Development of the SSMIS processing system and their impacts on the 3DVAR in KIAPS

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KPOP-SSMIS processing system

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- **KPOP**(**K**IAPS **P**ackage for **O**bservation **P**rocessing)
  - orbit angle calculation module developed (thanks to NRL and MetOffice)
  - bias correction using FFT(Fast Fourier Transform) to the orbit-angle
    → bc coefficients and departure STDs are stored for the pre-bc/qc (in 24Hr)
  - calculate ascending/descending node from difference of two ephemeris latitudes
  - LAS(lower atmosphere sounding) T channels(2-7) can be processed in KPOP
  - Cubed-sphere element based horizontal thinning method are used

- **SSMIS**(**S**pecial **S**ensor **M**icrowave **I**mager/**S**ounder) for KIAPS DA system
  - KMA(Korea Meteorological Administration) ingested BUFR typed obs. Data from UKMO and NESDIS/NOAA

- **DA impacts** are investigated
  - on KIAPS-3DVAR system for the **KIM**(**K**orean **I**ntegrated **M**odel)
  - KIM consists of a spectral element non-hydrostatic dynamical core on a cubed-sphere
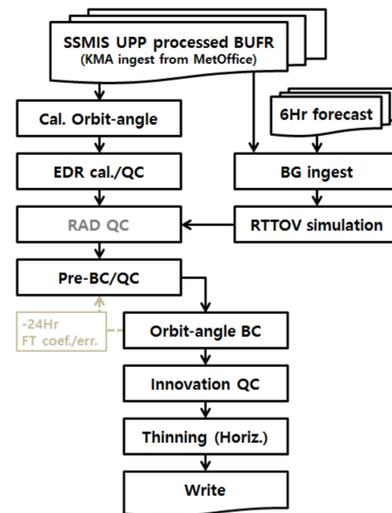 - DA experiments for cycle, cold, and case study are conducted in this study

Fig. 1. block diagram for the SSMIS processing in KPOP

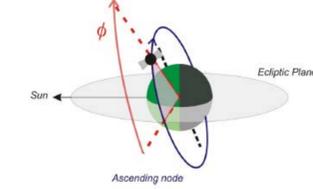- SSMIS bias correction using FFT(Fast Fourier Transform) with orbit-angle

Fig. 2. Sketch of the satellite orbiting the earth, with the satellite making an angle Φ about the orbital track, relative to the intersection of the satellite's ascending node with the ecliptic plane. (Anna Booton)
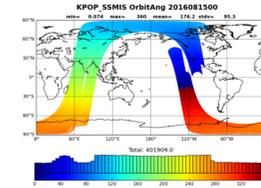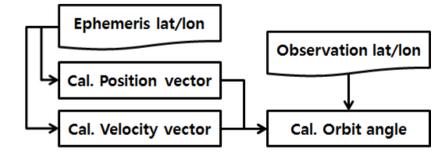

Fig. 3. block diagram for the orbit angle calculation

$$f(t) = a_0 + \sum_{n=1}^{\infty} a_n \cos(nt) + b_n \sin(nt)$$

$$a_0 = \frac{1}{T} \int_0^T f(t) dt$$

$$a_n = \frac{2}{T} \int_0^T f(t) \cos(nt) dt$$

$$b_n = \frac{2}{T} \int_0^T f(t) \sin(nt) dt$$

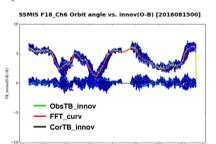
Fig. 5. spatial distribution of calculated orbit angle

Fig. 4. 2D histogram of Obs-Bkg TB departure plotted with regard to orbit-angle for data accumulated for F18 SSMIS Ch.6. Fourier series are over plotted in red, as calculated for n=1-10.

