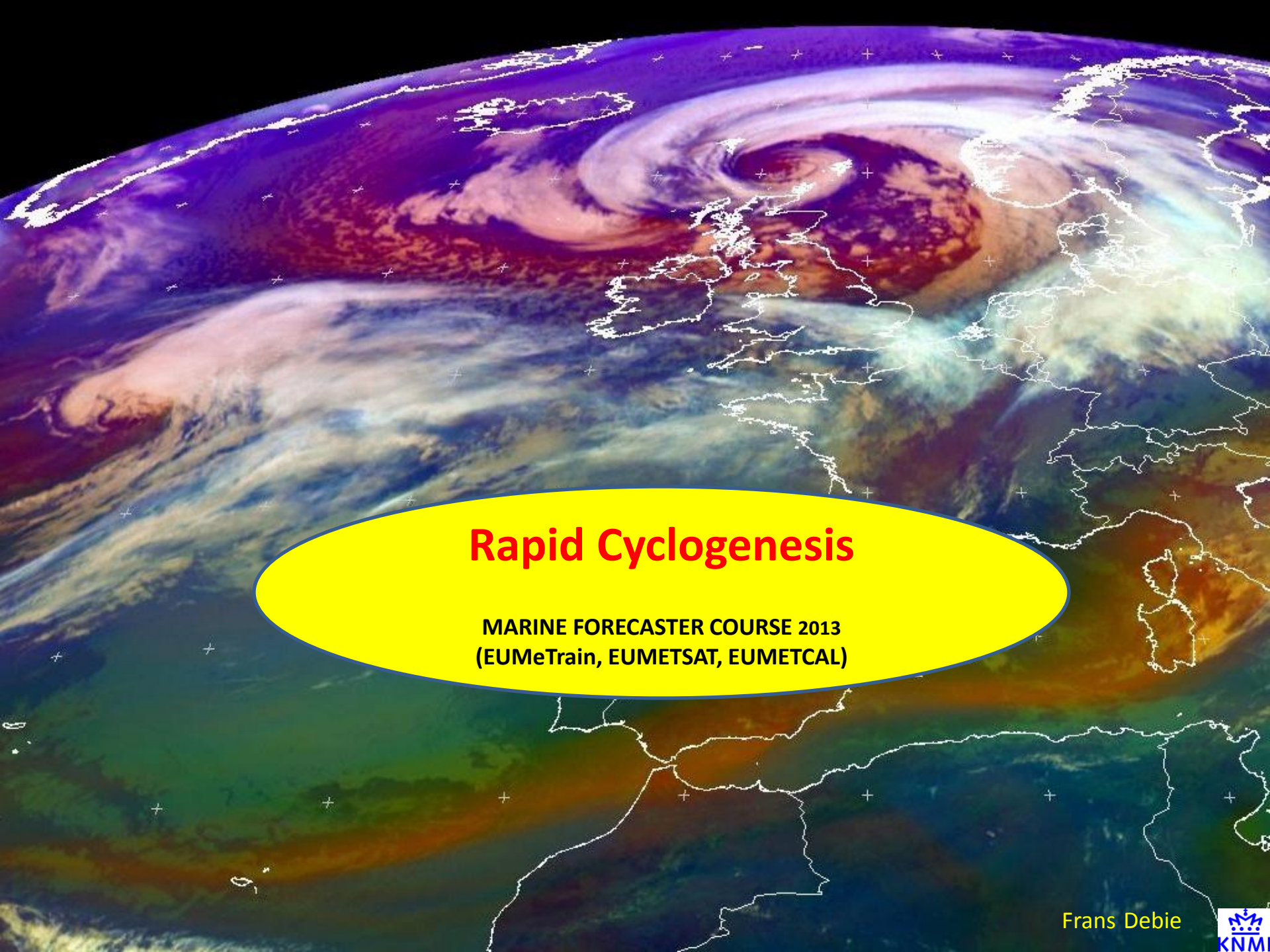


# Rapid Cyclogenesis

**MARINE FORECASTER COURSE 2013**
**(EUMeTrain, EUMETSAT, EUMETCAL)**

Frans Debie

KNMI

# One of the “Satmanu crew”

me

# Definition of Rapid Cyclogenesis

**Cyclogenesis** is the development or strengthening of cyclonic circulation in the atmosphere.

# Definition of Rapid Cyclogenesis

**Cyclogenesis** is the development or strengthening of cyclonic circulation in the atmosphere.

However, in this definition hurricanes, as well as extratropical cyclones, “Comma’s”, **C**old **A**ir **D**evelopments, etc will fit

# Definition of Rapid Cyclogenesis

- **Rapid Cyclogenesis** is the **fast** development or strengthening of cyclonic circulation in the atmosphere.

# Definition of Rapid Cyclogenesis

- **Rapid Cyclogenesis** is the **fast** development or strengthening of cyclonic circulation in the atmosphere

Still e.g. hurricanes wil fit in these definition

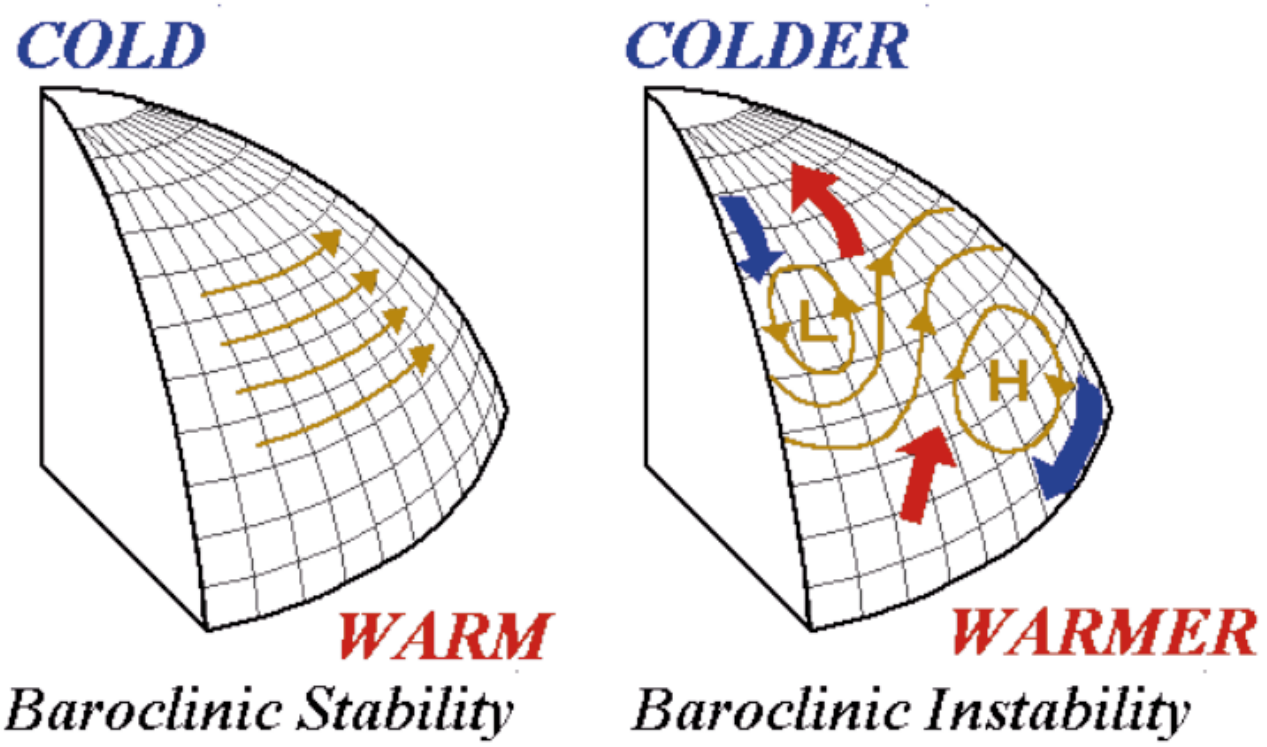
# Definition of Rapid Cyclogenesis

- **Rapid Cyclogenesis** is the **fast** development or strengthening of cyclonic circulation in the atmosphere **outside the tropics, whereby a frontal system is involved**

# Baroclinic instability

- Small disturbances grow through conversion of available potential energy of the background flow into kinetic energy
- Hydrostatic en geostrophic balance lead to a typical spatial scale of disturbances that become unstable first as temperature gradients cross a critical value

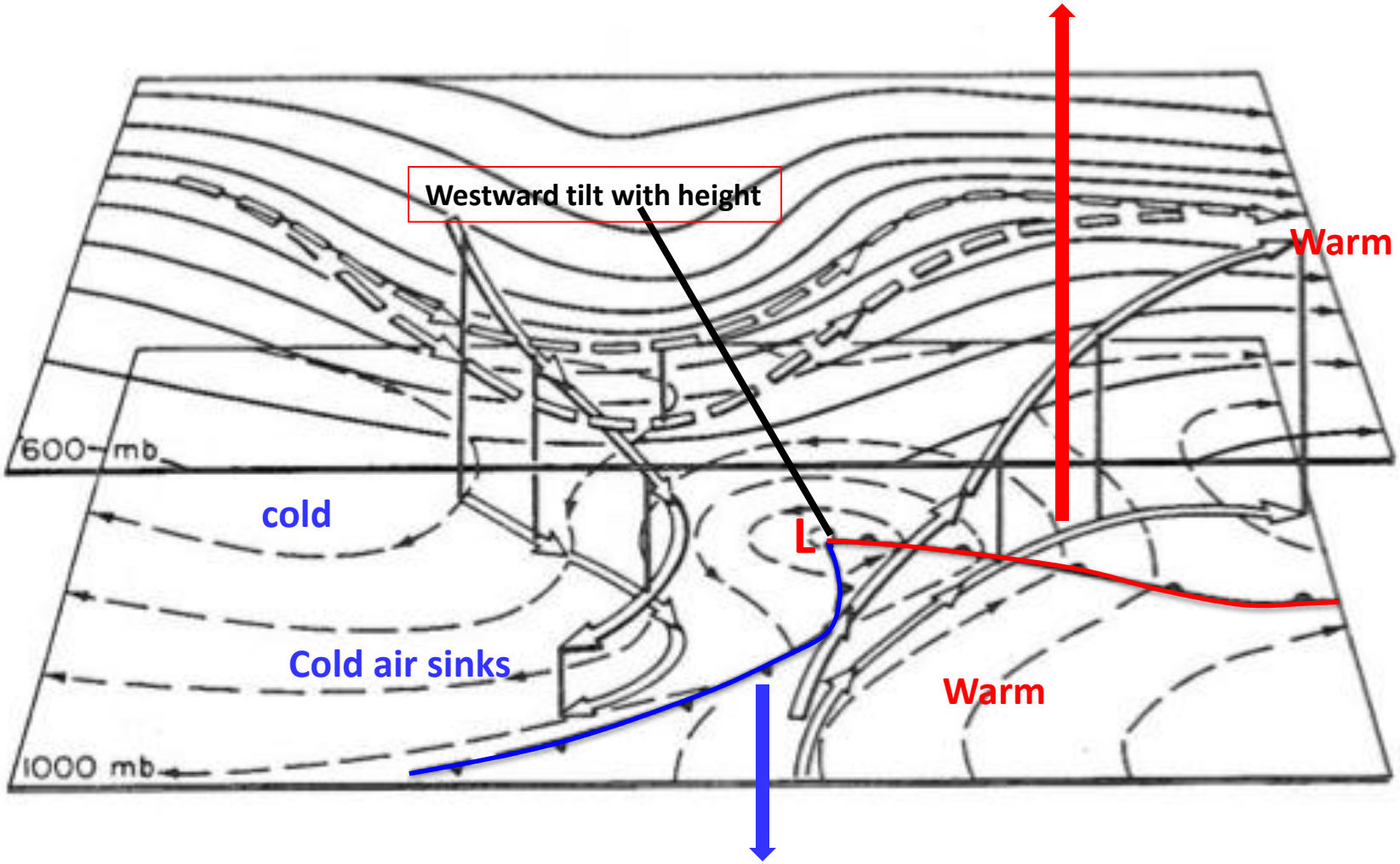
# Baroclinic instability




Instabilities develop if horizontal temperature gradients/ vertical wind shears become too large

# A baroclinically growing wave

warm air is advected underneath the upper air ridge: growth !




cold air is advected underneath the upper air trough: growth !

Starting point:
a **wave** in **polar front**

**How develop a *wave* into a Rapid Cyclogenesis?**

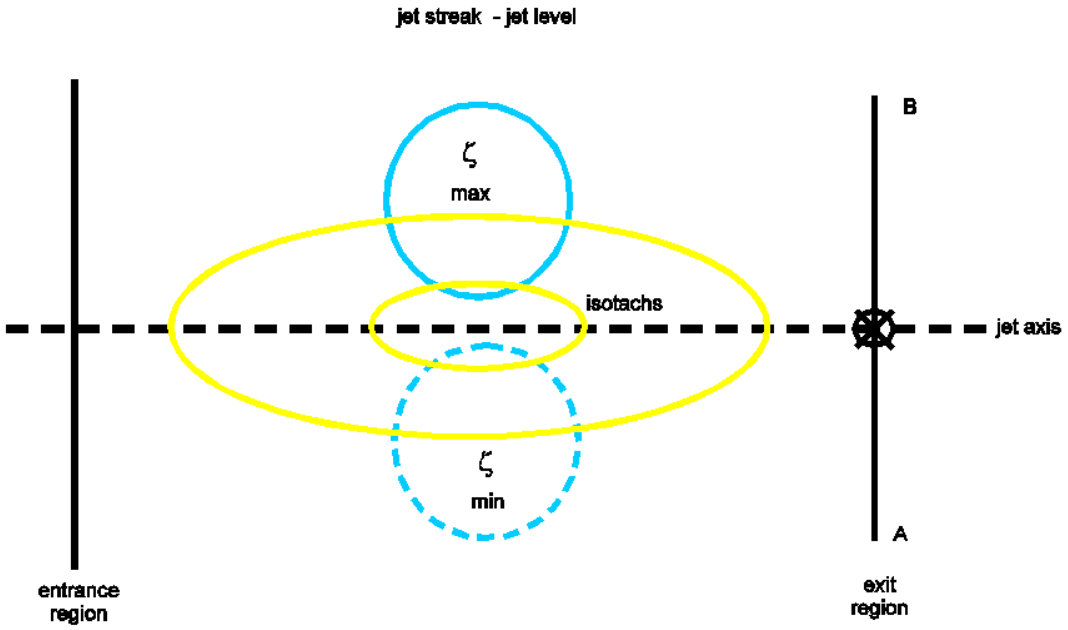
Starting point:

a **wave** in **polar front**

**How develop a wave into a Rapid Cyclogenesis?**

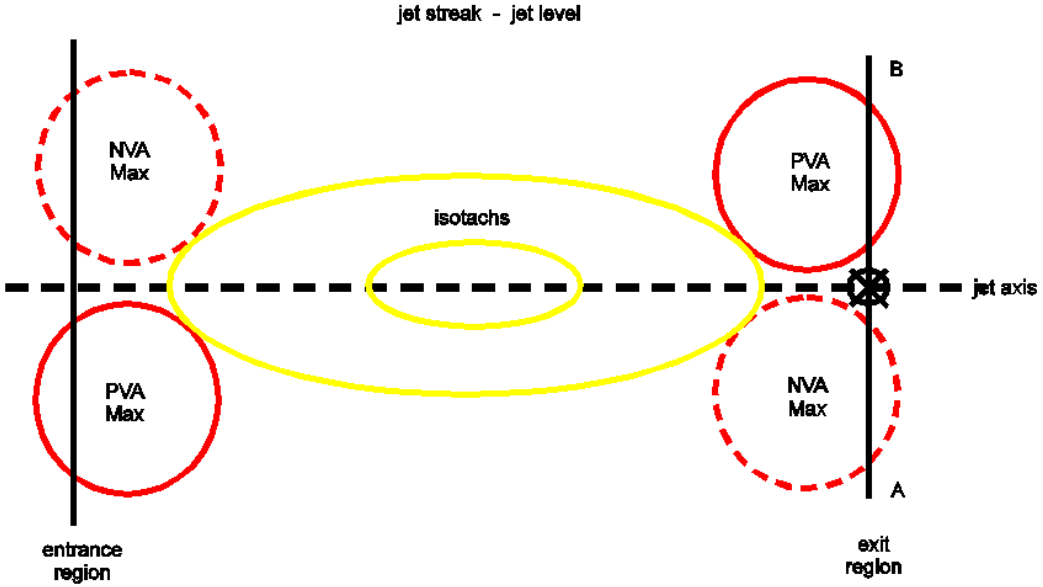
**Which *physical processes* can tribute to trigger a RaCy ?**

# A) Physical processes with Polar Jet

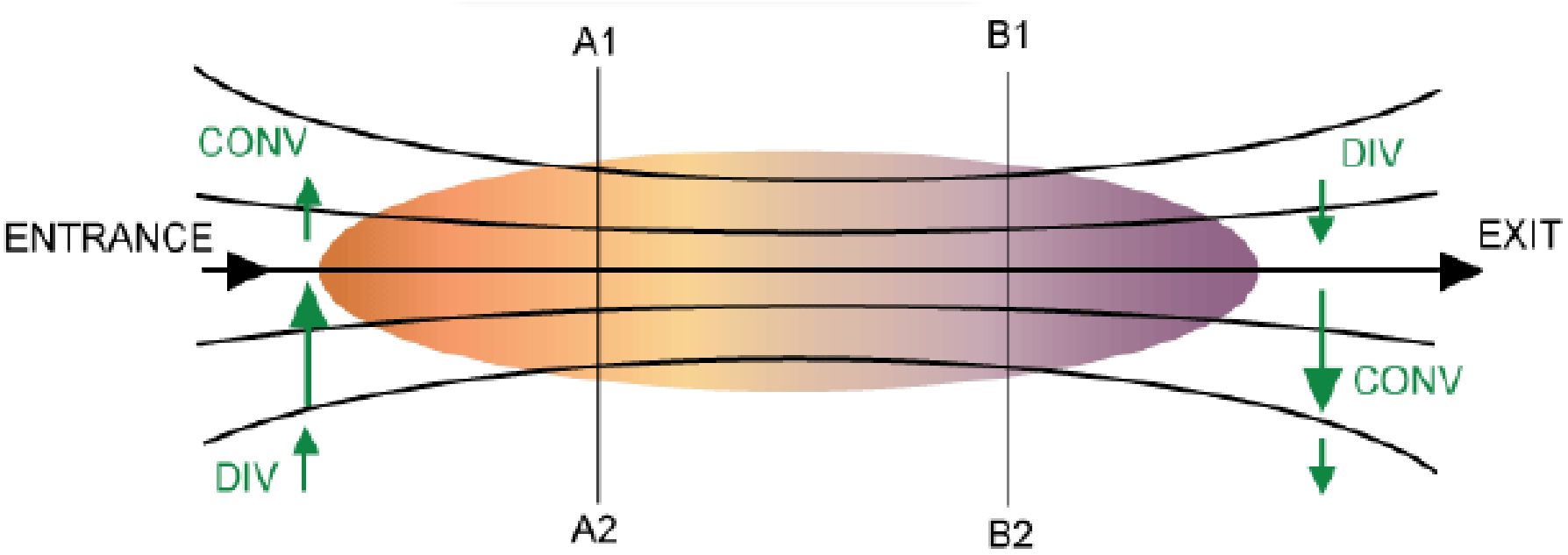


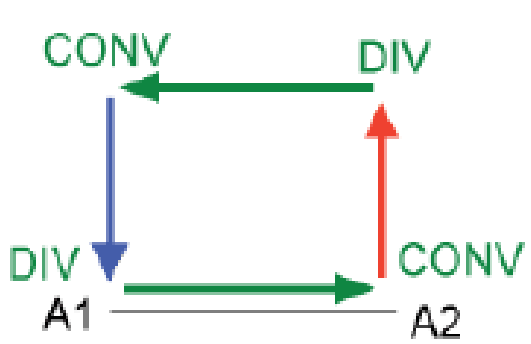

Shear vorticity

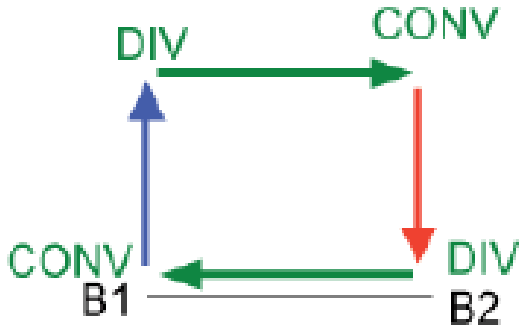
Shear vorticity advection



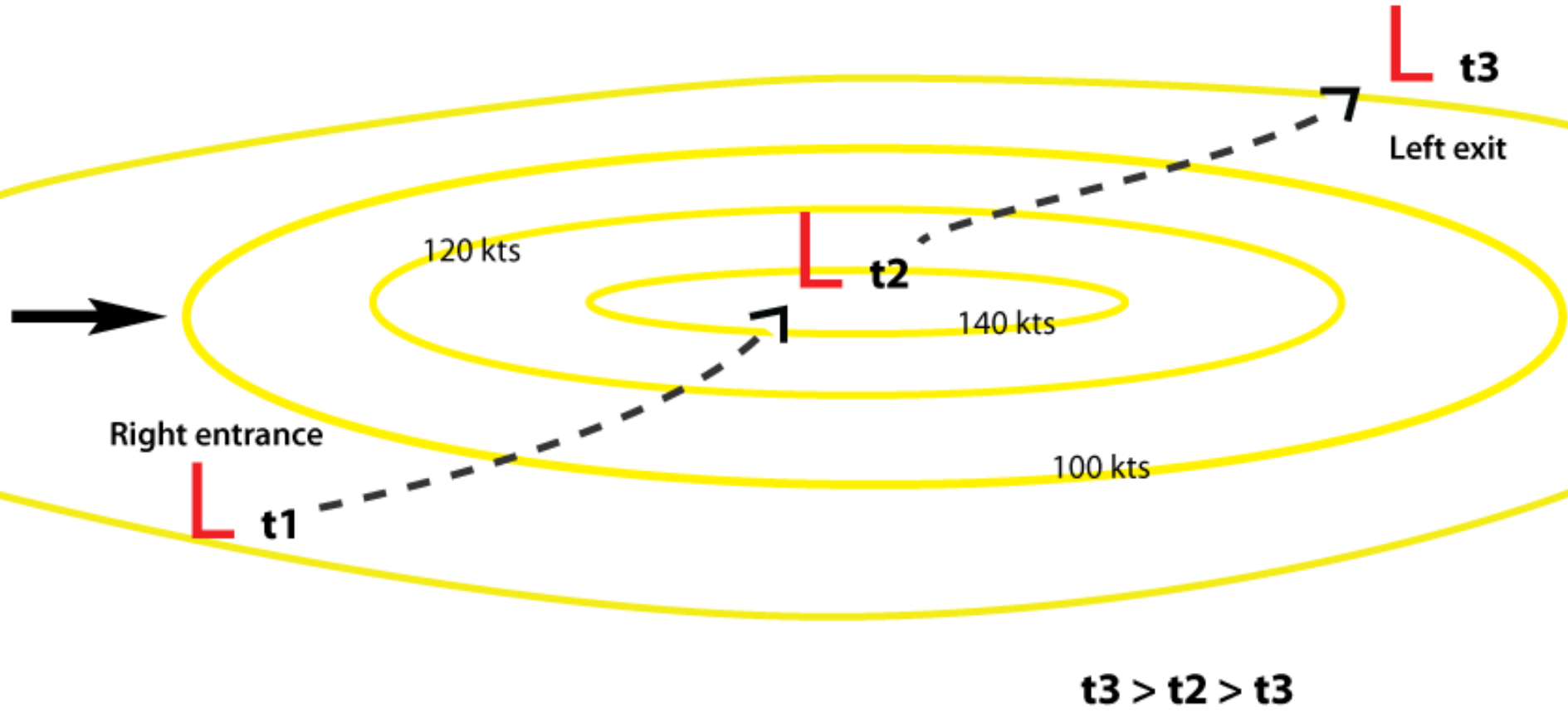
# Jet entrance and exit region



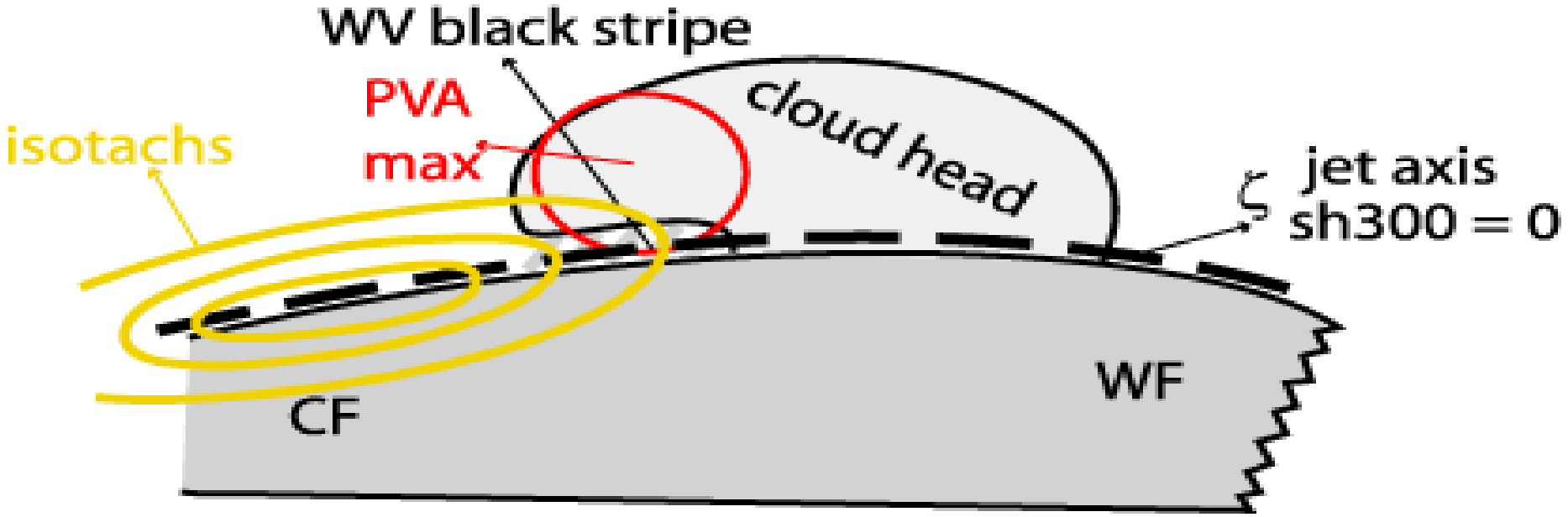



Jet streak with isotachs at 300 hPa
and
displacement of surface Low




t3 > t2 > t3




jet axis along rear side of CF-WF system

jet streak with left exit region at cloud head

PVA max in left exit region of jet streak over cloud head

# B) Physical processes with PV anomaly

# Potential Vorticity

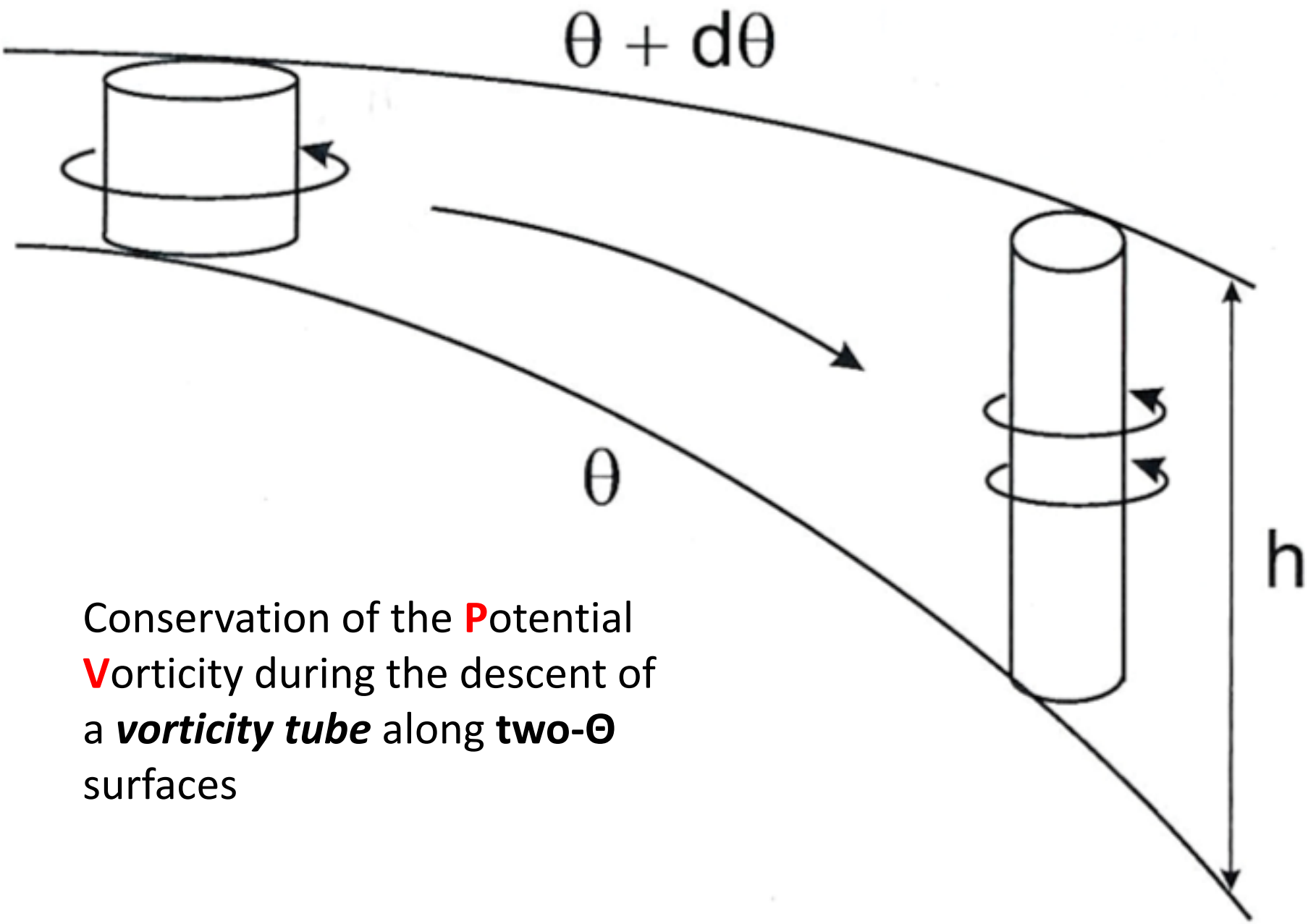
$$PV = (\zeta + f)\left(-g\frac{\partial\theta}{\partial p}\right) = \frac{\zeta_\theta + f}{\sigma}$$

