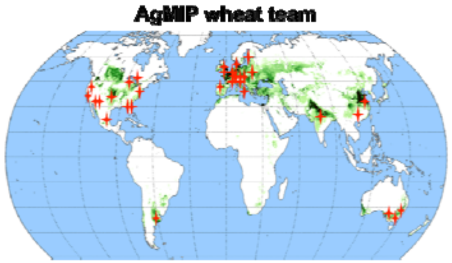


AgMIP The Agricultural Model Intercomparison and Improvement Project

Reducing uncertainty in prediction of wheat performance under climate change

Pierre Martre, Senthold Asseng, Frank Ewert

P.R. Rötter, D.B. Lobell, D. Cammarano, A. Maiorano, B.A. Kimball, M.J. Ottman, G.W. Wall, J.W. White, M.P. Reynolds, P.D. Alderman, P.V.V. Prasad, P.K. Aggarwal, J. Anothai, B. Basso, C. Biernath, A.J. Challinor, G. De Sanctis, J. Doltra, E. Fereres, M. Garcia-Vila, S. Gayler, G. Hoogenboom, L.A. Hunt, R.C. Izaurralde, M. Jabloun, C. Jones, C. Kersebaum, A.-K. Koehler, C. Müller, N.K. Soora, C. Nendel, G.J. O'Leary, J.E. Olesen, T. Palosuo, E. Priesack, E. Eyshi Rezaei, A.C. Ruane, M.A. Semenov, I. Shcherbak, C. Stöckle, P. Stratonovitch, T. Streck, I. Supit, F. Tao, P. Thorburn, K. Waha, E. Wang, D. Wallach, J. Wolf, Z. Zhao, Y. Zhu

Objectives and strategy

1. To quantify the uncertainty of wheat multi-model ensembles and to create simulation capacity to assist the assessment of impacts of climate change.

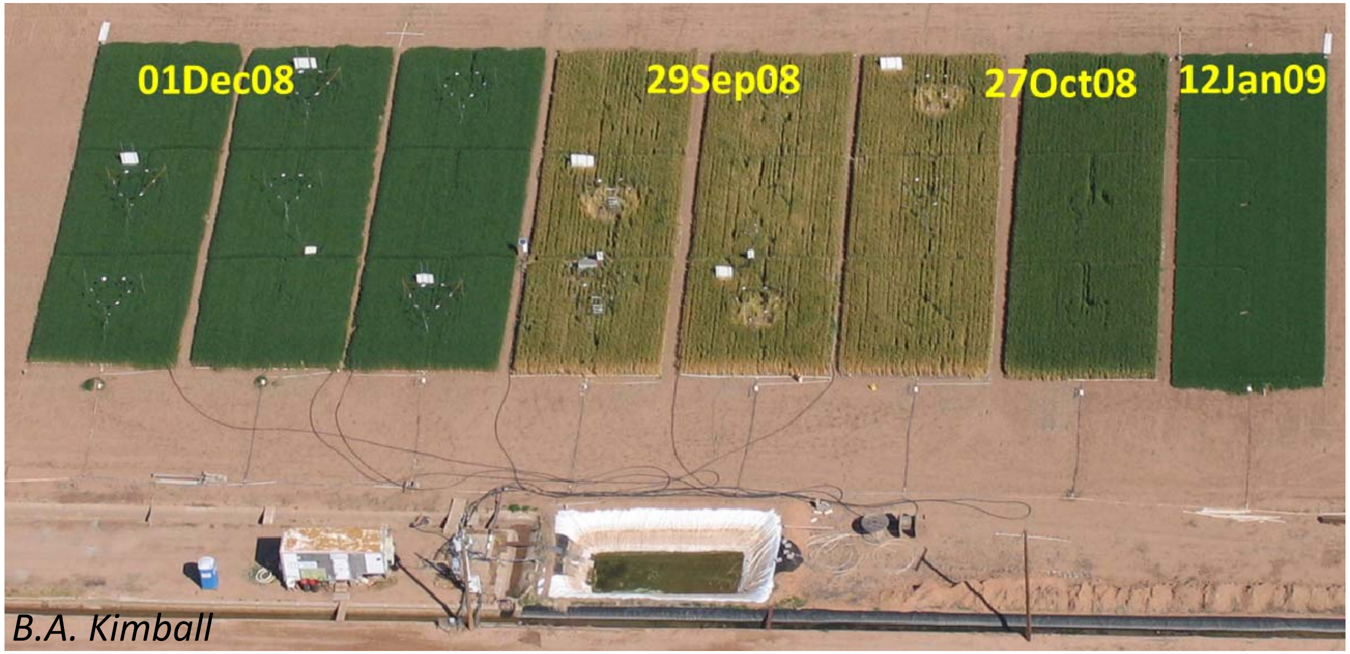
2. To improve identification of climate change hotspots, and promising regional-specific wheat breeding traits and crop management

3. To improve quantification of adaptation options across the globe.

Step-wise strategy to improve model accuracy through addressing physiological crop growth processes in increasing order of complexity.

Hot Serial Cereal Experiment, Maricopa, AZ, USA

"Cereal" because it's on wheat, "Serial" because the wheat is being planted serially every 6 wks for 2 y, "Hot" because IR heaters are deployed on some of the planting dates.



Grant R.F. et al., 2011; Kimball B.A. et al., 2012; Ottman M.J. et al., 2012, 2013; Wall G.W. et al., 2011; White J.W. et al., 2011, 2012

