Community Tools: "gen_be"

Syed RH Rizvi

National Center For Atmospheric Research (NCAR)

NESL/MMM/DAG, Boulder, CO-80307, USA

email*: *rizvi@ucar.edu

Talk overview

- **What is “gen_be”?**
- **How it works?**
- **Some technical details**
- **Important “namelist” options**
- **scripts and graphics**
- **“gen_be” diagnostics for “CON200” domain**

What is “gen_be”?

- It is a utility available as part of WRFDA community release. Soon it will be made available independently as “stand alone” branch.
- It computes background error (BE) statistics for regional GSI applications using regional WRF-ARW model forecasts input.
- It is designed to work either for NMC or Ensemble (ENS) methods.
- The source code resides in “gen_be” sub-directory under WRFDA main directory.

How "gen_be" works?

- After configuring "wrfda", all the desired executables may be built using "./compile all_wrfvar" command
- It works in three stages (stage0, stage1 and stage2)
- These three stages needs to be executed in the same order
- Each stage has its own corresponding parallel script which is executed via a suitable "wrapper" script

“gen_be” ----- Stage0:

- It executes “gen_be_stage0_gsi.f90” code
- Main function:
  - Process WRF-ARW forecasts and output the desired info about the domain configuration
  - Convert horizontal wind components (U,V) to stream function and velocity potential (Ψ,χ)
  - Forms desired perturbations depending on “NMC” or “ENS” method to be used
  - Desired WRF-ARW or ensemble forecasts needs to be stored in specific sub-directories, “date-wise”

"gen_be" ----- Stage1:

- It executes "gen_be_stage1_gsi.f90" code
- Its main function is to remove the temporal mean for "NMC" method

“gen_be” ----- Stage2:

- It executes “gen_be_stage2_gsi.f90” code
- Its main function is to compute the following:
  - Regression coefficients for velocity potential (χ), temperature (t) and surface pressure (ps)
  - Unbalanced parts of χ, t and ps
  - Variance of all the control variables
  - Horizontal and vertical length-scales of the control variables
  - Variance of relative humidity (rh) in 5% bins of mean rh

Technical details about "gen_be"

- **For each control variable, variance is computed in latitude-bands and thus it is latitude dependent**

- **Horizontal length-scale (*L*) is computed following Wan Shu *et al.* (*MWR*, 2002)**

$$\Psi_{corr} = \exp\left\{-\tfrac{1}{2}\left(\tfrac{x^2}{s^2}\right)\right\}$$

Thus Horizontal length-scale is latitude dependent

- **For each sigma level (*l*), vertical length-scale (*VL*) is computed using vertical error covariance (*vcor*) for each sigma level with adjacent level just below this level, as follows:**

$$VL(l) = \left\{\frac{1}{abs[2 - vcor(l) - vcor(l+1)]}\right\}^{1/2}$$

Thus vertical length-scale do not vary with latitude

Technical details about "gen_be" Contd.

- **Regression coefficients of velocity potential (χ), with stream function (Ψ) are computed in latitude-bands and so these are latitude dependent**

- **Regression coefficients of temperature (t) and surface pressure (P_s) is computed using basis vectors defined by the normalized vertical length-scale (s) of Ψ-field as follows.**

$$\Psi_{corr}(l,m) = \exp\left\{ -\tfrac{1}{2}\left(\tfrac{x^2}{s^2} \right) \right\}$$

x **– layer thickness in log(sigma) between sigma level *l* and *m***

s **– vertical length-scale of Ψ at level *l* normalized with log-sigma thickness of the adjacent level, just below the level *l*.**

Thus regression coefficients for t and P_s are not latitude dependent

Important "namelist" options

Variable Name	Type	Default Option	Description
BE_METHOD	Character	NMC	Method of computing BE statistics NMC or ENS, the ensemble based
POISSON_METHOD	Integer	1	Method for Poisson solver 1 – Spectral 2 – Relaxation
FFT_METHOD	Integer	2	Fast Fourier Transform 1 - Cosine 2 - Sine
FSTAT	Logical	False	Includes the contribution of coriolis parameter effect for temperature and psi regression coefficients
LAT_BINS_IN_DEG	Real	1.0	Width of Latitude bins in degrees
LESS_Q_FROM_TOP	Integer	0	Number of top model sigma levels to eliminate moisture BE statistics
Debug options	Integer	0	Flag for debugging the code