$$\sigma = -\frac{1}{g}\cdot\frac{\partial p}{\partial\theta}$$

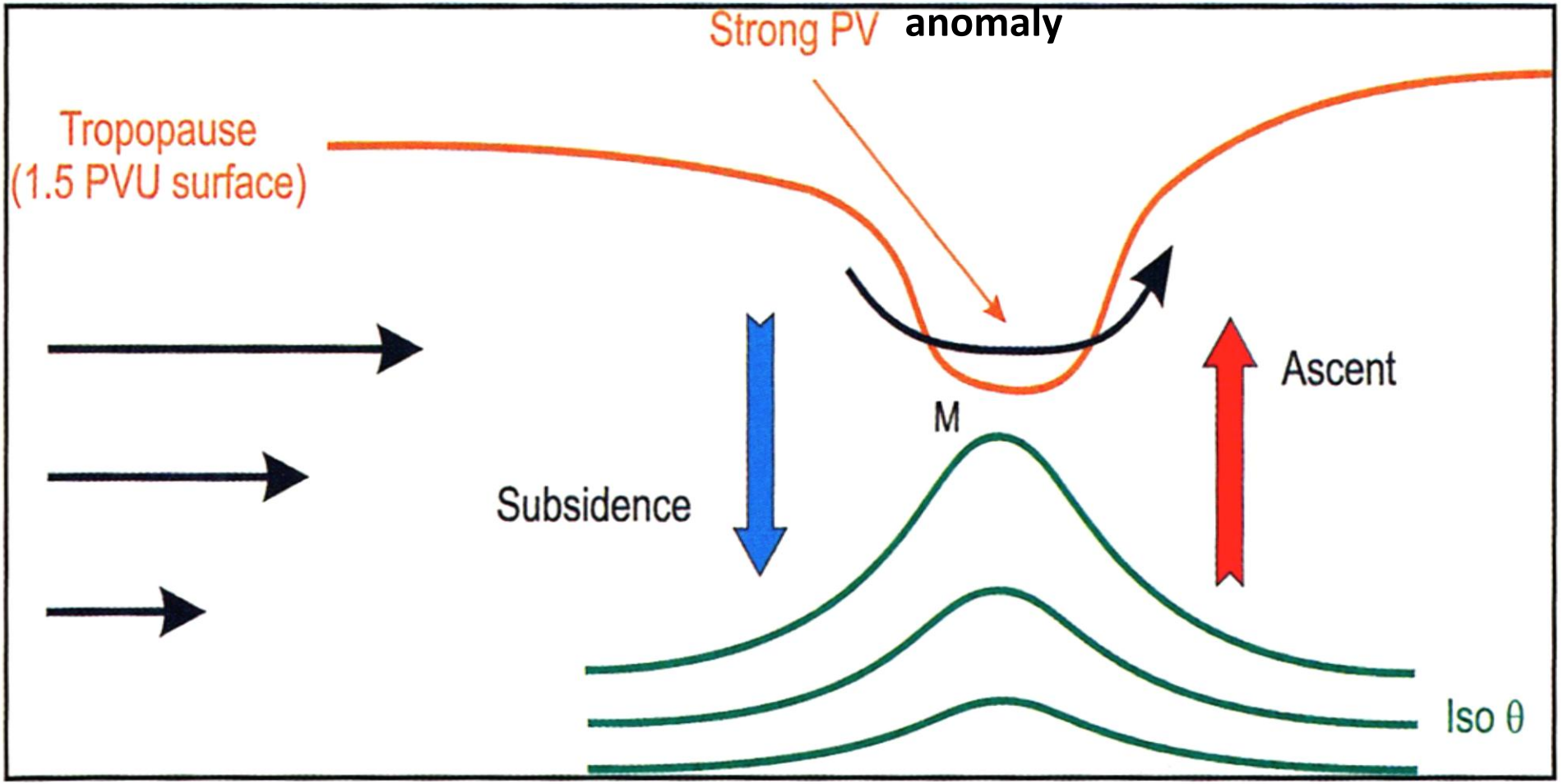
stability

| | |
|---|---|
| f | Coriolis parameter |
| g | gravitational acceleration |
| p | pressure |
| PV | potential vorticity |
| $\Theta$ | potential temperature |
| $\zeta_\Theta$ | relative isentropic vorticity |

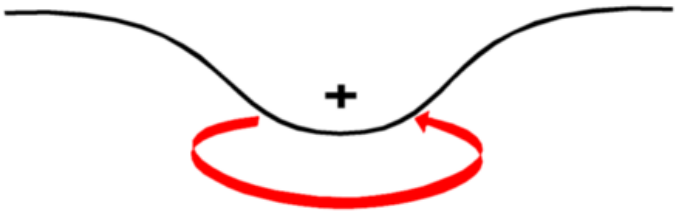
$$\frac{10^{-6}\cdot K\cdot m^2}{kg\cdot s} \equiv 1PVU$$

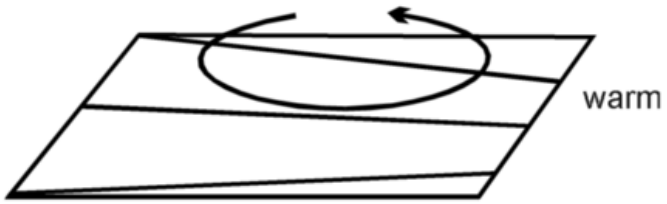



Conservation of the **P**otential **V**orticity during the descent of a ***vorticity tube*** along **two-Θ** surfaces

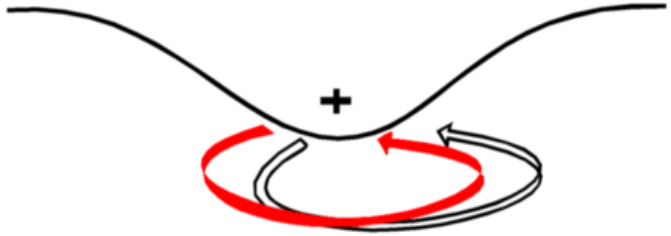


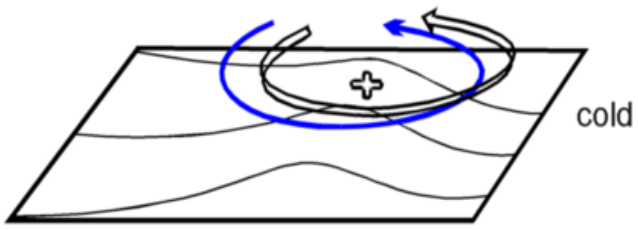

A schematic cross section, showing an idealized model of the modification of the troposphere associated with an upper-level positive **PV anomaly**, referred to as a tropopause dynamic anomaly



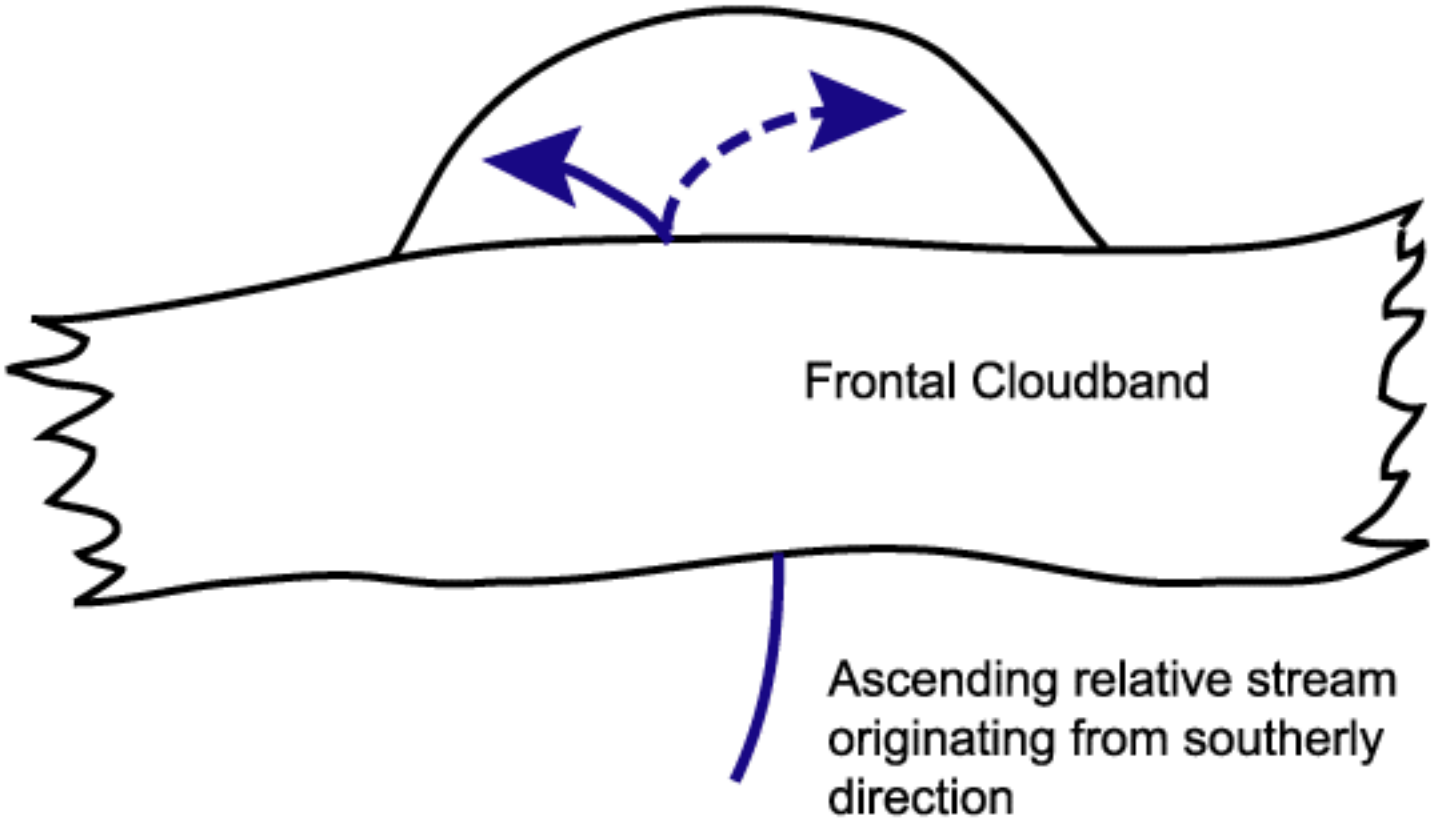

a



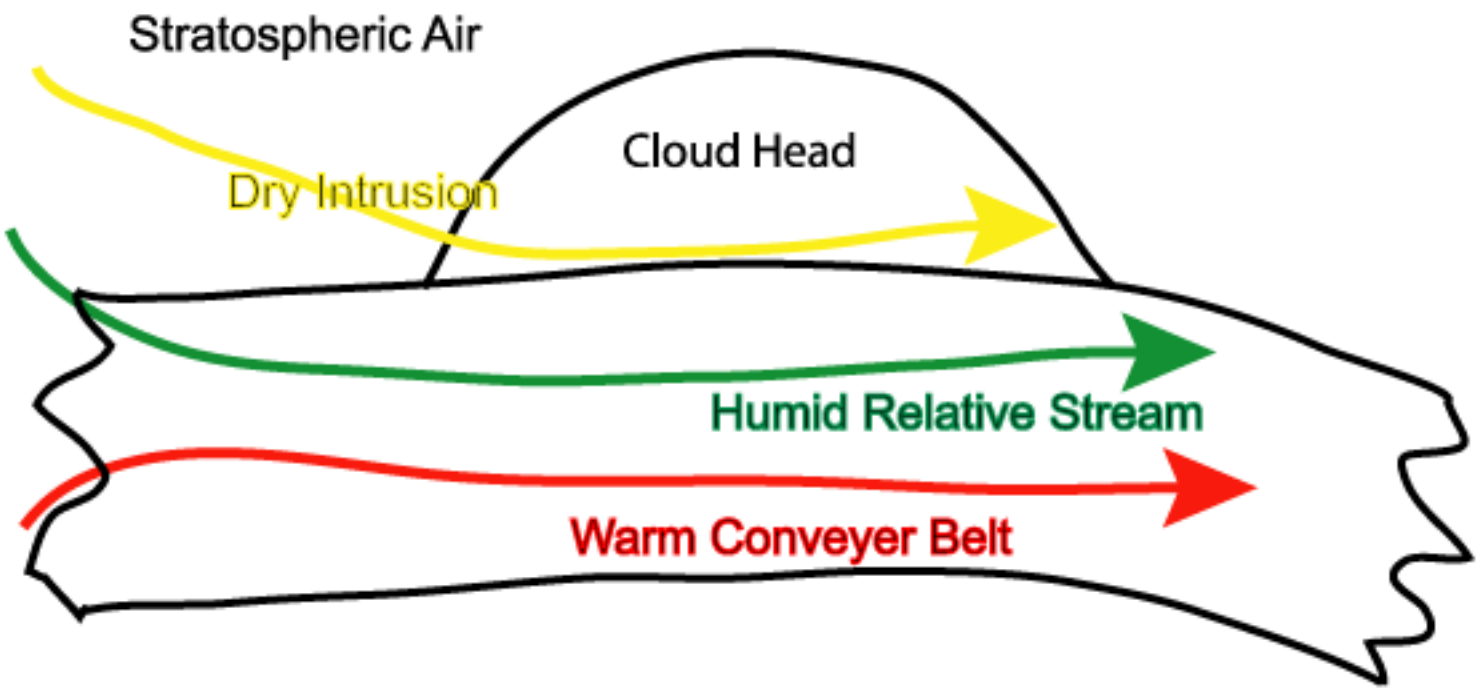




b

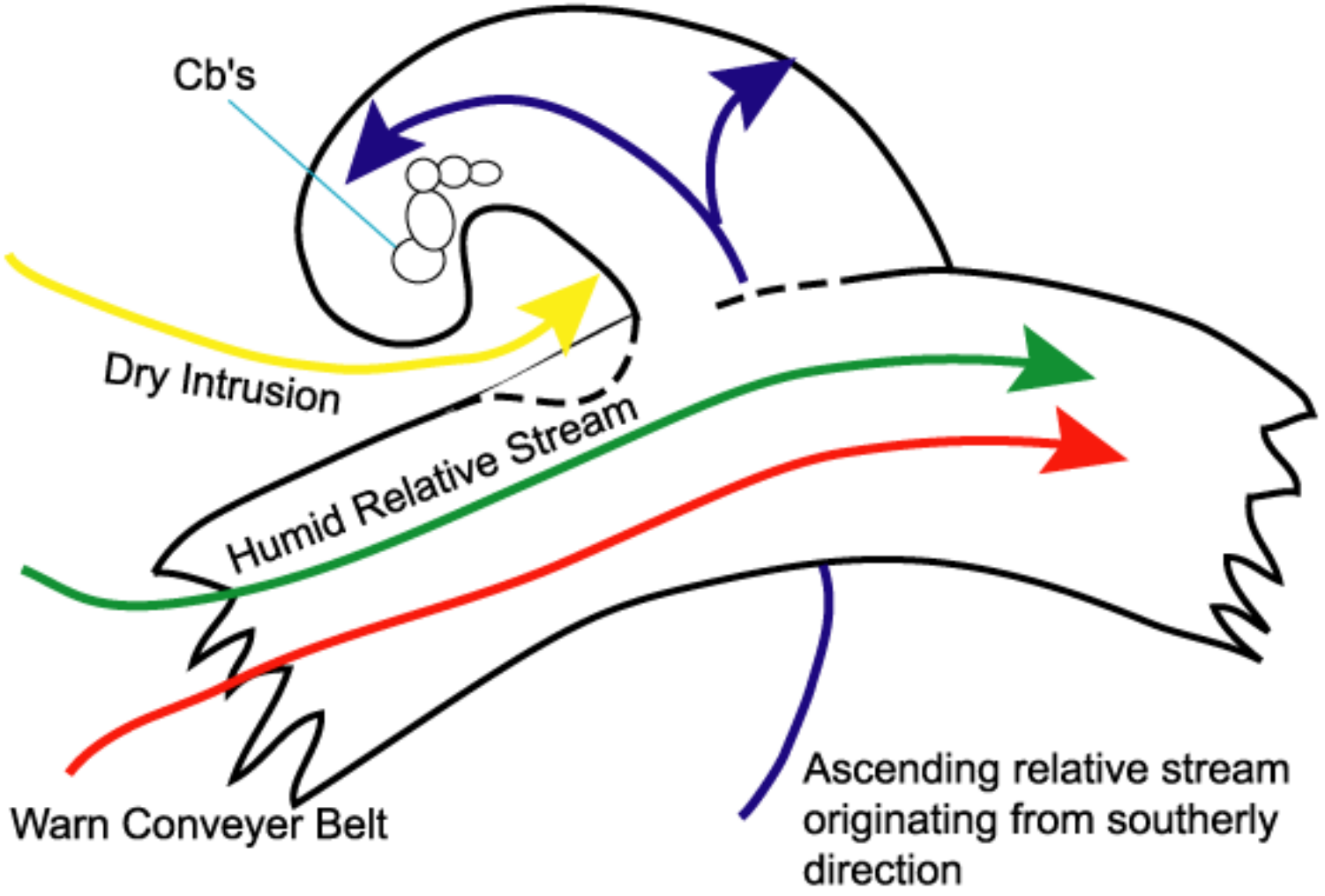
# Initial stage

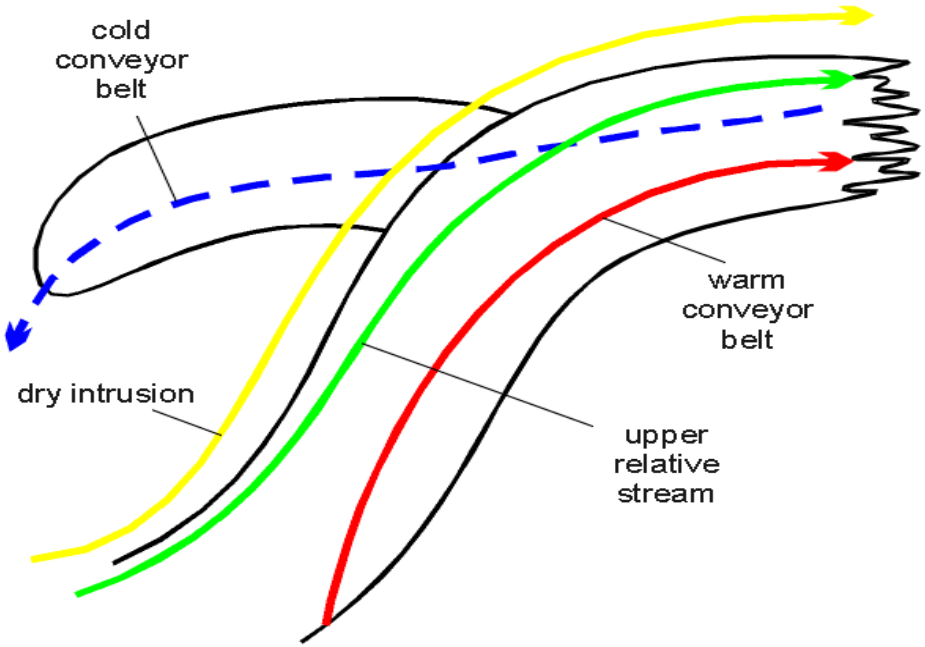


# Initial stage



# Advanced stage

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warm
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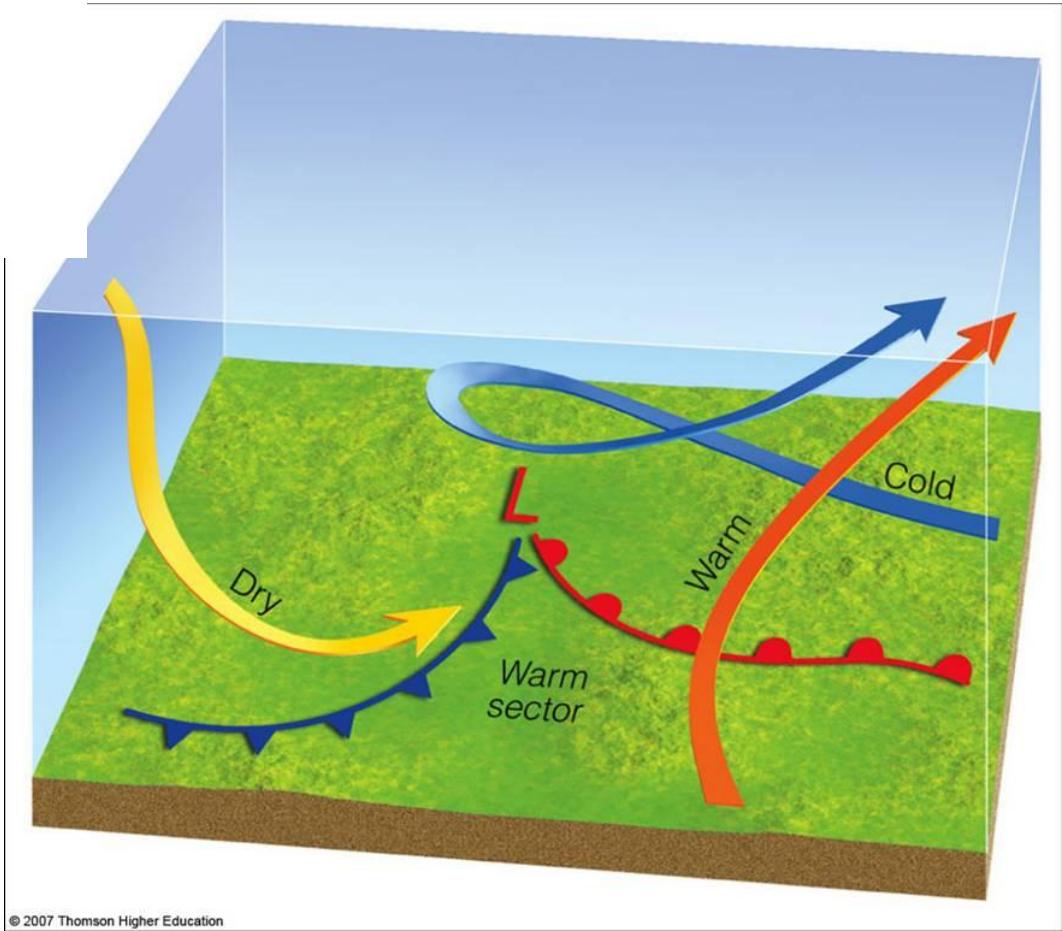
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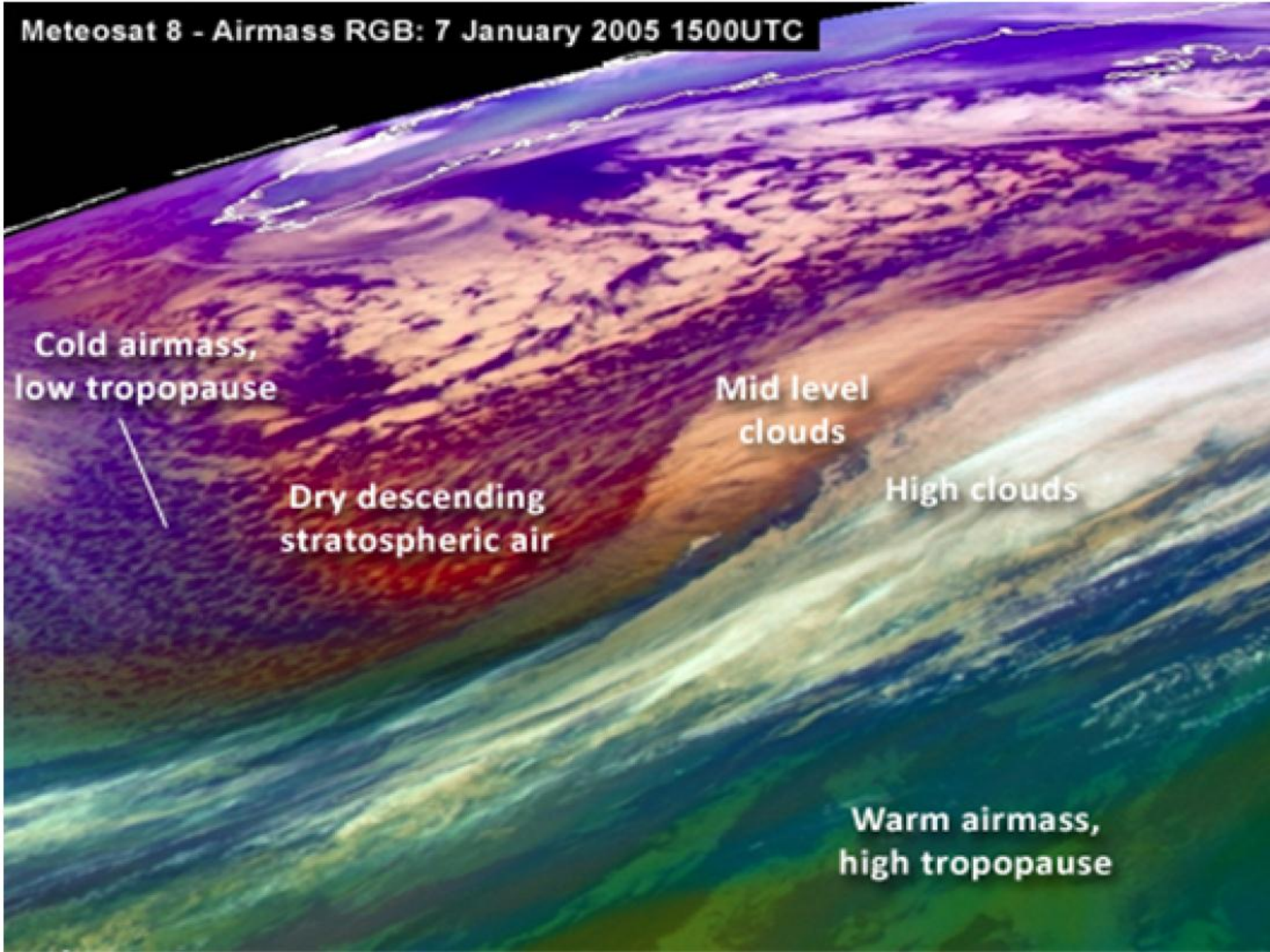
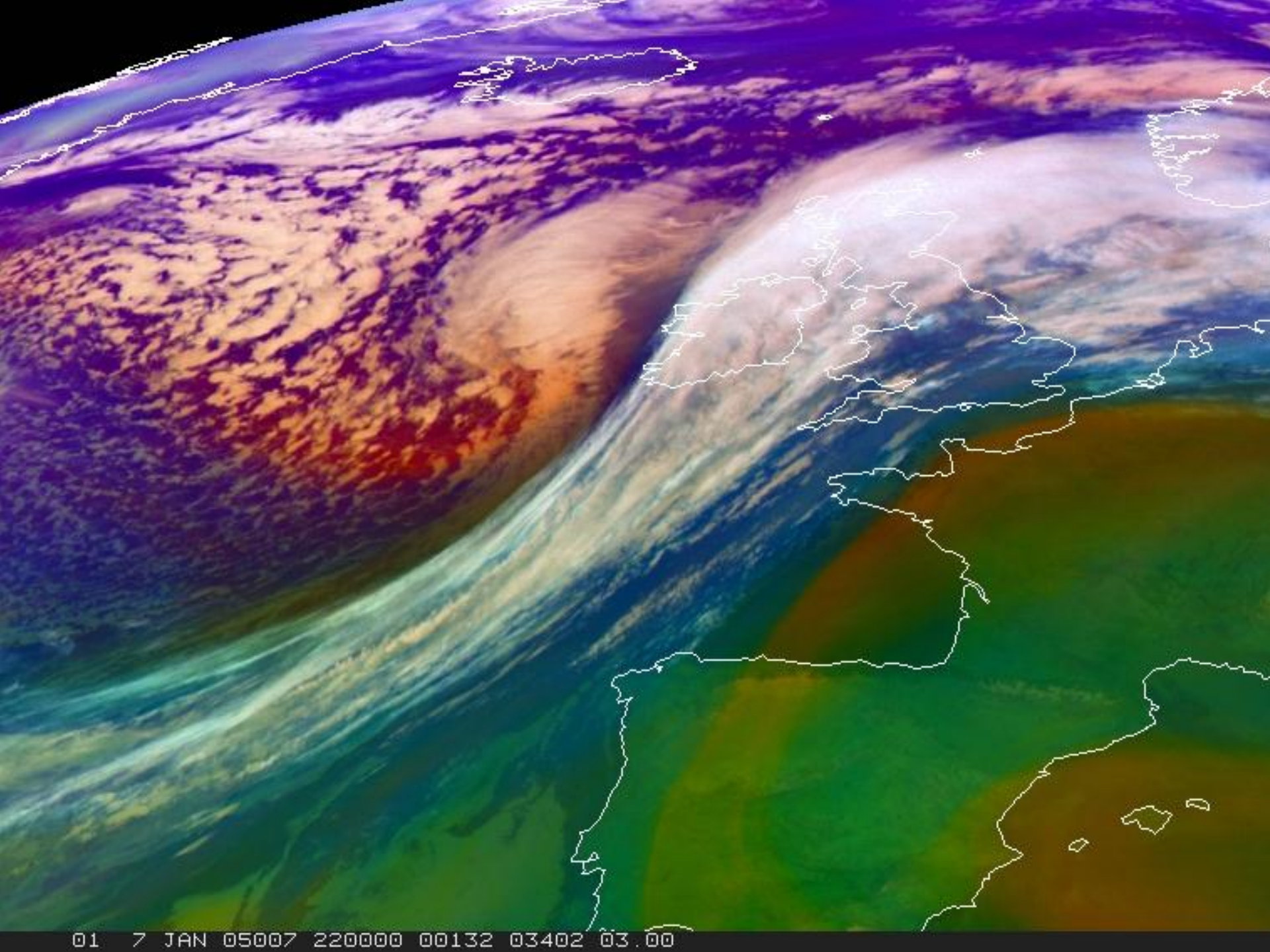
© 2007 Thomson Higher Education


