Agricultural impacts of climate change

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North North State

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Climate change – food, agriculture and land use

Complex problem

- Increasing wealth and consumption
- Very large differences in productivity and efficiency
- Large differences in waste and use of side streams
- Agriculture delivers food, materials and bioenergy

Many causes of greenhouse gases

- Food consumption
- Agricultural production
- Land use (including iLUC indirect land use change)

Climate change and adaptation is also important

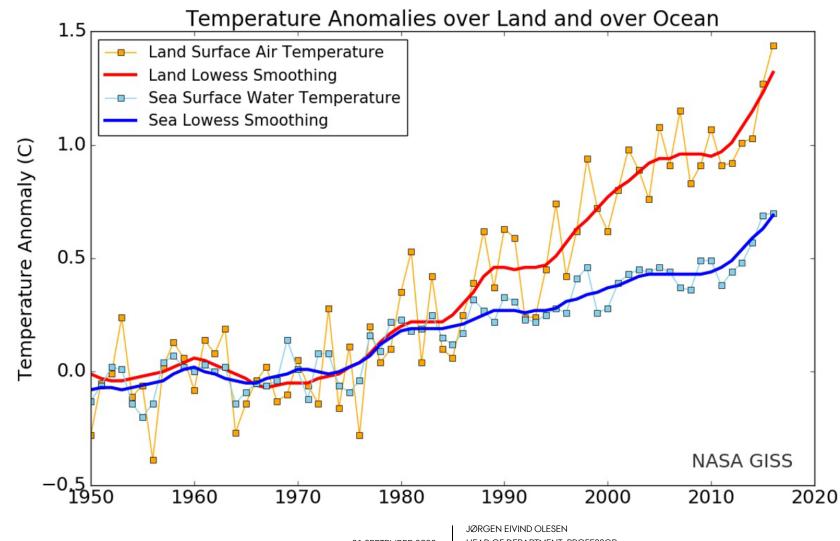
- Climate change will happen even with mitigation
- Warmer climate, more extremes, droughts, floods
- World food supply will be threatened







Temperature over land increase more over land than oceans





EEA (2017



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The warming is not evenly distributed

a) Annual mean temperature change (°C) at 1 °C global warming

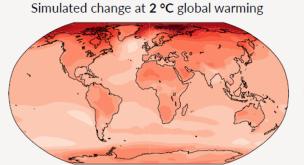
Warming at 1 °C affects all continents and is generally larger over land than over the oceans in both observations and models. Across most regions, observed and simulated patterns are consistent.

Across warming levels, land areas warm more than oceans, and the Arctic and Antarctica warm more than the tropics.

Simulated change at 1.5 °C global warming

relative to 1850-1900

b) Annual mean temperature change (°C)



Observed change per 1 °C global warming



Simulated change at 4 °C global warming

Simulated change at 1 °C global warming



Change (°C) Warmer



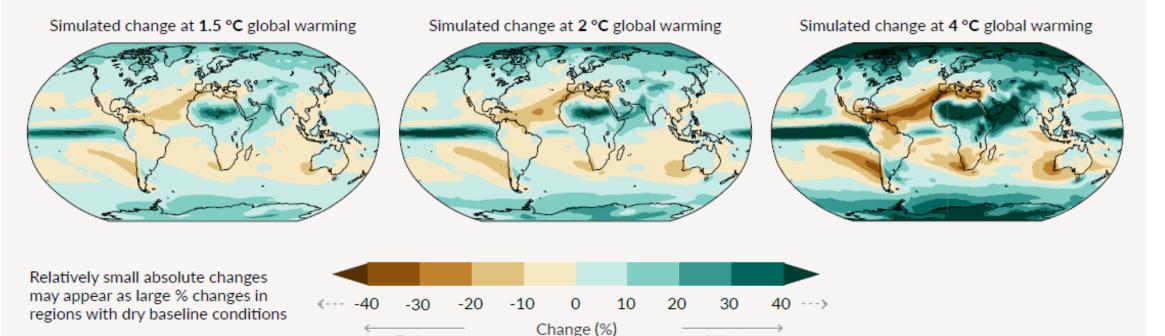


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The change in precipitation is not evenly distributed

c) Annual mean precipitation change (%) relative to 1850-1900

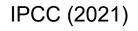
Precipitation is projected to increase over high latitudes, the equatorial Pacific and parts of the monsoon regions, but decrease over parts of the subtropics and in limited areas of the tropics.





