LOW LEVEL JET AND LARGE WILDFIRES IN CROATIA

VišnjaVučetić*
Croatian Meteorological and Hydrological Service, Zagreb, HR, vucetic@cirus.dhz.hr

Ivana Čavlina Tomašević
Croatian Meteorological and Hydrological Service, Zagreb, HR, tomasevic@cirus.dhz.hr

Boris Mifka
University of Rijeka, Department of Physics, Rijeka, HR, boris.mifka@phy.uniri.hr

1. Introduction

In Croatia, particularly in the area of the mid-Adriatic coast and islands, many wildfires have been recorded throughout history. Some of these fires showed their disastrous impact not only through the destruction of the vegetation, but also through material damage and human sacrifice such as the 12 dead and one badly injured firefighter in the Kornat fire on 30 August 2007 (Vučetić et al. 2007). Similar climatic features with Mediterranean vegetation prevail along the Adriatic coast. Therefore, forest fire analyses in Croatian earlier studies were based on weather conditions analysis of typical winds prevailing on the Adriatic. Three most common and strongest wind types are: *bura* (NE), *jugo* (SE) and *maestral* (NW). In three wildfire cases referred to mentioned wind types, a characteristic vertical wind profile was observed with maximum wind speed at 500–700 m. a. g. l. and abrupt speed decrease above followed by change in wind direction (Vučetić and Vučetić, 1999). According to previously defined criteria, if the maximum wind speed in the lower troposphere exceeds 12 m/s, it is classified as a low level jet (LLJ, Bonner, 1968). LLJ is a very important atmospheric phenomenon because it can have a strong influence on the dynamic processes in the atmosphere. The presence of a strong LLJ in the lower troposphere often precedes the passing of the cold front and can have a significant effect on the beginning and spread of the wildfires (Barad, 1961; Huang et al. 2009). Research in the United States found that a fire with turbulent behaviour may sometimes develop immediately before the cold front passage (Byram, 1954). Therefore, the aim of this study is to investigate the relation between the cold front in synoptic scale and LLJ in mesoscale and its impact on large wildfires propagation in the Adriatic. The large forest fire is defined by the burned area greater than 500 ha.

2. Material and method

Six synoptic situations related to nine large wildfires in the mid-Adriatic from July to September in the period 2001–2011 were selected for the research (Tab. 1). Each fire comprised burned area between 800 and 5600 ha. The German Meteorological Service (*Deutsche Wetterdienst, DWD*) surface and upper-level synoptic charts over Europe for the period of large wildfires were analysed. The radiosonde data at the Zadar station and the ALADIN/HR model products were used to analyze the vertical structure of the atmosphere during the fires. ALADIN/HR model is

* Grič 3, HR-10000 Zagreb, vucetic@cirus.dhz.hr, http://www.meteo.hr

the Croatian operative version of the METEO-France ALADIN mesoscale model (*Aire Limiteé Adaptation Dynamique dévelopement InterNational*). It is a hydrostatic model with a horizontal resolution of 8 km and 37 vertical levels and high-resolution dynamical adaptation for wind speed and direction with horizontal resolution of 2 km (Bajić et al., 2007).

Table 1: Location and duration of large forest fires in the mid-Adriatic in the period 2001–2011

Weather situation	Location of wildland fire	Burned area (ha)	Date	Year	Prevailing wind
A	Omiš near Split	3000	11–14 August	2001	*bura*
	Island of Brač	800	11–16 August		*bura*
	Dubrovnik	1900	12–16 August		*bura*
B	Island of Hvar	1197	29 July–11 August	2003	*bura*
	Island of Brač	2997	30 July–4 August		*bura*
C	Island of Hvar	2114	12–18 August		*bura*
D	Island of Lastovo	1825	3–9 September		*bura*
E	Makarska	850	19–20 September	2008	*bura*
F	Island of Brač	5600	14–17 July	2011	*jugo and maestral*

3. Results and discussion

In this study the A and F fire weather analysis results will be shown. In the situation A, a strong *bura*, NE wind, on the northern and mid-Adriatic occurred due to the high pressure gradient between the ridge over southern Germany and trough with cold front passing over mid-Adriatic on 11/12 August 2001 (Fig. 1, left). There were three active large wildfires on the mid-Adriatic in this case (tab 1). In the situation F the shallow Genoa cyclone above the northern and mid-Adriatic and a weak anticyclone above the Northern Macedonia were present (Fig. 1, right).

