FRAME - FiRe Across MultiplE Services

Fire is a widespread phenomenon in the Earth system that plays a key role in ecosystem composition and distribution. Because of its enormous impacts on society, much effort has been put into creating operational systems that are able to predict fire occurrences and assess their impact on human life both in terms of direct exposure and air quality. Indeed all of these aspects are considered crucial and are part of the Copernicus services.

Fire danger metrics (the Canadian Fire Weather Index, the US Forest Service National Fire-Danger Rating System and the Australian McArthur system are example) rely on semi-empirical relationship based on prevailing vegetation type, its flammability characteristics and meteorological conditions. These danger ratings systems are used by forest agency as early warning indicators to manage and control fire events. They are the modelling components of the Copernicus Emergency Management Service (Fire) and estimate how difficult would be to control a fire if one were to start.

Once fire are started their emissions into the atmosphere are often regarded as an air quality problem. Indeed an unwanted by-product of wildfires, smoke (biomass burning particulate), is one of the most important aerosol types and it is often referred to as the “silent killer”. Biomass burning emissions are estimated from satellite observations of Fire Radiant Energy which is then converted into chemical compounds assuming the burning properties of the underlying vegetation. These estimations are used by the the Copernicus Atmosphere Monitoring Service as initial conditions to predict the load of chemical species in the atmosphere. In the absence of a fire evolving module, fire emissions are kept constant during the air quality forecast produced by CAMS.

From the point of view of weather and climate, aerosols from fires are one of the most important components with significant impacts on radiation. The impact of black carbon can be the opposite of the cooling effect of scattering aerosols due to its absorption characteristics, which means that it can effectively act as a greenhouse gas and enhance surface warming . In fact, some studies show that black carbon makes the second biggest contribution to global warming after CO_2. Despite the large impact that fires can have on changing the weather conditions there is no direct link at the moment between vegetation, fire emissions and meteorological variables in terms of dynamical feedback. Establishing such feedbacks could clearly benefit the climate community and enhance C3S seasonal products.

Thus, while fires are accounted for in all three Copernicus services, they are looked at from completely different angles. We believe that this inhomogeneity of approaches stems from not considering fire as a dynamical physical process into the Earth-system and considering it only from the point of view of its impact.

The ground-breaking idea behind FRAMES is to treat fires as one of the processes in an Earth system model developed for weather forecasting. By doing so it will harmonise the way fire is treated across the various Copernicu services and will create a real opportunity to enhance all of the services by providing consistent and cross-cutting new copernicus products.

By the end of the research project, FRAMES will have:

(i) developed a dynamical fire model, using the vegetation types provided by the land-surface model that is used in IFS,
(ii) incorporated this fire module into the physics processes of ECMWF's Integrated Forecasting System (IFS). This will allow for the first time to initialise the fire variables through a data assimilation scheme with an underlying physical model. .
(iii) established relevant feedbacks between the various physical processes already present on the one hand and fires on the other, including vegetation burning and regeneration, change in planetary albedo, impact on radiation and cloud formation
(iv) improved estimates of the emissions from biomass burning as it will account for dynamical modulation of fire emissions
(v) run end-to-end fire-weather-air quality ensemble forecasts up to the monthly/seasonal scale including interactions with meteorological and land-surface processes.

The project will make it possible to fully understand the impact of fire on the Earth system as a whole as well as on individual aspects, such as the local and global circulation, convection, cloud formation and the energy balance, through various feedbacks. This will be of obvious benefits for forecast in the long range and the Copernicus Climate Change Services. Moreover, the system will provide a series of fire danger products in aid of fire management and control, such as consistent maps of fuel moisture content, fire ignition probability, and burnt area. While these products are comparable in their use to more classical fire danger systems used in the Copernicus Emergency Management Service, they would not be the result of postprocessing weather forecasts but are a dynamical outcome of an evolving system. This is a real paradigm shift in fire forecasting and will provide a new pathway for the developments of systems that are not calibrated over specific ecosystems. In addition, the system will be able to predict fire emissions for the most important chemical species (black carbon, organic matter, CO, CO2, O3 etc), enhancing the predictive capability of the Copernicus Atmosphere Monitoring Service (CAMS) in the time range from 5 days to up to a month thanks to the probabilistic ensemble approach that will be adopted.