

ERNSTSON CLAUDIN IMPACT STRUCTURES – METEORITE CRATERS

Research on impact geology, geophysics, petrology, and impact cratering



Comment on Rappenglück, M.A., Rappenglück, B., (2026) Towards a Methodological Validation of Digital Terrain Models as a Potential Impact Criterion: Requirements, Constraints, and a Roadmap for Empirical Testing. - 57th LPSC, #1078

Kord Ernstson¹ and Jens Poßekel²

Abstract. - The authors' abstract contribution, with 344 words spread over one and a half columns for the 57th LPSC, refers to TanDEM-X digital terrain models, mentions a quote from SRTM from 2000 with a resolution of 30 m to 90 m, and also cites only literature that ends in 2017 and dates back to the 1980s. The authors make no mention of the extremely high-resolution LiDAR data (horizontal 1 m, vertical 0.1 m, even in forests and inaccessible areas), which has been available online in many countries for several years and is often accessible free of charge. The authors have obviously not conducted any work of their own with digital terrain models. The reason for this LPSC abstract remains a mystery and suggests personal motives alone. Here we present a series of recent examples of countless LiDAR DGMs that have already prompted us to postulate a paradigm shift in impact research.

¹University of Würzburg, 97074 Würzburg (Germany) kernstson@ernstson.de, ²Geophysics Poßekel Mülheim (Germany) possekjens@gmail.com.

1 Introduction

In their abstract, the authors Rappenglück and Rappenglück [1] comment on digital terrain models (DTM) such as TanDEM-X (TerraSAR-X Add-on for Digital Elevation Measurements) based on data from radar satellites. The standard resolution is 12 m x 12 m and the elevation resolution is 1 m. The core of their assessment of the application of this DTM is that it does not allow for the identification and diagnosis of impact craters, e.g., to discriminate between geogenic and anthropogenic structures, and is currently not a potential criterion for new impacts.

This shows that the authors are apparently living 10 years in the past (as evidenced by their literature citations) and have not opened themselves up to developments and fantastic possibilities offered by newer, generally accessible DGMs. For example, the word LiDAR (Light Detection and Ranging) does not appear once in their abstract, and the extremely high-resolution DTMs that can be derived from LiDAR data today, have brought about a “quantum

leap” in impact research. For readers who are unfamiliar with LiDAR DTM and may be misled by the Rappenglück abstract, the next section provides a brief explanation.

2 LiDAR Digital Terrain Models and Data Processing

For some time now, the possibilities offered by Digital Terrain Models (DTM), also known as Digital Elevation Models (DEM) or Digital Surface Models (DSM) – in Germany: Digitales Geländemodell (DGM) – have become an important tool for many purposes in the geosciences of geography, geology, and geophysics, and in archeology. Based on airborne LiDAR data, topographic maps in a regular grid down to spacing of 1 m and with highest altitude resolution down to 10 cm (in Germany DGM 1) may be produced. The DTM represents the bare ground surface without any objects such as plants and buildings and can even be processed in thick forest. DTM data can often be obtained from land surveying offices as digital (x, y, z) files for standard coordinate systems (e.g., UTM). The data can then be processed by various contouring and 3D surface mapping software to produce maps as diverse as normal contour maps, 3D surface maps, vector maps, wireframe maps, or shaded relief maps. Processing can elaborate the data files by various filter processes, computation of field gradients, and production of any desired elevation profile. The data can be used on a computer to produce map resolutions horizontally down to the decimeter range and vertically down to the centimeter range through interpolation.

The following images show a selection of LiDAR DTMs of impact structures in the Czech Republic, Germany and the USA, which give a small impression of the current possibilities in impact research. We would like to add that the so-called impact community with the Canadian impact database refuses to take note of this.

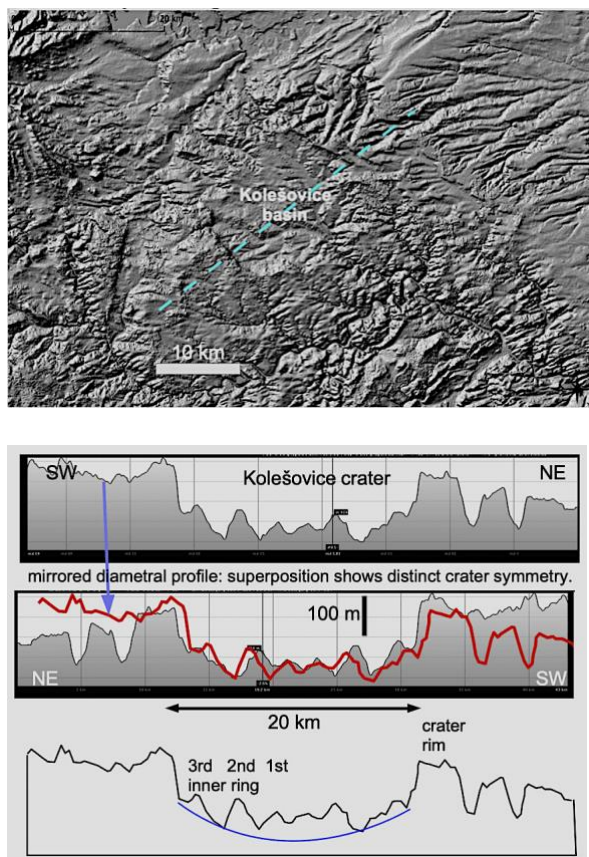


Fig. 1. The Kolečovice airburst impact structure in the Czech Republic from DTM data.

