Theoretical examination of non-summer daytime boundary layer height variability over coastal-mountain-valley topography: the case of central Israel

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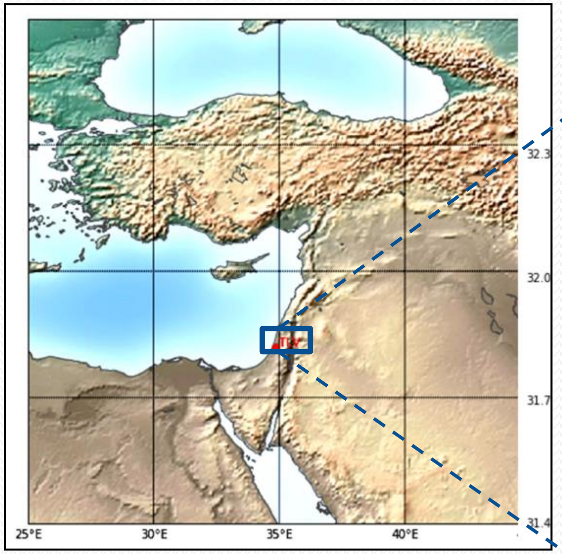
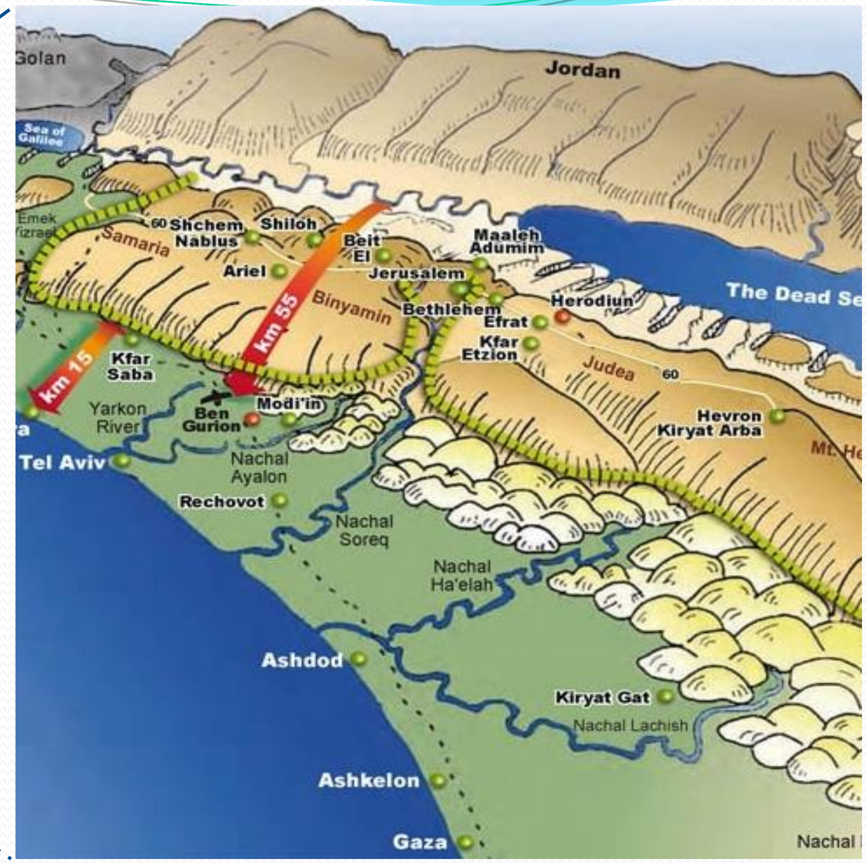
Israel, Eastern Mediterranean





https://jr.co.il/pictures/israel/maps/3d-topographic-map-of-israel.htm

- Coastal-mountain-valley-plateau topography
- Hyper terrain daytime boundary layer events were found during the summer

Avisar, D., & Berkovic, S. (2022). High spatiotemporal resolution planetary boundary layer dynamics across the Israeli coast—mountain—valley terrain unraveled by WRF simulations. *Journal of Geophysical Research: Atmospheres*, 127, e2022JD037090.
https://doi.org/10.1029/2022JD037090

Research questions:

