WRFDA Tools
Analysis/Forecast Verification

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Talk overview

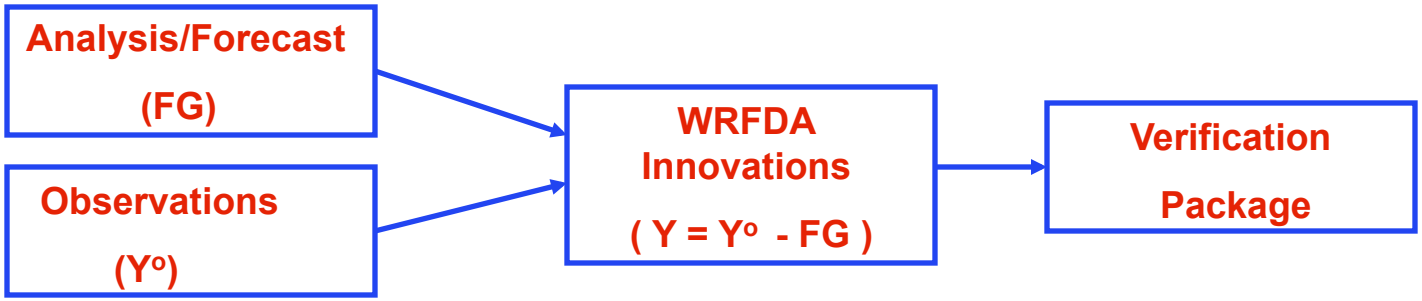
- WRFDA verification strategy:
  - What are its advantages/disadvantages?
  - How to run WRFDA verification package
  - Expected graphics
- WRFDA scripts and graphic tools
- Obs error tuning (Desroziers method)
  (QJRMS (2001), Vol. *127*, pp. 1433-1452)
- Obs error tuning Hollingsworth method)
  (Tellus (1986), Vol. *38*, pp. 111-161, Part I & II)

How to Verify Analysis/Forecast?

- Two ways:
  - Against Observations
  - Against any analysis available in grid space (Control Analysis)

- Verification scores:
  - Root Mean Square Error (RMSE)
  - Mean bias (BIAS)
  - Absolute Mean bias (ABIAS)

Observation based Verification



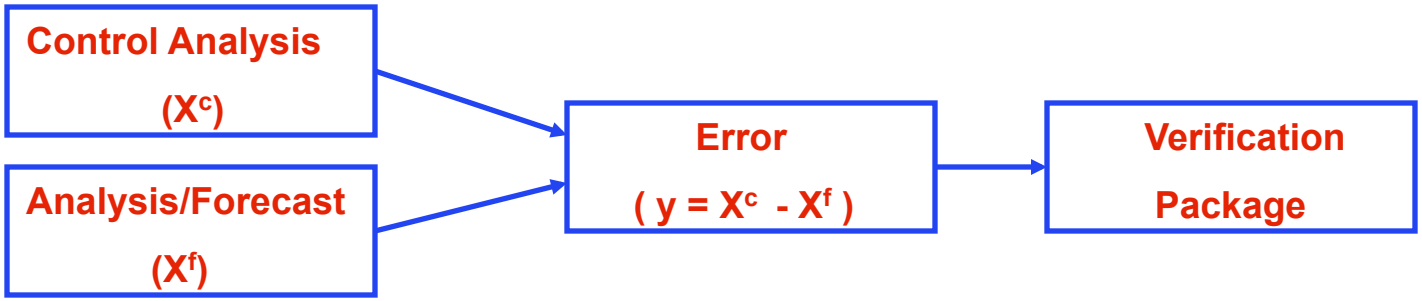
Verification code is under

var/da/da_verif_obs

compile all_wrfvar creates the desired executable

da_verif_obs.exe

Analysis based Verification



Code resides under "var/da/da_verif_grid" directory

"compile all_wrfvar" creates the desired executable

(da_verif_grid.exe)

Advantages/disadvantages

- Consistent with WRFDA QC
- Consistent with WRF model topography
- It makes use of built-in WRFDA observation operators
- In principle, verification is possible against any
  - Observation type individually or collectively
  - Verification analysis may be from any independent source or produced by any experiment
- It has its own built-in graphics (NCL) package
- In principle one can verify against only those observations which WRFDA can assimilate. Thus quantities like “rainfall” etc. cannot be verified.

How to run verification against observation?

It works in two steps

- Step 1: Execute "var/script/da_run_suite_verif_obs.ksh"
  It will create all the desired input files (gts_omb_oma") for verification
- Step 2: Execute "var/script/da_verif_obs_plot.ksh"
  It will generate the desired graphics
- These scripts are executed (in the same order) via a suitable wrapper script

Wrapper for da_run_suite_verif_obs

Important variables to be declared via wrapper script:

INITIAL_DATE	: Vrification starting date (yyyymmddhh)
FINAL_DATE	: Verification ending date (yyyymmddhh)
CYCLE_PERIOD	: Date advance increment in hour
EXP_DIR	: Experiment directory name (full path)
FILTERED_OBS_DIR	: Directory where the observations “filtered_obs” against which verification will be done
VERIFICATION_FILE_STRING	: It is either "wrfout" or "wrf_3dvar_input", depending on which files are saved while running WRF-forecasts in FC_DIR
VERIFY_HOUR	: 00 for analysis & 12, 24, etc. corresponding to the desired forecast hour verification

Wrapper for da_verif_obs_plot

Important variables:

WRFVAR_DIR : WRFDA main directory (full path)
REG_DIR : Directory holding sub-directories for each experiment generated in Step 1
For example: "gts_omb_oma" file corresponding to experiment "verify_12" (directory for 12 hr forecast verification) for "2005081700" should be in $REG_DIR/verify_12/2005081700/wrfvar
RUN_DIR : Full path of the directory where plots will be generated
NUM_EXPT : Total number of experiments (Currently maximum 10)
EXP_NAMES : Experiment directory names as they exist in REG_DIR (blank separated)
EXP_LEGENDS : Legend strings for each experiments respectively (comma separated)
START_DATE : Starting date ("YYYYMMDDHH") for verification
END_DATE : Ending date ("YYYYMMDDHH") for verification
INTERVAL : Time interval (in hours) for incrementing date/time.
NUM_OBS_TYPE : Number of observation types for verification
OBS_TYPES : Verification observation types like, "synop", "buoy", "sound" etc.
PLOT_WKS : Name of workstation for plots like "X11", "pdf" etc.
DESIRED_LEVELS : Pressure levels (in hPa) for plotting diagnostics
DESIRED_SCORES : Diagnostics like "RMSE", "BIAS" or "ABIAS"
EXP_LINES_COLORS : Color sequence for various experiments.
VERIFY_DATE_RANGE: String to specify title for X-axis

