June Sea Ice Outlook Key Statements

Contributor	Type	Dynamic Model Type	Arctic Extent	Antarctic Extent	Alaska Extent	Median	Ranges	Standard Deviation	Estimate Summary	Executive Summary	Method Summary	Sea Ice Concentration Data	Sea Ice Thickness Data
Morison	Heuristic		3.4					1 million sq km	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 RonKwok, 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 NOAAAO record	
MPAS-CESM	Dynamic Model	Coupled dynamical models	4.0	17.7	0.3	3.3, 17.6, 0.23 (Arctic, Antarctic, and Alaska)	3.1-5.8, 17.6-17.9, 0.1-0.6 (Arctic, Antarctic, and Alaska)		Experimental IC ensemble, perturbing atmosphere (GFS at several resolutions, GEFS) or other components (CESM-LE members).	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, the sampled uncertainty is remarkable. Perturbing the initial atmosphere creates a difference of ~3 M sq. km while using a different climate member to initialize the other components is ~1/10th of that. With the drivers of this variability a focus, note that the differences in the summer (JJA) mean atmospheres are global in scale, requiring a coupled system perspective for consistency.	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 2018-05-31 and the other components startup from a spun-up restart of CESM Large Ensemble member 020 in 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 degree) and using GEFS member 1 (available at 1 degree on nomads). An additional non-atmospheric IC ensemble member is from using CESM-LE member 005 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 020 and 005, using 2021-05-31.	Restarts of CESM Large Ensemble members 020 and 005, using 2021-05-31.
Gavin Cawley	Statistical		4.15			4.15	3.04 - 5.26 (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.	
Sean Horvath, NSIDC	Statistical		4.16							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, April monthly mean surface air temperature and geopotential height at 500hpa, May sea ice concentration, and a trend index. This model predicts a minimum September sea ice extent of 4.16 million square km 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.	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	
Muyin Wang	Heuristic		4.2							empirical	empirical		
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.
Grimm	Statistical		4.26					+/- 1.09	There is little expected skill at this point, as ocean temperature and ice thickness are large influencing factors 3 months out.	This method utilizes and compares three regression techniques, described as follows: (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 (+/-1.09) 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 (+/- 1.09) million square kilometers; and, (3.) A short-term, quadratic regression of daily-observed Arctic sea ice extent values from April 1, 2018 - June 9 2018. The short-term quadratic regression, is used to estimate a September 2018 extent of 3.19 (+/- 0.84) million square kilometers.	Figure 6, from the 2017 June Report -- ("Arctic Sea Ice Extent: time-series": https://www.arcus.org/files/resize/sio/27252/sio2017_june_fig6_combined-700x335.jpg), strongly suggests a quadratic regression pattern. Over the next three months, with the addition of daily-observations of Arctic sea ice extent, I believe the short-term quadratic regression (3.) will prove to be a fairly accurate predictor of September 2018 extent. At this time, there simply is not enough data, which is why the short-term quadratic regression was ignored in this analysis. Instead, the average of the long-term linear and quadratic regressions (1. and 2.) was used, and a predicted value of 4.26 (+/- 1.09) million square kilometers was ultimately determined.	ftp://sidads.colorado.edu/DATASETS/NOAA/G02135/	
Nico Sun	Statistical		4.3			4.3	3.66-4.93	1.28		The forecast model is based on a global surface radiation model and uses arctic albedo to calculate daily sea ice area and volume losses. The average error for the hind-cast (2007-2016 period) is 0.147 million km2 for daily minimum sea ice area. In the future it will be used as a reference for machine learning forecasts.	The forecast model treats the sea ice as a single ice cube with a start volume using PIOMAS and start surface using NSIDC Area. For each day during the astronomical summer the model calculates volume and area losses. The losses are mainly calculated by defining the (Extent - Area) area number as an active melt area. From the extent value the model derives a latitude for the active melt area and using the solar energy reaching the surface at this latitude the model calculates the daily volume and area loss. In June / July the northern hemisphere snow cover contributes losses as well. Ice volume change from the atmospheric temperature is approximated over the DMI 80N temperature. Calculation up to the model run date is a hind-cast based on observed values (Area/Extent) and the forecast uses historical compaction ratios.	NSIDC NASA Team, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM	PIOMAS, 20th March 2018
McGill (Tremblay et al.)	Statistical		4.31					0.48 million sq km	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).		
