

# Soil moisture stress JPEG

Update at JULES  
meeting  
23 July 2019  
Edinburgh

Anna Harper, Karina  
Williams and ...



Kirsty Ashworth, Beena Balan Sarojini, Cleiton Breder Eller, Eleanor Blyth, Penny Boorman, Patrick Bunker, Manoel Cardoso, Aline Castro, Peter Cox, Martin De Kauwe, Chetan Deva, Imtiaz Dharssi, Pete Falloon, Pierre Friedlingstein, Sebastien Garrigues, David Galbraith, Nicola Gedney, Breogan Gomez, Kate Halladay, Phil Harris, Garry Hayman, Debbie Hemming, Chris Huntingford, Chris Jones, Gillian Kay, Doug Kelley, Rob King, Daijun Liu, Camilla Mathison, Toby Marthews, Lina Mercado, Catherine Morfopoulos, Rodolfo Nobrega, Fred Otu-Larbi, Divya Pandey, Ewan Pinnington, Colin Prentice, Tristan Quaife, Eddy Robertson, Rafael Rosolem, Lucy Rowland, Heather Rumbold, Alistair Sellar, Darren Slevin, Mei Sun Yee, Anne Verhoef, Pier Luigi Vidale, Andy Wiltshire, Stephanie Woodward, Azin Wright, Yangang Xing

# What have we accomplished?

- Some papers being written, in review, or published
- New options in JULES for diagnosing and representing soil moisture stress
- Useful evaluation suite
- Connections made across projects and institutions
- Learning how soil moisture stress affects vegetation across a variety of ecosystems
- <https://code.metoffice.gov.uk/trac/jules/wiki/UKESMPEGSoilMoistureStressVegetation>



Happy birthday to us

# Papers related to the SMStress JPEG

- **Stomatal optimisation based on xylem hydraulics can predict leaf and ecosystem responses to climate around the globe** by Cleiton Eller et al. (in review)
- **Disentangling causes and effects of soil moisture stress in JULES** by Harper et al. (in prep)

## **Revisiting the First ISLSCP Field Experiment to evaluate water stress in JULESv5.0**

Karina E Williams<sup>1</sup>, Anna B Harper<sup>2</sup>, Chris Huntingford<sup>3</sup>, Lina M Mercado<sup>3,4</sup>, Camilla T Mathison<sup>1</sup>, Pete D Falloon<sup>1</sup>, Peter M Cox<sup>2</sup>, and Joon Kim<sup>5,6</sup>



## **Developing a sequential cropping capability in the JULESvn5.2 land-surface model**

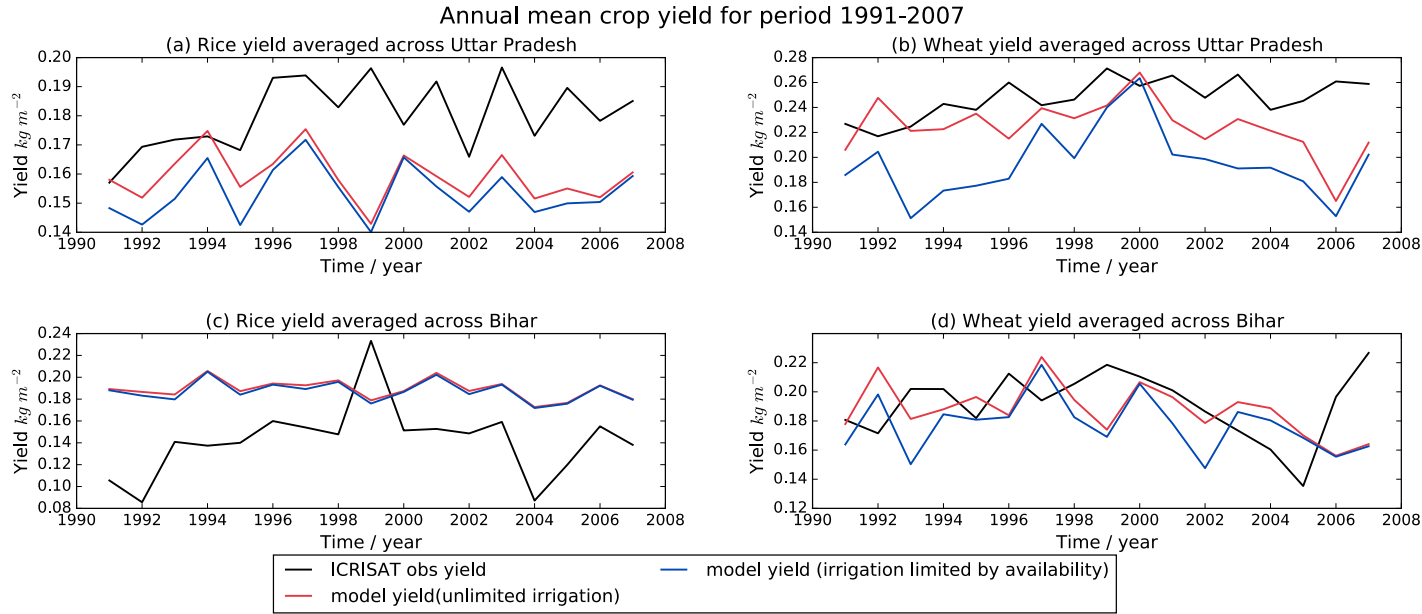
Camilla Mathison<sup>1,2</sup>, Andrew J Challinor<sup>2</sup>, Chetan Deva<sup>2</sup>, Pete Falloon<sup>1</sup>, Sébastien Garrigues<sup>3,4</sup>, Sophie Moulin<sup>3,4</sup>, Karina Williams<sup>1</sup>, and Andy Wiltshire<sup>1</sup>