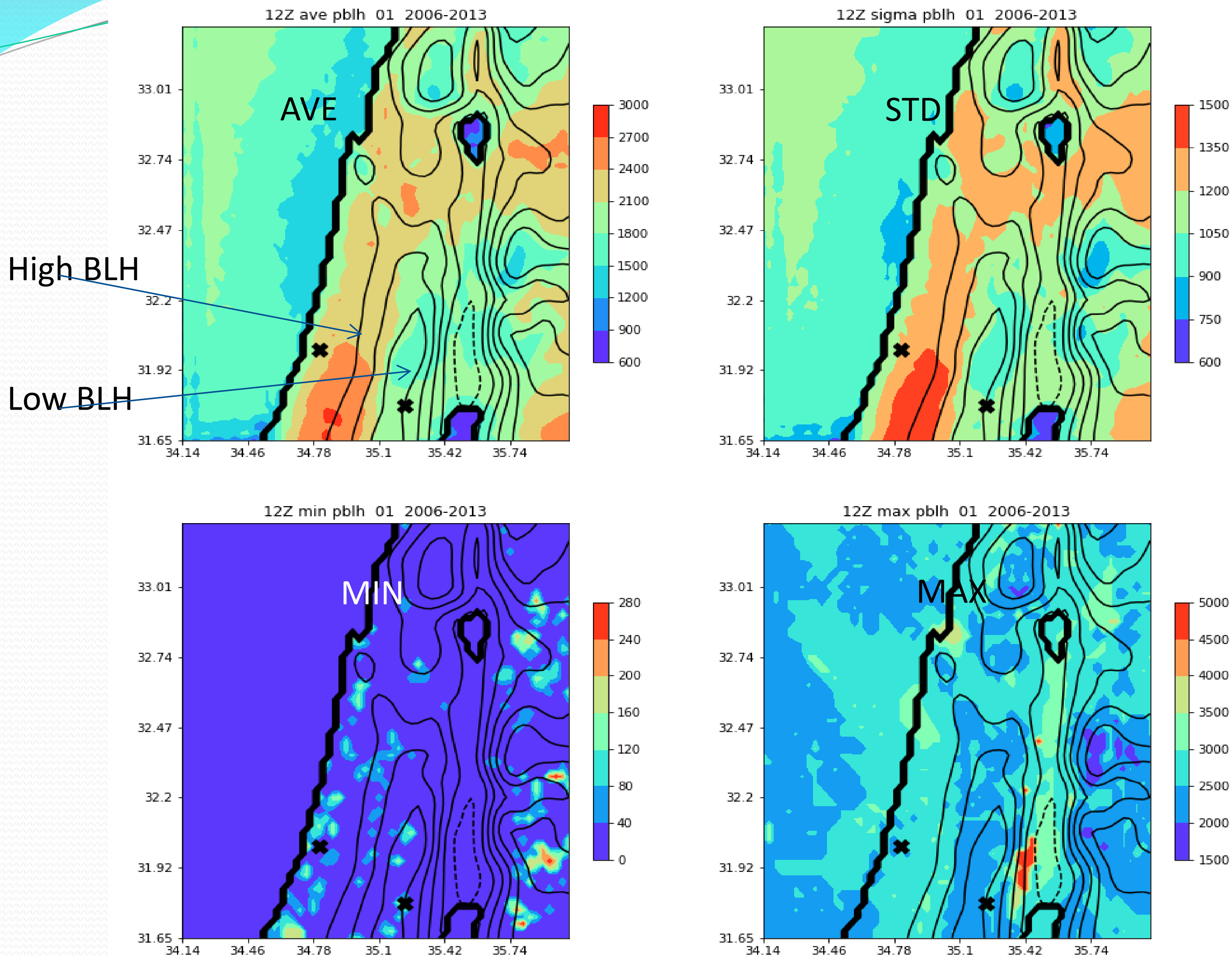
- What is the variability of the BL height over coastal-mountain-valley topography during the non-summer months ?
- What are the links between low BL events over the mountain peak and the regional synoptic gradients ?
- What is the flow mechanism of contra terrain BL events ?

- Climatological examination of the daytime BL height (BLH) variability during non-summer months according to WRF3.6 simulations with 3 km horizontal resolution during at least 5 years. MYJ BL scheme, TKE cutoff determines the BL height.