Drier

Wetter





The climate is getting more extreme

North GIC America Europe NWN NEN NEU RAR Asia CNA ENA WCE EEU WSB ESB RFE **WNA** ECA NCA MED **WCA** TIB EAS Small •• Islands SCA CAR SAH ARP SEA SAS Central PAC America •• NWS NSA WAF CAF NEAF NAU 0 ... •• Small NES WSAF SEAF SAM Islands MDG EAU CAU SWS SES ESAF South Africa SAU •• America NZ Australasia ... SSA 0 Type of observed change since the 1950s

Type of observed change in hot extremes

Increase (41)

Decrease (0) Low agreement in the type of change (2)

Limited data and/or literature (2)

Confidence in human contribution

to the observed change

- ●●● High
- •• Medium
- Low due to limited agreement
- Low due to limited evidence

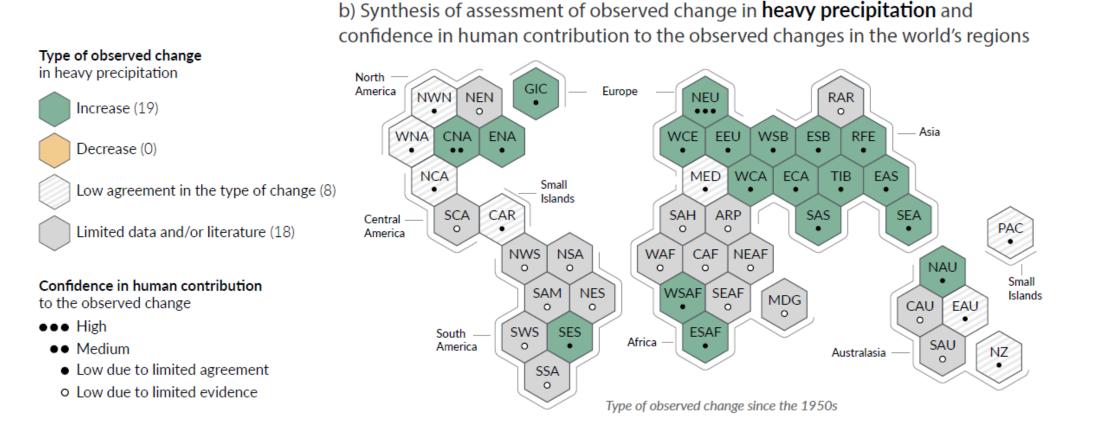


a) Synthesis of assessment of observed change in **hot extremes** and confidence in human contribution to the observed changes in the world's regions

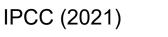


IPCC (2021)

The climate is getting more extreme



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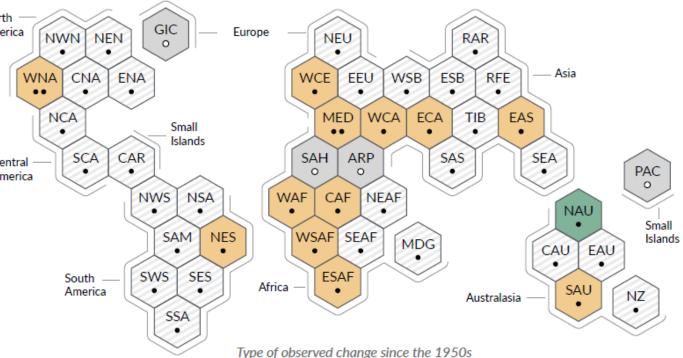
The climate is getting more extreme

Type of observed change in agricultural and ecological drought Increase (12) Decrease (1) Low agreement in the type of change (28) Limited data and/or literature (4)

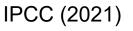
Confidence in human contribution to the observed change

- ••• High
- •• Medium
- Low due to limited agreement
- Low due to limited evidence

c) Synthesis of assessment of observed change in **agricultural and ecological drought** and confidence in human contribution to the observed changes in the world's regions



