Spatio-temporal Modeling And Monitoring Of Extreme Weather Events And Conditions

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Outline

1. The Julius Kühn Institute
2. Extreme Weather situation
3. Geodata integration approach
   - Phenological Modeling
   - Extreme weather events
4. Conclusion

The Julius Kühn Institute

„Securing tomorrow‘s resources“

What is the JKI?

- . . . is the Federal Research Centre for Cultivated Plants in Germany.
- . . . was constituted on January 1st, 2008, as the research branch of the German Ministry of Food and Agriculture (BMEL).
- . . . is both a research institute and a higher federal authority.

Who was Julius Kühn?

He lived from 1825 till 1910, established and developed the agrarian sciences as part of university education in Germany.

The Julius Kühn Institute

„Securing tomorrow‘s resources“

Reseach topics

- plant nutrition, agronomy and soil science
- plant genetics, breeding research
- plant protection and plant health

Organization

- 17 specialized institutes & several service units
- federal budget ≈ 91 Million €· third-party funds ≈ 8 Million €
- ≈ 750 permanent posts · ≈ 450 fixed-term contracts · ≈ 350 scientists

Extreme Weather in Europe and Germany

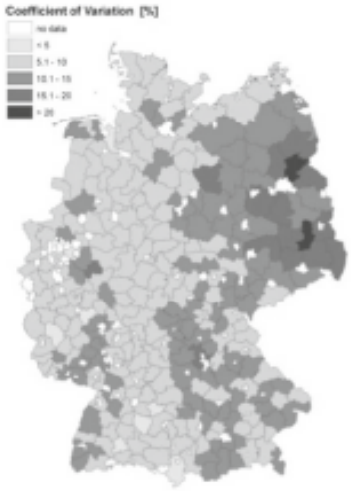
Climate change leads to increasing occurrence of extreme weather, which can have an impact on crop yield levels and yield stability.

Phenomena and impacts

- **Conditions** heat, frost, drought ⇒ damages to tissue and reproductive organs, significant reduction of photosynthesis up to irreversible tissue damages due to water deficit
- **Events** hail, heavy rainfall ⇒ root damages from oxygen deficit as a consequence of soil water logging, soil erosion and nutrient leaching

Mäkinen, H. et al. (2018): Sensitivity of European wheat to extreme weather. Field Crops Research 222, 209-217.

Winter Wheat yield variation between 2001 and 2010 [%]



Lüttger, A.B. & Feike, T. (2018): Development of heat and drought related extreme weather events and their effect on winter wheat yields in Germany *Theoretical and Applied Climatology* 132, 15-29.

EMRA - Extreme Weather Monitoring and Risk Assessment

EMRA web tool – practical decision support system ...

- ... for farmes and agricultural advisers
- ... enabling a risk assessment of reference units (e.g., parcels) regarding extreme weather

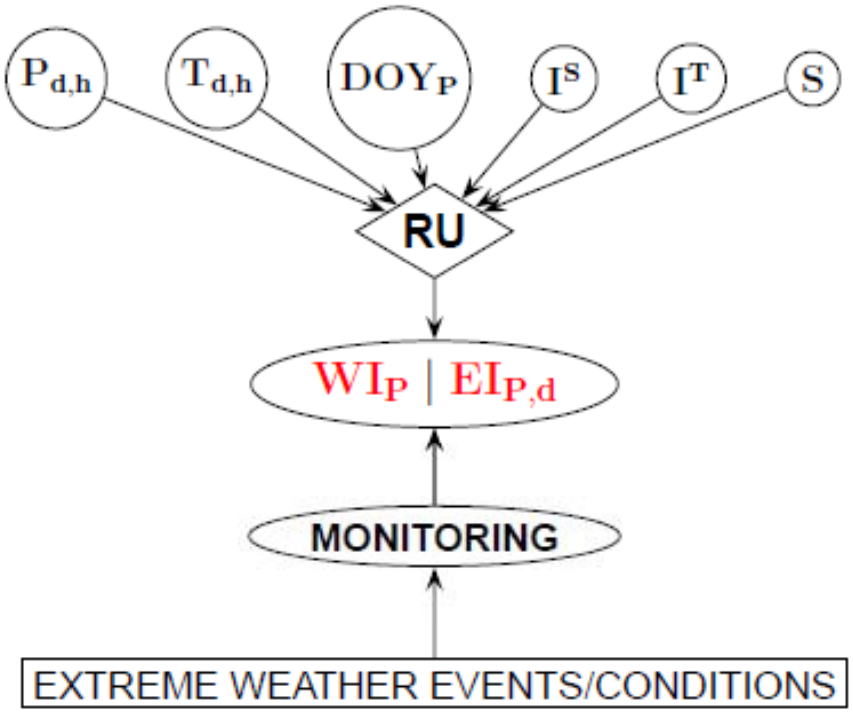
Agricultural crop types and test sites

- Winter Wheat in the district of Uckermark
- Apple in Altes Land region (district of Stade)

Components

- geodata integration
- dynamic risk assessment
- monitoring

Geodata integration approach



Dynamic WI/EI calculation

The impact of extreme weather events/conditions is related to phenological development stages/phases of crops.

