DHMZ

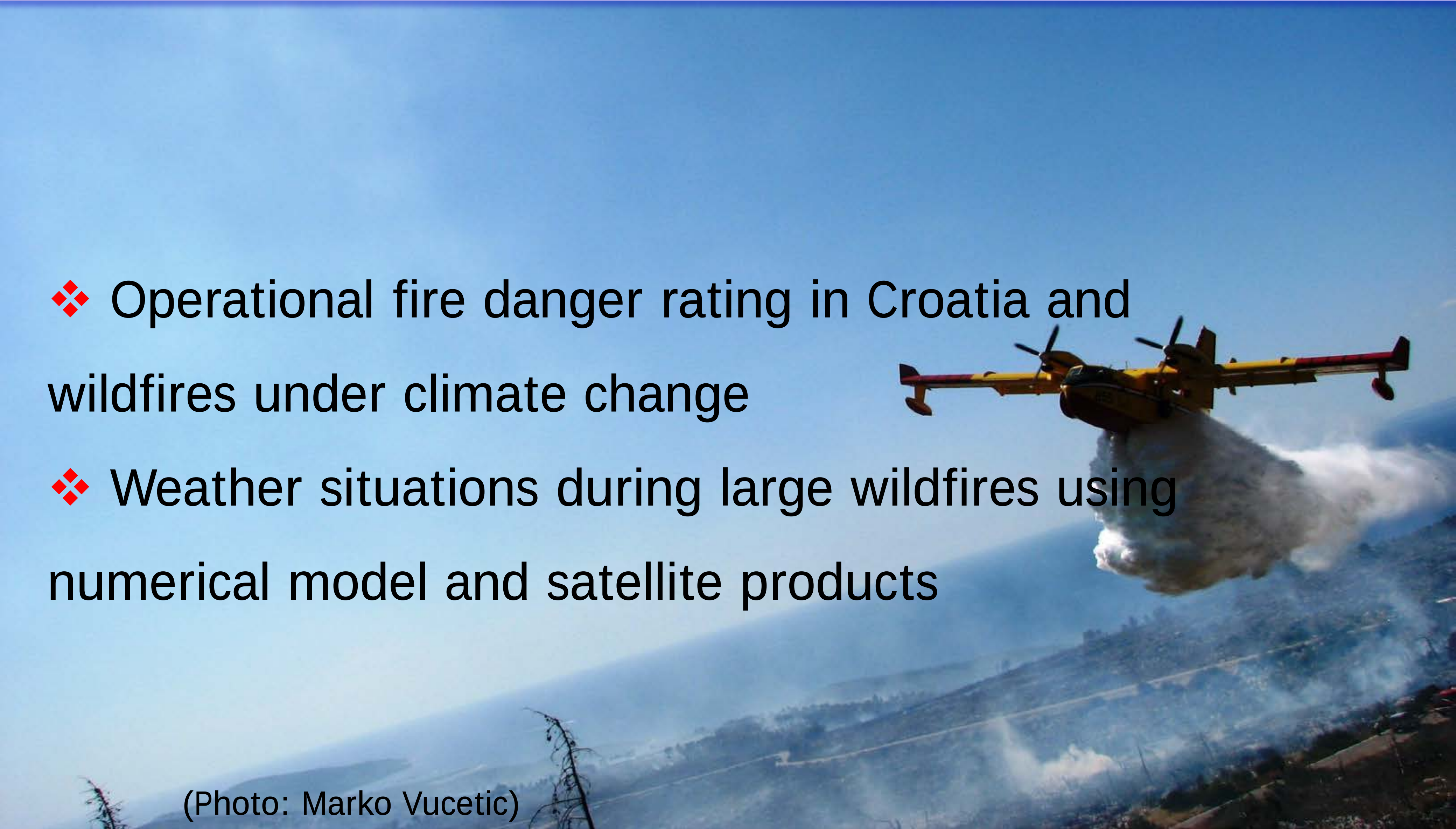
Forest/bush fire risk products in Croatia

dr. sc. Višnja Vučetić
Head of the Agrometeorological Department
Meteorological and Hydrological Service
E-mail:vucetic@cirus.dhz.hr
http://meteo.hr

Budapest, 27 April 2017

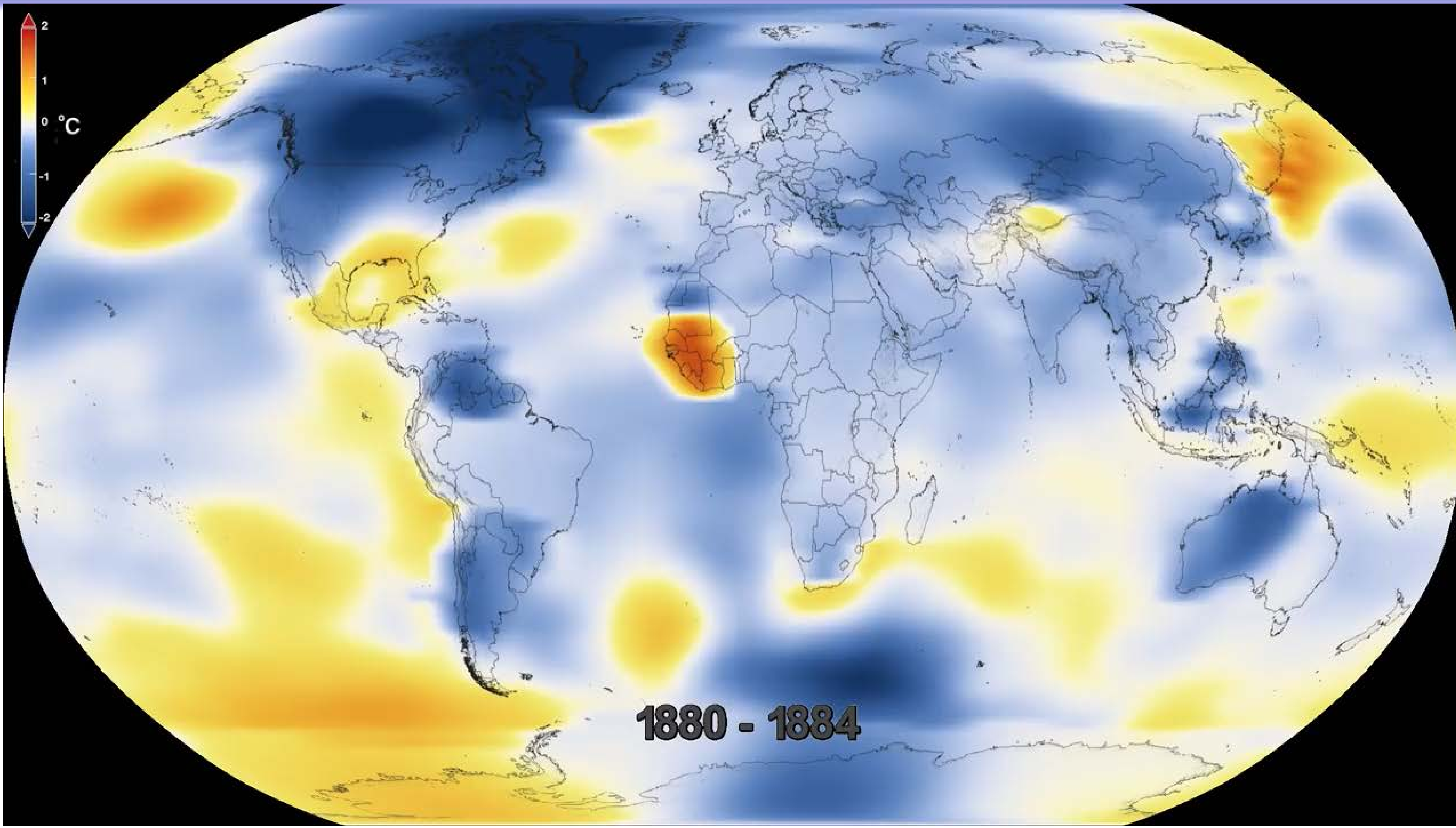
Outlines

- Operational fire danger rating in Croatia and wildfires under climate change
- Weather situations during large wildfires using numerical model and satellite products



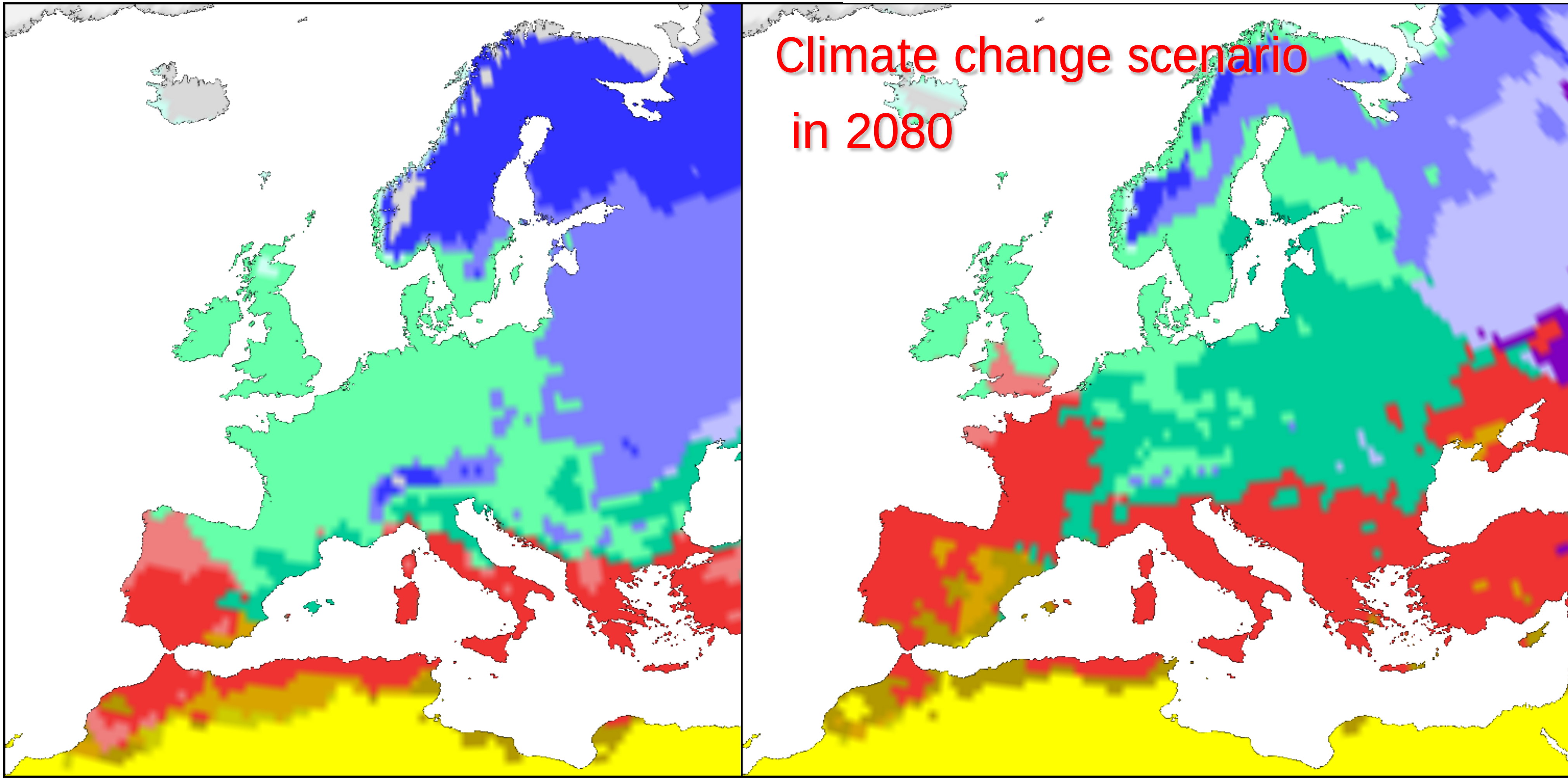
(Photo: Marko Vucetic)

Global warming



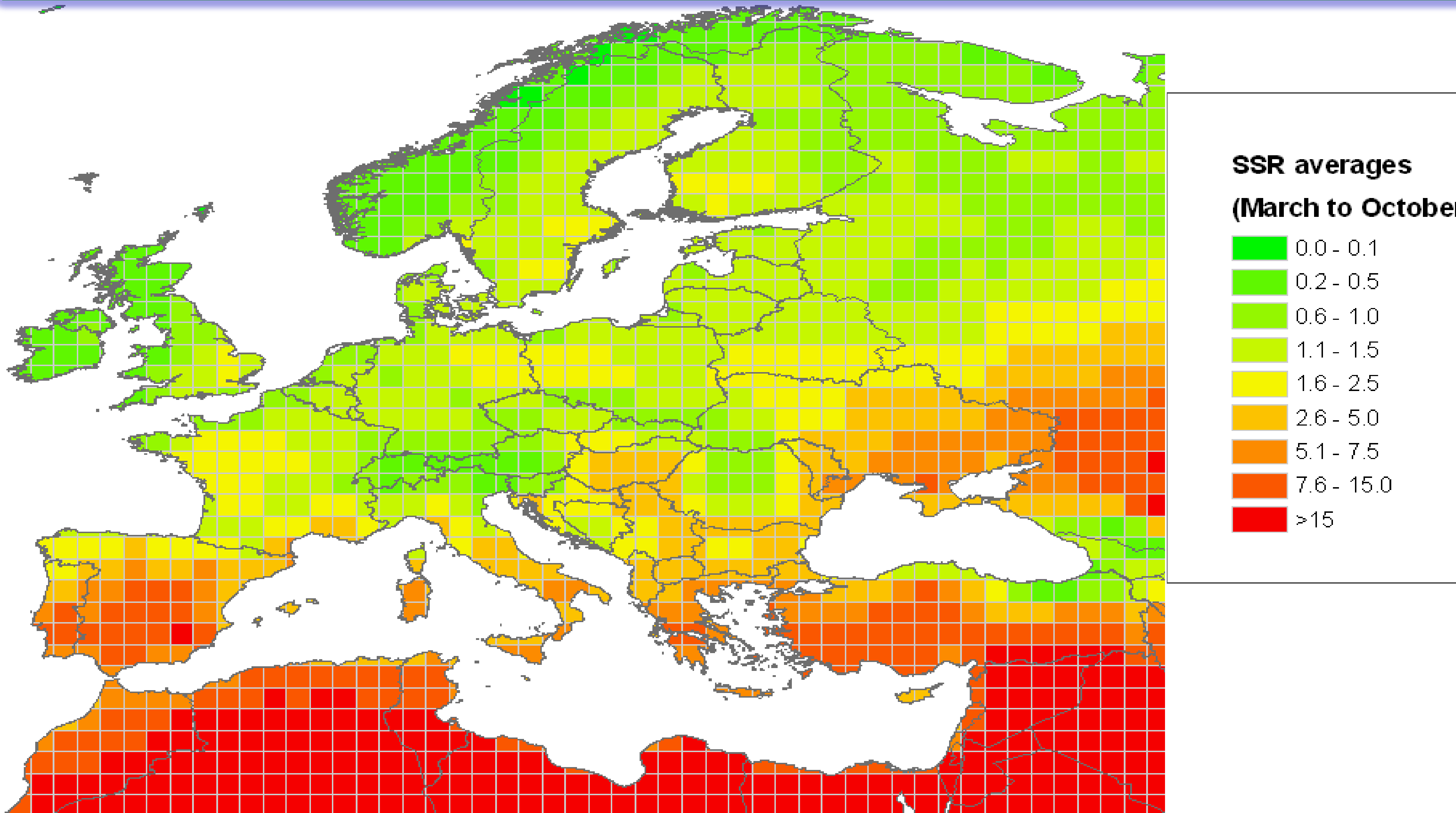
Source: NASA, 2017

Köppen climatic zone (1961-1990)



Source: Kristi Jylhä

Potential risk of forest fires in Europe from March to October



(Camia et al., 2008)

Forest Fire Warning in Europe (RA VI)

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	Country	days			Country	days	
1	Albania			26	Lebanon		
2	Armenia			27	Lithuania	3	
3	Austria	5		28	Luxembourg		
4	Azerbaijan			29	Malta		
5	Belarus			30	Monaco		
6	Belgium			31	Montenegro	2	
7	Bosnia and Herzegovina	2		32	Netherlands (the)		
8	Bulgaria			33	Norway	2	
9	Croatia			34	Poland		
10	Cyprus			35	Portugal		
11	Czech Republic	3		36	Republic of Moldova		
12	Denmark			37	Romania		
13	Estonia	2		38	Russian Federation	2	
14	Finland	2		39	Serbia	3	
15	France			40	Slovakia		
16	Georgia			41	Slovenia	5	
17	Germany			42	Spain		
18	Greece			43	Sweden	2	
19	Hungary			44	Switzerland	6	
20	Iceland			45	Syrian Arab Republic		
21	Ireland			46	TFRY of Macedonia		
22	Israel			47	Turkey		
23	Italy	2		48	Ukraine		
24	Jordan			49	United Kingdom		
25	Latvia	2					

- unavailable network site
- warning not visible
- warning that matches with MeteoAlarm
- extra warning besides MeteoAlarm
- MeteorAlarm but not forest fire warning
- days — number of warning days

- 34 European countries produce different warnings of extreme weather events every day for today and tomorrow in the frame of the MeteoAlarm but warning on forest fires is represented only in fifteen countries.

