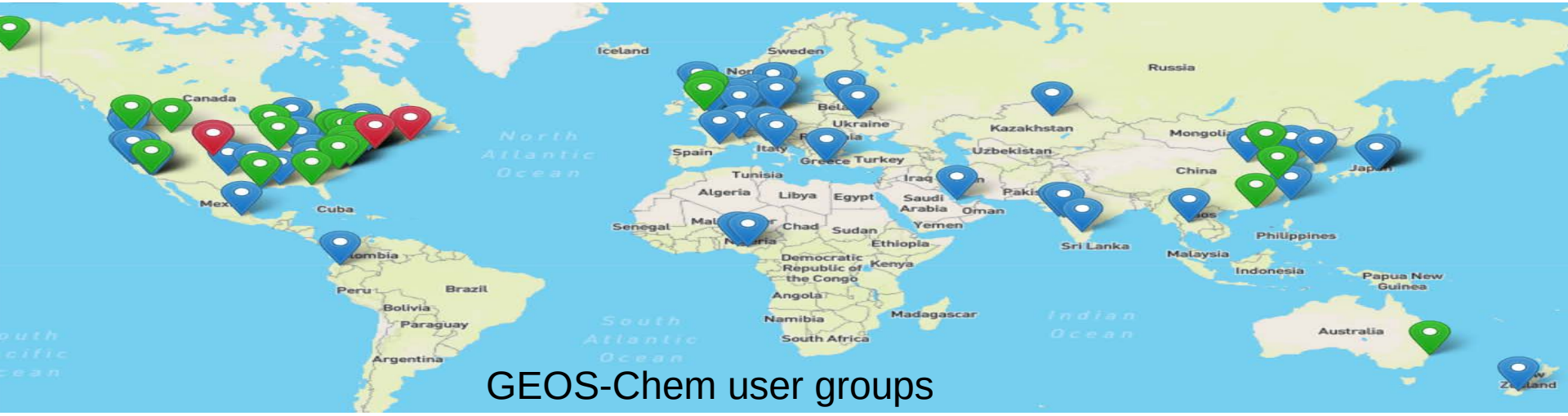
GEOS-Chem model overview

Daniel J. Jacob, Harvard University

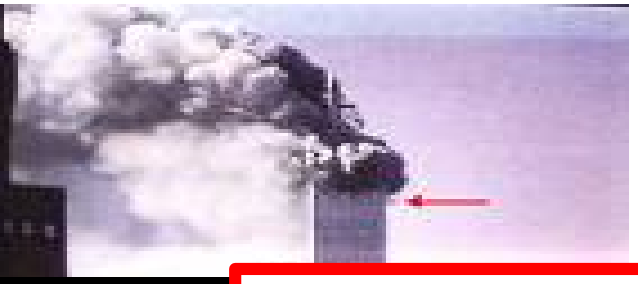
GEOS-Chem Community Mission: *to advance understanding of human and natural influences on the environment through a comprehensive, state-of-the-science, readily accessible global model of atmospheric composition*



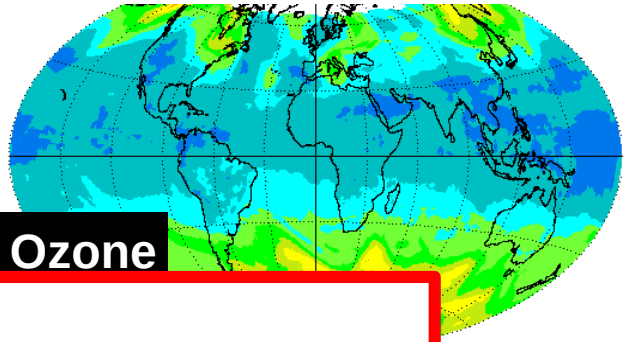
GEOS-Chem user groups

IGC8 meeting (Harvard, May 2017)

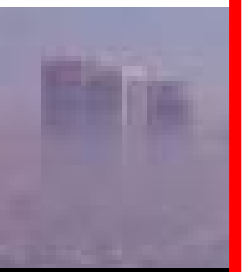
Atmospheric chemistry: many problems, many scales



