TEMPORAL VARIATIONS AND CHANGE OF FOREST FIRE DANGER IN CZECH REPUBLIC IN 1961–2014

MARTIN MOŽNÝ[1,2], MIROSLAV TRNKA[2,3], DANIEL BAREŠ[1], VERA POTOP[4], PETR HLAVINKA[2,3], ZDENĚK ŽALUD[2,3]

[1]*Czech Hydrometeorological Institute, Doksany Observatory, Doksany 105, 411 82 Doksany, Czech Republic*
[2]*Department of Agrosystems and Bioclimatology, Faculty of Agronomy, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic*
[3]*Global Change Research Centre AS CR, v. v. i. Bělidla 986/4a, 603 00 Brno, Czech Republic*
[4]*Czech University of Life Science, Faculty of Agrobiology, Food and Natural Resource, Kamýcká 129, 165 21 Prague, Czech Republic*

Understanding how fire-weather danger indices changed in the past, and detecting how changes affected forest fire activity is important in changing climate. We used the simple fire danger index FD to examine the temporal variation of forest fire danger in Czech Republic in 1961-2014. To illustrate, we used national forest-fires statistical data from Germany and Czech Republic to relate fire danger and fire activity.
Typically, fire danger rating systems combine meteorological information with estimates of the moisture content of the fuel to produce a fire danger index. The fire danger in the open countryside in the Czech Republic is modeled with a fire danger index FD. The simple fire danger index FD is mainly used for forecasting purposes. Input data are the data of air temperatures, wind speeds, air and soil moistures. The system is active from 15th of March to 15th of October. Fire danger is mapped in five classes (very low, low, medium, high and very high).
The number of high fire risk days shows an increasing trend which is significant at the 99 % confidence level.
The correlation between calculated indices and observed fires was higher, but while the trend of forest fires in Czech Republic was decreasing in terms of number and burned area, the meteorological fire danger in contrast increased. Reasons for this contrasting trend may be related to altered anthropogenic factors such as changes in forest management, technical progress, and higher awareness.

Keywords: forest fire danger, climate change, fire danger index, drought, fire statistics, Central Europe

INTRODUCTION

Chandler et al. (1983) define fire danger as the resultant of some factors that affect the inception, spread and difficulty of control of fires and the damage they cause. These factors include topographic attributes, fuel characteristics and weather variables as well as random factors such as arson. Many of these factors are difficult to quantify numerically.

Using historical datasets and a better understanding of regional and global climate variability improved assessment of the danger of fires (Veblen et al., 2003). However, the fire danger is a complex topic, influenced not only by climate or weather but also by a number of factors, including human interactions (activities likely to start fires). The general global trend is an increase in the area burned and number of fires, but with much variation between different areas (Flannigan et al., 2009; Liu et al., 2010). Wildland fires in Mediterranean Sea from the Iberian Peninsula to France, Italy and Greece have been on the rise since the early 1980s. Moriondo et al. (2006) observed both an increase in the length of the fire season and an increase of extreme events.

Simple fire danger indices are used throughout the world. These indices combine information about the current weather and drought. These indices are used, for example, in the United States, Canada and Australia (Cheney and Sullivan, 1997; Gill et al., 1987; Goodrick, 2002; Van Wagner, 1987).

Within the EU has created the European forest fire information system (EFFIS). This system generates the predictive maps for the whole of Europe using meteorological data from French and German meteorological services (Meteo-France and DWD). For modeling, the risk of forest fires is used the Canadian forest fire weather index (FWI).

Warning against extreme weather conditions is available on the website MeteoAlarm (www.meteoalarm.eu). Information's are provided by the individual national meteorological service for their country.

In this paper we study long-term trends in meteorological fire danger caused by climate change in the Czech Republic based on fire danger index *FD* (Možný and Bareš, 2013, 2014).

MATERIALS AND METHODS

Since 2006, the fire danger in the open countryside in the Czech Republic is modeled with the fire danger index *FD* (Možný and Bareš, 2013). *FD* incorporated the wind speed, soil moisture, air temperature and humidity. The model used equation:

$$FD = (b_1U - b_2F) / (b_3T - b_4H)$$

where T the air temperature in °C, H the air humidity in %, U the wind speed in $m.s^{-1}$, F the soil moisture in % of AWC, and b_1, b_2, b_3, b_4 are coefficients to be estimated.

Index *FD* was successfully validated with data on the frequency of fires in the Czech Republic and Germany. The following are the *FD* values used as thresholds of the fire danger classes in the Table 1.

