

A Portable Regional Weather and Climate Downscaling System Using GEOS-5, LIS-6, WRF, and the NASA Workflow Tool

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Regional Downscaling System

Acknowledgements

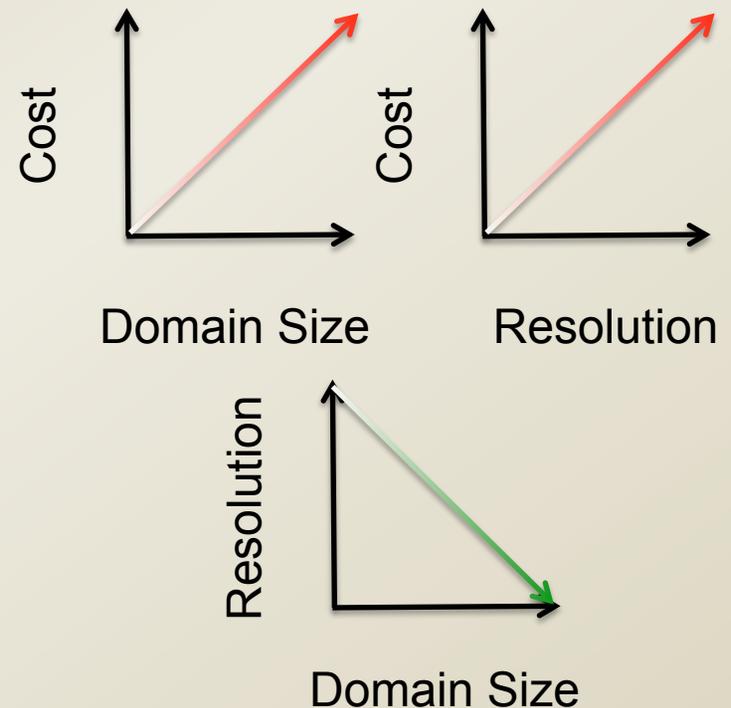
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- WRF simulation visualized by G. Shirah (SIVO)



Regional Downscaling System

Motivations

- High computational costs for numerical weather/ climate simulations with:
 - Large domains
 - High grid resolutions
- Low grid resolutions frequently reduce quality
 - Subgrid scale parameterizations



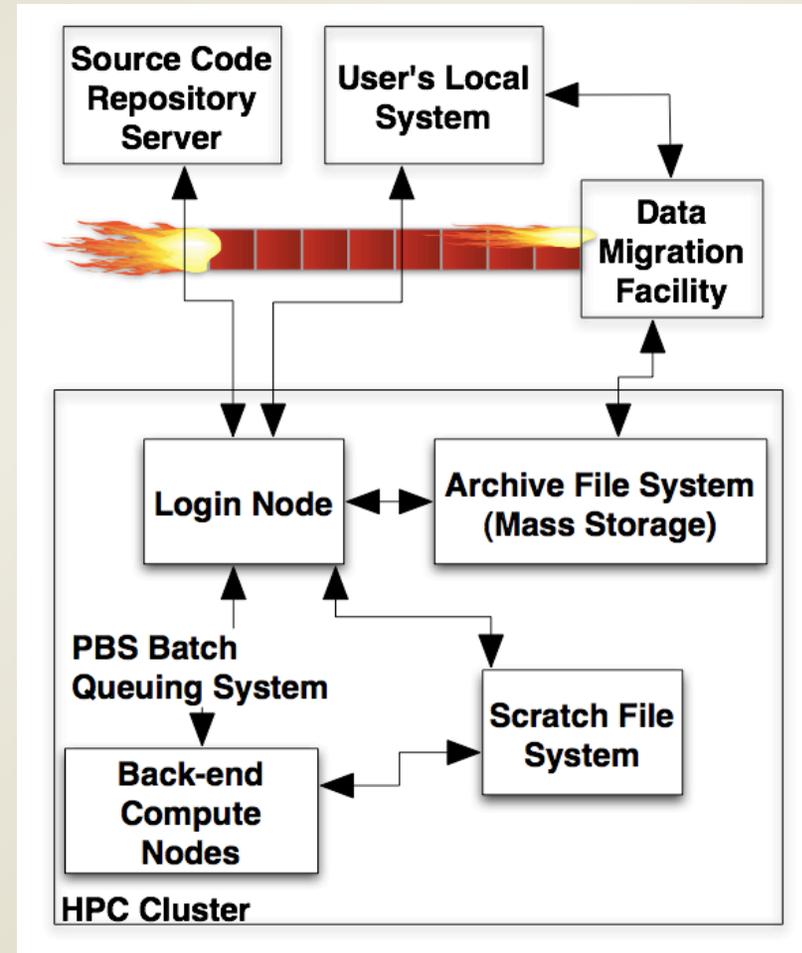
Regional downscaling can be a useful compromise



Regional Downscaling System

Motivations

- Must balance computational needs with availability
 - Access restrictions
 - Quotas on CPU hours
- Must manage file transfers, queuing systems, firewalls, etc.



