The KIAPS Observation Processing System Development for the Data Assimilation

Jeon-Ho Kang, Hataek Kwon, Hyoung-Wook Chun, Ju-Hye Kim, and Sihye Lee

Korea Institute of Atmospheric Prediction Systems (KIAPS), Republic of Korea, jh.kang@kiaps.org

KIAPS
KOREA INSTITUTE OF ATMOSPHERIC PREDICTION SYSTEMS
www.kiaps.org

Introduction

The Korea Institute of Atmospheric Prediction Systems (KIAPS) was founded in 2011 by the Korea Meteorological Administration (KMA) for a nine-year (2011-2019) project to develop Korea's own global Numerical Weather Prediction (NWP) system.

Most meteorological observations contain errors and those errors varies depending on the type of observation.

Observation Processing System has a critical role which figures out the observation errors and corrects or filter out the bias from the raw data.

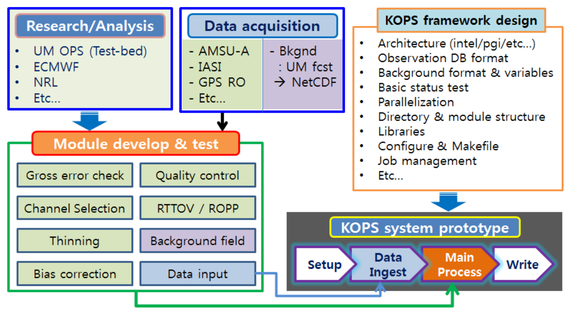
The KIAPS data assimilation team has been developing the KIAPS Observation Processing System (KOPS) to provide KIAPS data assimilation system with optimal observations.

At this stage, a prototype framework for the satellite radiance data (AMSU-A and IAIS), SONDE (Temp, Pilot, Wind profiler), and Global Positioning System Radio Occultation (GPS-RO) data processing system has been developed.

KOPS framework design

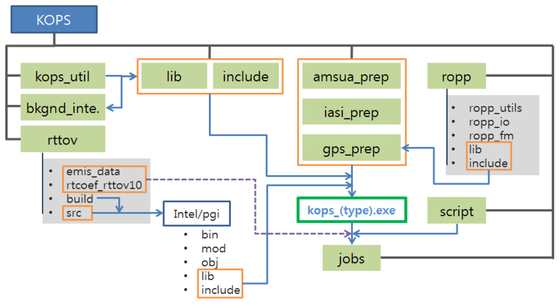
KOPS design and development plan

- study and analyze observation processing systems of advanced operational institutes (MetOffice, ECMWF, NRL, etc…)
- develop individual modules for the specific processing steps (err check, QC, thinning , BC, obs. operators, …)
- acquisition of observation database (BUFR) and model forecast (KMA operational forecast model)



Prototype of KOPS framework

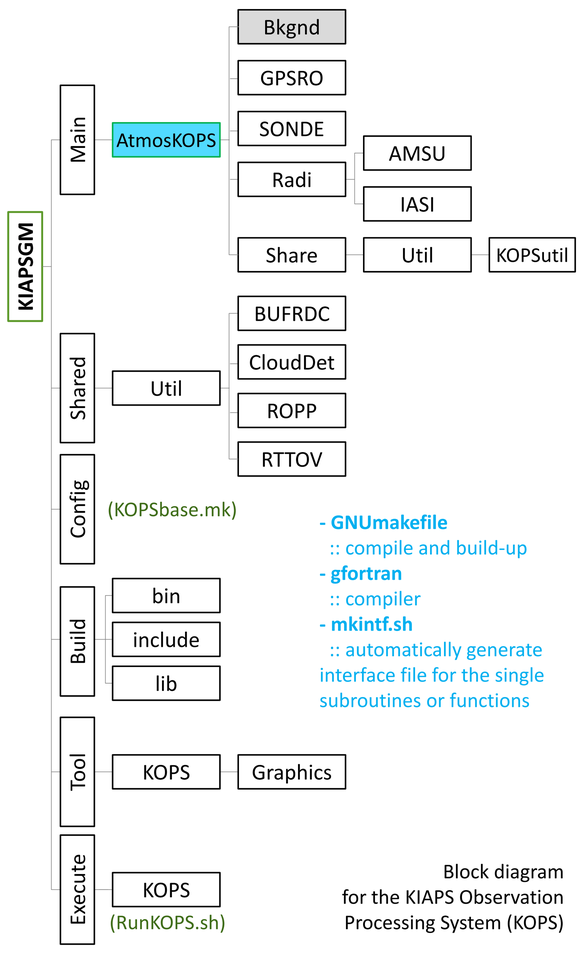
- construction of directory structure according to the function and observation types
- build-up libraries: modules and open packages (open packages: RTTOV_v10, ROPP, BUFRDC)
- shell scripts for the task management



