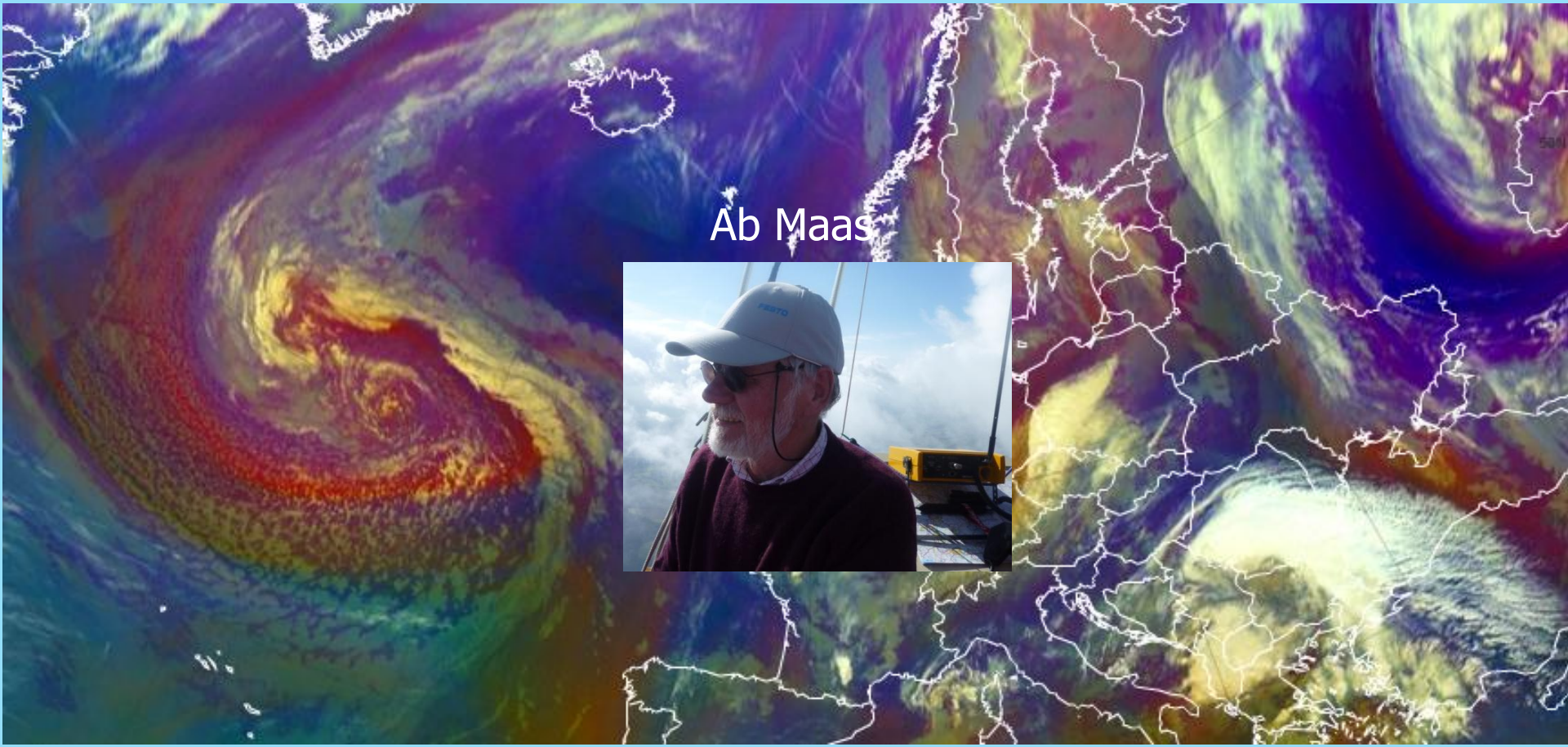
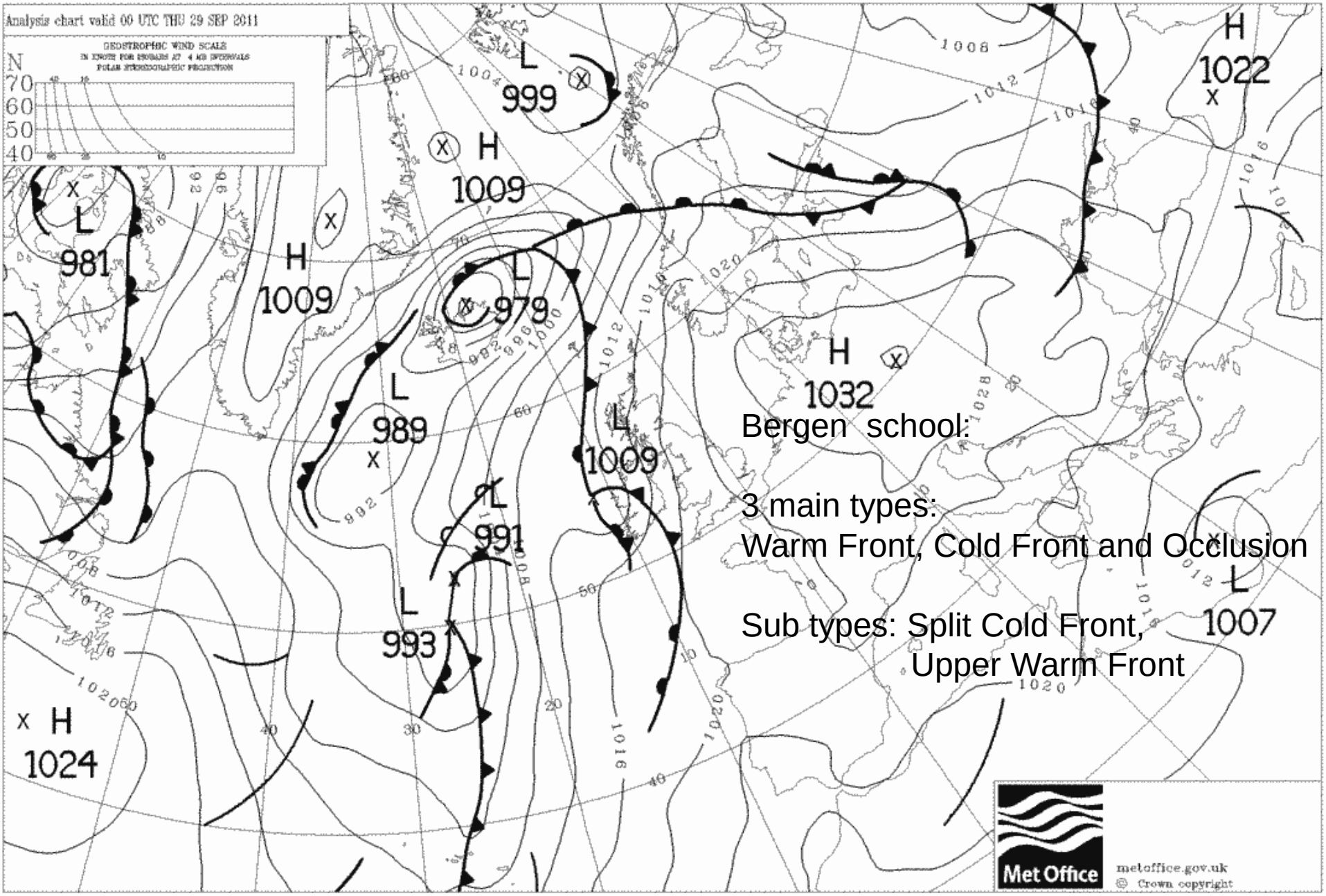
Conceptual Models
Cold Fronts and Warm Fronts



EUMeTrain

eumetcal


Analysis chart valid 00 UTC THU 29 SEP 2011
GEOSTROPHIC WIND SCALE
IN KNOTS FOR ISOBARS AT 4 MB INTERVALS
POLAR STEREOGRAPHIC PROJECTION
N
70
60
50
40
L
981
H
1009
L
999
H
1009
L
979
L
989
L
991
L
993
H
1032
H
1022
L
1009
L
1007
H
1024
Bergen school:
3 main types:
Warm Front, Cold Front and Occlusion
Sub types: Split Cold Front,
Upper Warm Front
Met Office
metoffice.gov.uk
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- COLD FRONT
  - Arctic Cold Front
  - Cold Front
  - Cold Front in Cold Advection
  - Cold Front in Warm Advection
  - Split Front
- WARM FRONT
  - Detached Warm Front
  - Warm Front Band
  - Warm Front Shield
- OCCLUSION
  - Back-Bent Occlusion
  - Cold Air Development
  - Instant Occlusion
  - Occlusion: Cold Conveyor Belt Type
  - Occlusion: Warm Conveyor Belt Type

Ana
Kata

In SatManu:

13 types of fronts

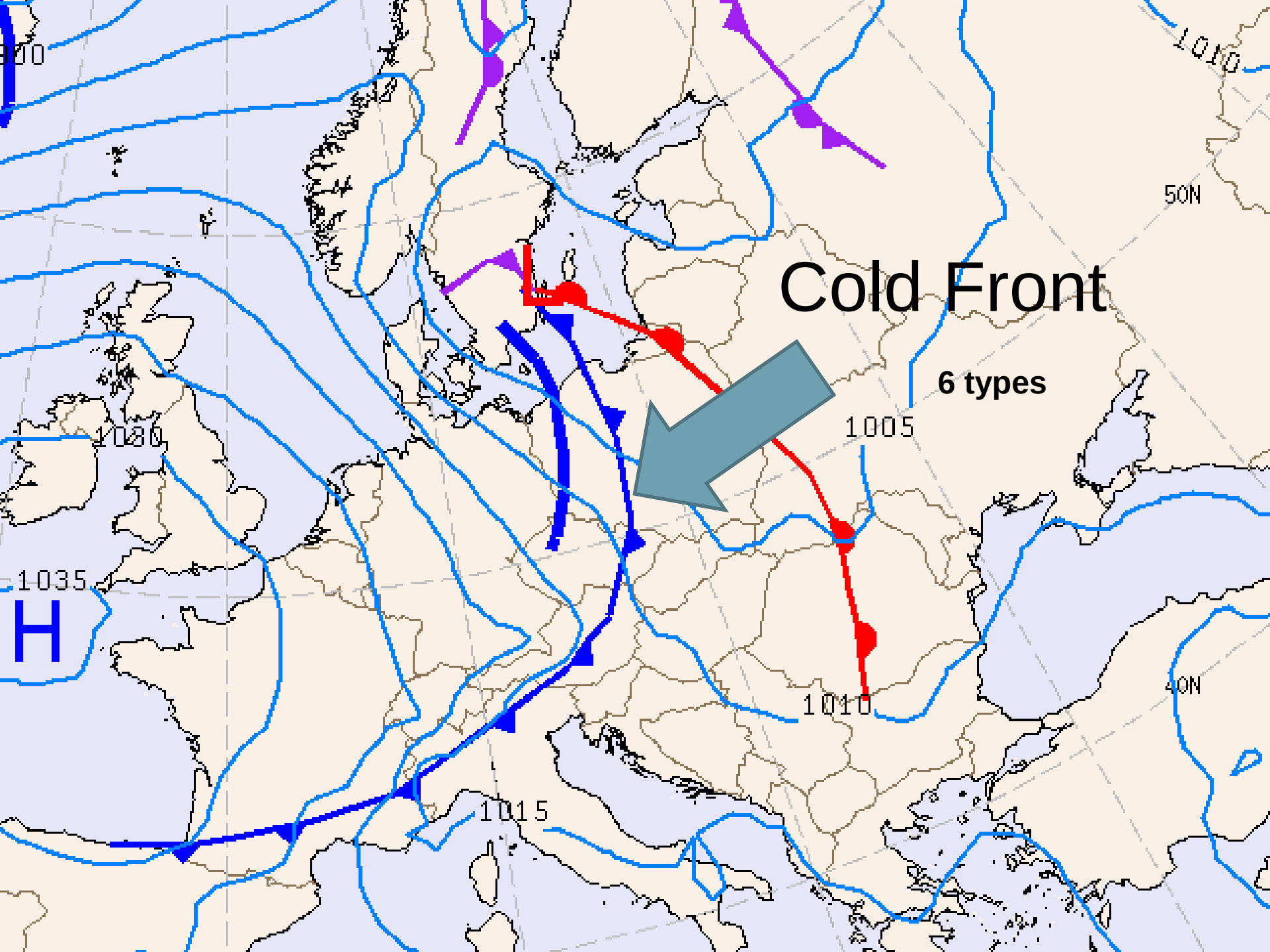
- COLD FRONT
  - Arctic Cold Front
  - Cold Front
  - Cold Front in Cold Advection
  - Cold Front in Warm Advection
  - Split Front
- WARM FRONT
  - Detached Warm Front
  - Warm Front Band
  - Warm Front Shield
- OCCLUSION
  - Back-Bent Occlusion
  - Cold Air Development
  - Instant Occlusion
  - Occlusion: Cold Conveyor Belt Type
  - Occlusion: Warm Conveyor Belt Type

13 types of fronts

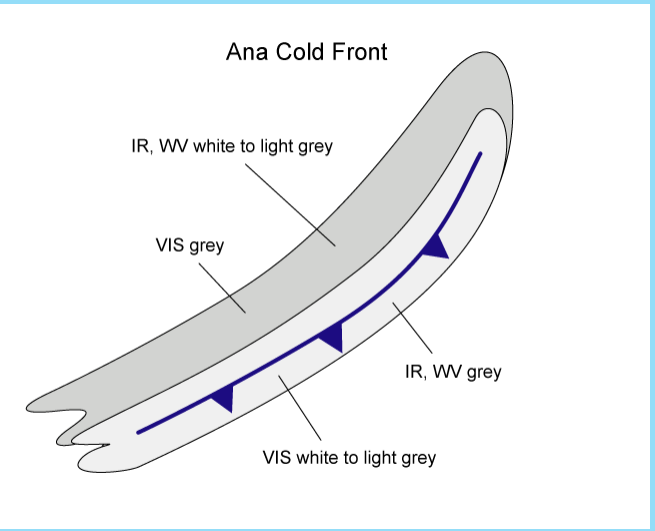
5(or 6) types of CF's
3 types of WF's

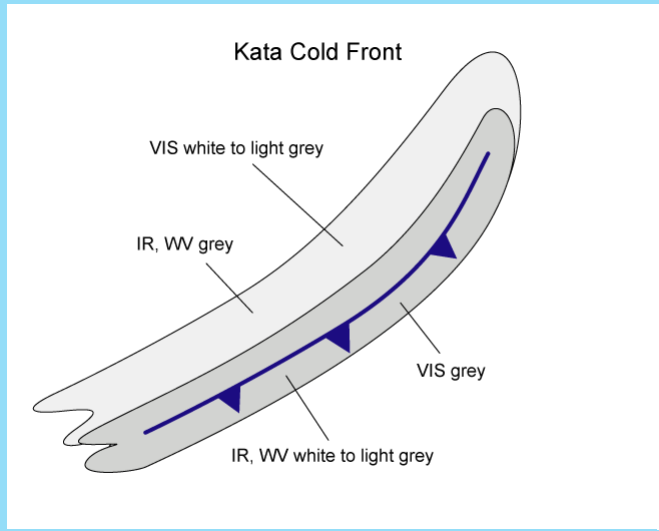
Five chapters

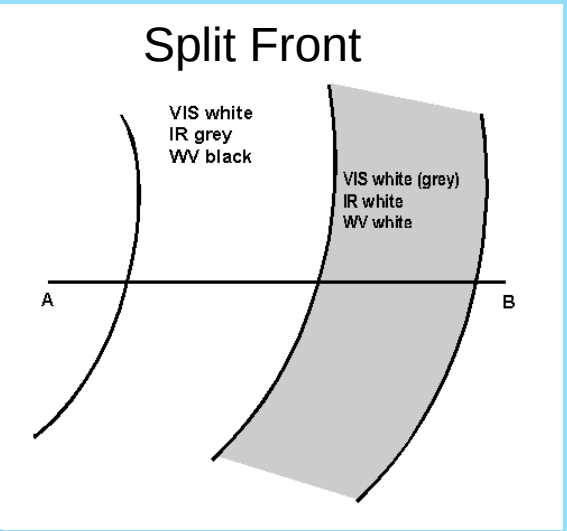
- Cloud Structure In Satellite Images
- Meteorological Physical Background
- Key Parameters
- Typical Appearance In Vertical Cross Sections
- Weather Events


Cold Front
6 types
1005
1010
1035
1030
1015
50N
40N

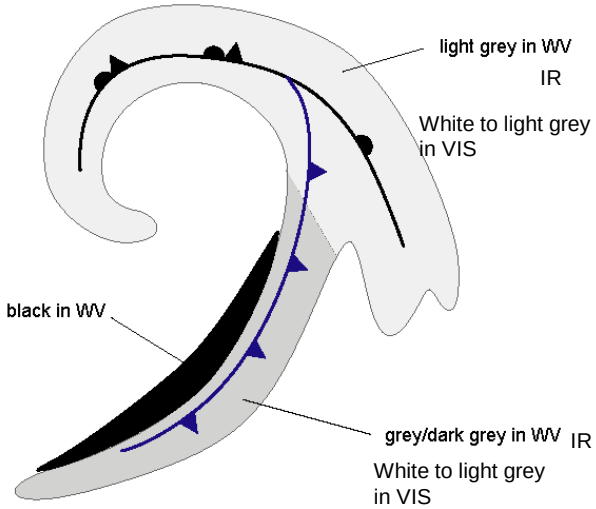
Cold Front: Cloud Structure In Satellite Images



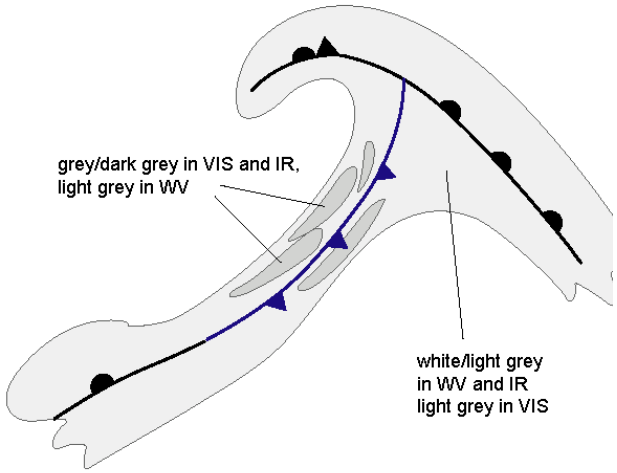




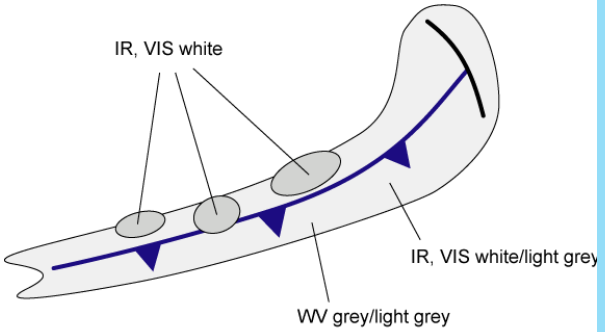
CF in CA



CF in WA

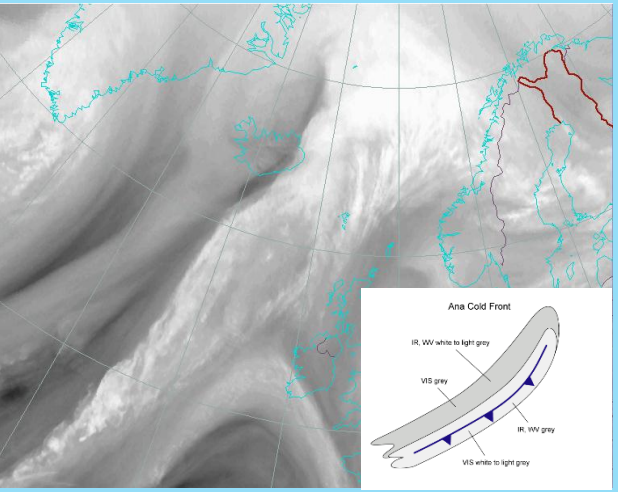


Arctic CF

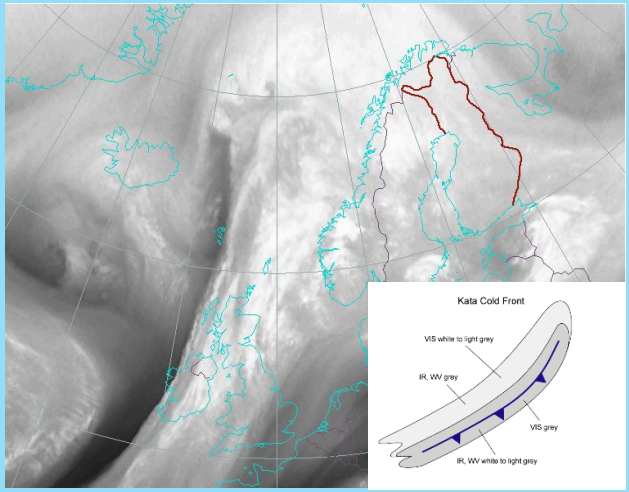


Cold Front: Cloud Structure In Satellite Images (WV)

