Developing a high-resolution global atmospheric simulation of CO_2 mole fraction

- Why?
- Technical issues
- Results
- Conclusion

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Why ?

1. Properly represent variability of atmospheric CO2 concentrations.

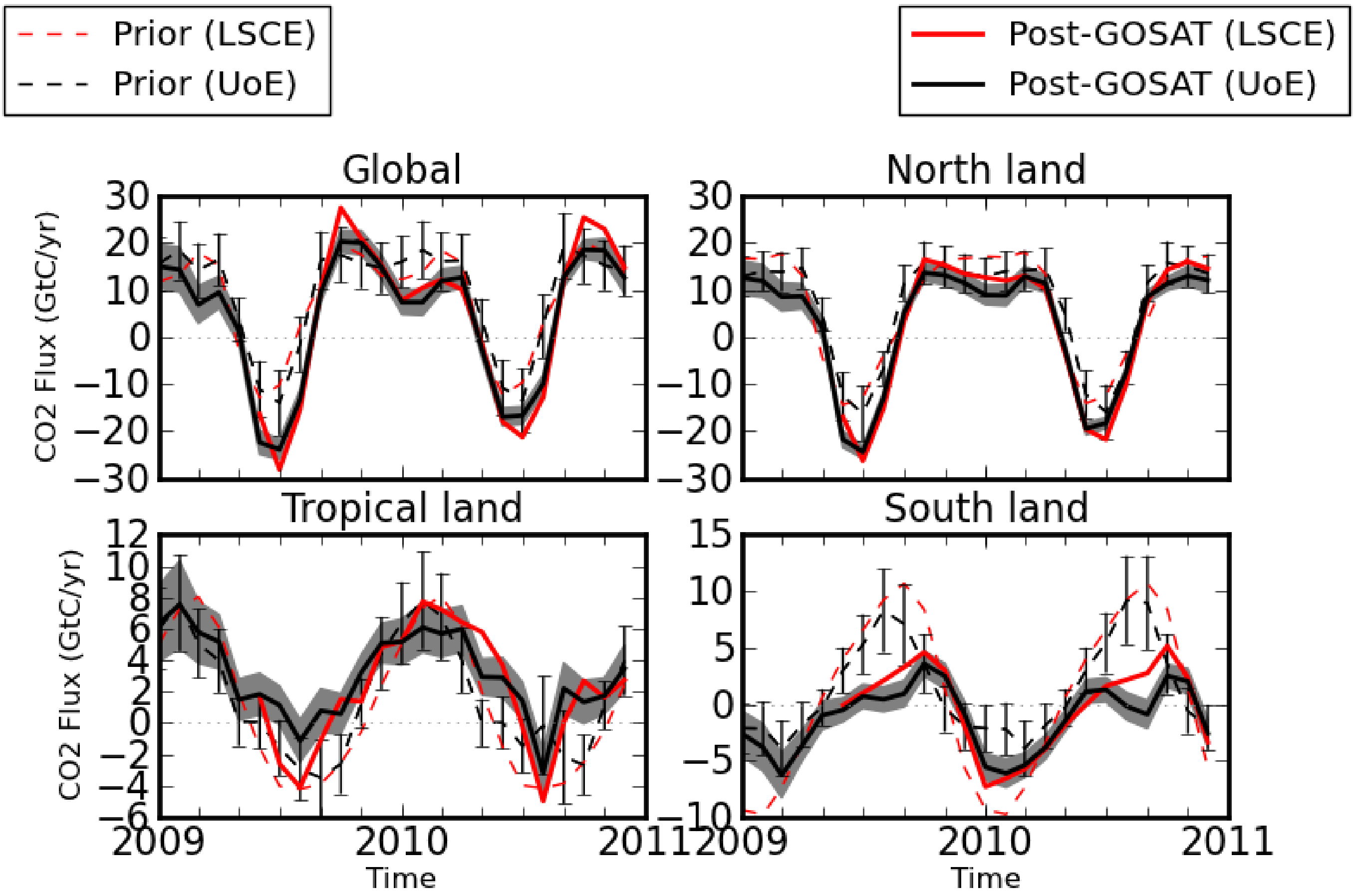
- Pixel sizes of OCO-2 and CarbonSat are <10 km^2, much smaller than ‘standard’ GEOS-Chem global model grids

2. Understand model errors and improve top-down flux estimates

- Model errors (transport and representation errors) may have significant adverse impacts on top-down estimates of surface fluxes.

- Higher model resolution usually means better transport modelling, and smaller representation errors.

