Advanced Hurricane WRF (AHW)
Overview

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AHW Introduction

- AHW is a sub-set of the community release of WRF defined by certain namelist choices

- Uses the ARW dynamical core and physics

- Introduced in 2005 Atlantic hurricane season

  - Paper by Davis et al. (2008, Mon. Wea. Rev.)

    Prediction of Landfalling Hurricanes with the Advanced Hurricane WRF Model, 2008,: *Mon. Wea. Rev.,* **136,** 1990-2005.

AHW Introduction

Features

- Option for automatic vortex-following multiple-level moving nests

- Special hurricane options since Version 3.0 include

  - 1d ocean mixed-layer model

  - high-wind surface flux and drag formulations

- Current domains are 36/12/4 km or 12/4/1.33 km for Atlantic real-time system at NCAR
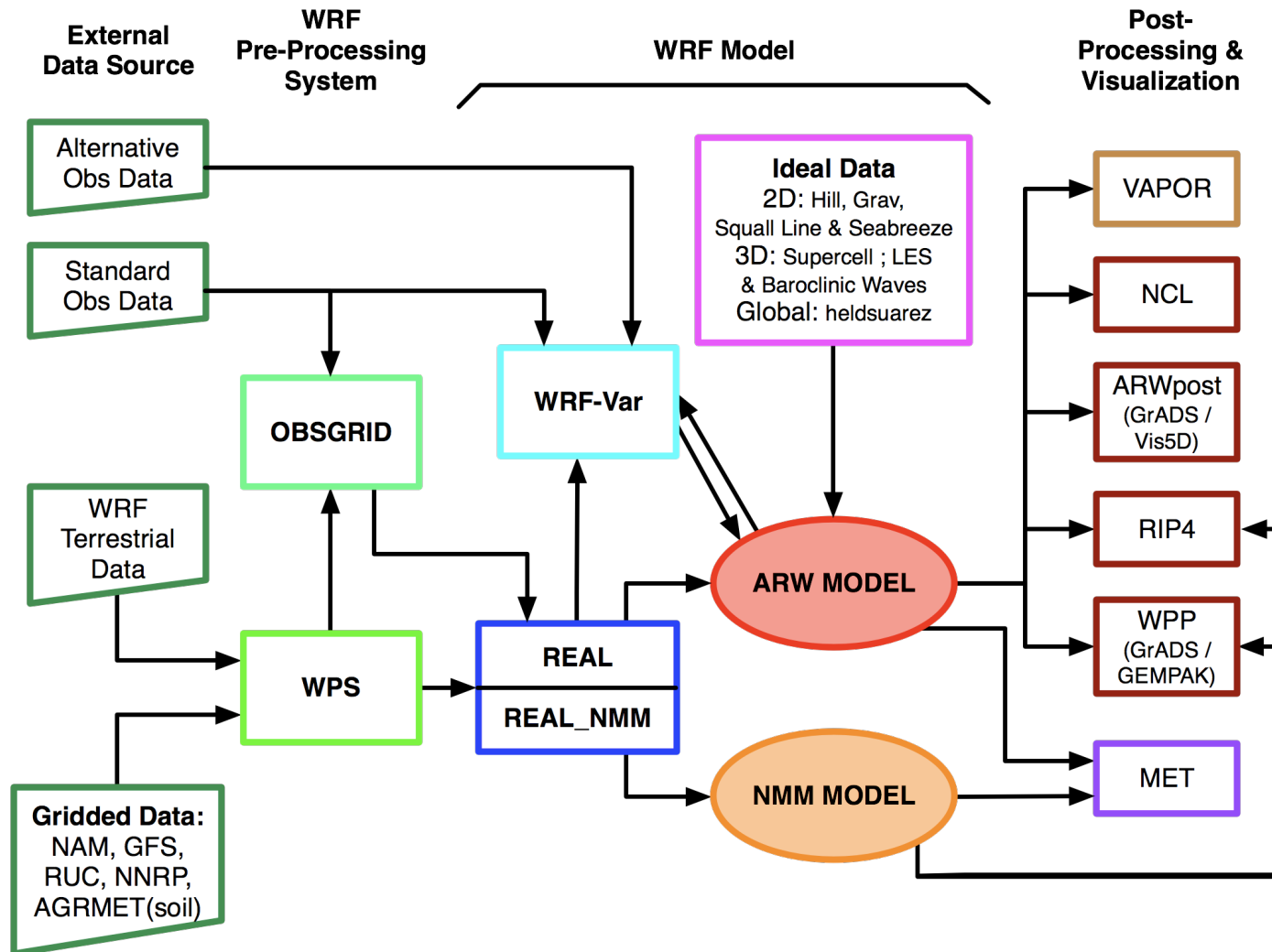
AHW Introduction

- Flexible configuration of grids, input datasets (e.g. ocean mixed layer information), data assimilation techniques

- Version 3.3 includes a new idealized case for a tropical cyclone

WRF Modeling System Flow Chart

External Data Source

Alternative Obs Data

Standard Obs Data

WRF Terrestrial Data

Gridded Data: NAM, GFS, RUC, NNRP, AGRMET(soil)

