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CORDEX.BE WORKSHOP ON AGRICULTURE

CLIMATE IMPACTS ON AGRICULTURE - *Anne Gobin*

- *WEATHER IMPACTS*
- *CLIMATE IMPACTS*
- *VULNERABILITY AND RISK PERCEPTION*

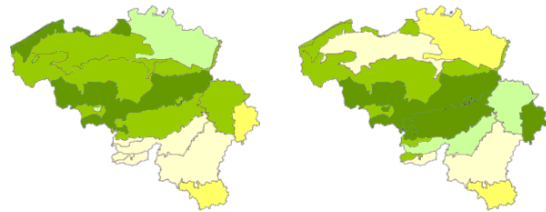


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WEATHER IMPACTS

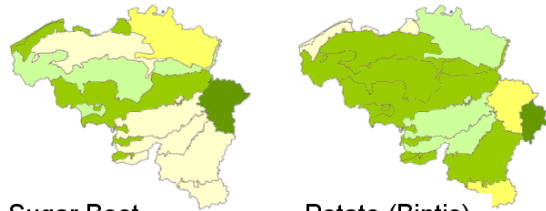
- Extreme and adverse weather conditions
- Impact on crop performance

RELATION BETWEEN YIELD AND WEATHER



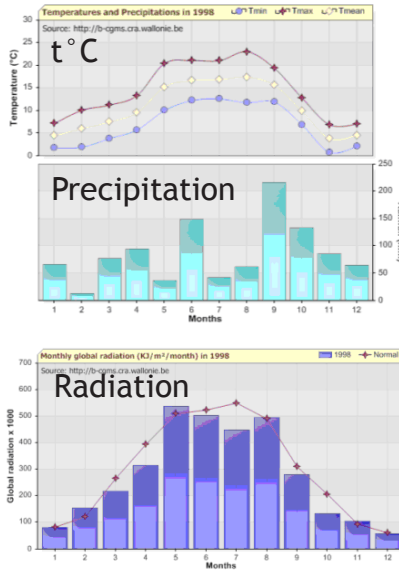
Winter wheat

Winter Barley



Sugar Beet

Potato (Bintje)



- » Variability between years, crops and between regions!
- » Variability depends on crop type, crop stage, **weather** during the cropping season
- » **Weather** and **Climate** have a large impact on agricultural crops

Drought



Heat stress



Hail

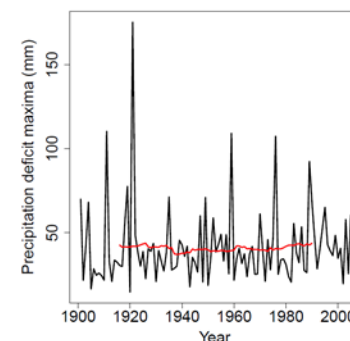
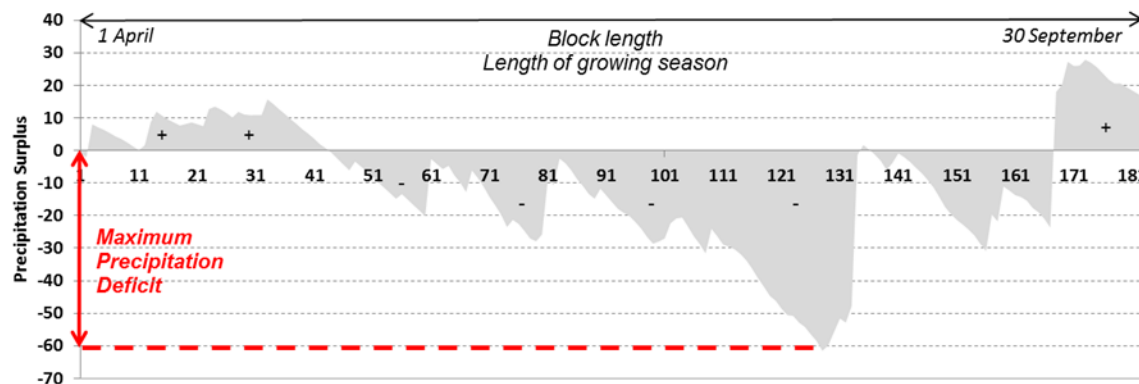


Waterlogging

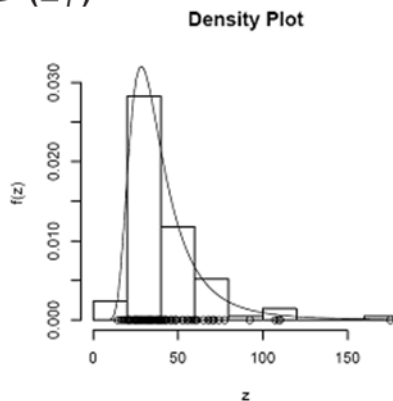
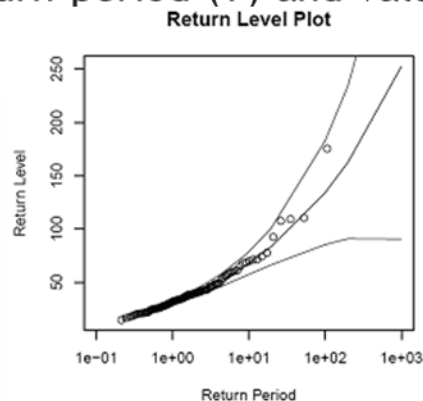


EXTREME WEATHER EVENTS AND ADVERSE WEATHER CONDITIONS

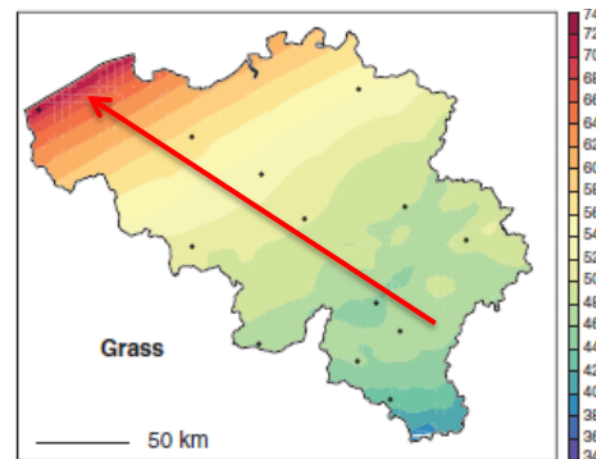
Trend analysis of time series and fitting distributions of individual stations



Return period (T) and value (z_T)

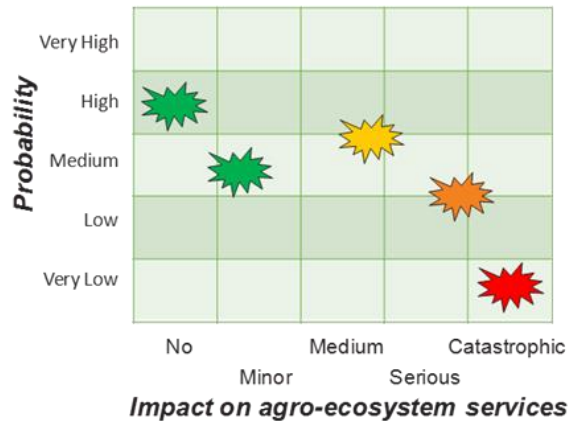


Cumulative precipitation deficit = $f(ET, P)$
(Zamani et al., 2015)



20y RP for precipitation deficit
20y RP = adverse condition!

