(2014).

The objective of the presented study is to evaluate how to make best use of available high (both spatial and thematic) resolution geologic and topographic information for soil survey. This is of special interest as, while the quaternary deposits were often neglected in older geologic surveys or aggregated in a single unit, the new generation of geologic maps created within the CARG (Geologic and geothematic cartography of Italy) framework exhibit high detail regarding these surficial deposits. The study area in the Überetsch/Oltradige region of the Autonomous Province Bolzano – South Tyrol was therefore chosen due to the availability of detailed geologic maps, but also the diversity of soil forming factors, especially geology and topography. By applying random forest classification and feature selection, we investigate which terrain parameters, with emphasis on roughness measures, are best suited to produce a parent material map based on an available geological maps as well as topography. Additionally, the same method is applied to distinguish terrain parameters that, for each soil parent material class, best separate those profile site points that are correctly classified in the geological map from those of the same class that are misclassified. Based on this analysis and a similar investigation into characteristic terrain parameters of the surficial geology map units, each of these is characterised with regard to topography and soil. We emphasize those units which are often confused or show overlap, and should therefore be surveyed with greater detail and in consideration of relevant topographic information. The main aim of the random forest classification is to identify the topographic characteristics of the parent material and geologic units in order to facilitate future detailed soil surveys, and not necessarily to improve the geological map with regard to its application as a parent material map.

? ? to ? ? ? effort ? muss das gesagt werden ?

2. Study area and data

„Location and short description“

2.1. *General description*

? Localisation / Overview ?

The study area includes the wide vale of Eppan-Kaltern, the Überetsch, located just south-west of Bozen in the Autonomous Province of Bolzano – South Tyrol, and extends in the north to the debris fan of Andrian in the Etsch Valley and the adjacent hill slope on the orographic right of the Etsch River. The western border of the study area is the steep slope of the Mendola-Roèn-Ridge (max. 2116 m a.s.l.), whereas the eastern border of the Überetsch as well as the study area is represented by the the Mitterberg, a

Paleovalley erwähnen!

of ?

schon bekannt?

ridge of Permic Vulcanites from which steep slopes descend to the Etsch Valley (approx. 200 m a.s.l.). The Kalterer Lake represents the southern limits of the investigated area. The land use of the paleovalley and its debris cones as well as the Etsch valley is dominantly apple orchards and vineyards, whereas the slope of the Mendola-Roèn-Ridge and the hilly outcrops of Vulcanites are covered by forests. Some Pastures are located mainly on ~~till covering~~ the flat areas of the Mendola-Roèn-Ridge. Figure 1 shows the study area as well as the surficial geologic units and soil profile locations. The study area is characterised by the mild and humid transition zone between the Mediterranean and Continental climate zone. The longtime mean annual precipitation in Montiggl, located in the southeastern quadrant of the study area is 802 mm along with longtime mean annaul temperature of 11.9° (Thalheimer, 2006).

woher?

11.9 °C

S.?

2.2. *Surficial Geology* geologic units

* A detailed description of the geologic situation can be found in the commentary to the new geologic map of Eppan (Avanzini et al., 2006). The paleovalley of Überetsch is described by Scholz et al. (2005) as a complex system of gravelly lateral moraines and large kame terraces, the result of the 'Kaltern lobe', a Pleniglacial tongue of the Etsch valley glacier. Additionally, laterally eroded remainders of debris fans that were deposited against the recessing glacier can be found along the lower slopes of the Mendola-Roèn-Ridge, as well as recent debris flow deposits, often composed of mainly limestone and dolomite fragments. The vale bottom itself is filled with Pleistocene sediments and Holocene? and contains a number of valleys carved into the gravels by fossil melt-water. At the eastern and western borders of the Pleistocene sediments, outcrops of Permic igneous rhyolite and Lapilli-Tuff are responsible for a hilly relief. neuer Satz most prominently at the eastern border of the study area where the Überetsch is separated from the Etsch valley by a steep slope down from the Mitterberg with an elevation difference of approximately 400 m. In the western part, .. The steep slopes of the Mendola-Roèn-Ridge are dominated by various Dolomite units, with intermittent layers of sand and siltstones. Except for the very steep Dolomite walls of the ridge, the rarely occurring outcrops of these formations are surrounded and mostly covered by Pleistocene and Holocene slope debris, and in locally flatter areas by till.

Super!

