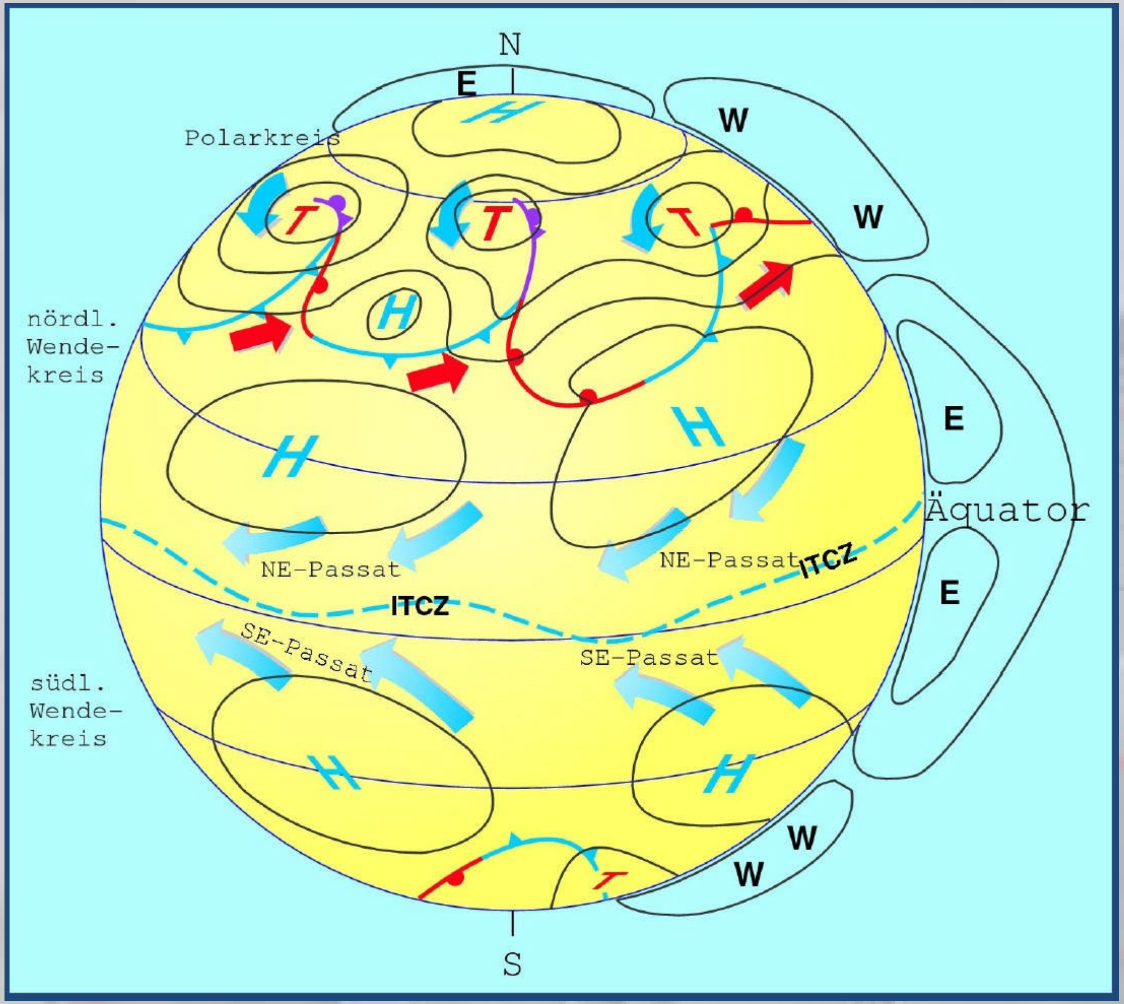
Global Circulation with Coriolis Force

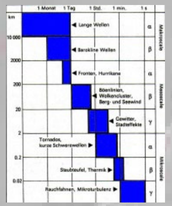


Global Circulation and Ideal cyclone

Similarities:

Energy input fed from meridional temperature differences

Differences:

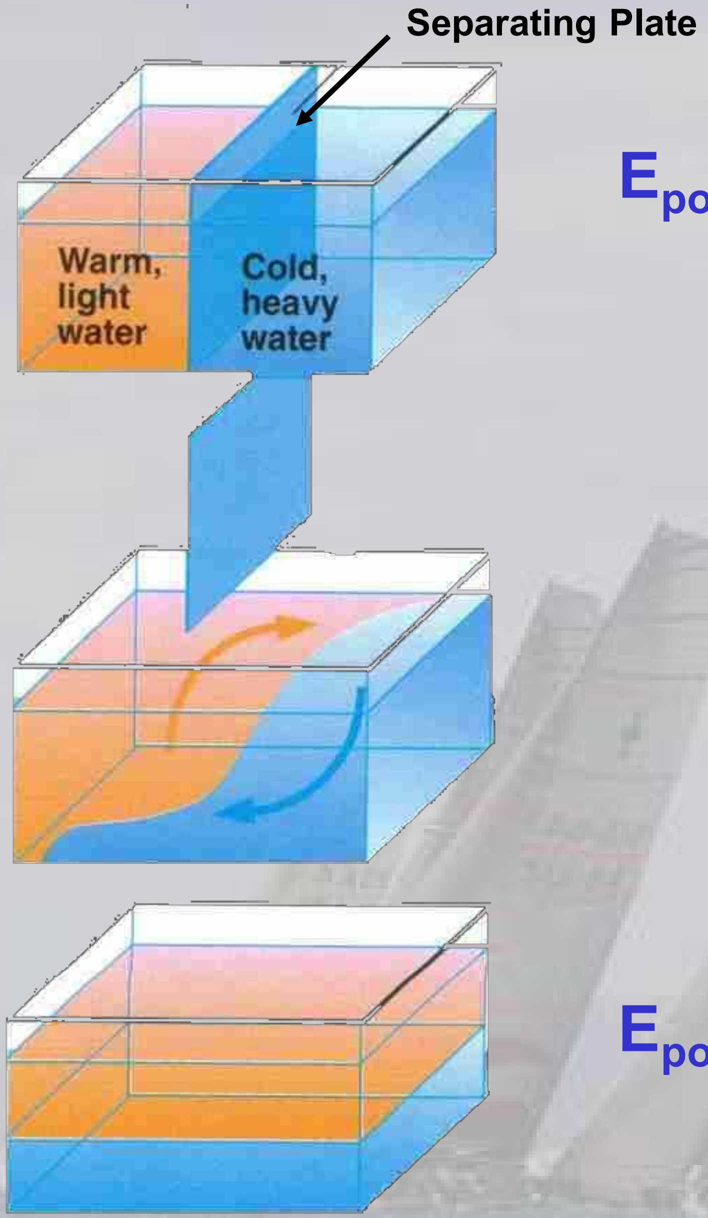


Space-time-scale accordingly other dynamics

Energy aspects

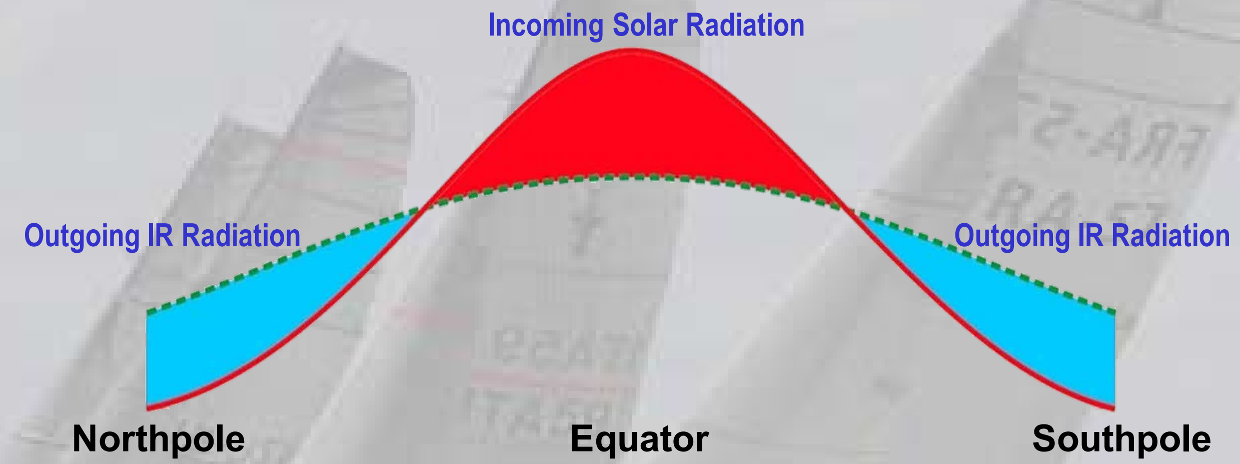
$$E_{pot} + E_{kin} = const.$$

Airmass boundary



$E_{pot} > min$

$E_{pot} = min$

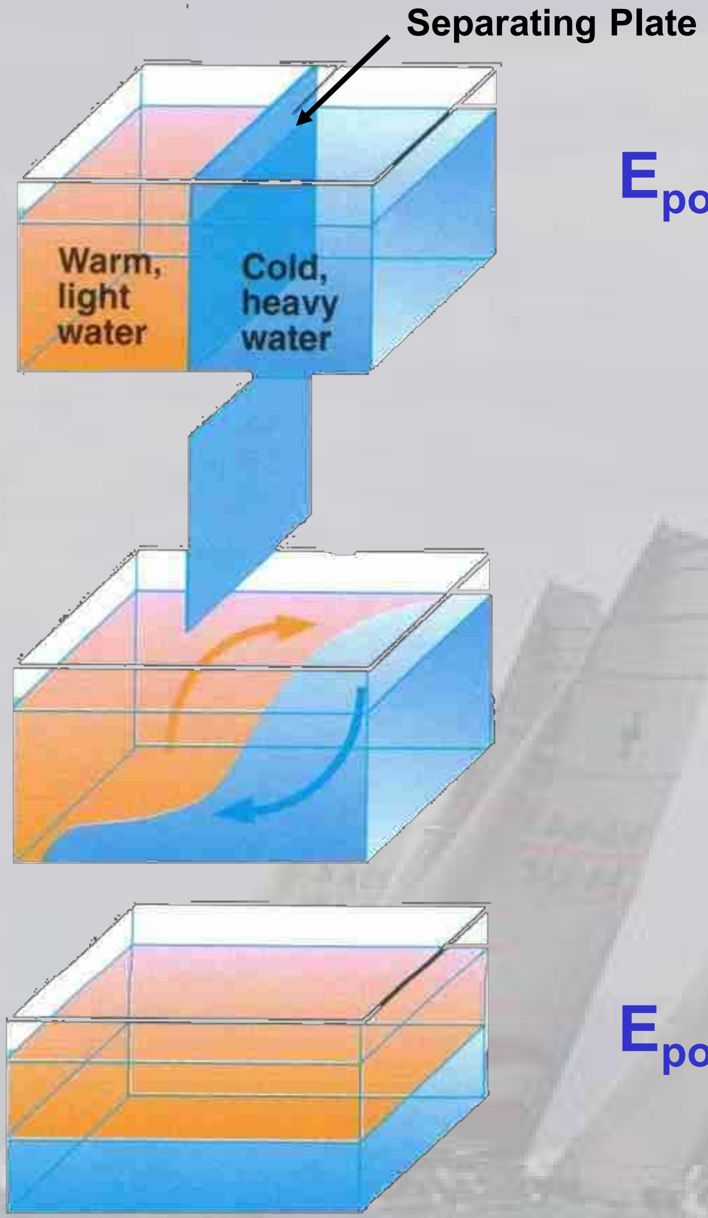


E_{pot} decrease <=> E_{kin} increase

WIND !

Energy aspects

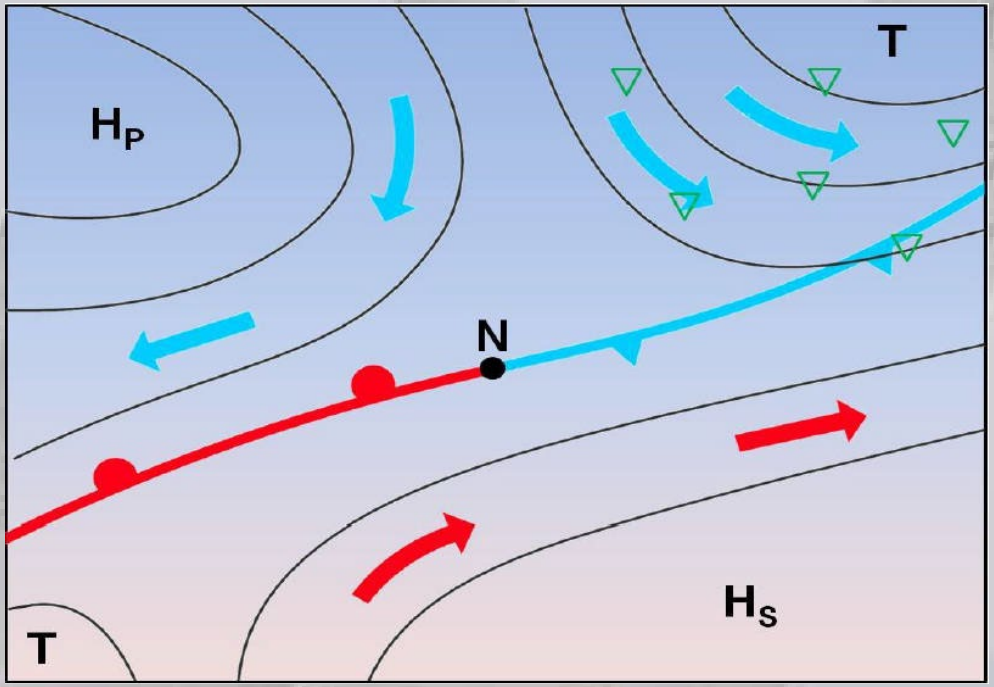
$E_{pot} + E_{kin} = const.$



$E_{pot} > min$

$E_{pot} = min$

Airmass boundary



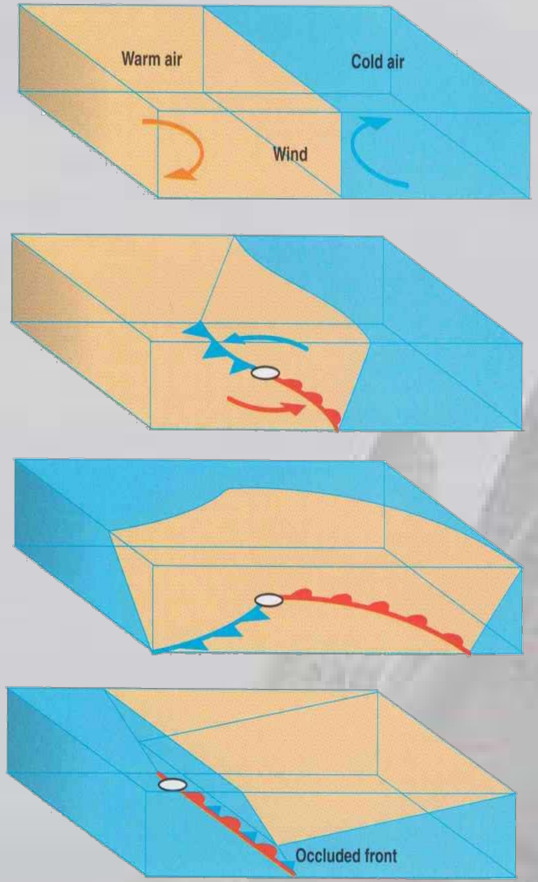
E_{pot} decrease <=> E_{kin} increase

WIND !

Energy aspects

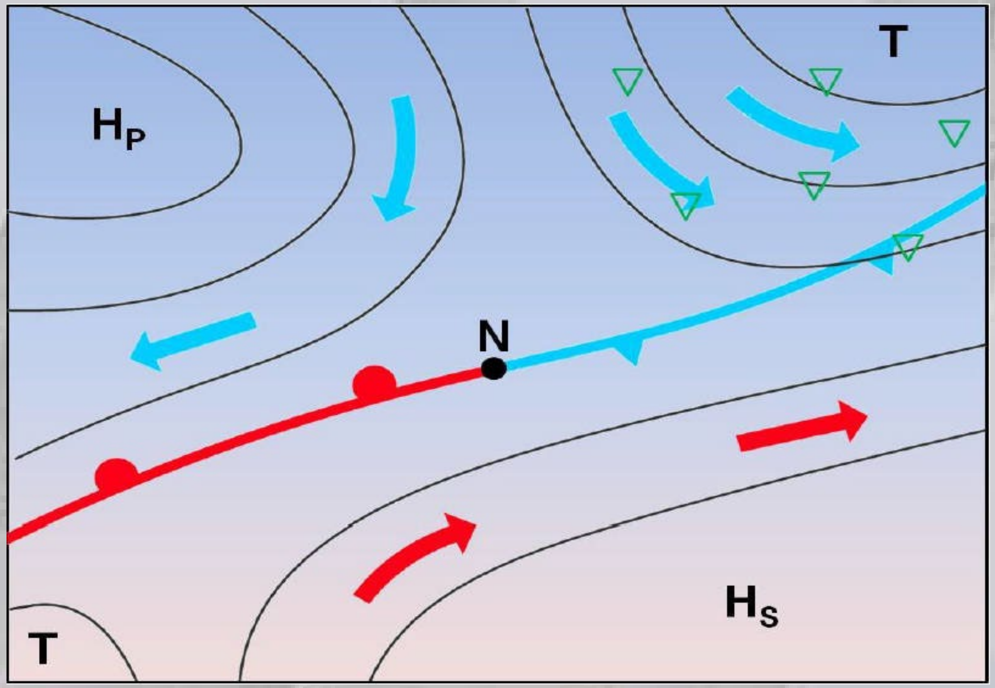
$E_{pot} + E_{kin} = const.$

Airmass boundary



$E_{pot} > min$

$E_{pot} = min$



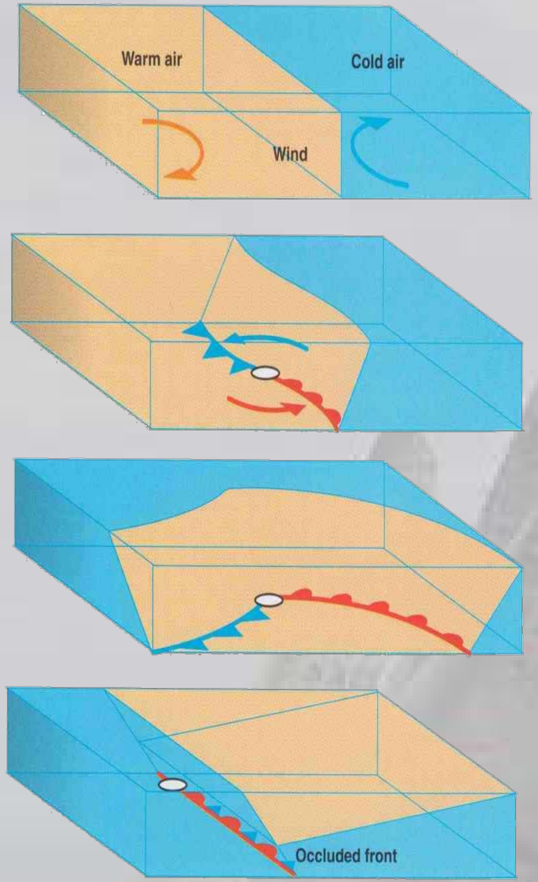
E_{pot} decrease <=> E_{kin} increase

WIND !