MAGNITUDE OF IMPACT ON AGRICULTURE



yield, biomass, soil quality, soil moisture

- Impact depends on
 - the **occurrence** of the event during the agricultural season
 - the **location** of the event vs system
 - the **magnitude** and duration of the event
 - the **vulnerability**/resilience of the system

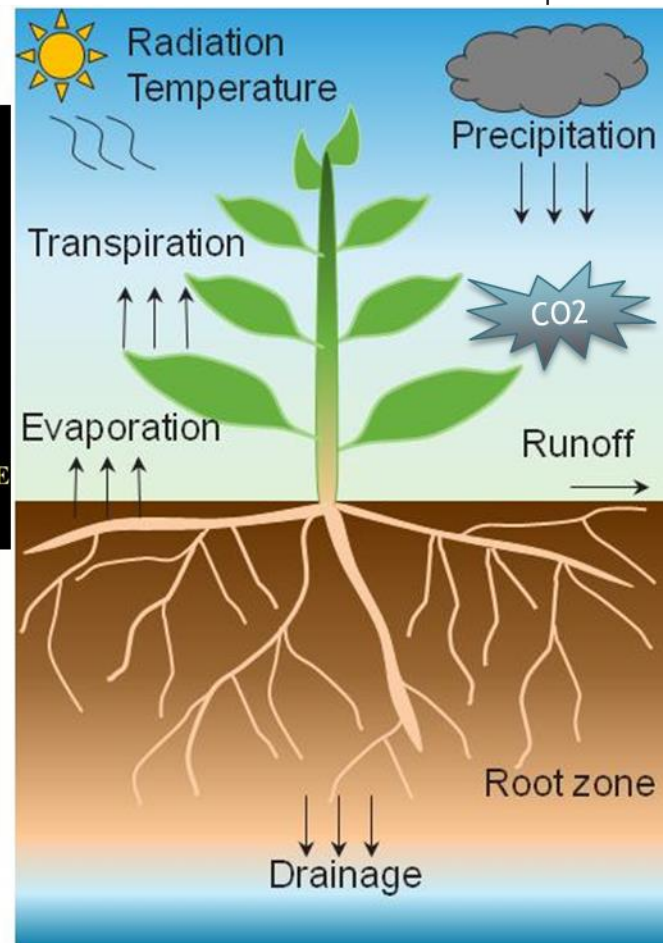
Farming calendar



ADVERSE WEATHER/CLIMATE CONDITIONS DURING THE GROWING SEASON



Biomass growth & Phenological stadia: in cumulative temperature days with base and maximum temperature & daylength as boundaries of phenological activity



Input

- Climate
- Soil
- Crop
- CO₂

Processes

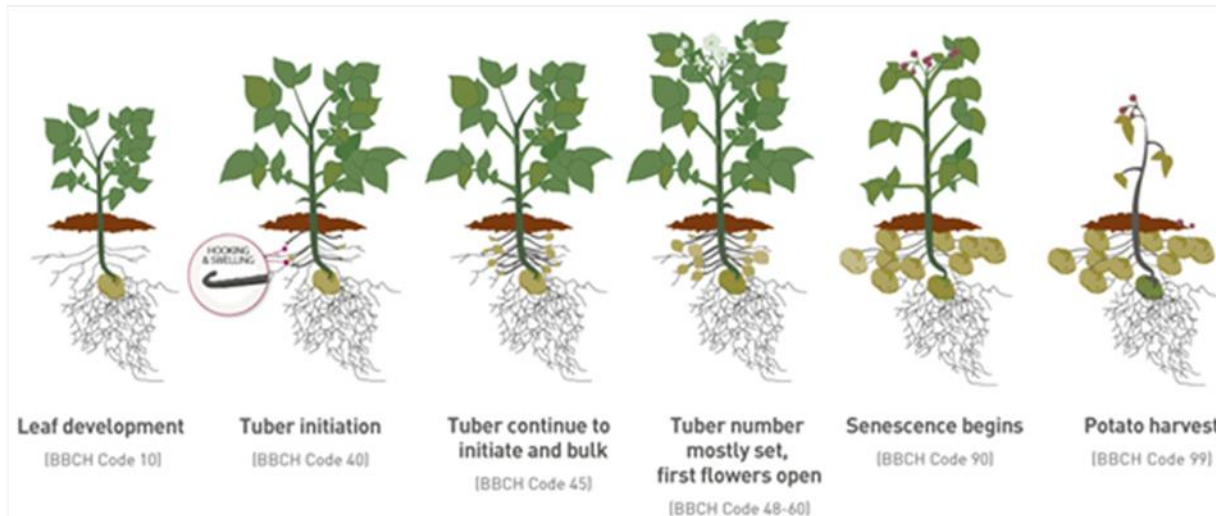
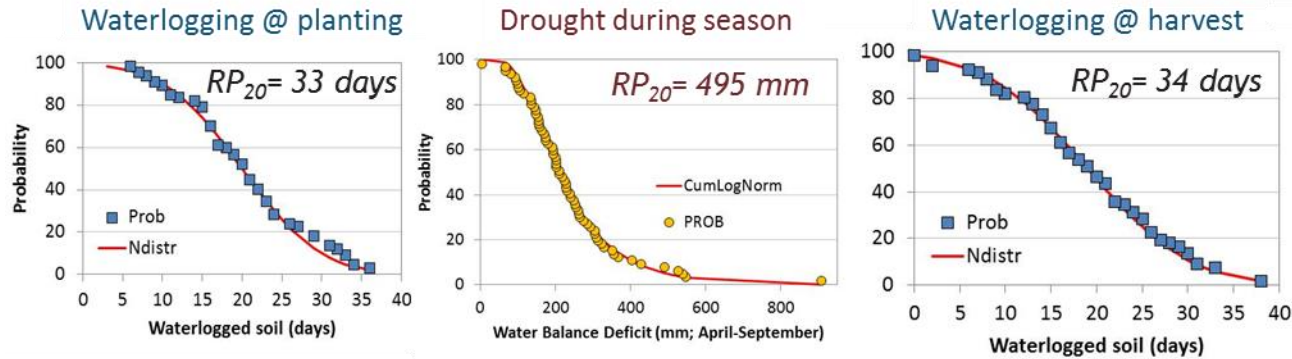
- Phenology
- Biomass Production
- Water Balance
- Energy Balance

