System for Integrated Modeling of the Atmosphere (**SIMA**)

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NCAR

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NSF

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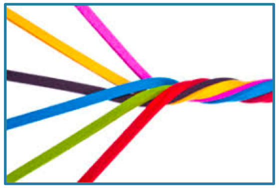

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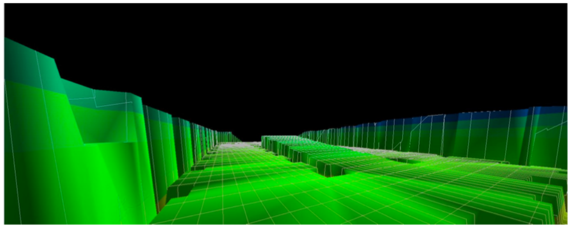


Why SIMA: Community Interests and External Recommendations

- NSF 2016 SVTs recommended that NCAR unify its modeling, particularly weather and climate
- Chemistry community desires unification of its various chemistry models
- WRF/MPAS community desires supported coupled (atmosphere-ocean) capability for high-resolution simulations
- Global air quality research requires local urban-scale resolution with global transport
- CESM research community needs to have improvements on ability to include new science (physics) in the Community Atmosphere Model (CAM)
- Geospace community has no access to full atmosphere (including deep dynamical core and magnetosphere) capability

What is the System for Integrated Modeling of the Atmosphere - SIMA?

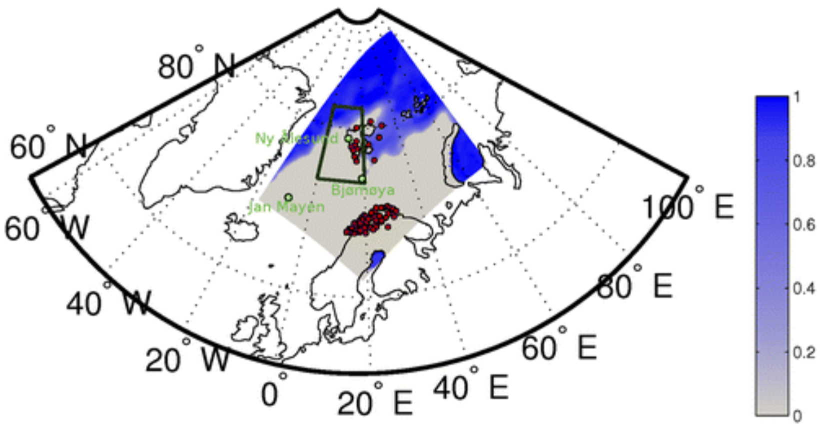
- SIMA is Infrastructure to:
  - Remove duplication of efforts across communities
  - Allow climate, weather, geospace and chemistry communities to collaborate and share innovations
  - Provide modeling capability that transitions smoothly across space and time scales
  - Permit new science for the research community
  - Ease the burden of implementing new technology: best practices
  - Provide a capability to explore feasibility of "complete" atmospheric modeling in the earth system
  - Allow capitalization on next-generation HPC technology
- SIMA is NOT:
  - A new model in addition to existing community models
  - Concerned directly with non-atmospheric components (but it could be a template for unification)

