Relative Sea Level Variations: PSMSL vs GPS data

Alfredo Graça; Joana Campos; Assunção Araújo

To understand the four areas of our study, we must take into account the Würm Glaciation which took place at the end of the Pleistocene. By comparing Sandy Hook (Connecticut), Grand Isle, Seldovia and Vaasa through charts and GPS we intend to understand which differences are between them relating sea level rise or sea level descent. While in some of these cases, you can observe a rise of the sea due to vertical land movements, in the other cases you can observe a very remarkable descent due also to vertical land movements that show a rise of the continent. Regarding the peak of the *Würm glaciation* (18,000 years BP), sea level receded about 120 meters due to the formation of large continental ice sheets (*inlandsis*). For example, in Scandinavia (with thicknesses up to 3km) according to the mechanism of isostasy, this overload made this part of the continent suffer a subsidence, thus causing the forebulge (for example the Netherlands area) to emerge. At present, the phenomenon is reversing. With the thawing of these immense ice sheets, the pressure which they exerted over Scandinavia was relieved, which has resulted in a gradual rebound and consequent subsidence of the Netherlands area. Thus the "sea level rise" that is observed today is partially a result of this phenomenon. This melting affected the entire world, but this effect has intensified in the forebulge areas. 5000 years BP is generally accepted as the chronology of maximum *Holocene Transgression*. In many places (Moura et al., 2007) it corresponds to a sea level a little above the current sea level.

The current level of the sea is due to the end of the *Little Ice Age* that ended in the middle of the XIX century and caused a slight rise of about 12 cm in 150 years (Mörner, 1973).

Sandy Hook (Connecticut)

