Subseasonal-to-Seasonal S2S Prediction Project

WWRP World Weather Research Programme

WCRP World Climate Research Programme

News Letter

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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.

2. 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.

Photos of "WMO S2S 7th Steering Group Meeting" in Boulder, USA

WMO S2S 7th Steering Group Meeting

The 7th S2S steering group meeting took place after the Sub-seasonal to Decadal Conferences on 21-22 September 2018. 29 people, including SG and liaison members, ICO members and several guests, attended the meeting. A main objective of this meeting was to discuss the plans of the **S2S Phase 2 sub-projects**.

- **MJO and teleconnections sub-project:** This sub-project will focus on the presentation of teleconnections and their modulation in S2S models. Metrics for assessing model teleconnections and diagnosing sources of errors in teleconnections will be applied. This sub-project will also evaluate MJO teleconnections in models based on MJO characteristics (slow vs. fast MJOs).
- **Stratosphere sub-project:** This is a joint sub-project between S2S and WCRP/SPARC/SNAP. Science plans include: developing additional stratospheric diagnostics and investigating the use of DynVarMIP additional diagnostics (eg momentum budget) to S2S models if the S2S vertical resolution is not too coarse for these diagnostics; Coordinating damping experiments to examine the dynamics of downward coupling in detail; Studying the link to tropospheric dynamics; Establishing strong links of S2S modeling groups with the QBOi multi-modeling effort that is spinning up.
- **Aerosols sub-project:** Extensive re-forecast experiments using the ECMWF model with and without interactive aerosols suggest good prediction skill of some aerosols (e.g. dust) up to week 4 and an important impact of the aerosol initialization. It is planned to organize coordinated experiments with other centres around the same setup as the one used for the ECMWF experiments. The coordinated experiments will be organized with WGNE which is also interested in assessing the impact of interactive aerosol with regional models and short-range forecasts around a field campaign taking place in South Africa.
- **Ensemble generation sub-project:** One of the main goals of this sub-project will be to study the influence of burst vs lagged ensemble initialization on the forecast spread using S2S database. A preliminary investigation was presented at the S2D conference. Other goals include benchmarking the spread-error relationship in S2S prediction systems, exploring the impacts of coupled initial perturbations on the sub-seasonal prediction, and developing techniques for coupled initial perturbations which is under development in a few centers (ECMWF,

NCEP, BoM, JMA) and investigating the impact of stochastic parameterizations for the sub-seasonal prediction (a discussion with PDEF/WGNE was initiated).

- **Land sub-project:** S2S Phase II will address the following questions:
  - What is the impact of the observing system on land initialization and S2S forecasts?
  - How well are the coupled land/atmosphere processes represented in S2S models?
  - How might anomalies in land surface states contribute to extremes?

- **Ocean sub-project:** Science questions to be addressed in S2S Phase2:
  - What ocean feedbacks directly influence sub-seasonal variability and prediction skill?
  - How is S2S predictability influenced by pre-existing ocean state?
  - How does low-frequency variability (e.g., ENSO, climate change) affect S2S predictability?
  - How does ocean mean state drift impact S2S predictability?
  - What mechanisms affect extreme ocean weather (heat waves) and their predictability?

  In addition, Coordinated Observing System Experiments (OSEs) will be organized to evaluate the role of oceans on improving sub-seasonal forecast skill. Discussions also took place on model experimentation for prioritizing satellite observations for S2S. On the second day, several topics were discussed: S2S database, R2O sub-project, real-time pilot, workshops/education outreach.

1. S2S database

Updates on the status of the S2S database at ECMWF, CMA and IRI were presented. Recent model changes include the extension of Météo-France reforecasts from twice a month (1st and 15th) to 4 times a month (8th and 22nd of each month added). Work is ongoing to archive ocean variables in 1 degree grid in netcdf in the S2S database. The S2S Indices ftp site is now populated with tropical cyclone tracks from all the S2S real-time and re-forecasts. It is planned to add sudden stratospheric warming indices and European weather regimes. Several new models, including one from IITM, may join the S2S database. At IRI, a maproom developed for SubX could be applied to S2S.

