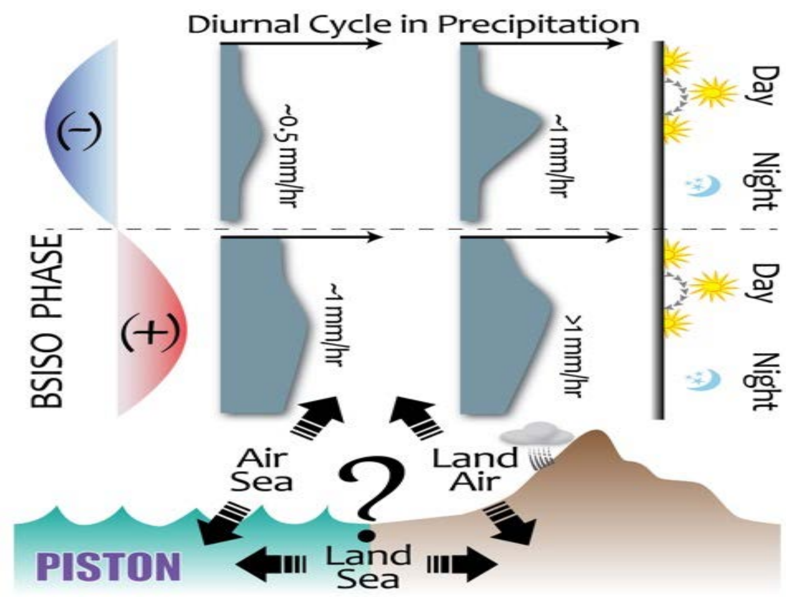
Subseasonal-to-Seasonal S2S Prediction Project

WWRP World Weather Research Programme WCRP World Climate Research Programme

News Letter

Propagation of Intra-Seasonal Tropical Oscillations (PISTON) Office of Naval Research Departmental Research Initiative (DRI)

During monsoon season over the South China Sea and Philippines, weather varies on the subseasonal time scale. Disturbances of the "boreal summer intraseasonal oscillation" (BSISO) move north and east across the region over periods of weeks. These disturbances, comprised of synoptic and mesoscale convective systems, are conditioned by the complex geography of the region. The diurnal cycle in convection over islands and adjacent coastal seas is strong. Air-sea interaction is modulated by ocean stratification and local circulation patterns that are themselves complex and diurnally varying. The multiple pathways and space-time scales in the regional ocean-atmosphere-land system make prediction on subseasonal to seasonal (S2S) time scales difficult. The PISTON field experiment (http://onrpiston.colostate.edu) aims to address these challenges.



The PISTON field campaign targets the west coast of Luzon in August/September 2018. Shipboard measurements will be made on the R/V Thomas G. Thompson, working closely with colleagues on BRP Gregorio Velasquez through the Philippine SALICA program (Sea Air Land Interactions in the Context of Archipelagos). Measurements will span the coastal ocean to 220 nm offshore and include polarimetric and Doppler radar, atmospheric soundings, fluxes and aerosols as well as detailed upper ocean measurements. Ship-based observations will be augmented by measurements from oceanographic moorings, land based soundings, radar and rain gauge stations. PISTON is timed to interact with the aircraft-based, NASA-funded CAMP^{2}EX campaign (Cloud and Aerosol Monsoonal Processes-Philippines Experiment).

Contents

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. The website is at **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. The primary function of the ICO is to provide support to planning and implementation of S2S priorities.

Six Sub-projects in S2S

The research topics of the WWRP/WCRP Sub-seasonal to Seasonal Predict ion project (S2S) are organized around a set of six subprojects, each intersected by the cross-cutting research and modeling issues, and applications and user needs. The science plans of each subproject which can be found at the S2S webpage, include:

1. Monsoons: The main goal of this sub-project is to develop a set of societally relevant intra-seasonal forecast products and metrics that are applicable to all the major monsoon systems which can be monitored with operational real-time forecast systems. Case studies of monsoon onsets will be investigated.

2. MJO: This sub-project will evaluate the state of the art and characterize shortcomings of MJO Maritime Continent interactions. A main goal is to get a better understanding of the roles of multi-scale interactions, topography and landsea contrasts, and ocean-atmosphere coupling in collaboration with the MJO Task Force of WGNE and Year of the Maritime Continent (YMC).

3. Africa: The goal of this subproject is to develop skilful forecasts on the S2S time scale over Africa and to encourage their uptake by national meteorological services and other stakeholder groups. This sub-project is more application oriented than the other sub-projects.

4. Extremes: This sub-project will evaluate the predictive skill and predictability of weather regimes and extreme events (droughts, floodings, heat and cold waves), assess the benefit of multi-model forecasting for extreme events and improve our understanding of the modulation of extreme weather events by climate modes. It is also planned to select case studies with strong societal impact.

