Essay 5

Expansion of the Tropics – Evidence and implications

Dr Joanne Isaac

Joanne Isaac is currently a post-doctoral researcher in the Centre for Tropical Biodiversity and Climate Change, at James Cook University in Townsville. She completed a PhD in the life history of brushtail possums in 2005, and has since undertaken a number of post-doctoral positions and also writes
Dr Joanne Isaac

There is accumulating evidence that the tropical zone is expanding poleward in both hemispheres, and that the subtropics are also expanding into regions which have previously enjoyed a more Mediterranean climate. This essay is a follow-up to an initial report by the same authors conducted in 2009; there has been considerable further work in this eld since 2009 and so we include up-to-date research, investigate how thinking has changed, or not, and whether predictions from ve years ago still hold true.

A poleward expansion of the tropical and subtropical zones is likely have signi cant consequences for a number of the issues raised in the State of the Tropics Report (2014), including the peoples of the Tropics, and for ecosystems and biodiversity.

For example, The State of the Tropics report highlights that the resources required to sustain larger populations and economic growth are putting signi cant pressures on the natural environment in tropical regions. An expansion of tropical regions will only increase these demands further, and may also cause a shift in ecosystems as some regions will become drier, and others may see more frequent heavy rain events.

The Report also highlights the fact that almost half the human population of the Tropics is vulnerable to water stress – a shift in climatic ate how)12acs otJ -mb.(2010(of)-20( )]TJ -0.02 Tw 0i[(at d54ahnu -0)19.9(others mayopics)a,meighbouring the subtropics could increase theothers mayopics of people wh

Furthermore, the State of the Tropics report nds

‘disproportionate share of the global burden of many communicable 12acsreventable diseases.’ An expansion of the tropical zone could increase the prevalence of many diseases, particularu -0 others mayopics ector-borne diseases, as more areas become climaticmb.(201suitable for insect ectors.

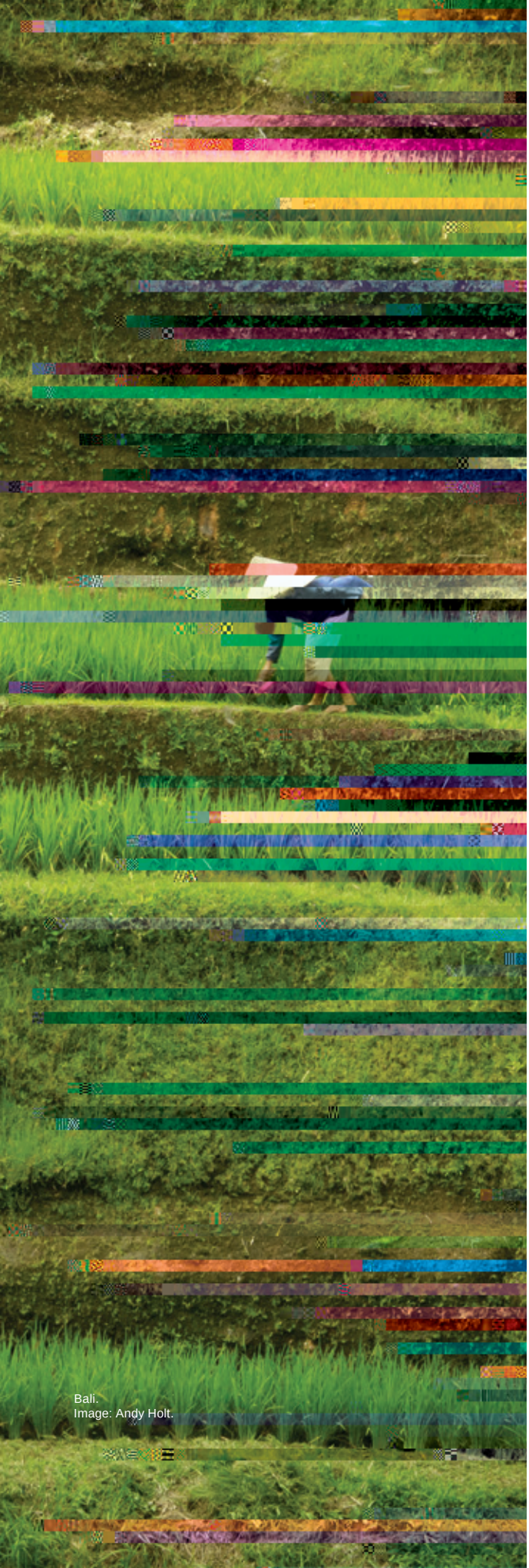
Introductionothers 0 0 0.8 k -0.02 Tw 8.5 0 0 8.5 208.9134 556.6713 Tm [(Climate)-20(
(GHGs) to unprecedented levels (IPCC 2014).
While some of the earliest signs of climate change included the warming of temperate regions a2a the melting of ice in the Arctic, a suite of studies have demonstrated signi cant impacts in tropical regions which are likel(2010(ofto be)20(dispr)12(oportionateu -0)19.9(otherT* [(affecte
Tropics, common.(201baseacon surface temperature a2acprecipitation patterns (Seidel et al. 2007).
Another, easi.(201tracked characteristic of the Tropics lies high above the Earth, at the boundary between the troposphere, the lowest layer of the earth’s atmosphere where weather systems form, and the stable stratosphere above it. This boundary is

