Multi-Frequency Satellite Approaches for Snow on Sea Ice
Polar+ Snow on Sea Ice (PSSI)

Deliverable 4.1 appendix:
Experimental Dataset Description (EDD)

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Document History

Version	Date	Updated by	Reason
1.a	*2/11/2024*	*UCL*	*Requested fusion approach by ESA*
1.b	*13/6/2025*	*UCL*	*Updated with merged product*

Detailed History of Changes

Version	Section	Updated by	Details
Authors		*Michel Tsamados* *Weibin Chen* *Connor Nelson*	Connor Nelson and Weibin have supported the coding (binning, neural network implementation and plotting)

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The project website is http://www.cpom.ucl.ac.uk/snow-on-sea-ice/index.html

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Acronyms and Abbreviations

AltiKa – Ka-band Altimeter
AMSR-E - Advanced Microwave Scanning Radiometer - Earth Observing System
ATBD – Algorithm Theoretical Basis Document
AVHRR - Extended Advanced Very High Resolution Radiometer
AWI – Alfred Wegener Institute
CICE – The Los Alamos Sea Ice Model
CRREL - Cold Regions Research and Engineering Laboratory
CryoVEx - CryoSat Validation Experiment
CS2 – CryoSat-2
DuST – Dual-altimeter Snow Thickness
ECMWF – European Centre for Medium-range Weather Forecasts
Envisat – Environmental Satellite
EO – Earth Observation
ERS – European Remote Sensing Satellite
ESA – European Space Agency
EXPRO – Express Procurement
FBEM - Facet-Based numerical Echo Model
FMI – Finnish Meteorological Institute
FYI – First-Year Ice
GLAS – Geoscience Laser Altimeter System
IABP – International Arctic Buoy Program
IAR – Impact Assessment Report
ICESat – Ice, Cloud and land Elevation Satellite
IMB – Ice Mass-balance Buoy
ITT – Invitation To Tender
KO – Kick-Off
KuKa – Ku (radar) / Ka (radar) snow thickness product
KuLa – Ku (radar) / Laser snow thickness product
LEGOS - Laboratoire d'Etudes en Géophysique et Océanographie Spatiales
LIM – Louvain-la-Neuve Sea Ice Model
MAF – Management, Administrative and Financial proposal
MYI – Multi-Year Ice
NASA – National Aeronautics and Space Administration
NCEP – National Centers for Environmental Prediction
NSIDC – National Snow and Ice Data Centre
OIB - Operation IceBridge
PP – Project Partner
RA2 – Radar Altimeter 2
RB – Requirement Baseline
SAR – Synthetic Aperture Radar
SARAL – Satellite for Argos and AltiKa
SHEBA - Surface Heat Budget of the Arctic Ocean
SIPN – Sea Ice Prediction Network
SMOS - Soil Moisture and Ocean Salinity satellite
SnoDSI – SNOw on Drifting Sea Ice
SOW – Statement Of Work
SR – Scientific Roadmap
SSM/I - Special Sensor Microwave Imager
SSMIS – SSM/I Sounder
STSE – Support To Science Element
SWE – Snow Water Equivalent
TP – Technical Proposal
UiT – Arctic University of Norway
UCL – University College London
W99 – Warren et al. (1999) snow climatology
WP – Work Package
YOPP – Year of Polar Prediction

1 Document objectives

This document aims at aligning all the snow depth products presented in the Experimental Dataset Description (EDD) deliverable in the framework of the ESAPolar+ project. This follows a request from ESA to provide one merged product from the variety of snow products delivered in the EDD, namely: UiT KuLa, UiT KuKa, LEGOS KuLa, LEGOS KuKa (both Samosa and T50) and CPOM KuLa, and CPOM KuKa. The suggestion by ESA was to merge the products using a bias correction approach. We describe this approach in this document as well as the merged final snow product, the code to obtain the merging from the individual snow products and the code to plot the results shown here.

2 Input data

We us the EDD snow products described below as input to our final merged product (Table 1). The period they cover, the original gridding and the method used to obtain the products are described in section 3 of the EDD.

Product	Period	Original gridding	Method
University of Tromso (UIT)	11/2018 - 04/2020 (November to April)	50 km (181X181)	KuLa - Waveform methodology
	11/2018 - 04/2020 (November to April)	50 km (181X181)	KuKa - Waveform methodology
University of Leeds (UoL)	10/2018 - 12/2021 (October to April)	25,67 km (267x267)	KuLa - Calibration methodology
	03/2013 - 12/2021 (October to April)	25,67 km (267x267)	KuKa - Calibration methodology
LEGOS	10/2018 - 04/2021 (October to April)	25 km (356x356)	KuLa - Bias correction
	10/2013 - 04/2021 (October to April)	25 km (712x712)	KuKa - pLRM/LRM - Bias correction

Table 1: Description of the characteristics of each snow product

3 Neural Network snow adjustment algorithm

The algorithm used here is inspired by multiparameter neural network (NN) based method to calibrate Envisat against CryoSat2 and ERS-2 against Envisat described in Bocquet et al (2023). The NN is motivated by the requirement to manage strong non-linearities and was shown to perform well in a similar setting (i.e. radar freeboard). Here we extend this approach to dual-frequency snow products with the underlying understanding that these snow products rely on radar and laser freeboards.

The neural network employed in our code is a multilayer perceptron (MLP) implemented with PyTorch. The MLP consists of two layers: the first hidden layer has 8 neurons, and the output layer has 1 neuron. This network uses ReLU activation for the hidden layer. We optimised the model using the AdamW optimiser with a learning rate of 0.001 and a weight decay of 1e-5. The loss function is SmoothL1 loss, and training is managed through a batch size of 512 over 50 epochs, with a ReduceLROnPlateau learning rate scheduler to adjust the learning rate based on validation loss.

