Climate and Potential Yield Losses to Fungal Plant Pathogens

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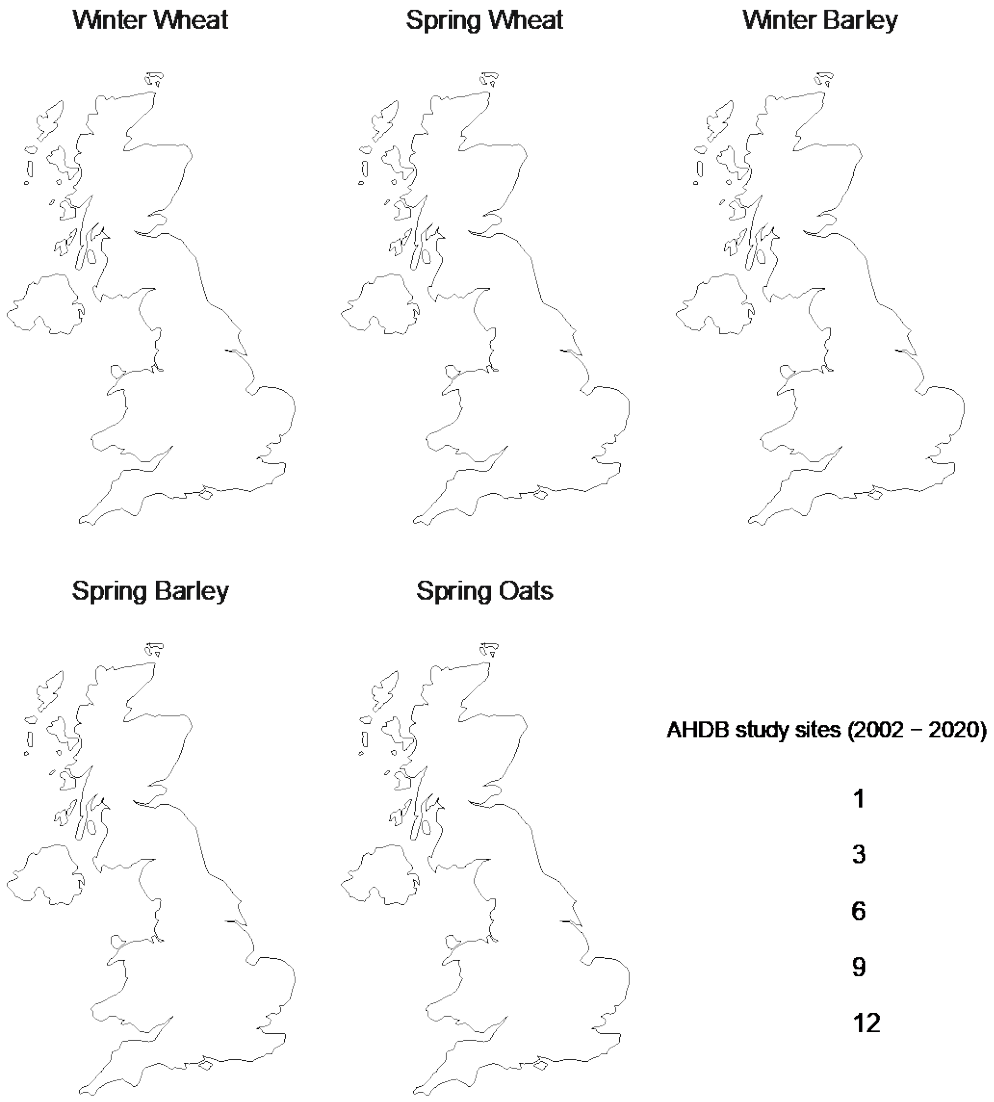
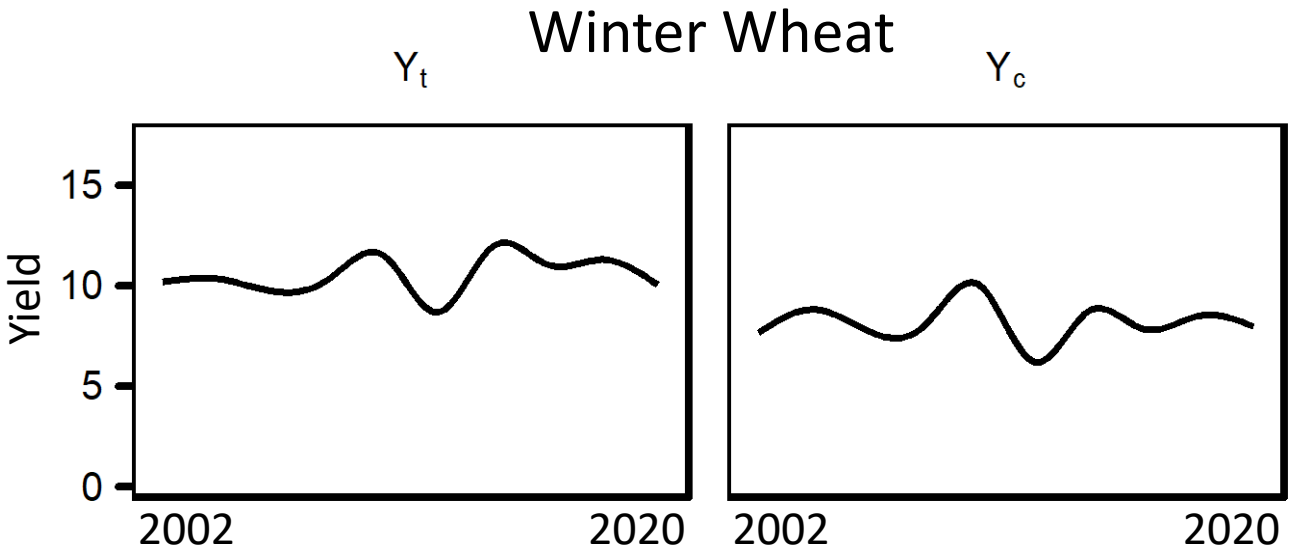
How does potential yield loss to fungal disease vary with weather?