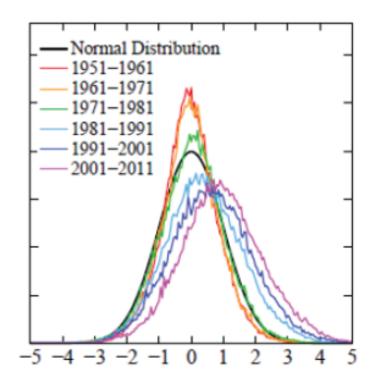


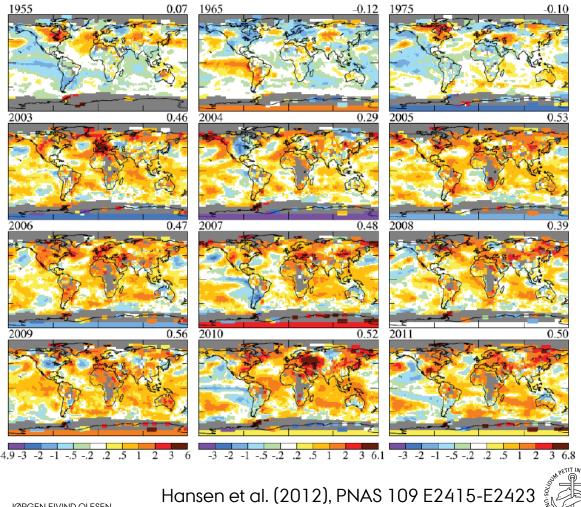




Summer temperatures are getting more extreme

- Global mean temperature increases
- But so does the interannual variation





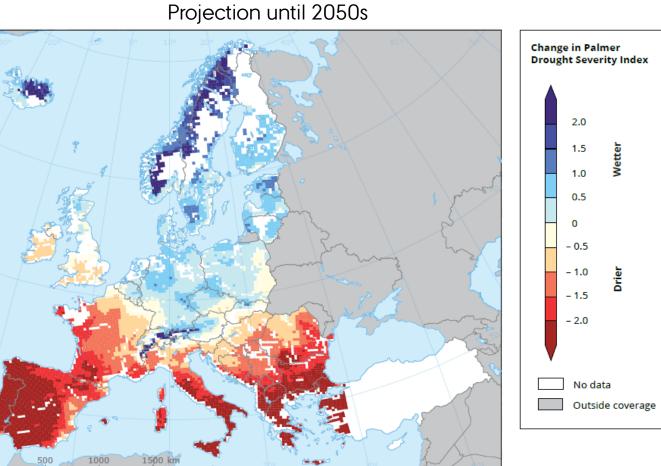


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Trends in summer soil moisture

Trend 1951-2012 10 50 50 NON 5.502. S SOS ዔ 1000 1500 km 500 1000 1500k





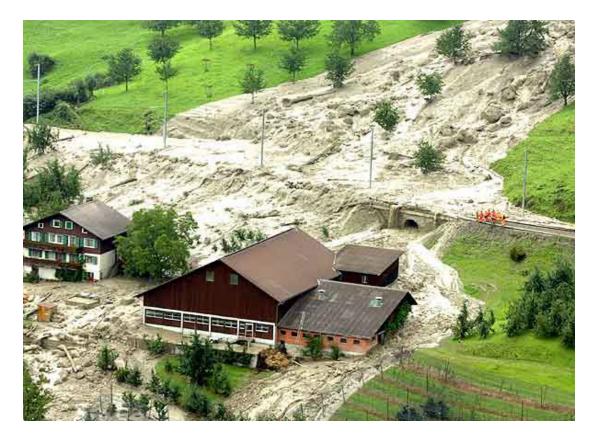






Climate change poses risks to current systems

- Risks to production systems are mostly related to extreme events and new biotic interactions
 - Heat waves
 - Frost, snow, ice
 - Droughts
 - Intense or long lasting rainfall (floods)
 - Storms
 - Pest and diseases
- Climate change increases
 - Frequency of extreme events
 - Inter-annual variability



