2017 EnKF Community Tutorial
July 13, 2017. College Park, MD

EnKF Fundamental (2): Diagnostics and Applications

Ming Hu*, Hui Liu, Kathryn Newman* and Chunhua Zhou***

*Developmental Testbed Center (DTC)

**UCAR/COSMIC and Developmental Testbed Center (DTC)

Developmental Testbed Center

Outline

- EnKF Overview and Theory
- EnKF Fundamentals (1): Run and namelists

- EnKF Fundamentals (2): Diagnostics and Applications
  - *Standard output (stdout)*
  - *Check ensemble spread and observation fits*
  - *Tuning EnKF through Namelist: inflation, localization*
  - Check analysis increment and ensemble spread
  - *Summary of EnKF applications*

✓ This talk is tailored to Chapter 4/5 of the EnKF User's Guide for community release

Standard Output (stdout)

Details in User's Guide Section 4.1

✓Including useful information about the EnKF:

1. Did EnKF successfully complete?
2. Does inflation look good?
3. Are the background and analysis fields reasonable?

✓Helpful in understanding where and why EnKF may have failed

stdout: structure

- The structure of stdout is as follows:

1. Read in data and prepare analysis:
    1. Read in configuration (namelist)
    2. Read in constant fields (fixed files)
    3. Read in observations
    4. Read in ensemble prior ensemble
2. EnKF analysis
3. Inflation of posterior ensemble

Indicates the start of the EnKF

```
Execute poe command line: poe  ./enkf.x
 running on            32  processors ...


* . * . * . * . * . * . * . * . * . * . * . * . * . * . * . * . * . * . * . * .
     PROGRAM ENKF_ANL HAS BEGUN. COMPILED 2011319.55      ORG: NP25
     STARTING DATE-TIME  JUL 09,2017  00:40:30.410  190  SUN   2457944
```

Stdout: read in namelist

```
 &NAM_ENKF
 DATESTRING     = 2014021300,
 DATAPATH       = ./,
 IASSIM_ORDER   =        0,
 COVINFLATEMAX  =   100.0000   ,
 COVINFLATEMIN  =   1.000000   ,
 DETERMINISTIC  =T,
 SORTINC =T,
 CORRLENGTHNH   =   500.0000   ,
 CORRLENGTHTR   =   500.0000   ,
 CORRLENGTHSH   =   500.0000   ,
 VARQC  = F,
 HUBER  = F,
 NLONS  =       129,
 NLATS  =       70,
...
 NLEVS  =       50,
 NANALS =       20,
 NVARS  =       5,
...
 ADP_ANGLEBC    =T,
 ANGORD =       4,
 NEWPC4PRED     = F,
 NMMB   = F,
 NHR_ANAL       =       6, 6*-1,
 FHR_ASSIM      =  6.000000   ,
...
 ISEED_PERTURBED_OBS    =       0,
 NPEFILES       =       0
 /
```

analysis time 2014021300
20 members
number of background forecast times to be updated = 1
first-guess forecast hours for analysis = 06
5 3d vars to update
total of **251 2d grids** will be updated (including **ps**)
using multiplicative inflation based on Pa/Pb

- Read in namelist
- show key parameters
- Configure analysis variables:
  Var 1, 2, 3, 4, 5

```
Updating U, V, T, QVAPOR, PH,
and MU for WRF-ARW...
```

Stdout: info files and bias correction coefficients

```
READ_CONVINFO: tcp     112    0  1   3.00000       0   0   0   75.0000      5.00000
1.000000      75.0000      0.00000        0  0.00000      0.00000        0
READ_CONVINFO: ps      120    0  1   3.00000       0   0   0   4.00000      3.00000
1.000000      4.00000     0.300000E-03    0  0.00000      0.00000        0
 line ignored in convinfo due to use flag  ps              132           0
         -1
```

```
OZINFO_READ:  jpch_oz=    272
  1 sbuv6_n14            lev =    1 use = -1 pob =     0.240 gross =   1.000 error =
1.000 b_oz =  10.000 pg_oz =   0.000
  2 sbuv6_n14            lev =    2 use = -1 pob =     0.490 gross =   1.000 error =
1.000 b_oz =  10.000 pg_oz =   0.000
```

```
RADINFO_READ:  jpch_rad=   4934

   1 amsua_n15            chan=    1 var=   3.000 varch_cld= 20.000 use=  1 ermax=
4.500 b_rad=   10.00 pg_rad=   0.00 icld_det=-2

   2 amsua_n15            chan=    2 var=   2.200 varch_cld= 18.000 use=  1 ermax=
4.500 b_rad=   10.00 pg_rad=   0.00 icld_det=-2

   3 amsua_n15            chan=    3 var=   2.000 varch_cld= 12.000 use=  1 ermax=
4.500 b_rad=   10.00 pg_rad=   0.00 icld_det=-2
```

```
  RADINFO_READ:  guess air mass bias correction coefficients below

   1          amsua_n15    2.680929    0.000000    0.000000    0.281644    0.735701
0.000000    0.000000   -0.016301    4.269251    3.092839   -4.917681   -2.043537

   2          amsua_n15    1.591210    0.000000    0.000000   15.459969   -3.826823
0.000000    0.000000   -0.015617    3.943127    9.279759   -4.624200   -1.794099
```