- Potential yield loss = loss in absence of disease control (i.e. fungicides)
- “Pathogen yield gap” or “Disease pressure”
- Affected by varietal resistance, management, weather etc. (disease triangle)
- How will climate change affect potential losses to pathogens?
- Usual approach is to model infection risk by specific plant pathogens
- Another option: measure directly in paired control-fungicide trials, and model influence of weather

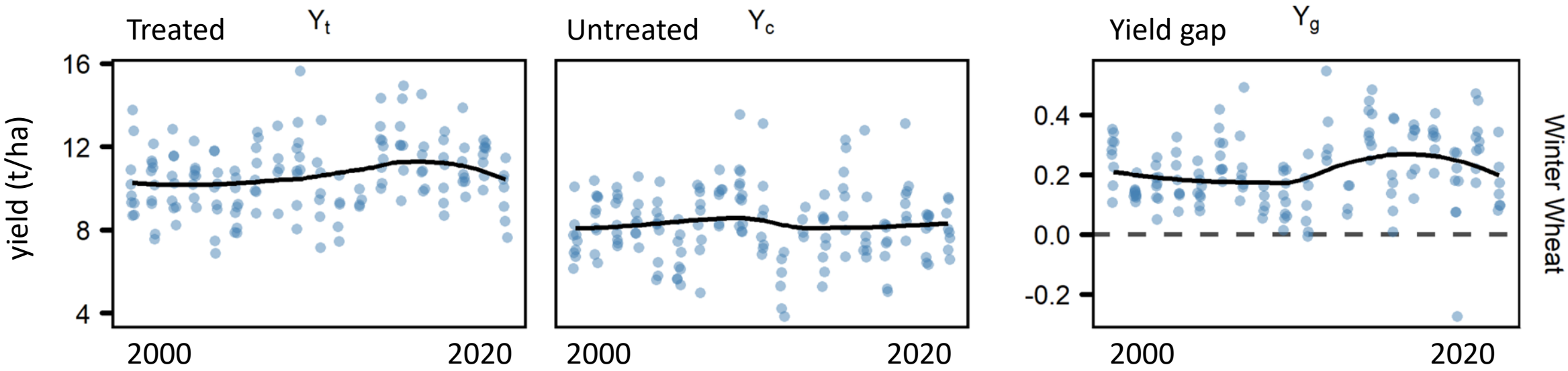
Field trials of crop varieties under fungicide-treated and untreated conditions





