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ADAPTATION TO CLIMATE CHANGE

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A real-time end-to-end satellite-based forest fire detection system for Sweden

Tackling the increased forest-fire risk under a changing climate

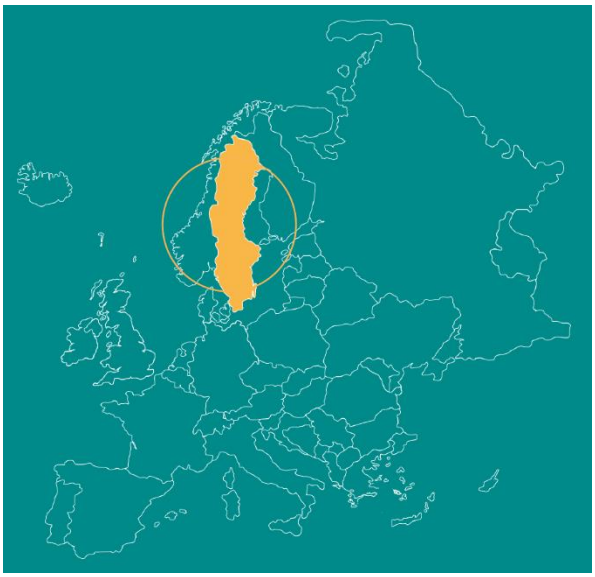
This tool supports early detection and localisation of wildfires, allowing for faster responses and helping to prevent fires from spreading uncontrollably. Fully automated, the system plays a crucial role in reducing the risk and impact of wildfires in Sweden.

Key Learnings

- **High-quality data is a prerequisite**: The municipal fire and rescue services can use the tool if they have the required knowledge and confidence. Trust in the service, reliable data represented by good geolocation accuracy and a low false-alarm ratio are prerequisites for its application. Post-processing helps reduce false alarms for early fire detection and increases the trust in the service.
- **User engagement and communication**: Engage end-users from the beginning and honestly communicate capabilities and limitations. It is necessary to establish good communication between developers and end users.

About the region

Sweden is the largest country in Scandinavia, covering a land area of approximately 450,000 km². Despite its size, the population density is low. Sweden has about 10.5 million inhabitants, mainly living in urban areas. Vast areas of wilderness and rural areas characterise Sweden's landscape. Mountains, forests, lakes and a long coastline diversify the country's landscape. Sweden is experiencing hotter and drier summers and shorter winters are contributing to an increased forest (and grass) fire risk.



Climate Hazards

Droughts, Extreme Temperatures

Sector

Forestry, ICT

Key system

Land use and Food systems

Climate Threats

In Sweden, the average temperature has already risen by 1°C when comparing the period 1961–1990 to 1991–2007. This warming trend is expected to continue, with projections estimating a 2–3°C increase by 2050. Compared to the early 2000s, forest fires have become slightly more frequent, although annual variations remain significant. In 2018, a prolonged heatwave and drought in Sweden led to an unprecedented number of large forest fires more extreme weather events such as storms, heavy rainfall and flooding as well as increased forest fire danger due to droughts are expected during the summer months. Additionally, milder and shorter winters are extending the wildfire season, with fire risks in southern Sweden, now beginning as early as February. The situation is especially tense in remote and sparsely populated regions where fires can go unnoticed, potentially escalating into large-scale fires before being reported by the public.

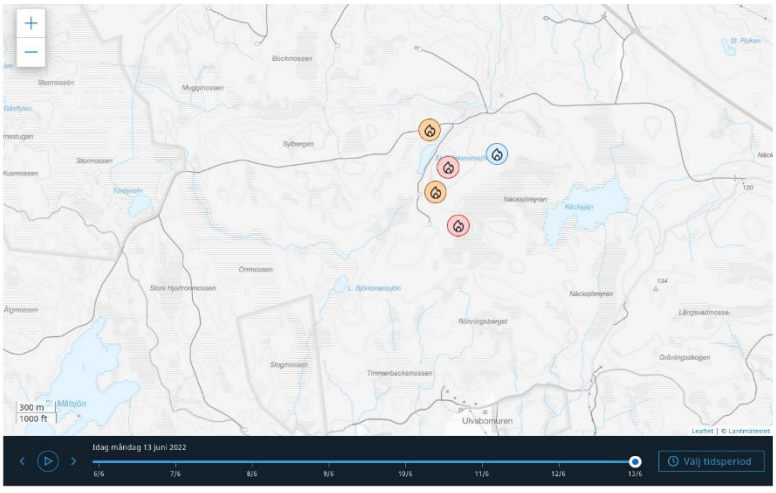
Figure 1: Forest Fires Sweden. Image Credit: Fire Rescue Service in Bergslagen, Sweden.

Early identification with a Satellite-Based Detection System

In response, the Swedish government, through the Swedish Civil Contingencies Agency (MSB) and the Swedish Meteorological and Hydrological Institute (SMHI), developed a real-time, satellite-based wildfire detection system. The system uses the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument on polar-orbiting satellites to detect vegetation fires. These satellites provide near real-time direct broadcast data for local real-time forecasting Forecasting and early warning applications. The U.S. National Oceanic and Atmospheric Administration provides free software to pre-process the Visible Infrared Imaging Radiometer Suite data. Further processing the data with software from the Swedish Meteorological and Hydrological Institute and the Swedish Civil Contingencies Agency reduces false alarms caused by non-fire heat sources like power plants and industrial processes and sun glints from solar panels or large metal rooftops.