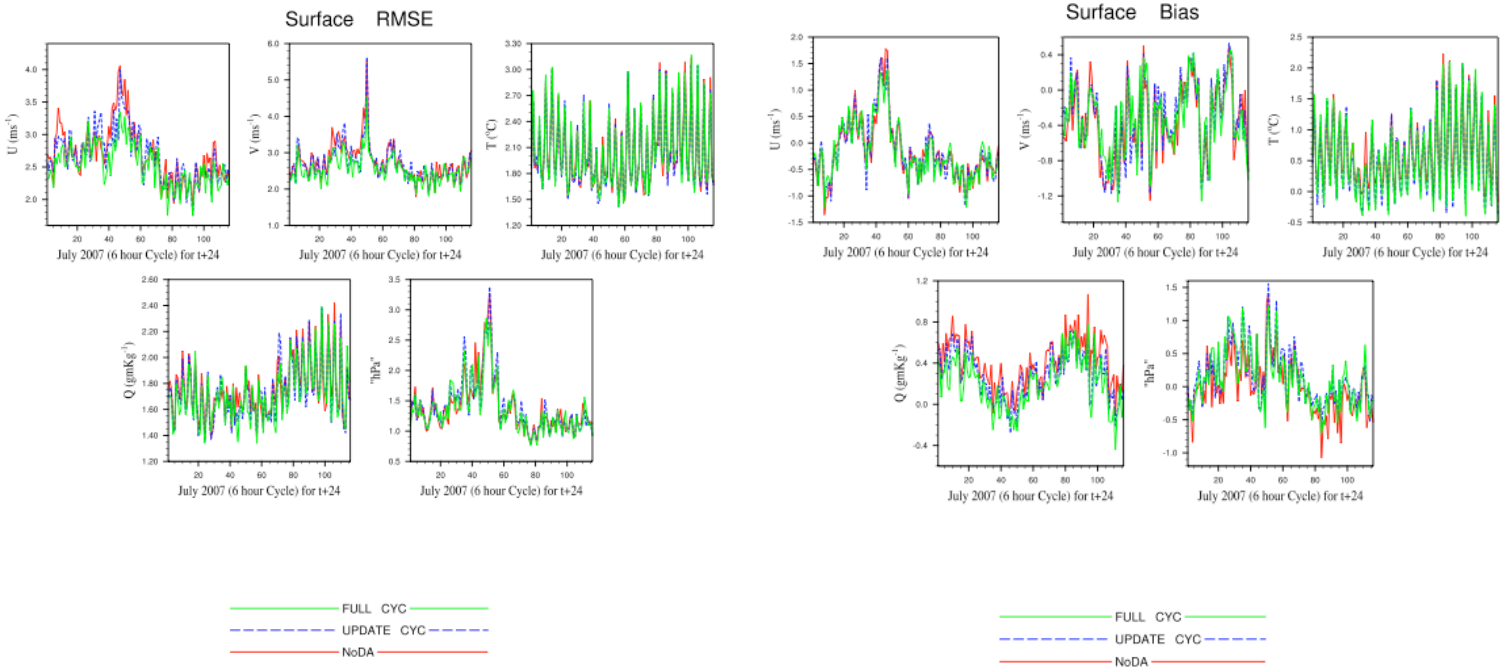
Verif_obs_plot output

In RUN_DIR, following graphics will be generated for each of the desired scores (RMSE, BIAS, ABIAS)

