SUPPLEMENT

EXPLAINING EXTREME EVENTS OF 2016 FROM A CLIMATE PERSPECTIVE

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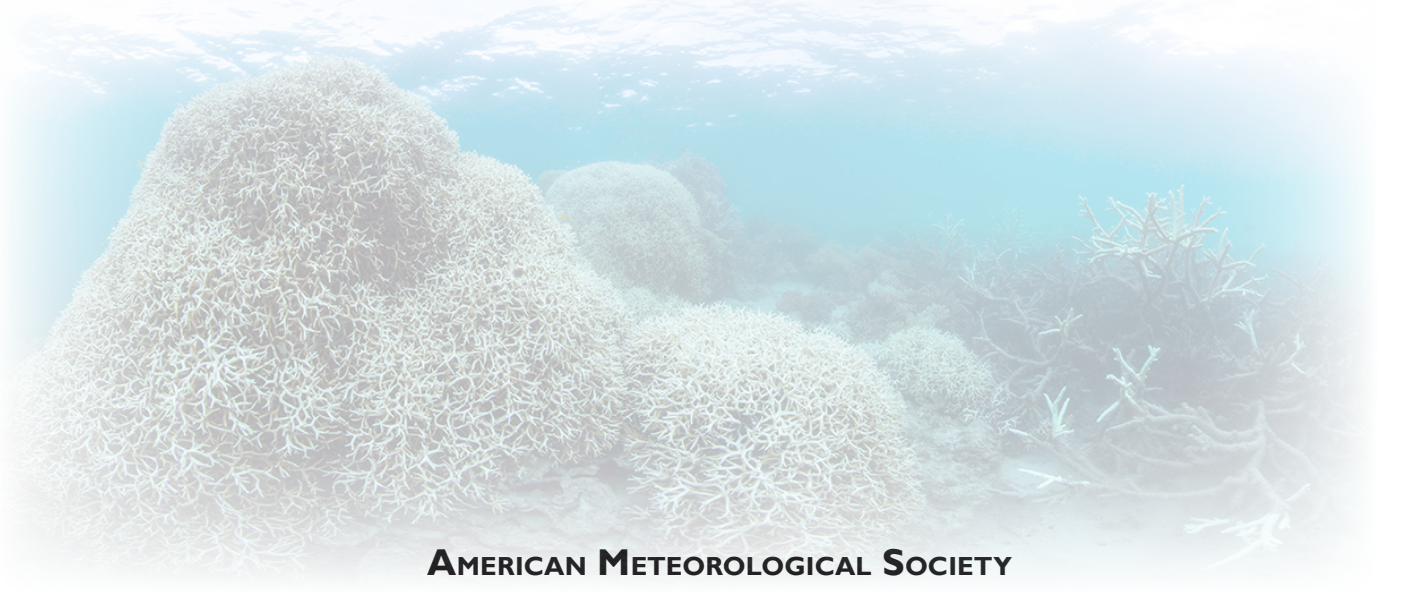
©The Ocean Agency / XL Catlin Seaview Survey / Chrisophe Bailhache—A panoramic image of coral bleaching at Lizard Island on the Great Barrier Reef, captured by The Ocean Agency / XL Catlin Seaview Survey / Christophe Bailhache in March 2016.



AMERICAN METEOROLOGICAL SOCIETY

ES13. A MULTIMETHOD ATTRIBUTION ANALYSIS OF THE PROLONGED NORTHEAST BRAZIL HYDROMETEOROLOGICAL DROUGHT (2012–16)

Eduardo S. P. R. Martins, Caio A. S. Coelho, Rein Haarsma, Friederike E. L. Otto, Andrew D. King, Geert Jan van Oldenborgh, Sarah Kew, Sjoukje Philip, Francisco C. Vasconcelos Júnior, and Heidi Cullen

This document is a supplement to "A Multimethod Attribution Analysis of the Prolonged Northeast Brazil Hydrometeorological Drought (2012–16)," by Eduardo S. P. R. Martins, Caio A. S. Coelho, Rein Haarsma, Friederike E. L. Otto, Andrew D. King, Geert Jan van Oldenborgh, Sarah Kew, Sjoukje Philip, Francisco C. Vasconcelos Júnior, and Heidi Cullen (*Bull. Amer. Meteor. Soc.*, **99** (1), S65–S69) • • DOI:10.1175/BAMS-D-17-0102.2

Figures ES13.1a–d show NEB annual precipitation return period curves with the corresponding observed precipitation for each drought year from 2012 to 2015. The estimated return period for the 2012 drought is 33 years (95% CI: 16–100), for the 2013 drought 2 years (95% CI: 1–2), for the 2014 drought 8 years (95% CI: 4–16) and for the 2015 drought 20 years (95% CI: 9–65). Figure ES13.1e shows a scatter plot of annual precipitation averaged over NEB versus global mean temperature for the 1901–2015 period, which does not present any indication of trend.