SIMA for the WRF/MPAS Community: New Science

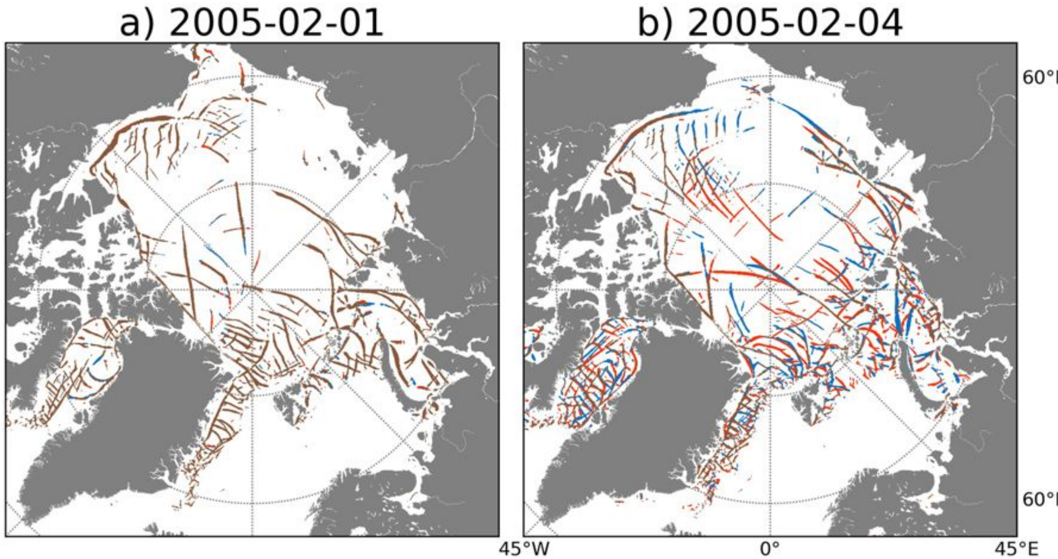
- Global coupled modeling (atmos.-ocean, atmos.-ice, atmos.-hydrology) at non-hydrostatic scales
  - Tropical cyclones
  - Tropical convection
  - Sea-ice-atmosphere feedbacks
  - Watershed scale seasonal modeling
- Regional coupled modeling (all the above)
- Air quality: local sources, global transport
- Deep-atmosphere applications: gravity waves
- Planetary geophysical systems

Coupled Atmosphere-ice-ocean Dynamics

Prediction of Linear Kinematic Features in Ice at 4.5 km Resolution



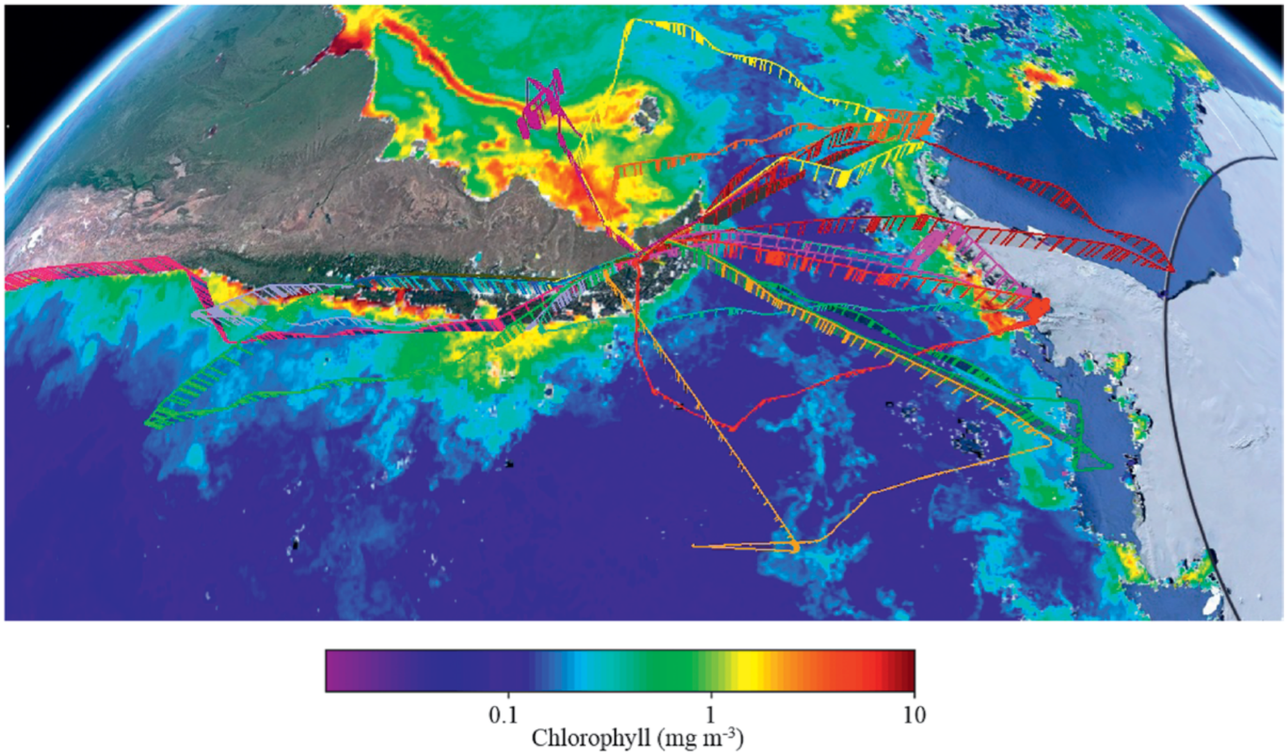
AROME-Arctic (2.5 km grid spacing)