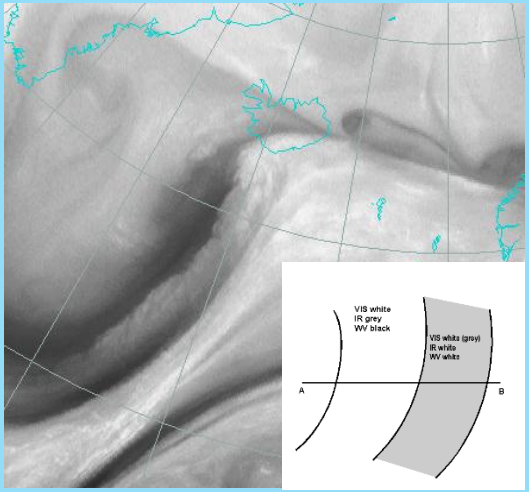
Ana CF



Kata CF



Split CF



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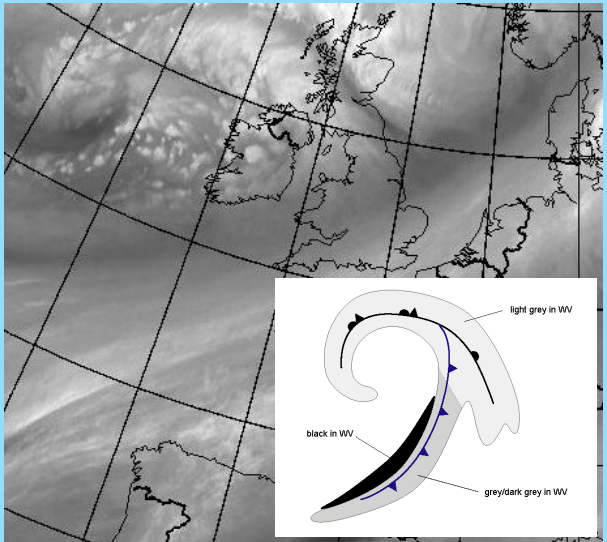
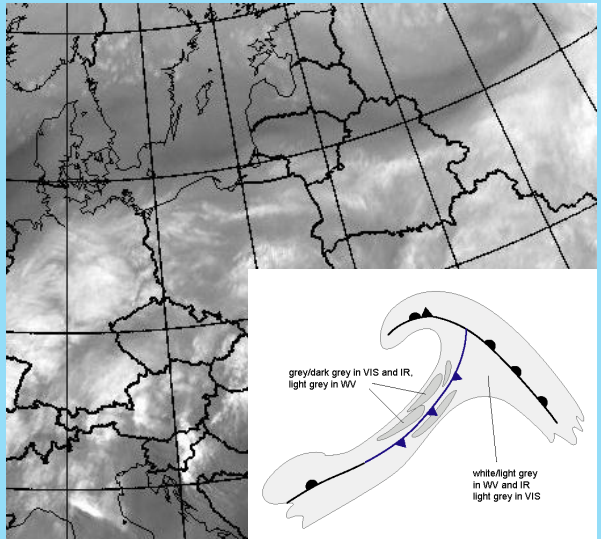
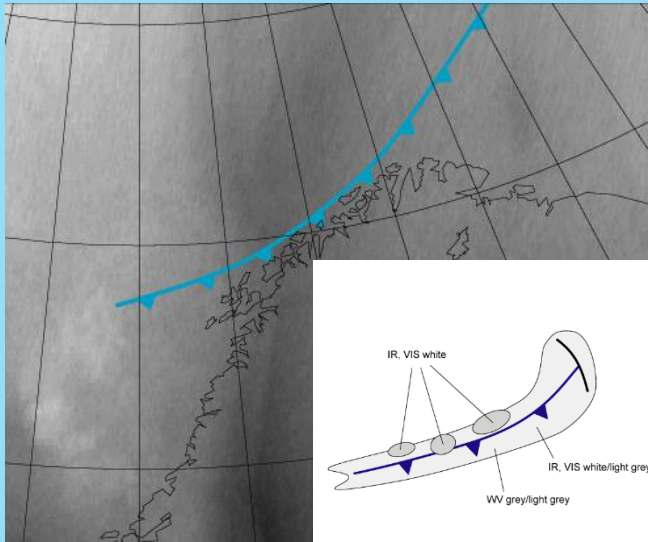


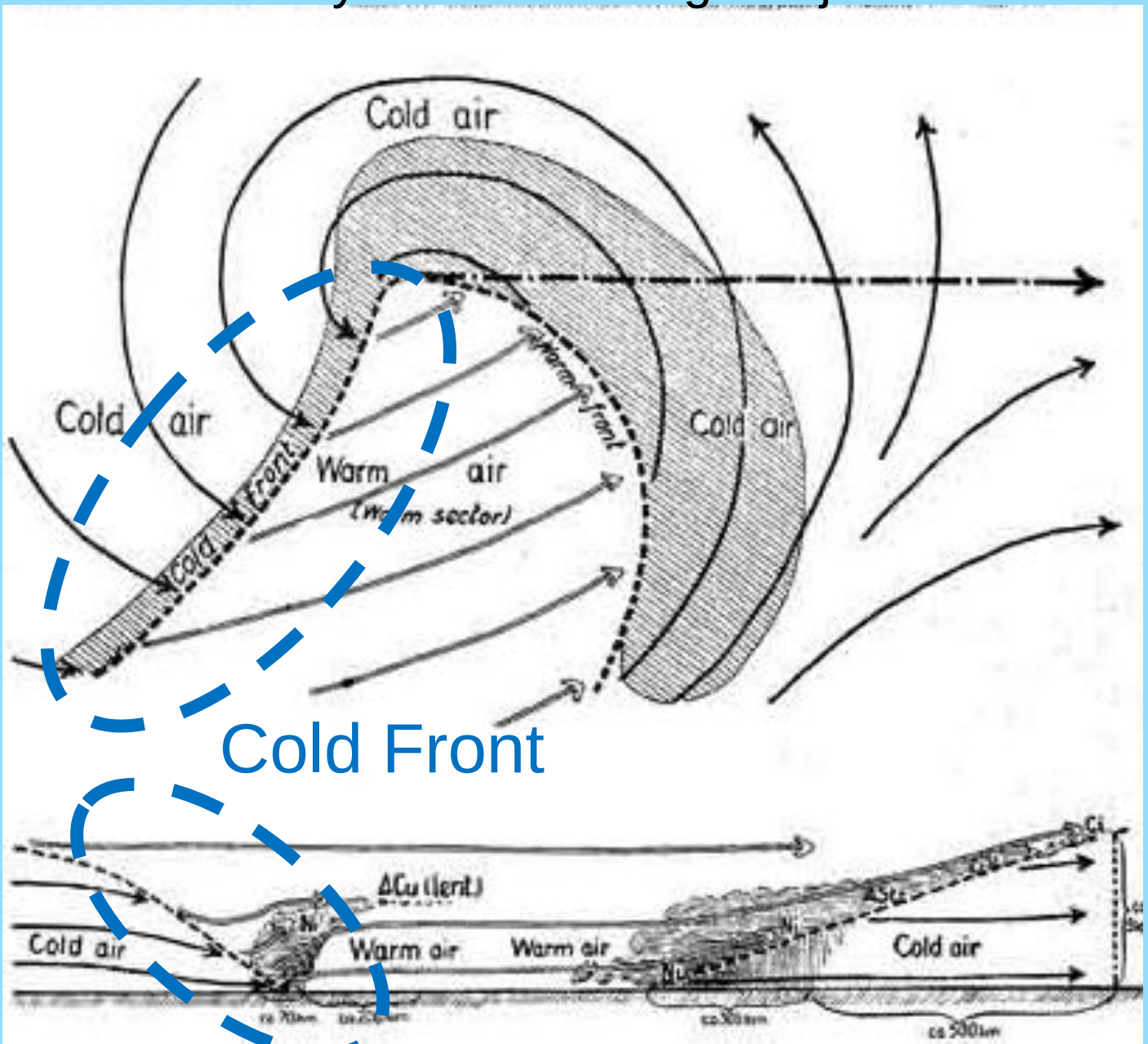
CF in WA



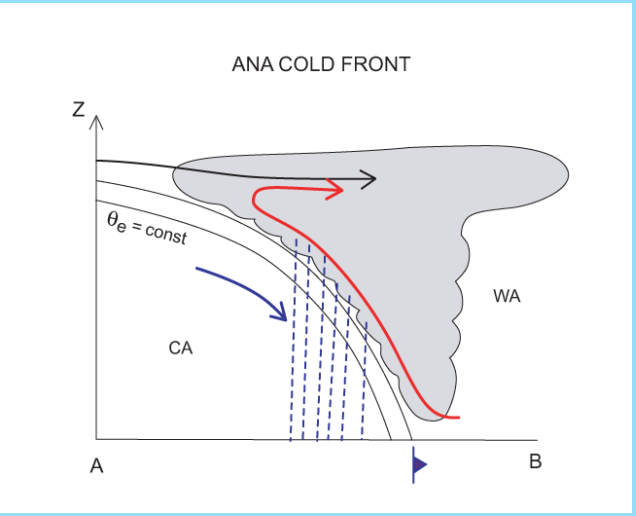
Arctic CF

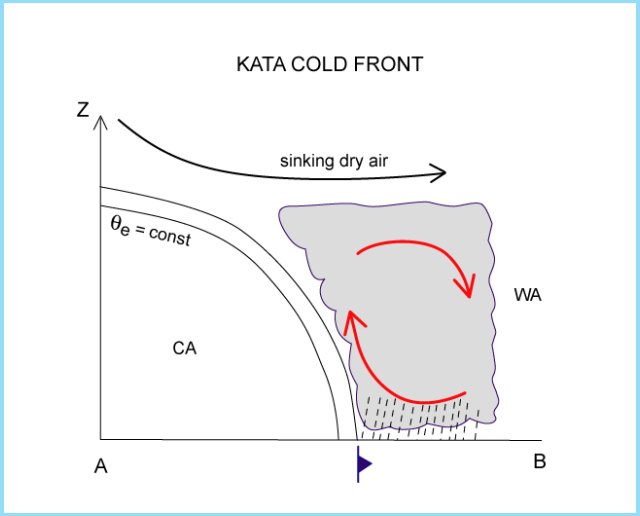


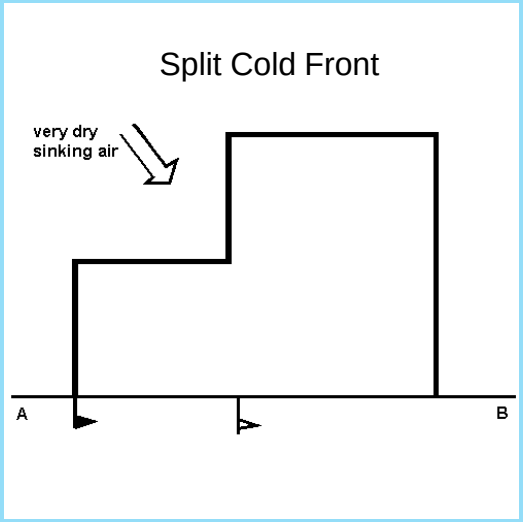
Physical background
Frontal system according to Bjerknes

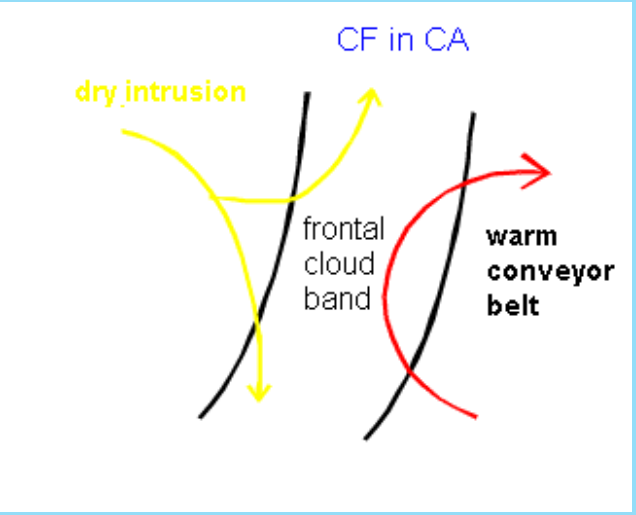


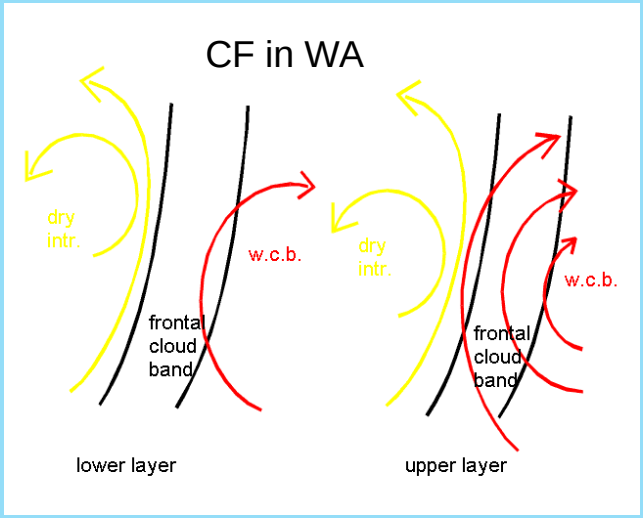
Cold Front: Meteorological Physical Background