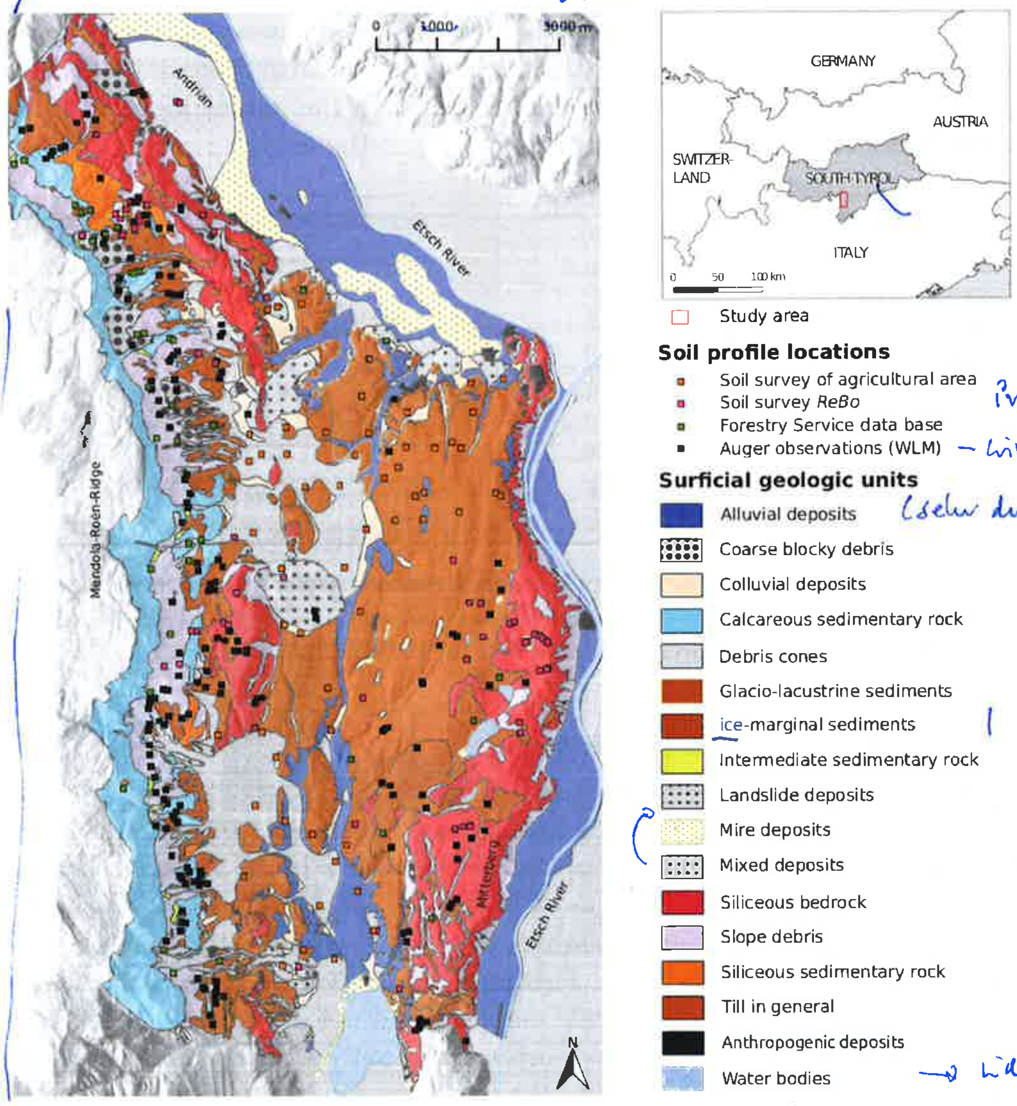
The study area comprises two map sheets of the new geologic map of Italy, sheet Eppan, which covers the northern and major part of the area, as well as sheet Mezzo-Lombardo in the southern part. The sheets were published at a scale of 1 : 50,000 in 2007 and 2012, respectively. Mapping was performed at

* Verweis auf Tab. 1?

Zitate von Berichten? (Researchgate)

Rahmen

3 km



Sieht man, dass es zu Italien gehört?

Project ReBo

wirklich nur Bohrstocke?

(sehr dunkel)

Reihenfolge? (Alter)

nicht geologie!

gic units

Figure 1: Overview of the study area showing the surficial geology as well as the locations of the soil profile sites analysed in this study. Computations were performed only for the areas covered by surficial geologic units.

a scale of 1 : 10,000, this information was kindly provided by the Department of Geology and Building Material Tests of the Autonomous Province Bolzano – South Tyrol, in shapefile format and used for the analysis performed in this study.

vorne noch in Englisch

Zusammenfassung in Bezug auf Bodenbildung!

(Anzahl?)

Gründe!