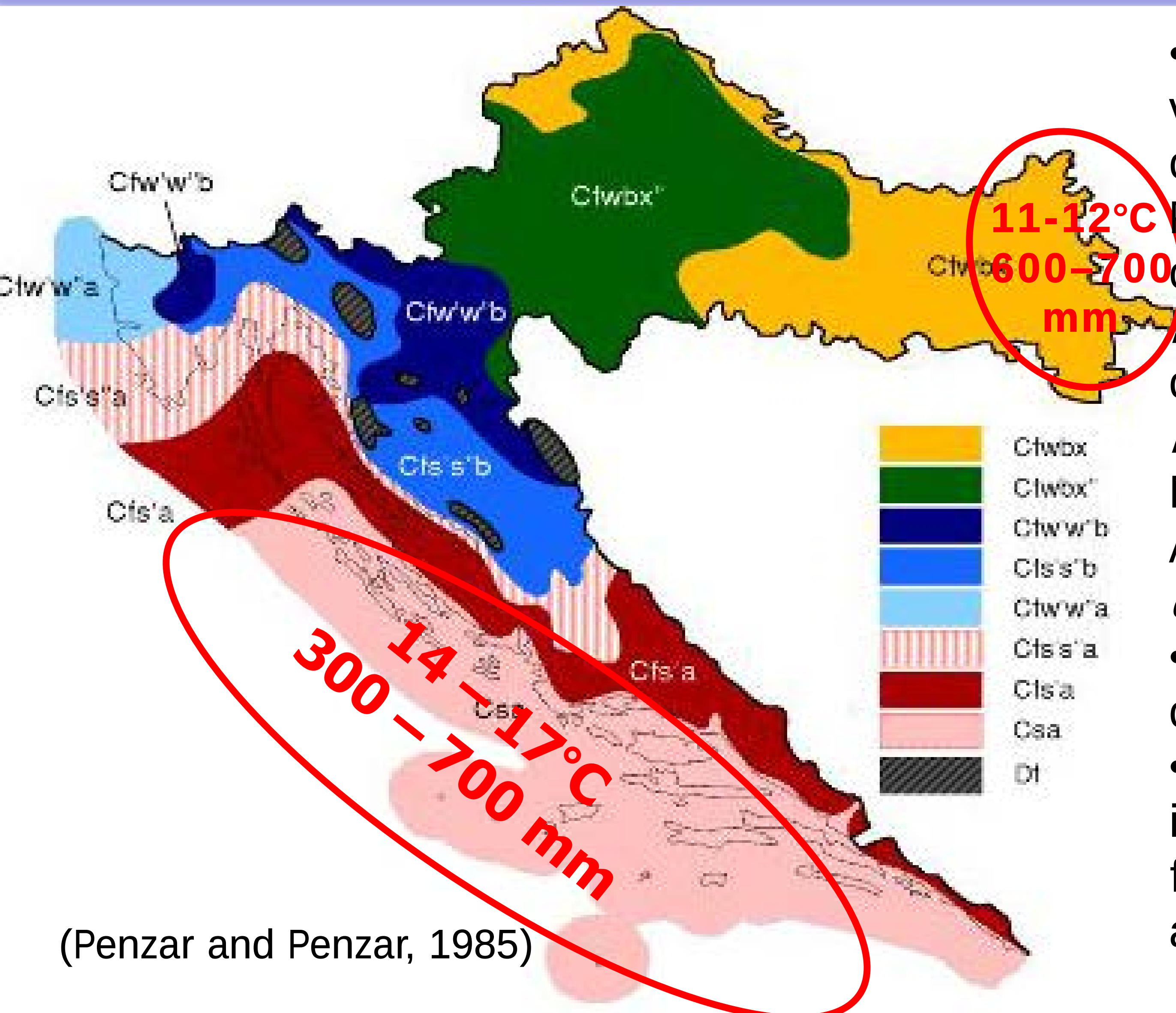
- Some of them have additional warnings as Italy, Serbia, Slovenia and Sweeden

- There are also examples of five day warnings like Austria and Slovenia.

Position of Croatia

- The climate in Croatia is influenced by the Alps in the north-west, the Pannonian lowlands in the north, the Bosnian mountains in the east and the Adriatic Sea in the south.
- The mountain barrier stretches along the Adriatic coast and separates the continental from the Mediterranean climate.
- The coastline is narrow and steep and there are more than 1200 islands.

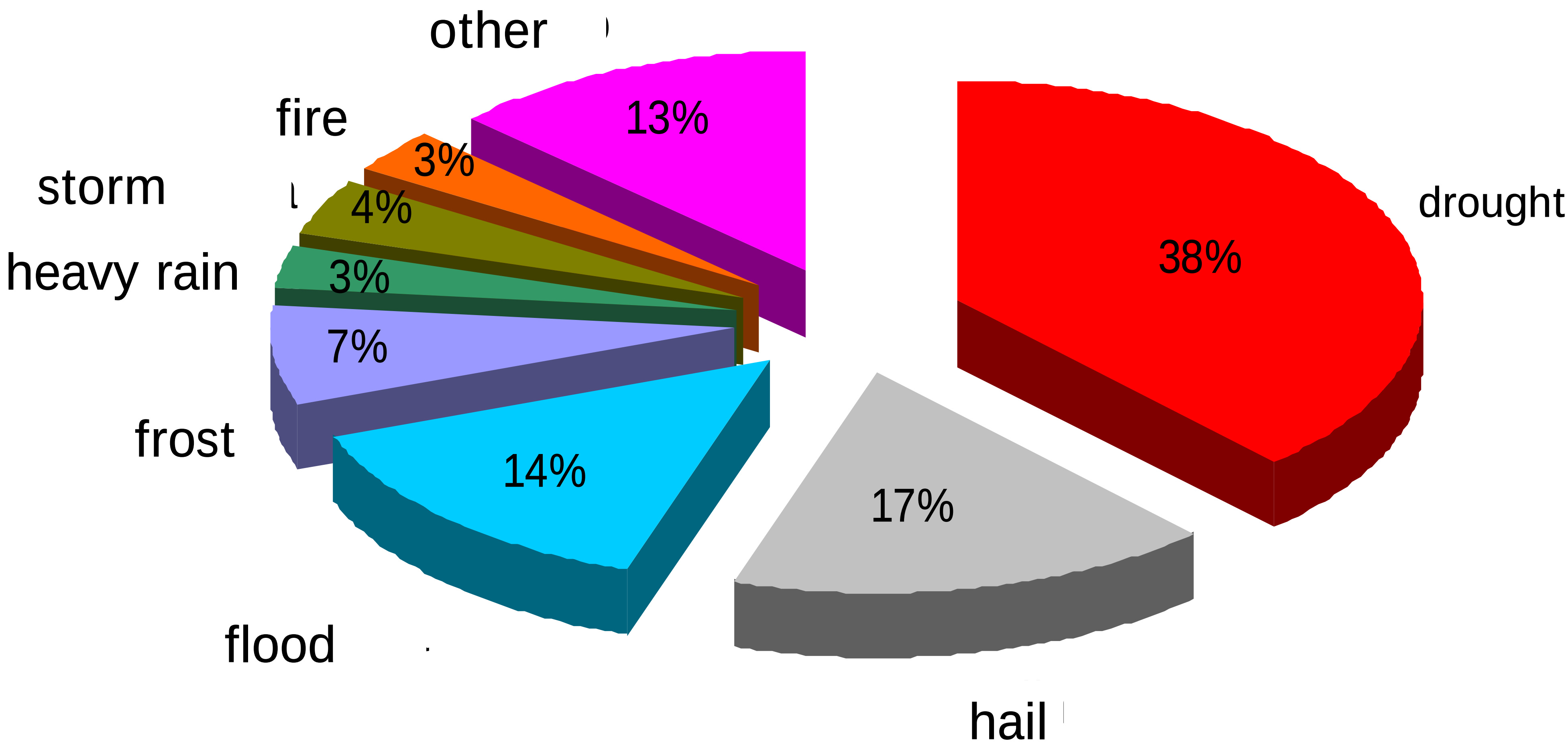
Köppen climatic zone in Croatia



(Penzar and Penzar, 1985)

- As maize accommodates very well to the continental climate conditions in the Pannonian lowlands, this climate type is known as *maize climate,* mountainous climate is known as *common beach climate* and the Mediterranean climate in the Adriatic coast as *olive climate*
- There are 19 varaiants of climate in Croatia
- Risk of summer droughts in the mid- Adriatic account for high vulnerability in agriculture and wildfires.

Economic losses (1995-2014)



The greatest damage (38%) to Croatian economy and agriculture is caused by droughts, particularly Eastern Croatia and mid-Adriatic coast and islands during summer season.

Operational fire danger rating in Croatia and wildfires under climate change

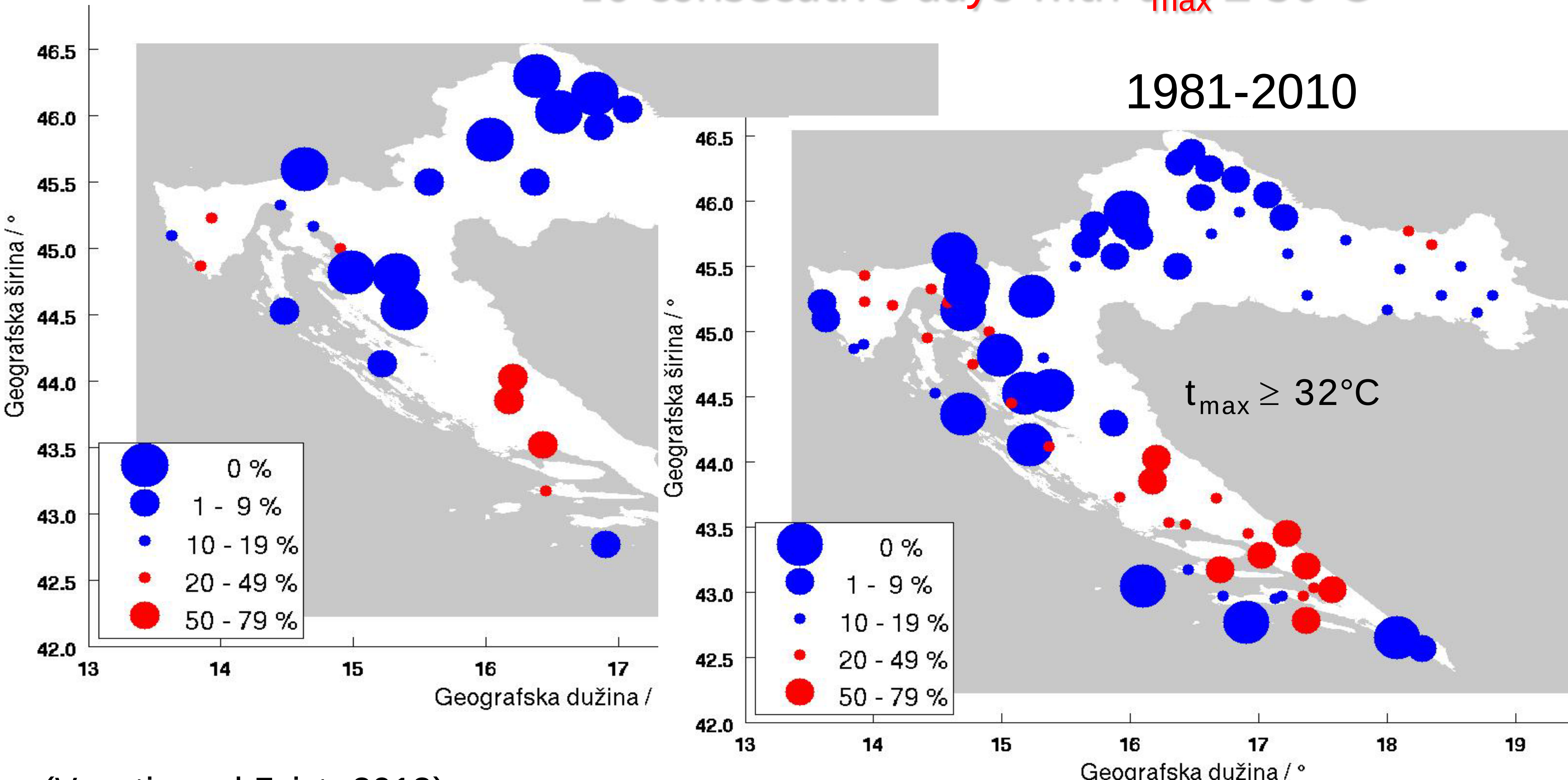
Extremely years

HVAR
1859-2016

extremely warm	extremely dry	extremely wet	extremely cold
1863 1994 2000 2002 2003 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016	1944 1945 1983	1862 1915 1976 2014	1970 1875 1940

Heat stress

1961-1990 10 consecutive days with $t_{max} \geq 30°C$



(Vucetic and Feist, 2013)

