Contents

Preface

Acknowledgments

Chapter 1: Monitoring the Weather
  Learning Objectives
  Case-in-Point
  Introduction
  Weather and Climate
  Accessing Weather Information
  Time Keeping
  Weather Systems and Weather Maps
  Describing the State of the Atmosphere
  Weather Satellite Imagery
  Weather Radar
  Sky Watching
  Conclusions
  Basic Understandings
  Enduring Ideas
  Key Terms
  Review
  Critical Thinking
  For Further Exploration
    Essay 1: Weather Maps, Historical Perspective
    Essay 2: Global Positioning System
Chapter 2: Atmosphere: Origin, Composition, & Structure

Learning Objectives
Case-in-Point
Introduction

Evolution of the Atmosphere
  PRIMEVAL PHASE
  MODERN PHASE
  AIR POLLUTION

Studying the Atmosphere
  THE SCIENTIFIC METHOD
  ATMOSPHERIC MODELS

Measuring the Atmosphere
  SURFACE OBSERVATIONS
  UPPER-AIR OBSERVATIONS
  REMOTE SENSING

Temperature Profile of the Atmosphere
The Ionosphere and the Aurora
Conclusions

Basic Understandings
Enduring Ideas

Key Terms
Review

Critical Thinking
Chapter 3: Solar & Terrestrial Radiation

Learning Objectives

Case-in-Point

Introduction

Electromagnetic Spectrum

Radiation Laws

Input of Solar Radiation

Solar Radiation and the Atmosphere

Stratospheric Ozone Shield

Solar Radiation and Earth’s Surface

Global Solar Radiation Budget

Outgoing Infrared Radiation
Chapter 4: Heat, Temperature & Atmospheric Circulation

Learning Objectives

Case-in-Point

Introduction

Distinguishing Temperature and Heat

TEMPERATURE SCALES AND HEAT UNITS
MEASURING AIR TEMPERATURE

Heat Transfer Processes

RADIATION
CONDUCTION AND CONvection
PHASE CHANGES OF WATER
Thermal Response and Specific Heat

THERMAL INERTIA
MARITIME AND CONTINENTAL CLIMATES

Heat Imbalance: Atmosphere versus Earth’s Surface

LATENT HEATING
SENSIBLE HEATING
BOWEN RATIO

Heat Imbalance: Tropics versus Middle and High Latitudes

HEAT TRANSPORT BY AIR MASS EXCHANGE
HEAT TRANSPORT BY STORMS
HEAT TRANSPORT BY OCEAN CIRCULATION

Why Weather?

Variation of Air Temperature

LOCAL RADIATION BUDGET
COLD AND WARM AIR ADVECTION
URBAN HEAT ISLAND EFFECT

Conclusions

Basic Understandings

Enduring Ideas

Key Terms

Review

Critical Thinking

For Further Exploration

Essay 8: Managing Weather Risk
Essay 9: Heating and Cooling Degree-Days
Essay 10: Wind Chill

Web Links

Scientific Literature

End Notes
Chapter 5: Air Pressure

Learning Objectives
Case-in-Point
Introduction
Defining Air Pressure
Air Pressure Measurement
Air Pressure Units
Variation in Air Pressure with Altitude
Horizontal Variations in Air Pressure
  INFLUENCE OF TEMPERATURE AND HUMIDITY
  INFLUENCE OF DIVERGING AND CONVERGING WINDS
Highs and Lows
The Gas Law
Expansional Cooling and Compressional Warming
  CONSERVATION OF ENERGY
  ADIABATIC PROCESS
Conclusions
Basic Understandings
Enduring Ideas
Key Terms
Review
Critical Thinking
For Further Exploration
  Essay 11: Human Responses to Changes in Air Pressure
  Essay 12: Comparing Air and Water Pressure
Chapter 6: Humidity, Saturation & Stability

Learning Objectives
Case-in-Point
Introduction

Global Water Cycle
   TRANSFER PROCESSES
   GLOBAL WATER BUDGET

How Humid Is It?
   VAPOR PRESSURE
   MIXING RATIO, SPECIFIC HUMIDITY, AND ABSOLUTE HUMIDITY
   SATURATED AIR
   RELATIVE HUMIDITY
   DEWPOINT
   PRECIPITABLE WATER

Monitoring Water Vapor
   HUMIDITY INSTRUMENTS
   WATER VAPOR SATELLITE IMAGERY

How Air Becomes Saturated

Atmospheric Stability
   SOUNDINGS
   STÜVE DIAGRAM
Chapter 7: Clouds, Precipitation & Weather Radar