2. R2O

The Research to Operations (R2O) sub-project for S2S phase 2 will work in coordination with WMO-CCl, IPET-OPSLS and JWGFVR. The proposed activities for Phase 2 include:

- Promote the development and inter-comparison of different methodologies for forecast calibration, multi-model combination, verification, and forecast formats
- Make recommendations for operational centres to harmonize their real-time and re-forecast set-ups to facilitate S2S forecast calibration, multi-model combination and verification
- Develop S2S training resources and coordinate/organize a series of capacity building training events
- Work with IPET-OPSLS to (a) develop standards to define criteria for the designation of GPCs for S2S Predictions, and (b) establish standards for data exchange and delivery of S2S hindcasts and real-time forecasts to the WMO LC-LRFMME

3. Real-time Pilot

An important part of S2S Phase 2 will be a real-time pilot, which will give access in real-time to the S2S database to a selected list of applications for a limited time (1 or 2 years). A network of application

3. S2S Database

The S2S Multi-Model database (Data Portals at the European Center for Medium-Range Weather Forecasts (ECMWF), China Meteorological Administration (CMA), and International Research Institute for Climate and Society (IRI)) contains near real-time and re-forecasts up to 60 days from 11 centres:

Australian Bureau of Meteorology (BoM), China Meteorological Administration (CMA), European Centre for Medium-Range Weather Forecasts (ECMWF), Environment and Climate Change Canada (ECCC), The Institute of Atmospheric Sciences and Climate (CNR-ISAC), Hydrometeorological Centre of Russia (HMCR), Japan Meteorological Agency (JMA), Korea Meteorological Administration (KMA), Météo-France/Centre National de Recherche Meteorologiques (CNRM), National Centers for Environmental Prediction (NCEP), and the United Kingdom's Met Office (UKMO). All except CNR-ISAC are WMO Global Producing Centres of Long-Range Forecasts (GPCs). Indian Institute of Tropical Meteorology (IITM) model based on CFSv2 integrations into the S2S database may be added in phase II.

4. Upcoming Events

- **Workshop on Subseasonal-to-Seasonal Predictability of the Mid-Summer Drought, *3-7 December, 2018, Antigua, Guatemala*:** It is a one-week hands-on training on Mid-summer drought characteristics and prediction. The classes will be given in both English and Spanish. (https://msdworkshop.iri.columbia.edu/)

- **AGU 2018 Fall Meeting: (A097) Sub-seasonal to seasonal prediction of weather and climate, *10-14, December, 2018, Washington DC*:** This meeting will provide an opportunity to learn pioneering research including Centennial events. (https://fallmeeting.agu.org/2018/)

- **Predictability, Dynamics and Applications Research using the TIGGE and S2S Ensembles, *2-5 April 2019, ECMWF, Reading, UK*:** The utilisation of the TIGGE and S2S databases are highlighted in this workshop. (https://www.ecmwf.int/en/learning/workshops/workshop-predictability-dynamics-and-applications-research-using-tigge-and-s2s-ensembles)

scientists interested in S2S could be formed in collaboration with SERA. Discussion took place on how to organize this activity.

4. Workshop

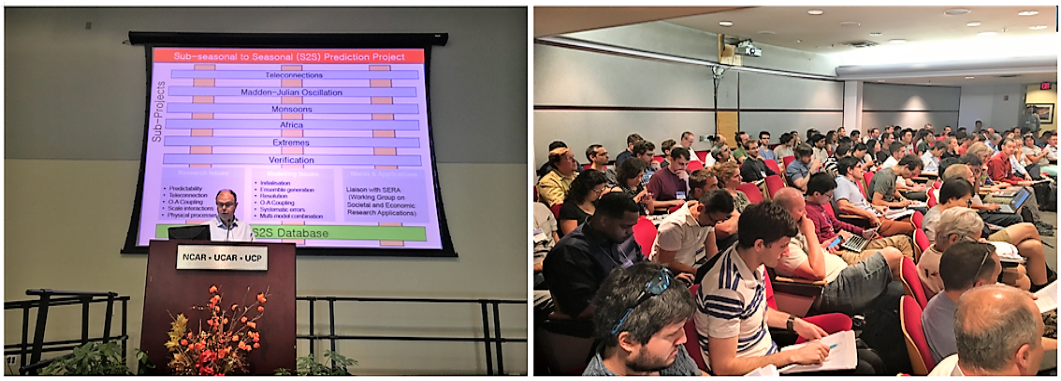
Future meetings include:

1. AGU session on S2S (Dec 2018) - More than 70 abstracts - 3 oral sessions plus poster session
2. EGU session on S2S (April 2019)
3. TIGGE-S2S workshop at ECMWF (April 2019)
4. IUGG/IAMAS meeting in Montreal (July 2019)

The Second International Conference on Sub-seasonal to Seasonal (S2S) Prediction

The Second International Conference on Sub-seasonal to Seasonal (S2S) Prediction and Second International Conference on Seasonal to Decadal (S2D) Prediction took place in Boulder, Colorado, USA, during the week 17-21 of September of 2018. The two conferences were organized as parallel sessions, except for plenary sessions during the first half day and the last day of the conferences. 347 people attended the two conferences (about 200 for S2S), including 98 early career scientists. Hindred participants followed it remotely. The conferences included 144 oral presentations and 224 posters. This conference was an important event for the WWRP/WCRP S2S project. The first international Conference on Sub-seasonal to Seasonal (S2S) Prediction, which took place in 2014, was the kick-off meeting of the S2S project. This second conference marks the end of the first phase of the S2S project and the start of S2S Phase 2. Therefore, the main goals of this international conference were to showcase the main achievements of S2S Phase 1 as well as to present the plans for Phase 2 and get feedbacks from the S2S community. Therefore, several S2S sessions were dedicated to Phase 2 research themes. The summary of the sessions can be found in the conference page.

This conference showed that the S2S database has enabled numerous research activities that are advancing the science of the extended range prediction, and facilitated the development of forecast applications. Highlights from the oral presentations include:



Photos of "Second International Conference on Sub-seasonal to Seasonal Prediction (S2S)" in Boulder, USA

- A good representation of the basic state is required for teleconnections between the MJO and the North Atlantic to be correct.
- There is increasing evidence of time scale interactions between various sources of predictability (for instance, MJO teleconnections modulated by ENSO; link between QBO and Sudden Stratospheric Warming, impact of QBO on tropical convection)
- The stratosphere is a valuable source of predictability on S2S timescales. However, models still have issues capturing stratosphere processes and stratosphere-troposphere interaction.
- Some operational centres are moving towards a unified, coupled forecast system that can work across timescales from days (or shorter) to seasons (or longer).
- Low order empirical models can provide valuable insight into S2S predictability and can be used as benchmarks for operational forecasts.
- Multimodel ensembling was shown to have higher skill than individual models.
- Weather regime analysis and teleconnection patterns provide a bridge between large-scale sources of predictability and impacts such as surface temperatures, heat/cold waves, and atmospheric rivers.
- S2S forecasts in real-time are needed for application research, but are not currently not provided by the S2S database.
- Applicability of S2S forecasts depends on prediction skill, which strongly depends on the target-user variable. Further case studies and evaluation are needed from the application context.

Capability-Building Programme in Sub-seasonal to Seasonal Prediction for Southeast Asia (S2S-SEA) - First and Second Workshop

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Introduction

The S2S-SEA Programme was initiated in 2017 by the Meteorological Service Singapore (MSS), host of the ASEAN Specialised Meteorological Centre (ASMC; http://asmc.asean.org), and in collaboration with the WMO's S2S Prediction Project (http://s2sprediction.net). The Programme is a multi-year series of workshops split into two phases. In the first phase, the workshops (S2S-SEA I and II) focused on assessing model skill for Southeast Asia, while the upcoming second phase workshops (S2S-SEA III and IV) will explore product development. Given the relatively good skill of subseasonal forecasts for the region (e.g. Li & Robertson, 2015), there is potential to maximise benefits of S2S predictions. This article summarises the outcomes of the first two workshops, which were conducted in Singapore from 27 February - 3 March 2017 and 13 - 17 August 2018.

Participants from the Second Workshop (S2S-SEA II), held on 13-17 August 2018 in Singapore: NMHS representatives and end-users from disaster risk and water resource management agencies in Southeast Asia.

Overview of practical workshop sessions

In both workshops, the skill of deterministic forecast variables was examined at lead times of +1, +2, +3, or +4-weeks (LT1, LT2, LT3, and LT4 respectively). Participants were introduced to the S2S Project Database in the first workshop, while in the second workshop they were familiarised with the copy of the S2S database hosted on the IRI Data Library. Participants installed a virtual machine pre-packaged with the required tools and pre-prepared codes, allowing them to continue S2S work in their home countries.