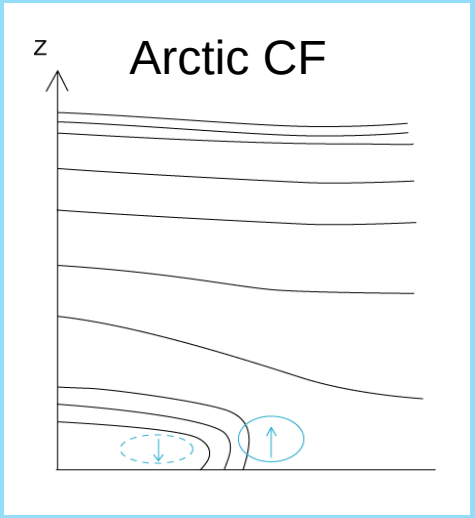






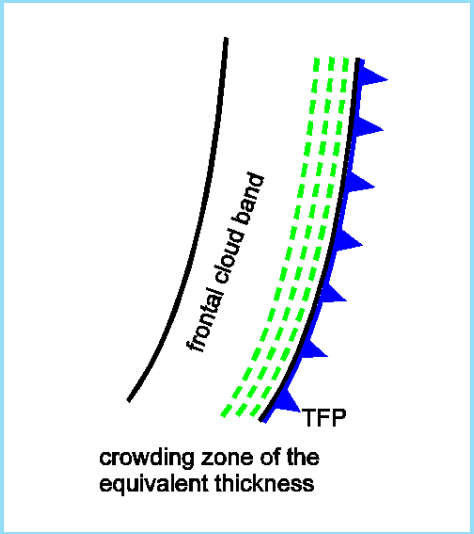


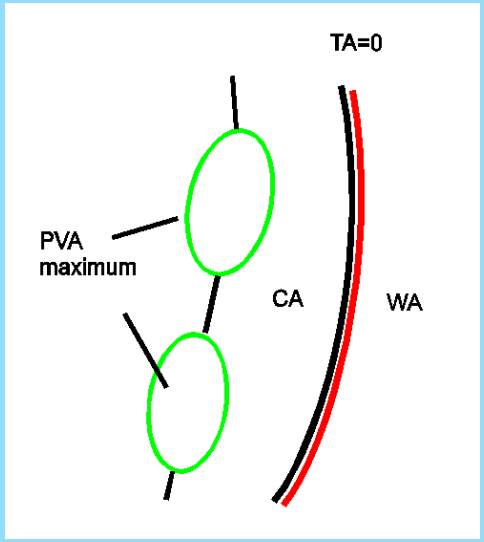


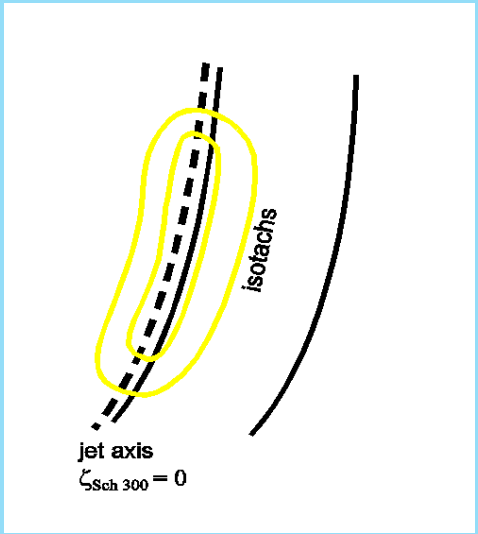


Cold Front: Key Parameters

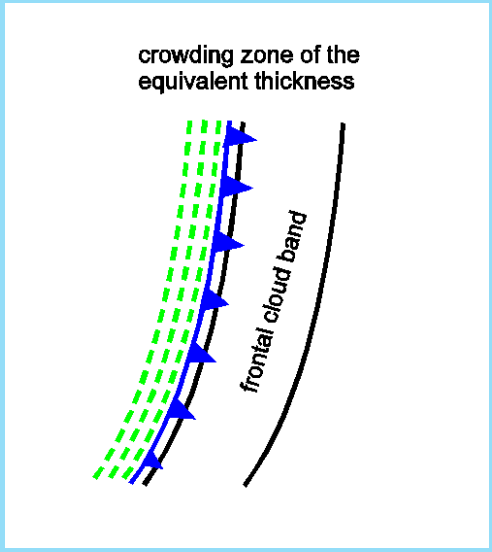
Ana Front

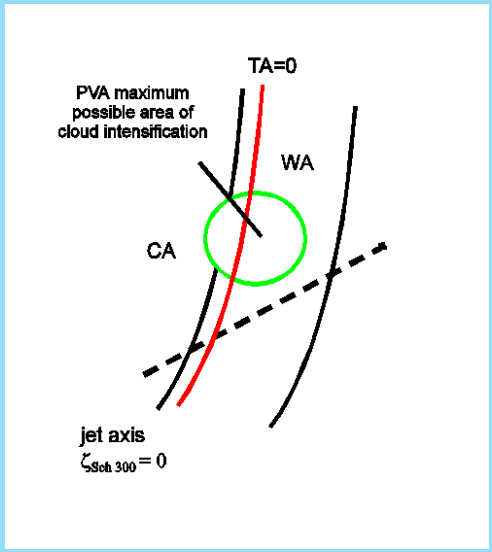


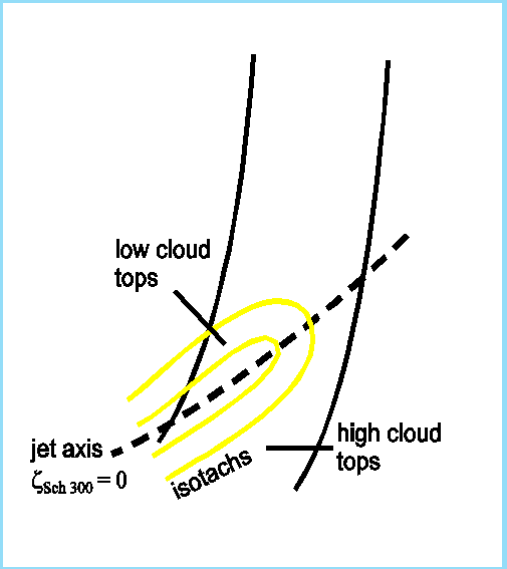




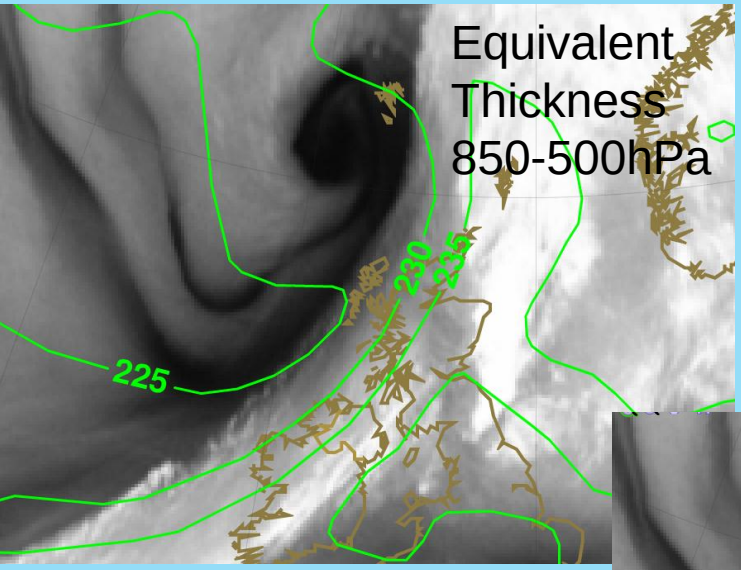
Kata Front

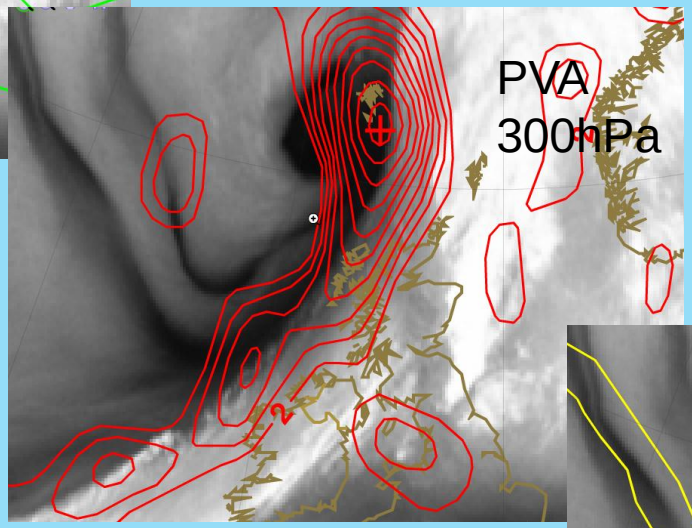


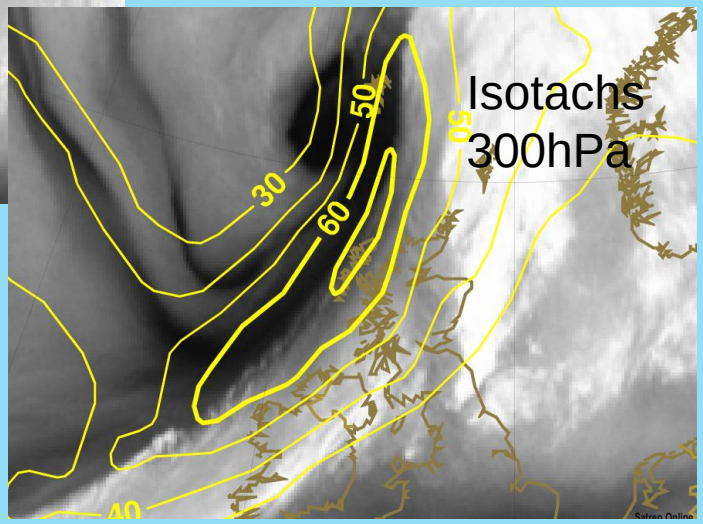




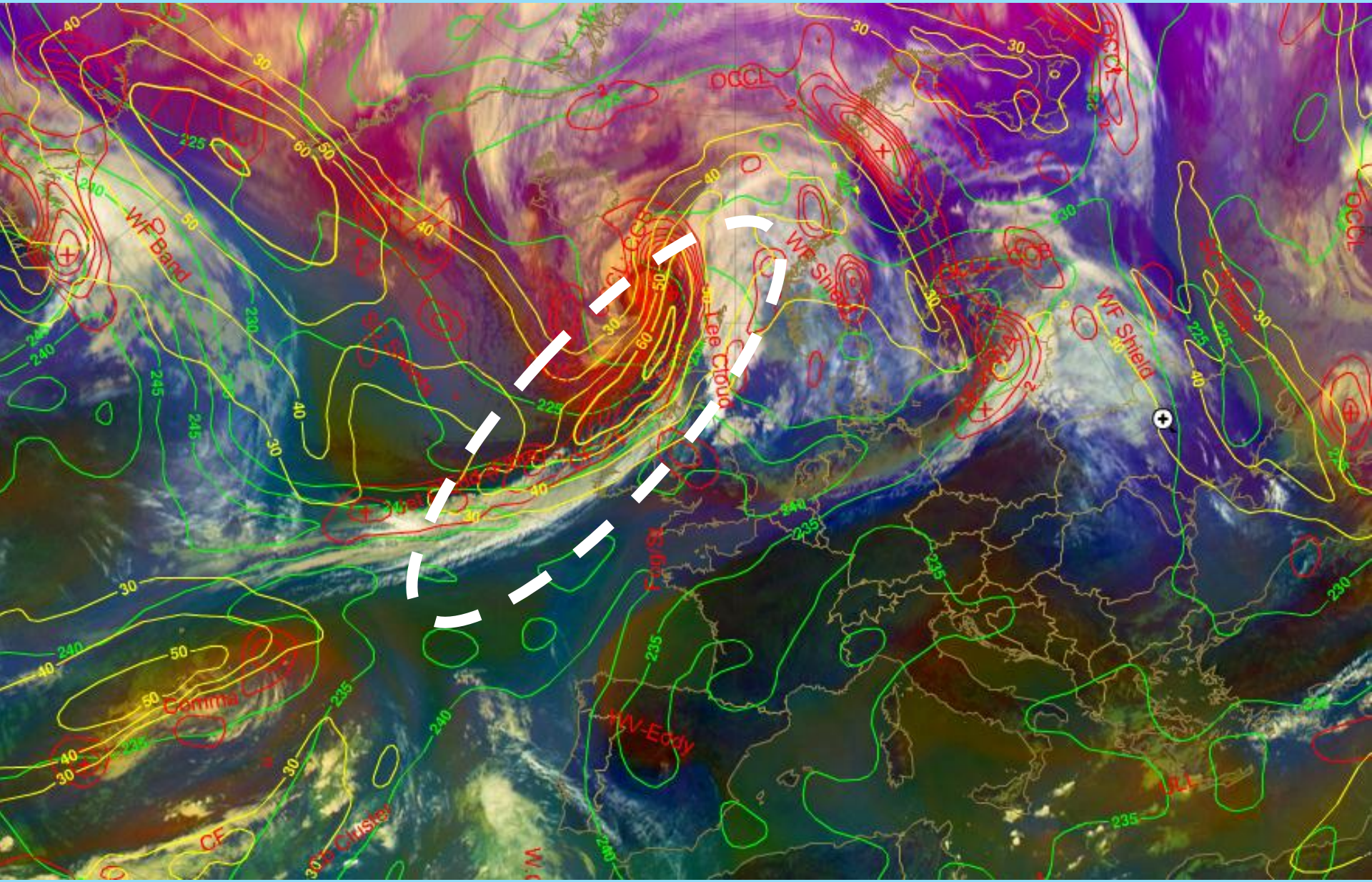
Ana Cold Front 3 October 2011 12 UTC





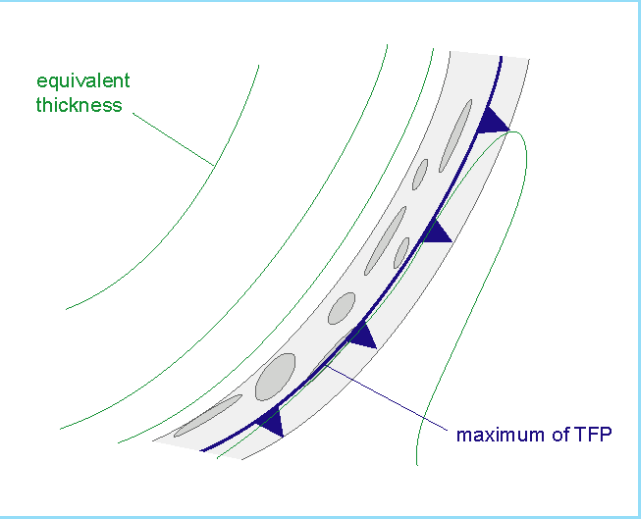


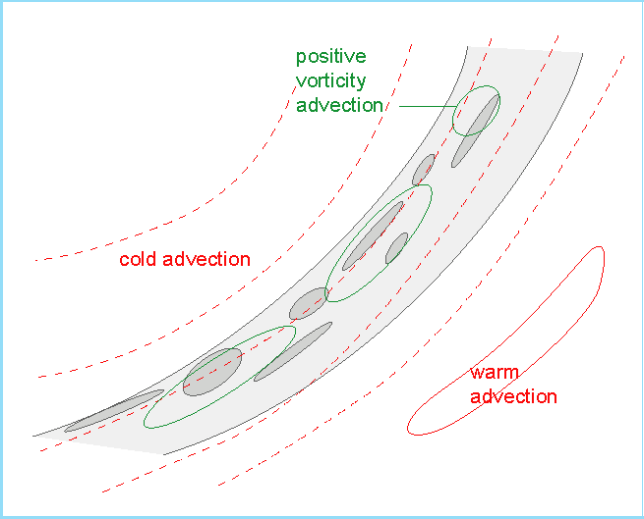
Ana Cold Front 3 October 2011 12 UTC Airmass RGB

