



WRFDA Tools Analysis/Forecast Verification

Syed RH Rizvi

National Center For Atmospheric Research

NCAR/ESSL/MMM, Boulder, CO-80307, USA

rizvi@ucar.edu



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)

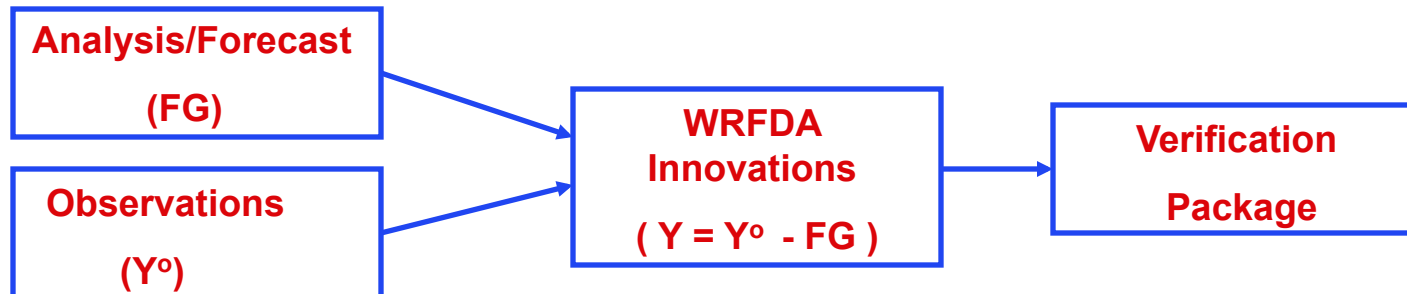


How to Verify Analysis/Forecast?

- 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

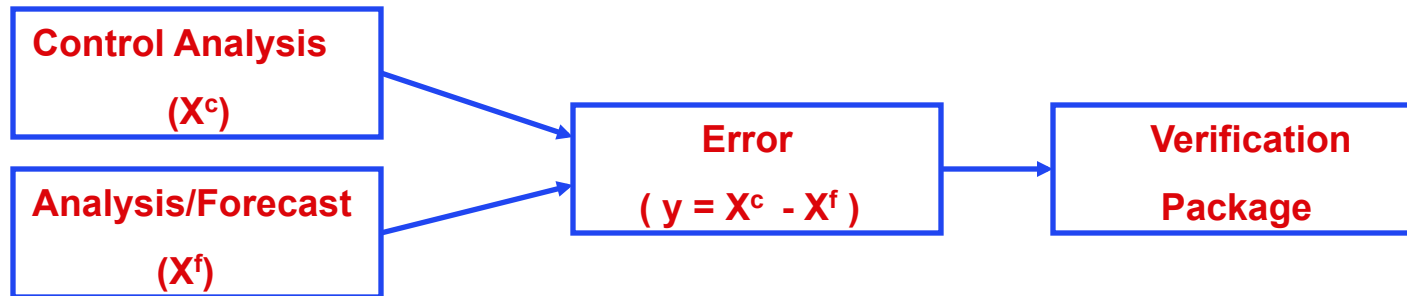
`var/da/da_verif_obs`

compile `all_wrfvar` creates the desired executable

`da_verif_obs.exe`



Analysis based Verification



Code resides under “var/da/da_verif_anal” directory

“compile all_wrfvar” creates the desired executable

(da_verif_anal.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

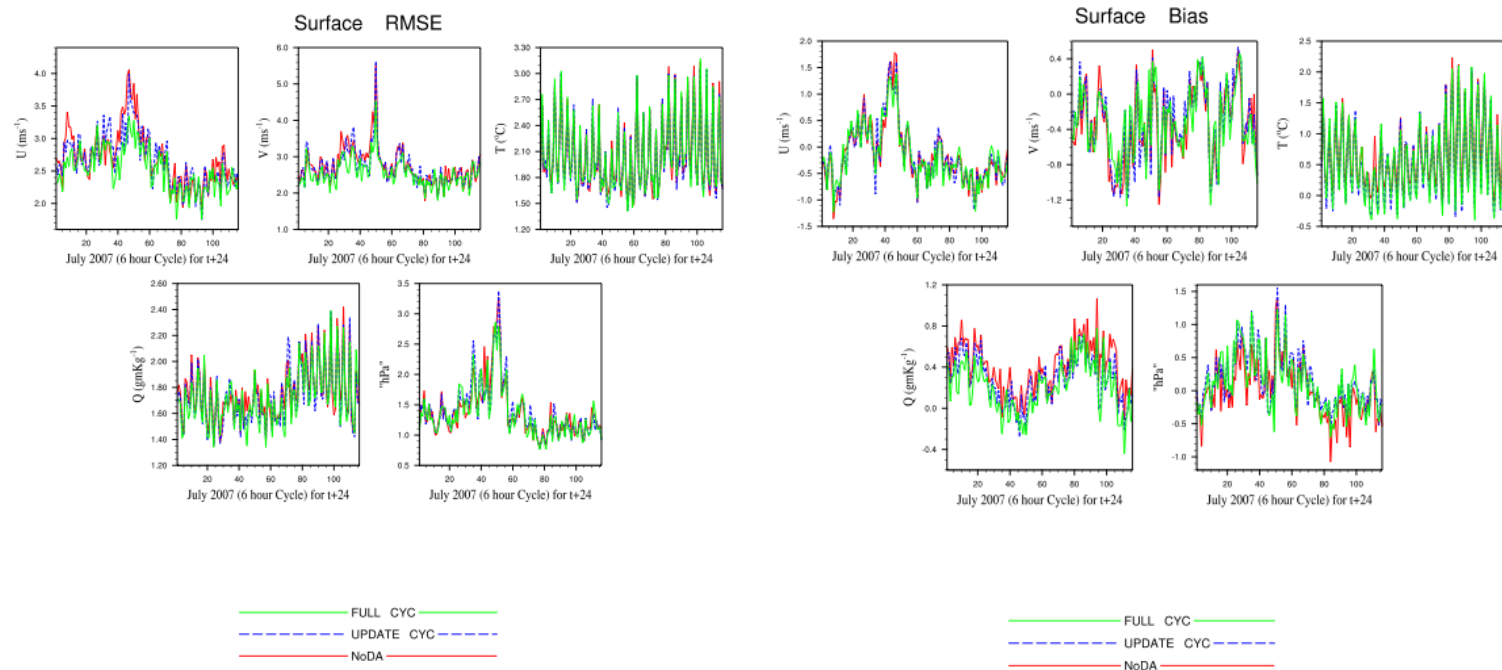
In RUN_DIR, following graphics will be generated for each of the desired scores (RMSE, BIAS, ABIAS)