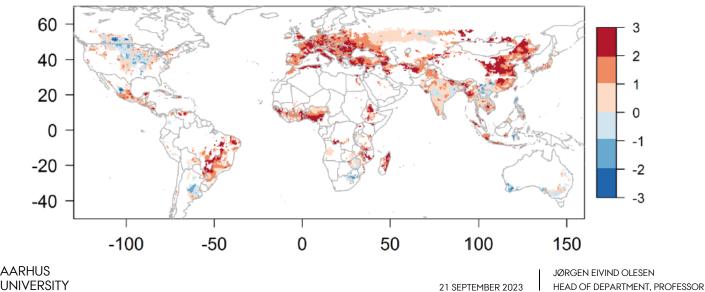




Observed impacts on crop yield of climate change globally

Сгор	Global production (1998-2002 average, million metric tons)	Global yield impact of temperature trends (%)	Global yield impact of precipitation trends (%)	Subtotal	Global yield impact of CO ₂ trends (%)	Total
Maize	607	-3.1 (-4.9, -1.4)	-0.7 (-1.2, 0.2)	-3.8 (-5.8, -1.9)	0.0	-3.8
Rice	591	(-0.9, 1.2)	(-0.2) (-1.0, 0.5)	(-0.1) (-1.6, 1.4)	3.0	2.9
Wheat	586	(-4.9) (-7.2, -2.8)	-0.6 (-1.3, 0.1)	(-5.5) (-8.0, -3.3)	3.0	-2.5
Soybean	168	(-0.8) (-3.8,1.9)	(-1.5, -0.1) (-1.5, -0.2)	(-4.9, 1.2)	3.0	1.3

(A) Linear Trend in Temperature, 1980-2008 (sd)

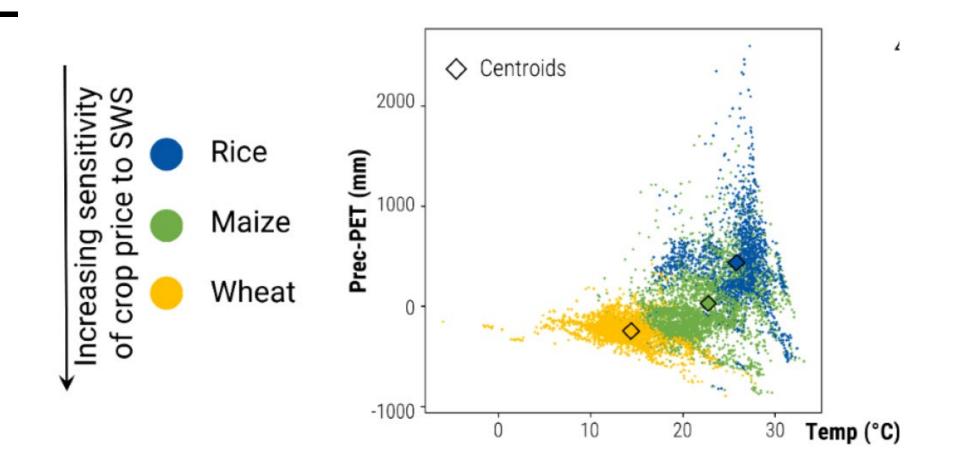


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Lobell et al. (2011)



Wheat, maize and rice are grown in different environments





N PETTING

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Plant and animal responses to temperature

Development (phenology)

• Timing of events, in particular reproduction

Growth

- Assimilation of energy and nutrients
- Respiration

Animal body temperatures

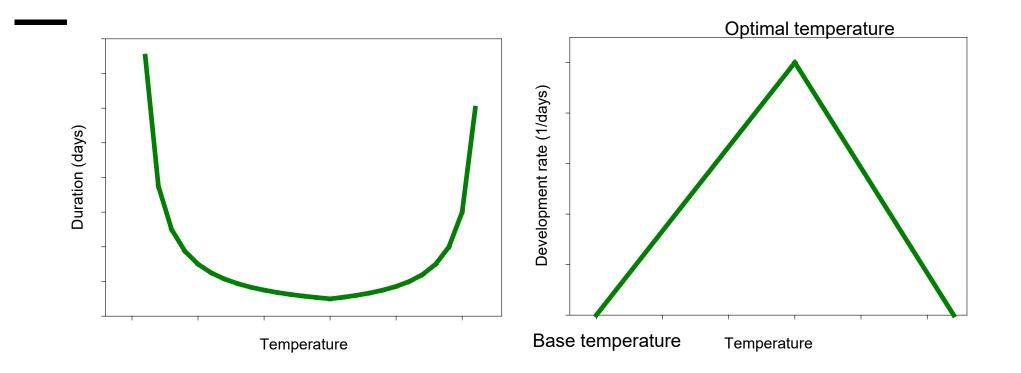
- Endotherms (constant body temperature)
- Poikilotherms (facultative endotherms)
- Ectotherms (body temperature depends on external temperature)







