

## TABLE OF CONTENTS

1	INTRODUCTION .....	1
1.1	Background.....	1
1.2	Motivation.....	2
1.3	Objectives .....	3
1.4	Problem definition .....	4
1.5	Overview .....	5
1.6	Organization of the thesis .....	6
2	LITERATURE SURVEY .....	8
2.1	General survey of existing strategies for representing subgrid scale effects.....	8
2.2	General problem of parameterizing the Planetary Boundary Layer (PBL) .....	12
2.2.1	Description of the PBL .....	13
2.3	Detail review of selected land surface parameter upscaling approaches .....	15
2.3.1	The blending height approach .....	15
2.3.2	The energy matching method .....	19
2.3.3	Simple averaging methods.....	25
2.3.4	Inverse modeling approach.....	25
2.3.5	Concluding remarks.....	28
3	THEORY AND MODEL DESCRIPTION OF THE INVERSE-SVAT METHOD .....	29
3.1	Introduction .....	29
3.2	The SVAT model.....	30
3.2.1	The boundary layer model .....	31
3.2.2	The surface layer model .....	31
3.2.3	The soil thermodynamics model.....	34
3.2.4	The soil moisture dynamics model.....	35
3.2.5	The surface runoff and infiltration model.....	37
3.2.6	The evapotranspiration model .....	38
3.2.7	Soil moisture initialization.....	41
3.3	The inverse-SVAT problem .....	42
3.3.1	Formulation of the inverse-SVAT problem.....	42
3.3.2	The Gauss-Levenberg-Marquardt method.....	43
3.4	The Monte Carlo random number generator for normally distributed fields .....	48
3.5	Concluding remarks.....	49

<b>4 SENSITIVITY OF SURFACE ENERGY FLUXES AND MOISTURE INDICATORS TO LAND SURFACE PARAMETERS IN THE VOLTA BASIN .....</b>	<b>50</b>
4.1 Introduction .....	50
4.2 The numerical experimentation .....	52
4.3 Analysis of sensitivity results .....	57
4.3.1 Response of surface energy fluxes and moisture indicators to changes in land surface parameters in the Volta Basin.....	57
4.4 Parameter sensitivities based on the Jacobian matrix formulation.....	67
4.5 General discussion: Comparison between Case I and Case II.....	69
4.6 Concluding remarks.....	72
<b>5 THE INVERSE-SVAT TECHNIQUE PART I: DESCRIPTION OF THE UPSCALING METHOD.....</b>	<b>74</b>
5.1 Introduction .....	74
5.2 Description of upscaling method.....	75
5.2.1 Problem definition .....	75
5.2.2 Conceptual design of the methodology.....	76
5.3 Concluding remarks.....	80
<b>6 THE INVERSE-SVAT TECHNIQUE PART II: NUMERICAL IMPLEMENTATION OF THE UPSCALING METHOD .....</b>	<b>81</b>
6.1 Introduction .....	81
6.2 Materials and methods.....	82
6.2.1 The Monte Carlo experiment.....	82
6.2.2 Initialization of the experimental Domains .....	86
6.2.3 Coupling of models to PEST .....	92
6.3 Concluding remarks.....	95
<b>7 ANALYSIS OF RESULTS .....</b>	<b>97</b>
7.1 Introduction .....	97
7.2 Results for coupled stand-alone SVAT and PEST .....	98
7.2.1 Upscaling laws.....	98
7.2.2 Comparison of proposed method with method of Hu et al. (1999).....	106
7.3 Results for coupled Mesoscale Climate Model MM5-PEST (3D SVAT) .....	116
7.3.1 Upscaling laws.....	116
7.3.2 Comparison of the proposed method to method of Hu et al. (1999): The 3D SVAT case .....	123
7.4 Effect of choice of objective functions, initial parameters and parameter bounds on results of the parameter estimation process .....	129
7.5 Chi square analysis: 1D SVAT case.....	133
7.5.1 Dependence of number of subgrids on estimation of effective parameters: The case of 9 and 81 subgrid parameter distributions with the same means .....	134

7.5.2	General remarks on the chi square analysis.....	143
7.6	Dependence of effective roughness length on the duration of episode ..	147
7.7	Concluding Remarks .....	151
8	SUMMARY AND CONCLUSION.....	153
8.1	Achievements .....	153
8.2	Method.....	154
8.3	Results .....	155
8.4	Conclusion .....	158
8.5	Outlook .....	158
9	REFERENCES.....	159
	APPENDIX A .....	167
	APPENDIX B .....	176

## ACKNOWLEDGEMENTS