June 2020 Sea Ice Outlook Key Statements

Contributor	Type	Dynamic Model Type	Arctic Extent	Median	Standard Deviation	Range	Arctic Minimum	Arctic Maximum	Antarctic Extent	Antarctic Minimum	Antarctic Median	Antarctic Maximum	Alaska Extent	Possible Max Extent	Estimate Summary	Executive Summary	Method Summary	Sea Ice Concentration Data	Sea Ice Thickness Data	Processing Description
University of Washington/APL	Dynamic Model	Dynamic model: Pan-Arctic Ice-Ocean Modeling and Assimilation System (PIOMAS, Zhang and Rothrock, 2003), with coupled sea ice and ocean model components. The ocean model is the POP (Parallel Ocean Program) model and sea ice model is the thickness, floe size, and enthalpy distribution (TFED) model (Zhang et al., 2016). Atmospheric forcing is from the NCEP Climate Forecast System (CFS) version 2 (Saha et al., 2014) hindcast and forecast. .	3.2													Driven by the NCEP CFS forecast atmospheric forcing, PIOMAS is used to predict the total September 2020 Arctic sea ice extent as well as ice thickness field and ice edge location, starting on June 1. The predicted September ice extent is 3.20¬± 0.40 million square kilometers. The predicted ice thickness fields and ice edge locations for September 2020 are also presented.	The PIOMAS forecasting system is based on a synthesis of PIOMAS, the NCEP CFS hindcast and forecast atmospheric forcing, satellite observations of ice concentration and sea surface temperature (SST), and CryoSat2 observations of sea ice thickness. 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 seasonal 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 SST data through the end of May 2020 using the CFS hindcast forcing data. We also assimilated CryoSat2 ice thickness available to April 2020. After the retrospective simulation (hindcast), 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).	Satellite sea ice concentration data (NASA team) for data assimilation in hindcast.	CryoSat2 sea ice thickness up to 4/2020 for data assimilation in hindcast.	
GFDL/NOAA (Bushuk et al.)	Dynamic Model	GFDL-FLOR	3.5	3.47	0.2	3.26-3.93	3.26	3.93					0.14	3.8	These statistics are computed using our 12 member prediction ensemble.	Our June 1 prediction for the September-averaged Arctic sea-ice extent is 3.50 million square km, with an uncertainty range of 3.26-3.93 million square km. 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), Bushuk et al. (2017), and Bushuk et al. (2018). For an evaluation of the model's September sea ice extent prediction skill from a June 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.	These forecasts are bias corrected based on an additive correction using a suite of retrospective forecasts spanning 1980-2019.
ANSO IAP-LASG	Dynamic Model	CAS-FGOALS-f2 (Atmospheric component: FAMIL2 ; Ocean component: POP; Sea ice component: CICE4; Land component: CLM4) Horizontal resolutions: Approximately 1¬∞ Initial methods: A nudging scheme to assimilate wind components (U and V), Temperature (T) in atmosphere and potential temperature in ocean	3.8	3.4	0.4	2.2-4.2	2.2	4.2							The uncertainty was estimated by the ensemble member spread.	The prediction for the sea ice outlook June 2020 was carried out on China‚Äôs Tianhe-2 supercomputer, with a dynamic model prediction system CAS FGOALS-f2 S2S V1.3 . 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 three major national operational prediction centers in China. Basing on the 4-month lead dynamic model prediction from June 9th, 2020 the outlook predictions of Sea Ice Extent are 3.8 million square kilometers for pan-Arctic in September 2020.	FGOALS-f2 S2S V1.3 is a global coupled dynamic prediction system. The initialization of this prediction system is based on a nudging scheme, which assimilates wind components (U and V), Temperature (T) in atmosphere and potential temperature in ocean from 1 Jan 1980 to 9 June 2020, and 48 ensemble members are generated by a time-lag method. The predictions are available here for 12 months. This real-time S2S prediction system is fully operated on China, Tianhe-2 supercomputer.			Model bias that is removed is calculated based on 2019 retrospective forecasts and corresponding observations.
CPOM	Statistical		3.8		0.5										Mean forecast error based on forecasts for the years 1984 to 2019.	We predict the September ice extent 2020 to be 3.8 (3.3-4.3) million km2. This is the lowest prediction we have made based on spring melt pond fraction. The likehood is around 30% that this September extent will be a new minimum record. In our model simulation since 1979, May 2020 has the highest mean melt pond fraction for May including some unprecedented melt pond formation in the Central Arctic during 15-18 May when air temperature exceeded 0deg C.	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., Schr√∂der, 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. Schr√∂der 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.			See references in Section 6.
