5th WMO Workshop on the Impact of Various Observing Systems on NWP
22-25 May 2012, Sedona, USA

The new NWP system at KMA and some preliminary results of sensitivity test to observational data

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Outline

Introduction

KMA NWP System & Observation Usage

Regional & Local DA impacts

Observation System Experiments

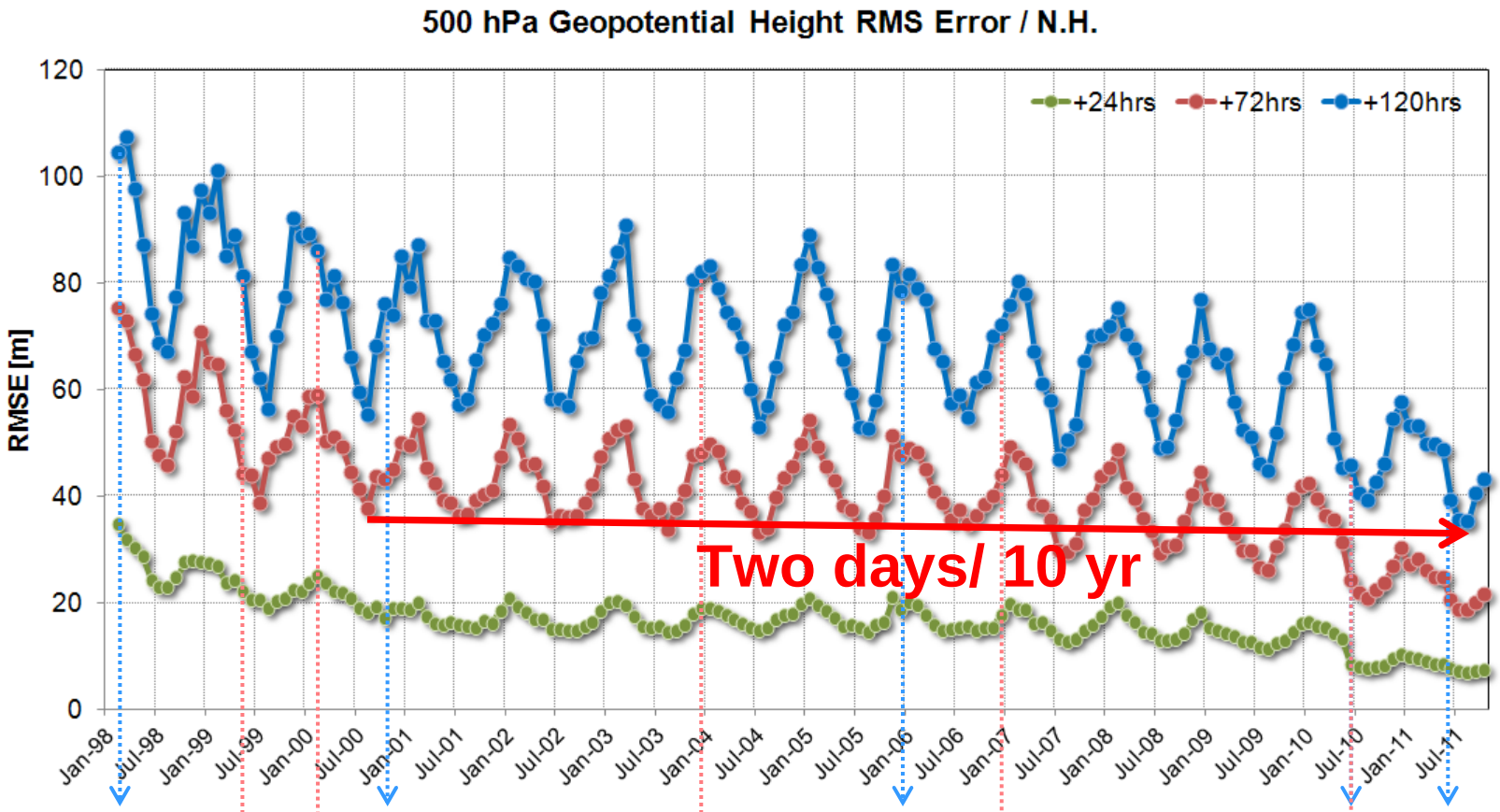
Preliminary results of Adjoint Sensitivity

Summary

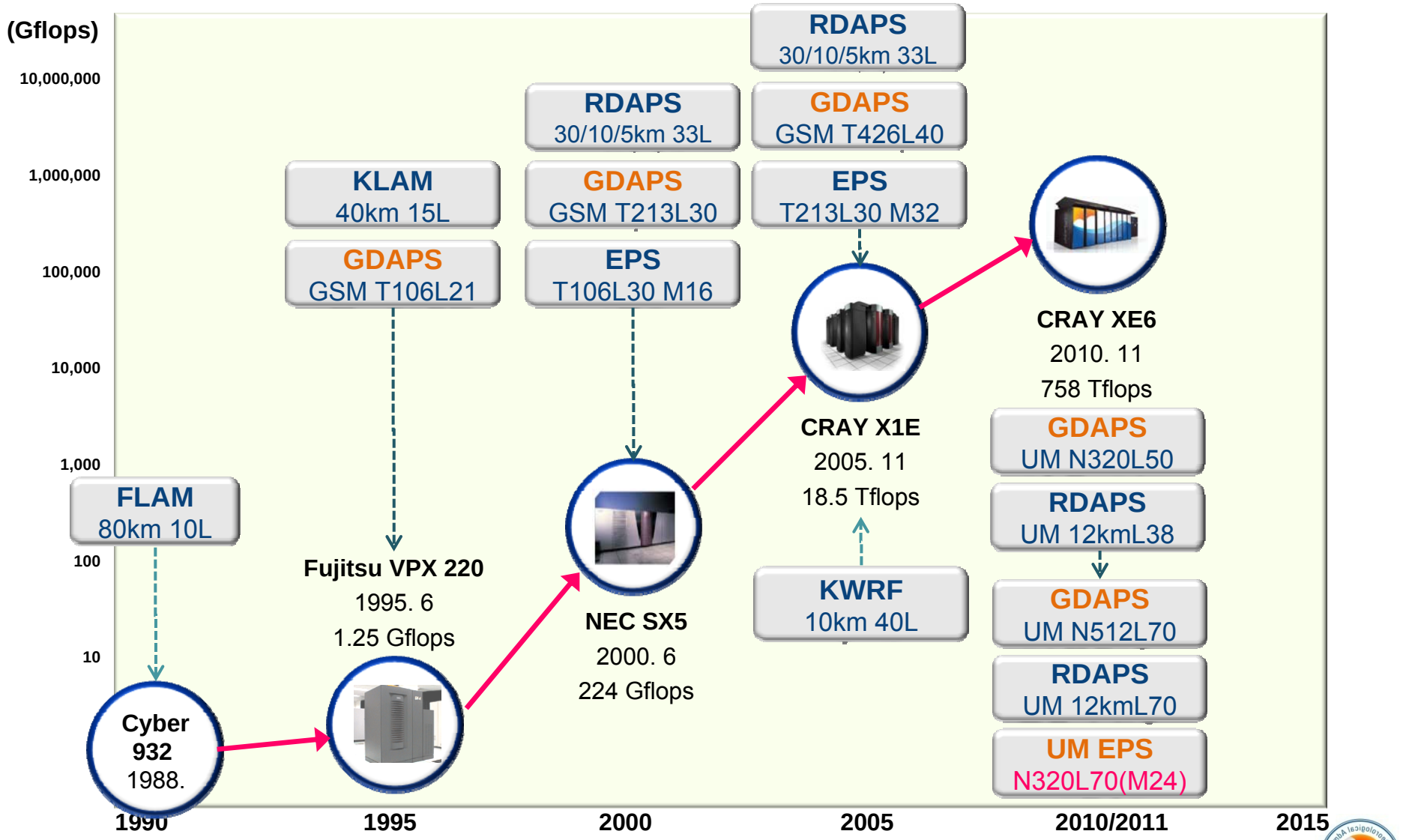
Implementation Background of KMA NWP System

- KMA has operated the Global Model since 1998
- Replacing NWP system from GSM to UM at 2010
  - N320/L50(~40km/top=60km)
  - Global D.A. cycle for UM including **ODB implementation** (’08~’10)
  - ODB library gradually upgraded(‘10~‘12) : observational data usage is rapidly increasing
- Global & Regional Model Update using UM (‘11~’12)
  - Resolution upgraded (N320/L50(~40km/top=60km) → N512/L70(~25km/top=80km))
  - Adapting Regional D.A. system & Ingest Local/KMA operation data(COMS, Ship(auto-sonde), AWS, light house, ocean observation station)
- Forecast Sensitivity to Observation using Adjoint Sensitivity method based on UM (’12~)
- KMA has started to develop the our own NWP system (‘10~’19)

