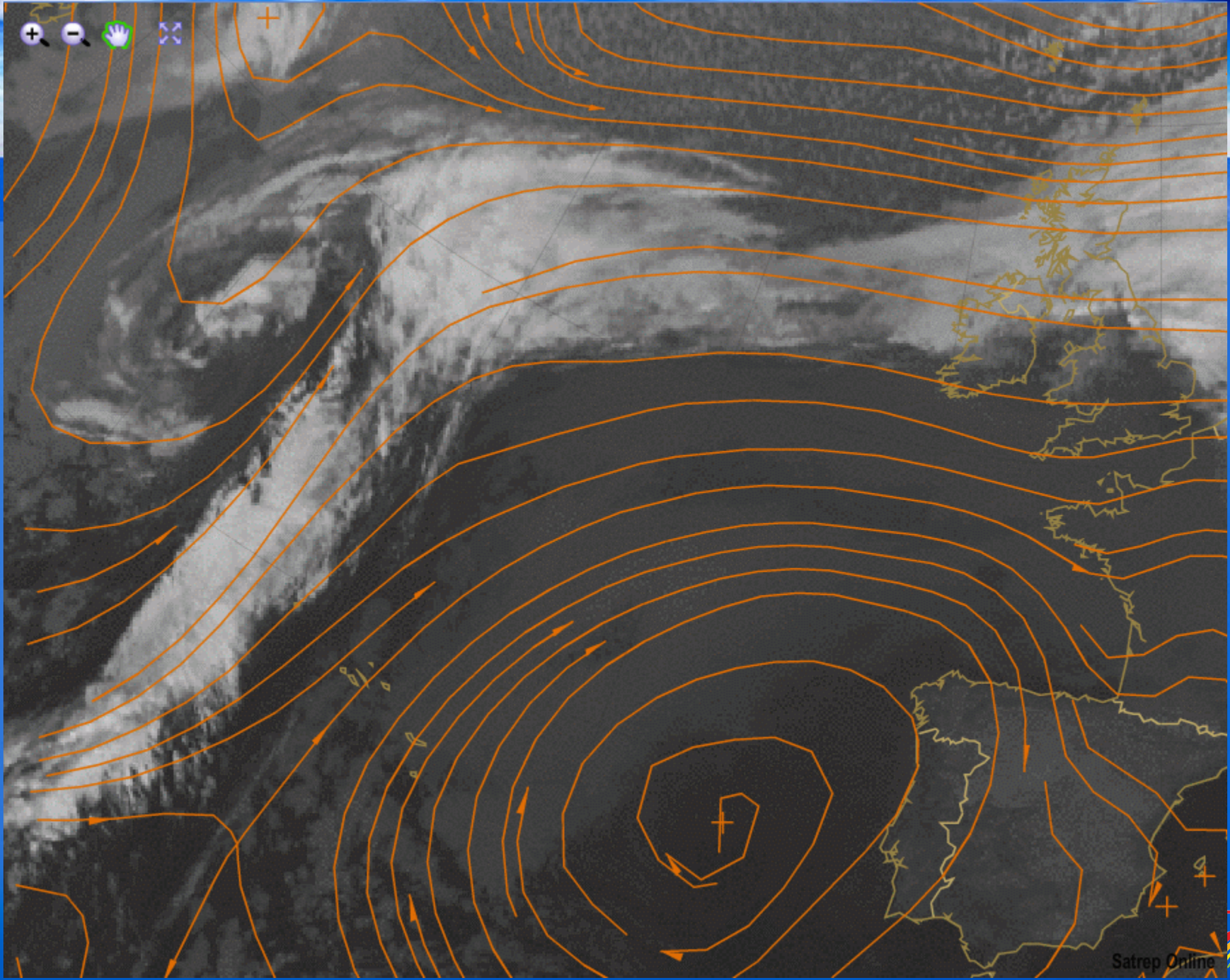
Front Decay - Summary

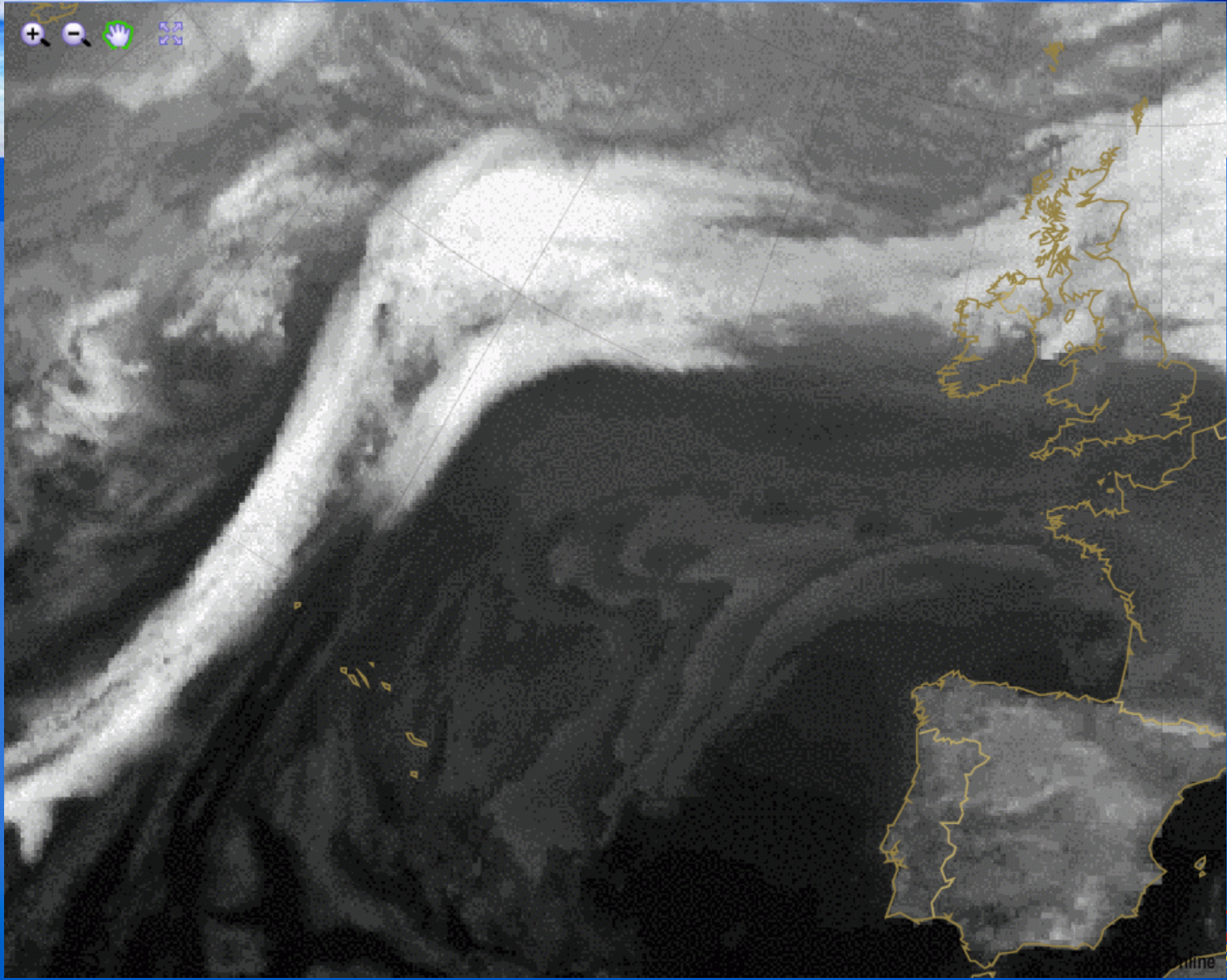
(Präsentation)
12.11.2014 Folie 33

- Front Decay is often located in the CF shortly upstream of the occlusion point.
- Easy to detect in the IR image.
- Upper level phenomenon, low level frontal characteristics remain unaffected, unless the dry intrusion is very strong and protruding into low levels (rare).
- Front Decay must not be mistaken for a low cold front, especially in frontal zones where warm and cold front are alternating.







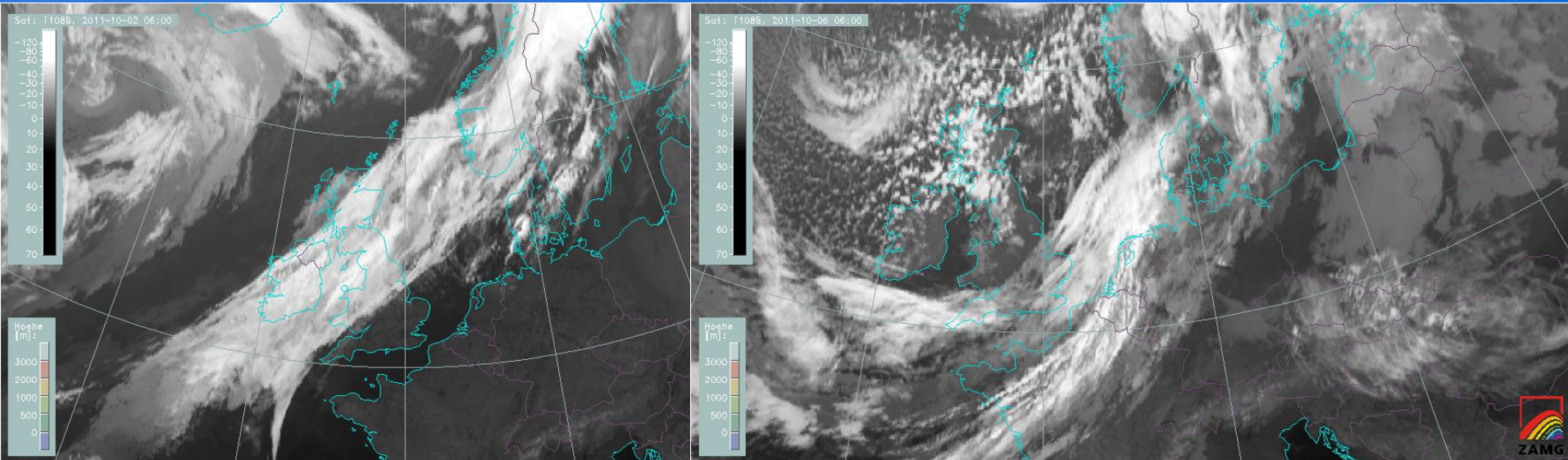


Frontal Waves and Upper Waves

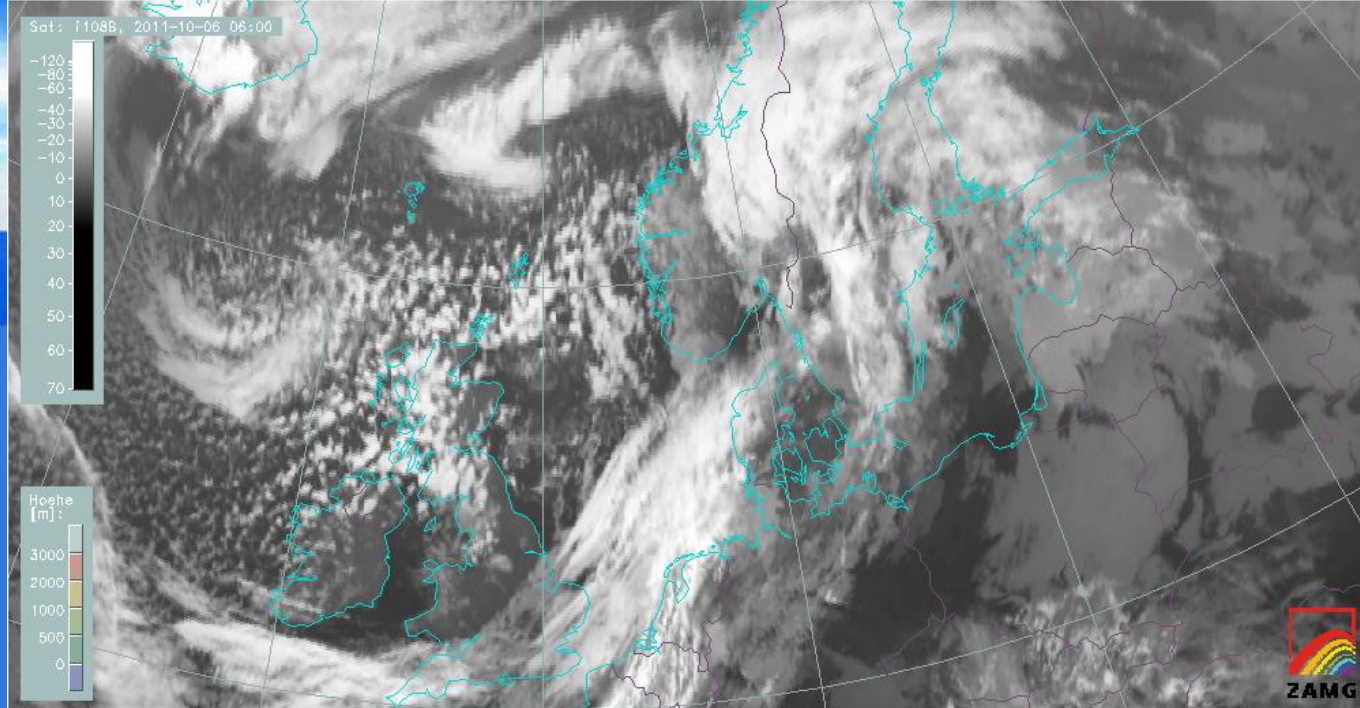
(Präsentation)
12.11.2014 Folie 37

Upper waves and **frontal waves** in their early stage are very similar from the satellite point of view. Nevertheless there are some fundamental differences concerning their life cycle and their key parameters from the model fields.

