Subseasonal-to-Seasonal S2S Prediction Project

WWRP World Weather Research Programme

WCRP World Climate Research Programme

Newsletter

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Topics:

1. What is S2S ?

To bridge the gap between medium-range weather forecasts and seasonal forecasts, the World Weather Research Programme (WWRP) and World Climate Research Programme (WCRP) launched a joint research initiative in 2013, the Subseasonal to Seasonal Prediction Project (S2S). The main goal of this project is to improve forecast skill and understanding of the subseasonal to seasonal timescale, and to promote its uptake by operational centres and exploitation by the applications communities.

Phase II of the S2S project began in January 2019 and will continue until 2023. A new set of scientific sub-projects has been developed, as outlined in the sidebar in next pages. Enhancements to the database will be made including access to the S2S ocean and additional models. The second phase will also include new research-to-operations activities and a real-time supplications initiative introduced in this edition of the newsletter.

S2S Phase II Proposal is available at http://s2sprediction.net/file/documents_reports/P2_Pro.pdf

Progress on the S2S Real Time Pilot Initiative

Joanne Robbins (UKMO) Met Office

In April, the S2S Real Time Pilot Initiative began issuing questionnaires as part of its knowledge gathering activity. The questionnaires aimed to collect information on the experiences of both researchers and users involved in projects that are accessing and using the real time S2S forecasts made available under this initiative. The questionnaires are specifically designed to better understand how researchers and users within these projects engage with one another to pull through evolving science into user orientated S2S forecasting applications. We are particularly interested in understanding how engagement might change depending on the type of user and sector involved and how research /user roles influence outcomes. The responses to this first questionnaire will provide a baseline understanding of the researcher /user dynamic within each project.

The first set of questionnaires were disseminated through April and May, with participants given four weeks to provide their responses. One questionnaire was sent to researchers and a mirror questionnaire shared with users. 13 out of the 16 projects were able to receive questionnaires at this time. Unfortunately, 2 projects are on hiatus due to the Coronavirus outbreak and we plan to re-engage with these projects shortly. A total of 61 questionnaires have been issued and 77% of recipients have provided responses to date. If anyone has received a questionnaire and has not yet had chance to return it, then we are still very keen to receive your contribution – please send any outstanding, completed questionnaires to joanne.robbins@metoffice.gov.uk.

A small team of researchers, including members from the WWRP Societal and Economic Research and Applications (SERA) working group and WCRP Coordination Office for Regional Activities (CORA) are now analysing the questionnaire responses to produce an initial

baseline assessment. This will focus on collating information around co-development, engagement activities and evaluation activities that are used across the projects. We hope to pull together some preliminary findings by the end of August 2020.

We plan to issue two further questionnaires throughout the life of the real time pilot initiative (1st November 2019 – 31st October 2021) which will allow us to review progress and development. Ultimately the information provided will support the development on best practice guidance which can help to support better pull-through of S2S science into sustainable applications.

We would like to thank everyone who has contributed to this activity so far!

Current activities of the Research to Operations (R2O) and S2S forecast and verification products development sub-project

Caio A. S. Coelho (CPTEC/INPE, Brazil)

The Phase II Research to Operations (R2O) and S2S forecast and verification products development sub-project has two objectives: 1) Scientific: To pursue research for testing and developing methodologies for calibration, multi-model combination, verification and generation of forecast products, and 2) Operational: To coordinate with the relevant World Meteorological Organization (WMO) technical commissions to define the standards and protocols for operational implementation and exchange of S2S forecasts such that by the end of the Phase II of the WMO S2S project, the infrastructure related to the data exchange to support research can be transitioned into the operational domain.

In order to facilitate and promote the execution of required initiatives for achieving these objectives a group of scientists has kindly agreed to be members of this sub-project. The members are: Caio Coelho (CPTEC/INPE, Brazil), Andrew Robertson (IRI, USA), Arun Kumar (NOAA, USA), Yuhei Takaya (JMA, Japan), Anca Brookshaw (ECMWF), Debra Hudson (BoM, Australia), Angel Muñoz (IRI, USA) and Joanne Robbins (UKMO, UK).

