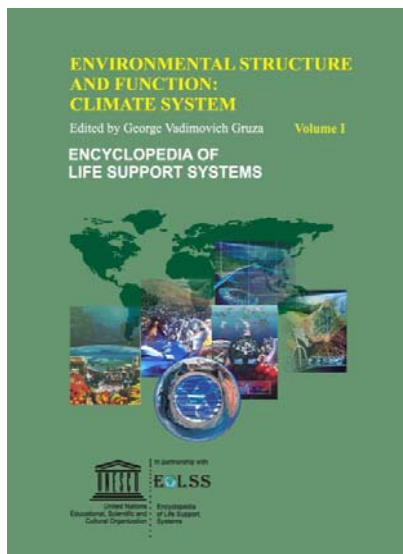


CONTENTS

ENVIRONMENTAL STRUCTURE AND FUNCTION: CLIMATE SYSTEM



Environmental Structure and Function: Climate System - Volume 1

No. of Pages: 366

ISBN: 978-1-84826-288-1 (eBook)

ISBN: 978-1-84826-738-1 (Print Volume)

Environmental Structure and Function: Climate System - Volume 2

No. of Pages: 394

ISBN: 978-1-84826-289-8 (eBook)

ISBN: 978-1-84826-739-8 (Print Volume)

For more information of e-book and Print Volume(s) order, please [click here](#)

[Or contact : eolssunesco@gmail.com](mailto:eolssunesco@gmail.com)

CONTENTS

VOLUME I

Environmental Structure and Function: Climate System	1
<i>G.V. Gruza, Institute for Global Climate and Ecology, Moscow, Russia</i>	

1. Introduction
2. Processes in the Global Climate System
 - 2.1. Atmospheric Processes
 - 2.1.1. Atmospheric Radiative Fluxes
 - 2.1.2. Water Vapor
 - 2.1.3. Clouds.
 - 2.1.4. Atmospheric Precipitation
 - 2.1.5. Atmospheric Chemistry.
 - 2.1.6. Atmospheric Circulation.
 - 2.2. Snow and Ice Processes
 - 2.3. Ocean Processes.
 - 2.3.1. Ocean Surface Layer Fluxes.
 - 2.3.2. Ocean Deep Convection and Circulation
 - 2.4. Terrestrial Processes
3. Climate Now
 - 3.1. Classification of climates
 - 3.2. Observed Climate as it is seen today
4. Weather Systems and Weather Forecasting
 - 4.1. Airmasses and atmospheric fronts
 - 4.2. Cyclones and anticyclones
 - 4.3. Circulation systems
 - 4.4. Weather forecasting
 - 4.5. Intentional weather modification
5. Observed Climate Change in the Twentieth Century
 - 5.1. Surface Temperature and Precipitation Patterns
 - 5.2. Upper Air Temperature
 - 5.3. Atmospheric Circulation Patterns
 - 5.4. Oceans
 - 5.5. Glaciers and Ice Sheets
 - 5.6. Permafrost
 - 5.7. Climatic Extremes
6. Global Climate Models
7. Climate Projections and Future Climate
 - 7.1. Model Experiments
 - 7.2. Emission Scenarios and Climate Projections
 - 7.3. Global Patterns of Expected Climate Change
 - 7.4. Regional Trends
8. International Activity Concerning Climate
 - 8.1. World Climate Program (WCP)
 - 8.2. Global Climate Observing System (GCOS)
 - 8.3. The Intergovernmental Panel on Climate Change (IPCC)
 - 8.4. UN FCCC and The Kyoto Protocol on Climate Change
9. Conclusion

Airmasses and Fronts	79
<i>Natalia Chakina, Hydrometeorological Research Center of Russia, Moscow, Russia</i>	