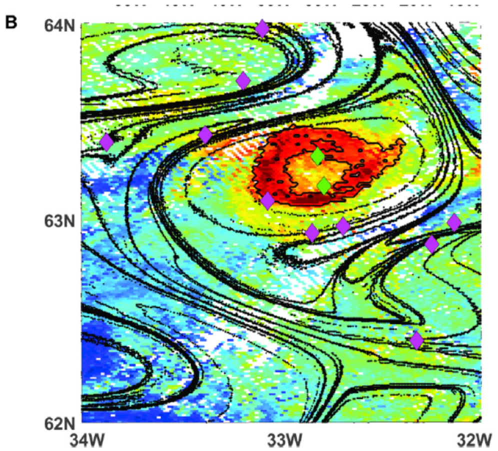
Müller, M., Y. Batrak, J. Kristiansen, M.A. Køltzow, G. Noer, and A. Korosov, 2017: Characteristics of a Convective-Scale Weather Forecasting System for the European Arctic. *Mon. Wea. Rev.,* **145**, 4771–4787

Mohammadi-Aragh, M., Goessling, H. , Losch, M. , Hutter, N. , Jung, T., 2018: Predictability of Arctic sea ice on weather time scales, nature scientific reports

Toward a Mesoscale Earth System View



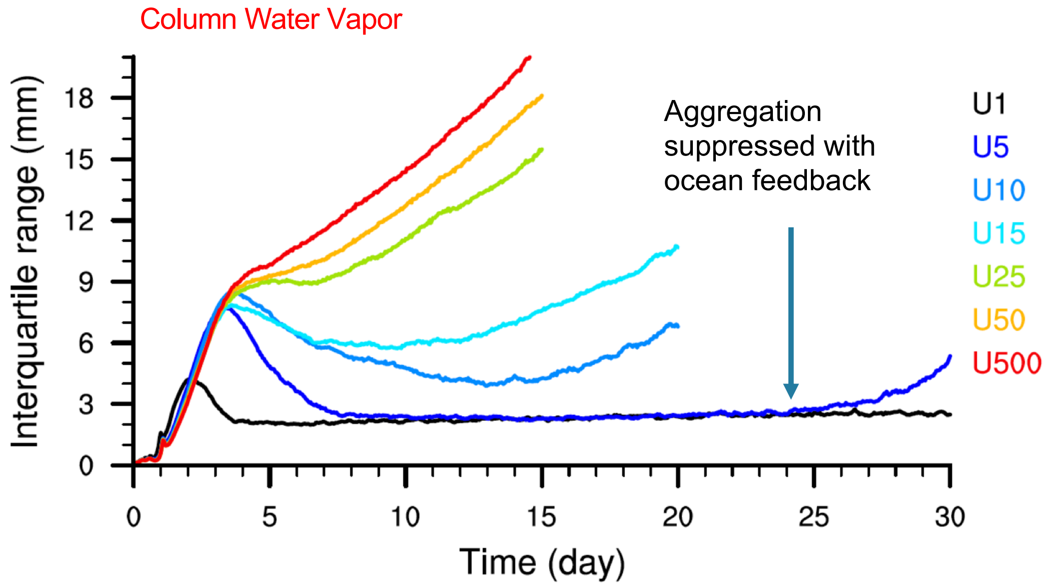
Stephens et al., 2018: BAMS: The O_2/N_2 Ratio and CO_2 Airborne Southern Ocean Study (ORCAS)