Includes many lines, skip if not work on related issues

stdout: check observations (diag files)

```
            0  ozone obs
     1              amsua_n15  num_obs_tot=      5447
     2              amsua_n18  num_obs_tot=     10772
     7          amsua_metop-a  num_obs_tot=     11531
    12               mhs_n18  num_obs_tot=     14098
    14            mhs_metop-a  num_obs_tot=     14568
  npred   =            12
           1 biasprednorm =    1.000000
          12 biasprednorm =    1.000000
```

```
      47872  obs in diag_conv_ges file
columns below obtype,nread, nkeep
   t        8043       7904
   q        2625       2621
  ps       14133      14133
  uv       21982      21982
 sst           0          0
 gps        1232       1232
  pw           0          0
  dw           0          0
 srw           0          0
  rw           0          0
 tcp           0          0
nobs_conv, nobs_oz, nobs_sat =        47872          0       14568
```

stdout: innovation statistics for prior

Most important statistics of ensemble and observations. Will discuss this table in details in next section.

```
 innovation statistics for prior:
conventional obs
 region, obtype, nobs, bias, innov stdev, sqrt(S+R), sqrt(S), sqrt(R):
NH    all ps  14083 -0.591E-02  0.860E+00  0.814E+00  0.601E+00  0.550E+00
TR    all ps     50 -0.629E-01  0.422E+00  0.661E+00  0.367E+00  0.550E+00
NH     all t   7766 -0.228E+00  0.163E+01  0.128E+01  0.480E+00  0.119E+01
TR     all t    138 -0.130E+00  0.118E+01  0.119E+01  0.234E+00  0.117E+01
NH    all uv  21680  0.136E-01  0.295E+01  0.276E+01  0.140E+01  0.237E+01
TR    all uv    302 -0.379E+00  0.251E+01  0.268E+01  0.124E+01  0.238E+01
NH     all q   2553 -0.323E-01  0.146E+00  0.157E+00  0.868E-01  0.131E+00
TR     all q     68 -0.721E-01  0.202E+00  0.164E+00  0.582E-01  0.154E+00
NH   all gps   1232 -0.262E-04  0.879E+00  0.117E+01  0.683E+00  0.950E+00
 satellite brightness temp
 instrument, channel #, nobs, bias, innov stdev, sqrt(S+R), sqrt(S), sqrt(R):
          amsua_n15   1   206  0.175E+00  0.198E+01  0.314E+01  0.916E+00  0.300E+01
          amsua_n15   2   207 -0.128E+00  0.149E+01  0.223E+01  0.334E+00  0.220E+01
          amsua_n15   3   207 -0.184E+00  0.134E+01  0.201E+01  0.223E+00  0.200E+01
          amsua_n15   4   207 -0.245E+00  0.408E+00  0.609E+00  0.106E+00  0.600E+00
          amsua_n15   5   207 -0.718E-01  0.280E+00  0.316E+00  0.991E-01  0.300E+00
          amsua_n15   7  1057 -0.323E+00  0.378E+00  0.254E+00  0.453E-01  0.250E+00
          amsua_n15   8  1033 -0.358E+00  0.439E+00  0.283E+00  0.650E-01  0.275E+00
          amsua_n15   9  1064  0.301E-01  0.269E+00  0.345E+00  0.606E-01  0.340E+00
          amsua_n15  10  1055  0.424E+00  0.512E+00  0.402E+00  0.415E-01  0.400E+00
          amsua_n15  15   204 -0.104E+01  0.184E+01  0.359E+01  0.818E+00  0.350E+01
                            ......
        mhs_metop-a   4    94 -0.574E+00  0.106E+01  0.253E+01  0.155E+01  0.200E+01
        mhs_metop-a   5    94 -0.127E+00  0.102E+01  0.308E+01  0.234E+01  0.200E+0
```