A wiki page has recently been created and populated containing linkages of this sub-project with other WMO activities. On the research side this sub-project has linkages with the Joint Working Group on Forecast Verification Research (JWGFVR), a WMO joint working group of the Working Group on Numerical Experimentation (WGNE) and the World Weather Research Programme (WWRP). This sub-project also has synergies with the World Climate Research Programme (WCRP) Working Group on Subseasonal to Interdecadal Prediction (WGSIP).

WWRP has flagged improving forecasts of precipitation over land as an important area for S2S to focus research and services development efforts. In order to help advance scientific knowledge, and the development of forecast and verification products in this priority area, this sub-project invites the S2S research and operational communities to address the following questions:

2. Six sub-projects in S2S Phase II

The new research Phase II sub-projects will address issues related to sources of predictability, forecast system configuration, and model development. These sub-projects are more oriented towards model experimentation than the Phase I sub-projects which were more about model assessment. Some of the new sub-project research plans will include coordinated experiments and also process studies in coordination with the Working Group on Numerical Experimentation (WGNE).

1. **MJO and teleconnections**: This sub-project focuses on the representation of teleconnections and their modulation in S2S models. Metrics for assessing model teleconnections and diagnosing sources of errors in teleconnections will be applied.

2. **Land**: This sub-project investigates the impact of the observing system on land initialization and S2S forecasts, the representation of the coupled land/atmosphere processes in S2S models, and contribution of anomalies in land surface states to extremes. It will work in concert with other relevant programs to pool resources and coordinate scientific studies (e.g. GEWEX/GLASS).

3. **Ocean**: This sub-project aims to evaluate the ocean feedbacks which directly influence sub-seasonal variability and prediction skill, the predictability influenced by pre-existing ocean state, the effect of low-frequency variability on S2S predictability, the impact of ocean mean state drift on S2S predictability, mechanisms which affect extreme ocean weather (heat waves) and their predictability.

4. **Aerosol**: This sub-project is a collaboration between S2S, WGNE and GAW. It aims to evaluate the benefit of interactive instead of climatological aerosols on sub-seasonal forecasts through a series of coordinated re-forecast experiment with and without interactive aerosols. The sub-seasonal predictability of aerosols will be assessed as well as their impact on sub-seasonal forecast skill scores.

5. **Ensembles**: This sub-project will study the influence of burst vs lagged ensemble initialization on the forecast spread using S2S database. It will also investigate the impacts of stochastic parameterizations and coupled initial perturbations on the sub-seasonal prediction, review the techniques for coupled initial perturbations which are under development in a few centers (ECMWF, NCEP, BoM, and JMA).

6. **Stratosphere**: This is a joint sub-project between S2S and WCRP/SPARC/SNAP. Its main goals include: developing additional stratospheric diagnostics and investigating the use of DynVarMIP additional diagnostics to S2S models; Coordinating damping experiments to examine the dynamics of downward coupling; Studying the link to tropospheric dynamics.

3. Upcoming events

• **EMS Annual Meeting 2020,** *7 to 11 September 2020, University of Economics, Bratislava, Slovakia.* ➔ *Cancelled.*
https://www.ems2020.eu

• **ECMWF-ESA Workshop on Machine Learning for Earth System Observation and Prediction,** *5 to 8 October 2020, Online.*
https://www.ecmwf.int/en/learning/workshops/ecmwf-esa-workshop-machine-learning-earth-system-observation-and-prediction

• **WCRP Workshop on Extremes in Climate Prediction Ensembles (ExCPEns),** *26 to 28 October 2020, Pusan, Korea.* ➔ *Postponed.*

• **2020 around-the-clock International Verification Methods Workshop Online (2020-IVMW-O),** *9 to 20 November 2020, Online.*
https://jwgfvr.univie.ac.at/

• **AGU Fall Meeting 2020,** *1 to 17 December 2020, San Francisco, CA, USA. Online.*
https://www.agu.org/Fall-Meeting

- What is the current performance level of sub-seasonal precipitation forecasts over land? Over which continental regions can these forecasts be best trusted? How performance levels vary through the seasons of the year?
- What is the current capability of S2S models in anticipating the occurrence of extreme precipitation events over land (periods of deficit or excess precipitation)?
- How well the main patterns of precipitation variability on the sub-seasonal time scale over various continental regions are represented in S2S prediction models?
- How best to combine and calibrate sub-seasonal precipitation forecasts over land in order to produce improved, combined and well-calibrated products and services?
- Are there identifiable opportunities for producing sub-seasonal precipitation forecasts over land with improved quality? For example, are forecasts produced during Madden and Julian Oscillation (MJO) and/or El Niño Southern Oscillation (ENSO) events more skilful than when neutral conditions are present? Are forecasts for active and break rainfall phases and dry/wet spells (or other quantities of interest) of adequate quality for developing forecast products for use in application sectors?

