Quantifying the robustness of coastal polder areas to meteorological droughts: a case in Holland

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Drought of 2003

- Hottest in Europe in about 500 years
- At least 100 million people affected
- Cost the European economy at least € 8.7 billion

France suffers worst drought for 25 years

Deaths up by 2,000 in heatwave

More than 2,000 people may have died in the UK because of the August heatwave.

Drought leaves Europe's farmers helpless

By Alex Kirby
BBC News Online environment correspondent

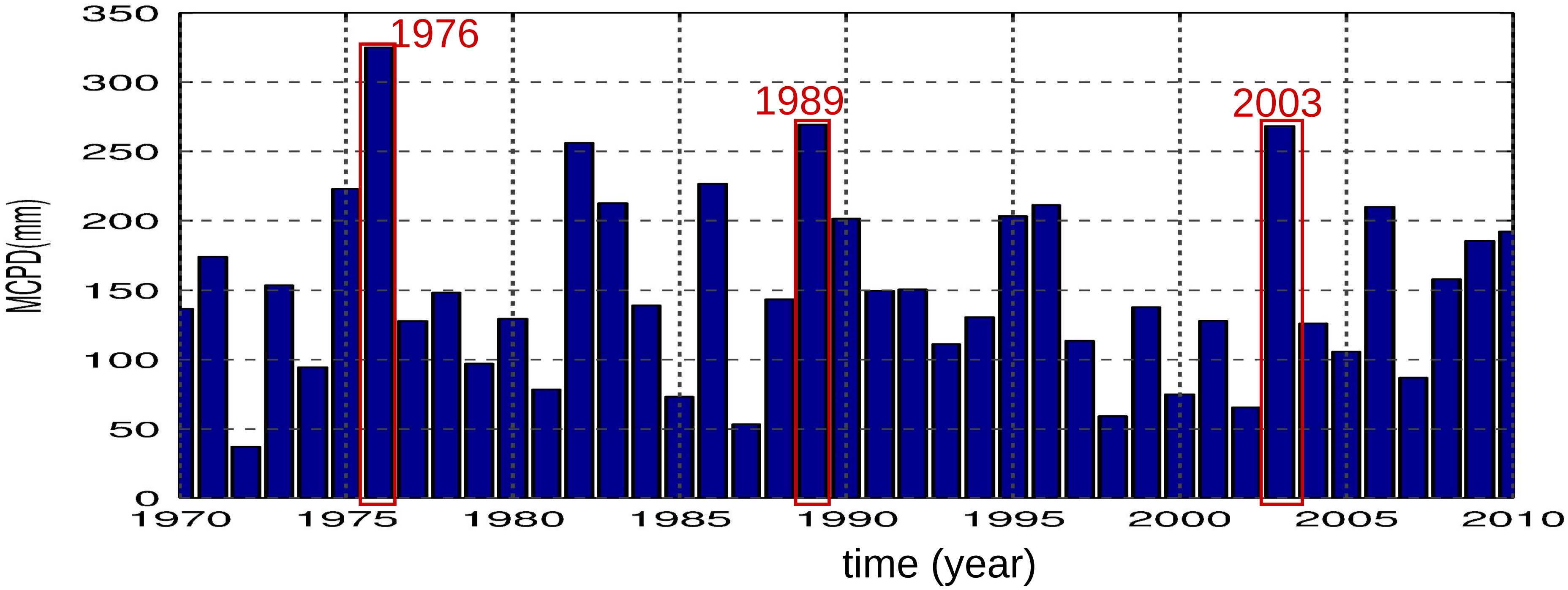
Europe is aflame, with little prospect of any imminent change in the weather to cool it off.