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

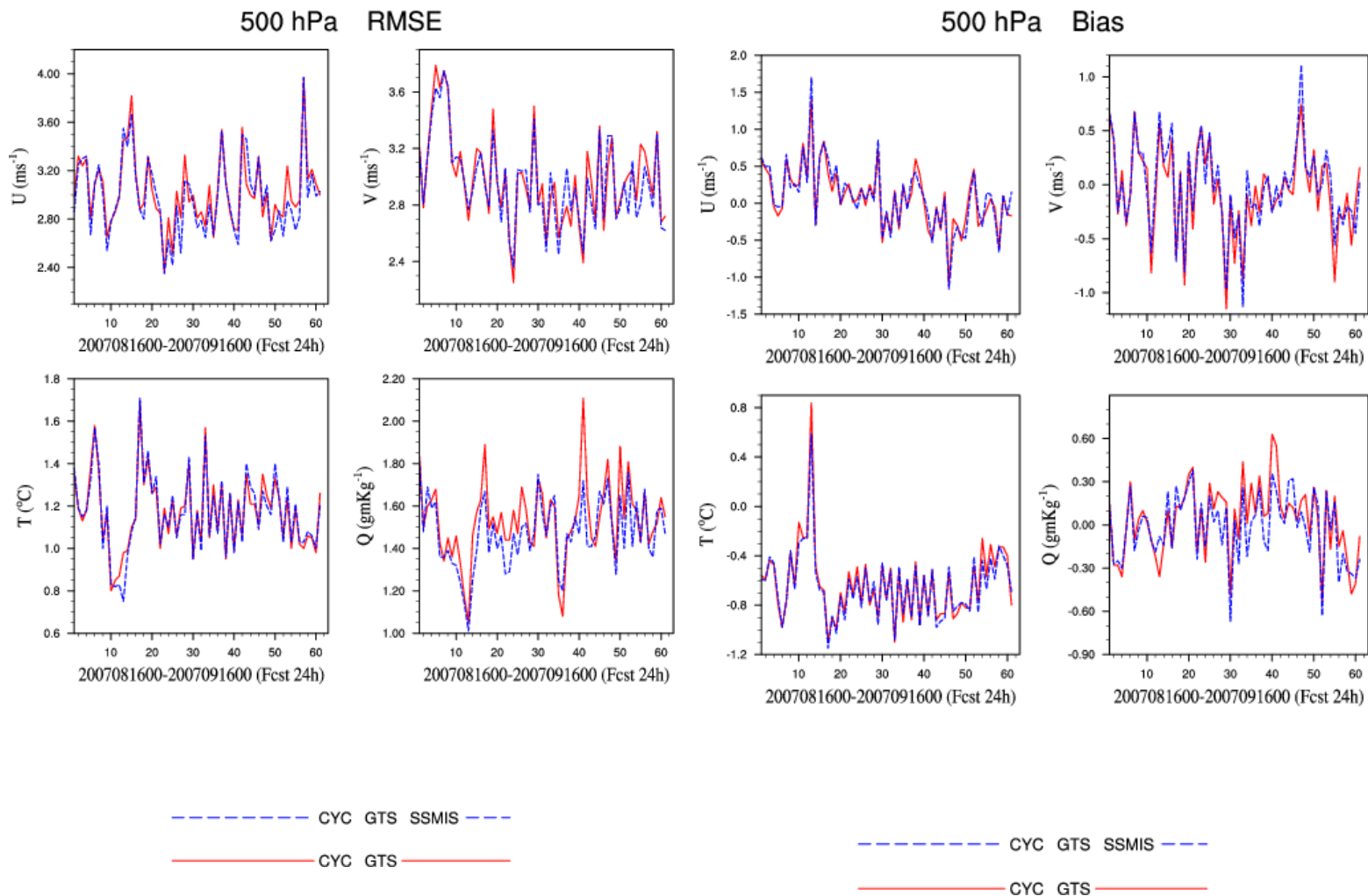
-rw-r--r--	1	rizvi	ncar	597691	Oct 13 12:49	Time_Series_SFC_RMSE.pdf
-rw-r--r--	1	rizvi	ncar	291856	Oct 13 12:49	Time_Series_SFC_BIAS.pdf
-rw-r--r--	1	rizvi	ncar	319570	Oct 13 12:49	Time_Series_SFC_ABIAS.pdf
-rw-r--r--	1	rizvi	ncar	1571714	Oct 13 12:49	Time_Series_UPA_RMSE.pdf
-rw-r--r--	1	rizvi	ncar	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

