Estimation of within field variation of SOM using UAV based RGB photos and elevation data
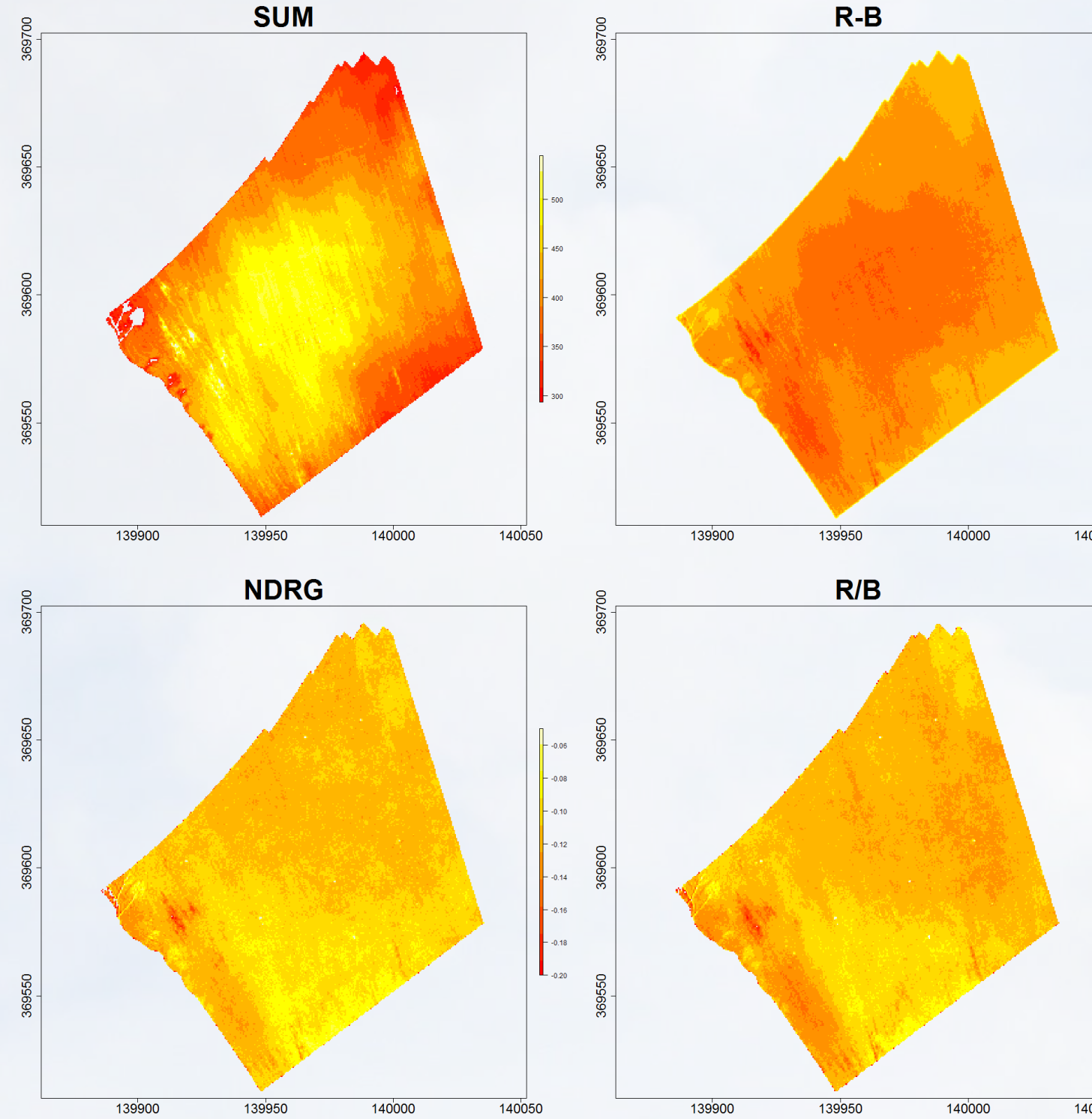