Dijkdoorbraak in Wilnis

Drought 2003 - the Netherlands

Meteorological drought:

•Very dry, but not extremely dry: 1976 was more extreme (1 in 100 year event):



Streamflow drought:

Lowest Rhine discharge since start of measurements

Drought impacts


- Crop losses
- Rotting of foundations of buildings
- Embankment instability
- Navigation problems
- Power plant problems (cooling water too warm)
- Heat-related fatalities

System robustness

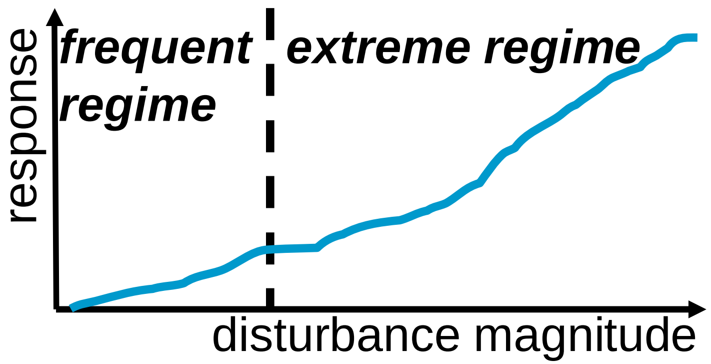
= ability of a system to remain functioning under a range of disturbances (Mens et al., 2011)

~ socio-ecological resilience (Resilience Alliance)

~ 1 / vulnerability

Approach:

1. Define system: disturbance and relevant response (impact)
2. Quantification by means of indicators
3. Evaluation of the response curve



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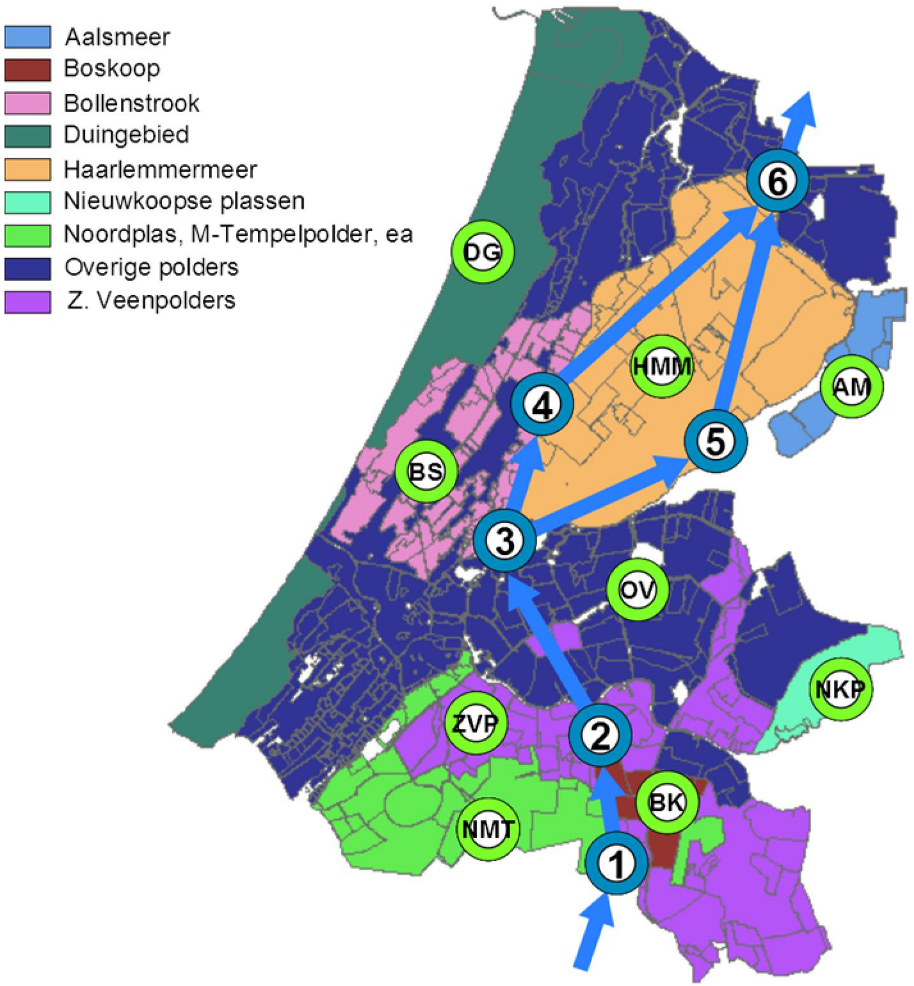
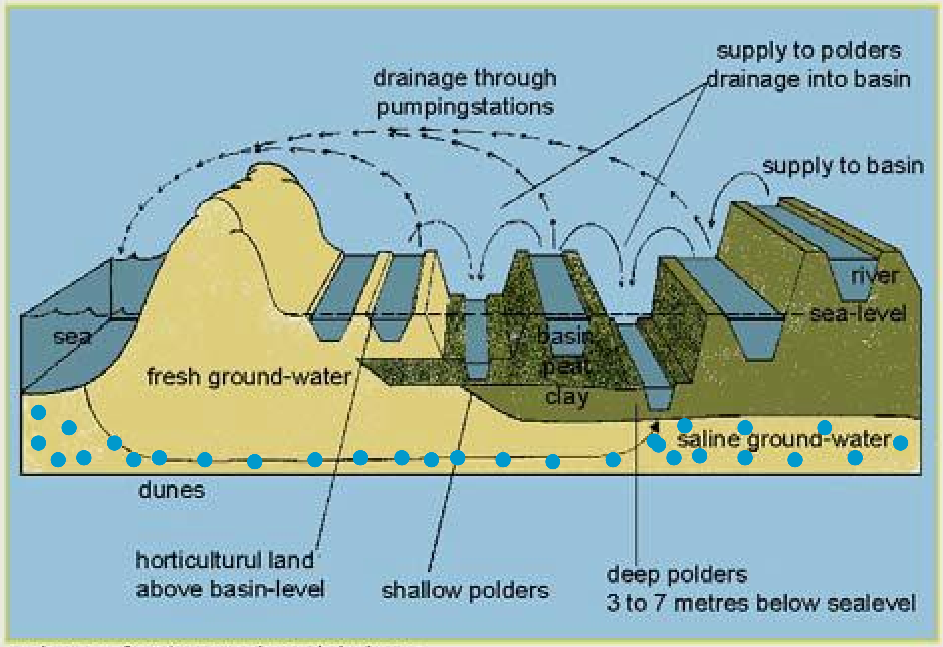
Study area: Rijnland