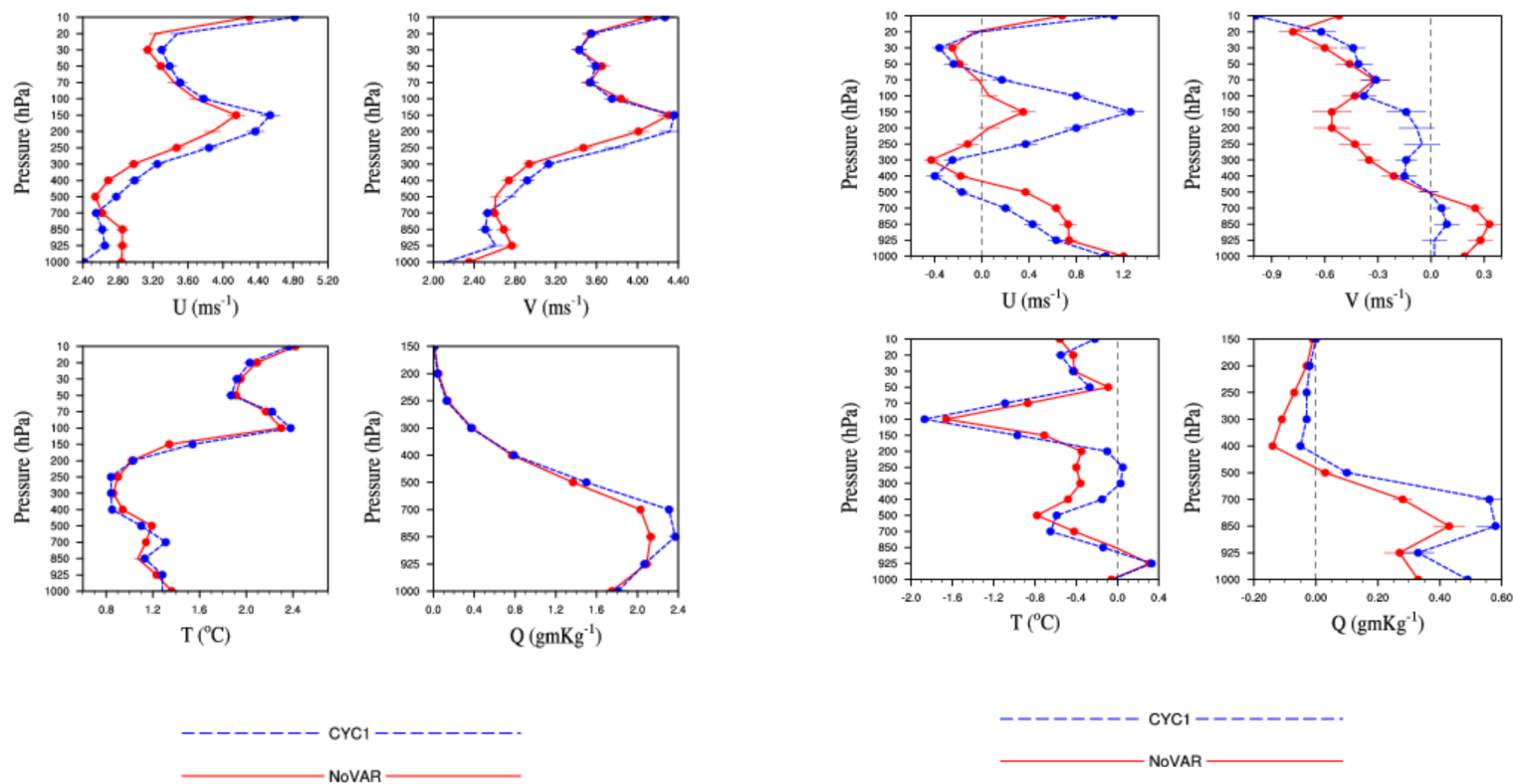


Verif_obs_plot -- Upper air Time Series

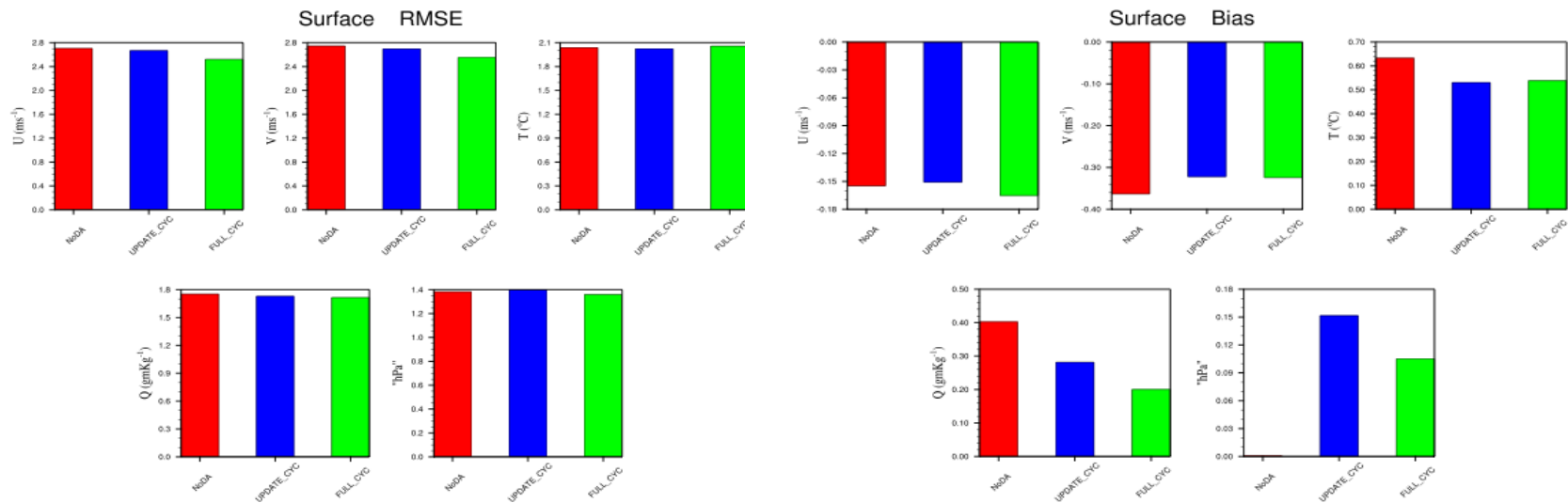


Verif_obs_plot -- Profile

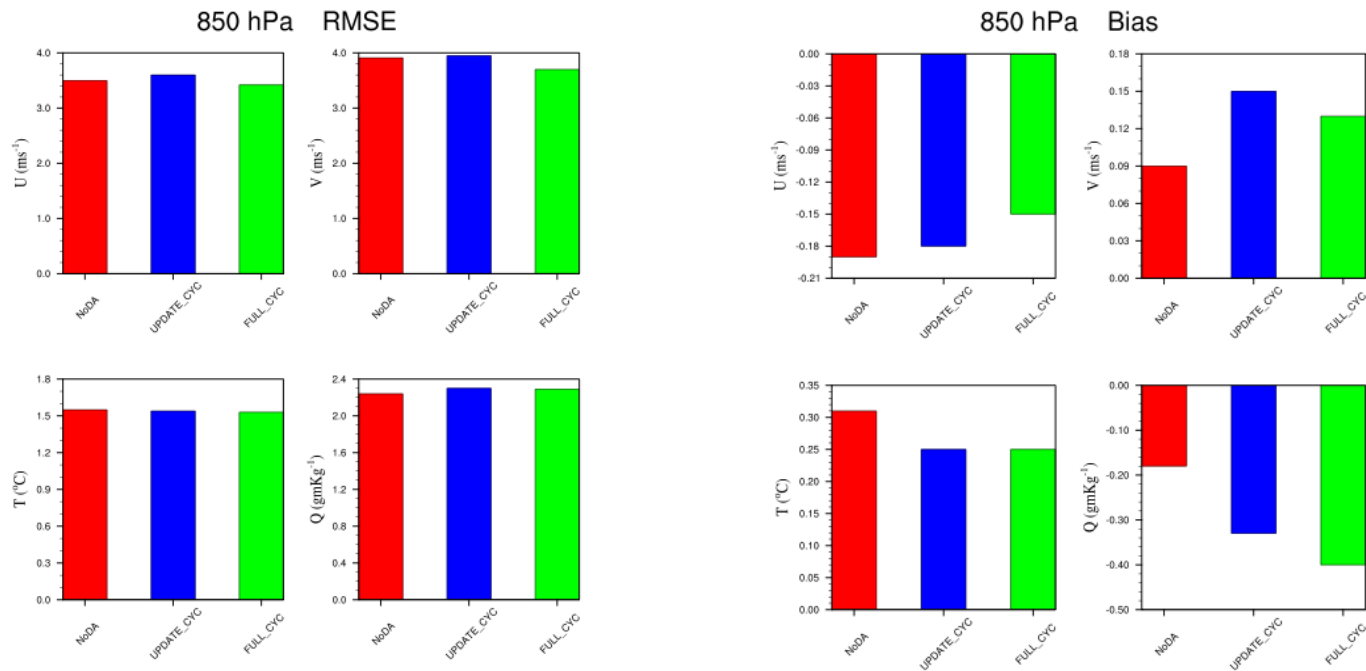
RMSE Profiles for t8_15km: 15th August-15th September 2007 (t+12) Bias Profiles for t8_15km: 15th August-15th September 2007 (t+12)



Verif_obs_plot -- Surface Time Average



Verif_obs_plot -- Upper air Time Average



How to run verification against Analysis?

