Mapping the soil water content variations in a torrential environment using Slingram electromagnetic method

(Draix field observatory, south Alps, France)

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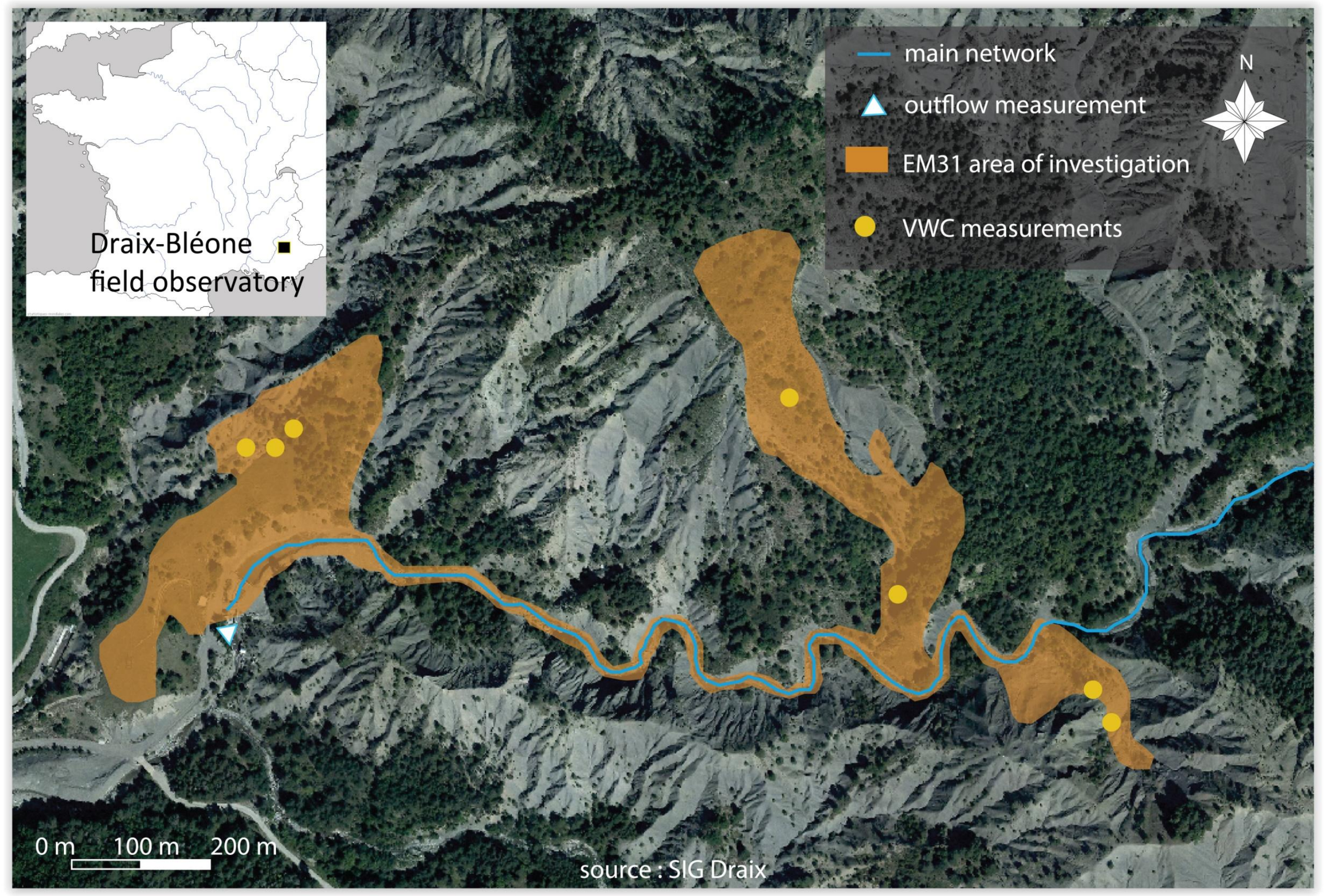
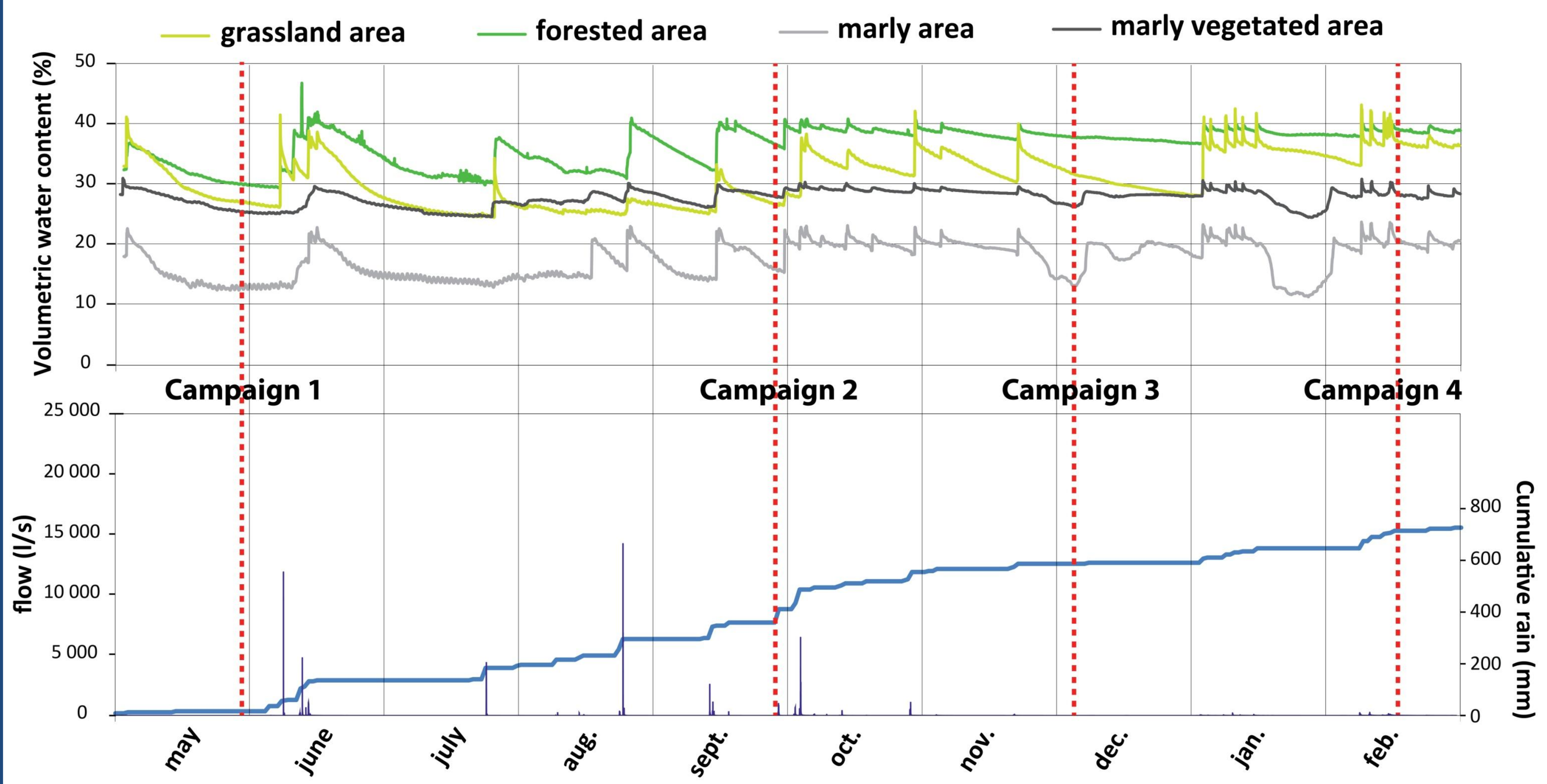
1. Introduction : The project aims at understanding runoff generation in torrential context and identifying the effect of local forcing parameters (land cover, soil type, slope, hillslope orientation...). **Soil water content (θ)** is a key parameter that controls runoff processes at the watershed scale (Beven et al., 2014). Identifying the spatial and temporal distribution of soil water content is still challenging especially in sloppy regions coupled with high erosion rates resulting in a significant gully network. **Hydrogeophysical** tools can help to better understand the distribution of runoff generation by mapping **soil apparent electrical conductivity** (**σ_a**) (Martini et. al, 2016). Spatio-temporal variation in **σ_a** are strongly influenced by soil depth and water content. The study focuses on a small marly catchment (0,86 km²) known for its peculiar hydrological behaviour during flood events with very high specific outflows.



