Multi-GNSS Precise Point Positioning with stochastic clock modeling

Global Navigation Satellite Systems (GNSS), such as GPS, GLONASS, Galileo, and BeiDou, are used for the determination of the receiver position, velocity, and timing. The International GNSS Service (IGS) was established with the aim to provide high-quality GNSS orbit, clocks, earth rotation, troposphere, and ionosphere parameters, and to realize the GNSS-based international terrestrial reference frames.

So far, standard approaches to GNSS precise point positioning (PPP) assumed that the clock parameter is independent for each observation epoch. Moreover, in multi-GNSS solutions, clock parameters are separately estimated for each system involved: GPS, GLONASS, Galileo, BeiDou due to inter-system biases. This approach deteriorates the GNSS solutions because the clock parameter is strongly correlated with the station vertical coordinate component and troposphere zenith delay.

The goal of this project is to improve multi-GNSS positioning by stochastic receiver clock modeling especially for those receivers which are connected to ultra-stable atomic clocks.

Most of the IGS stations employ internal temperature compensated crystal oscillators. However, some stations are equipped with external clocks, such as rubidium, cesium atomic clocks, or hydrogen masers, which guarantee high-frequency stability. The receiver atomic clocks are used for the time transfer or realization and distribution of the Coordinated Universal Time UTC. Modeling the receiver clock parameters provided by a stable oscillator improves the GNSS solutions, particularly, the up component in the kinematic positioning.

This project aims at improving the static and kinematic multi-GNSS positioning by introducing clock models to the Kalman filter in PPP as well as relative constraining between adjacent observation epochs assuming the derived noise level for the random walk process. The kinematic PPP solutions will be introduced for ground-based GNSS receivers as well as the space-borne receivers installed onboard low Earth orbiters (LEO). New satellite missions will be employed, such as Sentinel-6/Jason-CS, which are capable of tracking Galileo signals. Therefore, we will exploit, for the very first time, the full advantage of the Galileo satellites equipped with ultra-stable clocks, as well as new Galileo services, such as High Accuracy Service (HAS) for novel PPP algorithms with clock modeling. Therefore, the project will open new opportunities in terms of precise positioning of ground-based GNSS receivers as well as low-orbiting satellites, such as altimetry missions for sea level monitoring which require the utmost accurate position.