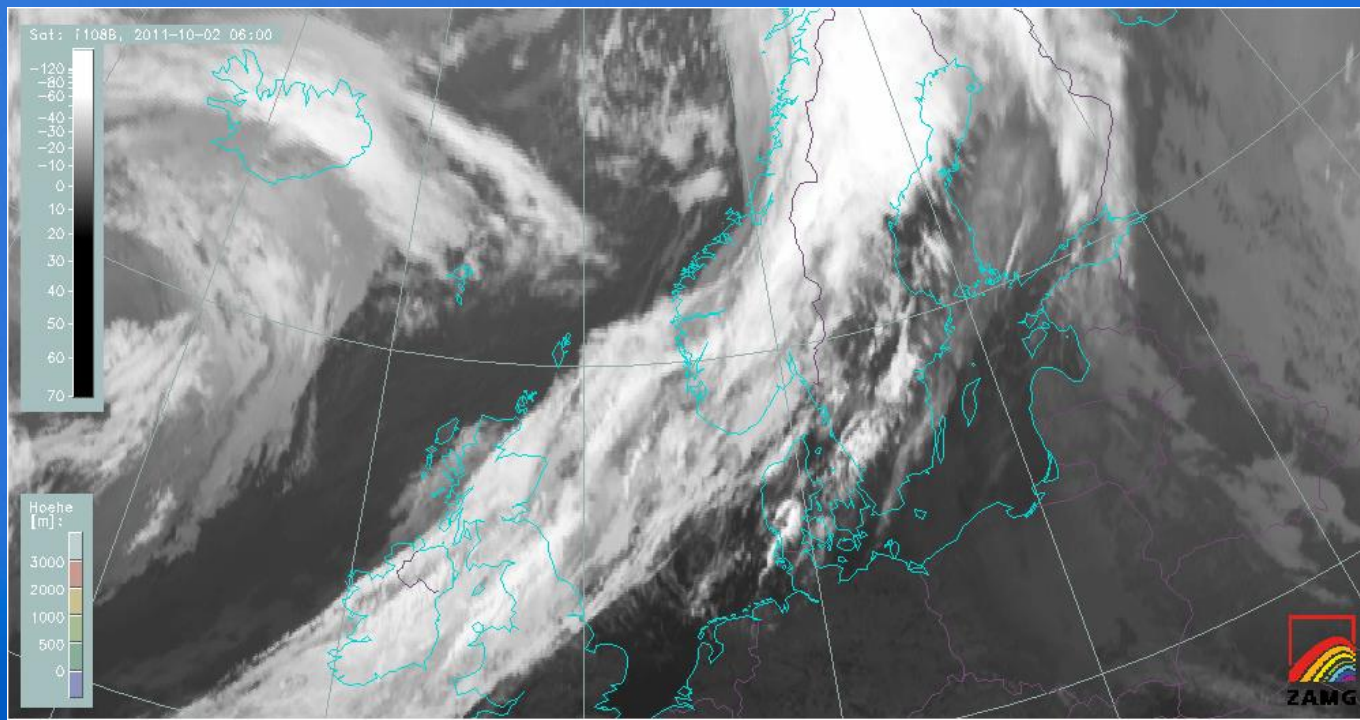
To better see these differences, they will be treated together.