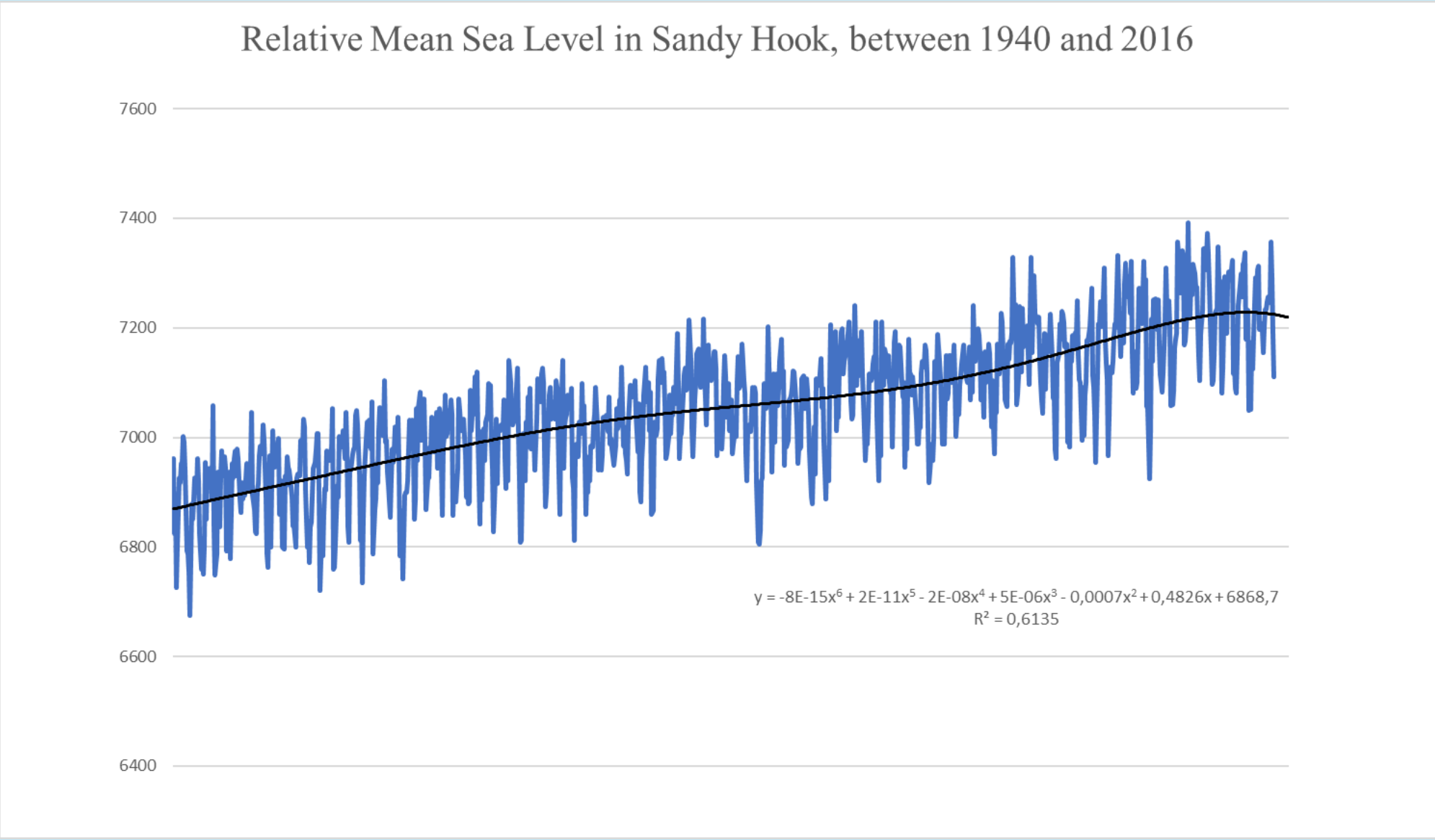


Fig.1- Relative mean sea level in Sandy Hook, between 1940 and 2016

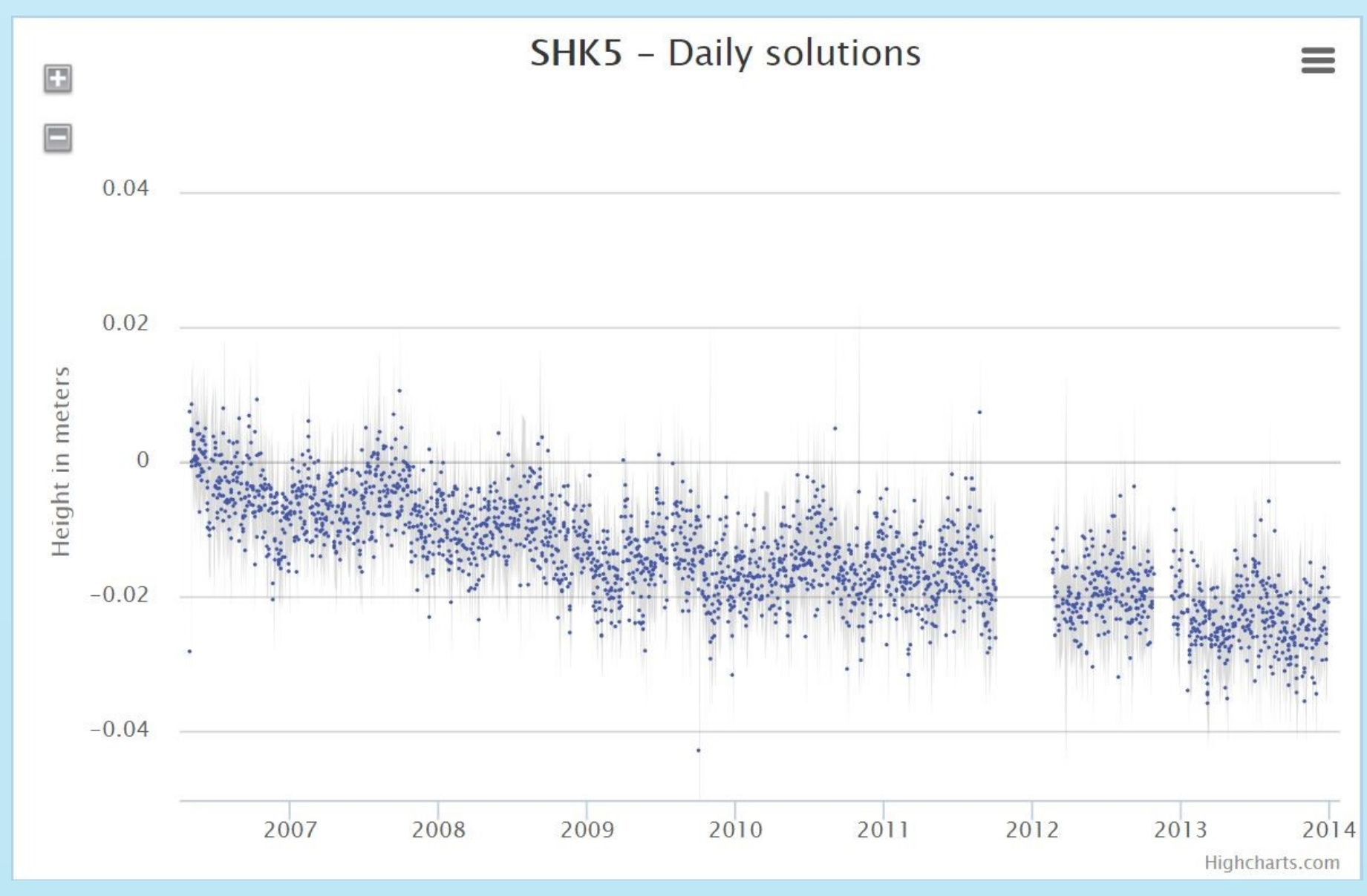


Fig. 2- Vertical land motions, in Sandy Hook, since 2006

Fig.3– Location of Sandy Hook's GPS. Scale 1:1000

Fig.4– Location of Sandy Hook's GPS. Scale 1:10000

Grand Isle (New Orleans)

