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

- Some useful runtime options:
  - IO options
  - Vertical interpolation options
  - Options for long simulations
  - Adaptive-time step
  - Digital filter
  - Global runs
  - Moving nest
  - TC options
  - Tracer / trajectory
  - Optional output
  - Stochastic kinetic-energy backscatter scheme (SKEB)
  - IO quilting
- Time series output (surface and profile)

namelist.input

general namelist records:

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

specialized namelist records:

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

Look for these in **`examples.namelist`**

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

Look for listing in **`Registry/registry.io_boilerplate`**

IO Control (2)

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

1. Change Registry.EM 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 a text file ('`my_output.txt`') to select io fields:

```
+:h:3:rainc,rainnc
```
← syntax in the file

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:

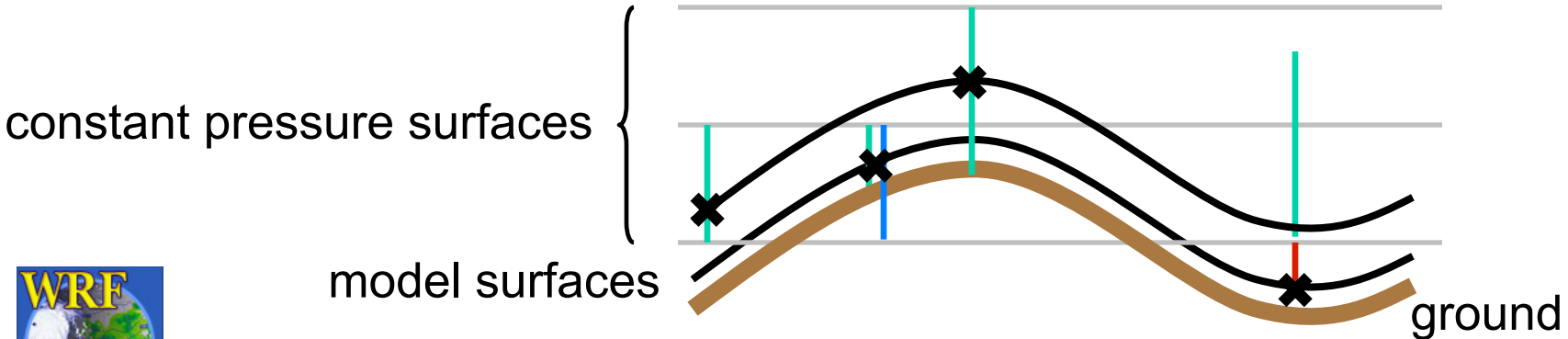
- **use_surface**: whether to use surface observations
- **use_levels_below_ground**: whether to use data below the ground
- **lowest_lev_from_sfc**: logical, whether surface data is used to fill the lowest model level values
- **force_sfc_in_vinterp**: number of levels to use surface data, default is 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`**: Δp where a non-surface pressure level is removed in vertical interpolation

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



Vertical interpolation options (3)

Since V3.3.1:

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

→ Help to improve biases introduced in vertical integration

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.exe`**, 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)

