Weather Research and Forecasting (WRF) Modeling System

A Brief Overview

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Outline

- What is WRF?
- WRF Dynamic Cores
- WRF Modeling System
- WRF Software Design
- What is WRF-NMM?
- WRF-NMM Model Physics

What is WRF?

- WRF: Weather Research and Forecasting Model
- Development led by NCAR/MMM, NOAA/FSL and NOAA/NCEP/EMC with partnerships at AFWA, FAA, NRL and collaborations with universities and other government agencies

WRF Characteristics

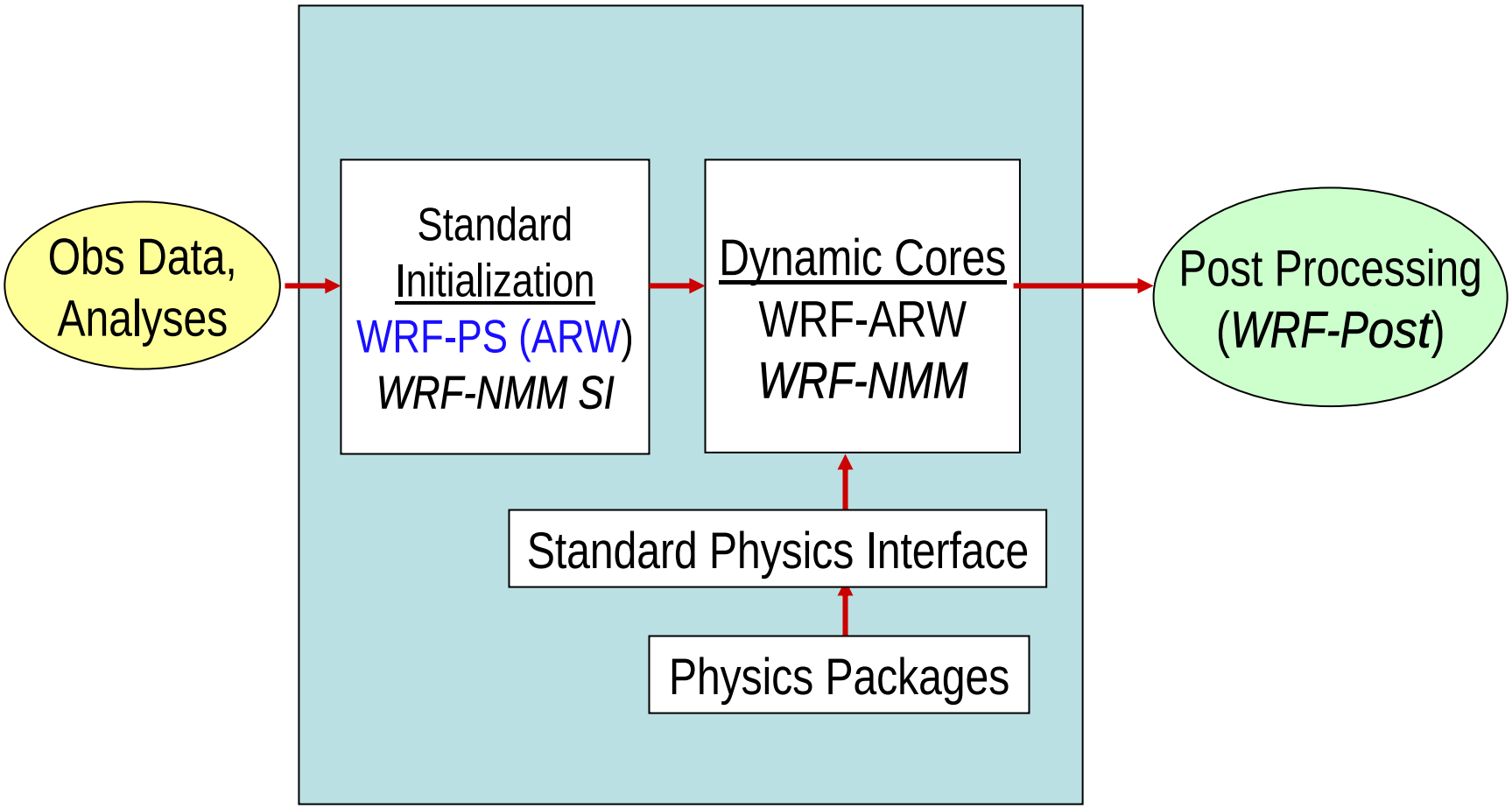
- Includes research and operational models
- Highly modular, single source code with plug-compatible modules,
- State-of-the-art, transportable, and efficient in a massively parallel computing environment,
- Design priority for high-resolution (nonhydrostatic) applications,