Predictability and Data Assimilation



Short history of KMA NWP system
- NWP Model & Computing Infrastructure -

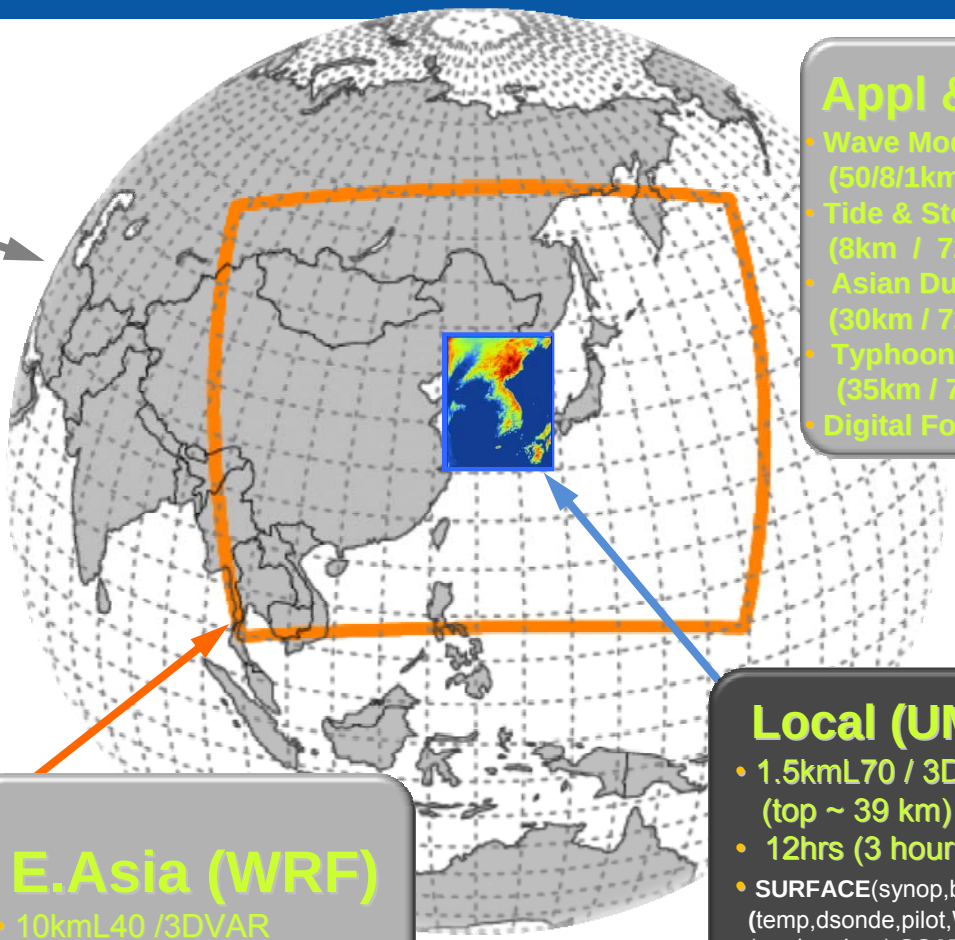


Main Model Configuration & obs. usage

Global (UM)
- N512L70/ 4DVAR (~25km / top = 80km)
- 252hrs (00/12UTC) 72hrs (06/18UTC)
- **ETKF ensemble (24M)**
- **SURFACE**(synop,buoy,ship),**SONDE**(temp,dsonde,pilot,WPF), **AIRCRAFT**(amdar,airep) **SCATWIND**(ascat), **IASI, AIRS, SSMIS, ATOVS**(gtovs,rars) **SATWIND**(mtsat,goes,msg,met7,coms, modis,avhrr), **GPSRO**(cosmic,gras)

Regional (UM)
- 12kmL70 / 4DVAR (0.11°x0.11° / top=80km)
- 72hrs (6 hourly)
- Same as Global UM except hi-resolution ascat add some local observations

AWS, AMEDAS, IEODO ocean research station, research vessel



Appl & Stat Model
- Wave Model(WW3) (50/8/1km, 252/72/24hr)
- Tide & Storm Model (RTSM) (8km / 72hr)
- Asian Dust Model(ADAM2) (30km / 72hr)
- Typhoon Model(DBAR) (35km / 72hr)
- Digital Forecast/Stats

E.Asia (WRF)
- 10kmL40 /3DVAR (top ~ 50hPa)
- 72hrs (6 hourly)
- **SURFACE(synop,buoy,ship), SONDE(temp,pilot,WPF), AIRCRAFT (amdar,airep) SCATWIND(ascat) RADAR(reflectivity),AMEDAS,AWS**

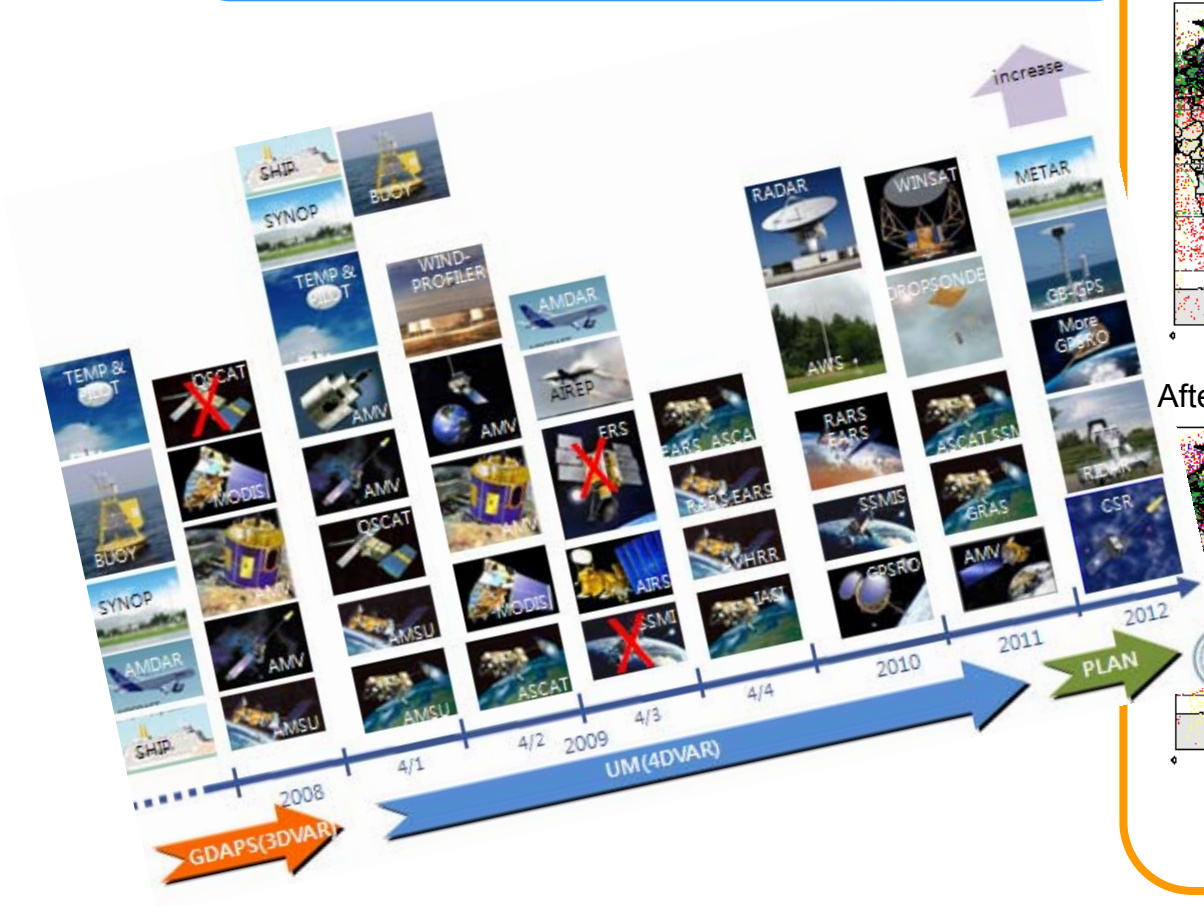
Local (UM)
- 1.5kmL70 / 3DVAR (top ~ 39 km)
- 12hrs (3 hourly)
- **SURFACE**(synop,buoy,ship),**SONDE**(temp,dsonde,pilot,WPF), **AIRCRAFT**(amdar,airep) **SCATWIND**(ascat)

add local observations
(RADAR(radial velocity), AMEDAS AWS, IEODO ocean research station, research vessel, local buoy, lighthouse station)

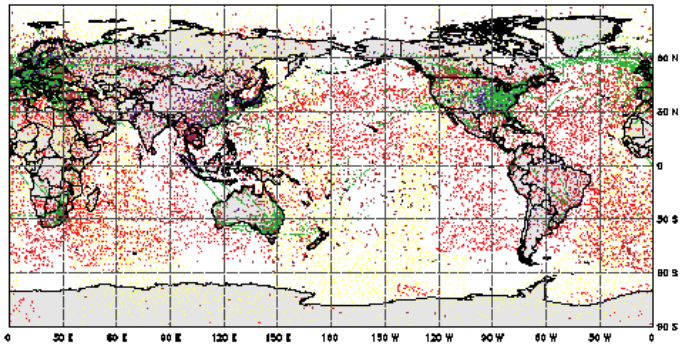
Observation Data for Global NWP vs. UKMO

