WRFDA 2012 Overview

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National Center for Atmospheric Research

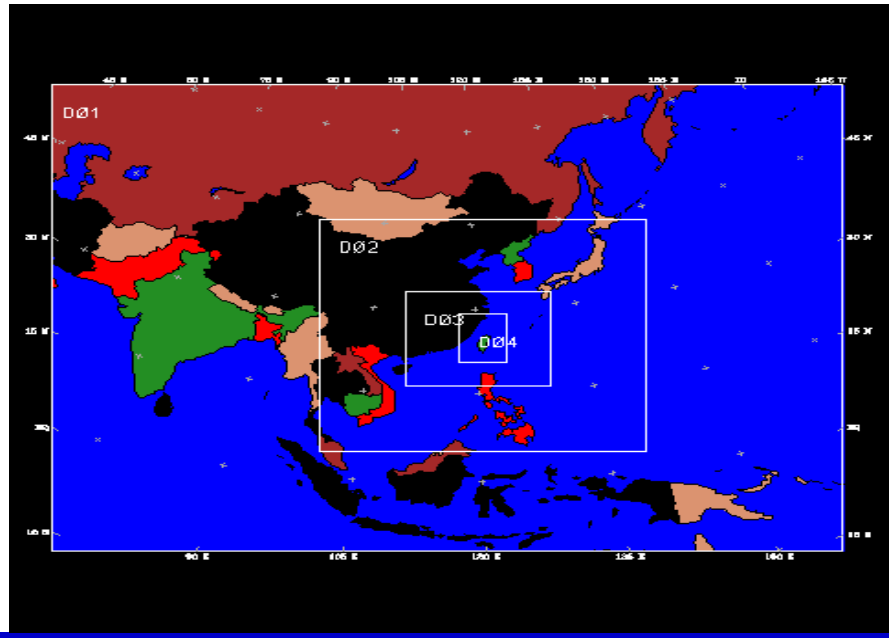
(NCAR is sponsored by the National Science Foundation)

Acknowledge:

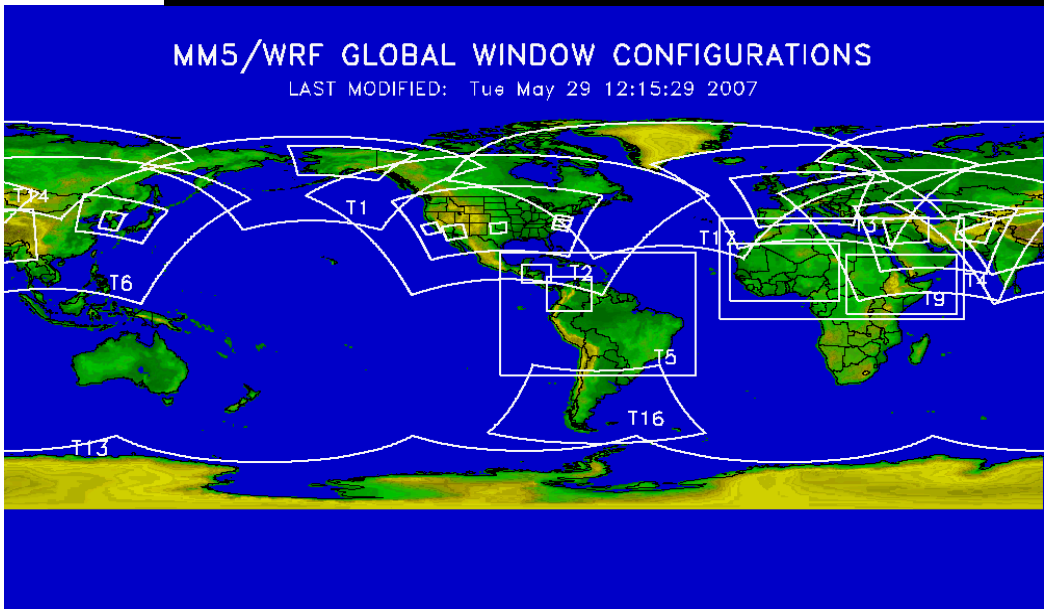
NCAR/NESL/MMM/DAS, NCAR/RAL/JNT/DAT,
AFWA, USWRP, NSF-OPP, NASA, AirDat,
KMA, CWB, CAA, BMB, EUMETSAT,
PSU, NUIST, RSMAS

WRFDA Overview

- **Goal:** Community DA system for
  - regional/global,
  - research/operations, and
  - deterministic/probabilistic applications.



- **Techniques:**
  - 3D-Var
  - 4D-Var (regional)
  - Ensemble DA,
  - Hybrid Var/Ens DA.



