Chapter 1  Monitoring the Weather

1.1 Introduction

1.2 Weather and Climate

1.3 Accessing Weather Information

1.4 Time Keeping

1.5 Weather Systems and Weather Maps

1.6 Describing the State of the Atmosphere

1.7 Weather Satellite Imagery

1.8 Weather Radar

1.9 Sky Watching

Chapter 2  Atmosphere: Origin, Composition & Structure

2.1 Introduction
2.2 Evolution of the Atmosphere

2.2.1 Primeval Phase

2.2.1.1 Origin of Earth’s Water: Comet Hypothesis
2.2.1.2 Asteroid Related Hypothesis
2.2.1.3 Hypothesis of Water Indigenous to Earth
2.2.1.4 The Elements of Earth’s Atmosphere

2.2.2 Modern Phase

2.2.3 Air Pollution

2.3 Studying the Atmosphere

2.3.1 The Scientific Method
2.3.2 Atmospheric Models

2.4 Measuring the Atmosphere

2.4.1 Surface Observations
2.4.2 Upper-Air Observations
2.4.3 Remote Sensing

2.5 Temperature Profile of the Atmosphere

2.6 The Ionosphere and the Aurora

Chapter 3 Solar & Terrestrial Radiation

3.1 Introduction

3.2 Electromagnetic Spectrum
3.3 Radiation Laws

3.4 Input of Solar Radiation
   3.4.1 Solar Altitude
   3.4.2 Earth’s Motions in Space and the Seasons
   3.4.3 The Solar Constant

3.5 Solar Radiation and the Atmosphere

3.6 Stratospheric Ozone Shield

3.7 Solar Radiation and Earth’s Surface

3.8 Global Solar Radiation Budget

3.9 Outgoing Infrared Radiation
   3.9.1 The Greenhouse Effect
   3.9.2 Greenhouse Gases
   3.9.3 The Callendar Effect
   3.9.4 Possible Impacts of Global Climate Change

3.10 Monitoring Radiation

Chapter 4  Heat, Temperature & Atmospheric Circulation

4.1 Introduction

4.2 Distinguishing Temperature and Heat
4.2.1 Temperature Scales and Heat Units

4.2.2 Measuring Air Temperature

4.3 Heat Transfer Processes

4.3.1 Radiation

4.3.2 Conduction and Convection

4.3.3 Phase Changes of Water

4.4 Thermal Response and Specific Heat

4.4.1 Thermal Inertia

4.4.2 Maritime and Continental Climates

4.5 Heat Imbalance: Atmosphere versus Earth’s Surface

4.5.1 Latent Heating

4.5.2 Sensible Heating

4.5.3 Bowen Ratio

4.6 Heat Imbalance: Tropics versus Middle and High Latitudes

4.6.1 Heat Transport by Air Mass Exchange

4.6.2 Heat Transport by Storms

4.6.3 Heat Transport by Ocean Circulation

4.7 Why Weather?

4.8 Variation of Air Temperature

4.8.1 Local Radiation Budget
4.8.2 Cold and Warm Air Advection

4.8.3 Urban Heat Island Effect

Chapter 5  Air Pressure

5.1 Introduction

5.2 Defining Air Pressure

5.3 Air Pressure Measurement

5.4 Air Pressure Units

5.5 Variation in Air Pressure with Altitude

5.6 Horizontal Variations in Air Pressure

5.6.1 Influence of Temperature and Humidity

5.6.2 Influence of Diverging and Converging Winds

5.7 Highs and Lows

5.8 The Gas Law

5.9 Expansional Cooling and Compressional Warming

5.9.1 Conservation of Energy

5.9.2 Adiabatic Process

Chapter 6  Humidity, Saturation & Stability
6.1 Introduction

6.2 Global Water Cycle
   6.2.1 Transfer Processes
   6.2.2 Global Water Budget

6.3 How Humid is it?
   6.3.1 Vapor Pressure
   6.3.2 Mixing Ratio, Specific Humidity, and Absolute Humidity
   6.3.3 Saturated Air
   6.3.4 Relative Humidity
   6.3.5 Dewpoint
   6.3.6 Precipitable Water