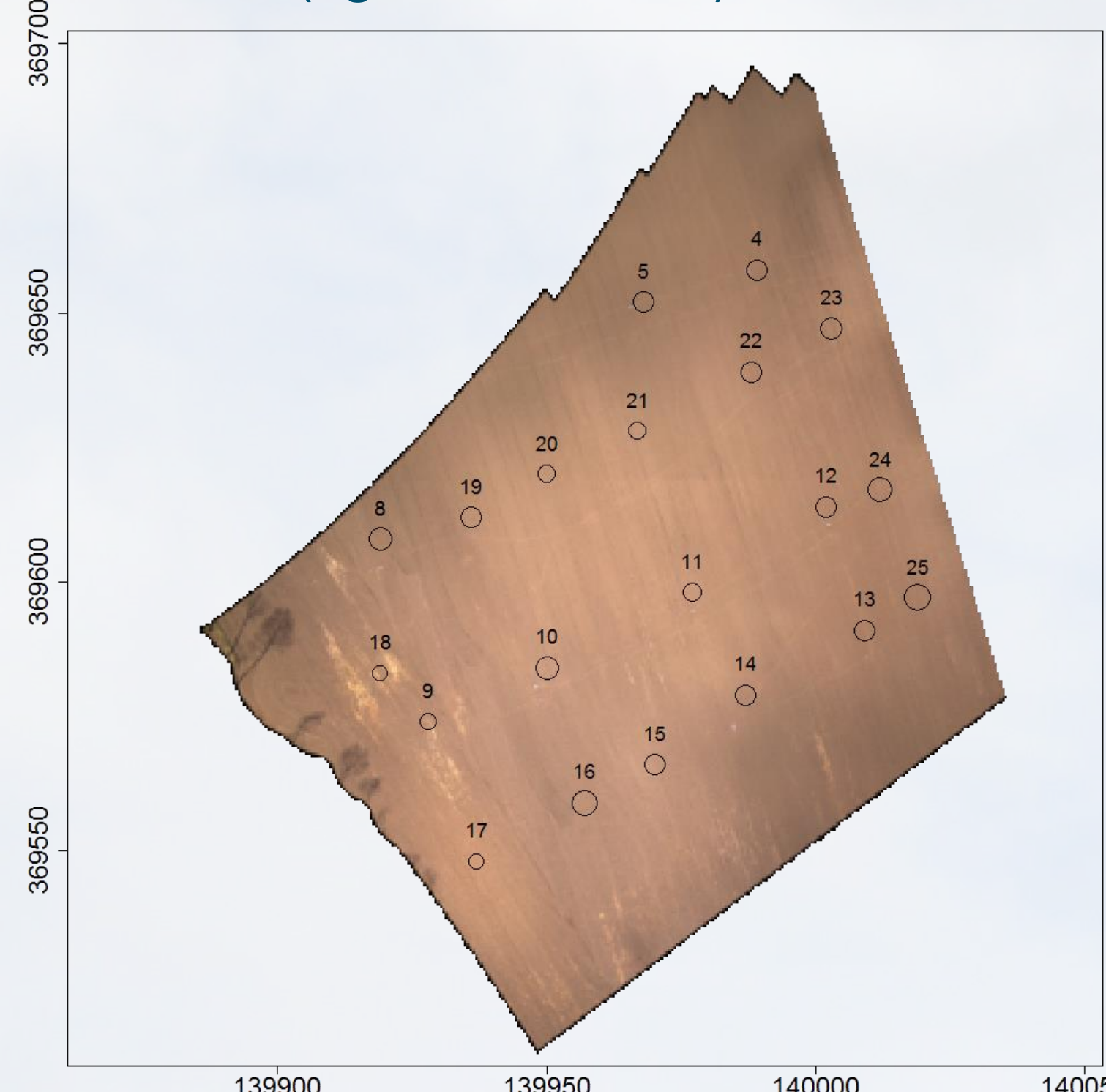
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Background