in their Fourth Assessment Report (2007) stated that increases in greenhouse gases and associated changes in climate could lead to a variety of changes in atmospheric and climatic phenomenon, including warming of the troposphere, cooling of the stratosphere, rise of the tropopause and a weakening of tropical circulation patterns – all of which may contribute to an expansion of the tropical zone. Hu and Fu (2006) further suggested that an increase in sea surface temperatures (SST) in the Tropics, associated with climate change, could result in an increase in the height of the tropopause and a wider HC.

Since then, numerous studies con rm that the tropopause is indeed warming (revieirm that th bing y0(r)12horn]TJ 0 -1.235 TD [(tr)12(oper)1l. 2010),h climate TeaTJ 0 -1.235 TD [(tr)12(opsopause 2(ehum12(eahat7u

including ((036r9.91nge,str)12spher)12(e,)menures (SST (036rmn atmoTJ 0 Tw 0 -1.235 TD [(tr)12(ophe)65(T)50exer)-ical zone.Noggestn Hemi(e,)-19.9 Ttropelsew, r

a poleward shift which was predicted to lead to mid-latitude tropospheric warming and contribute to an increased frequency of droughts in both hemispheres (Fu et al. 2006; Seidel et al. 2008). Of particular concern under these predictions were regions bordering the subtropics which currently experience a temperate 'Mediterranean' climate, including heavily populated regions of southern Australia, southern Africa, the southern Europe-Mediterranean-Middle East region, the south-western United States, northern Mexico, and southern South America – all of which were predicted to experience severe drying (Seager et al. 2007; Seidel et al. 2008).



Bali.
Image: Andy Holt.

than the more widespread warming (Gong and Ho 2002, Hu et al. 2003, Fu et al. 2006). There is some evidence that the severe polar vortex affecting the north east USA - following drought in California - was in uenced by GHG emissions and poleward shifts in other climatic phenomena (Wang et al. 2014).

Shifts in tropical cyclone tracks and activity

In 2009, a number of climate scientists were predicting a poleward shift in the paths of extra-tropical and tropical cyclones over the next 100 years (Yin 2005; IPCC 2007; Walsh and Kafney 1999). However, others were arguing that increased vertical wind shear and upper tropospheric warming might negate some effects (e.g.: Vecchi and Soden 2007). Extra-tropical storms, also known as mid-latitude cyclones, occur within the mid-latitudinal band from around 30º to 60º latitude in both hemispheres and studies have documented a poleward shift in the mean latitude of extra-tropical cyclones, by about 2º, over the past 60 years (McCabe et al. 2001; Fyfe 2003).

More recent studies add observational support for a change in storm tracks; for example Bender et al. (2012) nd a poleward shift in extra-tropical storm tracks between 1983-2008, while Solman and Orlanski (2013) nd an enhancement of the frontal activity shifted to higher latitudes in the northern hemisphere. Similarly, ozone depletion has been associated with a poleward shift in cyclone frequency over the Southern Ocean, but with minimal in uence on intensity and lifetime (Grise et al. 2014). Signi cantly, a very recent study shows a poleward shift in the area of maximum intensity in cyclones in both the Northern and Southern hemispheres, of 53 and 62 km per decade respectively; equivalent to a shift of around 2.5º in latitude per 25 years (Kossin et al. 2014). Shifts in the behavior and tracks of cyclones in Australia have also been noted with tropical cyclone activity is currently at its lowest in Queensland and Weste Australia for many centuries (Haig et al. 2014). However, Haig et al. (2014) caution that while there will be fewer cyclones, cyclones that do hit will be of higher intensity.

