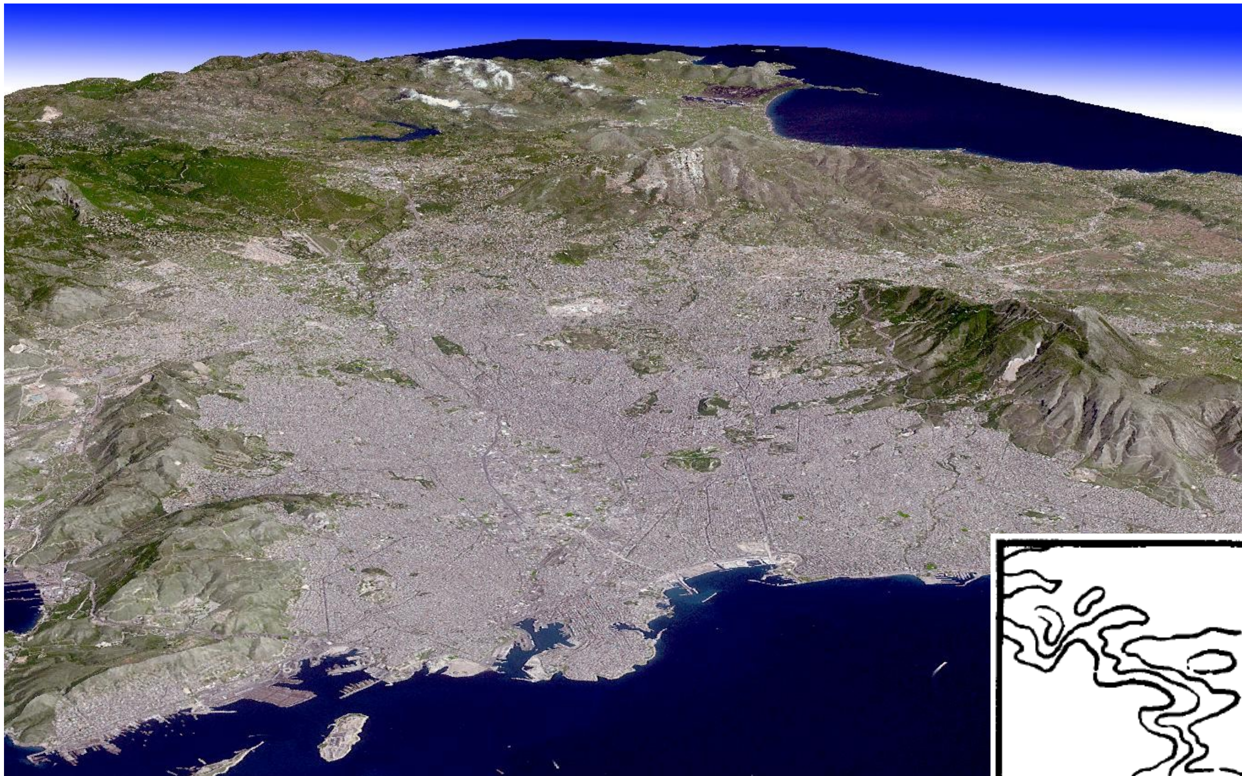
Lower Tropospheric Structure and Synoptic Scale Circulation Patterns During Prolonged Temperature Inversions over Athens, Greece

N. G. Prezerakos, *Theor. Appl. Climatol.* **60**, 63-76 (1998)

Lindsay Hatch
November 10, 2009

Athens Region



http://en.wikipedia.org/wiki/Athens

Prezerakos, N.G. *Bound.-Layer Meteorol.* **36** (1986) 245-266

Goal: Analyze synoptic conditions leading to prolonged temperature inversions for better prediction of future pollution events

Methods

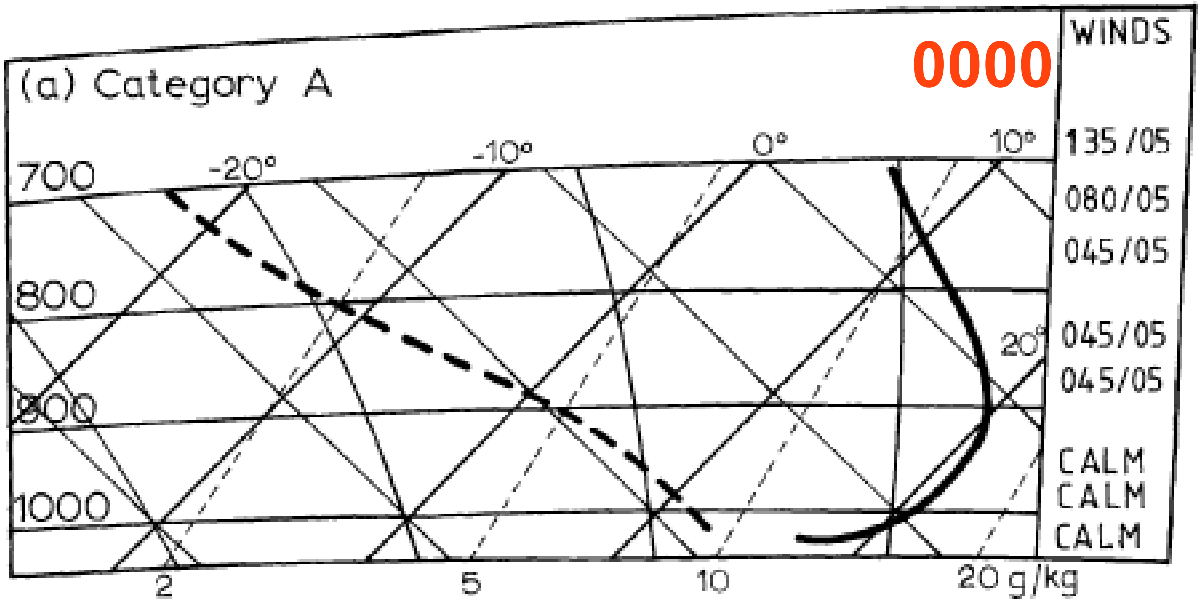
- Radiosonde measurements at 0000 & 1200 UTC (local time = UTC + 2)
  - Vertical temperature/wind structure
- Met data from European Centre of Medium range Weather Forecast (ECMWF)
  - Synoptic scale circulation patterns
- 297 Prolonged temperature inversions (>24 hrs) detected 1980-1994
  - Category A: radiation/subsidence; mostly in spring
  - Category B: advection; only during spring
  - Category C: radiation/subsidence + sea breeze; only during summer

Table 1. *Number of PTI per Month and Category within the 1980–1994 Period*

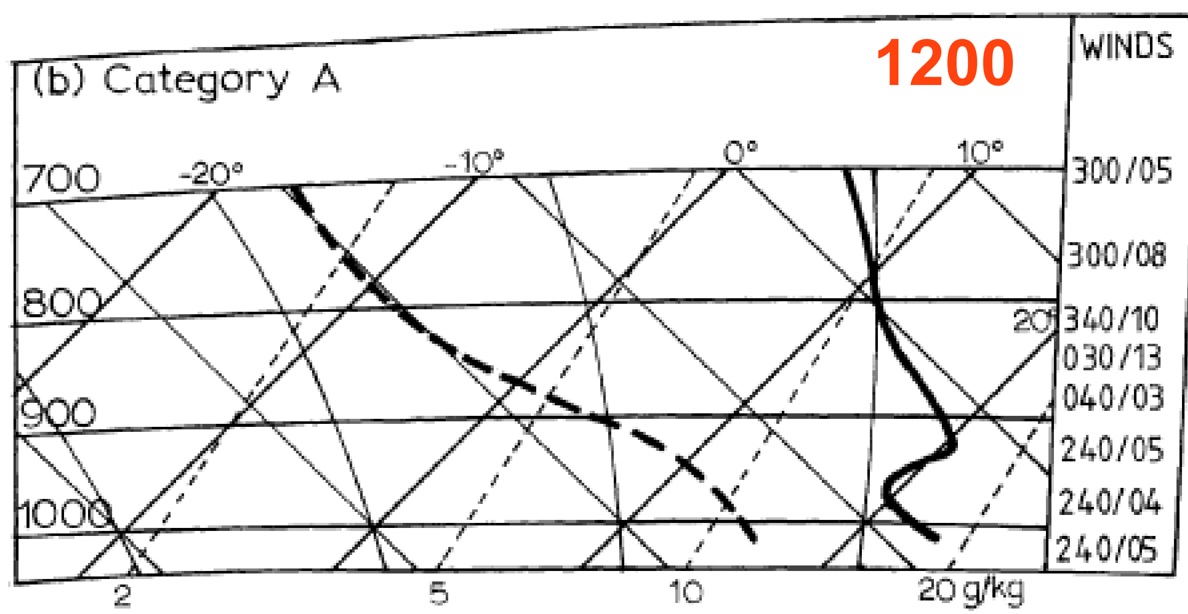
Month / Categ.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
A	7	12	18	26	36					23	5	3	130
B			15	12	5								32
C					15	60	15	15	30				135
Total	7	12	33	38	56	60	15	15	30	23	5	3	297

