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Investigation of Critical Fire Weather Pattern – Case Study

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Introduction

Forestry fires are a major risk and serious damage to the mankind, environment, and economic conditions around the world, due to:

Atmospheric Conditions (high temperatures, low relative humidity, strong surface wind, and unstable air which increases the probability of thunderstorms and strong downdraft winds).

The nature of the region (topographically) and Vegetation (their spatial distribution, species and moisture content).

human activities (ex. forest deforestation and land use).

Introduction

- Depending on the geographical position, phenomenon such as heat waves and extreme dry conditions with large fires and floods may arise in season under pre-existing conditions as a result of blocking.
- Atmospheric blocking is a large-scale phenomenon occurs in the mid-latitudes to high latitudes in the troposphere.
- It is characterized by nearly-stationary, stationary, or retrograding synoptic motion.
- When blocking starts, the weather pattern is moving from west to east and stops in certain places for several Consecutive days and sometimes it extends for a month.

Introduction

A series of huge wildfires occurred in some regions in Lebanon (located in the eastern Mediterranean) in mid - October 2019, in which the region witnessed a heat wave with high averages of minimum and maximum temperatures, accompanied with dry weather conditions.

In general, 15% of the areas of Lebanon, especially in Mount Lebanon and North Lebanon, where the density of vegetation is high, are subject to flaring in a "very high" manner, while 34% of the Lebanese land areas are subjected to fires whose risk ranges between medium and high.



The Aim of the Study

Due to the frequent cases of fires that Lebanon is exposed to, and because of its impact on life, climate and the environment, this research aims to **investigate the weather pattern and the blocking type that dominated over Lebanon in the period 13-18 of October 2019**, which led to several fires in northern and southern Lebanon, and **to study the weather factors that fueled and spread the fire in several places.**

Material and methods

- **Data for surface and upper levels were taken from ERA5 with spatial resolution of $0.25^\circ \times 0.25^\circ$ each three hours.**



- **At the surface:**

surface pressure, surface temperature and dew point at 2m, maximum and minimum temperature at 2m, u and v components of wind and wind gust at 10m, total and convective precipitation, and total cloud cover, total total index

- **At the upper levels (500, 700 and 850 hPa):**

geopotential height, relative vorticity, vertical velocity, relative humidity.

Material & methods

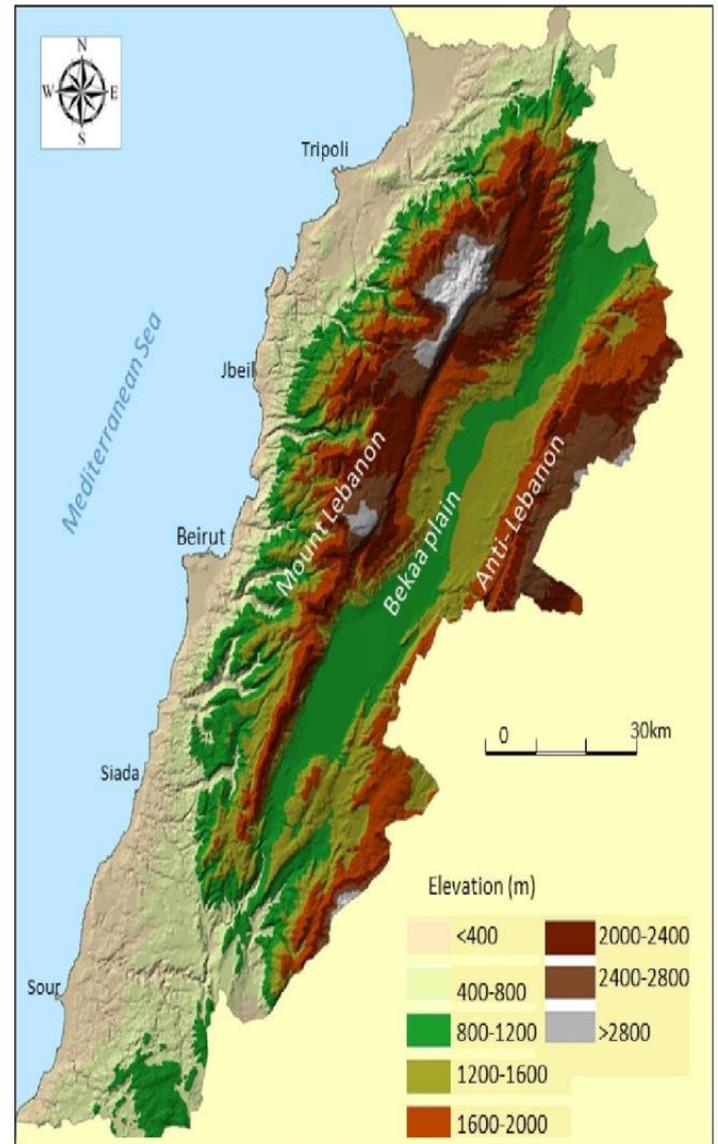
- **Burned areas**: were detected using the data acquired from the Visible Infrared Imaging Radiometer Suite (VIIRS) 375 m thermal anomalies / active fire product from the VIIRS sensor aboard the joint NASA/NOAA Suomi National Polar-orbiting Partnership (Suomi NPP) and NOAA-20 satellites



- **The study area includes:**
Mediterranean region (24°W - 60°E , 10°S - 65°N), focusing on the Mount Lebanon region in Lebanon and particularly Chouf (or Shouf) district (33.69556°N , 35.57917°E).