Walt Meier	Statistical		4.38	17.77				0.7 million sq km	Standard deviation of the projections from the 13 years (2005-2017).	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 predicted September average extent for 2018 is 4.38 (±0.70) million square kilometers. The minimum daily extent is predicted to be 4.27 (±0.70) million square kilometers and occurs on 14 September. The large range of estimates reflects the large variability in ice loss rates over the final 3+ months of the melt season. Based on the last 13 years, there is an 8% 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 17.77 (±0.61) million square kilometers. The maximum daily extent is predicted to be 17.88 (±0.65) million square kilometers and occurs on 24 September.	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.	NASA Team algorithm extents from the NSIDC Sea Ice Index, Version 3 (http://nsidc.org/data/seaice_index/). 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.	
Dmitri Kondrashov (UCLA)	Statistical		4.39		0.5					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 stochastic MSLM model is initialized from latest SIE conditions (June 2018) by ensemble of white 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		
Dr. Monica Ionita, Dr. Klaus Grosfeld	Statistical		4.4			4.4	Lower uncertainty bound: 3.7, Upper uncertainty bound: 5.1			Sea ice in both Polar Regions is an important indicator for the expression of global climate change and its polar amplification. Consequently, a broad information interest exists on sea ice, its coverage, variability and long-term change. Knowledge of sea ice requires high-quality data on ice extent, thickness, and its dynamics. As an institute on polar research we collect data on the Arctic and Antarctic sea ice, investigate its physics and role in the climate system and provide model simulations on different time scales. All this data is of interest for science and society. In order to provide insights into the potential development of the seasonal signal, we developed a robust statistical model based on ocean heat content, sea surface temperature, and atmospheric variables to calculate an estimate of the September minimum sea ice extent for every year. T	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	
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.	

Contributor	Type	Dynamic Model Type	Arctic Extent	Antarctic Extent	Alaska Extent	Median	Ranges	Standard Deviation	Estimate Summary	Executive Summary	Method Summary	Sea Ice Concentration Data	Sea Ice Thickness Data
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.
Modified CanSIPS	Dynamic Model	Coupled dynamical models	4.44			4.56	min=2.99, max=5.09	1 standard deviation = 0.52, uncertainty = ±1.02 (ie. 1.96*0.52)	The uncertainty values were calculated from the ensemble of 20 fcst SIE anomalies after adding the NSIDC climo of 6.5e6 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. These updates include changes to the data used to initialize both sea ice concentration (SIC) and sea ice thickness (SIT), as well as the methodology to produce probabilistic SIC forecasts.	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 4.44 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 zero and one inflated beta distribution the parametric 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.	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 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 May 31 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 May 31st was then used as the real-time predictor field in SMv3 to estimate real-time SIT.
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.	
Xingren Wu and Robert Grumbine	Dynamic Model	Coupled dynamical models	4.58	19.16				0.66 million sq km for the Arctic and 0.29 million sq km for the Antarctic		The projected Arctic minimum sea ice extent from the NCEP CFSv2 model with revised CFSv2 May initial conditions using 31-member ensemble forecast is 4.58 million square kilometers with a standard deviation of 0.66 million square kilometers. The corresponding number for the Antarctic is 19.16 million square kilometers with a standard deviation of 0.29 million square kilometers.	We ran the NCEP CFSv2 model with 31-case of May 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-May 31, 2018)	NCEP CFSv2 model guess with bias correction for the Arctic (May 1-May 31, 2018)
UNCW (McNamara & Wagner)	Statistical		4.61							We use a so-called genetic algorithm to predict the September sea ice extent. The algorithm is based on a non-linear forecasting technique that focuses on past system behavior to predict future states. As input to the algorithm we provide following variables: 1) Sept sea ice extent of the past 2 years, 2) May sea ice extent this year (2018), 3) mean Surface Air Temperature over the past year (June - May), measured at 6 Arctic Meteorological stations, and 4) mean SST north of the Arctic circle over the past year (June - May). Following a set of 'genetic' rules, and training itself on the 35-year time period from 1983-2017 (when data of all 4 variables is available), the algorithm identifies a combination of the variables that best predicts future Sept sea ice extents. The algorithm identifies the following map as most predictive: SIE(t) = 0.89*(SIE(t-1)-0.64) + SIE(t-2) / ((SST(t)+SIE(t-1))*SIE(t-1)/SIE(t-2)). Here t is the year (in this case 2018), SIE is Sept sea ice extent, and SST is Arctic mean sea surface temperature (June 201-May 2018). The first term represents a linear trend from the previous trend (89% of last year's SIE with 0.64 loss, in million km^2). The second term is an adjustment that depends on SST (and previous Sept SIE). As SST gets larger (warmer), the denominator in the second term gets larger, thus making the fraction smaller, and the amount added to the first term decreases. We note that this map does not make use of May 2018 sea ice conditions (nor SATs).	