5. Products and Verification: The main goals of this sub-project are to recommend metrics and datasets for assessing the forecast quality of S2S forecasts, provide guidance for a potential centralized effort for comparing forecast quality of different S2S forecast systems, including the comparison of multi-model and individual forecast systems and consider linkages with users and applications.

6. Teleconnections: This subproject aims at a better under-standing of sub-seasonal tropical-extratropical interaction pathways and identifying periods and regions of increased predictability ("forecasts of opportunity"). This would help improve sub-seasonal to seasonal forecasts of weather and climate for applications.

The PISTON observational effort will be closely complemented by a modeling program including global and regional atmosphere, ocean and coupled models. The modeling component includes process-oriented research as well as the use and validation of operational systems.

The diurnal cycle and its interaction with the BSISO are primary targets for PISTON. Key questions include how heat is stored and released in the upper ocean on intraseasonal time scales, how that heat storage interacts with atmospheric convection, and what role it plays in BSISO maintenance and propagation. Key processes include land-sea breezes, orographic influence on convection, river discharge, gravity waves, diurnal warm layers, internal tides, and a buoyancy-driven northward coastal current. As intraseasonal disturbances approach the region, the presence of islands, with their low surface heat capacity, mountains, inhomogeneous distribution of land surface type (urban/vegetation/soil), and strong diurnal cycle disrupts the air-sea heat exchange that likely sustains the BSISO over the ocean, confounding prediction models in which these processes are inadequately represented. Along with upscale influences, PISTON will seek to advance our understanding of how large scale atmospheric circulation variability over the South China Sea, related to the monsoon, BSISO, and convectively coupled waves, modifies the local diurnal cycle, synoptic systems, and air-sea interaction in coastal regions and nearby open seas. PISTON's coordinated observing and modeling program will attempt to unravel this complex web of interactions in the service of improved S2S prediction. PISTON's emphasis on multi-scale interactions in the Maritime Continent (MC) is relevant to S2S's subproject on MJO-MC (s2sprediction.net /xwiki/bin/view/Main/ MJO).

Update on the S2S Database

The S2S Newsletter No.1, published in September 2015, described the main characteristics of the S2S database and announced the opening of the ECMWF S2S data portal. The S2S Newsletter No. 2 (January 2016) included an update of the S2S database. Since January 2016, all the 11 S2S models are available (Environment and Climate Change Canada and the Korea Meteorological Administration extended range forecasts have been included in the S2S database in 2016) and some of the model's configurations have changed:

- **CNRM:** The real-time frequency has increased from once a month to once a week (every Thursday) since March 2016.
- **ECMWF:** IFS cycle 41r2 was introduced in March 2016 with an increase of the atmospheric horizontal resolution to about 16 km up to day 15 (Tco639) and 32 km after day 15 (Tco319). IFS cycle 43r1 became operational in November 2016. This upgrade included an increase of ocean horizontal and vertical resolution (from 1 degree to a ¼ degree ocean with 75 vertical levels) and the introduction of an active sea ice model (previously sea ice cover was persisted and relaxed towards climatology).
- **ISAC:** In June 2017, the forecast length has been extended from 31 to 32 days and the real-time forecasts are now produced every Thursday.
- **JMA:** A new version of the JMA model (GEPS1701) has been introduced in March 2017. The horizontal resolution is now TL479 (about 40 km) up to 18 days and TL319 (about 55 km)

after 18 days. The new JMA real-time ensemble system includes 4 start dates (Tuesdays at 00Z and 12Z + Wednesdays at 00Z and 12Z) instead of the previous 2 start dates only (25-member ensembles starting on Tuesday 12Z and Wednesday 12Z). The new real-time dataset is archived in the S2S database as a 50-member lag ensemble with Wednesday 12Z as a nominal start date.

- **HMCR:** The real-time forecasts are issued every Thursday (instead of Wednesdays) since June 2017.

- **UKMO:** The re-forecasts have been extended with 6 additional hindcast years (2010 to 2015) since April 2016 and with 3 additional hindcast years (1993, 1994 and 1995) since August 2016. In March 2017, the re-forecast ensemble size has increased to 7 members. since August 2016. In March 2017, the re-forecast ensemble size has increased to 7 members.

Therefore, an important change since 2016 is the fact that now ALL S2S models have a start date on Thursday 00Z or Wednesday 12Z (JMA). The list of provided parameters has also changed with some models now archiving vertical velocity at all pressure levels (ECMWF, CMA and ISAC). More details on these changes can be found at https://software.ecmwf.int/wiki/display/S2S/Models.

