July 2018 Sea Ice Outlook Key Statements

Contributor	Type	Dynamic Model Type	Arctic Extent	Antarctic Extent	Alaska Extent	Median	Ranges	Standard Deviation	EstimateSummary	Executive Summary	Method Summary	Sea Ice Concentration Data	Sea Ice Thickness Data
Morison	Heuristic		3.4					1	Experience	My June 2017 projection is for a new record low average September, 2017 Arctic sea ice extent of 3.4 million square kilometers. This heuristic estimate is based on what must be the worst pack ice conditions entering the summer season, namely: A) Analysis from Ron Kwok had most of the multiyear ice off Ellesmere Island being swept out of Fram Strait by a persistent low over the central Arctic, and the January 1 multiyear fraction for 2017 was an all time low. The total ice volume must be at a record low for this time of year. B) Temperatures over the Atlantic side of the Arctic Ocean up to the Pole were reportedly warm in late 2016 into early 2017. C) High winter AO should negatively correlate with following September ice extent [Rigor et al., 2002]. Winter (NDJFMA) 2016-17 AO was 9th highest since 1950 and 1.1 above the 1950-88 average. This should influence to ice extent negatively. As always, everything ultimately depends in the summer's weather, but the ice initial conditions starting the summer melt must be the worst ever so I'm predicting a new record minimum September average of 3.4 million square kilometers.	My method is heuristic based on experience, analysis of multiyear ice over the winter 2016-17 by Ron Kwok, NSIDC ice extent record, and NOAA AO record	analysis of multiyear ice over the winter 2016-17 by Ron Kwok, NSIDC ice extent record, and NOAA AO record	
NASA GMAO	Dynamic Model		3.91		0.21	Pan-Arctic: 3.93; Alaska region: 0.24	Pan-Arctic: 3.66 - 4.24; Alaska region: 0.00 - 0.41	Pan-Arctic: 0.21; Alaska region: 0.18	The given uncertainty is the standard deviation of the 7 member ensemble.	An experiment of the GMAO seasonal forecasting system using CryoSat-2 derived ice thickness predicts a September average Arctic ice extent of 3.93 ± 0.21 million km2. The experiment tests the application of ice thickness data in a near-real time setting for the seasonal forecast system. The forecast suggests a reduced Arctic ice cover for 2018 as compared to 2017.	The forecast uses the GEOS_S2S_2.1 coupled system that was modified for this forecast. The model has an approximate grid spacing of ½° in both the atmosphere and the ocean. The ocean data assimilation system is driven by a near real-time atmospheric analysis that is similar to MERRA-2, and uses the Local Ensemble Transform Kalman Filter (LETKF) for assimilation of available observations and along-track ocean altimetry. A branch of the ODAS system was integrated from 1-January to 31-May that included nudging to CryoSat-2 sea ice thickness fields over the available time period until 02-May. The forecast was initialized on 31-May and used 7 ensemble members based on initial condition perturbations of the atmosphere and ocean states.	NSIDC NASA Team, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM.	CryoSat-2 Level-4 Sea Ice Elevation, Freeboard, and Thickness, Version 1, https://nsidc.org/data/RDEFT4/, https://doi.org/10.5067/96JO0KIFDAS8. The data were incorporated into the ODAS over a four month period. The ODAS integrated for an additional 29 days after the end of the CryoSat-2 data period.
Gavin Cawley	Statistical		4.15			4.148614	3.0363 - 5.2609 (Bayesian 95% credible interval)		Gaussian Process models provide the posterior predictive distribution. Doesn't include hyper-parameter uncertainty.	This is a purely statistical method (related to Krigging) to extrapolate the long term trend from previous observations of September Arctic sea ice extent. As this uses only September observations, the prediction is not altered by observations made during the Summer of 2018.	A Gaussian Process model, with a squared exponential covariance function, is used to model the historical NSIDC September Arctic sea ice extent data. The hyper-parameters are optimised by maximising the marginal likelihood for the model (marginalising them would probably be better to include the additional predictive uncertainty due to uncertainty in estimating the hyper-parameters). The model was implemented in MATLAB using the GPML toolbox (http://www.gaussianprocess.org/gpml/code/matlab/doc/). An images has hopefully been uploaded showing how the predictive uncertainty increases as the model extrapolates into the future. For an animation showing how the model changes as the amount of calibration data increases, see https://twitter.com/Gavin_Cawley/status/1004987808367464448 .	NSIDC September average Arctic sea ice extent data.	
Kay/Bailey/Holland (NCAR/CU)	Heuristic		4.2				min: 3.14, max: 5.09	0.3	The uncertainty estimate is based on the scatter in entries in our informal pool.	An informal pool of 32 climate scientists in early June 2018 estimates that the September 2018 ice extent will be 4.20 million sq. km. (stddev. 0.30, min. 3.14, max. 5.09). Since its inception in 2008, the NCAR/CU sea ice pool has easily rivaled much more sophisticated efforts based on statistical methods and physical models to predict the September monthly mean Arctic sea ice extent (e.g. see appendix of Stroeve et al. 2014 in GRL doi:10.1002/2014GL059388 ; Witness the Arctic article by Hamilton et al. 2014 http://www.arcus.org/witness-the-arctic/2014/2/article/21066). We think our informal pool provides a useful benchmark and reality check for Sea Ice Prediction efforts based on more sophisticated physical models and statistical techniques.	An informal pool of 32 climate scientists in early June 2018 estimates that the September 2018 ice extent will be 4.20 million sq. km. (stddev. 0.30, min. 3.14, max. 5.09). Guesses were collected by sending an e-mail out to the scientists		
John, Christian	Statistical		4.24					0.33		The arctic and the sea ice is a area of interests for a lot of people, just not only Scientists also for the public, because it seems that arctic is most affected by ongoing climate change, its interesting to see how fast the climate is changing in this area, therefore i decide to contribute here. The Basic Idea is, that beyond the climate change driven decrease of sea ice extent, the variance from year to year could be explained by die variance of the weather (cold or warm weather)	I use the Air Temperature(1) and the Sea-Surface-Temperatur(2) to forecast the upcoming Extent Minimum(3) in September, for both the same domain: 70-90N to 0-360E, while the former version of the Model has used for all summer months, the new version is just using June for the forecast with a new methode, it more based on the idea, that the difference between the minimum in september and the minimum a year before is controlled by the difference between the weather (which is here presented as Air and Sea Temperatur) of the June and the June a year before. Calibration Period is 1980-2016 and gives a very good skill of R^2= 0.782, with an first Sigma Error of 0.33 Mio km^2. Since difference betwenn 1979 to 1980 is a massiv outlier(1.44 Mio km^2) which strongly impacts the skill of the Model i therefore decide to drop out this one.	Include source (e.g., which data center), name (algorithm), DOI and/or data set website, and date (e.g., "NSIDC NASA Team, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM.")	
UCL	Dynamic Model	Ocean-sea ice dynamical models	4.25	20.96	0.45	4.25	2.76 - 4.98	0.65	The range given [min-max] reflects the uncertainty associated to the atmosphere.Model/parameter uncertainty is not accounted for	Our estimate is based on results from ensemble runs with the global ocean-sea ice coupled model NEMO3.6-LIM3. Each member is initialized from a reference run on January 1st, 2018, and then forced with the JRA-55 atmospheric reanalysis from one year between 2008 and 2017. Our final estimate is the ensemble median, and the given range corresponds to the lowest and highest extents in the ensemble.	Our estimate is based on results from ensemble runs with the global ocean-sea ice coupled model NEMO3.6-LIM3. The ensemble members are expected to sample the atmospheric variability that may prevail this year. In practice, the model is forced with JRA-55 atmospheric reanalysis data from 1958 to December 31, 2017. No data are assimilated during this simulation. Ten ensemble members are then started from the obtained model state, each using atmospheric forcing from one year between 2008 and 2017. This choice is a compromise between a sufficiently large ensemble and the rapidly changing Arctic atmospheric conditions in recent decades. The estimate given above corresponds to the ensemble median monthly September extent; extents are always computed from the monthly mean sea ice concentration fields. No bias correction was applied.	The model is not initialized from observed SIC fields, but well from its own restart files.	The model is not initialized from observed SIT fields, but well from its own restart files.