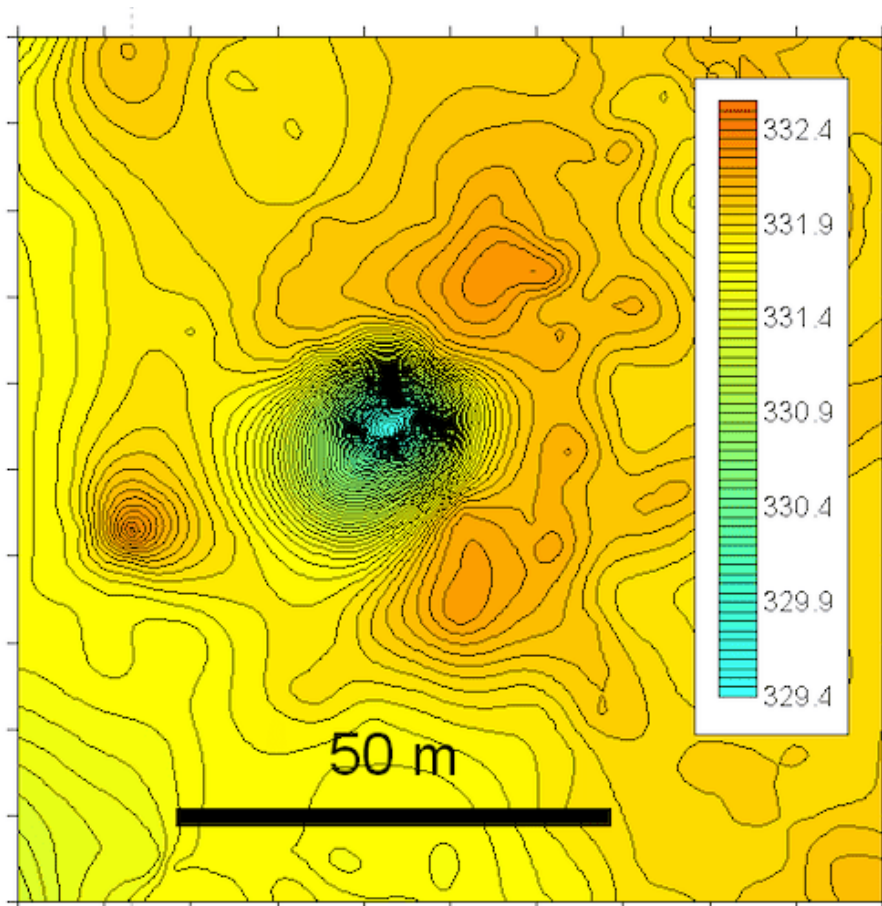


Fig. 2. Czech Republic Usto crater strewn field; doublet crater, DTM contour map, 5 cm contour interval.

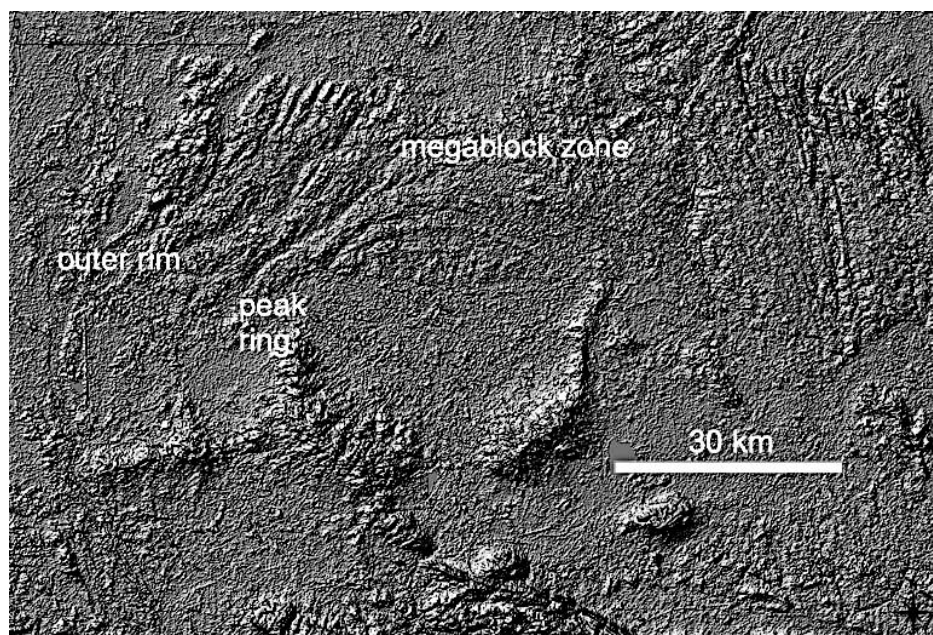


Fig. 3. DTM shadowed relief map, Cloppenburg 100 km-diameter multi-ring proposed impact structure; Saale ice age.

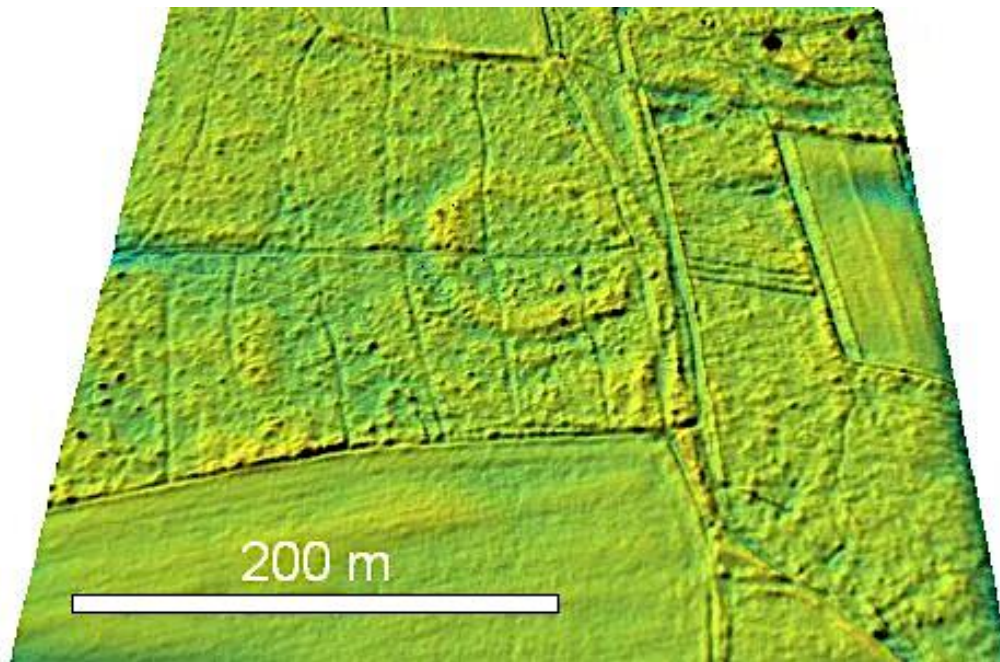


Fig. 4. DGM 1 surface map, Püssensheim (Lower Franconia) multi-ring impact structure in a forest, post-Cretaceous.