6.4 Monitoring Water Vapor
   6.4.1 Humidity Instruments
   6.4.2 Water Vapor Satellite Imagery

6.5 How Air Becomes Saturated

6.6 Atmospheric Stability
   6.6.1 Soundings
   6.6.2 Stüve Diagram

6.7 Lifting Processes
Chapter 7  Clouds, Precipitation & Weather Radar

7.1 Introduction

7.2 Cloud Formation

7.2.1 The Curvature Effect

7.2.2 The Solute Effect

7.2.3 Ice-forming Nuclei

7.2.4 Supercooled Water

7.3 Precipitation Processes

7.3.1 Terminal Velocity

7.3.2 Warm-Cloud Precipitation

7.3.3 Cold-Cloud Precipitation

7.3.4 Holes and Canals in Clouds

7.4 Forms of Precipitation

7.5 Acid Deposition

7.6 Weather Radar: Locating Precipitation

7.6.1 Reflectivity Mode

7.6.2 Velocity (Doppler) Mode

7.6.3 Dual-Polarization Weather Radar

7.6.4 Phased Array Weather Radar
7.7 Measuring Precipitation

7.7.1 Rain and Snow Gauges

7.7.2 Remote Sensing of Precipitation

7.8 Cloud Classification

7.8.1 High Clouds

7.8.2 Middle Clouds

7.8.3 Low Clouds

7.8.4 Clouds with Vertical Development

7.8.5 Unusual Clouds

7.9 Fog

Chapter 8  Wind & Weather

8.1 Introduction

8.2 Forces Governing the Wind

8.2.1 Pressure Gradient Force

8.2.2 Centripetal Force

8.2.3 Coriolis Effect

8.2.4 Friction

8.2.5 Gravity

8.2.6 Summary
8.3 Wind: Joining Forces

8.3.1 Hydrostatic Equilibrium

8.3.2 Geostrophic Wind

8.3.3 Gradient Wind

8.3.4 Surface Winds in Highs and Lows

8.4 Continuity of Wind

8.5 Monitoring Wind Speed and Direction

8.6 Scales of Atmospheric Circulation

Chapter 9  Atmosphere’s Planetary Circulation

9.1 Introduction

9.2 Idealized Circulation Pattern

9.3 Features of the Planetary-Scale Circulation

9.3.1 Pressure Systems and Wind Belts

9.3.2 Winds Aloft

9.3.3 Trade Wind Inversion

9.3.4 Seasonal Shifts

9.3.5 Ocean Surface Currents

9.4 Monsoon Circulation
9.5 Long Waves in the Westerlies

9.5.1 Zonal and Meridional Flow Patterns

9.5.2 Blocking Systems and Weather Extremes

9.6 Jet Streams

9.7 Cyclone Development

9.8 El Niño and La Niña

9.8.1 Historical Perspective

9.8.2 Ekman Transport

9.8.3 Neutral Conditions in the Tropical Pacific

9.8.4 Warm Phase

9.8.5 Cold Phase

9.8.6 Predicting and Monitoring ENSO

9.8.7 Frequency of El Niño and La Niña

9.9 North Atlantic Oscillation

9.10 Arctic Oscillation

9.11 Pacific Decadal Oscillation

9.12 Madden-Julian Oscillation

Chapter 10 Weather Systems of Middle Latitudes
10.1 Introduction

10.2 Air Masses
  
  10.2.1 North American types and Source Regions
  
  10.2.2 Air Mass Modification

10.3 Frontal Weather
  
  10.3.1 Stationary Front
  
  10.3.2 Warm Front
  
  10.3.3 Cold Front
  
  10.3.4 Occluded Fronts
  
  10.3.5 Summary

10.4 Extratropical Cyclones
  
  10.4.1 Life Cycle
  
  10.4.2 Conveyor Belt Model
  
  10.4.3 Cyclone Weather
  
  10.4.4 Principal Cyclone Tracks
  
  10.4.5 Cold Side, Warm Side
  
  10.4.6 Winter Storms
  
  10.4.7 Cold- and Warm-Core Systems

10.5 Anticyclones
  
  10.5.1 Arctic and Polar Highs
10.5.2 Warm Highs

10.5.3 Anticyclone Weather

10.6 Local and Regional Circulation Systems

10.6.1 Sea (or Lake) Breeze and Land Breeze

10.6.2 Mountain Breeze and Valley Breeze

10.6.3 Chinook Winds

10.6.4 Santa Ana Winds

10.6.5 Katabatic Wind

10.6.6 Desert Winds

10.6.7 Heat Burst

