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
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.
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

www.julius-kuehn.de
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


Extreme Weather in Europe and Germany

EMRA - Extreme Weather Monitoring and Risk Assessment

EMRA web tool – practical decision support system …

- … for farmers 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/El calculation

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


Geodata integration approach
Phenological Modeling: *Interpolation of phenological phases*

Growing Degree Days

\[ GDD = 0.5 \times (T_{\text{max}} - T_{\text{min}}) - T_B \]

Effective Temperature Sums

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

Geodata integration approach

**Phenological Modeling: Interpolation of phenological phases**

Beginning phenological phases (Winter Wheat, 2016)
Geodata integration approach

Phenological Modelling: *Crop-specific phenological windows*

Winter Wheat in the district of Uckermark (2016)

Winter Wheat in the district of Uckermark: **Shooting periods between 1998 and 2018**
Geodata integration approach

Extreme weather events: *Principle workflow*

Parcel-specific time series of phenological soil cover and precipitation

- **Phenological Observations**
  - DOY
  - Point
- **DEM**
  - Raster
  - 1 × 1 km
- **Satellite Imagery**
  - Raster
    - 20 × 20 m
    - 30 × 30 m
    - 250 × 250 m
- **Precipitation**
  - daily, hourly
  - Raster
  - 1 × 1 km

- **Phenological Windows**
  - Raster
  - 1 × 1 km

- **NDVI Precipitation Index**
  - Raster
  - daily
    - 10 × 10 m
    - 20 × 20 m
    - 30 × 20 m
    - 250 × 250 m

- **Parcel**

*NDVI* *PI/P* *DOY*
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
- 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
  - $1 \times 1$ km
Geodata integration approach

Extreme weather events: *Parcel-specific soil erosion*

Regional geodata
- DEM & soil erodibility
  - 10 × 10 m
  - © Soil survey of Brandenburg
    (https://1bgr.brandenburg.de)
Geodata integration approach

Extreme weather events: Parcel-specific soil erosion

Parcel DEBBLI0373300339-3901: Winter Wheat in 2016/2017 | 32 ha
Parcel DEBBLI0373300339-3901: NDVI and Precipitation Index profile for Winter Wheat in 2016/2017

DOY
Geodata integration approach

**Extreme weather events: Parcel-specific soil erosion**

Options for action

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

⇒ 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

Questions?

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