Robert Grimm	Statistical		4.3					+/- 0.54	Expected skill is still low at this point, as ocean temperature and ice thickness are large influencing factors 2 months out.	An update to the method used within the June 2018 Individual outlook. The method compares three regression techniques: (1.) A linear regression of the long-term, 1979-2017 September monthly average Arctic sea ice extents. For linear regression, a September 2018 extent value is predicted to be 4.48 (+/- 0.54)* million square kilometers; (2.) A quadratic regression of, 1979-2017 September Arctic sea ice extent. For long-term quadratic regression, a September 2018 value is found to be 4.04 (+/- 0.51)* million square kilometers; and, (3.) A short-term, quadratic regression of daily-observed Arctic sea ice extent values from April 1, 2018 - July 10 2018**. The short-term, quadratic regression is used to estimate a newly determined September 2018 extent of 4.38 (+/- 0.11) million square kilometers. *residual standard deviations, [updated: Jul2018]. **short-term time series data, [updated: Jul2018].	Similar to findings from June 2017, Figure 6 from June 2018's report--(https://www.arcus.org/files/resize/sio/28244/2018_sio_june_report_fig6_nsidc_extent-700x560.png) suggests inherent, quadratic regression characteristics within shorter-term, time series analysis for Arctic sea ice extent. The Individual outlook I submitted in June, ignored this short-term prediction. However, with the addition of daily-observations for sea ice extent, the April to July time series produced a September 2018 extrapolation that is in agreement with the longer-term regressions. Ultimately, the average of all regression methods (1., 2., and 3.) was used, and a predicted value of 4.30 (+/- 0.54) million square kilometers was determined.	ftp://sidads.colorado.edu/DATASETS/NOAA/G02135/	
McGill (Tremblay et al.)	Statistical		4.31					0.48 million square kilometers	We produce and compare hindcasts to the observed September SIE for the 1993-2017 period. We take the std of the error.	We are studying seasonal predictability of sea ice in the Arctic Ocean, taking an approach based on observations. The DovekSIE model (a combination of the words sea ice extent 'SIE' and 'dovekie', a small bird native to the Fram Strait), developed at McGill University, is a seasonal forecasting tool for the minimum sea ice extent in the Arctic Ocean based on the concept of late winter preconditioning and sea ice export through Fram Strait presented in Williams et al. (2016). The DovekSIE forecasts are issued daily from November 1 to May 31 for monitoring the evolution of the seasonal forecast through the winter season (https://twitter.com/dovekSIE; https://brunotremblayseaice.jimdo.com/sea-ice-forecast-doveksie/). This is our second participation in the Sea Ice Outlook exercise.	Our prediction for the monthly mean Arctic sea ice extent of September 2018 is 4.31 million square kilometers. We produce the prediction as a sum of the linear trend (climatology) and departure from the trend (interannual variability). We take the long-term linear trend for the 1993-2017 period. A positive departure from the trend is projected for the 2018 September mean sea ice extent. We use the integrated sea level pressure difference across Fram Strait from Nov 1 to May 31 in a linear least squares fit model as a predictor for the anomaly of monthly mean September sea ice extent over the same period. Sea level pressure difference is a proxy for Frams Strait Ice Export, which is in turn a proxy for coastal divergence. This builds on the idea of winter dynamic preconditioning - see Williams et al. (2016).		
NMEFC of China (Li and Li)	Statistical		4.42							We predict the September monthly average sea ice extent of Arctic by statistic method and based on monthly sea ice concentration and extent from National Snow and Ice Data Center. The monthly average ice extent of September 2018 will be 4.42 million square kilometers .	A simple statistical model is used to predict September monthly Arctic sea ice extent. We find that the sea ice extent of September is well related with the sea ice extent of Jan. to Apr. in the same year.Combined the multiple regression method and optimal climate normal method, the predicted September sea ice extent in 2018 is 4.42 million square kilometers.	Include source (e.g., which data center), name (algorithm), DOI and/or data set website, and date (e.g., "NSIDC NASA Team, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM.") Sea Ice Index - Daily and monthly sea ice concentration(NASA Team) and extent from National Snow and Ice Data Center.	
Sanwa elementary school	Heuristic		4.43							Monthly mean ice extent in September will be about 4.43 million square kilometers. We estimated the minimum ice area through discussion among 21 students based on the ice map from 2004 to 2017.	We first estimated the total ice area for September of 2004, 2006, 2008,2010, 2012, 2014,2016 and 2017 from the ice concentration map, by approximating the ice cover with a triangle or trapezoid. Based on this rough estimation, we discussed a yearly change of the ice area and calculated the ice area of this September.	Include source (e.g., which data center), name (algorithm), DOI and/or data set website, and date (e.g., "NSIDC NASA Team, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM.") SIC is not used.	SIT is not used.
Yizhe Zhan	Statistical		4.45				+/- 0.2 million km2		The uncertainty range is estimated from the standard error of the correlation between June TOA-RSR and September SIE.	Our prediction is based on the strong correlation between detrended June top-of-atmosphere (TOA) reflected solar radiation (RSR) and September Sea Ice Extent (SIE) anomalies, as proposed by Zhan and Davies [2017]. This method is telling because the main contributor of TOA RSR anomaly in June is from the change of underlying surfaces and the sea ice state in early summer (June) largely determines the total absorbed shortwave solar radiation during the whole melt season.	Our contribution is formulated by adding the main contribution part from September SIE trend (2000~2017) with the anomalous part from the June TOA-RSR (2018) anomaly. The detailed description of calculation is as follows. June TOA-RSR best-fit line (2000~2017): -0.57*X + 259.49 June TOA-RSR anomaly in 2018 is 4.01 (253.24-249.22) W/m2. September SIE best-fit line (2000~2017): -0.11*X + 6.16 September SIE for 2018 prediction is 4.45 (4.15+0.075*4.01) million km2. Note that the coefficient of 0.075 is estimated from the detrended anomalies of June TOA-RSR and September SIE between 2000 and 2017.	None	None
Nico Sun	Statistical		4.48			4.48	3.75-5.16	1.28		The forecast model uses incoming solar radiation and sea ice albedo derived from a predicted sea ice concentration to calculate thickness losses. A grid-cell is defined as ice covered when thickness is above 12cm.	The statistical forecast model uses ice persistence to forecast the September minimum. Each grid-cell is initialized with a thickness derived from my AMSR2 Sea Ice Volume model (v1.1, https://sites.google.com/site/cryospherecomputing/amsr2-sea-ice-volume). For each day the model calculates average thickness loss per grid cell using the exact solar radiation energy and the predicted sea ice concentration as an albedo value. iceloss = Energy(sun)*(1-SIC) / icemeltenergy iceloss in m Energy in MJ SIC = sea ice concentration icemeltenergy = Meltenergy per m3, (333.55 KJ/kg*1000(m3/dm)*0.92(density)/1000(MJ/KJ) Extent is defined for each grid-cell with a thickness > 0.12m	NSIDC NASA Team, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM."	AMSR2 Sea Ice Volume model (v1.1), 31st May 2018, developed by Nico Sun https://sites.google.com/site/cryospherecomputing/amsr2-sea-ice-volume)
GFDL/NOAA, Bushuk et al.	Dynamic Model	Coupled dynamical models	4.49		0.13	4.53	3.66-5.17	0.43	These statistics are computed using our 12 member prediction ensemble.	Our July 1 prediction for the September-averaged Arctic sea-ice extent is 4.49 million square kilometers, with an uncertainty range of 3.66-5.17 million square kilometers. Our prediction is based on the GFDL-FLOR ensemble forecast system, which is a fully-coupled atmosphere-land-ocean-sea ice model initialized using a coupled data assimilation system. Our prediction is the bias-corrected ensemble mean, and the uncertainty range reflects the lowest and highest sea ice extents in the 12-member ensemble.	Our forecast is based on the GFDL Forecast-oriented Low Ocean Resolution (FLOR) model (Vecchi et al., 2014), which is a coupled atmosphere-land-ocean-sea ice model. The model is initialized from an Ensemble Kalman Filter coupled data assimilation system (ECDA; Zhang et al., 2007), which assimilates observational surface and subsurface ocean data and atmospheric reanalysis data. The system does not assimilate any sea ice concentration or thickness data. The FLOR atmospheric initial conditions are produced from an AMIP run forced by observed SST and sea ice. Historical radiative forcing is used prior to 2005 and the RCP4.5 scenario is used for predictions after 2005. For the predictions initialized after 2004, the aerosols are fixed at the RCP4.5 scenario year of 2004. The performance of this model in seasonal prediction of Arctic sea ice extent has been documented in Msadek et al. (2014) and Bushuk et al. (2017). For an evaluation of the model's September sea ice extent prediction skill from a July 1 initialization, see attached report.	No SIC data is explicitly used in our initialization procedure.	No SIT data is explicitly used in our initialization procedure.
