

Contents

1	Dynamics of Vortices in Rotating and Stratified Fluids	1
	G.J.F. van Heijst	
1.1	Vortices in Rotating Fluids	1
1.1.1	Basic Equations and Balances	2
1.1.2	How to Create Vortices in the Lab	9
1.1.3	The Ekman Layer	12
1.1.4	Vortex Instability	14
1.1.5	Evolution of Stable Barotropic Vortices	15
1.1.6	Topography Effects	18
1.2	Vortices in Stratified Fluids	20
1.2.1	Basic Properties of Stratified Fluids	20
1.2.2	Generation of Vortices	22
1.2.3	Decay of Vortices	24
1.2.4	Instability and Interactions	30
1.3	Concluding Remarks	33
	References	33
2	Stability of Quasi Two-Dimensional Vortices	35
	J.-M. Chomaz, S. Ortiz, F. Gallaire, and P. Billant	
2.1	Instabilities of an Isolated Vortex	36
2.1.1	The Shear Instability	37
2.1.2	The Centrifugal Instability	37
2.1.3	Competition Between Centrifugal and Shear Instability	40
2.2	Influence of an Axial Velocity Component	41
2.3	Instabilities of a Strained Vortex	43
2.3.1	The Elliptic Instability	44
2.3.2	The Hyperbolic Instability	46
2.4	The Zigzag Instability	47
2.4.1	The Zigzag Instability in Strongly Stratified Flow Without Rotation	47
2.4.2	The Zigzag Instability in Strongly Stratified Flow with Rotation	50

2.5	Experiment on the Stability of a Columnar Dipole in a Rotating and Stratified Fluid	50
2.5.1	Experimental Setup	50
2.5.2	The State Diagram	51
2.6	Discussion: Instabilities and Turbulence	52
2.7	Appendix: Local Approach Along Trajectories	53
2.7.1	Centrifugal Instability	54
2.7.2	Hyperbolic Instability	55
2.7.3	Elliptic Instability	55
2.7.4	Pressureless Instability	56
2.7.5	Small Strain $ \epsilon \ll 1$	56
	References	57
3	Oceanic Vortices	61
	X. Carton	
3.1	Observations of Oceanic Vortices	62
3.1.1	Different Types of Oceanic Vortices	62
3.1.2	Generation Mechanisms	67
3.1.3	Vortex Evolution and Decay	70
3.1.4	Submesoscale Structures and Filaments; Biological Activity ..	72
3.2	Physical and Mathematical Framework for Oceanic Vortex Dynamics	73
3.2.1	Primitive-Equation Model	74
3.2.2	The Shallow-Water Model	76
3.2.3	Frontal Geostrophic Dynamics	86
3.2.4	Quasi-geostrophic Vortices	87
3.2.5	Three-Dimensional, Boussinesq, Non-hydrostatic Models ...	92
3.3	Process Studies on Vortex Generation, Evolution, and Decay	94
3.3.1	Vortex Generation by Unstable Deep Ocean Jets or of Coastal Currents	94
3.3.2	Vortex Generation by Currents Encountering a Topographic Obstacle	95
3.3.3	Vortex Generation by Currents Changing Direction	96
3.3.4	Beta-Drift of Vortices	98
3.3.5	Interaction Between a Vortex and a Vorticity Front or a Narrow Jet	99
3.3.6	Vortex Decay by Erosion Over Topography	100
3.4	Conclusions	100
	References	101
4	Lagrangian Dynamics of Fronts, Vortices and Waves: Understanding the (Semi-)geostrophic Adjustment	109
	V. Zeitlin	
4.1	Introduction: Geostrophic Adjustment in GFD and Related Problems	109

4.2	Fronts, Waves, Vortices and the Adjustment Problem in 1.5d Rotating Shallow Water Model	110
4.2.1	The Plane-Parallel Case	110
4.2.2	Axisymmetric Case	118
4.3	Including Baroclinicity: 2-Layer 1.5d RSW	121
4.3.1	Plane-Parallel Case	121
4.3.2	Axisymmetric Case	127
4.4	Continuously Stratified Rectilinear Fronts	128
4.4.1	Lagrangian Approach in the Case of Continuous Stratification	128
4.4.2	Existence and Uniqueness of the Adjusted State in the Unbounded Domain	130
4.4.3	Trapped Modes and Symmetric Instability in Continuously Stratified Case	133
4.5	Conclusions	136
	References	136
5	Wave–Vortex Interactions	139
	O. Bühler	
5.1	Introduction	139
5.2	Lagrangian Mean Flow and Pseudomomentum	142
5.2.1	Lagrangian Averaging	143
5.2.2	Pseudomomentum and the Circulation Theorem	144
5.2.3	Impulse Budget of the GLM Equations	147
5.2.4	Ray Tracing Equations	150
5.2.5	Impulse Plus Pseudomomentum Conservation Law	155
5.3	PV Generation by Wave Breaking and Dissipation	157
5.3.1	Breaking Waves and Vorticity Generation	157
5.3.2	Momentum-Conserving Dissipative Forces	159
5.3.3	A Wavepacket Life Cycle Experiment	160
5.3.4	Wave Dissipation Versus Mean Flow Acceleration	163
5.4	Wave-Driven Vortices on Beaches	165
5.4.1	Impulse for One-Dimensional Topography	166
5.4.2	Wave-Induced Momentum Flux Convergence and Drag	168
5.4.3	Barred Beaches and Current Dislocation	169
5.5	Wave Refraction by Vortices	171
5.5.1	Anatomy of Wave Refraction by the Mean Flow	172
5.5.2	Refraction by Weak Irrotational Basic Flow	173
5.5.3	Bretherton Flow and Remote Recoil	174
5.5.4	Wave Capture of Internal Gravity Waves	177
5.5.5	Impulse Plus Pseudomomentum for Stratified Flow	179
5.5.6	Local Mean Flow Amplitude at the Wavepacket	180
5.5.7	Wave–Vortex Duality and Dissipation	183
5.6	Concluding Comments	184
	References	185
	Index	189