FSO - Forecast Sensitivity to Observations

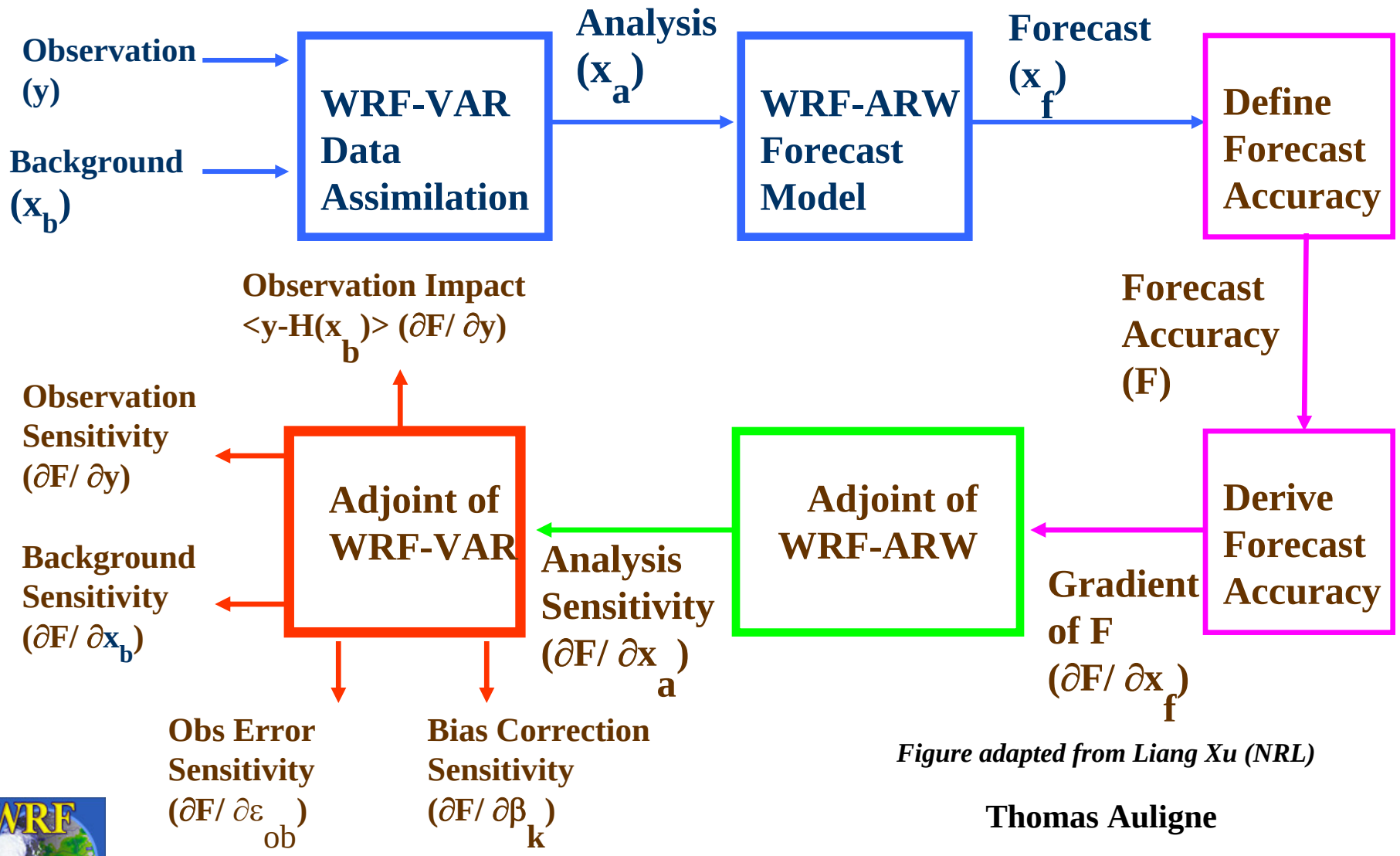
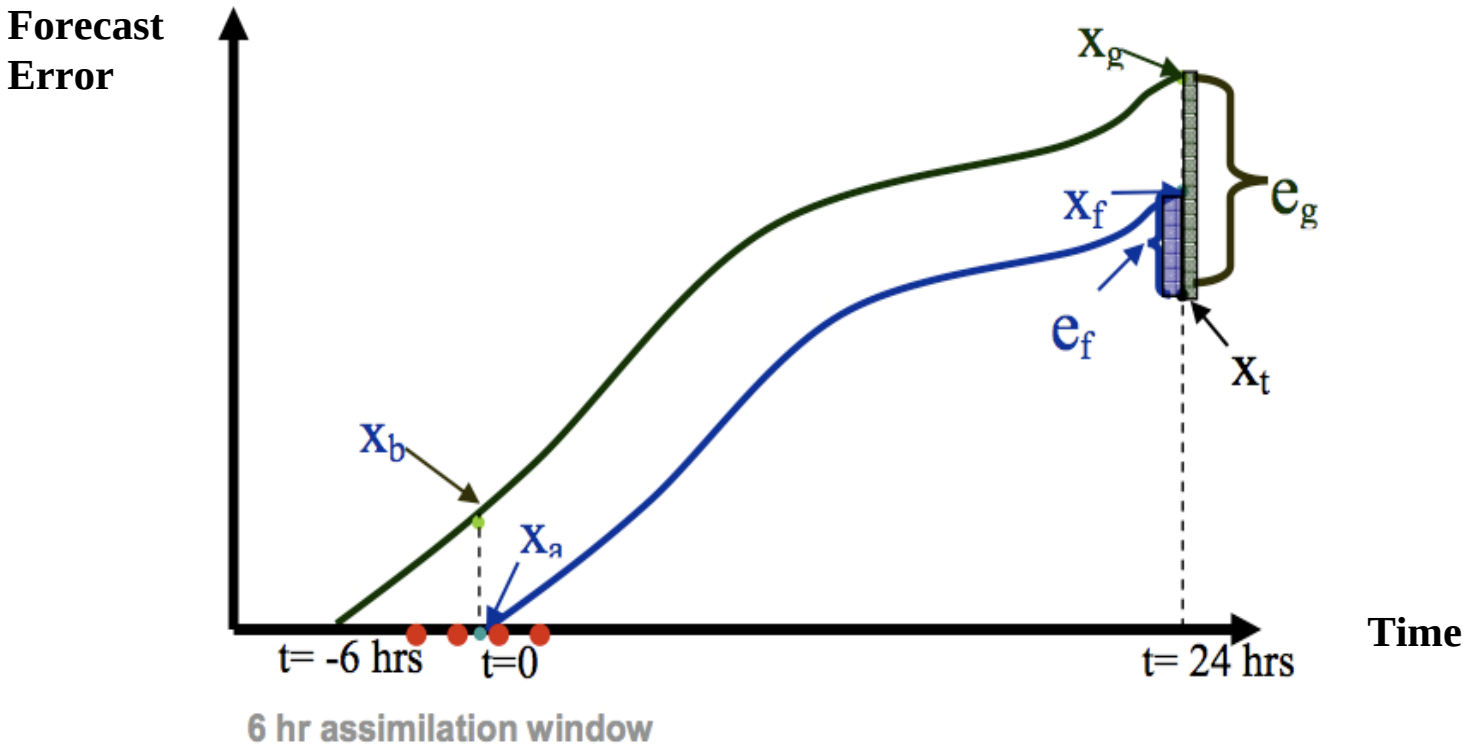


Figure adapted from Liang Xu (NRL)

Thomas Auligne

From Langland and Baker (2004)



x_t is the true state, estimated by the analysis at the time of the forecast
x_f is the forecast from analysis xa
x_g is the forecast from first-guess at the time of the analysis x_a

More details (for WRFDA implementation)
Thomas Auligne

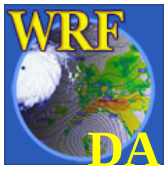
$$\mathbf{K^T = R^{-1} H P^a}$$

Reference state: Namelist ADJ_REF is defined as
1: x_t = Own (WRFDA) analysis
2: x_t = Other (NCEP or ECMWF) analysis
3: x_t = Observations

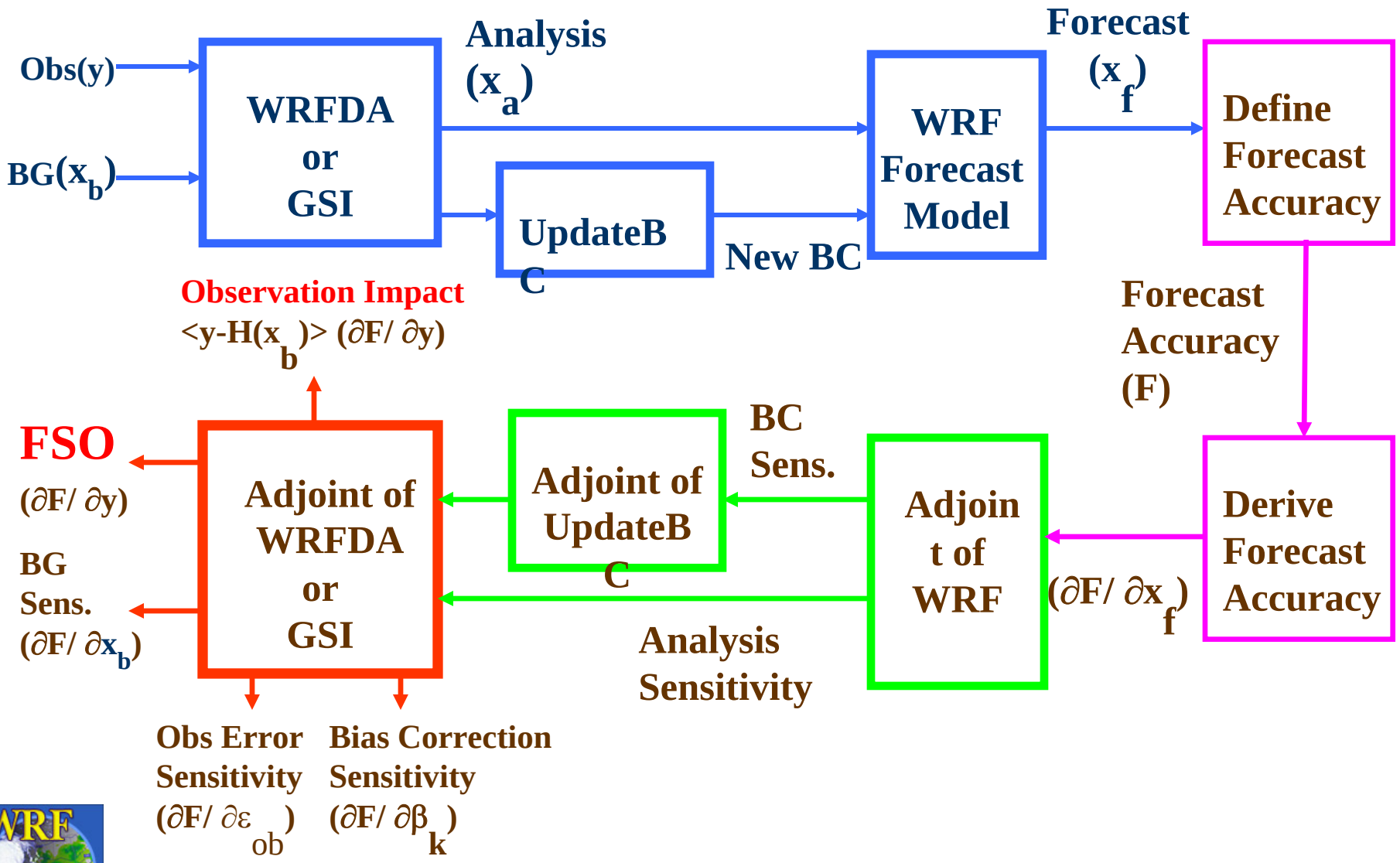
Forecast Aspect: depends on reference state
1 and 2: Total Dry Energy
3: WRFDA Observation Cost Function: Jo