Learning Objectives

Case-in-Point

Introduction

Cloud Formation

THE CURVATURE EFFECT
ROLE OF NUCLEI
SUPERCOOLED WATER

Cloud Classification

HIGH CLOUDS
MIDDLE CLOUDS
LOW CLOUDS
CLOUDS HAVING VERTICAL DEVELOPMENT
UNUSUAL CLOUDS

Fog

Precipitation Processes
   TERMINAL VELOCITY
   WARM-CLOUD PRECIPITATION
   COLD-CLOUD PRECIPITATION
   HOLES AND CANALS IN CLOUDS

Forms of Precipitation

Acid Deposition

Weather Radar: Locating Precipitation
   REFLECTIVITY MODE
   VELOCITY (DOPPLER) MODE
   DUAL-POLARIZATION WEATHER RADAR
   PHASED ARRAY WEATHER RADAR

Measuring Precipitation
   RAIN AND SNOW GAUGES
   REMOTE SENSING OF PRECIPITATION

Conclusions

Basic Understandings

Enduring Ideas

Key Terms

Review

Critical Thinking

For Further Exploration
   Essay 17: Clouds by Mixing
   Essay 18: Rainmaking
   Essay 19: When Is It Too Cold or Too Warm to Snow?
Chapter 8: Wind & Weather

Learning Objectives

Case-in-Point

Introduction

Forces Governing the Wind

PRESSURE GRADIENT FORCE
CENTRIPETAL FORCE
CORIOLIS EFFECT
FRICTION
GRAVITY
SUMMARY

Wind: Joining Forces

HYDROSTATIC EQUILIBRIUM
GEOSTROPHIC WIND
GRADIENT WIND
SURFACE WINDS IN HIGHS AND LOWS

Continuity of Wind

Monitoring Wind Speed and Direction

Scales of Atmospheric Circulation

Conclusions

Basic Understandings

Enduring Ideas
Chapter 9: Atmosphere’s Planetary Circulation

Learning Objectives

Case-in-Point

Introduction

Idealized Circulation Pattern

Features of the Planetary-Scale Circulation

PRESSURE SYSTEMS AND WIND BELTS
WINDS ALOFT
TRADE WIND INVERSION
SEASONAL SHIFTS
OCEAN SURFACE CURRENTS

Monsoon Circulation

Long Waves in the Westerlies

ZONAL AND MERIDIONAL FLOW PATTERNS
BLOCKING SYSTEMS AND WEATHER EXTREMES
Jet Streams
Cyclone Development
El Niño and La Niña

HISTORICAL PERSPECTIVE
EKMAN TRANSPORT
NEUTRAL CONDITIONS IN THE TROPICAL PACIFIC
WARM PHASE
COLD PHASE
PREDICTING AND MONITORING ENSO
FREQUENCY OF EL NIÑO AND LA NIÑA

North Atlantic Oscillation
Arctic Oscillation
Pacific Decadal Oscillation

Conclusions
Basic Understandings
Enduring Ideas
Key Terms

Review

Critical Thinking

For Further Exploration
Essay 23: Defining Drought

Web Resources
Scientific Literature

End Notes
Chapter 10: Weather Systems of Middle Latitudes

Learning Objectives

Case-in-Point

Introduction

Air Masses

NORTH AMERICAN TYPES AND SOURCE REGIONS
AIR MASS MODIFICATION

Frontal Weather

STATIONARY FRONT
WARM FRONT
COLD FRONT
OCCLUDED FRONTS
SUMMARY

Extratropical Cyclones

LIFE CYCLE
CONVEYOR BELT MODEL
CYCLONE WEATHER
PRINCIPAL CYCLONE TRACKS
COLD SIDE/WARM SIDE
WINTER STORMS
COLD- AND WARM-CORE SYSTEMS

Anticyclones

ARCTIC AND POLAR HIGHS
WARM HIGHS
ANTICYCLONE WEATHER

Local and Regional Circulation Systems

SEA (OR LAKE) BREEZE AND LAND BREEZE
MOUNTAIN BREEZE AND VALLEY BREEZE
CHINOOK WIND
Chapter 11: Thunderstorms & Tornadoes

