Glacial Isostatic Adjustment and ITRF solutions

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Introduction

1. A translation rate of -1.8 mm/yr has been observed between the two International Terrestrial Reference Frame editions ITRF2005 and ITRF2000, which had large implications on positioning accuracy with space geodetic techniques.
2. The up to date realization of the ITRF frame (ITRF2008) tends to confirm ITRF2005 origin and scale rates.
3. A few studies showed that local and global velocity measurements may be more coherent with a Glacial Isostatic Adjustment (GIA) model using ITRF2000 (Argus, 2007; Lidberg & Johansson, 2007; Tregoning & Lambeck, 2010).
4. Which frame is the most appropriate? We investigate here GIA as a geophysical estimator of ITRF quality.
5. What information ITRF solutions provides on GIA processes?

Geophysical quality assessment of ITRF solutions

We interpolated the GIA vertical velocities on the different ITRF-GNSS networks and we compared models with solutions .

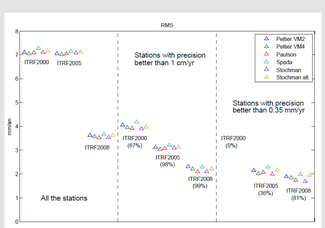

Fig. 8: Root Mean Scatter between GIA models and ITRF-GNSS solutions.

- Differences between GIA models are smaller than differences between ITRF solutions
- ITRF2005 is globally more consistent with GIA than ITRF2000
- ITRF2008 is highly coherent with GIA (RMS smaller than 2 mm/yr).

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ITRF solutions: ITRF2000, ITRF2005 and ITRF2008

Translation rate btw ITRS realizations	X-component (mm/yr)	Y-component (mm/yr)	Z-component (mm/yr)
From ITRF2005 to ITRF2000	**-0.2 ± 0.3**	**0.1 ± 0.3**	**-1.8 ± 0.3**
From ITRF2008 to ITRF2005	**0.3 ± 0.2**	**0.0 ± 0.2**	**0.0 ± 0.2**

Tab. 1: Translation rates between the latest ITRF solutions.

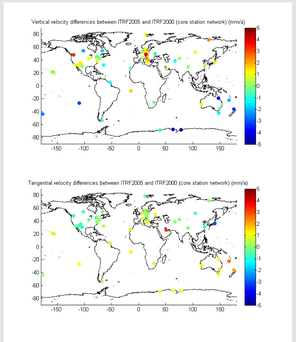


Fig. 1: Differences in velocity estimations between ITRF2005 and ITRF2000 on the core network used to compare the two solutions (Altamimi et al, 2007).

Vertical velocities

Mean relative difference between velocities:

700 %

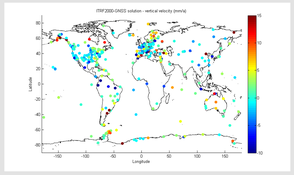
Tangential velocities

Mean relative difference between velocities: 4 %

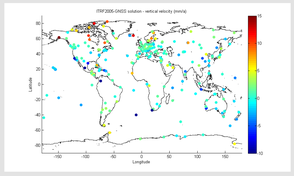
The global pattern of vertical velocities is very similar to GIA global pattern, particularly for the most recent ITRF solutions.

Fig. 2-4: Vertical velocities from ITRF GNSS solutions

ITRF2000



ITRF2005



ITRF2008

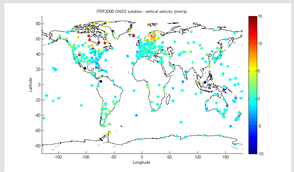
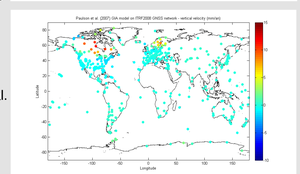


Fig 5: Paulson et al. (2007) GIA model interpolated on ITRF2008 GNSS network



Global Isostatic Adjustment

GIA Models

The GIA models have been downloaded from *Special Bureau for Loading (http://www.sbl.statkart.no/projects/pgs/authors/)*, except Paulson et al. (2007) model (NASA JPL).