MPAS-CESM	Dynamic Model	Coupled dynamical models	4.5	17.7	0.4	4.7, 17.7, 0.4 (Arctic, Antarctic, and Alaska)	3.6-4.9, 17.3-18.0, 0.3-0.5		Small initial condition ensemble	Our June outlook is an experiment with a fully coupled dynamical atmosphere-sea ice-ocean-land-river model and small initial condition ensemble. Focusing on Arctic SIE, small perturbations to the initial atmosphere create a spread of 0.2 M sq. km. Large perturbations to the other components yield a spread of 1.1 M sq. km.	Using CESM-CAM-MPAS (v2.0.b05), an Arctic-refined (~90-25 km) atmospheric mesh is coupled to ~1 degree other components. For the control, the atmosphere is cold-started from GFS initial conditions (0.25 degree) on 2018- 06-30 and the other components startup from a spun-up restart of CESM Large Ensemble member 005 i n 2021 (to match the expected 2018 Arctic SIE from CESM-LE and NSIDC). Additional atmospheric IC ensemble members are from perturbing the initial GFS resolution (0.5,1.0 degree). Non-atmospheric IC ensemble members use CESM-LE members 006 and 007 for the other components. A 15% threshold on the daily model sea ice concentration is used to calculate extent. Simulations are in 2018 using an RCP 8.5 forcing.	Restarts of CESM Large Ensemble members 005, 006, and 007 using 2021-06-30.	Restarts of CESM Large Ensemble members 005, 006, and 007 using 2021-06-30.
NSIDC Group Entry	Heuristic		4.55					0.49	Standard deviation of all entries.	The projection is the median of 13 entries by NSIDC employees.	NSIDC employees were asked to submit a guess at the September sea ice extent. All entries were collected and the median was used for this Outlook projection.	Entrants were provided the NSIDC Sea Ice Index (http://nsidc.org/data/seaice_index/) as a source of extents. The Sea Ice Index is based on the NSIDC NASA Team product, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM.	

Sean Horvath, NSIDC	Statistical		4.59							This statistical model computes the probability that sea ice will be present (concentration above 15%) for each grid cell in NSIDC's polar stereographic projection. Yearly data from 1980 through the present are used in a bayesian binomial linear regression. Predictors include mean winter (DJF) surface air temperature and geopotential height at 500hpa, May monthly mean surface air temperature and geopotential height at 500hpa, June sea ice concentration, and a trend index. This model predicts a minimum September sea ice extent of 4.59 million square km occurring on September 12th. Sea ice concentration data was obtained from NSIDC's Sea Ice Index V3 (Data Set ID: G02135), and the air temperature and geopotential height data was from NASA's MERRA2 dataset.	Yearly data from 1980 through the present are used in a binomial linear regression to predict the probability that sea ice concentration will be above 15%. Predictions are made every other day in September. To estimate total sea ice extent, grid cells with a percentage above a certain threshold (chosen from a drop-one cross-validation test) are multiplied by the pixel area grid dataset provided by NSIDC's polar stereographic toolset and then summed. This model predicts a minimum September sea ice extent of 4.16 million km2 occurring on September 4th. Sea ice concentration data was obtained from NSIDC's Sea Ice Index V3 (Data Set ID: G02135), and the air temperature and geopotential height data was from NASA's MERRA2 dataset.	NSIDC's Sea Ice Index V3 (Data Set ID: G02135) NASA's MERRA2 dataset	
International Arctic Research Center	Statistical		4.639			4.639	Upper: 5.074 million sq. km.; Lower: 4.109 million sq. km.		The range assessments represent 95th and 5th percentile confidence intervals.	The International Arctic Research Center has developed a prototype model to estimate Arctic sea ice extent using an analogs approach. The analogs approach looks at prior years and finds the best matches that most closely represent the current state of the atmosphere in 2018. The model run in early July 2018 indicates September sea ice will be slightly higher than the extrapolated linear trend of the previous four decades. We estimate a monthly extent of 4.639 million square kilometers.	Our statistical model uses the NCEP/NCAP (R1) Reanalysis data sets to develop analog matches of atmospheric variables that correlate with sea ice extent. The R1 data covers the time period of 1948-present. The model generates an estimated deviation from the 1979-2017 September sea ice linear trend line by identifying the top match years for a number of oceanic and atmospheric variables using the April through June time periods of each year, and then follows the seasonal decline in sea ice through the following September. The variables used are: 1) sea level pressure, 2) 500 mb heights, 3) 2-meter temperatures, 4) 925 mb temperatures, and 5) sea surface temperatures. A composite forecast is developed from a regression-weighted model.	Our model assumes no a priori knowledge of the current extent of Arctic sea ice. It does, however, rely on the NSIDC published monthly September sea ice extents to estimate the long-term trend line. We use the same linear trend that NSIDC adds to their published monthly extent graphics. Data source: Chapman, W. L. and J. E. Walsh. 1991, updated 1996. Arctic and Southern Ocean Sea Ice Concentrations, Version 1. [Indicate subset used]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center	Our model does not utilize sea ice thickness.