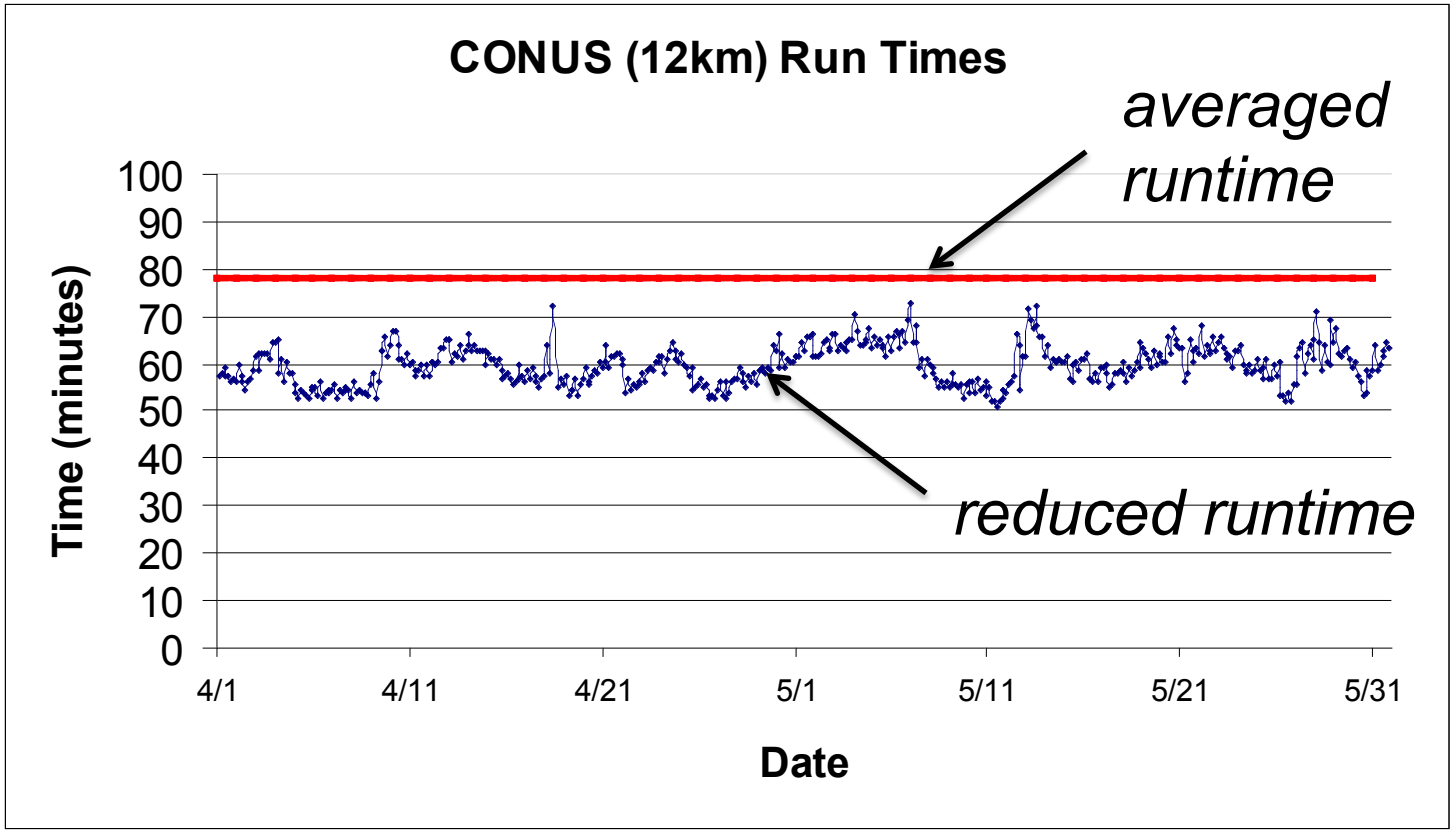
`sst_skin`	diurnal water temp update
`tmn_update`	deep soil temp update, used with lagday
`lagday`	averaging time in days
`bucket_mm`	bucket reset value for rainfall (e.g. `rainc=i_rainc*bucket_mm+rainc`)
`bucket_j`	bucket reset value for radiation fluxes
`spec_exp`	exponential multiplier for boundary zone ramping (set in *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)