Geo. projection: Script option for box (default = whole domain)

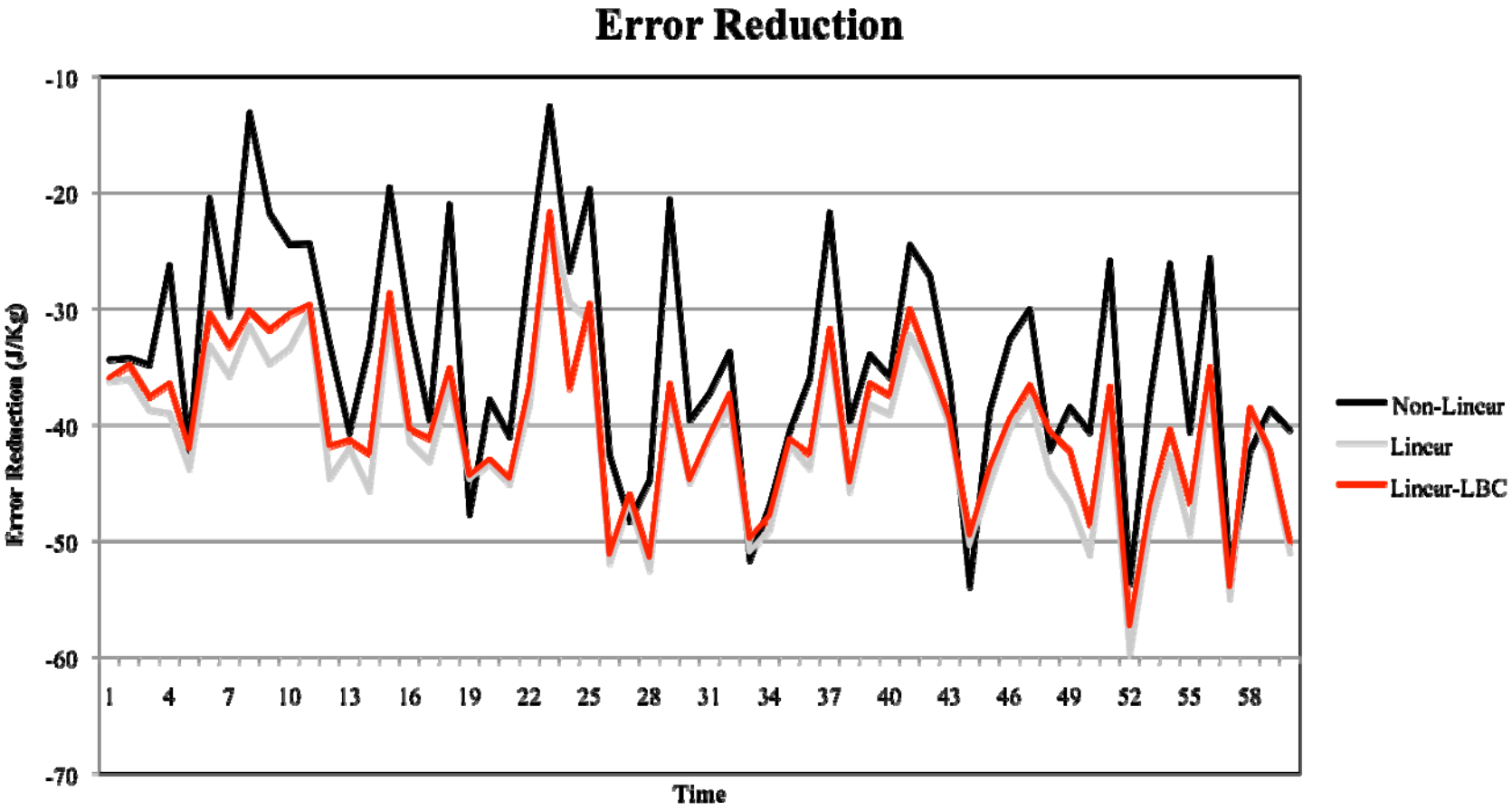
Forecast Accuracy Norm: $e = (x_f - x_t)^T C (x_f - x_t)$



FSO - Forecast Sensitivity to Observations for Regional Systems



12h forecast error estimations (00,12UTC) verified with EC reanalysis



Limitations

- Approximation of “truth”
- Dependence of norm
- Linear assumptions
  - Adjoint of the forecast model
  - Adjoint of the analysis (assimilation)
- …

WRFDA tutorials

21-22 July, 2008. NCAR.

2-4 Feb, 2009. NCAR.

18 April, 2009. South Korea.

20-22 July, 2009. NCAR.

15-31 Oct, 2009. Nanjing, China.

1-3 Feb, 2010. NCAR.

10 April, 2010. Seoul, South Korea.

3-5 August 2010. NCAR.

16 April. Busan, South Korea

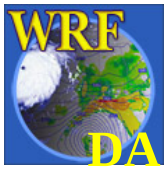
20-22 July 2011. NCAR

10-20 October. Bangkok, Thailand.

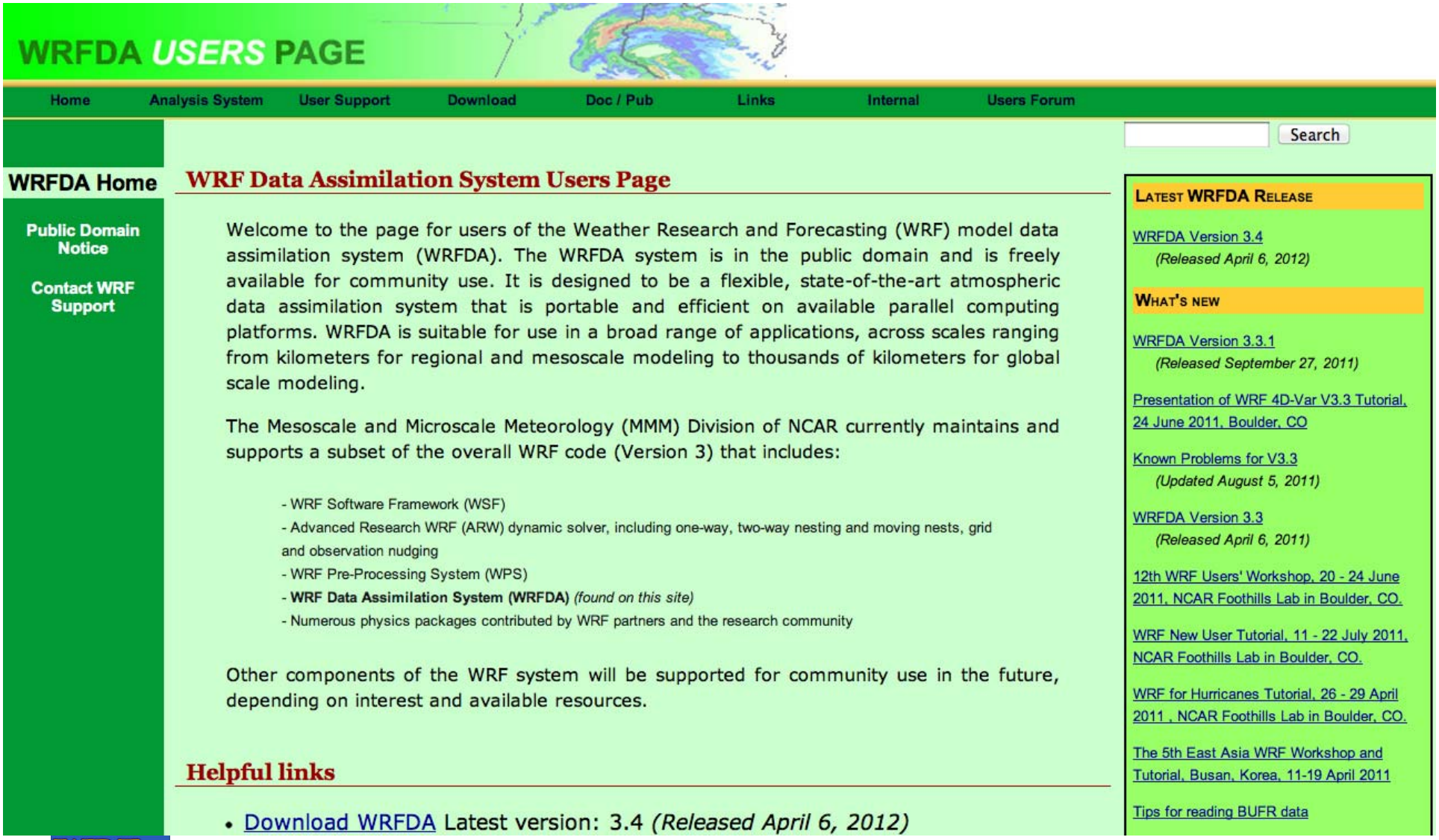
21 April 2012. Seoul, South Korea.