Energy aspects

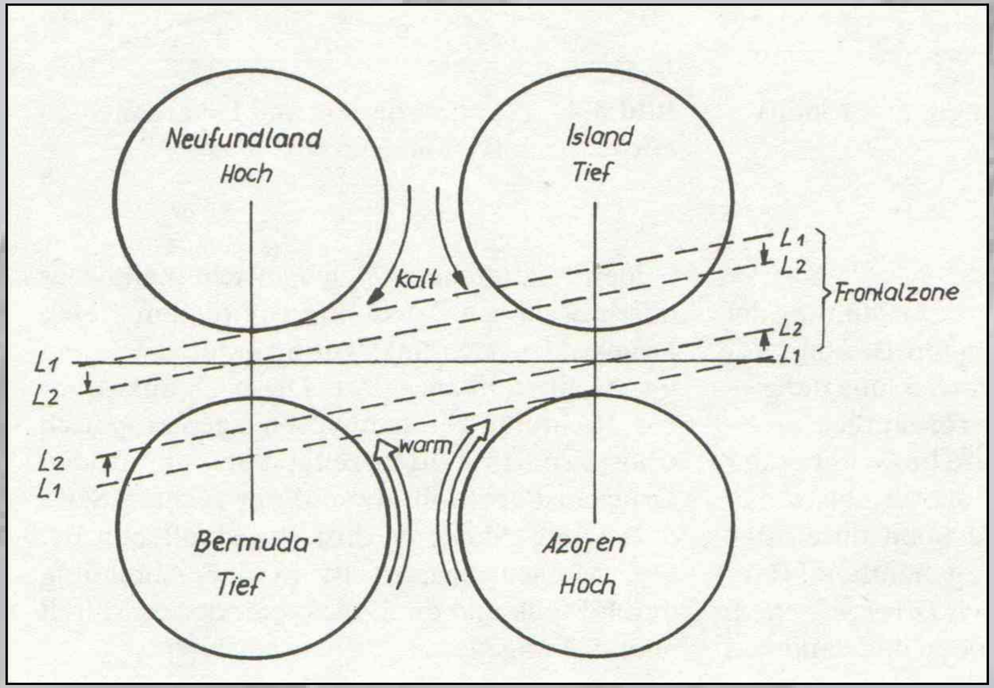
$E_{pot} + E_{kin} = const.$

Four center pressure pattern



$E_{pot} > min$

$E_{pot} = min$

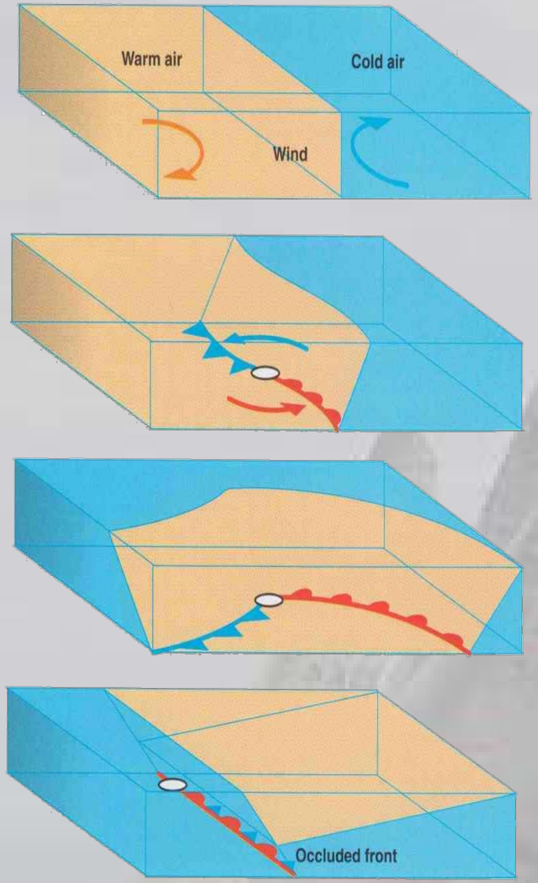


E_{pot} decrease <=> E_{kin} increase

WIND !

Energy aspects

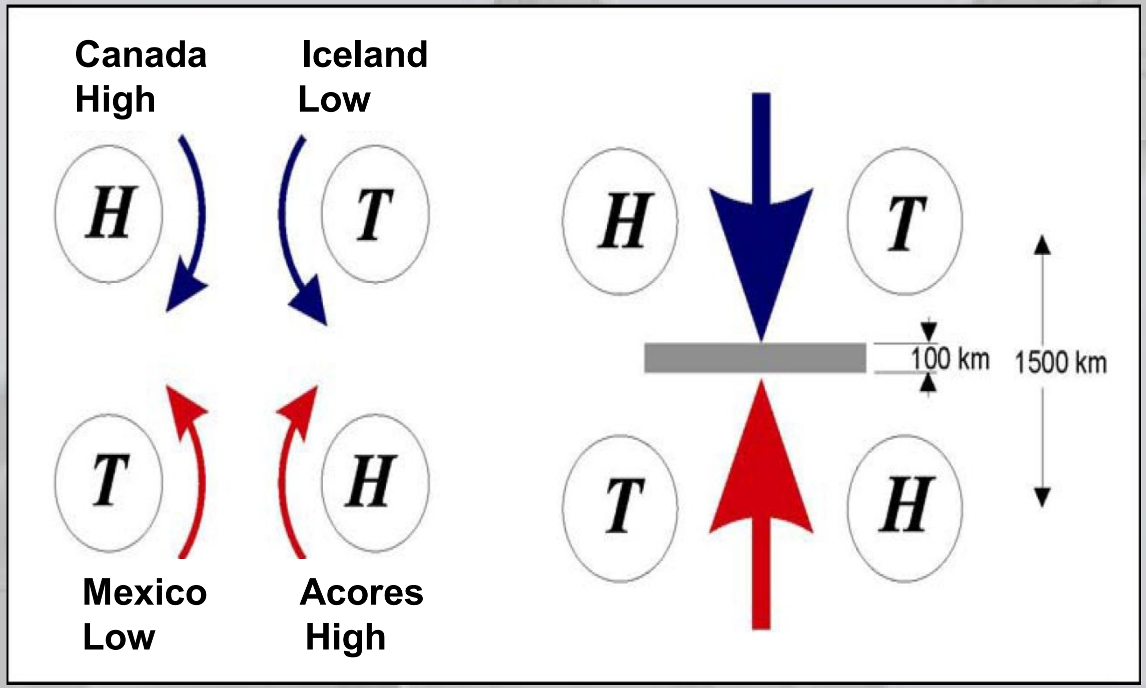
$E_{pot} + E_{kin} = const.$



$E_{pot} > min$

$E_{pot} = min$

Four center pressure pattern

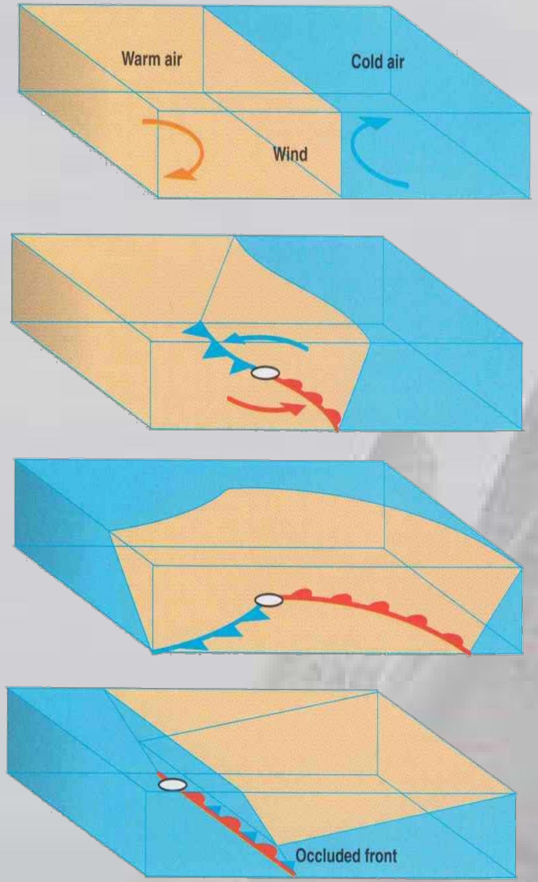


E_{pot} decrease <=> E_{kin} increase

WIND !

Energy aspects

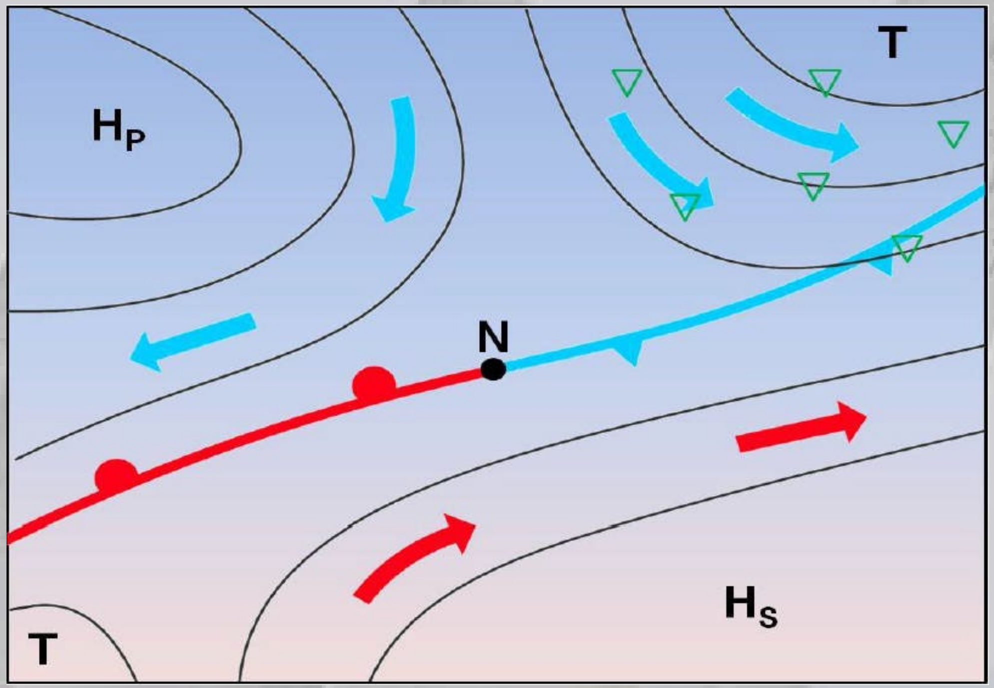
$E_{pot} + E_{kin} = const.$



$E_{pot} > min$

$E_{pot} = min$

Airmass boundary

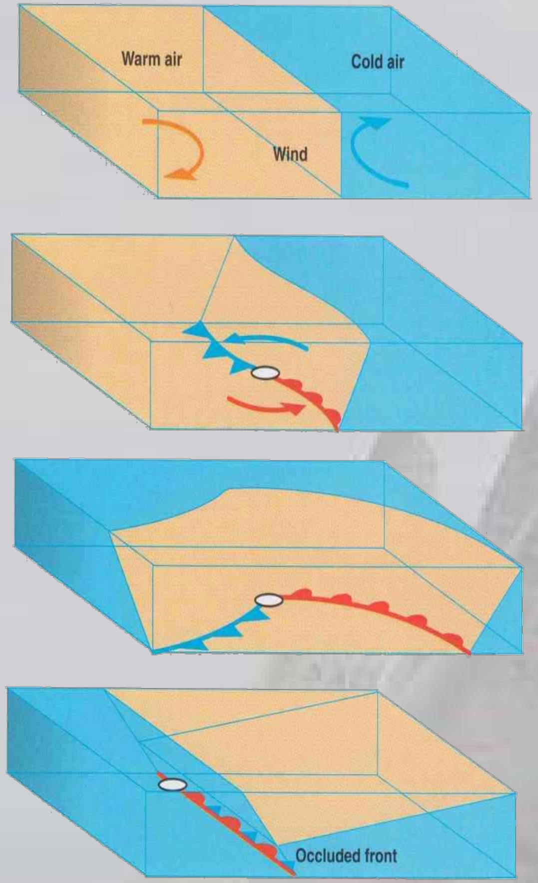


E_{pot} decrease <=> E_{kin} increase

WIND !

Energy aspects

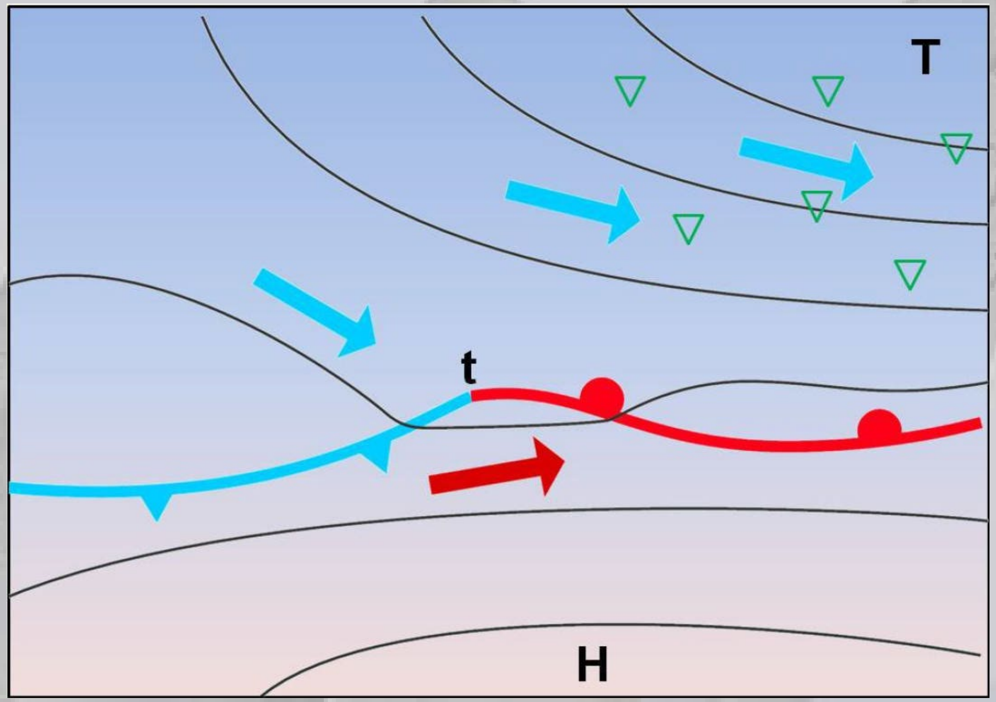
$E_{pot} + E_{kin} = const.$



$E_{pot} > min$

$E_{pot} = min$

Wave disturbance



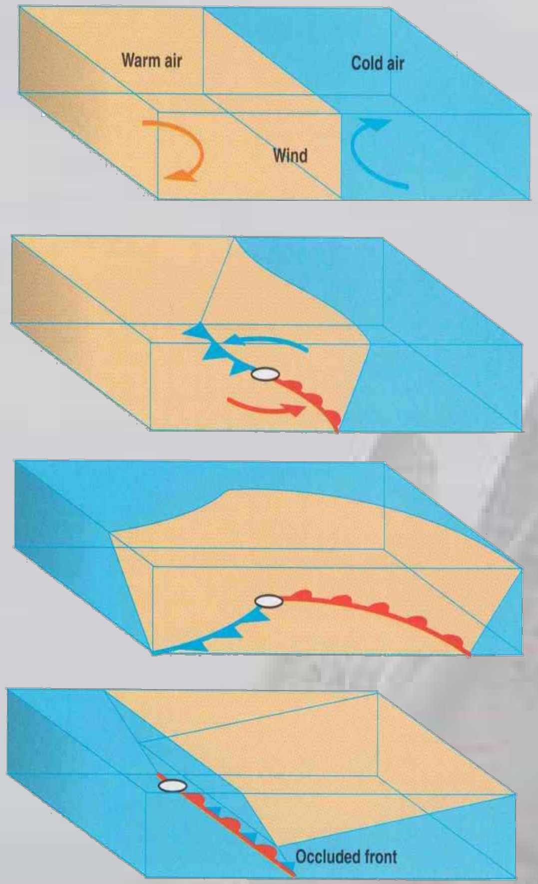
E_{pot} decrease <=> E_{kin} increase

WIND !