- Each experiment forecasts 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_anal_plot.ksh” via a suitable wrapper script



Wrapper for da_verif_anal_plot

Important variables:

WRFVAR_DIR	: Main WRFDA directory (full path)
REG_DIR	: Directory holding forecast sub-directories for each experiment
RUN_DIR	: Directory where plots will be generated
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 as they exist in REG_DIR (blank separated)
EXP_LEGENDS	: Legend string for each experiments (comma separated)
DESIRED_LEVELS	: Legend string for each experiments (comma separated)
DESIRED_SCORES	: Diagnostics like "RMSE", "BIAS" or "ABIAS"
START_DATE	: Starting date ("YYYYMMDDHH") for verification
END_DATE	: Ending date ("YYYYMMDDHH") for verification
INTERVAL	: Time interval (in hours) for incrementing date/time
VERIFY_HOUR	: Verification hour
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 in "CONTROL_EXP_DIR"
VERIFICATION_FILE_STRING	: It should be "wrfout" or "wrfinput" depending on what is available
VERIFY_DATE_RANGE	: String to specify X-axis title
PLOT_WKS	: Name of workstation for plots like "X11", "pdf" etc.



Verif_anal_plot output

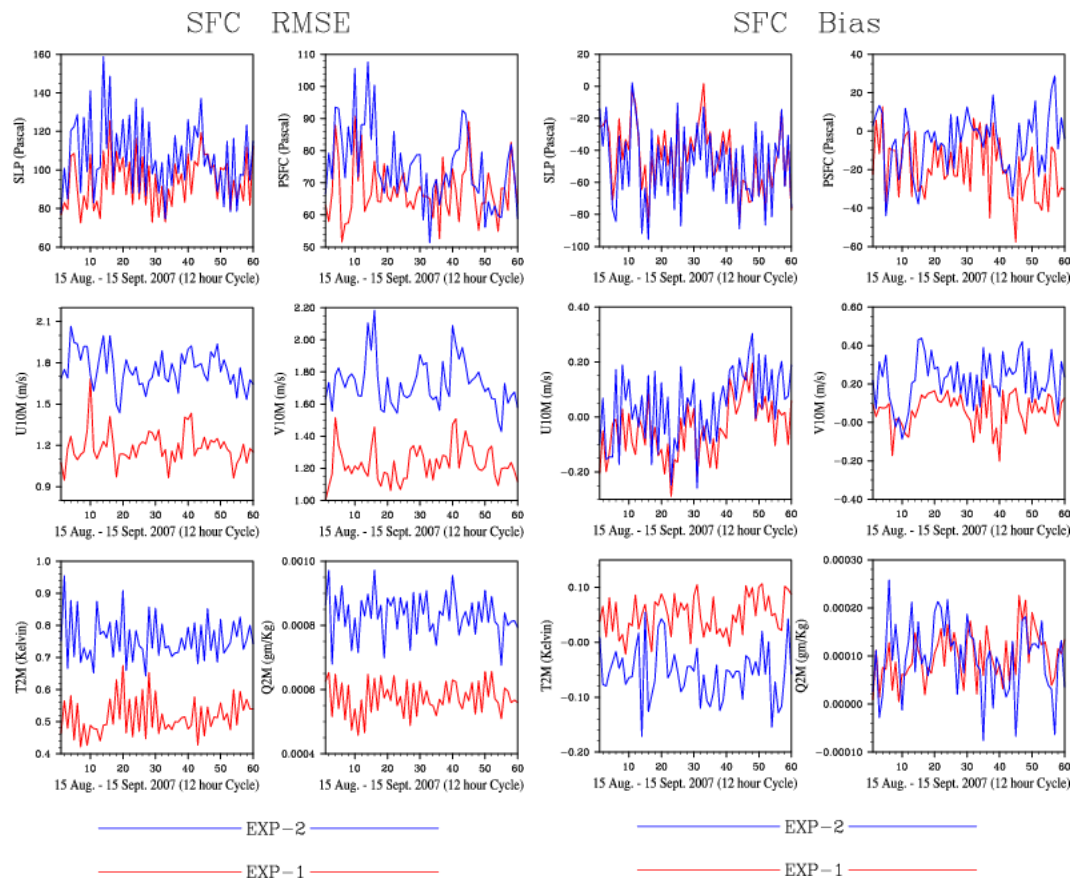
In RUN_DIR, following graphics will be generated for each of the the desired scores (RMSE, BIAS or ABIAS)

- 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)