In order to address these questions the research and operational communities are encouraged to explore existing and develop novel methodologies for forecast calibration, combination and verification. Following the S2S verification chapter produced by the JWGFVR (Coelho et al., 2018), it is particularly encouraged to identify the most relevant forecast quality attributes for the target audiences (e.g. model and forecast developers, and various application sectors) in order to choose appropriate scores and metrics to be able to adequately address clearly and previously defined verification questions of interest. This practice helps performing a thorough assessment of sub-seasonal forecasts from both the probabilistic and deterministic points of view.

On the operational side, this sub-project has linkages with WMO Inter-Programme Expert Team on Operational Predictions from Sub-seasonal to Longer-Time Scale (IPET-OPSLS). The February 2010 meeting of the IPET-OPSLS, with participation of members of this sub-project, led to progress in developing the designation criteria for future Global Producing Centers (GPCs) and Lead Centers (LC) for Subseasonal forecasts (SSF) multi-model ensemble (MME). This includes the definition of forecasts and verification products and scores to be produced and disseminated in GPCs and LCs webpages, and realtime and hindcast data to be exchanged via the LC.

The proposed list of subseasonal forecast variables to be exchanged between GPCs and the LC include: Surface (2 meter) temperature, sea surface temperature, total precipitation rate, mean sea level pressure, 850 hPa temperature, 500 hPa geopotential height, 850 and 200 hPa wind (zonal and meridional), outgoing longwave radiation at the top of the atmosphere, and 10 hPa zonal wind. Maps of both probabilistic and deterministic (ensemble mean) anomalies of these variables averaged over periods up to 4 weeks, and diagrams presenting forecasts of the tropical intraseasonal variability such as the MJO (Wheeler and Hendon 2004; Gottschalck et al. 2010) were proposed as recommended products to be generated by GPCs. The proposed sub-seasonal verification scores are similar to the scores currently used for operational seasonal predictions, including the Mean square skill score (MSSS) with respect to climatology and its three-term decomposition, Reliability diagrams with frequency histograms, and ROC diagram with area under the ROC curve.

The sub-project wiki page also contains information with web links to the current work of the S2S operational and research communities on calibration, multi-model combination, verification and forecast products generation including:

a) The WMO Lead Centre for Long Range Forecast Multi-Model Ensemble (LC-LRFMME) is developing prototype real-time sub-seasonal multi-model ensemble (MME) forecasts and verification products using a subset of models contributing to the WWRP/WCRP S2S research project accessed from the ECMWF data archive. Subseasonal models from eight Global Producing Centers (GPCs) are currently used: Beijing, ECMWF, Exeter, Melbourne, Montreal, Seoul, Tokyo and Washington. A range of forecast products has been developed including probabilities for tercile categories of weekly/fortnightly averages of 2 meter temperature and precipitation as well as the MJO and the Boreal Summer Intraseasonal Oscillation (BSISO) indices. Hindcast verification products have also been generated using ROC curves and scores, reliability diagrams, root mean square error and correlation between hindcast and observed anomalies.

b) The methodology followed by International Research Institute for Climate and Society (IRI) initiative on investigating the seasonality of subseasonal uncalibrated rainfall and temperature global prediction skill using the ECMWF's Integrated Forecast System (IFS) model, available through the WWRP/WCRP S2S Prediction Project Database via the IRI Data Library.

c) A list of projects and networks dealing with S2S predictions.

d) Software tools, including the Python (PyCPT) interface and enhancement for the command line version of the IRI´s Climate Predictability Tool (CPT), for seasonal and sub-seasonal skill assessment and forecast experiments, and

e) Web portals where the research and operational communities can visualize S2S forecasts and verification products.