Energy aspects

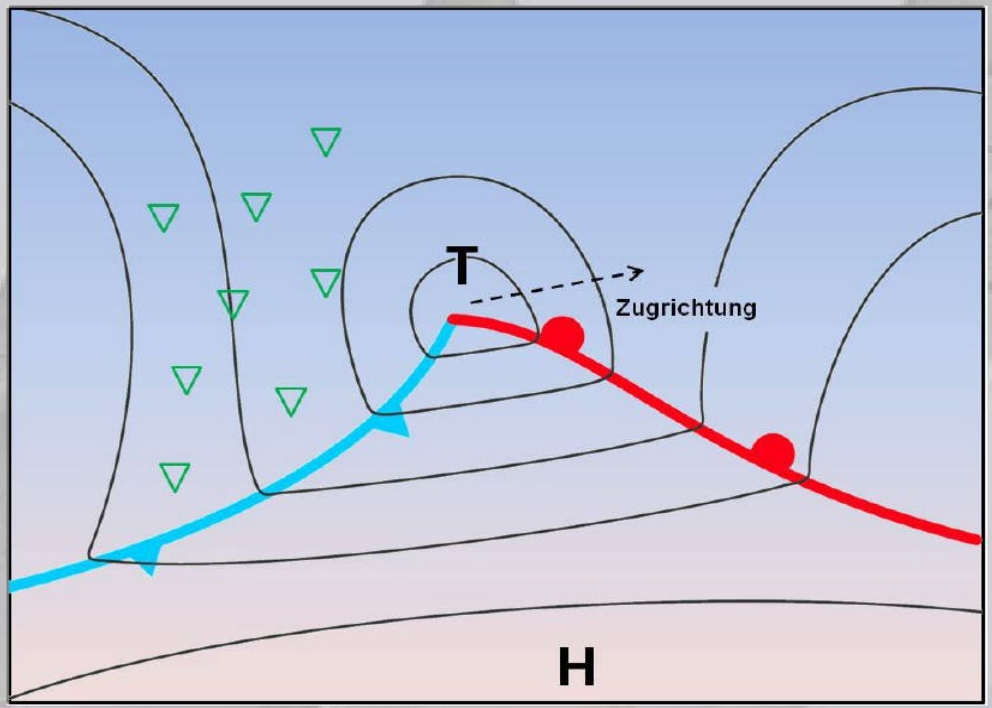
$E_{pot} + E_{kin} = const.$

Developing Low



$E_{pot} > min$

$E_{pot} = min$

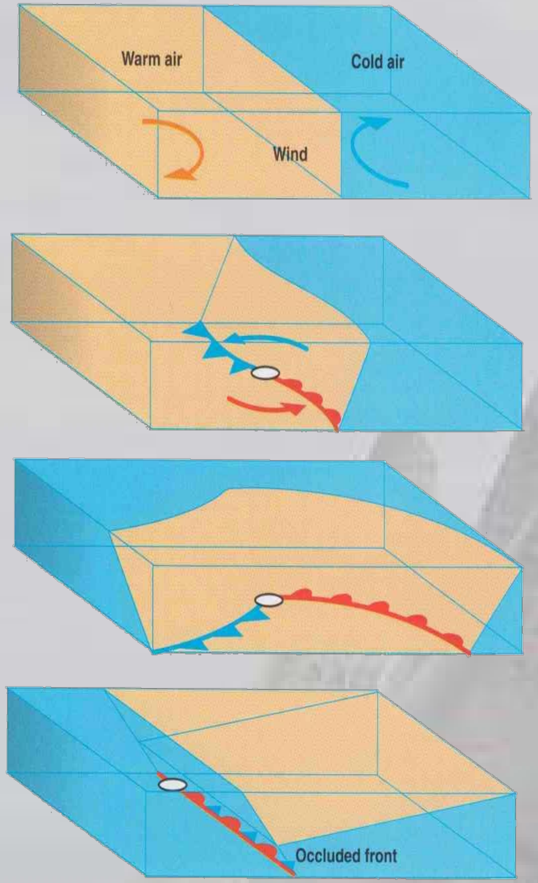


E_{pot} decrease <=> E_{kin} increase

WIND !

Energy aspects

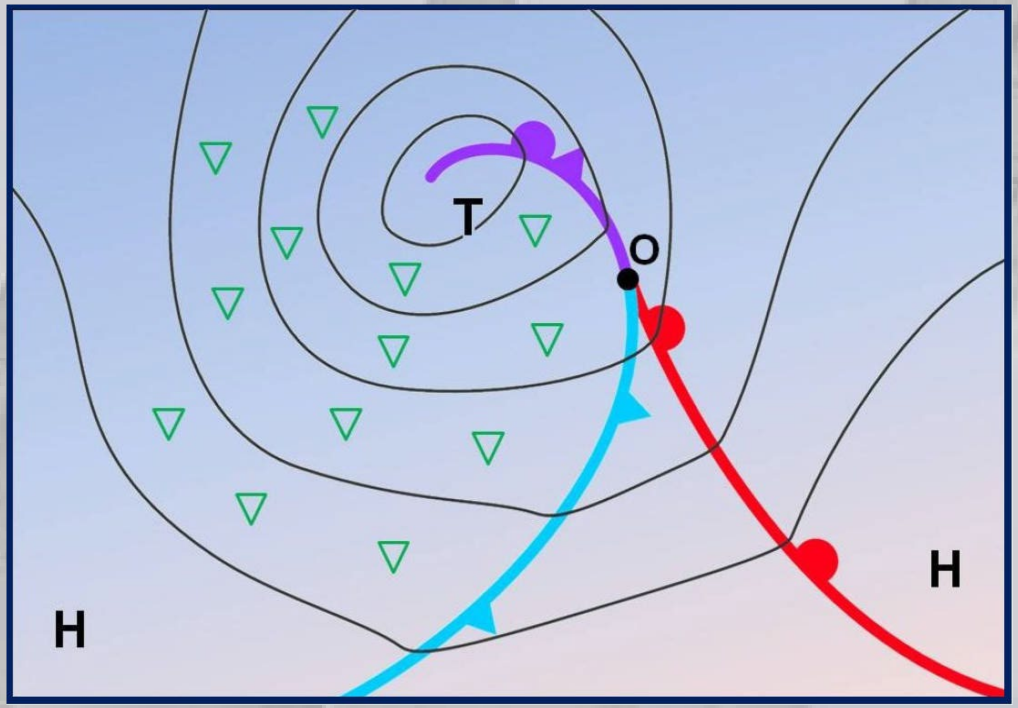
$E_{pot} + E_{kin} = const.$



$E_{pot} > min$

$E_{pot} = min$

Occluding Low



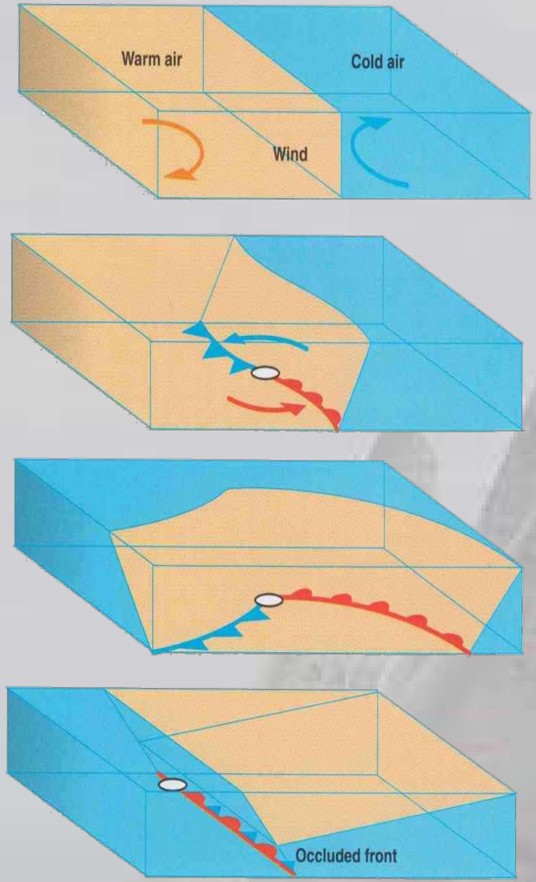
E_{pot} decrease <=> E_{kin} increase

WIND !

Energy aspects

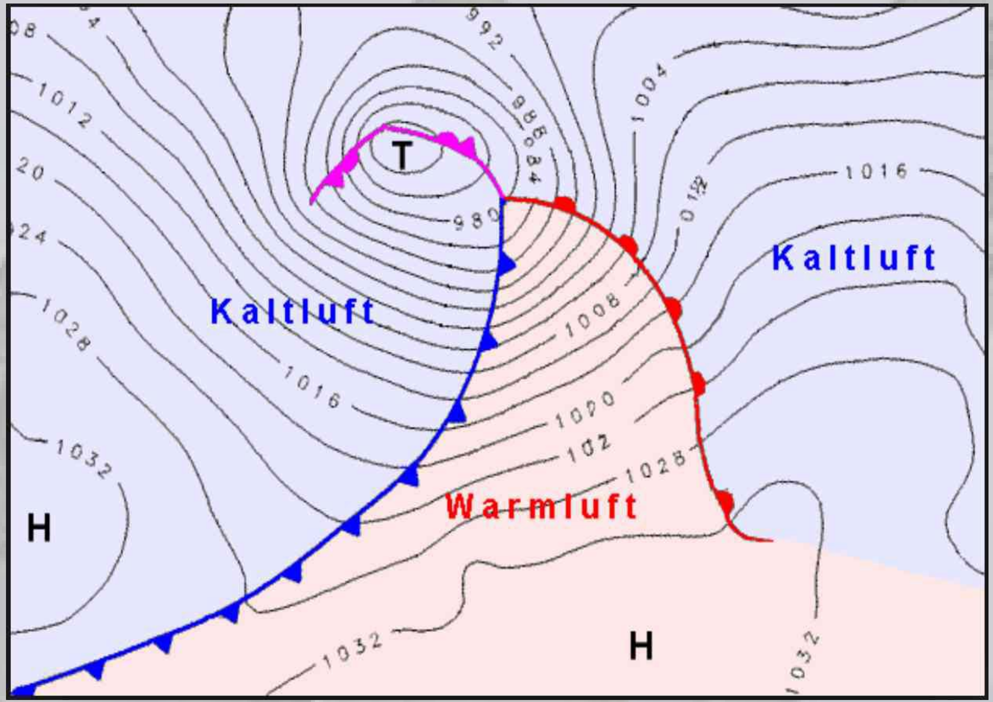
$E_{pot} + E_{kin} = const.$

Occluding Low



$E_{pot} > min$

$E_{pot} = min$

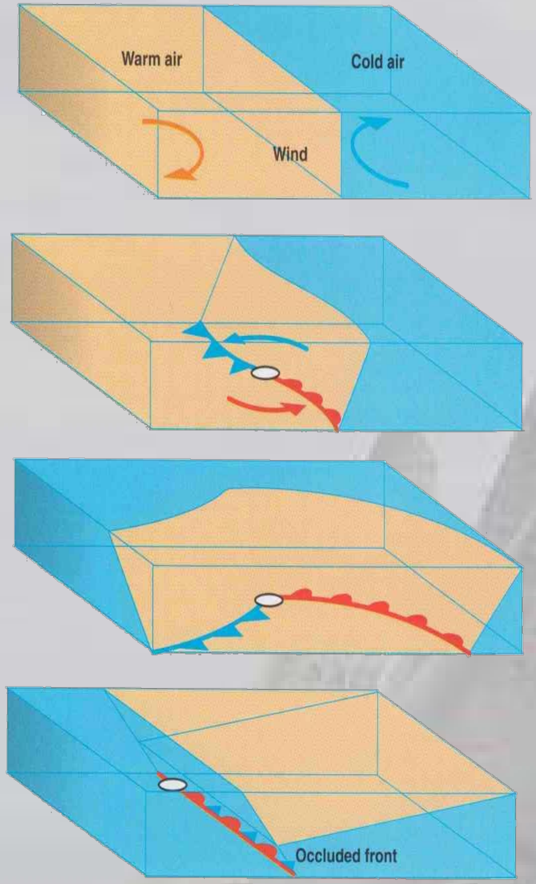


E_{pot} decrease <=> E_{kin} increase

WIND !

Energy aspects

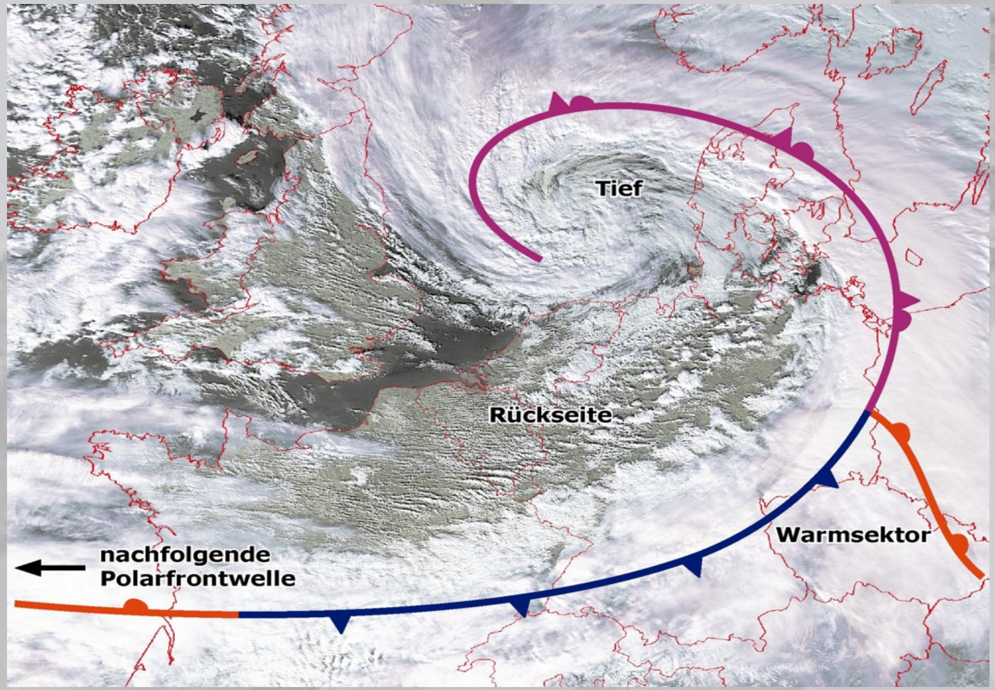
$E_{pot} + E_{kin} = const.$



$E_{pot} > min$

$E_{pot} = min$

Occluded Low

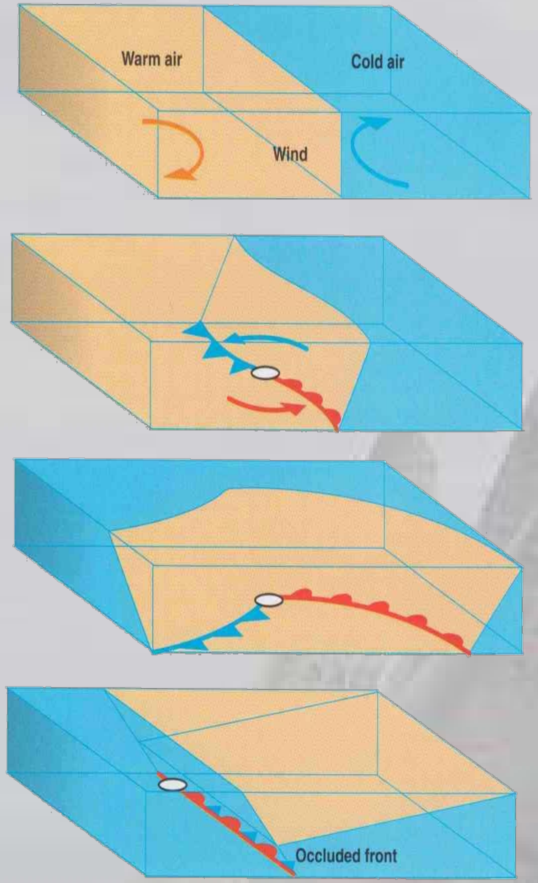


E_{pot} decrease <=> E_{kin} increase

WIND !

