Karlsruhe Institute of Technology

Institute of Meteorology and Climate Research
Atmospheric Environmental Research (IMK-IFU)

Remote sensing-based biomass estimation to support rangeland management and food security in the Sahel

Anne Schucknecht[1], Michele Meroni[2], Francois Kayitakire[2], Amadou Boureima[3]

[1] Karlsruhe Institute of Technology, Garmisch-Partenkirchen, [2] European Commission Joint Research Centre, Ispra, Italy; [3]Ministry of Livestock, Niamey, Niger

MOTIVATION

- Important economic role of livestock sector in the Sahel
- High vulnerability of rangeland production as a result of high temporal & spatial rainfall variability

OBJECTIVE

- Develop a remote sensing (RS) based approach to estimate rangeland biomass at the end of the season
  - Utilizing landscape phenology
  - Applicable in a predictive mode
- Create biomass production map
  - To identify areas with potential deficit (livestock mortality) or surplus (fire prevention)

STUDY AREA, DATA & METHODS

- Study area: Sahel of Niger (ø P_{annual} = 100 – 300 mm)

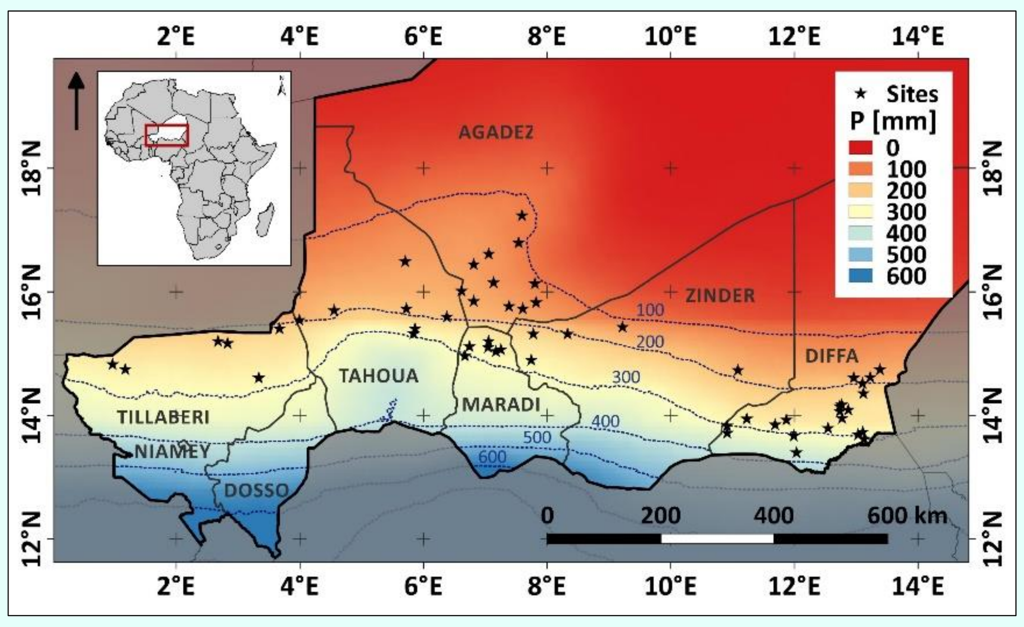

Fig. 1. ø P_{annual} (1986-2015; from TARCAT data), location of sample sites

- Time series of 10-day image composites of MODIS NDVI data (eMODIS product) from 01/2001 – 12/2015 → computation of phenology-based seasonal cumulative NDVI (cNDVI) as proxy for biomass production
- Measured above ground herbaceous biomass at the end of the growing season (B_m) → 56 sites (Fig. 1) with 616 records of dry matter production from 2001-2015
- Linear regression model
  - between B_m & corresponding cNDVI
  - Different aggregation levels for calibration (Fig. 2)
  - Cross-validation (cv) by leaving out one year at a time

SPATIAL DATA AGGREGATION

GLOBAL	GAES	SOIL	BIOPHYSICAL	DEPARTMENT	GAES+SOIL
Whole set of measurements	Global Agro-Environmental Stratification	Soil types	10-day NDVI images (2001-2015)	Administrative units	Overlay of GAES and soil types
1 unit	5 units	7 units	9 units	10 units	11 units
R^2_{cv} = 0.31 RMSE$_{cv}$ = 453 kg ha^{-1}	R^2_{cv} = 0.38 RMSE$_{cv}$ = 428 kg ha^{-1}	R^2_{cv} = 0.39 RMSE$_{cv}$ = 425 kg ha^{-1}	**R^2_{cv} = 0.47 RMSE$_{cv}$ = 398 kg ha^{-1}**	R^2_{cv} = 0.42 RMSE$_{cv}$ = 416 kg ha^{-1}	R^2_{cv} = 0.44 RMSE$_{cv}$ = 408 kg ha^{-1}

INCREASING COMPLEXITY OF THE MODEL →

Fig. 2. Applied spatial aggregations for model calibration

RESULTS

- Aggregated models with better performance than global one
- Biophysical model (calibration units derived from unsupervised ISODATA classification using 10-day NDVI images from 2001–2015) with highest R^2/R^2_{cv} & lowest RMSE$_{cv}$ (Tab. 1)

Tab. 1. Results of regression model for different aggregations

Aggregation	No. of units	R^2	R^2_{cv}	RMSE$_{cv}$ [kg ha^{-1}]
Global	1	0.33	0.31	453
GAES	5	0.42	0.38	428
Soil	7	0.44	0.39	425
Biophysical	9	0.52	0.47	398
Department	10	0.51	0.42	416
GAES + soil	11	0.50	0.44	408