Table 1 Fire danger classification thresholds for *FD*

Fire Danger Classes (INP)	***FD* ranges (upper bound excluded)**
1 - Very low	< 0.9
2 - Low	0.9 – 1.7
3 - Moderate	1.7 – 3.0
4 - High	3.0 – 6.0
5 - Very high	≥ 6.0

For analysis were used meteorological data from the database CLIDATA of the Czech Hydrometeorological Institute (CHMI), and the number of wildfires and burned areas in Germany from the Federal Office for Agriculture and Food

in Germany and in Czech Republic from the Fire Rescue Service of the Czech Republic.

RESULTS

Currently, the most forest fires in the Czech Republic significantly threaten the dry locations such as Saxon Switzerland or Moravian Sahara. In both these areas were the large forest fires in past years, namely in the Saxon Switzerland in 2006 (affected about 20 ha) and in the Moravian Sahara in 2012 (174 ha). Significant influence of dry and warm spring and summer on the frequency of fires in the Czech Republic was evident in 2003 (dry whole growing season), 2011 and 2012 (dry beginnings of spring).

According to statistics from the Fire and Rescue Service in the years 1992-2013 were registered in the Czech Republic at average 1,034 forest fires per year and the affected area was 468 ha, which corresponds to 0.02 % of the total area of forest. In this 22-year period, was a statistically significant decrease the number of fires and affected areas (fig. 1). Due to the relatively short period of time (after year 1992, there was a change in the assessment methodology fires), the analysis was completed on forest fire statistics from Germany.

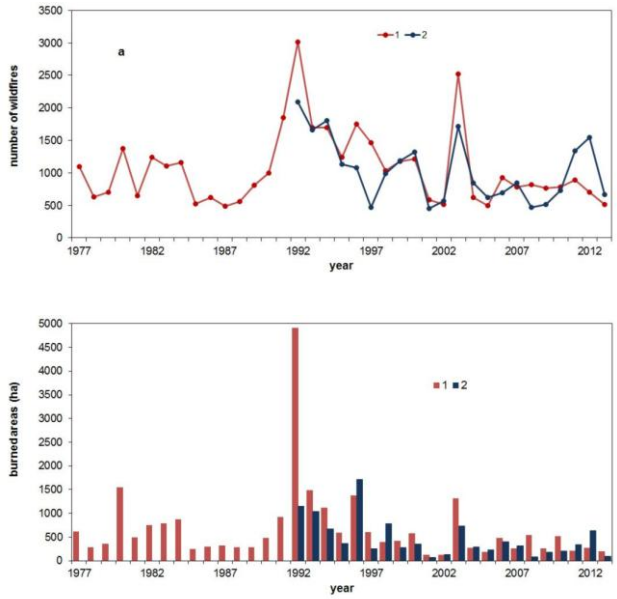

Figure 1. The number of wildfires (a) and burned areas (b) in Germany in the 1977–2013 period (1) and in the Czech Republic in the 1992–2013 period (2). Source of data: Federal Office for Agriculture and Food in Germany and Fire Rescue Service of the Czech Republic

Series of an average number of days with high and very high of fire danger risk (INP≥ 4) a very high danger (INP = 5) in the Czech Republic showed a statistically significant upward trend (0.76 day per year, respectively 0.07 day per year) in the years 1951-2013 (fig. 2). It is caused by the higher air temperatures and the rise of prolonged episodes of drought in last years. In the period 1951-2013, the average annual number of days with high of fire danger classes was 34.7 (26.6 day during the period 1951-1980 and 38.8 day during the period 1981-2010). The highest number of days with high and very high of fire danger risk (INP≥ 4) was in the year 2012 (102 days), 1976 (95), 2007 (81), 1973 (78), 2011 (76), 1992 (71), and 2003 (68). The years 1992, 2003, 2007 and 2012 represent the period with the highest number of forest fires for the past 22 years. The highest number of days with INP≥4 was recorded primarily in the period from April to May and the end of July to August.

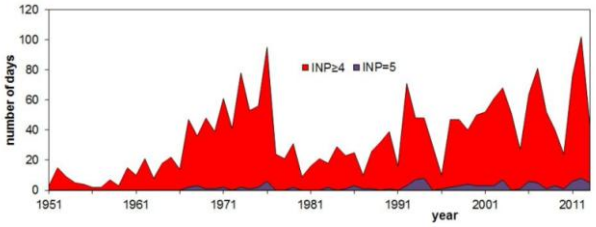

Figure 2. Mean number of days with high and very high fire risk (INP ≥4) and very high fire risk (INP = 5) during the 1951–2013 period in the Czech Republic

The highest average monthly indexes INP for the Czech Republic in the period 1951-2013 were achieved during April-August, with their average values from 2.57 (April) to 2.68 (July). Absolute extreme monthly values INP were recorded always in July (3.83 in 2006 and 1.03 in 1995). Most variable months with the highest standard deviation were July (0.54) and August (0.53). In the period 1951-1980 is characterized by a simple annual variation with its main maximum in July and main minimum in January, in the next thirty years featured an increase in value INP in May and April (fig. 3).

