

WRFDA Tools Analysis/Forecast Verification

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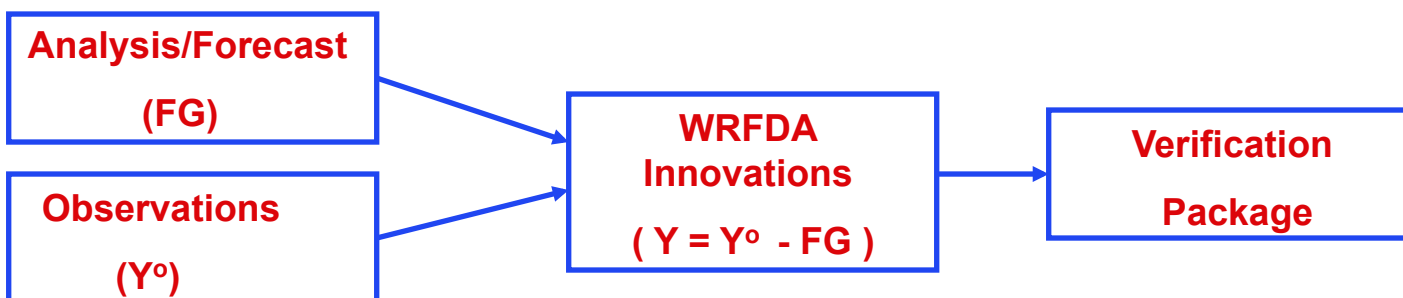
Talk overview

- WRFDA verification package
 - What are its advantages/disadvantages?
 - How to run WRFDA verification package
 - Expected graphics
 - Upcoming new feature - AFWA Go-Index
- 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



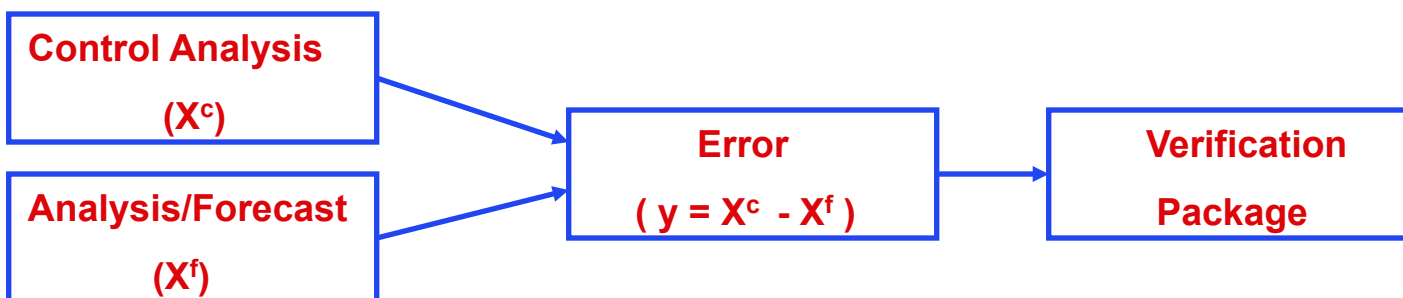
Verification code is under

