Response to Short Comment 2 (Nathan Kurtz)

I also note a similar discrepancy in Figure 5 for the GSFC product. In my plotting there is a difference in both the overall magnitude and month to month change. I'm not sure what the difference could be due to at a quick glance.

Thank you for this comment. Based on the response to SC1, we have revised Figure 5. We also conducted an extensive review of the GSFC product, to examine both the magnitude of the monthly means, and the month to month changes.

We examined 5 instances within the GSFC ice thickness time series where average monthly ice thickness decreased during the winter growth period: October 2010 - November 2010; December 2015 - January 2016; March 2016 - April 2016; October 2016 - November 2016; and March 2018 - April 2018 (see Figure 5). We examined 1 instance within the GSFC ice thickness time series where average monthly ice thickness increased rapidly during the winter growth period: December 2012 - February 2013 (see Figure 5). Below we provide our analysis of two of these six events: March 2018 - April 2018 (Figure SC2.1) and October 2016 - November 2016 (Figure SC2.2). These are illustrative of all 6 events noted above. We then provide our overall conclusion of the analysis at the end of this comment.

Analysis of Fig. SC2.1: For regions 1-6 there is no substantial difference between the GSFC sea ice thickness for March and April 2018 as directly downloaded from product provider's data source (a) and (b), versus the GSFC sea ice thickness data used in our analysis (c) and (d). This rules out any corrupt data in our GSFC data product files as was the case with the CS2SMOS data product, as described in our response to SC1 above.

Maps of average ice thickness for March 2018 (c) and April 2018 (d) in the GSFC product indicate a decrease in the areal extent of the thickest ice between March and April 2018, which was replaced with a larger area of thin ice in April 2018, particularly evident in region 1, north of regions 4 and 5. Conversely in the AWI data product, the maps show an overall thickening of the ice between March 2018 (e) and April 2018 (f) across all regions 1 - 6. The is a decline in average ice thickness between March 2018 (g) and April 2018 (h) in the GSFC product of 0.072 meters, while there is a corresponding increase in average ice thickness in the AWI data product between March 2018 (i) and April 2018 (j) of 0.098m. Modal ice thickness in the GSFC product is 1.875 m in March 2018 (g) and decreases to 1.625 m in April 2018 (h).

The decline in ice thickness in the GSFC product is associated with a reduction in the number of observations of ice > 2 m thick, and a corresponding increase in the number of observations of ice < 2 m thick, between March and April 2018. The total number of observations with ice > 2 m thick is 4721 in March 2018 (g) and 3752 in April 2018 (h) for the GSFC data product. The total number of valid ice thickness observations in the GSFC data product remains stable between March and April 2018, illustrating that the decline in ice thickness is not related to a decrease in the total ice extent within the data product.

Analysis of Fig. SC2.2: For regions 1-6, there is no substantial difference between the GSFC sea ice thickness for October and November 2016 as directly downloaded from product provider's data source (a) and (b) versus the GSFC sea ice thickness data used in our analysis (c) and (d). This again rules out any corrupt data in our GSFC data product files.

Maps of average ice thickness for October 2016 (c) and November 2016 (d) in the GSFC product indicate a large increase in the areal extent of thin ice (<1.5 m) between October 2016 and November 2016, particularly evident in region 3, and region 1, north of regions 3 and 4. There is a decline in average ice thickness between October 2016 (g) and November 2016 (h) in the GSFC product of 0.076 m, while there is a corresponding increase in average ice thickness in the AWI data product between October 2016 (i) and November 2016 (j) of 0.047m. Modal ice thickness in the GSFC product is 1.625 m in October 2016 (g) and decreases to 1.375 m in November 2016 (h). The decline in ice thickness in the GSFC product is associated with a strong increase in the number of observations of ice < 1.5 m thick between October and November 2016. The total number of observations with ice < 1.5 m thick is 1427 in October 2016 (g) and increases to 3756 in November 2016 (h) for the GSFC data product. The increase in ice thickness observations < 1.5m is 78.3% of the increase in total number of observations, which suggests that the decrease in thickness is related to increasing ice extent within the product.