Dmitri Kondrashov (UCLA)	Statistical		4.67		0.51					This statistical model forecast is based on inverse modeling techniques applied to the regional Arctic Sea Ice Extent (SIE).	This statistical model forecast is based on Data-adaptive Harmonic Decomposition (DAHD) and Multiscale Stuart-Landau Models (MSLM) inverse modeling techniques applied to the regional Arctic Sea Ice Extent (SIE) from Sea Ice Index Version 3 dataset. The daily SIE data were aggregated to provide weekly-sampled dataset over eight Arctic sectors. DAHD-MSLM predictive model has been derived from SIE anomalies with annual cycle removed. The MSLM model is initialized from latest SIE conditions (July 2018) by ensemble of stochastic noise realizations to provide probabilistic regional Arctic forecasts in September, as well as pan-Arctic ones. References: 1. Kondrashov, D., M. D. Chekroun, and M. Ghil, 2018: Data-adaptive harmonic decomposition and prediction of Arctic sea ice extent, Dynamics and Statistics of the Climate System, 3(1), doi:10.1093/climsys/dzy001. 2. Chekroun, M. D., and D. Kondrashov, 2017: Data-adaptive harmonic spectra and multilayer Stuart-Landau models, Chaos, 27, 093110: doi:10.1063/1.4989400		
NRL-NESM	Dynamic Model		4.7	21.3	0.81		4.3 to 5.2 Mkm^2		The uncertainty estimate is the range of the 10 member ensemble, and does not represent a full measure of uncertainty.	The projected Arctic 2018 September mean sea ice extent from the Navy Earth System Model (NESM) is 4.7 million km^2. This projection is the average of a 10 member time-lagged ensemble using initial conditions from 2 June to 11 June 2018. The range of the ensemble is 4.3 to 5.2 million km^2. The projected Alaskan Regional 2018 September mean sea ice extent is 0.81 million km^2 with an ensemble range from 0.43 to 1.01 million km^2. The projected Antarctic 2018 September mean sea ice extent is 21.3 million km^2 with an ensemble range from 20.4 to 21.8 million km^2. Note that our ensemble range does not represent a full measure of uncertainty, and the system is currently in a development stage.	We performed ensemble forecasts with the Navy Earth System Model using initial conditions on 2018-06-02 12Z through 2018-06-11 12Z. The atmospheric initial conditions are from NAVDAS-AR (Xu et al. 2005), which is part of the NAVGEM (Hogan et al. 2014) operational suite. The ocean/ice initial conditions are from the Navy's 3Dvar NCODA data assimilation system (Cummings 2005), which is a component of GOFS 3.1 using HYCOM and CICE (Metzger et al. 2014). SSMIS and AMSR2 ice concentrations are assimilated with NCODA (Posey et al., 2015). There was no bias correction performed on the results.	Forecasts were initialized from the pre-operational US Navy Global Ocean Forecasting System (GOFS) 3.1 for the ocean and sea ice using the Navy Coupled Ocean Data Assimilation (NCODA) system. The sea ice model assimilated SSMIS and AMSR2 sea ice concentration products. Atmospheric initial conditions were from the operational NAVy Global Environmental Model (NAVGEM) using the Naval Research Laboratory Atmospheric Variational Data Assimilation System (NAVDAS-AR).	The ensemble forecasts were initialized using ice thickness from the GOFS 3.1 restart files on the appropriate start date. Ice thickness products are not assimilated by GOFS 3.1.
CPOM (D. Schroeder, et al.)	Statistical		4.7					+/- 0.5 mill. km2	The given uncertainty is the mean forecast error based on forecasts for the years 1984 to 2017.	Based on May and June melt pond fraction we predict a mean 2018 September ice extent of 4.7 (4.2 to 5.2) mill km2. This is slightly above the linear trend line, but lower than our June prediction (5.3 +/- 0.5 mill km2). While melt pond fraction has been generally low in May, the area covered by ponds in June is avove the mean (the last 10 years) in the Central Arctic and below in the Siberian part.	This is a statistical prediction based on the correlation between the ice area covered by melt-ponds in May and ice extent in September. The melt pond area is derived from a simulation with the sea ice model CICE in which we incorporated a physically based melt-pond model1. See our publication in Nature Climate Change http://www.nature.com/nclimate/journal/v4/n5/full/nclimate2203.html for details2. References: 1. Flocco, D., Schröder, D., Feltham, D. L. & Hunke, E. C., 2012: Impact of melt ponds on Arctic sea ice simulations from 1990 to 2007. J. Geophys. Res. 117, C09032. 2. Schröder D., D.L. Feltham, D. Flocco, M. Tsamados, 2014: September Arctic sea-ice minimum predicted by spring melt-pond fraction. Nature Clim. Change 4, 353-357, DOI: 10.1038/NCLIMATE2203.	Include source (e.g., which data center), name (algorithm), DOI and/or data set website, and date (e.g., "NSIDC NASA Team, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM.")	
UTokyo (Kimura et al.)	Statistical		4.71							Monthly mean ice extent in September will be about 4.71 million square kilometers. Our estimate is based on a statistical way using data from satellite microwave sensor. We used the ice thickness in December and ice movement from December to April. Predicted ice concentration map from July to September is available in our website: http://ccsr.aori.u-tokyo.ac.jp/~kimura_n/arctic/2018e.html Sea ice cover in the Laptev and East Siberian Seas will retreat with nearly same speed as last year. Minimum sea ice cover in September of this year will be very similar to that of the last year	We predicted the Arctic sea-ice cover from coming July 1 to November 1, using the data from satellite microwave sensors, AMSR-E (2002/03-2010/11) and AMSR2 (2012/13-2017/18). The analysis method is based on our recent research (Kimura et al., 2013). First, we expect the ice thickness distribution in April 30 from redistribution (divergence/convergence) of sea ice during December and April, based on the daily ice velocity data. Then, we predict the summer ice area depending on the assumption that thick ice remains later and thin ice melts sooner than the average. For this analysis, we distributed particles homogeneously over the Arctic sea ice on December 1. We traced the trajectories of the particles to the end of April by using the satellite derived daily ice velocity (Kimura Dataset). Based on the relationship between particle density on April 30 and ice concentration in summer, we predicted the summer sea ice cover of this year. We also take it into account that thickness of sea ice on December 1 calculated by an algorithm of Krishfield et al. (2014) .	SIC dataset distributed by distributed by Arctic Data archive System (ADS, https://ads.nipr.ac.jp/index.html).	SIT dataset distributed by distributed by Arctic Data archive System (ADS, https://ads.nipr.ac.jp/index.html), December 1 of all AMSR-E/AMSR2 years. This SIT is calculated by an algorithm of Krishfield et al. (2014).
Jinlun Zhang and Axel Schweiger	Dynamic Model	Ocean-sea ice dynamical models	4.72							Driven by the NCEP CFS forecast atmospheric forcing, PIOMAS is used to predict the total September 2017 Arctic sea ice extent as well as ice thickness field and ice edge location, starting on July 1. The predicted September ice extent is 4.72± 0.40 million square kilometers. The predicted ice thickness fields and ice edge locations for September 2018 are also presented.	These results are obtained from a numerical seasonal forecasting system. The forecasting system is based on a synthesis of PIOMAS, the NCEP CFS hindcast and forecast atmospheric forcing, and satellite observations of ice concentration. The CFS forecast ranges from hours to months: there are a total of 16 CFS ensemble forecast runs every day, of which four ensemble runs go out to 9 months, three runs go out to 1 season, and nine runs go out to 45 days (Saha et al., 2014). These ensemble runs all create 6-hourly forecast atmospheric data that are widely accessible in real time, thus ideal for forcing PIOMAS forecasts on daily to seasonal time scales. Here we used four CFS forecast ensemble members to drive the PIOMAS ice–ocean ensemble forecasts. Ensemble mean values from these four members are considered to be the prediction. To obtain the "best possible" initial ice-ocean conditions for the forecasts, we conducted a retrospective simulation that assimilates satellite ice concentration and sea surface temperature data through the end of May 2018 using the CFS hindcast forcing data. After that, four ensemble PIOMAS forecast runs were conducted using atmospheric forecast forcing from four CFS ensemble runs. Additional information about PIOMAS prediction can be found in Zhang et al. (2008). Saha, S., and others, The NCEP climate forecast system version 2, J. Climate, 27, 2185–2208, 2014. Zhang, J., and D.A. Rothrock: Modeling global sea ice with a thickness and enthalpy distribution model in generalized curvilinear coordinates, Mon. Wea. Rev., 131(5), 681–697, 2003. Zhang, J., M. Steele, R.W. Lindsay, A. Schweiger, and J. Morison, Ensemble one-year predictions of arctic sea ice for the spring and summer of 2008.	Include source (e.g., which data center), name (algorithm), DOI and/or data set website, and date (e.g., "NSIDC NASA Team, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM.")	