Focus on "F-days" for each representative month

A: Temperature/Wind Profiles



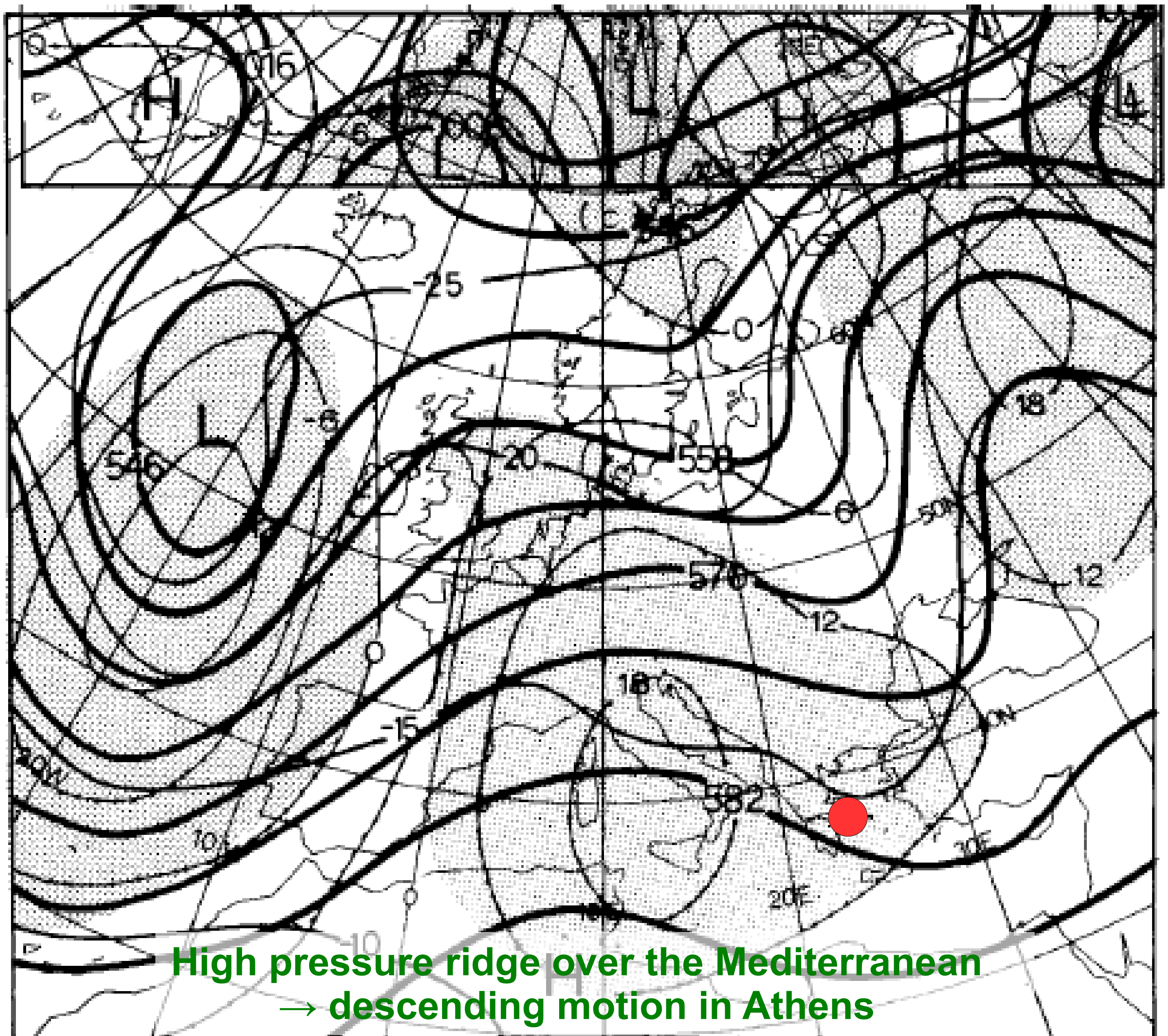
Typical nighttime surface inversion
• formed by radiative cooling & subsidence



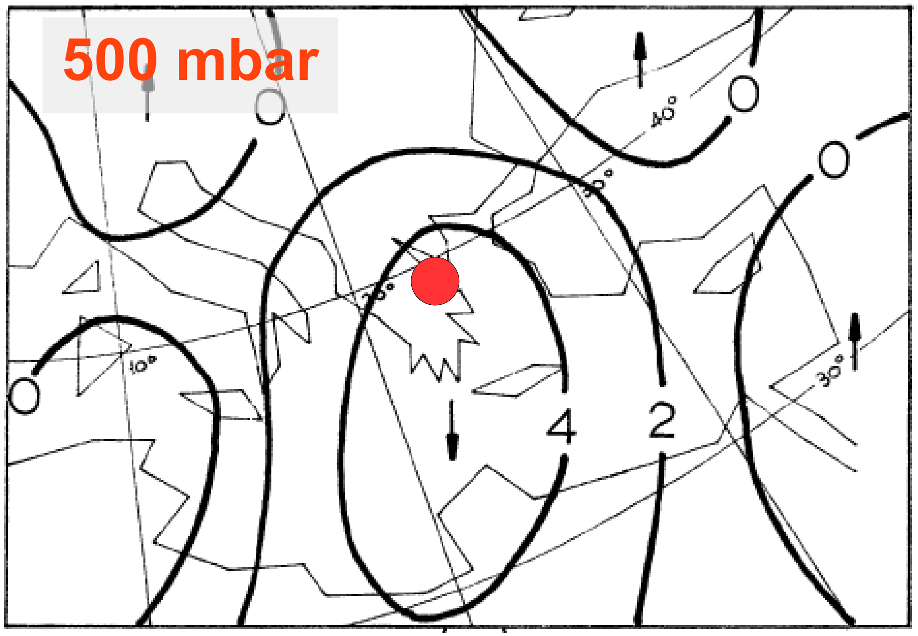
Inversion persists at 1200

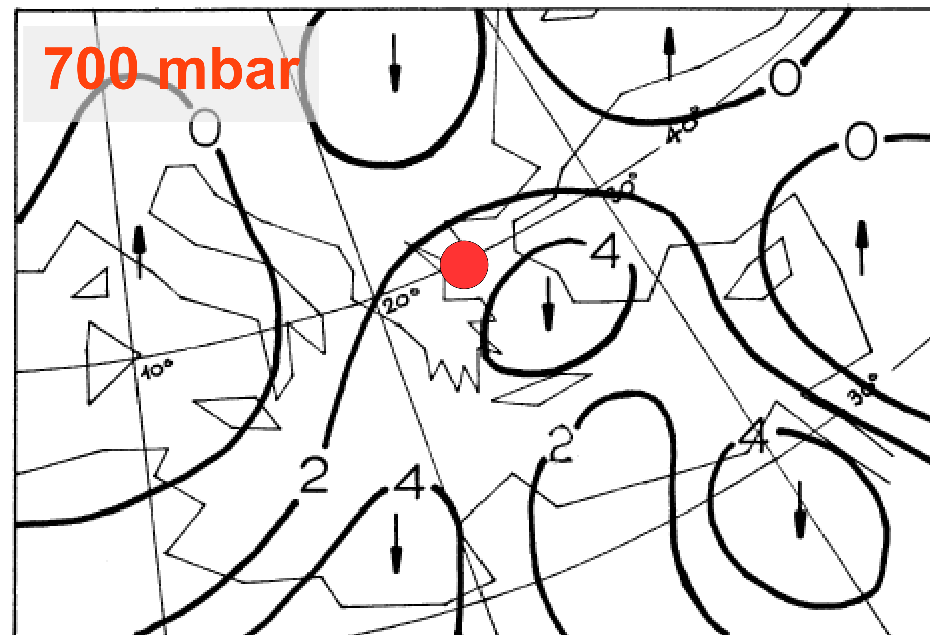
- Inversion base lifted
    - Surface heating & higher wind speeds
- intensity reduced