Scripts and graphics

- A top level script "*gen_be_gsi.ksh*" *executes various stages of* "*gen_be*" via a suitable "wrapper" script.
- "*stage0*" has its own separate script "*gen_be_stage0_gsi.ksh*". It is called by the top level script.
- Thus to run "*gen_be*", only a wrapper script needs to be developed which includes information about domain configuration, location of forecast output files, initial and final dates, desired namelist options etc.
- Successful execution produces the desired background error statistics file as "*wrf-arw-gsi_be*" in "*RUN_DIR*" directory
- To display the contents of "*wrf-arw-gsi_be*", the NCL script "*plot_gsi_be.ncl*" may be run via a suitable "*wrapper*" script

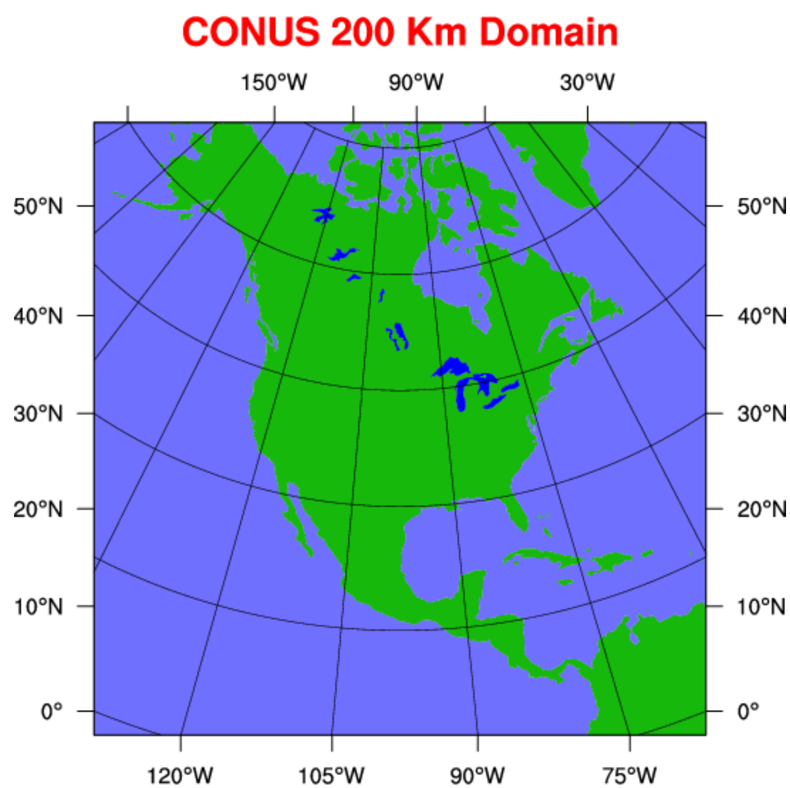
A sample "wrapper" to run "gen_be"

```
#! /bin/ksh -aeu
#---------------------------------------------------------------------------------------------------------------
# Script gen_be_wrapper.ksh
## Author : Syed RH Rizvi, MMM/ESSL/NCAR,  Date:04/15/2009
# Purpose: Calculates WRF-ARW background error statistics for GSI
#---------------------------------------------------------------------------------------------------------------
export WRFVAR_DIR=/mmm/users/rizvi/code/trunk_mbe
export SCRIPTS_DIR=/mmm/users/rizvi/code/WRFDA_scripts/var/scripts
export GRAPHICS_DIR=/mmm/users/rizvi/code/WRFDA_scripts/var/graphics/ncl
export NUM_WE=44                # 1 point less than stagger points in WE
export NUM_SN=44                # 1 point less than stagger points in SN
export NUM_LEVELS=27            # 1 point less than stagger point in vertical
export LESS_Q_FROM_TOP=0        # Exclude levels from top for moisture statistics
export LAT_BINS_IN_DEG=5.0      # Lat bins (in deg) for BE stats
export DEBUG=0
export REGION=con200
export DAT_DIR=/ptmp/rizvi/data
export REG_DIR=$DAT_DIR/$REGION
export EXPT=run_gsi_be_lat_bin_size_${LAT_BINS_IN_DEG}_lnps
export RUN_DIR=$REG_DIR/$EXPT
export FC_DIR=$REG_DIR/novar/fc
export RUN_GEN_BE_GSI_STAGE0=true
export RUN_GEN_BE_GSI_STAGE1=true
export RUN_GEN_BE_GSI_STAGE2=true
export START_DATE=2007070200    # the first perturbation valid date
export   END_DATE=2007073112    # the last perturbation valid date
export INTERVAL=12
${SCRIPTS_DIR}/gen_be/gen_be_gsi.ksh
```