Ratio of assimilated data w.r.t. UKMO

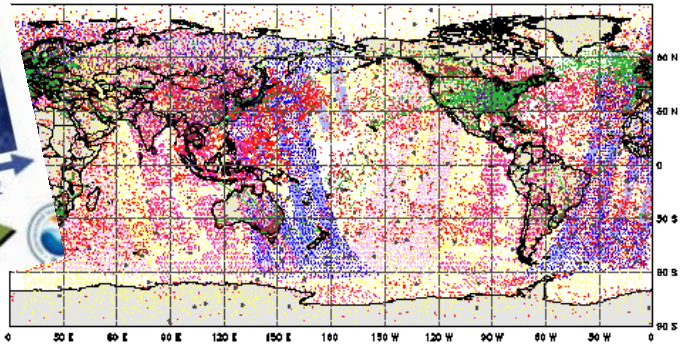
46% (April 2009) → 90% (May 2012)



Before UM (conventional data/20,000pts)

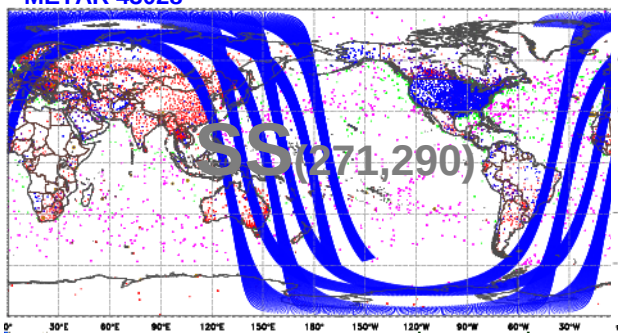


After UM (conventional & sat data)/120,000pts)

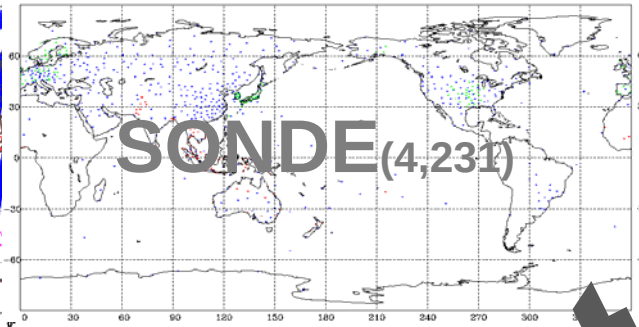


UM Observational Coverage (received data)

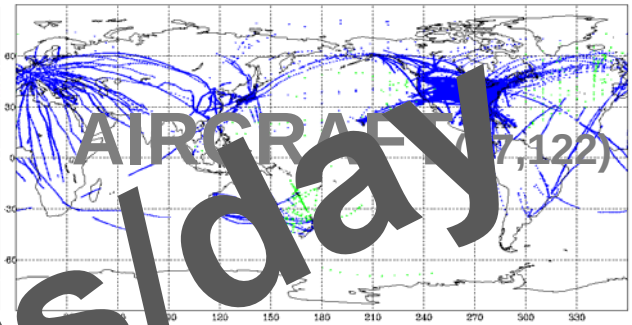
synop 13910 ship 2884 buoy 5248 ascat 206220
METAR 43028



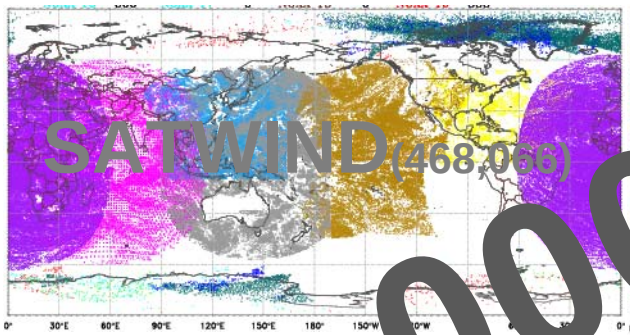
temp 811 pilot 231 windprofiler 3189



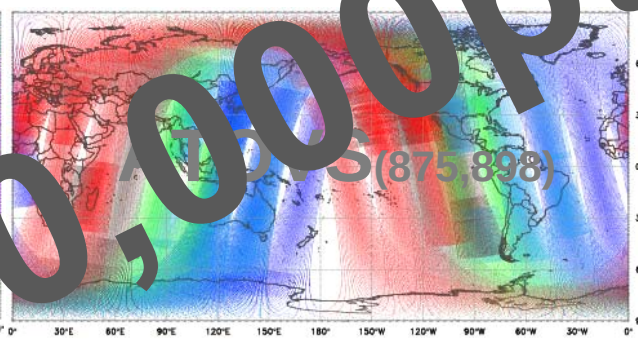
amdar 45750 airep 1372



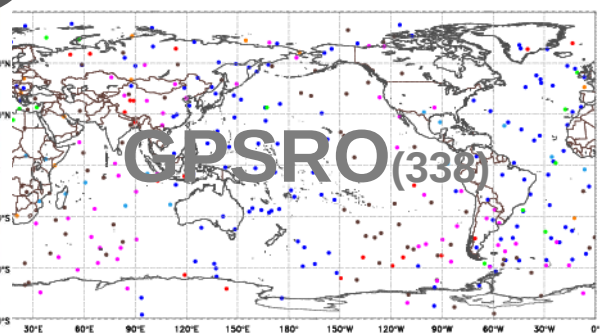
esa 34102 goes 102672 mtsat 21938 msg 181430
polar wind 36554



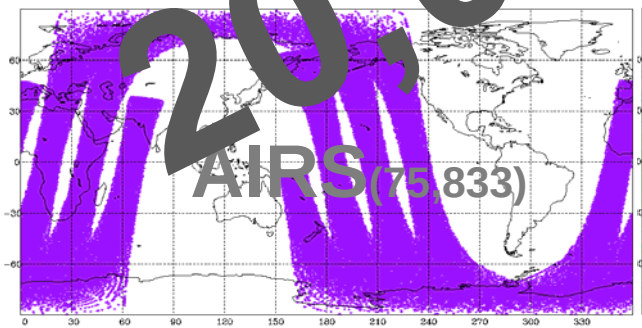
NOAA15 229320 NOAA17 308522 NOAA18 [illegible]752
NOAA19 277006 MetOp 1898[illegible]