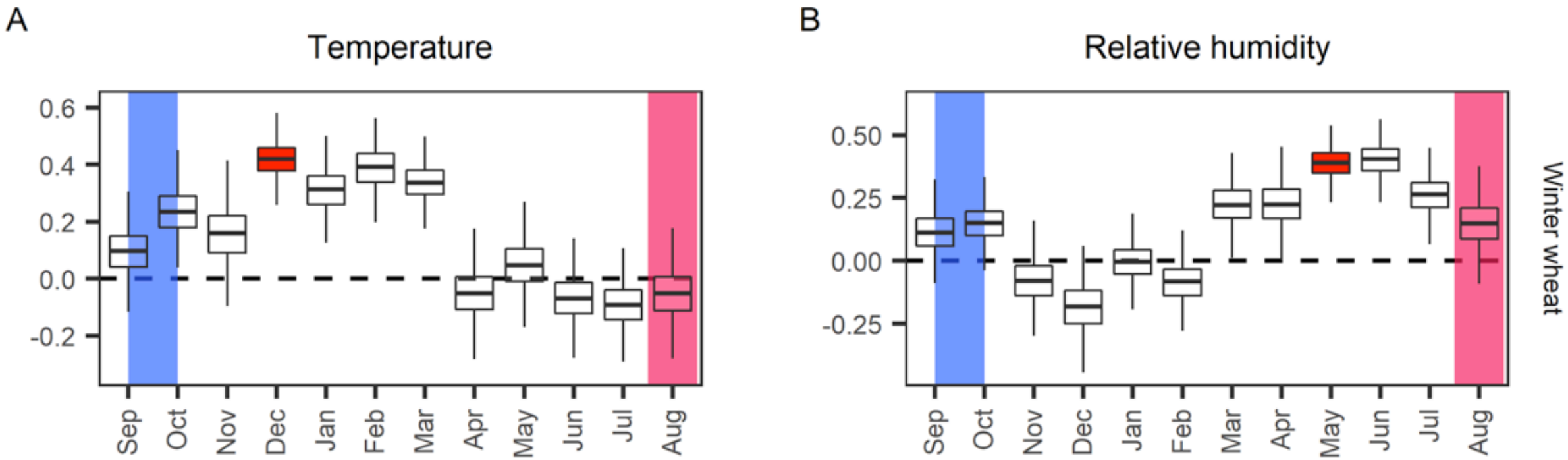
Trials allow us to investigate climate effects on potential loss

Pathogen Yield Gap = 1 - (Untreated/Treated)



Correlate loss with temperature and humidity through the growing season to build a simple model