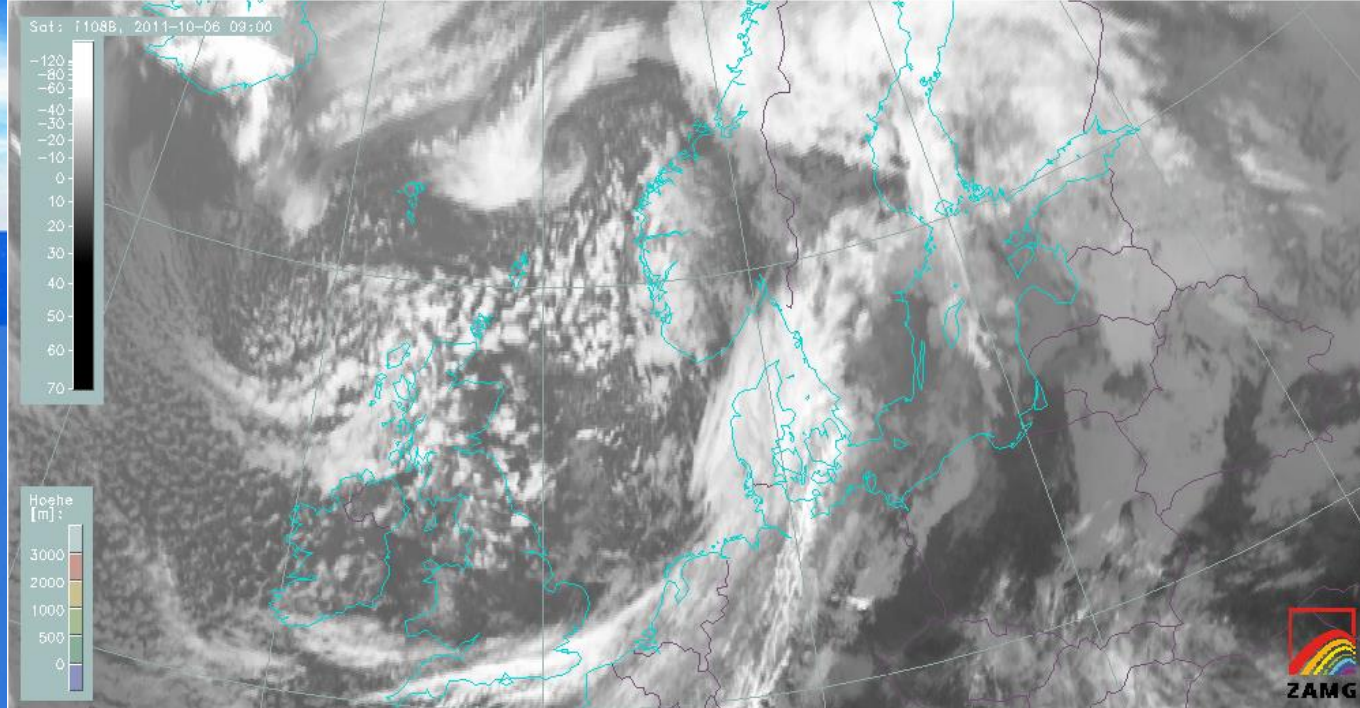
upper
wave



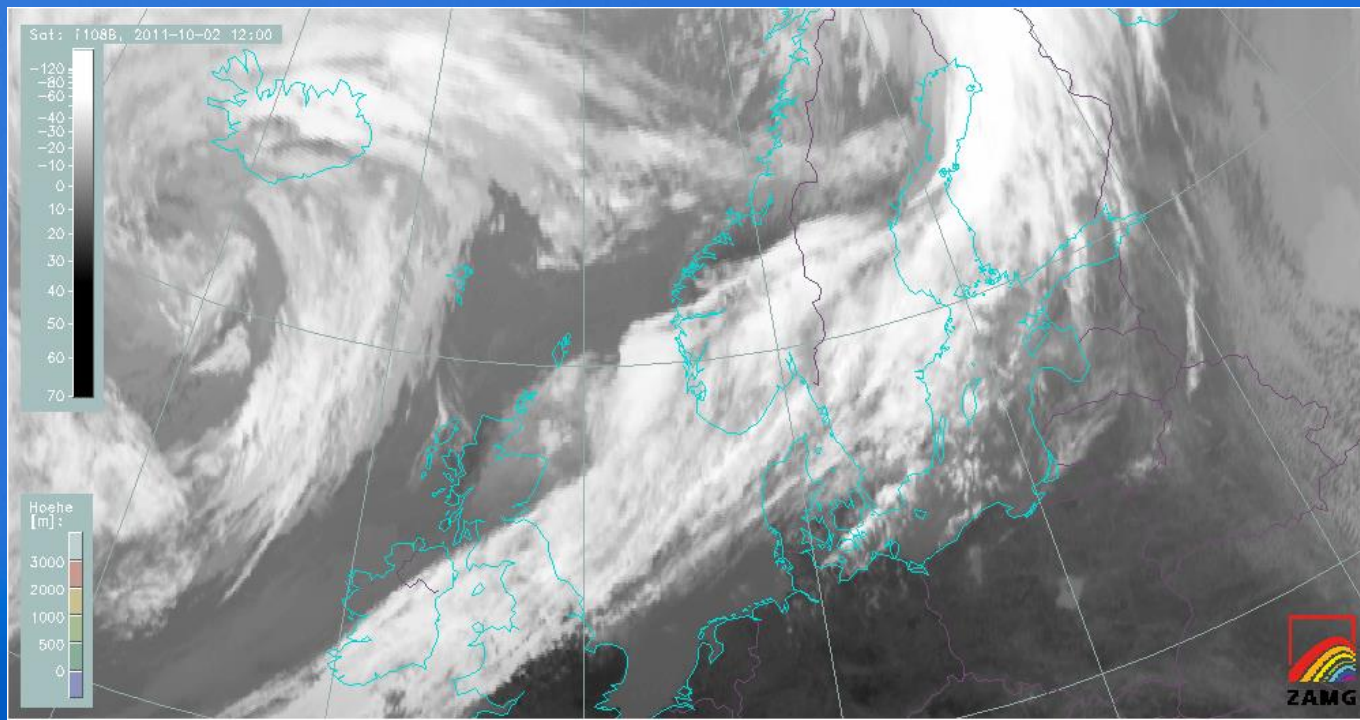
frontal
wave



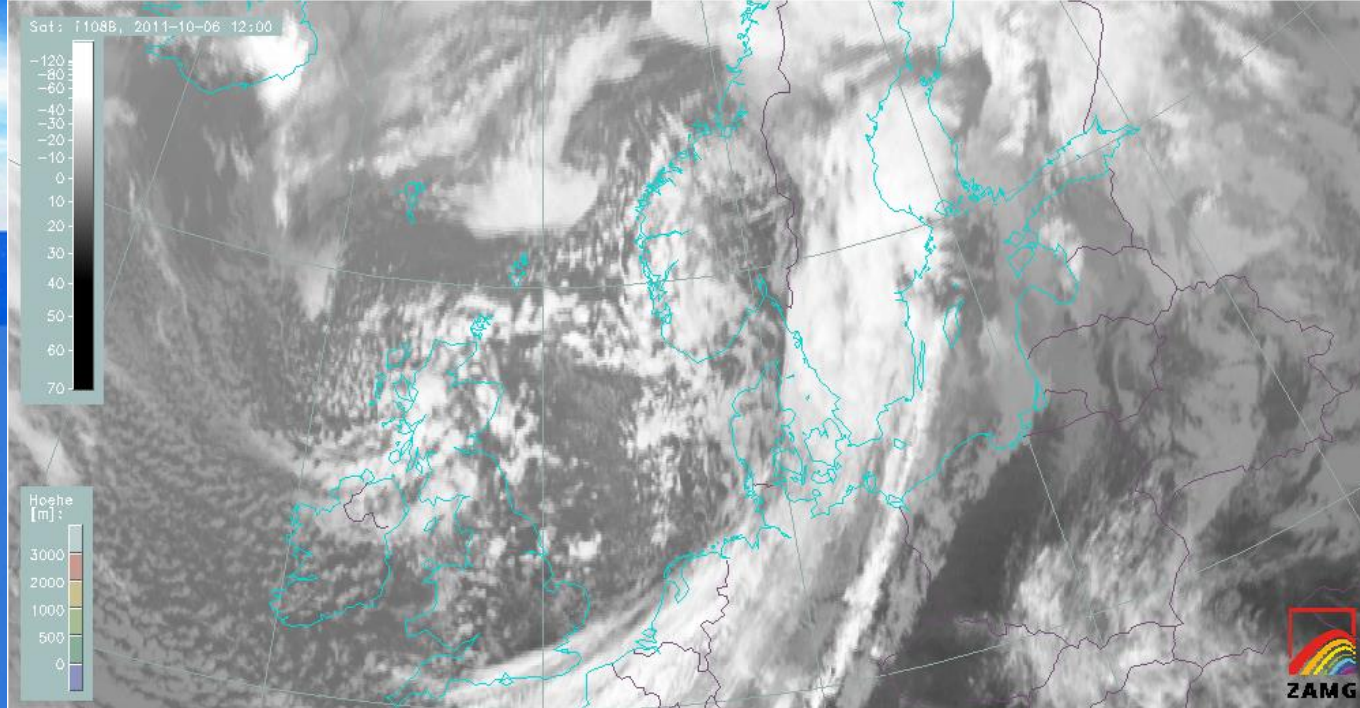
upper
wave



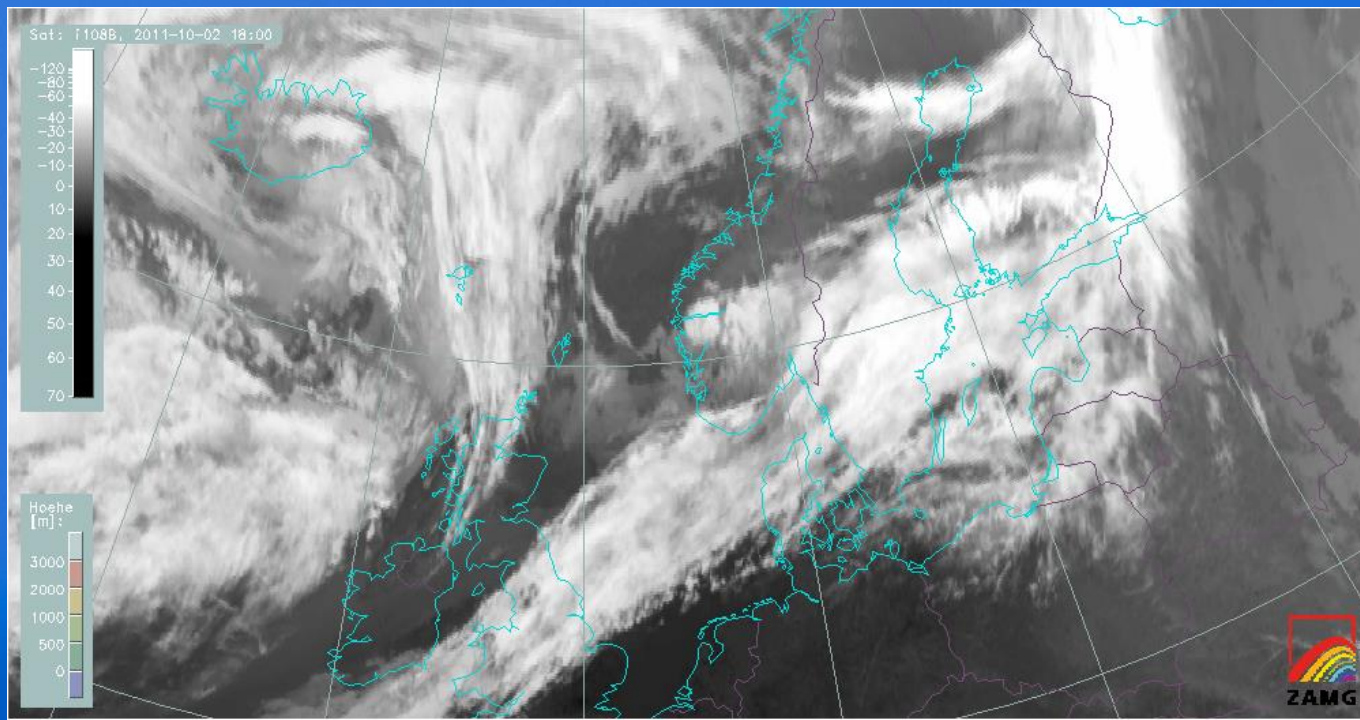
frontal
wave



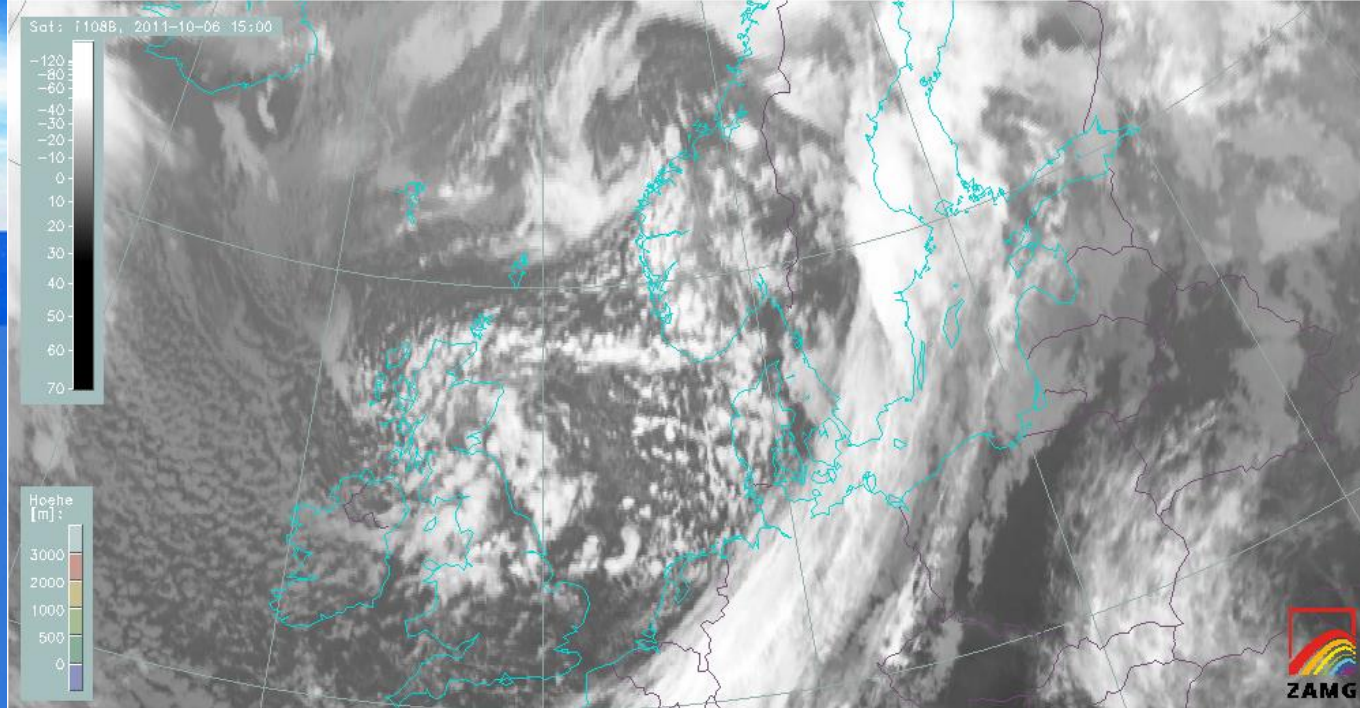
upper
wave



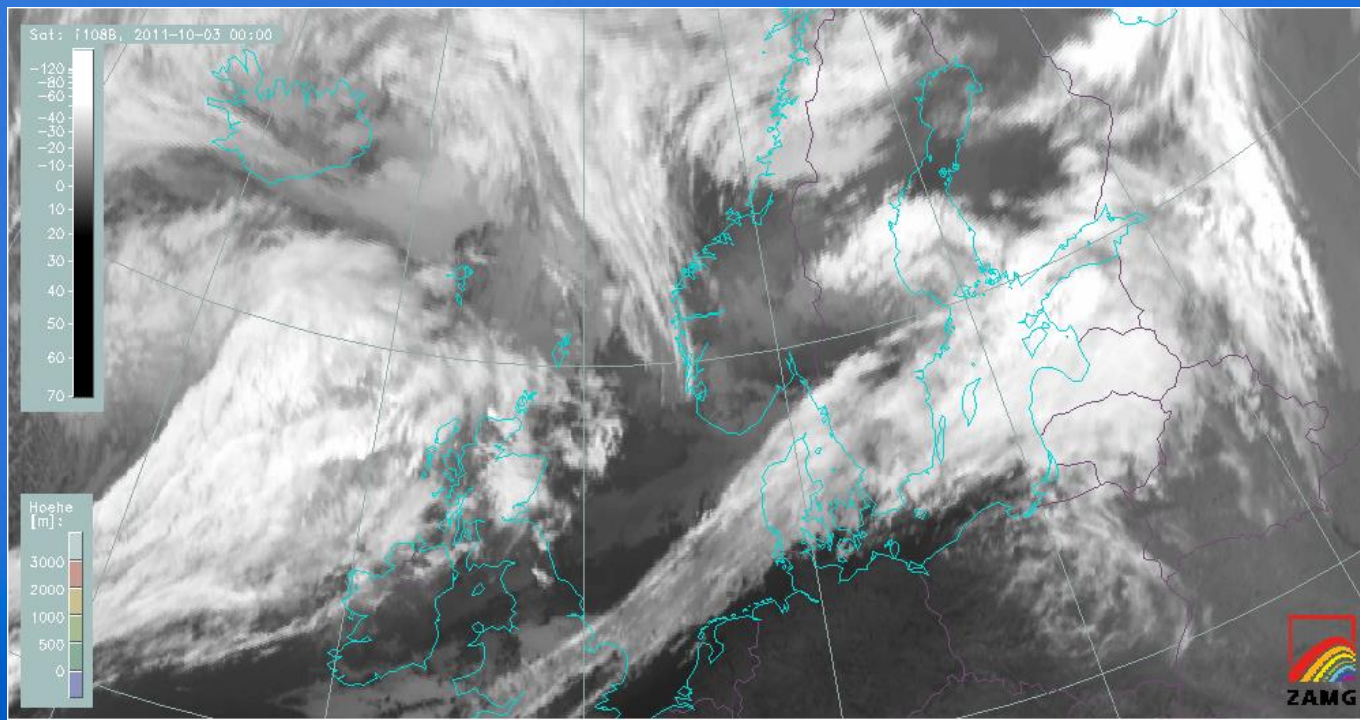
frontal
wave



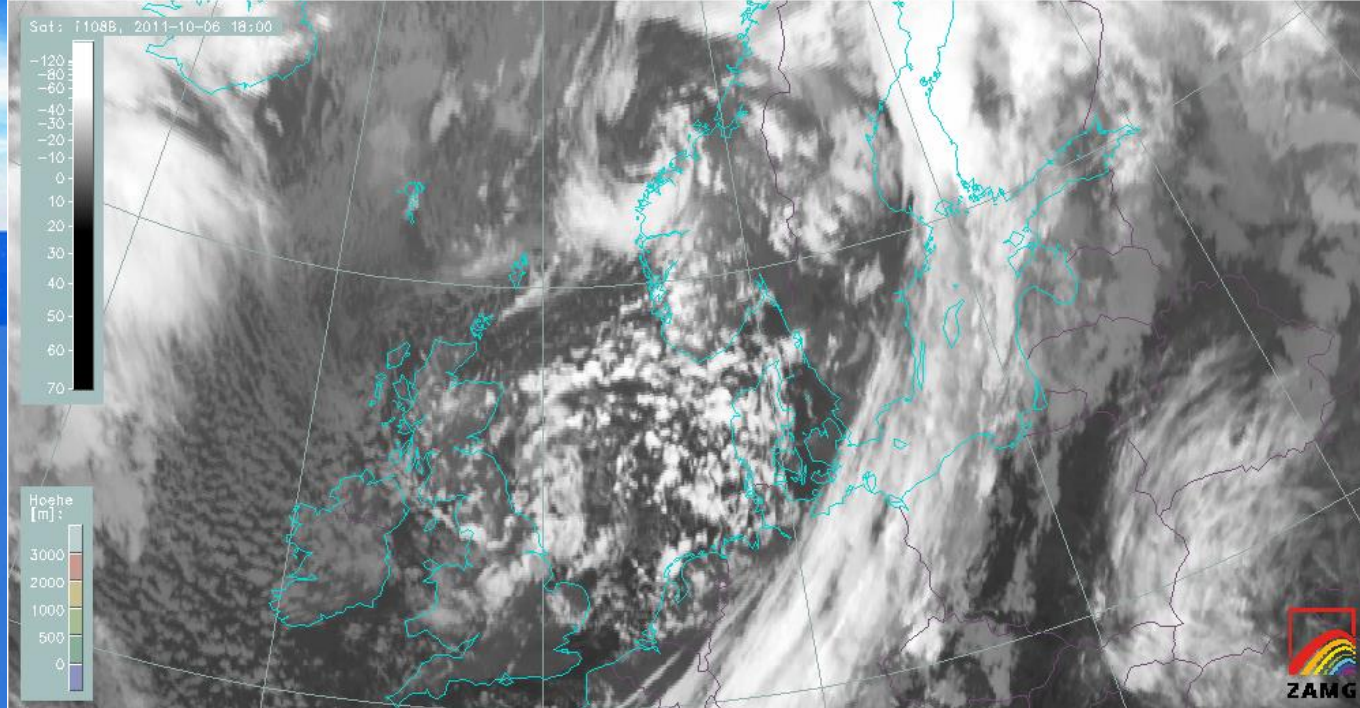
upper
wave



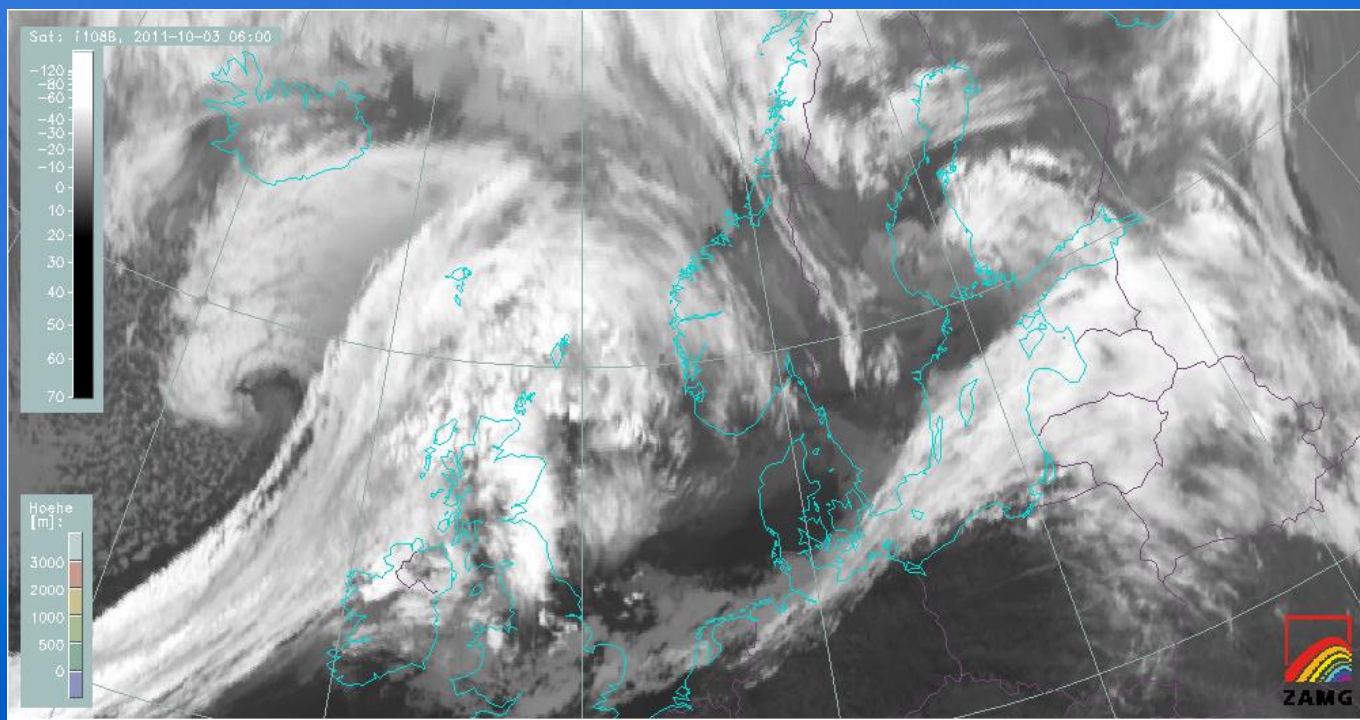
frontal
wave



upper
wave



frontal
wave



Frontal Waves and Upper Waves: life cycle

(Präsentation)
12.11.2014 Folie 43

Most fundamental differences in the **life cycle**:

