Fuel moisture model in WRF-Fire and assimilation of RAWS data

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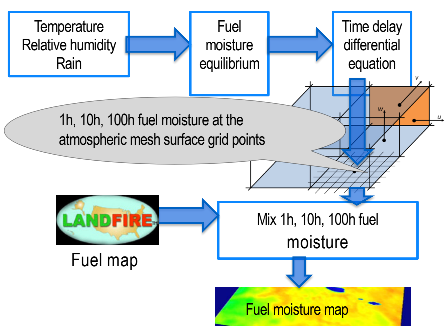
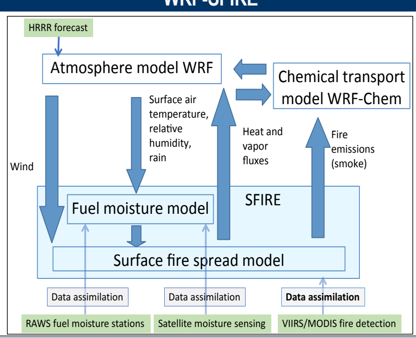
Summary

- Wildland fire propagation depends strongly on the fuel moisture contents (FMC).
- Over a long time in constant temperature T and relative humidity H, FMC approaches an equilibrium.
- As conditions change, FMC approaches the moving equilibrium with a delay – 1h, 10h, 100h (drying/wetting) fuel classes.
- In a rain, FMC approaches saturation with a delay dependent on fuel class and rain intensity.
- The fuel model runs for 1h, 10h, 100h fuel classes on a coarse mesh, the same as the weather model.
- The FMC is mixed from the 1h, 10h, 100h fuel classes to a finer fire simulation mesh. in proportions from fuel models and maps.
- The model resolves diurnal fire propagation change (nights are cooler and the relative humidity goes up), and the changes due to rain.
- FMC model online coupled with weather-fire simulation is integrated in WRF-SFIRE.
- A standalone implementation with the assimilation RAWS FMC data for FMR nowcasting, running continuously, available online.
- Accuracy improves by assimilating the RAWS FMC data.

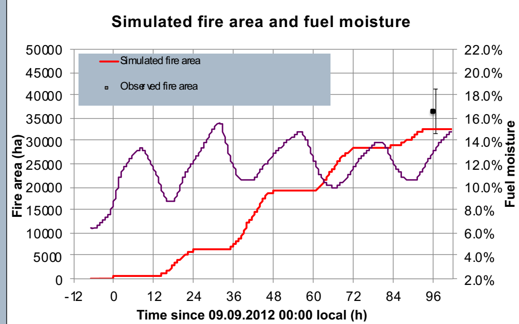
How does the fuel moisture model work?



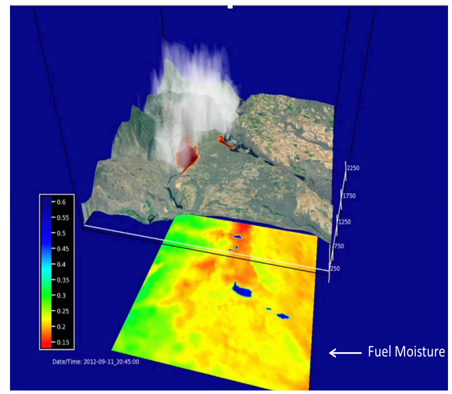
WRF-SFIRE



Online fuel moisture model in WRF-SFIRE resolves variability in time and space



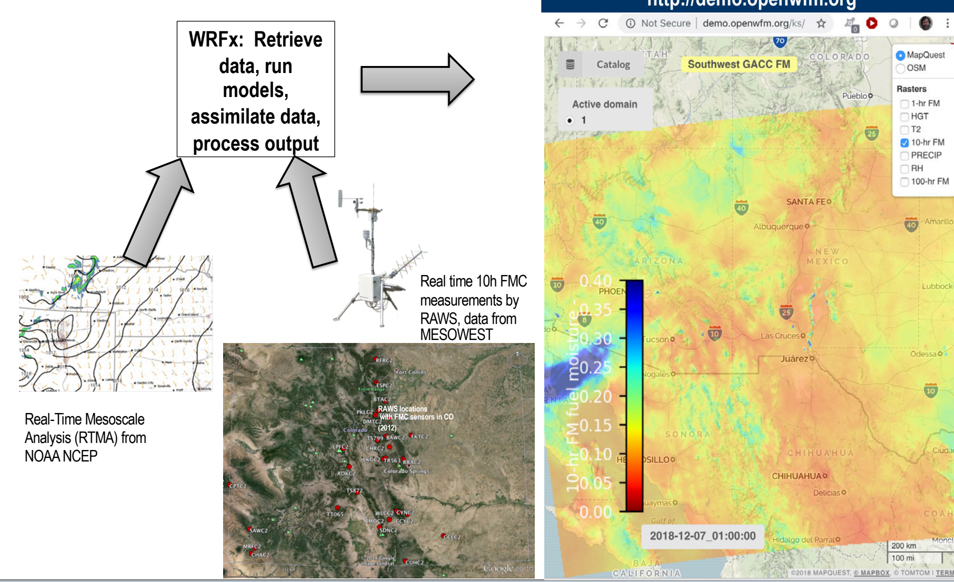
Strong diurnal variations in the fuel moisture impact fire activity and fire emissions. Night time fuel moisture recovery inhibits fire progression and reduces emissions. (Barker Canyon fire 2012)



Waves of fuel moisture follow weather patterns.

Fuel moisture nowcasting with RAWS data assimilation

http://demo.openwfm.org



Real-Time Mesoscale Analysis (RTMA) from NOAA NCEP

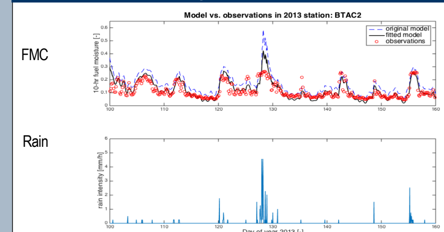
Real time 10h FMC measurements by RAWS, data from MESOWEST

Assimilation of RAWS fuel moisture

Run the FMC model at each mesh point independently and assimilate RAWS data hourly:

1. Extend the 10h fuel moisture data from RAWS locations to the whole domain by trend surface model (a version of regression). Regressors: constant, latitude, elevation, model output
2. Assimilate data into the FMC state and parameters at each mesh point independently by the Extended Kalman Filter.. Covariance between fuel classes extends 10h data to 1h and 100h fuels too.

Improvement by RAWS data assimilation



Example model trace for station BTAC2 (Sugarloaf: 40.018N, 105.361W) with the original parameters, model trace for the parameters fitted to Colorado station data 2012, and the station FMC observations, for days 100 to 160 of year 2013.

Future developments

- Github pull request outstanding to merge the FMC model into WRF
- Initialize simulations in WRFx from FMC with RAWS assimilated
- NASA Disasters, with USDA FS & CSU (Kyle Hilburn PI)
- Integration with FMC retrieval from MODIS by machine learning (Branko Kosovic PI, pending)

About WRF-SFIRE / WRF-Fire

- Started from Clark-Hall atmosphere model with fire propagation by tracers, which later became CAWFE
- WRF with fire propagation by a level set method in WRF 3.4 as WRF-Fire, then developed as WRF-SFIRE
- 2012 WRF-SFIRE foundation of the Israel national system
- 2017 WRF-Fire selected at NCAR as the foundation of CO-FPS and further improved, including a new level set method

References

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References specific to the FMC model are in ***boldface.***

Acknowledgements

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