

Climate Modelling

Elisabeth A. Lloyd • Eric Winsberg
Editors

Climate Modelling

Philosophical and Conceptual Issues

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Editors

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Preface

We have both been fascinated by models for our entire careers. Climate models are especially interesting, because they are the largest and most complex of models and also, in some sense, the most mysterious. The systems are completely filled with nonlinear equations and unpredictability, yet some climate models are valued for their predictive capacities. Others are appreciated for their abilities to represent causal forces within climate systems and their interactions, and yet others represent those systems simply, elegantly, and yet powerfully.

There are numerous philosophical questions involving representation, grounding, and reality itself that arise when using climate models, as well as conceptual issues concerning the models as tools themselves. Yet there is no book or collection available that addresses these issues. We have aimed to collect a set of essays here that discusses these and other philosophical and conceptual questions about climate models. We asked some of the best philosophers and some of the best modelers to contribute to the book, and they agreed, to our delight.

Our book is intended to be enjoyed by policy-makers, climate scientists, and philosophers alike, as well as the general public. Some essays, such as those concerning policy and robustness, in parts 2 and 3 of the book, are very accessible. There are sections of part 1 that are more technical, such as the Santer et al. paper, but that is explained in Lloyd's essay and in Santer et al.'s "Fact Sheet" in part 1.

Sadly, there is rampant disinformation circulating about climate models today, despite concerted efforts by climate scientists to correct the public record. The essays contributed to this book provide a foundation for an informed discourse concerning climate models, one based on theory, facts, and evidence.

We have both learned a great deal about climate modeling through editing this collection, and our hope is that anyone dipping into the book will experience the same benefit. Of course, modeling is an ongoing activity, and many of the facets explored in this book will continue to fascinate both modelers, philosophers, and policy analysts for some time to come.

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Elisabeth A. Lloyd
Eric Winsberg

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As usual for a book of this size, many people were involved in the creation of it, and we are able to thank just a fraction of those, here. We would start by thanking Linda Mearns, Jeffrey Kiehl, and Doug Nychka for making Lisa Lloyd's (EAL's) visits to the National Center for Atmospheric Research (NCAR) possible over the years. They and many climate scientists, including Caspar Amman, Melissa Bukovsky, Jim Hurrell, Brian O'Neill, Claudia Tebaldi, Kevin Trenberth, Tom Wigley, and others too numerous to name, introduced me (EAL) to the fundamentals of climate science and climate modeling and also introduced me to many more scientists who would help Lisa along my journey. Being an Affiliate Scientist at NCAR has also helped me meet many scientists from around the world who contributed enormously to her learning and to this book, such as Reto Knutti, Ricky Rood, Jonathan Rougier, Gabriel Hegerl, and her co-author Vanessa Schweizer, among many others. Her co-organization of a running session at the American Geophysical Union (AGU) allowed the opportunity to meet yet more climate scientists, such as Michael Mann, a key figure in understanding climate. She would also like to thank Ben Santer, to whom a debt is also owed for help, patience, and heroism in the face of adversity.

During my many years of research into the philosophy and foundations of climate modeling, Lisa was supported financially by two sources, my endowed chair and the National Science Foundation (NSF). The Arnold

and Maxine Tanis Chair of History and Philosophy of Science made my annual trips to NCAR possible, as well as the annual trips to the AGU. Lisa has had the privilege of knowing Bud and Maxine Tanis, and they are some of the finest and most lovely people She has met in my entire life. Lisa was also funded through two NSF Scholar Grants, “A case of objectivity in science: Climate change” (2007, #0646253) and “What is ‘Value Added’ in Regional Climate Modeling?” (2016–2017, #1632202). These grants helped make it possible for me to visit NCAR in Boulder for longer visits and to attend workshops and the AGU during those years. Lisa is indebted to Fred Kronz and the NSF for their support.

Finally, Lisa would also like to thank her research assistants, Chris ChoGlueck, Daniel Lindquist, and, most gratefully, Ryan Ketcham, for their patience and help over the several years that it took to get this book produced. She would also note that she owes much happiness and accomplishment to her beloved husband and partner, Teddy Alfrey. All of these people aided in overcoming the delaying effects of a car accident and spinal surgery on the production of this book. Lisa owes them a great deal indeed.