For quantitative estimation of soil properties by means of remote sensing, often hyperspectral data are used. But these data are scarce and expensive, which prohibits implementation of the developed techniques in agricultural management. For precision agriculture, observations at a high spatial resolution are required. Color aerial photographs at this scale can be acquired at very low costs using unmanned airborne vehicles (UAV's). We investigated whether RGB aerial photographs can be used to estimate levels of Soil Organic Matter (SOM) spatially. Further, we investigated if including Soil Moisture and Terrain Height (Z) in the stepwise multiple regression improves the estimation of SOM distribution.
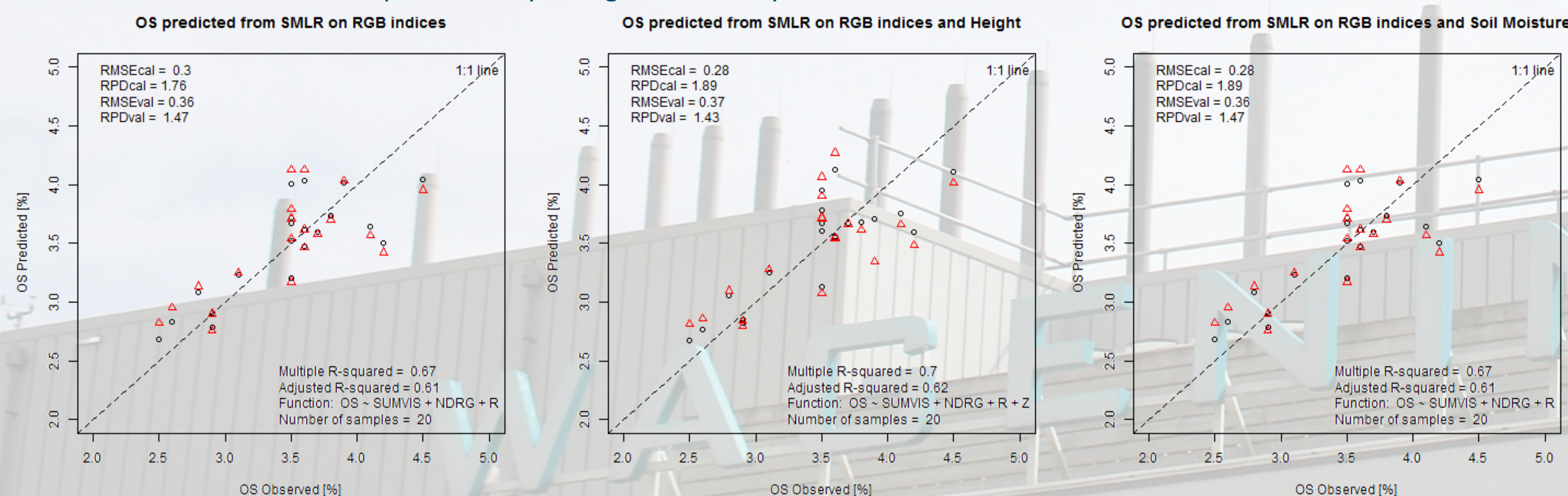
Image Acquisition 2013-04-18 → RGB Orthophoto (Agisoft Photoscan) → Calculation of Indices