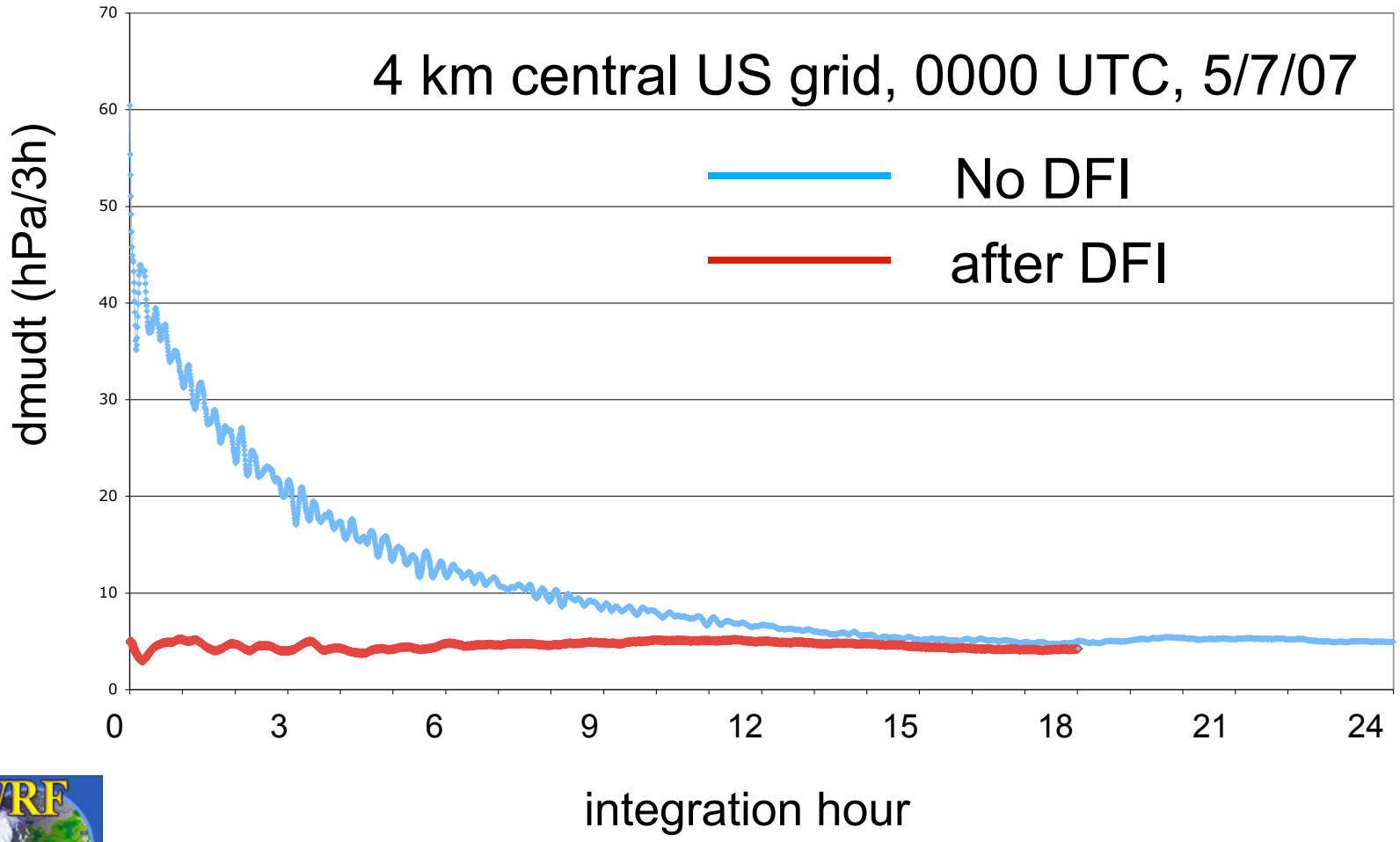
Using DFI

- 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

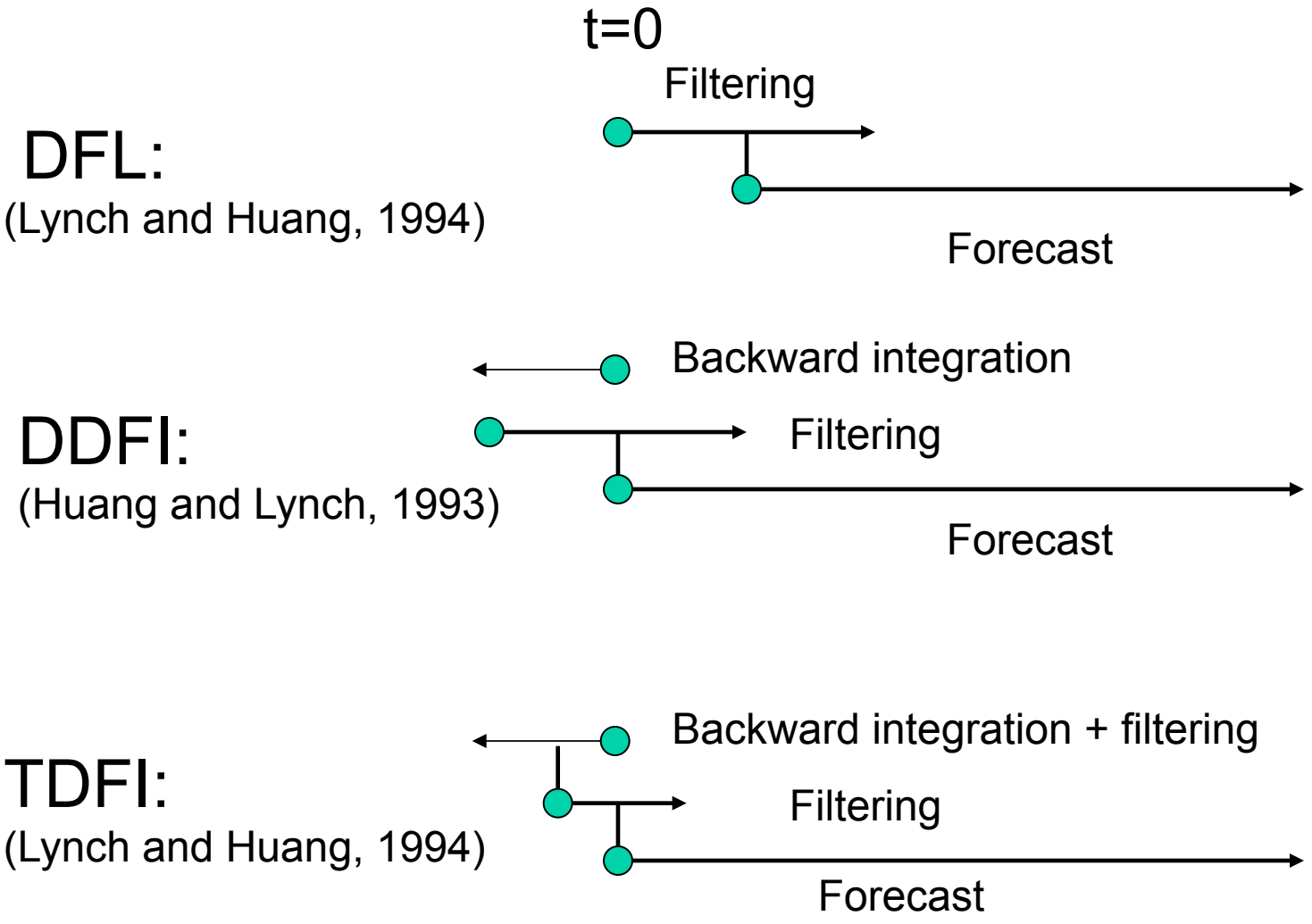
DFI is done after program **`real`**, or data-assimilation step, just before model integration

See ‘Using Digital Filter Initialization’, Chap 5, UG.

