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Discussion of Increased ice losses from Antarctica detected by CryoSat-2 – short periods of 3 years of data should not be used to infer any trend

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ABSTRACT

The latest paper[1] uses a computational record less than 36 months long based on the Cryosat-2 satellite data to claim that "Between 2010 and 2013, West Antarctica, East Antarctica, and the Antarctic Peninsula changed in mass by -134 ± 27, -3 ± 36, and -23 ± 18 Gtyr-1 respectively"to conclude that"We estimate that, since 2010, the average Antarctic ice sheet contribution to global sea level rise has been 0.45 ± 0.14 mm yr-1" It is commented here that the novel computation of the ice volume from the satellite altimetry data and other supporting indirect measurements used for validation and calibration is a difficult task still under development. The ice volume result has to be considered in the correct perspective together with the other information available for the region, from local temperature measurements by thermometers, to satellite inferred measurements of surface temperatures and sea ice extent, certainly much more reliable and covering a much more significant period. It is shown here that the temperatures and the sea ice extent are subject to intense inter-annual and multi-decadal oscillations about a cooling and expanding trend, and the 3 years' time window is misleading magnifying the effect of these oscillations about a longer term trend. Finally, the computed volume of ice melted appears excessive being the claimed global sea level rise not supported by tide gauge, satellite altimetry and salinity measurements.

INCREASED ICE LOSSES FROM ANTARCTICA DETECTED BY CRYOSAT-2A

The authors of[1] "use 3 years of Cryosat-2 radar altimeter data to develop the first comprehensive assessment of Antarctic ice sheet elevation change". According to them "This new dataset provides near-continuous (96%) coverage of the entire continent, extending to within 215 kilometres of the South Pole and leading to a fivefold increase in the sampling of coastal regions where the vast majority of all ice losses occur." The major results of their analysis is that "Between 2010 and 2013, West Antarctica, East Antarctica, and the Antarctic Peninsula changed in mass by "134±27, "3±36, and "23±18 Gt yr"1respectively. In West Antarctica, signals of imbalance are present in areas that were poorly surveyed by past missions, contributing additional losses that bring altimeter observations closer to estimates based on other geodetic techniques. However, the average rate of ice thinning in West Antarctica has also continued to rise, and mass losses from this sector are now 31% greater than over the period 2005–2011." Their conclusion is that this huge ice loss has significantly contributed to increase the rate of rises of sea levels "We estimate that, since 2010, the average Antarctic ice sheet contribution to global sea level rise has been 0.45 ± 0.14 mm yr^{-1}"

This paper is unfortunately only the last of a long series of attempts to show our planet is warming, the ice sheets are shrinking and the sea levels are rising by correcting or replacing consolidated measuring techniques.

In this case, the less than 36 months novel reconstruction based on the Cryosat-2 radar altimeter data should be preferred according to the authors to the complementary data sets from more consolidated measuring techniques as the local thermometer measurements[7] or the satellite reconstructions of surface air temperatures and sea ice extent[8,9], providing data since mid of the 1950s or the end of the 1970s respectively and not even mentioned in the work[1]. Similarly, the implication of the ice loss on the rate of rise of sea levels is made without any consideration of the complementary data sets as the PSMSL tide gauge data base[15], the ARGO measurements of ocean temperature and salinities[16] or the satellite based computation of the global mean sea level[17], cited in decreased order of reliability and increased computational content of the product.

The surface air temperatures and the sea ice extent data sets show cooling and increasing trends over more significant time windows[10]. The sea ice extent of Antarctica is presently increasing, as the surface air temperatures are cooling, as proved by the more consolidated and reliable techniques[8,9] consistently providing data over more significant periods of time. The temperatures and sea ice extent of Antarctica are everything but warming and shrinking[2,3,10], as the sea levels are not rising fast nor accelerating[4-6] or the oceans are changing salinity and temperatures[18].

There is for Antarctica a monitoring system working since 1979 for both surface air temperature and sea ice extent by satellite. These measurements permit to infer a trend over a period of much longer even if still long less than important periodicities detected, as for example the quasi 60 years, to understand how misleading a time window of less than 36 months is.

