

Climate services for drought and fire danger estimation on various time scales

Wildfires are critical natural hazards, both in the Mediterranean and boreal regions of Europe, causing significant environmental and economic damages and losses. Operational drought and fire risk forecast services on sub-seasonal, seasonal and climatic scale allow fire protection authorities to increase preparedness and response in drought and fire related emergencies and to develop mitigation and adaptation strategies in these regions.

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The ERA4CS SERV_FORFIRE project aims to develop operational services for fire assessment, monitoring and mitigation strategies from seasonal up to climatic time scale for different ecosystems and geographic areas ranging from Southern to Northern Europe. The tailored drought, fire and post-fire products have been implemented with the involvement of users, i.e. national and local authorities and decision makers in order to increase the user uptake and improve the preparedness level and efficiency of fire authorities in risk management. The usefulness of the developed services was demonstrated through applications both in Southern and Northern Europe. Four of the implemented and demonstrated drought and fire risk forecasting products and their related case studies are introduced in this paper. The selected case studies cover various time scales ranging from sub-seasonal to seasonal and climatic scale, all of them providing essential information on the meteorological conditions triggering wildfires in the present and future climate.

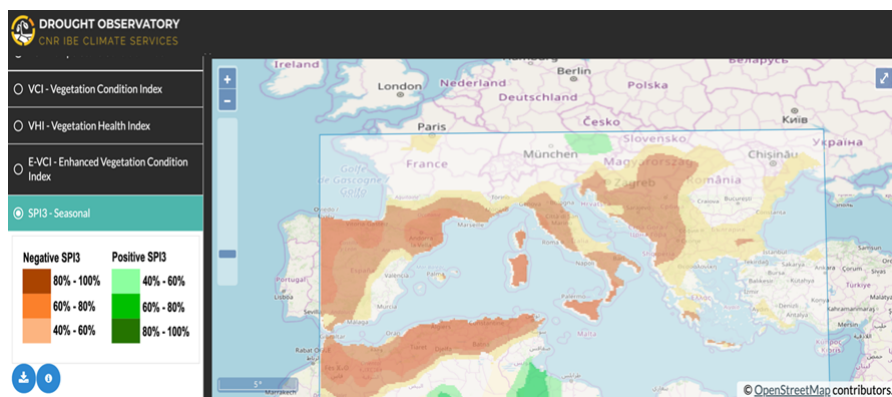


FIG 1: Standardized precipitation index (3-month) empirical seasonal forecasts are disseminated through the WebGIS application based on open source solutions customized to integrate different datasets and share maps and graphs of drought indices with researchers, decision makers and other stakeholders (<https://drought.climateservices.it/en/>).

Southern Europe and the Mediterranean basin are considered possible hot spots for drought and its consequences for fire risk and water security (Prudhomme et al. 2014). To reduce the temporal gap existing between the drought onset and development, and the response in managing the related emergencies, the **Italian National**

Research Council developed a **seasonal forecasting system** for drought for the Mediterranean basin to provide a semi-automatic, timely and comprehensive operational service for decision making, water authorities, researchers and stakeholders (Fig. 1). The seasonal forecasting component of the system is based on an empirical

