The Inclusion of chemistry modules into the NOAA UFS Weather Model with the Common Community Physics Package (CCPP)

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Online atmosphere-chemistry coupled models have been rapidly developed in recent years. In online models, the atmospheric model can impact air quality and atmospheric composition, while the aerosol feedbacks also impact the atmosphere through direct, semi-direct and indirect effects. At NOAA GSL, in collaboration with scientists from the Chemical Science Laboratory (CSL) and Air Resource Laboratory (ARL), we developed an atmospheric composition suite (based on WRF-Chem) and coupled it online with FV3GFS through the National Unified Operational Prediction Capability (NUOPC)-based NOAA Environmental Modeling System (NEMS) software. This modeling system has been operational since September 24\textsuperscript{th}, 2020 as an ensemble member of the Global Ensemble Forecast System (named as GEFS-aerosols) for global aerosol predictions. When using the NUOPC coupler, there are two independent components for atmosphere and chemistry that communicate via the NUOPC coupler every time-step. Because of the interactive and strongly coupled nature of chemistry and physics, it is natural to allow for some of the atmospheric composition modules to be called directly from inside the physics suite. This can be accomplished through the use of the Common Community Physics Package (CCPP). CCPP, designed to facilitate a host-model agnostic implementation of physics parameterizations, is a community development and will be used by many different organizations. All the physics parameterizations in the NOAA Unified Forecast System (UFS) Weather Model are CCPP-compliant. Here we broke up the chemistry suite used in GEFS-aerosols, and all the chemical modules were embedded into UFS Weather Model using CCPP as subroutines of physics. This newly developed model with CCPP has been running in real-time starting in the middle of November, 2020. Because of this development we were able to include the CCPP-compliant modules of sea salt, dust, and wild-fire emissions into the NWP model to provide input for the double moment Thompson microphysics parameterization. The inclusion of smoke and aerosol emission modules into the Rapid Refresh Forecast System (RRFS) with CCPP is also ongoing. We will show results from real-time experiments for medium range weather forecasting and compare results with runs that do not include aerosol impacts.