Title:	Emissions, diurnal variability and modelling of biogenic volatile organic compounds
Authors:	Mishra, Abhishek Kumar
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Abstract:	Biogenic volatile organic compounds are emitted from vegetation and play key roles in atmospheric chemistry, air quality and climate. Isoprene which is mainly emitted from trees and shrubs is the major contributor to the global biogenic budget, with annual emissions of about 600 Tg/year. Trees can emit biogenic compounds and impact the micrometeorology by modulating the surface sensible and latent heat flux through transpiration and evaporative cooling while also uptaking carbon dioxide during photosynthesis. Biogenic emissions are poorly constrained over the northwest Indo-Gangetic Plain which is one of the most under-studied regions of the world in terms of atmospheric emissions and chemistry. Farmers in northwest Indo-Gangetic Plain like many other regions of the world, practice mixed agroforestry due to which the croplands have large swathes of poplar and eucalyptus. These trees are strong isoprene emitters.The monsoon season which is characterized by strong convective activity provide ideal conditions for assessing biogenic emissions as it is a period characterized by the maximum signal to noise ratio for the biogenic emissions and sources. During this season, vegetation throughout the region is not limited by availability of moisture while many anthropogenic fire sources which can also emit VOCs are absent. This thesis investigates the complex interplay of biogenic emissions,micrometeorology, atmospheric chemistry and land use land cover using ground-based measurements of isoprene and its oxidation products by a high sensitivity proton transfer reaction mass spectrometer (PTR-MS), high-resolution land use land cover satellite data along with the Weather Research and Forecasting model coupled with online chemistry (WRF-Chem) and the Model of Emissions of Gases and Aerosol from Nature (MEGAN). In the first part of my thesis work, I reported and analyzed the measurements for isoprene, formaldehyde, methyl vinyl ketone, methacrolein and acetaldehyde performed in July, August and September months at a sub-urban site in northwest Indo-Gangetic Plain. In this study, I found that during the monsoon season biogenic emissions were the major source of isoprene with photo- oxidation of isoprene as the major source of methyl vinyl ketone and methacrolein. The daytime observed average ambient mixing ratios for isoprene during the monsoon season were comparable to mixing ratios observed over tropical forests (eg. Amazon rainforest, Borneo rainforest.). Additionally, formaldehyde and acetaldehyde were found to have strong photo-chemical sources from the oxidation of hydrocarbons, including isoprene. A comparison between summer and monsoon season data at the same site and year was also made which revised the paradigm derived from observations in northern latitudes which hold that ambient isoprene is always highest during summer season. In the second part of the thesis work, I set up the WRF-Chem model for north India at 10 x 10 km spatial resolution to study 3-D simulations of meteorology, atmospheric chemistry and biogenic emissions over the northwest Indo-Gangetic Plain during monsoon season. The default version of the model used in all previous works by national and international groups worldwide, significantly under-predicted isoprene and its oxidation products namely methyl vinyl ketone and methacrolein. There was also poor agreement for modeled and measured ozone and temperature over the region. I hypothesized that this was owing to the missing biogenic emission process. So, next I calculated the fractional tree cover over croplands in north India and some other intensely farmed regions of the world. The results demonstrated that the tree cover over intensely farmed regions in Asia, Australia and South America are significantly underestimated by the current chemistry-climate models, including all the ones used by the Intergovernmental Panel on Climate Change. In the third part of my thesis work , I incorporated the actual tree cover (~10%) over the north-west Indo Gangetic Plain in the land use land cover scheme of the WRF-Chem model. This greatly improved agreement between the modelled and measured temperature, boundary layerheight and surface ozone which were earlier overestimated. Agreement between measured and modelled isoprene and its oxidation products was achieved with accuracy close to 90%. Most remarkably, the surface latent heat flux regionally increased by 100%-300% while surface sensible heat flux reduced by 50%-100%, leading to a reduction in daytime boundary layer height by 200- 400 m, a key result with implications for the modulation of air pollution. Further, I could show that the trees over croplands in north India mitigate the peak daytime temperatures and ozone improving rice production yields by 10 to 20%. Expanding agroforestry cropland tree cover to 50% of the cropland area suggested that the rice yield could be improved by up to 40% yield regionally. Future climate mitigation and food security efforts should therefore actively consider stakeholder participation for increased cropland agroforestry because of its potential beneficial effects on both crop yields, heat stress and climate.
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