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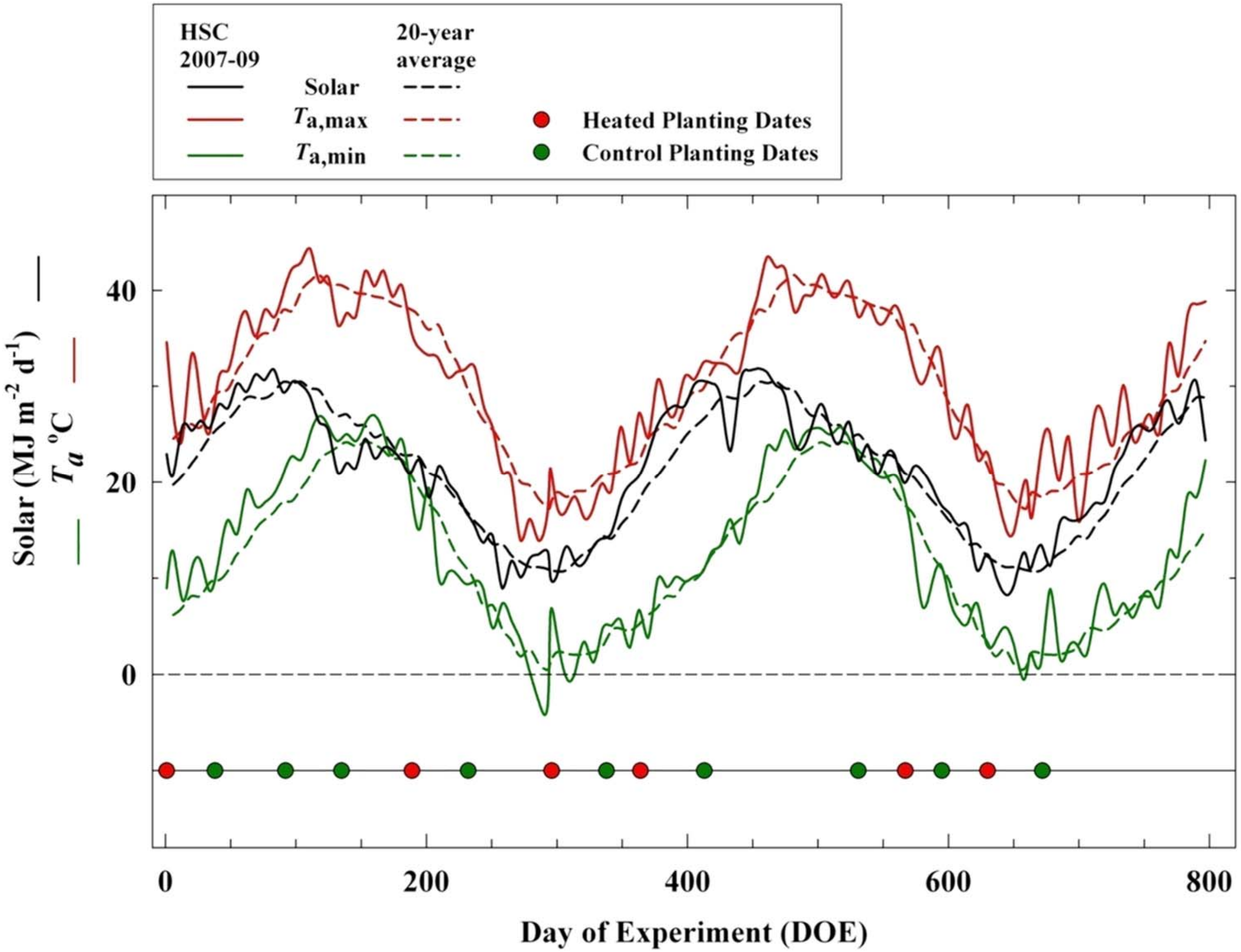
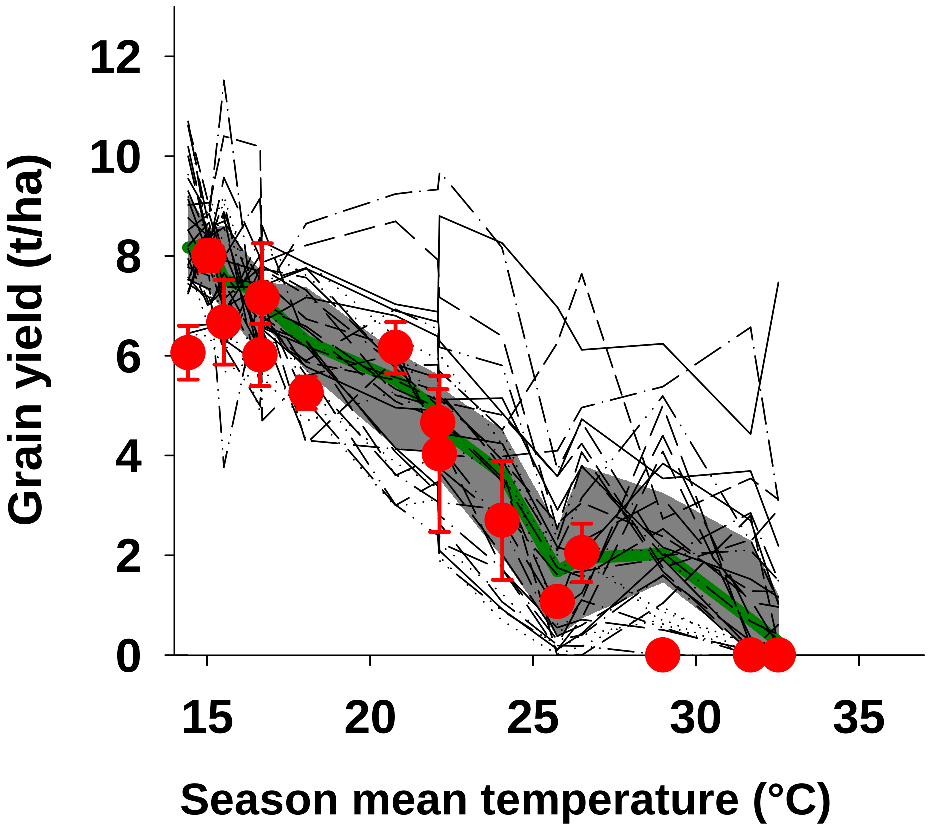
Hot Serial Cereal Experiment, Maricopa, AZ, USA