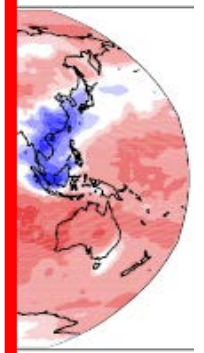
Disasters



Ozone



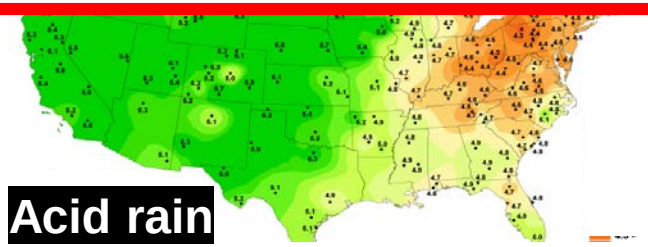
Urban sm



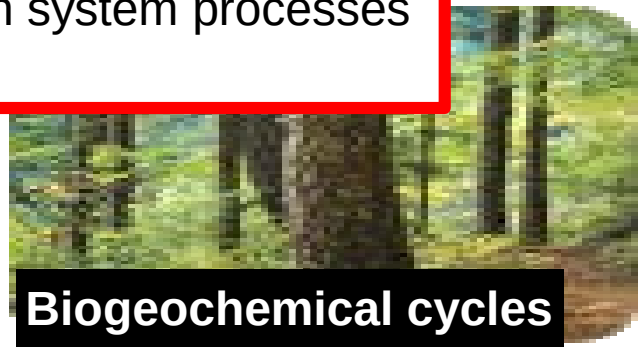
We need models to

- Understand processes
- Confront our understanding to observations
- Interpret observations to generate new knowledge
- Make projections
- Link atmospheric chemistry to other Earth system processes

Plume dispersion



Acid rain



Biogeochemical cycles

LOCAL
< 100 km

REGIONAL
100-1000 km

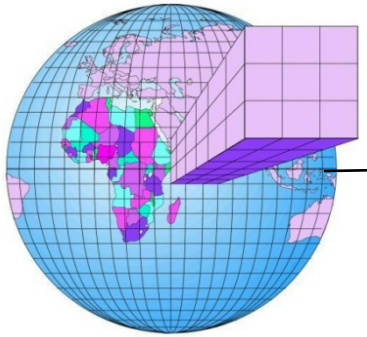
GLOBAL
> 1000 km

GEOS-Chem atmospheric chemistry model

Input meteorological data
NASA GEOS fields, 1980-present
0.25°×0.3125° or 0.5°x0.625°, 72 vertical levels

GEOS-Chem solves 3-D chemical continuity equations on global or nested Eulerian grid