Digital filter initialization (3)



Digital filter initialization (4)



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`**

To get pressure tendency data, set **`diag_print=1`** or **`2`**

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 not been tested with global domain. Start with template `'namelist.input.global'`

See 'Global Run' section, Chap 5, UG

Automatic moving nest options

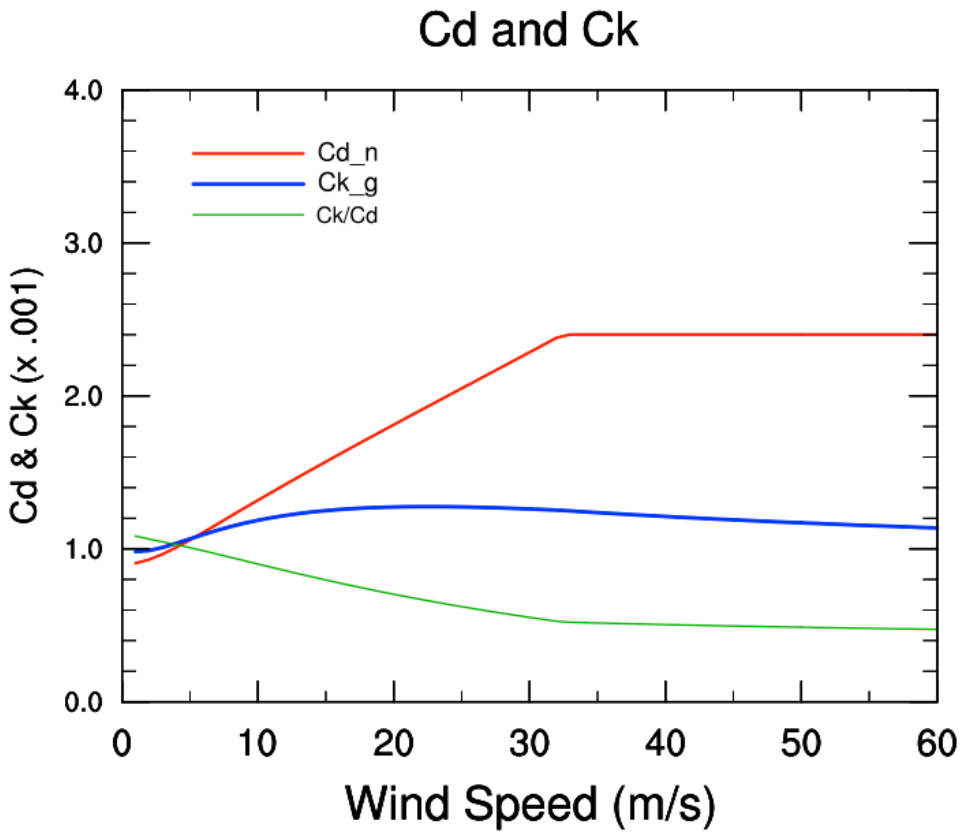
Tropical cyclone / typhoon / hurricane applications:

- **`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)

`sf_ocean_physics=1:` 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://www2.mmm.ucar.edu/wrf/users/hurricanes/wrf_ahw.html

TC options (3)

`sf_ocean_physics = 2:`

3D Price-Weller-Pinkel (PWP) ocean model based on Price et al. (1994). It has full ocean process (e.g. advection, pressure-gradient force, and mixing). It doesn't have ocean topography. Only simple initialization is provided in Version 3.5.

tracer option

Add the following in **`&dynamics`** to activate tracer option (default no. is 8: with array names **`tr17_1, tr17_2, …, tr17_8`**):

`tracer_opt` = 2,

One would need some way to initialize the tracer. A simple initialization can be found in program real (**`dyn_em/module_initialize_real.F`**)

trajectory option

Add the following in **`&physics`** to activate trajectory option:

`traj_opt` = 1,

And set the number of trajectories in **`&domains`**:

`num_traj` = 25, (default value)