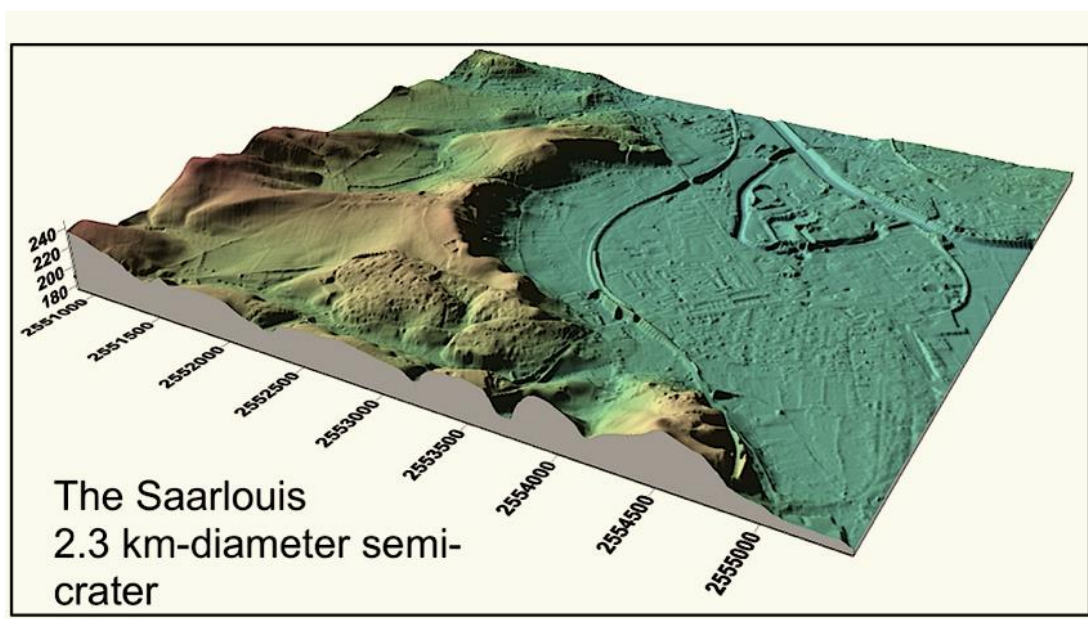


Fig. 5. The Saarlouis impact crater, halved by erosion from the Saar River. Probably Celtic period.

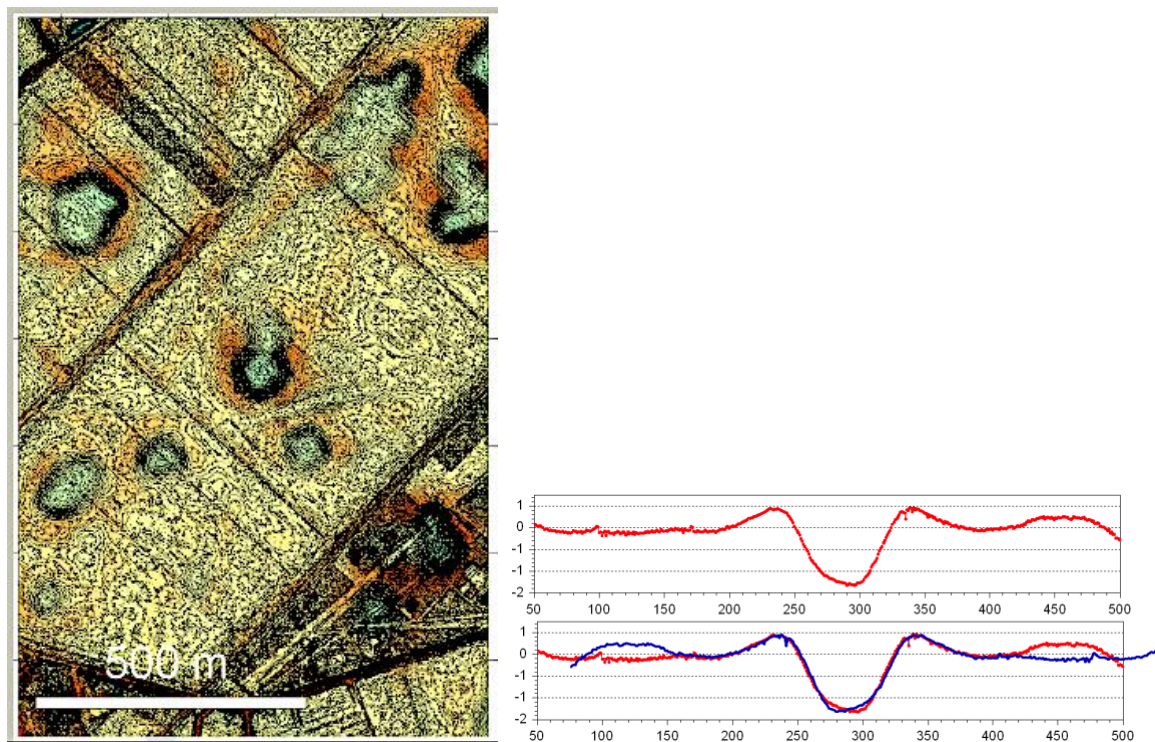


Fig. 6. Part of the Lower Rhine Airburst Impact, cluster of very shallow multiple crater structures. Next to it, a typical crater profile with a superimposed mirror image profile. The accuracy of fit over a 250 m profile section is impressive.