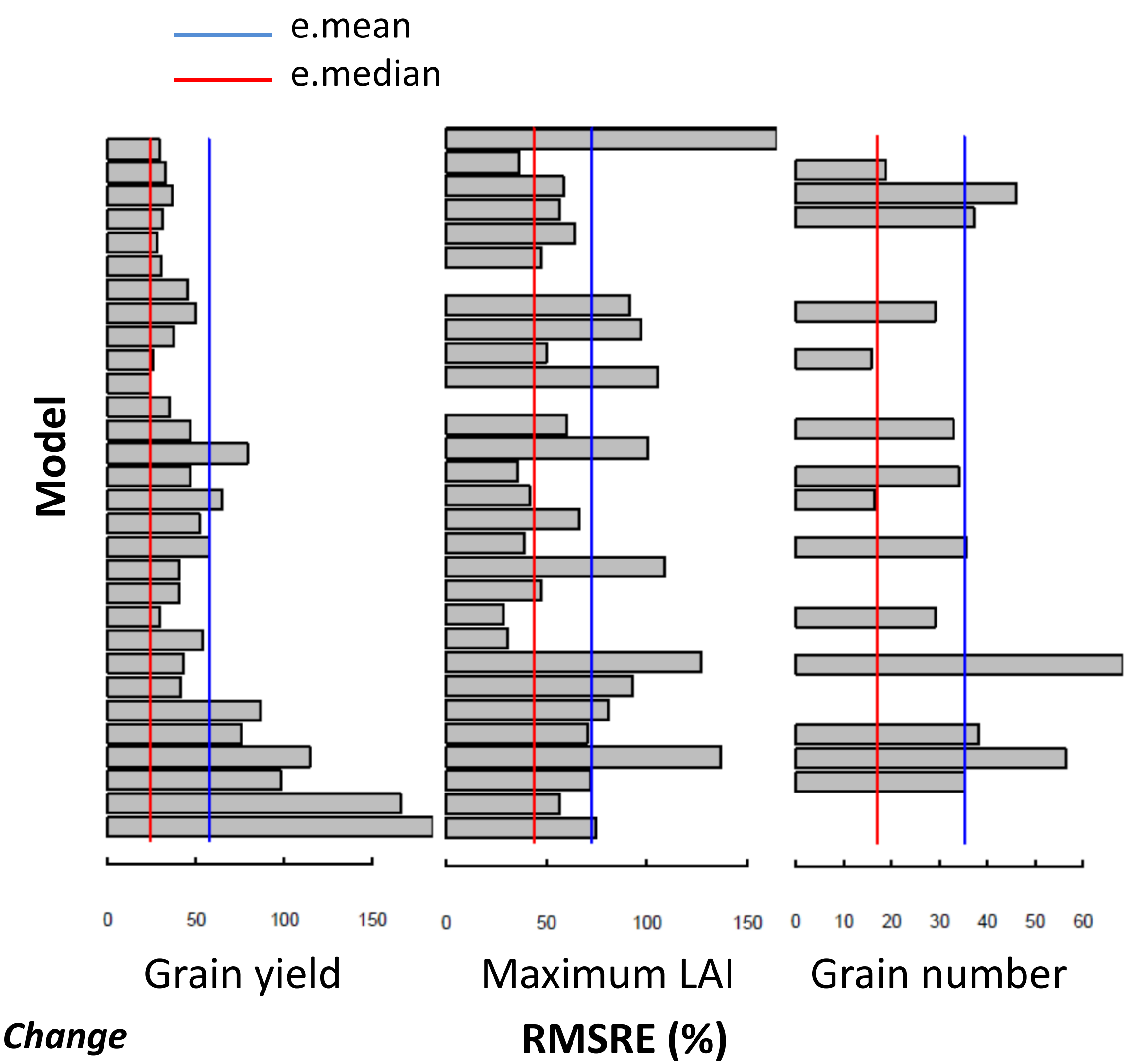


Wall et al. 2011 Global Change Biology

Simulation of wheat response to temperature in the HSC experiment

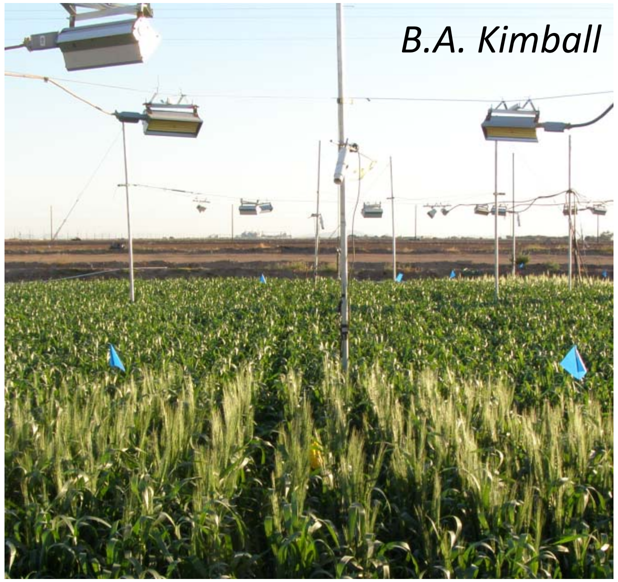
$$\mathrm{RMSRE}_m = 100 \times \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(\frac{y_i - \hat{y}_{m,i}}{y_i}\right)^2}$$

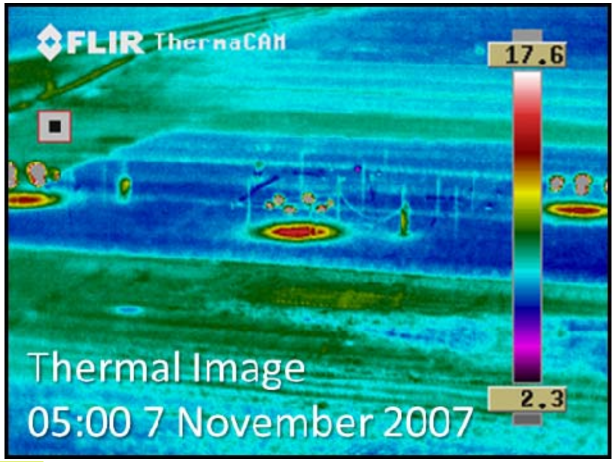




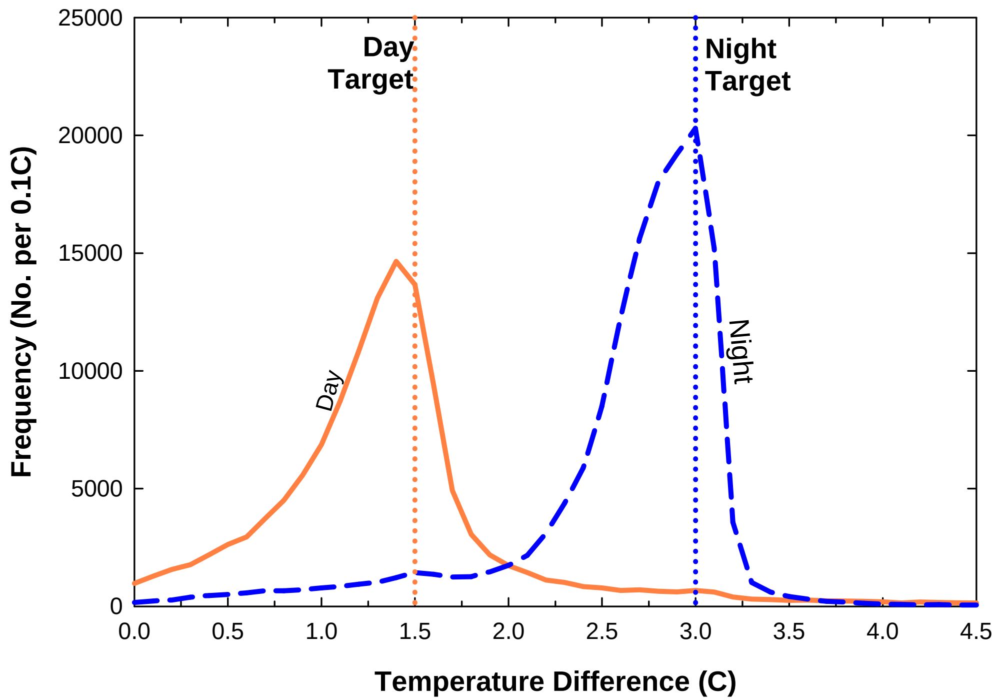
Asseng et al. 2015 Nature Climate Change