- **Example:** Impacts of differences in model transport of GEOS-Chem and LSCE LMDZ have been studied previously using simulated data (Chevallier et al 2010) . This example compares posterior fluxes estimated by these two CTMs from the same set of GOSAT XCO2 retrievals



Part of differences are due to transport models: ***GEOS-Chem vs LMDZ*** *(ECMWF)*

Why ?

3. Provide benchmarks for coarser simulations or nested model simulations.

- One by-product of our efforts to develop an EnKF approach based on nested GEOS-Chem transport model (**EnKF now available**).
- Our modified GEOS-Chem V8.02 nested model can use global met and emission files.

4. Incorporate other process-based models (such as plume model) into GEOS-Chem (*Gonzi et al, University of Edinburgh*).

- Due to the finer temporal and spatial resolutions, It is more sensitive to the details of ‘small scale’ processes.

5. Use other meteorological fields (such as ECMWF analysis) to drive GEOS-Chem simulations

Challenges

Availability of High-resolution emission inventories

- 1x1 monthly fossil fuel emissions (Oda et al).
- 1x1.25 3-hourly CASA biospheric CO_2 exchanges (Kawa , Collatz, and Liu)
- 1x1.25 weekly biomass burning (GFED)
- 4x5 monthly oceanic surface CO_2 flux (Takahashi et al)

Programming

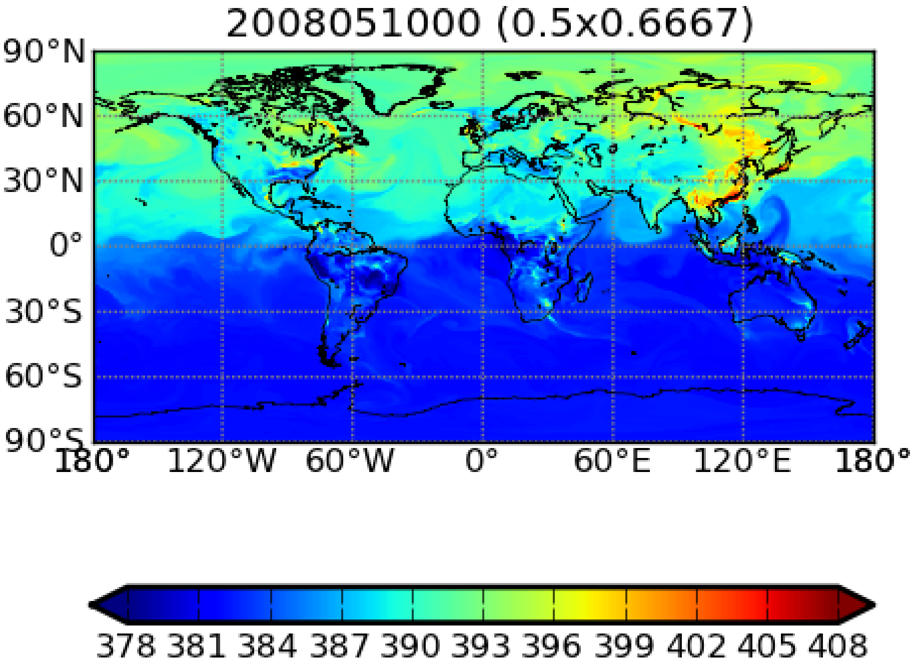
Memory: stack size is limited by most FORTRAN compilers.
Modifications have been made to GEOS-Chem v8.02 to limit the use of common block and avoid static arrays at module level.

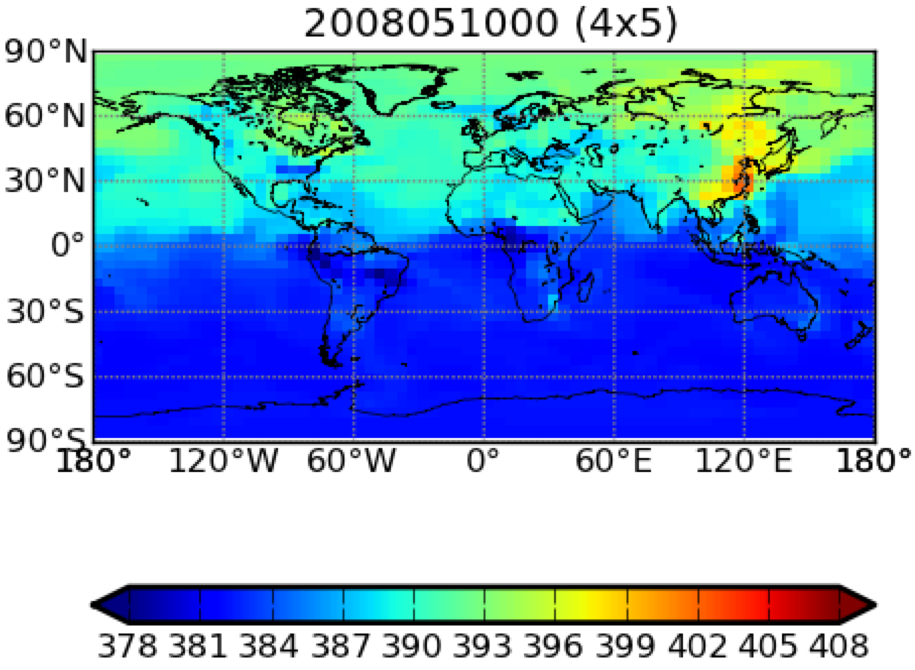
Parallelisation: *reschedule parallelisation in tpcore modules, and change functions in dao_mod.f .*

