Impact of Soil Moisture in Fire Simulation

Student: Kae Suarez, University of Tennessee at Knoxville

Mentor: Dr. Michela Taufer

Poster Overview & Background

Wildfires

- Wildfires are a devastating disaster
- Simulations have to be robust and accurate in order to be effective substitutes for overly dangerous/costly replication.
- Soil moisture is often not taken into account outside soil sciences, but may have an important influence on fire propagation

2016 Great Smoky Mountains Fire[2]

2016 Smoky Mountains Fire:
- 134 injured
- 14 dead
- Over 1600 structures[3]

California Camp Fire:
- 3 injured
- 85 dead
- 18804 structures[4]

Existing Model

- The Fire Dynamics Simulator (FDS)[1] is an existing fire simulation software maintained by the National Institute of Standards and Technology (NIST)
  - FDS has been established as accurate through computational testing and comparison to real fires
- The software is evolving to include more data over time, but soil moisture as a verified function is not a development priority

Soil Moisture

- Soil moisture data comes from soil scientists
  - Original data comes from satellites, which take moisture measurements every day, in a coarse resolution
  - The scientists refine input data to create a finer-grain dataset, which allows for a meter-by-meter definition of moisture

Research Target

In order to work towards a more robust model to study wildfires, we assess the inclusion of the oft-ignored variable of soil moisture by generating an FDS input file, simulating off of this input, and visualizing the outputs.

Method

Leveraging Existing Accuracy

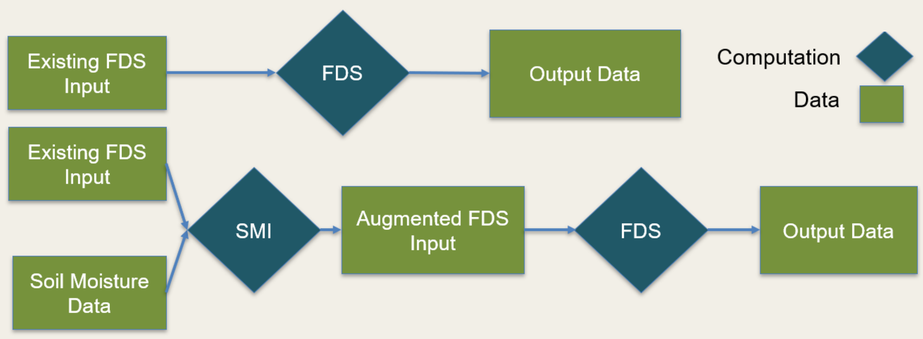
- FDS already handles math regarding heat transfer and water evaporation, which may assist us here
- Materials are important to fire propagation, and are specified in FDS through plaintext assignment of materials to geometry
- We implement the Soil Moisture Integrator (SMI) to create the input for simulation
  - Soil moisture input is made up of spatial x, y coordinates, with a value for moisture varying from 0, utterly dry, to 1, just water

Grass

- The original file relies upon grass for the fire to propagated, and the method is replicated here.
  - It is defined not through coordinates, nor through a layer of additional cells, nor as part of the soil mix, but as a particle type “sprinkled” over our geometrical cells.

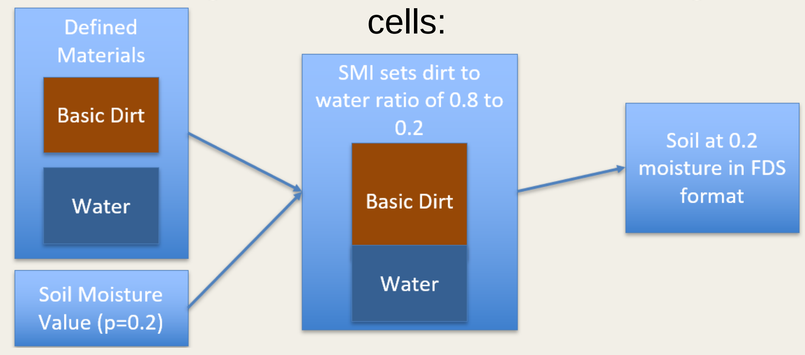
Testing

The testing workflow is shown here, and is focused on generating output for comparison.

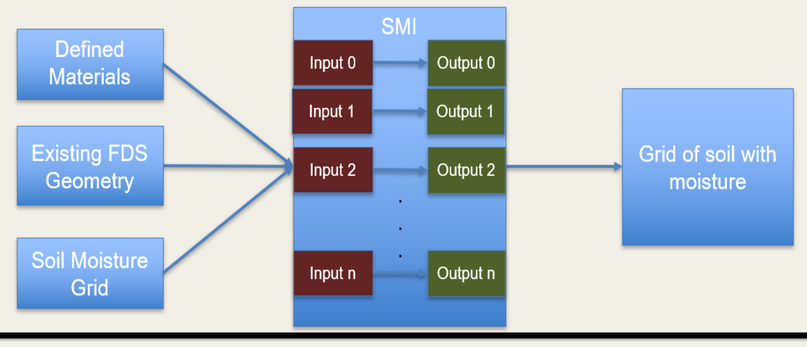


Soil Moisture Integrator (SMI)

SMI leverages the plaintext nature of FDS input in order to automate the integration of soil moisture – starting with single cells:



Then the method is easily adapted to a full domain model:



Outcomes & Conclusions

Results

Fire from original input at 30 simulated seconds

Fire from original input modified to have no grass at 30 simulated seconds.

Input using SMI with 5% soil moisture and grass at 30 simulated seconds

Discussion & Future Work

- The simulation does run with our modified input, which is a success in and of itself. Because it can run, we can now focus on improvement.
- **5% soil moisture is very dry, and in theory, should have some small influence on the model – but here we see that it’s similar to removing the main fuel source in the original input. This implies that the current method of adding soil moisture may be faulty.**
  - The current candidate is the manner in which grass is integrated into the model, since the behavior is similar to no grass.
- Future work is concerned with testing to locate a more successful method for soil moisture integration with grass, and testing its accuracy with other fires as well.

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References:

1. https://pages.nist.gov/fds-smv/
2. https://www.nps.gov/grsm/learn/chimney-tops-2-fire.htm
3. https://www.cnn.com/2016/12/05/us/tennessee-gatlinburg-wildfires/index.html
4. https://www.fire.ca.gov/incidents/2018/11/8/camp-fire/

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