Application of the Rosborough formulation to analysis of the gravitational gradients of the GOCE mission

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1 Rosborough formulation

The Rosborough formulation is derived through transformation of the time-wise formulation from orbital to spherical coordinates by expressing $\varepsilon^{(\text{r,la,n})}$ in terms of $\phi, \lambda, \text{and } I$.

$\varepsilon^{(\text{r,la,n})} = \sum_{k=1}^{m} \sum_{\text{Nn}} \sum_{\text{m,k,n}} R_{\text{m,k,n}} H_{\text{r,la,n}} W_{\text{r,la,n}} (\phi, I) e^{i\text{m}\text{k}\text{n}}$

$H_{\text{r,la,n}} = \frac{\text{GM}}{R^3} \frac{1}{I} \sum_{\text{m,k,n}} \text{f}_{\text{m,k,n}} \text{f}_{\text{r,la,n}} (\phi, I)$

$W_{\text{r,la,n}} (\phi, I) = \sin^\text{m} (\phi) \cos^\text{l} (\phi)$

$\Psi (\phi, I) = \sum_{\text{m,k,n}} \text{f}_{\text{m,k,n}} \text{f}_{\text{r,la,n}} (\phi, I)$

2 Harmonic estimation in the Rosborough approach

Assuming the nominal orbit (constant r and I approximation) and swapping $\Sigma_{\text{a}}$ and $\Sigma_{\text{m,}}$

$f^{(\text{r,la,n})} (\phi, \lambda, I) = \sum_{\text{Nn}} \sum_{\text{m,k,n}} C_{\text{m,k,n}} (\phi, I) e^{i\text{m}\text{k}\text{n}}$

with latitude lumped coefficients:

$C_{\text{m,k,n}} (\phi, I) = \sum_{\text{Nn}} \text{Q}_{\text{a,m,n}} (\phi, I)$

and the Rosborough base functions:

$\text{Q}_{\text{a,m,n}} (\phi, I) = \sum_{\text{Nn}} \text{H}_{\text{r,la,n}} \text{W}_{\text{r,la,n}} (\phi, I)$

3. Processing scheme for the GOCE data

3.1. Rotation from GRV to LORF

$GRF \rightarrow IRF \rightarrow LORF$

3.2. Filtering the GOCE gradients: Wiener filter

$S (\phi, I) = S_{\text{LAF}} (\phi, I) + S_{\text{LAF}} (\phi, I)$

3.3. Gridding along-orbit data on two spheres

3.4. Iterative scheme:

3.4.1. Complementary Wiener filter

3.4.2. GRF to LORF rotation corrections

3.4.3. Gridding error mitigation

4. Real GOCE processing

- The first 71 days (01.11.2009–10.01.2010) of reprocessed EGG NOM.2 data ($W_{25}, V_{13}, U_{5}$).
- EGM08 to d/o 250 is used in Wiener filtering, polar gaps filling, etc.
- A priori model is EGM08 to d/o 80.

5. Conclusions

Solution up to $N_{\text{max}}=200$ from 71 days of GOCE gradients with performance of 8 cm geoid RMS difference w.r.t the time-wise model in the relevant bandwidth

Relative contributions of $T_{\text{ex}}, T_{\text{ey}}$ and $T_{\text{ex}}$ are about 20%, 20% and 57%.

Error analysis of satellite data based on spatially variable parts: geomagnetic equator effect, track-specific errors, tidal mismodeling.

Lower accuracy of the Rosborough solution mostly due to gridding error.

The Rosborough method is a complementary method to the conventional approaches.