Energy aspects

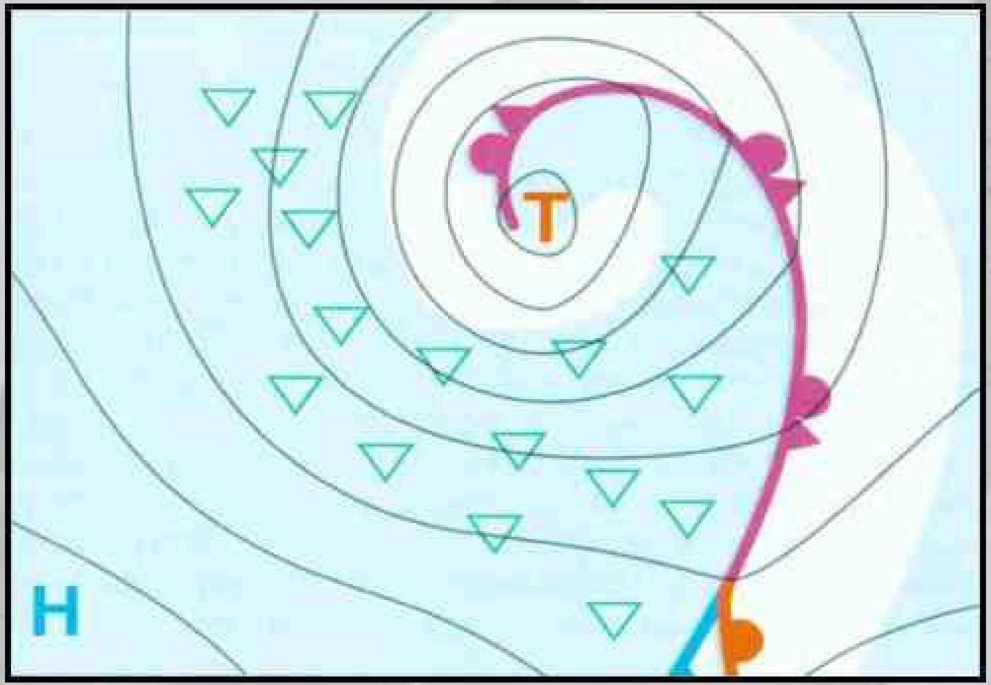
$$E_{pot} + E_{kin} = const.$$



E_{pot} > min

E_{pot} = min

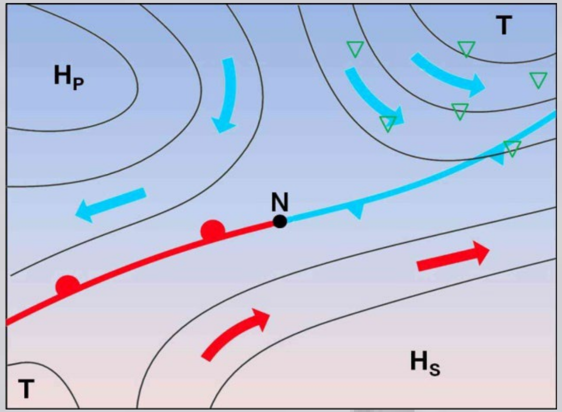
Occluded Low



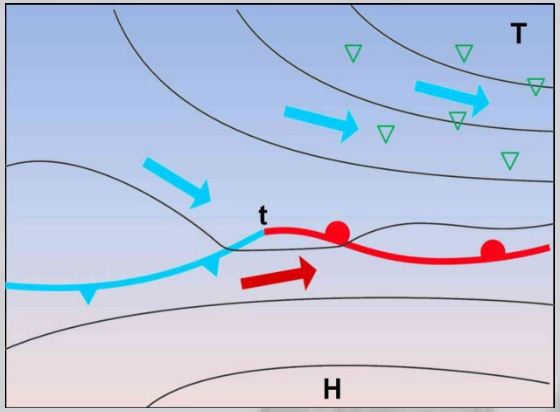
E_{pot} = min

Development accomplished

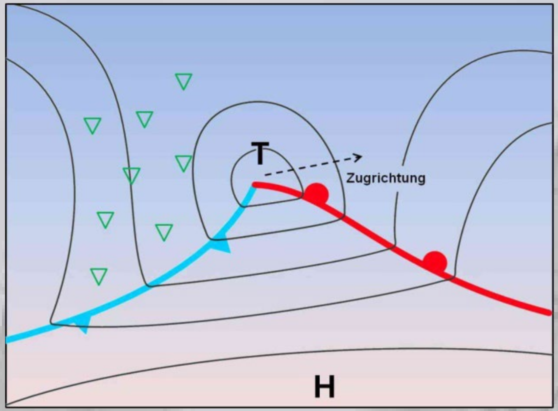
IDEAL LOW: STAGES OF DEVELOPMENT



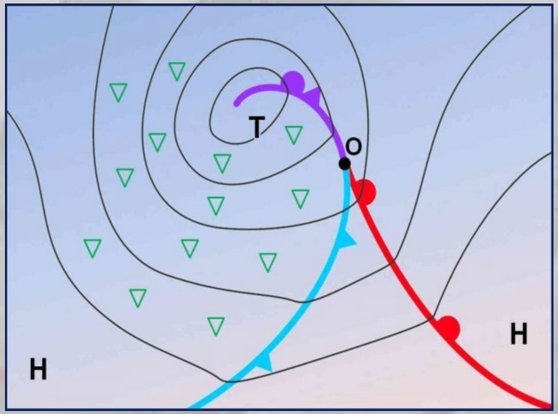
Airmass boundary



wave disturbance

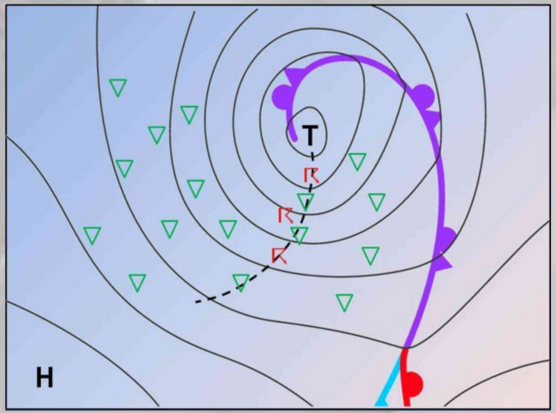


developing Low



Occluding Low

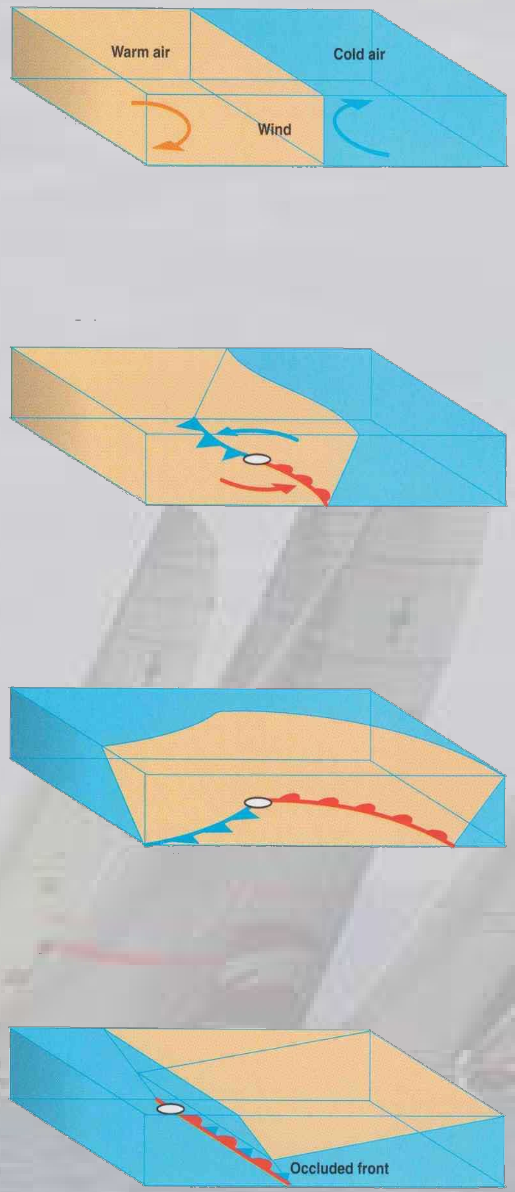
occluded Low

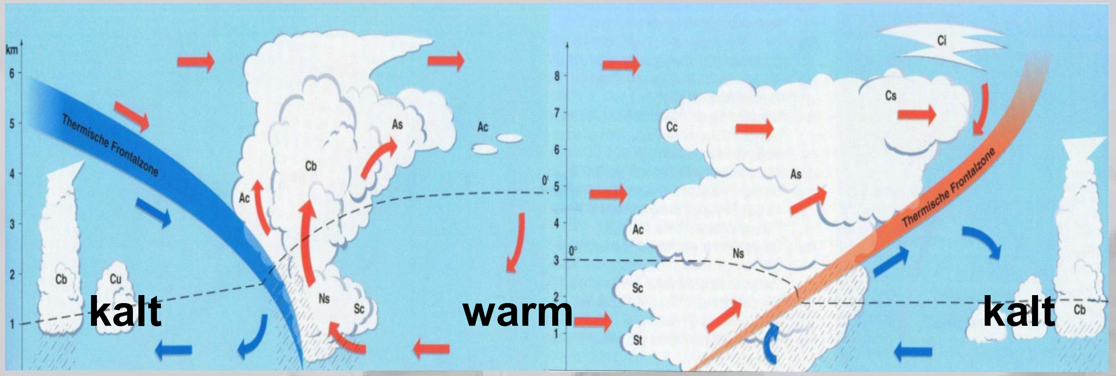


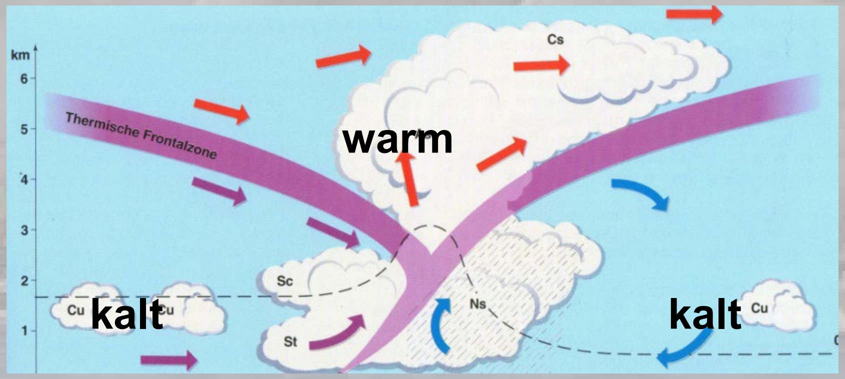
occluded Low with trough

Why ?