Meteosat 8 - Airmass RGB: 7 January 2005 1500UTC
Cold airmass,
low tropopause
Dry descending
stratospheric air
Mid level
clouds
High clouds
Warm airmass,
high tropopause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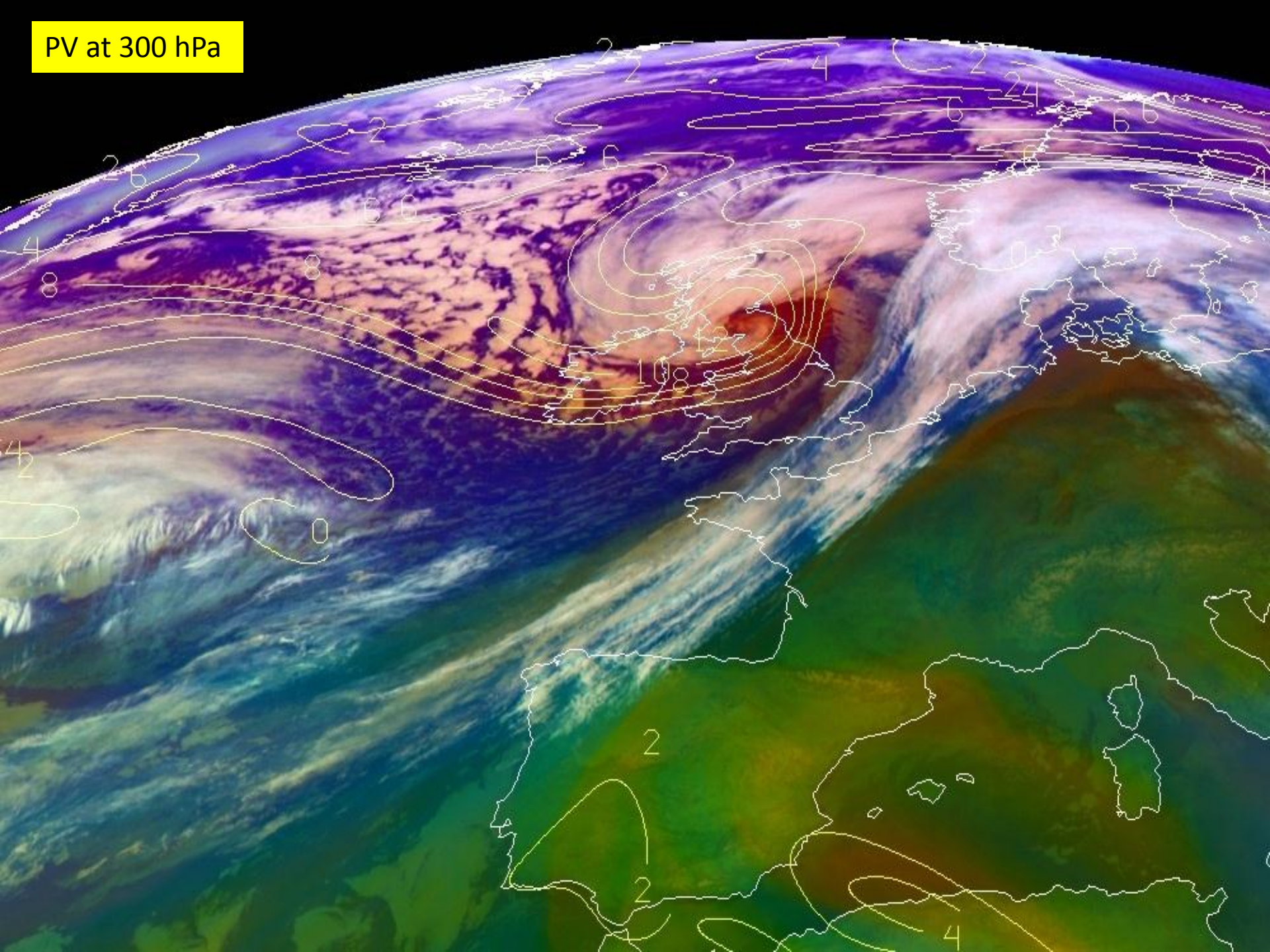
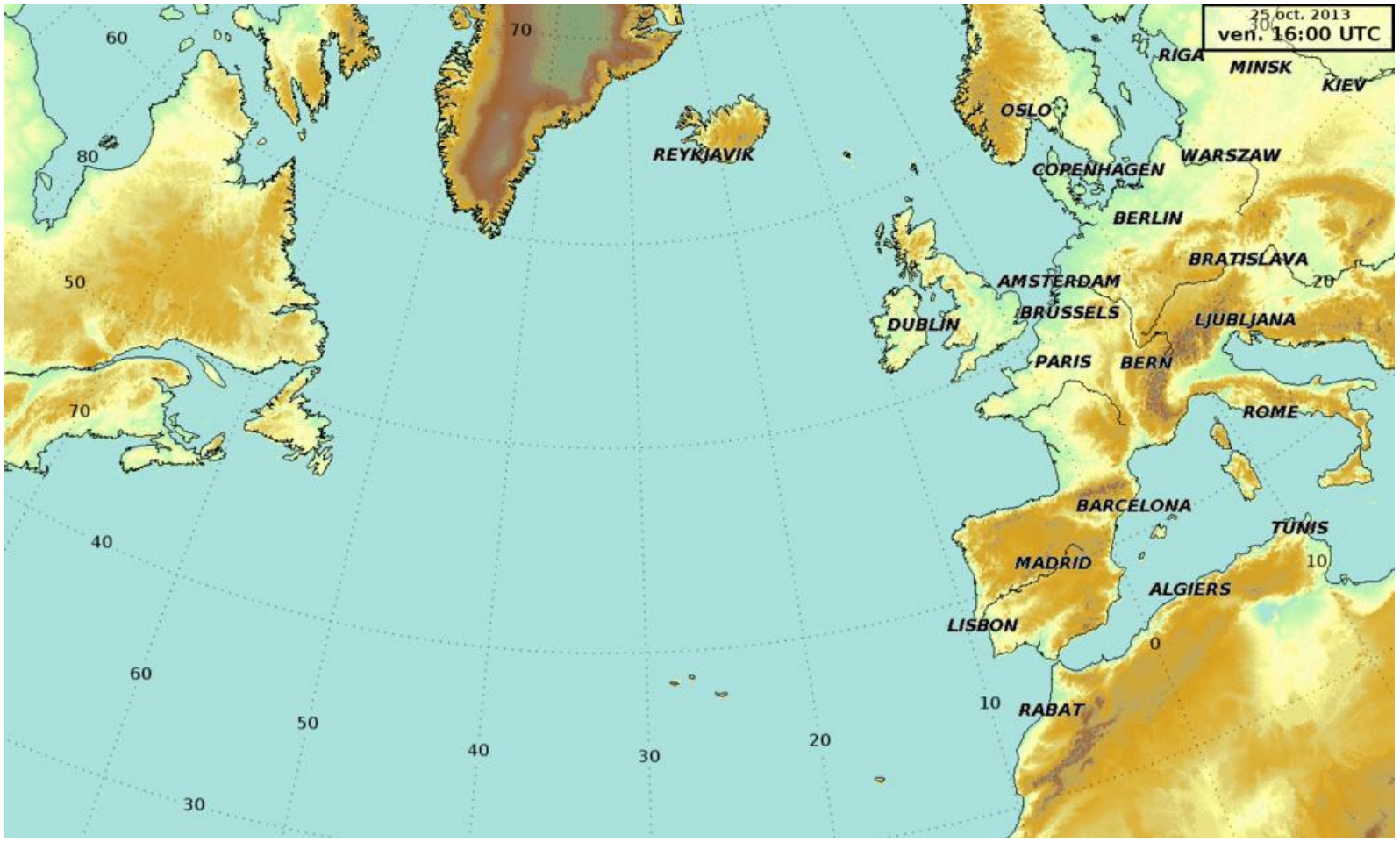
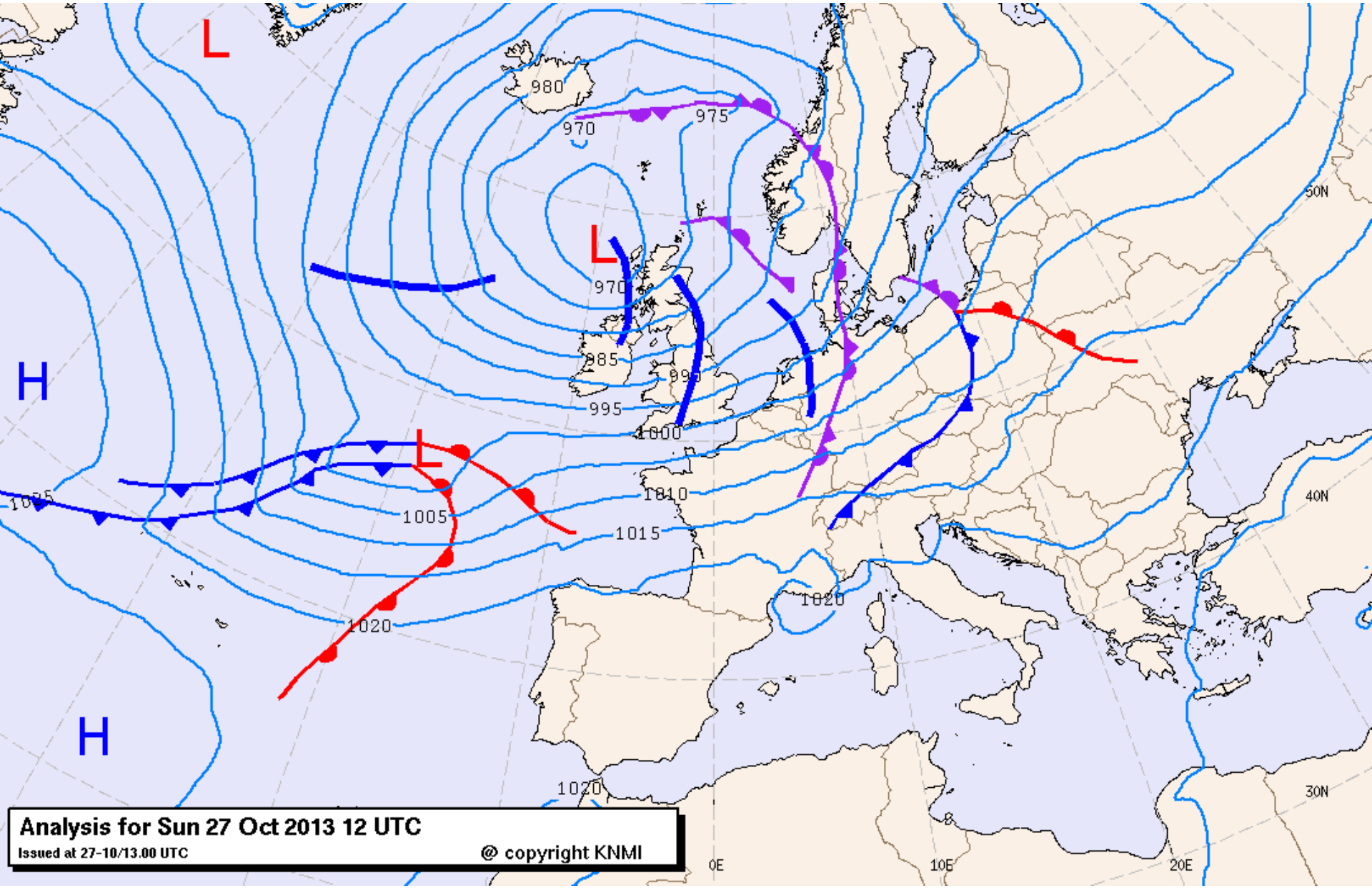

PV at 300 hPa

# Example of RACY
# North Atlantic Ocean and North Sea




# "St Jude" storm or cyclone "Christian"

(27/28 October 2013)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Analysis for Sun 27 Oct 2013 12 UTC
Issued at 27-10/13.00 UTC
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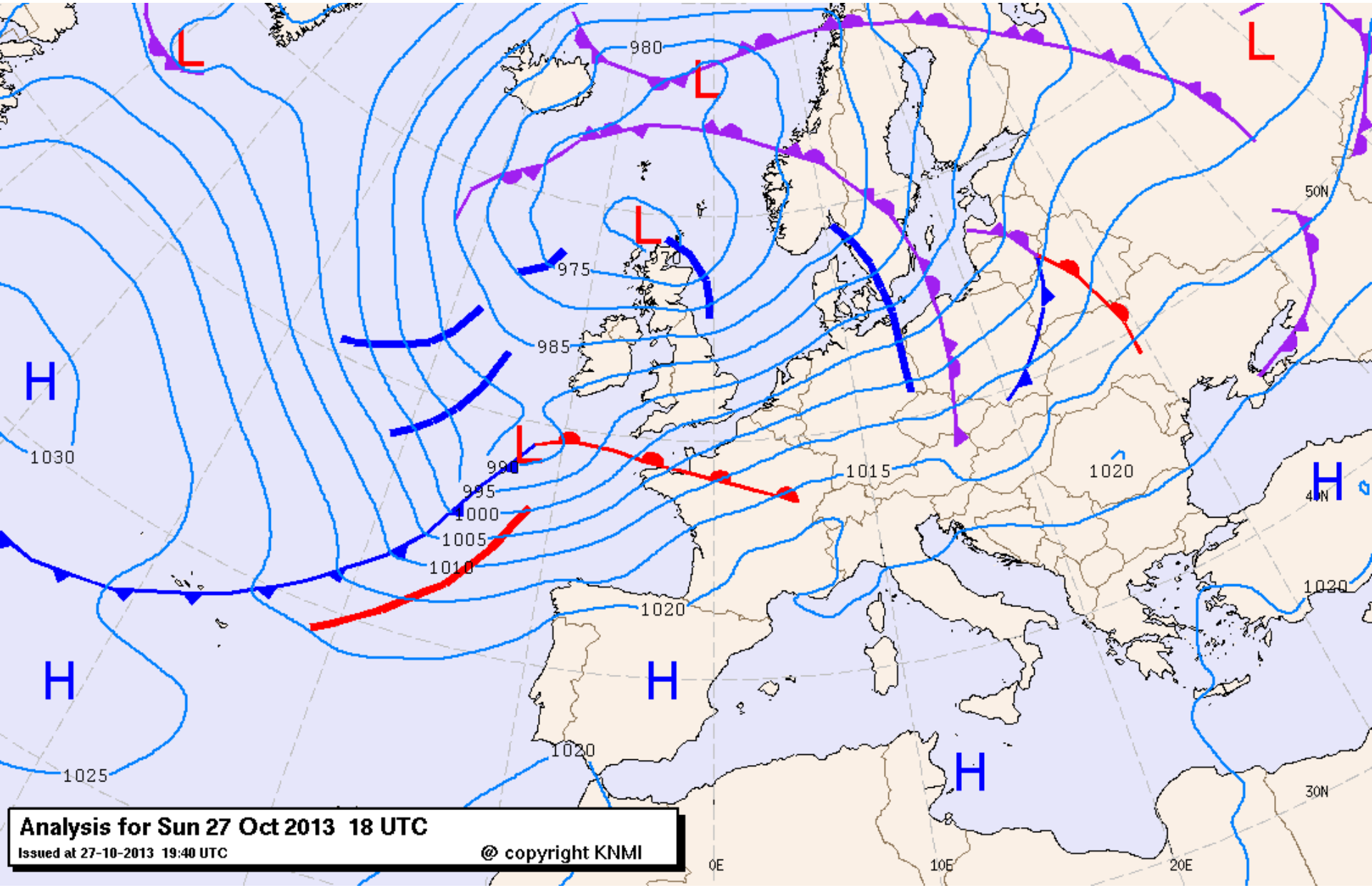
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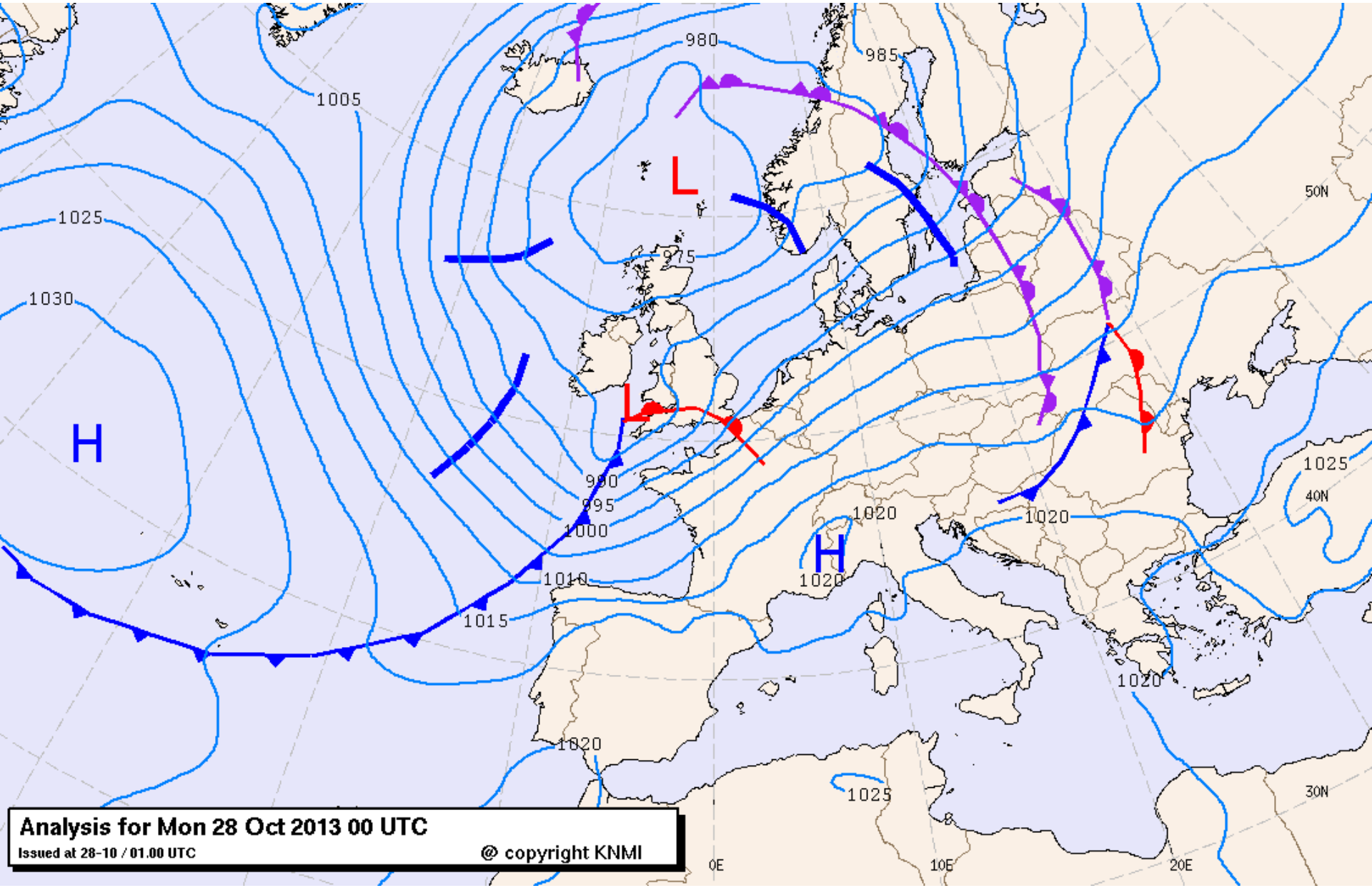
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Analysis for Mon 28 Oct 2013 00 UTC
Issued at 28-10 / 01.00 UTC
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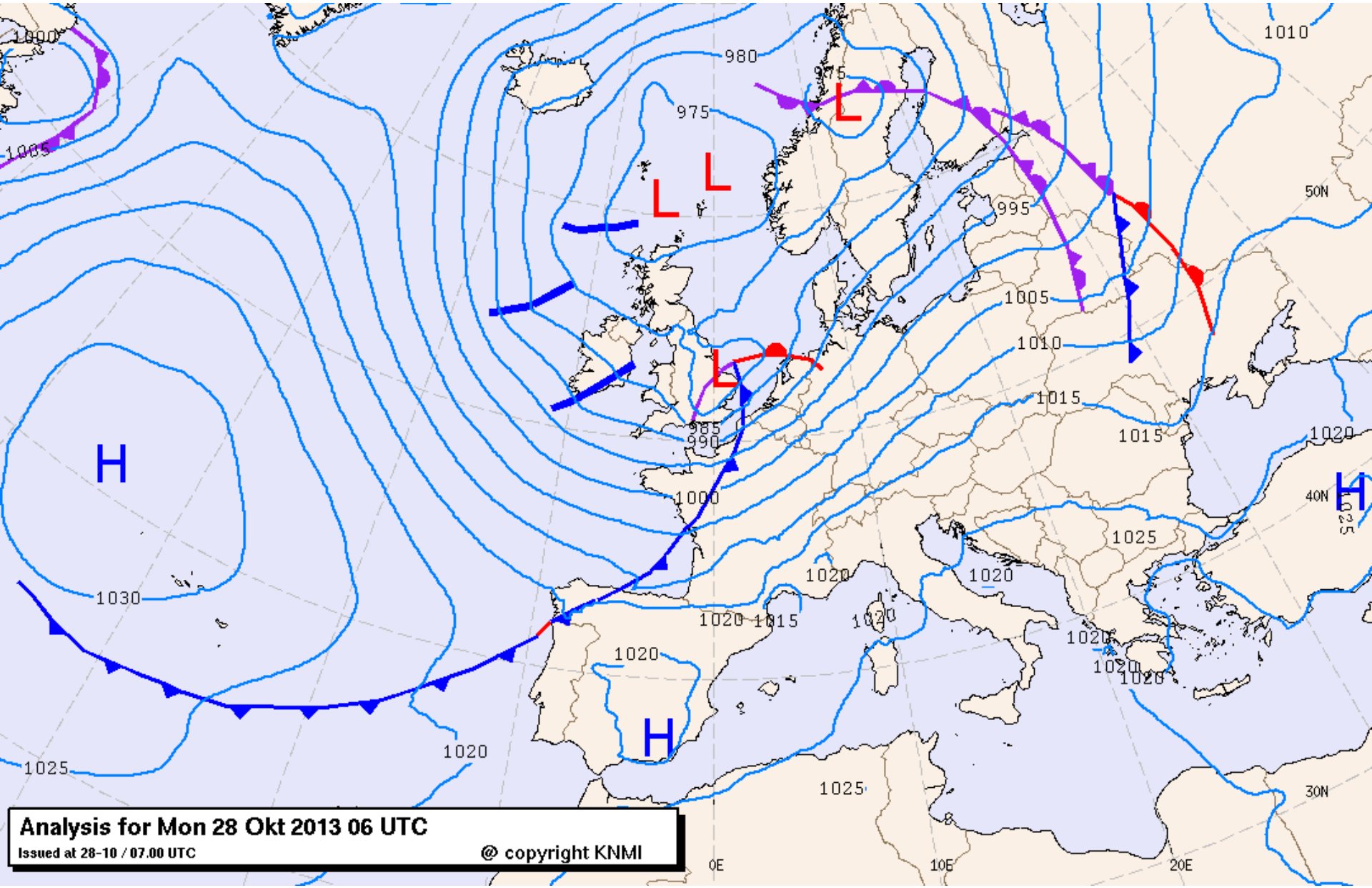
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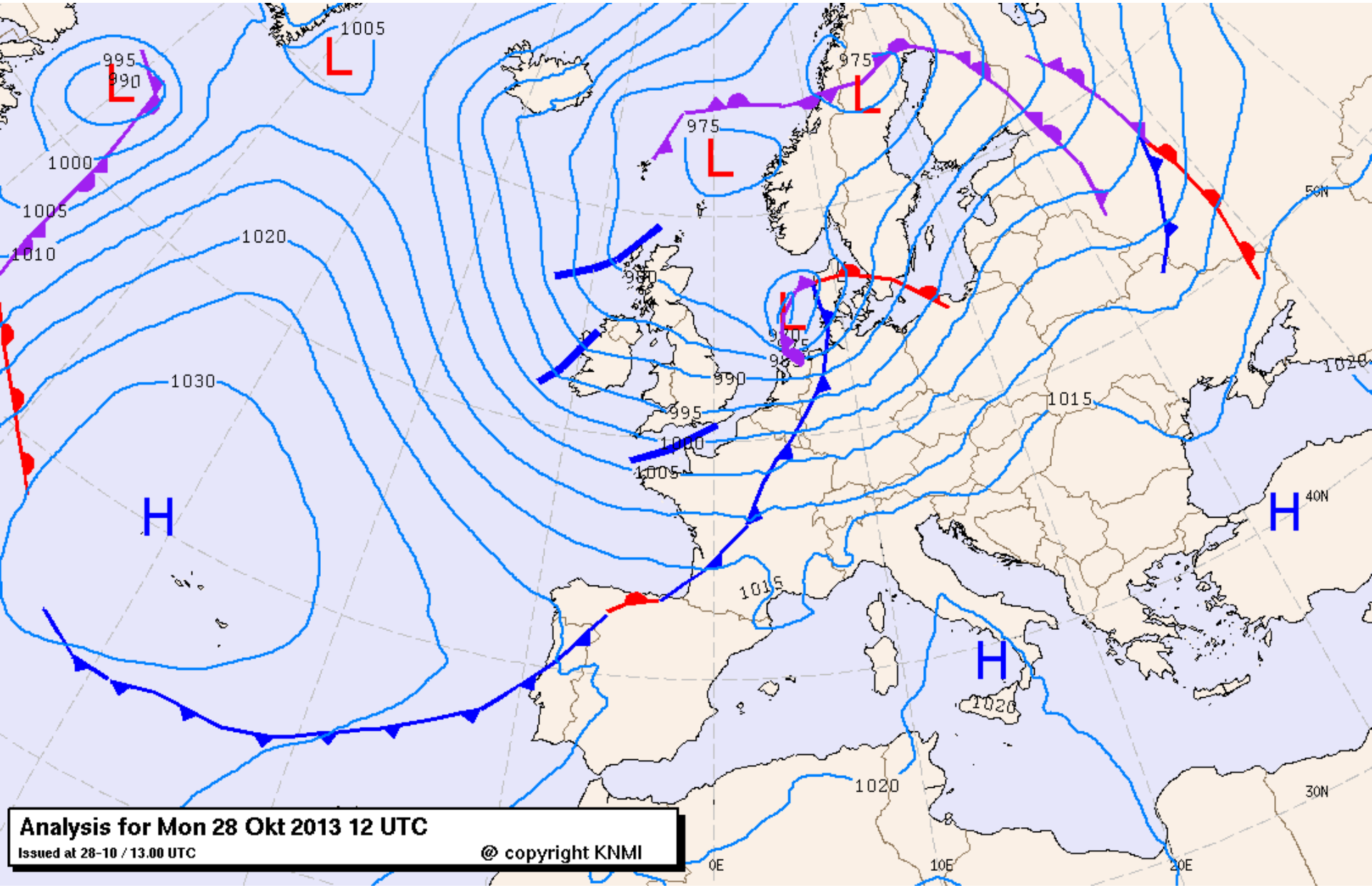
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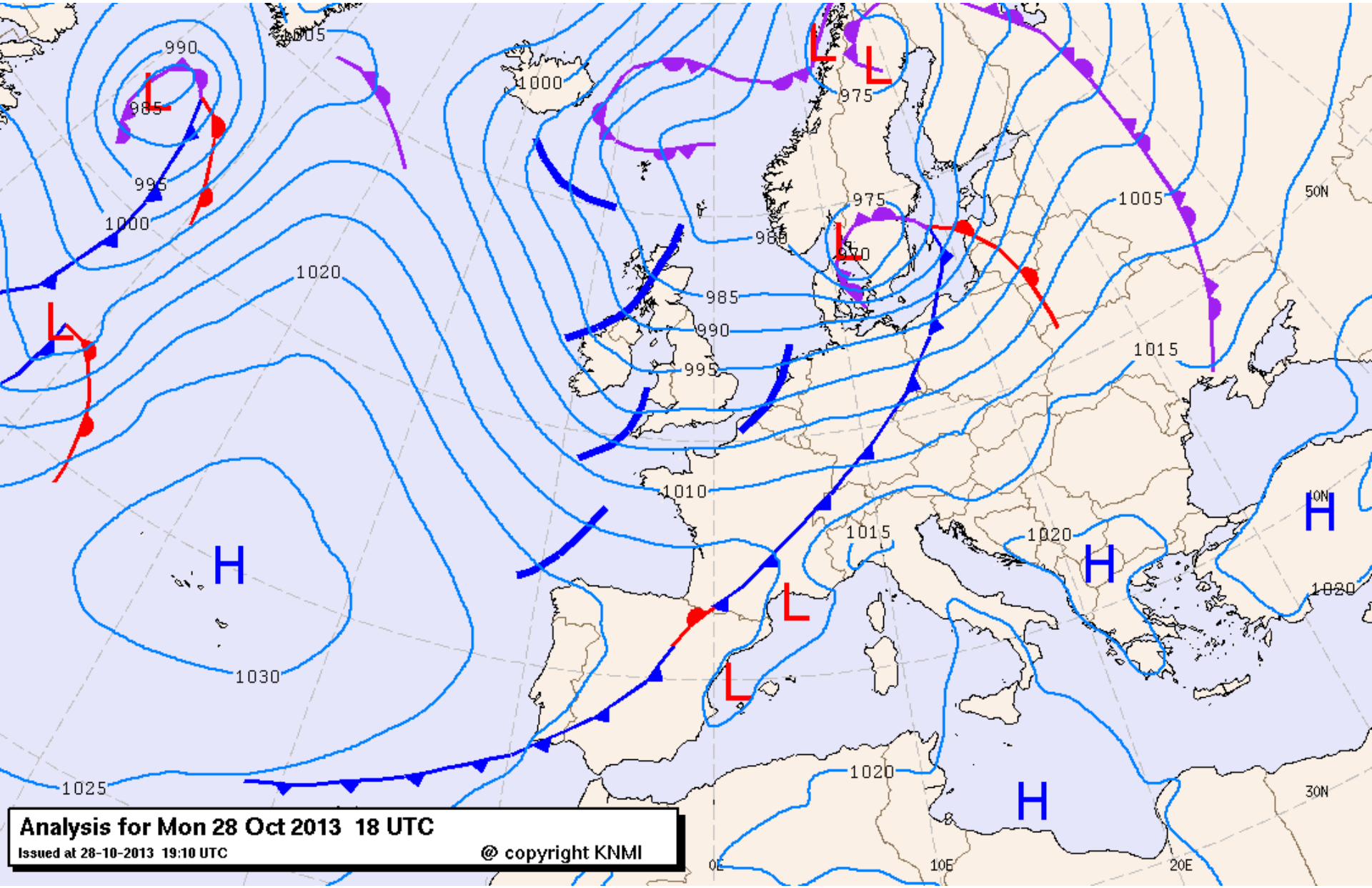
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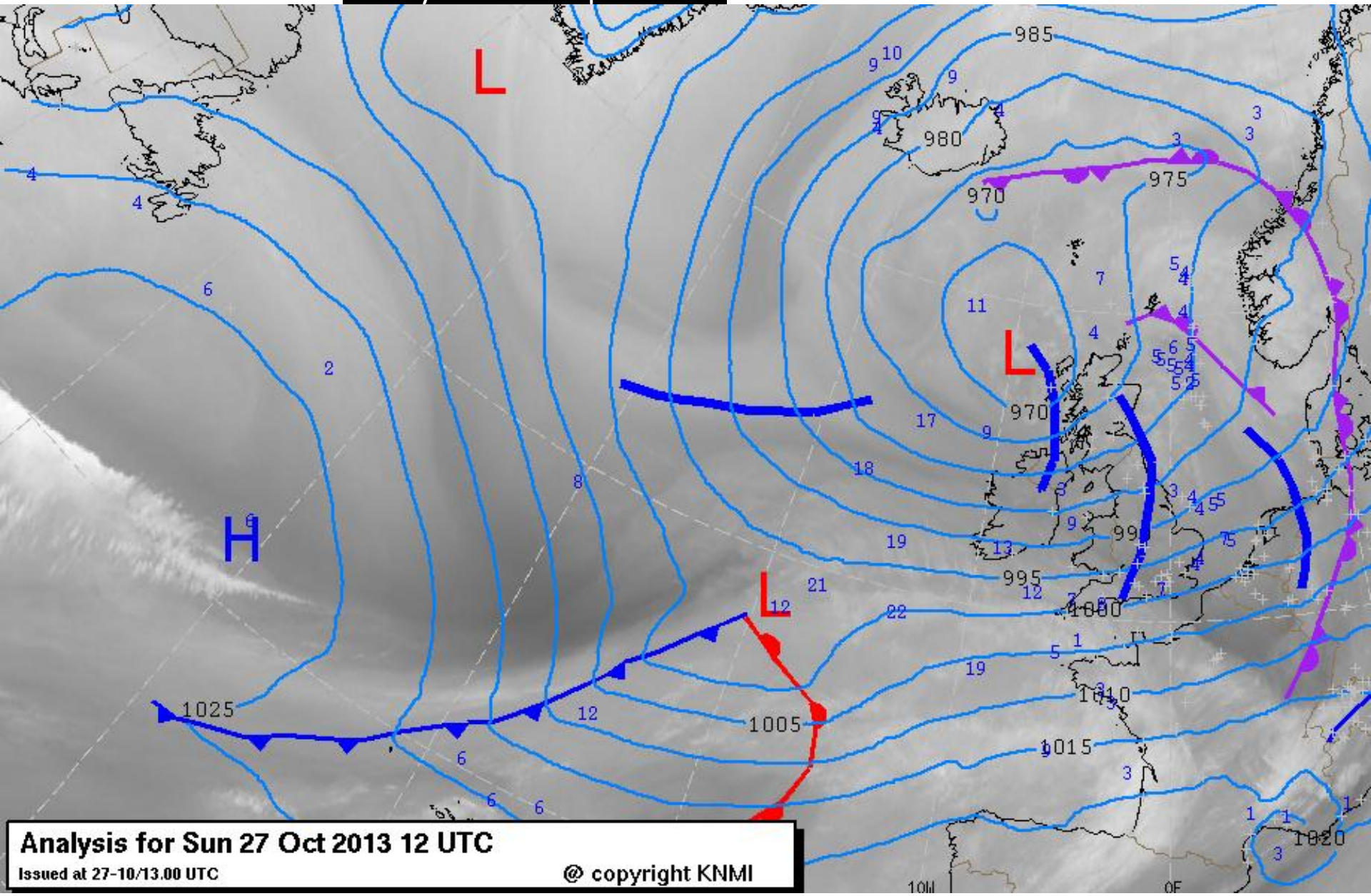
Analysis for Mon 28 Oct 2013 18 UTC
Issued at 28-10-2013 19:10 UTC
@ copyright KNMI