- Estimated biomass maps
  - High temporal & spatial variability (Fig. 3) → need for flexible & production adapted rangeland management
  - Use to calculate biomass anomalies (Fig. 4)

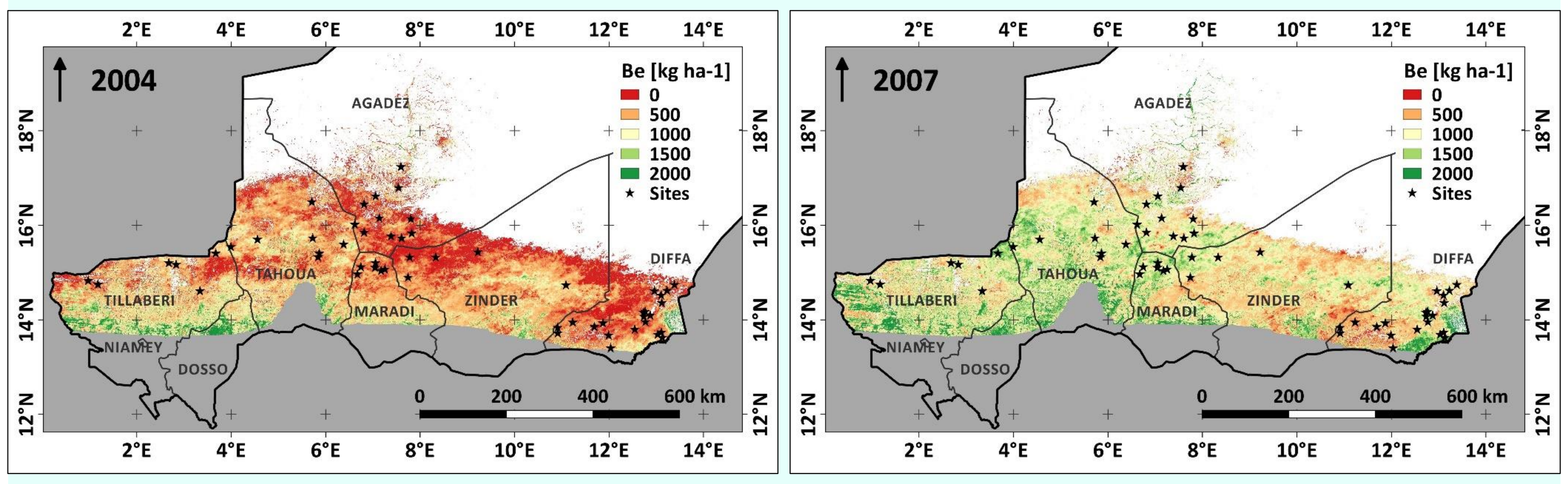

Fig. 3. Estimated biomass for the years 2004 (left) and 2007 (right)

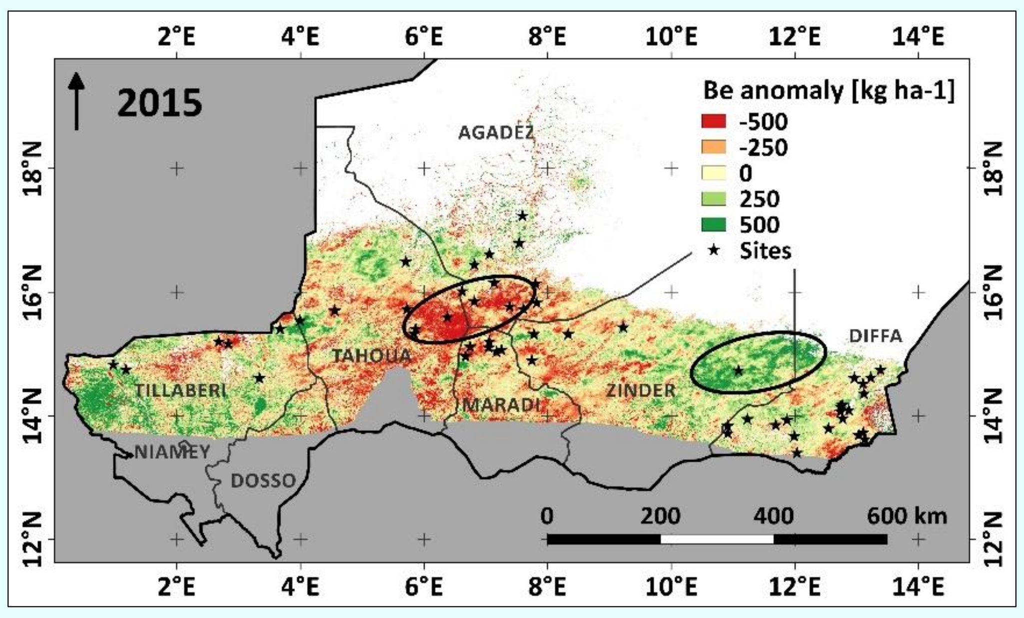

Fig. 4. Anomaly of estimated biomass (B_e) for 2015

CONCLUSIONS

- RS-based model to estimate rangeland biomass developed
- Different spatial aggregation schemes tested → biophysical performed best
- Approach can be applied for timely creation of estimated biomass production maps before field measurements are available
  - Time gain of 2 – 4 weeks
  - Planning of more in-depth field missions
  - Better management of rangeland resources → timely decisions on aid location & fire prevention
  - Back-up solution in case of no field measurements

For more details: Remote Sens, 2017, 463; doi:10.3390/rs9050463

Contact: anne.schucknecht@kit.edu