Modules
- emissions
- transport
- chemistry
- aerosols
- deposition



Applications

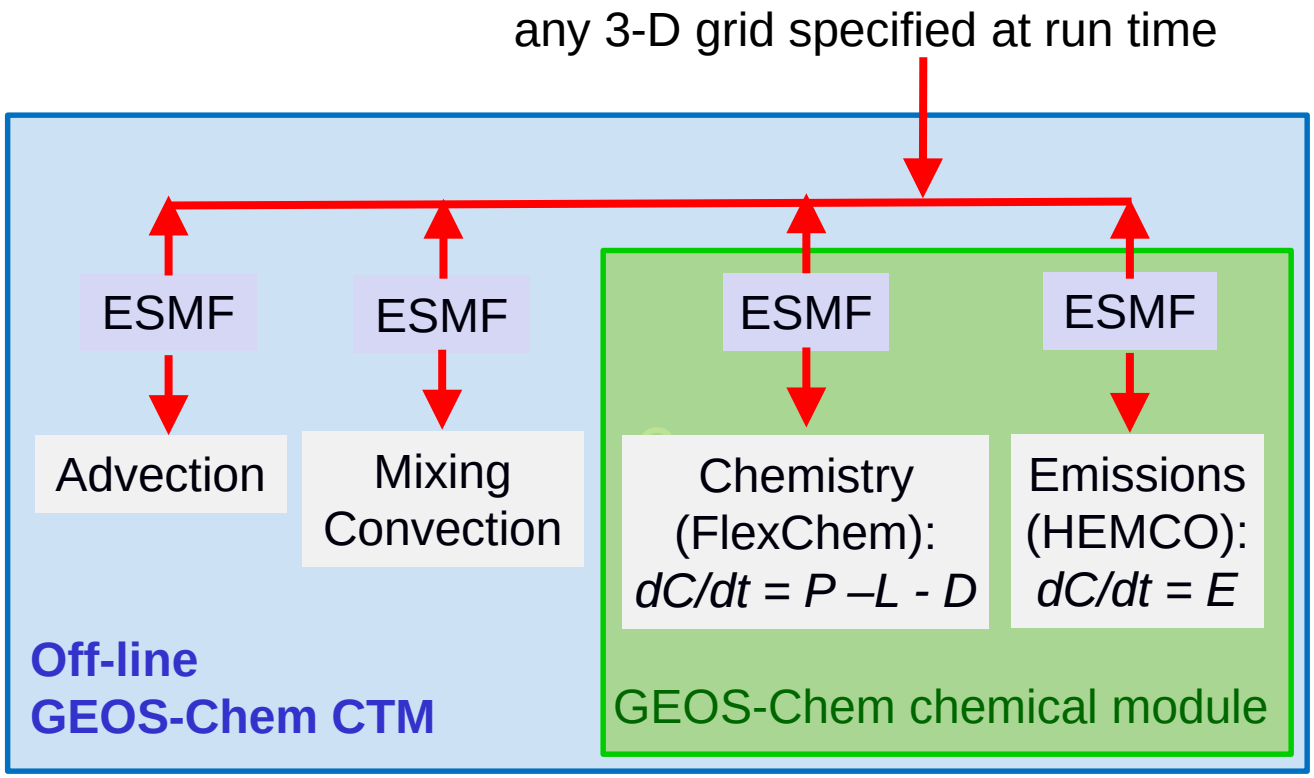
Model adjoint

- Tropospheric and stratospheric chemistry, aerosol microphysics, carbon gases, mercury including biogeochemical coupling, POPs, isotopes…

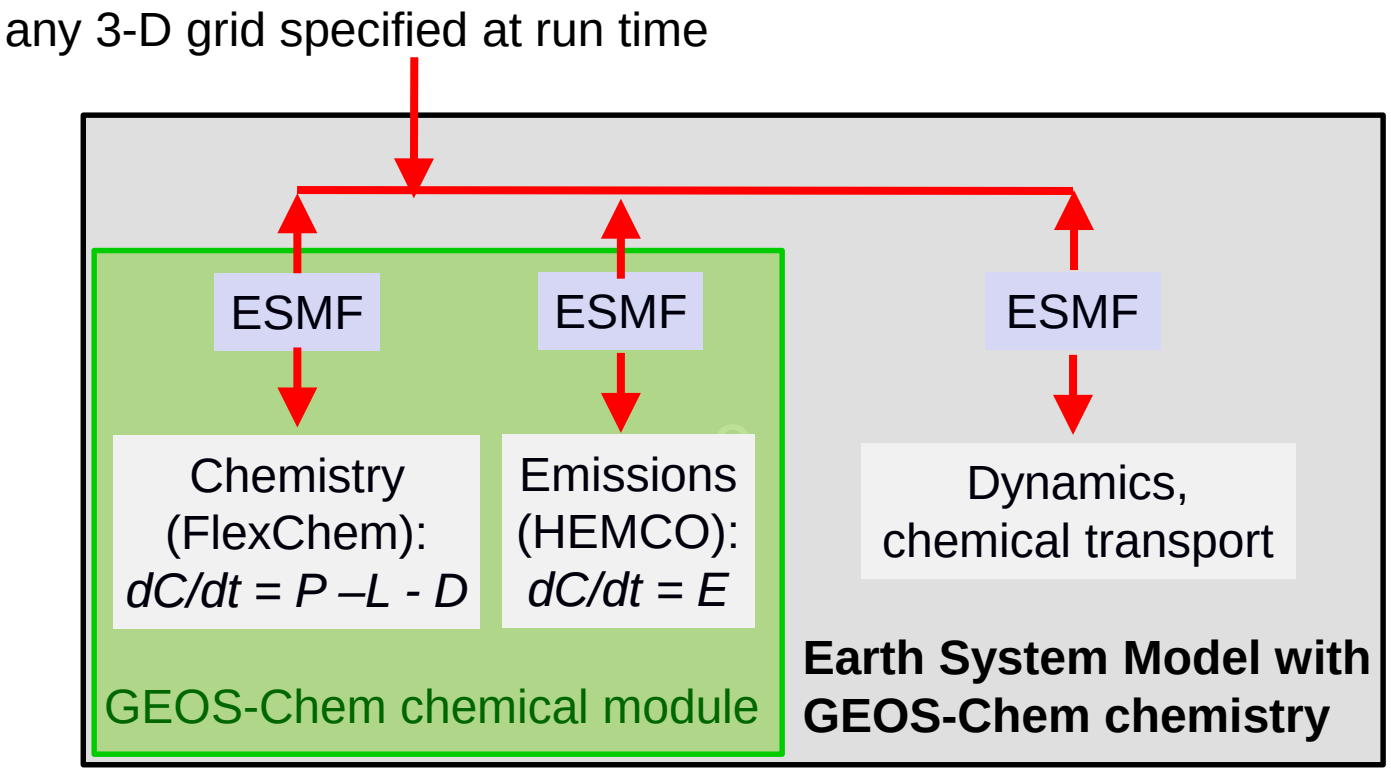
- New version releases every year: v11-2 (May 2018) to include updated SOA, isoprene chemistry, tropospheric halogen (Cl-Br-I) chemistry, methane, emissions…

