

The Application of Satellite Data in the Global Surface Data Assimilation System at KMA

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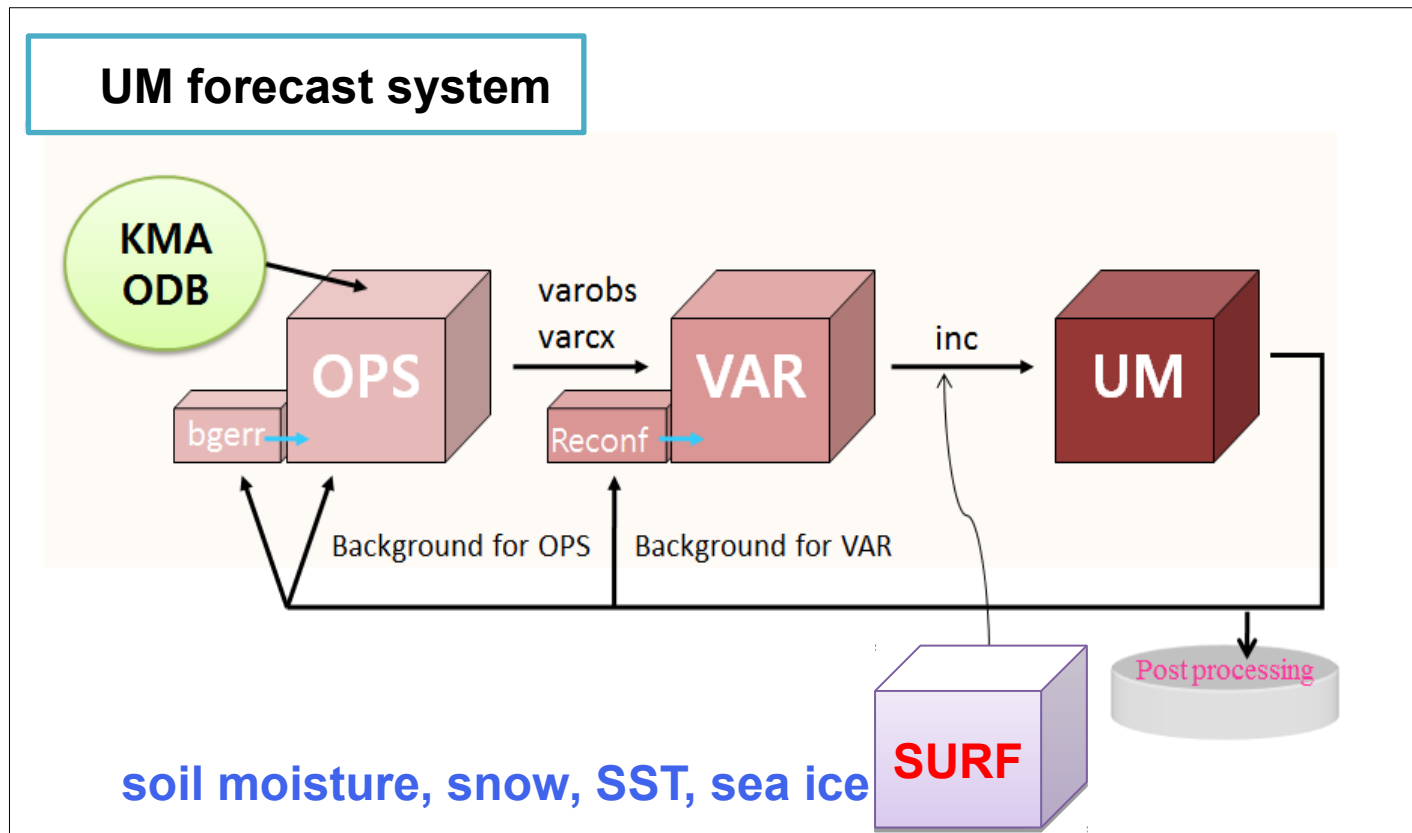
14 March, 2016



- **Overview of surface data assimilation at KMA**
- **Application of MetOp-B/ASCAT soil wetness**
- **Application of COMS snow cover**
- **Summary and future plan**

UM Forecast System at KMA

- ✓ OPS : Observation Processing System
- ✓ VAR : Variational data assimilation
- ✓ UM : Unified model (developed by Met-Office)



Surface Data Assimilation System of KMA

↙ **SURF**ace field processing system (current)

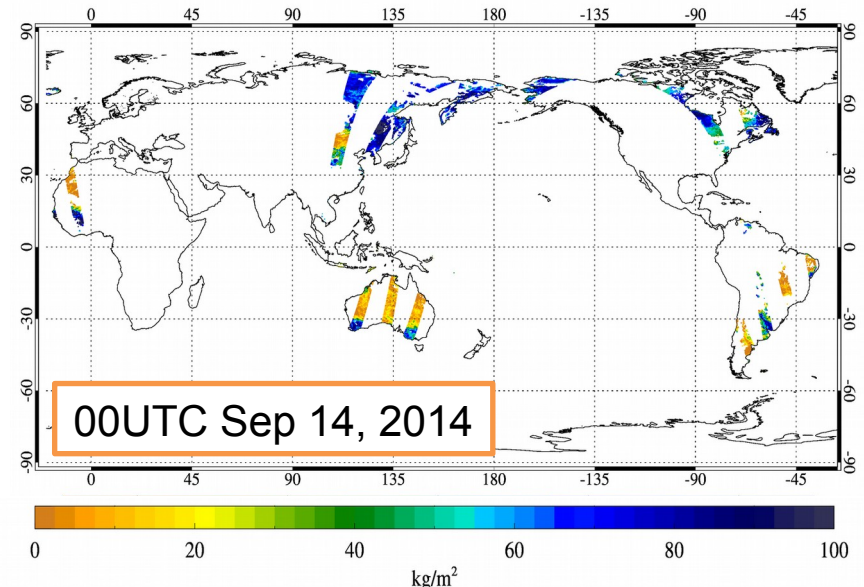
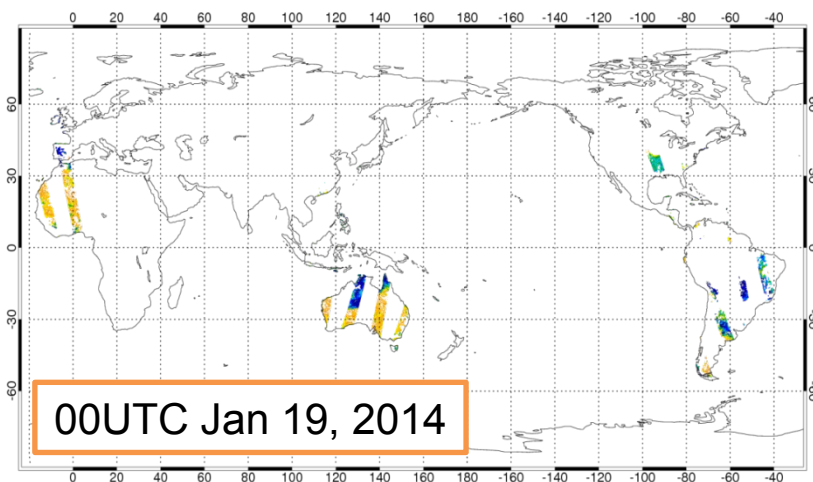
Factor	Method	Global (25km)	Regional (East Asia, 12km)	Local (Korea, 1.5km)
Soil Moisture	UM screen T/q Nudging SMC (W=0.8) + ASCAT Nudging SMC (W=0.2) ↓ Extended Kalman Filter (June 2016 ~)	MetOp-A ('10~), MetOp-B ('15.6~) / ASCAT (4times/day) (A:12.5km, B:25km)	Downscaling from global (4times/day)	Downscaling from global (1time/day)
Snow	Convert to snow amount from IMS fractional snow cover	IMS (4km, 1time/day)	Background (1time/day)	Background (1time/day)
SST Sea Ice	Interpolation Extrapolation	OSTIA (5km, 1time/day)	OSTIA (1time/day)	OSTIA (Not used sea ice) (1time/day)

Application of MetOp-B/ASCAT soil wetness

Soil Moisture Data Assimilation (OLD)

- Version : SURF VN18.5 (since June 2012)
- Operational schedule :
 - **4 times** per day (00, 06, 12, 18 UTC) for **global (25km)** and **regional (12km, July 2015~)** model
 - **1 time** per day (06 UTC) for **local model (1.5km)**
- Used satellite data : **MetOp-A/ASCAT soil moisture (12.5km)**

After QC



Soil wetness over the **northern hemisphere** in the **winter season** were mostly **rejected by QC flag (snow)**.

Application of MetOp-B/ASCAT soil wetness

Background

- QC passed ASCAT data are about **40~45%** compare to the total number of observations during a day.
- MetOp-B data cover the empty areas of soil wetness from MetOp-A (red circles).
- ASCAT soil wetness derived from **MetOp-A and MetOp-B** are shown a **similar distribution** because sensor specifications and retrieval algorithms are almost same.

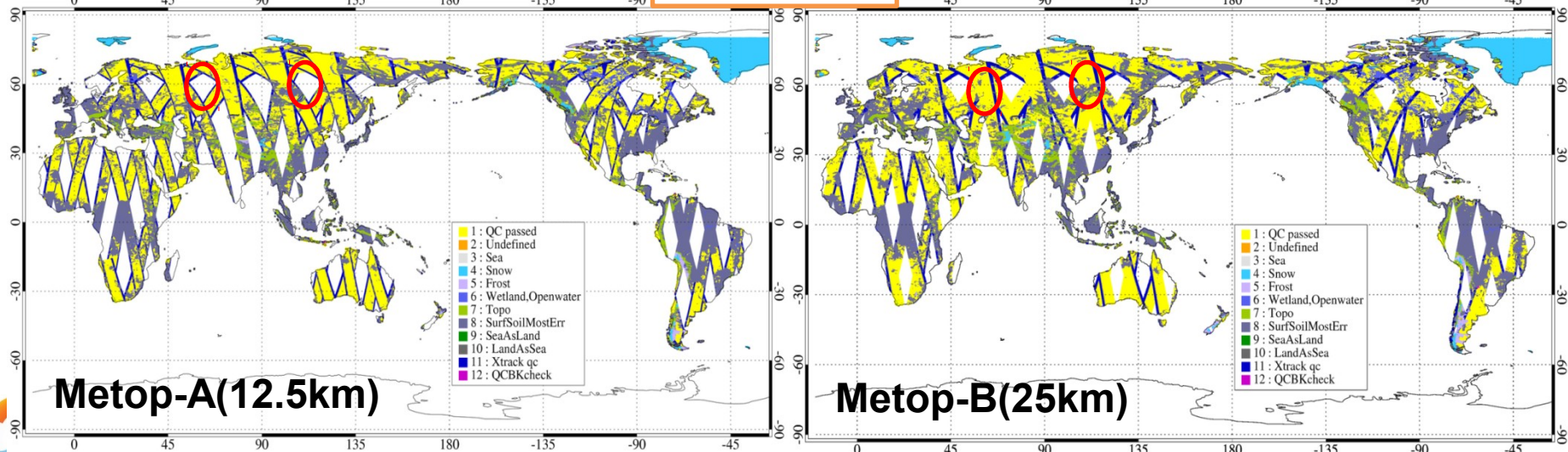
Purpose

- ➔ To increase the spatial coverage of daily soil moisture retrievals
- ➔ To improve the effect of surface soil moisture over East Asia in global model

METOP-A/ASCAT QC flag (20130715)

15 July, 2014

METOP-B/ASCAT QC flag (20130715)

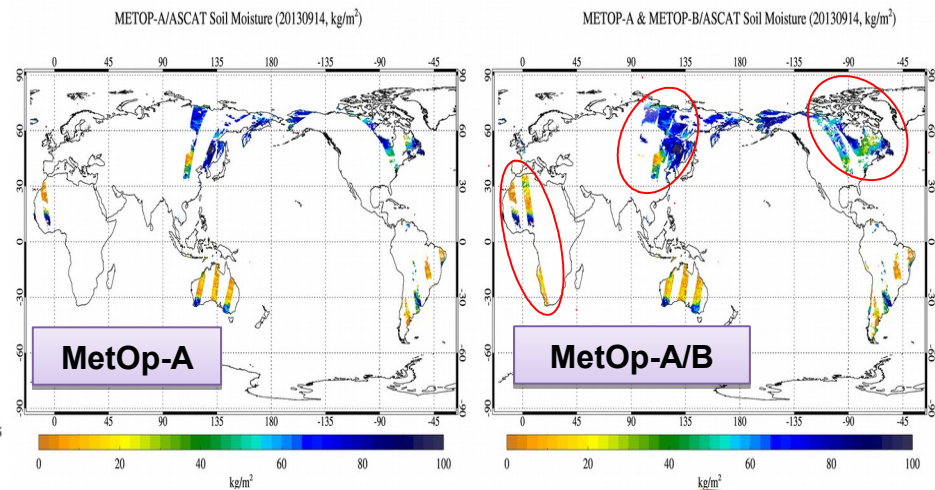
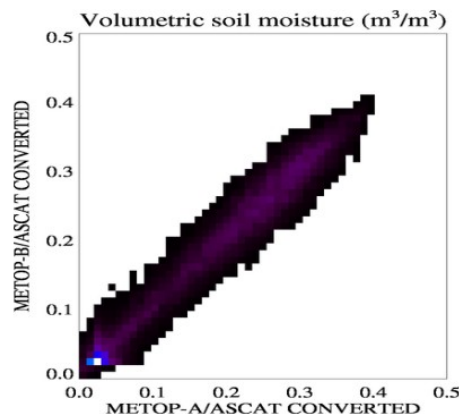
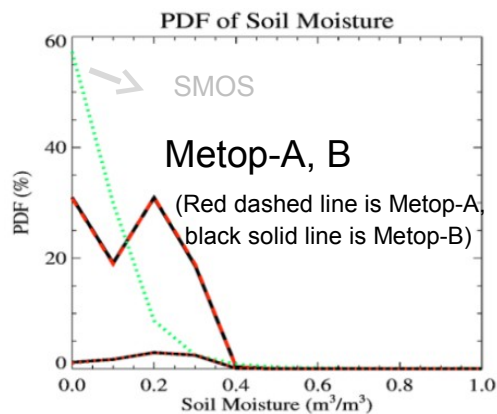


