Tyndall°Centre
for Climate Change Research

University of East Anglia

Briefing Note

May 2018

# Risks associated with global warming of 1.5°C or 2°C

This Briefing Note summarises research examining the risks associated with global warming of 1.5°C and 2°C funded by the UK department for Business, Energy and Industrial Strategy (BEIS) undertaken by researchers at the Tyndall Centre.

Global carbon emissions from fossil fuel burning, which reached an all-time high in 2017 after being nearly constant during 2014-2016, need to peak imminently and decline rapidly to have any possibility of achieving the Paris commitment of limiting warming to well below 2°C. The current pledges under the Paris agreement are insufficient to limit global mean temperature increases relative to pre-industrial levels to well below 2°C. Instead global mean surface temperatures will probably increase by around 3°C, or more.

The Tyndall Centre has explored the risks associated with emission pathways from the IMAGE model (Stehfest et al. 2014) that limit warming to 1.5 or 2C by 2100. In particular, these scenarios consider the range of climate sensitivities inherent in alternative global circulation models and provide 66% confidence (in terms of, 66% of the models) that the temperature limits will not be exceeded during this century. The global temperature time series associated with these IMAGE scenarios are shown below, and these were used to

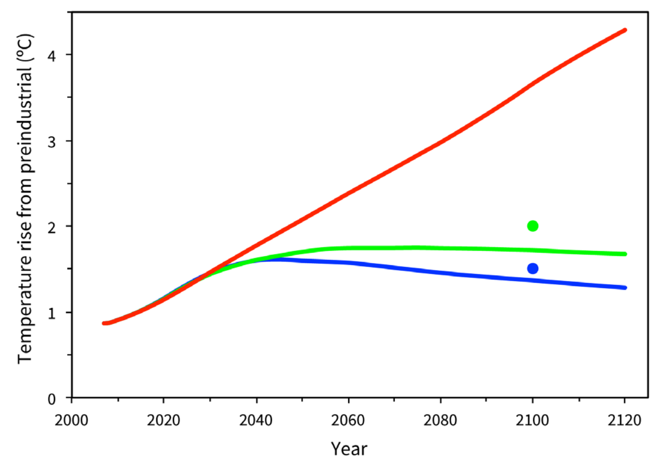
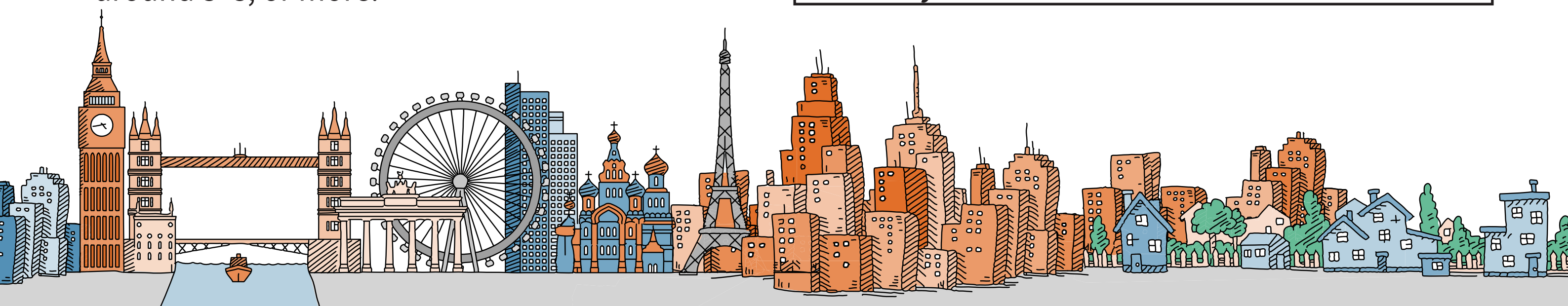



*Figure 1: Global temperature trajectories used in our study.*



derive regional climate change projections using a pattern scaling approach (Osborn et al. 2016) applied to a range of alternative global circulation model projections. Matching projections for sea level rise were also derived. Population projections from the SSP2 scenario that had been downscaled spatially were utilised (Jones & O'Neill,2016).