For simplification of the analysis and data harmonisation, the original geologic map units were generalised into the 16 surficial geology units (SGUs) described in Table 1, that allow comparison with the parent material units described and identified by the soil surveyors in the field.

doppelt

SGU	Abbrev.	short description	% area
alluvial deposits	AD	Holocene and Pleistocene deposits of silt, sand and gravels	14.9
coarse blocky debris	CBD	Holocene and Pleistocene blocky deposits of mass movements	1.8
colluvial deposits	CD	footslope deposits	2.4
calcareous sedimentary rock	CSR	limestones and dolomites	8.4
debris cones	DC	Holocene conic deposits from debris flows and torrents	12.7
glaciolacustrine and lacustrine deposits	GLD	(fine) sand deposits (with dropstones)	2.5
ice-marginal sediments	IMS	clast-supported gravels	0.2
intermediate sedimentary rock	ISR	silt- and sandstones	0.2
landslide deposits	LD	large landslide deposits	1.2
mire deposits	MrD	Holocene and Pleistocene silt and peat deposits	3.3
mixed deposits	MxD	Pleistocene deposits from debris flows, torrents and avalanches	2.1
siliceous bedrock	SB	rhyolite and rhyodazite tuffs and ignimbrites	13.0
slope debris	SD	Holocene and Pleistocene debris on slopes	10.3
siliceous sedimentary rock	SSR	silt- and sandstones	1.1
till in general	TG	undifferentiated glacial deposits	25.9

mit Karte gleich

sediments

Table 1: Generalised surficial geology units in alphabetic order with abbreviations and short descriptions. Additionally, the proportion of the study area covered by each unit is given. Anthropogenic deposits are not included in the analysis.

klingt so räumlich!

2.3. Soil data sets and soil classification

Article

Figure 2 gives an overview of the distribution of the soil types amongst the soil profiles incorporated into the analysis and located within study area. (Fig. 1) The soil classification scheme applied in this study is the Austrian system (Nestroy et al., 2000, 2011), as most of the soil profile descriptions available for this study apply this system which is also well adapted to the Alpine environment (Baruck et al., 2016). Furthermore, it is generally recommendable to use local systems for large-scale mapping and not all available soil profile data, especially those from points investigated only with augering, included sufficient information for deriving the reference soil group according to the World Reference Base for soil resources (IUSS Working Group WRB, 2015). Table 2 gives an overview of which reference soil groups are best correlated to the relevant soil types in the Austrian classification. Classification of the soil profiles was performed at the subtype level, a basic overview of the Austrian soil classification system can be found in Baruck et al. (2016).

nochmal Hinweis auf Fig. 1 (Profile)

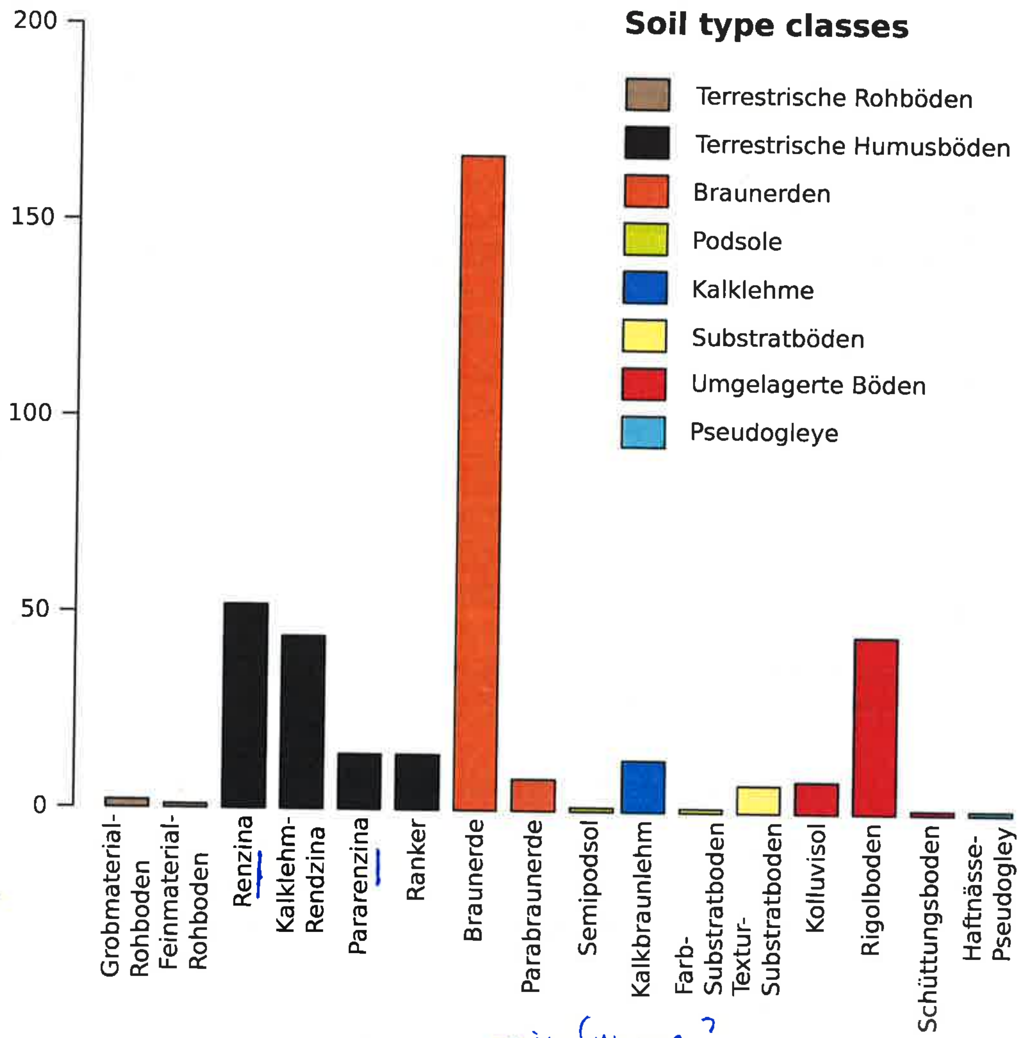
warum?

