Supporting Information for "Supercooled Southern Ocean Waters"

F. A. Haumann[1,2], R. Moorman[1], S. Riser[3], L. H. Smedsrud[4,5,6], T. Maksym[7], A. P. S. Wong[3], E. A. Wilson[8], R. Drucker[3], L. D. Talley[9], K. S. Johnson[10], R. M. Key[1], and J. L. Sarmiento[1]

[1]Atmospheric and Oceanic Sciences Program, Princeton University, Princeton, New Jersey, USA

[2]British Antarctic Survey, Cambridge, UK

[3]School of Oceanography, University of Washington, Seattle, Washington, USA

[4]Geophysical Institute, University of Bergen, Bergen, Norway

[5]Bjerknes Centre for Climate Research, Bergen, Norway

[6]University Centre in Svalbard, Longyearbyen, Svalbard

[7]Department of Applied Ocean Physics and Engineering, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA

[8]Environmental Sciences and Engineering, California Institute of Technology, Pasadena, California, USA

[9]Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California, USA

[10]Monterey Bay Aquarium Research Institute, Moss Landing, California, USA

Corresponding author: F. A. Haumann, Atmospheric and Oceanic Sciences Program, Princeton University, Princeton, New Jersey, USA (alexander.haumann@gmail.com)

Contents of this file

Introduction In this supporting information we provide details on the seasonal coverage of the analyzed data (Figure S1), example profiles illustrating the vertical structure of temperature in potentially and in-situ supercooled profiles (Figure S2), and maps of the vertical extent of potential supercooling for different categories defined in the main text (Figure S3). We also show maps and seasonality of profiles that match either both 'sea-ice' and 'ice-shelf' supercooling criteria or where either one of them cannot be ruled out (Figure S4). We present maps of potential and in-situ supercooling for each of the three data products separately (Figure S5), and show the seasonality for the continental shelf region alone (Figure S6) to illustrate the potential effects of sampling biases. We add a table (Table S1) that lists Argo floats, which have a supercooling signal and participate in the SOCCOM Adopt-a-Float program.