Eric Winsberg would like to thank the Institute of Advanced Study at Durham University, where he had the opportunity to learn about climate science from many of the practitioners affiliated with the university and to make climate science a focus of his philosophical study, and the Institute of Advanced Study on the Media Cultures of Computer Simulation at Leuphana University, which supported much of the work on this book. He would like to thank Jessica Williams for the support she gives him in all his endeavors.

Contents

1	Introduction	1
	<i>Elisabeth A. Lloyd and Eric Winsberg</i>	
Part I	Confirmation and Evidence	29
2	The Scientific Consensus on Climate Change: How Do We Know We’re Not Wrong?	31
	<i>Naomi Oreskes</i>	
3	Satellite Data and Climate Models	65
	<i>Elisabeth A. Lloyd</i>	
4	Fact Sheet for “Consistency of Modeled and Observed Temperature Trends in the Tropical Troposphere”	73
	<i>Ben Santer, Peter Thorne, Leo Haimberger, Karl Taylor, Tom Wigley, John Lanzante, Susan Solomon, Melissa Free, Peter Gleckler, Phil Jones, Tom Karl, Steve Klein, Carl Mears, Doug Nychka, Gavin Schmidt, Steve Sherwood, and Frank Wentz</i>	

5	Consistency of Modeled and Observed Temperature Trends in the Tropical Troposphere	85
	<i>B.D. Santer, P.W. Thorne, L. Haimberger, K.E. Taylor, T.M.L. Wigley, J.R. Lanzante, S. Solomon, M. Free, P.J. Gleckler, P.D. Jones, T.R. Karl, S.A. Klein, C. Mears, D. Nychka, G.A. Schmidt, S.C. Sherwood, and F.J. Wentz</i>	
6	The Role of “Complex” Empiricism in the Debates About Satellite Data and Climate Models	137
	<i>Elisabeth A. Lloyd</i>	
7	Reconciling Climate Model/Data Discrepancies: The Case of the ‘Trees That Didn’t Bark’	175
	<i>Michael E. Mann</i>	
8	Downscaling of Climate Information	199
	<i>L.O. Mearns, M. Bukovsky, S.C. Pryor, and V. Magaña</i>	
Part II	Uncertainties and Robustness	271
9	The Significance of Robust Climate Projections	273
	<i>Wendy S. Parker</i>	
10	Building Trust, Removing Doubt? Robustness Analysis and Climate Modeling	297
	<i>Jay Odenbaugh</i>	

Part III	Climate Models as Guides to Policy	323
11	Climate Model Confirmation: From Philosophy to Predicting Climate in the Real World <i>Reto Knutti</i>	325
12	Uncertainty in Climate Science and Climate Policy <i>Jonathan Rougier and Michel Crucifix</i>	361
13	Communicating Uncertainty to Policymakers: The Ineliminable Role of Values <i>Eric Winsberg</i>	381
14	Modeling Climate Policies: The Social Cost of Carbon and Uncertainties in Climate Predictions <i>Mathias Frisch</i>	413
15	Modeling Mitigation and Adaptation Policies to Predict Their Effectiveness: The Limits of Randomized Controlled Trials <i>Alexandre Marcellesi and Nancy Cartwright</i>	449
	Index	481

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List of Figures

- Fig. 2.1 A Web of Science analysis of 928 abstracts using the keywords “global climate change.” No papers in the sample provided scientific data or theoretical arguments to refute the consensus position on the reality of global climate change (It should be acknowledged that in any area of human endeavor, leadership may diverge from the views of the led. For example, many Catholic priests endorse the idea that priests should be permitted to marry (Watkin 2004)) 37
- Fig. 2.2 Changes in global mean surface temperature after carbon dioxide values in the atmosphere are doubled. The *black lines* show the results of 2579 fifteen-year simulations by members of the general public using their own personal computers. The *gray lines* show comparable results from 127 thirty-year simulations completed by Hadley Centre scientists on the Met Office’s supercomputer (<www.metoffice.gov.uk>). Figure prepared by Ben Sanderson with help from the <climateprediction.net> project team (Source: Reproduced by permission from http://www.climateprediction.net/science/results_cop10.php) 52
- Fig. 4.1 Estimates of observed temperature changes in the tropics (30 °N–30 °S). Changes are expressed as departures from

average conditions over 1979–2006. The *top panel* shows results for the surface and lower troposphere. The *thin red* and *black lines* in the *top panel* are 12-month running averages of the temperature changes for individual months. The *thick straight lines* are trends that have been fitted to the time series of surface and tropospheric temperature changes. The warming trend is larger in the tropospheric temperature data than in the surface temperature record, in accord with computer model results. The *bottom panel* shows a commonly used index of El Niño and La Niña activity, consisting of sea surface temperature changes averaged over the so-called Niño 3.4 region of the tropical Pacific. The *bottom panel* shows that much of the year-to-year variability in surface and lower tropospheric temperatures is related to changes in El Niños and La Niñas