gut

Soil data base 1: soil survey of agricultural areas in the Überetsch/Oltradige region. From 1993-1995 a soil survey of the farmlands in the region Überetsch was conducted (Thalheimer, 2006). Soil types were classified according to Soil

to

by



d

in Summe?

Figure 2: Barplot showing the number of soil profiles for each of the soil types identified at least for one of the data points in the study area. Coloring indicates the soil type classes. Classification was performed according to the Austrian soil classification (Nestroy et al., 2000, 2011). Relationships with WRB reference groups can be found in Table 2 .

Taxonomy, resulting in a soil map with 18 different soil series. 58 detailed soil pit descriptions were incorporated into the presented study, all located either in vineyards or apple orchards. Using the horizon descriptions, chemical properties as well as photographs of the pit face, theses soil profiles were

soil type	corresponding WRB groups	short description	soil class
Grobmaterial-Rohboden	Leptosol, Regosol, Histosol	same as Feinmaterial-Rohboden but with more than 40 V.-% coarse fraction	Terrestrische Rohböden
Feinmaterial-Rohboden	Leptosol, Regosol, Histosol, Arenosol	only initial soil formation (A_i horizon) on parent material with less than 40 V.-% coarse fraction	Terrestrische Rohböden
Rendzina	Leptosols, Histosols	only an A or organic horizon on calcareous bedrock	Terrestrische Humusböden
Kalklehm-Rendzina	Leptosol	soils with a loamy A-horizon on calcareous bedrock	Terrestrische Humusböden
Pararendzina	Leptosol, Regosol, Umbrisol, Histosol	only an A-horizon on carbonate-containing unconsolidated sediment or bedrock	Terrestrische Humusböden
Ranker	Leptosol, Umbrisol, Regosol	only an A or organic horizon on siliceous bedrock	Terrestrische Humusböden
Braunerde	Cambisol, Fluvisol, Luvisol, Umbrisol, Regosol	with brown B-horizon owing to weathering and (re-)formation of clay minerals	Braunerden
Parabraunerde	Luvisol, Albiluvisol, Cambisol	with eluvial A-horizon over clay-enriched B-horizon	Braunerden
Semipodsol	Podzol, Regosol	characterized by moderate podzolidation	Podsole
Kalkbraunlehm	Cambisol, Luvisol	with a yellow- to redbrown cohesive B-horizon on calcareous bedrock, often fossil soils	Kalklehme
Farb-Substratboden	Regosol, Luvisol	strong influence of color of parent material, overprinting horizon differentiation	Substratböden
Textur-Substratboden	Regosol	strong influence of texture of parent material, overprinting horizon differentiation	Substratböden
Kolluvisol	Anthrosol	developed from fine soil material relocated by (often human-induced) erosion	Umgelagerte Böden
Rigolboden	Anthrosol	influenced by deep, homogenizing human cultivation	Umgelagerte Böden
Haftnässe-Psuedogley	Stagnosol, Planosol	influenced by shallow, capillary stagnation phases	Pseudogleye

owing

build up

keine Punkte!

& ! mitting

Table 2: Corresponding WRB reference groups for the Austrian soil types encountered in the study area, along with a simplified description based on Nestroy et al. (2011). /2000

reclassified applying the Austrian System (Nestroy et al., 2000, 2011).

Soil data base 2: soil survey project *ReBo - Terrain Classification of ALS Data to support Digital Soil Mapping'.* During this project, ~~which was funded by the Autonomous Province Bolzano – South Tyrol and had the~~ aim to investigate optimal cooperation between soil survey and terrain classification, 55 soil pit profiles were described in the presented study area based on field work in 2014 and 2015. In addition to detailed soil profile descriptions, grain size distribution and pH analyses were performed in the lab. Soil classification was performed following Kilian (2015), based on Nestroy et al. (2000, 2011). 2x

that aims ..

organic matter?

Soil data base 3: data base of the Forestry Service of the Autonomous Province Bolzano – South Tyrol. From the point data base provided by the Forestry Service of the Autonomous Province Bolzano – South Tyrol, 42 soil pit locations are situated in the study area discussed in this article. For each of these sites, which either belong to the Forestry monitoring scheme or were mapped during the course of the Forestry type survey (APB, 2006), soil type, parent material and a detailed soil pit description are provided.

part?