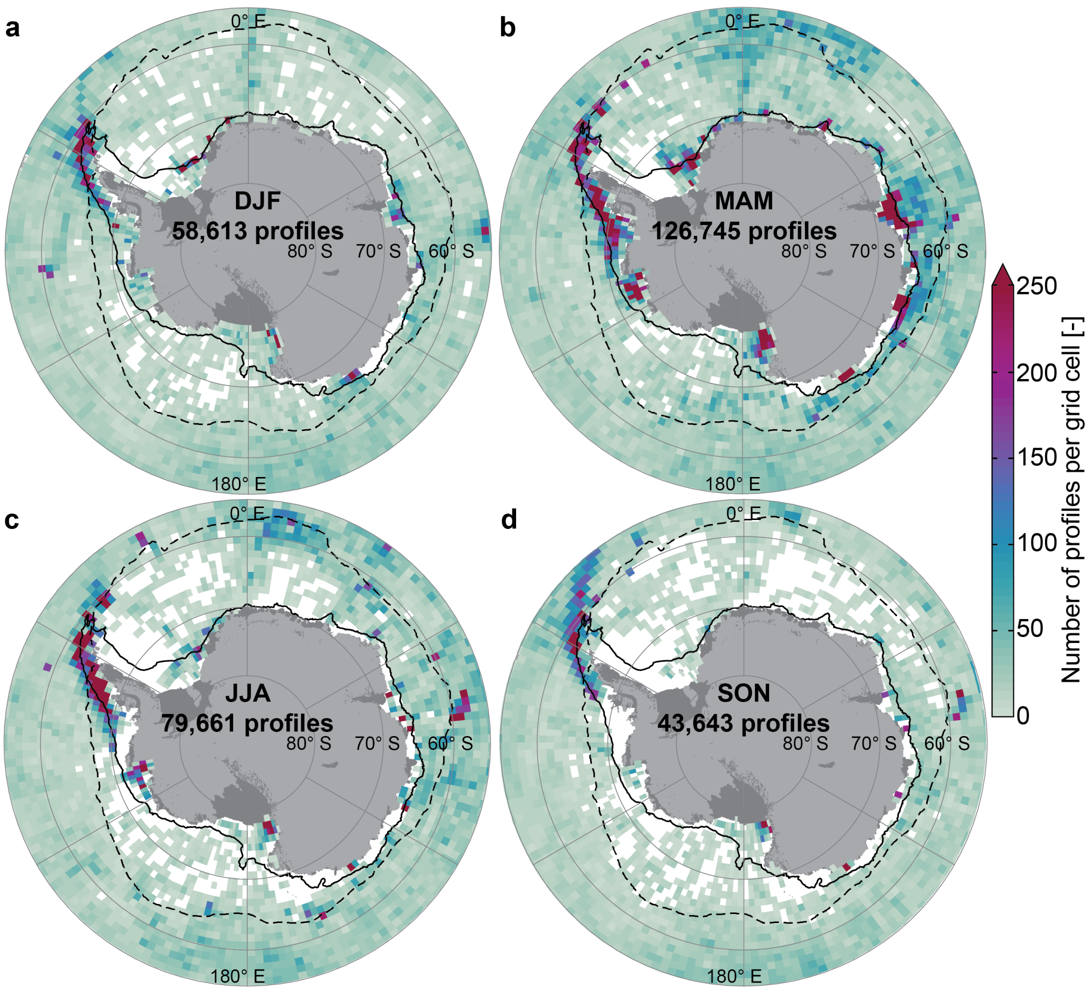

Figure S1. Spatial distribution of observations for each season. a) Austral summer (December to February). b) Austral fall (March to May). c) Austral winter (June to August). d) Austral spring (September to November). Profiles were mapped on a 2° longitude by 1° latitude spatial grid. Black: continental shelf (1000-m isobath; solid) and climatological mean sea-ice edge (25% ice concentration; dashed).

