

Contents

Abstract	ii
Acknowledgements	iii
Contents	iv
List of Figures	vii
List of Tables	xviii
1 Introduction: Humidity and Climate Change	1
1.1 Introduction - Rationale	1
1.2 The Role of Water Vapour in the Atmosphere	3
1.3 Measuring Surface Humidity	6
1.4 The Physical Relationships Between Humidity Variables of Interest	8
1.5 Recently Observed Climate Changes	10
1.5.1 Recent Changes in Atmospheric Humidity at the Surface	10
1.5.2 Recent Changes in Atmospheric Humidity Aloft	13
1.5.3 Recent Changes in Atmospheric Temperature at the Surface	16
1.5.4 Recent Changes in Atmospheric Temperature Aloft	17
1.6 Humidity in Climate Models	18
1.7 Conclusions and Project Outline	20
1.8 Tables and Figures for Chapter 1	22
2 Methodology for Calculating Humidity	29
2.1 Vapour Pressure	29
2.1.1 Choosing a Source of Surface Pressure Data	30
2.2 Wet-bulb Temperature	32
2.3 Specific Humidity	34
2.4 Relative Humidity	35
2.5 Deriving Humidity Variables at Different Resolutions	35
2.6 The Source Variables and Potential Errors	36
2.7 Conclusions	37
2.8 Tables and Figures for Chapter 2	38

3 The Land Data	42
3.1 The Origin of the Land Data	42
3.1.1 The ISH Database	42
3.1.2 The Climatology Period: 1974 to 2003	44
3.1.3 Duplicate Stations: Finding, Combining and Deleting	45
3.1.4 Comparing ISH with Other Data Sources	48
3.2 Removal of Poor Quality Data	48
3.2.1 Creating a Set of Quality Control Tests for Humidity Data	48
<i>ISSUE 1) Physical Constraints on Meteorological Variables: Bad Values QC</i>	49
<i>ISSUE 2) Strings of Repeated Values: Repeats QC</i>	50
<i>ISSUE 3) Events of Continuous Zero Dewpoint Depression: Zero DPD QC</i>	51
<i>ISSUE 4) Recording Problems in Temperature Extremes: Cutoffs QC</i>	52
<i>ISSUE 5) Reporting Timezones: Timezones QC</i>	54
<i>ISSUE 6) Wind Speed: Wind QC</i>	56
<i>ISSUE 7) Problems with Station Elevation</i>	58
<i>ISSUE 8) Outlier Removal: Outliers QC</i>	60
3.2.2 Running the Quality Control Process: From Raw Hourly Data to Pentad Mean Anomalies	63
3.3 Homogenisation of the Land Data	65
3.3.1 Why homogenise?	65
3.3.2 Homogenisation of Specific Humidity	66
3.3.3 Homogenisation of Relative Humidity	69
3.4 An Analysis of Surface Humidity over Land	70
3.4.1 The Climatology of Surface Humidity over Land	70
3.4.2 Recent Changes in Surface Humidity over Land	71
3.5 Conclusions	73
3.6 Tables and Figures for Chapter 3	75
4 The Marine Data	111
4.1 The Marine Data Source	111
4.2 Creating the Marine Dataset	112
4.2.1 The Marine Data System for Humidity	112
4.2.2 First Stage QC	113

4.2.3 Gridding the Marine Data	114
4.2.4 Second Stage QC and Subsequent Iterations	116
4.3 An Analysis of Marine Surface Humidity	118
4.3.1 The Climatology of Marine Surface Humidity	118
4.3.2 Recent Changes in Marine Surface Humidity	118
4.4 An Investigation into the 1982 Humidity Shift	120
4.5 Conclusions	123
4.6 Tables and Figures for Chapter 4	125
5 Investigating Recent Changes in Observed Surface Humidity and Possible Causes	149
5.1 Blending the Land and Marine Gridded Data	150
5.2 Humidity and Temperature – HadCRUH and HadCRUT3	151
5.2.1 How do Changes in T , q and RH Compare on a Global and Hemispheric Scale?	151
5.2.2 How do Changes in T , q and RH Compare on a Regional Scale?	152
5.2.3 How do Changes in T , q and RH Compare at the Grid-box Scale?	154
5.2.4 Implications of the Combined Humidity and Temperature Analysis	154
5.3 Specific Humidity in HadCM3 – Investigating Possible Causes	155
5.3.1 Comparing HadCM3 and HadCRUH at Large Spatial Scales	157
5.3.2 Comparing HadCM3 and HadCRUH at Regional Scales	158
5.3.3 comparing HadCM3 and HadCRUH at the Grid-box Scale	158
5.4 Conclusions	159
5.5 Tables and Figures for Chapter 5	161
6 Conclusions and Further Work	175
6.1 Principle Findings in the Land Data	176
6.2 Principle Findings in the Marine Data	176
6.3 Principle Findings in the Climate Analyses of HadCRUH	177
6.4 Avenues of Further Work	178
6.5 Conclusions	181
6.6 Tables and Figures for Chapter 6	182
References	183
Definitions	196