- The upper wave is tightly connected to a jet streak. It shows no evolution and moves along the CF rear side towards the occlusion point.
- The frontal wave often develops into a synoptic scale system, it is the initial stage of a cyclogenesis.



upper wave

Upper air feature driven by a jet streak

The CF is under cold air advection

Shear vorticity prevails

PVA maximum from trough along the rear side of the CF

frontal wave

Mid to low level feature driven by a developing surface low

A weak WA – CA dipole is developing

Curvature vorticity is equally important

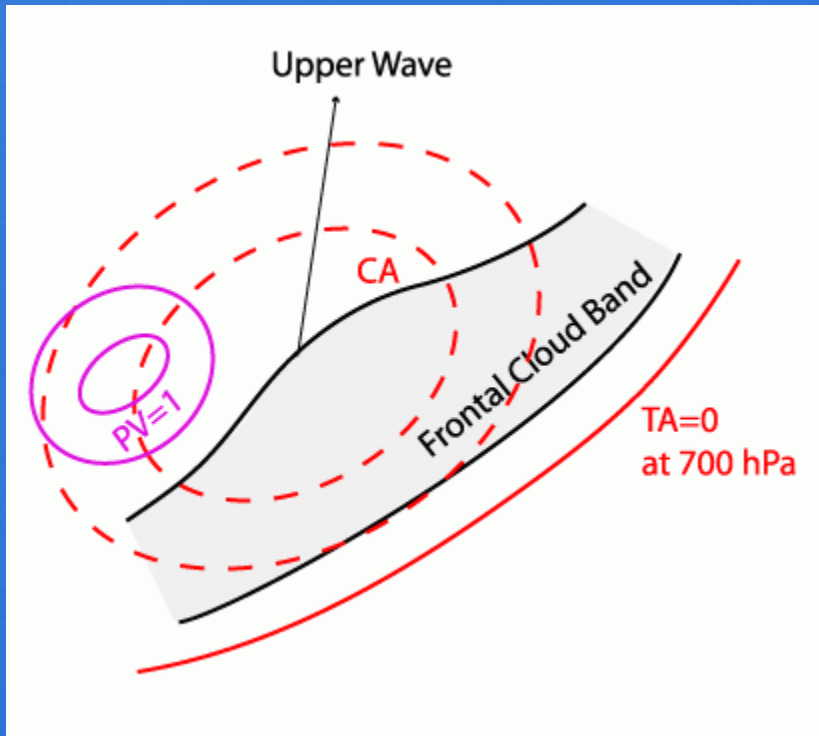
Distinct PVA maximum from developing low