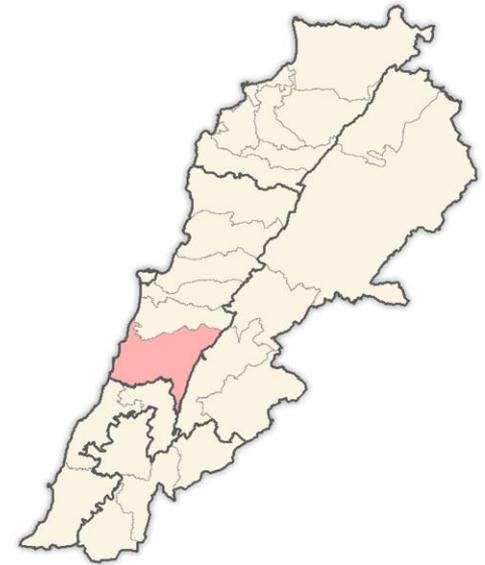
Geography of Lebanon

1. A flat, narrow **coastal strip** parallel to the sea.
 2. The Mount-Lebanon chain.
 3. The Bekaa Valley.
 4. The Anti-Lebanon Mountains chain along the border with Syria.
- Lebanon's physical geography is complex as any mountainous country.
 - In short distances, land shapes, atmosphere, soil and vegetation differ markedly.
 - Certain aspects of the climate, from good to bad soil, often shift dramatically.



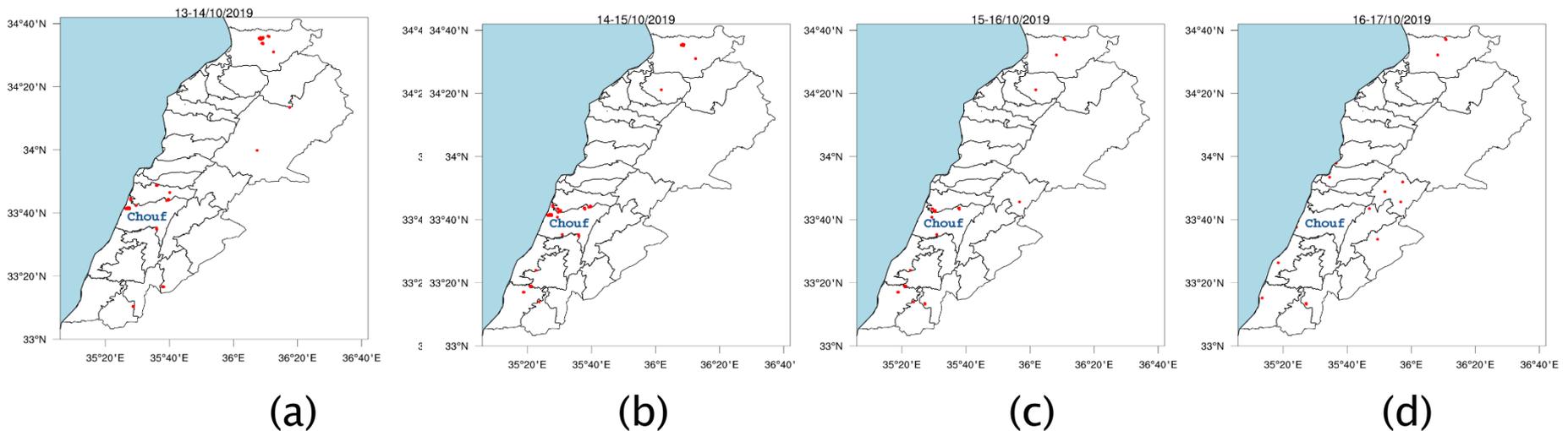
Chouf District

- Chouf District is one of the six districts of Mount Lebanon Governorate.
- extending from the Mediterranean Sea coast westerly to Barouk mountain easterly, and from Damour river northly to El Aouali Markits southerly.
- It has a typical Mediterranean climate, with a maximum average temperature of 20 °C in August (hot and dry summer) and minimum temperature of 4°C in January (cold and wet winter).
- It is characterized in having natural reserve of Cedar lies to the west of Mount Lebanon.



Results & Discussion

In mid-October 2019, Lebanon witnessed a series of destructive wildfires, in which it started on 13th October in Chouf District and some other regions, and gradually the fires started and spreaded in many regions, and last till 17th of October.



