WRF Modeling System Overview

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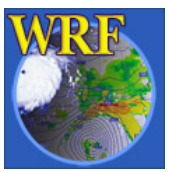
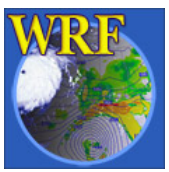


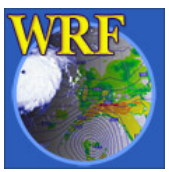
What is WRF?

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



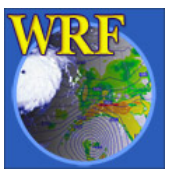
What is ARW?

- 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
  - WRF Pre-Processing System (WPS), WRF-Var, 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



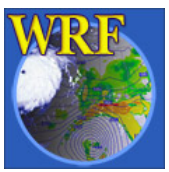
What is ARW not?

- ARW does not include (yet)
  - WRF-Chem - coupled on-line chemistry
    - Available from NOAA
  - Coupled Ocean/Wave models
  - Adjoint model (4DVAR)
  - FDDA (nudging)
    - Preliminary version will be in Version 2.2
- Work is proceeding in all these areas



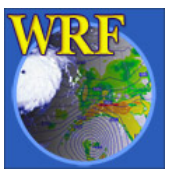
ARW for the Community

- Version 1.0 WRF was released December 2000
- Recent releases:
  - Version 2.0 May 2004 (nesting major 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 (August 2005)
  - Version 2.1.1 Nov 2005
  - Version 2.1.2 Jan 2006
- Version 2.2 (soon)



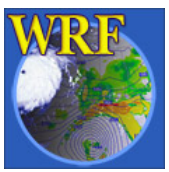
What can WRF be used for?