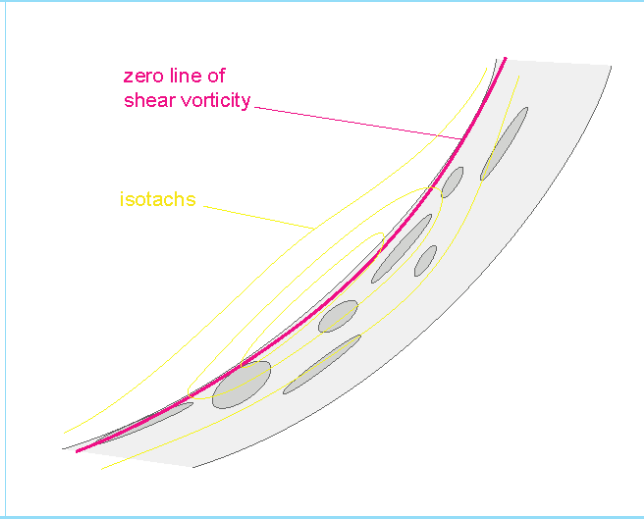


Cold Front: Key Parameters

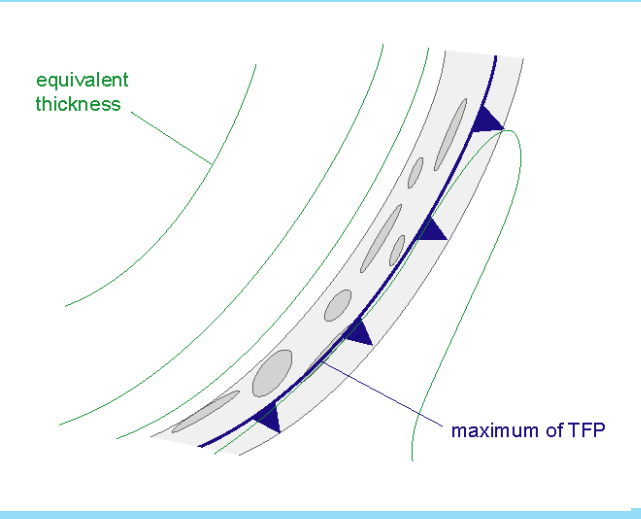
CF in CA

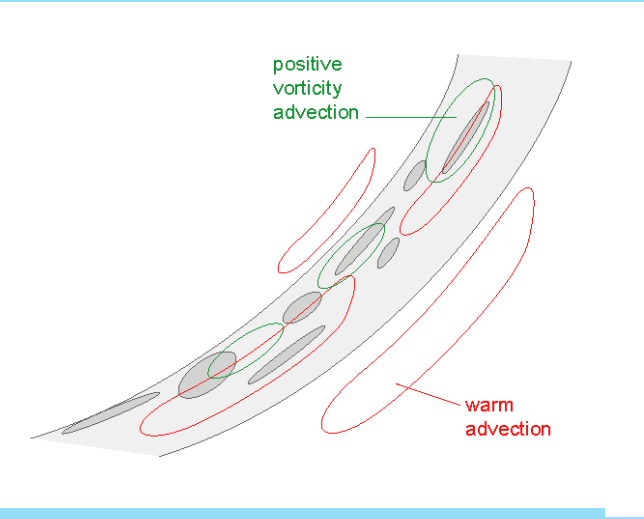


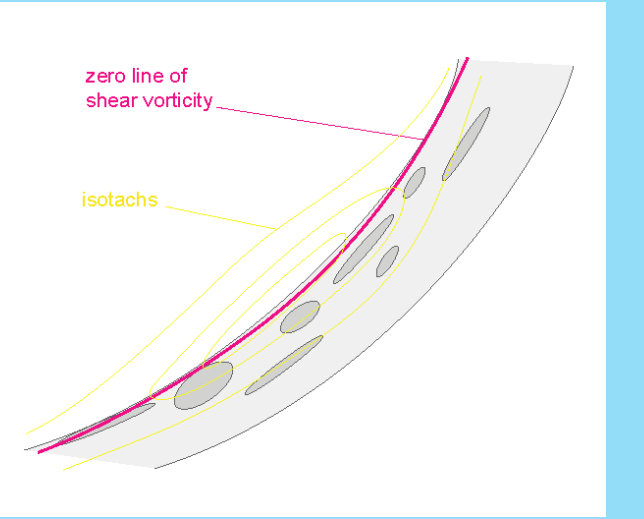




CF in WA

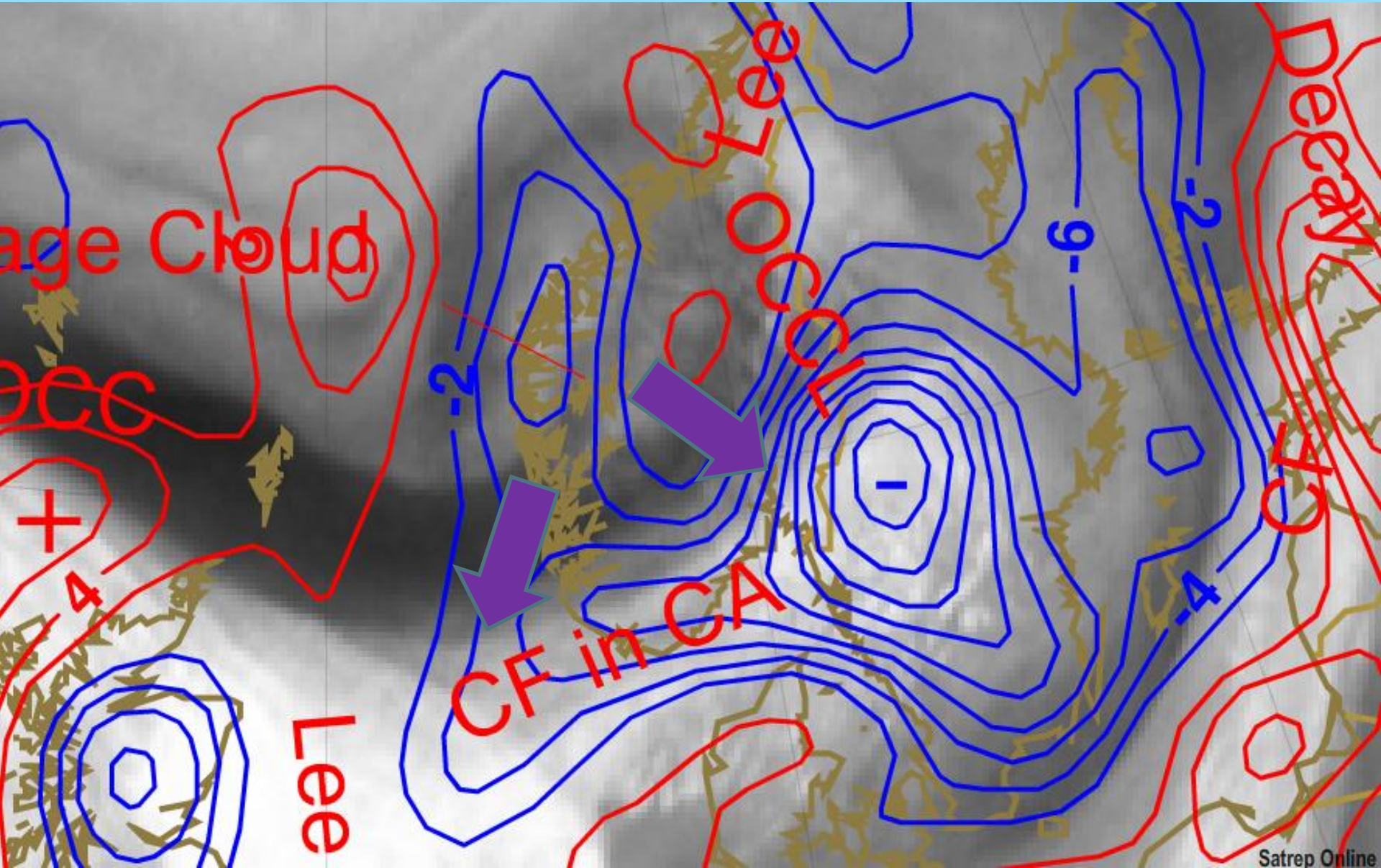




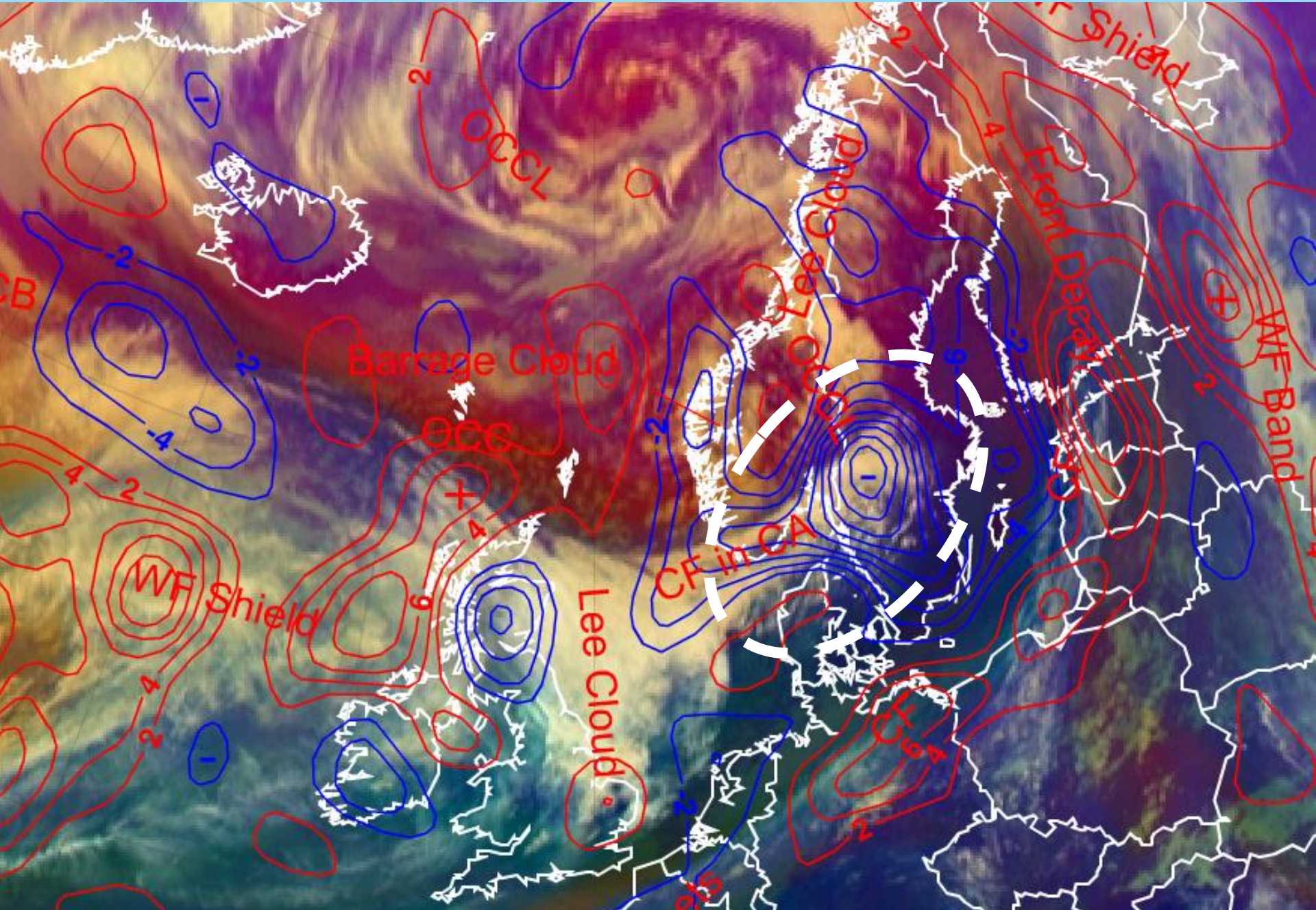


CF in CA: 4 October 2011 12 UTC

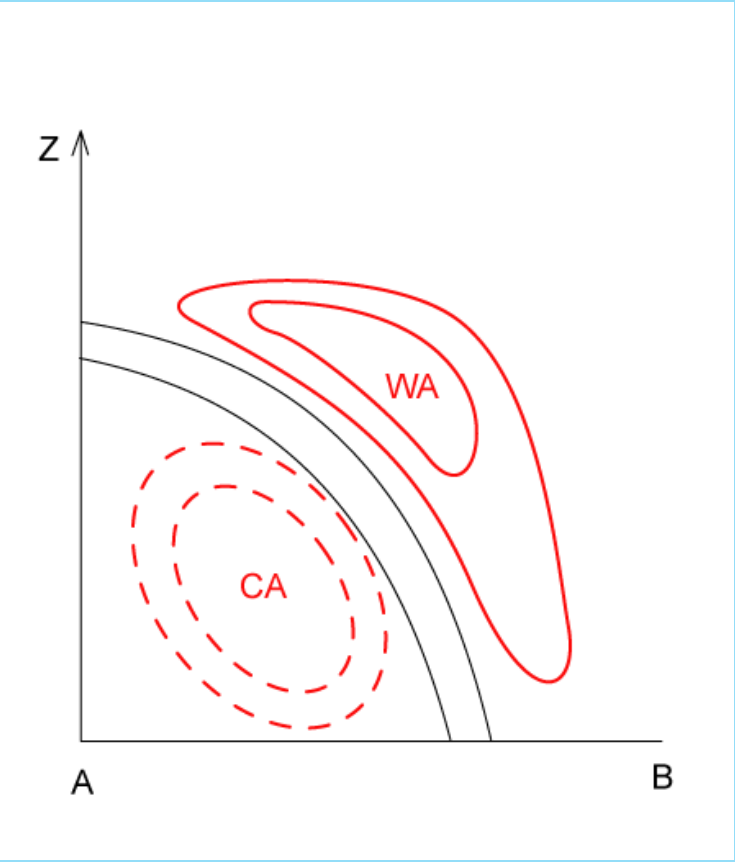
Temperature advection 700hPa

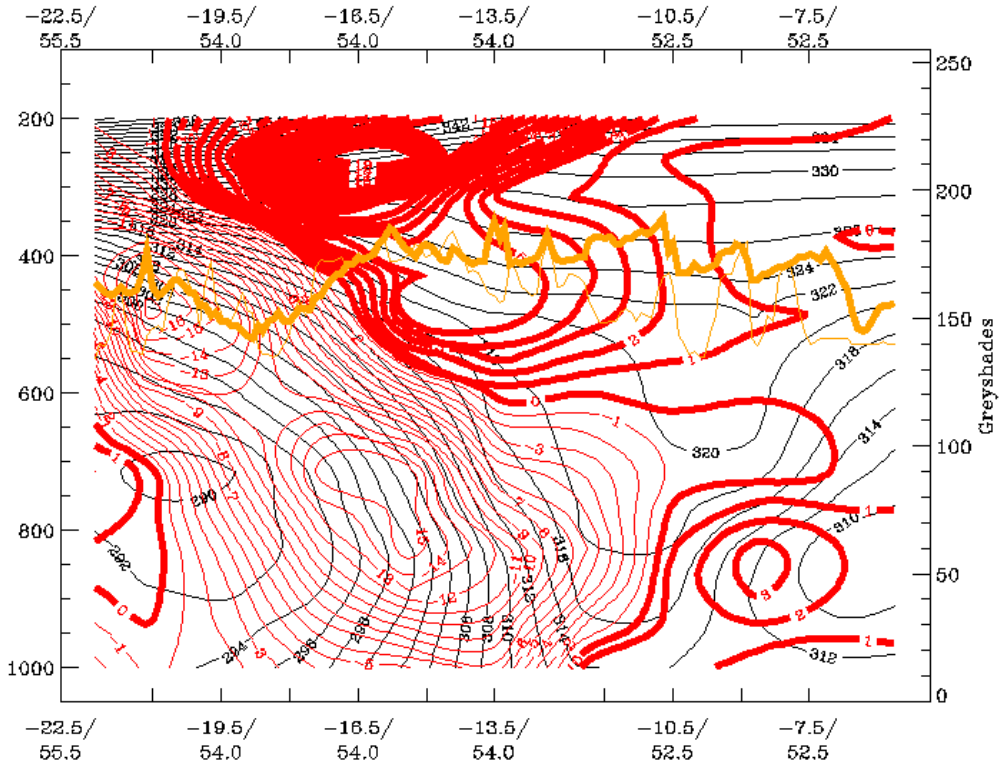


CF in CA: 4 October 2011 12 UTC Airmass RGB



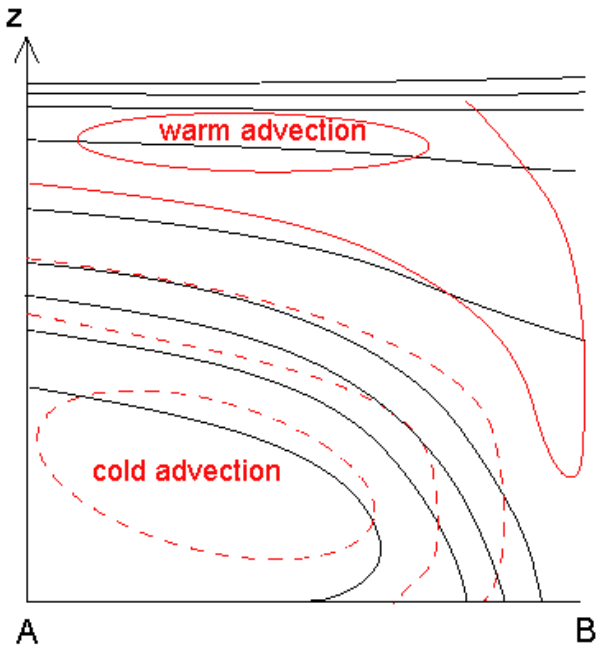
Vertical Cross Section
CF and TA

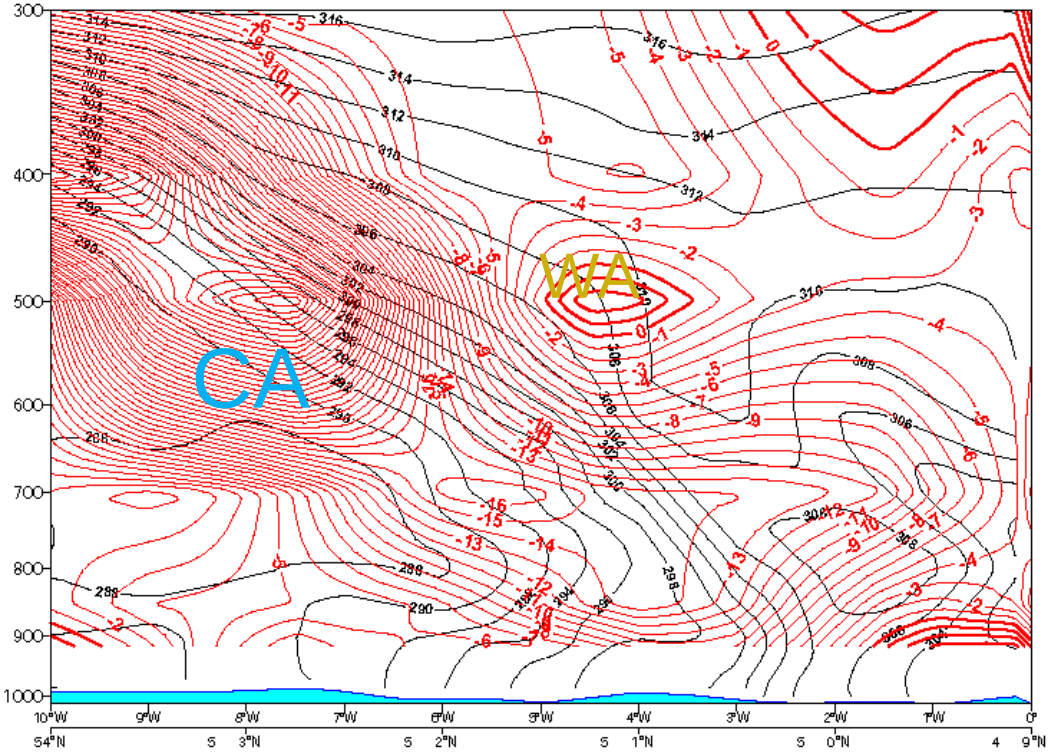




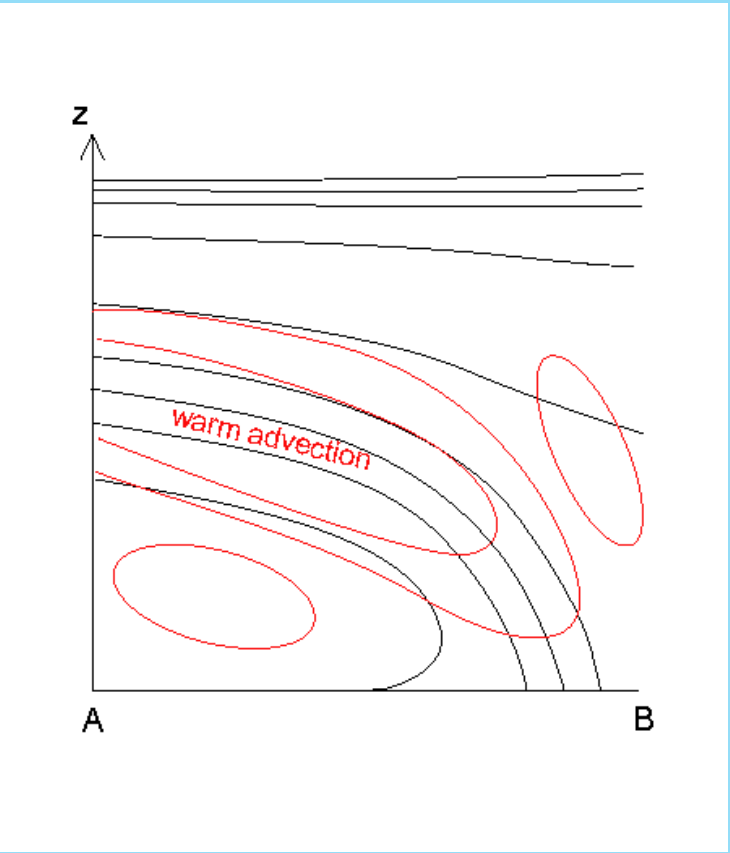
Vertical Cross Section

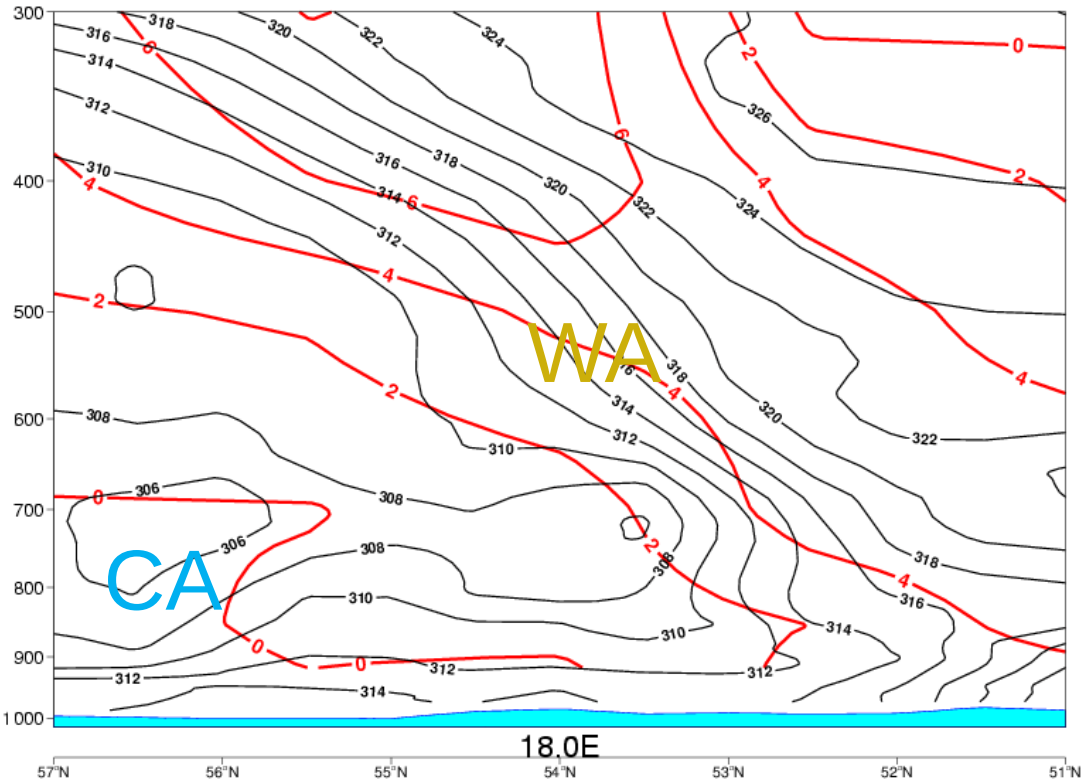
TA CF in CA



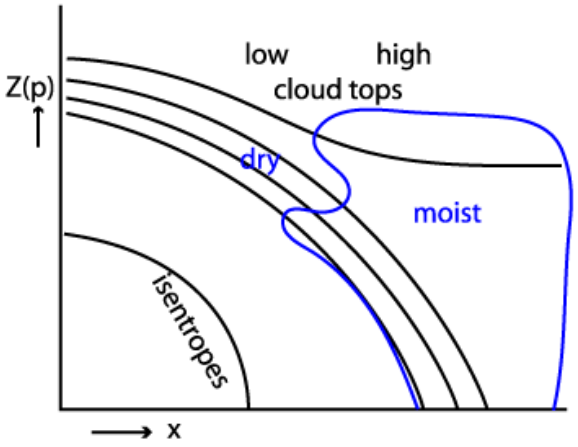


Vertical Cross Section
TA CF in WA

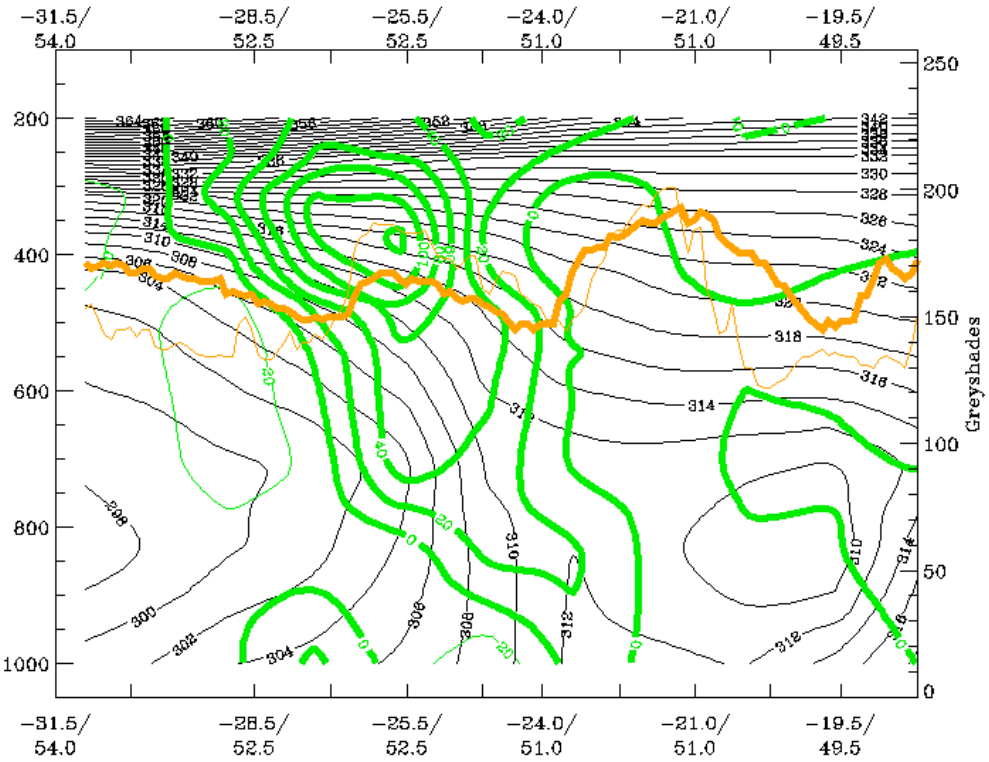




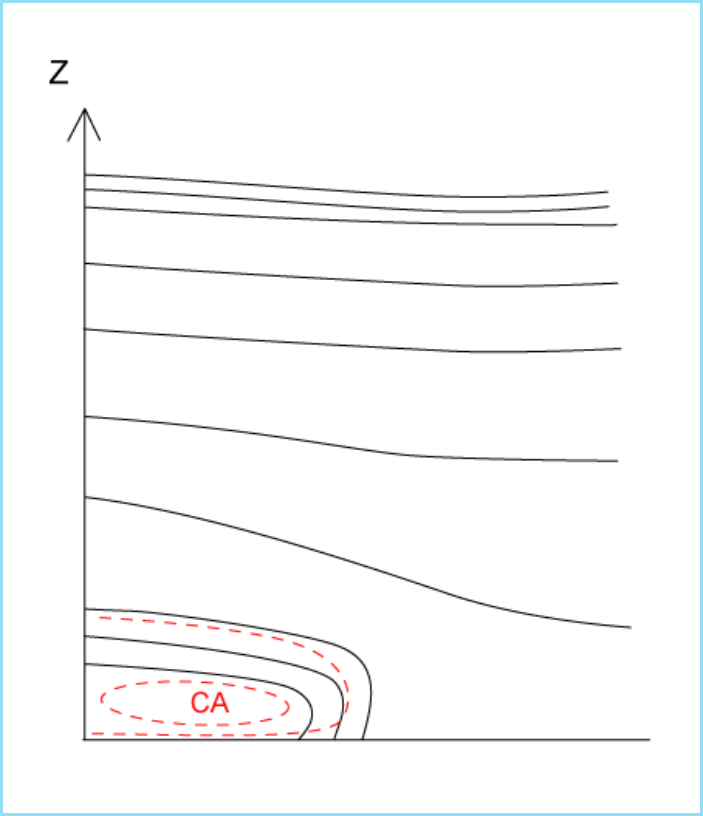
Vertical Cross Section
Moist distribution Split Front

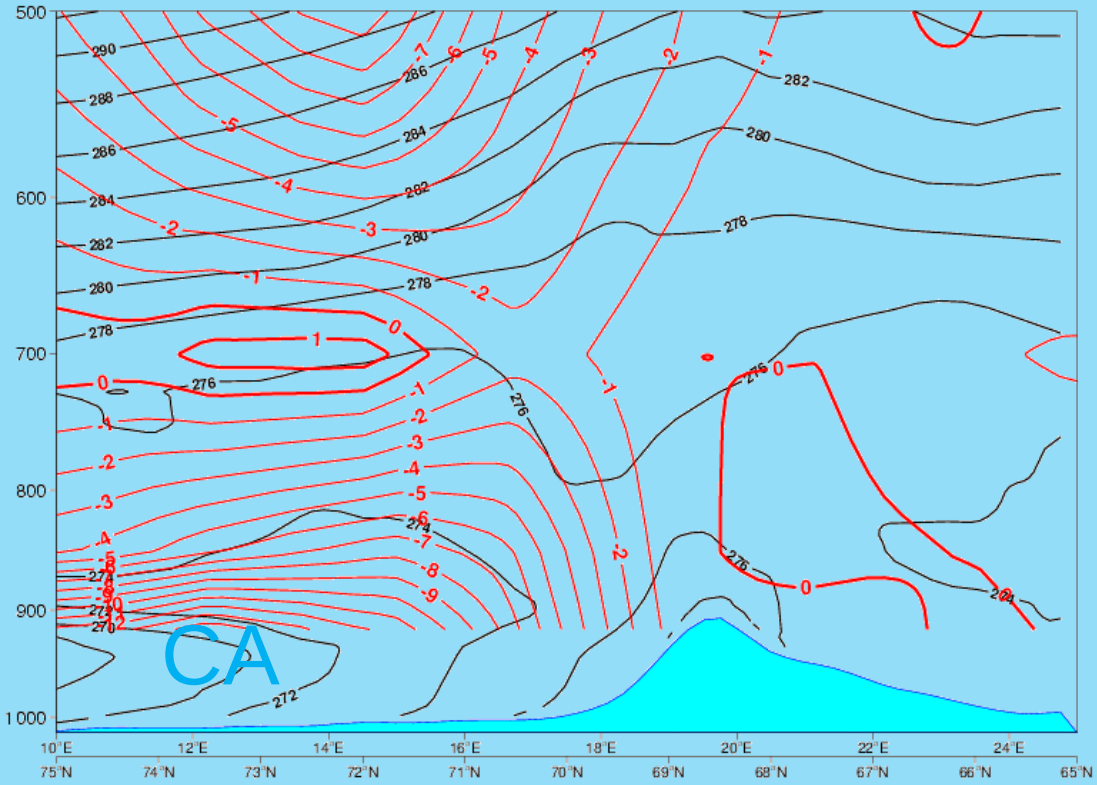


dry air in upper levels within and above frontal zone



Vertical Cross Section
TA in Artic Front



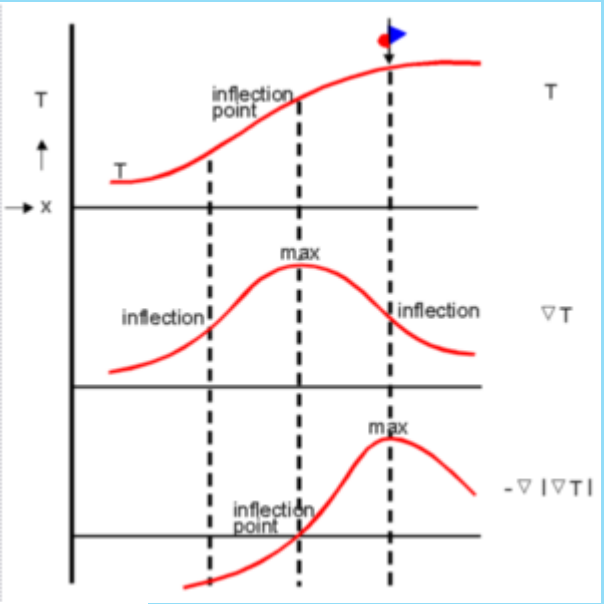


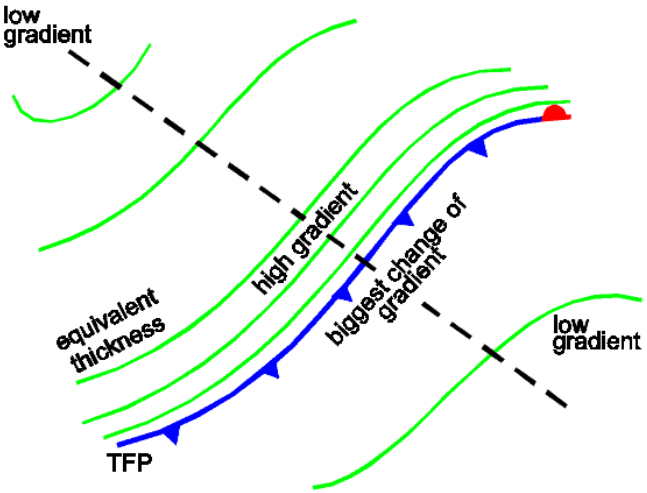
Thermal Front Parameter

$$TFP = -\nabla |\nabla T| \cdot \frac{\nabla T}{|\nabla T|}$$

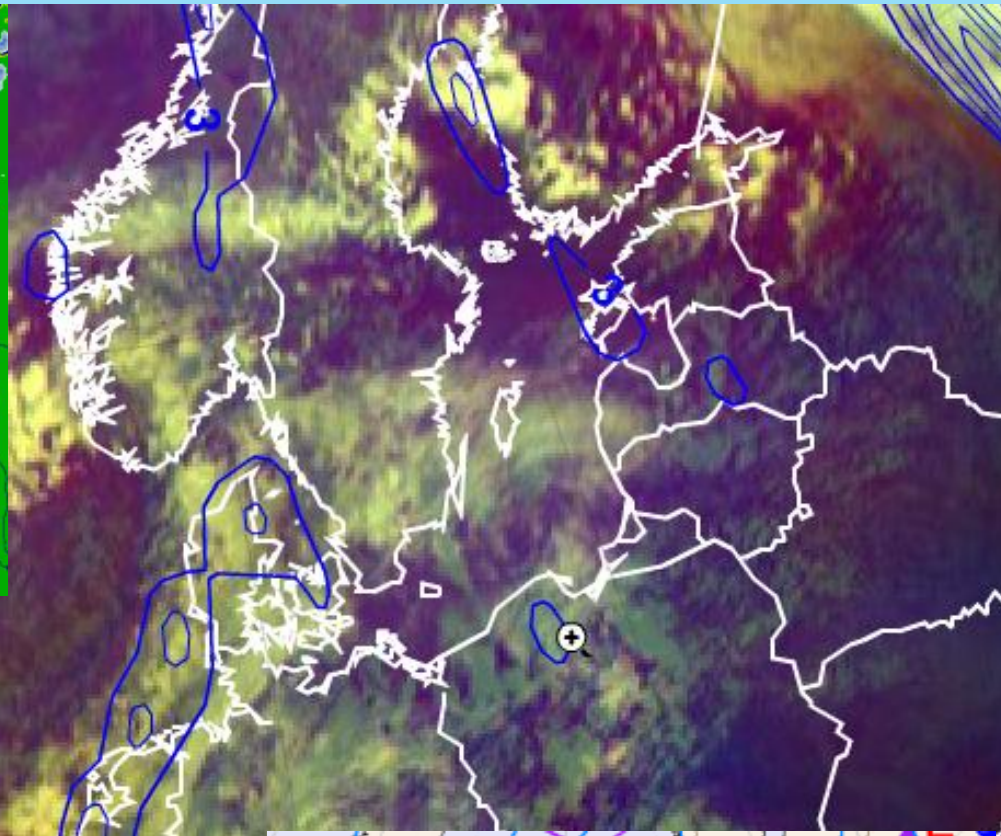
- $|\nabla T|$: temperature gradient
- $\frac{\nabla T}{|\nabla T|}$: projection in direction of the temperature gradient
- $-\nabla$: change of the temperature gradient