The algorithm relies on the deterministic nature of the system dynamics (as opposed to dynamics dominated by noise). This aspect of determinism can be expressed by relating values of the time series at a time t, to previous values in the time series through a nonlinear map (Takens, Springer, 1981). The map function is typically not known a priori and a systematic search through all possible map functions is not feasible. A genetic algorithm has been proposed as a tool that looks for such a map function (Szpiro, Phys Rev E, 1997; Lopez et al, PRL, 2000). The genetic algorithm optimizes the accuracy of possible prediction equations by evolving a group of potential solutions for the map function and selecting those that best represent the observed data. More specifically, the genetic algorithm produces an initial population of solutions and then tests them on the data to see how accurately they predict changes. Those with the best prediction accuracy, or fitness, are copied and then allowed to reproduce with their choice of mate equations left in the population of solutions, while those with the worst fitness are discarded. Mutations occur in a fraction of the reproduced equations. These steps are repeated until an equation is found that optimizes predictability. Previously, the genetic algorithm has been successfully applied to predicting an artificially generated chaotic time series and to predicting the occurrence of sunspots in a physical data set. Other natural time series that have been predicted with this technique include summer rainfall over India (Kishtawal et al., GRL, 2003), Indian Ocean wave heights (Basu et al. , GRL, 2005), and coastline change (Grimes et al., Chaos, 2016). Here we explore the algorithm's ability to forecast the September sea ice extent.	We didn't use SIC fields, only the monthly Sea Ice Index.	
NCEP CPC	Dynamic Model		4.63		0.85			0.24	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 (https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM.")	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 (https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM.")
Rob Dekker	Statistical		4.65					470 thousand sq km	Standard deviation of the residuals after regression.	For this projection, I use three variables that affect albedo of the Arctic in May, to predict Sea Ice Extent in September : Land snow cover, sea ice 'area' and sea ice 'extent'. I use Extent-minus-Area as a metric to estimate the presence of open water such as leads and melt ponds. I regress the combination of these three variables against known September extent data over the 1992-2015 period. This method is based on the physics of albedo amplification during summer, and obtains a 0.47 million km2 standard deviation in the prediction, which is better than most other methods, albeit not that much better than a simple "linear trend" prediction. June prediction will be much better than that. An important finding is that spring land snow cover signal is clearly present in the September Arctic sea ice extent.	For this projection, I use three variables that affect albedo of the Arctic in May, to predict Sea Ice Extent in September. I use land snow cover data from the Rutgers Snow Lab, as well as the NSIDC May sea ice Area, as well as NSIDC Extent-minus-Area as a metric to estimate the presence of open water such as leads and melt ponds. I regress the combination of these three variables against known September extent data over the 1992-2015 period. This method is based on the physics of albedo amplification during summer, and obtains a 0.47 million km2 standard deviation in the prediction, which is better than most other methods, albeit not that much better than a simple "linear trend" prediction. June prediction will be much better than that. An important finding is that spring land snow cover signal is clearly present in the September Arctic sea ice extent.	Monthly NSIDC sea ice extent and area from : ftp://sidads.colorado.edu/DATASETS/NOAA/G02135/north/monthly/data/ Monthly Northern Hemisphere land snow cover from Rutgers Snow Lab from here : https://climate.rutgers.edu/snowcover/table_area.php?ui_set=1&ui_sort=0	
CNRM	Dynamic Model	Coupled dynamical models	4.66	17.2		Arctic : 4.67 ; Antarctic : 1	Arctic min-max : 4.09-5.38 ; Arctic 25%-75% : 4.37-4.95 ; Antarctic min-max : 16.50-17.76 ; Antarctic 25%-75% : 16.94-17.46	Arctic : 0.33 ; Antarctic : 0.34	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 June 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 near	Sea above (same as SIC).