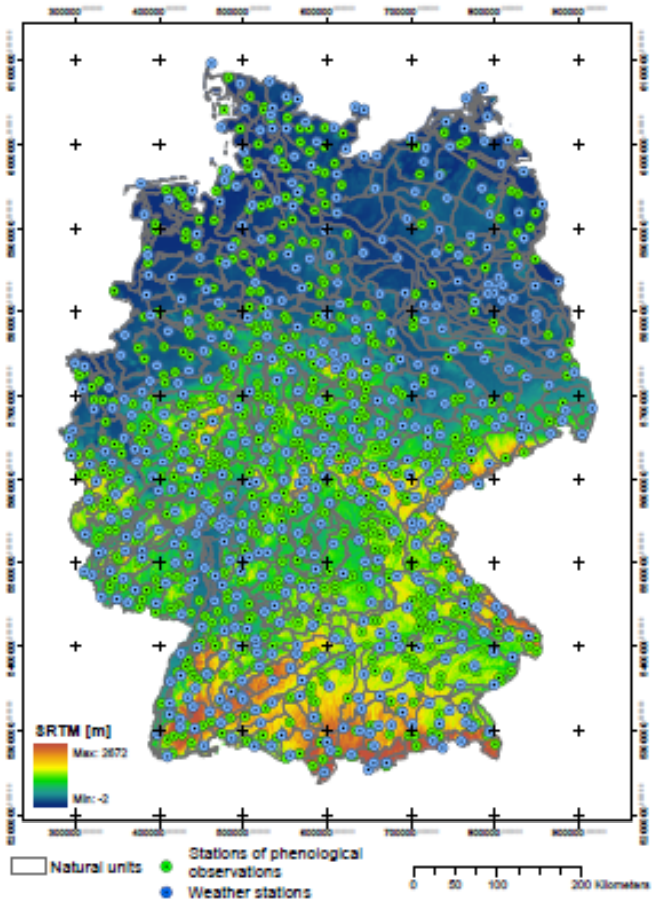
Möller, M., Doms, J., Gerstmann, H., Feike, T., 2018. A framework for standardized weather index calculation in Germany. Theoretical and Applied Climatology. URL https://link.springer.com/article/10.1007/s00704-018-2473-x

$P_{d,h}$ – daily and hourly precipitation | **T_d** – daily mean temperature | **DOY^P** – DOY of begining phenological phases | **I^S** – spectral index | **I^T** – terrain index | **S** – soil data | **RU** – Reference unit | **WI_P** – Weather Index | **$EI_{P,d}$** – Erosion Index

Volk, M., Möller, M. & Wurbs, D. (2010). A pragmatic approach for soil erosion risk assessment within policy hierarchies. *Land Use Policy*, 27, 997–1009.

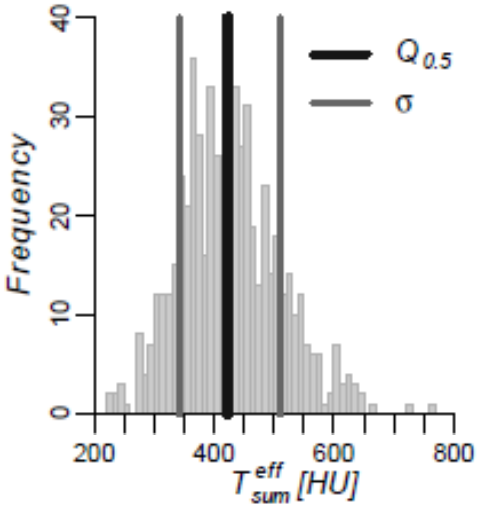
Geodata integration approach

Phenological Modeling: *Interpolation of phenological phases*



Growing Degree Days $GDD = 0.5 \times (T_{max} - T_{min}) - T_B$

Effective Temperature Sums $T_{sum}^{eff}[j] = \sum_{i=DOY_{start}}^{DOY_{obs}} \left((\overline{T}_{i,j} - T_B) \times \frac{DL_i}{24} \right)$