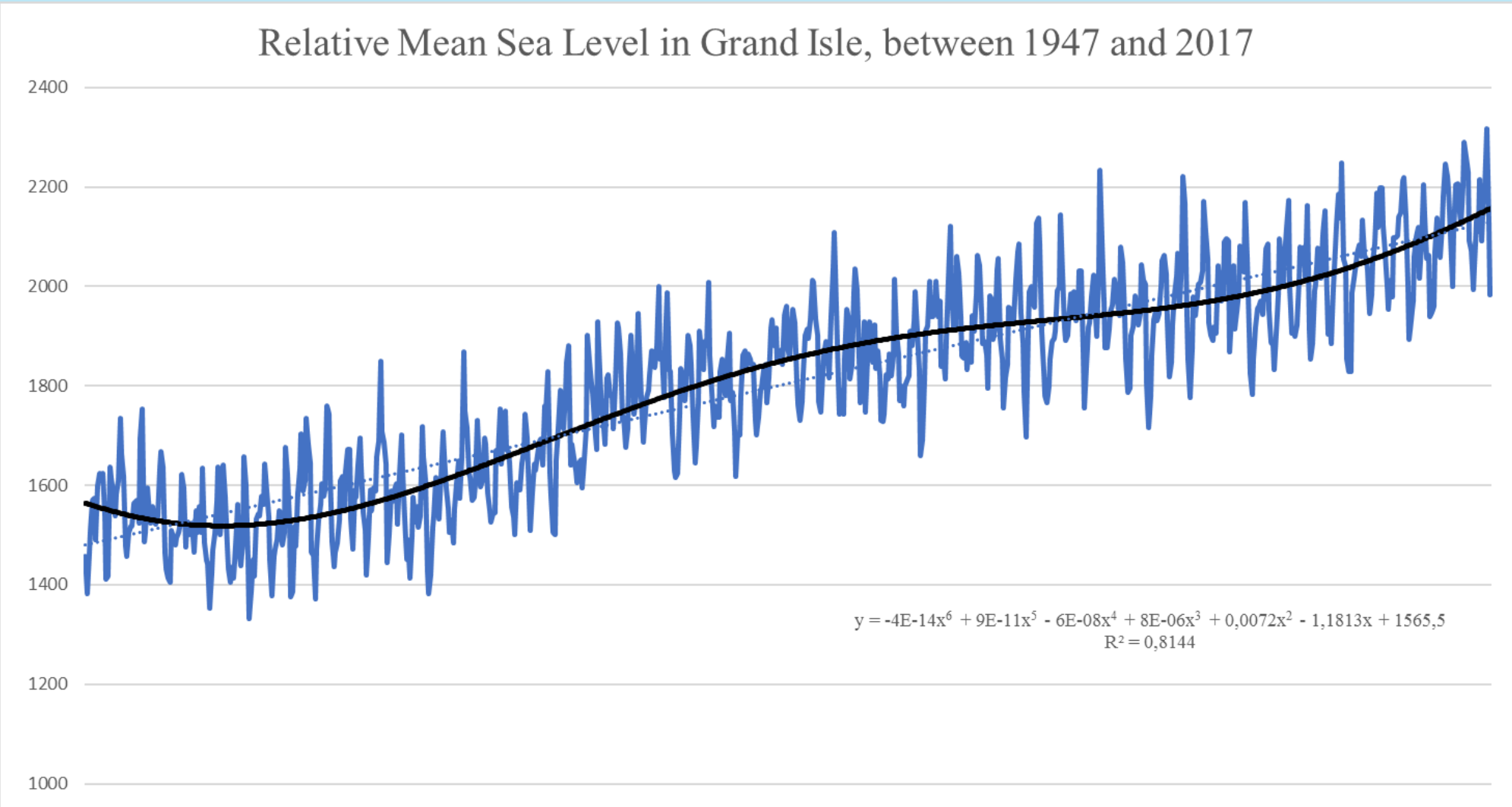


Fig.5- Relative mean sea level in Grand Isle, between 1947 and 2017

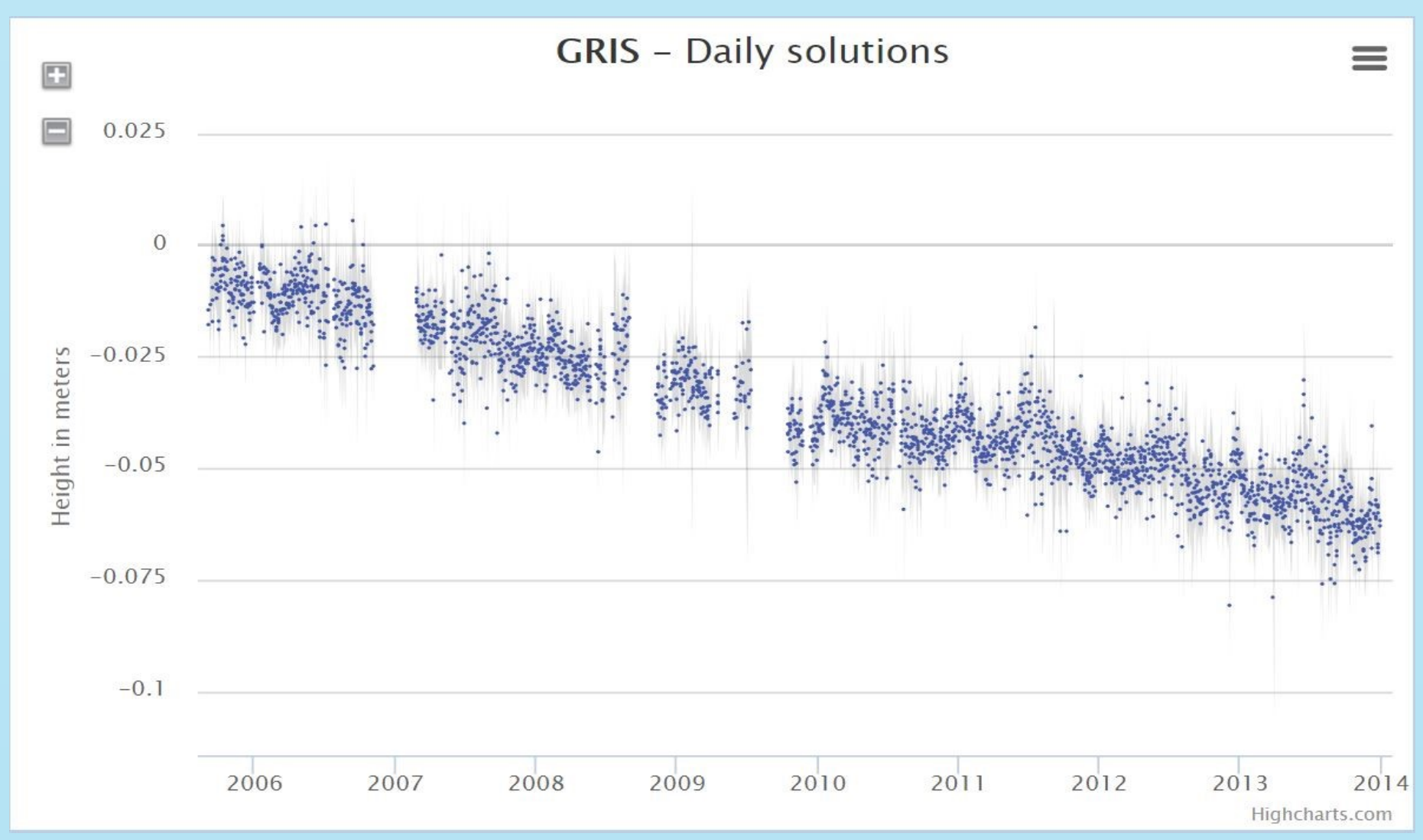


Fig.6- Vertical land motions in Grand Isle, between 2006 and 2014