Hot Serial Cereal Experiment, Maricopa, AZ, USA

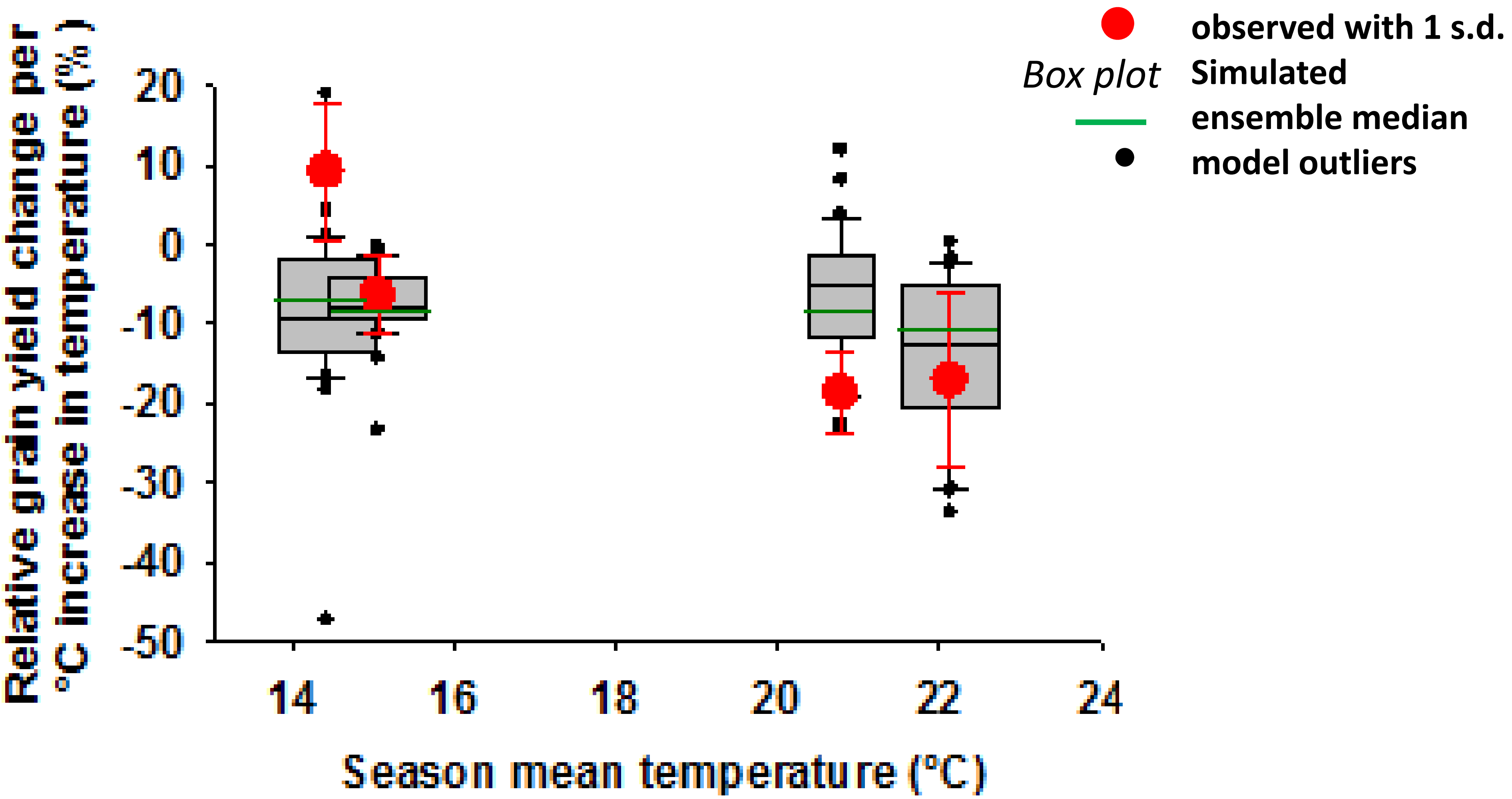




Frequency distribution of 10-min. average wheat canopy temperature differences from day- and nighttime setpoints.



Yield response to artificial temperature increase



Asseng et al. 2015 Nature Climate Change

Multivariate analysis of model error

Removed unpublished AgMIP Wheat Team

AgMIP Wheat model improvement

30 models

↓

14 models participated to model improvement

↓

12 models improved both yield and biomass

IMPROVED MODELS
APSIM-E
APSIM-Nwheat
APSIM-Wheat
FASSET
GLAM
HERMESS
N-SPASS
N-SUCROSS
O'LEARY MODEL
SIMPLACE
SIRIUS2010
SIRIUSQUALITY

A. Maiorano, P. Martre, AgMIP Wheat Team, unpublished

Outlines of model improvement

Temperature related processes	No. of models
Leaf senescence	6
Grain number	4
Grain weight	3
Development (phenology)	3
Leaf growth	2
Potential harvest index	1
Yield reduction	1
Photosynthesis/respiration	1
Bug correction	1
Parameters calibration	2