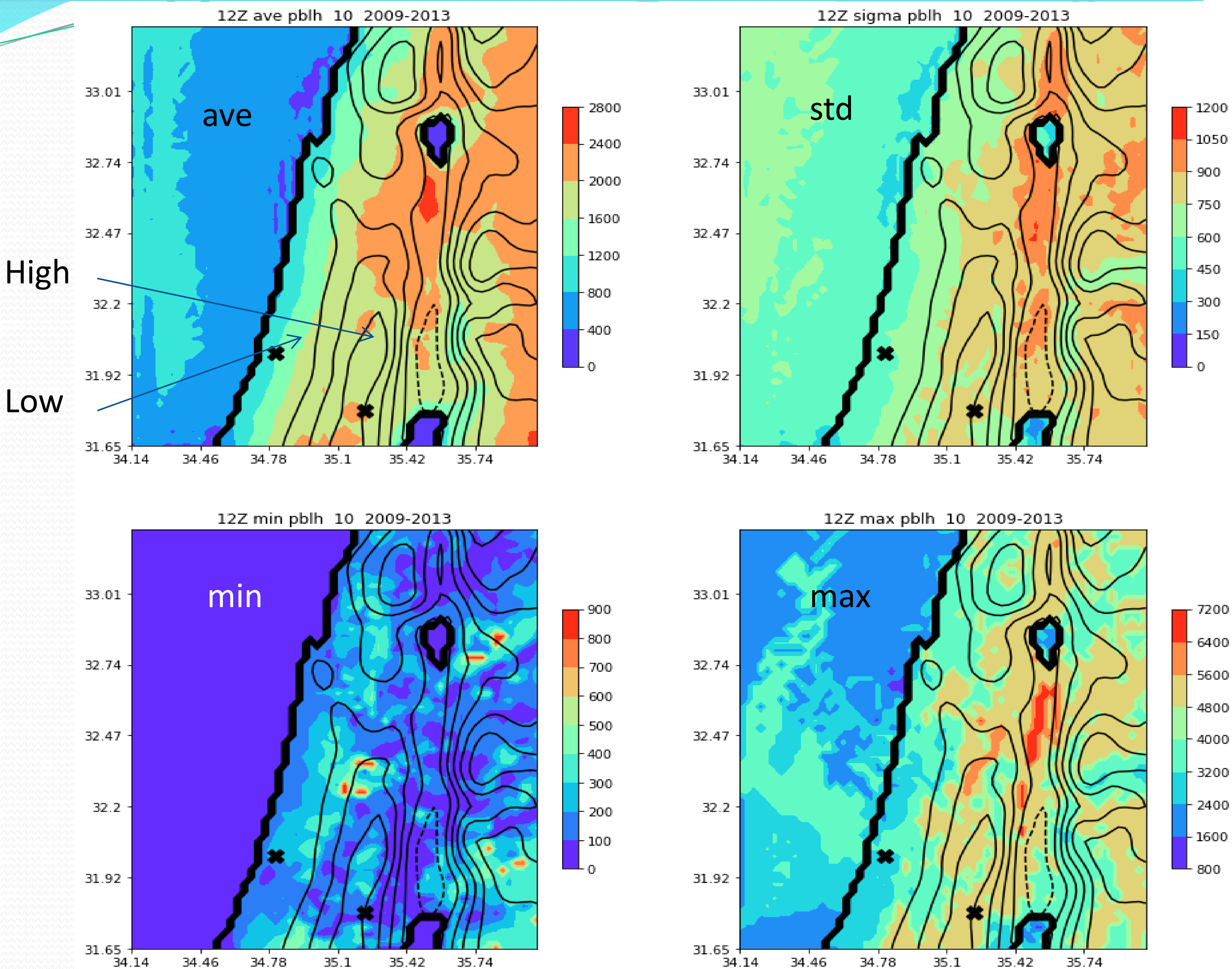
- The monthly average BLH above the mountain peak and its easterly slope is found to be lower than that over the coastal area (1-2.5 .vs. 2-3 km) during the winter months, November-February.

- During the rest of the year (April-October) the situation is reversed (1-2.5 .vs. 0.5-2 km) .

January average + STD BL height[m] (BLH)



October average + STD BLH[m]