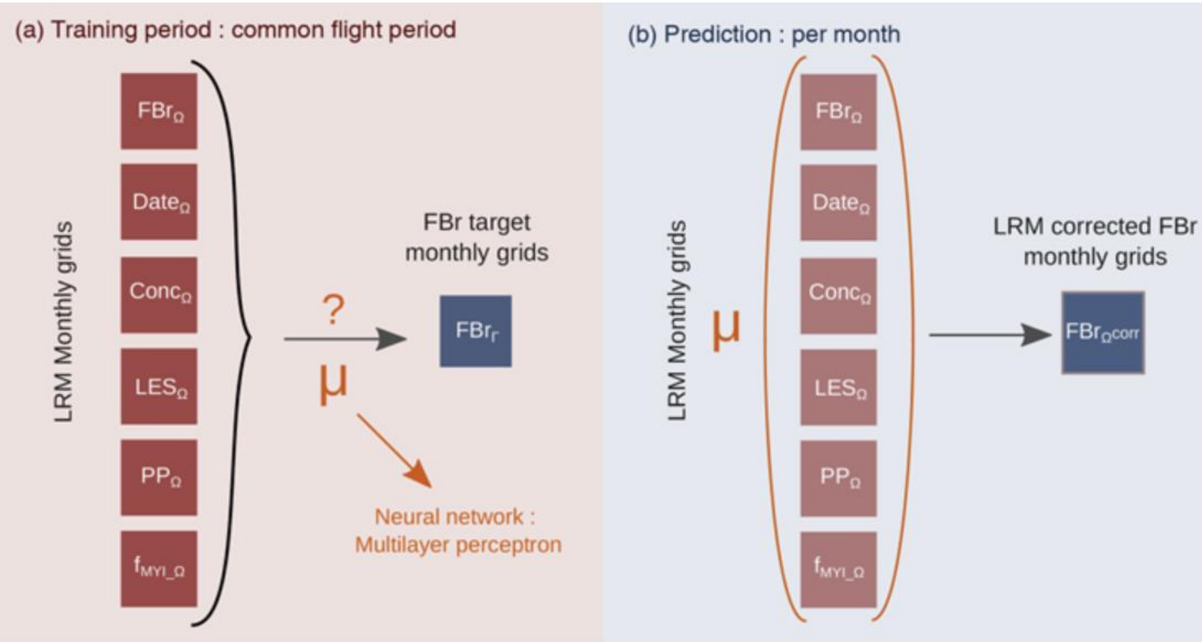


Figure 1. Diagram from Bocquet et al (2023) illustrating the principle of freeboard correction by a neural network with the two main steps: in panel (a), the neural network training phase, and in panel (b), the prediction (correction) phase. corresponds to the inputs and to the output of the neural network. FB: radar freeboard; Conc: sea ice concentration; LES: leading-edge slope; PP: pulse peakiness, fMYI: MYI proportion. Here we adapt that model and replace the input freeboards FB by our snow products and the reference freeboard by our reference snow product (i.e. UiT KuLa).

The NN is trained on the common period 2018-10 to 2020-04 when all snow products are available. We have chosen UiT KuLa as the snow product to be considered a reference due to its overall good performance in the validation analysis (validation report). All other snow products are corrected ('adjusted') against this reference.

Following the approach presented by Bocquet et al (2023), the NN takes as inputs monthly grids of the following parameters: snow products (one at a time to be corrected), the CryoSat-2 (CS2) pulse peakiness, CS2 leading-edge slope, ice concentration, MYI proportion, the month and, as a target, the reference UiT KuLa snow product. Note that the month of the year is taken to capture the seasonal variability better, as snow on sea ice and sea ice physical properties change along the seasons. Inputs and targets are standardized before the training step.

Note that all snow products and auxiliary products have been binned on the same EASE2 monthly 25km resolution grid. The grid is 350x350 and is provided with the products.

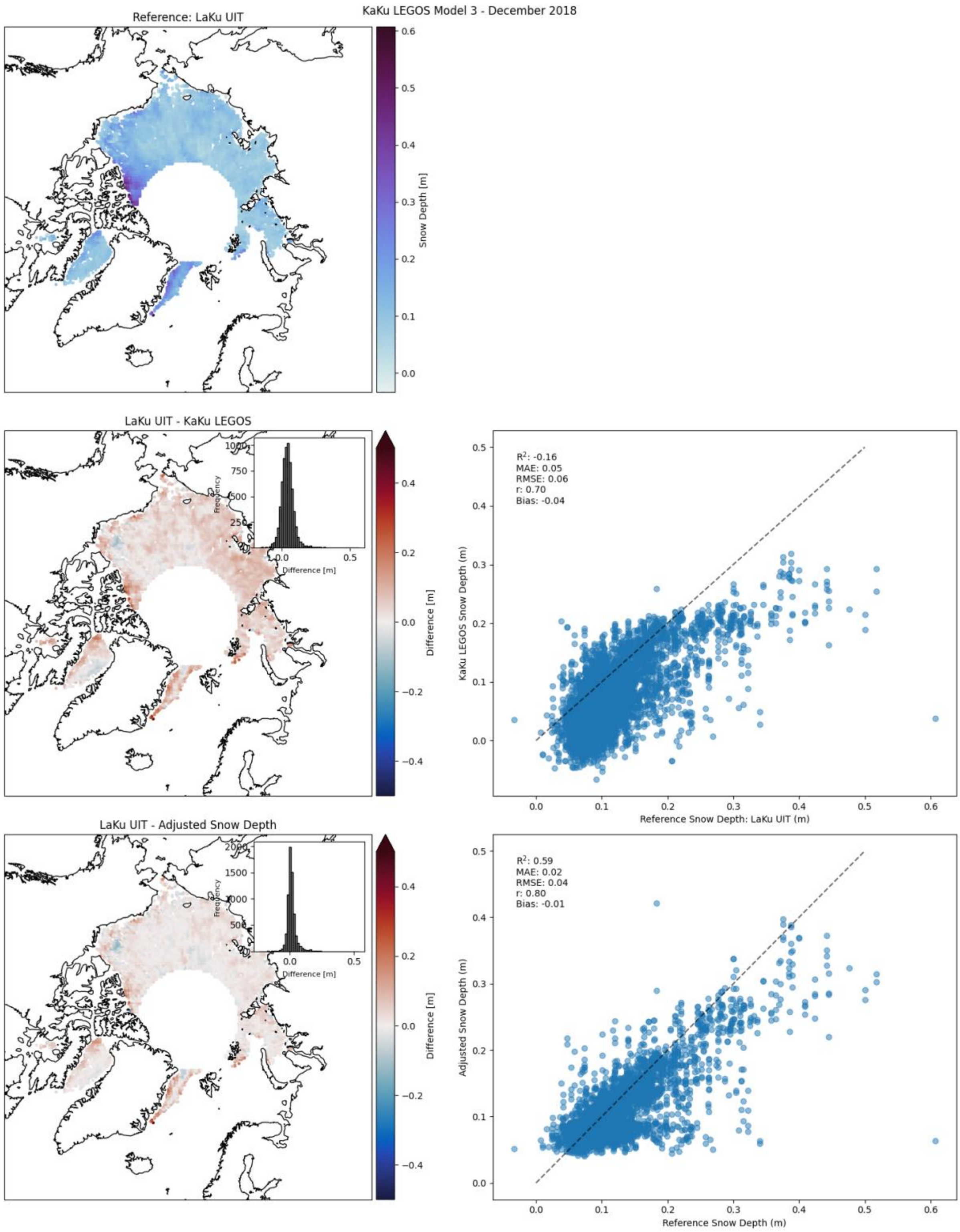
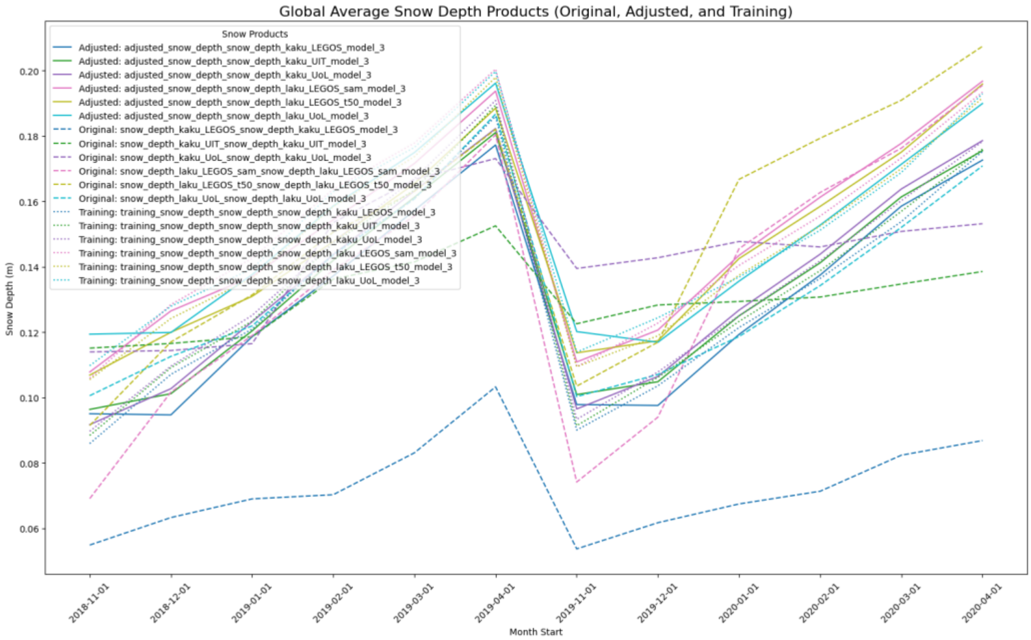