A. Maiorano, P. Martre, AgMIP Wheat Team, unpublished

Improvement of grain yield simulations in the HSC experiment

Removed unpublished AgMIP Wheat Team

Models were more improved at higher temperature

Removed unpublished AgMIP Wheat Team

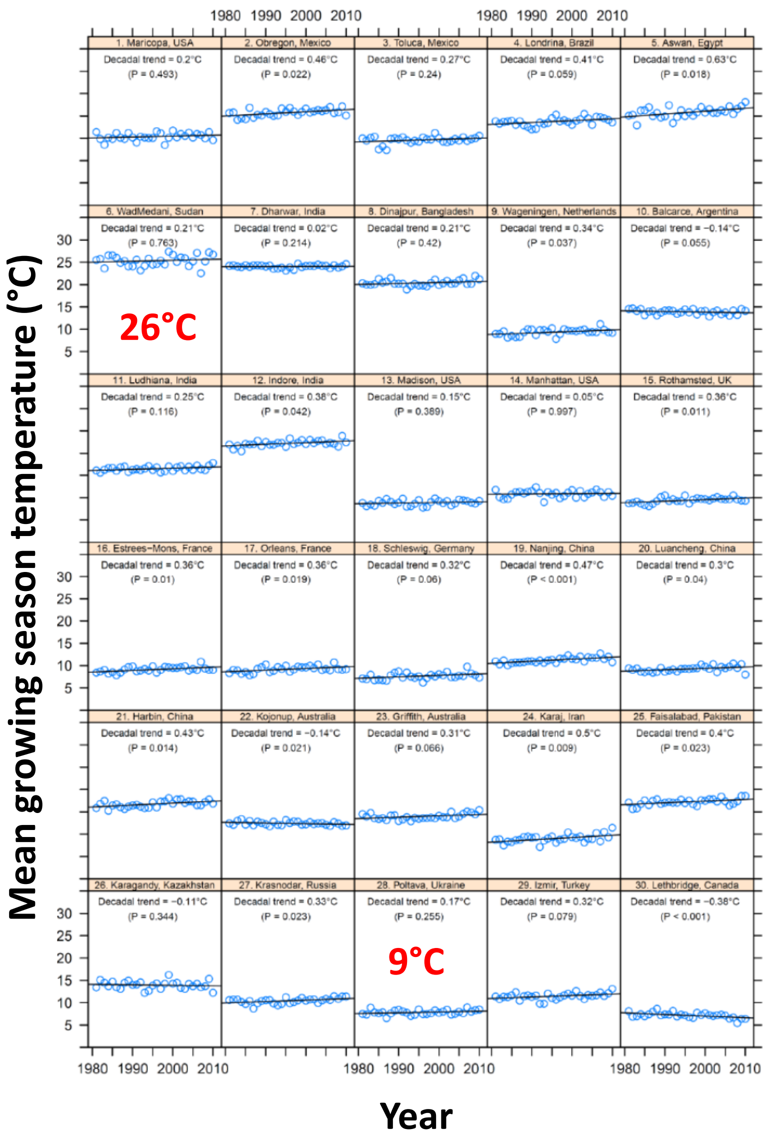
Propagation of model improvements

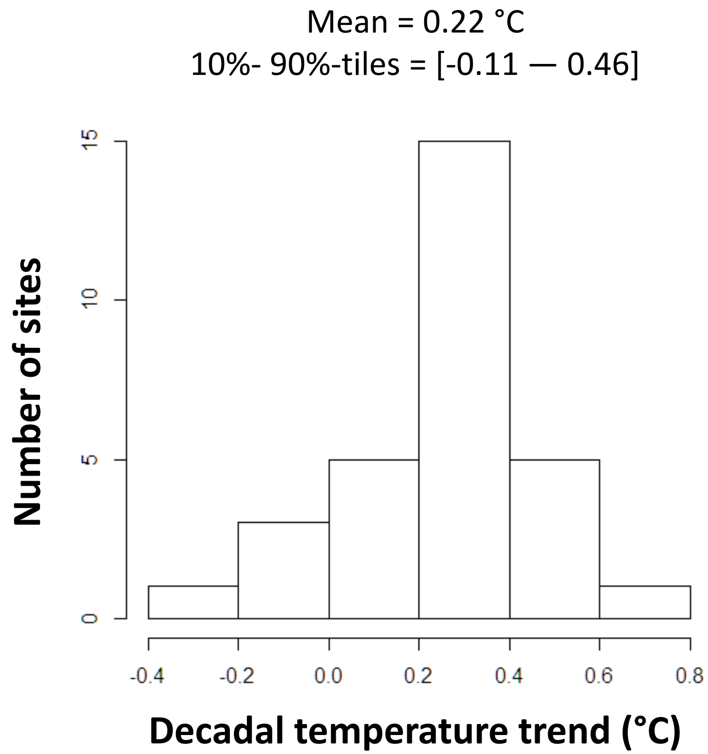
Removed unpublished AgMIP Wheat Team

Can model improvement reduce the size of crop model ensembles?

Removed unpublished AgMIP Wheat Team

Temperature trends at 30 global irrigated or high rainfall wheat growing sites

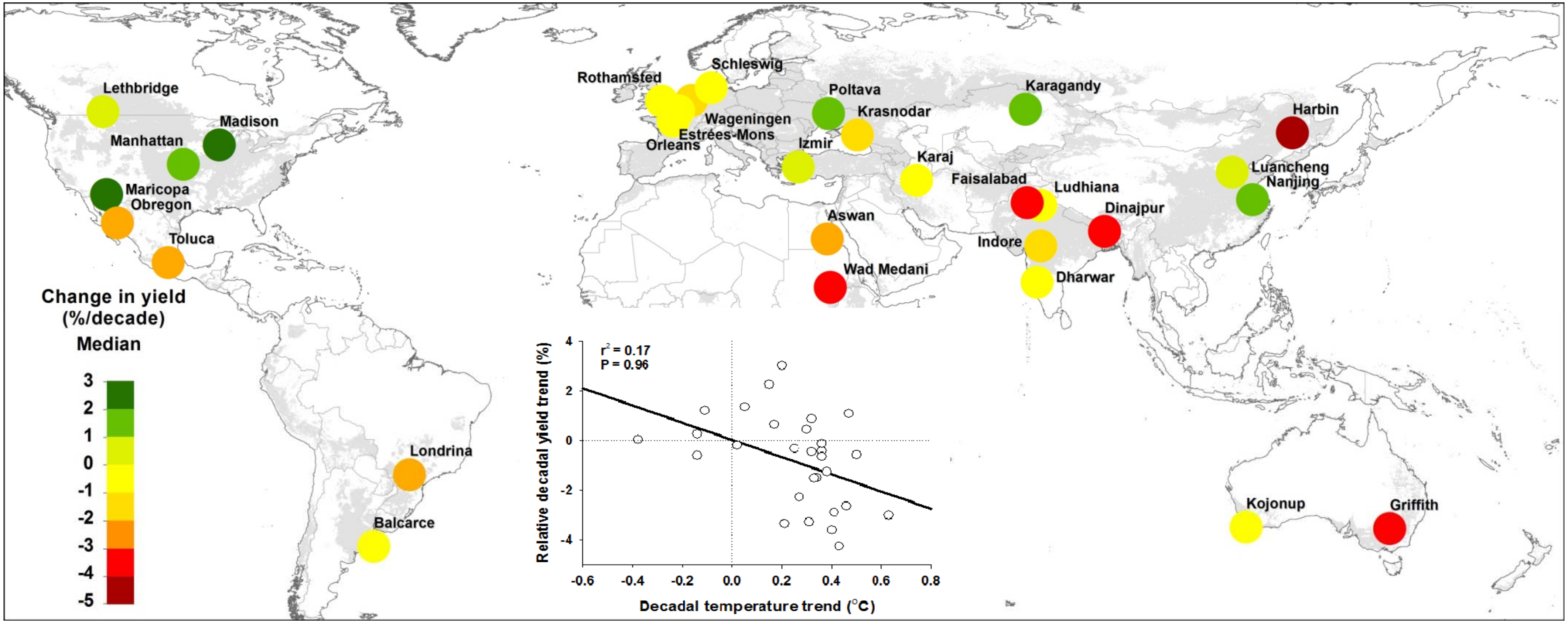




Asseng et al. 2015 Nature Climate Change

Past yield trends (1981-2010)