Statistical review of forest fires
> 10 ha

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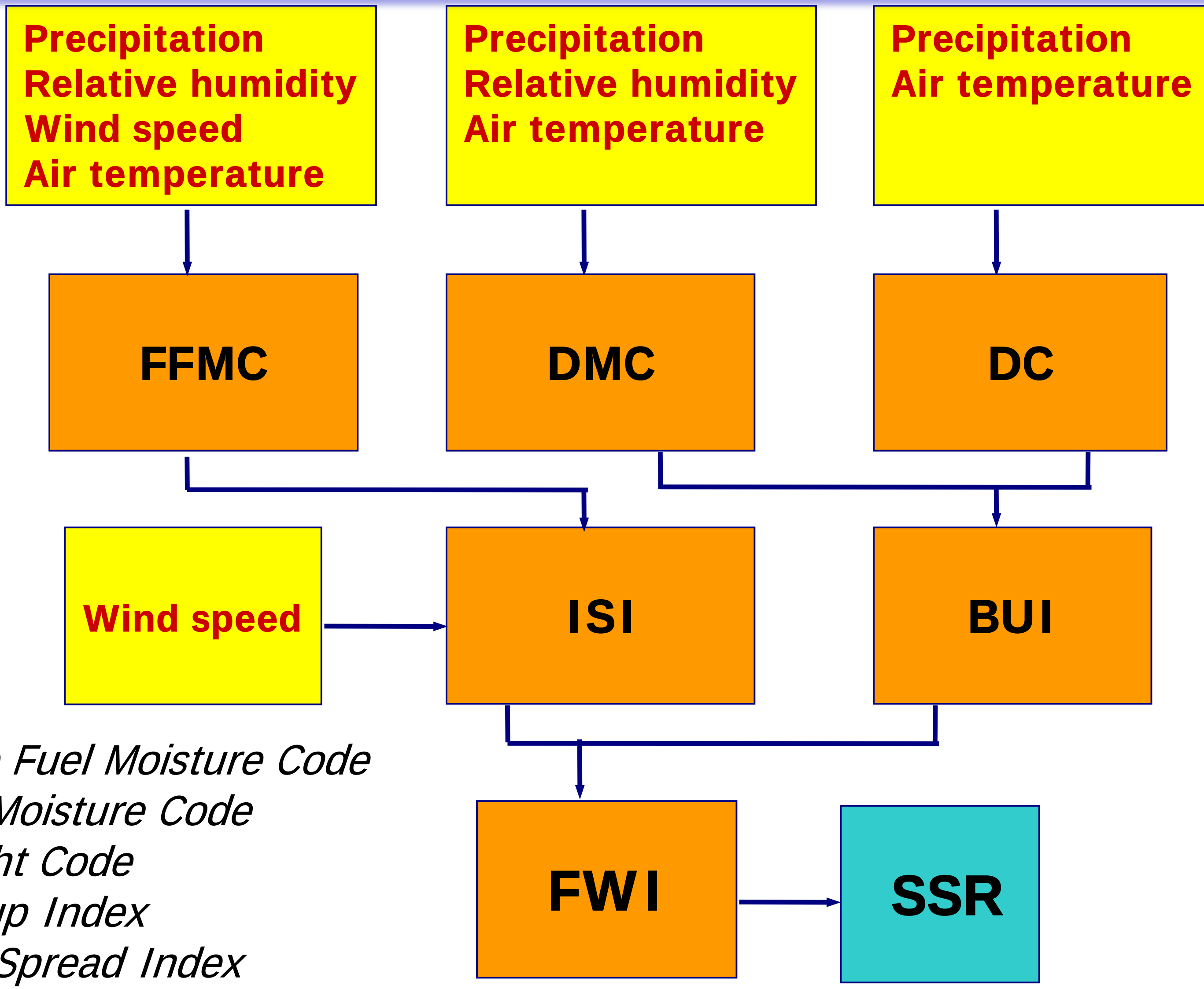
Years	Number of wildfires	Burned area (ha)	Burned area / Number of wildfires
2008	695	8541	12.3
2007	576	19121	33.3
2006	250	1694	6.8
2005	185	1044	5.6
2004	198	1466	7.4
2003	560	14155	25.3
2002	329	5997	18.2
2001	358	1818	5.1
2000	730	27407	37.5
1999	386	1659	10.1
1998	711	17691	24.9
1997	682	6819	10.0
Mean	**472**	**8951**	**16.4**

Source: Vatrogasni vjesnik / Fire News

- The largest number of fires and burned vegetation area occur in an extremely warm and dry summers when dry periods last longer than a month.

Canadian method
Fire Weather Index (FWI)



FFMC - *Fine Fuel Moisture Code*
DMC - *Duff Moisture Code*
DC - *Drought Code*
BUI - *Buildup Index*
ISI - *Initial Spread Index*
SSR – *Seasonal Severity Rating*

Operational Fire Danger Rating in Croatia

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- Since 1981 the Canadian method Fire Weather Index has been applied to the fire weather indices once a day, from April to October.

- The indices for a particular date are based on real-time data for 40 meteorological stations.

- The predicted indices for the following two days are based on the products of the ALADIN/HR limited area numerical weather prediction model.

- The actual fire weather indices are available on the web site of the Meteorological and Hydrological Service **http://meteo.hr**.

Fire Weather Index in Croatia http//:meteo.hr

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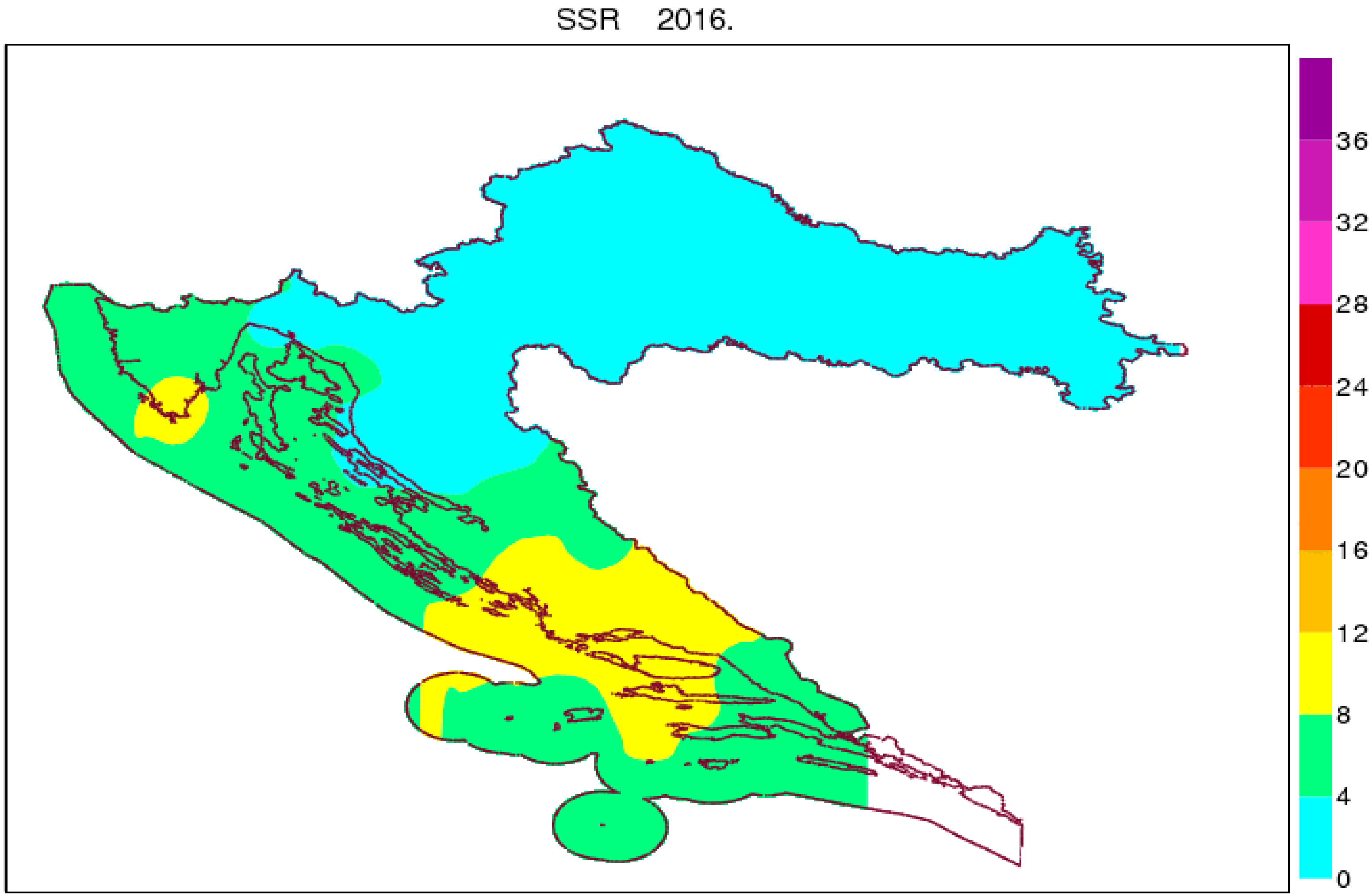
Karlovac	
mjerenja 11.04.2017. u 12 UTC	
temperatura zraka	21.7 °C
relativna vlažnost	48 %
brzina vjetra	5 m/s
oborina (posljednja 24h)	0.0 mm
FFMC	90
DMC	72
DC	117
ISI	10
BUI	72
FWI	27
opasnost	umjerena

Seasonal Severity Rating (1960-2016)

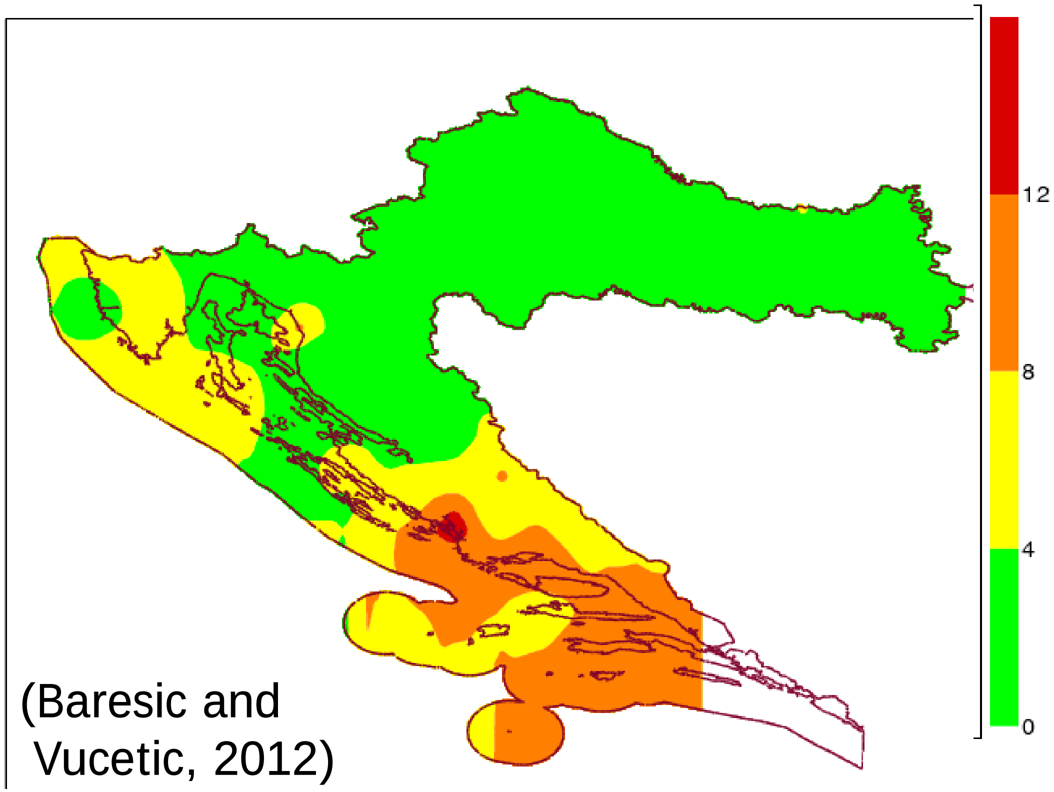
Potential wildfire risk from June to September



Source: DHMZ

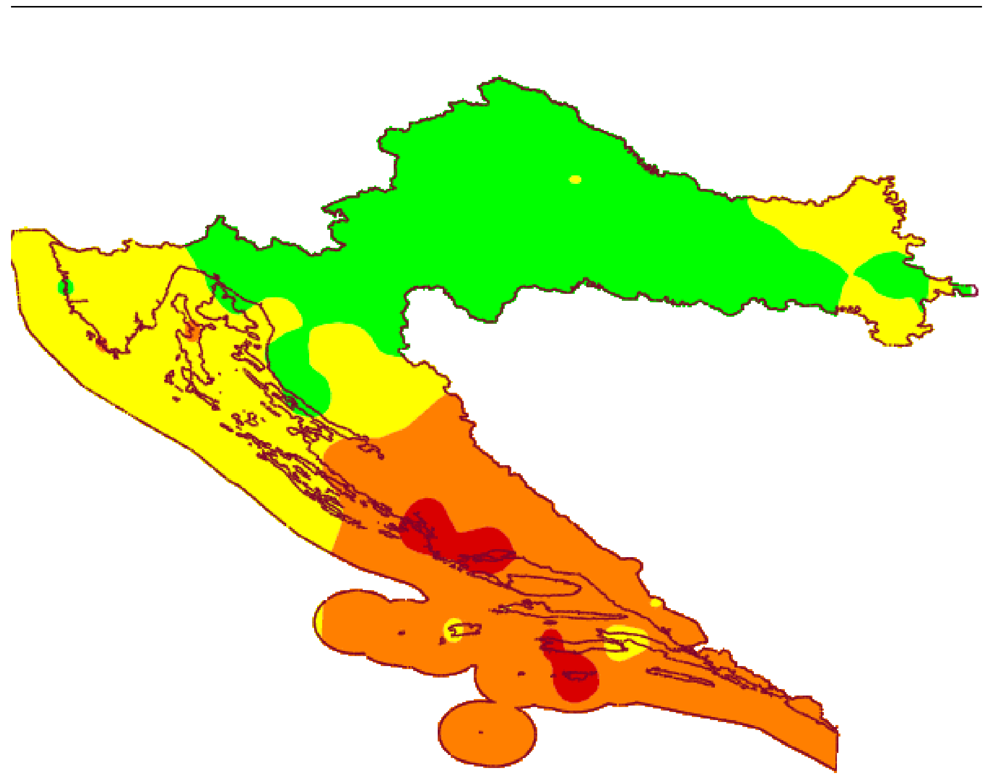
Mean Seasonal Severity Rating

Mean SSR (1961-1990)