The analysis of[10] "indicates for the temperatures of the region a nearly flat profile over the last 35 years of continuous measurements, and actually a present cooling trend rather than a present warming trend. Over the 35 years of the record, globally the Antarctic region has been cooling of $-4.30 \cdot 10^{-4}$ °C per year, with a minimal warming for the land component, more sensitive to other anthropogenic biases not related to the changed composition of the atmosphere, of $2.90 \cdot 10^{-3}$ °C per year, but a more significant cooling of the ocean component, less affected by these other anthropogenic biases, of $-3.07 \cdot 10^{-3}$ °C per year. Over the period 1980-2010, the NSSTC global cooling trend for Antarctica is -0.08 °C per decade. The NSSTC measurement of the planetary temperatures during the period 1980-2010 shows significant warmings of $1.38 \cdot 10^{-2}$, $1.90 \cdot 10^{-2}$ and $1.08 \cdot 10^{-2}$ °C per year global, land and ocean, covering 22 years of the upwards phase and only 13 years of the downward phase of a quasi-60 years oscillation superimposed to a mildly warming movement."

The analysis of[10] also indicates that "The sea ice in the Antarctic has proved to be remarkably robust and new measurements have now confirmed that it has extended over the highest area since measurements began in December 1978. In September 2013, the ice surrounding Antarctica reached its annual winter maximum and set a new record of over 19.47 million square kilometers of the Southern Ocean up to a previous record of 19.44 million square kilometers set in September 2012. The time history of the maximum sea ice extent for each September 1979 to 2013 shows that despite a significant variability affects the datum from year to year, the overall trend is of a growth of about 1.5% per decade."

The latest surface air temperatures and sea ice extent downloaded from[8,9] are analyzed in Figure 1 with focus on the long term trends and the misleading 3 years long time window only showing inter-annual and multi-decadal variability.

Figures 1a to 1.c present the temperature of the South Pole May 1979 to April 2014 (latest release as per May 26, 2014). Data are monthly values. Data are available since December 1978, but trends are significant only when inferred covering multiples of the overwhelming 12 months periodicity. The data November 2010 to October 2013 are also analysed for analogy with[1], even if the data of[1] actually cover less than 36 months missing some cold months of 2013 further adding to the lack of significance of the very short time series analysis.

Figure 1.d presents the sea ice extent for the South Pole May 25, 1979 to May 24, 2014 (latest release as per May 26, 2014). Data are daily values. Data are available since October 26, 1978, but a shorter window is used because trends are significant only cover-