Phytoplankton bloom: Lehahn et al. 2014: Current Biology

Priorities for C-P model Development and Investigation

- Cloud-radiative-dynamics coupling
- Atmosphere-ocean and atmosphere-land coupling
- Consistency with coarse-resolution global models (cloud-radiative sensitivity)

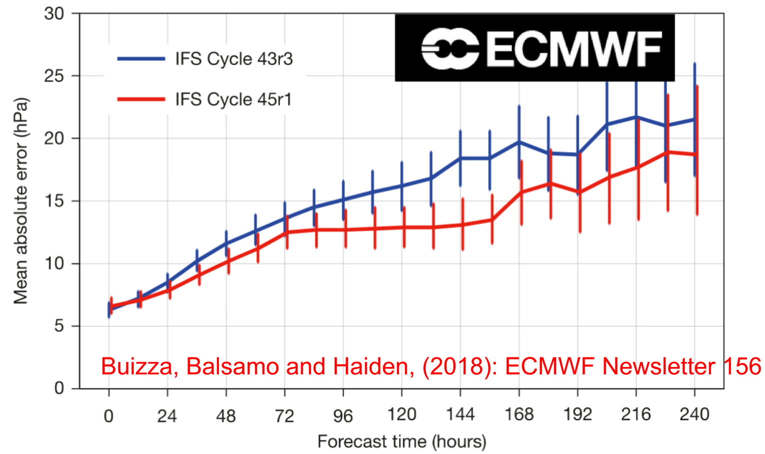


Hohenegger and Stevens, 2016: JAMES
see also Grabowski 2006: J. Atmos. Sci.

Other Centers are Already (Nearly) There

- Integrated Forecast System (IFS), June 2018: coupled forecasts at all lead times
- HRES: 9 km atmosphere, 137 levels
- NEMO: .25-deg ocean, 75 layers
- LIM2: sea ice

Tropical Cyclone Forecasts (N~750)



Met Office

Unified Model
- Regional down to dx=1.5 km
- Global at dx=10 km
- Seasonal and Climate Configurations

Unified Model

Current Impediments

- Dynamical core
  - CAM-6 does not include a nonhydrostatic dycore
  - A true deep atmosphere dycore does not exist
  - Chemistry modeling redundancy
- Code infrastructure
  - Lack of physics modularity in CAM
  - CAM parallelization layout does not allow for large numbers of grid columns
- Coupling
  - Weather community has no well supported coupled (atmos/ocean/land/ice) research system
  - Insufficient coupling capability to MHD
- Climate, weather and geospace communities have not traditionally worked closely together, but need to in order to have physical parameterizations that are usable across communities

Tasks Underway To Quantify Feasibility

(Through CY 2019)

- Including MPAS in CESM (single version from single GitHUB repository)
- Model Independent Chemistry Module
- Common Physics Framework, compatible with NOAA CCPP
- Evaluating solutions to CAM physics scalability

❖ All these are proceeding slowly given resource limitations and support of current systems

Near-Term Strategy

- Conduct development to enable science demonstrations and feasibility assessment
- Work with NWSC-3 effort to ensure consistency between SIMA infrastructure and future computing architecture
- Communicate with our constituents at upcoming meetings
  - MUSICA (unified chemistry)
  - WRF/MPAS Workshop
  - CESM Workshop
- SIMA Community workshop
  - Geospace, weather, chemistry, climate, hydrology, and HPC
  - Identify how various existing communities can collaborate
  - Intended to enhance, not compete with, existing governance