Was there a basis for anticipating the 2010 Russian heat wave?

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[1] The 2010 summer heat wave in western Russia was extraordinary, with the region experiencing the warmest July since at least 1880 and numerous locations setting all-time maximum temperature records. This study explores whether early warning could have been provided through knowledge of natural and human-caused climate forcings. Model simulations and observational data are used to determine the impact of observed sea surface temperatures (SSTs), sea ice conditions and greenhouse gas concentrations. Analysis of forced model simulations indicates that neither human influences nor other slowly evolving ocean boundary conditions contributed substantially to the magnitude of this heat wave. They also provide evidence that such an intense event could be produced through natural variability alone. Analysis of observations indicate that this heat wave was mainly due to internal atmospheric dynamical processes that produced and maintained a strong and long-lived blocking event, and that similar atmospheric patterns have occurred with prior heat waves in this region. We conclude that the intense 2010 Russian heat wave was mainly due to natural internal atmospheric variability. Slowly varying boundary conditions that could have provided predictability and the potential for early warning did not appear to play an appreciable role in this event. **Citation:** Dole, R., M. Hoerling, J. Perlwitz, J. Eischeid, P. Pegion, T. Zhang, X.-W. Quan, T. Xu, and D. Murray (2011), Was there a basis for anticipating the 2010 Russian heat wave?, *Geophys. Res. Lett.*, *38*, L06702, doi:10.1029/2010GL046582.

1. Introduction

[2] Questions of vital societal interest are whether the 2010 Russian heat wave might have been anticipated, and to what extent human-caused greenhouse gas emissions played a role. Exceptional heat and poor air quality due to wildfires led to large increases in deaths in Moscow and elsewhere in western Russia, despite international efforts to improve public health responses to heat waves [*World Health Organization*, 2009]. Russia's extreme heat commenced in July nearly coincident with the peak temperatures in the annual cycle, thereby exacerbating human and environmental impacts. During July, when daily temperatures (Figure 1, top) were consistently near or above record levels, the heat wave spanned western Russia, the Republic of Belarus, the Ukraine, and the Baltic nations (see Figure S1 in Text S1 of the auxiliary material).[1] Despite record warm globally-averaged surface temperatures over the first six months of 2010 [*National Climatic Data Center*, 2010], Moscow experienced an unusually cold winter and a relatively mild but variable spring, providing no hint of the record heat yet to come (Figure 1, top).

[3] For the 2003 western European heat wave, human influences are estimated to have at least doubled the risk for such an extreme event [*Stott et al.*, 2004]. Other boundary forcings also contributed to the 2003 European heat wave, including anomalous sea surface temperatures (SSTs) [*Feudale and Shukla*, 2010]. The goal of this study is to identify the primary causes of the Russian heat wave and to assess to what extent it might have been anticipated from prior knowledge of natural and human forcings and observed regional climate trends.

2. Data and Model Experiments

[4] The National Oceanic and Atmospheric Administration (NOAA) Land/Sea Merged analyses [*Smith and Reynolds*, 2005] are the primary surface temperature data used in this study. Results derived from this data set are compared with those obtained from three other observational temperature data sets (see Table S1 and references for these data sets in the auxiliary material). In the following analyses, western Russia temperatures are defined as area-averages over the region 50°N–60°N and 35°E to 55°E, the region of highest heat wave intensity and approximately centered over Moscow.

[5] Model simulations were performed to determine the potential for anticipating the Russian heat wave. First, the potential influence of increasing greenhouse gas concentrations, aerosols, and other natural external forcings on western Russian temperatures was assessed from simulations of 22 CMIP3 models [*Meehl et al.*, 2007]. These models are forced by specified monthly variations in greenhouse gases and tropospheric sulphate aerosols for 1880–1999, and with the IPCC Special Emissions Scenario (SRES) A1B thereafter. About half of the models also include changes in solar radiance and the effects of volcanic eruptions for the period 1880–1999. Model time series of western Russia temperatures were normalized relative to the observed mean standard deviation for July from 1880 to 2009 so that the magnitude of interannual variability in all models was comparable with observed variability. Second, possible effects of specific boundary conditions observed during July 2010 were evaluated. For this purpose, 50-member ensemble simulations were performed for each of two atmospheric general circulation models, the GFDL AM2.1 [*Delworth et al.*, 2006] and the middle atmosphere configuration of ECHAM5

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[1]Auxiliary materials are available in the HTML. doi:10.1029/2010GL046582.