WRF Dynamic Cores

- Advance Research WRF (ARW)
  - ✓ Terrain-following hydrostatic pressure vertical coordinate
  - ✓ Arakawa C-grid
  - ✓ 3rd order Runge-Kutta split-explicit time differencing, 5th or 6th order differencing for advection
  - ✓ Conserves mass, momentum, dry entropy, and scalars using flux form prognostic equations
- Non-hydrostatic Meso-Scale Model (NMM)
  - ✓ Terrain-following hybrid (sigma-pressure) vertical coordinate
  - ✓ Arakawa E-grid
  - ✓ Explicit time differencing
  - ✓ Conserves mass, kinetic energy, enstrophy and momentum, as well as a number of additional first order and quadratic quantities using 2nd order finite differencing

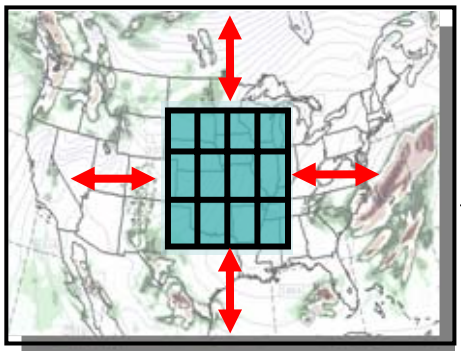
WRF-NMM dynamics will be presented in detail by Tom Black.

WRF Modeling System

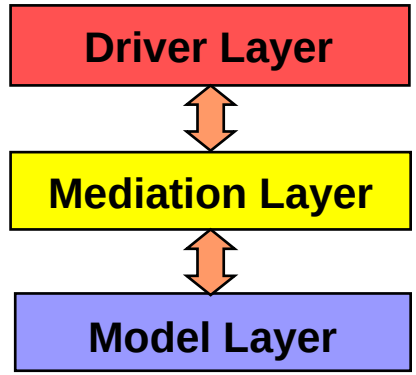


WRF Software Infrastructure

WRF Software Design



- **Modular, hierarchical design**
- **Plug compatible physics, dynamical cores**
- **Parallelism on distributed- and shared memory processors**
- **Efficient scaling on foreseeable parallel platforms**
- **Integration into Earth System Model Framework (ESMF)**



WRF-Software will be explained in detail by Dave Gill.

What is WRF-NMM?

- WRF Non-hydrostatic Meso-Scale Model (WRF-NMM) is a large sub-set of WRF. (Dynamical core developed by NOAA/NWS/NCEP/EMC).
- WRF-NMM is a freely available community model.
- WRF-NMM system includes: initialization (WRF-NMM SI), NMM dynamical core and post-processing (WRF Post-Processor and graphic packages) components.
- This tutorial covers all the WRF-NMM components.
- Physics and software framework are shared with WRF-ARW.
- User support for WRF-NMM will be provided by DTC and NCEP.