1. Introduction

2. Airmasses
 - 2.1. Source regions, Airmass transformation
 - 2.2. Geographic classification of airmasses
 - 2.3. Warm and cold airmasses
 - 2.4. Transformation rate
3. Atmospheric fronts
 - 3.1. Frontogenesis and frontolysis
 - 3.2. Geographic classification of fronts
 - 3.3. Warm and cold fronts. Typical schemes
 - 3.3.1. Warm front
 - 3.3.2. Cold front
 - 3.4. Anafronts and katafronts
 - 3.5. Primary and secondary fronts
 - 3.6. Occlusions
 - 3.7. Topographic effects on the fronts
 - 3.7.1. Orographic Occlusion
 - 3.7.2. Obstacle Overflowing: Foehn, Bora
 - 3.8. Internal (mesoscale) structure of the fronts
 - 3.8.1. Precipitation bands. Embedded convection
 - 3.8.2. Wind field. Low-level jet streams
 - 3.8.3. Temperature field. Cold surges and warm cores
 - 3.9. Frontal zones in the middle and upper troposphere
 - 3.9.1. Tropospheric jet streams
 - 3.9.2. Transverse circulations in the jet streams
 - 3.9.3. Stratospheric intrusions
4. Conclusions

Extratropical Cyclones and Anticyclones

101

Natalia Chakina, *Hydrometeorological Research Center of Russia, Moscow, Russia*

1. Introduction
2. Typical cyclone evolution
 - 2.1. Incipient Disturbance
 - 2.2. Young Cyclone
 - 2.3. Maturity
 - 2.4. Decay
3. Mesoscale structure of extratropical cyclone
 - 3.1. Warm Conveyor Belt
 - 3.2. Cold Conveyor Belt
 - 3.3. Dry Air Descending Flow
 - 3.4. Areas of Enhanced Precipitation
 - 3.5. Occlusions
 - 3.6. Satellite View of Cyclone-Comma Cloud
4. Typical anticyclone evolution
5. Special cases of cyclone and anticyclone development
 - 5.1. Explosive Cyclogenesis
 - 5.2. Orographic Effects
 - 5.3. Regeneration
 - 5.4. Cut-off Lows and Highs
 - 5.5. Blocking Highs and Lows
6. General properties of cyclonic activity
 - 6.1. Families of Extratropical Eddies
 - 6.2. Cyclonic Activity Areas
 - 6.3. Cyclones and Anticyclones in the General Circulation of the Atmosphere
 - 6.4. Cyclonic Activity and Stratospheric Air Intrusions
7. Mechanisms of cyclogenesis and cyclonic activity
 - 7.1. Hydrodynamic Instability Concept

- 7.2. Linear Baroclinic Instability- Incipient Growth of Disturbances
- 7.3. Basic Linear Models of Cyclogenesis
- 7.4. Nonlinear Development
- 8. Conclusions

Principal Weather Systems in Subtropical and Tropical Zones 120

I. G. Sitnikov, *The Hydrometeorological Research Center of Russia, Moscow, Russia*

- 1. Introduction
- 2. The general circulation: tropics and subtropics
 - 2.1. Main Elements
 - 2.2. Trade Winds
 - 2.3. The Intertropical Convergence Zone
 - 2.4. Monsoons
- 3. Main perturbation systems in tropical and subtropical zones
 - 3.1. Tropical cyclones
 - 3.2. Waves in the tropical atmosphere
 - 3.2.1. Easterly waves
 - 3.2.2. Other waves in the tropical and equatorial zone
 - 3.3. Monsoon depressions and monsoon lows
 - 3.4. Madden-Julian oscillation (MJO)
 - 3.5. Quasi-biennial Oscillation (QBO)
 - 3.6. Mesoscale Rain and Convective Systems
 - 3.7. Cloud Clusters and Squall Lines
 - 3.8. Tornadoes
- 4. Conclusion

Principal Weather Systems in Temperate and Continental Zones 140

E. P. Veselov, *Hydrometeorological Research Center of Russia, Moscow, Russia*

- 1. Introduction
- 2. Weather Systems Typical of Temperate Latitudes
- 3. Weather Systems Typical of Continental Zones
- 4. Conclusions