Analysing model skill

In the first workshop, participants assessed model skill using the Correlation of Anomalies (CORA) and Mean Square Skill Score (MSSS) for the ECMWF model hindcasts' prediction of the weekly (1) accumulated rainfall anomalies, and (2) daily mean temperature anomalies. The hindcast anomalies were calculated by subtracting the hindcasts' lead-dependent climatologies (1998-2014) for the corresponding week. The hindcast anomalies were then compared against ERA-Interim (temperature) and TRMM (rainfall). For each LT, the monthly skill scores were determined by pooling all weeks within the month. The IRI Data Library was also introduced for analysing case studies. Groups assessed and presented on their own months and case studies of interest.

The second workshop focused on anomalies in the number of dry days per week, following feedback from the first workshop to look at specific variables. The dry day threshold was initally set at the 20th percentile value, with participants testing out other thresholds. Time was also spent exploring Model Output Statistics (MOS) for S2S prediction, with guidance from the International Research Institute for Climate and Society (IRI), using the Python package of IRI's Climate Predictability Tool (CPT), PyCPT.

Outcomes of the workshops

The ECMWF S2S model performed well for temperature for up to LT3, and in some cases LT4 depending on the month assessed. The model was also much more skilful compared to persistence (Figure 1). For rainfall, there were wider variations in skill across different months and regions, and in some cases intense mesoscale events affected model predictions. Case studies analysed showed generally better predictions in the presence of large-scale drivers such as MJO and ENSO. Nevertheless, even in situations where the predicted intensities are significantly biased (e.g. in LT4), large-scale patterns of anomalies were often predicted by the model and can, therefore, be potentially useful as warnings.

Lessons learnt and next steps

There was a large spread in experience on S2S within Southeast Asia. While some participants had little programming or S2S experience, by the end of the workshops, all participants were able to plot model skill and had a basic understanding of S2S concepts. Participants that attended S2S-SEA I found it very beneficial for S2S-SEA II, highlighting the importance of continuity amongst participants. But continuity is often difficult, given the staffing constraints at NMHSs.

Further discussions with end-users on the last day of the second workshop revealed different variables of interest for the region. Indicators of extreme rainfall associated with tropical cyclones, droughts, and floods were of general interest across various sectors, while indicators of temperature extremes were of interests particularly for the health sector and fisheries. There is still a need, however, to convince users of the usefulness of such products

while managing their expectations.

Access of near real-time subseasonal model information is limited for some NMHSs, and this prevents them from pursuing research and development work in S2S. Lack of real-time forecast data, coupled with workforce and resource constraints, resulted in NMHSs prioritising other more established timescales.

Nevertheless, it is increasingly recognised in Southeast Asia that the agricultural and food, disaster-risk reduction, health, and water resources often require forecasts on the S2S timescale. Judicious use of the S2S forecasts by operational centres, especially those co-developed with end-users, can potentially minimise the losses from weather and climate-related disasters. To this end, the upcoming two workshops will bring together NHMSs and end-users in Southeast Asia to further explore potential products, including probabilistic forecasts.

