ExIST Conference "The impact of data, science, and technology on food security and production"
University of Exeter, 4th September 2014

Met Office
Hadley Centre

Impacts of climate variability and change on crops and water resources:

Globe to catchment, season to century..

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The perfect storm?

(John Beddington, 2009)

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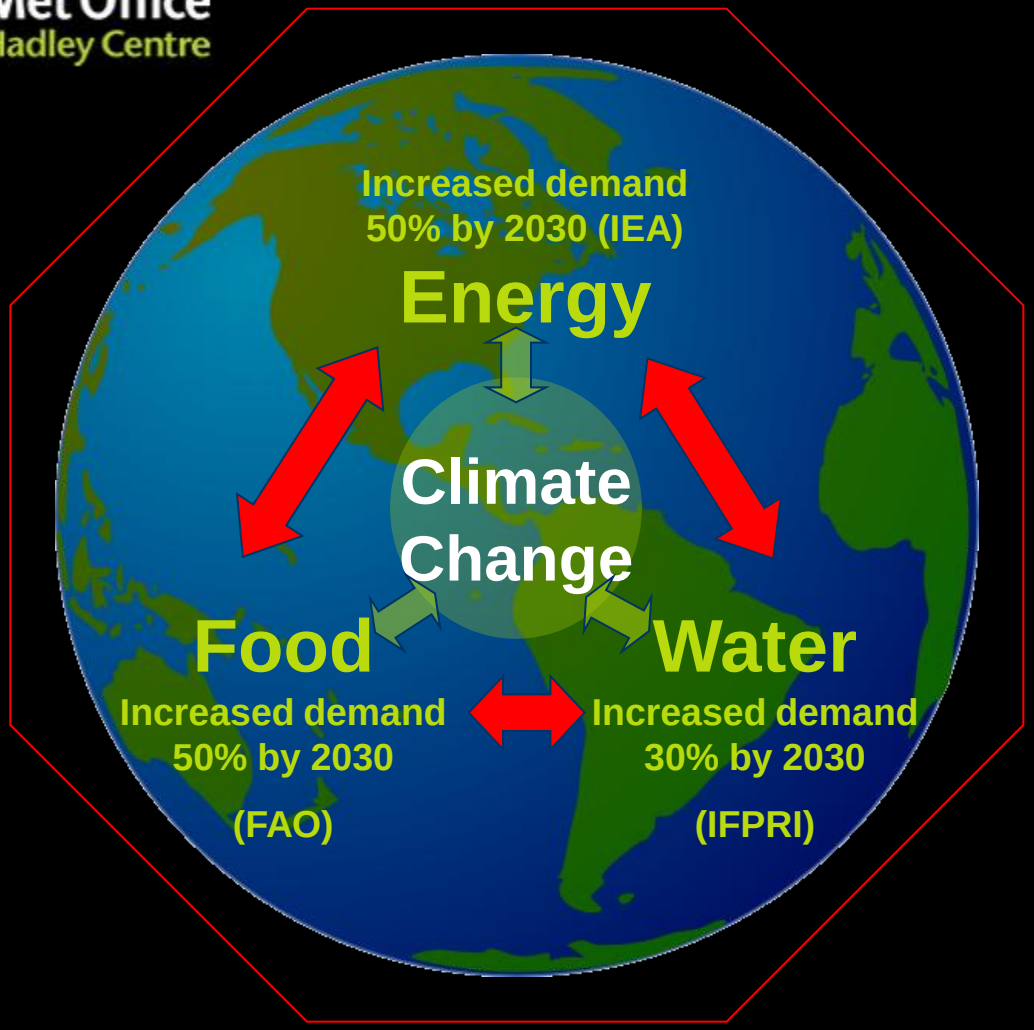
Government Office for Science



1. Can 9 billion people be fed equitably, healthily and sustainably?
2. Can we cope with the future demands on water?
3. Can we provide enough energy to supply the growing population coming out of poverty?
4. Can we mitigate and adapt to climate change?
5. Can we do all this in the context of redressing the decline in biodiversity and preserving ecosystems?

