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A framework for standardized calculation of weather indices in Germany

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Background

- Global climate change leads to increasing occurence of extreme weather events
- Impact on crop yield levels and yield stability
- Weather indices (WI) for science and practice to explain crop yields and yield losses
- Consideration of crops‘ (most sensitive) phenological phases increases accuracy
- Standardized derivation of WIs is lacking
- Geodata of known spatio-temporal quality data are crucial for designing WIs

Objectives

- Development of transparent workflow for standardized calculation of WIs for German crop production
- Workflow is demonstrated for simple cumulative precipitation index during the phenological phase *shooting* of winter wheat

Materials and methods

Data (time series 1994-2014)

- SRTM (Shuttle Radar Topography Mission) DEM (Digital Elevation Model) – 1 x 1 km raster
- Public DWD data sets (Deutscher Wetterdienst):
  - Phenological monitoring network (approx. 2 x 2 km in average)
  - Daily precipitation data REGNIE (1 x 1 km raster)

Workflow

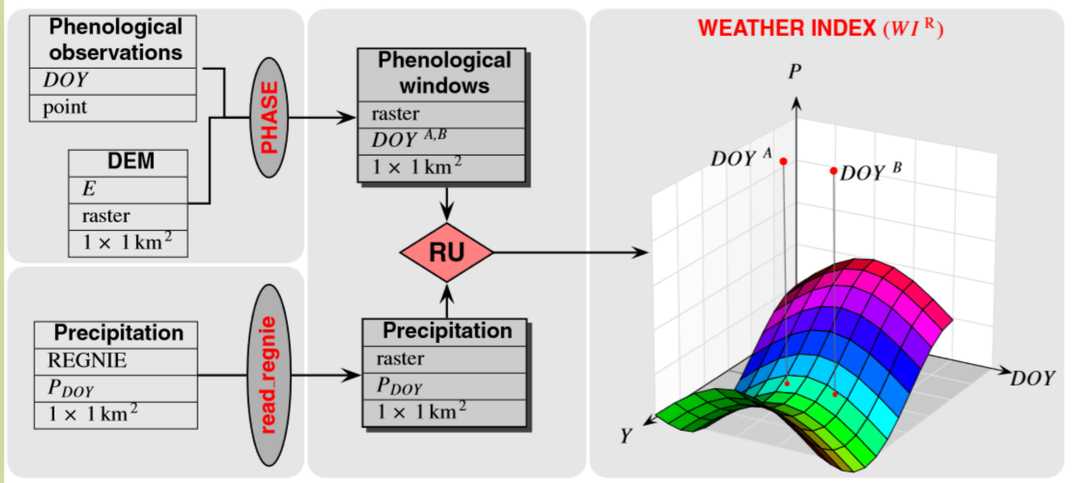

Fig. 1 *Principle workflow for the derivation of a phase-specific and raster-based weather index WI_R. RU – reference unit | DOY – day of year | P_{DOY} – daily precipitation | $DOY_{A,B}$ – DOYs phase start and end | DEM – digital elevation model | E – elevation | Y – year | PHASE – model for interpolation of beginning phenological phases | read regnie – model for import REGNIE data.*

- Phenological raster-data are generated using PHASE model (https://doi.org/10.1016/j.compag.2016.07.032)
  - GDD concept: heat sums required to reach specific phase retrieved annually from DWD pheno- and weather station data
  - Spatial interpolation using regression kriging
- Derivation of phenological windows for any year and location in Germany (https://doi.org/10.1016/j.catena.2016.11.016)
- Dynamic WI calculation considering phenological information (https://doi.org/10.1007/s00704-018-2473-x)

Results and Discussion

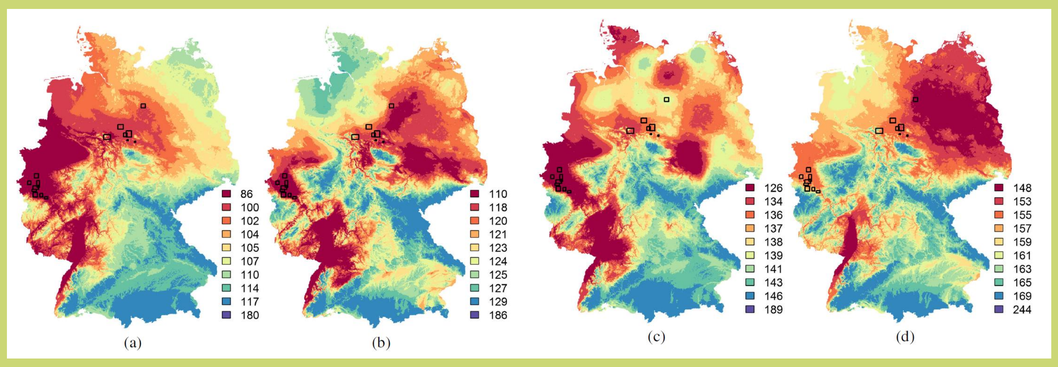

Fig. 2. *Predicted DOY of the beginning of phenological phases shooting (a, b) and heading (c, d) of winter wheat in 2007 (a, c) and 2013 (b, d).*

- Strong spatio-temporal differences in phenological development of winter wheat in Germany

