Modelling European Agriculture with Climate Change for Food Security
– a FACCE JPI knowledge hub –

Cross-cutting uncertainties

1 April 2014 (1530-1800h), Session 1.6.2
(chaired by F Ewert and R Rötter; rapporteur: M Rivington)
FACCE MACSUR Mid-term Conference at Sassari/SARDINIA

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CONTENTS

- Uncertainty – and how it has been treated in the past in CC impact projections
- Integrated regional assessment in MACSUR
- Uncertainty and risk assessment in MACSUR
- Outlook

Definitions:

Ignorance, uncertainty, error, accuracy, precision,risk

(=> presentation M Rivington)

The Drunken Alcibiades Interrupting the Symposium, 1648

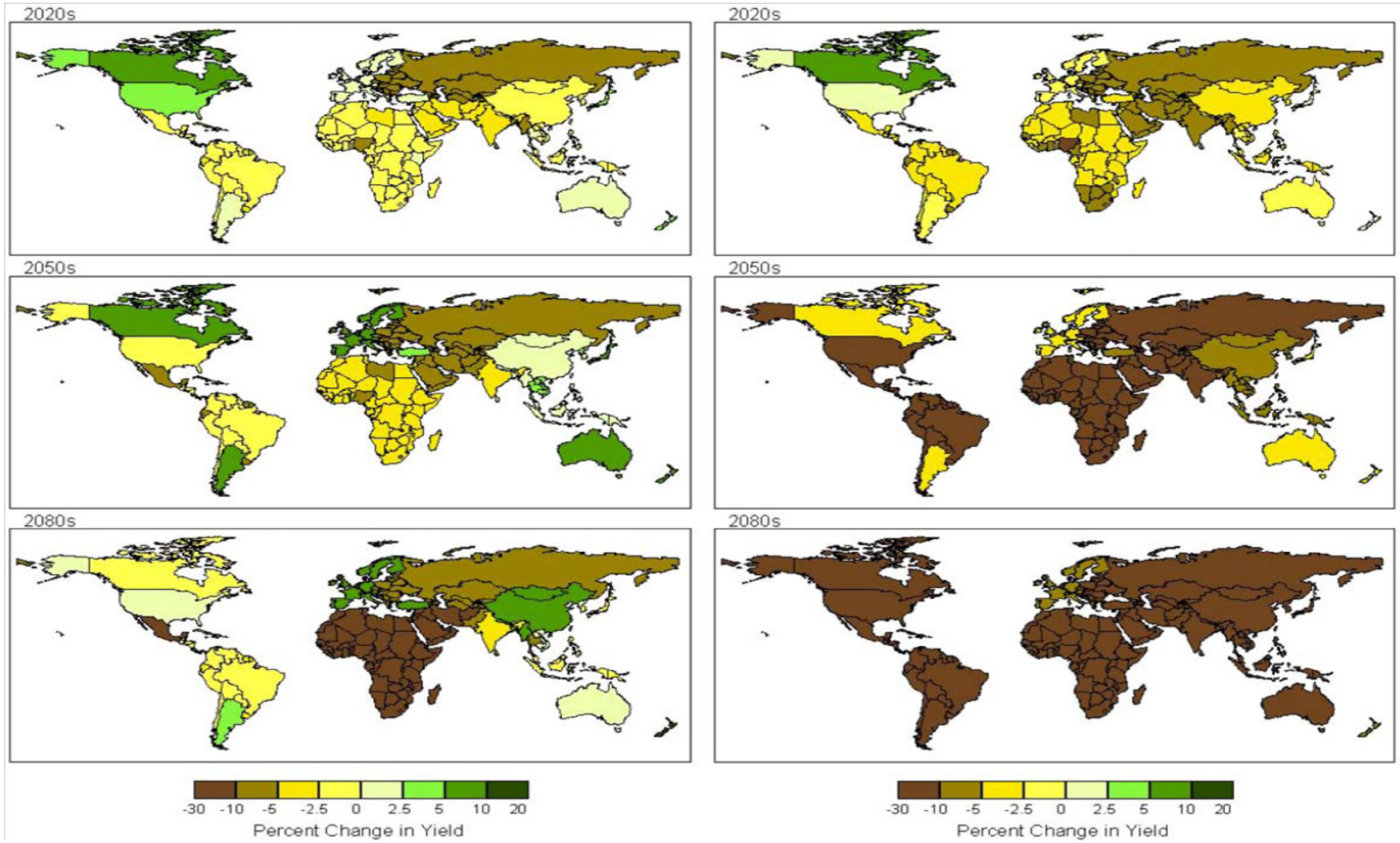
Objectives of uncertainty evaluation

- To estimate uncertainty
  - important for model developers, users, stakeholders
- To understand what is driving uncertainty
  - in order to prioritize improvement efforts