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** : Verification 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

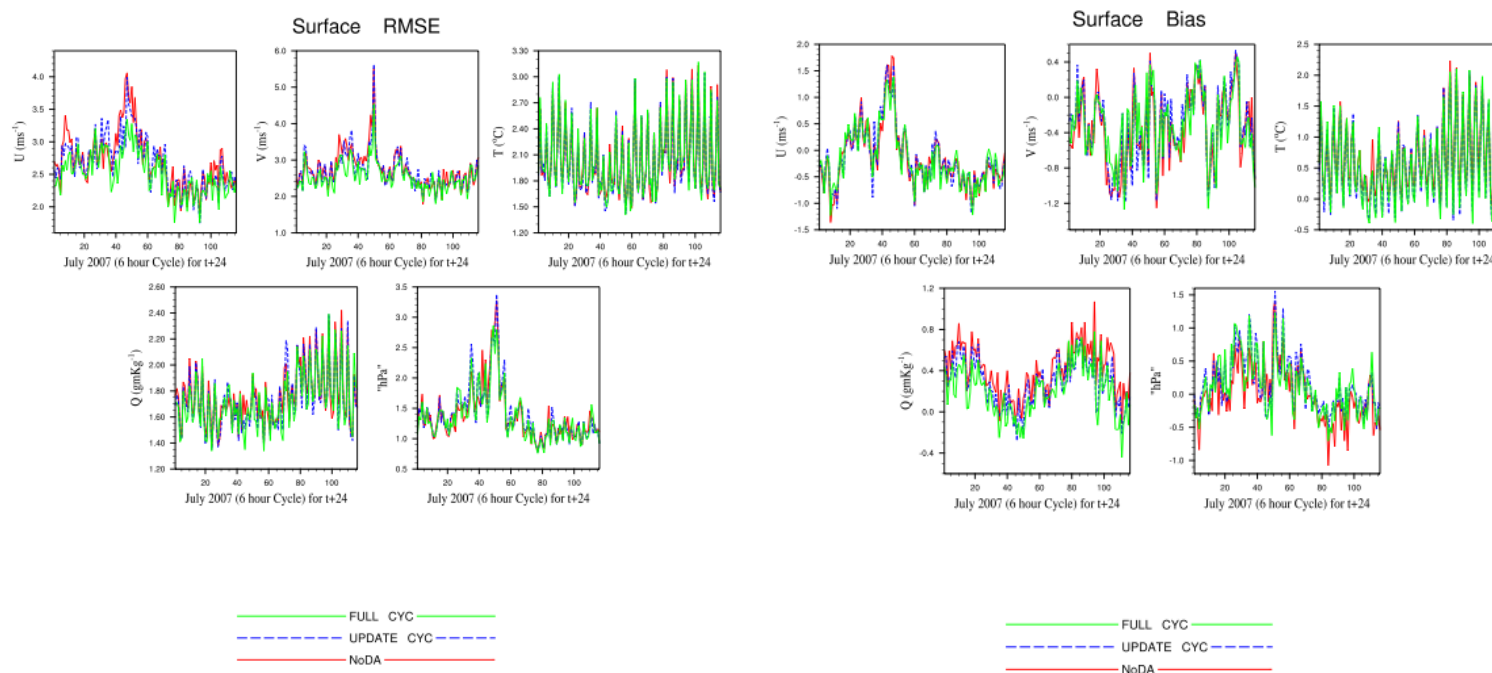
Verif_obs_plot output

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

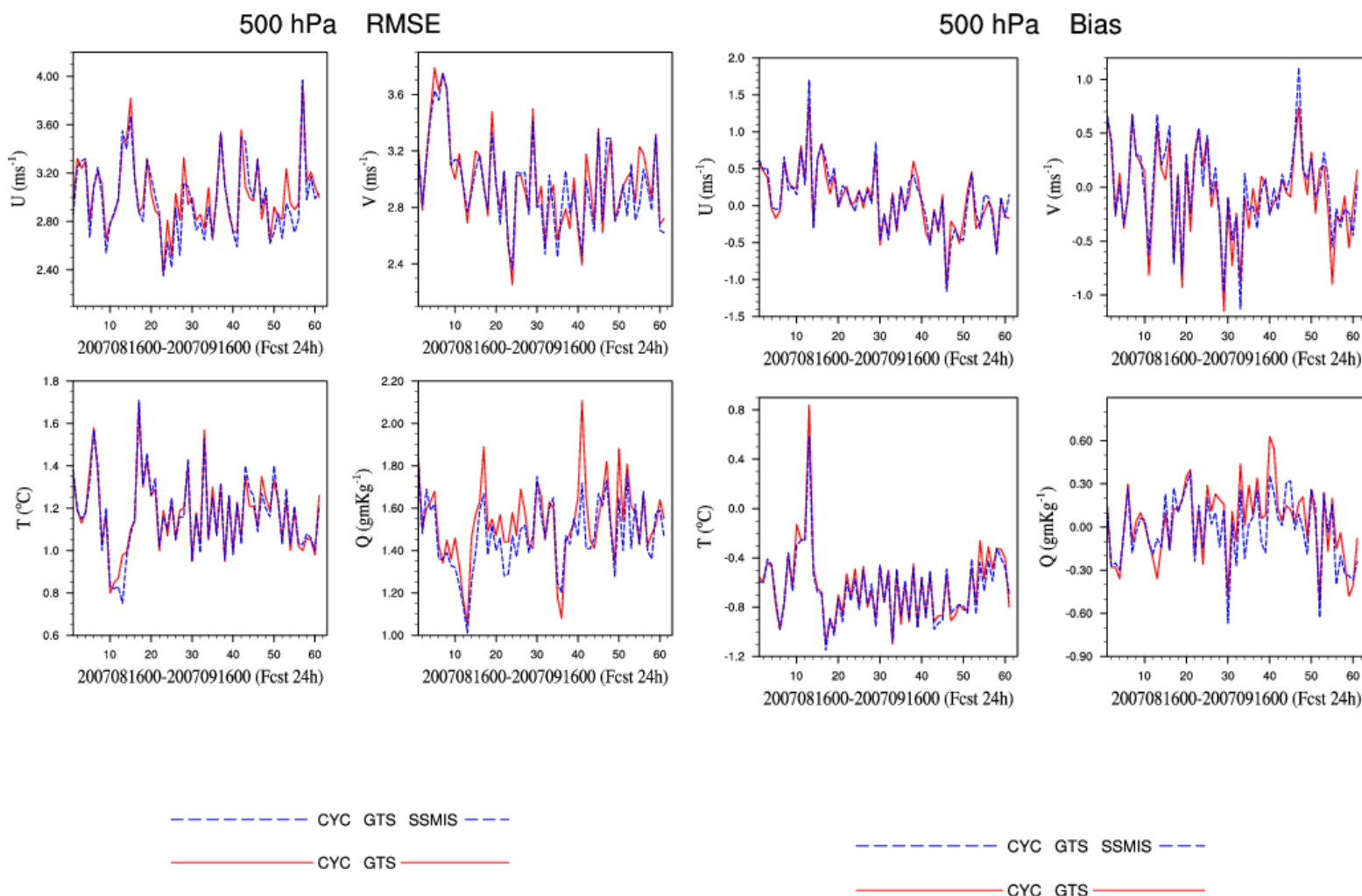
- Time series for surface and all the desired upper air levels
- Vertical profiles
- Time Average for surface and all the upper air levels (Histograms)

```
-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