Developmental rate



Growing degree days (GDD) or Effective temperature sum (ETS): Σ (T-T_b)₊

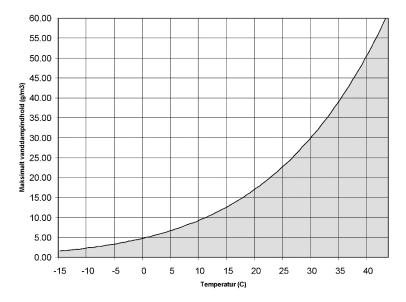




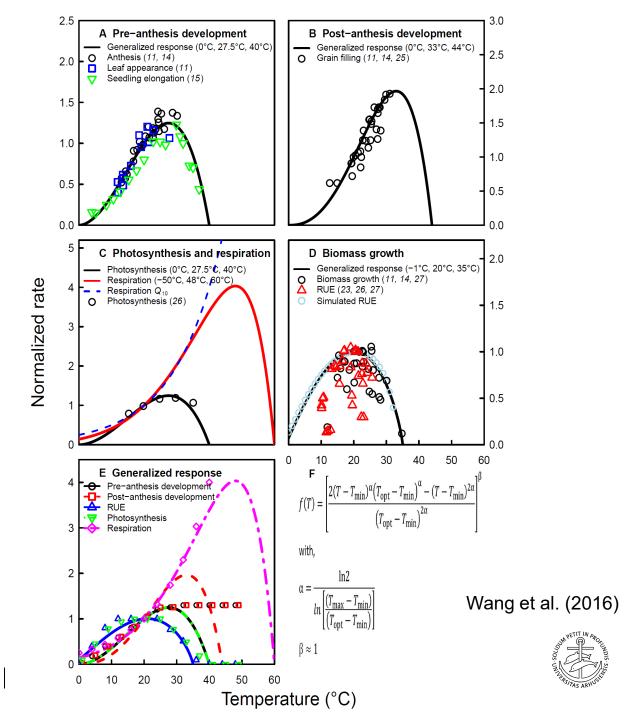
Temperature responses

Evapotranspiration increases with increase temperature due to the vapour pressure curve that increases vapour pressure deficit with increasing temperature.

Saturated water vapour - temperature curve



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Projected yield change

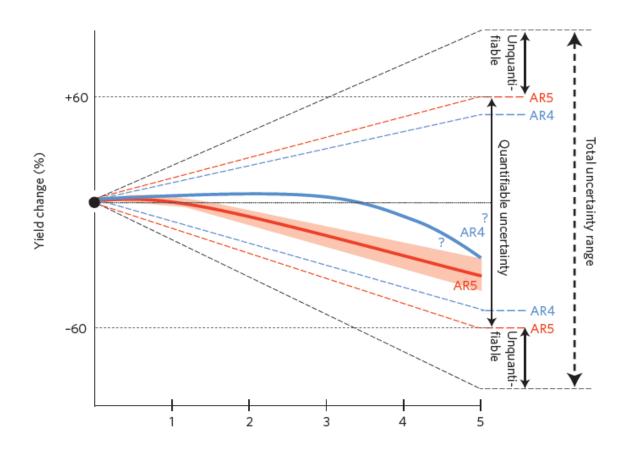
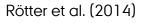