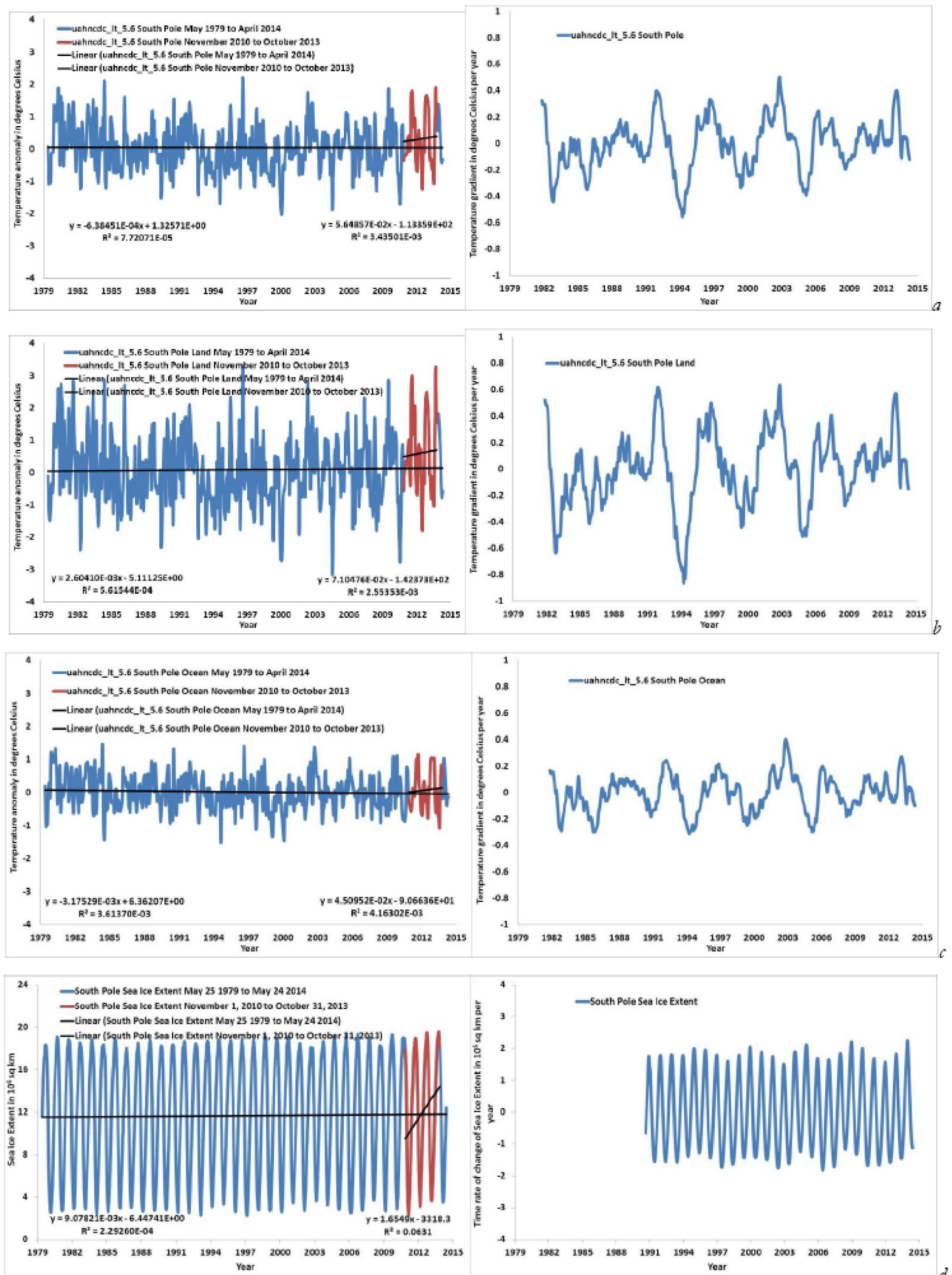

Figure 1 : Air surface temperatures and sea ice extent for the South Pole. The 3 years' time window is definitively too short and does not permit to infer any trend but only the presence of inter annual and multi decadal oscillations

ing multiples of the overwhelming 12 months periodicity. The data November 1st, 2010 to October 31st, 2013 are also analysed for analog[2y with[1].

The figures also present the very misleading time rates of change of temperatures and sea ice extent computed by linearly fitting 3 years' of data, not only for a single time window, but as a time series over the full record length.

The following conclusions may be drawn:

(1) The global temperature of the South Pole is decreasing at a rate $-6.38451 \cdot 10^{-4}$ C/year over the time window May 1979 to April 2014.

(2) This is not the correct long term warming trend because the period of observation is less than a quasi-60 years' multi-decadal periodicity[11-14]. The actual long term warming or cooling may be different.

(3) Over the time window November 2010 to October 2013, the global temperature of the South Pole is increasing at a rate $5.64857 \cdot 10^{-2}$ C/year. This