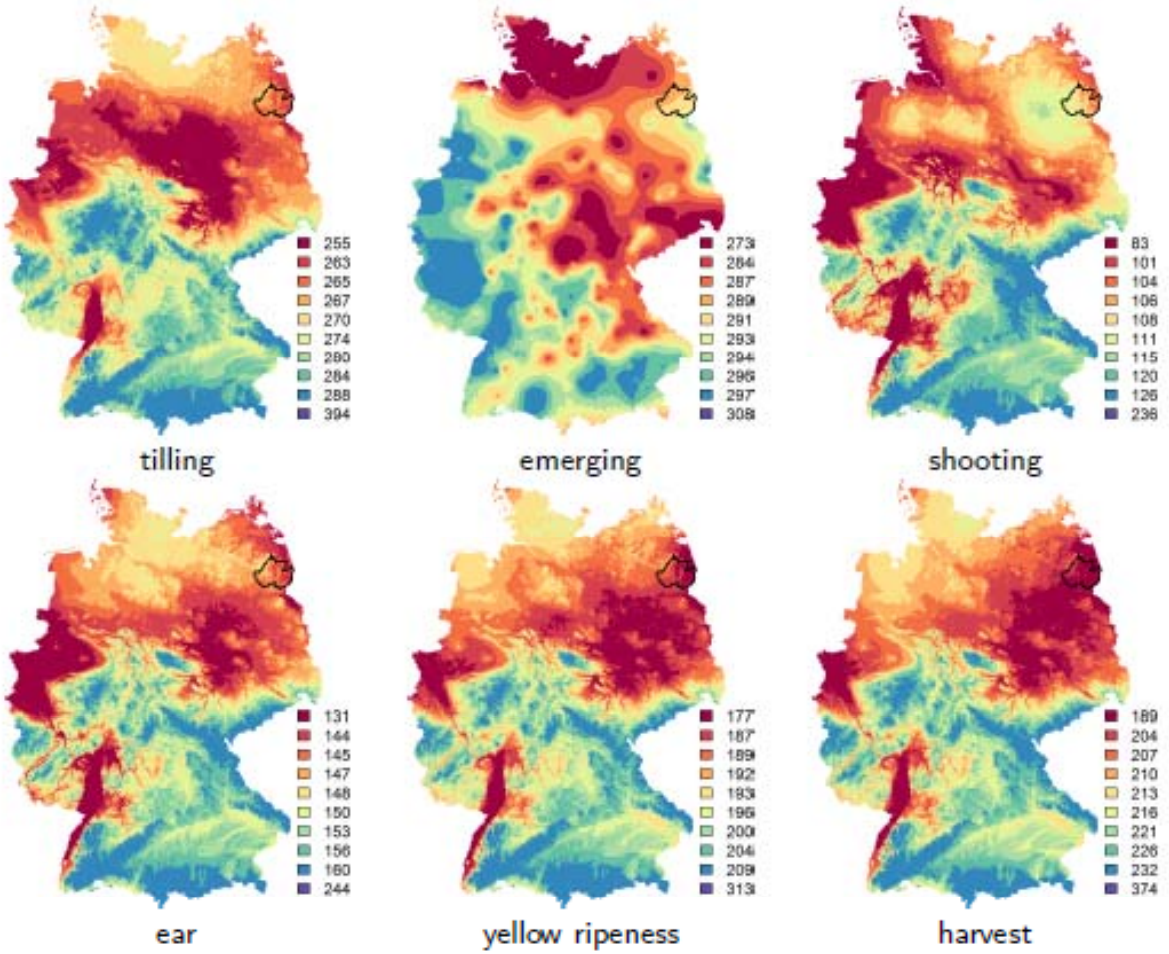


Gerstmann, H., Doktor, D., Gläßer, C. & Möller, M. (2016): PHASE: A geostatistical model for the Kriging-based spatial prediction of crop phenology using public phenological and climatological observations. *Computers and Electronics in Agriculture* 127, 726–738.

Geodata integration approach

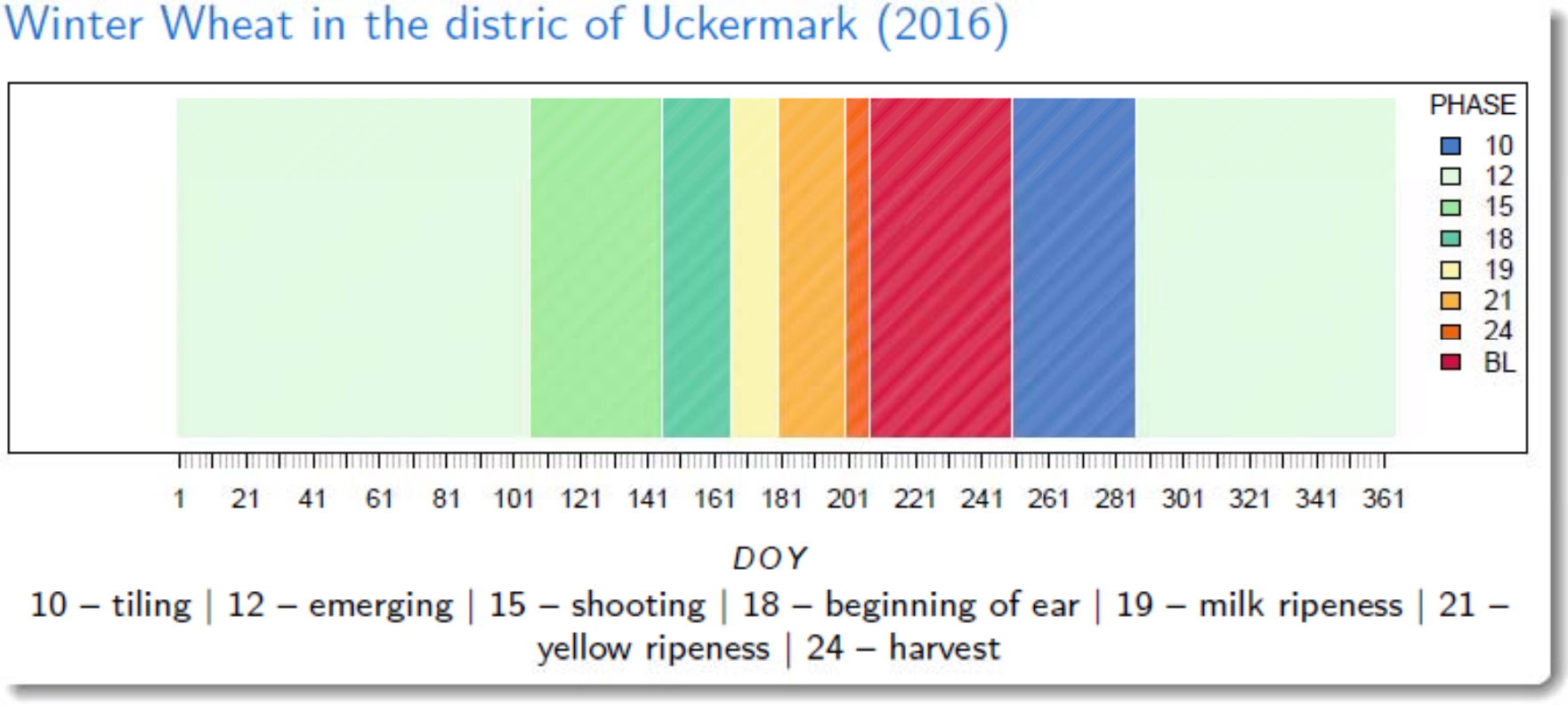
Phenological Modeling: *Interpolation of phenological phases*

