25 years of GEOS-Chem

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with material from a paper by Jonathan Moch on GEOS-Chem governance (in prep.)

Before GEOS-Chem…the first global 3-D models of atmospheric chemistry

1980s – the pioneers: focus on transport, ozone

- NOAA GFDL: tracers and simple tropospheric chemistry on-line in GCM
- NASA GSFC: on-line stratospheric chemistry
- MPI (Moguntia, TM), NCAR (IMAGES): tropospheric chemistry with monthly winds
- Harvard: tropospheric tracers with off-line archive from GISS GCM

1990s – expansion to aerosols, assimilated data, chemistry-climate

- DOE: GRANTOUR, IMPACT off-line models
- Harvard: tropospheric ozone and sulfate, still driven by GISS GCM archive
- NASA DAO (former GMAO): off-line tracers, GOCART
- ECHAM: coupled aerosols-climate

What started GEOS-Chem in the late 1990s:

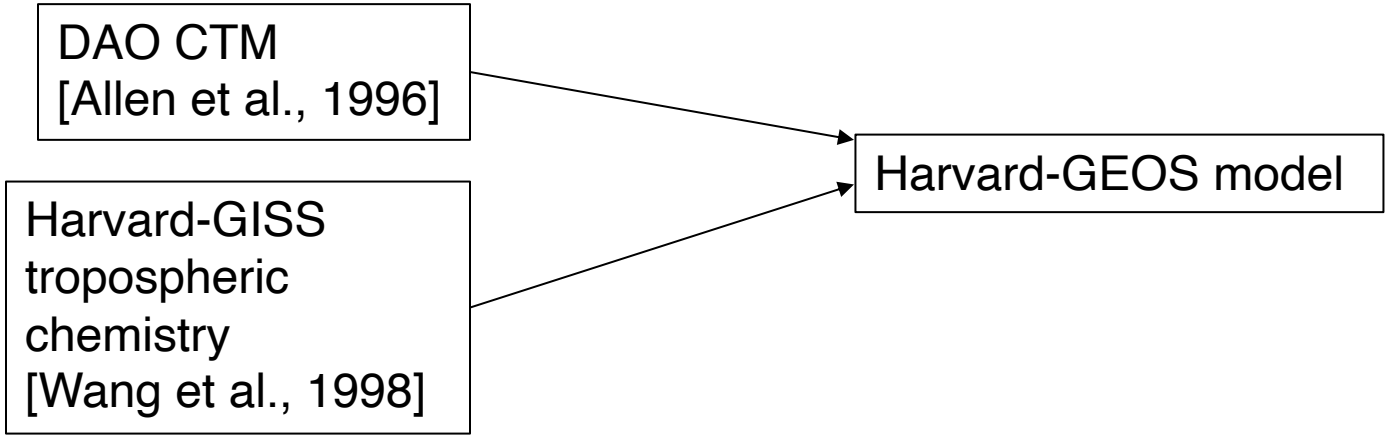
1. A conversation with Ricky Rood, then head of DAO

"why aren't you using our GEOS archive of real winds rather than those GCM winds?"

2. The NASA Subsonic Assessment Program (SASS)

NASA vision: develop a modular assessment model (GMI) supported by modules from research models (Harvard, GSFC, UCI, AER…)

With funding from SASS, I hired postdoc Isabelle Bey and programmer Bob Yantosca to build Harvard-GEOS model:



How did it become GEOS-Chem?

- A conversation with Prasad Kasibhatla:

"How about making it a community model? But it needs a different name. GEOS-CHEM"?

GEOPHYSICAL RESEARCH LETTERS, VOL. 27, NO. 21, PAGES 3461-3464, NOVEMBER 1, 2000

Satellite observations of formaldehyde over North America from GOME

Kelly Chance[1], Paul I. Palmer[2], Robert J.D. Spurr[1], Randall V. Martin[2], Thomas P. Kurosu[1], and Daniel J. Jacob[2]

radiances. Second, a combination of radiative transfer calculations using the Smithsonian Astrophysical Observatory (SAO) LIDORT code [*Spurr et al.*, 2000] and results from the GEOS-CHEM global 3-D model of tropospheric chemistry and transport [*Bey et al.*, 1999] is used to determine the appropriate air-mass factors (AMFs) which convert the

Bey, I., D.J. Jacob, R.M. Yantosca, J.A. Logan, B.D. Field, A.M. Fiore, Q. Li, H. Liu, and M.G. Schultz, Asian outflow to the Pacific Ocean in springtime: A 3D simulation of the PEM-West (B) mission with assimilated meteorology, submitted to *J. Geophys. Res.*, August 2000.

