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High-resolution climate projections for the islands of Lombok and Sumbawa, Nusa Tenggara Barat Province, Indonesia: Challenges and implications ☆

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ABSTRACT

The regional climate of Nusa Tenggara Barat (NTB) Province, eastern Indonesia is simulated for 130 years (1971–2100) for the SRES A2 Delayed Development or 'Business as Usual' emissions scenario using the CSIRO conformal-cubic atmospheric model (CCAM). Regional climate simulations are generated using a multiple downscaling technique where a CCAM 200 km uniform-grid global simulation is driven by bias-corrected sea surface temperatures (SSTs) from host coupled Global Climate Models (GCMs). Next, the 200 km resolution CCAM simulations are dynamically downscaled to 14 km resolution for the islands of Lombok and Sumbawa. To provide an ensemble of results, separate simulations are performed from six host GCMs. The present-day model results are validated against available observations. Generally, the CCAM 14 km resolution simulations produce rainfall, maximum and minimum temperatures that are similar to the observations. However, the 14 km simulations have rainfall biases of around 5 mm/day in the wet December–February season and lesser biases in the other seasons. Climate projections are examined for two future time intervals centred on 2030 and 2060. The simulations of rainfall changes by 2060 suggest both increases and decreases of up to 5% in December–February, with more acute declines of 10% in some areas, and decreases of up to 10% in March–May. For the other seasons, generally little change is simulated. The regional temperatures are projected to increase by about 1 °C by 2030 and 1.6–2 °C by 2060. The high-resolution model outputs enable detailed differentiation between locations across the islands. Our results show that due to orographic effects there are steep climate gradients, resulting in significant local differences in climate projections. We discuss the challenges and implications of these results for adaptation planning.

Introduction

The climate of Indonesia's eastern island archipelago is highly variable, both temporally and spatially. The climate is strongly influenced by monsoon and trade winds which are responsible for the two distinct seasons experienced across

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the entire Indonesian archipelago. The NTB dry season (April–October) occurs as a result of the dry south-easterly trade winds, while the wet season (November–March) occurs when the monsoon winds blow from a north-westerly direction, carrying air masses from mainland Asia and the Indo-west Pacific Ocean. As described further by Kirono et al. (2016), orographic effects on rainfall are also apparent across the NTB islands.

Temporally, there is significant interannual variability in seasonal rainfall over the Indonesian archipelago, which is closely related to large-scale ocean–atmosphere phenomena such as the El Niño Southern Oscillation (ENSO). Over the NTB, the interannual variability is particularly apparent for the dry season; this is discussed in detail by Kirono et al. (2016). There is already evidence of climate change over Indonesia. Hulme and Sheard (1999) report that since 1900 mean annual temperature has increased by about 0.3 °C in Indonesia, whilst the overall annual precipitation has decreased by 2–3%. They report a decline in annual rainfall in the southern regions, and an increase in the northern regions.

Spatially, the islands have very steep climate gradients, related to their mountainous terrain and complex coastlines. To account for this, downscaled or fine-scale climate change projections are required. Downscaling to 60 km resolution over Indonesia has been undertaken previously (Katzfey et al., 2010). Whilst this resolution should be adequate for capturing the broad seasonal migration of the Inter Tropical Convergence Zone, and the associated seasonal cycle in rainfall, it is still inadequate for capturing the detailed seasonal orographic interactions that are required to properly inform adaptation planning processes (Butler et al., 2014, 2015), such as presented in this special issue (Butler et al., 2016). In this paper we describe the methodology and provide selected results for climate projections downscaled to 14 km in the islands of Lombok and Sumbawa, Nusa Tenggara Barat (NTB) Province (Fig. 1). A map showing the NTB province in relation to the whole of Indonesia is provided by Kirono et al. (2016). These simulations represent the first time regional climate simulations have been performed at such high resolution over the Indonesia region.

