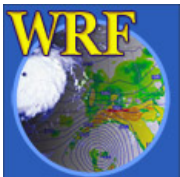# WRF Modeling System V2.1 Overview

Jimy Dudhia

What is WRF?

- WRF: Weather Research and Forecasting Model
  - Now with ARW and NMM components
- Its development is led by NCAR/MMM, NOAA/FSL and NOAA/NCEP/EMC with partnerships at AFWA, FAA, NRL and collaborations with universities and other government agencies
- Includes research and operational models

What is ARW?

- Advanced Research WRF is a large sub-set of WRF
- It is a freely available community model
- Eulerian mass dynamical core
- ARW system includes modeling system components to go with this core
  - SI, 3DVAR, graphics packages
- Its support and development are centered at NCAR/MMM
- This tutorial is for all the ARW components
- Physics and software framework are shared with NMM model
- NMM will be supported and developed by DTC and NCEP
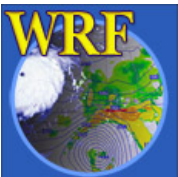
ARW for the Community

- Version 1.0 WRF was released December 2000
- Recent releases:
  - Version 2.0 May 2004 (nesting release)
  - Version 2.0.1 Jun 2004
  - Version 2.0.2 Jun 2004
  - Version 2.0.3.1 Dec 2004
- Current Version: Version 2.1 (July 2005)

What can WRF be used for?

- Idealized simulations at many scales (e.g. convection, baroclinic waves, large eddy simulations)
- Atmospheric physics/parameterization research
- Data assimilation research
- Case-study research
- Real-time NWP and forecast system research
- Regional climate and seasonal time-scale research
- Coupled-model (e.g. ocean, chemistry) applications
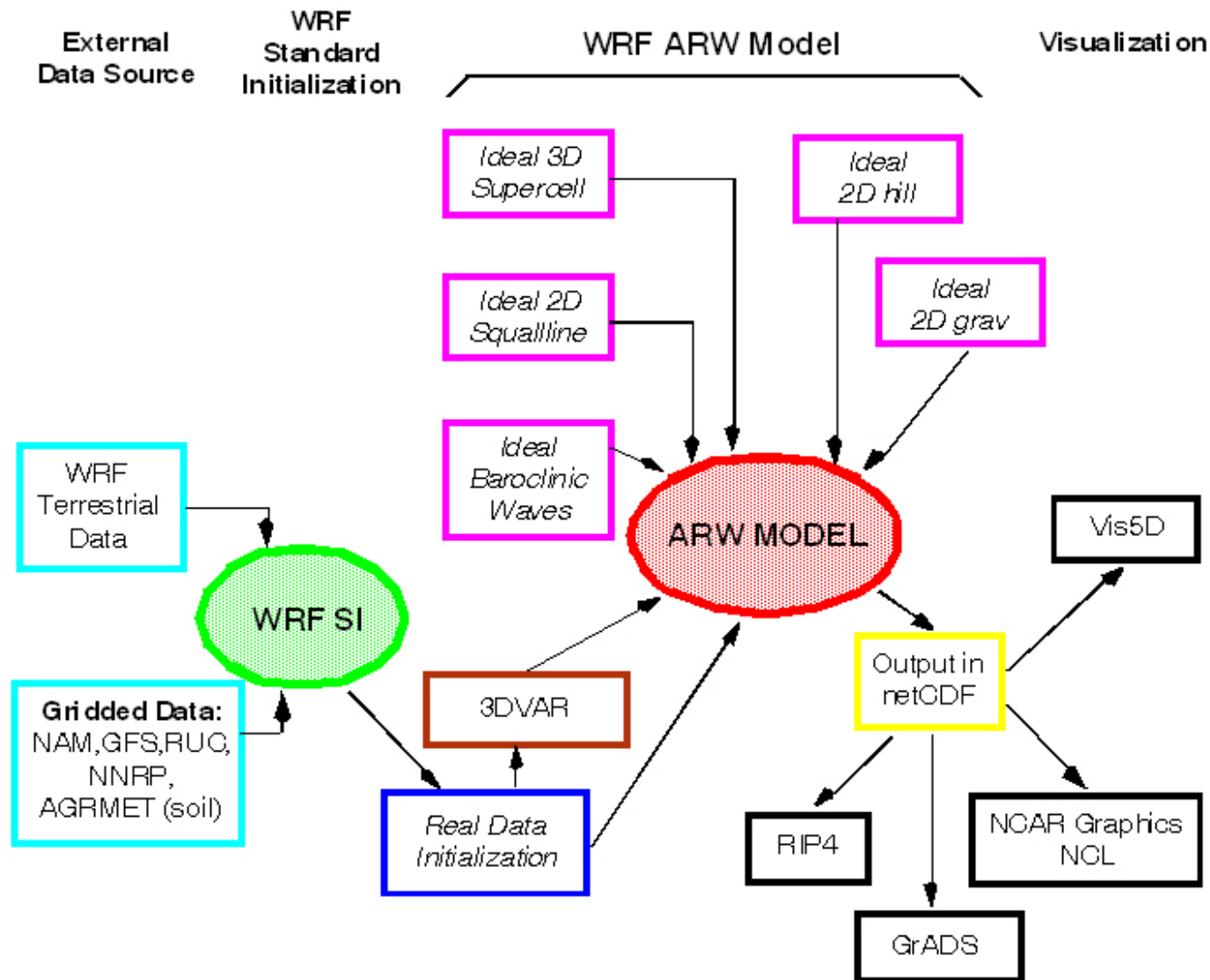- Teaching
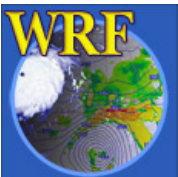
Who uses WRF?