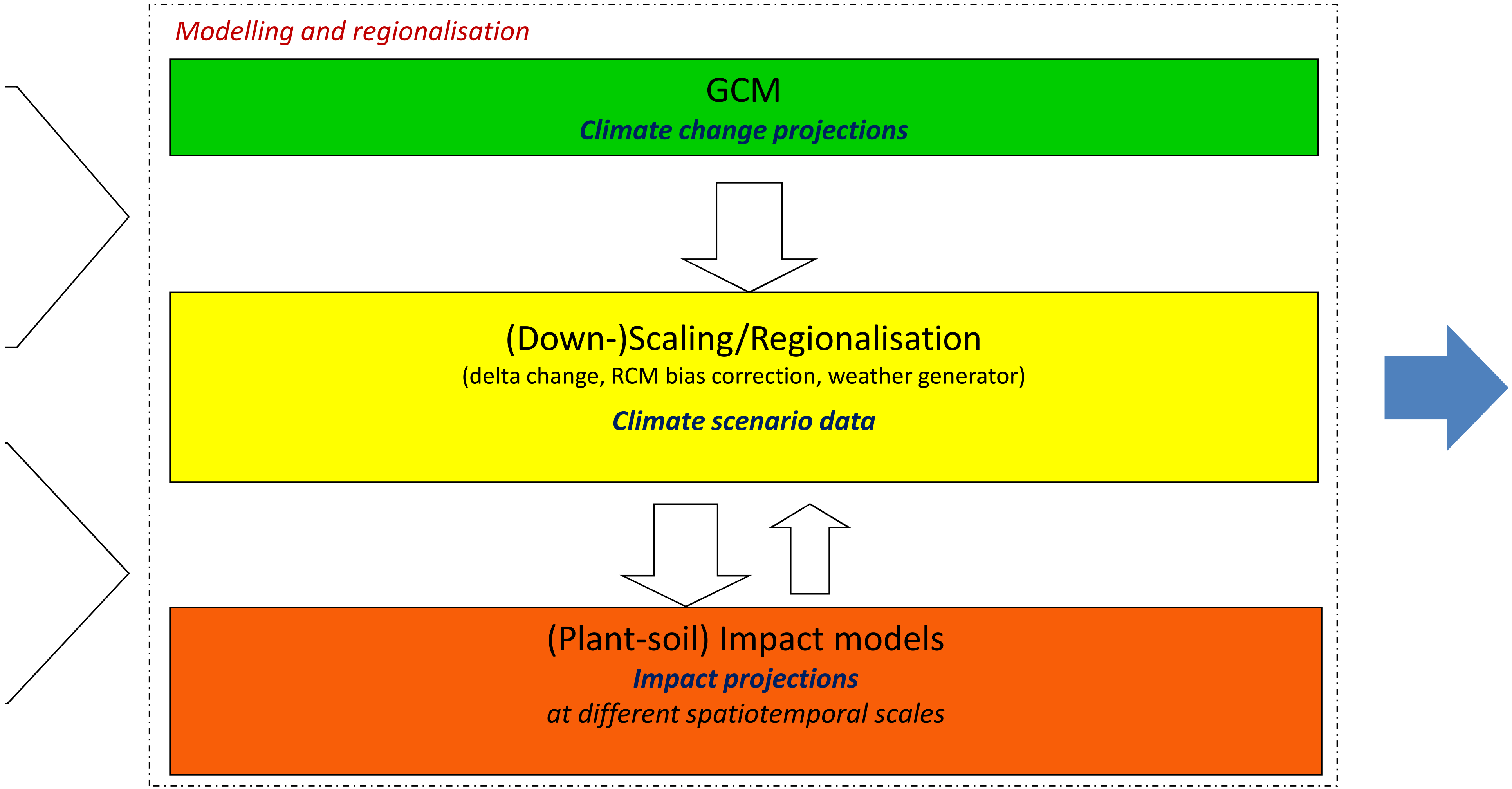
Estimating uncertainty

- **Three approaches :**
  1) Based on error in hindcasts *(based on difference between simulated and observed)*
  2) Based on sources of error *(model input, model parameters...)*
  3) Based multiple models /inter-comparison *(ensemble modelling approach...)*

Conv. CC IA meth. /Winners /Loosers; mean changes; Here: P**otential changes in cereal yields, A2 (*Parry et al., 2004*)**



Uncertainty in biophysical impact modelling



(source: Rötter et al. 2012, Acta Agric Scand. Section A, 62(4), 166-180).

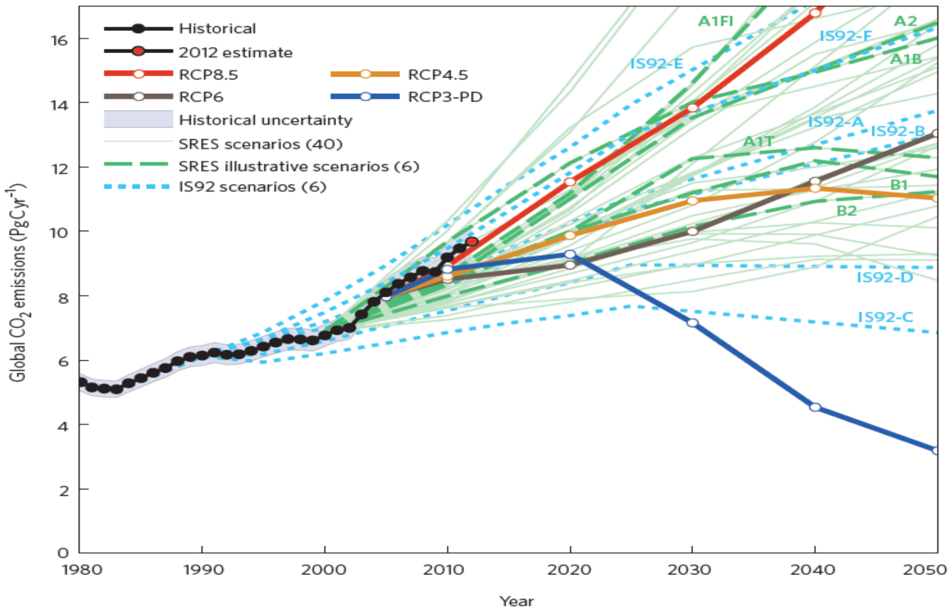


Figure 1 | Estimated CO_2 emissions over the past three decades compared with the IS92, SRES and the RCPs. The SA90 data are not shown, but the most relevant (SA90-A) is similar to IS92-A and IS92-F. The uncertainty in historical emissions is ±5% (one standard deviation). Scenario data is generally reported at decadal intervals and we use linear interpolation for intermediate years.

(Source: Peters, 2013; Nat Clim Change)