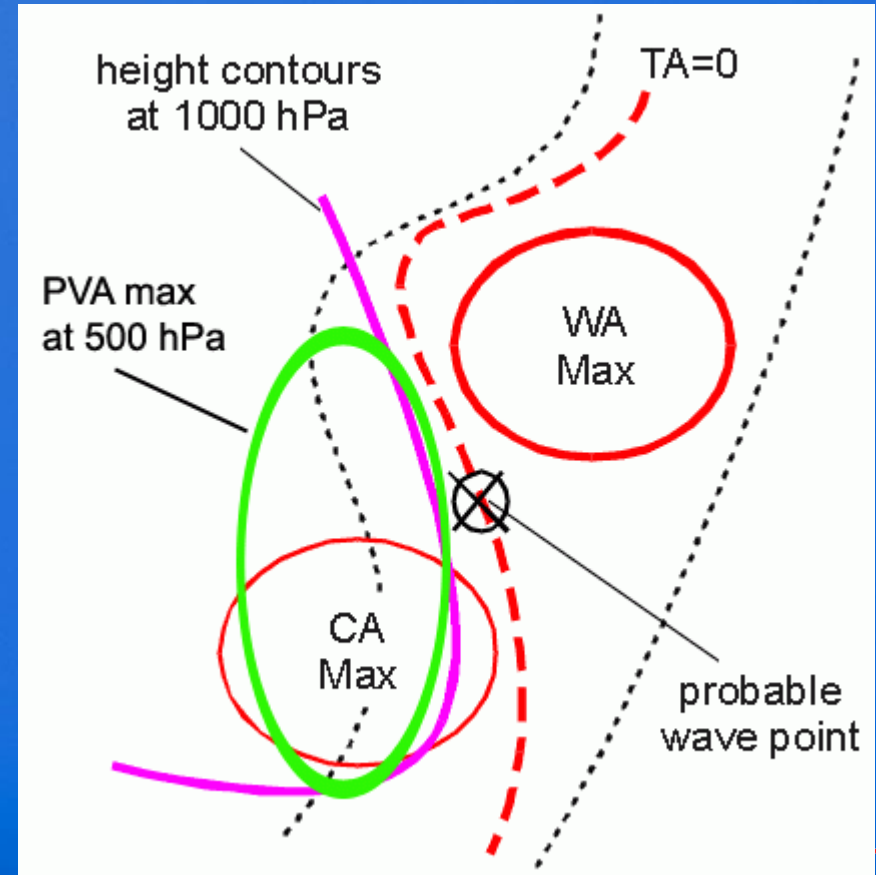
Key Parameters: Temperature Advection

(Präsentation)
12.11.2014 Folie 45

upper wave



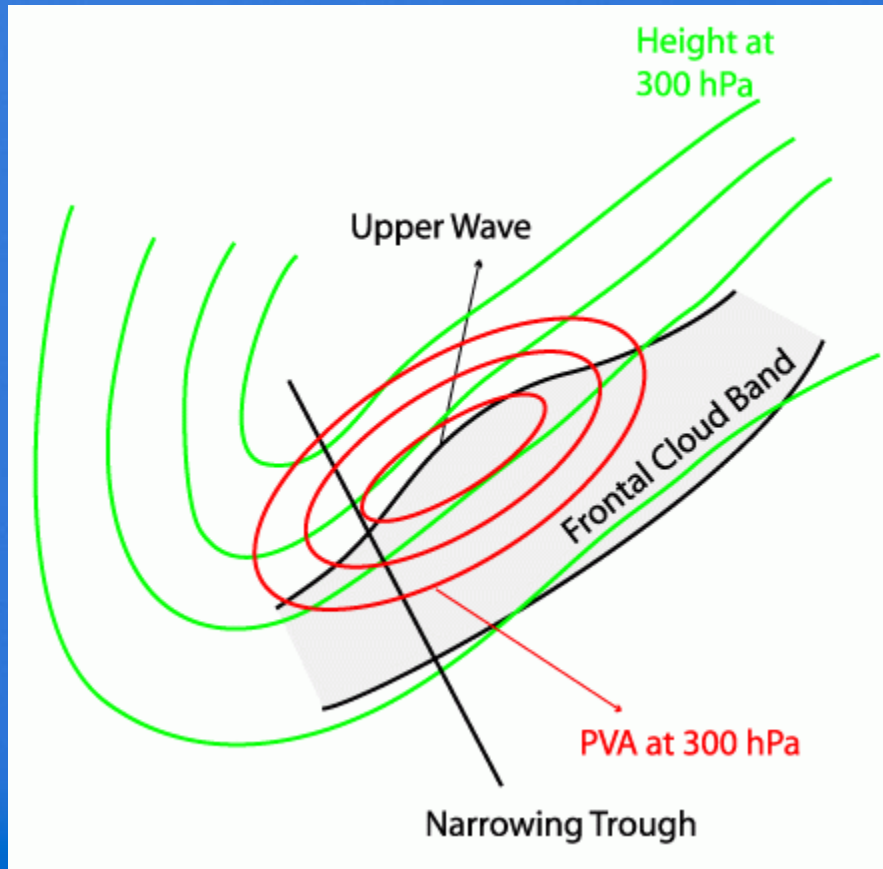
frontal wave



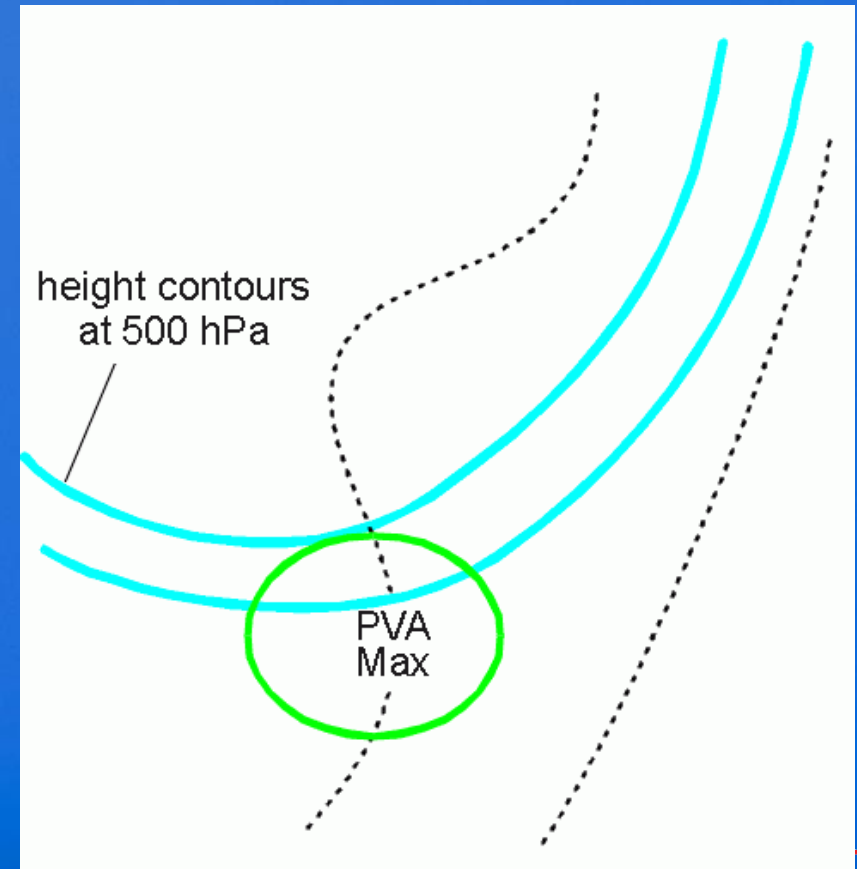
Key Parameters: Vorticity Advection

(Präsentation)
12.11.2014 Folie 46

upper wave



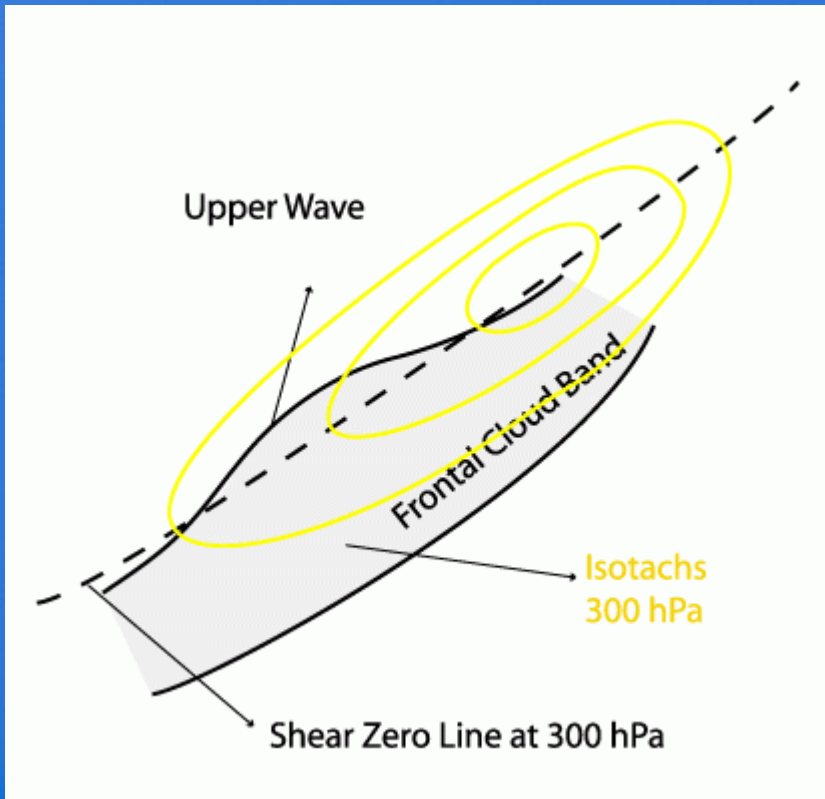
frontal wave



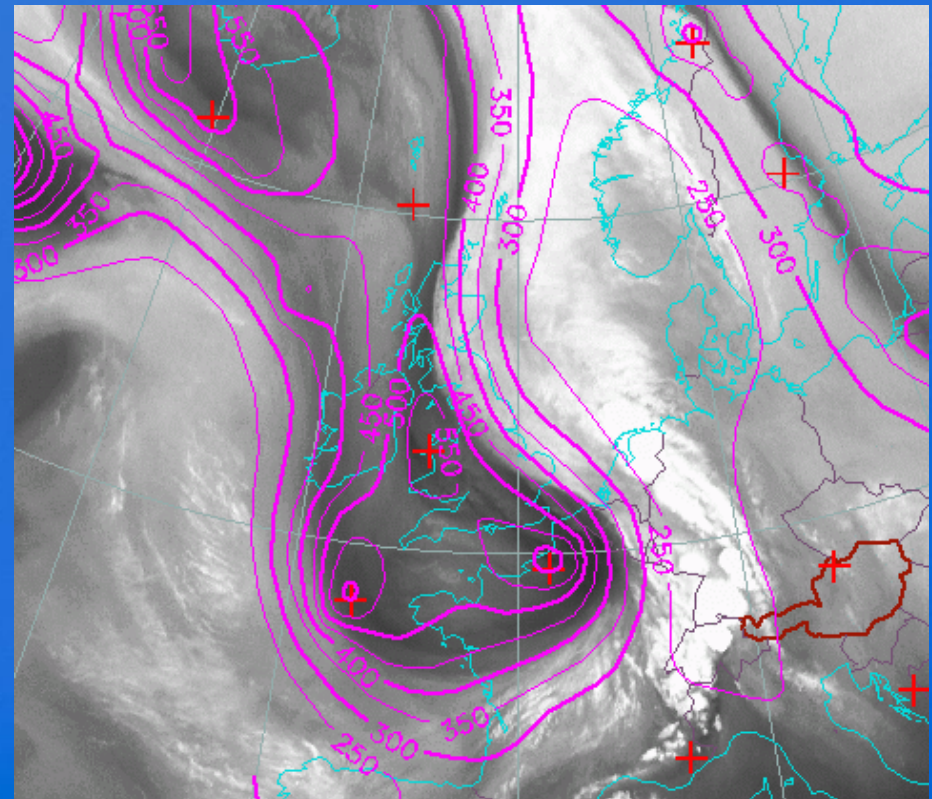
Key Parameters

(Präsentation)
12.11.2014 Folie 47

upper wave



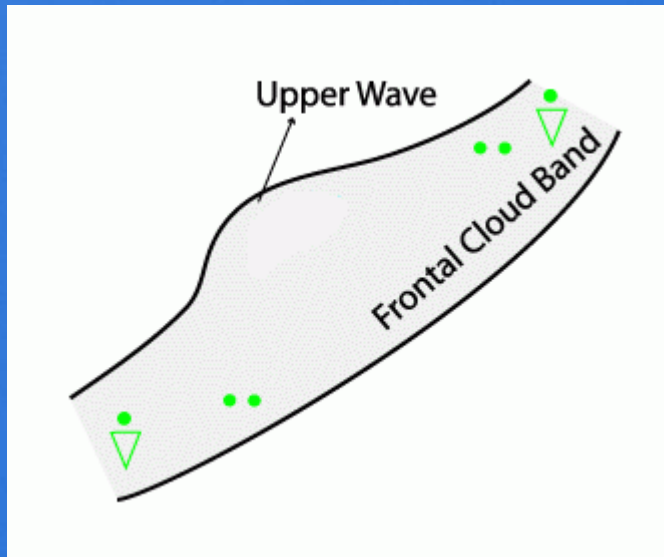
frontal wave (PV)



Frontal Waves and Upper Waves: Weather Events

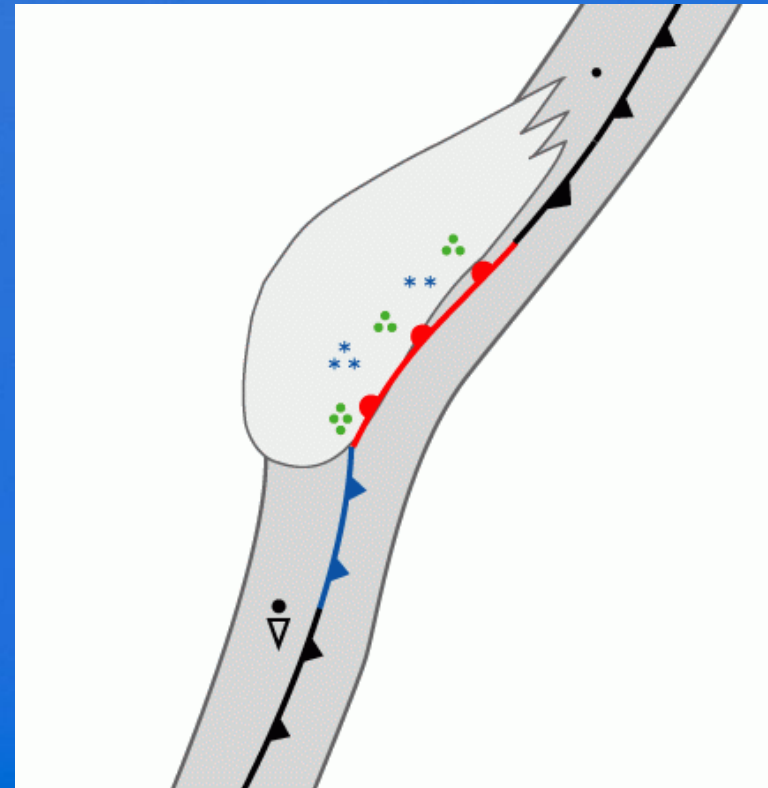
(Präsentation)
12.11.2014 Folie 48

upper wave



No precipitation under the upper wave bulge.

