Front shape similarity measure for shape-oriented sensitivity analysis and data assimilation for eikonal equation.

Summary: We present a shape-oriented data assimilation strategy suitable for front-tracking problems through the example of wildfire. The concept of “front” is used to model, at regional scales, the burning area delimitation that moves, undergoes shape and topological changes under heterogeneous orography, biomass fuel and micrometeorology. The simulation-observation discrepancies are represented using a front shape similarity measure deriving from image processing and based on the Chan-Vese contour fitting functional. We show that consistent corrections of the front location and uncertain physical parameters can be obtained using this measure applied on a level-set fire growth model solving for an eikonal equation. This study involves a Luenberger observer for state estimation, including a topological gradient term to track multiple fronts, and of a reduced-order Kalman filter for joint parameter estimation. We also highlight the need – prior to parameter estimation – for sensitivity analysis based on the same discrepancy measure, and for instance using polynomial chaos metamodels, to ensure a meaningful inverse solution is achieved. The performance of the shape-oriented data assimilation strategy is assessed on a synthetic configuration subject to uncertainties in front initial position, near-surface wind magnitude and direction. The use of a robust front shape similarity measure paves the way toward the direct assimilation of infrared images and is a valuable asset in the perspective of data-driven wildfire modeling.

MSC:
65-XX Numerical analysis
93-XX Systems theory; control

Software:
FARSITE; Verdandi; FlamMap; Multivac

Full Text: DOI

References:


N. Papadakis and E. M´emin. A variational technique for time consistent tracking of curves and motion. Journal of Mathet-