WRF-Var
Analysis/Forecast Verification

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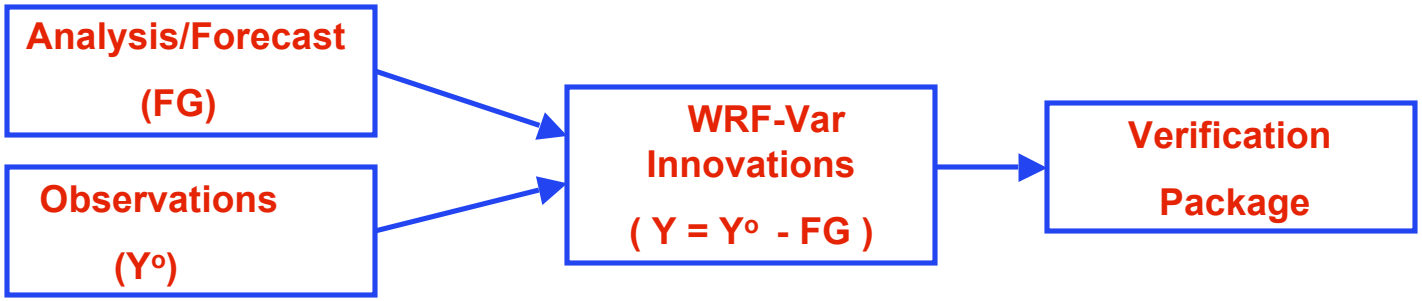
How to Verify Analysis/Forecast?

- 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



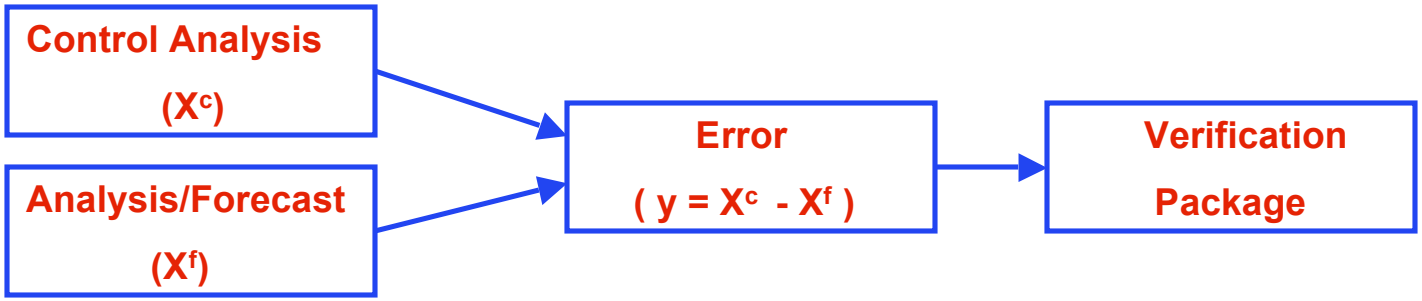
Verification code is under

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

- Consistent with WRF-Var QC
- Consistent with WRF model topography
- It makes use of built-in WRF-Var 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

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, which needs to be written depending on the requirements

Wrapper for da_run_suite_verif_obs

Important variables needs to be declared for this 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 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	: 0 for analysis & 12, 24, etc. corresponding to the desired forecast hour verification

Wrapper for da_verif_obs_plot

Important variables:

WRFVAR_DIR : Main WRFDA 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

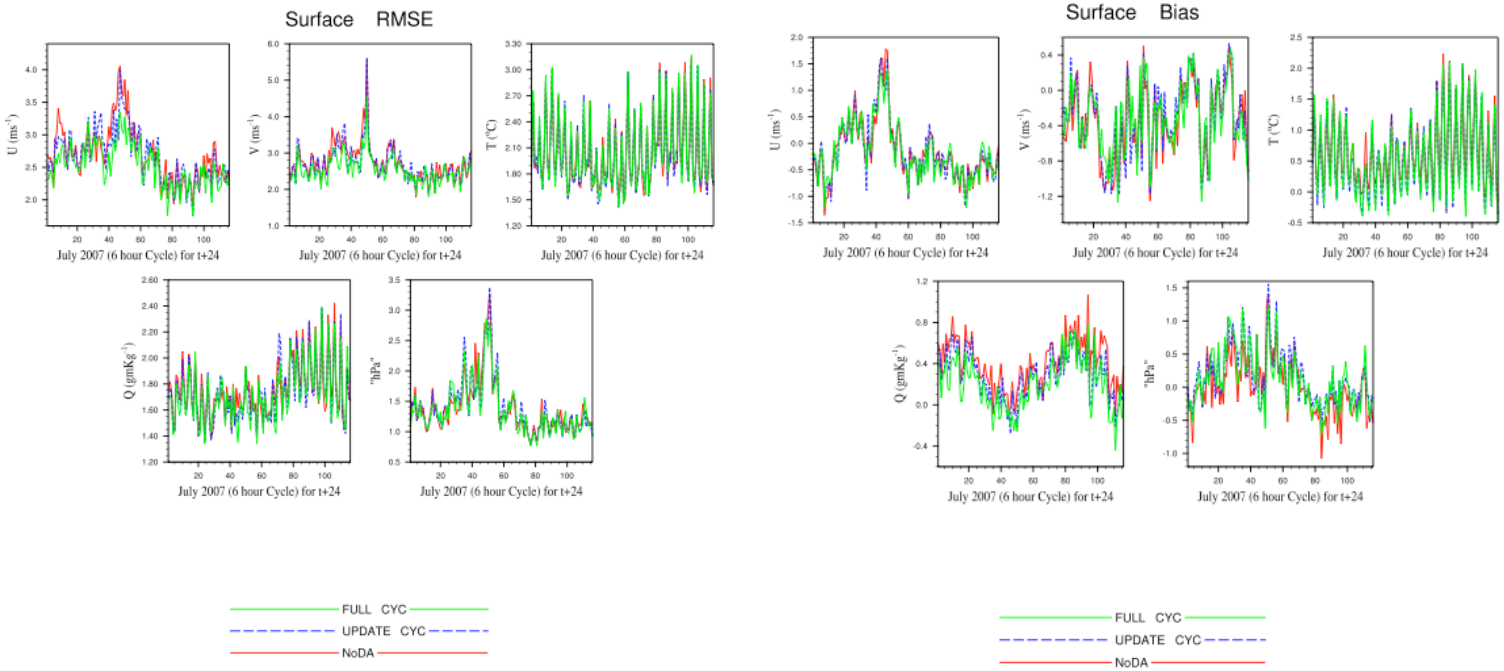
Verif_obs_plot output

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

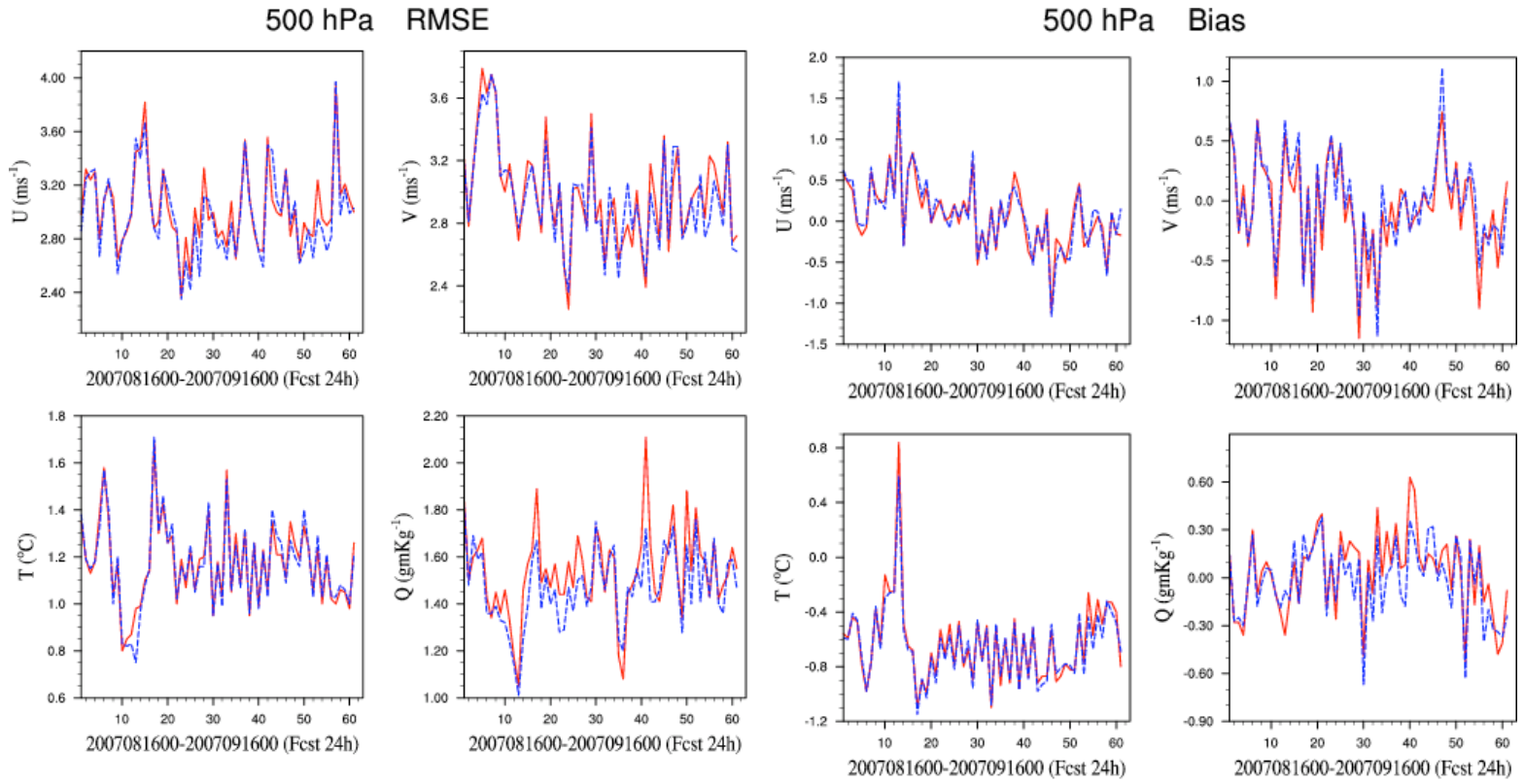
- Time series for surface and all the desired upper air levels
- Vertical profiles
- Time Average for surface and all the upper air levels (Histograms)

```
-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
```

