Geosci. Model Dev. Discuss., 4, C357–C361, 2011
www.geosci-model-dev-discuss.net/4/C357/2011/

Geoscientific Model Development Discussions

GMDD

4, C357–C361, 2011

Interactive Comment

Interactive comment on "Coupled atmosphere-wildland fire modeling with WRF-Fire version 3.3" *by* J. Mandel et al.

J. Mandel et al.

jan.mandel@gmail.com

Received and published: 11 June 2011

Response to anonymous referee 2

First, we would like to thank the reviewer for useful comments that will improve the paper and, in particular, for suggested directions of future research.

Introductory remark: This paper was submitted as a model description paper. Requirements for this type of papers are defined at http://www.geoscientific-model-development.net/submission/manuscript_types.html . The first goal is reproducibility and a sufficiently detailed description, including numerical schemes, which are therefore given more attention. We provide examples of model output as also called for, including some comparison with experiments. A more detailed validation will be treated

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

in separate case studies, which are a different type of manuscripts, called "model evaluation papers" in the context of GMD.

p.498 (line 18): "analysis".

p.501 (line 21-26): The fire spread model is based on average values of fuel properties. The fuel categories assign a single vector of fuel coefficients to a fairly broad description of vegetation cover, with similar average fire propagation properties. Fuel data from Landfire is available at 30m resolution. Downscaling and upscaling to the fire mesh resolution is handled in WPS by setting a cell in the model to whatever category is dominant in the data for that area.

p.502 (lines 10 and 12): We will delete formula (2) and replace it by a statement that our implementation supports also a chaparral model from Clark at al (2004).

p. 502 (line 22): The wind U is at 6.1m as indicated in the caption to Table 2 where this page refers to for the details of the computation in eq. (1). We will make this explicit here. The wind speed in the formula indeed depends on the roughness effect, which is treated later in Section 6 (coupling of the atmospheric and the fire models).

p.503 (line 11): The fuel weight (burn time) is given by the user in the input data as one of the coefficients in the fuel categories. The default values are from the CAWFE code, which, according to Clark et al. (2004), p. 55, were chosen to approximate the mass-loss curve from the BURNUP algorithm (Albini and Reinhardt, 1995). The speed of burning is currently taken to be independent of the wind speed and the fuel moisture, as seen from eq. (4) and Table 1. Taking these factors into consideration is a subject of future research, and it will have to be justified by comparison with experiments.

p. 504 (line 5-13): The grid sizes are addressed in Section 8.3 (which the other referee asked to delete). We will also add further detail along the following lines.

The practical limit of the atmospheric domain resolution for forecasting applications seems to be currently around 400m. At that resolution, the simulation to wall clock

GMDD

4, C357–C361, 2011

Interactive Comment

time ratio may be kept around 6, that is, 24h forecast may be completed within 4h. The limiting factor is the short time step required for higher resolutions. Using more processor cores does not help enough, because each core gets a smaller domain to work on and the parallel efficiency decreases. One should keep in mind that even this relatively coarse atmospheric resolution (from the fire modeling point of view) already extends beyond the maximum resolution of the standard meteorological static surface data, which is currently 1km. At the atmospheric model resolution of 400m, the refinement ratio of 10 brings the fire model mesh size close to maximum resolution of the available fuel data, which is currently 30m. So, from the fuel data point of view, running real forecasting simulations at higher than 30m resolutions does not seem practical. However, since the fire spread depends on the slope gradient that is computed on the fire mesh, using finer fire model mesh in complex terrain may be justified. The topographical data are generally available at higher resolutions than the fuel maps (for US it is 2m), so in cases when the sub-grid variability in the fuel composition is expected to be relatively small, and the topographical effects are expected to be important, further increasing of the fuel model resolution beyond the 30m limit may be desirable.

