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Natural Hazards and Earth System Sciences
Discussions

# *Interactive comment on* "Towards predictive data-driven simulations of wildfire spread – Part I: Reduced-cost Ensemble Kalman Filter based on a Polynomial Chaos surrogate model for parameter estimation" *by* M. C. Rochoux et al.

**Anonymous Referee #1**

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The paper investigates an interesting direction for the simulation of wildfire spread. It relies on data assimilation and polynomial chaos to propose a model/observation coupling adapted to operational constraints. The paper includes many explanations on all aspects of the work: simulation model, data assimilation, polynomial chaos. There is however one key point about the application of the Kalman filter that is unclear at the moment. See the comments below for further details.

—Main comments—



Page 3297, line 10: "The required size of the sample significantly increases with the complexity of the physics (multi-parameter estimation) and the model non-linearities (complex physics), thus emphasizing the need for a reduced-cost EnKF." Why? Is there any reference on this? There are many examples where EnKF is applied to the very complex models and does not require large ensembles (30 to 50 members).

Page 3299, line 23: Why do you assume that there is no correlation between the observational errors?

Page 3301, line 14: What does it mean for beta to be optimum?

Page 3304, line 21: "the flame is the region where c takes values between 0 and 1" -> Can you explain this approach? Usually, level set methods identify only one front, e.g., at the zero level set. The initial function can be the distance to the initial front. In your case, you start from a discontinuous function so as to track a thick front (or actually two fronts). There is the multi-level-set method, but your initial function does not seem to follow this method.

I do not understand the way the ensemble Kalman filter seems to be applied. There is a clear need for clarification. In equation 10, where is the state in this equation? x_t only includes the control parameters, if I correctly understood section 3.1. What about the position of the front at t-1? It should be somehow part of the state (as such or in the form of c). Indeed, M_[t-1, t](x_t) is incomplete if x_t does not include the front position at t-1. See equation (8) where M also depends on c. If x_t does not contain the front position, then you update only the control parameters in the analysis step and I do not understand how this can be a legal application of the filter. Usually one would extend the state with the control and proceed with the assimilation, hence the position of the front should be corrected at analysis stage too. On page 3312, line 16-21, the analysis front positions are said to be derived from the analysis controls. Note that it is not clear what is the initial front at time t-1 for each ensemble member. Anyway, the control vectors should serve for the next step [t, t+1], not for [t-1, t] – otherwise we deal with a smoother intead of a filter. In addition, I believe the analysis front positions should be computed by the filter at time t, along with the analysis control vectors at time t. If not, explain how you can skip this. Maybe you correctly applied the filter, but then the text brings confusion due to the lack of state equation. Currently, there is the model M and the model F for the controls. Plus, according to equation (8), one cannot define the state equation with M because it maps from the level set function and the controls to the markers positions (instead of the updated level set function). The introduction of F as sole state equation is misleading and I am under the impression it might have led to an erroneous application of the filter. In order to settle the issue, I recommend to clearly write a state equation and an observation equation (with all dependencies) to which the filter is applied. I can see two possible options; if you used another way, please explain it in details. (Option 1) You rely on an extended state vector (classical approach) which includes the front position and the controls. But the analysis (equation (20)) then includes the front position, as you cannot "mute" a part of the state at analysis stage. (Option 2) Your state only includes the controls, but then your controls cannot depend on time anymore and, in the observation equation (10), the model is applied from time 1 (not from time t-1) to time t. And all members of the ensemble would start from the same initial condition (at time 1).

Figure 6: The error bars are narrower for lower numbers of members. Why? The standard deviation computed with a low number of members is probably not reliable.

—Minor comments—

Page 3292, line 5: future perspective -> perspective

Page 3292, line 23: resolution on -> resolution of

In many places: Monte-Carlo -> Monte Carlo

methodologies -> methods

Page 3298, line 3: regional-scales -> regional scales



Page 3298: "These information are" -> "This information is"

towards -> toward

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 2, 3289, 2014.