

# The Smart Management of WRF Simulation (SMWRFS) System for the Smarter Operations of the WRF Model for Regional Climate Simulations

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## Background

Led by the Purdue Climate Change Research Center, scientists at Purdue, IU, Ball State Univ., Notre Dame, and Midwestern Regional Climate Center and decision makers from across the state are working together to develop the Indiana Climate Change Impacts Assessment (IN CCIA). The IN CCIA consists of nine Working Groups (WGs): Agriculture, Aquatic-Ecosystems, Climate, Energy, Health, Infrastructure, Terrestrial-Ecosystems, Tourism and Recreation, & Water Resources. The series of reports stemming from the IN CCIA will take a comprehensive look at the many ways a changing climate is expected to affect state and local interests. Regional climate simulation is the most pivotal sources of climate information for the WGs to assess climate change and its multifaceted risks and impacts for the state. This assessment will give Hoosiers access to the best available climate information, allowing us to build more effective plans for a more productive future.

## Objectives

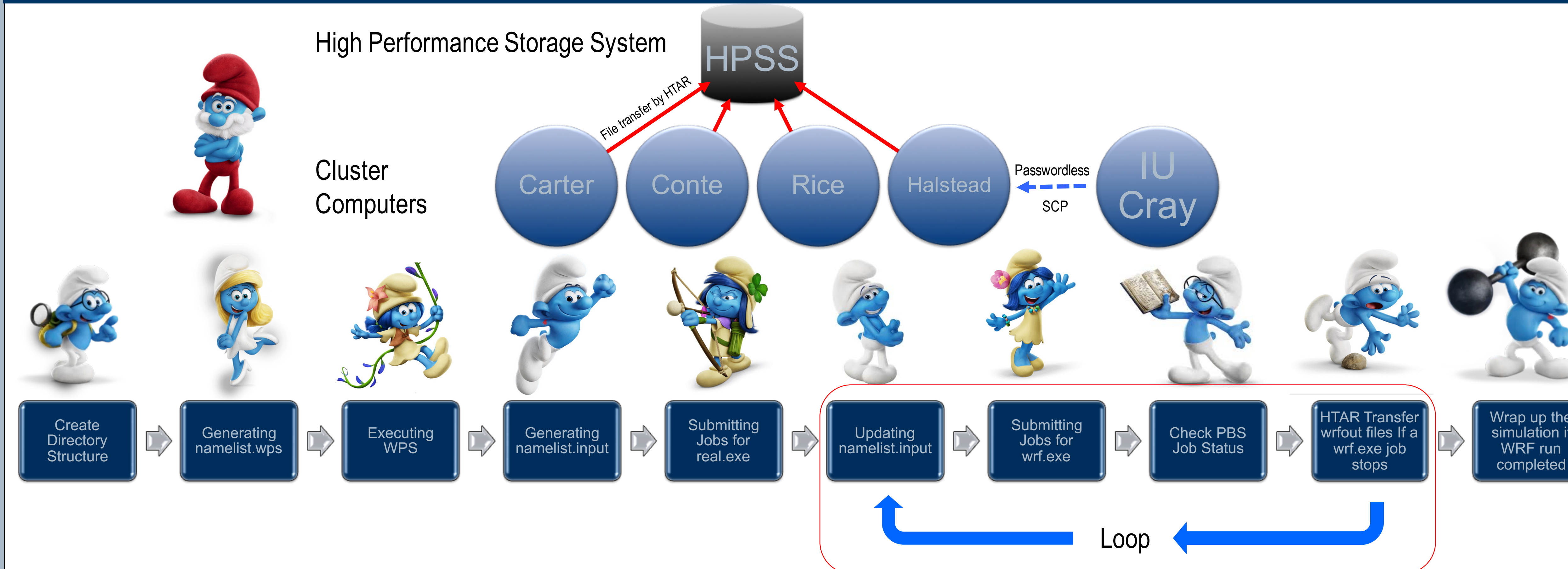
A prototype of the Smart Management of WRF Simulation (SMWRFS, pronounced as “Smurfs”) system was developed and employed for the efficient and seamless execution of parallel regional climate simulations for the IN CCIA. The main purpose of the SMWRFS is to run any number of WRF simulations in an automated fashion, avoiding time-consuming manual management of namelist files, job scripts files, and output files on the production scratch directories during restarts of simulations, which can be overwhelming in a long-term climate simulation with many time slices. With the SMWRFS, researcher can work more on scientific topics of regional climate modeling such as modeling design and model evaluation with less time spent on efforts for “seemingly endless” regional model executions.