Figure 2. Figure showing an example of the reference LaKu UIT snow product for December 2018 (top) and the different with the original KaKu LEGOS snow product

(middle) and adjusted KaKu LEGOS snow product (bottom). Scatter plots on the right column show the improvement before and after NN correction is applied.

Timeseries

Comparison of the original snow products, adjusted snow products and training reference UIT KuLa snow product averaged over the entire Arctic and over the overlap period 2018-10 to 2020-04 (Figure XX) and over the longer 2013-10 to 2022-04 period (Figure XX).



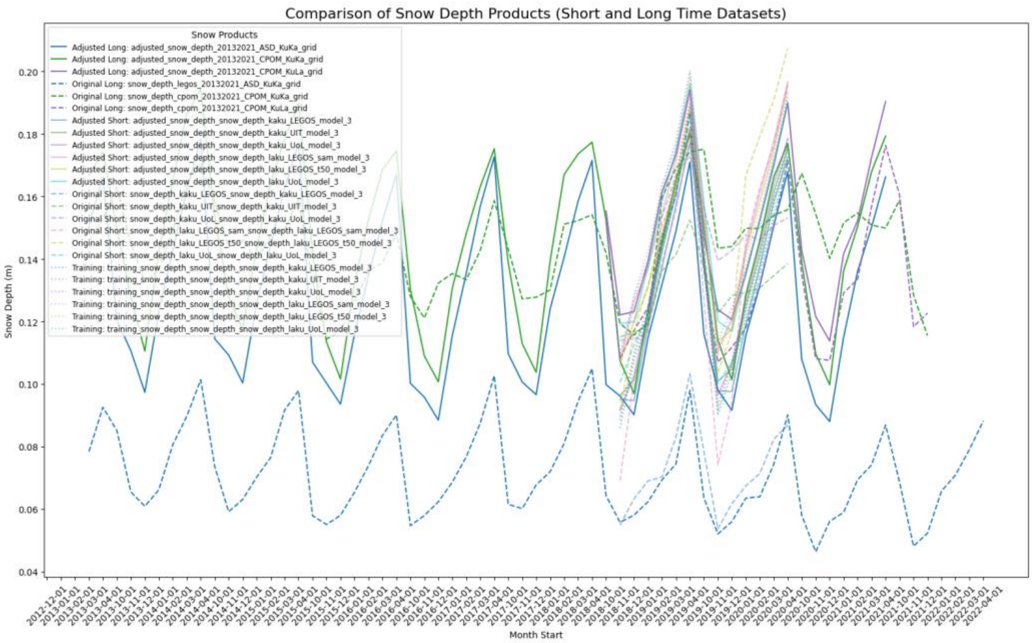


Figure 3. Figures showing the global average snow for each original products (dashed lines), each adjusted products (solid lines) and for the reference training UIT KuLa product (dotted lines). Not that the dotted lines are different from each other because of

the difference of averaging regions as averages are taken for each product where both original and reference product coexist.

Timeseries by regions are shown below for the regions as defined by NSIDC and below in Figure XX.

```
regions = ['Baffin','Greenland','Barents','Kara','Laptev','E. Siberian','Chukchi','Beaufort','Central Arctic']
regs = [6,7,8,9,10,11,12,13,15]
```