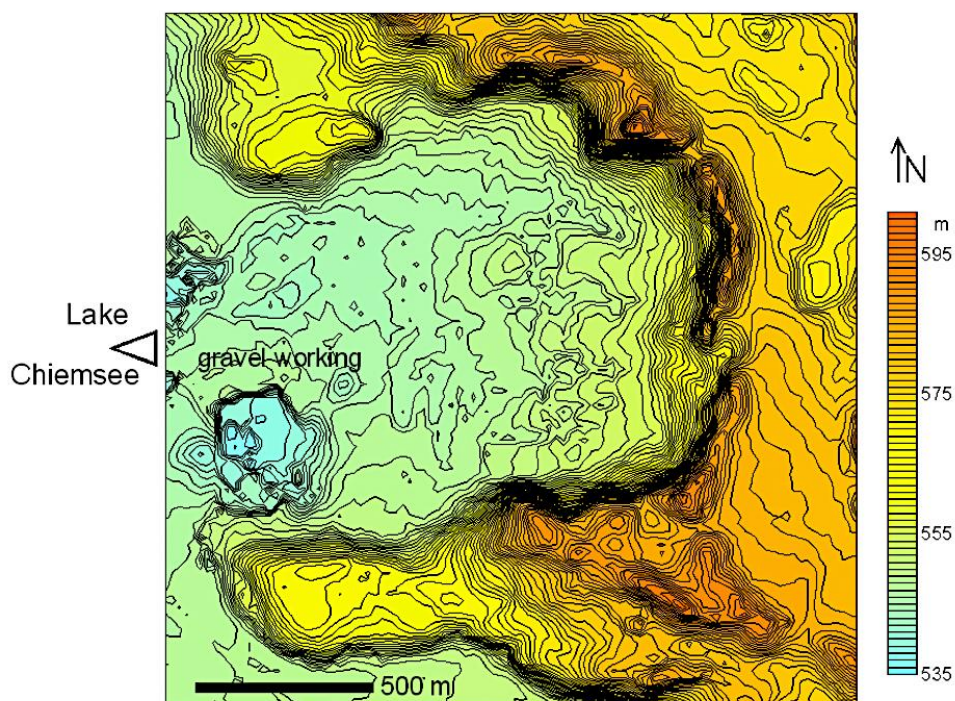


Fig. 7. Eglsee: the Chiemgau impact's largest crater; DGM 1 contour map, contour interval 1 m. The sharply contoured crater wall is incorrectly labeled as a terminal moraine on geological maps.

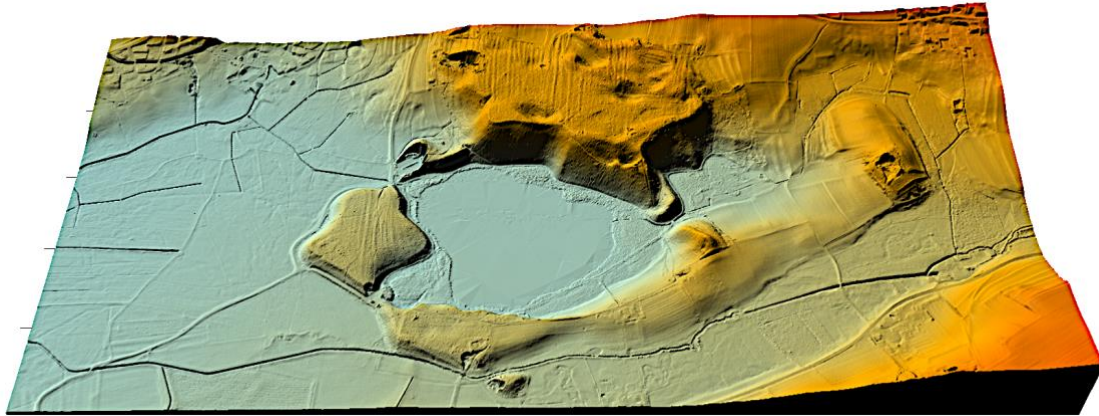


Fig. 8. DGM 1 surface map: the Lake Tüttensee impact crater ensemble. Die main crater's diameter is 600 m.

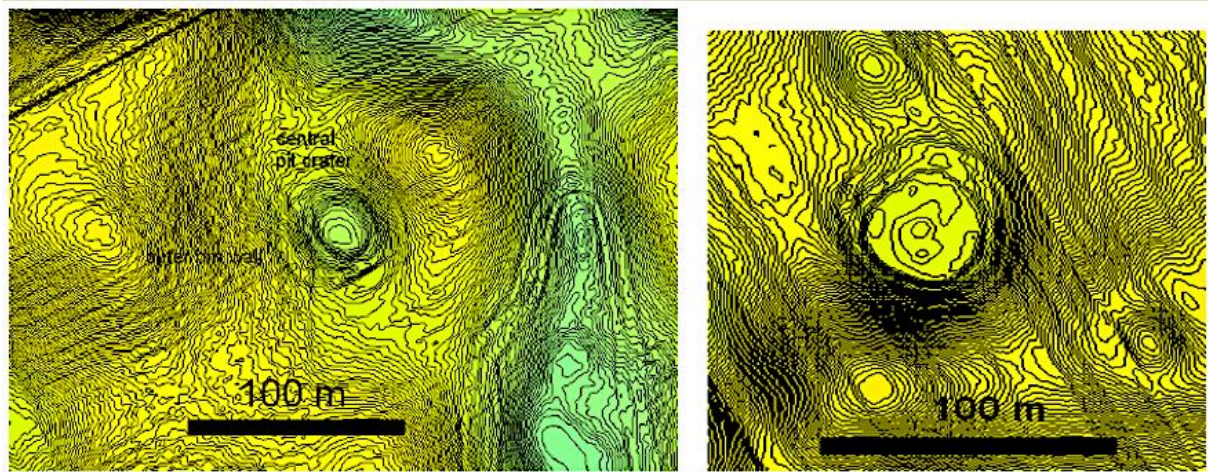


Fig. 9. DGM 1 contour maps; Mecklenburg-Vorpommern impact crater strewn field.

