GEOS-Chem Nested Model Tutorial

Nested Model Co-Scientist

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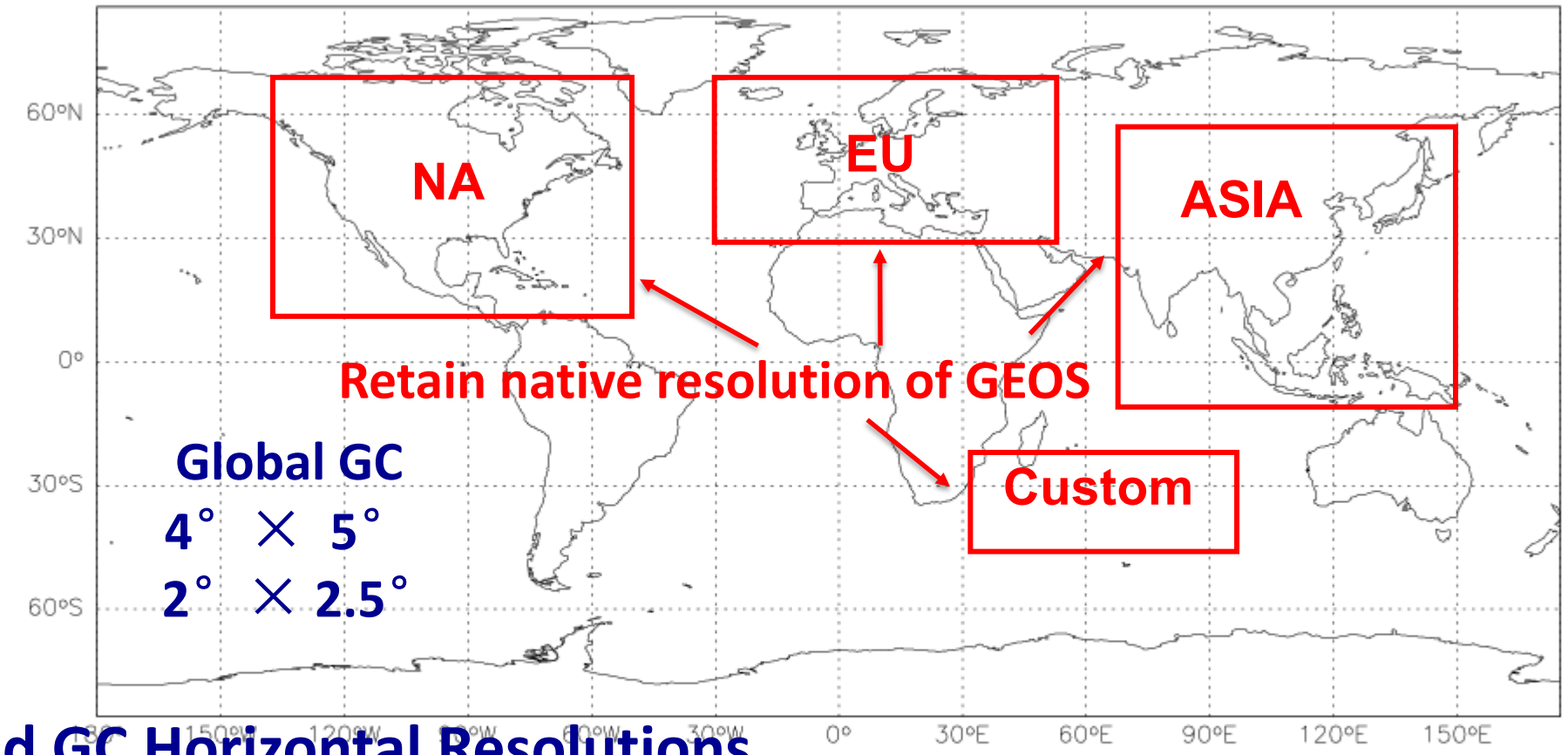
What is Nested GEOS-Chem?

