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Is the surface mass balance in inland East Antarctica decreasing? (with reference to D. Wang's paper in the "Nature Geoscience" journal)

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Abstract. This article offers critical comments on the paper "Sustained decrease in inland East Antarctic surface mass balance between 2005 and 2020" by Dr. Danhe Wang and co-authors published on the 11th of June 2025 in the "Nature Geoscience" journal. There is no doubt about the high quality of the data presented in the Wang et al.'s manuscript, but the results of the study are applicable only to a relatively short interval of time and to a small fraction of the East Antarctic Ice Sheet (in particular, to the vicinity of Dome A). In this respect, the paper's title is to a large extent misleading since there is no evidence of sustained decrease in surface mass balance in inland East Antarctica as a whole, even though there is no disputing the fact that the total mass of the Antarctic Ice Sheet is decreasing due to ablation at the edges.

Keywords: Antarctica, mass balance, snow accumulation rate

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The Antarctic Ice Sheet (AIS) is currently losing mass, contributing about 10 % of the mean 3.6 mm yr^{-1} sea level rise in 2006–2018 [1]. The total AIS mass budget is an interplay between ice ablation on Antarctica's edges (mainly iceberg calving and ice shelf basal melt) and net snow accumulation in the AIS's interior; the latter is often referred to as "surface mass balance" (SMB) and represents a function of precipitation, sublimation and snow transport by wind [2]. The mass loss is dominated by the increased ice ablation, while the contribution of the SMB is less clear [3]. It is argued that in a warmer climate the SMB should increase due to enhanced water vapor capacity of air [4]. Therefore, it is crucial to know the SMB's sensitivity to the current climate change in order to project the future AIS's mass change and its final contribution to the sea level rise. However, such studies suffer from a dramatic paucity of ground-based reliable data on SMB, so the researchers have to rely upon the climate models, despite the fact that they do not necessarily reproduce the instrumental data correctly, especially in the inland parts of the AIS [5, 6].

On the 11th of June 2025 a paper was published in the "Nature Geoscience" journal entitled "Sustained decrease in inland East Antarctic surface mass balance between 2005 and 2020" (https://doi.org/10.1038/s41561-025-01699-z), by D. Wang and others [7]. The authors presented a new unique dataset of instrumentally observed snow mass balance values along the transect between the coastal Zhongshan Station and the main East Antarctic ice dome, Dome A (Fig. 1) in order to demonstrate a significant decrease in SMB between 2005 and 2020 in the inland part of the transect, and to reveal a role of atmospheric circulation in this trend. Although the quality of the instrumental SMB data and the robustness of the results are not in doubt, three main concerns arise: (1) the article only discusses the atmospheric circulation drivers of the SMB variability ignoring the thermodynamic factor; (2) the findings of the article are applicable only to a relatively short interval of time and to a small fraction of the East AIS and (3) as such, the article's title is to a large extent misleading. These concerns motivated me to write comments on the Wang et al.'s work, which is the subject of this short article. The comments were sent to Dr. D. Wang and his colleagues, and their reply is attached as supplementary material to this article.

The study of Wang et al. is based on measuring the heights of the accumulation stakes installed along the Zhongshan – Dome A logistic traverse. The authors are aware of a very weak climatic signal in the instrumental SMB data (due to a very high amount of "depositional noise", which constitutes more than 90 % of the total variance, [8]), so to overcome this problem they use averaging of the SMB values over a number of adjacent stakes. The reliability of the data could be further improved if the authors used the SMB data from the stake farms situated in the vicinity of Dome A [9].

The next issue concerns the choice of the time interval discussed in the paper, from 2005 to 2020. The data shown in their Figure 5*a–c* demonstrates that it is actually the only 15-yr period between 1979 and 2024 when the SMB (and precipitation rate, as seen in ERA5 reanalysis data) was significantly decreasing. Looking at the same graph for the period up to 2024, one can see no negative SMB trend between 2005 and 2024. There is also no overall negative trend in precipitation between 1979 and 2024. The selection of the 2005–2020 interval is explained by the fact that 2005 was the first year when the SMB data was available along the whole length of the Zhongshan – Dome A profile, although other parts of the accumulation-stake profile are operating since January 1997 [10]. It is just a pure coincidence that the time interval of the study covers the only 15-year period of time when the SMB was decreasing.