According to most common definition of ideas about speed of deepening **6 hPa/6 hrs** or 24 hPa / day this October-case fits into the definition:

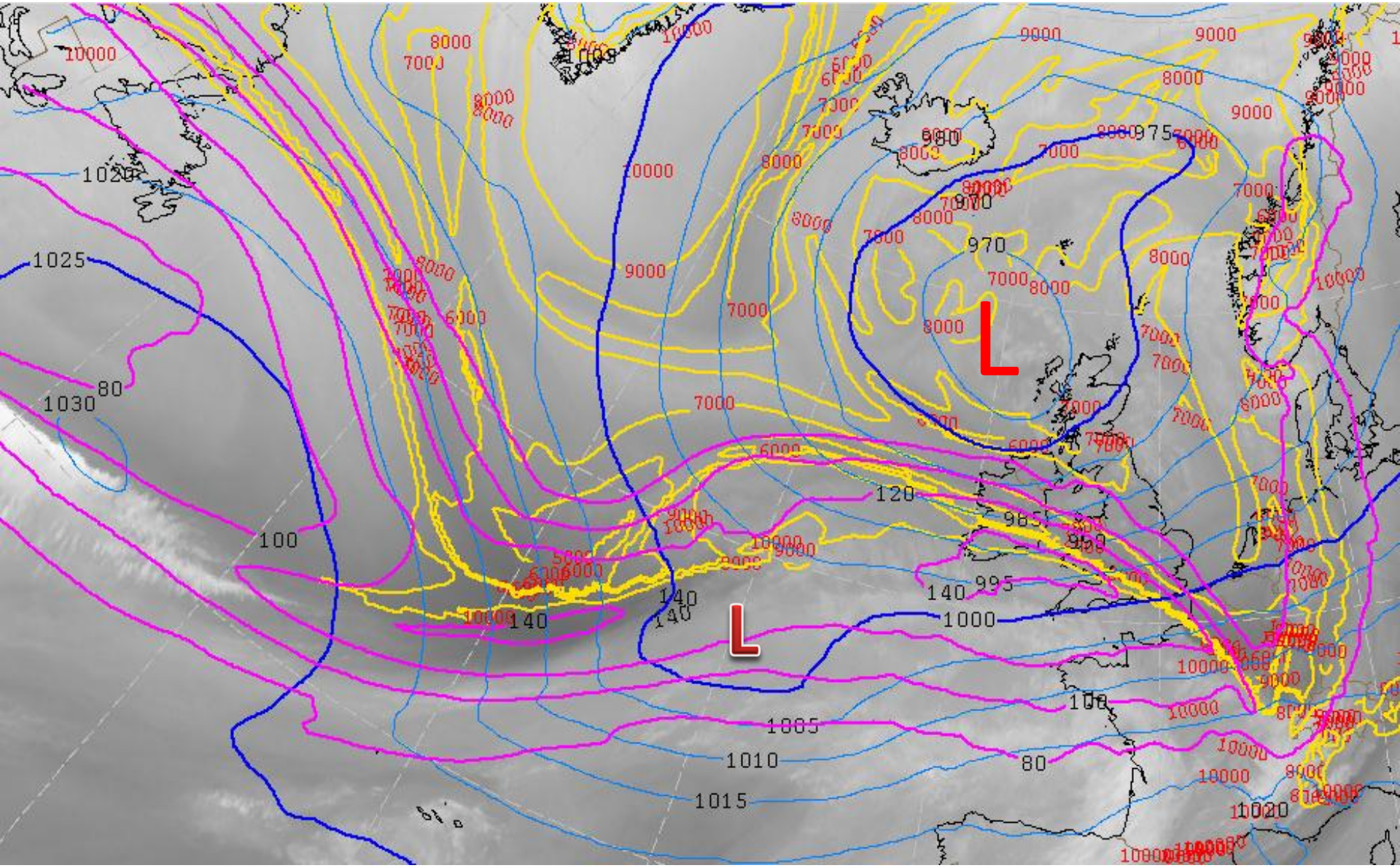
- 27 October 2013 12 UTC 998 hPa
- 27 October 2013 18 UTC 990 hPa ) 8
- 28 October 2013 00 UTC 984 hPa ) 6
- 28 October 2013 06 UTC 979 hPa ) 5
- 28 October 2013 12 UTC 968 hPa ) 9
- 28 October 2013 18 UTC 970 hPa ) +2

Analysis Surface pressure



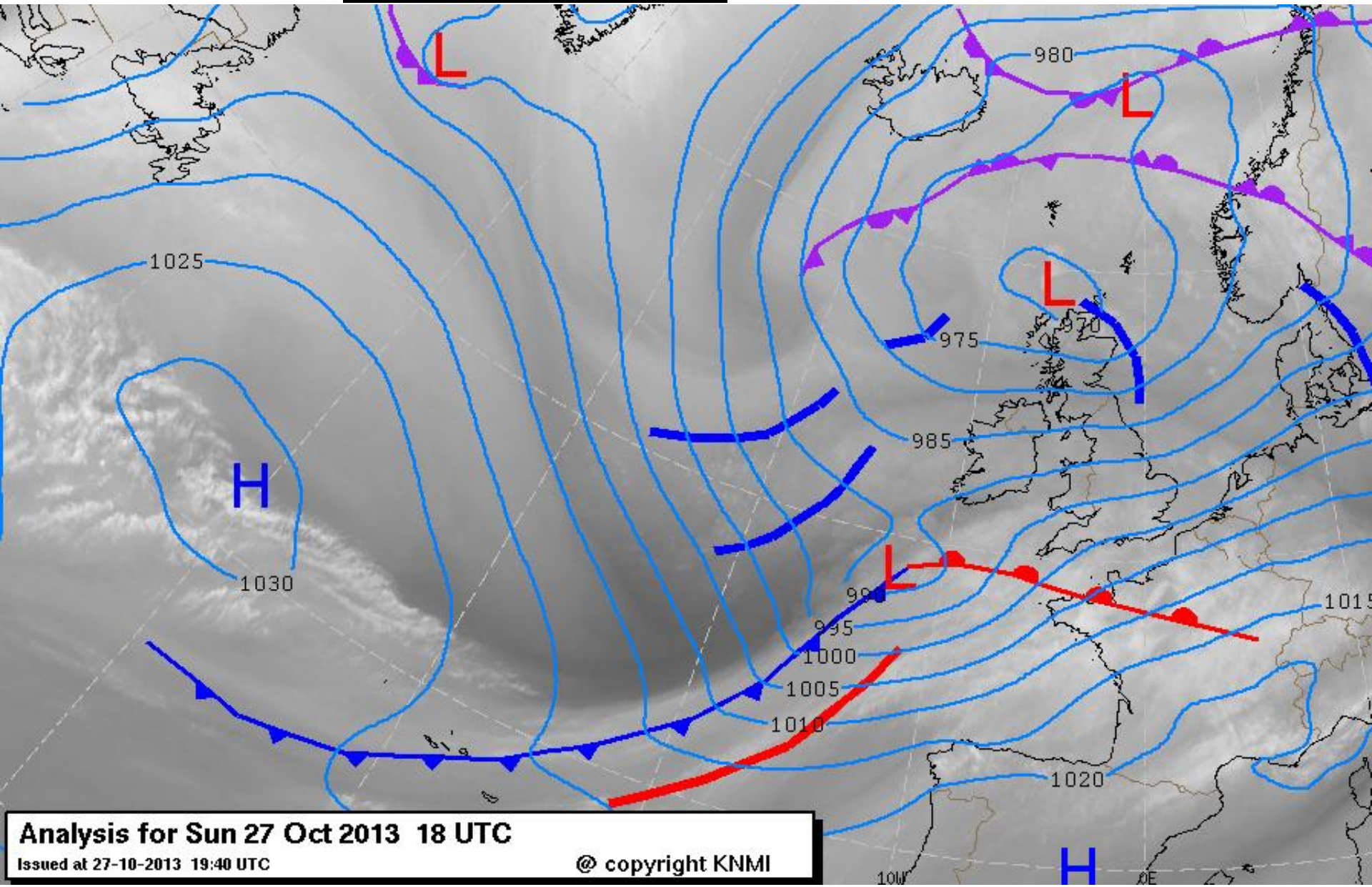

WV 6.2 µm 27 Oct 2013 12 UTC

Surface pressure PV1.5 Height isotachs (300 hPa)