# Developing a sequential cropping capability in the JULESv5.2 land-surface model

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- Soil moisture stress affecting wheat yields in Uttar Pradesh but not Bihar
- Paper also evaluates Avignon (JULES golden site)



Wheat (not in India)

# Revisiting the First ISLSCP Field Experiment to evaluate water stress in JULESv5.0

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- Using a historic data set to diagnose stressed and unstressed GPP and latent heat fluxes.
- FIFE is a JULES golden site (located in Konza prairie, Flint Hills, Kansas)
- Original site for JULES SM stress parameterization (Cox et al. 1998)

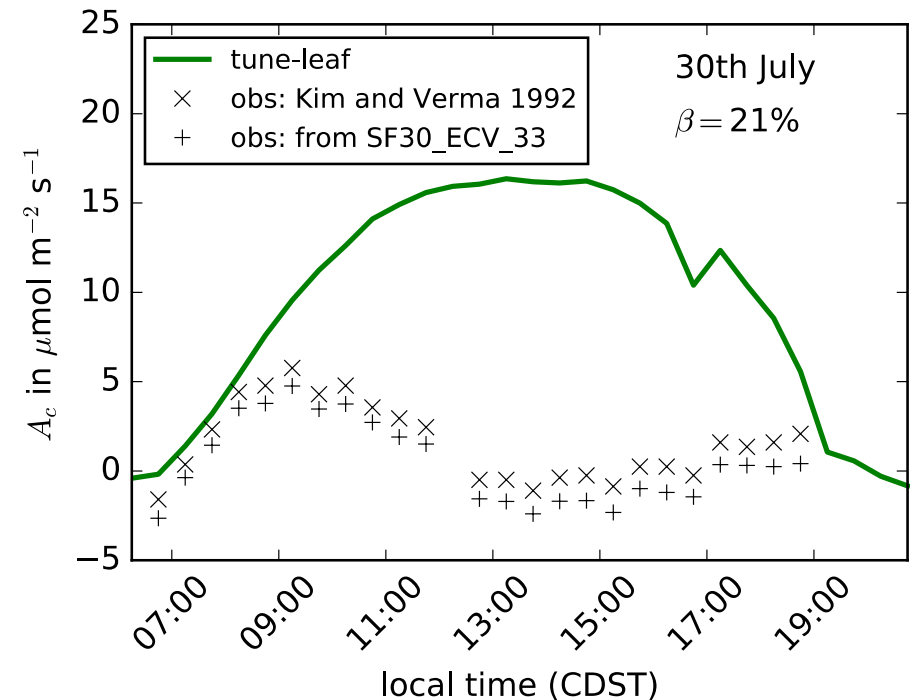
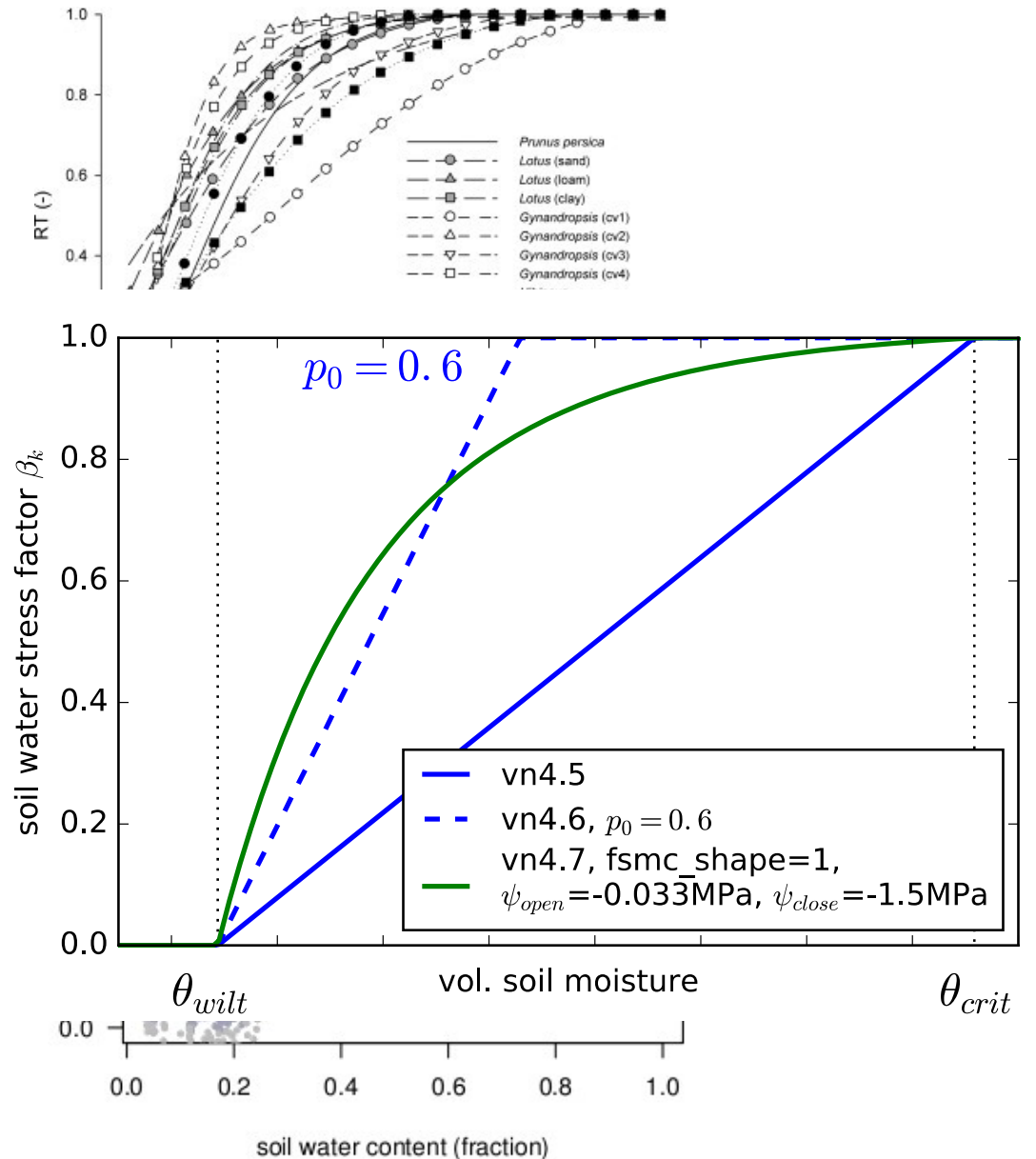


Photo of actual Kansas prairie: <https://kpbs.konza.k-state.edu/>

# New options

- $\beta$  can be linear in soil potential instead of vol. soil moisture
- Parameters  $\psi_{open}$  and  $\psi_{close}$  are PFT-dependent.
- $\psi_{open}=0.0$  reduces to the approximation used in Sinclair et al 2005.