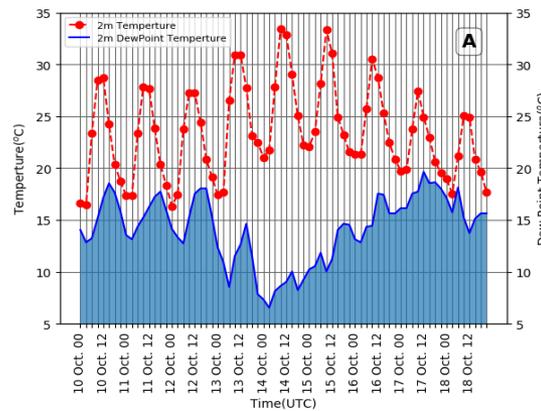
Burned areas in Lebanon on: (a) 13-14 October 2019; (b) 14-15 October 2019; (c) 15-16 October 2019 and (d) 16-17 October 2019.

Results & Discussion

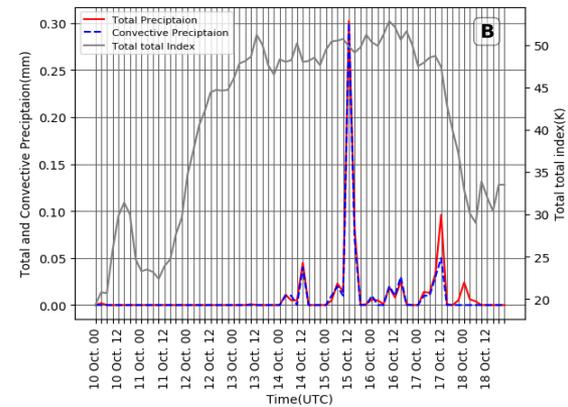
High temperature and low humidity, active wind and gust wind, unstable conditions, convective precipitation with thunder

Time series of some atmospheric parameters over Chouf district during 10-18 October 2019 including:

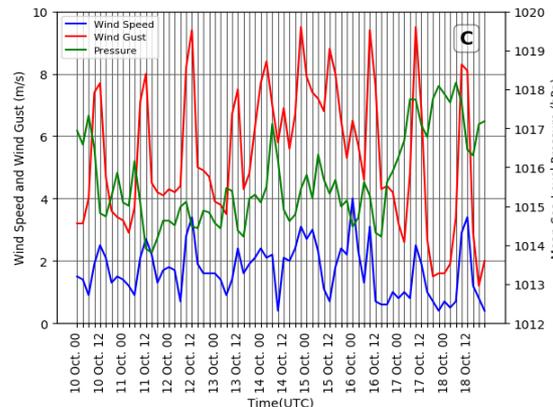
- (a) dew point temperature and temperature;
- (b) total precipitation, convective precipitation and total total index;
- (c) pressure, gust wind and wind speed and
- (d) total cloud cover.



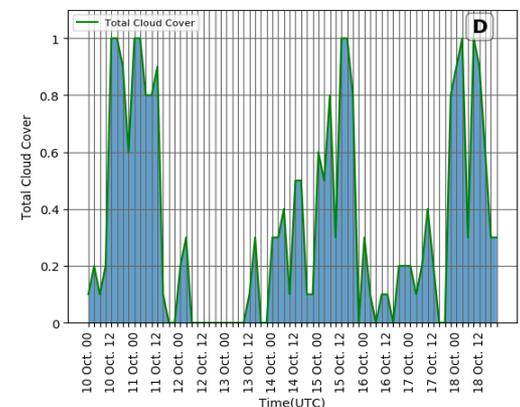
(a)



(b)



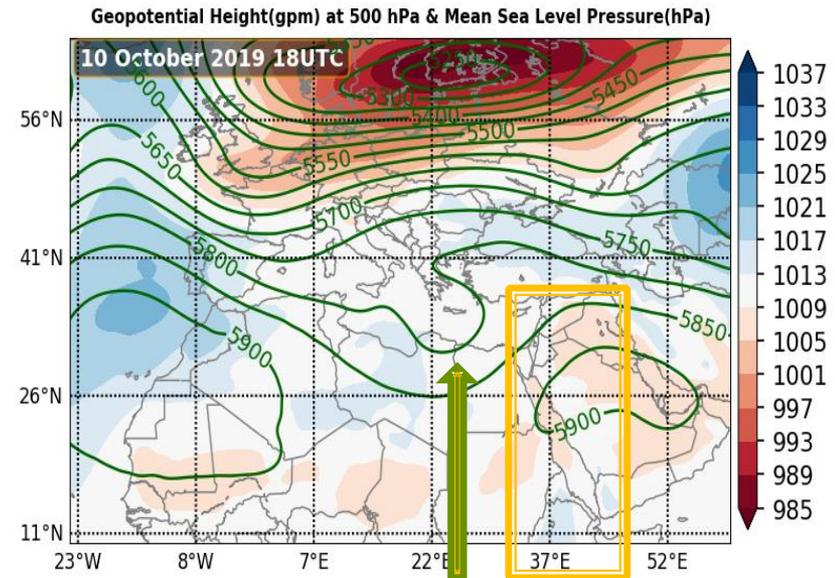
(c)



(d)

10th of October 2019 at 18 UTC

- The open wave is progressing towards the east, in which this motion causes to deepen the open wave trough and distort long wave ridge.
- A cold dry front has started to progress towards the eastern Mediterranean causing atmospheric instability.