Application of MetOp-B/ASCAT soil wetness (NEW)

[Experiment] Add MetOp-B/ASCAT soil wetness (25km)

- Model : Global
- Period : 2 - 30 Sep., 2013 (fall)
14 July - 31 Aug., 2014 (summer),
- Soil layers : **0.1**, 0.25, 0.65, 2m thickness
- Verification factors : 1000hPa GPH/MSLP, 850hPa Temp, 500hPa GPH, 250hPa Wind
- Convert to **Volumetric Soil Moisture (m^3/m^3)** from ASCAT soil wetness (%)

PDF and Scatter plot of MetOp-A and B (July, 2013)



Convert to VSM (m^3/m^3) from ASCAT soil wetness (%)

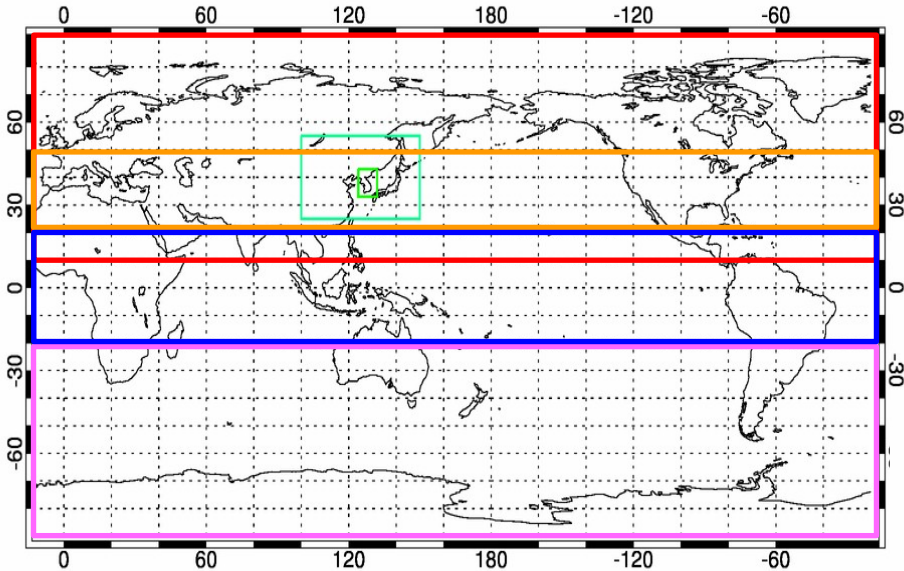
VSM : Volumetric Soil Moisture (m^3/m^3)

VSM = Clim_today + (SATN-(1-BARE)*WILT)*ANOMALY

- ✓ Clim_today : Time interpolation from monthly data
(JULES output using GSWP2, '86-'95)
- ✓ **ANOMALY = ASCAT_SM - Mean_SM** (ERS-1/2 mean soil moisture, '91-'00)
- ✓ GSWP : Global Soil Wetness Project
- ✓ SATN : UM volumetric saturation point
- ✓ WILT : UM volumetric wilting point
- ✓ BARE : UM bare soil fraction (SATN, WILT, BARE: UM Ancillary)

Verification Regions

Verification areas for Analysis



[Analysis]

Northern Hemisphere[20N-90N]

NH MID-Latitude[20N-50N]

Tropics[20S-20N]

Southern Hemisphere[20S-90S]

Asia

East Asia

[Observation:sonde, synop]

Northern Hemisphere[20N-90N]

Tropics[20S-20N]

Southern Hemisphere[20S-90S]

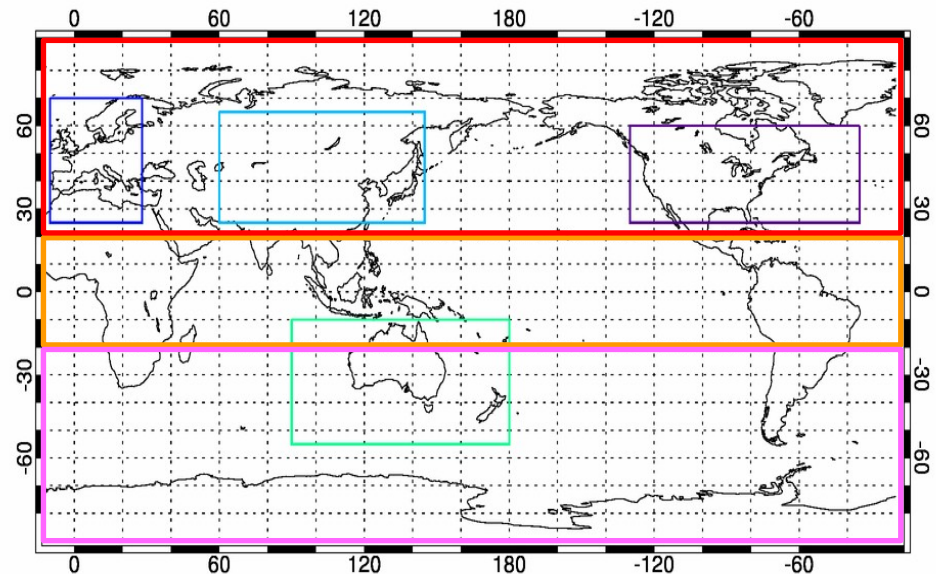
Europe

Asia

Australia/New Zealand

North America

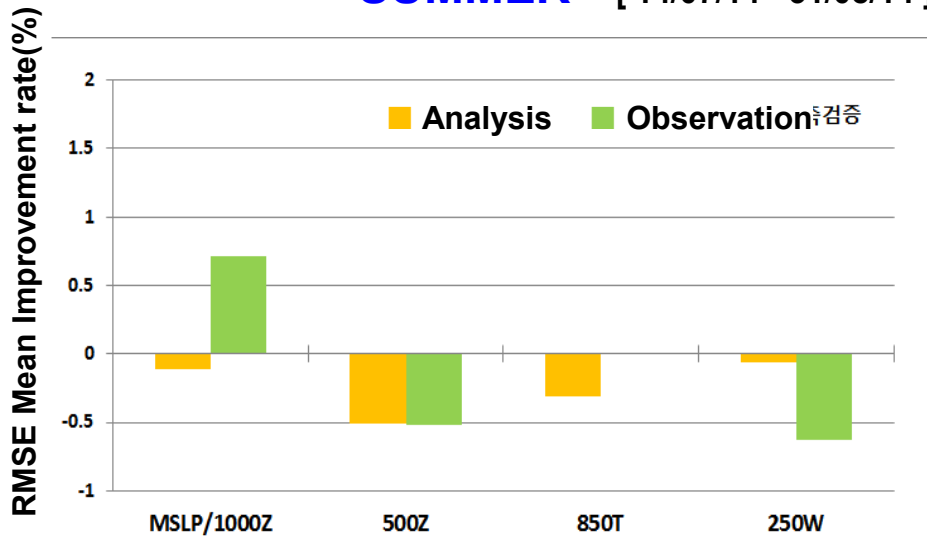
Verification areas for Observation



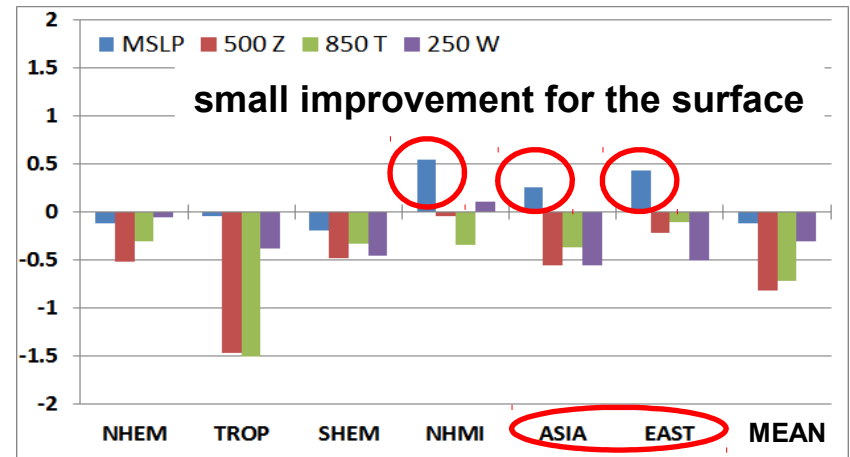
Impact of MetOp-B/ASCAT soil wetness

Positive : Improved

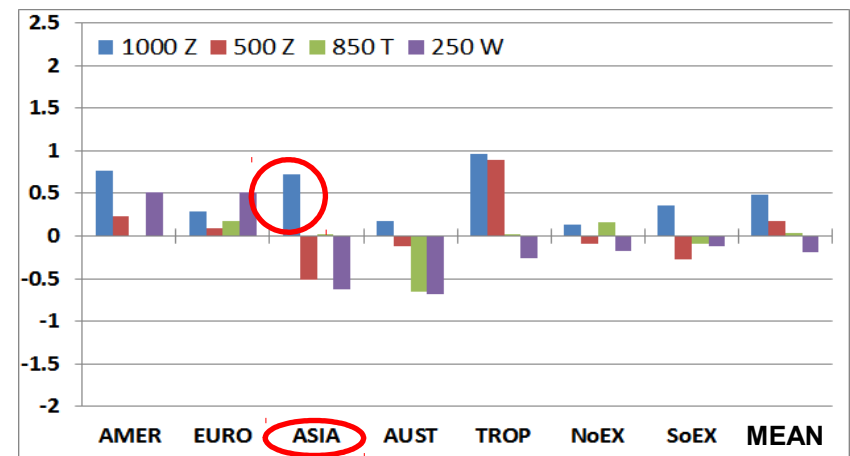
SUMMER [14/07/14 - 31/08/14]



Analysis



Observation

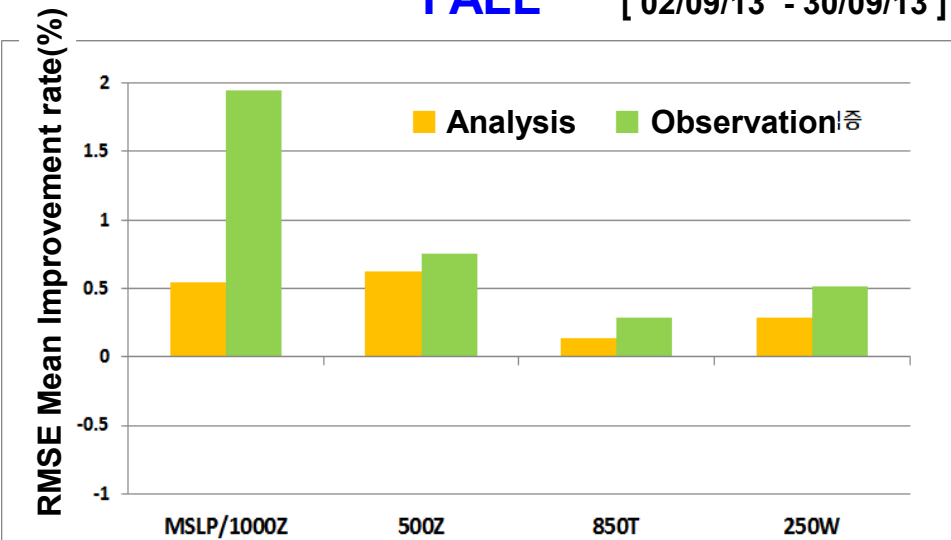


※ Mean improvement rate(%) of RMSE are small positive for the surface over the Asia region in summer season.

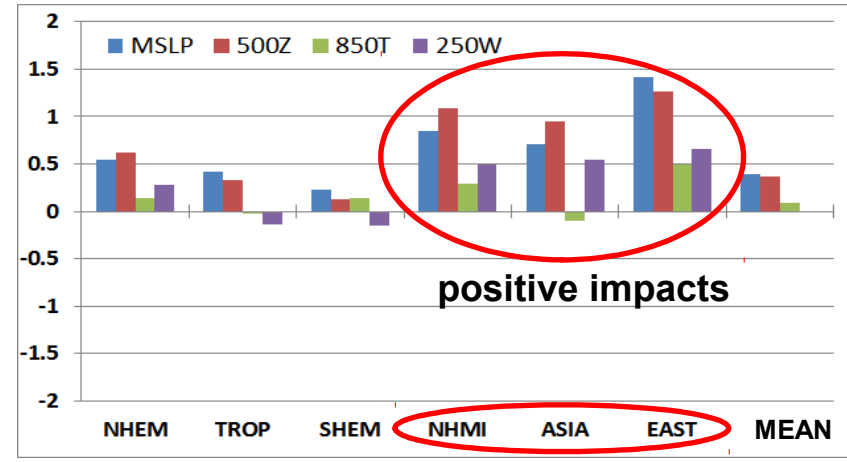
Impact of MetOp-B/ASCAT soil wetness

Positive : Improved

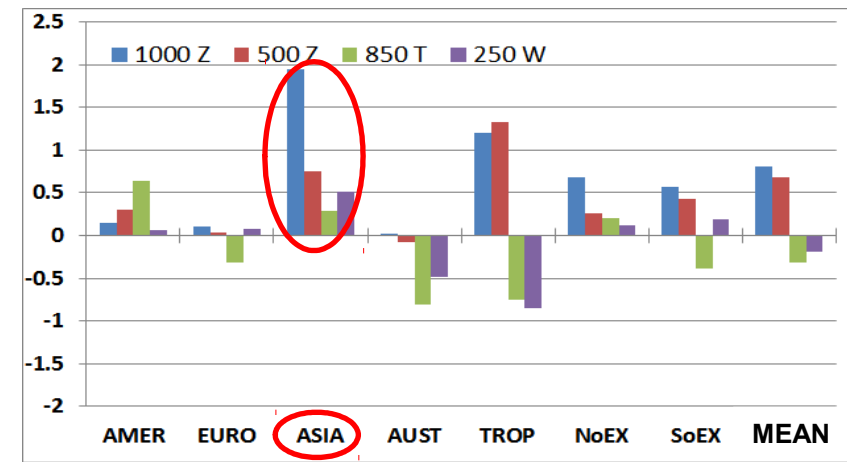
FALL [02/09/13 - 30/09/13]



Analysis



Observation

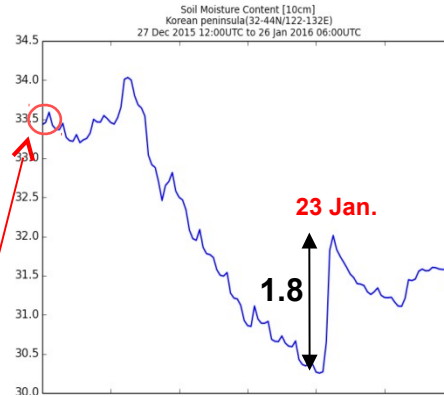
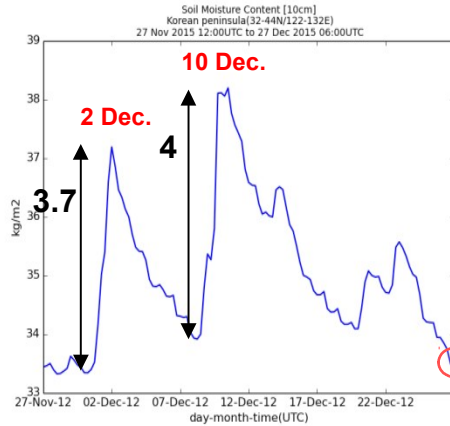


※ Mean improvement rate(%) of RMSE are an overall positive for all components in fall season.