RASM (Kamal et al.)	Dynamic Model	Coupled dynamical models	4.75		0.468			0.239 million square kilometers	The uncertainty was estimated based on standard deviation of the 29-member ensemble.	We used RASM version 2.01, which is a recent version of the limited-area, fully coupled climate model consisting of the Weather Research and Forecasting (WRF), Los Alamos National Laboratory (LANL) Parallel Ocean Program (POP) and Sea Ice Model (CICE), Variable Infiltration Capacity (VIC) land hydrology and routing scheme (RVIC) model components (Maslowski et al. 2012; Roberts et al. or 2015; DuVivier et al. 2015; Hamman et al. 2016; Hamman et al. 2017; Cassano et al. 2017). The model uses CFSR or CFSv2 output for RASM-WRF lateral boundary conditions and for nudging winds and temperature starting above 500 mbar. We used one root case utilizing WRF371, including the Grell-3D parameterization scheme (with shallow cumulus convection option only turned on over the ocean grid).	For the July forecast we used one root case forced with CFSR to generate the initial conditions for all 29-member ensemble starting at time 0000 on July 1, 2018. The root case is a hindcast forced from September 1979 through the end of June 2018, providing internally- and physically-consistent initial conditions for all ensemble member forecasts. Each of the 29-member ensembles were integrated for 5 months forward using respective outputs from CFSV2. The CFSV2 forcing streams used for the ensemble were initialized everyday (at 0000) between June 1st and June 29th, and used for RASM forcing at time 0000 on July 1st 2018.	Self-generated from a 39 year hindcast run.	Self-generated from a 39 year hindcast run.
NCEP CPC	Dynamic Model		4.77		0.9			0.19	The standard deviation is calculated from the 20-member ensemble.	This contribution is from a 20-member ensemble forecast from the Climate Prediction Center Experimental sea ice forecast system (CFSm5). Model bias that is removed is calculated based on 2006-2017 retrospective forecasts and corresponding observations.	The outlook is produced from the Climate Prediction Center Experimental sea ice forecast system (CFSm5). The forecast is initialized from the Climate Forecast System Reanalysis (CFSR) for the ocean, land, and atmosphere and from the CPC sea ice initialization system (CSIS) for sea ice. Twenty forecast members are produced. Model bias that is removed is calculated based on 2006-2017 retrospective forecasts and corresponding observations.	Both sea ice concentration and sea ice thickness are initialized from the CPC sea ice initialization system (CSIS). The CSIS analysis is produced with GFDL MOM5 which uses surface fields from CFSR and assimilates satellite sea ice concentration retrieval from NSIDC NASA Team	Both sea ice concentration and sea ice thickness are initialized from the CPC sea ice initialization system (CSIS). The CSIS analysis is produced with GFDL MOM5 which uses surface fields from CFSR and assimilates satellite sea ice concentration retrieval from NSIDC NASA Team
Xiaojun Yuan, LDEO	Statistical		4.78	18.95	0.6				The uncertainty of SIC prediction measured by RMSE was estimated based on cross-validated model experiments for 34 years.	A linear Markov model is used to predict monthly Arctic sea ice concentration (SIC) at all grid points in the pan-Arctic region. The model is capable of capturing the co-variability in the ocean-sea ice-atmosphere system. The September pan-Arctic sea ice extent (SIE) is calculated from predicted SIC. The model predicts negative SIC anomalies throughout the pan-Arctic region. These anomalies are relative to the 1979-2012 climatology. The September mean pan-Arctic SIE is predicted to be 4.78 million square kilometers with an RMSE of 0.46 million square kilometers, at a three-month lead. Similar statistical models were also developed to predict the SIE in the Alaskan region and in the Antarctic. The September mean pan Antarctic SIE is predicted to be 18.95 million square kilometers with an RMSE of 0.42 million square kilometers. The Alaskan regional SIE is predicted to be 0.60 million square kilometers with an RMSE of 0.22 million square kilometers.	The linear Markov model has been developed to predict sea ice concentrations in the pan-Arctic region at the seasonal time scale. The model employs 6 variables: NASA Team sea ice concentration, sea surface temperature (ERSST), surface air temperature, GH300, vector winds at GH300 (NCEP/NCAR reanalysis) for the period of 1979 to 2012. It is built in multi-variate EOF space. The model utilizes first 11 mEOF modes and uses a Markov process to predict these principal components forward one month at a time. The pan-Arctic sea ice extent forecast is calculated by summarizing all cell areas where predicted sea ice concentration exceeds 15%. Bias corrections have been applied to ice concentration predictions at grid points as well as the total sea ice extent prediction. The predictive skill of the model was evaluated by anomaly correlation between predictions and observations, and root-mean-square errors (RMSE) in a (take one-year out) cross-validated fashion. On average, the model is superior to the predictions by anomaly persistence, damped anomaly persistence, and climatology (Yuan et al, 2016). For the three-month lead prediction of September sea ice concentrations, the model has the higher skill (anomaly correlation) and lower RMSE in the Chukchi Sea and the Beaufort Sea than in other regions (figure 4). The skill of the three-month lead prediction of the pan-Arctic sea ice extent in September is 0.88 with an RMSE of 0.46 million square kilometers. The Alaskan regional SIE prediction is produced by a regional linear Markov model developed by using SIC, SST, and SAT, in the EOF space. Following the NSIDC regional mask, the Alaska SIE forecast is calculated from predicted SIC. The skill of the regional SIE is 0.90 (correlation using cross-validated experiments) with RMSE of 0.22 million square kilometers. A similar model is used for Antarctic SIE forecast (Chen and Yuan 2004).	NSIDC NASA Team, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM. ERA-interim atmospheric variables, http://apps.ecmwf.int/datasets/data/interim-full-moda/levtype=sfc/ NOAA NCDC ERSST version3b sst: Extended reconstructed sea surface temperature data, http://iridl.ldeo.columbia.edu/expert/SOURCES/.NOAA/.NCDC/.ERSST/.version3b/.sst/	
Xingren Wu and Robert Grumbine	Dynamic Model	Coupled dynamical models	4.84	19.62						The projected Arctic minimum sea ice extent from the NCEP CFSv2 model with revised CFSv2 May and June initial conditions using 61-member ensemble forecast is 4.84 million square kilometers with a standard deviation of 0.79 million square kilometers. The corresponding number for the Antarctic is 19.62 million square kilometers with a standard deviation of 0.69 million square kilometers.	We ran the NCEP CFSv2 model with 61-case of May and June 2018 revised initial conditions (ICs). The IC was modified from real time CFSv2 of each day at 00Z by thinning the Arctic ice pack (based on test from previous years' sea ice outlook). If this thinning would have eliminated ice from areas observed to have sea ice, a minimum thickness of 10 cm was left in place for the ice ICs. Bias correction was applied to the Antarctic sea ice extent.	Include source (e.g., which data center), name (algorithm), DOI and/or data set website, and date (e.g., "NSIDC NASA Team, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM.") NCEP Sea Ice Concentration Analysis for the CFSv2 (May 1-June 30, 2018)	NCEP CFSv2 model guess with bias correction for the Arctic (May 1-June 30, 2018)