78

Fig. 5.1 Anomaly time series of monthly-mean T_{2LT} , the spatial average of lower tropospheric temperature over tropical (20°N – 20°S) land and ocean areas. Results are for five different realizations of twentieth-century climate change performed with a coupled A/OGCM (the MRI-CGCM2.3.2). Each of the five realizations (*panels A–E*) was generated with the same model and the same external forcings, but with initialization from a different state of the coupled atmosphere-ocean system. This yields five different realizations of internally generated variability, $\eta_m(t)$, which are superimposed on the true response to the applied external forcings. The ensemble-mean T_{2LT} change is shown in panel F. Least-squares linear trends were fitted to all time series; values of the trend and lag-1 autocorrelation of the regression residuals (r_1) are given in each panel. Anomalies are defined relative to climatological monthly means over January 1979 to December 1999, and synthetic T_{2LT} temperatures were calculated as described in Santer et al. (1999)

95

Fig. 5.2 Calculation of unadjusted and adjusted standard errors for least-squares linear trends. The standard error $s\{b_o\}$ of the least-squares linear trend b_o (see Sect. 5.4.1) is a measure

of the uncertainty inherent in fitting a linear trend to noisy data. Two examples are given here. Panel A shows observed tropical T_{2LT} anomalies from the RSS group (Mears and Wentz 2005). The regression residuals (shaded blue) are highly autocorrelated ($r_1 = 0.884$). Accounting for this temporal autocorrelation reduces the number of effectively independent time samples from 252 to 16, and inflates $s\{b_o\}$ by a factor of four (see “Results from A” in panel C). The anomalies in panel B were generated by adding Gaussian noise to the RSS tropical T_{2LT} trend, yielding a trend and temporal standard deviation that are very similar to those of the actual RSS data. For this synthetic data series, the regression residuals (shaded red) are uncorrelated and r_1 is close to zero, so that the actual number of time samples is similar to the effective sample size, and the unadjusted and adjusted standard errors are small and virtually identical (see “Results from B” in panel C). All results in panel C are 2σ confidence intervals (C.I.). The analysis period is from January 1979 to December 1999

99

Fig. 5.3 Comparisons of simulated and observed trends in tropical T_{2LT} over January 1979 to December 1999. Model results in panel A are from 49 individual realizations of experiments with twentieth-century external forcings, performed with 19 different A/OGCMs. Observational estimates of T_{2LT} trends are from Mears and Wentz (2005) and Christy et al. (2007) for RSS and UAH data, respectively. The dark and light gray bands in panel A are the 1σ and 2σ confidence intervals for the RSS T_{2LT} trend, adjusted for temporal autocorrelation effects. In the paired trends test applied here, each individual model T_{2LT} trend is tested against each observational T_{2LT} trend (Sect. 5.4.1). Panel B shows the three elements of the DCPS07 “consistency test”: the multi-model ensemble-mean T_{2LT} trend, $\langle\langle b_m \rangle\rangle$ (represented by the horizontal black line in panel B); σ_{SE} , DCPS07’s estimate of the uncertainty in $\langle\langle b_m \rangle\rangle$; and b_o , the individual RSS and UAH T_{2LT} trends (with and without their 2σ confidence intervals from panel A).