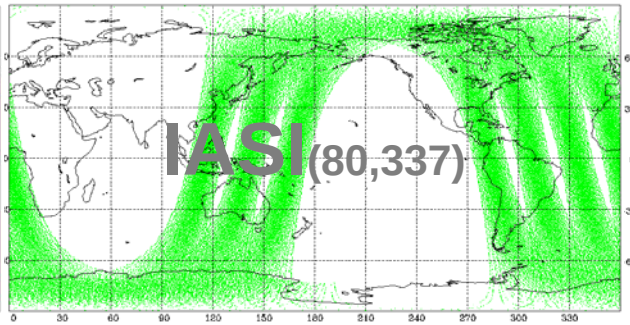
gpsro (6 cosmics & gras) 653



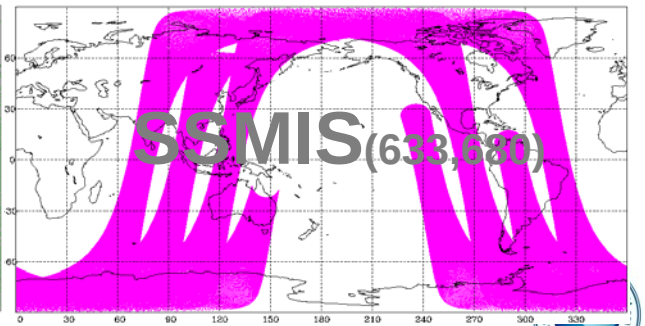
[illegible] 75833



MetOP 80337

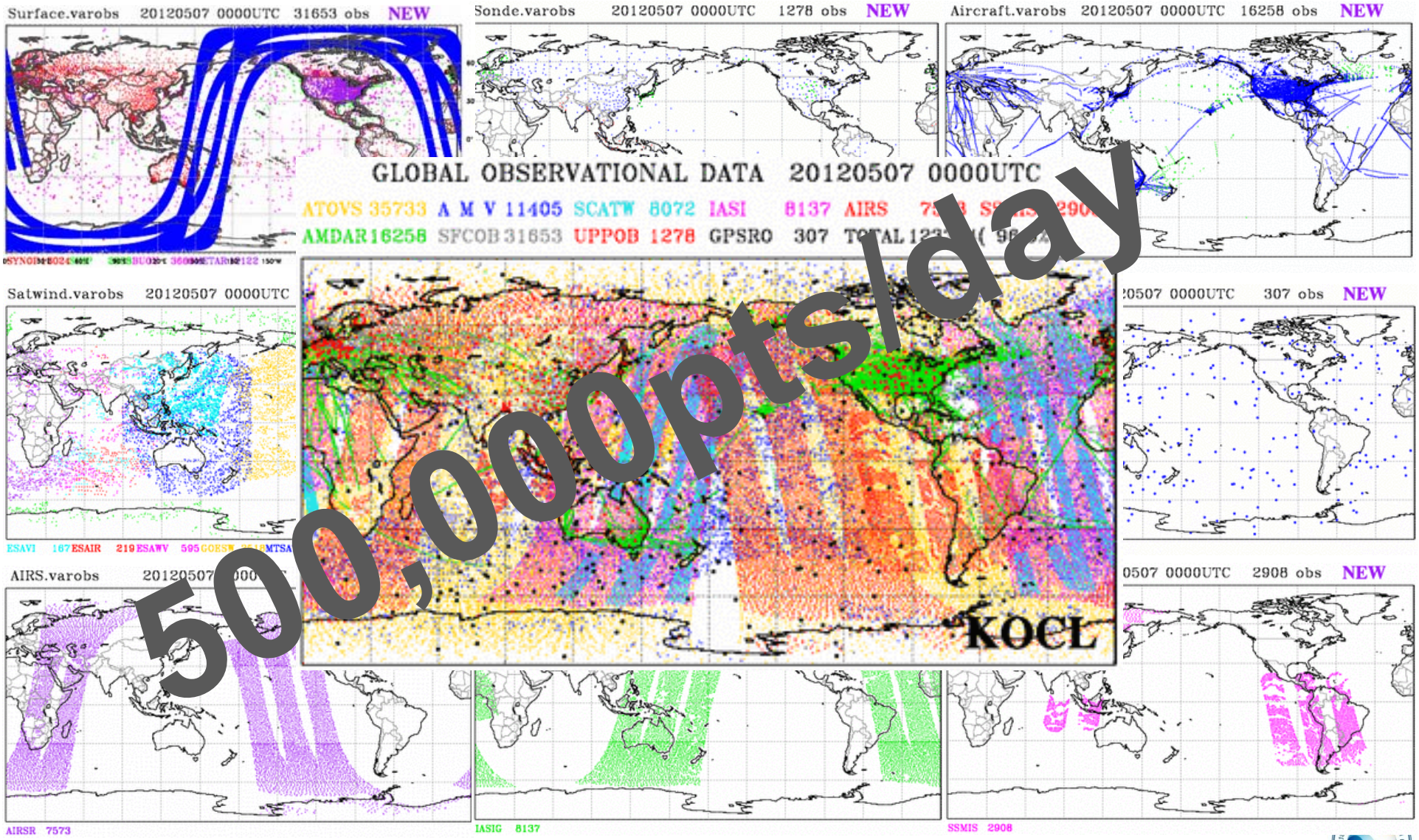


DMSP-16 633660

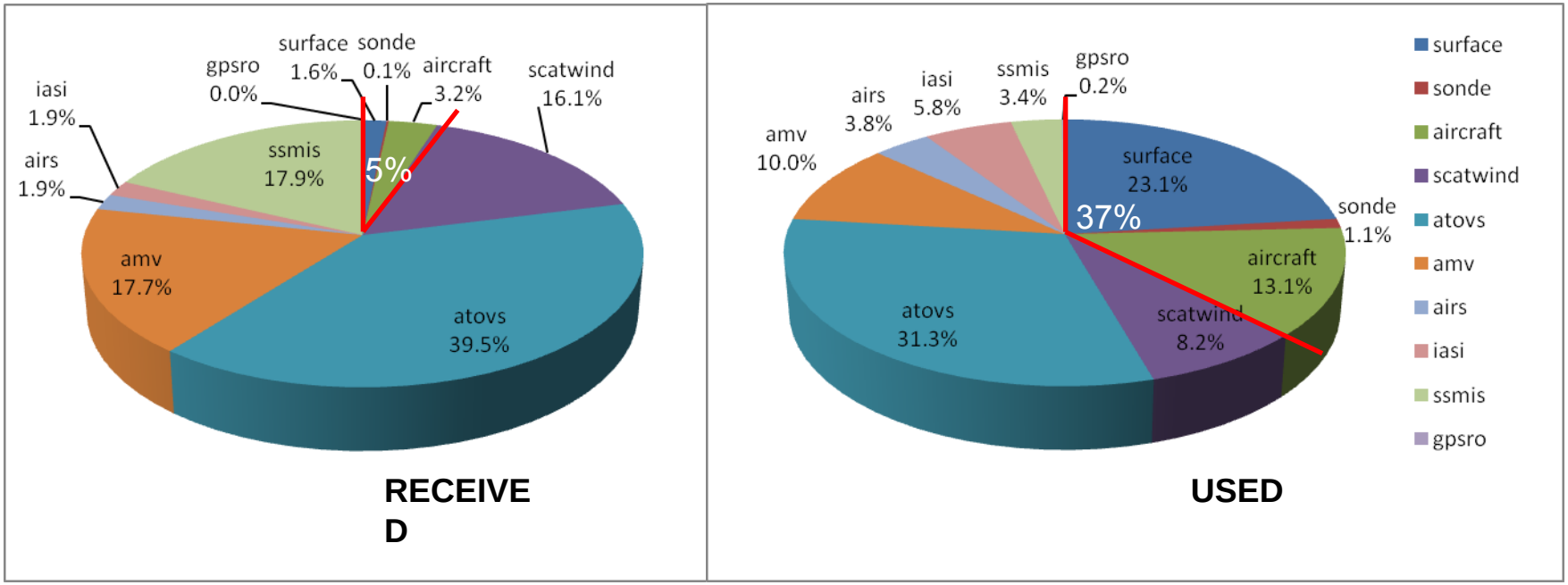


20,000,000pts/day

UM Observational Coverage (assimilated data)



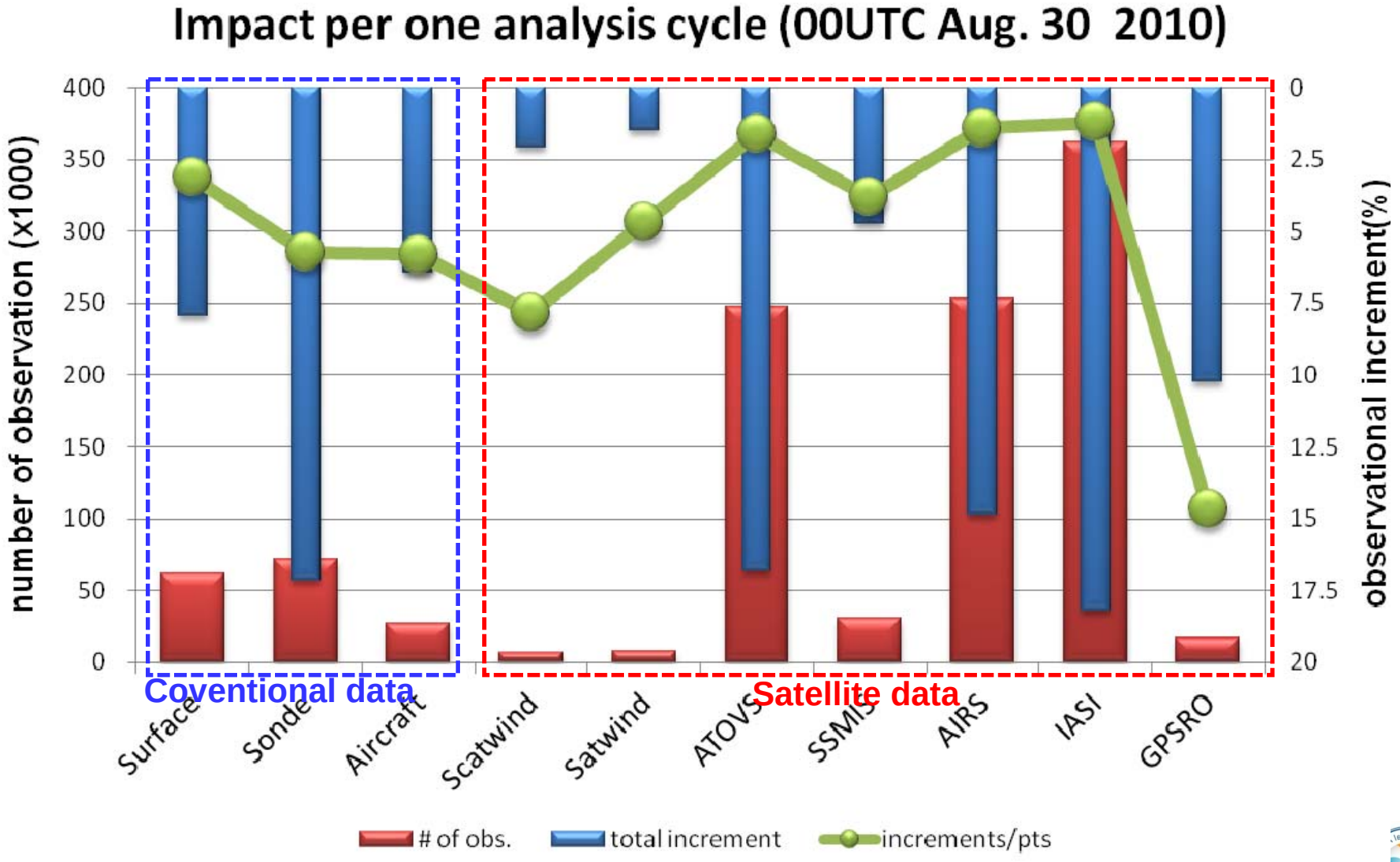
Observation Received & Assimilated



12UTC November 30, 2011

95 % received and 63 % used data come from satellite measurements

The Comparison between # of obs. & total increments(O-B)