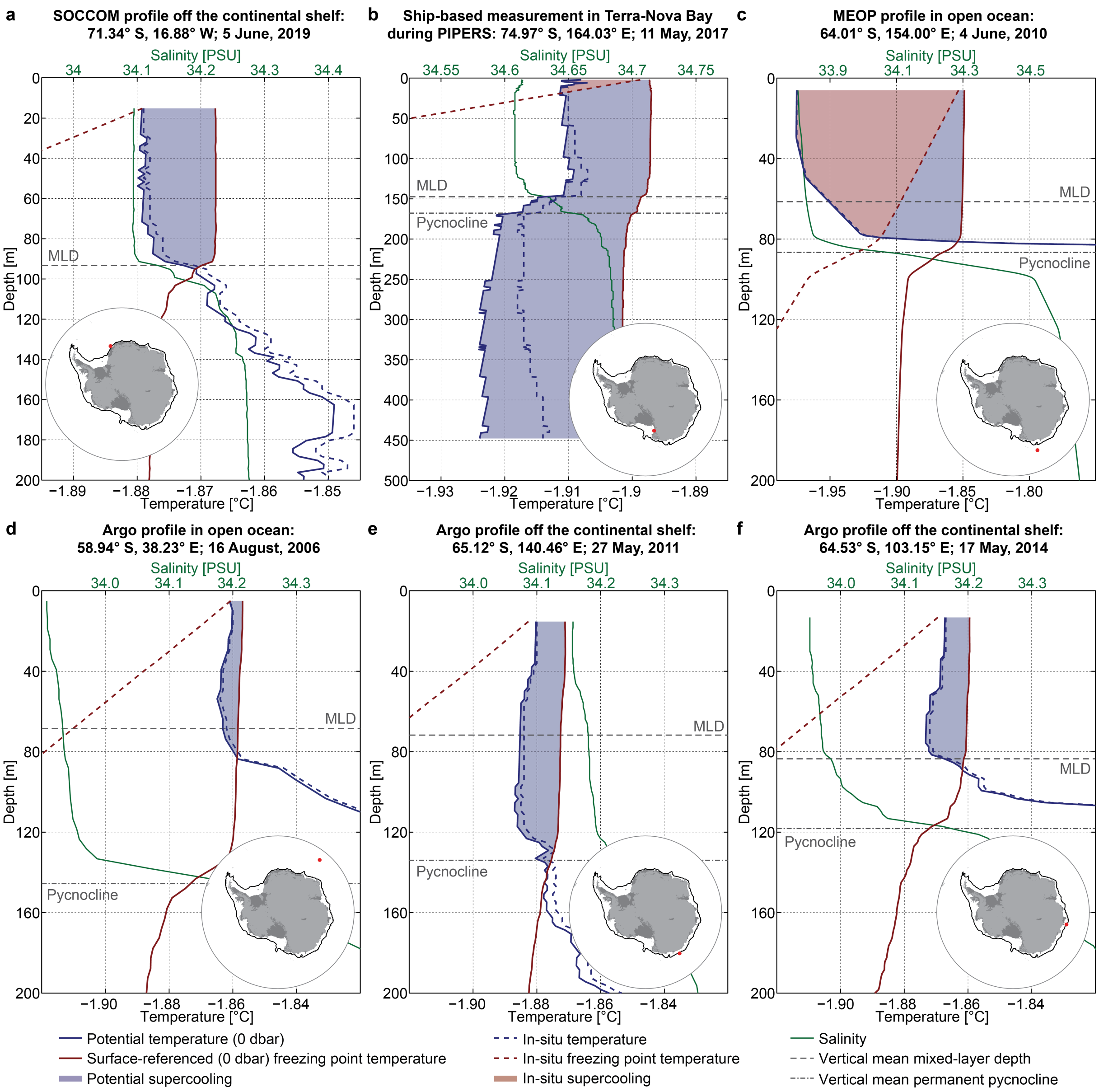

Figure S2. Example profiles showing potential and in-situ supercooling. a) Argo profile from float 'Sadie' (Table S1) from the SOCCOM project. b) Ship-based profile from the PIPERS project (De Pace et al., 2019). c) MEOP profile in the south-western Pacific. d-f) Argo profiles from three locations. In-set maps show the corresponding location (red dot).