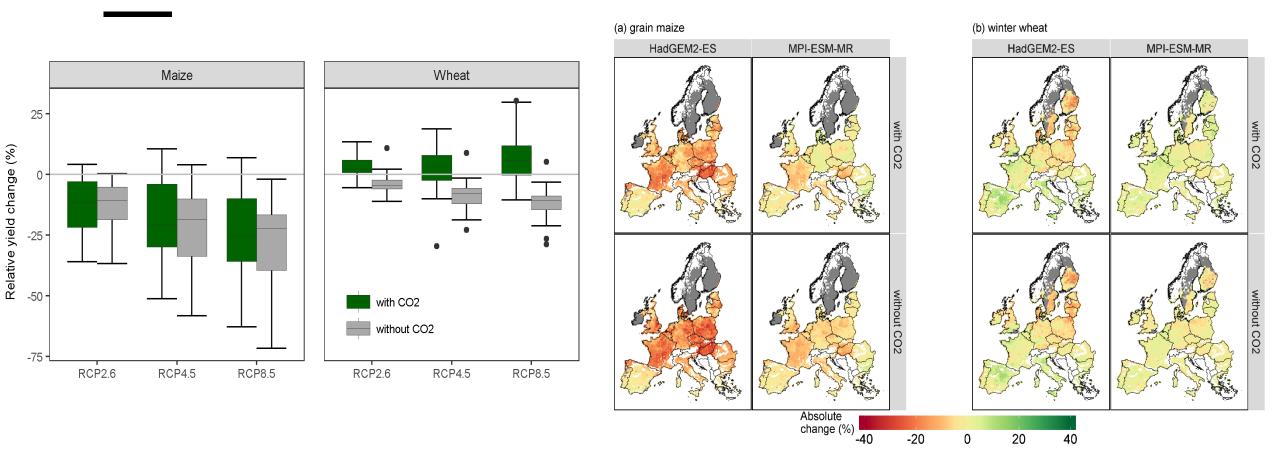
Figure 1 Schematic illustration of the relationship between total uncertainty, projected ranges of relative yield changes and best fits of aggregate yield changes. The figure refers to model-based results from AR4 (ref. 5) and AR5 (WGII chapter 'Food security and food production systems') and indicatively depicts the main message and novelties of this study⁴. Figure modified from ref. 6.







Drought is the major threat for cereals under climate change in Europe (2050s)

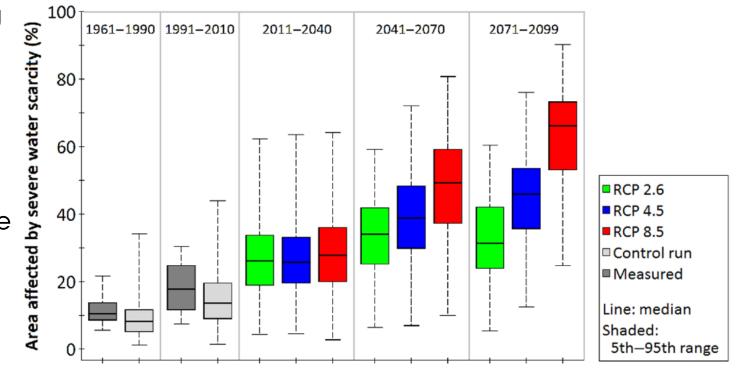






Future severe drought in wheat

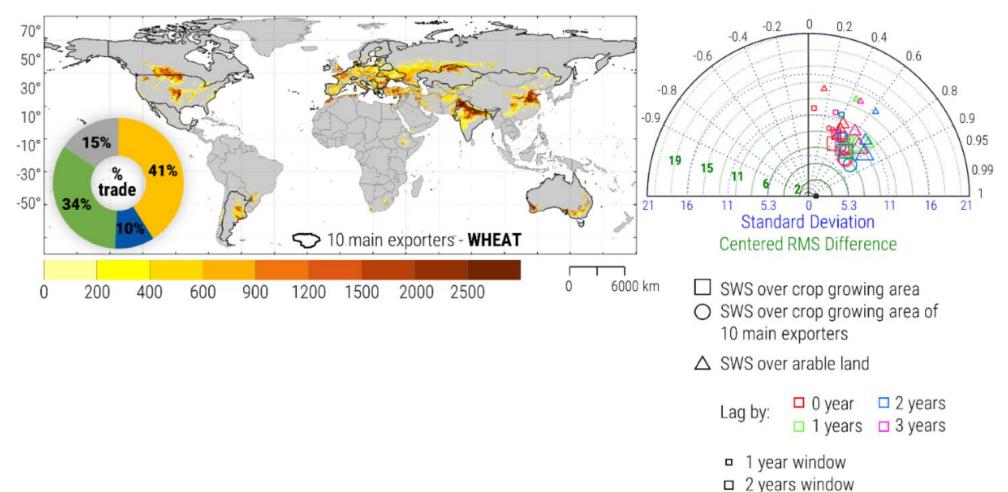
- Calculated area with severe drought for the world wheat area over the growing period for wheat
- The area with severe drought has increased by 50 % relative to 1961-1990
- Under moderate climate change the area with severe drought will quadruple by mid century
- This increase in severe drought also happens in the world wheat exporting countries, affecting grain price