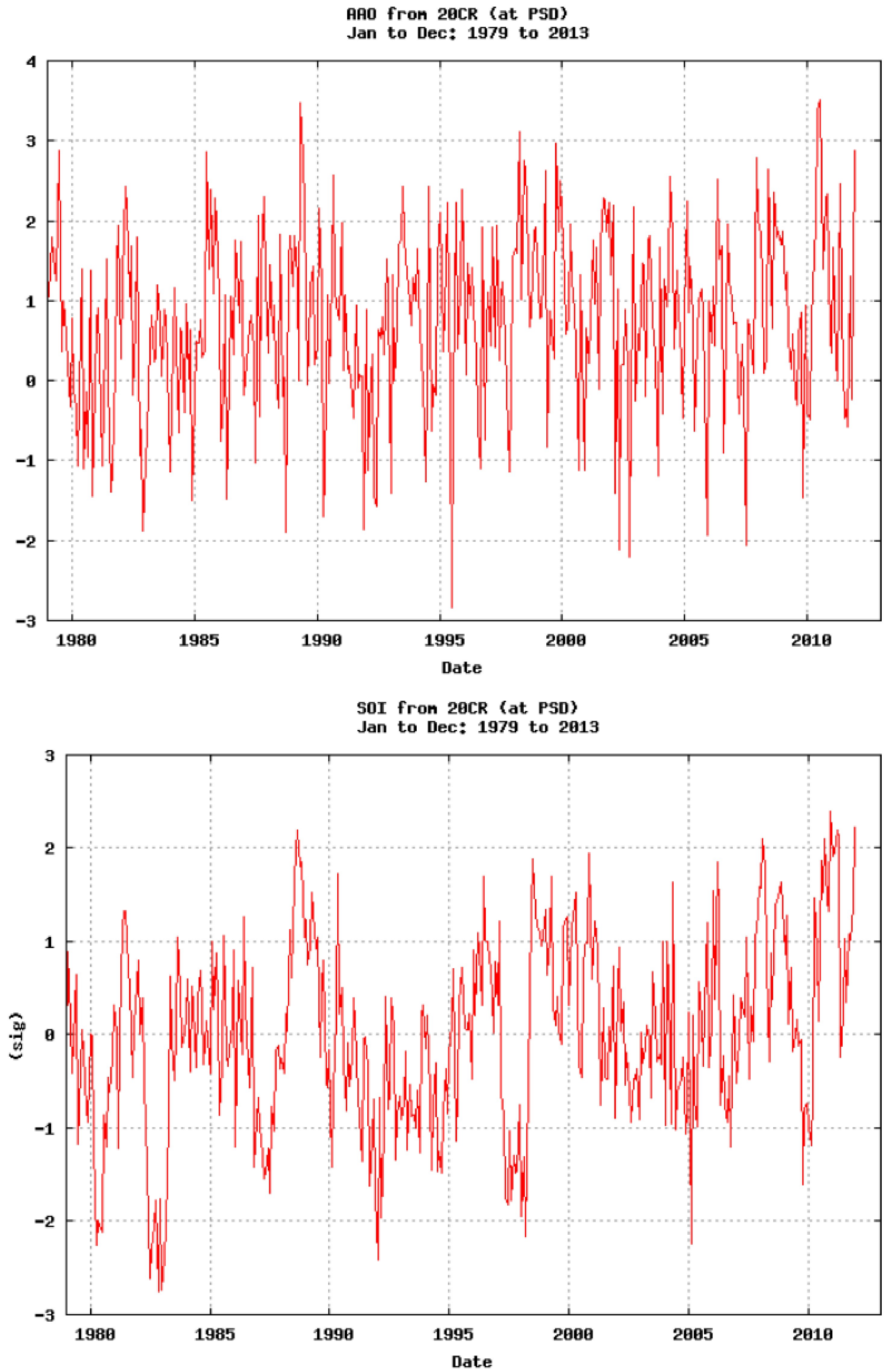

Figure 2 : AAO and SOI indices over the time window 1979 to present (from [20]). The inter-annual variability is clear

warming trend includes the effect of inter-annual and multi-decadal oscillations and should not be proposed as a long term trend.

(4) Over the time window May 1979 to April 2014, the warming rates computed over periods of three years have been oscillating up on down simply because of the inter annual and multi decadal oscillations.

(5) Larger values of the short term temperature gradient have been clearly obtained in the past, as smaller values have been obtained before and after October 2013. These values are not an indication of

any warming or cooling trend, but only that short time windows of less than 36 months should not be used to infer any trend.

(6) The Land component is warming marginally at a rate $2.60410 \cdot 10^{-3}$ C/year over the time window May 1979 to April 2014, while the Ocean component is cooling more at a rate of $-3.17529 \cdot 10^{-3}$ C/year over the same time window.

(7) The Land and Ocean components present same pattern of the global land and ocean result over the short time windows, and same conclusions apply.

(8) The sea ice extent is increasing over the South Pole from May 25, 1979 to May 24, 2014 at a rate of $9.07821 \cdot 10^{-3}$ million square kilometers per year.

(9) Over the short three year time window November 1st, 2010 to October 31st, 2013 the sea ice is also increasing and a faster than ever rate of 1.6549 millions square kilometers per year.

(10) The sea ice extent oscillates similarly to the surface temperature and the focus on the short time window is similarly misleading. However, phasing and length of the oscillations are different for surface air temperatures and sea ice extent.