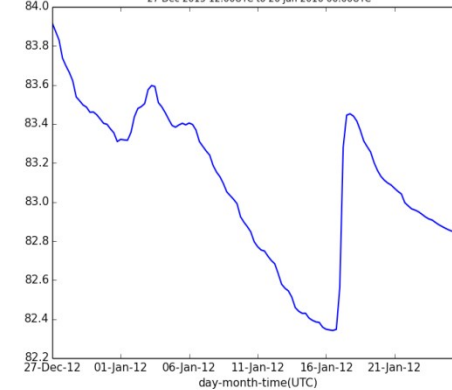
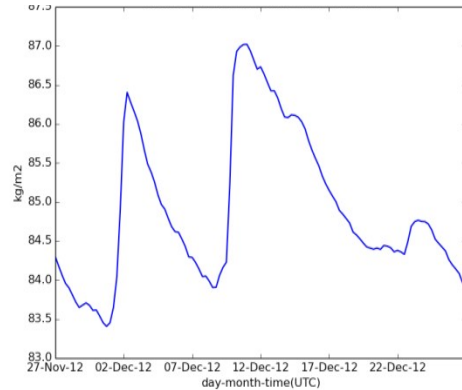
Soil Moisture Contents Monitoring System

SMC timeseries
(27 Nov., 2015 – 26 Jan., 2016)

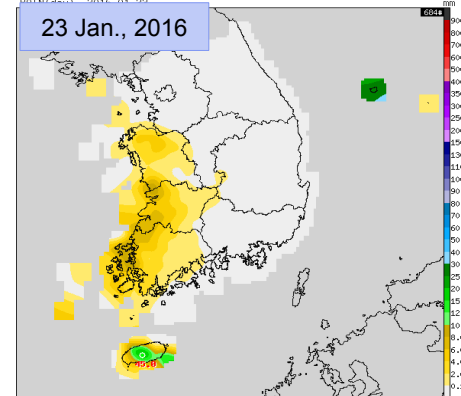
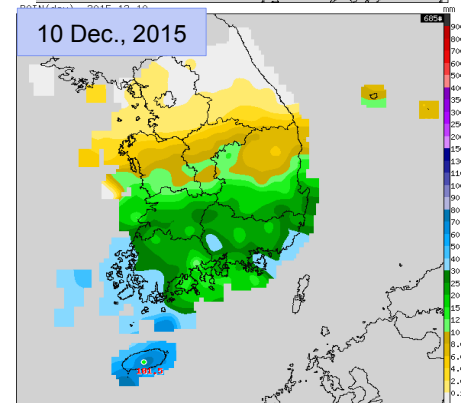
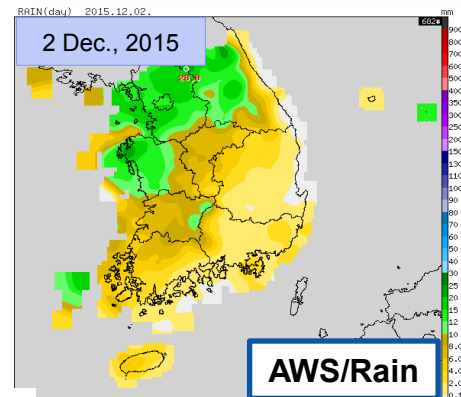
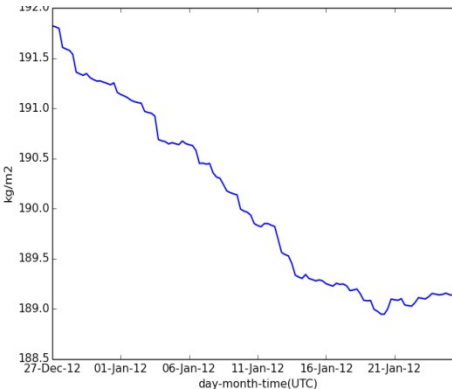
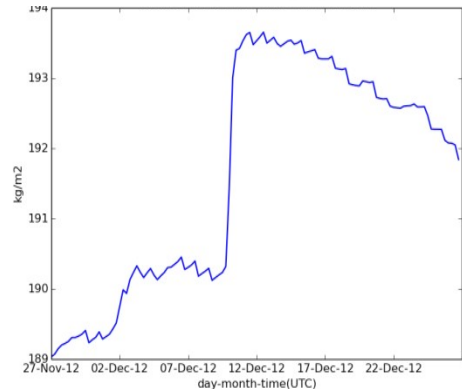
**Level1
(10cm)**



**Level2
(25cm)**



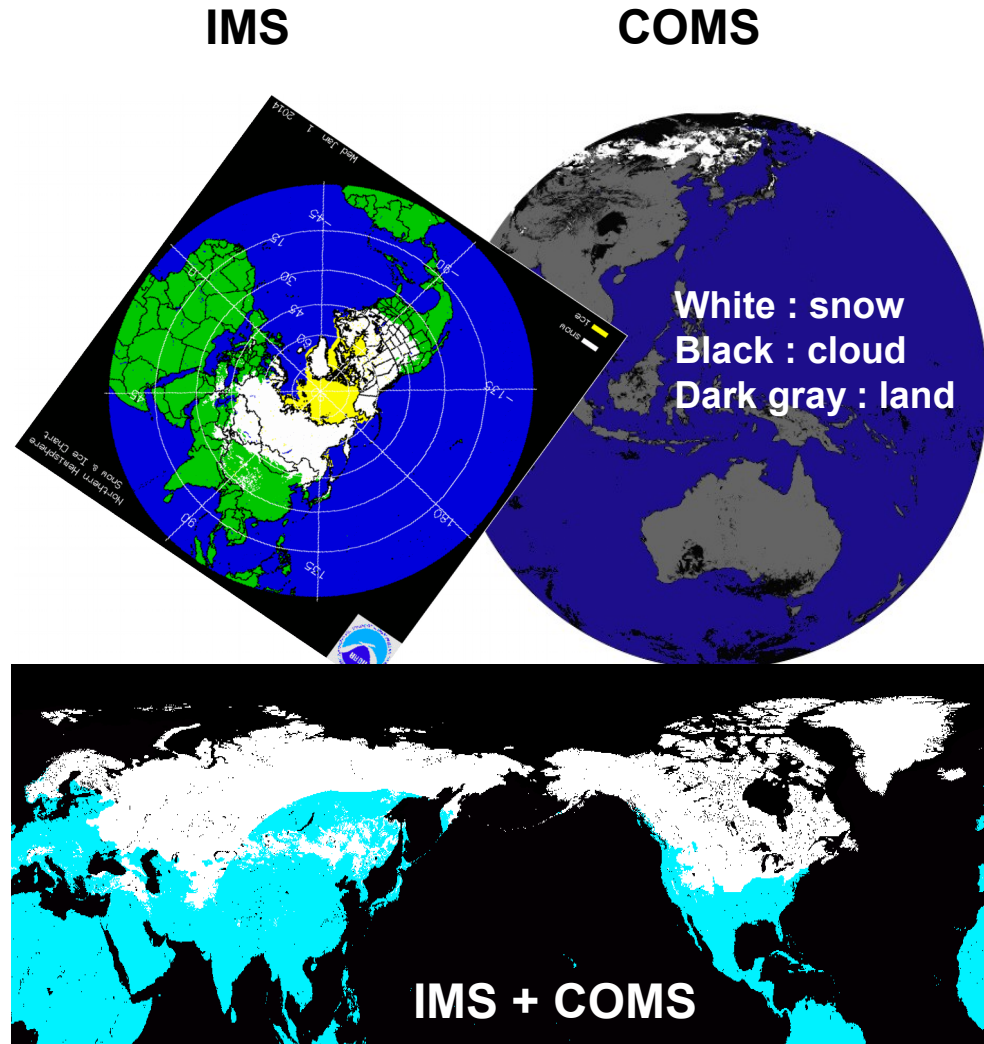
**Level3
(65cm)**



Application of COMS snow cover

Background

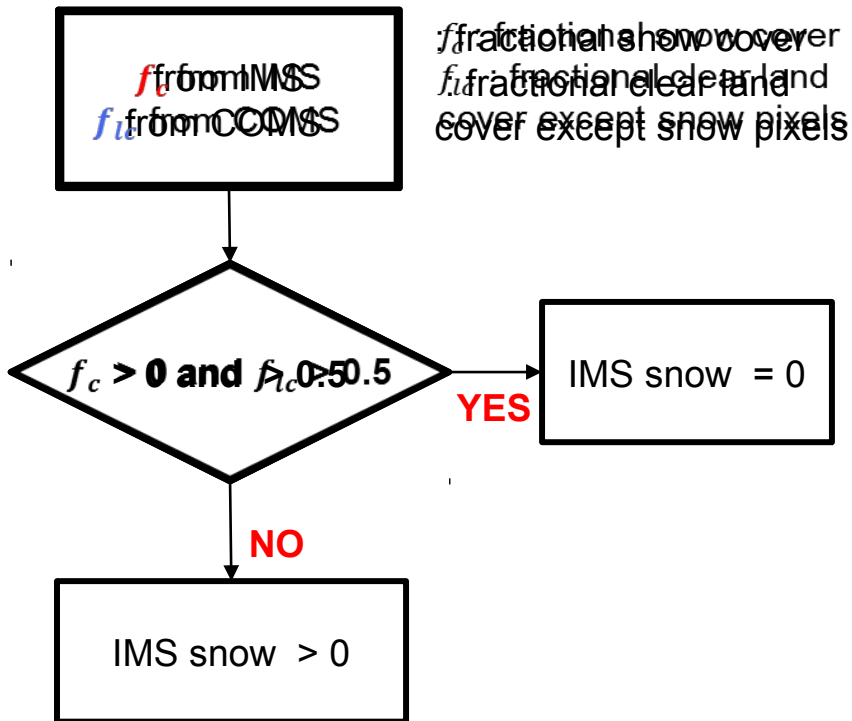
- UM snow shows that snow cover formed build-up too quickly in the winter and melted far too rapidly in the spring.
 - Met Office developed snow analysis scheme using IMS snow data to improve the model representation of snow cover at analysis time (Met Office Technical Report).
 - IMS snow tends to overestimate the snow covered area against ground observations (Chen *et al.*, 2015, Yang *et al.*, 2015).
 - Analysis of COMS snow shows about 0.7-0.8 of a POD (Probability of Detection) compare to IMS and MODIS snow.
- ➔ **Adjustment of IMS snow using COMS data over East Asian region.**



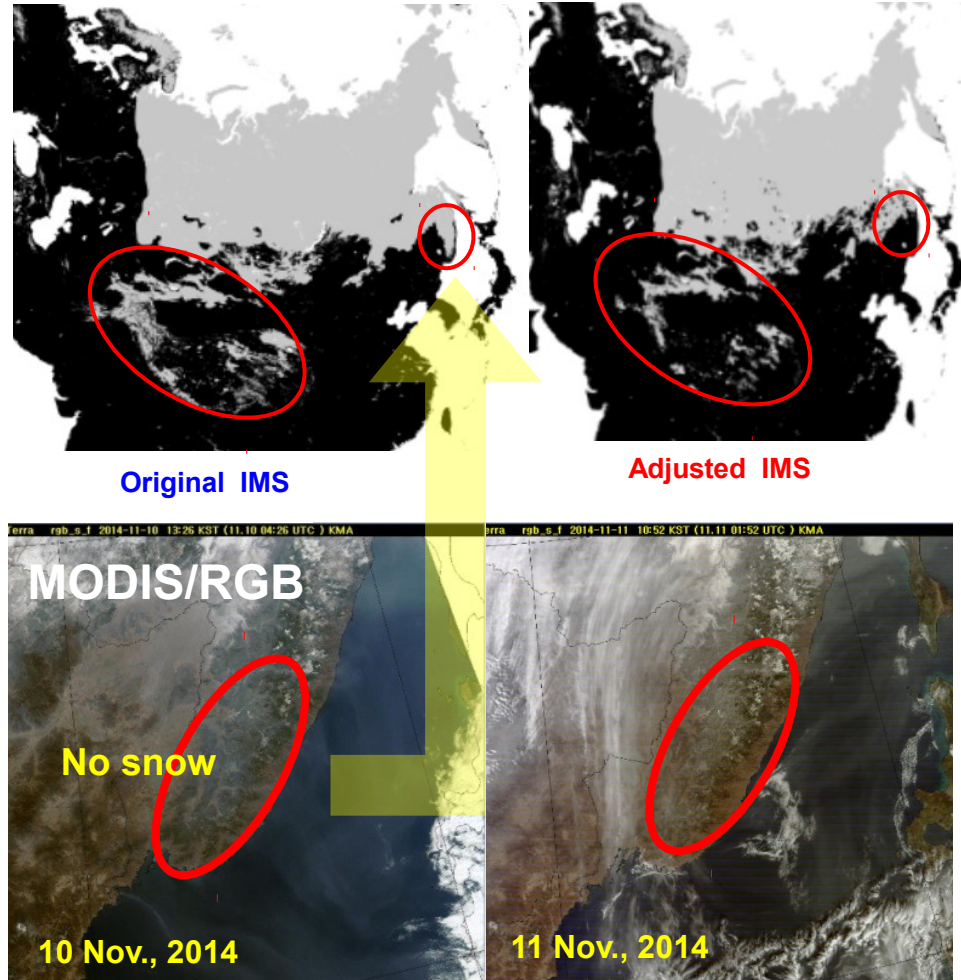
Application of COMS snow cover

[Experiment] Adjustment of IMS snow with COMS snow

- Model : Global
- Period : 11 Nov., 2014 ~ 31 March, 2015



Adjustment results (10 Nov., 2014)