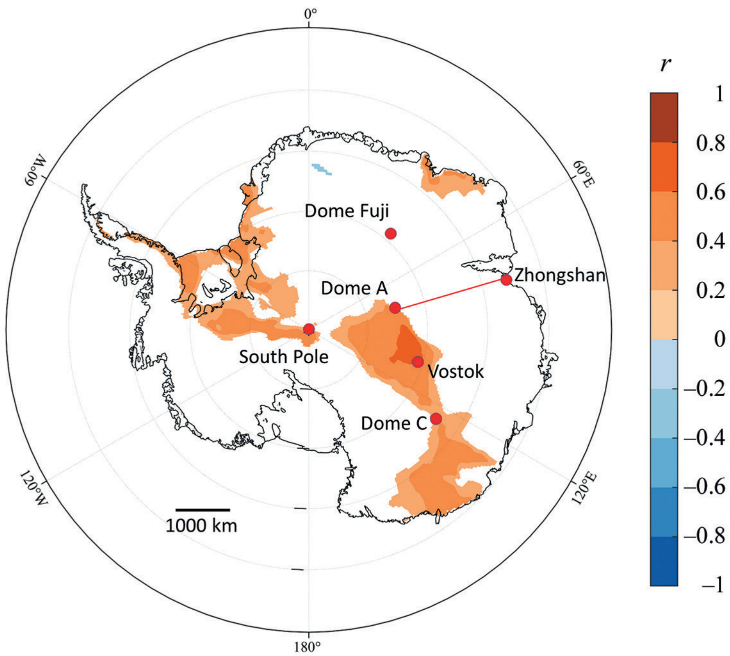

Fig. 1. The location of the sites mentioned in the paper.

The red line is the Zhongshan – Dome A transect (ref. 7). The colors denote the spatial variability of the correlation coefficients between detrended time-series of instrumentally measured SMB at Vostok in 1979–2021 [8] and the SMB time-series produced by ERA-5 reanalysis [15]

Рис. 1. Местоположение пунктов, упомянутых в статье.

Красная линия — профиль Жонгшан – Купол А [7]. Цветом показано пространственное распределение коэффициентов корреляции между временным рядом инструментально измеренной скорости снегонакопления на станции Восток в 1979–2021 гг. [8] и скоростью снегонакопления по данным реанализа ERA-5 (из работы [15])

When discussing the factors responsible for the observed negative SMB trend in 2005–2020, the authors focus on the atmospheric circulation in the Southern Hemisphere, such as the intensity of zonal circulation, the anomalies of 500 hPa geopotential height and the related anomalies of the poleward transport of the water vapor. However, it is known that the variability of SMB is closely related to the local air temperature, which is evident both from the climate models [11], the instrumental observations [8, 12] and the ice core data [13]. Thus, the discussion part of the Wang et al.'s article could be substantially improved if the authors analyzed the relationship between the SMB and the surface air temperature at Dome A, data on which is available for the region of study [14]. Having said that, it is necessary to note that the circulation and the thermodynamic factors are certainly not fully independent as it is atmospheric circulation that brings heat and moisture to central Antarctica.

The most important issue concerns the geographical extent of the validity of the results of the paper. The title refers to the region as "inland East Antarctica", but it is very unlikely that the results are applicable to the entire plateau of East Antarctica. For example, one of the reasons of the decreasing SMB in the Dome A region in 2005–2020 is the deepening of

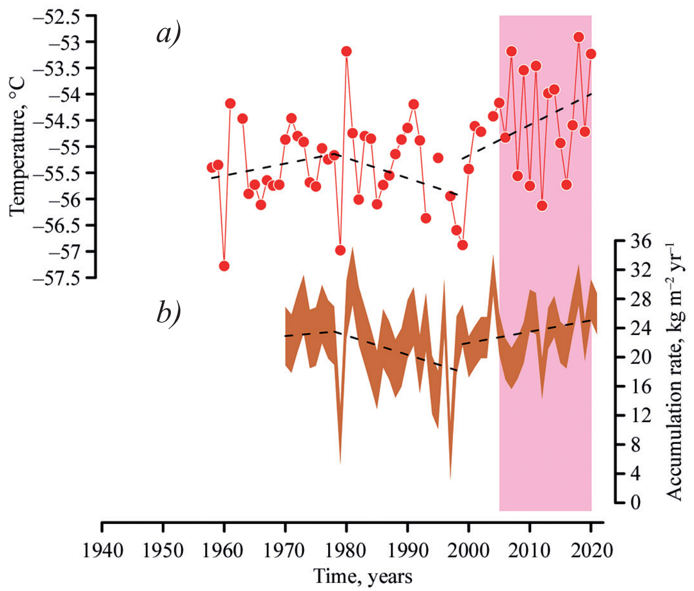

Fig. 2. Vostok snow accumulation rate (*b*) vs local air temperature (*a*).

The shading depicts the error bars (± 2 SEM). The dashed lines in (*a*) and (*b*) are the linear trends of temperature and accumulation rate for the time intervals 1960–1978, 1978–1999 and 1999–2021. Pink color highlights the time interval (2005–2020) studied by D. Wang et al. [7]. The figure is from [8] with modifications

Рис. 2. Скорость снегонакопления на ст. Восток (*b*) и местная приземная температура воздуха (*a*).

