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MISTRALE: Soil moisture mapping service based on a UAV-embedded GNSS-Reflectometry sensor

Laura Van de Vyvere (1) and Olivier Desenfans (2)

(1) M3 Systems Belgium, Belgium (vandevyvere@m3systems.eu), (2) M3 Systems Belgium, Belgium (desenfans@m3systems.eu)

Around 70 percent of worldwide freshwater is used by agriculture. To be able to feed an additional 2 billion people by 2030, water demand is expected to increase tremendously in the next decades. Farmers are challenged to produce “more crop per drop”. In order to optimize water resource management, it is crucial to improve soil moisture situation awareness, which implies both a better temporal and spatial resolution.

To this end, the objective of the MISTRALE project (Monitoring soIl moiSture and waTeR-flooded Areas for agricuLture and Environment) is to provide UAV-based soil moisture maps that could complement satellite-based and field measurements. In addition to helping farmers make more efficient decisions about where and when to irrigate, MISTRALE moisture maps are an invaluable tool for risk management and damage evaluation, as they provide highly relevant information for wetland and flood-prone area monitoring.

In order to measure soil water content, a prototype of a new sensor, called GNSS-Reflectometry (GNSS-R), is being developed in MISTRALE. This approach consists in comparing the direct signal, i.e. the signal travelling directly from satellite to receiver (in this case, embedded in the UAV), with its ground-reflected equivalent. Since soil dielectric properties vary with moisture content, the reflected signal’s peak power is affected by soil moisture, unlike the direct one. In order to mitigate the effect of soil surface roughness on measurements, both left-hand and right-hand circular polarization reflected signals have to be recorded and processed. When it comes to soil moisture, using GNSS signals instead of traditional visible/NIR imagery has many advantages: it is operational under cloud cover, during the night, and also under vegetation (bushes, grass, trees). In addition, compared to microwaves, GNSS signal (which lies in L-band, between 1.4 and 1.8 GHz) is less influenced by variation on thermal background. GNSS frequencies are then ideal candidates for soil moisture observation. In the context of the MISTRALE project, both GPS and GALILEO signals will be used. Thanks to a higher number of available satellites and to the GALILEO signals characteristics, the sensor’s measurements accuracy will be improved.

The GNSS-R sensor will be embedded on Boreal, a fixed-wing UAV weighing less than 20 kg and allowing about 5 kg payload. Boreal is able to fly continuously for 10 hours and has a range of 1000 km. Due to the low elevation (100-150m) of UAV flights, high spatial resolution can be achieved.

Test flights have already been performed in Pech Rouge and Camargue areas, France. During these campaigns, soil moisture maps were computed using GNSS-R data. These were successfully correlated with in-situ measurements, considered as ground truth, demonstrating the feasibility of the MISTRALE concept.

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