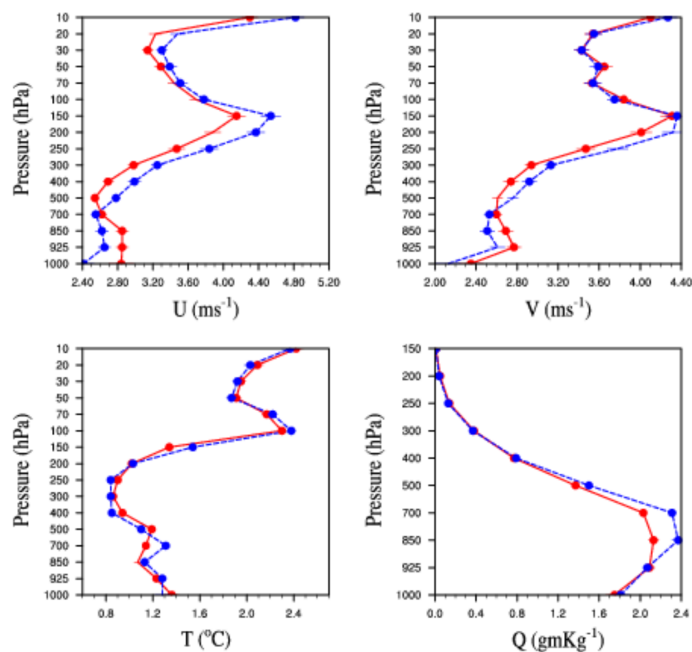


Verif_obs_plot -- Upper air Time Series

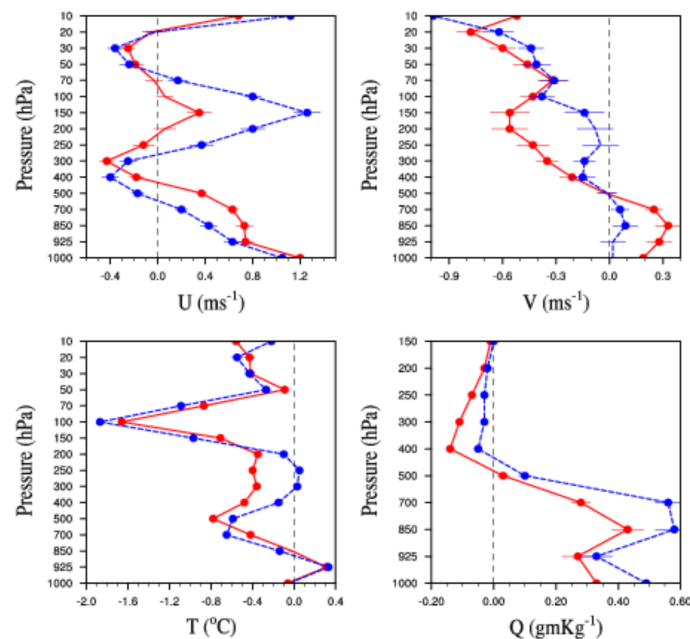


Verif_obs_plot -- Profile

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

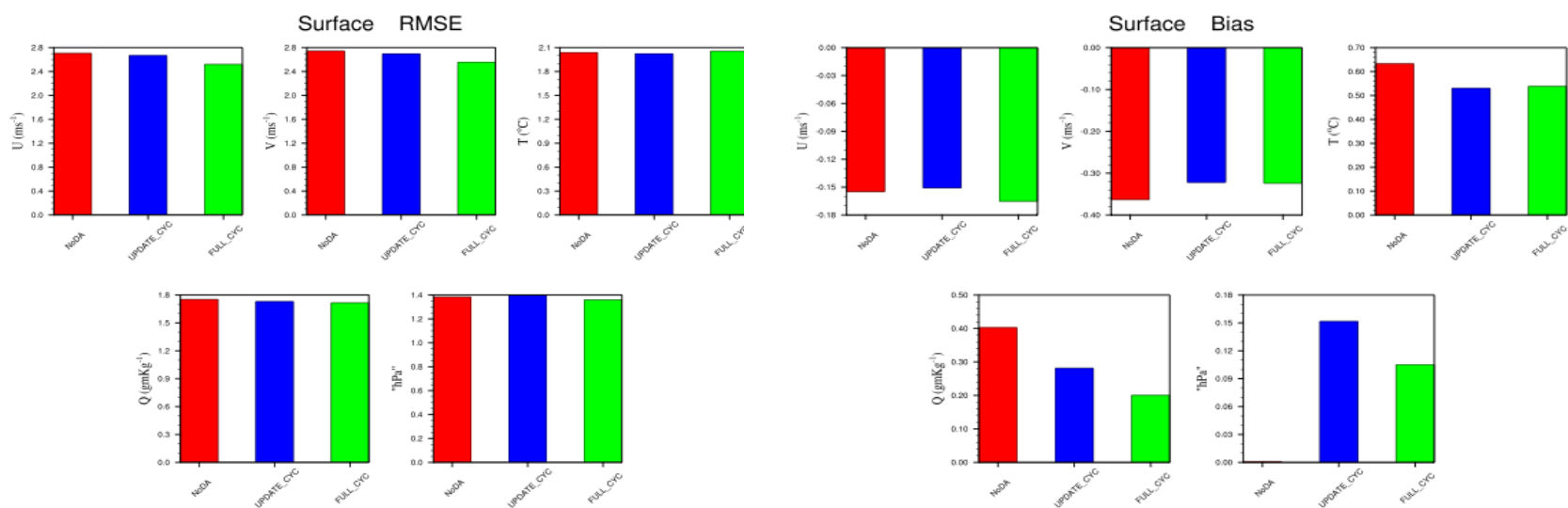


--- CYC1
--- NoVAR

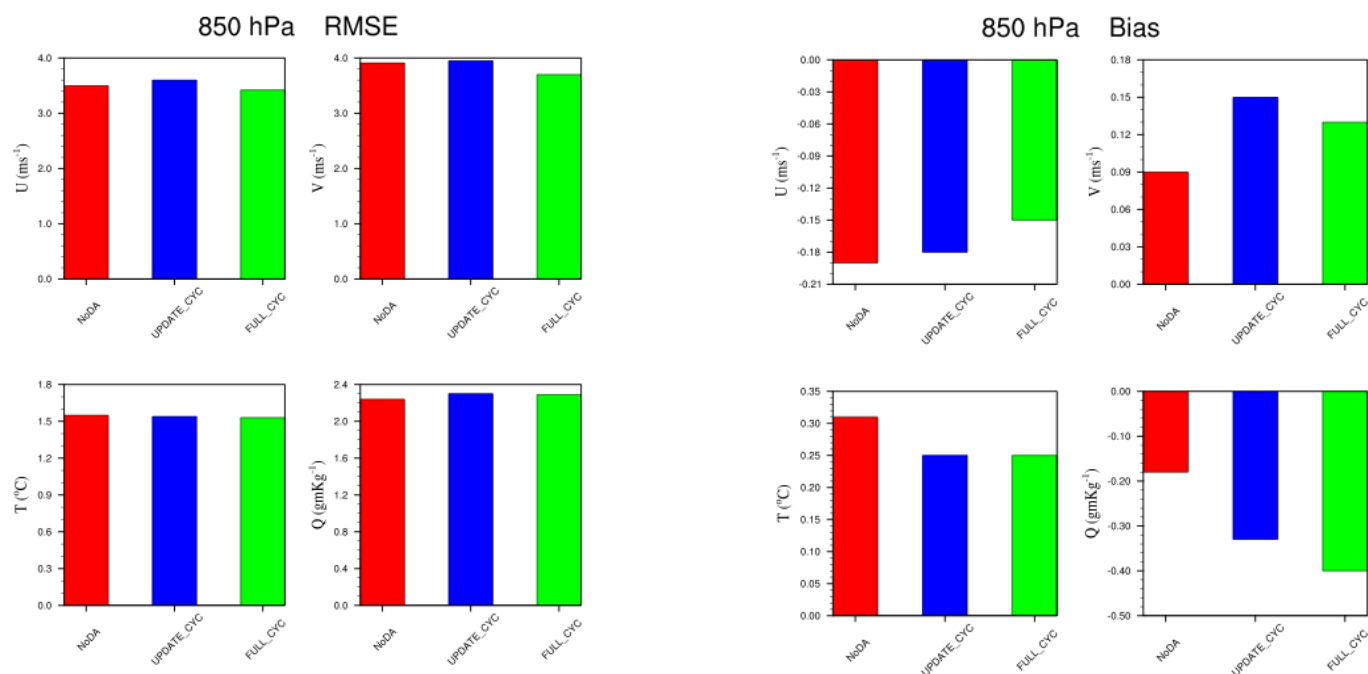


--- CYC1
--- NoVAR

Verif_obs_plot -- Surface Time Average



Verif_obs_plot -- Upper air Time Average



How to run verification grid verification?

Basic requirement for each experiment output:

- It should be in standard “wrf-netcdf” format with standard “wrfout” like file names
- It should be at the same horizontal and vertical resolution
- Forecasts corresponding to each experiment needs to be arranged in separate directories with date-wise (YYYYMMDDHH) sub-directories

How to run?

- 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:

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.