Beginning phenological phases (Winter Wheat, 2016)



Geodata integration approach

Phenological Modelling: *Crop-specific phenological windows*

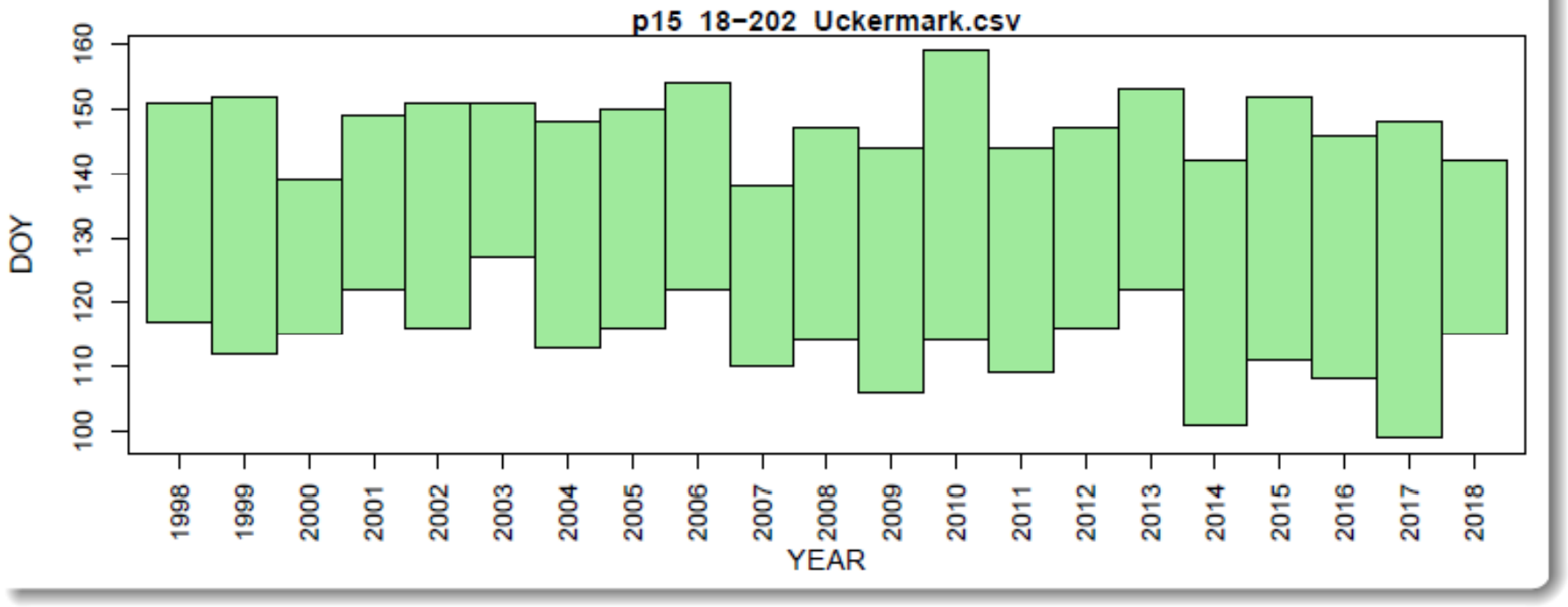


Möller, M., Gerstmann, H., Dahms, T.C., Gao, F. & Förster, M. (2017): Coupling of phenological information and simulated vegetation index time series: Limitations and potentials for the assessment and monitoring of soil erosion risk. *CATENA* 150, 192–205.