Pathogen yield gap ~ Winter Temperature + Summer Humidity



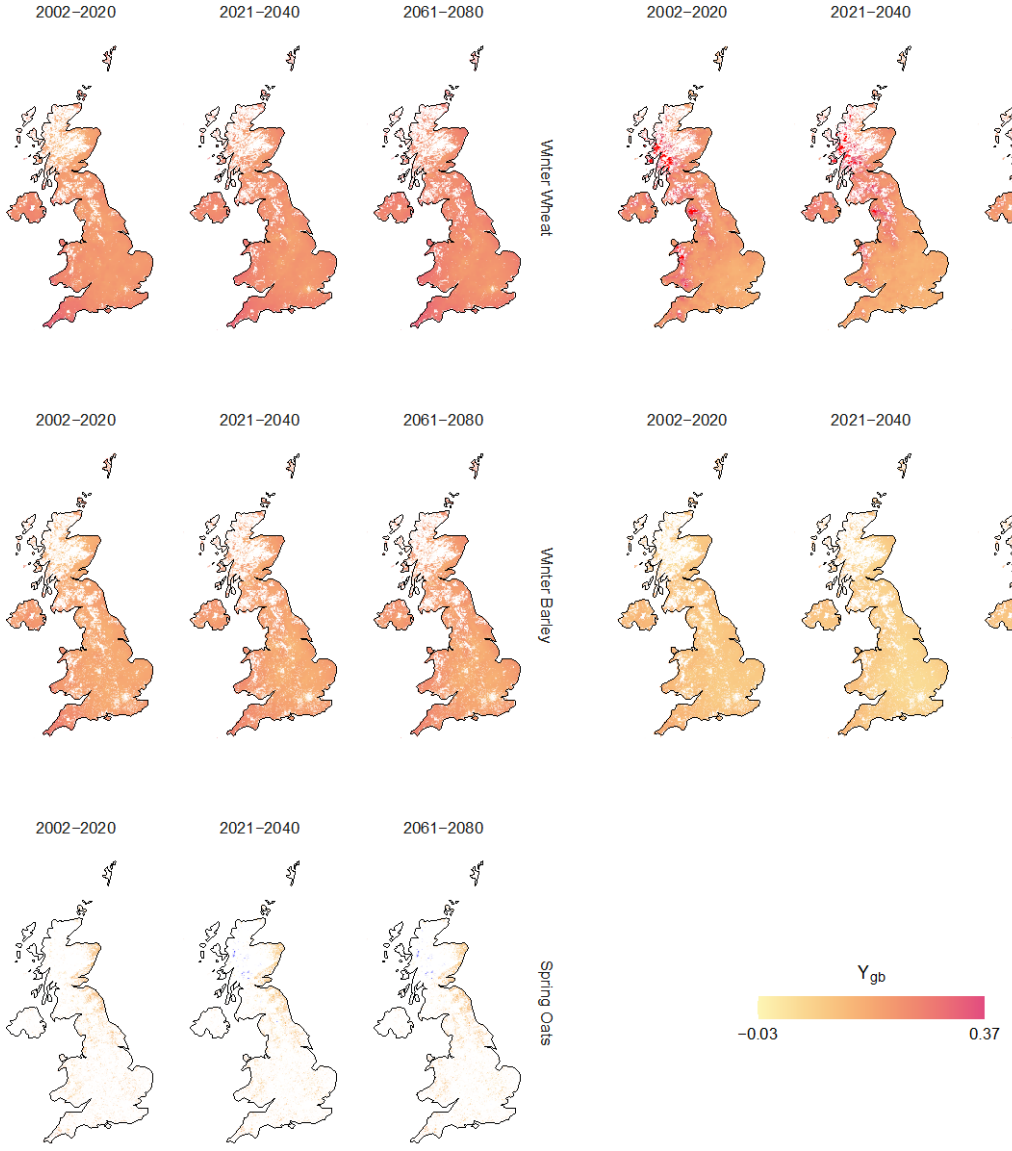
Use current and future climate projections to model yield gap