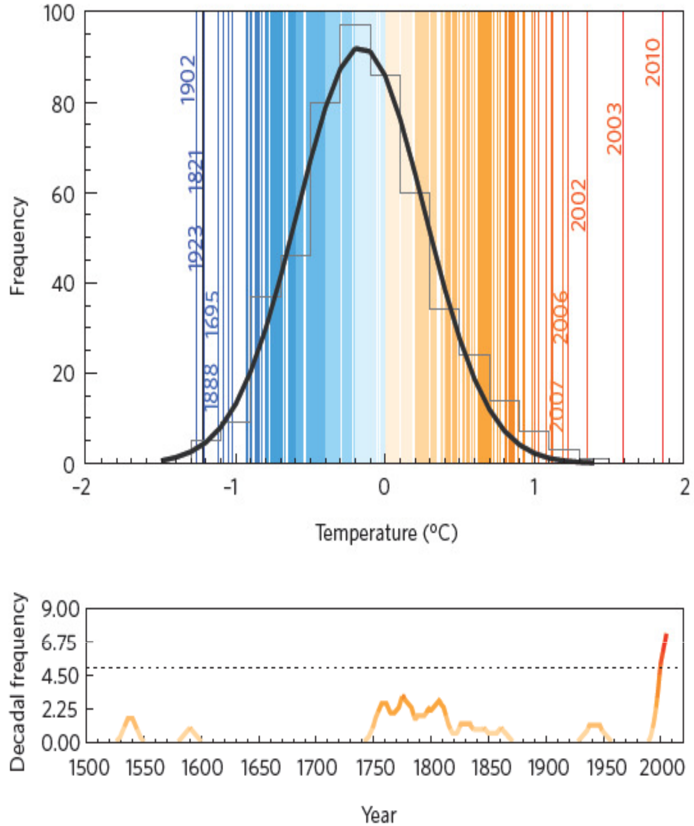
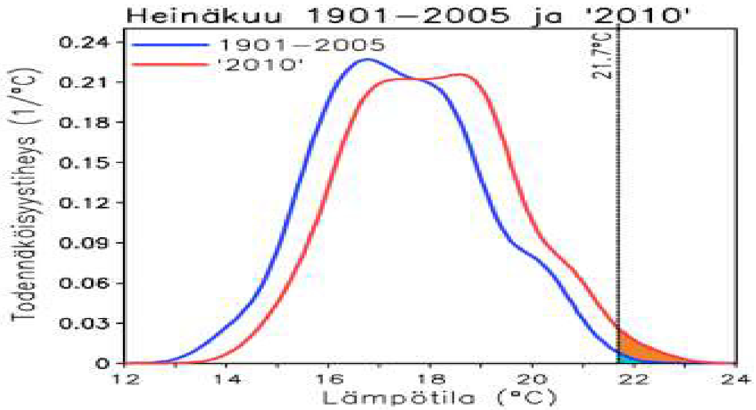


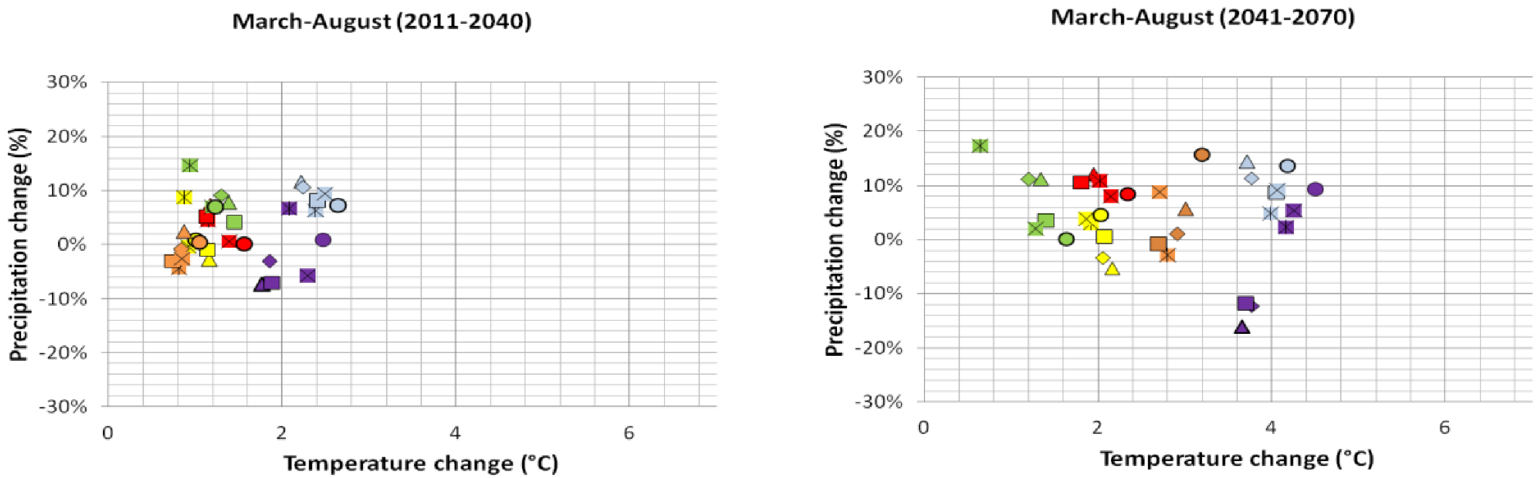
Figure 4 | European summer temperatures for 1500–2010. The upper panel shows the statistical frequency distribution of European (35° N, 70° N; 25° W, 40° E) summer land-temperature anomalies (relative to the 1970–1999 period) for the 1500–2010 period (vertical lines). The five warmest and coldest summers are highlighted. Grey bars represent the distribution for the 1500–2002 period with a Gaussian fit shown in black. The lower panel shows the running decadal frequency of extreme summers, defined as those with a temperature above the ninety-fifth percentile of the 1500–2002 distribution. A ten-year smoothing is applied. Reproduced with permission from ref. 69, © 2011 AAAS.

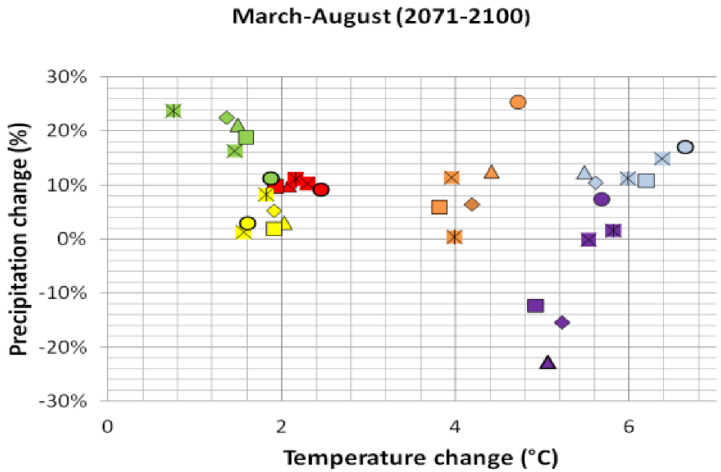


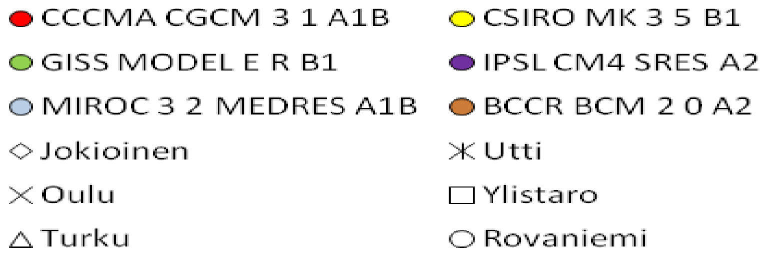
Shift in PDF of July temperatures
S Finland (*Source:* Räisänen 2010)