# Fluxnet evaluation suite (u-al752)

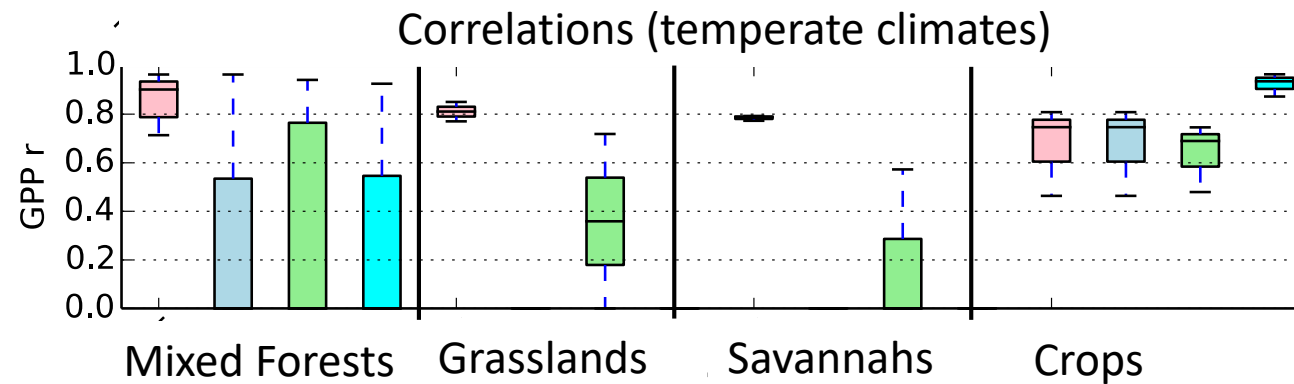
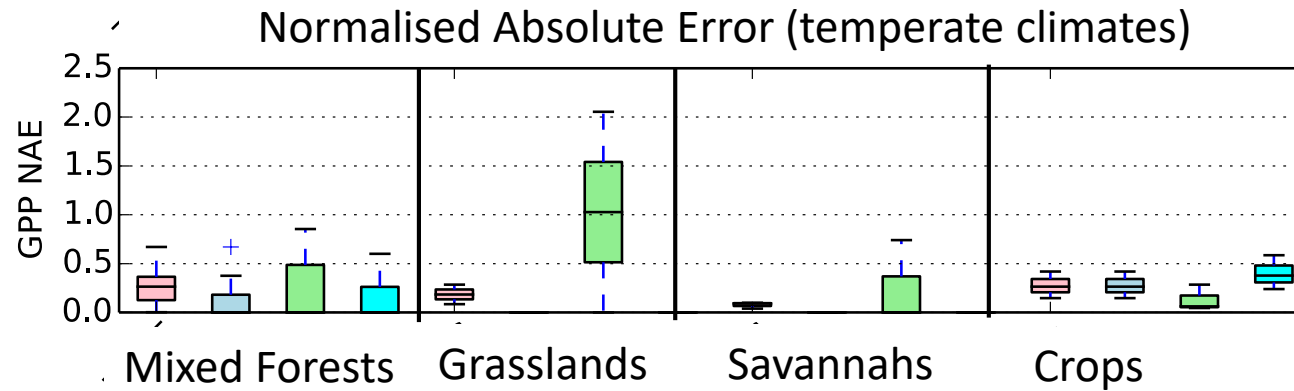
- Community effort to continually update and add to a Fluxnet suite (P. McGuire, K. Williams, A. Harper)
- Updates will include some plotting routines, evaluation tools and statistics
- Lots of applications and hopefully easy to use for new users or for evaluating developments (e.g. Rob King, Azin Wright, Cleiton Eller, Garry Hayman)



Photo by: aluarts / Flickr

# Developments for u-al752

Group sites by climate and biome to calculate mean stats (example shown for temperate climates)



Pink=All sites, default

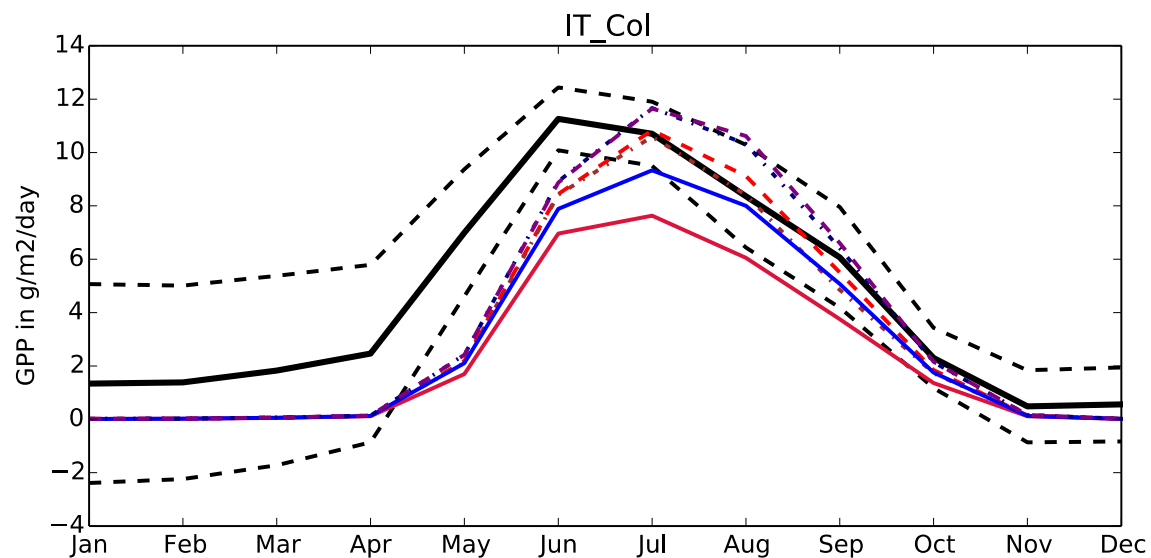
Light Blue=Default, only sites with prescribed SM & LAI