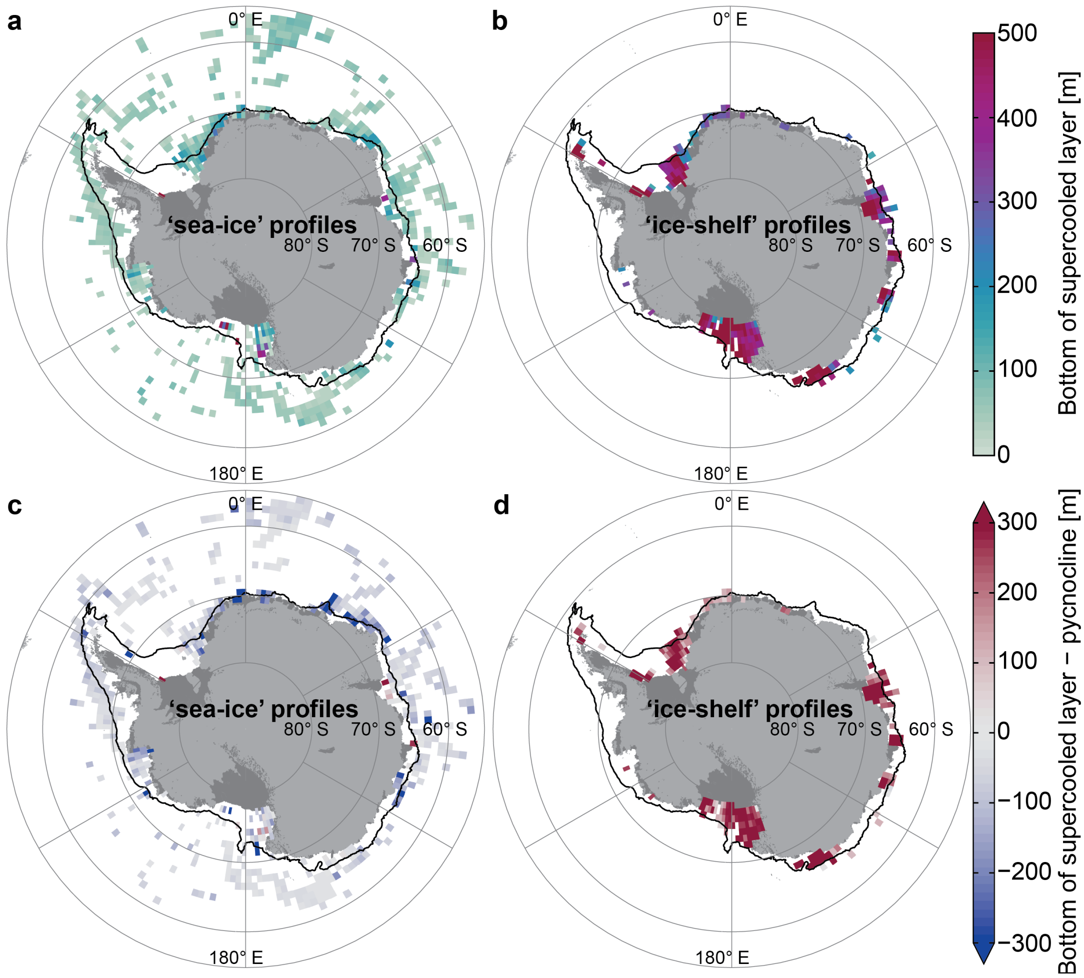

Figure S3. a,b) Maximum depth of the supercooling signal found in a) 'sea-ice' and b) 'ice-shelf' supercooled profile, binned and averaged onto a 2° longitude by 1° latitude spatial grid. c,d) Difference between the depth of the base of the supercooled layer and the pycnocline depth in c) 'sea-ice' and d) 'ice-shelf' supercooled profiles, binned and averaged onto a 2° longitude by 1° latitude spatial grid. Negative values show a maximum depth of the supercooled layer shallower than the pycnocline and positive values a maximum depth of the supercooled layer deeper than the pycnocline. Profiles with coincident 'sea-ice' and 'ice-shelf' supercooling signals, along with 'sea-ice' profiles where the entire water column is potentially supercooled or the maximum degree of supercooling is found below the pycnocline (section 2.2) are excluded. Black: continental shelf (1000-m isobath).