2. Method & Data : Hydrological and meteorological data are obtained continuously at the catchment's outlet. Sub-catchments with various land cover and soil types have been equipped from may 2015 onwards for **θ** monitoring (**Decagon 10HS capacitance probes**). Since may 2015, four geophysical surveys were conducted in various moisture conditions and following the same pathway using the **Slingram electromagnetic technique** (EM31) in horizontal dipole to identify changes in soil properties until 4m.



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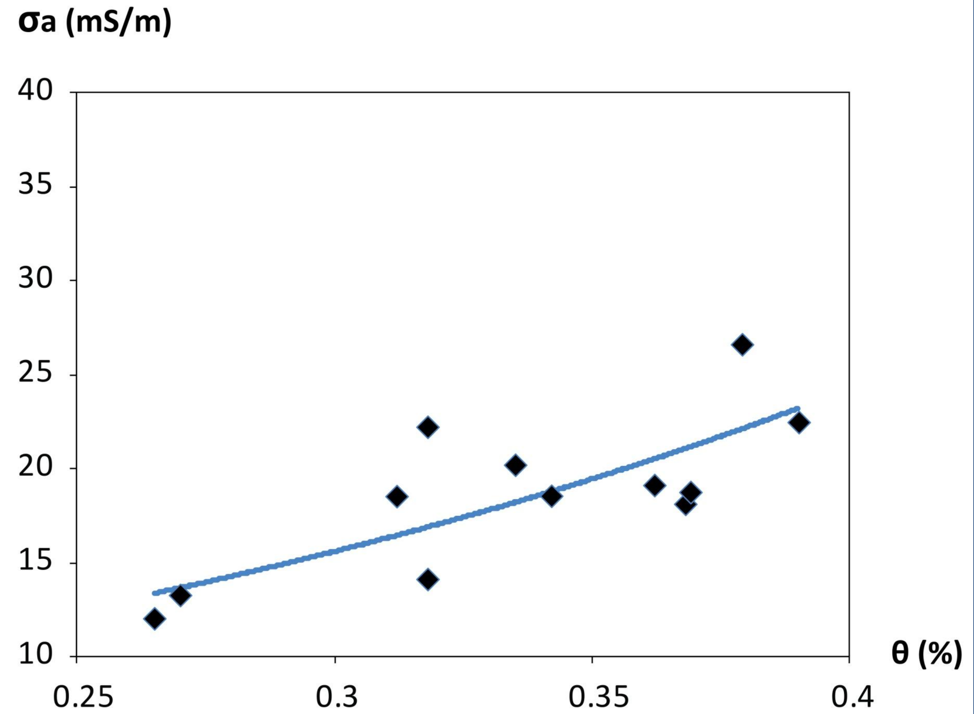
3. Results