Impact of COMS snow

Global

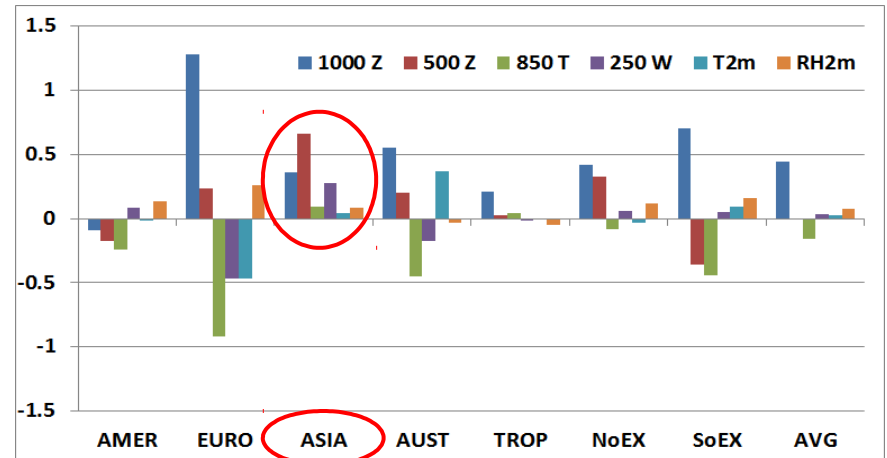
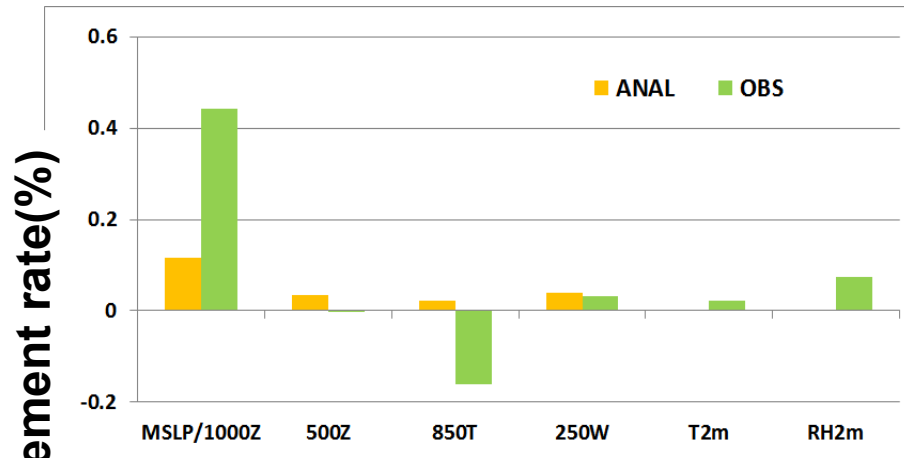
Regional

Positive : Improved

SNOW build-up

[24/11/14 – 20/12/14]

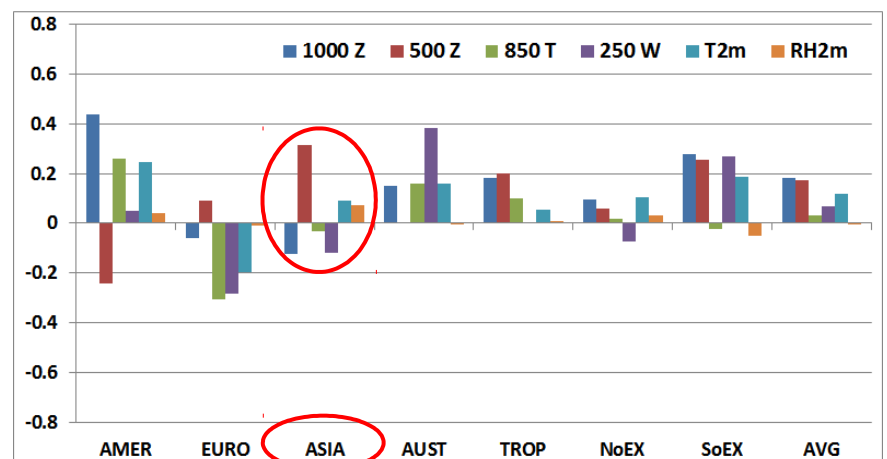
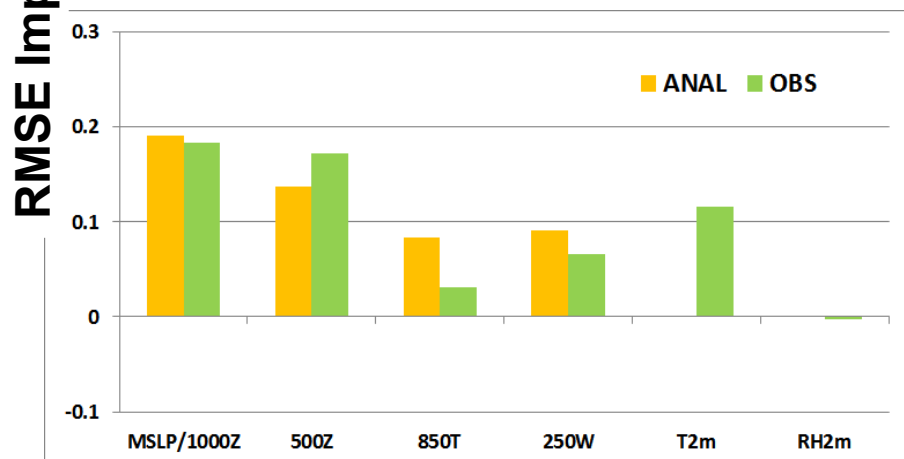
OBS



ALL

[23/11/14 – 23/03/15]

OBS



Impact of COMS snow

Asia

Positive : Improved

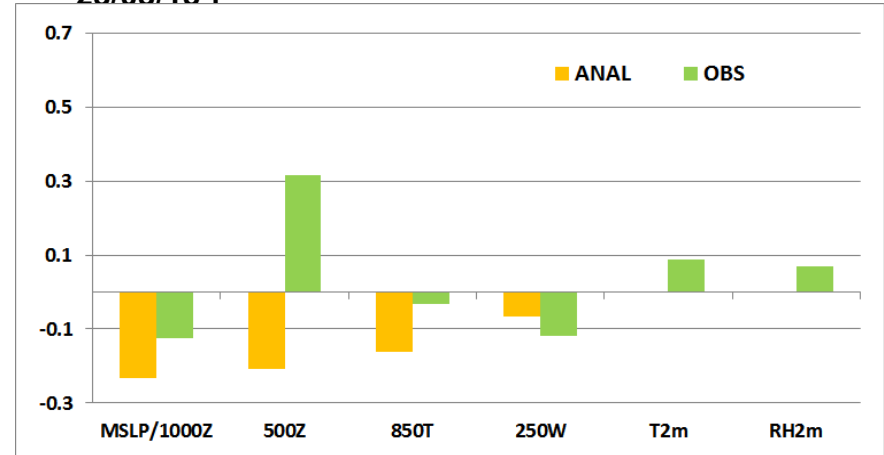
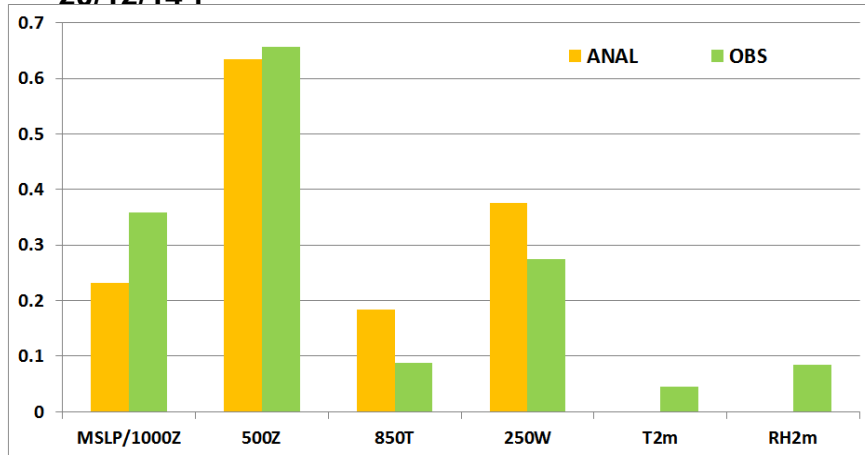
SNOW build-up

[23/11/14 – 20/12/14]

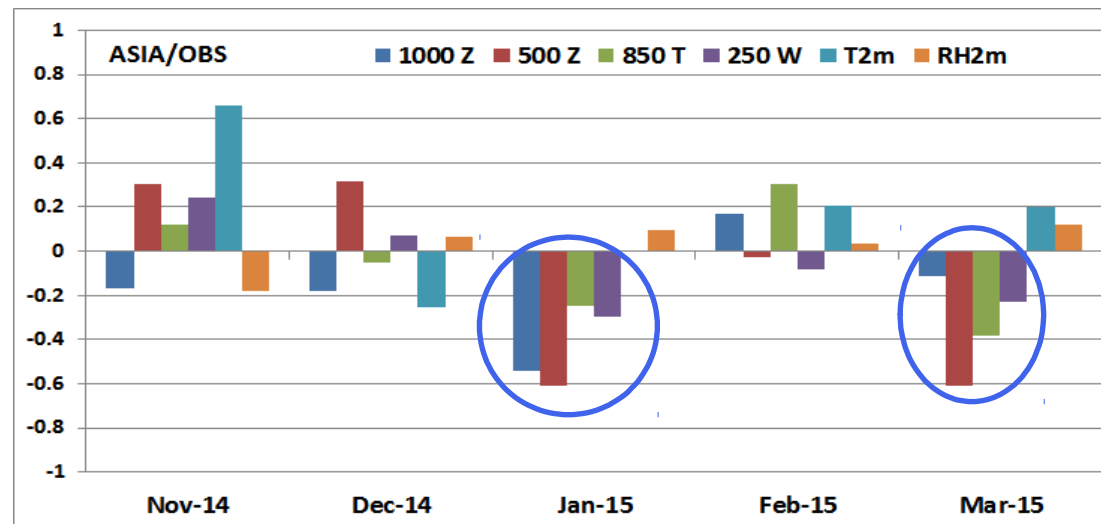
ALL

[23/11/14 – 23/03/15]

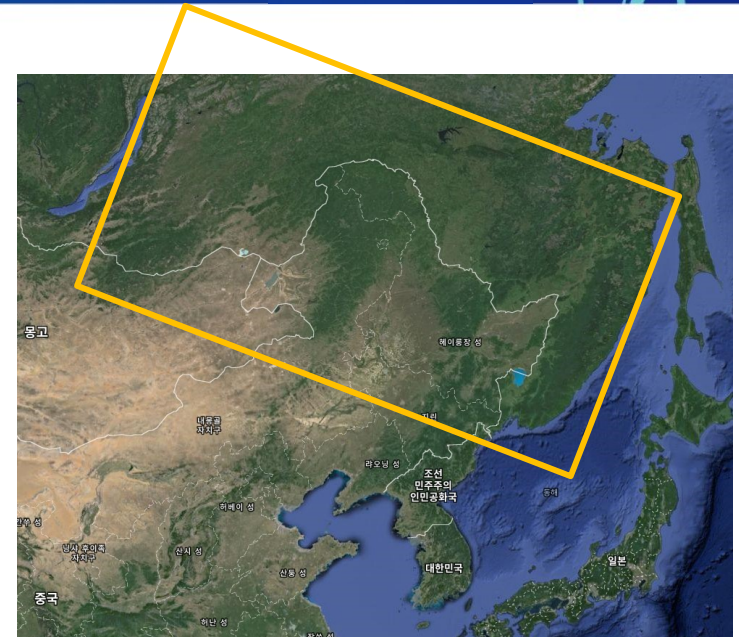
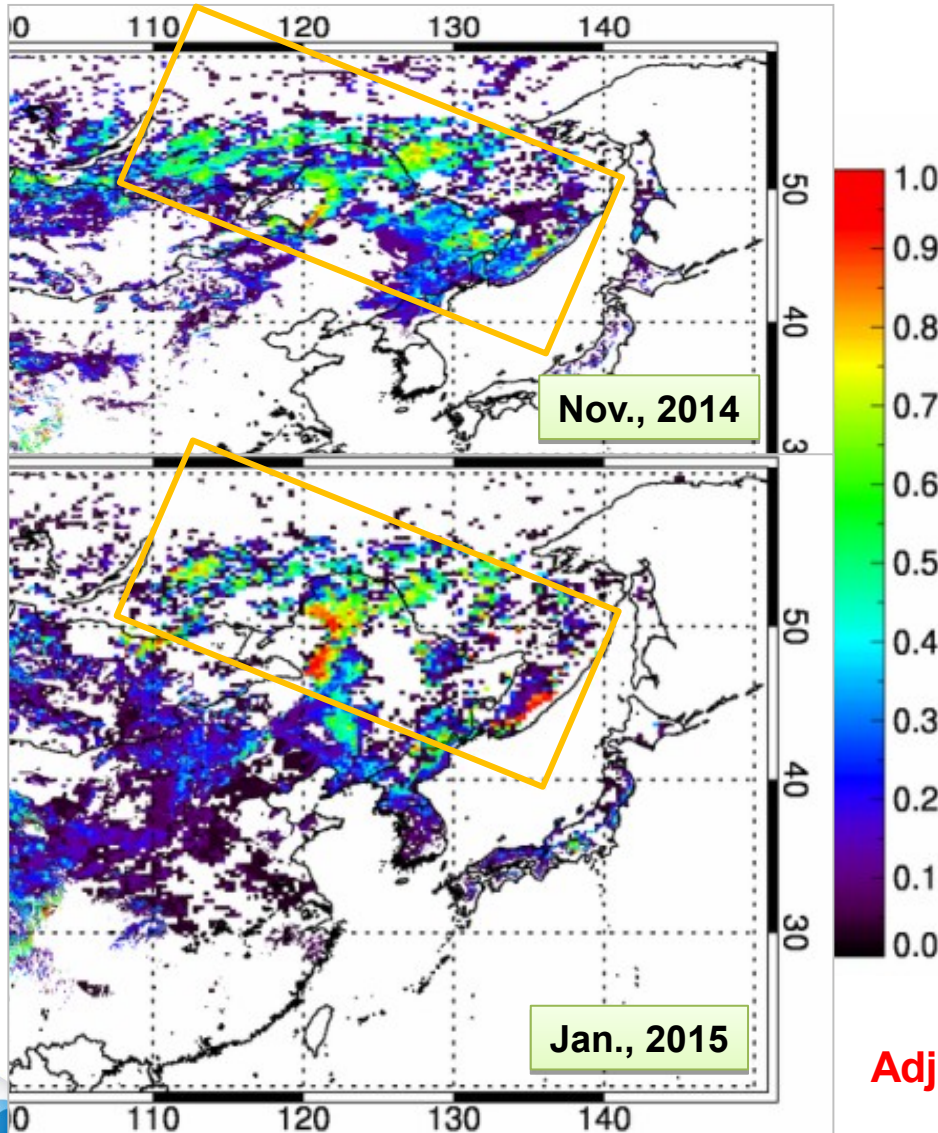
RMSE Improvement rate(%)