frontal wave

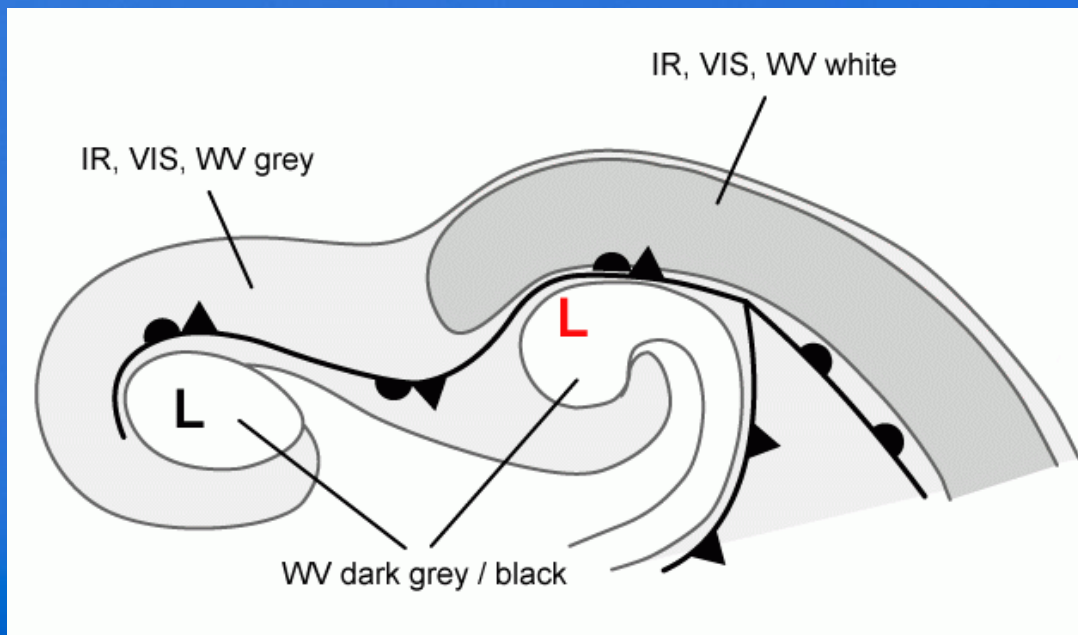


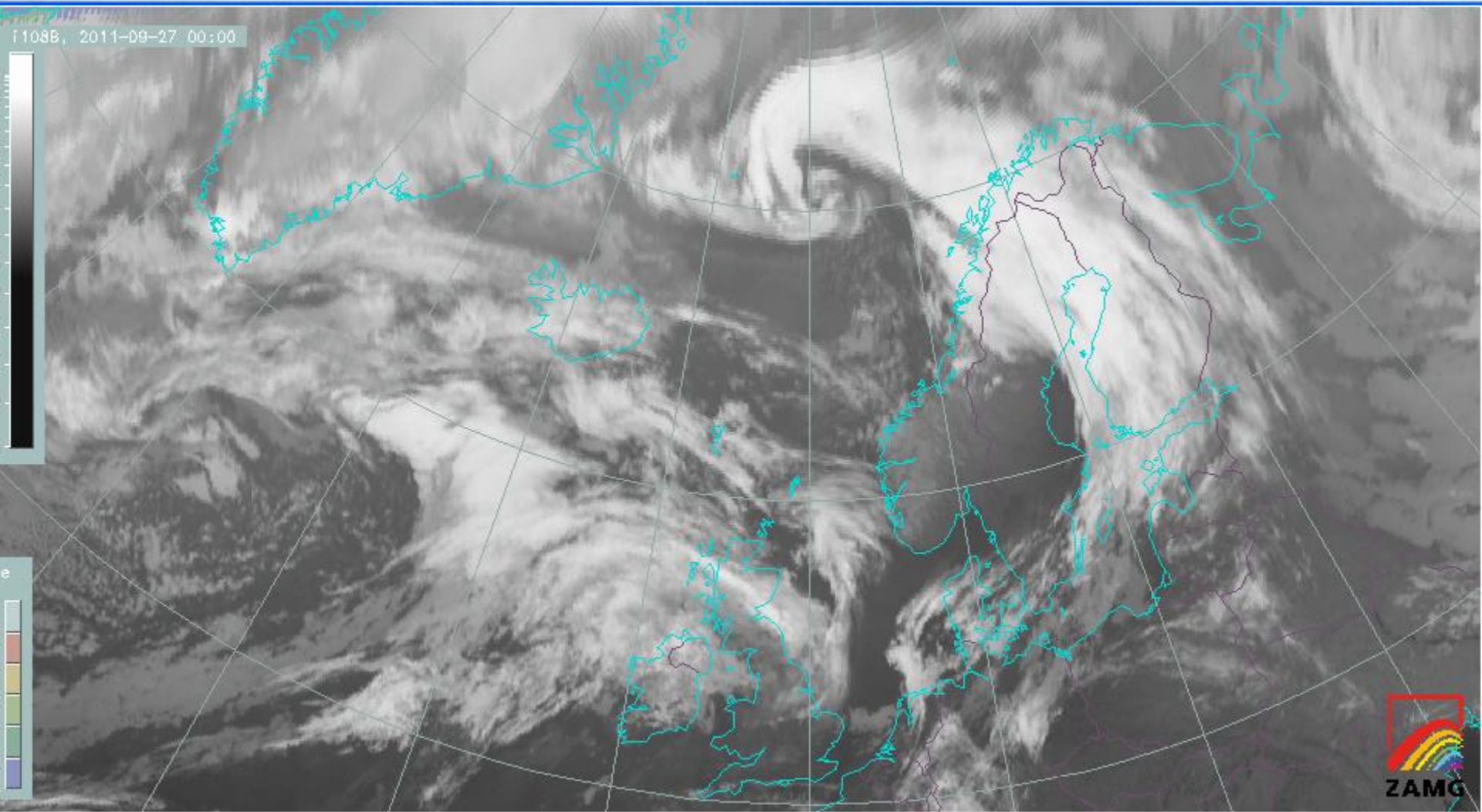
Secondary Low Centers in Occlusions (a.k.a. Occlusion 2nd Low)

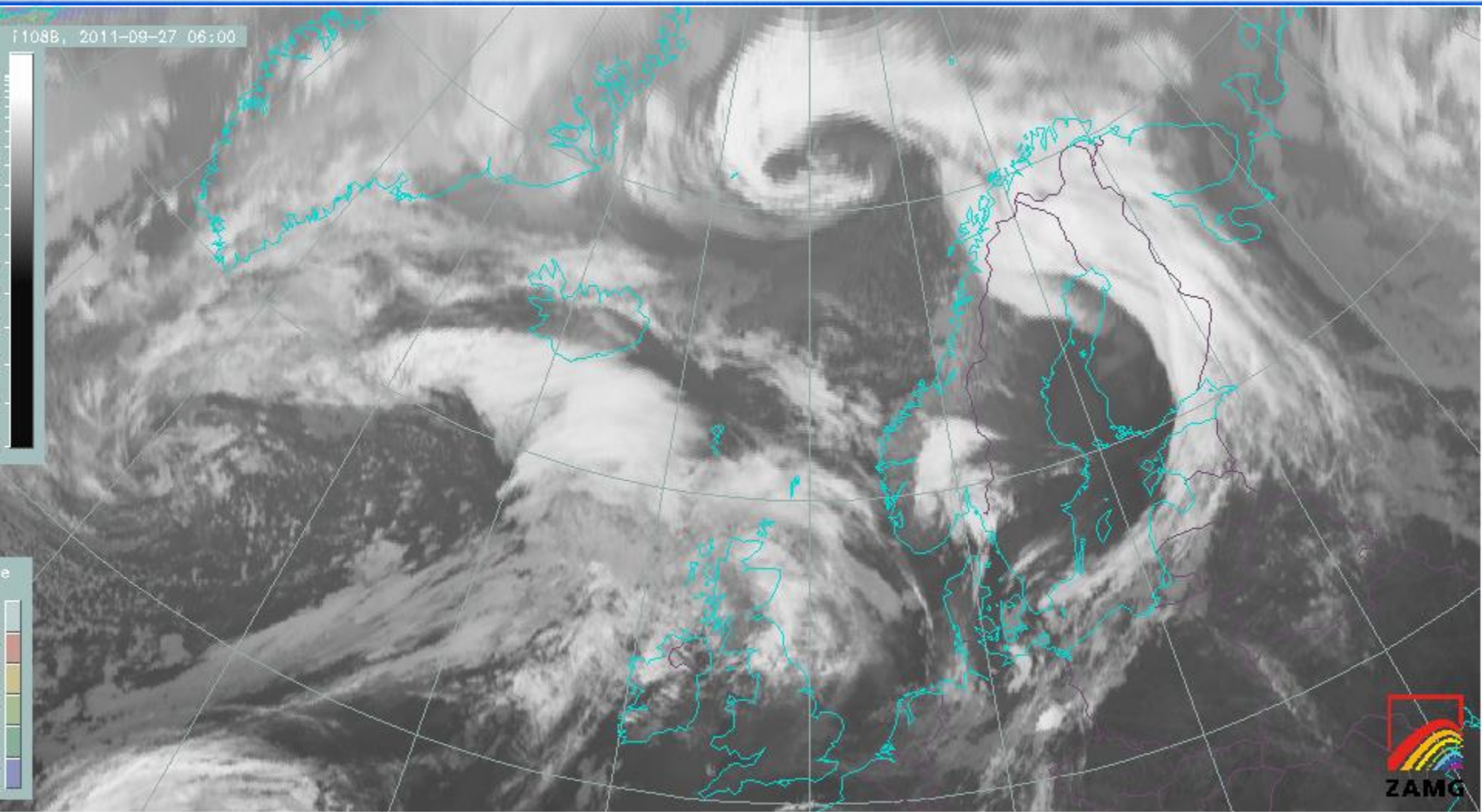
(Präsentation)
12.11.2014 Folie 49

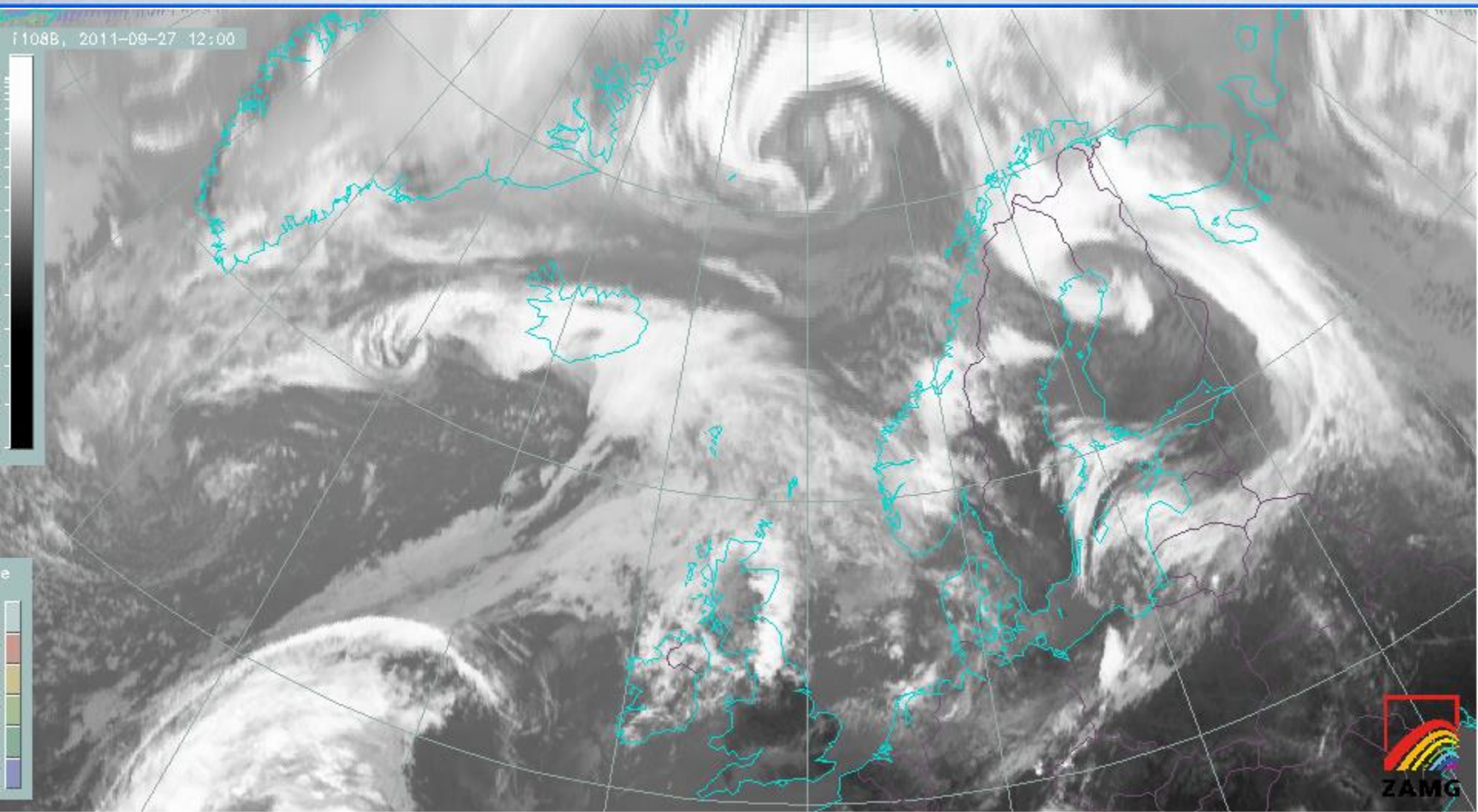
Occlusions 2nd low are very often observed in satellite imagery and easy to detect.