- Grid-independent, ESMF-compatible architecture for coupling to Earth System models

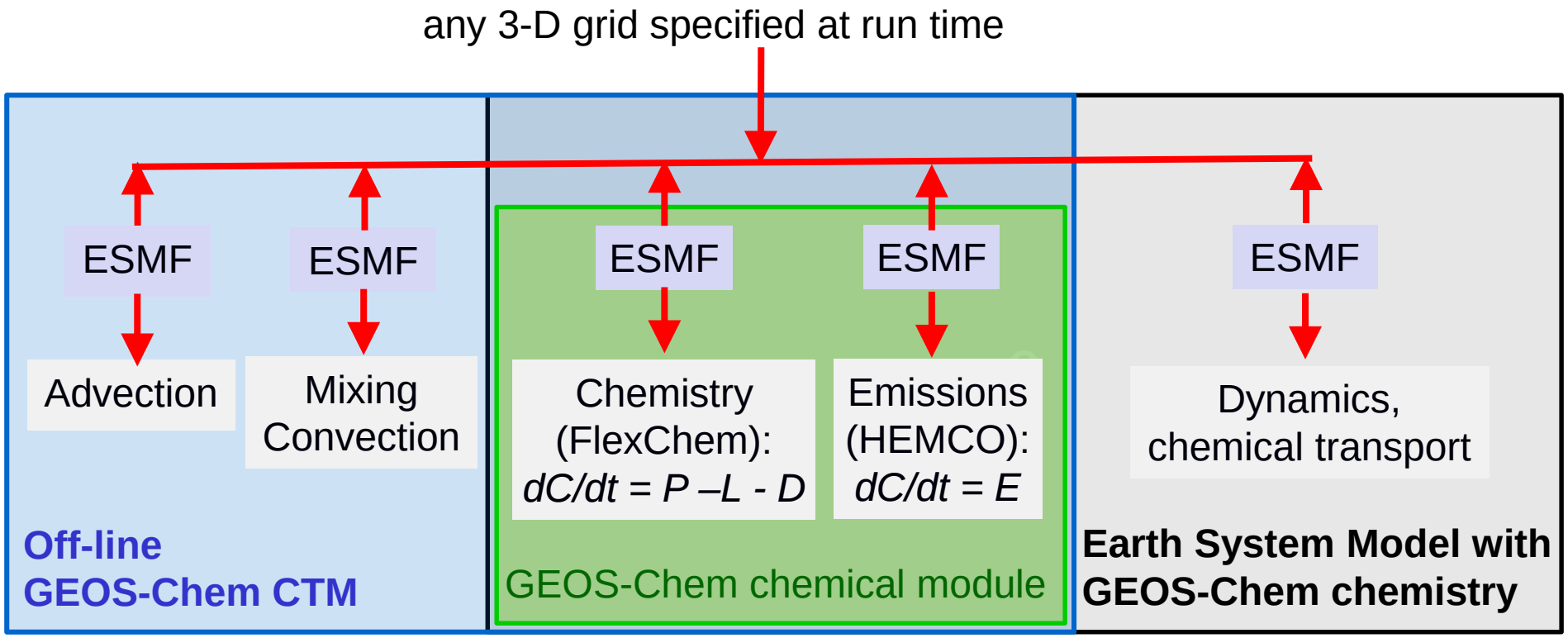
GEOS-Chem as on-line chemical module for Earth system models (ESMs)