## Key Tasks of the SMWRFS

In general, the SMWRFS can handle all the WRF modeling processes including WPS. But its key tasks include:

- 1) To restart the WRF climate simulation from the point where the previous WRF simulation ends by updating namelist.input and submitting job script.
- 2) To monitor WRF jobs and handle the simulation outputs professionally by storing the outputs (if available) to High Performance Storage System (HPSS) tape archive storage using HTAR method, managing the scratch disc space of the cluster computer efficiently.

## Multiple HPCs Setting & SMWRFS Workflow



## Dynamical Downscaling

### General

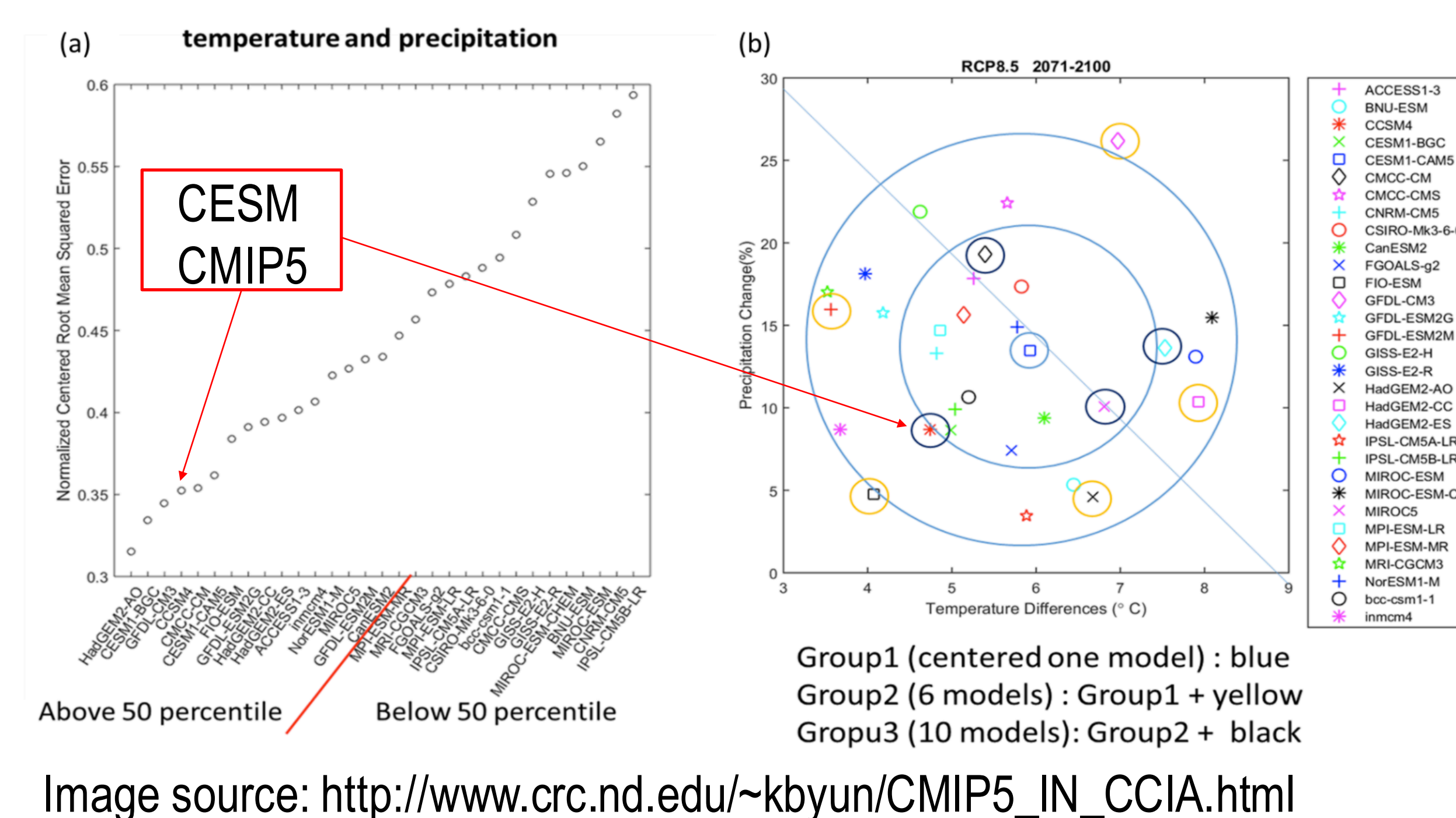
- WRF V3.8.1
- Inner-most (4 km) domain for states of Indiana, Illinois, lower Michigan
- Historical: 1976-2005
- Future: 2006-2100 (RCP8.5)
- GCM input: NCAR Community Earth System Model (CESM) CMIP5 run output (CCSM4 with CAM4) (a.k.a. NCAR CESM Global Bias-corrected CMIP5 Output)