Development of the KOPS framework

KOPS in the KIAPSGM framework

- based on the KIAPS Global NWP Model (KIAPSGM) framework
- library share with assimilation system on the observation operators



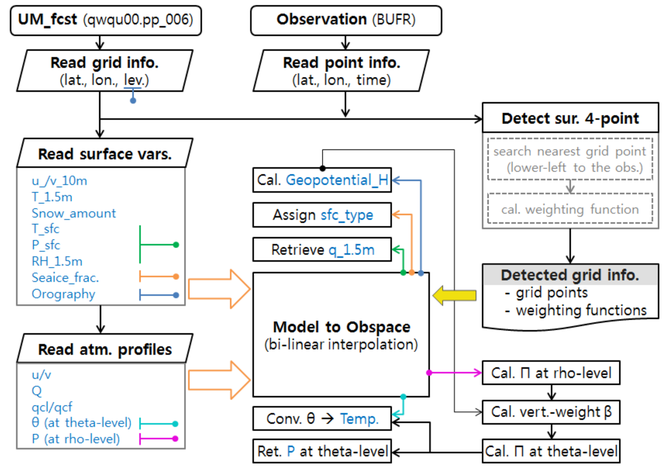
- **GNUmakefile**
  :: compile and build-up
- **gfortran**
  :: compiler
- **mkintf.sh**
  :: automatically generate interface file for the single subroutines or functions

Block diagram for the KIAPS Observation Processing System (KOPS)

Development of Background ingest process

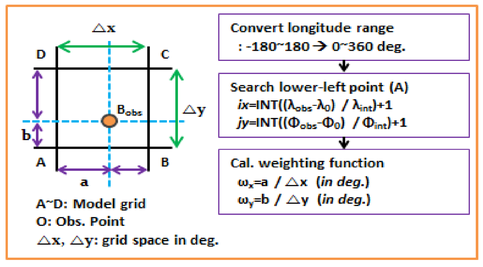
Background ingest process

- using netcdf type background file converted from UM forecast (operational in KMA, pp type)
  · global model / H. ~25km / V. 70L & 80 km
  · Arakawa-C staggered grid / hybrid coordinate
- interpolate forecast variables from model grid to the observation space
  · horizontal : bi-linear interpolation
  · vertical : weighting interpolation using geopotential height and /or logarithmic pressure
- variable transform and calculation of the 2nd (additional) variables
  · e.g.:: RH → Q / θ → T / …
- calculate geopotential height at each rho and theta-level



Horizontal interpolation method

1st stage: bi-linear interpolation

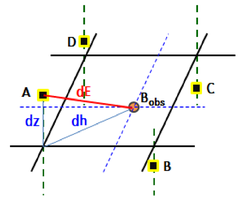


$$B_{obs} = A(1-\omega_x)(1-\omega_y) + B(\omega_x)(1-\omega_y) + C(\omega_x)(\omega_y) + D(1-\omega_x)(\omega_y))$$

- disregard the difference of vertical height between each grid points (A~D)
- vertical height at the B_{obs} point are assigned by mean of the grid points height

Improvement of interpolation method

- 3D-interpolation method using euclidian distance
- reflection of vertical height differences



Cal. mean height at B_{obs} point

a. $z_{mean} = (z_A + z_B + z_C + z_D) / 4$ or
b. apply bi-linear interpolation only for the height

$$(dh)^2 = (\lambda_{obs}-\lambda_A)^2 + (\Phi_{obs}-\Phi_A)^2$$
$$(dz)^2 = (z_A-z_{mean})^2$$

$$dE = SQRT((dh)^2 + (dz)^2)$$

$$d_{tot} = (dE_A + dE_B + dE_C + dE_D)$$
$$B_{obs} = (A(d_{tot}-dE_A) + B(d_{tot}-dE_B) + C(d_{tot}-dE_C) + D(d_{tot}-dE_D)) / 3(d_{tot})$$