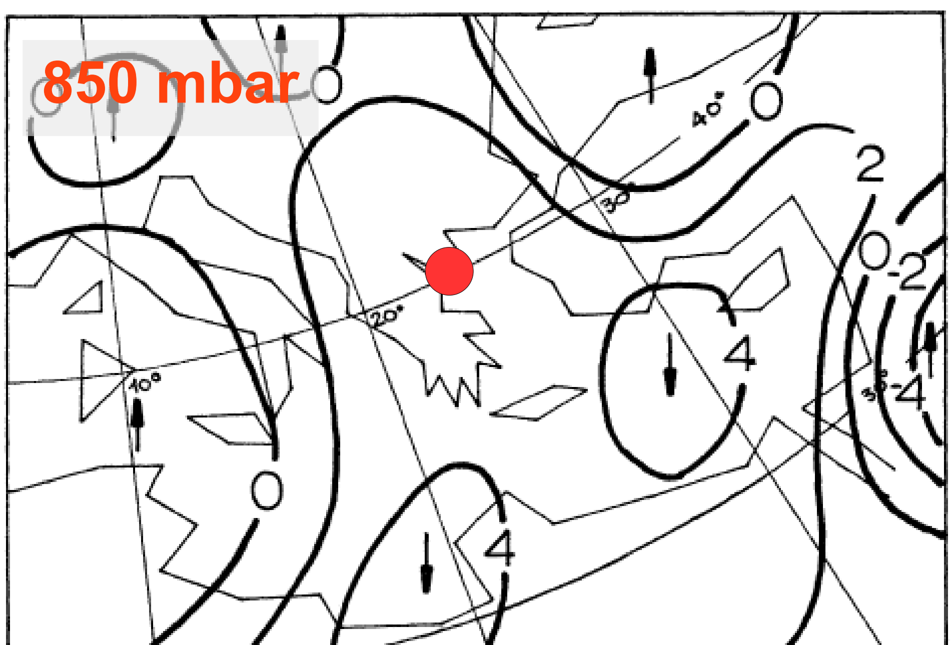
A: Afternooon *500* mbar height



A: Vertical Velocity (1200 UTC)





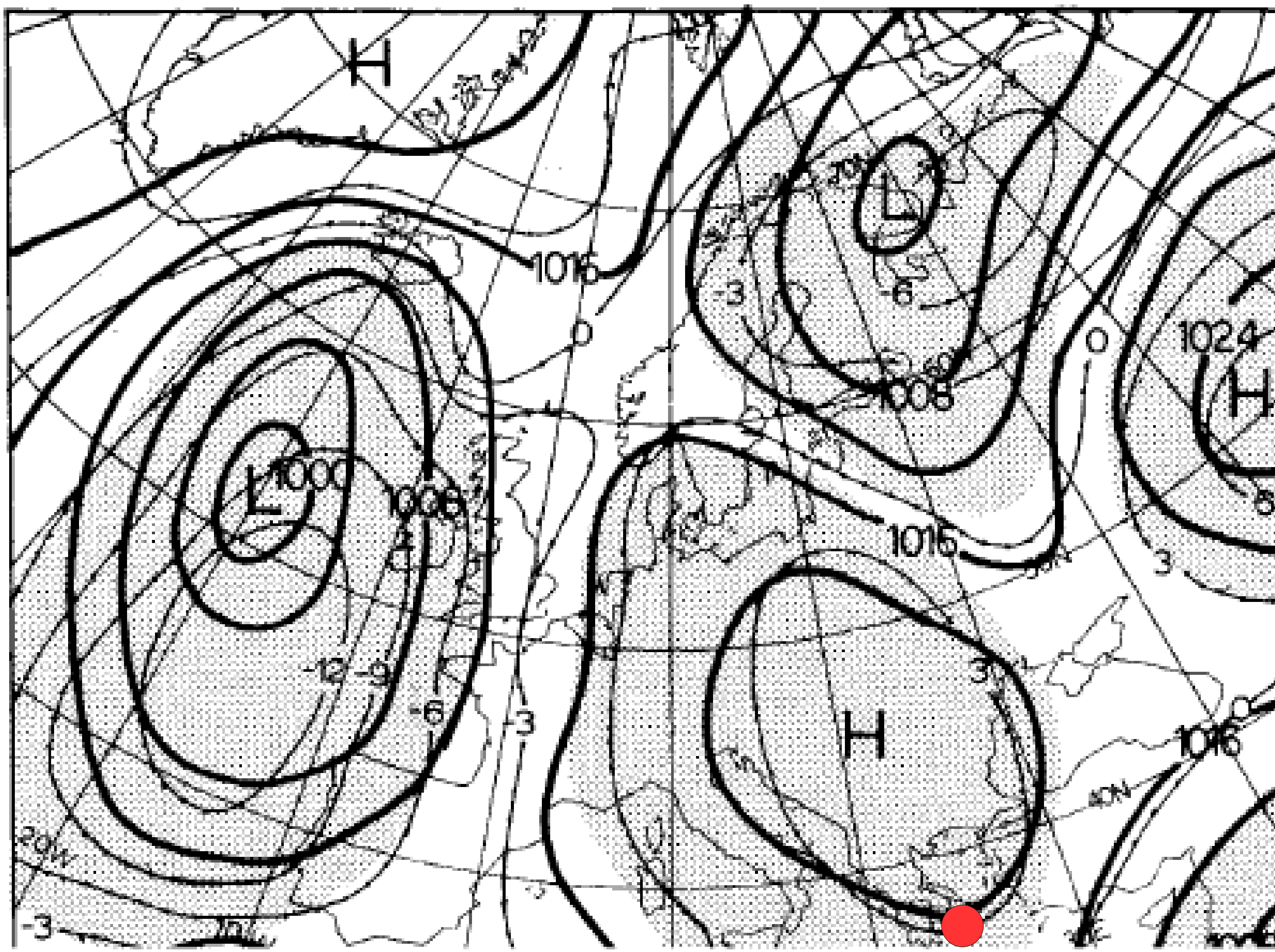


$$\omega = dp/dt$$

(mbar/hr)