scheme of water-supply and drainage

Study area: Rijnland

Fresh water supply from river:

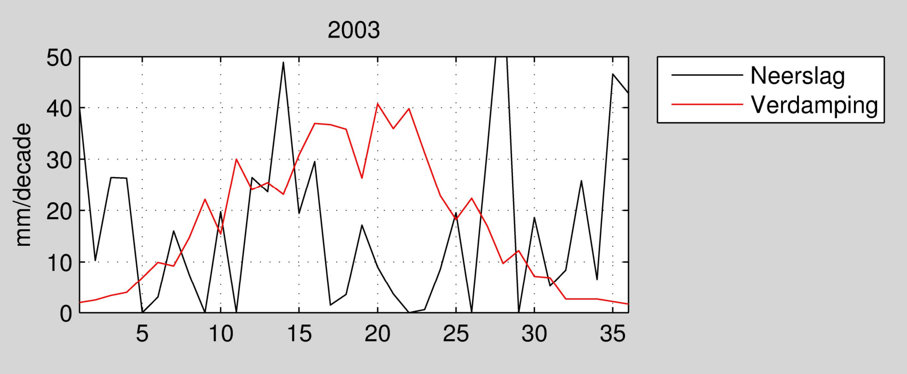
1. Flushing
2. Water level control
3. Irrigation

Dry summer: 100 Mm^3 inlet water (~7 m^3/s),
average river discharge ~ 2200 m^3/s

Uncertainties

System robustness:

Given uncertainties, how well can the system remain functioning under a range of circumstances?