A new ftp site containing MJO indices from the S2S database

The S2S database is very large database and downloading data from all the S2S models can take a significant amount of time and can be quite complex because of the different model configurations. In addition, there is also a limit in the number of people who can download S2S data simultaneously. Therefore there is a benefit in rationalizing the use of the S2S database to avoid as much as possible duplications in its usage.

For example, many research groups are interested in calculating MJO indices for model inter-comparison but also to assess the impact of the MJO on various fields. By far the most popular MJO index is the Real-time Multivariate MJO (RMM) index from Wheeler and Hendon (2004).

Therefore, the S2S Steering Group decided to compute the RMM indices once for all and make them available through an ftp site. Later on, the same procedure could be applied to other popular weather indices, such as sudden stratospheric warming (SSW) indices, weather regimes indices, tropical cyclone tracks, and etc. This ftp site should provide an important service to the S2S research community.

The computation of the MJO index follows the methodology described in Gottschalk et al (2010) which is a slight variant of Wheeler and Hendon (2004) for real-time forecasts, except that the indices are computed from forecast anomalies rather than the full fields. The procedure contains the following steps:

1. Interpolate zonal wind at 200hPa (U200), 850hPa (U850) and outgoing longwave radiation (OLR) on a 2.5 by 2.5 degree grid and average the fields between 15N and 15S (each re-forecast date is represented by a record of 144 longitudinal points for each field and each ensemble member).

S2S data usage

The major achievement of S2S project has been the establishment of a database containing 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).

Because S2S is a research project, the real-time forecasts are only available with a 3-week delay. The data is archived at ECMWF and CMA, and an increasingly large subset of the S2S data is available from the International Research Institute for Climate and Society (IRI), Columbia University. Users are required to sign the S2S Terms and Conditions which stipulate non-commercial use of the S2S data. The ECMWF data portal was opened to the research community in May 2015 via the Data Portal and ECMWF Web API (Application Programming Interface). The number of active users per month is increasing and reaches up to 90 different active users per month in 2017. By June 2017, 843 users from 88 countries had registered and had executed over 5,000,000 requests to extract 165 Terabytes of data from ECMWF. ECMWF and CMA are working together closely to ensure the timely synchronization of the two databases. To assess the user satisfaction with the S2S database and the quality of the service provided by ECMWF to access the S2S data, a survey was sent in 2017 to all S2S database registered users. About 120 people replied. The overall level of satisfaction is high (45.4% are satisfied and 27.8 % are very satisfied), although the percentage of "very satisfied" is not high enough. The survey highlighted the need to improve the speed of data retrieval and also the need for more training on use of the database (survey results can be found at https://www.s2sprediction.net). Work is ongoing to add the possibility of retrieving the data directly in NetCDF from the ECMWF data portal. The current list of variables provided by participating model can be found at https://software.ecmwf.int/wiki/display/S2S/Provided+parameters.

New Manager of S2S ICO appointed

Dr. Won-Tae Yun (wtyun0309@gmail.com) has been appointed Manager of S2S ICO. He took up the position on 1 April 2017. He joined the KMA in 1996. During his career in KMA, he worked mainly in area of long-range prediction and international cooperation. He is the author of many publications especially related to multi-model ensemble prediction. He awarded a Service Merit Medal and received a Presidential Citation for his dedication to work.

Upcoming Events

The IAPSO-IAMAS-IAGA assembly

27 August to 1 September, 2017, Cape Town, South Africa

The 2017 joint IAPSO-IAMAS-IAGA assembly, endorsed by the University of Cape Town and the South African Department of Science and Technology, will take place from 27 August to 1 September 2017 at the Cape Town Inter-national Convention Centre (CTICC). More information on the joint assembly is available at http://www.iapso-iamas-iaga2017.com/.

ICTP-Rwanda Joint School on S2S Weather and Climate Prediction

4-8 September, 2017, Kigali, Rwanda

ICTP-Rwanda Joint School on Sub-seasonal to Seasonal Weather and Climate Prediction will take place from 4-8 September 2017 at the Kigali Rwanda. This school focuses on sub-seasonal to seasonal prediction research and related climate products, as many management decisions in agriculture and food security, water, disaster risk reduction and health fall into this range. More information on the school is available at http://indico.ictp.it/event/7984/.

6th WMO International Workshop on Monsoons (IWM-VI)

13-17 November, 2017, Singapore

6th WMO International Workshop on Monsoons will take place from 13-17 November, 2017, Singapore. The workshop provides a forum for researchers and forecasters to discuss recent advances and current issues covering all time scales that are relevant to the forecasts of high-impact weather in the monsoon regions around the world. More information on the workshop is available at

https://www.wmo.int/pages/prog/arep/wwrp/new/iwm-6.html.

2. Interpolate U200, U850 and OLR from ERA Interim over the 120 days preceding the first forecast day and average over 15N and 15S.