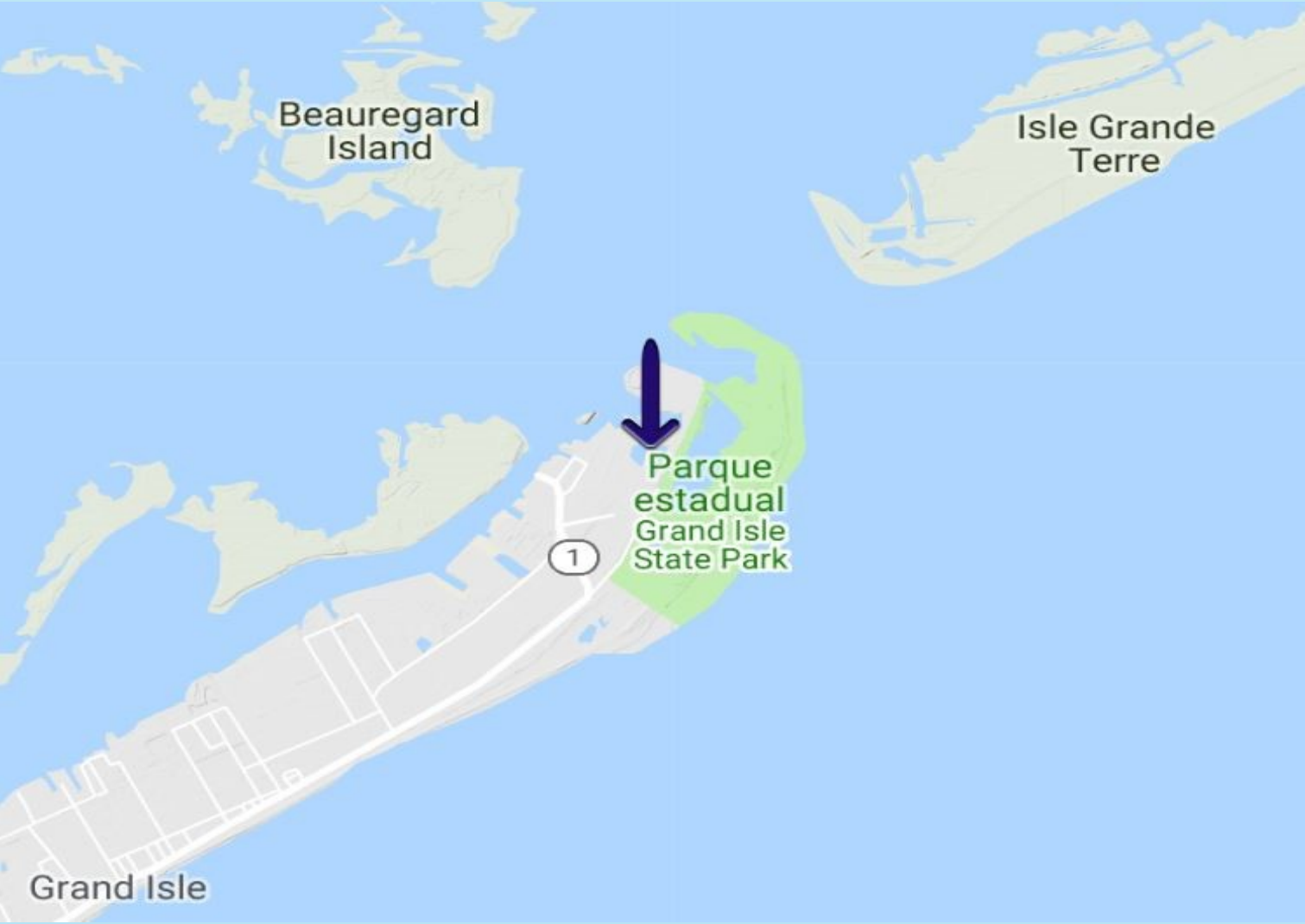


Fig.7– Location of Grand Isle's GPS. Scale 1:1000

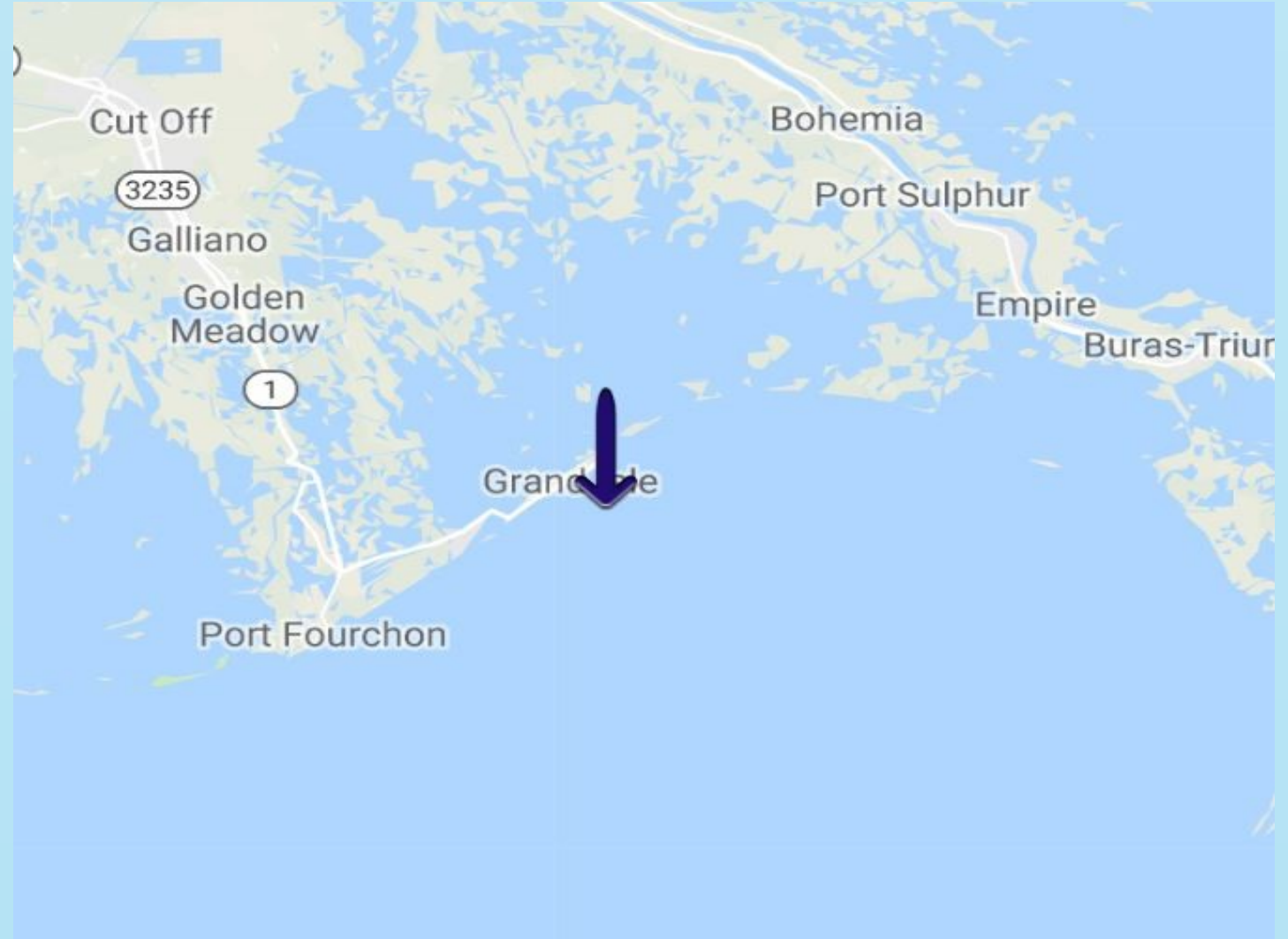


Fig.8– Location of Grand Isle's GPS. Scale 1:10000

Seldovia (Alaska)