- The 1σ and 2σ values of σ_{SE} are indicated by orange and yellow bands, respectively. The colored dots in panel B are either the ensemble-mean T_{2LT} trends for individual models or the trend in an individual 20CEN realization (for models that did not perform multiple 20CEN realizations). Statistical uncertainties in the observed trends are neglected in the DCSP07 test. If these uncertainties are accounted for, $\langle\langle b_m \rangle\rangle$ is well within the 2σ confidence intervals on the RSS and UAH T_{2LT} trends (Sect. 5.5.1.2) 105
- Fig. 5.4 As for Fig. 5.3, but for comparisons of simulated and observed trends in the time series of differences between tropical T_{SST} and T_{2LT} . The observed T_{SST} data are from NOAA ERSST-v3 (Smith et al. 2008). For trends and confidence intervals from other observed pairs of surface and T_{2LT} data, refer to Table 5.4 109
- Fig. 5.5 Performance of statistical tests with synthetic data. Results in panel A are for the “paired trends” test [d ; see Eq. (5.3)], in which trends from “observed” temperature time series are tested against trends from individual realizations of “model” 20CEN runs. Two versions of the paired trends test are evaluated, with and without adjustment of trend standard errors for temporal autocorrelation effects. Panel B shows results obtained with the DCPS07 “consistency test” [d^* ; see Eq. (5.11)] and a modified version of the DCPS07 test [d_1^* ; see Eq. (5.12)] which accounts for statistical uncertainties in the observed trend. In the d^* and d_1^* tests, the “model average” signal trend is compared with the “observed” trend. Synthetic $x(t)$ time series were generated using the standard AR-1 model in Eq. (5.14). Rejection rates for hypotheses H_1 (for the “paired trends” test) and H_2 (for the d^* and d_1^* tests; see Sect. 5.4) are given as a function of N , the total number of synthetic time series, for $N = 5, 6, \dots, 100$. Each test is performed for stipulated significance levels of 5%, 10%, and 20% (denoted by dashed, thin, and bold lines, respectively). For each value of N , rejection rates are the mean of the sampling distribution of rejection rates

obtained with 1000 realizations of N synthetic time series. The specified value of the lag-1 autocorrelation coefficient in Eq. (5.14) is close to the sample value of r_1 in the UAH and RSS T_{2LT} data (Table 5.1). Similarly, the noise component of the synthetic $x(t)$ data was scaled to ensure $x(t)$ had (on average) approximately the same temporal standard deviation as the observed T_{2LT} anomaly data. See Sect. 5.6 for further details

Vertical profiles of trends in atmospheric temperature (panel A) and in actual and synthetic MSU temperatures (panel B). All trends were calculated using monthly-mean anomaly data, spatially averaged over 20°N–20°S. Results in *panel A* are from seven radiosonde datasets (RATPAC-A, RICH, HadAT2, IUK, and three versions of RAOBCORE; see Sect. 5.2.1.2) and 19 different climate models. Tropical T_{SST} and T_{L+O} trends from the same climate models and four different observational datasets (Sect. 5.2.1.3) are also shown. The multi-model average trend at a discrete pressure level, $\langle\langle b_m(z) \rangle\rangle$, was calculated from the ensemble-mean trends of individual models [see Eq. (5.7)]. The gray shaded envelope is $s\langle b_m(z) \rangle$, the 2σ standard deviation of the ensemble-mean trends at discrete pressure levels. The yellow envelope represents $2\sigma_{SE}$, DCPS07's estimate of uncertainty in the mean trend. For visual display purposes, T_{L+O} results have been offset vertically to make it easier to discriminate between trends in T_{L+O} and T_{SST} . Satellite and radiosonde trends in panel B are plotted with their respective adjusted 2σ confidence intervals (see Sect. 5.4.1). Model results are the multi-model average trend and the standard deviation of the ensemble-mean trends, and gray and yellow shaded areas represent the same uncertainty estimates described in panel A (but now for layer-averaged temperatures rather than temperatures at discrete pressure levels). The y -axis in panel B is nominal, and bears no relation to the pressure coordinates in panel A. The analysis period is January 1979 through December 1999, the period of maximum overlap between the

Fig. 5.6

- observations and most of the model 20CEN simulations. Note that DCPS07 used the same analysis period for model data, but calculated all observed trends over 1979–2004 118
- Fig. 6.1 The NOAA raw data as interpreted by three teams of analysts—UAH, RSS, and UMd—and their resulting trend lines. Note the difference in slopes of the trend lines (Karl et al. 2006) 150
- Fig. 6.2 Note that the models are presented within the bounds of two standard errors at the top of the figure, while the four observational radiosonde datasets below are presented as lone points, as are the satellite datasets on the side (Douglass et al. 2008) 163
- Fig. 6.3 Note that the model realizations are all found within two standard deviations of the RSS trend, thus demonstrating the compatibility of the satellite data and various models (Santer et al. 2008) 164
- Fig. 7.1 Estimates of the equilibrium climate sensitivity (“ECS”) based on various independent lines of evidence summarized by Knutti and Hegerl (2008) (Modified from Mann 2014 Scientific American) 176
- Fig. 7.2 Shown in the above is the D’Arrigo et al. tree-ring-based NH reconstruction (*blue*) along with the climate model (NCAR CSM 1.4) simulated NH mean temperatures (*red*) and the “simulated tree-ring” NH temperature series based on driving the biological growth model with the climate model-simulated temperatures (*green*). The two insets focus on the response to the AD 1258 and AD 1809+1815 volcanic eruption sequences. Also shown in the insets are the results (dashed magenta) when the volcanic diffuse-light impact is ignored (From Mann et al. (2012a)) 181
- Fig. 7.3 Ensemble of hemispheric tree-ring temperature reconstructions derived from available regional tree-ring composites resampled to account for predicted age model errors. Shown are the raw composite based on the D’Arrigo et al. (2006) tree-ring data (*green*), Monte Carlo surrogate reconstructions (8000 in total—blue curves),