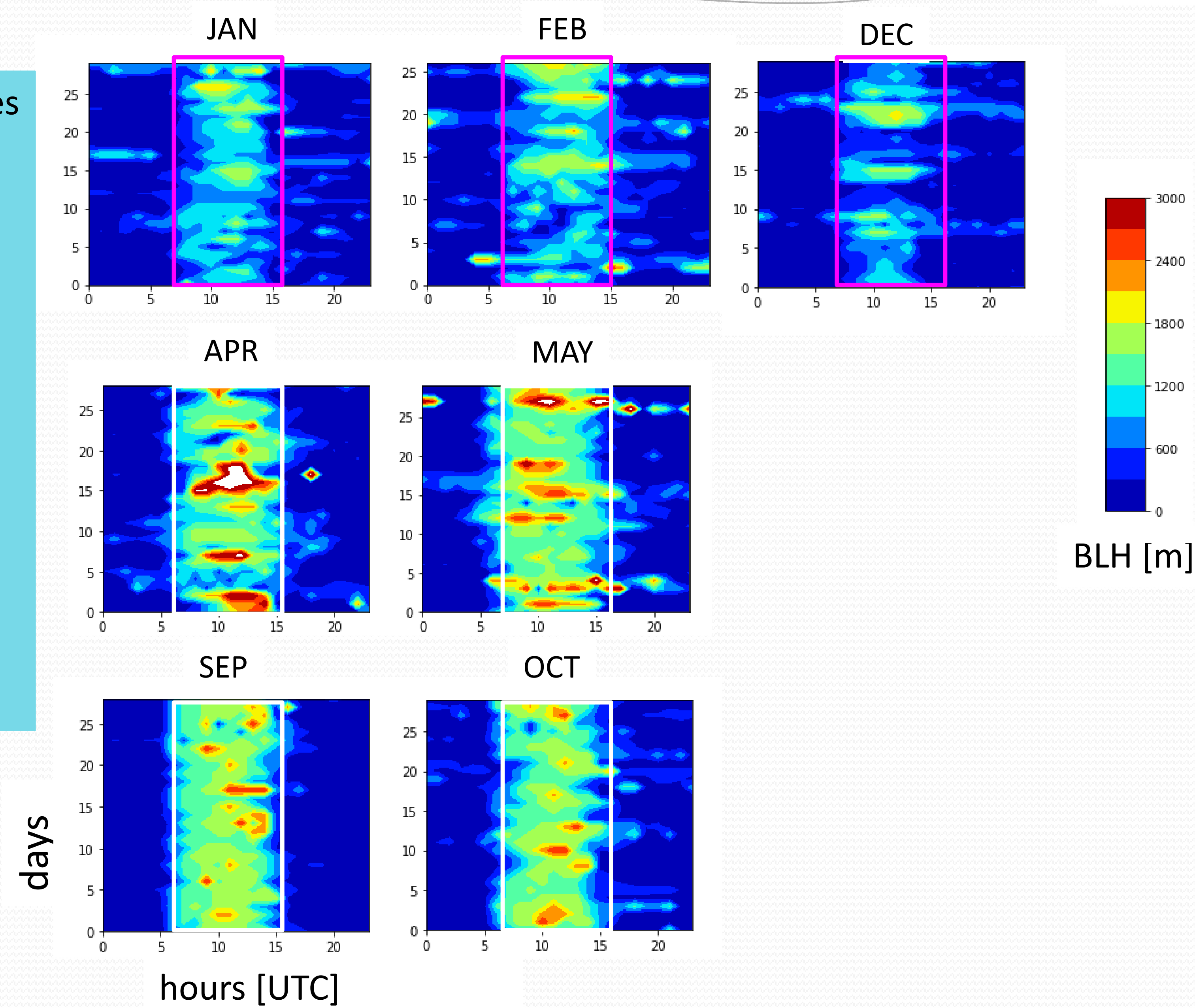


BLH variability (2011) at the Mountain peak (Jerusalem)

BLH time series

Lowest BL :
January
February
December

Highest BL:
April, May,
September,
October



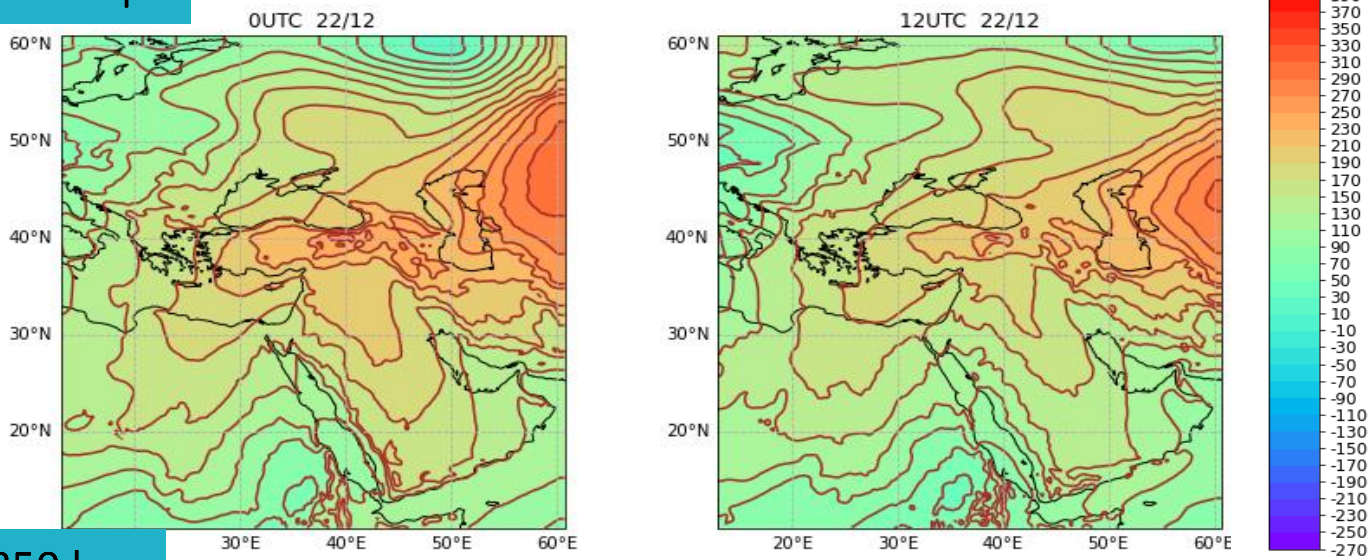
- In order to track the mechanism responsible for the reduction of the BLH over the mountain peak during winter, an examination of the BLH variability during 10-13 UTC (4 hours) was performed.

- Accordingly, 9 events with relatively weak pressure gradients and weak (< 5 m/s) easterly flow were found to be responsible for minimal BLH (< 350 m) during daytime. Under 7 out of these 9 events the BLH at Beit –Dagan at 12UTC (the central coastal plain) was ≤ 500m according to radiosonde measurements.

- The synoptic pressure during these events is characterized by a ridge from the south in the middle troposphere (500 hPa) and central Red Sea Trough or high to the east or to the north of Israel next to the surface.
- High pollution levels were reported during such synoptic conditions (Saaroni et al 2010, Levi et al 2008) in the Tel Aviv area