We then used a set of climate change impacts models to project the risks associated with these levels of warming, using both process based and empirical modelling approaches to assess risks to crop yields and the risks of human exposure to heat stress, disease vectors, water stress, fluvial and coastal flooding. Table 1 shows the models used. We also explored the economic implications of these scenarios using the PAGE09 integrated assessment model (Hope 2013).

Limiting warming to 1.5°C rather than 2°C would reduce the exposure of millions of people to drought, heat stress and water scarcity, fluvial flooding, and exposure to dengue infection. It would avoid the loss of thousands of square km to sea level rise and would avoid several reductions in crop yields of several percentage points. Losses in 2100 relative to the observed 1961-1990 climate for temperature changes of 3.7oC, 2oC and 1.5oC are projected to be (i) 13%, 5.1% and 3.7%, for crop yields; (ii) 146.0, 40.6, and 22.5 millions of people affected by 100-year fluvial flooding events; and (iii) 2870.7, 1316.3, and 969.5 millions of people at risk from drought (1.5 SPEI 12 event) in any given month. The economic benefits of limiting warming are also significant, with mean values of NPV of climate change induced damages (including market, non-market impacts, impacts due to sea level rise and impacts associated with large scale discontinuities) of 551, 69, and 54 trillion $ for NPV.

The distribution of benefits is not uniform, for example Figure 3 shows the distribution of the avoided reductions in crop yields.

Note: A journal publication is currently under review and if this is accepted and published, further details will be available therein.