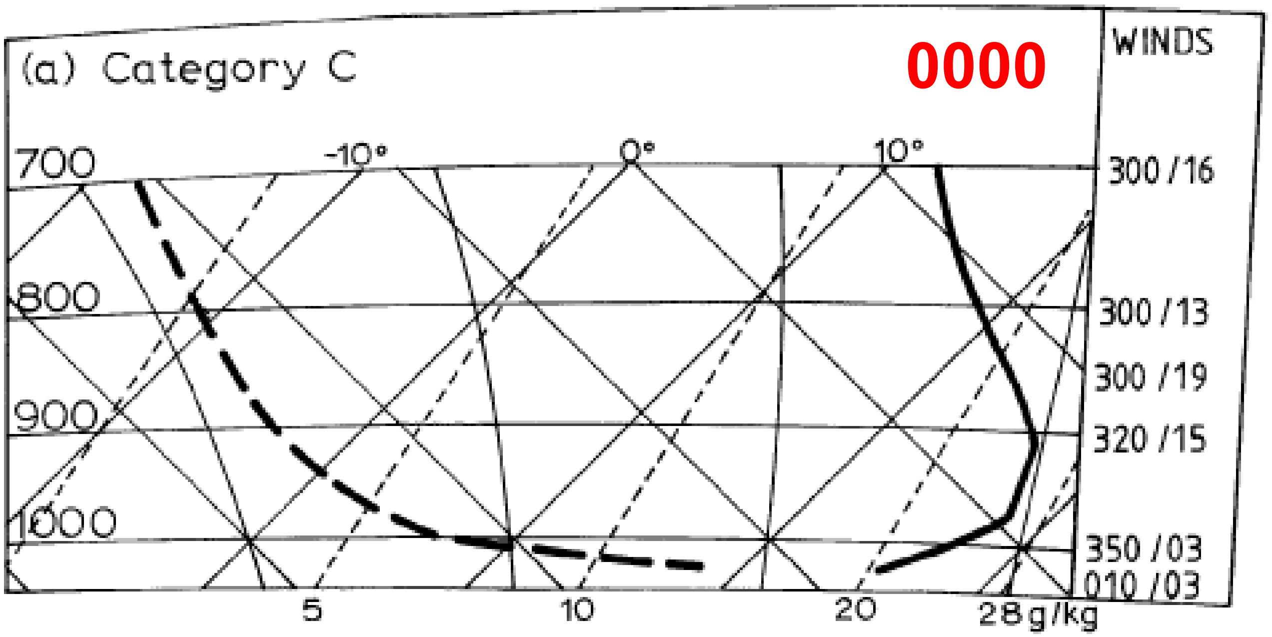
Differential vertical velocity maintains inversions through afternoon

A: Mean Sea Level Pressure



Lower pressure gradient at the surface → stationary high & prolonged inversion

C: Temperature/Wind Profiles



Formed overnight by subsidence & radiative cooling

Inversion persists at 1200

- Inversion base lifted
- intensity reduced
- Driven by sea breeze??

Offshore: 300 – 130º
Onshore: 150 – 280º

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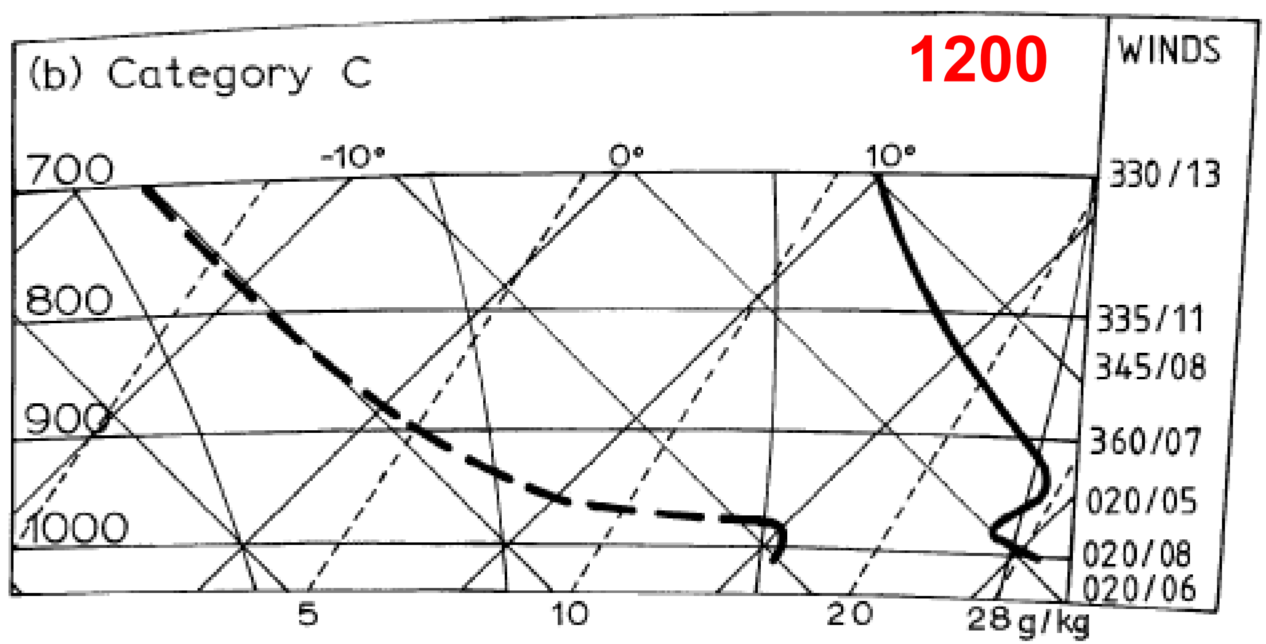
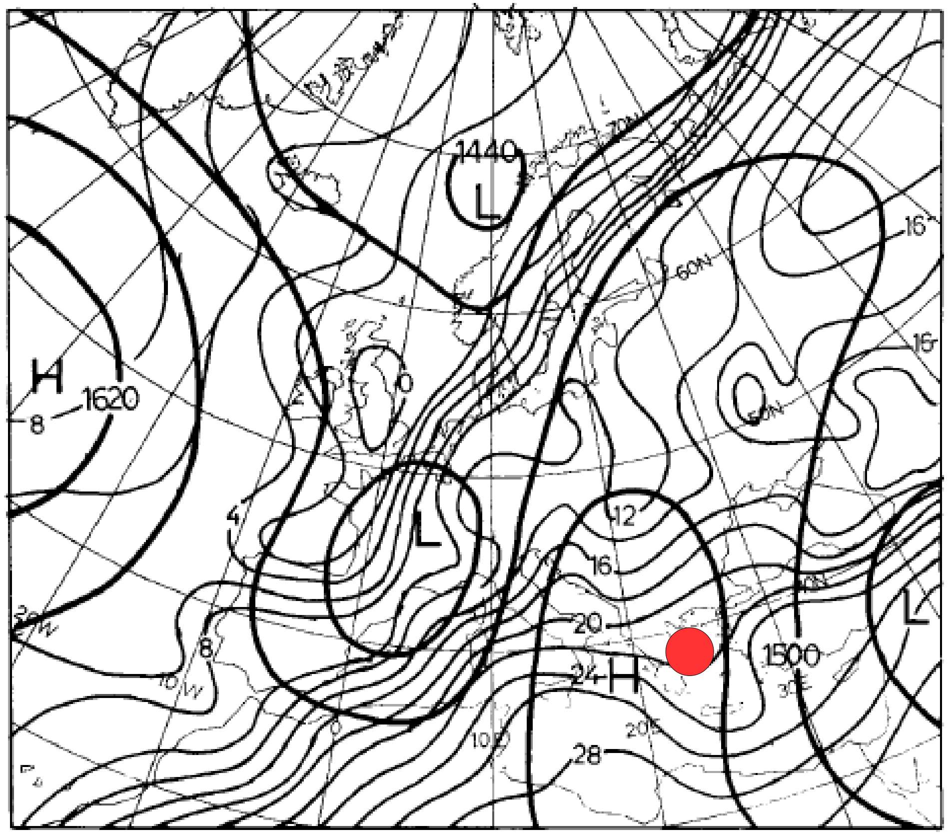
Wind profiles not consistent with sea breeze?