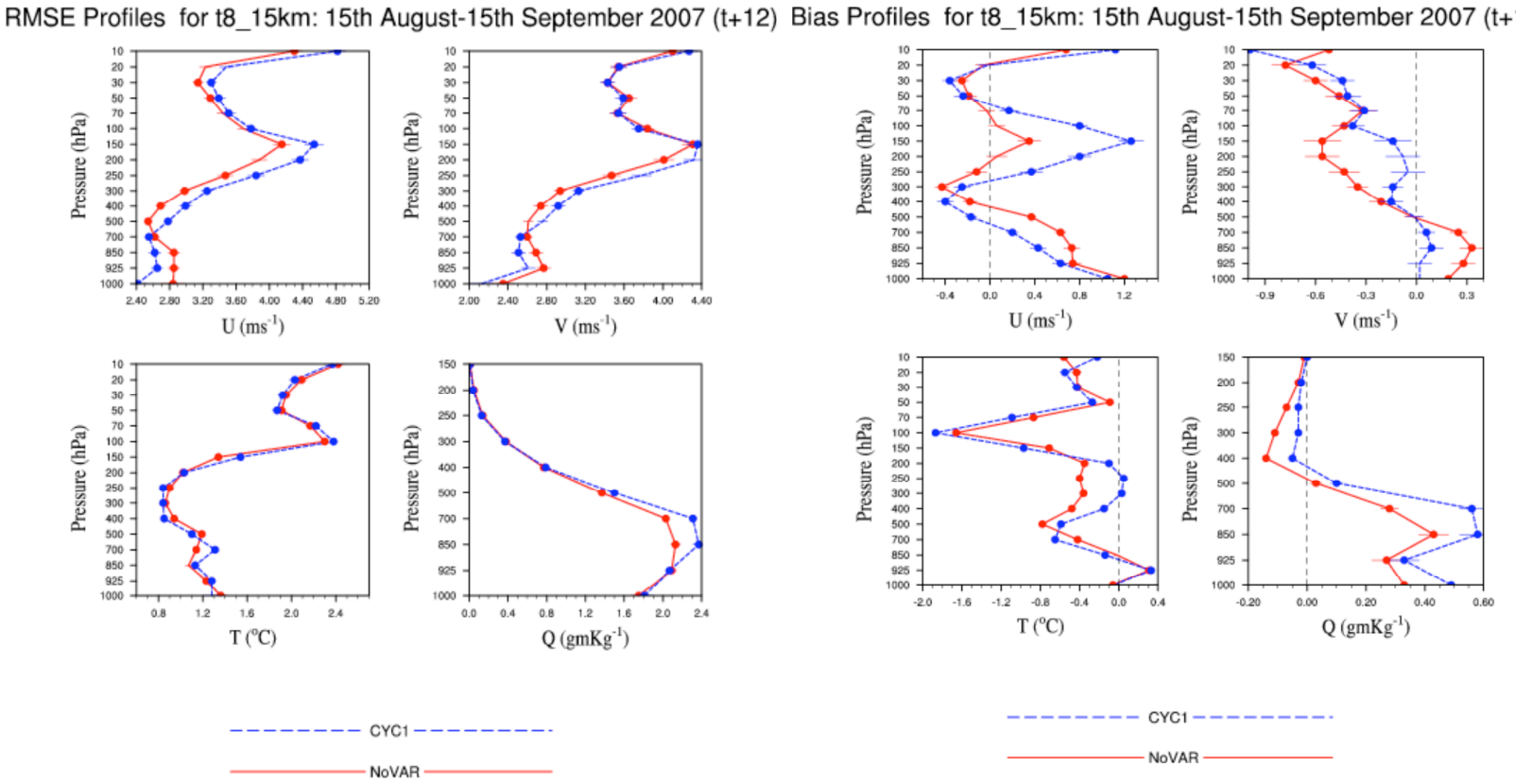
Verif_obs_plot -- Surface Time Series



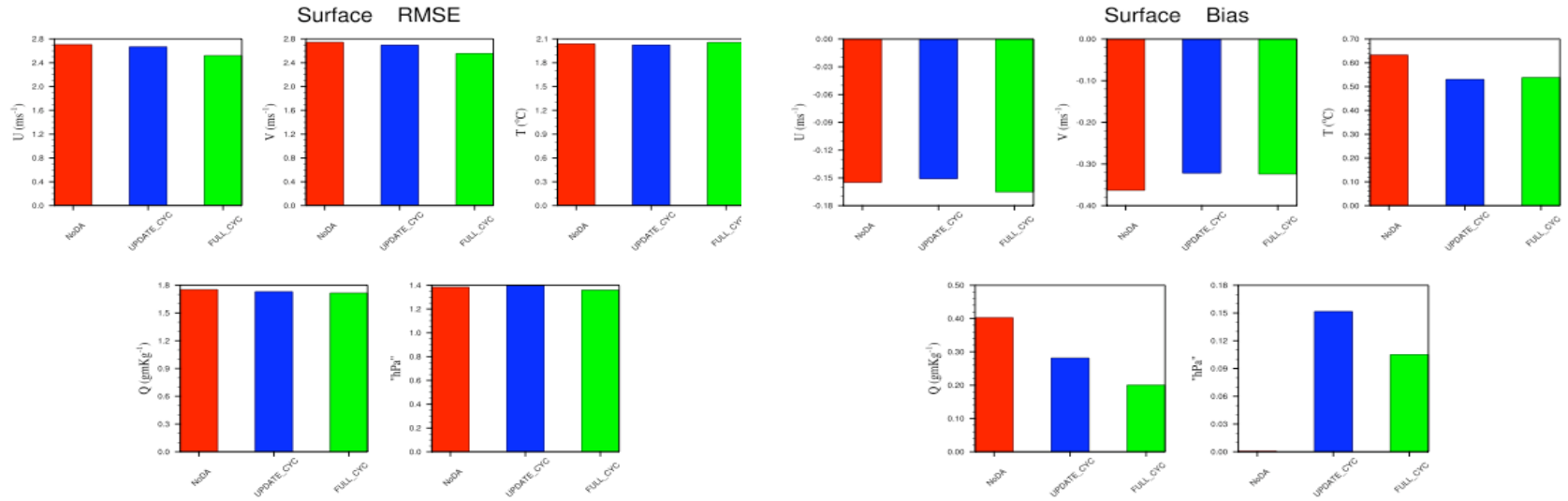
Verif_obs_plot -- Upper air Time Series



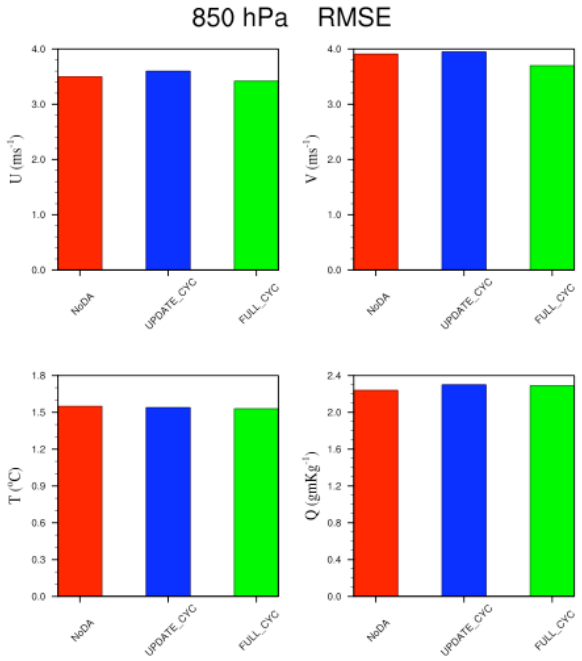
Verif_obs_plot -- Profile

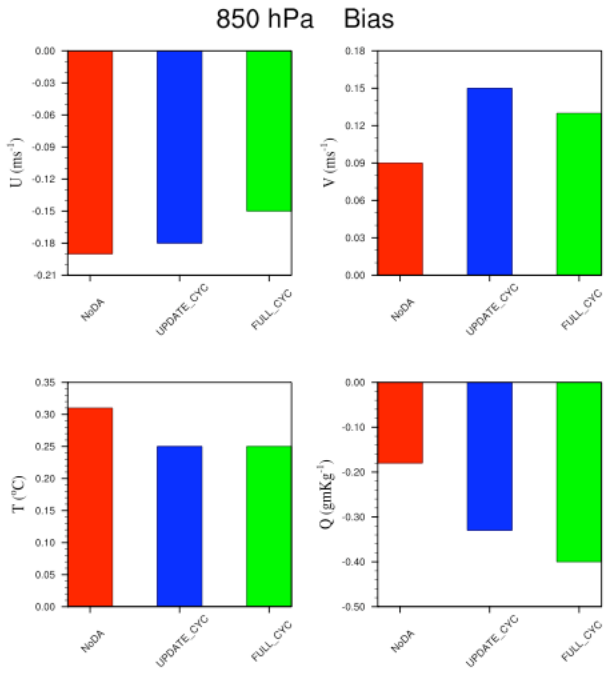


Verif_obs_plot -- Surface Time Average



Verif_obs_plot -- Upper air Time Average





How to run verification against Analysis?

- Each experiment forecasts needs to be arranged in separate directories with date-wise sub-directories
- By executing “var/script/da_verif_anal_plot.ksh” via a suitable wrapper script will generate the desired graphics in RUN_DIR

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.