McGill Team	Statistical		3.89												RMSE = 0.46 million km2. We compare hindcasts to the observed mean September sea ice extent for the 1993-2019 period.	Our research focuses on seasonal predictability of sea ice in the Arctic Ocean, using observations-based approaches. We are interested in the winter preconditioning effect on the pack ice before the summer melt. Specifically, we investigate how dynamic processes affect preconditioning, in other words, we ask how anomalies in the general circulation of sea ice will influence later conditions of the Arctic Ocean pack ice under a typical melt season. We investigate the skill of different sea ice predictors, including atmospheric forcing parameters that physically connect to wintertime sea ice dynamics. The dovekSIE method builds on the correlation between winter Fram Strait sea ice export and the following September minimum sea ice extent, presented in Williams et al., 2016. A positive anomaly of the winter Fram Strait sea ice export is associated with enhanced circulation of ice through the Transpolar Drift Stream and positive anomalies of coastal divergence of sea ice along the Eurasian coastlines. Increased coastal divergence late in the winter causes anomalies of younger and thinner ice in the peripheral seas, which is more vulnerable to melting in the summer. The dovekSIE forecasts are generated using the sea level pressure difference between Greenland and Svalbard as a proxy for area of ice exported through Fram Strait. Sea ice tends to flow parallel to isobars and the pressure difference across Fram Strait correlates with sea ice export (r=0.44). Sea level pressure fields are available in near-real-time and therefore enable the continuous update of dovekSIE forecasts during winter via the web app. We are supporting the activities of the Sea Ice Prediction Network with great enthusiasm. This is our fourth contribution to the Sea Ice Outlook.	The dovekSIE prediction for the 2020 monthly mean September ice extent is 3.89 million square kilometers. The dovekSIE prediction is computed as a sum of the linear trend (climatology) and departure from the trend (interannual variability). We take the long-term linear trend in a time series of the monthly mean September sea ice extent over the 1993-2019 period. A negative departure from the trend is projected for the 2020 September monthly mean sea ice extent. We use the integrated sea level pressure difference across Fram Strait from November 1 to May 31 in a linear least squares fit model as a predictor for the anomaly of monthly mean September sea ice extent.	Sea ice concentration is not used as an initial condition (such as in a dynamical model). However, we use sea ice extent from the NSIDC Sea Ice Index V3 to fit our statistical model. https://doi.org/10.7265/N5K072F8		
Simmons, Charles	Statistical	This is a variant of Dekker's model. This is a simple linear regression on three variables from 1979 through 2020, used to predict NSIDC September montly sea ice extent: * May average northern hemisphere sea ice area (ftp://sidads.colorado.edu/DATASETS/NOAA/G02135/seaice_analysis/) * May average northern hemisphere snow area (https://climate.rutgers.edu/snowcover/table_area.php?ui_set=2) * May average atmospheric CO2 as measured at Moana Loa (https://www.esrl.noaa.gov/gmd/ccgg/trends/data.html)	3.949		0.495 million square kilometers										Standard Error of Linear Regression	The model used here assumes September sea ice extent is mostly based on three things: * the temperature of the ocean's and atmosphere, * the albedo of the earth and the energy it reflects away from the arctic, * weather patterns in August. Moana Loa CO2 measurements are used as a proxy for the temperature of the Earth. The northern hemisphere snow and ice area are used as a proxy for the amount of energy reflected away from the arctic. The residual error is assumed to be due to weather patterns in August that we don't know how to predict.	This is a variant of Dekker's model. This is a simple linear regression on three variables from 1979 through 2020, used to predict NSIDC September montly sea ice extent: * May average northern hemisphere sea ice area (ftp://sidads.colorado.edu/DATASETS/NOAA/G02135/seaice_analysis/) * May average northern hemisphere snow area (https://climate.rutgers.edu/snowcover/table_area.php?ui_set=2) * May average atmospheric CO2 as measured at Moana Loa (https://www.esrl.noaa.gov/gmd/ccgg/trends/data.html)			None
CPOM UCL (Gregory et al.)	Statistical		3.96		0.34										Forecasts are Gaussian distributions. Forecast repsents the mean, and uncertainties are given by the standard deviation	This statistical model computes a forecast of pan-Arctic September sea ice extent . Monthly averaged May sea ice concentration and sea surface temperature fields between 1979 and 2020 were used to create a climate network (based on the approach of Gregory et al 2020). This was then utilised in a Bayesian Linear Regression in order to forecast September extent. The model predicts a pan-Arctic extent of 3.96 million square kilometres. Sea ice concentration data were taken from NSIDC (Cavalieri et al., 1996; Maslanik and Stroeve,1999). Sea surface temperature data were from ERA5 reanalysis.	Monthly averaged May sea ice concentration (SIC) data between 1979 and 2020 were used to create a May SIC climate(complex) network, and similarly for sea surface temperature (SST). Individual SIC(SST) grid cells were first clustered into regions of spatio-temporal homogeneity by using a community detection algorithm (see Gregory et al, 2020). Links between each of these network regions (covariance) were then passed into a Bayesian Linear Regression model to estimate on the prior distribution of the regression parameters. Subsequently a posterior distribution of the regression parameters was then derived in order to generate the forecast of September sea ice extent.	NSIDC NASA Team Sea Ice Concentrations: 1979 - 1987: Nimbus-7 SSMR 1987 - 2007: DMSP F-8, F-11, F-13 SSM/Is 2007 - 2018: DMSP F-18 SSM/I 2018 - 2020: Near-real time SIC		
Climate Prediction Center	Dynamic Model	Whole Model: CFSm5 Atmospheric component: NCEP GFS Oceanic component: GFDL MOM5	4.01	4.01	0.176	3.72-4.45	3.72	4.45					0.56		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 2007-2019 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 2007-2019 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	Twenty forecast members are produced. Model bias that is removed is calculated based on 2007-2019 retrospective forecasts.
Cawley, Gavin	Statistical	Gaussian Process Regression	4.0791	4.0791		2.9757 - 5.1825	2.9757	5.1825							Bayesian posterior predictive uncertainty from Gaussian Process	This is a purely statistical method (related to Krigging) to estimate 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 2020.	This is a purely statistical method, which uses a Gaussian process regression (c.f. Krigging) model to estimate the (non-linear) long term trend from previous observed September Arctic sea ice extent. The model uses a radial basis covariance function and tunes the parameters via marginal likelihood maximisation (using the GPML toolbox for MATLAB). As this uses only September observations, the prediction is not altered by observations made during the Summer of 2020.	Only uses previous mothly September sea ice extent data.		