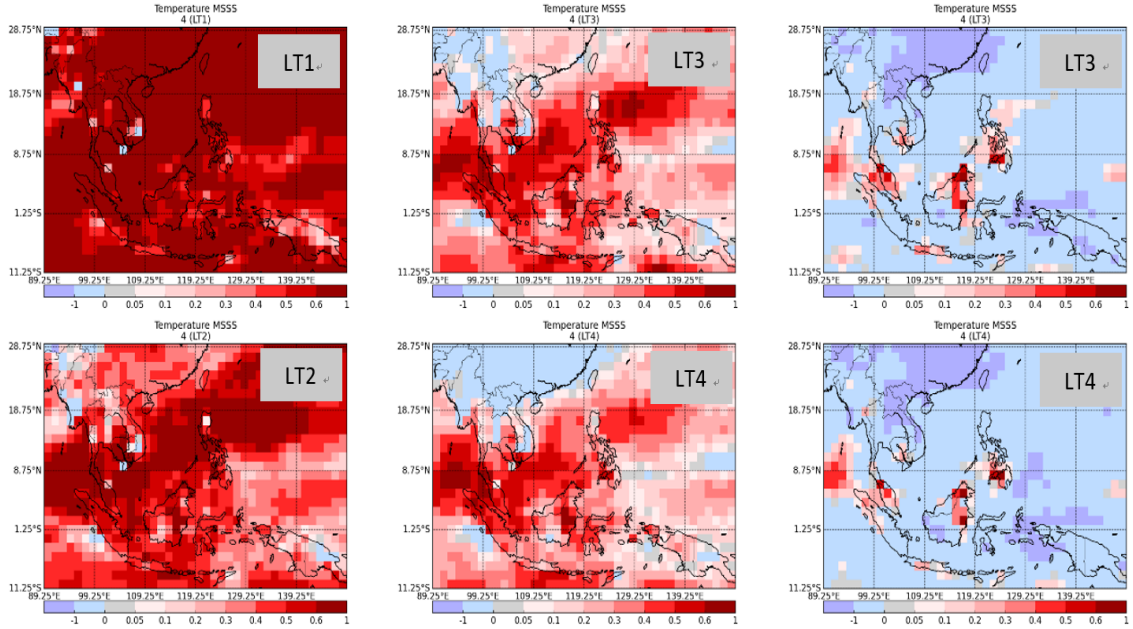

Figure 1. Mean-square skill score (MSSS; measured against climatology) for ECMWF S2S model temperature anomaly hindcasts for April against corresponding ERA-Interim anomalies for LT1 to LT4 (first two columns) for the period 1998-2014. More intense red shades indicate better skill. The last column shows the MSSS of persistence forecasts for LT3 and LT4.

Acknowledgements

MSS would like to thank the WMO S2S Prediction Project and its co-chairs for contributions to the S2S-SEA Programme by providing support during both workshops; the International Research Institute for Climate and Society (IRI) and the Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) for their contributions during the second workshop; and the United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) for co-funding S2S-SEA II.

Website resources for S2S-SEA I and II

-https://github.com/S2S-SEA/workshop1/wiki
-https://github.com/S2S-SEA/workshop2/wiki

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Sub-seasonal to Seasonal Activities in Southern South America

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The Southeast of South America, also known as SESA, is a region comprised of northeastern Argentina, southern Brazil and eastern Paraguay. Since the 80s this region was identified as presenting submonthly and intraseasonal variability, varying opposite to the South Atlantic Convergence Zone (SACZ). This seesaw or dipole in precipitation and convection is the regional leading pattern of variability, and the region with enhanced precipitation may also present extreme events. Heat waves in SESA could also be associated to enhanced SACZ activity, extending the

regional influence of this seesaw pattern. The Madden Julian Oscillation has been proven to have an influence in South America and, in particular, in the activity of the regional leading pattern. Therefore, subseasonal forecasts for the continent may turn promising results.

In the past years there have been several studies that addressed the predictability in the region using the S2S database. Osman and Alvarez (2017) studied the subseasonal prediction of an intense heat wave of December 2013 using the models of the BOM and CMA. Doss-Gollin and coauthors (2018) used the ECMWF real-time forecasts to study the predictive skill of an event of heavy rainfall in SESA using also an approach of Model Output Statistics. Coelho and coauthors (2018) presented a verification framework for South American subseasonal precipitation predictions using a week of April 2016 as an example and comparing the skill for that week against the skill for the whole season, in hindcasts and real time forecasts of the ECMWF.

During 2017 and 2018 two training activities were conducted, both tailored to young scientists and professionals from met services in the S2S field. In July 2017 the 1st South American school on Subseasonal to Seasonal Predictability and Prediction was held in Asunción, Paraguay, supported by WMO and the S2S project. In that opportunity, more than 20 participants learnt about the sources of S2S prediction and how to access S2S database. In addition, they developed a mini-project applying the knowledge they acquired during the training. Recently, The 10th NOAA-USAID International Training Workshop developed in Guayaquil, Ecuador had an special emphasis in S2S prediction. Both activities have helped to raise the awareness of the relevance of having monitoring and prediction tools of weekly anomalies beyond the synoptic scale in a regional scale.

In line with most of the WMO regions, there are some research centers and Met Services using and developing S2S monitoring and prediction tools. In this sense, The DIVAR group in Argentina has developed the CLIMAR portal (http://climar.cima.fcen.uba.ar) which includes many monitoring tools such as the SIS index (Alvarez et al. 2014) to follow the intraseasonal variability in SESA. In addition, it provides the real-time weekly anomalies (up to the week four) forecasted by the CFSv2 model over South America for the most relevant climate variables such as temperature, precipitation and geopotential heights anomalies. The development of this products not only underpins the activities of the Climate Services Centers but also opens up new research questions to be addressed by the community.