Learning Objectives

Case-in-Point

Introduction

Thunderstorm Life Cycle

TOWERING CUMULUS STAGE
MATURE STAGE
DISSIPATING STAGE
Thunderstorm Classification
Where and When
Severe Thunderstorms
Thunderstorm Hazards
  LIGHTNING
  DOWNBURSTS
  DERECHO
  FLASH FLOODS
  HAIL
Tornadoes
Tornado Characteristics
Where and When
Tornado Hazards and the EF-Scale
The Tornado-Thunderstorm Connection
Monitoring Tornadoic Thunderstorms
Conclusions
Basic Understandings
Enduring Ideas
Key Terms
Review
Critical Thinking
For Further Exploration
  Essay 28: Lightning Safety
  Essay 29: Hail Suppression
  Essay 30: Tornado Look-Alikes
Web Resources
Scientific Literature
End Notes
Chapter 12: Tropical Weather Systems

Learning Objectives
Case-in-Point
Introduction
Weather in the Tropics
Hurricane Characteristics
Where and When
Hurricane Life Cycle
Hurricane Hazards
  INLAND FLOODING
  WIND
  STORM SURGE
  SAFFIR-SIMPSON HURRICANE WIND SCALE
Trends in Hurricane Frequency
Hurricane Threat to the Southeast United States
  BARRIER ISLANDS
  EVACUATION
Long-Range Forecasting of Atlantic Hurricanes
Hurricane Modification
Conclusions
Basic Understandings
Enduring Ideas
Key Terms
Review
Critical Thinking
Chapter 13: Weather Analysis & Forecasting

Learning Objectives

Case-in-Point

Introduction

International Cooperation

Acquisition of Weather Data

SURFACE WEATHER OBSERVATIONS
UPPER-AIR WEATHER OBSERVATIONS

Weather Data Assimilation, Depiction and Analysis

SURFACE WEATHER MAPS
UPPER-AIR WEATHER MAPS

Weather Prediction

NUMERICAL WEATHER FORECASTING
FORECASTING TROPICAL CYCLONES
FORECASTING FOR AVIATION
FORECASTING SEVERE STORMS
RIVER AND FLOOD FORECASTING
MARINE FORECASTING
SPACE WEATHER FORECASTING
Chapter 14: Light & Sound in the Atmosphere

Learning Objectives

Case-in-Point

Introduction

Atmospheric Optics

VISIBLE LIGHT AND COLOR PERCEPTION

RED SUN, WHITE CLOUDS, AND BLUE SKY
Atmospheric Acoustics

Conclusions
Basic Understandings
Enduring Ideas
Key Terms
Review
Critical Thinking
For Further Exploration

Web Resources
Scientific Literature
End Notes

Chapter 15: Climate & Climate Change

Learning Objectives
Case-in-Point

Introduction

What is climate?

Importance of the Climate System

A CHANGING CLIMATE
CLIMATE VARIABILITY VERSUS CLIMATE CHANGE
ASSESSING CREDIBLE CLIMATE INFORMATION

Current Climate Paradigm

MODES BY WHICH CLIMATE IS DEFINED
LESSONS FROM THE CLIMATE OBSERVATIONS

Natural Drivers of Climate Change

SOLAR CHANGES
FAINT YOUNG SUN PARADOX
SUNSPOTS
MAUNDER MINIMUM AND THE LITTLE ICE AGE

CHANGES IN EARTH’S ORBIT
MILANKOVITCH CYCLES
EVIDENCE FROM DEEP-SEA SEDIMENT CORES

GEOLOGIC CONTRIBUTIONS
Plate Tectonics
Volcanoes

Feedbacks

TYPES OF FEEDBACKS
SNOW AND ICE COVER
SHRINKAGE OF ARCTIC SEA-ICE COVER

Projections of Climate

WHAT ARE MODELS?
Global Climate Models
Weather versus Climate Models
Physical Basis for Modeling Earth’s Climate
Enhanced Greenhouse Effect and Global Warming

ASSESSMENT OF CLIMATE MODEL OUTPUT

Impacts of Climate Change

RISING SEA LEVELS
SHRINKING GLACIERS
ARCTIC ENVIRONMENT
MARINE LIFE
HUMAN VULNERABILITIES

Conclusions

Basic Understandings

Enduring Ideas

Key Terms

Review

Critical Thinking

For Further Exploration

Essay 36: Why the Arctic warms faster
Essay 37: Heat-related mortality in the 21st century

Web Resources

Scientific Literature

Topics-in-Depth

Glossary

Appendix I: CONVERSION FACTORS

Appendix II: MILESTONES IN THE HISTORY OF ATMOSPHERIC SCIENCE
Appendix III: Climate Classification