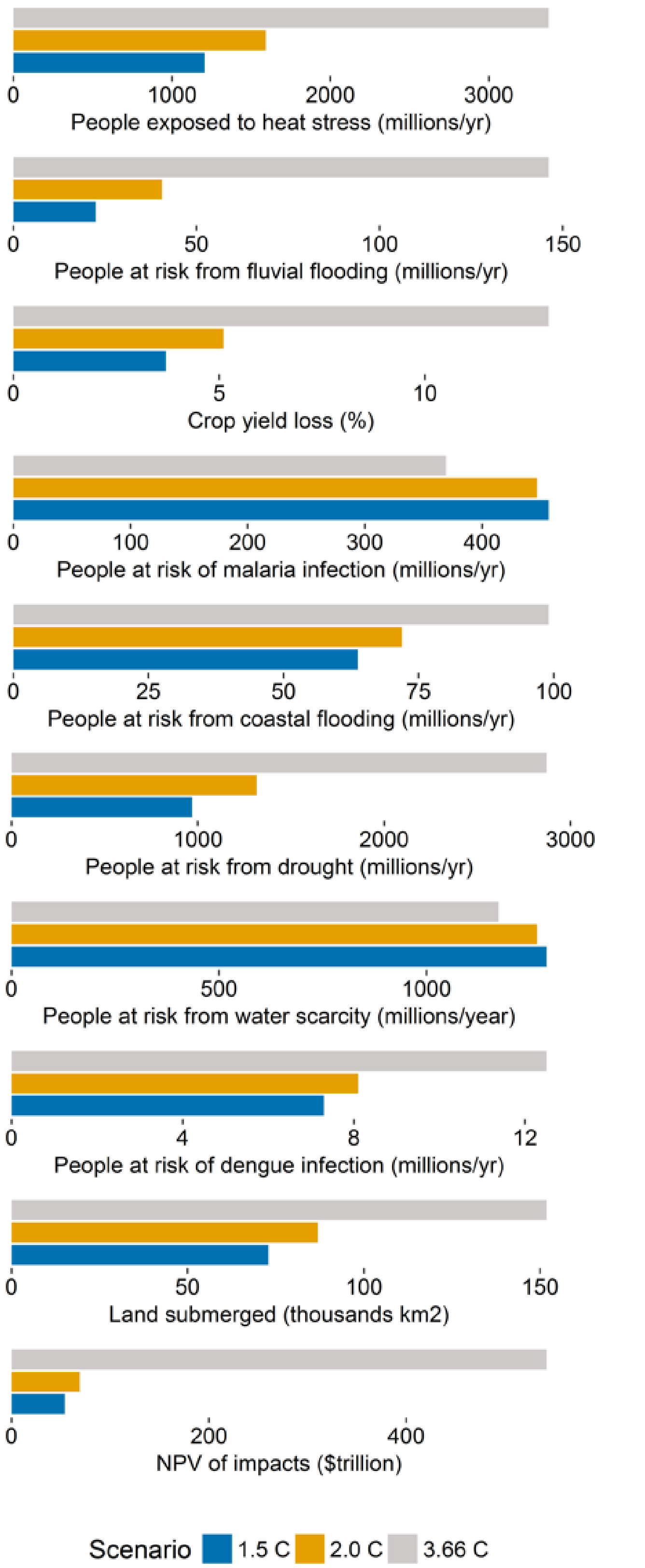



***Figure 2. Magnitude of projected risks at different levels of warming***

*Rachel Warren, Oliver Andrews, Sally Brown, Nicole Forstenhaeusler, David Gernaat, Phil Goodwin, Ian Harris, Helen He, Chris Hope, Felipe Gonzalez-Colon, Robert Nicholls, Tim Osborn, Jeff Price, Detlef Van Vuuren, Rebecca Wright*

## References


Stehfest, E., van Vuuren, D., Bouwman, L. & Kram, T. Integrated assessment of global environmental change with IMAGE 3.0: Model description and policy applications. (Netherlands Environmental Assessment Agency (PBL), 2014).

Osborn, T. J., Wallace, C. J., Harris, I. C. & Melvin, T. M. Pattern scaling using ClimGen: monthly-resolution future climate scenarios including changes in the variability of precipitation. Clim. Change 134, 353–369 (2016).

Jones, B. & O'Neill, B. C. Spatially explicit global population scenarios consistent with the Shared Socioeconomic Pathways. Environ. Res. Lett. 11, 084003 (2016).

Hope, C. Critical issues for the calculation of the social cost of CO2: why the estimates from PAGE09 are higher than those from PAGE2002. Clim. Change 117, 531–543 (2013).


This paper was funded by the UK Government, Department for Business, Energy and Industrial Strategy, as part of the Implications of global warming of 1.5°C and 2°C project.