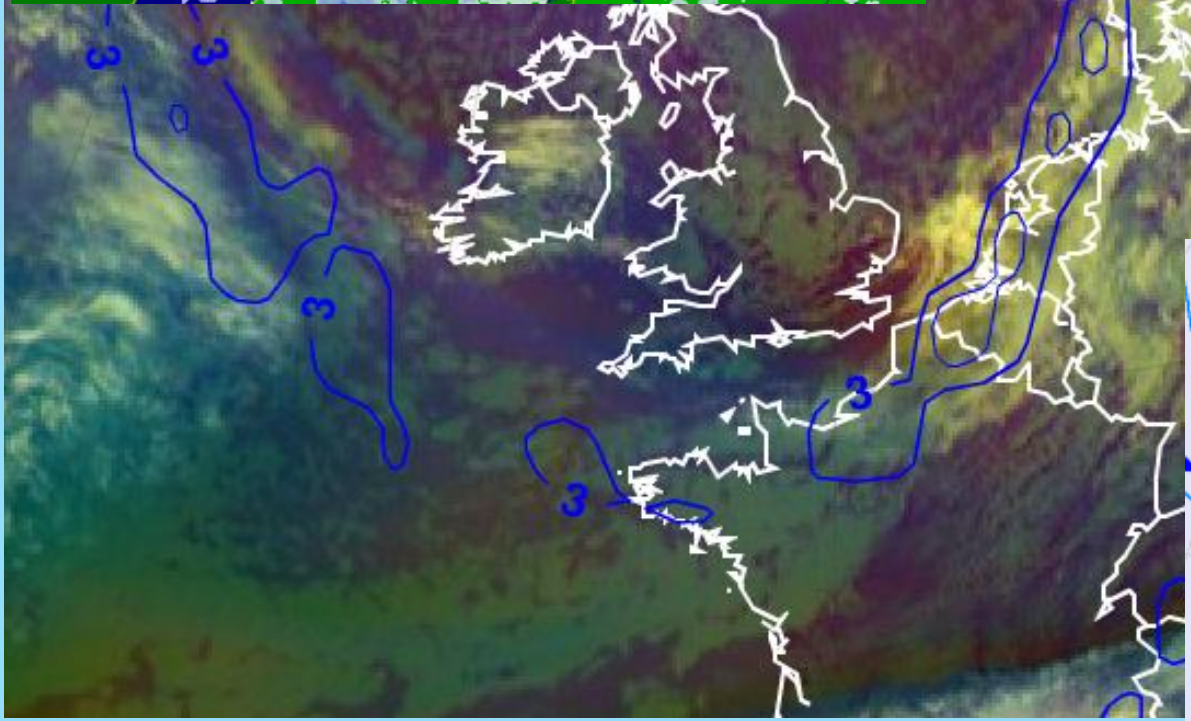
TFP thermal front parameter
T temperature

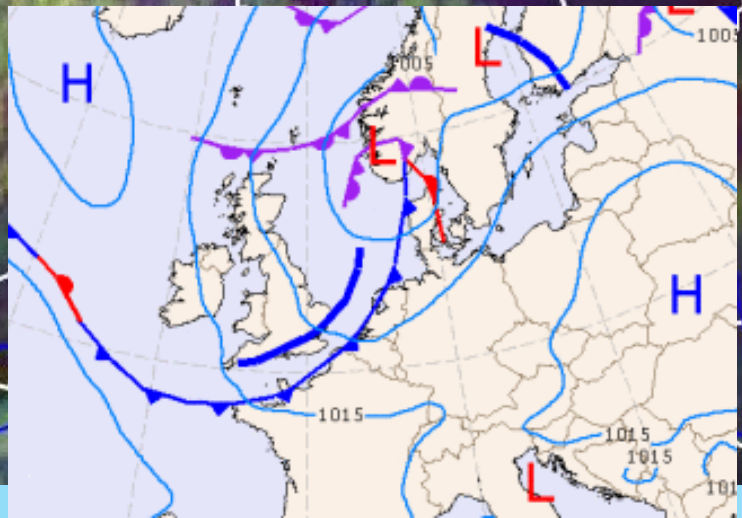


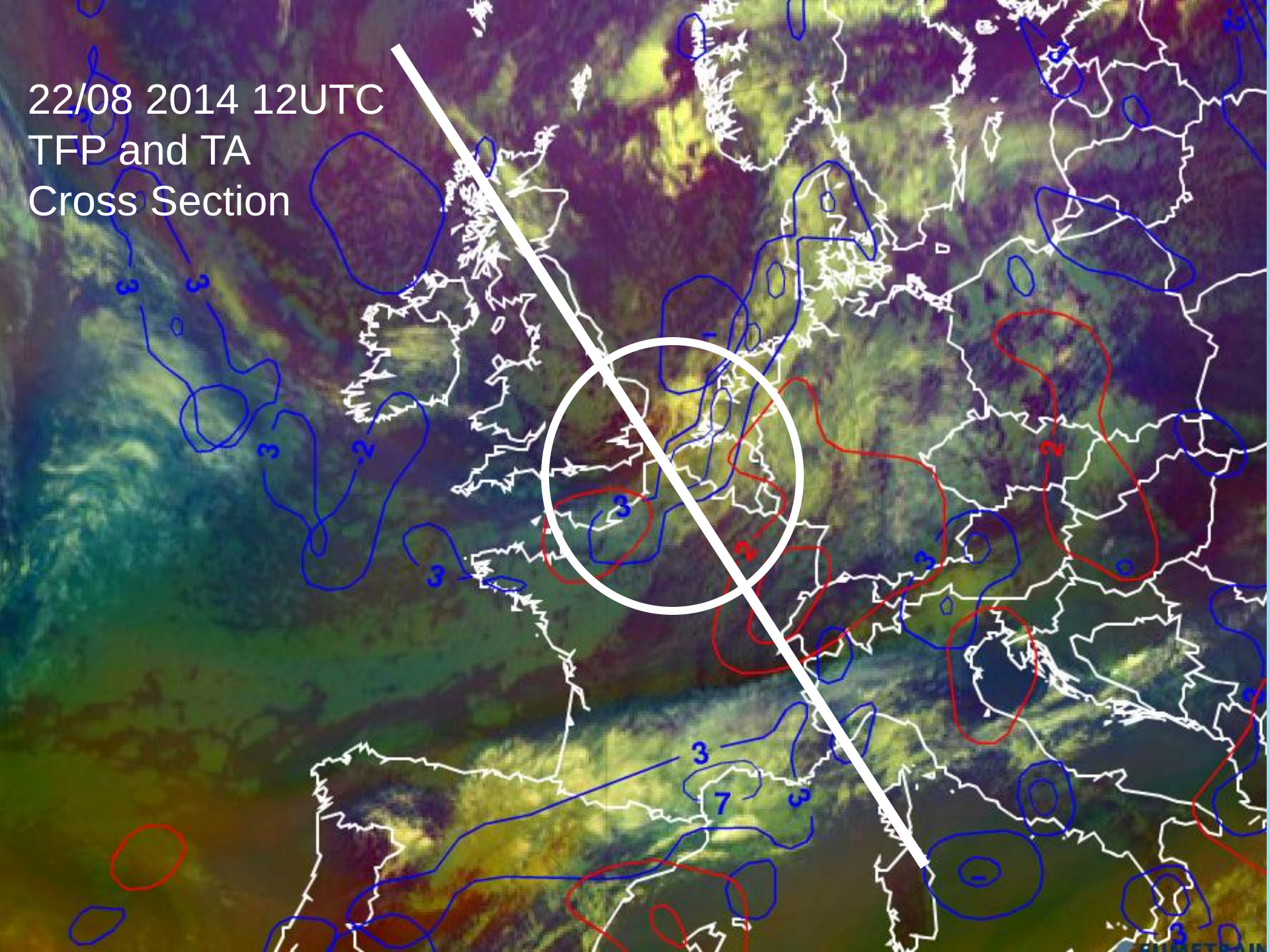


TFP 22/08 2014 12UTC

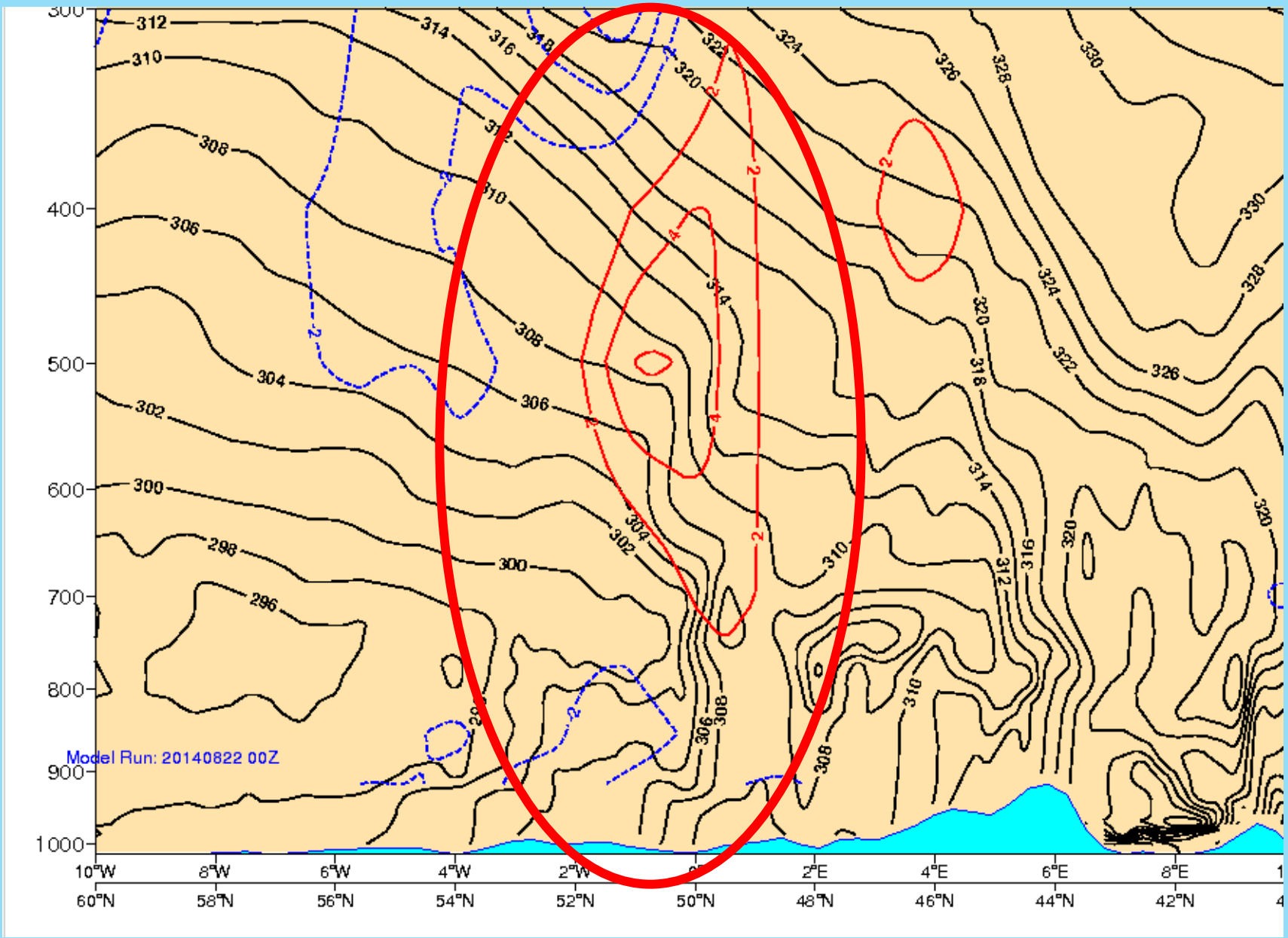




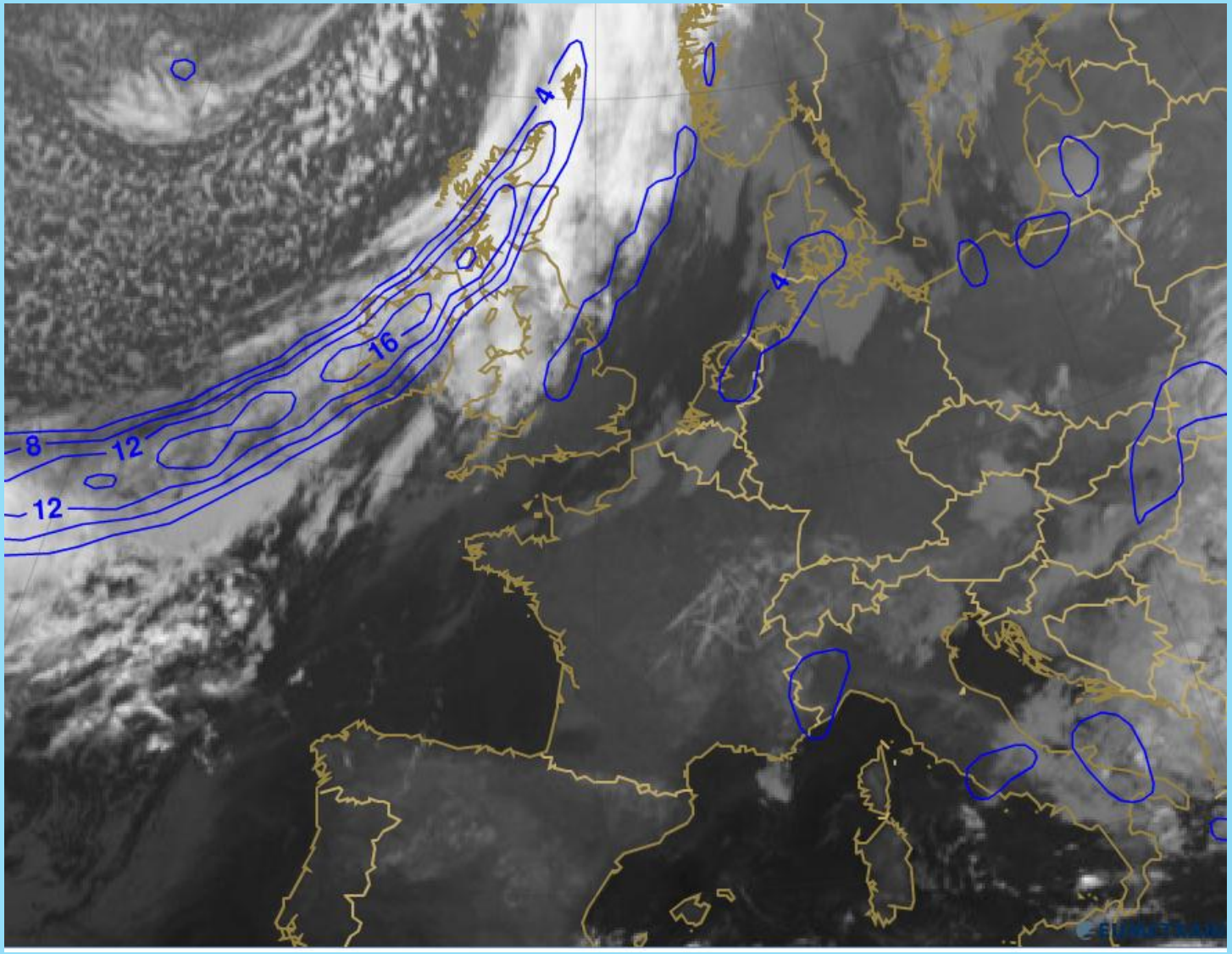



22/08 2014 12UTC
TFP and TA
Cross Section

TA 22/08 2014 12UTC



03 – 10 06 UTC IR +TFP



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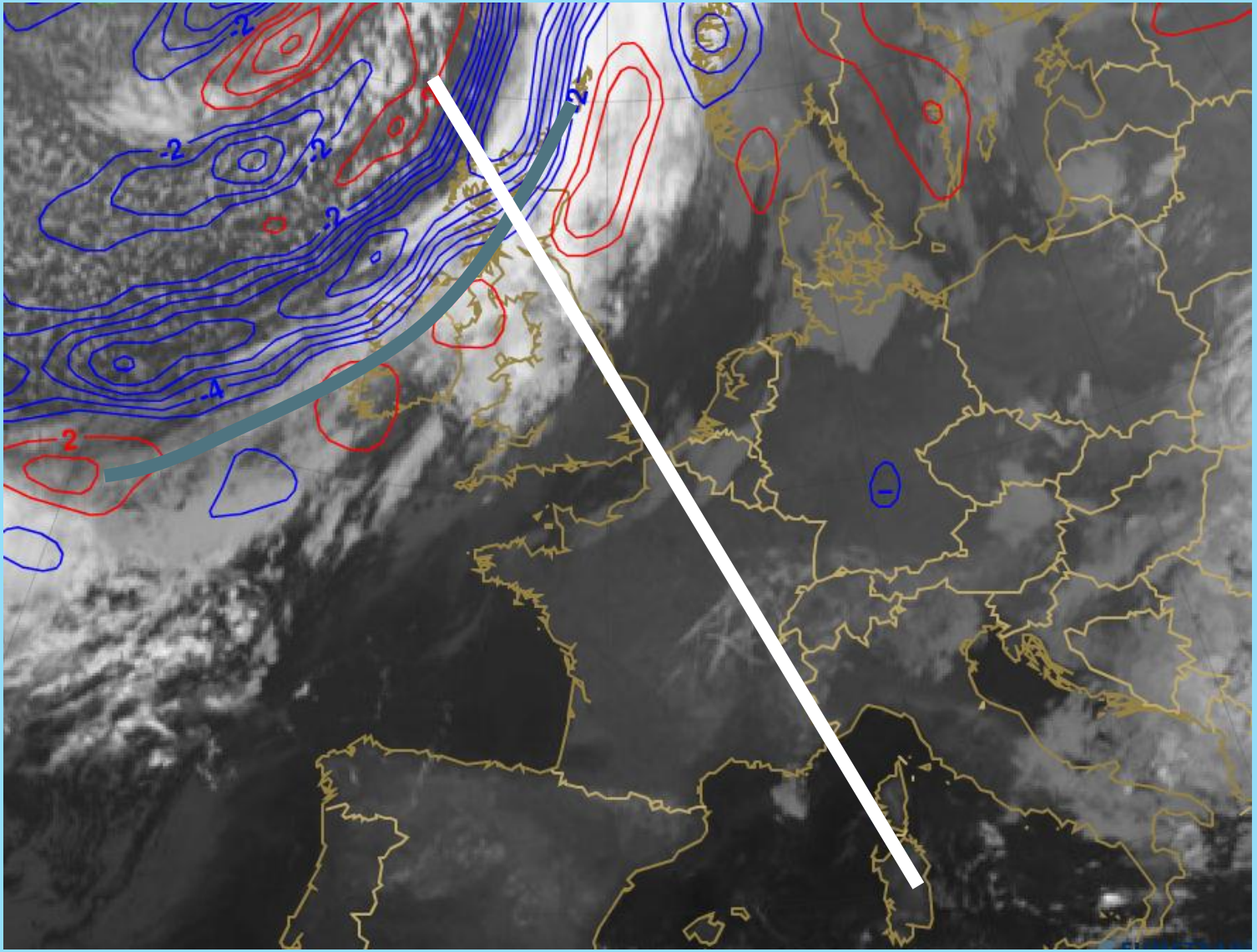