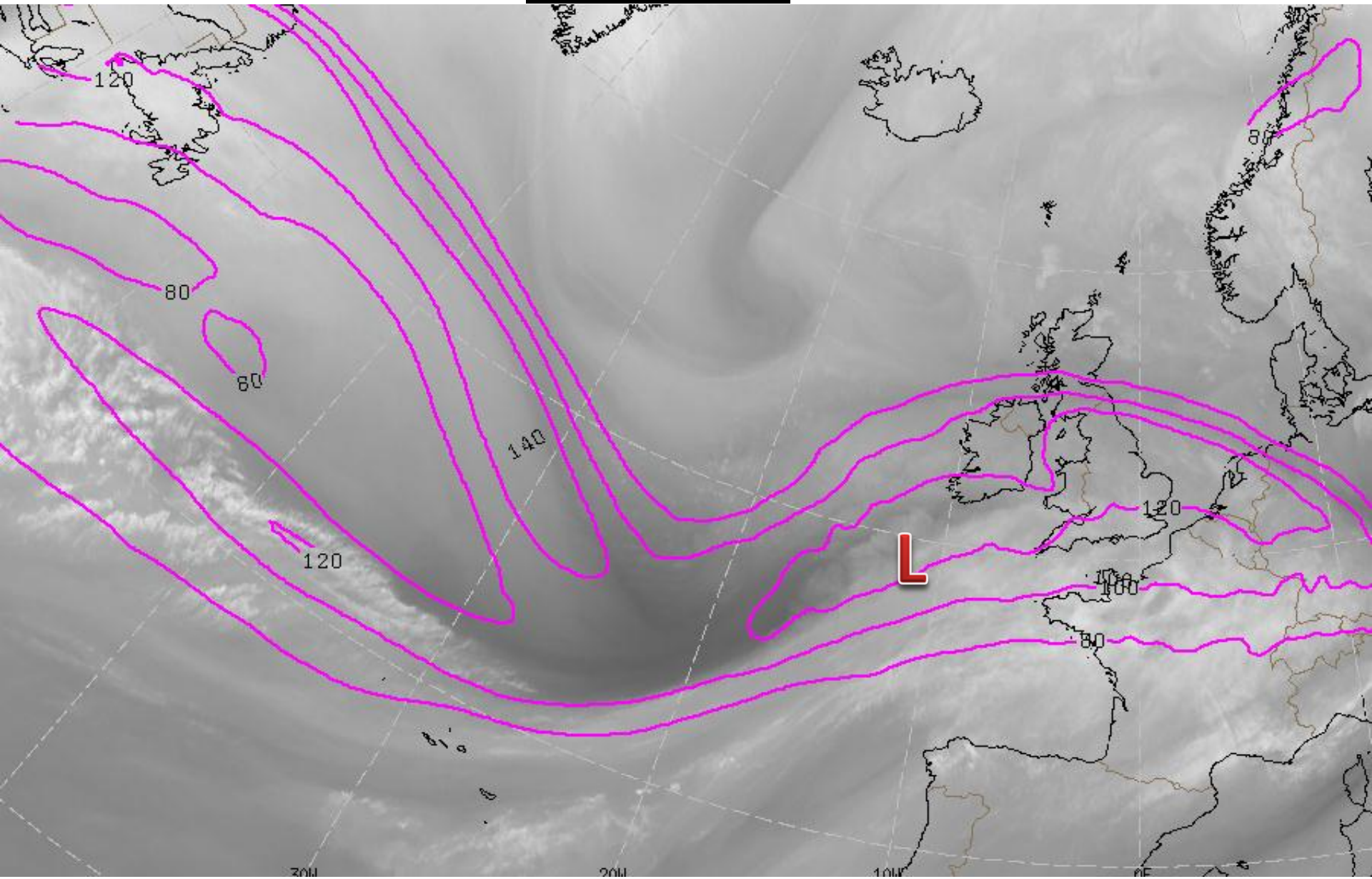

WV 6.2 µm 27 Oct 2013 12 UTC

Analysis Surface pressure



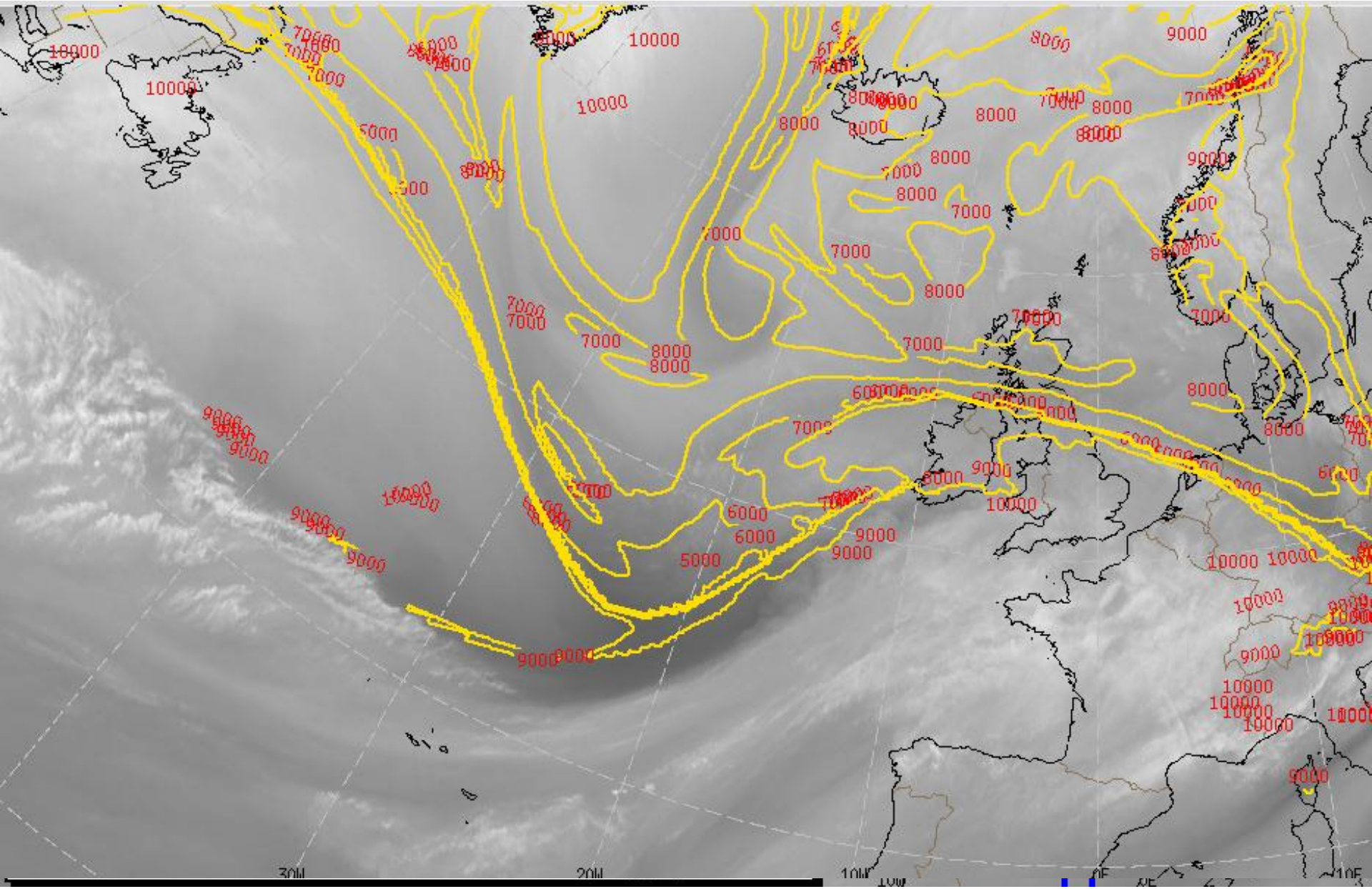

WV 6.2 µm 27 Oct 2013 18 UTC

# Isotachs 300 hPa



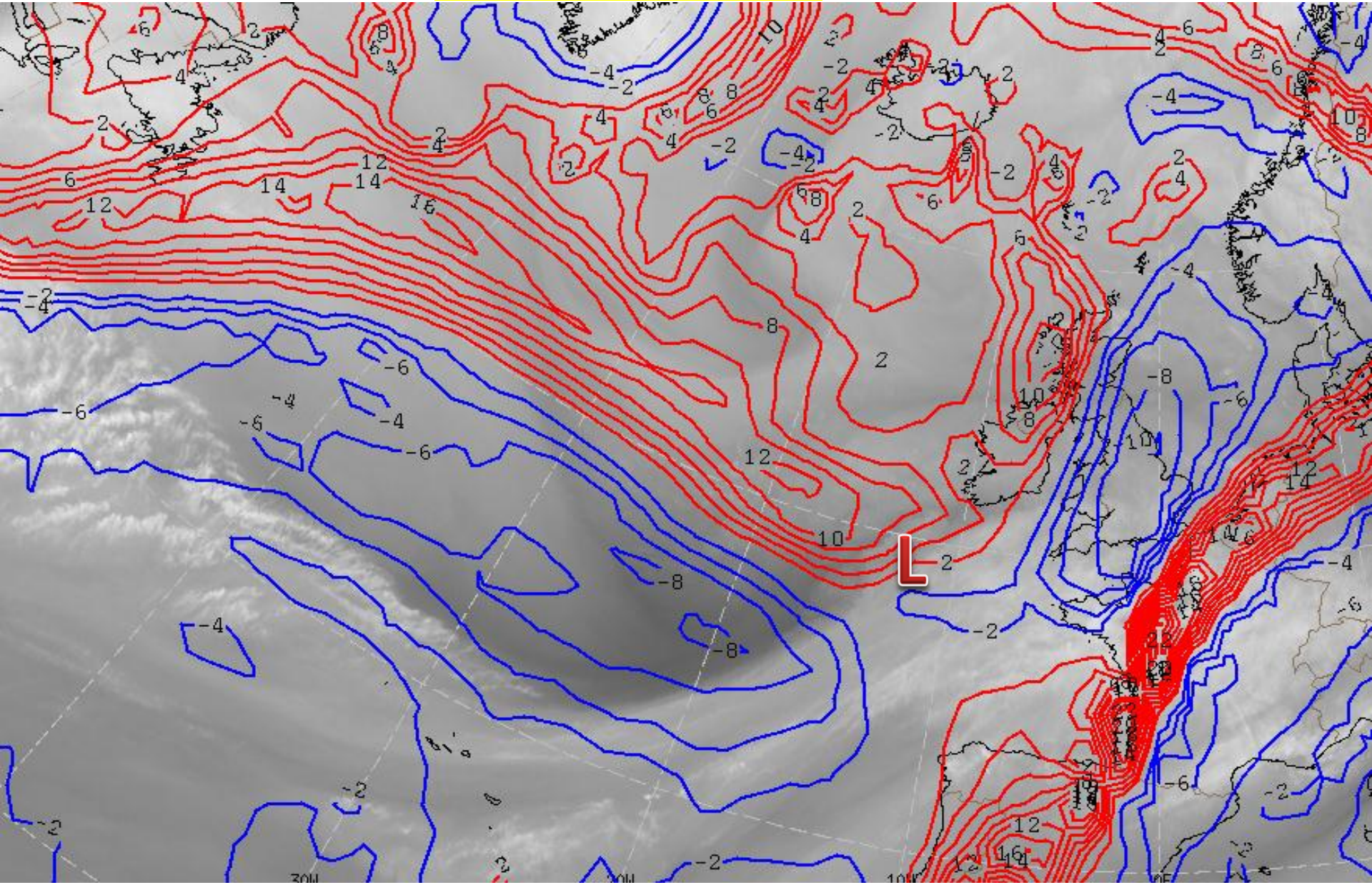

WV 6.2 µm 27 Oct 2013 18 UTC

PV1.5 Height



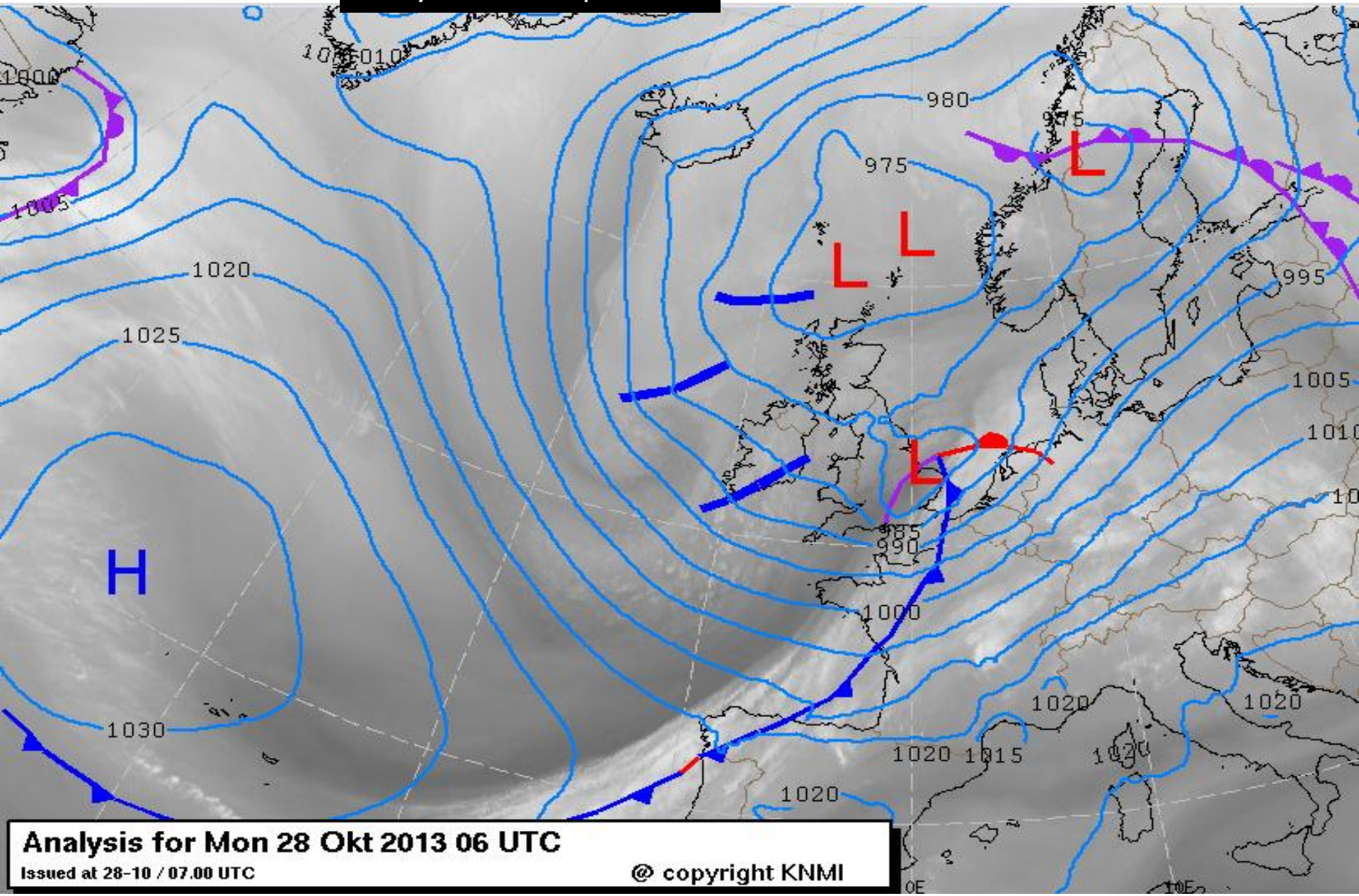

WV 6.2 µm 27 Oct 2013 18 UTC

Shear vorticity at 300 hPa



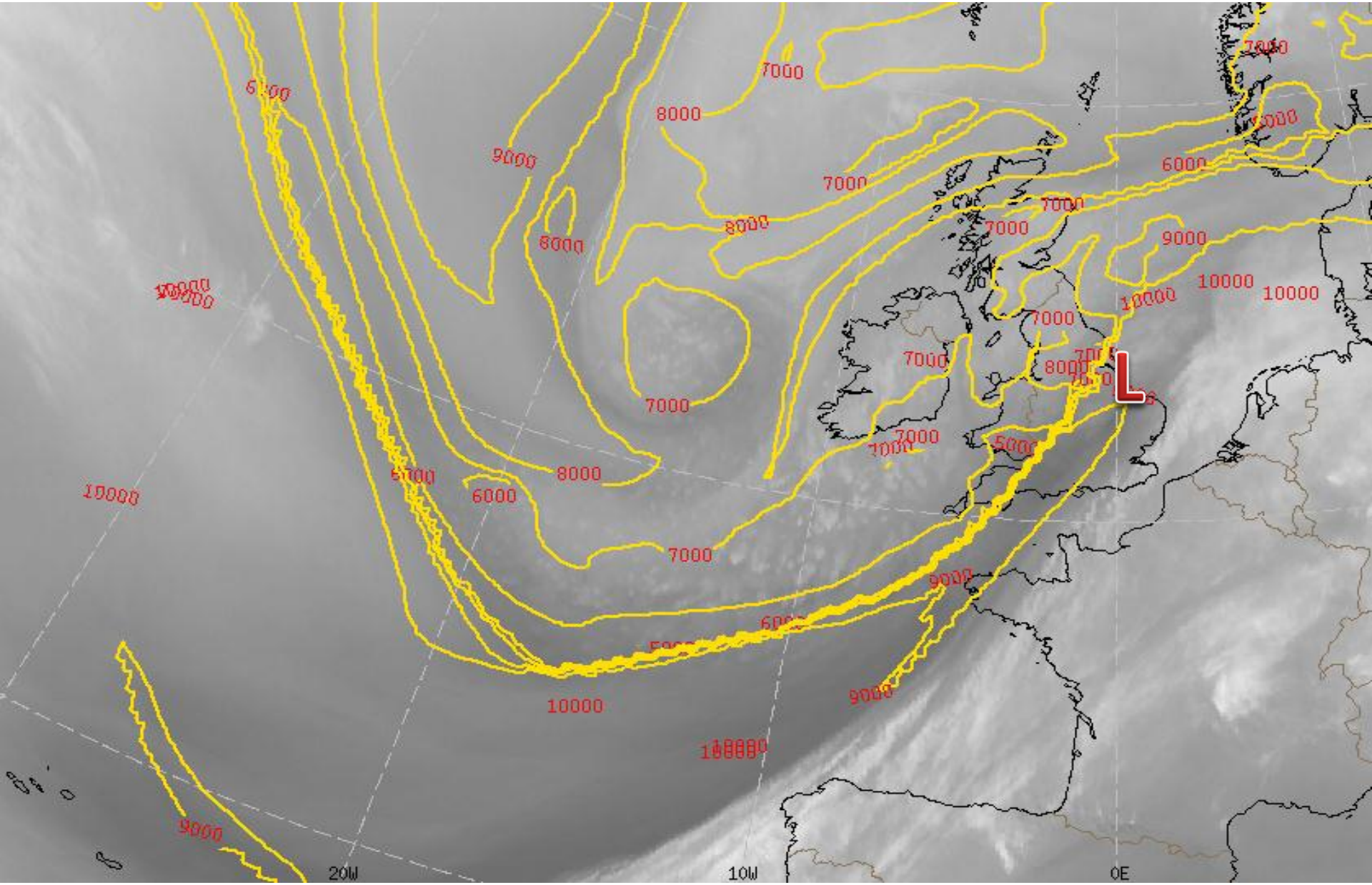

WV 6.2 µm 27 Oct 2013 18 UTC

Analysis Surface pressure



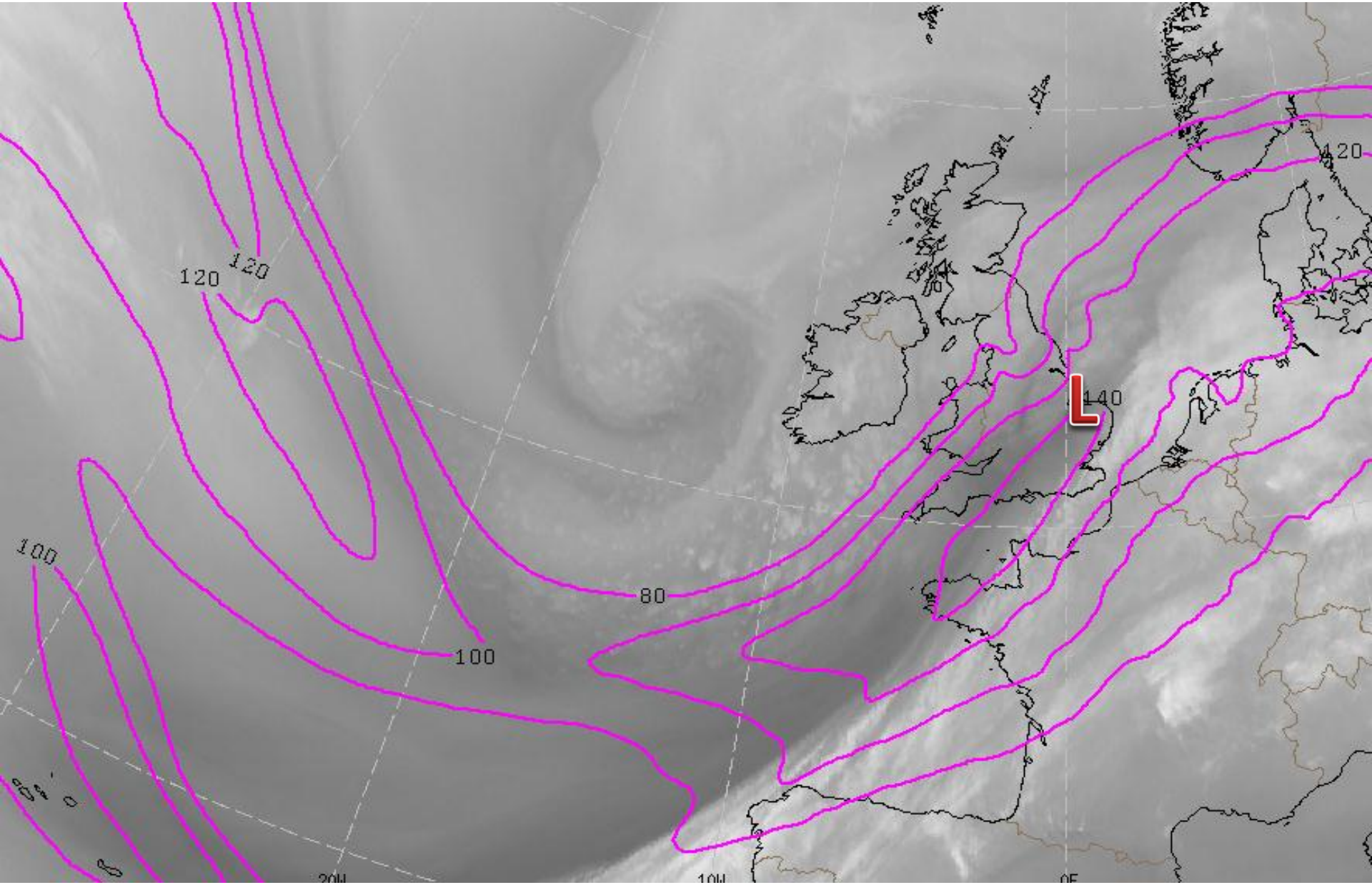

WV 6.2 µm 28 Oct 2013 06 UTC

PV 2 Height



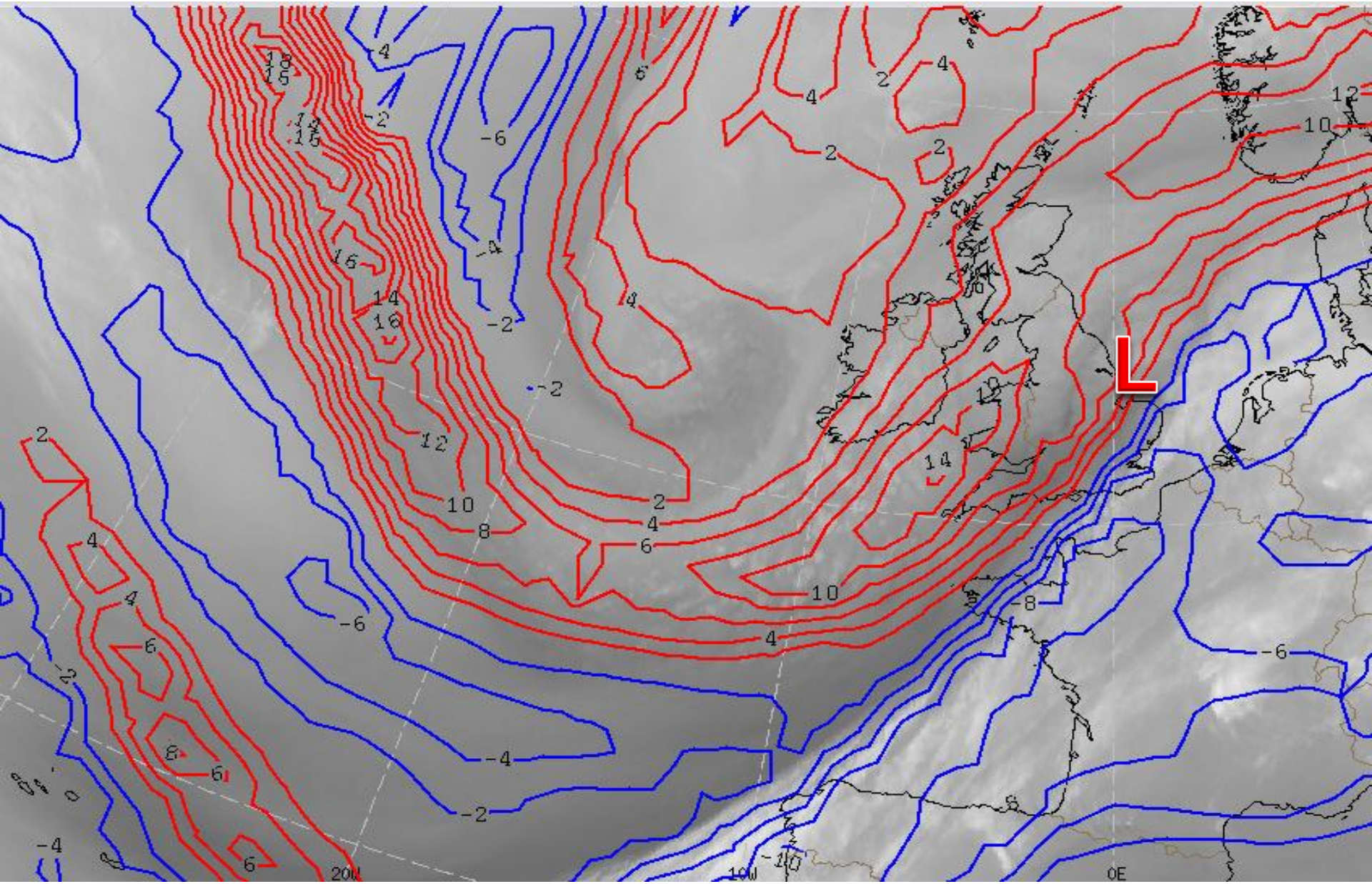

WV 6.2 µm 28 Oct 2013 06 UTC

# Isotachs at 300 hPa



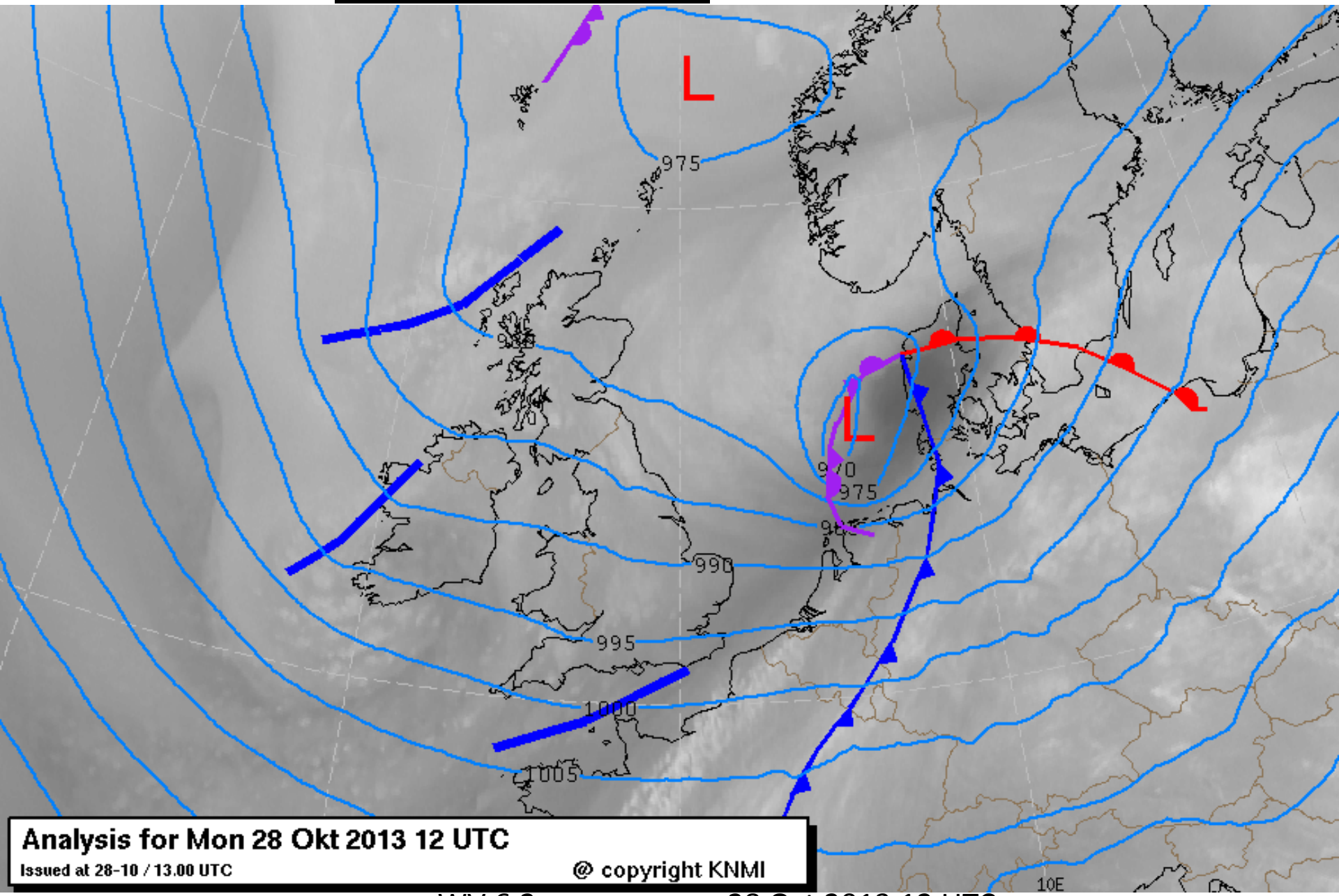

WV 6.2 µm 28 Oct 2013 06 UTC