The shifts in tropical storm tracks have been related to enhanced warming in the tropical upper troposphere and increased tropopause height (Yin 2005); there is also some evidence that the degree of shift is likely to be greater in the mid-latitudes of the southern hemisphere (IPCC 2007; Yin 2005). Predictions were for greater cyclonic activity at higher latitudes in both the tropical and mid-latitude bands (IPCC 2007), increasing ood risk in regions not prepared for extreme precipitation events.

A change in the activity and tracks of tropical cyclones has been noted in some regions. For example, tropical cyclone Gonu tracked unusually far to the northwest into the Gulf of Oman in 2007, hitting landfall in Oman and Iran, a region with no known records of having been hit by a cyclone (WMO 2008). Similarly, in Asia there has been a signi cant westward shift in typhoon (cyclone) tracks over the past 40 years, resulting in greater storm activity in subtropical East Asia but a decline in typhoons over the South China Sea. 2004 saw a record number of storms hit Japan, while South China faced drought due to a lack of land falling typhoons, and the authors suggest this shift is related to the westward movement of the WPSH (Wu et al. 2005).

More recent studies highlight further changes in cyclone activity; black carbon and other aerosols have been implicated in causing intensi cation of cyclones in the Arabian Sea region, with signi cant impacts expected for human health (Evan et al. 2011). In Taiwan, cyclone frequency has almost doubled since 2000, consistent with a northward shift of the typhoon track over the western North Paci c-East Asian region, and an increase of typhoon frequency over the Taiwan-East China Sea; the authors associate these changes with the weakening of the Western North Paci c subtropical high (Tu et al. 2009). Finally, Murakami (2013) nds a decline in typhoon frequency over western Japan and the Korean peninsula, but an increase over eastern Japan, related to the southward shift of the subtropical jet stream.

The economic costs of increasing extreme weather events such as drought, extreme heat

AghaKouchak A, Feldman D, Stewardson MJ, Saphores JD, Grant S, Sanders B. (2014) Australia's drought: lessons for California. Science, 343 (6178), 1430-1431.

Arbuszewski JA Cléroux C, Bradtmiller L, Mix A. (2013) Meridional shifts of the Atlantic intertropical convergence zone since the Last Glacial Maximum. Nature Geoscience, 6 (11), 959-962.

Allen RJ, Sherwood SC, Norris JR, Zender, CS (2012) Recent Northern Hemisphere tropical expansion primarily driven by black carbon and tropospheric ozone. Nature 485:350–354.

Balek J. (1983) Hydrology and water resources in tropical regions. Elsevier Press.

Bar-Yam T, Lagi M, Bar-Yam Y. (2013) South

References | Continued

Intergovernmental Panel on Climate Change (2007) Climate change 2007: the physical science basis.

Sachs J, Stege M, Keju T. (2009) Recent movements of the ITCZ in the tropical Paci c and rami cations for the Marshall Islands. IOP Conference Series: Earth and Environmental Sciences, 6, 072010.

Santer BD, Painter JF, Bon ls C et al. (2013) Human and natural in uences on the changing thermal structure of the atmosphere. Proceedings of the National Academy of Sciences, 110, 17235-17240.

Santer BD, Bon ls C, Painter JF. et al. (2014) Volcanic contribution to decadal changes in tropospheric temperature. Nature Geoscience, 7, 185-189.

Santer BD, Wehner MF, Wigley TML et al., (2003) Contributions of anthropogenic and natural forcing to recent tropopause height changes. Science, 301, 479-483.

Seager R, Godard, L., Nakamura, J., Henderson, N., Lee, D.E. (2014) Dynamical causes of the 2010/11 Texas-Northern Mexico drought. Journal of Hydrometeorology, 15, 39-68.

Seager R, Ting MF, Held I et al.(2007) Model projections of an imminent transition to a more arid climate in southwestern North America. Science, 316, 1181-1184.

Seidel DJ. Fu Q. Randel WJ. Reichler TJ. (2008) Widening of the tropical belt in a changing climate Nature Geoscience, 1, 21 – 24.

Seidel DJ, Randel WJ. (2007) Recent widening of the tropical belt: evidence from tropopause observations. Journal of Geophysical Research – Atmospheres, 112 (D20), D20113.

Shin SE0hysaeaahulim1gSC(Kim 16.T1_1.478 0 Td (, 1181-1184.)Tj 0.7esa1 1 Tf -5.(uli17(., Nakamura,)28(J., Hen20( )]TJ 0 Tw -15.m)-20( )]Tam) -15