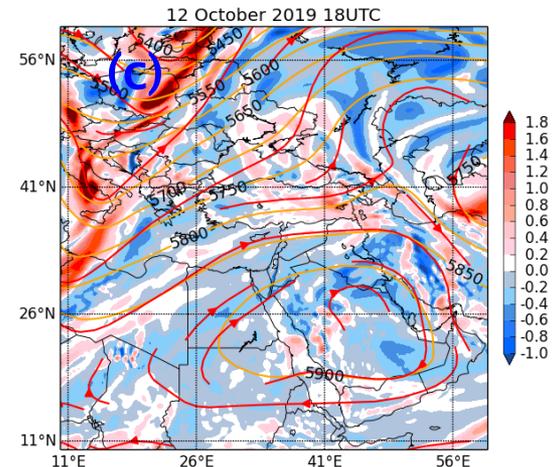
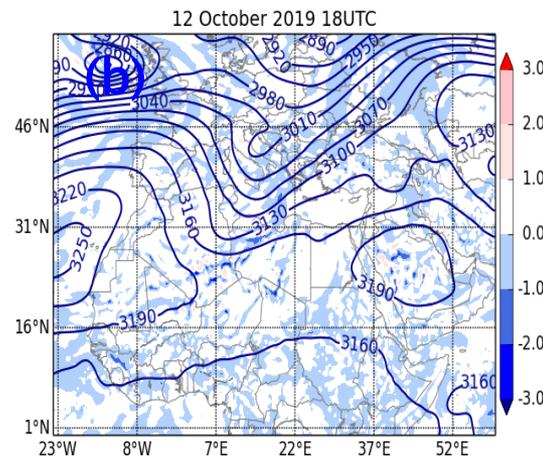
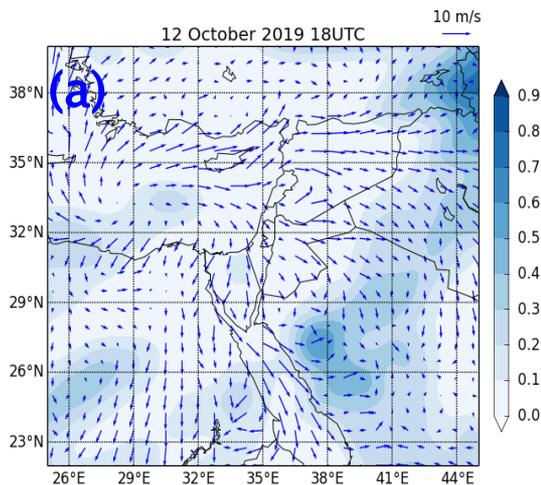
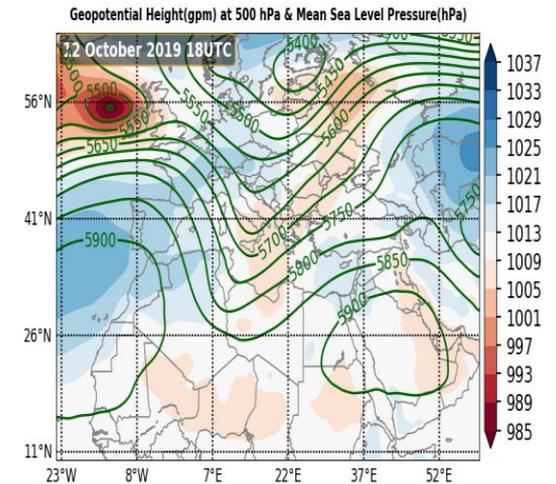
**Upper trough
(open wave
(negative tilt)**

**High pressure
systems**

Geopotential height at 500 hPa (contour lines),
and the MSLP (shaded) on 10th October 2019