Last, but not least, the JWGFVR is pleased to announce the around-the-clock **2020 International Verification Methods Workshop Online (2020-IVMW-O)**, which will be held virtually, during two weeks, from the 9th to the 13th and from the 16th to the 20th of November 2020. This workshop will consist in 2-hour online daily sessions, with live-stream presentations and discussion. **The goal of the workshop is to discuss recent aspects of verification research and keep the research community updated on new verification practices**, as applied to different types of weather forecasts and environmental predictions, on all spatial and temporal scales, from weather and sub-seasonal to seasonal and decadal, as well as for long climate projections. Participants are welcome from operational, research and forecast-user communities. **The S2S community is cordially invited to submit abstracts on S2S verification methodologies to the workshop**. Registration and abstract submission is open at the workshop website https://jwgfvr.univie.ac.at/

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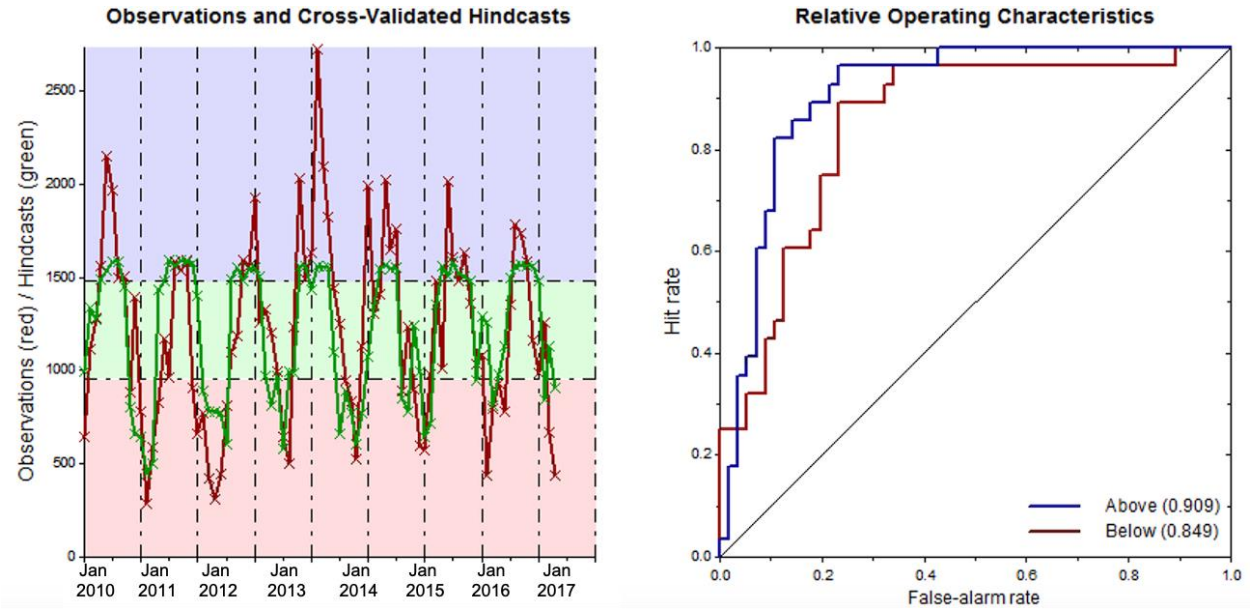
Subseasonal real-time forecasts for food security

Ángel G. Muñoz, Nachiketa Acharya, Carmen González Romero, Diego Pons, Andrew W. Robertson
(on behalf of the IRI ACToday team)

ACToday: Adapting Agriculture to Climate Today, for Tomorrow

The Columbia University World Project "Adapting Agriculture to Climate Today, for Tomorrow" (ACToday), led by the International Research Institute for Climate and Society (IRI), was launched at the end of 2017 to create climate service solutions to help end hunger, achieve food security, improve nutrition, and promote sustainable agriculture in six pilot countries: Colombia, Guatemala, Ethiopia, Senegal, Bangladesh and Vietnam. Through international and national partner networks, ACToday has been using IRI's innovations in climate services, targeted through a wide variety of solutions to improve local decisions.

ACToday uses a holistic approach to address the entire food system chain, as climate permeates not only the production side, but also the packaging, distribution, consumption and final disposal of food. This approach requires the generation, translation, implementation and use of climate information at multiple timescales. So far, ACToday has been successfully using real-time seasonal predictions, but the user communities in the pilot countries are urgently requesting real-time sub-seasonal forecasts for a set of key targeted products, which could give rise to prototype climate services for food security at this timescale. Some examples in Latin America are discussed below.