- 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

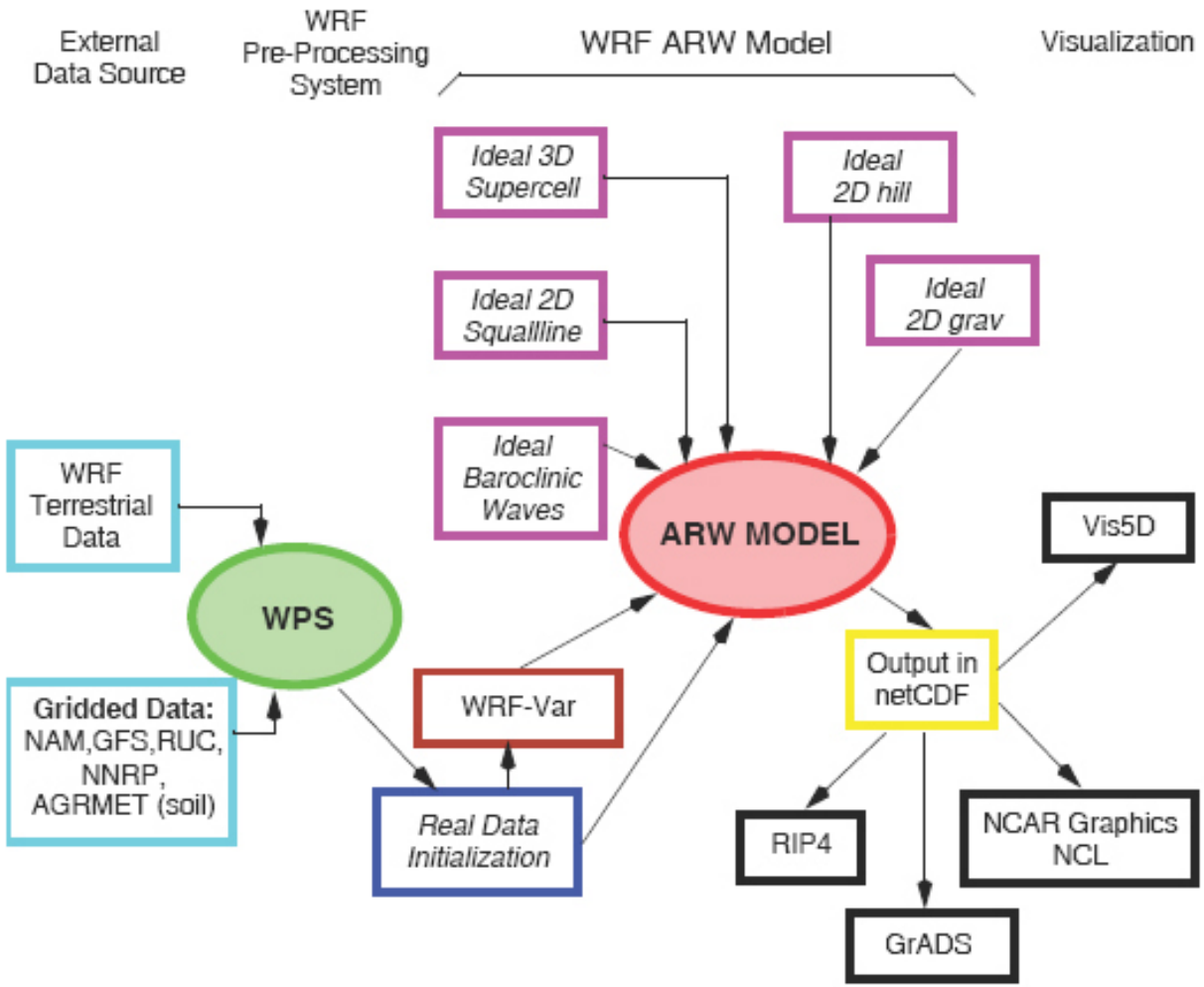


Who uses WRF?

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

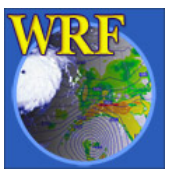


WRF ARW Modeling System Flow Chart (*for WRFV2*)



Modeling System Components

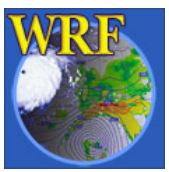
- WRF Pre-processing System (WPS)
  - New real-data interpolation for NWP runs
  - Replaces Standard Initialization (SI) - still maintained
- WRF-Var (including 3d-Var)
- WRF Model (Eulerian mass dynamical core)
  - Initialization programs for real and idealized data (real.exe/ideal.exe)
  - Numerical integration program (wrf.exe)
- Graphics tools



WPS

Function

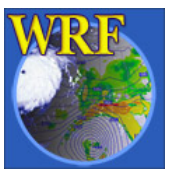
- Define simulation domain area (and nests)
- Produce terrain, landuse, soil type etc. on the simulation domain (“static” fields)
- De-grib GRIB files for meteorological data (u, v, T, q, surface pressure, soil data, snow data, sea-surface temperature, etc.)
- Interpolate meteorological data to WRF model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



WPS

Function (cont)

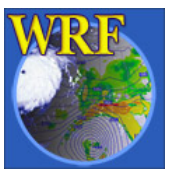
- Support WRF nesting
- Three map projections:
  - Lambert conformal
  - Polar stereographic
  - Mercator
- Compile, edit namelist, run, methodology for each stage



WRF-Var

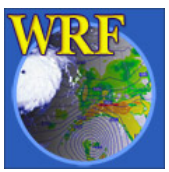
Function

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



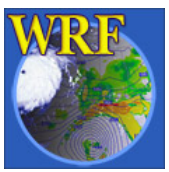
WRF 3DVAR

- 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 real and ideal

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



WRF Model

Key features:

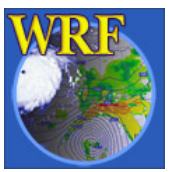
- Fully compressible, non-hydrostatic (with hydrostatic option)
- Mass-based terrain following coordinate, η

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

where π is hydrostatic pressure, μ is column mass

- Arakawa C-staggering $\rightarrow$

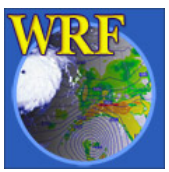
v
u T u
v



WRF Model

Key features:

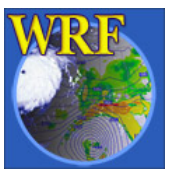
- 3rd-order Runge-Kutta time integration scheme
- High-order advection scheme
- Scalar-conserving
- Complete Coriolis, curvature and mapping terms
- Two-way and one-way nesting



WRF Model

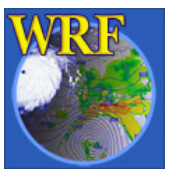
Key features:

- 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



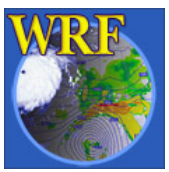
Graphics Tools

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



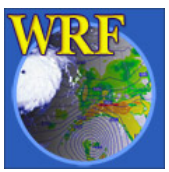
Software Requirement

- 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

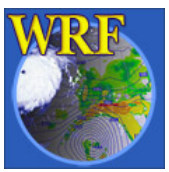


User Support

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

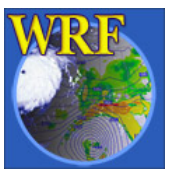
  http://www.mmm.ucar.edu/wrf/users/

  – Latest update for the modeling system
  – WRF software download
  – Various documentation



Hurricane Katrina Simulation (4km)

QuickTime™ and a
BMP decompressor
are needed to see this picture.