WRF Pre-Processing System

OBSGRID

WPS

WRF Model

WRF-Var

Ideal Data
2D: Hill, Grav, Squall Line & Seabreeze
3D: Supercell ; LES & Baroclinic Waves
Global: heldsuarez

REAL

REAL_NMM

ARW MODEL

NMM MODEL

Post-Processing & Visualization

VAPOR

NCL

ARWpost (GrADS / Vis5D)

RIP4

WPP (GrADS / GEMPAK)

MET

Modeling System Components

- WRF Pre-processing System (WPS)
  - Real-data interpolation for NWP runs
  - New obsgrid program for adding more obs to analysis
- WRF Model ARW dynamical core
  - Initialization programs for real and (for ARW) idealized data (real.exe/ideal.exe)
  - Numerical integration program (wrf.exe)
- Graphics and verification tools including MET
- WRF-Var - data assimilation
- WRF-Chem - WRF coupled with atmospheric chemistry model

WPS Functions

- Define simulation domain area (and nests)
- 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.), e.g. GFS, GFDL analyses.
- Interpolate meteorological data to WRF model grid (horizontally)
- Optionally add other gridded information, such as ocean mixed layer/heat content initial conditions
- Optionally add more observations to analysis (separate obsgrid program)

WPS

Function (cont)

- Support WRF nesting
- Map projections:
  - Lambert conformal, Polar stereographic, Mercator, rotated lat/long
- C-grid staggering

WRF-DA (Data Assimilation)

- Variational data assimilation (3D-Var and 4D-Var)
- Ensemble DA (*used currently for real-time AHW system*)
- Hybrid variational/ensemble DA

Function

- Ingest observations to improve WRF input analysis from WPS
- May be used in cycling mode for updating WRF initial conditions after WRF run
- Also used for observation impact data studies

WRF real and ideal functions

- REAL
  - Creates initial and boundary condition files for real-data cases
  - Does vertical interpolation to model levels (when using WPS)
  - Does vertical dynamic (hydrostatic) balance
  - Does soil vertical interpolations and land-use mask checks
- IDEAL (ARW only)
  - Programs for setting up idealized case
  - Simple physics and usually single sounding
  - Initial conditions and dynamic balance

WRF Model

- WRF
  - Dynamical core (ARW) is compile-time selectable
  - Uses initial conditions from REAL or IDEAL
  - Real-data cases use boundary conditions from REAL
  - Runs the model simulation with run-time selected namelist switches (such as physics choices, timestep, length of simulation, etc.)
  - Outputs history and restart files

ARW Dynamics

Key features:

- Fully compressible, non-hydrostatic (with hydrostatic option)
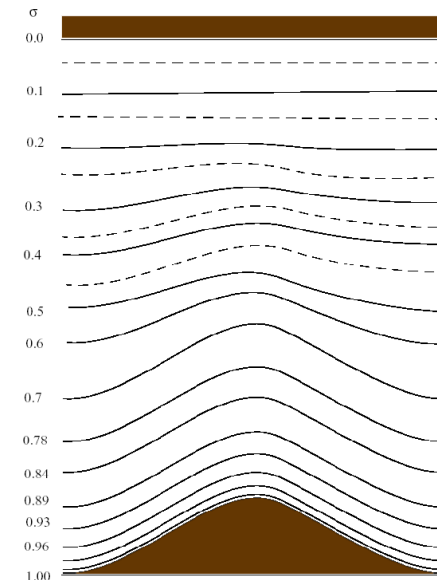- Mass-based terrain following coordinate, ☒

$$\eta = \frac{(\pi - \pi_t)}{\mu}, \qquad \mu = \pi_s - \pi_t$$

where ☒ is hydrostatic pressure, ☒ is column mass

- Arakawa C-grid staggering

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ARW Model

Key features:

- 3rd-order Runge-Kutta time integration scheme

- High-order advection scheme

- Scalar-conserving (positive definite option)

- Complete Coriolis, curvature and mapping terms

- Two-way and one-way nesting

ARW Model

Key features:

- Choices of lateral boundary conditions suitable for real-data and idealized simulations
  - Specified, Periodic, Open, Symmetric, Nested
- Full physics options to represent atmospheric radiation, surface and boundary layer, and cloud and precipitation processes
- Grid-nudging and obs-nudging (FDDA)
- New Digital Filter Initialization option

Graphics and Verification Tools

- NCAR Graphics Command Language (NCL)
- RIP4 (Read, Interpolate and Plot)
- ARWPost
  - Conversion program for GrADS and Vis5D
- WRF Post-Processor (WPP)
  - Conversion to GriB (for GrADS and GEMPAK)

User Support

- Email: wrfhelp@ucar.edu
- User Web pages:

  http://www.mmm.ucar.edu/wrf/users/

  – Latest update for the modeling system

  – WRF software download

  – Various documentation

    - Users' Guide
    - Technical Note (ARW Description)

ARW Hurricane Katrina Simulation (4km)