A sample "wrapper" to display BE

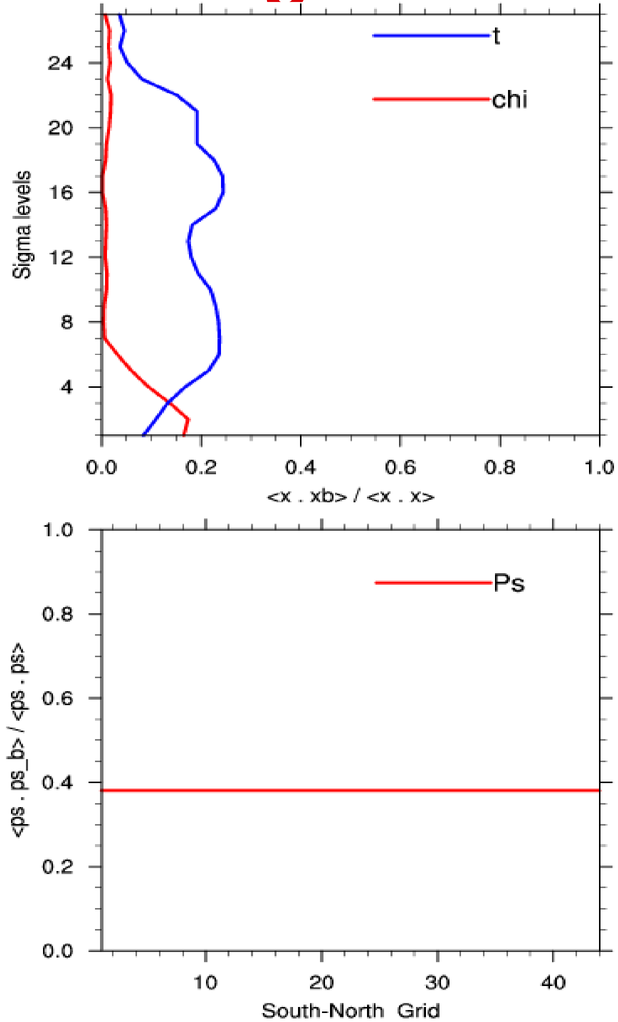
```
#! /bin/ksh -aeu
#-----------------------------------------------------------------------------------------------------------
# Script : wrapper_gen_be_gsi_plot.ksh
# Author: Syed RH Rizvi,  UCAR/NCAR/ESSL/MMM/DAG Date: 08/12/2009
# Purpose: Wrapper for the display of  background error statistics for GSI
#-----------------------------------------------------------------------------------------------------------
export SCRIPTS_DIR=/mmm/users/rizvi/code/WRFDA_scripts/var/scripts
export GRAPHICS_DIR=/mmm/users/rizvi/code/WRFDA_scripts/var/graphics/ncl
export GRAPHIC_WORKS=pdf
export NUM_WE=44                    # 1 point less than stagger points in WE
export NUM_SN=44                    # 1 point less than stagger points in SN
export NUM_LEVELS=27                # 1 point less than stagger point in vertical
export REGION=con200
export PLOT_CORRELATION=true
export DAT_DIR=/ptmp/rizvi/data
export REG_DIR=$DAT_DIR/$REGION
export EXPT=run_gsi_be
export RUN_DIR=$REG_DIR/$EXPT
ncl ${GRAPHICS_DIR}/gen_be/plot_gsi_be.ncl
#-------------------------------------------------------
if $PLOT_CORRELATION  ; then
# Plot Correlation:
ncl ${GRAPHICS_DIR}/gen_be/gsi_correlation.ncl
fi
```