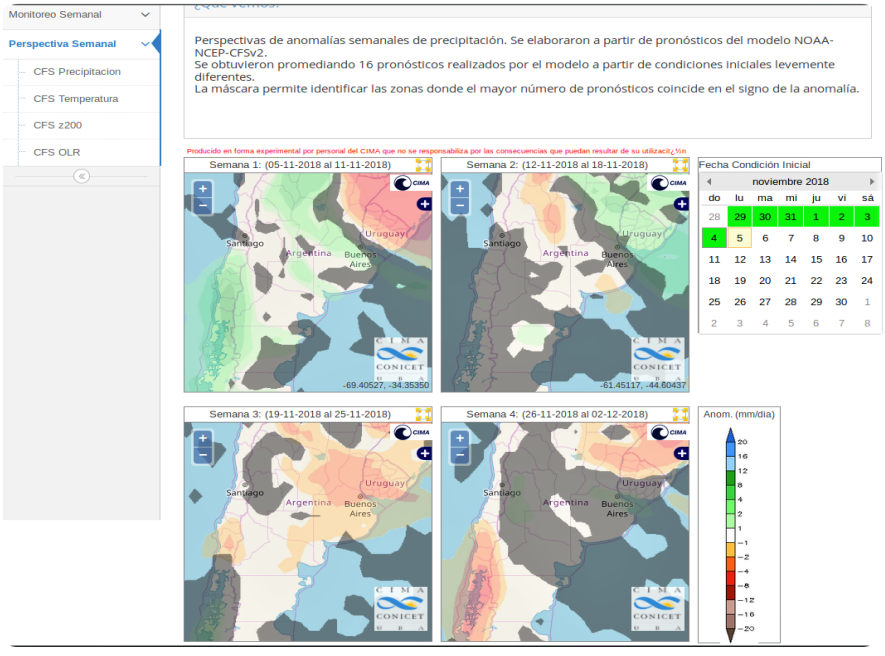

Figure 1. Weekly precipitation forecast from CFS V2 available at CLIMAR portal.

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S2S Activities in South and Central America: Prediction quality assessment and capacity building

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There exists a vast amount of interest by the academic, operational and applied communities in sub-seasonal predictions in South America, as these predictions have the potential to help inform decisions in various sectors (e.g. water management, food production and tourism), particularly because they bridge the gap left for several years between traditional weather forecasts and seasonal predictions. This interest was substantially boosted after the initiation of the WWRP/WCRP sub-seasonal to seasonal (S2S) project in 2013, which made available in a coordinated way retrospective forecasts (hindcasts) and near real time (3-week delayed) forecasts from 11 contributing models through the S2S Database hosted at ECMWF (mirrored at CMA), and with a subset available through the IRI Data Library.

S2S stimulated great interest in the South American operational community, which has been actively engaged for two decades in issuing seasonal predictions through national and regional climate outlook forums. Due to the existing practices of regularly consulting the available climate model predictions from various global centres for issuing operational seasonal prediction, this community has high expectations for starting issuing operationally sub-seasonal predictions in a similar manner in South America. However, an important aspect to be considered is managing expectations, particularly with respect to the quality of the emerging sub-seasonal predictions, and also building knowledge about the strengths, weaknesses and limitations of the under-development sub-seasonal predictions prior to starting an operational service. And this is where research plays an important role. The S2S sub-project on verification and products, under the guidance of the Joint Working Group on Forecast Verification Research (JWGFVR), has been promoting and encouraging research addressing specific aspects of S2S prediction quality. In this context the CLIMAX project (Climate Services Through Knowledge Co-Production: A Euro-South American Initiative For Strengthening Societal Adaptation Response to Extreme Events), involving researchers from Brazil, Argentina, France, Germany and the Netherlands, was motivated to investigate S2S prediction quality, with two papers being recently published.