12th of October 2019 at 18 UTC

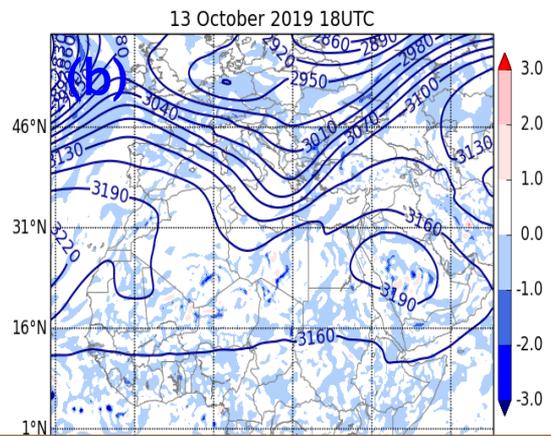
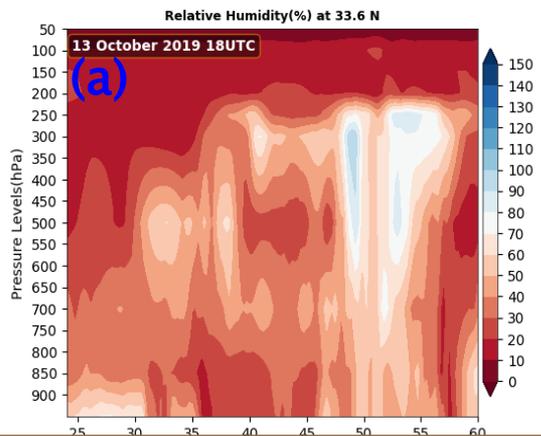
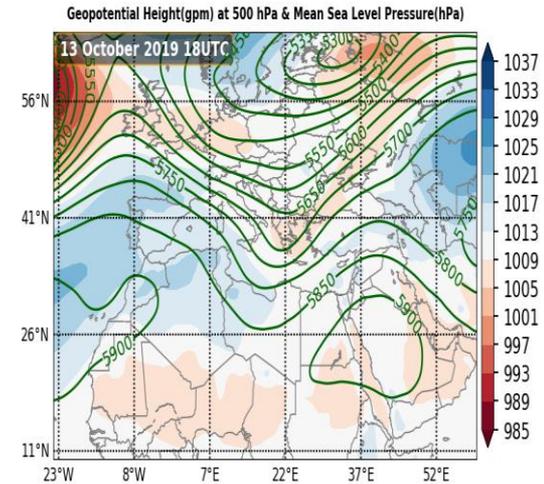
- The cold front has passed the region
- The upper trough has deepened and progressed rapidly to the east (positive tilt), and the shortwave moved into the western side of the upper ridge causing to flattening it, meanwhile the surface high is still dominating over the region



Same as previous but it is for 12th October 2019

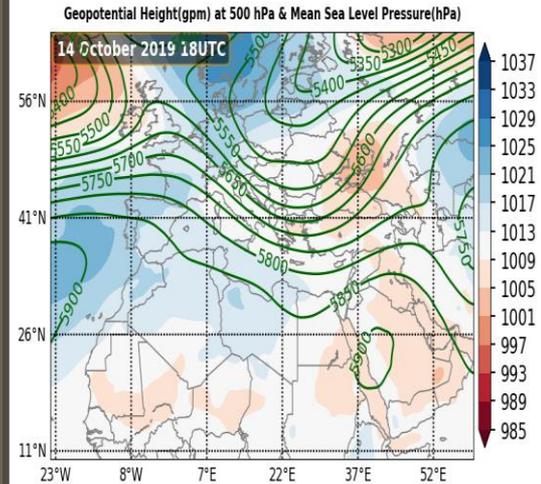
13th of October 2019 at 18 UTC

Lebanon is placed in the transition zone between upper trough and upper ridge (instability) due to strong wind aloft sinking to low levels producing (low level jet), and surface daytime heating leading to warmer and drier conditions, with mid-level moisture for convective clouds formation (thunder as the spark of the fire ignition in Chouf)

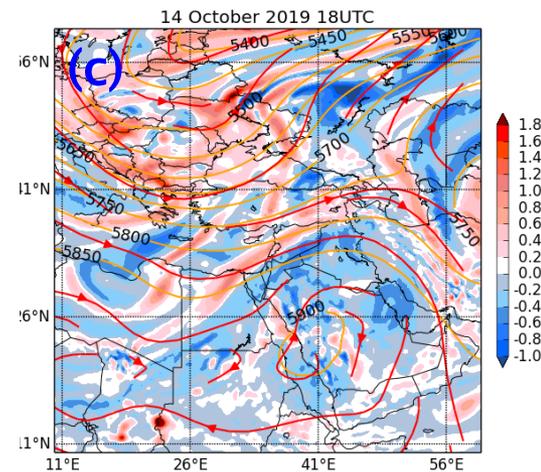
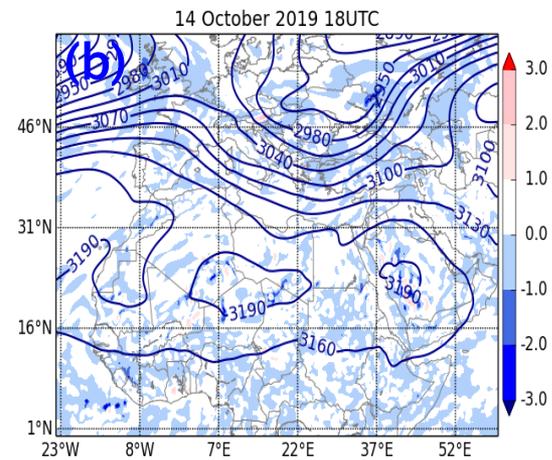
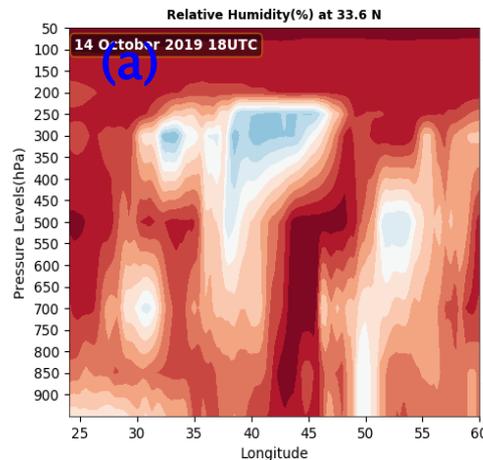