But how to make this a community model? We needed

1. A willing community
2. A patron

Building the GEOS-Chem community

- Model community and credibility feed on themselves
- But how to build the community?
  - Make the model easy to use and develop
  - Make the model nimble: low bar for innovation, frequent updates, empower community contributions, give credit
  - Make the model credible: publications, benchmarking, traceability
  - Remove institutional ownership, retain central management and version control
  - Commit to serve

- Grass-roots means empowering users
  - No centralized institutional authority, leadership is strong but light, model belongs to users
  - Users identify model development priorities through GC meetings
  - Prioritization of model developments is transparent
  - Developers get credit trough co-authorships and citations; there is no central authority to take over credit

Trust, respect, inclusiveness, user support are absolutely critical to success

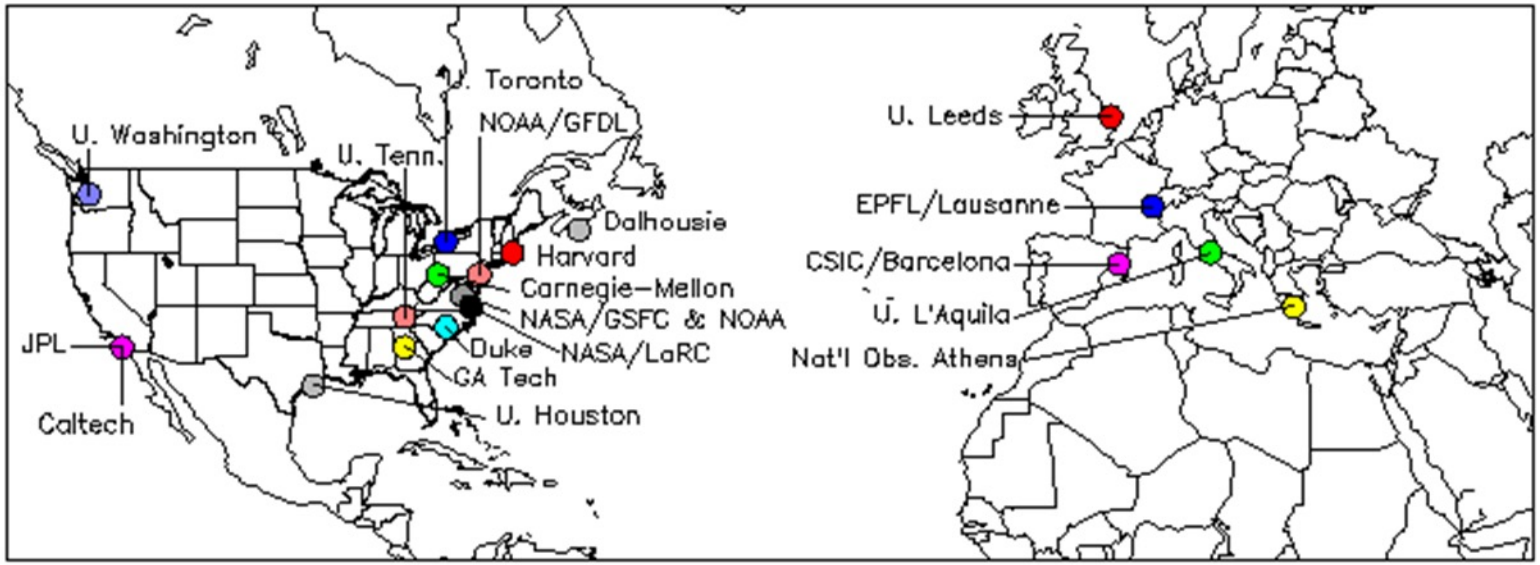
NASA support was crucial

- We needed a patron and NASA was willing
  - NASA relies on external community for much of its science
  - Exploding need to interpret satellite data for atmospheric composition
  - Benefit of having large community using GEOS data

