

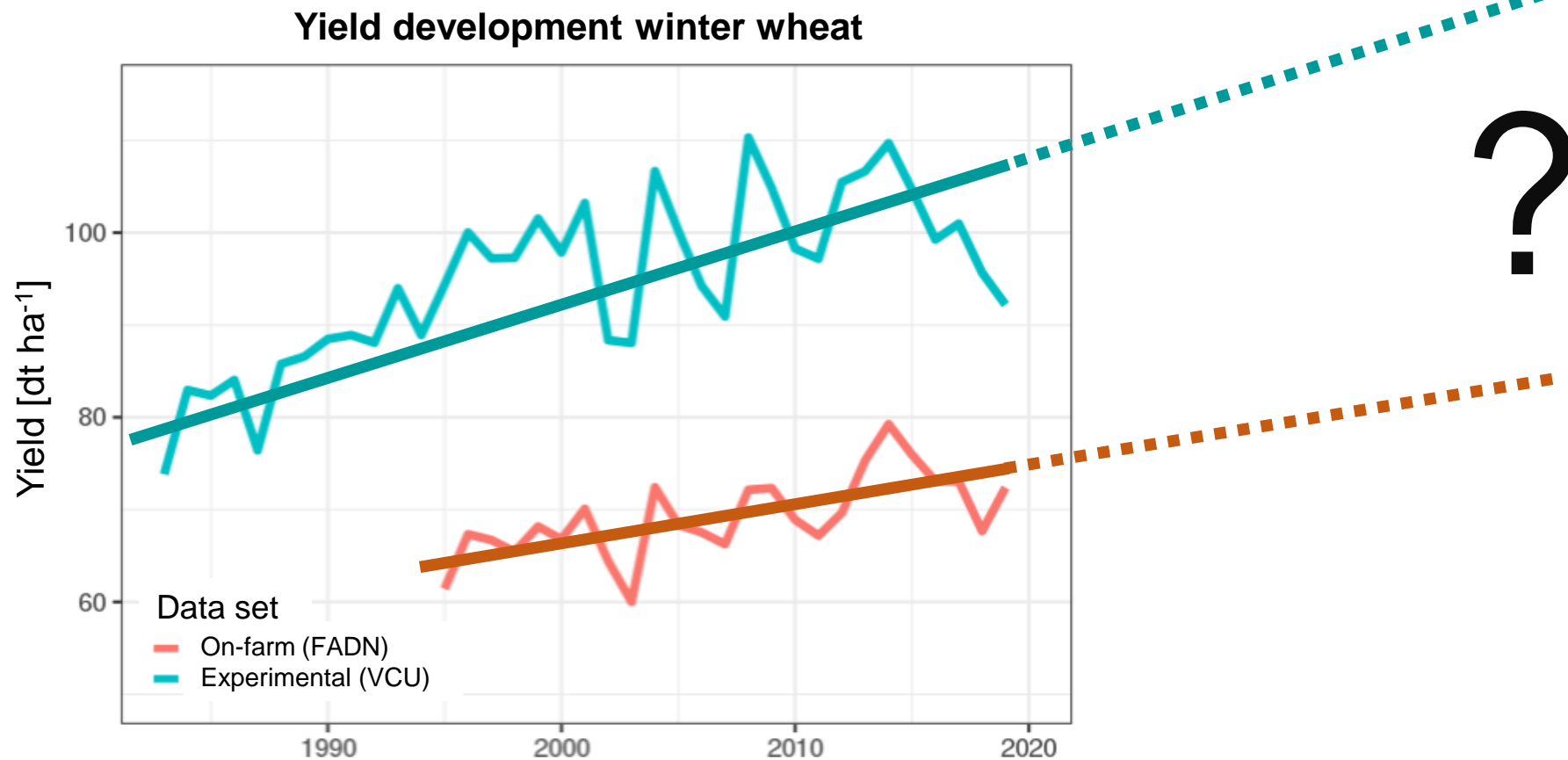
Decision Support for CC Adaptation – Challenges and prospects

Til Feike, Christian Jorzig, Ludwig Riedesel, *et al.*

JKI-Coordination Unit Climate Change
Institute for Strategies and Technology Assessment, Kleinmachnow

Yield development winter wheat Germany

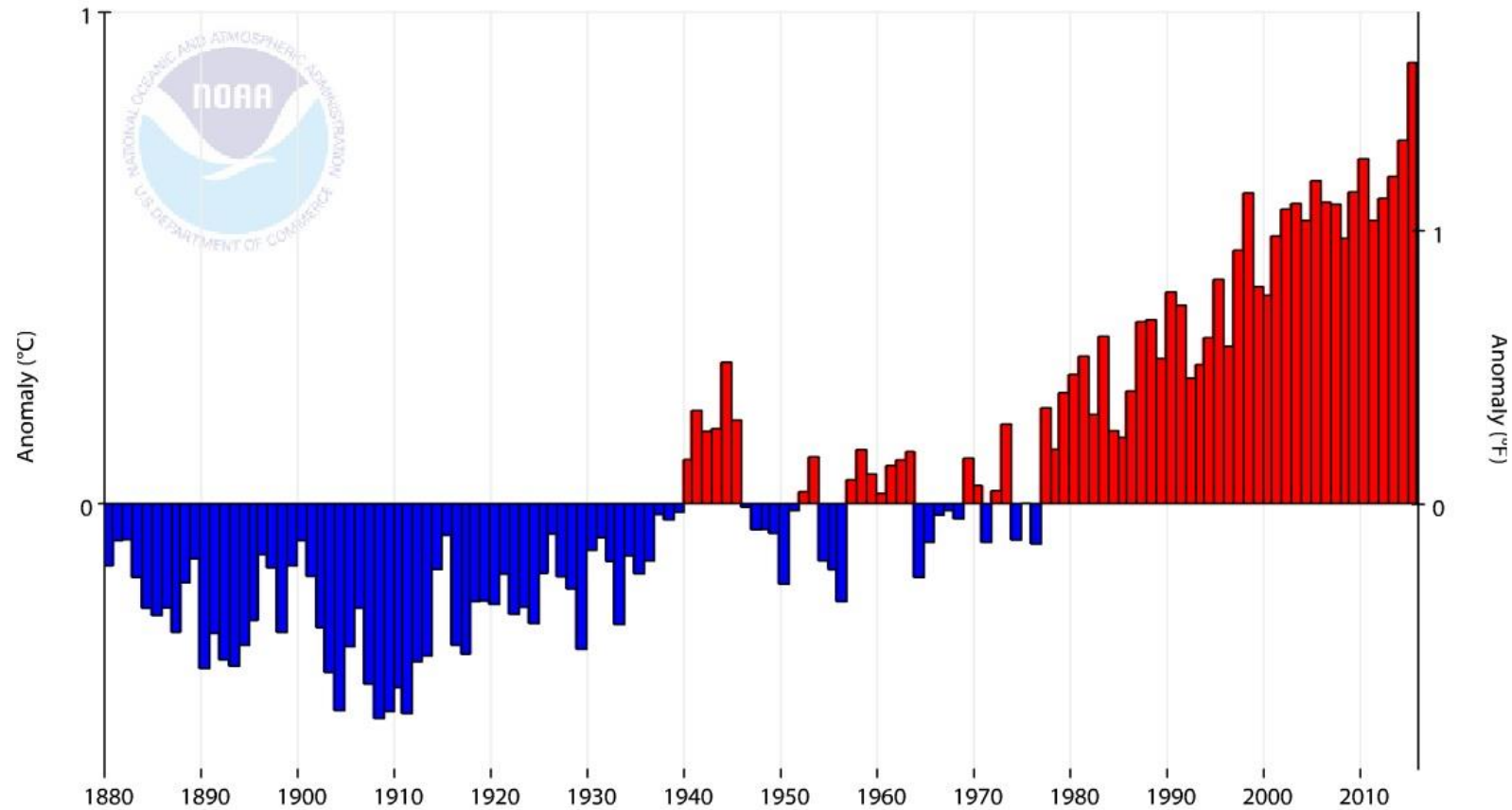
Wheat yields at mid-century?