NSIDC (Meier)	Statistical		4.13		0.66				18.39						Standard deviation of September extents of projections from years 2007-2019	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 2007-2019. The 2007-2019 average daily rates are used to estimate the official submitted estimate. The predicted September average extent for 2020 is 4.13 (¬±0.66) million square kilometers. The minimum daily extent is predicted to be 4.01 (¬±0.66) 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 15 years, there is a 13% chance that 2020 will be lower than the current record low September extent of 3.57 million sq km in 2012. Using the same method, the predicted Antarctic average extent for September 2020 is 18.39 (¬±0.61) million square kilometers. The maximum daily extent is predicted to be 18.50 (¬±0.63) million square kilometers and occurs on 30 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 2007 to 2019 are used, as well as averages over 1981-2010 and 2007-2019. The 2007-2019 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 ‚Äúwindow‚Äù of possible outcomes narrows.	NASA Team algorithm extents from the NSIDC Sea Ice Index, Version 3 (http://nsidc.org/data/seaice_index/)		
NSIDC (Horvath et al.)	Statistical	Bayesian Logistic Regression	4.19													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 logistic regression. Predictors include local surface air temperature, downwelling longwave radiation, and sea ice concentration, as well as the first principal component of geopotential height at 500mbars, and Pacific and Atlantic sea surface temperatures. Sea ice concentration data was obtained from NSIDC's Sea Ice Index V3 (Data Set ID:G02135), all other variables are from NASA's MERRA2 dataset.	Yearly data from 1980 through the present are used in a Bayesian logistic regression to predict the probability that sea ice concentration will be above 15%. 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. Sea ice concentration data was obtained from NSIDC's Sea Ice Index V3 (Data Set ID:G02135), all other variables are from NASA's MERRA2 dataset.	NSIDC's Sea Ice Index V3 (Data Set ID:G02135)		

APPLICATE (UCLouvian)	Dynamic Model	NEMO3.6 (ocean) LIM3 (sea-ice) JRA-55 (atmospheric forcing) Initialized from 1958 01 01 - 2019 12 31 forced simulation	4.23	4.23	0.67 million sq. km	2.73 million km¬≤			20.77				0.47	5.39	The uncertainty is given as the range between minimum and maximum extents in the ensemble.	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 Jan 1, 2020, then forced with the JRA-55 atmospheric reanalysis from one year between 2009 and 2019 except 2015, which caused the model to crash. 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 summer. In practice, the model is forced with JRA-55 atmospheric reanalysis data from 1948 to Dec 31, 2019. 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 2009 and 2019 (forcing year 2015 was not used as it caused the model to crash). This choice of 10 members forced by 10 forcings from previous years 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. No bias-correction is applied.	Initial sea ice concentrations come from a model free run on Jan 1, 2020	Initial sea ice thicknesses come from a model free run on Jan 1, 2020	None.
AWI Consortium	Dynamic Model	NAOSIM 25km pan-arctic	4.27		0.38											Scientific curiosity.	For the present outlook the coupled sea ice-ocean model NAOSIM has been forced with atmospheric surface data from January 1948 to June 3rd 2020 (combination of NCEP-CFSR and NCEP-CFSv2). All ensemble model experiments have been started from the same initial conditions on June 3rd 2020. The model setup has changed compared to the SIO in 2019 with respect to the resolution of the forecasting model (now about 25km) and the forecasting model's parameters have been optimized with a generic algorithm (Sumata et al, 2019, https://doi.org/10.1175/MWR-D-18-0360.1). We used atmospheric forcing data from each of the years 2010 to 2019 for the ensemble prediction and thus obtain 10 different realizations of potential sea ice evolution for the summer of 2020. The use of an ensemble allows to estimate probabilities of sea-ice extent predictions for September 2019. A variational assimilation system around NAOSIM has been used to initialize the model using the Alfred Wegener Institute's CryoSat-2 ice thickness product and the OSI SAF ice concentration. In contrast to previous years no snow depth and sea surface temperature are assimilated due the lack of these data streams. Observations from March and April were used. The assimilation system (Kauker et al, 2015, http://www.the-cryosphere-discuss.net/tc-2015-171) is unchanged to with respect to previous year s but no bias correction is applied any more to the CryoSat-2 ice thickness - this is not necessary any more due to the optimization of the forecasting model.	OSI SAF EUMETSAT OSI-401b March and April 2019 (http://osisaf.met.no/docs/osisaf_cdop3_ss2_pum_ice conc_v1p6.pdf)	CryoSat-2 SIT from Alfred Wegener Institute of March and April 2019 (Hendricks, S. and Ricker, R.(2019): Product User Guide & Algorithm Specification: AWI CryoSat-2 Sea Ice Thickness (version 2.1), Technical Report, hdl:10013/epic.7dacf2fe-bead-4a1b-a266-c4fdd022877f,https://epic.awi.de/id/eprint/49542/).	Ensemble spread
Wu, Tallapragada, and Grumbine	Dynamic Model	Model Name: NCEP CFSv2 ComponentNameInitialization AtmosphereNCEP GFSNCEP CDAS OceanGFDL MOM4 NCEP GODAS ICEModified GFDL SISSIC nudging 124 ensemble members (May 1-May 31 2020, each day from all 4 cycles)	4.3						18.88							The projected Arctic minimum sea ice extent from the NCEP CFSv2 model May initial conditions (ICs) using 124-member ensemble forecast (4 cycles each day May 1-31) is 4.30 million square kilometers with a standard deviation of 0.12 million square kilometers. The corresponding number for the Antarctic (maximum) is 18.88 million square kilometers with a standard deviation of 0.52 million square kilometers.	We used the NCEP CFSv2 model with 124-case of May 2020 initial conditions (4 cycles each day May 1-31) and model.	NCEP Sea Ice Concentration Analysis for the CFSv2 (May 1-31, 2020)	NCEP CFSv2 model guess (May 1-31, 2020)	
NCAR/CU-Boulder	Heuristic		4.3	4.37	4.89	3.14									The uncertainty estimate is based on the scatter in entries in our informal pool.	An informal pool of 31 climate scientists in early June 2020 estimates that the September 2020 ice extent will be 4.30 million sq. km. (stdev. 0.34, min. 3.14, max. 4.89). 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 31 climate scientists in early June 2020 estimates that the September 2020 ice extent will be 4.30 million sq. km. (stdev. 0.34, min. 3.14, max. 4.89). Guesses were collected by sending an e-mail out to the scientists and tempting them with local bragging rights and with local ice cream.			