Output

- Waterlogging
- Drought
- Heat stress
- Temperature stress
- Biomass
- Yield

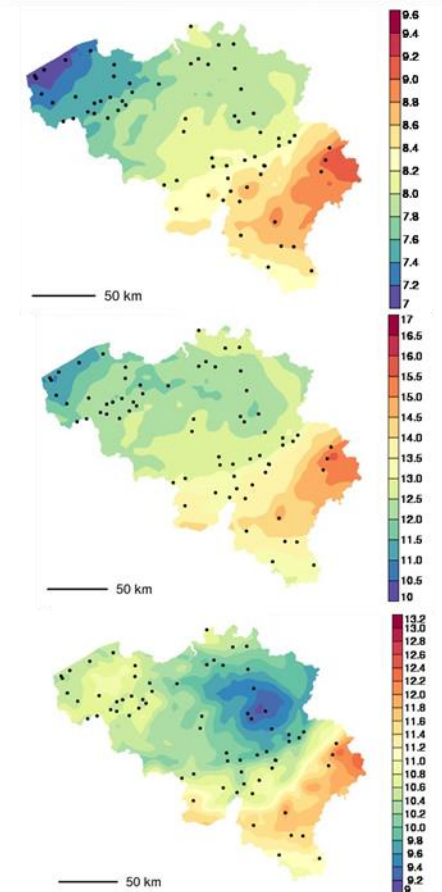
(Gobin, 2010, 2012, 2015, 2017)

EXAMPLE: RISKS FOR POTATO CULTIVATION IN BELGIUM



Probability of exceedance and 20-y return period

Consecutive rainy days



Spatial return period

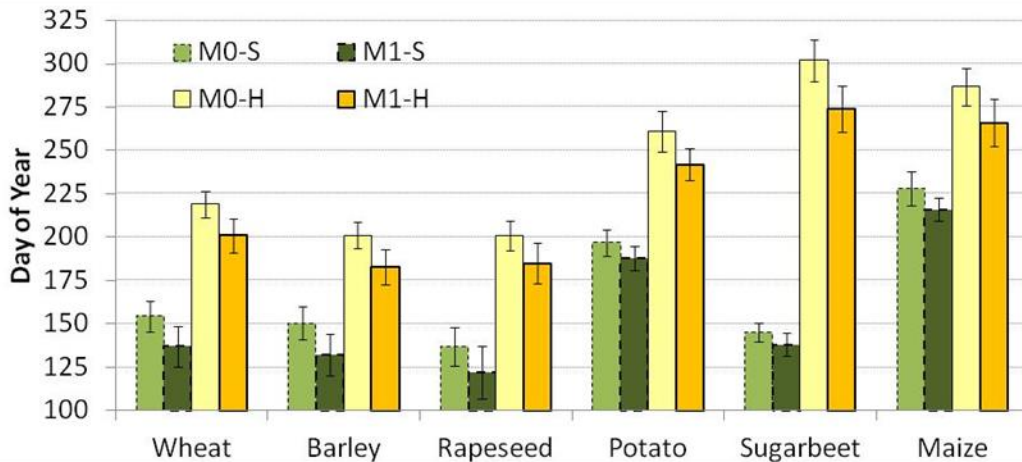


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CLIMATE IMPACTS

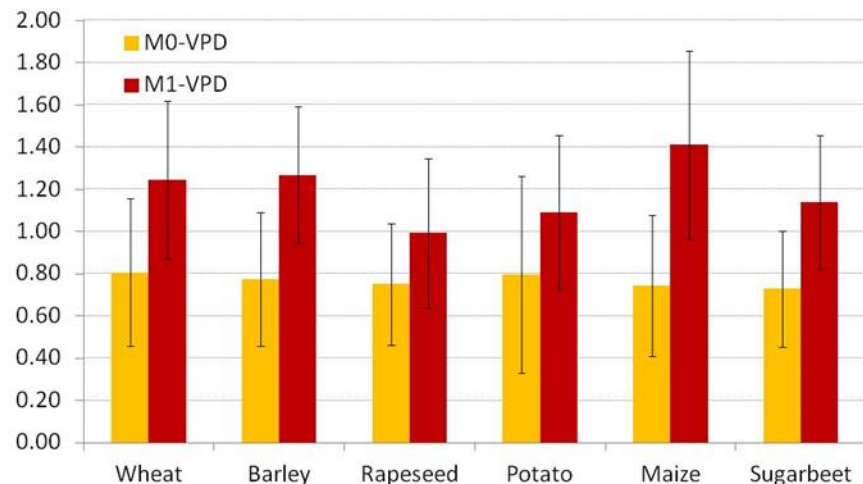
- GCM & Downscaling
- Projected time series
- Impact on crop performance