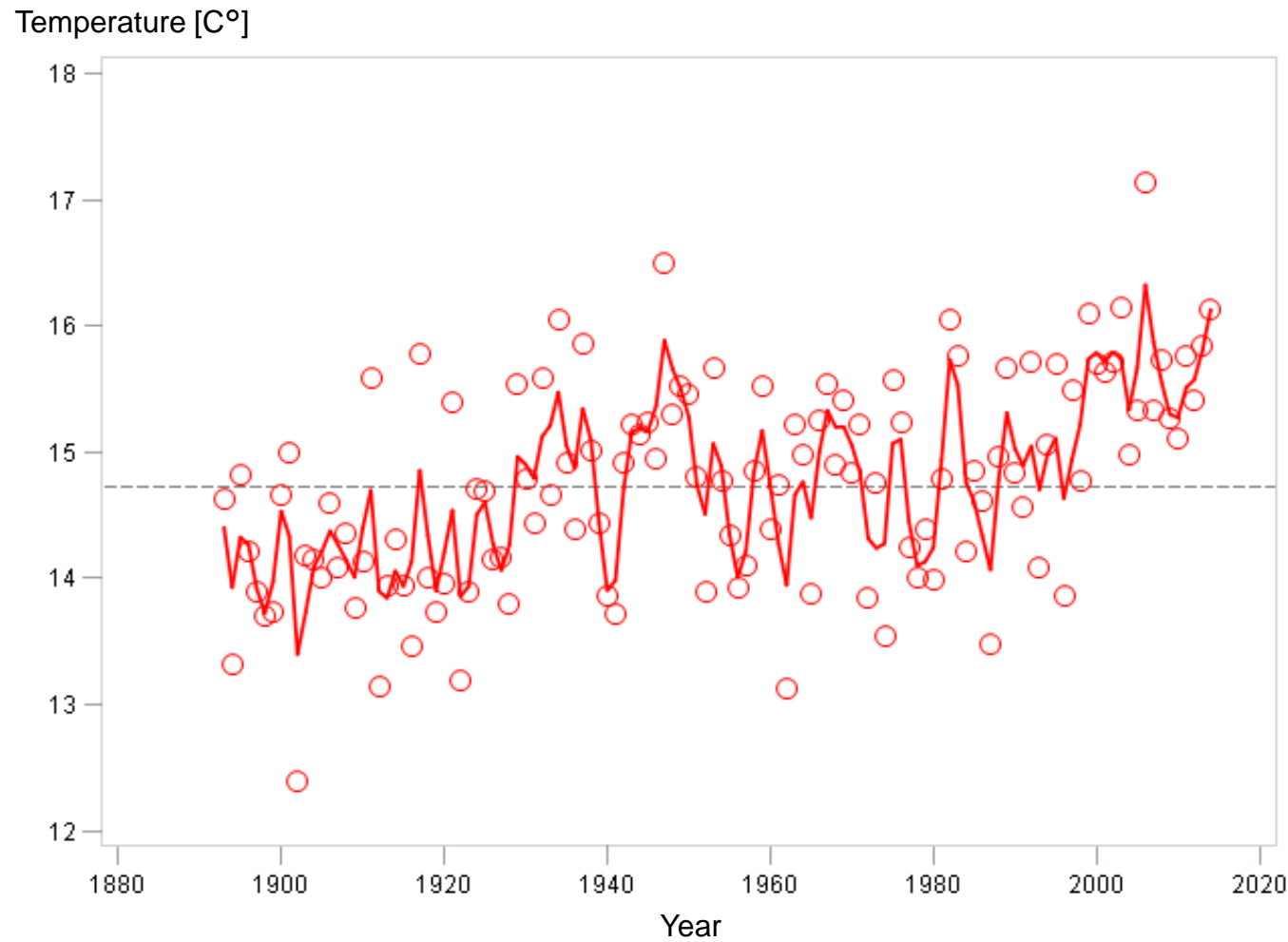
Climate change is evident



Global Land and Ocean Temperature Anomalies, January-December



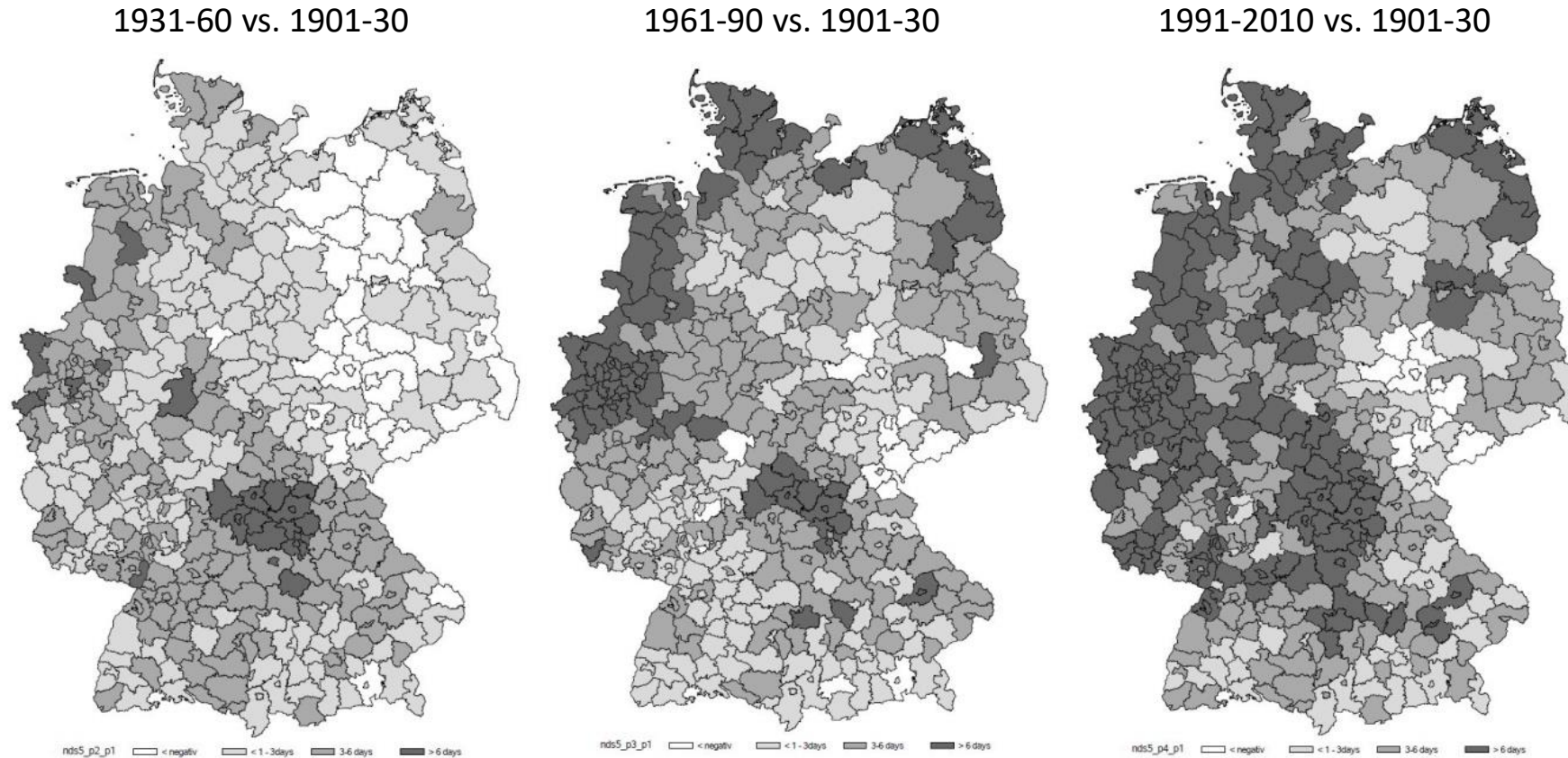
Climate change is evident



Reference line:
Average T 1961-90

Average temperature during summer (April-October) in
Potsdam, Germany during 1893-2014

Climate change is evident



Difference in the average number of precipitation free days longer than five days compared to the reference period 1901-1930

Climate change is evident

- Drought years 2018, 2019, 2022
- Yield losses due to extreme weather
- Decision support?



Image: Martin Dawes



CANARI

Climate ANalysis for Agricultural Recommendations and Impacts

CANARI ist ein frei zugängliches Webportal für landwirtschaftliche Akteure, die direkt online, einfach und schnell lokale agroklimatische Indikatoren aus Klimaprojektionen berechnen möchten. Diese Indikatoren werden aus mehreren Klimamodellen konstruiert, um mögliche Veränderungen bis 2050 zu veranschaulichen.

[IAC anzeigen »](#)

[Verwendete Daten anzeigen »](#)

[Indikatoren verstehen »](#)

Zusammenfassend

Die CANARI-Anwendung ermöglicht eine schnelle und direkte Online-Visualisierung von mehr als hundert Agrarklimaindikatoren (IAC), die die Bedürfnisse der verschiedenen landwirtschaftlichen Sektoren abdecken. Jeder IAC kann lokal über das gesamte französische Mutterland für den Zeitraum

1. Interessengebiet

Wählen Sie eine Zone aus, in der Sie die Entwicklung eines agrarklimatischen Indikators visualisieren möchten

2. Zeitraum und RCP

3. Agroklimatischer Indikator

4. Visualisierung

Hineinzoomen

Zoomen Sie, um einen Rasterpunkt auszuwählen

300km

CANARI



CANARI Um Indikatoren Daten Häufig gestellte Fragen Ausloggen

<p>1. Interessengebiet</p> <p>Wählen Sie eine Zone aus, in der Sie die Entwicklung eines agrarklimatischen Indikators visualisieren möchten</p>	<p>2. Zeitraum und RCP</p>	<p>3. Agroklimatischer Indikator</p>	<p>4. Visualisierung</p>
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Hineinzoomen

20km

Flugblätter | © Mapbox © OpenStreetMap

1. Interessengebiet

Wählen Sie eine Zone aus, in der Sie die Entwicklung eines agrarklimatischen Indikators visualisieren möchten

2. Zeitraum und RCP

Wählen Sie einen Zeitraum aus, über den Sie die Entwicklung eines agrarklimatischen Indikators und des Referenz-RCP anzeigen möchten
HLW 4.5

3. Agroklimatischer Indikator

Wählen Sie den anzuzeigenden agrarklimatischen Indikator aus

4. Visualisierung

[Liste des indicateurs](#) / Céréales d'hiver

Wählen Sie einen Indikator

- Niederschlag während einer Phase des Entwicklungszyklus (mm)
- Risiko von zu viel Wasser nach der Aussaat (mm)
- Kältestress zu Beginn des Laufs
- Spätes Einfrieren während des Anlaufs
- Gefahr vorzeitiger Verbrühung (Anzahl Tage)
- Überschrift Hitzestress - Blüte (Anzahl Tage)
Anzahl der Tage, an denen die Höchsttemperatur für den Zeitraum vom 15. April bis 15. Juli über dem Schwellenwert von 25 °C liegt. Dieser Zeitraum umfasst das Köpfen und Blühen von Getreidekulturen, während denen sie besonders empfindlich auf das Phänomen der thermischen

