Welcome to NOAA/ OAR/ GFDL Symposium

V. “Ram” Ramaswamy
SYMPOSIUM is dedicated to the Memory of ANTS LEETMAA (1942 – 2017)
Logistics

- Please silence your cellphone during the Symposium
- Breaks will be upstairs (note: Taylor Auditorium is on B Level)
- No food or beverages allowed in the Taylor auditorium
- Restrooms are located on the A Floor – right side
- The GFDL “bell” will be used to call you all back from the breaks.
- See Dale Walton or Morina Royer for any logistics questions.
DOC Strategic Objective
NOAA - Alignment of Strategy

OAR MISSION
Conduct research to understand and predict the Earth’s oceans, weather and climate, to advance NOAA science, service and stewardship and transition the results so they are useful to society.
Adapted from
Donald Stokes (Woodrow Wilson School, Princeton University):
“Pasteur’s Quadrant: Basic Science and Technological Innovation” (1997)
“To advance scientific understanding of climate and its natural and anthropogenic variations and impacts, and improve NOAA’s predictive capabilities, through the development and use of world-leading computer models of the Earth System.”

Partnership with Princeton University since 1968
The Earth System
(Atmosphere, Oceans, Biosphere, Cryosphere, Ecosystems)
Chronology of recent GFDL Symposia and Review

- 2008: *Climate Research and Modeling Review*
- 2009: *OAR External Review*
- 2011: Symposium: “Advancing Scientific Understanding”
- 2013: Symposium: “*Frontiers in Climate and earth System Modeling*”
- 2014: *OAR External Review*
- 2015: GFDL 60th Anniversary (Diamond Jubilee): “Past, Present, and Future GFDL Success”
The Earth System
(Atmosphere, Oceans, Biosphere, Cryosphere, Ecosystems)

- Comprehensive, integrative modeling of the Earth System:
  *Atmosphere, Oceans, Cryosphere, Biosphere, Ecosystems*

- Unified Modeling System, for “seamless” predictability, from hours to decades, and from global-to-regional space scales
Major advancements in weather and climate science have come about with

- Improvements in theory & observations;
- Improved understanding of processes; and
- Advances in computational modeling

Oceans, Atmosphere, Biosphere, Cryosphere, Ecosystems

### Mathematical Modeling

\[ \frac{\partial v}{\partial t} + \frac{u}{a \cos \phi} \frac{\partial v}{\partial \lambda} + \frac{v}{a \sin \phi} \frac{\partial v}{\partial \phi} + w \frac{\partial v}{\partial z} + \frac{u^2 \tan \phi}{a} + \frac{v w}{a} = - \frac{1}{\rho_0 a^2 \sin \phi} F + P_0 \]

\[ f = 2 \Omega \sin \phi \]

\[ p(z) = \int_0^z \rho g dz + p_s \]

\[ \frac{1}{a \cos \phi} \frac{\partial u}{\partial \lambda} + \frac{1}{a \sin \phi} \frac{\partial v}{\partial \phi} + \frac{\partial w}{\partial z} = 0 \]

\[ \frac{dT}{dt} = \frac{u}{a \cos \phi} \frac{\partial T}{\partial \lambda} + \frac{v}{a \sin \phi} \frac{\partial T}{\partial \phi} + w \frac{\partial T}{\partial z} + D^{T_\lambda} + D^{T_\phi} + D^{T_z} \]
Use-inspired Research ➔

“Seamless” models across weather to climate timescales [powered by the NOAA “FV3” atmospheric dynamical core, and MOM]

GFDL HiRAM Global climate model
12.5 km resolution

Resolution

Surface currents and salinity
GFDL CM2.5 Model
Atmosphere: 50km
Ocean: 10-25km

Earth System Complexity

Aerosols - GFDL Atmospheric model (AM3)

Primary Productivity GFDL Global Coupled Earth System model

Stratospheric cooling

Surface-tropospheric warming

Severity of Summer Heat Waves

Observation

Model Simulation
FV3 core and GFS-based physics

- FV3-powered Global Forecast System to be a unified modeling system for regional to global predictions from 1-km to 100-km.
- Atmospheric dynamical core of NOAA’s Next Generation Global Weather Model
Frontiers in ocean/ice-sheet modeling: **MOM6**

**Role of ocean eddies in climate/earth system**

- 23 Dec 2004 Aqua Modis
- $L_d = 27$ km
- $100$ km
- $1/10^\circ$
- $8$ km

**Sea-level rise and ice-sheet/ocean interaction**

- Getz Ice Shelf, Antarctica
- $200$ ft (60 m)
- $1500$ ft below ocean surface (500 m)
GFDL ESMs for Coupled Biogeochemistry - Atmospheric Chemistry - Ecosystems - Climate

- Atmospheric circulation and radiation
  - Allows Interactive CO₂ and/or Chemistry
    - Self-consistent Physical and Biogeochemical Fluxes

- Ocean ecology and Biogeochemistry
- Ocean circulation
- Plant ecology and land use
- Land physics and hydrology
- Sea Ice
- Land Ice
Multiple weather-climate phenomena to be addressed

Quantify variability, extremes, and change

National Research Council (2012) Recommendation:
“Unified” modeling approaches

Internal Variability and External Forcings

- Tornadoes
- Snowstorms
- Hurricanes
- Typhoons
- Heat Waves
- Storm Track Variations
- Madden-Julian Oscillation
- El Niño-Southern Oscillation Precipitation extreme
- Intra- & Inter-season Variation
- Changes in the Arctic
- Decadal to Multi-decadal Variability
- Cryospheric
- Solar Variability
- Ocean: Circulation, SLR, Heat Content
- Greenhouse Gases and Aerosols

Weather to Climate is “Seamless”
Multiple weather-climate phenomena to be addressed

Quantify variability, extremes, and change

- Seamless Modeling of Weather, Climate, and Earth System:
  - Components
  - Coupled Interactions

- Earth System Processes: Atmosphere-Land Focus

- Earth System Processes: Oceans-Cryosphere Focus

Weather to Climate is “Seamless”
THANK YOU to ALL for your presence here, and for tuning in to the Webinar

The Scientific Organizing Committee:
Rong Zhang (Chair), John Krasting, Olga Sergienko, and Ming Zhao

The Communications and Logistics Committee:
Whit Anderson, Cathy Raphael, Laura Rossi, Morina Royer, Maria Setzer, Anna Valerio, and Dale Walton