GEOS-Chem as on-line chemical module for Earth system models (ESMs)



GEOS-Chem as on-line chemical module for Earth system models (ESMs)

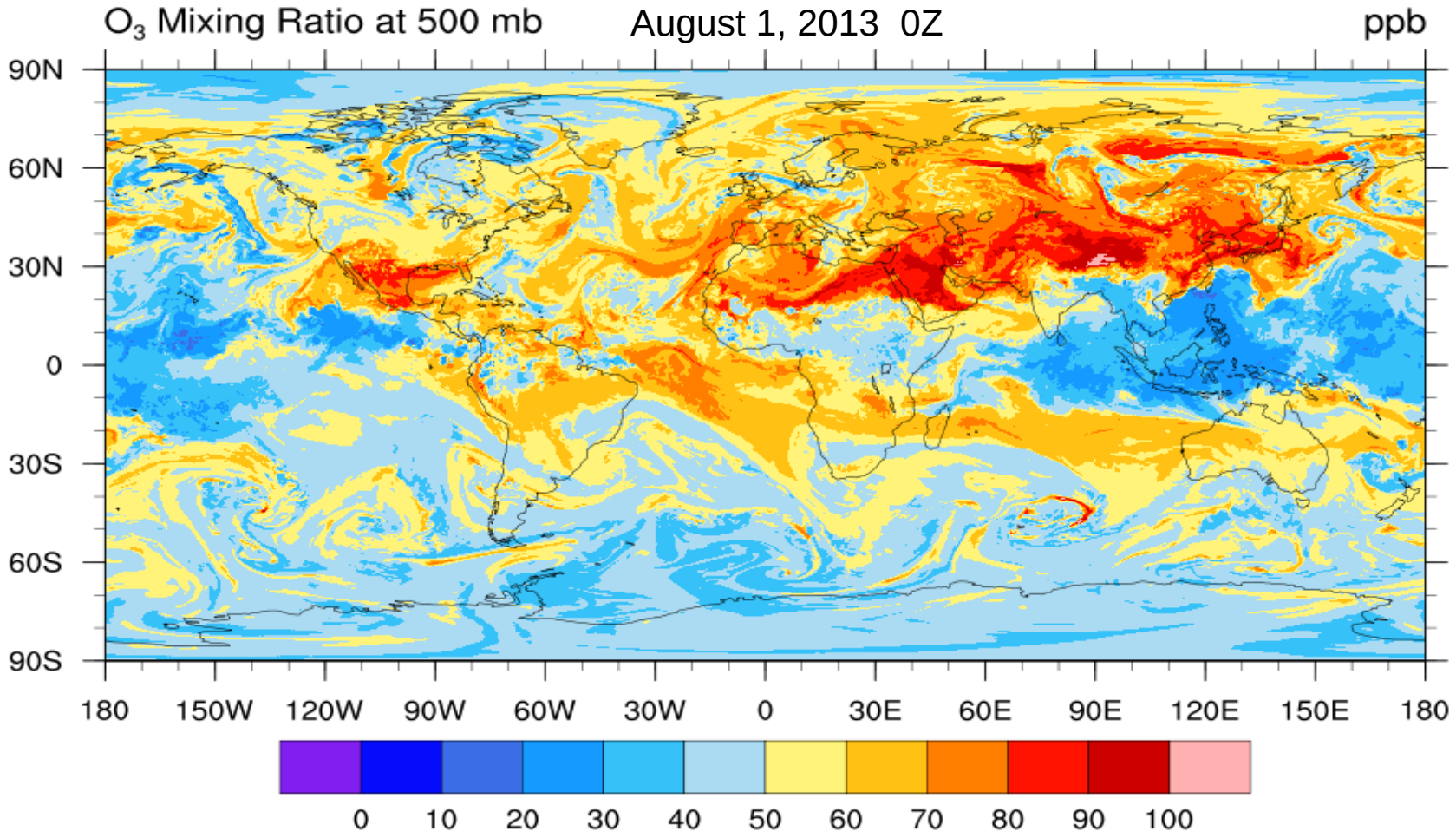


CTM and ESM use exactly the same GEOS-Chem code

GEOS-Chem CTM users contribute model advances → Advances are incorporated into GEOS-Chem → ESM GEOS-Chem module always stays referenced to latest version