Geodata integration approach

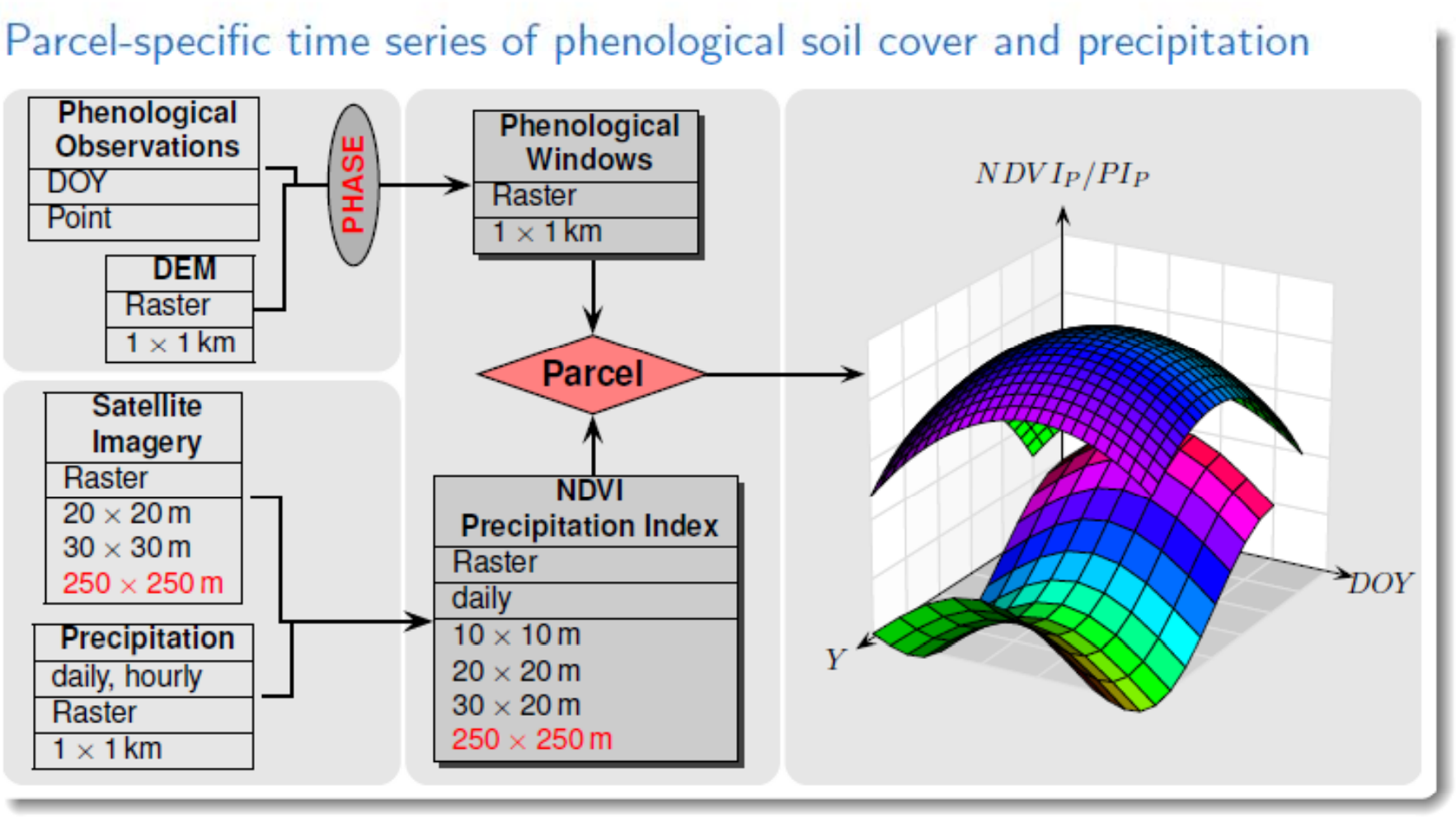
Phenological Modelling: ***Crop-specific phenological windows***