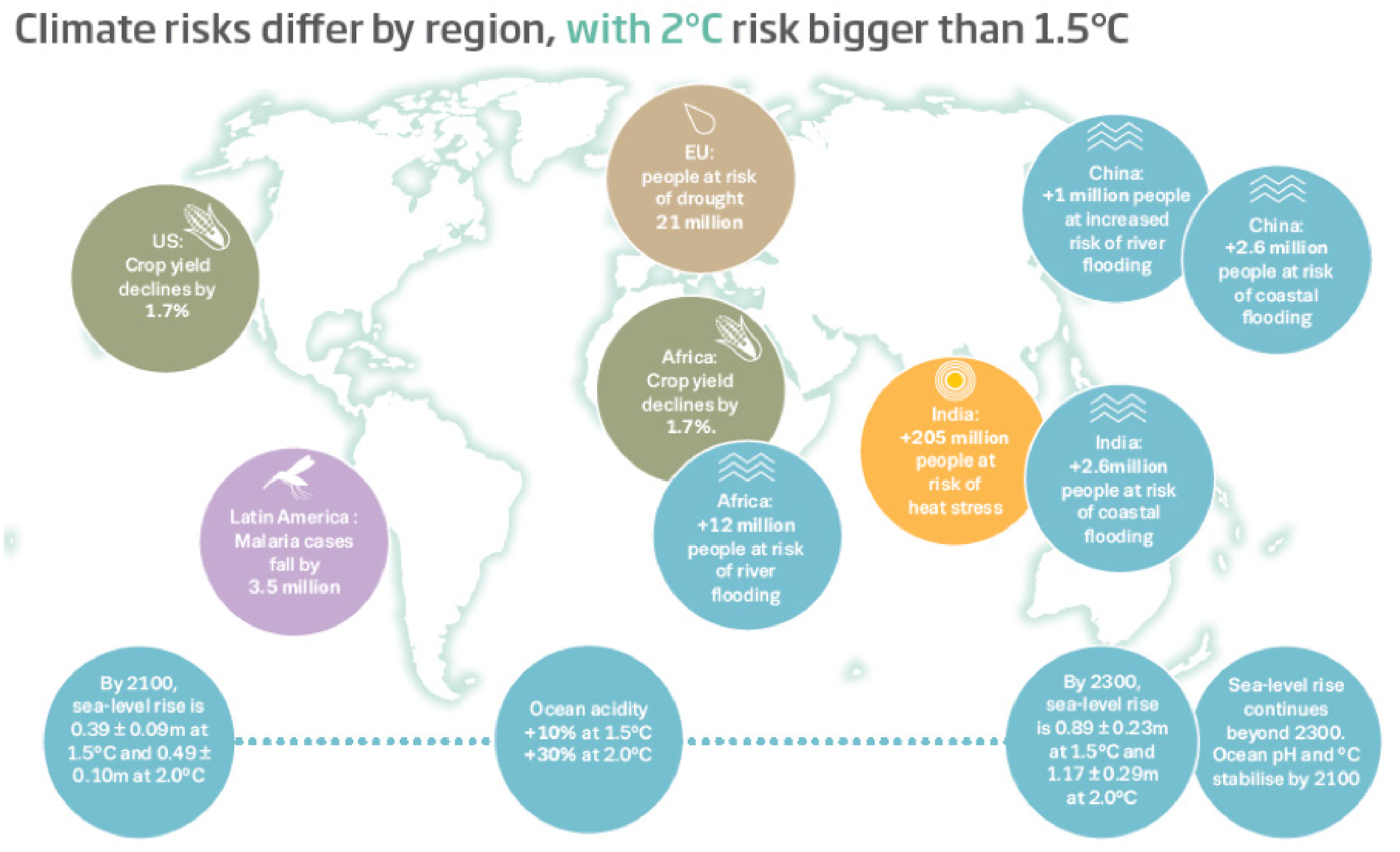



*Figure 3. Examples of salient regional risks avoided by limiting warming to 1.5°C and not 2°C.*

*Table 1: Models used in the risk assessment.*

| Risk assessed | Model name/Approach | Citation |
|---|---|---|
| Exposure to extreme heat | simplified Wet Bulb Globe Temperature | Kjellstrom, T., Kovats, R. S., Lloyd, S. J., Holt, T. & Tol, R. S. J. The Direct Impact of Climate Change on Regional Labor Productivity. Arch. Environ. Occup. Health 64, 217–227 (2009). |
| Exposure to drought | Standardised 202 Precipitation–Evapotranspiration Index | Vicente-Serrano, S. M., Beguería, S. & López-Moreno, J. I. A Multi-scalar Drought Index Sensitive to Global Warming: The Standardized Precipitation Evapotranspiration Index. J. Clim. 23, 1696–1718 (2009). |
| Exposure to water stress and fluvial flood | HBV (Hydrologiska Byråns Vattenbalansavdelning) and CaMa flood | Bergström, S. & Forsman, A. Development of a conceptual deterministic rainfall-runoff mode. Nord. Hydrol. 4, (1973), Yamazaki Dai, Kanae Shinjiro, Kim Hyungjun & Oki Taikan. A physically based description of floodplain inundation dynamics in a global river routing model. Water Resour. Res. 47, (2011). |
| Exposure to coastal flood | Dynamic Interactive Vulnerability Assessment (DIVA) model 349 (model 2.0.1 | Hinkel, J. et al. Coastal flood damage and adaptation costs under 21st century sea-level rise. Proc. Natl. Acad. Sci. 111, 3292 (2014). |
| Crop yield changes | Statistical crop yield models | Adapted from: Schlenker, W. & Lobell, D. B. Robust negative impacts of climate change on African agriculture. Environ. Res. Lett. 5, 014010 (2010). |
| Exposure to malaria infection | Vector-borne disease community model of the International Centre for Theoretical Physics, Trieste 332 (VECTRI) | Tompkins, A. M. & Ermert, V. A Regional-Scale, High Resolution Dynamical Malaria Model That Accounts for Population Density, Climate and Surface Hydrology. Malar J 12, 65 (2013). |
| Exposure to dengue infection | Dengue Statistical Model (DSM) | Colón-González, F., Fezzi, C., Lake, I. & Hunter, P. The Effects of Weather and Climate Change on Dengue. PLoS Negl Trop Dis 7, e2503 (2013). |
| Sea level rise | Warming, Acidification and Sea-level Projector (WASP) Earth system model | Goodwin, P., Haigh, I. D., Rohling, E. J. & Slangen, A. A new approach to projecting 21st century sea- level changes and extremes. Earths Future 5, 240–253 (2017). |