Soil data base 4. While performing field work for the Forestry type survey (APB, 2006), the engineering office 'Wald Landschaft Mensch' (WLM) also produced a model of the forest substrate for South Tyrol for use in modeling forest types. For validation, a large number of augur points were described and geolocated, of which 227 are located within the study area and were kindly proveded by the company. The information for each point includes the soil type as well as a description of the geologic situation, including information on cover?layers if present.

cover beds ?

mal ausbessern wo ?

2.4. *Digital terrain model*

→ Wahn ?

The digital terrain model applied in this study has a grid cell size of 2.5 m and was computed as the result of an airborne laser scanning mission. For the flatter valley bottoms and densilty inhabited areas, the average achieved last-pulse point density is reported as 1.3 pts/m^2 by Wack and Stelzl (2005), while this measure is lower for the remaining, less populated areas and mountain slopes (0.8 pts/m^2). Using 8 independent sites with 60 ground points for elevation accuracy asessment, the average standard deviation of heights was established as 6.7 cm. While all tiles were previously available for download at the homepage the Autonomous Province of Bolzano – South Tyrol (APB, 2016), the entire data set is now provided freely upon request per email, while smaller areas can still be downloaded. In addition to being used at this high resolution, the DTM was also resampled to 10 and 50 m using average aggregation with the tool 'r.resamp.stats' implemented in GRASS GIS (GRASS Development Team, 2016), in order to ~~to~~ consider the issue of scale in the analyses.

Zahl bis 12 ?

3. Methods

3.1. *Terrain parameters with emphasis on roughness measures*

3.1.1. *Local and regional terrain parameters*

üblich ?

The terrain parameters used in this study were computed using the open source GIS GRASS (GRASS Development Team, 2016) and SAGA (Conrad et al., 2015). They were performed at different spatial resolutions (2.5, 10 and 50 m) and, where applicable, at different moving window sizes. Local terrain parameters, including slope and minimal, maximal,profile, longitudinal as well as cross-sectional curvature were computed based on the algorithms of Wood (1996) as implemented in the tool 'r.param.scale' in GRASS,

? if

which allows varying the computational window size. Regional terrain parameters, amongst them catchment area, topographic wetness index, height above channel network and others, were computed with SAGA both at high (2.5 m) and low (50 m) spatial resolution.

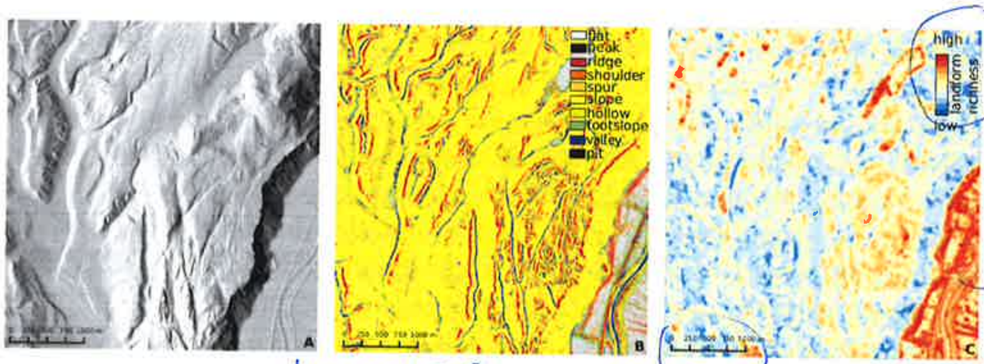
3.1.2. Surface roughness-related terrain parameters

Topographic roughness index. The topographic roughness index was presented by Riley et al. (1999) for use in habitat analyses. It compares the elevation of a central pixel to the elevations of cells within a given search window by calculating the square root of the sum of the squared differences.

Terrain texture. In their automated landform classification algorithm, Iwahashi and Pike (2007) present terrain texture, or feature frequency, which can also be interpreted as a measure for surface roughness. This measure is quantified by the number of features, i.e. pits or peaks, in a specified search window. These features are extracted by computing the difference between a DTM and its median-filtered version.

Vector-based roughness measures. In an attempt to decorrelate roughness from slope, Sappington et al. (2007) expanded on the work of Hobson (1972) to introduce vector ruggedness measure (VRM), which is calculated based on the orientation of vectors normal to the surface in a given area. Its implementation as the tool 'r.vector.ruggedness' in GRASS was used for computation in this study. Grohmann et al. (2010), who also authored a GRASS implementation ('r.rougness.vector'), analysed several roughness measures at different resolutions and window sizes with regard to their ability to depict terrain features. They highlight the ability of VRM to detect fine-scale roughness features and attribute low roughness values to steep but smooth slopes, but also acknowledge its inability to delimit slope breaks and identify regional relief.

