) [1] - 30 DK: 559. 511. 3 59

NUMERICAL METHODS IN WEATHER PREDICTION

G. I. Marchuk

COMPUTING CENTER SIBERIAN BRANCH USSR ACADEMY OF SCIENCES NOVISIBIRSK, USSR

Translated by

K. N. Trirogoff and V. R. Lamb

DECEASED

DEPARTMENT OF METEOROLOGY UNIVERSITY OF CALIFORNIA LOS ANGELES, CALIFORNIA

Translation edited by A. Arakawa and Y. Mintz

DEPARTMENT OF METEOROLOGY UNIVERSITY OF CALIFORNIA LOS ANGELES, CALIFORNIA



ACADEMIC PRESS New York and London 1974 A Subsidiary of Harcourt Brace Jovanovich, Publishers

INSTITUTI 35/1757 FÜR METEOROLOGIE U. KLIMATOLOGIE Der techn. Universitet

3 HANNOVER . HERRENHAUSER STR. 2

CONTENTS

Pre	eface	to the English Edition	IX
Pre	eface	to the Russian Edition	х
Int	rodu	ction	1
1	Bas	ic Equations of Atmospheric Dynamics	
	1.1	THE SYSTEM OF EQUATIONS OF ATMOSPHERIC DYNAMICS	13
	1.2	THE FREE CONVECTION APPROXIMATION	20
	1.3	Equations of dynamics in the (x, y, p) coordinate system	24
2	The	Quasigeostrophic Approximation	
	2.1	THE BASIC QUASIGEOSTROPHIC SYSTEM OF EQUATIONS	30
	2.2	THE EQUATION FOR PRESSURE VARIATION	33
	2.3	THE EQUATION FOR TEMPERATURE VARIATIONS	53
	2.4	THE EQUATION FOR THE VERTICAL VELOCITY	63
	2.5	THE EFFECT OF SURFACE FRICTION ON THE EVOLUTION OF	
		METEOROLOGICAL VARIABLES IN THE FREE ATMOSPHERE	68

CONTENTS

3	The	Splitting-Up Method		
	3.1	BASIC PRINCIPLES OF THE RELAXATION METHOD APPLIED		
		TO STATIONARY PROBLEMS	86	
	3.2	THE SPLITTING-UP METHOD APPLIED TO STATIONARY PROBLEMS	99	
	3.3	A SCHEME FOR THE SPLITTING UP OF NONSTATIONARY		
		PROBLEMS	104	
	3.4	HYDRODYNAMIC EQUATIONS OF TRANSPORT ALONG	110	
		TRAJECTORIES	110	
4	The Splitting-Up Method Applied to the Weather Prediction Equations			
	4.1	SPLITTING UP THE SYSTEM OF HYDRODYNAMIC EQUATIONS	118	
	4.2	INVESTIGATION OF THE EQUATIONS OF DYNAMIC ADJUSTMENT		
		OF FIELDS FOR SIMPLE MODELS	126	
	4.3	A GENERAL APPROACH TO THE DYNAMIC ADJUSTMENT		
		OF FIELDS	140	
	4.4	INVESTIGATION OF THE STABILITY OF AN ALGORITHM	144	
	4.5		152	
	4.6	CONSTRUCTION OF A GENERAL SPLITTING-UP SCHEME	157	
5		leather Prediction Scheme Based on servation Laws		
	5.1	THE HYDROTHERMODYNAMIC EQUATIONS IN THE FORM OF		
		CONSERVATION LAWS	162	
	5.2	EQUATIONS FOR THE DEVIATIONS OF METEOROLOGICAL		
		VARIABLES FROM THEIR STANDARD VALUES IN THE		
		QUASISTATIC APPROXIMATION	166	
	5.3	THE COMPLETE SET OF EQUATIONS OF ATMOSPHERIC		
		DYNAMICS IN TERMS OF DEVIATIONS	169	
	5.4	THE SPLITTING-UP METHOD	170	
	5.5	CONSTRUCTION OF THE EQUATIONS FOR PRESSURE VARIATION	172	
	5.6	DIFFERENCE SCHEMES BASED ON THE CONSERVATION LAWS	176	
	5.7	NEW DIFFERENCE SCHEMES FOR SOLVING WEATHER	185	
		PREDICTION PROBLEMS	105	
6	Hur	nidity Prediction in the Atmosphere		
	6.1	BASIC EQUATIONS	201	
	6.2	BOUNDARY CONDITIONS AND INITIAL DATA	207	
	6.3	THE SPLITTING-UP METHOD	210	
	6.4	DIFFERENCE SCHEMES FOR SOLVING THE EQUATIONS OF		
		HUMIDITY TRANSPORT	215	

vi

CO	N	т	E	N	т	S

7	The	Radiation Field in Weather Prediction				
	7.1	BASIC CHARACTERISTICS OF THE RADIATION FIELD	221			
	7.2	THE EQUATION OF RADIANT ENERGY TRANSFER	226			
	7.3	APPROXIMATE SOLUTION OF THE RADIATION TRANSFER				
		EQUATIONS	232			
	7.4	THE SPLITTING-UP METHOD FOR SOLVING THE RADIATION				
		TRANSFER PROBLEM	235			
8	Obje	ective Analysis of Meteorological Fields				
	8.1	METHODS OF OPTIMAL INTERPOLATION	243			
	8.2	ADJUSTMENT OF THE METEOROLOGICAL FIELDS	245			
	8.3	OBJECTIVE ANALYSIS OF THE HUMIDITY FIELD	253			
References			259			
Subject Index						

vii