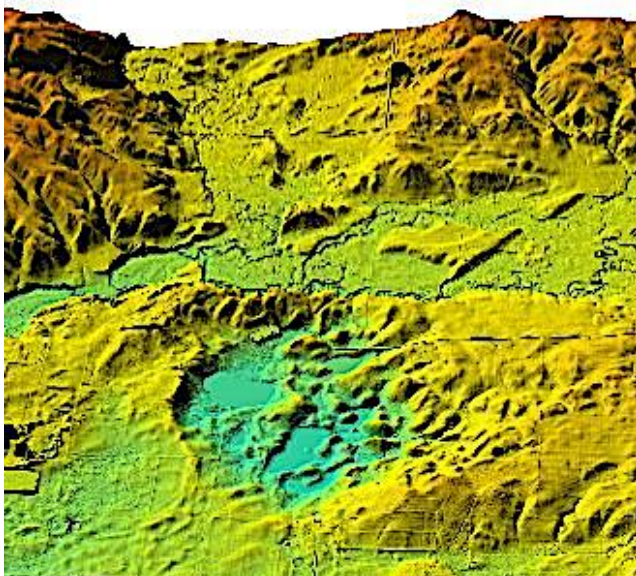


Fig. 10. DTM surface map. North Dakota, USA; LiDAR data from Allen West.

3 LiDAR DTM as in proof of impact structures

In their LPSC abstract, authors Rappenglück write that digital terrain models currently do not allow for the identification and diagnosis of impact craters and do not enable the distinction between impact craters and geogenic and anthropogenic structures. With LiDAR DTM and its extreme morphological resolution, this has become possible, as shown by a small sequence of images with examples from our analyses, which may soon number 100 structures.

How do maps with profiles of the DTM recognize an impact and rule out geological and anthropogenic origins? It is the extreme circular and track symmetries with deviations in the centimeter and decimeter range, even for structures with dimensions of up to several 100 meters. It is evident and understandable that no geological process and no human activity can produce such a thing. When you add to this the fact that craters are surrounded by walls, have internal bulges and multiple rings, which the eye cannot perceive at all but which the DTM documents with centimeter precision, only a more or less point-shaped deformation originating above the Earth's surface could have produced this. In the case of a touchdown airburst with a shock front that impacts the Earth's surface in a circular pattern and is immediately followed by a correspondingly configured reflected rarefaction wave, we have exactly this scenario.

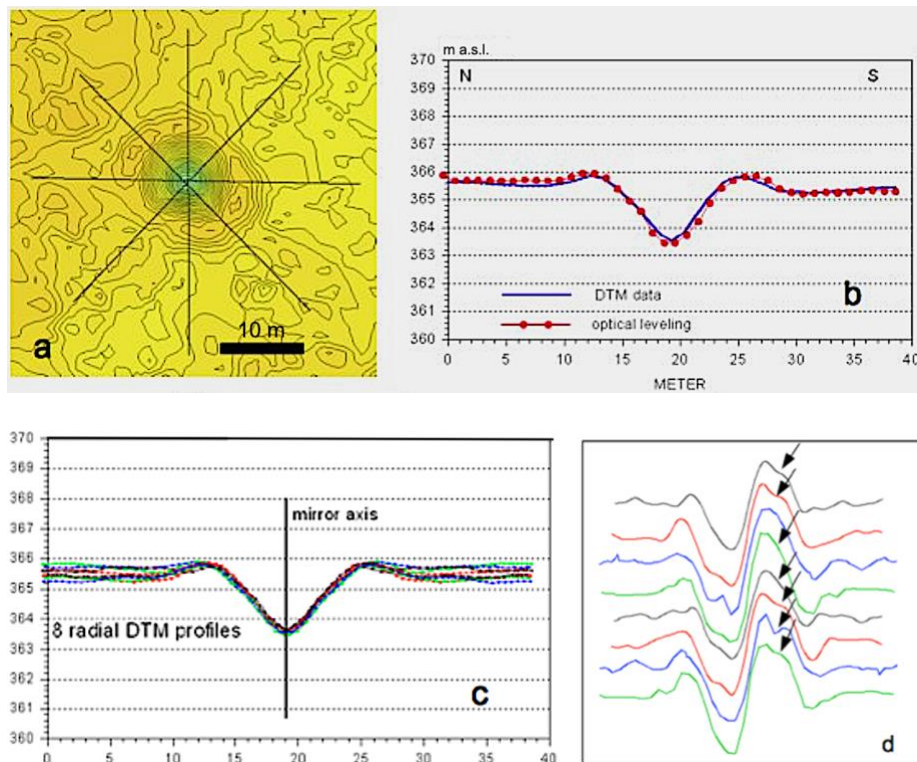


Fig. 11. The Schatzgrube #001 Chiemgau impact crater located in a forest. a: DTM, contour interval 0.1 m. b: DTM cross section along a north - south profile compared with ground optical leveling with 1 m spacing. c: DTM cross sections for four diametrical profiles (see a) which have additionally been mirrored to show the stacking of eight radial cross sections. d: Horizontal gradient profiles for the cross sections in c. Please note that even minor elevation features along the eight radial profiles can be traced around the crater (arrows). The enormous potential for detailed impact crater studies is evident.