Experimental design and Results

- **Experimental design**
  - 3DVAR experiment: cycle, cold and case study
    (KIAPS semi-operational DA system is Hybrid 4DEnVAR
    : data assimilation test for a new observation are conducted on 3DVAR first at KIAPS)

Experiment	Description	DA method
CTRL	SONDE, SURFACE, AIRCRAFT, SCATWIND, AMSUA, IASI, MHS, GPSRO w/o SSMIS	cycle
ExpOCN	CTRL + **SSMIS**, only over **ocean**	cycle & cold
ExpLND	CTRL + **SSMIS**, containing over **land**	case study

  * cold: no background at each analysis time (fixed background)

- **SSMIS observation status**
  - NOAA BUFR 2017040106 ~ 2017041000 period (DMSP F17)
    (TB profile compared wit MetOffice BUFR data - UPP Averaged?)

  - Monitor KPOP-SSMIS results [1/2]
    : departure mean, standard deviation for corrected/uncorrected obs. and observation errors that are used for innovation QC and DA
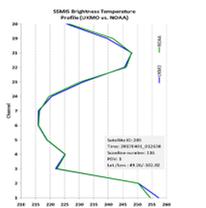

Fig. 6. SSMIS TB profiles from UKMO(B) and NOAA(G) BUFR at the same obs.
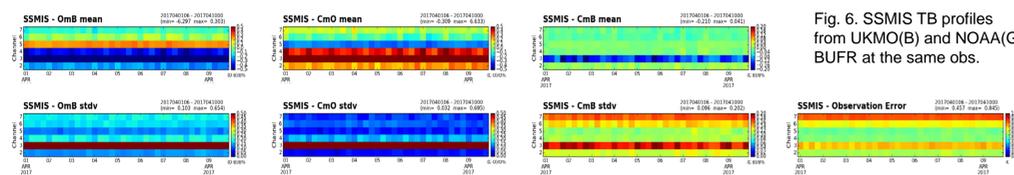

Fig. 7. KPOP-SSMIS radiance monitor. Departure mean(U) and stds(L) with observation error(R)

  - Monitor KPOP-SSMIS results [2/2]
    : spatial averaged departure mean and standard deviation for corrected/uncorrected obs.
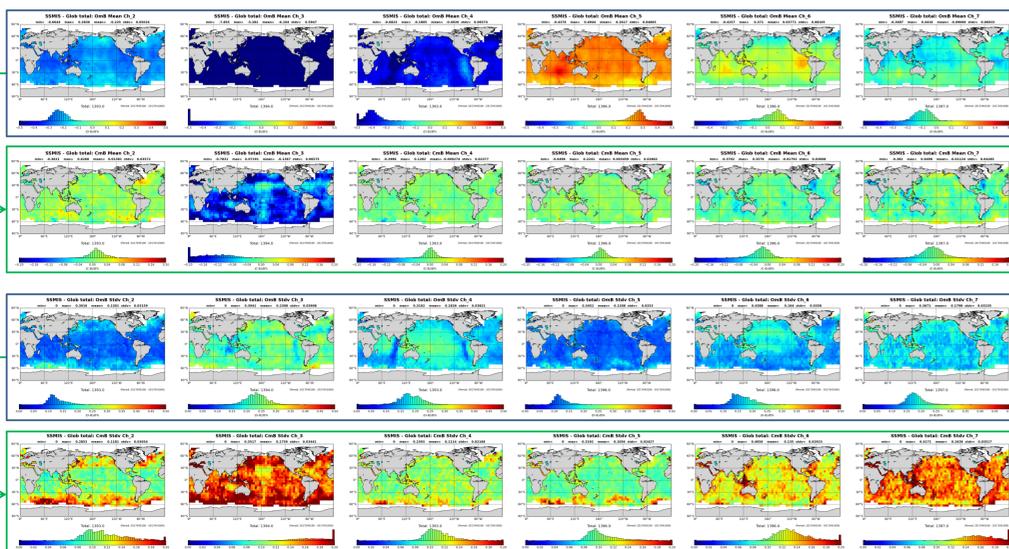   (5 x 5 degree rectangular (lat/lon) grid box averaged)

Fig. 8. spatial distribution of KPOP-SSMIS period averaged departure mean and standard deviation for corrected and uncorrected obs.

