Attributing and predicting changes in the probability of temperature extremes

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As temperatures change in response to external drivers, for example, greenhouse gas increases, extremes of the temperature distribution are changing as well. While in many regions, this change is similar to that of mean temperature, shifting towards more frequent hot extremes and less frequent cold extremes, there are interesting variations in how the hot and cold days of minimum and maximum temperatures change, even in models (e.g. Hegerl et al., 2004), which means that it is worthwhile to understand and attribute changes in temperature extremes. This presentation discusses causes of observed changes in the frequency and intensity of temperature extremes. Changes in circulation can shift the probability of extremes substantially, and in ways that is different between the cold and warm season (e.g., Kenyon and Hegerl, 2008). However, external forcing also influences the frequency and intensity of hot and cold extremes on global and regional scales. There is evidence that external forcing has significantly increased the number of warm nights in many regions of the globe (Morak et al., submitted). Exceptions include small regions with strong climate variability, or regions where the increase in temperature extremes has been slow, for example, in parts of North America. The increase in the number of hot days is weaker, and shows fewer regions where the role of external forcing is detectable. The number of cold extremes has decreased in many regions of the world, and this change can also be attributed to external influences. This presentation investigates to what extent the observed changes are explained by those of mean temperature change, to what extent individual external drivers, such as aerosols and land use change may play a role, and discusses if climate models driven by a realistic combination of external drivers simulate a magnitude of change that is consistent with that observed. Regions where changes are different from those expected, for example, Southeastern North America (see also Portmann et al., 2009), are discussed. Observed changes in extremes that can be attributed to external forcing can be used to provide probabilistic predictions of future probabilities of extremes and their uncertainty based on the role of external forcing (see, e.g. Stott and Kettleborough, 2002). The second part of this presentation discusses first results attempting to forecast near-term changes in temperature extremes. We investigate if there is any evidence from recent decadal hindcasts (see Meehl et al., 2010) that climate simulations that use initial conditions close to those observed can provide near term predictions of change in temperature extremes that go beyond the predictable component due to external forcing. First results indicate that these further predictable components for European summertime extremes are modest at best. Hegerl, G. C., F. Zwiers, S. Kharin and Peter Stott (2004): Detectability of anthropogenic changes in temperature and precipitation extremes. J. Climate, 17, 3683-3700. Kenyon, J and G. C. Hegerl (2008): The Influence of ENSO, NAO and NPI on global temperature extremes. J. Climate 21, 3872-3889 Meehl, G.A. L. Goddard, J. Murphy, R.J. Stouffer, G. Boer, G. Danabasoglu, K. Dixon, M.A. Giorgetta, A. Greene, E. Hawkins, G. Hegerl, D. Karoly, N. Keenlyside, M. Kimoto, B. Kirtman, A. Navarra, R. Pulwarty, D. Smith, D. Stammer, and T. Stockdale, 2009:† Decadal prediction:† Can it be skillful?† Bull. Amer. Meteorol. Soc., 90, 1467--1485. (22) Morak, S., Hegerl G. Kenyon J (2011): Detectable Regional Changes in the Number of Warm Nights. Submitted to GRL. Portmann R. W., S. Solomon and G.C. Hegerl (2009): Linkages between climate change, extreme temperature and precipitation across the United States. PNAS, 106, 7324-7329(6) Stott, P.A., J.A. Kettleborough (2002) Origins and estimates of uncertainty in predictions of twenty-first century temperature rise. Nature, 416, 723 - 726.