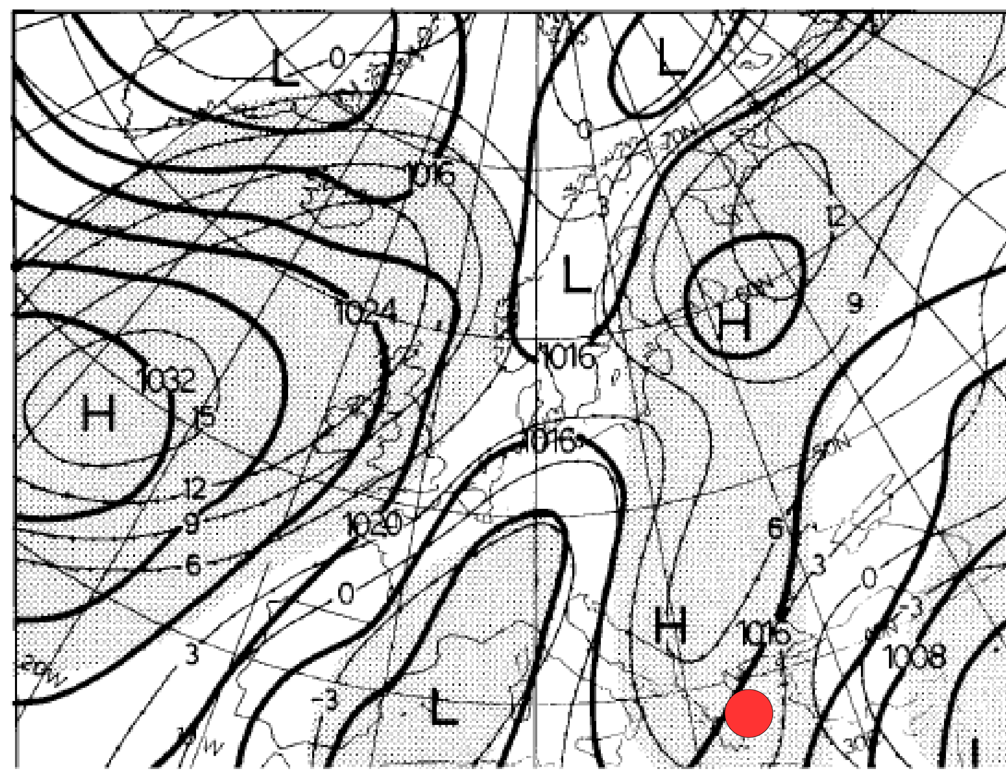


C: *Lower tropo synoptic charts*



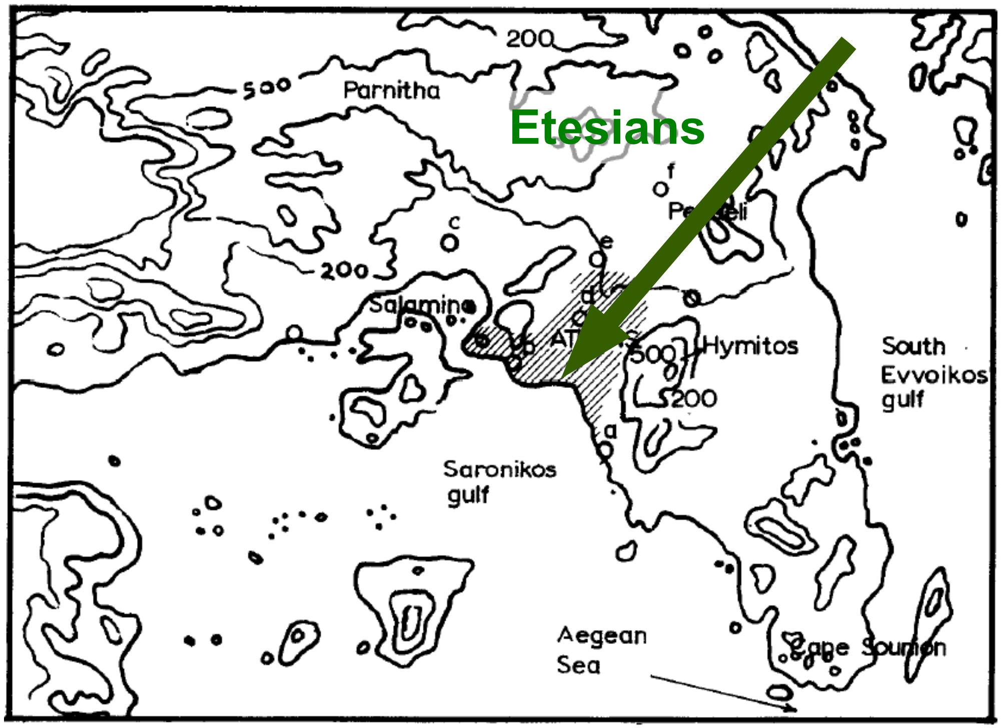
850 mbar heights

Sea Level Pressure



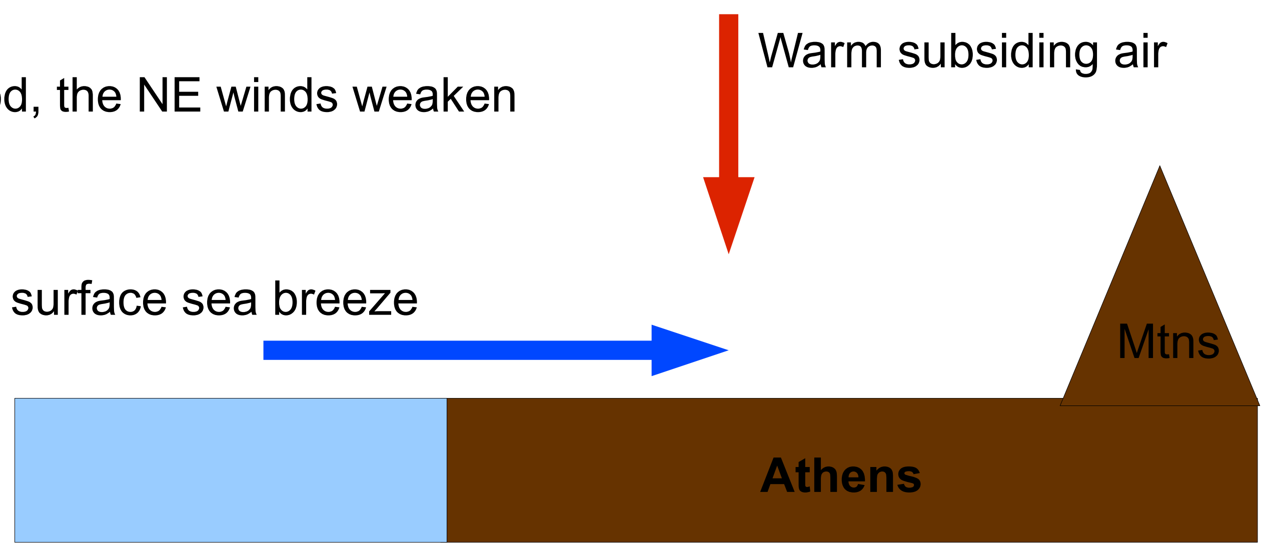
Northeasterly winds... off-shore flow?