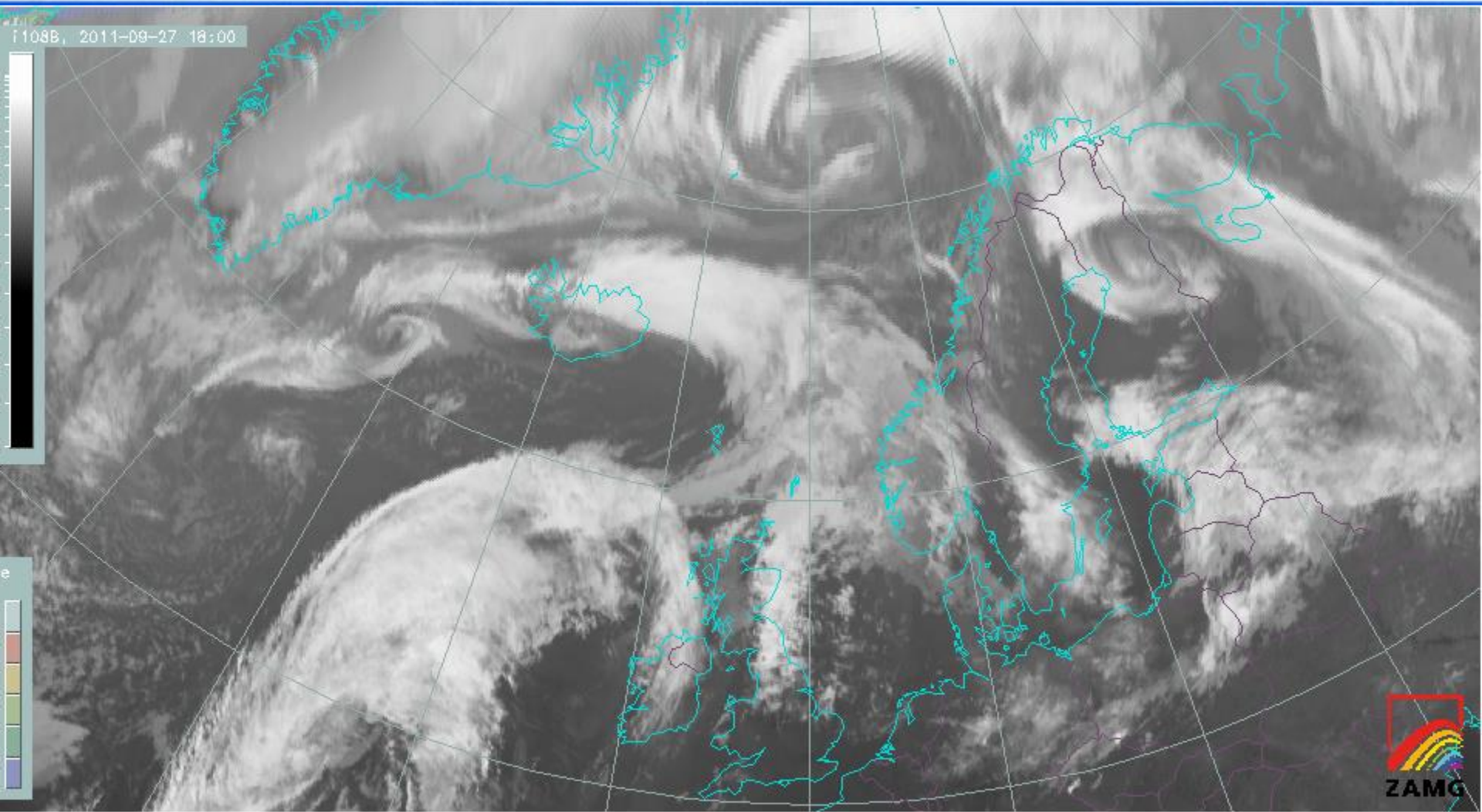
They are formed by a developing secondary low between the main low and the occlusion point.









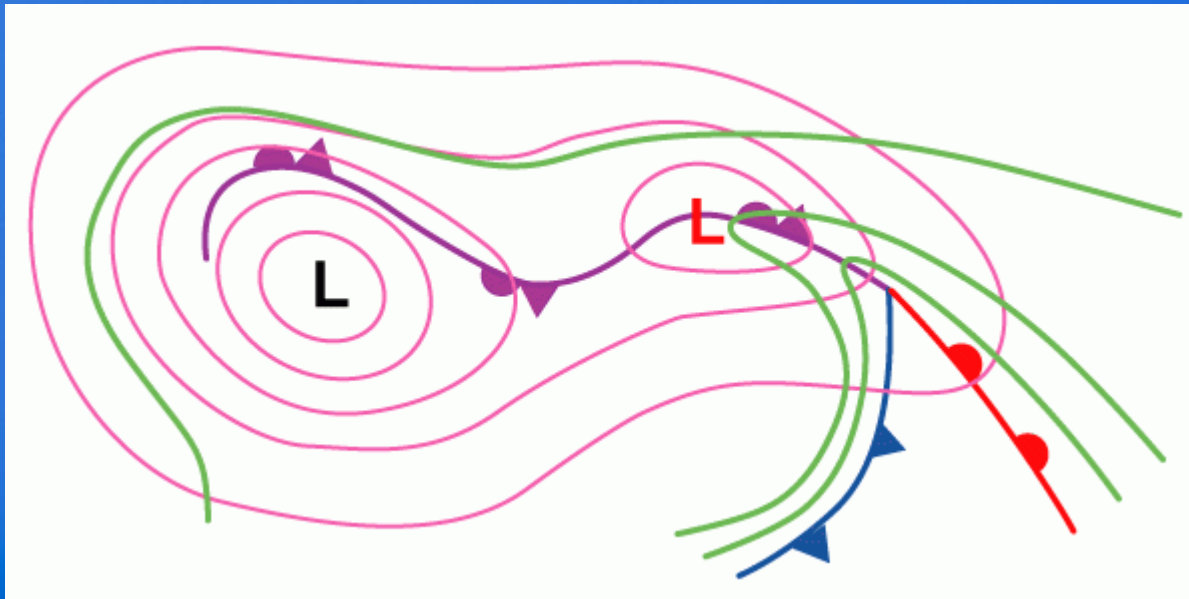


Occlusion 2nd Low: Key Parameters

(Präsentation)
12.11.2014 Folie 54

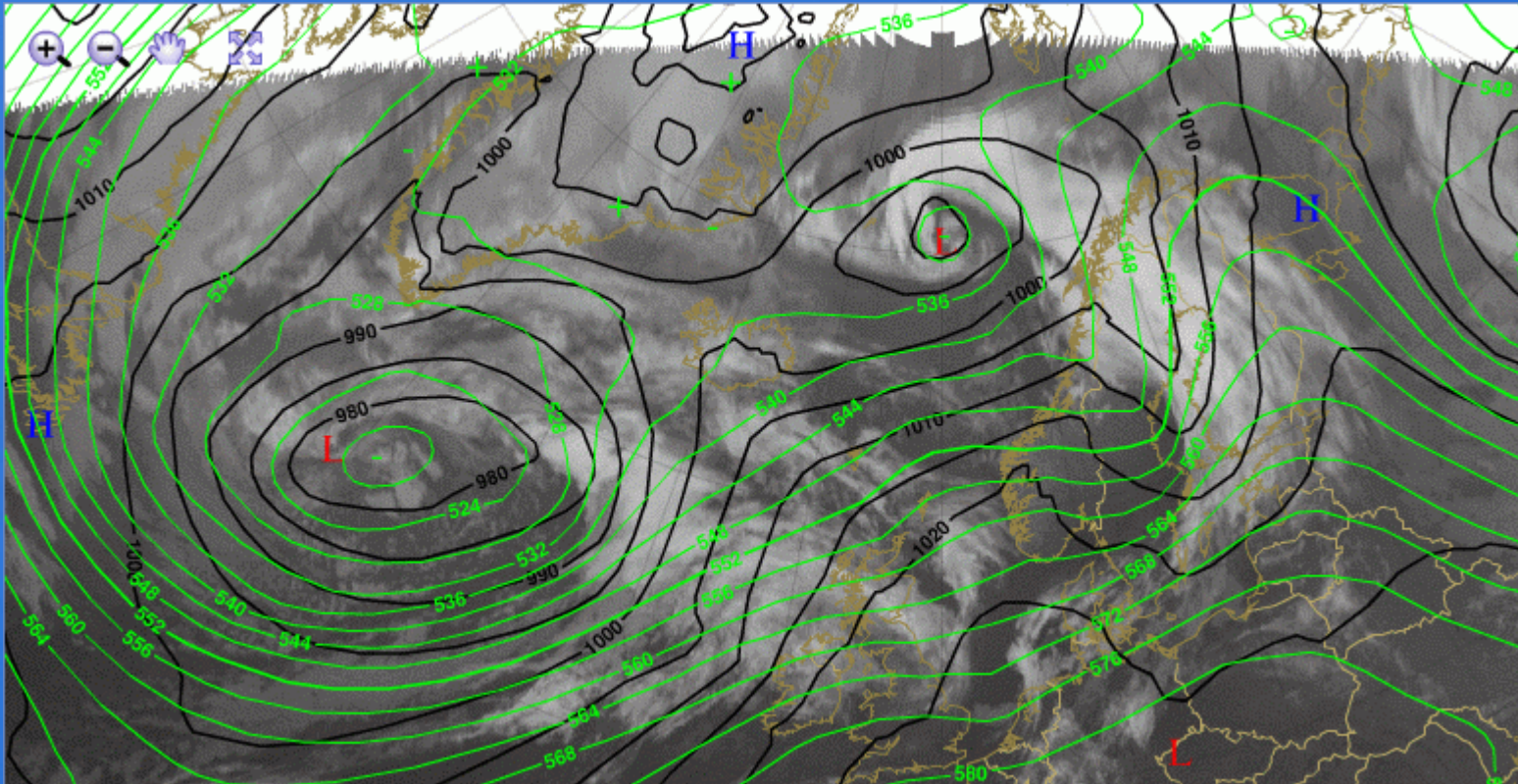
The new cloud spiral within the occlusion cloud band is formed because of a newly forming low. Therefore the key parameters are closely related to this low:

- Height contours 1000 hPa
- Relative vorticity (500 and 1000 hPa)



