**Task: Aerosols and Chemistry in NGGPS**

1. **Principal investigator**: Georg Grell (GSD), Pius Lee (ARL), Stuart McKeen (CSD), Jeff McQueen (EMC)
2. **Overall objective**: To continue work on aerosol modeling approaches in NGGPS. This will be a collaborative effort between GSD, CSD, ARL, and EMC. Currently two aerosol related NGGPS projects are funded. The first project spans 1 May 2015 to 30 April 2017 with the goal to determine the complexity needed to adequately predict aerosol impacts on NWP. One of the aerosol/chemistry modules tested is similar to the approach used by ECMWF. But more complex versions are also evaluated. We are planning to include the most appropriate modules, depending on results of evaluations, into FV3. The proposed modeling system will provide a tool to evaluate aerosol dependent physics parameterizations, and aerosol dependence in atmospheric data assimilation, resulting in improved NWP. Code management protocols will be followed for the entire project (for NEMS, FV3, NUOPC physics/aerosol driver, CCPP). Proposed work consists of two steps:

# **Development and implementation:**

## Implementation of the most simple approach to have aerosol dependence, including radiation and microphysics interaction. In addition to the already included radiation parameterization (RRTMG, GBPHYS), this requires aerosol aware microphysics, and convection parameterization. The aerosol aware Thompson scheme is proposed for inclusion into the advanced physics suite. This work is done in collaboration between ESRL/GSD and EMC (Task 1, activity 1). Both, the new SAS (Jongil Han, personnel communication) and the GF convective parameterization include the capability to treat the interaction with aerosols. The Thompson scheme needs only 2 additional variables for the interaction, water friendly and ice friendly aerosols. For this simple interaction we will use dust, sea-salt, anthropogenic, and biomass burning emission sources to provide the variables needed by the Thompson scheme. This work (1.1) will be provided in kind. Emissions sources have already been implemented into a version of FV3, and work is ongoing to implement the Thompson scheme into GBPHYS.

## Implementation of the GOCART modules that are not included in (1.1). Dust and sea-salt modules will already be included for (1.1). However, (1.2) will include all GOCART variables as well as the simple GOCART chemistry modules for the treatment of sulfate, black, and organic carbon. A couple of species will also be added that include non-speciated primary aerosols that may also be used for volcanic eruptions. This work is already nearly finished with a version of FV3 from December 2016. Completion will be provided in kind with updated versions of FV3.

## Implementation of a more complex approach for chemistry and aerosols. This may be a chemistry/aerosol suite from the NGGPS funded FIM-Chem approach, or aerosol module could be swapped with a version of MAM, which is intended for implementation at EMC (NGAC), as well as NASA.

# **Evaluation:**

## Scientists from CSD will be mostly involved with evaluation of aerosols and chemistry. This work will include comparisons to the ATom aircraft observations, AERONET data, and additional data sets from previous and ongoing field experiments.  These observations can also be used to evaluate products from ARL’s emissions system.  CSD also has significant expertise in aerosol interactions with radiation, microphysics, and the chemistry leading to aerosol formation.

## GSD will set up the experiments, provide the data sets for evaluation using the most recent emissions data sets as well as chemistry modules. Several different dust and biomass burning approaches are available for testing in (1.1 – 1.3). GSD will provide evaluation with respect to meteorology. This will include looking at scorecards for 2 one month periods with 10 day forecasts at medium resolution, since multiple setups have to be tested. At the end of the funding period we will select 2 approaches to test using the current operational resolution. The length of the test period will depend on available computer resources.

## Emission inputs are a critical component not only for air quality forecasting, but also for global atmospheric composition modeling and the resulting impact on medium range NWP. ARL will provide a regional and global emissions modeling system to serve multiple emission data needs. As an additional benefit, we will insure that ARL’s HYSPLIT model will work properly with FV3.

# 3 For the current NGGPS FIM-Chem project we are also evaluating the possible impact of biomass burning (and aerosols) on sub-seasonal and seasonal prediction. If a coupled FV3/Ocean model becomes available during the funding period, we would like to also evaluate this impact with FV3. This will be done in hindcast mode. Especially with respect to biomass burning and wildfires, research may be necessary to determine the best possible approach for forecasting. At NOAA, GFDL has probably the most experience in estimating how to handle the forecasting of fires in dependence of sub seasonal and seasonal weather and climate. For this funding period and sub-seasonal evaluations, we would focus only on hindcasting research where fire location and strength are reasonably well known, since the forecasting part should be considered a separate research project that may need strong involvement of GFDL.

1. **Anticipated resources**:  3 FTE (1 FTE ARL/CICS MD, 1 FTE CSD/CIRES, 1FTE GSD/CIRES, $600K).
2. **Key dependencies**:  Adequate high-performance computing to complete this task.  Requests will be O(1000K) CPU hours on Theia.
3. **In-kind contributions**: 0.5 Fed FTE at GSD, .25 FTE from ARL
4. **Deliverables**: (1) We will provide a rigorously evaluated chemistry/aerosol suite for global applications. We will provide scientific publication describing test and evaluation results. Each chemistry/aerosol suite will be a part of CCPP. (2) We will provide an emissions modeling system for regional as well as global applications (including dust and forest fire emissions)