Monthly (OBS)



Characteristics of Adjustment



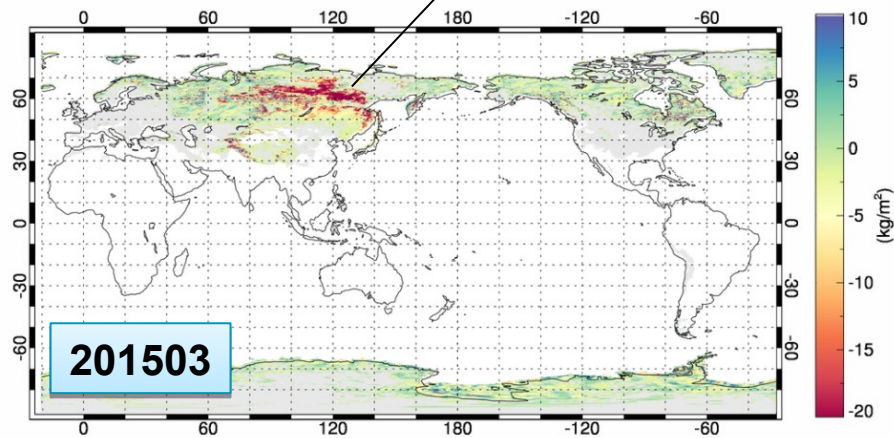
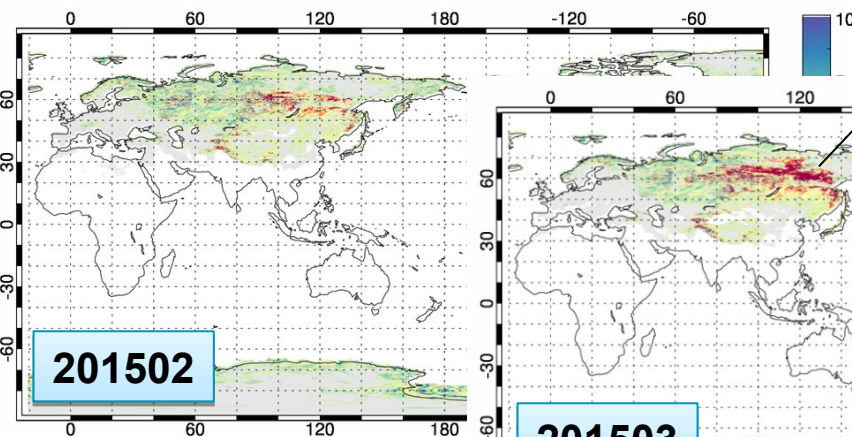
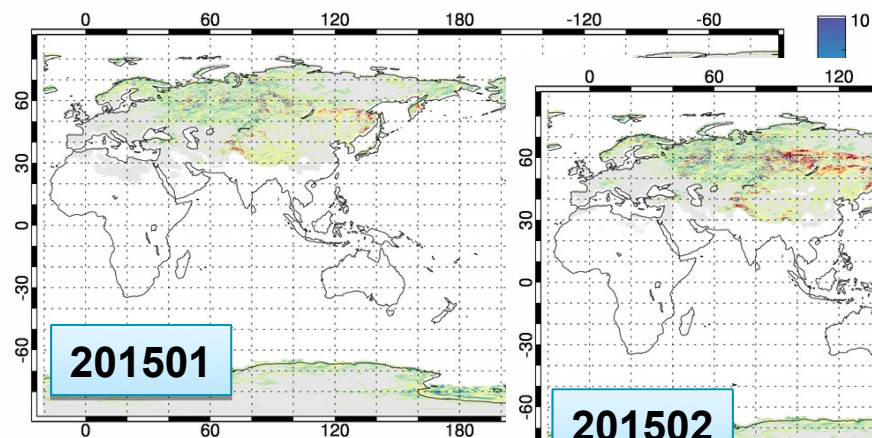
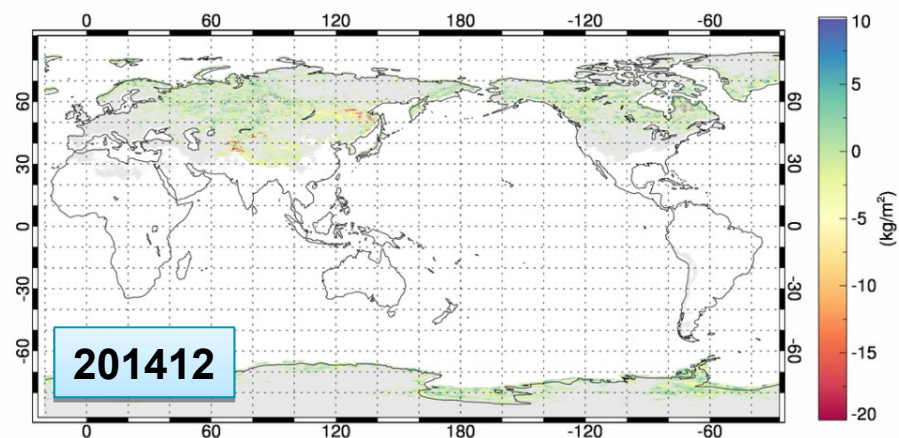
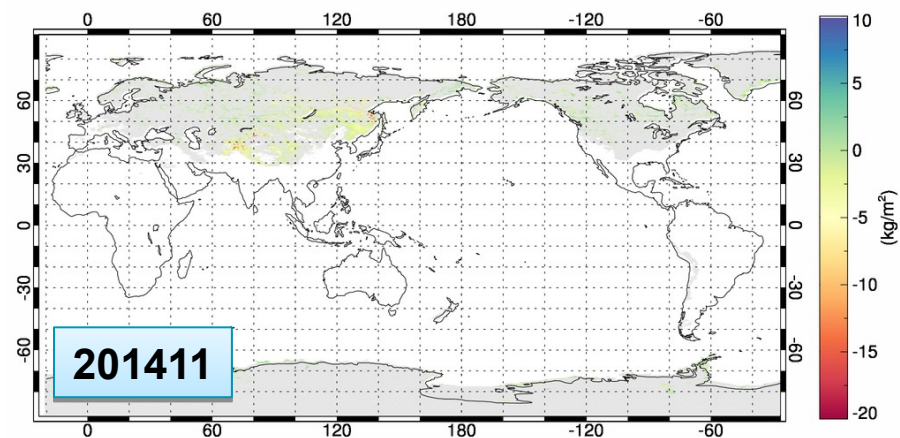
Probability of IMS adjusted by
COMS data is increasing.

It will need to check the accu-
racy of COMS snow in vegeta-
tion region.

Adjustment probability

Mean Differences of Analyzed Snow Amount(S_a) Between Control and Experiment

[Experiment – Control, gray color : $-0.5 < \text{mean difference} < 0.5$]



Snow amount was decreasing
in experiment.

Mean Difference and SD of S_r and T_s : Global

[Experiment – Control]

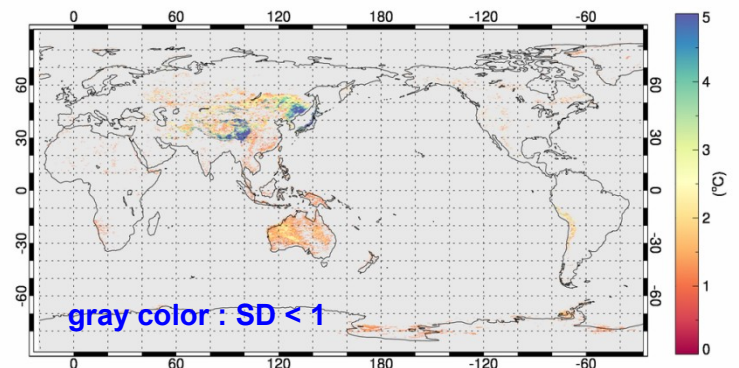
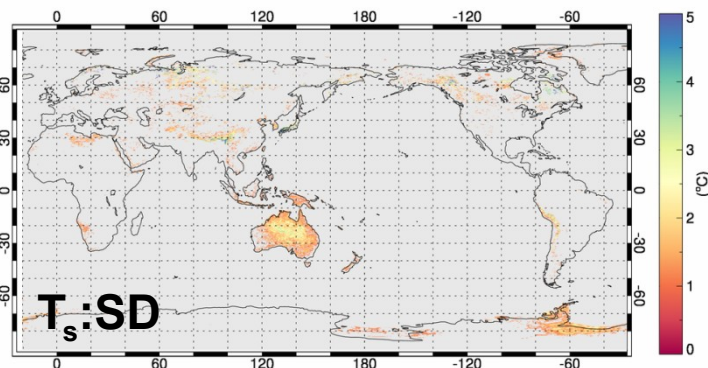
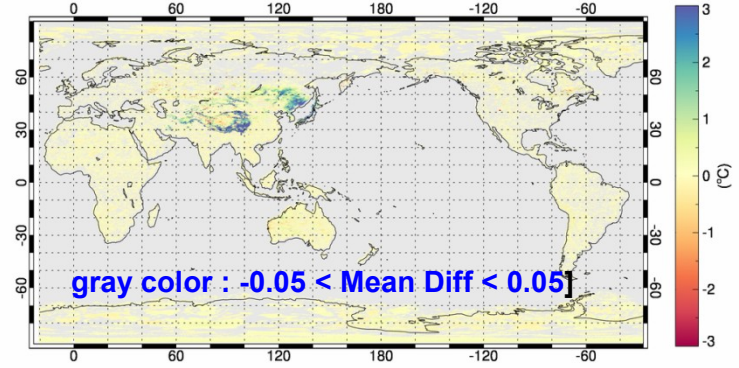
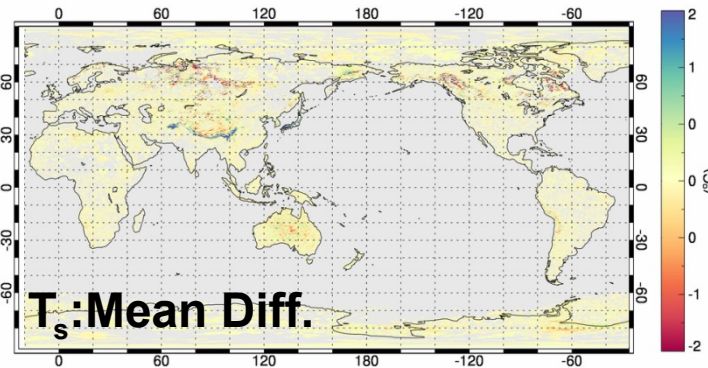
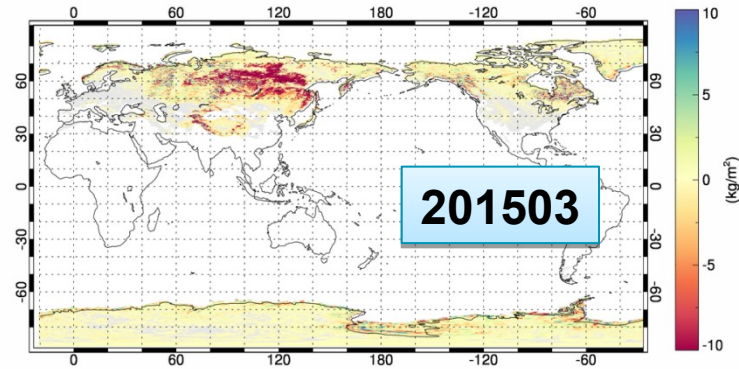
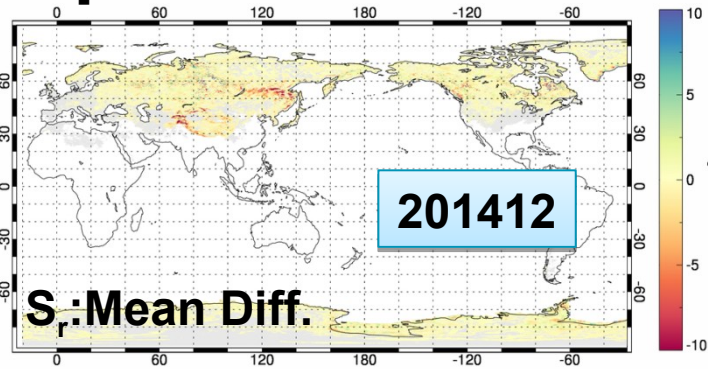
UM model input :

S_r :
snow amount reconfigured by S_a

T_s :
surface temperature affected by S_r

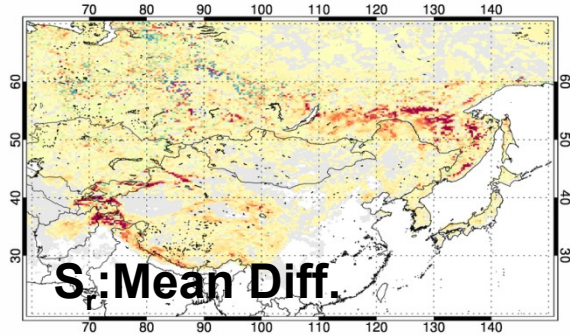
Mean Difference :
Monthly mean difference between control and experiment