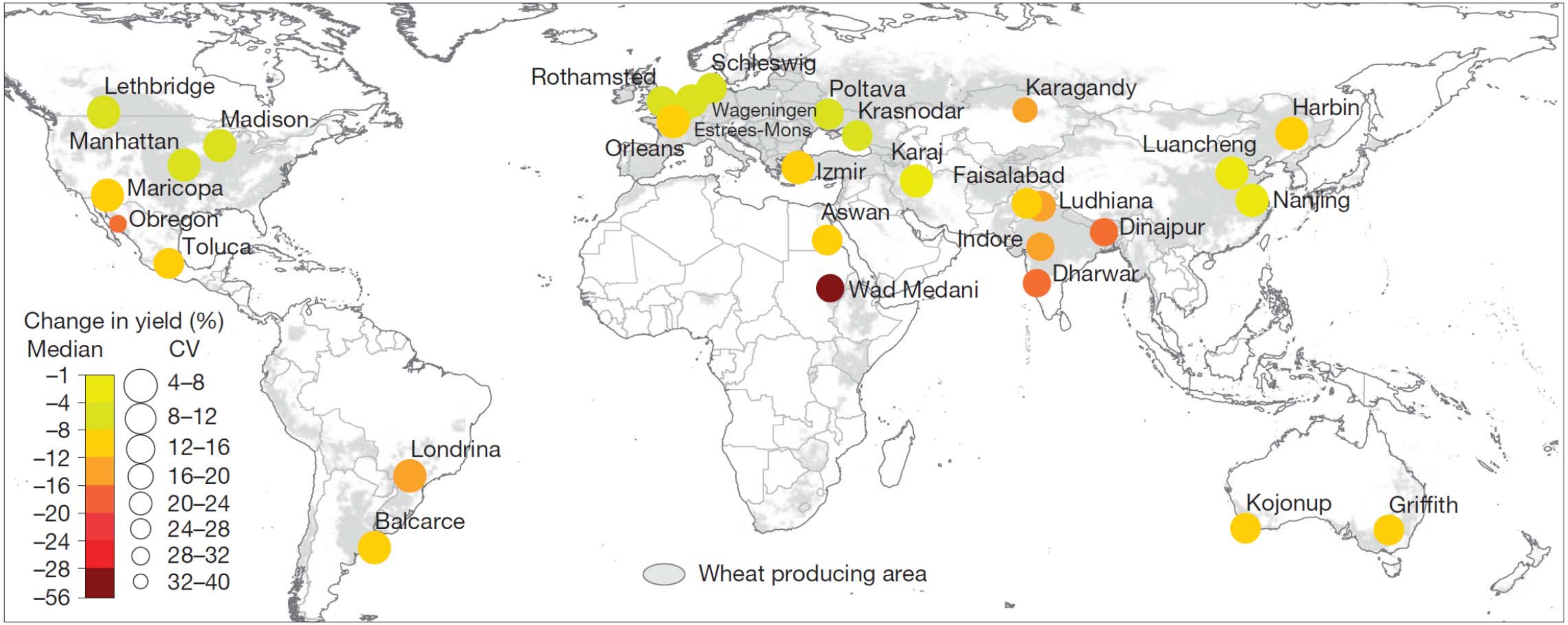
30 model ensemble median



Asseng et al. 2015 Nature Climate Change

Assessment of the global impact of temperature increase

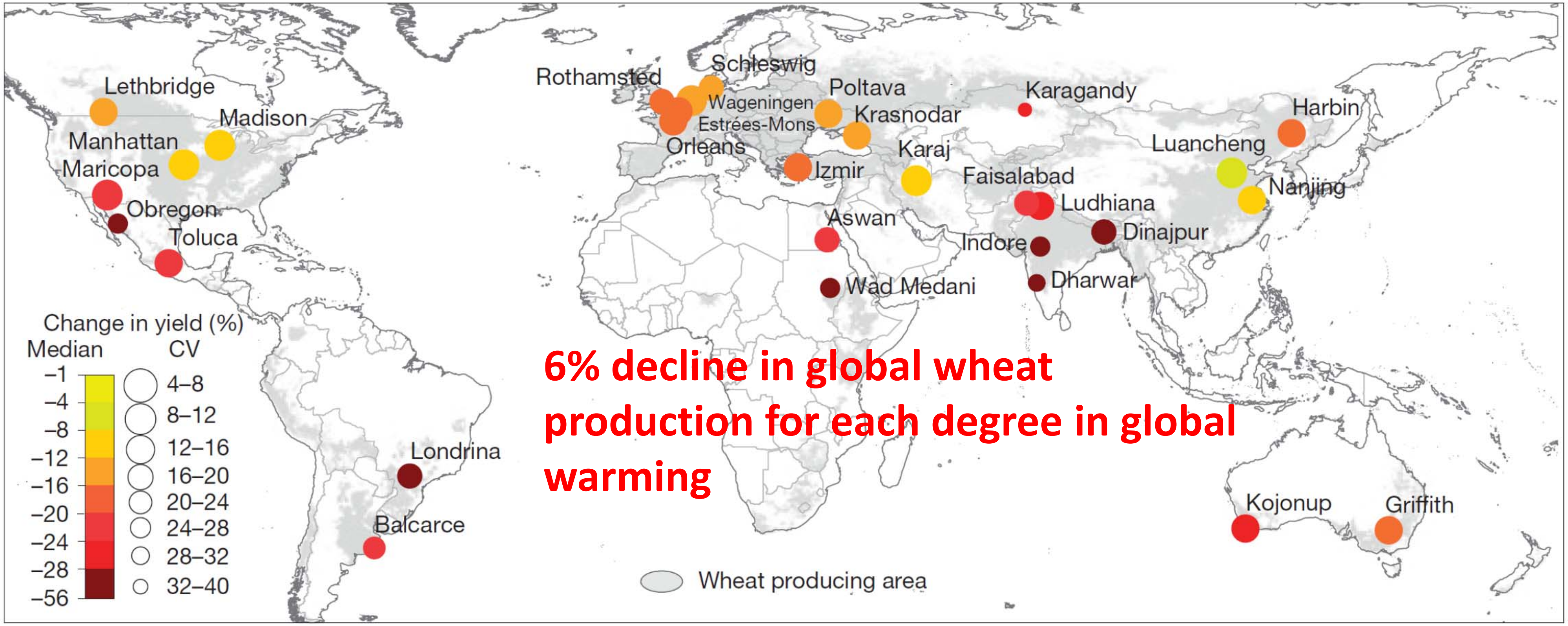
+2 °C temperature increase imposed on the 1981-2010 period