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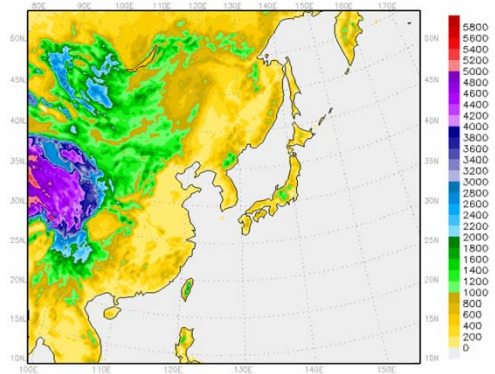
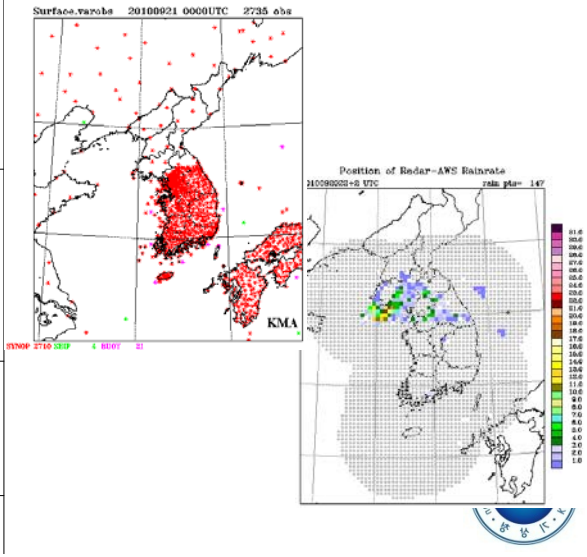
Introduction of Regional DA

Item	NO DA (cold)	Regional DA (cycle)
Model version	6.6	7.7(7.5)
DA version	23.4	26.1
H resolution	12km	12km
V resolution	38 layers	70 layers
Domain Top	39km	80km

East Asia Domain



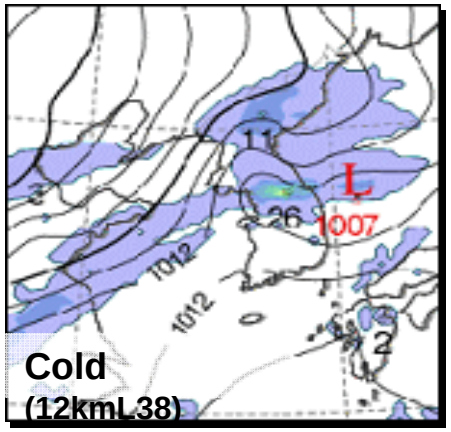
Rotated coordinate

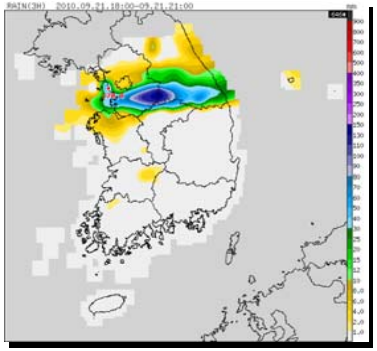


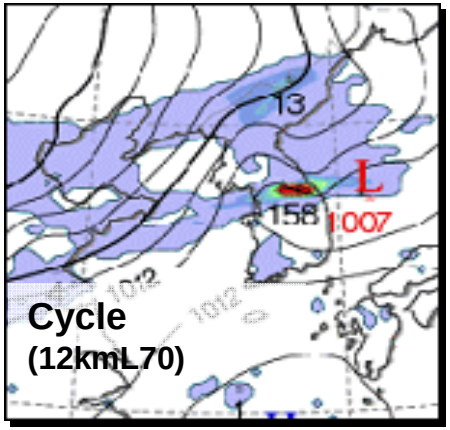
Test period: Summer: 2010.6-8 / Winter: 2010.12-2011.2

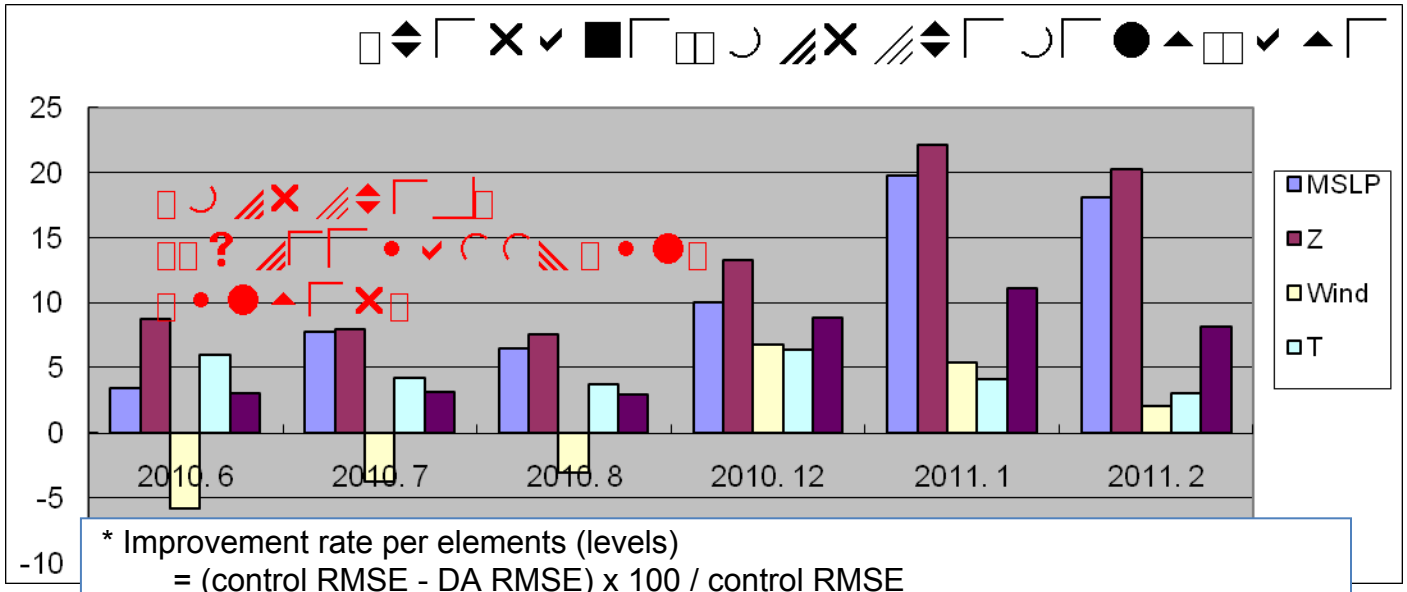
Impact of Regional DA

Regional Model (3-hour accumulated precipitation)









* Improvement rate per elements (levels)
  = (control RMSE - DA RMSE) x 100 / control RMSE
* Average improvement rate = Mean of the improvement rate per elements(levels)

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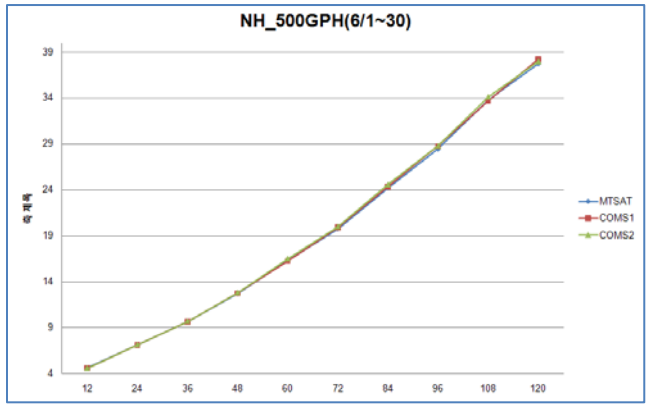
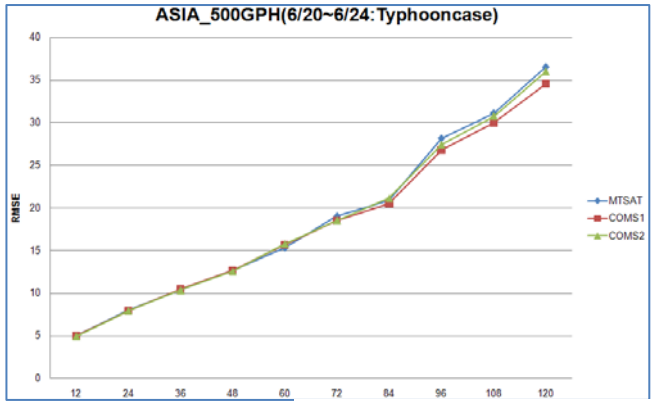
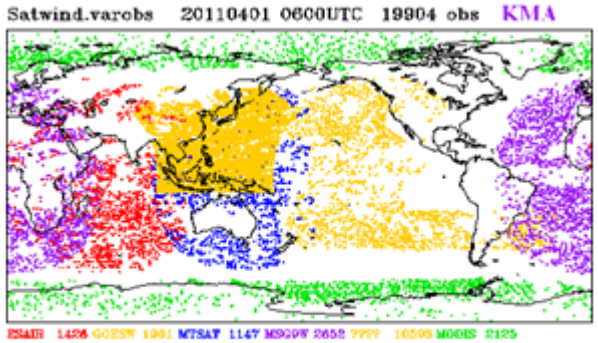
COMS Impacts

