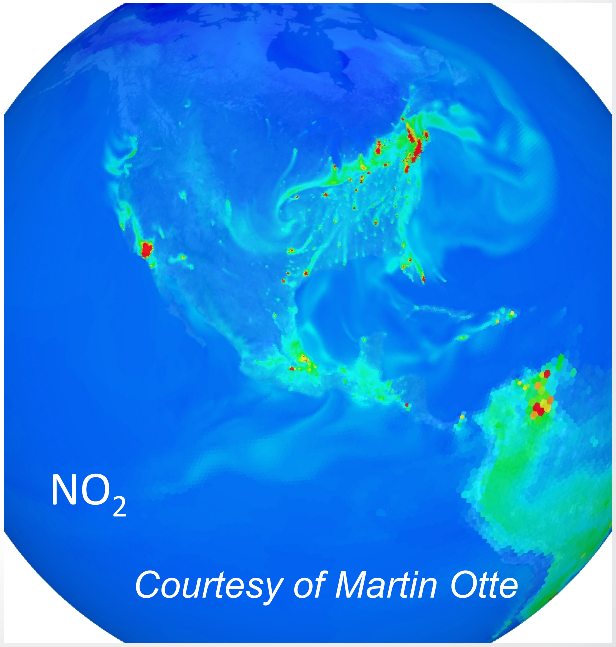
Next Gen AQ model

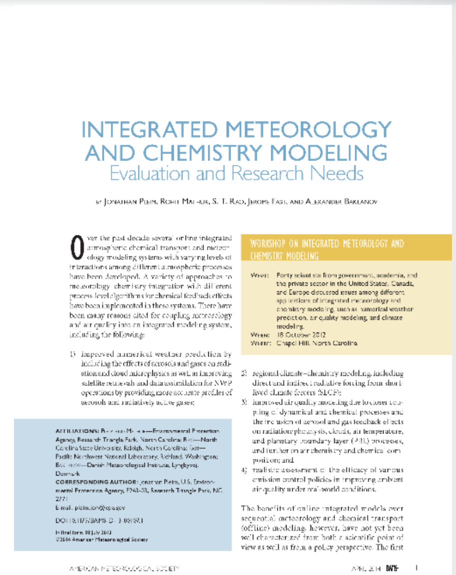
- **Need AQ modeling at Global to Continental to Regional to Urban scales**
  - Current systems using cascading nests is cumbersome
  - Duplicative modeling in overlap regions
  - Interpolation errors at boundaries
  - Seamless multi-scale grid refinement (e.g OLAM, MPAS)
    - Minimize interpolation errors in transition from coarse to fine resolution
- **Tighter AQ standards require global modeling:**
  - Inter-continental transport (Ozone and PM)
  - Stratospheric ozone
  - Marine chemistry
- **Earth system Linkages**
  - Greenhouse gases
  - Nitrogen, carbon cycling
  - AQ – Climate interactions
  - Eco, hydro linkages



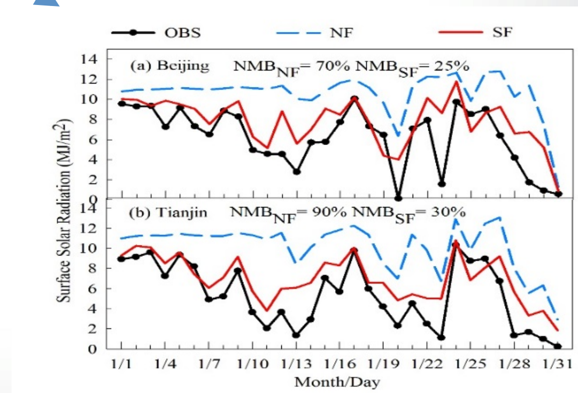
OLAM-Chem

Need for online Met-Chem model

- **Growing trend toward integrated Met-Chem modeling**
  – Improve NWP – radiative feedbacks and satellite data assimilation
  – Regional climate-chemistry modeling including SLCF
  – Improve AQ modeling
- **Chem affects Met which affects AQ**
  – Aerosol direct effects
    - Reduced SW ground → reduces PBL → greater concentrations
  – Aerosol indirect effects
    - Effects cloud cover, COD, radiative forcing, precipitation
    - Effects propagate through AQ
  – Gaseous direct effects on LW
    - Ozone, methane, N_2O, etc
  – AQ effects on land surface
    - Ozone damages stomatal function which affects:
      – Transpiration, CO_2 uptake, dry deposition
    - CO_2 changes, including regulatory controls, affect stomatal conductance