Uncertainties

- Natural variability of:
  - Precipitation
  - Evaporation
  - River discharge and salt concentration at inlet
- Salt seepage (where and how much)
- Crop growing season (timing of demand for irrigation water)

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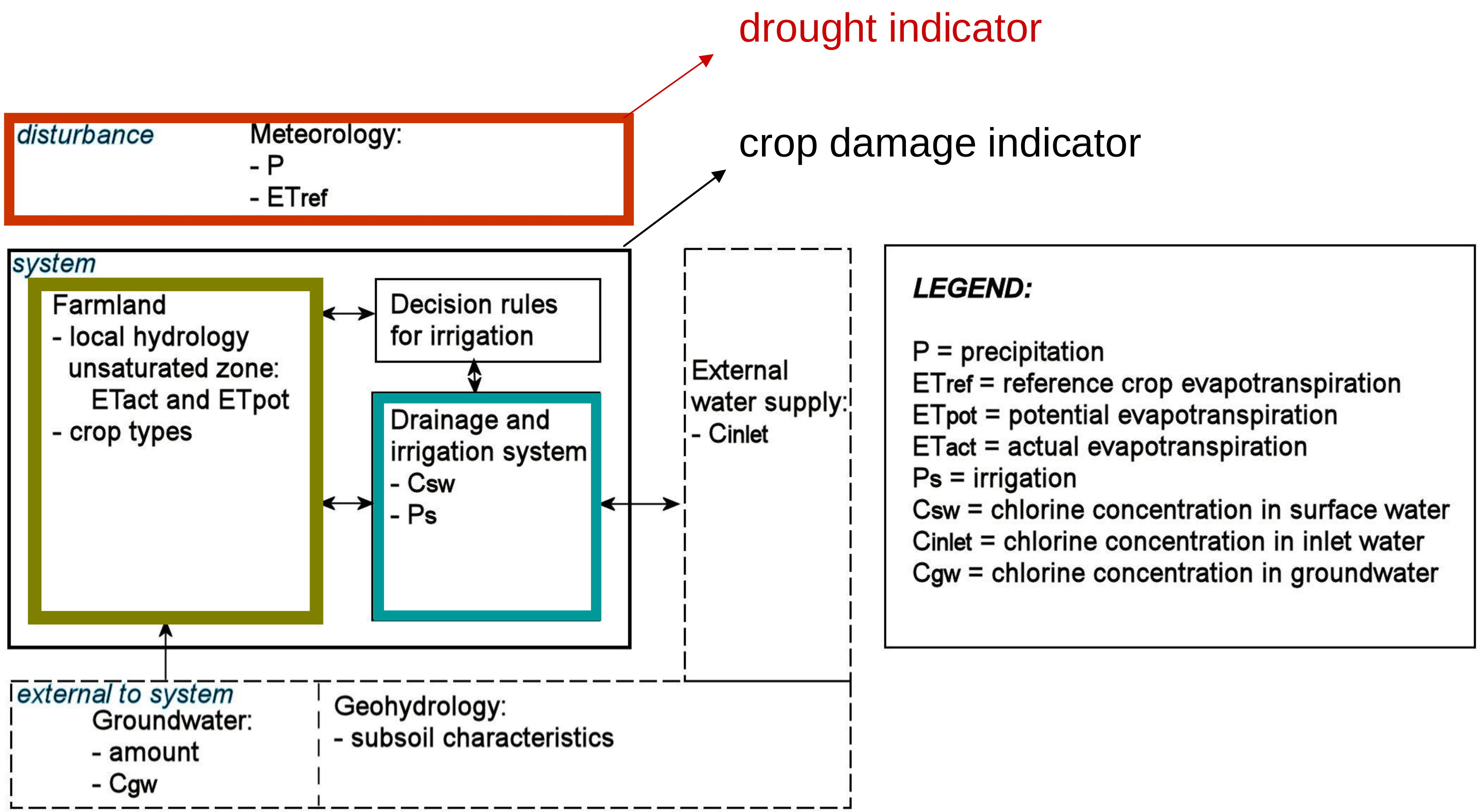
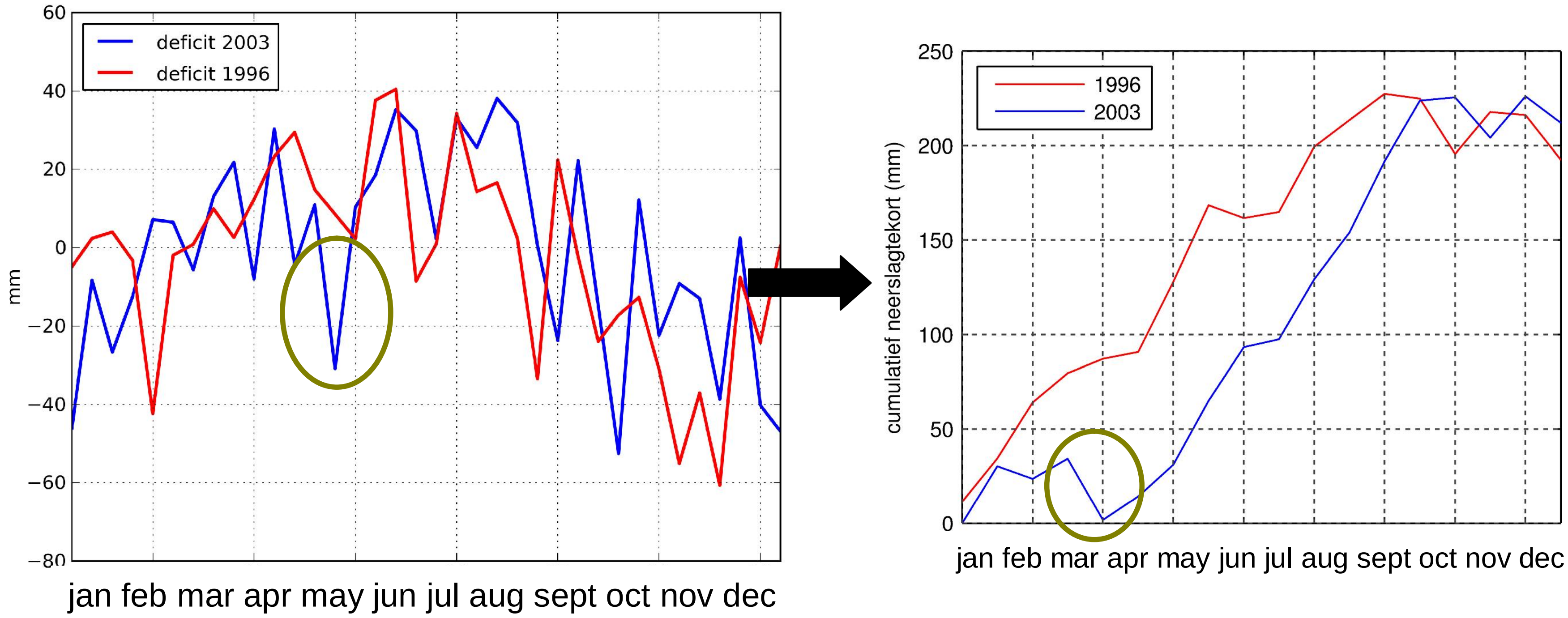
System and disturbance



