WRF:
More Runtime Options

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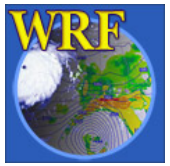


Fortran namelist

- Fortran 90 namelist is used to configure a run without recompiling the code
- Fortran 90 namelist has very specific format, so edit with care:

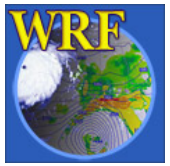
  `&namelist-record` - start

  `/` - end

- As a general rule:

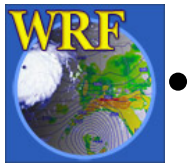
  Multiple columns: domain dependent

  Single column: value valid for all domains



More options

- Have covered basic, physics / diffusion options, and nudging options..
- More are introduced here:
  - IO options
  - Vertical interpolation options
  - Options for long simulations
  - Adaptive-time step
  - Digital filter
  - Global runs
  - Moving nest
  - TC options
  - Tracer
  - Stochastic kinetic-energy backscatter scheme (SKEB)
  - IO quilting
- Time series output



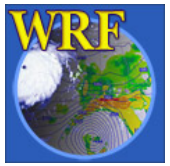
namelist.input

general namelist records:

- `&time_control`
- `&domains`
- `&physics`
- `&dynamics`
- `&bdy_control`
- `&namelist_quilt`

specialized namelist records:

- `&dfi_control`
- `&fdda`
- `&grib2`
- `&scm`
- `&tc`

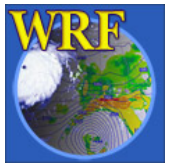


IO Control (1)

History output control in **`&time_control`**

`history_interval`: used often, unit in minutes
`history_interval_h`: history output interval in hours
`history_interval_s`: history output interval in seconds
`history_begin_h`: history output beginning time in hours
`history_begin_d`: history output beginning time in days

Complete listing in **`Registry/registry.io_boilerplate`**



IO Control (2)

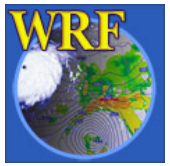
Optional history output in **`&time_control`**

1. Change Registry.EM_COMMON and **recompile**:

```
state integer rainc ij misc 1 - h03 "RAINC" ""
  "ACCUMULATED TOTAL CUMULUS PRECIPITATION"
state integer rainnc ij misc 1 - h03 "RAINC" ""
  "ACCUMULATED TOTAL GRID SCALE PRECIPITATION"
```

2. Edit namelist.input to output these variables:

```
auxhist3_outname = "rainfall_d<domain>"
auxhist3_interval = 10, 10,
frames_per_auxhist3 = 1000, 1000,
io_form_auxhist3 = 2
```



IO Control (3)

Starting in V3.2, there is an alternative to add/remove additional output at **runtime** (state variables in Registry only)

1. new namelists in &time_control:

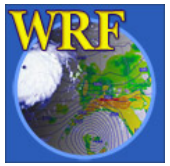
```
iofields_filename(max_dom) = 'my_output.txt',
ignore_iofields_warning = .true.
```

2. prepare text file ('`my_output.txt`') to define new io fields:

```
+:h:3:rainc,rainnc
```

3. set other namelists under **`&time_control`**:

```
auxhist3_outname = "rainfall_d<domain>"
auxhist3_interval = 10, 10,
frames_per_auxhist3 = 1000, 1000,
io_form_auxhist3 = 2
```

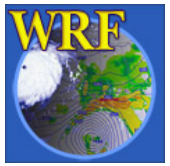


See 'Run-Time IO' section in Chapter 5, User's Guide

Vertical interpolation options (1)

Program **`real`** for ARW only, optional, &domains:

- **`use_surface`**: whether to use surface observations
- **`use_levels_below_ground`**: whether to use data below the ground
- **`lowest_lev_from_sfc`**: logical, whether surface data is used to fill the lowest model level values
- **`force_sfc_in_vinterp`**: number of levels to use surface data, default is 1
- **`extrap_type`**: how to do extrapolation: 1 - use 2 lowest levels; 2 - constant
- **`t_extrap_type`** : extrapolation option for temperature: 1 - isothermal; 2 - 6.5 K/km; 3 - adiabatic

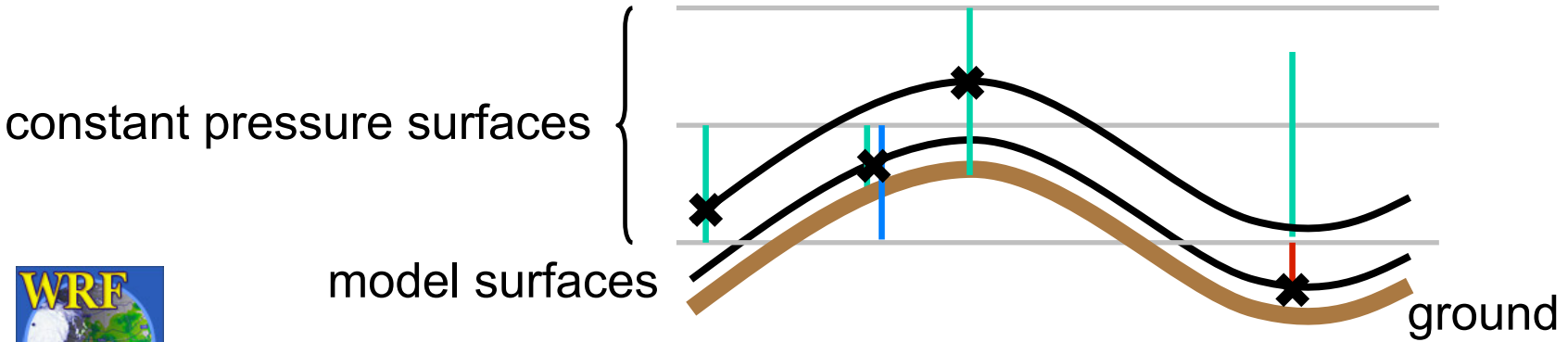


Vertical interpolation options (2)