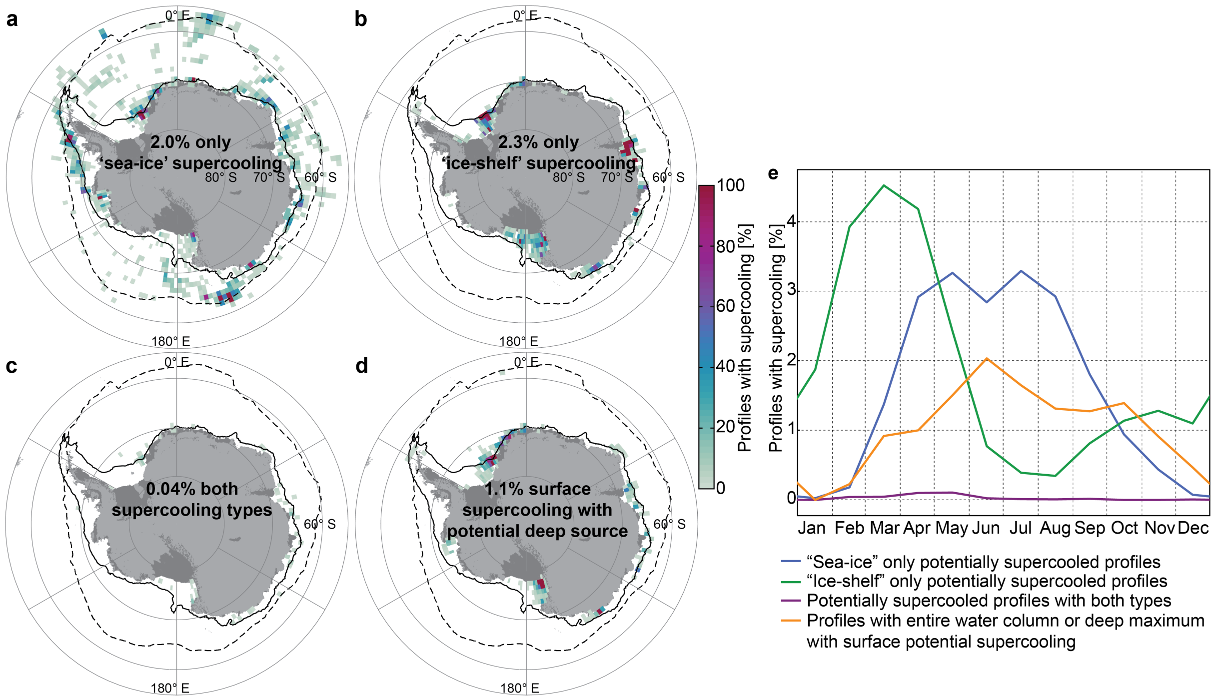

Figure S4. a-d) Percentage of profiles per grid cell that are a) only 'sea-ice' supercooled, b) only 'ice-shelf' supercooled, c) both 'sea-ice' and 'ice-shelf' supercooled, defined where the conditions for 'sea-ice' supercooling are satisfied and one or more additional supercooled layers (separated by non-supercooled layers) are found in the subsurface (section 2.2), and d) 'sea-ice' supercooled with possible ISW influence. The latter are defined as profiles satisfying the 'sea-ice' supercooling criteria and potential supercooling either extends to the seabed or is at a maximum beneath the pycnocline depth (section 2.2). Black: continental shelf (1000-m isobath; solid) and climatological mean sea-ice edge (25% ice concentration; dashed). e) Percentage of all profiles collected south of 55° S that are only 'sea-ice' supercooled (blue), only 'ice-shelf' supercooled (green), both 'sea-ice' and 'ice-shelf' supercooled (purple), and 'sea-ice' supercooled with possible ISW influence (orange), calculated for each month.