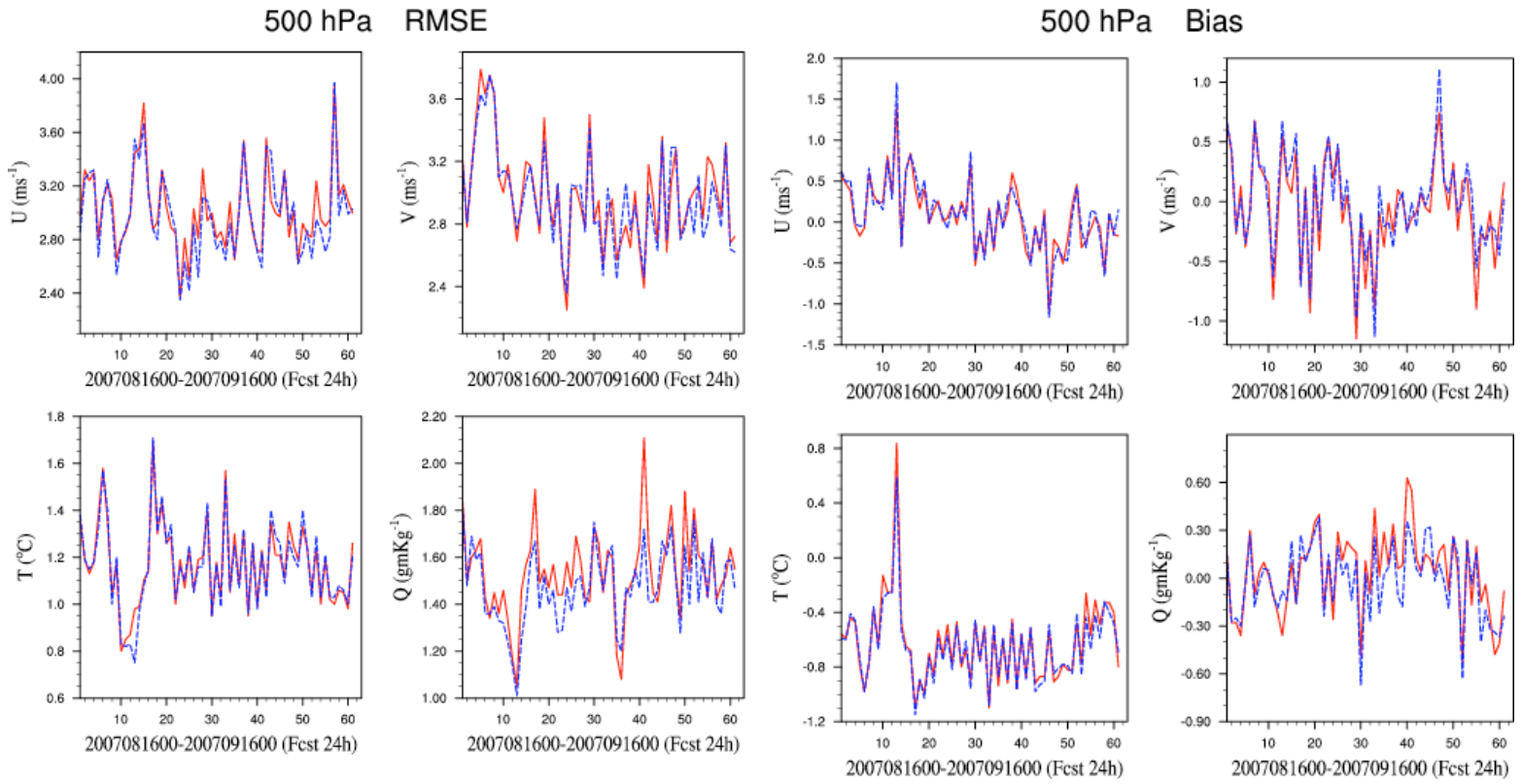
- Time series for surface and all the desired upper air levels
- Vertical profiles
- Time Average for surface and all the upper air levels (Histograms)

```
-rw-r--r--  1 rizvi  ncar     597691 Oct 13 12:49 Time_Series_SFC_RMSE.pdf
-rw-r--r--  1 rizvi  ncar     291856 Oct 13 12:49 Time_Series_SFC_BIAS.pdf
-rw-r--r--  1 rizvi  ncar     319570 Oct 13 12:49 Time_Series_SFC_ABIAS.pdf
-rw-r--r--  1 rizvi  ncar    1571714 Oct 13 12:49 Time_Series_UPA_RMSE.pdf
-rw-r--r--  1 rizvi  ncar     753440 Oct 13 12:49 Time_Series_UPA_BIAS.pdf
-rw-r--r--  1 rizvi  ncar     769452 Oct 13 12:49 Time_Series_UPA_ABIAS.pdf
-rw-r--r--  1 rizvi  ncar     463151 Oct 13 12:49 Profile_RMSE.pdf
-rw-r--r--  1 rizvi  ncar     467553 Oct 13 12:49 Profile_BIAS.pdf
-rw-r--r--  1 rizvi  ncar   12769280 Oct 13 14:54 Profile_ABIAS.pdf
-rw-r--r--  1 rizvi  ncar     129469 Oct 13 12:49 Time_Average_SFC_RMSE.pdf
-rw-r--r--  1 rizvi  ncar     136679 Oct 13 12:49 Time_Average_SFC_BIAS.pdf
-rw-r--r--  1 rizvi  ncar     142219 Oct 13 12:49 Time_Average_SFC_ABIAS.pdf
-rw-r--r--  1 rizvi  ncar     352928 Oct 13 12:49 Time_Average_UPA_RMSE.pdf
-rw-r--r--  1 rizvi  ncar     402740 Oct 13 12:49 Time_Average_UPA_BIAS.pdf
-rw-r--r--  1 rizvi  ncar     365264 Oct 13 12:49 Time_Average_UPA_ABIAS.pdf
```