MAGNITUDE OF EVENTS DURING SENSITIVE STAGES ACROSS MULTIPLE YEARS



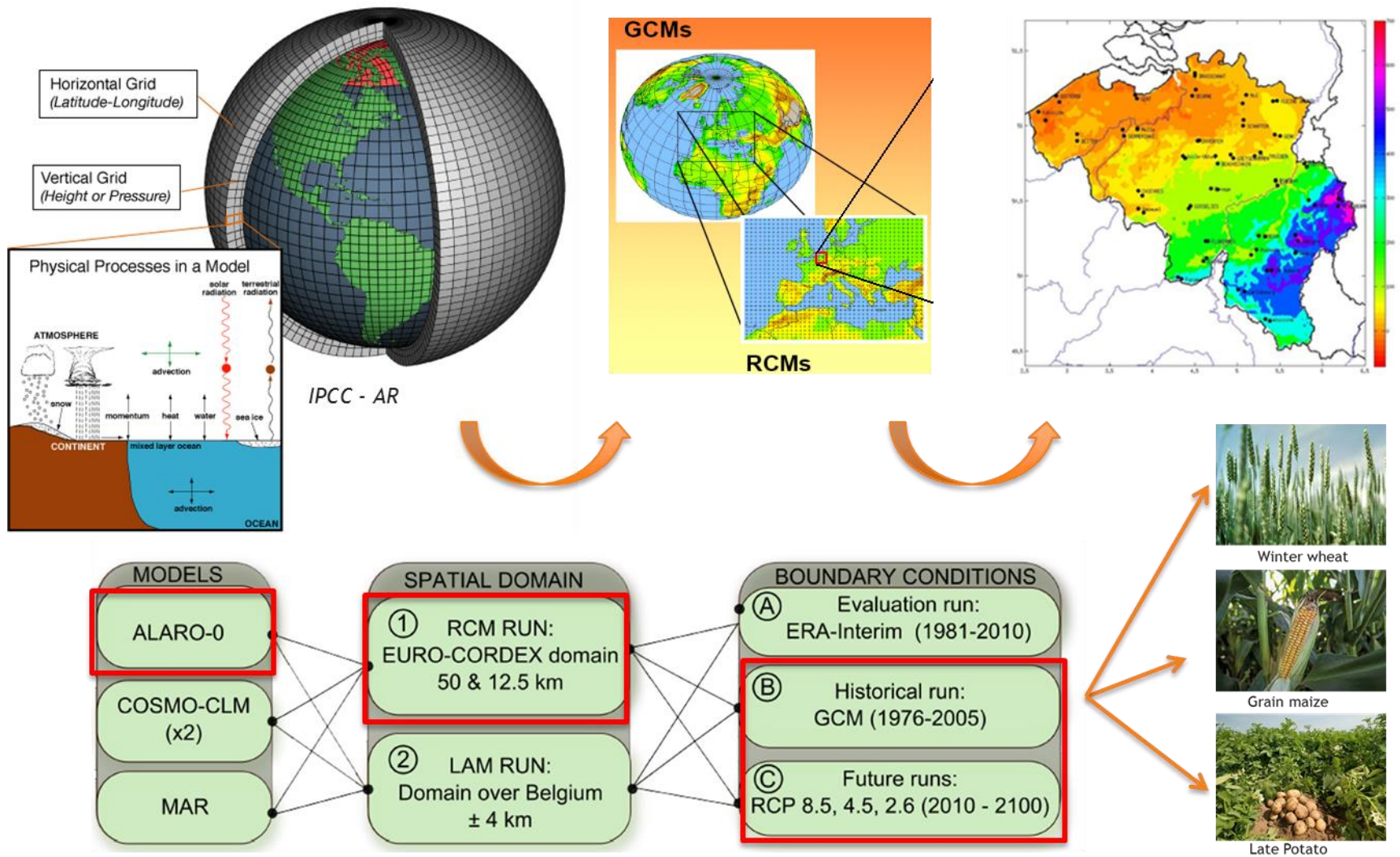
- » M0: < 1988; M1: >1988
- » Occurrence of **S**ensitive stages and **H**arvesting
- » Variability between years is captured, growth stages occur significantly **earlier** during the 1988-2008 growing seasons

- » Magnitude of heat stress during sensitive stages: increased heat stress during 1988-2008 period
- » Implication for the **coincidence** between a meteorological hazard and the sensitive stage

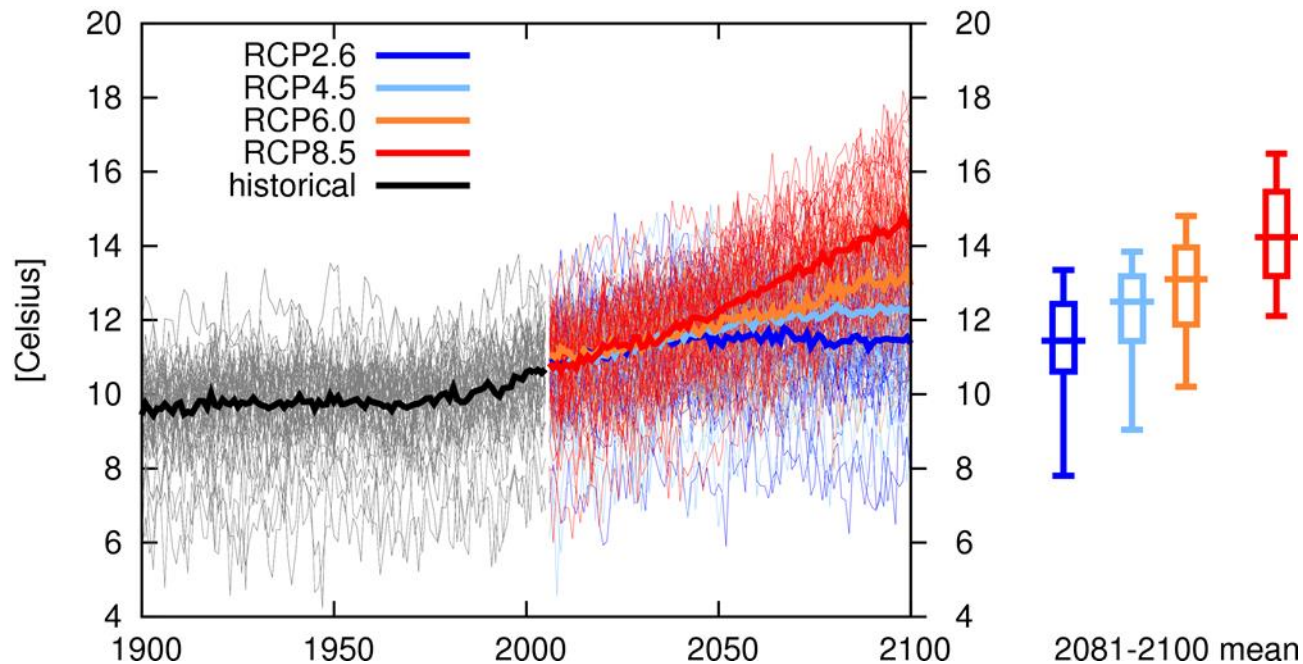


(Gobin, 2012)