Figure 2: Visible Infrared Imaging Radiometer Suite (VIIRS) instrument. Image Credit: Fire Rescue Service in Bergslagen, Sweden.

The population detects around 90% of wildfires in Sweden. Historically, manned aeroplane surveillance detected the remaining 10%, increasing the lead time and lowering the risk of undetected potentially dangerous fires. However, manned aeroplane surveillance is expensive and limited to daytime, and public reporting is less reliable at nighttime or in sparsely populated areas. A fully automatic satellite-based system complements manned aeroplane surveillance and enables fire detection in remote parts of the country. The early detection system processes the Visible Infrared Imaging Radiometer Suite data within only 15 minutes using an Active Fires algorithm. It sends an SOS message to the municipal fire and rescue services via an automated notification system and provides fire data on the "Brandrisk skog och mark" (Fire Danger – Forest and Grassland) web portal. All municipal fire and rescue services in Sweden have access to the service.



Datum	Position	Fire Radiative Power (MW)	Strålningstemperatur (K)
2022-06-13 12:18	59.823223, 16.061855	12.05	338.52
2022-06-13 12:18	59.820702, 16.053457	10.12	332.77
2022-06-13 13:08	59.824898, 16.052805	80.97	342.32
2022-06-13 13:59	59.818401, 16.056433	3.18	335.77
2022-06-13 13:59	59.822384, 16.055204	7.52	349.93

Figure 3: Forest fire detections in June 2022, including the fire locations. Image Credit: SMHI.

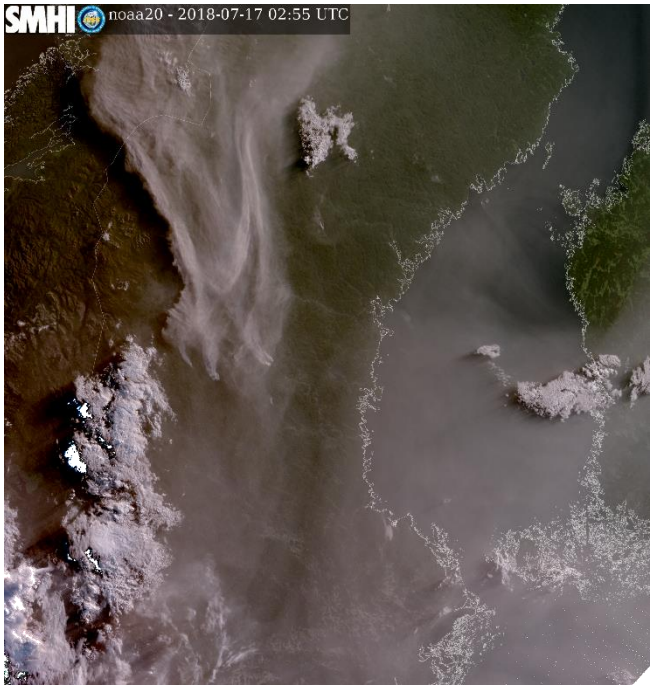


Figure 2: VIIRS image showing smoke spreading over large parts of Sweden from some of the fires in 2018. Image Credit: SMHI.

Beneficial Impact of the system

Three factors mainly constrain the satellite-based system: a) there is a lower limit to the size and intensity a fire must have to be detectable, b) the satellite cannot in general “see” through clouds, c) the satellites pass over Sweden only a few times every day (observing southern Sweden around 8-10 times and up to 30 times a day in northern Sweden). However, satellites are useful for locating the position of wildfires. The system has also proven cost-effective and has reduced firefighting costs by enabling quicker, more precise responses. Thus, this satellite-based system represents a significant technological advancement in Sweden's fight against the increasing threat of wildfires caused by climate change.

> *"In sparsely populated areas, a fully automated satellite system with quick response capabilities has proven highly valuable, reducing wildfire response times and helping prevent fires from spreading out of control.”,*
>
> *Adam Dybbroe, SMHI*

Feedback from the local fire brigades and rescue services has been very positive. After training, they can apply the tool which depends on high-quality data. The fire brigades and rescue services find the system reliable with a lower level of false alarms (10%) compared to not applying post-processing. They also find it very accurate in identifying the actual location of the fire. The precise localisation has proven helpful, even when ground detection identified the fire before the satellite did. In general, ground reports are not as precise as satellite detections. The latter provides the coordinates of the detected fire with an accuracy that is, most of the time, better than 250 meters. Besides the early detection of grassfires, the system can also detect other types of fires, such as fires in small cabins or remote houses.

Summary

The real-time end-to-end forest fire detection system is an effective tool to complement human fire observations and has proven more cost-effective than aeroplane detection in Sweden. High-quality data and early user engagement are prerequisites for effective tool applications. To ensure timely action, the system also sends an SOS message to the municipal fire and rescue services via an automated notification system.

Further information

- https://www.smhi.se/en/q/Stockholm/2673730
- https://www.msb.se/en/
- https://github.com/adybbroe/activefires-pp

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