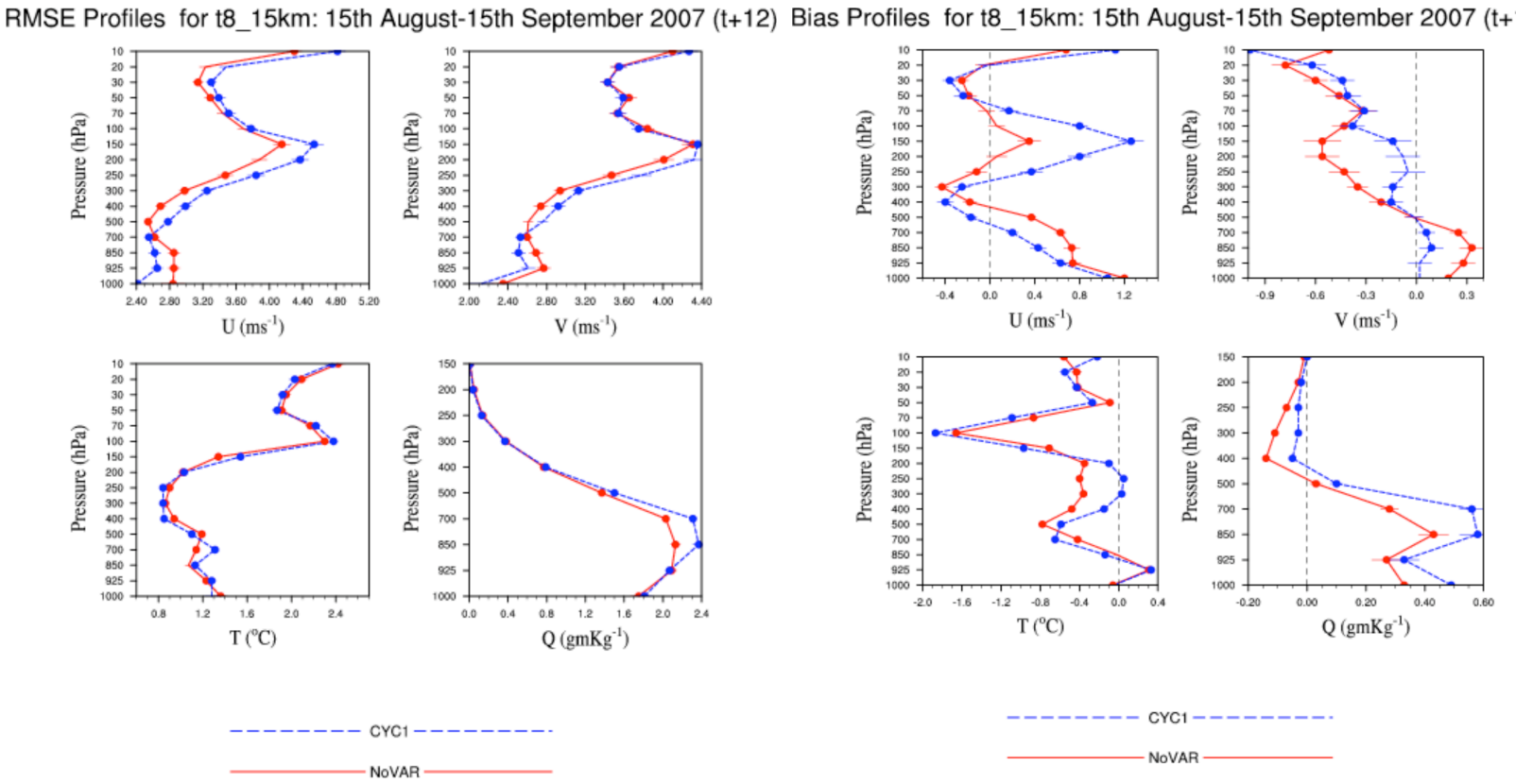
Verif_obs_plot -- Surface Time Series



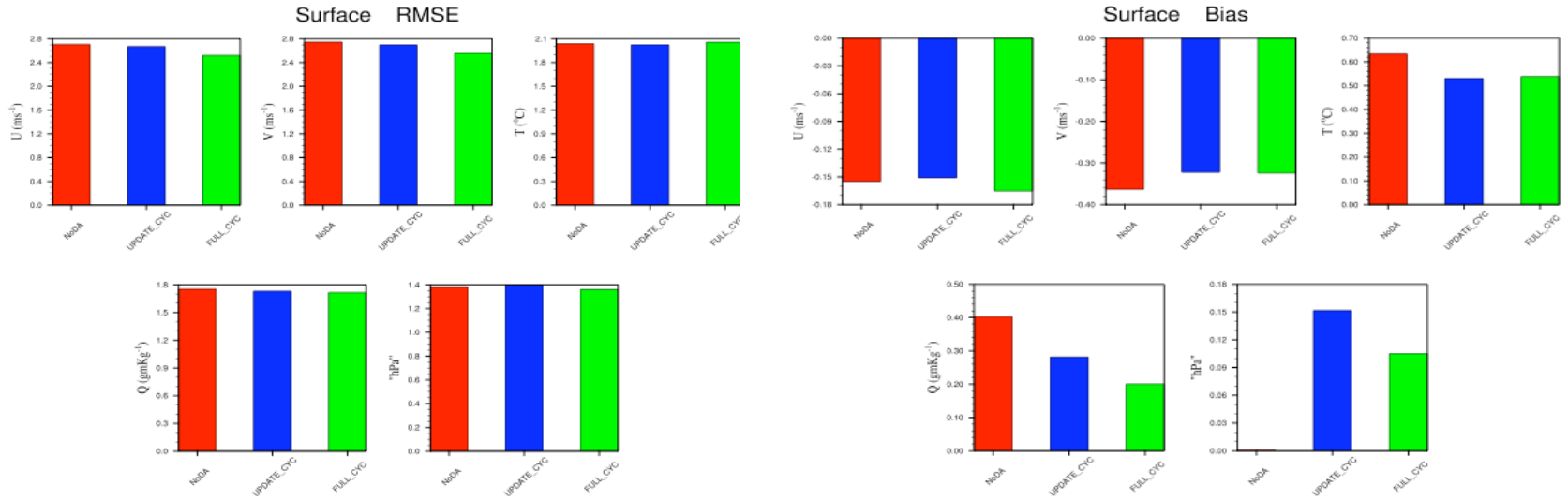
Verif_obs_plot -- Upper air Time Series



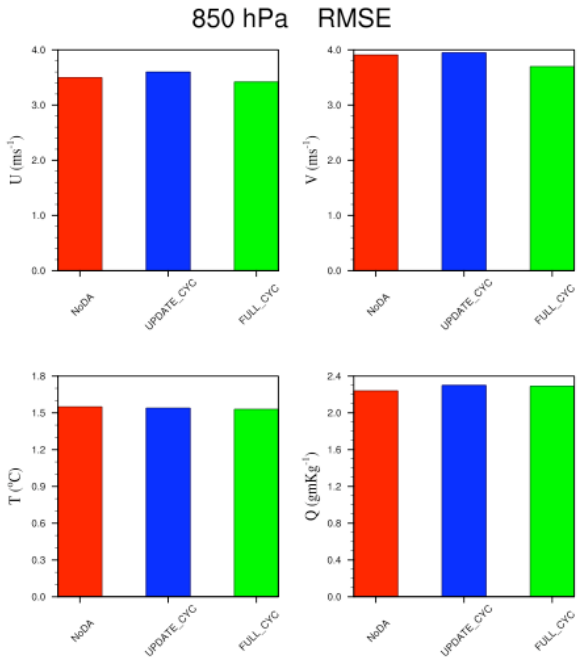
Verif_obs_plot -- Profile

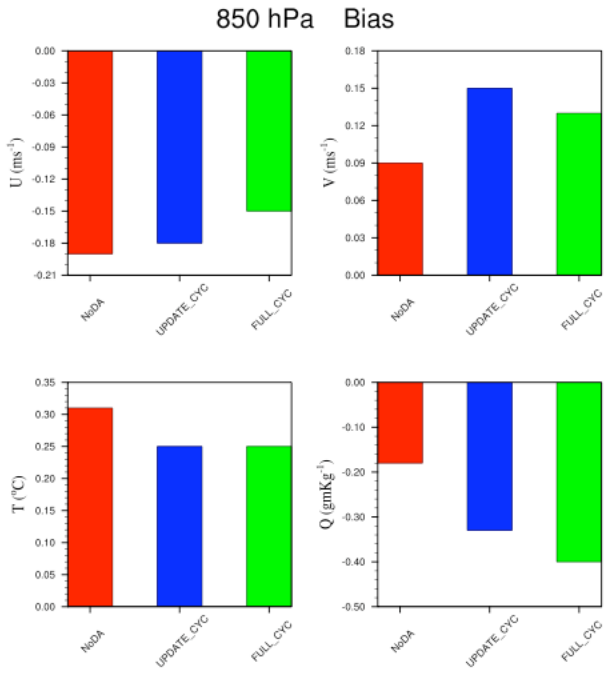


Verif_obs_plot -- Surface Time Average



Verif_obs_plot -- Upper air Time Average





How to run verification against Analysis?