NATURAL VARIABILITY OF THE ANTARCTIC ICE

The natural variability of the climate in Antarctica is very well known [19]. The Antarctic sea ice is exposed to a broad range of land, ocean, and atmospheric influences, and it is much more variable from year to year than Arctic sea ice. "In addition, climate oscillations don't affect ice in all sectors the same way, so it is more difficult to generalize the influence of climate patterns to the entire Southern Hemisphere ice pack". The primary variation in atmospheric circulation in the Antarctic is the Antarctic Oscillation (AAO) involving a large-scale seesawing of atmospheric mass between the pole and the mid-latitudes. This oscillation influences "wind speeds, temperature, and the track that storms follow, any of which may influence sea ice extent". Changes in the El Niño-Southern Oscillation Index (ENSO)" can lead to a delayed response (three to four seasons later) in Antarctic sea ice extent". Graphs of AAO and SOI (from[20]) are presented in Figure 2. In [20] the AAO is wrongly indicated as "AAO Arctic Oscillation" rather than "AAO Antarctic Oscillation" on May 27, 2014. Another atmospheric pattern of natural variability that appears to influence Antarctic sea ice is the periodic strengthening and weakening of the "zonal wave three" or ZW3 pattern. The effect is most apparent in some areas than other. These oscillatory indices suggest that the ice volumes will consequently oscillate with about same periodicities and the focus on the short term oscillation will be consequently misleading.

DISCUSSION

The measure of the ice sheet thickness has been quite troublesome with the NASA Icesat-1 mission, started in 2003 and concluded in 2010, with some of the downfalls also mentioned in[1]. The actual volume of ice has already proven difficult to be determined, and the major issues of detection, calibration and analysis are certainly not fully addressed with Cryosat.

The latest ESA Cryosat mission has still to demonstrate the better accuracy claimed through detailed validation in addition to the better coverage that we may certainly concede. The validation of the Cryosatbased results is still ongoing and it is depending on other indirectly measured data as airborne monitoring. The computational component of the procedure is overwhelming.

Contrary to the satellite altimetry ice volume result of IcesatorCryosat, the satellite recognition of the sea ice extent is a much more reliable product. Of the results of[1] and those presented in Figure 1, the temperature trends of Figure 1 are certainly the most reliable data.

Considering all the individual climate products are not exactly direct measurements but more a sort of computations with accuracy and reliability still far from being assessed, it does not make any sense to consider an individual product especially a novel one while neglecting the other products for consistency analysis.

The result of the Cryostat data set has to be integrated with the other data sets as the surface air temperatures of[8], the sea ice extent data of[9], or the temperatures measured by thermometers in selected locations of[7] and other sources to understand a pattern.

It is shown here that the temperatures and the sea ice extent are subject to intense inter-annual and multi-decadal oscillations, and the 3 years' time window is misleading magnifying the effect of these oscillations about a longer term trend.

For what concerns the surface air temperatures, the long term trend is of small cooling, and the 3 years' time rates of change of temperatures oscillates up and down about this long term trend.

For what concerns the sea ice extent, the long term trend is of small increasing, and the 3 years' time rates of change of sea ice extent oscillates up and down about this long term trend however not in phase with the temperatures.

Integrating the information of[1] with those of[8] and[9] proposed in Figure1, the ice volume over the 3 years November 2010 to October 2013 has very likely reduced, and the surface air temperatures have warmed over the same time window. However, same short term warmings have been experienced also in the past, always followed by short term cooling.

Very likely, the ice melting during warming oscillations have been experienced also in the past, and very likely this melting has been always followed by freezing during the cooling oscillations.

For what concerns the actual volumes of melted ices, the numbers proposed in [1] appear to be an exaggeration, because the consequent sea level rises of 0.45 mm y^{-1} could have otherwise been detected by the tide gauges or the satellite based computation of the ocean volume and the salinity changes could have been evident in the ARGO monitoring of the world oceans.

CONCLUSIONS

The more consolidatedmeasurements of temperatures and sea ice extentof[7-9] extending over more significant time windows show a completely different pattern from the one inferred from the authors of[1] focusing on less than 36 monthssatellite based computation.

While the reliability and accuracy of the novel CryoSat-2 altimetry based reconstruction of ice volumes proposed by the authors may be questioned as for every other indirect measurement strongly dependent on computations in the early stages, without any doubt no relevance should be attributed to climate analyses based on less than 36 months of computed data only representing inter-annual and multi-decadal variability.

Over the 3 years 2010-2013, the land temperatures have certainly oscillated up in Antarctica, and there may have been a melting of the land based ice. However, this warming has been just an oscillation about a stable trend of actually a small overall cooling.

The actual melting associated to the warming oscillation is very likely much less than the claims of[1], that appear exaggerated especially when considering the large increment of the rate of rise of sea levels that has not been detected by other data sets. However,the cooling oscillation very likely following the warming oscillation as it has been so far would produce about same freezing of the melting.

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