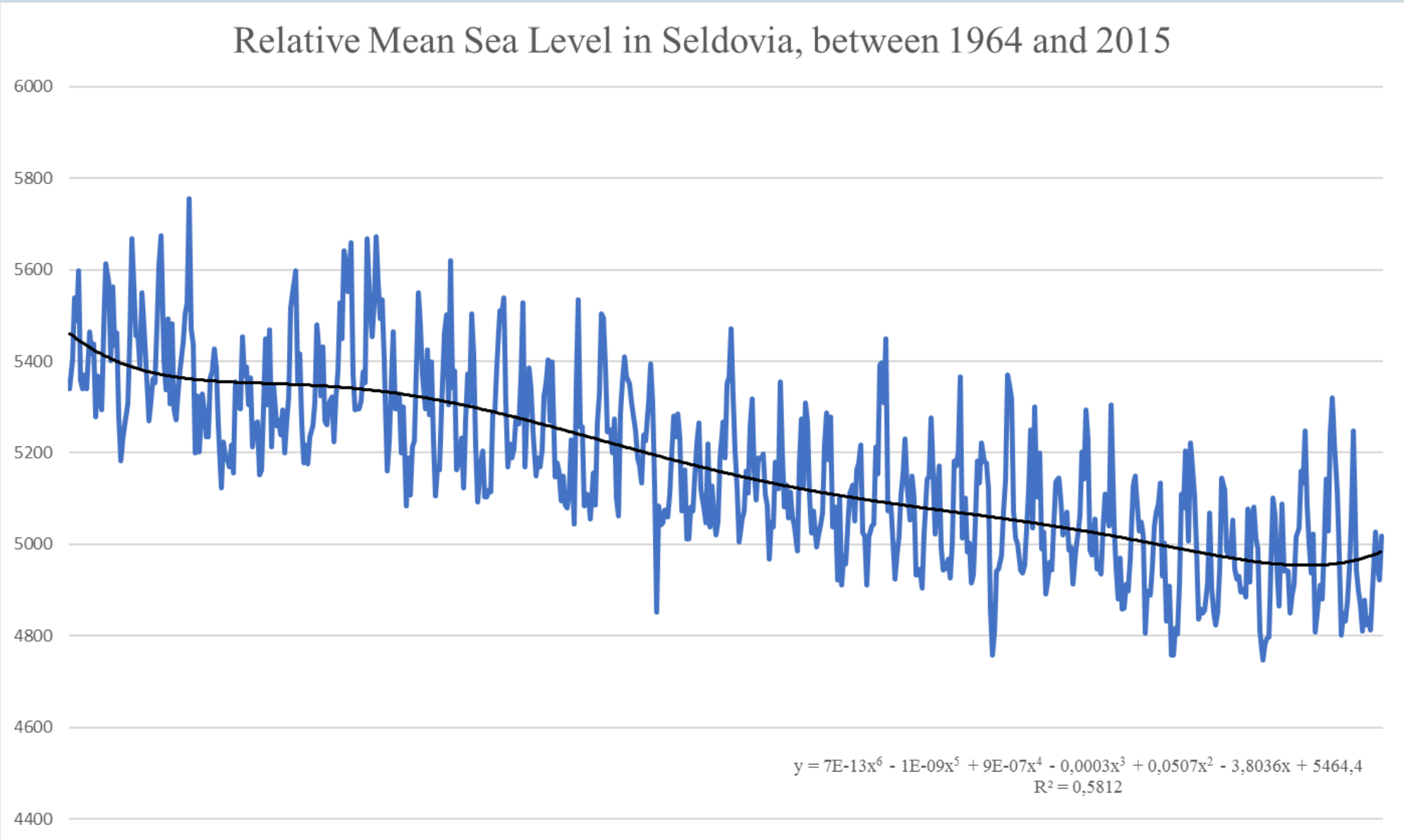


Fig.9- Relative mean sea level in Seldovia, between 1964 and 2015

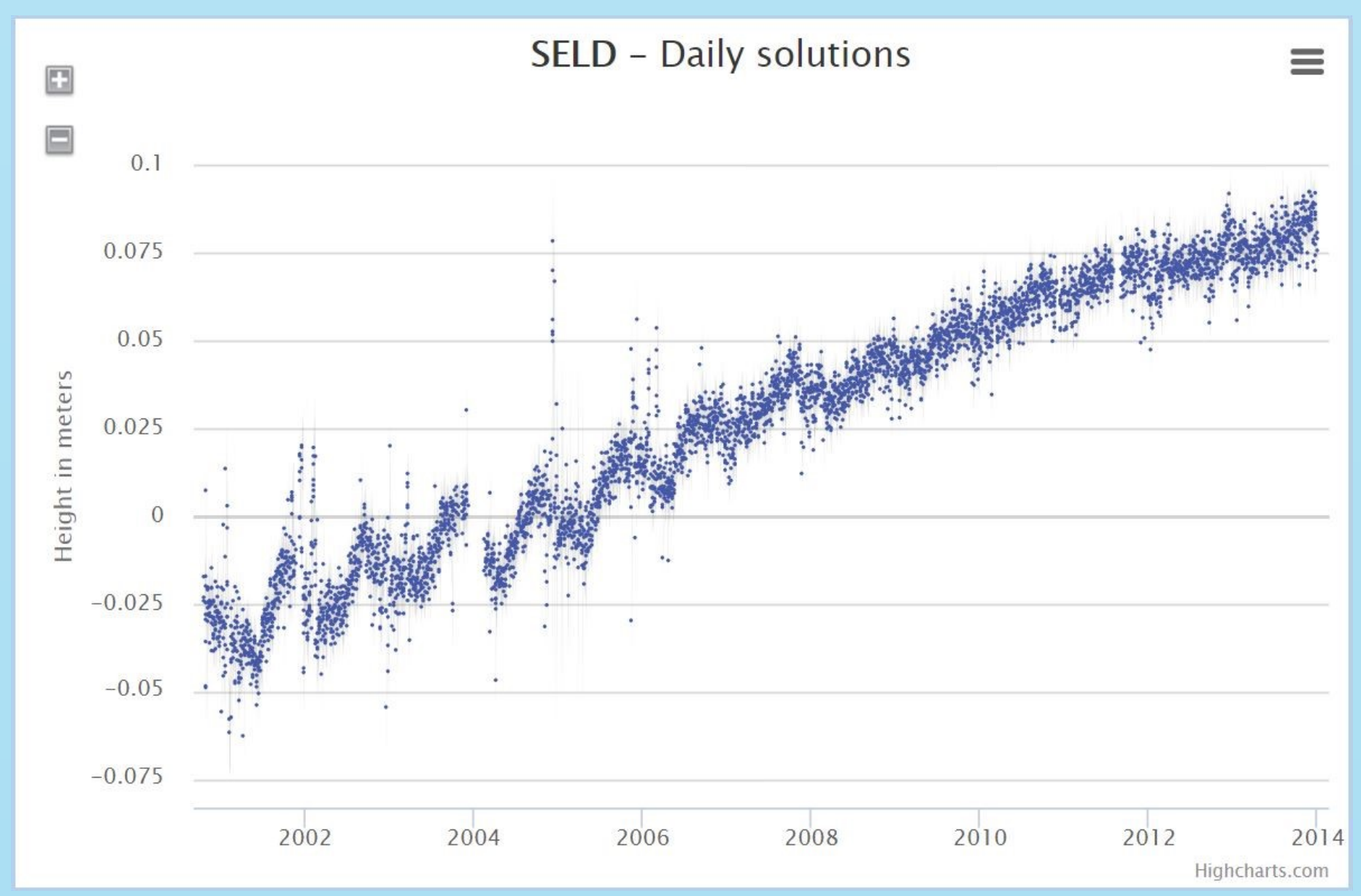


Fig.10- Vertical land motions in Seldovia, since 2000

Fig.11– Location of Seldovia's GPS. Scale 1:1000

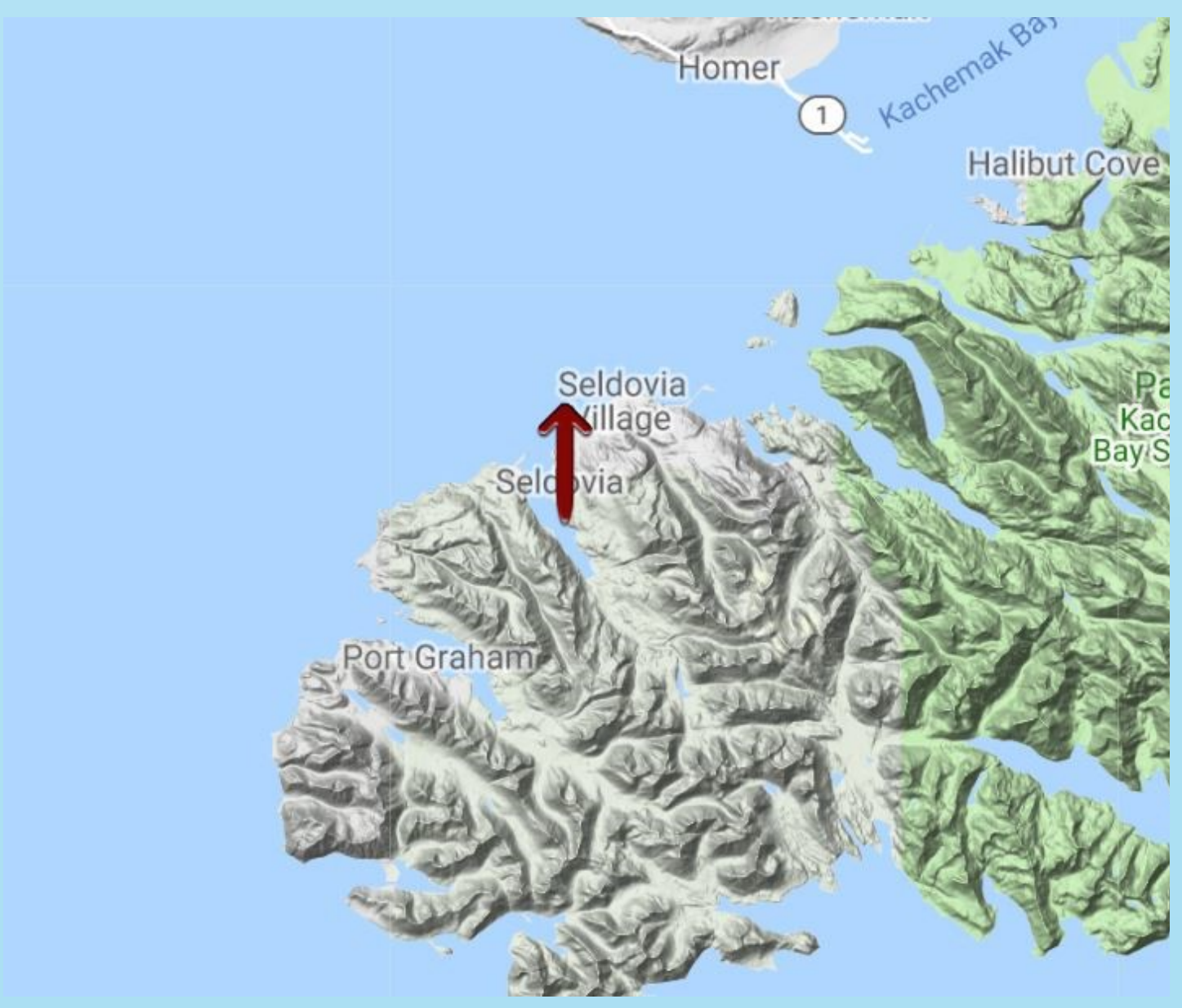


Fig.12– Location of Seldovia's GPS. Scale 1:10000

Vaasa (Finland)