BE diagnostics for CONUS domain



Grid: 45 x 45 x 28

WRF-ARW BE diagnostics -- balanced fields

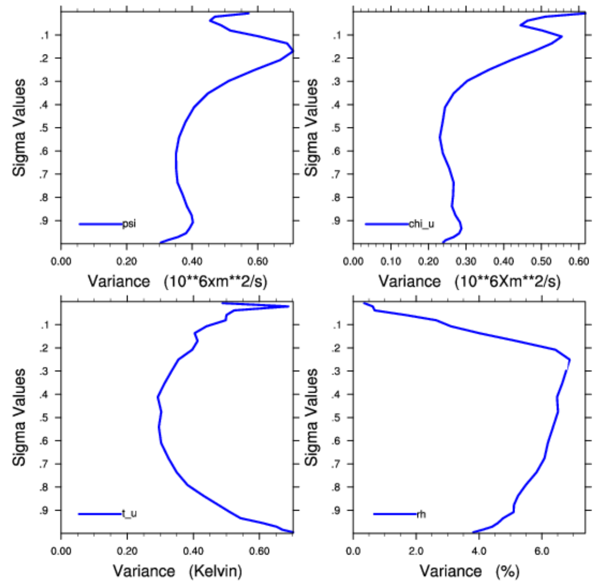


CONUS, 200 Km Domain

WRF-ARW BE diagnostics -- Variance

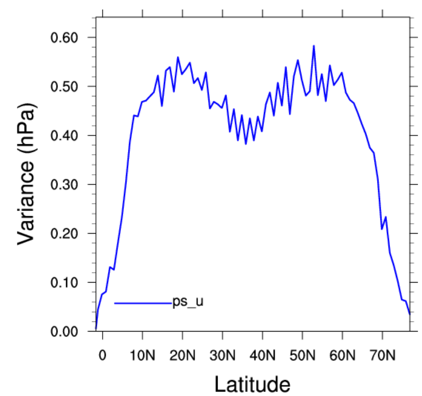
psi **chi_u**

t_u **rh**



Averaged profile

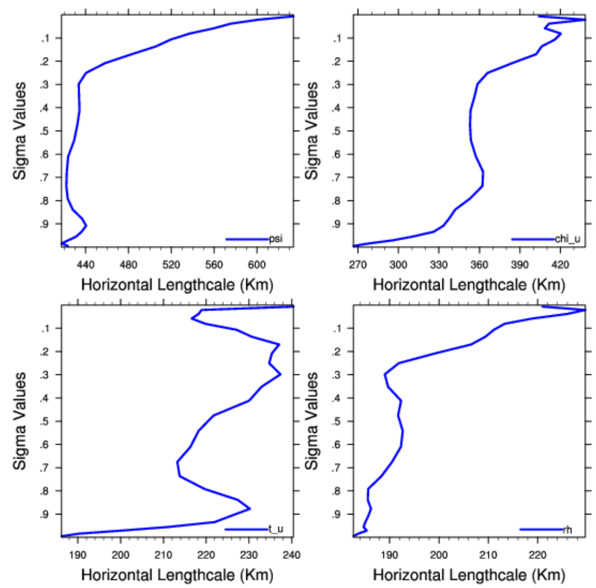
ps_u



BE diagnostics -- Horizontal Length-scales

psi

chi_u

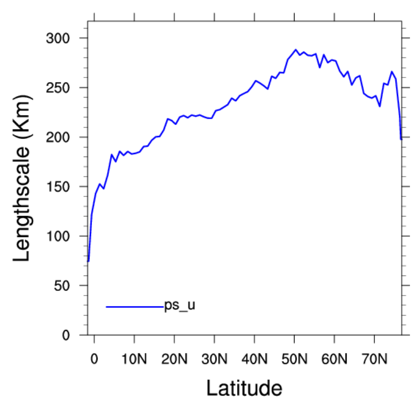


t_u

rh

Averaged profile