Winter Wheat in the distric of Uckermark: Shooting periods between 1998 and 2018



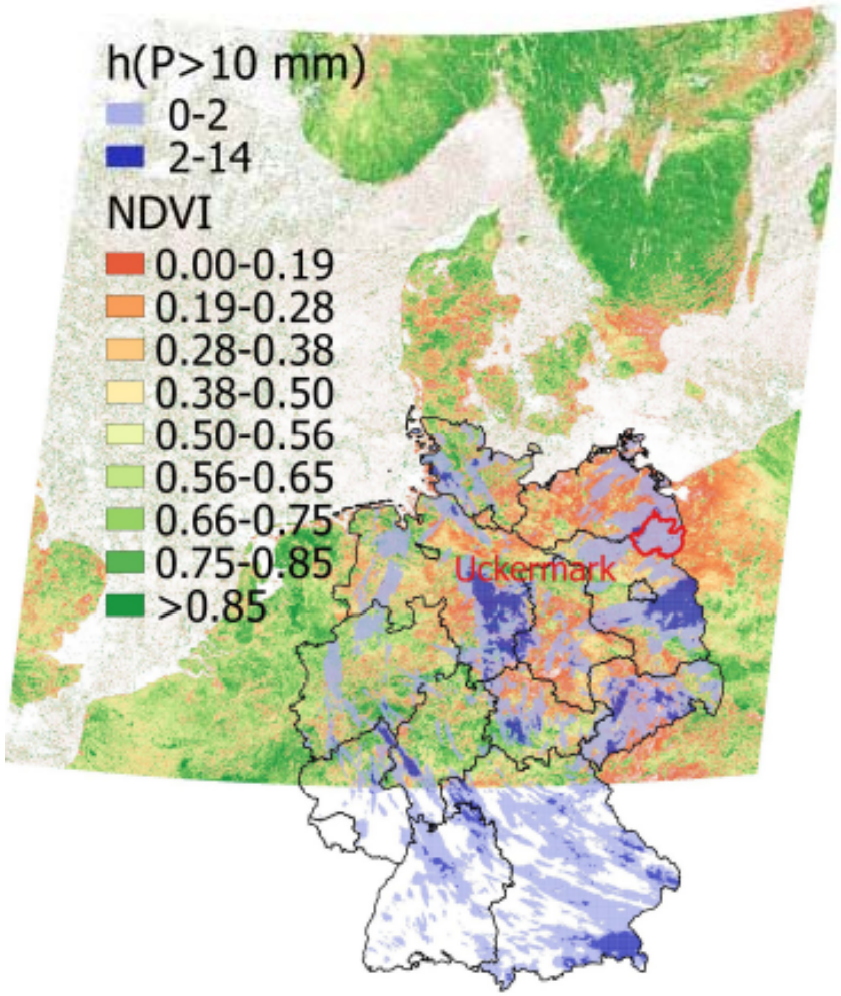
Geodata integration approach

Extreme weather events: *Principle workflow*



Geodata integration approach

Extreme weather events: *Satellite and precipitation*

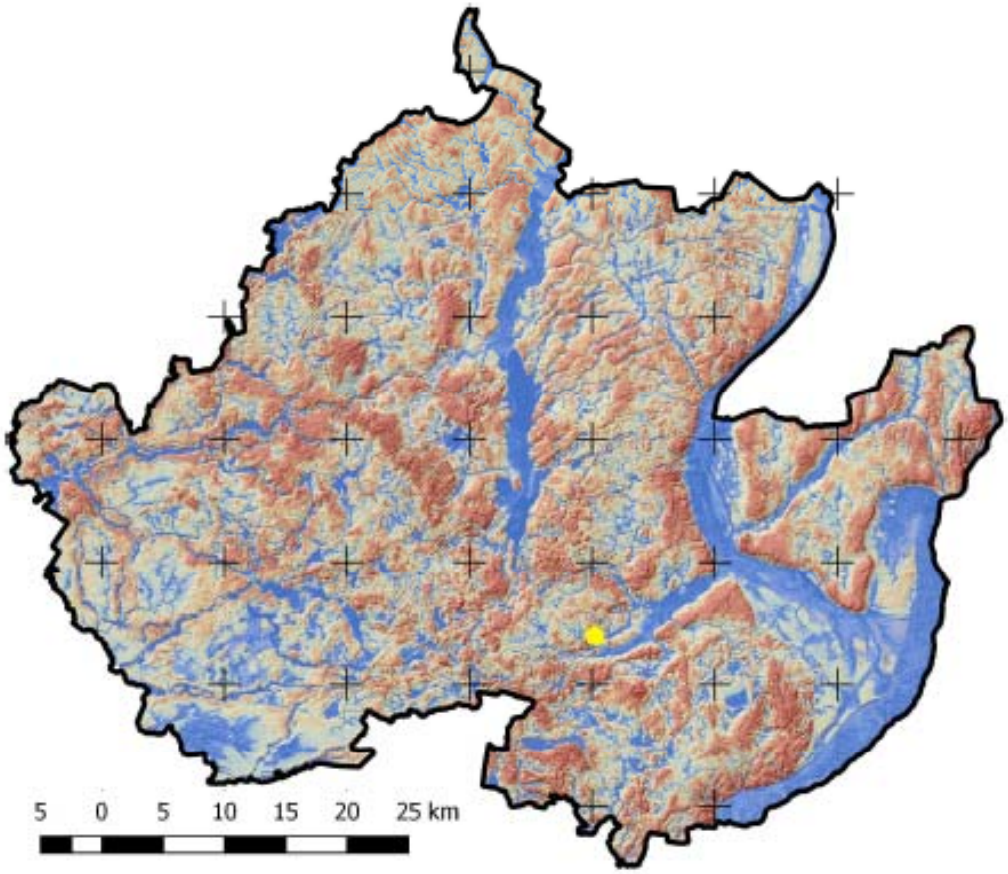


Germany-wide geodata sets

- MODIS (7th Oct 2016)
  - Terra Surface Reflectance 8-Day L3 Global 250 m SIN Grid V006 (MOD09Q1; © USGS)