- and GCM simulation (*red*). Insets: Expanded views of the response to the AD 1258/1259 and AD 1815 eruptions responses showing the 10 coldest surrogates (*blue*) for each eruptions and the 2 and 4 sigma significance thresholds for cooling (*dashed black*). Shown also for AD 1815 eruption is the recently back-extended instrumental NH land temperature record of Rohde et al. (2013) (*black*). Centering of all series is based on a 1961–1990 modern base period (From Mann et al. (2013)) 187
- Fig. 7.4 Tree-ring records across the AD1258 eruption. The three D'Arrigo et al. regional series that begin before AD774 (Coastal Alaska, Tornestraesk, and Taymir), along with the Icefields series for reference, are shown on their original time scale (a) and age-adjusted (b) in a way consistent with our hypothesis. The Icefields series is unaltered, the Coastal Alaska series is shifted four-years older (~0.6%), and the Tornestraesk and Taymir series are both shifted one year older (~0.1%) (From Rutherford and Mann (2014)) 193
- Fig. 8.1 Change (%) in winter precipitation mid-twenty-first century (2041–2070) vs. late-twentieth century (1971–2000) from simulations with the HadCM3 AOGCM (a) (*left*) downscaled using the BCSD method (1/8° resolution) and (b) (*right*) in the original HadCM3 model which was run at a spatial resolution of 2.5° latitude by 3.5° longitude (Graphics by Seth McGinnis and Joshua Thompson, NCAR, using data acquired from: <https://esgcat.llnl.gov:8443/index.jsp> for raw HadCM3 data; http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections/dcpInterface.html for BCSD data) 204
- Fig. 8.2 Change in total precipitation (expressed in %) at 936 stations in (a and b) cold season (NDJFM) and (c and d) warm season (MJJAS) and for 2046–2065 or 2081–2100 relative to 1961–2000 derived from statistical downscaling of 10 AOGCMs (BCCR-BCM2, CCCMA-CGCM3, CNRM-CM3, CSIRO-MK3, GFDL-CM2, GISS-Model

- E-R, IPSL-CM4, MIUB-ECHO, MPI-ECHAM5, and MRI-CGCM2) (Schoof et al. 2010) 214
- Fig. 8.3 Regional histograms for the ensemble mean difference in seasonal precipitation 2046–2065 v 1961–2000 at each station based on downscaling of 10 AOGCMs (BCCR-BCM2, CCCMA-CGCM3, CNRM-CM3, CSIRO-MK3, GFDL-CM2, GISS-Model E-R, IPSL-CM4, MIUB-ECHO, MPI-ECHAM5, and MRI-CGCM2) (Schoof et al. 2010). The *upper panels* show the results for the warm season (MJJAS), and the *lower panel* shows results for the cool season (NDJAM). The frequency denotes the percentage of stations in a given region that show a ratio of a given magnitude. If the Fraction of the historical value is 1 the historical and future periods have equal precipitation totals 215
- Fig. 8.4 Transect of terrain height (m) along, approximately, 40 °N from 95 °W westward to the California Central Valley in the regional climate models (RCMs), at five different resolutions. A few geographic landmarks are labeled for reference. Longitude labels at the *bottom* are valid for the AOGCMs only, as the transect paths in the RCMs vary from those in the AOGCMs due to differences in model map projections and model grid cell sizes. Paths of the transects from the west coast to about 100 °W are given in the *lower right panel* of Fig. 8.5 220
- Fig. 8.5 Terrain height (m) for model grid cells at four different horizontal resolutions. Paths for the transects shown in Fig. 8.4 are given in the *lower right panel*. AOGCM transect paths are represented by the *pink line*, while the 2-km and 10-km RCM paths are given by the *solid black line*, and the 50-km RCM path is represented by the *dashed gray line*. Differences in the paths are a result of differences in map projections and grid cell sizes 221
- Fig. 8.6 An MPAS Voronoi hexagonal mesh centered over North America, configured with 10,242 grid cells with an 85-km horizontal resolution in the fine-mesh region and a 650-km resolution in the coarsest region. (Fig. 10 from Skamarock et al. 2012) 225