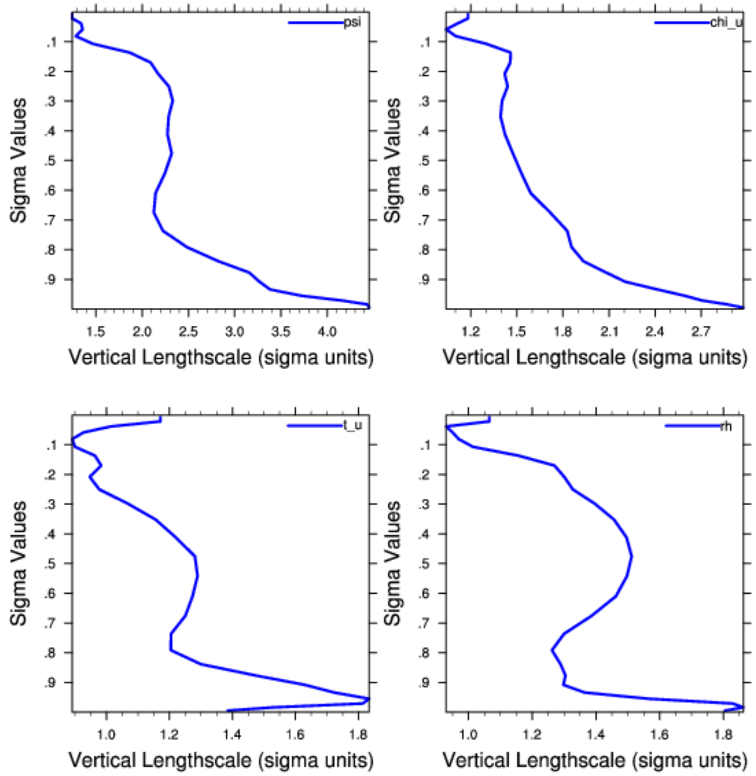
ps_u



BE diagnostics -- Vertical Length-scales

psi

chi_u

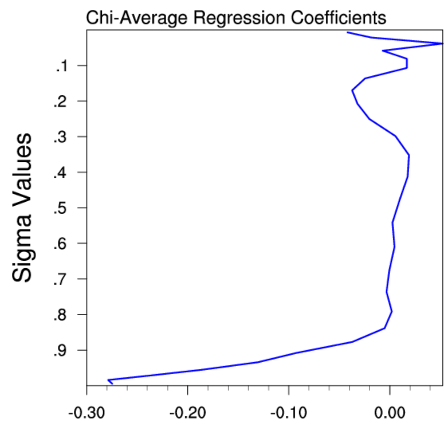


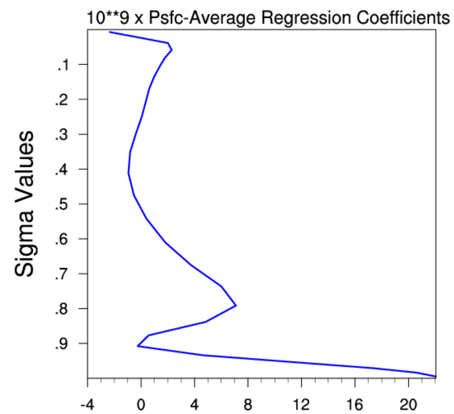
t_u

rh

BE diagnostics – Regression coeff

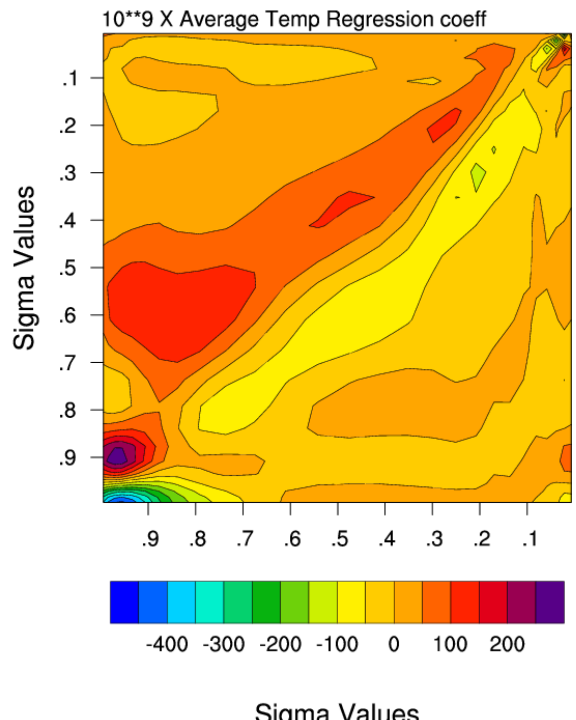
Chi





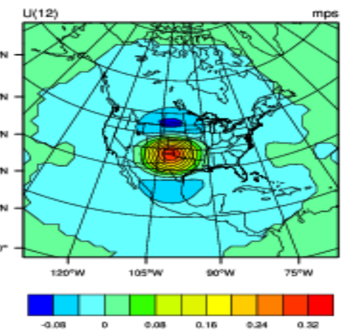
P_s

Temperature

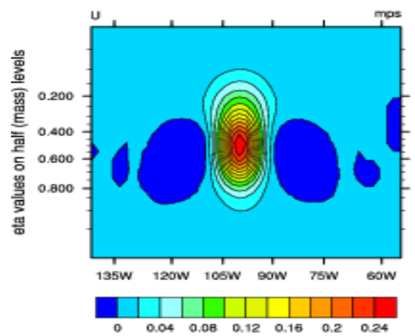


Single Obs (U) test

XY cross-section



XZ cross-section



YZ cross-section