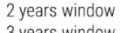






World wheat price (WPI) is primarily driven by variation in drought



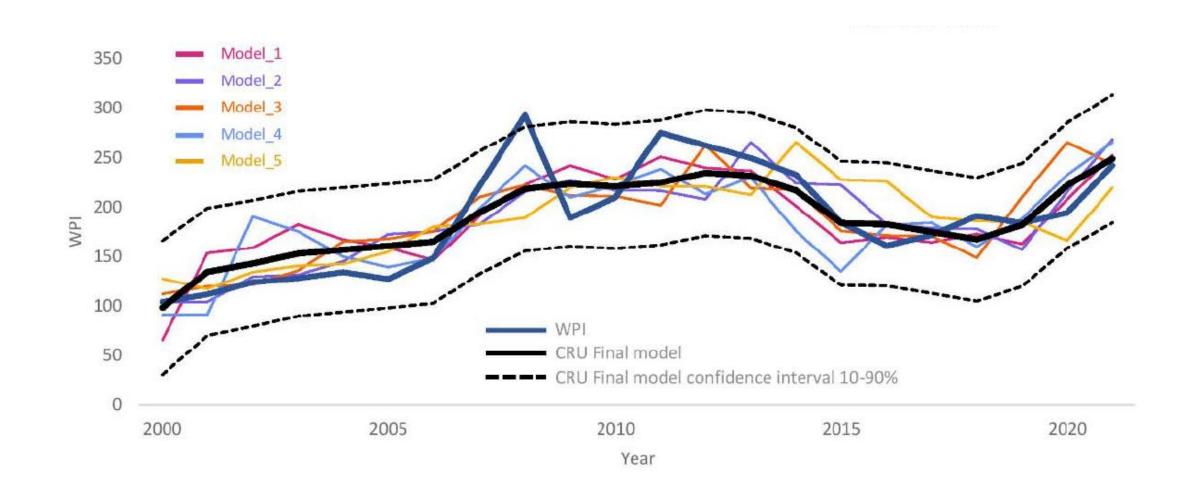


□ 3 years window





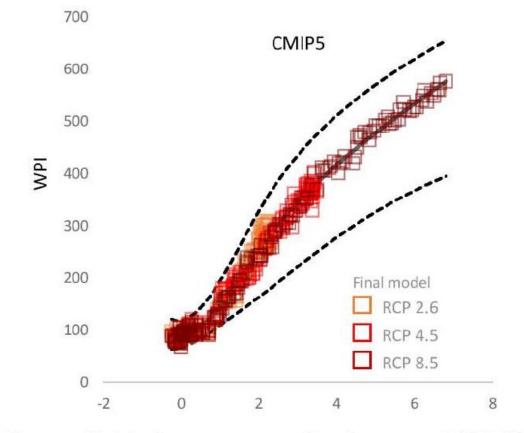
World wheat price (WPI) is primarily driven by variation in drought







Climate change is projected to increase wheat price (WPI)

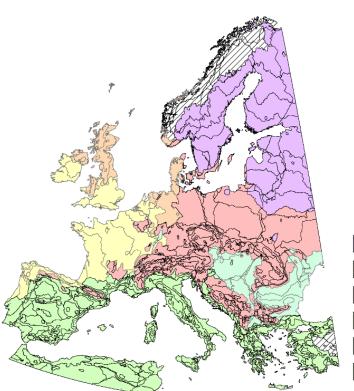


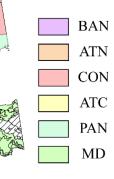
Change of global temperature related to mean 1951-1980