Asseng et al. 2015 Nature Climate Change

Assessment of the global impact of temperature increase

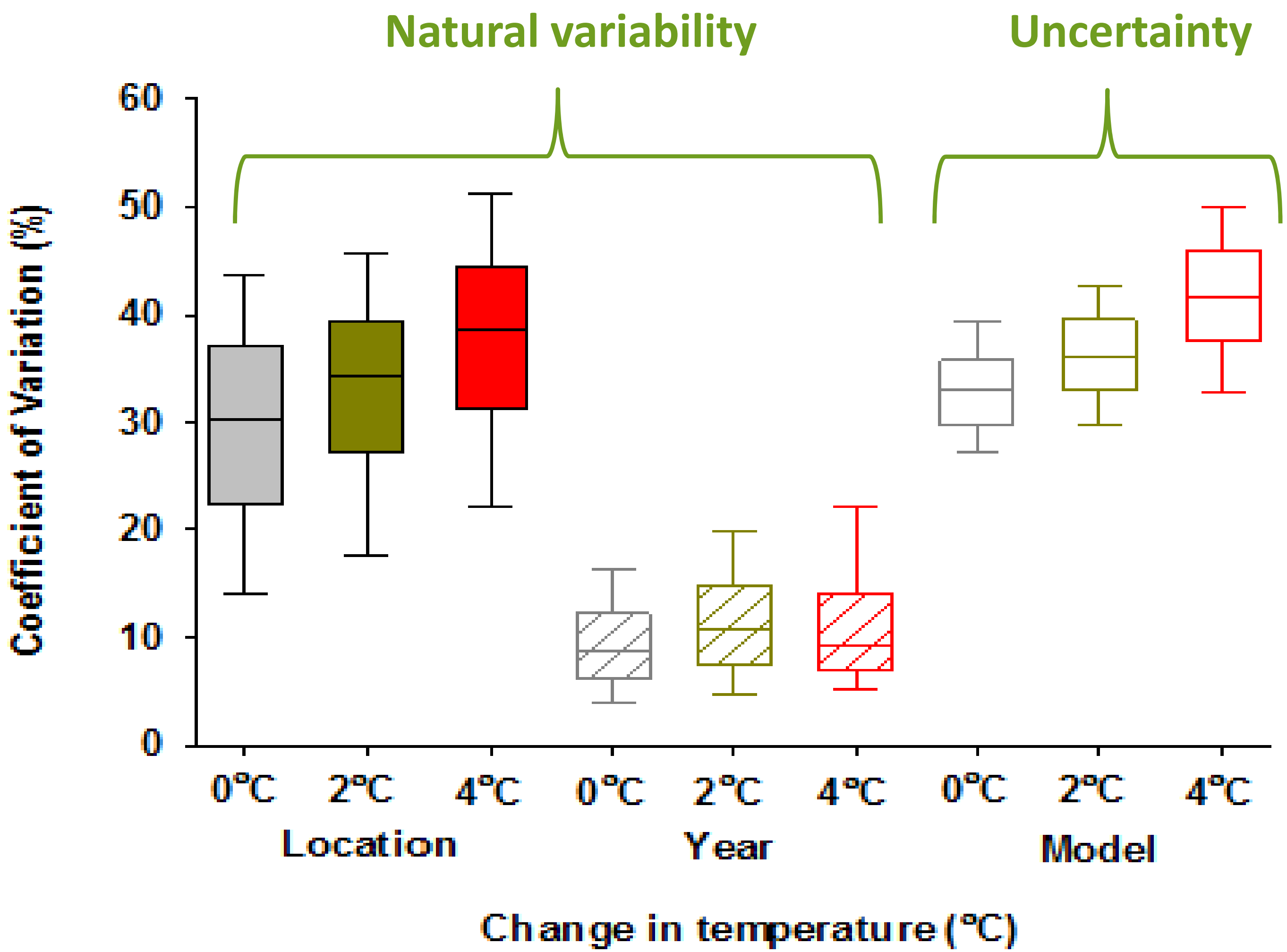
+4 °C temperature increase imposed on the 1981-2010 period



6% decline in global wheat production for each degree in global warming

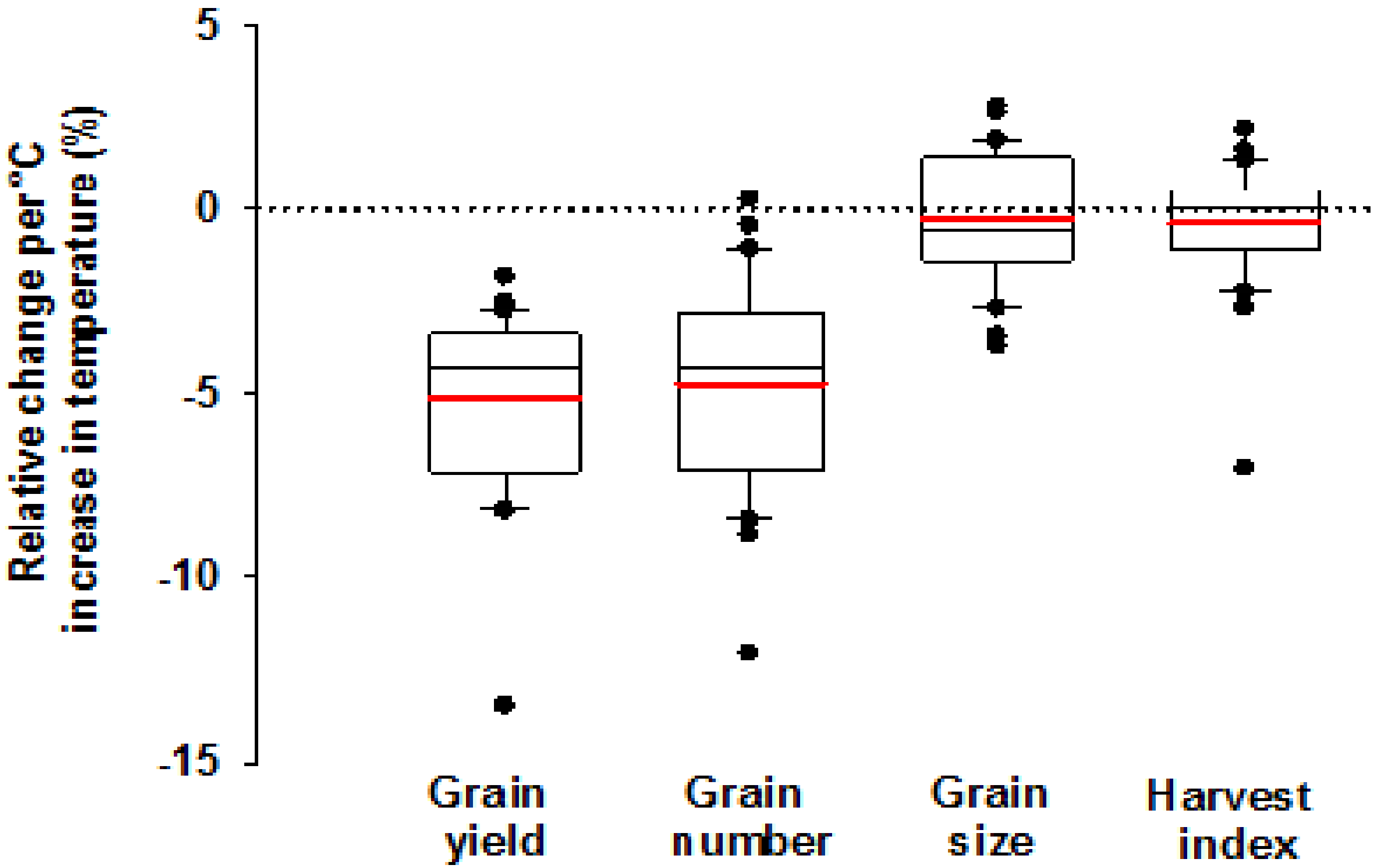
Asseng et al. 2015 Nature Climate Change

