TANDEM-X DEM CHANGE MAPS STACKS: TOWARDS TANDEM-X 4D

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ABSTRACT

The TanDEM-X mission acquires data used for the generation of Digital Elevation Models (DEMs) since 2010. From this data two global DEMs are already generated or in generation. The DEM acquisitions used for new TanDEM-X DEM 2020 are also used to generate TanDEM-X DEM Change Maps. Furthermore, the DEM Change Maps can be combined with the additional TanDEM-X DEM datasets and used for the generation of TanDEM-X DEM Change Map Stacks. This paper presents these new products on the basis of an example of an open-pit mining area in Australia. Additionally, the potentials and challenges of the DEM Change Map stacks are presented.

Index Terms— TanDEM-X mission, TanDEM-X DEM, terrain changes

1. INTRODUCTION

The TanDEM-X mission acquired data for a second global DEM, the TanDEM-X DEM 2020 mainly between 2017 and 2020. This data was interferometrically processed to so-called CRaw-DEM scenes by the Integrated TanDEM-X Processor (ITP) [1][2] with the help of an edited version of the first global TanDEM-X DEM [3].
Additionally, these CRaw-DEM scenes are also used to produce the TanDEM-X DEM Change Maps [4]. These DEM Change Maps are a global product and contain the DEM differences between a unique pixelwise time-tagged value from the new CRaw-DEM scenes and the edited first global TanDEM-X DEM as a reference [3]. Currently, TanDEM-X DEM Change Maps are produced globally in tile pairs with a 30m posting. One of these maps contains the oldest available CRaw-DEM data (2017 - 2020) for each pixel and the other map contains the newest CRaw-DEM data for each pixel. The DEM Change Maps will be produced for other time periods additionally in the future.
In order to create the first global DEM multiple acquisitions from different acquisition times were mosaicked and fused together to improve the product and gain the great accuracy [5]. Consequently, the DEM Change Maps cannot give the DEM change corresponding to a particular time interval but only from one particular point in time to a time period. This allows the detection of DEM height changes, however no explcit change velocity and quantitative value.

2. STACKS OF TANDEM-X DEM CHANGE MAPS

In order to create DEM Change Maps between two specific points in time, TanDEM-X DEM Change Maps can be produced as a difference of two time tagged layers instead of the reference global DEM. This paper presents the possibility to create even multiple time tagged layers in the form of DEM Change Map stacks, using the former acquisitions used for the global DEM (2010 - 2016) and also up-to-date data (since 2020). Each stack layer is defined by a time period. For this period, e.g. 2017 - 2019, two mosaics of the DEM scenes are created. One with the newest acquisition for each pixel and one with the oldest acquisition of the time interval of interest for each pixel. The difference gives the DEM change map for this time period. Additionally, a map with the difference of time between the two acquisitions used for the map is created.
Stacks like this can be used to analyze DEM height changes be of all sorts, like geophysical, vegetative or anthropological changes. Within this paper we present parts of a DEM change map stack over an open-pit mining area in Australia. Open pit mining is an excellent test and demonstration site, because this kind of DEM height change affects small test with time-restricted changes on bare soil.

3. EXAMPLE OF OPEN-PIT MINING IN AUSTRALIA

Australia is a common area to find active open-pit mining sites. An example of the two DEM Change Maps over a coal mining area in Queensland (Australia) is given in Fig. 1. The left side of the figure shows the TanDEM-X DEM Change Map with the newest CRaw-DEMs. On the right two zoom-ins can be seen which show the DEM Change Map with the oldest CRaw-DEM scenes (top) and newest CRaw-DEM scenes (bottom). The reference is the edited version of the

first global TanDEM-X DEM in both cases. Even though the time tags of both Change Maps are only a good year apart, differences can already be spotted in the lower mine (Coppabella). The identification of the mines and names was performed with the help of [6].