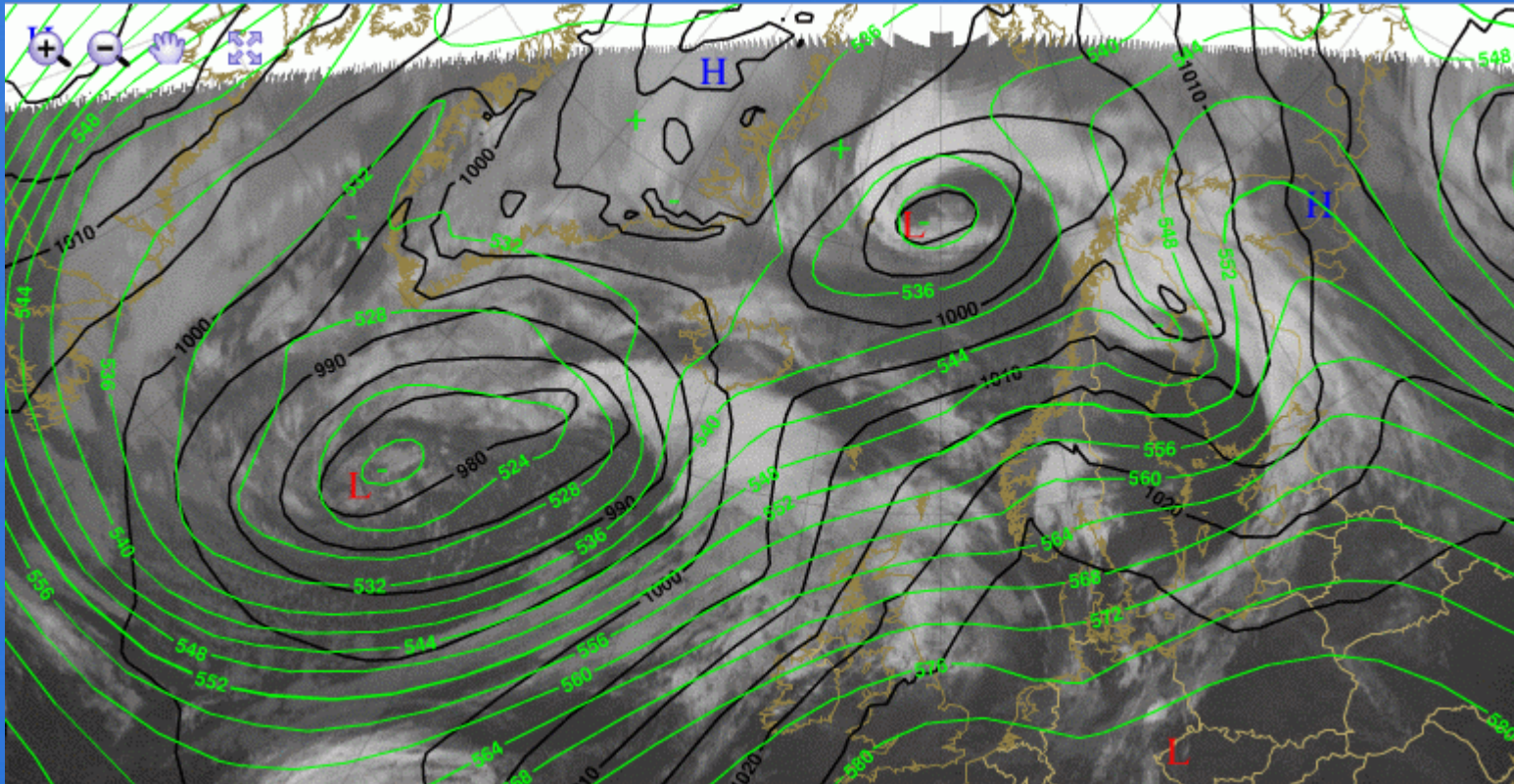
green: H500, black: MSLP

(Präsentation)
12.11.2014 Folie 55



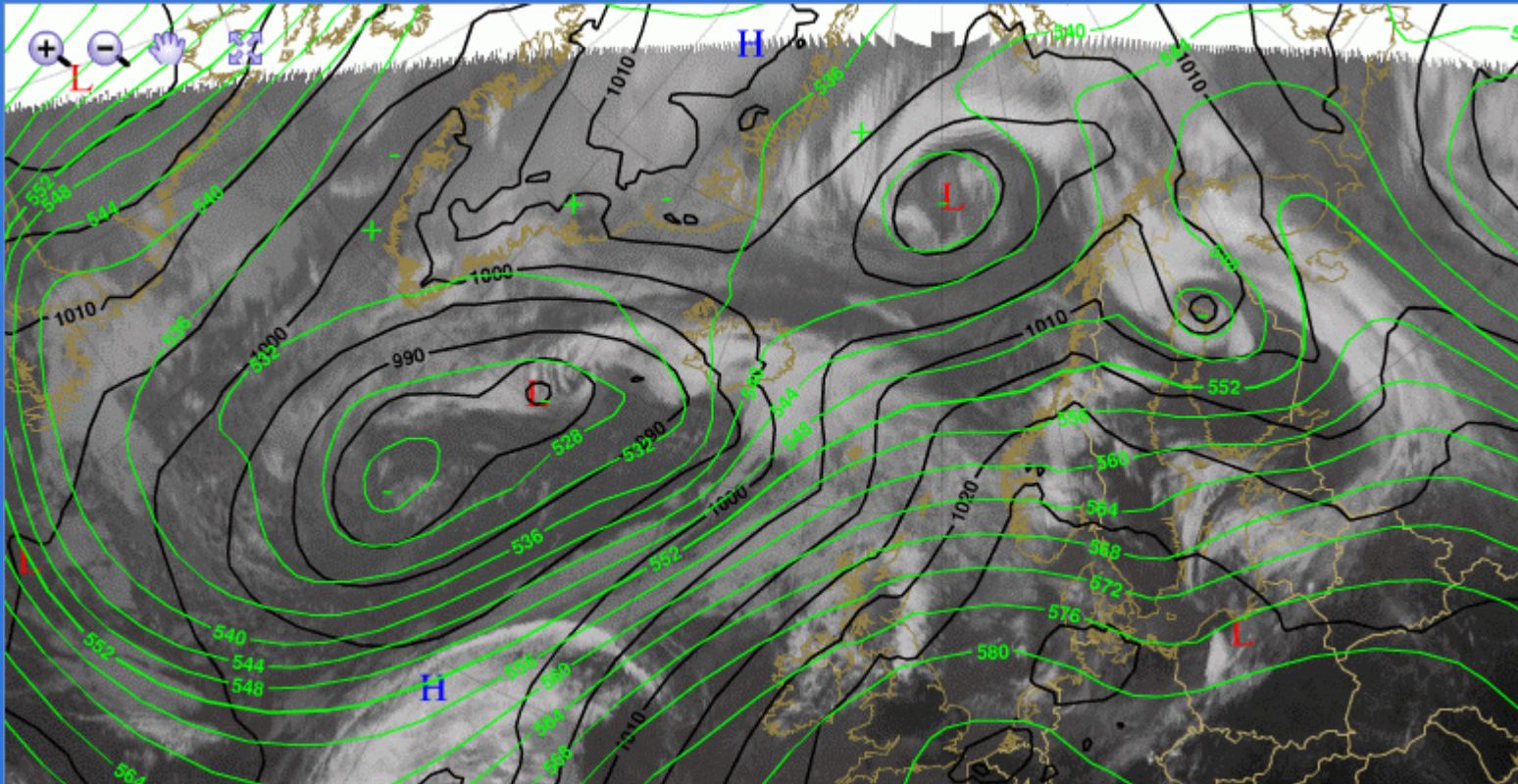
green: H500, black: MSLP

(Präsentation)
12.11.2014 Folie 56



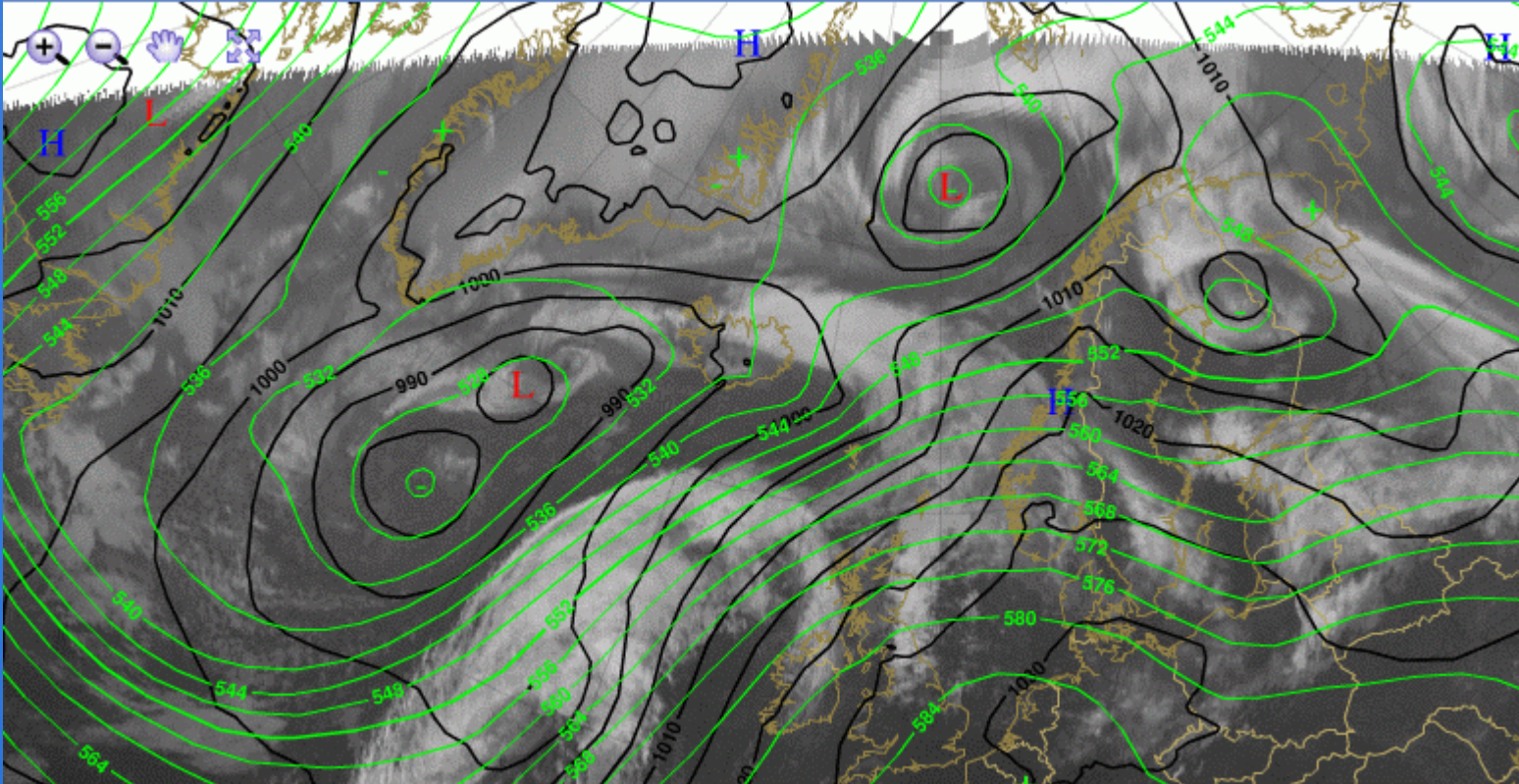
green: H500, black: MSLP

(Präsentation)
12.11.2014 Folie 57



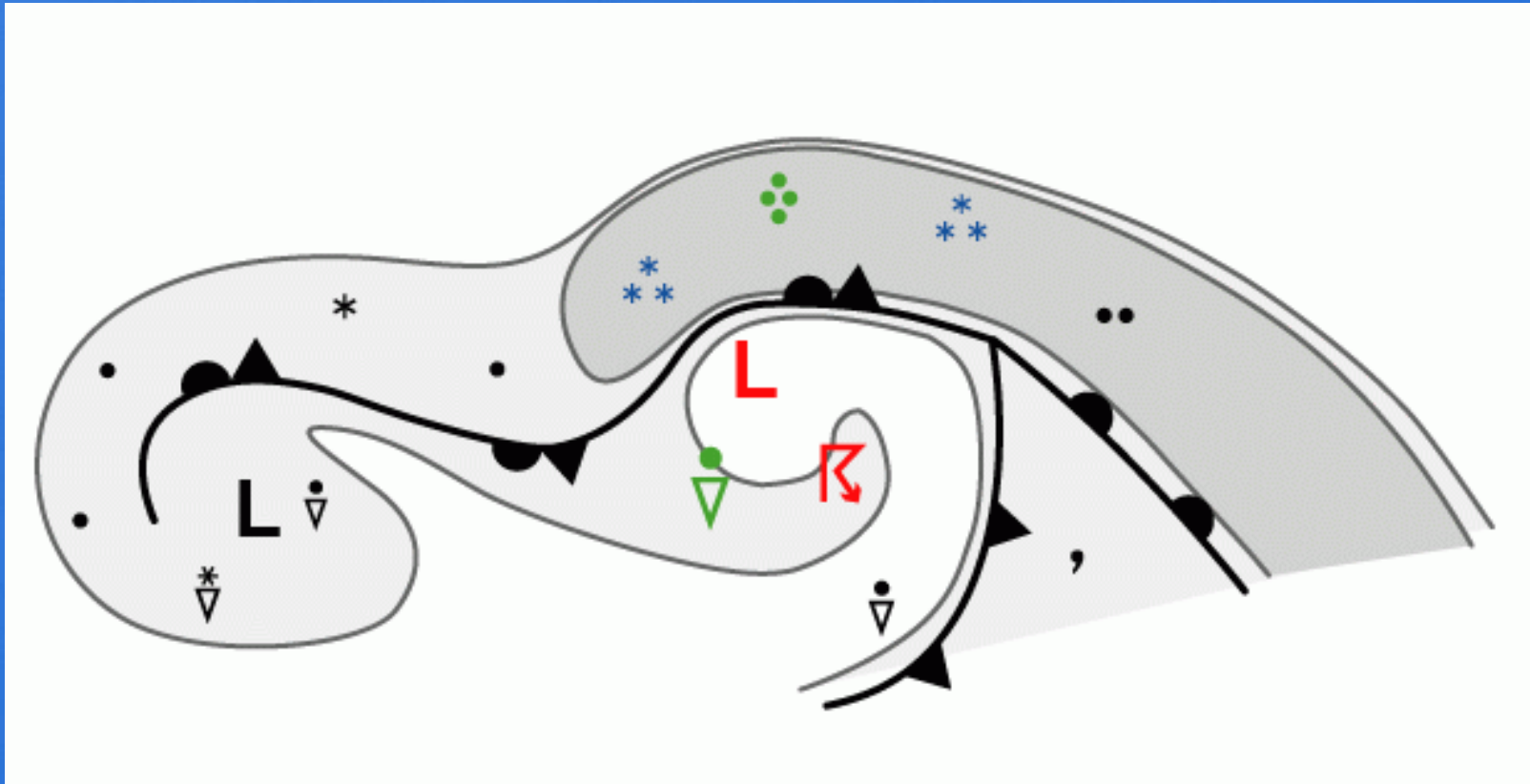
green: H500, black: MSLP

(Präsentation)
12.11.2014 Folie 58



Occlusion 2nd Low: Weather Events

(Präsentation)
12.11.2014 Folie 59



A black and white photograph of a city skyline at night, with the text "The End" overlaid in a white, cursive font. The skyline features several prominent skyscrapers, including the Empire State Building, set against a dark sky. The foreground is dark and out of focus, showing some faint lights and structures.

The End