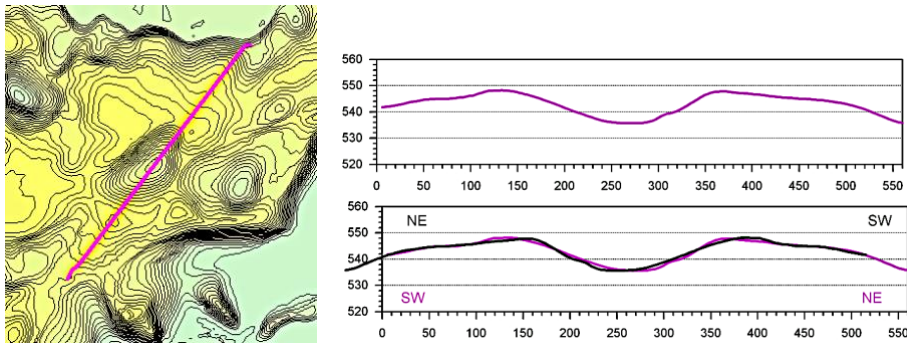


Fig. 12. DGM 1 topography: A cluster of low-altitude "touchdown" airburst impact craters in the Chiemgau strewn field. The 250 m long trough and the 500 m sized complete structure show extreme trace symmetry in the mirror overlay. Meter scales. The maximum difference over 500 m profile length does not exceed 1 m.

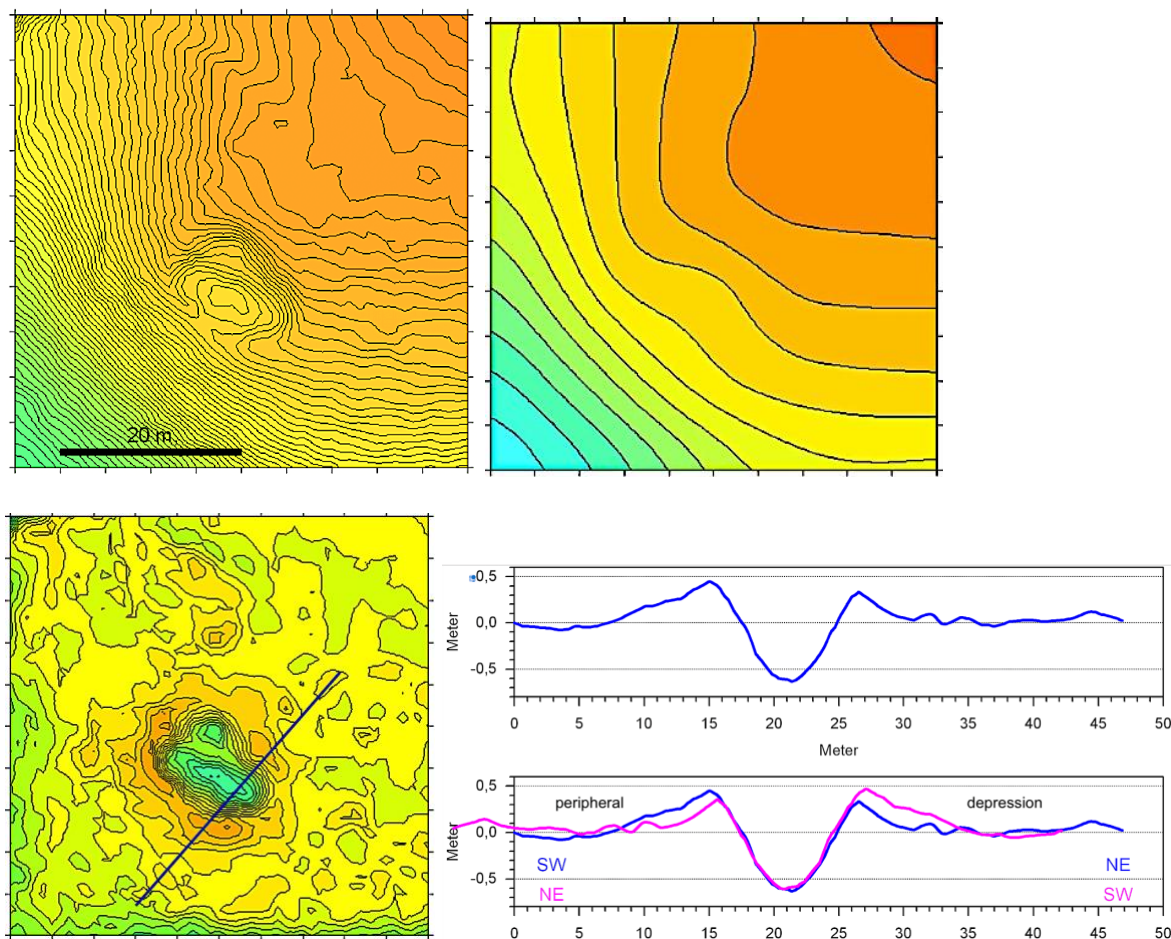


Fig.13. DGM 1 topographic map. Leonberg quadruple crater (Chiemgau impact), contour interval 0.2 m. The topographic trend field: low-pass filter 2D moving average, contour interval 1 m. The DGM 1 topographic residual field (trend removed), contour interval 0.1 m. Profile across the rimmed multiple crater. The overlap of the blue and its pink mirror profile differs by no more 20 cm over the complete 50 m length and is perfect in the bowl. This fundamental symmetry excludes any geogenic or anthropogenic formation and highlights the new DTM possibilities.

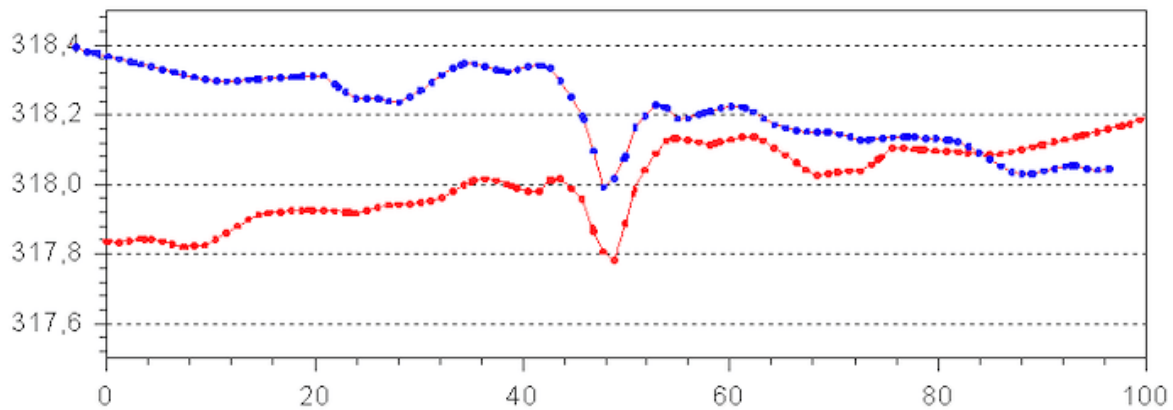


Fig. 14. DTM profile across a crater and its horizontal mirror image show symmetry even in details of the wavy rim morphology up to 30 m radial distance. The example shows how the high-resolution DGM 1 helps to study complex impact cratering with low-altitude airburst impacts. Koli low-altitude impact strewn field