14th of October 2019 at 18 UTC

- The surface Indian Monsoon enhanced, and shifted towards the eastern Mediterranean
- The surface heating and unstable conditions
- The breakdown of upper ridge leading to the advection of dry wind with high speed (low level jet) associated with surface front, convective clouds producing thunderstorms with no rain over Chouf causing lightning that “we believe” it ignites fires and rapid fire has spread due to gusty surface winds.

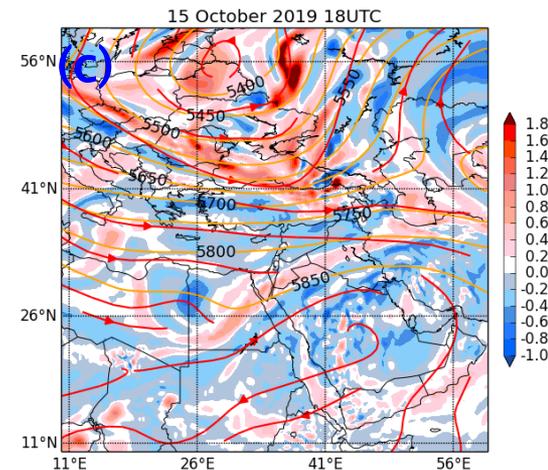
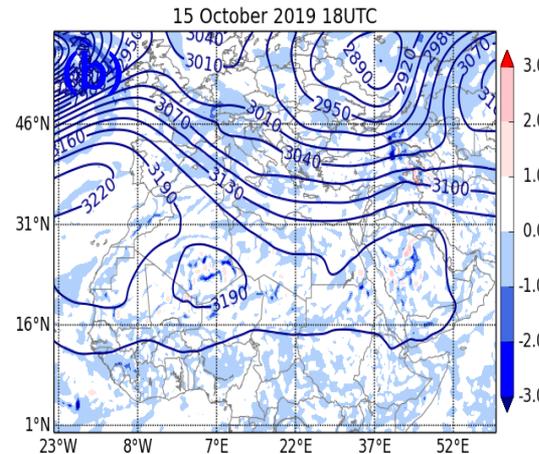
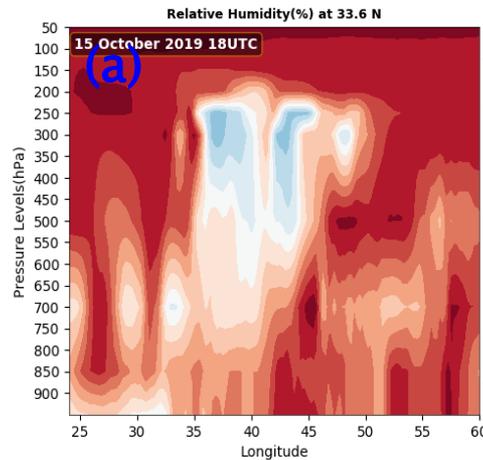
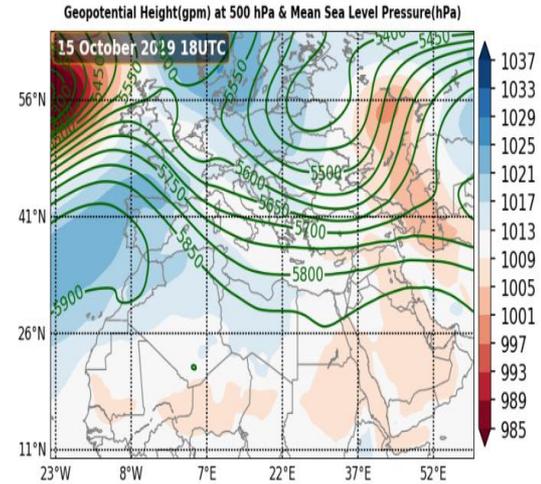