<Figure 1. (Left) Observed number of cases of undernutrition for children under 5 years of age (in red) and cross-validated hindcasts (in green). (Right) Relative Operating Characteristic curves for the above-normal (blue) and below-normal (red) categories. The vertical axis in the left panel has been multiplied by 10. >

In Guatemala, the National Secretariat for Food Security and Nutrition (SESAN) has been working with the Bioversity-CIAT Alliance and ACToday to create an undernutrition early warning system. This system is based on multiple predictors, using a (subjective) expert-advice-based approach. With the support of ACToday, a set of cross-validated statistical models are being developed, which can skillfully forecast the seasonality of acute undernutrition in children under 5 years of age (Figure 1). The new objective system uses a combination of climate and non-climate predictors; the climate predictors involve subseasonal rainfall characteristics, like monthly rainfall total and rainfall onset. Real-time subseasonal forecasts, available via the S2S Real-Time Forecast Pilot Project, provide both useful climate information for local experts, and are part of the input needed by the new acute undernutrition forecast system.

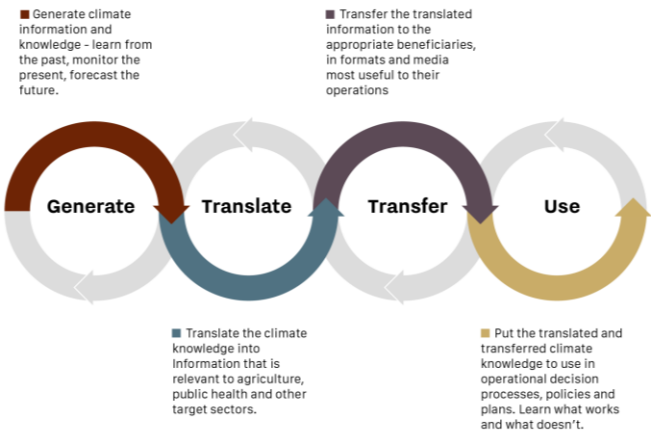
Also in Guatemala, a new calibrated, multi-model system has been developed by ACToday, the National Coffee Association (ANACAFÉ) and the National Meteorological Service (INSIVUMEH), providing deterministic and probabilistic seasonal and sub-seasonal forecasts of coffee yield in the Samalá river basin. Thanks to the involvement of local experts in the region, these new forecasts can be translated into a set of concrete decisions at different lead times, that coffee farmers can implement depending on their particular conditions.

In Colombia, ACToday is working with the Ministry of Health (MINSALUD) and the National Institute of Health (INS) on co-developing an early warning/early action system for undernutrition in selected regions of the country.

The system's design is similar to the one described for Guatemala, and subseasonal forecasts of rainfall totals, onset and demise are still deemed key to make decisions; nonetheless, climate variables tend to play a more indirect role in the Colombian undernutrition model, due to the specific characteristics of the Colombian food system.

Real-time subseasonal forecasts are essential for the work that ACToday is conducting with the Colombian National Meteorological Service (IDEAM) and the National Rice Federation (FEDEARROZ), enabling them to force locally-calibrated rice models to produce rice forecasts at subseasonal scale for the Meta Department.

Our team expects to write a publication on the lessons learned in these and the other countries involved in the ACToday project, regarding best practices on how to use real-time subseasonal forecasts to co-develop local climate services to improve agricultural practices and food security around the world.



< The four pillars of climate services, and the expertise needed with regard to the ACToday project. >

Predictability of the Arctic sea ice extent from S2S multi model

Jinkyung Park (Seoul Nat'l Univ.) Yu-Kyung Hyun (NIMS, South Korea)

1. Purpose

This study examines the predictability of the Arctic sea ice extent from Sub-seasonal to Seasonal (S2S) prediction systems. The analysis is focused on verification of predictability in each model compared to the observation and prediction in particular, on lead time in S2S scales.

2. Data

For multi model comparison, three models coupled with sea ice model (KMA, Meteo France, and NCEP) are selected out of eleven WMO S2S database. Hindcasts from three models during 11 years (1999~2009) are used. Initial fields are 1 and 15 every month (1 and 17 for KMA) with 3 ensemble members and Week 1~6 lead time. MME (Multi-Model Ens.) produced from three models are also considered. NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration is used as observation for evaluation. Sea ice extent is defined as a total area corresponding to model grids containing more than 15% of sea ice concentration in Northern Hemisphere.

