2013 Beijing GSI Tutorial
May 29, 2013
Beijing, China

# Introduction to GSI Background Error Covariance (BE)

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# BE related Tutorial lectures

## GSI Tutorial 2010

Background and Observation Error Estimation and Tuning

# BE related Tutorial lectures

GSI Tutorial 2011

Background and Observation Errors:
Estimation and Tuning

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# BE related Tutorial lectures

## *Community Tools: "gen_be"*

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# Goals of this talk

- BE is a complex and important topic in variational analysis
- This talk is a quick summary of BE related talks to help users to correctly use BE in their GSI practices
  - Understand the impact of the BE
  - Available BE in release package
  - Set right configure for available BE
  - Tuning BE related parameters

# BE in VAR Analysis

$$J(x) = (x-x_b)^T \boldsymbol{B}^{-1}(x-x_b)+(y-\mathrm{H}[x])^T \boldsymbol{R}^{-1}(y-\mathrm{H}[x])$$

- Background error covariance matrix: B (usually called as BE or B matrix)
  - Variance (diagonal values)
  - Correlation (off diagonal values)
    - Horizontal and vertical impact scales for same analysis variable
    - Balance among different analysis variables
- Definition:

# Daryl's notes on BE

- Vital for controlling amplitude and structure for correction to model first guess (background)
- Covariance matrix
  - Controls influence distance
  - Contains multivariate information
  - Controls amplitude of correction to background
- For NWP (WRF, GFS, etc.), matrix is prohibitively large
  - Many components are modeled or ignored
- Typically estimated a-priori, offline

# Estimate Background Error

- NMC method
  - Lagged forecast pairs (i.e. 24/48 hr forecasts valid at same time, 12/24 hr lagged pairs, etc.)
  - Assume: Linear error growth
  - Easy to generate statistics from previously generated (operational) forecast pairs
- Ensemble method
  - ensemble differences of forecasts
  - Basic assumption: ensemble represents real spread
- Conventional method
  - differences of forecasts and obs
  - difficulties: observation coverage and multivariate components

# Available BEs in GSI release package

- Global BE:
  - ./fix/nam_glb_berror.f77.gcv (Big_Endian binary file)
    ./fix/nam_glb_berror.f77.gcv_Little_Endian
  - Coverage:
    - Latitude: 192 latitude from -90 to 90
    - Vertical: 42 sigma level from 0.99597 to 0.013831
- Regional (NAM) BE
  - ./fix/nam_nmmstat_na.gcv (Big_Endian binary file)
    ./fix/nam_nmmstat_na.gcv_Little_Endian
  - Coverage
    - Latitude: 93 latitude from -2.5 to 89.5
    - Vertical: 60 sigma level from 0.9975289 to 0.01364
- GSI will interpolate above BE into analysis grid

# Testing Background Error

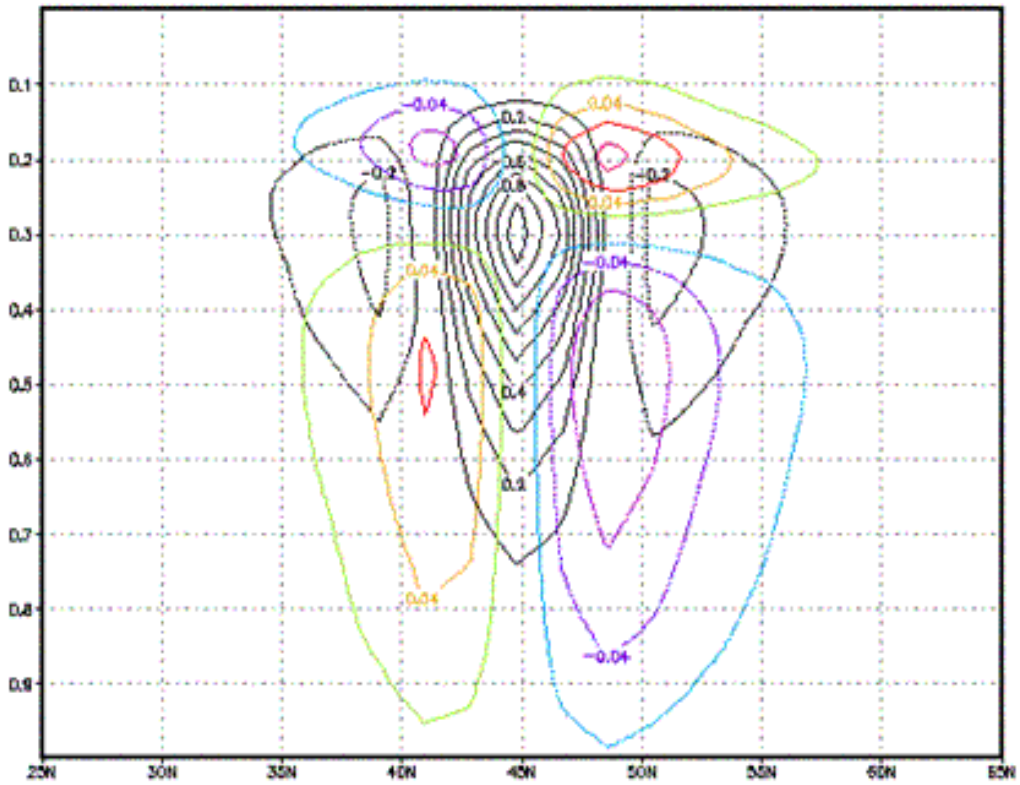
- Best way to test background error covariance is through single observation experiments (as shown in some previous plots)

