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

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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 (Ω \( P_{\text{annual}} = 100 – 300 \text{ mm} \))

- 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 \( (B_m) \rightarrow 56 \) 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

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 \( R^2 \) & lowest RMSEcv (Tab. 1)

<table>
<thead>
<tr>
<th>Aggregation</th>
<th>No. of units</th>
<th>( R^2 ) cv</th>
<th>RMSEcv (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>1</td>
<td>0.33</td>
<td>453</td>
</tr>
<tr>
<td>GAES</td>
<td>5</td>
<td>0.42</td>
<td>428</td>
</tr>
<tr>
<td>Soil</td>
<td>7</td>
<td>0.44</td>
<td>425</td>
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<tr>
<td>Biophysical</td>
<td>9</td>
<td>0.52</td>
<td>398</td>
</tr>
<tr>
<td>Department</td>
<td>10</td>
<td>0.51</td>
<td>416</td>
</tr>
<tr>
<td>GAES + soil</td>
<td>11</td>
<td>0.50</td>
<td>408</td>
</tr>
</tbody>
</table>

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

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

Tab. 1. Results of regression model for different aggregations

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