Figure ES13.2a shows weather@home $P–E$ return period curves over NEB for 2015 in HadAM3P in actual and counterfactual ensembles. The displacement of the two curves suggests a reduced drought risk due to anthropogenic greenhouse gas emissions. Figures ES13.2b,c show High São Francisco (Três Marias) and Medium São Francisco (Sobradinho) annual flow pdf plots for 2015 using actual and counterfactual HadAM3P ensemble simulations. The overlap of the two curves for the lower extremes indicates that the risk for extremely low flow has not changed due to anthropogenic greenhouse gas emissions.

Table ES13.1 shows CMIP5 models. In bold are the models that passed the test for simulating the observed climate variability during the 20th century using a Kolmogorov–Smirnov test and removing models where at least one-third of historical simulations were significantly different to GPCC at the 5% level.

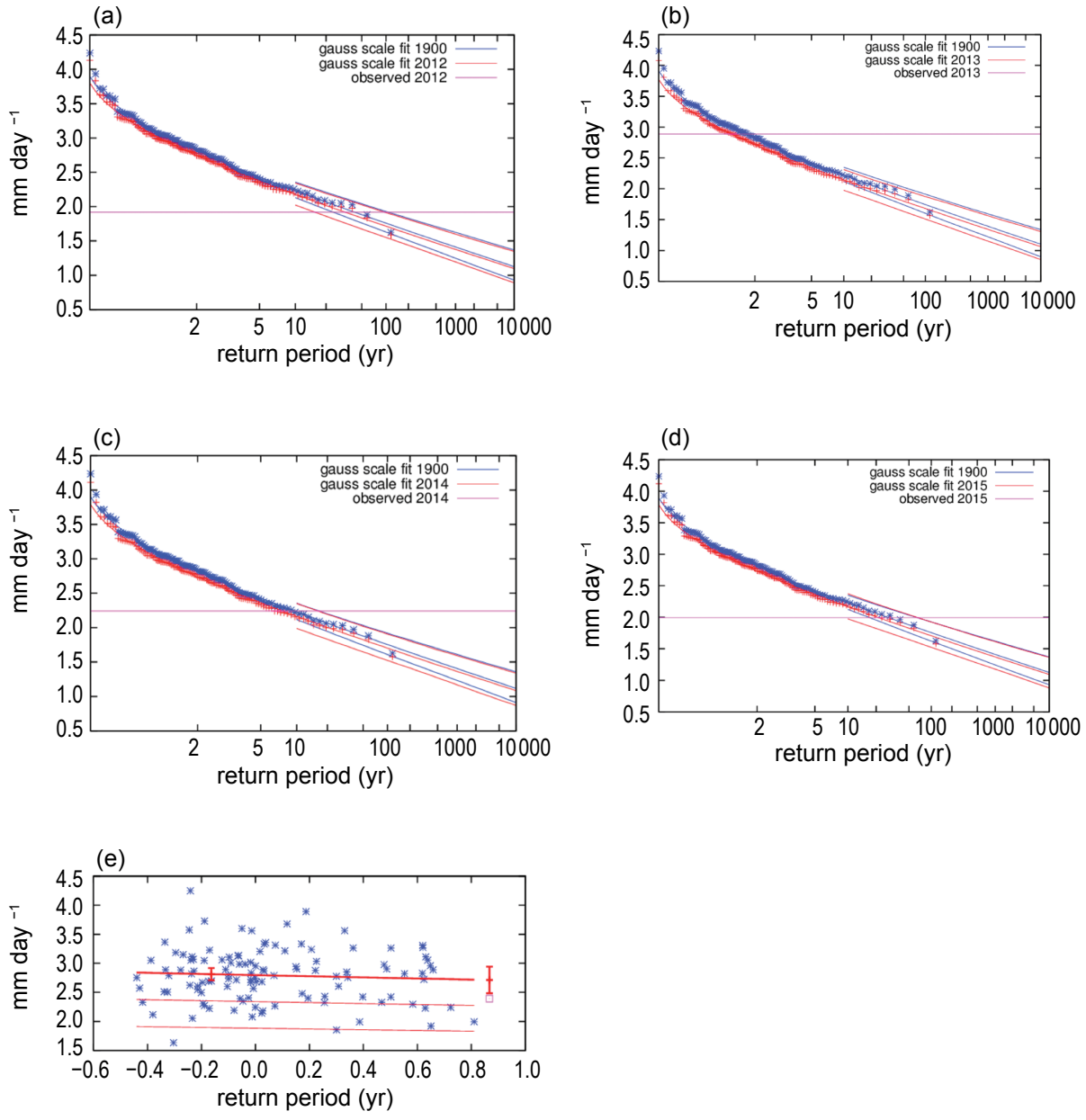


Fig. ES13.1. (a) Return period curves obtained by inverting the fit of annual sum of monthly mean precipitation (mm day^{-1}) to a Gaussian distribution that scales with the smoothed global mean surface temperature. Observations are shown twice; scaled to the 2012 climate (red) and the 1900 climate (blue). (b) As in (a) but for 2013. (c) As in (a) but for 2014. (d) As in (a) but for 2015. (e) Annual precipitation (mm day^{-1}) versus global mean temperature (1901–2015). Thick lines denote the time-varying mean and the thin lines are 1 and 2 std. dev. below. Purple squares show the 2016 average value (not included in the fit) and the two vertical red lines show the 95% confidence interval of the fitted location parameter for the climates of 1901 and 2016.