# Shear vorticity at 300 hPa



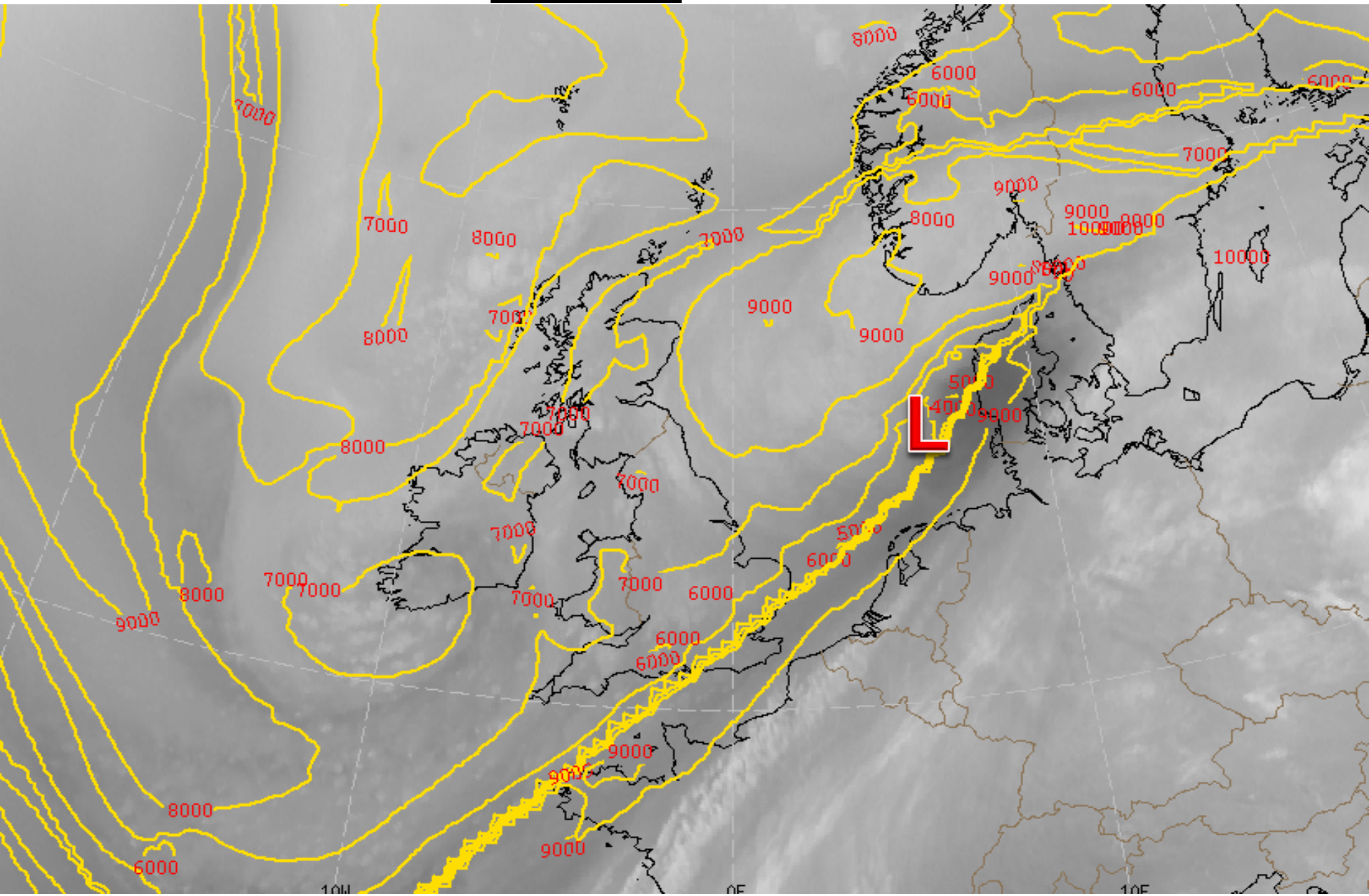

WV 6.2 µm 28 Oct 2013 06 UTC

Analysis Surface pressure



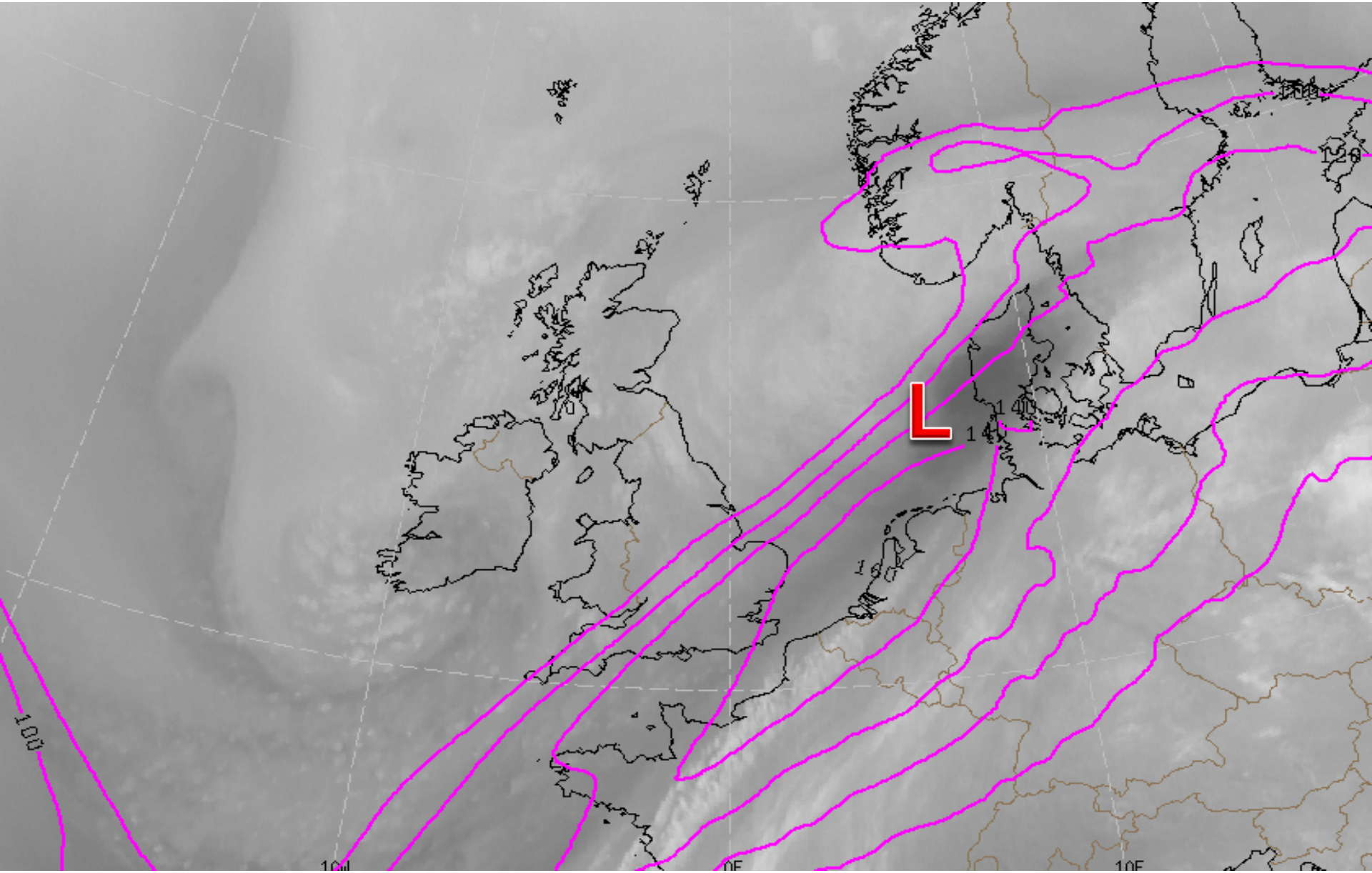

WV 6.2 µm 28 Oct 2013 12 UTC

PV 2 Height



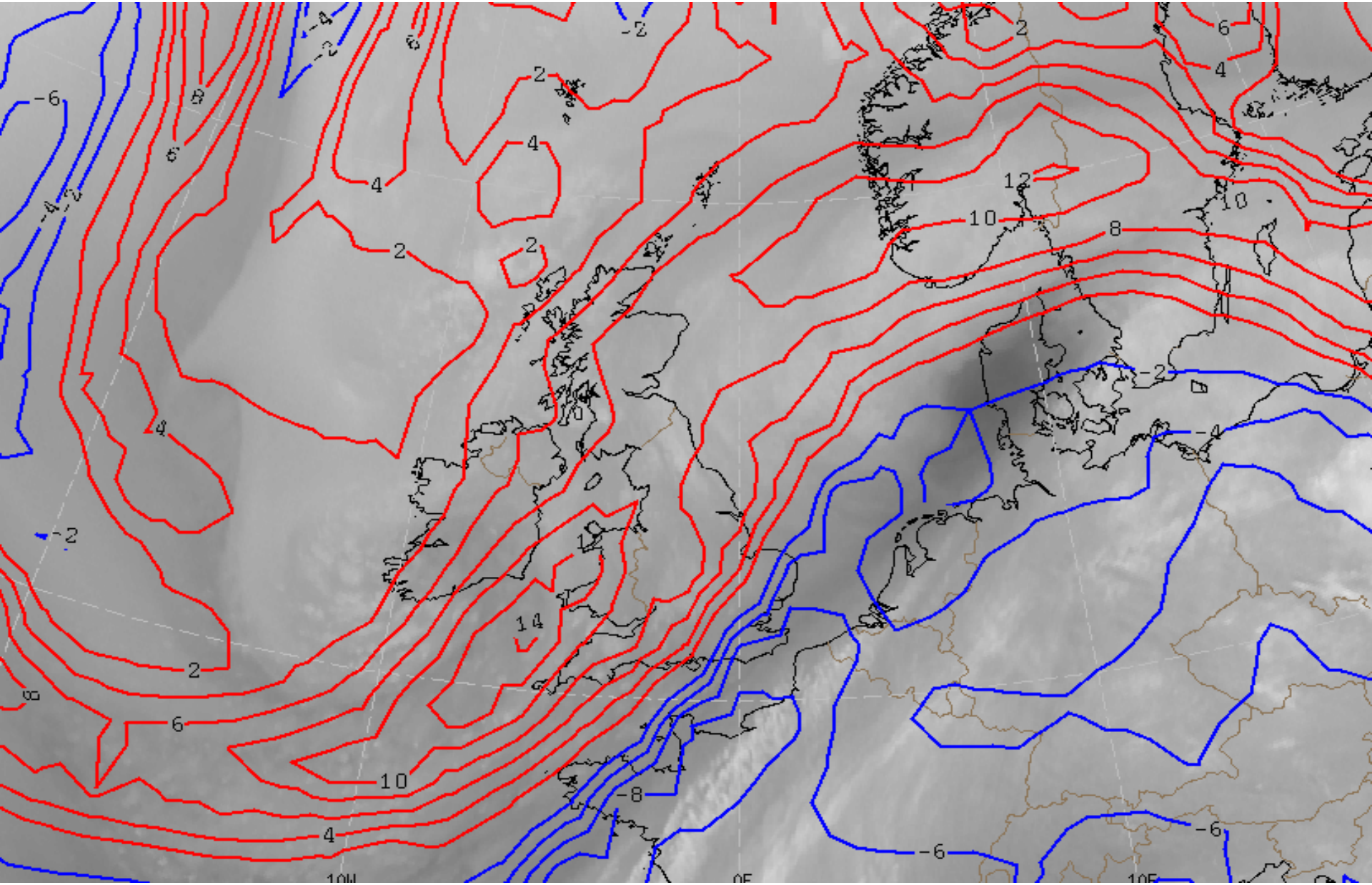

WV 6.2 µm 28 Oct 2013 12 UTC

Analysis Surface pressure



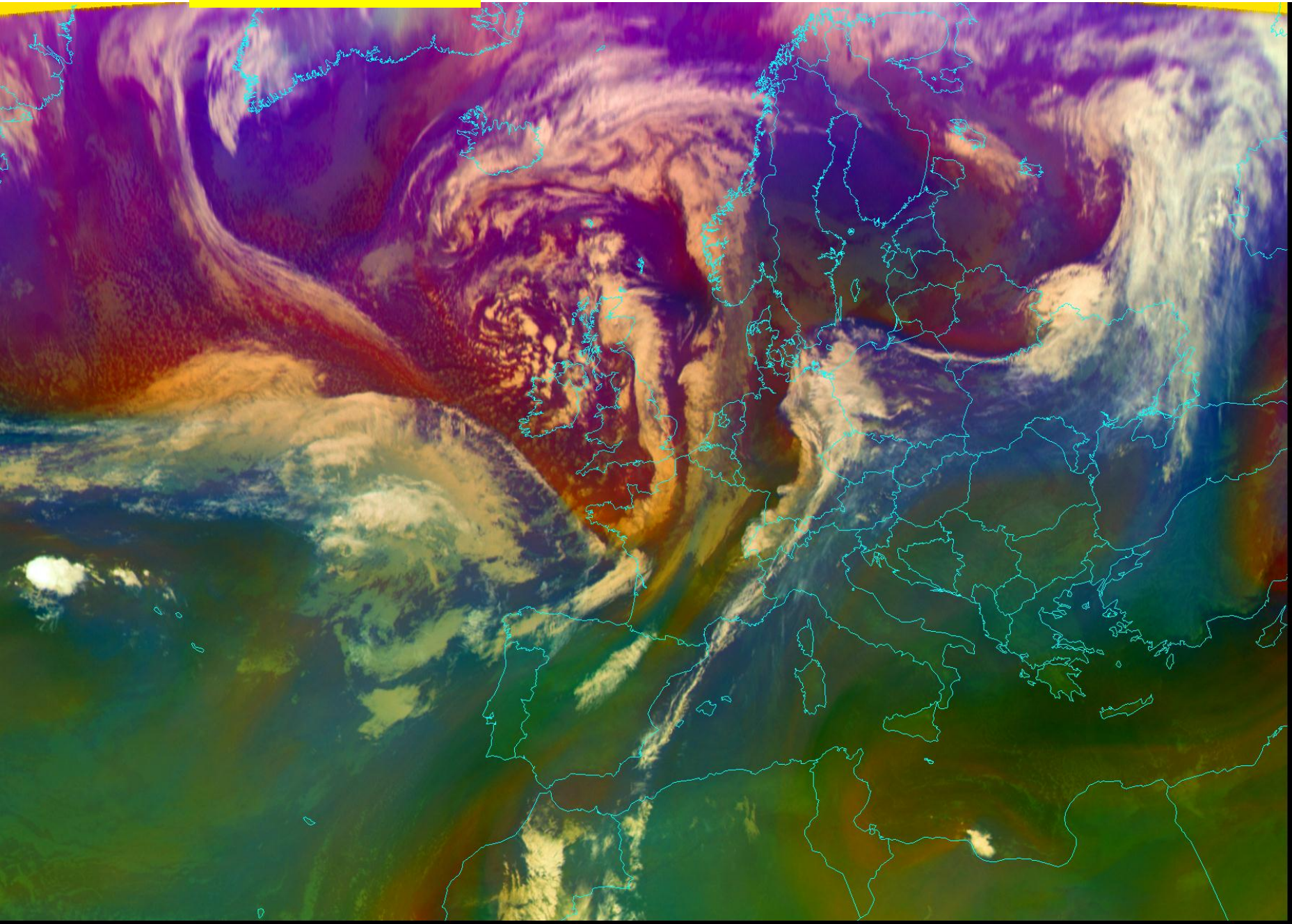

WV 6.2 µm 28 Oct 2013 12UTC

# Shear Vorticity at 300 hPa




WV 6.2 µm 28 Oct 2013 12UTC

27-11-2013 12 UTC



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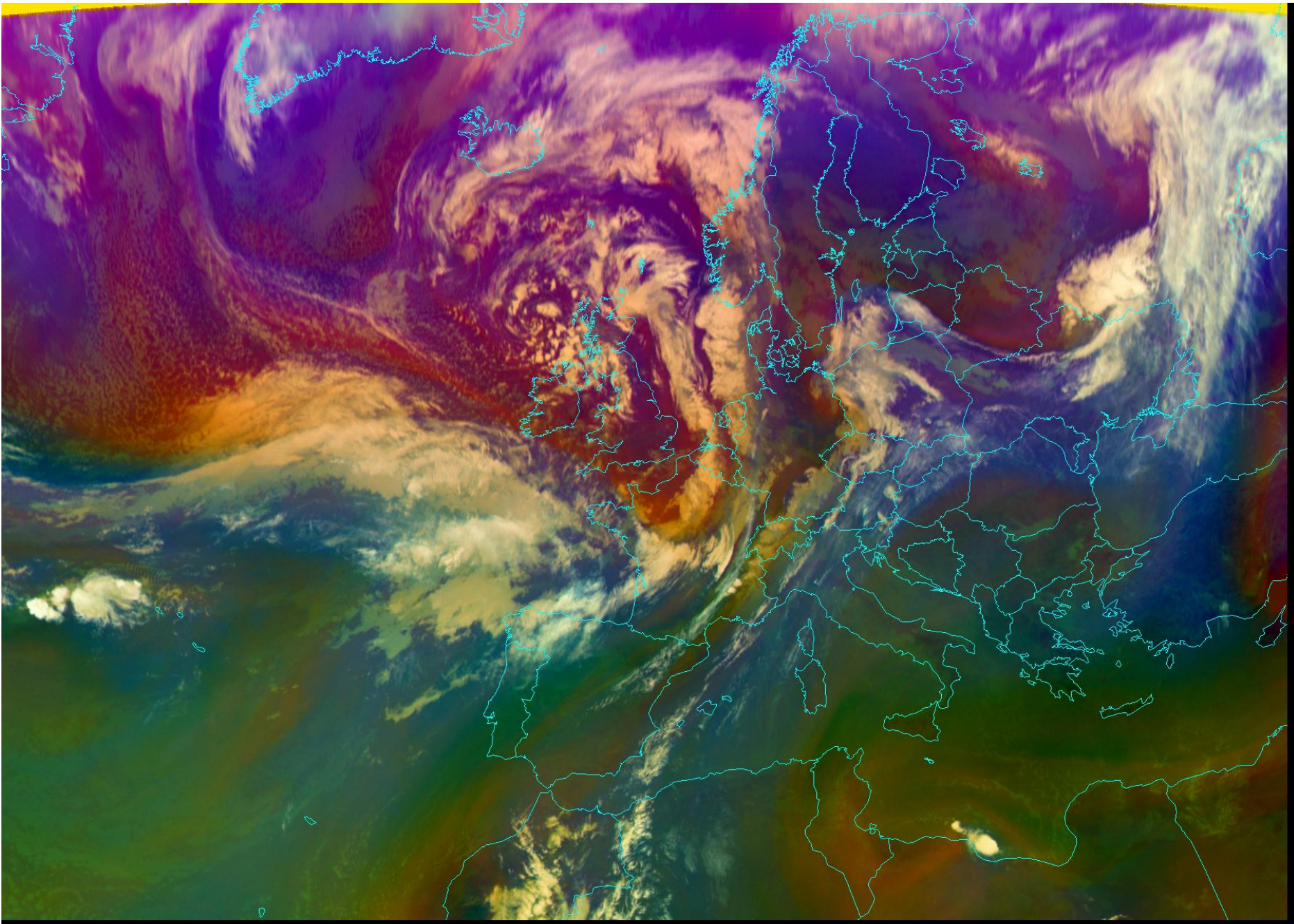

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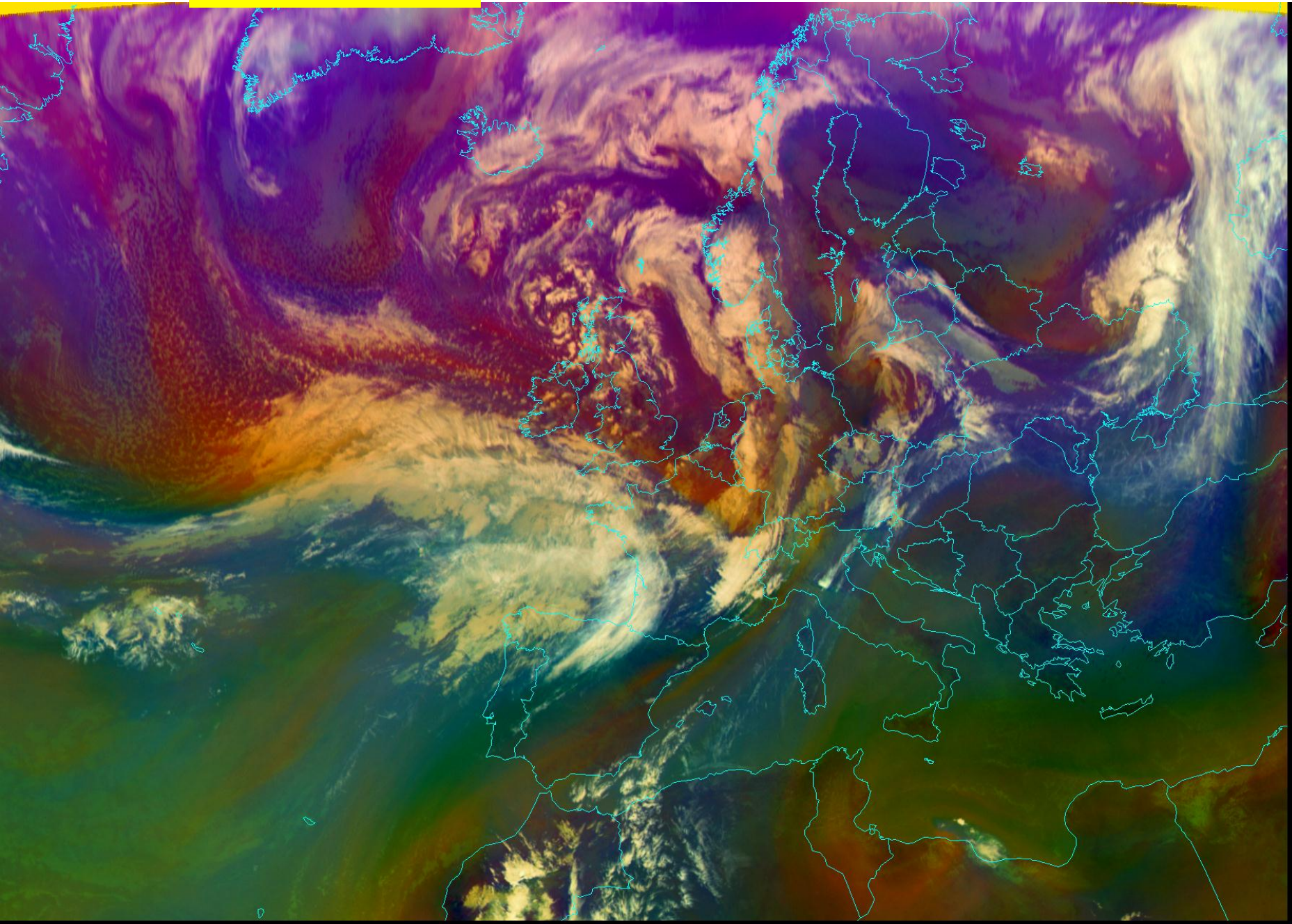
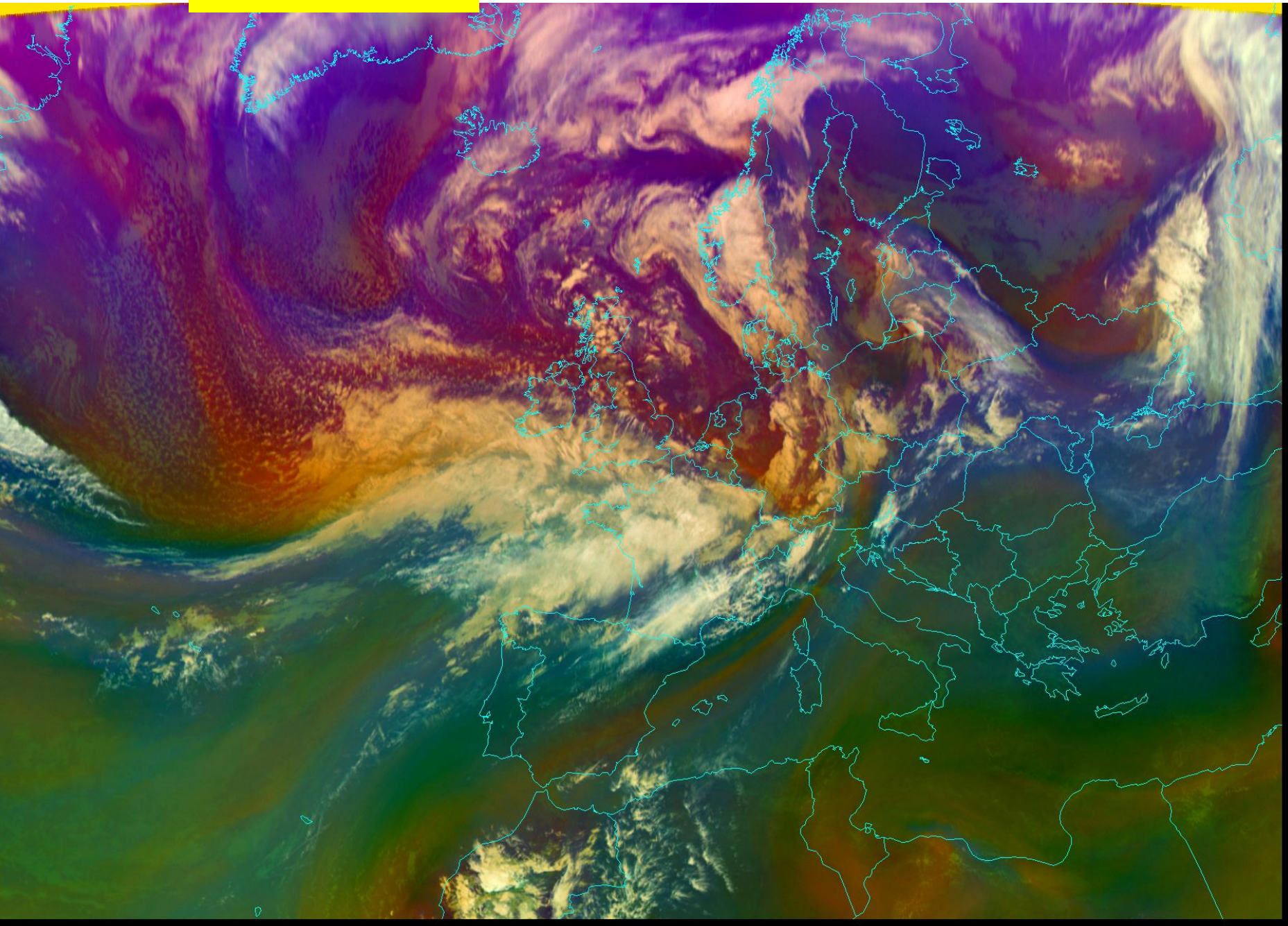
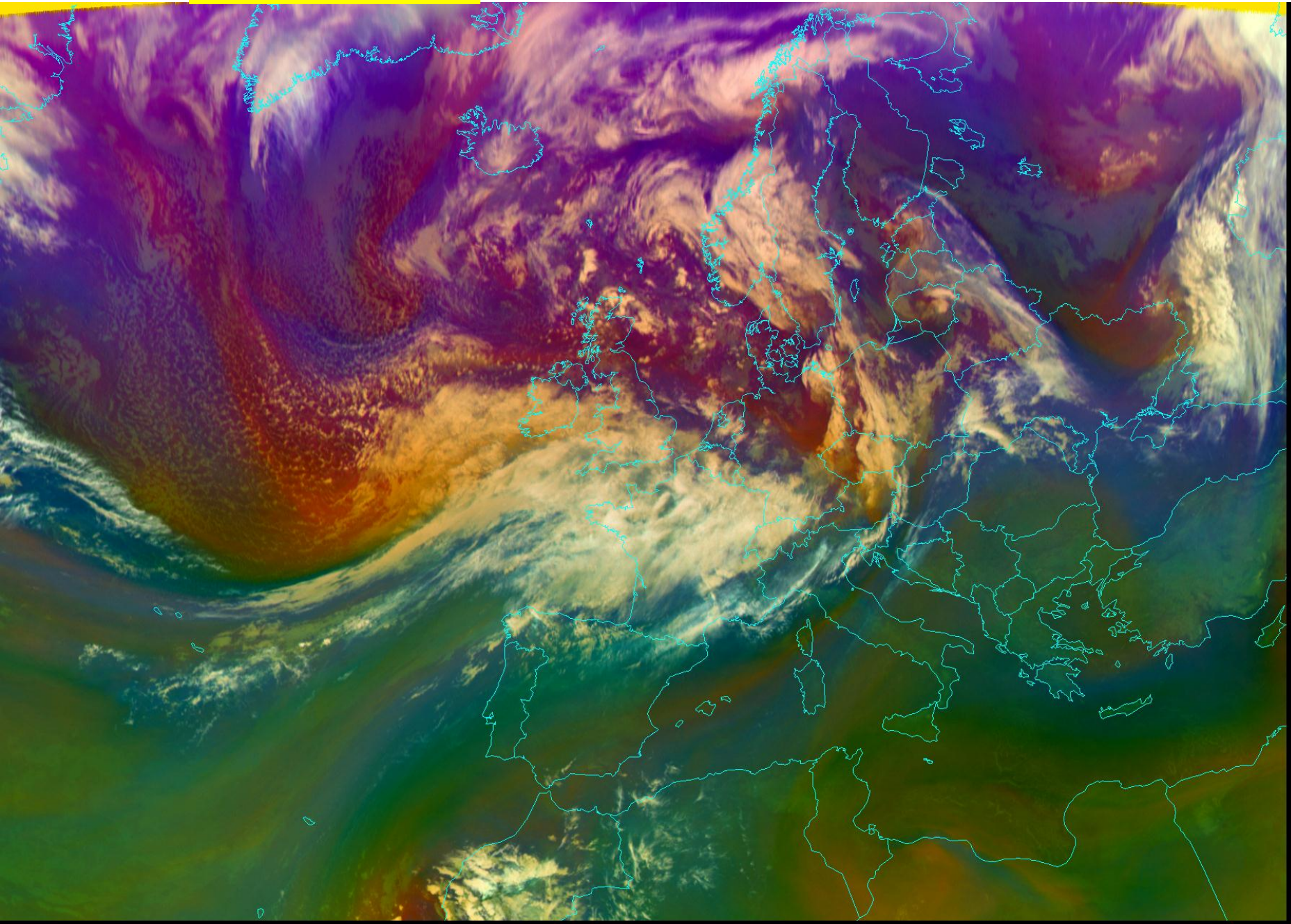