Convective-scale Forecasting (4km)

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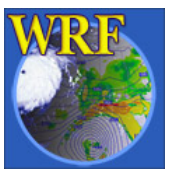

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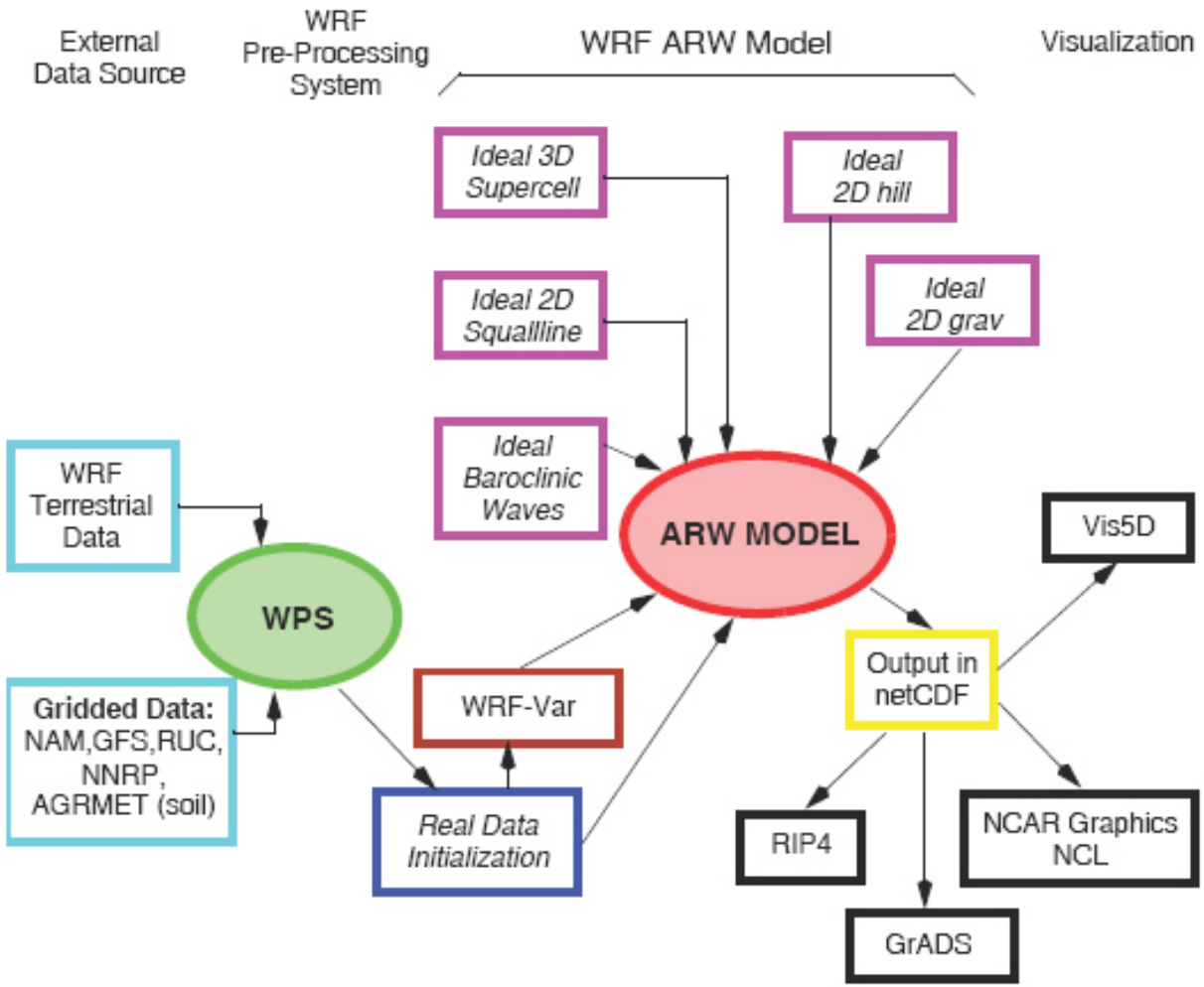

Tutorial Schedule

- 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.)