Drought indicator: MCPD

Maximum Cumulative Precipitation Deficit



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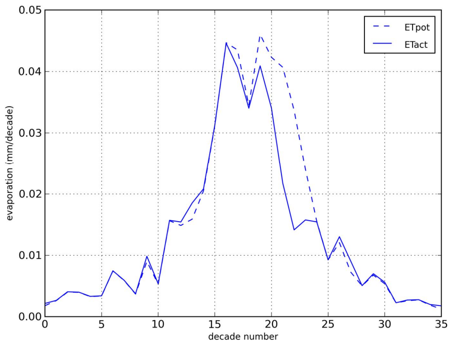
Response indicator: crop yield loss

Hydrological model

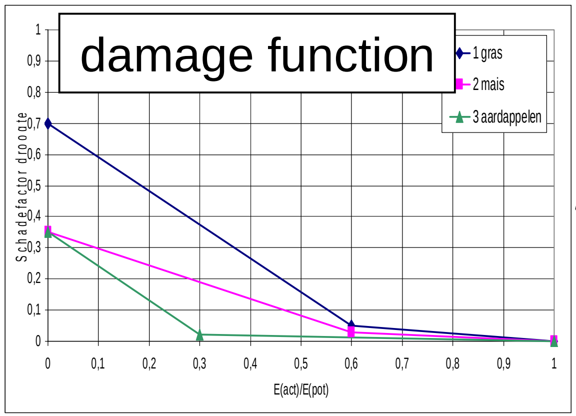
NHI

per crop type and per year:

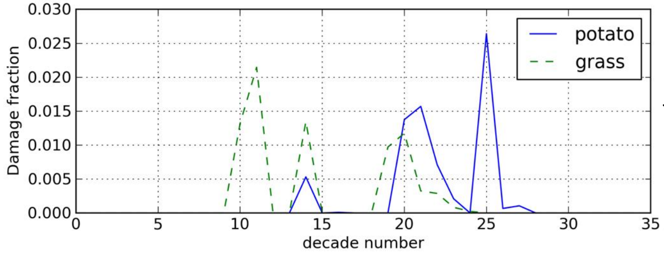
ETact / ETpot



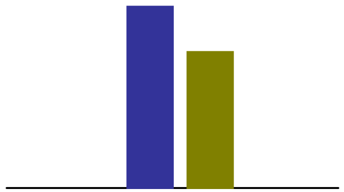
damage function



damage fraction



potential yield / actual yield



typical yield without drought

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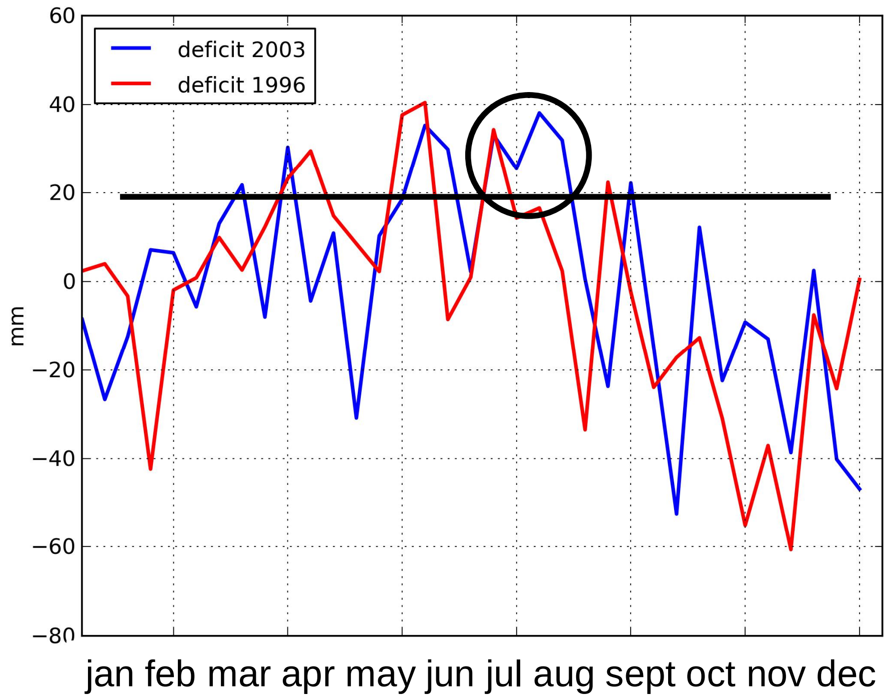
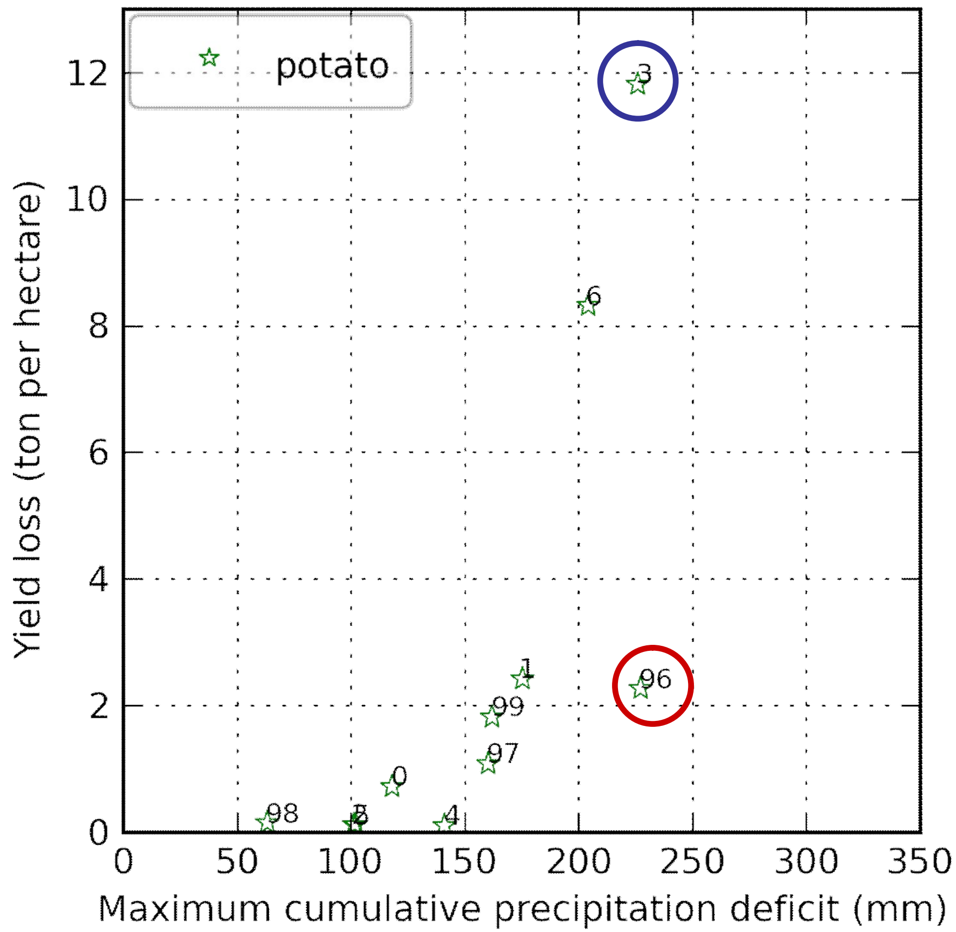
Response curve potato: effect of timing