Contributor	Type	Dynamic Model Type	Arctic Extent	Antarctic Extent	Alaska Extent	Median	Ranges	Standard Deviation	Estimate Summary	Executive Summary	Method Summary	Sea Ice Concentration Data	Sea Ice Thickness Data
Lamont (Yuan et al.)	Statistical		4.71	18.68	0.54				We use RMSE between predicted (from cross-validate model experiments) and observed SIE to assess uncertainty.	Executive Summary: 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 4.71 million square kilometers with an RMSE of 0.48 million square kilometers, at the four-month lead. It is slightly below the September SIE in 2017. Similar statistical models were also developed to predict the SIE in the Alaskan region and the Antarctic. The September mean pan Antarctic SIE is predicted to be 18.68 million square kilometers with an RMSE of 0.57 million square kilometers. The Alaskan regional SIE is predicted to be 0.54 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 six 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 developed 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 four-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 four-month lead prediction of the pan-Arctic sea ice extent in September is 0.87 with an RMSE of 0.48 million square kilometers. The Alaskan regional SIE prediction is produced by a regional linear Markov model developed by using SIC, SST, SAT, GPH, and winds at 500mb and 200mb, and in a rotated-EOF space (Li et al., in revision). 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).	Sea ice concentration data are from NSIDC NASA Team, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM. Sea surface temperature data are from NOAA NCDC ERSST version3b sst: Extended reconstructed sea surface temperature data, http://iridl.ldeo.columbia.edu/expert/SOURCES/.NOAA/.NCDC/.ERSST/.version3b/.sst/ Atmospheric variables are obtained from ERA-interim reanalysis data, http://apps.ecmwf.int/datasets/data/interim-full-moda/levtype=sfc/	
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).
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 Sounder (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.
Slater, Barrett, NSIDC	Statistical		4.91							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 June 1 for September have lead times spanning 92 to 121 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.	None
GFDL/NOAA, Bushuk et al.	Dynamic Model	Coupled dynamical models	4.93		0.14	4.92	4.19-5.85	0.58	These statistics are computed using our 12 member prediction ensemble.	Our June 1 prediction for the September-averaged Arctic sea-ice extent is 4.93 million km^2, with an uncertainty range of 4.19-5.85 million km^2. 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 June 1 initialization, see attached pdf.	No SIC data is explicitly used in our initialization procedure.	No SIT data is explicitly used in our initialization procedure.
Alek Petty, NASA-GSFC	Statistical		4.98	18.51	0.53			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	
FIO-ESM (Qiao et al.)	Dynamic Model	Coupled dynamical models	5.11							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 5.11 (+/-0.34) million square kilometers. 5.11 and 0.34 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 June 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.
RASM (Kamal et al.)	Dynamic Model		5.12		0.45			0.305 million sq km	The uncertainty was estimated as the ensemble standard deviation.	We used RASM201, 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 parametrization scheme, with shallow cumulus convection only turned on over the ocean grid.	For the June forecast we used one root case laterally-forced with CFSR to generate the initial conditions for all 31 ensemble members starting at time 0000 on June 1, 2018. The root case is a hindcast forced from September 1979 through the end of May 2018, generating internally- and physically-consistent initial conditions for all ensemble member forecasts. Each of the 31 ensemble members ran forward for 6 months using outputs from CFSv2. The CFSV2 forcing streams used for the ensemble members were initialized everyday (at 0000) between May 1st and May 31st, and used for RASM forcing at time 0000 on June 1st 2018	Self-generated from a 39 year hindcast run.	Self-generated from a 39 year hindcast run.
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/inodc_temp700_0-360E_65-90N_n.dat	
AWI consortium (Kauker et al.)	Dynamic Model	Ocean-sea ice dynamical models	5.27					0.19 million sq km			For the present outlook the coupled ice-ocean model NAOSIM has been forced with atmospheric surface data from January 1948 to June 5th 2018 (combination of NCEP/NCAR and NCEP-CFSR and NCEP CFSv2). All ensemble model experiments have been started from the same initial conditions on June 5th 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
CPOM	Statistical		5.3					+/- 0.5 million sq km	The given uncertainty is the mean forecast error based on forecasts for the years 1984 to 2016.	Based on May melt pond fraction we predict a mean 2018 September ice extent of 5.3 (4.8 to 5.8) mill km2. This would be the largest September ice extent since 2006. The likehood for a new record minimum is below 1%. According to our model simualtions, pond formation has been weak in most regions of the Arctic, in particulary along the Siberain coast.	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.		

Contributor	Type	Dynamic Model Type	Arctic Extent	Antarctic Extent	Alaska Extent	Median	Ranges	Standard Deviation	Estimate Summary	Executive Summary	Method Summary	Sea Ice Concentration Data	Sea Ice Thickness Data
NRL-NESM	Dynamic Model	Coupled dynamical models	5.9	20.4	0.94	5.9 Mkm^2	5.2 - 6.8 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 is 5.9 million km^2. This projection is the average of a 10 member time-lagged ensemble using initial conditions from 1 May to 10 May 2018. The range of the ensemble is 5.2 to 6.8 million km^2. The projected Alaskan Regional 2018 September mean sea ice extent is 0.94 million km^2 with an ensemble range from 0.32 to 1.18 million km^2. The projected Antarctic 2018 September mean sea ice extent is 20.4 million km^2 with an ensemble range from 19.7 to 20.9 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 2018-05-01 12Z through 2018-05-10 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.