### Model Physics

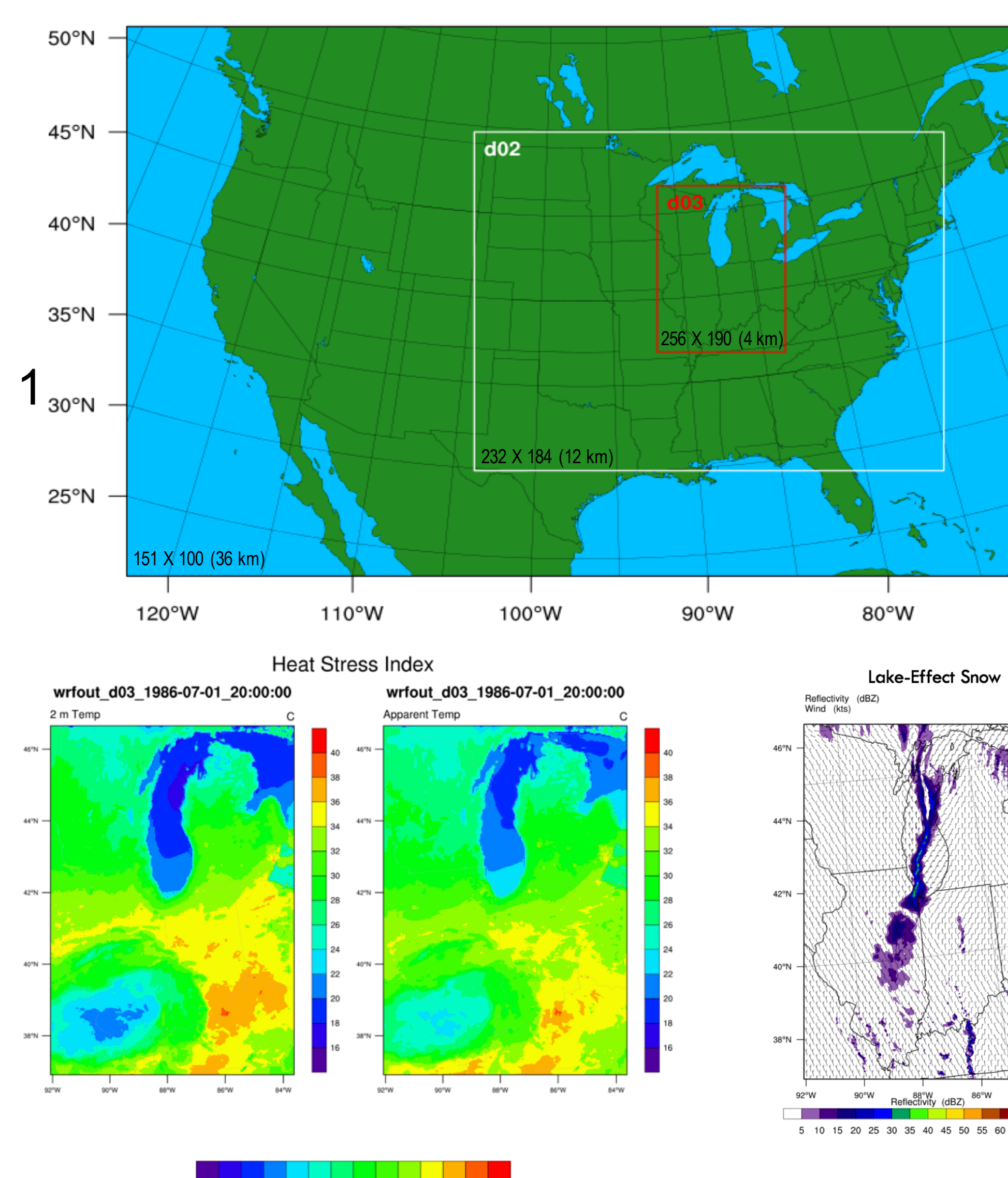
- CAM5.1. 5-class microphysics (mp\_physics, 11)
- RRTMG long & short wave radiation scheme (ra\_lw & SW\_physics, 4)
- Revised MM5 Monin-obukhov scheme (sf\_sfclay\_physics, 1)
- CLM4 (Community Land Model Version 4) land surface option (sf\_surface\_physics, 5)
- YSU boundary layer option (bl\_pbl\_physics, 1)
- Kain-Fritzsche (New Eta) cumulus parameterization for domain 1 & 2 only (cu\_physics, 1)
- With/Without CLM v3.5 1-Dimensional Lake Model (mass and energy balance) (Gu et al. 2015)