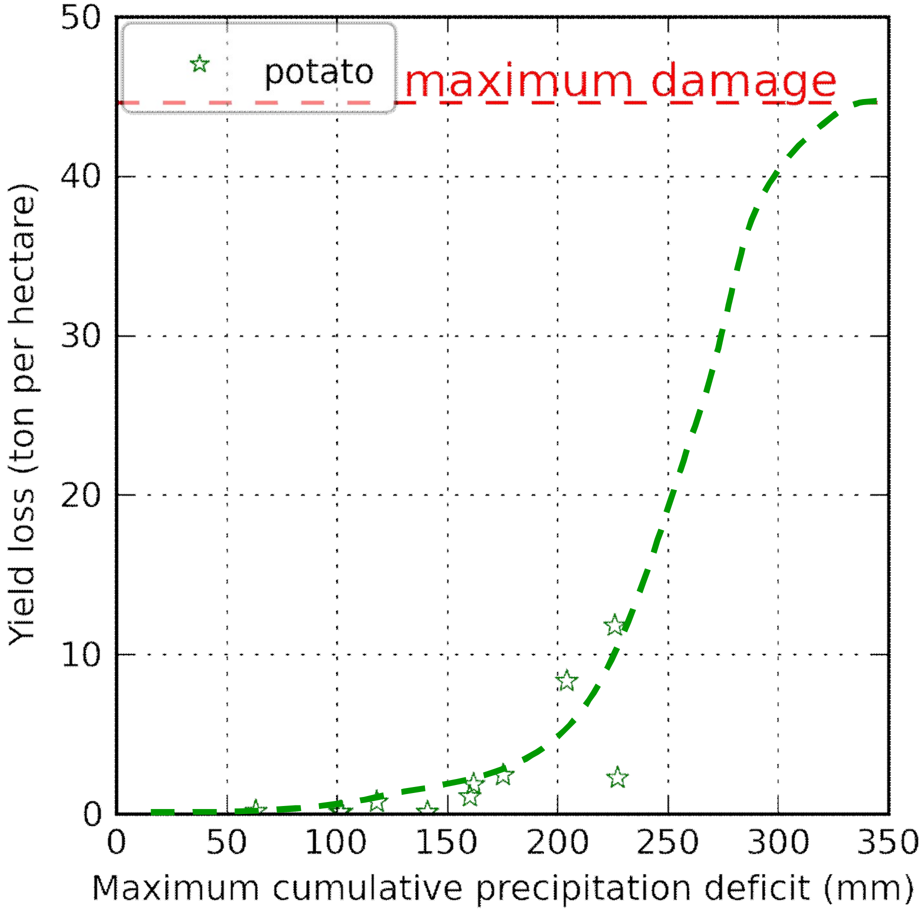
Slightly different timing → significantly more damage → not robust

