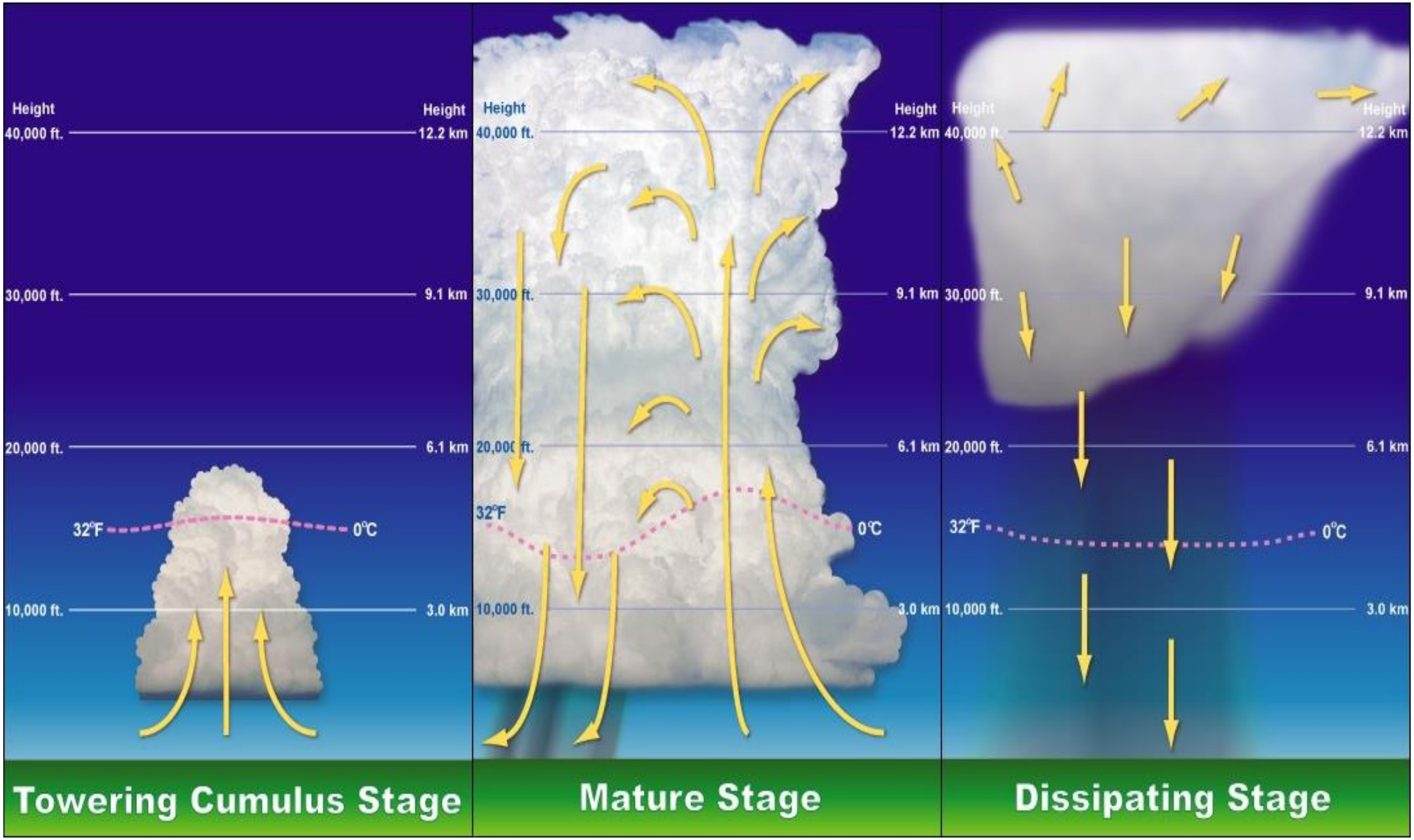
Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Verkeer en Waterstaat

Convective Cloud Features in typical synoptic situations

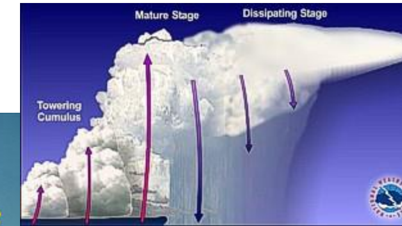
Frans Debie

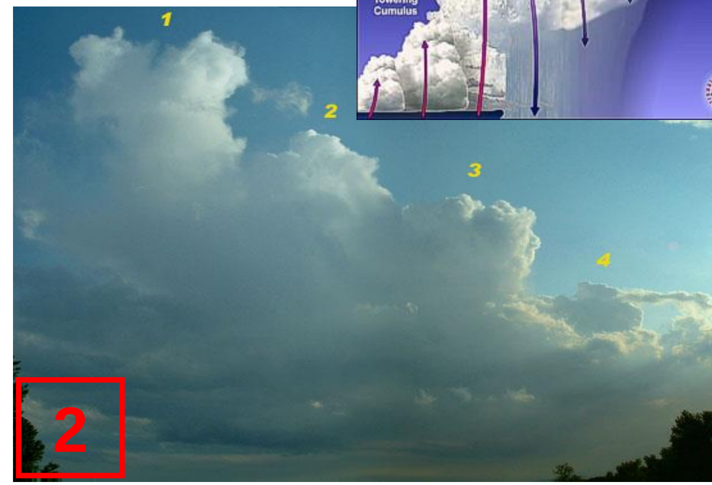
me
SATRAPPERS
Henk
vesa
ab
Frans
Veronika
Teachers classroom Langen

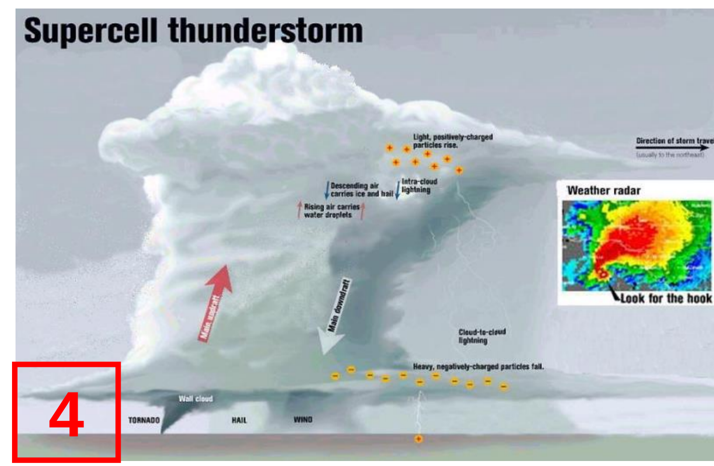
Cumulonimbus: Convection

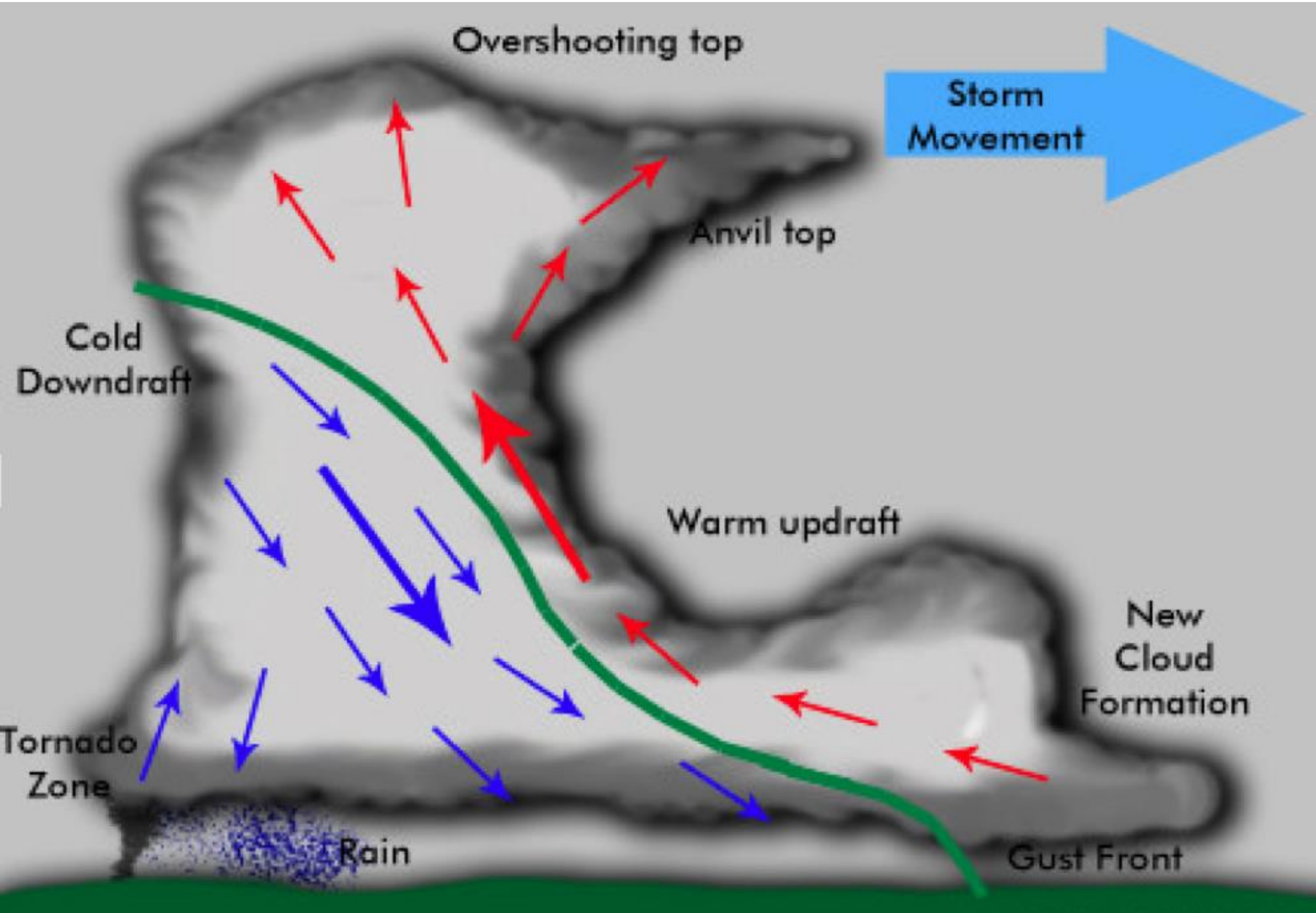


Convection, seen from ground

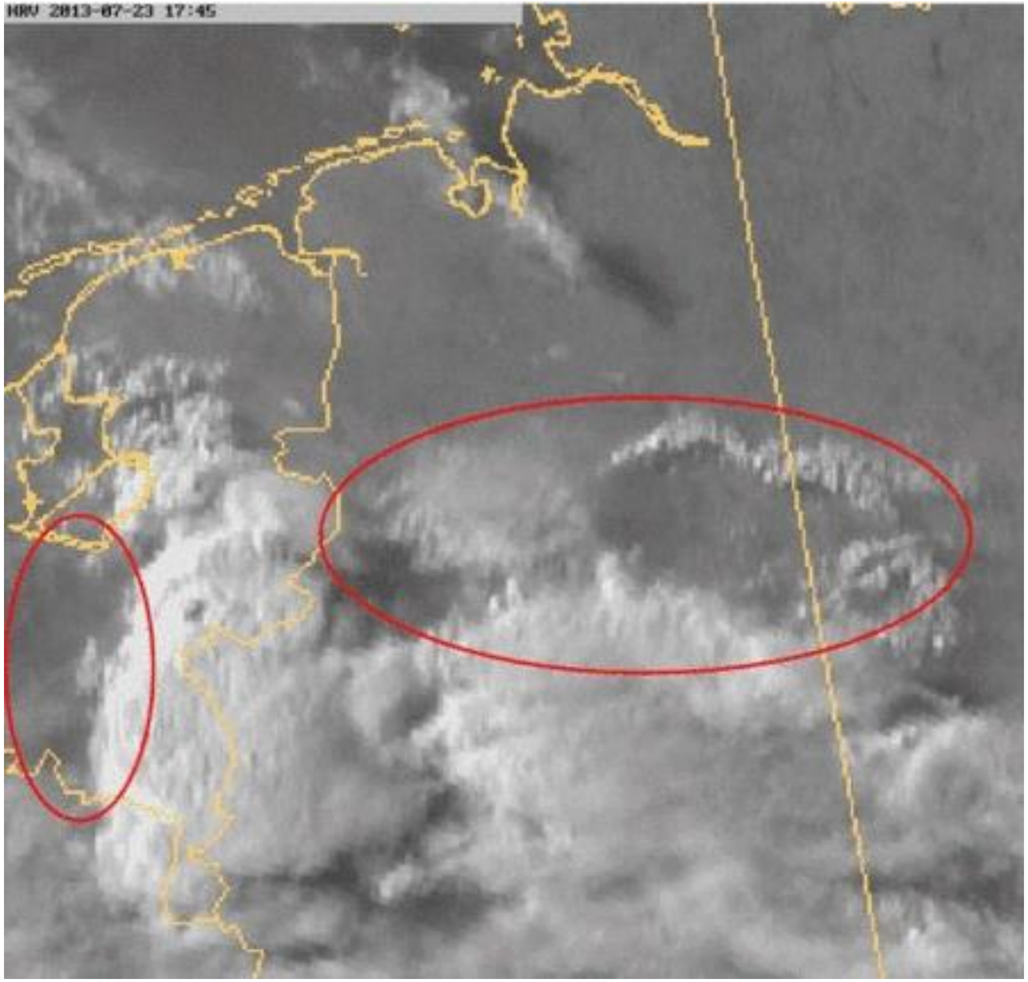







Overshooting top
Storm Movement
Anvil top
Cold Downdraft
Warm updraft
New Cloud Formation
Tornado Zone
Rain
Gust Front

Outflow boundaries



Which features are important for convection?

- **Humidity (eg. mixing ratio)**

- **Stability (lapse rate, conditional unstable)**

- **Lift (Cape, CIN)**

Which features are important for convection?

- **Humidity (eg. mixing ratio)**

- **Stability (lapse rate, conditional unstable)**

- **Lift (Cape, CIN)**

Necessary, however **not always** sufficient enough

- **Shear**

Features

[1] Humidity

- Evaporation
- Advection

[2] Stability

- Insolation
- Change Humidity
- Cold Advection at higher levels

[3] Lift

- Front
- PVA (Upper level trough)
- Jet streaks
- Outflow boundary
- Convergence zone
- Orography

[4] Shear

- Mostly in lowest 6000 ft

Lift is vertical motion due to forcing

- **"Convergence lines"**
  - Fronts
  - Thermal lows / troughs
  - Outflow Boundaries
  - Sea breeze (lakes) front

- **Upper level forcing**
  - Jet streaks
  - Upper level troughs

- **Other forcing mechanism**
  - Low-level jet
  - Orography

CAPE and **CIN**:
(convective available potential energy / convective inhibition)

Typical values CAPE (J/kg)

- 100-500: Winter
- 500-2000: Summer
- >1500: Spanish plume

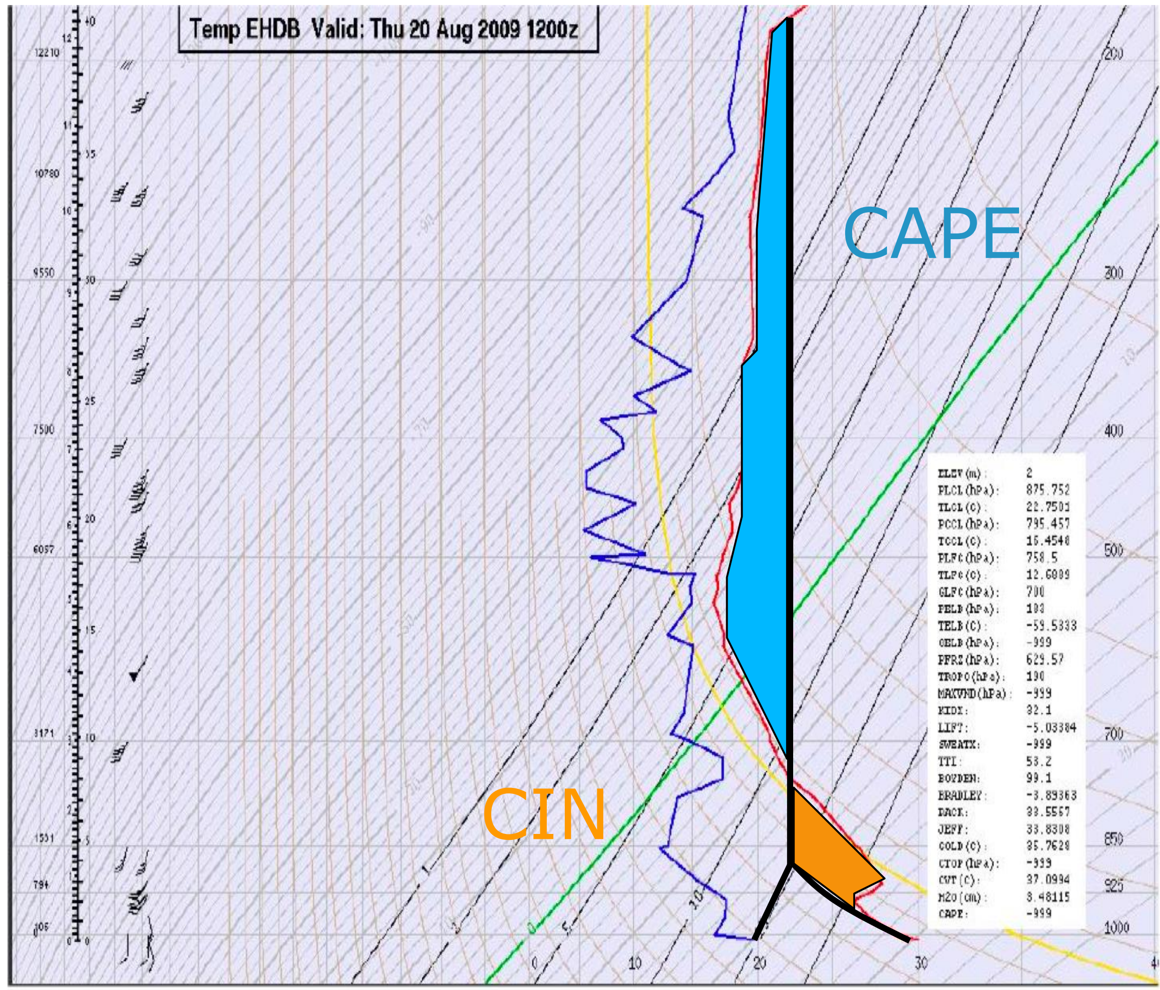
Typical values CIN (J/kg)

0: free convection

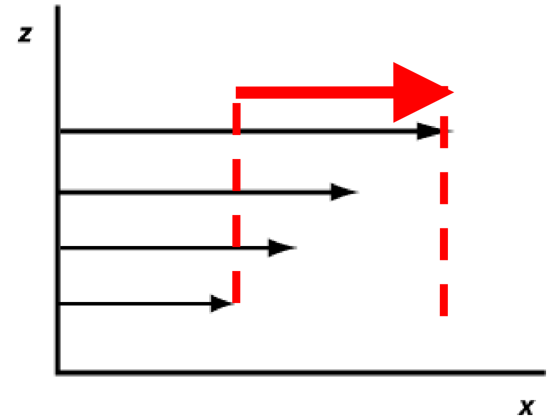
1-30 convection with *enough* heating/lift

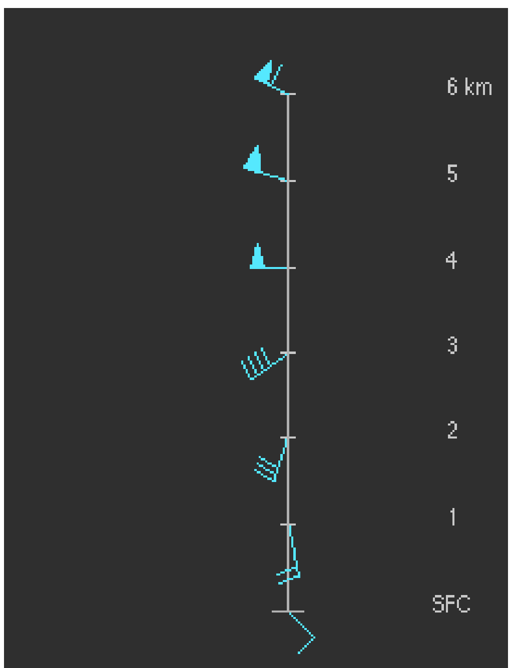
30-100: convection with strong heating / lift

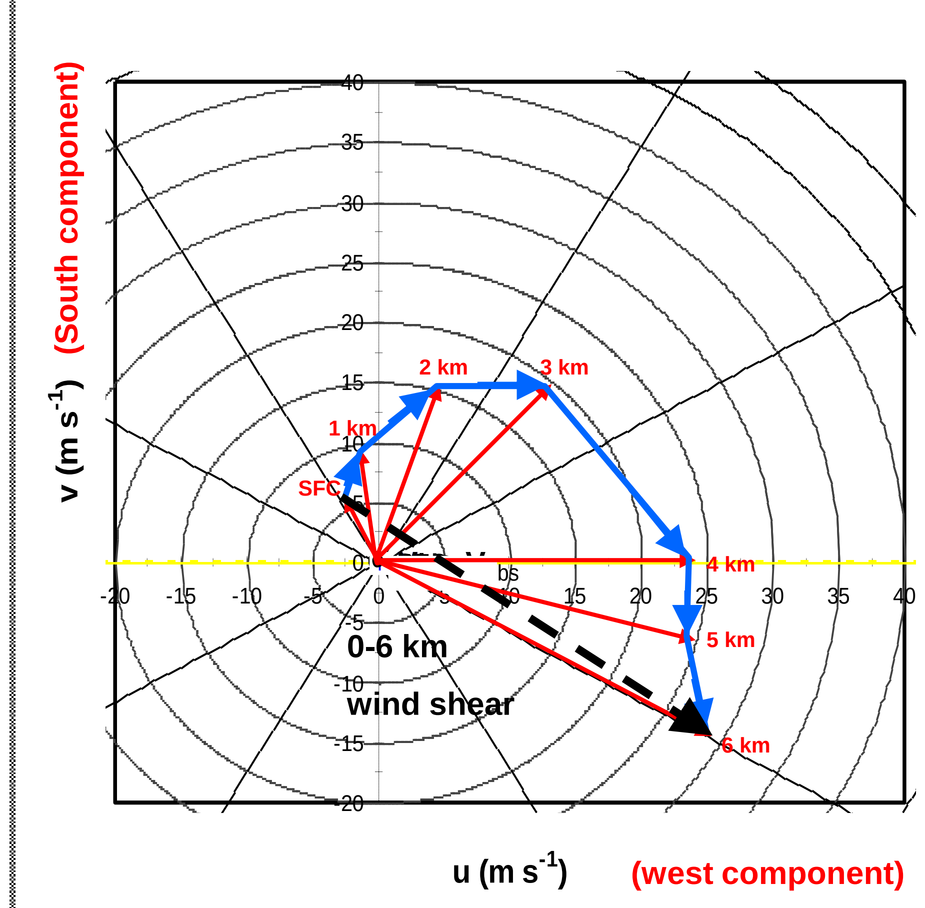
>100: convection almost impossible



Hodogram Shear in lowest 6000 ft

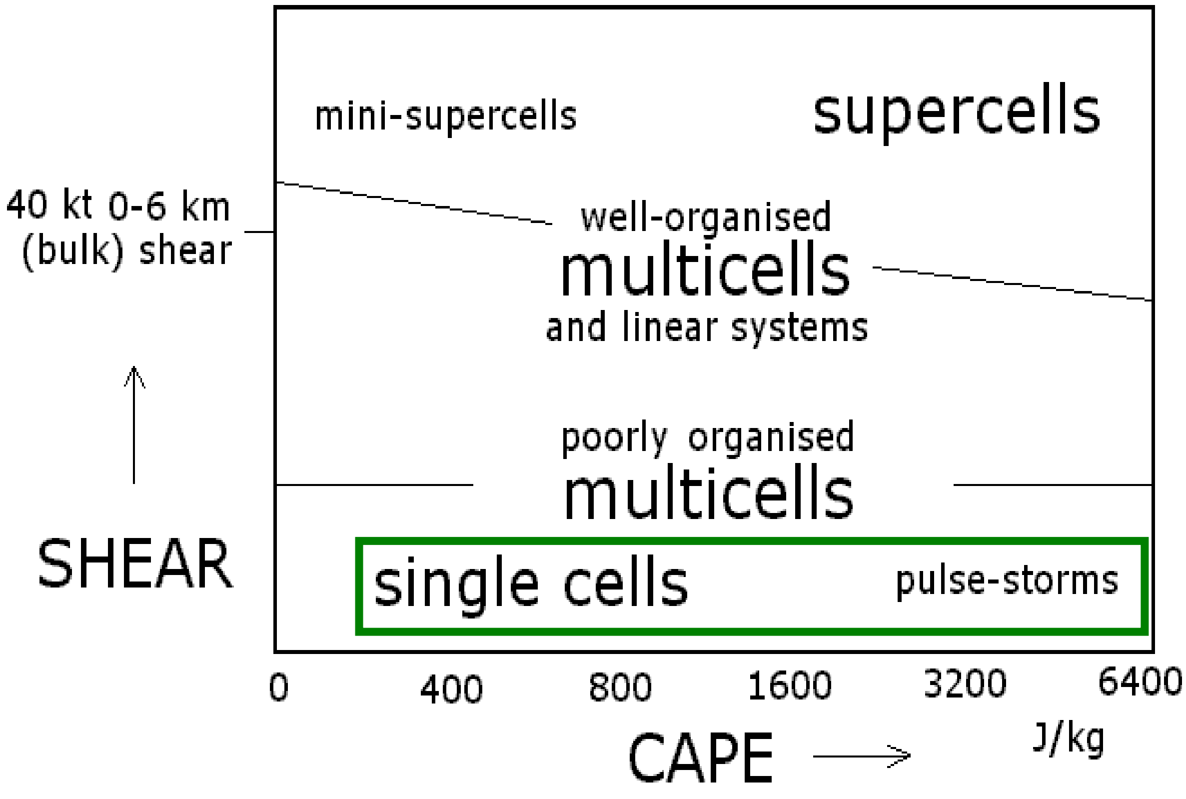






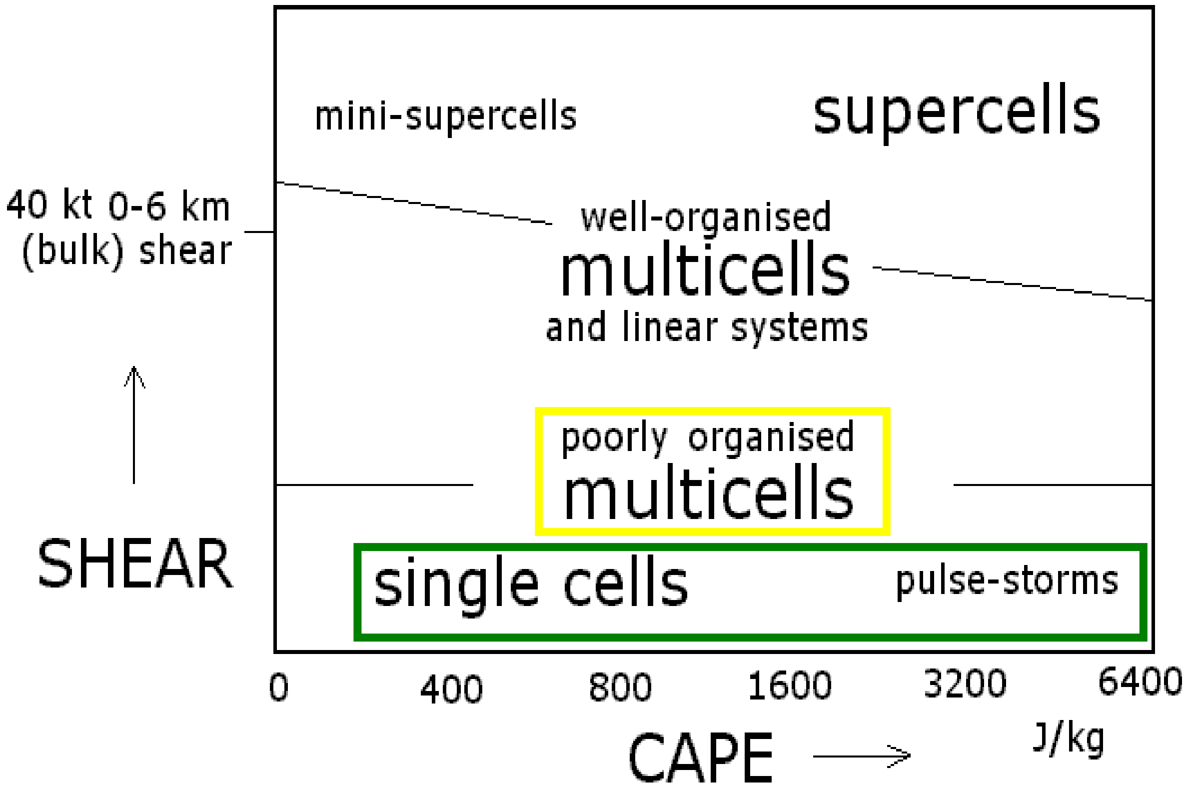
Convection spectrum:
4 main types

- **Single cell   Pulse storms**



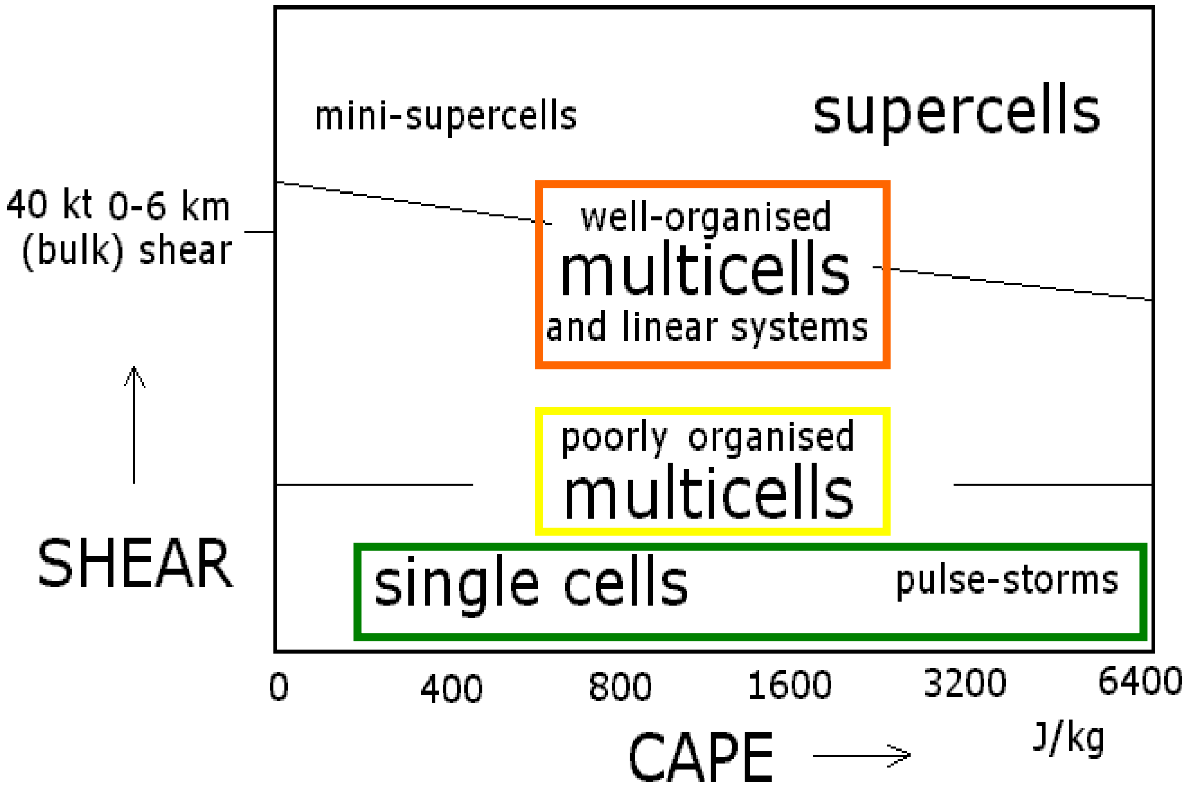
Convection spectrum:
4 main types

- **Single cell   Pulse storms**
- **Multicell**



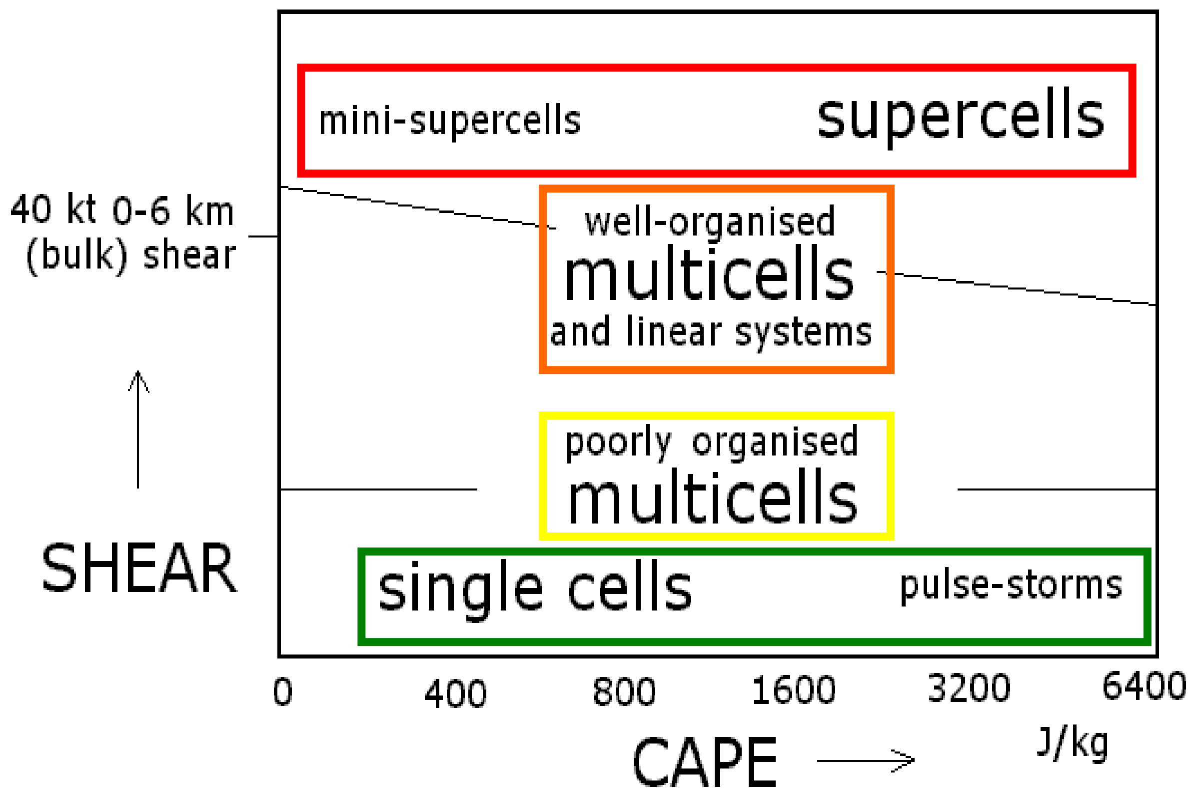
Convection spectrum:
4 main types

- **Single cell Pulse storms**
- **Multicell**
- **Squall lines**



Convection spectrum:
4 main types

- **Single cell   Pulse storms**
- **Multicell**
- **Squall lines**
- **Supercell**



Question:

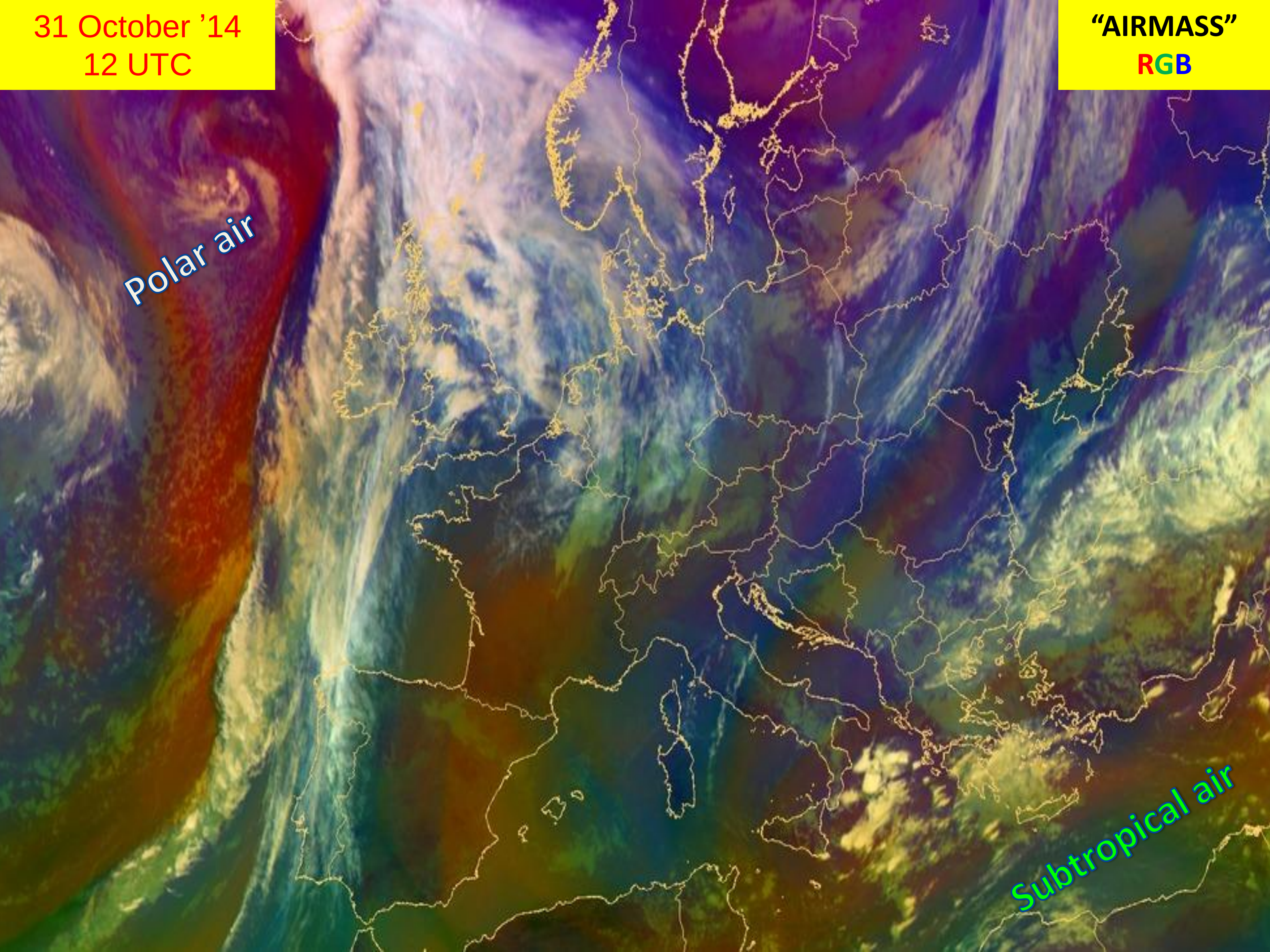
Can we recognize polar air with satellite images?