FIO-ESM (Shu et al.)	Dynamic Model	FIO-ESM1.0 Atmosphere CAM3 1992-2020 integration Ocean POP2 DA ‚Äì EAKF DA system Ice CICE4 1992-2020 integration Wave MASNUM-wave model 1992-2020 integration	4.33				3.96	4.7								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 2020 is 4.33 (+/-0.37) million square kilometers. 4.33 and 0.37 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-ESM1.0) but with ocean 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 Jun 2020 are assimilated into FIO-ESM1.0 model to get the initial condition for the prediction of the Arctic Sea Ice. There is no sea ice data assimilation.			
University of Colorado	Statistical		4.33													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 July sea ice outlook to have some 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 daily sea ice concentrations NSIDC-0051	None	
ARCUS Team (Wiggins et al.)	Heuristic		4.35	4.35	n/a	Range: 3.79 to 6.28	3.79	6.28							n/a	The ARCUS team submission is the median of the September monthly average mean sea ice extent values contributed by 11 ARCUS team members.	ARCUS staff and board members were invited to provide an informal guess of the 2020 September minimum sea ice extent, defined as the September monthly average. Eleven individuals participated.			n/a
NSIDC Hivemind	Heuristic		4.36		0.26 million sq km										Uncertainty is based on the standard deviation of the 18 guesses.	The approach is heuristic expert elicitation method based on entries to an informal NSIDC sea ice contest. Interested employees submitted their guesses and the ensemble average of all guesses. There were 18 total entries, with an average guess of 4.26 million sq km for the September average.	The approach is heuristic expert elicitation method based on entries to an informal NSIDC sea ice contest.	Guesses were based on the NASA Team algorithm extents from the NSIDC Sea Ice Index, Version 3 (http://nsidc.org/data/seaice_index/).		
RASM (Maslowski et al.)	Dynamic Model	The version of Regional Arctic System Model (RASM v2_1_00) used for this contribution consists of the following components: Ocean: POP2.1 Atmosphere: WRF3.7.1 Sea-ice: CICE 5.1.2 Land hydrology: VIC 4.0.6 River streamflow routing: RVIC 1.0.0 Flux Coupler: CPL 7	4.378	4.365	0.285	Ranges: 3.680 to 4.880	3.68	4.88					0.394	3.927	The uncertainty of pan-Arctic September sea ice extent was estimated from the 23 ensemble members.	We used RASM2_1_00, 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/CFSv2 reanalysis output for RASM-WRF lateral boundary conditions and for nudging winds and temperature starting above 500 mbar. This model initial condition for ensemble forecast was derived from a hindcast, forced with CFSR/CFSv2 reanalysis for September 1979 through May 2020. The ocean and sea ice initial conditions at the beginning of the hindcast were derived from the 32-year spin-up of the ocean-sea ice model only (RASM G-case) forced with CORE2 reanalysis for 1948-1979.	As explained in the "Executive summary", RASM is used for dynamic down-scaling of the global NOAA/NCEP CFSv2 7-month forecasts. The initial conditions for the June Sea Ice Outlook were derived from the RASM 1979-2019 hindcast and are physically and internally consistent across all the model components. Neither data assimilation nor bias correction was used. Each of the 23 ensemble members ran forward for 7 months using outputs from CFSv2 reanalysis. The CFSV2 forcing (https://www.ncei.noaa.gov/data/climate-forecast-system/access/operational-9-month-forecast/) streams used for the ensemble members were initialized every day (at 00:00) between May 1st and May 23rd (no input data were available between 24th and 31st of May 2000) and used for RASM forcing at 00:00 on June 1st, 2020.	Self-generated from the fully coupled RASM hindcast simulation dynamically downscaling NCEP CFSR/CFSv2 reanalysis for 1979-2020.	As stated above in 7a).	Sea ice with concentration <=15% and thickness <= 20 cm was not included in the estimates of sea ice extent.
Kondrashov, Dmitri	Statistical		4.47										0.42		0.15MKm2	This statistical model forecast is based on inverse stochastic modeling techniques applied to the regional Arctic Sea Ice Extent (SIE) dataset.	Nonlinear inverse stochastic modeling techniques have been 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 several Arctic sectors. The predictive model has been derived from SIE anomalies with annual cycle removed, and 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. Kondrashov, D., M.D. Chekroun, and M. Ghil, 2015: Data-driven non-Markovian closure models, Physica D, 297, 33-55, doi:10.1016/j.physd.2014.12.005.			This uncertainty corresponds to standard deviation of stochastic ensemble spread.