- Each experiment forecasts output needs to be arranged in separate directories with date-wise sub-directories
- Desired graphics will be generated in "RUN_DIR" by executing "var/script/da_verif_grid.ksh" via a suitable wrapper script

Wrapper for da_verif_grid.ksh

Important variables:

RUN_DIR : Directory where plots will be generated
CONTROL_EXP_DIR : Directory name for verifying analysis
VERIFY_ITS_OWN_ANALYSIS : Set “true” or “false” if each experiment is going to be verified against its own analysis or against a fixed analysis for “CONTROL_EXP_DIR”
NUM_EXPT : Total number of experiments (Currently maximum 10)
EXP_DIR : Experiment directory names as they exist in REG_DIR (blank separated)
EXP_NAMES : Experiment names for plotting purposes under REG_DIR (blank separated)
DESIRED_LEVELS : Verifying pressure (hPa) levels (comma separated)
DESIRED_SCORES : Diagnostics like "RMSE", "BIAS" or "ABIAS”
NUM2D/VAR2D : Number/Type of surface variables like T2M, Q2M, U10M, SLP, PSFC, etc.
NUM3D/VAR3D : Number/Type of 3D verifying fields like , U, V, T, etc.
INTERVAL : Time interval (in hours) for incrementing date/time
VERIFY_HOUR : Verification hour
CONTROL_EXP_DIR : Directory name for verifying analysis
VERIFICATION_FILE_STRING : It should be “wrfout” or “wrfinput” depending on what is available
RUN_VERIF_GRID_STATS : Set “true”, if only verification scores needs to be computed
RUN_VERIF_GRID_PLOTS : Set “true”, if scores are ready and the graphics is needed
TOP_HPA_LEVEL_FOR_VERT_PROFILES: Top level (hPa) for display of results

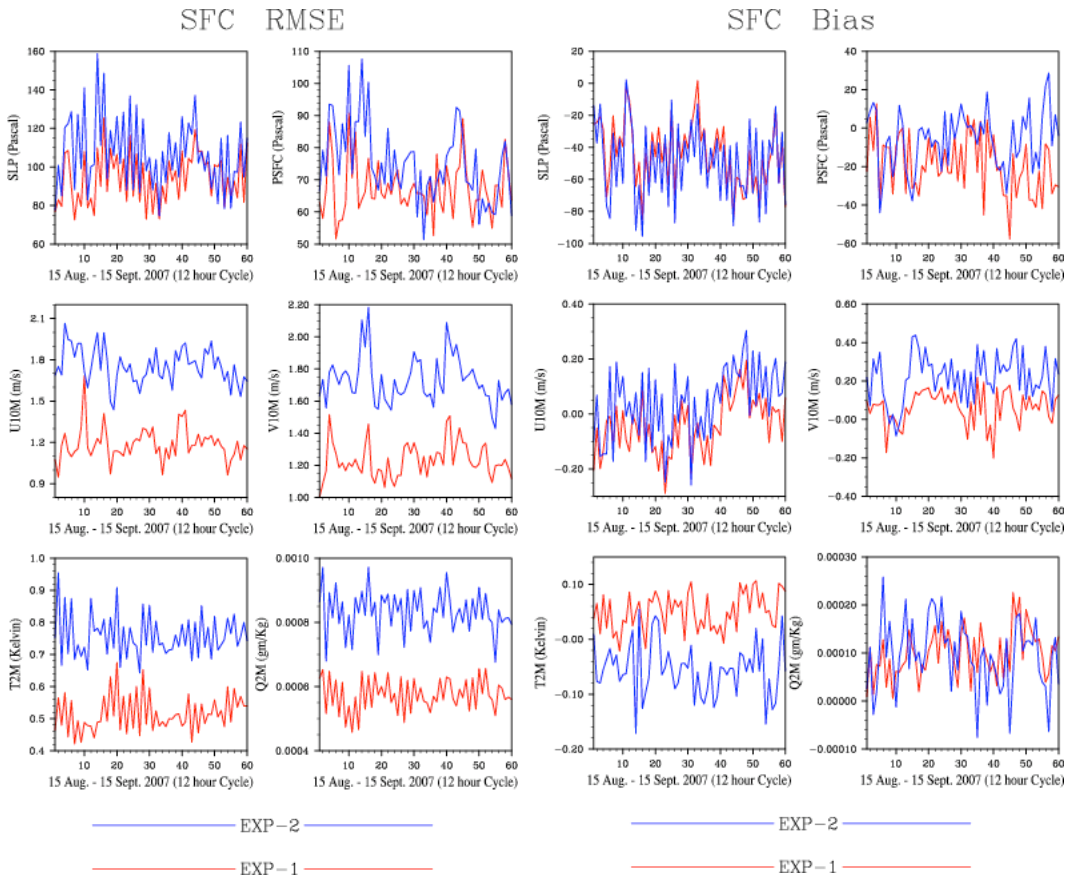
Verif_anal_grid output

In RUN_DIR, following graphics will be generated for each of the the desired scores (RMSE, BIAS or ABIAS)