Answer:

Yes

↓

AIRMASS RGB


31 October '14
12 UTC
"AIRMASS"
RGB
Polar air
Subtropical air

Convective Cloud Features

in

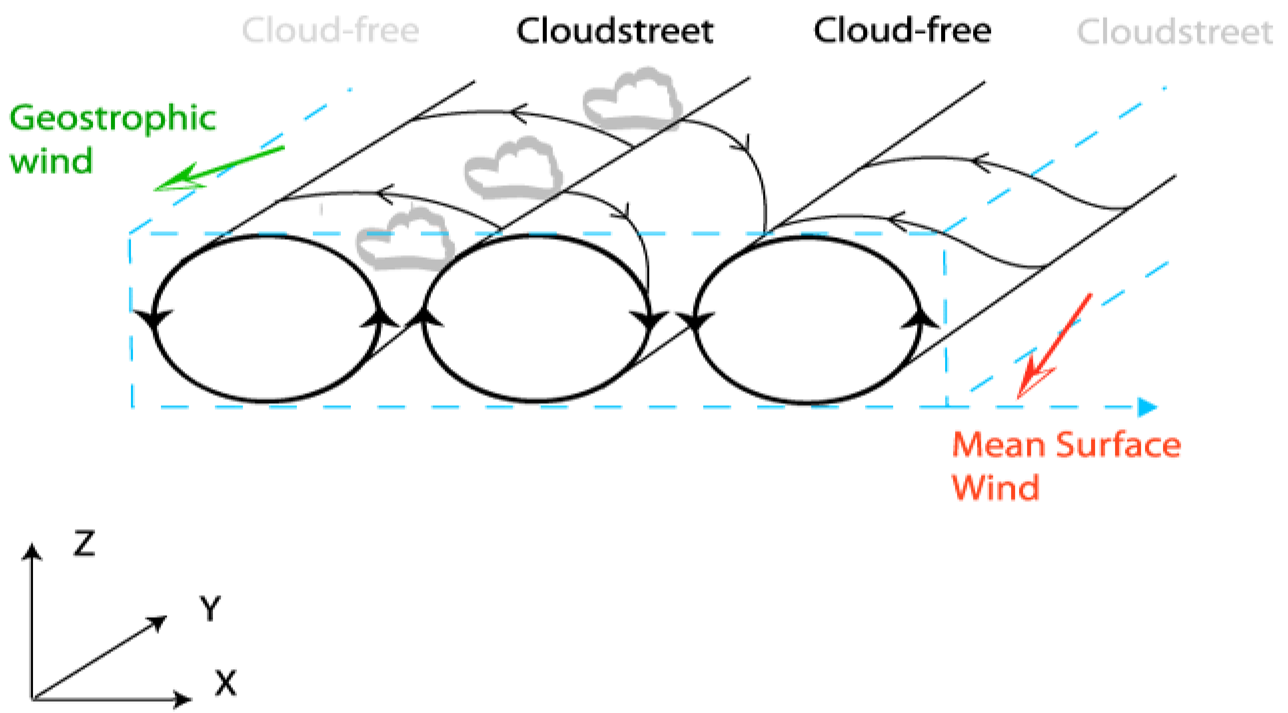
Polar Airmass

from "**Cloud Streets**" to "**Cb's**"

Schematic drawing of development

cloud streets

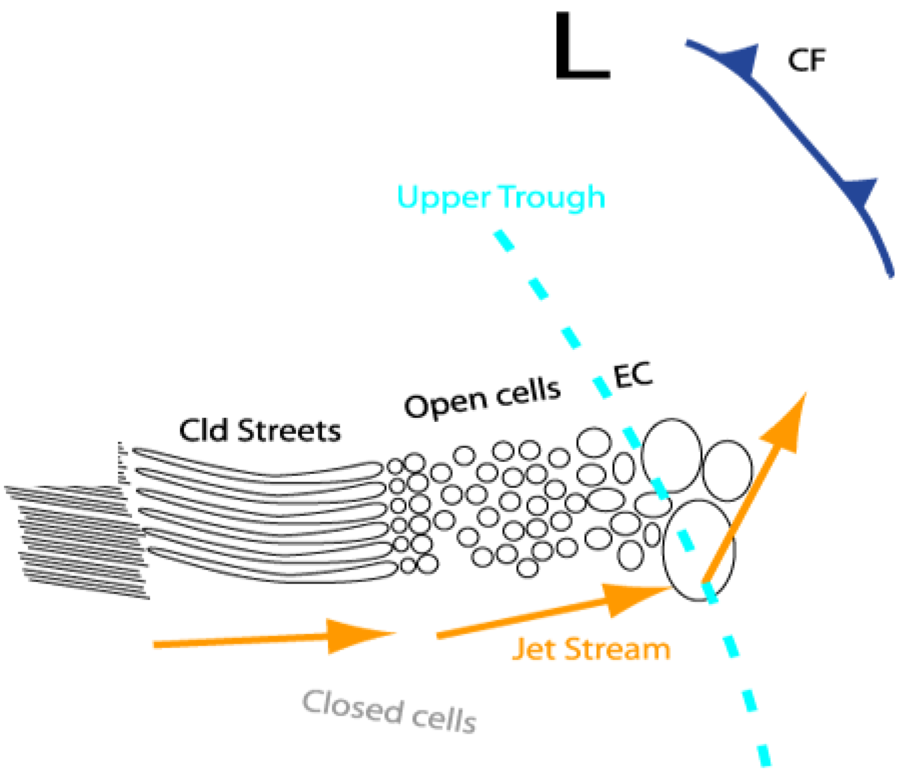
(from satmanu)



Schematic drawing transition

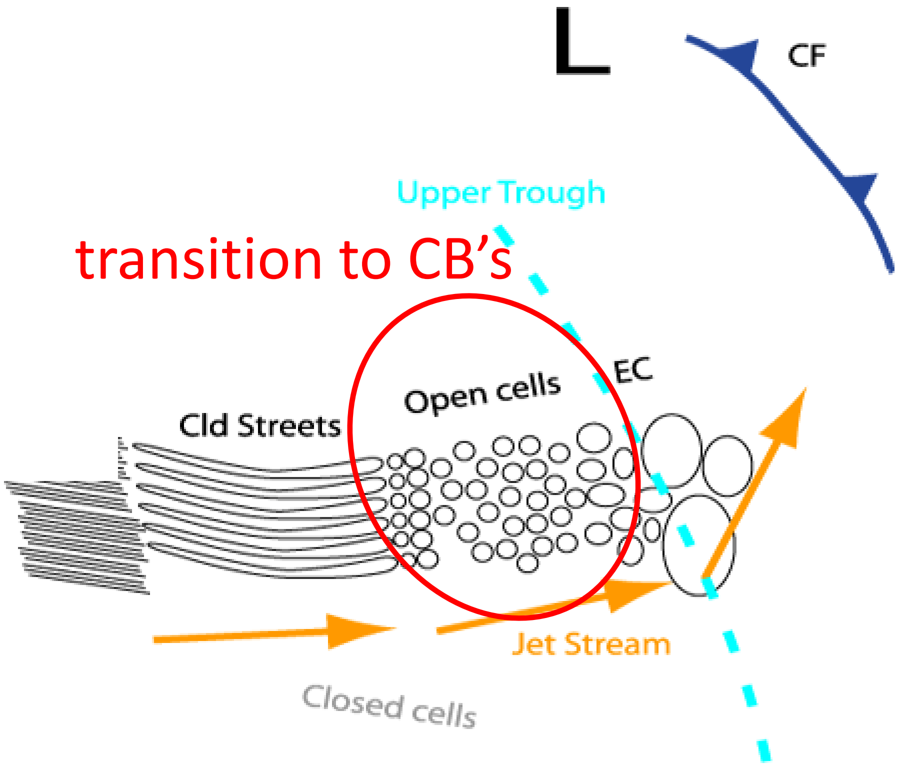
cloud street to **CB**

(from satmanu)



Schematic drawing transition **cloud street** to **CB**

(from satmanu)

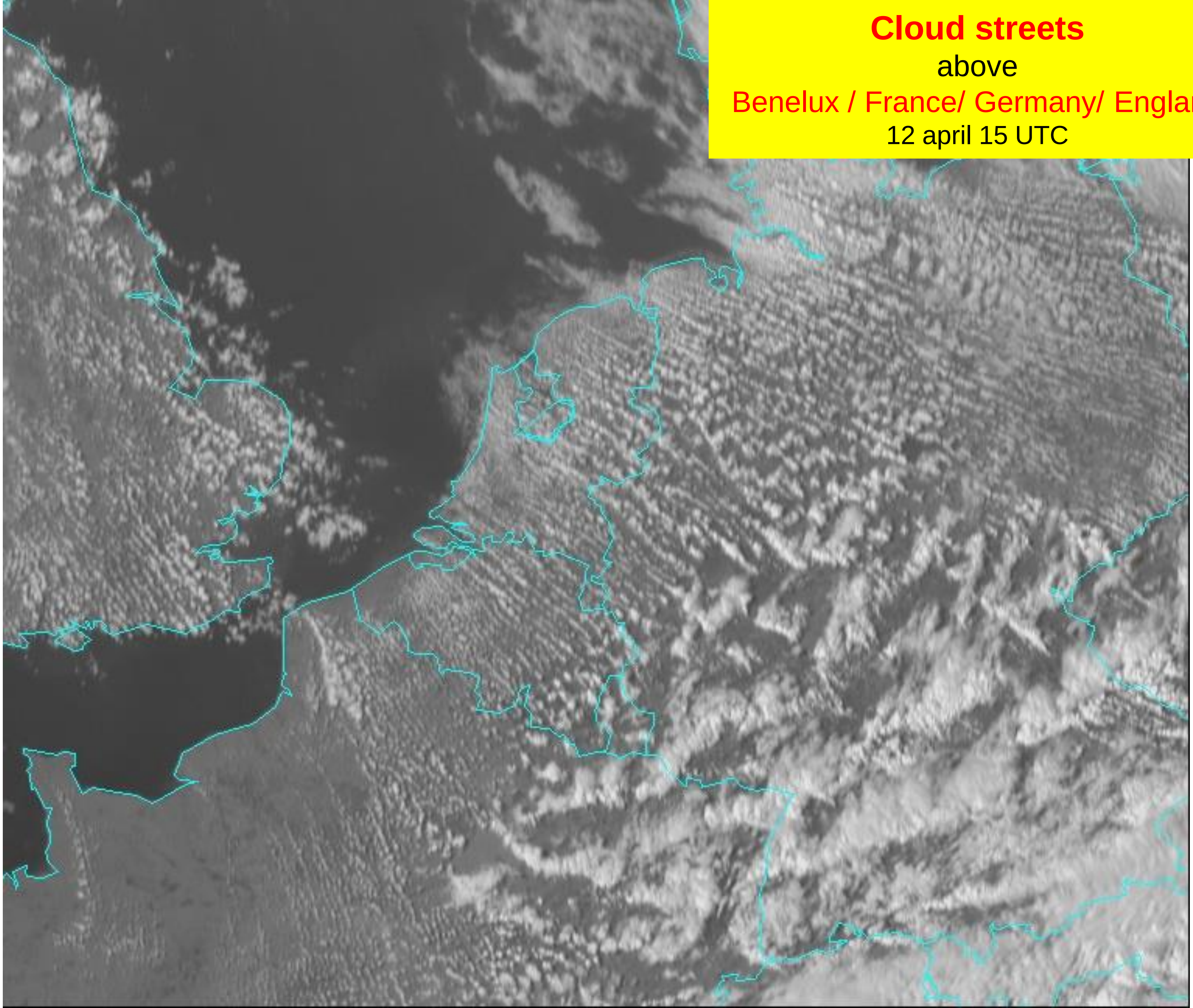


Cloud streets

above

Benelux / France/ Germany/ England

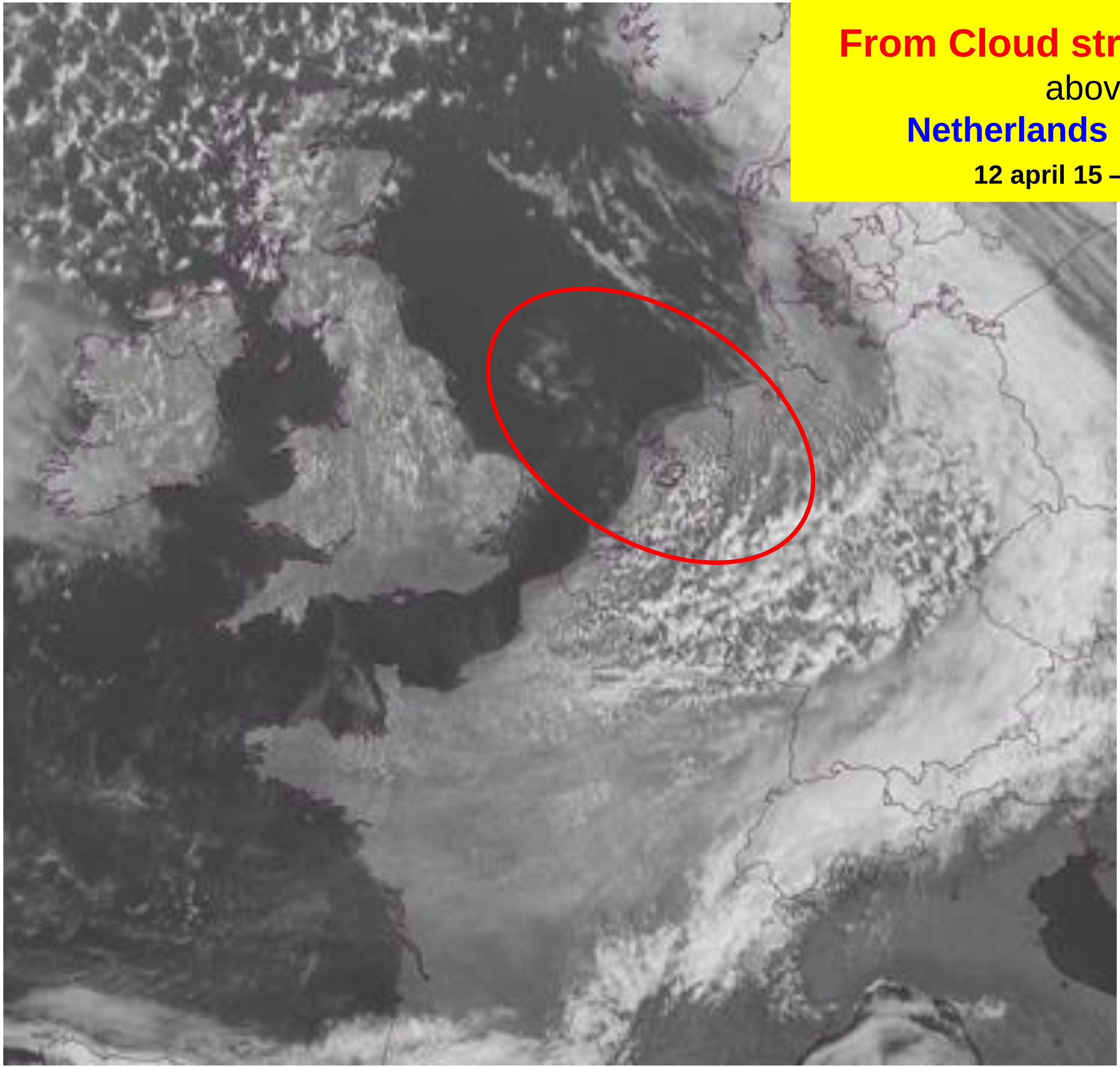
12 april 15 UTC



Just info for Liliane
Next slide is an animation:

file name:
Hrvis_Cloudstreets1.gif

Delete this sheet!!

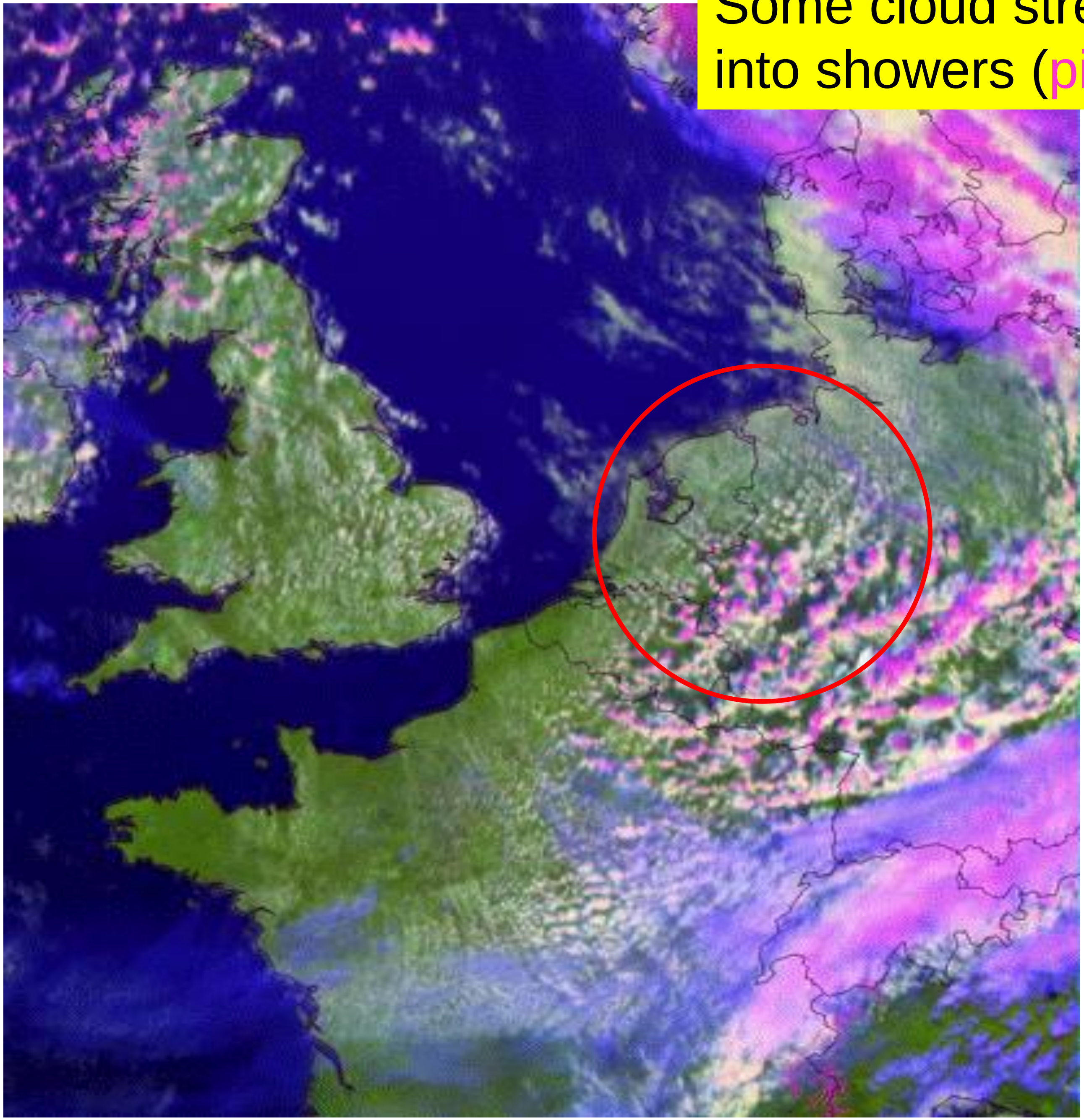


From Cloud streets to CB's
above
Netherlands Germany
12 april 15 – 19 UTC

Info for Liliane
Next slide is an animaton
file name : cloudstreets.gif

Delete this sheet!!

Some cloud streets develop into showers (pink tops)



Convective Cloud Features

in

Polar Airmass

Enhanced Cumulus

(EC)

Conceptual model

- **Enhanced Cumulus**

Definition:

Enhanced Cumulus area (EC) consists of a cluster of thicker and larger cloud cells within the usual cold air cloudiness behind frontal cloud bands, but sometimes are also a part of Open Cell Cloudiness

There are two main conditions to develop **EC** :

1. (Increasing) **vertical instability** in de troposphere, eg:

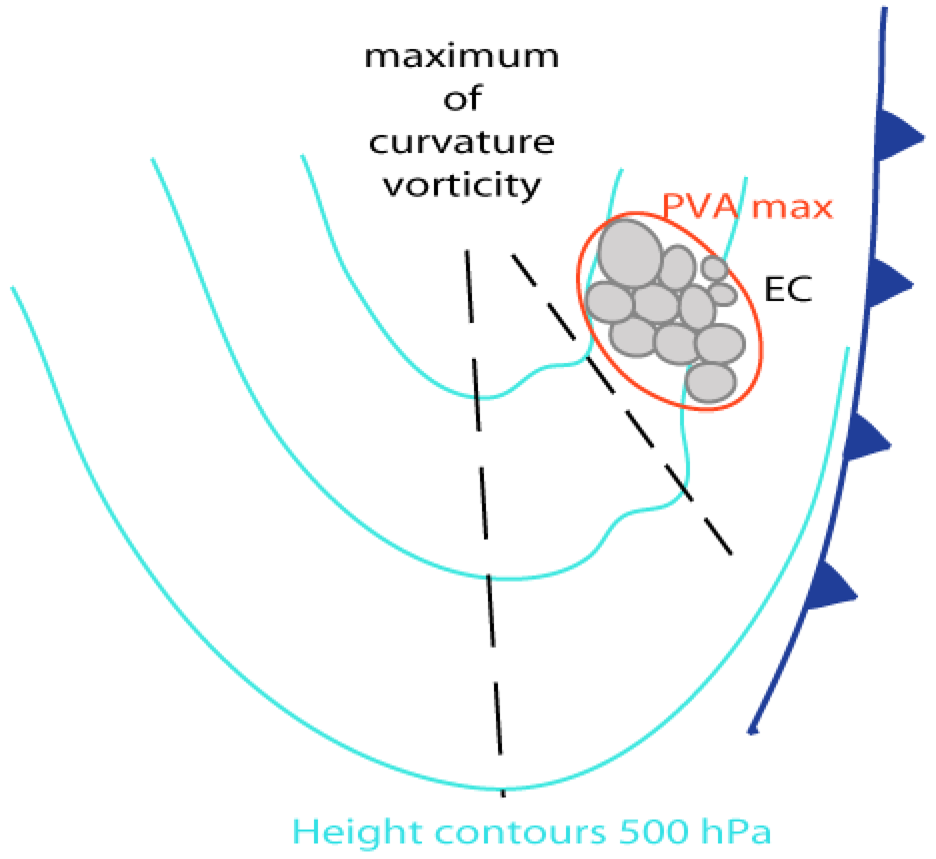
- **Cold** air above **warm** (*sea)water*
- **Cold** air over relative **warm** *land*

2.(Existing of) **PVA maxima**

- At leading side of a moving *upper level trough*, due to advection of **curvature vorticity**
- In the left exit region of a *jet streak* , due to advection of **shear vorticity**

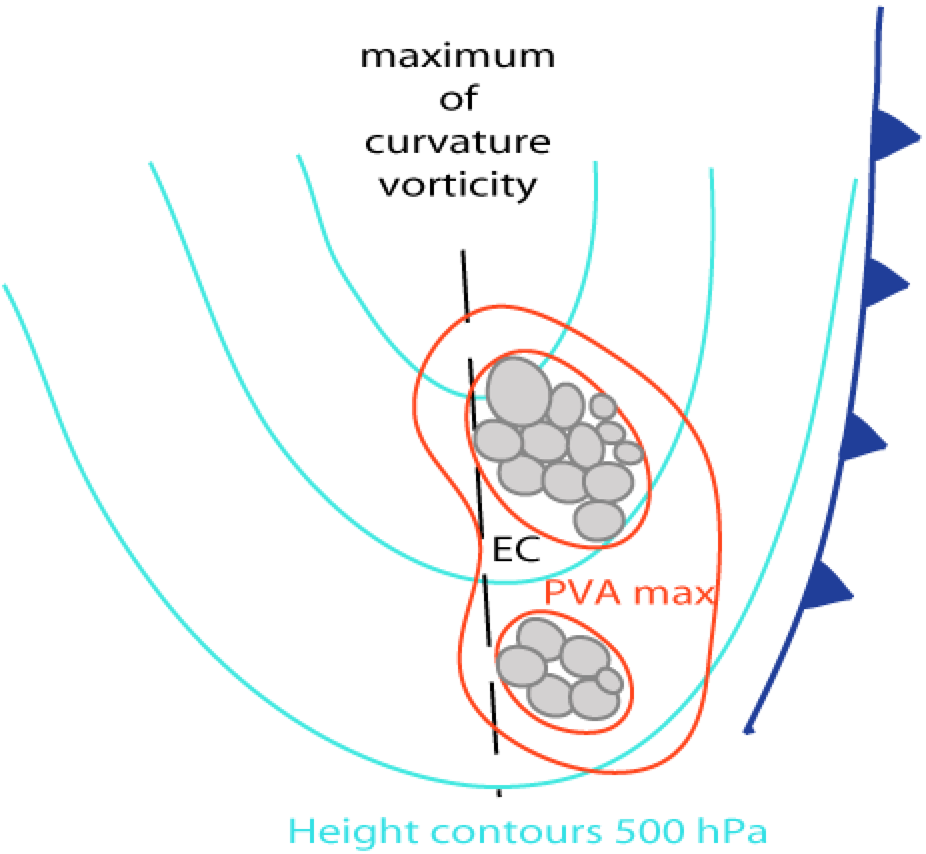
Schematic 1

PVA$_{max}$, associated with an **u**pper **l**evel **trough**



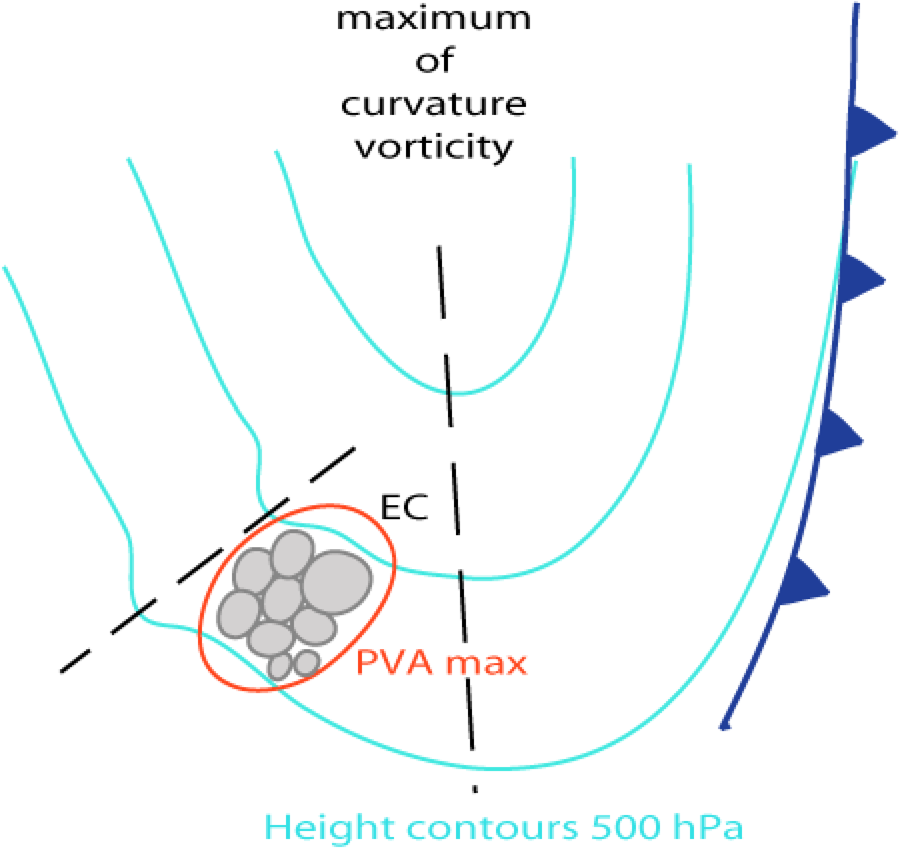
Schematic 2

PVA$_{max}$, associated with main **u**pper **l**evel **trough**



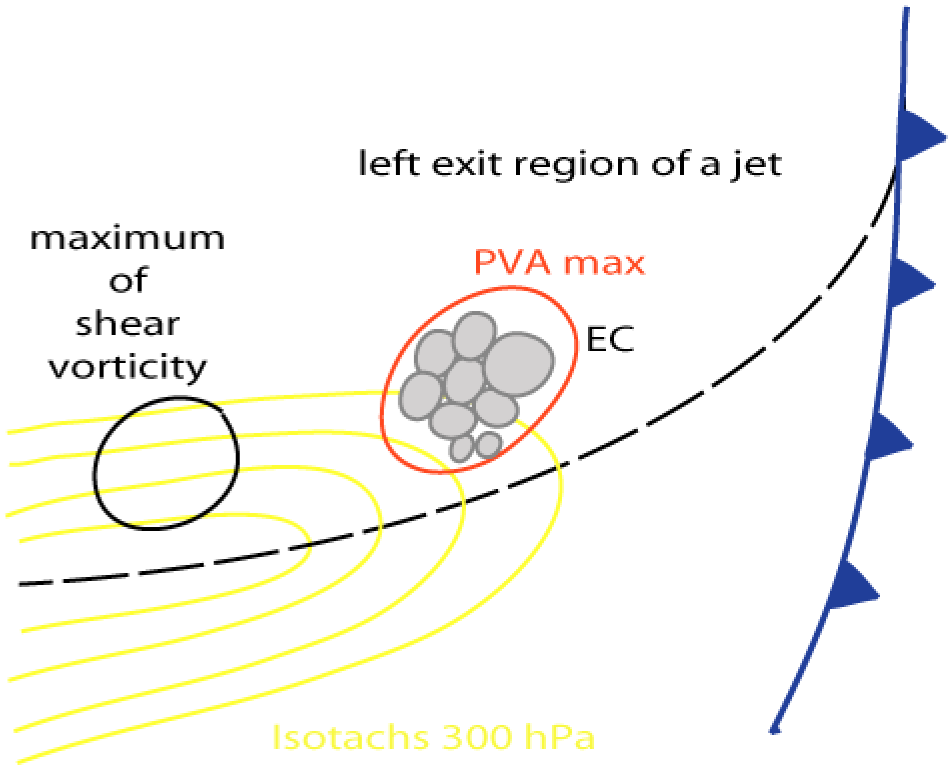
Schematic 3

PVA_{max}, associated with an **u**pper **l**evel **trough**



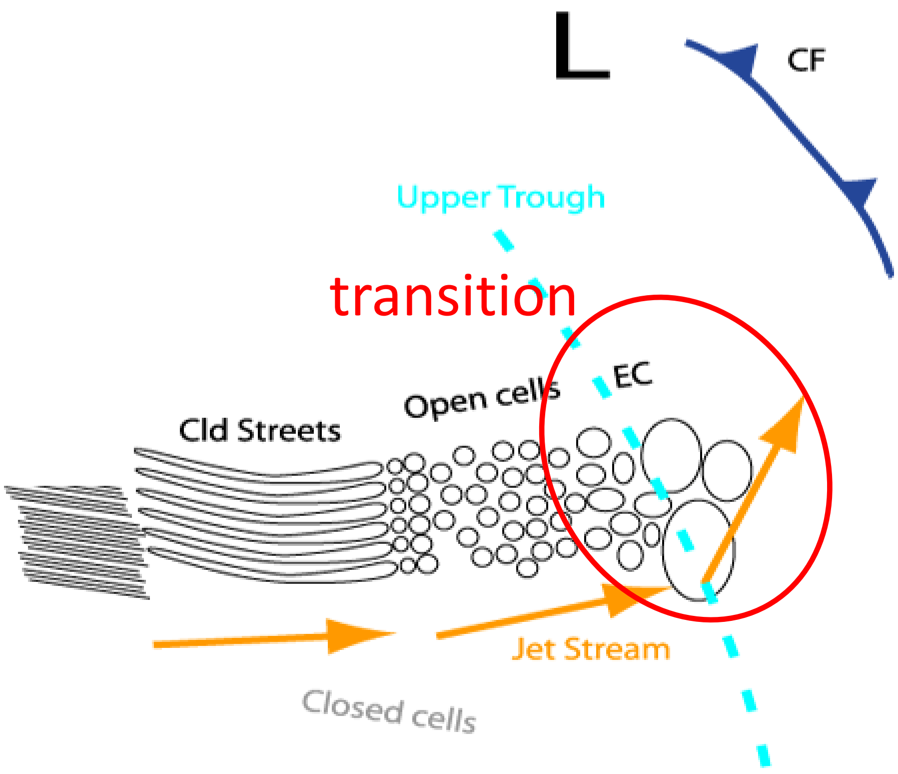
Schematic 4

PVA$_{max}$, associated with **jet streak**



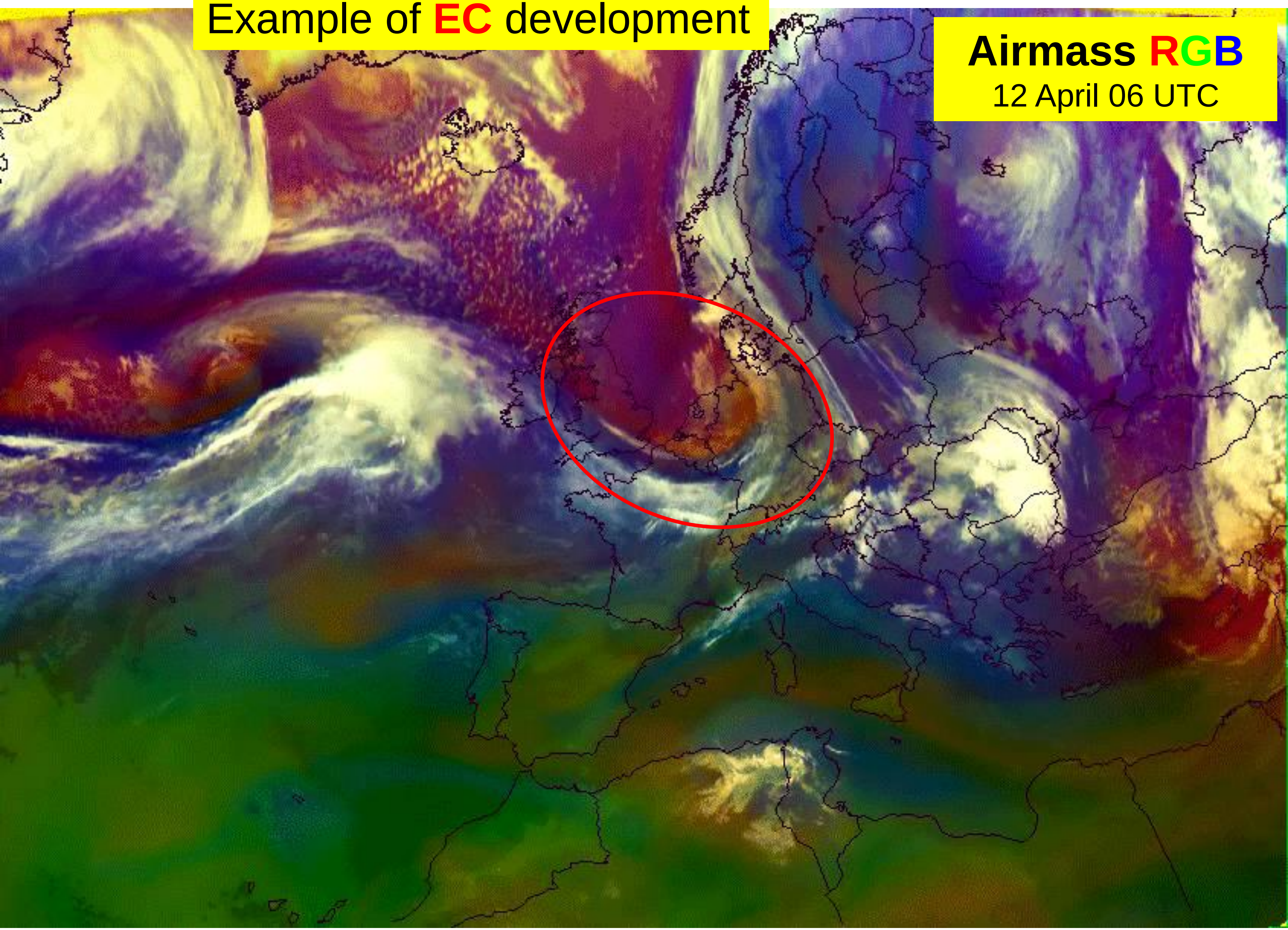
Schematic 4
transition
cloud street to **EC**

(from satmanu)



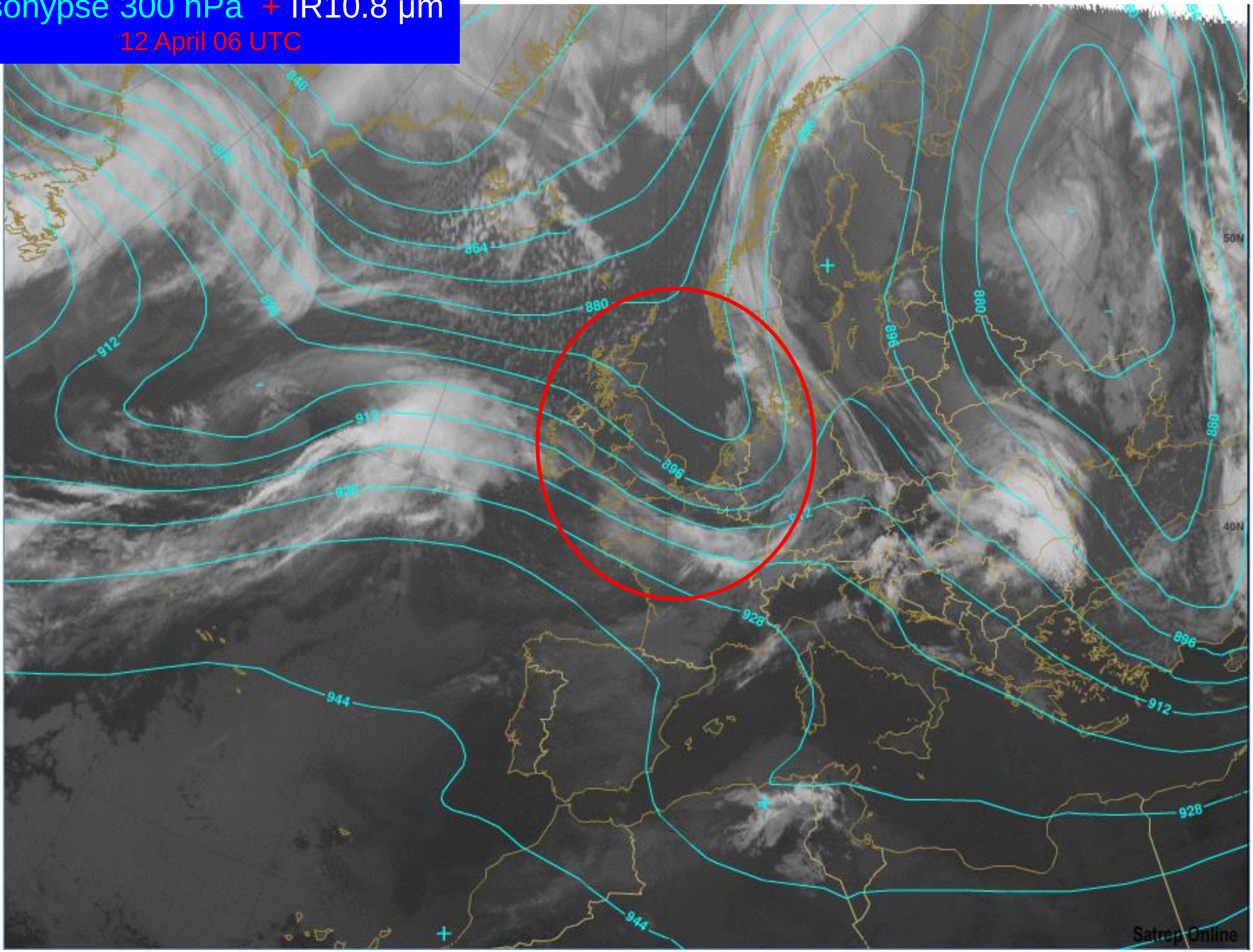
Info for Liliane
next slide is an animation:
file name: airmass_tot.gif
Delete this sheet!!