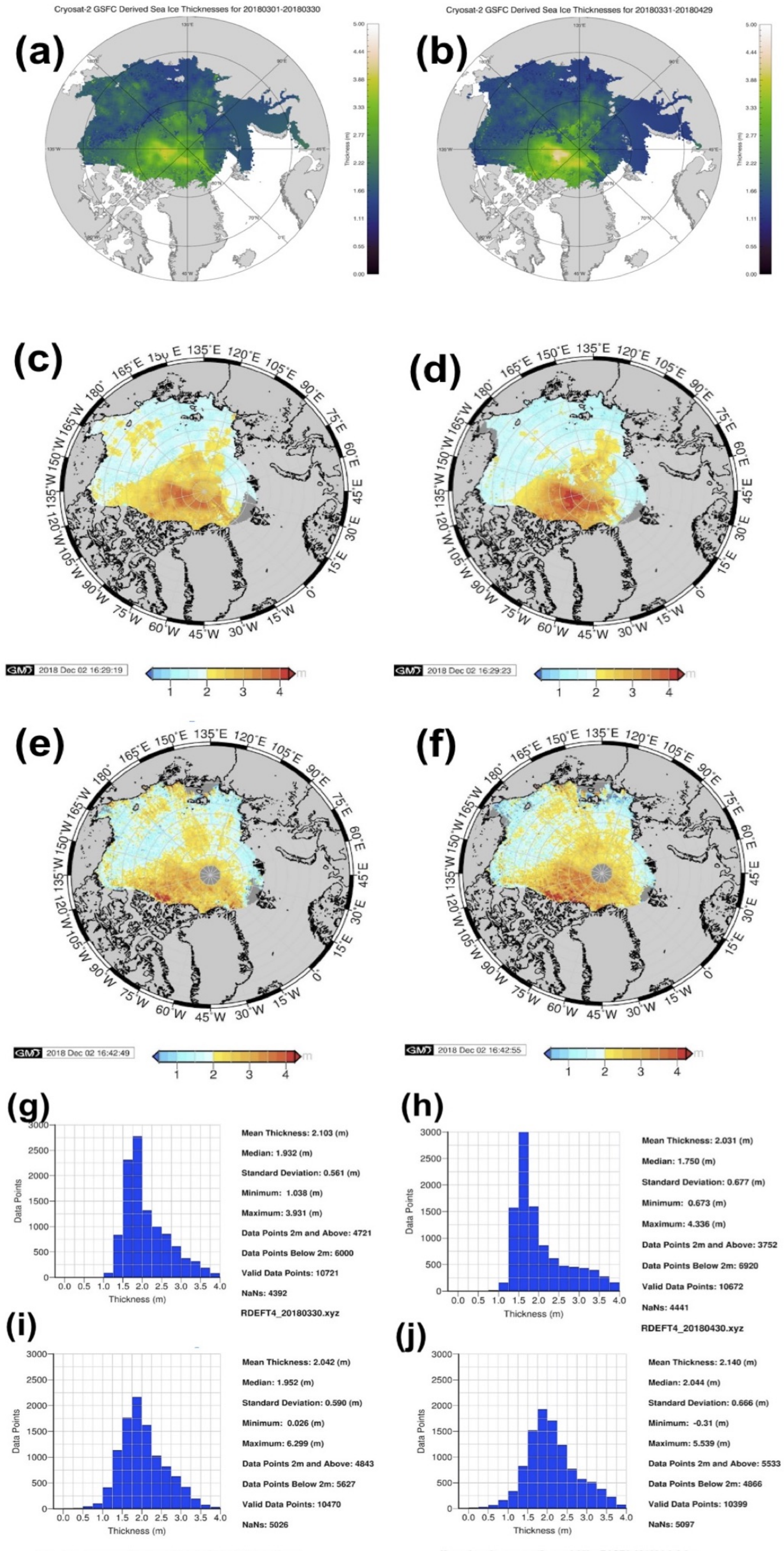

Fig. SC2.1 Comparison of monthly GSFC thickness data with monthly AWI thickness data. (a) GSFC sea ice thickness for March 2018, directly downloaded from product providers data source (Table 1) and (b) for April 2018. (c) GSFC sea ice thickness for March 2018, for regions 1-6 and (d) for April 2018, for regions 1-6, based on our analysis. (e) AWI sea ice thickness for March 2018, for regions 1-6 and (f) for April 2018, for region 1-6.