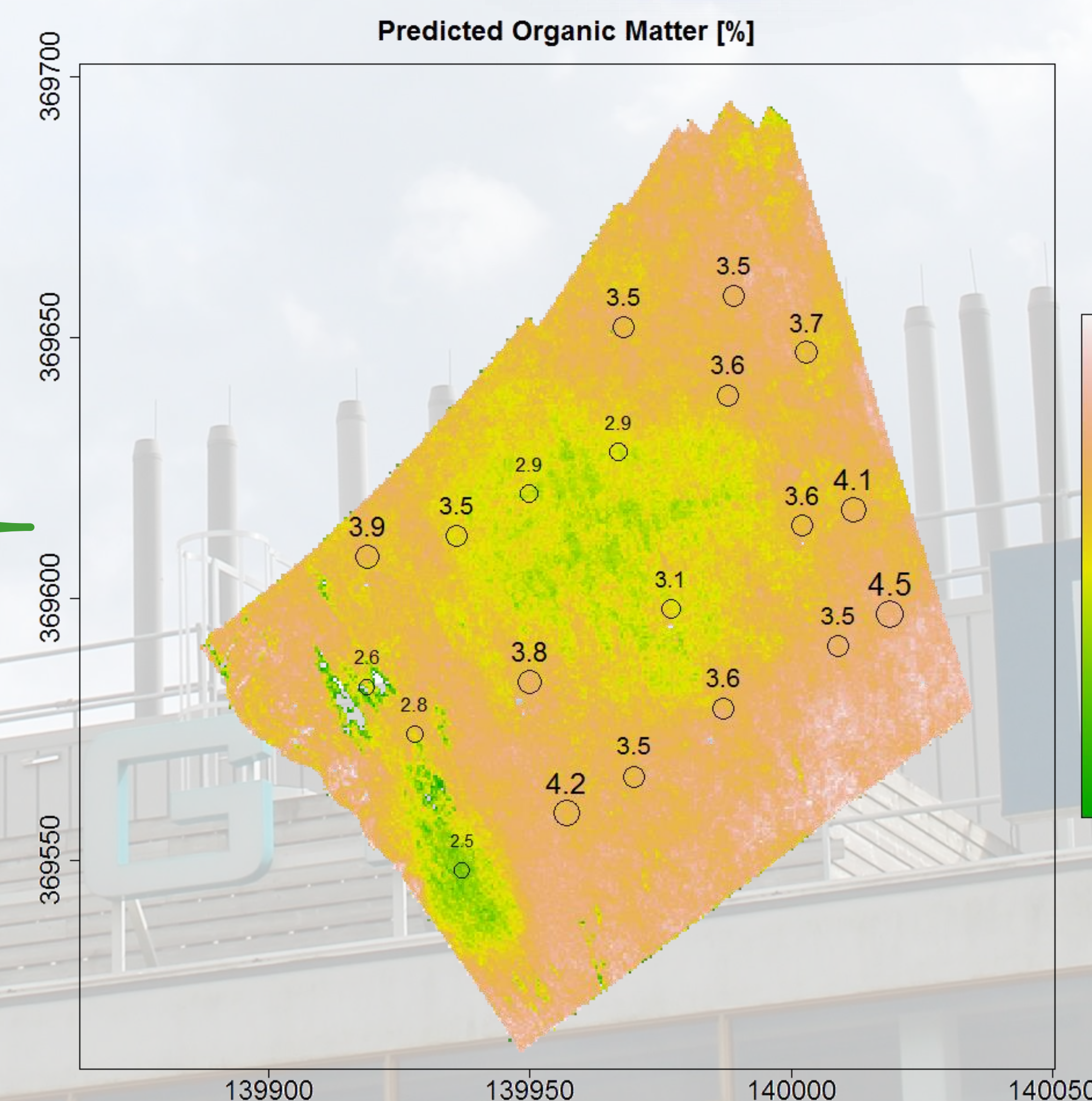SUM R-B NDRG R/B

Materials

Image acquisition:
- Altura PRO AT8 multicopter system with a fully autonomous flying functionality
- High-resolution orthophoto camera system (Panasonic Lumix GX1)
- Georeferencing using ground control markers (for this study)

Soil sampling:
- 20 samples
- Location determined with Garmin Etrex handheld GPS
- Soil Organic Matter and soil moisture determined in the laboratory

Elevation data:
- AHN2 –> publically available digital elevation model for the Netherlands

Predicted Organic Matter [%]

Stepwise Multiple Regression Analysis with Leave-one-out cross Validation

OS predicted from SMLR on RGB indices

RMSEcal = 0.3
RPDcal = 1.76
RMSEval = 0.36
RPDval = 1.47

Multiple R-squared = 0.67
Adjusted R-squared = 0.61
Function: OS ~ SUMVIS + NDRG + R
Number of samples = 20

OS predicted from SMLR on RGB indices and Height

RMSEcal = 0.28
RPDcal = 1.89
RMSEval = 0.37
RPDval = 1.43

Multiple R-squared = 0.7
Adjusted R-squared = 0.62
Function: OS ~ SUMVIS + NDRG + R + Z
Number of samples = 20

OS predicted from SMLR on RGB indices and Soil Moisture

RMSEcal = 0.28
RPDcal = 1.89
RMSEval = 0.36
RPDval = 1.47

Multiple R-squared = 0.67
Adjusted R-squared = 0.61
Function: OS ~ SUMVIS + NDRG + R
Number of samples = 20

Conclusions

- UAV based RGB aerial photographs can be a valuable tool for the estimation of the spatial distribution of organic matter
- Using elevation as an addition data source does not increase the prediction accuracy significantly
- Stepwise Multiple Regression can yield good results if indices are included
- Since aerial photographs are publically available or can easily be acquired using UAV's, they offer great possibilities for implementing remote sensing techniques in agricultural management

- A stepwise multiple linear regression results in a good relation between RGB image derived indices
- Adding Terrain Height (elevation differences of max 50 cm) or Soil Moisture (2.4-7.5 %) does not significantly improve the correlation