SYSTEMATICS EFFECTS OF TERRESTRIAL REFERENCE FRAMES ON MEAN SEA LEVEL DETERMINATIONS

Laurent MOREL, Pascal WILLIS
Institut Géographique National (France)
http://lareg.ensg.ign.fr/

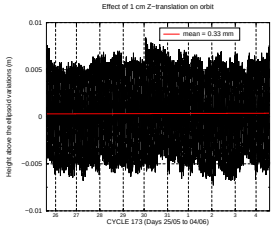
Several oceanographic studies are based on the scientific interpretation of mean sea level variations. However, the mean sevel determinations themselves are strongly dependent on the Precise Orbit Determination. At this early stage, the adoption of a Terrestrial Reference Frame is done differently by the several orbit determination groups, leading to possible inconsistencies in mean sea level derived from different satellite altimetric missions. These conventions are also changing in time (due to improvements on tracks station coordinates) and could lead to possible inconsistencies between past and present oceanographic missions.

The goal of this paper is to try to determine the main systematic effects coming from the adoption of Terrestrial Reference Frames transformed by translations or a scale factor on mean sea level determination. In the first two parts we will study respectively the effect on orbit and subsenquently on the mean sea level. The third part will consider the new results applied to the NASA / CNES orbit of TOPEX / POSEIDON.

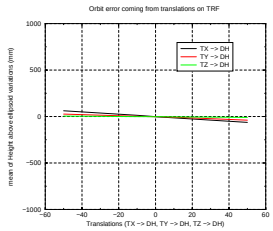
1 Systematic effect of terrestrial reference frame on orbit

TRANSLATIONS

Figure 1 illustrates the orbit error repartition for one cycle after a Z-translation applied to the Terrestrial Reference Frame from the orbit production (1 cm). Mean value about 0.5 mm and standard deviation very large mean that this transformation has no significant systematic effect on the orbit.



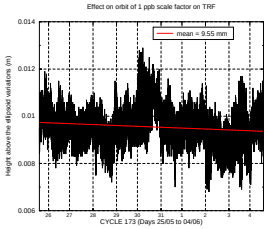
In a second step we generalize our precedent procedure for the three translations with several values from -100 cm to +100 cm (biggest values are ten times superior than expected ones), in each case we kept the mean value presented before. On the left figure we have drawn the mean value of the orbit error function of translation values. Taking into account our current knowledge of translations between TRF (-10 cm to +10 cm) we notice that no translations have a significant effect on orbit.



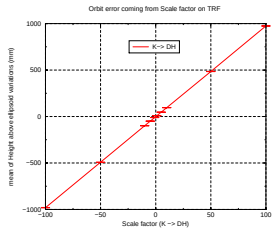
Z BIAS on ORBIT : 1 cm → 0.4 mm

SCALE FACTOR

Similar procedure was used with a scale factor transformation applied to a Terrestrial Reference Frame (1 ppb). Effect on orbit seems to be very significant if we consider this case with a mean value about 1 cm and a standard deviation about 1 mm.



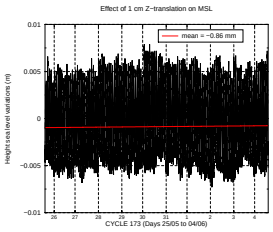
With a similar systematic study than translations, considering values between -100 ppb and +100 ppb the effect on orbit of a scale factor applied to the terrestrial reference frame was determined. 10 mm for 1 ppb was solved which is superior than a direct effect that would be 7.7 mm taking into account only the satellite semi major axis (close to 7700 km).



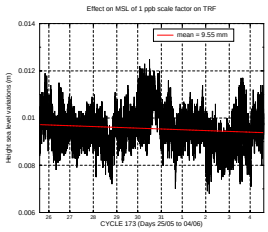
SCALE FACTOR on ORBIT : 1 ppb → 10 mm

2 Systematic effect of terrestrial reference frame on mean sea level

Assimilating the orbit error as an height sea level error for the points above the sea surface we can give an estimation of the effect on mean sea level coming from a transformation of the terrestrial reference frame. A systematic rise close to 1 mm for 1 cm Z-translation was observed whereas no effect was detected on orbit. This particularity is due to the dissymetry of ocean between the north and south hemisphere.



Z BIAS on MEAN SEA LEVEL : 1 cm → 1 mm



In case of scale factor the orbit error and the mean sea level evolution coming from a scale factor of 1 ppb applied to the terrestrial reference frame is exactly the same : 10 mm for 1 ppb. This similarity explains itself because the orbit will be identically transformed wherever we look around the earth, so results on Mean SEA Level (MSL) are independant from the ocean dissymetry.

SCALE FACTOR on MEAN SEA LEVEL : 1 ppb → 10 mm

Transfer function derived from simulations (using actual TOPEX / DORIS data using the Gipsy / Oasis software at IGN) show that the scale factor is a critical factor. The Z-translation do not seem to affect strongly the mean sea level determination.

3 Application on NASA/CNES orbits of TOPEX/POSEIDON

Now, to illustrate our precedent results we can apply to estimate the correction to apply between the NASA and CNES orbit production centers. This can be done because we know very well the Terrestrial Reference System used in their processing : CSR95D02 and SST96 for NASA and CNES respectively. Thanks to their collaboration we have received their frames and compared them. For this study scale factor and Z-translation evolutions are only used and their values are :

$\dot{T}Z$ = -0.8 cm / an

$\dot{K}$ = 0.3 ppb / year

Now, actual inconsistency due to present Terrestrial Reference Frame adoption can be processed using transfer function presented before, so we give below results coming from our precedent transfer function and parameter evolution :

NASA / CNES TRF Z drift → + 0.8 mm / an

NASA / CNES TRF scale drift → + 3 mm / an

Scale factor effect on Mean Sea Level is very significant relative to the effect of Z-translation. But remember that the Z-translation leads a Mean Sea Level rise in the Northern Hemisphere and a MSL decrease in the Southern hemisphere about to 2 mm / an. In case of scale factor, only a MSL rise can be observed.

Even if the effect of Z-translation can't be neglected it can't be responsible for the present drift between MSL estimation coming from CNES and NASA altimeter. Z-translation and scale factor effect behaviour, together or separetly, don't explain this drift. So reference system present errors are not responsible in this case anyhow we should also keep in mind that Z-translation and Scale factor can lead to significant systematics effects and absolutely need to be considered.