Temperature change

Relative Humidity change

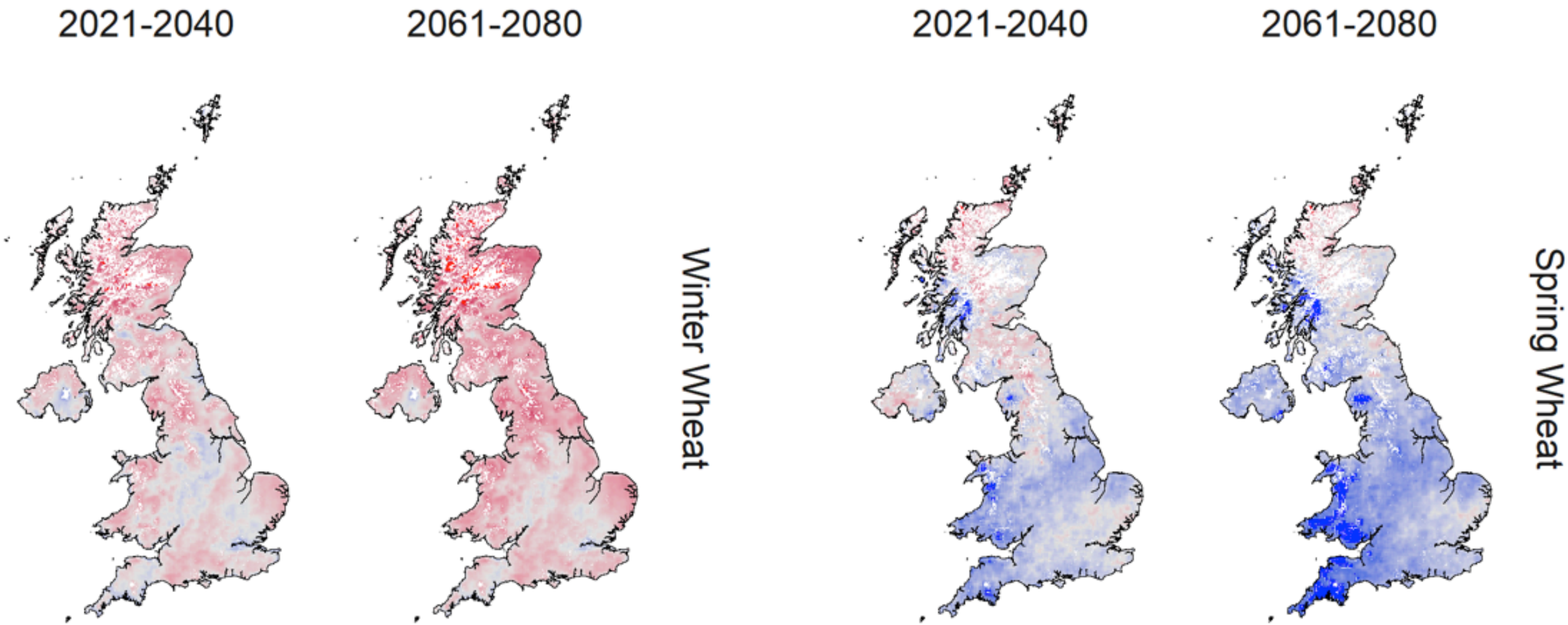
HadUK-Grid Gridded Climate Observations UKCP18

Historical and projected yield gaps



Crop	2002 - 2020	2021 - 2040	2061 - 2080
Winter Wheat	21.4	22.8	24.3
Spring Wheat	22.0	20.4	17.9
Winter Barley	18.1	18.7	19.3
Spring Barley	10.3	7.5	6.9
Spring Oats	12.0	9.7	10.1