Landform diversity. Landform diversity can also be interpreted as a form of surface roughness, i.e. a high number of landforms in a given search window signifies high terrain roughness. Jasiewicz and Stepinski (2013) present an automated landform classification based on a pattern recognition approach using line-of-site calculations. The two main parameters that can be tweeked for landform segmentation are the search radius up to which the surroundings of a central raster cell are scanned and the flatness threshold angle, under which a surface is considered as flat. In this study, the resulting map featuring a maximum of ten landform classes is used as the input for the calculation of patch indices such as edge density or mean patch size (mps) and diversity indices like dominance or richness with the GRASS module 'r.li' for landscape structure analysis. The landform maps were calculated at micro and meso scale (search radii of 7.5 and 50 m, respectively) applying flatness thresholds of 1 and 10°, based on Gruber et al. (2017), who analysed 'r.geomorphon' and other automated landform classifications with regard to optimal parameter values for representing topographic position in soil survey.



freistellen bitte

Warum hier so hoch?

Ausschnitt? Bezug zu Abb 1?

Hinweis auf Fig 3 im Text

Figure 3: Example of a landscape diversity measure based on a landform map computed with a search radius of 50 m and a flatness threshold of 1°. **A** shows the shaded relief of the 2.5 m DTM on which the calculations are based and **B** the resulting landform map. Based on this, **C** landform richness is computed as the number of different landforms in a search window of 20 cells.

in ?

3.2. Random Forest classification

According to Breiman (2001) Random forests ...

Random forests (Breiman, 2001) belong to the family of machine learning algorithms, meaning that based on test data, statistical patterns between explanatory variables and the dependent variables are sought and then applied to predict the latter based on new data sets comprised of the dependent variables. A comparison of machine learning approaches for classification in soil mapping can be found in Heung et al. (2016). Contrary to single classification trees, random forests use an ensemble of classification trees to predict class affiliation, each based on a bootstrap sample of the test data and a limited number of randomly chosen explanatory variables. Random forest classification, as implemented in the R (R Core Team, 2014) package 'randomForest', also has the advantage of computing variable importance measures such as 'mean decrease accuracy' and 'mean decrease Gini' that

?

provide insight into and quantify the importance of each predictor variable in a specific model. Additionally, the out-of-bag error, in which each model based on the bootstrap sample is validated with the remaining unused data, provides a valuable estimate of the prediction error of random forests. Due to the rather investigative use of random forest classification in this study, the authors refrained from optimizing the parameters of the classification algorithm.

3.3. General workflow

In a first step we investigate how well the units of the geologic map correspond to the parent material identified by the soil surveyor at the soil pit locations, thus evaluating the performance and reliability of available geologic maps to support soil survey in South Tyrol. After generalisation of the geologic map units into surficial geology units (SGUs) which can be compared to the parent material units used in the various surveys, a confusion matrix is produced which shows to which extent the geologic units are in accordance with the parent material mapped by the surveyor.

As ... The next step, a data mining approach using random forest classification, is performed to better understand the topographic characteristics of the surficial geology and parent material units. By applying a five-fold cross-validated forward step-wise feature selection and evaluating the 'mean decrease accuracy' of the predictor variables, we identify which terrain parameters are best suited to perform the different tasks of:

1. Expanding the geological map to a parent material map by modeling parent material based on the profile site descriptions, the topography of their locations and the information provided by the new geologic map with its detailed information with regard to surficial geology.
2. Discriminating for each SGU those points that where correctly classified to a parent material class by the geological map from those where this information differed to the parent material identified by the field surveyors.
3. Distinguishing between adjacent soil parent material classes as identified by the soil surveyors during field survey.
4. Separating and consequently characterising the surficial geology units as described by the geological map.

In contrast to using all possible terrain parameters at once, this procedure produces only a limited number of explanatory variables, which has the advantage of simplifying interpretability, as the main aim is to identify, highlight, and understand those situations were the most confusion between parent material units as documented by surveyors on the one side, and the geologic map on the other side, occur. The whole feature selection procedure for each of the tasks was itself performed in five-fold cross-validation with four parameter sets: 1) all terrain parameters, 2) local terrain parameters, 3) regional terrain parameters, 4) surface roughness-related parameters. Regarding task 1, emphasis was soon set on the roughness measures, which are deemed best suited to enhance the geologic map, as the geological units already implicitly contain information with regard to regional and local terrain parameters.

The connection between the two important soil forming factors, parent material and topography, on the one hand, and soil as the result of theses factors on the other, is then investigated by analysing the diversity and distribution of soils for each geologic unit. This is performed from two points of view: the soil type distribution is done for profile sites per geologic unit, but also per parent material unit as attributed by the soil surveyor. This gives insight into how the surveyors' soil landscape model relates specific parent material units to specific soil types, especially when applying a morphologic-genetic classification such as the Austrian soil classification (Nestroy et al., 2000, 2011). The synthesis of this information regarding topography, parent materials, and soils then leads to a geologic-topographic characterisation (GTC) that describes each surficial geology unit.