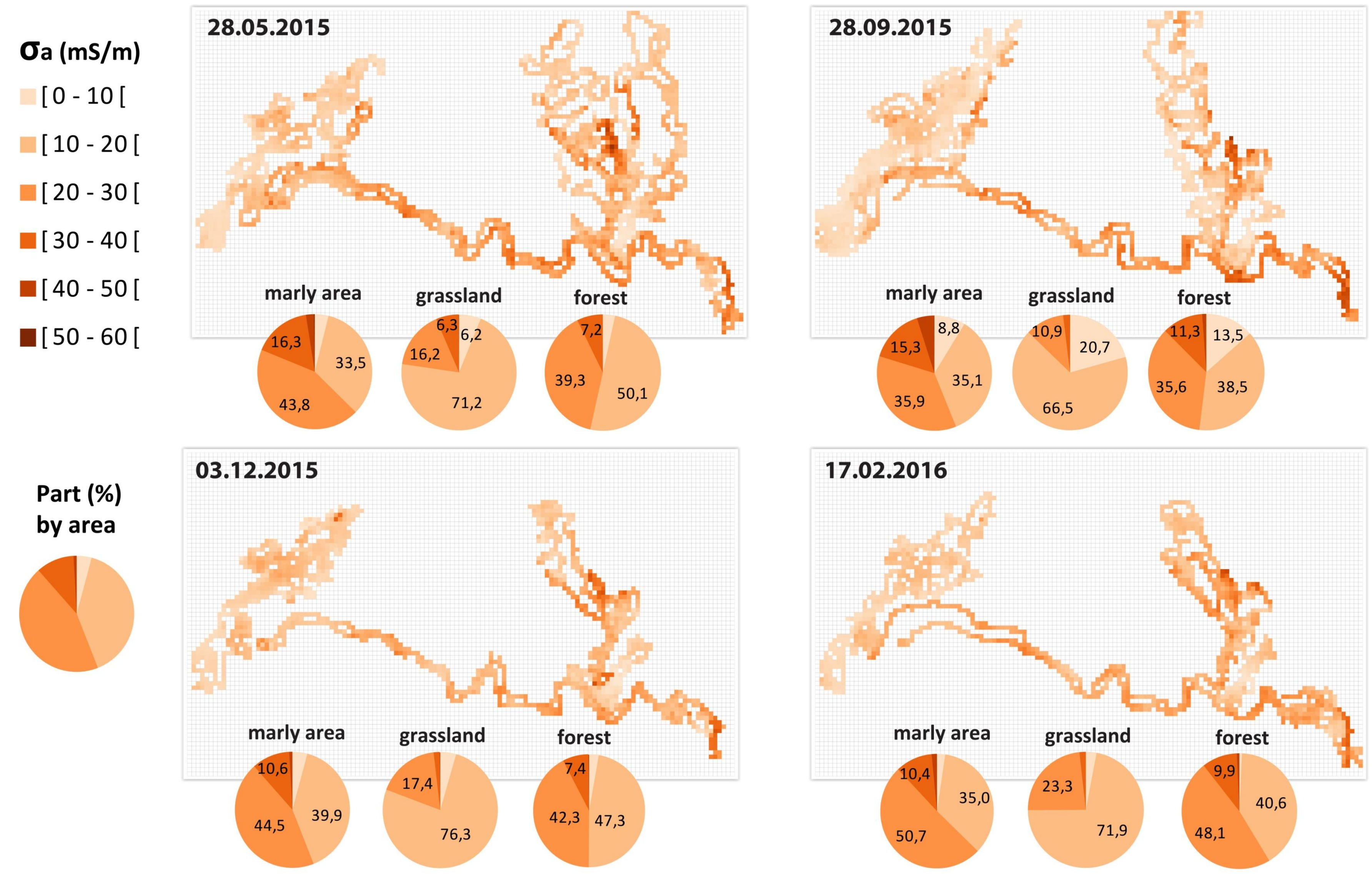
3.1. Correlation between σ_a and θ : Measurements were obtained in **horizontal dipole** and have been averaged by rasters of 25m². We observe a significant correlation between **σ_a**'s rough values and **θ** measured by 7 capacitance probes in grassland and forested areas.