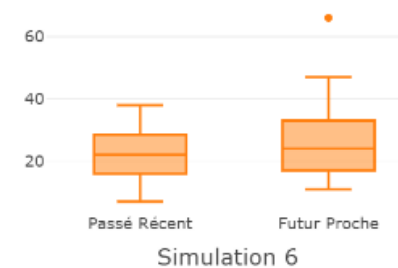
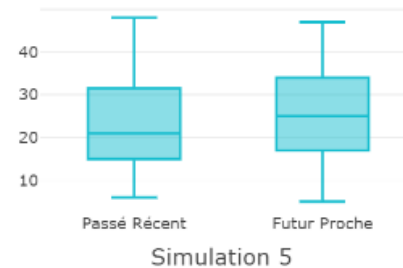
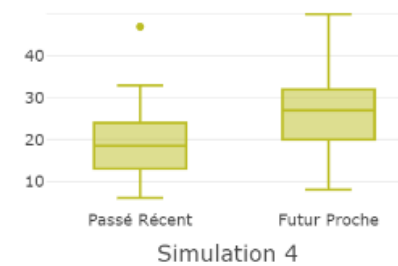
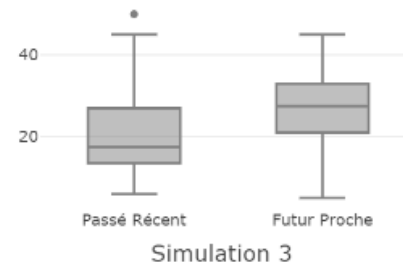
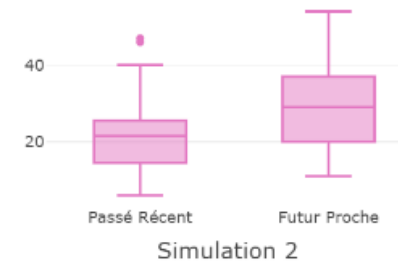
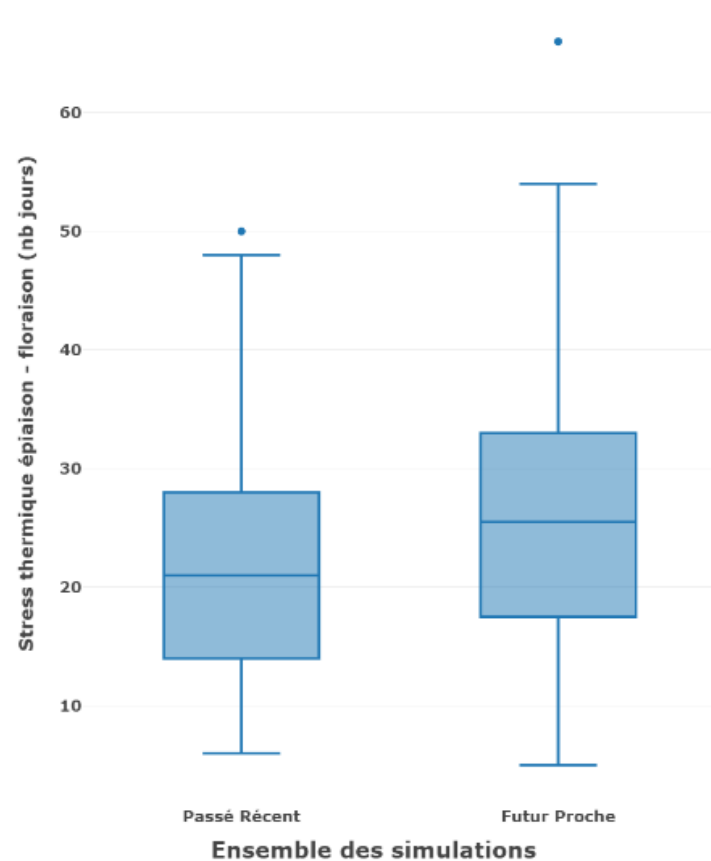
Überschrift Hitzestress - Blüte (Anzahl Tage) **HLW 4.5**

Anzahl der Tage, an denen die
Höchsttemperatur zwischen dem 15.
April und dem 15. Juli über 25 °C liegt

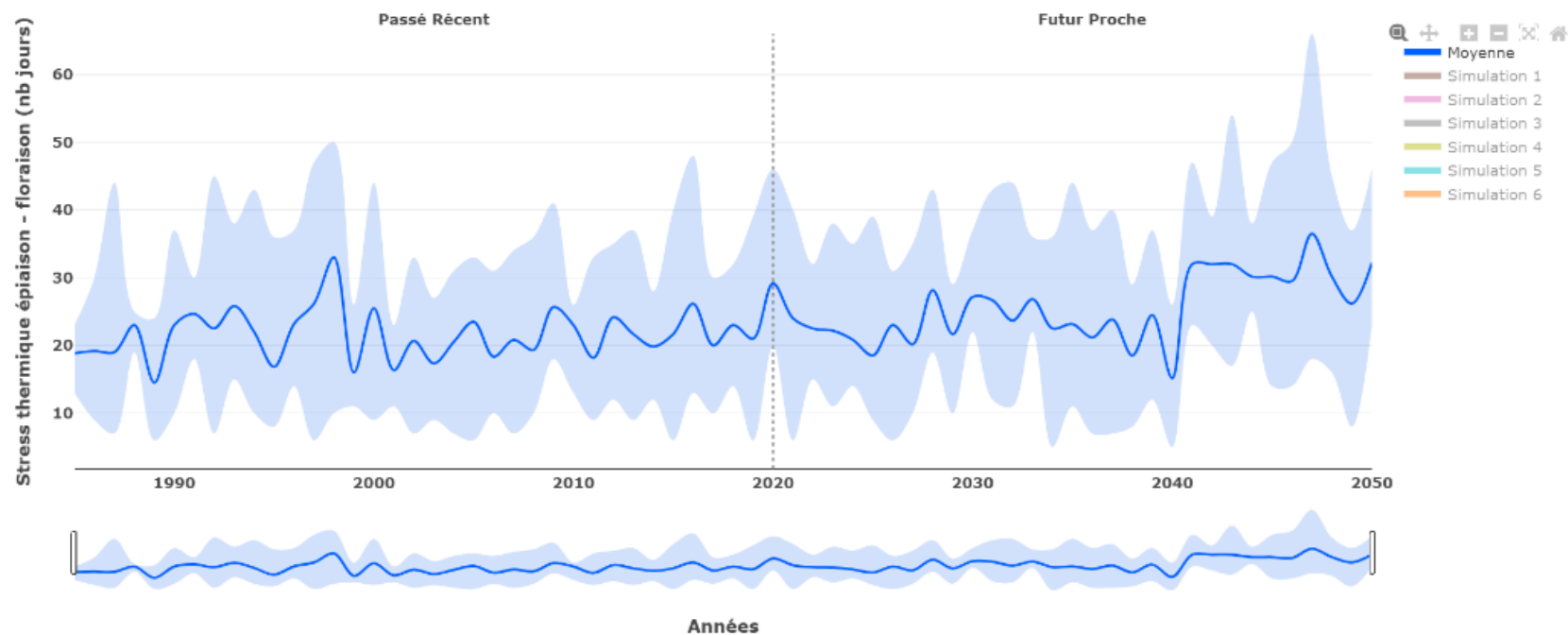


Den Boxplot verstehen:

- **Median** = Linie innerhalb der Box, Wert, der die untere Hälfte von der oberen Hälfte eines Datensatzes trennt
- **q1** = untere Zeile des Kästchens, begrenzt 25 % der unteren Werte
- **q3** = obere Zeile des Kästchens, begrenzt 25 % der oberen Werte
- **Oberer und unterer Zaun** = Schnurrhaare, deren Länge das 1,5-fache des Quartilsabstands erreichen kann ($q_3 - q_1$)



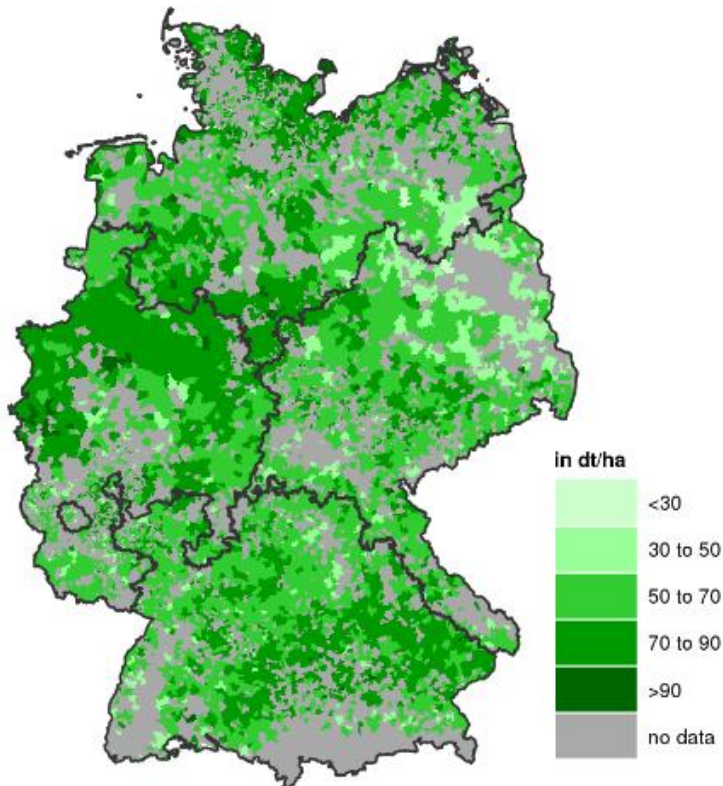
CANARI



	Alle Simulationen		Simulation 1 ?		Simulation 2 ?		Simulation 3 ?		Simulation 4 ?		Simulation 5 ?		Simulation 6 ?	
	Kürzlich	Nahe Zukunft	Kürzlich	Nahe Zukunft	Kürzlich	Nahe Zukunft	Kürzlich	Nahe Zukunft	Kürzlich	Nahe Zukunft	Kürzlich	Nahe Zukunft	Kürzlich	Nahe Zukunft
Minimum	6.00	5.00	7.00	6.00	6.00	11.00	6.00	5.00	6.00	8.00	6.00	5.00	7.00	11.00
Bedeutend	21.76	25.50	23.44	19.43	21.97	28.50	20.86	26.13	19.06	27.40	23.11	25.53	22.14	26.00
Maximal	50.00	66.00	44.00	44.00	47.00	54.00	50.00	45.00	47.00	50.00	48.00	47.00	38.00	66.00