Program **`real`** for ARW only, optional:

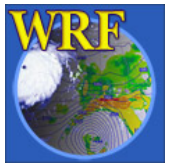
- **`interp_type`**: in pressure or log pressure
- **`lagrange_order`**: linear or quadratic
- **`zap_close_levels`**: delta p where a non-surface pressure level is removed in vertical interpolation

related namelists: **`examples.namelist`**



Vertical interpolation options (3)

`interp_theta`	Whether to interpolate T or theta; = .false., interpolate T, default in V3.4
`hypsometric_opt`	An alternative way to obtain geopotential height in program real, and pressure in the model. = 2, default in V3.4



Options for long simulations (1)

Lower boundary update control: allow SST, seaice, monthly vegetation fraction, and albedo to be updated regularly during a model run:

`sst_update:` 0 – no update
1 – update all above fields

Set before running **`real`**, and this will create additional output files: wrflowinp_d01, wrflowinp_d02, ..

Other namelists required in **`&time_control`**:

`auxinput4_inname` = "wrflowinp_d<domain>"

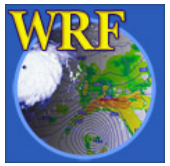
`auxinput4_interval` = 360, 360,

`io_form_auxinput4` = 2 (netCDF)

See 'Using sst_update Option' in Chapter 5, User's Guide

Options for long simulations (2)

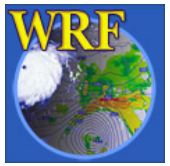
`sst_skin`	diurnal water temp update
`tmn_update`	deep soil temp update, used with lagday
`lagday`	averaging time in days
`bucket_mm`	bucket reset value for rainfall
`bucket_j`	bucket reset value for radiation fluxes
`spec_exp`	exponential multiplier for boundary zone ramping (*real*). Usually used with wider boundary zone



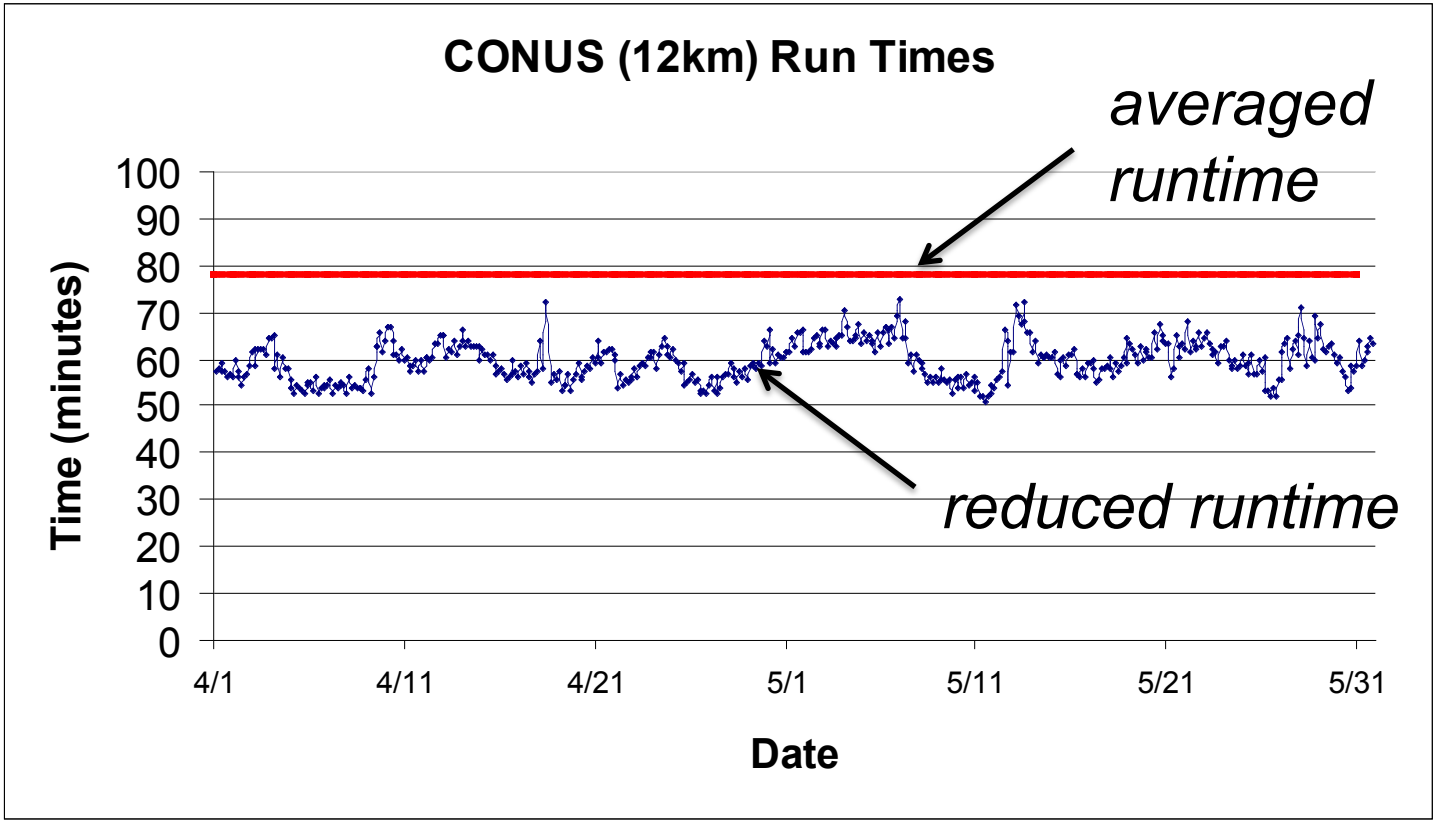
Adaptive time steps (1)

- Adaptive-time-step is a way to maximize the model time step while keeping the model numerically stable.
- New in V3. Good to use for real-time run.
- May not work in combination with other options.