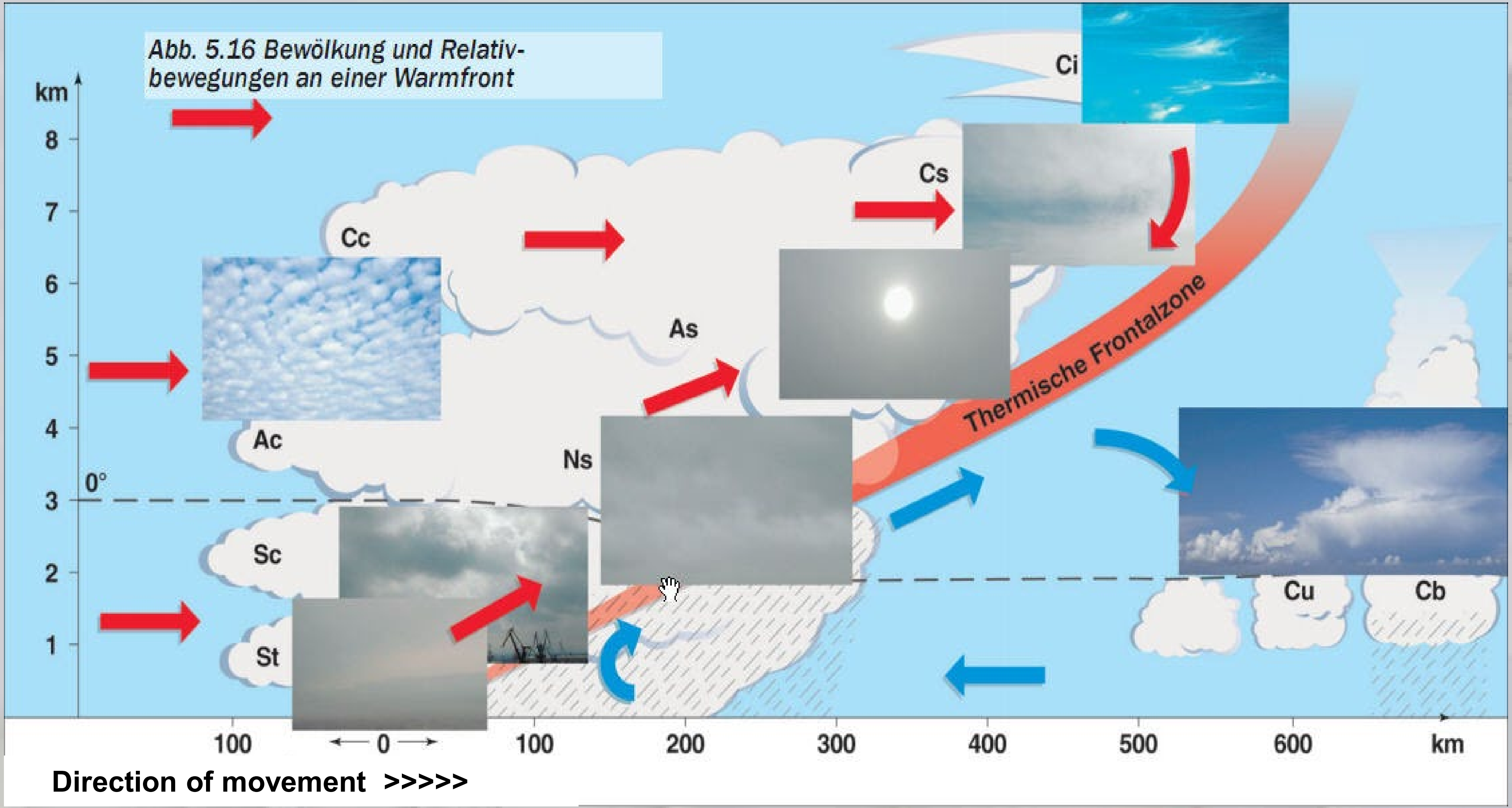
IDEAL LOW: STAGES OF DEVELOPMENT



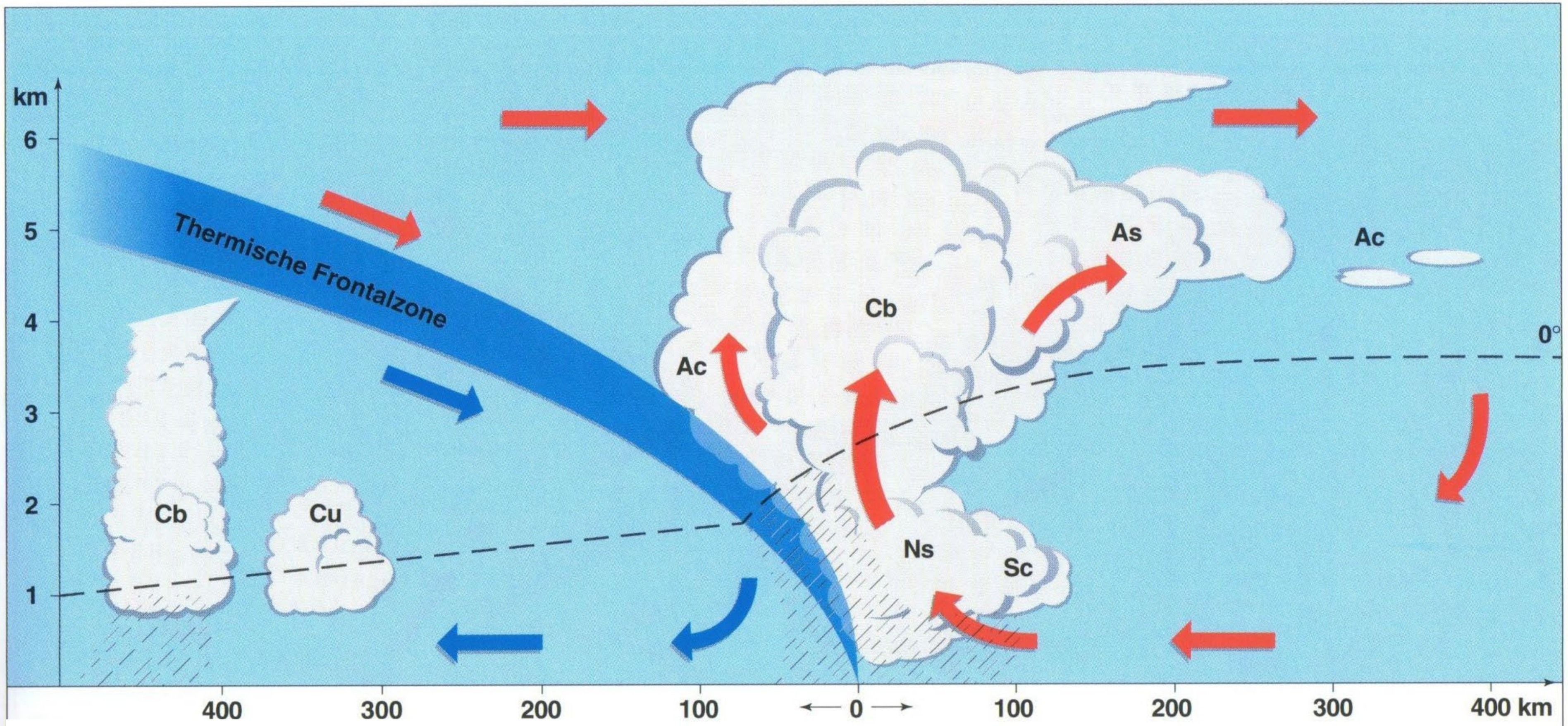




IDEAL LOW: WARMFRONT



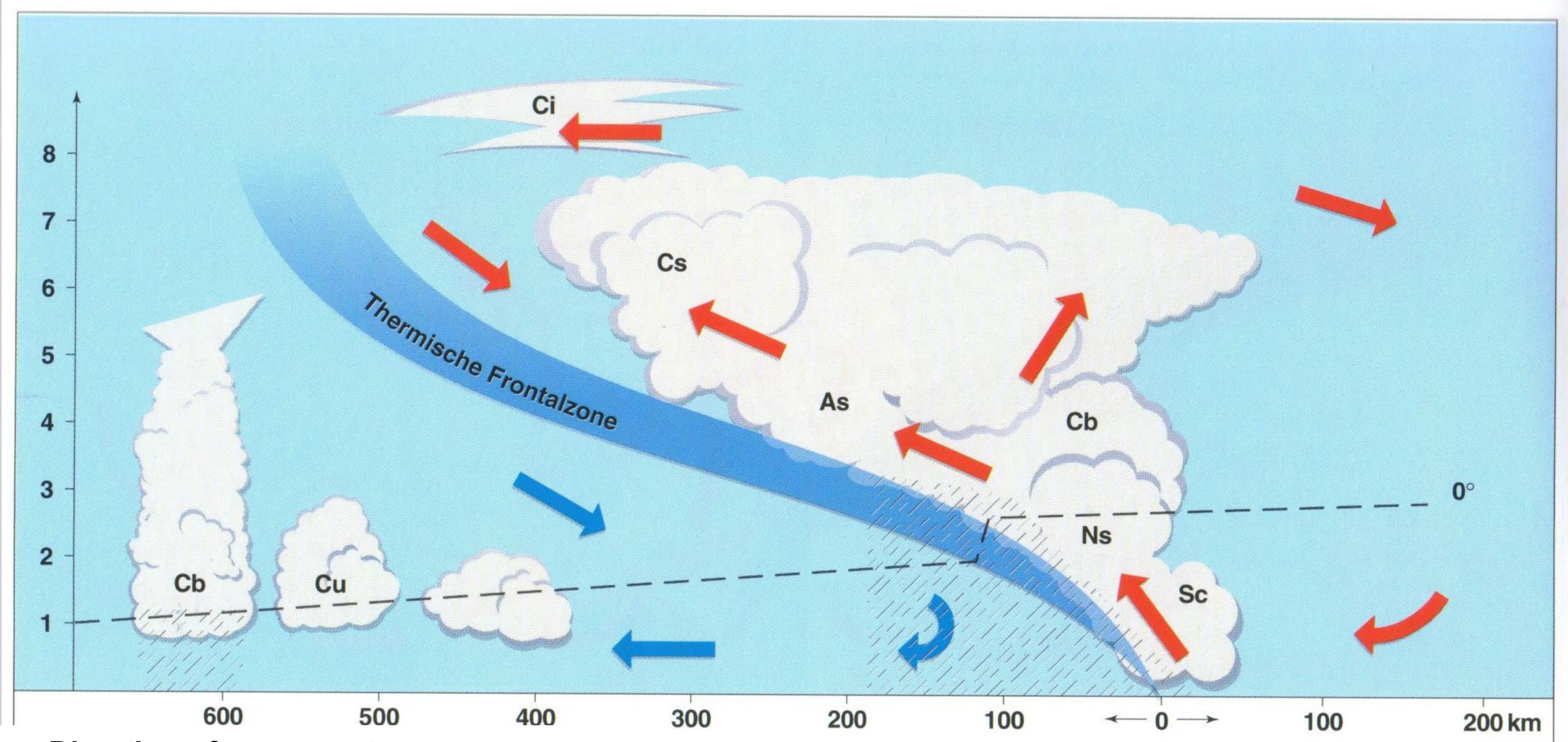
COLDFRONT 1. TYPE ACTIVE OR FAST MOVING COLDFRONT



Direction of movement >>>>>

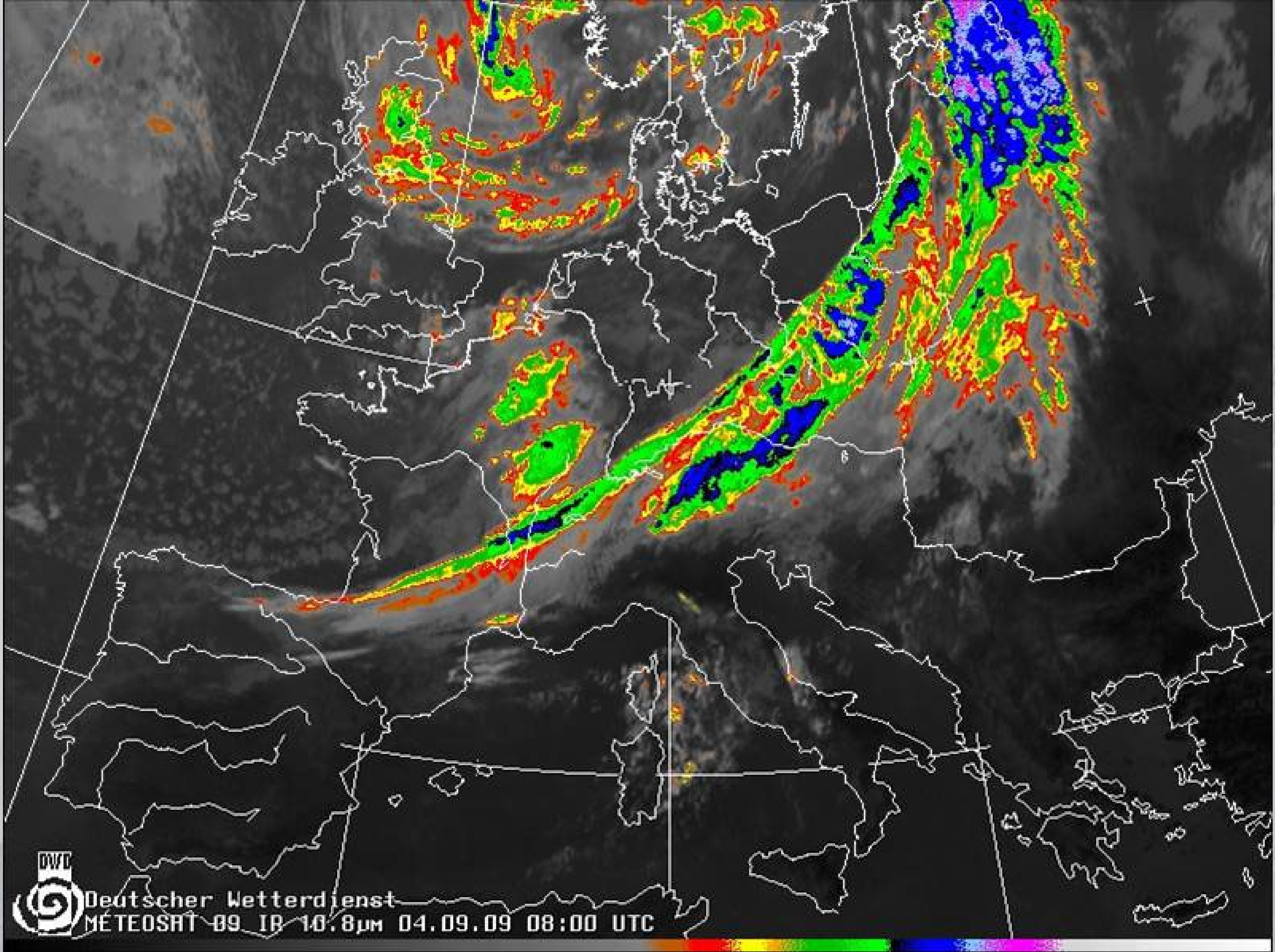
Active lifting of warm air by the cold air, fast moving,
Precipitation ahead of the coldfront (prefrontal), strong winds/gusts behind

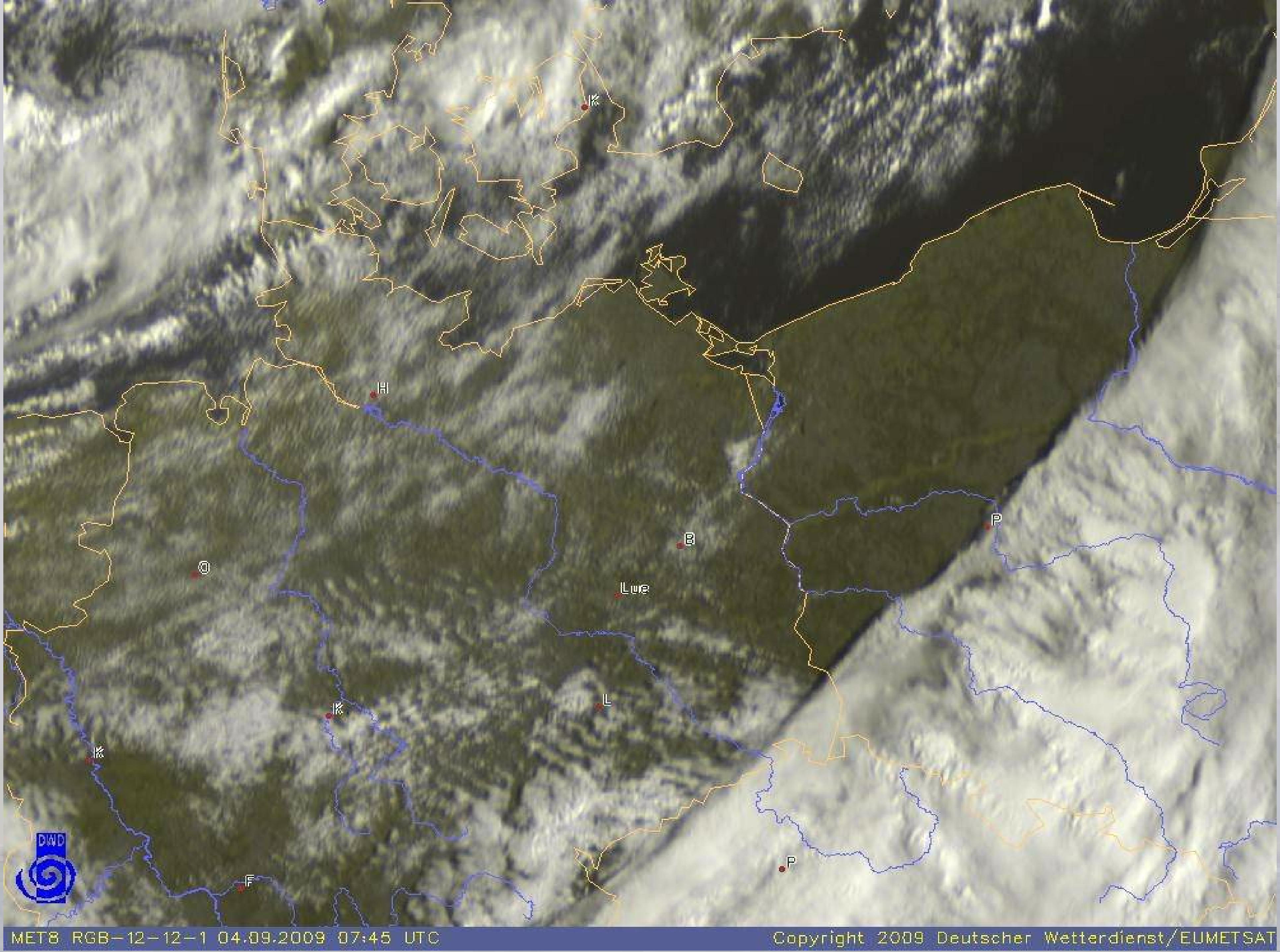
Coldfront 2. Passive Coldfront or kata coldfront



Direction of movement >>>>>

Passive lifting of warm air, slowly moving, may be stationary,
Precipitation behind the coldfront (post-frontal), wind decreasing


DWD
Deutscher Wetterdienst
METEOSAT 09 IR 10.8μm 04.09.09 08:00 UTC



K
H
B
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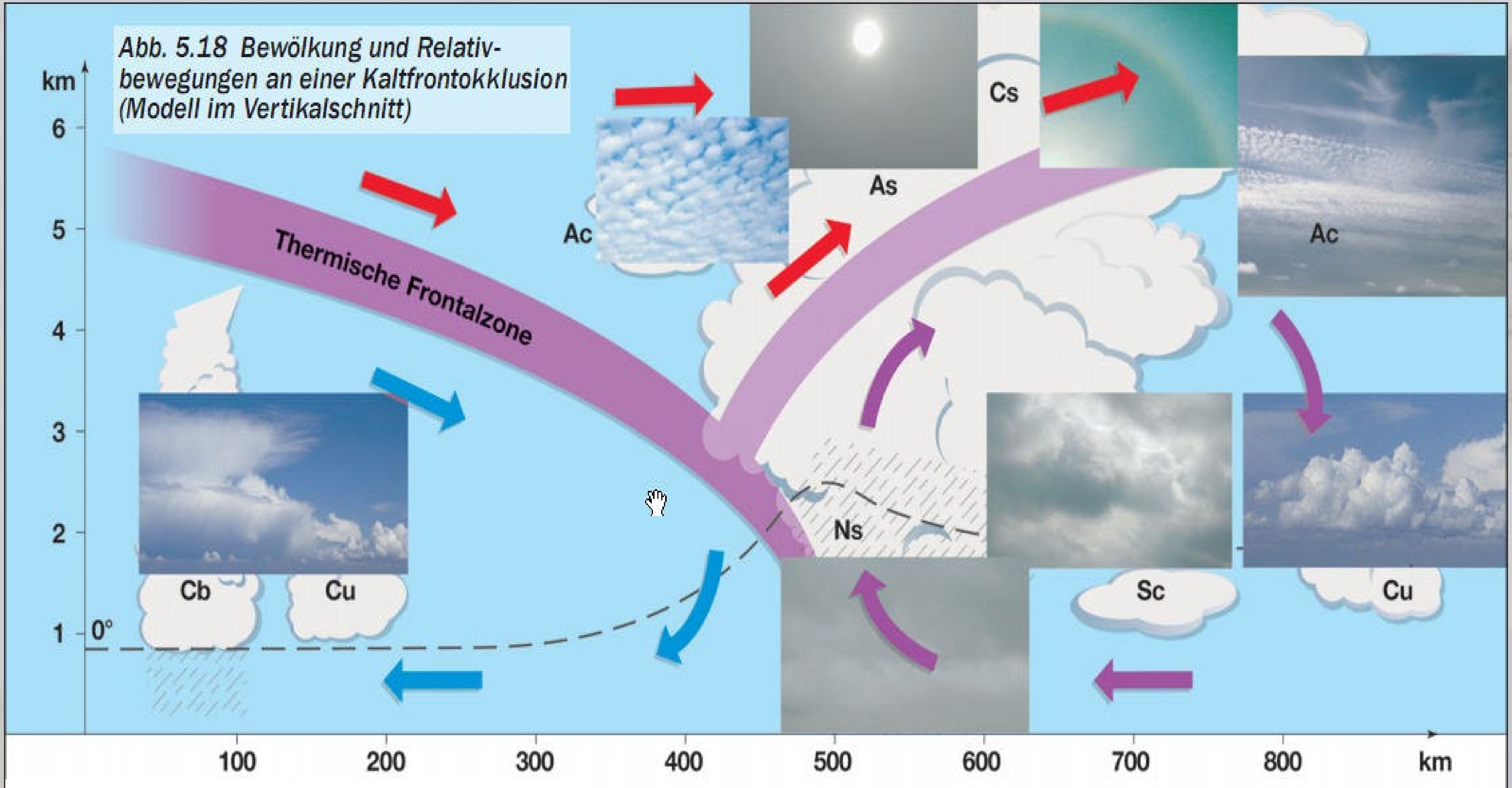
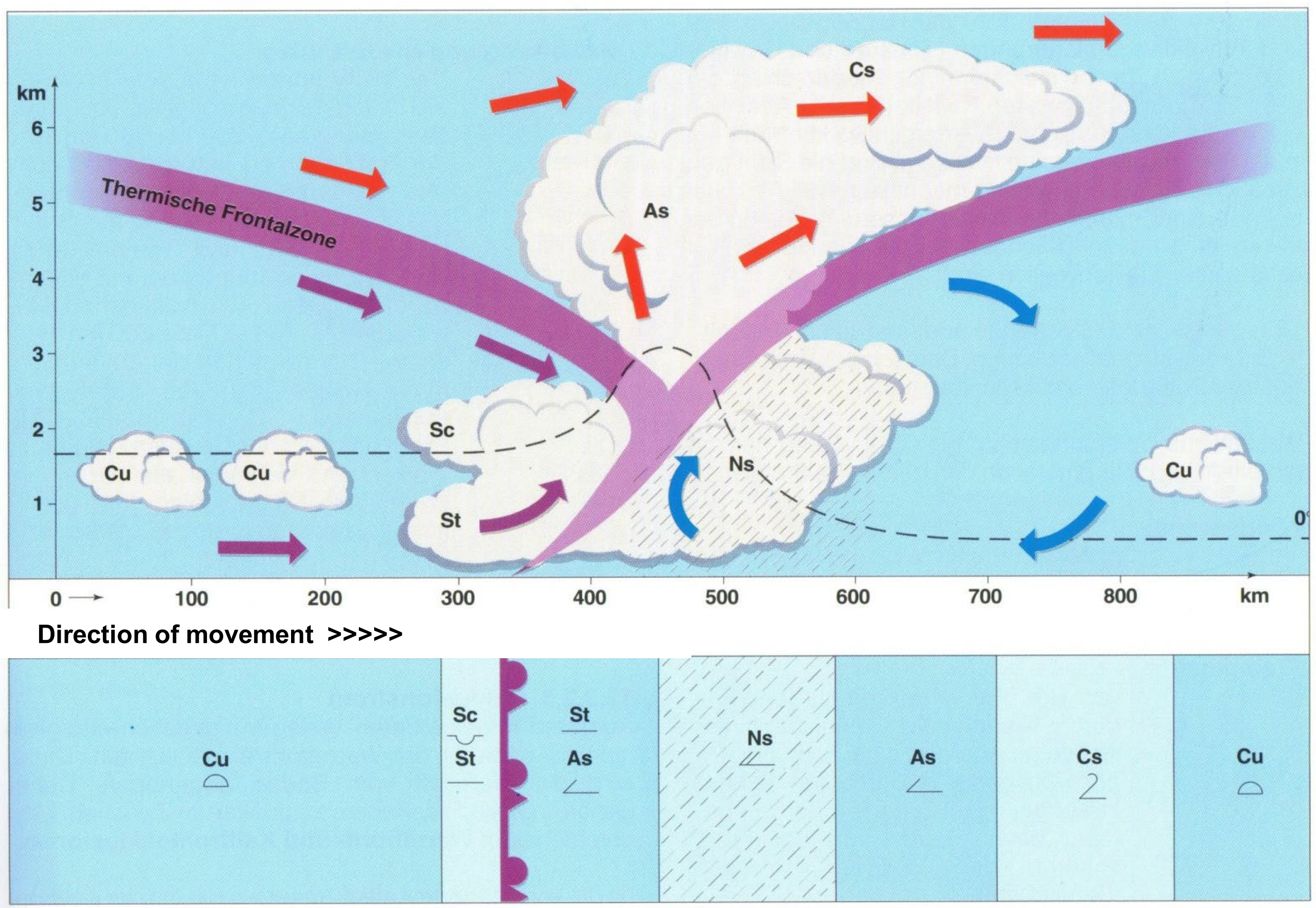
Lue
L
K
K
P
P
F
DWD
MET8 RGB-12-12-1 04.09.2009 07:45 UTC
Copyright 2009 Deutscher Wetterdienst/EUMETSAT