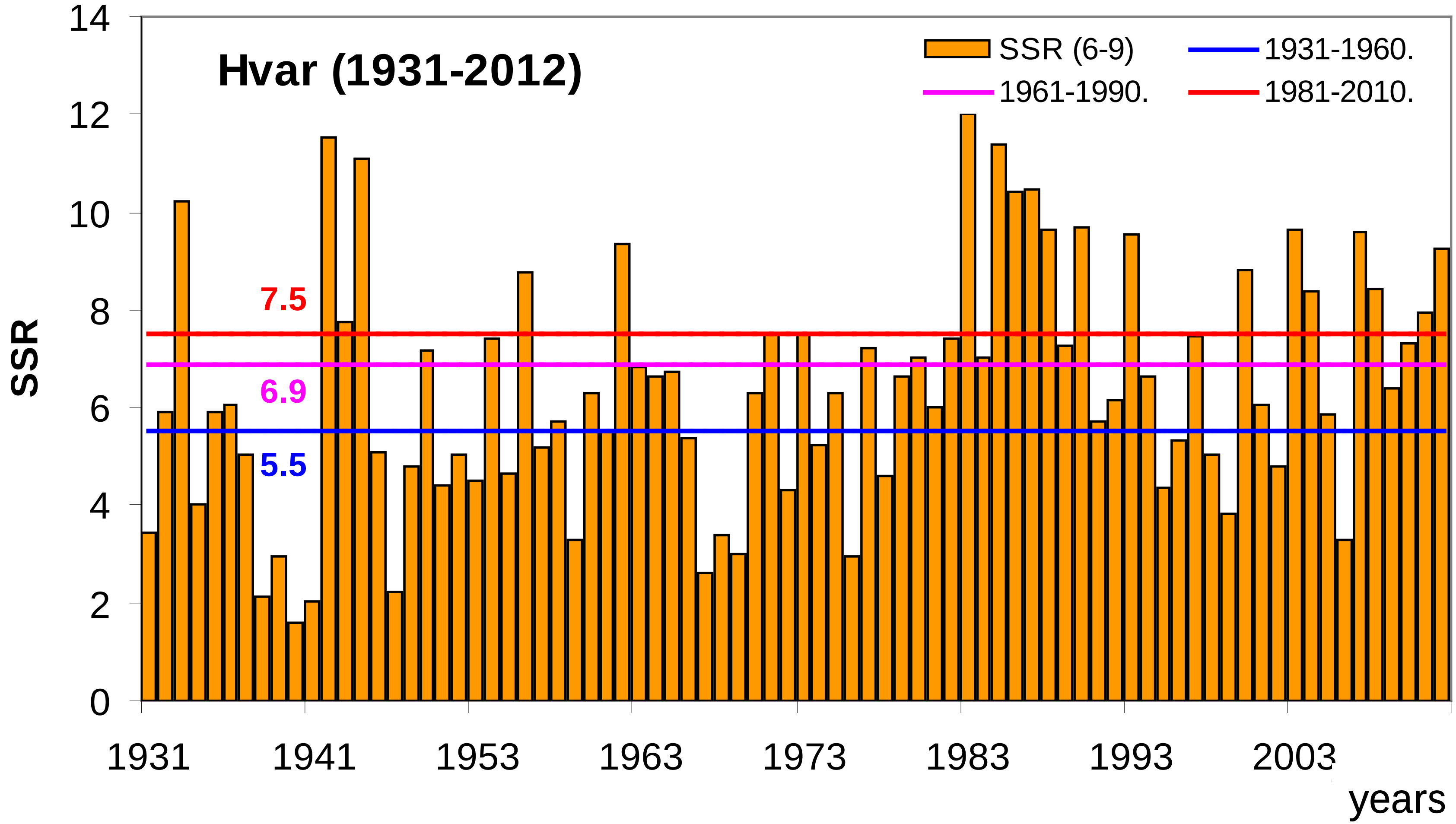
(Baresic and
Vucetic, 2012)

Mean SSR (1981-2010)



Spreading of high wildfire risk from the mid-Adriatic to the northern Adriatic but also to inland and the eastern part of Croatia

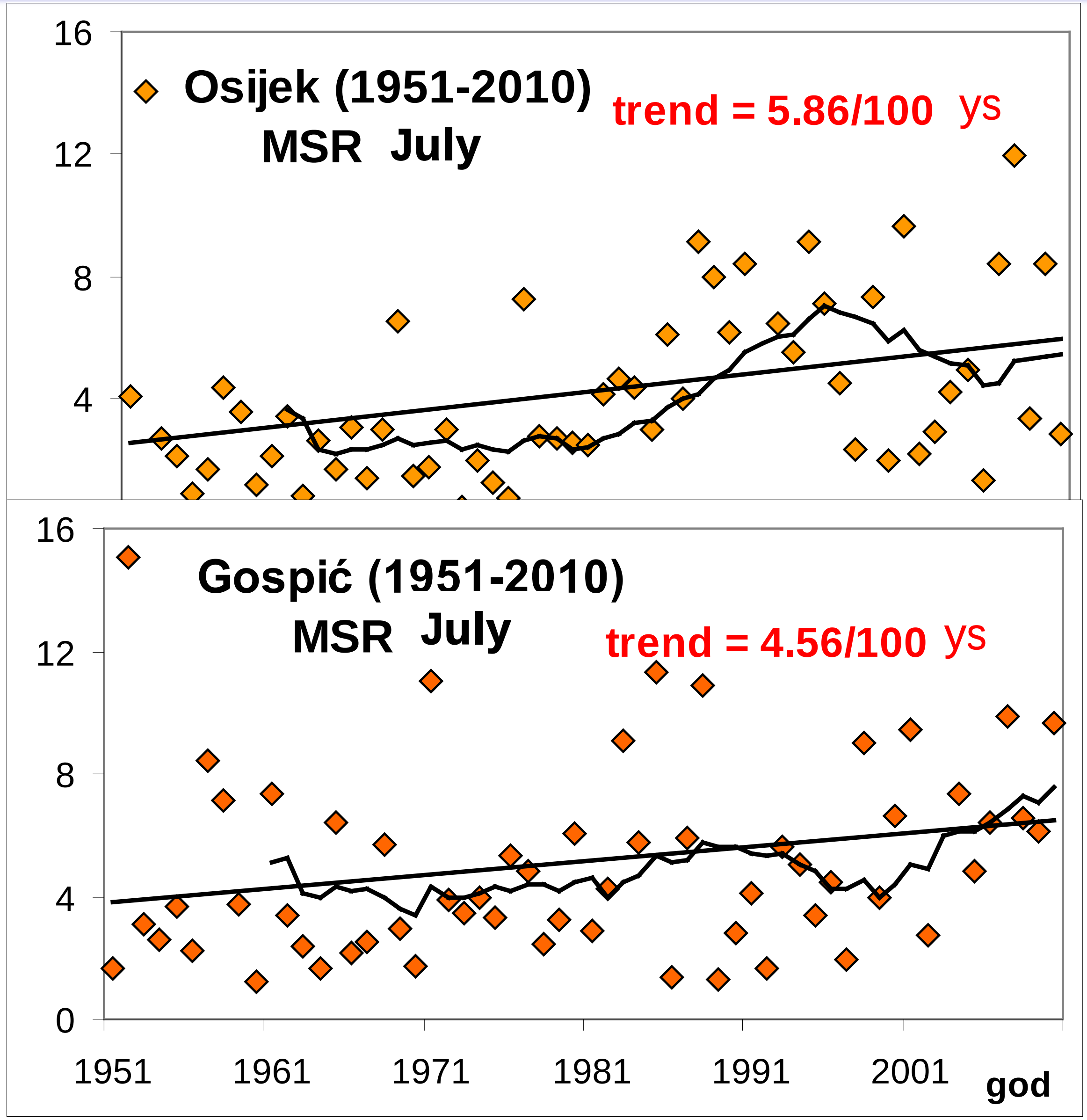
Seasonal Severity Rating



- SSR> 7 has appeared in 17 fire seasons in the last 30 years compared to 11 seasons in the previous 50 years.

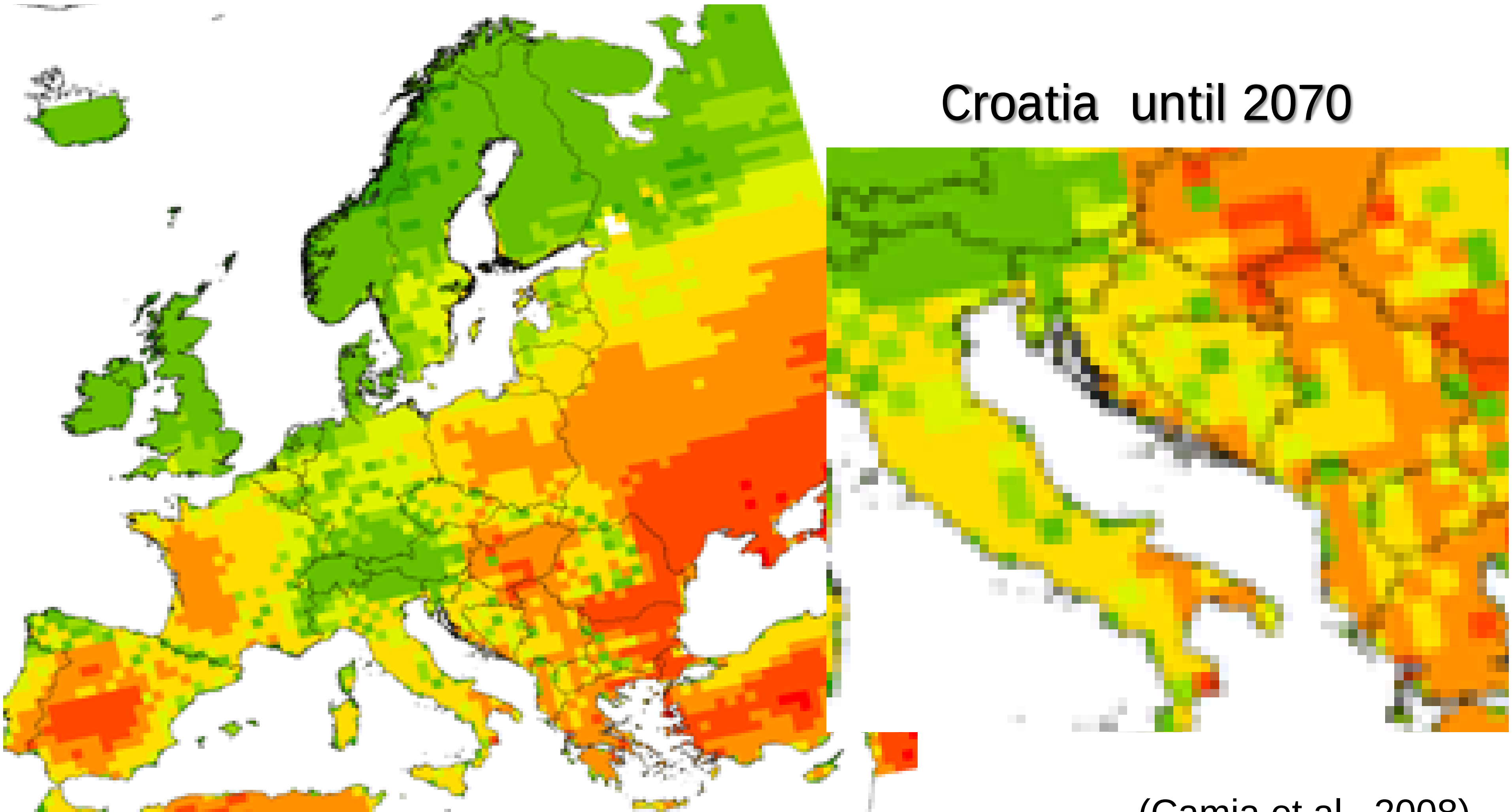
Linear trend of monthly severity rating

(Baresic and Vucetic, 2012)



Climate scenarios

Difference SSR 2041-2070 and normal 1958-2006



(Camia et al., 2008)

Sensitivity experiments using MUKLIMO_3 model with resolution of 100 m

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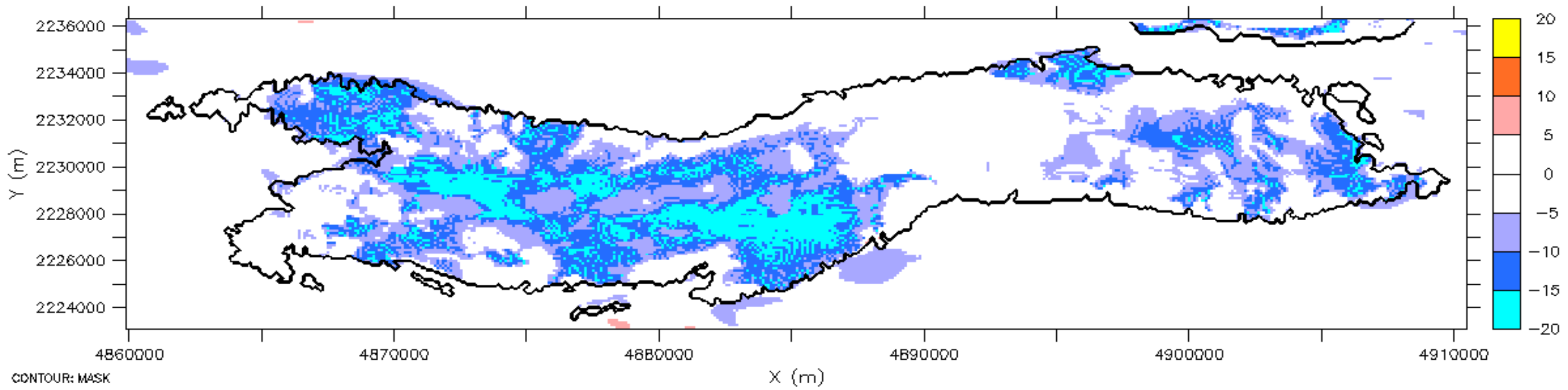
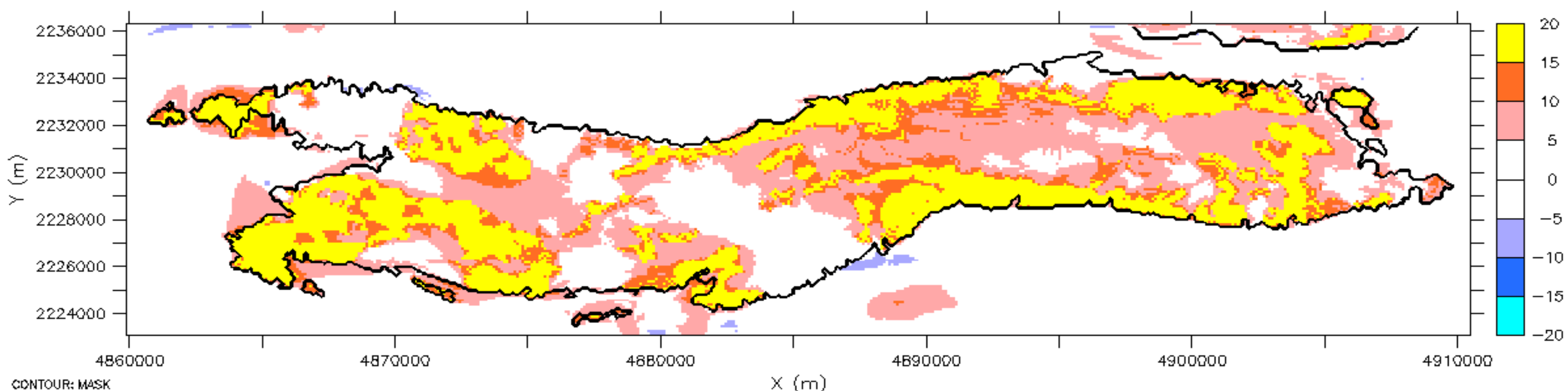
Foresation

Difference in mean annual summer days if agricultural areas are modified into forest



Forest fire

Difference in mean annual summer days if all forest areas are turned into bare rocks



(Zuvela-Aloise et al., 2013)

Conclusion 1

DHMZ

- Since 1981 the Canadian *Fire Weather Index* has been used to determine the potential risk of wildfire in the Meteorological and Hydrological Service of Croatia

- The impact of climate change on wildfire risk is reflected:

a) in the tendency of the fire season to start earlier (in May), as well as the possibility for the fire season to extend until October, particularly along the Adriatic.

b) spreading of high wildfire risk from the mid-Adriatic to the northern Adriatic but also to inland and the eastern part of Croatia

- The fire regime in Croatia fits into the bigger picture, which indicates that areas running a higher potential wildfire risk in the Mediterranean and eastern Europe in the summer months are expanding in size.