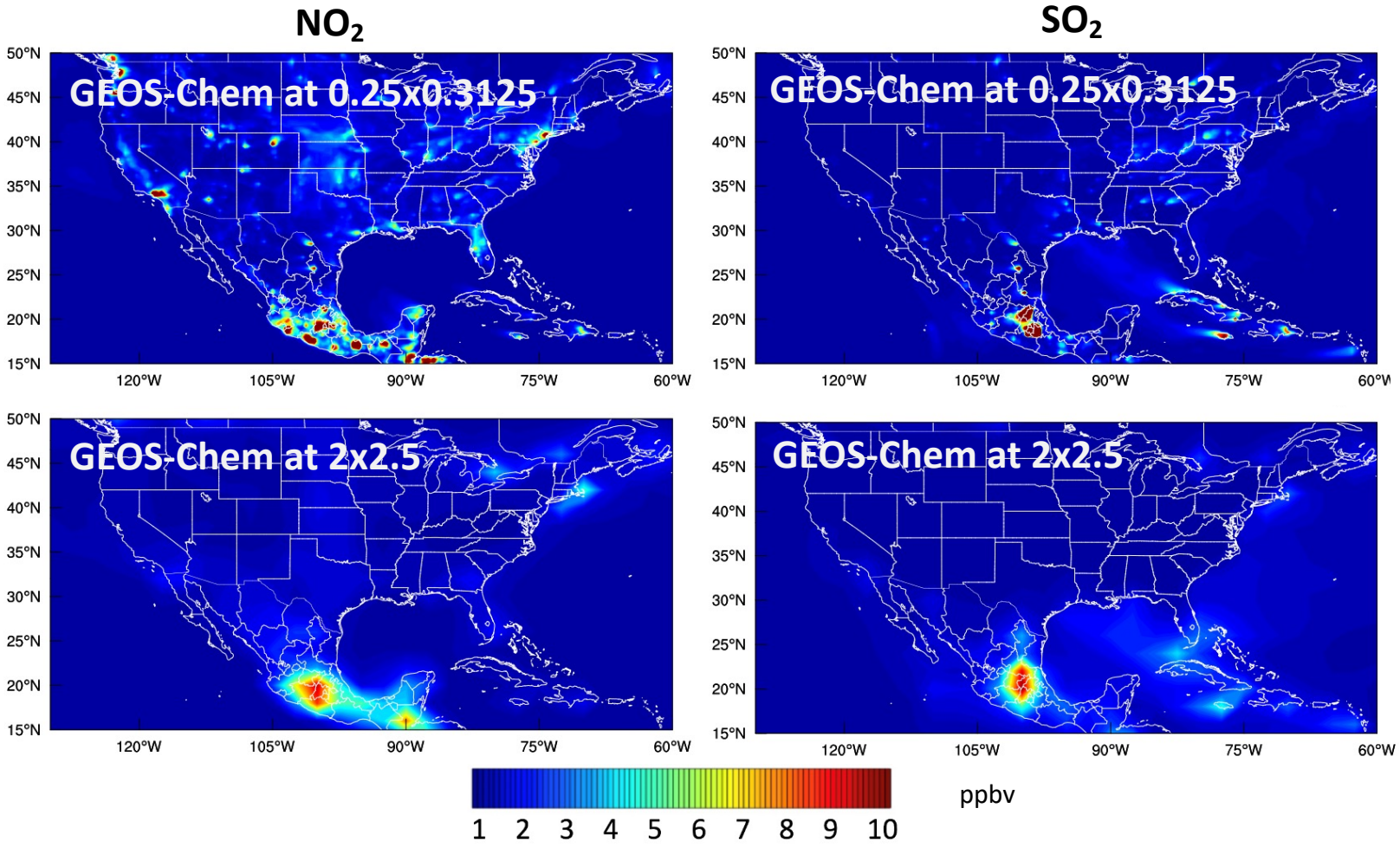


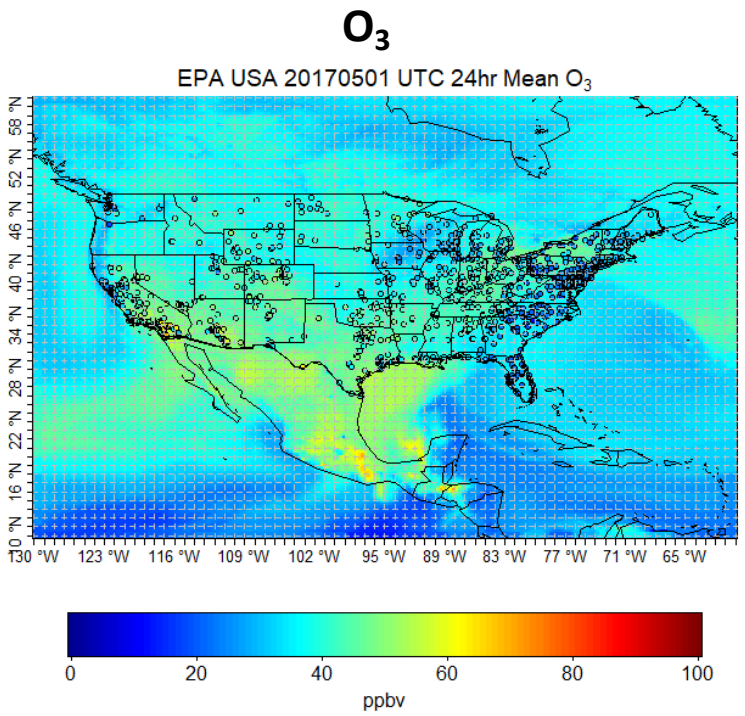
Nested-grid GC Horizontal Resolutions

- ✓ 1° × 1° (GEOS-3) (Wang et al., 2004) (obsolete)
- ✓ 1/2° × 2/3° (GEOS-5) (Chen et al., 2009) (obsolete)
- ✓ **1/4° × 5/16° (GEOS-FP)**
- ✓ **1/2° × 5/8° (MERRA-2)**

Nested-grid vs. coarse grid

GEOS-Chem surface NO_2, SO_2 and O_3 from May 2017 over the US





Nested-grid provides better details of surface sources

Plots generated by Lin Nan and Elizabeth Klovenski

How to run GEOS-Chem nested model?

Tutorial based on GC version 13.4.0

Step 1: Download the native-resolution met field

Step 2: Run the global simulation to generate boundary conditions

Either 2^o x 2.5^o or 4^o x 5^o boundary conditions

Step 3: Run the nested model (with boundary conditions from Step2)

1. Decide which met field to use

- Two options: GEOS-FP and MERRA2
- Check the horizontal grid first before you prepare the met field!
- http://wiki.seas.harvard.edu/geos-chem/index.php/GEOS-Chem_horizontal_grids

Region	Met field	Resolution	Lon-lat coverage
US	MERRA2	0.5x0.625	140-40W, 10-70N
	GEOS-FP	0.25x0.3125	130-60W, 9.75-60N
Europe	MERRA2	0.5x0.625	30W-50E, 30-70N
	GEOS-FP	0.25x0.3125	15W-40E, 32.75-61.25N
Asia	MERRA2	0.5x0.625	60-150E, 11S-55N
China	GEOS-FP	0.25x0.3125	70-140E, 15-55N
Custom (FlexGrid)	*User defined*	*User defined*	*User defined*

