Subseasonal-to-Seasonal S2S Prediction Project

Newsletter

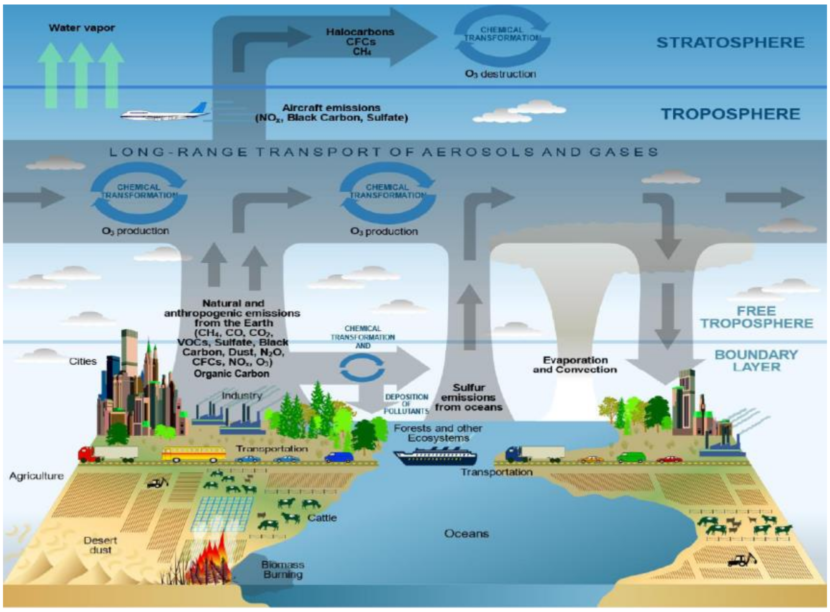
In This Issue ...

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



The S2S Aerosol Subproject

Angela Benedetti, Frédéric Vitart (ECMWF)

Aerosols are important players in the Earth's radiation balance and have an impact on climate and weather. Several researchers have recognized the important role of aerosols in global warming studies. Aerosols acts to reduce incoming solar radiation and have hence a cooling effect. However, some species such as black carbon absorb solar radiation and hence have a warming effect on temperature. The balance between greenhouse gases, aerosols and absorbing aerosols is therefore what ultimately determines the net radiative impact on climate. Since background aerosol forcing exerts itself over longer time scales, it has not been demonstrated that sophisticated interactive aerosol schemes such as those used in climate model are needed for accurate numerical weather prediction at the medium range scales. Aerosol climatologies are instead used that allow for computational efficiency and reasonable accuracy.

Postulating that background aerosol effects can be more important at longer timescales as it is seen in climate models, Benedetti and Vitart (2018) investigated whether aerosol variability could afford some predictability in the subseasonal-to-seasonal forecast, given that persisting aerosol biases might manifest themselves more over time scales of weeks to months and thus create a non-negligible forcing. The paper explored this hypothesis using the ECMWF's Ensemble Prediction System including interactive prognostic aerosols developed in the Copernicus Atmosphere Monitoring Service. Species active in the forecast were desert dust, sea salt, organic matter, black carbon and sulphate. The interaction of these species with the radiation was accounted for as well as all relevant aerosol physical processes. Only the direct aerosol effect was considered. Twelve years of summer monthly re-forecasts from 55 ensemble members were analyzed. Results indicated that the interactive aerosols have a positive impact on the subseasonal prediction at the monthly scales for the spring/summer season. This predictability is likely afforded by the aerosol variability in connection with the different phases of the Madden–Julian oscillation, particularly the variability of dust and carbonaceous aerosols. The degree of improvement depends crucially on the aerosol initialization, which stresses the importance of having accurate aerosol analysis, well constrained by observations. As a side benefit it was demonstrated that the prediction of desert dust aerosols on the monthly timescale was more skillful than persistence, opening the way to new possibilities in air quality prediction at the extended range.