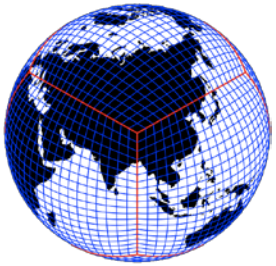
Keller et al.. [2014]; Long et al. [2015]

Full-year tropospheric chemistry simulation at c720 (~12 km) resolution using on-line GEOS-Chem in GEOS ESM



Hu et al. [2018]

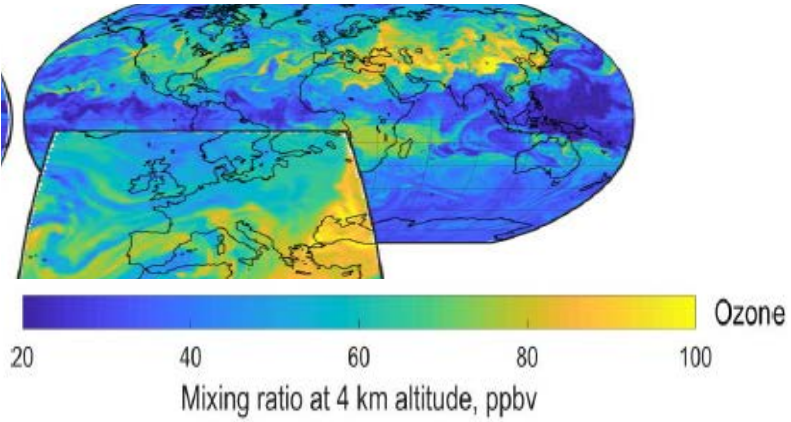
GEOS-Chem high performance (GCHP):



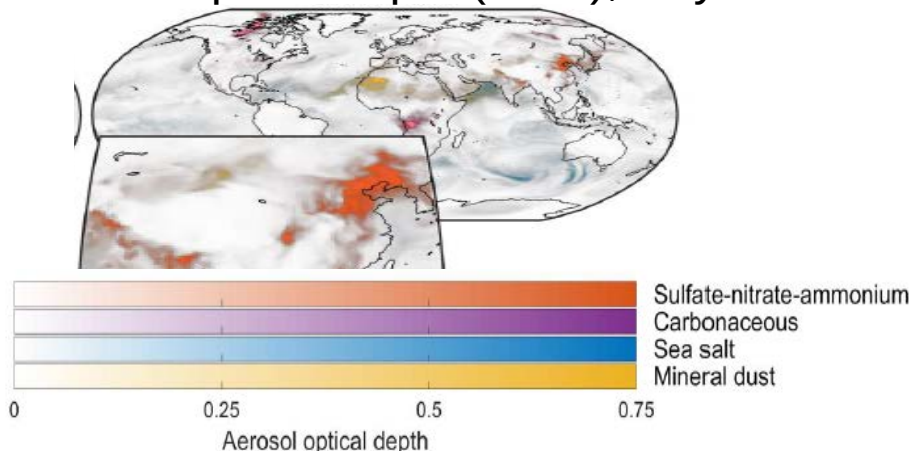
Massively parallel capability with cubed-sphere advection
uses distributed-memory MPI parallelization enabled by ESMF