Source: Coumou & Rahmsdorf, 2012

Projected changes in mean temperature and precipitation during March-August for selected stations in Finland





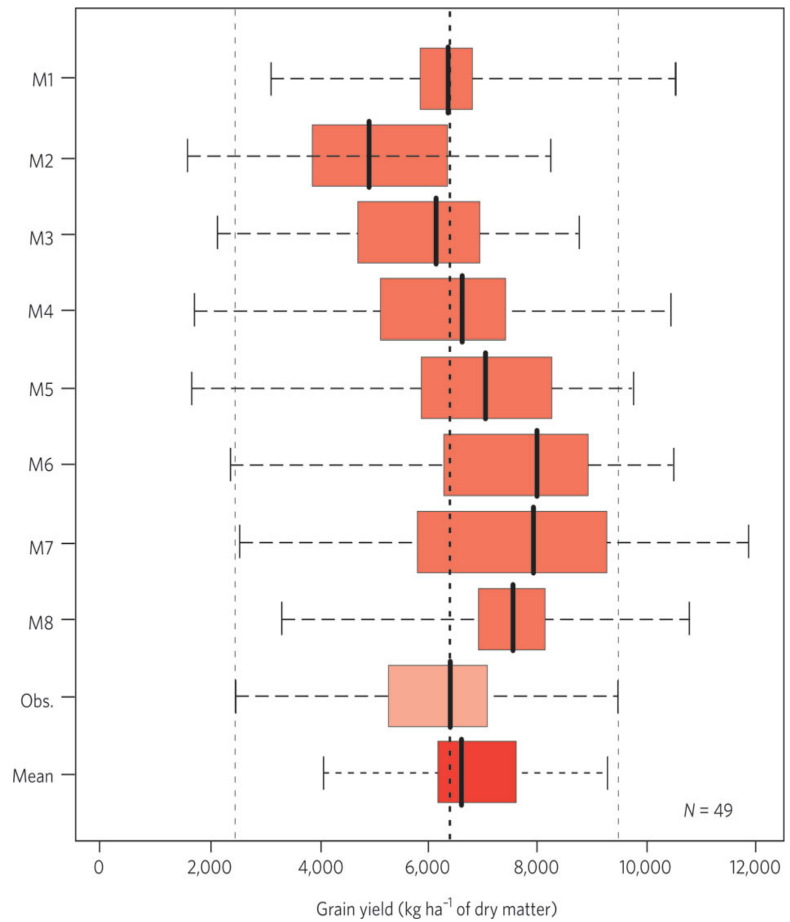


Source: Rötter et al. 2013

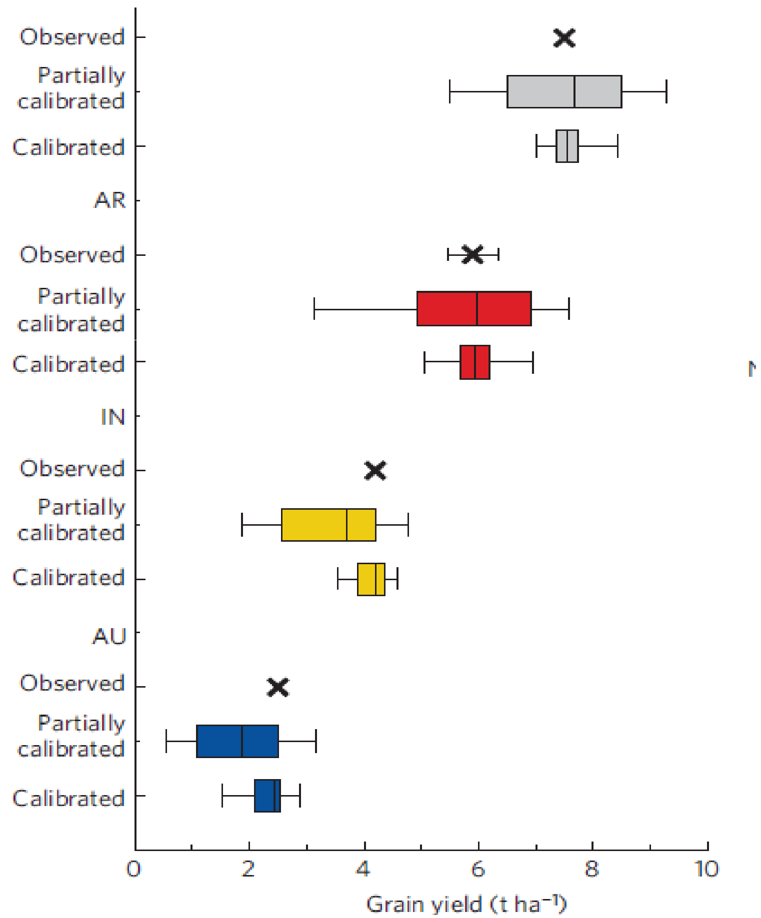
Changes in T and PRECIP for time periods 2011-2040, 2041-2070 and 2071-2100 compared with 1971–2000 for six representative locations relevant for agricultural production in Finland (see Fig.). Six GCMs (CCCMA CGCM 3 1, CSIRO MK 3 5, GISS MODEL E R, IPSL CM4, MIROC 3 2 MEDRES and BCCR BCM 2 0) are presented.