Example of EC development

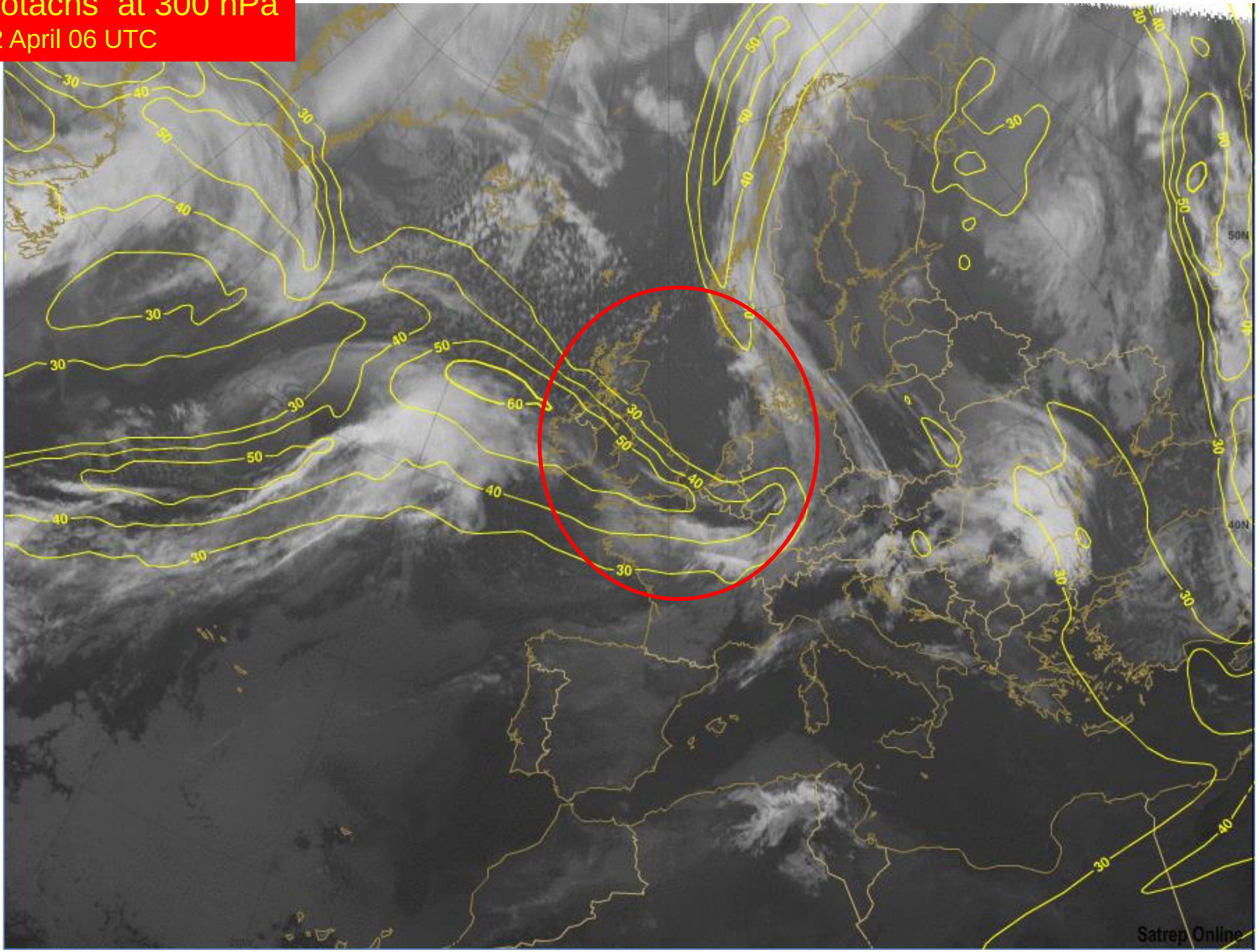


Isohypse 300 hPa + IR10.8 µm

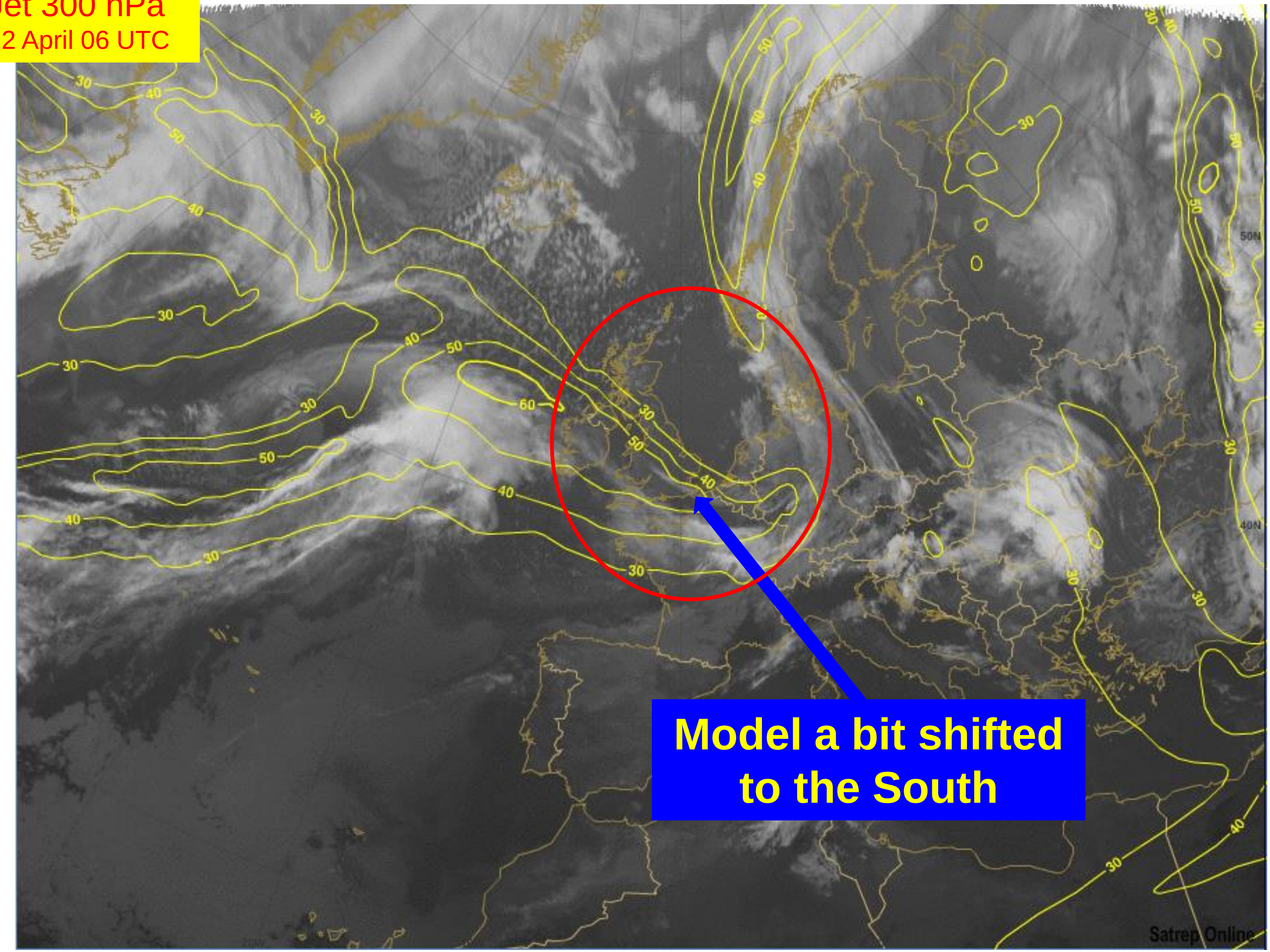
12 April 06 UTC



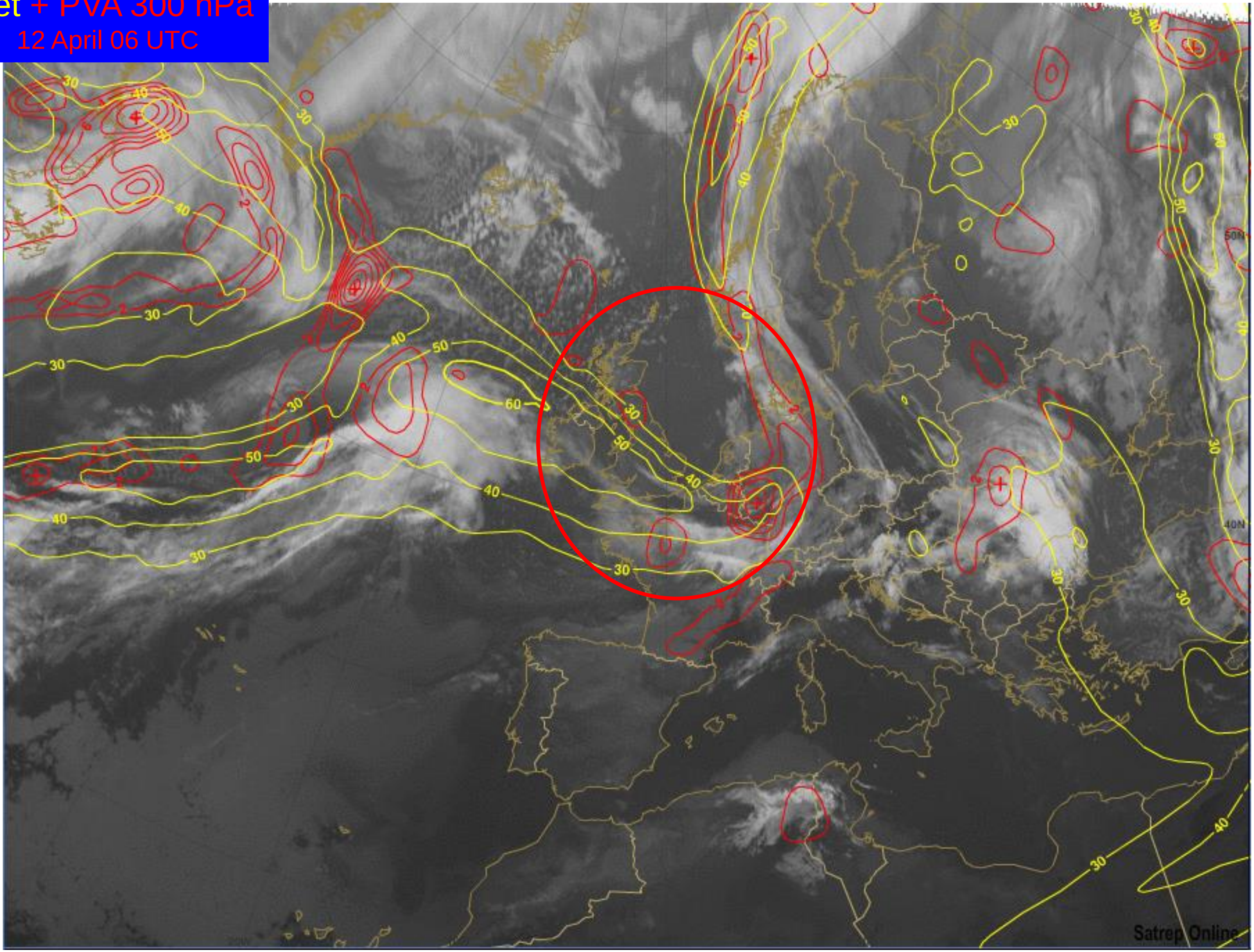
Isotachs at 300 hPa
12 April 06 UTC



Jet 300 hPa
12 April 06 UTC

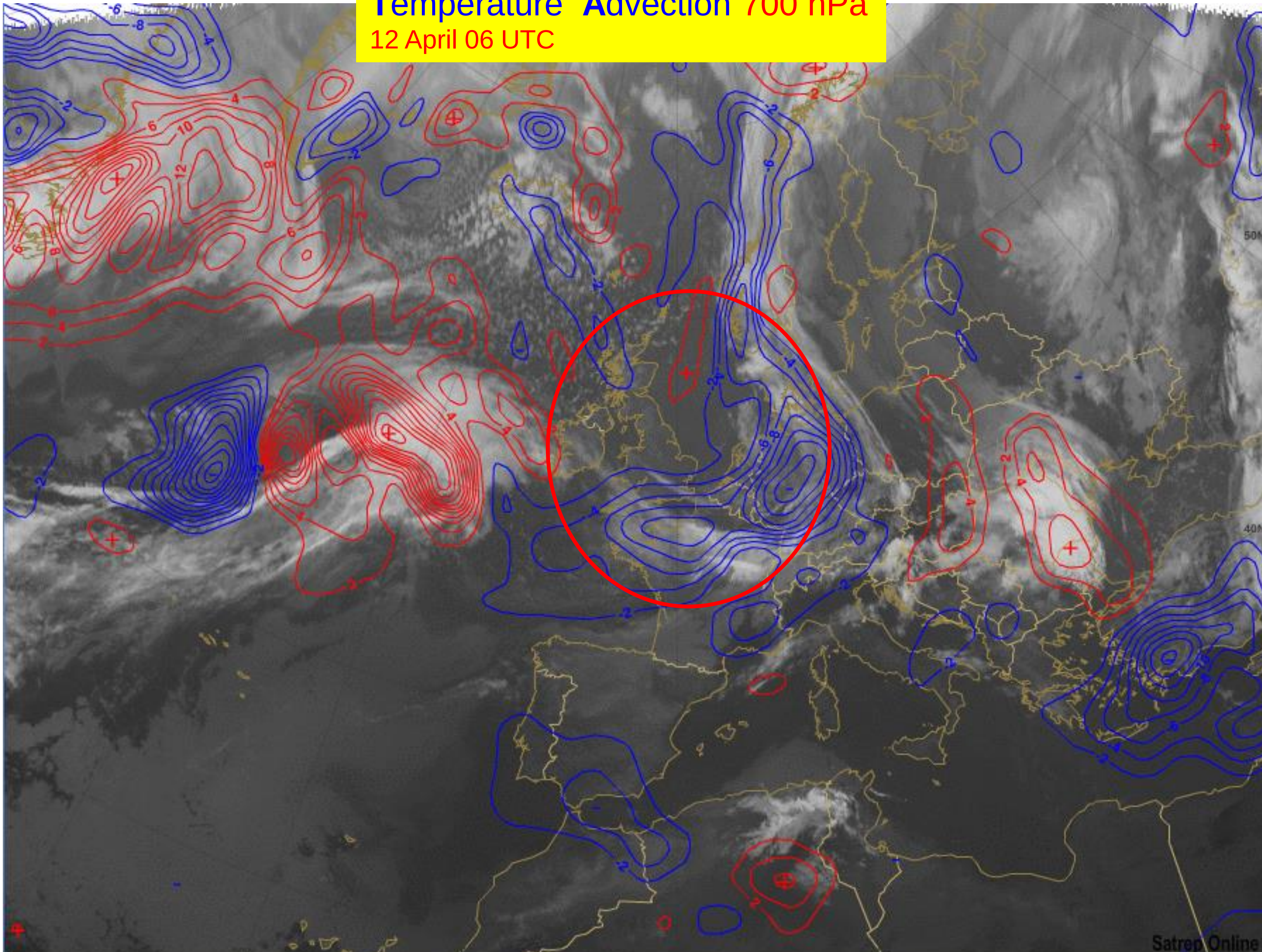


Jet + PVA 300 hPa
12 April 06 UTC

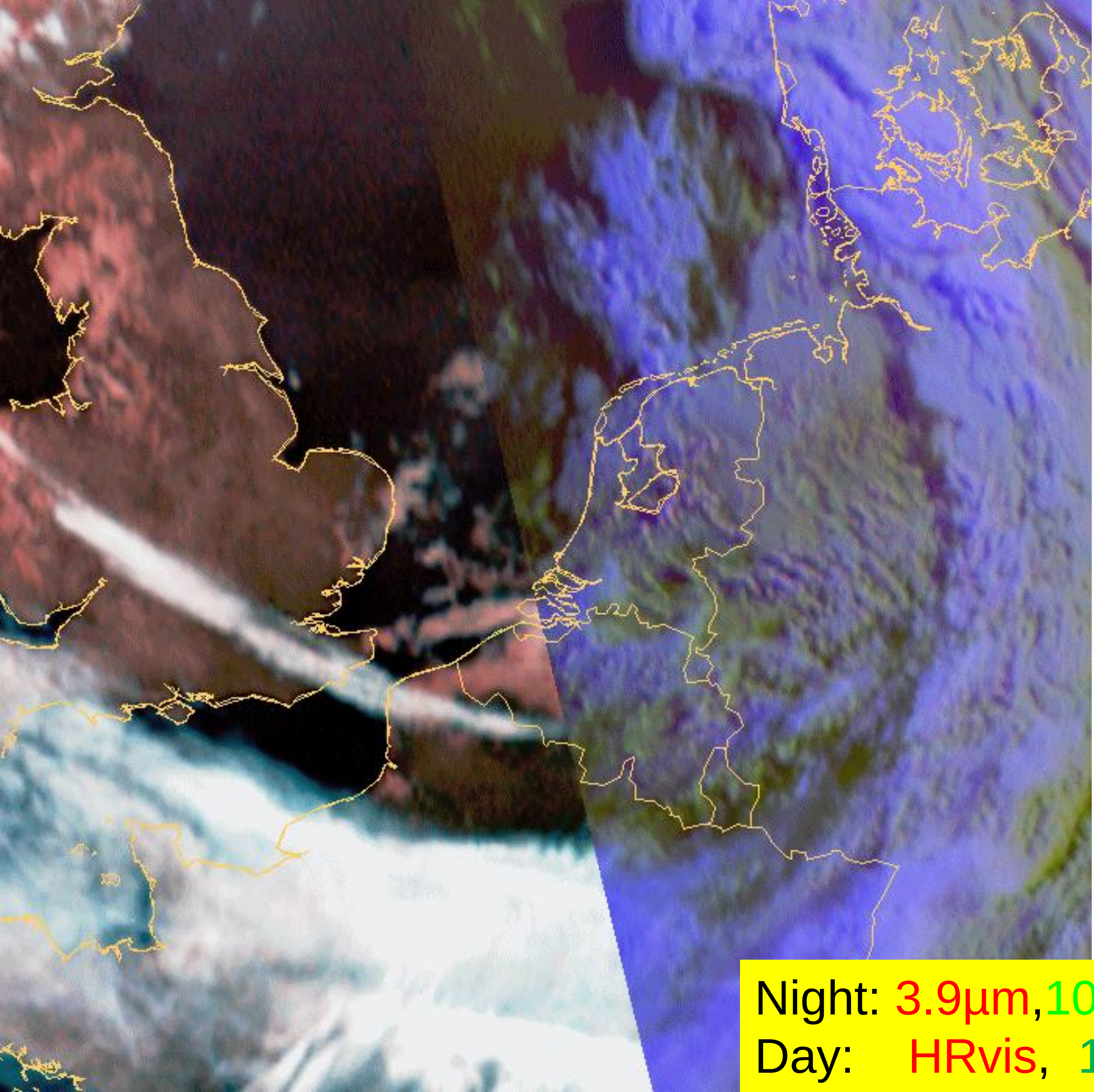


Temperature Advection 700 hPa

12 April 06 UTC



Info Liliane
next slide is an animation:
EC_Rapidscan.gif
Delete this sheet !!



Met 8 Rapid Scan

12 April
05:25-08:35 UTC

"day/night" window:

Night: 3.9µm, 10.8µm, 12.0µm
Day: HRvis, 1.6µm, 10.8µm

Convective Cloud Features

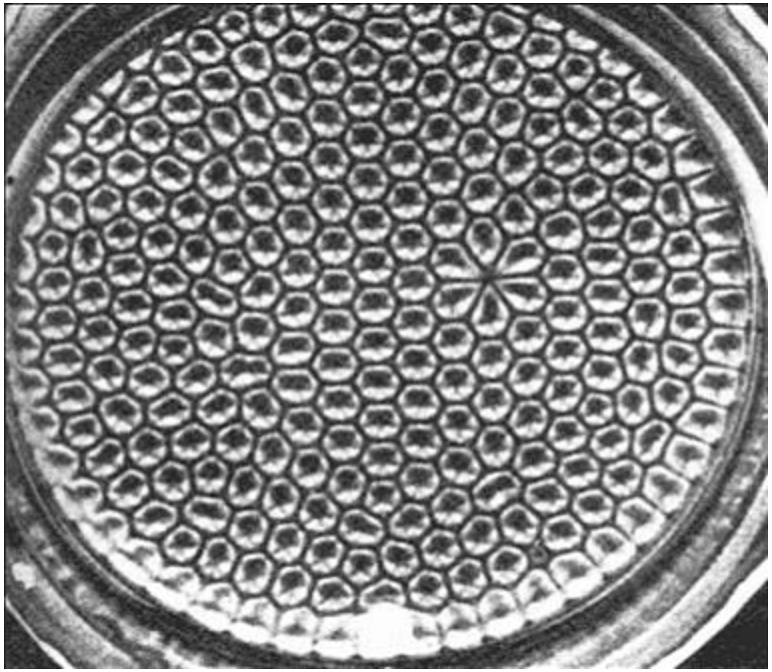
in

Polar Airmass

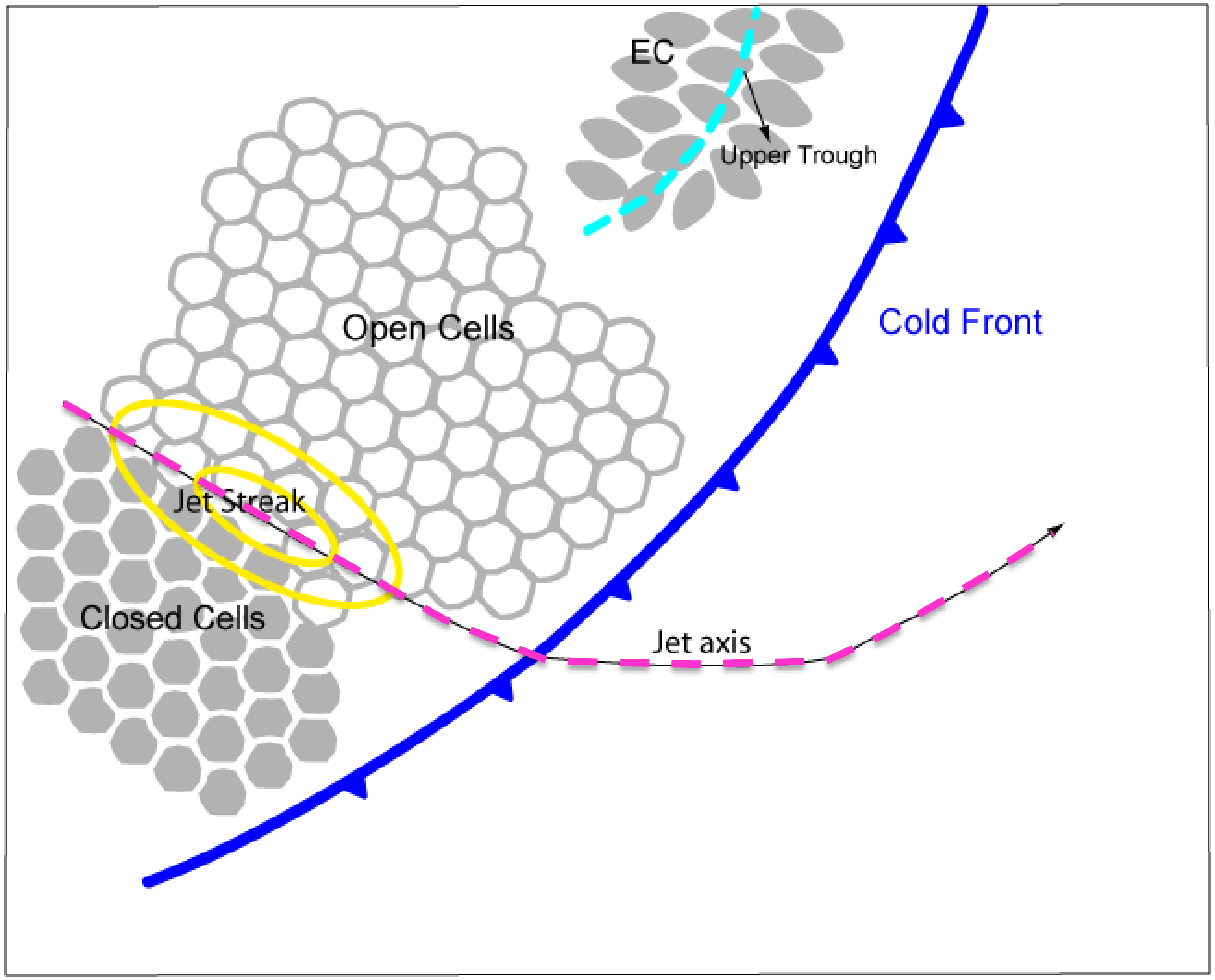
"Open/Closed Cell Convection"

Open Cell Convectie (OCC)

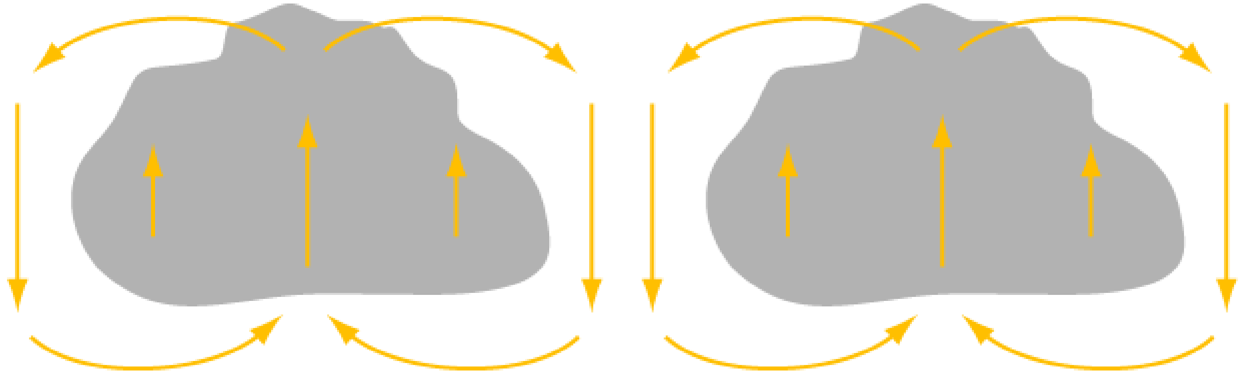
Atmospheric example of
Rayleigh-Bénard convection



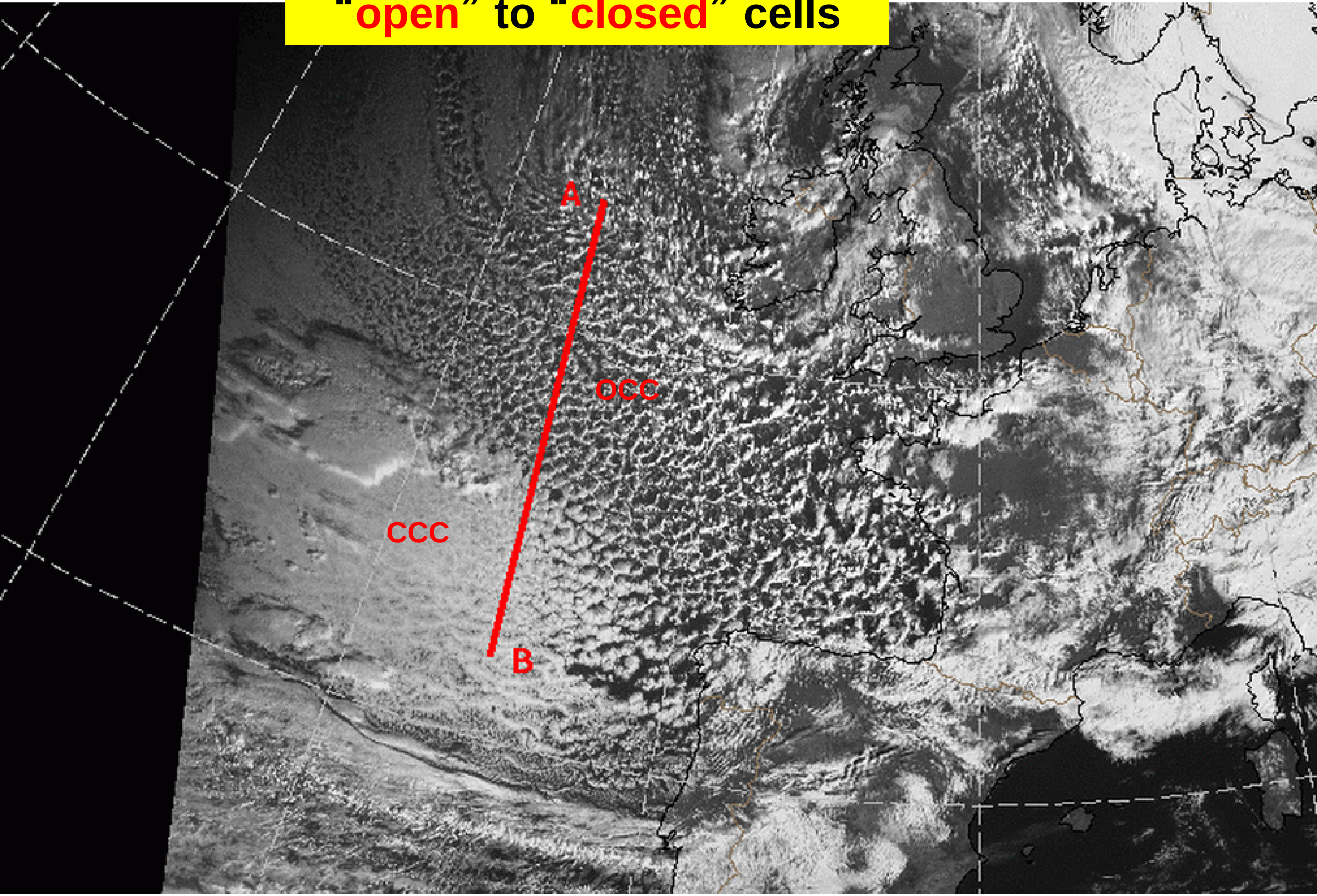
frying pan with heating oil
and
floating
aluminium flakes


EC
Upper Trough
Open Cells
Cold Front
Jet Streak
Closed Cells
Jet axis

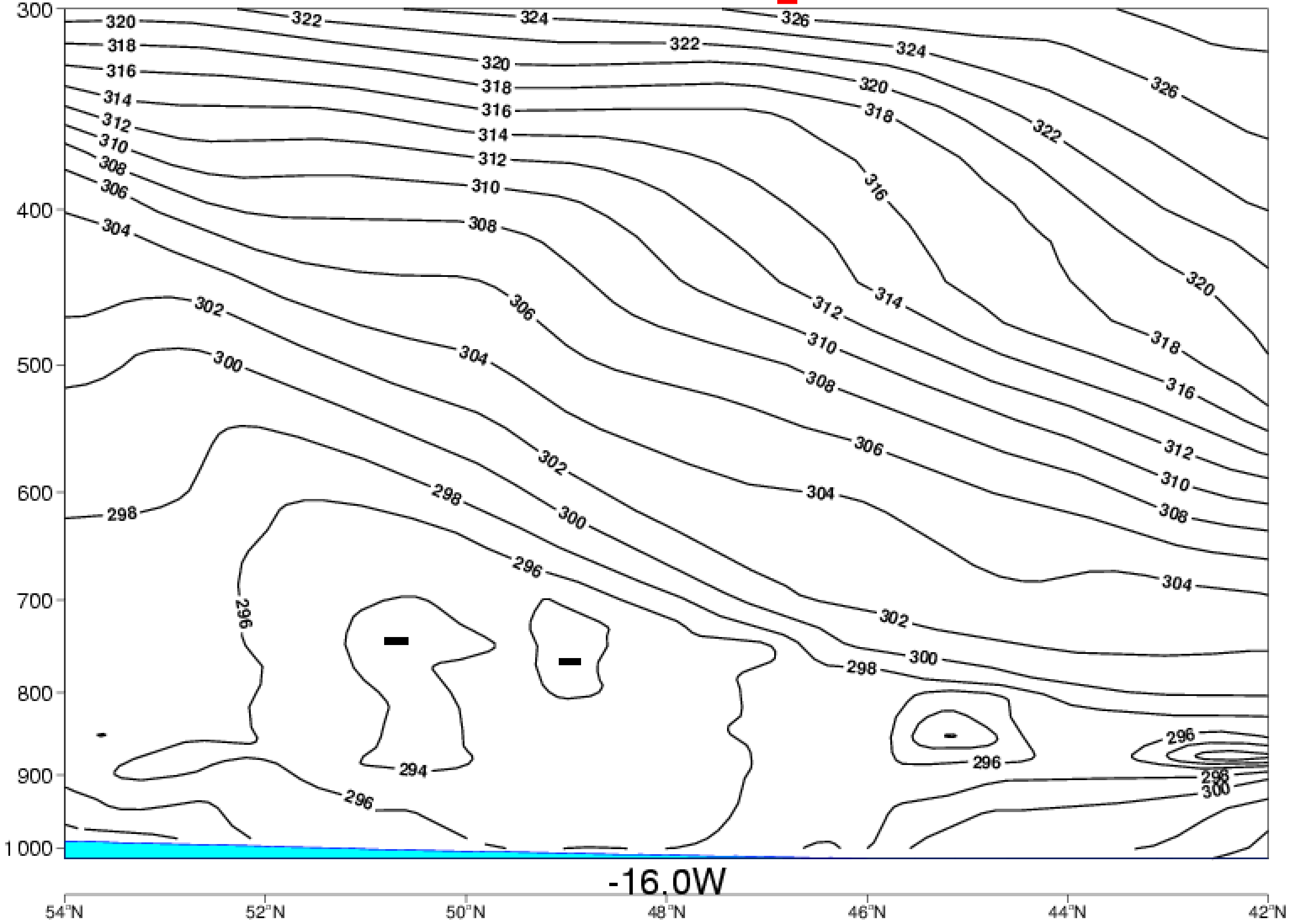
Schematic vertical circulation and cloudiness in Open Cell Convection