2. Run global simulation

Everything is the same except you need to modify the Boundary Conditions menu in HISTORY.rc

```
COLLECTIONS: 'Restart',
             'BoundaryConditions',
             ...

#============================================================================
# %%%%% THE BoundaryConditions COLLECTION %%%%%
#
# GEOS-Chem boundary conditions for use in nested grid simulations
#
# Available for all simulations
#============================================================================
  BoundaryConditions.template:   '%y4%m2%d2_%h2%n2z.nc4',
  BoundaryConditions.format:     'CFIO',
  BoundaryConditions.frequency:  00000000 030000
  BoundaryConditions.duration:   00000001 000000
  BoundaryConditions.mode:       'instantaneous'
  BoundaryConditions.LON_RANGE:  -130.0 -60.0,
  BoundaryConditions.LAT_RANGE:  10.0 60.0,
  BoundaryConditions.fields:     'SpeciesBC_?ADV?            ', 'GIGCchem',
::
```

You need to add and set the BoundaryConditions.LON_RANGE and BoundaryConditions.LAT_RANGE region in HISTORY.rc ONLY IF you are running the simulation over a nested domain or custom domain.

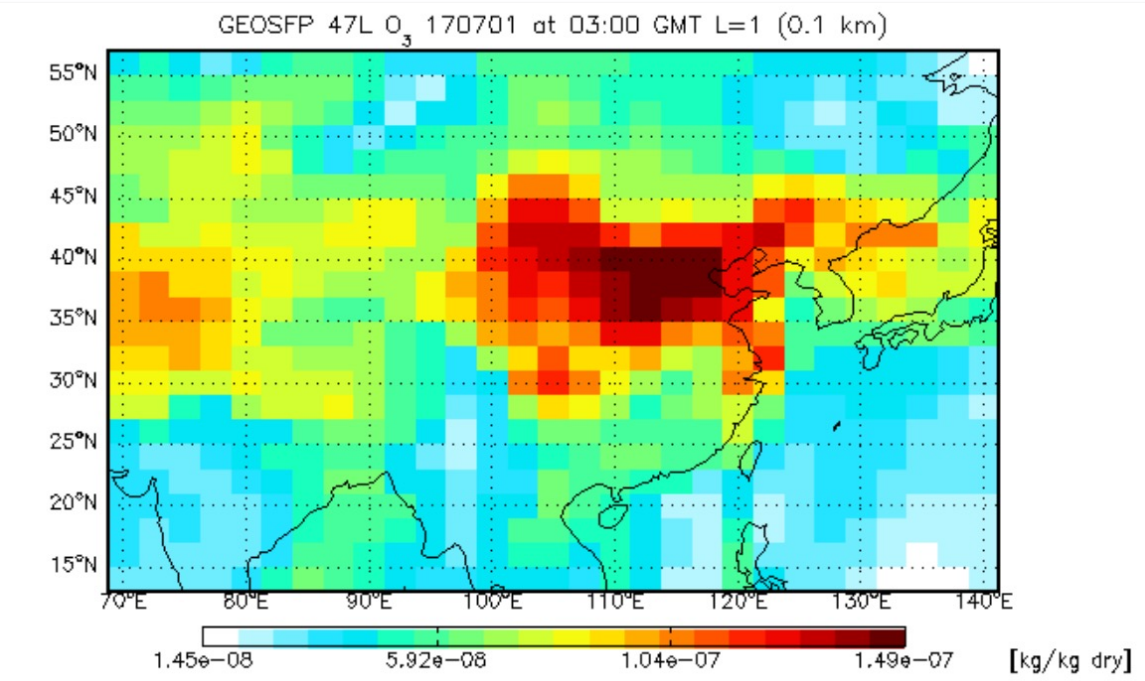
The first number in the LON_ and LAT_RANGE is the minimum value and the second number is the maximum value.

