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Forecasting wind-driven wildfires using an inverse modelling approach

Wildfires are complex multiscale phenomena involving a series of nonlinear and transient processes. They are governed by coupled physicochemical interactions that are not yet known which pose the main obstacle when trying to model their behaviour. Thus, a technology able to forecast wildfire dynamics would lead to a paradigm shift in the response to emergencies, providing the Fire Services with essential information about the on-going fire. The thesis at hand presents and explores a novel methodology to forecast wildfire dynamics using real time data assimilation and solving an inverse problem for the invariants- governing parameters that remain constant for a significant amount of time- with a tangent linear approach and a forward automatic differentiation. Rothermel's rate of spread theory with a perimeter expansion model based on Huygens principle are used to build up the forecasting algorithm. Its potential is investigated using synthetic data and evaluated in different wind-driven wildfire scenarios. The results show the high capacity of the method to quickly predict the location of the fire front with a positive lead time (ahead of the event). This work opens the door to a further advanced framework with more sophisticated models (e.g. pyrolysis models, CFD) keeping the computational time suitable for operativeness.