Cross section A ↔ B
"open" to "closed" cells

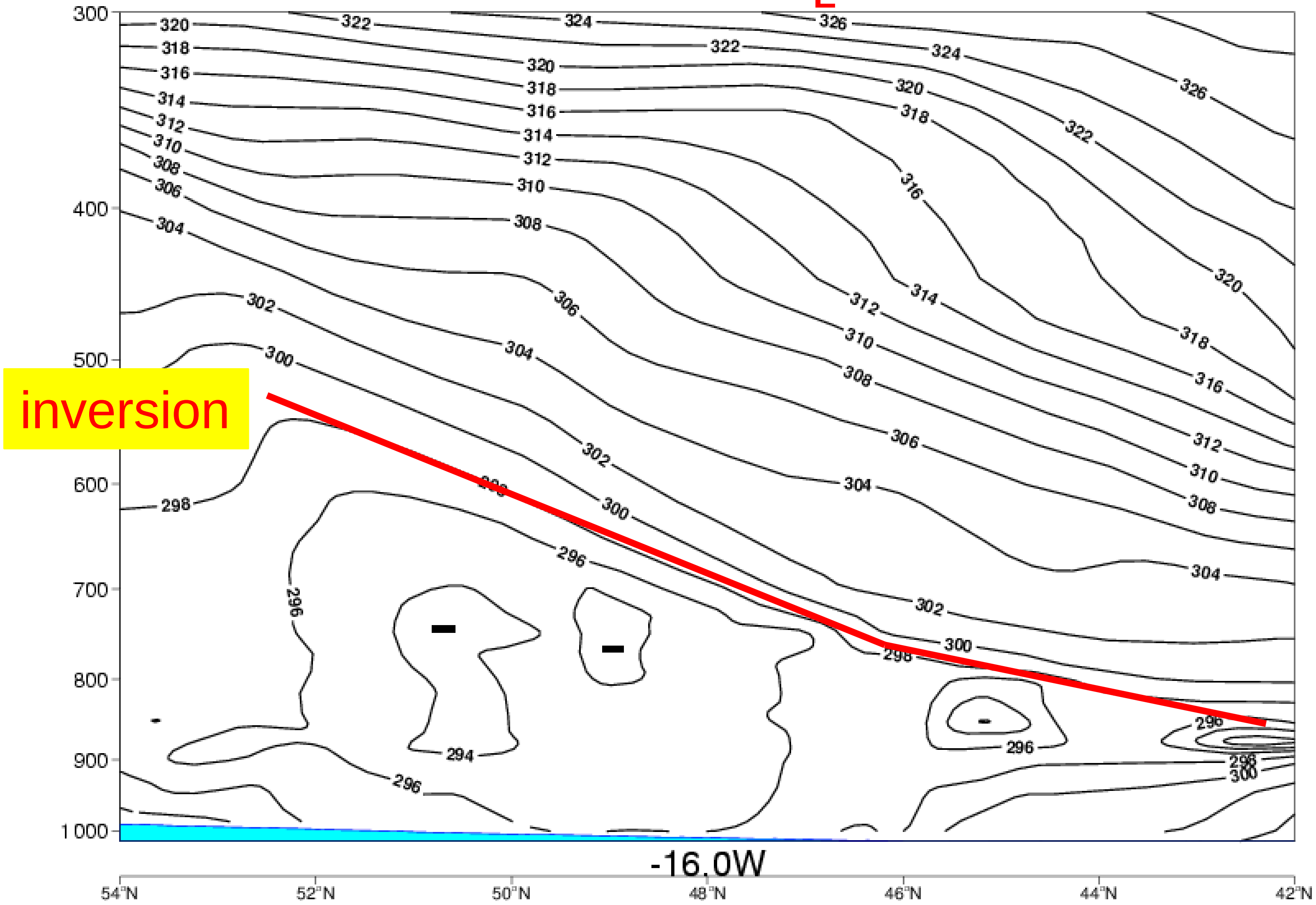


Cross section Θ_E



A ⇐ open closed ⇒ **B**

Cross section Θ_E



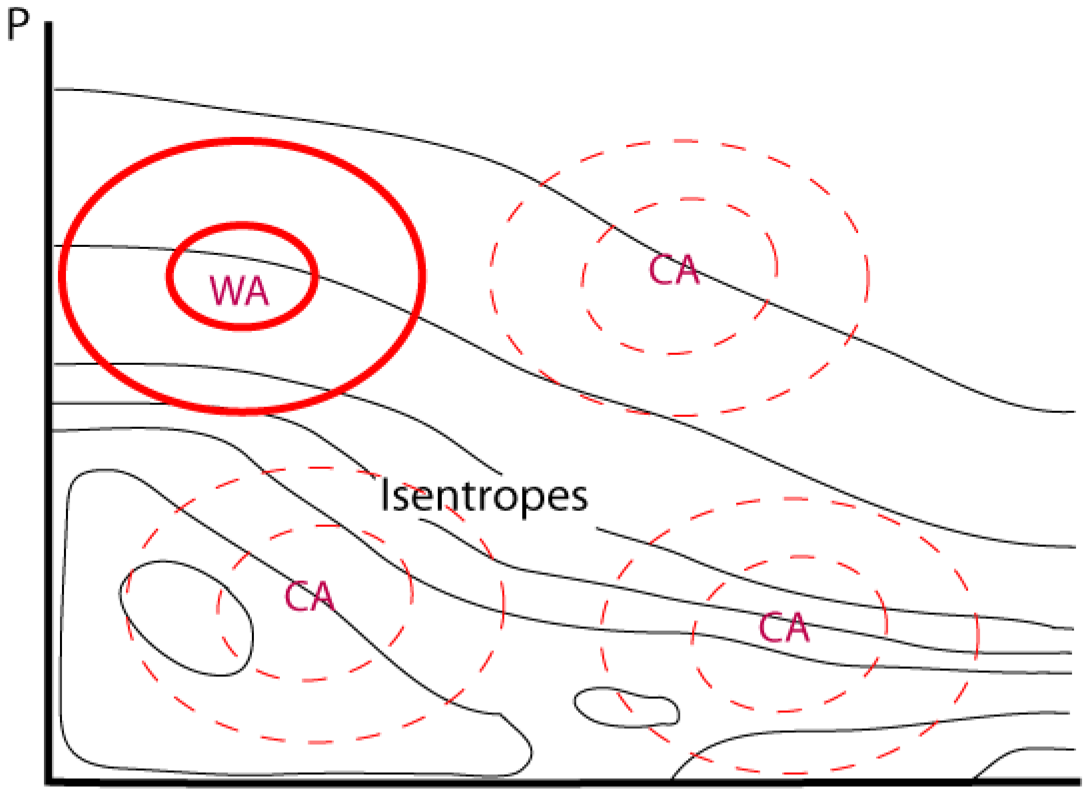
A ⇐ open

closed ⇒ **B**

Cross section Θ_E

+

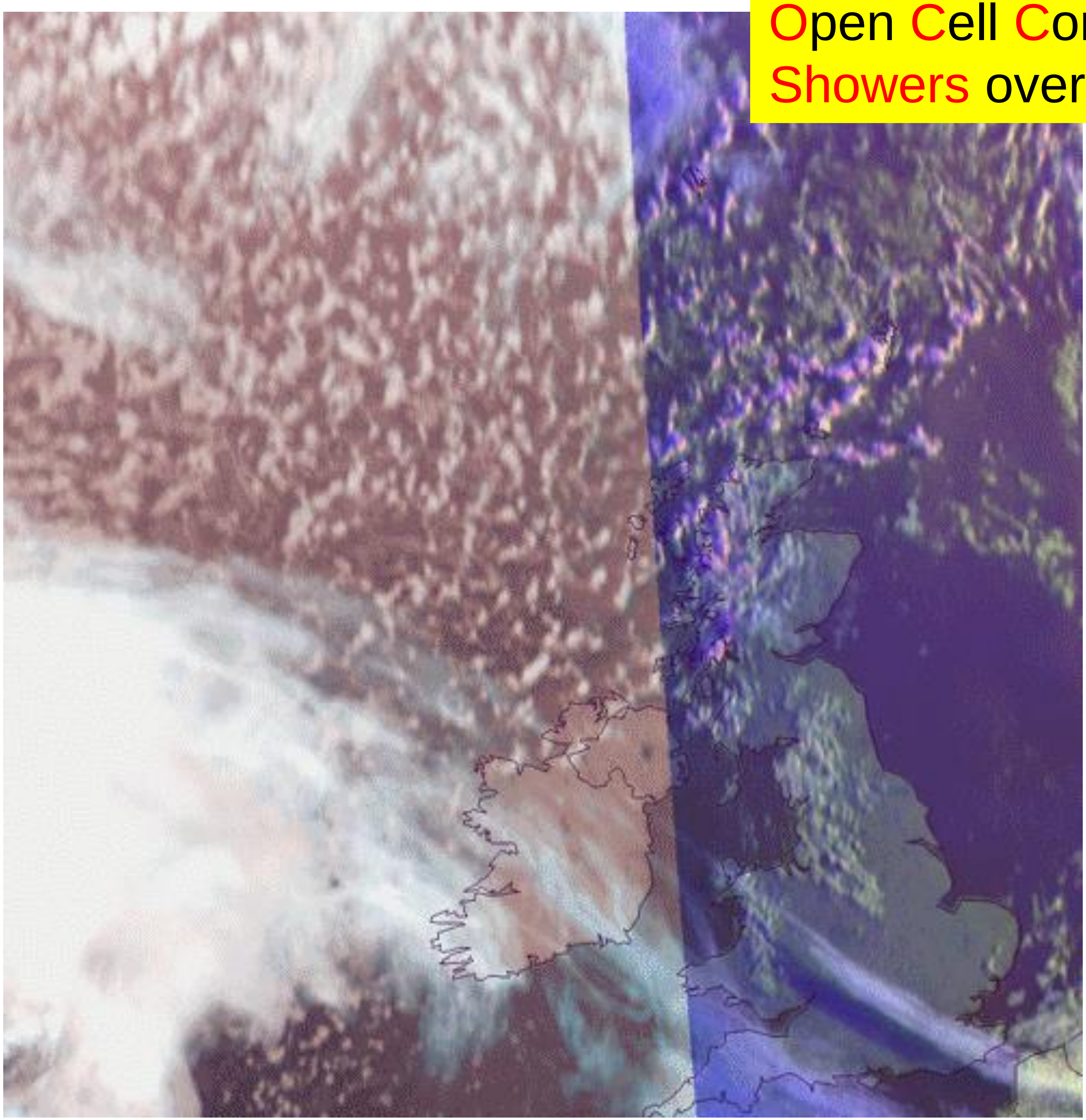
Temperature **A**dvection



A ⇐ open closed ⇒ **B**

Info for Liliane
Next slide is an animation:
file name: OCC_animation.gif
Delete this sheet !!

Open Cell Convection: Showers over Scotland



Convective environment

tropical Airmass

Cb Clusters (MCS)

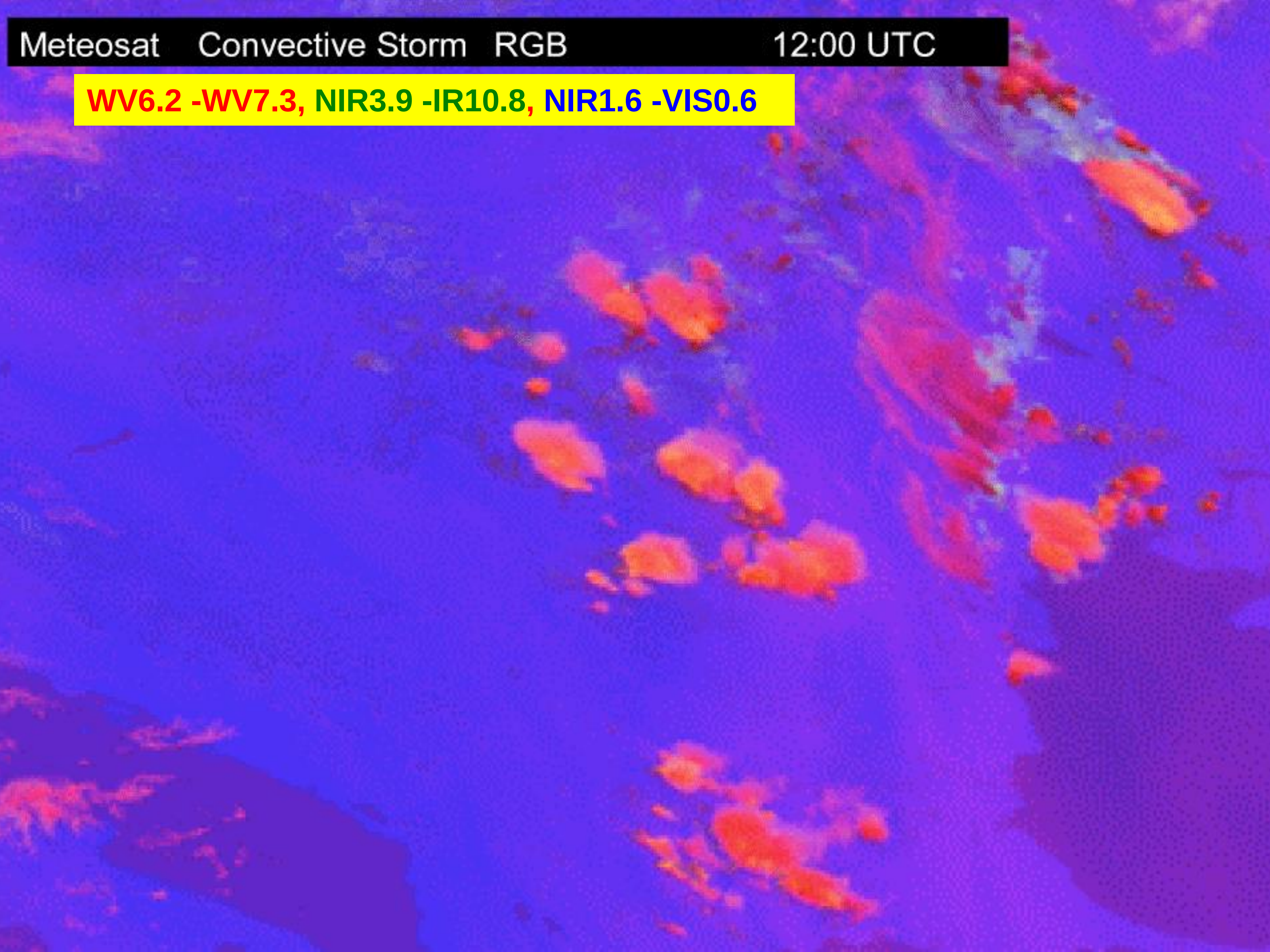
Fair Weather Conditions

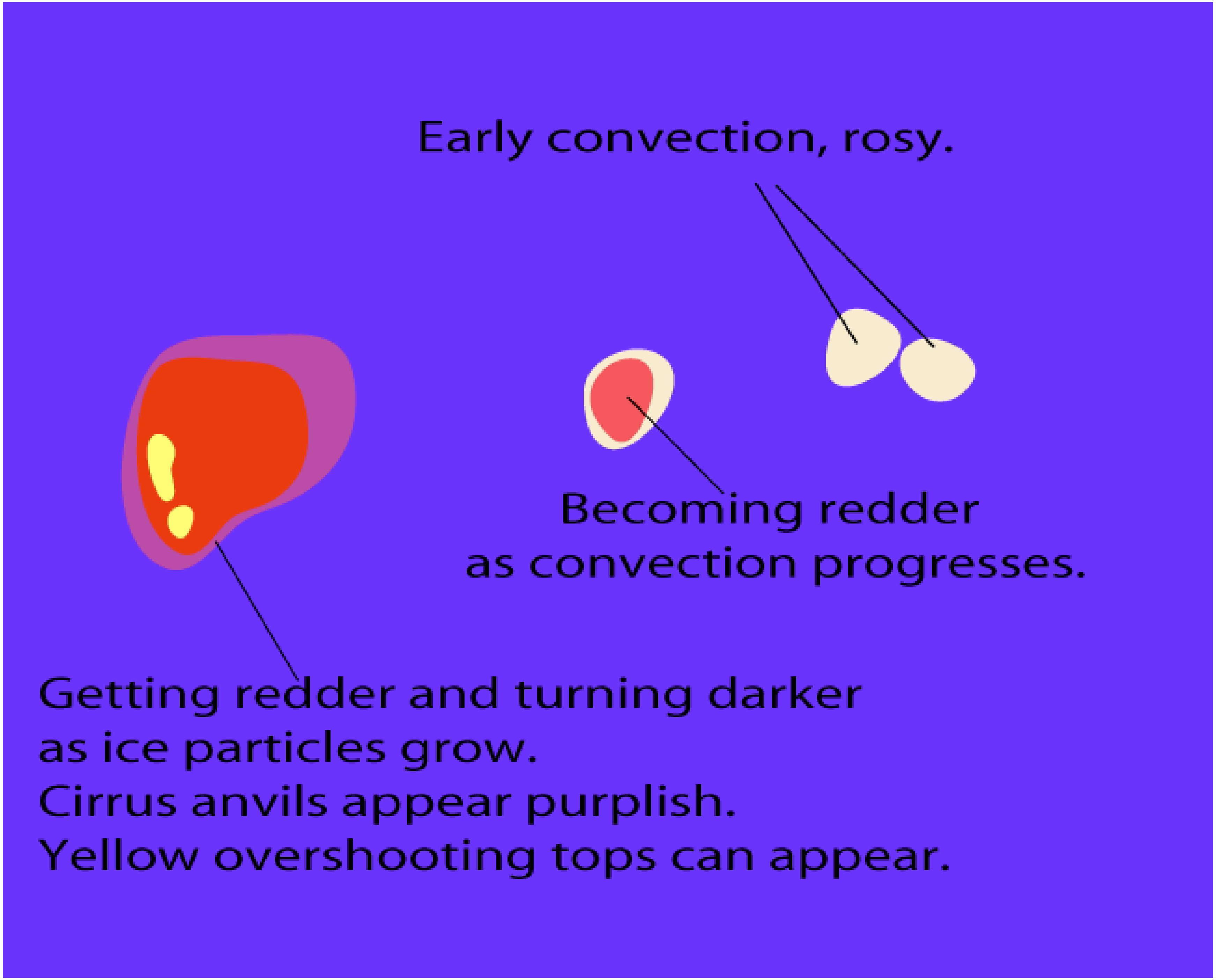
"Conceptual Models"

Enhancement of convection by "PV"

Spanish Plume Leading edge front

CB
Clusters


Meteosat Convective Storm RGB
12:00 UTC
WV6.2 -WV7.3, NIR3.9 -IR10.8, NIR1.6 -VIS0.6



Early convection, rosy.
Becoming redder
as convection progresses.
Getting redder and turning darker
as ice particles grow.
Cirrus anvils appear purplish.
Yellow overshooting tops can appear.

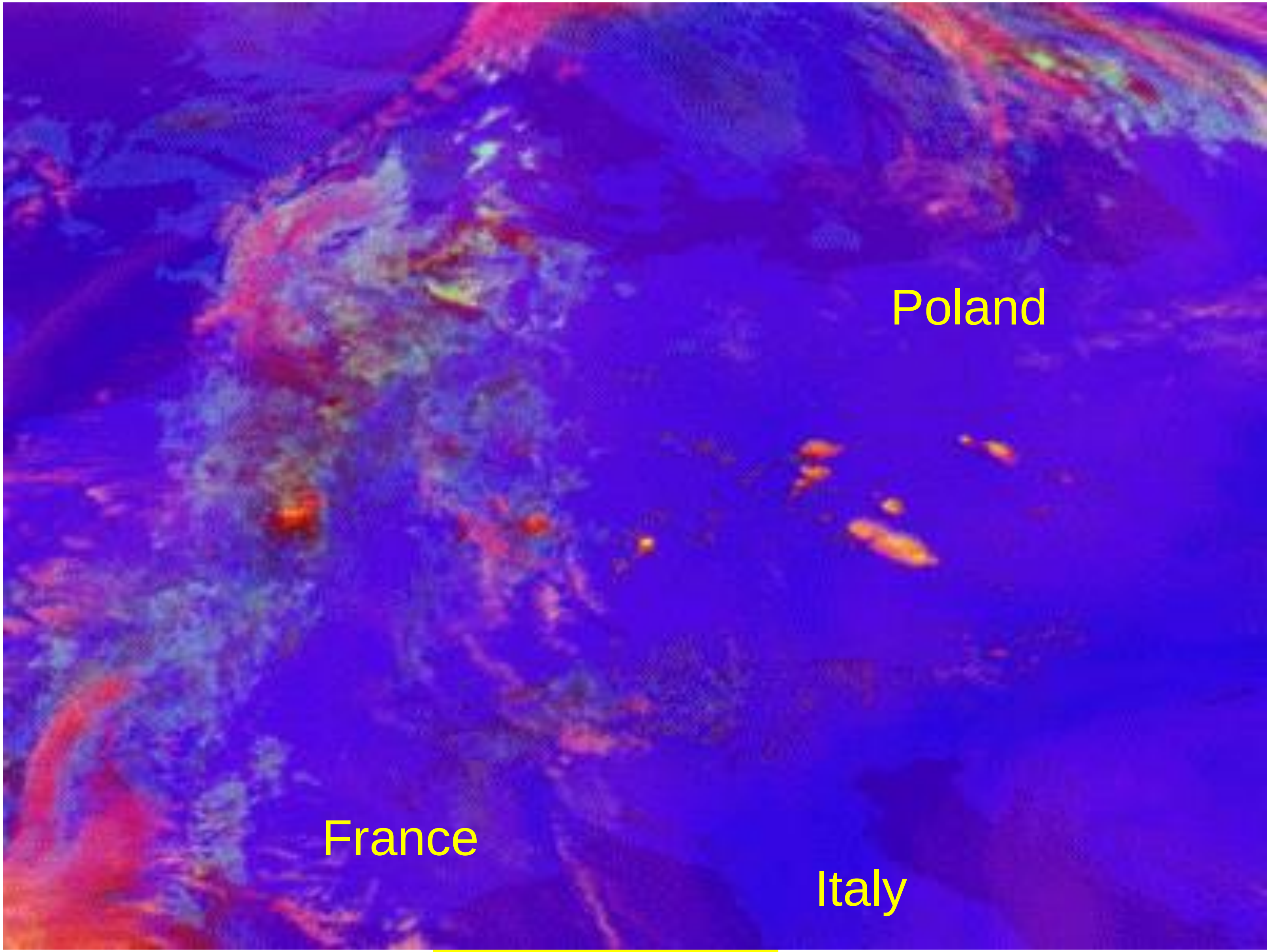
Info for Liliane

next slide is an animation:

file name: Cb-RGB.gif

Delete this sheet !!

Cb development



severe storm RGB

Key parameters
Cb Clusters

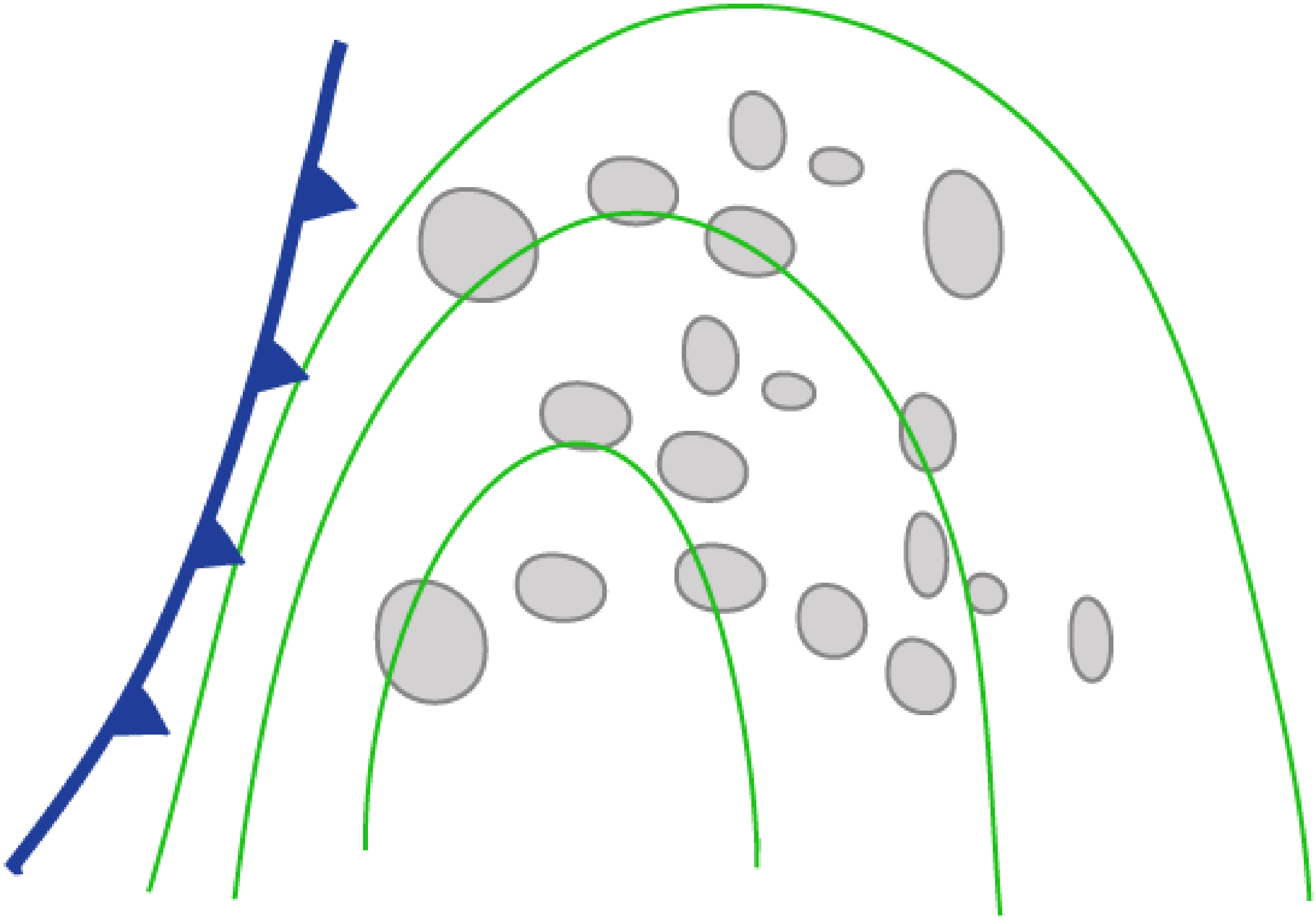
- **(Equivalent) Thickness**
  1000-500 hPa

- **Potential (Wet Bulb) Temperature $\theta_{E(w)}$**
  Indication of warm airmass

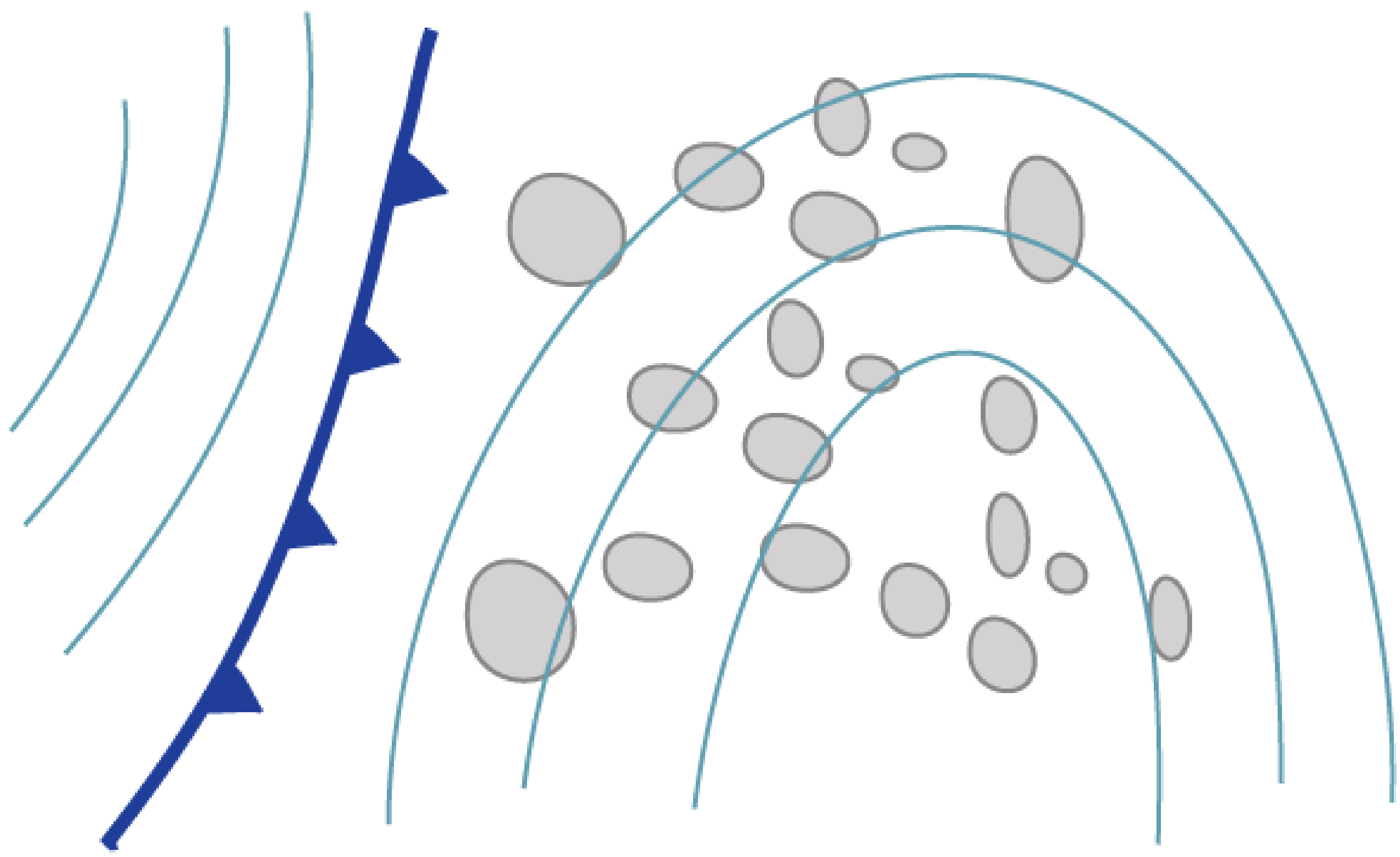
- **Low level Convergence:**
  Areas of high convergence are preferable for convective development.

- **Instability indices**:
  CAPE, Boyden index, Showalter index, K index, etc

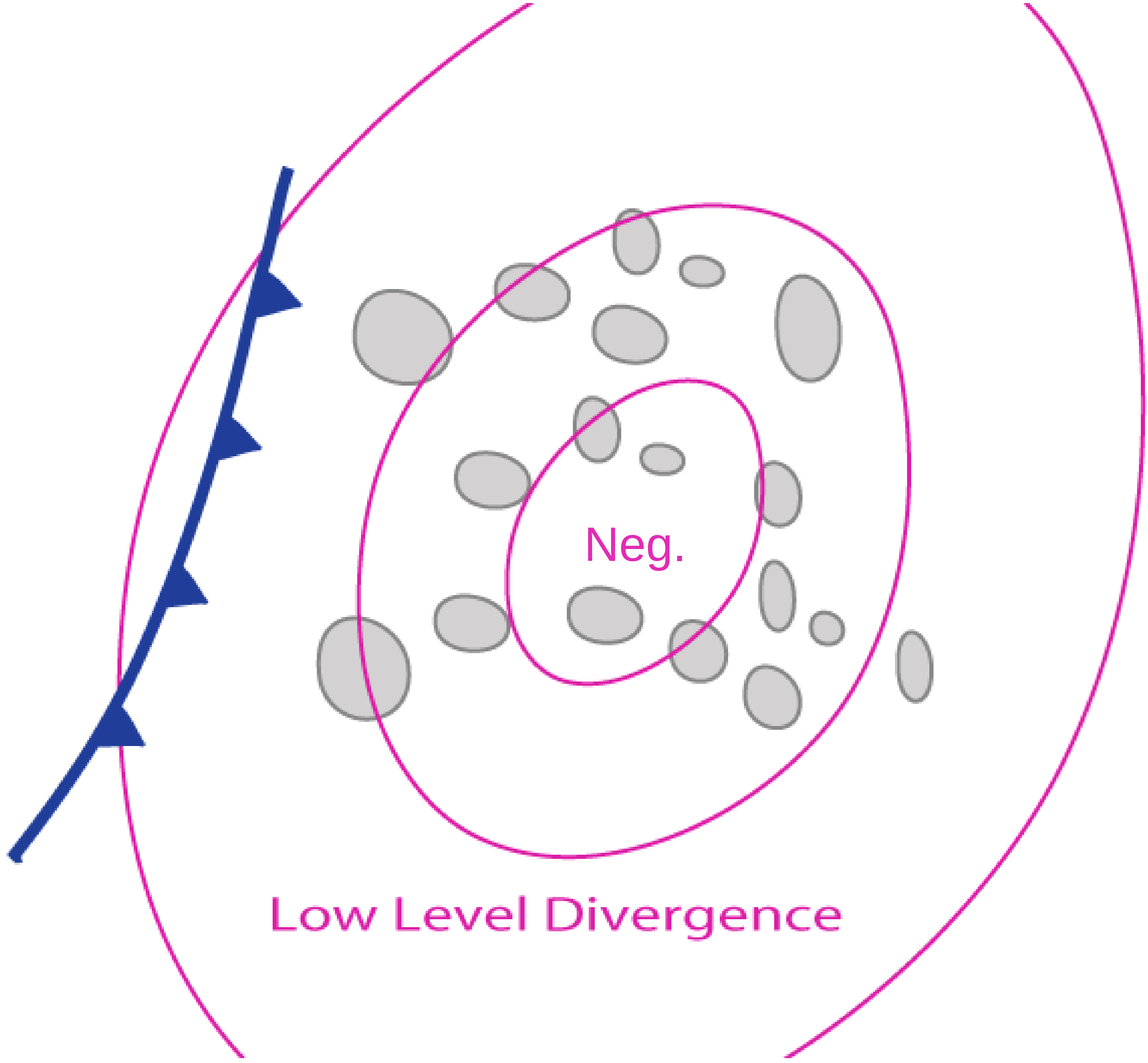
- **Shear**
  Lowest 6000 ft



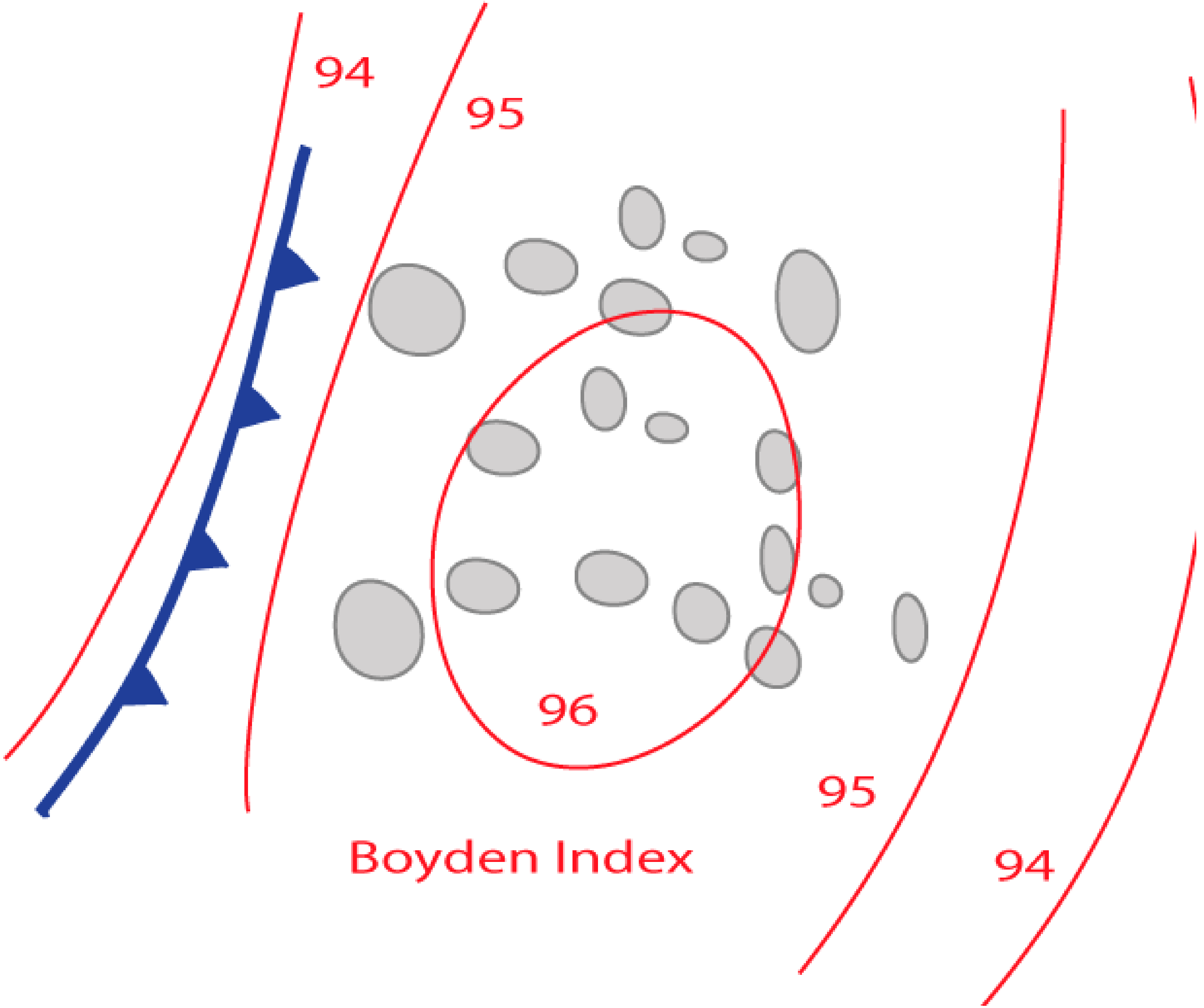
Equivalent Thickness



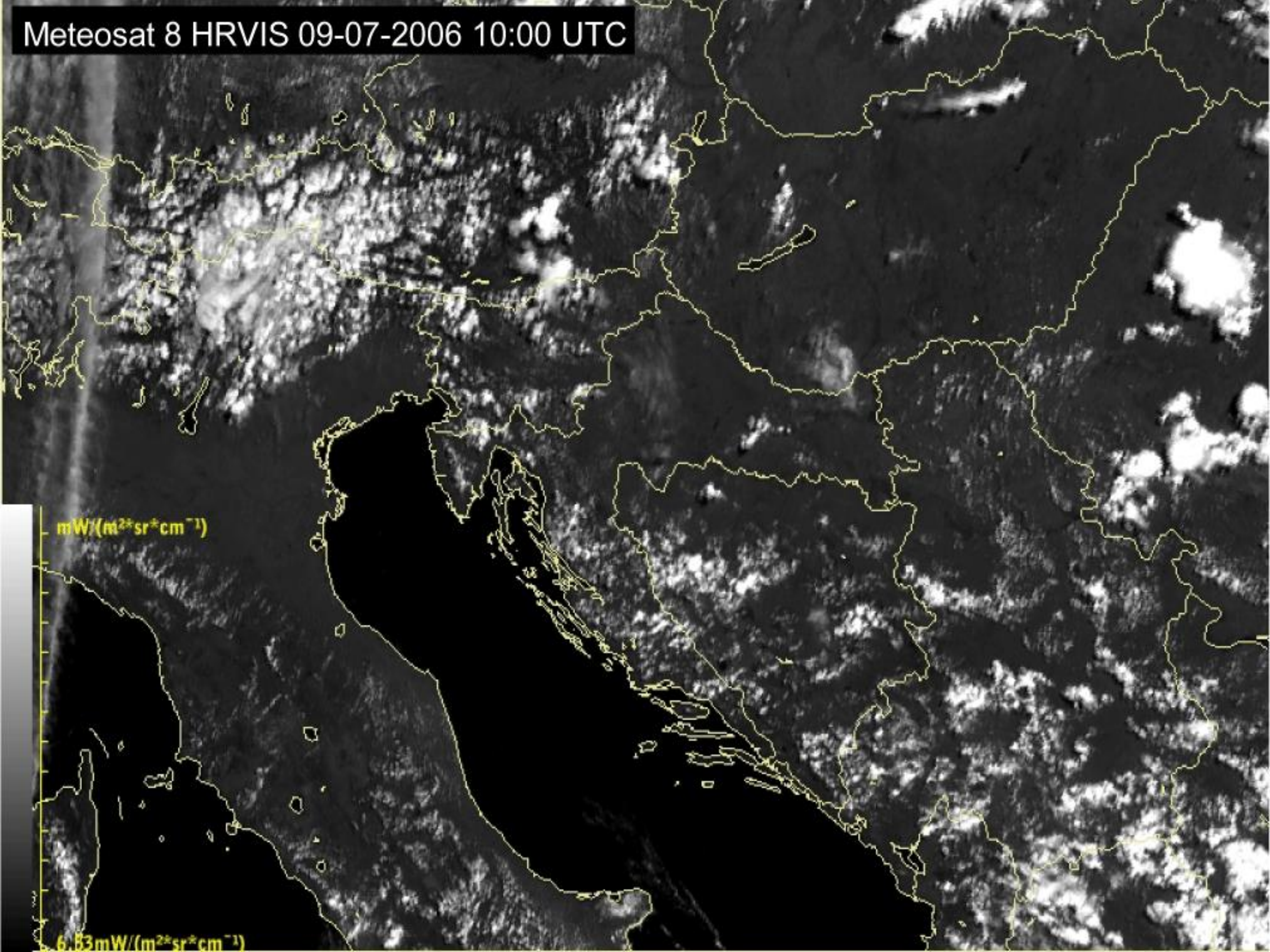
(Wet Bulb) Potential Temperature at 850 hPa



