Development of a Regional Arctic Climate System Model (RACM)

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Need for Regional
Arctic Climate System Model

• There are large errors in global climate system model simulations of the Arctic climate system

• Observed rapid changes in Arctic climate system
  – Sea ice decline
  – Greenland ice sheet
  – Temperature

• Arctic change has global consequences
  – Sea ice change can alter the global energy balance and thermohaline circulation
Project Goals

• Develop a state-of-the-science regional Arctic climate system model (RACM)

• Include high resolution:
  – Atmosphere (WRF – 50 km)
  – Ocean (POP – 9 km)
  – Sea ice (CICE – 9 km)
  – Land (VIC – 50 km)

• Model components coupled using NCAR CCSM4 coupler (CPL7)
Science Objectives

• Perform multi-decadal simulations to:
  – Gain improved understanding of coupled Arctic climate system processes responsible for changes in
    • Arctic sea ice cover
    • hydrologic cycle
    • freshwater export
  – Improve predictions of Arctic climate change
  – Identify limitations and physical and numerical requirements of global climate system model simulations of Arctic
Accomplishments to Date

• 3\textsuperscript{rd} year of 4 year DOE funded project
• Coupling of all model components has been completed
• Model component and coupled model evaluation studies
  – WRF evaluation
  – Coupled VIC/WRF simulations
  – Simulation of sea ice loss with POP/CICE
  – Oceanic heat transport
  – Fully coupled WRF/POP/CICE/VIC simulations
VIC Coupling: Initial Results
Chunmei Zhu

- WRF, POP, CICE and VIC are coupled and run for more than 1 month, currently testing restarts.
- Moving to a 10-15 year fully coupled simulation
Sea ice: Modeled Sea Ice Loss

NPS Arctic Model Effort (NAME): POP/CICE
Sea ice thickness (m) in (a) 1982, (b) 1992, (c) 2002
(Maslowski et al., 2007)
Heat accumulating in the sub-surface western Arctic Ocean since late 1990s contributes to sea ice melt.
Coupling of WRF and CPL7

- Led by Juanxiong He with contributions from Tony Craig and Mark Seefeldt
- Minimize changes to WRF and CPL7
- Added new surface routine to WRF to accept fluxes from CPL7

- Variables passed from WRF to CPL7
  - Atmospheric state
  - Downwelling radiative fluxes
  - Precipitation

- Variables passed to WRF from CPL7
  - Turbulent fluxes
  - Upward radiative fluxes
  - Surface state
WRF/POP/CICE Coupling: Initial Results
Juanxiong He

Sea ice: 1 Feb 2003

Sea ice: 1 July 2003
Next Steps

• Run long duration fully coupled simulation
  • Evaluation of fully coupled model
  • Multi-decadal simulations
    – Retrospective
    – Future climate

• Long-term goals
  – Regional simulations for next IPCC report
  – Additional climate system components
    • Ice sheets
    • Biogeochemistry