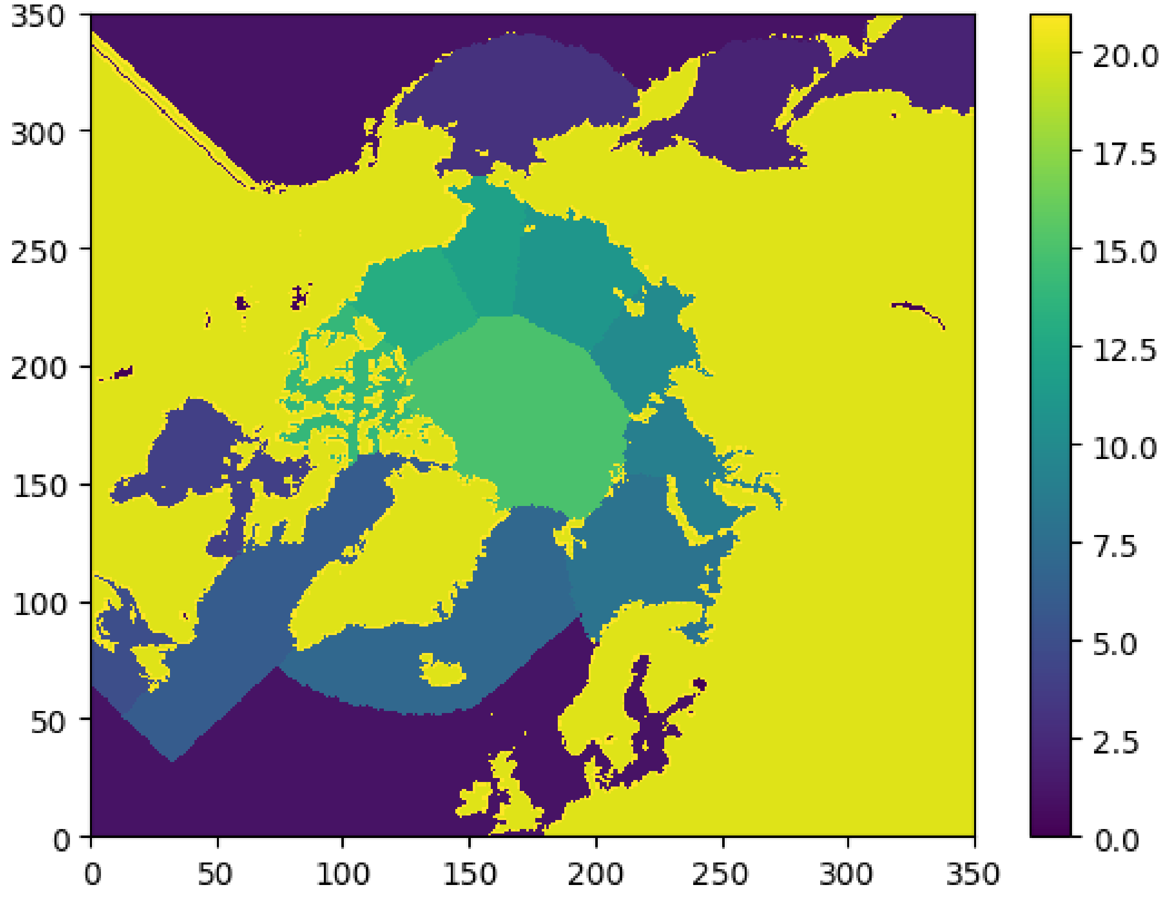


Figure 4. Figure showing the indices for each region used for our regional analysis.

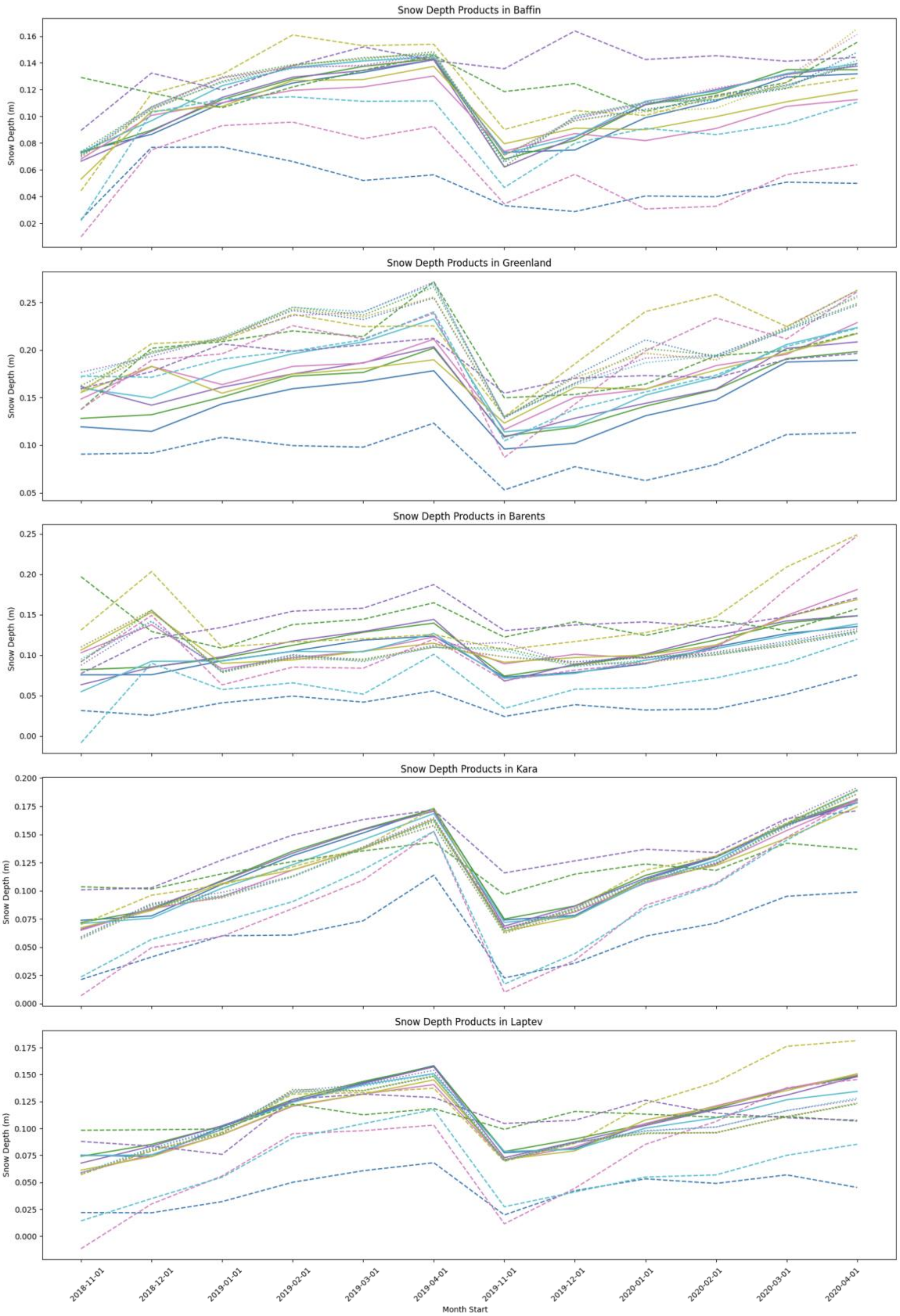

Snow Depth Products in Baffin
Snow Depth Products in Greenland
Snow Depth Products in Barents
Snow Depth Products in Kara
Snow Depth Products in Laptev
Snow Depth (m)
Month Start
2018-11-01
2018-12-01
2019-01-01
2019-02-01
2019-03-01
2019-04-01
2019-11-01
2019-12-01
2020-01-01
2020-02-01
2020-03-01
2020-04-01

Figure 5. Average snow depth for each region and each product.