Neg.
Low Level Divergence



94
95
96
95
94
Boyden Index

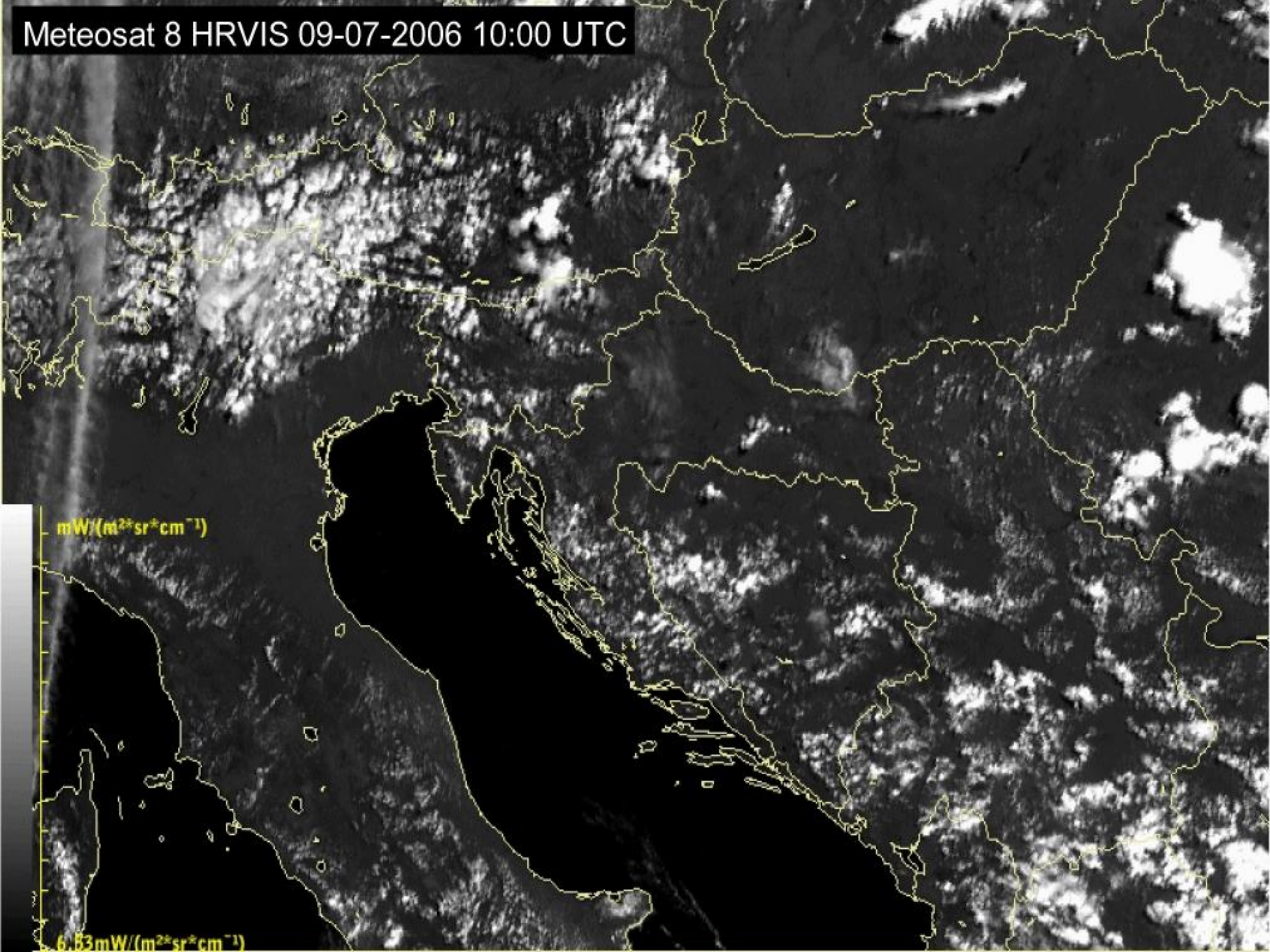

Meteosat 8 HRVIS 09-07-2006 10:00 UTC
mW/(m²*sr*cm⁻¹)
6.53mW/(m²*sr*cm⁻¹)

Info for liliane

next slide is an animation:

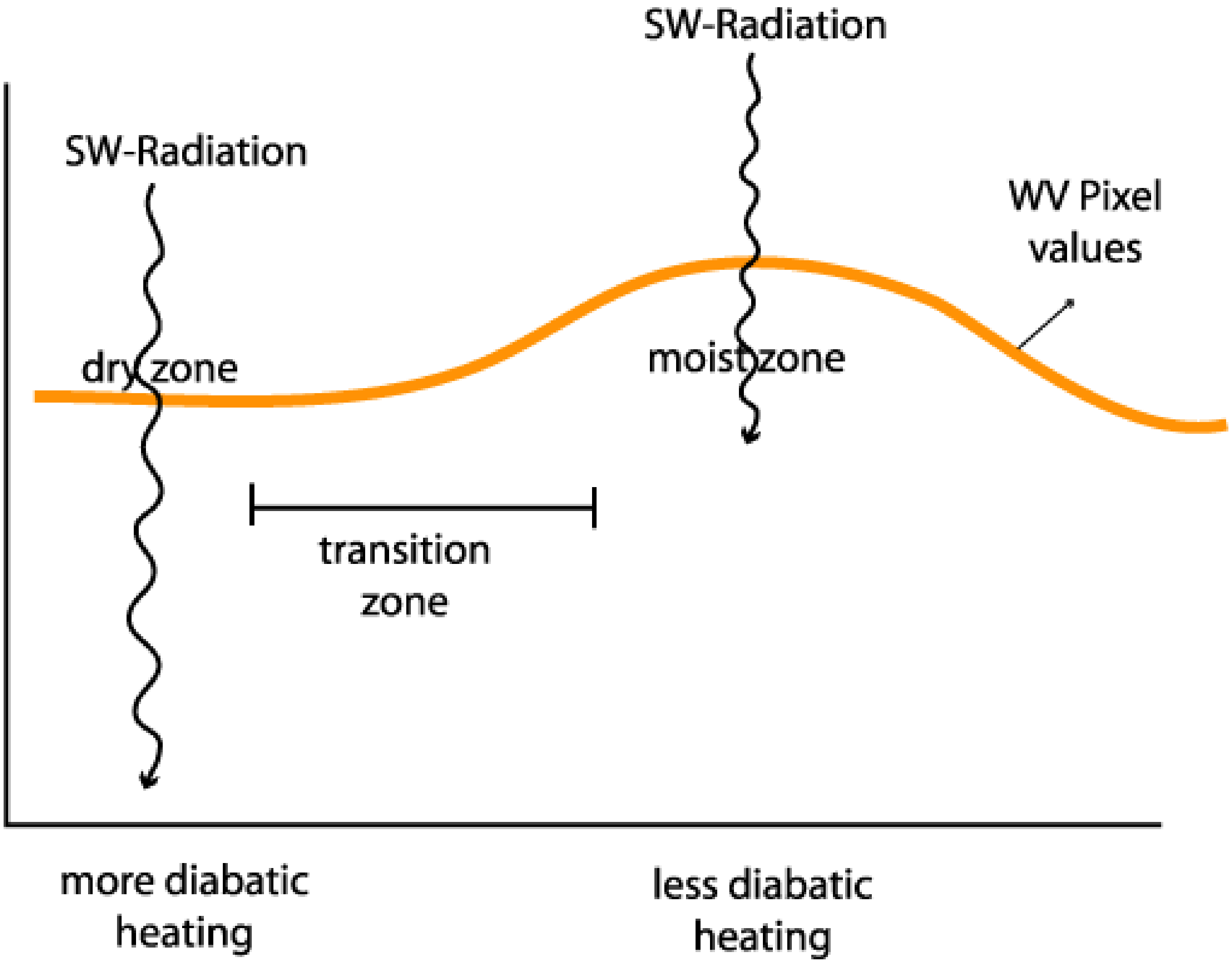
filename: cbclusters.gif

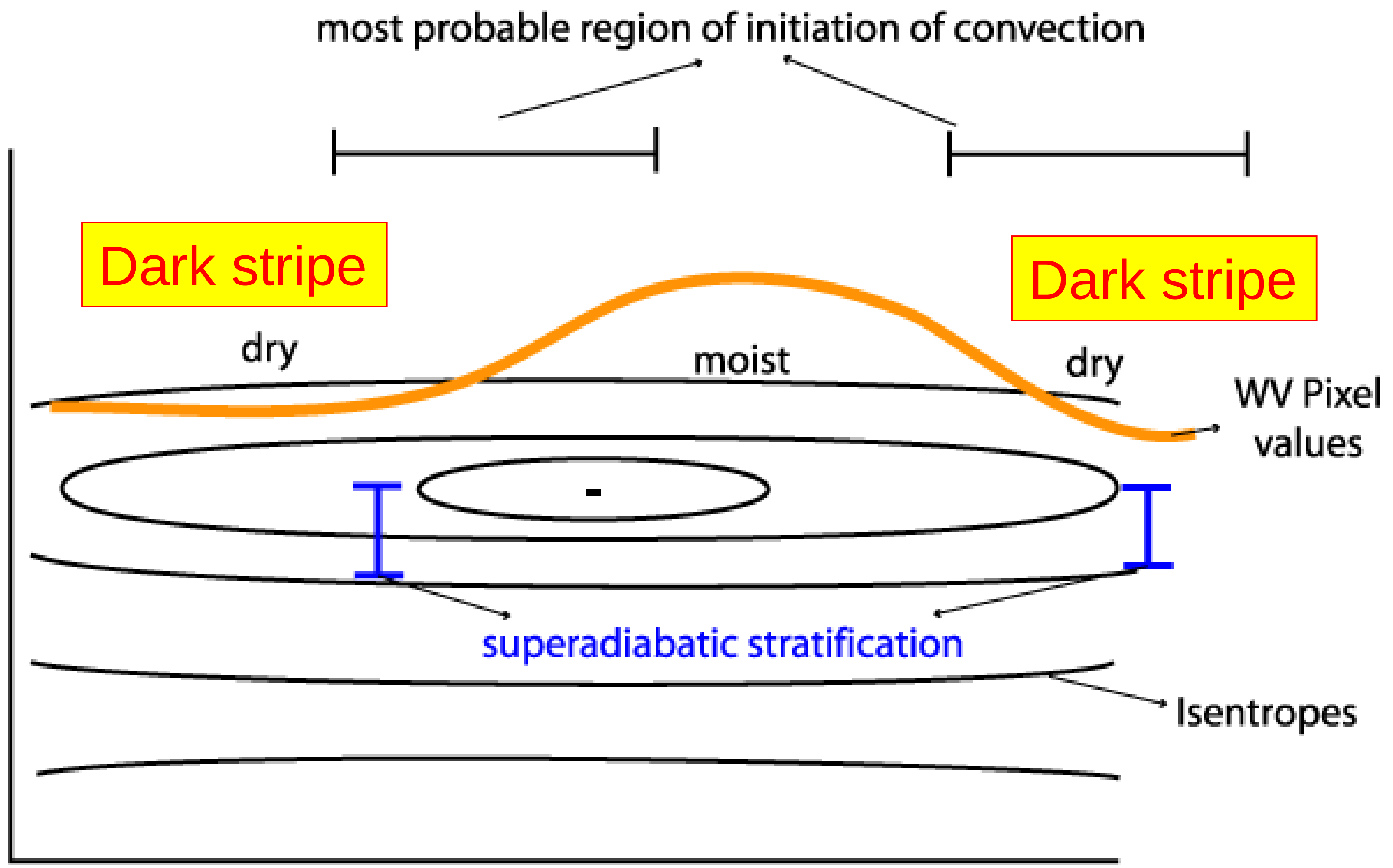
DELETE this sheet!!

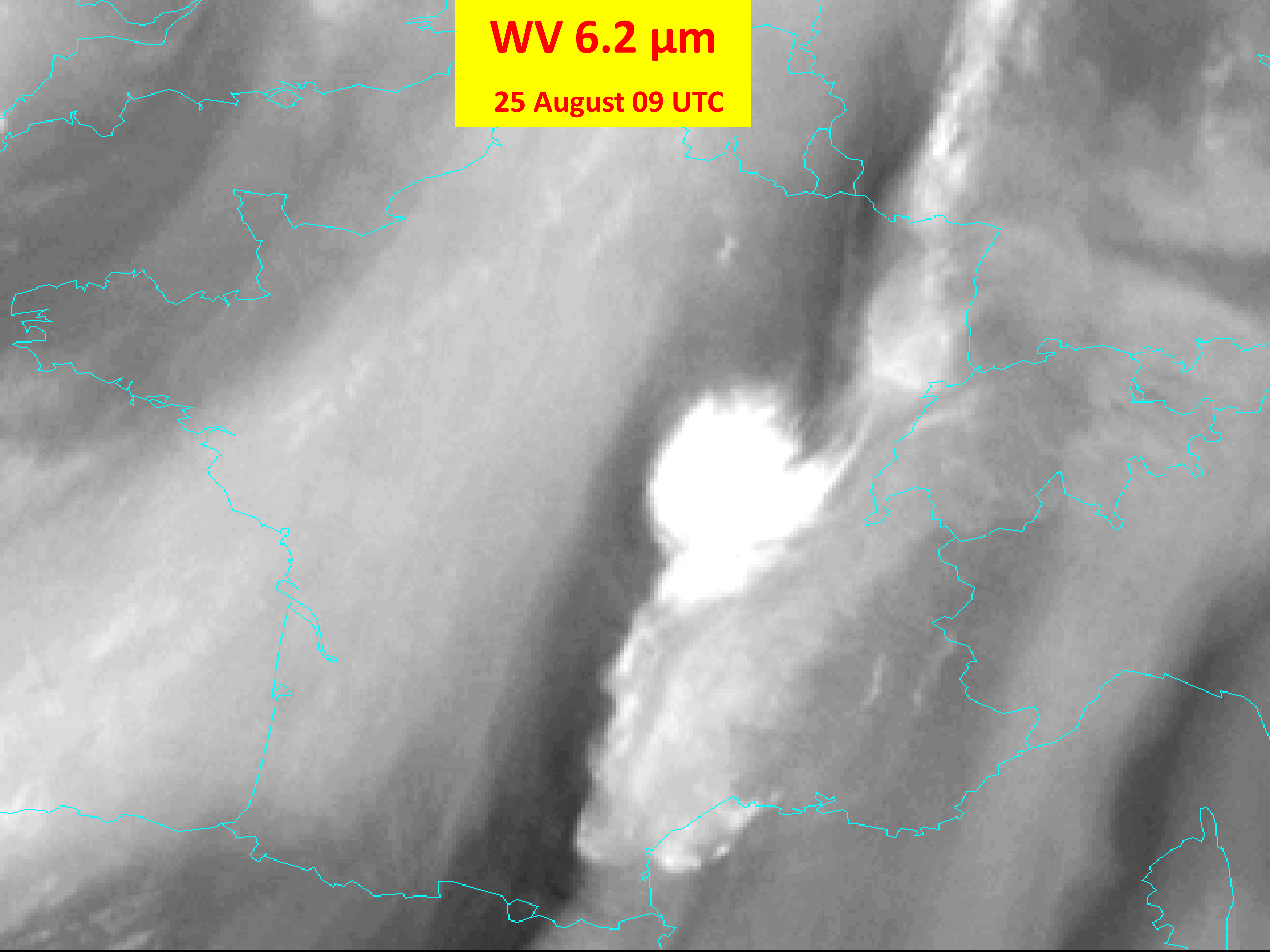

Meteosat 8 HRVIS 09-07-2006 10:00 UTC
mW/(m²*sr*cm⁻¹)
6.53mW/(m²*sr*cm⁻¹)

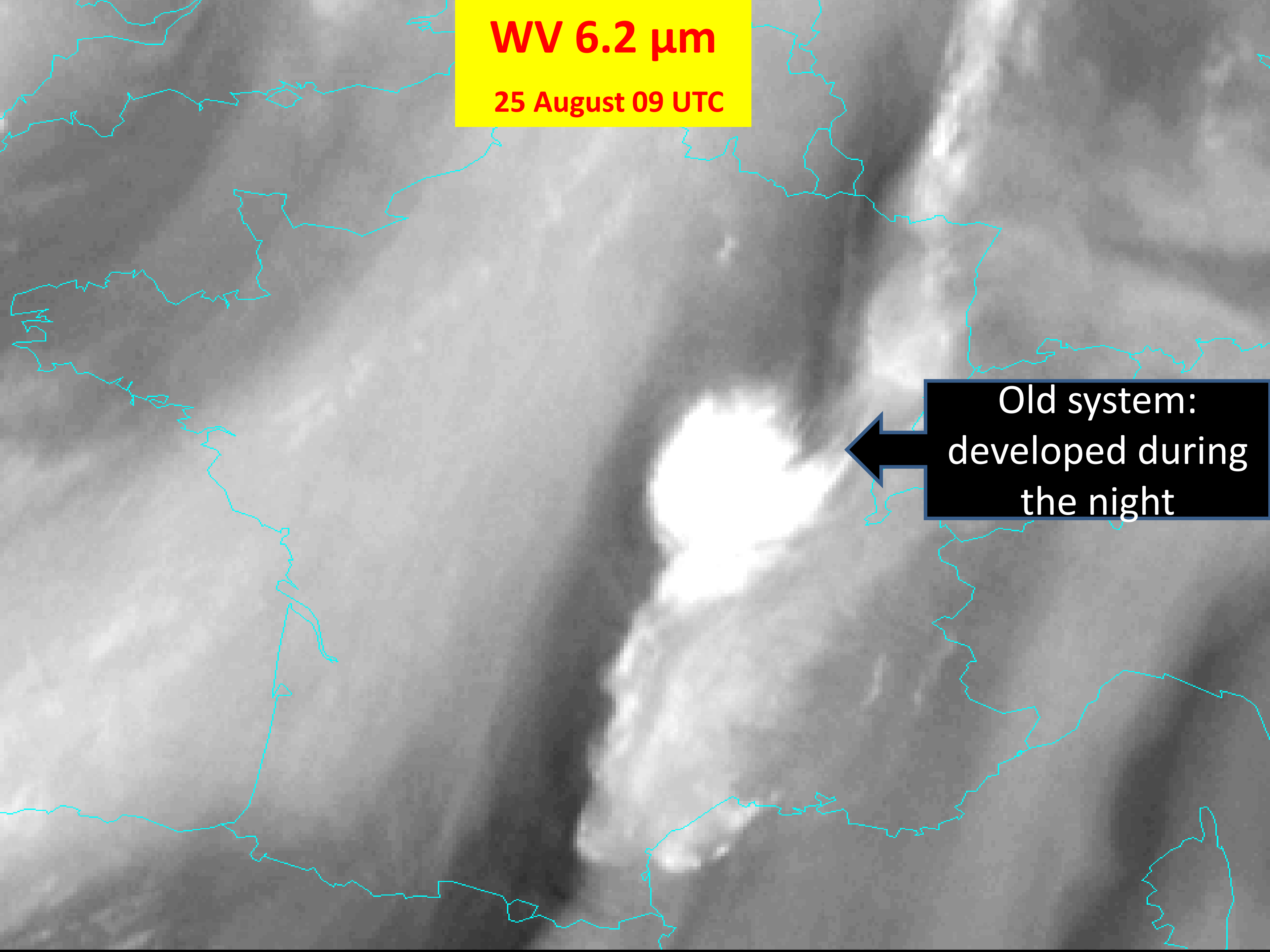
Convective Cloud Features In typical synoptic Environments:

Fair Weather Conditions


SW-Radiation
SW-Radiation
WV Pixel values
dry zone
moist zone
transition zone
more diabatic heating
less diabatic heating


most probable region of initiation of convection
Dark stripe
Dark stripe
dry
moist
dry
WV Pixel values
superadiabatic stratification
Isentropes

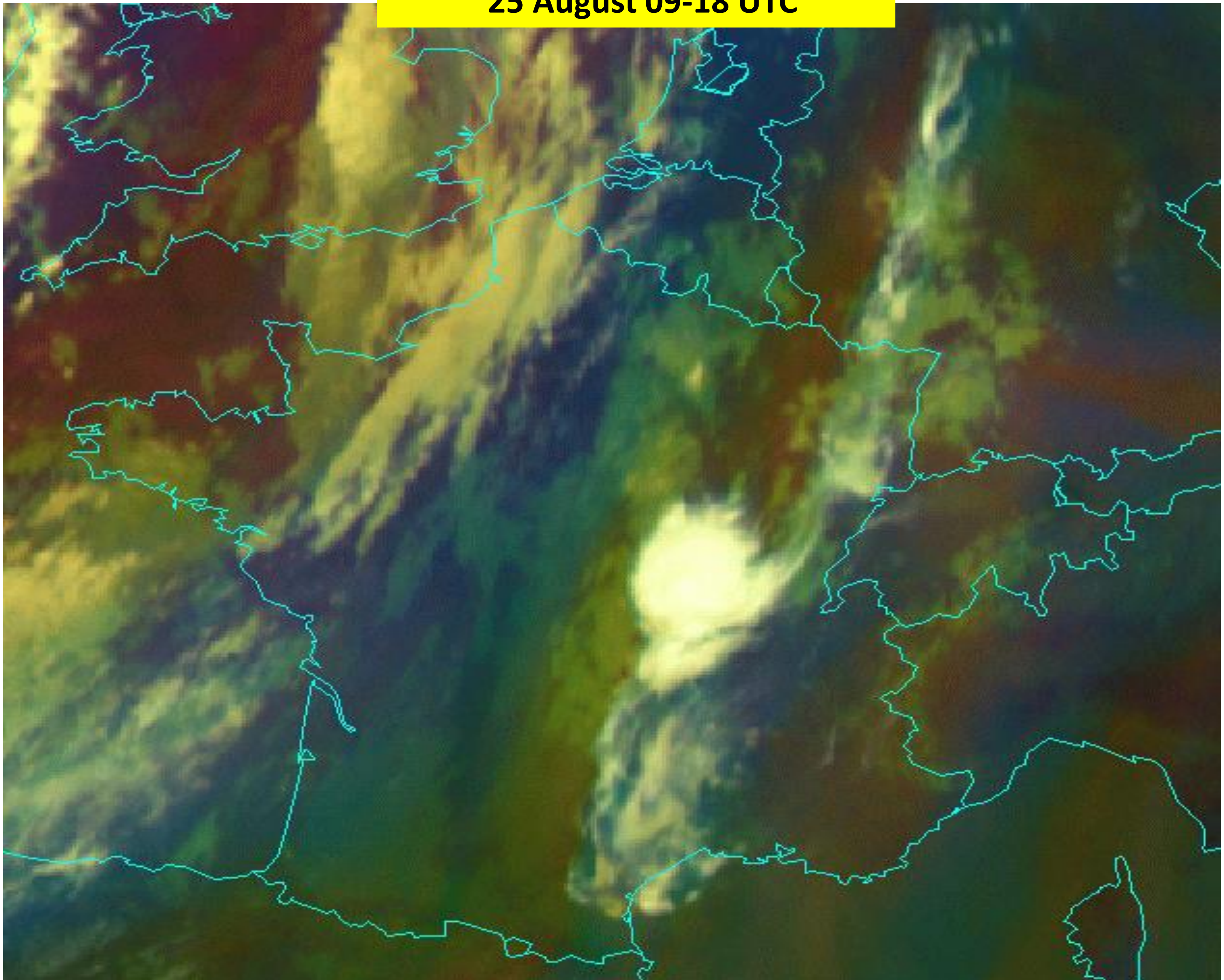

WV 6.2 µm
25 August 09 UTC


WV 6.2 µm
25 August 09 UTC
Old system: developed during the night

Info for Liliane
next slide is an animation:
file name: Airmass_25aug.gif
Delete this sheet!!

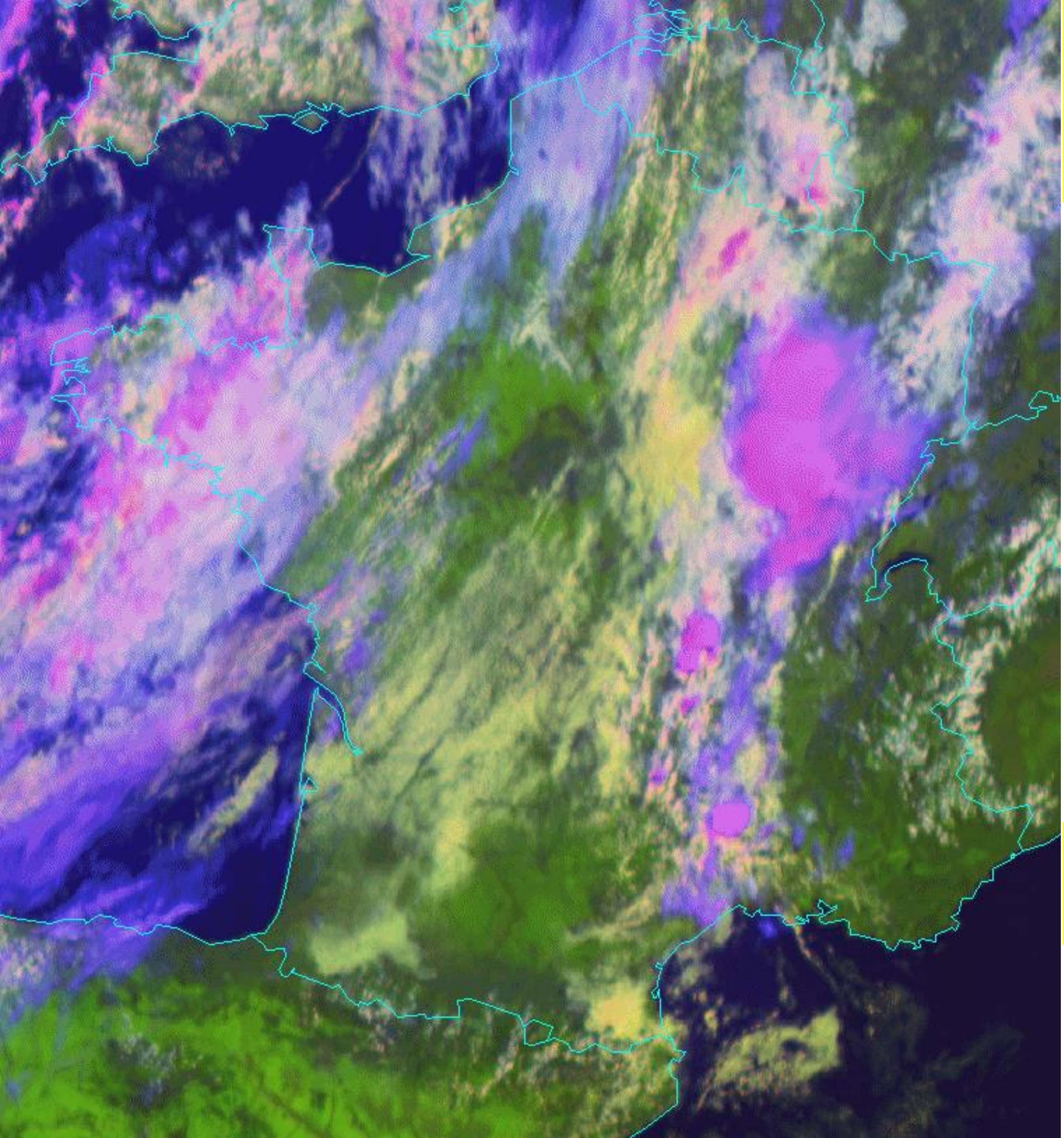
Airmass RGB

25 August 09-18 UTC

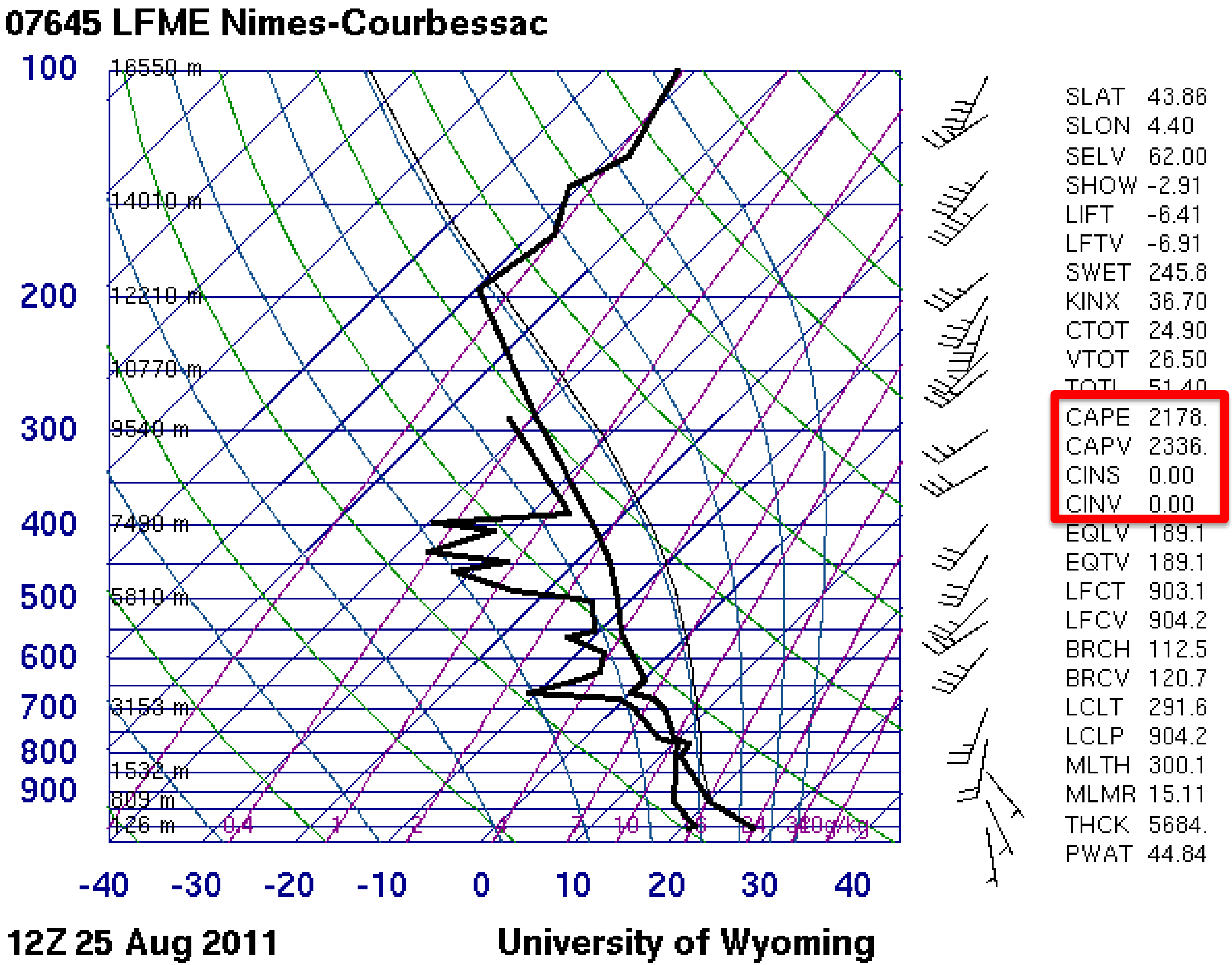


Info for Liliane
next slide is an animation:
file name:
HRvis_RGB_25aug.gif
Delete this sheet!!

Cb development in area of dark stripe



HRvis, 1.6μm,10.8μm
25 August 09-18 UTC


07645 LFME Nimes-Courbessac
100
200
300
400
500
600
700
800
900
16550 m
14010 m
12210 m
10770 m
9540 m
7490 m
5810 m
3153 m
1532 m
809 m
126 m
0.4
1
2
4
7
10
16
24
32
40g/kg
-40
-30
-20
-10
0
10
20
30
40
SLAT 43.86
SLON 4.40
SELV 62.00
SHOW -2.91
LIFT -6.41
LFTV -6.91
SWET 245.8
KINX 36.70
CTOT 24.90
VTOT 26.50
TOTL 51.40
CAPE 2178.
CAPV 2336.
CINS 0.00
CINV 0.00
EQLV 189.1
EQTV 189.1
LFCT 903.1
LFCV 904.2
BRCH 112.5
BRCV 120.7
LCLT 291.6
LCLP 904.2
MLTH 300.1
MLMR 15.11
THCK 5684.
PWAT 44.84
12Z 25 Aug 2011
University of Wyoming

CONVECTIVE CLOUD FEATURES IN TYPICAL SYNOPTIC ENVIRONMENTS:

ENHANCEMENT OF CONVECTION
BY
"Potential Vorticity"

Ascending / Descending air: Increasing / Decreasing Vorticity

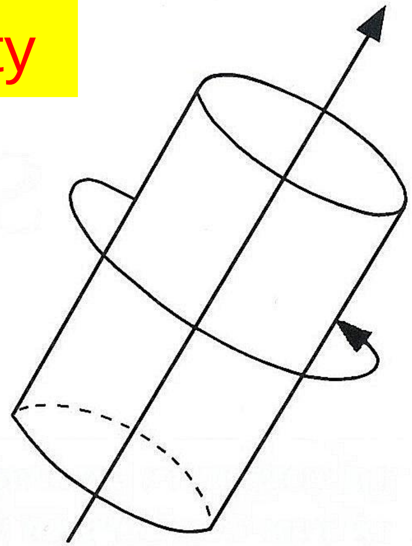


FIGURE A vorticity vector and the local rotation in the atmosphere indicated by the circulation around a cylinder of air oriented along the vorticity vector. (Adapted from Hoskins, 1997.)

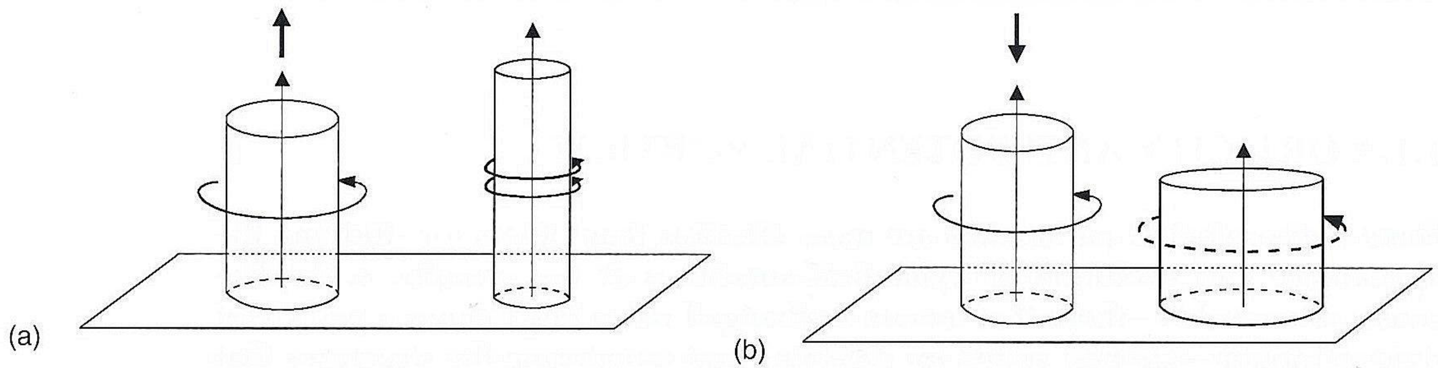
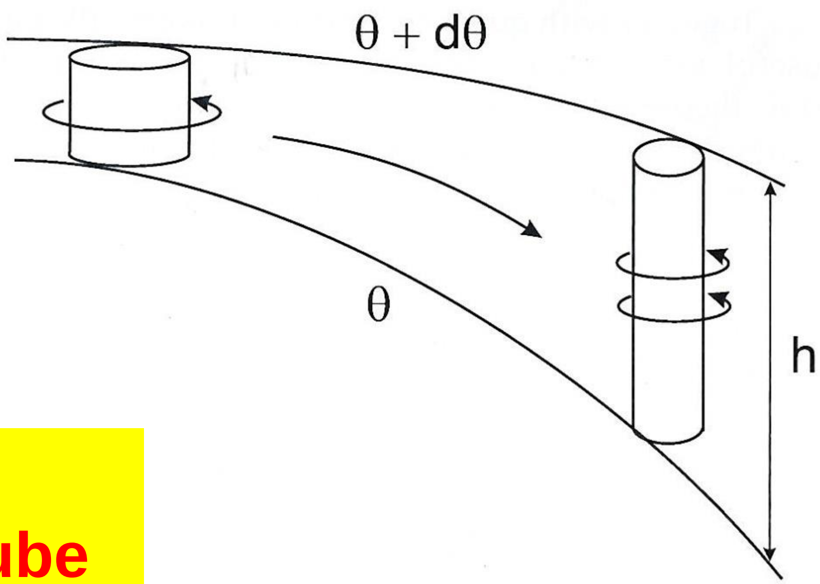


FIGURE Tropospheric (a) ascent and (b) descent that leads to, respectively, (a) stretching and (b) shrinking of vorticity associated with (a) an increase and (b) a decrease of vorticity and circulation. (Adapted from Hoskins, 1997.)