Weather-yield relations

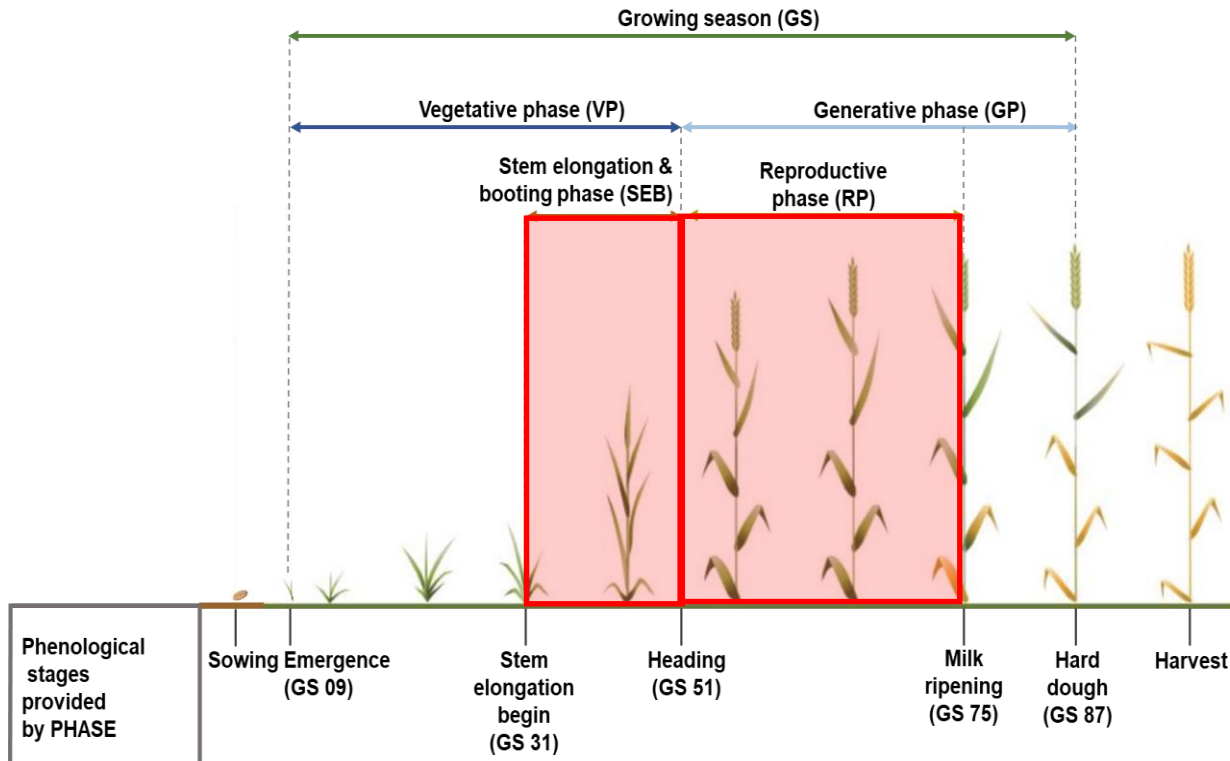
Average yield
(1995-2019)



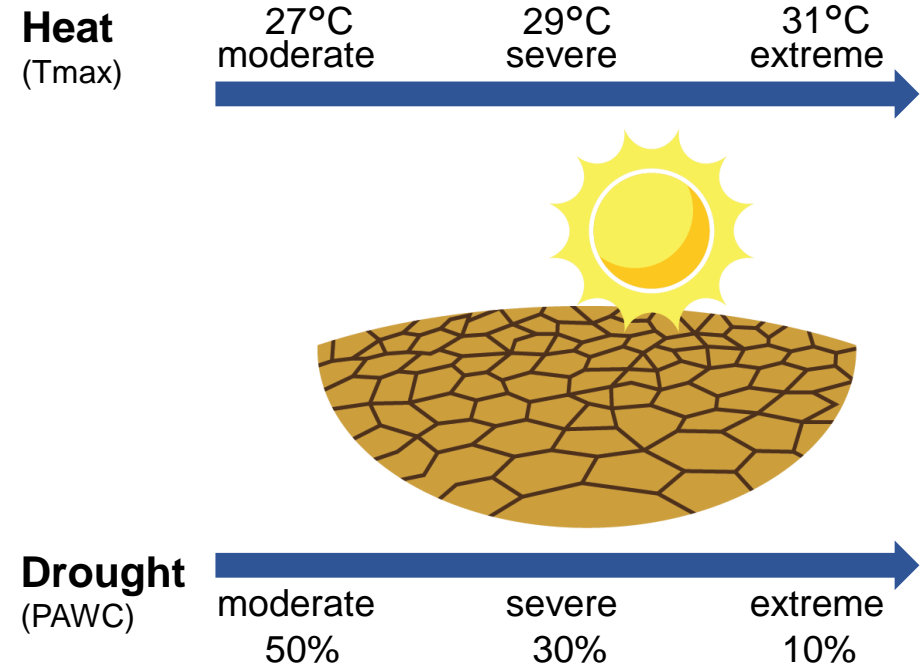
- On-farm wheat yield data of ~11.500 farms from 1995-2019
- Assess weather-yield relations using mixed models
- Integration of high-resolution yield, weather, phenology, soil and land-use data
- Timing and intensity of heat and drought stress

Timing & intensity

- Phenological phases



- 3 intensity levels



Drought (BBCH 31-50)

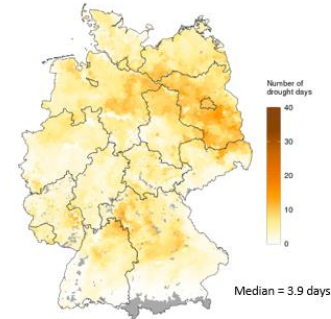
Occurrence:

- ↑ northeast and east
- ↓ north (coast) and south

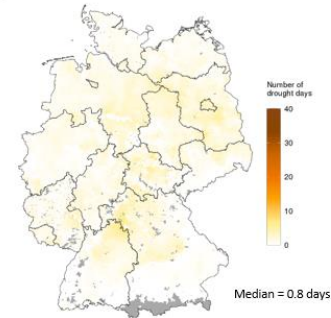
Drought stress BBCH 31-50

PAW < 50% ^A

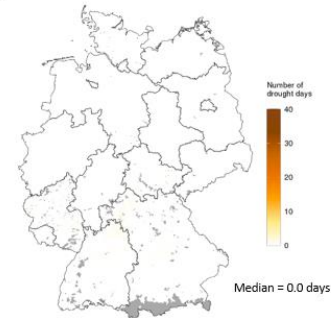
Mean occurrence



PAW < 30% ^D



PAW < 10% ^G



moderate
intensity

severe
intensity

extreme
intensity

Drought (BBCH 31-50)

Occurrence:

- ↑ northeast and east
- ↓ north (coast) and south

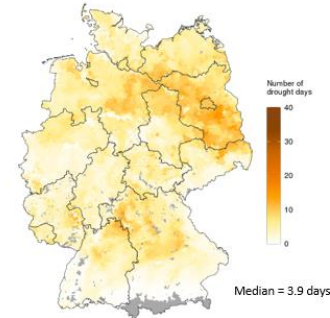
Effect size:

- north-south gradient

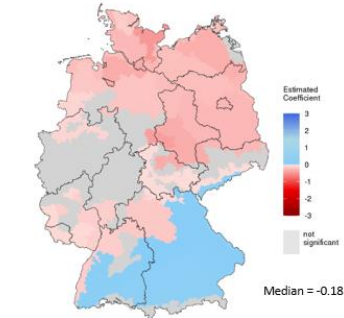
Drought stress BBCH 31-50

PAW < 50% A

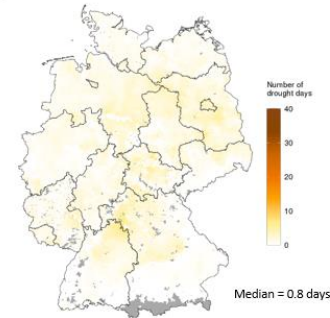
Mean occurrence



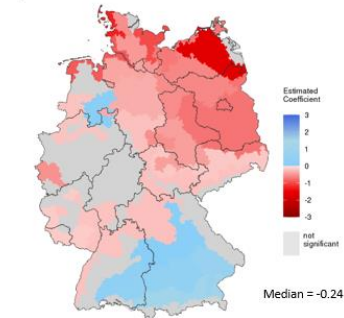
Estimated coefficients



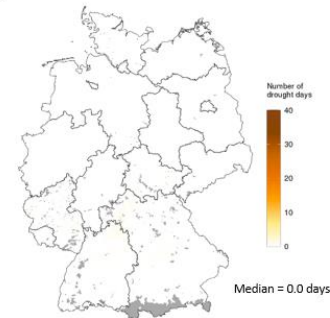
PAW < 30% D



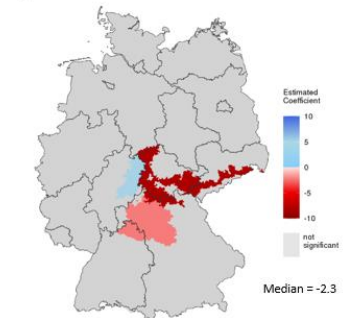
E



PAW < 10% G



H



moderate
intensity

severe
intensity

extreme
intensity

Drought (BBCH 31-50)

Occurrence:

- ↑ northeast and east
- ↓ north (coast) and south

Effect size:

- north-south gradient

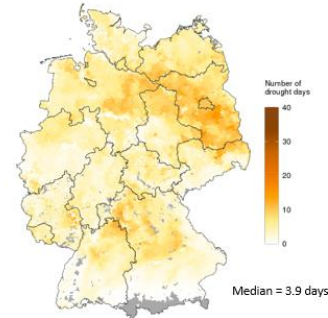
Yield effect:

- moderate stress
↑ **yield loss**
- extreme stress
0 yield loss

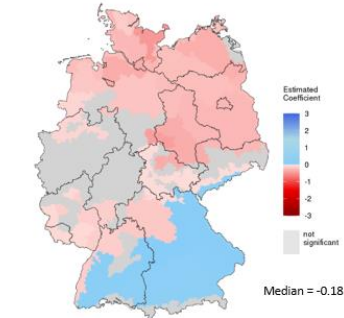
Drought stress BBCH 31-50

PAW < 50% A

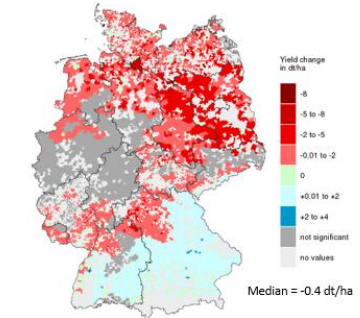
Mean occurrence



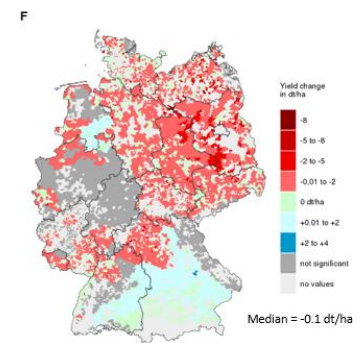
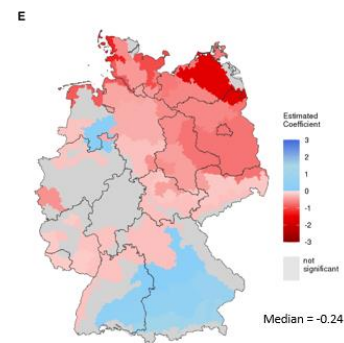
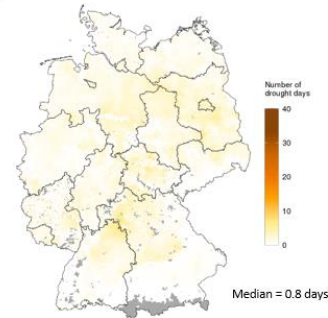
Estimated coefficients



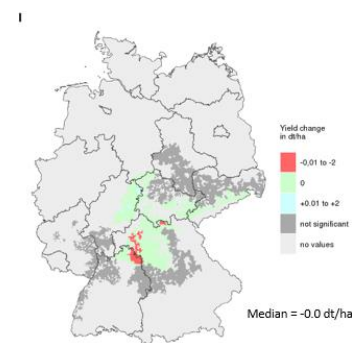
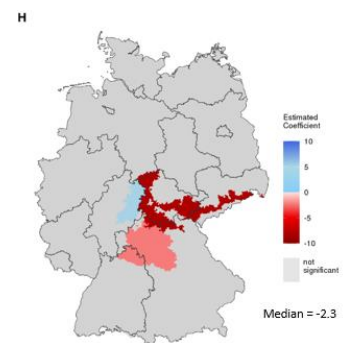
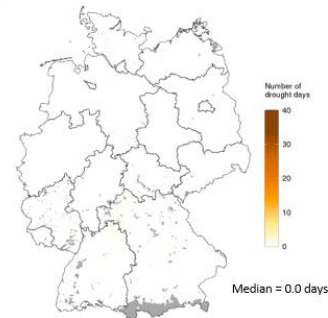
Mean yield effects



PAW < 30% D



PAW < 10% G



moderate
intensity

severe
intensity

extreme
intensity

Drought (BBCH 51-75)

Occurrence:

- ↑ north and east
- ↓ south and west

Effect size:

- linear correlation to occurrence

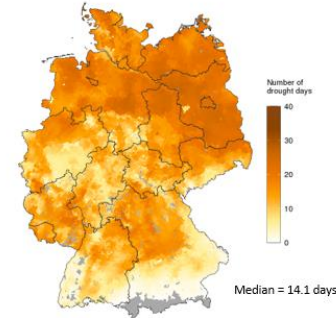
Yield effect:

- severe stress: ↑ yield losses
- extreme stress: ↑ municipalities with significant yield loss

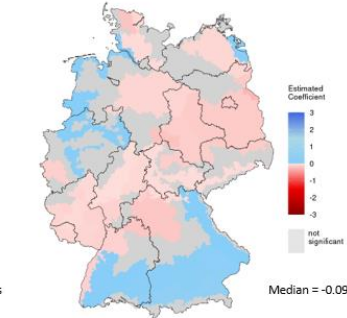
Drought stress BBCH 51-75

PAW < 50% A

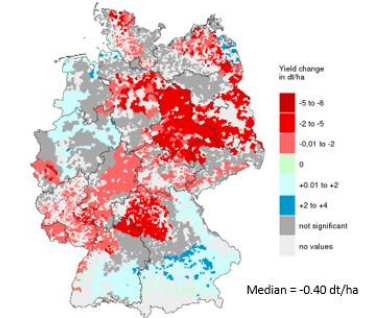
Mean occurrence



Estimated coefficients

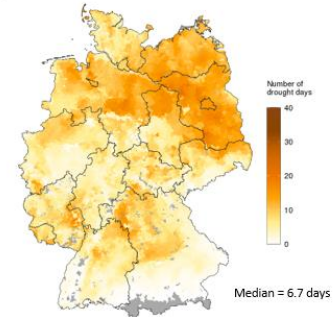


Mean yield effects

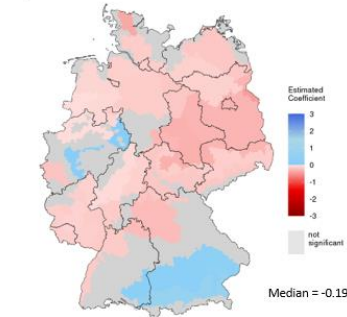


moderate
intensity

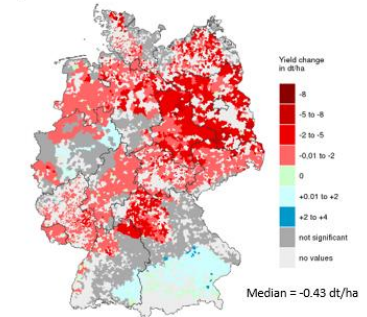
PAW < 30% D



Estimated coefficients

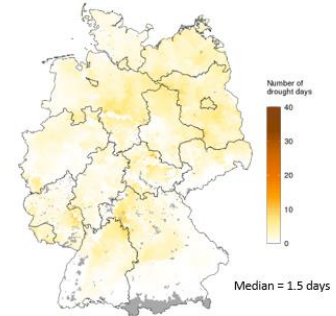


Mean yield effects

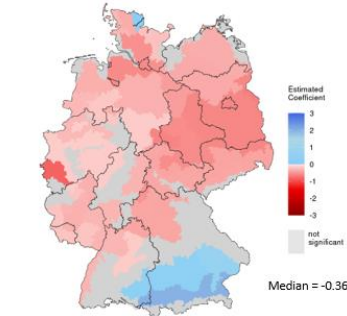


severe
intensity

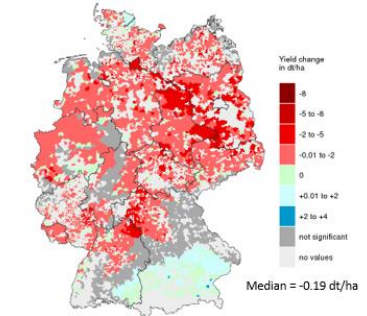
PAW < 10% G



Estimated coefficients



Mean yield effects



extreme
intensity

Heat (BBCH 51-75)

Occurrence:

- ↑ south and east
- ↓ north (coasts)

Effect size:

- moderate stress: northeast-south gradient

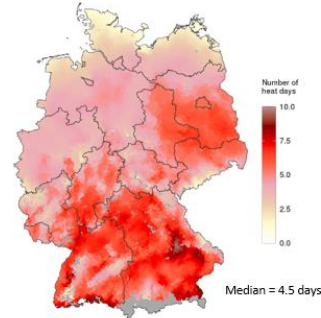
Yield effect:

- moderate stress: ↑ yield losses
- extreme stress: ↑ municipalities with significant yield loss