- **COMS** : Communication, Ocean and Meteorological Satellite (Korea)
- Preparation for application of COMS AMV data to UM system (OPS / 6 hourly) is finished
- Testing for implementation of hourly COMS AMV data is on-going





Exp. Name	assi. window / temp. thinning	Satellites
CTRL	±00h / -	MTSAT(QI85) only
COMS1	±02h / 7200s	COMS(QI90)+MTSAT(QI85)
COMS2	±03h / 3600s	COMS(QI90)+MTSAT(QI85)



MTSAT+COMS

COMS1: 2 hourly local COMS(T-2, T+0, T+2) + full MTSAT at T+0
COMS2: 1 hourly local COMS(T-3,T-2,T-1,T+1,T+2,T+3) + full MTSAT at T+0

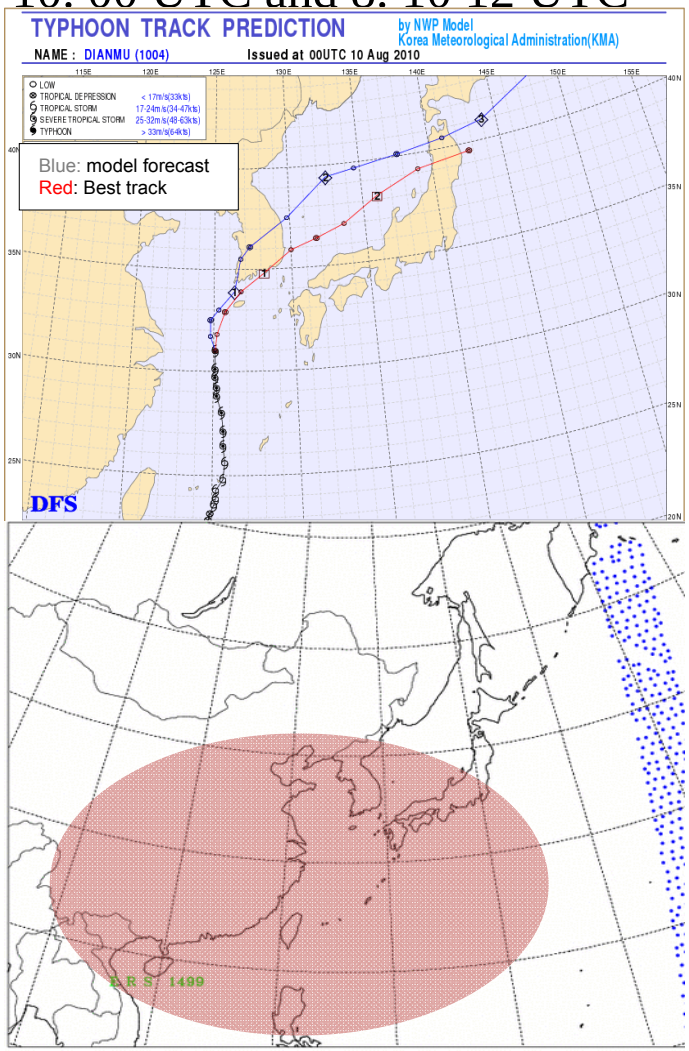
➔ **Neutral for NH and improved for the typhoon case in Asia region**

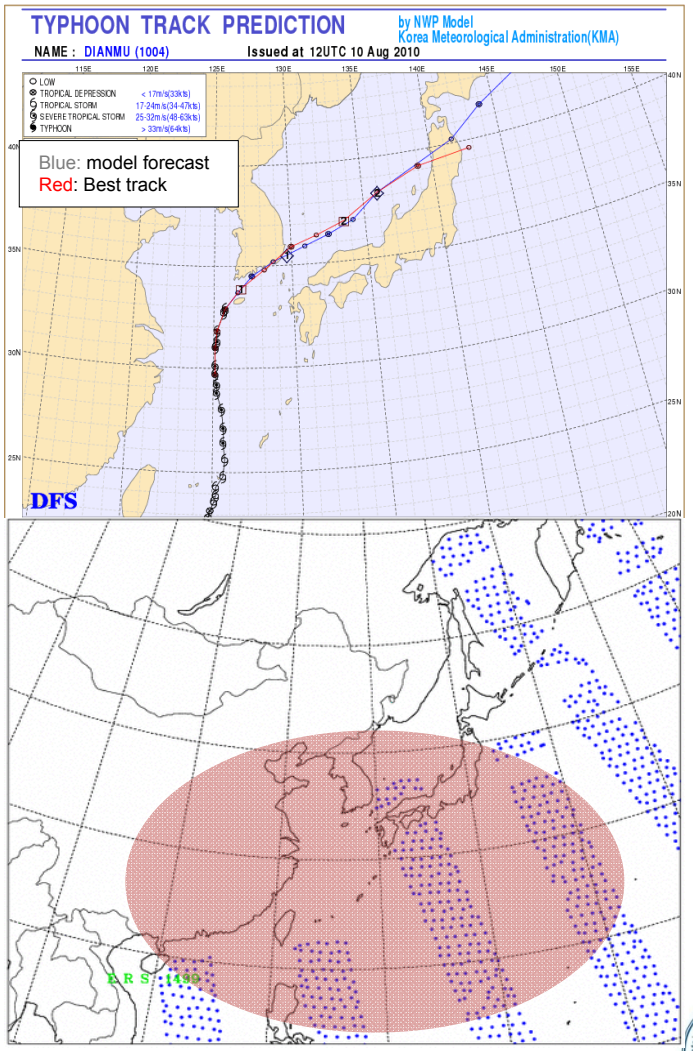
OSE of Typhoon case

- The forecast tracks of Typhoon “DIANMU” are quite different between 8. 10. 00 UTC and 8. 10 12 UTC