2. Run global simulation

BC will then be saved for daily output (3-hour frequency). Keep an eye on your storage!

```
-rw-------  1 luxiao luxiao 133M Mar 30 08:17 BC.20171208
-rw-------  1 luxiao luxiao 133M Mar 30 09:27 BC.20171209
-rw-------  1 luxiao luxiao 133M Mar 30 10:39 BC.20171210
-rw-------  1 luxiao luxiao 133M Mar 30 11:51 BC.20171211
-rw-------  1 luxiao luxiao 133M Mar 30 13:04 BC.20171212
-rw-------  1 luxiao luxiao 133M Mar 30 14:18 BC.20171213
-rw-------  1 luxiao luxiao 133M Mar 30 15:31 BC.20171214
-rw-------  1 luxiao luxiao 133M Mar 30 16:44 BC.20171215
-rw-------  1 luxiao luxiao 133M Mar 30 17:55 BC.20171216
-rw-------  1 luxiao luxiao 133M Mar 30 19:08 BC.20171217
-rw-------  1 luxiao luxiao 133M Mar 30 20:22 BC.20171218
-rw-------  1 luxiao luxiao 133M Mar 30 21:36 BC.20171219
-rw-------  1 luxiao luxiao 133M Mar 30 22:48 BC.20171220
-rw-------  1 luxiao luxiao 133M Mar 31 00:02 BC.20171221
-rw-------  1 luxiao luxiao 133M Mar 31 01:14 BC.20171222
-rw-------  1 luxiao luxiao 133M Mar 31 02:27 BC.20171223
-rw-------  1 luxiao luxiao 133M Mar 31 03:40 BC.20171224
-rw-------  1 luxiao luxiao 133M Mar 31 04:54 BC.20171225
-rw-------  1 luxiao luxiao 133M Mar 31 06:07 BC.20171226
-rw-------  1 luxiao luxiao 133M Mar 31 07:21 BC.20171227
-rw-------  1 luxiao luxiao 133M Mar 31 08:35 BC.20171228
-rw-------  1 luxiao luxiao 133M Mar 31 09:48 BC.20171229
-rw-------  1 luxiao luxiao 133M Mar 31 11:01 BC.20171230
-rw-------  1 luxiao luxiao 117M Mar 31 12:06 BC.20171231
```

You can also use IDL -> GAMAP to check the BC file.



3. Create run directory and run the nested model

```
------------------------------
Choose horizontal resolution:
------------------------------
  1. 4.0  x 5.0
  2. 2.0  x 2.5
  3. 0.5  x 0.625
```

```
------------------------------------------------------------
Choose horizontal grid domain:
------------------------------------------------------------
  1. Global
  2. Asia
  3. Europe
  4. North America
  5. Custom
```

When creating a run directory from the GCClassic superproject folder, selections are the same as the Global simulation, but now you select 3 in Choose horizontal resolution for Nested or Custom simulations.

The Nested-Grid Menu populates where you can Choose horizontal grid domain matching your decided simulation domain (AS, CH, EU, NA, or Custom).

3. Create run directory and run the nested model

- Make sure input.geos has correct Latitude and Longitude Bounds

```
%%% GRID MENU %%%          :
Grid resolution            : 0.25x0.3125
Longitude min/max          : -130.0 -60.0
Latitude  min/max          :   9.75  60.0
 Half-sized polar boxes?: F
Number of levels           : 47
Nested grid simulation? : T
 Buffer zone (N S E W ) :  3  3  3  3
```

For existing domains: Longitude min/max and Latitude min/max are already set when you create the Nested simulation run directory.

For custom domains (FlexGrid): Specify custom Latitude and Longitude ranges

3. Create run directory and run the nested model

☐ Edit HEMCO_Config.rc and HEMCO_Config.rc.gmao_metfields

```
###############################################################################
### BEGIN SECTION SETTINGS
###############################################################################

ROOT:                   /n/holylfs/EXTERNAL_REPOS/GEOS-CHEM/gcgrid/data/ExtData/HEMCO
METDIR:                 /n/holylfs/EXTERNAL_REPOS/GEOS-CHEM/gcgrid/data/ExtData/GEOS_4x5/GEOS_FP
...

###############################################################################
### NON-EMISSIONS DATA (subsection of BASE EMISSIONS SECTION)
###
### Non-emissions data. The following fields are read through HEMCO but do
### not contain emissions data. The extension number is set to wildcard
### character denoting that these fields will not be considered for emission
### calculation. A given entry is only read if the assigned species name is
### an HEMCO species.
###############################################################################
```