4 The LiDAR DTM at the LPSC, PCC conferences, AGU Fall Meetings, and the MetSoc Meetings

Below is a list of 32 contributions from the last 10 years to internationally renowned conferences in which we, together with co-authors, describe and apply the high-resolution LiDAR DGM in varying degrees of detail. Attentive readers will notice that M.A. Rappenglück and B. Rappenglück, the authors of the LPSC abstract commented on here, appear as co-authors in some of the contributions, meaning that they participate in scientific contributions on LiDAR DTM, which, on the other hand, does not seem to exist for them at all.

Hydrocode modeling of impact craters: Chiemgau low-altitude airburst impact strewn field, Germany. - 57th LPSC 2026, Allen West, Kord Ernstson

Eggstätt-Hemhofen Lakes (Upper Bavaria): "Touchdown" airburst impact instead of kettle holes in a landscape of glacial disintegration - The lake district in the new light of impact research: Chiemgau airburst impact - Digital terrain model - Hydrocode models - Rayleigh-Taylor/Kelvin- Helmholtz instabilities. Preprint
<https://www.researchgate.net/publication/401016566> _ DOI: 10.13140/RG.2.2.36084.82564

High-resolution digital terrain models DTM: Rayleigh-Taylor and Kelvin- Helmholtz instabilities and impact cratering in unhardened loose sediments - the Holocene Chiemgau airburst impact case. - 57th LPSC 2026, Kord Ernstson, Jens Poßekel, Allen West

High-resolution Digital Terrain Models (DTM): a new approach to impact cratering . - AGU 2025, Kord Ernstson, Jens Poßekel

The Chiemgau Impact (Germany) meteorite crater strewn field and the role of high-resolution Digital Terrain Models. - Model craters, Part 3: the large craters. - Preprint Researchgate 2025, Kord Ernstson, Jens Poßekel

The Chiemgau Impact (Germany) meteorite crater strewn field and the role of Digital Terrain Models. -Model craters, Part 2: the Bergham, Riederting, Seon Natural-Monument, Purkering

and Windschnur medium-sized craters. - Preprint Researchgate 2025, Kord Ernstson, Jens Poßekel

Digital terrain model DTM 1: The impact airburst strewn field of the granitic melt plate Bach a.d. Donau - evidence of a separate event to the Chiemgau impact (computer-translated from the German original). - Article <https://www.researchgate.net/publication/396389601>, Kord Ernstson, Jens Poßekel

The Dead Ice Basin Hiking Trail from Haag i.Obb. and the Digital Terrain Model DTM 1: The ice age dead ice holes turn out to belong to a meteorite crater impact strewn field. (computer-translated from the German original). - Preprint 2025, DOI: 10.13140/RG.2.2.25355.14885, Kord Ernstson, Jens Poßekel

The Schlitzer Kauten (Hesse, Germany) and the high- resolution Digital Terrain Model DGM 1: a low-altitude airburst impact event with a crater strewn field (computer-translated from the German original). - Preprint 2025, DOI: 10.13140/RG.2.2.33409.36963, Kord Ernstson, Jens Poßekel, Rudolf Auth

Lake Bärnsee in the Chiemgau Holocene impact strewn field (Germany): ice-age tongue basin lake vs. Holocene low-altitude touchdown airburst impact formation. - Meteoritical Society Meeting 2025, Kord Ernstson, Jens Poßekel, DOI: 10.13140/RG.2.2.23872.24323

Many of a kind: the Digital Terrain Model and a new cluster of larger and smaller craters accumulate the Chiemgau meteorite impact strewn field. - DOI: 10.13140/RG.2.2.27227.68642, Meteoritical Society Meeting 2025, Kord Ernstson, Jens Poßekel

The Digital Terrain Model: New Insights into the Holocene Lake Tüttensee (Germany) Multiple Impact Structure as Part of the Chiemgau Low Altitude Touchdown Airburst Event. - DOI: 10.13140/RG.2.2.29631.01446, Lunar & Planetary Science Conference 2025, Jens Poßekel, Kord Ernstson

The New World of Impact Cratering: The High- Resolution Digital Terrain Model and Hydrocode Modeling -The Saarland (Germany) Low Altitude Touchdown Airburst Impact Event. - DOI: 10.13140/RG.2.2.12853.79849, Lunar & Planetary Science Conference 2025, Kord Ernstson, Werner Müller, Andreas Gawlik-Wagner, Allen West

The Chiemgau Meteorite Impact Strewn Field and the Digital Terrain Model: "Earthquake" Liquefaction from Above and from Below. - DOI: 10.13140/RG.2.2.11274.79041, American Geophysical Union AGU 2024, Kord Ernstson, Jens Poßekel

A Probable Holocene Meteorite Impact Crater Strewn Field in Lower Franconia (Germany) Evidence from Digital Terrain Models and Geophysical Surveys (GPR, Electrical Imaging, Geomagnetism). - AGU Fall Meeting 2022, Kord Ernstson, Georg Schulz-Hertlein, Till Ernstson, Jens Poßekel

The Chiemgau Impact (Germany) meteorite crater strewn field. Model craters, Part 1: the small #004 Emmerting, Kaltenbach and Mauerkirchen craters, and the role of Digital Terrain Models. - Preprint 2024, DOI: 10.13140/RG.2.2.15337.30563, Kord Ernstson, Hans-Peter Matheisl, Jens Poßekel, Werner Mayer