From the point of view of the atmosphere-fire interaction, a coarser horizontal and vertical atmospheric resolution means less intense feedback from fires of the burning area smaller than the atmospheric grid cells, since the fire heat flux computed on the fire mesh gets averaged over a bigger atmospheric cell. Smaller heat flux leads to weaker fire-induced updraft, less intense surface convergence and finally weaker wind speed up at the fire front, which in turn could theoretically result in underestimation of the fire rate of spread. However, since the Rothermel fire model was calibrated, based on undisturbed wind speed measured upwind from the fireline at 20ft height, the local speed up at the fire line has been already captured by the model constants. Whether further adjustments to the fire parameterization are needed, depending on the resolution and fire-atmosphere refinement ratio, is a question for future research.

For real simulations, where the errors in fuel description are much more severe, the resolution issue does not have to be critical. However, in fine-resolution simulations focused on the atmosphere-fire coupling with well-known fuel conditions, such as the FireFlux experiment (Figs. 6 and 7), realistic rendering of the atmospheric response to the surface heating associated with fire is absolutely crucial. For these applications, the fire model should use the wind speed taken from the level as close to the mid-flame height as possible. This requirement translates into a need for very high vertical resolution. For realistic modeling of the fire of expected flame height of let us say 4m, the first atmospheric model level should be at 2m. Updrafts associated with fire plumes, may easily reach a rising speed of 5 m/s, so in order to keep the simulation numerically stable, the time step should not be greater than 0.4s. Assuming the horizontal wind speeds below 25m/s, the vertical model resolution will be a limiting factor in terms of the time step as long as the horizontal grid spacing will be greater than 10m. This reasoning was applied during the design of the FireFlux simulation, for which the horizontal resolution has been set to 10m, as an optimal value providing high horizontal resolution yet not requiring further reduction in the time step. Detailed analysis of the FireFlux experiment is in progress and will be published as a separate case study elsewhere.

Since the fine-resolution simulations are mostly run in the LES mode as opposed to the coarser real cases that rely on boundary layer parameterization, the degree to which the vertical mixing is captured by the model directly depends on the model resolution. From that point of view the grid refinement for fine-resolution cases should be expected to bring more benefits than for real cases utilizing boundary layer and cloud parameterizations, which were originally designed for much coarser atmospheric meshes.

p. 522 (line 15-26): Please see the response to the introductory remarks above. Regarding Fig. 6, due to the instrument failure that took place during the experiment about 20s after the fire front passage, the recorded temperature drop is unrealistically slow, and do not represent the actual cooling phase. Therefore the discrepancies in the temperature drop at the short tower should not be treated as an indication of the model

GMDD

4, C357–C361, 2011

Interactive Comment

error. The turbulent kinetic energy and the wind profile at that tower were captured well and they do not indicate specific problems associated with realistic rendering of the post fire cooling.

p. 523 (line 9): Figures 10-12 are examples of output. A validation on a large fire requires a much more detailed analysis, which is beyond the scope of this paper, and a well-documented fire. All we can say here is that the fire behaves qualitatively as could be expected, hence the remark that realistic behavior was obtained. Case studies comparing model output with measurements quantitatively are currently in progress, and will be published elsewhere. Please see also the response to the introductory remarks above.

p. 524 (line 18): ARW and NMM identify versions of WRF dynamic solver (called core). ARW stands for Advanced Research WRF, and it is the core version described in Skamarock et el. (2008). We will repeat the reference here and note that we currently use the ARW core.

p. 525 (line 12-14): We plan to add the evaporation of the fuel moisture to the latent heat flux and subtract it from the sensible flux in a future version of the code. We also plan to consider different moisture for different fuels (see http://www.treesearch.fs.fed.us/pubs/29408) and input of fuel moisture from WRF surface models. We will discuss these points in the paper.

p. 527: We have split the discussion into separate Section 11, because it appeared too long for a conclusion, and a conclusion with subsections seemed unwieldy. We will put it back together.

Interactive comment on Geosci. Model Dev. Discuss., 4, 497, 2011.