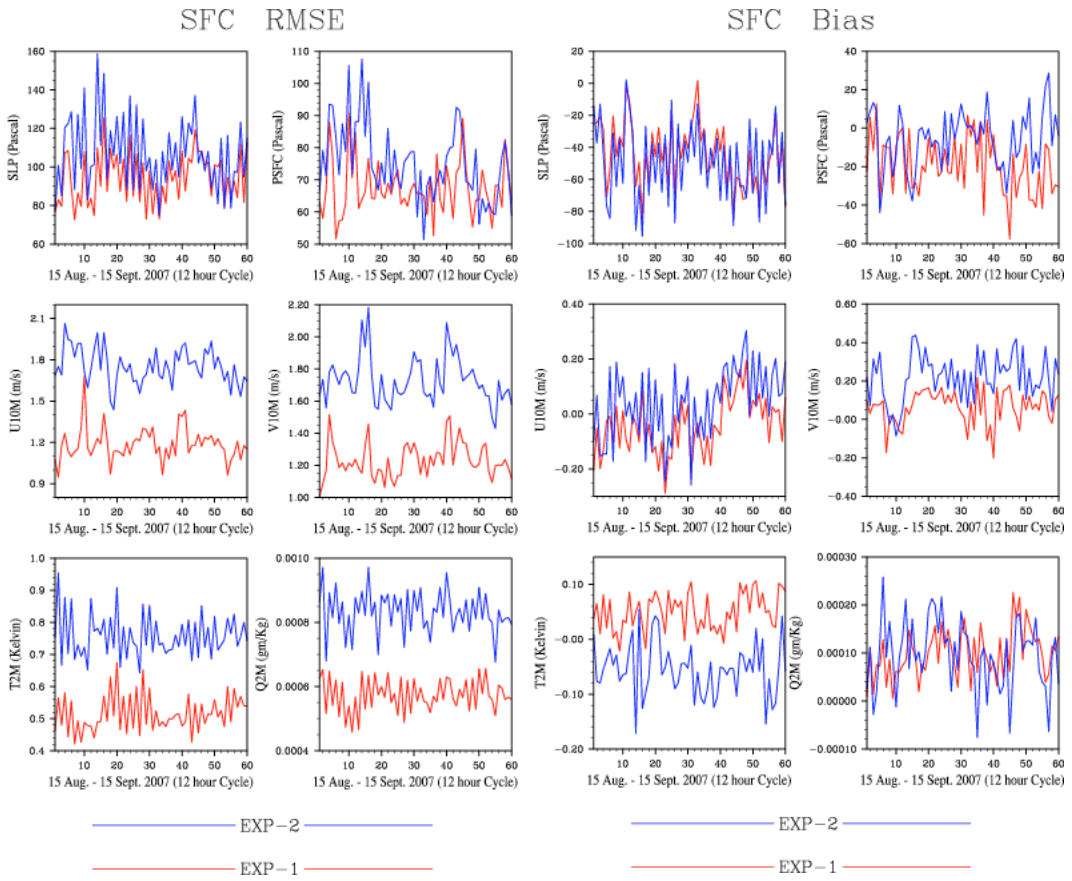
Verif_anal_plot output

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

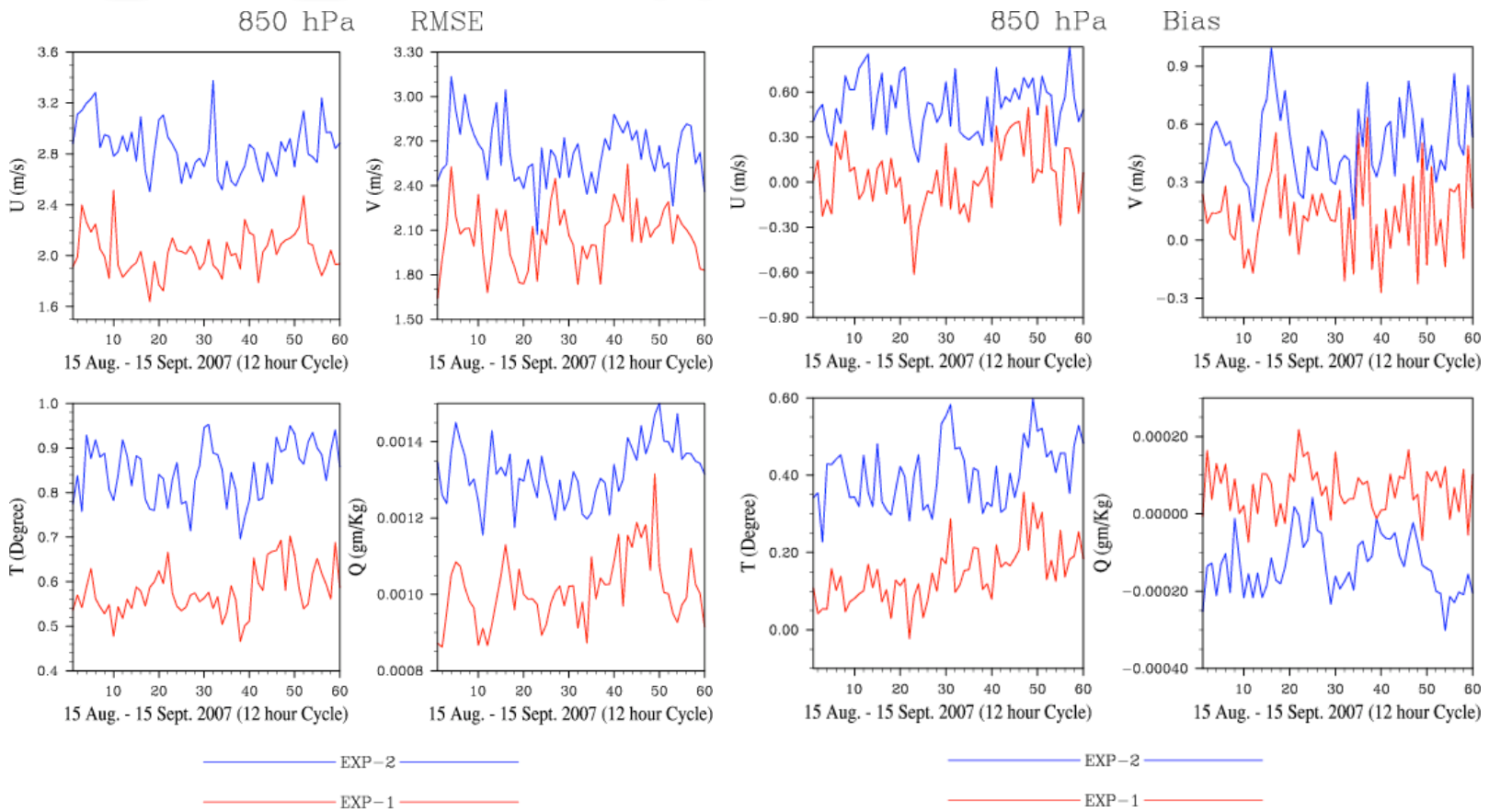
- Time series for surface fields (U10, V10, T2, Q2 & Psfc)
- Time series for upper air fields (U, V, T & Q) for the desired levels
- Upper air profiles for U, V, T & Q
- Time average for surface and upper air fields for the desired levels (Histogram)

```
-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
```