At recent NCAR tutorials, we have a lecture and a practice session on FSO

The next: 23-25 July 2012. NCAR.



www.mmm.ucar.edu/wrf/users/wrfda



New features, v3.4, 6 April 2012

- WRFPLUS3 (WRF TL/AD) updated/parallelized/optimized.
- 4D-VAR redesigned/upgraded/parallelized/mulit-incremental.
- Precipitation assimilation capability added.
- The fully multivariate background error option, cv6, updated.
- Hybrid Var/Ens updated/documented.
- Capability to generate forecast sensitivity to observations (FSO) updated/parallelized.
- NOAA-19 AMSUA and MHS added/tested.

WRF FSO applications

- AFWA data assimilation testbed (at NCAR, both WRFDA and GSI)
- Arctic System Reanalysis project (conv and rad)
- Nanjing Univ of Info Sci Tech, Hubei Met Bureau, Yonsei Univ, Seoul Natl Univ, …
- AFWA operational system (at AFWA)
- AIRDAT pre-operational system (TAMDAR)
- Taiwan Central Weather Bureau operational system.

Monitoring observation impact with Taiwan Central Weather Bureau opearational analysis/forecast system

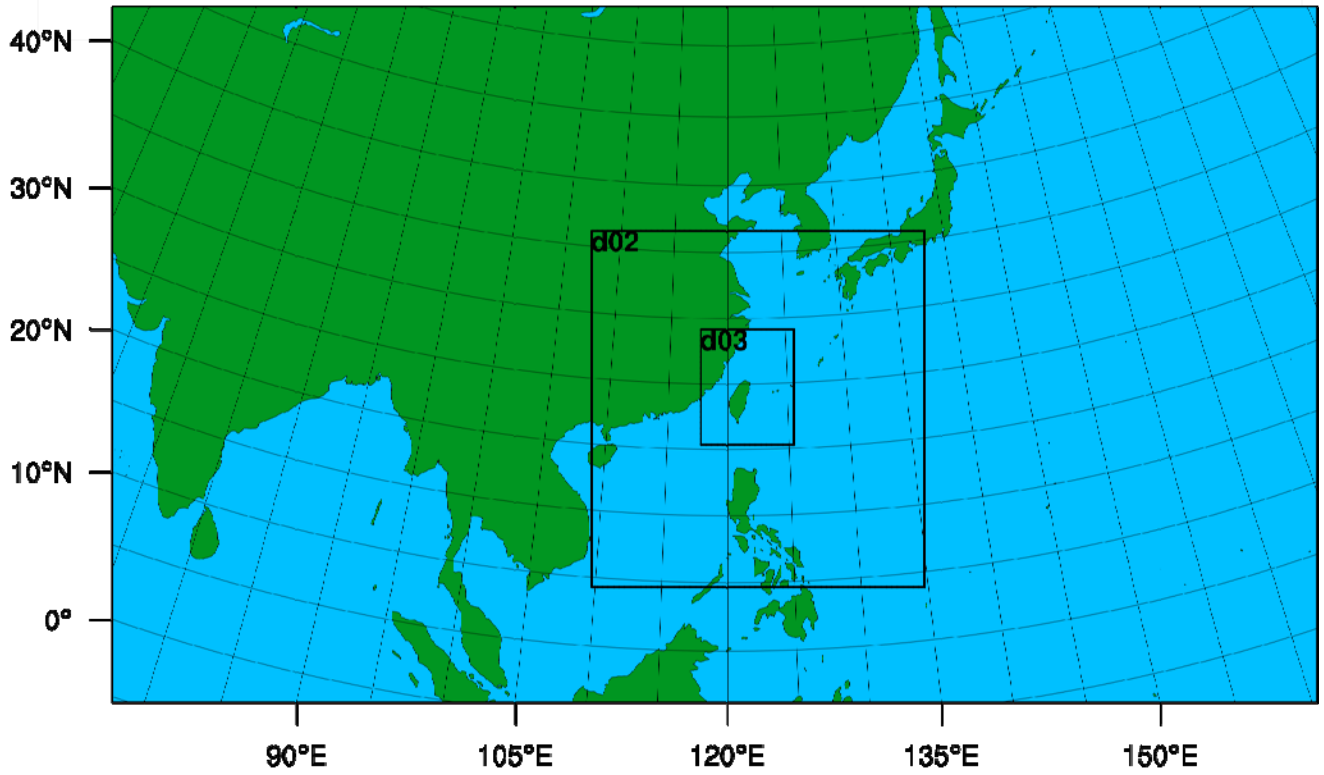
Xin Zhang annd Hans Huang

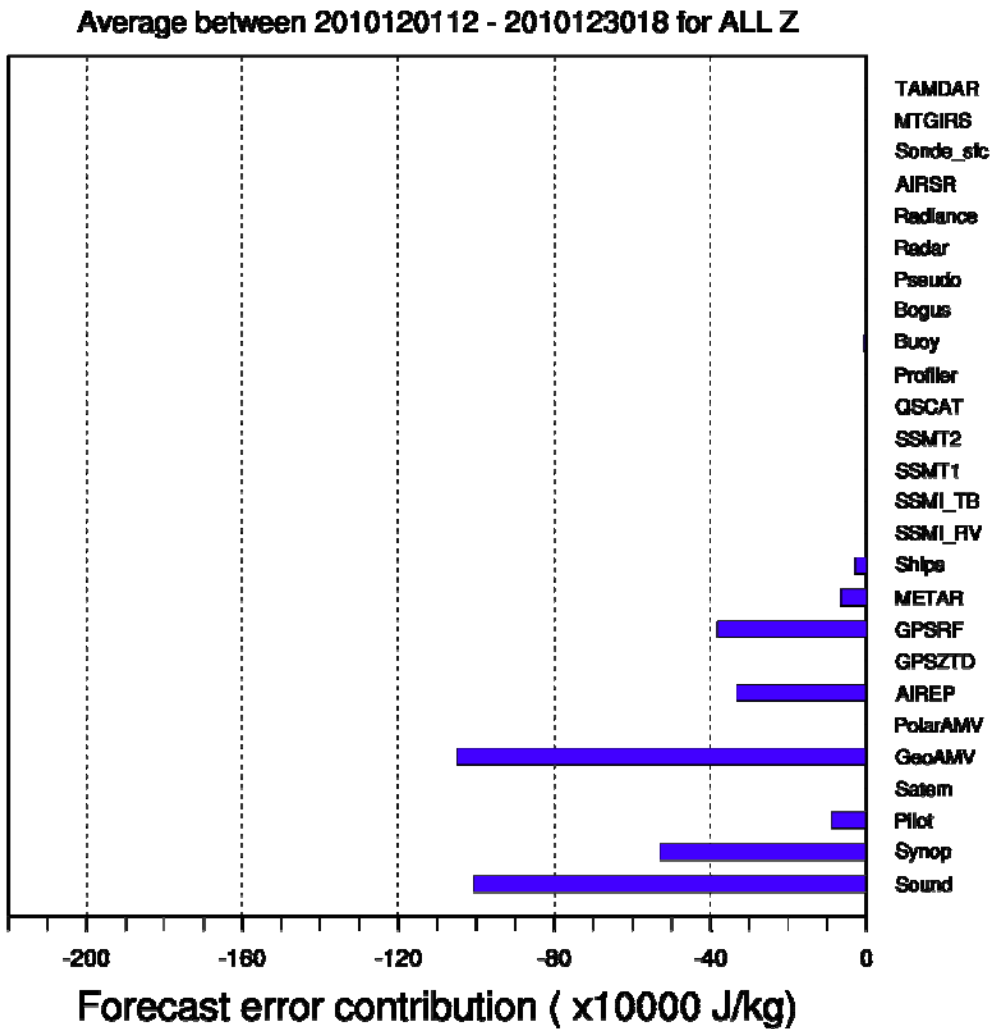
National Center for Atmospheric Research