- Academic atmospheric scientists
- Forecast teams at operational centers
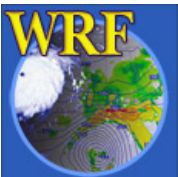- Air Quality scientists
- Others

WRF ARW Modeling System Flow Chart (*for WRFV2*)

External Data Source

WRF Standard Initialization

WRF ARW Model

Visualization

- Ideal 3D Supercell
- Ideal 2D Squallline
- Ideal Baroclinic Waves
- Ideal 2D hill
- Ideal 2D grav

WRF Terrestrial Data

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

WRF SI

3DVAR

Real Data Initialization

ARW MODEL

Output in netCDF

Vis5D

RIP4

GrADS

NCAR Graphics NCL

WRF

Modeling System Components

- WRF Standard Initialization (SI)

- WRF 3DVAR (now part of WRF-Var)

- WRF Model (Eulerian mass dynamical core)

  – Initialization programs for real and idealized data (real.exe/ideal.exe)

  – Numerical integration program (wrf.exe)

- Graphics tools

WRF SI

Function

- 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.)

- Interpolate meteorological data to WRF model grid (horizontally and vertically)
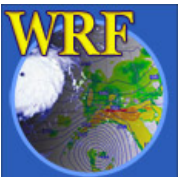
WRF SI

Function (cont)

- Support WRF nesting
- Three map projections:
  - Lambert conformal
  - Polar stereographic
  - Mercator
- GUI for running the program
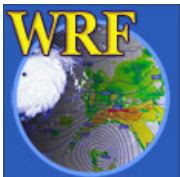
WRF 3DVAR

Function

- 3D variational data assimilation
- Ingest observations into WRF input analysis from WRF SI
- May be used in cycling mode for updating WRF initial conditions after WRF run
- Observation impact data studies
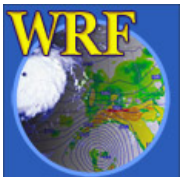
WRF 3DVAR

- **Supported data types**
  - Conventional surface and upper air, wind profiler
  - Remote sensing data: Cloud-track winds, ATOVS thickness, ground-based GPS TPW, SSM/I, SSM/T1, SSM/T2, SSM/I brightness temp, Quikscat ocean surface winds, radar radial velocity

- **Two background error covariance models**
  - NCEP model
  - UK / NCAR
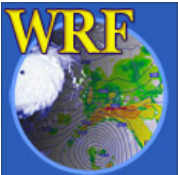
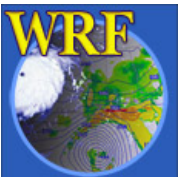# WRF Model

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 π is hydrostatic pressure

- Arakawa C-staggering $\rightarrow$

$$
\begin{array}{ccc}
 & v & \\
u & T & u \\
 & v & \\
\end{array}
$$

WRF Model

Key features:

- 3rd-order Runge-Kutta time integration scheme

- High-order advection scheme

- Scalar-conserving

- Complete Coriolis, curvature and mapping terms

- Two-way and one-way nesting
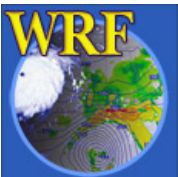
WRF Model

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

Graphics Tools

- RIP4 (Read, Interpolate and Plot)
- NCAR Graphics Command Language (NCL)
- Conversion program for GrADS
- Conversion program for Vis5D

Software Requirement

- Fortran 90/95 compiler
- C compiler
- Perl
- netCDF library
- Public domain mpich for MPI