Need flexible automation tool to manage low-level details



Regional Downscaling System

Objectives

- Nest fine-grid limited-area atmospheric model within coarse-grid global model
- Generalize for a range of applications, including:
 - Chesapeake Bay environment modeling (runoff, water temperature/chemistry, ecology, etc.)
 - Observing System Simulation Experiments (OSSEs)
- Use current-generation physics and numerics
- Design for flexibility across computer systems
- Simplify the tasks for the modeler



Regional Downscaling System

Goddard Earth Observing System Model 5 (GEOS-5)

- Global general circulation model with chemistry
- Ocean model option (MIT, MOM4, POSEIDON)
- Used for weather prediction, OSSEs, global climate
- Initialized from:
 - Modern Era Retrospective-Analysis for Research and Analysis (MERRA; 0.5 deg grids, 1979-2009)
 - Gridpoint Statistical Interpolation (GSI) data assimilation system (DAS)



Regional Downscaling System

Weather Research and Forecasting Model (WRF)

- Non-hydrostatic mesoscale/large-eddy scale model
- State-of-the-art numerics and physics
 - Recent modifications for climate runs (e.g., prognostic deep soil temperature, CO₂ profiles in CAM radiation)
- Used for weather prediction, regional climate
- SIVO software (GEOS2WRF) converts GEOS-5 fields into initial and lateral boundary conditions
 - Effectively a one-way nest



Regional Downscaling System

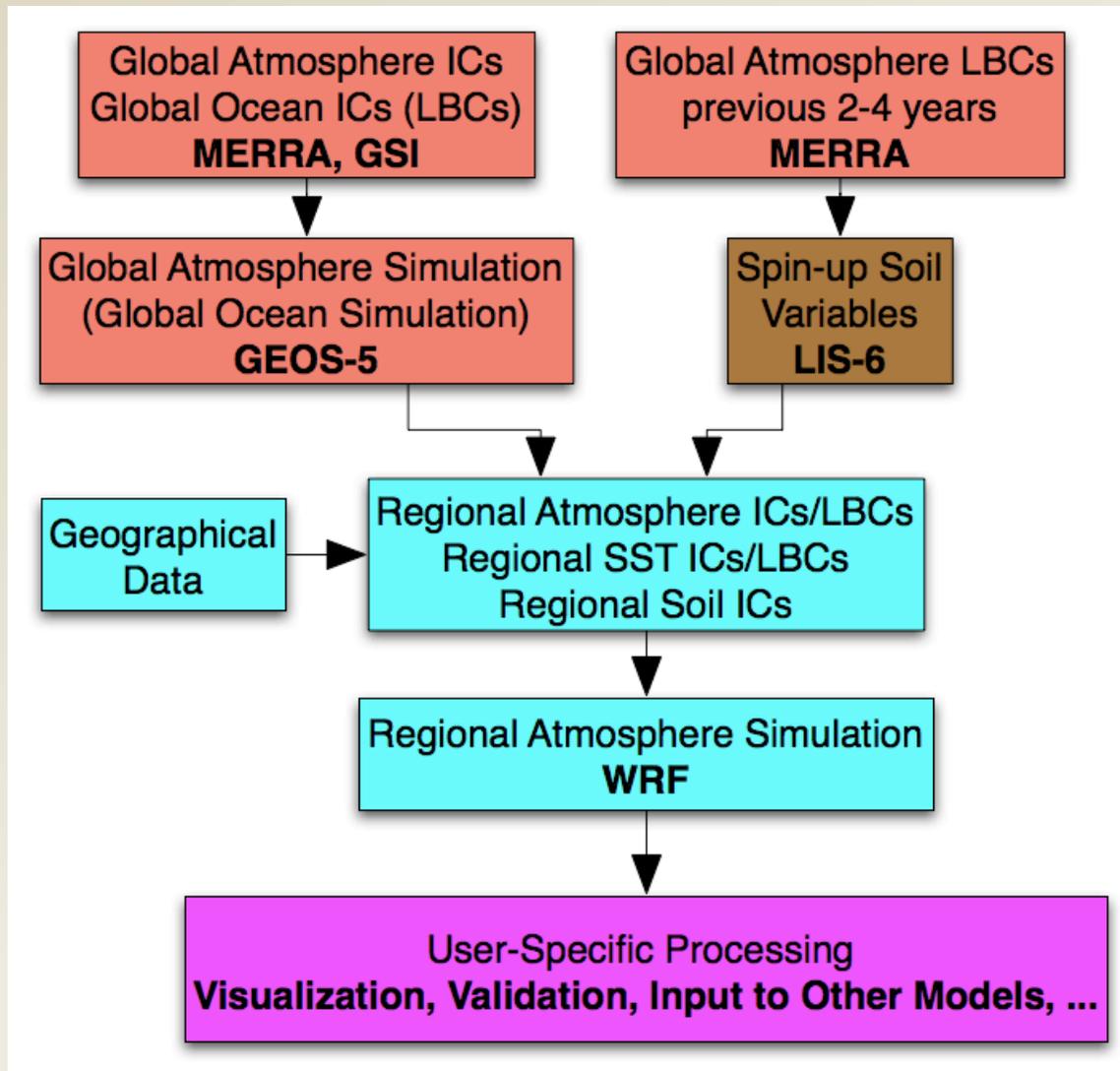
Land Information System 6 (LIS-6)