Minor issues: *Mainly they are associated with Diag outputs*.

Results

➢Comparison with standard GEOS-Chem 4x5 simulations





CO_2 /ppm (ML1-8)

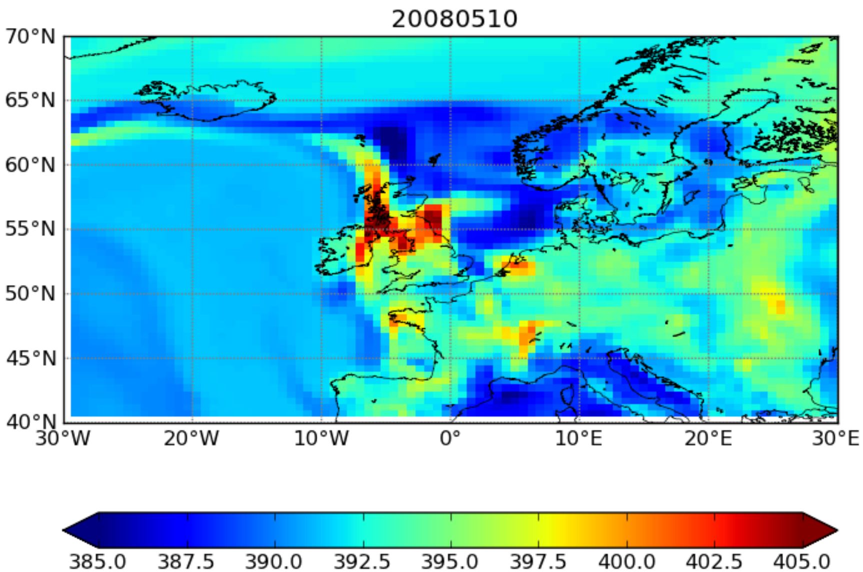
CO_2/ppm (ML1-8)

Range: 374 – 415 ppm

Range: 377 ppm – 403 ppm

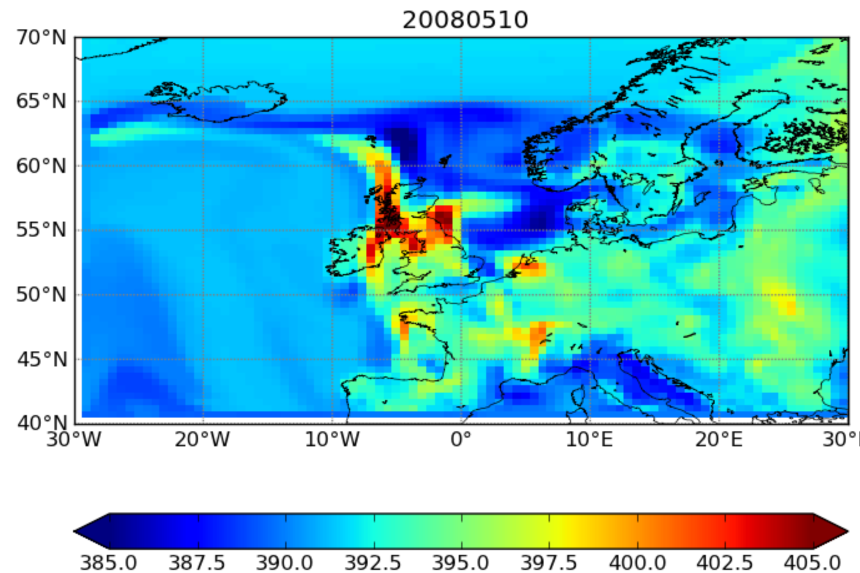
➢Comparison with nested simulation

Global 0.5x0.666



CO_2 /ppm (ML1-4)

