Monthly Technical Report

PROJECT TITLE	Development and Evaluation of an Interactive Sub-Grid Cloud Framework for the CAMx Photochemical Model	**PROJECT #**	14-025
PROJECT PARTICIPANTS	ENVIRON Texas A&M University	**DATE SUBMITTED**	8/5/14
REPORTING PERIOD	**From:** July 1, 2014 **To:** July 31, 2014	**REPORT #**	2

A Financial Status Report (FSR) and Invoice will be submitted separately from each of the Project Participants reflecting charges for this Reporting Period. I understand that the FSR and Invoice are due to the AQRP by the 15th of the month following the reporting period shown above.

Detailed Accomplishments by Task

This project was initiated on May 21, 2014. This report documents progress during the month of July 2014.

Task 1: Preparation and Software Design

A team conference call was held on July 17 among ENVIRON staff and Dr. Nielsen-Gammon of Texas A&M to discuss the current version of the WRF model that includes the Alapaty (EPA) updates to the Kain-Fritsch (K-F) cumulus parameterization. We anticipate coupling outputs from the updated WRF K-F scheme to the new CAMx sub-grid cloud model, per our proposal and workplan. The general approach and certain issues to consider in the final design of the CAMx cloud treatment were discussed at length. The major issues currently identified and requiring resolution as part of the final design are listed below. To gain insight and perspective on how sub-grid cloud processes are handled in other models, we have reviewed literature on the K-F approach, the technique in CMAQ, and the techniques employed in two European models (TOMCAT and CHIMERE).

- Specific K-F flux variables are not output in the Alapaty version of WRF, specifically updraft/downdraft fluxes and entrainment/detrainment rates. WRF must be modified to extract these to the output registry as it will be difficult and inconsistent to diagnose them externally.

- The WRF output interval is instantaneous each hour. K-F variables will be output at the top of each hour with all other standard parameters (temperature, winds, etc.); time-averaging will not be applied.
- K-F variables will be passed to CAMx via new fields in the cloud/rain input files. If no cumulus parameterization is run in WRF (e.g., skipped for a high-resolution grid) or some other cumulus option other than K-F is run in WRF, then the cloud/rain file will not contain K-F variables and the CAMx sub-grid cloud model will not be run for that grid (CAMx will revert to its current cloud treatments).
- How to partition grid column mass between ambient vs. in-cloud columns and back? This is a major consideration with no clear solution at this time. We have identified many ideas, ranging from completely sequestering column mass in the cloud for an entire hour but allowing for entrainment/detrainment, to calculating hourly concentration tendencies resulting from cloud mixing, wet scavenging, and aqueous chemistry and applying to the full column profiles.
- How often to update calculations of cloud mixing, chemistry and scavenging? Since cloud information is read once per hour, we are assuming a constant cloud environment over that time in each column. Ideas range from transport calculations each model time step (typically 1-10 minutes) to once or twice per hour (on "coupling steps"). K-F makes profile adjustments to heat and moisture in WRF; CAMx convection should be viewed as doing the same for pollutants.
- What type of numerical solver is needed for convective dynamics (iterative, explicit/implicit, high-order accuracy, mass conservation, etc.)? The solution will depend on decisions for issues listed above.
- How should aqueous chemistry and wet removal be integrated with convective transport? Should all processes be combined, or operated separately? At what time scales?
- How will sub-grid and resolved cloud water be used for aqueous chemistry and calculation of optical depth for gas-phase chemistry? We need to avoid double-counting effects.
- How should in-cloud and ambient pollutant mass profiles be combined for time-averaged output array?
- What are the effects of "collapsing" the WRF layer structure to fewer CAMx layers on the definition of the sub-grid cloud field?
- Decisions for all of the issues need to consider inclusion of Probing Tool tracers in a future version of the model.

Preliminary Analysis

Preliminary analyses are not yet available.

Data Collected

No additional data were collected during the reporting period. Once a contract is established with Texas A&M, collection of field study measurements from DISOVER-AQ and START08 will commence.

Identify Problems or Issues Encountered and Proposed Solutions or Adjustments

Outside of design considerations described above, no additional problems or issues were encountered during the reporting period.

Goals and Anticipated Issues for the Succeeding Reporting Period

We anticipate completing work under Task 1 (refining of the convective model design), to be described in the next monthly progress report.

Detailed Analysis of the Progress of the Task Order to Date

Progress on Task 1 is ongoing. Tasks 2 through 5 have not yet commenced.

The project remains on schedule and budget for completion and delivery of the final AQRP-reviewed report by the AQRP contract end date of June 30, 2015.

Submitted to AQRP by: _Chris Emery_____

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