Qing Bao (LASG, IAP)	Mixed		4.87	18.01	0.36					The Sea Ice outlook prediction becomes an area of active scientific research with profound socioeconomic implications. A mixed method has been carried out for the sea ice outlook projection on China's Tianhe-2 supercomputer, which combines a dynamic model prediction system and a statistical approach of machine learning. The dynamic model prediction system, named FGOALS-f2 (ice-ocean-atmosphere-land model), provides a real-time predictions in the subseasonal-to-seasonal (S2S) timescales. FGOALS-f2 S2S system has been established in 2017 by R&D team of FGOALS-f2 from both LASG Institute of Atmospheric Physics Chinese Academy of Sciences and PAEKL Chengdu University of Information Technology. The FGOALS-f2 S2S prediction results are used in two major national climate operational prediction centers in China. A machine deep learning (MDL) method using convolutional neural network (CNN) is proposed in the work as a statistical technique for the correction of the dynamic model predictions. Basing on the 4-month lead dynamic model prediction from May 20, 2018 and MDL using CNN, the outlook predictions of Sea Ice Extent are 4.87, 18.01, and 0.36 million square kilometers for pan-Arctic, pan-Antarctic and Alaska Regions in September 2018 respectively. As for the 4-month-lead prediction skills of this mixed method in , the correlation coefficients between the reforecast results and observations are 0.73, 0.86, 0.86, and the Root mean squared error (RMSE) is 0.48, 2.14, 0.02, for the Pan-Arctic , pan-Antarctic and Alaska regions respectively in the past 7 years (2011-2017).	A mixed method has been carried out for the sea ice outlook projection, which combines a dynamic model prediction system and a statistical approach of machine learning. A "reforecast" (retrospective forecast) dataset of 37 years from 1981-2016 has been developed. This dataset is comprised of a 24-member ensemble run for reforecast and 35-member ensemble run for realtime prediction out to a 6-month lead. Machine Deep Learning (MDL) methods using Convolutional Neural Network (CNN) have been proposed in the work as a statistical technique for correction of the dynamic model prediction. 37-year reforecast results of atmospheric variables are taken as the training (input) datasets. The last 7 years of 2011-2017 have been taken as a testing period for the calculation of the relevant prediction skills. Both the realtime S2S prediction system and MDL using CNN are fully operated on China's Tianhe-2 supercomputer.	None	None
Met Office	Dynamic Model		4.9	17.8	0.58			0.6 (0.9 for southern hemisphere) million sq. km.	Two standard deviations of the 42 member ensemble spread around the ensemble mean.	Using the Met Office GloSea5 seasonal forecast system we are issuing a model based mean Northern (Southern) Hemisphere September sea ice extent outlook of 4.9 +/- 0.6 (17.8 +/- 0.9) million sq. km. This has been assembled using start dates between 15 May and 4 June to generate an ensemble of 42 members.	Ensemble coupled model seasonal forecast from the GloSea5 seasonal prediction system (MacLachlan et al, 2015), using the Global Coupled 2 (GC2) version (Williams et al, 2015) of the HadGEM3 coupled model (Hewitt et al, 2011). Forecast compiled together from forecasts initialized between 15 May and 4 June (2 per day) from an ocean and sea ice analysis (FOAM/NEMOVAR) (Blockley et al, 2014; Peterson et al. 2014) and an atmospheric analysis (MO-NWP/4DVar) (Rawlins et al, 2007) using observations from the previous day. Special Sensor Microwave Imager Sensor (SSMIS) ice concentration observations, OSI-401-b, from EUMETSAT OSI-SAF (Sea ice concentration product of the EUMETSAT Ocean and Sea Ice Satellite Application Facility; OSI SAF, www.osi-saf.org, available from http://osisaf.met.no) were assimilated in the ocean and sea ice analysis, along with satellite and in-situ SST (GHRSST), subsurface temperature and salinity profiles (ENACT), and sea level anomalies from altimeter data (AVISOv4). No assimilation of ice thickness was performed.	Initial sea ice concentration from FOAM ocean and sea ice analysis version 12 (Blockley et al, 2014) using Special Sensor Microwave Imager Sensor (SSMIS) ice concentration observations, OSI-401-b, from EUMETSAT OSI-SAF (Sea ice concentration product of the EUMETSAT Ocean and Sea Ice Satellite Application Facility; OSI SAF, www.osi-saf.org, available from http://osisaf.met.no).	Initial sea ice thickness from FOAM ocean and sea ice analysis version 12 (Blockley et al, 2014) using model dynamics and thermodynamics. No observations of sea ice thickness were assimilated.
Monica Ionita, Klaus Grosfeld	Statistical		4.9			4.9	Lower uncertainty bound: 4.6, Upper uncertainty bound: 5.3				The forecast scheme for the September sea ice extent is based on a methodology similar to the one used for the seasonal prediction of river streamflow. The basic idea of this procedure is to identify regions with stable teleconnections between the predictors and the predictand. The September sea ice extent has been correlated with the potential predictors (ocean heat content, sea surface temperature, sea level pressure, air temperature) from previous months, up to 8 months lag, in a moving window of 21 years.	NSIDC NASA Team, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM	
ECMWF SEAS5	Dynamic Model	Coupled dynamical models	4.93			bias-corrected median of the ensemble is 4.95 Mio sqkm	bias-corrected ensemble: minimum 4.53, maximum 5.45	ensemble standard deviation is 0.22 Mio sqkm	standard deviation of forecast ensemble (standard method)	This contribution is calculated from the operational ECMWF seasonal forecast from 1st July. This is an ensemble forecast with a global atmosphere-ocean-sea-ice model that is also used for weather forecasting. The model is known to over-predict sea-ice extent in summer, so the average amount of over-prediction for the last 10 years (the so-called bias) of the raw model output has been subtracted to arrive at the number contributed. This bias removal is standard procedure in seasonal forecasting.	Initial conditions for the forecast are from the ECMWF operational atmosphere, ocean, and sea-ice analyses. 51 ensemble members are run, constructed from an ensemble of 5 3DVAR-FGAT analyses in the ocean sea-ice, and from an ensemble of 25 4DVAR analyses with singular-vector perturbations added/subtracted for the atmosphere. The resolution of the atmospheric model is about 35km, and about 15km for the ocean/sea-ice model in the Arctic. The September monthly-mean sea-ice extent for the Northern hemisphere is calculated for each ensemble member, and then the ensemble mean is calculated to arrive at the raw forecast value of 5.68 Mio sqkm). A set of re-forecasts of montly-mean September sea-ice extent for 2008-2017 is compared to the NSIDC sea-ice extent for September to estimate the forecast bias as +0.75 Mio sqkm), which is then subtracted from the raw forecast to arrive at the calibrated forecast of 4.93 Mio sqkm that has been submitted as a contribution.	initial sea-ice concentration is from OCEAN5, the ECMWF operational ocean/sea-ice analysis. OCEAN5 assimilates observed sea-ice concentration from OSTIA, which is a level-4 observational product derived from the OSI-SAF level-3 sea-ice concentration product OSI-401b.	Initial sea-ice thickness is from OCEAN5, the ECMWF operational ocean/sea-ice analysis. SEAS5 does not assimilate any sea-ice thickness observations.
