THE ROLE OF VERTICAL WIND SHEAR IN THE GREAT PYROCUMULUS OF COSTA DEL SOL (MÁLAGA, SPAIN) ON 30 AUGUST 2012

José María Sánchez-Laulhé[1], Miguel Ángel Catalina[2], Roberto Fraile[3], María Fernández Raga[3]

[1] *AEMET, Málaga Meteorological Center, Spain.*

[2] *Regional Service against fire (Infoca) in Málaga, Spain.*

[3] *Department of Applied Chemistry and Physics, IMARENAB, University of León, Spain España*

maria.raga@unileon.es

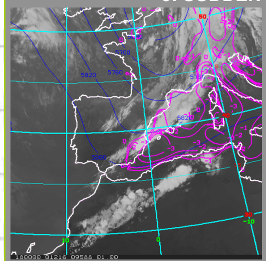
ABSTRACT

On August 30th, 2012 a disastrous fire was recorded on the Costa del Sol, Spain (1) in a situation of northerly flow at low levels called "*Terral*". This *terral* creates an environment of high temperatures, low humidity and strong winds, very favorable to the forest fires spreading to the coast very quickly. During the fire started on August 30th, the NW flow at low levels changed abruptly to a east maritime wind (2) with a behavior of gravity wind and a sudden wind entrance from east (3), and very serious consequences: a sudden change in the speed and the direction of propagation, and in magnitude of the fire (4), which greatly hindered its control. The sharp increase in vertical wind shear that caused the outbreak of the density current (5 and 6) is proposed as an explanation for the extreme fire characteristics (duration, propagation speed and intensity).

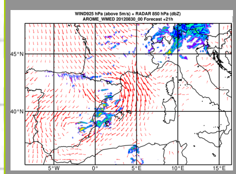
1: THE FIRE

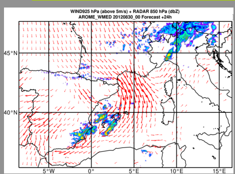
The most virulent wildfire occurred in Andalusia was recorded on August 30th, 2012 in the area of Barranco Blanco (Málaga). It will be remembered not only for its speed of propagation, with high incidence in long transported sparks but also for the magnitude of the economic losses caused, affecting 8592.16 hectares. It caused one death and the evacuation of about 4,000 people, including the entire town of Ojén.

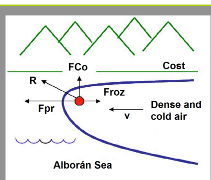
3: SUDDEN WINDS ENTRANCE FROM EAST



Usually a sudden wind entrance from east occurs after the passage through the Iberian Peninsula of a cold thin front, like the one of August 30th 2012 (IR image; 18 UTC). The "cold" air, after the front reaches the Mediterranean Sea through the Ebro and the Rhone valleys and arrives, after surrounding the peninsula on its eastern coast, to the Andalusian Mediterranean coast (see maps of low-level wind fields at the end of the day 30). This "cold" Mediterranean stream converges with the warm borders terral winds creating strong temperature, humidity, and density gradients. These gradients create imbalances on the coast resulting in the advance of cold air to the west along the north coast of the Alboran Sea, as a density stream, which produces a sudden entrance od eastern winds (Sanchez-Laulhé and Polvorinos, 1995)

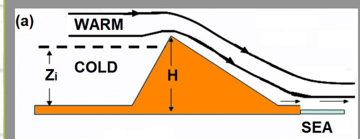


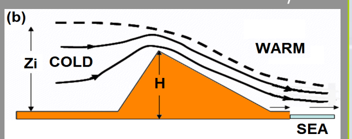




φ is the latitud, Ω the Earth rotation speed, and k is the vertical unit vector

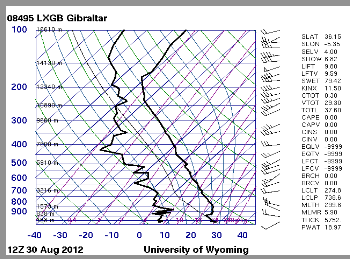
$$f = 2\Omega sen\phi \qquad F_{Co} = f\vec{k}\times\vec{V} \qquad F_p = -\frac{1}{\rho}\cdot\nabla p$$

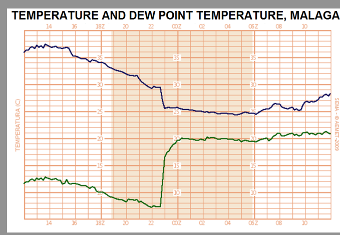


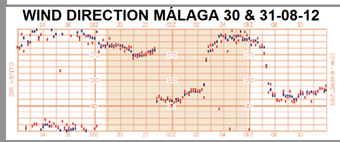


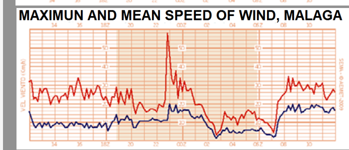
(a) Foehn wind; (b) Bora wind, caused by synoptic situations that force strong winds over the montain. Solid lines are paths; dotted line represents the temperature inversion.