Model intercomparison

COST 734 (blind test, current climate); AgMIP wheat (partially and fully calibrated, current and future)

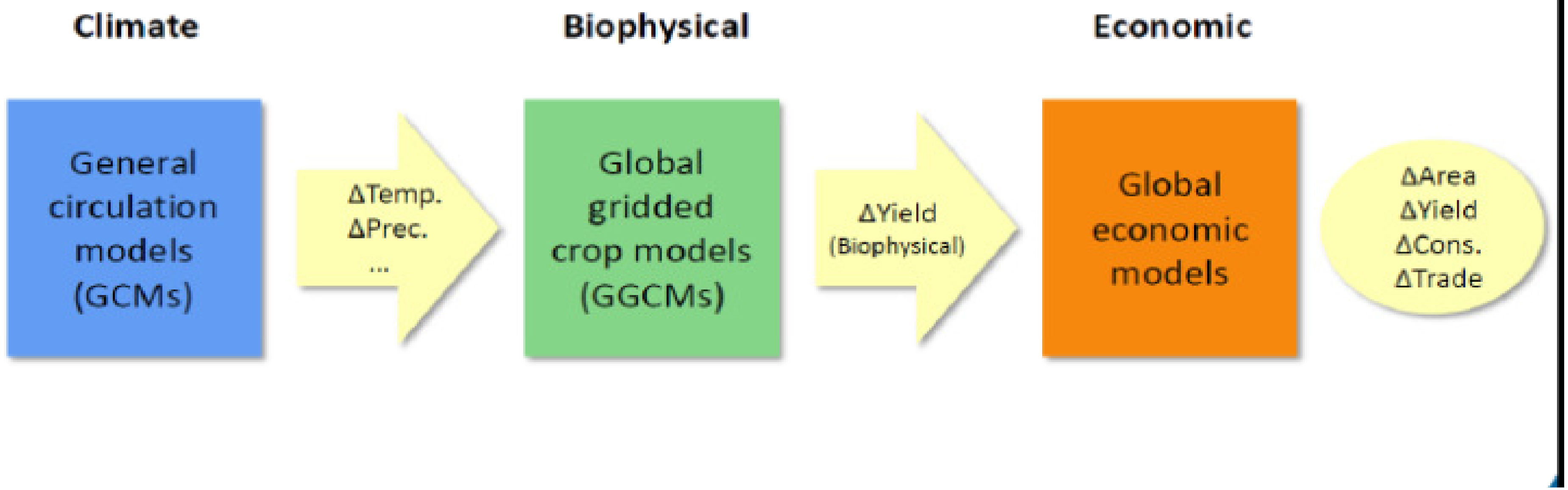


Source: Rötter et al., Nature Clim. Change 1, 175-177 (2011)



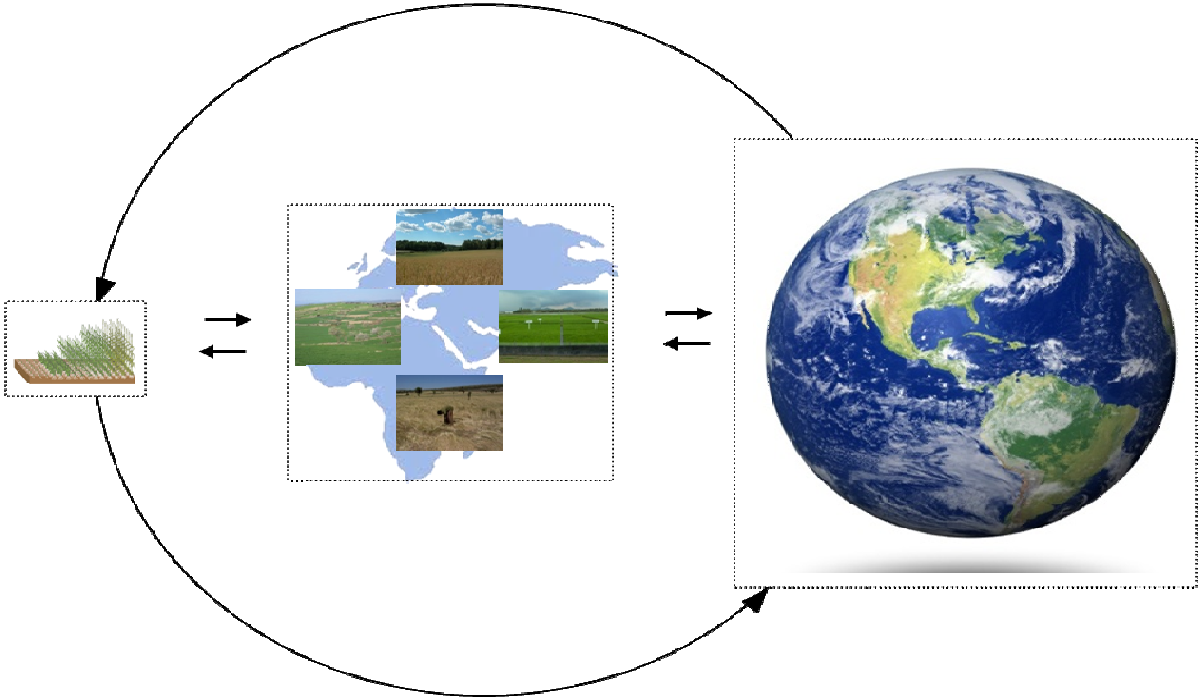
Source: Asseng et al., Nature Clim. Change 3, 827-832 (2013)

Modelling chain from climate via crop to economic



(source: Nelson et al 2014, PNAS)