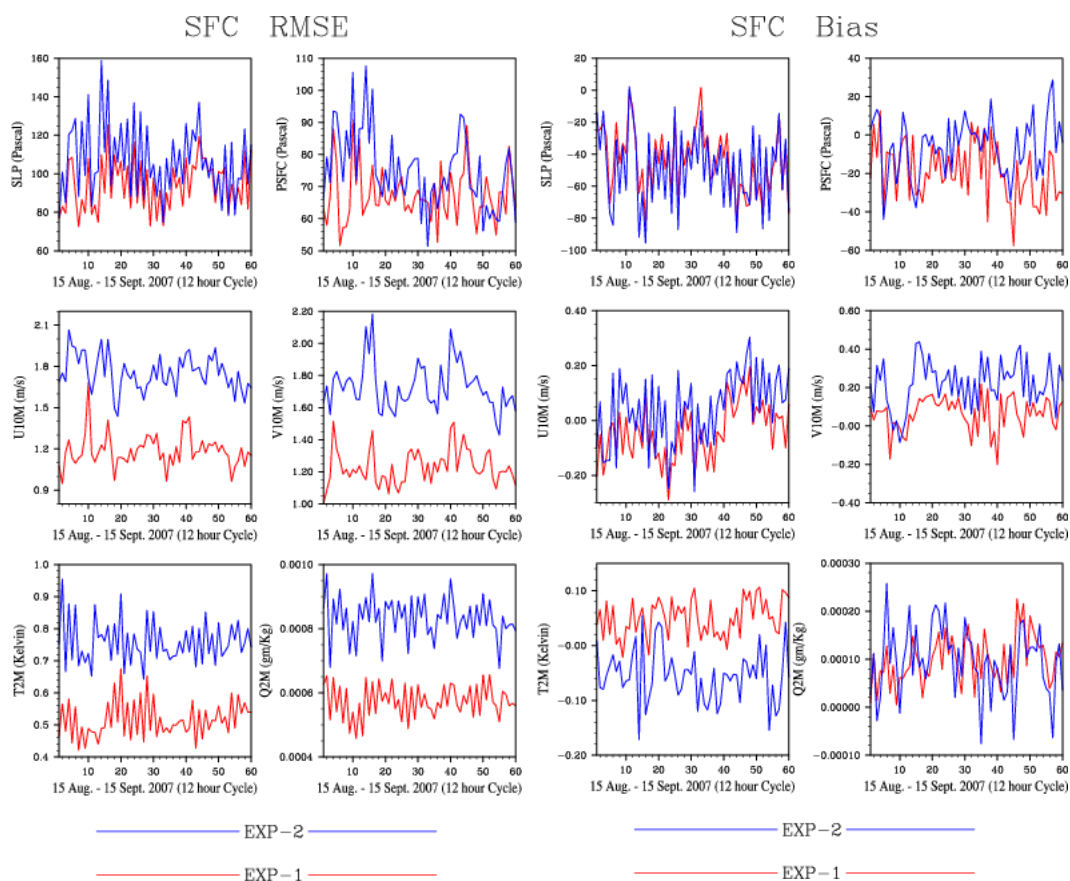
da_Verif_grid.ksh output

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

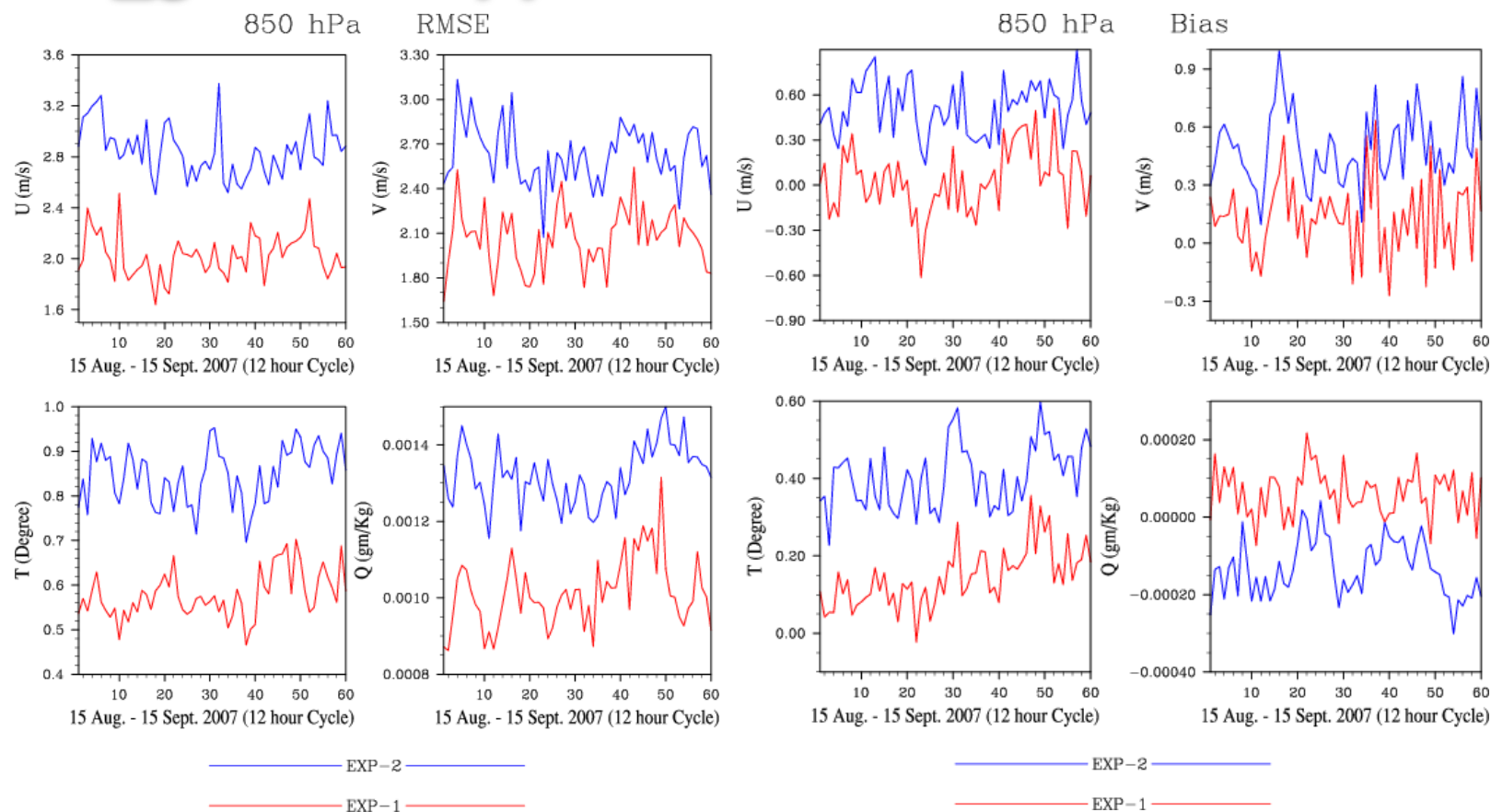
- Time series for surface fields (U10, V10, T2, Q2 & Psfc)
- Time series for upper air fields (U, V, T & Q) for the desired levels
- Upper air profiles for U, V, T & Q
- Time average for surface and upper air fields for the desired levels (Histogram)