- Easy to run within GSI, namelist options:

```
&SETUP
   oneobtest=.true.
&SINGLEOB_TEST
   maginnov=1.,magoberr=1.,oneob_type= 'u' ,oblat=45.,oblon=180,
   obpres=300.,obdattime= 2010101312,obhourset=0.,
```

# Multivariate Example

Single zonal wind observation (1.0 $ms^{-1}$ O-F and error)




u increment (black, interval 0.1 $ms^{-1}$ ) and T increment (color, interval 0.02K) from GSI

# Tuning Parameters for BE

- The anavinfo file contains information about control variables and their background error amplitude tuning weights

control_vector::

| !var | level | itracer | **as/tsfc_sdv** | an_amp0 | source | funcof |
|---|---|---|---|---|---|---|
| sf | 64 | 0 | **0.60** | -1.0 | state | u,v |
| vp | 64 | 0 | **0.60** | -1.0 | state | u,v |
| ps | 1 | 0 | **0.75** | -1.0 | state | p3d |
| t | 64 | 0 | **0.75** | -1.0 | state | tv |
| q | 64 | 1 | **0.75** | -1.0 | state | q |
| oz | 64 | 1 | **0.75** | -1.0 | state | oz |
| sst | 1 | 0 | **1.00** | -1.0 | state | sst |
| cw | 64 | 1 | **1.00** | -1.0 | state | cw |
| stl | 1 | 0 | **3.00** | -1.0 | motley | sst |
| sti | 1 | 0 | **3.00** | -1.0 | motley | sst |