INTEGRATED METEOROLOGY AND CHEMISTRY MODELING
Evaluation and Research Needs

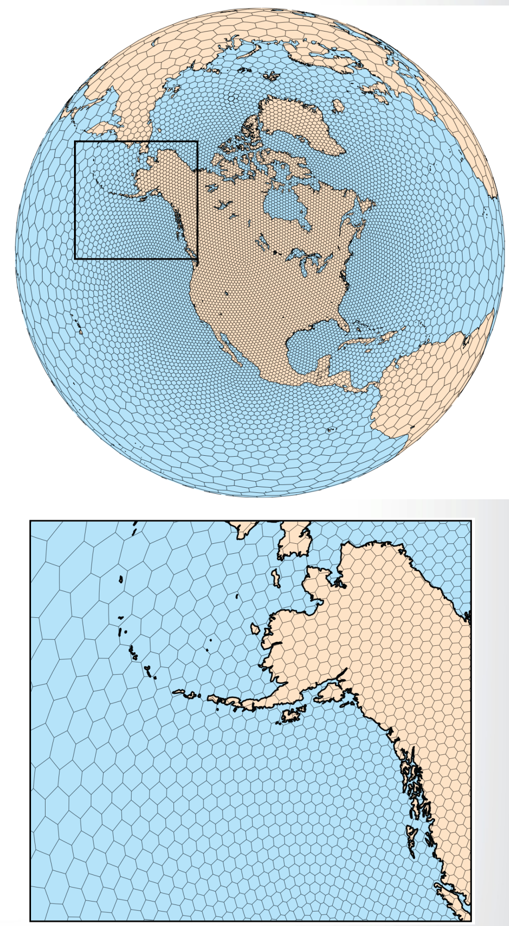
BAMS 2014



Jiandong Wang et al., 2014, ERL

Vision

- **Extend to global scales**
  - Single global mesh with seamless refinement to local scales
  - Integrated chemistry, dynamics, physics
- **Three configurations of flexible systems:**
  - On-line global variable grid (e.g. MPAS, OLAM)
  - Online regional (WRF-AQ)
  - Offline regional (redesigned CMAQ)
- **Interoperability of as much model code as possible**
  - Gas, aerosol, aqueous in modular box
  - Modules for biogenic emissions, dry dep/bidi, wind-blown dust, photolysis, etc
- **Transport in met models for online systems (adv, diffusion)**
  - Ensure mass conservation
  - Consistency with met parameters
  - Minimize numerical diffusion and dispersion



MPAS

Community development

- **Initial discussions among EPA, NCAR, NOAA, DOE**
  - Leverage diverse expertise across community
- **Multiple purposes:**
  - Air quality policy development and regulation
  - Air quality forecasting
  - Atmospheric chemistry research
  - Climate modeling with short-lived climate forcers
  - Earth system applications: coupled system for air, hydro, eco, ag, energy, etc…
- **Standardize model engineering for coupling chemical components to different dynamics models**
- **Initial steps: add chemistry to existing global models**
  - For example: MPAS-Chem, OLAM-Chem
- **Involve grant programs to foster development**
  - EPA STAR grants
  - DOE Model development grants

Integrated Met-Chem modeling

- **High temporal coupling (data exchange frequency > once per hour)**
  - Better resolve high-frequency meteorological dynamics
    - WS, WD changes, PBL height variations, cloud formation, rainfall
  - Affects chemical transport, transformation, and removal at high spatial resolution
- **More consistent dynamical, physical, and numerical modeling**
  - More constant cloud convective transport of chemistry and met
  - Closer integration of cloud microphysics and aqueous chemistry
  - More consistent advection and diffusion
- **On-line chemistry necessary for global models with non-uniform, refining grid meshes (e.g. OLAM, MPAS)**
  - Advection and horizontal diffusion must be integrated in dynamics solver

Domain config	WRF-CMAQ	WRFadv-CMAQ	Data transfer (min)	Increased time
CA 12 km, 16 cores	1:44:20	2:09:07	2.6	24% (3 run avg)
CA 4 km, 64 cores	9:37:21	15:05:05	46	57% (4 run avg)