



## UvA-DARE (Digital Academic Repository)

### Modeling alpine geomorphology using laser altimetry data

Anders, N.S.

**Publication date**  
2013

[Link to publication](#)

#### **Citation for published version (APA):**

Anders, N. S. (2013). *Modeling alpine geomorphology using laser altimetry data*. [Thesis, fully internal, Universiteit van Amsterdam].

#### **General rights**

It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

#### **Disclaimer/Complaints regulations**

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: <https://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.

---

# Contents

---

<b>Preface</b> . . . . .	<b>9</b>
<b>Summary</b> . . . . .	<b>13</b>
<b>Samenvatting</b> . . . . .	<b>17</b>
<b>Zusammenfassung</b> . . . . .	<b>21</b>
<b>1 General introduction</b> . . . . .	<b>27</b>
1.1 Digital terrain analysis and geomorphometry . . . . .	28
1.1.1 LiDAR data and processing . . . . .	28
1.1.2 DEMs and Land Surface Parameters . . . . .	29
1.1.3 Automated extraction of geomorphological features . . . . .	29
1.2 Object-Based Image Analysis . . . . .	30
1.3 Dynamic modeling of geomorphological processes . . . . .	32
1.4 Research objectives and structure of this thesis . . . . .	33
1.5 Study area . . . . .	33
<b>2 Segmentation optimization and stratified object-based analysis for semi-automated geomorphological mapping</b> . . . . .	<b>37</b>
2.1 Introduction . . . . .	38
2.2 Study area . . . . .	39
2.3 LiDAR data acquisition and processing . . . . .	40
2.4 Methods . . . . .	40
2.4.1 Data preparation . . . . .	41
2.4.2 Parametrization . . . . .	42
2.4.3 Stratified feature extraction . . . . .	44
2.4.4 Validation . . . . .	44
2.5 Results . . . . .	44
2.5.1 Segmentation parametrization . . . . .	45
2.5.2 Classification results . . . . .	45
2.6 Discussion . . . . .	45
2.6.1 RGB composite . . . . .	45
2.6.2 Segmentation Accuracy Assessment . . . . .	47
2.6.3 Stratified feature extraction . . . . .	49
2.7 Conclusions . . . . .	51

<b>3</b>	<b>A protocol for digital geomorphological mapping in mountainous areas . . . .</b>	<b>53</b>
3.1	Introduction . . . . .	54
3.2	Study area . . . . .	56
3.3	Data & Methods . . . . .	58
3.3.1	Data sources . . . . .	58
3.3.2	Digital geomorphological mapping of representative areas . . . . .	59
3.3.3	Object-based digital terrain analysis . . . . .	60
3.3.4	Software . . . . .	64
3.4	Results & Discussion . . . . .	65
3.4.1	Segmentation optimization . . . . .	65
3.4.2	Automated development of classification rules . . . . .	66
3.4.3	Classification results . . . . .	67
3.4.4	A protocol on digital geomorphological mapping . . . . .	68
3.5	Conclusions . . . . .	71
<b>4</b>	<b>Semi-automated mapping of geoconservation value in Lech, Vorarlberg . . . .</b>	<b>73</b>
4.1	Introduction . . . . .	74
4.2	Study area and data sources . . . . .	75
4.3	Methods . . . . .	76
4.3.1	Geomorphological mapping . . . . .	76
4.3.2	Identification and ranking of potential geoconservation areas . . . . .	77
4.4	Results and discussion . . . . .	79
4.4.1	Geoconservation map . . . . .	79
4.4.2	Potential geoconservation sites . . . . .	80
4.5	Final remarks . . . . .	83
<b>5</b>	<b>Geomorphological change detection using object-based feature extraction from multi-temporal LiDAR DTMs . . . . .</b>	<b>87</b>
5.1	Introduction . . . . .	88
5.2	Study area . . . . .	88
5.3	Methods . . . . .	89
5.3.1	Lidar data processing . . . . .	89
5.3.2	Object-based feature classification and extraction . . . . .	89
5.3.3	Feature-based change analysis . . . . .	90
5.4	Results and discussion . . . . .	90
5.4.1	Lidar point processing . . . . .	90
5.4.2	Classifications . . . . .	91
5.4.3	Change detection . . . . .	92
5.5	Conclusions . . . . .	94
<b>6</b>	<b>Modeling channel incision and alpine hillslope development using laser altimetry data . . . . .</b>	<b>97</b>
6.1	Introduction . . . . .	98
6.2	Field setting . . . . .	99
6.3	LiDAR data and processing . . . . .	100
6.4	Methods . . . . .	102
6.4.1	Initiation (1) module . . . . .	102
6.4.2	The CIM (2) module . . . . .	104
6.4.3	The landscape response (3) module . . . . .	105
6.4.4	Model evaluation (4) module . . . . .	106

---

6.5	Results . . . . .	106
6.5.1	Model results . . . . .	108
6.6	Discussion . . . . .	110
6.6.1	Initial model conditions . . . . .	110
6.6.2	Model evaluation . . . . .	111
6.7	Conclusions . . . . .	112
<b>7</b>	<b>Evaluating landscape evolution models with object-based landform classifications . . . . .</b>	<b>115</b>
7.1	Introduction . . . . .	116
7.2	Study area and data sources . . . . .	117
7.3	Methods . . . . .	117
7.3.1	The modular erosion and sedimentation model . . . . .	117
7.3.2	Landform classifications . . . . .	121
7.4	Results . . . . .	123
7.4.1	Model results . . . . .	123
7.4.2	Model evaluation based on landform classifications . . . . .	123
7.5	Discussion . . . . .	127
7.6	Conclusions . . . . .	128
	<b>Epilogue . . . . .</b>	<b>131</b>
	<b>About the author . . . . .</b>	<b>135</b>
	<b>Bibliography . . . . .</b>	<b>137</b>