Need for INTEGRATION



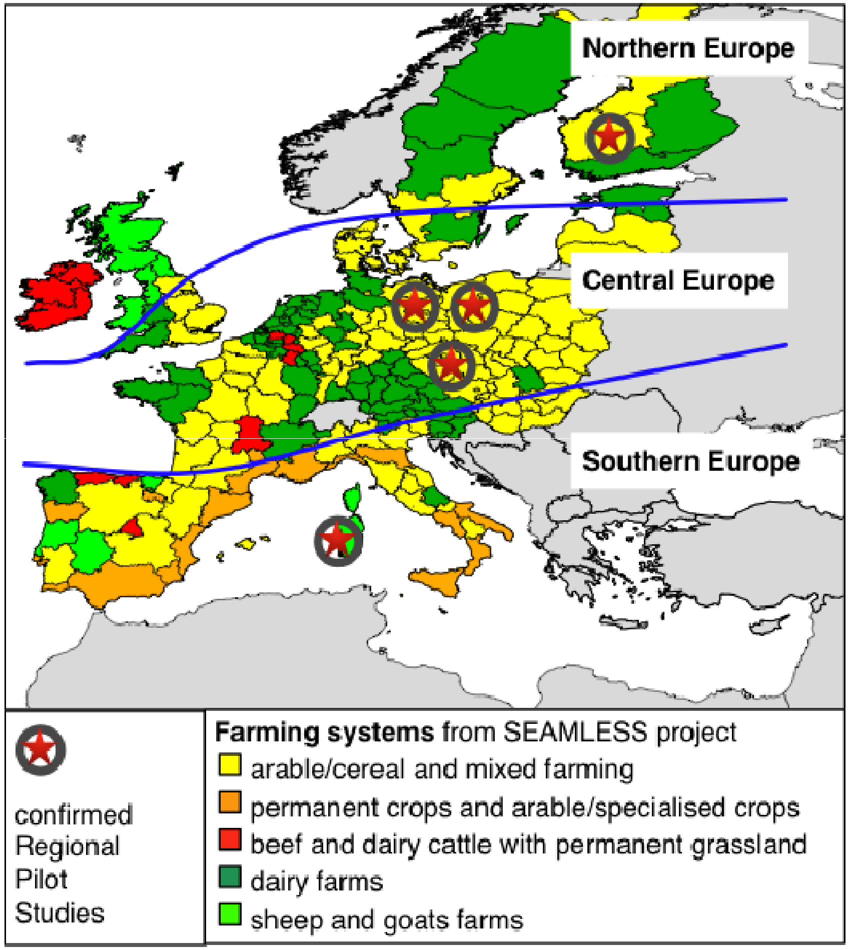
UNCERTAINTY caused by ...

SSP, scenarios, e.g. New technologies /their diffusion ?

Model deficienices/ lack of data /scaling and model linkage

Short-term variability/ volatility

MACSUR Regional Pilot Studies



Multitude of appoaches – one direction is upscaling from ***farm level*** (for typical farm types) of mitigative adaptation

Options via region/national to supra-national scales – also taking Into account other Sustainable Development Goals – e.g. In NORFASYS (*Rötter et al., 2013*)

MODDELING APPROACHES AND THEIR INTEGRATION

Climate scenarios
Crop and variety information
Soil data
Agronomic practices

Market and policy drivers

Modelling framework

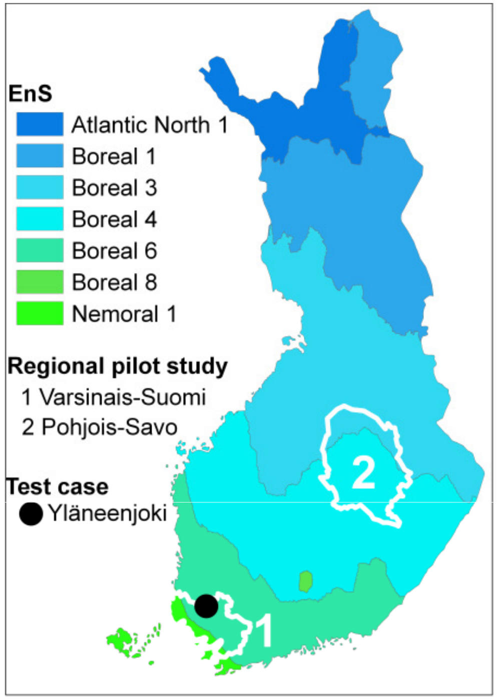
Field level
Plant-soil models

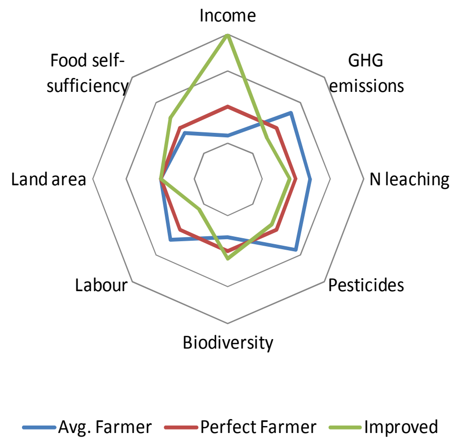
Farm level
Static and dynamic farm level models

Sector level
Dynamic regional sector model

Environmental and economic impacts and land-use

FINNISH REGIONAL PILOT: Pohjois Savo





Lehtonen, H.S., Rötter, R.P., Palosuo, T.I., Salo, T.J., Helin, J.A., Pavlova, Y., Kahiluoto, H.M. (2010). A Modelling Framework for Assessing Adaptive Management Options of Finnish Agrifood Systems to Climate Change. Journal of Agricultural Science, Vol 2, No 2 (2010), p. 3-16. ISSN: 1916-9752. E-ISSN: 1916-9760. http://ccsenet.org/journal/index.php/jas/article/viewFile/4599/4888

Uncertainty and risk in MACSUR

- Approaches pursued so far:

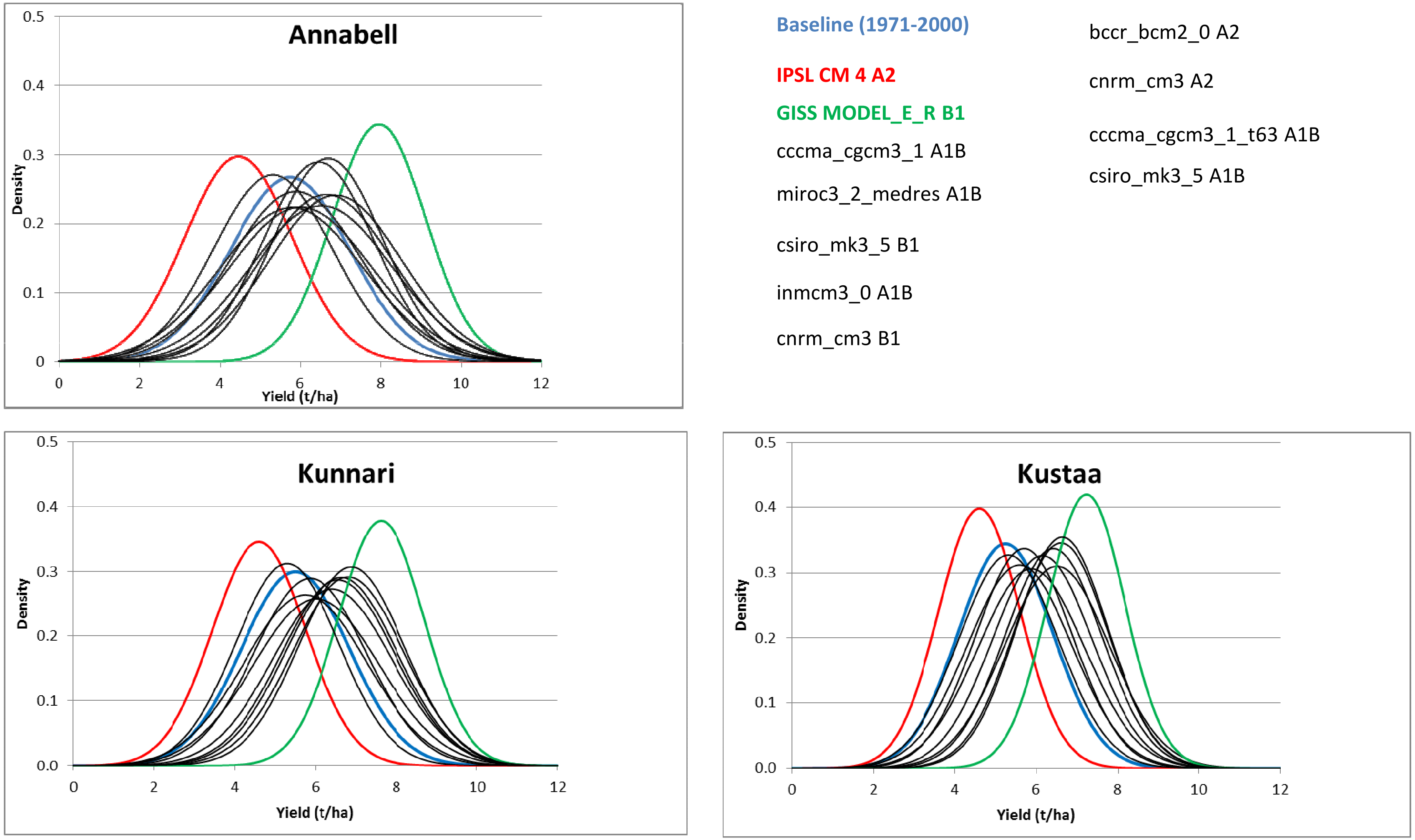
- Use of multi-model ensembles to evaluate uncertainty and causes of uncertainty

  Building on experience in COST action 734 and AgMIP

- Use of Impact Response Surface Method overlaid with joint probabilities of projected changes in T and Precip

  Building on experience in modelling CC impacts in Finnish ecosystems (S Fronzek & T Carter) and in the framework of the ENSEMBLES project (Special Issue in NHESS; Carter et al. 2011); related to C3MP (Ruane/AgMIP)

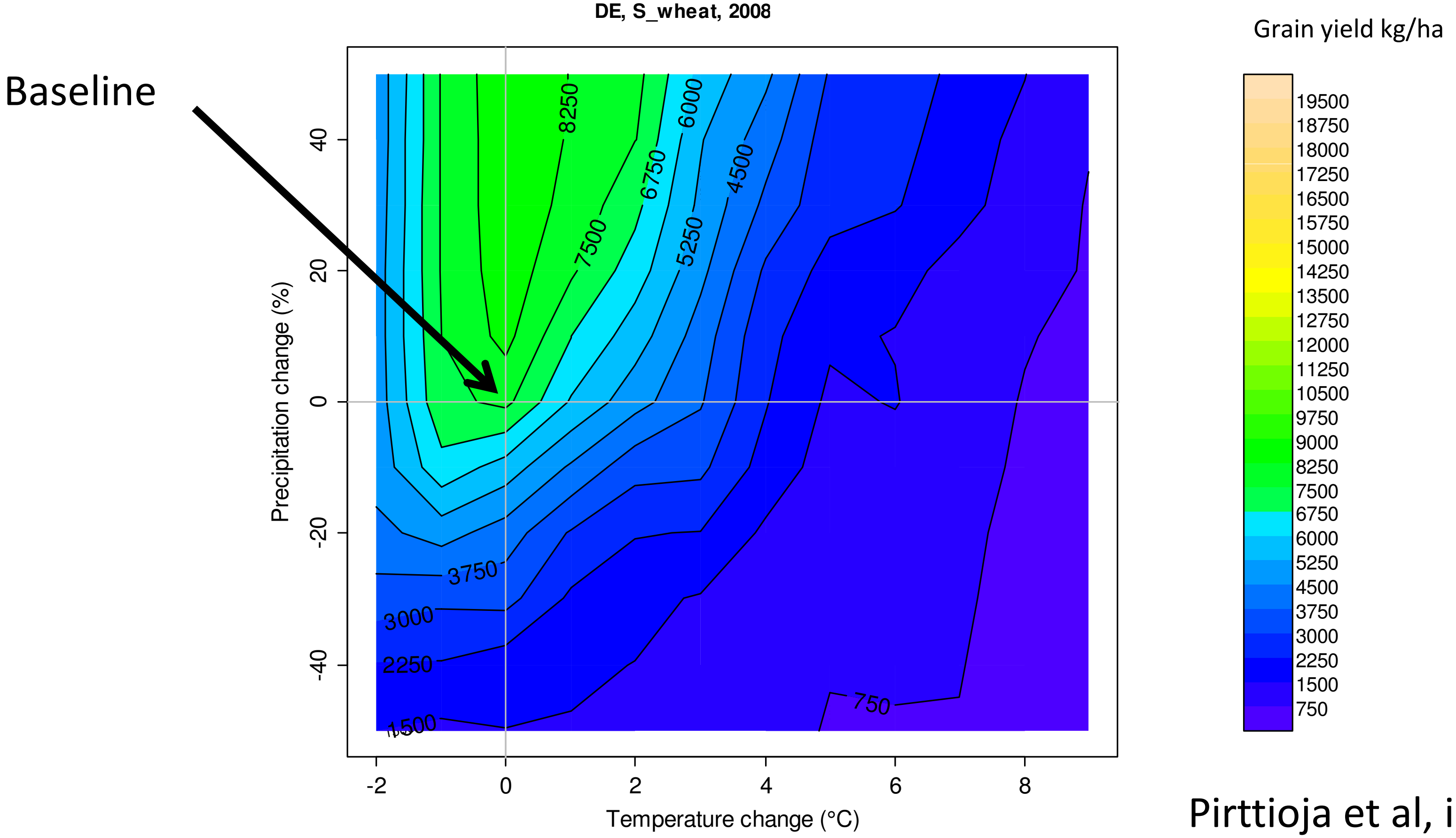
Probability density functions of spring barley yields during 1971-2000 and 2071-2100 under selected climate change scenarios at Utti