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HM Government

Human dynamics of climate change

- Latest climate projections
- ‘Business-as-usual’ greenhouse gas concentration scenario (RCP 8.5)
- ‘Middle of the road’ population scenario (SSP2)
- Changes from present day to end of century

ISI-MIP

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Universiteit Utrecht

University of Southampton

GCF Global Climate Forum

AgMIP The Agricultural Model Intercomparison and Improvement Project

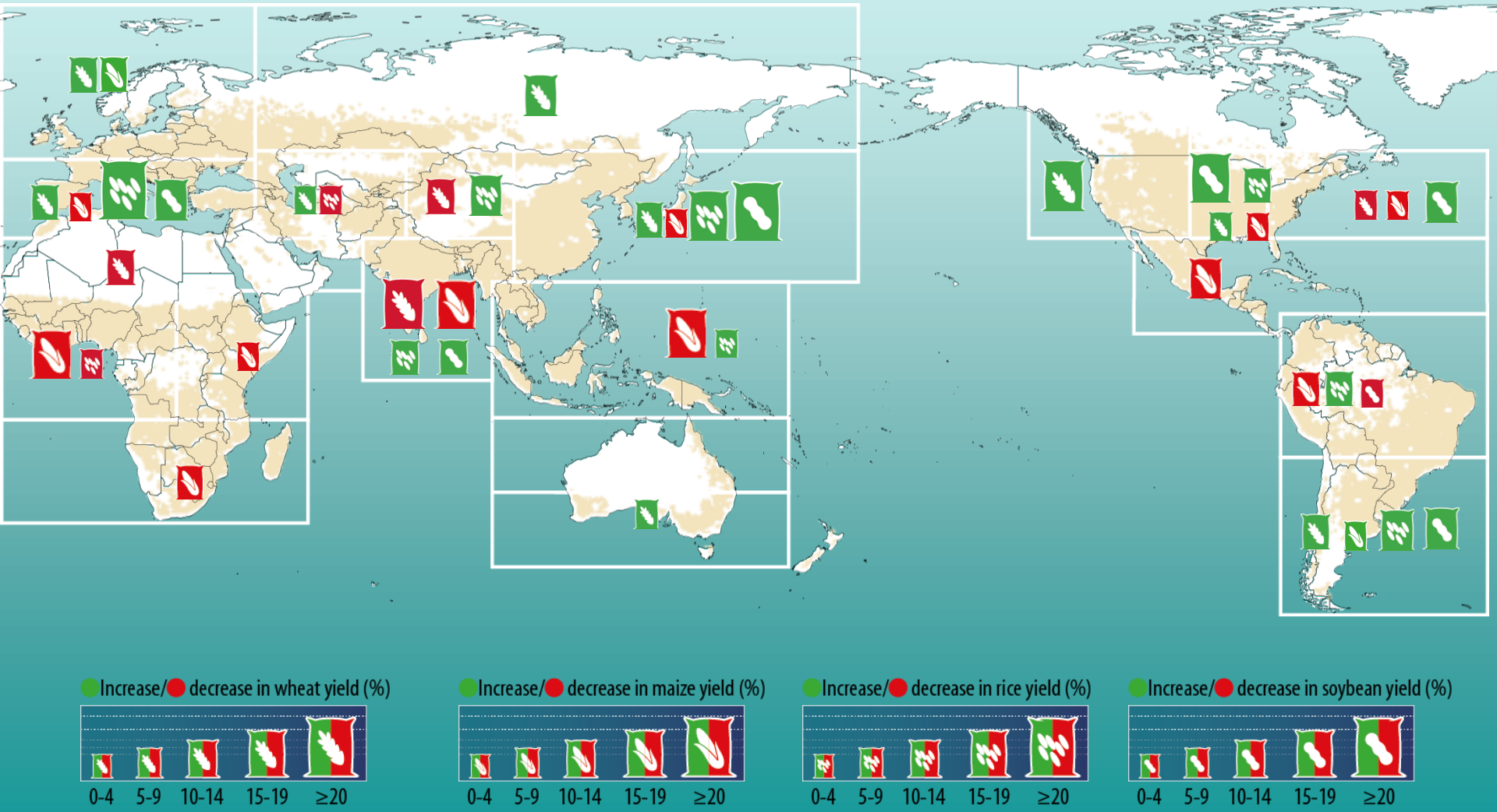
RDCEP

Future global climate impacts

Run off Regions of both increase and decrease	**Flood frequency** Increases in flood frequency over large regions, smaller areas seeing decreases
Water demand for irrigation Global increases in the amount of water needed by crops	**Coastal flooding** Millions of people at risk of coastal flooding due to sea level rise and population increases
Average crop yield Both increases and decreases in yield of wheat, rice and soybeans Decreases for maize	**Temperature of warm days** Increases globally
Drought Global increases in number of days in drought	**Sea surface temperature** Warming sea temperatures and acidification of the ocean threaten marine ecosystems