CLIMATE DATA

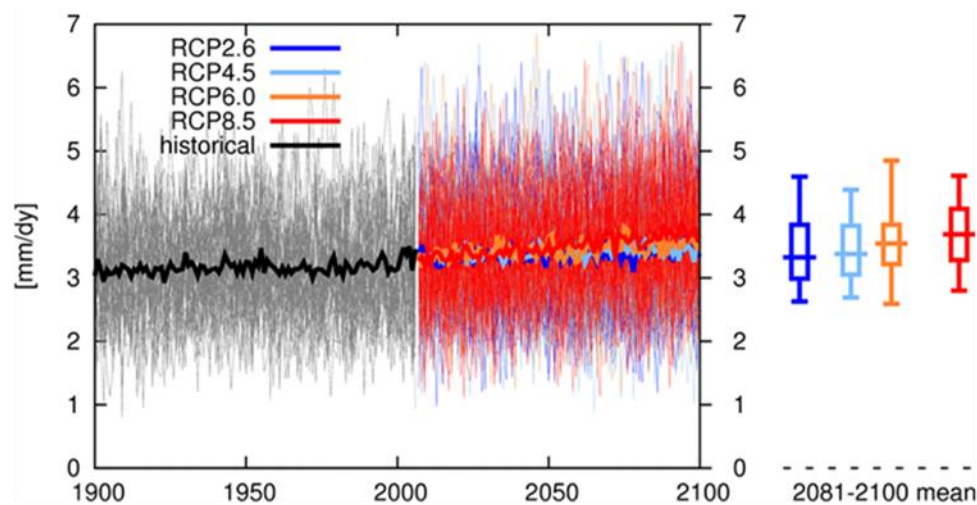


PROJECTED TEMPERATURE

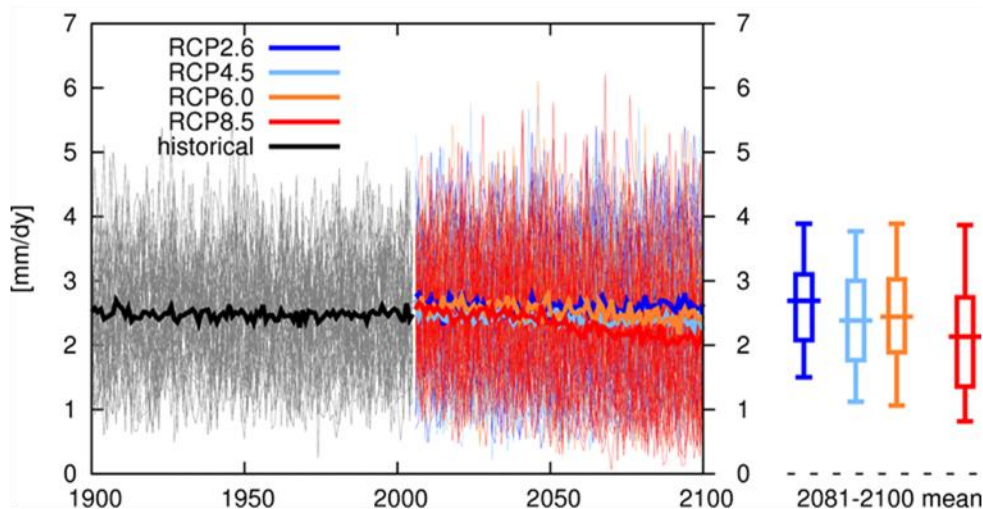


Higher annual mean temperatures with
higher minimum- and maximum temperatures during all seasons
extreme maximum temperatures during the summer
increased heat stress!

PROJECTED PRECIPITATION



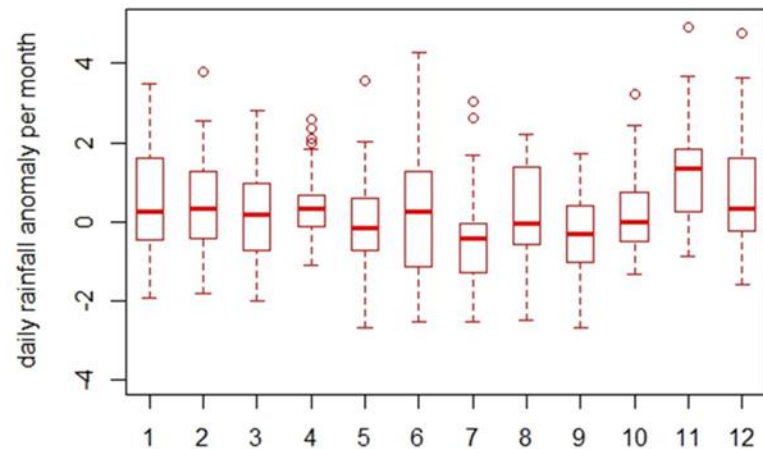
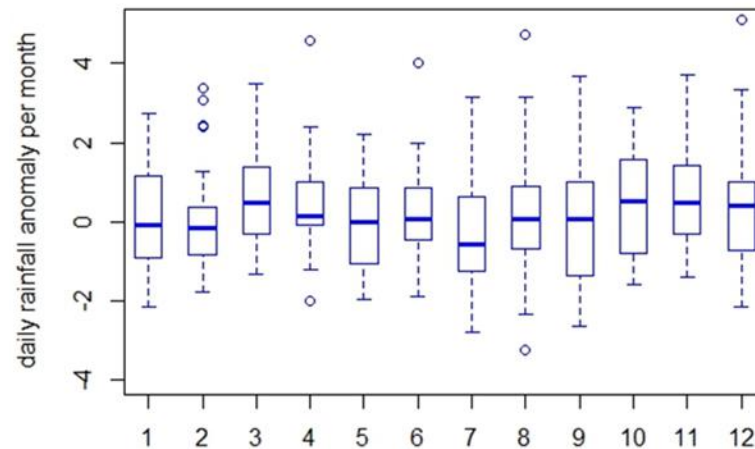
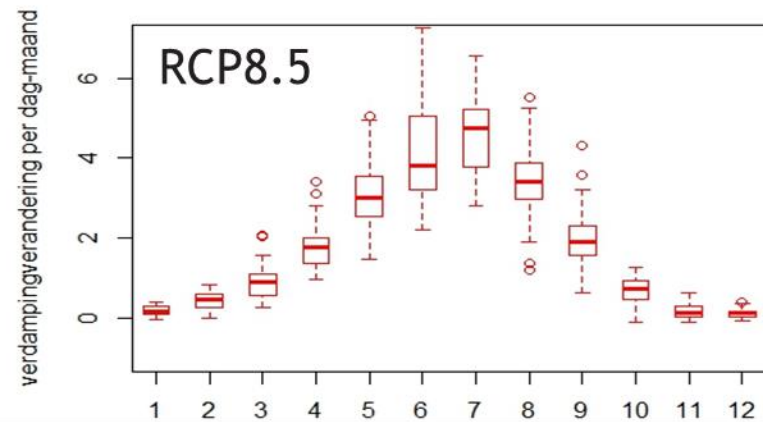
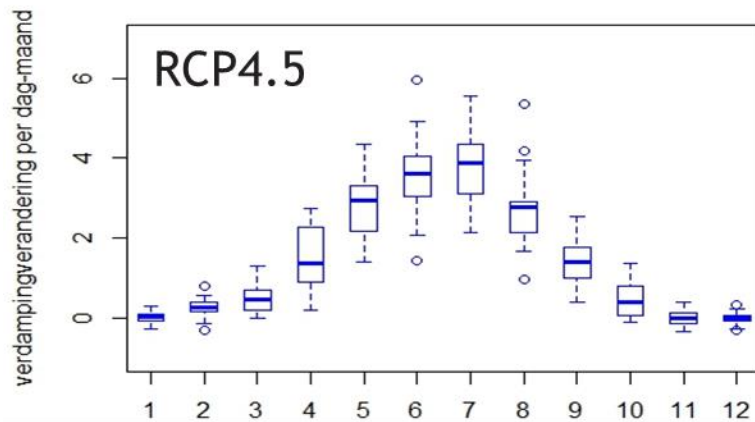
Winters will be wetter



Extreme rainfall events during summer storms.

Extreme rainfall does not replenish the soil water nor does it fulfil crop water requirements.