ECCC-CanSIPSv2	Dynamic Model	CanSIPSv2 (https://doi.org/10.1175/WAF-D-19-0259.1) CanCM4i: Component Name/Description Initialization Atmosphere CanAM4 CCMEP GDPS Ocean CanOM4 CCMEP GIOPS Sea Ice Cavitating Fluid CCMEP GDPS SIC, SMv3 SIT GEM-NEMO: Component Name/Description Initialization Atmosphere GEM v4.8-LTS.16 CCMEP GEPS Ocean NEMO v3.1 CCMEP GIOPS Sea Ice CICE4.0 CCMEP GIOPS SIC/SIT	4.48	4.41	0.37	95% C.I.: (3.75,5.21)	3.75	5.21							The uncertainty values were calculated from the bias-corrected SIE across the 20 ensemble members (see section 6).	Our Outlook for bias-corrected Arctic sea ice extent (SIE), bias-corrected sea ice concentration (SIC), calibrated sea ice probability (SIP), and bias-corrected ice free dates (IFD) was produced using the Canadian Seasonal to Interannual Prediction System version 2 (CanSIPSv2). CanSIPSv2 is now the operational seasonal forecasting system for Environment and Climate Change Canada.	CanSIPv2 combines ensemble forecasts from two models, CanCM4i and GEM-NEMO, with a total of 20 ensemble members (10 from each model). Our pan-Arctic SIE estimate was formulated by calculating (for each ensemble member) the SIE anomaly relative to a piecewise linear trend fitted to the respective model‚Äôs ensemble-mean SIE time series over 1980-2019. These anomalies were then added to the fitted piecewise linear trend for the NSIDC sea ice index SIE time series, and then averaged over all 20 ensemble members to yield a total SIE of 4.48 million square kilometers. The piecewise linear fit, including the breakpoint year, was found using non-linear least squares. Sea ice probability maps were produced by first calibrating the ensemble SIC forecasts for each respective model using trend-adjusted quantile mapping (TAQM), computing the probability for SIC>15%, and then averaging those probabilities across both models. Our outlook for the 80% SIC contour was prepared by first bias correcting the full ensemble SIC fields for each model separately using a 2011-2019 baseline, and then averaging the ensemble mean SIC across both models. The resultant SIC field was then converted to 0‚Äôs and 1‚Äôs corresponding to which grid cells have SIC<80% and which have SIC>=80%, respectively. Similarly, our IFD forecast has been bias corrected based on the 2011-2019 mean IFD, where we have defined the IFD as the first date that SIC falls below 50% and remains below that value for 10 consecutive days.	CanCM4i: CCMEP GDPS analysis (assimilates SSM/I and SSMIS satellite & CIS ice charts) (https://doi.org/10.1175/MWR-D-14-00354.1) GEM-NEMO: CCMEP GIOPS analysis (assimilates SSM/I and SSMIS satellite & CIS ice charts) (https://doi.org/10.1002/qj.2555)	CanCM4i: SMv3 statistical model (SIT trends from PIOMAS + anomalies proportional to observed SIC anomalies; https://doi.org/10.1175/JCLI-D-16-0437.1); no actual sea ice thickness observations used GEM-NEMO: CCMEP GIOPS analysis (~constrained by SIC projection onto each thickness category; https://doi.org/10.1002/qj.2555); no actual sea ice thickness observations used	This is described in section 6

APPLICATE Benchmark	Statistical		4.51	4.51	0.66 million sq. km	3.22 - 5.8 million km¬≤ (95% confidence interval corresponding to 1.96 standard deviations assuming a Gaussian distribution)	3.22	5.8	18.54						The forecasting procedure is done retrospectively for each year between 1991 and 2019, providing 29 hindcast values. These 29 hi	We forecast that September 2020 monthly mean Arctic sea ice extent will be between 3.22 and 5.8 million km¬≤ (95% confidence interval), with 4.51 million km¬≤ as our best estimate. We estimate that the 2012 minimum is very unlikely (7.5% chance) to be broken, that the September mean extent is very likely to lie in the first tercile of the observed record (76.3% chance) and that it is exceptionally unlikely to line in the upper tercile of the observed record (all medium confidence statements).	The APPLICATE-benchmark outlook is a simple statistical forecast based exclusively on the knowledge of past daily Arctic sea ice extent. It is produced in three steps: Step 1: Sea ice extent is forecasted for each day between the initial time (June 1st, 2020) and December 31st, 2020, as the June 1st sea ice extent anomaly (calculated with respect to the quadratic trend line computed over 1979-2019) added to the relevant day background estimate. The background estimate itself is calculated as the 1979-2019 quadratic trend of extent for that day extrapolated to 2020. A weight is applied to the anomaly term, equal to the correlation between the relevant day and June 1st anomalies estimated over 1979-2019 so that more weight is put on the anomaly term when the autocorrelation of the time series is high, and more weight is put on the background term when the autocorrelation tends to zero. Step 2: The September mean of daily forecasts is then estimated and is used to produce an initial 2020 forecast. Step 3: The 2020 forecast is finally recalibrated by linearly regressing the 1991-2019 forecasts onto the verification data. A 95% confidence interval is calculated around the recalibrated value and provided			See b)
UTokyo (Kimura et al.)	Statistical		4.57													Monthly mean ice extent in September will be about 4.57 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/2020e.html	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 (2012/13-2019/20). 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.	Sea ice concentration distributed by ADS. (https://ads.nipr.ac.jp/vishop/)	No sea ice thickness data.	
