Simultaneous measurement of soil moisture and biomass pattern with a CRNS rover

Jannis Jakobi[1], Johan A. Huisman[1], Martin Schrön[2], Steffen Zacharias[2] and Heye R. Bogena[1]

[1]Forschungszentrum Jülich GmbH, IBG 3 – Agrosphere, Jülich, Germany; [2]UFZ Helmholtz Centre for Environmental Research, Leipzig, Germany

Motivation

- Cosmic-ray neutron intensity is an established predictor for the temporal variability of soil moisture at the field scale
- Recent studies suggest using the thermal-to-fast neutron ratio (N_r) for estimating aboveground biomass (1) and for correcting aboveground biomass influence on cosmic-ray based soil moisture estimation (2)
- Hypothesis: A cosmic-ray neutron sensing (CRNS) rover allows for measuring soil moisture (3) and biomass (4) at the regional scale

N_r-biomass estimation & soil moisture correction

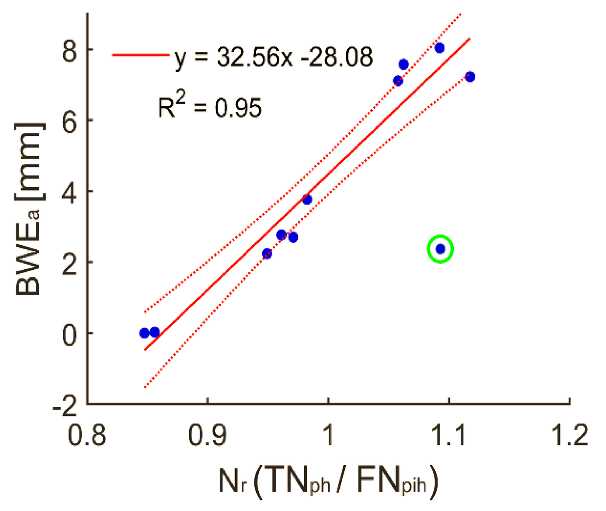
Neutron ratio (N_r):

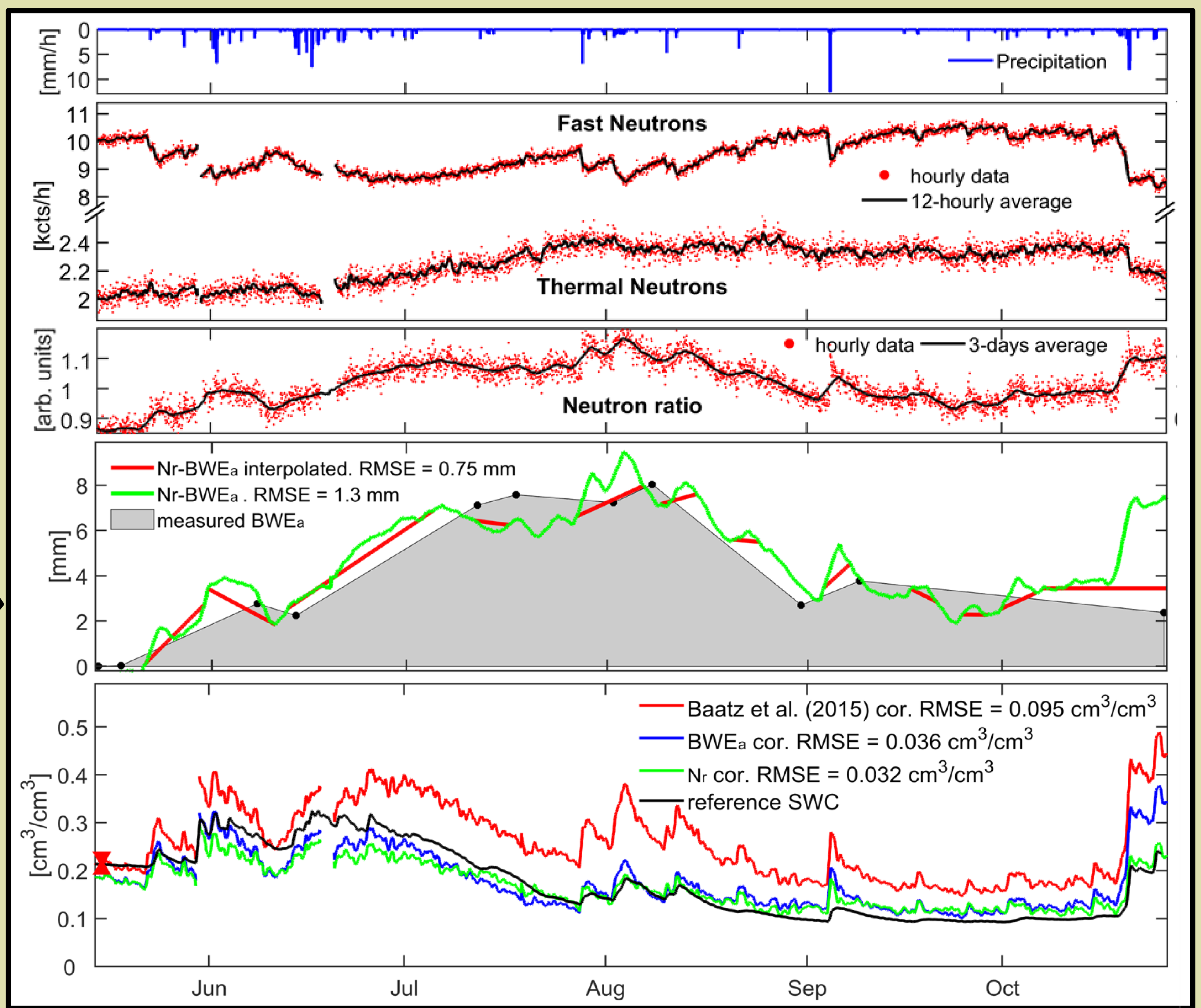
$$N_r = \frac{\textit{Thermal Neutrons}}{\textit{Fast Neutrons}}$$