- GEOS-5 soil physics incompatible with WRF
 - Soil conditions must come from another source
- LIS-6:
 - Framework for running soil parameterizations forced by atmospheric data
 - Includes Noah soil physics also found in WRF
- SIVO software (MERRA2LIS) generates lateral boundary conditions from MERRA data



Regional Downscaling System

Implementation



- IC: Initial conditions
- LBC: Lateral boundary conditions
- SST: Sea surface temperatures



Regional Downscaling System

Workflow Tool

- Developed by SIVO
- “Glue” for downscaling system
- GUI front-end simplifies experiment setup
- Saves multiple configurations, detects errors prior to runtime

The screenshot shows the NED 1.4 Workflow Tool interface. The title bar reads "NED 1.4 User: rburns Mode: USER". The menu bar includes "File", "Search", "Tools", "Run", "Views", and "Help". The interface is divided into several panels:

- Configuration Tree:** A hierarchical tree view on the left showing the configuration structure. The "Resolution and layout" folder is expanded, showing sub-items: "V= MODEL_RES", "V= NX", "V= NY", and "V= DT".
- Configuration Panel:** A table on the right showing configuration details. It has two columns: "Group Property" and "Information".
- Configuration Table:** A table below the configuration panel with columns "Name", "Description", and "Values".
- Status Panel:** A table at the bottom with columns "Status", "Affects", and "Description".

Current File: /home/workflow/sharedExperiments/geos5gcm.ned Logged Into: localhost:8222[NCCS Alpha]

Group Property	Information
Name	Resolution and layout
Description	Settings for model resolution and computational layout

Name	Description	Values
MODEL_RES	Model resolution (IMxJM)	2.5x2
NX	CPU decomposition in x-direction	2.5x2
NY	CPU decomposition in y-direction	1.25x1
DT	Model time step	2/3x1/2 1/3x1/4

