CESM-GC: GEOS-Chem in CESM

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Work planned as part of an MIT, Harvard, and NCAR ACOM collaboration
Motivation

**GEOS-Chem**

GEOS-Chem: State-of-the-art chemistry, *but*..

- Becoming I/O limited for high-resolution applications
- Want ability to include climate/surface feedbacks in chemistry studies
- Community not focused on (e.g.) dynamics

**CESM**

CESM: Industry standard for climate, *and*..

- GEOS-Chem could provide a new atmospheric chemistry option
- Specific components of GEOS-Chem (e.g. emissions) could be generically useful
- Pipeline for GC developments into CESM
Proposal
Agenda

Objectives of the proposed work

1. GEOS-Chem in CESM 2

2. Flexible emissions and gridded I/O with HEMCO

3. Ongoing integration

Conclusions
Objectives

1. **CESM-GC**: GEOS-Chem as a chemistry option in CESM 2

2. **HEMCO**: Grid-independent I/O in CESM 2

3. **Ongoing integration**: Future-proofing
Objective 1: GEOS-Chem in CESM 2

- GEOS
- GEOS-Chem Classic
- Beijing Climate Center GCM
- CESM 2.1.0
- GEOS-Chem High Performance
What we mean by “GEOS-Chem”

- UCX stratospheric chemistry
- Flexible emissions datasets
- Full tropospheric chemistry (NOx/HOx/VOC, SOA, Cl/Br/I, SO$_4$$^-$-NH$_4$$^-$-NO$_3$$^-$...)
- Wet scavenging inc. convection
- Fast-JX UV transfer, photolysis
- Dry deposition
**Status**

- Demonstration implementation completed in late 2018

- Includes:
  - Gas-phase & het. chemistry
  - UV radiative transfer & photolysis (Fast-JX v7)
  - Aerosol thermodynamics (ISORROPIA II)
  - Wet (non-convective) and dry scavenging

- **Challenges** remain…

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**NO₂ at 7 km after 6 hours, ppbv**
### (Some of the) integration challenges

#### Aerosols
- GEOS-Chem tuned for bulk aerosol modeling
- CESM expects size-resolved aerosols
- Likely need to implement size-resolved aerosols into GEOS-Chem

#### Convection
- Need **convective scavenging** and **convective transport** to be simultaneous
- CAM currently separates the operations – not clear how to resolve the issue without changing “ownership” of a process

#### Emissions
- GEOS-Chem relies on a large emissions dataset library
- Data stored at many resolutions, with different spatial/temporal limits
- How can this be easily translated to CESM?
Objective 2: HEMCO in CESM 2

- GEOS-Chem uses the Harmonized Emissions Component (HEMCO) to read in all gridded input

- HEMCO can be standalone (GEOS-Chem Classic) or can expect regridded fields (GEOS, GCHP)

- Proposal: implement HEMCO as the gridded data broker for CESM
HEMCO

Native I/O component

Data on disk 4°×5° Monthly mean

Model component requesting data for current time

HEMCO Regrider

Current month "Left bracket" 4°×5° "Right bracket"

Next month "Left bracket" 1°×1° "Right bracket"

HEMCO Interpolator

Now 1°×1° Interpolated Abstraction layer

Model component requesting data for current time
HEMCO work plan

- Offline
  - Use HEMCO fully offline to generate pregridded emissions

- Same grid
  - HEMCO handles data transfer, no regridding

- Flexible grid
  - Build regridding interface
Objective 3: GEOS-Chem in SIMA
Conclusions

• GEOS-Chem is viable as a chemistry option in CESM 2

• Implementation will allow:
  • Seamless pipeline for improvements in GEOS-Chem to transfer to CESM
  • Opportunity for GEOS-Chem users to run online simulations
  • New chemistry option for CESM users

• Side-benefit will be grid-independent emissions and data handling in CESM

• Plan includes future proofing – will need ongoing inter-community collaboration
Some basic elements to create slide structure (1/2)

Box heading goes here

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