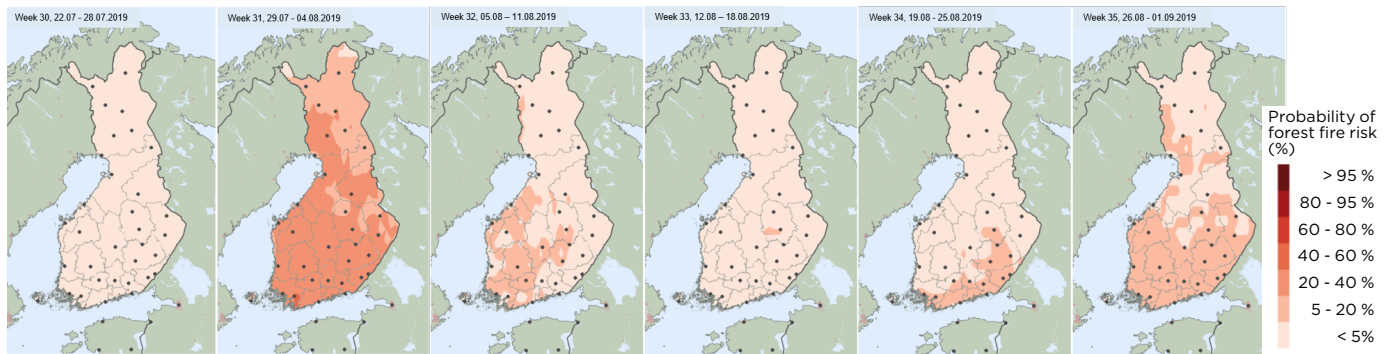


FIG 2: An example of 6-week forest fire risk climate outlook issued to the end-users for testing on July 22, 2019.

approach that predicts meteorological drought up to three months in advance using the standardized precipitation index, from large-scale observed climate indices. This empirical system adopts a physically based statistical approach which uses a multivariate regression model to estimate future anomalies. Predictors are selected from observed atmospheric (Seasonally Varying NH Annular Mode, Arctic Oscillation, North Atlantic Oscillation, and Modified zonal index) and oceanic sea surface anomaly patterns (Atlantic Multidecadal Oscillation, Multivariate ENSO Index among others) as described in details in Magno et al. 2018.

To extend the fire warning services run by the **Finnish Meteorological Institute**, a novel **six-week forest fire danger outlook** prototype was developed and piloted with Finnish end-users, i.e. the Regional State Administrative Agency (AVI) from Northern Finland and the Finnish Rescue Services from North Karelia during the fire season 2019. The sub-seasonal fire forecast product would complement the already existing forest fire risk monitoring system and the regularly issued short-range forest fire warnings. To predict the probability of sub-seasonal fire danger a statistical model originating from the Finnish Forest Fire Index (FFI) was developed and tested (Wolff et al. 2019). The Finnish Forest Fire Index (FFI) is determined by estimating the volumetric moisture of a 60 mm thick surface

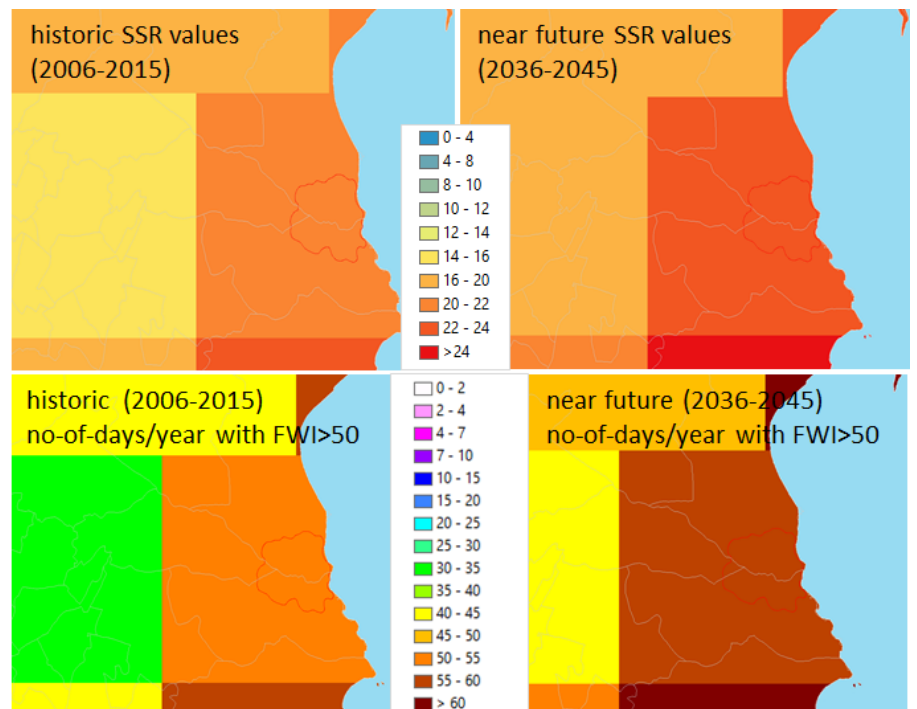


FIG 3: Seasonal Severity Rating values (top) and number of days per year with FWI greater than 50 (bottom) for past and near-future 10-year time period in Eastern Attica, Greece, calculated from an ensemble of two EURO-CORDEX regional climate models under RCP4.5.

layer (Vajda et al. 2014) and it is already used by FMI in the operational fire monitoring and warning system. The six-week forest fire outlooks (Fig. 2) were produced using as input the ECMWF EPS system data and observed daily FFI values to spin-up the index and delivered to the users twice a week through an operational service. According to the feedback received from the end-users, the outlooks were

very useful when planning in advance the fire survey flights. The product is further improved and iterated again with the users during the fire season 2020.

