Prediction of wildland fire danger in Sweden

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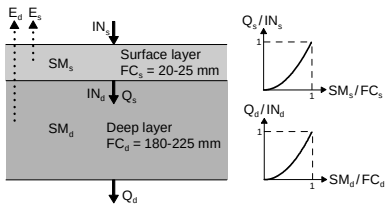
The wildland fire prediction system in Sweden is based on two forest fire models and a separate grassland fire model. The forest fire models are the Canadian Fire Weather Index Model and the Swedish HBV Forest Fire Model. The HBV Grassland Fire Model is used to predict fire danger during springtime in grass from the last year's period of growth.

All models are driven on a daily time-step by analysed meteorological data with a resolution of 11x11 km. Nationwide forecasts extending over two days are produced from March to September. The models are run at the Swedish Meteorological and Hydrological Institute (SMHI) in co-operation with the Swedish Civil Contingencies Agency (MSB).

Forest Fire Model

The HBV Forest Fire model is a modified version of the hydrological HBV runoff model, which is used for operational hydrological forecasting at the SMHI. The main components of the forest fire model are a snow routine and a two-layered soil moisture routine. The model requires daily values of precipitation and temperature as input. Model performance has been evaluated against records of forest fires in Sweden.

In the snow routine, snow accumulation is calculated using a threshold temperature to distinguish snowfall from rainfall. Snow melt is calculated using a degree-day approach based on air temperature.



HBV model soil routine with two layers. IN = inflow, Q = outflow, E = evapotranspiration, SM = soil moisture content, FC = field capacity, s = surface layer, d = deep layer

The soil routine uses calculations of soil moisture in two soil layers, where the most important component is an upper soil layer which has a water storage capacity of 20-25 mm. The soil moisture level is computed depending on the amount of precipitation, snow melt, evapotranspiration and runoff to deeper soil layers. Evapotranspiration is determined by the soil moisture level and the potential evapotranspiration, which is calculated as being proportional to air temperature. The contribution to the soil moisture storage from rainfall or snow melt varies depending on the current soil moisture level.

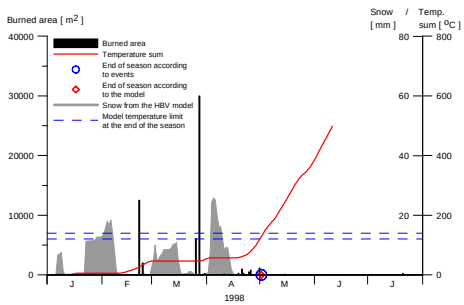
A combined soil moisture value is calculated as the harmonic mean of the relative soil moisture deficits in the two soil layers. This formulation gives a combined soil moisture value that also takes into account the variation of soil moisture content in deeper soil layers and thereby gives a more realistic description of the seasonal variation of water availability.

The model also includes a correction of the fire danger values during days when precipitation occurs. This correction term makes it possible to take into account small precipitation amounts during dry periods.

Grassland Fire Model

The HBV grassland fire model is used only to predict fire danger during springtime in grass from the last year's period of growth. Main components of the model are a snow routine, a routine to determine the end of the grassland fire season and a routine for the estimation of the danger index. The model requires daily values of precipitation, temperature and relative humidity as input. Model performance has been evaluated against records of grassland fires in Sweden.

The snow routine is the HBV model snow routine with parameters adapted for snow accumulation and snow melt in open land conditions in Sweden.



Example of accumulated growing degree-day sum for the Blankaström basin in southern Sweden. Fire statistics are from surrounding communities.

The growth of new vegetation into the grass bed from the previous season limits the season for grassland fires during springtime. In the model, the end of the grassland fire season is determined by a degree-day method to estimate the vegetation growth. Air temperature is used with corrections to take into account the insulating effect of snow cover and the time lag between air temperature and soil temperature.

The growing degree-day sum is accumulated from January 1 and potential grassland fire danger is assumed when there is no snow cover and the sum is below 120°C. The interval 120°C to 140°C is classified as declining grassland fire season. The season is considered to be over when the sum exceeds 140°C.

The routine to determine the fire danger index is based on relative air humidity and moisture conditions in the soil surface as calculated in a very thin layer by the HBV model. The grassland fire index varies dependent on different conditional statements for these two variables. The high danger index is always indicated when relative air humidity is below 30%.

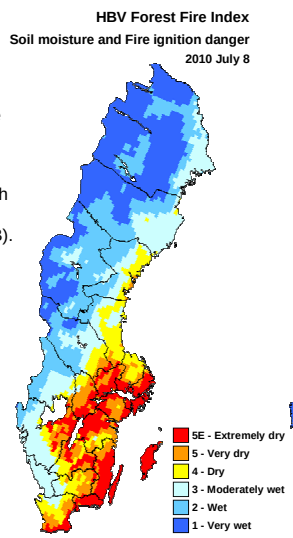
Operational use

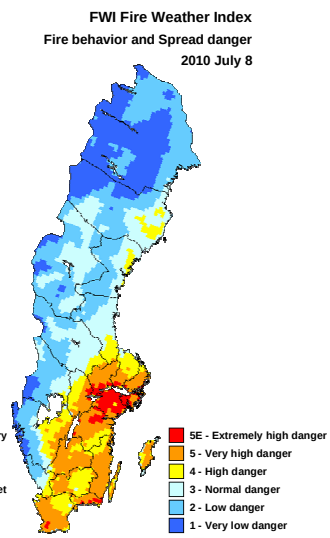
The fire danger models are driven on a daily time-step by analysed meteorological data with a resolution of 11x11 km. Land-use is in all grids assumed to be forest when applying the forest models, and similarly, grassland when applying the grassland model.

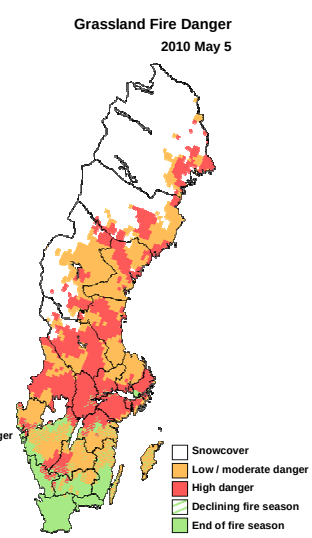
Nationwide forecasts extending over two days are produced from March to September. The models are run at the Swedish Meteorological and Hydrological Institute (SMHI) in co-operation with the Swedish Civil Contingencies Agency (MSB).

SMHI issues general warnings to the public for wildland fires based on information from the models. Basic fire danger information is available to the public at the websites of SMHI and MSB. Detailed outputs from the fire models are available at a separate website for professionals at municipal rescue services, regional emergency centres and at county administrative boards. This website also presents lightning detection maps, thunderstorm forecasts and general weather forecasts for Sweden.

The model system and the websites are presently being further developed. In 2011 the forecasts will extend over 6 days and the website presentations will be based on dynamical on-demand maps.







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