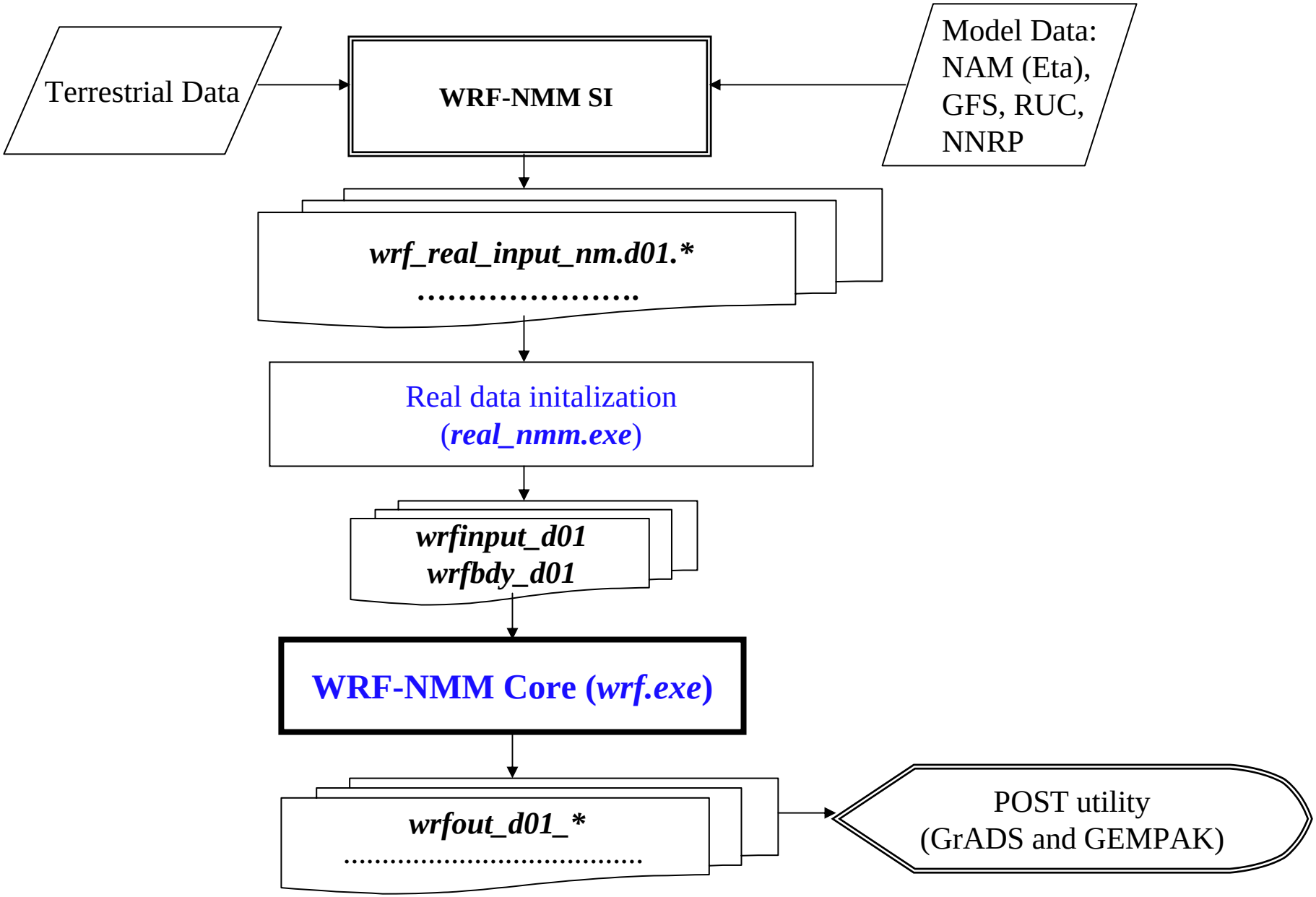
WRF-NMM Model Physics

- Plug-compatible interface defined for physics modules
- NCEP's operationally used physics options for WRF-NMM:
  - ✓ Microphysics: Ferrier
  - ✓ Cumulus Convection: Betts-Miller-Janjic
  - ✓ Shortwave Radiation: GFDL
  - ✓ Longwave Radiation: GFDL
  - ✓ Lateral diffusion: Smagorinsky
  - ✓ PBL, free atmosphere: Mellor-Yamada-Janjic
  - ✓ Surface Layer: Janjic Scheme
  - ✓ Land-Surface: 4-layer soil model

Physics section will be given in detail by Jimy Dudhia, Tom Black and Mike Ek.