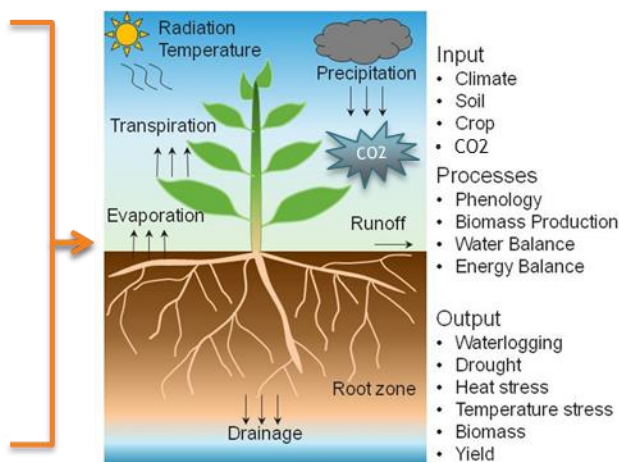
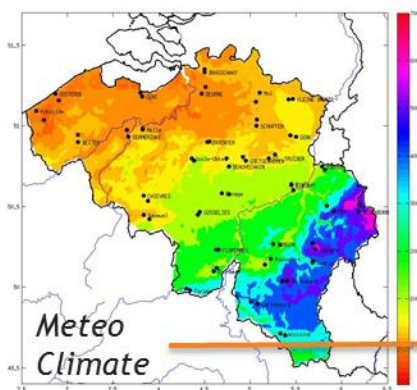
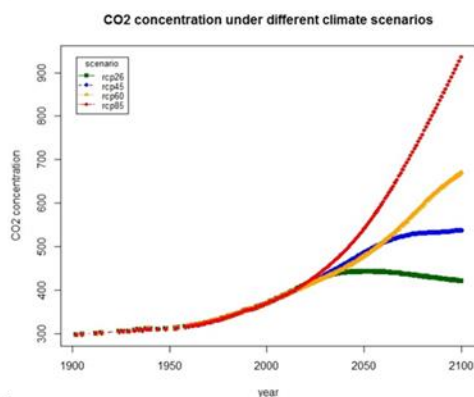
PROJECTED RAINFALL AND EVAPOTRANSPIRATION



Water requirements increase with rising temperatures.

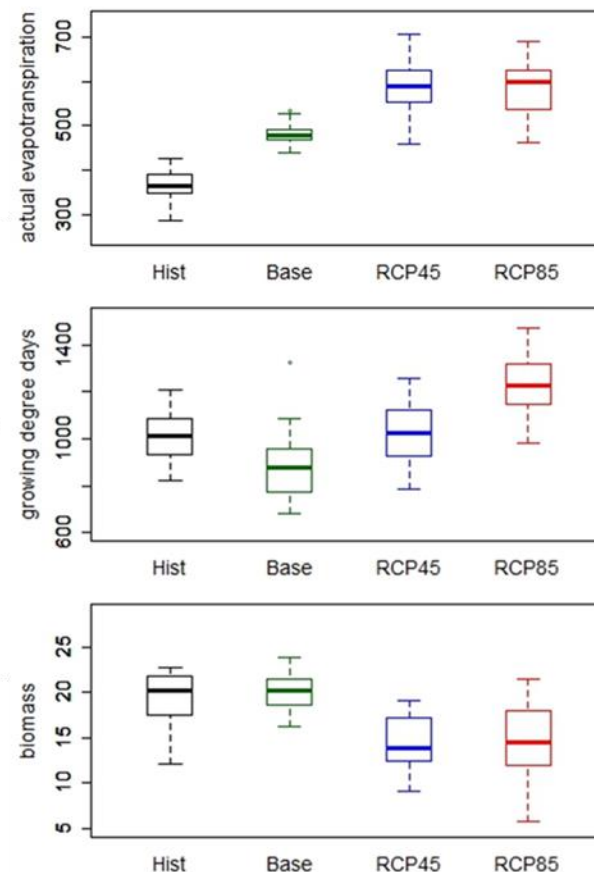
CLIMATE IMPACT ON CROP GROWTH (CORDEX.BE)

- Projected shifts - observed weather 1960-1990 (Hist), GCM 1976-2005 (Base), and 2070-2100 (RCP45, RCP85). ALARO 12 km Downscaling. Model runs on locations of synoptic stations across Belgium.



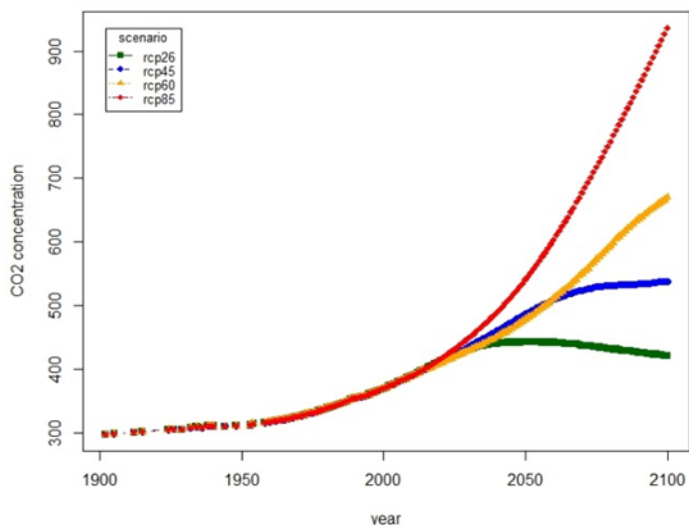
(Gobin, 2010, 2012, 2015)