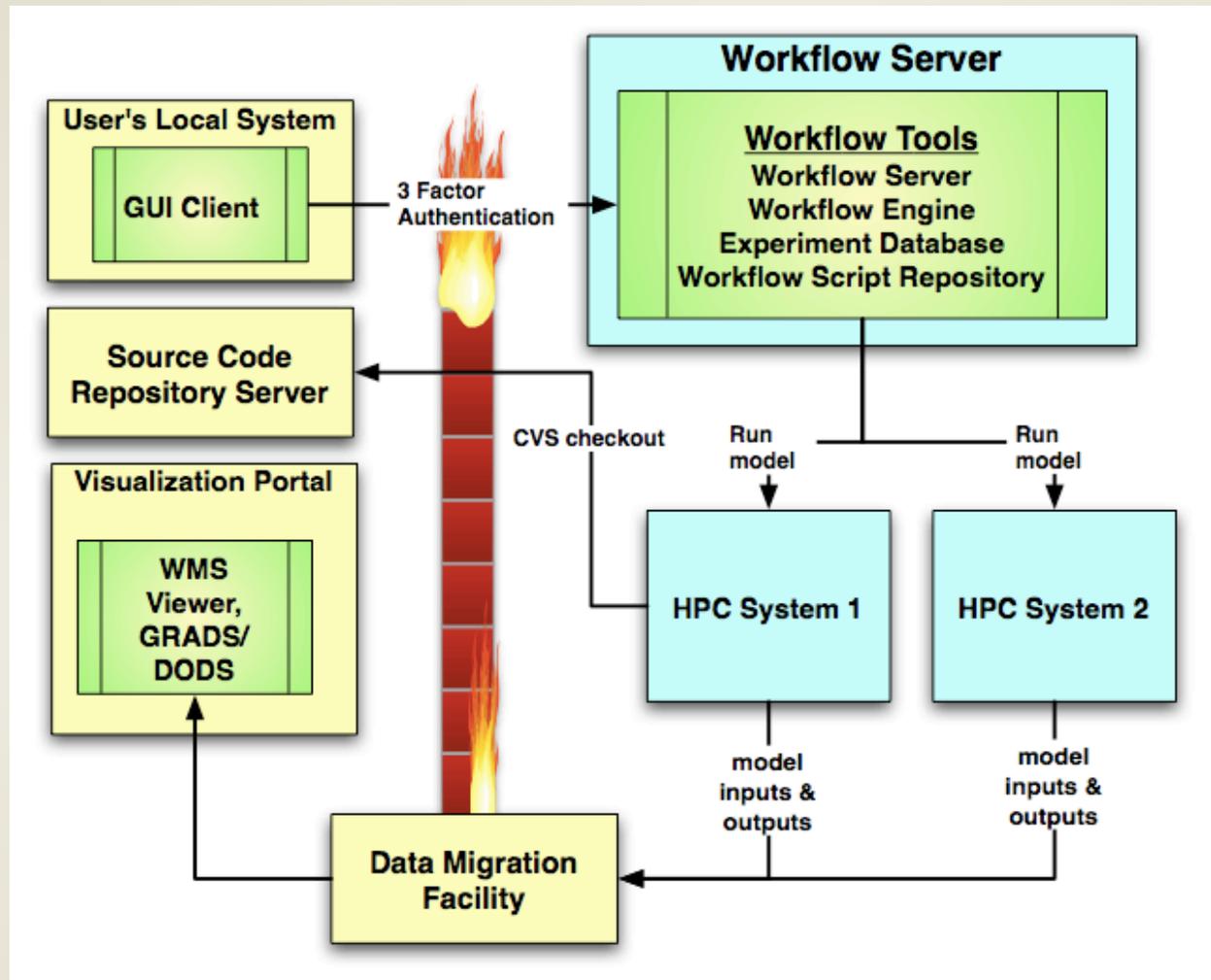
Status	Affects	Description
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Regional Downscaling System

Workflow Tool

- Retrieves/compiles source code from repository
- Submits/monitors runs in batch queues
- Uploads/downloads from mass storage





Regional Downscaling System

Status

- GEOS-5, LIS-6, and WRF run sequentially but separately for downscaling
 - Run on GSFC DISCOVER supercomputer
 - Simulated Hurricane Isabel landfall (18-20 Sep 2003)
- MERRA data from 2001-2007 retrieved from mass storage and processed for LIS-6
- Workflow configurations written for:
 - GEOS-5
 - Most preprocessing for WRF



Regional Downscaling System

Status

- Workflow development still underway for:
 - LIS-6 (including pre- and post-processing)
 - Running jobs outside of DISCOVER (CX-1)
- Separate software development underway to run WRF directly from MERRA re-analyses
 - Workflow option will need to be added



Regional Downscaling System

Example Simulation



48-hour simulation of Hurricane Isabel, valid 18-20 September 2003
Three WRF grids (36/12/4 km) initialized from GEOS-5 (0.5°), LIS-6 (36/12/4 km)
Cloud water mixing ratio (white) and cloud ice mixing ratio (blue)



Regional Downscaling System

Summary

- Developing a regional downscaling system for multiple weather and climate applications
- Components include:
 - a global atmosphere/ocean model (GEOS-5)
 - a regional land surface model system (LIS-6)
 - a regional non-hydrostatic atmosphere model (WRF)
- Components can be run separately using MERRA re-analysis data from 2001-2007



Regional Downscaling System

Future Work

- Complete end-to-end workflow integration
- Port workflows to other machines (CX-1)
- Pre-process entire MERRA re-analysis dataset (1979-2009) for LIS-6
- Automate GSI as front-end to GEOS-5
- Produce and validate present-day climate runs
- Interface with Chesapeake Bay models (e.g., ChesROMS ocean model)
- Hurricane OSSEs