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# *Interactive comment on* "Spatiotemporal variations in the surface velocities of Antarctic Peninsula glaciers" *by* J. Chen et al.

**Anonymous Referee #2**

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General comment

The authors derive surface velocities of glaciers and ice shelves on the Antarctic Peninsula for four 3-year periods between 2000 and 2012, applying feature tracking in medium resolution optical satellite images. The velocity maps presented are very coarse and fragmented, by no means suitable for depicting the complexity of the flow fields of glaciers and ice sheets on the Antarctic Peninsula. Studies on ice motion of Antarctic Peninsula glaciers and ice shelves, mainly based on satellite images, have been reported during the last several years by various authors. Several of these publications are cited, but appropriate discussion of those results and achievements in respect to the work presented by the authors is missing. Compared to the previously published data, the ice motion maps and velocity data presented in the manuscript



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are of lower quality regarding spatial detail and accuracy. The data presented here are lumping together details of motion fields that are important for documenting and analysing the highly varied behaviour of individual glaciers on the Antarctic Peninsula. Also the analysis of temporal changes of velocity over the four time periods is inconclusive, the presented data being very noisy and lacking the assignment to individual glaciers and ice streams. Glaciological interpretation is missing. In summary, the manuscript does not provide any progress versus the current knowledge on ice motion of Antarctic Peninsula glaciers and ice shelves, and the material presented is not suitable for studies on ice dynamics and glacier evolution in this region. Moreover, the manuscript contains a considerable number of errors, including wrong quotation of information from references.

Details

Introduction (pp. 5877, 5878, 5879):

One page 5877 and 5878 a rather generic overview on satellite methods for ice motion retrieval is provided, not treated in any balanced way, and containing various errors. The topic has been covered well in various review papers; no need repeating this here.

Further details:

Page 5878, line 4-6: "It (refers to optical sensors) is therefore more suitable than SAR monitoring methods for estimating the speed of glacial movement and the analysis of relevant spatiotemporal variations over long time series." This statement is plainly wrong. Ice motion maps covering all of Antarctica and Greenland, and many other glacier regions of the world, including time series, are based on SAR data. SAR works with phase information where the lack of features prohibits the application of optical sensors (e.g. interior of Antarctica, Greenland, . . .), there is no problems with illumination and clouds, etc.

Page 5878, line 7-8: " the accuracy of COSI-Corr is primarily determined by the spatial



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resolution of a pixel "; Spatial resolution is one issue, but as well of importance for use of optical imagery is the availability and quality of features.

Page 5878, line 26-27: " . . .few studies have been reported for the Antarctic ice sheet with regard to ice velocities on larger spatial scales over longer time spans." Incorrect, see comment on Page 5878, line 4-6.

Study area (pp. 5879, 5880):

This section refers rather randomly to some previous publications on Antarctic Peninsula glaciers and climate, lacking a clear focus relating the work reported by the authors and containing many errors.

Further details: Page 5879, line 13-14: "The average annual rainfall is up to 500–600 mm. " This is certainly not rainfall. Besides, this statement is out of context.

Page 5879, line 16-17: "Over the period 1952–2000, the Antarctic Peninsula experienced a temperature rise of 5.6 deg C (Turner et al., 2005)". Incorrectly quoted. Turner states: "major warming over the last 50 years, with temperatures at Faraday/Vernadsky station having increased at a rate of 0.56 deg C / decade over the year . . .."

Page 5879, line 19-20: " the area lost from the Larsen Ice Shelf since 1986 has exceeded 8500 km2 ". The are is >10000 km2, see Cook and Vaughan (2012).

Page 5879, line 21-22: "The collapse of the Larsen Ice Shelf has caused substantial ice loss in upstream supplies of the Antarctic Peninsula, e.g. up to 6.8±0.3 km3 a−1 in the Fleming Glacier". Fleming Glacier is on the W-coast, does not drain into Larsen Ice Shelf.

Page 5879, line 23-24: " Pritchard and Vaughan (2007) monitored the velocities of more than 300 glaciers on the Antarctic Peninsula . . . acceleration 12 % . . . " Incomplete quotation; These are only glaciers along the West Coast.

Page 5880, line 26-27: " These authors further estimated the mass output of the

Antarctic Peninsula to be 60±46 Gt a−1 in 2005 Pritchard and Vaughan (2007)" Incorrectly quoted. The "mass output" (calving flux and melt) is much higher.

Page 5879, line 1: " If the marine ice sheet in West Antarctica completely disintegrates, sea level will rise 3.3 m (Bamber et al., 2009)." Incorrectly quoted, 3.3 m do not refer to complete disintegration of WAIS.

Page 5880, line 4: "In short, Antarctic Peninsula glacier surface velocities have great implications for estimating Antarctic ice sheet mass balance and the study of global climate change (Skvarca et al., 1999; Osmanoglu et al., 2013)." Osmanoglu et al. report on King George Island, not Antarctic ice sheet.