stdout: read in ensemble priors

U, V, T, QVAPOR, PH, MU from member 001

```
READGRIDDATA_ARW: U          1   -20.63564      14.28071
READGRIDDATA_ARW: U          2   -23.05487      16.09545
READGRIDDATA_ARW: U          3   -24.08159      17.07574

      . . .    . . .

READGRIDDATA_ARW: U         56   -17.74460      22.63066
READGRIDDATA_ARW: V         57   -13.06189      19.37896
READGRIDDATA_ARW: V         58   -14.51239      22.18587

      . . .    . . .

READGRIDDATA_ARW: PH       250    7195.078      14206.67
READGRIDDATA_ARW: MU       251   -1326.610      3290.569
```

n	Minimum	Maximum

Check that background fields look reasonable

5 3d vars to update
total of **251 2d grids** will be updated (including **ps**)
using multiplicative inflation based on Pa/Pb

stdout: observation order and inflation

```
 assimilate obs in order they were read in
1 timing on proc     0  =    0.58    0.28    0.01    0.13    0.00    0.16    0
      29368  out of       62440 obs skipped,       33072  used
      23755  out of       33072  same lat/long
```

```
 global ps prior std. dev min/max =    21.52301       172.3270
NH mean ps prior standard deviation =    57.82043
NH mean ps posterior standard deviation (before inflation)=    29.30882
NH mean ps posterior standard deviation (after inflation) =    54.59410
NH mean ps inflation =    2.407953
TR mean ps prior standard deviation =    31.09246
TR mean ps posterior standard deviation (before inflation)=    28.31958
TR mean ps posterior standard deviation (after inflation) =    30.79387
TR mean ps inflation =    1.106180
```

stdout: innovation statistics for posterior

```
 innovation statistics for posterior:
 conventional obs
 region, obtype, nobs, bias, innov stdev, sqrt(S+R), sqrt(S), sqrt(R):
NH     all ps  14083  0.298E-02  0.757E+00  0.569E+00  0.145E+00  0.550E+00
TR     all ps     50 -0.535E-01  0.399E+00  0.584E+00  0.195E+00  0.550E+00
NH      all t   7766 -0.828E-01  0.145E+01  0.122E+01  0.261E+00  0.119E+01
TR      all t    138 -0.107E+00  0.115E+01  0.118E+01  0.199E+00  0.117E+01
NH     all uv  21680  0.377E-01  0.267E+01  0.246E+01  0.656E+00  0.237E+01
TR     all uv    302 -0.260E+00  0.236E+01  0.246E+01  0.636E+00  0.238E+01
NH      all q   2553 -0.174E-01  0.114E+00  0.138E+00  0.443E-01  0.131E+00
TR      all q     68 -0.280E-01  0.168E+00  0.159E+00  0.413E-01  0.154E+00
NH    all gps   1232 -0.141E-04  0.489E+00  0.101E+01  0.350E+00  0.950E+00
 satellite brightness temp
 instrument, channel #, nobs, bias, innov stdev, sqrt(S+R), sqrt(S), sqrt(R):
           amsua_n15   1   206 -0.123E+02  0.141E+02  0.305E+01  0.529E+00  0.300E+01
           amsua_n15   2   207 -0.839E+01  0.172E+02  0.221E+01  0.194E+00  0.220E+01
           amsua_n15   3   207 -0.232E+01  0.270E+01  0.200E+01  0.138E+00  0.200E+01
           amsua_n15   4   207  0.642E+00  0.119E+01  0.604E+00  0.695E-01  0.600E+00
           amsua_n15   5   207  0.511E+00  0.969E+00  0.307E+00  0.630E-01  0.300E+00
           amsua_n15   7  1057 -0.184E+00  0.504E+00  0.252E+00  0.318E-01  0.250E+00
           amsua_n15   8  1033 -0.975E-01  0.454E+00  0.278E+00  0.433E-01  0.275E+00
           amsua_n15   9  1064 -0.559E+00  0.676E+00  0.343E+00  0.454E-01  0.340E+00
           amsua_n15  10  1055  0.123E-01  0.358E+00  0.401E+00  0.346E-01  0.400E+00
           amsua_n15  15   204 -0.186E+01  0.330E+01  0.353E+01  0.476E+00  0.350E+01
                   ......
         mhs_metop-a   4    94 -0.848E+00  0.391E+01  0.219E+01  0.902E+00  0.200E+01
         mhs_metop-a   5    94 -0.247E+00  0.492E+01  0.238E+01  0.129E+01  0.200E+01
```