May need to add abbreviation (AS, CH, EU, NA) to match nested domain selection

```
# --- CN fields ---
* FRLAKE    $METDIR/$CNYR/01/$MET.$CNYR0101.CN.$RES.$NC        FRLAKE    */1/1/0              C xy  1  * -  1 1
* FRLAND    $METDIR/$CNYR/01/$MET.$CNYR0101.CN.$RES.$NC        FRLAND    */1/1/0              C xy  1  * -  1 1
* FRLANDIC  $METDIR/$CNYR/01/$MET.$CNYR0101.CN.$RES.$NC        FRLANDIC  */1/1/0              C xy  1  * -  1 1
* FROCEAN   $METDIR/$CNYR/01/$MET.$CNYR0101.CN.$RES.$NC        FROCEAN   */1/1/0              C xy  1  * -  1 1
* PHIS      $METDIR/$CNYR/01/$MET.$CNYR0101.CN.$RES.$NC        PHIS      */1/1/0              C xy  1  * -  1 1

# --- A1 fields ---
* ALBEDO    $METDIR/$YYYY/$MM/$MET.$YYYY$MM$DD.A1.$RES.$NC     ALBEDO    1980-2018/1-12/1-31/0-23/+30minute CY xy  1  * -
* CLDTOT    $METDIR/$YYYY/$MM/$MET.$YYYY$MM$DD.A1.$RES.$NC     CLDTOT    1980-2018/1-12/1-31/0-23/+30minute CY xy  1  * -
* EFLUX     $METDIR/$YYYY/$MM/$MET.$YYYY$MM$DD.A1
* EVAP      $METDIR/$YYYY/$MM/$MET.$YYYY$MM$DD.A1
...
```

May need to add abbreviation (AS, CH, EU, NA) to match nested domain selection

1: Specify METDIR in HEMCO_Config.rc

2: Ensure that meteorology file names are correct in HEMCO_Config.rc.gmao_metfields

3. Create the run directory and run nested model

☐ Edit HEMCO_Config.rc

```
# ExtNr ExtName                 on/off  Species
0       Base                    : on    *
# ----- RESTART FIELDS ----------------------
    --> GC_RESTART              :       true
    --> GC_BCs                  :       true
    --> HEMCO_RESTART           :       true

...

#============================================================================
# --- GEOS-Chem boundary condition file ---
#============================================================================
(((GC_BCs
* BC_   $ROOT/SAMPLE_BCs/v2019-05/tropchem/GEOSChem.BoundaryConditions.$YYYY$MM$DD_$HH$MNz.nc4 SpeciesBC_?ADV?  1980-2019/1-12/1-31/0-23 RFY xyz 1 * - 1 1
)))GC_BCs
```

3: GC_BCs should be already set to true for nested simulations

4: Specify path for boundary condition files generated by your global simulation

Nested Simulation Summary and References

	Checklist
1	**Step 1: Have you decided and downloaded the met fields for your simulation?**
2	**Step 2: Have you turned on and correctly save the boundary conditions in your global simulation? (HISTORY.rc in global simulation)**
3	**Step 3.1: Have you created the nested model run directory from the GCClassic superproject folder? (~/GCClassic.13+/run)**
4	**Step 3.2: Have you set the Met and BC pathway correctly? (HEMCO_Config.rc in nested simulation)**

http://wiki.seas.harvard.edu/geos-chem/index.php/GEOS-Chem_Nested_Model

http://wiki.seas.harvard.edu/geos-chem/index.php/Setting_up_GEOS-Chem_nested_grid_simulations

http://wiki.seas.harvard.edu/geos-chem/index.php/FlexGrid