Also see ‘Using Adaptive Time Stepping’ section in Chapter 5, UG



Adaptive time steps (2): an example

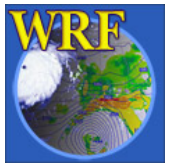


On average, forecasts finish in 60 min (50-73min) as compared to 79 min standard runtime

Adaptive time steps (3)

Namelist control: **`&domains`** * USE WITH CARE

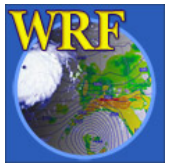
`use_adaptive_time_step`	logical switch
`step_to_output_time`	whether to write at exact history output times
`target_cfl`	maximum cfl allowed (1.2)
`max_step_increase_pct`	percentage of time step increase each time; set to 5, 51, 51 (larger value for nest)
`starting_time_step`	in seconds; e.g. set to 4*DX
`max_time_step`	in seconds; e.g. set to 8*DX
`min_time_step`	in seconds; e.g. set to 4*DX



Digital filter initialization (1)

Digital filter initialization is a simple way to remove initial model imbalance:

- May be introduced by simple interpolation, different topography, or by objective analysis, or data assimilation
- It may generate spurious gravity waves in the early simulation hours, which could cause erroneous precipitation, numerical instability and degrade subsequent data assimilation

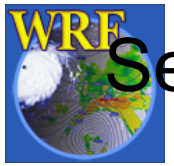


Digital filter initialization (2)

Using DFI

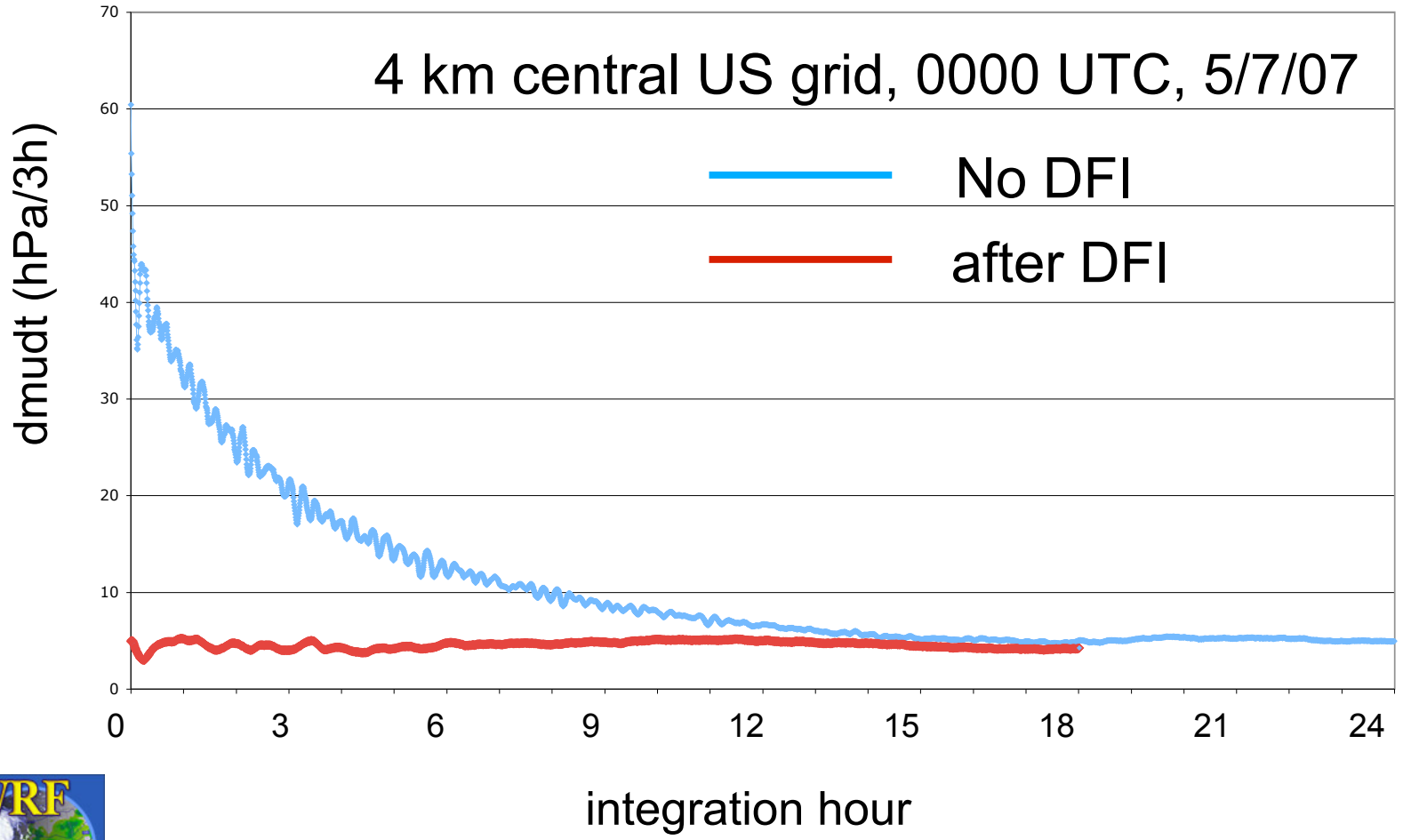
- can construct consistent model fields which do not exist in the initial conditions, e.g. vertical motion, cloud variables
- may reduce the spin-up problem in early simulation hours
- Useful if the first few hours of forecast is the interest

DFI is done after program **`real`**, or data-assimilation step, just before model integration



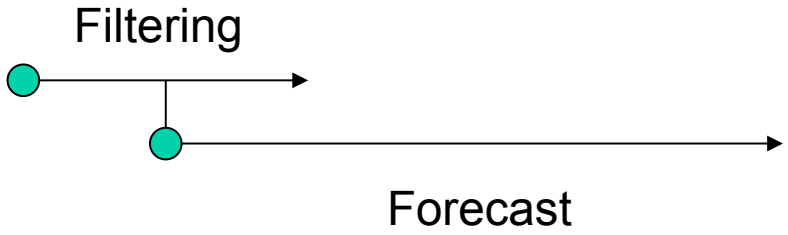
See 'Using Digital Filter Initialization', Chap 5, UG.

