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Low-cost multi-constellation GNSS receivers for Earth observation

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Low-cost, multi-constellation GNSS receivers that output raw data (i.e. at least code pseudorange and carrier phase observations) have been introduced on the market in the last three years, enabling several advanced applications in the field of Earth observation, including atmospheric measurements, in a cost-effective way. Such receivers, in fact, combine the benefits of using low-cost hardware with those of multi-constellation receivers. The former include, for example, the possibility to make the densification of existing GNSS networks more practical in terms of cost, or to deploy receivers in hazardous locations that might put at risk the integrity of the hardware itself. The latter are at least twofold:

· the increased redundancy provided by satellites belonging to constellations other than GPS makes the estimation process more robust, and increases the available slant measurement directions at any given epoch;

· new signals can be exploited that may prove beneficial for specific applications.

As regards the first point, the number of available multi-GNSS satellites can already be increased to about 2-3 times that of GPS satellites alone, depending on the region of observation, only considering those already in orbit and functioning. This number is going to be further increased when taking into account the new launches scheduled for the next few years.

The second point includes new signals, on frequencies other than L1 or L2, which could be used to obtain more precise measurements (e.g. by the precise code of the Galileo E5 signals) or to provide a second frequency at affordable cost (e.g. exploiting the L2C or L5 signals).

As an example, the advantage of using a cost-effective dual-frequency receiver could be significant for GNSS/MET analyses. In fact, GNSS-based tropospheric estimation and water vapor retrieval are typically performed by using high-grade dual-frequency GPS receivers. A densification of existing GNSS networks is beneficial for precipitable water vapor (PWV) monitoring at a local scale, which is expected to be useful to improve the nowcasting and forecasting of localized heavy rain. However, such a densification would have a high economic impact when standard dual-frequency receivers are involved. On the other hand, when dealing with single-frequency receivers one has to take into account the ionospheric delay, which has to be removed in order to retrieve the tropospheric delay (and consequently the PWV). A second frequency onboard a low-cost GNSS receiver would allow to compensate the ionospheric delay by linear combination of the two frequencies, excluding the need of performing complex interpolations from available dual-frequency stations surrounding the single-frequency receiver.

In general, all the applications requiring the processing of GNSS observations by PPP (precise point positioning), or by relative positioning over long baselines, would benefit from the availability of cost-effective dual-frequency receivers.

This presentation will give an overview of the current status of low-cost receivers and multi-GNSS, describing experiments and test cases related to the combination of the two technologies. Details about the feasibility of designing cost-effective dual-frequency receivers will also be investigated and reported.

Keywords: GNSS, low-cost, multi-GNSS