Portability

- Runs on Unix single, OpenMP and MPI platforms:
  - Alpha
  - IBM
  - Linux (PGI and Intel compiler)
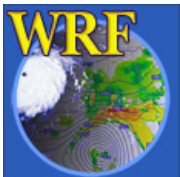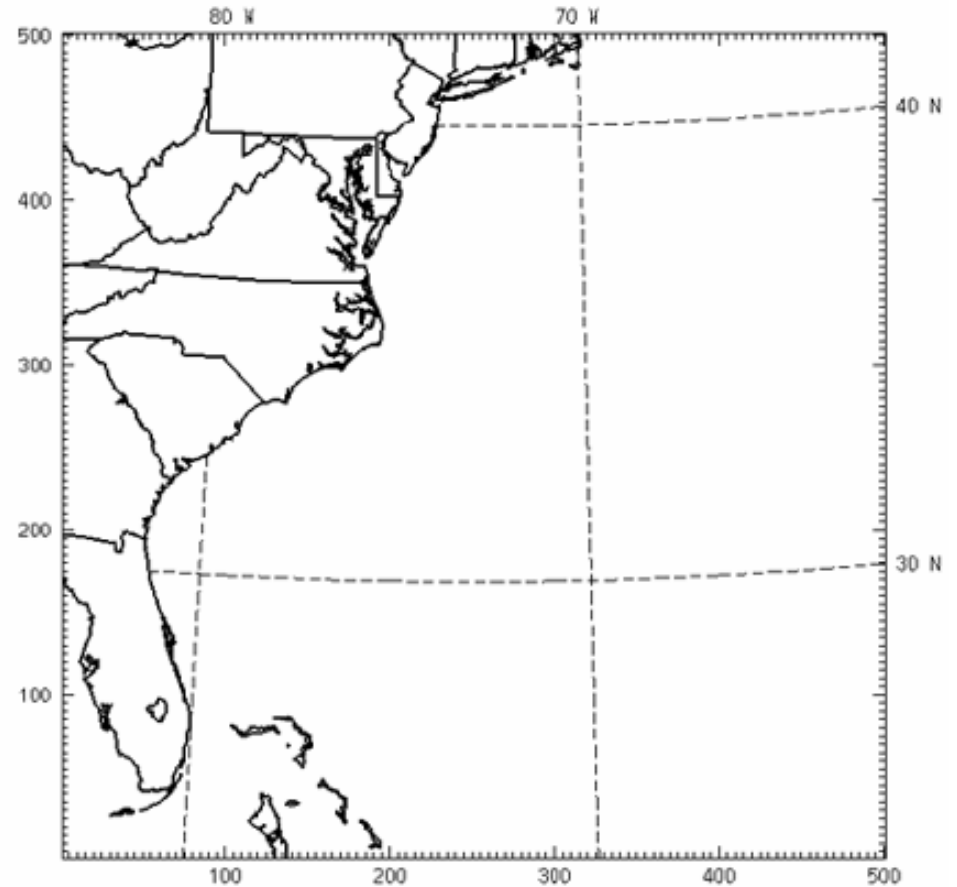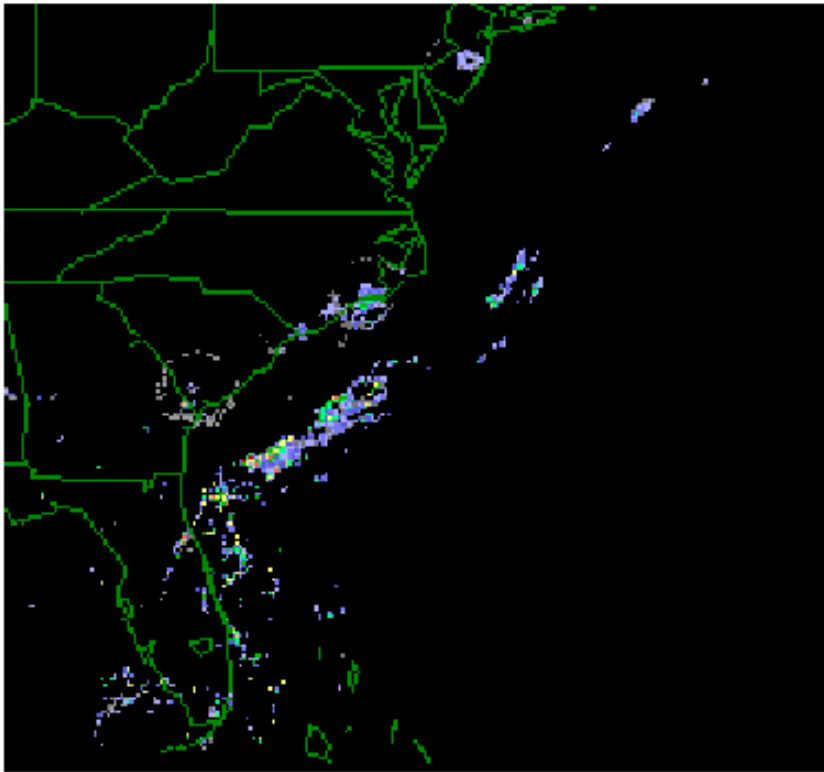 - SGI Origin and Altix
  - Sun

User Support

- Email: wrfhelp@ucar.edu

- User Web page:

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

  – Latest update for the modeling system

  – WRF software download

  – Various documentation

Hurricane Isabel Simulation (4km)

00 UTC, 17 Sep 03

Tutorial Schedule

- Lectures for WRF: Mon., Tue., Wed.
- Practice for WRF: Tue., Wed.
  - 2 Groups (a.m./p.m.)
- Lectures for WRF-Var: Thu.
- Practice for WRF-VAR: Thu., Fri.
  - 2 Groups (Thu./Fri.)