Digital filter initialization (3)

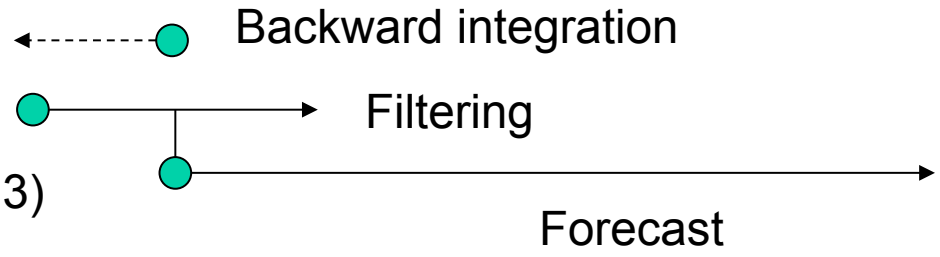


Digital filter initialization (4)

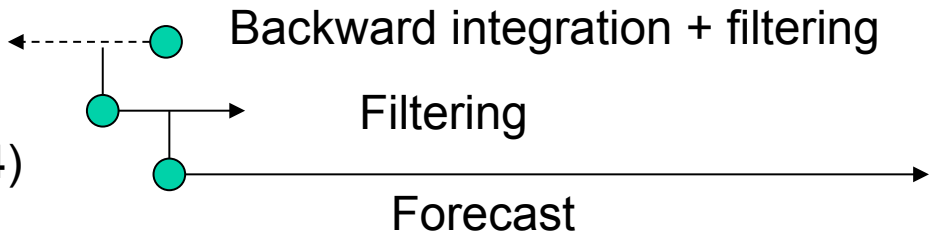
DFL:
(Lynch and Huang, 1994)



DDFI:
(Huang and Lynch, 1993)



TDFI:
(Lynch and Huang, 1994)

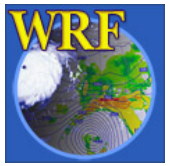


Digital filter inilialization (5)

Namelist control: **`&dfi`**

- **`dfi_opt`**: dfi options: 0: no DFI; 1: DFL; 2: DDFI; 3: TDFI (recommended)
- **`dfi_nfilter`**: filter options 0 - 8, recommended: 7
- **`dfi_cutoff_seconds`** : cutoff period
- **`dfi_write_filtered_input`** : whether to write filtered IC
- **`dfi_bckstop_*`** : stop time for backward integration
- **`dfi_fwdstop_*`** : stop time for forward integration

related namelists: **`examples.namelist`**



Global application

Setup mostly done in WPS:

`map_proj = 'lat-lon'`

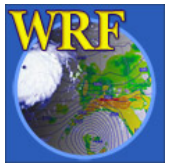
`e_we, e_sn:` **`geogrid`** will compute dx, dy

See template `'namelist.wps.global'`

In the model stage:

`fft_filter_lat:` default value is 45 degrees

Caution: some options do not work, or have been tested with global domain. Start with template `'namelist.input.global'`

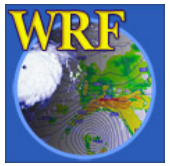


See 'Global Run' section, Chap 5, UG

Automatic moving nest options

Tropical cyclone / typhoon / hurricane applications:

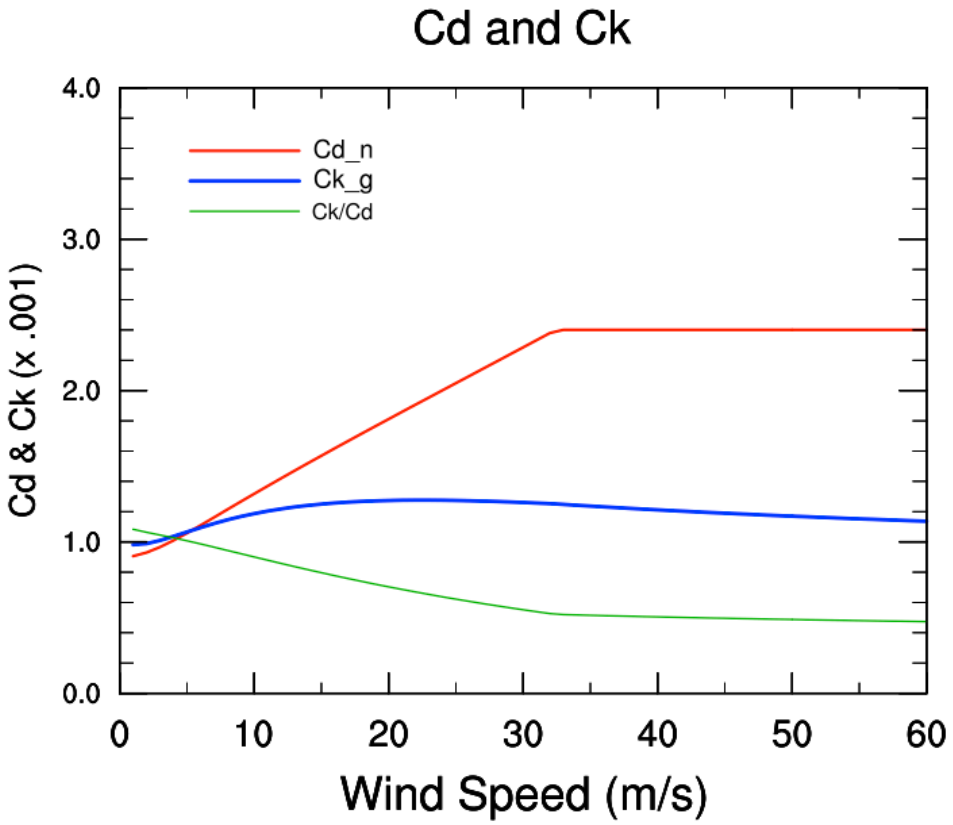
- **`vortex_interval:`** time interval when vortex location is estimated
- **`max_vortex_speed:`** used to compute the search radius for vortex location
- **`corral_dist:`** how far the vortex can move near the parent domain boundary (number of grids)
- **`track_level:`** e.g. 700 or 500 mb
- **`time_to_move:`** hold nests still until this time