It is recognized that more work is required to fully assess the potential of interactive aerosols to increase predictability at the subseasonal scales. This will be addressed in a series of experiments coordinated by the Working Group on Numerical Experimentation (WGNE), the WWRP/S2S Steering Group and the WMO Global Atmosphere Watch (GAW) Scientific Advisory Group (SAG) on Modelling Applications (SAG–APP) (Frassoni et al, 2019) which will investigate the role of aerosols in numerical weather prediction at different timescales.

The WGNE-S2S-GAW Aerosols project (WGNE-S2S-GAW-Aer) will consider two main components: one is built on a previous phase of experimentation coordinated by WGNE (Freitas et al, 2015) and will involve running higher resolution regional models in order to address the importance of interactive aerosols on medium-range weather predictability; the second component considers sub-seasonal reforecasts experiments based on ensemble approach in a global scale in order to address the importance of interactive aerosol on sub-seasonal predictability. The WGNE-S2S-GAW-Aer will benefit from the expertise of the Joint Working Group on Forecast Verification Research (JWGFVR) regarding the best metrics to be used to assess both NWP deterministic and ensemble forecasts, taking advices on what metrics to evaluate meteorological and air quality variables. Participation from modelling groups contributing with either global and/or limited-area models is anticipated.

For more information, please visit the wiki page http://www.s2sprediction.net/xwiki/bin/view/Phase2/Aerosol or contact Angela.Benedetti@ecmwf.int.

New version of S2S prediction model of CMA

Hu Xing (China Meteorological Administration)

• **New S2S forecast model: BCC-CPS-S2Sv2**

The new version of CMA prediction model (BCC-CPS-S2Sv2) started operation since November 2019. At the phase 2 of S2S Prediction Project, CMA uses a new model version, the high-resolution version of Beijing Climate Center Climate System Model (BCC-CSM2-HR). BCC-CSM2-HR is a fully coupled model with atmosphere, ocean, land surface, and sea ice components, including interactive vegetation and global carbon cycle.

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

• **EGU 2020** (NH9.10 Improving livelihoods with subseasonal to seasonal climate and hydrological forecasts: co-production to empower at-risk communities)*, 4-8 May 2020, Vienna, Austria. → CANCELLED. Changed to Online.*
https://www.egu2020.eu

• **The Fifth International Workshop on the Years of the Maritime Continent (YMC),** *30 May to 4 June 2020*, *National Taiwan University, Taiwan. → RESCHEDULED for the summer of 2021.*

• **2020 ASP summer colloquium**, *6-24 July 2020, NCAR, Boulder, US.*
https://asp.ucar.edu/asp-colloquia

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

• **AGU Fall Meeting 2020,** *7 to 11 December 2020, San Francisco, CA, USA.*
https://www.agu.org/Fall-Meeting

The atmospheric component is based on the high-resolution Beijing Climate Center Atmospheric General Circulation Model version 3 (BCC-AGCM3-HR), which has a spectral truncation at wavenumber 266 with an associated Gaussian grid of ~0.45° resolution. BCC-AGCM3-HR is a stratosphere-resolving model with 56 vertical layers from surface to 0.1 hPa. The typical vertical resolution of the 56-layer grid is 750 m from the mid troposphere to the lower stratosphere.

Parameterizations of two different sources of gravity waves are included in BCC-AGCM3-HR: stationary waves generated by flow over orography, and waves with a spectrum of phase speeds generated by convection. Both the high vertical resolution and parameterized convective gravity waves benefit a self-generated stratospheric quasi-biennial oscillation. The University of Washington moist turbulence scheme is implemented for the parameterization of boundary-layer processes and new triggering functions are used in the shallow convection scheme. These modifications result in alleviation of the double intertropical convergence zone (ITCZ) problem in BCC-CSM2-HR. The Beijing Climate Center Atmosphere-Vegetation Interaction Model version 2 (BCC-AVIM2) serves as the land component. It includes major land surface biophysical and plant physiological processes. The oceanic component is based on the Modular Ocean Model version 5 (MOM5) and the sea ice component is the Sea Ice Simulator (SIS).

