Effects of Global Change on Asian Pollution Outflow and Long-Range Transport

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Modeling and Analysis Program (MAP)

PI: Hongyu Liu (NIA / NASA Langley)

Co-Is:
Larry Horowitz (GFDL/NOAA, Institutional PI)
Arlene Fiore (GFDL/NOAA)
David Considine (NASA Langley)

Collaborators:
Leo Donner (GFDL/NOAA)
Jose Rodriguez (NASA GSFC)
Jack Fishman (NASA Langley)
Scientific Programmer (GFDL/NOAA)

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Motivation

- **Projected rapid increase in anthropogenic emissions in Asia and its environmental and climate consequences over the coming decades**

- **A globally changing climate**

- **However, there are few focused studies so far of how changes in climate and in anthropogenic emissions of O_3 precursors affect the meteorological and chemical processes associated with the Asian continental outflow as well as the LRT of this outflow**

- **New meteorological fields needed to be incorporated into the GMI modeling framework, contributing to GMI's goal of understanding and reducing uncertainties in atmospheric composition predictions due to the use of different met fields.**

Research objectives

1). To improve our understanding of uncertainties in model predictions due to the use of different input met fields by <u>incorporating output from GFDL AM3 GCM into the GMI modeling framework</u>

- To assess the AM3 meteorological fields through intercomparison with those from other major global climate models or data assimilation systems
- To synergistically improve and develop the representation of precipitation scavenging in AM3 and GMI using constraints from radionuclide tracers

2). To understand and quantify the effects of global change on <u>transport pathways and chemical outflow for Asian pollution</u> to the western Pacific, low latitude easterly outflow to the Middle East and to the UT/LS via vertical transport over the Tibetan Plateau

3). To assess and quantify the effect of climate change on the <u>source-receptor relationships</u> for ozone pollution

Models and data

- **GMI CTM**
  - **222Rn-210Pb-7Be (GEOS-STRAT, GISS II', fvGCM, GEOS-4, GEOS-5)**
  - **GMI Combo (AM3)**

- **GFDL AM3**
  - **Cubed-sphere grid, 48 vertical levels**
  - **Advection: FV dynamical core of Lin [2004]**
  - **Deep convection: the Donner parameterization [Donner, 1993; Donner et al., 2001, 2007]**
  - **Shallow convection: the Univ of Washington parameterization [Bretherton et al., 2004]**
  - **Prognostic cloud scheme: Rotstayn [1997] and Tiedtke [1993]**

- **Surface, In-situ and satellite data**
  - **<u>210Pb-7Be</u>: Preiss et al. [1996]; Koch et al. [1996]; EML's RANDAB database**
  - **<u>O3</u>: Logan [1999]; <u>Surface CO</u>: the NOAA/GMD flask network [Novelli et al.,1998]**
  - **<u>Aircraft data</u> [e.g., Emmons et al., 2000]: O3,CO,NOx,PAN,HNO3,H2O2, and VOCs.**
  - **<u>Satellite data</u>: monthly mean TOR [Fishman et al., 2003; Ziemke et al., 2006]; CO climatology from MOPTT, TES, AIRS and MLS; NO2 from OMI.**

Proposed tasks

1) **Incorporate AM3 met fields into GMI**

2) **Synergistically improve and develop the representation of precipitation scavenging in AM3-CHEM and GMI using constraints from radionuclide tracers**

3) **Characterize transport/scavenging in GMI using AM3 fields in comparison with other meteorological datasets**

4) **Evaluate full-chemistry GMI Combo model simulations driven by AM3 fields**

5) **Perform future climate predictions with AM3 and examine changes in climate**

Proposed tasks – cont'd

6) Conduct model experiments within GMI to examine the effect of changes in climate and anthropogenic emissions on global ozone and its precursors

7) Examine the effects of climate change on transport pathways for Asian pollution outflow to the western Pacific, low latitude easterly outflow to the Middle East, and vertical transport to UT/LS over the Tibetan Plateau

8) Examine the effects of changes in climate and anthropogenic emissions on Asian chemical outflow to the North Pacific and compositions in the Tibetan anticyclone

9) Examine the effects of changes in climate and anthropogenic emissions on intercontinental source-receptor relationships for ozone

Proposed timeline

Activity	**Year 1**	**Year 2**	**Year 3**	**Year 4**
Run AM3 for present-day climate, regrid and interface with GMI, improve wet scavenging, compare AM3 and GMI/AM3 CTM radionuclide simulations, assess AM3 fields, evaluate GMI/AM3 Combo model simulations (**Task 1-4**)	x	x		
Run AM3 for future climate, regrid and interface with GMI, examine changes in climate (**Task 5**)		x		
Effects on global chemistry (sensitivity runs, **Task 6**)		x	x	
Effects on transport pathways (**Task 7**)			x	
Effects on chemical outflow (**Task 8**)			x	x
Effects on intercontinental S-R relationships (**Task 9**)				x

Expected need for resources from "core" team

- **Provide guidance on regridding AM3 (present-day / future) met fields to GMI grids. Regridding will be conducted at GFDL.**

- **Interface AM3 met fields with GMI CTM and provide programming support as necessary.**

Relationship to chemistry-climate coupling

- **Provide important insights into the strength and weakness of the AM3 fields.**

- **Provide GMI team members with a way to address composition-related climate change issues (for the first time).**

- **Sensitivity tests within the GMI framework will allow us to understand and potentially improve the “online” simulation, thus enhancing the predictive capability of the AM3 fully-coupled chemistry-climate model.**