Will discuss this table in details in next section.

stdout: analysis increments

```
ens. mean anal. increment min/max ps  -121.7333        264.4750
ens. mean anal. increment min/max var            1  -8.104809        6.951488   U
ens. mean anal. increment min/max var            2  -7.671415        6.891113   V
ens. mean anal. increment min/max var            3  -4.570885        4.644295   T
ens. mean anal. increment min/max var            4 -0.3538572       0.4068496   Q
ens. mean anal. increment min/max var            5  0.0000000E+00  0.0000000E   PH
```

- Read in namelist
- show key parameters
- Configure analysis variables:

  Var 1, 2, 3, 4, 5

```
Updating U, V, T, QVAPOR, PH,
and MU for WRF-ARW...
```

stdout: final exit information

```
     ENDING DATE-TIME    JUL 09,2017  00:40:39.197  190  SUN   2457944
     PROGRAM ENKF_ANL HAS ENDED.
* . * . * . * . * . * . * . * . * . * . * . * . * . * . * . * . * . * . * . * .
*****************RESOURCE STATISTICS*******************************
The total amount of wall time                        = 8.787587
The total amount of time in user mode                = 6.850958
The total amount of time in sys mode                 = 1.010846
The maximum resident set size (KB)                   = 129268
Number of page faults without I/O activity           = 47820
Number of page faults with I/O activity              = 0
Number of times filesystem performed INPUT           = 0
Number of times filesystem performed OUTPUT          = 0
Number of Voluntary Context Switches                 = 22770
Number of InVoluntary Context Switches               = 376
*****************END OF RESOURCE STATISTICS*************************

 all done!
```

Check Inflation and observation fits

Details in User's Guide Section 4.2

stdout: innovation statistics for prior

```
conventional obs
 region, obtype, nobs, bias, innov stdev, sqrt(S+R), sqrt(S), sqrt(R):
NH    all ps  14083 -0.591E-02  0.860E+00  0.814E+00  0.601E+00  0.550E+00
TR    all ps     50 -0.629E-01  0.422E+00  0.661E+00  0.367E+00  0.550E+00
NH     all t   7766 -0.228E+00  0.163E+01  0.128E+01  0.480E+00  0.119E+01
TR     all t    138 -0.130E+00  0.118E+01  0.119E+01  0.234E+00  0.117E+01
NH    all uv  21680  0.136E-01  0.295E+01  0.276E+01  0.140E+01  0.237E+01
TR    all uv    302 -0.379E+00  0.251E+01  0.268E+01  0.124E+01  0.238E+01
NH     all q   2553 -0.323E-01  0.146E+00  0.157E+00  0.868E-01  0.131E+00
TR     all q     68 -0.721E-01  0.202E+00  0.164E+00  0.582E-01  0.154E+00
NH   all gps   1232 -0.262E-04  0.879E+00  0.117E+01  0.683E+00  0.950E+00
 satellite brightness temp
 instrument, channel #, nobs, bias, innov stdev, sqrt(S+R), sqrt(S), sqrt(R):
          amsua_n15   1   206  0.175E+00  0.198E+01  0.314E+01  0.916E+00  0.300E+01
          amsua_n15   2   207 -0.128E+00  0.149E+01  0.223E+01  0.334E+00  0.220E+01
          amsua_n15   3   207 -0.184E+00  0.134E+01  0.201E+01  0.223E+00  0.200E+01
          amsua_n15   4   207 -0.245E+00  0.408E+00  0.609E+00  0.106E+00  0.600E+00
          amsua_n15   5   207 -0.718E-01  0.280E+00  0.316E+00  0.991E-01  0.300E+00
          amsua_n15   7  1057 -0.323E+00  0.378E+00  0.254E+00  0.453E-01  0.250E+00
          amsua_n15   8  1033 -0.358E+00  0.439E+00  0.283E+00  0.650E-01  0.275E+00
          amsua_n15   9  1064  0.301E-01  0.269E+00  0.345E+00  0.606E-01  0.340E+00
          amsua_n15  10  1055  0.424E+00  0.512E+00  0.402E+00  0.415E-01  0.400E+00
          amsua_n15  15   204 -0.104E+01  0.184E+01  0.359E+01  0.818E+00  0.350E+01
                          ......
        mhs_metop-a   4    94 -0.574E+00  0.106E+01  0.253E+01  0.155E+01  0.200E+01
        mhs_metop-a   5    94 -0.127E+00  0.102E+01  0.308E+01  0.234E+01  0.200E+01
```

Most important statistics of ensemble and observations.