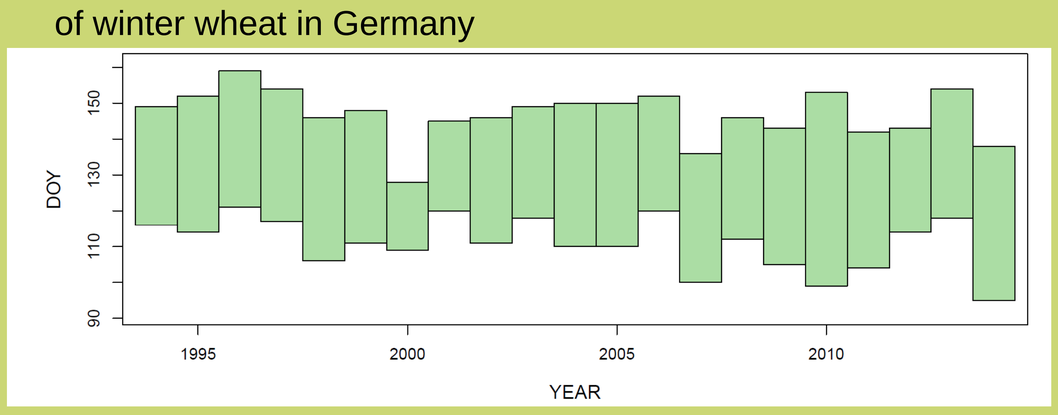

Fig. 3. *Phenological windows of shooting of WW for a test site (Fig. 4, marked in black).*

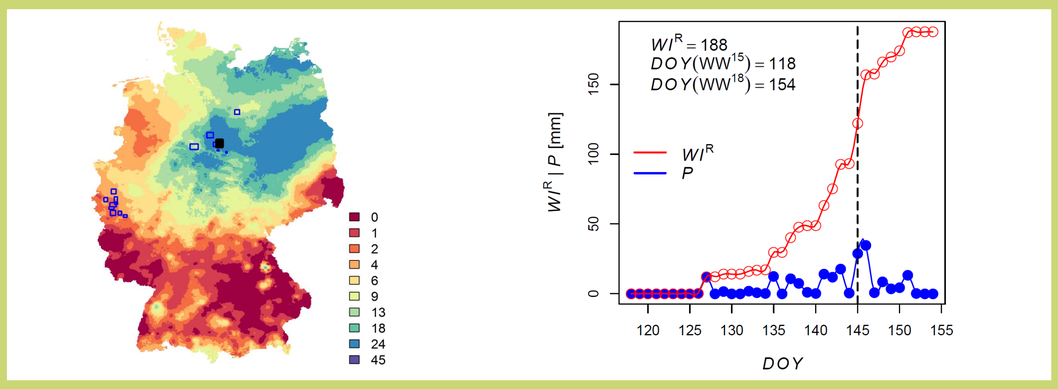

Fig. 4. *REGNIE precipitation raster (P) [mm] for DOY = 145 in 2013 (left) and phase-specific precipitation and corresponding WI (P and WI in mm) during shooting of WW for a test site (marked in black) in 2013 (right). DOY is emphasized by a dashed black vertical line.*

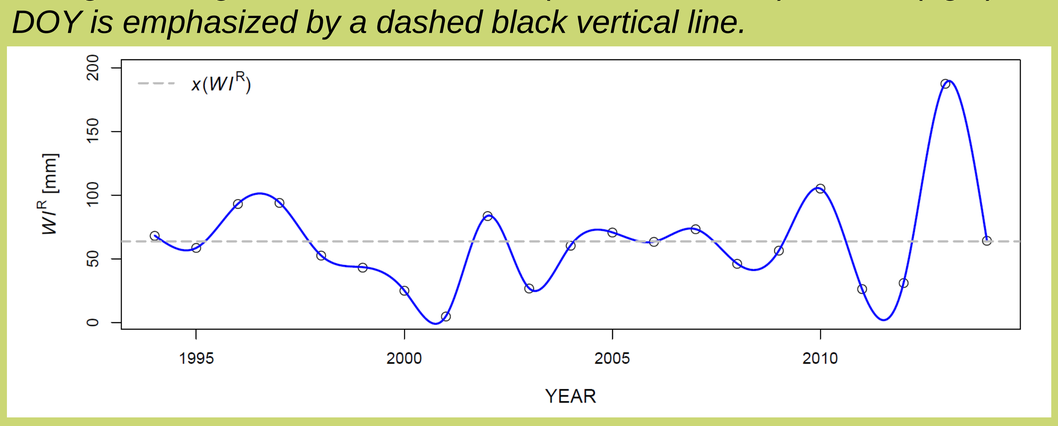

Fig. 5. *WI variation between 1994 and 2016 for a test site (see Fig. 4, marked in black).*

- WI design framework enables a dynamic definition of phenological phases for main cultivated crops in Germany
- Interactions between extreme weather conditions and specifically sensitive periods of phenological development can be considered

Conclusions and Outlook

- An automatic, dynamic standardized calculation of weather indexes for Germany was succesfully developed
- Especially relevant for practical applications, like weather index insurances or extreme weather monitoring

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