WRF Version 3.2: New Features and Updates

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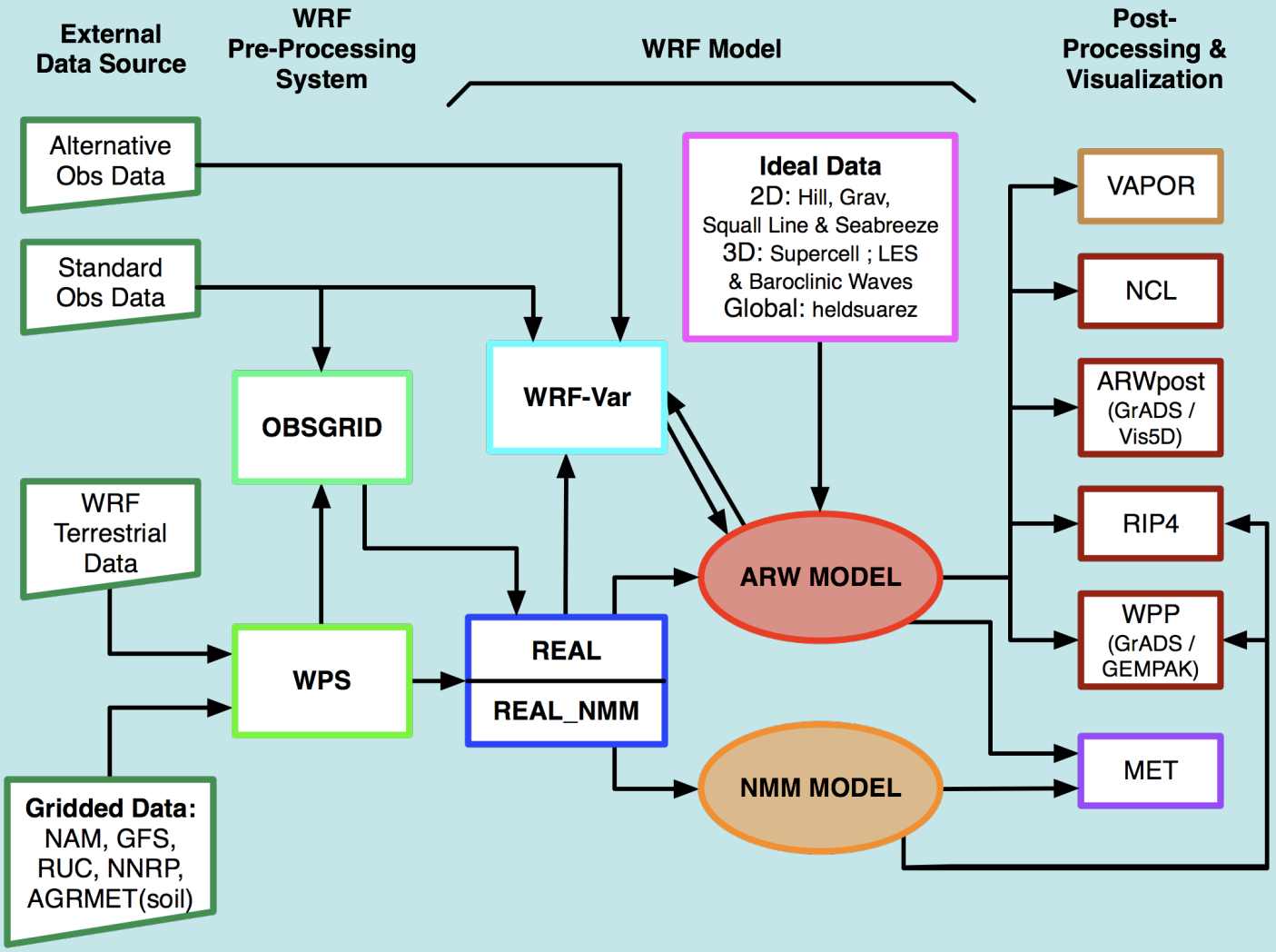
WRF Community Model

- Version 1.0 WRF was released December 2000
- Version 2.0: May 2004 (NMM added, EM nesting released)
- Version 2.1: August 2005 (EM becomes ARW)
- Version 2.2: December 2006 (WPS released)
- Version 3.0: April 2008 (add global ARW version)
- Version 3.1: April 2009
  - Version 3.1.1: August 2009
- Version 3.2: Released April 2010

WRF Community Model

- Over 4000 registered users world-wide
- Operational users include Korea KMA, US AFWA and NCEP, Taiwan CWB
- wrf-help support service answers over 400 questions per month
- NCAR hosts two tutorials and a workshop each year
  - Tutorials include 1-week basic training and options for WRF-Chem, WRF-DA, MET verification package
  - Special tutorial and workshop on Hurricane WRF was held February 2010
  - Recent overseas tutorials were held in Korea (April, 2010) and UK (September, 2009)