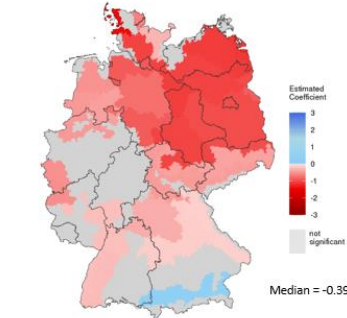
Heat stress
BBCH 51-75

*T*_{max} > 27°C A

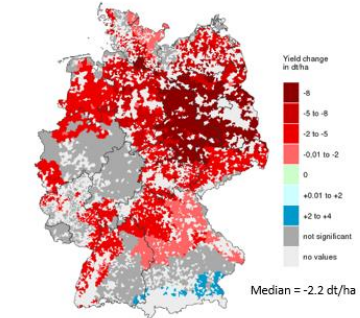
Mean occurrence



B Estimated coefficients

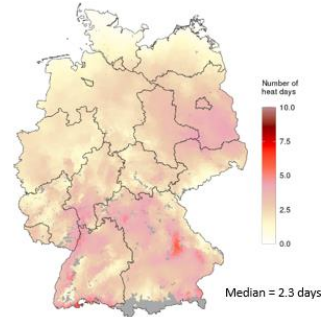


C Mean yield effects

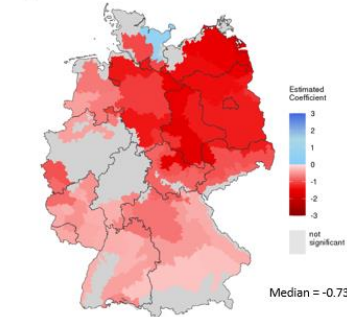


moderate
intensity

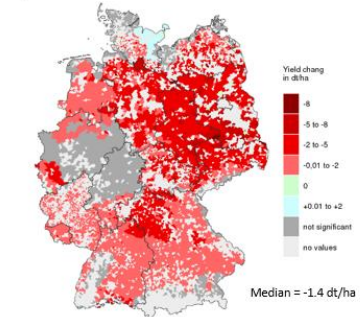
*T*_{max} > 29°C D



E

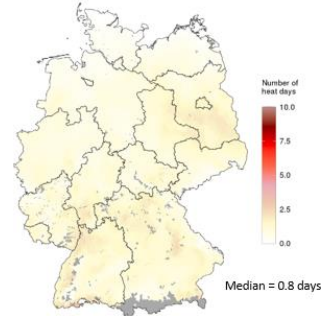


F

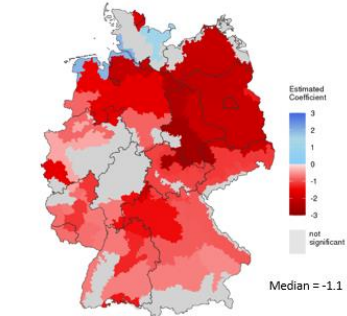


severe
intensity

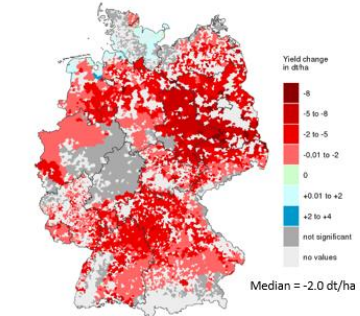
*T*_{max} > 31°C G



H



I



extreme
intensity

Discussion

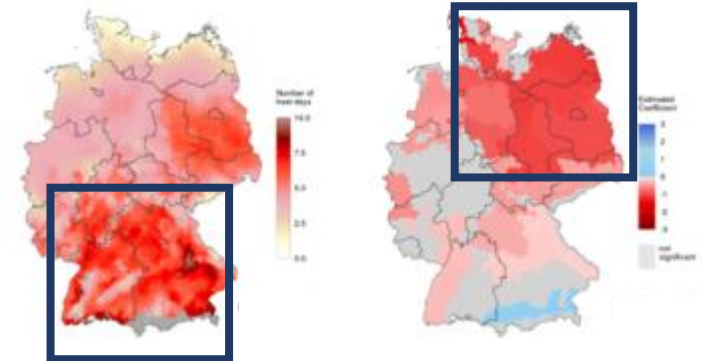
- Similar weather conditions → regionally differing yield effects

1. Data specific aspects

- Soil water characteristics not fully captured in model leading to:
 - differing **plant water availability** → Drought
 - differing **soil temperature** → Heat

2. Model specific aspects

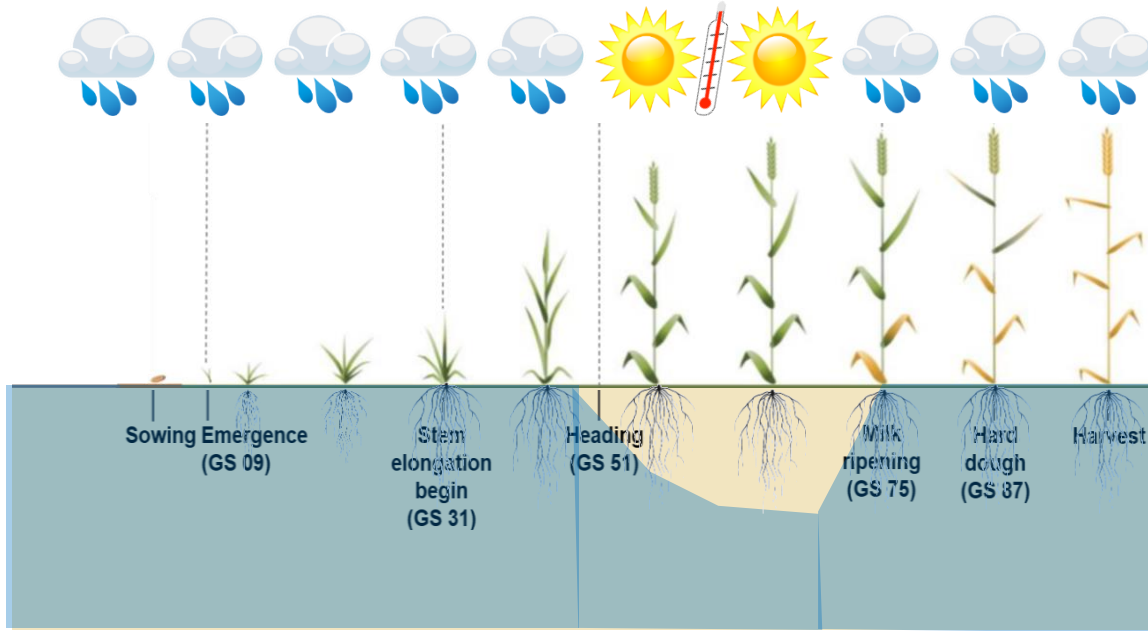
- **Other weather events** along the growing season
- **Compound** weather effects (e.g., heat and drought)
- **Lack of data** regarding **farm management** (e.g., nitrogen fertilization, crop rotations, cultivars, plant protection)



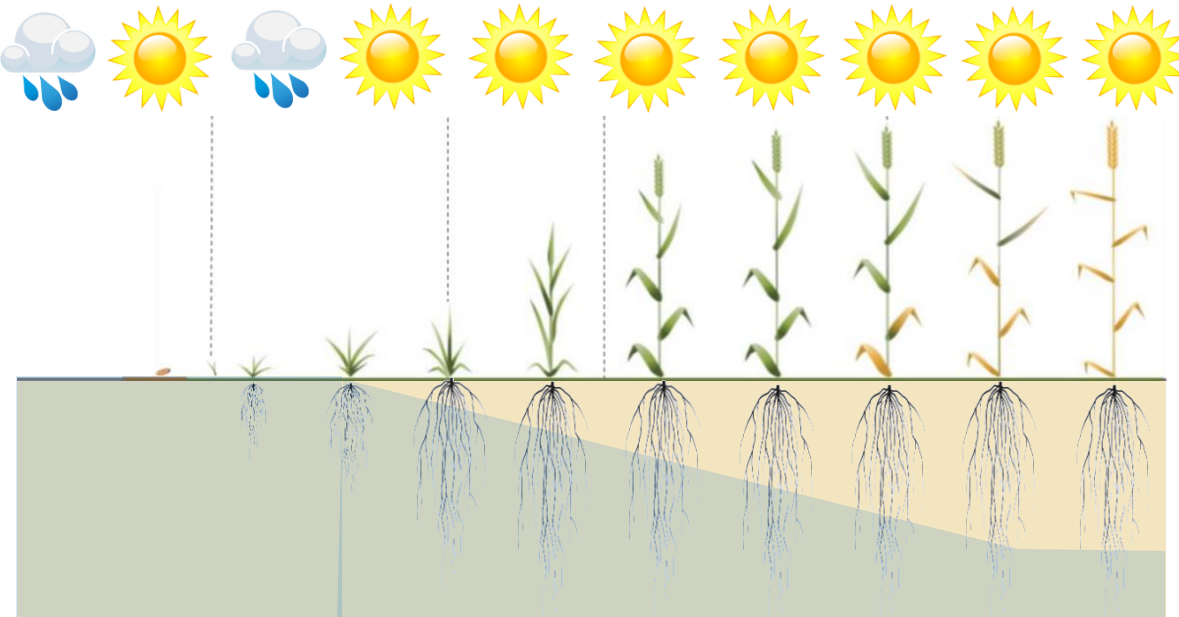
Trockenstress über die Wachstumsaison 2021 vs. 2022



2021



2022



Climate change impact assessment

- Experimental facilities
 - Controlled greenhouse & climate chambers



Climate change impact assessment

- Experimental facilities
 - Controlled greenhouse & climate chambers
 - FACE – Free Air Carbon Dioxide Enrichment
 - Rain-out shelters