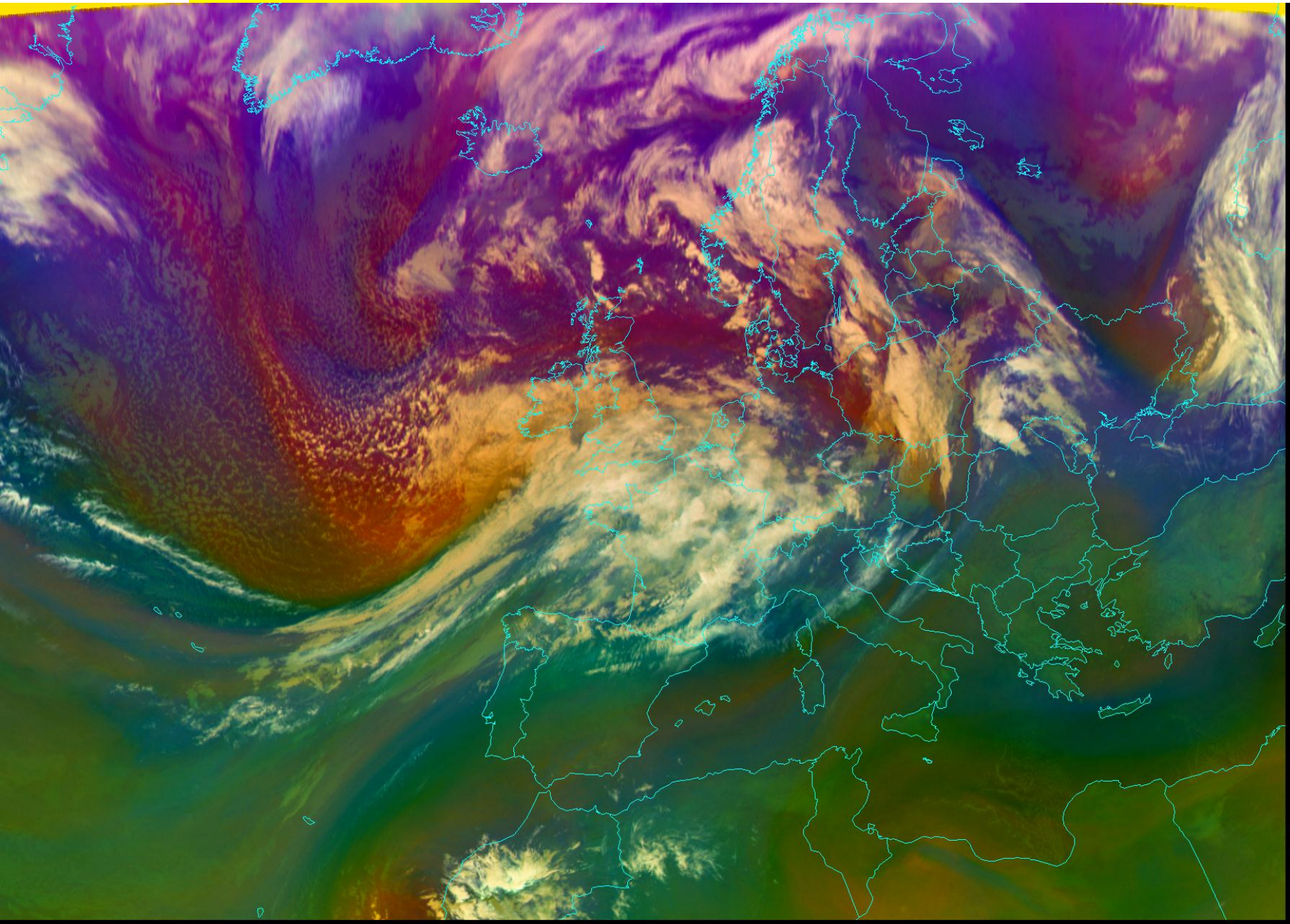
27-11-2013 21 UTC



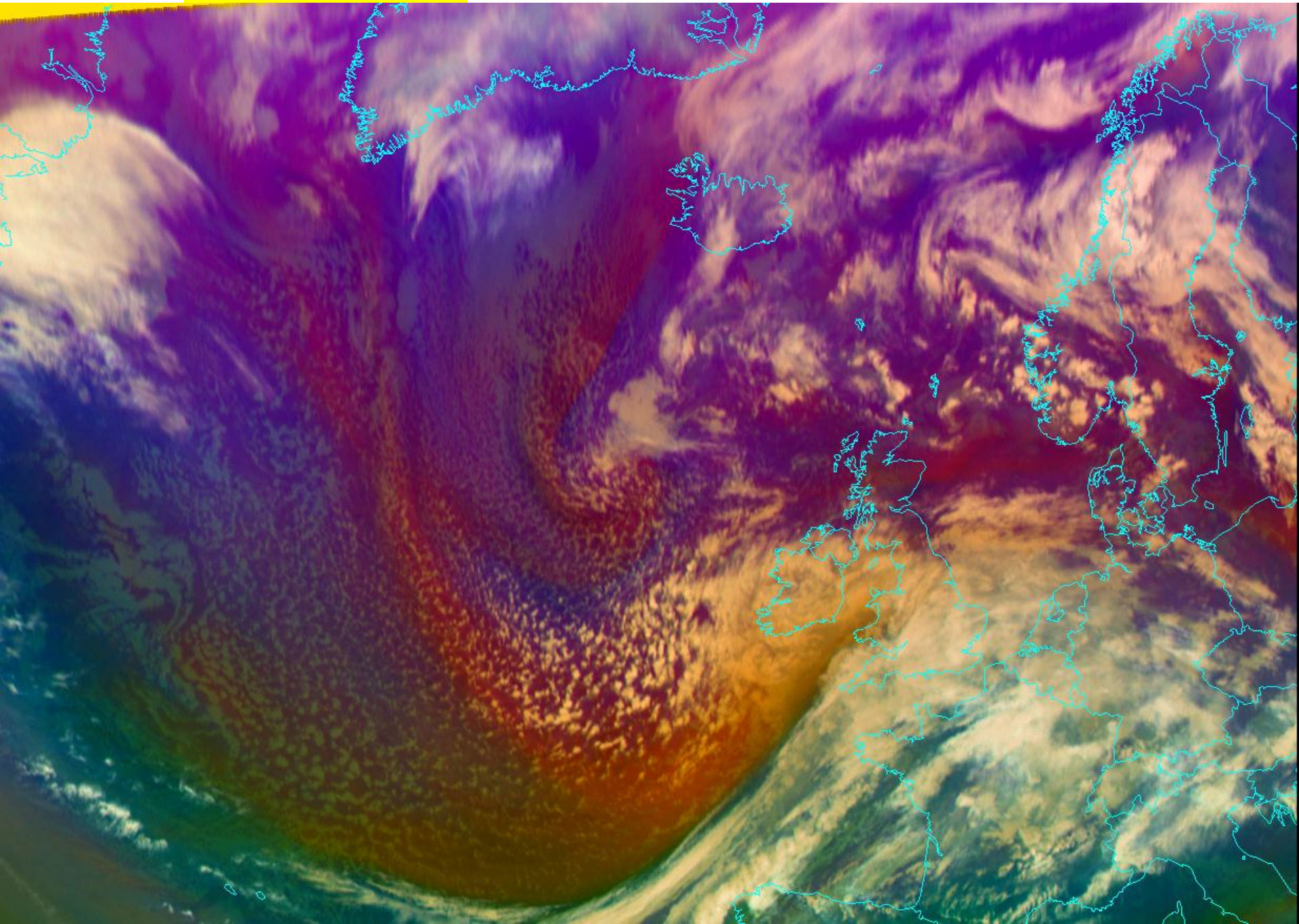
28-11-2013 00 UTC

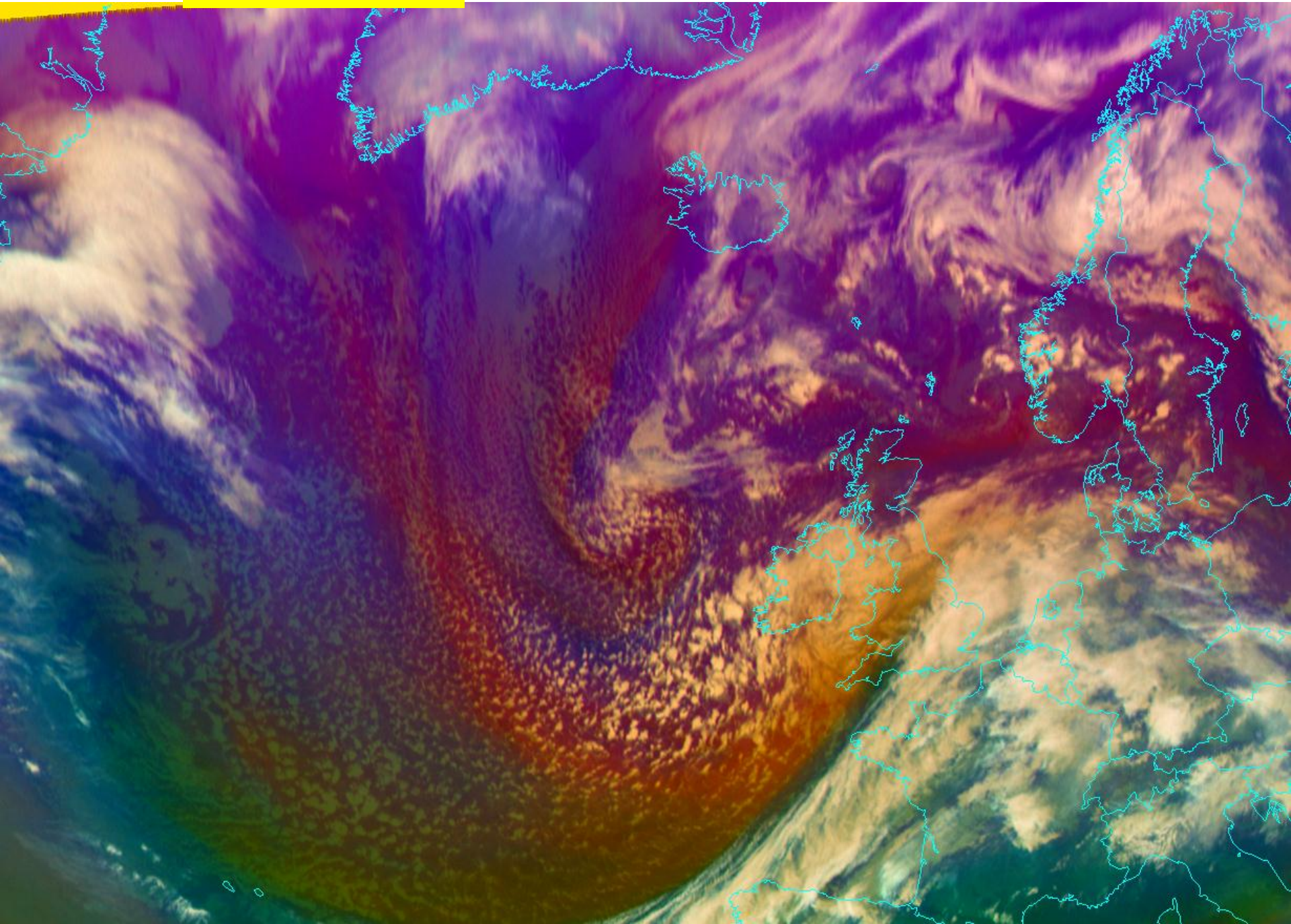


27-11-2013 12 UTC

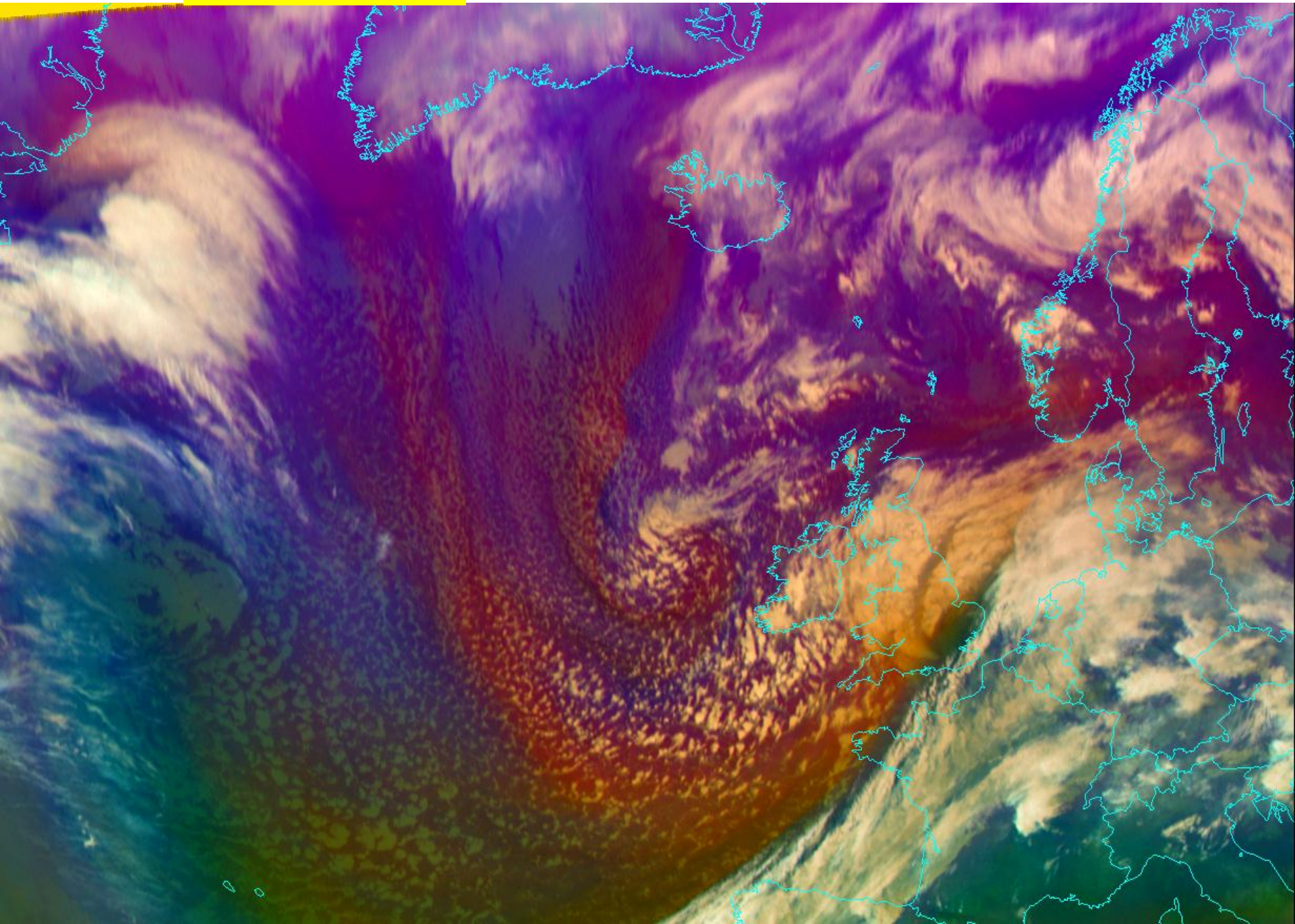


28-11-2013 06 UTC

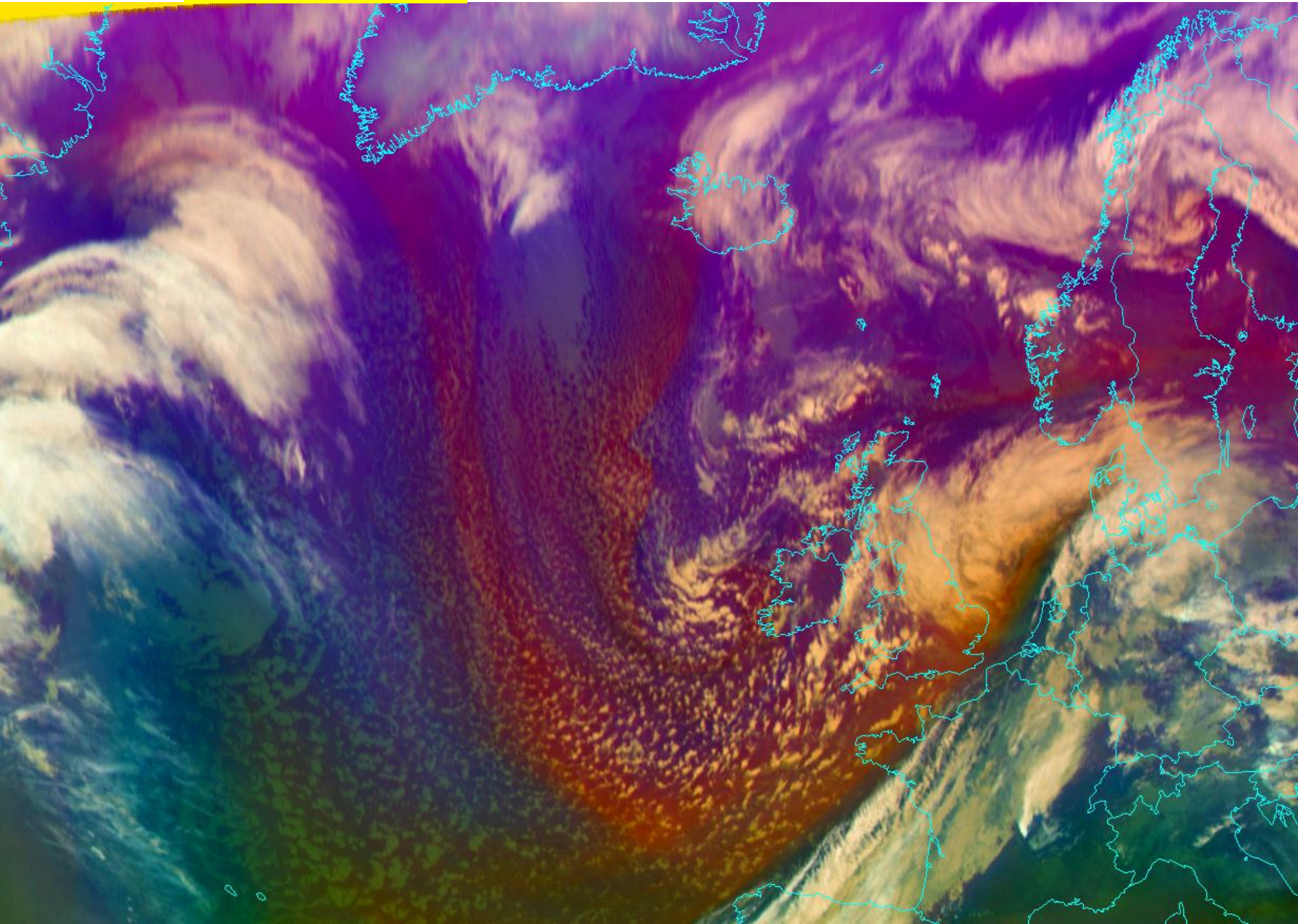



28-11-2013 03 UTC

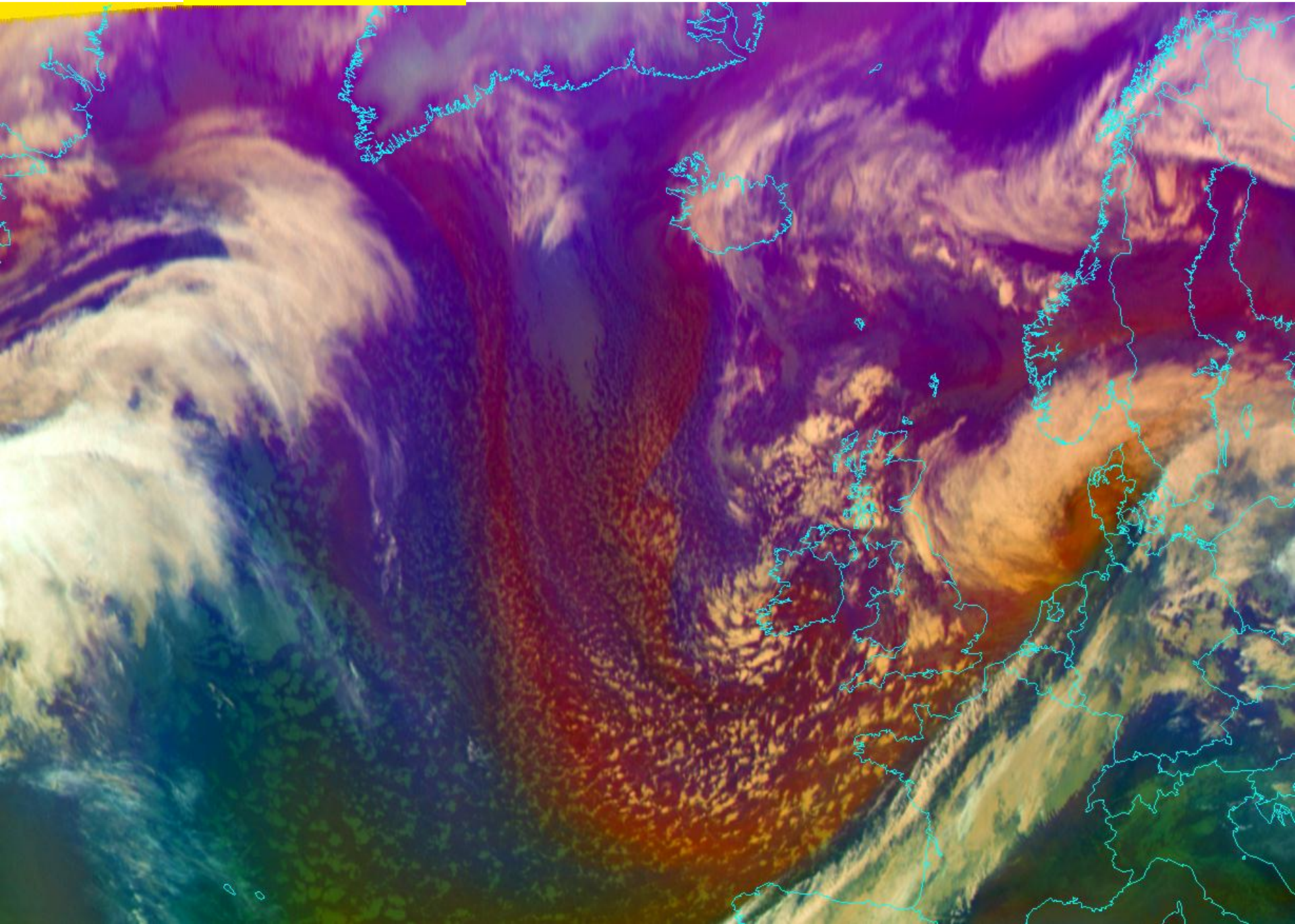
28-11-2013 06 UTC

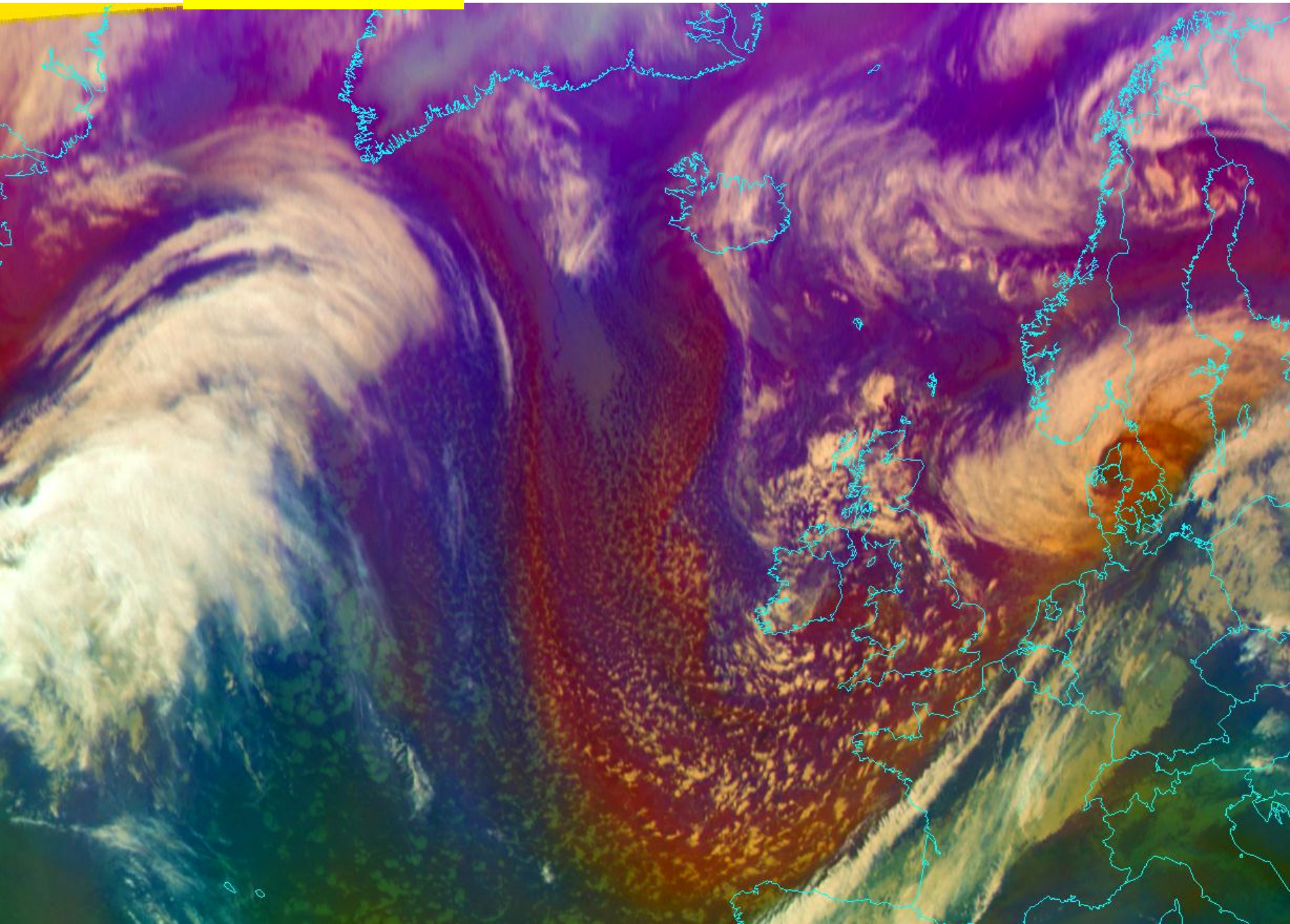


28-11-2013 06 UTC

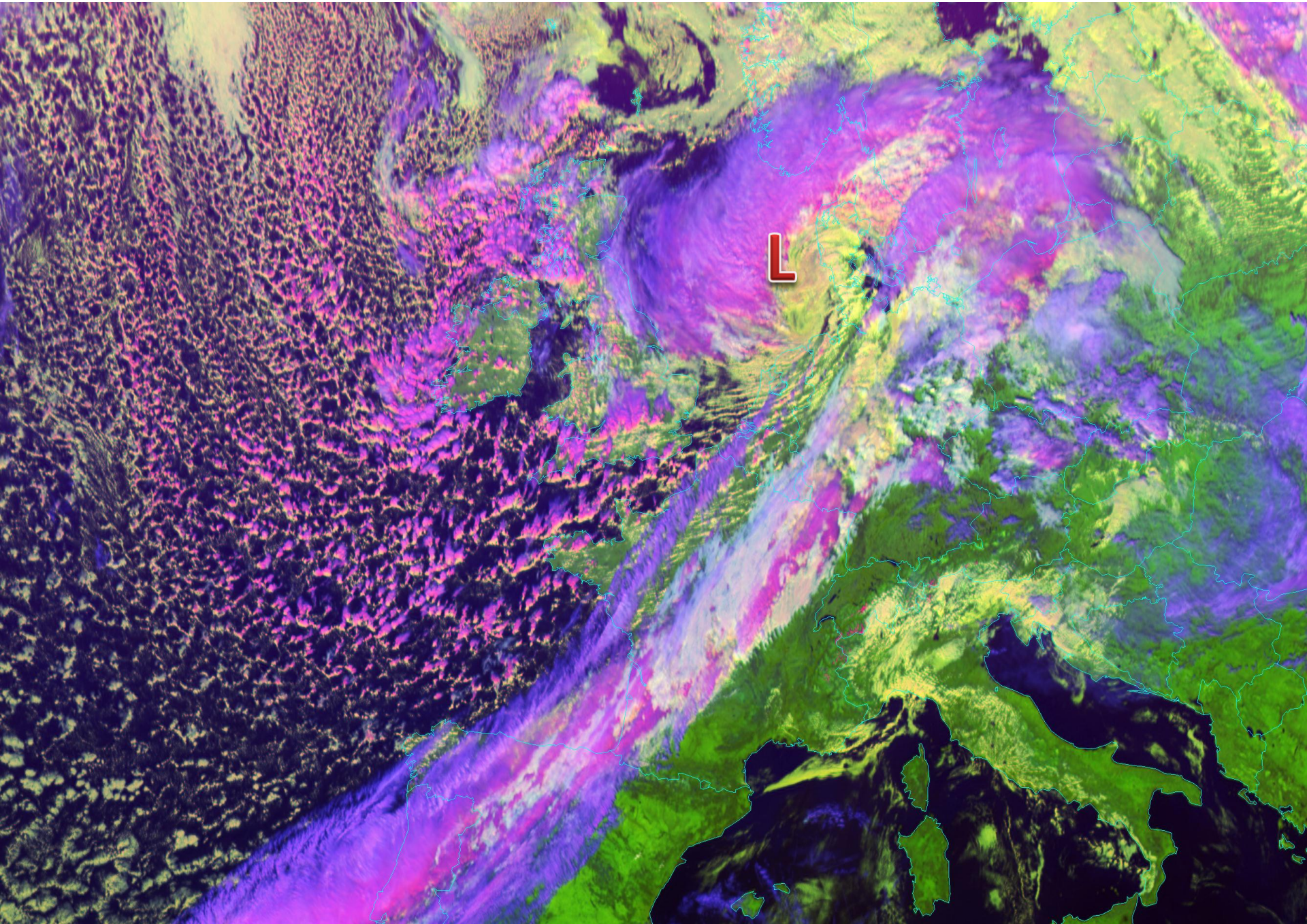


28-11-2013 09 UTC




28-11-2013 12 UTC

28 Oct 2013 12 UTC RGB HrVis , 1.6 µm, 10.8 µm

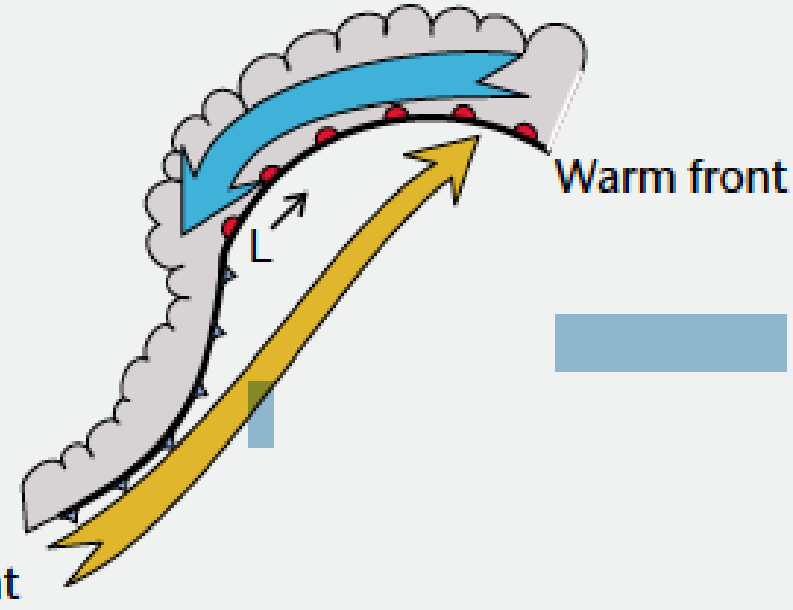


# The Sting Jet:

## What we see at the ground

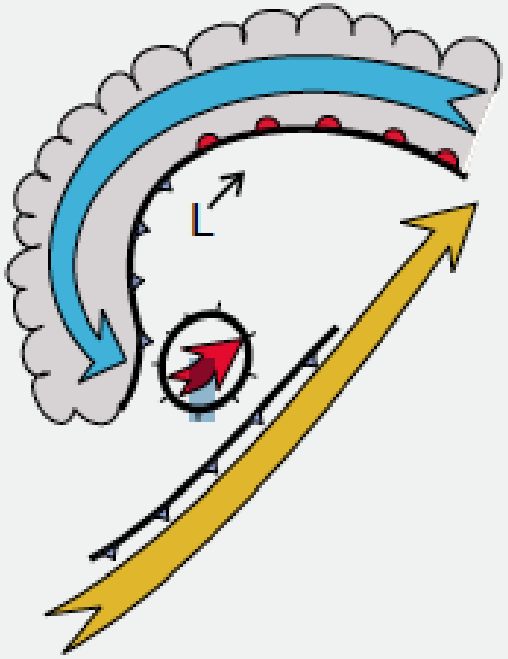
There are four stages in the life of a damaging mid-latitude cyclone:

1.



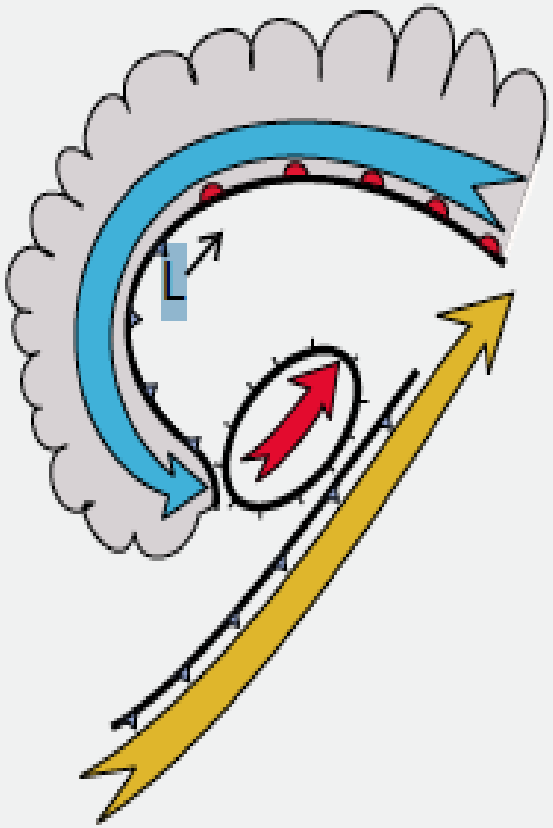

As the pressure starts to drop, two narrow jets of air form near the surface, one cold (blue) the other warm (orange). The low pressure centre (L) is usually moving with the warm jet, so the warm jet produces stronger winds.

2.



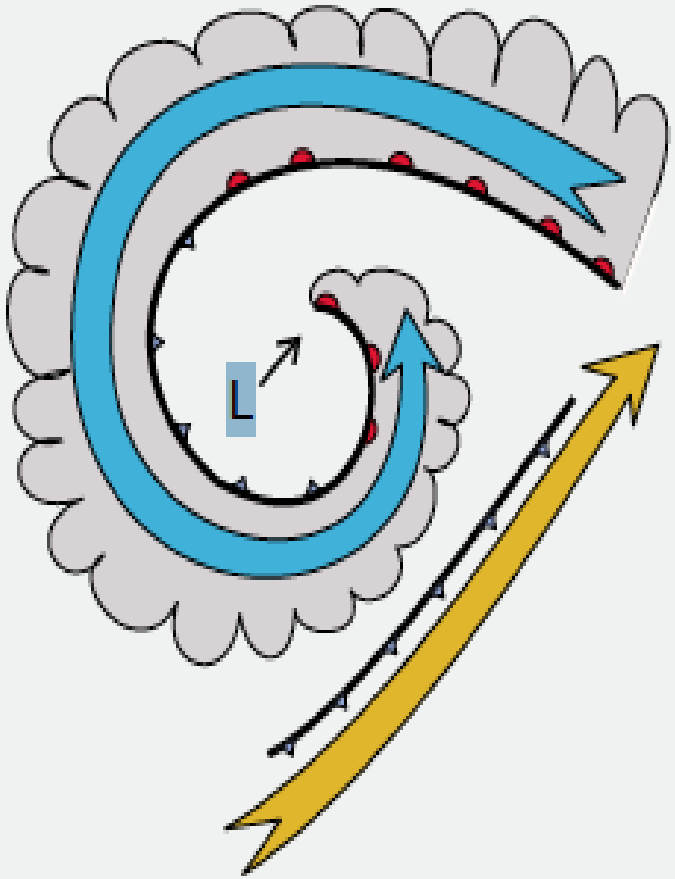

The weather front 'fractures', shortly afterwards the Sting Jet reaches the ground near the break (red). The most damaging winds occur here.

3.

