Proposal for AeroCOM Biomass Burning emissions experiment

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Background and Motivation:

Major uncertainties in modeling biomass burning (BB) aerosols and their effects are associated with emissions, specifically the source strength and injection height. Petrenko et al. (2012) show that the emission source strength estimates among commonly used methods or inventories can differ vastly both on global and regional scales. Using one aerosol transport model (GOCART), Petrenko et al. (2012) compared a set of BB aerosol emission estimates and assessed the biases in their regional performance by comparing model-simulated AOD with MODIS AOD snapshots over BB source areas. The results showed systematic regional behavior of modeled BB AOD using a given source-strength estimate, and the "best" match with MODIS AOD would require regional adjustments of the existing emission datasets. However, the results shown in Petrenko et al. (2012) are based on only one global model; other models may show different behavior, even with the same emission datasets, since models treat aerosol properties and processes differently. In order to draw more robust conclusions about the global and regional BB emission strengths, it is necessary to test the BB emissions in multiple global models and evaluate the results with satellite AOD observations.

To accurately represent fire emissions in chemical transport and climate models, knowledge of the emission injection height is also crucial. At present, a wide range of arbitrary procedures is used to represent the vertical distribution of fire emissions in models, e.g., emissions released in the surface layer, within the boundary layer, uniformly mixed throughout the troposphere, or preselected fractions are released within and above the BL). In recent years, more elaborate plume-rise parameterizations based on empirical and physical approaches have been incorporated into models to take into account fire buoyancy and atmospheric conditions; however, Val Martin et al. (2012) demonstrated that the use of even advanced plume-rise models, constrained with currently available fire parameters, cannot reproduce the dynamic range of smoke plume heights retrieved over North America from MISR observations. In that work, a simplified correlation-based relationship was proposed, that represents the observed relationship between MISR-retrieved plume injection height, and fire intensity and atmospheric stability, that can be tested within transport models.

Objectives:

We propose an AeroCom-coordinated multi-model BB experiment that uses the GFED v3 daily BB emissions as a prescribed input with a series of perturbation runs. Our objectives are:

1. To inter-compare and quantify the accuracy and diversity of the AeroCom model simulated BB AOD using the same emissions.
2. To propose a region-based emission correction scheme based on the comparisons of model output with satellite observations, which would bring the widely used GFED v3 emissions to the levels needed to improve model-observation comparisons.
3. To test the smoke injection height–emission intensity relationship in global models.

[Notes: (a) The correction scheme in objective 2 is meant to provide key information for improving the BB emission inventory. We will be collaborating with the inventory producers, and will present our finding regarding quantified regional emission biases as a joint effort. (b) Objective 3 should provide information for developing a plume-injection-height parameterization in future large-scale BB studies.]

Experiment design:

We propose the year 2008 as the "benchmark year" for this study. We will use the MODIS AOD and MISR stereo-derived plume height as the key parameters to evaluate and constrain the models. MODIS AOD will be provided in a series of pre-selected fire/smoke cases in different biomass burning regions. The MISR BB plume height for the year 2008 over the globe is being retrieved at JPL and GSFC, which will be available for this study.

Experiment Setup:

To quantify the effect of model configuration on the simulated AOD, we propose to use the GFED v3 daily emissions with the other settings "native" to the model. As the GOCART tests with GFED v3 daily emissions produced underestimates of the observed AOD over most regions, we suggest perturbation runs with the same inventory multiplied by a factor of 0.7 and 5 to create an ensemble of three runs where multiples of GFED v3 represent the range of possible emission estimates for the same fire. Quantitative analysis of the different model AOD values in response to prescribed increase in emissions will characterize the model-specific AOD-emission relationship.

Exp.	BB emission	Injection height
BB0	No BB emission	
BB1 (control)	GFED v3	Boundary layer
BB2	GFED v3 x 0.7	Boundary layer
BB3	GFED v3 x 5	Boundary layer
BB4	GFED v3	Val Martin
BB5	GFED v3 x 5	Val Martin

Study period:

January 1 – December 31 of 2008 preceded by a few months spin-up.

Requested output:

2-D, 3-hourly, instantaneous:

- Total column 550 nm AOD
- Biomass burning AOD, if available (or AOD's of individual aerosol species)
- Wind speeds (at the level in the middle of your emission injection height, e.g., if all smoke is distributed within PBL, output mid-PBL winds)
- PBL height

3-D [3-hourly]

- Aerosol species concentrations
- Aerosol extinction at 550 nm

Schedule:

- *September 2013*. Discuss and refine the experiment plan at the AeroCom meeting.
- *2013-early 2014:* Finalizing the preparation of reference fire cases dataset, and reference AOD field; set up model simulations
- *June 30, 2014:* submission of model outputs
- *July-September, 2014:* preliminary analysis of model outputs
- *September/October 2014:* presentation at AeroCom, feedback from participants
- *Late 2014 - first half of 2015:* – finalize data analysis and manuscript preparation

References:

Petrenko, M., R. Kahn, M. Chin, A. Soja, T. Kucsera, and Harshvardhan, The use of satellite-measured aerosol optical depth to constrain biomass burning emissions source strength in the global model GOCART, J. Geophys. Res., 117, D18212, doi:10.1029/2012JD017870, 2012.

Val Martin, M., R. Kahn, J. A. Logan, R. Paugam, M. Wooster, and C. Ichoku, Space-based observational constraints for 1-D fire smoke plume-rise models, J. Geophys. Res., 117, D22204, doi:10.1029/2012JD018370, 2012.