NMEFC of China (Li and Li)	Statistical		4.59													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 predicted monthly average ice extent of September 2020 is 4.59 million square kilometers .	An optimal climate normal method is used to predict September average Arctic sea ice extent. The predicted September sea ice extent in 2020 is 4.59 million square kilometers .	Sea Ice Index - Daily sea ice concentration(NASA Team) and monthly sea ice extent from National Snow and Ice Data Center.		
Met Office (Blockley et al.)	Dynamic Model	Model: HadGEM3 [Hewitt et al., 2011], Global Coupled Model 2.0 [Williams et al., 2015] in use within the GloSea5 seasonal prediction system [MacLachlan et al., 2015]. Sea ice component: CICE4.1 [Hunke and Lipscomb, 2010] model using Global Sea Ice 6.0 configuration [Rae et al., 2015]. Initialised using the Met Office FOAM ocean and sea ice analysis [Blockley et al., 2014], which assimilates the SSMIS sea ice concentration observation product from EUMETSAT OSI-SAF. Ocean component: NEMO [Madec, 2008] ocean model using Global Ocean 5.0 configuration [Megann et al., 2014]. Initialised using Met Office FOAM ocean and sea ice analysis [Blockley et al., 2014] assimilating in-situ and satellite observations of SST [GHRSST], satellite observations of sea level anomaly [AVISO/CLS] and temperature and salinity sub-surface profiles. Atmospheric Component: Met Office Unified Model (MetUM) [Brown et al., 2012] using Global Atmosphere 6.0 configuration [Walters et al., 2017]. Initialised using Met Office operational numerical weather prediction (NWP) 4D-Var data assimilation system [Rawlins et al., 2007]. Land Component: Joint UK Land Environment Simulator (JULES) [Best et al., 2011] using Global Land 6.0 configuration [Walters et al., 2017]. Initialised using soil temperature and snow over land from atmospheric 4D-Var analysis [Rawlins et al., 2007]. Soil moisture is model climatology. Coupling: Ocean and sea ice are hard coupled. Atmosphere and land are hard coupled. Ocean/ice and atmosphere/land are coupled using the OASIS3 coupled [Valcke, 2006].	4.6		Arctic: 0.3 million sq km; Antarctic: 0.35 million sq km	Arctic: +/- 0.6 million sq km; Antarctic: +/- 0.7 million sq km	4	5.2	18.2	17.5		18.9			Uncertainty range is provided as +/- 2 two standard deviations of the (42 member) ensemble spread around the ensemble mean.	A dynamic model forecast made using the Met Office‚Äôs seasonal forecasting system (GloSea). GloSea is a fully coupled Atmosphere-Ocean-sea Ice-Land (AOIL) model that produces a small 2-member ensemble of 210-day forecasts each day. Forecasts initialised over a 21-day period are used together to create a 42-member lagged ensemble or forecasts of September sea ice cover.	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 22 May and 10 June (2 per day) from an ocean and sea ice analysis (FOAM/NEMOVAR) [Blockley et al., 2014, Peterson et al., 2015] 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 from EUMETSAF OSI-SAF [OSI-SAF] were assimilated in the ocean and sea ice analysis, along with satellite and in-situ SST, sub surface temperature and salinity profiles, and sea level anomalies from altimeter data. No assimilation of ice thickness was performed.	Sea ice concentration (as all variables) is initialised using the operational FOAM ocean-sea ice analysis. SSMIS sea ice concentration is assimilated using the EUMETSAT OSI-SAF (OSI-401b; See http://osisaf.met.no/docs/osisaf_cdop3_ss2_pum_ice-conc_v1p6.pdf)	Sea ice thickness (as all variables) is initialised using the operational FOAM ocean-sea ice analysis. Sea ice thickness is not assimilated in FOAM.	Bias correction calculated from hindcast evaluation over 1993-2016. Arctic: -0.5 million sq km; Antarctic: -0.5 million sq km
Lamont (Yuan and Li)	Statistical	Lamont linear Markov model for seasonal prediction of Arctic sea ice concentration	4.64						18.57				0.53		The uncertainty of SIC prediction was measured by RMSE. They were estimated based on 34 years cross-validated model experiments.	A linear Markov model is used to predict monthly Arctic sea ice concentration (SIC) at all grid points in the pan-Arctic region (Yuan et al., 2016). 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 4.64 million square kilometers (mskm) with an RMSE of 0.48 mskm, at the four-month lead. It is 0.32 mskm above September SIE in 2019. Similar statistical models were also developed to predict the SIE in the Alaskan region and the Antarctic (Chen and Yuan, 2004). The Alaskan regional SIE is predicted to be 0.53 mskm with an RMSE of 0.22 mskm, which is about 50% above the last year Alaska SIE. The September mean pan Antarctic SIE is predicted to be 18.57, higher than September 2019 (18.24), with an RMSE of 0.57 mskm.	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).	Sea ice concentration: NSIDC NASA Team, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM. Atmospheric variables, NOAA NCEP/NCAR Reanalysis-1 http://iridl.ldeo.columbia.edu/SOURCES/.NOAA/.NCEP-NCAR/.CDAS-1/ SST: NOAA NCDC ERSST version3b: Extended reconstructed sea surface temperature data, http://iridl.ldeo.columbia.edu/expert/SOURCES/.NOAA/.NCDC/.ERSST/.version3b/.sst/		A constant bias correction was applied to Arctic SIC prediction at each grid point.
