Popular summary

The use of satellite-measured aerosol optical depth to constrain biomass burning emissions source strength in a global model GOCART

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Mariya Petrenko (mshcherb@purdue.edu)
Ralph Kahn(ralph.kahn@nasa.gov)
Mian Chin (mian.chin@nasa.gov)
Amber Soja (amber.j.soja@nasa.gov)
Tom Kucsera (tom.l.kucsera@nasa.gov)
Harshvardhan(harshvar@purdue.edu)

Small particles in the atmosphere, called "atmospheric aerosol" have a direct effect on Earth climate through scattering and absorbing sunlight, and also an indirect effect by changing the properties of clouds, as they interact with solar radiation as well. Aerosol typically stays in the atmosphere for several days, and can be transported long distances, affecting air quality, visibility, and human health not only near the source, but also far downwind. Smoke from vegetation fires is one of the main sources of atmospheric aerosol; other sources include anthropogenic pollution, dust, and sea salt.

Chemistry transport models (CTMs) are among the major tools for studying the atmospheric and climate effects of aerosol. Due to the considerable variation of aerosol concentrations and properties on many temporal and spatial scales, and the complexity of the processes involved, the uncertainties in aerosol effects on climate are large, as is featured in the latest report of Intergovernmental Panel on Climate Change (IPCC) in 2007. Reducing this uncertainty in the models is very important both for predicting future climate scenarios and for regional air quality forecasting and mitigation.

During vegetation fires, also called biomass burning (BB) events, complex mixture of gases and particles is emitted. The amount of BB emissions is usually estimated taking into account the intensity and size of the fire and the properties of burning vegetation. These estimates are input into CTMs to simulate BB aerosol. Unfortunately, due to large variability of fire and vegetation properties, the quantity of BB emissions is very difficult to estimate and BB emission inventories provide numbers that can differ by up to the order of magnitude in some regions. Larger uncertainties in data input make uncertainties in model output larger as well. A powerful way to narrow the range of possible model estimates is to compare model output to observations.

We use satellite observations of aerosol properties, specifically aerosol optical depth, which is directly proportional to the amount of aerosol in the atmosphere, and compare it to the model output. Assuming the model represents aerosol transport and particle properties correctly, the amount of BB emissions determines the simulated aerosol optical depth. In this study, we

explore the regional performance of 13 commonly used emission estimates. These are each input to global Goddard Chemistry Aerosol Radiation and Transport (GOCART) model. We then evaluate how well each emission estimate reproduces the smoke aerosol optical depth measured by the MODIS instrument. We compared GOCART-simulate aerosol optical depth with that measured from the satellite for 124 fire cases around the world during 2006 and 2007. We summarize the regional performance of each emission inventory and discuss reasons for their differences by considering the assumptions made during their development.

We also show that because stronger wind disperses smoke plumes more readily, in cases with stronger wind, a larger increase in emission amount is needed to increase aerosol optical depth. In quiet, low-wind-speed environments, BB emissions produce a more significant increase in aerosol optical depth, other things being equal. Using the region-specific, quantitative relationships derived in our paper, together with the wind speed obtained from another source for a given fire case, we can constrain the amount of emission required in the model to reproduce the observations.

The results of this paper are useful to the developers of BB emission inventories, as they show the strengths and weaknesses of individual emission inventories in different regions of the globe, and also for modelers who use these inventories and wish to improve their model results.