Nested 0.5x0.666

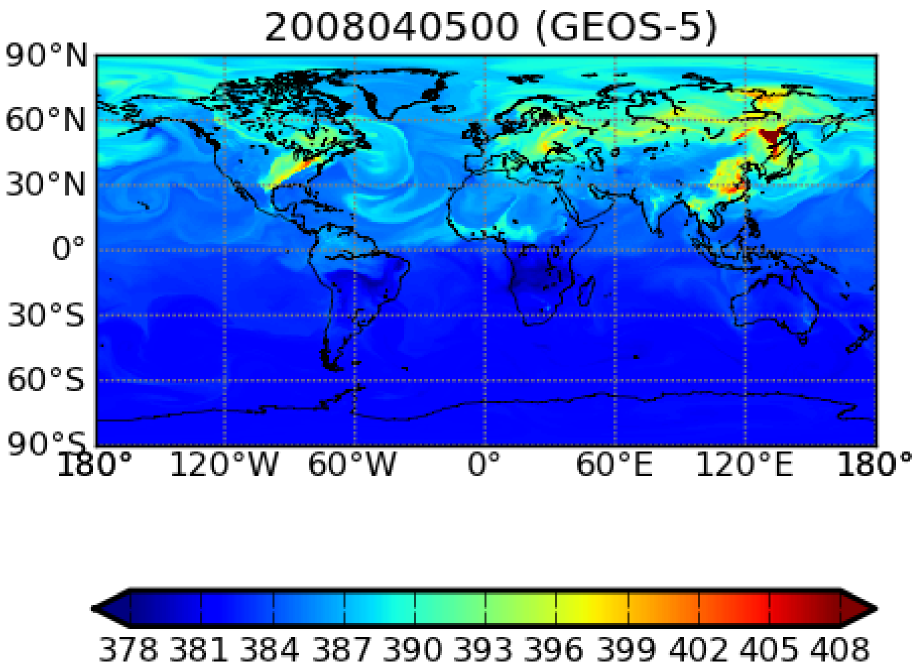


CO_2 /ppm (ML1-4)

Nested model being used in UK GAUGE project

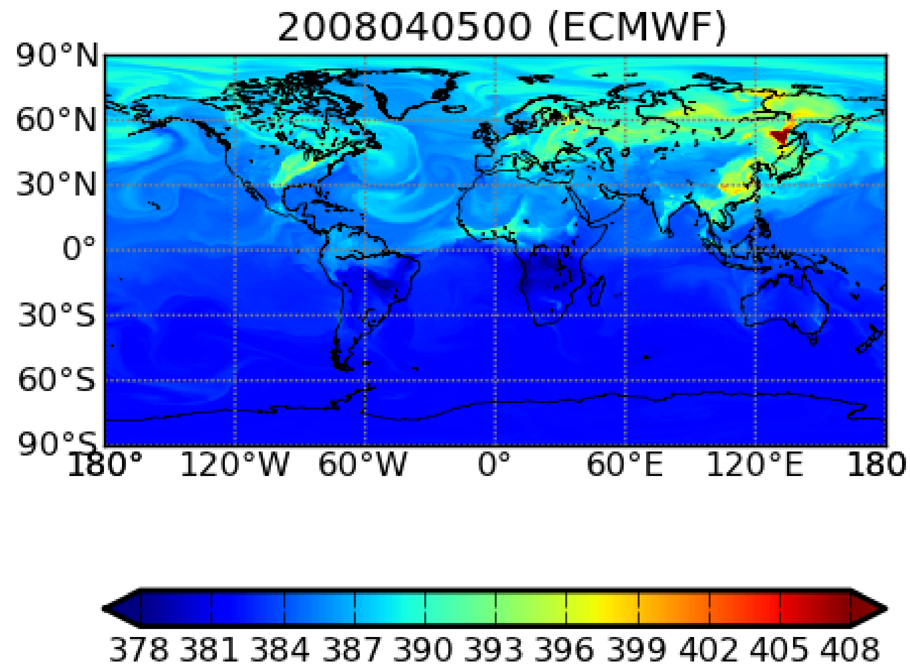
➢Comparison with GEOS-Chem drived by ECMWF winds

GEOS-5 winds



CO_2 /ppm (ML1-8)

ECMWF winds



CO_2 /ppm (ML1-8)

ECMWF Met fields may have stronger vertical transport   across boundary layer.

Conclusion

- Native resolution simulation provides:
    a) More realistic descriptions of observed variations
    b) Benchmark for lower-resolution model
    c) Framework for including detailed process models
    d) Framework for comparing with other meteorology

- Our comparisons also reveal some possible model errors.

Thanks!

Stronger ECMWF vertical transport