  - NDVI/SAVI
  - 250 × 250 m
- Precipitation (3rd Oct 2016)
  - highly resolved (5 min) and adjusted radar rain data (RADOLAN, © DWD)
  - aggregated to hours per day exceeding a threshold of $P > 10$ mm
  - 1 × 1 km

Geodata integration approach

Extreme weather events: *Parcel-specific soil erosion*

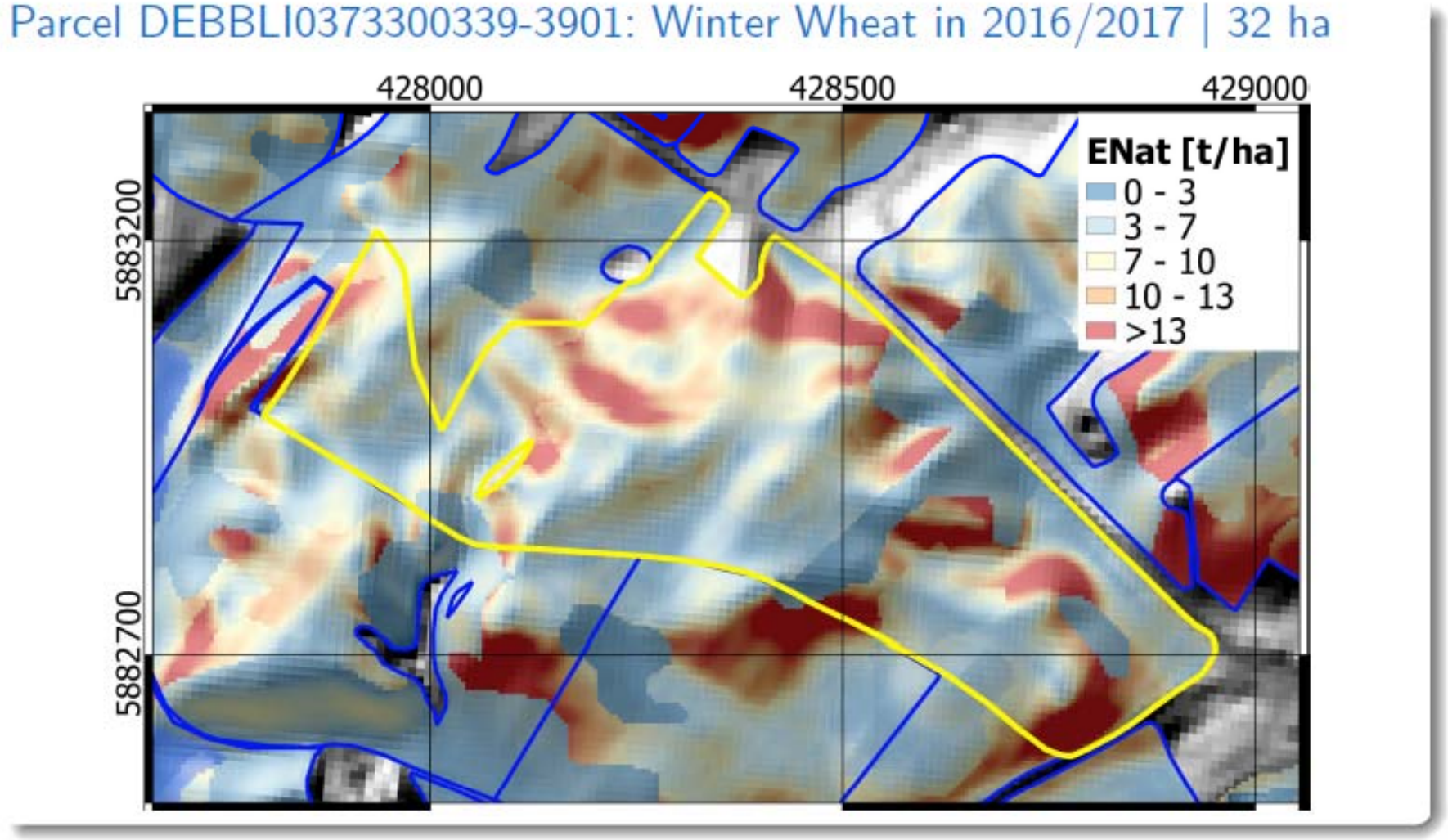


Regional geodata

- DEM & soil erodibility
  - 10 × 10 m
  - © Soil survey of Brandenburg (https://lbgr.brandenburg.de)

