

# Contents

## List of symbols

Preface	9
<b>1 Introduction</b>	<b>10</b>
<b>2 Uncertainty</b>	<b>15</b>
2.1 Components of uncertainty . . . . .	17
2.2 Influence of uncertainty on a model . . . . .	18
2.3 Mathematical theories for modelling uncertainty . . . . .	20
2.4 Semantics of uncertainty . . . . .	21
2.5 Example . . . . .	22
2.6 Uncertainty in geographical sciences . . . . .	25
<b>3 Fuzzy set theory</b>	<b>28</b>
3.1 Fuzzy set . . . . .	29
3.2 $\alpha$ -cuts of a fuzzy set . . . . .	30
3.3 The decomposition theorem . . . . .	31
3.4 Properties of a fuzzy set . . . . .	33
3.5 Operations with fuzzy sets . . . . .	34
3.6 Fuzzy numbers . . . . .	34
3.7 Properties of fuzzy numbers . . . . .	36
3.8 Types of fuzzy numbers . . . . .	36
<b>4 Fuzzy arithmetic and other operations with fuzzy numbers</b>	<b>41</b>
4.1 The extension principle . . . . .	42
4.2 Fuzzy arithmetic based on the decomposed fuzzy numbers . .	43
4.3 Basic arithmetic operations . . . . .	44

4.4	Functions of a fuzzy number . . . . .	45
4.5	Special functions . . . . .	46
4.6	Limitations and disadvantages of fuzzy arithmetic . . . . .	53
4.7	Further operations with fuzzy numbers . . . . .	53
<b>5</b>	<b>Surface Uncertainty</b>	<b>58</b>
5.1	Fuzzy surface models . . . . .	60
5.2	Statistical models of a surface error . . . . .	64
5.3	Comparison of methods for uncertainty propagation . . . . .	66
<b>6</b>	<b>Surface derivatives</b>	<b>70</b>
6.1	Methods of partial derivatives calculation . . . . .	71
6.2	Calculation of slope and aspect . . . . .	73
6.3	First derivatives of fuzzy surfaces . . . . .	74
6.4	Example . . . . .	77
<b>7</b>	<b>Visibility analysis</b>	<b>82</b>
7.1	Algorithm . . . . .	83
7.2	Visibility on surfaces with uncertainty . . . . .	87
7.3	Possibilistic visibility on fuzzy surfaces . . . . .	89
7.4	Example . . . . .	95
<b>8</b>	<b>Decision making with results of fuzzy surface analyses</b>	<b>98</b>
<b>9</b>	<b>Case Study</b>	<b>102</b>
9.1	Elevation points . . . . .	103
9.2	Fuzzy surface creation . . . . .	104
9.3	First derivatives of fuzzy surface . . . . .	108
9.4	Visibility analysis . . . . .	114
<b>10</b>	<b>Discussion</b>	<b>118</b>
10.1	Future work . . . . .	119
<b>11</b>	<b>Conclusions</b>	<b>121</b>
<b>References</b>		<b>123</b>
<b>Shrnutí</b>		<b>132</b>