For the S2S prediction, the new model uses the atmospheric initial conditions from the ECMWF real-time analysis and ocean and ice initial conditions from the BCC coupled assimilation analysis. The ensemble forecast adopts a stochastically perturbed physics tendencies (SPPT) scheme. The real-time S2S forecasts are running on every Monday and Thursday with a 60-day integration. Each forecast consists of four SPPT ensemble members, which are initialized at 00 UTC of the first forecast day. Meanwhile, the corresponding re-forecasts are also performed with a 60-day integration on the same forecast day as the real-time forecasts, including four SPPT ensemble members. The re-forecasts cover the past 15 years (2004-2018) of the forecast dates and are provided with an "on the fly" mode.

• An Introduction to CAS FGOALS-f2-V1.3 S2S prediction system

Institute of Atmospheric Physics
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Version 1.3 of Flexible Global Ocean-Atmosphere-Land System finite-volume 2 (FGOALS-f2-V1.3) S2S prediction system was developed at The State Key Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG) by Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS). The prediction model is CAS FGOALS-f2, which is a Climate System Model representing the interaction between the atmosphere, oceans, land and sea ice.

The atmospheric component of CAS FGOALS-f2 is the Finite-volume Atmospheric Model of the IAP/LASG version 2 (FAMIL2), which is characterized by a scale-aware convection scheme and the Finite-Volume Cubed-Sphere Dynamical Core (FV3); the ocean component is the Parallel Ocean Program version 2 (POP2), the land component is the Community Land Model version 4 (CLM4) and the sea ice component is the Los Alamos Sea Ice Model version 4 (CICE4). The resolution of the prediction system is approximately 100km resolution for both atmospheric and ocean grids. The nudging technique is adopted as the initialization method for both atmospheric and ocean components.

The FGOALS-f2-V1.3 S2S runs 16-ensemble members each day for real-time forecast since 1st June 2019 and 4-ensemble members each day for re-forecast since 1st January 1999. This S2S prediction ends with a 65-day integration, and the quick look of the real-time prediction can be previewed in the website (http://project.lasg.ac.cn/FGOALS_f2-S2S/index.php?Var=MJO). The S2S prediction products from this system have been shared and operationally used in Ministry of Water Resources of the People's Republic of China and Sea Ice Prediction Network (https://atmos.uw.edu/sipn/).

New ocean and sea-ice variables in the S2S database

Frederic Vitart, Manuel Fuentes, Richard Mladek, Christopher Roberts, Sebastien Villaume, Matthew Manoussakis
(ECMWF)

1. The S2S database

The S2S database builds on the experience of creating the TIGGE database and can be seen as its extension to the longer forecast ranges. The S2S database includes 3-weeks behind real-time ensemble forecasts and reforecasts up to 60 days from 11 centres: the Australian Bureau of Meteorology (BoM), the China Meteorological Administration (CMA), the European Centre for Medium-Range Weather Forecasts (ECMWF), Environment and Climate Change Canada (ECCC), the Institute of Atmospheric Sciences and Climate of the National Research Council (CNR-ISAC), the Hydrometeorological Centre of Russia (HMCR), the Japan Meteorological Agency (JMA), the Korea Meteorological Administration (KMA), Météo-France/Centre National de Recherche Meteorologiques (CNRM), the National Centers for Environmental Prediction (NCEP), and the Met Office (UKMO). The data is archived at ECMWF and CMA. A large subset is also available from the International Research Institute for Climate and Society (IRI) data library.

The database opened on 1st January 2015. By the end of 2019, 1371 users had registered and extracted 675 TBs of data from ECMWF. More than 100 articles based on the S2S database have been published so far in the peer reviewed literature.

The S2S database contains standard variables at 10 pressure levels between 1000 and 10 hPa, together with a large number of single-level variables, including thermodynamic, hydrological, and surface flux fields on a 1.5 degrees latitude/longitude grid. The frequency of archiving is once a day, except for maximum and minimum near-surface temperature and total precipitation, which are available four times a day (computed over 6-h periods). The data are archived in Gridded Binary 2 (GRIB2) format.