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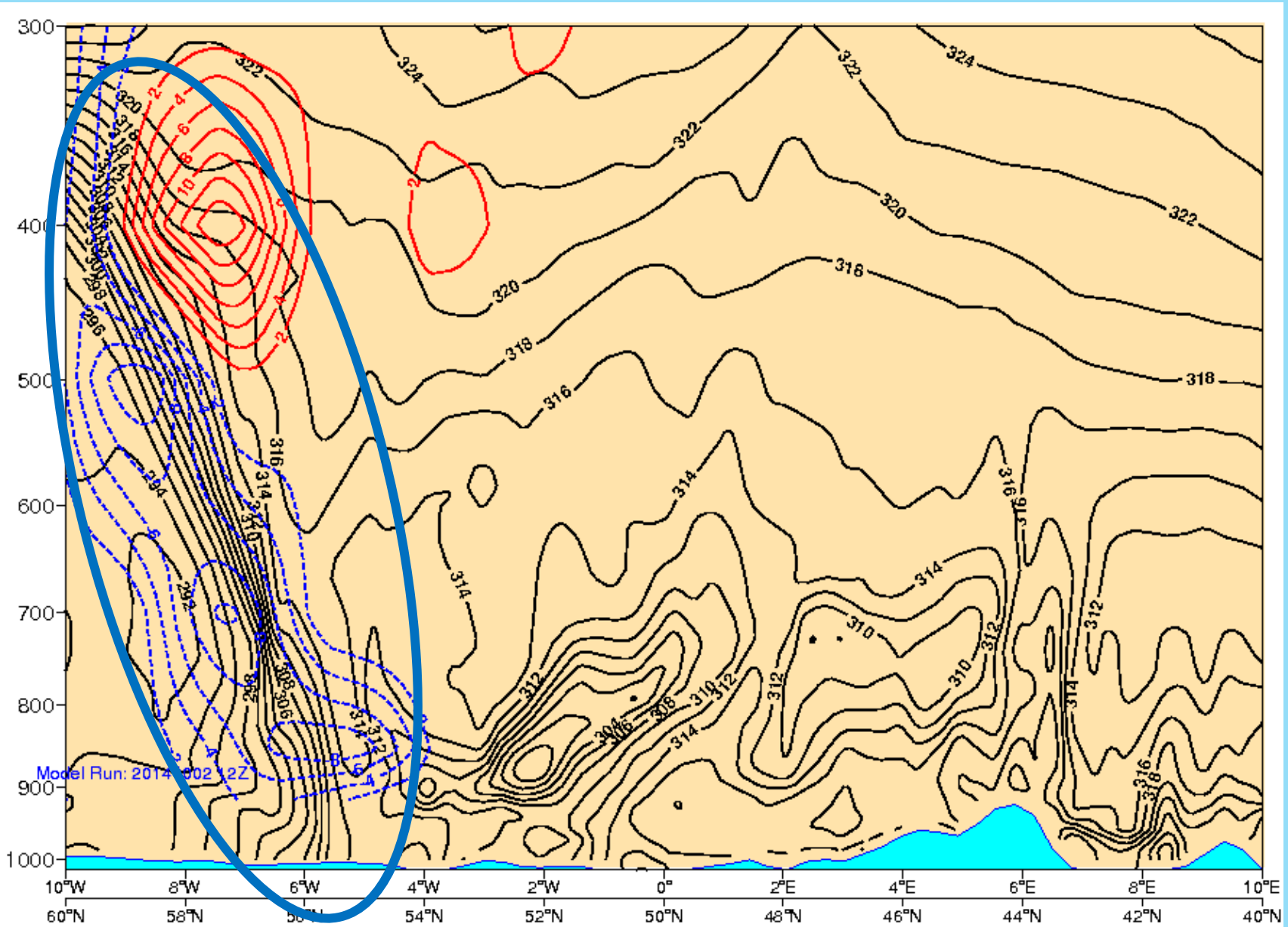
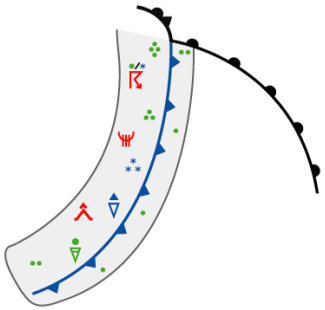
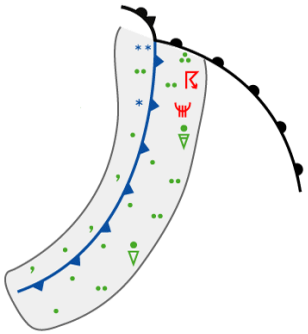


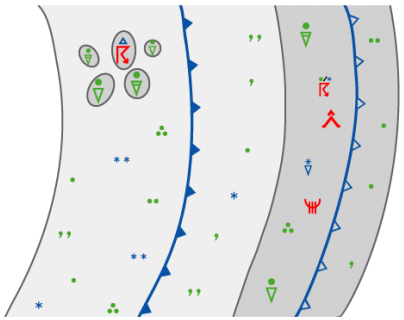
Cold Fronts: Weather Events



ANA COLD FRONT

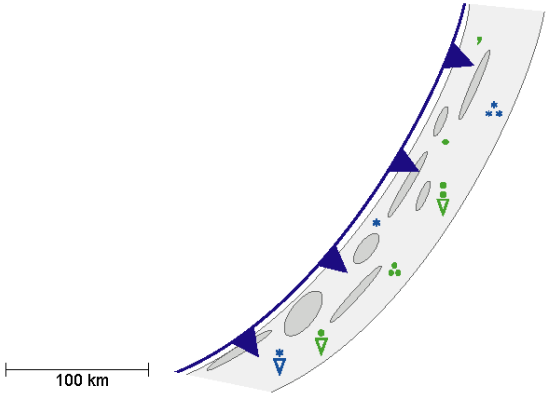


KATA COLD FRONT

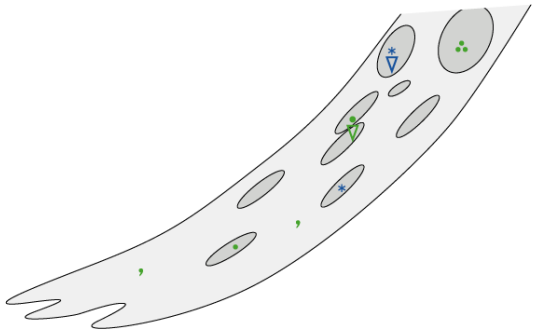


SPLIT FRONT

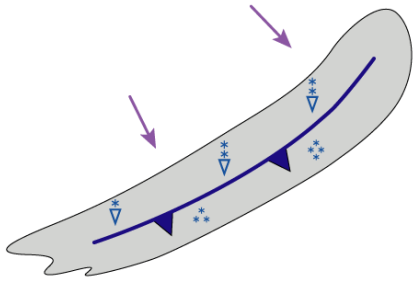
COLD FRONT IN COLD ADVECTION - WEATHER EVENTS



COLD FRONT IN WARM ADVECTION

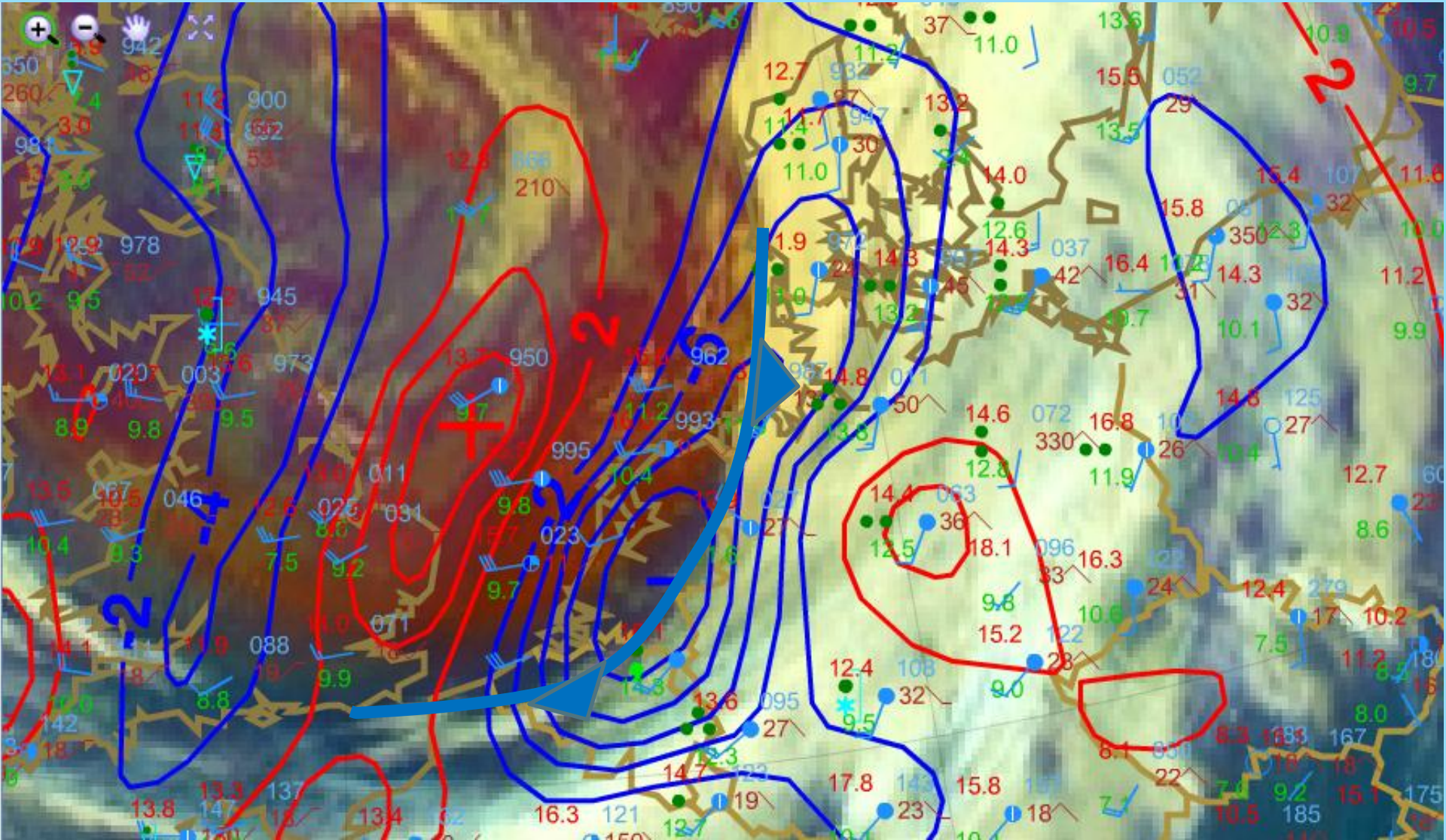


ARCTIC COLD FRONT



Cold Fronts: Weather Events
CF in CA

7 September 2011 00 UTC Airmass RGB

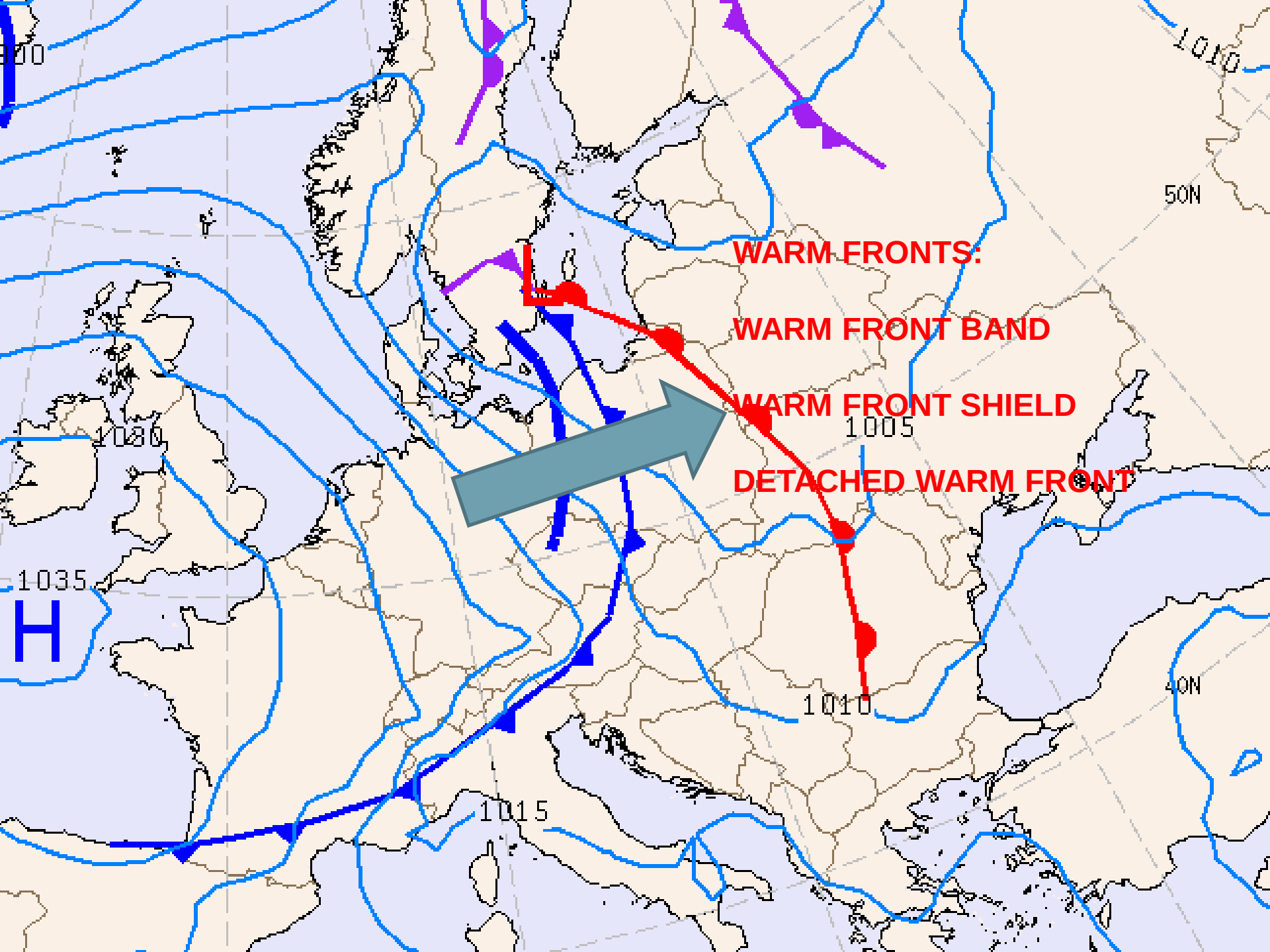


- COLD FRONT
  - Arctic Cold Front
  - Cold Front
  - Cold Front in Cold Advection
  - Cold Front in Warm Advection
  - Split Front
- WARM FRONT
  - Detached Warm Front
  - Warm Front Band
  - Warm Front Shield
- OCCLUSION
  - Back-Bent Occlusion
  - Cold Air Development
  - Instant Occlusion
  - Occlusion: Cold Conveyor Belt Type
  - Occlusion: Warm Conveyor Belt Type