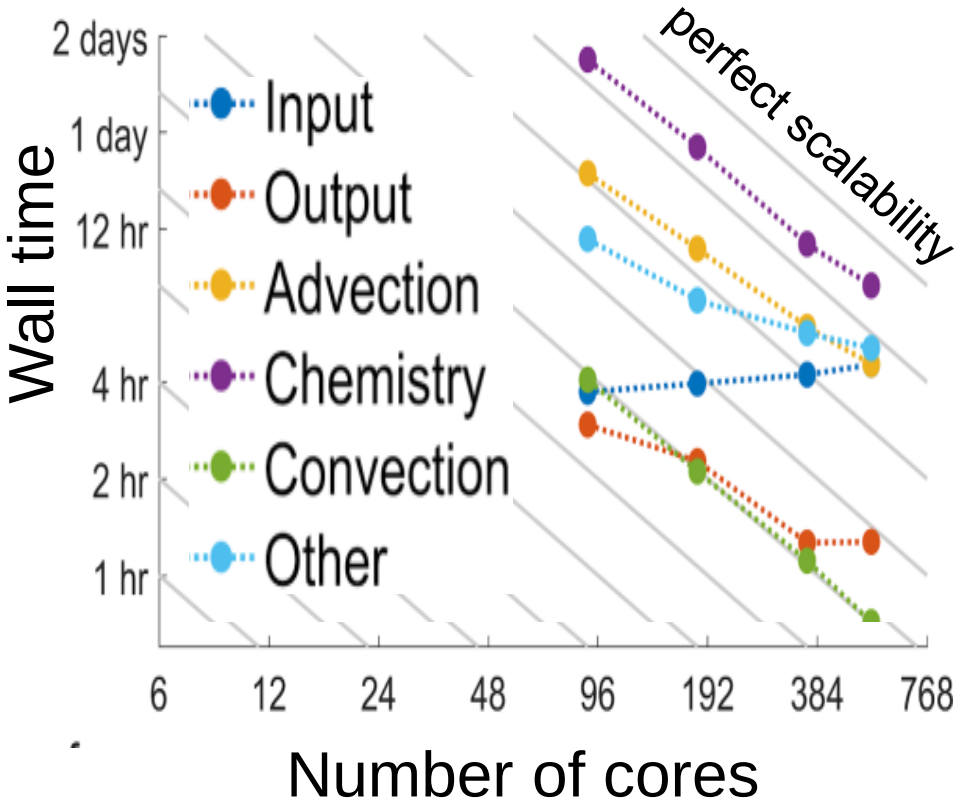
1-month simulation of troposphere-stratospheric chemistry at c180 (~50 km) resolution requires only 1 day of wall time with 540 cores