SD :
Standard deviation of differences of T_s

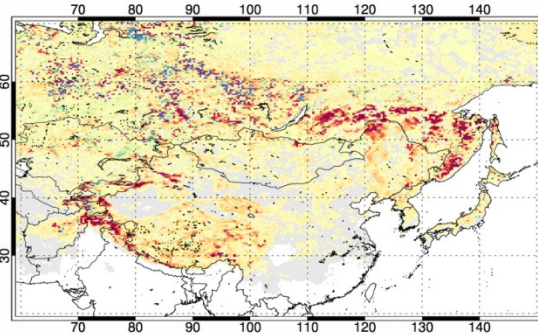


Mean Difference and SD of S_r and T_s : Asia

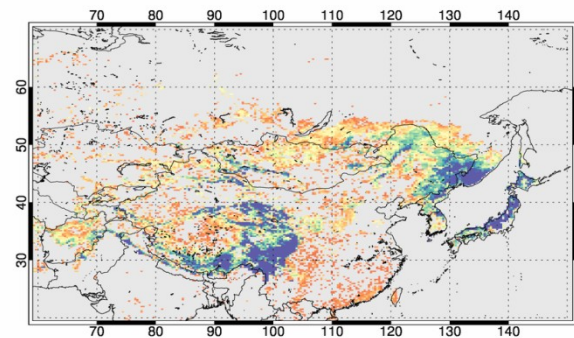
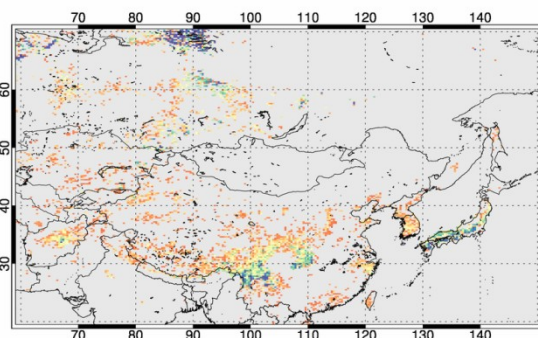
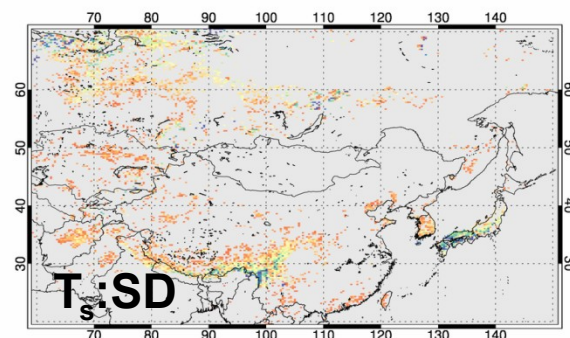
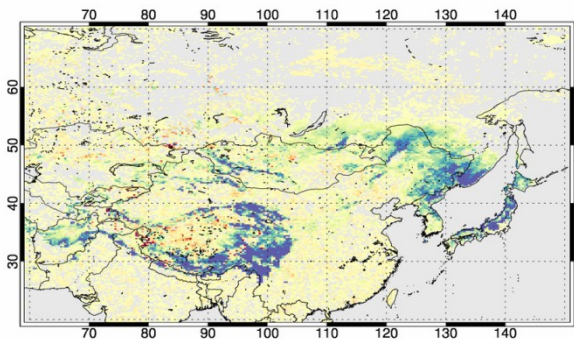
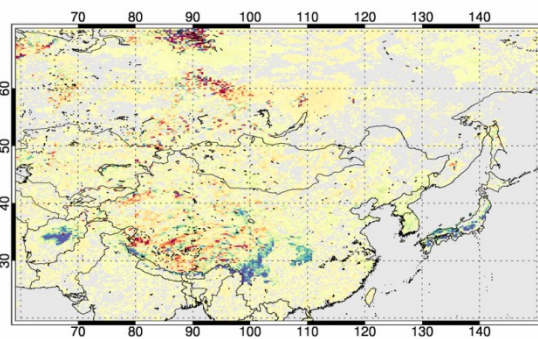
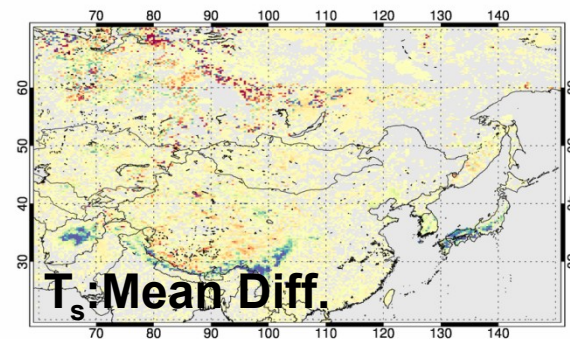
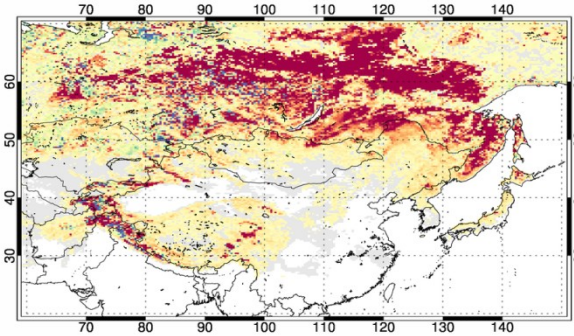
201412



201501



201503



[Experiment - Control]

Summary and Future Plans

- KMA conducted two experiments using **MetOp-B/ASCAT soil wetness** and **COMS snow cover** to improve surface data assimilation in global NWP system.
- **Impacts of soil moisture** experiment were a **slightly positive in fall** and **slightly negative in summer** (neutral).
- KMA has been operationally used **MetOp-B/ASCAT soil wetness** in global NWP system **since July 2015**.
- **Snow experiment** with COMS data shows a **significant positive impacts** for all components **over global area**. However, it is **not good performance in January and March over Asia region**. Related to this result, the research on the relationship between S_r and T_s in the process of reconfiguration will be performed.
- KMA has a plan to study on **diagnosis for surface data** to understand the effects in model and to apply **EKF scheme in local model** using AMSR2, SMOS, and so on.

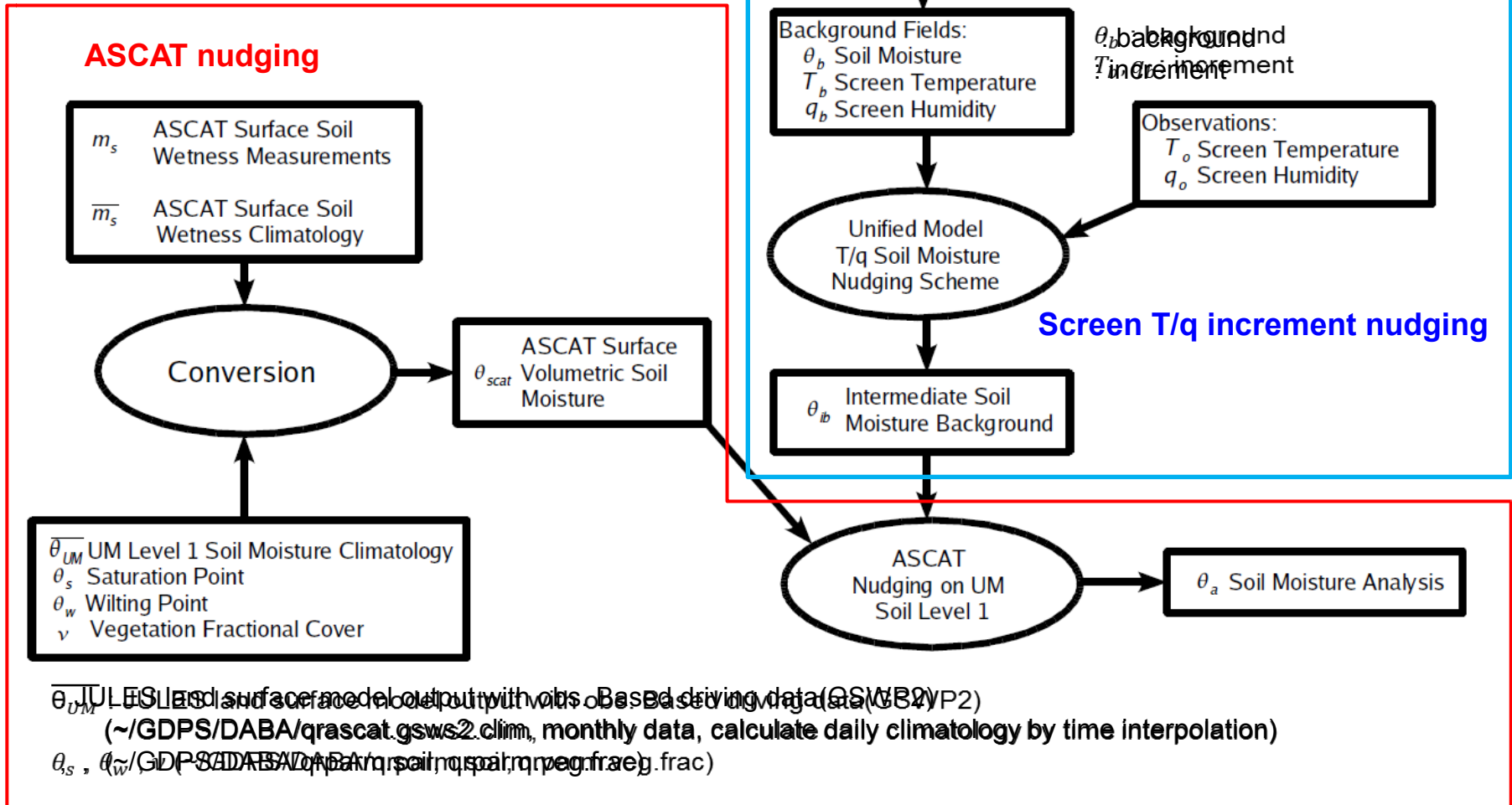
Thank you for your attention !!

Backup

Nudging Scheme with screen T/q increment and ASCAT SM

[Referenced by Met-Office Technical Report]

m_s ASCAT observation (kg/kg/m^2)
 $(\text{ascat_yyyymmdd_hhmm00_metopa_orbit_eps_o_125.12_buf})$
 \bar{m}_s Mean soil moisture (m^3/m^3) derived only time period of ERSST1/2
 $(\text{MEAN_SRFC_SOIL_MSTR;buf code 40003})$



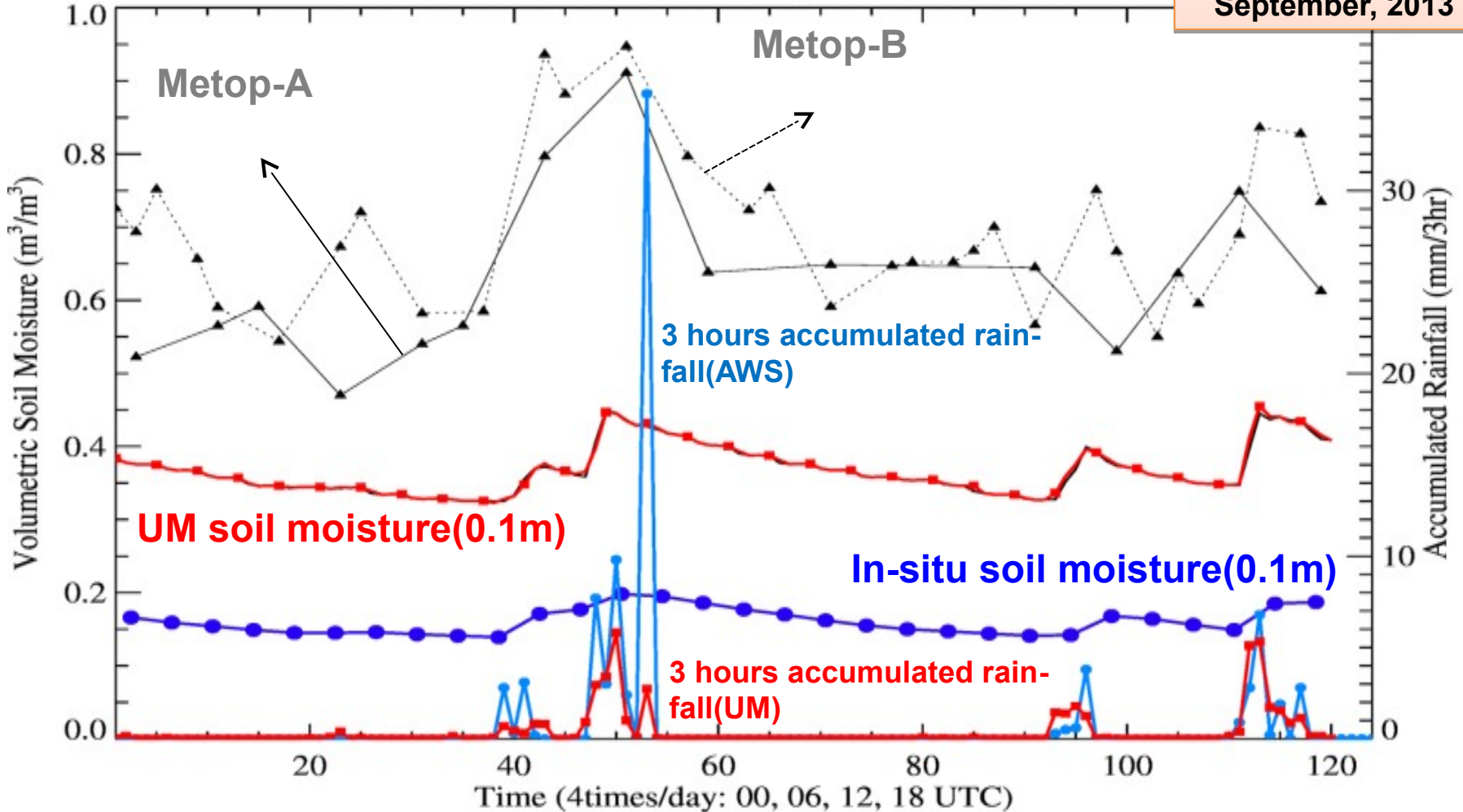
Timeseries of Soil Moisture and Rainfall