Principal Weather Systems in Polar Zones 156

E. P. Veselov, *Hydrometeorological Research Center of Russia, Moscow, Russia*

- 1. Introduction
- 2. Weather Systems Typical of the Arctic
- 3. Weather Systems Typical of the Antarctic
- 4. Conclusions

Short-Term Weather Forecasting 167

S. L. Belousov and L. V. Berkovich, *Hydrometeorological Research Centre of Russia, Moscow, Russia*

- 1. Introduction
- 2. Hydrodynamic Modeling of Meteorological Fields and Large-scale Weather-producing Mechanisms
 - 2.1. Physical Basis of Atmospheric Models Relevant for Short-range Prediction of Meteorological Fields
 - 2.1.1. Simulation of the Vortex Formation in Three-dimensional Modeling of Atmospheric Flows
 - 2.1.2. Scales of the Weather-producing Mechanisms Simulated by the Forecast Models
 - 2.1.3. Physical Processes Accounted for in Atmospheric Models of Different Scale

- 2.2. Numerical Evaluation of Atmospheric Models used in Short-range Weather Forecasting
- 2.3. Numerical Analysis of Meteorological Data in the Short-range Weather Forecasting
- 3. Prediction of local weather patterns
 - 3.1. Methods used for Prediction of Weather Patterns
 - 3.2. Local Weather Forecasting by Statistical Treatment of the Output Provided by Numerical Prediction Models
 - 3.3. Local Weather Predictions as Output of the Hydrodynamic Forecast Model itself
 - 3.4. Very-short-range Weather Forecasting
- 4. Conclusions

Long-Range Weather Forecasting **187**

A.V. Muraviev and R.M. Vilfand, *Hydrometeorological Research Center of Russia, Moscow, Russia*

- 1. Introduction
- 2. Synoptic long -range Weather Forecasting
 - 2.1. General overview
 - 2.2. Prospects
- 3. Statistical Long-range Weather Forecasting
 - 3.1. Methodology
 - 3.2. Scheme formulation
 - 3.3. Prospects: pros and cons
 - 3.4. Example
- 4. Hydrodynamic Long-range Weather Forecasting
 - 4.1. Laws of nature
 - 4.2. Numerical experimentation
 - 4.3. Recent history
 - 4.4. Blending
- 5. Verification Systems for Long-range Forecasts
- 6. Conclusions

Scientific Weather Modification **205**

A. A. Chernikov and Yu. V. Melnichuk, *Central Aerological Observatory, Dolgoprudny, Russia*

N. A. Zaitseva, *Department of Earth Sciences, Russian Academy of Sciences, Moscow, Russia*

- 1. Introduction
- 2. History of the Problem
- 3. Physical Basis for Artificial Modification of Clouds and Precipitation
- 4. The Enhancement and Redistribution of Precipitation
- 5. Hail Suppression
- 6. Fog Dispersal
- 7. Dispersal of Super cooled Low-level Clouds and Precipitation
- 8. Other Weather Modification Experiments
- 9. Conclusions

Classification of the Climate of the Earth **229**

E.I. Khlebnikova, *Main Geophysical Observatory, St. Petersburg, Russia*

- 1. Introduction
- 2. Methods of climate classification
- 3. Descriptive classifications
 - 3.1. Objective empiric classifications
 - 3.2. Landscape-geographical classifications
- 4. Genetic classifications
- 5. Conclusions

Methods of Climate Classification 246E.I. Khlebnikova, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. General structure of methods of climate classification
3. Approaches to geographical classifications of climates
 - 3.1. Soil classifications of climates
 - 3.2. Hydrological classifications of climates
 - 3.3. Landscape-geographical classification