Weather situation during large wildfires using numerical model and satellite products

Main goal

to improve the warning of the wildfire risk predicting the an additional indicators for ”initial trigger" to start a large fire using numerical model products.

Deficit of rain amount + High air temperature + Low relative humidity

→ Dry period

\+ Very dry fuel material

\+ Specific weather situation???

← Large wildfires

Fire weather researches

Mid-Adriatic fires

- Fire weather surface analysis (M. Vucetic 1987, 1992 and 1998)
- Vertical wind profiles using ALADIN/LACE model (M. Vucetic and V. Vucetic 1999)
- Detailed fire weather analysis using ALADIN/HR and MM5 models (V. Vucetic et al., 2007; M. Vucetic and V. Vucetic, 2012)
- Analysis of vertical wind profiles during the 8 large wildfires using ALADIN/HR model (Tomasevic, 2012)
- Analysis of the largest wildfire in Croatia using ALADIN/HR model and satellite products (Mifka and V. Vucetic, 2012; Vodaric, 2015)
- Fire weather analysis using ALADIN/HR and WRF models (Omazic et al., 2017)

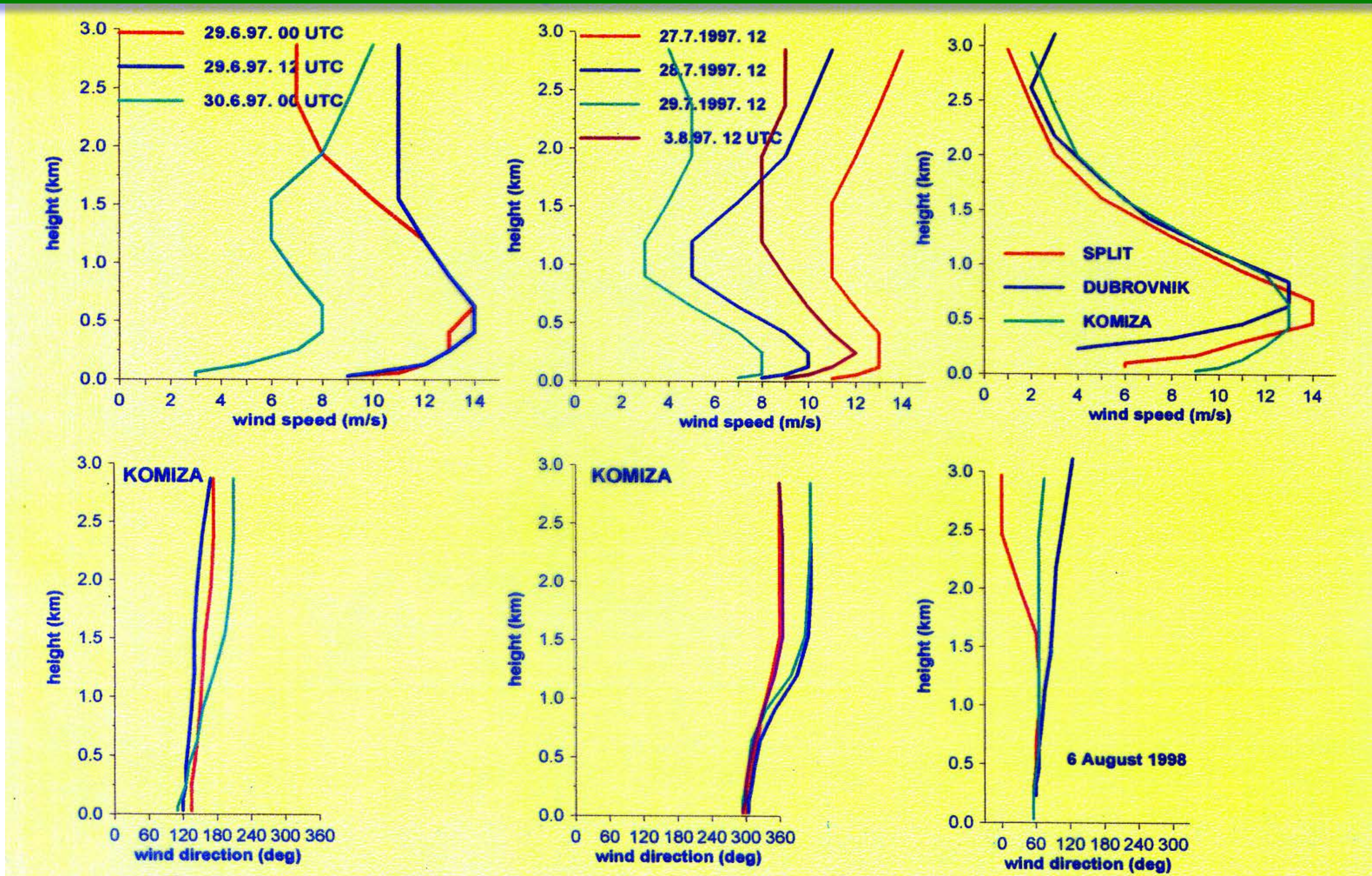
Northen Adriatic fires

- Fire weather analysis using Heines index (Kozaric and Mokoric, 2012; 2014)

Continental fire

- Detailed fire weather analysis of the largest continental fire using ALADIN/HR model (Kurazi and V. Vucetic, 2015)

Preliminary results using ALADIN/LACE model



(M. Vučetić and V. Vučetić, 1999)

Low level jet

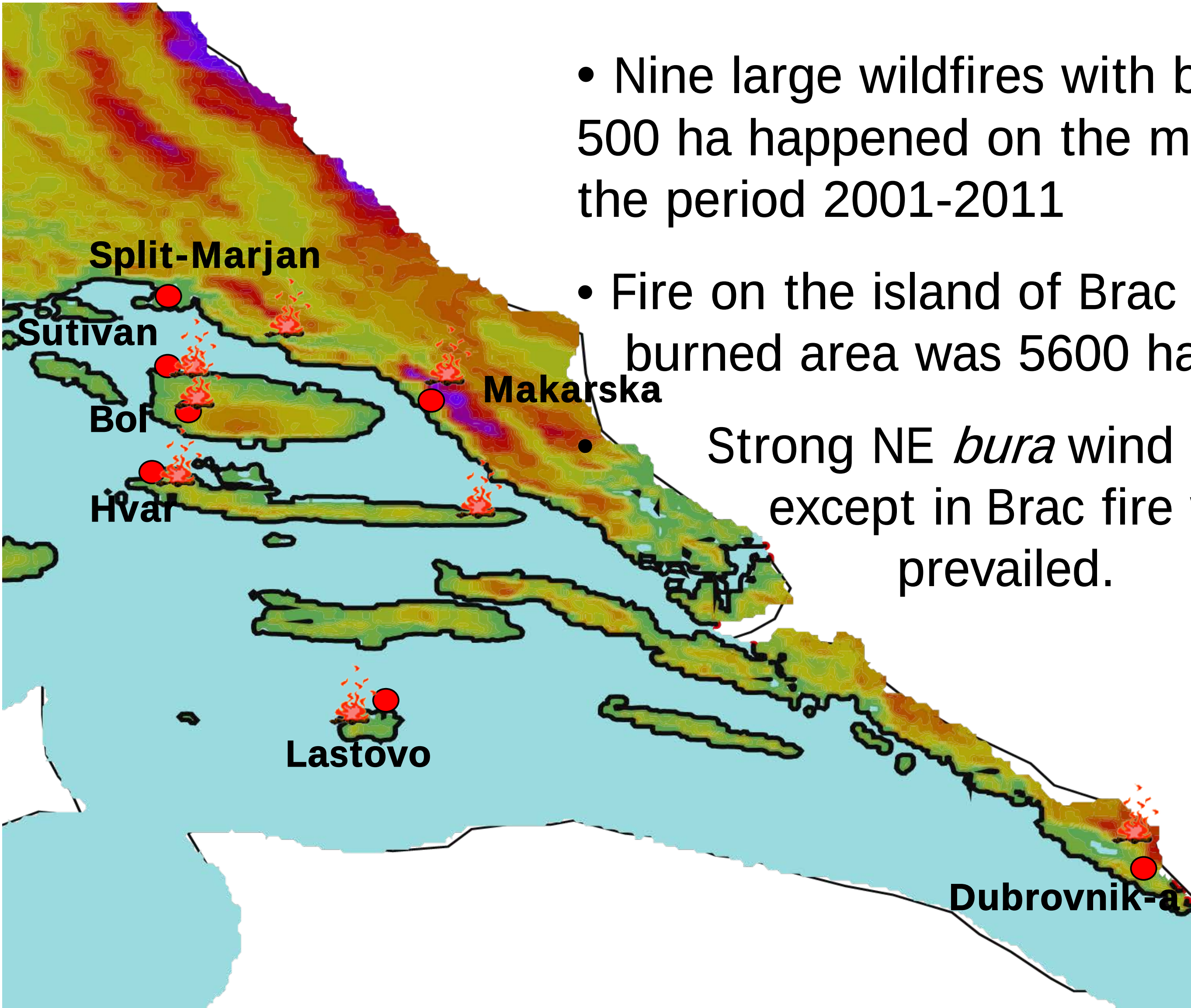
- Significant maximum wind speed up to 1500 m
- There are three criteria for definition of LLJ

Low level jet	Maximum wind speed	
Criterion 1	≥ 12 m/s	≥ 43 km/h
Criterion 2	≥ 16 m/s	≥ 58 km/h
Criterion 3	≥ 20 m/s	≥ 72 km/h

(Bonner, 1968)

Adriatic wildfires

Large wildfires (2001-2011)

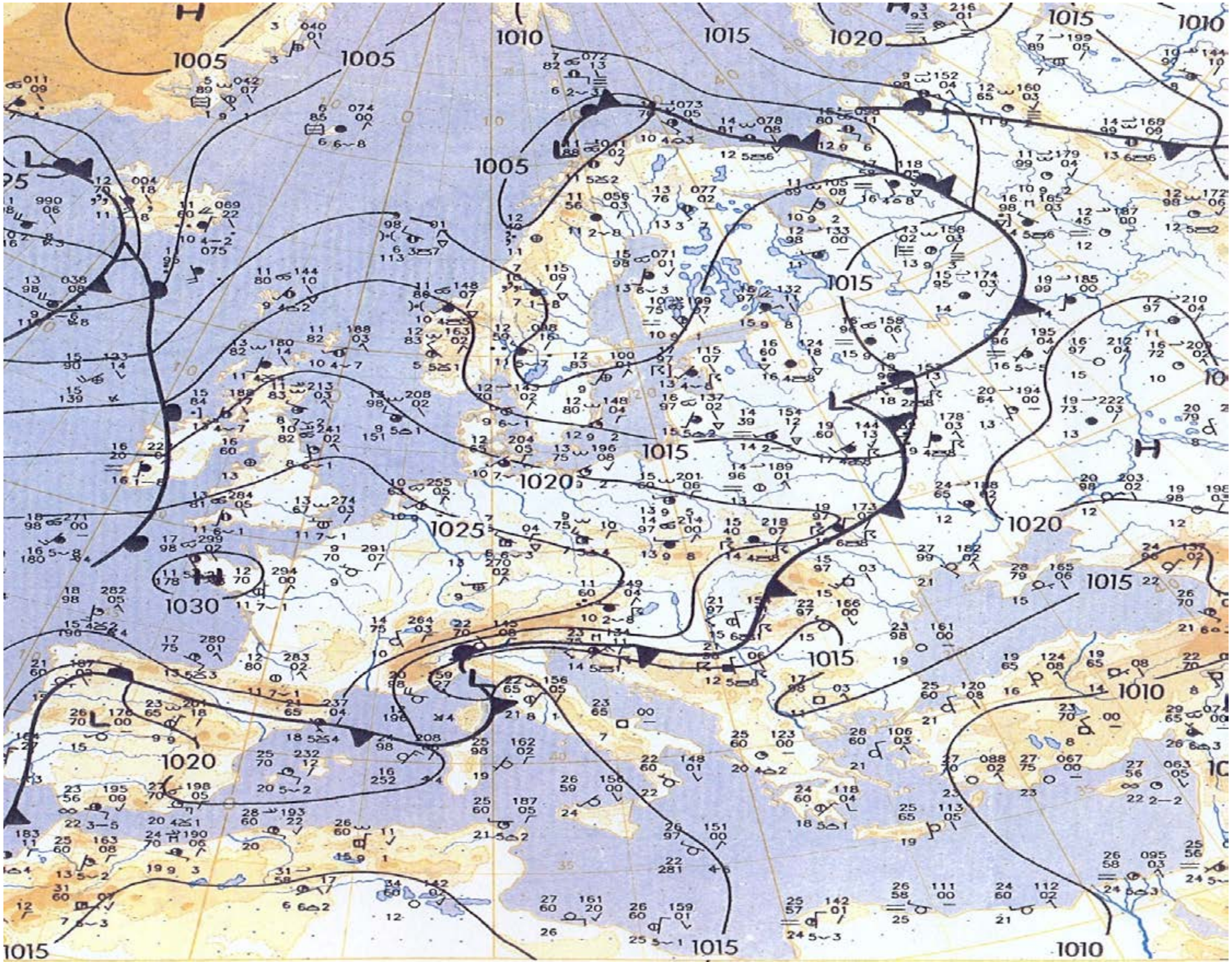


- Nine large wildfires with burned area great than 500 ha happened on the mid-Adriatic during the period 2001-2011
- Fire on the island of Brac was the largest fire and burned area was 5600 ha.
- Strong NE *bura* wind blew in all fire situations except in Brac fire when SE *jugo* wind prevailed.