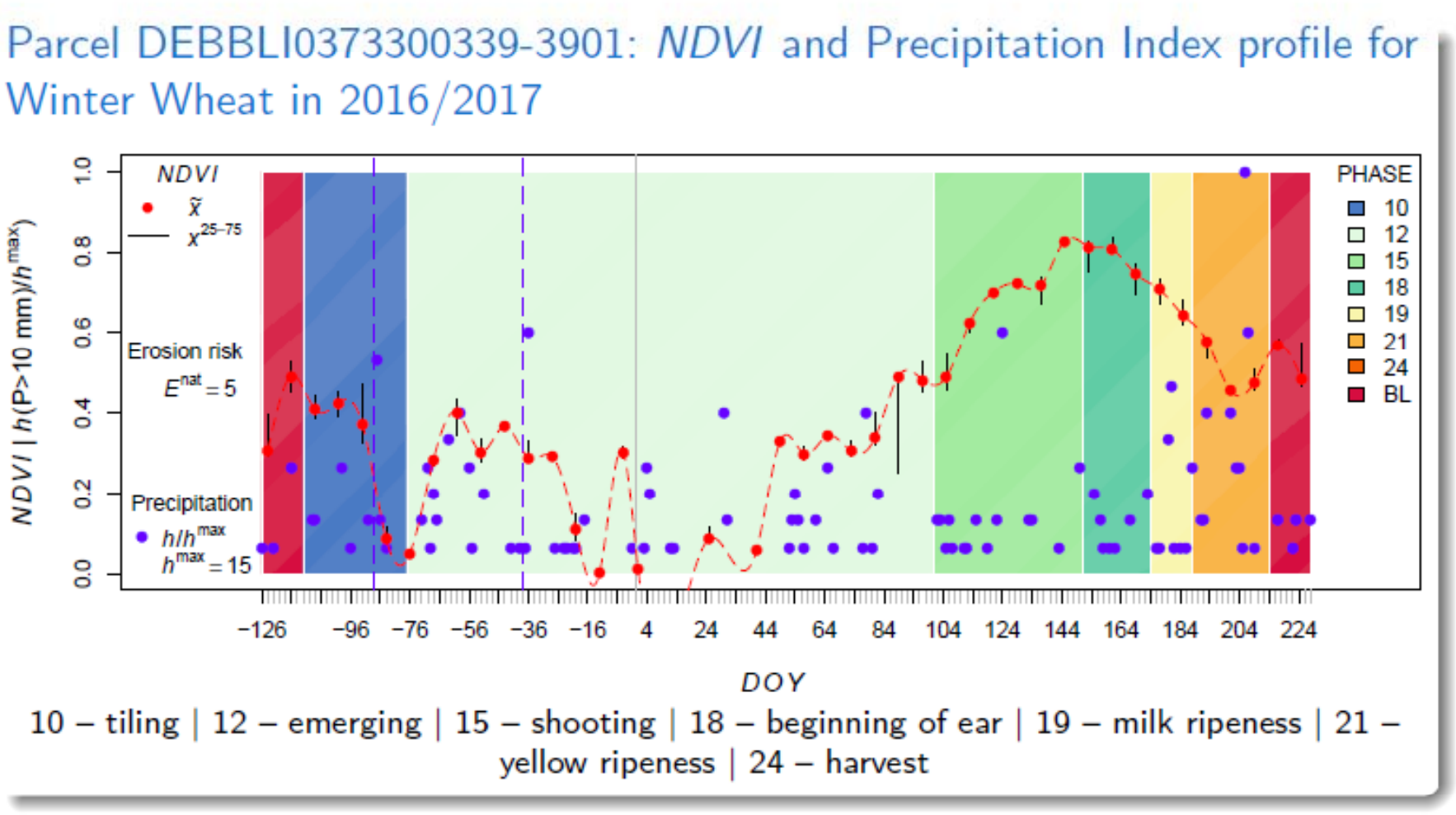
Geodata integration approach

Extreme weather events: *Parcel-specific soil erosion*



Geodata integration approach

Extreme weather events: *Parcel-specific soil erosion*



Geodata integration approach

Extreme weather events: *Parcel-specific soil erosion*

Parcel DEBBLI03733-00339-3901: SPOT 5 image taken on 26th September 2016 ($DOY = 269$)

Options for action

- detailed parametrization and soil cover detection (bare soil, crop residues, vital vegetation), soil erosion modeling and simulation
- historical and current monitoring

$\Rightarrow$ slope length reduction by vegetation strips, no maize cultivation

Summary

Geodata integration

Scale-specific and Germany-wide geodata integration of current and historical geodata is a crucial precondition for the parcel-specific assessment of extreme weather.

- phenological information
- daily weather data
- satellite imagery

Applications

- Parcel-specific localization of historical/up-to-date soil erosion events of high probability
- Weather Index calculation

Möller, M., Doms, J., Gerstmann, H., Feike, T., 2018. A framework for standardized weather index calculation in Germany. Theoretical and Applied Climatology. URL https://link.springer.com/article/10.1007/s00704-018-2473-x

Questions?

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