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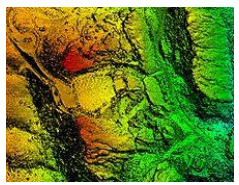
EGU General Assembly 2020, GM2.1

Assessing the Impact of Uncertainties of Digital Elevation Models on Hydro-Geomorphological Analysis Using Gaussian White Noise



Uncertainty

"*A **measurement result** is only **complete** if it is accompanied by a **statement of the uncertainty in the measurement**. Measurement uncertainties can come from the **measuring instrument**, from the **item being measured**, from the **environment**, from the **operator**, and from **other sources**. Such uncertainties can be estimated using **statistical analysis of a set of measurements**, and using other kinds of **information about the measurement process**...*"

BELL, Stephanie A. A beginner's guide to uncertainty of measurement. 2001.

Digital Elevation Model (DEM) Uncertainty

Various sources (e.g. ALS, photogrammetry)

Sources of DEM uncertainty:

- Measurement device and process
- Analog-Digital Conversion
- Data processing steps

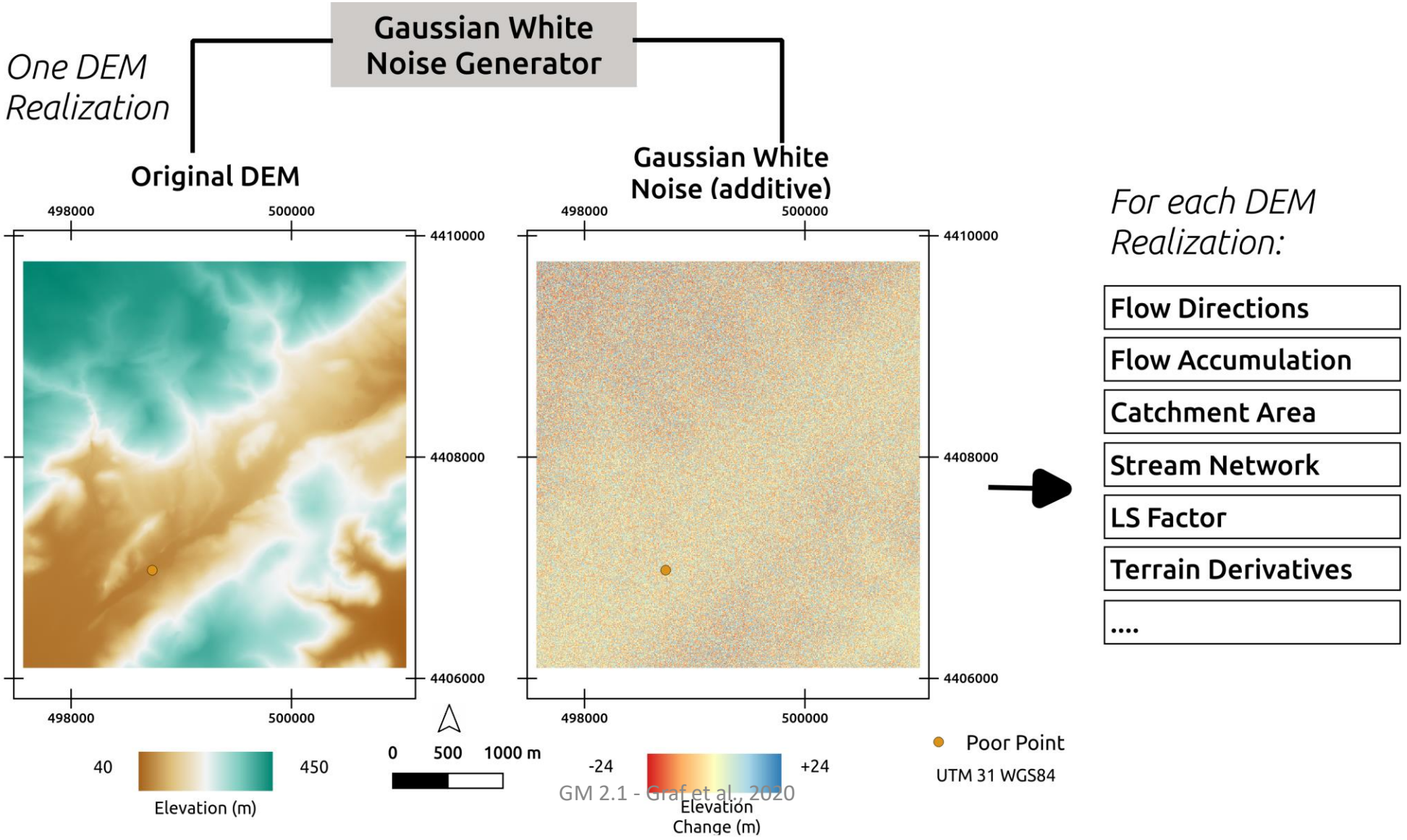
Measurement process is usually only carried out once during data acquisition because of time and labor costs