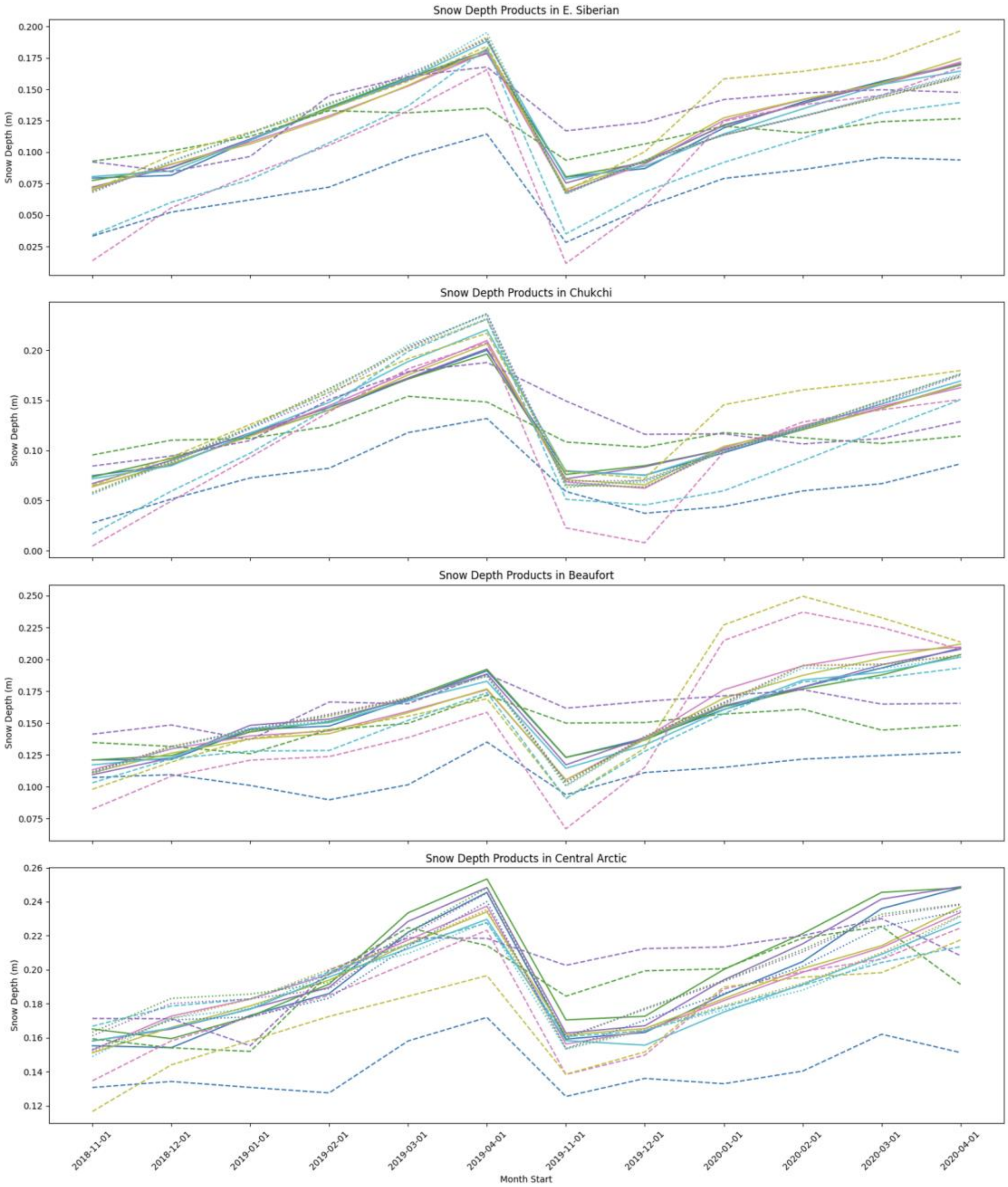


Figure 6. Average snow depth for each region and each product (continued).

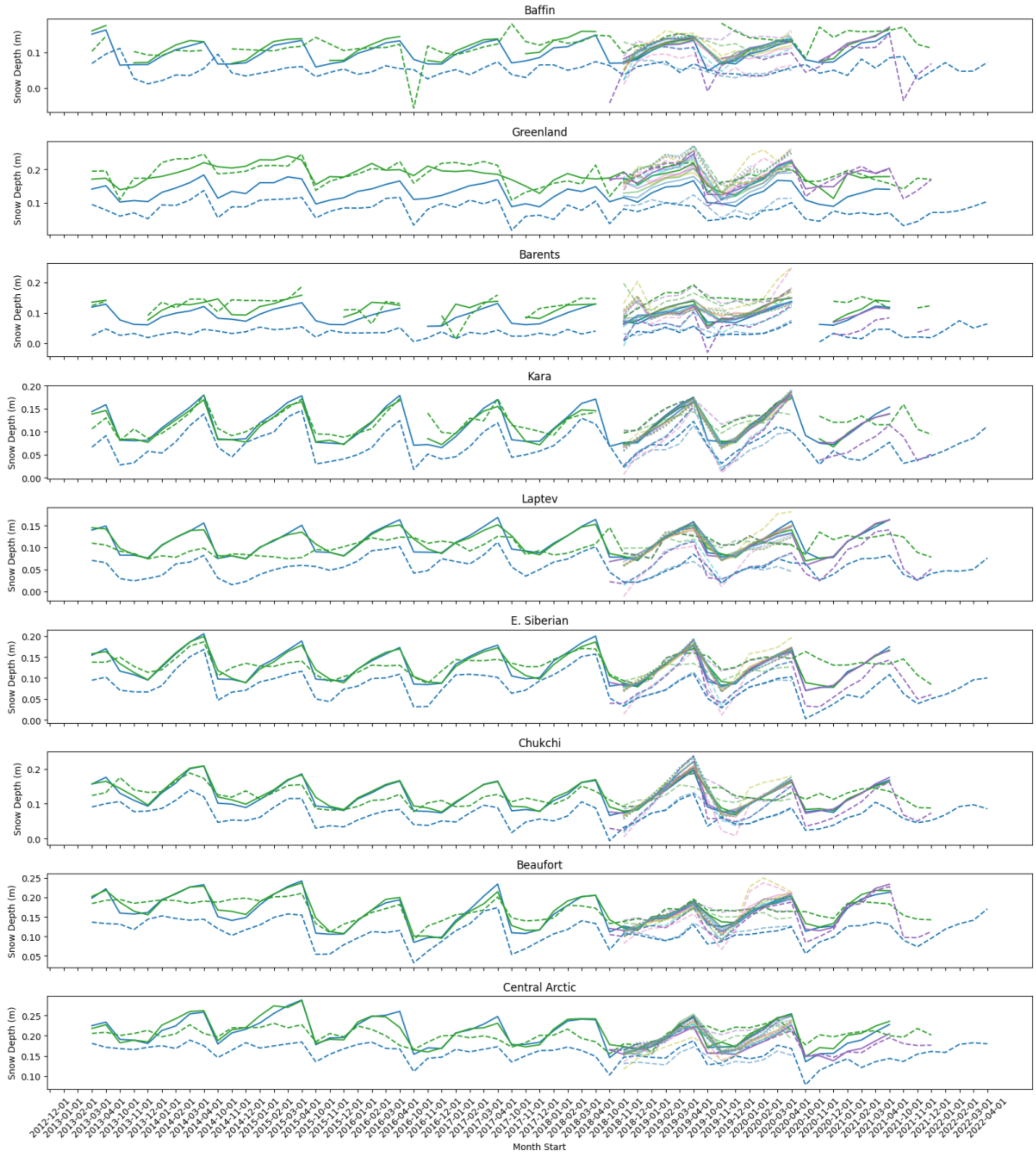


Figure 7. Average snow depth for each region and each product over the extended period.

4 Fusion of the bias corrected snow products

Here we compare the original products and adjusted products and show the consolidated time series.

The idea for the merged product is to average all the adjusted / bias corrected snow products and provide also the standard deviation (or min-max) as a product. Example of such mean and standard deviation are shown in the figure below for a given month.