Fig. 8.7	11 RCM + 2 HR-AGCM ensemble mean 2-m temperature change from 1971–1999 to 2041–2069 for December–January (DJF), March–May (MAM), June–August (JJA), and September–November (SON)	231
Fig. 8.8	Left column: 11 RCM + 2 HR-AGCM ensemble mean precipitation change from 1971–1999 to 2041–2069. Right column: The number of simulations (out of 13) that project an increase in precipitation	232
Fig. 8.9	Dynamically downscaled seasonal-mean surface air temperature change (2041–2060 minus 1981–2000) from the CCSM4 downscaled by WRF to 2-km in °F (Fig. 7 from Hall et al. 2012)	236
Fig. 8.10	The percentage (<i>right</i>) and variance (<i>left</i>) of different factors contributing to the total uncertainty under a given emissions scenario averaged across the domain of North America. Terms PRED, RCM_R, GCM, Internal, and Interaction represent contributions from statistical downscaling, choice of RCM, choice of AOGCM, internal variability simulated by the AOGCM, and interactions terms combined, respectively (From Li et al. 2012, Fig. 6)	244
Fig. 10.1	A comparison of GCM and Mt. Pinatubo (From Houghton 2009, 123)	300
Fig. 10.2	Average surface temperatures compared with GCM with anthropocentric and natural forcing and with GCM with only natural forcing (From Randall et al. 2007)	313
Fig. 11.1	(<i>Top</i>) A model of the climate with the sun (S*), clouds (C*), a lake (L*), and trees (T*) that takes some boundary conditions (B*) and forcing (F*) to predict several quantities ((P1*, P2*), <i>bottom</i>) the corresponding target system, with the main difference that it includes more that the model (e.g., mountains (M)) and only some parts are observed (P1) but not others (P2). The question is whether we confirm (a) the model (equation, structure), (b) its prediction, (c) the relationship between the two, or a combination, e.g., the model structure being sufficiently similar to the target such that P1* is an adequate estimate of P1	333

- Fig. 12.1 Policy tableau, showing the effect of different possible interventions under different scenarios. These frequency histograms might in this case measure simulated global warming by 2100 under different not-implausible simulator configurations, but more generally they would measure losses, inferred from simulated distributions for weather in 2100. Please note that these histograms are *completely fictitious!* 365
- Fig. 13.1 Projections and uncertainties for global mean temperature increase in 2090–2099 (rel. to 1980–1999 avg.) for the six SRES marker scenarios (Source: IPCC AR4 WG1 2007) 404
- Fig. 14.1 Equilibrium Climate Sensitivity (ECS) estimated from observational constraints (Bindoff et al., Fig. 10.20b, IPCC AR5 WGI 2013, p. 925) 422
- Fig. 14.2 Calculation of prospective damages from business-as-usual climate changes (From Fig. 5b, Burke et al. 2015, p. 4) 434

List of Tables

Table 5.1	Statistics for observed and simulated time series of land and ocean surface temperatures, SST, and tropospheric temperatures	100
Table 5.2	Significance of differences between modeled and observed tropospheric temperature trends: Results for paired trends tests	106
Table 5.3	Significance of differences between modeled and observed tropospheric temperature trends: Results for tests involving multi-model ensemble-mean trend	107
Table 5.4	Statistics for observed and simulated time series of differences between tropical surface temperature and lower tropospheric temperature	110
Table 5.5	Significance of differences between modeled and observed trends in lower tropospheric lapse rates: Results for paired trends tests	111
Table 5.6	Significance of differences between modeled and observed trends in lower tropospheric lapse rates: Results for tests involving multi-model ensemble-mean trend	112
Table 10.1	Comparison of GCM in IPCC AR4 2007 (From Pirtle et al. 2010)	307
Table 10.2	Comparison of GCM in IPCC AR4 2007 (From Pirtle et al. 2010)	312