Same as
previous
but it is
for 14th
October
2019



15th of October 2019 at 18 UTC

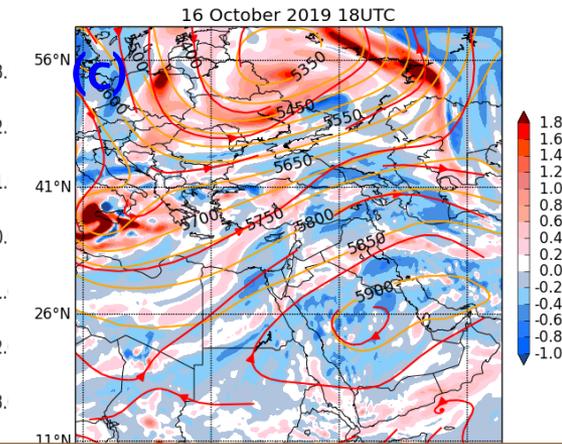
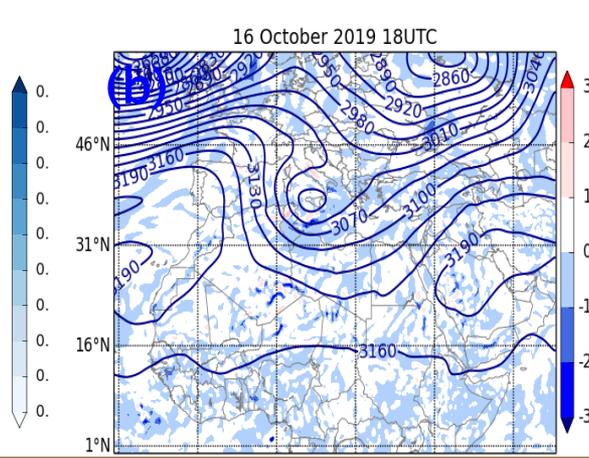
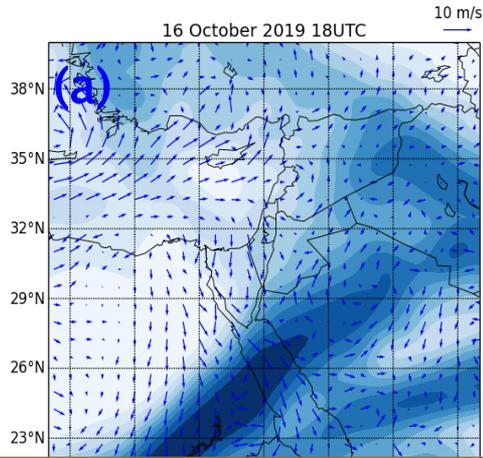
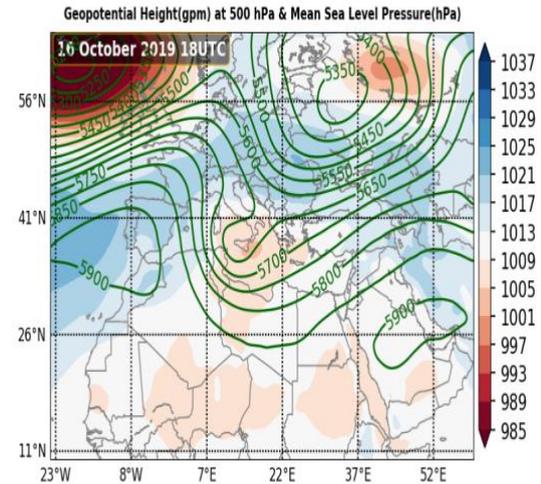
The upper flow is “Zonal”, and as a result the weather at the surface remains warmer and drier, developing convective clouds producing thunderstorms and lightning with convective precipitation over Chouf of about 0.3 mm and the number of affected regions of Chouf district has increased



Same as previous but it is for 15th October 2019

16th of October 2019 at 18 UTC

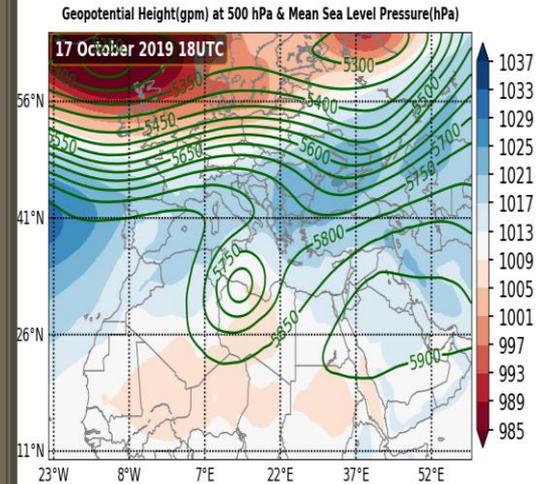
- Fires have ignited again after rainy day in many regions due to the unstable and warm conditions associated to the upper ridge breakdown.
- The upper trough with positive tilt is moving towards the east, resulting in surface low retrogression, activating the surface high and leading to cold air advection.