IDEAL LOW : OCCLUSION

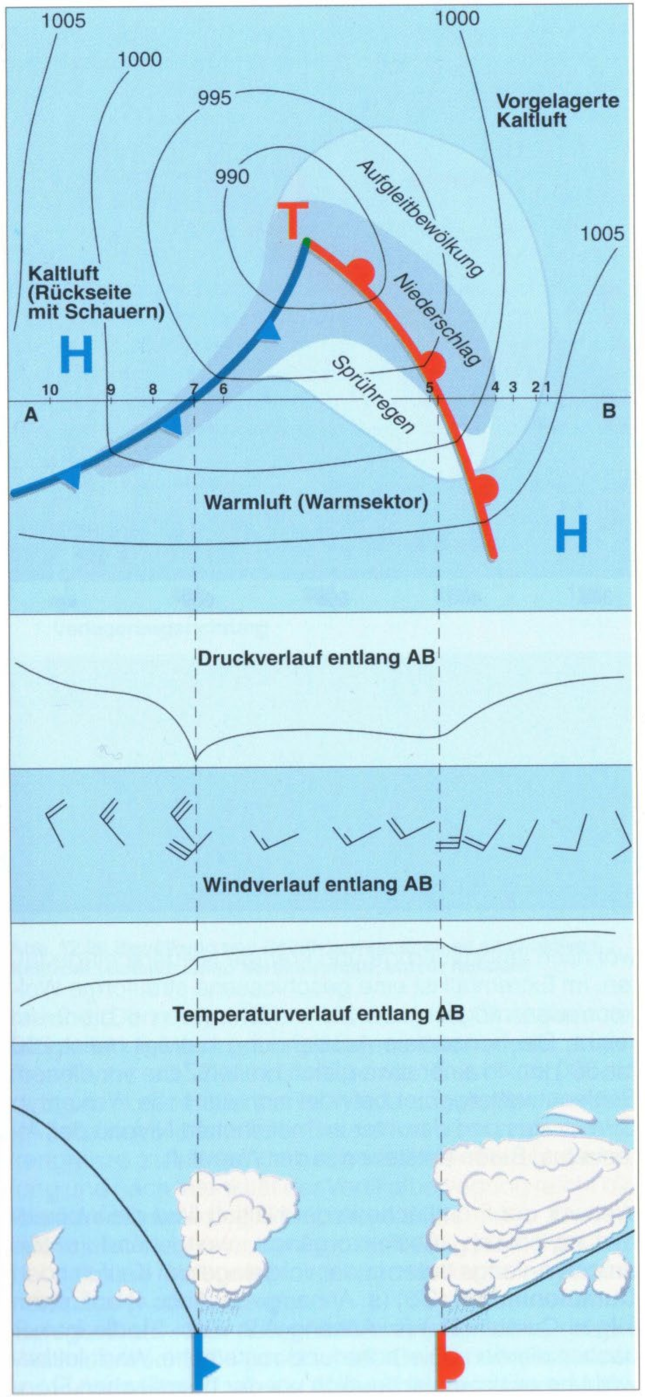


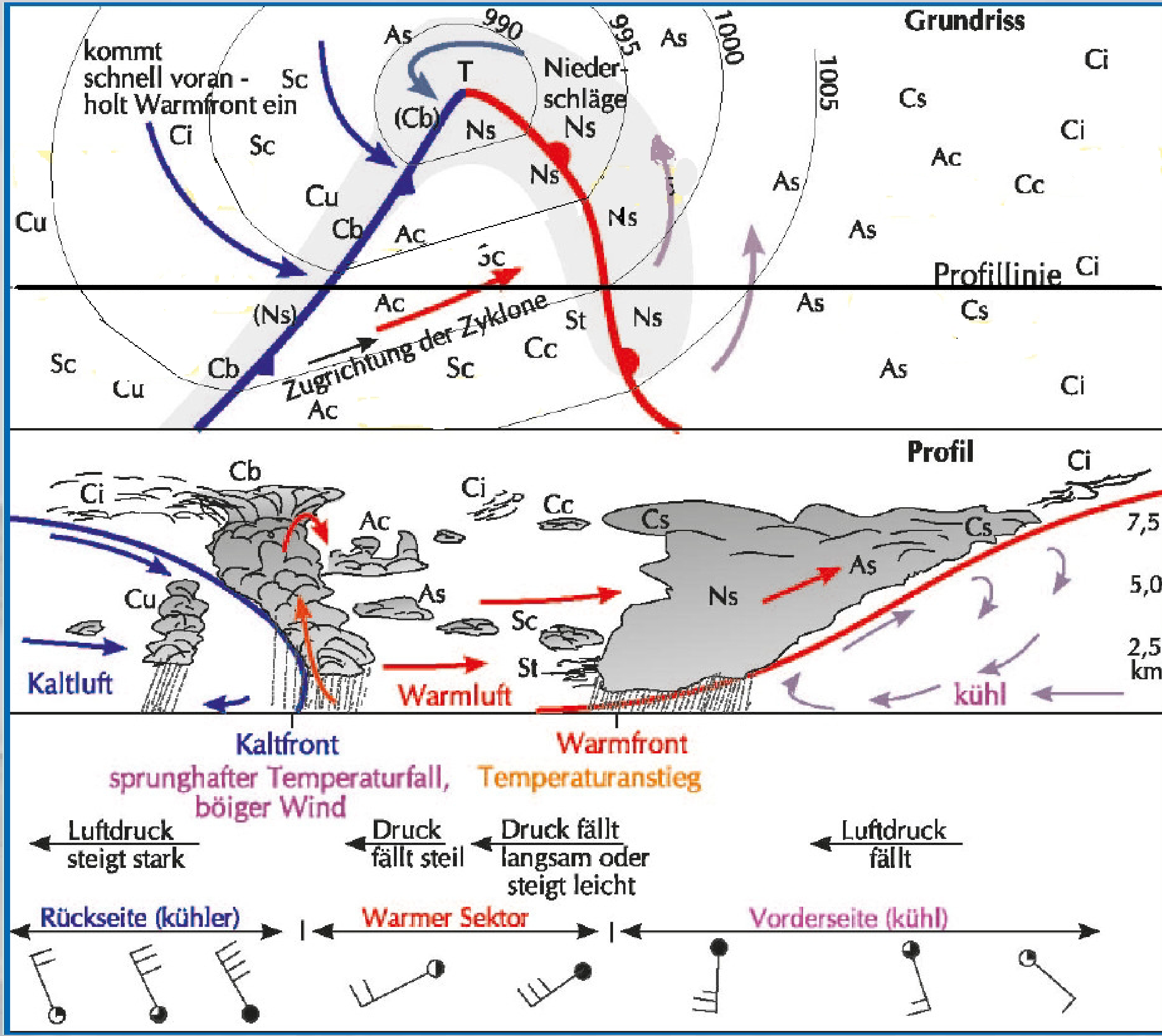
Direction of movement >>>>>

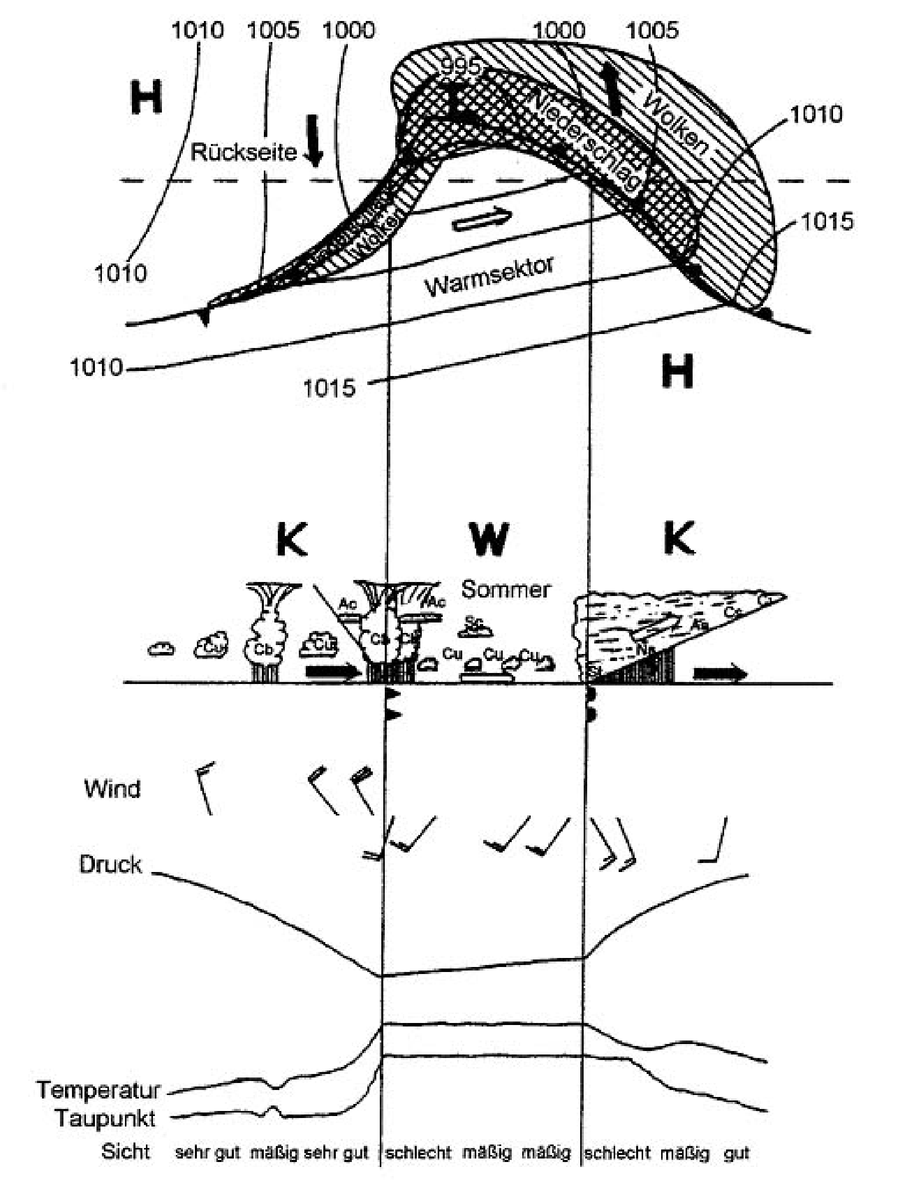
Ideal Low: Warmfront occlusion

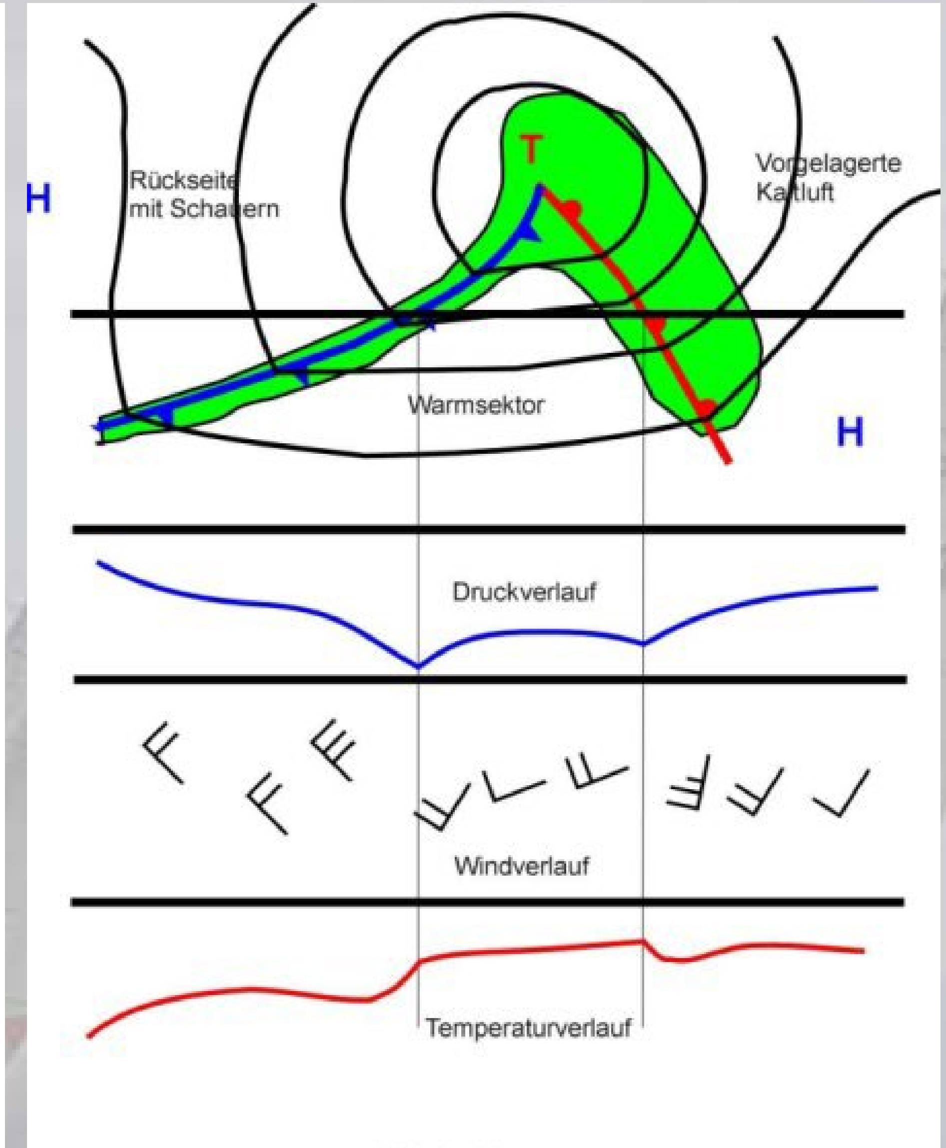


Vertical structure and relative movement of a Warmfron Occlusion


1005
1000
995
990
1000
1005
Vorgelagerte Kaltluft
T
Aufgleitbewölkung
Niederschlag
Sprühregen
Kaltluft (Rückseite mit Schauern)
H
A
B
10 9 8 7 6 5 4 3 2 1
Warmluft (Warmsektor)
H
Druckverlauf entlang AB
Windverlauf entlang AB
Temperaturverlauf entlang AB


Grundriss
kommt schnell voran - holt Warmfront ein
T
(Cb)
Nieder-schläge
990
995
1000
1005
Profillinie
Zugrichtung der Zyklone
Profil
Kaltluft
Warmluft
kühl
7,5
5,0
2,5 km
Kaltfront
sprunghafter Temperaturfall, böiger Wind
Warmfront
Temperaturanstieg
Luftdruck steigt stark
Druck fällt steil
Druck fällt langsam oder steigt leicht
Luftdruck fällt
Rückseite (kühler)
Warmer Sektor
Vorderseite (kühl)





Idealzyklone

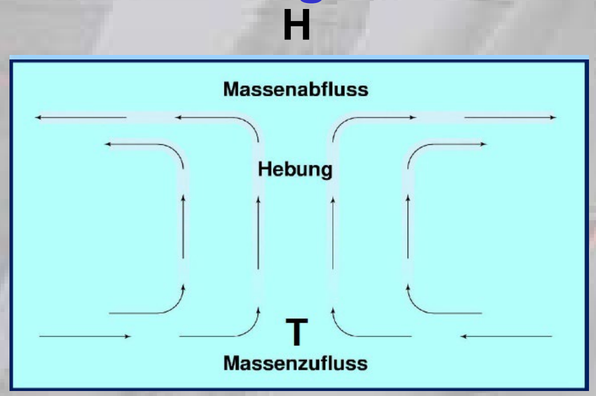
WHEN DOES A LOW DEVELOP – WHEN DOES IT NOT?

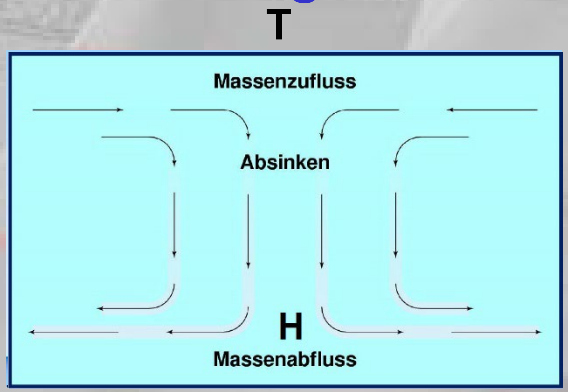
Thermal conditions are required – see above! (N/S-temperature difference)
… but also required are …
Dynamic conditions of the upper air flow:

Impact of the upper air flow on …

- … development of rotational motion
- … vertical motion
- … cyclogenetic developments

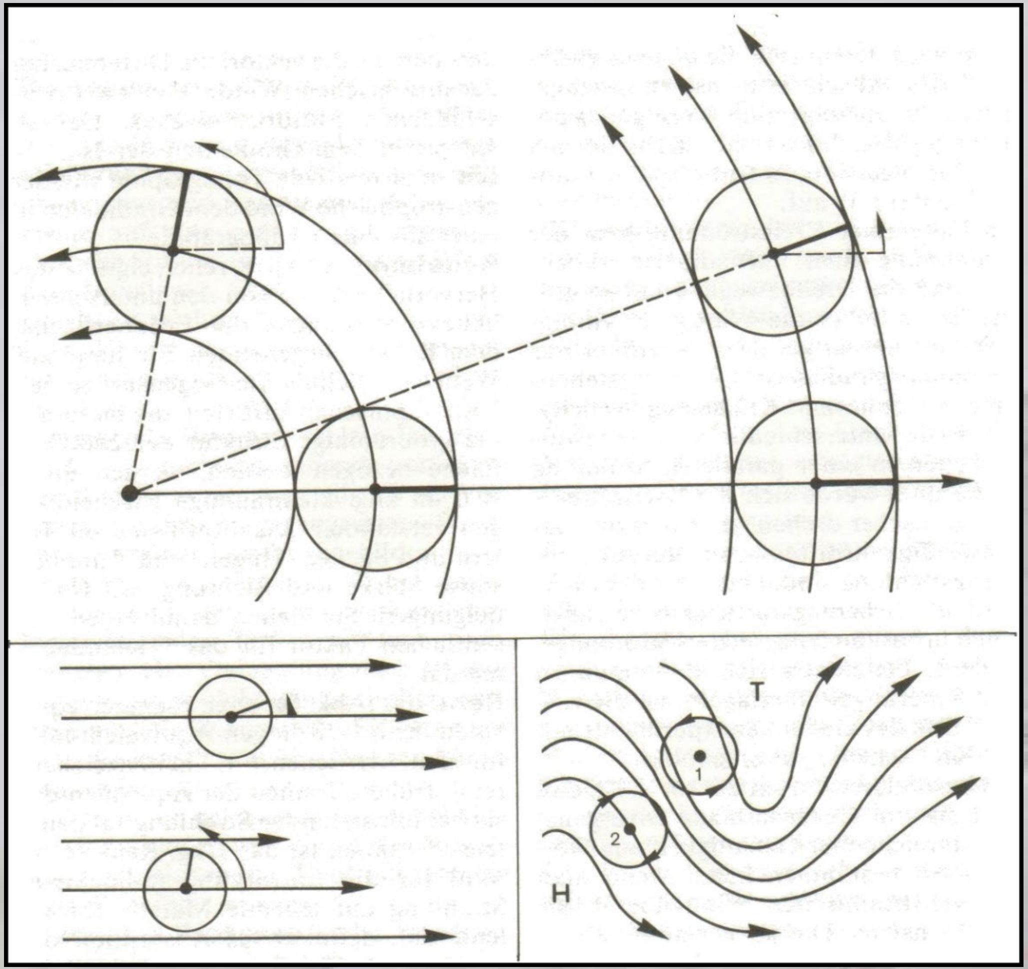
Upper air - **Divergence** **Convergence**