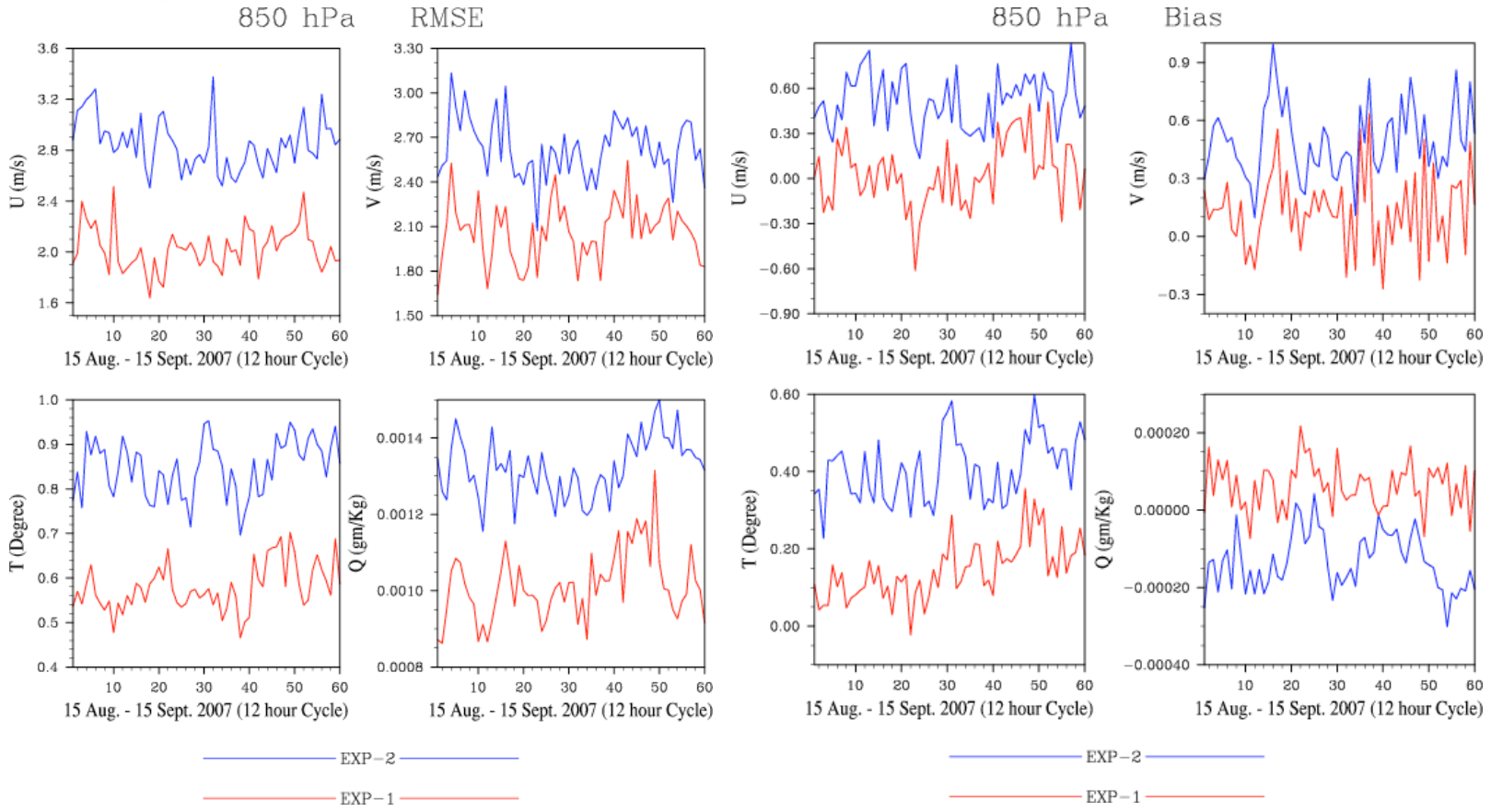
- Time series for surface fields (U10, V10, T2, Q2 & Psfc)
- Time series for upper air fields (U, V, T & Q) for the desired levels
- Upper air profiles for U, V, T & Q
- Time average for surface and upper air fields for the desired levels (Histogram)

```
-rw-r--r--  1 rizvi  ncar   235624 Dec 31 15:14 Time_Series_UPA_RMSE-850-hr24.pdf
-rw-r--r--  1 rizvi  ncar   237504 Dec 31 15:14 Time_Series_UPA_BIAS-850-hr24.pdf
-rw-r--r--  1 rizvi  ncar   183367 Dec 31 15:14 Time_Series_UPA_RMSE-200-hr24.pdf
-rw-r--r--  1 rizvi  ncar   173293 Dec 31 15:14 Time_Series_UPA_BIAS-200-hr24.pdf
-rw-r--r--  1 rizvi  ncar   322432 Dec 31 15:14 Time_Series_SFC_RMSE-hr24.pdf
-rw-r--r--  1 rizvi  ncar   325796 Dec 31 15:14 Time_Series_SFC_BIAS-hr24.pdf
-rw-r--r--  1 rizvi  ncar   100323 Dec 31 15:14 Time_Average_UPA_RMSE-850-hr24.pdf
-rw-r--r--  1 rizvi  ncar   112711 Dec 31 15:14 Time_Average_UPA_BIAS-850-hr24.pdf
-rw-r--r--  1 rizvi  ncar    71525 Dec 31 15:14 Time_Average_UPA_RMSE-200-hr24.pdf
-rw-r--r--  1 rizvi  ncar    81035 Dec 31 15:14 Time_Average_UPA_BIAS-200-hr24.pdf
-rw-r--r--  1 rizvi  ncar   163671 Dec 31 15:14 Time_Average_SFC_RMSE-hr24.pdf
-rw-r--r--  1 rizvi  ncar   182593 Dec 31 15:14 Time_Average_SFC_BIAS-hr24.pdf
-rw-r--r--  1 rizvi  ncar   237409 Dec 31 15:14 Profile_RMSE-hr24.pdf
-rw-r--r--  1 rizvi  ncar   238775 Dec 31 15:14 Profile_BIAS-hr24.pdf
```