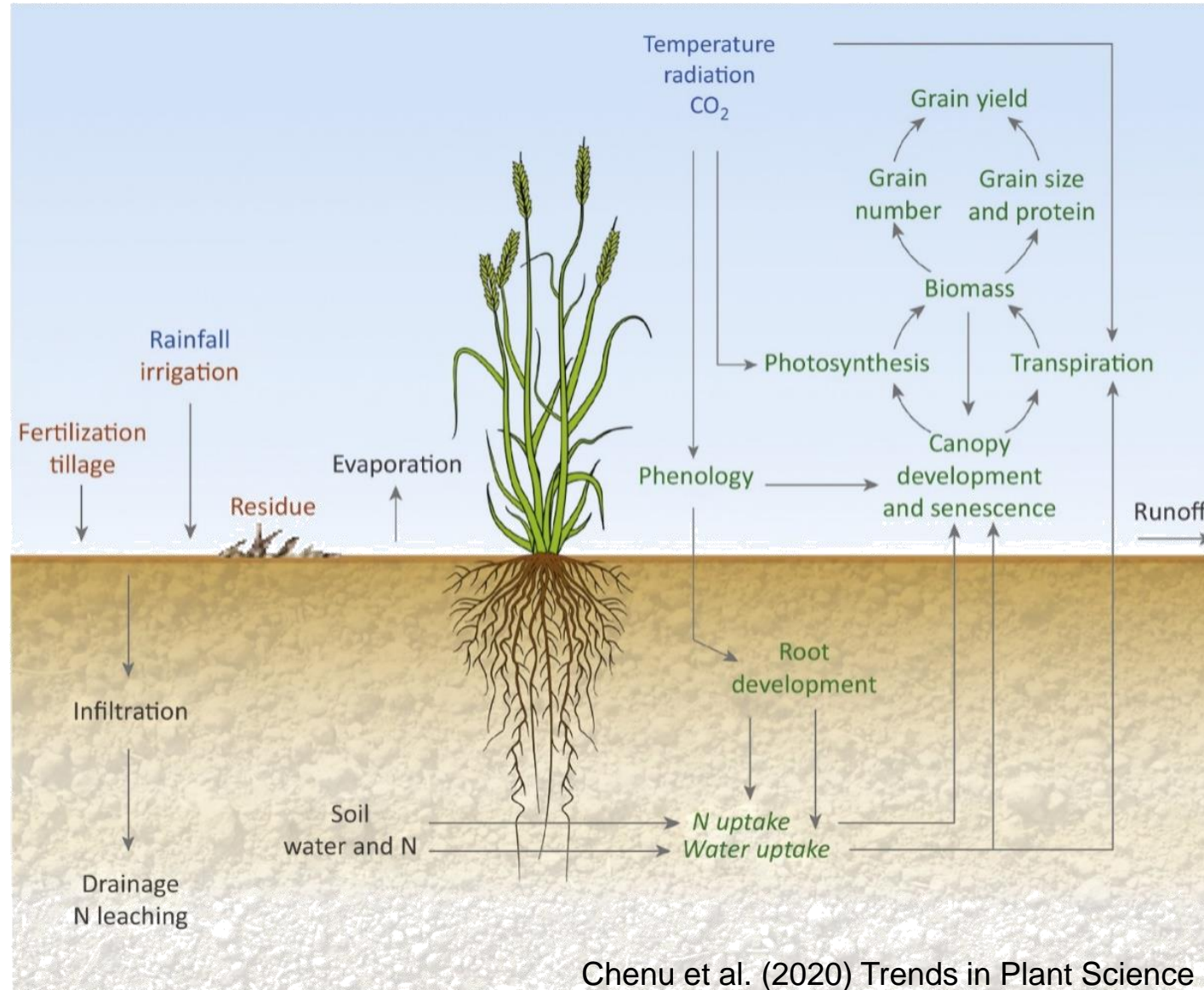


Kämpfer/Kottmann, JKI-PB



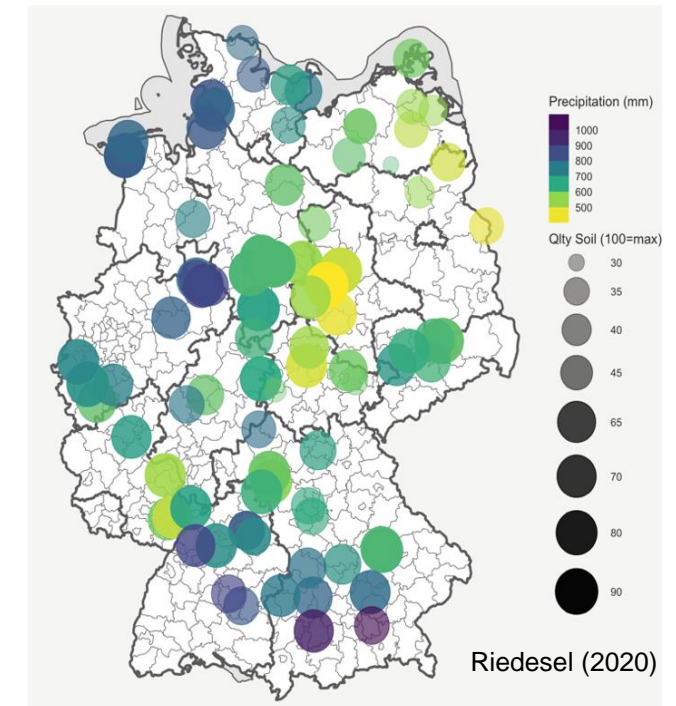
Kämpfer/Kottmann, JKI-PB3

Process-based crop models

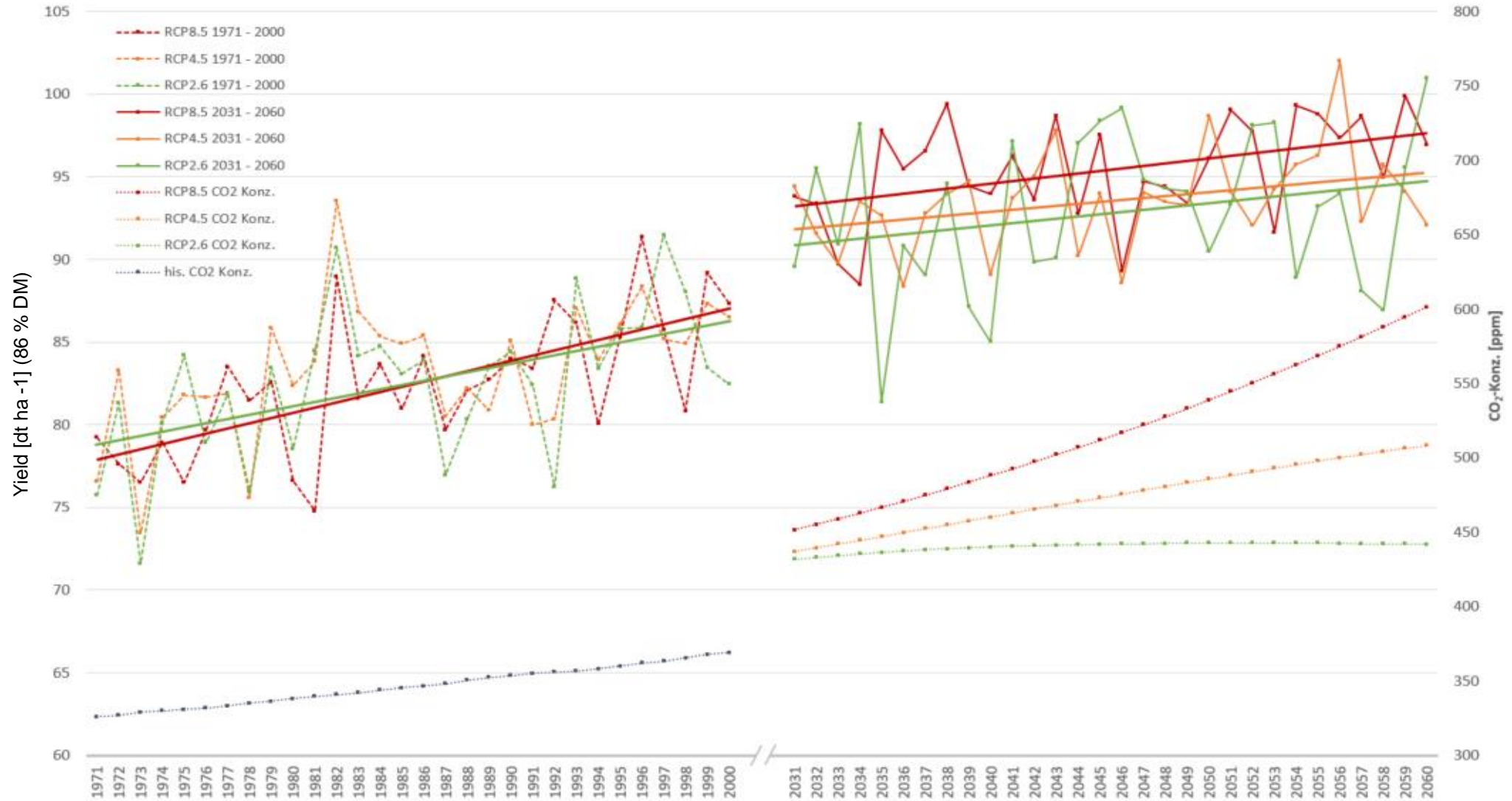


Crop model simulations wheat in 2050

- Small multi-model-ensemble (CERES, CROPSIM, Nwheat)
 - Cultivar-specific Calibration and Evaluation based on data of ~100 value for cultivation and use trials (1995-2011)
 - Calibration conducted in similar extent for the three DSSAT models
- Simulation 1971-2000 vs. 2031-2060 (+2031-2060 without CO₂-increase)
- 17 climate scenarios (DWD Core-ensemble)
- Point-based simulations at 12 VCU-sites
 - Relevant wheat growing regions of Germany