Content of the table

```
conventional obs
 region, obtype, nobs, bias, innov stdev, sqrt(S+R), sqrt(S), sqrt(R):
NH    all ps  14083 -0.591E-02  0.860E+00  0.814E+00  0.601E+00  0.550E+00
TR    all ps     50 -0.629E-01  0.422E+00  0.661E+00  0.367E+00  0.550E+00
NH     all t   7766 -0.228E+00  0.163E+01  0.128E+01  0.480E+00  0.119E+01
TR     all t    138 -0.130E+00  0.118E+01  0.119E+01  0.234E+00  0.117E+01
NH    all uv  21680  0.136E-01  0.295E+01  0.276E+01  0.140E+01  0.237E+01
TR    all uv    302 -0.379E+00  0.251E+01  0.268E+01  0.124E+01  0.238E+01
NH     all q   2553 -0.323E-01  0.146E+00  0.157E+00  0.868E-01  0.131E+00
TR     all q     68 -0.721E-01  0.202E+00  0.164E+00  0.582E-01  0.154E+00
NH   all gps   1232 -0.262E-04  0.879E+00  0.117E+01  0.683E+00  0.950E+00
 satellite brightness temp
 instrument, channel #, nobs, bias, innov stdev, sqrt(S+R), sqrt(S), sqrt(R):
          amsua_n15   1   206  0.175E+00  0.198E+01  0.314E+01  0.916E+00  0.300E+01
          amsua_n15   2   207 -0.128E+00  0.149E+01  0.223E+01  0.334E+00  0.220E+01
```

Meanings of each column:

- region : NH=north hemisphere; TR=tropic
- obtype : ps, t, uv, q, radiance channel, …
- nobs : number observations
- bias : bias of innovation
- innov stdev: standard deviation of innovations
- sqrt(S+R) : total spread
- sqrt(S) : S=spread of ensemble
- sqrt(R) : R=observation error variance

Check ensemble prior spread

```
conventional obs
 region, obtype, nobs, bias, innov stdev, sqrt(S+R), sqrt(S), sqrt(R):
NH     all ps  14083 -0.591E-02  0.860E+00  0.814E+00  0.601E+00  0.550E+00
TR     all ps     50 -0.629E-01  0.422E+00  0.661E+00  0.367E+00  0.550E+00
NH      all t   7766 -0.228E+00  0.163E+01  0.128E+01  0.480E+00  0.119E+01
TR      all t    138 -0.130E+00  0.118E+01  0.119E+01  0.234E+00  0.117E+01
NH     all uv  21680  0.136E-01  0.295E+01  0.276E+01  0.140E+01  0.237E+01
TR     all uv    302 -0.379E+00  0.251E+01  0.268E+01  0.124E+01  0.238E+01
NH      all q   2553 -0.323E-01  0.146E+00  0.157E+00  0.868E-01  0.131E+00
TR      all q     68 -0.721E-01  0.202E+00  0.164E+00  0.582E-01  0.154E+00
NH    all gps   1232 -0.262E-04  0.879E+00  0.117E+01  0.683E+00  0.950E+00
 satellite brightness temp
```

The ensemble spread should be satisfy the following relation (Houtekamer, et al., 2005), as close as possible:

$$\left\langle (\mathbf{y}^o - \mathbf{H}\bar{\mathbf{X}}^b)(\mathbf{y}^o - \mathbf{H}\bar{\mathbf{X}}^b) \right\rangle = (\mathbf{H}\mathbf{P}^b\mathbf{H}^T + \mathbf{R})$$

The RMS of observation innovation (ensemble priors against observations)

The total ensemble spreads = ensemble spreads + observational error covariance

```
512E+0                                                                  0
184E+0                                                                  1
106E+0                                                                  1
   mhs_metop-a    5     94 -0.127E+00  0.102E+01  0.308E+01  0.234E+01  0.200E+01
```