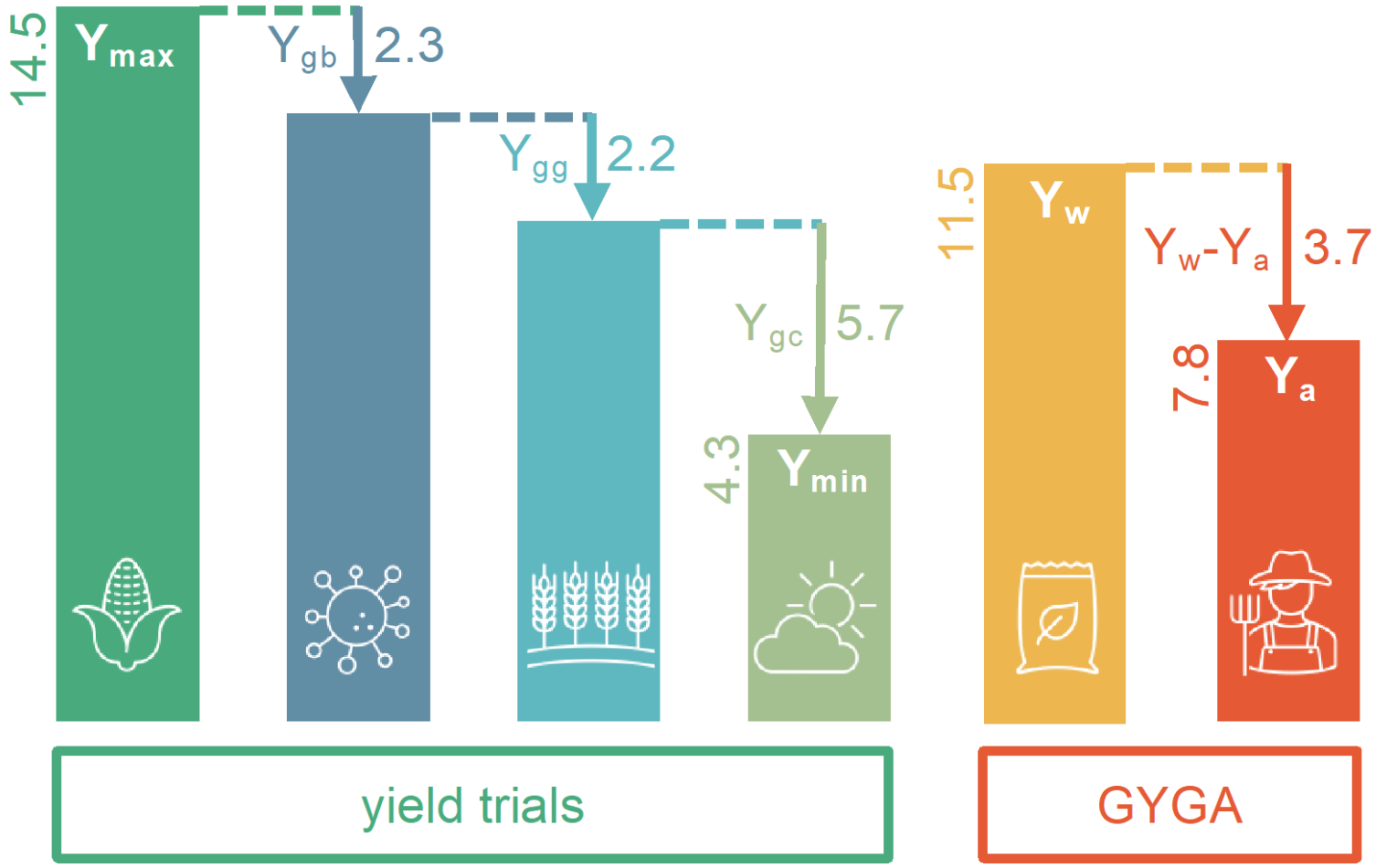
Yield gaps increase for winter crops, decrease for spring crops



Warmer wetter winters increase potential losses

Hotter drier summers decrease potential losses

We can decompose yield gap into different components



Y_{max} = mean of top 5% of treated yields

Y_{gb} = mean difference between treated and untreated

Y_{gg} = mean difference between highest and lowest-yielding varieties within a trial