Source: Vatrogasni vjesnik / Fire News

Surface synoptic situation under Europe

11 August 2001 at 00 UTC



(Source: DWD)

Vertical profile of wind speed using ALADIN/HR model

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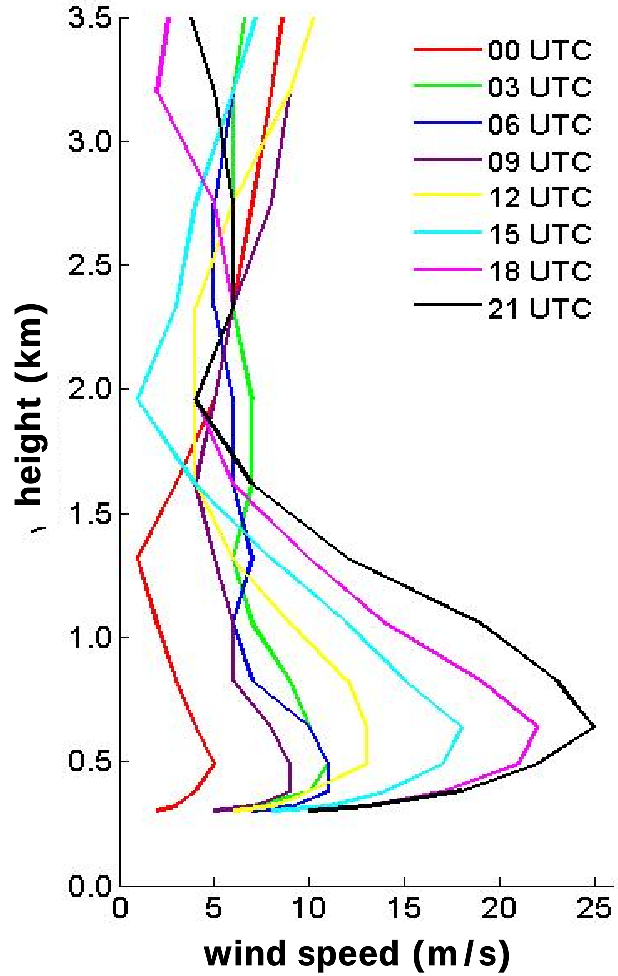
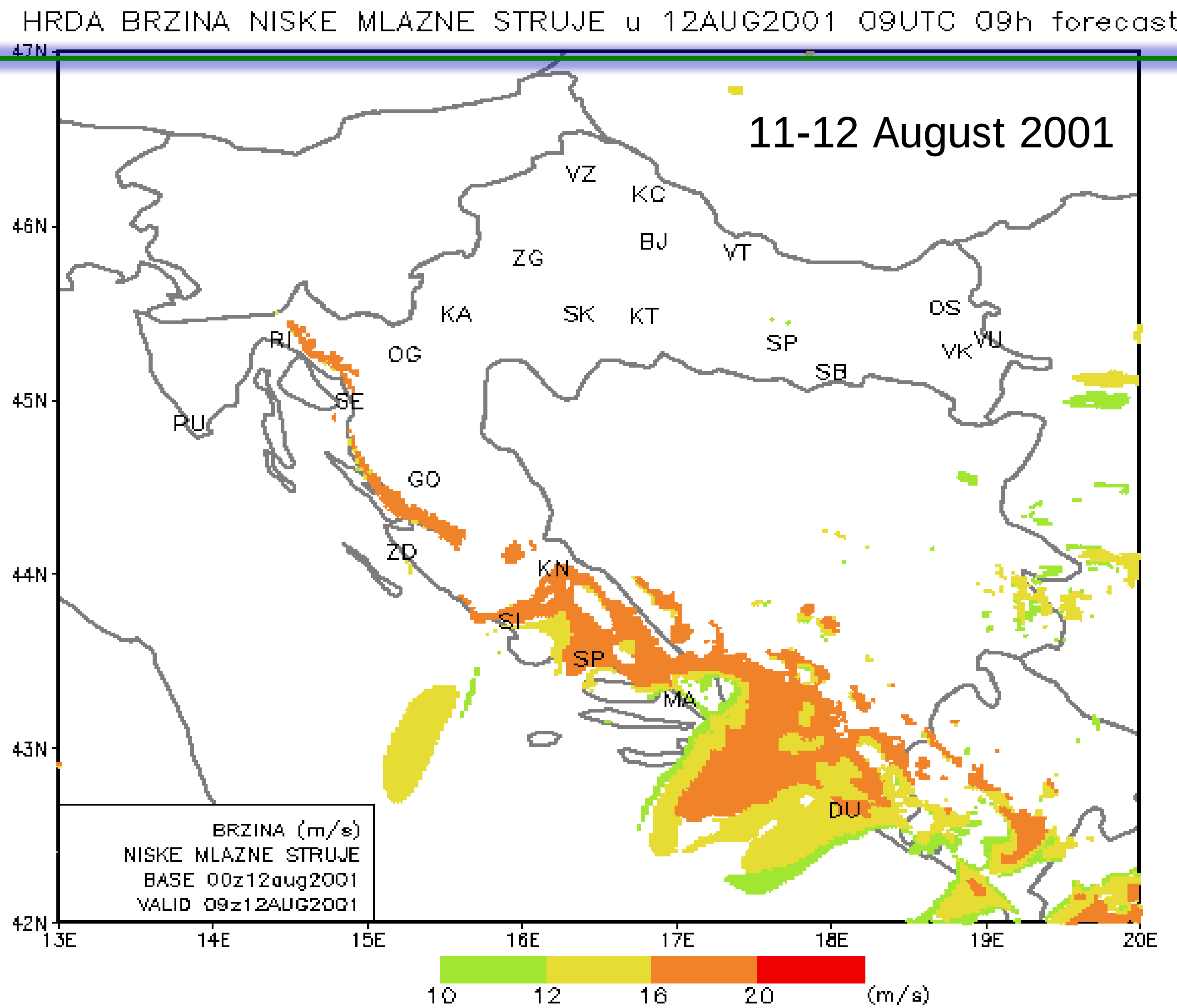


Split, 11 August 2001

UTC	Altitude (m)	v_{max} (m/s)	v_{max} (km/h)	d_{max} (°)
0	490	5	18	NNE
3	490	11	40	NE
6	380-490	11	40	ENE
9	380-490	9	32	ENE
12	490-640	13	47	NE
15	640	18	65	NE
18	640	22	79	NE
21	640	25	90	NE
criterion 1		criterion 2		criterion 3

Low Level Jet using ALADIN/HR model



Brac, mid-Adriatic, 14 July 2011

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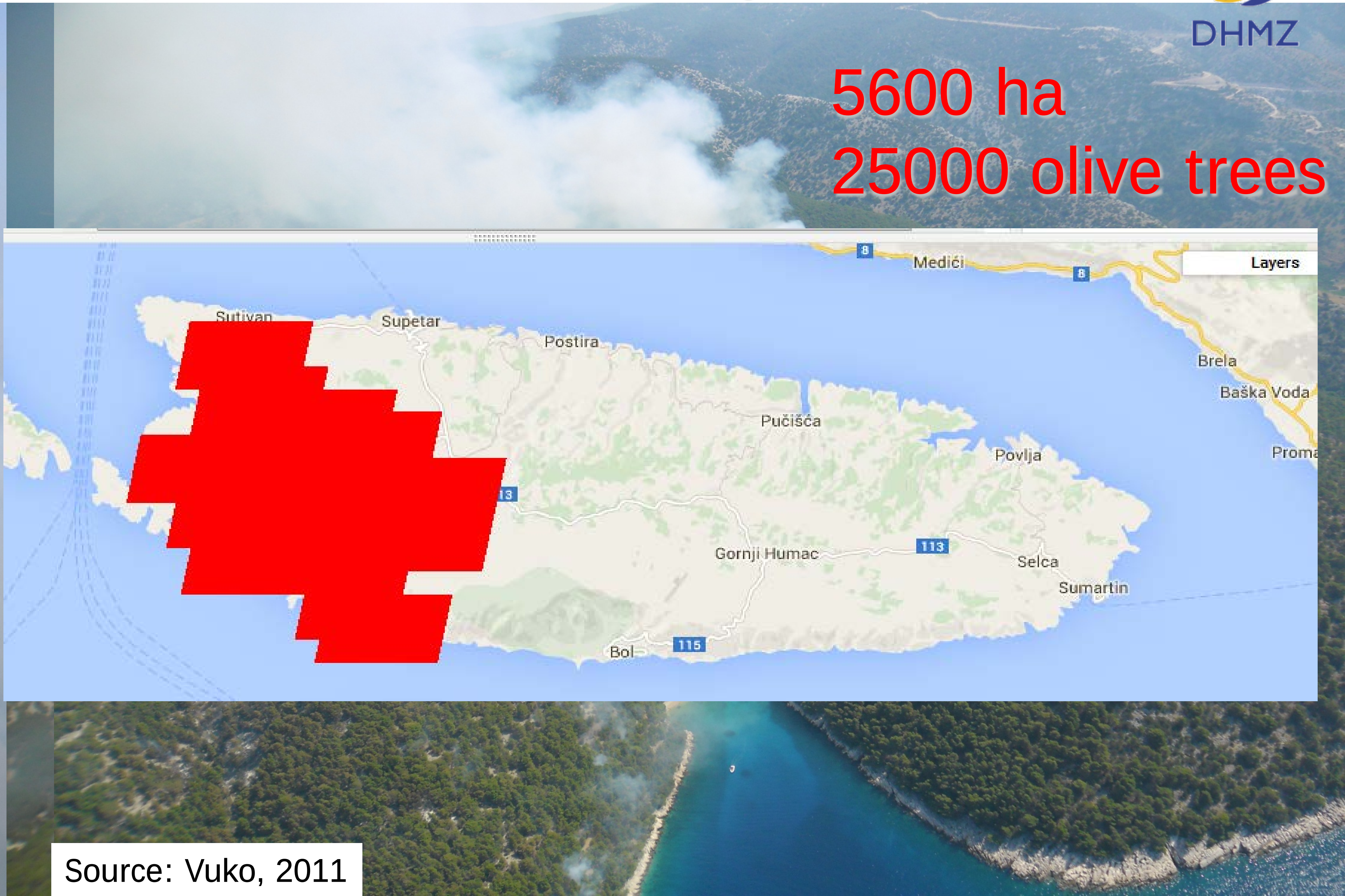
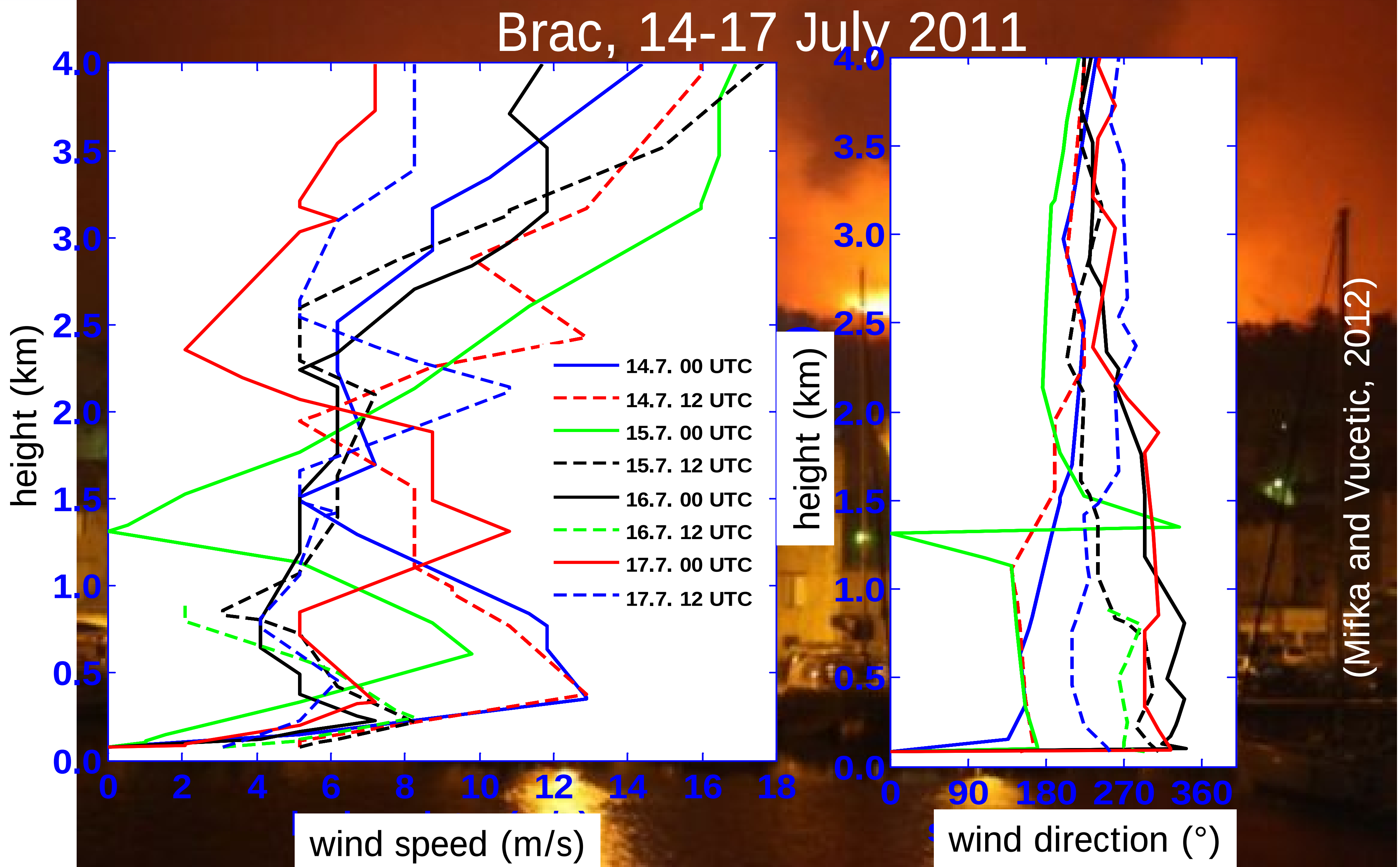
5600 ha

25000 olive trees



Source: Vuko, 2011

Wind vertical profiles of the Zadar sounding



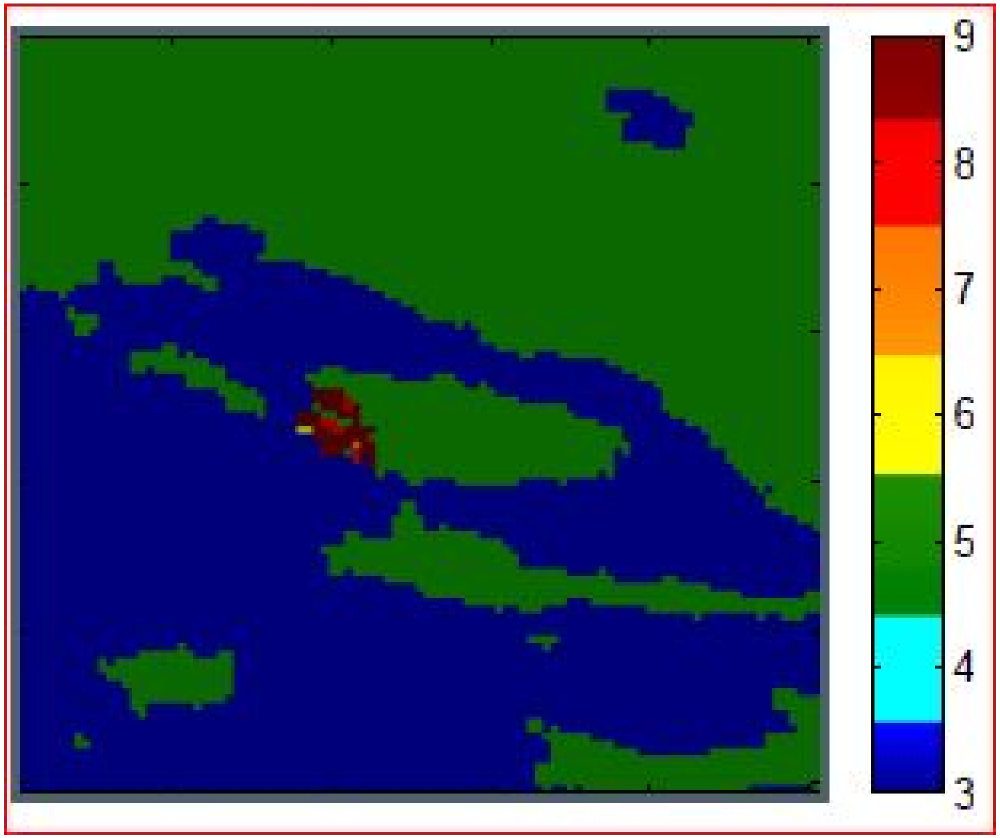
Satellite products for the Brac fire

True Image (RGB mixing channel 1 (0,62 – 0,67 µm), 4 (0,545 – 0,565 µm), 3 (0,459 – 0,479 µm)) for 15 July 2011 from 10:05 do 10:10 UTC.
The smoke is visible as a result of a fire on the island of Brac.