See ‘Moving Nested Run’, Chap 5, UG

TC options (1)

`isftcflx:` alternative C_d (Donelan) and C_k (=2, Garratt) formulation for TC application



TC options (2)

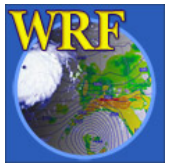
`omlcall:` simple ocean mixed layer

`oml_hml0:` initial ocean mixed layer depth

`oml_gamma:` lapse rate in deep water

The ocean mixed layer model can also be initialized with real-data, e.g. HYCOM. More info can be found at

http://www.mmm.ucar.edu/wrf/users/hurricanes/wrf_ahw.html

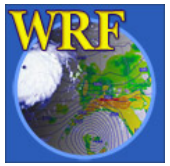


tracer options

Add the following in **`&dynamics`** to activate tracer option (default no. is 8):

`tracer_opt` = 2,

One would need some way to initialize the tracer



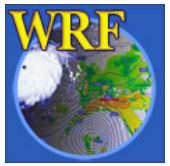
Stochastic kinetic-energy backscatter scheme

This is a way to stochastically perturb forecasts.

`stoch_force_opt:` = 1, activate the scheme

`nens:` = N, an integer that controls the random number stream; a different integer will give a differently perturbed forecast

Also see ‘Option to stochastically perturb forecasts’ section in Chap 5, UG



IO quilting: &namelist_quilt

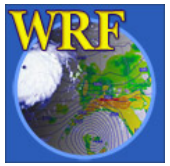
Parallel I/O control:

`nio_tasks_per_group (>0):` allow IO to be done on separate processors. Performance improvement for large domain runs. A value of 2 to 4 works well.

`io_groups (>1):` number of I/O streams that the quilting applies.

See 'Using IO Quilting' section, Chap 5, UG

Note that using p-netCDF is another way to improve IO



Time Series Output (1)

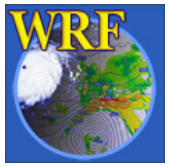
- It is a special output in text format with file name like

  ***prefix*.d<domain>.TS**

- It outputs 14 surface variables at every time step:

  e.g. 10 m u/v, 2 m T/qv, precipitation, radiation, surface fluxes

- One file per location (e.g. at weather station)

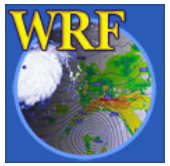


Time Series Output (2)

- Not a namelist option
- If output more than 5 locations, use namelist **`max_ts_locs`**
- Depends the presence of a file called '**`tslist`**' (a sample of the file is available in **`WRFV3/run/`**

```
#-----------------------------------------#
# 24 characters for name | pfx |  LAT   |   LON   |
#-----------------------------------------#
Cape Hallett             hallt -72.330  170.250
McMurdo Station          mcm   -77.851  166.713
```

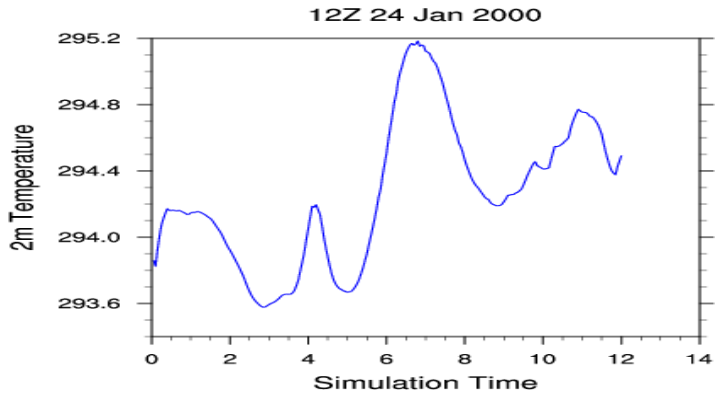
- This file provides a list of locations where you would like to output time series
- More information in **`run/README.tslist`** and 'Output Time Series' section, Chapter 5, UG



Time Series Output (3)

Content in `hallt.d01.TS`:

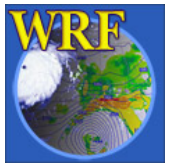
```
Cape Hallett                  1  1 hallt ( 36.710, -79.000) (  41,  38)
    ( 36.600, -79.142)  159.6 meters
 1      0.050000     1   41    38      275.47397        0.00288
    3.52110       -2.34275    99988.76563      244.81276
 0.00000      -29.94841         4.09765     273.90295      278.20197
    0.00000        0.00000         0.00000
 1      0.100000     1   41    38      275.56287        0.00282
    3.14414       -2.05875    99956.98438      244.81276
 0.00000      -25.64095         4.18446     273.78323      278.18314
    0.00000        0.00000         0.00000
```



Additional Output Option (1)

`prec_acc_dt = 60:`

Output precipitation in an interval:
PREC_ACC_C, PREC_ACC_NC,
SNOW_ACC_NC

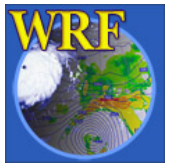


Additional Output Option (2)

output_diagnostics = 1:

output max, min, time of max and min, mean value, standard deviation of the mean for 8 surface variables (T2, Q2, TSK, U10, V10, 10 m wind speed, RAINCV, and RAINNCV [time step rain])