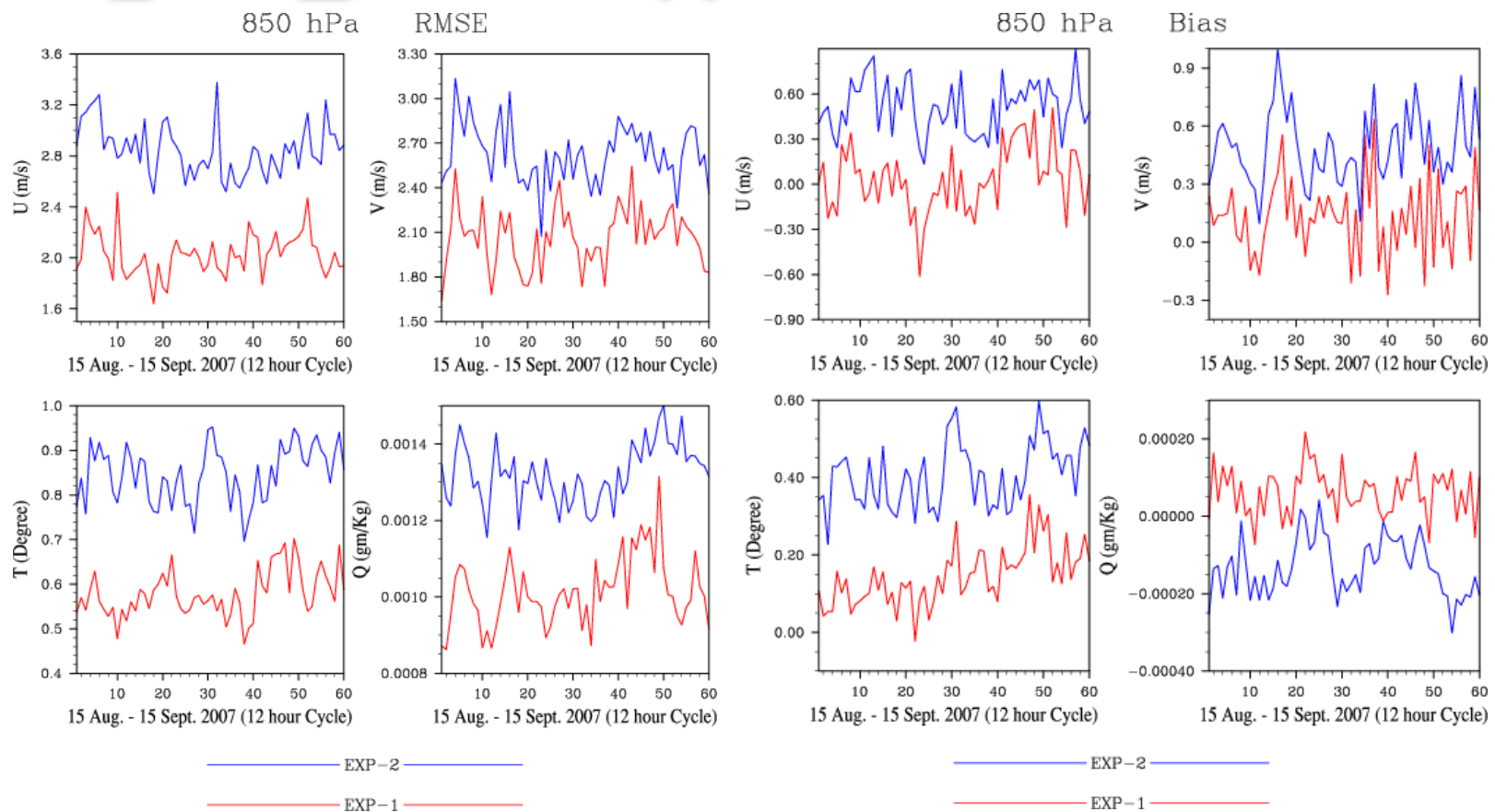
-rw-r--r--	1	rizvi	ncar	235624	Dec 31 15:14	Time_Series_UPA_RMSE-850-hr24.pdf
-rw-r--r--	1	rizvi	ncar	237504	Dec 31 15:14	Time_Series_UPA_BIAS-850-hr24.pdf
-rw-r--r--	1	rizvi	ncar	183367	Dec 31 15:14	Time_Series_UPA_RMSE-200-hr24.pdf
-rw-r--r--	1	rizvi	ncar	173293	Dec 31 15:14	Time_Series_UPA_BIAS-200-hr24.pdf
-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_anal_plot -- Surface Time Series