-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 -- Surface Time Series

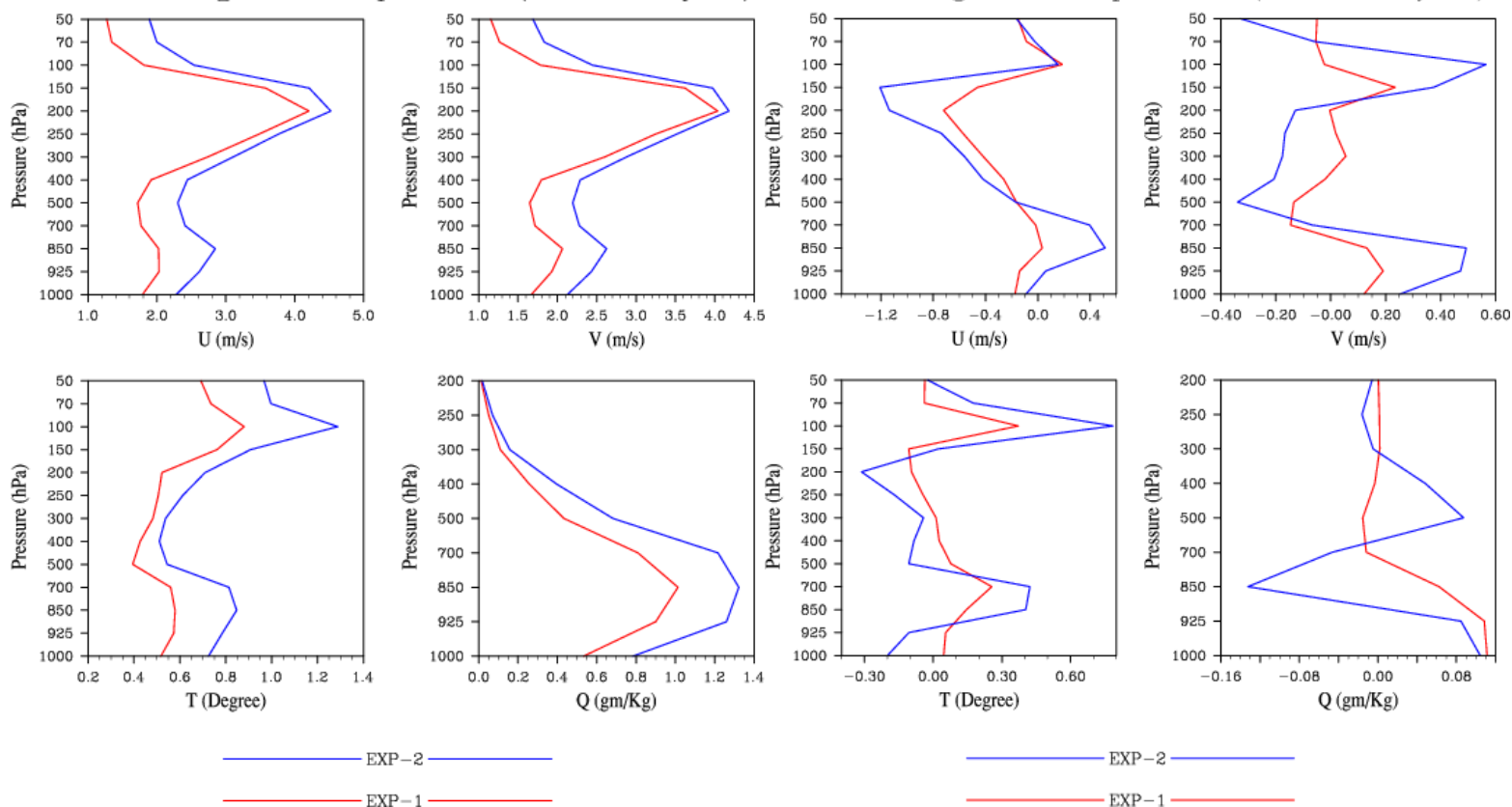


Verif_grid -- Upper air Time Series

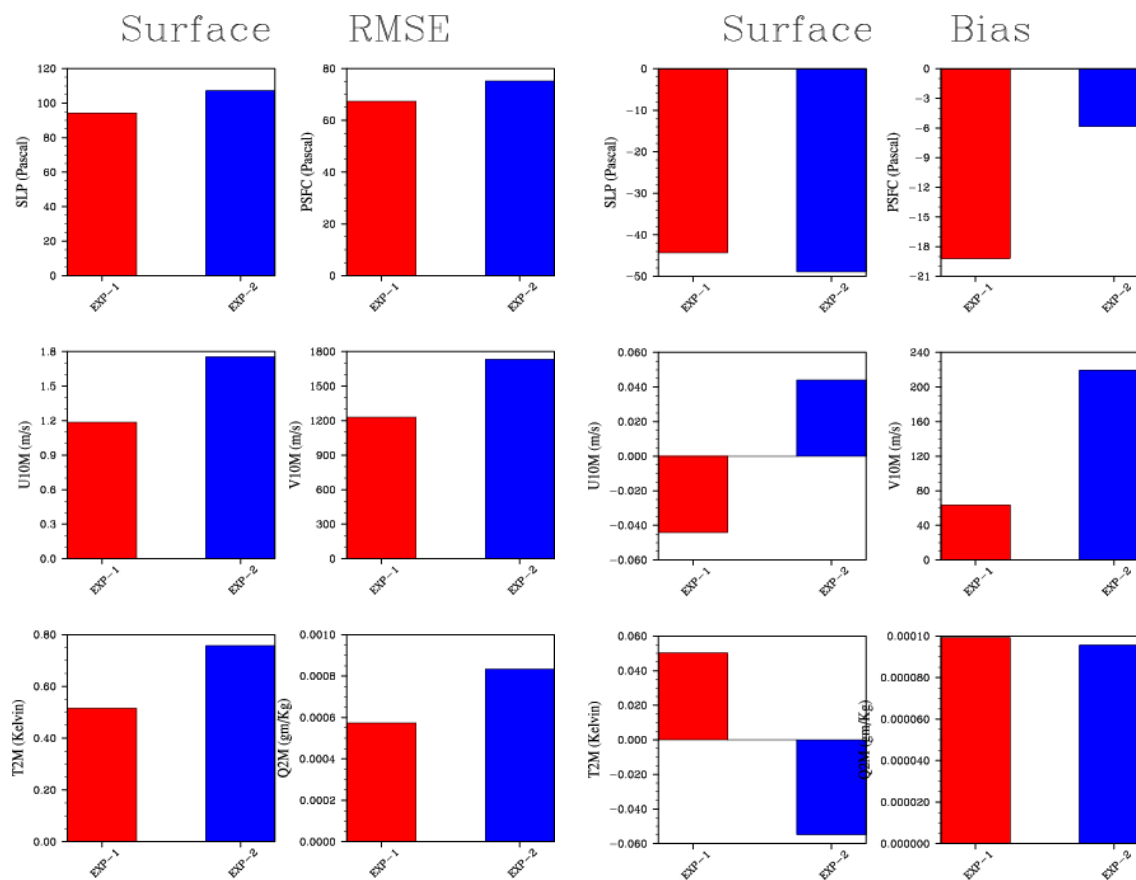


Verif_grid -- Profile

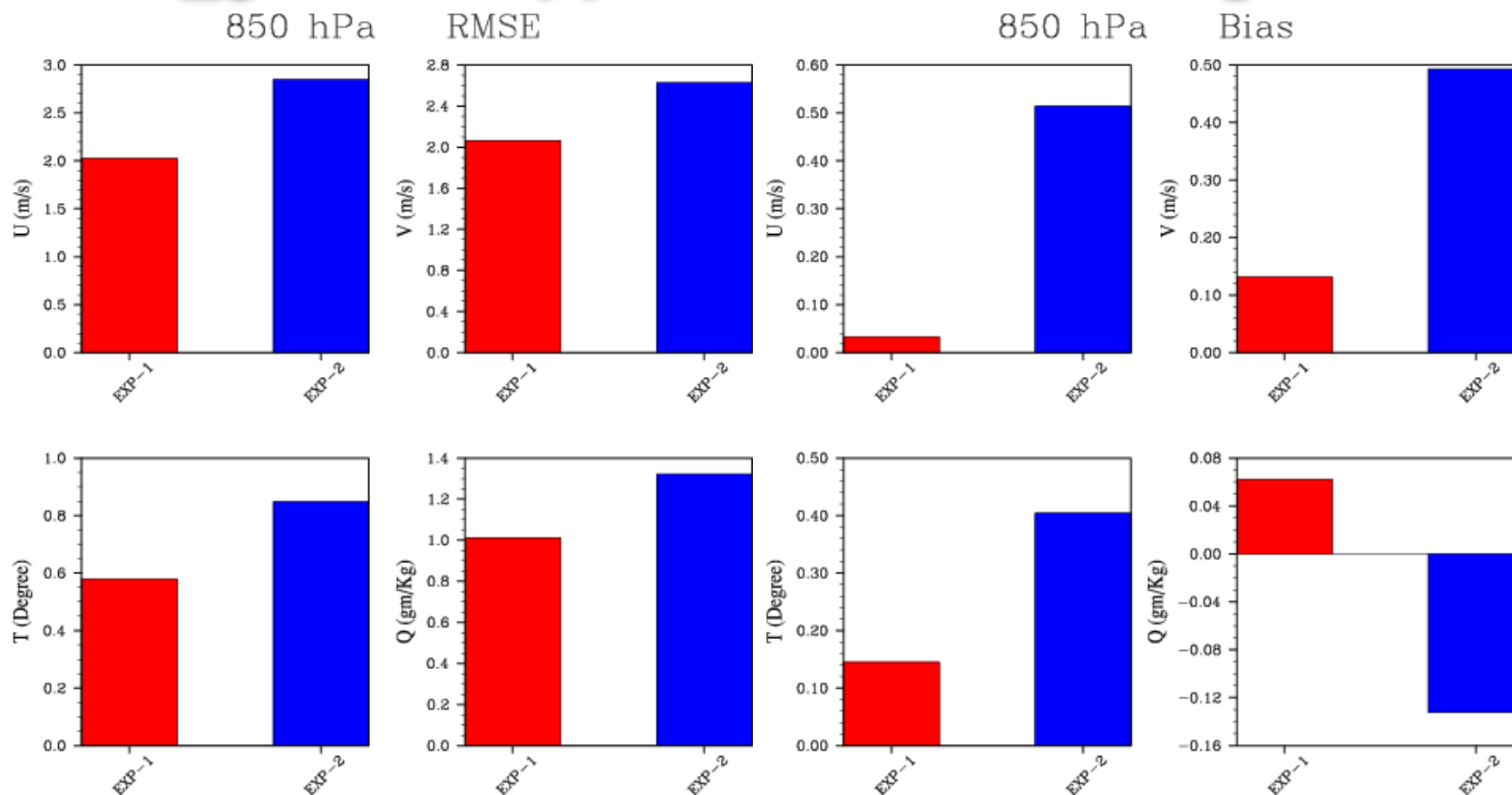
RMSE 15 Aug. – 15 Sept. 2007 (12 hour Cycle) Bias 15 Aug. – 15 Sept. 2007 (12 hour Cycle)



Verif_grid -- Surface Time Average



Verif_grid -- Upper air Time Average



Upcoming new feature -AFWA Go-Index

- Go-Index (**N**) is defined in terms of weighted average of RMSE of some selected variables at different levels for 12, 24, 36 and 48 hours forecast lead time (**i**)

$$S_i = 1 - \left\{ \frac{RMSE_{\text{expt}}}{RMSE_{\text{ctrl}}} \right\}^2$$

$$S_w = \frac{1}{\sum_i w_i} \left(\sum_i w_i S_i \right)$$

$$Go\ Index\ (N) = \sqrt{\frac{1}{1 - S_w}}$$

- Pre-defined weights (**W_i**) are as follows

Variable	Level	Weights by lead time			
		12 h	24 h	36 h	48 h
Wind Speed	250 hPa	4	3	2	1
	400 hPa	4	3	2	1
	850 hPa	4	3	2	1
	Surface	8	6	4	2
Dew Point Temperature	400 hPa	8	6	4	2
	700 hPa	8	6	4	2
	850 hPa	8	6	4	2
	Surface	8	6	4	2
Temperature	400 hPa	4	3	2	1
	Surface	8	6	4	2
Height	400 hPa	4	3	2	1
Pressure	Mean sea level	8	6	4	2

- Go-Index > 1 means, experiment (**expt**) performed better than control (**ctrl**)

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>