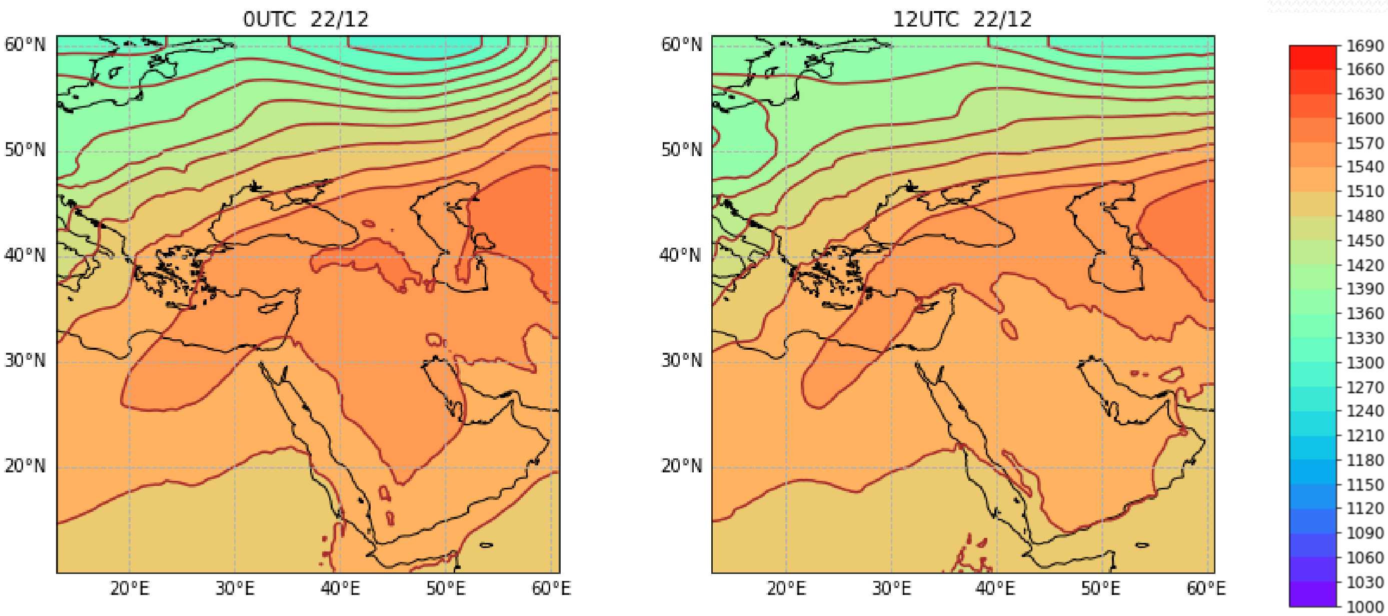
Case study 22/12/2010 geopotential height (gph) [m]