Code to load and plot this new merged dataset is available on the project website.

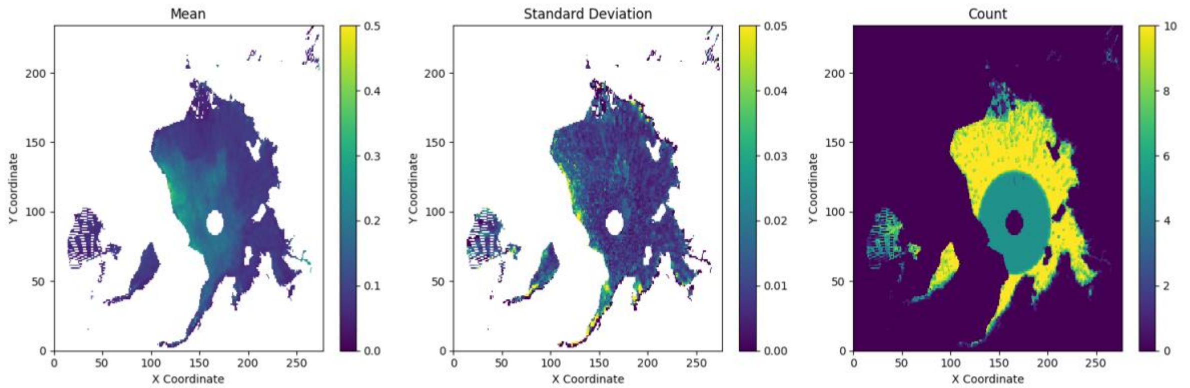


Figure 8. Left: Mean of all adjusted snow products for 2019-12-01. Middle: Standard Deviation of all snow products for 2019-12-01. Right: Count of number of snow products for each EASE2 grid cell contributing to the mean and standard deviation.

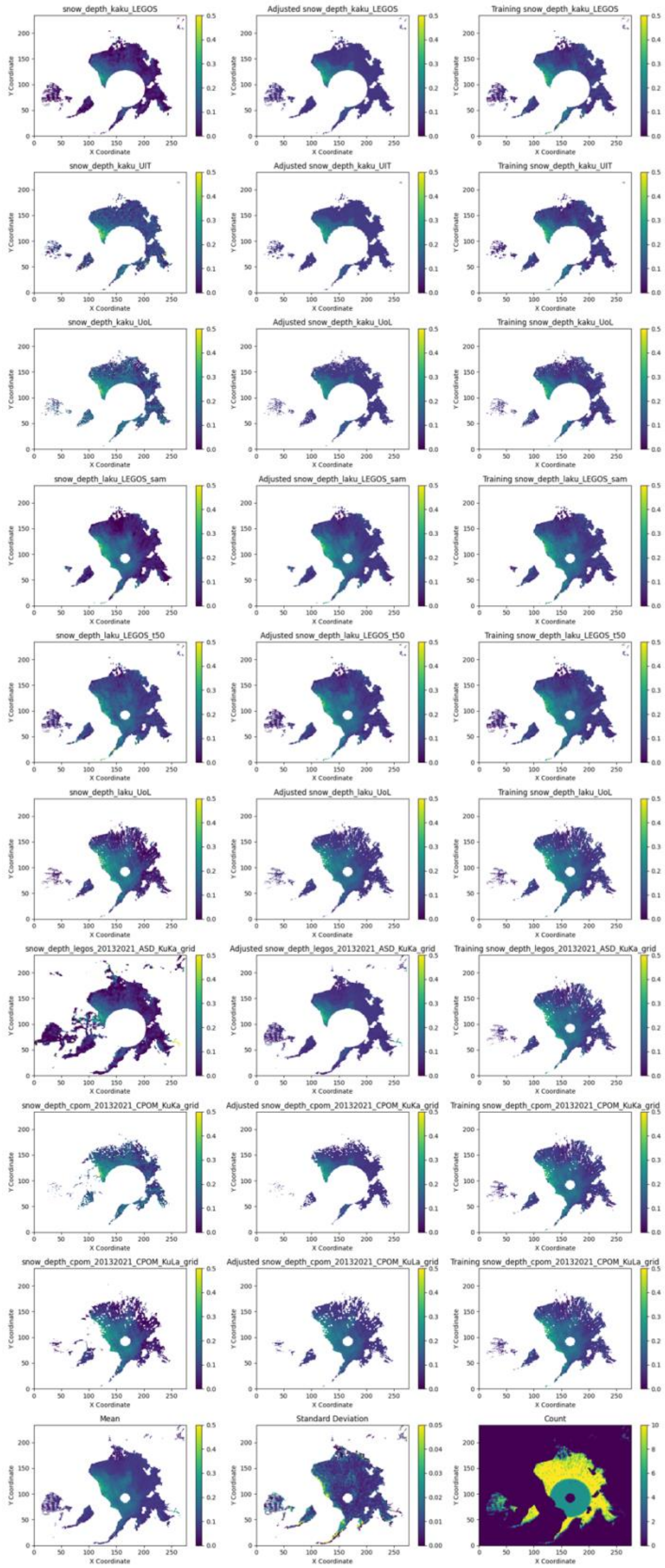

snow_depth_kaku_LEGOS
Adjusted snow_depth_kaku_LEGOS
Training snow_depth_kaku_LEGOS
snow_depth_kaku_UIT
Adjusted snow_depth_kaku_UIT
Training snow_depth_kaku_UIT
snow_depth_kaku_UoL
Adjusted snow_depth_kaku_UoL
Training snow_depth_kaku_UoL
snow_depth_laku_LEGOS_sam
Adjusted snow_depth_laku_LEGOS_sam
Training snow_depth_laku_LEGOS_sam
snow_depth_laku_LEGOS_t50
Adjusted snow_depth_laku_LEGOS_t50
Training snow_depth_laku_LEGOS_t50
snow_depth_laku_UoL
Adjusted snow_depth_laku_UoL
Training snow_depth_laku_UoL
snow_depth_legos_20132021_ASD_KuKa_grid
Adjusted snow_depth_legos_20132021_ASD_KuKa_grid
Training snow_depth_legos_20132021_ASD_KuKa_grid
snow_depth_cpom_20132021_CPOM_KuKa_grid
Adjusted snow_depth_cpom_20132021_CPOM_KuKa_grid
Training snow_depth_cpom_20132021_CPOM_KuKa_grid
snow_depth_cpom_20132021_CPOM_KuLa_grid
Adjusted snow_depth_cpom_20132021_CPOM_KuLa_grid
Training snow_depth_cpom_20132021_CPOM_KuLa_grid
Mean
Standard Deviation
Count
X Coordinate
Y Coordinate

Figure 9. Individual snow products that have contributed to the mean snow product, standard deviation and count show here and in the previous figure for 2019-12-01.