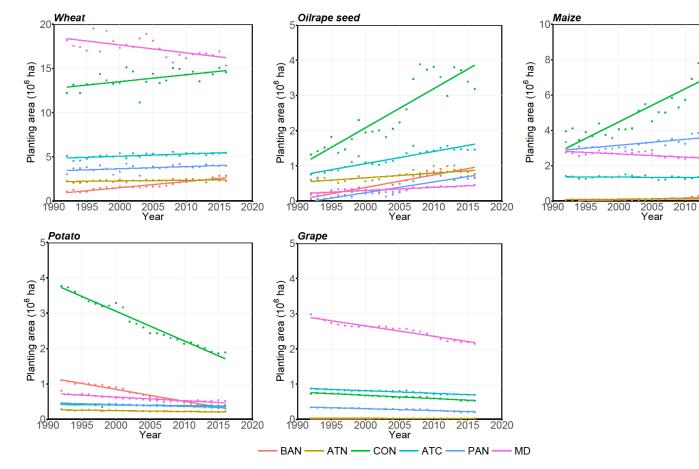




Survey of impacts and adaptation in European crops









2015

2020



JØRGEN FIVIND OLESEN 21 SEPTEMBER 2023

HEAD OF DEPARTMENT, PROFESSOR

Observed changes and attribution

		Observed change					Climate change attribution								
nanges	Timing of field operations	3	1	2	2	2	2		2	1	1	2	1	2	
	New crops (silage maize)	2	2	2	3	1	2		1	1	1	0	0	2	
	New crops (grain maize)	2	1	1	2	2	2		1	1	1	0	0	1	
n	New crops (soybean)	2	1	1	2	1	1		1	0	1	1	0	1	
	New crops (sunflower)	2	1	1	1	2	2		1	0	0	1	1	1	
	New crops (grapevine)	2	2	2	2	2	2	-	1	1	1	2	1	1	
	New crops (other, specify)	2	0	2	1	2	2	-	2	0	1	1	2	1	
New cultivars (specify which crops)		4	2	2	2	3	1	-	2	1	1	2	1	1	
Water saving cultivation		1	1	2	1	2	2		1	0	1	1	2	2	
Erosion protection cultivation Expansion of irrigated area		3	1	2	1	3	1	-	0	0	1	1	1	2	
		0	0	1	1	2	3	-	0	0	1	2	2	3	
Reduction of irrigated area		0	0	1	0	3	2	-		0	0	1	0	2	
Reduced cultivation of water demanding crops		0	0	0	0	1	2	-		0	1	1	2	3	
Improvement of drainage systems		1	1	1	2	1	0	-	0	1	1	1	1	1	
Breeding for changed crop phenology		0	0	2	2	2	1	-	0	0	1	2	2	2	
Breeding for better drought tolerance		0	0	2	1	2	2	-	0	0	2	1	2	2	
Breeding for changed disease and pest resistance		2	3	3	2	2	2	-	1	1	1	1	1	2	
Changes in crop protection measures		3	1	2	1	2	3	-	1	0	1	1	1	2	
Soil management for water harvesting		0	0	1	1	2	2	-		0	1	1	1	2	
Soil management to conserve water-		2	1	2	1	2	2	-	0	1	1	2	1	2	
New/changed scheme insurance against droughts •		2	1	2	1	1	3	-	1	0	2	1	1	2	
New/changed scheme insurance against heat•		4	0	1	0	2	2	•	1	0	1	2	1	2	
New/changed scheme insurance against hail		0	0	1	1	0	2	-		0	1	1	0	2	
New/changed scheme insurance against flood		4	1	1	2	0	2	•	1	1	1	2	0	2	
New/changed scheme insurance against bad weather during harvest		3	1	0	2	0	2	-	1	1	0	2	0	1	
Change to other agricultural activities (e.g. livestock)		5	0	1	0	2	1	-	0	0	0	0	1	1	
	Leaving agriculture sector-	2	1	1	2	2	2	-	0	0	0	0	0	1	
Changing subsidy schemes		0	1	2	2	3	2			0	0	1	0	0	
Early warning/forecast systems – national/regional		2	1	2	1	3	3	-	1	0	2	1	2	2	
Early warning/forecast systems – farm based		2	1	1	2	2	2		1	0	1	1	1	2	
	_	BAN	ATN	CÓN	ATC	PAN	MD		BÁN	AŤN	CÓN	ATC	PAN	MD	
		o	1	2	3	4	5		0		1	2		3	
		-		-	-	-	-		5		•	-		-	





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Response of agriculture to climate change

- The ongoing climate change with higher temperatures, increased variability and extremes will challenge most agricultural systems and often make mitigation efforts more challenging
- Globally, climate change will increase extent and frequency of drought, negatively affecting food supply and food security
- This necessitates development of technologies and agricultural systems that emphasize both low GHG emissions as well as resilience to climatic stresses



Satellite image showing drought in 2018 over West Zealand