Ozone at 4 km altitude, July 2016



Aerosol optical depth (AOD), July 2016



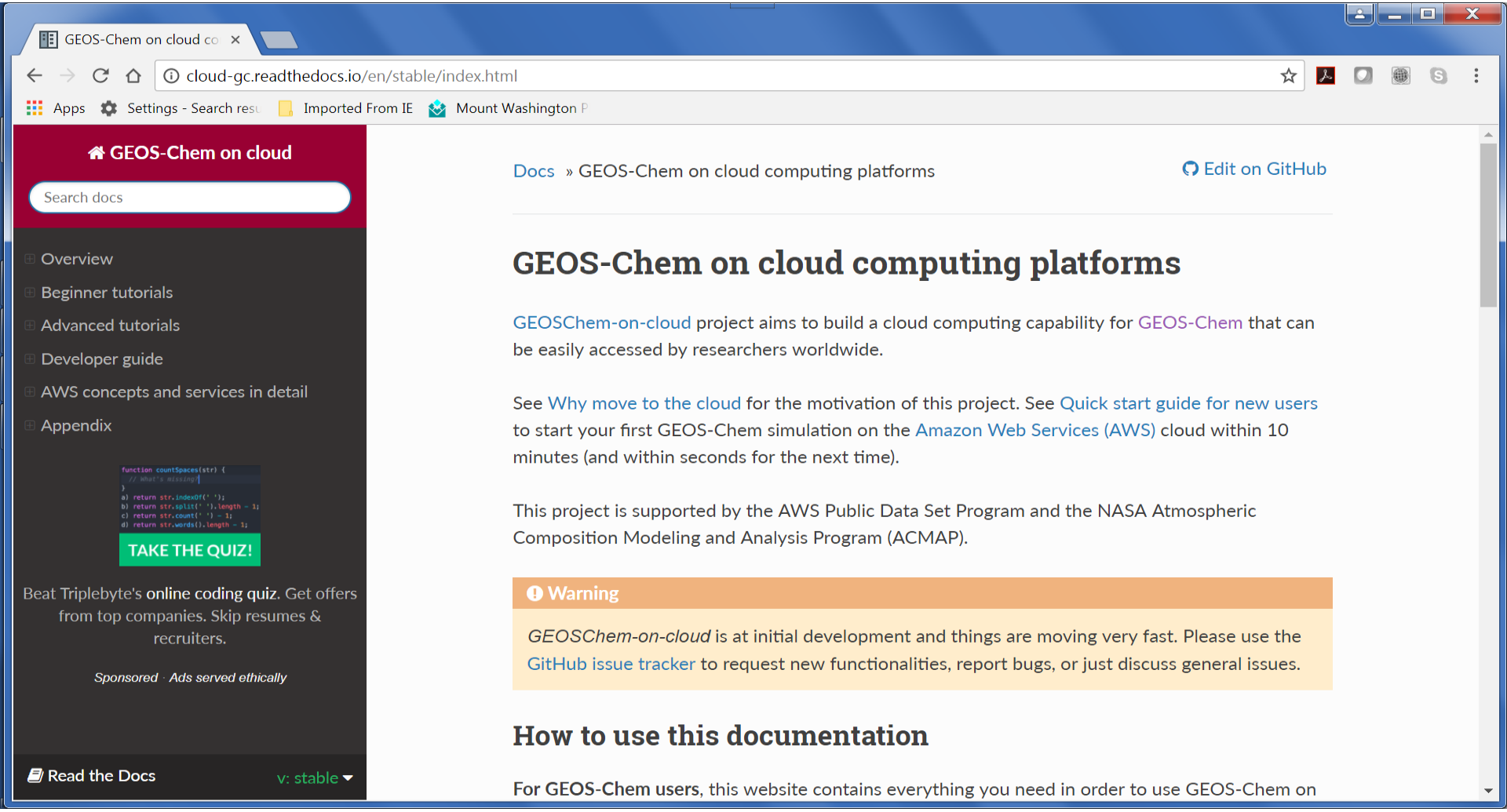


Eastham et al. [2018]

Running GEOS-Chem on the cloud

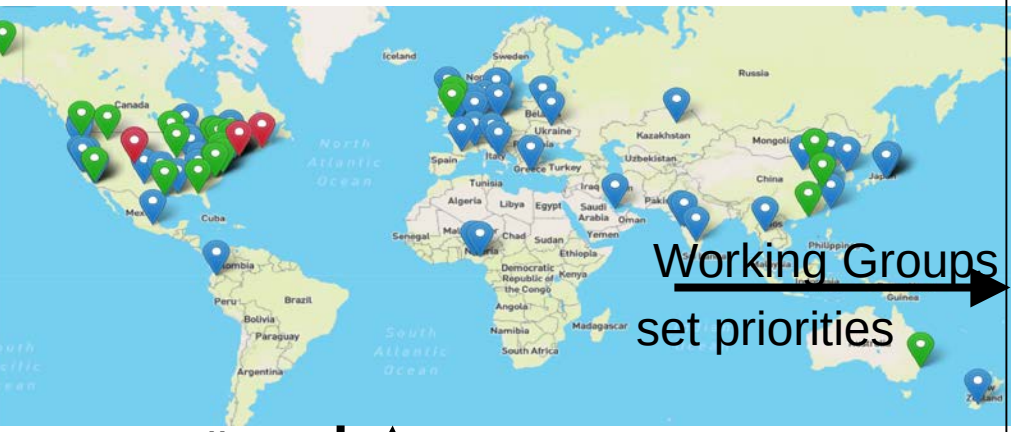
GEOS-Chem is now fully operational on the AWS cloud; GCHP is on the way

Many advantages for access, reproducibility, sharing of model versions and data



Jiawei Zhuang, Harvard

GEOS-Chem development is driven by its user community



Working Groups set priorities

contribute developments, report bugs

support

implement priorities

benchmark updates

Model Support Team (Harvard, Dalhousie, U. Colorado)

Model version updates

Emphasize grass-roots development, fast innovation, traceability, user support

GEOS-Chem Steering Committee

Model scientist: Jacob (Harvard)
co-scientist: Martin (Dalhousie)
Adjoint scientist: Henze (U. Colorado)
Nested model scientists: Wang (Tsinghua/UH), Zhang (PKU)
Engineer: Yantosca (Harvard)
Aerosols WG:
Heald (MIT), Alexander (UW), Pierce (CSU), Yu (SUNYA)
Chemistry WG:
Henderson (EPA), Evans (York), Mao (U. Alaska), Hu (U. Montana)
Emissions and Deposition WG:
Lin (PKU), Fischer (CSU), Millet (U. Minnesota)
Chemistry-Ecosystems-Climate WG:
Liao (NIUST), Tai (CUHK), Murray (U. Rochester), Geddes (Boston U)
Carbon WG:
Jones (U. Toronto), Bowman (JPL)
Adjoint and Data Assimilation WG:
Wang (U. Iowa), Henze (U. Colorado)
Transport WG:
Liu (NIA), Molod (NASA)
Hg and POPs WG:
Holmes (FSU), Fisher (U. Wollongong)
GCHP WG: Martin (Dalhousie), Eastham (MIT)
GMAO Liaison: Keller (NASA)
At large: Kasibhatla (Duke).)