Objective Empiric Classifications of Earth's Climate 259E.I. Khlebnikova, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. Koeppen's classification
3. Thornthwaite's classification

Genetic Classifications of Earth's Climate 271E.I. Khlebnikova, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. Classifications derived from air mass analysis
 - 2.1. Alisov's classification
 - 2.2. Strahler's classification
3. Classifications based on characteristics of surface energy budget

Applied Classifications of Earths Climate 285N.V. Kobysheva, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. Agroclimatic classification
3. Bioclimatic classification
4. Climatic classifications for technical purposes
5. Energy-climatic classifications

Index 303**About EOLSS** 309**VOLUME II****Climate Zones and Types** 1E.I. Khlebnikova, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. General circulation features of major climate belts
 - 2.1. Equatorial belt
 - 2.2. Subequatorial belt (the belt of equatorial monsoons)
 - 2.3. Tropical belt
 - 2.4. Subtropical belt
 - 2.5. Temperate belt
 - 2.6. Subarctic belt

- 2.7. Arctic and Antarctic zones
3. Heat-balance components in the main climate zones
4. Brief description of the main climatic types
 - 4.1. Low-latitude climatic types
 - 4.1.1. Equatorial continental climate
 - 4.1.2. Subequatorial continental (equatorial monsoon) climate
 - 4.1.3. Tropical continental climate
 - 4.1.4. Tropical west-coast climate
 - 4.1.5. Tropical east-coast climate
 - 4.2. Mid-latitude climatic types
 - 4.2.1. Subtropical continental climate
 - 4.2.2. Subtropical west-coast climate
 - 4.2.3. Subtropical east-coast climate
 - 4.2.4. Continental climate of the temperate belt
 - 4.2.5. West-coast climate of the temperate belt
 - 4.2.6. East-coast climate of the temperate belt
 - 4.3. High-latitude climatic types
 - 4.3.1. Subarctic continental climate
 - 4.3.2. Arctic continental climate
 - 4.3.3. Antarctic continental climate
 - 4.3.4. Arctic oceanic climate
5. Conclusions

Low-Latitude Climate Zones and Climate Types

24

E.I. Khlebnikova, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. Equatorial belt
3. Subequatorial belt
4. Tropical belt
 - 4.1. Continental climate
 - 4.2. Oceanic climate
 - 4.3. Climate of the western coasts of the continents
 - 4.4. Climate of the eastern coasts of the continents

Middle-Latitude Climate Zones and Climate Types

40

E.I. Khlebnikova, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. Subtropical belt
 - 2.1. Subtropical continental climate
 - 2.2. Subtropical oceanic climate
 - 2.3. Subtropical west-coast climate
 - 2.4. Subtropical east-coast climate
3. Temperate belt
 - 3.1. Continental climate
 - 3.2. Oceanic climate
 - 3.3. Climate of the western coasts of the continents
 - 3.4. Climate of the eastern coasts of the continents

High-Latitude Climate Zones and Climate Types

62

E.I. Khlebnikova, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. Climate types of subarctic and subantarctic belts

- 2.1. Continental climate
- 2.2. Oceanic climate
- 3. Climate types in Arctic and Antarctic Regions
 - 3.1. Climates of Arctic Region
 - 3.2. Climates of Antarctic continent
 - 3.2.1. Highland continental region
 - 3.2.2. Glacial slope
 - 3.2.3. Coastal region

High-Altitude Climate Zones and Climate Types **74**

E.I. Khlebnikova, *Main Geophysical Observatory, St. Petersburg, Russia*

- 1. Introduction
- 2. Basic controlling factors of highland climates
- 3. Highland climates in different climatic zones
 - 3.1. Low-latitude highland climates
 - 3.2. Middle-latitude highland climates

Local Climates **87**

N.V. Kobysheva, *Main Geophysical Observatory, St. Petersburg, Russia*

- 1. Introduction
- 2. Spatial scales of local climate
- 3. Heat balance of active surface
- 4. Turbulent mixing
- 5. Local circulation
- 6. Influence of Relief on the Local Climate Formation