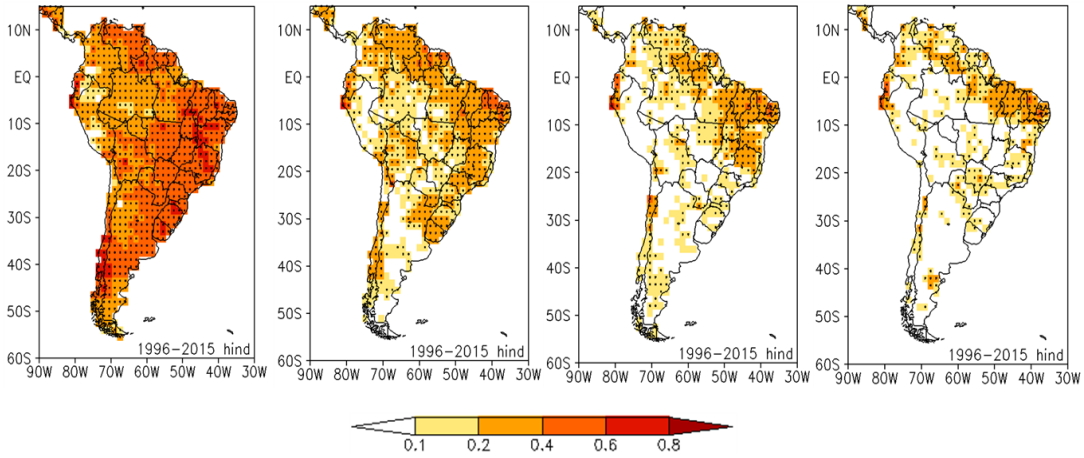

Figure 1. Maps of correlation between the ECMWF ensemble mean precipitation anomaly prediction produced one to four weeks in advance (1st to 4th columns) and the corresponding observed (CPC) precipitation anomalies at each grid point for the all season hindcast verification sampling strategy (260 samples) as described in section 2.3 of Coelho et al. (2018). ECMWF ensemble mean anomalies were computed with respect to the 1996-2015 hindcast period produced with the 2016 model version in cross-validation (leaving one year out). The dots mark grid points where the computed correlation coefficient was found to be statistically significantly different from zero at the 5% level using a two-sided Student's test. Adapted from Figure 2 of Coelho et al., 2018.

In the first paper (Coelho et al., 2018) an attribute-based verification framework has been proposed for assessing the quality of sub-seasonal precipitation predictions over South America, taking into account the existing large degree of complexity between ECMWF sub-seasonal hindcasts and near real time forecasts available in the S2S project database. Predictions produced one to four weeks in advance were assessed using a three-level procedure for aggregating the hindcasts and near real time forecasts. This procedure has been shown to be useful for helping forecasters to learn how well in advance sub-seasonal precipitation can be predicted over South America, to identify regions where to best trust both deterministic and probabilistic predictions, to diagnose particular aspects re-

quiring improvements in these predictions, and therefore build confidence and learn about the limitations of the model guidance information. Figure 1 shows and example of the performed assessment over South America.

The second paper (de Andrade et al., 2018) assessed deterministic sub-seasonal global precipitation hindcast quality of all 11 S2S project models considering lead times up to 4 weeks. This assessment revealed higher quality during the first week and dropped as lead time increased, confining meaningful signals in the tropics mostly due to El Niño-Southern Oscillation and Madden-Julian Oscillation-related effects. The contribution of these two phenomena to hindcast quality was assessed by removing their regressed precipitation patterns from predicted fields. The atmospheric circulation hindcast quality was also examined suggesting the importance of using a relatively finer spatial resolution and a coupled model for resolving the tropical circulation dynamics, particularly for simulating tropical precipitation variability. The extratropical circulation hindcast quality was found to be low after the second week likely due to the inherent unpredictability of the extratropical variability and errors associated with model deficiencies in representing teleconnections.

The Columbia World Project ACToday (Adapting Agriculture to Climate Today, for Tomorrow) is also addressing sub-seasonal prediction aspects in Colombia and Guatemala. A cross-validated skill assessment has been performed for both deterministic and probabilistic sub-seasonal forecasts produced by the ECMWF model, analyzing changes of sub-seasonal skill across the year. Furthermore, the use of pattern-based statistical calibration methods, like Canonical Correlation Analysis, has been explored for northern South America, Central America and part of the Caribbean (Figure 2), showing potential for skill improvement. The analysis is being now extended to other models in the S2S Database and in the NOAA-funded SubX project.