Green=Prescribed soil moisture

Cyan=Prescribed SM & LAI

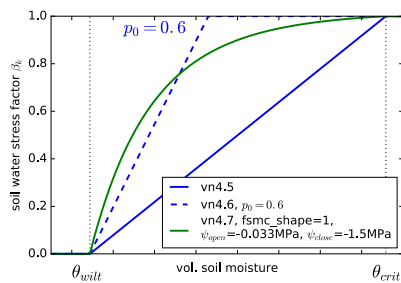


# Developments for u-al752

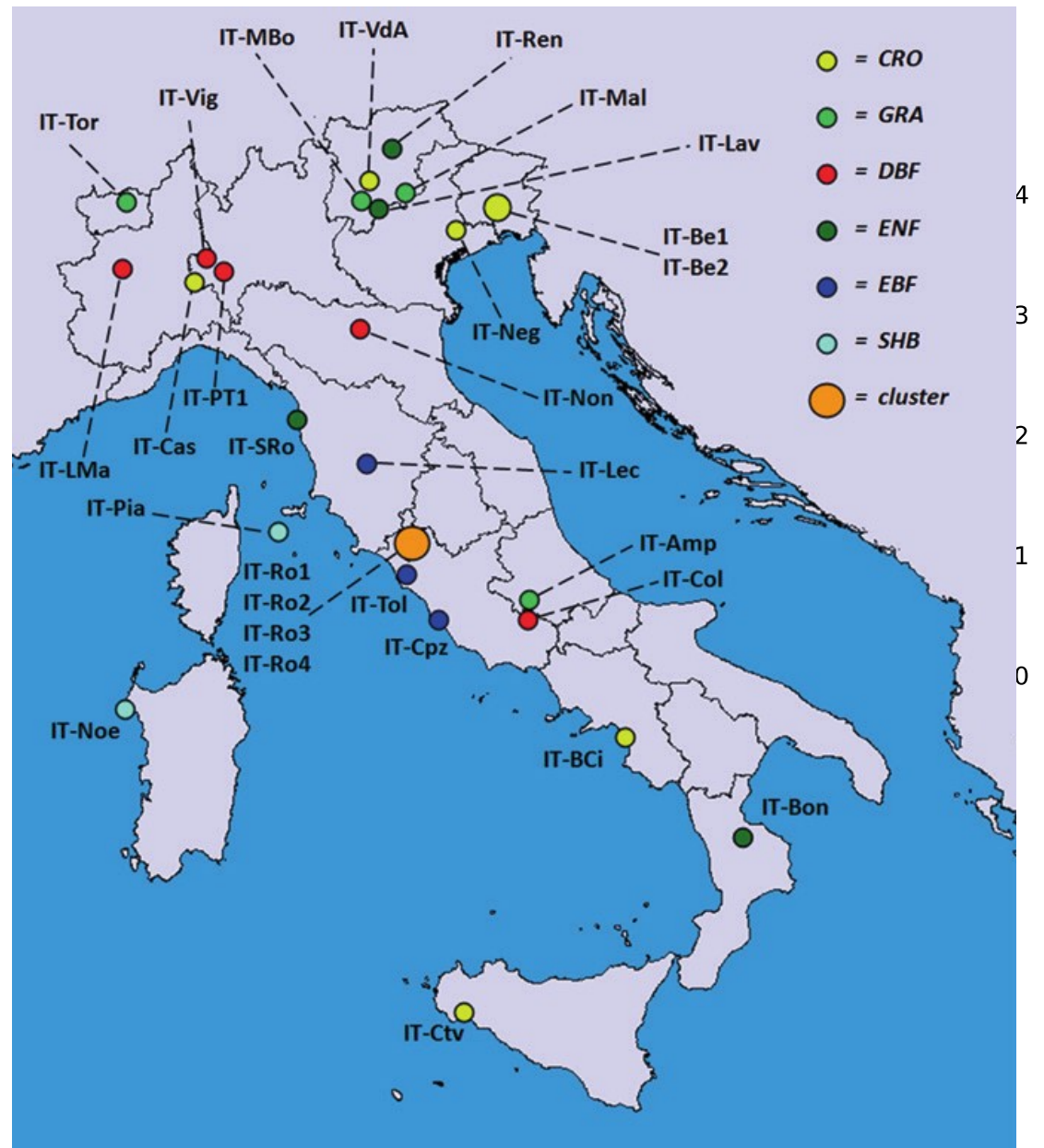


Example: IT-Col, deciduous broadleaf in Italy. Obs in black with dashed black lines showing  $\pm 1 \sigma$

- obs
- default
- psi
- - p0
- soil14
- soil14\_psi



Soil14 = 14 layer soil to 10.8m



# Linking with other projects: AgMIP

- AgMIP evapotranspiration study. Round 1: 29 maize models compared against eddy covariance ET measurements (including JULES) (Kimball et al. 2019, Agric. For. Met.)
- Round2 will use data from Mead, Nebraska (currently one of the sites identified as a JULES golden site) and Bushland, Texas.
- This MIP is a good opportunity to learn from the agricultural modelling community about how we can improve drought stress in JULES for crops

# Linking with other projects

- Links with vegetation dynamics (Doug Kelley)
- CSSP Brazil and CSSP China: contributing to Fluxnet evaluation, long-term drought effects.
- Nordeste project
- Andy Cunliffe (Exeter, DRIVING-C NERC project): dryland carbon dynamics, US Southwest. Has ~20 locations, most not in FLUXNET2015 product.



Dryland ecosystem in Utah

# Lessons learned?

- Being in a group has strengthened our analyses, given us access to data sets we wouldn't have known about otherwise, and created a collaborative community to address this problem
- Tools used by the community



# What is next?

- Consolidate our findings in upcoming papers
- Build upon standard configurations to run tests with new options (Sinclair model, SOX) and develop recommendations for future configurations (eventually)
- Continue collaborative spirit so we can be more than the sum of our parts
- <https://code.metoffice.gov.uk/trac/jules/wiki/UKESMPEGSoilMoistureStressVegetation>



Happy birthday to us

Thank you  
Questions?