Agroclimatological Functions

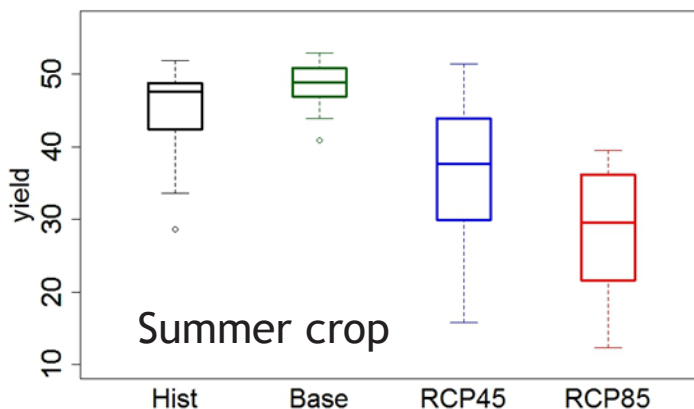
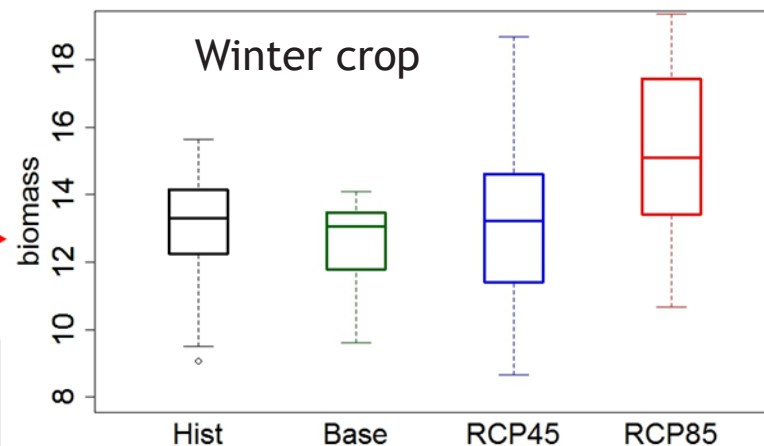
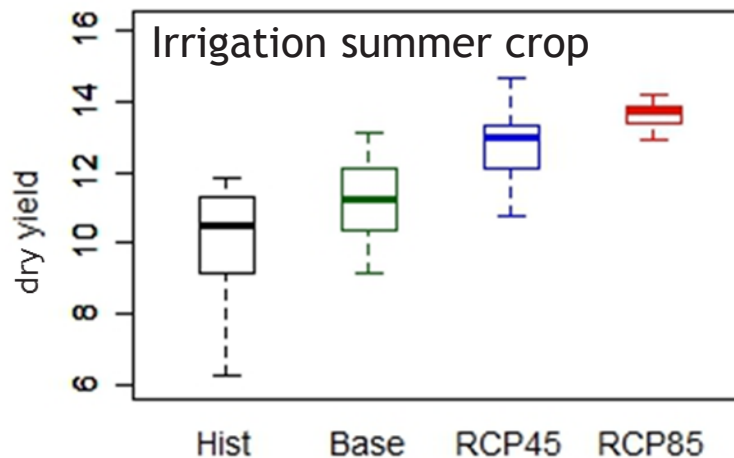


EFFECTS OF INCREASED [CO₂] CONCENTRATION AND CHANGING CLIMATE

CO₂ concentration under different climate scenarios



Carbon concentration & effets



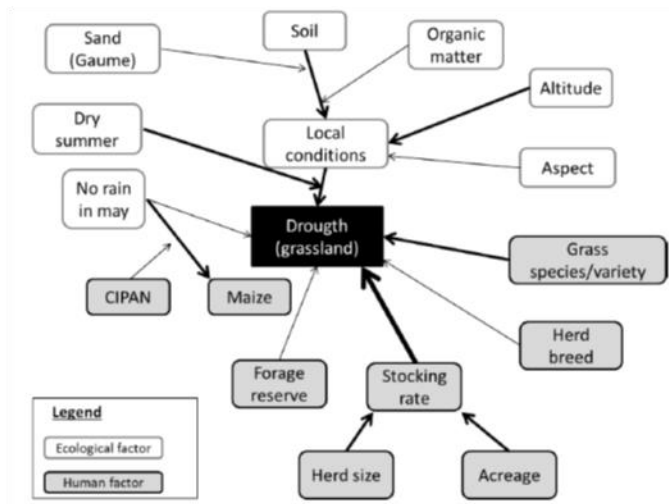


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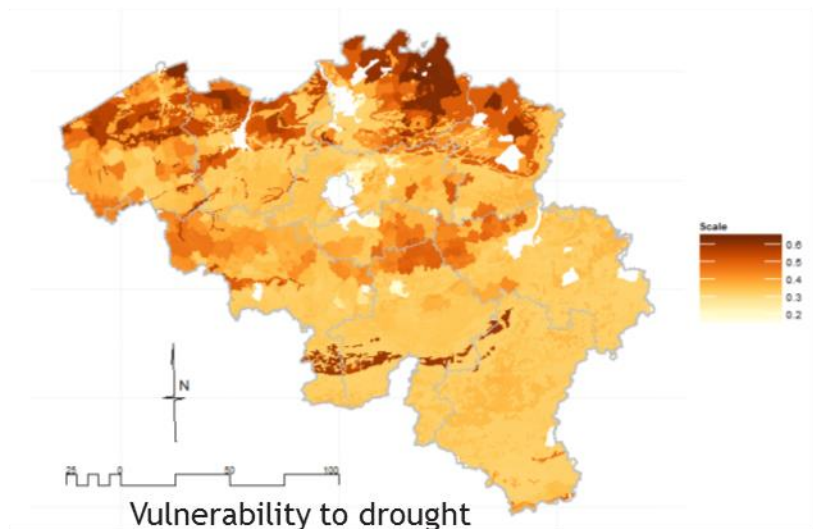
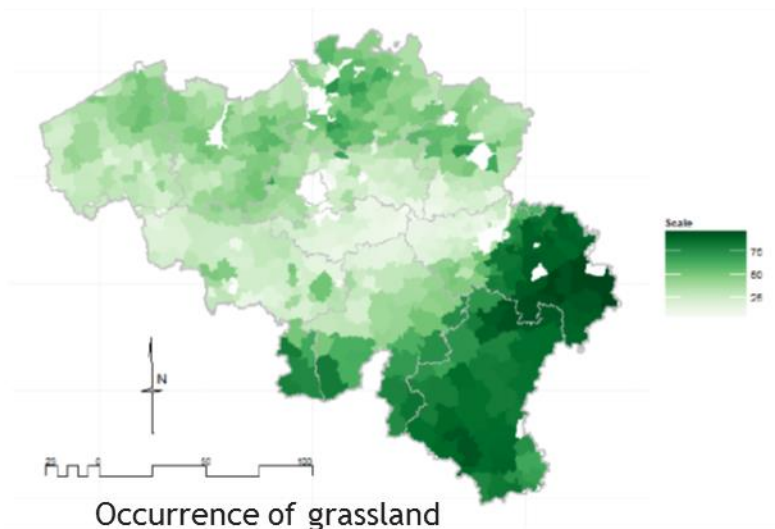
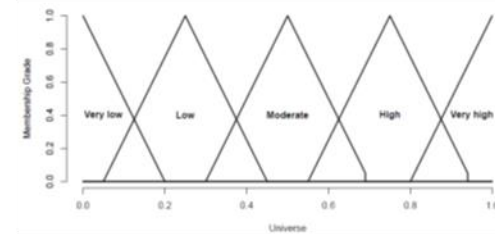
VULNERABILITY AND RISK PERCEPTION