NMEFC (Jiechen Zhao)	Dynamic Model	MITgcm	4.82													This Sea Ice Outlook is a part of the official sea ice service for Chinese Arctic activities, targeting for icebreakers and commerical ships. This prediciton was carried out by National Marine Environmental Forecasting Center (China), using a ocean-sea ice coupled model, MITgcm.	The sea ice prediciton was carried out by National Marine Environmental Forecasting Center (China), using a ocean-sea ice coupled model, MITgcm. The prediction was initialized on 20 May 2020 and run for 6 months forced by CFS 9-month operational forecast. The initial condition came from a operational assimilation system by assimilating sea ice concentration and thickness. The sea ice outlook was a mean value from 10 ensemble runs.	AMSR2	SMOS, CryoSat-2	
Sun, Nico	Statistical	Model Name: Sun_SIPN_forecast_V2.2020.06	4.84	4.84		4.09-5.41	4.09	5.41					0.561	4		The forecast model is based on ice persistence. It uses incoming solar radiation and sea ice albedo derived from a predicted Sea Ice Concentration (SIC) value to calculate daily thickness losses for every NSIDC 25km grid cell. The initial thickness is calculated from AMSR2 sea ice volume and NSIDC SIC data. The mean forecast uses the 2007-2019 mean SIC (1/4 weight) and mean SIC change per day (3/4 weight) to predict future SIC. The low forecast reduces the predicted SIC by 0.38Stdv for previously observed SIC for this day and a 10% increased bottom melt. The high forecast increases the predicted SIC by 0.20Stdv and a 10% decreased bottom melt. The 2020 model includes an extra cooling/heating layer to simulate sea ice drift. In re-forecasts it eliminated the persistent underprediction of sea ice in the Eastern Beaufort Sea, the Canadian Archipelago and Eastern Greenland Sea during the late melt season.	Each grid-cell is initialized with a thickness derived from the AMSR2 Sea Ice Volume model (https://cryospherecomputing.tk/SIT). 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. Ice-loss(m) = Energy(solar in MJ)*(1-SIC) / icemeltenergy SIC = sea ice concentration icemeltenergy = Meltenergy per m3, (333.55 KJ/kg*1000(m3/dm)*0.92(density)/1000(MJ/KJ) For 2020 the model was upgraded with an icedrift simulation layer.	NSIDC NASA Team, https://nsidc.org/data/nsidc-0081, https://doi.org/10.5067/U8C09DWVX9LM. Initial SIC 1st June 2019. The model used observed SIC until 9th June 2020 to calculate melt.	AMSR2 Sea Ice Volume model (v1.5), 31st May 2020, developed by Nico Sun (https://cryospherecomputing.tk/SIT) The average thickness of this model was used to initialise thickness on the NSIDC SIC field on the 1st June.	
APPLICATE CNRM (Batte et al.)	Dynamic Model	CNRM-CM6-1 HR (Meteo-France system 7) Ocean: NEMO 3.6 0.25¬∞ initialized from NEMO-GELATO run constrained to GLORYS12V1 Sea ice: GELATO v6 0.25¬∞ initialized from NEMO-GELATO run constrained to GLORYS12V1 Atmosphere: ARPEGE-Climat v6.4 0.5¬∞ reduced Gaussian grid initialized from IFS analysis Land surface: SURFEX v8.1 0.5¬∞ reduced Gaussian grid initialized from IFS analysis	4.95	4.98	0.22 million km2	4.38 to 5.43 million km2	4.38	5.43							These estimates are based on a 51-member ensemble	This contribution is part of the H2020-APPLICATE project and based on Meteo-France System 7 June initialization forecast. It is a 51-member ensemble forecast initialized from three sets of ocean/ice and atmosphere/land initial conditions from May 21 (25 members), May 28 (25 members), and June 1st (1 member).	This is a model estimate based on the Meteo-France operational seasonal forecast (nominal start date June 1st), applying bias correction based on the hindcast period to the model forecast for September 2020 mean SIC. The ensemble combines both a lagged approach and stochastic perturbations in the atmosphere dynamics to generate spread.	Initial conditions for the ocean and sea ice (both concentration and thickness) are provided by Mercator Ocean International. These are based on the Mercator Ocean International operational analysis, run at 1/12¬∞ horizontal resolution with NEMO-LIM. This analysis is upscaled to the 1/4¬∞ ocean resolution of CNRM-CM6 HR used for Meteo-France system 7, and fields are used to nudge a NEMO-GELATO run (Meteo-France configuration) forced by IFS operational analysis and restoring SST towards Mercator. Sea ice concentration and thickness (and ocean fields) are used to initialize forecasts.	See above.	Data was corrected for systematic error in SIC, as well as trend in SIE, based on hindcast data for the corresponding starts.