2

Chuncheon
September, 2013

Timeseries of Forecast and In-situ soil moisture



Convert to snow amount from snow cover

IMS V2 grib2 : Snow cover, unit % (0 or 100)

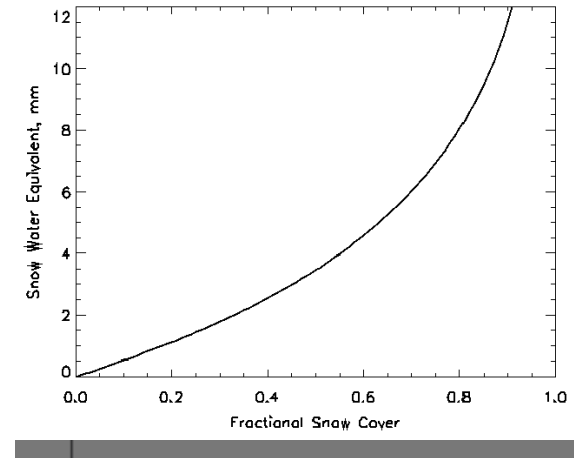
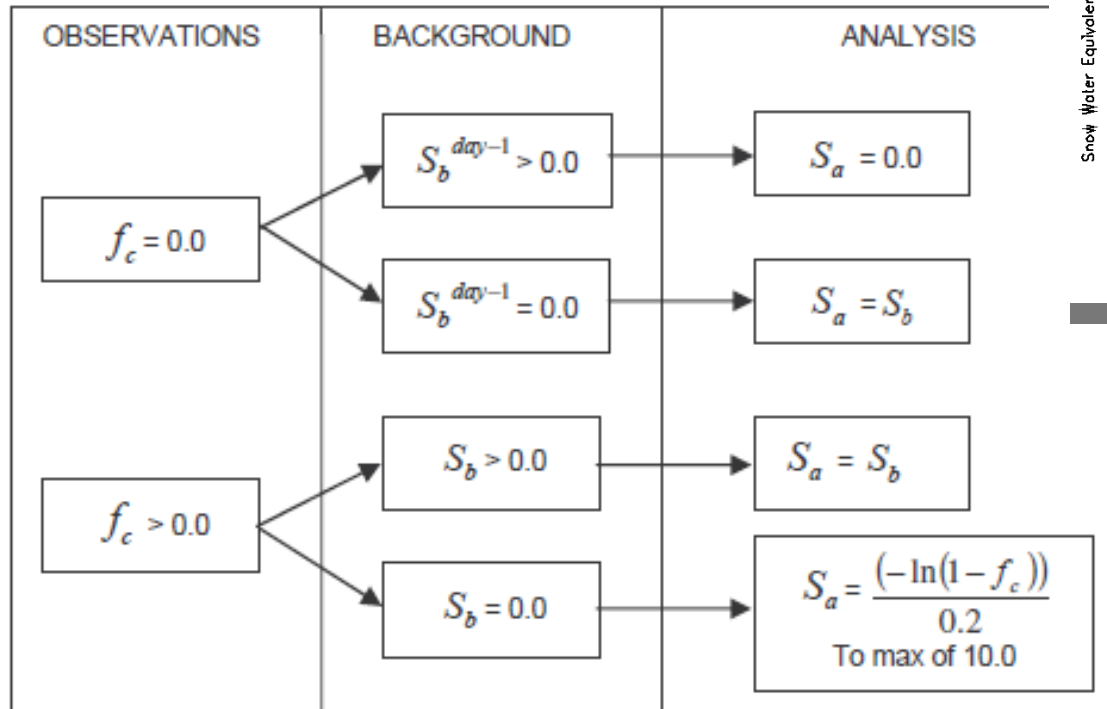
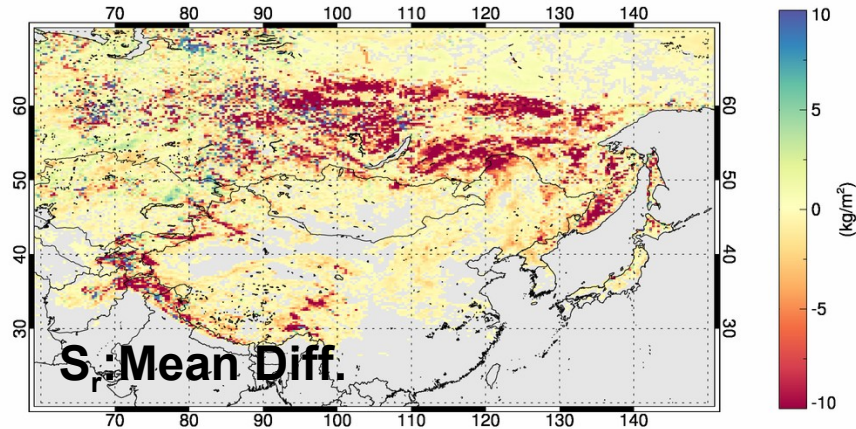


Figure 17. Schematic diagram showing how the upgraded snow analysis would work, where f_c = fractional cover, S_b = background snow amount and S_a = analysed snow amount.

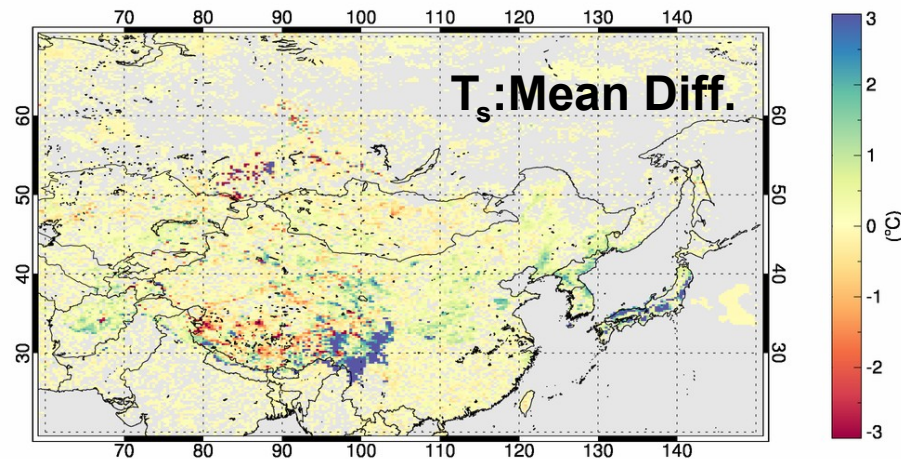
Mean Difference and SD of S_r and T_s : Asia

201502

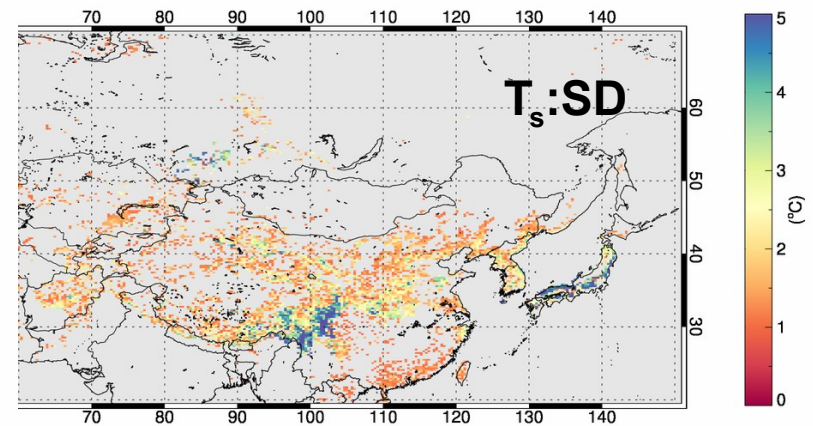
Mean difference between background snow amount : 201502



Mean difference between background surface temperature : 201502



D of mean difference between background surface temperature : 201502



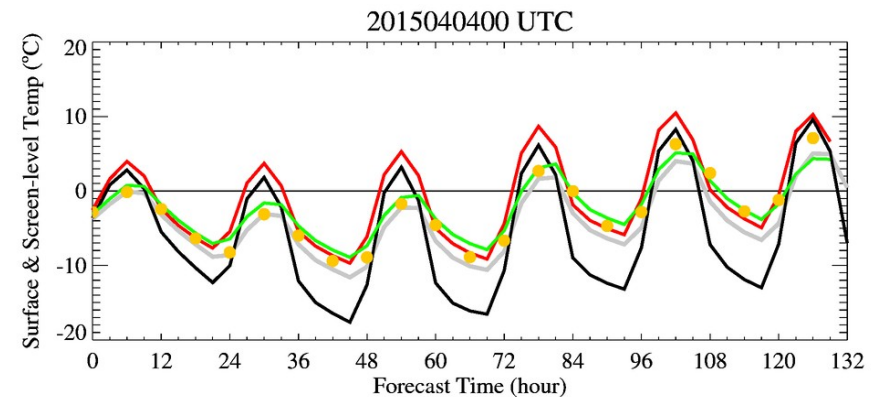
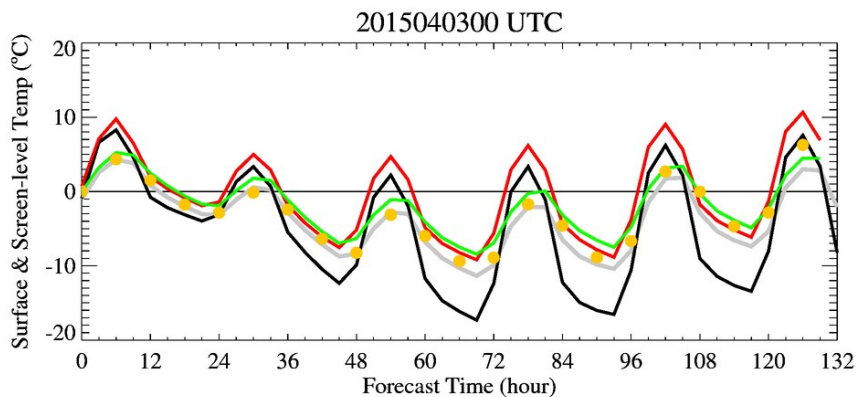
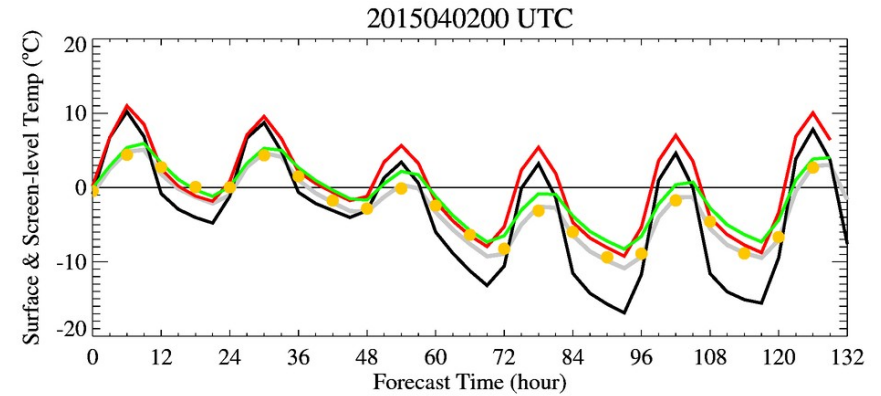
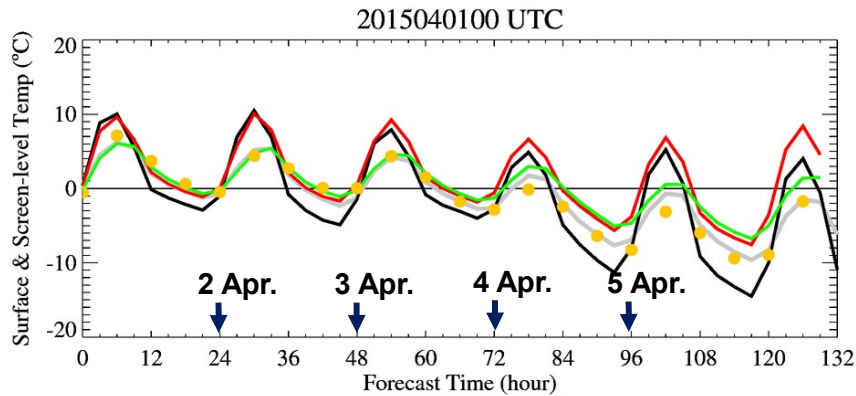
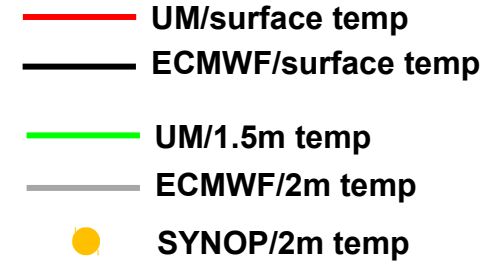
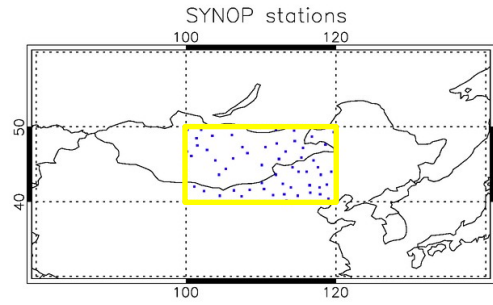
[Experiment – Control]