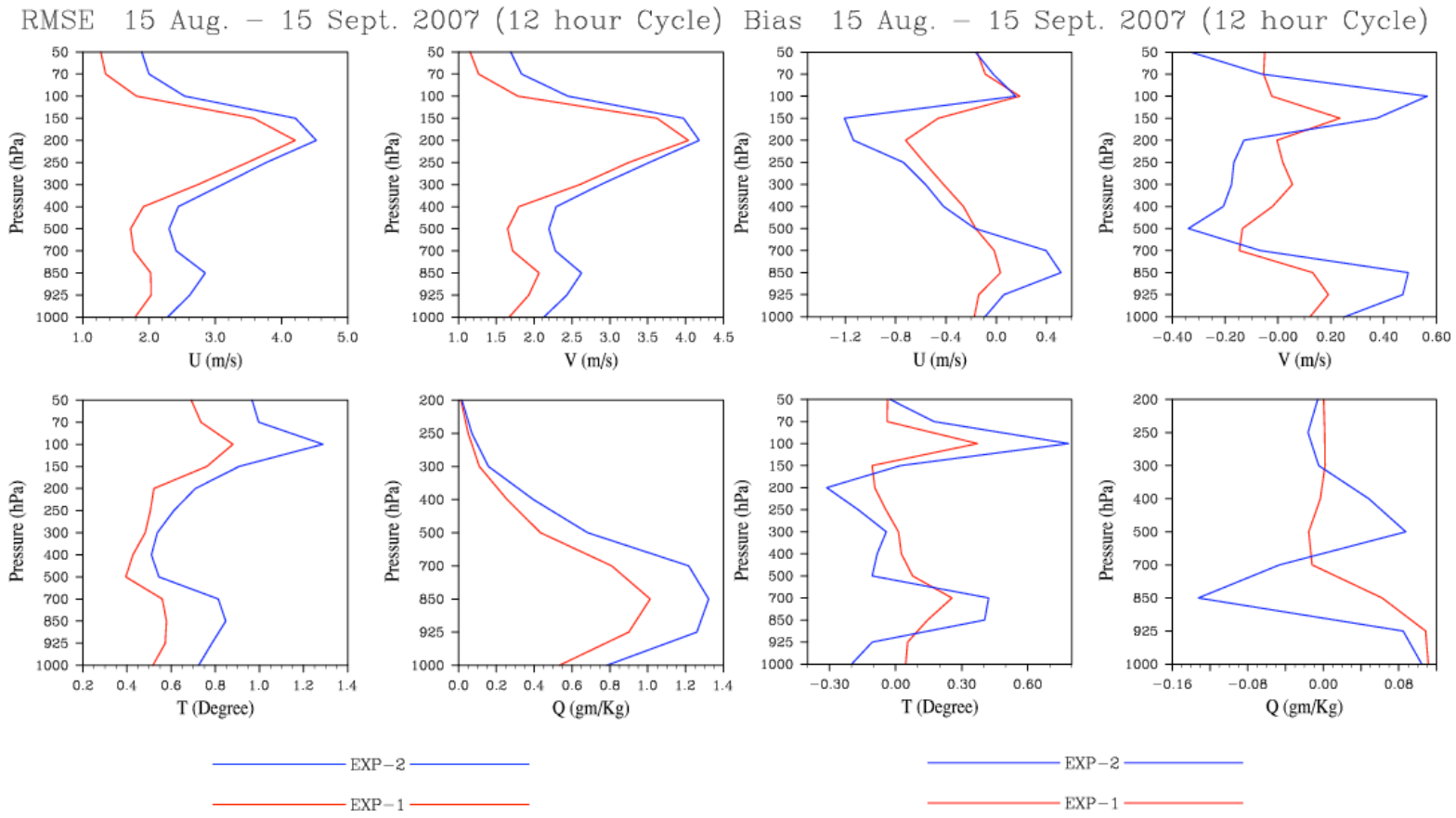
Verif_anal_plot -- Surface Time Series



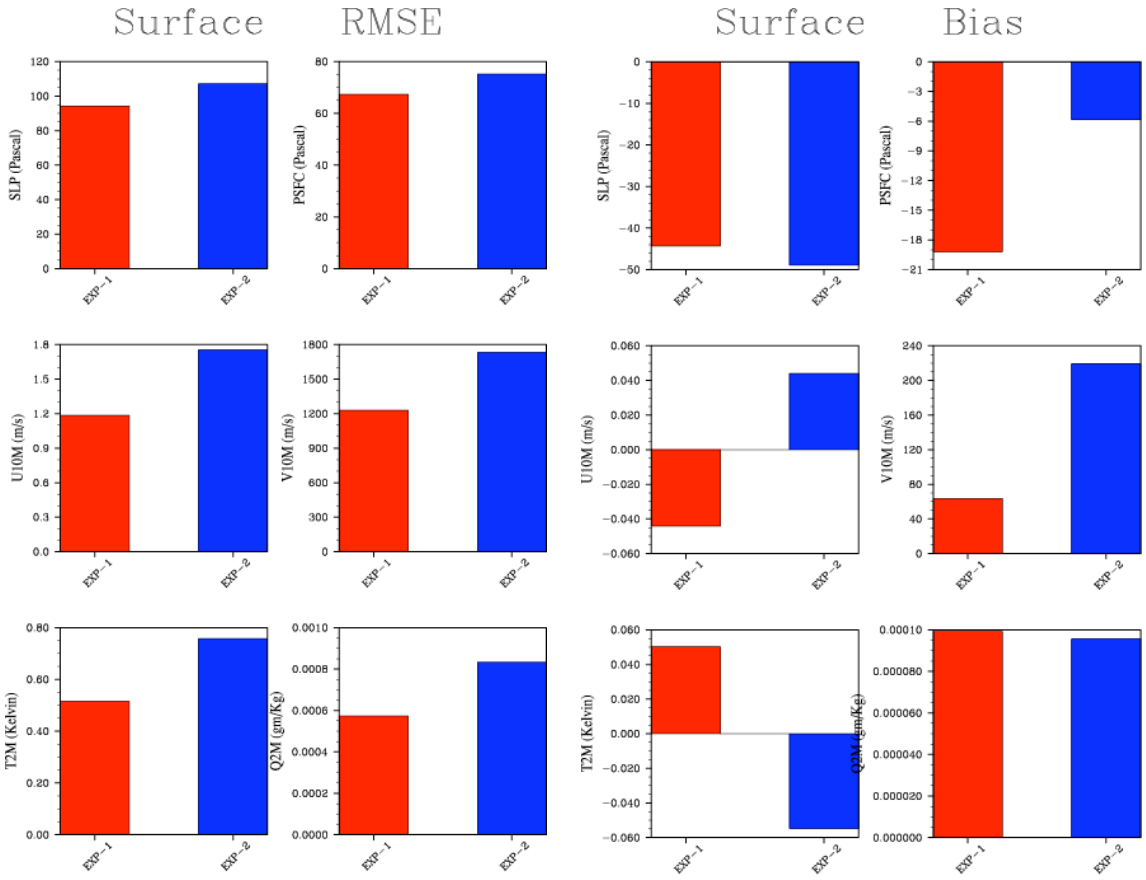
Verif_anal_plot -- Upper air Time Series



Verif_anal_plot -- Profile



Verif_anal_plot -- Surface Time Average



Verif_anal_plot -- Upper air Time Average