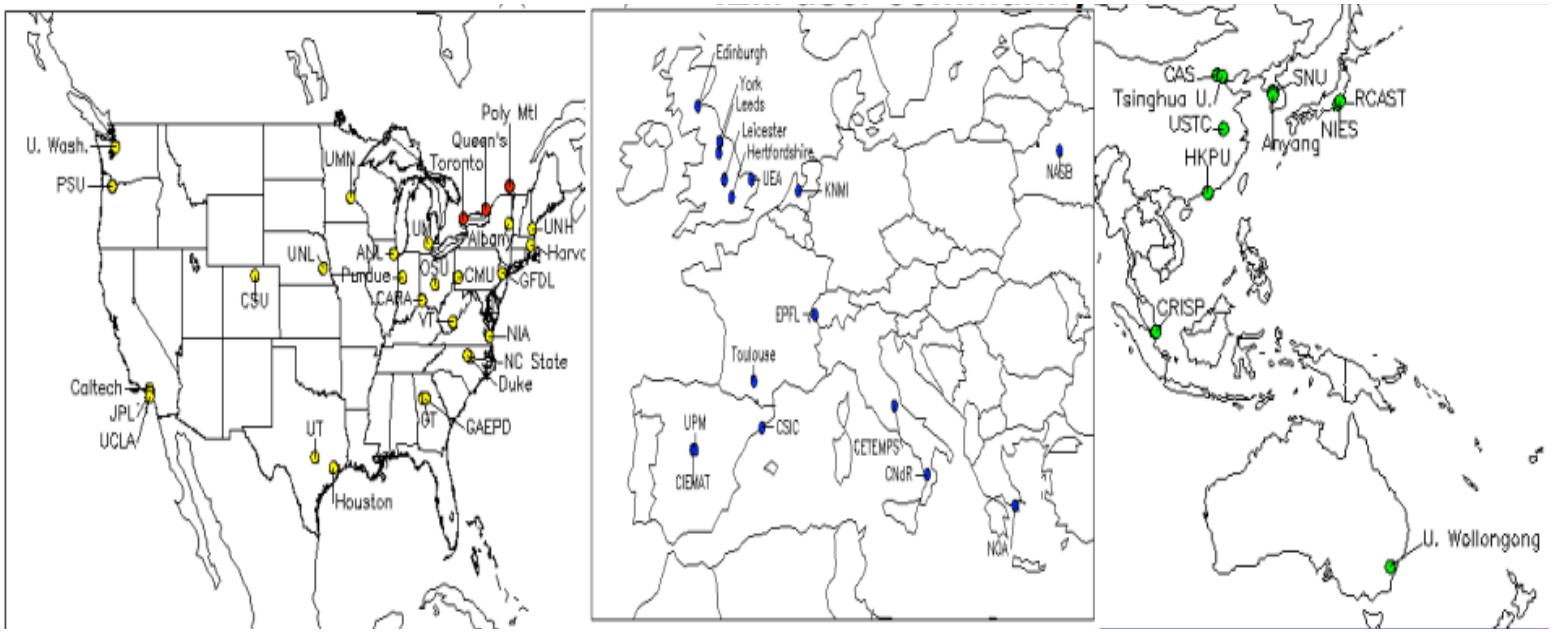
- Critical role of strong personalities at NASA supporting GEOS-Chem
  - GMAO: Steven Pawson (then chemistry lead), Andrea Molod
  - ACMAP: program managers Phil DeCola, Richard Eckman
  - JPL: Kevin Bowman, John Worden

- NASA never asked for GEOS-Chem to be a ‘NASA model’
  - This enabled multi-agency, international buy-in

Rapid growth of GEOS-Chem community

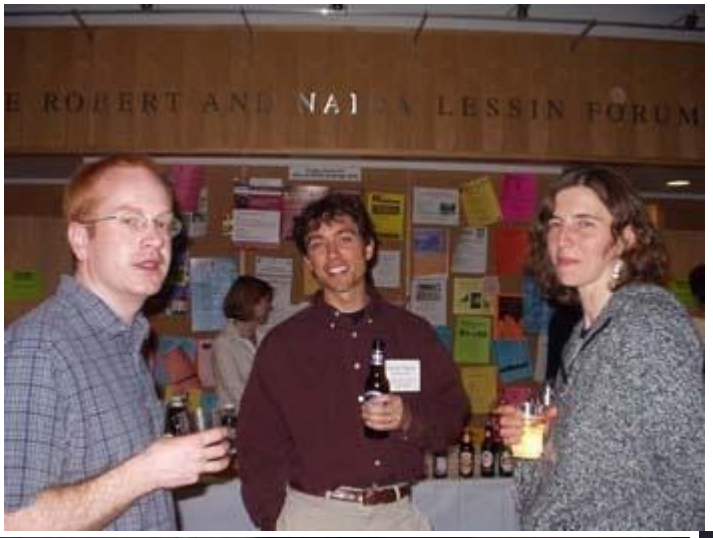


IGC2
(2005)