BSC (Acosta Navarro et al.)	Dynamic Model	EC-Earth3.3: Ocean (NEMO3.6): initialized from in-house reconstruction driven by ERA5 forcing fields and assimilating temperature and salinity from ORAS4. Sea ice (LIM3): Same as the ocean Atmosphere IFS c36r4: Interpolated fields from ERA5 Initialization: November of the previous year (2019 for the 2020 SIO)	5	5	Arctic: 0.6 Million sq km; Antarctic: 0.6 Million sq km	Arctic: 4.1-5.8 Million sq km | Antarctic: 14.4-16.4 Million sq km	4.1	5.8	15.7	14.4	15.7	16.4			The forecast consist of 10 members, the range is taken from the lowest and highest values.	This contribution is part of a larger APPLICATE (EU-funded H2020 project) contribution involving four research centers. The same approach used to produce this individual contribution has been used to produce a retrospective decadal prediction system with EC-Earth , which shows significant skill to predict September Sea Ice Extent over the period 1960-2019.	Initialized climate model (EC-Earth3.3) in November 2019. Ten members were produced in total. We provide the ensemble mean of the raw forecasted SIE values.	The forecast (EC-Earth3.3) uses sea ice concentration initial conditions from an ocean-sea ice (NEMO36 - LIM3) reconstruction in which only ocean temperature and salinity are restored to ORAS4 values (Balmaseda et al., 2012), both at the surface and below the mixed layer. The ocean-sea ice model is forced with ERA5 (Hersbach et al., 2020) surface fluxes. No direct assimilation of Sea Ice Concentrations was performed. Balmaseda M.A., Mogensen K.S., Weaver A.T., 2012, Evaluation of the ECMWF Ocean Reanalysis ORAS4. Quart J Roy Meteor Soc DOI 10.1002/qj.2063. Hersbach, H., Bell, B., Berrisford, P., Hirahara, S., Horányi, A., Muñoz-Sabater, J., Nicolas, J., Peubey, C., Radu, R., Schepers, D., Simmons, A., Soci, C., Abdalla, S., Abellan, X., Balsamo, G., Bechtold, P., Biavati, G., Bidlot, J., Bonavita, M., De Chiara, G., Dahlgren, P., Dee, D., Diamantakis, M., Dragani, R., Flemming, J., Forbes, R., Fuentes, M., Geer, A., Haimberger, L., Healy, S., Hogan, R.J., Hólm, E., Janisková, M., Keeley, S., Laloyaux, P., Lopez, P., Lupu, C., Radnoti, G., de Rosnay, P., Rozum, I., Vamborg, F., Villaume, S. and Thépaut, J.-N. (2020), The ERA5 Global Reanalysis. Q J R Meteorol Soc. Accepted Author Manuscript. doi:10.1002/qj.3803	As for SIC, no direct assimilation of Sea Ice Thickness observations was done to initialize the forecasts.	We provide the raw forecasts, so no post processing of the data has been performed.
METNO SPARSE (Wang et al.)	Dynamic Model	METROMS model is used, which is based on ROMS (3.6) and CICE(5.1.2). The initial fields are f	5													We use the coupled ocean-sea ice model to make the seasonal forecast. The starting ocean and sea ice conditions are from the NEMO short-term analysis on June 5. The atmosphere forcing is obtained from ECMWF seasonal forecast product SEAS5, the May forecast (starting from 1 May 2020).	We use the coupled ocean-sea ice model to make the seasonal forecast. The starting ocean and sea ice conditions are from the NEMO short-term analysis on June 5. The atmosphere forcing is obtained from ECMWF seasonal forecast product SEAS5, the May forecast (starting from 1 May 2020).	The NEMO short-term operational product from CMEMS.	same as a, the date is on June 5, 2020.	
Navy ESPC (Metzger and Barton)	Dynamic Model	Navy Earth System Prediction Capability (ESPC) NAVy Global Environmental Model (NAVGEM) CV2.0 HYbrid Coordinate Ocean Model (HYCOM) V2.2.99DHi Community Ice CodE (CICE) V4.0 All model components are fully coupled and the system is initialized from pre-operational ensemble Navy ESPC run by Fleet Numerical Meteorology and Oceanography Center (FNMOC) at the Navy DoD Supercomputing Resource Center (DSRC).	6.2	6.2		5.5 to 6.9 Mkm2	5.5	6.9	21.3				1.03	3.97	The uncertainty estimate is the range of the 16 member ensemble.	The projected Arctic 2020 September mean sea ice extent from the Navy Earth System Prediction Capability (ESPC) is 6.2 million km2. This forecast is the average of a 16 member ensemble using initial conditions on 1 May 2020 from a pre-operational Navy ESPC ensemble with perturbed observations. The range of the ensemble is 5.5 to 6.9 million km2. The projected Antarctic 2020 September mean sea ice extent is 21.3 million km2 with an ensemble range from 20.3 to 22.4 million km2.	We performed a 16 member ensemble forecast with Navy ESPC using initial conditions on 1 May 2020 from the pre-operational system using perturbed observations and run by FNMOC. The pre-operational cycling system assimilates atmospheric observations using the Naval Research Laboratory Atmospheric Variational Data Assimilation System (NAVDAS-AR) (Xu et al., 2005) and the ocean/sea ice assimilate observations using Navy Coupled Ocean Data Assimilation (NCODA) (Cummings, 2005). CICE assimilates passive microwave satellite sea ice concentration observations such as SSMI/S and AMSR2, but does not assimilate sea ice thickness. There was no bias correction performed on the results.	We performed a 16 member ensemble forecast with Navy ESPC using initial conditions on 1 May 2020 from the pre-operational system using perturbed observations and run by FNMOC. SIC initials conditions came from CICE.	We performed a 16 member ensemble forecast with Navy ESPC using initial conditions on 1 May 2020 from the pre-operational system using perturbed observations and run by FNMOC. SIT initials conditions came from CICE.	The Sea Ice Probability (SIP) and Ice-Free Day (IFD) were computed from the Navy ESPC sea ice output forwarded to the SIPN Data