

Improvement of gravimetric geoid model for Japan based on analysis with Halo wavelets

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A gravimetric geoid model for Japan was improved by a newly developed method based on 2-dimensional wavelet analysis with Halo wavelets. In the method, a 2-dimensional wavelet analysis was applied to take localized medium wavelength components out of an altimetry-derived global marine gravity anomaly model, KMS99 (Andersen & Knudsen, 1998), and the components were used as a correction to the gravity model developed for the latest gravimetric geoid model for Japan, JGEOID2000 (Kuroishi, 2001).

JGEOID2000 was constructed from land and marine gravity data and a digital terrain model, using a 1-dimensional FFT method for Stokes integration in a remove-restore manner with EGM96 (Lemoine et al., 1997) as a foundation. The marine gravity data were collected mainly in 1970's and 1980's and were processed by a network adjustment for crossover errors to improve inter-consistency of the gravity field. Previous studies suggested that the marine gravity model contained systematic errors in the Sea of Okhotsk and in parts of the Pacific Ocean off Aomori Prefecture to off Erimo Cape because of a nonuniform distribution of ship observation tracks.

Kuroishi and Denker (2001) applied a low-pass filtering using 2-dimensional FFT to a marine gravity model, KMS98 and corrected the JGEOID2000 gravity model with the filtered signals. They revealed that the JGEOID2000 gravity model contained systematic errors of a few tens of mgals in the suggested areas and that KMS98 also contained systematic errors in Suruga, Sagami and Toyama Bays and waters around Okushiri Island. Therefore, it becomes clear that either gravity model suffer from localized systematic errors.

Based on these studies, the following approach was employed for improvement:

A) In the entire region of JGEOID2000, the difference field between KMS99 and the JGEOID2000 gravity model is analyzed by 2-dimensional wavelet analyses to localize the differences.

B) Halo wavelet with a special discretization of scales, namely multi-voice, is used for the wavelet analysis. Halo wavelet is a rotationally symmetric, 2-dimensional, real wavelet in Space and Fourier domain.

C) The areas where KMS99 contains systematic errors are manually removed from the wavelet components. Several correction models are created from the remaining wavelet components by taking different valid scale ranges.

D) The correction models are used as correction to the JGEOID2000 gravity model and from those gravimetric geoid models are computed by the same method as that applied for JGEOID2000 development.

Thus obtained gravimetric geoid models were compared with the nationwide net of GPS/leveling. The best one among the geoid models showed significant improvement over JGEOID2000:

- A) Standard deviation of the geoid differences is reduced from 17.6 cm to 13.3 cm
- B) Tilt of a fitted plane to the geoid differences is reduced from 0.44 ppm to 0.30 ppm
- C) Standard deviation after plane fit is reduced from 15.3 cm to 10.9 cm
- D) Range of postfit residuals is reduced from 141.1 cm to 72.2 cm