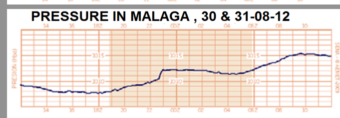
2: CHANGES FOR THE SUDDEN OUTBREAK FROM EAST





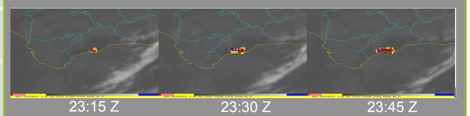




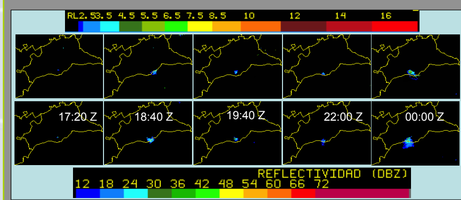


In the Radiosounding from Gibraltar at 12 UTC, a dry and warm air layer with NW wind is observed over a temperature inversion at low levels, forcing a *terral* on the Malaga coast of. At 17 UTC, when the fire started, the temperature was 34 ºC, the relative humidity was 24% and northerly wind was around 8 km/h with gusts of 25 km/h . At the end of the day a sudden outbreak of wind form east changed the conditions across the coast from east to west .In the Meteorological Centre of Malaga the wind shifted abruptly to the east, increasing its average speed to 20 km/h with gusts of wind of about 58 km/h; the relative humidity rose above 70% and the pressure rose about 2 hPa.

4: SATELLITE AND RADAR IMAGES DURING THE CHANGE OF WIND



In the MSG IR3.9 channel (indicating temperature of hot ashes and CO_2 on the burned area), the details of the most virulent fires are lost in fires like this. The reason is that there are effects on the sensor operation, such as the recovery time after saturation by brightness temperatures of 336 K (blinding effect). Blinding affects the values of a few pixels which are west of saturant pixel. In this case it occurs from 2330 UTC.



The Málaga radar shows the development of a pyrocumulus with eastern wind both in echotops (maximum height of the radar cloud echoes) and in the PPI reflectivity.

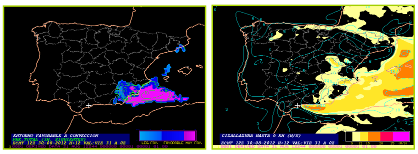
5: INTERACTION WIND SHEAR – VERTICAL WIND SPEED

The interaction of vertical wind shear $\frac{\partial \vec{V}}{\partial z}$ with an updraft *w'* creates pressure disturbances in high levels (Bluestein, 1993)

$$p' \propto \frac{\partial \vec{V}}{\partial z}\cdot\nabla_z w'$$

that organize and intensify vertical movements: negative and positive pressure perturbations are created on both sides of the updraft in the direction of shear vector , negative on the side towards the shear vector is directed, and positive on the opposite side, favoring downdrafts.

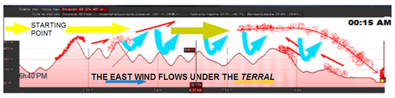
Left:environment favorable to convection. Right: vertical wind shear in the first 6 km. (Data provided by the ECMWF IFS model for August 31st at 00 UTC.)

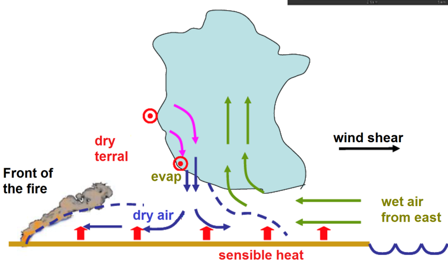


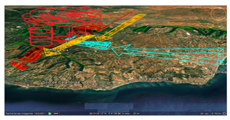
The atmosphere was not favorable to trigger a deep convection on the province of Malaga but the entrance of wet air at low levels, the fire trigger, and the upward acceleration caused by vertical shear contributed to a pyrocumulus with a large vertical development.

The wind shear itself organized the upward and downward movements so that the pyrocumulus acquired stationary characteristics (see diagram in 6).

6: SCHEME OF INTERACTION FLOW-PYROCUMULUS-FIRE







Top: flow diagrams made "in situ" by staff from INFOCA-Málaga. Bottom: proposed scheme where the pyrocumulus generated by the fire, maintained the maritime eastern flow, rised it, dried it in the downdraft, and fed the fire. All of this was induced by the organization of vertical currents in the pyrocumulus due to the vertical wind shear.

Therefore it seems that the wind shear is an important factor in organizing the convection, making it more stationary and severe. It can also be an important factor in the organization and duration of fires.

REFERENCIAS

Bluestein H. B., 1993: Synoptic-Dynamic Meteorology in Midlatitudes: Volume II: Observations and Theory of Weather Systems Oxford University Press .

Sánchez-Laulhé JM; Polvorinos F.,1995: Entradas bruscas de vientos de levante en la costa norte de Alborán. Boletín de la Asociación Meteorológica Española, Volumen:18/19, 30-35.