4. Results and discussion

4.1. Comparison of soil parent material at soil profile sites with geologic map units

For the following results and discussion, the confusion matrices and the accuracy measures are calculated and interpreted as if the field observations described by the surveyors had been planned to validate the use of the geologic map as a map of soil parent material. That is, the columns represent the reference classes while the rows are the classified classes. The producer's reliability is therefore calculated by considering the values and sum per column of the confusion matrix, whereas user's accuracy, or its counterpart, the error of commission, is obtained by aggregating across the rows. A comparison of the soil parent material class identified in the field survey and the SGU from the geological map for the same position shows that while these match for 186 of the profile sites, leading to an overall accuracy, or correct classification rate, of 49 %, there is a high number of misclassification.

A first view at the confusion matrix (Table 3) indicates that a considerable amount of these~~s~~ misclassifications involve the classes till (TG) and slope deposits (SD).

4.2. Geologic-topographic characterisation of the predominant SGUs

Through synthesis of i) results of the comparison of the soil point data and the geologic map, ii) the random forest analysis of terrain parameters and iii) the distribution of soil types in the study area, a geologic-topographic characterisation (GTC) of the SGUs for use in soil survey is performed. Only those units with substantial areal extent and sufficient soil profile points are described in detail.

4.2.1. Alluvial deposits

The SGU alluvial deposits (AD) occupies 16.3 km^2, amounting to 14.9 % of the study area. It incorporates alluvial deposits in the paleovalley but also in the Etsch valley.* The existing soil profile points are however limited to the paleovalley. The alluvial deposits share very long borders with the SGUs till, debris cones, mire deposits and colluvial deposits, due to its bifurcated vertical transection of the study area. Long borders can therefore also be found with the units glacio-lacustrine deposits, mixed deposits, slope debris and till. There is agreement between the geological map and the soil profile description in 7 (54 %) of the 13 profiles for which the soil surveyors identified ?

* (see Fig. 1)

Begriffe immer einheitlich?

	AD	CBD	CD	CSR	DC	GLD	IMS	ISR	LD	MrD	MxD	SB	SD	SSR	TG
AD	7	0	0	0	0	1	0	0	0	0	0	0	1	0	3
CBD	0	4	0	0	0	0	0	0	0	0	0	0	8	0	2
CD	0	0	3	0	0	0	0	1	0	0	0	0	1	0	0
CSR	0	0	1	2	0	0	0	7	0	0	1	0	13	0	12
DC	4	0	3	0	5	0	0	2	0	0	0	0	20	0	2
GLD	0	0	0	0	0	5	0	0	0	0	0	0	0	0	2
IMS	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ISR	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
LD	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0
MrD	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1
MxD	0	0	1	0	0	0	0	0	0	0	0	0	6	0	1
SB	0	1	1	0	0	2	0	1	0	0	2	14	3	1	24
SD	0	3	0	2	1	0	0	4	0	0	0	4	55	0	15
SSR	0	0	0	0	0	0	0	2	0	0	1	0	3	3	1
TG	1	0	0	1	0	1	0	3	0	1	5	0	9	0	88

Anzahl der Punkte insgesamt?

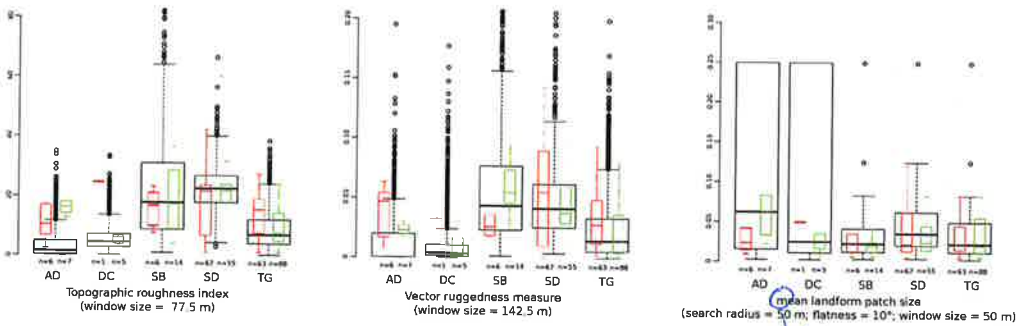
Table 3: Tabular comparison of parent material geounits as observed by soil surveyor (columns) and in the geologic map (rows). Abbreviations: AD = alluvial deposits, CBD = coarse blocky debris, CD = colluvial deposits, CSR = calcareous sedimentary rock, DC = debris cones, GLD = glaciolacustrine and lacustrine deposits, IMS = ice-marginal deposits, ISR = intermediate sedimentary rock, LD = landslide deposits, MrD = mire deposits, MxD = mixed deposits, SB = silceous bedrock, SD = slope deposits, SSR = siliceous sedimentary rock, TG = till in general

debris → vorne!

this SGU as the soil parent material. Some confusion with the SGUs debris cones and till can be observed, the former from the viewpoint of producer's reliability and the latter as an error of commission.

