

Contents

<i>Preface</i>	page ix
<i>Acknowledgements</i>	xi
<i>Contributors</i>	xiii
<i>Frequently Used Symbols</i>	xvii
1. Overview	1
<i>I. S. F. Jones, Y. Volkov, Y. Toba, S. Larsen and N. E. Huang</i>	
1.1 Exchanges at the Sea Surface	1
1.2 Background	2
1.3 Fluid Mechanics	2
1.4 Irrotational Waves and Forced Waves	6
1.5 Wind-wave Sheltering and Wave Age	8
1.6 Drag Generating Mechanisms	9
1.7 Aerodynamically Rough Flow	13
1.8 Ocean Wind-wave Spectra and Wind-wave Equilibrium	15
1.9 The Real Ocean	18
1.10 Drag Observations	24
1.11 The Angle between Stress and Wind	26
1.12 A Representative Expression for the Drag Coefficient	27
1.13 Drag Expressions for Different Purposes	28
1.14 Further Complications	30
1.15 Summary	31
PART 1	
2. Historical Drag Expressions	35
<i>Y. Toba, S. D. Smith and N. Ebuchi</i>	
2.1 Introduction	35
2.2 A Brief History of Sea-Surface Wind Stress Field Experiments	36
2.3 A Review of the Form of Nondimensional Roughness Length	46
3. Atmospheric and Oceanic Boundary Layer Physics	54
<i>V. N. Lykossov</i>	
3.1 Introduction	54

3.2	Marine Atmospheric Boundary Layer	55
3.3	Oceanic Upper Boundary Layer	72
3.4	Processes at the Air–Sea Interface	77
4.	Ocean Wave Spectra and Integral Properties	82
	<i>N. E. Huang, Y. Toba, Z. Shen, J. Klinke, B. Jähne and M. L. Banner</i>	
4.1	Introduction	82
4.2	Equilibrium Ranges for Gravity Waves	85
4.3	Short <i>Wind-waves</i>	95
4.4	The Variability of Gravity–Capillary Waves in Presence of Long Waves	109
4.5	Integral Properties and Local Wind– <i>Wind-wave</i> Equilibrium	115
4.6	<i>Wind-wave</i> Modelling	122
4.7	Concluding Remarks	122
5.	Drag Generation Mechanisms	124
	<i>G. T. Csanady</i>	
5.1	Introduction	124
5.2	Pathways of Air–Sea Momentum Transfer	124
5.3	The Origin of Short <i>Wind-waves</i>	128
5.4	Flow Pattern and Forces on Short Waves	132
5.5	Handover of Momentum Transport	134
5.6	Breaker Dynamics	138
5.7	Concluding Remarks	141
6.	Coupling Mechanisms	142
	<i>J. Bye, V. Makin, A. Jenkins and N. E. Huang</i>	
6.1	Introduction	142
6.2	The <i>Wind-wave</i> Model	143
6.3	Momentum Transfer Below the Sea Surface	145
6.4	Coupling <i>Wind-waves</i> with the Atmosphere	147
6.5	Flow Similarity in the <i>Wind-wave</i> Boundary Layer	150
7.	The Measurement of Surface Stress	155
	<i>S. E. Larsen, M. Yelland, P. Taylor, I. S. F. Jones, L. Hasse and R. A. Brown</i>	
7.1	Introduction	155
7.2	The Measurement of Surface Stress	155
7.3	Reynolds Stress Measurements	156
7.4	Inertial Dissipation Method	160
7.5	The Profile Method to Measure Momentum Fluxes at the Sea Surface	165
7.6	Instrumentation	170
7.7	Airflow Distortion and Platform Motion	171
7.8	Pressure Supported Stress	177
7.9	Satellite Remote Sensing	178
PART 2		
8.	The Influence of Swell on the Drag	181
	<i>M. A. Donelan and F. W. Dobson</i>	
8.1	Introduction	181
8.2	Wind–Swell Interaction	182

8.3	Swell-Wind Sea Interaction	184
8.4	Swell Attenuation in Adverse Winds	184
8.5	Change in the Drag due to Swell	185
8.6	Summary	189
9.	The Influence of Unsteadiness	190
	<i>Y. Toba and I. S. F. Jones</i>	
9.1	Introduction	190
9.2	Wave Field Response to Change in the External Forcing	192
9.3	Field Data	193
9.4	Laboratory Data	198
9.5	The Influence on Drag	203
9.6	Slow Rates of Change of Wind Speed	203
9.7	Turning Winds	203
9.8	Physical Model	204
9.9	Concluding Remarks	205
10.	The Dependence on Wave Age	206
	<i>Y. Volkov</i>	
10.1	Introduction	206
10.2	Long Waves	208
10.3	Wind-wave Drag	209
10.4	Short <i>Wind-waves</i>	211
10.5	Total Drag	211
10.6	Wave Age Dependence	212
10.7	Measurement of Drag as a Function of Wave Age	214
10.8	Model of Aerodynamic Roughness	215
10.9	Geostrophic Drag Coefficient	217
11.	The Influence of Mesoscale Atmospheric Processes	218
	<i>L. Hasse and R. A. Brown</i>	
11.1	Introduction	218
11.2	Influences of Open Ocean Subgridscale Processes on Stress	219
11.3	Mesoscale Atmospheric Processes in Coastal Seas	226
11.4	Consequences for Drag Determination	230
12.	Wind, Stress and Wave Directions	232
	<i>C. A. Friehe, J. A. Smith, K. F. Rieder, N. E. Huang, J-P. Giovanangeli and G. L. Geernaert</i>	
12.1	Introduction	232
12.2	Definitions	232
12.3	Stress Directions in Boundary Layers	233
12.4	Laboratory <i>Wind-wave</i> Measurements	234
12.5	Aircraft Results	234
12.6	Numerical Models	234
12.7	Measurement Accuracy	235
12.8	Over-land Results	235
12.9	Tower and Open Ocean Experiments	236
12.10	Wind and Wave Alignment	239

13. The Influence of Surface Tension	242
<i>H. Mitsuyasu and E. J. Bock</i>	
13.1 Introduction	242
13.2 Surfactants	243
13.3 Damping of Waves	246
13.4 The Impact of Surfactants	251
13.5 Field Studies	252
14. The Influence of Spatial Inhomogeneity: Fronts and Current Boundaries	254
<i>G. L. Geernaert and N. E. Huang</i>	
14.1 Introduction	254
14.2 Theory	255
14.3 Wind Stress Dynamics in the Vicinity of SST Fronts	257
14.4 Atmospheric Fronts	266
14.5 Conclusions	269
15. Basin Boundaries	270
<i>K. B. Katsaros</i>	
15.1 Effects of Boundaries	270
15.2 Basin Width	270
15.3 Shallow Water	271
15.4 Land–Sea Boundary	274
15.5 Conclusion	274
<i>References</i>	277
<i>Index</i>	305