A TanDEM-X DEM Change Maps Stack was created over

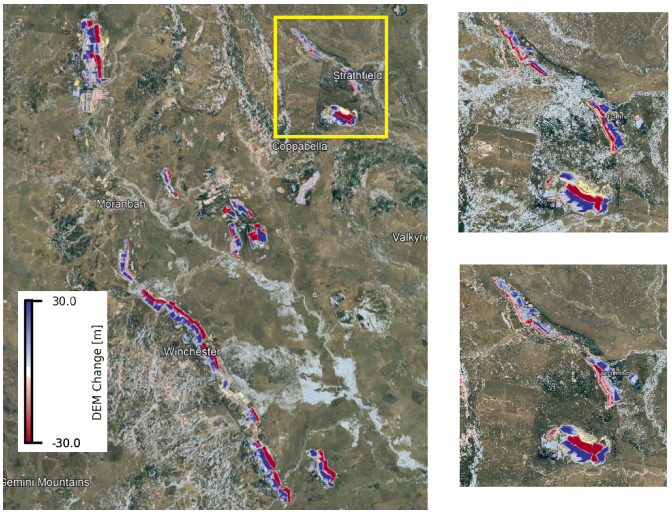

Fig. 1. TanDEM-X DEM Change Maps example over multiple coal mines in Queensland, Australia. The zoom-in shows the Coppabella and South Walker Creek mines. The background is provided by GoogleEarth [7]. Changes below 1.5m are transparent. The acquisitions are from April 2019 (left and bottom right) and September 2017 with April 2018 (top right).

this mine for all acquisitions between 2017 and 2021. Figure 2 shows the DEM Chaneg Map of the difference between the end of September in 2017 and the end of May 2020. Figure 3, 4 and 5 show the corresponding DEM Change Maps for the stack layers. This means the differences between 2018-2017, 2019-2018 and 2020-2019 respectively. It can be noted that the decrease in height began between 2017 and 2018, however the decrease in height continued also between 2018 and 2019. The time intervals between the stack layers are not identical, this is why the DEM height change had to be normalized on the time interval to analyze the change velocity. Altogether the decrease in DEM height during these years is corresponding well with large extraction masses off approx. 2.5 Mt of coal per year with a decreasing trend from 2017 to 2019 stated by [6].

4. POTENTIAL AND CHALLENGES

These challenges include the calibration quality of the DEM scenes and different viewing geometries of the separate acquisitions which can lead to shifts between the different time layers. Another potential challenge is the differentiation between real DEM changes and possible phase unwrapping errors. This can be especially challenging when the magnitude of the DEM change is in the order of the height of ambiguity of the corresponding acquisitions. Additionally, DEM changes over glaciers, ice fields and also forests have to be analyzed with more caution taking different penetration depths and seasonal changes into account.

Even though there are still some challenges to tackle, the potential of a global set of DEM Change Map Stacks can bring great value to understanding open-pit mining sites as well as many more applicataions.

5. OUTLOOK

Altogether, stacks of TanDEM-X DEM Change Maps hold a great potential for a temporal DEM height analysis which span over multiple years and is globally available. With an even further improved calibration a more advanced change detection can be developed in the future to make it even easier to find and monitor DEM height changes of interest. This paper gives a small insight in the great possibilities of a tempospatial or 4D use of TanDEM-X DEM data.

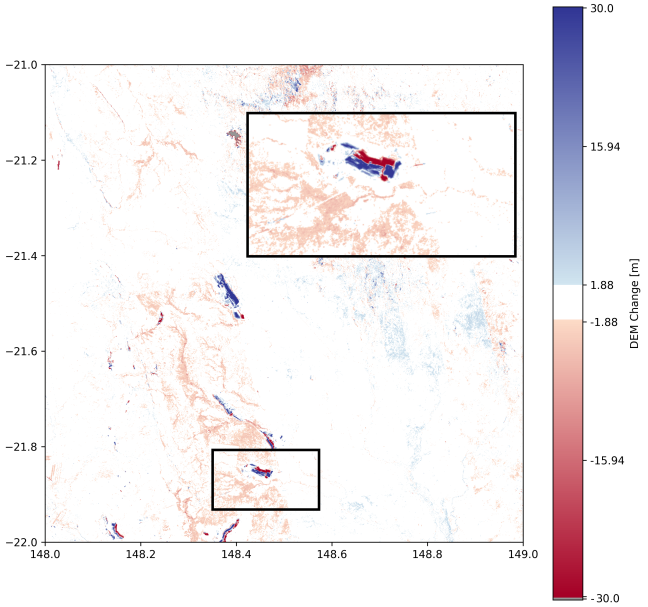

Fig. 2. TanDEM-X DEM Change Maps example over Coppabella Mine in Queensland between the years 2017 and 2021. The datatakes over the Coppabella Mine were acquired on the 2020-05-25 and the 2017-09-24.