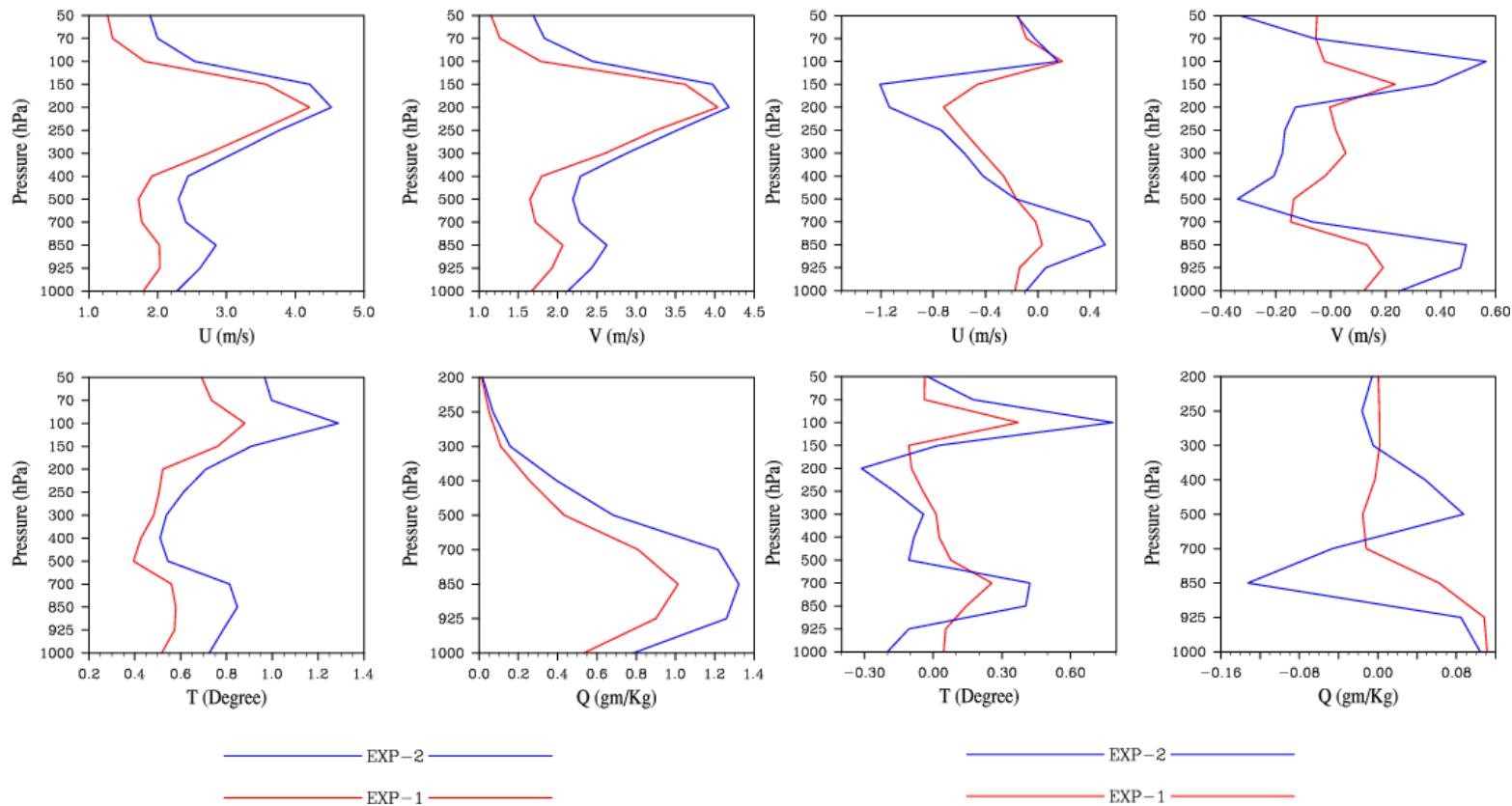


Verif_anal_plot -- Upper air Time Series

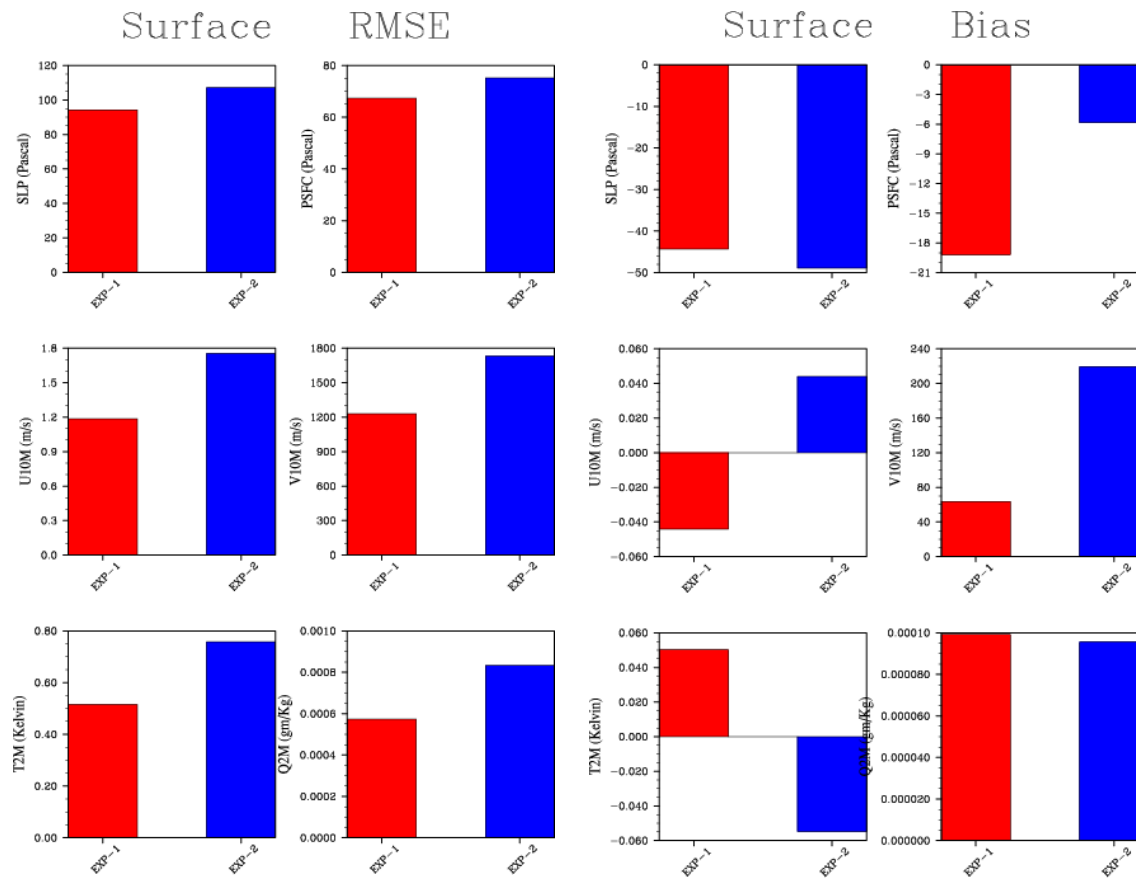


Verif_anal_plot -- Profile

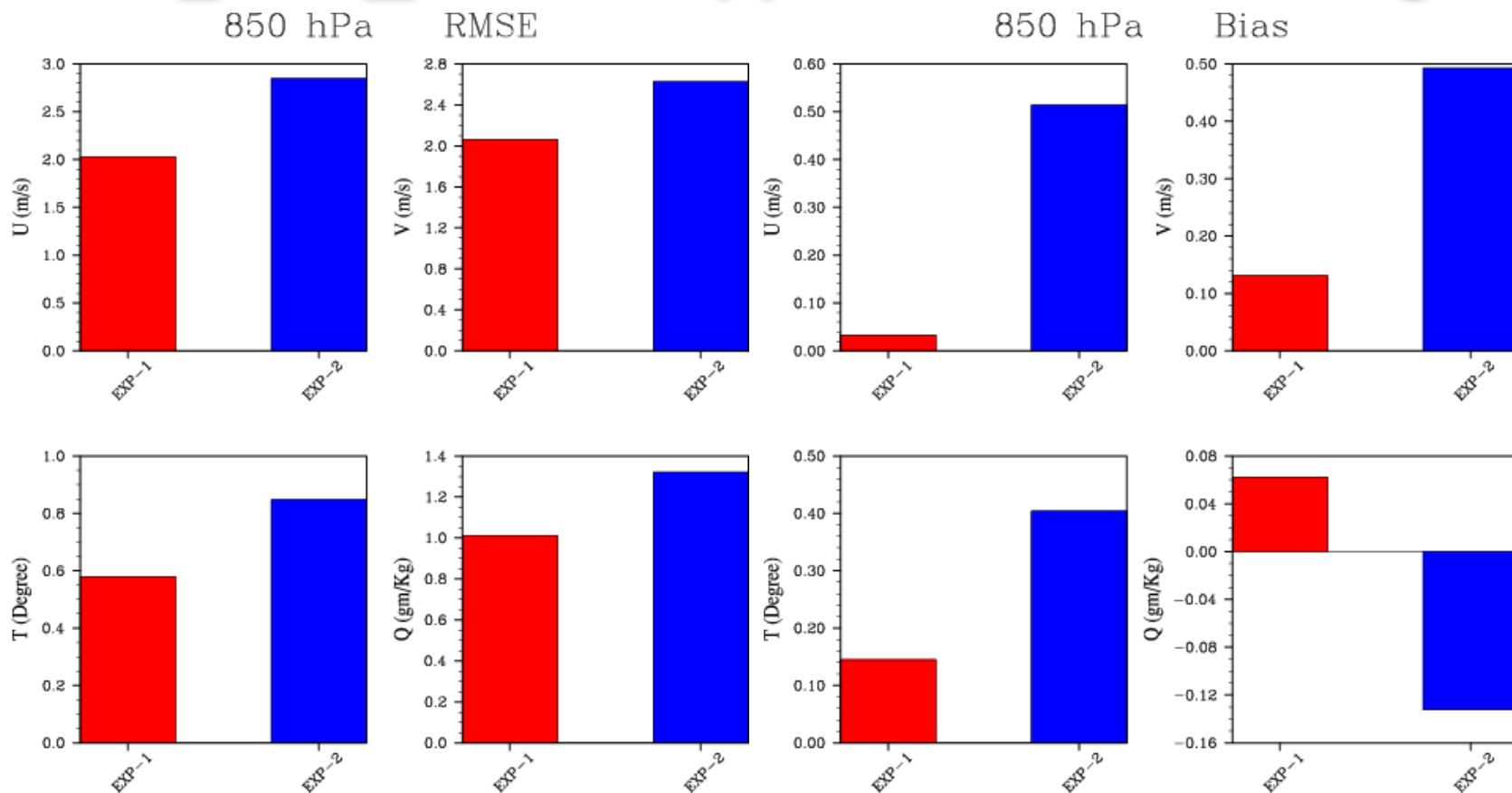
RMSE 15 Aug. – 15 Sept. 2007 (12 hour Cycle) Bias 15 Aug. – 15 Sept. 2007 (12 hour Cycle)



Verif_anal_plot -- Surface Time Average



Verif_anal_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_wrfvar_psot.ksh
da_run_suite_verif_obs.ksh	da_run_suite_wrapper_qc_obs.ksh
da_run_psot.ksh	da_plot_psot.ksh
da_run_gsi.ksh	da_run_gsi_psot.ksh
da_tune_obs_hollingsworth.ksh	da_tune_obs_desroziers.ksh
da_run_suite_wrapper_verif_obs.ksh	da_verif_obs_plot.ksh
da_verif_anal_plot.ksh	da_run_wps.ksh da_run_wrf.ksh
da_run_obsproc.ksh	da_run_real.ksh

Some useful NCL Scripts:

WRF-Var_plot.ncl	plot_cost_grad_fn.ncl	plot_obascii_loc.ncl
plot_gts_omb_oma.ncl	plot_rad_diags.ncl	plot_rad_varbc_param.ncl
Verif_obs_time_series.ncl	verif_obs_time_average.ncl	verif_anal_vert_profile.ncl
verif_anal_time_series.ncl	verif_anal_time_average.ncl	verif_anal_vert_profile

Note: For details read "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>