Natural variability vs. uncertainty



Asseng et al. 2015 Nature Climate Change

Components of yield change with increasing temperature

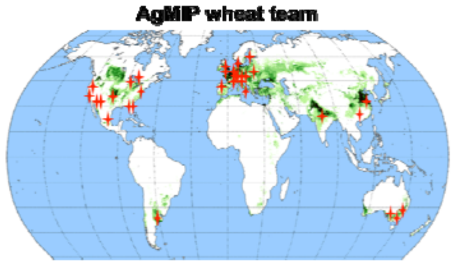


Asseng et al. 2015 Nature Climate Change

Conclusions

1. Many of the crop models can reproduce observed temperature response,
2. Yet the median of multi-model ensembles is consistently more accurate in simulating the crop temperature response than any single model.
3. Uncertainty in simulated grain yield shows a strong dependency on temperature.
4. Extrapolating the model ensemble temperature response (at current atmospheric [CO_2]) indicates that warming is already slowing yield gains at a majority of wheat-growing locations.
5. Global wheat production is estimated to fall by 6% for each °C of further temperature increase and to become more variable over space and time (at current atmospheric [CO_2]).
6. Model improvement can reduce the number of models required to reduce projection uncertainty

Publications



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nature climate change opinion & comment

doi:10.1038/nclimate2117

COMMENTARY: Making the most of climate impacts ensembles

Andy Challinor, Pierre Martre, Senthold Asseng, Philip Thornton and Frank

Global Change Biology

Global Change Biology (2014), doi:10.1111/gcb.12768

Multimodel ensembles of wheat growth: many models are better than one

Pierre Martre, Daniel Wallach, Senthold Asseng, Frank Ewert, James W. Jones, Reimund P. Rötter, Kenneth J. Boote, Alex C. Ruane, Peter J. Thorburn, Davide Cammarano, Jerry L. Hatfield, Cynthia Rosenzweig, Pramod K. Aggarwal, Carlos Angulo, Bruno Basso, Patrick Bertuzzi, Christian Biernath, Nadine Brisson, Andrew J. Challinor, Jordi Doltra, Sebastian Gayler, Richie Goldberg, Robert F. Grant, Lee Heng, Josh Hooker, Leslie A. Hunt, Joachim Ingwersen, Roberto C. Izaurralde, Kurt Christian Kersebaum, Christoph Müller, Soora Naresh Kumar, Claas Nendel, Garry O'leary, Jørgen E. Olesen, Tom M. Osborne, Taru Palosuo, Eckart Priesack, Dominique Ripoche, Mikhail A. Semenov, Iurii Shcherbak, Pasquale Steduto, Claudio O. Stöckle, Pierre Stratonovitch, Thilo Streck, Iwan Supit, Fulu Tao, Maria Travasso, Katharina Waha, Jeffrey W. White and Joost Wolf

Proceedings

of the Workshop **Modeling Wheat Response to High Temperature**

PD Alderman, E Quilligan, S Asseng, F Ewert and MP Reynolds (Editors)

CIMMYT, El Batan, Texcoco, Mexico
June 1921, 2013

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nature climate change LETTERS
PUBLISHED ONLINE: 22 DECEMBER 2014 | DOI: 10.1038/NCLIMATE2470

Rising temperatures reduce global wheat production

S. Asseng, F. Ewert, P. Martre, R. P. Rötter, D. B. Lobell, D. Cammarano, B. A. Kimball, M. J. Ottman, G. W. Wall, J. W. White, M. P. Reynolds, P. D. Alderman, P. V. V. Prasad, P. K. Aggarwal, J. Anothai, B. Basso, C. Biernath, A. J. Challinor, G. De Sanctis, J. Doltra, E. Fereres, M. Garcia-Vila, S. Gayler, G. Hoogenboom, L. A. Hunt, R. C. Izaurralde, M. Jabloun, C. D. Jones, K. C. Kersebaum, A-K. Koehler, C. Müller, S. Naresh Kumar, C. Nendel, G. O'Leary, J. E. Olesen, T. Palosuo, E. Priesack, E. Eyshi Rezaei, A. C. Ruane, M. A. Semenov, I. Shcherbak, C. Stöckle, P. Stratonovitch, T. Streck, I. Supit, F. Tao, P. J. Thorburn, K. Waha, E. Wang, D. Wallach, J. Wolf, Z. Zhao & Y. Zhu

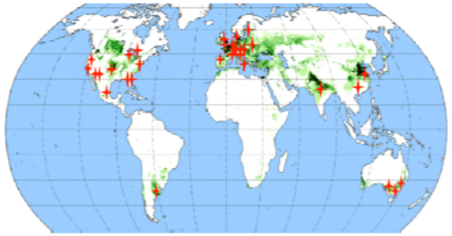
Global Change Biology

Global Change Biology (2014), doi:10.1111/gcb.12830

Response of wheat growth, grain yield and water use to elevated CO_2 under a Free Air CO_2 Enrichment (FACE) experiment and modelling in a semi-arid environment

O'Leary G.J, Christy B, Nuttall J, Huth N, Cammarano D, Stöckle C, Basso B, Shcherbak I, Fitzgerald G, Luo Q, Farre-Codina I, Palta J, Asseng S.

AgMIP wheat team



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