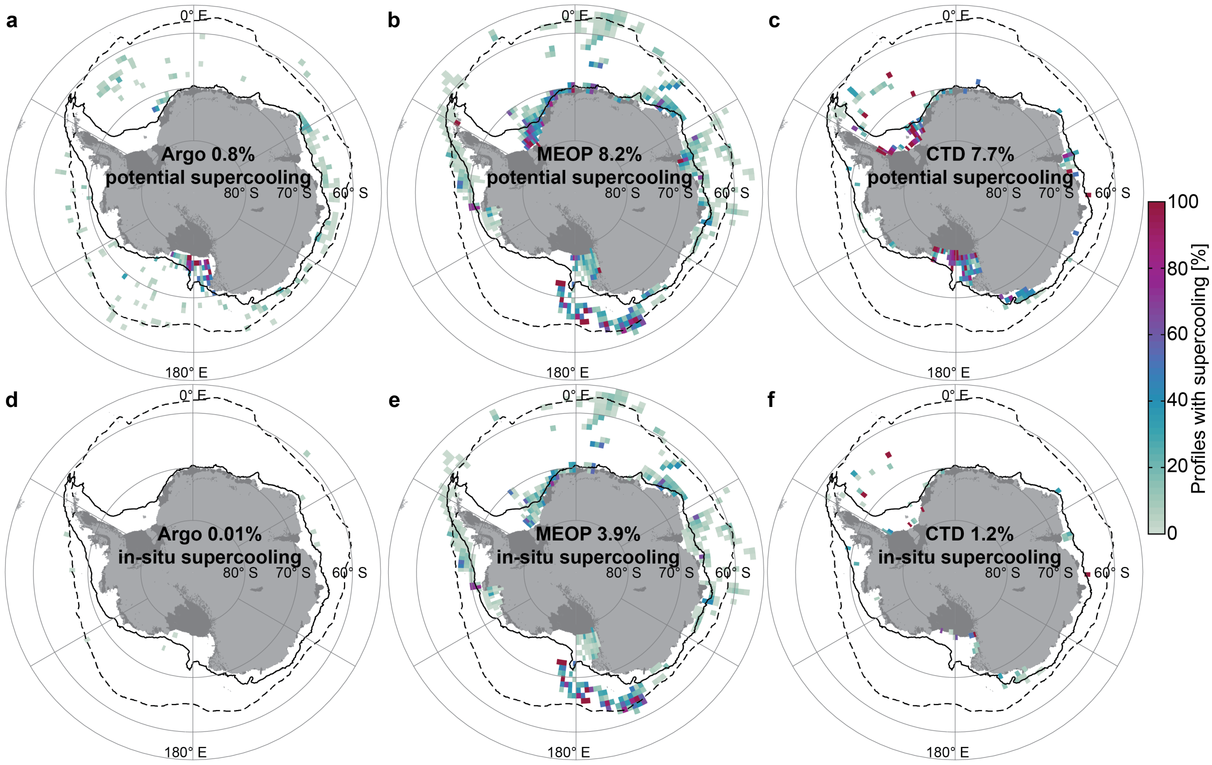

Figure S5. Spatial distribution of percentage of profiles per grid cell that are a-c) potentially and d-f) in-situ supercooled for each data product separately. a,d) Profiling Argo floats. b,e) Marine mammals (MEOP). c,f) Ship-deployed CTD measurements. Profiles were mapped on a 2° longitude by 1° latitude spatial grid. Black: continental shelf (1000-m isobath; solid) and climatological mean sea-ice edge (25% ice concentration; dashed).

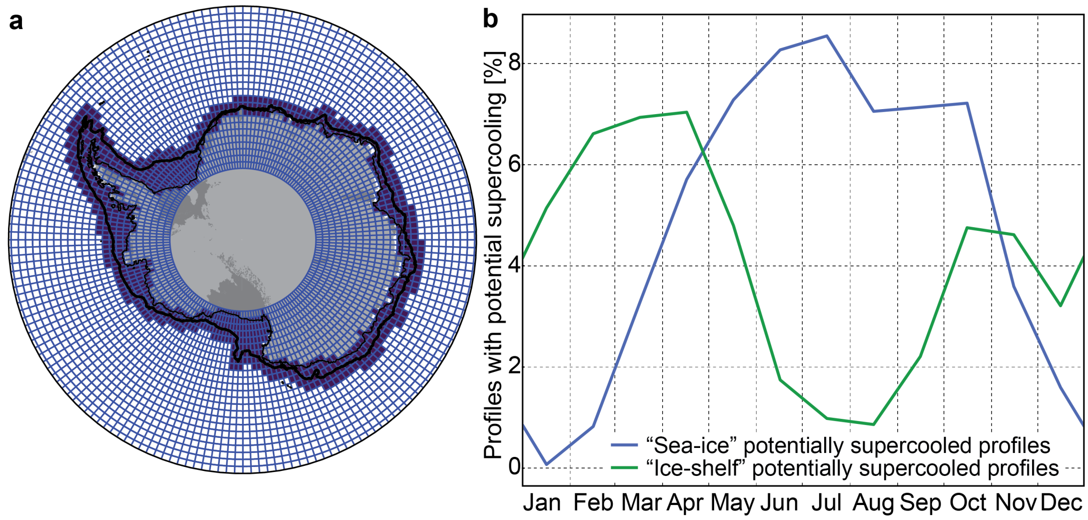

Figure S6. Seasonal cycle of 'sea-ice' and 'ice-shelf' supercooling on and near the Antarctic continental shelf. a) Map of these grid cells shaded in blue. This region includes all grid cells overlapping with the continental shelf region south of the 1000-m isobath (black contour) plus a one grid cell dilation. b) Percentage of all profiles collected within the region defined in (a) that are 'sea-ice' supercooled (blue) and 'ice-shelf' supercooled (green), calculated for each month to demonstrate the seasonality of the supercooling types.

Table S1. Argo floats with supercooling signal from schools participating in the SOCCOM Adopt-a-Float program.

School Name	Town	State	Float Name	WMO ID
Sandia Prep School	Albuquerque	NM	Sundevil Sam	5904858
Sandia Prep School	Albuquerque	NM	Sundevil Lion	5904860
Albert Schweitzer Elementary	Levittown	PA	Schweitzer Lions	5906000
Penn Alexander School	Philadelphia	PA	Sadie	5905993