Factors Controlling Local Climate **99**

N. V. Kobysheva, *Main Geophysical Observatory, St. Petersburg, Russia*

- 1. Introduction
- 2. Radiation balance
- 3. Turbulent heat flow
- 4. Heat flow into the ground
- 5. Evaporation

Urban Climate: The Most Important Modified **107**

N. V. Kobysheva, *Main Geophysical Observatory, St. Petersburg, Russia*

- 1. Introduction
- 2. Cities of high and middle latitudes
 - 2.1. Temperature and humidity
 - 2.2. Wind
 - 2.3. Cloudiness, precipitation, fogs, thunderstorms
- 3. Low latitudes cities

Forest Climates **122**

N.V. Kobysheva, *Main Geophysical Observatory, St. Petersburg, Russia*

- 1. Introduction
- 2. Solar radiation.
- 3. Temperature and humidity.
- 4. Wind
- 5. Precipitation.

Island Climates**128**N.V. Kobysheva, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. Ocean and sea islands
 - 2.1. Surface air temperature
 - 2.2. Atmospheric precipitation
 - 2.3. Air humidity
 - 2.4. Wind
3. Lake and river islands

History of the Earth's Climatic Changes**139**Irena I. Borzenkova, *Department of Climatology, State Hydrological Institute, Russia*

1. Introduction
2. Methods of palaeoclimatic reconstructions
 - 2.1. Lithological-genetic methods
 - 2.2. Ecological-palaeontological methods
 - 2.3. Isotopic and geochemical methods
 - 2.4. Dating techniques
3. Ancient climates of the Earth (Late Precambrian and Palaeozoic)
 - 3.1. Precambrian climates
 - 3.2. Early Palaeozoic climates
 - 3.3. Late Palaeozoic climates
 - 3.4. Mesozoic climates
 - 3.4.1. Triassic and Jurassic climates
 - 3.4.2. Cretaceous climates (135-65 Ma)
4. Cenozoic climatic change
 - 4.1. The Palaeogene climates
 - 4.2. Climates of the Neogene time
5. The Pleistocene and Holocene climates
6. Climates of the historical time
7. Conclusion

History of Planetary and Geological Factors**169**I. I. Borzenkova, *Department of Climatology, State Hydrological Institute, Russia*

1. Introduction
2. Planetary factors of climatic variations
 - 2.1. Changes in solar radiation over the geological past
 - 2.1.1. Changes in solar luminosity or brightness throughout the Earth's history
 - 2.1.2. Changes in the incoming solar radiation due to orbital factors
 - 2.1.3. Variations in solar radiation due to changes in atmosphere's transparency
 - 2.2. Changes of Earth's atmospheric composition as a forcing factor
 - 2.3. Albedo variations as a climatic forcing factor
3. Main geological factors of climate variations
 - 3.1. Continental displacement (or continental drift) and mountain building as climatic factors
 - 3.2. Role of ocean gateways and sea-level changes in the past climatic changes
4. Conclusion

History of Atmospheric Composition**184**I. I. Borzenkova and I. Ye. Turchinovich, *Department of Climatology, State Hydrological Institute, Russia*

1. Introduction

2. Evolution of the Ancient Atmosphere
 - 2.1. The Earlier Secondary Earth's Atmosphere (the Precambrian and Cambrian Period)
3. Atmospheric Composition during the Phanerozoic Time
4. History of the Cenozoic Atmosphere
 - 4.1. Atmosphere gas composition in the Pre-Pleistocene epoch
 - 4.2. Changes in Atmospheric Composition during the Pleistocene
5. Anthropogenic Changes in the Atmospheric Composition
6. Conclusion

Global Climatic Catastrophes (Volcanism and Impact Events)