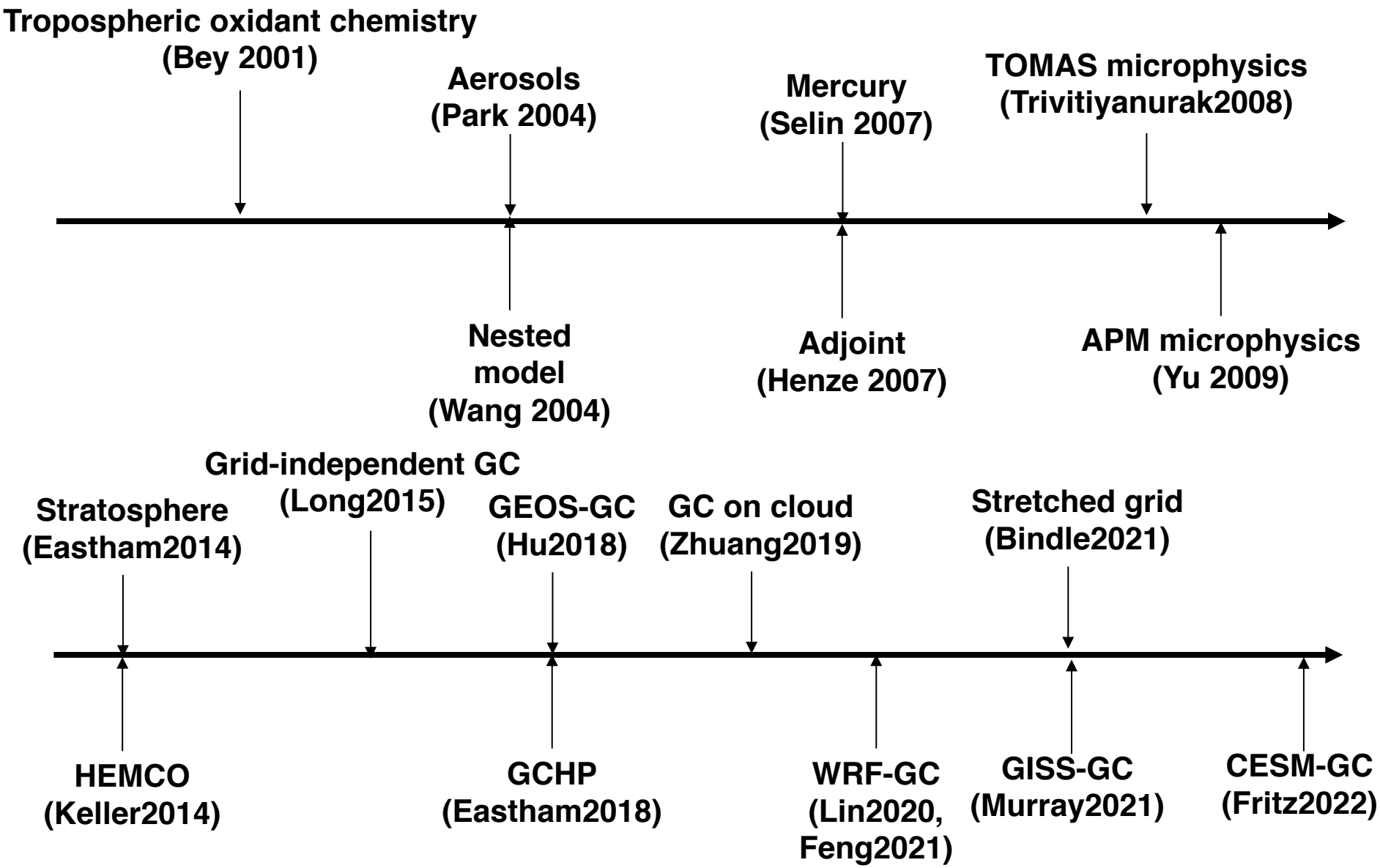


IGC4
(2009)