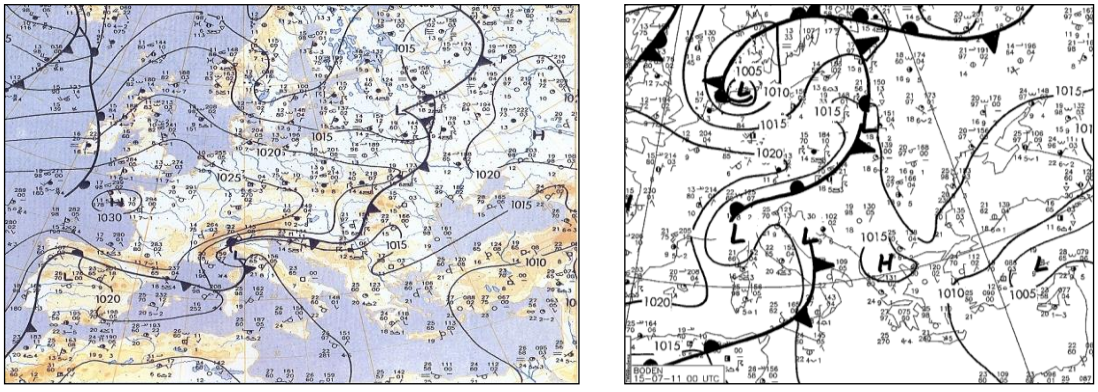

Figure 1: Surface synoptic situation over Europe on 11 August 2001 at 00 UTC (left) and on 15 July 2011 at 00 UTC (right). Source: Deutsche Wetterdienst (DWD)

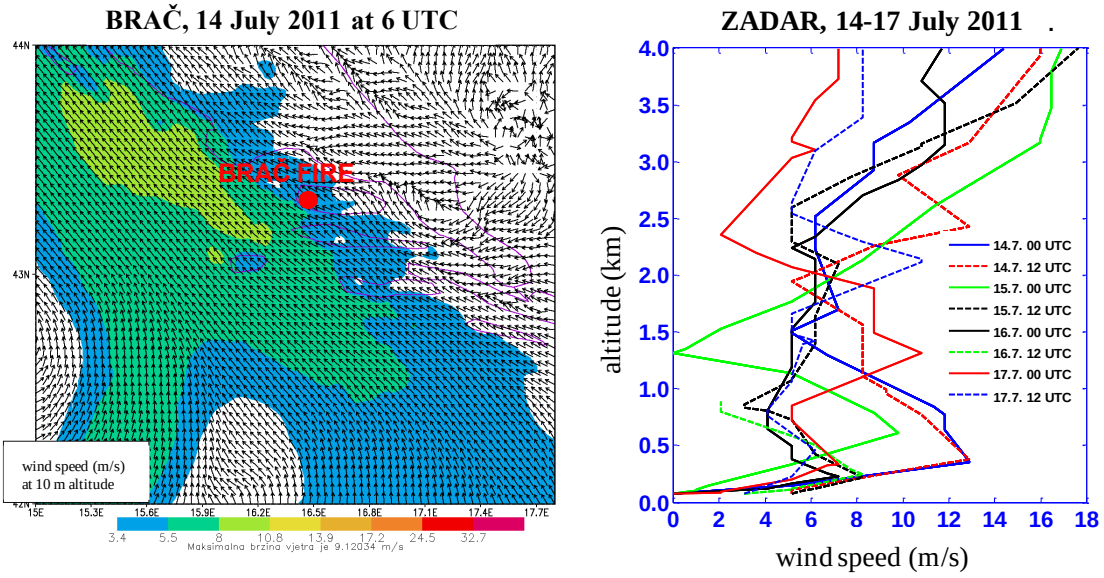

Figure 2: Surface wind direction (arrows) and wind speed (m/s, shaded) at the 10 m altitude on mid-Adriatic area on 14 July 2011 at 6 UTC using the ALADIN/HR model with the 2 km horizontal resolution (left) and vertical profiles of wind speed (m/s) for Zadar for 14–17 July 2011 using the radiosonde data (right).

Therefore, moderate to strong *jugo*, SE wind, blew above Adriatic at the beginning of wildfire on the island of Brač on 14 July 2011 (Fig. 2, left). The weather was very dry and warm with relative humidity of 38 % at 13 UTC and maximum temperature of 36 °C (Mifka, 2012). Next day the cold dry front passed the Adriatic Sea and *jugo* turned to *maestral*, NW wind. *Maestral* is superposition of the etesian winds and sea breeze.