2. New S2S variables

The S2S database contained only 2 ocean and sea-ice variables: sea-surface temperature and sea-ice cover. Since 1st January 2020, 9 new ocean and sea-ice parameters have been added:

- Depth of 20˚C isotherm
- Mean salinity in the upper 300 metres
- Mean potential temperature in the upper 300 metres
- Ocean mixed-layer thickness defined using a sigma-theta density threshold of 0.01 kg/m^3
- Eastward surface current
- Northward surface current
- Sea-ice thickness (of the ice covered fraction)
- Sea-surface height
- Sea-surface salinity

These 9 new variables are archived in GRIB2 in a 1-degree latitude/longitude grid with a daily frequency for real-time and re-forecast. More details on these new variables can be found here: https://confluence.ecmwf.int/display/S2S/Parameters#Parameters-Oceanparameters

At the time of writing, these variables are available only from the ECMWF and ECCC 3-week behind real-time forecasts from 1st January 2020 and the corresponding re-forecasts, which are produced on-the-fly. In the coming weeks, the new variables will become available from some other S2S models: CMA and CNRM. 3 of the 11 S2S models (JMA, ISAC and HMCR) are currently based on atmosphere-only integrations and therefore will not be able to provide this new data.

The ocean variables are now available from the ECMWF and CMA data archives as well as from the IRI data library.

3. Potential use of the new variables

The addition of the new variables will make the S2S database more useful for the research community to explore the predictability and predictive skill of ocean and sea-ice variables, as well as for diagnosing the representation of air-sea interaction processes in the S2S models. For example, the S2S database can now be used to better understand air-ice-ocean atmosphere interactions at the sea-ice margin as illustrated in Figure 1. The new subsurface ocean data will also be useful to better understand the exchange of energy between the ocean and atmosphere during the passage of tropical cyclones in S2S forecasts (see example in Figure 2).

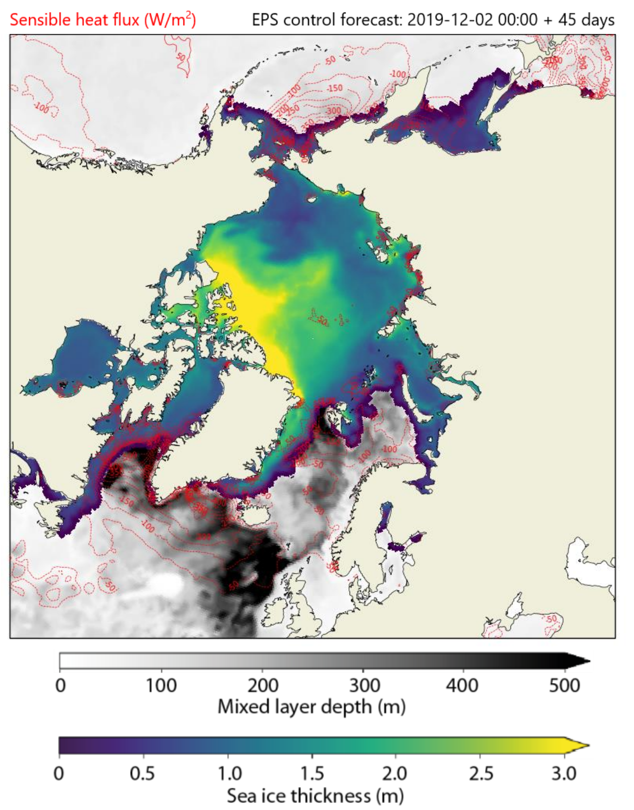

Figure 1: Sea-ice thickness, mixed layer depth, and sensible heat fluxes over the ocean from the ECMWF extended-range control forecast starting on 2 December 2019 and verifying on 16 January 2020 (45-day lead time).