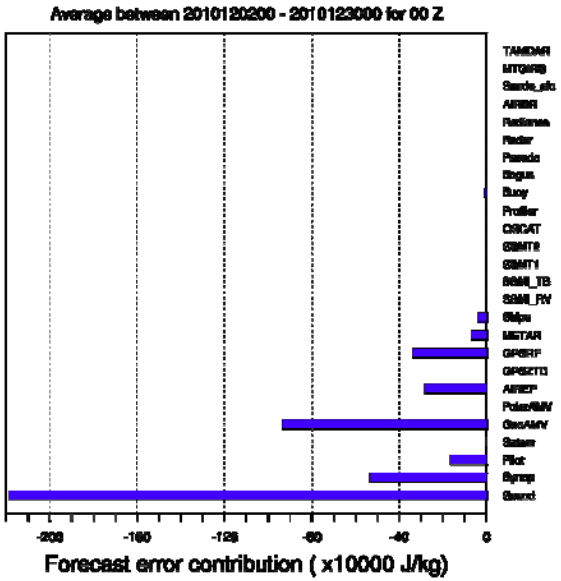
(NCAR is sponsored by the National Science Foundation)

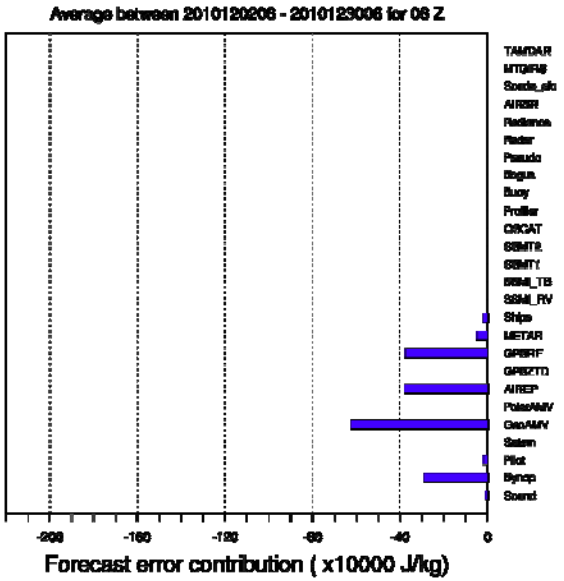
Monitoring observation impact with Taiwan Central Weather Bureau opearational analysis/forecast system

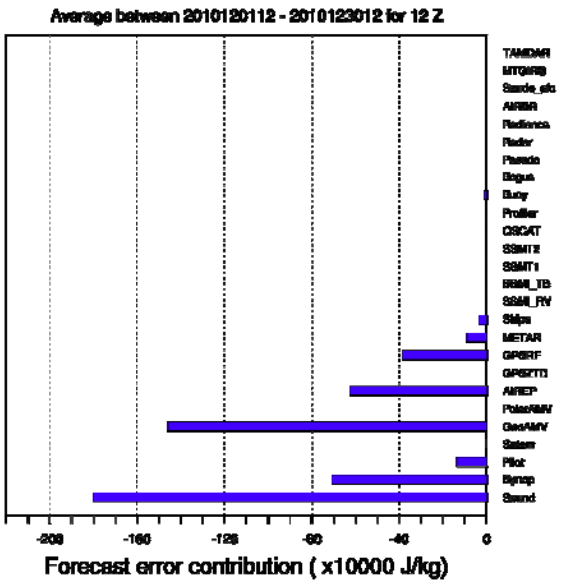
Xin Zhang and Xiang-Yu Huang

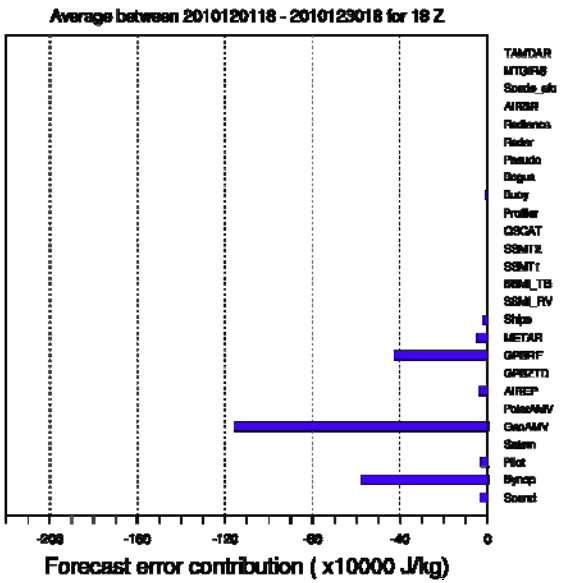



Average between 2010120112 - 2010123018 for ALL Z
TAMDAR
MTGIRS
Sonde_sfc
AIRSR
Radiance
Radar
Pseudo
Bogus
Buoy
Profiler
QSCAT
SSMT2
SSMT1
SSMI_TB
SSMI_RV
Ships
METAR
GPSRF
GPSZTD
AIREP
PolarAMV
GeoAMV
Satem
Pilot
Synop
Sound
-200
-160
-120
-80
-40
0
Forecast error contribution (x10000 J/kg)

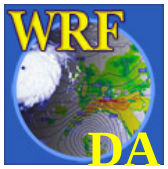

Average between 2010120200 - 2010123000 for 00 Z
TAMDAR
MTGIRS
Sonde_sfc
AIRSR
Radiance
Radar
Pseudo
Bogus
Buoy
Profiler
QSCAT
SSMT2
SSMT1
SSMI_TB
SSMI_RV
Ships
METAR
GPSRF
GPSZTD
AIREP
PolarAMV
GeoAMV
Satem
Pilot
Synop
Sound
-200
-160
-120
-80
-40
0
Forecast error contribution (x10000 J/kg)

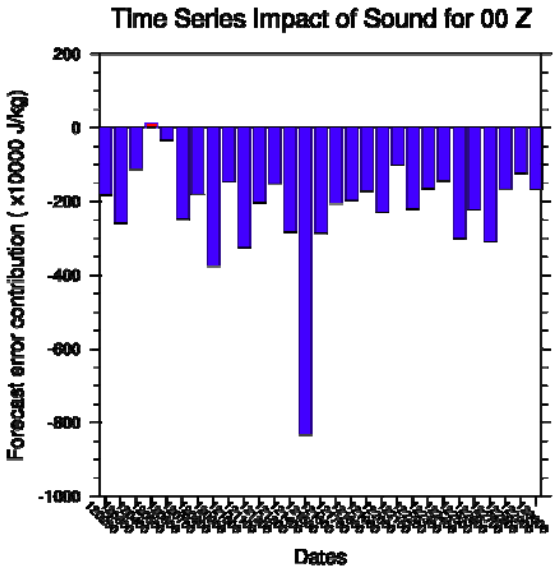

Average between 2010120206 - 2010123006 for 06 Z
TAMDAR
MTGIRS
Sonde_sfc
AIRSR
Radiance
Radar
Pseudo
Bogus
Buoy
Profiler
QSCAT
SSMT2
SSMT1
SSMI_TB
SSMI_RV
Ships
METAR
GPSRF
GPSZTD
AIREP
PolarAMV
GeoAMV
Satem
Pilot
Synop
Sound
-200
-160
-120
-80
-40
0
Forecast error contribution (x10000 J/kg)