Forecast

Observation

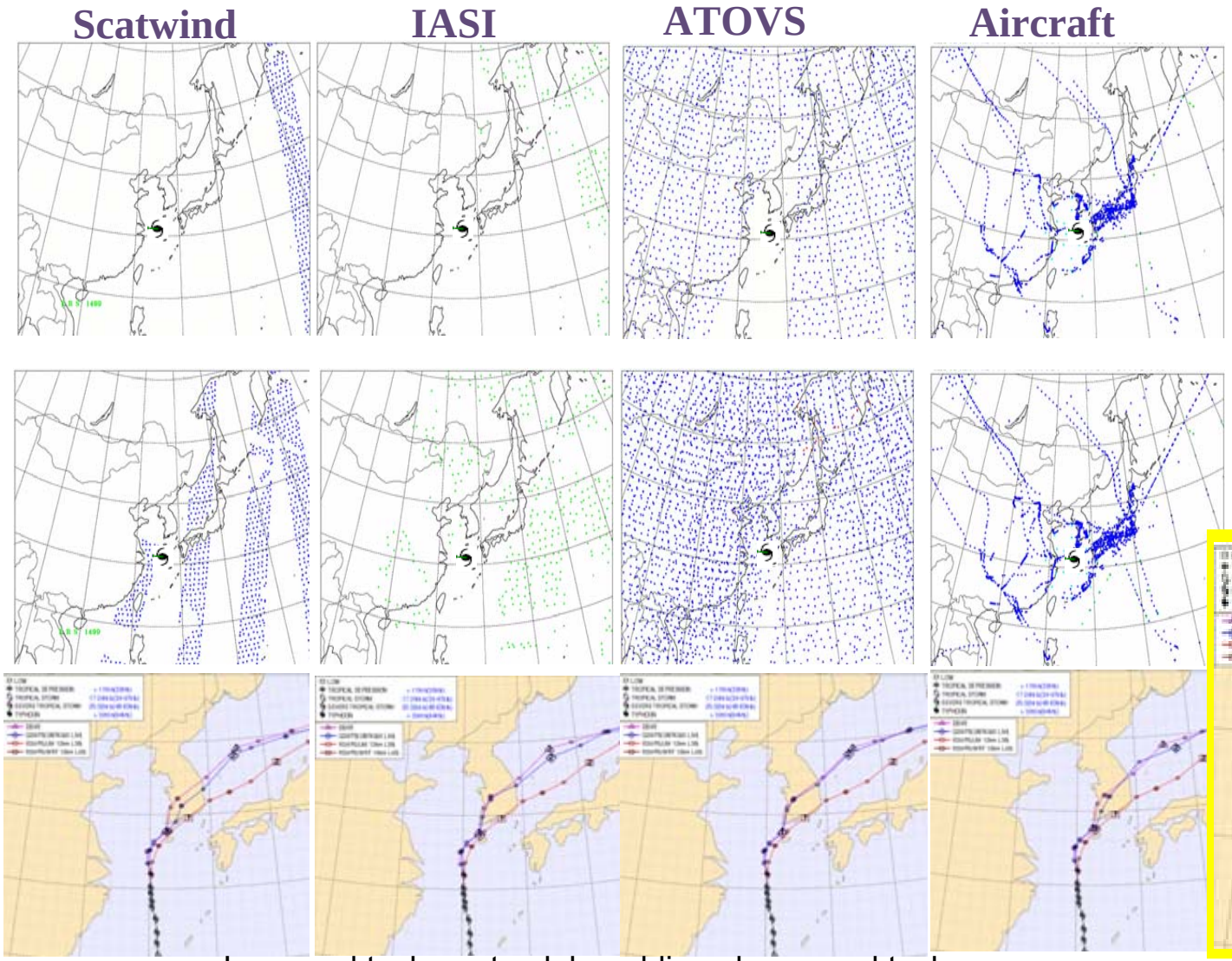




8.10.00 UTC

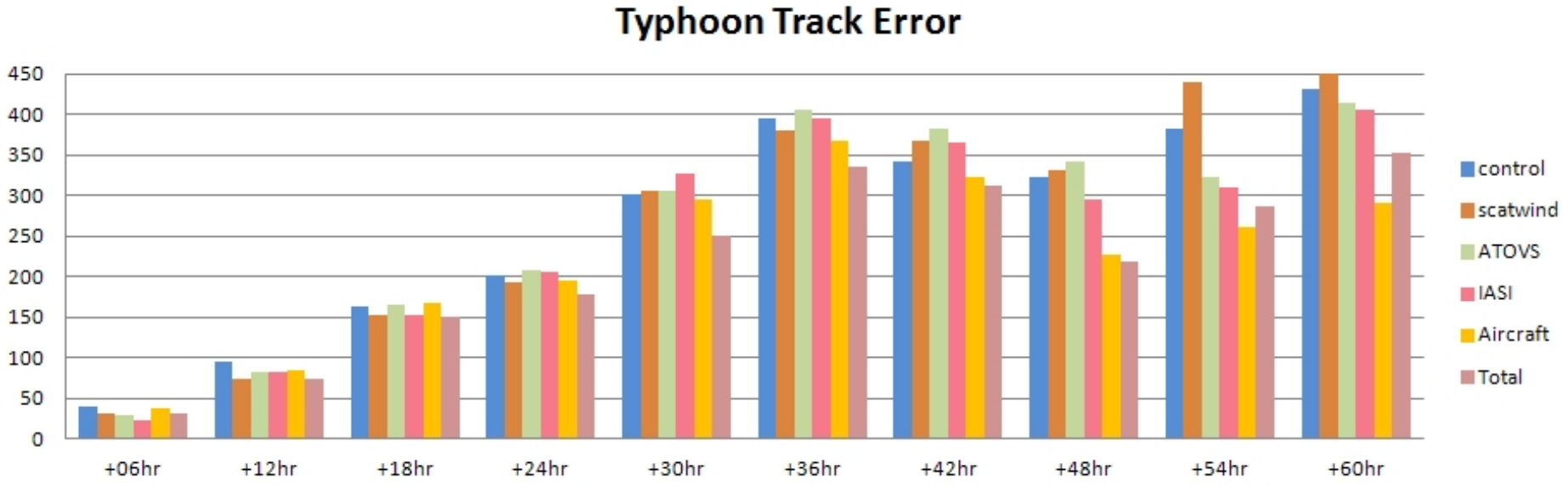
8.10.12 UTC

Additive data test for Typhoon track



o Imporved typhoon track by adding obs around typhoon
- Reduced error by 19.45 km

Additive data test for Typhoon track



- The experiment with all data shows the best result
- The impact of aircraft per data volume is noticeable
- Scatwind shows smaller and larger error in early and last forecast time
- ATOVS and IASI contribute the positive impact

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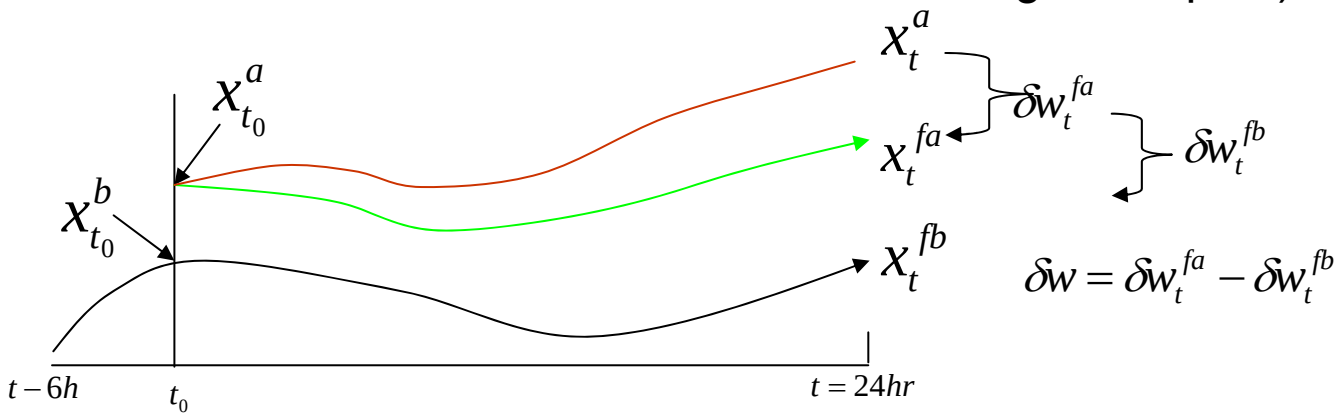
Adjoint Based FSO method

Forecast Sensitivity to Observation (FSO) calculates an aspect of forecast error reduction due to analysis

(Negative value means error reduction and then it means a good impact)



$$\delta J = (\delta w)^T \mathbf{C}\left(\delta w_t^{fa} - \delta w_t^{fb}\right) = \left(\delta y^o\right)^T \delta \hat{y}^o \qquad \delta w \approx \mathbf{MK}\delta y^o \qquad \delta \hat{y}^o = \mathbf{K}^T\mathbf{M}^T\mathbf{C}\left(\delta w_t^{fa} - \delta w_t^{fb}\right)$$

$\mathbf{M}$: Linear model $\mathbf{K}$: Karman Gain δy^o: innovation $\delta \hat{y}^o$: observation sensitivity

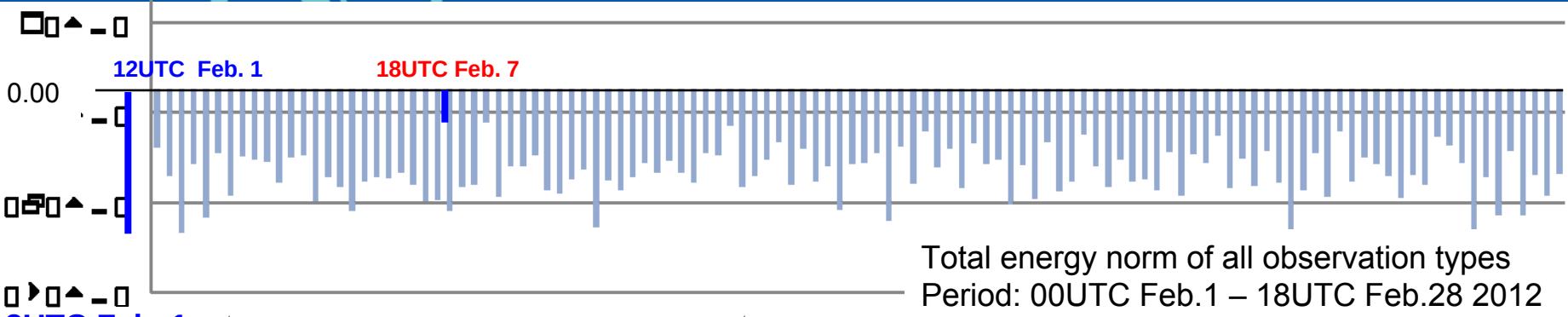
x^b: background x^a: analysis x^{fb} x^{fa} : forecast from background and analysis respectively

t_0 : analysis time t : forecast time

δJ is a decrease of the global energy norm error(24hours) due to analysis and negative value means reduction of forecast error and better performance.