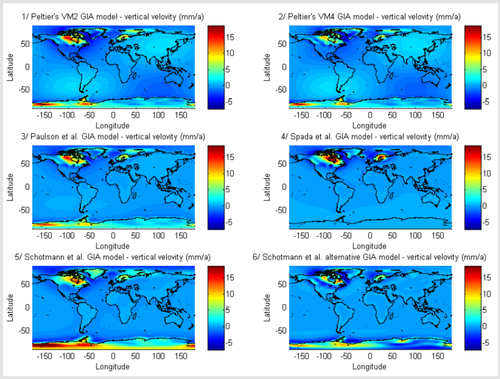


Fig. 6: Ground vertical velocities predicted by 6 different GIA models.

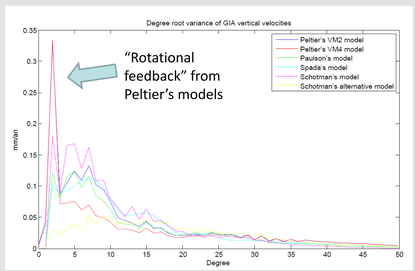


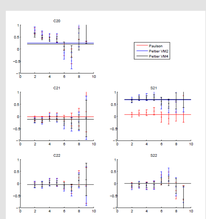
Fig. 7: Degree root variance of GIA vertical velocities.

The large degree 2 value in Peltier's models is due to the impact of polar wander. Paulson et al. (2007) model also includes a rotational feedback, but with a smaller impact. Note that Chambers et al. (2010) concluded that the latter model is more consistent with GRACE observations.

ITRF2008 constraints on GIA

We investigated degree two spherical harmonic (SH) coefficients from ITRF2008 GNSS vertical velocities, and compared our results to GIA spherical harmonic spectrum.

Fig. 9: Tests of SH-coefficient inversion method on synthetic data issued from GIA models. Each plot presents estimations of one coefficient depending on the maximum degree of the inversion. These tests suggest an optimal maximum degree of inversion of 5.



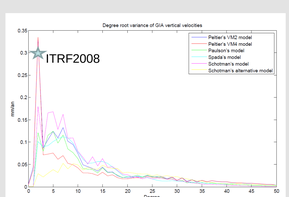


Fig. 10: Degree Root Variance of GIA models and Degree 2 Root Variance of ITRF2008 GNSS solution.

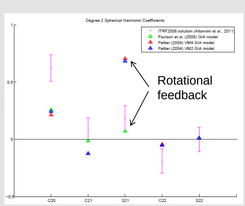


Fig. 11: Detail of degree 2 spherical harmonic coefficients

- ITRF2008 presents a particularly large zonal C20 coefficient, probably due to other phenomena than GIA (recent ice melting...).
- ITRF2008 S21 coefficient, which is the coefficient impacted by rotational feedback, is consistent with Paulson et al. (2007) model.
- GIA models and ITRF2008 other degree 2 coefficients are globally coherent.

Conclusions

1. A large part of the anomalous translation rate observed between ITRF2005 and ITRF2000 solutions is due to large differences on vertical velocity estimations.
2. Vertical velocities from ITRF-GNSS solutions present global patterns very similar to GIA typical pattern.
3. Comparisons between ITRF solutions and 6 GIA models show that differences between GIA models are smaller than differences between ITRF solutions, and that ITRF2005, and particularly ITRF2008, are more consistent with GIA than ITRF2000.
4. ITRF2008 tends to confirm the conclusion of Chambers et al. (2010), based on GRACE observations, about the impact of rotational feedback on GIA models, valorising Paulson et al. (2007) model.
5. ITRF2008 suggests an ellipticity rate (C20 coefficient) two times larger than GIA models.