# A few references

- Cox, P. M., Huntingford, C., and Harding, R. J.: A canopy conductance and photosynthesis model for use in a GCM land surface scheme, *Journal of Hydrology*, 212-213, 79–94, [https://doi.org/10.1016/s0022-1694\(98\)00203-0](https://doi.org/10.1016/s0022-1694(98)00203-0), 1998.
- Mathison, C., Challinor, A. J., Deva, C., Falloon, P., Garrigues, S., Moulin, S., Williams, K., and Wiltshire, A.: Developing a sequential cropping capability in the JULESv5.2 land–surface model, *Geosci. Model Dev. Discuss.*, <https://doi.org/10.5194/gmd-2019-85>, in review, 2019.
- Papale, D. et al. (2015) Chapter 2 Carbon, Water and Energy Fluxes of Terrestrial Ecosystems in Italy in: R. Valentini and F. Miglietta (eds.), *The Greenhouse Gas Balance of Italy*, Environmental Science and Engineering, DOI 10.1007/978-3-642-32424-6\_2
- Williams, K. E., Harper, A. B., Huntingford, C., Mercado, L. M., Mathison, C. T., Falloon, P. D., Cox, P. M., and Kim, J.: Revisiting the First ISLSCP Field Experiment to evaluate water stress in JULESv5.0, *Geosci. Model Dev. Discuss.*, <https://doi.org/10.5194/gmd-2018-210>, in review, 2018.

- Documenting and evaluating the current representation using site observations → paper in prep.
- Rose suites shared across the group, including evaluation software.
- Sensitivity studies (global and regional, online and offline).
- Investigating and evaluating model extensions e.g. SOX.
- Review of methods in other models.
- Changing soil depth and root distribution at the Amazon sites.
- Diagnosing stress from satellite obs: LST, Tair relations (Rob King, Phil Harris), sign of correlation between LST and ET (Gill Kaye)
- Where to apply the stress - stomatal, biochemical, mesophyll (Pier Luigi Vidale).
- Impact of uncertainties in soil moisture, LAI and precip measurements
- Impact of different methods for calculating soil properties.