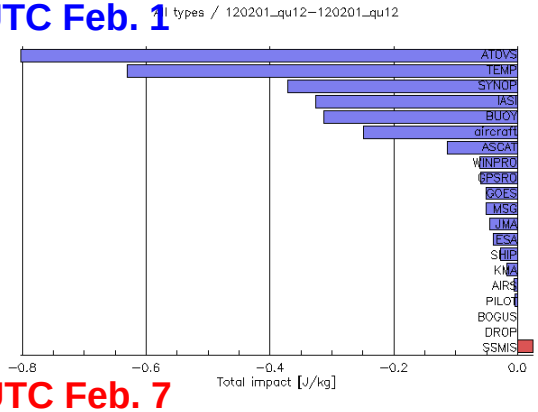
(Reference : Met Office VSDP 63

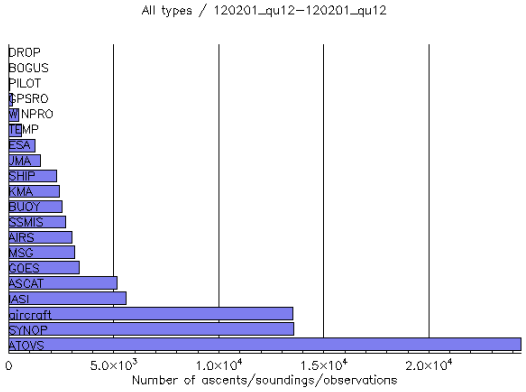
Case study of Observation Sensitivity

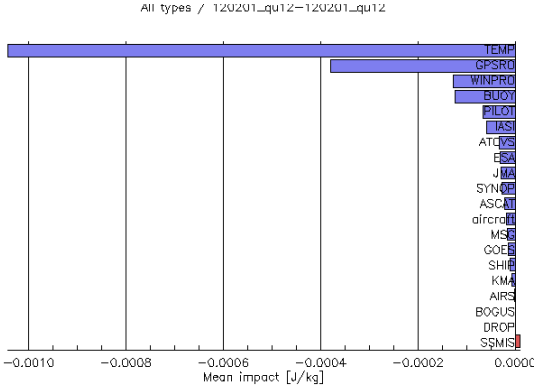


Total energy norm of all observation types
Period: 00UTC Feb.1 – 18UTC Feb.28 2012

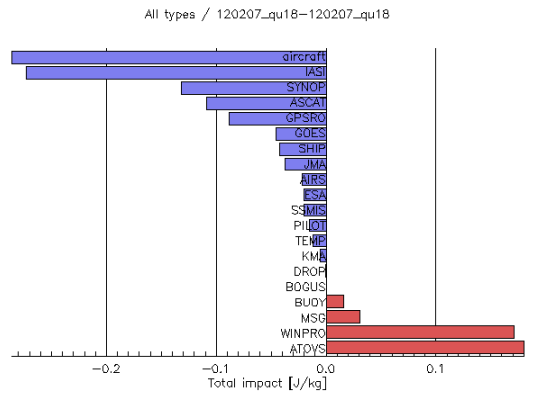
12UTC Feb. 1

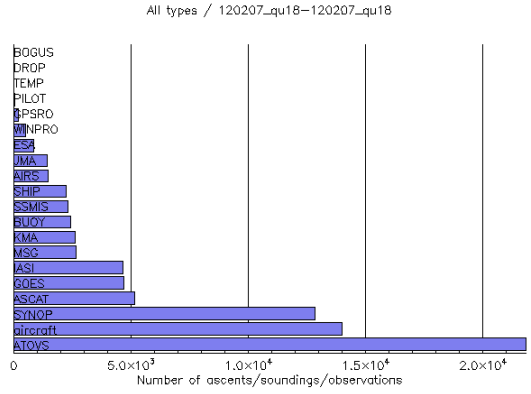


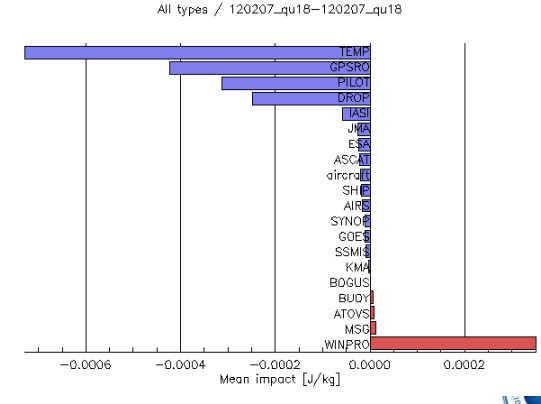




18UTC Feb. 7

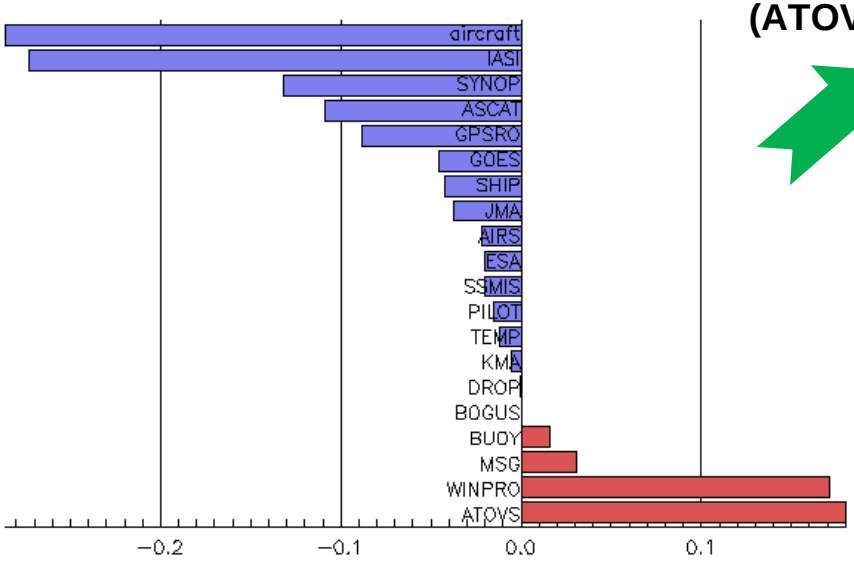




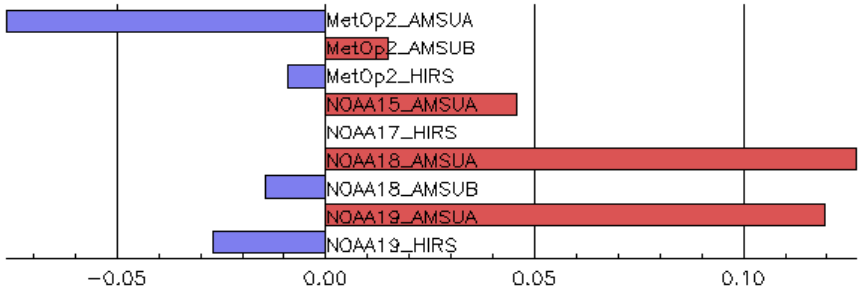


Case study of Observation Sensitivity

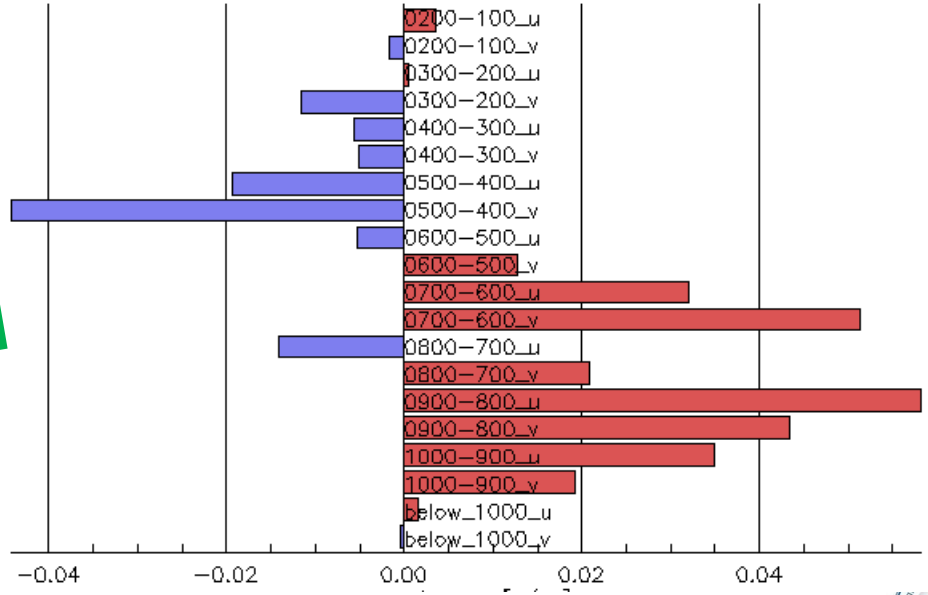
18UTC Feb. 7



by channel (ATOVS)



by level (Windprofiler)



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- The development of data assimilation technique (4DVAR) and huge increase of observational data play an important role in model performance. Super computer make it possible to run 4DVAR system operationally.
- The impact on analysis depends on the choice of observation.
- Generally the more obs, the more impact on analysis. But Synoptic and aircraft shows relatively great impact with even less number of data
- Track error of typhoon is enhanced by information of steering wind due to addition of data around typhoon
- More impact studies of the observation are needed


Thank you