5 Merged snow product description

The snow_depth_statistics_with_maps.nc file is as follows:

```
netcdf snow_depth_statistics_with_maps {
dimensions:
	month_start = 83 ;
	y = 350 ;
	x = 350 ;
variables:
	double mean_snow_depth(month_start, y, x) ;
		mean_snow_depth:_FillValue = NaN ;
	double std_snow_depth(month_start, y, x) ;
		std_snow_depth:_FillValue = NaN ;
	double max_min_snow_depth(month_start, y, x) ;
		max_min_snow_depth:_FillValue = NaN ;
	int64 product_count(month_start, y, x) ;
	int64 month_start(month_start) ;
		month_start:units = "days since 2010-11-01 00:00:00" ;
		month_start:calendar = "proleptic_gregorian" ;
	double x(x) ;
		x:_FillValue = NaN ;
	double y(y) ;
		y:_FillValue = NaN ;
```

This contains monthly maps of:

- the average of all available snow corrected snow products (mean_snow_depth)
- the standard deviation of all the corrected snow products (std_snow_depth)
- the maximum – minimum range of values (max_min_snow_depth)
- the product count (product_count)
- the month (month_start)
- the location (x, y)

6 Adjusted data product description

The corrected_snow_depth.nc files are as follows:

```
corrected_snow_depth {
dimensions:
        index = 40953600 ;
variables:
        double y(index) ;
                y:_FillValue = NaN ;
        double x(index) ;
                x:_FillValue = NaN ;
        string month_start(index) ;
        double stack_peakiness(index) ;
                stack_peakiness:_FillValue = NaN ;
        double stack_peakiness_bin_count(index) ;
                stack_peakiness_bin_count:_FillValue = NaN ;
        double stack_skewness(index) ;
                stack_skewness:_FillValue = NaN ;
        double stack_skewness_bin_count(index) ;
                stack_skewness_bin_count:_FillValue = NaN ;
        double stack_scaled_amplitude(index) ;
                stack_scaled_amplitude:_FillValue = NaN ;
        double stack_scaled_amplitude_bin_count(index) ;
                stack_scaled_amplitude_bin_count:_FillValue = NaN ;
        double stack_standard_deviation(index) ;
                stack_standard_deviation:_FillValue = NaN ;
        double stack_standard_deviation_bin_count(index) ;
                stack_standard_deviation_bin_count:_FillValue = NaN ;
        double stack_kurtosis(index) ;
                stack_kurtosis:_FillValue = NaN ;
        double stack_kurtosis_bin_count(index) ;
                stack_kurtosis_bin_count:_FillValue = NaN ;
        double ocog_width(index) ;
                ocog_width:_FillValue = NaN ;
        double ocog_width_bin_count(index) ;
                ocog_width_bin_count:_FillValue = NaN ;
        double ocog_amplitude(index) ;
                ocog_amplitude:_FillValue = NaN ;
        double ocog_amplitude_bin_count(index) ;
                ocog_amplitude_bin_count:_FillValue = NaN ;
        double peakiness(index) ;
                peakiness:_FillValue = NaN ;
        double peakiness_bin_count(index) ;
```

```
        peakiness_bin_count:_FillValue = NaN ;
double peakiness_normed(index) ;
        peakiness_normed:_FillValue = NaN ;
double peakiness_normed_bin_count(index) ;
        peakiness_normed_bin_count:_FillValue = NaN ;
double leading_edge_width(index) ;
        leading_edge_width:_FillValue = NaN ;
double leading_edge_width_bin_count(index) ;
        leading_edge_width_bin_count:_FillValue = NaN ;
double peak_power(index) ;
        peak_power:_FillValue = NaN ;
double peak_power_bin_count(index) ;
        peak_power_bin_count:_FillValue = NaN ;
double sigma0(index) ;
        sigma0:_FillValue = NaN ;
double sigma0_bin_count(index) ;
        sigma0_bin_count:_FillValue = NaN ;
double sea_ice_concentration(index) ;
        sea_ice_concentration:_FillValue = NaN ;
double sea_ice_concentration_bin_count(index) ;
        sea_ice_concentration_bin_count:_FillValue = NaN ;
double sea_ice_type(index) ;
        sea_ice_type:_FillValue = NaN ;
double sea_ice_type_bin_count(index) ;
        sea_ice_type_bin_count:_FillValue = NaN ;
double longitude(index) ;
        longitude:_FillValue = NaN ;
double latitude(index) ;
        latitude:_FillValue = NaN ;
double snow_depth_cpom(index) ;
        snow_depth_cpom:_FillValue = NaN ;
double sea_ice_region_surface_mask(index) ;
        sea_ice_region_surface_mask:_FillValue = NaN ;
double snow_depth_laku_UIT(index) ;
        snow_depth_laku_UIT:_FillValue = NaN ;
int64 month(index) ;
double adjusted_snow_depth(index) ;
        adjusted_snow_depth:_FillValue = NaN ;
int64 index(index) ;
```

7 References

Bocquet, Marion, Sara Fleury, Fanny Piras, Eero Rinne, Heidi Sallila, Florent Garnier, and Frédérique Rémy. "Arctic sea ice radar freeboard retrieval from the European Remote-Sensing Satellite (ERS-2) using altimetry: Toward sea ice thickness observation from 1995 to 2021." *The Cryosphere* 17, no. 7 (2023): 3013-3039.

8 Assessment

Appendix A: Adjusted and fused product description

The final product will contain the LEGOS LaKu and KaKu snow depth products, the corresponding freeboards used to compute the snow depth and the standard deviation values of all products, for the 3 KaKu products and the 3 LaKu products with also a variable containing the number of products used to compute these statistics at each grid point. It is provided in 356x356 EASE2 grids on a monthly basis over the common period.