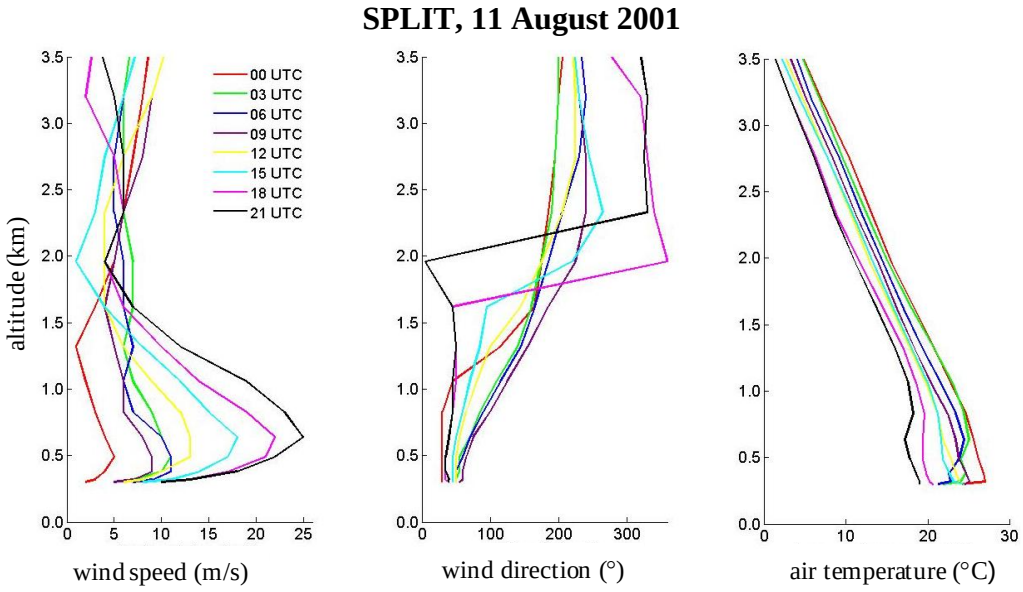

Figure 3: Vertical profiles of wind speed (left, m/s), wind direction (middle, °) and air temperature (right, °C) for Split on 11 August 2001 using the ALADIN/HR model

The vertical wind and temperature profiles near the fire locations were simulated by the ALADIN/HR model. On 11 August 2011 at 12 UTC in Split a strong vertical gradient of wind speed occurred between 6 m/s at the surface and 13 m/s at 500 m.a.s.l. (Fig. 3) which undergoes the LLJ criterion. LLJ strengthened towards the end of day and maximum of 25 m/s was reached at 21 UTC. Due to the strong inversion layer (stable layer) above maximum wind speed, an abrupt wind speed decrease occurred. Additionally, the Zadar sounding data for Brač fire from 14 to 17 July 2011 were also used (Fig. 2, right). At the beginning of fire the vertical wind profiles have similar shapes as in in previous case, but with half of the maximum speed (12.9 m/s). In the considered weather situations all the fires started before the cold front passage and were associated with strong wind shear (up to 5 m/s per 100 m) and turbulence below the LLJ.

Therefore, in the high fire risk situations in Adriatic, the cold front passage and LLJ forecasts could be used as additional warning indicators. Recognizing these additional critical weather conditions during wildfires could be of great help in alerting firefighters to standby. This approach would be beneficial in wildfire natural and material damage reduction as well as in human live protection.

References:

Bajić A, Ivatek-Šahdan S, Horvath K, (2007) Spatial distribution of wind speed in Croatia obtained using the ALADIN model. *Croatian Meteorological Journal* **42**, 67–77. (in Croatian)

Barad ML (1961) Low-Altitude Jet Streams. *Scientific American* **205**, 120–131.

Bonner WD, (1968) Climatology of the Low Level Jet. *Monthly Weather Review* **96**, 833–850.

Byram GM, (1954) Atmospheric conditions related to blow up fires. A Publication of the National Wildfire Group, PMS 815-NFES 2239, Forest Experiment Station Asheville, Station Paper 35, p. 29

Huang C, Lin Y-L, Kaplan ML, Charney JJ, (2009) Synoptic-Scale and Mesoscale Environments Conductive to Forest Fires during the October 2003 Extreme Fire Event in Southern California, *Journal of Applied Meteorological and Climatology* **48**, 553–579.

Mifka B. and V. Vučetić (2012), Weather analysis during extreme forest fire on island of Brač from 14 to 17 July 2011. *Vatrogastvo i upravljanje požarima* **1**, 13–25. (in Croatian)

Vučetić M, Vučetić V, (1999) Different types of the forest fires on the Croatian coast. *Forest fires: Needs & innovations, DELFI99,* Athens, Greece, 17–20 November 1999, 365–369.

Vučetić V, Ivatek-Šahdan S, Tudor M, Kraljević L, Ivančan-Picek B, Strelec Mahović N, (2007) Weather Analysis during the Kornat Fire on 30 August 2007. *Croatian Meteorological Journal* **42**, 41–66. (in Croatian).