Paradigm Shift in Impact Research: The Holocene Chiemgau Meteorite Impact Crater Strewn Field and the Digital Terrain Model, DOI: 10.13140/RG.2.2.33205.90086, Lunar & Planetary Science Conference LPSC 2024, Kord Ernstson, Jens Poßekel

Mars and Moon on Earth: Multiple Impact and Oblique Impact Patterns from Digital Terrain Models in the Holocene Chiemgau Crater Strewn Field, DOI: 10.13140/RG.2.2.23585.21604, Lunar & Planetary Science Conference LPSC 2024, Kord Ernstson, Jens Poßekel, Michael A. Rappenglück

Pingos and mardels: high-resolution digital terrain models suggest meteorite impact craters in addition to permafrost, sinkhole and dead-ice formation models. - Article 2023, <https://www.researchgate.net/publication/369692658>, Kord Ernstson, Jens Poßekel

End Moraine vs. Impact Event: The Cloppenburg (Northern Germany) Peak Ring Structure and the Ice Age Paradox. - 54th Lunar & Planetary Science Conference LPSC 2023, Jens-U. Keilmann, Jens Poßekel, Kord Ernstson

The Proposed Meteorite Impact Event in the Czech Republic: Evidence Strengthened by Investigations with the Digital Terrain Model, DOI: 10.13140/RG.2.2.17849.65123, Lunar & Planetary Science Conference LPSC 2022, Jens Poßekel, Martin Molnár, Kord Ernstson

Mars and Moon on Earth: formation of small terraced impact craters and ground penetrating radar investigations. - 12th Planetary Crater Consortium Meeting 2021, Michael A. Rappenglück, Jens Poßekel, Kord Ernstson

The enigmatic Sachsendorf Bay structure (Oderbruch, Northeast Germany): evidence of a Pleistocene/Holocene meteorite impact event. - 12 Planetary Crater Consortium Meeting 2021, Kord Ernstson Jens Poßekel, Jürgen Kurtz

The so-called "Sölle" Late Pleistocene circular formations in the Brandenburg and Mecklenburg-Vorpommern Federal States (Northern Germany): evidence of meteorite impact crater strewn fields. - 12th Planetary Crater Consortium Meeting 2021, Jens Poßekel, Kord Ernstson

Pingos, Mardels and Meteorite Impact Craters. Article 2020, <https://www.researchgate.net/publication/387089967>, Kord Ernstson, Poßekel

Complex Impact Cratering in a Soft Target: Evidence from Ground Penetrating Radar (GPR) for Three Structures in the Chiemgau Meteorite Impact Strewn Field, SE Germany (1.3 km-Diameter Eglsee, 250 m-Diameter Riederting, 60 m-Diameter Aiching). - AGU Fall Meeting 2020, Kord Ernstson, Jens Poßekel

Digital Terrain Model (DTM) topography of small craters in the Holocene Chiemgau (Germany) meteorite impact strewn field. - Conference 11th Planetary Crater Consortium 2020 (LPI Contrib. No. 2251), Kord Ernstson, Jens Poßekel

Not just a rimmed bowl: ground penetrating radar (GPR) imagery of small craters in the Holocene Chiemgau (Germany) meteorite impact strewn field. - Conference 11th Planetary Crater Consortium 2020 (LPI Contrib. No. 2251), Jens Poßekel, Kord Ernstson

Anatomy of Young Meteorite Craters in a Soft Target (Chiemgau Impact Strewn Field, SE Germany) from Ground Penetrating Radar (GPR) Measurements. - DOI: 10.13140/RG.2.2.14155.64802, 50th Lunar & Planetary Science Conference 2019, Jens Poßkel, Kord Ernstson

Cosmic collision in prehistory - The Chiemgau Impact: research in a Bavarian meteorite crater strewn field (translated from the German original). Zeitschrift für Anomalistik, vol. 17 (2017), p. 235-260. Available from: <https://www.researchgate.net/publication/322687320>. Michael Rappenglück, Barbara Rappenglück, Kord Ernstson

The Saarlouis semi crater structure: notable insight into the Saarland (Germany) meteorite impact event achieved. - DOI: 10.13140/RG.2.2.20958.74560, 49th Lunar & Planetary Science Conference LPSC 2018, Kord Ernstson, Werner Müller, Andreas Gawlik-Wagner

The Digital Terrain Model (DTM) and the evaluation of known and the search for new craters in the Chiemgau meteorite impact strewn field. - Article 2017, <https://www.researchgate.net/publication/313069361>, Kord Ernstson

5 Discussion and conclusions

In recent impact research, which the authors Rappenglück do not appear to be aware of in their LPSC paper, two things come together: the extremely high-resolution LiDAR digital terrain model and the now very large number of newly discovered low-altitude touchdown airburst impacts, with the former largely contributing to the latter.

As new hydrocode modeling shows, such airburst impacts from comets or asteroids with explosions at low altitudes can create extensive strewn fields of flat to very flat impact structures, which can also overlap densely and shape the Earth's surface with sometimes very complex forms.

Geologically speaking, such very flat structures have three effects: they remain hidden from view in the terrain, they can be eroded in a relatively short time, or, thirdly, they can be sedimented and simply begin to disappear. Another very important point is that LiDAR DTM scan the bare ground without vegetation, even in dense forests, and documents impacts in otherwise inaccessible areas such as swamplands.

The result of these previously unimagined possibilities has led us to write about an imminent paradigm shift in impact research, which particularly applies to the part of the so-called impact community that continues to reject airburst impacts near the Earth's surface and, moreover, ignores the impressive, published results of high-resolution digital terrain models. Unfortunately, the authors Rappenglück subscribe to this unscientific view with their LPSC abstract.

References: see the listing in 4.

Data Sources: Czech Office for Surveying, Mapping and Cadastre (ČÚZK), Bayerische Vermessungsverwaltung, BayernAtlas.