Page 5880, line 9: " the affiliated islands are neglected in this study to improve the accuracy of computation." How can excluding an area improve the accuracy elsewhere?

Page 5880, line 10, 11; Fig.2: cannot see any "melt lines" on the ice shelves. The message of this Figure is unclear.

Page 5880, line 14: how are "the minimum freeze/melt lines of sea ice" linked with retrievals of ice velocity.

Page 5880, line 16: "mainly covering Graham Land and the Larsen Ice Shelf (10.5 km2)." Area inorrect by at least 3 orders of magnitude.

Data (pp. 5880, 5881):

Concluding from the rather low quality of the velocity data, it seems that the selected data sample for velocity retrievals (only 5 images spread over 12 years) is inadequate. There are certainly many more MODIS images available.

Further details:

Page 5881, line 8: The split in "geographic data" and "scientific data" is a bit confusing.

Page 5881, line 11: " . . . data products (Geolocation 1 km) for geocoding prior to crosscorrelation calculations. “ Geolocation accuracy of 1 km is not sufficient for retrieval of ice velocity.

Page 5881, line 11: ” During calibration, the pixel values are synchronically converted from reflectance to DN values, ultimately producing images with precise geographic coordinates.” How can conversion from reflectance to DN improve geolocation accuracy.

Page 5881, line 18 to 30: The standard ASTER GDEM has large errors on the Antarctic Peninsula. Cook et al. (2012) produced an improved DEM for the Antarctic Peninsula that is freely available.

Methods (pp. 5882 - 5886):

This section reports (verbosely) on standard procedures for velocity retrievals using optical satellite images. As these are routine procedures, most of the text, the equations, and Figs. 3, 4, and 5, can be omitted. On the other hand, the parameter settings which the authors used should be specified precisely, as well as the impact on retrieval performance. E.g., it is rather doubtful if good correlation peaks can be obtained with 10m x 10 pixels template size.

Spatial distribution and temporal variations of velocities (pp. 5886 - 5889): The velocity maps presented in Fig. 6 are very coarse and not suitable for supporting studies on ice dynamics in this region. The motion fields of individual glaciers are not resolved. Even on Larsen-C ice shelf, a large homogeneous area, the motion field is coarse and noisy, not reproducing the actual spatial pattern of ice motion mapped with high resolution sensors (see Fig. 2 of Khazendar et al., 2011). Also the temporal trend, presented in Figs. 9b and 10 b, is very noisy, varying form one point to another from acceleration to deceleration. The amplitude of the temporal changes greatly exceeds the values in Fig. 3 of Khazendar et al. (2011). Besides, it seems that there is major trend of overestimating velocities on Larsen-C.

Zooming into the velocity map (e.g. as shown in Fig. 7, for Cabinet Inlet on Larsen-C and some of its tributary glaciers) shows the weakness of the velocity products: motion vectors show up also on stable surface (mountain ridges); the high velocities on the narrow glacier channels (Eden Gl., Morrison Gl.) are not resolved, whereas the velocity on Cabinet Inlet is overestimated. Adjacent velocity vectors on the ice shelf are angling off by up to 90 degrees, contradicting laws of mass continuity and ice flow. Also the velocity time series for individual points on outlet glaciers (Figs. 9a and 10 a) are very noisy. There are many points (out of the total sample of the 50 points) showing two- to three-fold (and even higher) increase of velocities from 2000 to 2012. Actually, among the 50 points analysed only 3 are located on glaciers that showed such high acceleration rates (those are draining into Larsen-B embayment). It seems that many of these "temporal changes" are actually artefacts of velocity retrievals and geo-referencing.

Error analysis (pp. 5889-5890):

In this section the authors compare some of their results with previously published velocity data and mention various factors that are commonly affecting the quality of ice motion products derived from optical satellite imagery. A rigorous assessment of error sources and the quantification of errors of the ice motion products presented in the manuscript is completely missing. The "comparison" with published velocity data (1st paragraph of this section) is not meaningful, because data of different epochs are compared and no attention is paid to the spatial congruence.

Further details:

Page 5889, line 8 - 10, and Fig. 11: The motion field of Crane Glacier, presented in Fig. 11, does not agree with high resolution velocity data. Rott et al. (2011) present velocity data of Crane Glacier and several other glaciers of the Larsen-B embayment for various epochs between 1995 and 2008 based on SAR data. For Crane glacier see also Rignot et al. (2004), Hulbe at al., (2008); Scambos et al., (2011).

Page 5889, line 12 - 15, and Fig. 12: The velocities presented here for five points on a single line across the remnant part of Larsen-B ice shelf are not representing the “average velocity of the Larsen-B ice shelf”. This section of the ice shelf shows a rather complex field of ice motion and deformation (Rack et al., 2000).

Page 5889, line 16: Incorrectly quoted. Scambos et al. (2004) do not provide velocity data for any point on Larsen ice shelf

Additional References:


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