WRF Modeling System Flow Chart



V3.1 Highlights (2009)

- PBL options: QNSE, MYNN2.5,MYNN3.0, BouLac
- Microphysics options: new Thompson, WDM5, WDM6
- Radiation: RRTMG shortwave and longwave
- Regional climate upgrades
- Noah LSM updates including BEP urban option
- Spectral nudging
- Surface analysis nudging
- Orographic gravity-wave drag
- Sea-Ice fraction

New Options in V3.2

- Milbrandt-Yau double-moment microphysics (mp_physics=9)
  - Includes separate categories for graupel and hail, and number concentrations for all condensate species (13 variables including vapor)
  - Provided by Jason Milbrandt (Environment Canada)

New Options in V3.2

- Building Energy Model (BEM) (sf_urban_physics=3) including building anthropogenic terms
  - Provided by F. Salamanca and A. Martilli (CIEMAT, Spain)

New Options

- Nonlinear Backscatter Anisotropic (NBA) sub-grid turbulent stress (sfs_opt=1,2) for LES
  - Provided by Jeff Mirocha (Lawrence Livermore NL)
- WRF-Fire
  - A surface fire-spread model with some idealized example cases
  - Provided by Mandel, Beezley, Coen and Kim
- NDOWN vertical nesting option using constant refinement factor (e.g. 2 or 3)
  - Provided by M. Moustaoui (Arizona State U, poster P.3)

New Features

- Shallow convection option added to G3 (Grell-3) cumulus scheme (ishallow=1)
- Obs-nudging vertical-weighting flexibility for surface observations (talk 2.3 by A.-J. Deng)
- NMM SST update capability added

New Features

Land-related

- Vegetation-height dependent thermal roughness length in sfclay and myjsfc (iz0tlnd=1) from Chen and Zhang
- Noah LSM improvements to time-dependent snow albedo (talk 4.3 by K. Manning)
- PXLSM and RUCLSM added sea/lake-ice capability
- Slope/shading effects generalized to work with all shortwave radiation and land-surface options

New Features

Hurricane-related

- ARW 1d ocean-mixed layer can now be used with any LSM options (omlcall=1)
- ARW tropical cyclone surface flux formulation (isftcflx) modified and also now includes Garratt Ck option (2) and dissipative heating
- HWRF (talk 2.2 by V. Tallapradaga)
  - physics (NMM) updated (GFS PBL, SAS cumulus, Ferrier microphysics, GFDL radiation)
  - HWRF vortex-following added

New Features

- Run-time input/output field specification
- 4d tracer array that can be used to trace air by specifying initial concentrations in regions (any number of tracers can be set)
- Option to accumulate rainfall over specified periods in ARW (prec_acc_dt)
- Option to output time-averaged mass fluxes for off-line transport models including Grell-Devenyi option cumulus fluxes (do_avgflx_em, do_avgflx_cugd)

Improvements

Radiation

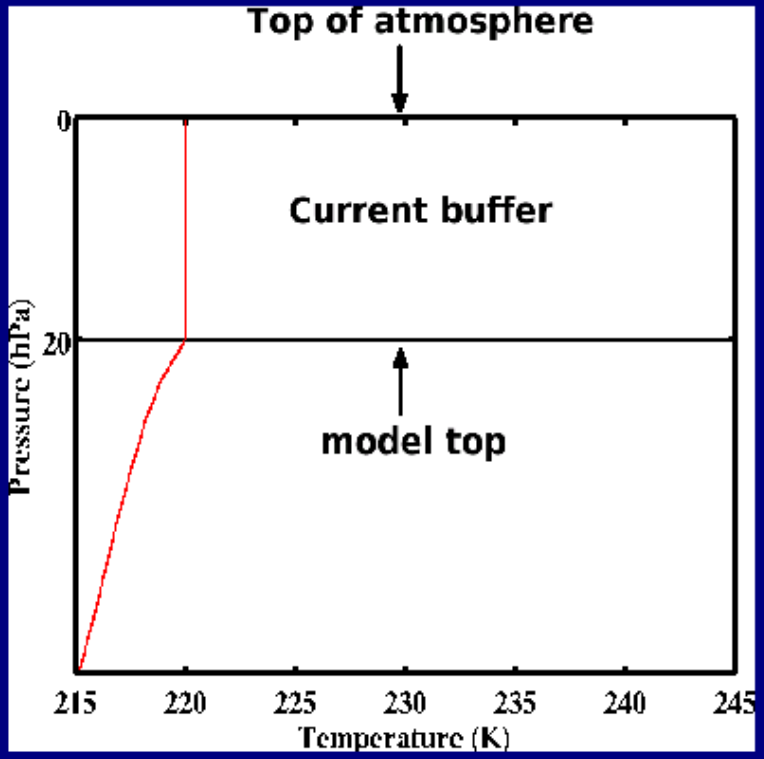
- RRTM: Improved temperature profile assumption above model top (from Steven Cavallo, NCAR)
- RRTMG: Improved assumption to consider ice+snow as ice clouds instead of just ice
- Ungrib/Real: Improve high-level RH assumptions when RH data is missing (e.g. FNL/GFS datasets). Previous assumptions led to too much water vapor in stratosphere