Check ensemble prior spread

```
conventional obs
 region, obtype, nobs, bias, innov stdev, sqrt(S+R), sqrt(S), sqrt(R):
NH     all ps   14083 -0.591E-02  0.860E+00  0.814E+00  0.601E+00  0.550E+00
TR     all ps      50 -0.629E-01  0.422E+00  0.661E+00  0.367E+00  0.550E+00
NH      all t    7766 -0.228E+00  0.163E+01  0.128E+01  0.480E+00  0.119E+01
TR      all t     138 -0.130E+00  0.118E+01  0.119E+01  0.234E+00  0.117E+01
NH     all uv   21680  0.136E-01  0.295E+01  0.276E+01  0.140E+01  0.237E+01
TR     all uv     302 -0.379E+00  0.251E+01  0.268E+01  0.124E+01  0.238E+01
NH      all q    2553 -0.323E-01  0.146E+00  0.157E+00  0.868E-01  0.131E+00
TR      all q      68 -0.721E-01  0.202E+00  0.164E+00  0.582E-01  0.154E+00
NH    all gps    1232 -0.262E-04  0.879E+00  0.117E+01  0.683E+00  0.950E+00
 satellite brightness temp
```

The ensemble spread should be satisfy the following relation (Houtekamer, et al., 2005), as close as possible:

$$\left\langle (\mathbf{y}^o - \mathbf{H}\bar{\mathbf{X}}^b)(\mathbf{y}^o - \mathbf{H}\bar{\mathbf{X}}^b) \right\rangle = (\mathbf{H}\mathbf{P}^b\mathbf{H}^T + \mathbf{R})$$

The RMS of observation innovation (ensemble priors against observations)

The total ensemble spreads = ensemble spreads + observational error covariance

```
512E+0                                                                  0
184E+0                                                                  1
106E+0                                                                  1
mhs_metop-a    5     94 -0.127E+00  0.102E+01  0.308E+01  0.234E+01  0.200E+01
```

Check fit of analysis to observations

```
innovation statistics for prior:
conventional obs
 region, obtype, nobs, bias, innov stdev, sqrt(S+R), sqrt(S), sqrt(R):
NH     all ps  14083 -0.591E-02  0.860E+00  0.814E+00  0.601E+00  0.550E+00
TR     all ps     50 -0.629E-01  0.422E+00  0.661E+00  0.367E+00  0.550E+00
NH      all t   7766 -0.228E+00  0.163E+01  0.128E+01  0.480E+00  0.119E+01
TR      all t    138 -0.130E+00  0.118E+01  0.119E+01  0.234E+00  0.117E+01
```

O-B versus O-A:
Bias and standard deviation reduced after analysis

```
 innovation statistics for posterior:
 conventional obs
 region, obtype, nobs, bias, innov stdev, sqrt(S+R), sqrt(S), sqrt(R):
NH     all ps  14083  0.298E-02  0.757E+00  0.569E+00  0.145E+00  0.550E+00
TR     all ps     50 -0.535E-01  0.399E+00  0.584E+00  0.195E+00  0.550E+00
NH      all t   7766 -0.828E-01  0.145E+01  0.122E+01  0.261E+00  0.119E+01
TR      all t    138 -0.107E+00  0.115E+01  0.118E+01  0.199E+00  0.117E+01
```

Tuning EnKF through Namelist

Details in User's Guide Section 4.3

Options related to inflation

The inflation can be set up by the following parameters:

anapertwtnh: inflation parameter in NH.
anapertwttr: inflation parameter in TR.
anapertwtsh: inflation parameter in SH.

The parameters = 0 means no inflation.
= 1 means inflation all the way back to prior spread.

The minimum and maximum inflation values allowed can be controlled by the following parameters:

covinflatemin: minimum inflation factor
covinflatemax: maximum inflation factor

Options related to inflation

The inflation factor fields can be smoothed out using the following parameter:

smoothparm: parameter for smoothing inflation factor,
= -1 for no smoothing.
> 0, the estimated inflation factor is smoothed using a Gaussian spectral filter with an e-folding scale of the parameter.

latbound: where the transition latitude starts (=25N or 25S)

delat: latitude width of transition zone where the inflation parameter is smoothed.

Options related to localization

readin_localization: =.true., customized horizontal and vertical localization values varying with model levels are read in from the external text file "*hybens_locinfo*".

