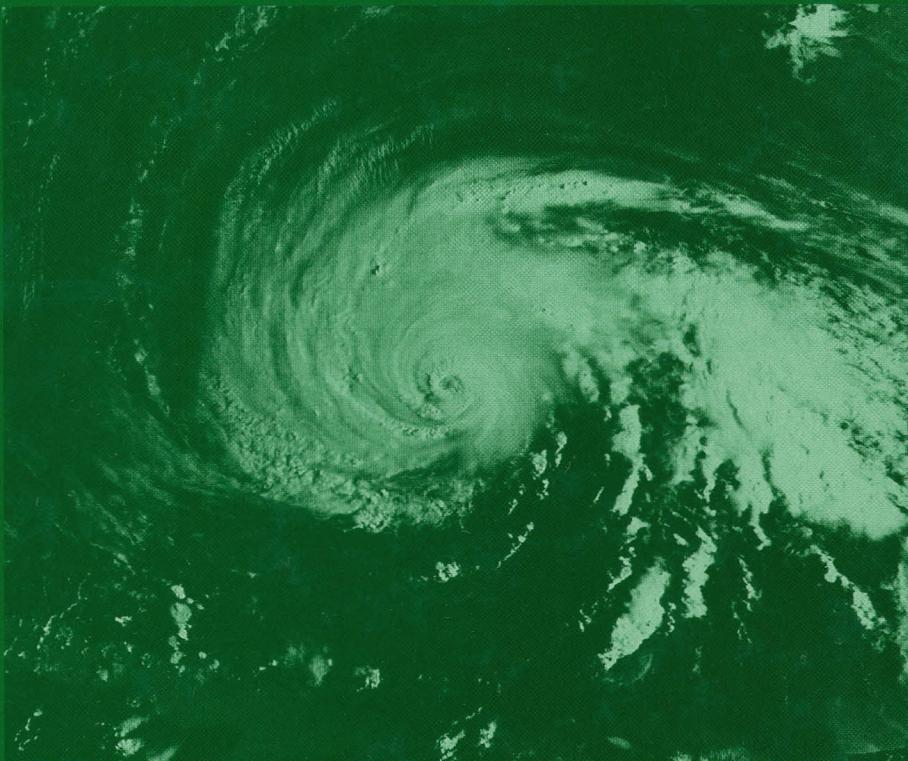


# Calculating the Weather



Meteorology in the 20th Century

Frederik Nebeker



# Calculating the Weather

## *Meteorology in the 20th Century*

Frederik Nebeker

IEEE CENTER FOR THE HISTORY OF  
ELECTRICAL ENGINEERING  
RUTGERS UNIVERSITY  
NEW BRUNSWICK, NEW JERSEY

*311/3885* INSTITUT  
FÜR METEOROLOGIE U. KLIMATOLOGIE  
UNIVERSITÄT HANNOVER  
HERRENHÄUSER STR. 2 - 30419 HANNOVER



ACADEMIC PRESS  
San Diego New York Boston London  
Sydney Tokyo Toronto

# Contents

## **Chapter 1** Introduction

Three Traditions in Meteorology .....	1
The Unification of Meteorology .....	2
Transformations of Meteorology .....	3
Algorithms, Calculation, and Computation .....	4
Forces Leading to an Increased Use of Algorithms .....	6

## **Part I** Meteorology in 1900

### **Chapter 2** An Empirical Tradition: Climatology

Quantitative Description .....	11
Calculational Demands .....	13
Trying to Find Regularities by Tabulating .....	15
Finding Regularities by Mapping .....	16
Finding Regularities by Graphing .....	19
Finding Regularities by Statistical Analysis .....	21
The Establishment of Climatology .....	24

### **Chapter 3** A Theoretical Tradition: Physics of the Atmosphere

The Beginnings of Dynamical Meteorology .....	27
William Napier Shaw .....	29
The Theorists and the Empiricists .....	30
Calculation in Theoretical Meteorology .....	31

### **Chapter 4** A Practical Tradition: Weather Forecasting

The Weather Map .....	36
Skepticism about Weather Forecasting .....	39
“Science, Not Art” .....	40
Calculation in Weather Forecasting .....	43

**Part II Meteorology in the First Half of the 20th Century****Chapter 5 Vilhelm Bjerknes's Program to Unify Meteorology**

Aerology .....	47
From Physics to Meteorology .....	49
The Program to Calculate the Weather .....	50
The Graphical Calculus .....	52
A Turn toward Practical Forecasting .....	56

**Chapter 6 Lewis Fry Richardson: The First Person to Compute the Weather**

Into and out of Meteorology .....	58
Discovery of a Numerical Method .....	62
A Scheme to Compute the Weather .....	65
The Data Requirements .....	67
The Theoretical Basis .....	71
A Test of the Scheme .....	74
The Necessity of Numerical Analysis .....	76
The Inclusiveness of the Scheme .....	78
The Influence of Richardson's Work .....	80

**Chapter 7 The Growth of Meteorology**

Meteorology in World War I .....	83
The Bergen School .....	84
The Growth of Dynamical Meteorology .....	86
Meteorology as a Profession .....	87
Carl-Gustaf Rossby .....	88

**Chapter 8 Meteorological Calculation in the Interwar Period**

The First Use of Punched-Card Machines .....	91
The Search for Weather Cycles .....	94
Calculating Aids .....	99
Calculation in Weather Forecasting .....	104
The Beginnings of Numerical Experimentation .....	107

**Chapter 9 The Effect of World War II on Meteorology**

Operation Overlord .....	111
The Wartime Importance of Meteorology .....	113
The Increased Use of Punched-Card Machines .....	115
Changes in Meteorological Practice .....	118
Changes in Meteorological Research .....	123
Interest in Objective Forecasting .....	127

**Part III** The Beginning of the Computer Era in Meteorology**Chapter 10** John von Neumann's Meteorology Project

Von Neumann's Interest in Meteorology .....	135
The Start of the Meteorology Project .....	138
The Arrival of Jule Charney .....	141
Charney's Program .....	143
The Use of the ENIAC .....	145
The Use of the IAS Computer .....	148

**Chapter 11** The Acceptance of Numerical Meteorology

The Beginnings of a New Style of Meteorology .....	152
The Spread of Numerical Meteorology .....	154
Steps toward Operational Forecasting by Means of Computer .....	156
The Establishment of Numerical Forecasting .....	158
The Computers Used by Meteorologists .....	162
The Abandonment of Other Calculating Aids .....	165
Advances in Numerical Meteorology .....	169

**Chapter 12** The Unification of Meteorology

Growth of the Profession .....	173
Advances in Observational Techniques .....	174
A New Style of Research .....	177
Numerical Experimentation .....	181
Numerical Analysis .....	183
The Unification of Meteorology .....	184

**Chapter 13** The Recognition of Limits to Weather Prediction .....

Notes .....	195
Note on Sources .....	225
References .....	227
Index .....	243