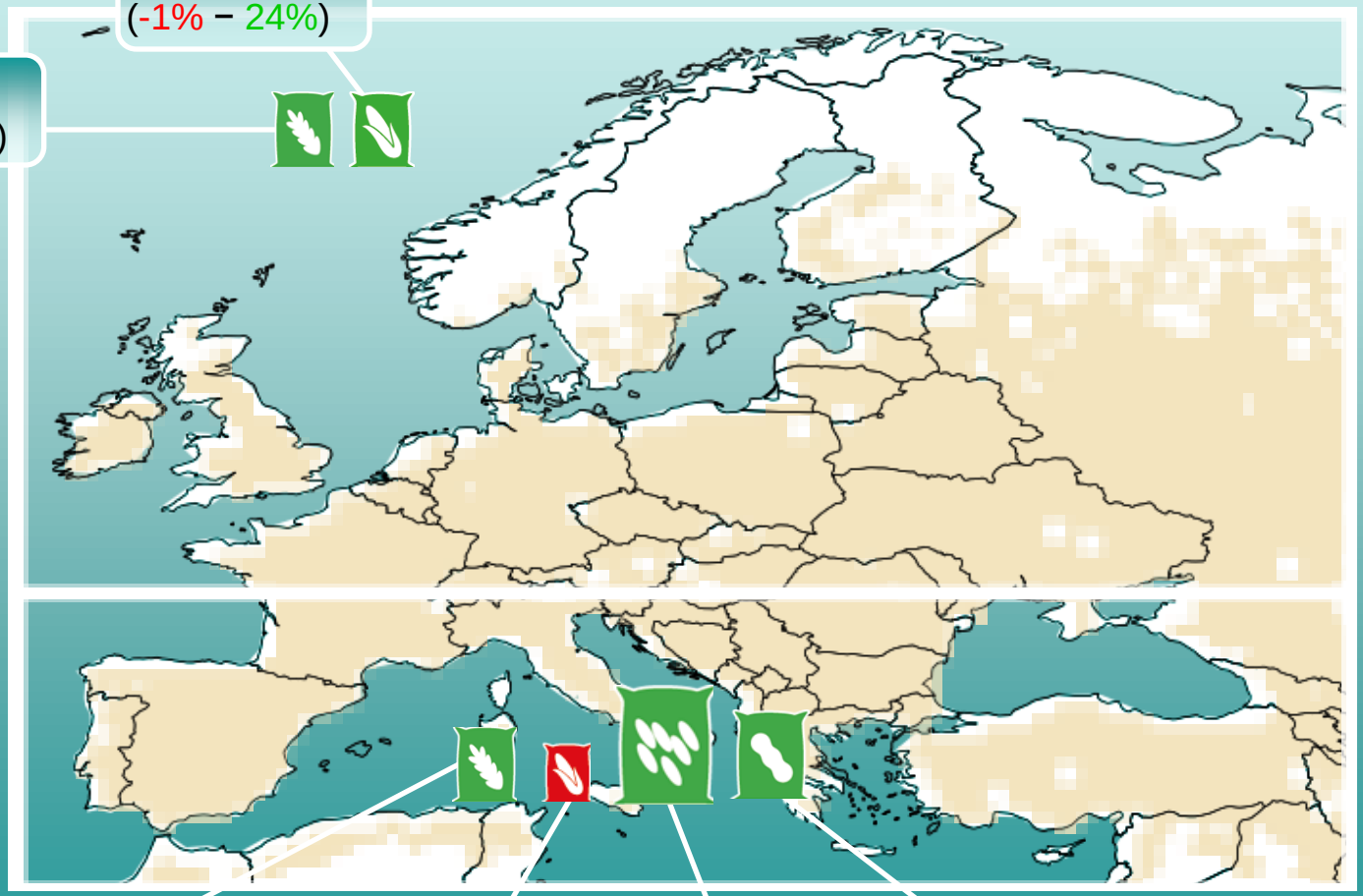
Global crop yield changes:

regional gains and losses



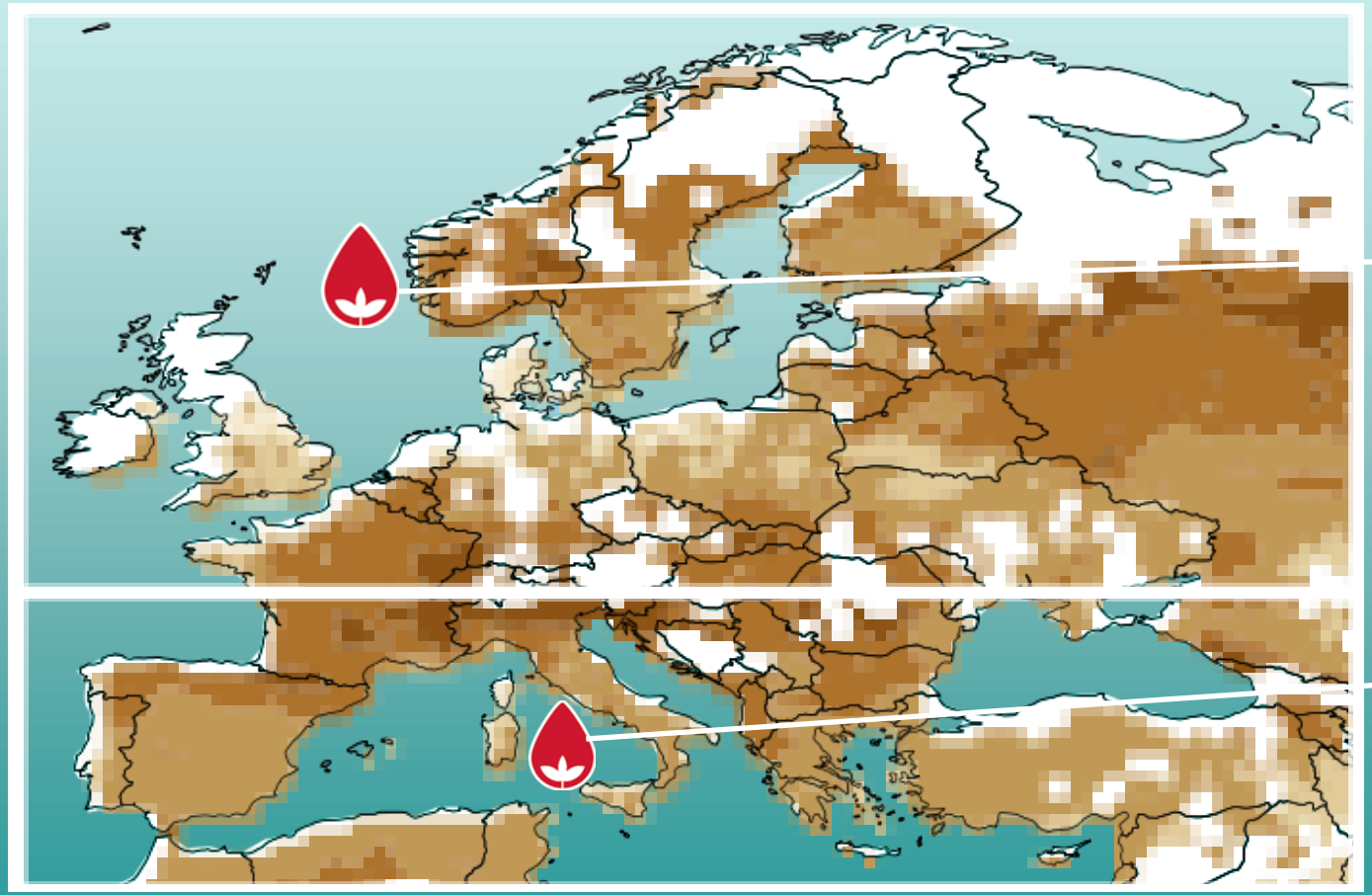
Europe crop yield changes:

Gains in the North; some losses in the South



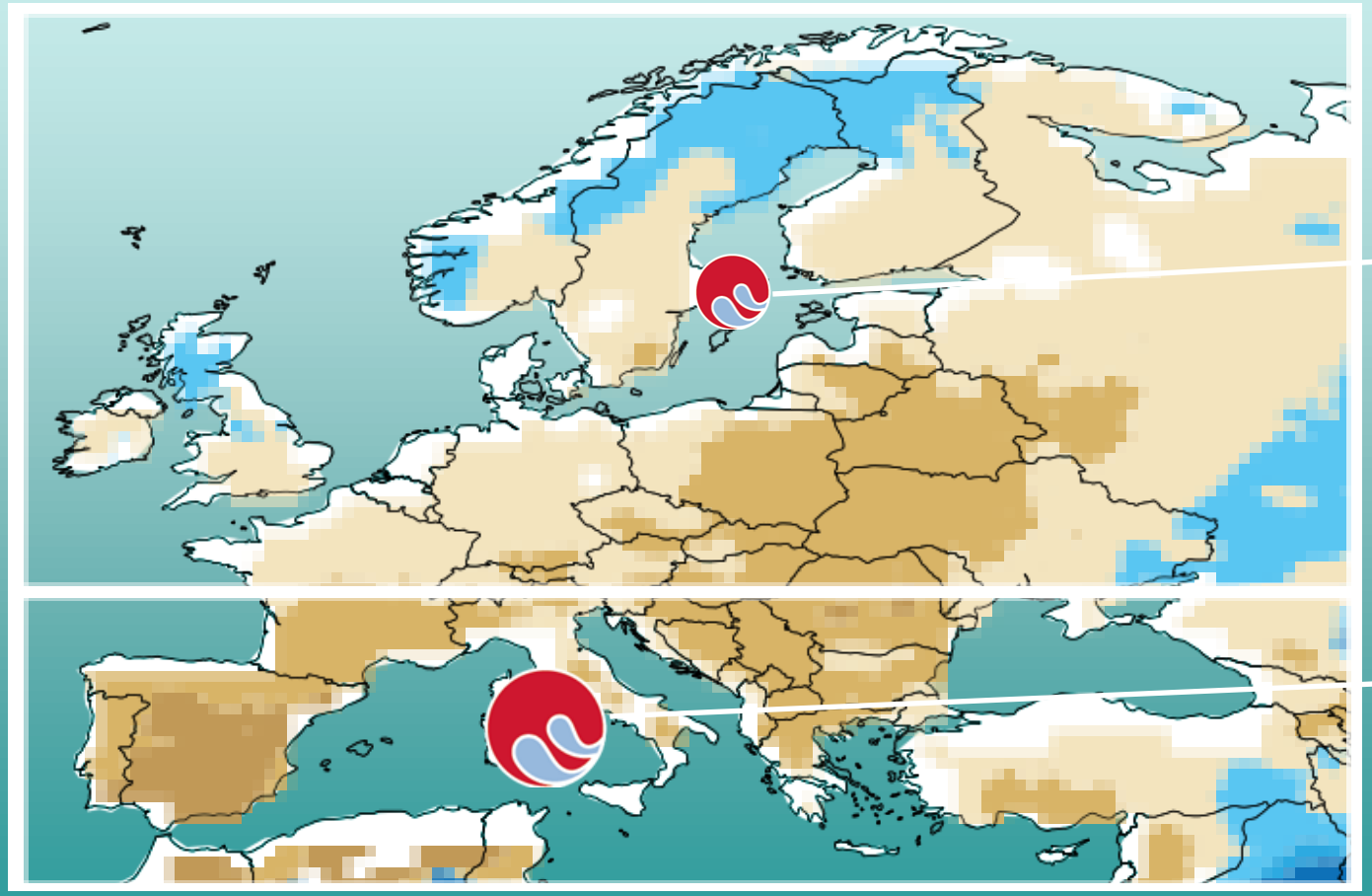
Europe changes in Water demand for irrigation:

increases



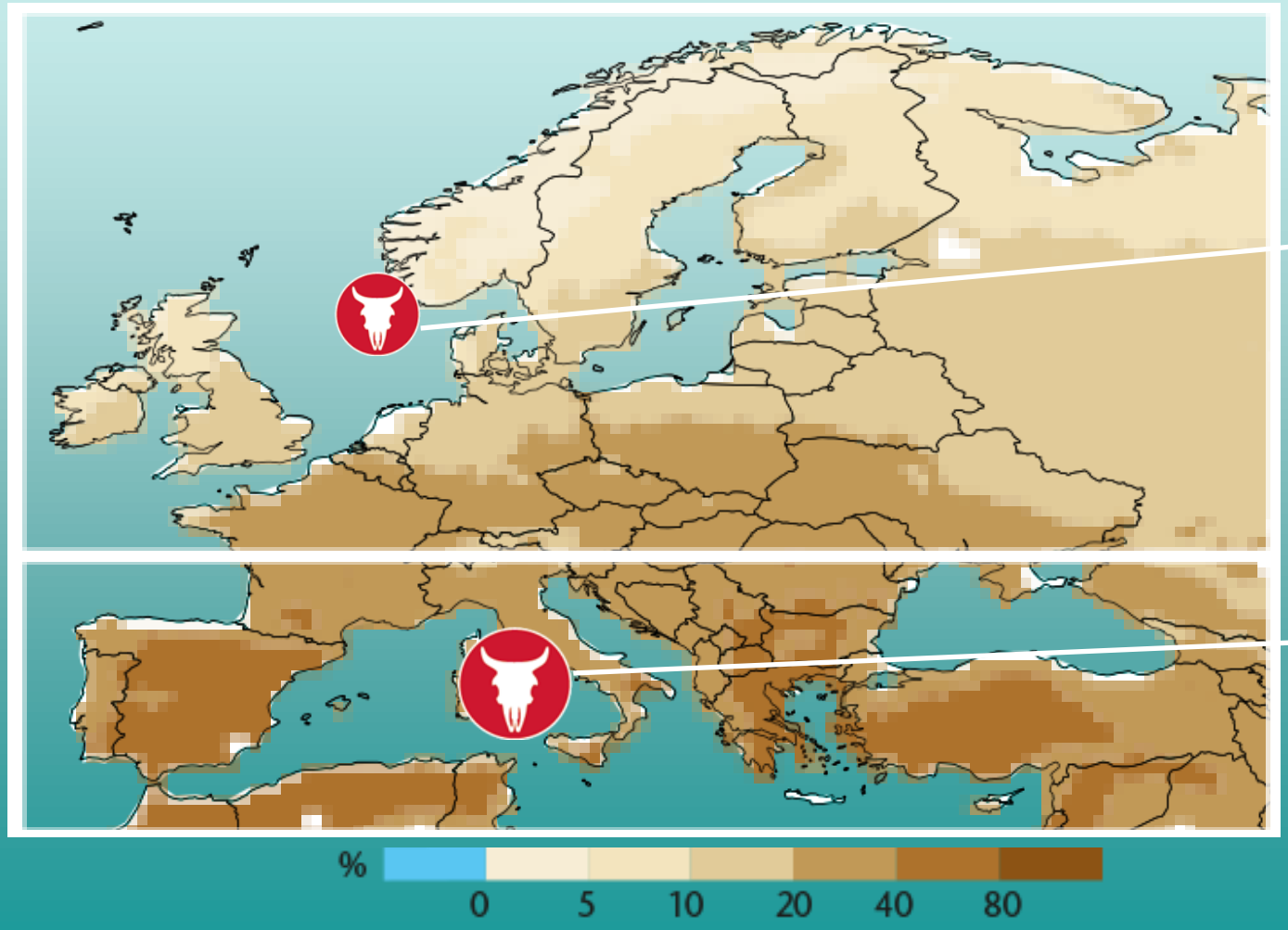
Europe changes in Water runoff:

Reductions, largest in the South



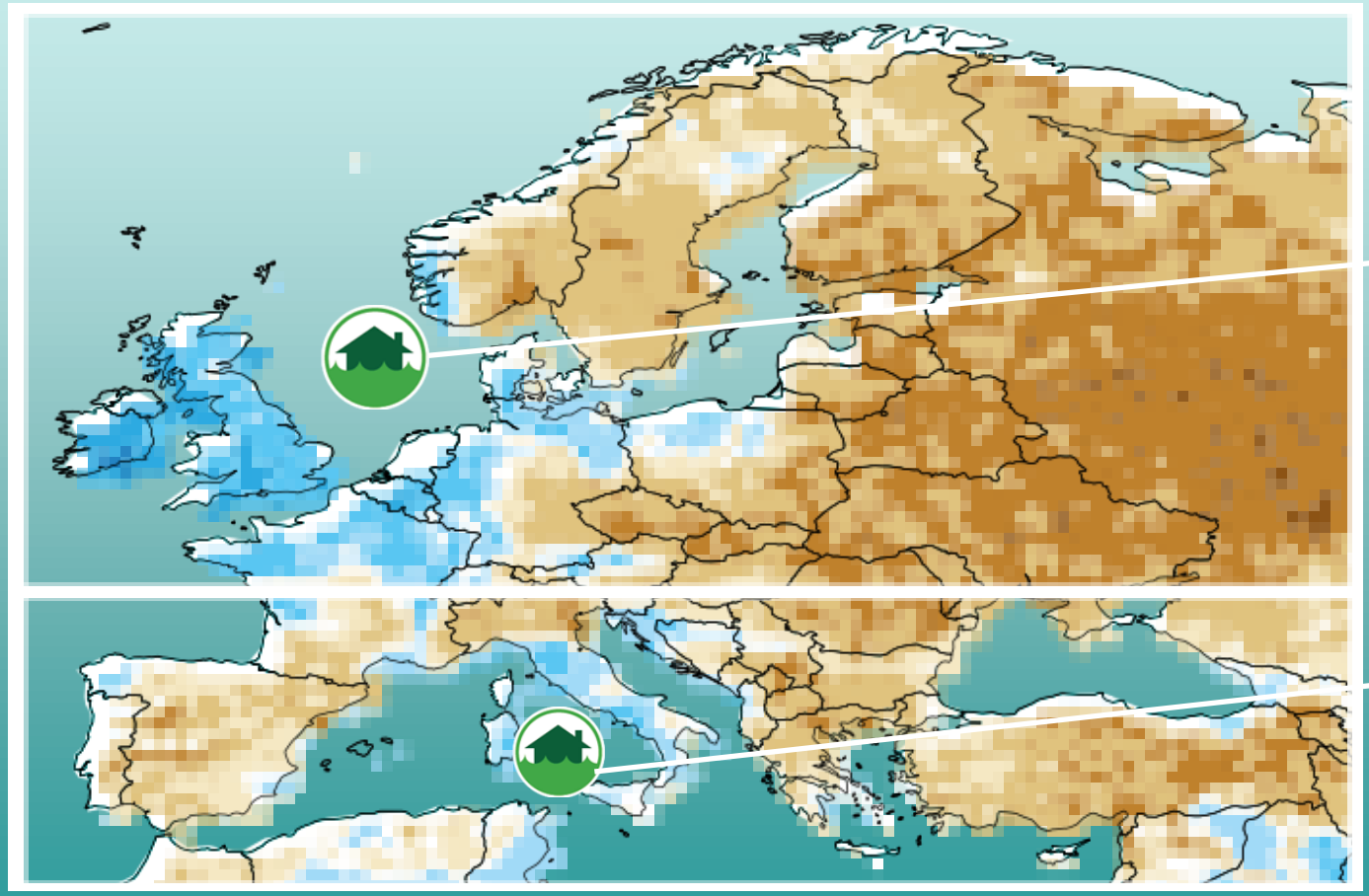
Europe change in days in drought:

Increases, largest in the South



Europe change in area with Increase/decrease in flooding:

Overall reductions but strong regional variations



UK food security in a Globalised World

Met Office Hadley Centre

40% of food consumed in the UK is imported, and this proportion is rising

Price and security of supply of food to the UK market affected by:

- Floods
- Drought
- Sealevel rise
- River flow
- Tropical cyclone
- High temperatures
- Changes in seasonal patterns
- Disease

Future changes in UK climate

- Headline message from UKCP09:
  - Hotter drier summers
  - Warmer wetter winters
- *But* in the recent past..
  - Cold winter 2010
  - Wet summer 2011
  - Cold spring 2013

…Headline is for average changes

What can we say about seasonal climate *extremes?*

Belfast, Northern Ireland, - 23rd October 2011

By 2100:

Very hot summers increase 20-fold

Very wet winters increase six-fold

Very dry summers increase eight-fold

But:

35% chance of wet summer until 2040s

20-30% chance of cold winters until 2020s

Sexton & Harris (2014) *submitted*

2050s climate change and UK agriculture

UK Climate Change Risk Assessment, 2012; Cho et al. 2012; Dunn et al. 2012

- Increasing crop yields:
  - 40-140% for wheat
  - 20-70% for sugar beet
  - 20-50% for grass
  - (If heat and drought stress not limiting; regional differences)

- 2x current area of high-quality horticultural/arable land flooded at least once every 3 years

- -10 to +80% change in irrigation demand (England and Wales)

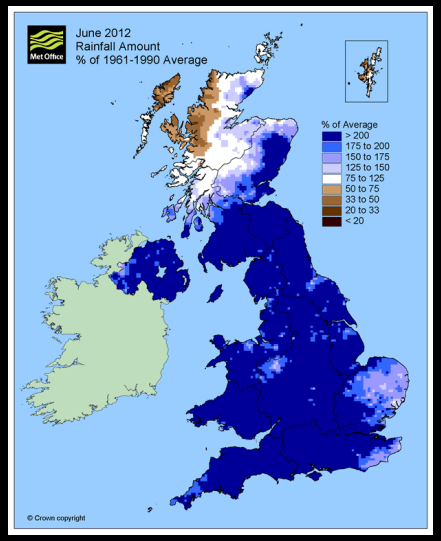
- Up to 1% of current UK annual milk production lost due to heat stress

