PHILOSOPHY AND CLIMATE SCIENCE

ERIC WINSBERG
University of South Florida

CAMBRIDGE
UNIVERSITY PRESS

Contents

List of Figures *page* x
List of Boxes xi
List of Tables xii
Preface xiii

1 Introduction 1

2 Data 7
2.1 Introduction 7
2.2 The Nature of Scientific Data 7
2.3 Evidence of Warming 9
2.4 Satellite Data: A Cautionary Tale 11
2.5 Evidence of Warming, Continued 16
2.6 Conclusion 24
Suggestions for Further Reading 24

3 Models 26
3.1 Introduction 26
3.2 Energy Balance Models 26
3.3 The Nature of Models: Mediating Models 29
3.4 Conclusion: How Good Are Energy Balance Models? 33
Suggestions for Further Reading 37

4 Simulations 38
4.1 Introduction 38
4.2 What Is Computer Simulation? 39
4.3 The Purposes of Climate Modeling 41
4.4 Features of Computer Simulations of the Climate 44
Suggestions for Further Reading 54

5 Chaos 55
5.1 Introduction 55
5.2 What Is Chaos? 55
5.3 Two Toy Chaotic Models 60

5.4 Mitigating Butterflies 63
5.5 The Joint Weather/Climate Strategy 69
5.6 The Hawkmoth Effect 70
5.7 Conclusion 72
Suggestions for Further Reading 73

6 Probability 75
6.1 Introduction 75
6.2 Interpretations of Probability for Climate Science 76
6.3 Chances and Credences 78
6.4 ... And How to Tell Them Apart 81
6.5 Probabilities in Weather and Climate 83
6.6 Conclusion 87
Suggestions for Further Reading 89

7 Confidence 90
7.1 Introduction 90
7.2 Sources of Uncertainty 90
7.3 How Uncertainty Is Quantified I: Ensembles and Sampling 95
7.4 How Uncertainty Is Quantified II: Expert Elicitation 100
7.5 Group Credences 102
7.6 Confidence 103
7.7 Conclusion 106
Suggestions for Further Reading 107

8 Decision 108
8.1 Statistical Inference: Two Paradigms 108
8.2 Probability and Inference 112
8.3 Risk and Uncertainty – Three Approaches 114
8.4 Probability and Decision 120
8.5 Cost Benefit Analysis 122
8.6 Conclusion 128
Suggestions for Further Reading 129

9 Values 130
9.1 Introduction 130
9.2 Risk 132
9.3 Replies to the BRAIR 136
9.4 A Model-Specific Response to BRAIR: Prediction Preference 138
9.5 Models, Values, and Probabilities 145
9.6 Imprecise Probabilities 147
9.7 Values and Biases 150
9.8 Conclusion 151
Suggestions for Further Reading 152

10 Skill 154
10.1 Introduction 154
10.2 Verification and Validation 155
10.3 An Alternative Picture 160
10.4 Tuning Revisited 163
10.5 Conclusion 173
Suggestions for Further Reading 174

11 Robustness 175
11.1 Introduction 175
11.2 Robustness Analysis – A Focus on Models 177
11.3 Robustness Analysis in Climate Science: Lloyd and Parker 178
11.4 Robustness Analysis – Beyond Model Agreement 183
11.5 Sufficient Diversity of Evidence – Cumulative Epistemic Power 184
11.6 Conclusion: RA Diversity 185
Suggestions for Further Reading 186

12 Diversity 188
12.1 Introduction 188
12.2 Explanatory Robustness 191
12.3 Evidence of an ECS Hypothesis: Solely from Model Diversity 194
12.4 Evidence of an ECS Hypothesis: Beyond Model Diversity 202
12.5 Conclusion 206
Suggestions for Further Reading 206

13 Social Epistemology 208
13.1 Introduction 208
13.2 First Branch: Social Interaction 210
13.3 Second Branch: From Individuals to Groups 215
13.4 Third Branch: Institutional Arrangements 221
Suggestions for Further Reading 226

14 Epilogue 227

Appendix: Structural Stability and the "Hawkmoth Effect" 232
A.1 What Is the Hawkmoth Effect Supposed to Be? 232
A.2 Two Routes to a Hawkmoth Effect 235
A.3 The Structural Stability Route 236
A.4 The Demon's Apprentice Route 241
A.5 Small Arbitrary Model Perturbations 244

References 247
Index 259