Potential Vorticity Definition:

$$PV = -g\,(\zeta_{\Theta} + f)\frac{\partial \Theta}{\partial p}$$

f	Coriolis parameter
g	gravitational acceleration
p	pressure
PV	potential vorticity
Θ	potential temperature
ζ_{Θ}	relative isentropic vorticity



Conservation of PV during descent of a vorticity tube along 2 iso Theta surfaces

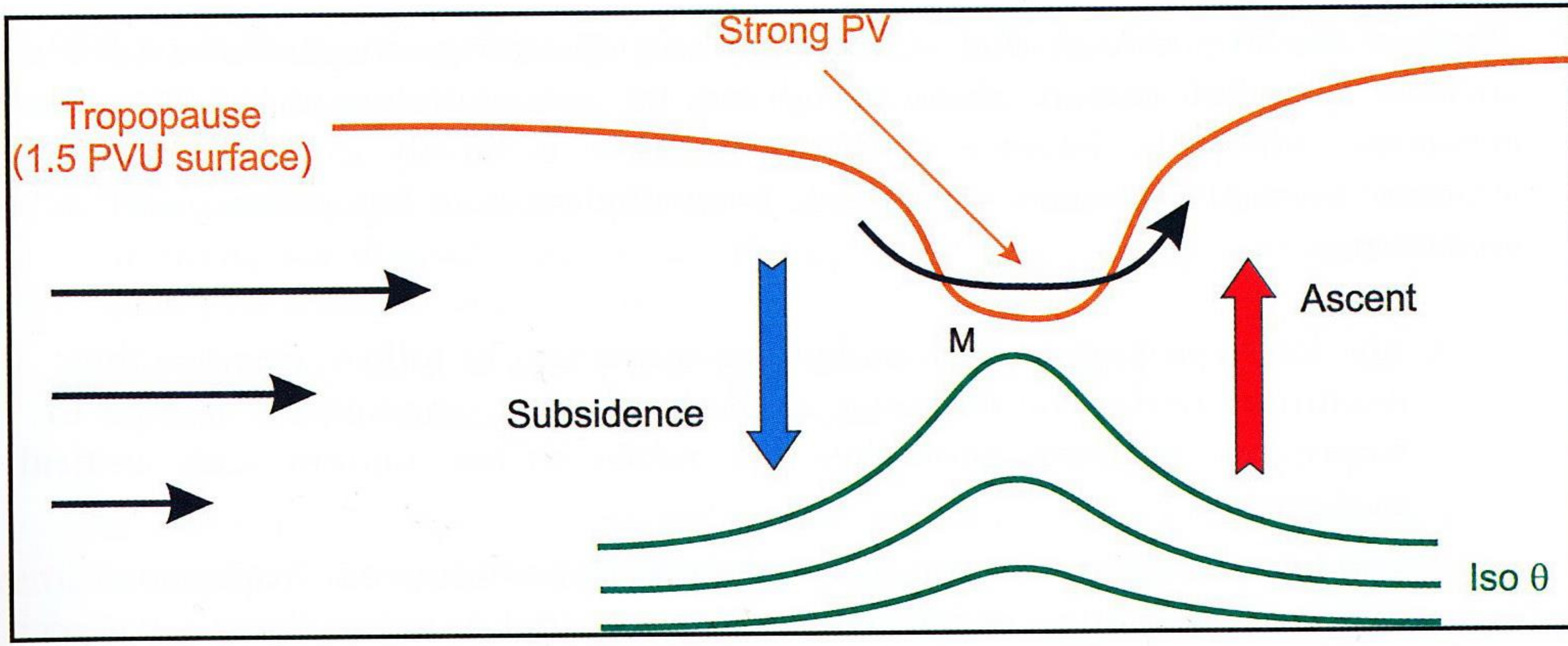
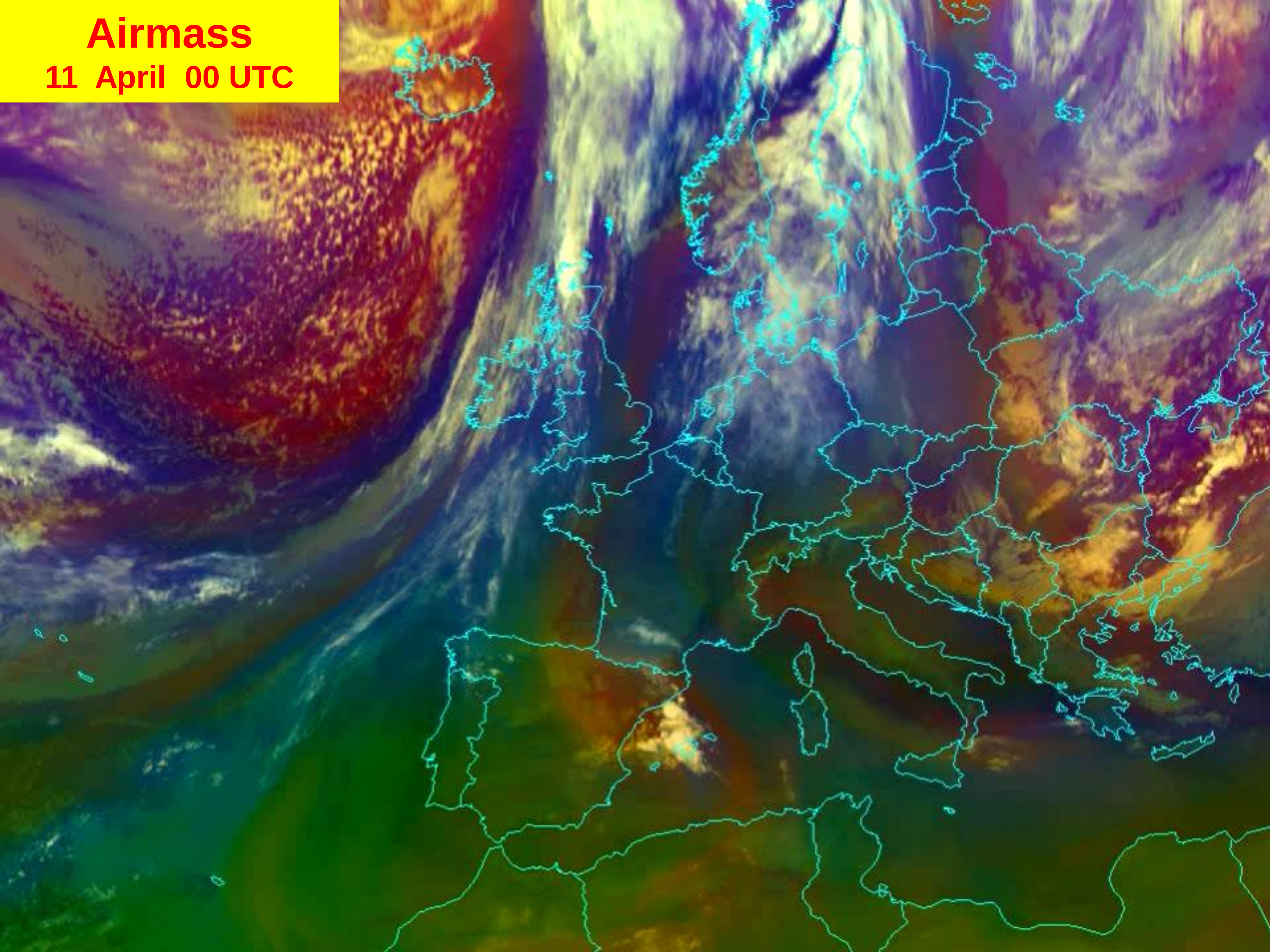
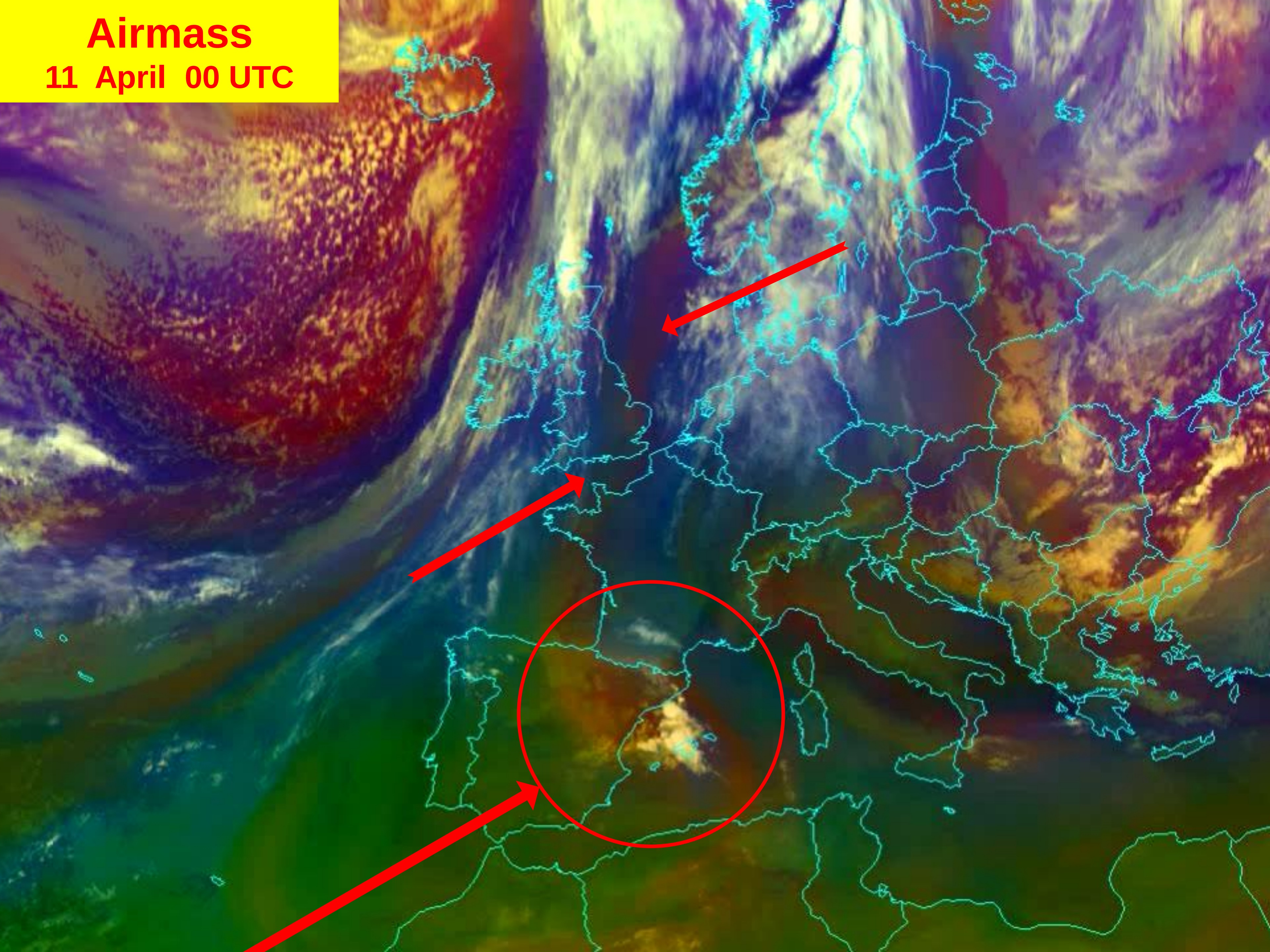
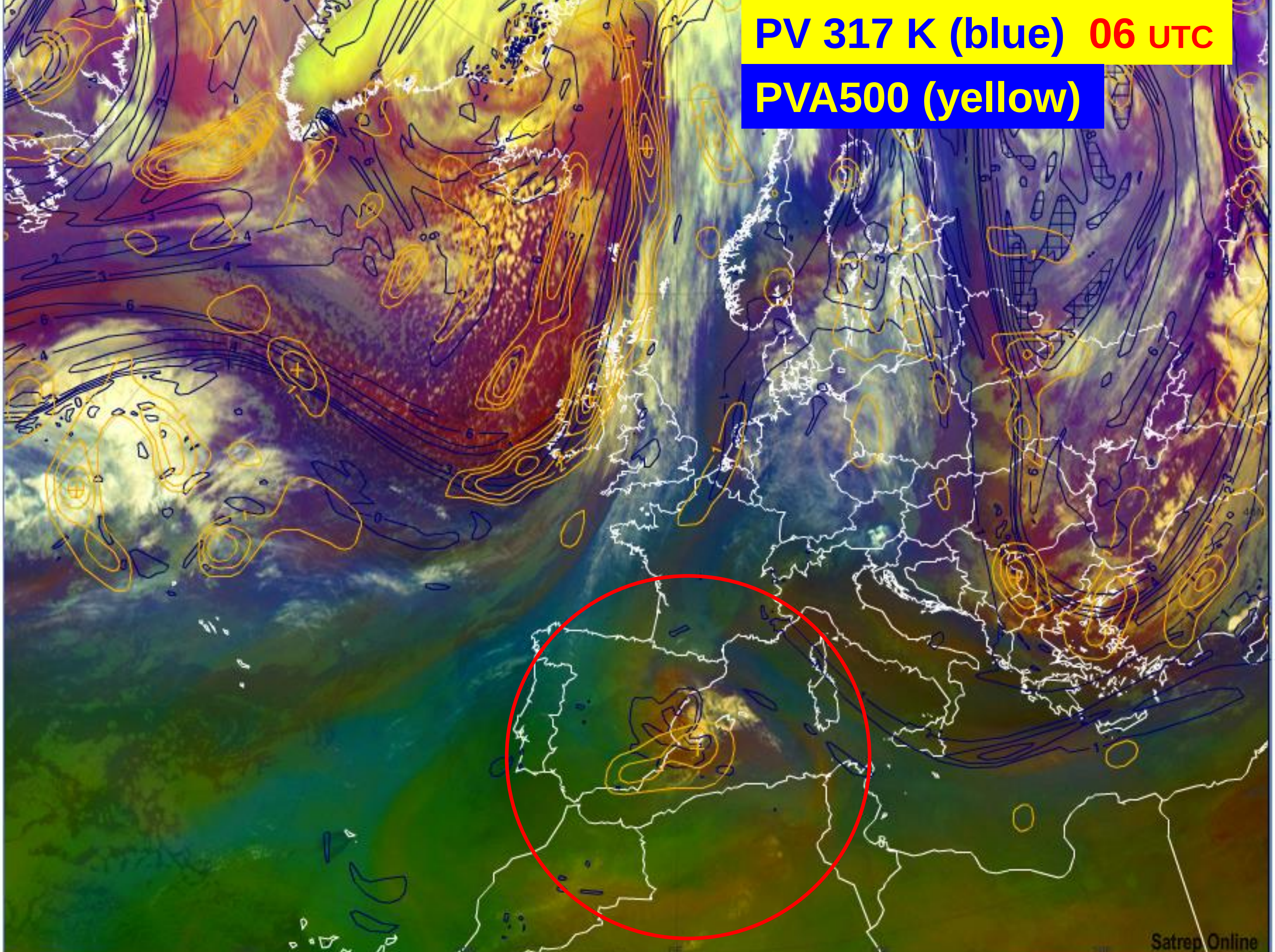


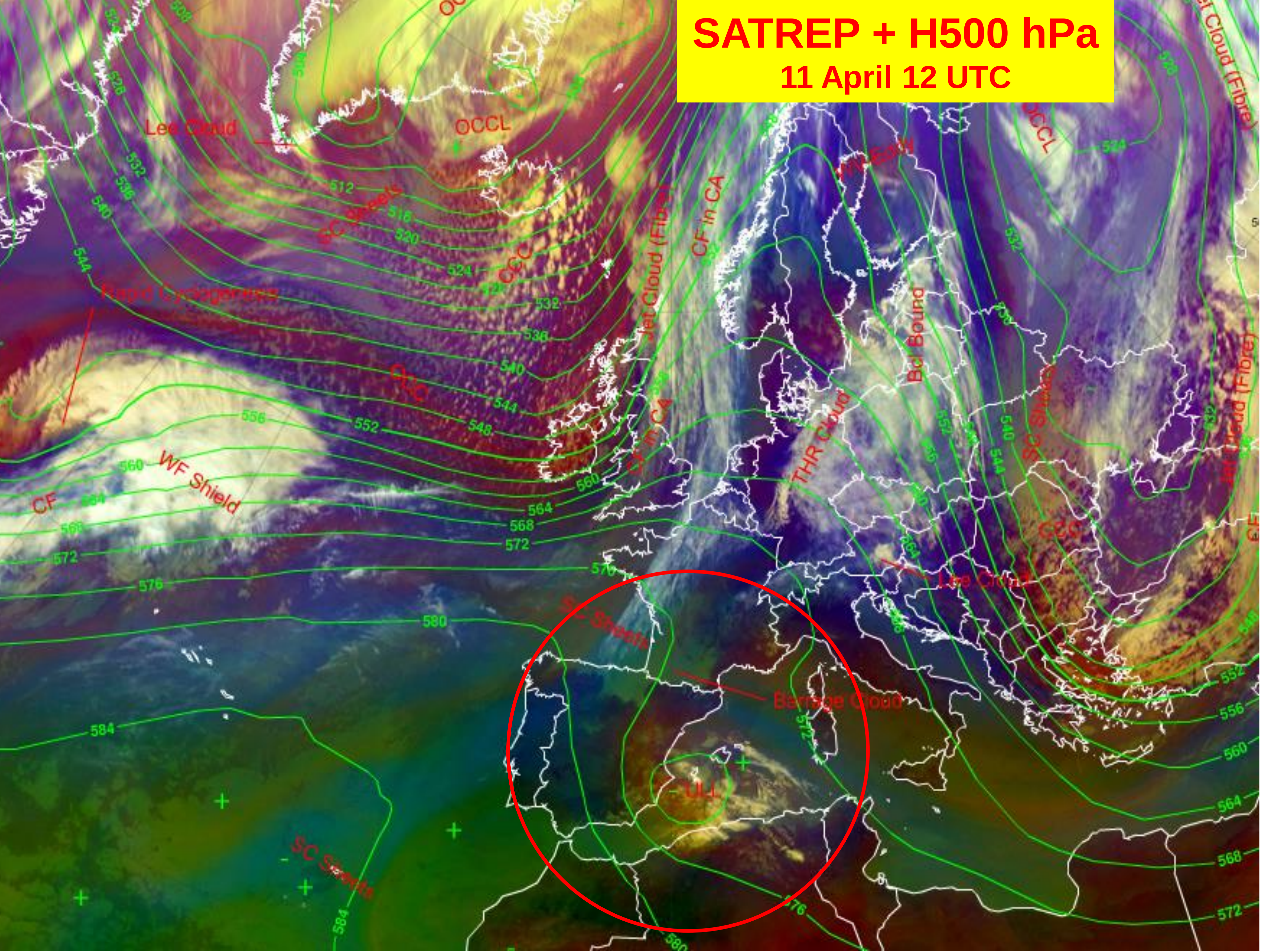
FIGURE A schematic cross section, showing an idealized model of the modification of the troposphere associated with an upper-level positive PV anomaly, referred to as a tropopause dynamic anomaly.

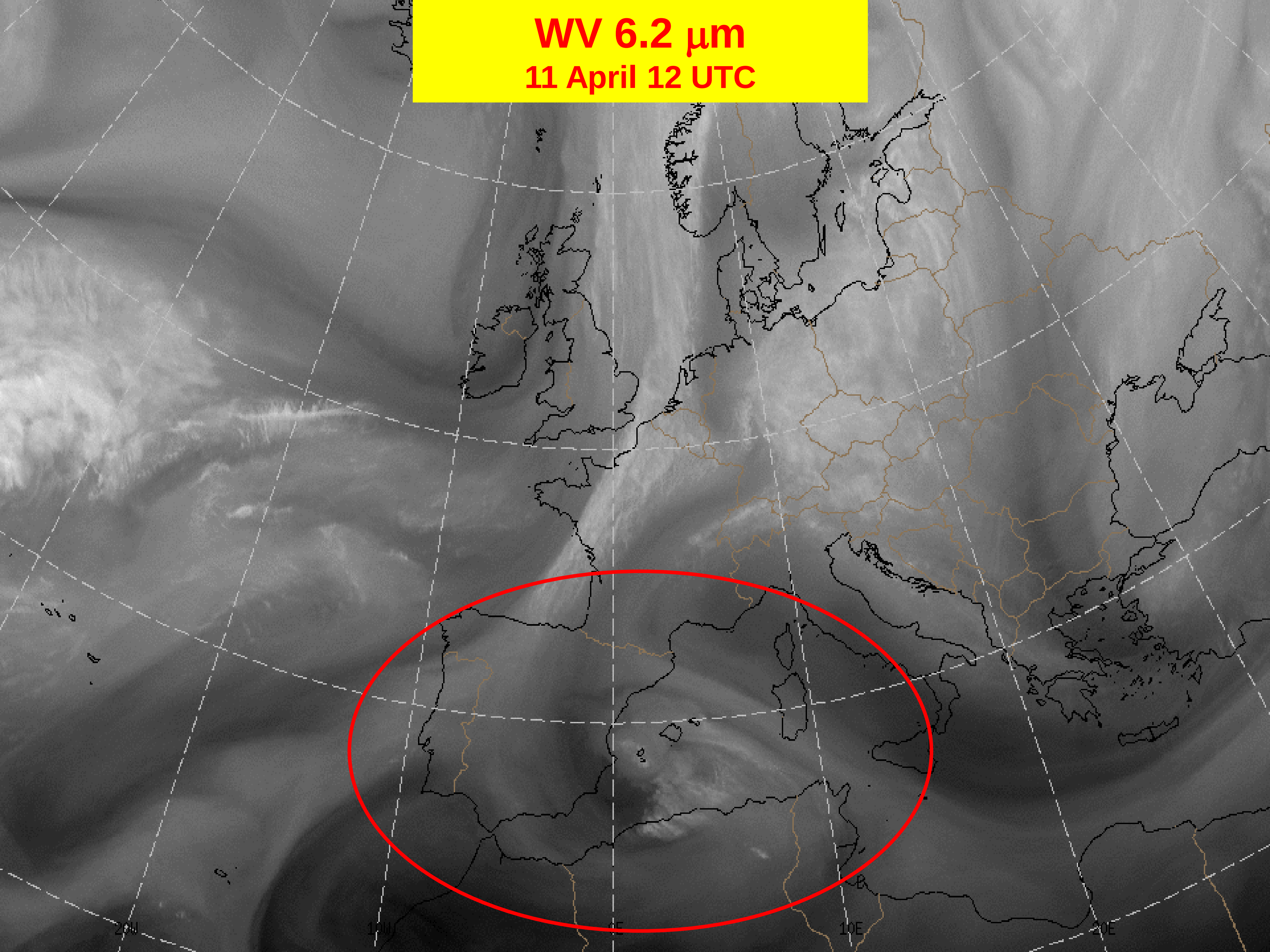

Airmass
11 April 00 UTC

Airmass
11 April 00 UTC

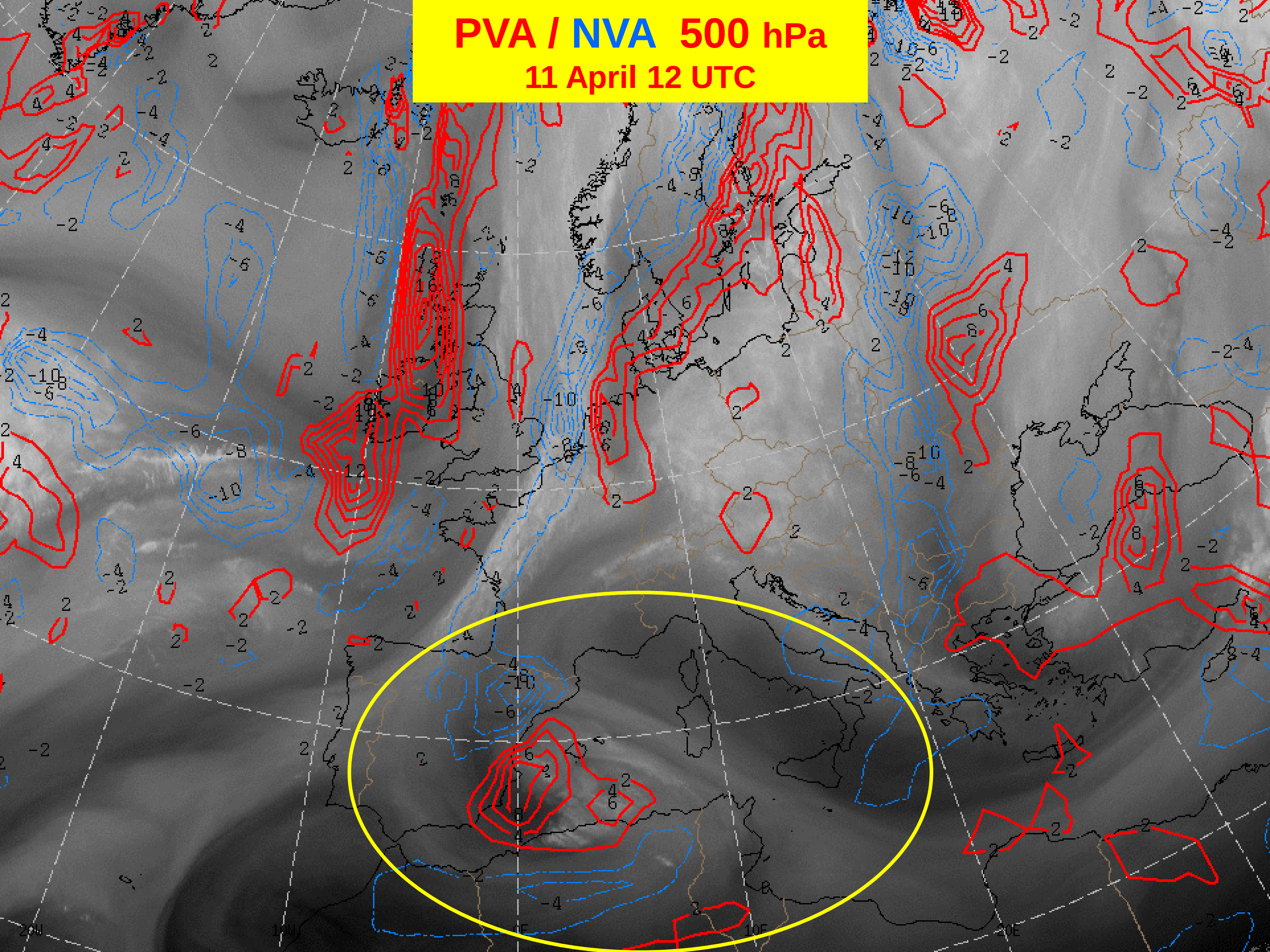


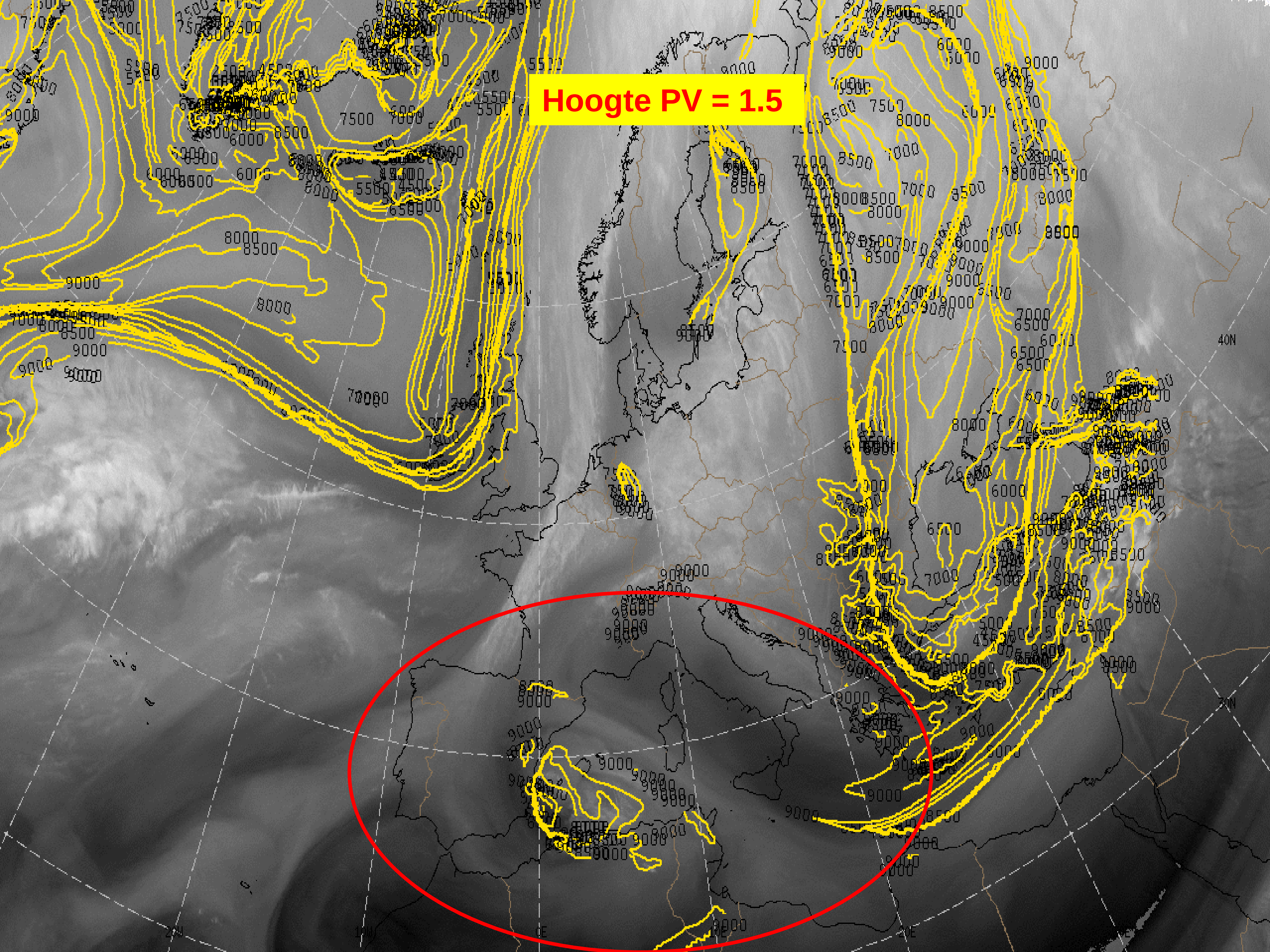

PV 317 K (blue) 06 UTC
PVA500 (yellow)
Satrep Online


SATREP + H500 hPa
11 April 12 UTC
Lee Cloud
OCCL
SC Sheets
CCC
Rapid Cyclogenesis
Jet Cloud (Fibre)
CF in CA
WV Eddy
Bd Bound
THR Cloud
SC Sheets
WF Shield
CF
Lee Cloud
SC Sheets
Barrage Cloud
ULL
SC Sheets


WV 6.2 μm
11 April 12 UTC
20W
10W
10E
20E

PVA / NVA 500 hPa
11 April 12 UTC

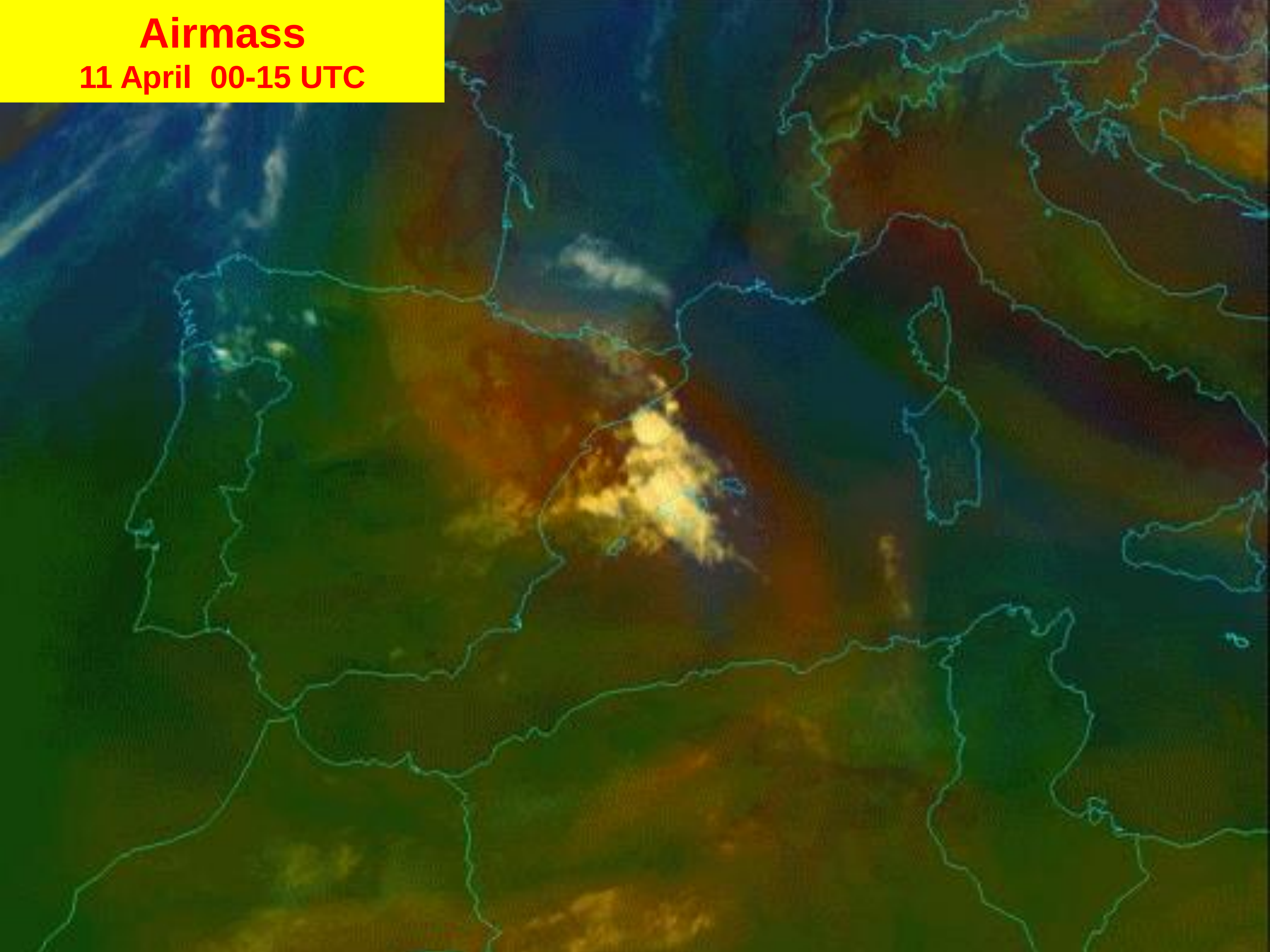



Hoogte PV = 1.5

Info for Liliane
next slide is an animation:
file name: ULL_zoom11april.gif
Delete this sheet !!