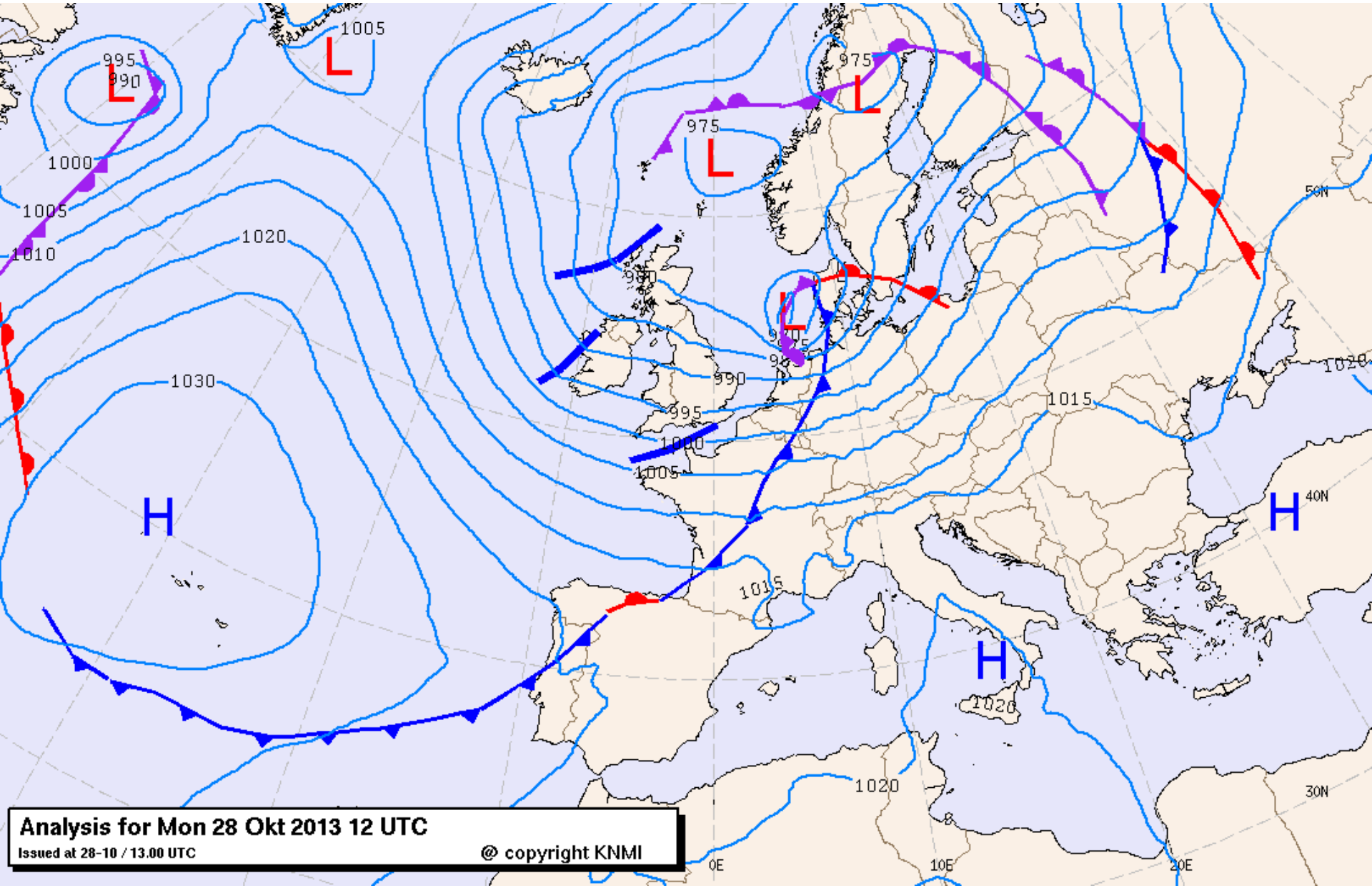



The Sting Jet region enlarges over a few hours.

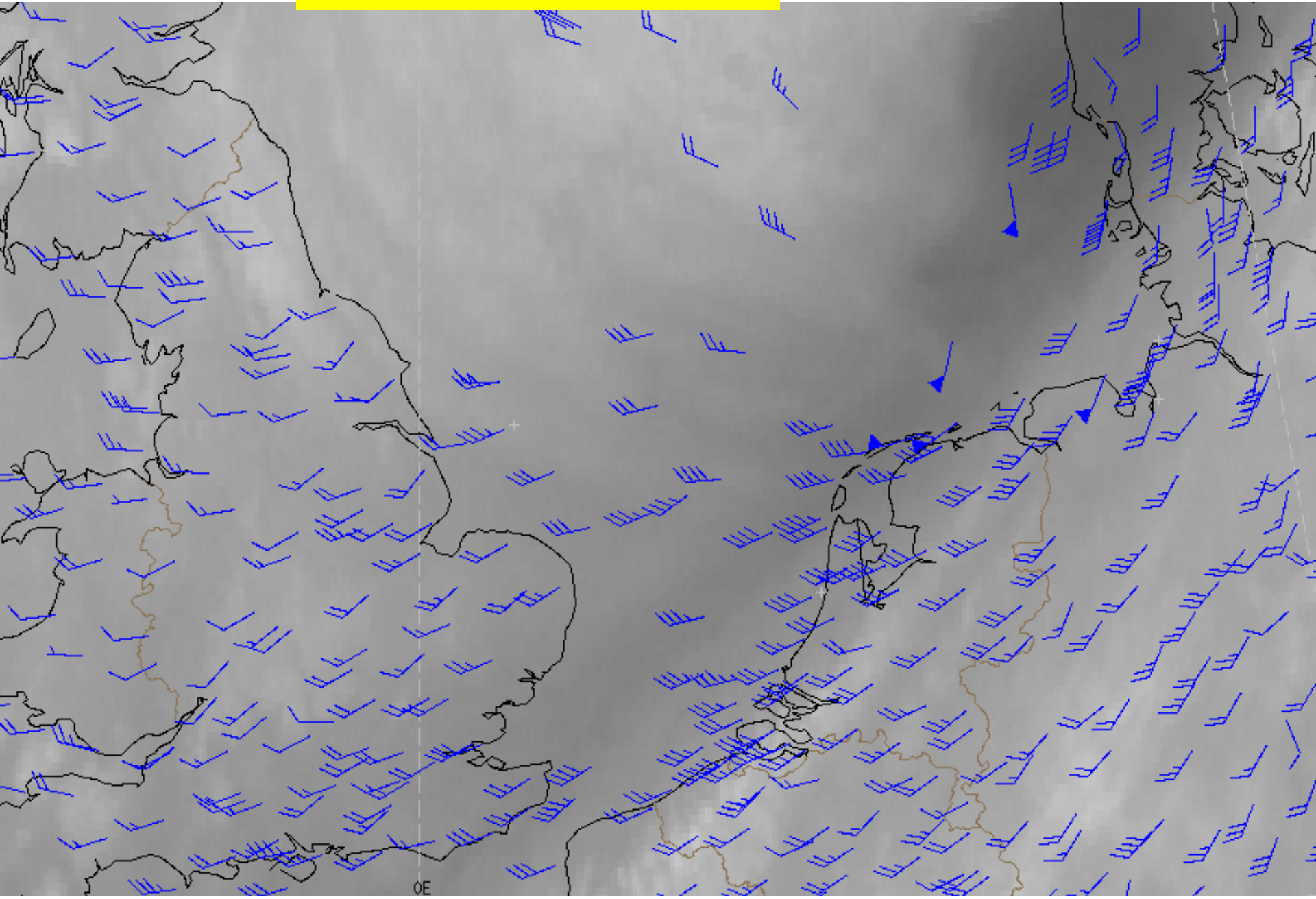
4.




The cold jet eventually wraps round the low centre and catches up with the Sting Jet. Strong winds may still occur, but the most damaging are over.

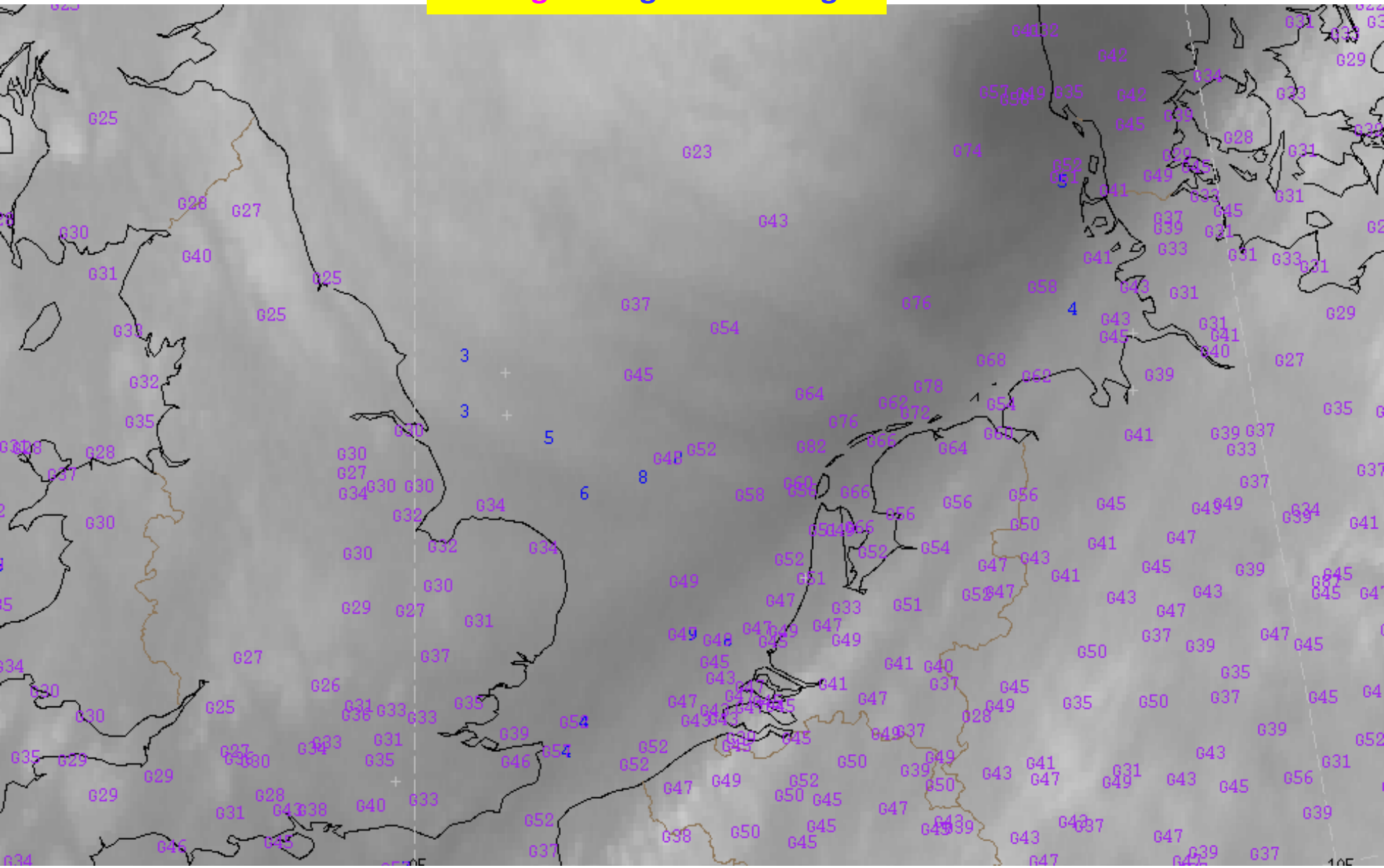

Analysis for Mon 28 Okt 2013 12 UTC
Issued at 28-10 / 13.00 UTC
@ copyright KNMI
1005
995
990
1000
1005
1010
1020
1030
975
975
990
995
1000
1005
1015
1020
1015
1020
1020
H
H
H
L
L
L
L
50N
40N
30N
0E
10E
20E

# Windspeed 28 Oct 2013 12 UTC



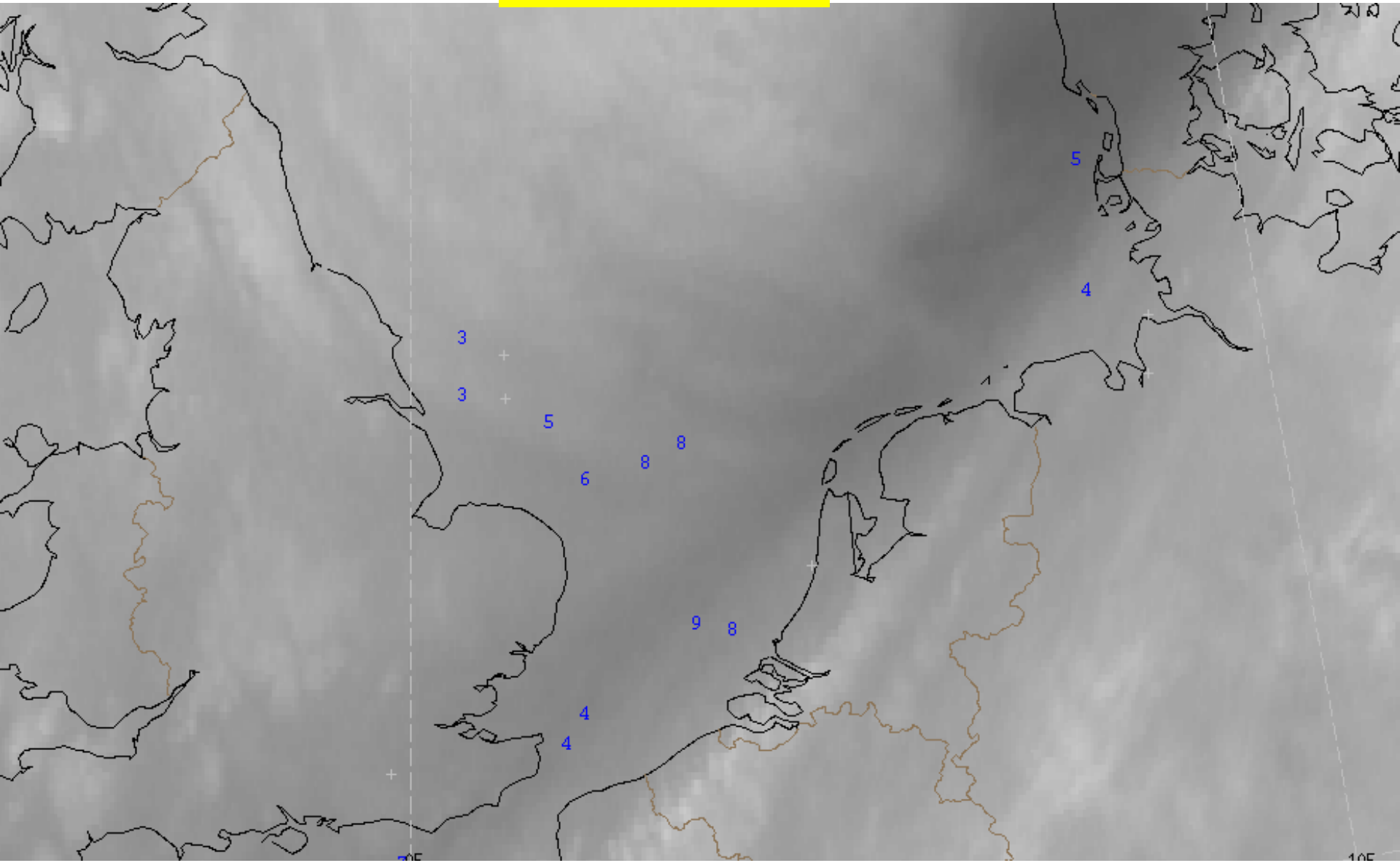
# 28 Oct 2013 12 UTC

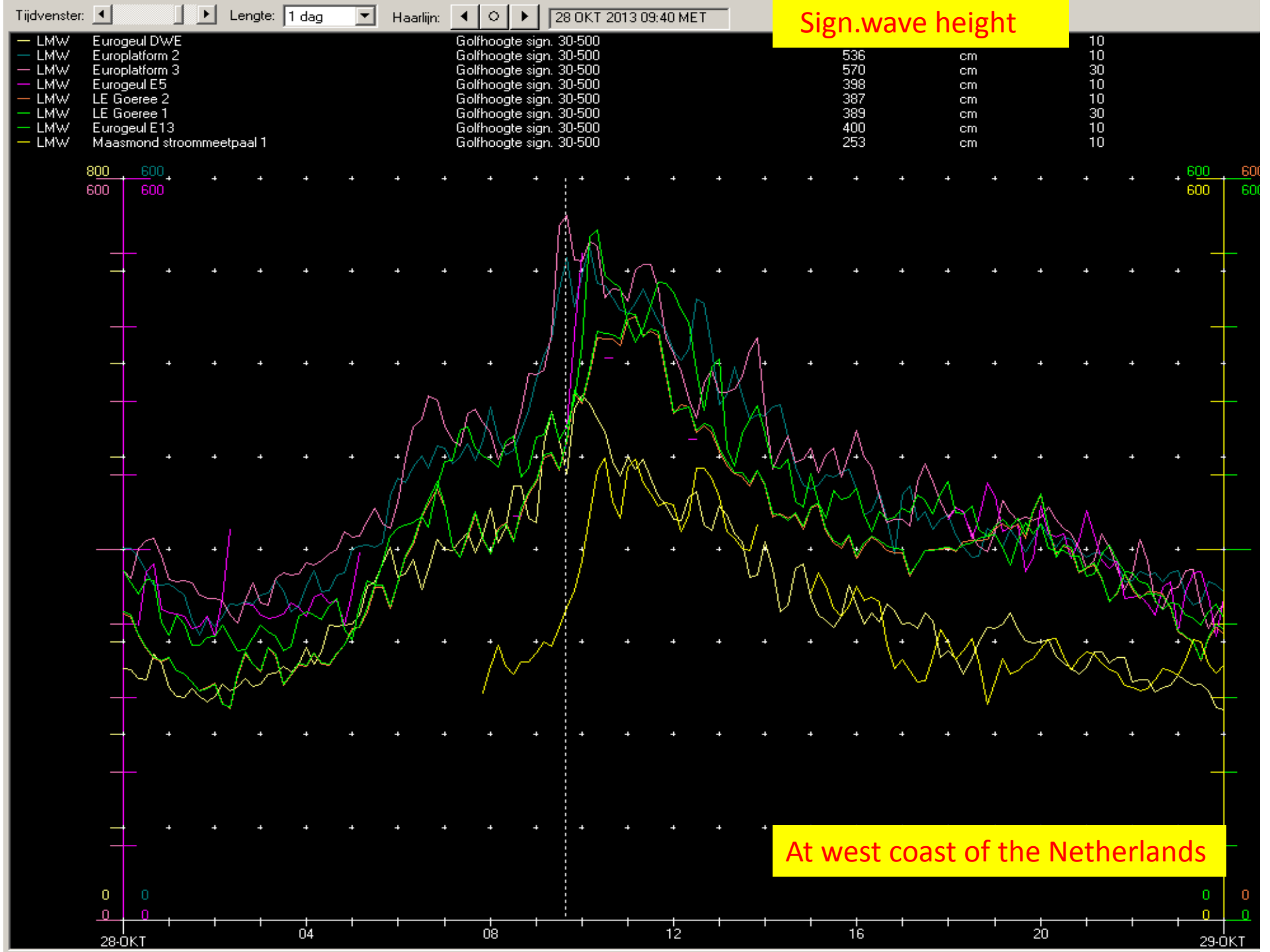
Wind gust Sign wave height

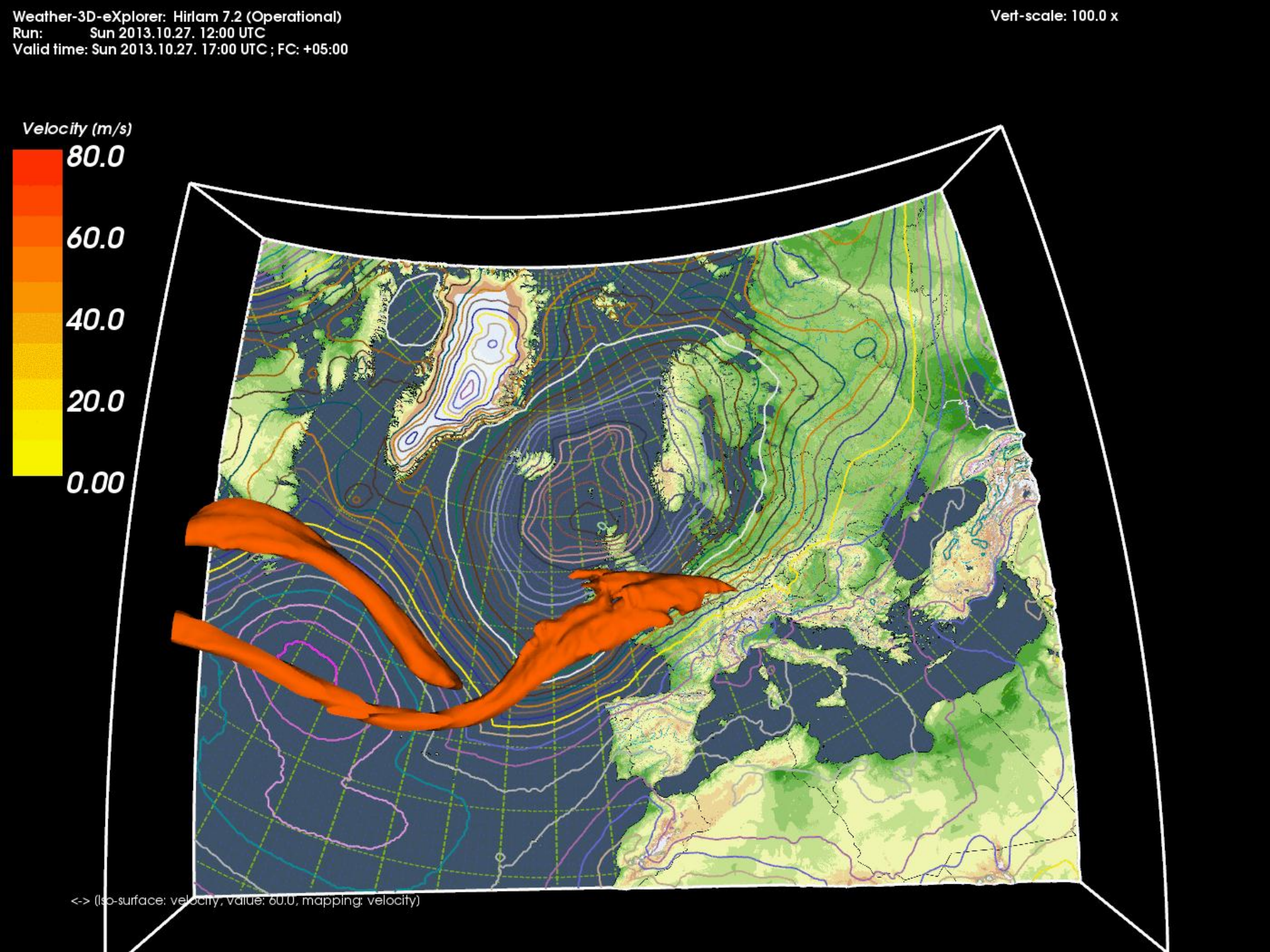


# 28 Oct 2013 12 UTC

## Sign wave height




Tijdvenster:
Lengte: 1 dag
Haarlijn:
28 OKT 2013 09:40 MET
Sign.wave height
LMW Eurogeul DWE Golfhoogte sign. 30-500 536 cm 10
LMW Europlatform 2 Golfhoogte sign. 30-500 570 cm 30
LMW Europlatform 3 Golfhoogte sign. 30-500 398 cm 10
LMW Eurogeul E5 Golfhoogte sign. 30-500 387 cm 10
LMW LE Goeree 2 Golfhoogte sign. 30-500 389 cm 30
LMW LE Goeree 1 Golfhoogte sign. 30-500 400 cm 10
LMW Eurogeul E13 Golfhoogte sign. 30-500 253 cm 10
LMW Maasmond stroommeetpaal 1
800 600
600 600
600 600
600 600
0 0
0 0
0 0
0 0
28-OKT
04
08
12
16
20
29-OKT
At west coast of the Netherlands


Weather-3D-eXplorer: Hirlam 7.2 (Operational)
Run: Sun 2013.10.27. 12:00 UTC
Valid time: Sun 2013.10.27. 17:00 UTC ; FC: +05:00
Vert-scale: 100.0 x
Velocity (m/s)
80.0
60.0
40.0
20.0
0.00
<-> (Iso-surface: velocity, value: 60.0, mapping: velocity)

# Info Wikipedia

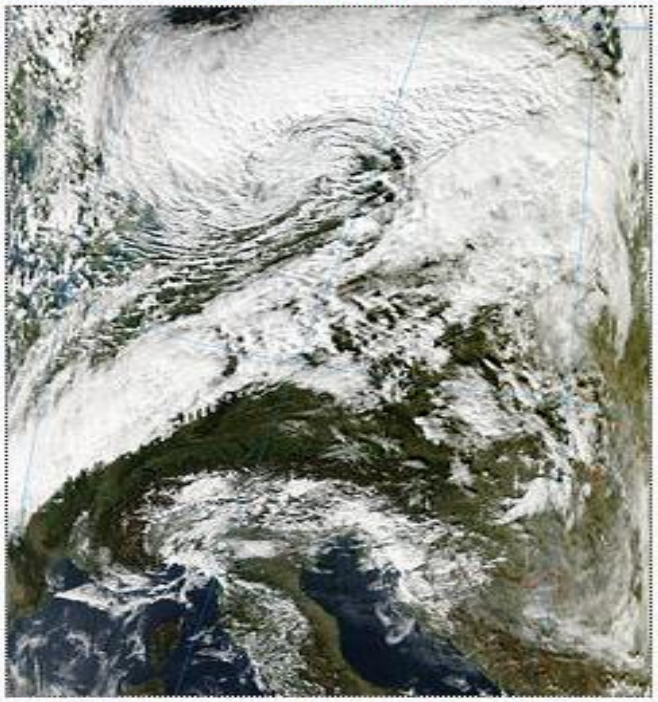
### Sea

- In the Atlantic Ocean, the container ship *Maersk Salina* lost 45 containers whilst off the coast of Brittany, France.[107]
- Irish Ferries cancelled services between Holyhead, Anglesey and Dublin.[104]
- Sailings between Penzance and the Isles of Scilly, operated by the Isles of Scilly Steamship Company's *Scillonian III*, were cancelled.[108]
- The Fal River ferry in Cornwall was suspended.[108]
- In France, Penn-ar-Bed cancelled its sailings between Ouessant, Finistère and the Île de Sein.[34]
- Brittany Ferries cancelled a number of sailings on 27 October. The 16:30 from Roscoff, Finistère, France to Plymouth, Devon and the 23:00 from Plymouth to Roscoff.[108]
- Condor Ferries cancelled its sailings on the Poole–Weymouth–Channel Islands route and also those between Saint-Malo and the Channel Islands.[34]
- The Port of Dover was closed between 06:00 and 09:30 on 28 October; two P&O ferries with a total of 463 passengers on board were held at sea in The Downs, off Deal, Kent.[78][109]
- In the Netherlands, ferries between Harlingen, Friesland and Vlieland were cancelled.[110]
- In the North Sea, the container ship *YM Unicorn* lost two containers off Terschelling, Friesland, Netherlands.[111]
- In Germany, ferry services to Heligoland and Sylt were cancelled on 27 and 28 October.[112]
- Mols Line cancelled four sailings between Jutland and Odde.[113]
- In the Baltic Sea, a Stena Line passenger ferry, with 33 staff on board has been driven by high winds to ground, the *Stena Alegra* was anchored outside the Swedish port of Karlskrona when it was pushed by high winds. The 89 metres (292 ft) long bulk carrier *Rotterdam* has also been driven towards the coast, but managed to weigh anchor and are preparing to be towed if needed.[114]
- One hundred people were evacuated from the Siri oil platform in the North Sea.[115]
- Ferry services between Bornholm and Rønne, Denmark were also cancelled.[113]

## Casualties

| Country | Fatalities | Missing |
|---|---|---|
| Germany | 8 | 0 |
| United Kingdom | 4 | 1 |
| Netherlands | 3 | 0 |
| Denmark | 2 | 0 |
| France | 1 | 0 |
| **Total** | **18** | **1** |

**St Jude storm**



St Jude storm over Europe, 12:10 UTC, 28 October 2013

| | |
|---|---|
| **Type** | European windstorm, extratropical cyclone |
| **Formed** | 26 October 2013 |
| **Dissipated** | 31 October 2013[1] |
| **Lowest pressure** | Est. 965 mb (28.5 inHg) Obs. 967.6mb |
| **Highest wind (sustained)** | Estimated 80 to 90 miles per hour (130 to 140 km/h)) gusts |
| **Highest gust** | 120.8 miles per hour (194.4 km/h), Als, Denmark |
| **Fatalities** | 17 dead, 1 missing |
| **Areas affected** | Ireland, United Kingdom, France, Belgium, Netherlands, Germany, Denmark, Sweden, Norway, Latvia, Estonia, Finland, Russia |

wikipedia

# Thx

- **Questions, Comments?**