Surface - **Convergence** **Divergence)))**

Generation of rotation (disc in horizontal flow)



In flow with curved trajectories due to curvature effects

or

In flow with straight parallel trajectories due to wind shear effects

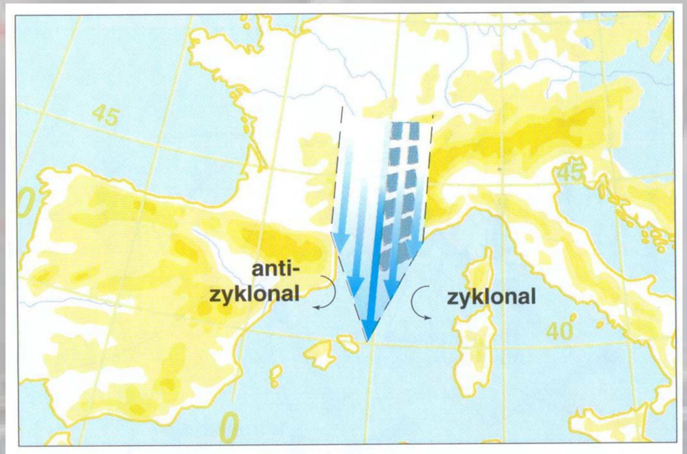
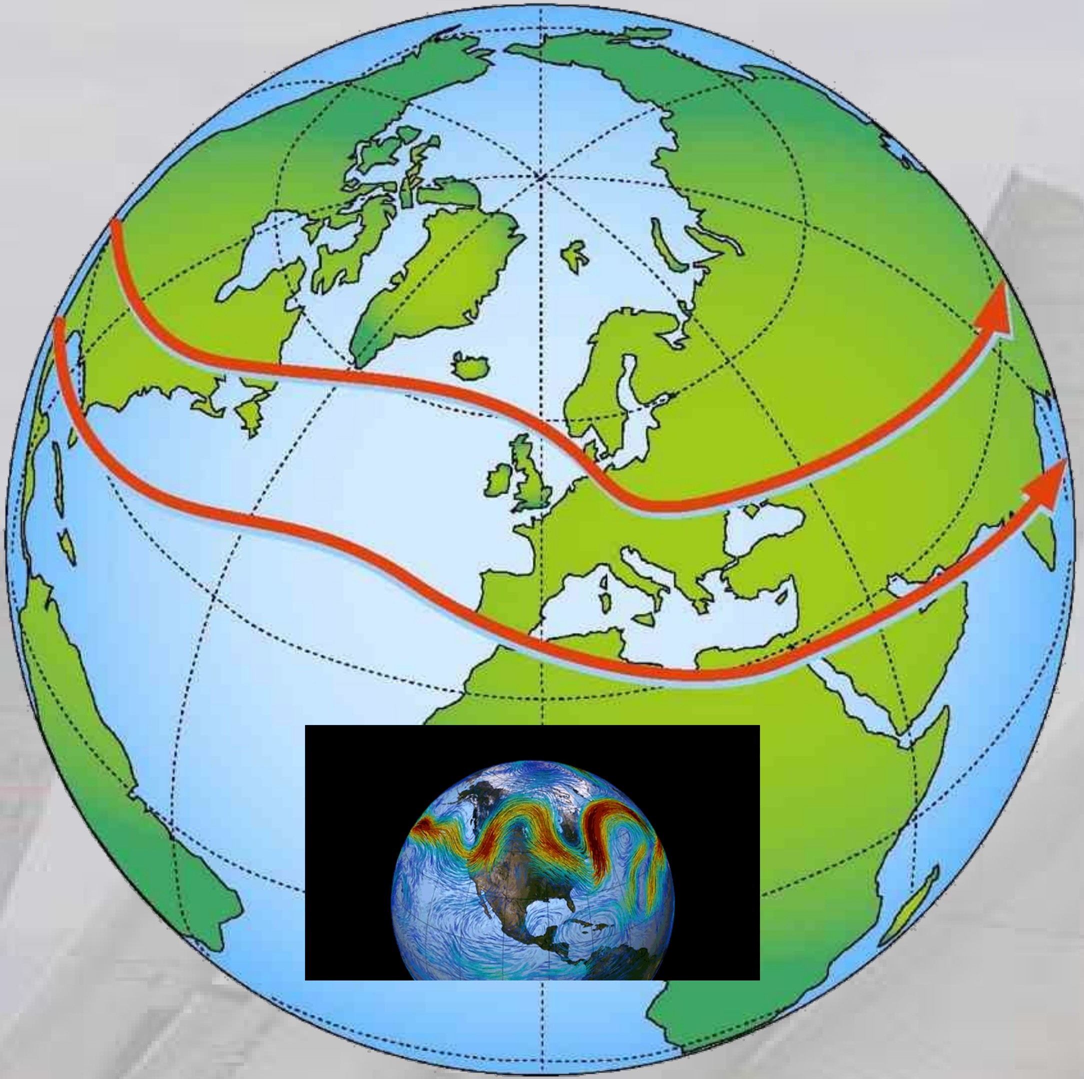
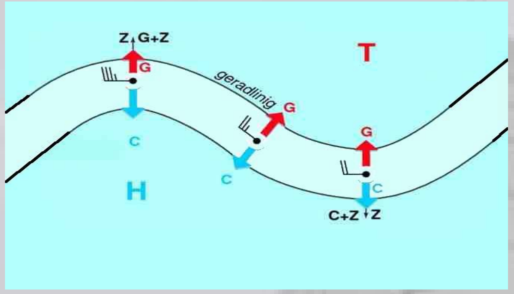


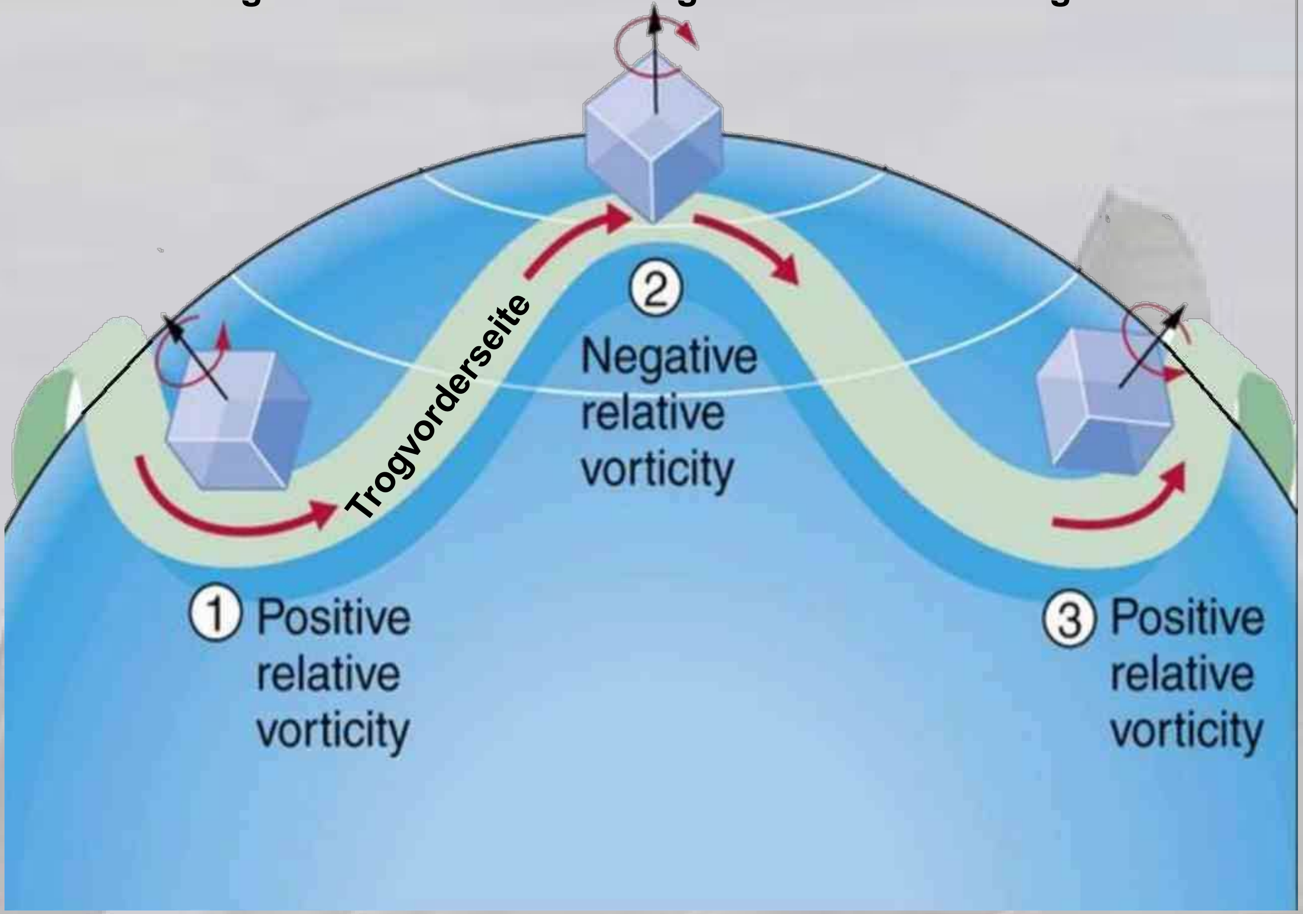
Abb. 23.7 Entstehung von Scherungs-Vorticity in einem bodennahen Starkwindfeld

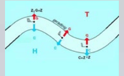
Vorticity is a measure of vortex




Z
G+Z
G
T
geradlinig
G
C
H
C
G
C
C+Z
Z

Vorticity:	Maximum	Minimum	Maximum
Upper air flow:	Trough	Ridge	Trough

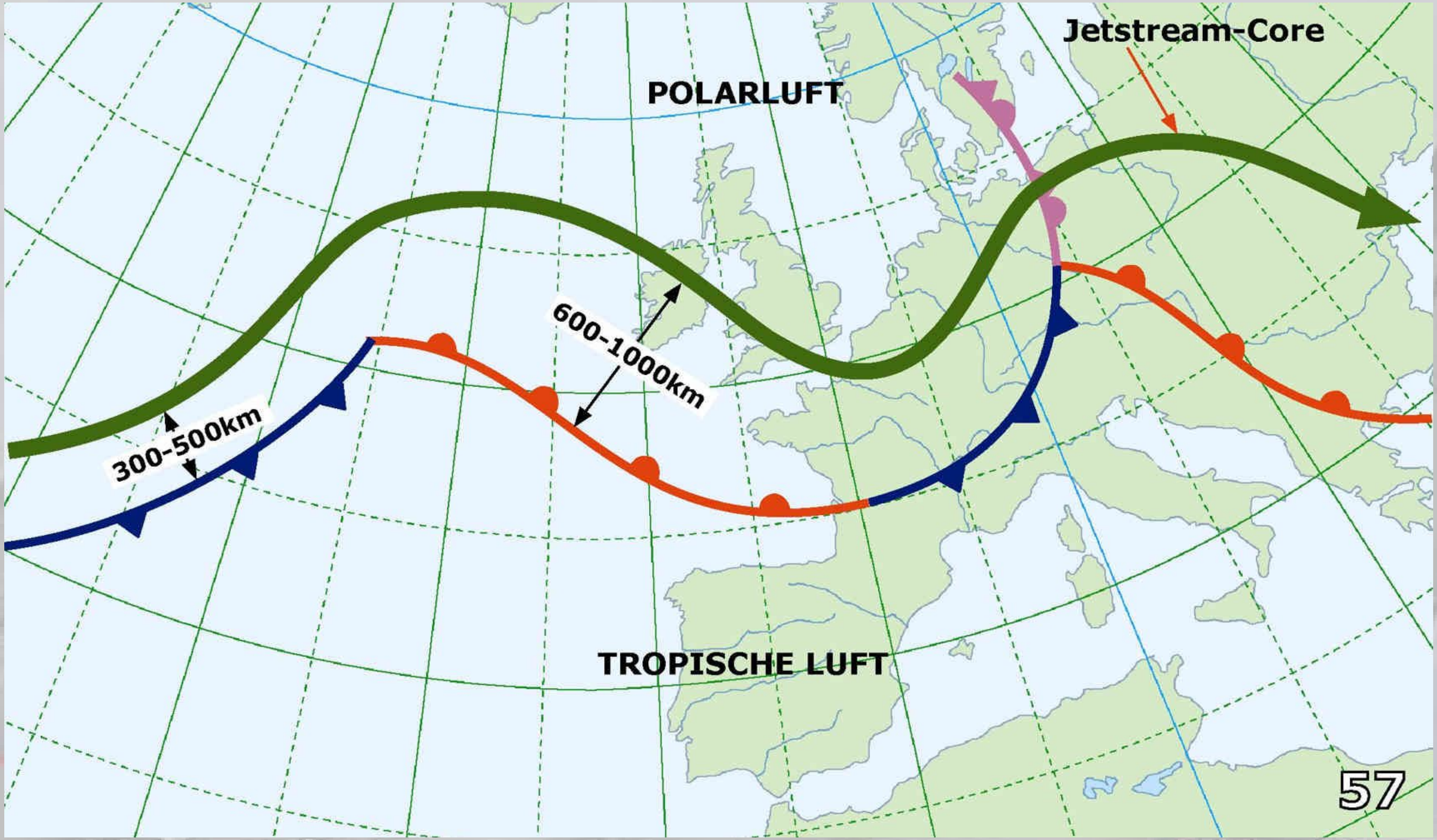




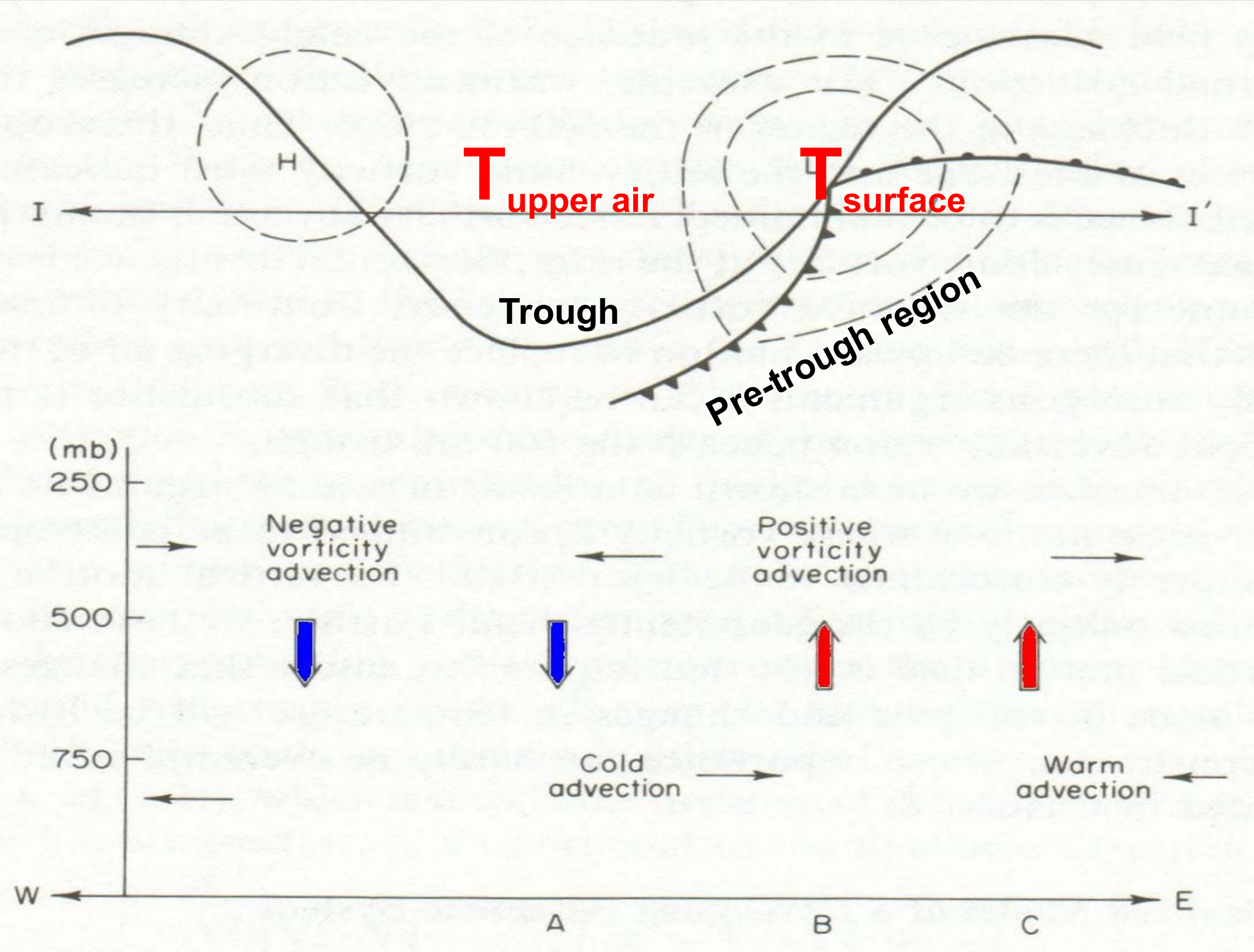
Lifting by **- Positive vorticity advection**

Subsidence by **- Negative vorticity advection**

Vorticity:	**Minimum**	**Maximum**	**Minimum**
Upper air flow:	**Ridge**	**Trough**	**Ridge**