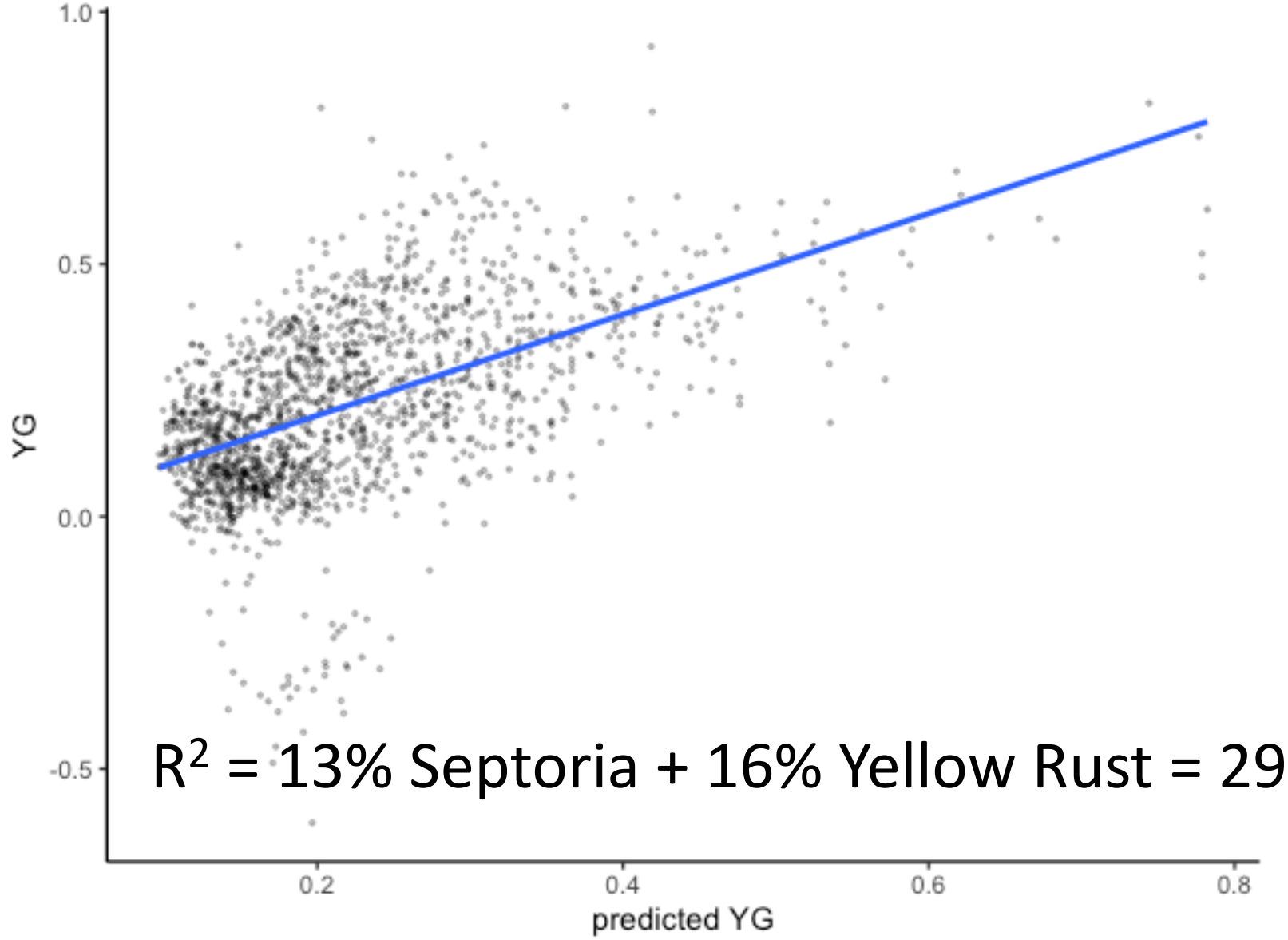
Y_{gc} = mean difference between best and worst years within a variety within a site

Y_{min} = mean of bottom 5% of untreated yields

Y_w = modelled mean rainfed yield

Y_a = reported mean yield

Yield gaps are poorly explained by monitored diseases



R^2 = 13% Septoria + 16% Yellow Rust = 29%

Summary

- ‘Disease pressure’ is strongly influenced by weather
- Weather influence varies by crop type (Winter vs Spring)
- Paired trials are an under-explored resource for investigating climate change effects on ‘disease pressure’

University of Exeter

- Dr. Muhammad Mohsin Raza (now at FMC, Philadelphia)

The Alan Turing Institute

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