climate extremes

ARC centre of excellence

Australian Government
Australian Research Council

Research on heatwaves and droughts by the ARC Centre of Excellence for Climate Extremes supports a major international report on Climate Change and Land

ARC Centre Of Excellence for Climate Extremes Briefing Note 10

Research by the ARC Centre of Excellence for Climate Extremes has been highlighted in a major international report on Climate Change and Land by the Intergovernmental Panel on Climate Change.

Centre research quoted in the report shows the important influence of water in the soil on the severity of heatwaves and droughts but cautions that the climate models that underpin projections of future climate conditions do not give reliable simulations of these effects.

Ongoing work by the Centre with CSIRO and other national and international partners aims to improve how modelling techniques represent interactions between the atmosphere and the land, including soil moisture and vegetation.

What is the Intergovernmental Panel on Climate Change's Climate Change and Land report?

The Intergovernmental Panel on Climate Change (IPCC) is best known for its regular 5-yearly assessments of our knowledge of climate change, its impacts and options to manage risks and opportunities that arise from it. However, the IPCC also publishes special in-depth reports that assess our knowledge of more specific aspects of climate change. In August 2019, the IPCC released a special report on Climate Change and Land[1]. The report was prepared over 2 years by 107 leading international scientists, including Prof Jason Evans from the ARC Centre of Excellence for Climate Extremes. The report summarises the international science community's current knowledge of how climate change interacts with desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.

How does the report use research by the ARC Centre of Excellence for Climate Extremes?

A key point made by the report is that climate change can contribute to desertification and land degradation. Heat

waves and droughts are among the climate extremes that play a role in this. The report highlights that "warming has resulted in an increased frequency, intensity and duration of heat-related events, including heat waves in most land regions". Determining changes in drought is challenging due to difficulties related to how best to define drought, the availability and quality of rainfall records and isolating long-term changes from natural climate variations. Nonetheless, the report highlights that "the frequency and intensity of drought has increased in Amazonia, north-eastern Brazil, the Mediterranean, Patagonia, most of Africa and north-eastern China", though notes research showing that other regions have experienced decreases in the frequency and/or severity of drought. The report refers to research by the Centre of Excellence in discussing our ability to say how these extremes might change in the future.

How does Centre of Excellence research support the report's messages on heatwaves?

Climate change projections show extreme heat waves becoming more intense in many regions of the world in the future. These changes could potentially affect the land. However, the report also emphasises the effect that changes in land conditions can have on extreme heat. Research by the Centre of Excellence for Climate Extremes relates to a particular point that "drier soil conditions resulting from climate change can increase the severity of heat waves, while wetter soil conditions have the opposite effect (high confidence)". The Centre's research has helped to demonstrate the importance of

changes in the amount of water held in the soil to changes in heat waves (Donat et al. 2018)[2]. However, research by the Centre also shows that it is currently not possible to resolve exactly how large the influence of soil moisture on heat waves is. There are several reasons why this is a challenge, but the Centre's research highlights that the computer models of the climate system that underpin climate change projections are unable to adequately represent interactions between moisture in the soil and the atmosphere (Donat et al. 2018, Ukkola et al. 2018a)[2,3]. This problem limits how certain we can be about how large future changes in heat waves will be in different parts of the world.

How does Centre of Excellence research support the report's messages on drought?

On drought, the report stated that, globally-speaking, climate change is expected to increase the frequency and severity of droughts. However, research by the Centre of Excellence is quoted as warning that there is limited confidence in projections of future changes in drought, again due to limitations of the climate models. The Centre of Excellence is systematically evaluating the simulation of droughts by climate models. Results for 20 different climate models that have been used in recent drought projections are described in a Centre-led paper quoted by the report (Ukkola et al. 2018b)[4]. While the models broadly agree on the links between the behaviour of rainfall and drought risk, they disagree on how droughts influence the amount of water in soils, and river flows. This again suggests that the models are unable to adequately represent interactions between the land surface and the atmosphere.

What is the Centre of Excellence doing to overcome the current limitations of the science?

In addition to its work on evaluating climate models, the Centre of Excellence is undertaking research to develop a deep understanding of, and overcome, issues with current models and methods used to generate projections of future changes in heat waves and droughts. For example, a recent paper that the Centre has contributed to (Yang et al. 2019)[5] explains how some contemporary techniques are likely overestimating future increases in aridity by disregarding the response of plants to increasing atmospheric carbon dioxide concentrations. The paper demonstrates an alternative method that accounts for this. Work with CSIRO and other national and international partners to improve how climate models represent interactions between the atmosphere and the land surface is particularly relevant to heat extremes and drought. This work includes research on how to better represent soil moisture, how soil moisture responds to a lack of rainfall, how plants respond to low soil moisture and predicting whether plants will die during drought.

References

1. Intergovernmental Panel on Climate Change (2019) Climate Change and Land. https://www.ipcc.ch/report/srccl/

2. Donat, Pitman and Angélil (2018) Understanding and reducing future uncertainty in midlatitude daily heat extremes via land surface feedback constraints. Geophysical Research Letters. https://doi.org/10.1029/2018GL079128

3. Ukkola, Pitman, Donat, De Kauwe and Angélil (2018a) Evaluating the contribution of land-atmosphere coupling to heat extremes in CMIP5 models. Geophysical Research Letters. https://doi.org/10.1029/2018GL079102

4. Ukkola, Pitman, De Kauwe, Abramowitz, Herger, Evans and Decker (2018b) Evaluating CMIP5 model agreement for multiple drought metrics. Journal of Hydrometeorology. https://doi.org/10.1175/JHM-D-17-0099.1

5. Yang, Roderick, Zhang, McVicar and Donohue (2019) Hydrologic implications of vegetation response to elevated CO2 in climate projections. Nature Climate Change. https://doi.org/10.1038/s41558-018-0361-0

Ian Macadam, 4th November 2019