The Impact of Regional Meteorological Network Data on AOD1B Products

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Introduction

- The Atmospheric and Oceanic De-aliasing products (AOD1B) show the short-term variations of gravity field and are removed from satellite observations in the post-processing step known as de-aliasing. The meteorological networks play an important role in the calculation of AOD1B products.
- The AOD1B products use the re-analysis data out of the global Numerical Weather Prediction (NWP) models currently and get the results is satisfactory in global. The NWP models assimilate of observations of various measurement methods, and use a global forecast model. So the re-analysis data can truly reflect the variations of atmospheric elements over global, however, some model errors will be introduced in regional area while compare with the regional station measurements.
- There are about 2170 meteorological network stations all over China, but the number of international meteorological network stations in China is 192. So it is worth to use the Chinese region meteorological network data to evaluate the data quality of the re-analysis data from NWP model.

Interpolation Approach

- To assess the quality of local meteorological network and NWP models, every datasets should be interpolated from grid to meteorological station or from meteorological station to grid at the same position (see Fig. 1).
- The pressure variation can be written as atmospheric static equations as:

$$dP = -\rho(h)g(\theta,h)dh \cdot \qquad (1)$$

The density function in terms of pressure can be written as:

$$\rho(h) = \frac{P(h)}{R_d T_v(h)} \cdot \qquad (2)$$

We assume that the variation of temperature with the height h blow 80km is linear:

$$T = T_0 - \Gamma \Delta h \cdot \qquad (3)$$

The surface pressure at the target point can be formulated as:

$$\ln\frac{P_1}{P_0} = \frac{g_0}{R_d\Gamma}\ln\frac{T_{v0} - \Gamma(H_1 - H_0)}{T_{v0}} \cdot \qquad (4)$$

- The quality of interpolation result depends on distance between two points. For example in Fig. 1, the point C and the station O has the shortest distance, therefore we expect the precise interpolation solution.

dP:	surface pressure variation
$\rho(h)$:	density at height h
$g(\theta,h)$:	gravity acceleration at latitude θ and height h
R_d:	dry air gas constant
$T_v(h)$:	virtual temperature
T:	terpertature
$P_{0,1}$:	surface pressure at given point and target point
g_0:	mean gravity acceleration
$H_{0,1}$:	geopotential heigh at given point and target point

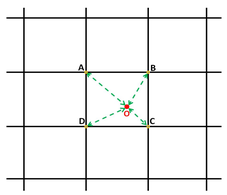

Fig. 1: Interpolation of surface pressure at station from global NWP models and vice-versa.

Quality Assessment of Regional Meteorological Network

- The surface pressure at Chinese region stations have been interpolated from global ECMWF ERA-Interim datasets and compared with station measurements. Fig. 2 shows the differences between station measurements and interpolated surface pressure. For example, the differences can reach up to ±40 [mbar] in Sichuan Basin. The statistical analysis shows the vast majority of surface pressure differences are in the range of -5 to 20 [mbar] (see Fig. 3).

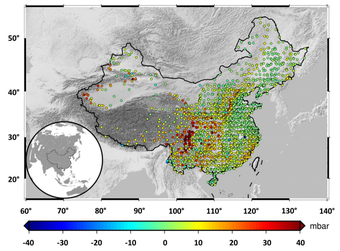

Fig. 2: The surface pressure differences between ECMWF ERA-Interim and Chinese regional meteorological network for the period of 2017-01-02 00 [h].

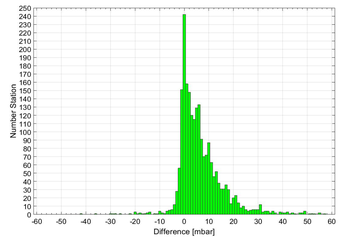

Fig. 3: The histogram of pressure differences at stations for the period of 2017-01-02 00 [h].

- The interpolation results for surface pressure differences between NCEP re-analysis dataset and Chinese regional network show a large bias. The real reason for such big differences is not clear now.

Impact of Regional Meteorological Network on Ecmwf Era-Interim

Tab. 1: The attributes of Chinese regional datasets and ECMWF ERA-Interim.

Name	Regional dataset	ECMWF ERA-Interim
Region	China	Global
Data type	Discrete point	Grid
Temporal resolution	1h	6h
Spatial resolution	2170 stations	0.5°× 0.5°
Result type	Measurement	Re-analysis model

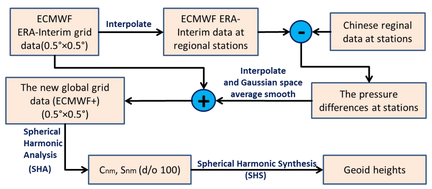

Fig. 4: Data processing scheme for Chinese regional datasets and ECMWF ERA-Interim global model.

