



The nature and causes of climate change

Assessing the long-term future

C.M. GOODESS, J.P. PALUTIKOF AND T.D. DAVIES

293/3628 INSTITUT
FÜR METEOROLOGIE U. KLIMATOLOGIE
UNIVERSITÄT HANNOVER
HERRENHÄUSER STR. 2 - 30419 HANNOVER



Belhaven Press
London



Lewis Publishers
Boca Raton Ann Arbor

Contents

| | |
|--|------------|
| List of figures | vii |
| List of tables | ix |
| Acknowledgements | xi |
| Editor's Preface | xii |
| 1 Introduction | 1 |
| 1.1 The context | 1 |
| 1.2 Definition of time scales | 2 |
| 1.3 Terminology | 7 |
| 1.4 The structure | 9 |
| 2 Long-term climate change: orbital forcing | 11 |
| 2.1 Mechanisms | 11 |
| 2.2 Geological evidence of orbital/climate cycles | 14 |
| 2.3 Modelling the Quaternary glacial – interglacial cycles | 25 |
| 2.4 Internal forcing and cause-and-effect mechanisms | 34 |
| 2.5 Conclusions | 49 |
| 3 Short-term climate change | 51 |
| 3.1 Introduction | 51 |
| 3.2 Geological evidence of post-glacial climate change | 53 |
| 3.3 Causes of short-term climate change | 57 |
| 3.4 Discussion and conclusions | 69 |
| 4 Anthropogenic greenhouse gas-induced warming | 72 |
| 4.1 Introduction | 72 |
| 4.2 Emissions, detection and persistence | 72 |
| 4.3 Regional scenario development | 75 |
| 4.4 The reliability of general circulation models | 77 |
| 4.5 Conclusions | 97 |
| 5 Natural versus anthropogenic forcing | 99 |
| 5.1 Introduction | 99 |
| 5.2 Orbital versus greenhouse gas forcing | 99 |
| 5.3 Long-term effects of a greenhouse gas-induced warming | 101 |
| 5.4 Conclusions | 105 |
| 6 Sea-level change | 106 |
| 6.1 Introduction | 106 |
| 6.2 Mechanisms | 106 |
| 6.3 The record of sea-level change | 106 |
| 6.4 Greenhouse gas-induced warming and future sea-level change | 120 |
| 6.5 Conclusions | 125 |

Contents

| | | |
|-----------|---|-----|
| 7 | Regional sequences of past climate | 127 |
| 7.1 | Introduction | 127 |
| 7.2 | Land-based records from the British Isles | 130 |
| 7.3 | Ocean records | 146 |
| 7.4 | European pollen records | 150 |
| 7.5 | Regional – global and land – ocean correlations | 157 |
| 7.6 | Conclusions | 173 |
| 8 | Climate reconstructions of the last glacial – interglacial cycle | 174 |
| 8.1 | Introduction | 174 |
| 8.2 | Reconstructions based on general circulation models | 174 |
| 8.3 | Reconstructions based on palaeoclimate proxy data | 180 |
| 8.4 | Discussion | 182 |
| 9 | Models of future climate | 188 |
| 9.1 | Introduction | 188 |
| 9.2 | Greenhouse gas-induced warming | 188 |
| 9.3 | Orbital forcing | 196 |
| 10 | The uncertainties in future climate assessment | 203 |
| 10.1 | The end of the Holocene: what next? | 203 |
| 10.2 | Unexplained variability | 206 |
| 10.3 | Climate transitivity/intransitivity and chaos theory | 207 |
| 10.4 | Concluding remarks | 210 |
| | References | 212 |
| | Index | 242 |