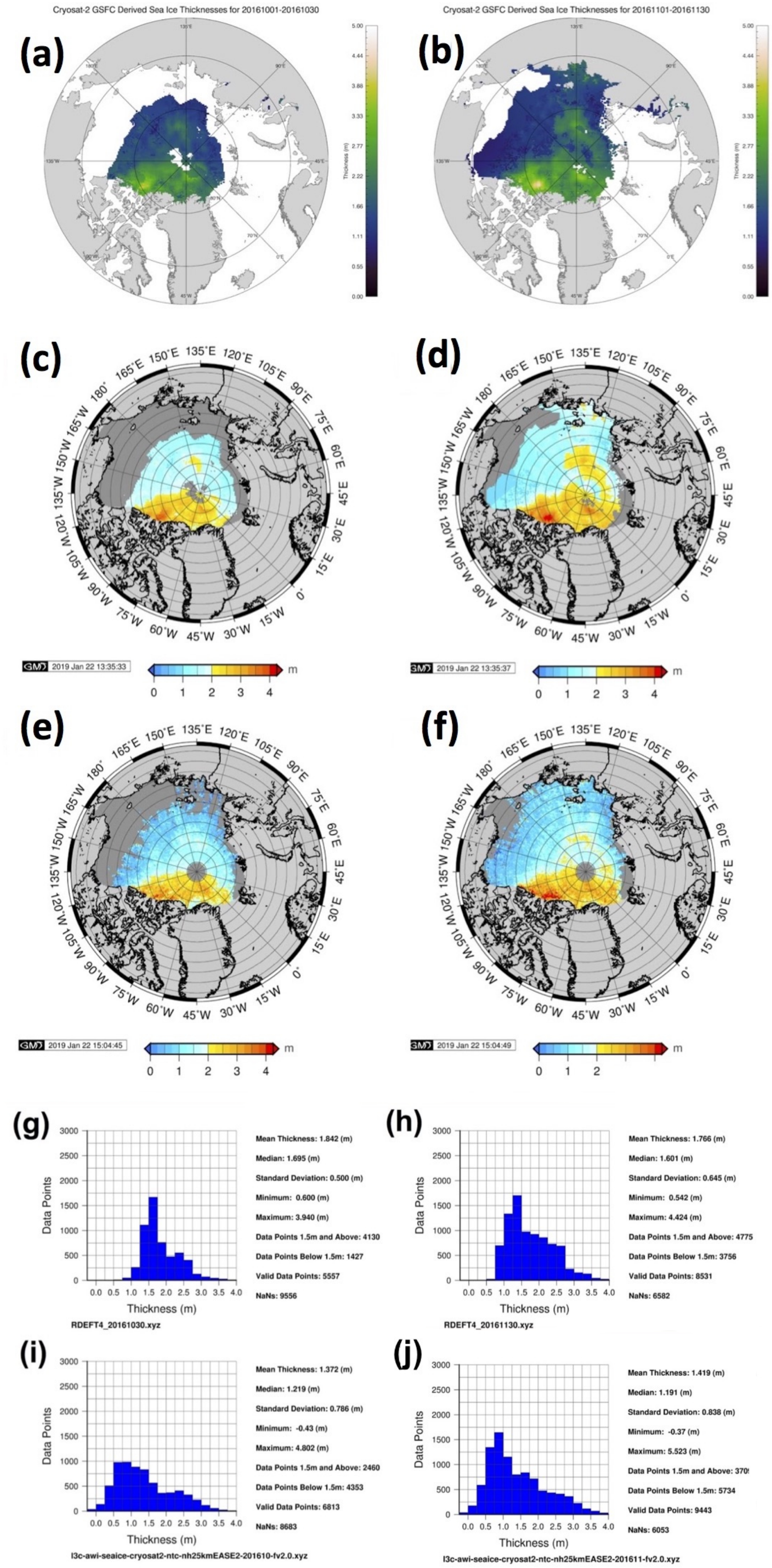

Fig. SC2.2 Comparison of monthly GSFC thickness data with monthly AWI thickness data. (a) GSFC sea ice thickness for October 2016, directly downloaded from product providers data source (Table 1) and (b) for November 2016. (c) GSFC sea ice thickness for October 2016, for regions 1-6 and (d) for November 2016, for regions 1-6, based on our analysis. (e) AWI sea ice thickness for October 2016, for regions 1-6 and (f) for November 2016, for region 1-6.

Conclusion: When considering monthly mean ice thickness, the GSFC ice thickness data product does in fact diverge from other data products that are also based on CryoSat-2 observations.

After extensive examination of the GSFC data product we have found at least 5 instances where mean ice thickness decreased from one month to the next, during the winter growth period. This result is contrary to the results of other CryoSat-2 data products, and is also contrary to the conventional wisdom of overall growth in ice thickness, through thermodynamics, during the winter season. We are confident that the values we show in Figure 5 associated with the GSFC data product averaged over the central Arctic (regions 1-6), are correct.