= .false., the horizontal and vertical localization distances are set by the namelist parameters

length for horizontal localization in km:

corrlengthnh: northern hemisphere (25N-90N, NH)
corrlengthtr: tropics (25S-25N, TR)
corrlengthsh: southern hemisphere (25S-90S, SH)

scale height for vertical localization in $-\log(P/P_{ref})$:

lnsigcutoffnh: North Hemisphere
lnsigcutofftr: Tropic.
lnsigcutoffsh: South Hemisphere

Options related to localization

The vertical localization distances for satellite radiance :

lnsigcutoffsatnh,
lnsigcutoffsattr,
lnsigcutoffsatsh

The vertical localization distances for surface pressure observations:

lnsigcutoffpsnh,
lnsigcutoffpstr,
lnsigcutoffpssh

The time localization window
(time away from the analyses time in hour)

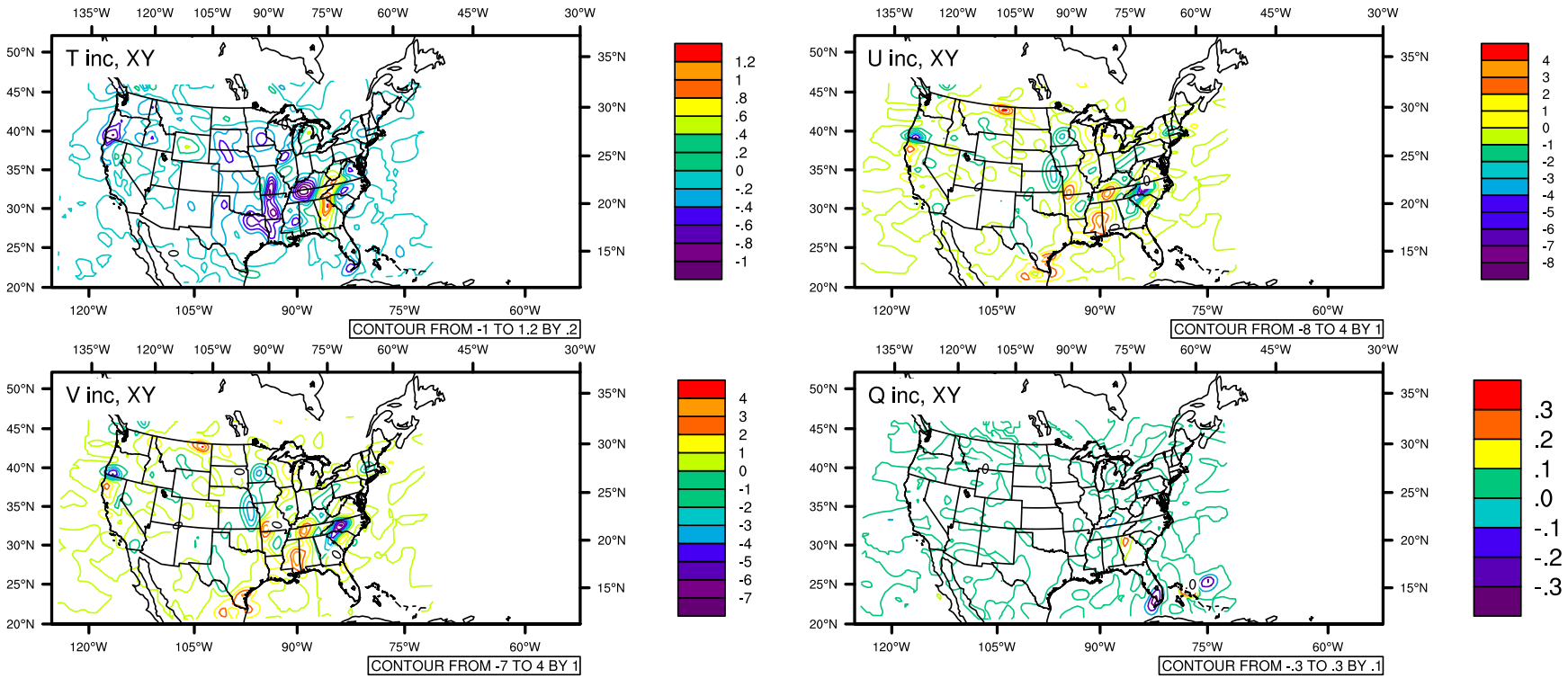
obtimelnh: for the northern hemisphere
obtimeltr: for the tropics
obtimelsh: for the southern hemisphere

Check analysis increment and ensemble spread

Details in EnKF basical practical case

Checking Analysis Increment

- Analysis increment gives an idea where and how much the background fields have been changed by the observations
  - Graphic tool available in GSIv3.4 release: *./util/Analysis_Utilities/plot_ncl/Analysis_increment.ncl*