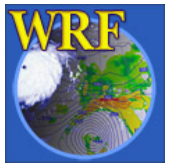
```
auxhist3_outname ="wrfxtrm_d<domain>_<date>"
io_form_auxhist3 = 2
auxhist3_interval = 60
frame_per_auxhist3 = 10
```



Additional Output Option (3)

`do_avgflx_em = 1:`

output history-time-averaged, column-pressure-coupled u, v and w: AVGFLX_RUM, AVGFLX_RVM, AVGFLX_RWM – useful for driving downstream transport model



Recommended

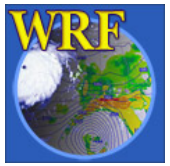
Start with the namelist template in a particular test directory, and the options specified in the file, and make modifications.

For special applications in ARW, look for related namelists in the file *examples.namelist* in *test/em_real/* directory.

Chapter 5 of User's Guide, pages 5-25 – 5-27: examples for various applications.

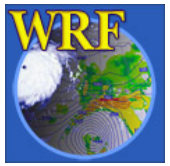
For more information on global extension, DFI and adaptive time step, read Tech Note, and User's Guide.

Considerations for Designing an Numerical Experiment

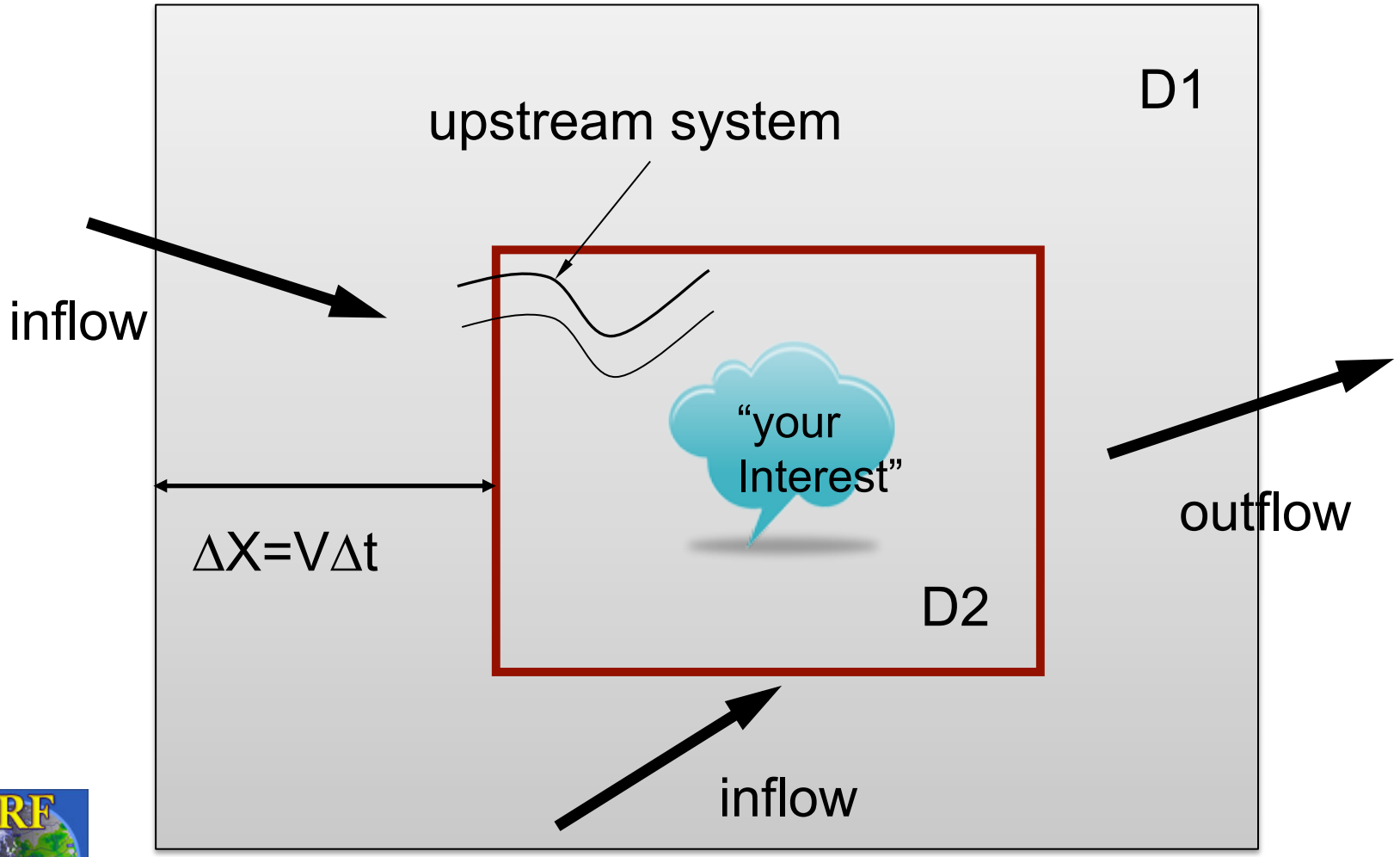


Domains

- How large do they need to be?
  - Depending on applications
    - Simulations for a few days: IC
    - Simulations for a few months, or years: BC
  - Domain sizes should not be too small: no less than 100x100
- Where to place my lateral boundaries?
  - Avoid steep topography
  - Away from my interest