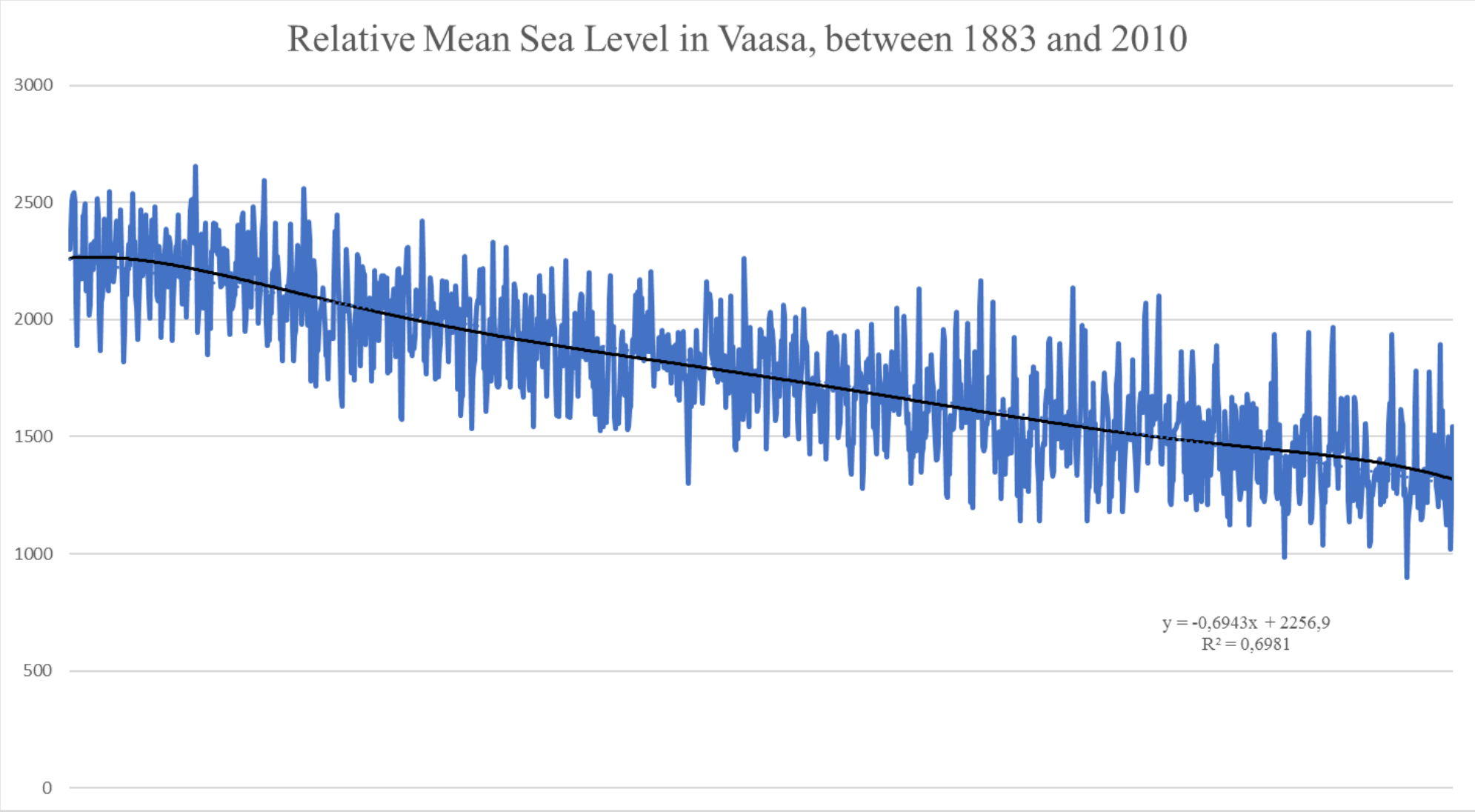


Fig.13- Relative mean sea level in Vaasa, between 1883 and 2010

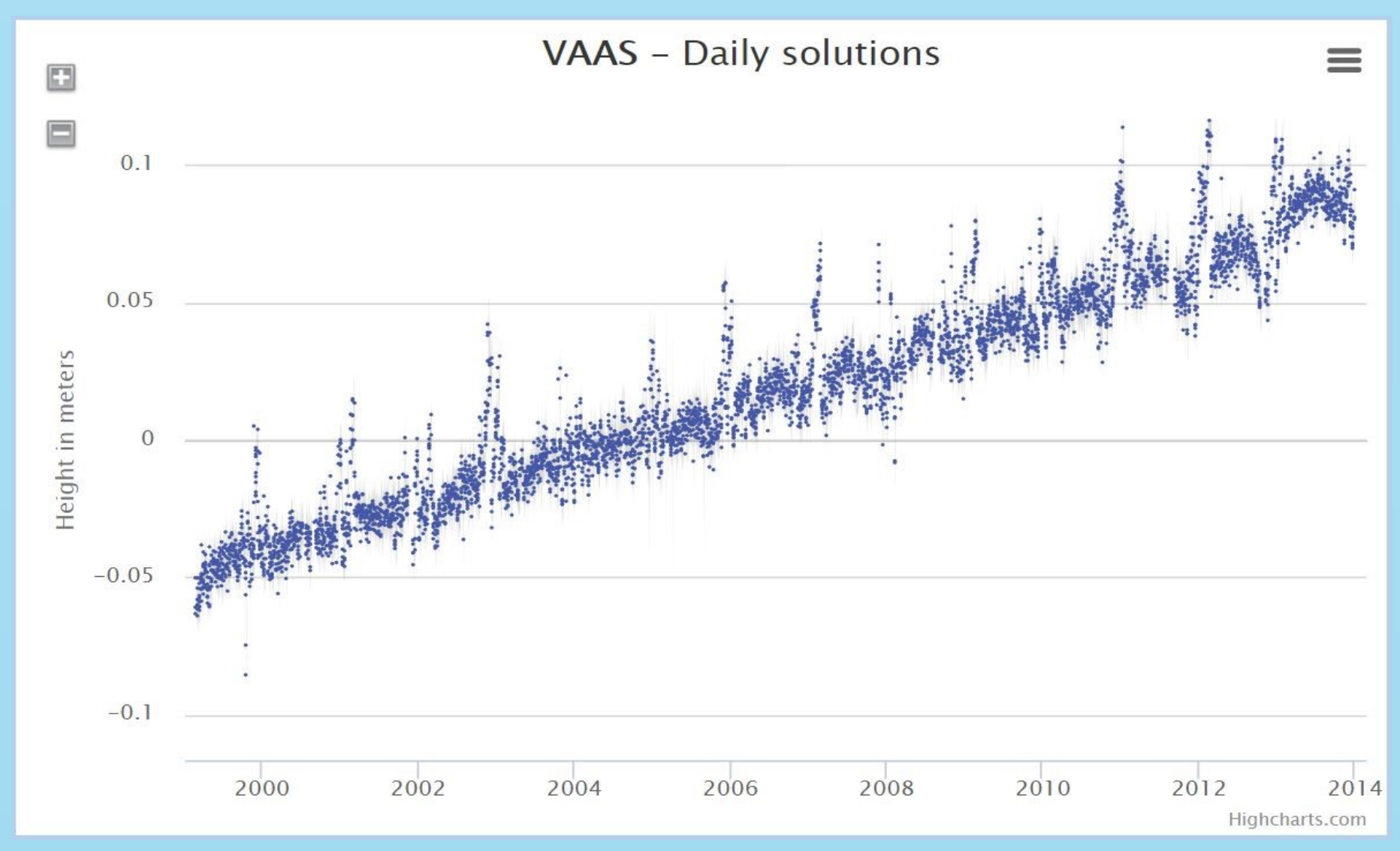


Fig.14- Vertical land motions in Vaasa, since 1995

Fig.15– Location of Vaasa's GPS. Scale 1:1000

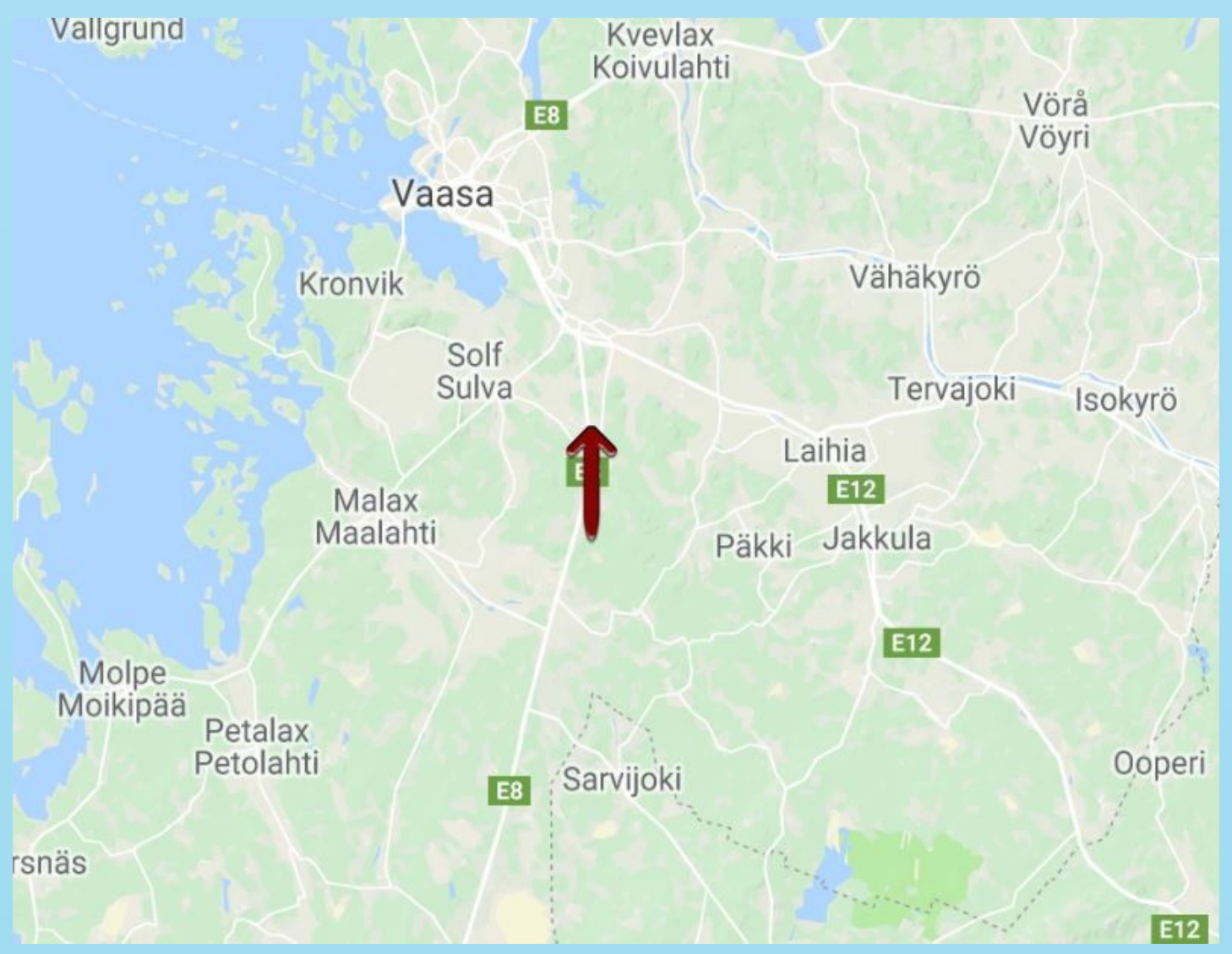
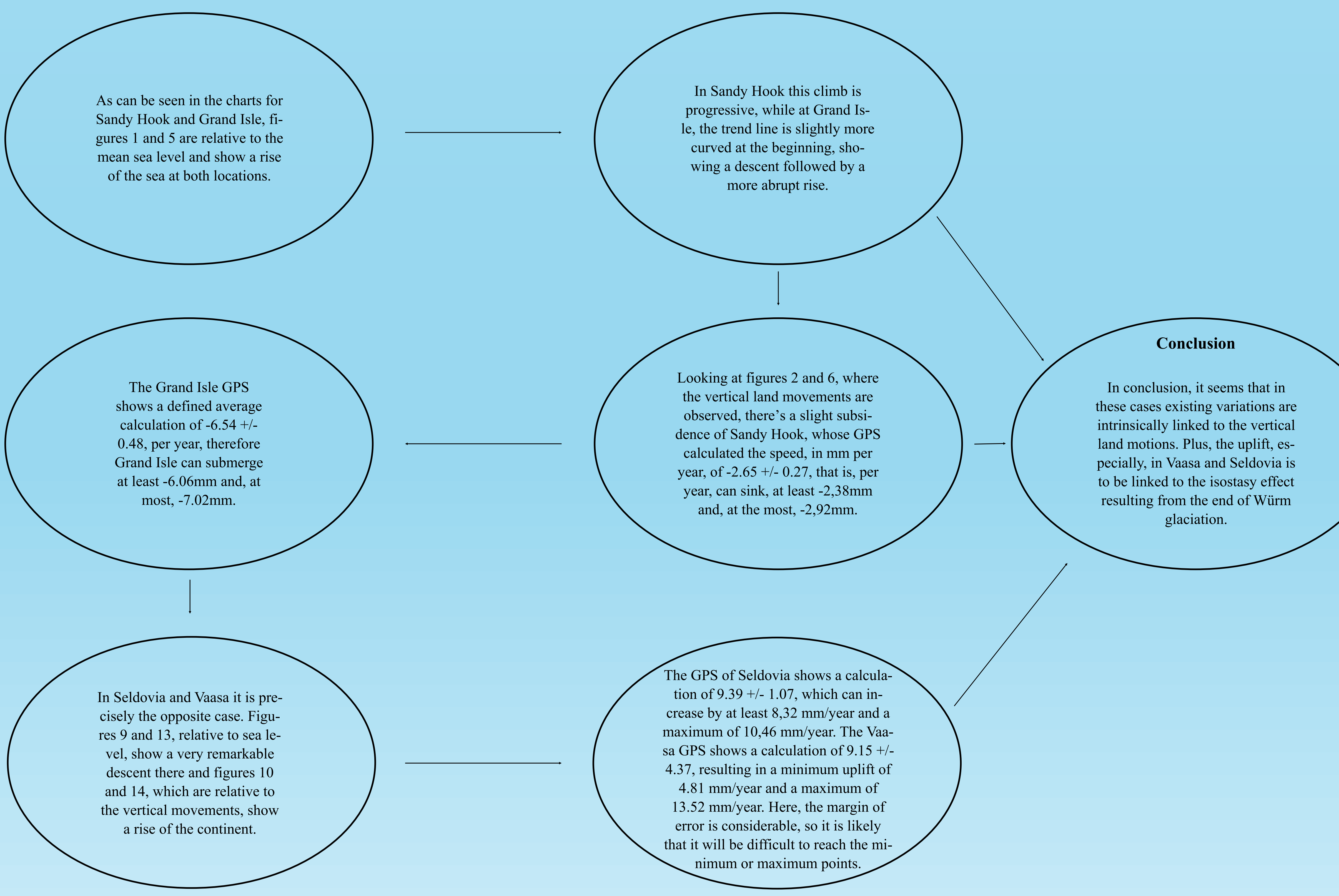


Fig.16– Location of Vaasa's GPS. Scale 1:10000

Discussion



As can be seen in the charts for Sandy Hook and Grand Isle, figures 1 and 5 are relative to the mean sea level and show a rise of the sea at both locations.

In Sandy Hook this climb is progressive, while at Grand Isle, the trend line is slightly more curved at the beginning, showing a descent followed by a more abrupt rise.

Looking at figures 2 and 6, where the vertical land movements are observed, there's a slight subsidence of Sandy Hook, whose GPS calculated the speed, in mm per year, of -2.65 +/- 0.27, that is, per year, can sink, at least -2,38mm and, at the most, -2,92mm.