# Tuning Parameters for BE

- Length scale tuning controlled via GSI namelist

  &BKGERR

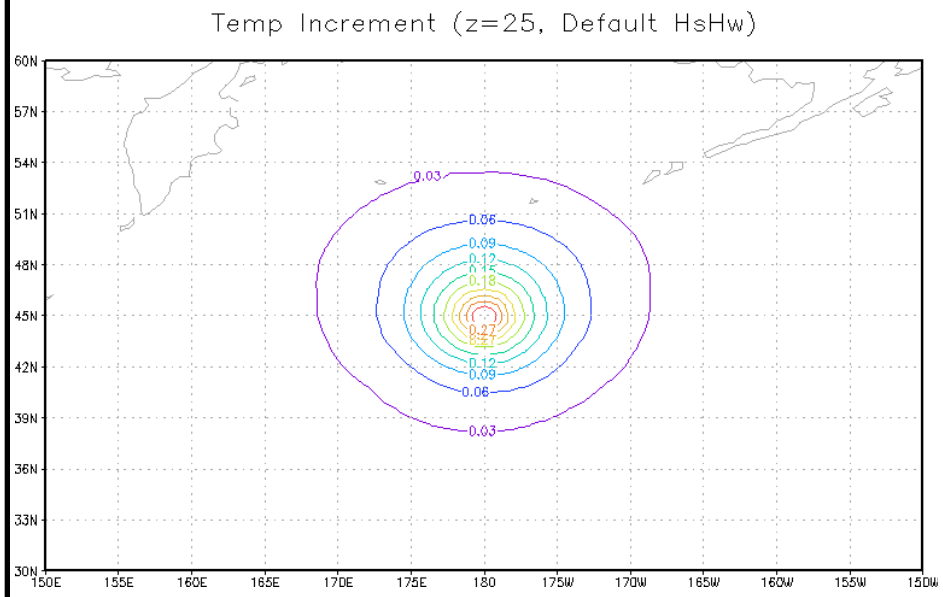
  hzscl = 1.7, 0.8, 0.5

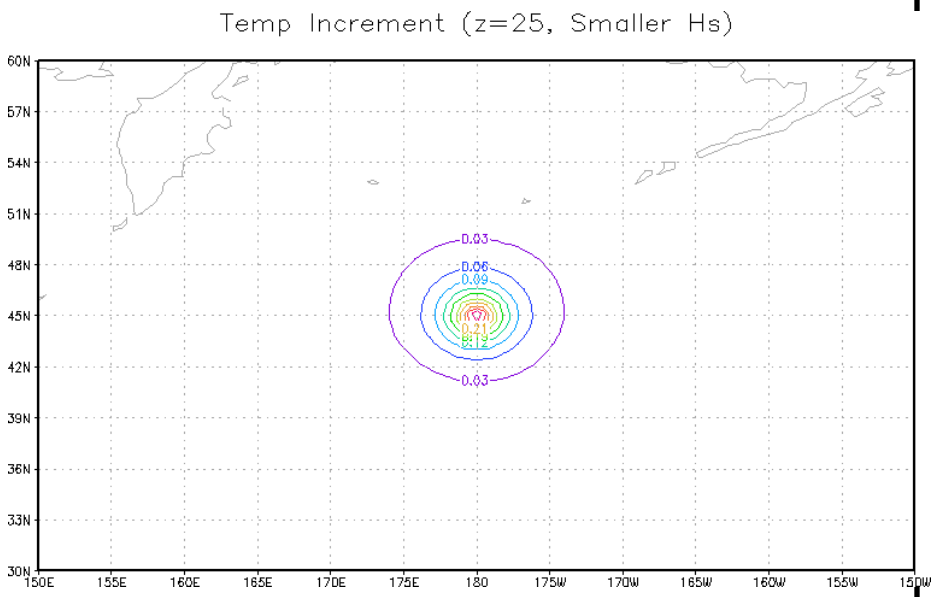
  hswgt = 0.45, 0.3, 0.25

  vs=0.7 [separable from horizontal scales]

- Hzscl/vs/as are all multiplying factors (relative to contents of "berror" fixed file)
- Three scales specified for horizontal (along with corresponding relative weights, hswgt)

