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Synergetic merging of Cartosat-1 and RAMP to generate improved digital elevation model of Schirmacher oasis, east Antarctica

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Abstract. Available digital elevation models (DEMs) of Antarctic region generated by using radar altimetry and the Antarctic digital database (ADD) indicate elevation variations of up to hundreds of meters, which necessitates the generation of local DEM and its validation by using ground reference. An enhanced digital elevation model (eDEM) of the Schirmacher oasis region, east Antarctica, is generated synergistically by using Cartosat-1 stereo pair-derived photogrammetric DEM (CartoDEM)-based point elevation dataset and multitemporal radarsat Antarctic mapping project version 2 (RAMPv2) DEM-based point elevation dataset. In this study, we analyzed suite of interpolation techniques for constructing a DEM from RAMPv2 and CartoDEM-based point elevation datasets, in order to determine the level of confidence with which the interpolation techniques can generate a better interpolated continuous surface, and eventually improves the elevation accuracy of DEM from synergistically fused RAMPv2 and CartoDEM point elevation datasets. RAMPv2 points and CartoDEM points were used as primary data for various interpolation techniques such as ordinary kriging (OK), simple kriging (SK), universal kriging (UK), disjunctive kriging (DK) techniques, inverse distance weighted (IDW), global polynomial (GP) with power 1 and 2, local polynomial (LP) and radial basis functions (RBF). Cokriging of 2 variables with second dataset was used for ordinary cokriging (OCoK), simple cokriging (SCoK), universal cokriging (UCoK) and disjunctive cokriging (DCoK). The IDW, GP, LP, RBF, and kriging methods were applied to one variable, while Cokriging experiments were employed on two variables. The experiment of dataset and its combination produced two types of point elevation map categorized as (1) one variable (RAMPv2 Point maps and CartoDEM Point maps) and (2) two variables (RAMPv2 Point maps + CartoDEM Point maps). Interpolated surfaces were evaluated with the help of differential global positioning system (DGPS) points collected from study area during the Indian Scientific Expedition to Antarctic (ISEA). Accuracy assessment of the RAMPv2 DEM, CartoDEM, and combined eDEM (RAMPv2 + CartoDEM) by using DGPS as ground reference data shows that eDEM achieves much better accuracy (average elevation error 8.44 m) than that of existing DEM constructed by using only CartoDEM (13.57 m) or RAMPv2 (41.44 m) alone. The newly constructed eDEM achieves a vertical accuracy of about 7 times better than RAMPv2 DEM and 1.5 times better

than CartoDEM. After using accurate DGPS data for accuracy assessment, the approximation to the actual surface of the eDEM extracted here is much more accurate with least mean root mean square error (RMSE) of 9.22 m than that constructed by using only CartoDEM (RMSE = 14.15 m) point elevation data and RAMPv2 (RMSE = 69.48 m) point elevation data. Our results indicate that, the overall trend of accuracy for the interpolation methods for generating continuous elevation surface from CartoDEM + RAMPv2 point elevation data, based on RMSE, is as follows: GP1 > IDW > GP2 > OK > LP2 > DK > LP1 > RBF > SK > UK. In case of cokriging interpolation methods, OCoK yields more accurate eDEM with the least RMSE of 8.16 m, which can be utilized to generate a highly accurate DEM of the research area.. Based on this work, it is inferred that GP2 and OCok interpolation methods and synergistic use of RAMPv2 and CartoDEM-based point elevation datasets lead to a highly accurate DEM of the study region. This research experiment demonstrates the stability (w.r.t multi-temporal datasets), performance (w.r.t best interpolation technique) and consistency (w.r.t all the experimented interpolation techniques) of synergistically fused eDEM. On the basis of average elevation difference and RMSE mentioned in present research, the newly constructed eDEM may serve as a benchmark for future elevation models such as from the ICESAT-II mission to spatially monitor ice sheet elevation.

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