205

I. I. Borzenkova, *Department of Climatology, State Hydrological Institute, Russia*

1. Introduction
2. Climatic catastrophes in the Earth's history
3. Volcanic explosions and climate
 - 3.1. Types of volcanic eruptions
 - 3.2. Explosive eruptions and climate
4. The fall of celestial bodies and climate
 - 4.1. Climatic events at the Cretaceous-Cenozoic boundary
5. Local climatic catastrophes
 - 5.1. Dust storms
 - 5.2. Smoke from forest fires
 - 5.3. Anthropogenic climatic catastrophes
6. Conclusion

Changes in Biogeochemical Cycles

223

I. Ye. Turchinovich, *Department of Climatology, State Hydrological Institute, Russia*

1. Introduction
2. The Global Carbon Cycle
 - 2.1. Natural Carbon Cycle
 - 2.1.1. Changes in carbon cycle on the time scale over 10^6 years
 - 2.1.2. Changes in Carbon Cycle during Glacial-Interglacial Transitions
 - 2.1.3. Changes in the Carbon Cycle on the Time Scale of Decades to Thousands of Years
 - 2.2. Anthropogenic Disturbances of the Global Carbon Cycle
 - 2.2.1. Observed Changes in Atmospheric CO₂ Concentration
 - 2.2.2. Historical CO₂ Emissions
 - 2.2.3. Historical Changes in CO₂ Concentration and Projections of Future Concentrations
3. The Nitrogen Cycle
4. Conclusion

Greenhouse Gases, Aerosols and Ozone Layer

239

I.L. Karol, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. Parameters connected with atmospheric substances and their effects on climate
3. Greenhouse gases
4. Aerosols
5. Conclusion

Carbon Dioxide

252

I.L. Karol, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction

2. Carbon dioxide sources and sinks
3. Carbon dioxide content distributions in the atmosphere
4. Climatic impact of carbon dioxide
5. Conclusions. Future of the carbon dioxide issue

Methane**262**I.L. Karol, and A.A. Kiselev, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. Methane sources
3. Methane sinks
4. Distribution of methane content in the atmosphere
5. Methane concentration trends
6. The influence of methane on climate
7. Conclusion. How methane will change in the future?

Halocarbons**273**I.L. Karol, and A.A. Kiselev, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. Halocarbon sources
3. Halocarbons sinks
4. The influence of halocarbons on climate
5. Distribution of halocarbons content in the atmosphere
6. Conclusion. How halocarbons will change in the future?

Nitrous Oxide**285**I.L. Karol, and A.A. Kiselev, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. Nitrous oxide sources
3. Nitrous oxide sinks
4. Distribution of nitrous oxide content in the atmosphere
5. The influence of nitrous oxide on climate
6. Conclusion. How nitrous oxide will change in the future?

Tropospheric Ozone and Related Trace Gases**294**I.L. Karol, and A.A. Kiselev, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. Ozone photochemical sources and sinks
3. Tropospheric ozone content measurements
4. Ozone and the environment
5. Tropospheric ozone forming species
 - 5.1. Nitrogen oxides
 - 5.2. Carbon monoxide
 - 5.3. Non-Methane Hydrocarbons
 - 5.4. Hydrogen radicals
6. Conclusion. Ozone and its precursors in the future

Physics of Aerosols and Their Effect on Climate**311**I.L. Karol, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. Atmospheric aerosol sources and sinks
3. Physico-chemical properties of aerosols
4. Aerosol effects on climate
5. Conclusions

Reduction of the Ozone Layer

321

I.L. Karol, and A.A. Kiselev, *Main Geophysical Observatory, St. Petersburg, Russia*

1. Introduction
2. Photochemistry of stratospheric ozone
3. Stratospheric ozone: spatial distribution and seasonal variations
4. Antarctic ozone hole
5. Ozone in the Northern hemisphere and nonpolar regions
6. Conclusion. How ozone will change in the future?

Index

331

About EOLSS

337