Eastern Attika (Greece), is a wildland-urban interface area frequently affected by forest fires. **Fire risk estimation** for the area and its change in the future was performed by the **National Centre for Scientific**

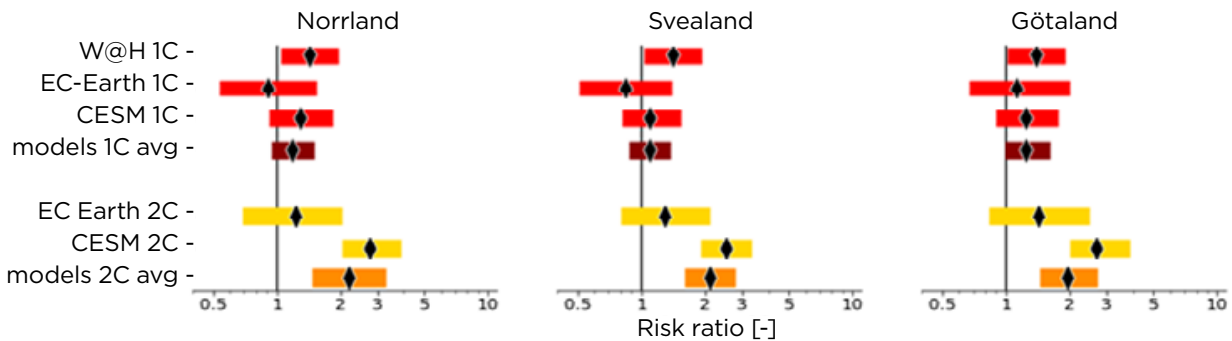


FIG 4: Risk ratios for maximum July-August FWI values as high as observed in 2018 for the different regions for multiple climate models. The risk ratios are calculated as following: first the return times of this specific event for the pre-industrial, current and future climate were calculated. If this event becomes more likely in a current or future climate it has lower return times. The risk ratio is computed by dividing the return time of the pre-industrial climate by the return time for e.g. current climate and indicates how much more likely such an event will occur in the current climate (red) and future climate (yellow) relative to pre-industrial climate.

Research “Demokritos” computing and mapping the Canadian FWI system components (Van Vagner 1987) on a daily basis during the fire seasons (May-October) for ten years, for the past (2006-2015) and near future (2036-2045) climate. The Canadian Fire Weather Index (FWI) represents the potential fire line intensity and it is a good indicator of general fire danger. The Daily Severity Rating (DSR), calculated as an exponential function of FWI, is a numeric rating of the difficulty of controlling fires, whereas Seasonal Severity Rating (SSR) is the averaged DSR during a fire season. These FWI components and their maps (Fig. 3) were produced using an ensemble of two high resolution (12.5 km) EURO-CORDEX regional climate models with medium emission scenario (RCP4.5).

In the summer of 2018 forest fires raged through large parts of Sweden. To answer the question to what extent

climate change has influenced such extreme event a **climate attribution analysis** was performed by **The Royal Netherlands Meteorological Institute** by studying the Canadian FWI in multiple observational and climate datasets. Analysis showed that the maximum FWI in July 2018 had return times of ~24 years. The climate models pointed to a ~10% increased risk for such events in the current climate relative to pre-industrial climate. For the future climate (2°C warming) a roughly 2 times increased risk for such events relative to pre-industrial climate was found, which is mainly attributed to the increase in temperature. In summary, a small but positive role of global warming up to now in the 2018 forest fires in Sweden, but a more robust increase in the risk for such events in the future was found (Fig. 4).

The climate services implemented and demonstrated through the

presented case studies provide science-based, useful tools for end-users and decision makers in the fire-prone regions facilitating their preparedness and development of adaptation strategies on various timescales.

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