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An Optical Lightning Simulator in an Electrified Cloud-Resolving Model to Prepare the Future Space Lightning Missions

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The future decade will see the launch of several space missions designed to monitor the total lightning activity. Among these missions, the American (Geostationary Lightning Mapper – GLM) and European (Lightning Imager – LI) optical detectors will be onboard geostationary satellites (GOES-R and MTG, respectively). For the first time, the total lightning activity will be monitored over the full Earth disk and at a very high temporal resolution (2 and 1 ms, respectively). Missions like the French Tool for the Analysis of Radiation from lightNIng and Sprites (TARANIS) and ISS-LIS will bring complementary information in order to better understand the lightning physics and to improve the weather prediction (nowcasting and forecasting).

Such missions will generate a huge volume of new and original observations for the scientific community and weather prediction centers that have to be prepared. Moreover, before the launch of these missions, fundamental questions regarding the interpretation of the optical signal property and its relation to cloud optical thickness and lightning discharge processes need to be further investigated. An innovative approach proposed here is to use the synergy existing in the French MesoNH Cloud-Resolving Model (CRM). Indeed, MesoNH is one of the only CRM able to simulate the lifecycle of electrical charges generated within clouds through non-inductive charging process (dependent of the 1-moment microphysical scheme). The lightning flash geometry is based on a fractal law while the electrical field is diagnosed thanks to the Gauss' law. The lightning optical simulator is linked to the electrical scheme as the lightning radiance at 777.4 nm is a function of the lightning current, approximated by the charges neutralized along the lightning path. Another important part is the scattering of this signal by the hydrometeors (mainly ice particles) that is taken into account.

Simulations at 1-km resolution are done over the Langmuir Laboratory (New Mexico). This site has been chosen for two main reasons: presence of a Lightning Mapping Array (LMA) and high frequency of TRMM overpasses. With a complete set of simulations, the electrical scheme is compared to LMA data while the lightning optical simulator is validated thanks to LIS data. First, we will present the electrification and lightning schemes. The principles of the optical lightning simulator will then be presented. Examples of simulation will then be discussed with a particular attention on the ice water content along the path of the optical signal.