3. Conclusions

Most of models are able to reproduce characteristics of the sea ice, but have bias with seasonal dependence and lead time. The Arctic sea ice extent can be skillfully predicted up to 6 weeks ahead in S2S scales.

4. Results

The monthly Arctic sea ice extent from all models and observation is shown in Fig. 1. On the whole, METFR (Meteo France) prediction and MME show closer trend to observation than KMA and NCEP. All models show decreasing sea ice extent trends with a maximum magnitude in warm season. Models and observation indicate the minimum sea ice extent on September except for KMA.

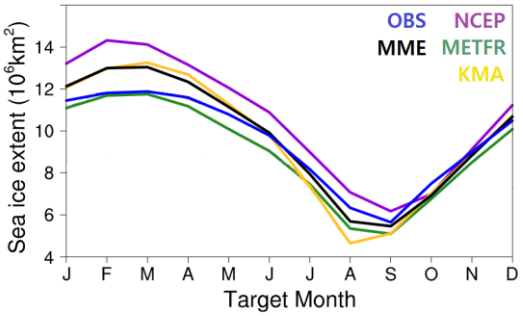


Fig. 1. Climatology of monthly sea ice extent from observation (OBS) and models, multi-model ensemble mean (MME) on Week 1- Week 6 lead time.

This article is extracted from Park et al. (2018) published in Atmosphere (Korean Meteorological Society) written in Korean with English abstract.

The difference of monthly Arctic sea ice extent between models and observation with respect to lead time is displayed in Fig. 2. METFR simulates negative bias over all months, while KMA and NCEP do comparatively negative in summer season and positive in winter season. METFR of three models has the smallest magnitude of bias. But, MME shows the smallest magnitude of bias on the average.

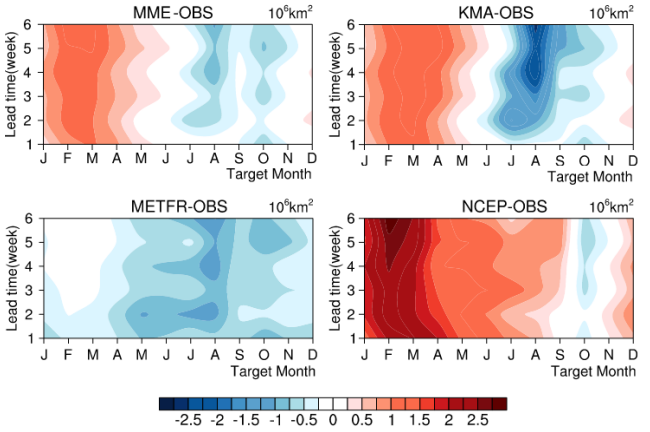


Fig. 2. Bias of monthly sea ice extent from observation with respect to week lead time.

Monthly ACC (Anomaly Correlation Coefficient) with respect to week lead time is analyzed (Fig. 3). Sea ice extent is more skillfully predicted from MME and KMA. The ACC is higher over those seasons with maximum and minimum sea ice extent. Over that seasons, the ACC for Week 3-6 lead time is similar to that for Week 1-2 lead time, which indicates that predictability is reasonable in the subseasonal time scale. Skill is higher over August-October as well as April-June, but lower over July and December-January. Especially, the predictability in September is statistically significant up to Week 6 lead time (> 0.8). Over April-June, the predictability is greater than 0.6 up to Week 6 lead time.

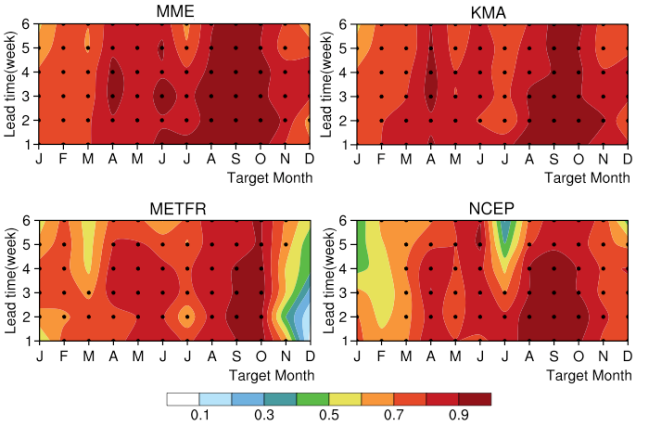


Fig. 3. ACC of sea ice extent between observation and models including MME. The ACC are plotted with respect to target month and lead time. Black dots represent statistical significance of a linear correlation coefficient at the 95% confidence level.