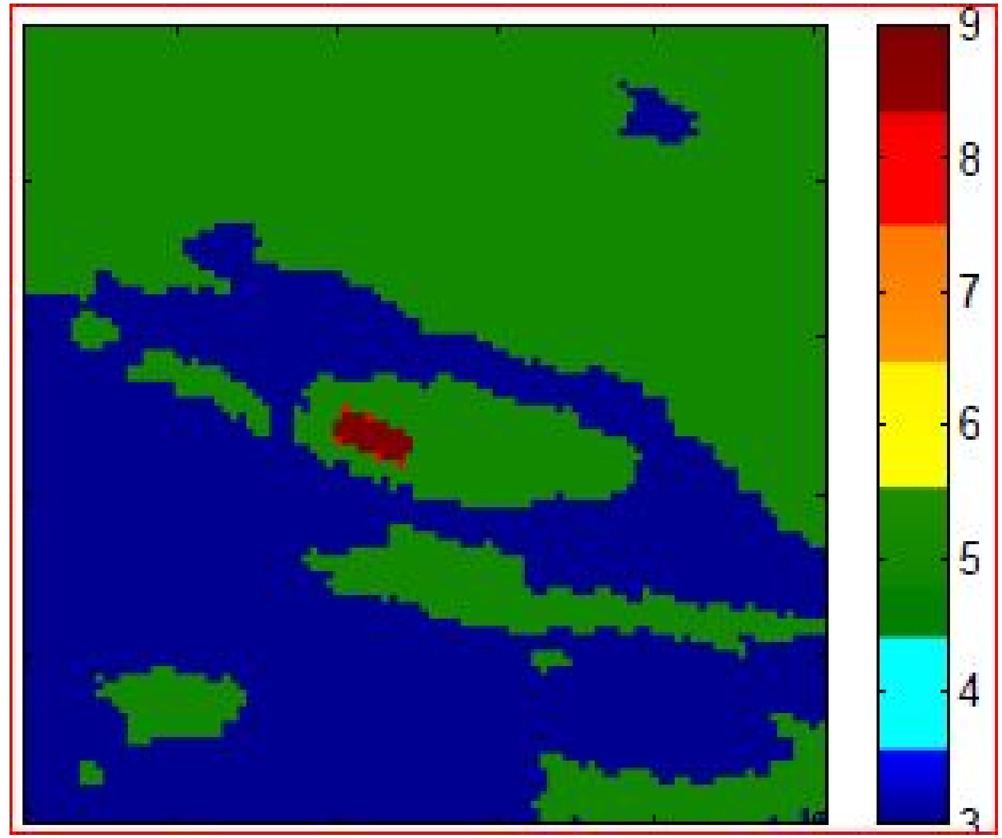
(Vodaric, 2014)

MODIS product MOD14A1
with resolution of 1 km

14 July 2011 at 13:30 h



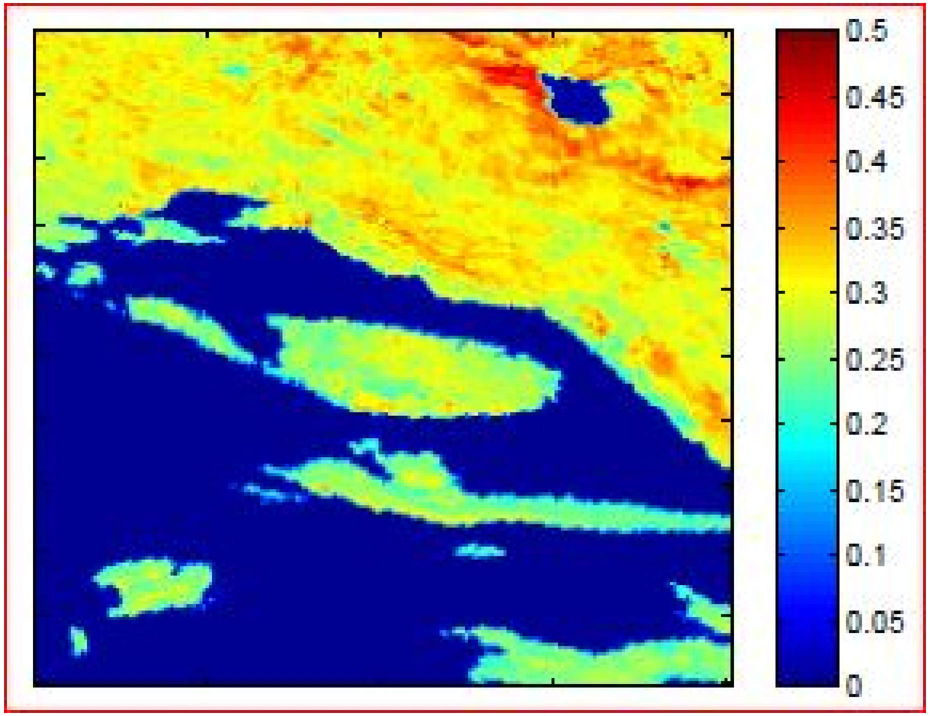
15 July 2011 at 12:45 h



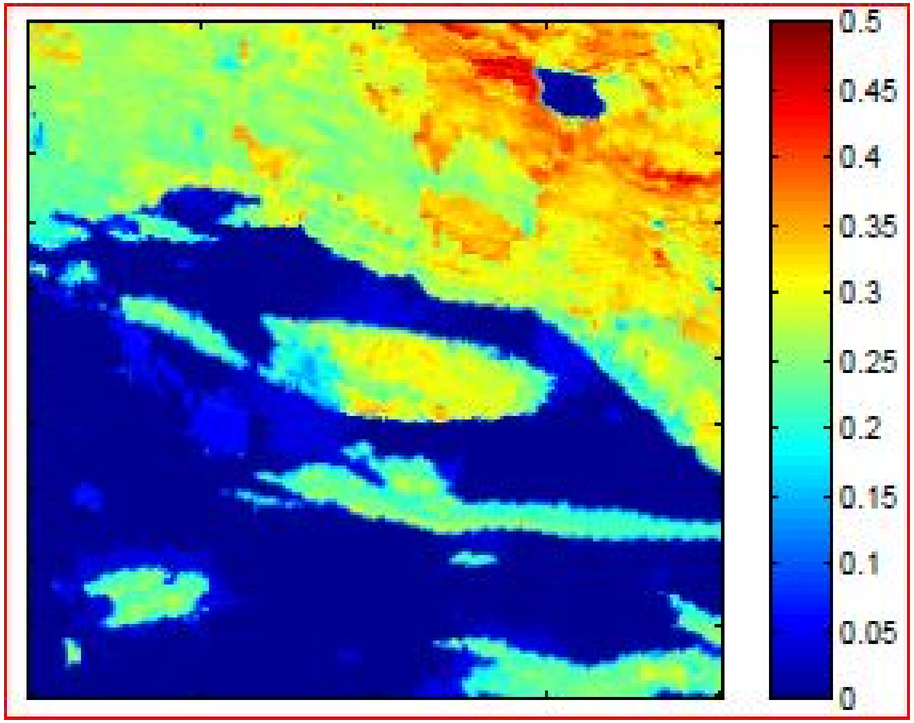
Vodaric, 2014

7-day composite of the MODIS product MOD09A1 with resolution of 250 m

4–11 July 2011



12–19 July 2011



Earth's surface reflectivity in the wavelength range from 841 μm to 874 μm.

(Vodaric, 2014)

Using satellite data to locate forest fires

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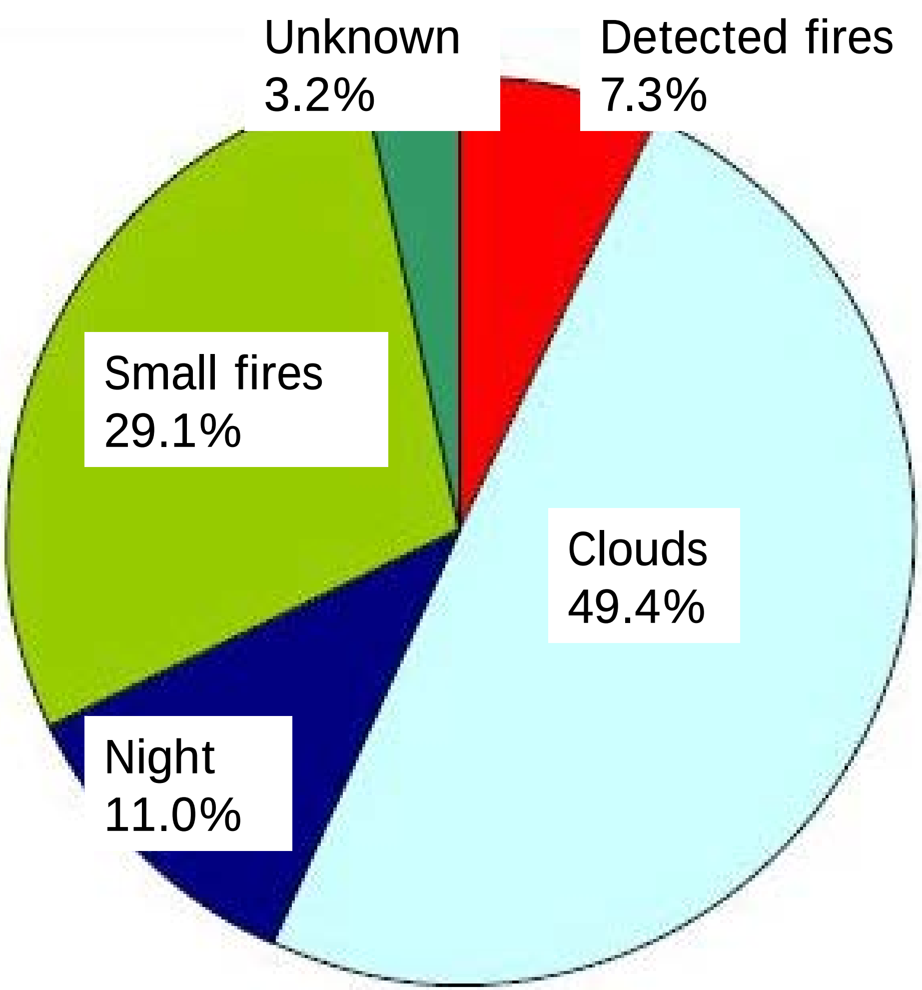
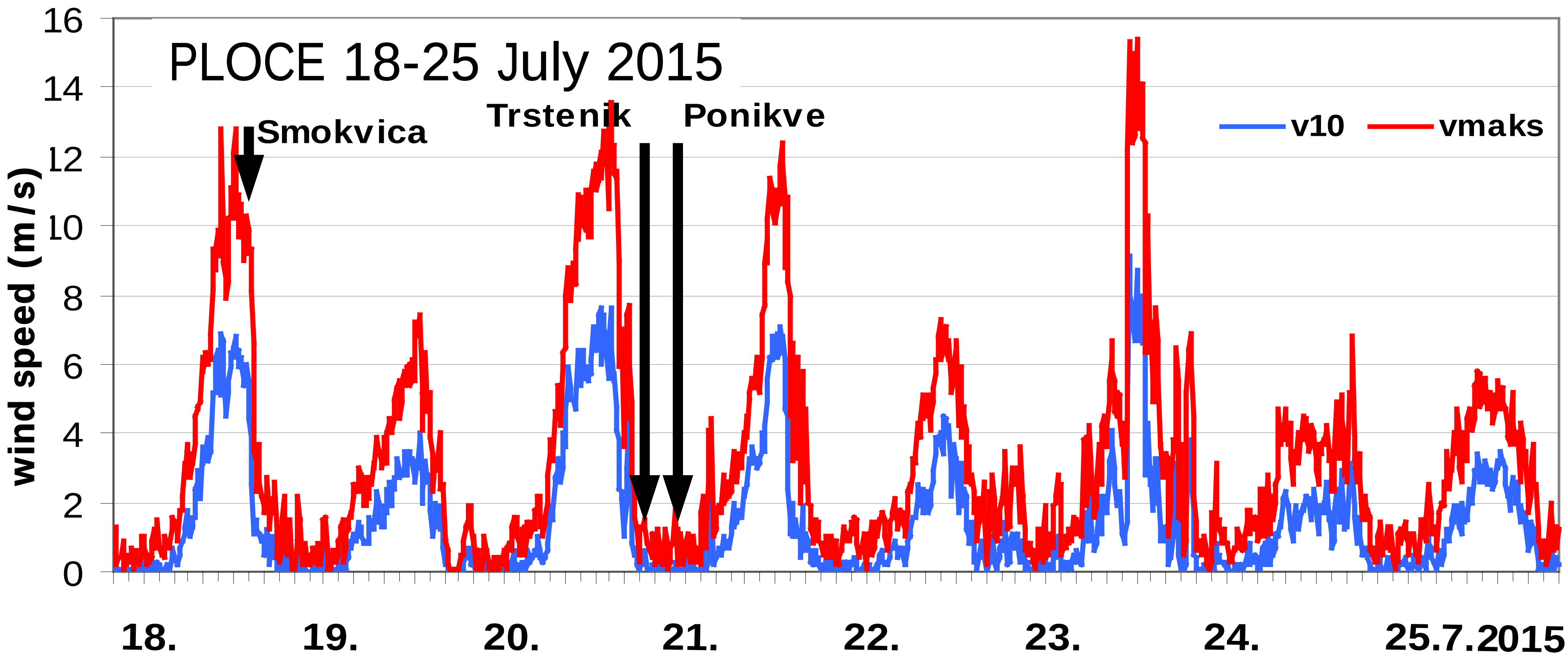
Fire season 2009



- The key in hot-spot detection is the 3.9 μm temperature, whereas an additional criterion is provided by the temperature difference of channels 3.9 and 10.8 μm.
- The analysis of all recorded fires larger than 1 ha, during fire season 2009, was performed. The results show that only 7% of fires were evident in satellite data. For all other fires detection was not possible. The most frequent reason were clouds above the fires, but in many cases fires were too small to be recognized and a large number of fires during dawn, dusk or even night was also not visible.
- This result indicates that the early warning system could not be based only on satellite data from geostationary satellites, since the probability of fire detection is too low, especially for small fires up to 15 ha.