1000 hpa



Decay of high over W Russia and Turkey, Red Sea trough

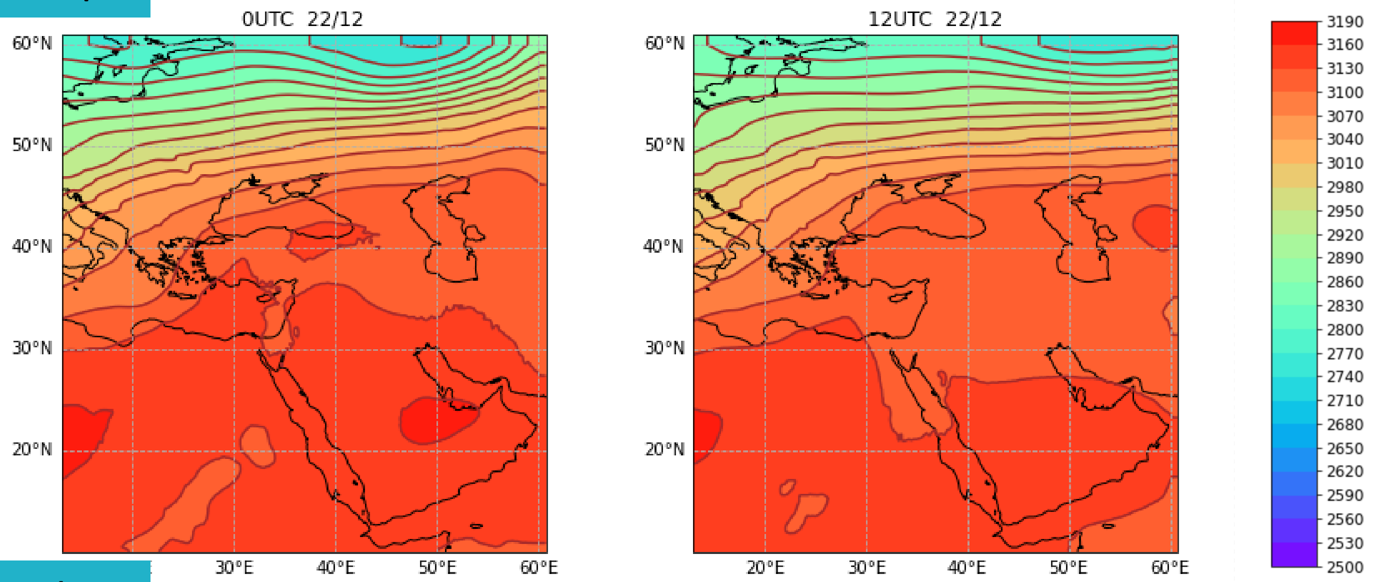
850 hpa



Shallow high over the Eastern Mediterranean

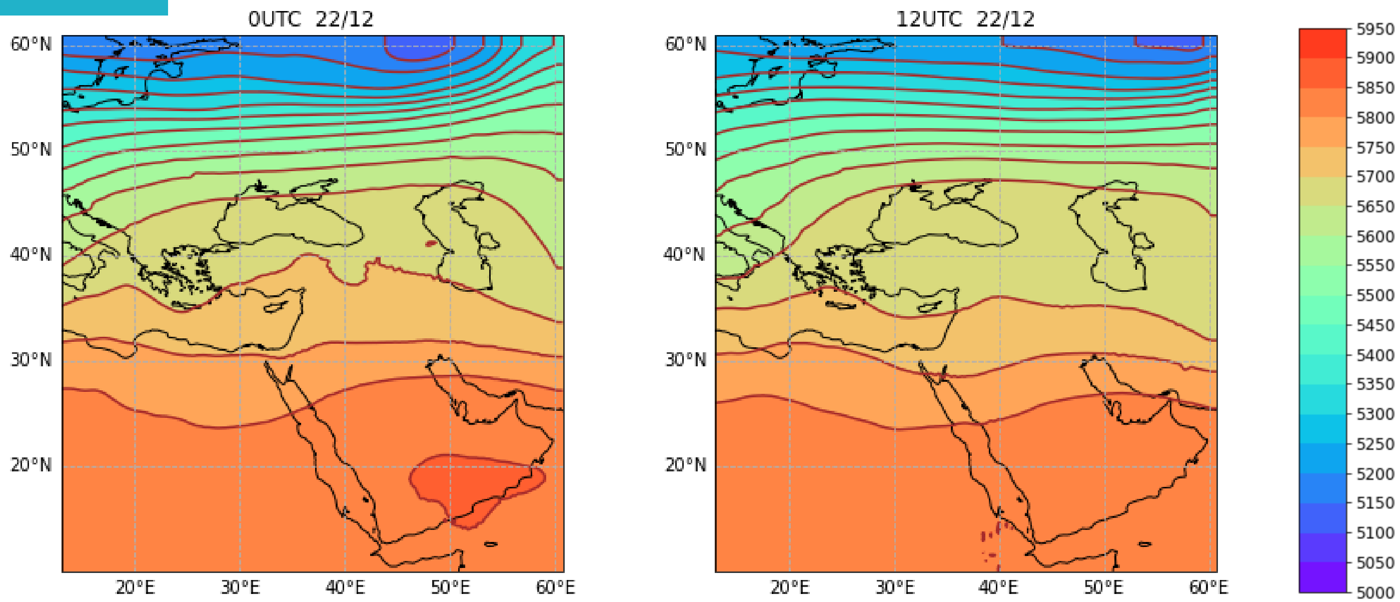
Case study 22/12/2010 gph[m]

700 hpa



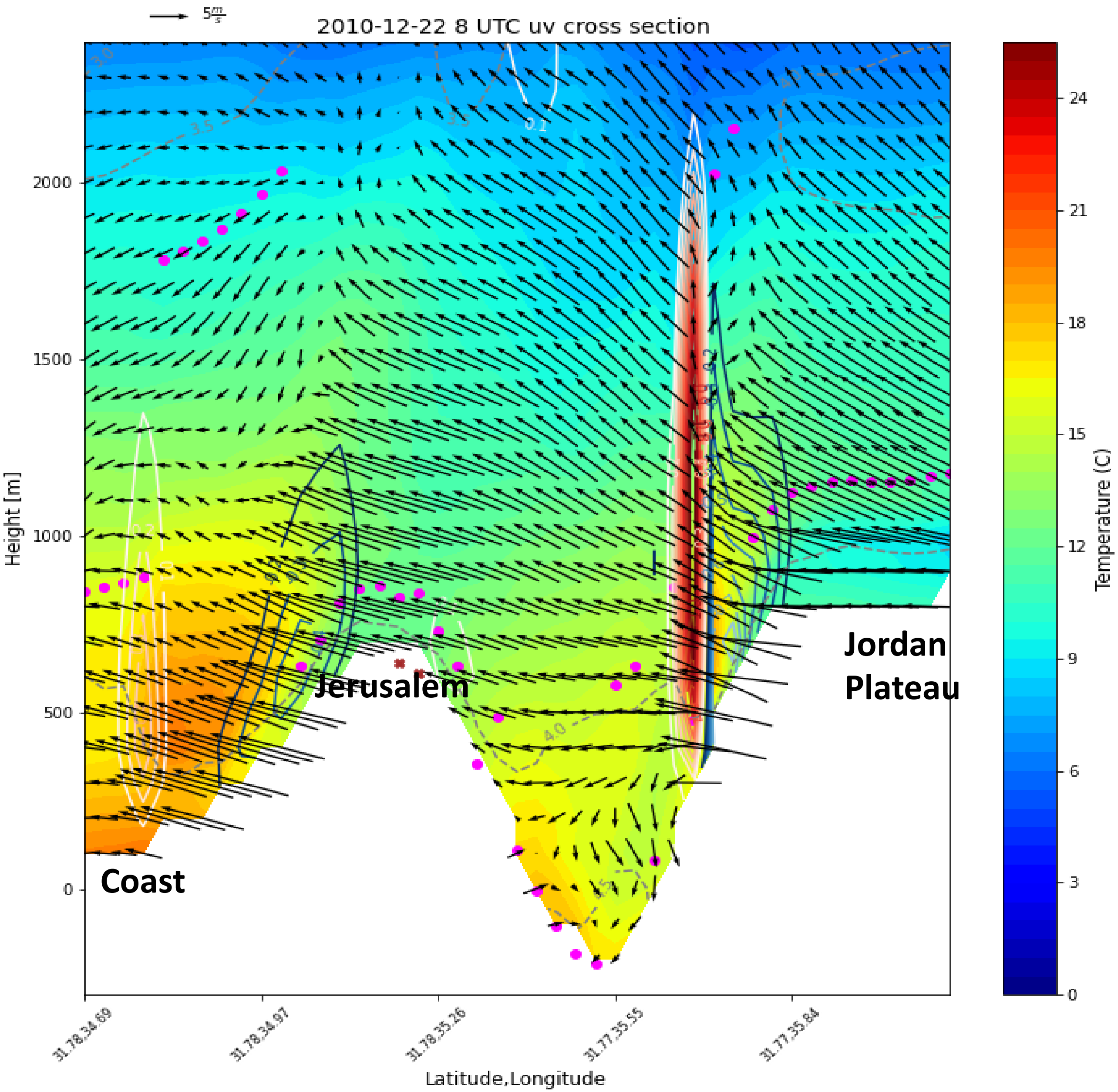
Shallow high over the Eastern Mediterranean