Output: **`traj_i(num_traj), traj_j, traj_k, traj_lat, traj_long`**

To change initial launch points, edit code in initialization program **`real.exe`** (**`dyn_em/module_initialize_real.F`**)

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

`perturb_bdy:` = 1, use SKEB pattern; = 2, use user-provided pattern (new in 3.5)

Also see '**Option to stochastically perturb forecasts**' section in Chap 5, UG

(Berner et al. 2011, MWR)

Additional Output Option (1)

```
prec_acc_dt = 60.:
```

Output precipitation in a time interval (e.g. 60 min):
PREC_ACC_C, for convective rain
PREC_ACC_NC, for explicit rain
SNOW_ACC_NC, for explicit snow

(May not suitable for use in long runs)

Additional Output Option (2)

Since V3.4.1:

```
&diags
 p_lev_diag = 1.
 num_press_levels = 4,
 press_levels = 85000,70000,50000,20000
```

Output a few met fields on pressure levels :

U_PL, V_PL, S_PL, T_PL, TD_PL, RH_PL, GHT_PL,

Output goes to auxiliary stream 23, so need to set

auxhist23_outname, io_form_auxhist23,
auxhist23_interval, frames_per_auxhist23

Additional Output Option (3)

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 = 1440, 1440,

frame_per_auxhist3 = 10, 10,

Additional Output Option (4)

`nwp_diagnostics = 1:`

Output max 10 m wind speed, max helicity in 2 – 5 km layer, max w in updraft and downdraft below 400 mb, mean w in 2 – 5 km layer, and max column graupel in a time window between history output times.

Data goes to history file.

Additional Output Option (5)

`do_radar_ref = 1:`

Compute radar reflectivity using parameters used by different microphysics. Works for options mp_physics = 2,4,6,7,8,10,14,16. Option 9 also produces radar ref.

Data goes to history file.

Additional Output Option (6)

`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

Additional Output Option (7) *(extra)*

`afwa_*_opt = 1:`

output over 60 diagnostic variables to history file (for example, MSLP, precipitable water, cloud cover, etc.)

See Registry/registry.afwa for full listing.

Data goes to history as well as auxhist2 file.

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

Other ways to improve IO: 1) p-netCDF; 2) use netCDF4 compression option; 3) use io_form_history=102 to output patches of data

Time Series Output (1)

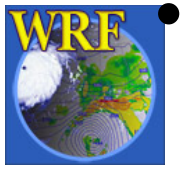
- It is a special output in text format with file name like

  ***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

- It also outputs profiles of U, V, Th, Qv, PH (levels set by **max_ts_level**, default 15)
- 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/`**

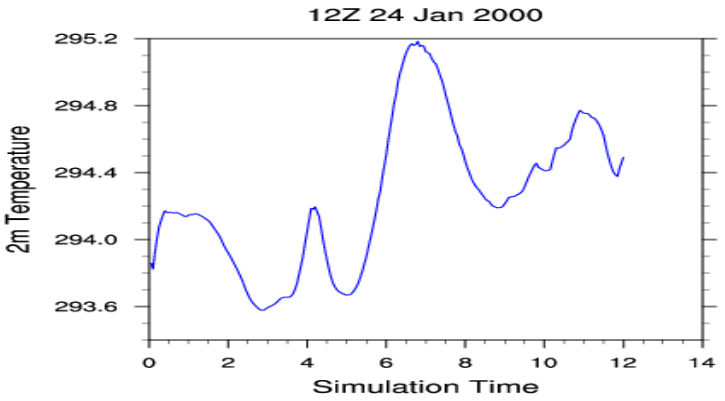
```
#-----------------------------------------#
# 24 characters for name | pfx |  LAT   |   LON   |
#-----------------------------------------#
Cape Hallett             hallt -72.330  170.250
McMurdo Station          mcm   -77.851  166.713
```

- 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
```



Recommended

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

Chapter 5 of ARW User's Guide, pages 5-32 – 5-34: examples for various applications.

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

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