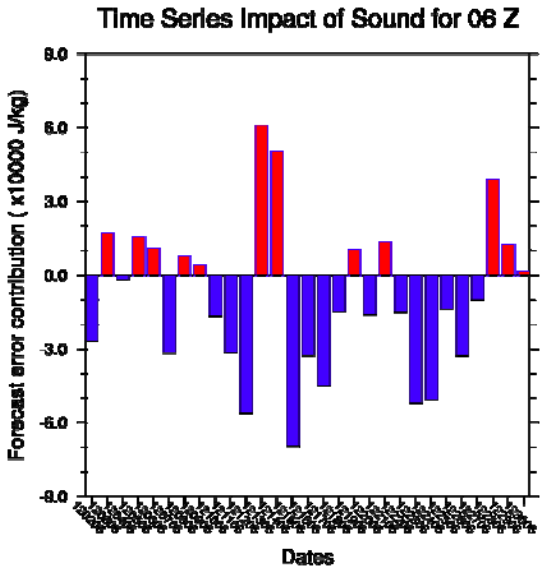

Average between 2010120112 - 2010123012 for 12 Z
TAMDAR
MTGIRS
Sonde_sfc
AIRSR
Radiance
Radar
Pseudo
Bogus
Buoy
Profiler
QSCAT
SSMT2
SSMT1
SSMI_TB
SSMI_RV
Ships
METAR
GPSRF
GPSZTD
AIREP
PolarAMV
GeoAMV
Satem
Pilot
Synop
Sound
-200
-160
-120
-80
-40
0
Forecast error contribution (x10000 J/kg)

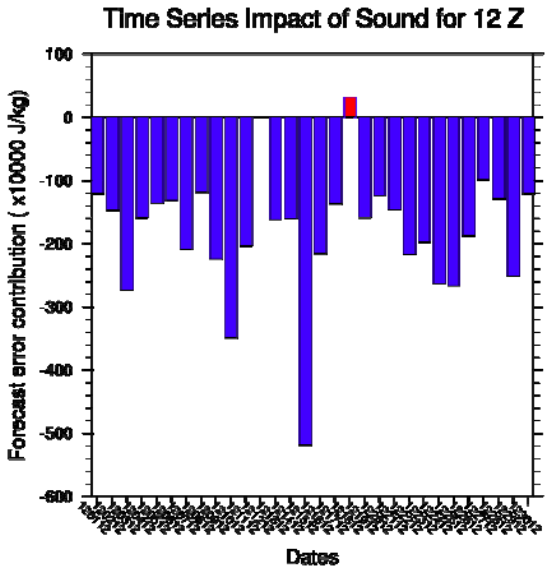

Average between 2010120118 - 2010123018 for 18 Z
TAMDAR
MTGIRS
Sonde_sfc
AIRSR
Radiance
Radar
Pseudo
Bogus
Buoy
Profiler
QSCAT
SSMT2
SSMT1
SSMI_TB
SSMI_RV
Ships
METAR
GPSRF
GPSZTD
AIREP
PolarAMV
GeoAMV
Satem
Pilot
Synop
Sound
-200
-160
-120
-80
-40
0
Forecast error contribution (x10000 J/kg)

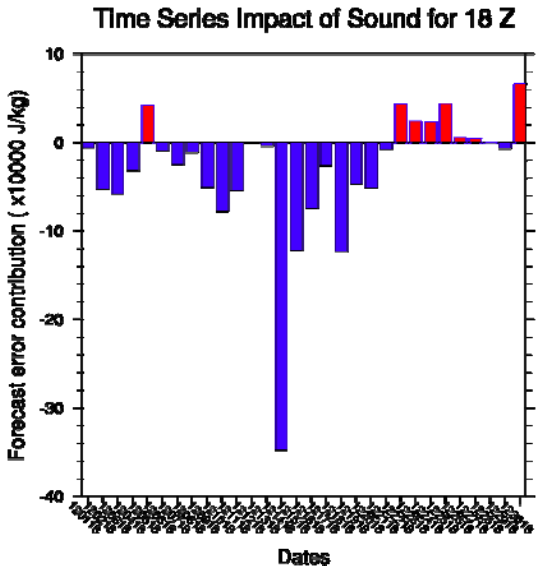
- In terms of the observational type
  - The largest error decrease is due to GeoAMV followed by SOUND, SYNOP and GPSREF
  - The impact from SATEM is marginal and neutral.
  - On 0000UTC and 1200UTC, the SOUND is the most important observation to decrease the forecast error, followed by GeoAMV, SYNOP, GPSREF/AIREP
  - on 0600UTC and 1800UTC, the GeoAMV is the most important observation to decrease the forecast error, followed by SYNOP/GPSREF, AIREP

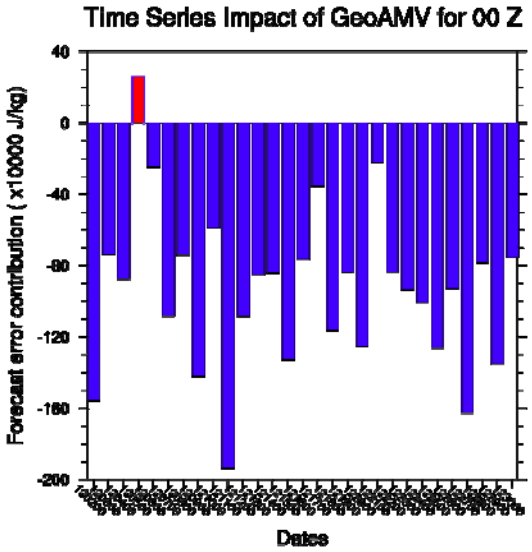


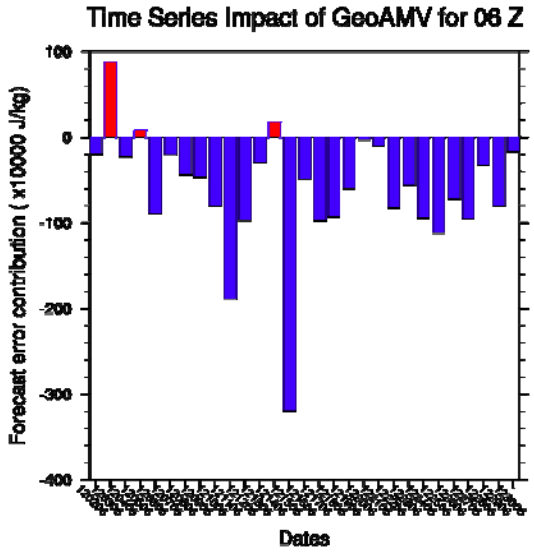

Time Series Impact of Sound for 00 Z
Forecast error contribution (x10000 J/kg)
200
0
-200
-400
-600
-800
-1000
Dates

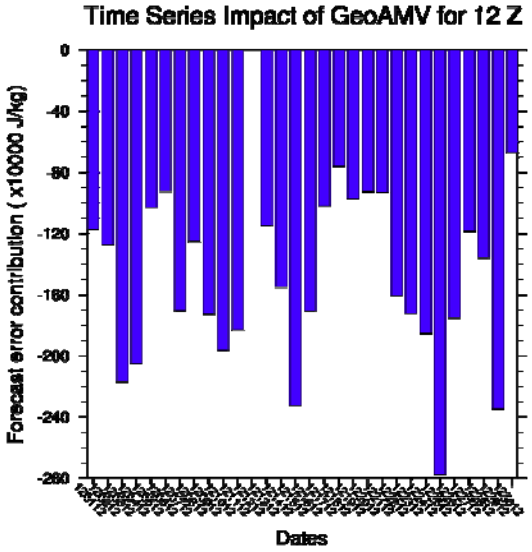

Time Series Impact of Sound for 06 Z
Forecast error contribution (x10000 J/kg)
9.0
6.0
3.0
0.0
-3.0
-6.0
-9.0
Dates