An investigation of the soil profile sites that were identified by surveyors as having alluvial deposits as parent material but are located on a different unit on the geological map, shows that these are characterized by consistently lower vector strength at 112.5 m window size, indicating rougher terrain. This is confirmed by higher landform richness values at meso scale along with higher vector ruggedness for the incorrectly classified data points (Table 4). Addressing the confusion of alluvial deposits with till, the random forest investigation shows that besides obvious channel-level-related terrain parameters, which well separate the units, convexity contributes strongly to distinguishing between alluvial deposits and till on the geologic map, with the former characterised by lower values. It must however be taken into account

Wohl zu klein!



Hinweis im Text?

Figure 4: Boxplots of three different roughness measures for the most common and confused parent material classes. The large black boxplots characterise the topography of the respective units of the geologic map, while the smaller boxplots inside the larger ones represent the values of the soil profile sites for which the surveyors identified the corresponding parent material class. Green boxes indicate the distribution of the terrain parameters for those profile sites for which surveyor and SGU map agreed regarding the parent material, whereas red boxes represent sites located on a different SGU.

that the SGU in the study area also incorporates parts of the wide Etsch valley floor, whereas the soil profile points are situated in the paleovalley of the Überetsch. The same investigation, but performed from the viewpoint of the surveyor (i.e. using the field data points and their parent material information), identifies a very local (small window size) version of the TRI as best suited to distinguish between the two parent material groups, with AD interestingly characterised by higher values indicating higher ruggedness. This can be attributed to the relative smooth surface of the till unit on the one hand, and the often entrenched location of alluvial deposits in the paleovalley. The separation of the profile sites of the parent material classes AD and debris cones, the second most common confusion for AD, is less clear than for AD and TG. High resolution roughness values are less important than in the case of till, with texture computed with 50 m grid cell size being the most decisive parameter. A comparison of the geological map units' topography also highlights the importance of this roughness parameter, which is surpassed only by the regional terrain parameter catchment slope, computed at the same low DTM resolution. The choice of these parameters seems closely linked to the transitional landscape position of debris cones, situated between the steep slopes of the Mendola-Roèn-Ridge and the flatter valley bottoms.

Of the 11 soil profile or auger points located on areas covered by alluvial of paleo-valley

im Grundsatz eher nicht (Überflutung)

deposits according to the reclassified geological map, the soil type Braunerde is predominant, with some occasional anthrosols, represented by the Austrian class Rigolboden. These brown soils are to be expected as the more or less pronounced stability of the flat alluvial deposits have allowed a certain degree of pedogenetic processes to occur. The anthrosols on the other hand are typical for the orchards, and to a lesser degree vineyards, commonly found on alluvial deposits in the region, were landscape as well as soil have seen strong anthropogenic influence. The distribution of the soil types of the profile points identified to have alluvial deposits as parent material by the surveyors is comparable regarding the dominance of brown soils. Additionally, the soil types Kalklehm-Rendzina and Pararendzina were encountered, both characterised by A horizons rich with organic material, on more or less unweathered carbonate containing parent material, indicating that alluvial deposits were also identified at places lacking the stable conditions necessary for the development of a B horizon as presented by the alluvial deposits unit of the geological map. So while the alluvial deposits unit is characterised on the geological map by the lowest mean slope aside from mire deposits, the soil data as well as the topographic analysis indicate it is nevertheless necessary for future surveys to also investigate the less typical, rougher and sloping areas at the border or in proximity of alluvial deposit units. Furthermore, the carbonate components suggest that local material from the western slopes is also incorporated in alluvial deposits of the paleovalley.

verstärkt ?

wirklich so herum ?

Kalk verstärkt langsamer !

?

gut !

4.2.2. Siliceous bedrock

The SGU siliceous bedrock in the study area is characterised by outcrops of rhyolitic ignimbrite in the Überetsch paleovalley, for instance forming the Mitterberg which seperates the paleovalley from the current Etsch valley. The unit represents 13 % of the study area, and shares a long border with the SGU till, but also the units coarse blocky debris and debris cones. Shorter borders exist with almost all other SGUs, especially mixed deposits and slope deposits. Regarding the comparison of the unit on the geological map with the parent material as reported by the surveyors, there is an interesting discrepancy between user's accuracy and and producer's reliability when attempting to use the geological map as a parent material map. While the parent material of only 14 of the 49 profile sites located on siliceous bedrock according to the geological map was identified as siliceous bedrock by the surveyors, 70 % of all soil pits with this parent material were actually on the correct unit of the geological map. This means that when investigating