# Tuning Example (Scales)




**Hzscl = 1.7, 0.8, 0.5**

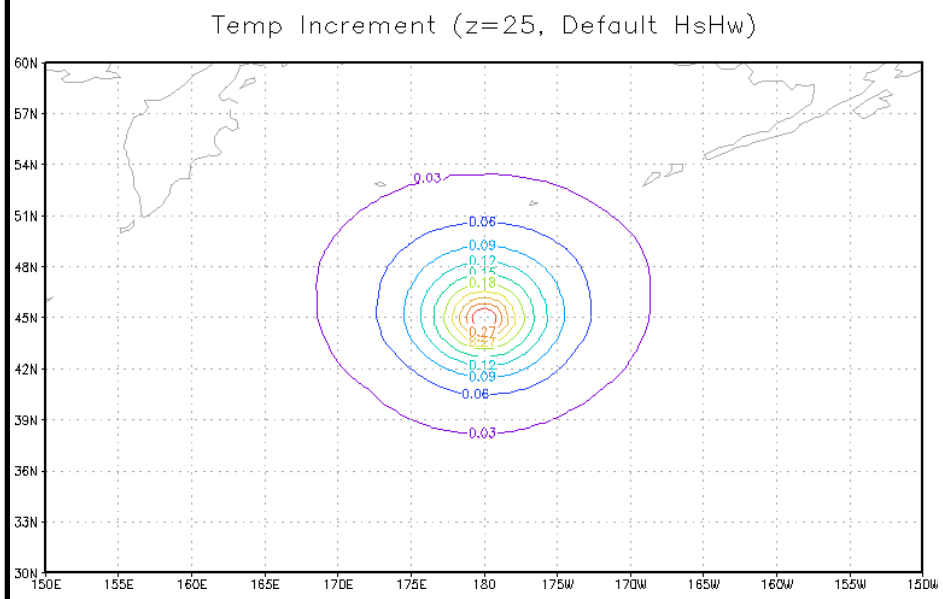
Hswgt = 0.45, 0.3, 0.25

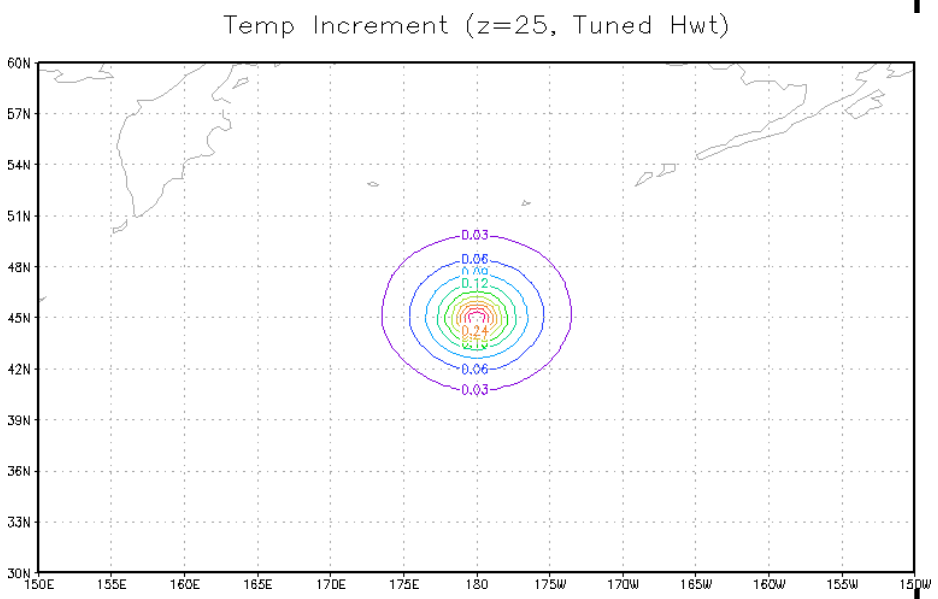
**Hzscl = 0.9, 0.4, 025**

Hswgt = 0.45, 0.3, 0.25

500 hPa temperature increment (K) from a single temperature observation utilizing GFS default (left) and tuned (smaller scales) error statistics.

# Tuning Example (Weights)




Hzscl = 1.7, 0.8, 0.5

**Hswgt = 0.45, 0.3, 0.25**

Hzscl = 1.7, 0.8, 0.5

**Hswgt = 0.1, 0.3, 0.6**

500 hPa temperature increment (K) from a single temperature observation utilizing GFS default (left) and tuned (weights for scales) error statistics.

# Recommended BE tuning values

GLOBAL

nam_glb_berror.f77.gcv

nam_glb_berror.f77.gcv_Little_Endian

```
 &BKGERR
   vs=0.7,
   hzscl=1.7,0.8,0.5,
```

**global_anavinfo.l64.txt**

control_vector::

| !var | level | itracer | **as/tsfc_sdv** | an_amp0 |
|---|---|---|---|---|
| sf | 64 | 0 | **0.60** | -1.0 |
| vp | 64 | 0 | **0.60** | -1.0 |
| ps | 1 | 0 | **0.75** | -1.0 |
| t | 64 | 0 | **0.75** | -1.0 |
| q | 64 | 1 | **0.75** | -1.0 |
| oz | 64 | 1 | **0.75** | -1.0 |
| sst | 1 | 0 | **1.00** | -1.0 |
| cw | 64 | 1 | **1.00** | -1.0 |
| stl | 1 | 0 | **3.00** | -1.0 |
| sti | 1 | 0 | **3.00** | -1.0 |

NAM

nam_nmmstat_na.gcv

nam_nmmstat_na.gcv_Little_Endian

```
&BKGERR
   vs=1.0,
   hzscl='0.373,0.746,1.50,
```

**anavinfo_arw_netcdf**

control_vector::

| !var | level | itracer | as/tsfc_sdv | an_amp0 |
|---|---|---|---|---|
| sf | 30 | 0 | **1.00** | -1.0 |
| vp | 30 | 0 | **1.00** | -1.0 |
| ps | 1 | 0 | **0.50** | -1.0 |
| t | 30 | 0 | **0.70** | -1.0 |
| q | 30 | 1 | **0.70** | -1.0 |
| oz | 30 | 1 | 0.50 | -1.0 |
| sst | 1 | 0 | 1.00 | -1.0 |
| cw | 30 | 1 | 1.00 | -1.0 |
| stl | 1 | 0 | 1.00 | -1.0 |
| sti | 1 | 0 | 1.00 | -1.0 |