Thus, no repeated measurements ->DEM uncertainty needs to be addressed statistically

Our proposal therefore:

- To assess **uncertainty** related to the measurement process using a set of "**DEM realizations**"
- A good starting point might be the **Signal-to-Noise Ratio (SNR)**
- To use a **Gaussian White Noise Generato**r to produce sets of DEM realizations (**model ensemble members**) to assess the effect of the measurement **uncertainty** on **terrain analysis**

How it works


Gaussian White Noise Generator
One DEM Realization
Original DEM
Gaussian White Noise (additive)
498000
500000
4410000
4408000
4406000
For each DEM Realization:
Flow Directions
Flow Accumulation
Catchment Area
Stream Network
LS Factor
Terrain Derivatives
....
40
450
Elevation (m)
0
500
1000 m
-24
+24
Elevation Change (m)
Poor Point
UTM 31 WGS84

How it works

Python3 script for generating Gaussian white noise based on device SNR available on **Github**:

Visit https://gist.github.com/lukasValentin/341c66029d2dffaf96341da2c39a9f1f

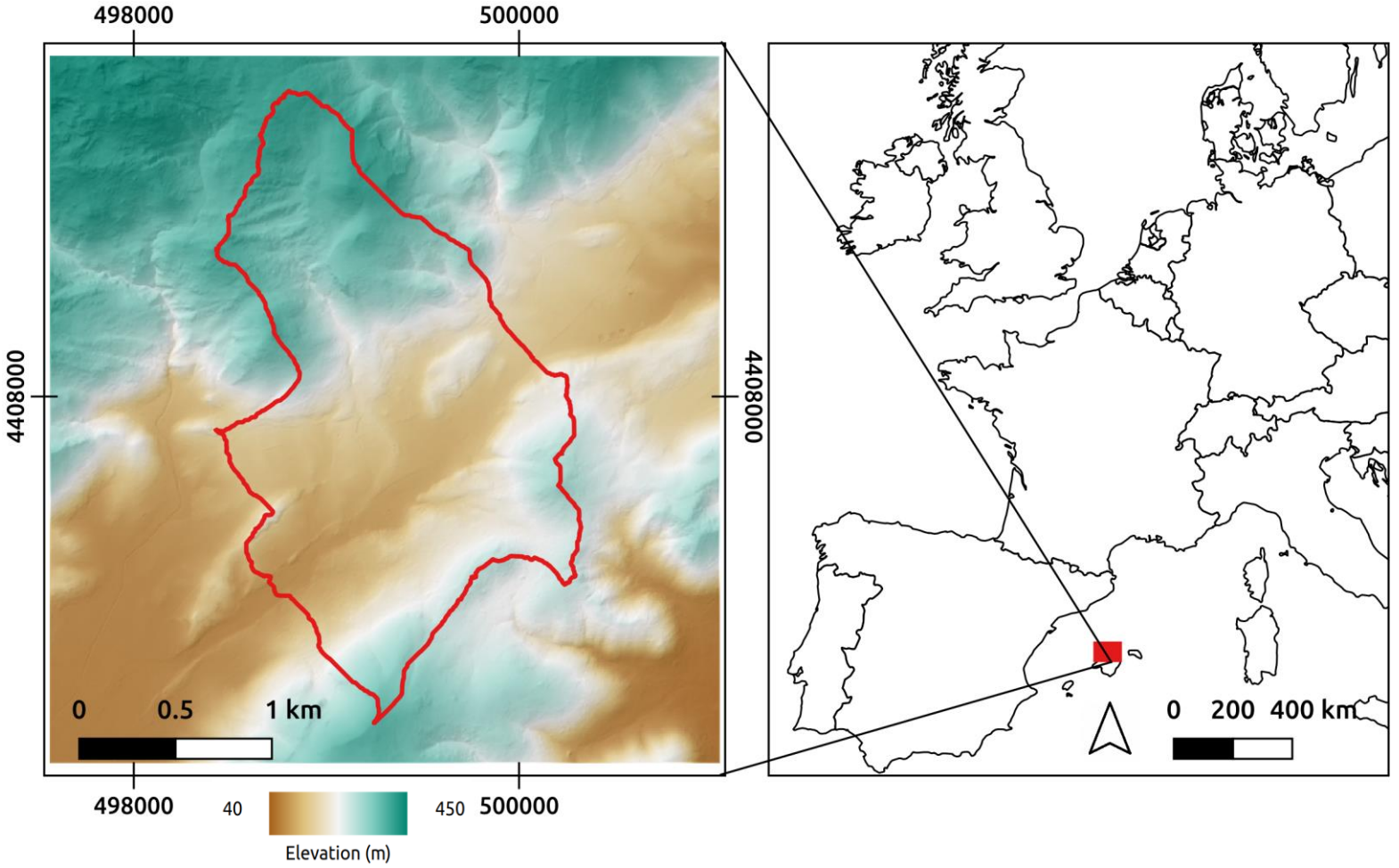
to get the code

Case Study

Uncertainty of ALS derived DEM data on the example of a small Mediterranean Catchment

Study Area and Data

- Mediterranean small catchment (3-5 km²) located at the Island of Mallorca, Spain
- Airborne discrete return LiDAR data acquired in 2014, processed to DTM grid of 5m spatial resolution
- Sensor: LEICA ALS60
- No SNR information directly available but SNR inversely proportional to ranging accuracy
- **Assumption: SNR around 20 dB (see also work by Baltsavias, 1999)**