Rötter et al., 2013

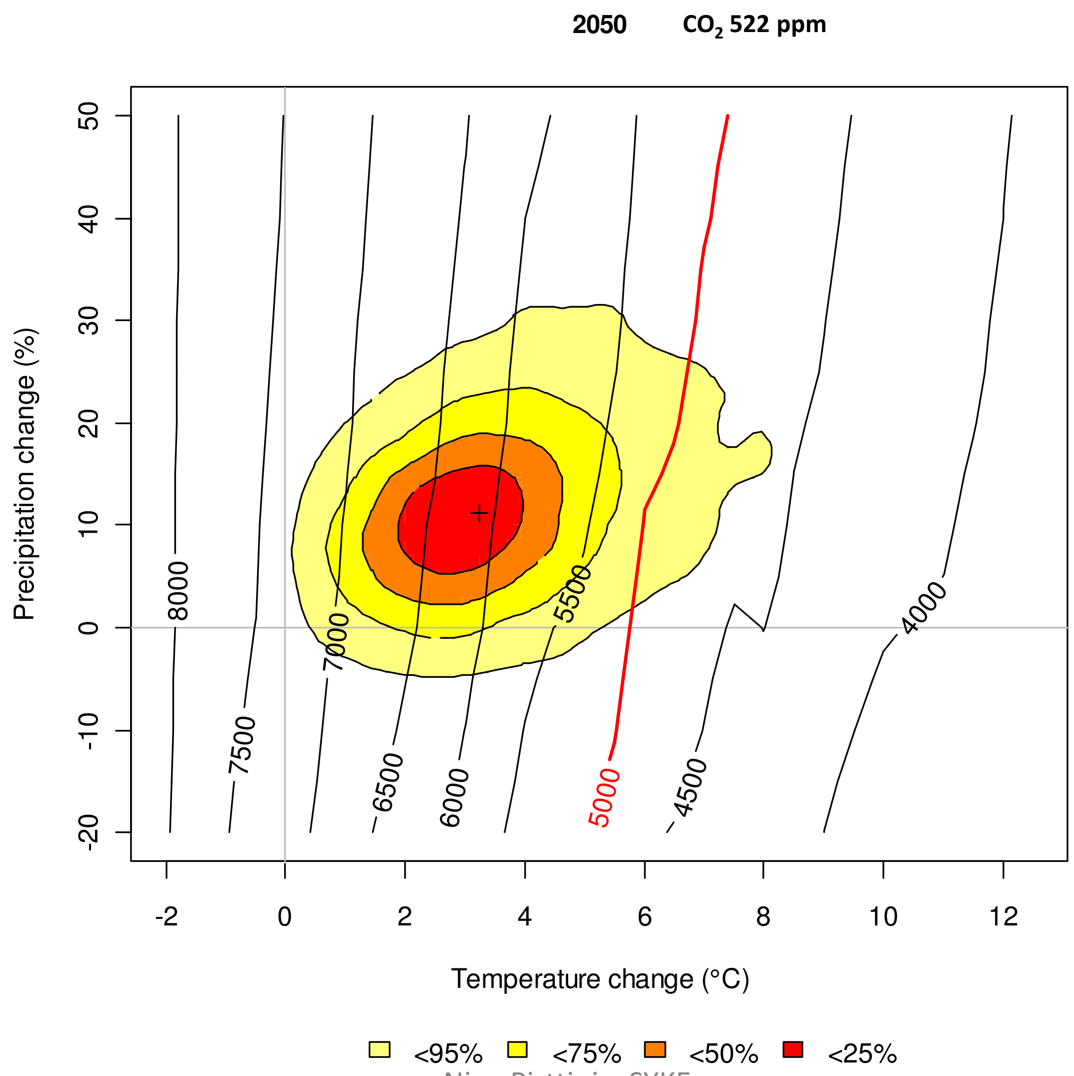
IRS : Methods and data

- Impact response surfaces (IRS) were constructed from the results of the model simulations
- IRSs represent the sensitivity of modelled crop yield to incremental changes in precipitation (vertical) and temperature (horizontal), here represented as absolute yields (baseline ~ 7500 kg/ha)



Pirttioja et al, in prep

Constructing impact response surfaces for analysing risk of crop yield shortfall



Change through coordinated international efforts

- **one avenue towards more robust** global results: AgMIP (www.agmip.org)
- regionally/EU: Modelling European Agriculture with Climate Change for Food Security (www.macsur.eu)
- *Both networks coordinate efforts to improve agricultural models and develop common protocols to systematize modelling for the assessment of climate change impacts on crop production. They emphasize the importance of integrating biophysical and socioeconomic analysis from farm to global scale*
- *Some conclusions form Oslo, 10-12 Feb:* a continuous monitoring of the 'state of knowledge' is proposed .- e.g. To be coordinated by AgMIP closely collab. FACCE-MACSUR.

- **another avenue** is international support to building bottom-up "low-regret" adaptation strategies in response to an uncertain climate and utilizing a.o. response diversity in management e.g. for climate resilient cropping systems *(can also be supported by crop modelling; see, Kahiluoto et al., 2014a,b)*

Further reading

- Asseng, S. *et al. Nature Clim. Change* ***3, 827–832 (2013).***
- Jones, R. N. *Clim. Change* ***45, 403–419 (2000).***
- Kahiluoto, H. *et al*., Global Environmental Change **(in press)** doi: 10.1016/gloenvcha2014.02.002
- Kahiluoto, H. et al., The role of modelling in buidling climate resilience in cropping systems. Chapter 13 in J´Fuhrer & P Gregory, CABI **(in press)**
- Müller, C. & Robertson, R. D. *Agric. Econ.* ***45, 85–101 (2014).***
- Nelson, G. C. *et al.. Proc. Nat. Acad. Sci. of the United States of America*, 10.1073/pnas.1222465110 **(2014)**
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- Wheeler, T. & von Braun, J. *Science* ***341, 508–513 (2013).***
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•*Presentations in the uncertainty session 1.1 of the CropM* ***Oslo International Symposium, 10-12 February 2014 at www.macsur.eu***