Some familiar faces at IGC2



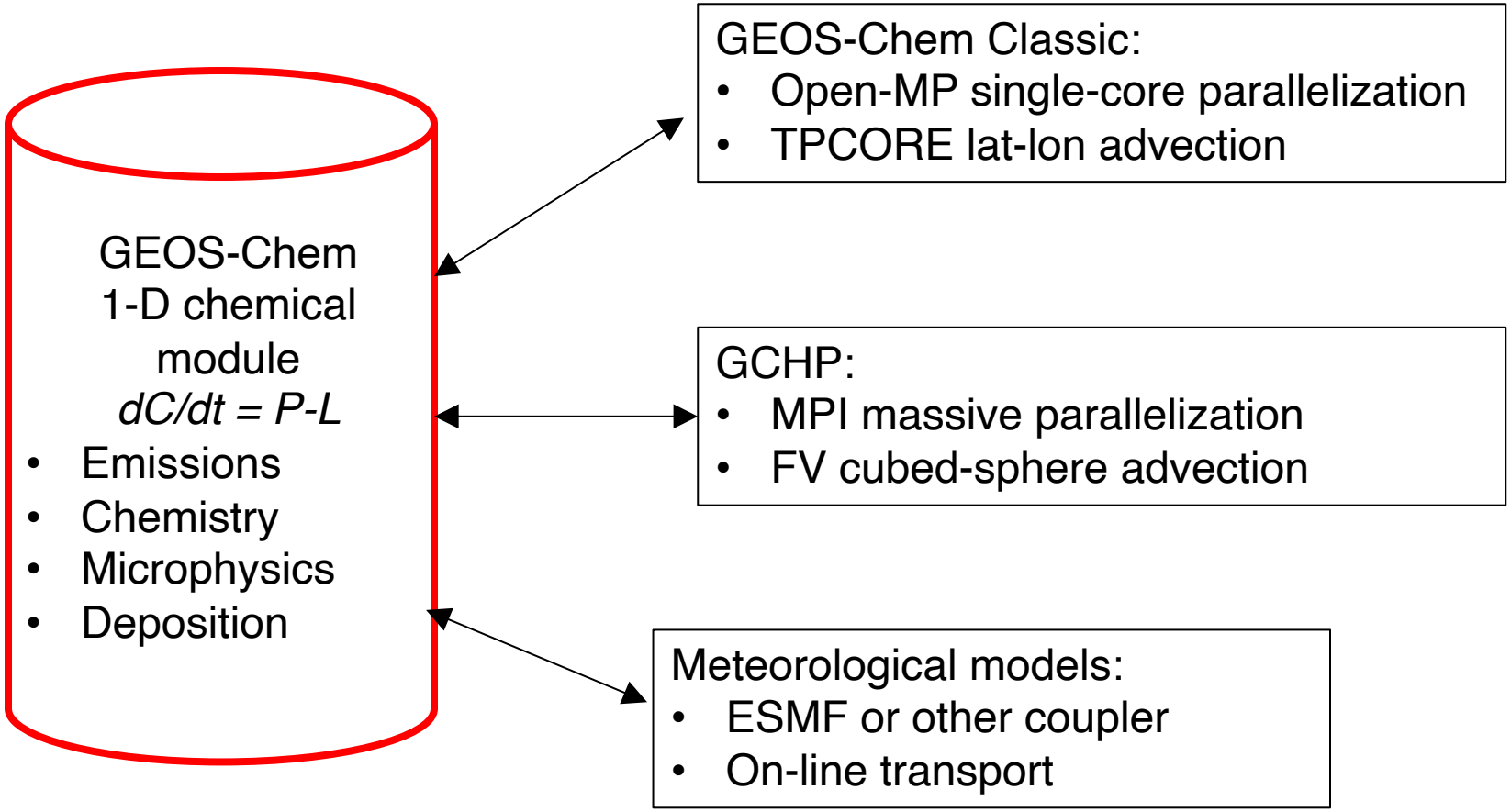
Major development milestones



Healthy tension between science and software engineering

GEOS-Chem needs to be both:

- A simple-to-use basic tool for advancing atmospheric chemistry knowledge;
- Capable of exploiting massively parallel systems, coupling with climate models



All implementations use the same cutting-edge, referenceable chemical module

But it still feels like surfing a wave

- GEOS-Chem cannot let up; our success is in remaining cutting-edge
- Not having a comfort zone makes us freer to innovate

A few things I have learned over the past 25 years

- **A grass-roots model can be a recipe for success**
  - Enables open participation of a broad community
  - Prioritize developments based on community needs, not external imperatives
  - Prioritize service to folks who will actually contribute
- **Getting scientists to use and contribute to GEOS-Chem is not difficult**
  - Scientists appreciate ease of use, inclusiveness, nimbleness, community
  - Developers want to be relevant and are willing to invest time for that
  - Trust is essential and is built at IGC meetings
- **Credit for model developers is critical**
  - No centralized GEOS-Chem paper to cite; instead, long list of individual papers
- **Relationship with NASA is crucial**
  - Without GMAO support we would be nothing
  - NASA support can be extensively leveraged with other funding sources
- **We cannot be everything to everyone**
  - Model developments need to be prioritized, with transparent process
  - Steering Committee advises, model scientist ultimately calls the shot
  - Low-end users cannot be supported
- **Don't micromanage the Support Team**
  - Define scientific/programmatic imperatives but let them define software engineering needs, ensure model integrity
  - Keep the Support Team happy!

Looking forward to the next 25 years of GEOS-Chem!

Thank you Randall for taking over the leadership!