Ana
Kata

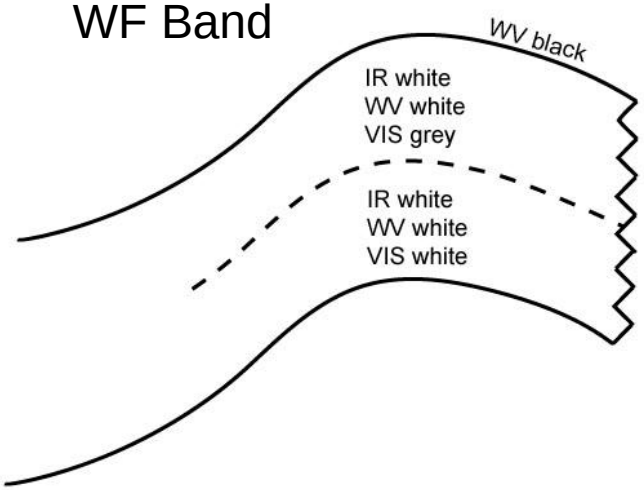
In SatManu: 13 types of fronts

3 types of WF's

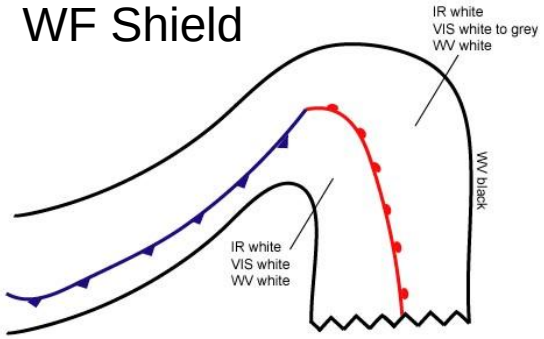

WARM FRONTS:
WARM FRONT BAND
WARM FRONT SHIELD
DETACHED WARM FRONT
1005
1010
1015
1030
1035
H
50N
40N

Warm Fronts: Cloud Structures in Satellite Images

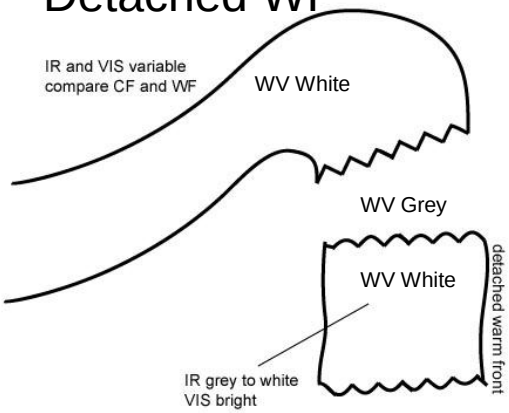
WF Band



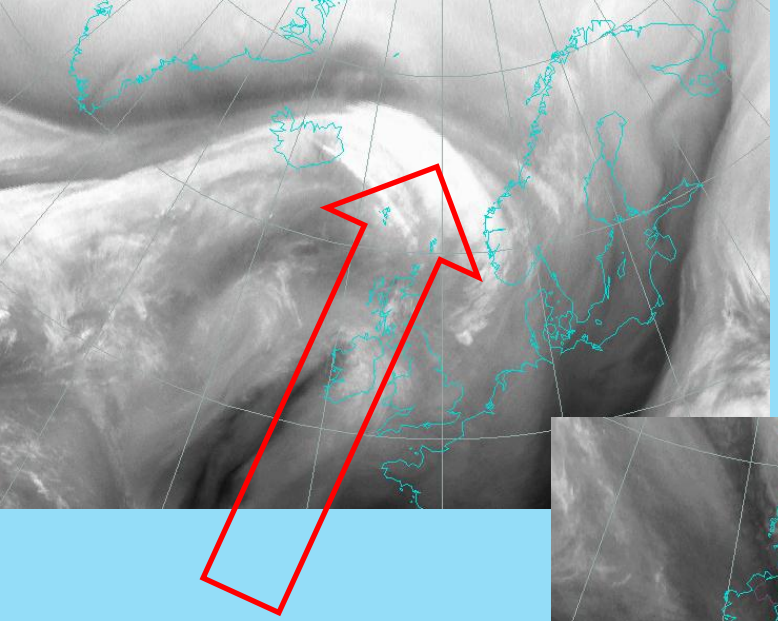
WF Shield



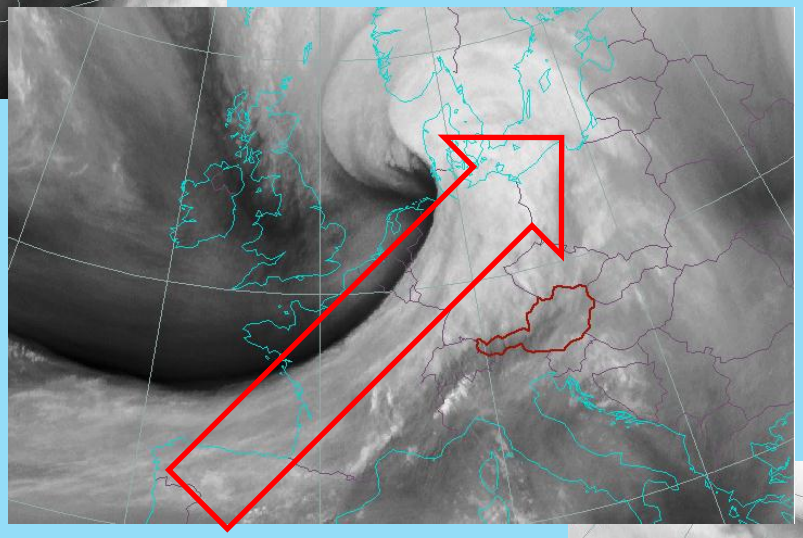
Detached WF



Warm Fronts: Cloud Structures in Satellite Images

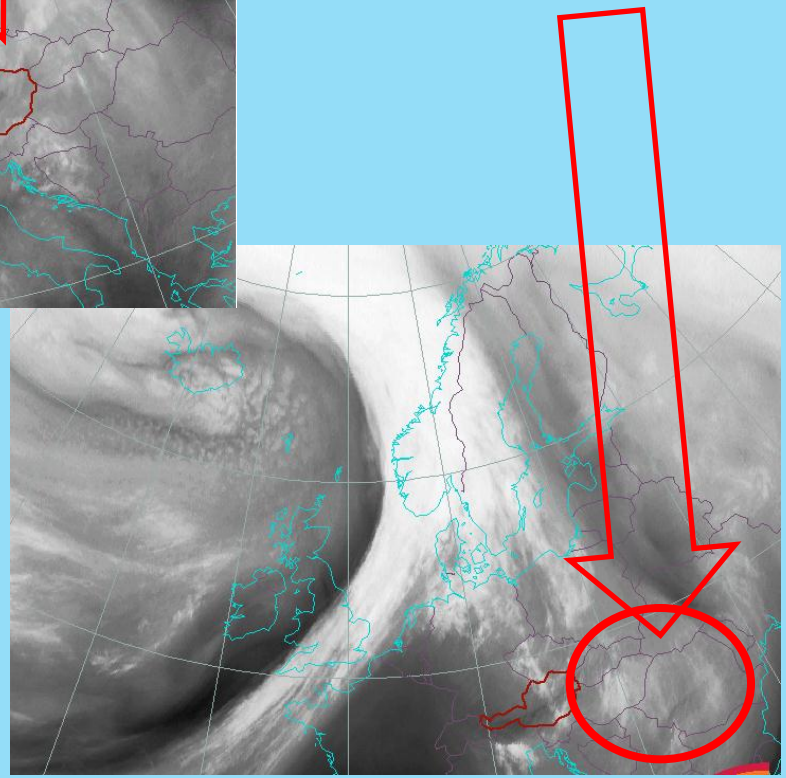


WF Band

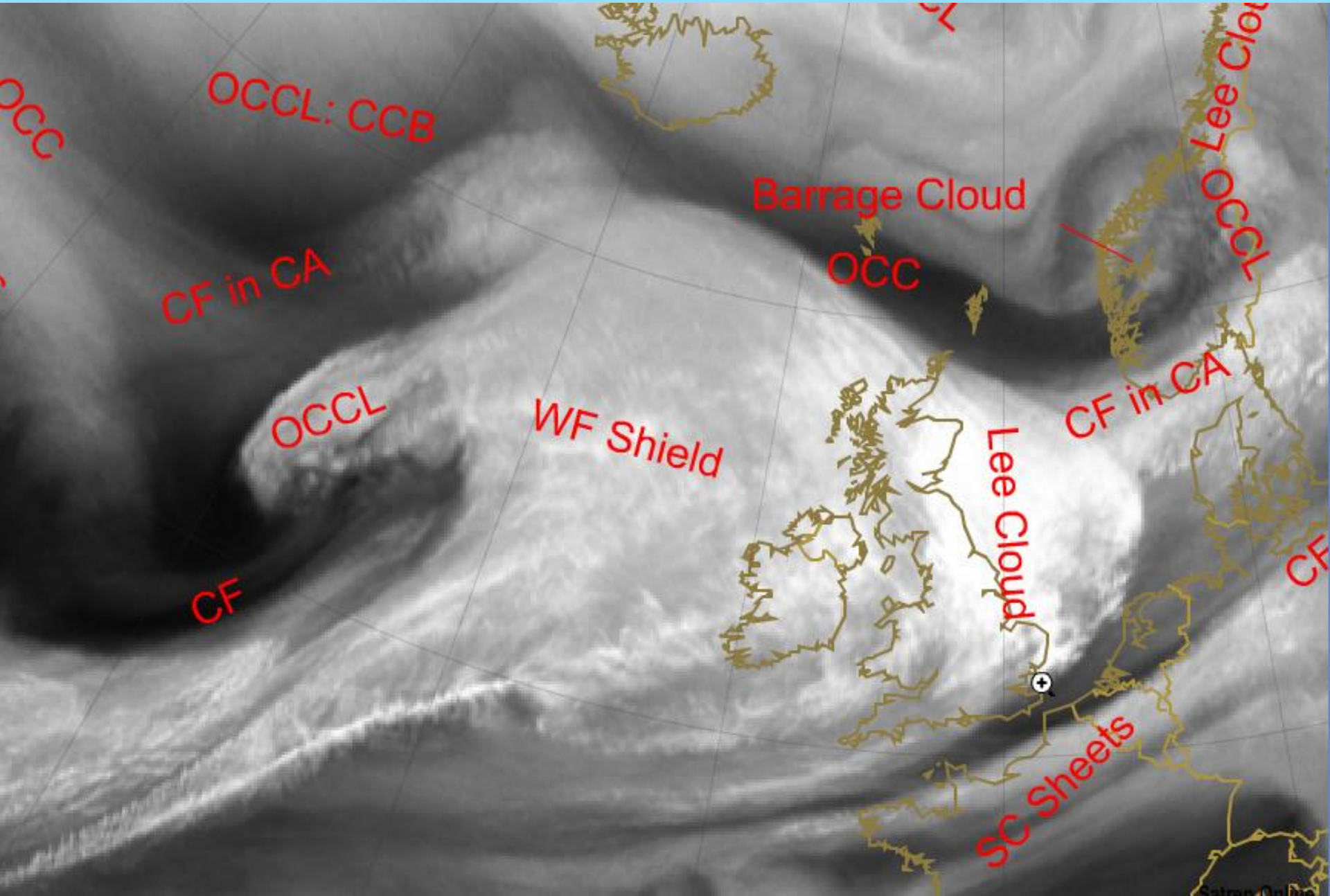


WF Shield

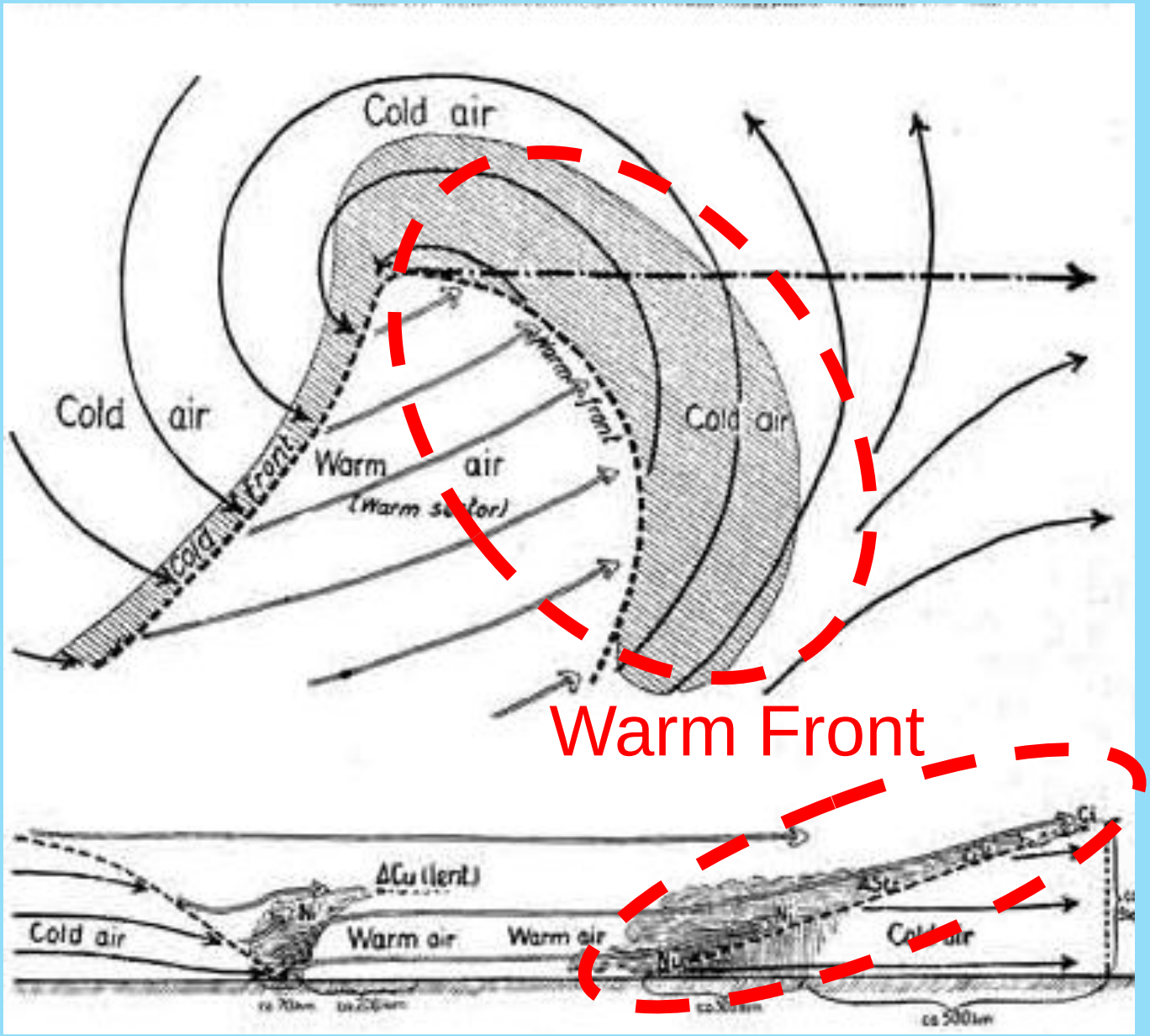
Detached WF



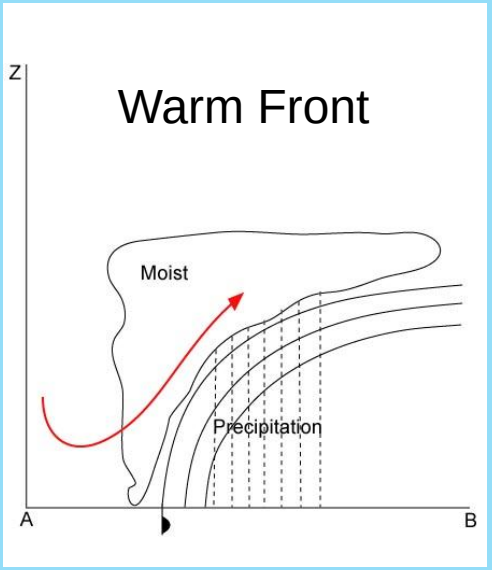
Warm Front Shield: 4 October 2011 12 UTC



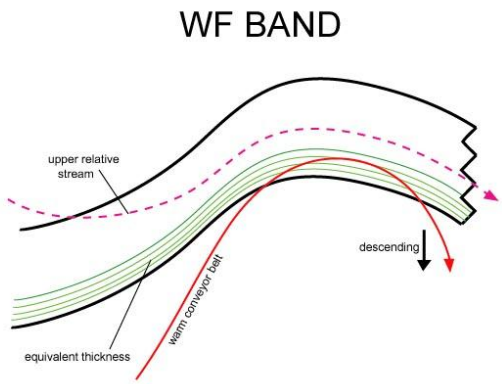
Physical background
Frontal system according to Bjerknes

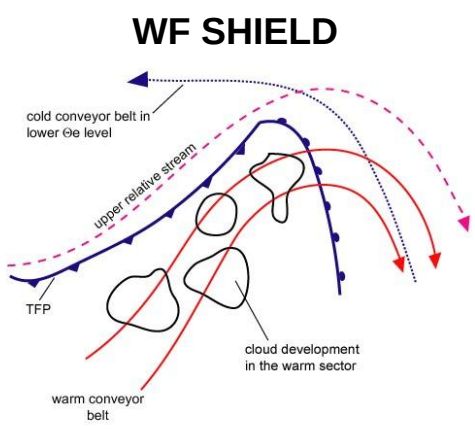


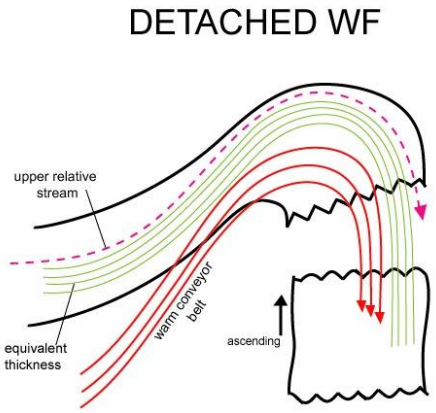
Warm Fronts: Meteorological Physical Background



Warm Fronts: Conveyor Belts





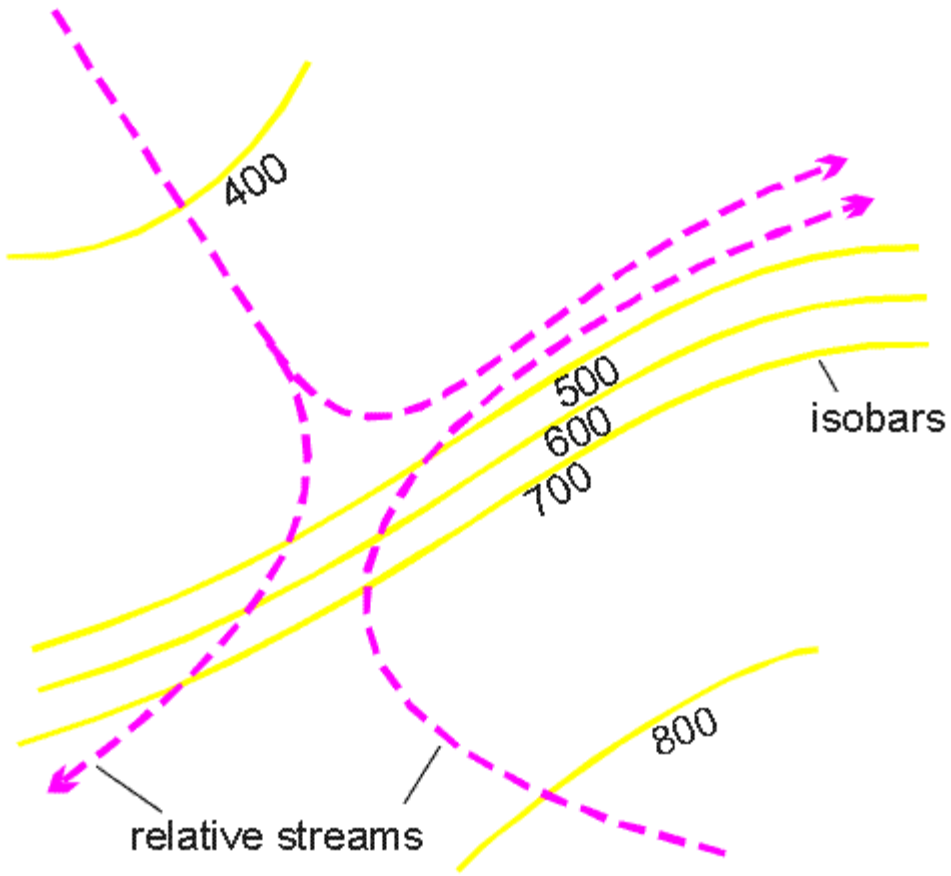


RELATIVE STREAMS

Conveyor Belts

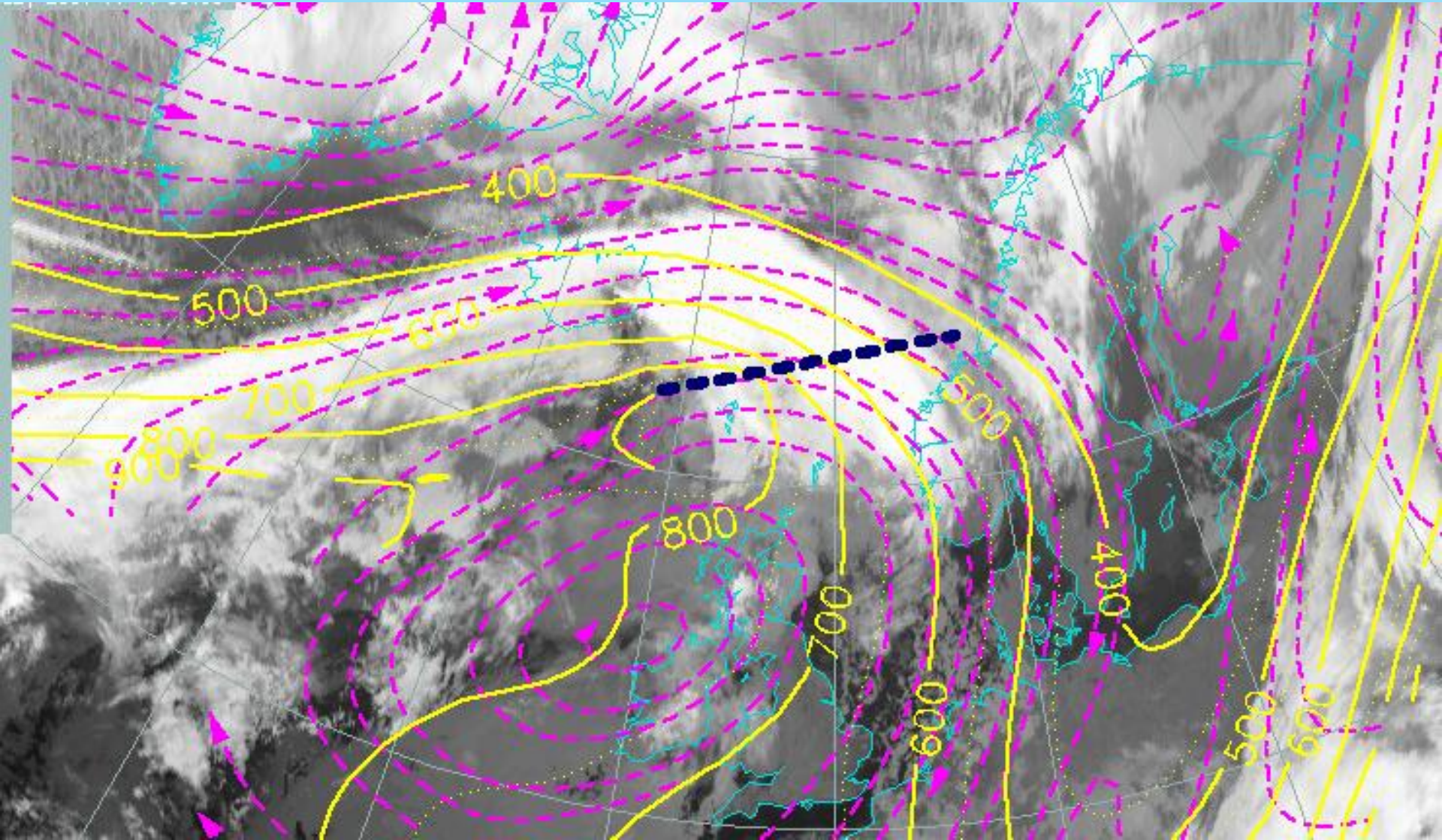
Team Time Trial

Relative Streams on an isentropic level



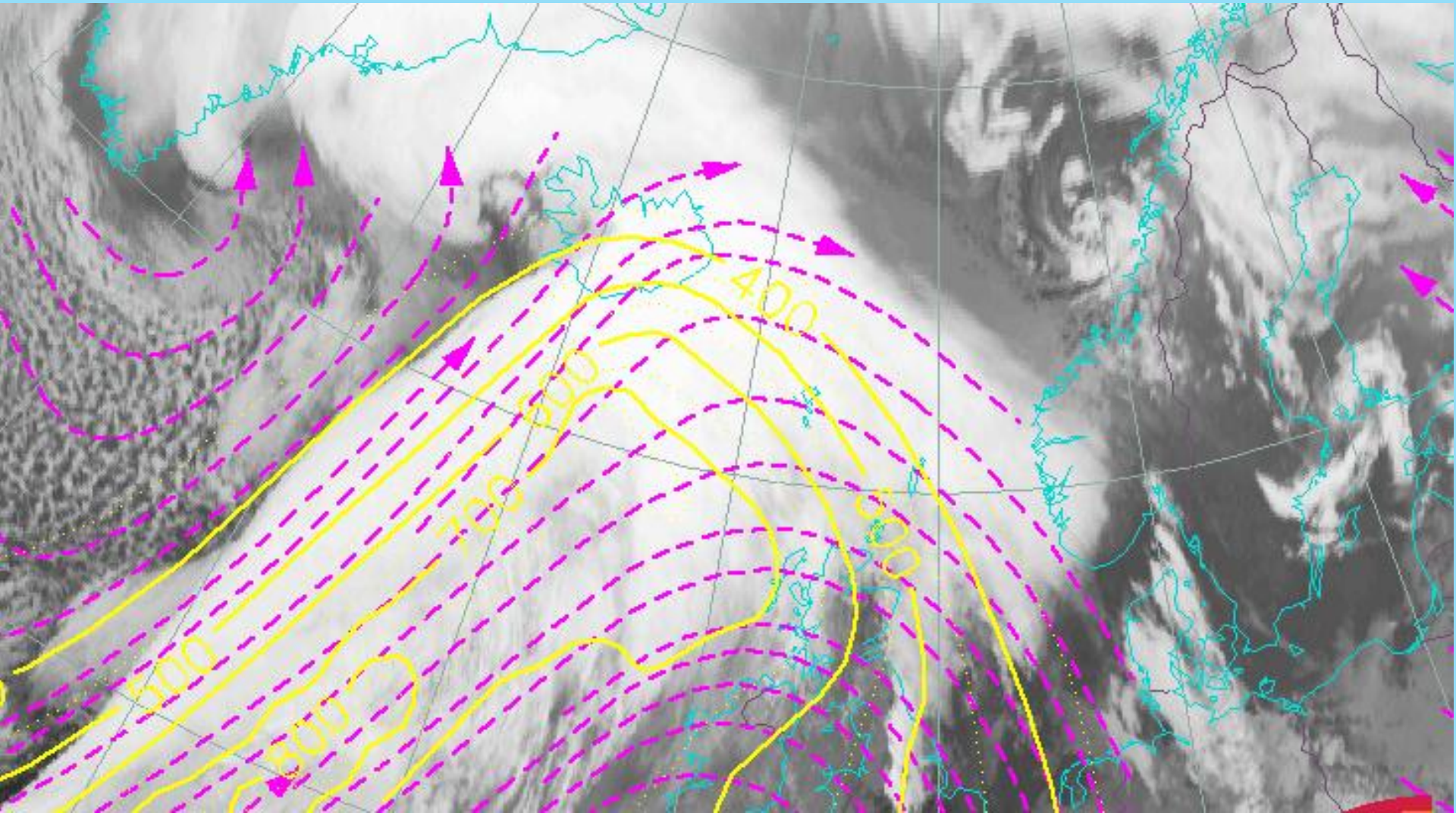
Warm Fronts: Meteorological Physical Background
Conveyor Belts/Relative Streams