More on RRTM Improvement

- Corrects a cooling bias near model top
- May impact lower levels
- Isothermal assumption above top replaced by a climatological global-mean lapse rate that warms significantly up to 1 hPa
- Extra layers added above model top in radiation code to better represent thermal structure
- Water vapor effect was also significant leading to modified assumptions for missing relative humidity at high levels

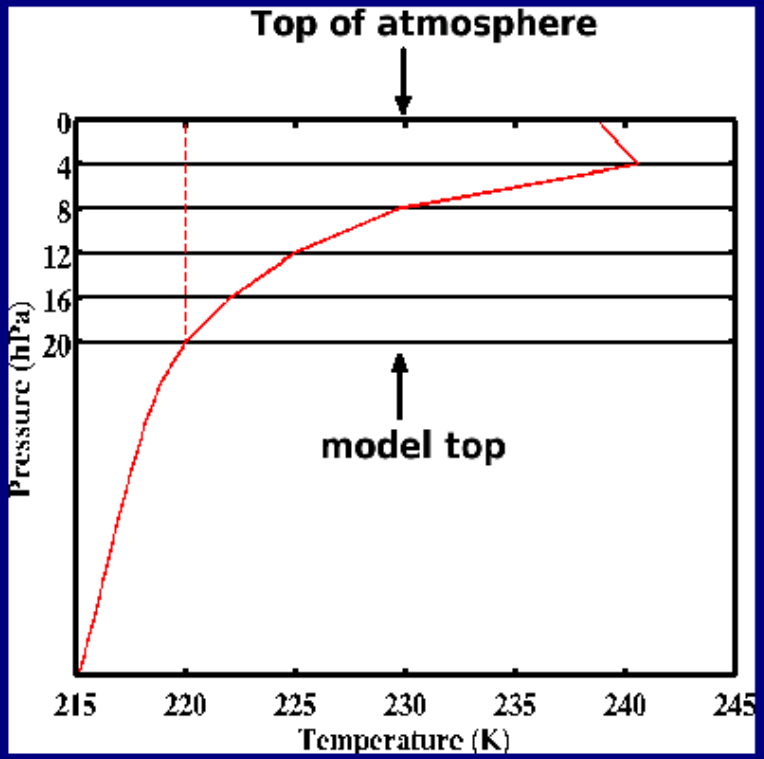
How are we correcting it?