Summertime wind conditions

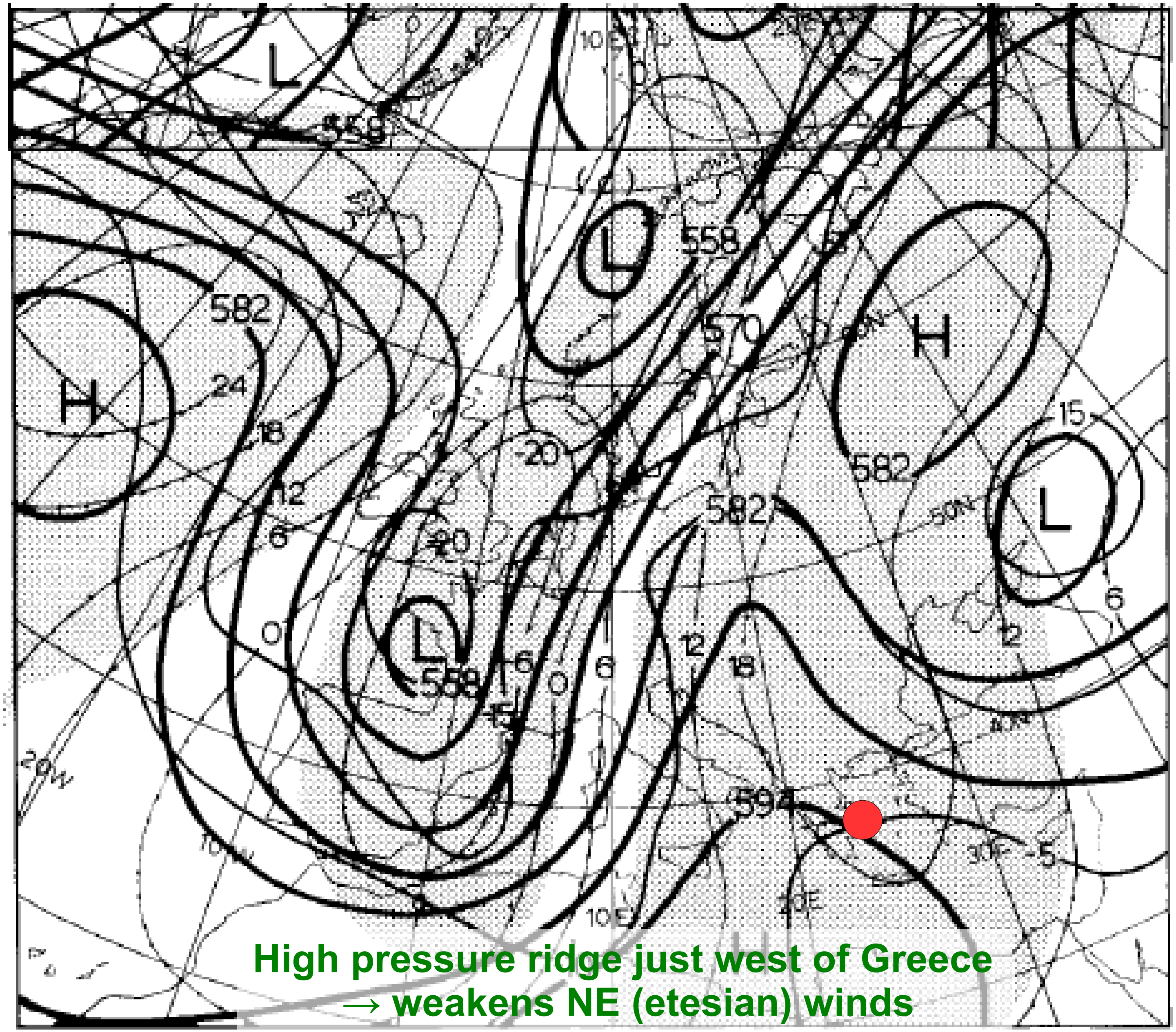


Typically synoptic scale etesian (NE) winds dominate
→ Driven by a high near Greece with a low over the Mediterranean

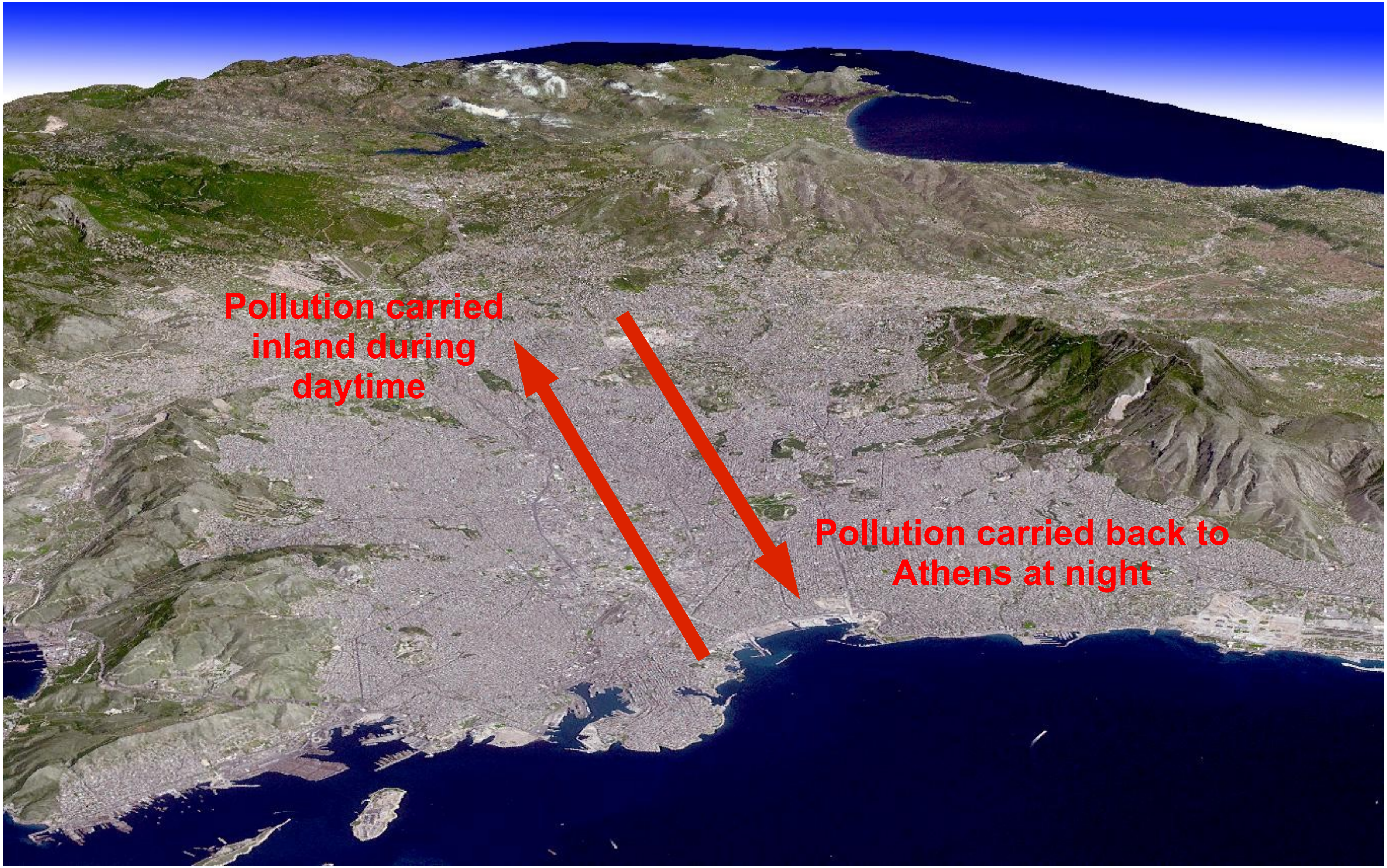
At the end of the etesian period, the NE winds weaken & the sea breeze takes over...