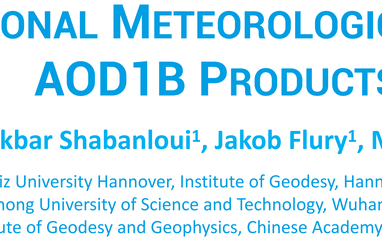

Fig. 5: The differences over global between ECMWF ERA Interim and the ECMWF+ model in terms of geoid heights for the period of 2017-01-02 00 [h].

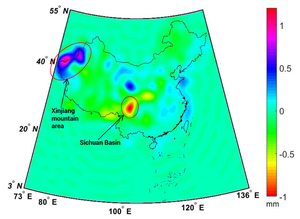

Fig. 6: The differences in terms of geoid heights in Chinese region between ECMWF ERA Interim and ECMWF+ for the period of 2017-01-02 00 [h].

- Fig. 6 shows the signal leakage at the Chinese border due to surface pressure differences between ECMWF and regional network.
- The impact over the globe is negligible (see Fig. 5).
- The biggest differences appear in Sichuan basin and Xinjiang mountain area (see Fig. 6).

Impact of Regional Meteorological Network on Ncep-Ncar

Tab. 2: The attributes of Chinese regional datasets and NCEP-NCAR.

Name	Regional dataset	NCEP-NCAR
Region	China	Global
Data type	Discrete point	Grid
Temporal resolution	1h	6h
Spatial resolution	2170 stations	2.5°× 2.5°
Result type	Measurement	Reanalysis model

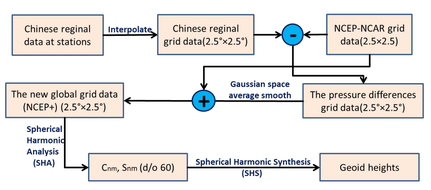

Fig. 7: Data processing scheme for Chinese regional datasets and NCEP-NCAR global model.

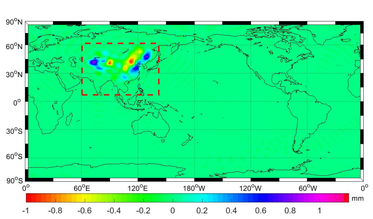

Fig. 8: The differences over global between NCEP-NCAR and NCEP-NCAR+ model in terms of geoid heights for the period of 2017-01-02 00 [h].

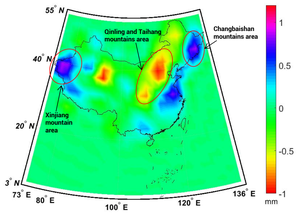

Fig. 9: The differences in terms of geoid heights in Chinese region between NCEP-NCAR and NCEP-NCAR + for the period of 2017-01-02 00[h].

- Fig. 9 shows a significant leakage at the Chinese border due to pressure differences between NCEP-NCAR and regional network.
- The impact over the globe is negligible (see Fig. 8).
- The biggest differences appear in northern China and Xinjiang mountain area (see Fig. 9), but it differs from ECMWF results.

Degree Variances Assessment

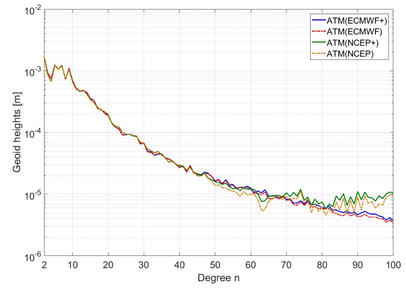

Fig. 10: The degree variances of the ATM spherical harmonic coefficients (d/o 100) of selected datasets in terms of geoid heights for the period of 2017-01-02 00 [h].

ECMWF+:	The dataset resulted by combination of ECMWF ERA-Interim and Chinese regional meteorological network (see Fig. 4).
ECMWF:	The dataset from ECMWF ERA-Interim model.
NCEP+:	The dataset resulted by combination of NCEP-NCAR and Chinese regional meteorological network (see Fig. 5).
NCEP:	The dataset from NCEP-NCAR model.

- The accuracy of ECMWF+ and ECMWF is almost the same, however the differences appear after degrees 80 (see Fig. 10).
- The differences between NCEP+ and NCEP appear after degrees 50 (see Fig. 10).

Conclusions

- The re-analysis dataset from global NWP model have significant differences over Chinese region. Those differences have a big impact on the gravity field recovery by GRACE, GRACE-FO and NGGM missions.
- In this investigation, a physical interpolation approach instead of a pure mathematical interpolation approach is used. The surface pressure differences between Chinese regional dataset and the global re-analysis model at selected stations smeared into spherical harmonic coefficients of the gravity field. The impact of regional meteorological network on global models ECMWF(+) and NCEP(+) are visible after degree 80 and degree 50, respectively.
- The signal leakage at Chinese border should be evaluated for correctness with other extra geophysical models. Interpolation approach should be improved with efficient approach.
- In this study, all Chinese regional datasets were evaluated. It is necessary to consider an efficient approach for interpolation of surface pressure on other region to assess the quality of approach.
- The impact of regional meteorological network should be evaluated for different period of time over China.

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