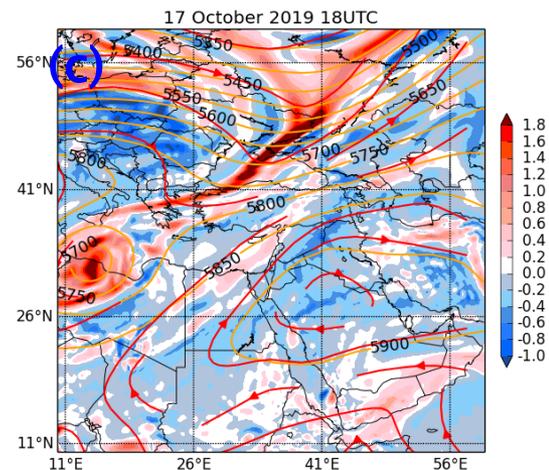
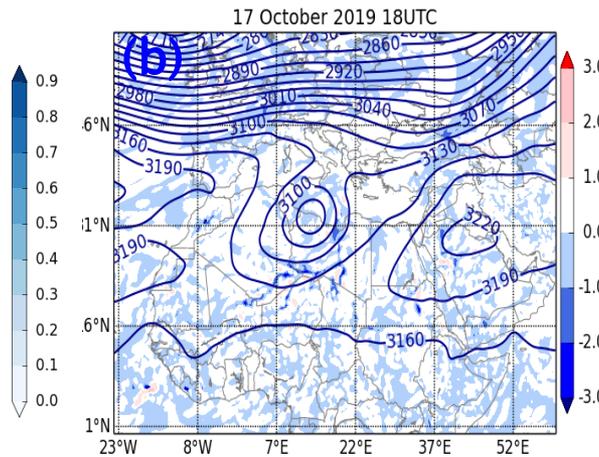
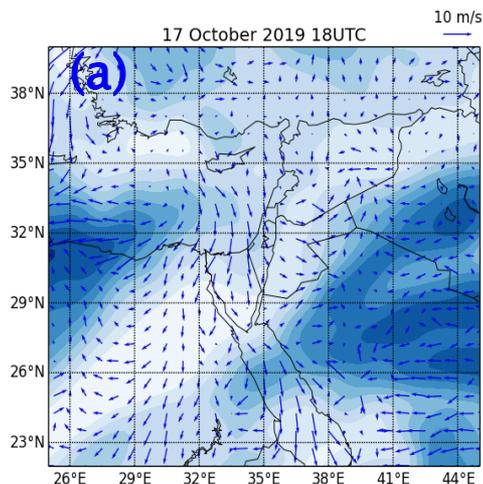
(a) Total cloud & wind, (b) vertical velocity (shaded) and geopotential height at 700 hPa (contour lines), (c) wind speed at 500 hPa (red contour line), geopotential height (orange contour line) and relative vorticity at 500 hPa (shaded)

17th of October 2019 at 18 UTC

- Lebanon again lies under blocking atmospheric system with continues warming, which forced the sea breeze towards the lands (cold front)
- This situation resulted in convective clouds formation and less precipitation particularly in high terrain regions (ex. Chouf), and thus the fires continues in many regions, but the situation has become less critical

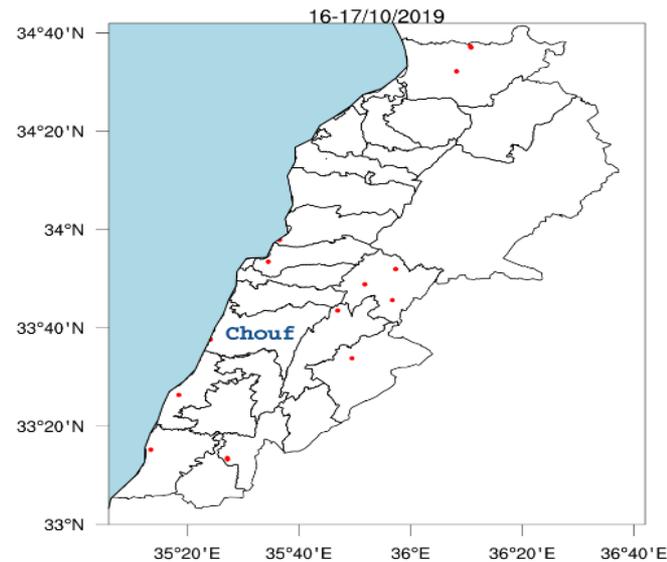


Same as previous but it is for 17th October 2019



18th of October 2019 at 18 UTC

- Due to the previous situation, the heat wave has receded on 18th October, and fire ignition has stopped in Chouf district



Burned areas in Lebanon on 16-17 October 2019.

Conclusions

- The wildfire occurrence over Lebanon in mid-October 2019 is caused due to atmospheric situation represented by the domination of upper ridge and surface high pressure system leading to the formation of blocking, and resulting in heat wave over the eastern Mediterranean region due to adiabatic warming with sinking motion and warm air advection.
- On 13th to 14th October, the eastern movement of the upper open wave towards eastern Mediterranean caused the breakdown of upper ridge, in which Lebanon lied under transition zone between upper trough and ridge systems.

Conclusions

- The advection of dry air aloft to low level with cold front passage on the surface producing low level jet. The instability on the surface with the available moisture in mid-levels due to upper front leads to convective clouds producing thunderstorms with no rain (because of the lack in moisture on the surface) over Chouf district causing lightning, which is a critical tool to ignite fires in a rich area of dry fuels associated with low moisture and higher temperature and high wind speed.
- The period of fires has elongated till 18th October due to unstable and warm conditions associated to the upper ridge breakdown.



ENDING SLIDE

THANK YOU FOR YOUR ATTENTION!