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Simulation of the FRP Product

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Among the different alternative of remote sensing technologies for estimating global fire carbon emission, the thermally-based measures of fire radiative power (FRP; and its temporal integration, fire radiative energy or FRE) has the potential to capture the spatial and temporal variability of fire occurrence. It was shown that a strong linear relationship exists between the total amount of thermal radiant energy emitted by a fire over its lifetime (the FRE) and the amount of fuel burned. Since all vegetation is 50(±5)% carbon, it is therefore in theory a potentially simple matter to measure the FRE and estimate the carbon release. In a fire inventory like the Global Fire Assimilation System (GFAS), the total carbon emission is derived from a gridded FRE product forced by the MODIS observation, using Ct = β x FRE x Ef, where β is a conversion factor initially estimated from small scale experiment as β=0.368 and later derived for different bio dome by comparison with the Global Fire Emission Database (GFED). The sensitivities of the above equation to (i) different types of fire activity (ie, flaming, smoldering, torching), (ii) sensor view angles or (iii) soot/smoke absorption have not yet been well studied. The investigation of these types of sensitivity, and of the information content of thermal IR observations of actively burning fires in general, is one of the primary subjects of this study.

Our approach is based on a combination of observational work and simulations conducted via the linkage of different fire models and the 3D radiative transfer (RT) model DART operating in the thermal domain. The radiation properties of a fire as seen from above its plume (e.g. space/air borne sensor) depend on the temperature distribution, the gas concentration (mainly CO_2, H_2O), and the amount, shape, distribution and optical properties of the soot particles in the flame (where they are emitting) and in the cooling plume (where they are mainly absorbing). While gas and soot radiative properties can be estimated from the literature, their concentration and temperature are calculated from output of fire models. Due to the large range of length scale involved in fire dynamics, a twofold approach is use to model the fire scene with (i) first the multi-phases model WFDS which can handle fire size ranging from a 1m2 to 1ha with a particular focus on flame-plume interaction, (ii) and then the meso scale model WRF-fire which can handle larger fires and the interaction plume-atmosphere (e.g. pyroconvection). In the former case, as the Radiative Transfer is WFDS is based on a Gray Body assumption (WFDS only focuses on fire dynamics) the main challenge is to derive the radiative properties of the different component of the fire scene (soot and gas) for the different bands (optical and IR) solved in DART to re-process a multispectral RT. In the later case, because WRF-fire is running at a resolution of tens of meters, pyrolysis and combustion processes cannot be resolved and to predict the fire front dynamics, the use of an empirical model based on the Rothermel equation and the level set method is required. In this later case, it is therefore necessary to use empirical relationship to determine: (i) the 3D structure of the flame defined by: flame length, flame height and fire front depth derived from Rate of Spread and residence time, (ii) the gas and soot concentration profile within the flame, and (iii) the convective flux generated by the flame. The development of these empirical relationships presents one of the main challenges of this work.

Thought this work is still undergoing, first results show the potential impact of view angle on the evaluation of FRP.