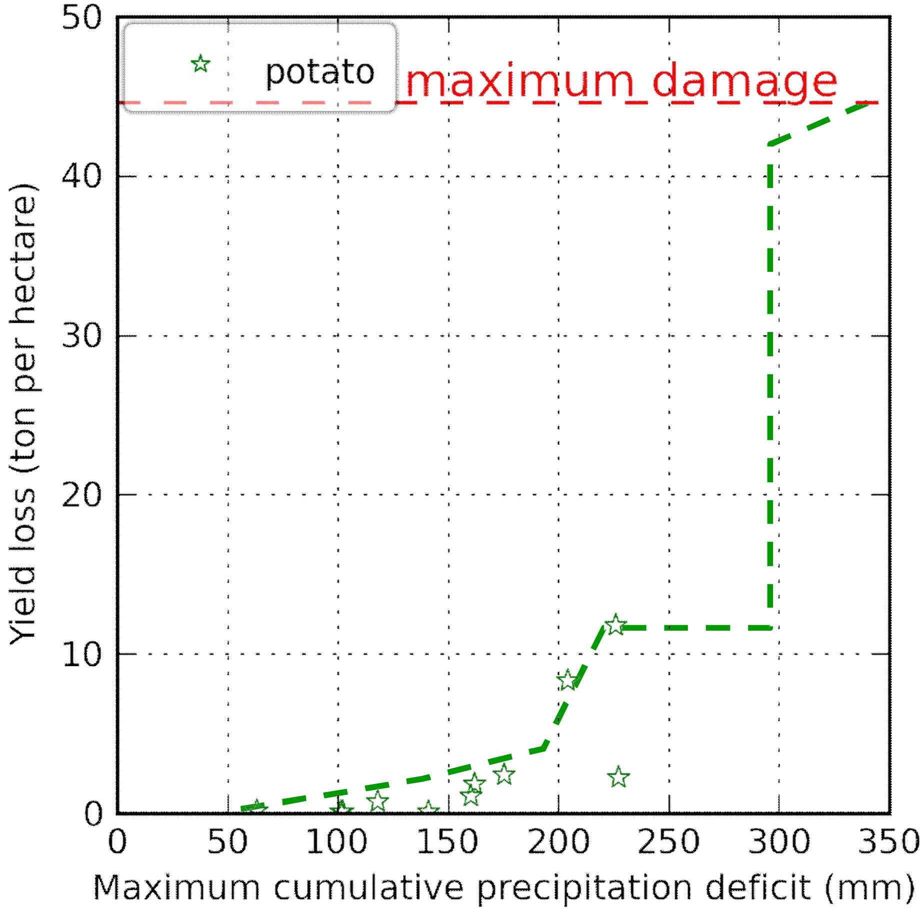




Response curve potato: shape?

Indicator for maximum damage: average actual yield = 44.6 ton/ha





Conclusion

Insight into system robustness: by exploring relation between drought and expected crop losses:

- > Sensitivity of crop yield to drought timing, drought severity

Robustness may support decision makers in drought risk management:

- > To prepare for uncertain and extreme events: ‘what if’
- > To prepare for uncertain future changes

when a system is robust to climate variability, it is better prepared for climate change

Future work

1. Explore other drought indicators
2. More scenarios to further explore response curve
3. Calculate the effect of measures
4. Include other uncertainties