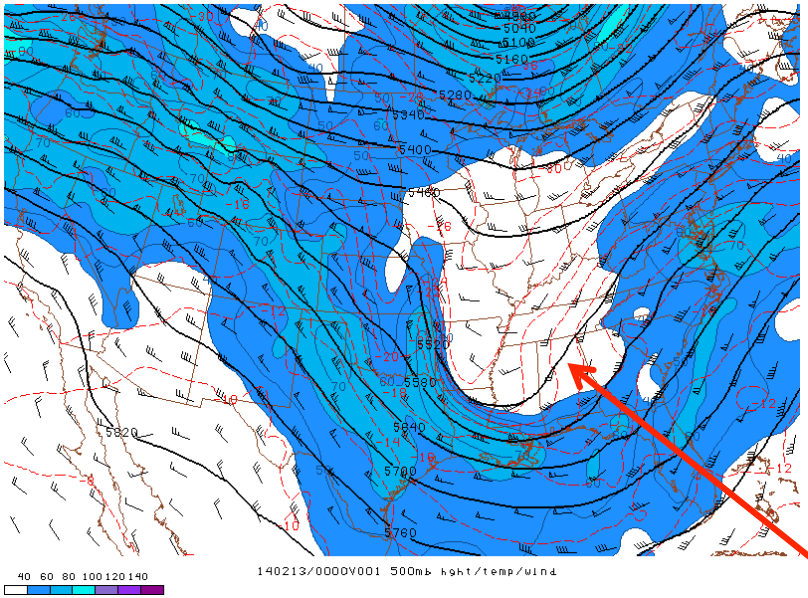
✓ The U.S. CONUS domain has many upper level observations

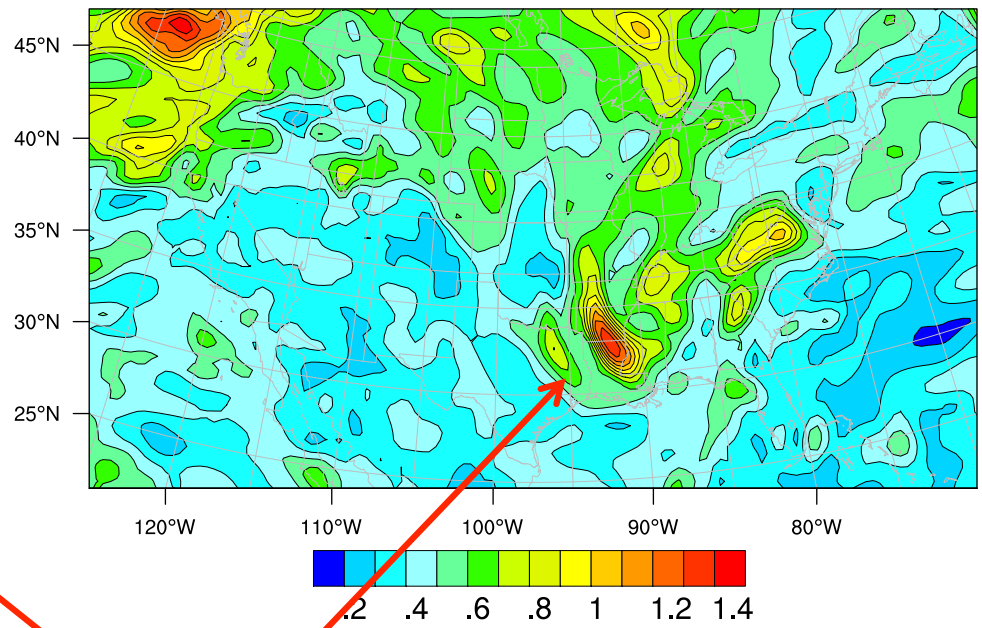
✓ Notice larger increments in area of interest for case

Analysis Increment at the 20th Level: ensemble member 001

Checking Ensemble Spread

- Analysis ensemble spread, T @ level 20:





Summary of EnKF Applications

- Steps to running a successful EnKF Analysis:
  1. Obtain background ensemble
  2. Grab desired observation data

GSI Observer

3. Modify GSI run script to properly link observation data and ensembles
4. Run GSI observer and check run status
5. Check completion (*stdout*), existence of *diag** files for ensemble member/mean

EnKF

6. Modify run script for EnKF
7. Run EnKF and check run status
8. Check completion (*stdout*)
9. Check analysis increment, ensemble spread (*some DTC graphics utilities available*)

Questions?

enkf-help@ucar.edu