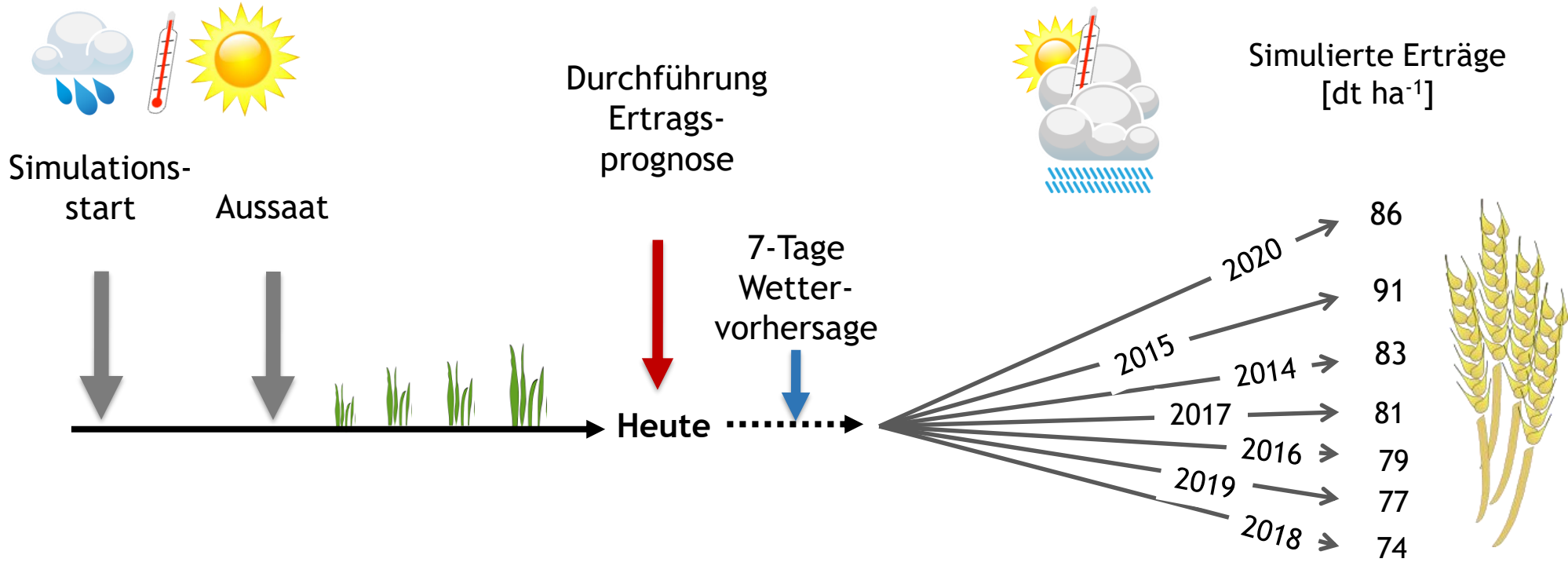
Wheat yield development 1971-2060



ProgErtrag & Hy-PiPE



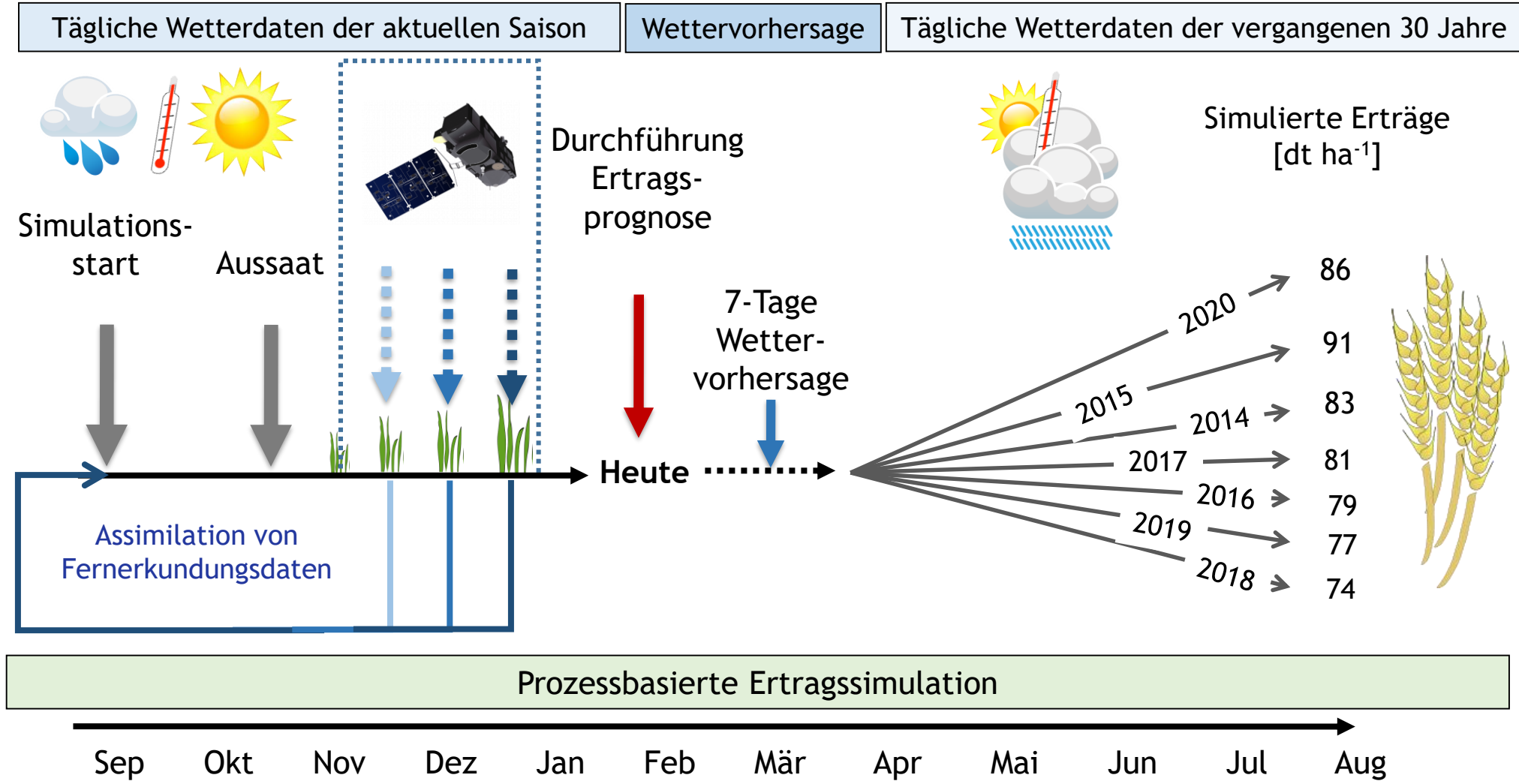
Tägliche Wetterdaten der aktuellen Saison Wettervorhersage Tägliche Wetterdaten der vergangenen 30 Jahre



Prozessbasierte Ertragssimulation

Sep Okt Nov Dez Jan Feb Mär Apr Mai Jun Jul Aug

ProgErtrag & Hy-PiPE



Take home

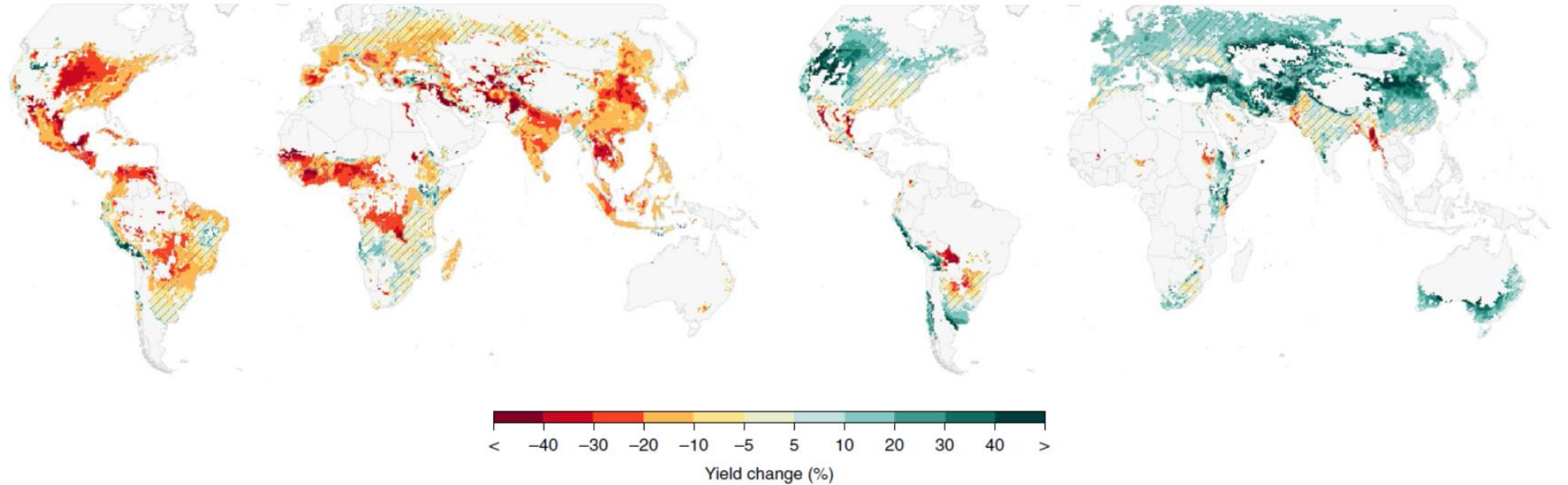
- Decision support for CC change adaptation of crop production important
- Need to understand weather-yield-relations
- Models can help
- Good data is crucial



Global gridded crop models

Maize

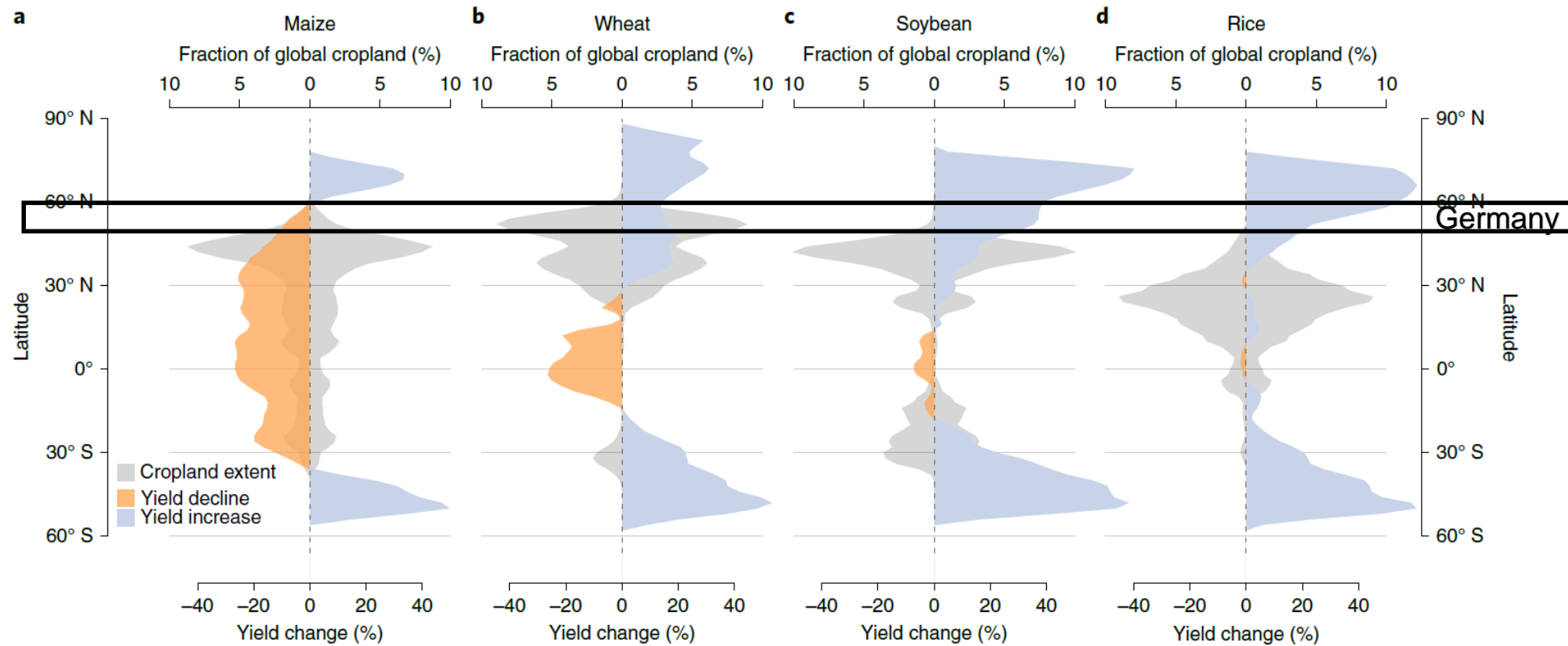
Wheat



2069-2099 vs. 1983-2013

Jägermeyr et al. (2021) *Nature Food*

Global gridded crop models



2069-2099 vs. 1983-2013

Jägermeyr et al. (2021) *Nature Food*