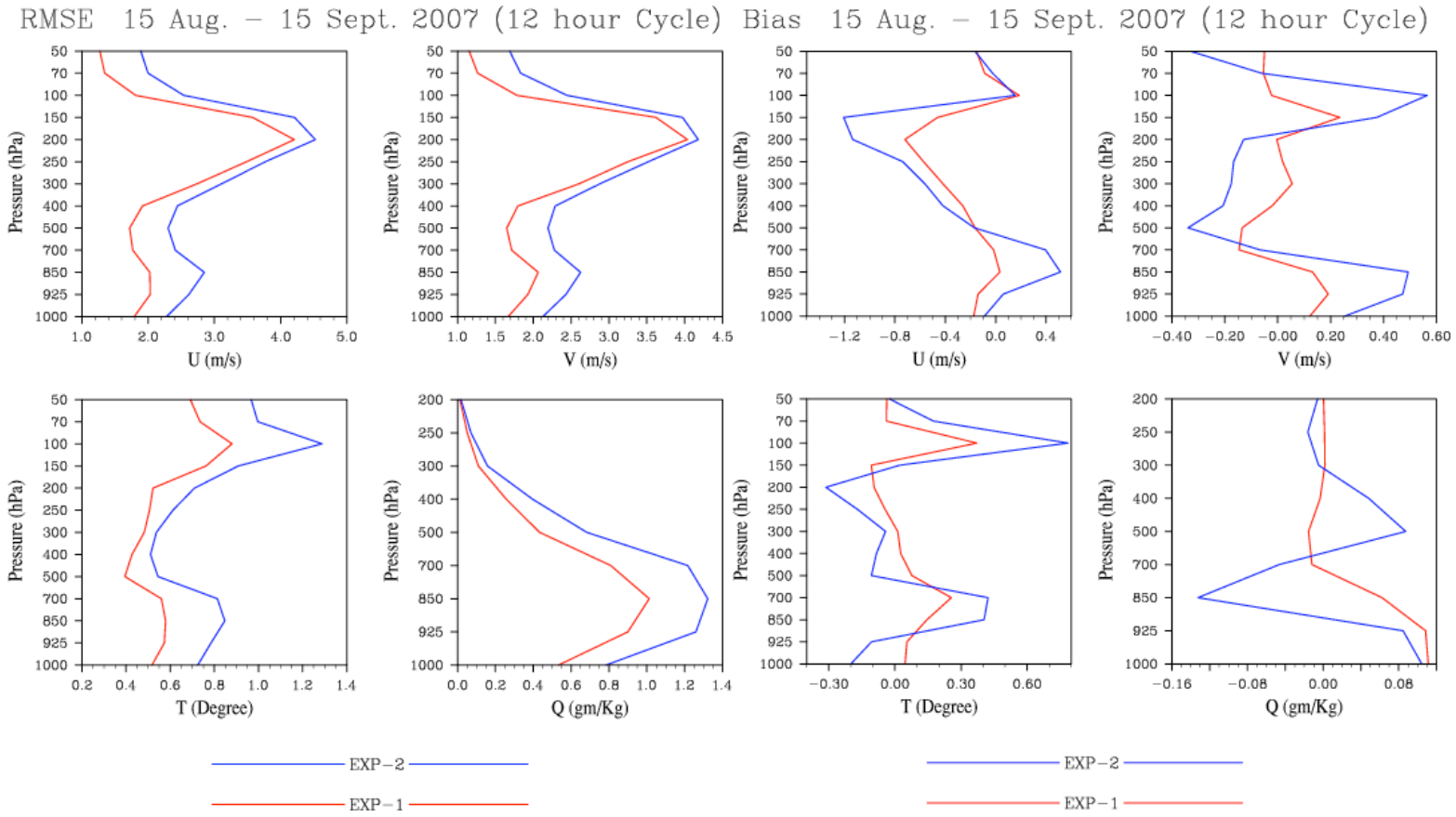
Verif_grid_plot -- Surface Time Series



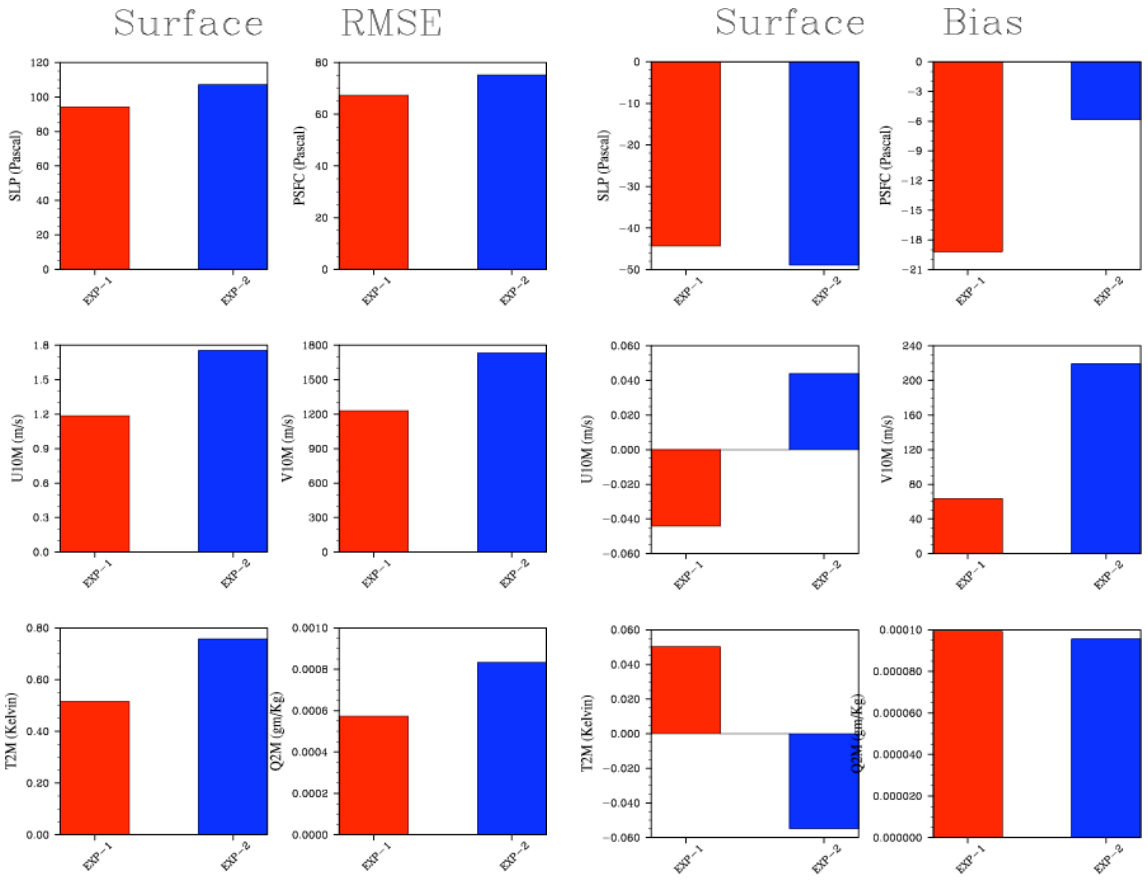
Verif_grid_plot -- Upper air Time Series