500 hpa



Nearly straight E-W oriented iso-contours

Example: 22-12-2010 vertical cross section



BLH – magenta full circles

Vertical winds:
Downwards – blue
upwards – red > 0.1 m/s,
0.1 m/s resolution

Horizontal wind vectors

Fohn winds along the slopes :
increases temperature,
reduces humidity
(grey truncated contours)

Jerusalem relatively cooler

6-11 UTC
very similar conditions

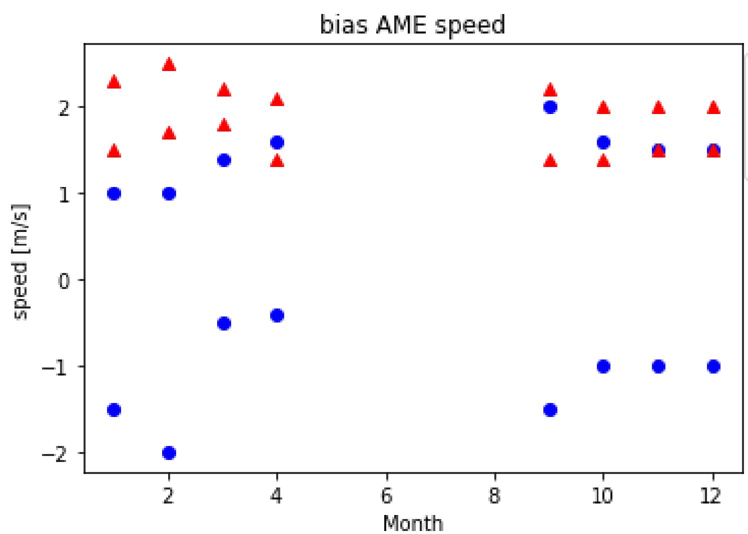
Fohn winds which locally reduce the humidity and enhance the temperature due to subsidence flow over the eastern slope of the valley and the western slope of the mountain. In such cases, the mild synoptic pressure gradients are responsible for the maintenance of the local cooling over the mountain peak. The advection of hot air to the mountain peak is limited and therefore relatively stable thermal stability is obtained over the mountain peak and its eastern slope.

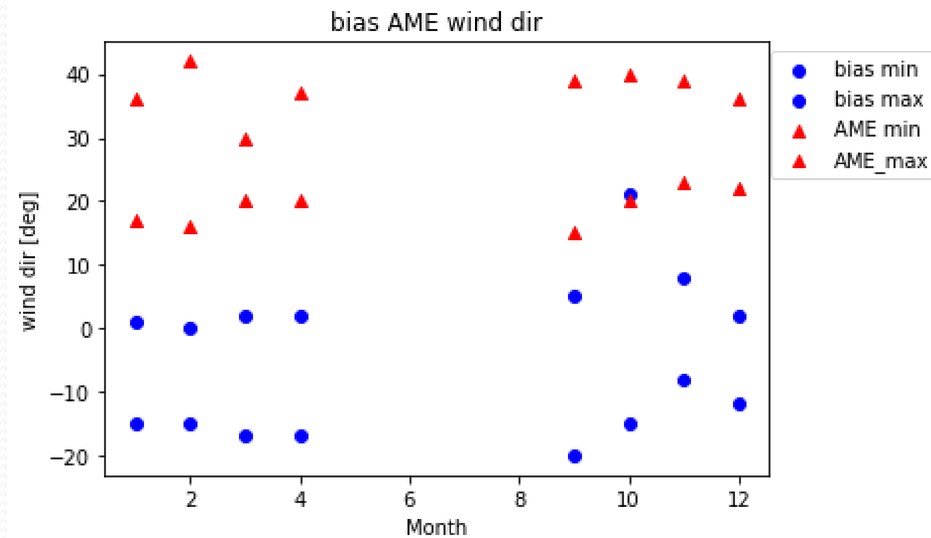
WRF3.6 verification against radiosonde measurements from Beit Dagan (central coastal plain) at 12UTC