BWE_a: Sum of aboveground hydrogen in plants

(1)

- Peaks coincide with precipitation
- Interpolating 24h periods with precipitation ≥ 1.5 mm (red lines) reduced the influence of rainfall



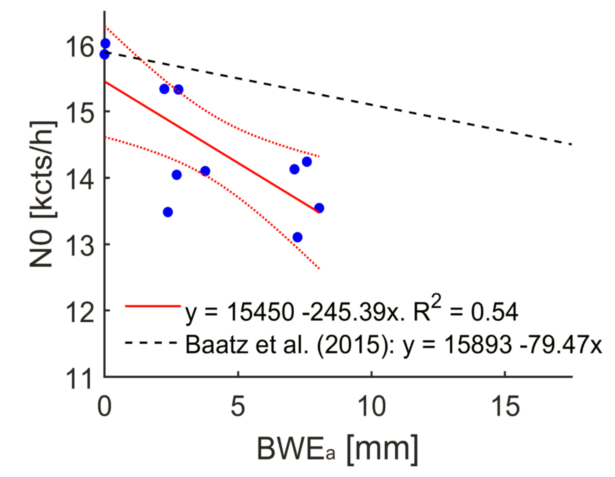


(2)

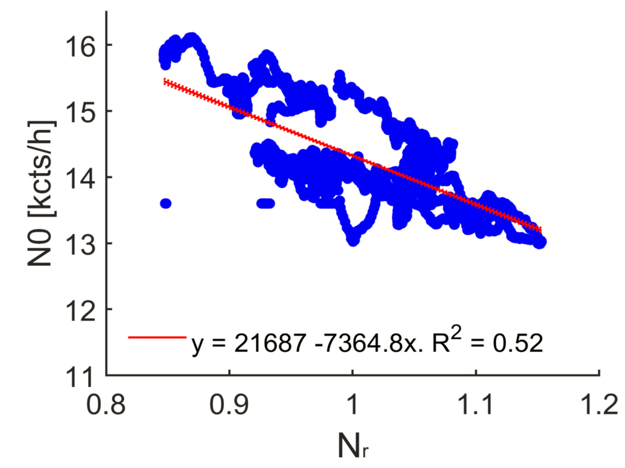
Aboveground biomass corrections:

1) Baatz et al. (2015) correction

2) Own linear regression function



3) Linear regression with N_r



- For N_r-based correction no direct biomass measurement necessary

Jakobi et al. (2018)