Vorticity: Minimum Maximum Minimum
Upper air flow: Ridge Trough Ridge



Lifting by - Positive vorticity advection
- Warm air advevtion

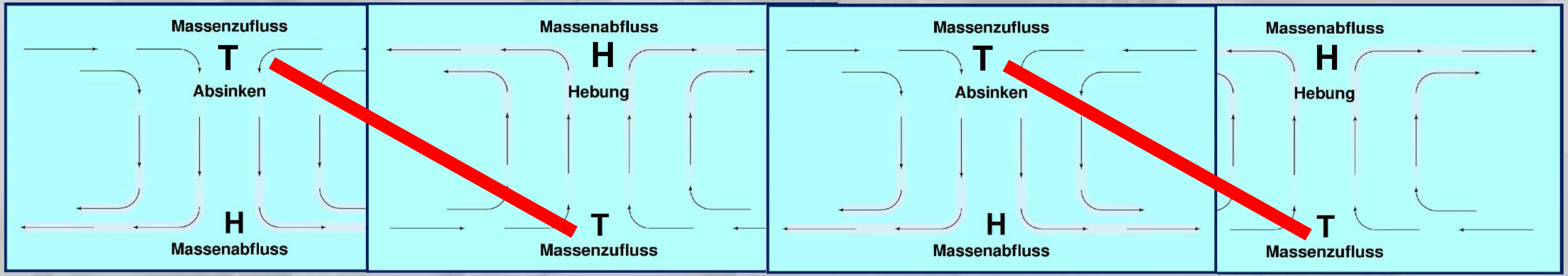
Subsidence by - Negative vorticity advection
- Cold air advection

Coupling of upper air flow and surface pressure field

Impact of the upper air flow on …

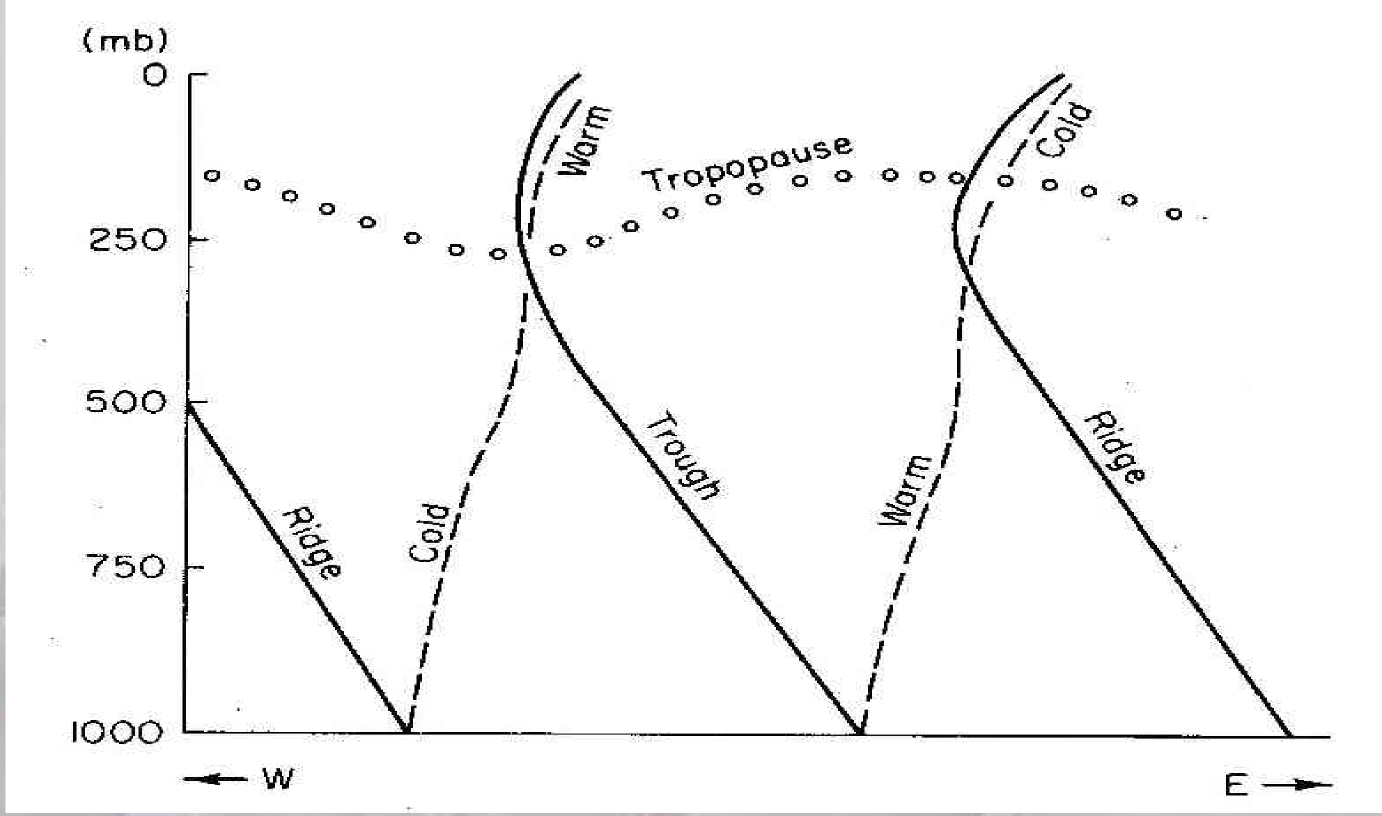
- … development of vortices
- … vertical motion
- … Cyclogenesis

Upper air - Convergence Divergence Convergence Divergence



Surface - Divergence Convergence Divergence Convergence

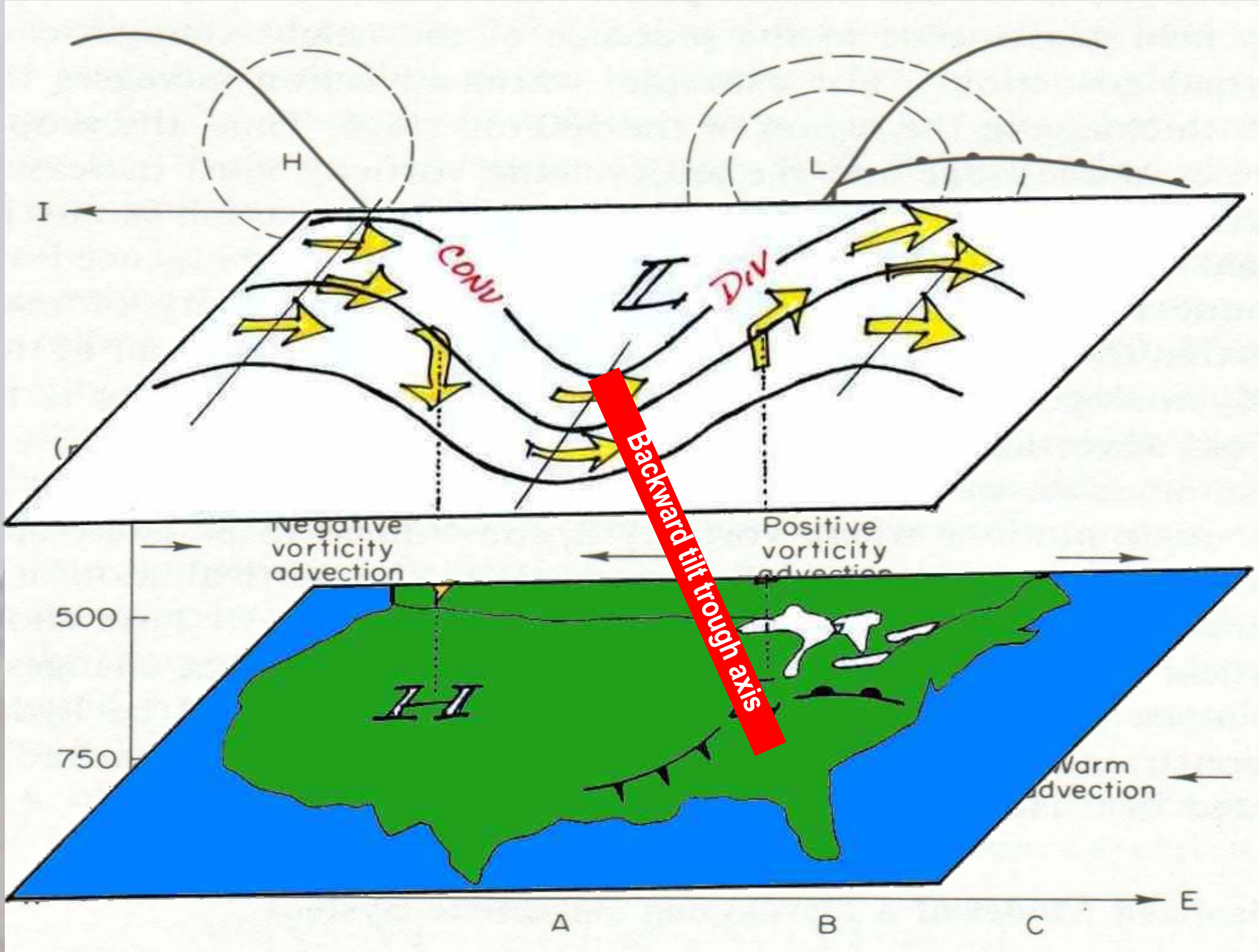
Vorticity:	**Minimum**	**Maximum**	**Minimum**
Upper air flow:	**Ridge**	**Trough**	**Ridge**



Lifting by - **Positive vorticity advection**
- **Warm air advevtion**

Subsidence by - **Negative vorticity advection**
- **Cold air advection**

Vorticity:	**Minimum**	**Maximum**	**Minimum**
Upper air flow:	**Ridge**	**Trough**	**Ridge**

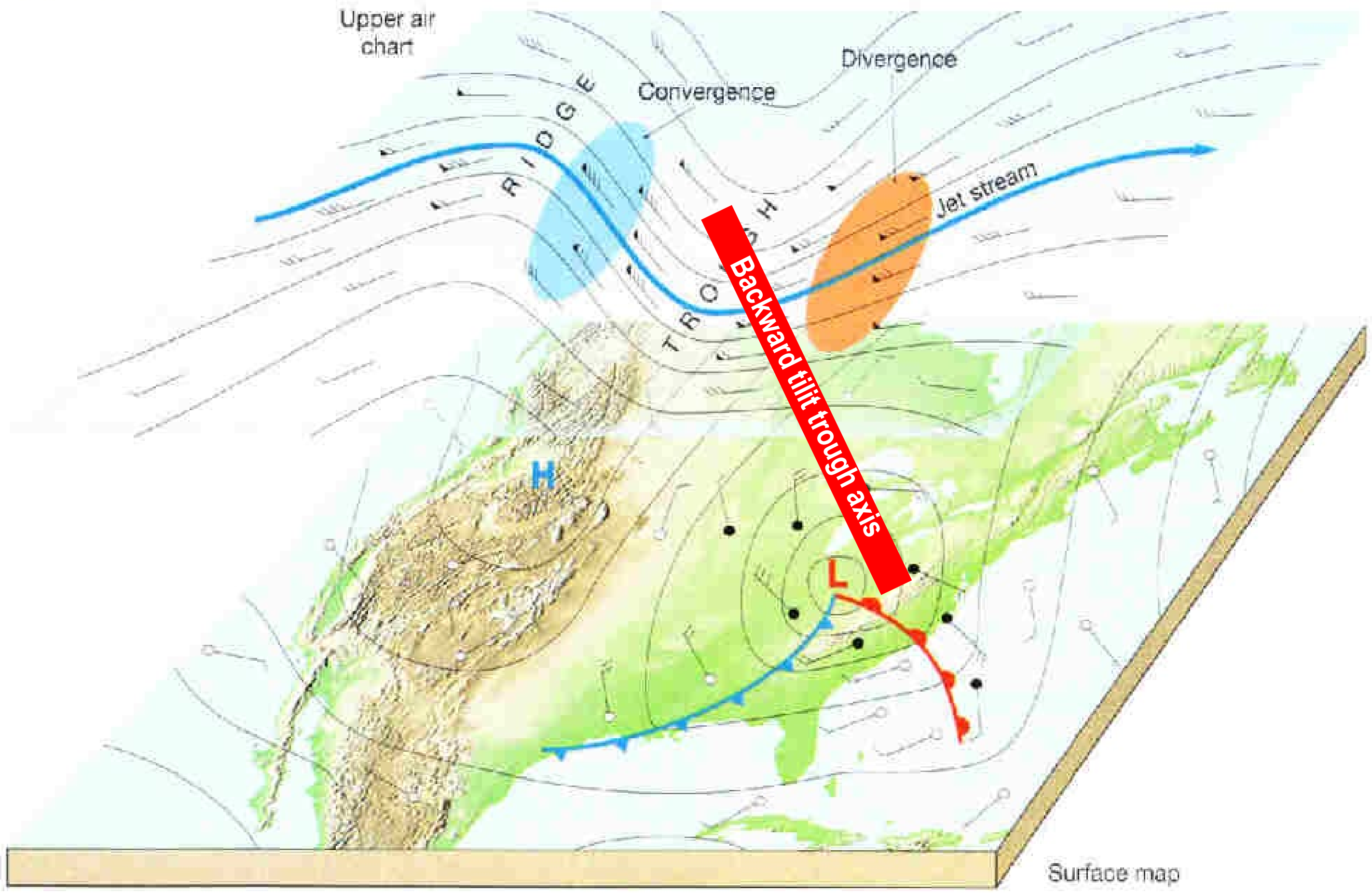


Lifting by - Positive vorticity advection
- Warm air advevtion

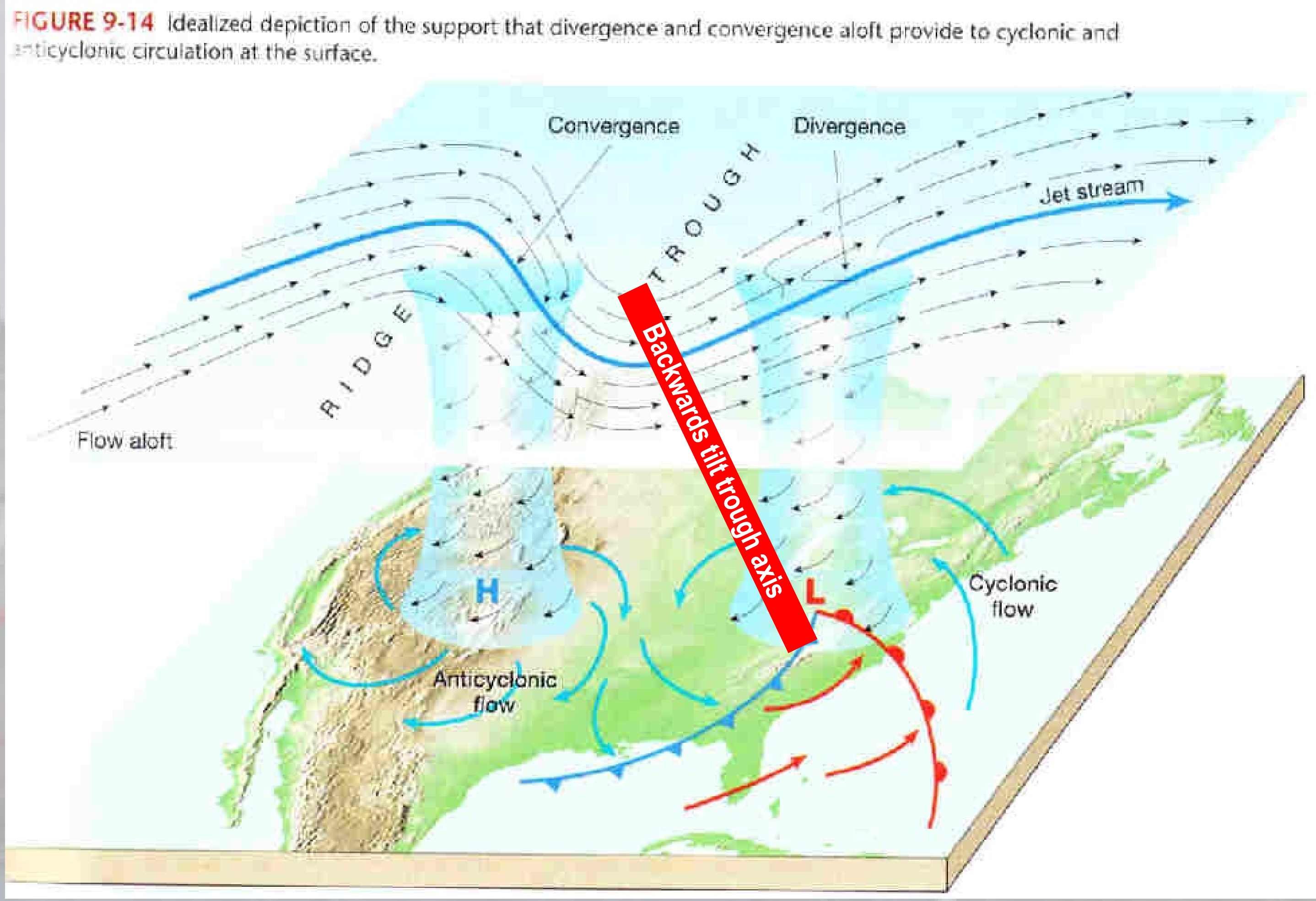
Subsidence by - Negative vorticity advection
- Cold air advection

Coupling of Upper air flow and Surface pressure field

FIGURE 9-13 Relationship of the wavy flow pattern aloft to surface cyclones and anticyclones.



Coupling of Upper air flow and Surface pressure field



CHECKLIST IDEAL CYCLON AND CYCLOGENESIS

Ideal Cyclone

- ✓ How do Cyclones develop
  - ✓ 1. Baroclinic situation (i.e. horizontal temperature gradient)
  - ✓ 2. Upper Air flow pattern: Pre-Trough Area with high level divergence

Ideal Cyclone Questions you should be able to answer

Ideal Cyclone

- ✓ **How?**
  - ✓ **…**
  - ✓ **…**
  - ✓ **…**

- ✓ **How?**
  - ✓ **…**
  - ✓ **…**