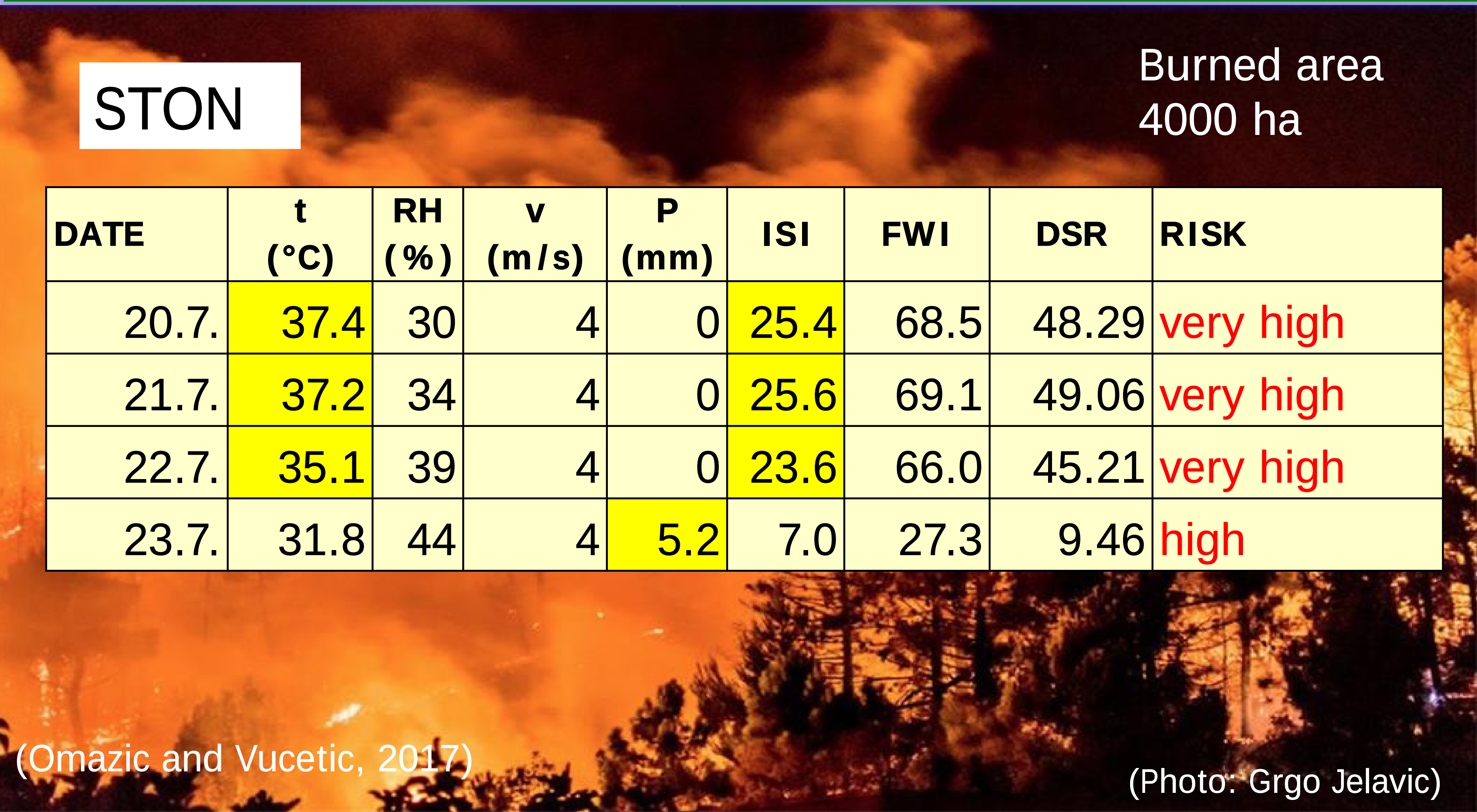
(Mahovic Strelec, 2011)

Peljesac wildfires, July 2015



Peljesac wildfire, July 2015

Crown fire



STON

Burned area
4000 ha

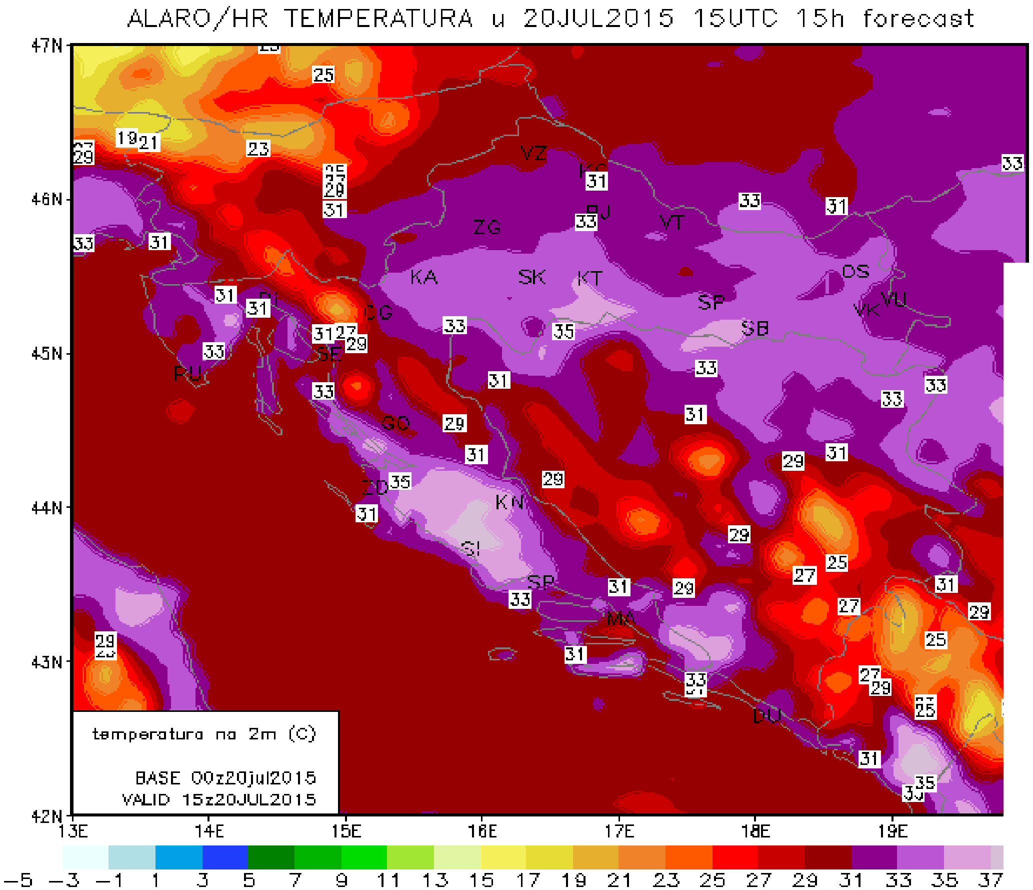
DATE	t (°C)	RH (%)	v (m/s)	P (mm)	ISI	FWI	DSR	RISK
20.7.	37.4	30	4	0	25.4	68.5	48.29	very high
21.7.	37.2	34	4	0	25.6	69.1	49.06	very high
22.7.	35.1	39	4	0	23.6	66.0	45.21	very high
23.7.	31.8	44	4	5.2	7.0	27.3	9.46	high

(Omazic and Vucetic, 2017)

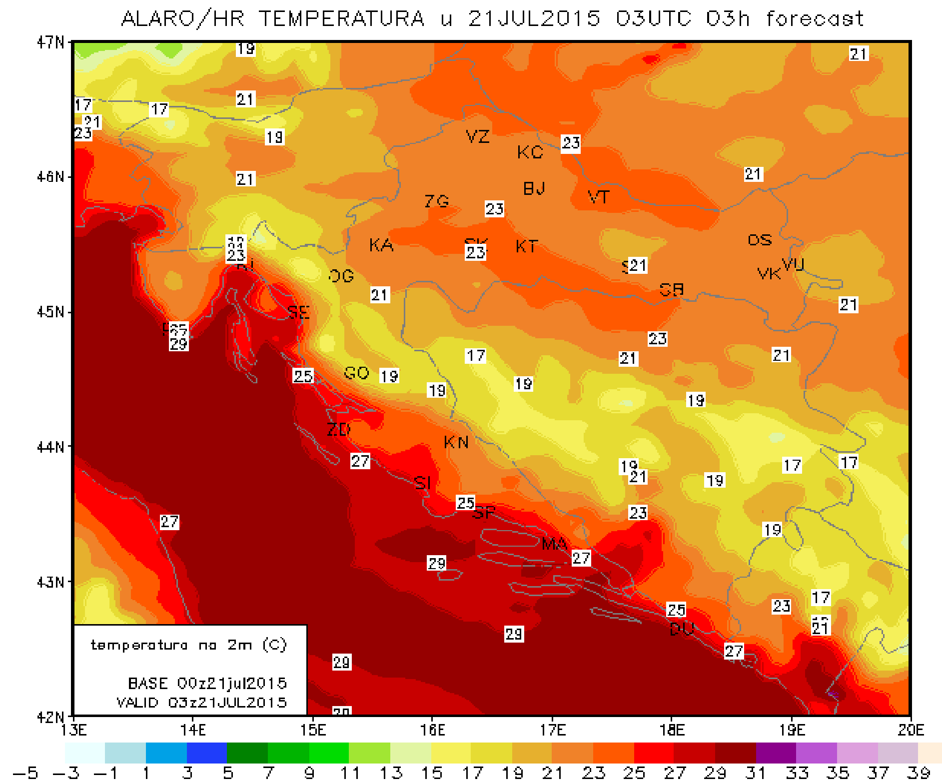
(Photo: Grgo Jelavic)

Field of air temperature using ALADIN/HR model

20 July 2015 at 15 UTC



21 July 2015 at 3 UTC



(Omazic i Vucetic, 2017)

Continental wildfire

Continental wildfire, March 2012

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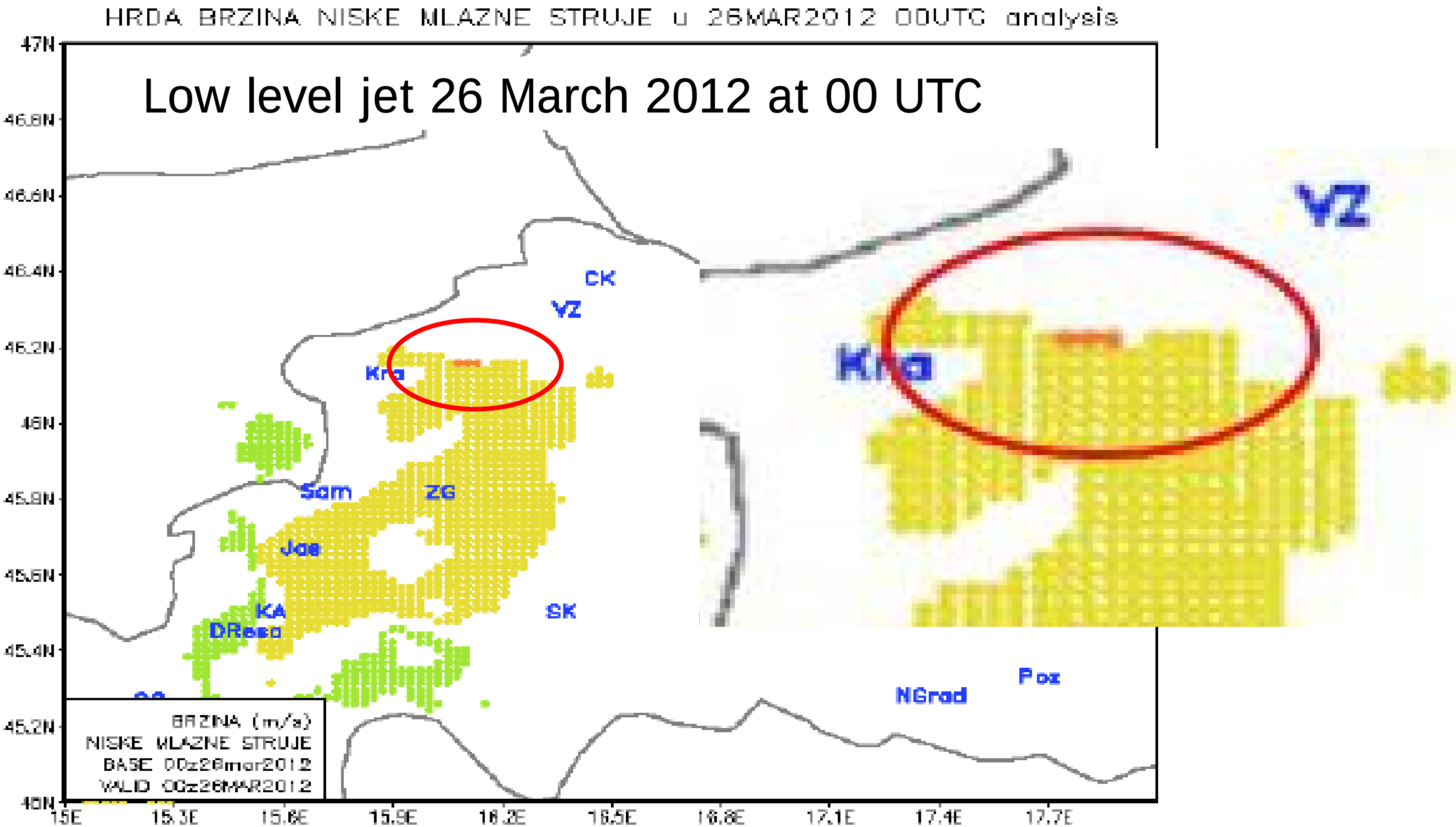
Krapina, 22-26 March 2012 at 14 h

Date	t_{air} (°C)	$t_{soil2\ cm}$ (°C)	mean $t_{soil2\ cm}$ (°C)	RH (%)	v (m/s)	FWI	Risk
22.3.2012.	20.0	22.8	12.9	35	2	14.2	low
23.3.2012.	22.6	23.1.	13.6.	28	2	17.8	moderate
24.3.2012.	22.3	23.9	14.0	32	2	18.5	moderate
25.3.2012.	20.3	22.8.	14.6.	39	2	17.9	moderate
26.3.2012.	17.9	22.2.	14.1	27	4	31.5	high

(Kurazi and Vucetic, 2015)

Ccontinental wildfire, March 2012



(Kurazi and Vucetic, 2015)

Conclusion 2

High Fire Weather Index

Cold front + Low level jet

→ Large wildfires

Conclusion 2

- Common characteristics of Peljesac and Krapina wildfires are:

a) a long-lasting dry and warm period before the wildfires

b) Although the wind was weak, very dry dead fuel, strong convection of warm air and a very steep terrain helped in fire rapid spreading.

- Polar and geostationary satellites have their advantages and disadvantages in recognition and monitoring of forest fire:

a) The advantage of polar satellites is that they can record with very large spatial resolution, but time interval is too long.

b) Geostationary satellites give data every 15 minutes but have smaller spatial resolution.

- Thus, the early warning system in Croatia could not be based only on satellite data, since the probability of fire detection is too low, especially for small fires up to 15 ha.

Animated film “The fire is no joke”

Croatian Agrometeorological Society

- One of measures of forest protection against fire is a good education of the youngest.
- As the animated film is the most popular medium in children's lives, HAgMD produced the film with motto: “Do not play with flame and smoke, fire is no joke!"

Thank you for your attention