APPENDIX B

Data and Methods Used for Attribution

Convening Lead Author: Martin Hoerling, NOAA
Lead Authors: Gabriele Hegerl, University of Edinburgh; David Karoly, University of Melbourne; Arun Kumar, NOAA; David Rind, NASA

B.1 OBSERVATIONAL DATA

North American surface temperatures during the assessment period of 1951 to 2006 are derived from four data sources, which include: the U.K. Hadley Centre's HadCRUT3v (Brohan *et al.*, 2006); NOAA's land/ocean merged data (Smith and Reynolds, 2005); NOAA's global land gridded data (Peterson *et al.*, 1998); and NASA's gridded data (Hansen *et al.*, 2001). For analysis of U.S. surface temperatures, two additional datasets used are NOAA's U.S. Climate Division data (NCDC, 1994) and PRISM data.

Spatial maps of the surface temperature trends shown in Chapter 3 are based on combining all the above datasets. For example, the North American and U.S. surface temperature trends during 1951 to 2006 were computed for each dataset, and the trend map is based on equal-weighted averages of the individual trends. The uncertainty in observations is displayed by plotting the extreme range among the time series of the 1951 to 2006 trends from individual datasets.

North American precipitation data are derived from the Global Precipitation Climatology Project (GPCC) (Rudolf and Schneider, 2005); the NOAA gridded precipitation data has also been consulted (Chen *et al.*, 2002). However, the North American analysis shown in Chapter 3 is based on the GPCC data alone which is judged to be superior, owing to its greater volume of input stations over Canada and Alaska in particular. For analysis of U.S. precipitation, two additional datasets used are NOAA's U.S. Climate Division data and PRISM data. Spatial maps of U.S. precipitation trends during 1951 to 2006 were computed for each of these three datasets, and the U.S. trend map is based on equal-weighted averages of the individual trends.

Free atmospheric conditions during 1951 to 2006, including 500 hPa geopotential heights, are derived from the NCEP/NCAR reanalysis (Kalnay *et al.*, 1996). A comparison of various reanalysis data is provided in Chapter 2, but only the NCEP/NCAR version is available for the entire 1951 to 2006 assessment period.

B.2 CLIMATE MODEL SIMULATION DATA

Two configurations of climate models are used in this Report: atmospheric general circulation models (AMIP), and coupled ocean-atmosphere general circulation models (CMIP). For the former, the data from two different atmospheric models are studied; the European Center/Hamburg model (ECHAM4.5) (Roeckner *et al.*, 1996) whose simulations were performed by the International Research Institute for Climate and Society at LaMont Doherty (L. Goddard, personal communication), and the NASA Seasonal-to-Interannual Prediction Project (NSIPP) model (Schubert *et al.*, 2004) whose simulations were conducted at NASA/Goddard. The models were subjected to specified monthly varying observed global sea surface temperatures during 1951 to 2006. In a procedure that is commonly used in climate science, multiple realizations of the 1951 to 2006 period were conducted with each model in which the separate runs started from different atmospheric initial conditions but were subjected to identically evolving SST conditions. A total of 33 AMIP runs (24 ECHAM and 9 NASA) were available.

The coupled models are those used in the IPCC Fourth Assessment Report (IPCC, 2007a). These are forced with estimated greenhouse gases, atmospheric aerosols, solar irradiance, and the radiative effects of volcanic activity for 1951 to 1999, and with the IPCC Special Emissions Scenario (SRES) A1B (IPCC, 2007a) for 2000 to 2006. The model data are available from the Program for Climate Model Diagnosis and Intercomparison (PCMDI) archive as part of the Coupled Model Intercomparison Project (CMIP3). Table 3.1 lists the 19 different models used and the number of realizations conducted with each model. A total of 41 runs were available.

The SST-forced (externally-forced) signal of North American and U.S. surface temperature and precipitation variability during 1951 to 2006 is estimated by averaging the total of 33 AMIP (41 CMIP) simulations. Trends during 1951 to 2006 were computed for each model run in a manner identical to the observational method; the trend map shown in Chapter 3 is based on an equal-weighted ensemble average of the individual trends. The uncertainty in these simulated trends is displayed graphically by plotting the 5 to 95 percent range amongst the individual model runs.

All the observational and model data used in this Product are available in the public domain (see Table 3.2 for website information). Further, these data have been widely used for a variety of climate analysis studies as reported in the refereed scientific literature.

B.3 DATA ANALYSIS AND ASSESSMENT

Analysis of observational and model data is based on standard statistical procedures used extensively in climate research and the physical sciences (von Storch and Zwiers, 1999). Trends for 1951 to 2006 are computed using a linear methodology based on least squares which is a mathematical method of finding a best fitting curve by minimizing the sums of the squares of the residuals. Statistical estimates of the significance of the observed trends are based on a non-parametric test in which the 56-year trends are ranked against those computed from CMIP simulations subjected to only natural forcing (solar irradiance and volcanic aerosol). The principal uncertainty in such an analysis is knowing the population (number) of 56-year trends that are expected in the absence of anthropogenic forcing. Chapter 3 uses four different coupled models, and a total of sixteen 100-year simulations to estimate the statistical population of naturally occurring 56-year trends, though the existence of model biases is taken into account in making expert assessments.

Observed and modeled data are compared using routine linear statistical methods. Time series are intercompared using standard temporal correlations. Spatial maps of observed and simulated trends over North America are compared using standard spatial correlation and congruence calculations. Similar empirical methods have been applied for pattern analysis of climate change signals in the published literature (Santer *et al.*, 1994).

Expert judgment is used in Chapter 3 to arrive at probabilistic attribution statements. The analyses described above are only a small part of the information available to the authors, who also make extensive use of the scientific peer-reviewed literature. For more details on the use of expert assessment in this Product, the reader is referred to Box 3.4 and the Preface.