Slater-Barrett, NSIDC	Statistical		4.97							This projection was made using the Slater Probabilistic Ice Extent model developed by Drew Slater (http://cires1.colorado.edu/~aslater/SEAICE/). The model computes the probability of sea ice concentration greater than 15% for Arctic Ocean grid cells in the EASE 25 km grid. These probabilities are aggregated over the model domain to arrive at daily ice extents. A September mean ice extent is calculated from daily forecasts issued on July 1. While the model has predictive skill at lead times up to 90 days, NSIDC runs the forecast model with a 50 day lead time. Forecasts issued on July 1 for September have lead times spanning 62 to 91 days. Therefore we consider the mean September ice extent forecast for the May sea ice outlook to have very little skill. Subsequent forecasts for June and July will have improved skill.	This is a non-parametric statistical model of Arctic sea ice extent. The model computes the probability of whether ice concentration greater than 15% will exist at a particular location for a particular lead time into the future, given current ice concentration. The only input is sea ice concentration. Probabilities are computed using data from the past 10 years. These probabilities are adjusted using daily near-real-time concentrations to make a forecast. Pan-Arctic Ice extent is the sum of the product of grid-box area the probability of a grid-box containing ice on the forecast date. While not as sophisticated as a coupled ocean-ice-atmosphere models, this statistical method has the advantage that the forecasts for all points are completely independent in both space and time; that is, the forecast at any given point is not affected by its neighbors, nor its result from the prior day. Therefore, the model can adapt to changing conditions and is not inherently subject to drift. The model has performed well in comparison to others in the 2013/2014 SIPN Outlooks, in both extent value and spatial distribution. For 2012, a September mean forecast of below 4 million square kilometers was given. However, the model has also missed by as much as 0.6 million square kilometers in some years. Forecasting is difficult, but the model does have genuine skill at lead times as long as 90 days. Skill improves as lead time decreases, and September is the month with highest skill.	NSIDC NASA Team, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM	
Walt Meier, NSIDC	Statistical		4.98	18.05				0.55	Standard deviation of projection extents using 2005-2017 rates.	This method applies daily ice loss rates to extrapolate from the start date (July 1) through the end of September. Projected September daily extents are averaged to calculate the projected September average extent. Individual years from 2005 to 2017 are used, as well as averages over 1981-2010 and 2005-2017. The 2005-2017 average daily rates are used to estimate the official submitted estimate. The predicted September average extent for 2018 is 4.98 (±0.55) million square kilometers. The minimum daily extent is predicted to be 4.86 (±0.55) million square kilometers and occurs on 14 September. This is a substantial increase from the June submission of 4.38 and 4.27 million square kilometers for the monthly average and daily minimum respectively. This reflects slow retreat during the month of June. The range of the estimates dropped from 0.70 to 0.55 million square kilometers, which reflects the one month shorter time period of variability in ice loss rates over the rest of the melt season. None of the rates based on the last 13 years indicate that this year will be lower than the record-low extent of 2012. Thus, there is little chance that 2018 will be lower than the current record low extent of 2012. Using the same method, the predicted Antarctic average extent for 2018 is 18.05 (±0.57) million square kilometers. The maximum daily extent is predicted to be 18,18 (±0.61) million square kilometers and occurs on 29 September. These are slightly higher than projected in June.	This method applies daily ice loss rates to extrapolate from the start date (June 1) through the end of September. Projected September daily extents are averaged to calculate the projected September average extent. Individual years from 2005 to 2017 are used, as well as averages over 1981-2010 and 2005-2017. The 2005-2017 average daily rates are used to estimate the official submitted estimate. The method essentially provides the range of September extents that can be expected based on how the ice has declined in past years, though it is possible that record fast or slow daily loss rates may yield a value outside the projected range. It also can provide a probability of a new record by comparing how many years of loss rates yield a record relative to all years. It has the benefit that it can easily and frequently (daily if desired) be updated to provide updated estimates and probabilities and as the minimum approaches the "window" of possible outcomes narrows.	Maslanik, J. and J. Stroeve. 1999, updated daily. Near-Real-Time DMSP SSMIS Daily Polar Gridded Sea Ice Concentrations, Version 1. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: https://doi.org/10.5067/U8C09DWVX9LM. Fetterer, F., K. Knowles, W. Meier, M. Savoie, and A. K. Windnagel. 2017, updated daily. Sea Ice Index, Version 3. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. doi: https://doi.org/10.7265/N5K072F8.	
Alek Petty, NASA-GSFC	Statistical		4.99	18.4	0.6			0.4	The uncertainty represents one standard deviation of the 2018 prediction interval.	Based on an analysis of May sea ice concentration data provided by the NSIDC (NASA Team, NRT), I forecast a 2018 September Arctic sea ice extent of 4.98 +/- 0.40 M km2. The forecast does not suggest a new record low September extent will be reached in 2018 (lower than the 3.62 M km2 observed in 2012). Due to the historical weighting scheme, the record low sea ice conditions in Bering Strait and around Svalbard are not being included, so the forecast should be treated with caution!	In this statistical forecast system we use sea ice concentration (SIC) data (1979-present day), derived from passive microwave brightness temperature using the NASA Team algorithm. The SIC data are detrended spatially using linear trend persistence (from the given forecast year) then averaged using a simple weighting scheme by correlating with historical SIE, to generate a detrended SIC dataset. A least-squares linear regression model is fit from the mean detrended SIC/SIE data. To produce the SIE forecast, the relevant monthly mean/detrended SIC data are applied to the linear regression model. See the original paper (http://alekpetty.com/papers/petty2017.html) for more details.	NSIDC NRT NASA Team SIC data, https://nsidc.org/data/nsidc-0081	
CNRM	Dynamic Model	Coupled dynamical models	4.99	17.83		Arctic: 5.03; Antarctic: 17.83	Arctic min-max: 4.50-5.49; Arctic 25%-75%: 4.81-5.13; Antarctic min-max: 16.60-18.60; Antarctic 25%-75%: 17.67-18.11	Arctic: 0.25; Antarctic: 0.36	Statistics are based on the 51-member ensemble.	This outlook has been run with Meteo France "System 6" global seasonal forecasting system. This system is based on CNRM-CM6 global climate model developed by CNRM and CERFACS and on ocean-sea ice initial conditions produced by Mercator Ocean.	This outlook is a model estimate based on a dynamical ensemble forecast with CNRM-CM global coupled model, initialized from atmospheric states from ECMWF operational analysis and ocean-sea ice states derived from Mercator Ocean operational analysis for a few days before 1 July 2018. A 51-member ensemble is generated by adding statistical perturbations during the simulation.	Initial conditions for the ocean and sea ice (including concentration and thickness) are provided by Mercator Ocean. Basis is the Mercator Ocean operational analysis (NEMO-LIM2+SAM ocean data assimilation system, 1/4° resolution). The 1/4° analysis is upscaled to the 1° horizontal grid of CNRM-CM model. These fields are used to nudge the ocean-sea-ice component of CNRM-CM (NEMO-GELATO6, 1° resolution) run in forced mode (driven by ECMWF operational analysis). Sea ice fields (SIC, SIT,...) from this 1° "initialization run" are used to initialize the coupled model (as well as ocean fields from this run). A strong restoring is applied	See above (same as SIC).