- **Application test on 3DVAR**
  - checkup the temperature jacobian
    : due to fail to minimization on 3DVAR for the channel 5~7
    → found "NaN" over land (on Antarctica in most & Greenland) but we didn't find any reasons causing fail to calculate Jacobian so, filtering out that observation pixels
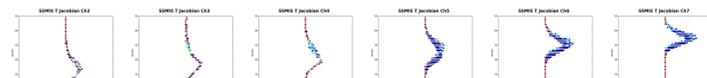

Fig. 9. temperature jacobian profiles for each channel when it contains land pixels(Ch. 5~7)
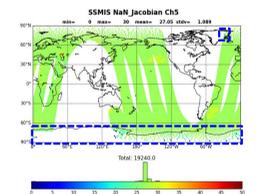

Fig. 10. T jacobian peaking level(G) with mark of "NaN"pixel(K)

  - Case study with ExpLND and ExpOCN (2017041006)
    : temperature analysis showed better impact on only ocean exp.
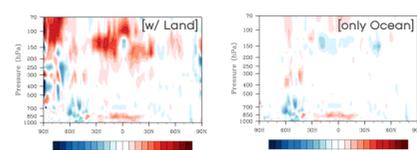   → reject over land and rainfall effected pixels through all LAS chan.

Fig. 11. temperature analysis zonal averaged RMSE difference (against ECMWF IFS) for ExpLND(L) and ExpOCN(R). blue color means improvement
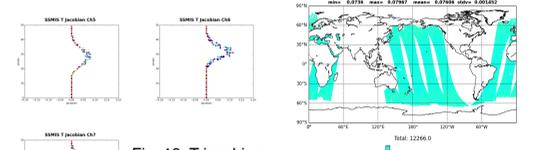

Fig. 12. T jacobian profiles for channel 5 to 7 without land pixels

Fig. 13. maximum T jacobian values for Ch.5

- **SSMIS DA impacts**
  - cold and cycling experiment are conducted
    → zonal averaged RMSE difference (Exp. – CTRL) (against IFS/ECMWF)
  - cold experiment period: 2017040106 ~ 2017040818
    → positive impacts at around 150 hPa tropics in most
  - cycle experiment period: 2017040106 ~ 2017040418
    → big positive impacts on geopotential height through the troposphere of SH T, q, and zonal wind(u) showed positive impacts as well
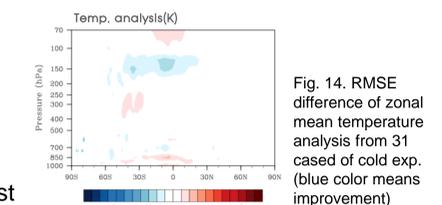

Fig. 14. RMSE difference of zonal mean temperature analysis from 31 cased of cold exp. (blue color means improvement)
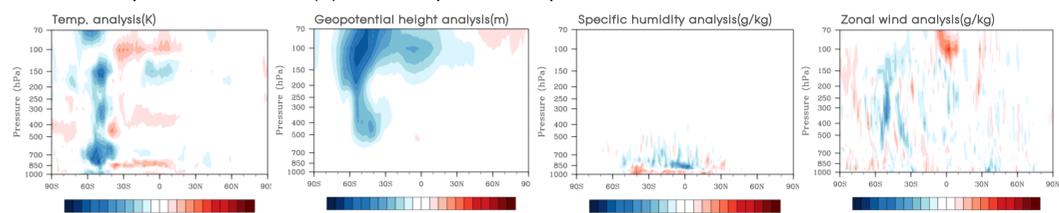

Fig. 15. RMSE difference of zonal mean T, z, q and u analysis from 15 cased of cycling experiment. (blue color means improvement)

Summary and Discussion

- KPOP-SSMIS is developed for the KIAPS DA system, with BC and Pre-BC/QC module using FFT
- Applied SSMIS LAS-T observation to KIAPS-3DVAR system and showed positive impacts
- **Future work**: investigate SSMIS observation DA impact on KIAPS Hybrid 4D-EnVar / Var-BC
- **Discussion:**
  - Why "NaN" jacobian, even if the TB simulations are succeeded
  - What can we do to assimilate the land pixels well.
  - How can we improve/reduce positive/negative impacts – more sophisticated BC/QC or Obs-Err?