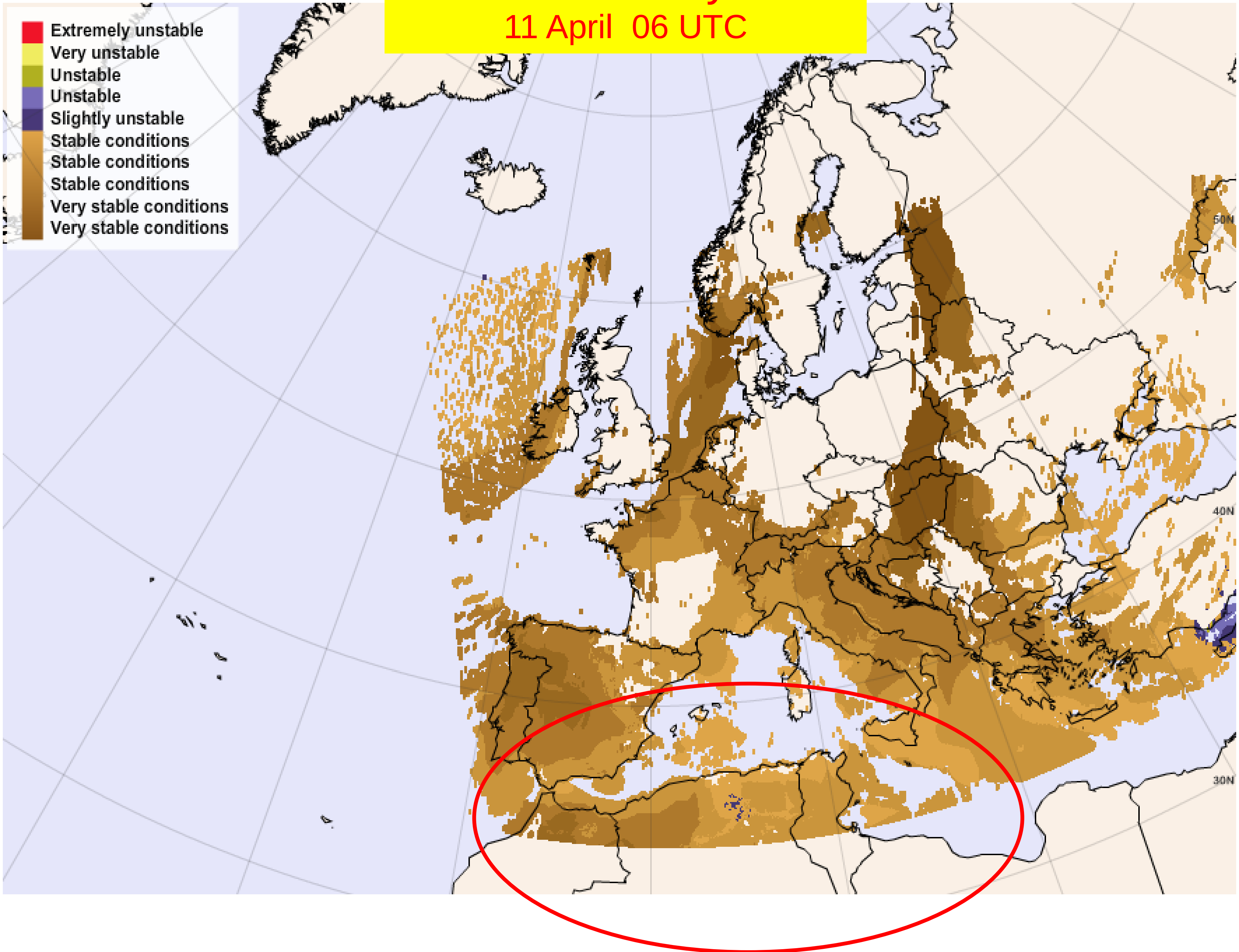
Airmass

11 April 00-15 UTC



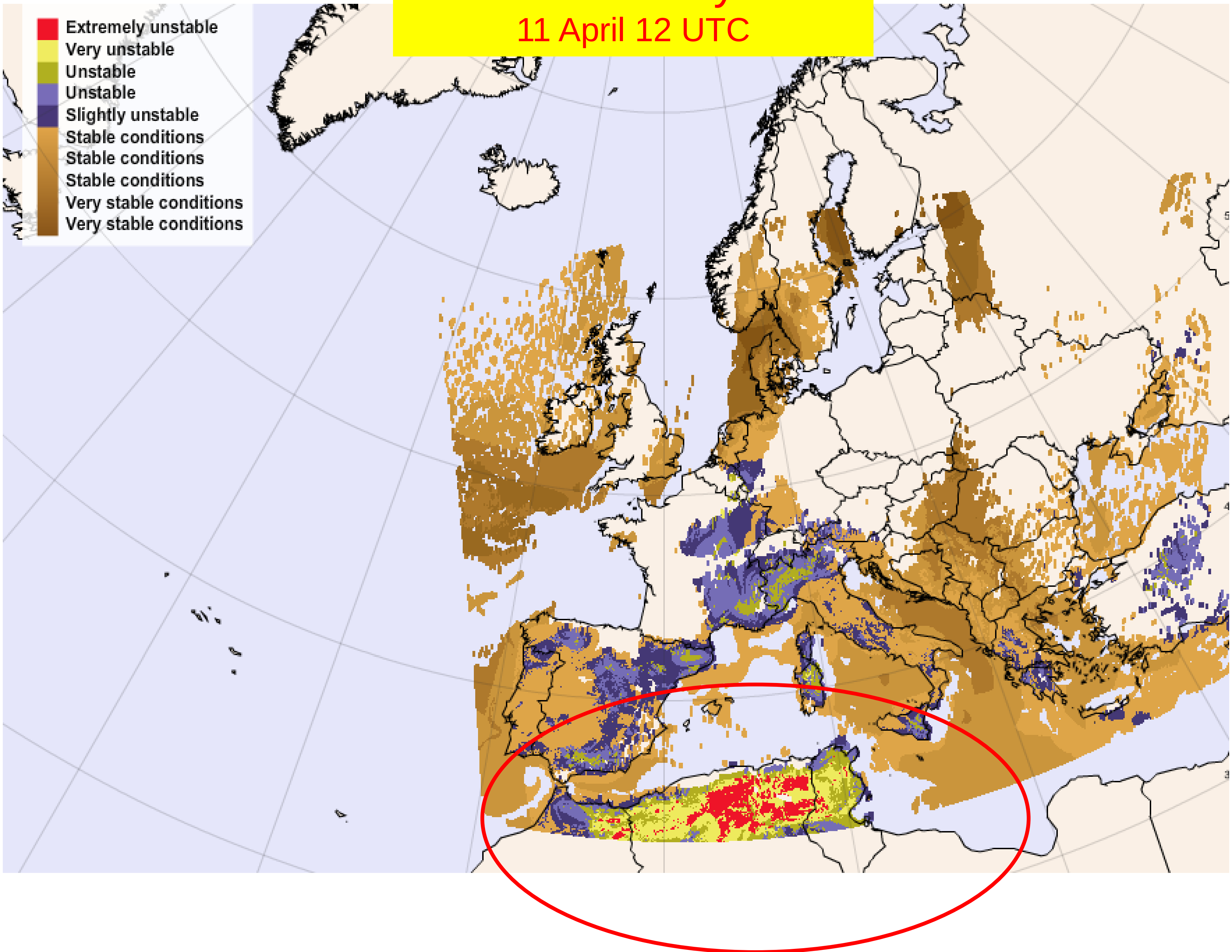
Global Instability Index

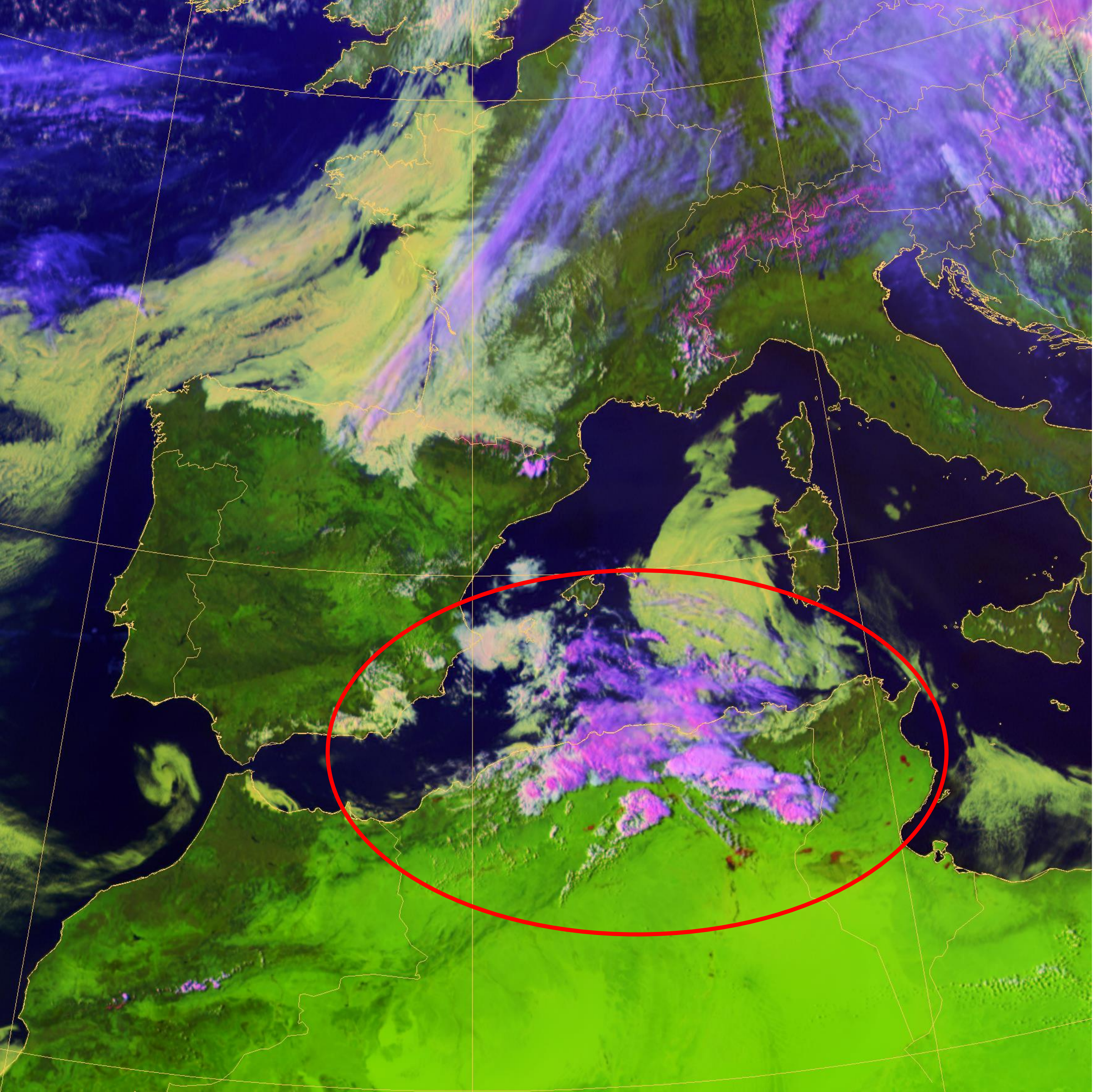
11 April 06 UTC



Global Instability Index

11 April 12 UTC





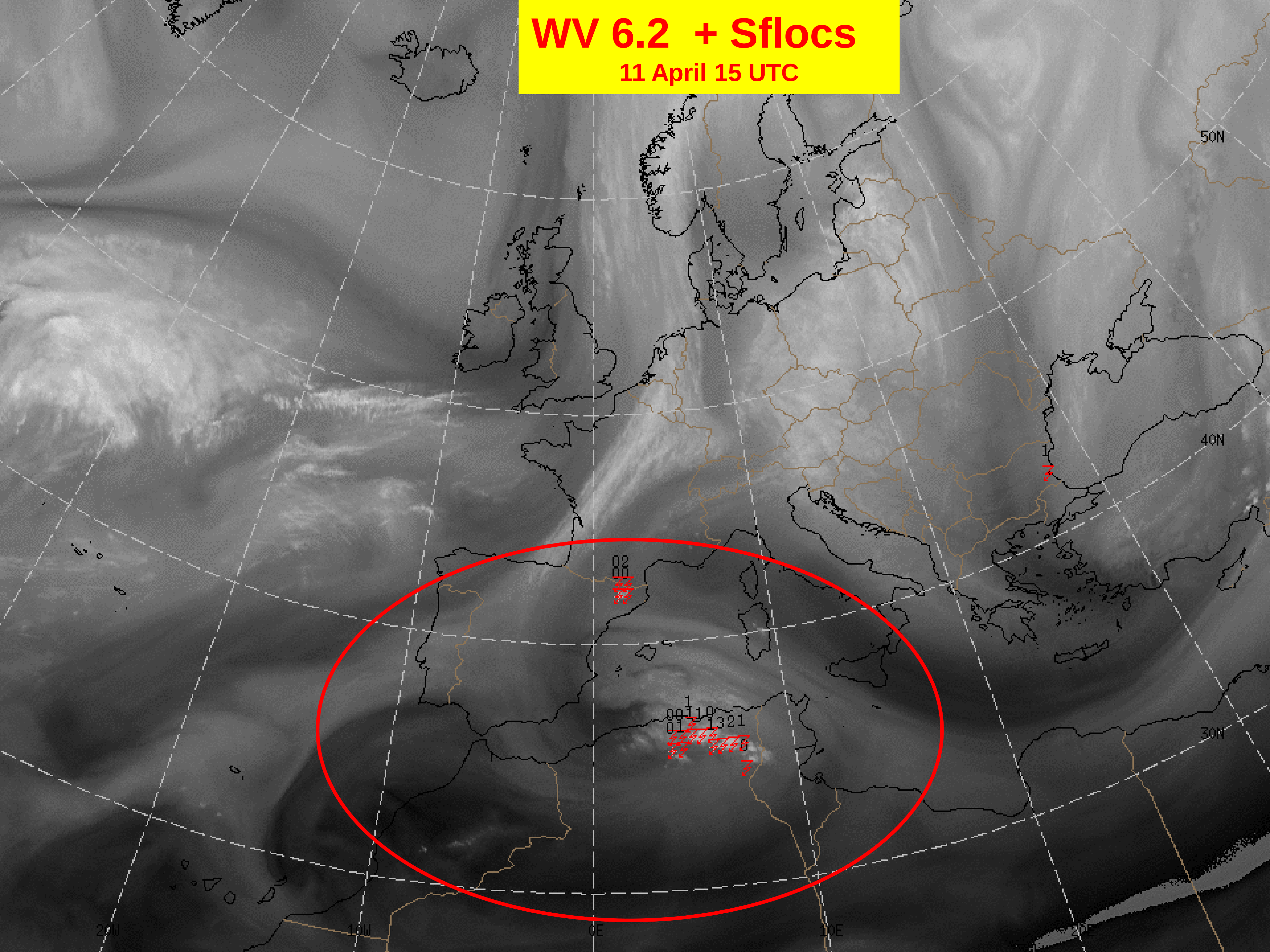
11 April
15 UTC

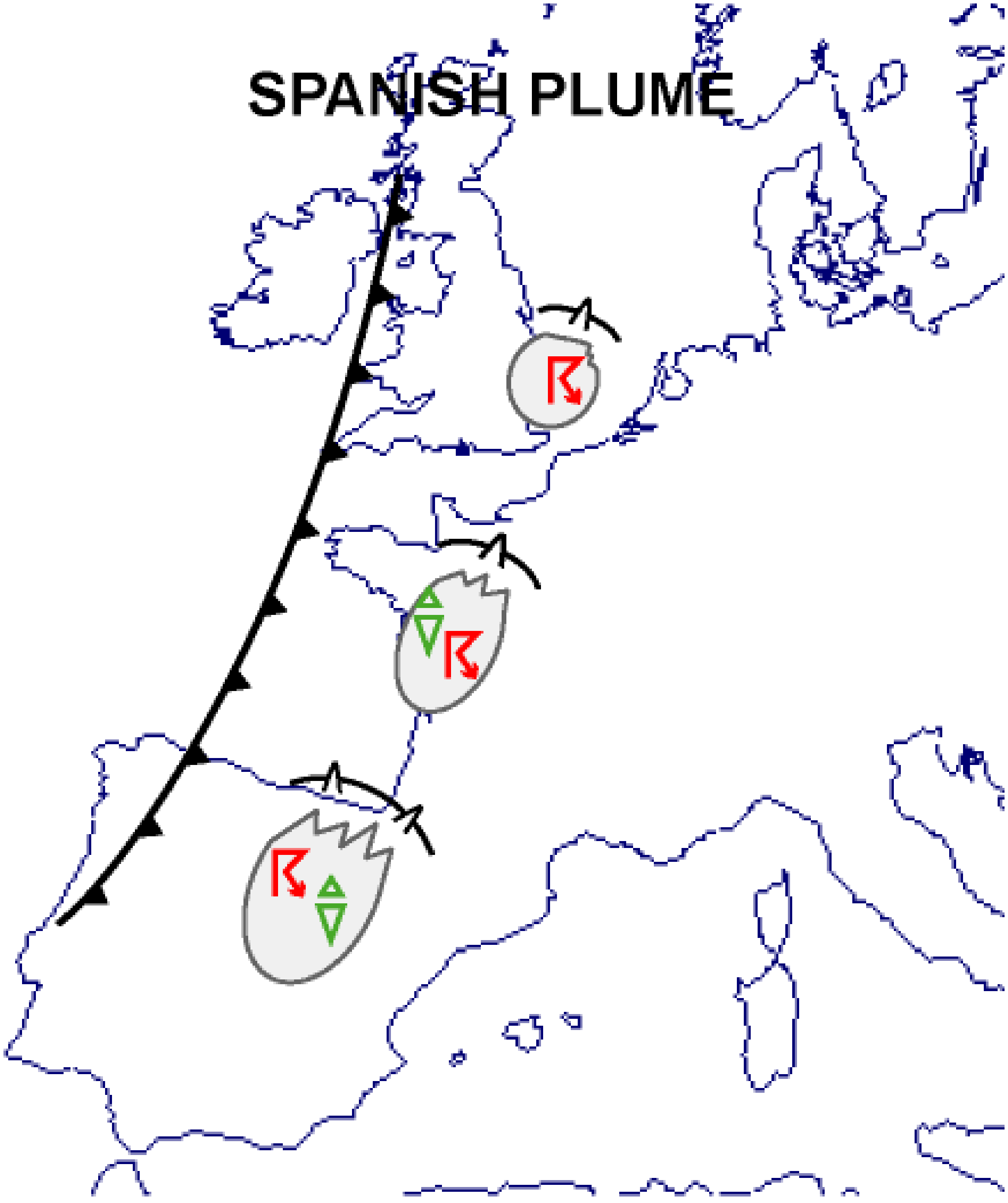
CONVECTIVE CLOUD FEATURES IN TYPICAL SYNOPTIC ENVIRONMENTS:

"Spanish Plume"

+

"leading edge of front"


WV 6.2 + Sflocs
11 April 15 UTC
50N
40N
30N
20W
10W
0E
10E
20E


SPANISH PLUME

Key parameters

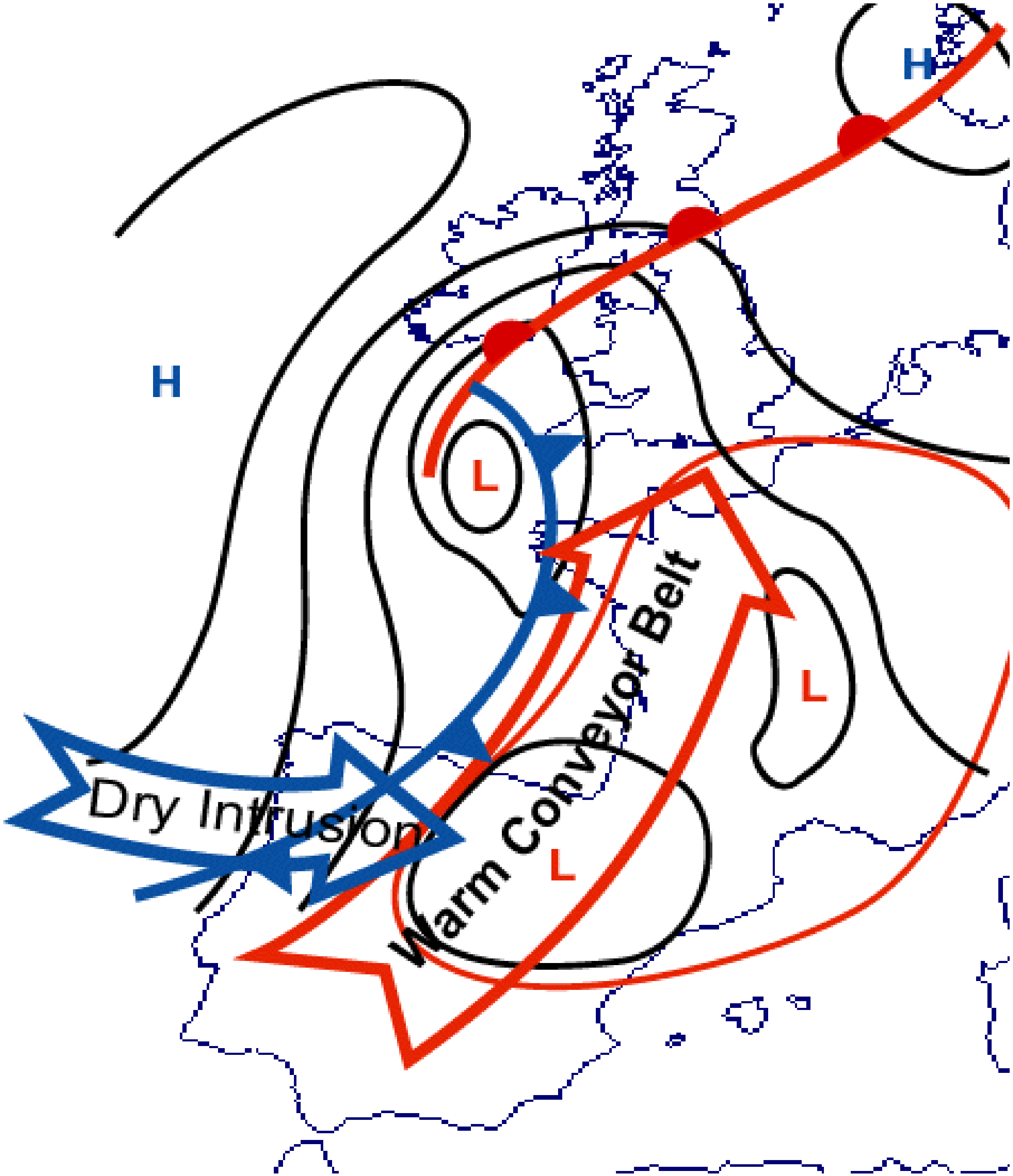
- **Stability indices** on isobaric surfaces: CAPE, Showalter Index

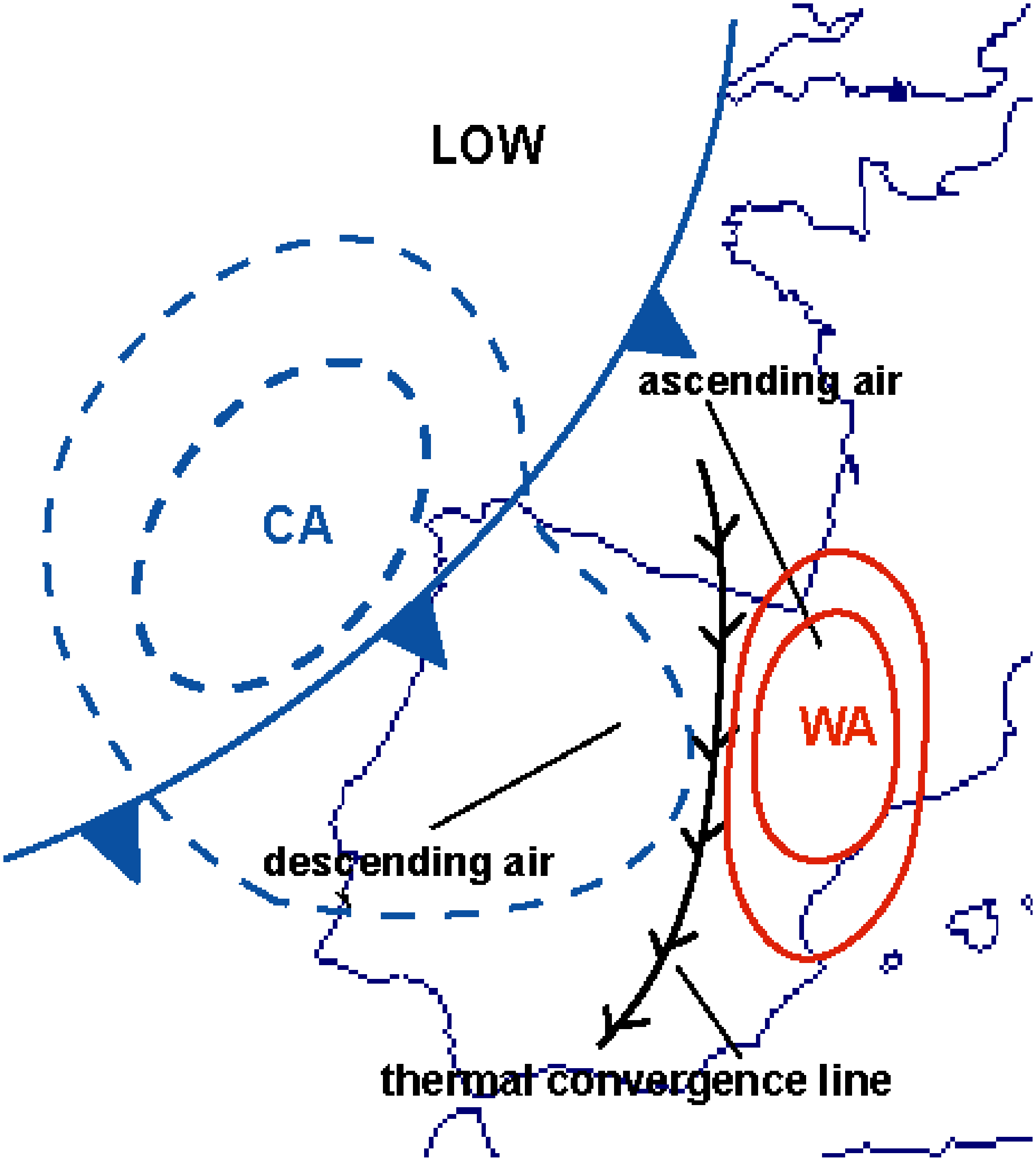
- **Equivalent potential temperature** θ_E :
Tongue of high values of θ_E; deep convection develops in the area of maximal values.

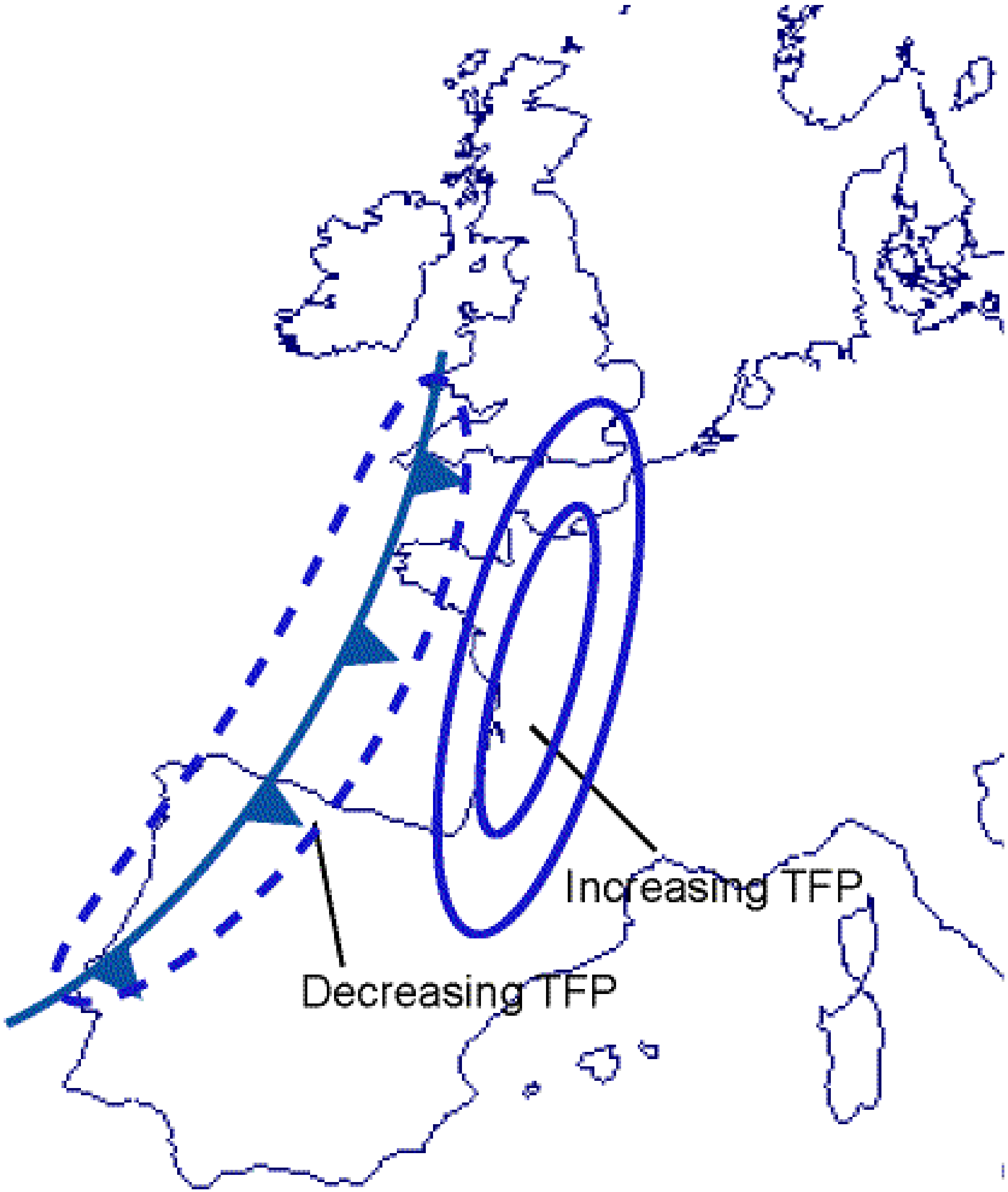
- **Temperature Advection** (TA)

- **Thermal Front Parameter** (TFP): TFP associated with the gradually weakening Cold Front, and potential new front development ahead of the original Cold Front.

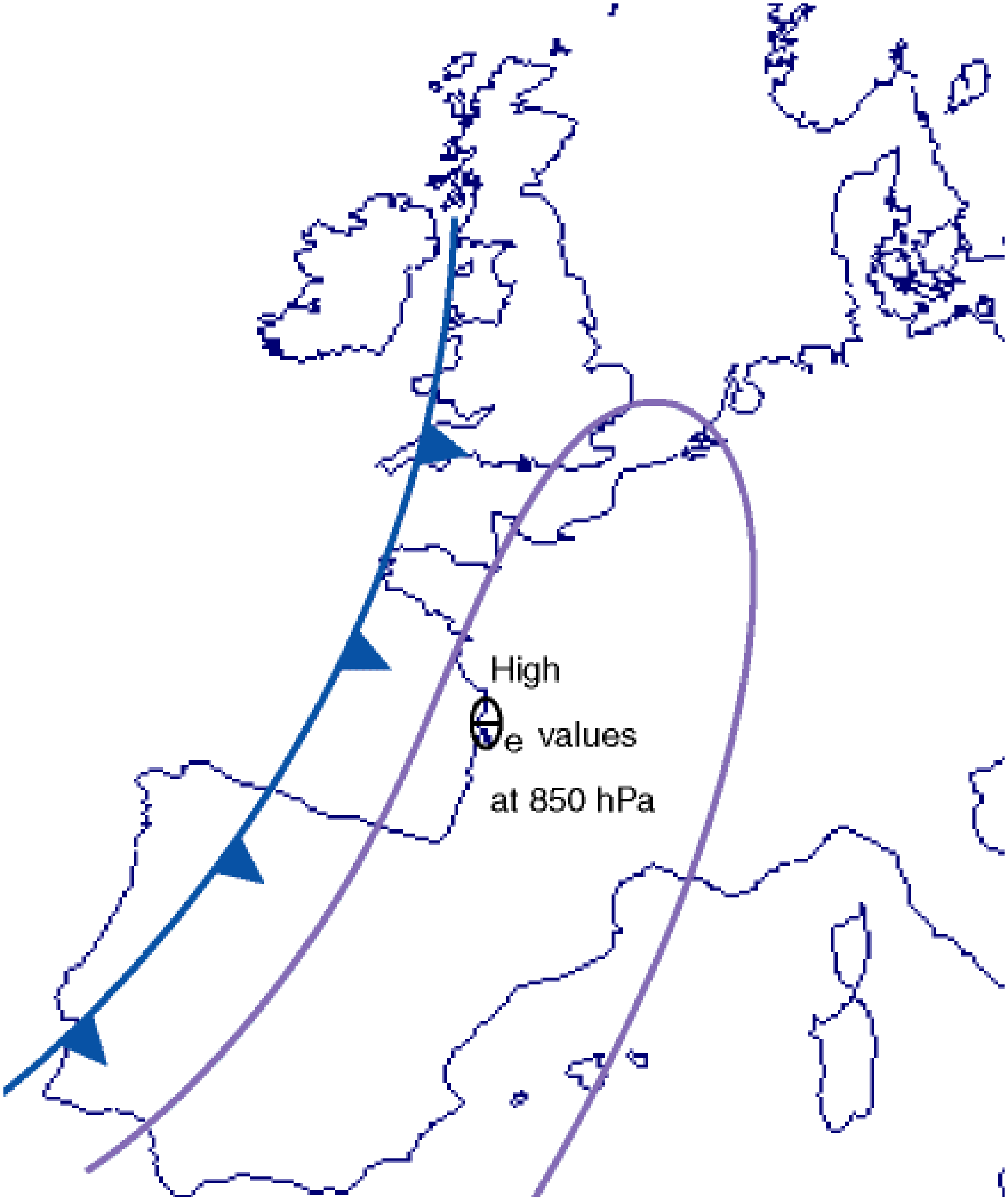
- **Thickness**
Equivalent thickness 1000-500 hPa