For downscaling to a fine resolution, various methodologies may be used. The earliest method, and still being used, is to use a limited-area model, forced at its lateral boundaries by a host Global Climate Model (GCM). There are a number of reviews of this methodology (e.g. McGregor, 1997; Wang et al., 2004). Limited-area models inherit large-scale errors that may exist in the host GCM and this can be problematic (e.g. Pielke and Wilby, 2012). The downscaling methodology adopted for this study proceeds with a variable-resolution GCM, the conformal-cubic atmospheric model (CCAM). A review of current variable-resolution GCMs is given by McGregor (2013).

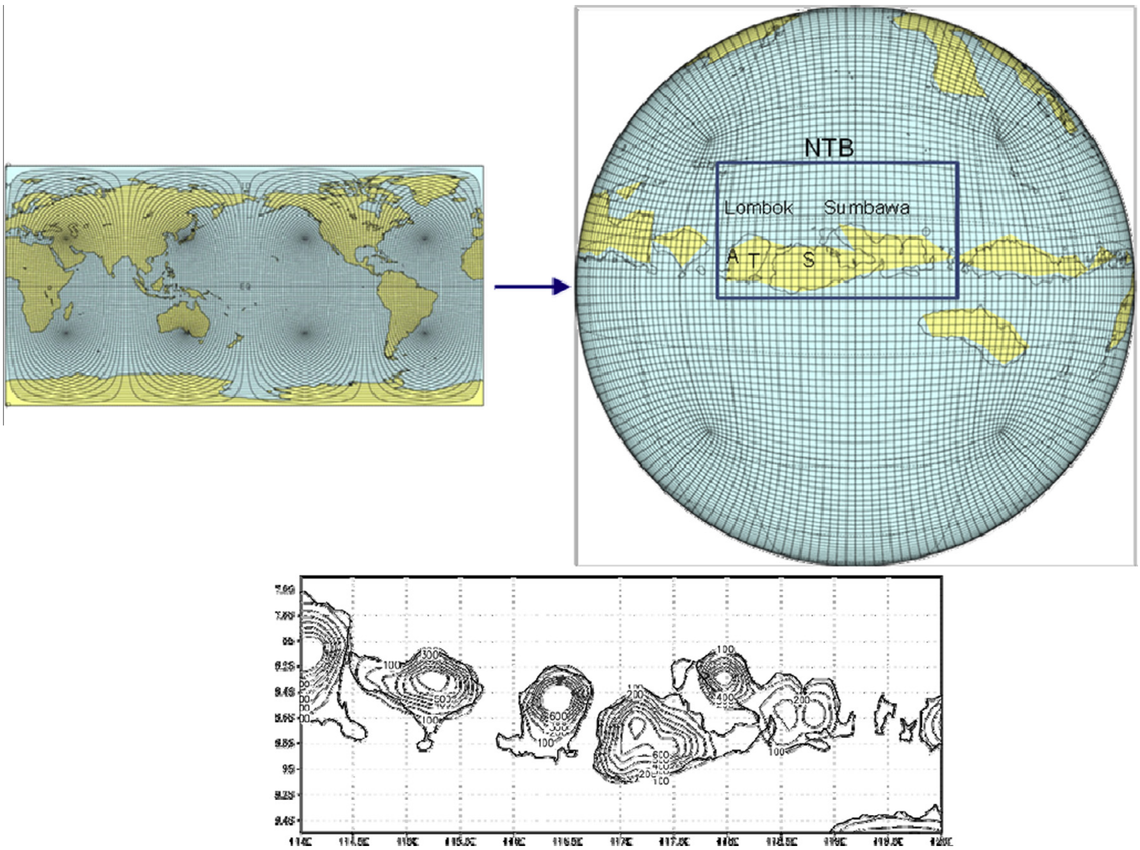

Fig. 1. The 200 km global grid (top left), and the 14 km stretched grid (top right) for the eastern Indonesian archipelago, showing NTB, Lombok and Sumbawa. The symbols A, T and S denote respectively the station locations of Ampenan, Terara and Sumbawa. The model orography (m) is also shown (bottom) over a domain that extends somewhat beyond NTB.