- Vulnerability
- Risk perception

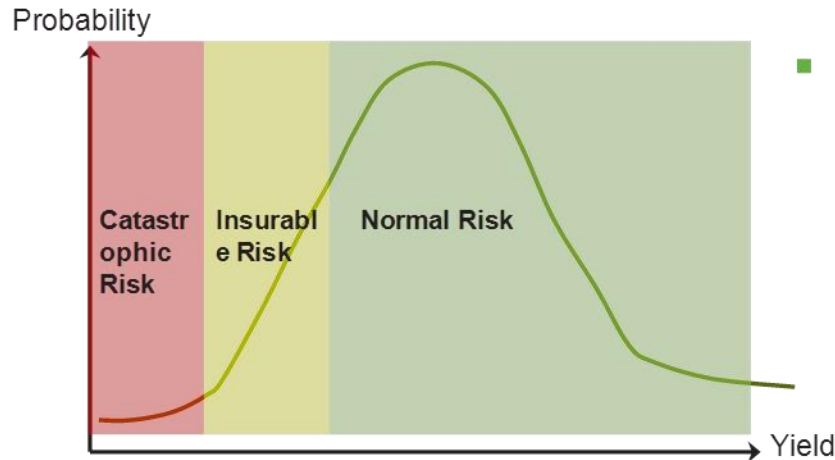
VULNERABILITY



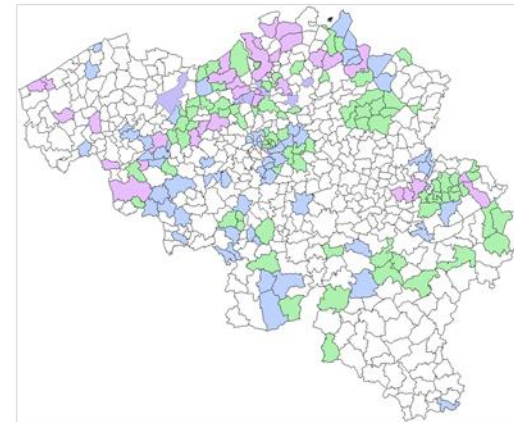
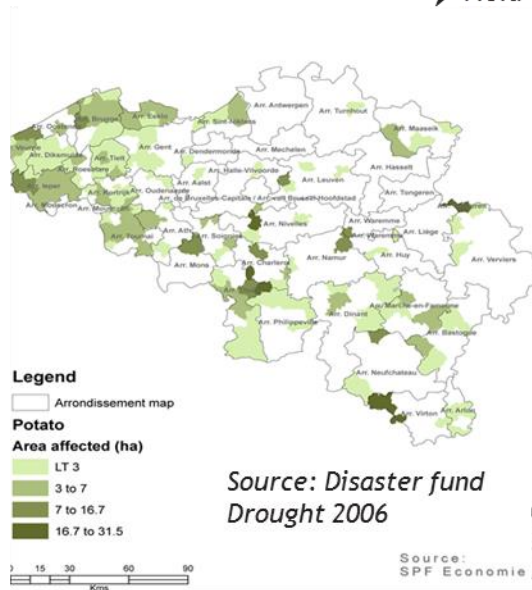
- (Cognitive) map of vulnerability factors
- Vulnerability map: Fuzzy Inference systems + GIS in R
 - membership functions
 - Rules to combine membership data



RISK PERCEPTION: INSURANCES



- Risk segmentation
 - Disaster risk
 - Insurable risk
 - Normal to zero risk



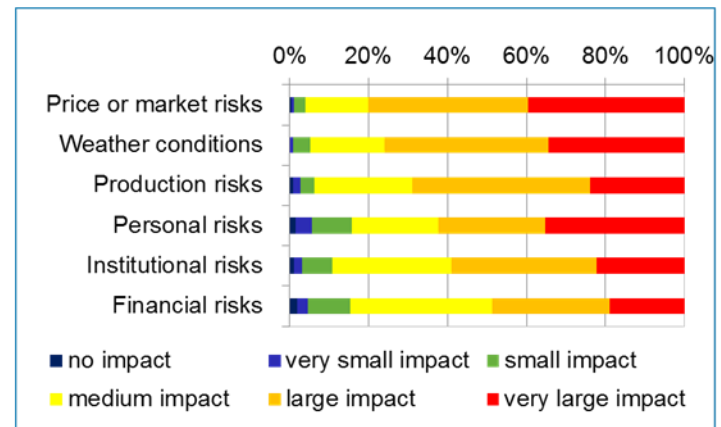
Source: private insurer
Excess rain, hail, frost



RISK PERCEPTION: FARMERS



- Farmers perceive an **increased risk**:
 - Increase in extreme weather and adverse weather conditions in a changing climate
 - Decrease in direct income support
 - Directive on agricultural damage
 - Payment is reduced to 50% unless the farmer has a private insurance





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CONCLUSIONS AND PERSPECTIVES

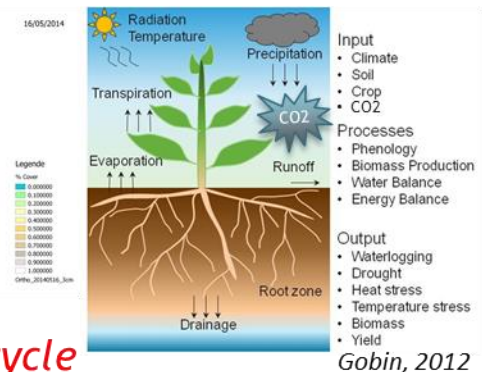
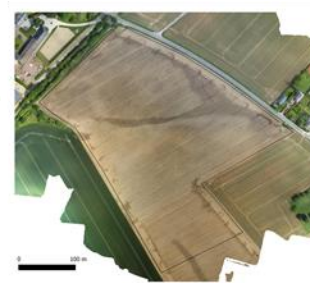
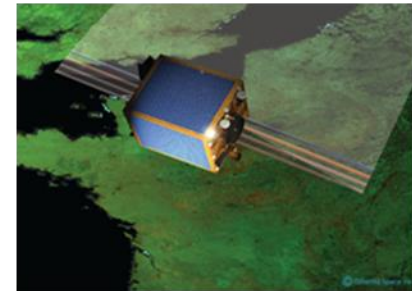
CONCLUSIONS

- From weather to climate is a shift in spatio-temporal scale.
 - Climate change is visible in long-term weather series (**extremes**, **adverse** conditions)
 - Adverse weather conditions have a large impact. Methods exist for the characterisation of adverse weather conditions.
- Climate impact on agriculture requires modelling methods to establish overlap between crop sensitive stages and adverse weather conditions.
 - Weather series belonging to a future climate show a **larger projected variability** in crop productivity
 - CO₂ **fertilisation** does not compensate for this variability.
- **Vulnerability**/resilience and **risk perception** of involved stakeholders are important to establish measures and options.
- **Observations** of yield, weather and impact allow for elucidating meaningful relationships and projections! **BIG DATA** encompass remote sensing, meteo data, yield observations and modelling results.

PERSPECTIVES: CLIMATE SMART FARMING

- **Satellite imagery**
crop phenology
crop performance
- **Meteo data**
rainfall excess, high temperatures, drought
extreme events & adverse weather conditions
- **Agri-environmental Modelling**
crop development
resources use

BIG DATA encompass
*remote sensing, meteo,
yield observations and
modelling methods to
understand climate
impacts on agriculture.*



Interaction crop growth with water, carbon & nutrient cycle
“Resilience to climate extremes, sustainable intensification”



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THANK YOU!