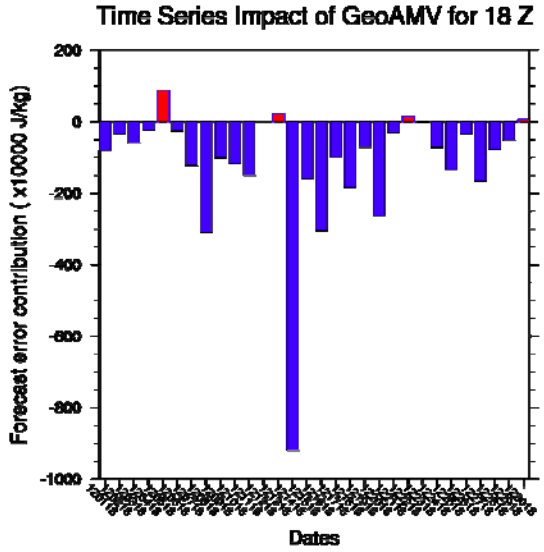

Time Series Impact of Sound for 12 Z
Forecast error contribution (x10000 J/kg)
100
0
-100
-200
-300
-400
-500
-600
Dates

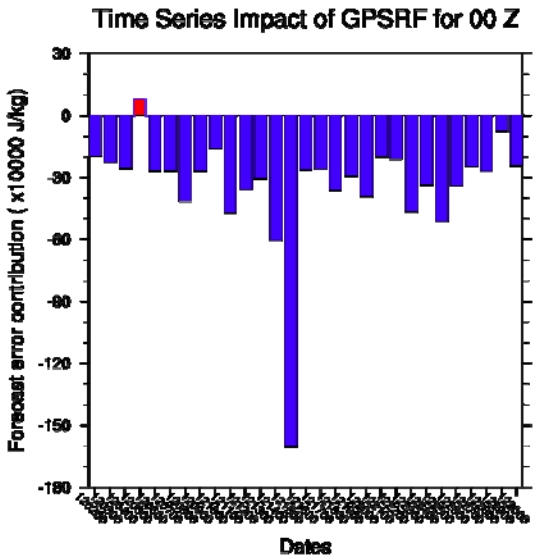

Time Series Impact of Sound for 18 Z
Forecast error contribution (x10000 J/kg)
10
0
-10
-20
-30
-40
Dates

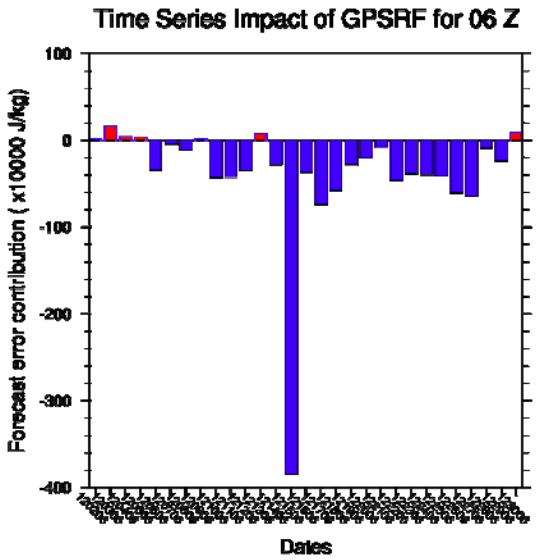

Time Series Impact of GeoAMV for 00 Z
Forecast error contribution (x10000 J/kg)
40
0
-40
-80
-120
-160
-200
Dates

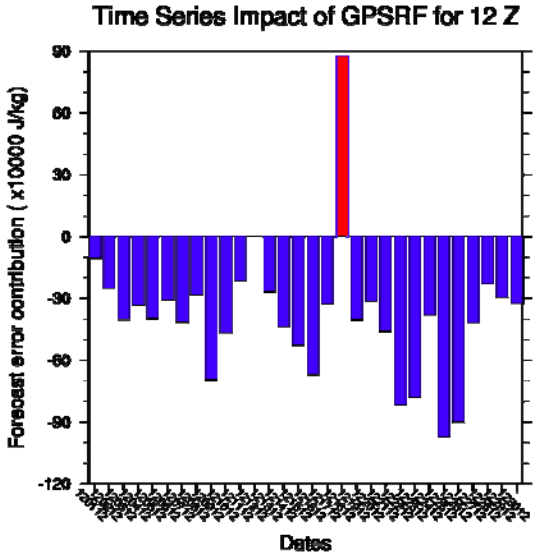

Time Series Impact of GeoAMV for 06 Z
Forecast error contribution (x10000 J/kg)
100
0
-100
-200
-300
-400
Dates

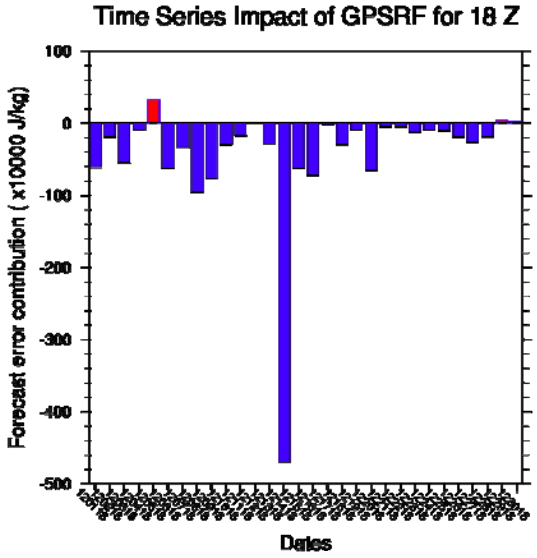

Time Series Impact of GeoAMV for 12 Z
Forecast error contribution (x10000 J/kg)
0
-40
-80
-120
-160
-200
-240
-280
Dates

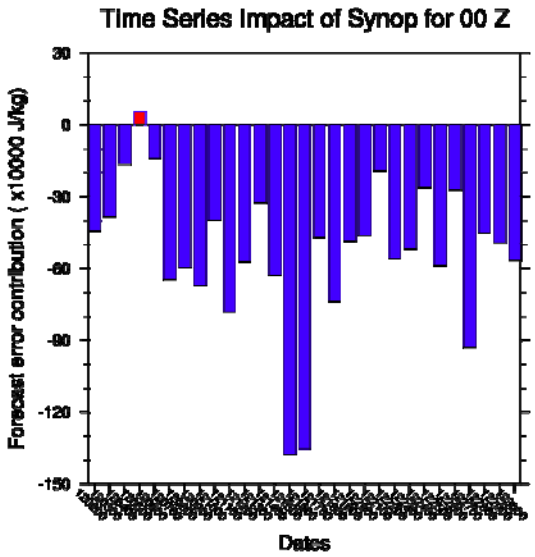

Time Series Impact of GeoAMV for 18 Z
Forecast error contribution (x10000 J/kg)
200
0
-200
-400
-600
-800
-1000
Dates

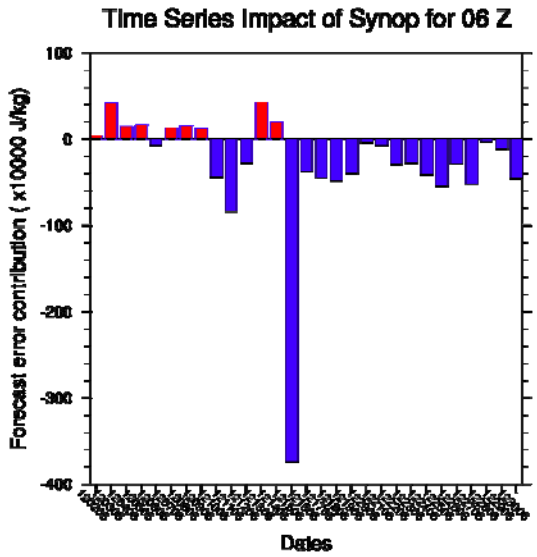

Time Series Impact of GPSRF for 00 Z
Forecast error contribution (x10000 J/kg)
30
0
-30
-60
-90
-120
-150
-180
Dates