S2S Webinar Series

Seung-On Hwang (S2S ICO, manager)

As many people are aware, most of our planned activities to meet and share our research works have been cancelled due to COVID-19. Because sharing the knowledge with our peers help us get feedback and is essential for S2S subprojects to achieve success, WMO S2S Prediction Project organized a monthly S2S project webinar series, highlighting various aspects of the project and promoting engagement from the broader community. The idea was to cycle through the various S2S sub-projects/activities. The first S2S webinar has begun on May 2020. This online webinar consists of a few short presentations of just one session for about an hour via Cisco Webex system.

1. The first webinar (May 27th), 99 people attended.
- **Joshua Dorrington** (U. of Oxford): Beyond skill scores: exploring sub-seasonal forecast value through a case study of French month-ahead energy prediction.
- **Dave MacLeod** (ForPAc): Subseasonal forecasts for humanitarian decision-making in Kenya: understanding forecast skill and the latest results from the S2S ForPAc real-time pilot study.
- **Julian F. Quinting** (Karlsruhe Institute of Technology): Using a statistical model to verify warm conveyor belts in ECMWF's sub-seasonal forecasts.
- **Steffen Tiesche** (ECMWF): Improving sea-ice cover and SST forecasts by sea-ice thickness initialization

2. The second webinar (June 24th), 57 people attended.
- **Charlotte DeMott** (CSU): Tropical SST anomaly pattern and drift biases in the S2S database
- **Susana Camargo** (Columbia): Ocean feedbacks and tropical cyclone forecasts on subseasonal time-scales
- **Bruno Tremblay** (McGill University): (Sub-)Seasonal Forecast of the Minimum Arctic sea Ice Extent
- **Mike Jacox** (NOAA SWFSC): S2S Forecasts for US West Coast Oceanography and Fisheries Applications

3. The third webinar (July 29th), 75 people attended.
- **Catherine De Burgh-Day** (BoM): Forecasting climate extremes to aid decisions on multi-week timescales
- **Christian M. Grams** (IMK-TRO, KIT): The mutual impact of weather regimes and the stratospheric circulation on European surface weather
- **Zizhen Dong** (IAP, CAS): Quasi-biweekly oscillation over the tropical northwestern Pacific in boreal winter and its influences on the North American temperature
- **Hannah Bloomfield** (Univ. of Reading): Characterisation and predictability of the wintertime meteorological drivers of the European electricity system

The webinar schedule is delivered via emails to people who are enrolled in S2S mailing list. The recording of S2S webinar and presentation files are available on S2S homepage (s2sprediction.net). During webinar, questions are submitted in the form of 'written chat' and the chair announces them, then presenter answers. Webinar time varies from month to month to suit the speaker's location.

There will be no webinar on August. We will resume the webinar series in September. Upcoming S2S webinar will be about 'Land process' on September, 'Machine learning' on October, and 'Real-Time Pilot' on November. We are looking forward to seeing you on-line.

New S2S LG members

Professor **Zhuo Wang**, Department of Atmospheric Sciences, U. of Illinois at Urbana-Champaign. USA. WWRP Working Group on Topical Meteorology Research (WGTMR).

Dr. **Atul Kumar Sahai**, Indian Institute of Tropical Meteorology (IITM), Pune, India. WWRP Scientific Steering Committee (SSC).

Dr. **Susanna Corti**, Institute of Atmospheric Science and Climate (ISAC) of the National Research Council (CNR), Italy. WCRP Joint Scientific Committee (JSC).

Call for articles in S2S Newsletter

The S2S Newsletter is published every four months. S2S ICO welcomes the submission of articles to the S2S Newsletter related to the research in a diverse range of S2S subprojects (http://s2sprediction.net).

S2S ICO at NIMS in Jeju

The S2S International Coordination Office (ICO) is located at the National Institute of Meteorological Sciences (NIMS) of the Korea Meteorological Administration (KMA), in Jeju, Republic of Korea.