Timeseries of Forecasts of UM and ECMWF

UM vs ECMWF Forecast

: surface temperature

: screen-level(1.5m) temperature

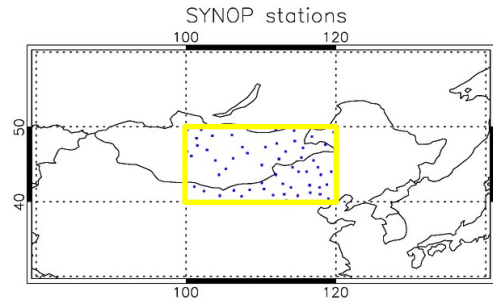


Timeseries of Forecasts of UM and ECMWF

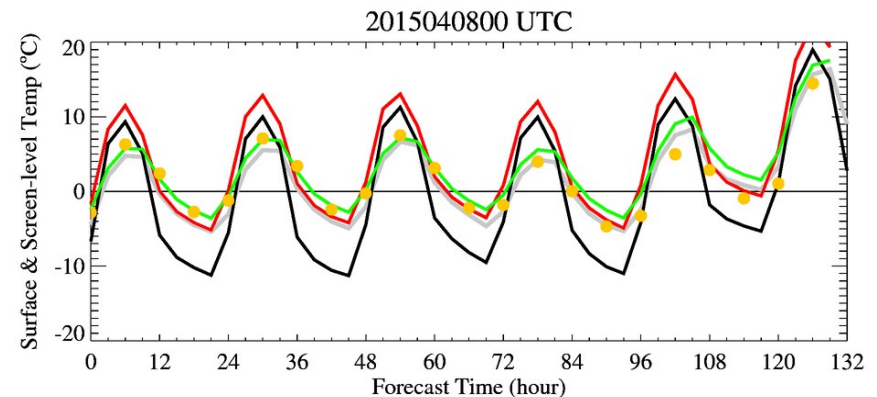
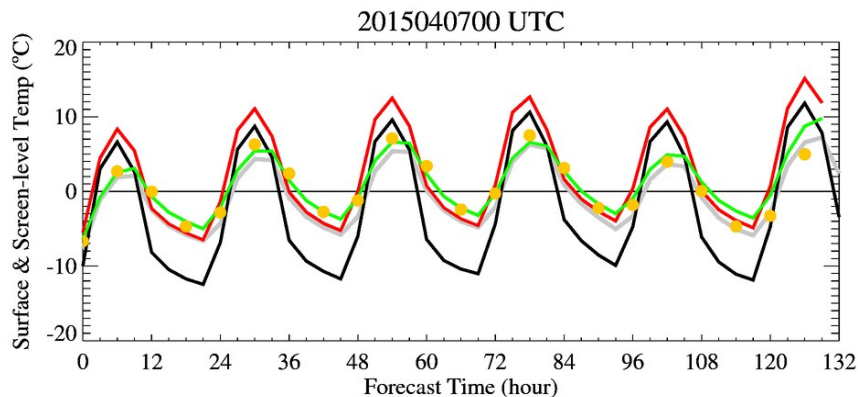
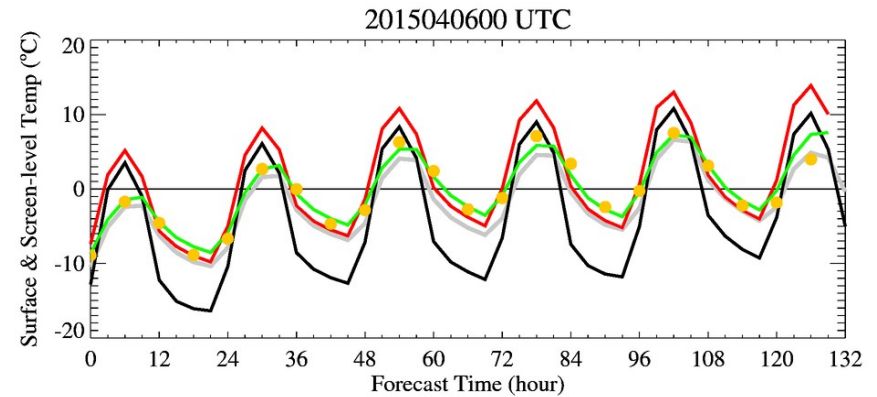
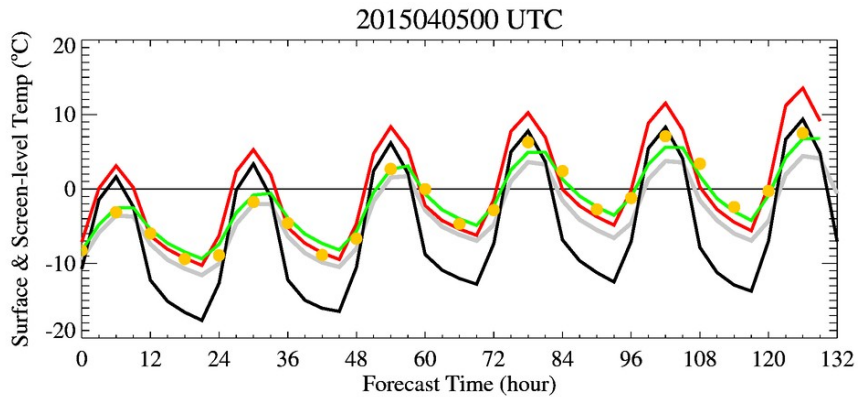
UM vs ECMWF Forecast

: surface temperature

: screen-level(1.5m) temperature



- UM/surface temp
- ECMWF/surface temp
- UM/1.5m temp
- ECMWF/2m temp
- SYNOP/2m temp

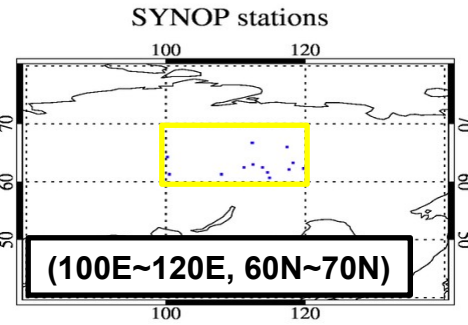


Timeseries of Forecasts of UM and ECMWF

UM vs ECMWF Forecast

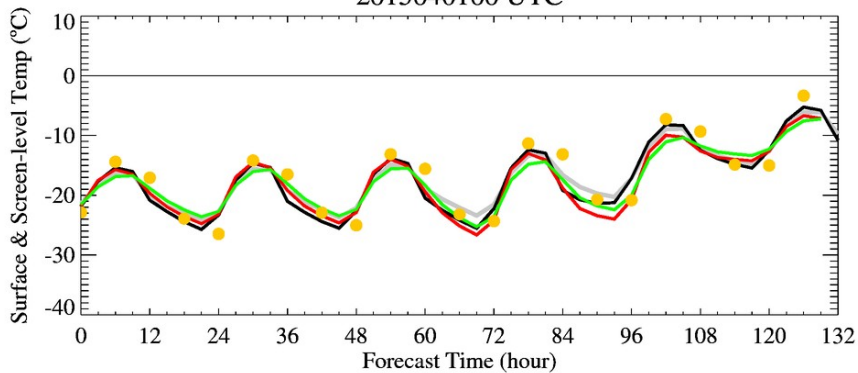
: surface temperature

: screen-level(1.5m) temperature

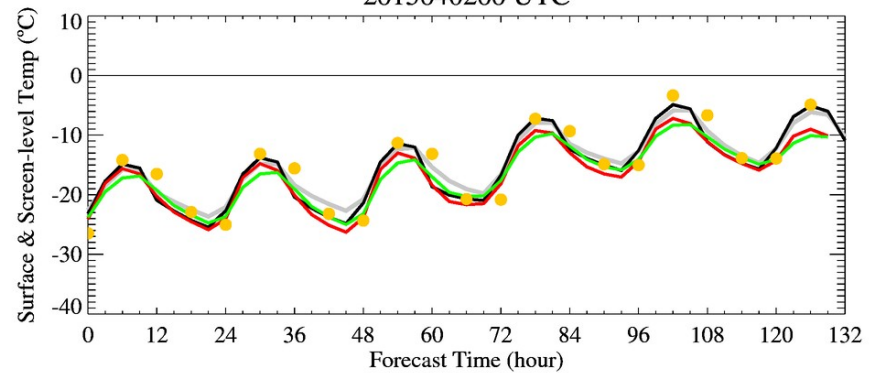


- UM/surface temp
- ECMWF/surface temp
- UM/1.5m temp
- ECMWF/2m temp
- SYNOP/2m temp

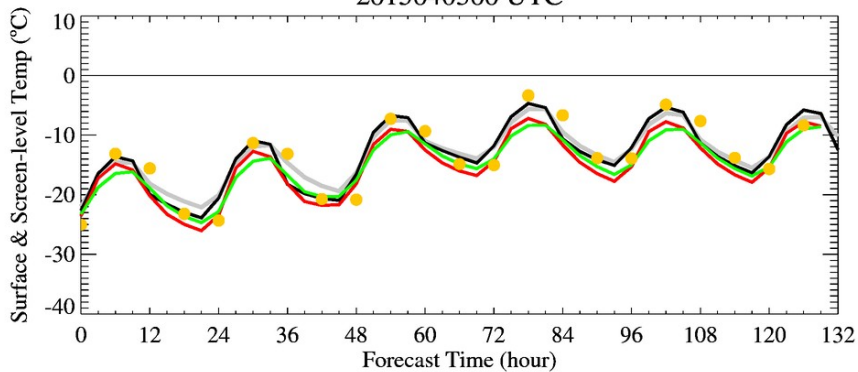
2015040100 UTC



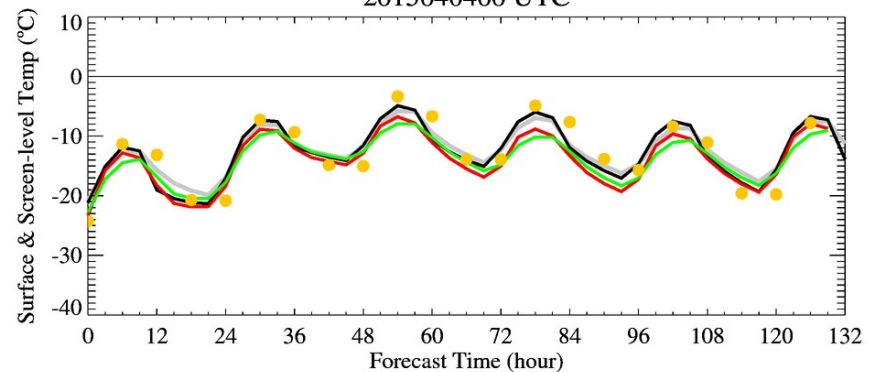
2015040200 UTC



2015040300 UTC



2015040400 UTC



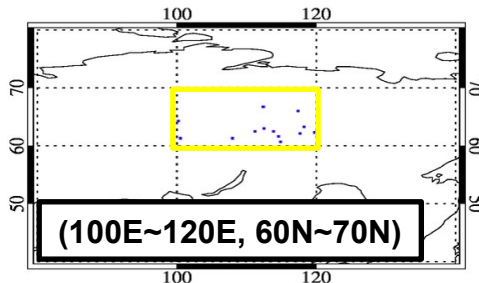
Timeseries of Forecasts of UM and ECMWF

UM vs ECMWF Forecast

: surface temperature

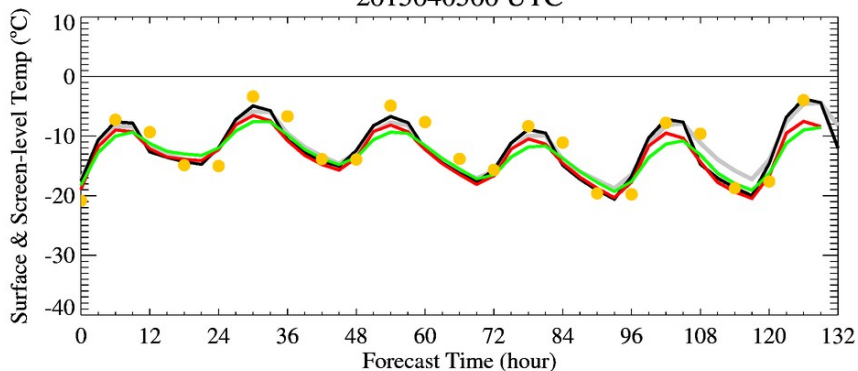
: screen-level(1.5m) temperature

SYNOP stations

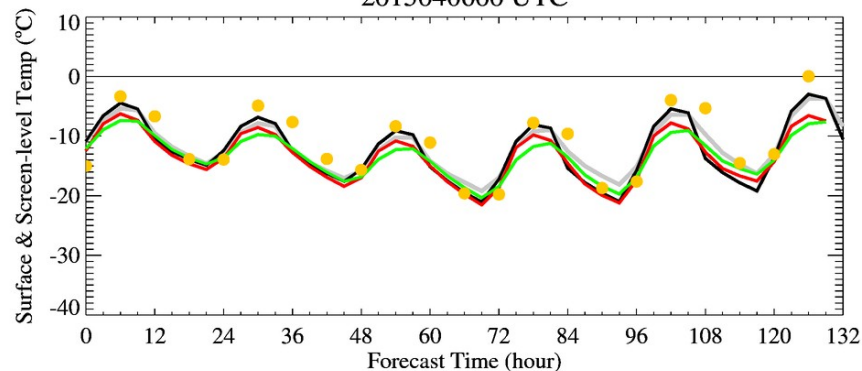


- UM/surface temp
- ECMWF/surface temp
- UM/1.5m temp
- ECMWF/2m temp
- SYNOP/2m temp

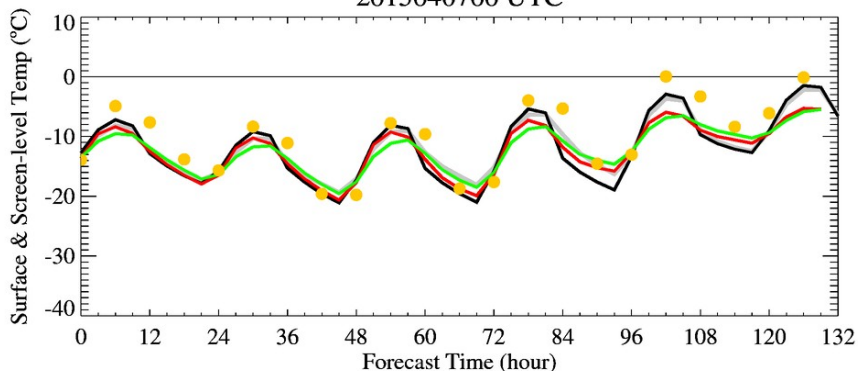
2015040500 UTC



2015040600 UTC



2015040700 UTC



2015040800 UTC