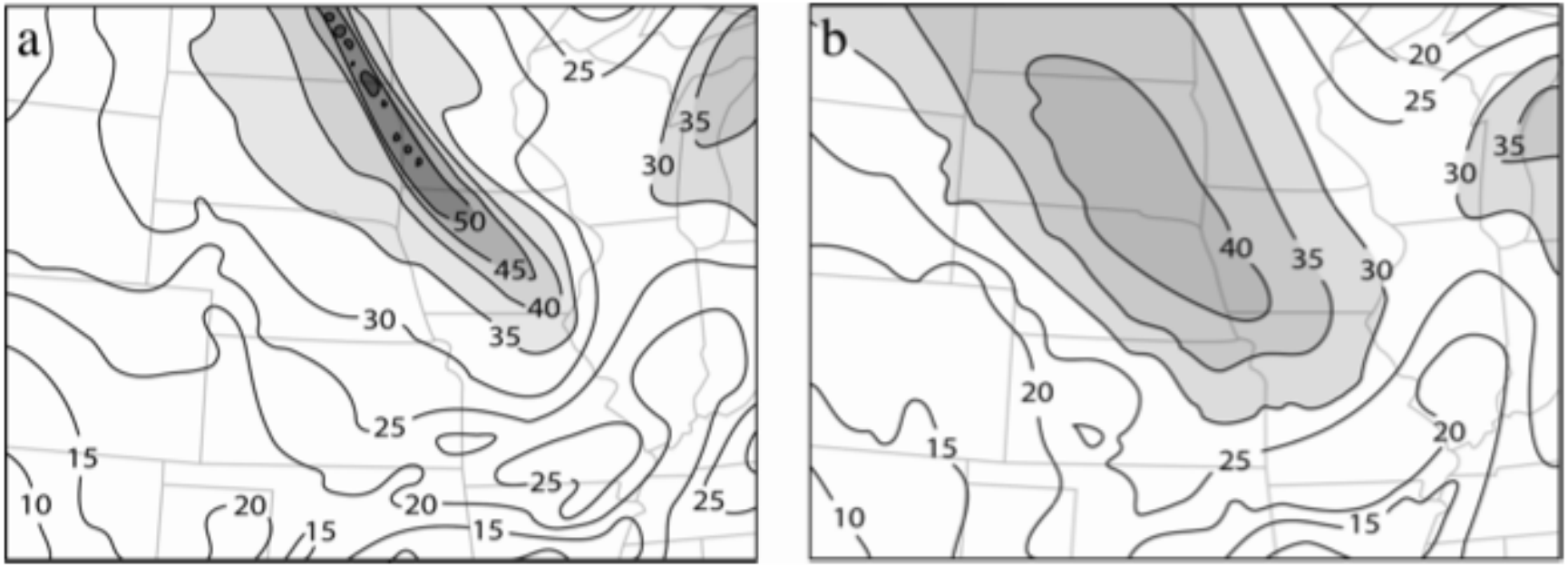
Note on Configuring Domains: Horizontal



Note on Configuring Domains: Horizontal

Large regional domain

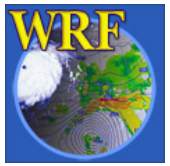
Smaller regional domain



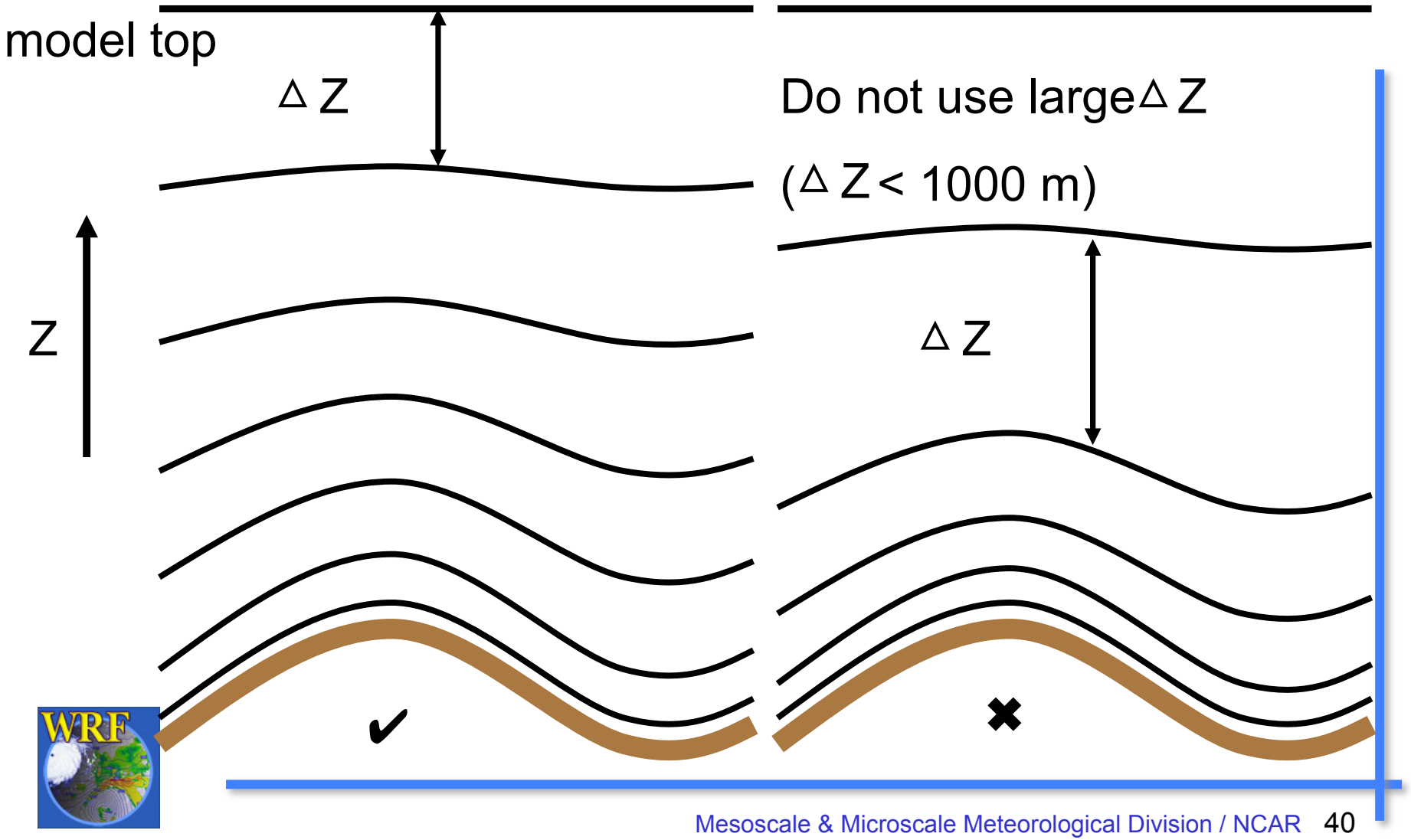
(From Warner, 2011)