$$\sigma_a = 4.14 \exp(4.42 * \theta)$$

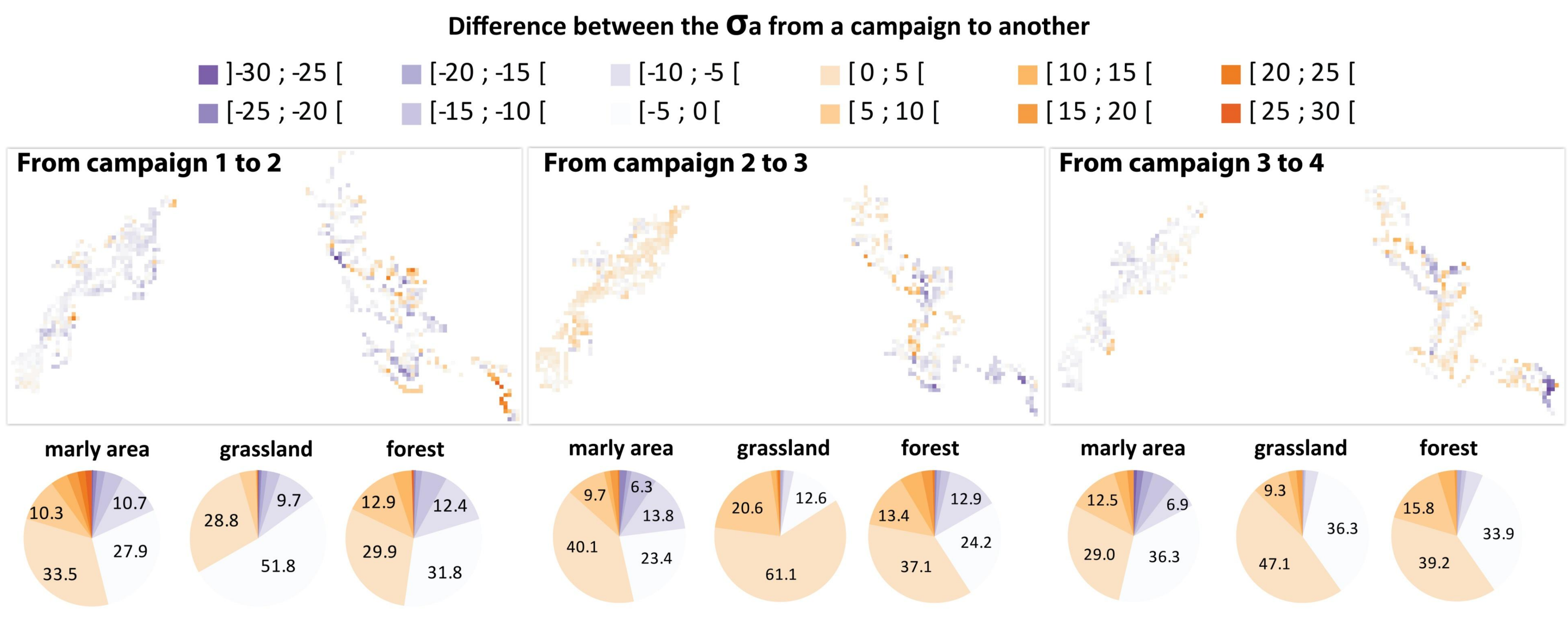
R Spearman = 0.711 (α = 0.05 , p-value = 0.012)
R Pearson = 0.785 (α = 0.05 , p-value = 0.002)