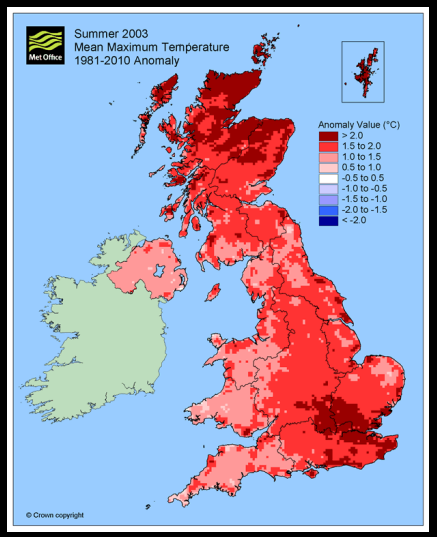
- Adapting to climate change:
  - Changing sowing dates/varieties
  - Improved water management:
    - water harvesting
    - on-farm storage
    - improved irrigation techniques
  - Changes in grassland species
    - deep-rooting
    - drought-tolerant
  - Changes in livestock production cycles
    - Autumn lambing & calving
  - Tree planting
    - livestock shading
    - crop windbreaks

Unusual seasons and variability are important,

not just long-term averages

- Summer 2012, UK
  - Wettest summer since 1912
  - Wheat yields down 15%
  - Cost insurers £800 million
- Summer 2003, Europe
  - Hottest summer in Europe since 1540
  - River Danube:
    - Worst drought for over 50 years
      - Levels dropped by 50cm
      - Reduced electricity production in Romania.
  - Very likely that human influence at least doubled risk of temperatures
  - Normal by 2040s and cool by 2080s





Can we be better prepared for extreme seasons?

Improved skill in Monthly to Seasonal Forecasts for UK winters

Recent cold snap: March 2013

DfT notified on 4th January:

"*…there is now an increasing risk of cold conditions returning later in January and an increased chance of wintry conditions starting later this month…*"

"Wintry weather brings disruption to airports, road and rail networks across the UK, with more snow and ice on the way"

The Guardian 20th Jan

Working with stakeholders to develop prototypes e.g.: UK land management tool (cover crops) with Clinton Devon Estates

Better rainfall extremes, different future changes in high-resolution models

Future change in heavy hourly rainfall (upper 5%)

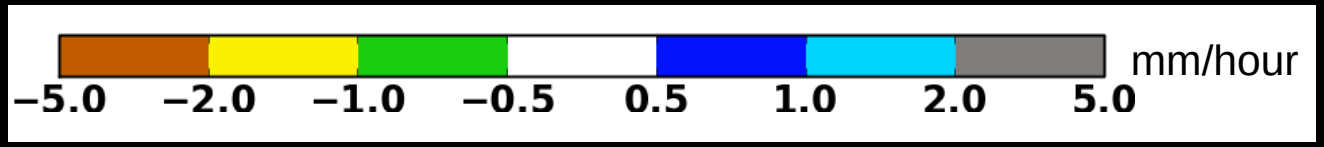
Current Capability: 12km model Future Capability: 1.5 km model

WINTER

SUMMER

NERC project NUTCAT-2050

What do these changes mean for nutrient transfers in small UK catchments?



Kendon et al. 2014

Conclusions

- **Climate change and variability could have significant impacts on food and water resources**
  - Strong regional differences
  - Uncertainty across scenarios, climate models, impact models...
  - Implications for agricultural management, trade and economics
- **Key "big data" challenges for future food and water:**
  - Impacts of extremes (crops, nutrients, erosion, flooding) – high resolution models
  - Climate variability and seasonal forecasts (limited skill in UK)
  - Confidence and uncertainty in impacts[1] – usability for decision making?
  - Overlapping priorities and links between sectors[2]: the food-energy-water-environment "nexus"

[1]Falloon et al. 2014; [2]Falloon & Betts, 2010

References

- **Human Dimensions of Climate Change map**
  - http://www.metoffice.gov.uk/climate-guide/climate-change/impacts/human-dynamics/projections
- **EUPORIAS project**
  - http://www.euporias.eu/
- **NERC NUTCAT-2050 project**
  - http://nutcat2050.org.uk/
  - Kendon et al. (2014):http://www.nature.com/nclimate/journal/v4/n7/full/nclimate2258.html
- **Other**
  - Cho et al. 2012: http://www.int-res.com/abstracts/cr/v54/n1/p49-68/
  - Falloon & Betts (2010): http://www.sciencedirect.com/science/journal/00489697
  - Falloon et al. (2014): http://journal.frontiersin.org/Journal/10.3389/fenvs.2014.00033/abstract
  - International Dimensions of Climate Change: https://www.gov.uk/government/publications/international-dimensions-of-climate-change
  - CCRA http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=15747
  - Dunn et al. 2012: http://iopscience.iop.org/1748-9326/9/6/064006/article

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