Here is the netcdf description using the *ncdump* command.

```
netcdf SD_201910 {
dimensions:
        u = 356 ;
        v = 356 ;
        time = UNLIMITED ; // (1 currently)
variables:
        float latitude(u, v) ;
                latitude:units = "degree_north" ;
                latitude:long_name = "latitude" ;
                latitude:description = "ease grid" ;
                latitude:_CoordinateAxisType = "Lat" ;
        float longitude(u, v) ;
                longitude:units = "degree_east" ;
                longitude:long_name = "ease grid" ;
                longitude:_CoordinateAxisType = "Lon" ;
        float time(time) ;
                time:units = "days since 2000-01-01" ;
                time:long_name = "time" ;
        float snow_depth_laku_LEGOS_sam(time, u, v) ;
                snow_depth_laku_LEGOS_sam:units = "m" ;
                snow_depth_laku_LEGOS_sam:long_name =
"snow_depth_laku_samosa_LEGOS" ;
                snow_depth_laku_LEGOS_sam:description = "snow depth from LEGOS
computed from freeboard elevation difference between IS2 ATL10 product and CS2 (GPOD
SAMOSA). The snow delay correction is calculated using Mallett et 2020 formula" ;
                snow_depth_laku_LEGOS_sam:coordinates = "lat lon" ;
        float freeboard_ku_sam(time, u, v) ;
                freeboard_ku_sam:units = "m" ;
                freeboard_ku_sam:long_name = "radar_freeboard_sam_LEGOS" ;
                freeboard_ku_sam:description = "Ku-band SAR radar freeboard from the
CryoSat-2 mission calculated using SAM+ retracker (for more details see laforge et al, 2020)"
```

```
;
                freeboard_ku_sam:coordinates = "lat lon" ;
        float freeboard_ku_sam_std(time, u, v) ;
                freeboard_ku_sam_std:units = "m" ;
                freeboard_ku_sam_std:long_name = "radar_freeboard_sam_LEGOS_std" ;
                freeboard_ku_sam_std:description = "Standard deviation of
radar_freeboard_sam_std parameter" ;
                freeboard_ku_sam_std:coordinates = "lat lon" ;
        float snow_depth_laku_LEGOS_t50(time, u, v) ;
                snow_depth_laku_LEGOS_t50:units = "m" ;
                snow_depth_laku_LEGOS_t50:long_name = "snow_depth_laku_t50_LEGOS" ;
                snow_depth_laku_LEGOS_t50:description = "snow depth from LEGOS
computed from freeboard elevation difference between IS2 ATL10 product and CS2
(BASELINE-D L1B + LEGOS PROCESSING TFMRA50). The snow delay correction is calculated
using Mallett et 2020 formula" ;
                snow_depth_laku_LEGOS_t50:coordinates = "lat lon" ;
        float freeboard_ku_t50(time, u, v) ;
                freeboard_ku_t50:units = "m" ;
                freeboard_ku_t50:long_name = "freeboard_ku_tfmra50_LEGOS" ;
                freeboard_ku_t50:description = "Ku-band SAR radar freeboard from the
CryoSat-2 mission calculated using TFMRA50 retracker from baseline-D L1B official product"
;
                freeboard_ku_t50:coordinates = "lat lon" ;
        float freeboard_ku_t50_std(time, u, v) ;
                freeboard_ku_t50_std:units = "m" ;
                freeboard_ku_t50_std:long_name = "freeboard_ku_tfmra50_LEGOS_std" ;
                freeboard_ku_t50_std:description = "Standard deviation of
radar_freeboard_t50" ;
                freeboard_ku_t50_std:coordinates = "lat lon" ;
        float snow_depth_laku_UoL(time, u, v) ;
                snow_depth_laku_UoL:units = "m" ;
                snow_depth_laku_UoL:long_name = "snow_depth_laku_UoL" ;
                snow_depth_laku_UoL:description = "Snow depth derived from (IS2-
Ku_calibrated)*0.781 [m]" ;
                snow_depth_laku_UoL:coordinates = "lat lon" ;
        float snow_depth_laku_UIT(time, u, v) ;
                snow_depth_laku_UIT:units = "m" ;
                snow_depth_laku_UIT:long_name = "snow_depth_laku_UIT" ;
                snow_depth_laku_UIT:description = "Snow Depth from ICESat-2 ATLAS
freeboard minus CryoSat-2 SIRAL freeboard (multiplied by correction factor 0.781)" ;
                snow_depth_laku_UIT:coordinates = "lat lon" ;
        float snow_depth_kaku_LEGOS(time, u, v) ;
                snow_depth_kaku_LEGOS:units = "m" ;
```

```
                snow_depth_kaku_LEGOS:long_name = "snow_depth_kaku_LEGOS" ;
                snow_depth_kaku_LEGOS:description = "computed as (saral_radar_freeboard_40hz_median- c2esaOC1_radar_freeboard_20hz_median)/1.238) to take in account the speed reduction of radar in snow" ;
                snow_depth_kaku_LEGOS:coordinates = "lat lon" ;
        float freeboard_ka(time, u, v) ;
                freeboard_ka:units = "m" ;
                freeboard_ka:long_name = "radar_freeboard_SRL_LEGOS" ;
                freeboard_ka:description = "Radar (ku-band) freeboard computed from differences between the ila_smooth_40hz (12.5km smoothed) and the sla_smooth_40hz (12.5km)" ;
                freeboard_ka:coordinates = "lat lon" ;
        float snow_depth_kaku_UoL(time, u, v) ;
                snow_depth_kaku_UoL:units = "m" ;
                snow_depth_kaku_UoL:long_name = "snow_depth_kaku_UoL" ;
                snow_depth_kaku_UoL:description = "Snow depth derived from (Ka_calibrated-Ku_calibrated)*0.781 [m]" ;
                snow_depth_kaku_UoL:coordinates = "lat lon" ;
        float snow_depth_kaku_UIT(time, u, v) ;
                snow_depth_kaku_UIT:units = "m" ;
                snow_depth_kaku_UIT:long_name = "snow_depth_kaku_UIT" ;
                snow_depth_kaku_UIT:description = "Snow Depth from AltiKa SARAL freeboard minus CryoSat-2 SIRAL freeboard (multiplied by correction factor 0.781)" ;
                snow_depth_kaku_UIT:coordinates = "lat lon" ;
        float std_sd(time, u, v) ;
                std_sd:units = "m" ;
                std_sd:long_name = "standard_deviation_snow_depth" ;
                std_sd:coordinates = "lat lon" ;
        float std_sd_laku(time, u, v) ;
                std_sd_laku:units = "m" ;
                std_sd_laku:long_name = "standard_deviation_snow_depth_laku" ;
                std_sd_laku:coordinates = "lat lon" ;
        float std_sd_kaku(time, u, v) ;
                std_sd_kaku:units = "m" ;
                std_sd_kaku:long_name = "standard_deviation_snow_depth_kaku" ;
                std_sd_kaku:coordinates = "lat lon" ;
        float nb_data_per_pixel(time, u, v) ;
                nb_data_per_pixel:units = "" ;
                nb_data_per_pixel:long_name = "number_of_data_per_pixel" ;
                nb_data_per_pixel:coordinates = "lat lon" ;
                nb_data_per_pixel:description = "Number of products (LaKu and KaKu from LEGOS and UIT) used to compute the standard deviation for each grid point" ;
        float nb_laku_data_per_pixel(time, u, v) ;
```

```
                nb_laku_data_per_pixel:units = "" ;
                nb_laku_data_per_pixel:long_name = "number_of_laku_data_per_pixel" ;
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                nb_laku_data_per_pixel:description = "Number of products (LaKu from
LEGOS and UIT) used to compute the standard deviation for each grid point" ;
        float nb_kaku_data_per_pixel(time, u, v) ;
                nb_kaku_data_per_pixel:units = "" ;
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LEGOS and UIT) used to compute the standard deviation for each grid point" ;

// global attributes:
                :institution = "LEGOS, UIT, UoL" ;
                :contact = "sara.fleury@cnrs.fr, jack.c.landy@uit.no,
i.r.lawrence@leeds.ac.uk" ;
                :references = "Technical document available on request" ;
                :project = "Polar+ Snow on Sea Ice" ;
                :title = "6 altimetry snow depth products from Polar+ Snow on Sea Ice ESA
project" ;
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End of the document