3.2. σ_a partition by campaign and environment

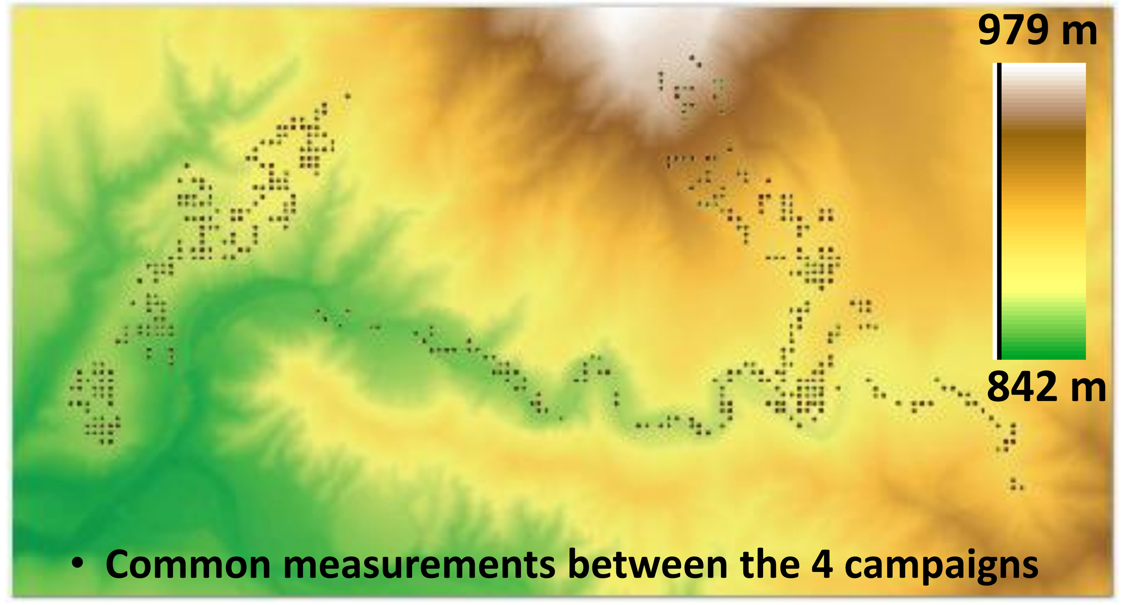


3.2. Difference of σ_a values between campaigns (pixels in the main thalweg are excluded)

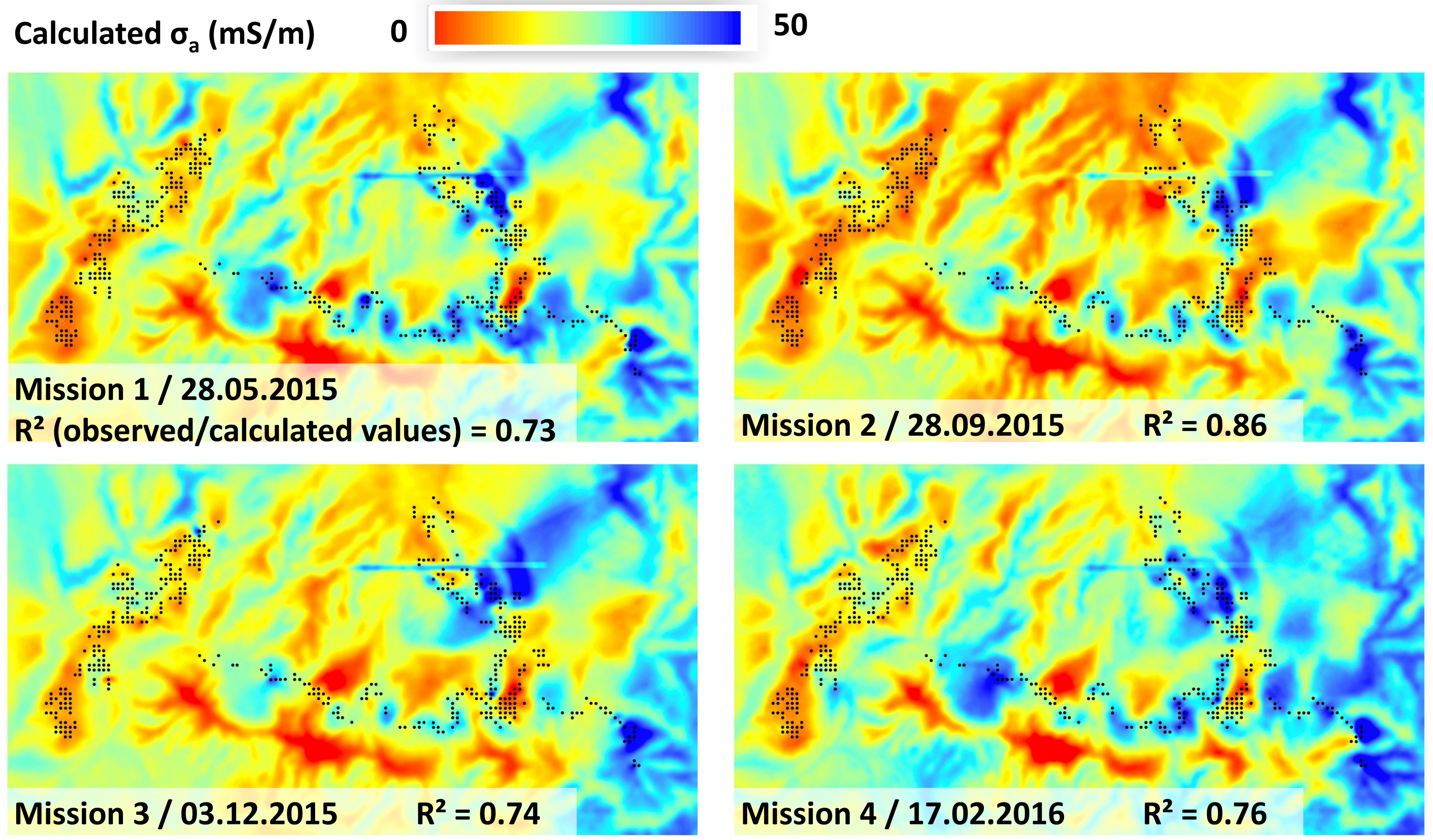


Partition of the difference of σa by environment (%)

3.4. Interpolation of σ_a data : We propose a soil water content mapping procedure at the catchment scale using a local interpolation method (Joly et.al, 2008). The **LISDQS** model takes into account local topographic forcing parameters derived from a high resolution DEM (1m LIDAR). A three steps method is based on 1. regressions, 2. krieging and 3. regressions and krieging the residuals. This technique is used to interpolate the data and provides a continuous spatial field.



The interpolation is based on topographical variables and vegetation cover. It seems that the **deep of the valley** explains most of **σ_a** variations., then the **hillslope orientation** and the **slope**.



4 . Conclusions & perspectives : Water content changes presents high spatial and temporal variability, controlled by site properties and climate. It seems that the **σ_a** mapping can be a way to understand **θ** variations (Mc Donnell & Von Tromp Meerveld, 2009) in areas where mapping process is complicated by topography, soil properties and land cover changes. We obtained a significant correlation between the soil **σ_a** and **θ** for grassland and forested areas. The next step is to map the **σ_a** at the watershed scale and use this correlation to map the **θ** in grassland and forested areas, then compare the calculated values of **θ** with measured datas (capacitance probes).

5. References

- **Beven et. al, 2014** : "Debates—The future of hydrological sciences […]", AGU, Water Resources Research 50, 5342-5350
- **Martini et. al, 2016** : " Repeated electromagnetic induction measurements for mapping soil moisture […]", EGU 2016
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- **Mc Donnell & Tromp Von Meerveld, 2009** : "Assessment of multi-frequency electromagnetic induction for determining soil moisture patterns at the hillslope scale", Joural of hydrology 368, 56-67