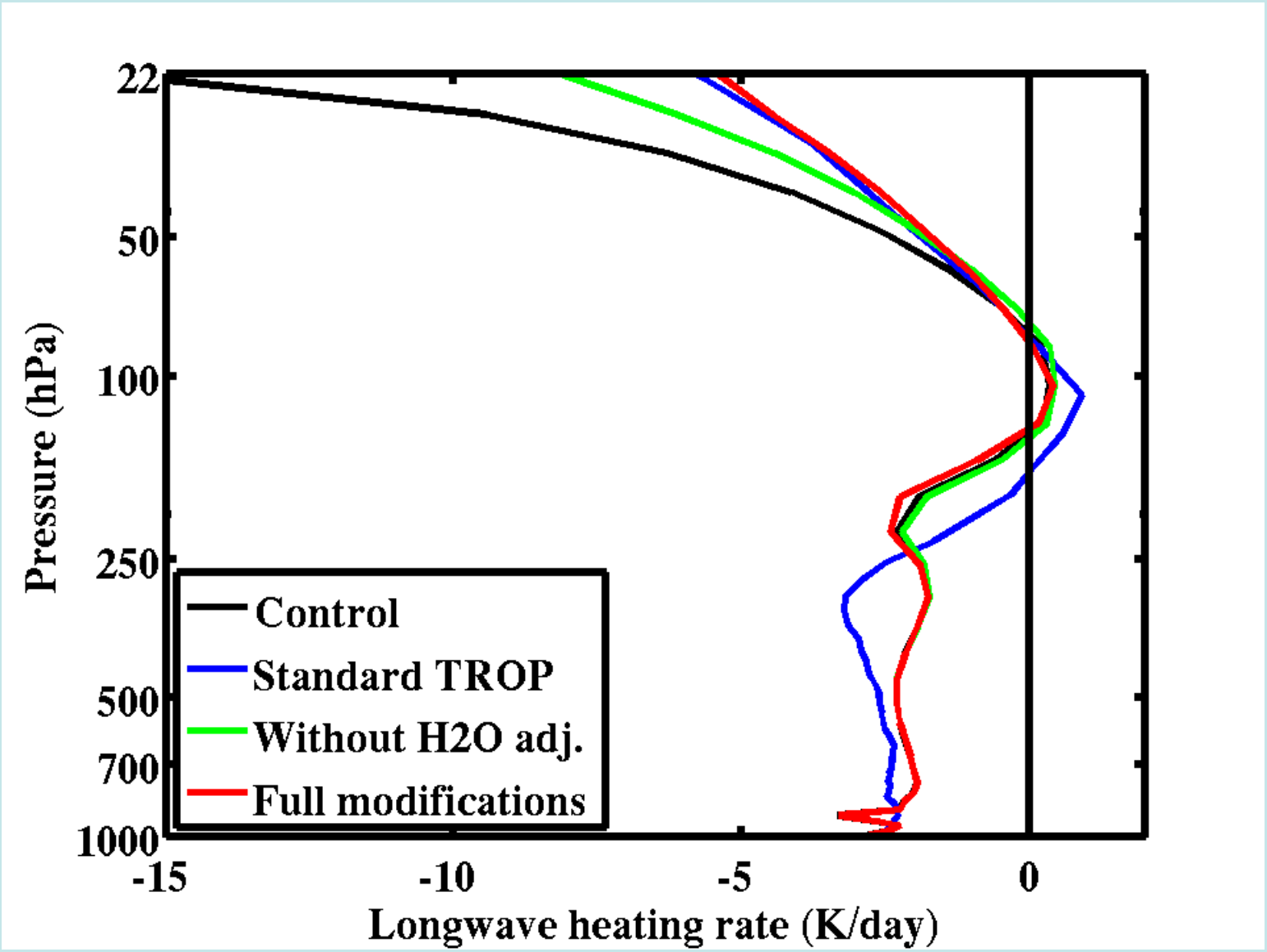
- Currently, one level is added from model top to TOA at $p = 0$ hPa
- Temperature is assumed isothermal
- Mixing ratios are held constant, *except* for O_3 which is reduced to $0.6 * O_3(\textit{model top})$



How are we correcting it?

- New method adds several "buffer" layers from model top to TOA with a constant pressure interval between levels of $\Delta p = -4$ hPa
- Results sensitive to Δp
- Temperature profile interpolated from a new table to WRF column pressure with buffer layers appended
- Because of the stratopause located $\sim$1 hPa, method is not suitable for model tops under 5 hPa.




22
50
100
250
500
700
1000
Pressure (hPa)
-15
-10
-5
0
Longwave heating rate (K/day)
Control
Standard TROP
Without H2O adj.
Full modifications

Improvements

Microphysics

- WSM and WDM schemes now use a new semi-lagrangian fall-term calculation instead of time-splitting approach

Physics Code (Cumulus and Radiation)

- Use of hydrostatic pressure for physics was unified. Computed now in phy_prep instead of separately in various packages (cu_gd, cu_g3, ra_rrtmg_lw, ra_rrtmg_sw, ra_rrtm, ra_gsfcsw, ra_cam, ra_gfdleta)
  - Hydrostatic pressure also available in output (p_hyd)

Bug-fixes

- WSM and WDM schemes have a correction for long time-steps (> 120 s) where non-convective rainfall going into the LSM was half or less its proper value
- KF cumulus schemes have a correction for convective rainfall going into the LSMs that may have been underestimated by a few percent
- Two-way nesting has been fixed to avoid drift and possible blow-ups for long integrations with boundary over complex terrain
- Sea-ice (with sst_update) corrected to reset albedo, snow cover, etc. when sea-ice disappears
- QNSE PBL 2m and 10m diagnostics corrected

Known Problems

To be fixed in 3.2.1 (July/August 2010)

- Grid-nudging wrffdda file may contain zeros (I/O fix)
- Care needed in specifying auxinput_interval, io_form with new I/O (will fix by putting namelist checks in)
- For upper stratosphere (pressure < 5 hPa) all microphysics options may give spurious clouds (WSM, WDM and Morrison schemes will be fixed first)

Release 3.2 Information

- A more complete list of new features, improvements and bug-fixes can be found on WRF ARW Web site
- New WRF and WPS tar files can be downloaded
- Updated User Guide available

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

Plans

Next version (V3.3) due in Spring 2011

- More CCSM physics (talk 6.2 by W. Gustafson)
  - U. Washington PBL/shallow convection (Bretherton-Park)
  - Current Zhang-McFarland cumulus version
- Tiedtke cumulus scheme (from Y. Wang, U. Hawaii)

Also possible

- Simple SiB LSM (Y. Xue, UCLA)
- QNSE/EDMF PBL (Galperin/Pergaud)
- hybrid TKE/YSU PBL (Hong)

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