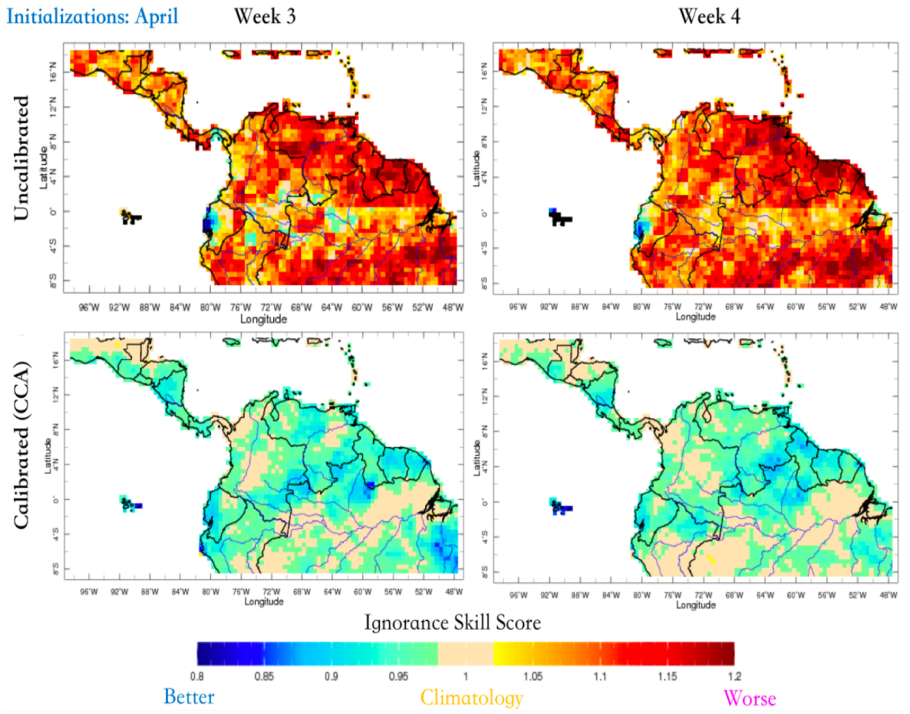

Figure 2. Skill assessment of uncalibrated (top panels) and calibrated (bottom panels) probabilistic sub-seasonal rainfall forecasts initialized three and four weeks in advance (Week 3 and Week 4 columns, respectively), using the ECMWF model and all April initializations. Ignorance Skill Score is a negatively-oriented metric based on Shannon's information theory, with unitary values corresponding to climatology and zero to a perfect forecast. The Canonical Correlation Analysis (CCA) calibration approach tends to increase probabilistic skill almost everywhere. After Muñoz et al. (2018).

Another important aspect of S2S activities in South America is capacity building. In this regard from 10 to 14 July 2017 the First South American School on Sub-seasonal predictability and prediction took place in Asunción, Paraguay, and from 16 to 20 July 2018 the Tenth International Training Workshop on Climate Variability and Predictions (10ITWCVP) took place in Guayaquil, Ecuador, the latter organized by NOAA, USAID, WMO and CIIFEN. These training activities targeted the academic (university and research scientists) and operational communities (personnel from national meteorological services) focusing on various sub-seasonal prediction aspects, such as understanding the sources of predictability in this time scale, methodologies for assessing prediction quality, and practical sessions on how to access and process sub-seasonal predictions available through the IRI data library, including the use of the IRI Climate Predictability Tool (CPT) software. These training activities have proved to be fundamental for raising awareness about the need for a critical and detailed evaluation of the sources of predictability

and the current quality levels of sub-seasonal predictions over South America prior to setting up an operational service. The next sub-seasonal prediction training in the region will take place in Antigua, Guatemala, during the first week of December 2018, and will be focused on predictability of the Mid-Summer Drought characteristics in Central America, the Caribbean and northern South America. For details, visit the workshop website.

In summary, although sub-seasonal predictions are still treated as an under-development research activity in South America, there is a clear interest by the operational community, which is motivated by demands of the applied communities on a time scale that received for several years much less attention than traditional weather and seasonal predictions. This highlights the need for further understanding and documenting the strengths and limitations of these predictions, including the involved sources of predictability, as well as performing a detailed assessment of the current prediction quality levels of the emerging sub-seasonal predictions for South America.

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