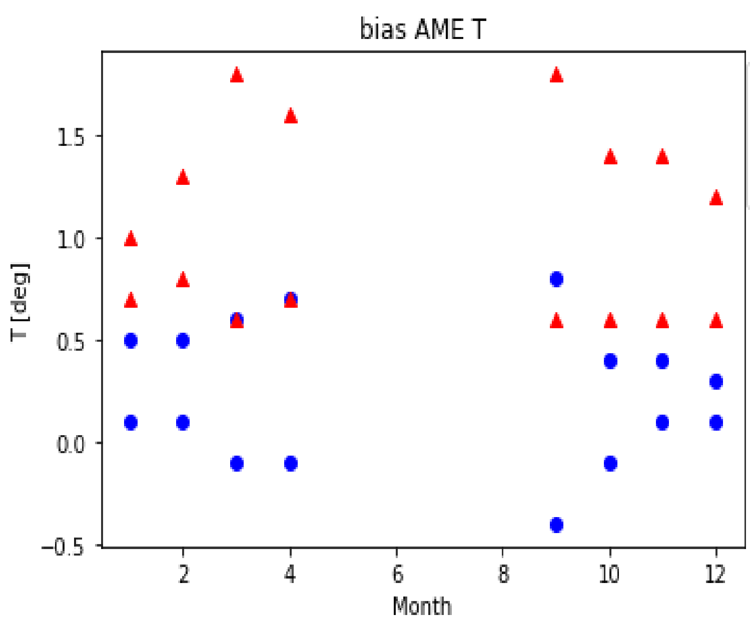
Interpolation of model results to 100 m slabs along 0-2500 m a.g.l
Wind speed and direction errors (bias and AME) were calculated for events under speed > 0.5 m/s
The wind speed is over predicted at the lowest levels (up to 500 m a.g.l) and under predicted at the upper levels (1.5-2.5 km a.g.l).
Wind direction AME is reduced at the upper levels (not shown)
A summary of minimal and maximal bias and AME values is shown in the following figures (next slide).

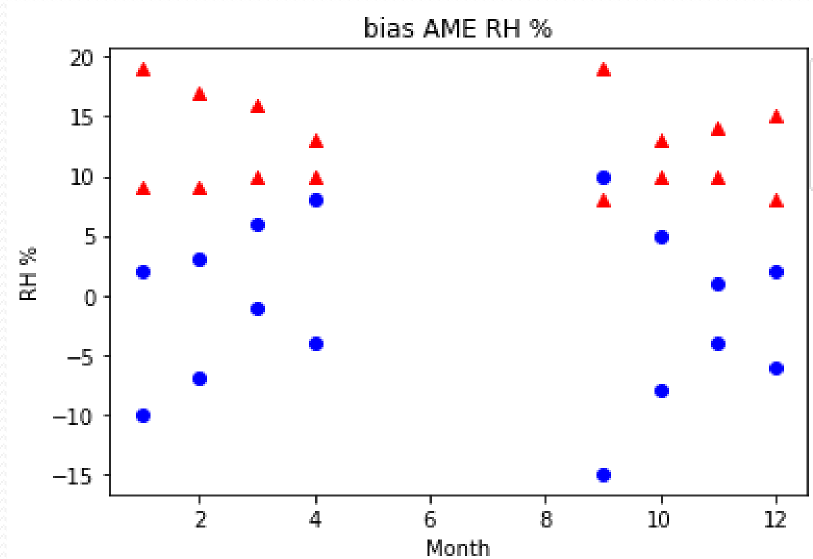
The bias contributes to the AME, especially in the case of: wind speed, wind direction and RH.

The verification shows that the model reasonably predicts the variability of the atmospheric profile at the coastal plain.
Further verification of the model ability to predict the profile at the mountain peak is needed.


bias AME speed
speed [m/s]
2
1
0
−1
−2
2
4
6
8
10
12
Month


bias AME wind dir
wind dir [deg]
40
30
20
10
0
−10
−20
2
4
6
8
10
12
Month
bias min
bias max
AME min
AME_max


bias AME T
T [deg]
1.5
1.0
0.5
0.0
−0.5
2
4
6
8
10
12
Month


bias AME RH %
RH %
20
15
10
5
0
−5
−10
−15
2
4
6
8
10
12
Month

Take home message (THM)

- During the winter months, November-February, the monthly average BLH above the mountain peak, its easterly slope and the valley are found to be lower than that over the coastal area (1-2.5 .vs. 2-3 km), while during the rest of the year (except March) the situation is reversed.
- Events with relatively weak pressure gradients and weak (< 5 m/s) easterly flow were found to be responsible for minimal BLH (< 350 m) over the mountain peak.
- The synoptic pressure during these events is characterized by shallow ridge from the south in the middle troposphere (500 hPa) and central Red Sea Trough or high to the east or to the north of Israel next to the surface.
- Fohn winds under mild synoptic pressure gradients are responsible for the maintenance of the local cooling over the mountain peak.