Assimilation of MODIS and VIIRS satellite active fires detection in a coupled atmosphere-fire spread model

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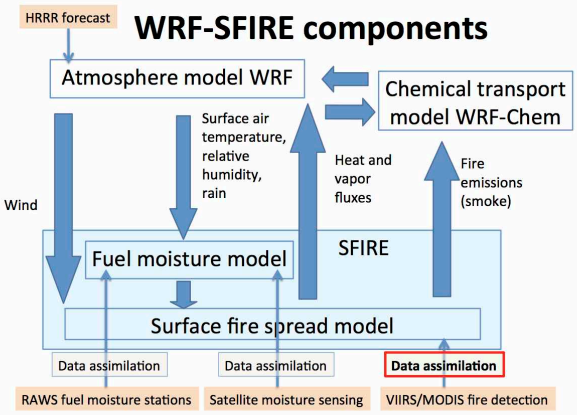
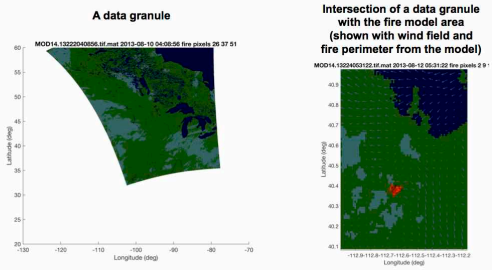
The model

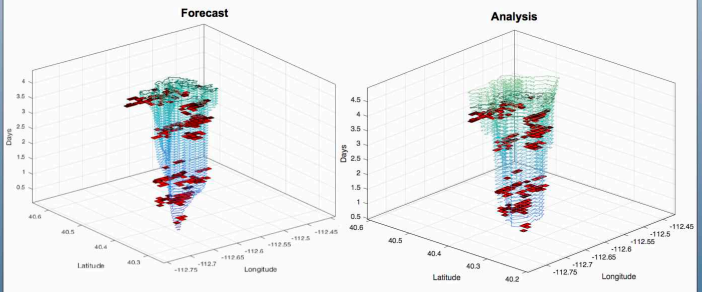


Active Fires data



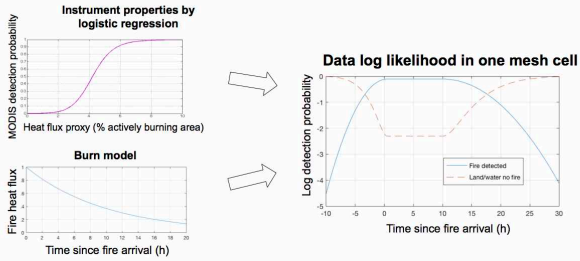
- Active Fires data resolution 375m-1km is much coarser than the resolution of fuel data (Landfire, 30m) and fire model (6m-200m)
- False positives, false negatives, geolocation errors, artifacts,…
- Confidence levels for cells with fire detection, but not for no fire.
- Gridded data granules along satellite flight path.
- Missing values: clouds, instrument failures, lunar roll maneuvres,…
- Can improve the model in a statistical sense. Not suitable for direct use.

Analysis step



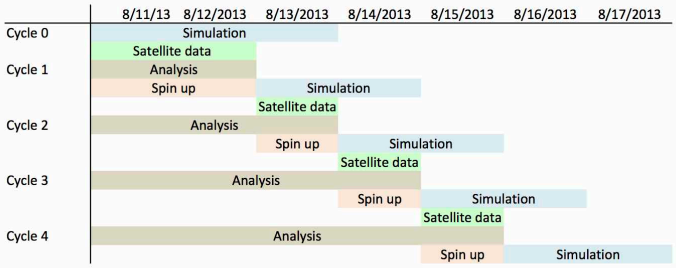
- Fire model state is encoded as the fire arrival time.
- Horizontal contours shown are model fire perimeters. Fire detections in the same horizontal plane are from the same satellite overflight.
- Data likelihood is derived from instrument properties and model heat flux.
- Forecast probability distribution is taken as a gaussian random field.
- Analysis fire state is the maximum aposteriori probability estimate.
- Consistent atmospheric model state is recovered by a spin-up phase with the atmospheric model driven by heat fluxes from an interpolation between the forecast at the beginning and the analysis at the end of the assimilation window.

Data likelihood

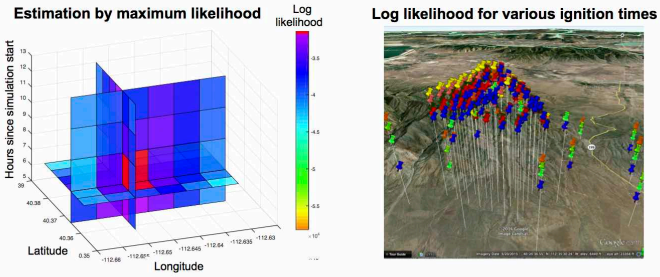


$$\log \text{likelihood} = \sum_{\text{granules}} \sum_{\text{mesh cells}} (\text{confidence level})(\text{cell log likelihood})$$

Cycling



Estimating ignition



Conclusions

- Goal: Autonomous fire behavior forecasting on the web from satellite active fires detection and other automatically available data only.
- The present data assimilation scheme deforms the model's space-time fire-arrival surface towards the data successfully.
- Fire has a big effect on the atmosphere. Changing the fire state abruptly in response to data results in inconsistent state. A spin up recovers consistency.
- Cycling with the spin up is stable and tracks the data successfully.
- The ignition point and time can be estimated by maximization of likelihood after enough data has accumulated. Weather, terrain, and fuel are accounted for through the model automatically.

Bibliography

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3. Schroeder, W., E. Prins, L. Giglio, I. Csiszar, C. Schmidt, J. Morisette, D. Morton, 2008: Validation of GOES and MODIS active fire detection products using ASTER and ETM+ data. Remote Sensing of Environment, 112, 2711–2726.

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