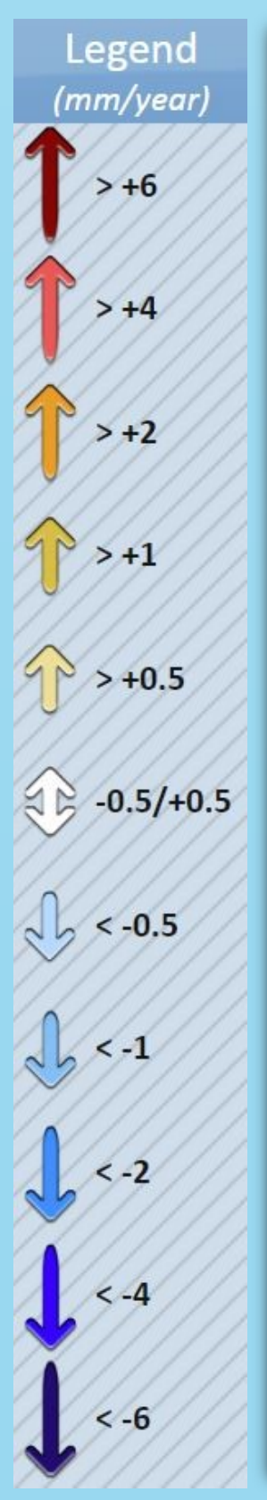
The Grand Isle GPS shows a defined average calculation of -6.54 +/- 0.48, per year, therefore Grand Isle can submerge at least -6.06mm and, at most, -7.02mm.

In Seldovia and Vaasa it is precisely the opposite case. Figures 9 and 13, relative to sea level, show a very remarkable descent there and figures 10 and 14, which are relative to the vertical movements, show a rise of the continent.

The GPS of Seldovia shows a calculation of 9.39 +/- 1.07, which can increase by at least 8,32 mm/year and a maximum of 10,46 mm/year. The Vaasa GPS shows a calculation of 9.15 +/- 4.37, resulting in a minimum uplift of 4.81 mm/year and a maximum of 13.52 mm/year. Here, the margin of error is considerable, so it is likely that it will be difficult to reach the minimum or maximum points.

Conclusion

In conclusion, it seems that in these cases existing variations are intrinsically linked to the vertical land motions. Plus, the uplift, especially, in Vaasa and Seldovia is to be linked to the isostasy effect resulting from the end of Würm glaciation.



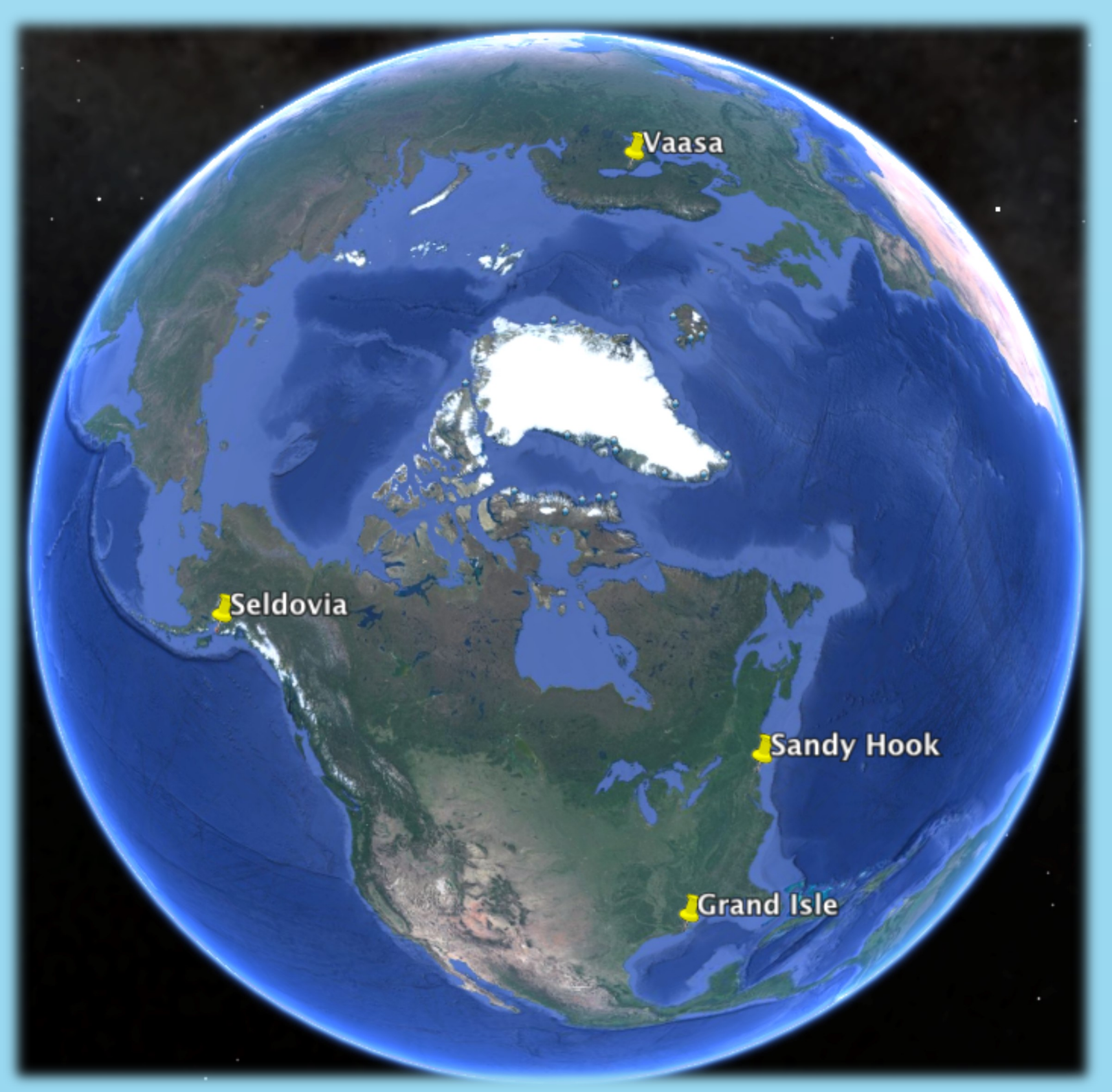


Fig.17– Legend of figures 3, 4, 7, 8, 11, 12, 15 and 16

Fig. 18– Location of the GPS's at global scale (Google Earth)

Bibliography

Frederikse, T., Jevrejeva, S., Riva, R., Dangendorf, S. (2018). "A Consistent Sea-Level Reconstruction and Its Budget on Basin and Global Scales over 1958–2014."Journal of Climate 31: 1267-1280.

Gendt, G. R., S.; Schon, N.; Uhlemann, M.; (2012). "Reprocessed height time series of GPS stations at tide gauges." Solid Earth Discussions 4: 1025–1067.

Mörner, N. A. (1973). "Eustatic changes during the last 300 years." Palaeogeography, Palaeoclimatology, Palaeoecology 13 (1): 1-14.

Moura D, Veiga-Pires C, Albardeiro L et al. (2007) Holocene sea level fluctuations and coastal evolution in the central Algarve (southern Portugal). Marine Geology 237: 127–142.

Watson, P. J. (2017). "Acceleration in European mean sea-level? A new insight using improved tools." Journal of Coastal Research 33: 23–38. Coconut Creek (Florida), ISSN 07490208.

Watson, P.J., 2016. Acceleration in U.S. mean sea level? A new insight using improved tools. Journal of Coastal Research, 32(6), 1247–1261. Coconut Creek (Florida), ISSN 07490208.

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