WRF-NMM Modeling System Components

- WRF-NMM Standard Initialization (WRF-NMM SI)
- WRF-NMM Model
  - An Initialization program for real data ***(real_nmm.F)***
  - Numerical integration program ***(wrf.F)***
- WRF Post-Processor and Graphics tools



WRF-NMM Flow-Chart

WRF-NMM Standard Initialization (WRF-NMM SI)

- For real-data runs
- Inputs
  - Terrain/land-use/soil texture/albedo
  - Grid location/levels
  - Gridded fields (in GRIB format)
- Output
  - Surface and meteorological fields on WRF grid at various times e.g. *wrf_real_input_nm.d01.(date_string)*

WRF-NMM SI will be presented in detail by Matthew Pyle.

WRF-NMM SI software package

Functions:

- ✓ Define simulation domain area
- ✓ Produce terrain, landuse, soil type etc. on the simulation domain (“static” fields)
- ✓ De-grib GRIB files for meteorological data (u, v, T, q, surface pressure, soil data, snow data, sea-surface temperature, etc.)
- ✓ Interpolate meteorological data to WRF model grid (horizontally and vertically)
- ✓ GUI for running the program

WRF-NMM SI software package will be presented in detail by Paula McCaslin.

An initialization program (*real_nmm.F)* for real-data

- ✓ Used for model initialization
- ✓ Convert meteorological fields to WRF model variables
- ✓ Provide fields in WRF I/O format

- Inputs
  - WRF namelist.input
  - Standard Initialization output
- Outputs
  - WRF input file (*wrfinput_d01*)
  - WRF boundary file (*wrfbdy_d01*)
- Executable: ***real_nmm.exe***

WRF-NMM model initialization will be presented in detail by Matthew Pyle.

Numerical integration program *wrf.F*

- Inputs
  - ✓ WRF-NMM namelist.input
  - ✓ WRF-NMM input file (*wrfinput_d01*)
  - ✓ WRF-NMM boundary file (*wrfbdy_d01*)
  - ✓ Various physics data files
- Outputs
  - ✓ WRF output files [*wrfout_d01_(time)*]
  - ✓ WRF restart files [*wrfrst_d01_(time)*]
- Executable: ***wrf.exe***

WRF-NMM model run will be presented in detail by Meral Demirtas.

WRF Post-Processor (Version 2)

- Processes output from WRF-NMM and WRF-ARW
- De-staggers variables
- Interpolates to pressure levels and user defined-grid
- Outputs in standard GRIB format, which can be read by most graphical packages
- Scripts available for GEMPAK and GrADS visualization packages.

Post-processing tools for WRF-NMM will be presented in detail by Hui-Ya Chuang.

Software Aspect

- WRF-NMM SI
  - Single-processor job
  - Currently tested on LINUX-PCs and IBM
- WRF-NMM
  - ***real_nmm.F***: can be run as a parallel job **using MPI**
  - ***WRF-NMM*:** fully parallelized for 3-D cases, OpenMP, and MPI (or MPICH fort LINUX systems)

Software Aspect

- WRF modeling system software requires the following:
  - FORTRAN 90/95 compiler
    (Preferably PGI for LINUX systems)
  - C compiler
  - Perl
  - netCDF library
  - NCAR Graphics (optional)
  - Public domain ***mpich*** to run WRF model in MPI

User Support

- Available by email:
  wrfhelp@ucar.edu

- WRF-NMM Users page:
  http://www.dtcenter.org/wrf-nmm/users/

  - WRF software download
  - Release updates
  - Documentation
  - Copies of tutorial presentations
  - Links to useful sites

Tutorial Schedule

Lectures for WRF-NMM: Tue., Wed., Thu., Fri

Practical Sessions for WRF-NMM: Wed., Thu., Fri

Acknowledgements: Thanks to earlier presentations of NCAR/MMM Division, for providing excellent starting point for this talk and others to come during this Tutorial.