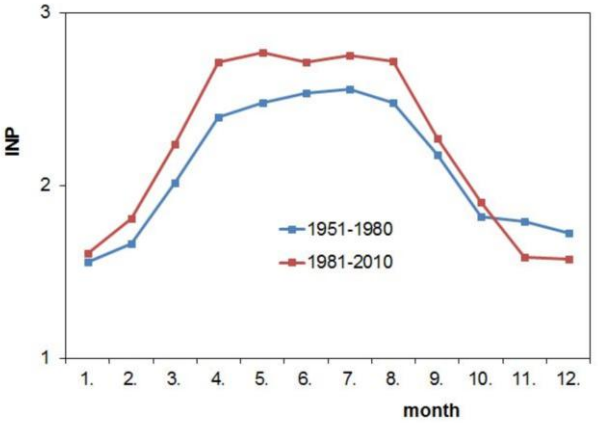

Figure 3. Annual variation of mean monthly indices of fire danger (INP) in the Czech Republic during the 1951–1980 and 1981–2010 periods

CONCLUSION

The trend of forest fires in Czech Republic was decreasing in terms of number and burned area, but the meteorological fire danger in contrast increased. Reasons for this contrasting trend may be related to altered anthropogenic factors such as less military activities, change in leisure activities (drop tramping, cycling growth), and higher awareness. In Bavaria found the same trend Wast et al., 2012. The growing influence of leisure activities on forest fires can be documented a statistically significant increase in the number of forest fires in the Czech Republic during weekends in the period 1992-2004 compared to the period 1974-1983 (Kula, Jankovská, 2013).

Acknowledgement

This work was supported by the Project ‘Establishment of International ScientificTeam Focused on Drought Research’ (no. OP VK CZ.1.07/2.3.00/20.0248) and by project CzechAdapt – System for Exchange of Information on Climate Change Impacts, Vulnerability and Adaptation Measures on the Territory of the Czech Republic (EHP-CZ02-OV-1-014-2014) which was supported by grant from Iceland, Liechtenstein and Norway.

LITERATURE

Chandler, C., Cheney, P., Thomas, P., Trabaud, L., Williams, D., 1983, Fire in forestry. In: Eds. C. Chandler, P. Cheney, P. Thomas, L. Trabaud & D. Williams, John Wiley & Sons: Forest Fire Behaviour and Effects, vol. I., John Wiley and Sons, New York, pp. 171-202.

Flannigan, M.D., Krawchuk, M.A., DeGroot, W.J., Wotton, B.M., Gowman, L.M., 2009, Implications of changing climate for global wildland fire. Int. J. Wildland Fire 18, 483–507.

Gill, A.M., Christian, K.R., Moore, P.H.R., Forrester, R.I., 1987, Bushfire incidence, fire hazard and fuel reduction burning. Australian Journal of Ecology 12, 299–306.

Goodrick, S.L., 2002, Modification of the Fosberg fire weather index to include drought. International Journal of Wildland Fire 11, 205–211.

Kula, E., Jankovská, Z., 2013, Forest fires and their causes in the CR (1992-2004). Journal of Forest Science, 59, 2, 41-53.

Liu, Y.Q., Stanturf, J., Goodrick, S., 2010, Trends in global wildfire potential in a changing climate. Forest Ecol. Manage. 259, 685–697.

Moriondo, M., Good, P., Durao, R., Bindi, M., Ginnakopoulos, C., Corte-Real, J., 2006, Potential impact of climate change on fire risk in the Mediterranean area. Clim. Res. 31, 85–95.

Možný, M., Bareš, D., 2013, Czech Fire-Danger Rating System. The Integrated Warning Service System. Czech Hydrometeorological Institute, Praha. Methodological Guideline No 3/2013.

Možný, M., Bareš, D., 2014, Forecast danger of vegetation fires in the open countryside in the Czech Republic. In: Rožnovský, J., Litschmann, T., eds.: Mendel a bioklimatologie. Brno, 3.–5. 9. 2014. Masarykova univerzita, Brno, 275-285.

Van Wagner, C.E., 1987, Development and structure of the Canadian forest fire weather index system. Canadian Forestry Service 35 Ottawa, Canada.

Veblen, T.T., Baker, W.L., Montenegro, G., Swetnam, T.W., 2003, Fire and climatic change in temperate ecosystems of the western Americas. Ecol. Stud. 160, 1–444.

Wastl, C., Schunk, C., Leuchner, M., Pezzatti, G.B., Menzel, A., 2012, Recent climate change: Long-term trends in meteorological forest fire danger in the Alps. Agricultural and Forest Meteorology, 162–163, 1–13.