Warm Front Band



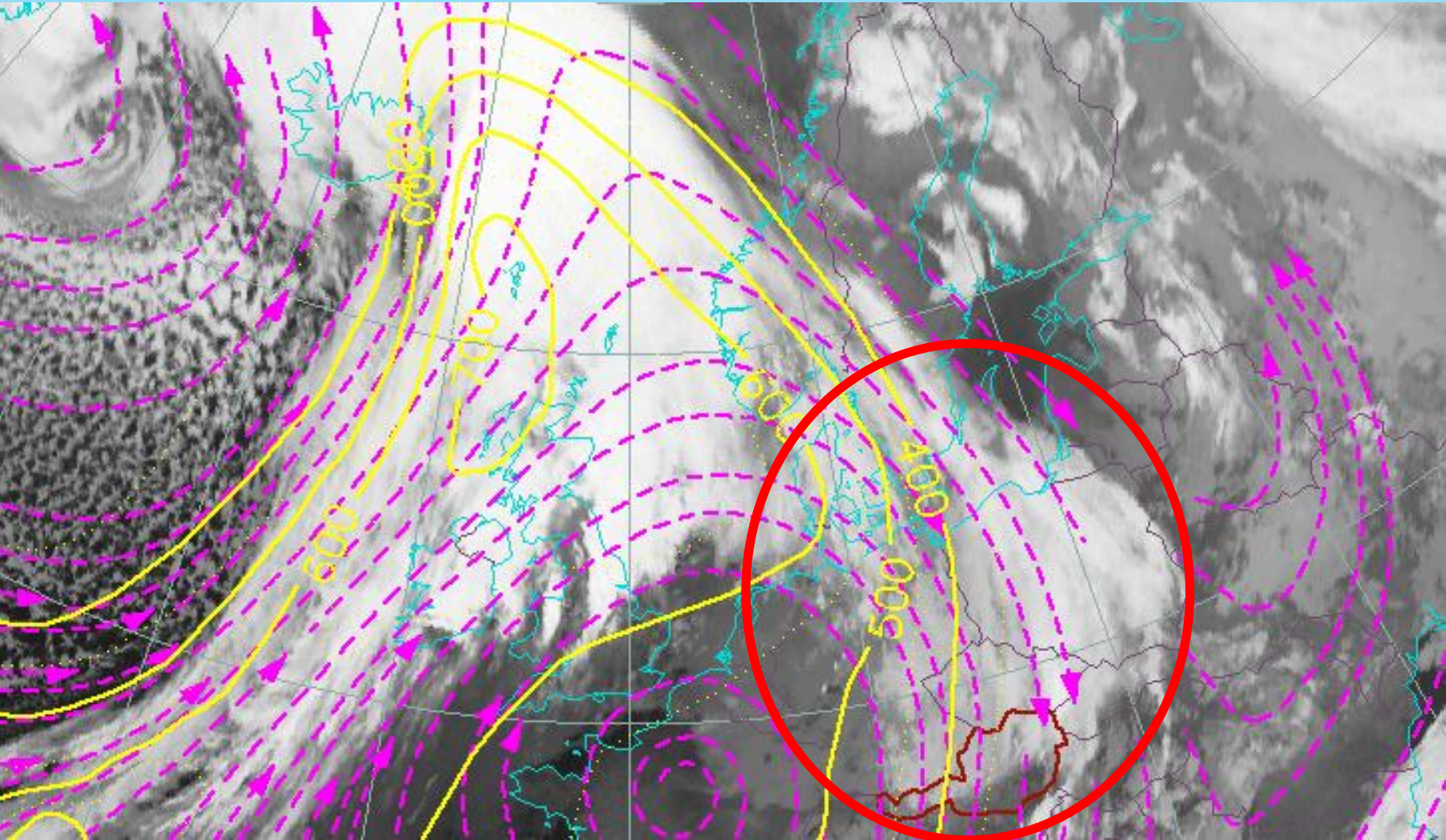
Warm Fronts: Meteorological Physical Background
Conveyor Belts/Relative Streams

Warm Front Shield



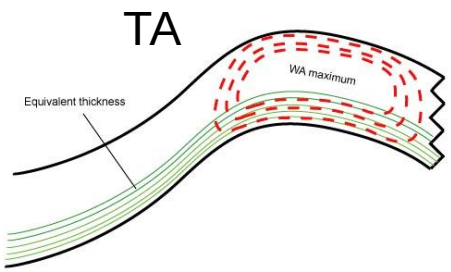
Warm Fronts: Meteorological Physical Background
Conveyor Belts/Relative Streams

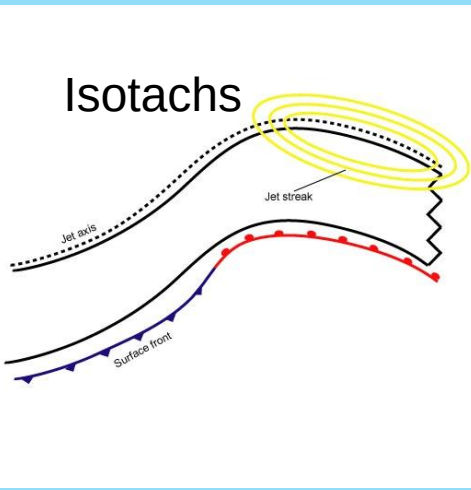
Detached Warm Front



Warm Fronts: Key Parameters

WF Band





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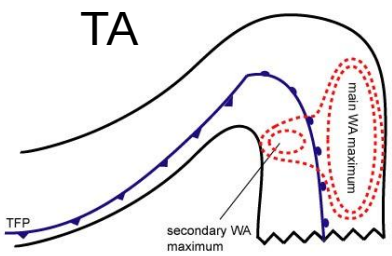

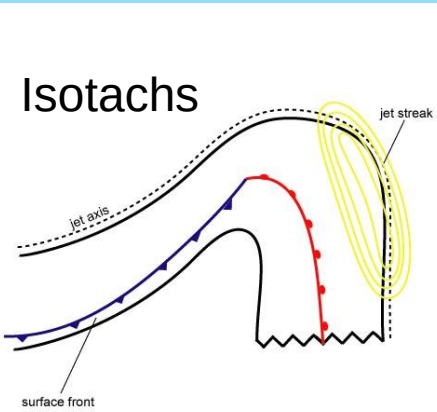

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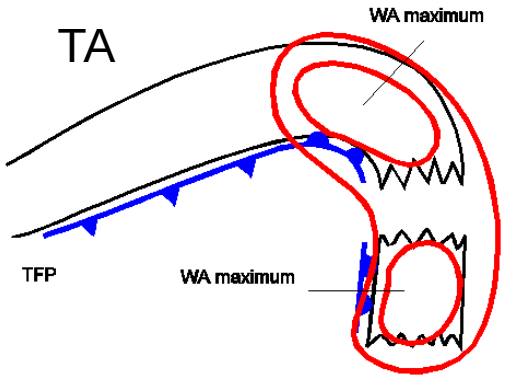
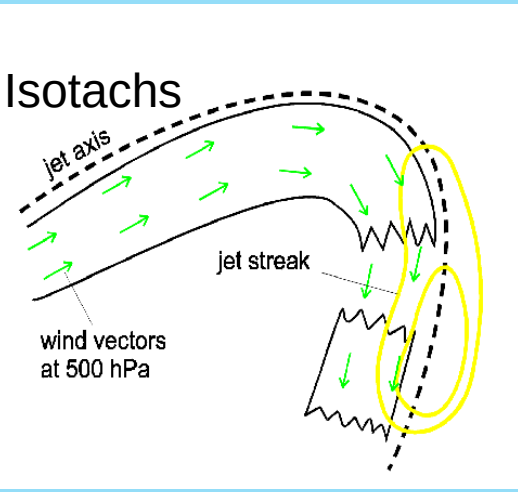
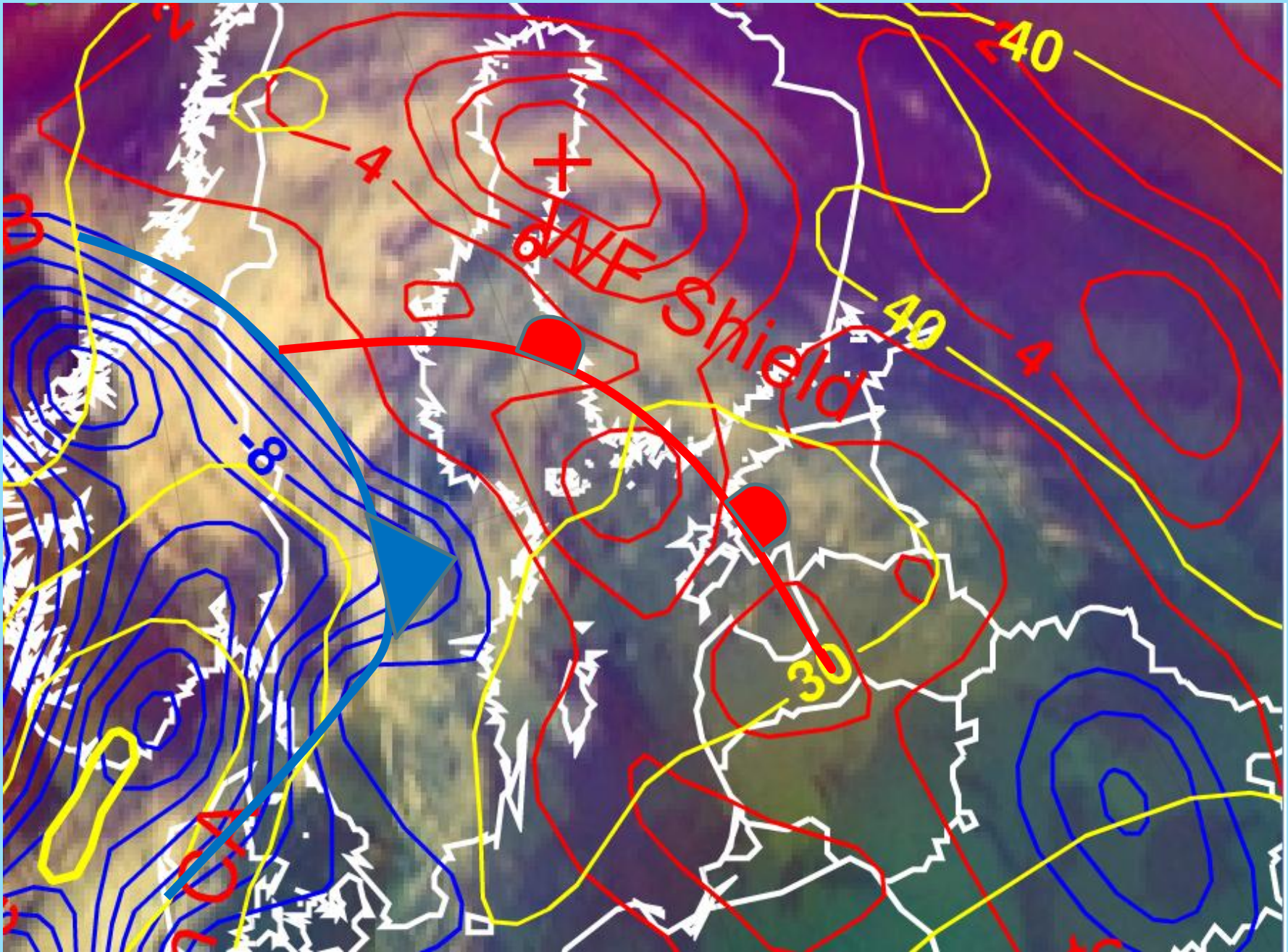
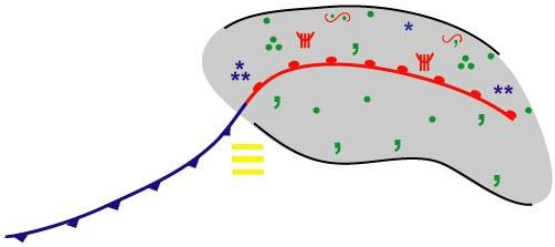




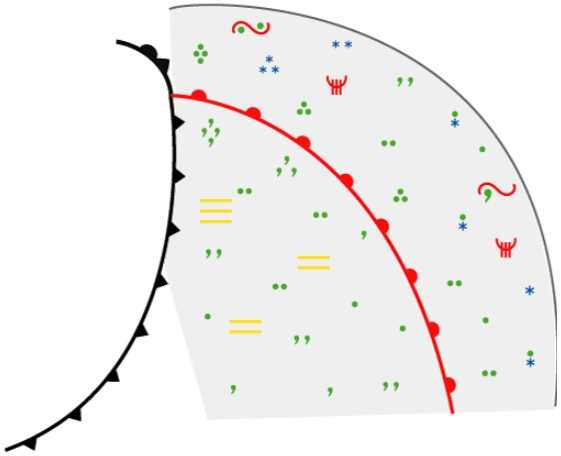
WF Shield 6-10-2011 06 UTC TA and Isotachs



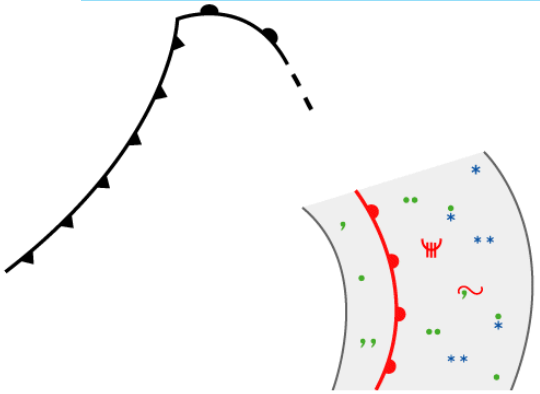
Warm Front: Weather events



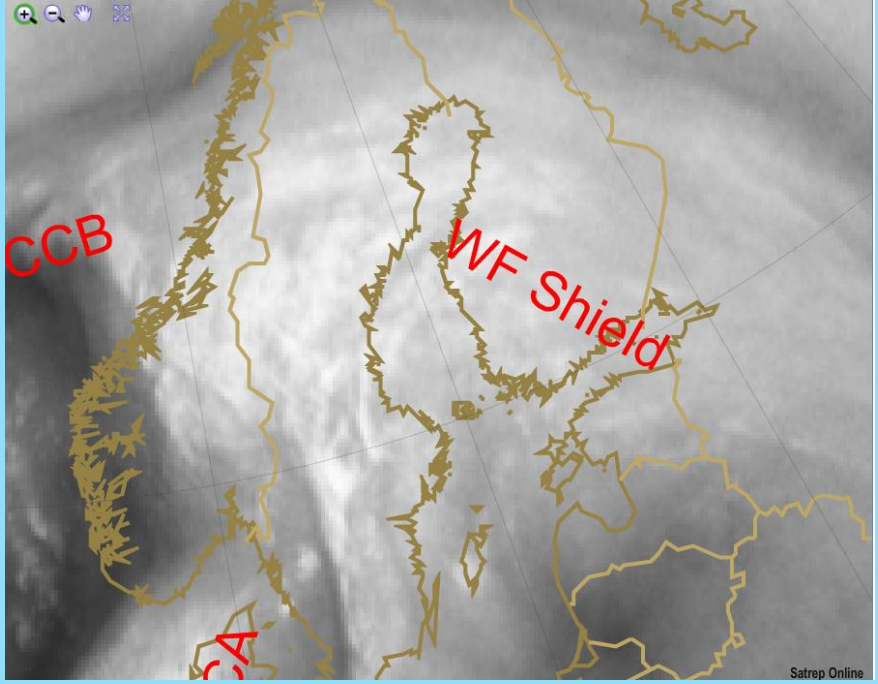
WARM FRONT BAND



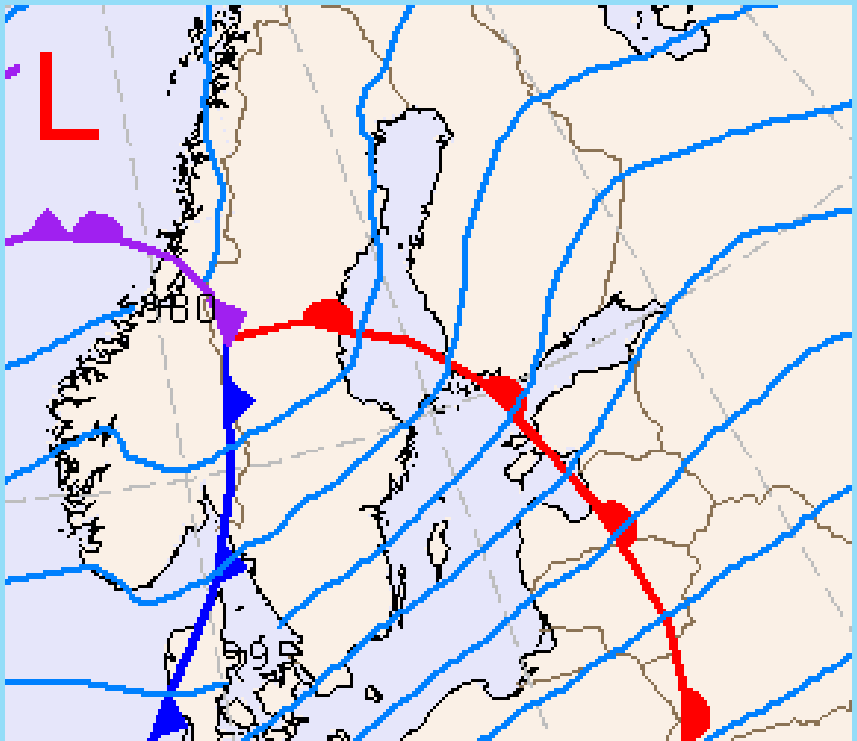
WARM FRONT SHIELD

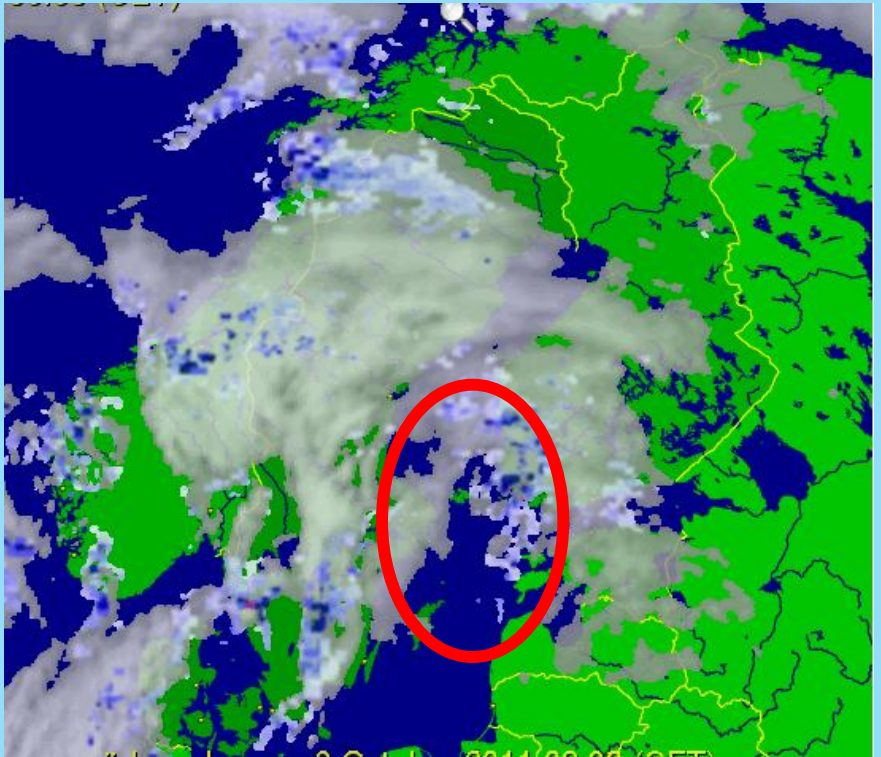


DETACHED WARM FRONT



Thursday 6 October 2011 06 UTC





THANK YOU
FOR YOUR ATTENTION