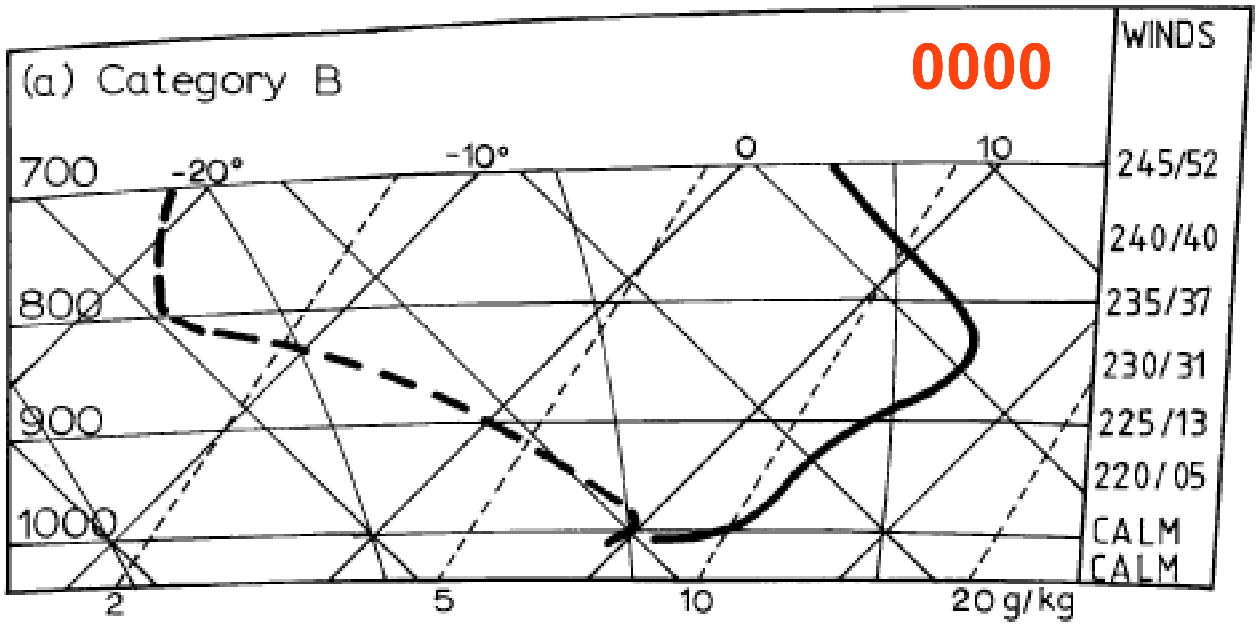
C: Afternoon *500* mbar height

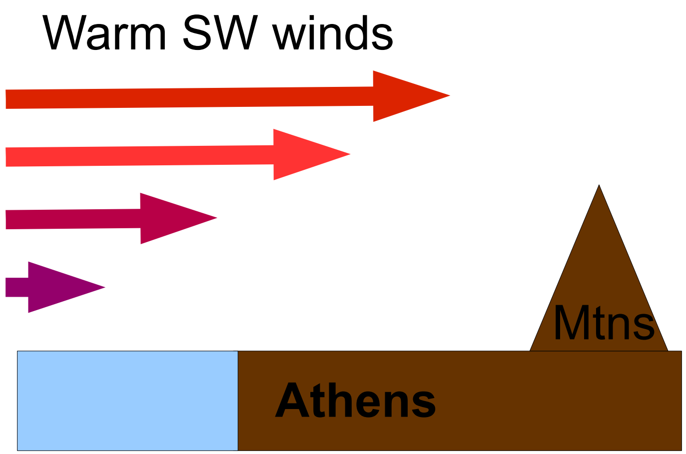


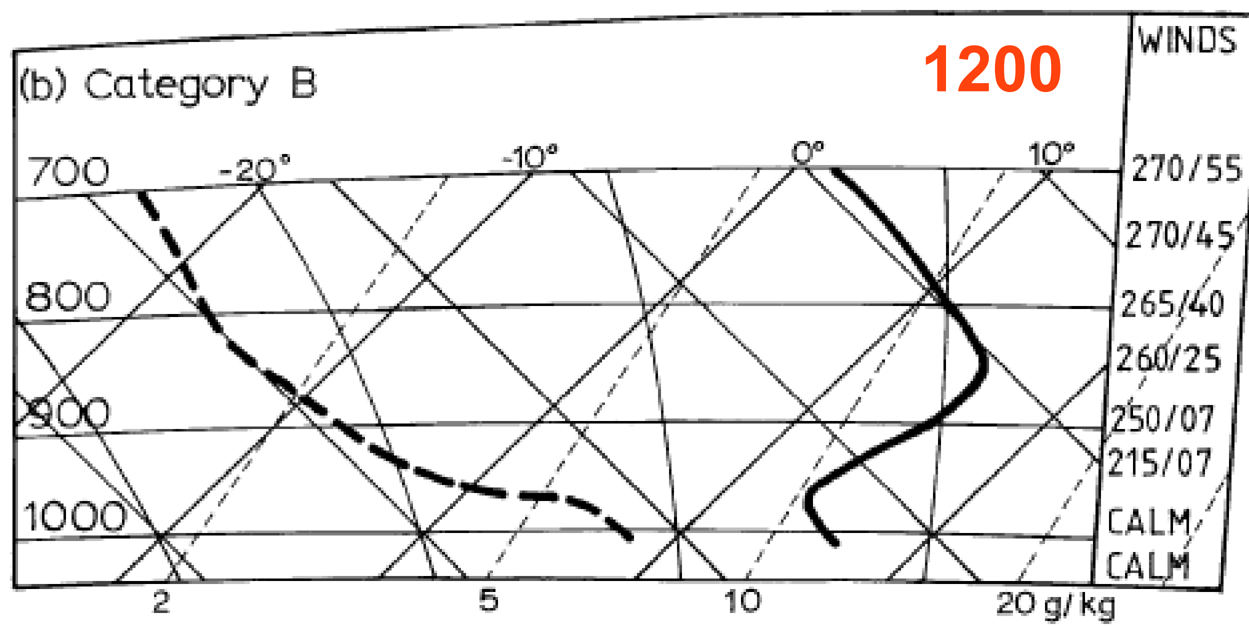
C: Pollution transport



B: Temperature/Wind Profiles

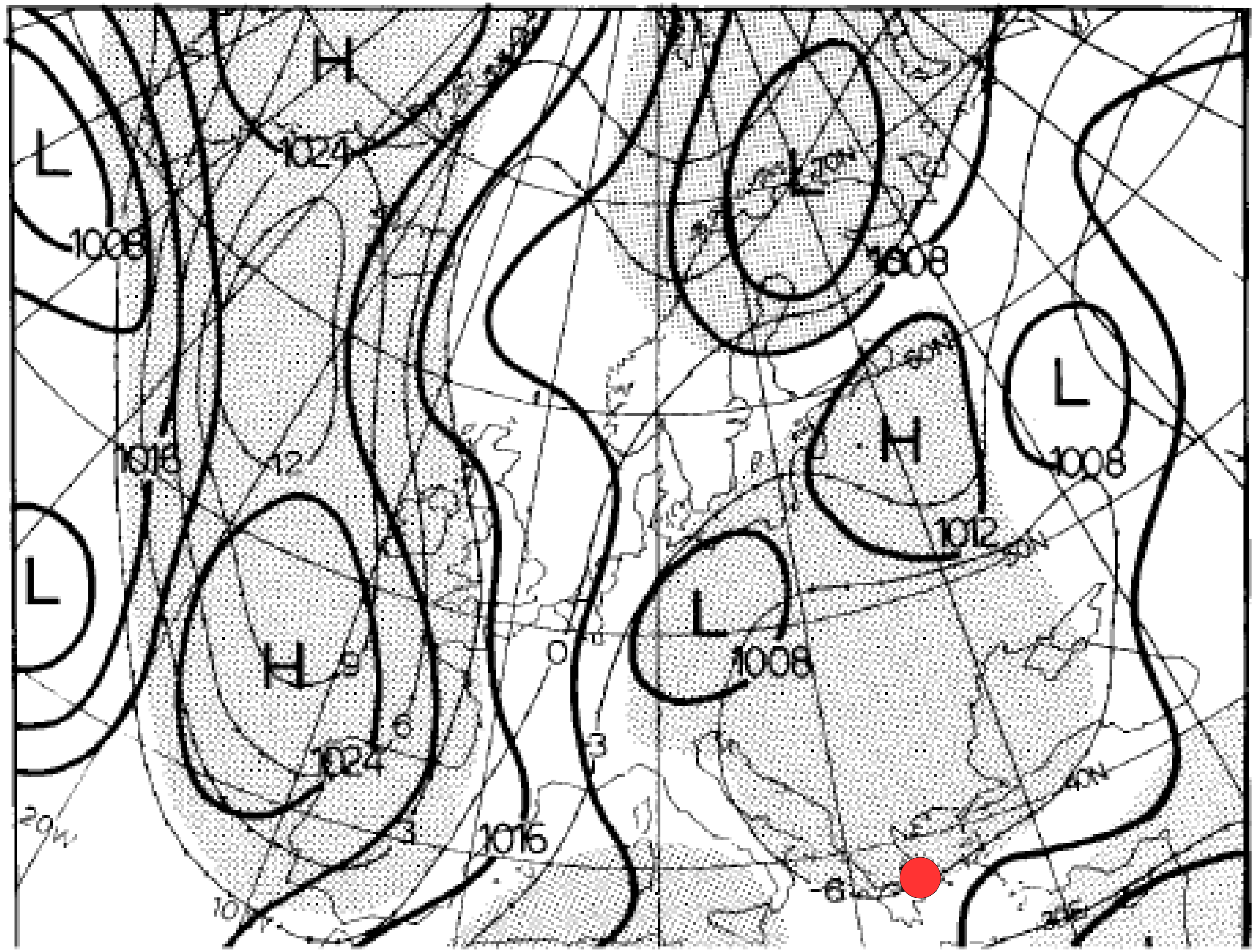






Higher wind speeds aloft carry more warm Saharan air → creates an inversion

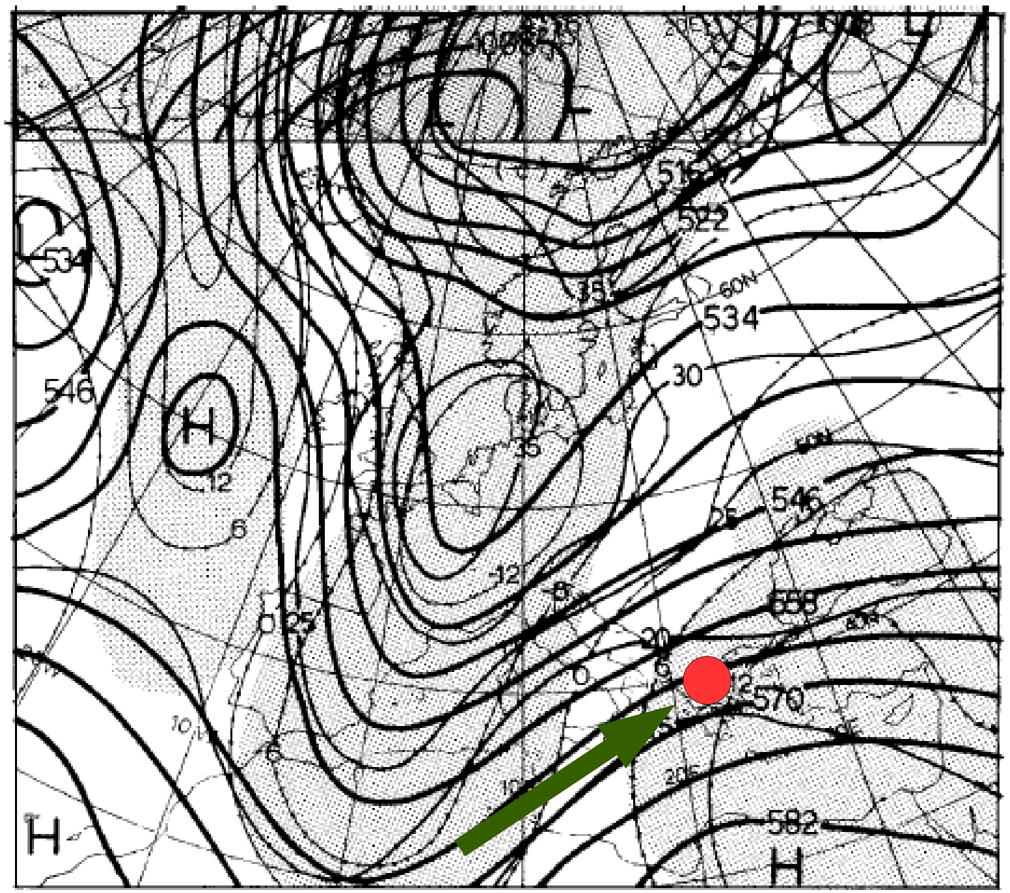
B: Mean Sea Level Pressure



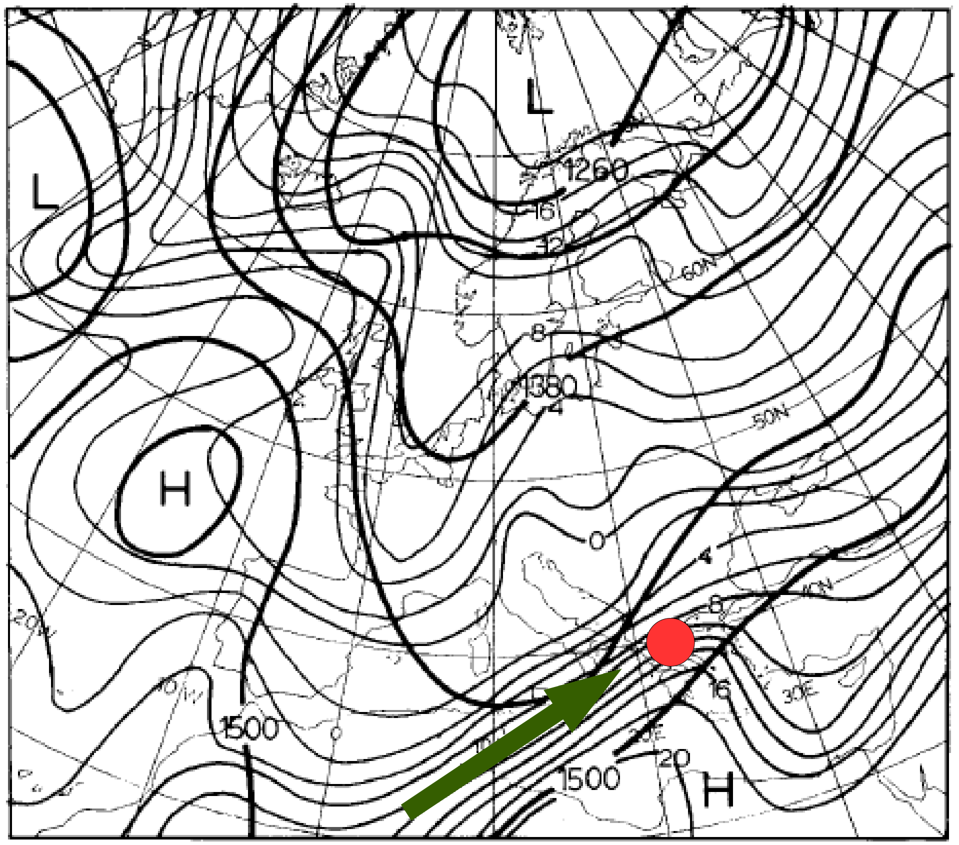
Low surface pressure gradient results in calm winds below 950 mbar
→ suppresses advection at the surface

B: Synoptic charts

500 mbar



850 mbar



Strong southwesterly flow into Athens at higher altitudes

Thermal Advection

Advection at 850 mbar:

$$-\vec{V} \cdot \nabla_p T = -V\left(\frac{\partial T}{\partial S}\right) = 4 \times 10^{-5}\,^\circ\mathrm{C s}^{-1}$$

Overall Temp change at 850 mbar:

$$\left(\frac{\partial T}{\partial t}\right)_p = -\vec{V} \cdot \nabla_p T + \omega(\Gamma_a - \Gamma) + \left(\frac{1}{c_p}\right)\left(\frac{\delta q}{dt}\right)$$

Advection	Upward motion	Diabatic heating
T ↑	T ↓	T ↑

Heating from advection & diabatic processes → raise T by 2 ºC
Actual temp change → -1 ºC

Upward motion actually cools the layer, but not enough to break up the inversion

Summary

3 Inversion categories identified in the Athens Basin:

- Nighttime Radiation Inversion
  - Daytime subsidence
    - Anticyclonic circulation
  - Daytime sea breeze
    - Weakening of etesian (NE) winds
- Differential vertical advection
  - Low surface pressure gradient; Strong SW flow aloft

Radiation/subsidence inversions are stronger than the advection type