Заливка обозначает погрешность измерения (± 2 ошибки среднего). Пунктиром на рис. 2*a* и 2*b* обозначены линейные тренды температуры и снегонакопления в интервалы 1960–1978, 1978–1999 и 1999–2021 гг. Розовым цветом выделен интервал времени (2005–2020 гг.), которому посвящена работа Д. Вонга с соавторами [7]. Рисунок заимствован из работы [8] с изменениями

the low-pressure anomaly in the south-eastern part of the Indian Ocean (South Indian Ocean Low, SIOL), to the eastern side of the study area, thus enhancing offshore tropospheric winds along the SIOL's western flank and reducing the water vapor transport into the interior of Antarctica (see the Wang et al.'s figures 3 and 6). Does it mean that along the eastern flank of SIOL the offshore tropospheric winds are weakened and the poleward water transport is enhanced? Does it mean that the depleted SMB in the region of study is (at least, partly) balanced by the increased snow accumulation somewhere to the east of Dome A, e.g. in the vicinity of Vostok or Dome C? (see Fig. 1). To test this hypothesis and to study the geographical extent of the results obtained at Dome A, it is necessary to involve the SMB data from the other sites where robust instrumental observations of the snow accumulation are available: South Pole [12], Dome C [15] and Vostok [8]. In particular, at Vostok a clear growth of SMB was observed in 2005–2020 (Fig. 2); the accumulation rate has increased by about 28 %, from 20.3 to 26.1 kg m^{-2} yr^{-1} [8]. Moreover, it is very likely that the mean present-day (1970–2020) SMB value at Vostok exceeds that during any 50-year interval in the pre-industrial era [16]. At the South Pole, the SMB increased by as much as 57 % between 2005 and 2020 [12], while no significant trend is detected at Dome C [15]. These results do not contradict the observed decline of snow accumulation rate at Dome A, given a large regional variability of the SMB trends on decadal scale [1, 6].

For example, interannual variability of SMB at Vostok significantly correlates with that at the South Pole and Dome C vicinity, but not with the Wang et al.'s area of study (600 km to the north of Dome A), Fig. 1.

In conclusion, the article by D. Wang et al. is an important contribution to the understanding of the processes lying behind the decadal SMB variability in Antarctica, but its results should not be interpreted as evidence of a sustained recent accumulation rate decline. Because of the large spatial (between different Antarctic sectors) and temporal (on decadal scale) variability of SMB, it is likely that during a short (15 years) time interval the snow accumulation rate may reveal decreased values in a certain region of Antarctica, but there is also evidence that on the continental and multi-decadal scale the SMB in central Antarctica has increased probably as a result of increasing air temperature [6, 16].

Supplementary materials

The reply of Dr. D. Wang and his colleagues on my comments can be found here:
http://cerl-aari.ru/wp-content/uploads/2025/08/Reply_to_matter_arising_v4.docx

Competing interests. The author declares no competing interests.

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Конфликт интересов. Конфликт интересов отсутствует.

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Уменьшается ли скорость снегонакопления в центральных районах Восточной Антарктиды? (комментарии к статье D. Wang с соавторами в журнале “Nature Geoscience”)

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Расширенный реферат

Изменение массы Антарктического ледяного щита будет служить основным фактором, определяющим глобальный уровень моря в XXI в. и дальше. В настоящее время Антарктида активно теряет массу, что связано с увеличенной абляцией на краю ледника. При этом изменение приходной части баланса массы — снегонакопления в центральных районах Антарктиды — изучено недостаточно вследствие 1) нехватки инструментальных данных и 2) большой пространственной и временной изменчивости этого параметра. Предполагается, что при повышении температуры воздуха количество осадков должно расти вслед за ростом влагосодержания атмосферы. Данная заметка посвящена критике недавно опубликованной в престижном журнале "Nature Geoscience" статьи, озаглавленной «Устойчивое снижение баланса массы снежной поверхности во внутренней части Восточной Антарктиды в период с 2005 по 2020 год». Несмотря на то, что к качеству исходного материала, к его обработке и интерпретации претензий нет, тщательный анализ этой статьи приводит к заключению, что она может быть ошибочно истолкована читателем как свидетельство снижающейся скорости снегонакопления в Центральной Антарктиде. Во-первых, упомянутый период — с 2005 по 2020 г. — является единственным 15-летним отрезком времени, когда скорость снегонакопления снижалась в районе исследования (окрестности Купола А). Во-вторых, авторы рассматривают только циркуляционные факторы, влияющие на скорость снегонакопления, игнорируя термодинамический фактор. В-третьих, выводы статьи применимы лишь к ограниченной территории, прилегающей к Куполу А (станция Куньлунь) и не могут быть экстраполированы на всю территорию Центральной Антарктиды.

Ключевые слова: Антарктида, баланс массы, скорость снегонакопления

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