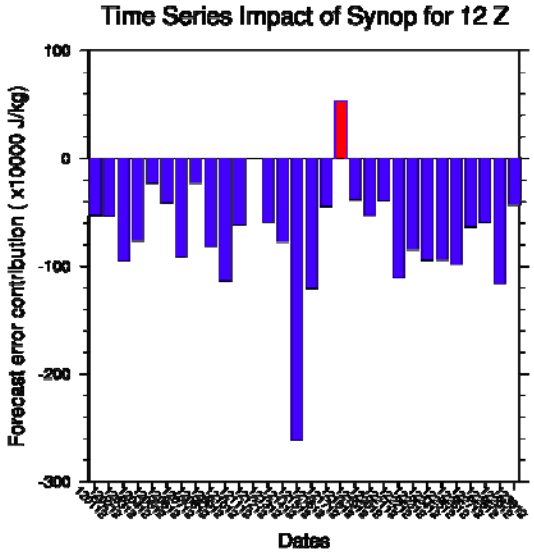

Time Series Impact of GPSRF for 06 Z
Forecast error contribution (x10000 J/kg)
100
0
-100
-200
-300
-400
Dates

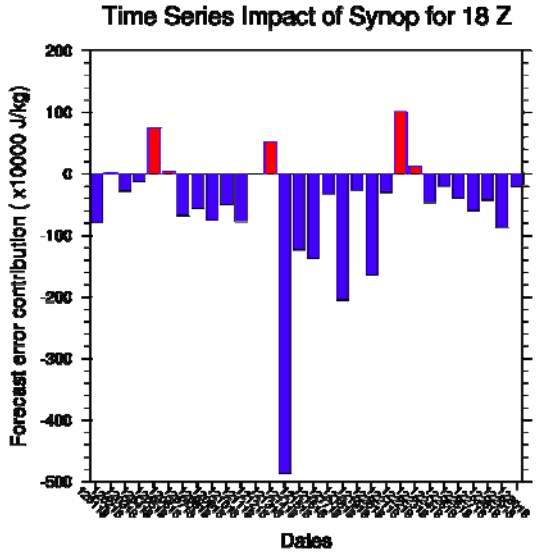

Time Series Impact of GPSRF for 12 Z
Forecast error contribution (x10000 J/kg)
90
60
30
0
-30
-60
-90
-120
Dates


Time Series Impact of GPSRF for 18 Z
Forecast error contribution (x10000 J/kg)
100
0
-100
-200
-300
-400
-500
Dates

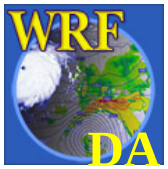

Time Series Impact of Synop for 00 Z
Forecast error contribution (x100000 J/kg)
30
0
-30
-60
-90
-120
-150
Dates

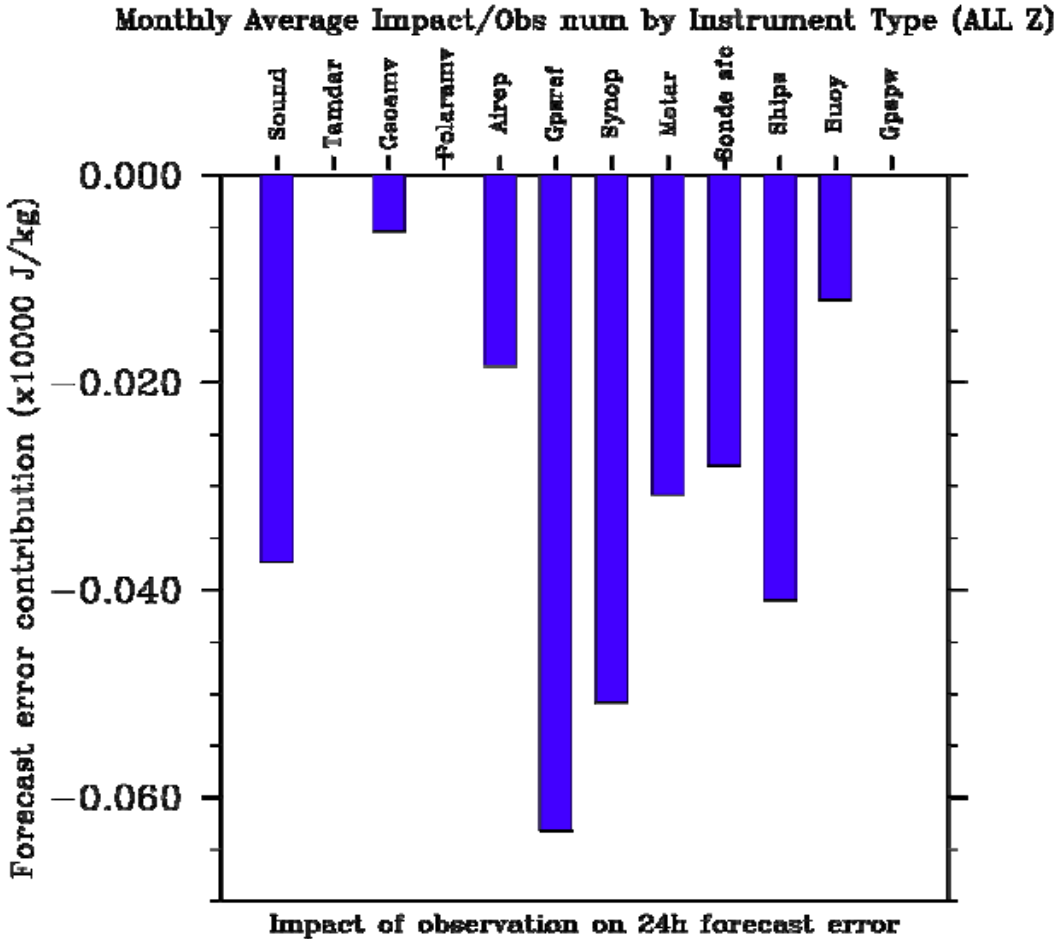

Time Series Impact of Synop for 06 Z
Forecast error contribution (x100000 J/kg)
100
0
-100
-200
-300
-400
Dates


Time Series Impact of Synop for 12 Z
Forecast error contribution (x100000 J/kg)
100
0
-100
-200
-300
Dates


Time Series Impact of Synop for 18 Z
Forecast error contribution (x100000 J/kg)
200
100
0
-100
-200
-300
-400
-500
Dates

- In terms of the time series of impact of observational type
  - On 0000 and 1200UTC, the SOUND improve the forecasts in general.
  - On 0600UTC and 1800UTC, the SOUND almost degrades the 1/3 of the forecasts. Still trying to understand these results.
  - For other observation types, at 0600UTC and 1800UTC, there are many degraded cases due to observations. Need further investigation.




Monthly Average Impact/Obs num by Instrument Type (ALL Z)
Sound
Tamdar
Geoamv
Polaramv
Airep
Gpsref
Synop
Metar
Sonde_sfc
Ships
Buoy
Gpspw
0.000
−0.020
−0.040
−0.060
Forecast error contribution (x10000 J/kg)
Impact of observation on 24h forecast error

- In terms of impact per observation for each type
  - The GPSREF is the most efficient observation to reduce the 24h forecast error per observation, followed by SYNOP, SHIPS and SOUND. It is consistent with the result from AFWA domains (personal communication with Jason T. Martinelli of AFWA)

Ongoing research activities

- Identify observations with continuous negative impact.
- Tune WRFDA based on observation impact results.
- Improve the assimilation strategy of surface observation assimilation.
- Investigate the differences of verifying forecasts to EC analysis, NCEP GFS analysis, WRFDA analysis and Observations.