Modified CanSIPS	Dynamic Model	Coupled dynamical models	5.17			5.14	min=4.25, max=6.01	1 standard deviation = 0.41, uncertainty = ±0.81 (ie. 1.96*0.41)	The uncertainty values were calculated from the ensemble of 20 fcst SIE anomalies after adding the NSIDC climo of 6.5 m sq km	Our Outlook of forecast total Arctic sea ice extent (SIE), post-processed Ice-Free-Date (IFD) and Freeze-up-Date (FUD), and post-processed sea ice probability (SIP) was produced using the Canadian Seasonal to Interannual Prediction System (CanSIPS), but (as in 2017) in a modified experimental mode intended to test several potential updates to the sea ice forecast methodology including changes to the data used to initialize both sea ice concentration (SIC) and sea ice thickness (SIT). Relative to our June 2018 contribution, our results indicate higher ice coverage than previously forecast and a shorter open-water season. Specifically, our mean SIE forecast value has increased from 4.44 to 5.17 million square kilometers, and our SIP and IFD/FUD forecasts respectively show greater probabilities for ice coverage and a shorter open-water season in the western Arctic.	CanSIPS combines forecasts from two models, CanCM3 and CanCM4, with a total of 20 ensemble members (10 from CanCM3, 10 from CanCM4). The Arctic SIE anomaly was calculated for each individual ensemble member relative to the 1981-2010 climatology for the respective model. These anomalies were then added to the NSIDC climatological value of 6.5 million square kilometers, and then averaged over all 20 ensemble members to yield a total SIE of 5.17 million square kilometers. The IFD/FUD is defined as the first date in the retreat season (April 1 to September 30) or advance season (October 1 to March 31) at which the grid box sea-ice concentration drops below/exceeds 50% and stays below/above that threshold for at least 10 days (more details in Sigmond et al GRL, 2016). The dates are bias corrected based on 1981-2010 hindcasts. For the SIP field, we first interpolated the raw SIC fields from the model grid onto a 1deg by 1deg regular grid, fit each grid point and each model SIC ensemble to the parametric zero and one inflated beta distribution. We then calibrated each distribution using 'trend-adjusted quantile mapping' (Dirkson et al., submitted to JClim), and calculated the probability that local SIC will exceed 15% (or equivalently SIP) directly from the calibrated parametric distribution. Lastly, the average was taken between CanCM3 and CanCM4 SIP estimates to produce the final SIP field.	SIC is initialized by nudging model SIC to the Meteorological Services of Canada (MSC) analysis with a 3 day time constant. Initial conditions for the June submission are from June 30 nudged SIC.	SIT was estimated using the statistical model 'SMv3' described in Dirkson et al., 2017 (doi:10.1175/JCLI-D-16-0437.1). The parameters in SMv3 were fit using PIOMAS SIC and SIT data over the period 2002-2017. The daily MSC SIC described above for June 30 was then used as the real-time predictor field in SMv3 to estimate real-time SIT.
Rob Dekker (individual)	Statistical		5.19					380 k km^2	Standard deviation of the residuals, as compensated with the use of three variables in the regression	My projection is based on an estimate of how much heat the Northern Hemisphere absorbs during spring and early summer. I use three variables (land snow cover, ice concentration, ice area) that are available in June, in a formula which shows particularly strong correlation with Sept sea ice extent. Regressed over the1992 - 2015 period, the formula projects 5.19 M km^2 for September 2018, with a standard deviation of 380 k km^2. Past performance of this June forecast method for September ice extent over the past 26 years shown in a graph here : https://forum.arctic-sea-ice.net/index.php?action=dlattach;topic=292.0;attach=104209;image The interesting finding is that the June land snow cover signal is clearly present in the September ice extent numbers, suggesting land snow cover could be used to improve other prediction methods as well.	The concept behind my method pertains to estimating albedo-based Arctic amplification during the melting season. I use the "whiteness" of the Arctic in June as a predictor for how much ice will melt out between June and September. Specifically, I set up a formula which reflects how "dark" areas near the Arctic in June would create heat that will melt out ice over the months until the September minimum. As an educated guess, such a formula could take the following form : Melt_formula = 0.25 * Snow - 1.0 * (Extent - Area) + 0.5 * Area With factors explained like this : For (Extent - Area): 1.0 (assuming that ALL solar radiation onto melting ice and into polynia will cause ice to melt later in the season. For (Area): 0.5 (assuming that half of the heat absorbed in the ocean OUTSIDE of the main pack will cause ice melt (while the other half would cause the ocean to warm up. For (snow cover): 0.25 (assuming that half the heat from lack of snow cover will be blown North, and half of that will go to ice melt. Then I set up a regression equation for how much ice will melt out between	NSIDC monthly June sea ice 'extent' and 'area' numbers : ftp://sidads.colorado.edu/DATASETS/NOAA/G02135/north/monthly/data/N_06_extent_v3.0.csv Rutgers Snow Lab Northern Hemisphere monthly land snow cover : http://climate.rutgers.edu/snowcover/table_area.php?ui_set=1&ui_sort=0	
Frank Bosse	Mixed		5.2			5.2 Mio km²	+/- 0.5 Mio km²		It's the standard deviation of the residuals estimations-observed NSIDC september SIE 1979...2017	see https://www.arcus.org/files/sio/27252/sio2017_june_bosse.pdf	Just as in the four years before I calculate the value for the September-minimum of the arctic sea ice extent of the year n (NSIDC monthly mean for September) from the mean temperature (0...700m depth) northward 65°N during JJAS of the year n-1.	https://climexp.knmi.nl/data/iodc_temp700_0-360E_65-90N_n.dat	

FIO-ESM (Qiao et al.)	Dynamic Model	Coupled dynamical models	5.2							Our prediction is based on FIO-ESM (the First Institute of Oceanography-Earth System Model) with data assimilation. The prediction of September pan-Arctic extent in 2018 is 5.2 (+/-0.5) million square kilometers. 5.2 and 0.5 million square kilometers is the average and one standard deviation of 10 ensemble members, respectively.	This is a model contribution. The initialization is also from the same model (FIO-ESM) but with data assimilation. The data assimilation method is Ensemble Adjustment Kalman Filter (EAKF). The data of SST (sea surface temperature) and SLA (sea level anomaly) from 1 January 1992 to 1 July 2018 are assimilated into FIO-ESM model to get the initial condition for the prediction of the Arctic Sea Ice. There is no sea ice data assimilation.	No dataset are used for initial sea ice concentration.	No dataset are used for initial sea ice thickness.
AWI consortium (Kauker et al.)	Dynamic Model	Ocean-sea ice dynamical models	5.2					0.14	Ensemble spread of the forcing years 2008 to 2017 used by the sea ice - ocean model (from July 8 to end of September).		For the present outlook the coupled ice-ocean model NAOSIM has been forced with atmospheric surface data from January 1948 to July 8th 2018 (combination of NCEP/NCAR and NCEP-CFSR and NCEP CFSv2). All ensemble model experiments have been started from the same initial conditions on July 8th 2018. The model setup has not changed with respect to the SIO in 2015. We used atmospheric forcing data from each of the years 2008 to 2017 for the ensemble prediction and thus obtain 10 different realisations of potential sea ice evolution for the summer of 2018. The use of an ensemble allows to estimate probabilities of sea-ice extent predictions for September 2018. A variational assimilation system around NAOSIM has been used to initialize the model using the Alfred Wegener Institute's CryoSat-2 ice thickness product, the University of Bremen's snow depth product, and the OSI SAF ice concentration and sea-surface temperature products. Observations from March and April were used. A bias correction scheme for the CryoSat-2 ice thickness which employs a spatially variable scaling factor could enhance the skill considerably (Kauker et al, 2015, http://www.the-cryosphere-discuss.net/tc-2015-171/).	OSI SAF EUMETSAT OSI-401 March and April 2018	CryoSat-2 from Alfred-Wegener Institute of March and April 2018