### Operational Perspectives

- Hourly outputs for 125 years long (1500 months)/15-day spin up before each month (45 or 46 days simulation)
- “Restart” after each day’s simulation due to wallclock limits (e.g., 4 hours or 48 hours)
- 125 years’ simulation completed within five month (late November 2016 ~ early April 2017).



## WPS Domain Configuration



## More on SMWRFS

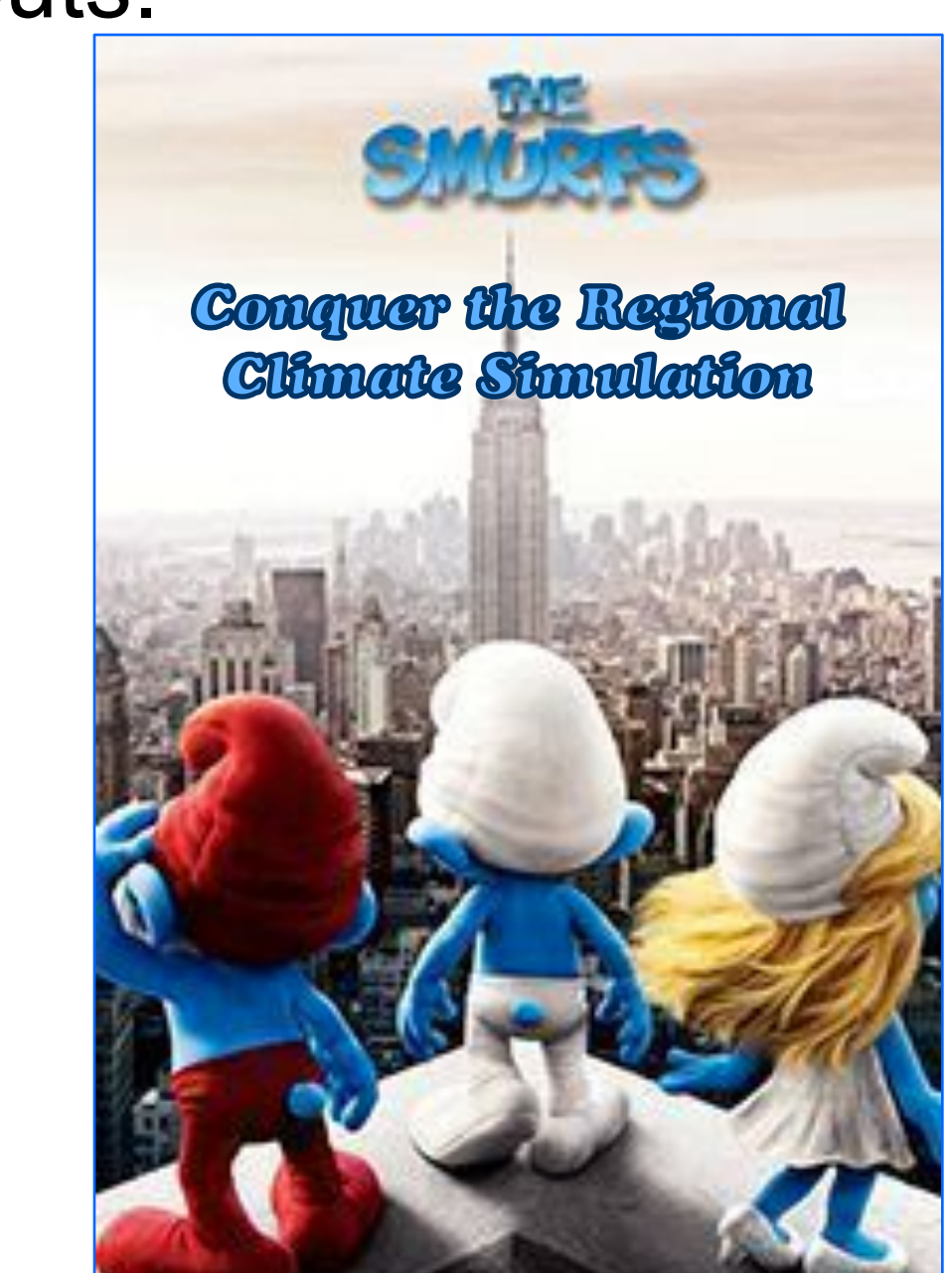
- Being coded in Bash shell script language, the SMWRFS can be easily adopted and used on many Unix/Linux/Clay environment machines.
- The SMWRFS was successfully applied on four Linux clusters at Purdue University and one Cray cluster at Indiana University, storing the WRF simulation outputs on a HPSS simultaneously and collaboratively.
- Users should determine model designs (e.g., domain, physics schemes, simulation periods through a template of namelist.input), work machines (e.g., HPCs), data storage location.
- Using template files (e.g., namelist.wps, namelist.input, job script files), the SMWRFS control the entire work processes.

## Code Improvements

- SMWRFS will be incorporated with NCEP Unified Post Processor (UPP) so that WRF output files can be converted into GRIB2 files before WRF output files are stored at HPSS. This will shorten the time for the post-processing and data analysis by avoiding the bottle-neck of file transfer between cluster scratch disc and the tape archive system.

## Ongoing Works Relevant

- **WRF-Lake coupled regional climate simulation for IN CCIA**  
For the IN CCIA the SMWRFS is being employed to run a WRF-Lake coupled regional climate simulation with the same domain & configuration setting except the WRF 1-D lake options.
- **Connect to NCAR Model Evaluation Tools (MET)**  
Similar methods using Bash shell script will be employed to control the front-to-end processes of the MET to generate the state-of-the-art statistical evaluation & analysis of the WRF regional climate simulations against various observation data (e.g. TRMM, MODIS, Stage II & IV, USHCN) and model outputs.



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