H
H
L
L
L
Dry Intrusion
Warm Conveyor Belt


LOW
ascending air
CA
WA
descending air
thermal convergence line

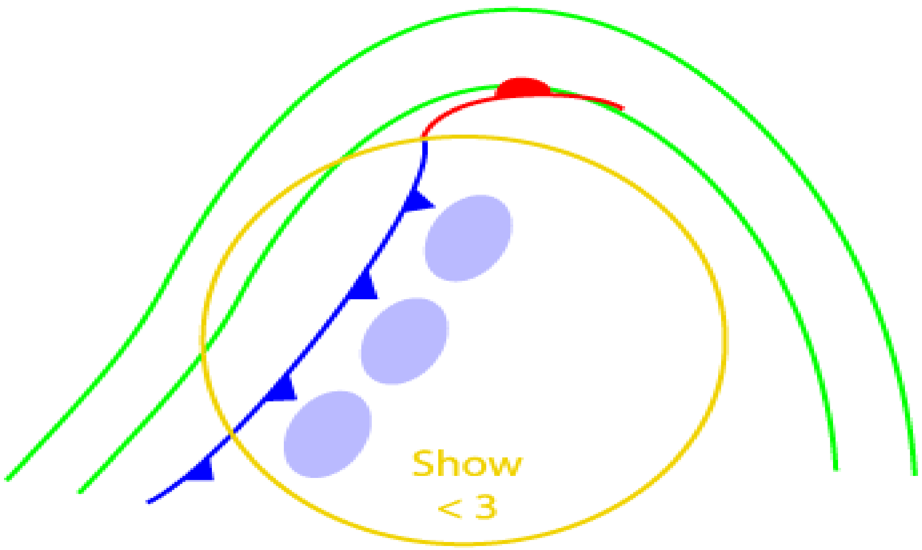


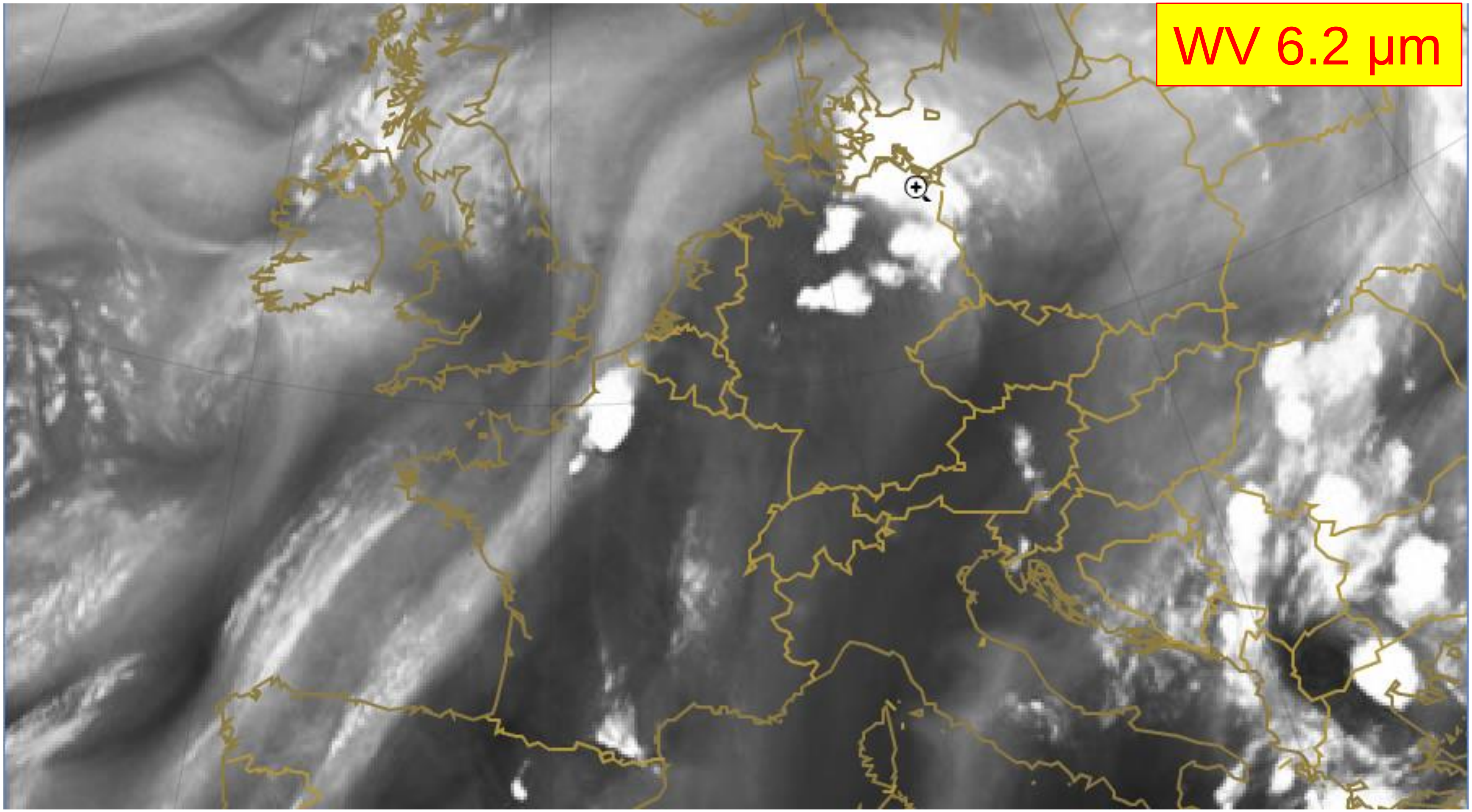
Increasing TFP
Decreasing TFP


High
θ_e values
at 850 hPa

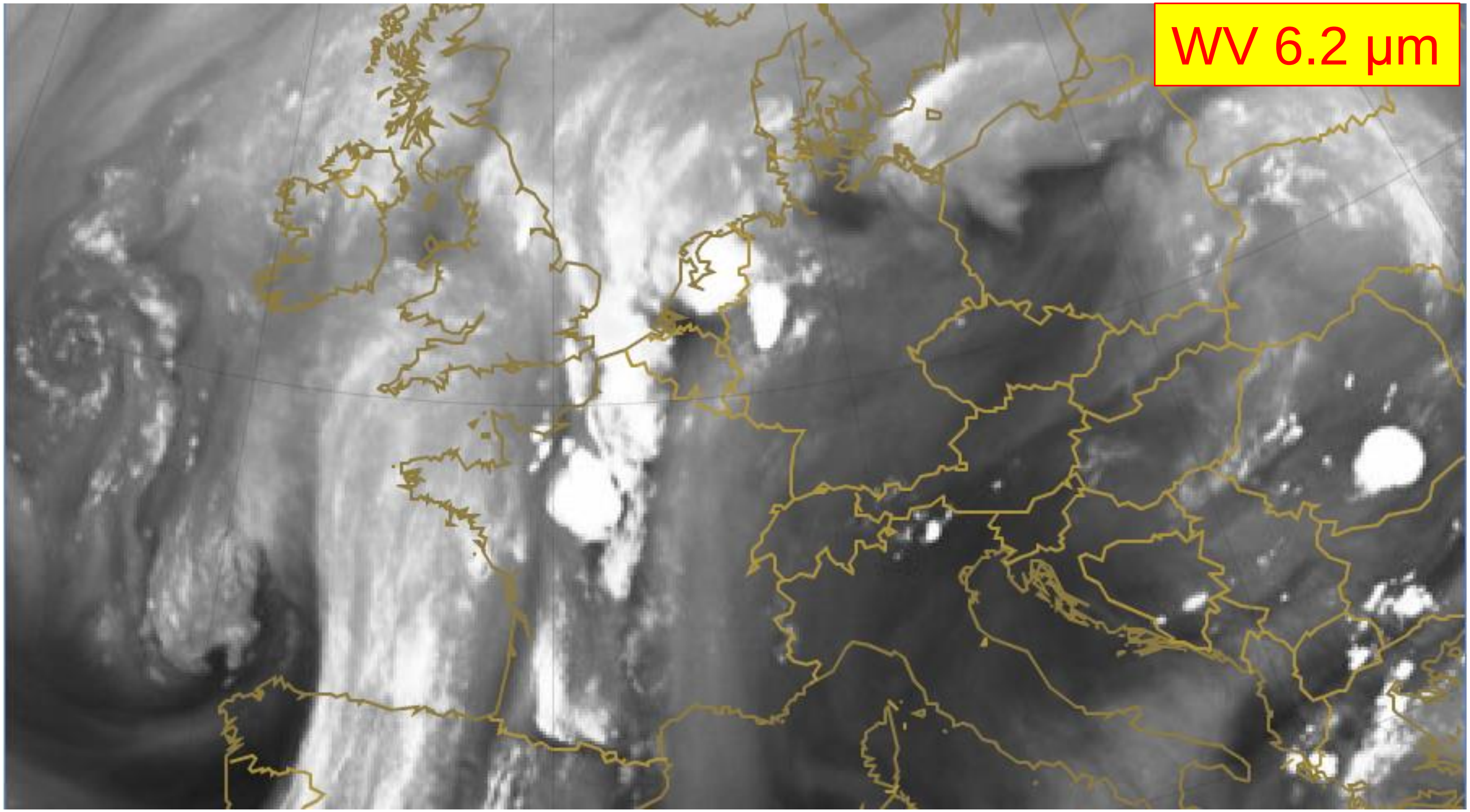
Thickness + Showalter index

Leading edge of frontal cloud

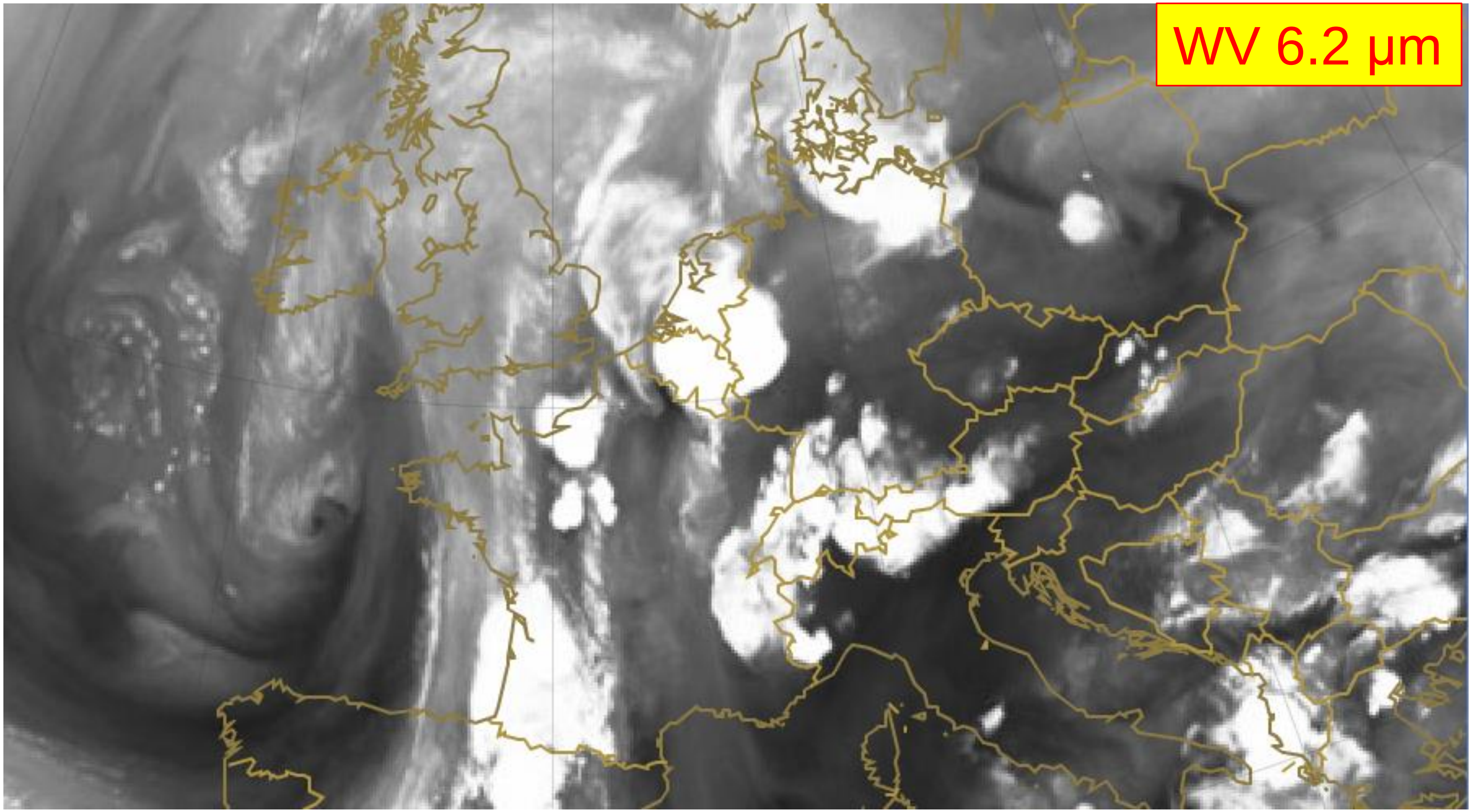




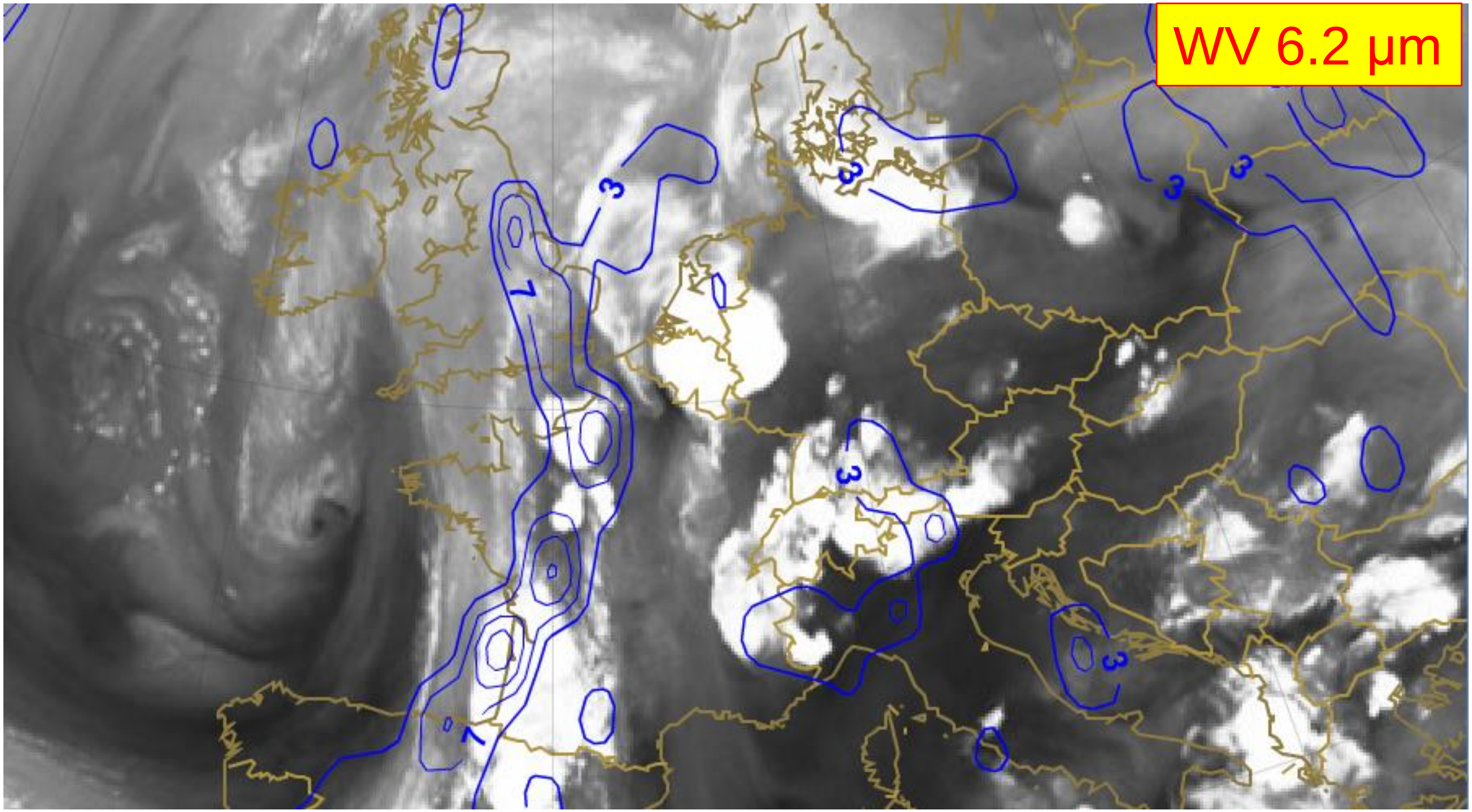
9 June 2014 06 UTC



9 June 2014 12 UTC

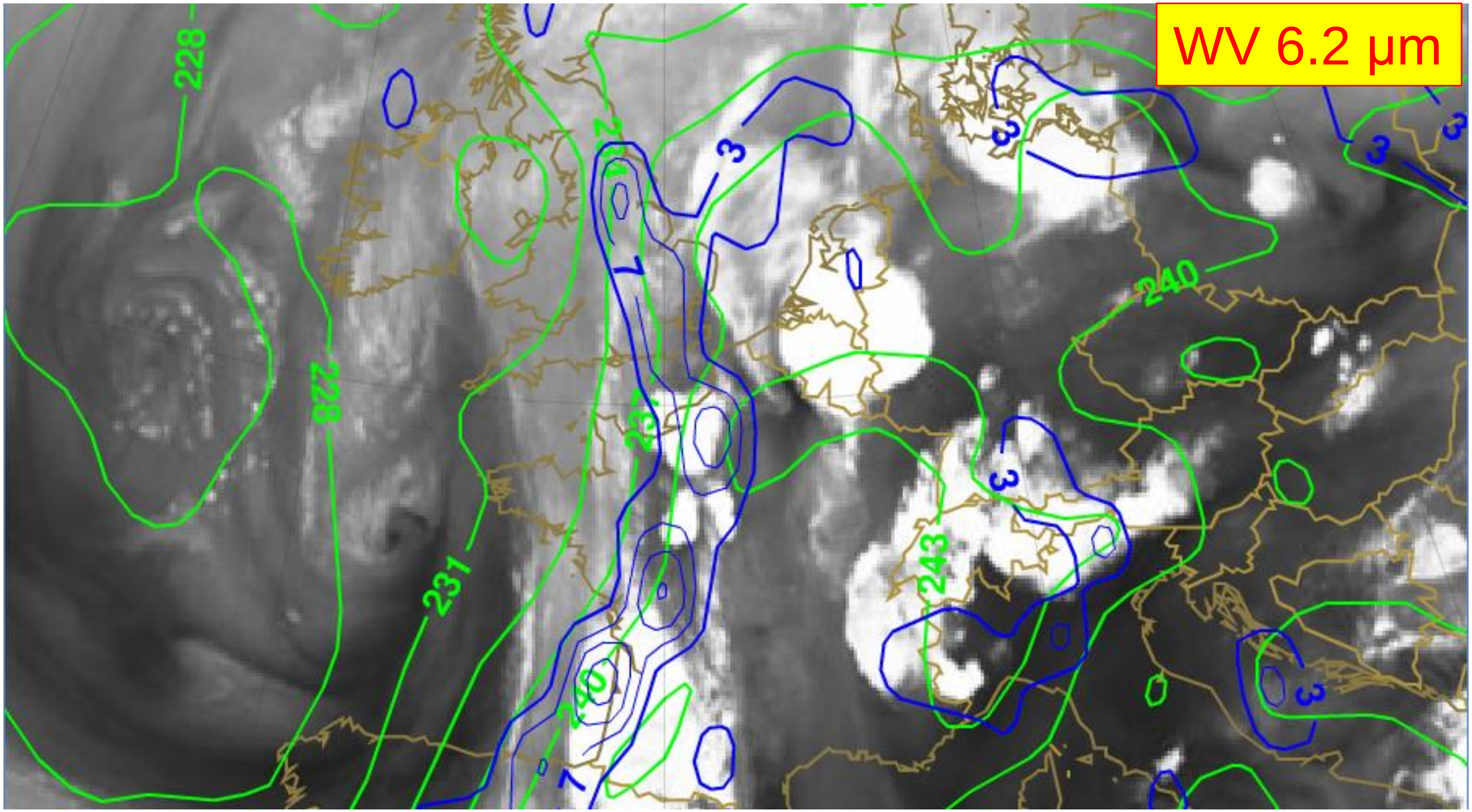


9 June 2014 18 UTC



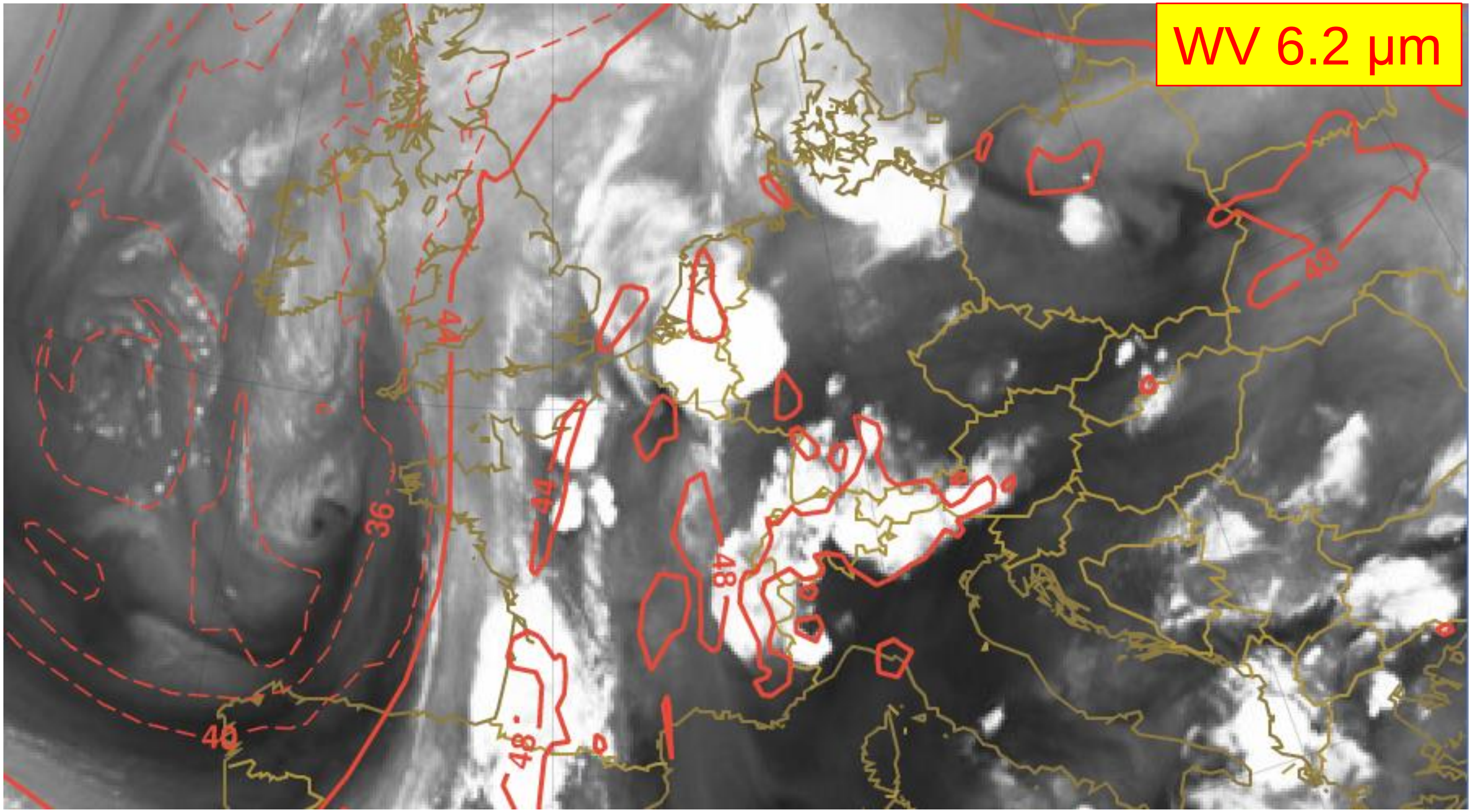
9 June 2014 18 UTC

TFP+ Thickness



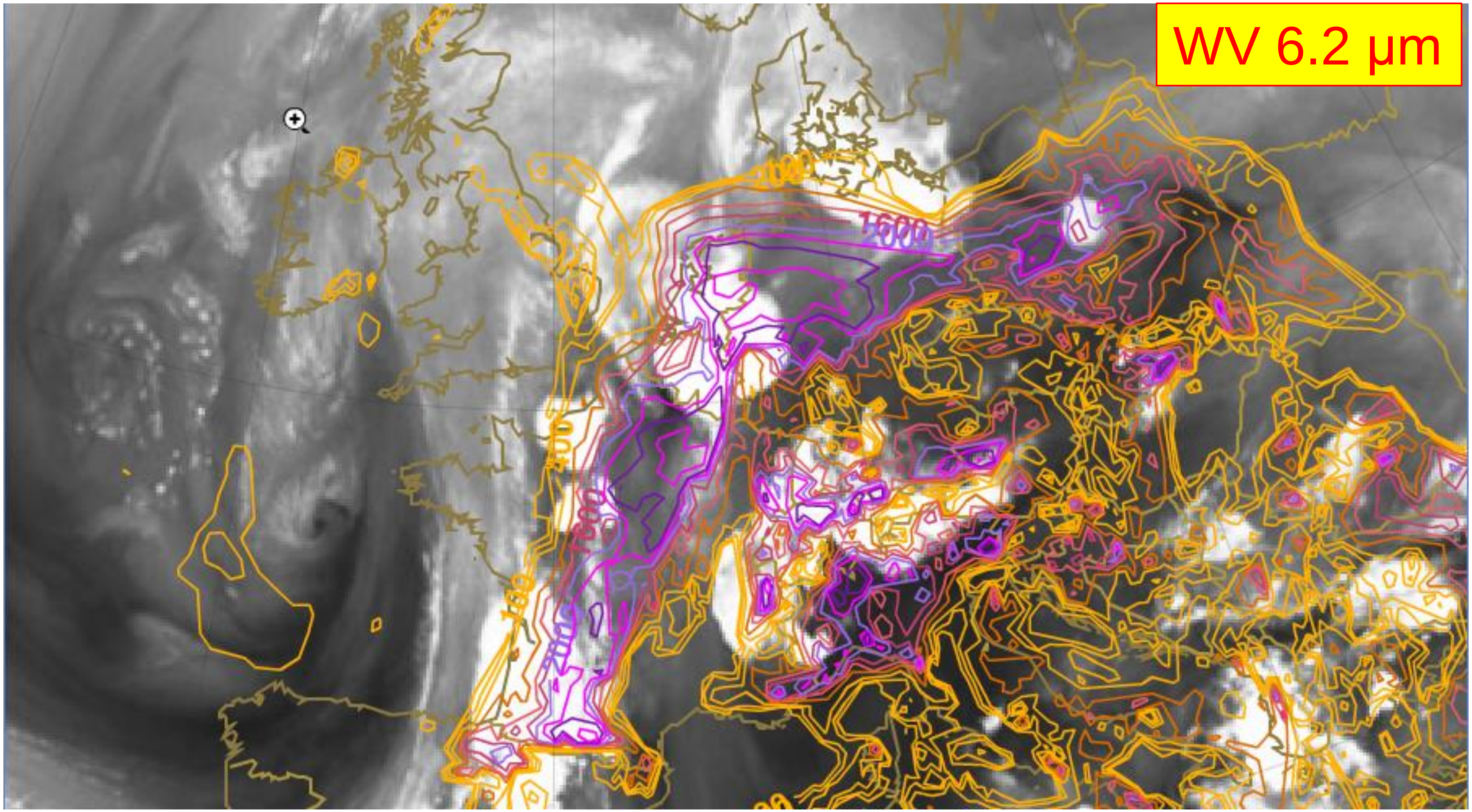
9 June 2014 18 UTC

θ_E (500 hPa)

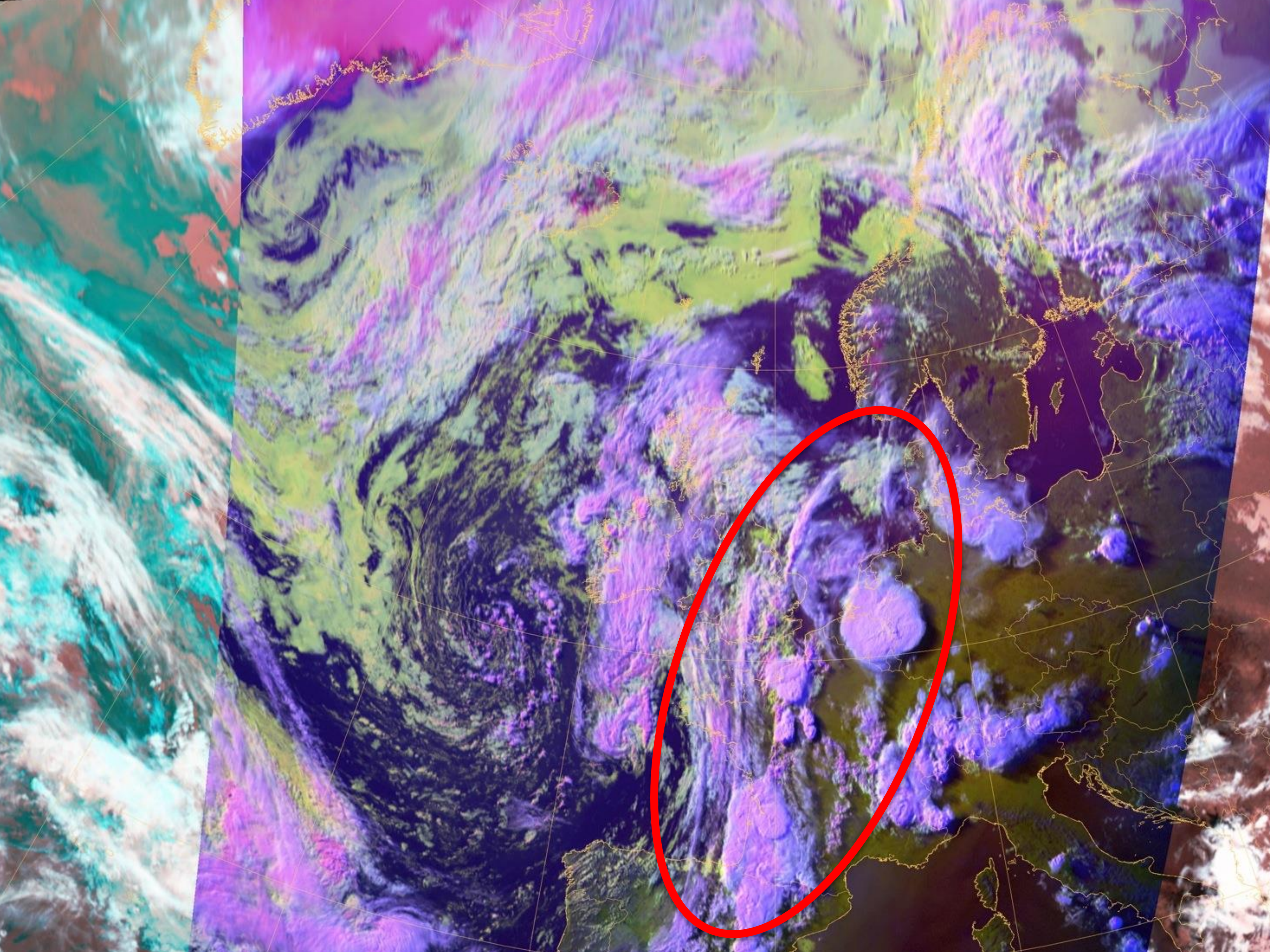


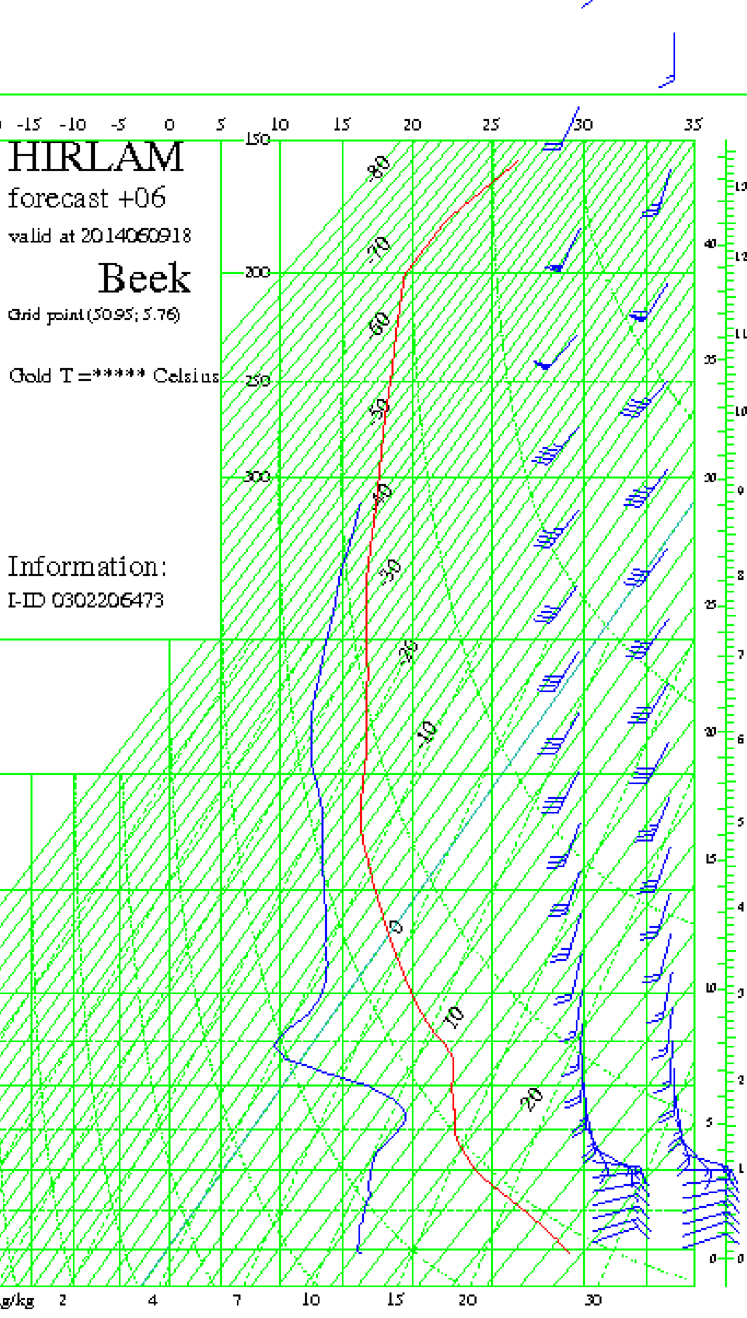
9 June 2014 18 UTC

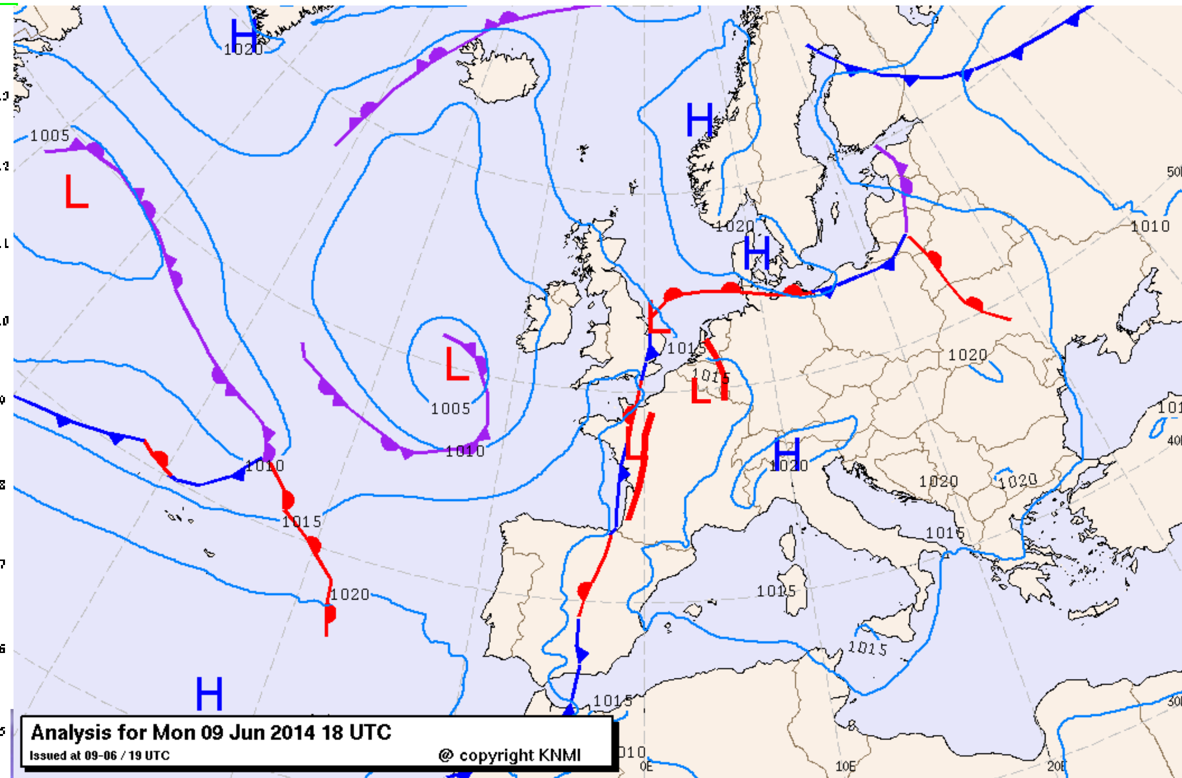
WV 6.2 µm + CAPE
9 June 2014 18 UTC

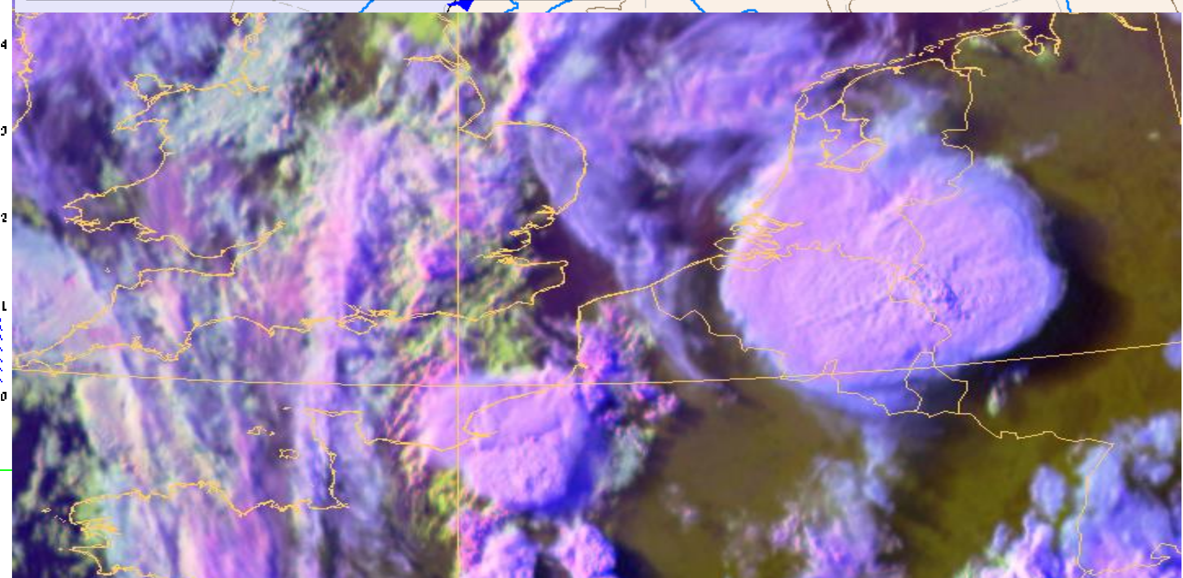


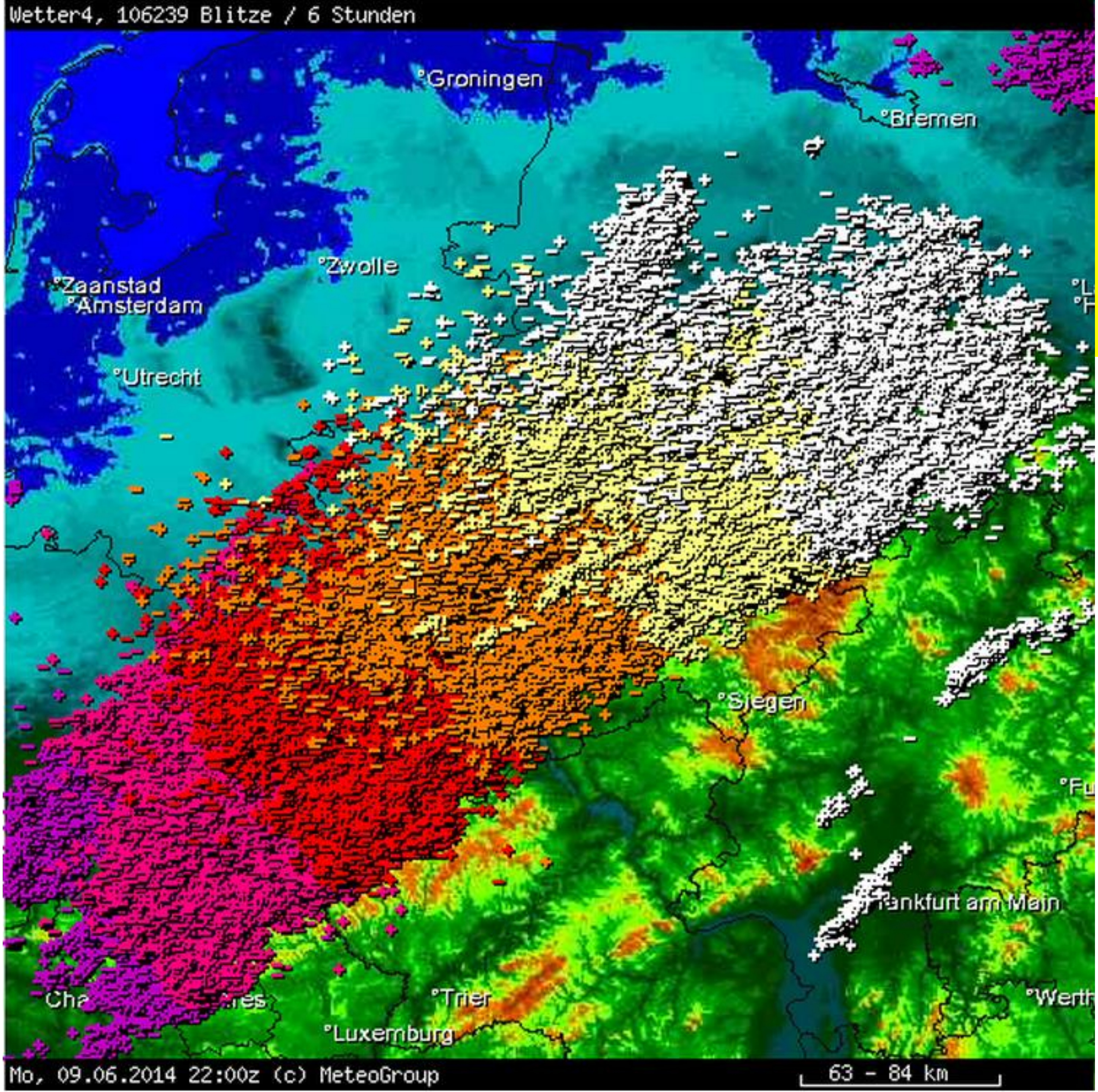
9 June 2014 18 UTC




HIRLAM
forecast +06
valid at 2014060918
Beek
Grid point (50.95; 5.76)
Cold T =***** Celsius
Information:
I-ID 0302206473
g/kg


Analysis for Mon 09 Jun 2014 18 UTC
Issued at 09-06 / 19 UTC
@ copyright KNMI





In 6 hours more than 100.000 lightnings


pinkpop
STAGE
WC

Thx for your attention

and

Maybe we see each other in Langen

Thx for your attention

and

Maybe we see each other in Langen

Questions / Remarks ?

Recommended
"Background" web addresses

- www.zamg.ac.at/docu/Manual/SatManu
- www.satreponline.org
- www.eumetrain.org
- www.eumetsat.int/Home/Main/Image_Gallery/
  Real_Time_Imagery/index.htm
- www.meted.ucar.edu/training_module.php?id=16