Chapter 11 Thunderstorms & Tornadoes

11.1 Introduction

11.2 Thunderstorm Life Cycle

11.2.1 Towering Cumulus Stage

11.2.2 Mature Stage

11.2.3 Dissipating Stage

11.3 Thunderstorm Classification

11.4 Where and When

11.5 Severe Thunderstorms
Chapter 12   Tropical Weather Systems

12.1 Introduction

12.2 Weather in the Tropics

12.3 Hurricane Characteristics

12.4 Where and When

12.5 Hurricane Life Cycle
12.6 Hurricane Hazards

12.6.1 Inland Flooding

12.6.2 Wind

12.6.3 Storm Surge

12.6.4 Saffir-Simpson Hurricane Wind Scale

12.7 Trends in Hurricane Frequency

12.8 Hurricane Threat to the Southeast United States

12.8.1 Barrier Islands

12.8.2 Evacuation

12.9 Long-Range Forecasting of Atlantic Hurricanes

12.10 Hurricane Modification

Chapter 13 Weather Analysis & Forecasting

13.1 Introduction

13.2 International Cooperation

13.3 Acquisition of Weather Data

13.3.1 Surface Weather Observations

13.3.2 Upper-Air Weather Observations

13.4 Weather Data Assimilation, Depiction, and Analysis
13.4.1 Surface Weather Maps
13.4.2 Upper-Air Weather Maps

13.5 Weather Prediction

13.5.1 Numerical Weather Forecasting
13.5.2 Forecasting Tropical Cyclones
13.5.3 Forecasting for Aviation
13.5.4 Forecasting Severe Storms
13.5.5 River and Flood Forecasting
13.5.6 Marine Forecasting
13.5.7 Space Weather Forecasting
13.5.8 Forecast Skill
13.5.9 Long-Range Forecasting
13.5.10 Single-Station Forecasting
13.5.11 Private Sector Forecasting

13.6 Communication and Dissemination

13.6.1 Weather-Ready Nation

Chapter 14    Light & Sound in the Atmosphere

14.1 Introduction

14.2 Atmospheric Optics
14.2.1 Visible Light and Color Perception

14.2.2 Red Sun, White Clouds, and Blue Sky

14.2.3 Halo

14.2.4 Rainbow

14.2.5 Corona

14.2.6 Glory

14.2.7 Mirage

14.2.8 Sunrise, Sunset, and Twinkling Stars

14.2.9 Twilight

14.3 Atmospheric Acoustics

14.3.1 Sounds Waves

14.3.2 Thunder

14.3.3 Sonic Boom

14.3.4 Aeolian Sounds

Chapter 15  Climate & Climate Change

15.1 Introduction

15.2 What is Climate?

15.3 Importance of the Climate System

15.3.1 A Changing Climate
15.3.2 The Climate Norm

15.3.3 Differentiating Climate Variability and Climate Change

15.3.4 Assessing Credible Climate Information

15.4 Current Climate Paradigm

15.4.1 Modes by which Climate is Defined

15.4.2 Lessons from Climate Observations

15.5 Natural Drivers of Climate Change

15.5.1 Solar Changes

15.5.1.1 Sunspots

15.5.1.2 Maunder Minimum and the Little Ice Age

15.5.2 Changes in Earth’s Orbit

15.5.2.1 Milankovitch Cycles

15.5.2.2 Evidence from Ocean Sediment Cores

15.5.3 Geologic Contributions

15.5.3.1 Plate Tectonics

15.5.3.2 Volcanoes

15.6 Feedbacks

15.6.1 Types of Feedback

15.6.2 Snow and Ice Cover

15.6.3 Shrinkage of Arctic Sea-Ice Cover

15.7 Projections of Climate

15.7.1 Scientific Models
15.7.1.1 Global Climate Models
15.7.1.2 Enhanced Greenhouse Effect and Global Warming
15.7.1.3 Assessment of Climate Model Output

15.8 Impacts of Climate Change

15.8.1 Rising Sea Level

15.8.2 Shrinking Ice Sheets
   15.8.2.1 Antarctic Ice Sheets
   15.8.2.2 Greenland’s Ice Sheet

15.8.3 Arctic Environment

15.8.4 Marine Life

15.8.5 Human Vulnerabilities

Glossary

Appendix I

Appendix II

Appendix III