Domains

- How many vertical levels should I use?
  - At least 30 or more levels
  - Vertical grid distance should not be larger than 1000 m:
    - Radiation, microphysics, less accurate lateral BDY
  - Related to horizontal grid size too: if finer horizontal grid size is used, consider adding a few more levels in the vertical



Note on Configuring Domains: Vertical



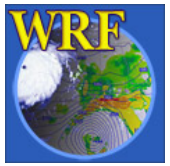
Nests:

- When should I use nests?

  For example,

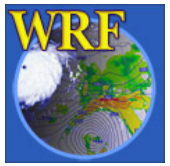
  – Input data resolution is too coarse

  – There isn't sufficient computing resources
- Nest domain sizes should not be too small;
- Nest boundary should be kept away from coarse domain boundary, and steep topography.



Input Data

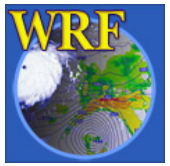
- Check land data:
  e.g. landuse: *does it represent my area well?*
- Know about the data: *how good are the data?*
  - Forecast data
  - Reanalysis data
  - Climate model data
- How frequent do I need to have boundary conditions?
  - More frequent is better



Model Options

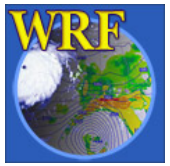
- What do I start with?
  - What other people have success with?
    - References, papers
  - Simple options first:

    For example,
    - Graupel may not be important if dx >> 10 km
    - mixed layer ocean model may not be needed if the modeled track isn't correct
    - Use analyses from weather centers before trying to create your own (via either *obsgrid* or DA) for both initial and lateral boundary conditions



Bottomline..

- Model results can be affected by many choices:
  - Domain configuration, both horizontal and vertical;
  - Input data;
  - Lateral boundary conditions.
- Model has limitations:
  - Physics: biases, may not handle certain process well, etc.



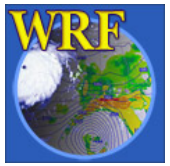
References:

Numerical Weather and Climate Prediction, 2011. By Thomas Warner, *Cambridge University Press*.

Warner, T., 2011. Quality assurance in atmospheric modeling. *Bull. Amer. Met. Soc. Dec. issue, p1601 – 1611.*

Stensrud, D., 2007. Parameterization Schemes: Keys to Understanding Numerical Weather Prediction Models. *Cambridge University Press*.

Haltiner G. and R. Williams, 1980. Numerical Prediction and Dynamic Meteorology. *Wiley*.



WRF USERS PAGE

Home | Model System | User Support | Download | Doc / Pub | Links | Users Forum | WRF Forecast

Search

wrf-model.org

Public Domain Notice

Contact WRF Support

WRF Model Users Page

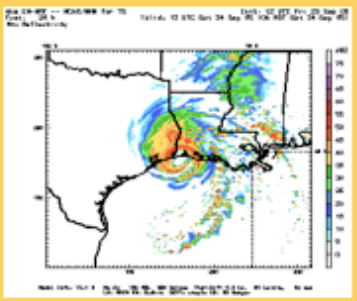
Welcome to the users home page for the Weather Research and Forecasting (WRF) modeling system. The WRF system is in the public domain and is freely available for community use. It is designed to be a flexible, state-of-the-art atmospheric simulation system that is portable and efficient on available parallel computing platforms. WRF is suitable for use in a broad range of applications across scales ranging from meters to thousands of kilometers, including:

- Idealized simulations (e.g. LES, convection, baroclinic waves)
- Regional and global applications
- Parameterization research
- Data assimilation research
- Forecast research
- Real-time NWP
- Hurricane research
- Coupled-model applications
- Teaching

The Mesoscale and Microscale Meteorology Division of NCAR is currently maintaining and supporting a subset of the overall WRF code (Version 3) that includes:

- WRF Software Framework (WSF)
- Advanced Research WRF (ARW) dynamic solver, including one-way, two-way nesting and moving nests, grid and observation nudging
- WRF Pre-Processing System (WPS)

WRF Forecast



WRF Real-time forecast *(old site)*

Announcements

WRF Version 3.3 Release (4/6/2011)

'Known Problems' posts for V3.3 (posted 4/8/11)

12th WRF Users' Workshop: June 20 - 24, 2011. Registration is open..

New Users' tutorial, July 11 - 22. Registration is open.

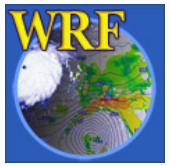
'Known Problems' posts for V3.2 and V3.2.1 WRF (12/13/10)

Program, extended abstracts, and presentations from the 11th WRF Users' Workshop, June 21 - 25, 2010.

planetWRF released.

Miscellaneous Information for Users

- Become a registered user
- Visit Users' web pages
  - Check code updates, bug reports, updated documents, Version 3
  - Check upcoming events, like annual workshop
- Write to wrfhelp@ucar.edu for WRF related problems / feedback
- Participate in annual users' workshop (June)



Good Luck & Happy Computing!

THANKS FOR COMING TO THE TUTORIAL!