- not only for the regular grid background such as UM fcst. but also non-regular such as cubed-sphere grid background could be processed

Vertical interpolation methods

Exner pressure at theta-level

T1. arithmetic mean

$$\Pi_\theta = \frac{(\Pi_{\theta-1/2}+\Pi_{\theta+1/2})}{2} = 0.5(\Pi_\rho + \Pi_{\rho+1})$$

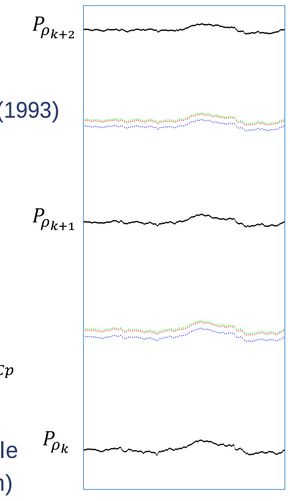
T2. new algorithm using logarithmic pressure (1993)

$$\Pi_m = \frac{\Pi_{k+1/2} - \Pi_{K-1/2})}{k(lnP_{k+1/2} - lnP_{k-1/2})} = \frac{\Delta\Pi_k}{k\Delta(lnP)_k})$$

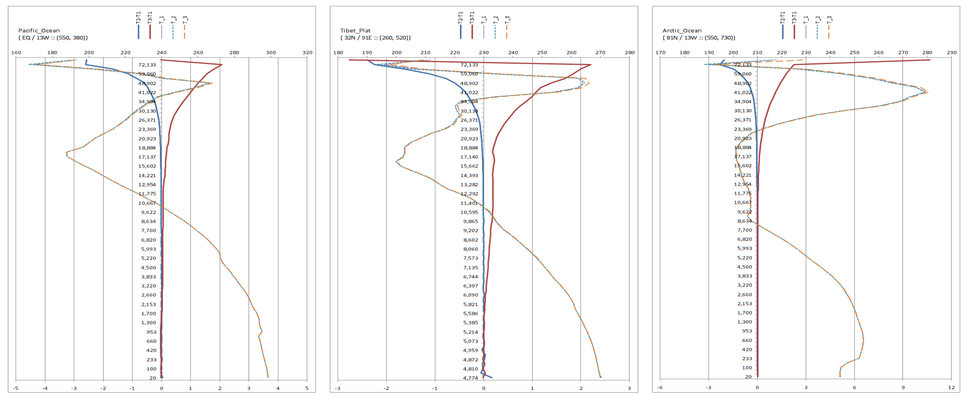
T3. weighted interpolation using directly calculated geopotential height

$$\Pi_\theta = \beta\Pi_{\rho i} + (1-\beta)\Pi_{\rho i+1}$$
$$\beta = \frac{Z_{\rho_{i+1}} - Z_\theta}{Z_{\rho_{i+1}} - Z_{\rho_i}}$$
$$<= 50(R)\ level:\ Z_k = Z_k + h(1 - \frac{\Pi_{\theta k}}{\Pi_{\rho R}})^{r/Cp}$$
$$Z_k = \Pi(h_{top})$$

· geopotential height calculation is applicable only for below 50th levels (from the bottom)



Comparison of the temperature profiles



- T1 can produce a warm bias to the derived temperature on high altitude levels (MetOffice)
- all of the T profiles are not much different at troposphere
- T2 and T3 tend to be cooler and warmer than T1 at stratosphere, respectively

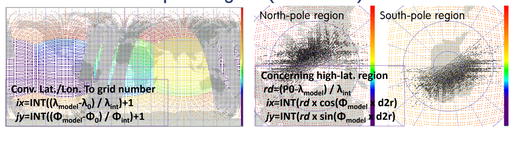
Summary and future plans

Summary

- KIAPS Observation Processing System (KOPS) framework has been developing based on the KIAPS Global NWP Model (KIAPSGM) framework
- Improved H. interpolation method are applied on the background ingest module and the T-profiles according to the V. interpolation methods are compared each other

Future plan

- development of the "grid point search module" for the treatment of irregular grid model data to cope with the Cubed-Sphere grid (KIAPSGM)



- development of the processing module for the hyperspectral IR satellite observation, MW, geostationary satellite data, and synoptic observations