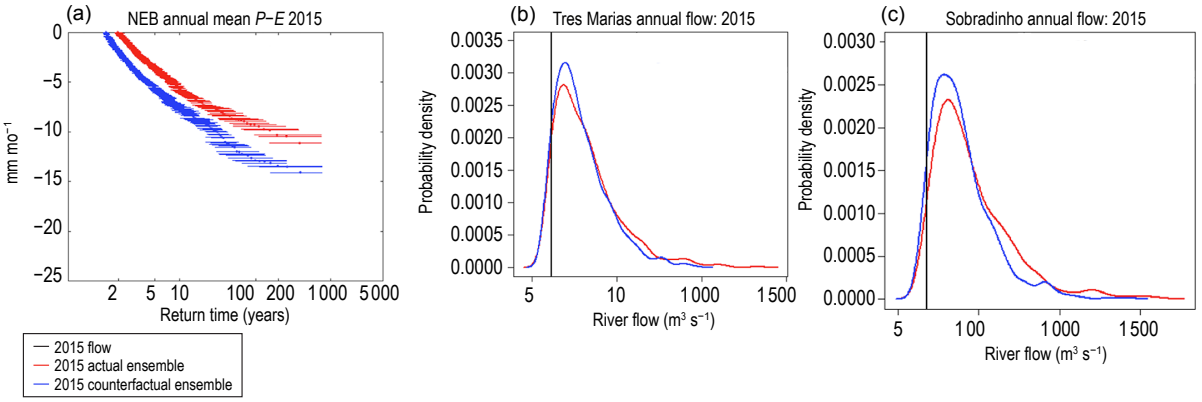


Fig. ES13.2. (a) Return period curve obtained by inverting the empirical distribution fit of *P–E* (mm mo $^{-1}$) over São Francisco River Basin for 2015 in HadAM3P. (b) High São Francisco (Três Marias) annual flow (m^3 s^{-1}) pdf for 2015 using HadAM3P simulations. (c) Medium São Francisco (Sobradinho) annual flow (m^3 s^{-1}) pdf plots for 2015 using HadAM3P simulations.

Table ES13.1: CMIP5 models and simulations analyzed for this study. Only models shown in bold passed the evaluation step and were used in the event attribution calculations. The numbers shown are the available ensemble members for each modelling experiment [Historical: all observed greenhouse forcing; HistoricalNat (Historical natural): natural forcing, and RCP8.5: a strong greenhouse forcing future scenario].

Model Name	Modelling Experiment		
	Historical	Historical-Nat	RCP8.5
ACCESS1.3	1,2,3	1	1
bcc-csm1-1	1,2,3	1	1
CanESM2	**1,2,3,4,5**	**1,2,3,4,5**	**1,2,3,4,5**
CCSM4	**1,2,3,4,5,6**	**1,2,4,6**	**1,2,4,6**
CESM1-CAM5	**1,2,3**	**1,2,3**	**1,2,3**
CNRM-CM5	1,2,3,4,5,6,7,8,9,10	1,2,4	1,2,4
CSIRO-Mk3.6.0	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5	1,2,3,4,5
GFDL-CM3	**1,2,3,4,5**	**1**	**1**
GISS-E2-H	1,2,3,4,5	1	1
GISS-E2-R	1,2,3	1	1
HadGEM2-ES	**1,2,3,4,5**	**1,2,3,4**	**1,2,3,4**
IPSL-CM5A-LR	1,2,3,4,5,6	1,2,3	1,2,3
IPSL-CM5A-MR	1,2,3	1	1
MIROC-ESM	**1,2,3**	**1**	**1**
MRI-CGCM3	**1,2,3**	**1**	**1**
NorESM1-M	**1,2,3**	**1**	**1**