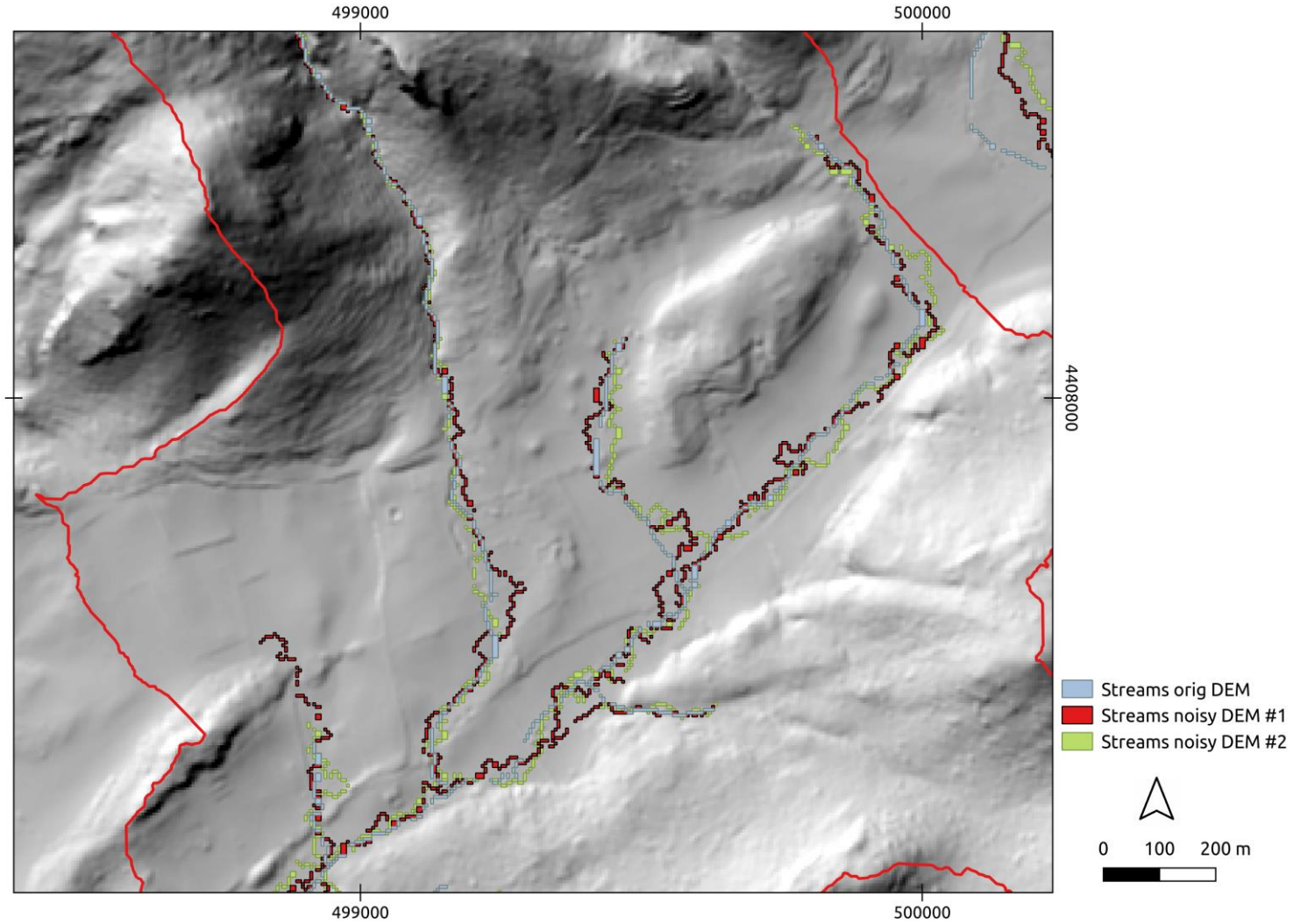


BALTSAVIAS, E. P. Airborne laser scanning: basic relations and formulas. 1999. Photogrammetry and Remote Sensing, 54, pp. 199-214

Descriptive Statistics

	Min Elevation (m)	Max Elevation (m)	Mean Elevation (m)	Median Elevation (m)	Standard Deviation (m)
original DEM	42.34	550.52	175.94	135.05	107.81
DEM with noise #1	41.25	553.89	175.94	135.04	107.82
DEM with noise #2	41.16	554.19	175.94	134.99	107.82
DEM with noise #3	41.32	553.81	175.94	135.00	107.82
DEM with noise #4	41.14	552.60	175.94	135.02	107.82
DEM with noise #5	41.58	553.39	175.94	135.04	107.82

Flow Accumulation -> Stream Network



Results of Case Study

- Although overall descriptive statistics remain unchanged, small-scale deviations are clearly visible
- DEM uncertainty has impact on e.g. flow accumulation and, thus, the organization of flow paths
- The proposed method, however, assembles only a small part of DEM uncertainty. More research is necessary to assess space-time dependent characteristics of DEM uncertainty and its implications on hydro-geomorphological modelling

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