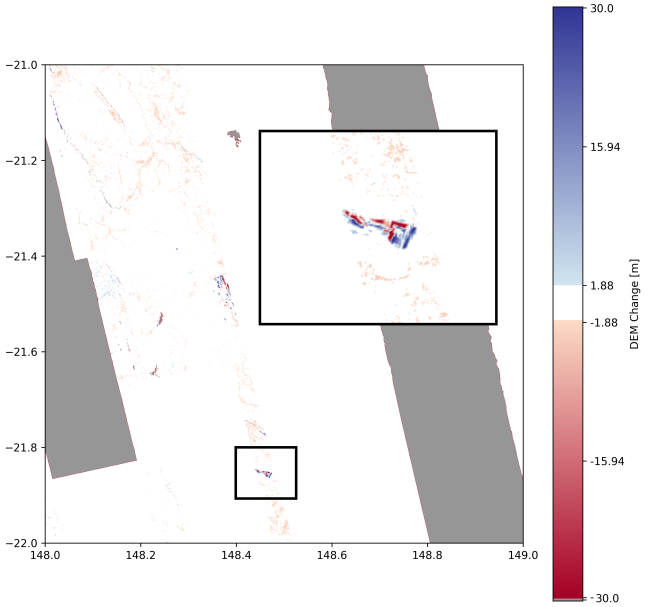

Fig. 3. TanDEM-X DEM Change Maps example over Coppabella Mine in Queensland between the years 2017 and 2018. The datatakes over the Coppabella Mine were acquired on the 2018-04-05 and the 2017-09-24.

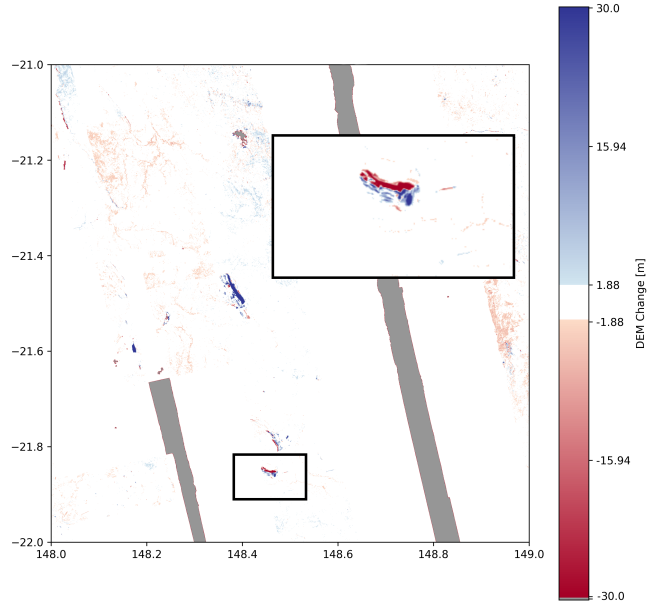

Fig. 4. TanDEM-X DEM Change Maps example over Coppabella Mine in Queensland between the years 2018 an 2019. The datatakes over the Coppabella Mine were acquired on the 2019-04-03 and the 2018-04-05.

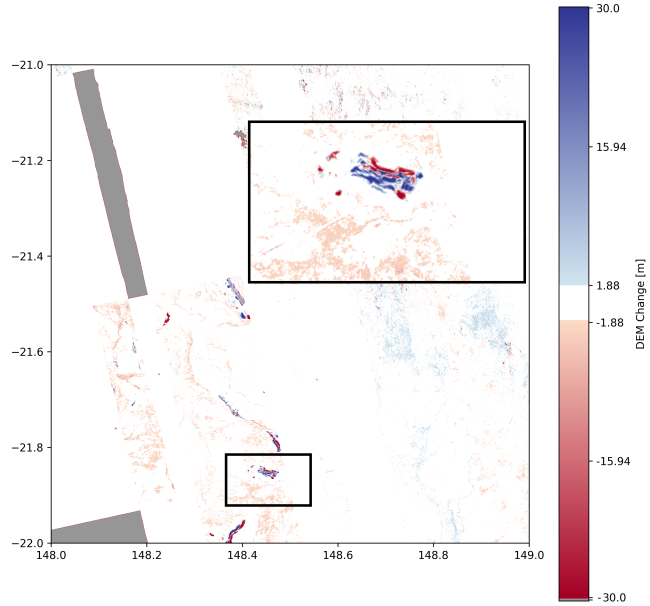

Fig. 5. TanDEM-X DEM Change Maps example over Coppabella Mine in Queensland between the years 2019 an 2020. The datatakes over the Coppabella Mine were acquired on the 2020-05-25 and the 2019-04-03.

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