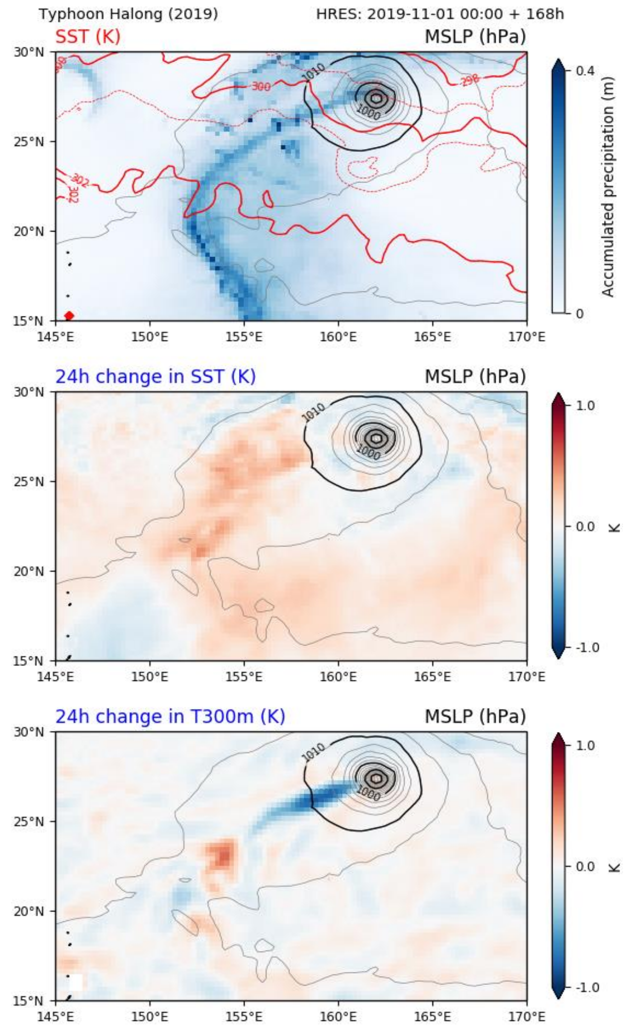

Figure 2: Impact of typhoon Halong: The top panel shows MSLP, rainfall accumulation since the start of the forecast, and SSTs. The middle panel shows the change in SSTs over the previous 24 hours. The bottom panel shows the change in ocean potential temperature averaged over the top 300 metre. This figure suggests that there was not a prominent cold wake in the SST forecasts, but there is a clear signal from the change in ocean potential temperature averaged over the top 300 metres.

New S2S SG member

Dr. **Zewdu T. Segele** from the Intergovernmental Authority on Development (IGAD) Climate Prediction and Applications Centre (ICPAC) in Nairobi has joined us as a new S2S SG member. He leads the Climate Modelling and Prediction Group at ICPAC in operational forecasting from medium-range to seasonal time scales over the Greater Horn of Africa (GHA). He has over 15 years of experience in weather and seasonal forecasting and extensively worked with various stakeholders in forecast applications and early warning activities. He was a chief meteorologist and team leader of the Weather Forecast and Early Warning Team of the National Meteorological Agency of Ethiopia.

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).

New S2S website created for Phase II of S2S (2019-2023)

Seung-On Hwang (Manager, S2S ICO)

S2S ICO is happy to announce that WMO S2S Prediction Project website has been newly changed under the protocol of S2S Phase II starting 2019. In this renewal ICO improved design and functionality, aiming for a website that made most of information visible on the front page of website and visitors understand S2S research works and initiatives. The leaders of each subproject are to further enhance the content and wiki pages linked to S2S subprojects to provide more valuable information. ICO is constantly updating our content with helpful information. We look forward to your interest and use. Always welcome to visit!

The website contains new features as follows.

① S2S news, events such as workshop, conference, meeting and training course, and published newsletter.

② Click the button of three 'S2S archiving data centers' to enter directly each website.

③Click to enter three other S2S products sites.

④ Click the name of six S2S sub-projects and machine learning to enter corresponding wiki page.

⑤ Click the title to enter the Real-time Pilot wiki page.

⑥ Click the title to enter the R2O wiki page.

⑦ Click three S2S archiving data center to see the statistics of S2S data volumes, number of requests, active users, and users per country.

⑧ Click to the title to enter the section the list of papers, report, and presentation, and you can download materials.

⑨ Bar graph representing the number of papers only using the S2S data through S2S archiving data centers. The total number of publications is also shown.

⑩ Click to join the S2S mailing list.

⑪ The number of visitors to this S2S website since Nov. 19 2019. Already more than 20 thousand!

< The front page of S2S prediction project website. 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.