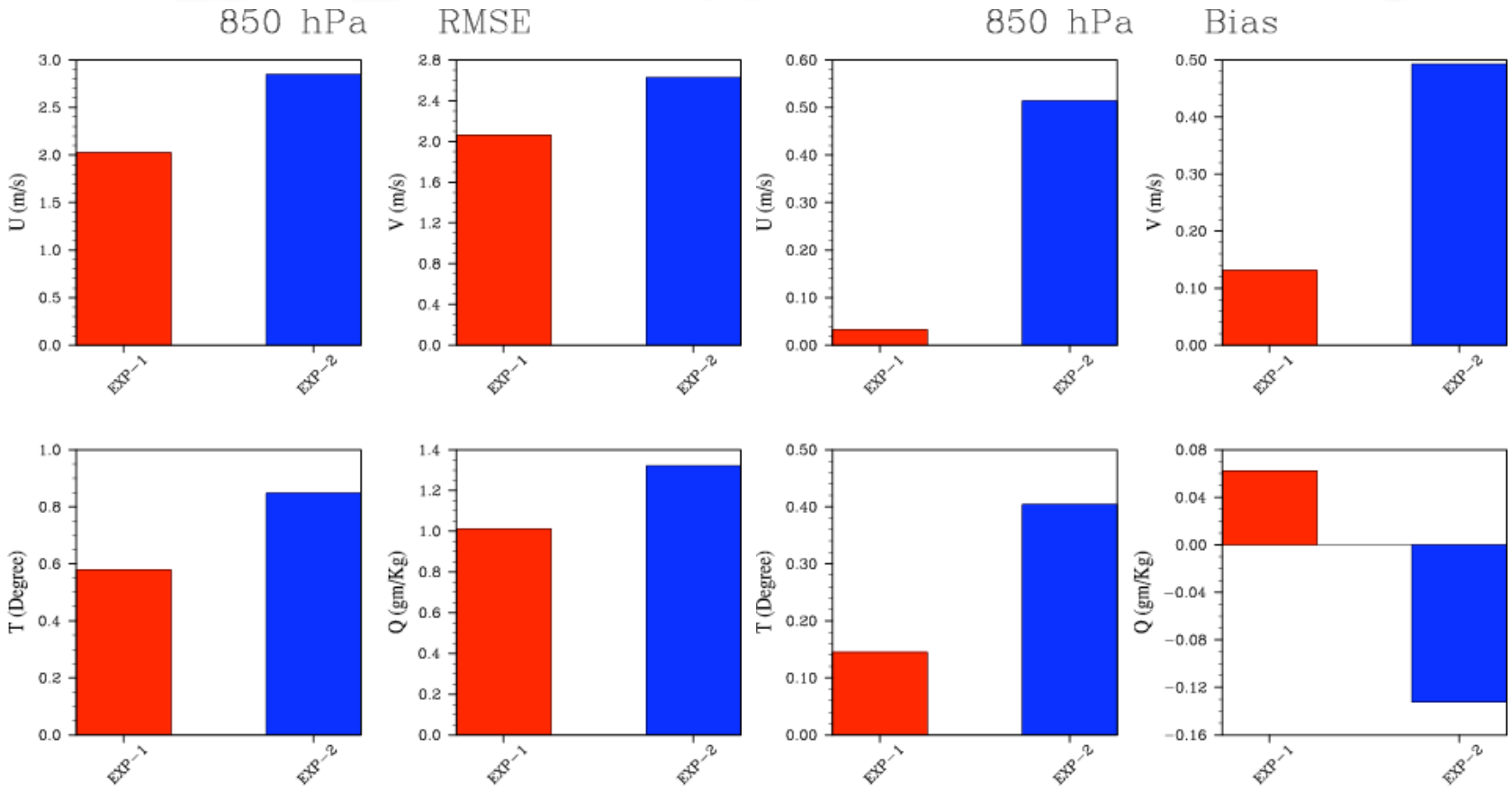
Verif_grid_plot -- Profile



Verif_grid_plot -- Surface Time Average



Verif_grid_plot -- Upper air Time Average



WRFDA Scripts and GroaphicTools

Shell scripts and NCL based graphics are available

http://www.mmm.ucar.edu/wrf/users/wrfda/download/tools.html

Some useful Shell Scripts:

da_run_wrfvar.ksh
da_run_suite_verif_obs.ksh
da_run_psot.ksh
da_run_gsi.ksh
da_tune_obs_hollingsworth.ksh
da_run_suite_wrapper_verif_obs.ksh
da_verif_grid_plot.ksh
da_run_obsproc.ksh
da_run_wrfvar_psot.ksh
da_run_suite_wrapper_qc_obs.ksh
da_plot_psot.ksh
da_run_gsi_psot.ksh
da_tune_obs_desroziers.ksh
da_verif_obs_plot.ksh
da_run_wps.ksh da_run_wrf.ksh
da_run_real.ksh

Some useful NCL Scripts:

WRF-Var_plot.ncl
plot_gts_omb_oma.ncl
Verif_obs_time_series.ncl
Verif_grid_time_series.ncl
plot_cost_grad_fn.ncl
plot_rad_diags.ncl
verif_obs_time_average.ncl
verif_grid_time_average.ncl
plot_obascii_loc.ncl
plot_rad_varbc_param.ncl
verif_grid_vert_profile.ncl

Further details are available at: "WRFDA/var/graphics/ncl/README"

Obs error tuning (Desroziers method)

- Step 1: Make sure that "va/build/da_tune_obs_desroziers.exe" exists
- Step 2: Run two set of parallel WRFDA cycling experiments:

  a) "unperturbed" : Normal WRFDA cycling run with default option

  b) "perturbed" : WRFDA cycling run with "omb_add_noise" and "put_rand_seed" as "TRUE"

- Step 3: Execute "var/scripts/da_tune_obs_desroziers.ksh" via a "wrapper" script.
- Important environment variables to be declared in "wrapper" script

  WRFVAR_DIR: Path for main WRFDA

  Y_DIR : Path for WRF-Var normal run "unperturbed run"

  YP_DIR : Path for WRF-Var run with "put_rand_seed" & "oma_add_noise" as true "perturbed run"
- Finally, a file named "errfac.dat" will be generated which needs to be copied in "wrfda/run" directory
- More details are available at: https://wiki.ucar.edu/display/mmm/Syed+Rizvi

Obs error tuning (Hollingsworth method)

- Step 1: Make sure that "va/build/da_tune_obs_hollingsworth1.exe" & "var/build/da_tune_hollingsworth2.exe" exists

- Step 2: Run WRFDA cycling run for at least one month

- Step 3: Execute "var/scripts/da_tune_obs_hollingsworth.ksh" via a "wrapper" script.

  Important environment variables to be declared in "wrapper" script

  WRFVAR_DIR : Path for main WRFDA

  EXP_DIR : RUN_DIR for WRFDA cycling run

  START_DATE : Start date for the tuning period

  END_DATE : End date for the tuning period

- Finally, for each desired observation type like "sound" , "sound_u_omb.sigma_o_b", "sound_v_omb.sigma_o_b" etc. will be created

- More details are available at: https://wiki.ucar.edu/display/mmm/Syed+Rizvi