Roving estimate s of soil moisture and BWE_a

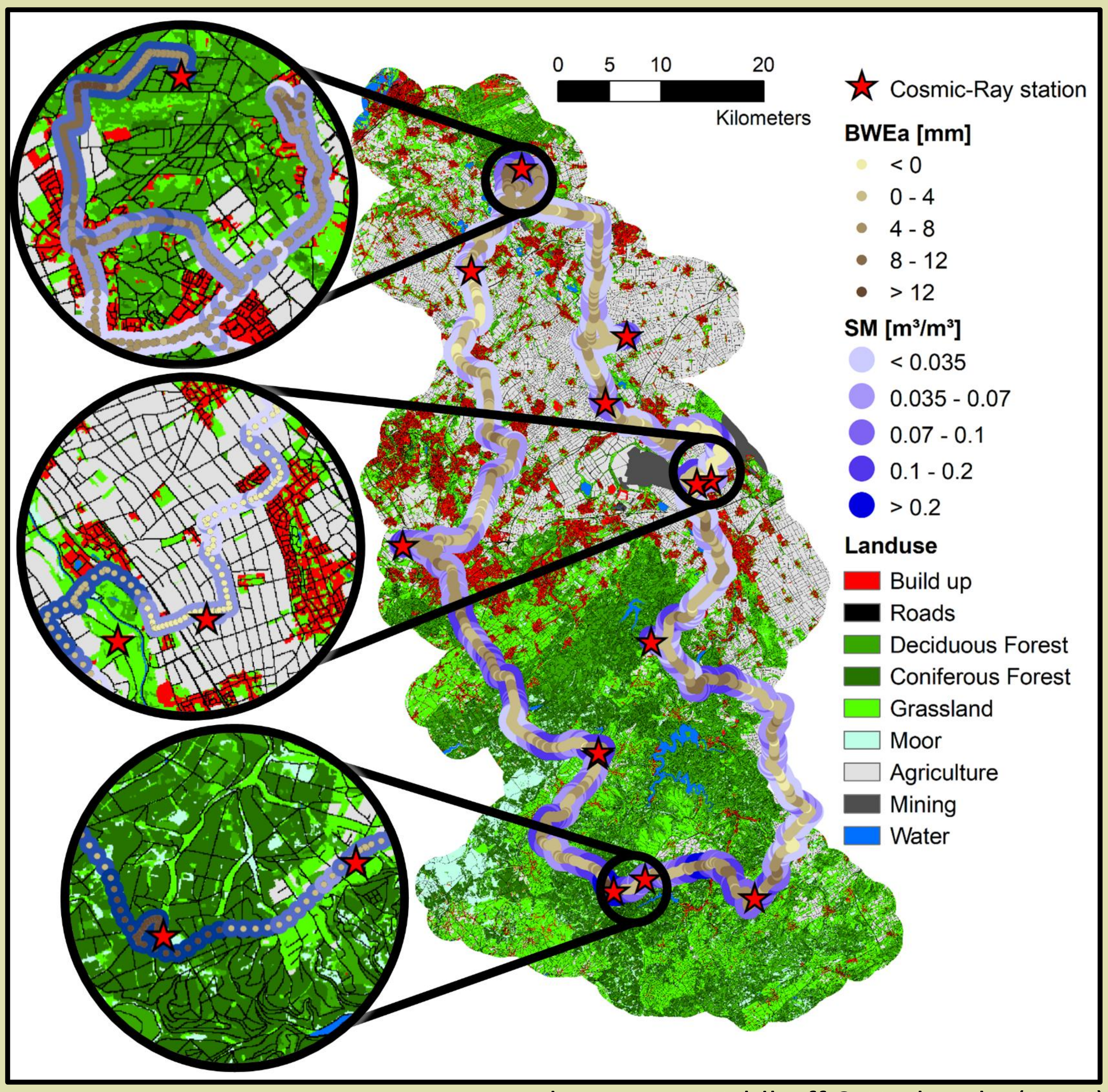
Methods

- Rover with high countrate (~60k cts/h; total of 36 CR probes) and possibility to flexibly modify from fast neutron to thermal neutron detectors:

- Use of median count rates in a 1000 m radius around each measurement
- Soil moisture calculated from fast neutrons and the standard calibration (Desilets et al. 2010) with N_0~130 cts/10 sec
- BWE_a calculated from linear regression shown in (1)

Results

- (3) Soil moisture estimates show expected North-South gradient
- (4) BWE_a estimates increase in forest (top and bottom zoom) and when close to surface water (middle zoom)
- In some agricultural areas, BWE_a estimates are below 0



Landuse-map: Waldhoff & Herbrecht (2018)

Conclusion & Outlook

- N_r can be used to predict aboveground biomass and to correct biomass influence on fast neutron derived soil moisture
- For roving applications, regression for BWE_a estimation (1) needs adjustment due to limited biomass range, possible influence of soil moisture, and possible non-linearity
- Future work: generalisation of N_r-approach for other crops and land uses

Jakobi, J., J. A. Huisman, H. Vereecken, B. Diekkrüger and H. R. Bogena (2018). Cosmic ray neutron sensing for simultaneous soil water content and biomass quantification in drought conditions. Water Resources Research 54. DOI: 10.1029/2018WR022692.