

Providing Global Navigation Satellite System (GNSS) signals to civilian users was a milestone for a wide range of applications, including both strictly scientific purposes (e.g., geodynamics, atmospheric research) and our everyday life (e.g., personal and vehicle navigation). Since then, GNSS technology has been developed in two main domains. On the one hand, efforts were focused on improving the accuracy of satellite positioning. On the other hand, to make the broadest possible use of the advantages of the GNSS technology. The natural consequence of the latter path has become the increasing number of low-cost GNSS receivers. In principle, these devices were supposed to be used for navigation. Still, they have also been subject to development trends, taking advantage of the technological progress of precise receivers. The above process included not only GNSS receivers but all other devices, such as inertial sensors, which measure accelerations and angular velocities. Since the latter sensors are complementary to GNSS receivers regarding displacement measurements, their integration allows us to improve the accuracy of the solution. Notably, GNSS and inertial sensors are often implemented in our smartphones, allowing them to be considered permanently operating measuring stations. Another advantage of smart devices is their ubiquity, which creates a very dense sensor network. Nonetheless, the quality of such observational data and, consequently, their possible application in Earth sciences must be verified.

In this project, we will address both of these scientific questions. The first one, related to the quality of observations, is predominantly crucial concerning smartphones with embedded GNSS chipsets. The studies conducted in recent years have proven that these observations are characterized by much higher measurement noise and various factors distorting observations. The consequence is the need to develop algorithms customized for mass-market receiver data to address their low quality. As one of the project's goals, such a task is of decisive importance for determining the possibilities offered by the low-cost devices tested in the project. Concerning this goal, particular emphasis will be placed on integrating data provided by GNSS and inertial sensors.

The research in the following part of the project will focus on the applicability of data obtained from low-cost receivers & smartphones and dense networks of such devices. We will verify the hypothesis on whether such mass-market instruments initially dedicated to assisting in our everyday life have a chance to become scientific instruments. In this regard, the planned tests cover two main areas: atmospheric and seismic studies. Concerning the former, the primary goal will be to evaluate the quality of ionospheric and tropospheric characteristics derived from low-cost GNSS receiver data. In case of satisfactory results, the research will also include atmosphere monitoring with high spatiotemporal resolution. In the second area of study, which covers seismic activity and its effects, earthquake studies based on simulation experiments are planned. The investigations will include the displacement of the ground itself and the analysis of their causes. We will use machine learning to process large data sets for the latter purpose. It is worth noting that the research planned in the project will also utilize data from smartphones in regular use. This innovation seems to be crucial from the point of view of creating dense networks of such sensors.