3. For each year from 1999 to 2010 compute the forecast anomalies, by removing the ensemble mean of the climatology to each re-forecast ensemble member and the ensemble mean. The climatology is calculated in a cross-validated way by averaging all the re-forecasts starting the same day and month from 1999 to 2010, but the actual year of the re-forecasts is excluded. For instance, for a re-forecast starting on 1st January 1999, the climatology will contain all the re-forecasts starting on 1st January 2000-2010. The same procedure is applied to the 120 day of ERA Interim re-analysis.

4. Append the past 120 days ERA Interim anomalies with the re-forecasts.

5. Normalize U200, U850 and OLR 1-D anomaly fields computed above using the same pre-computed coefficients as in Gottschalk et al (2010).

6. Project the U200, U850 and OLR anomaly fields onto the pre-computed combined EOFs from WH04 to compute RMM1 and RMM2.

7. Normalize RMM1 and RMM2 using pre-computed coefficients as in Gottschalk et al (2010).

8. Remove the average of the past 120 days. For the past 121 days of re-analysis, remove the average of the first 120 days. The main goal of this step is to remove the low frequency variability such as the El-Niňo Southern Oscillation (ENSO).

The MJO indices have been computed for all the real-time time and re-forecasts of the S2S models (except for KMA which did not provide OLR, at the time of writing). A text format for the MJO indices has been defined. In this format, the RMM file names are z_s2s_rmm_cccc_vvvv_rt_yyyymmddhh.txt for real-time forecasts and z_s2s_rmm_cccc_vvvv_rf_yyyymmddhh_YYYYMMDD.txt for re-forecasts where cccc is the centre name, vvvv is the version of the data (either prod or test), YYYMMDD is the model version date, yyyymmddhh is the start date of the real-time or re-forecast. The file contains a RMM indices as well as their amplitude and phase for each time step (24 hourly frequency), each ensemble member or ensemble mean.

The MJO indices are available to the research community from the European Centre for Medium-Range Weather Forecasts (ECMWF) ftp site s2sidx@acquisition.ecmwf.int(User/Pass:s2sidx/s2sid). This ftp site is updated routinely to include the RMMs computed from the latest near real-time (3-weeks behind real-time) and re-forecasts archived in the S2S database. These index are also copied into the International Research Institute for Climate and Society (IRI) data library and work is ongoing to develop graphic tools to automatically plot the RMM indices.

Gottschalck, J., M. Wheeler, K. Weickmann, F. Vitart, N. Savage, H. Lin, H. Hendon, D. Waliser, K. Sperber, C. Prestrelo, M. Nakagawa, M. Flatau, W. Higgins, 2010: A Framework for Assessing Operational Model MJO Forecasts: A Project of the CLIVAR Madden-Julian Oscillation Working Group. Bull. Amer. Meteor. Soc., 91(9), 1247-1258.

Wheeler and H. H. Hendon, 2004: An all-season real-time multivariate MJO index: Development of an index for monitoring and prediction. Mon . Wea . Rev., 132, 1917–1932.

7th International Verification Methods Workshop (7IVMW; Berlin, 3-11 May 2017)

Photo 1: Participants of the tutorial on forecast verification methods (Berlin, May 3-6 2017) including students, local organizers and lecturers.

The 7th International Verification Methods Workshop (7IVMW) was held in Berlin, Germany, 3-11 May 2017 having as main theme "Forecast verification methods across time and space scales". The workshop was organized by the WMO WWRP/WGNE Joint Working Group on forecast Verification Research (JWGFVR), jointly with the Free University of Berlin, the Max-Planck-Institute for Human Development, the Hans-Ertel-Centre for Weather Research (HErZ) and the German Weather Service DWD. The goal of the workshop was to discuss and promote all aspects of verification methodology research and practice, as applied in different time and space scales.

After Boulder, Montreal, Reading, Helsinki, Melbourne and New Delhi the seventh in the very successful series of verification methods workshops returned to Europe, to bring together almost 40 students and about 80 presenters from 35 countries from all continents, from national and private weather services, from universities and research institutions and intergovernmental organizations to teach, learn, discuss and enjoy the growing multitude of verification methods developed for weather forecasts and warnings, climate predictions, and their applications.

The workshop was divided in two parts, starting with a tutorial on forecast verification methods (May 3-6) with lectures and hands-on laboratory sessions, which was hosted by the Max-Planck-Institute for Human Development. The lectures and laboratory sessions focused on both data handling aspects and interpretation of verification results. The lectures included the following topics: basics of verification, verification of continuous variables, verification of categorical variables, probability and ensemble forecast verification, assessing confidence in verification results, spatial verification methods, and warning verification. Participants had the opportunity to bring their own datasets for analysis during the tutorial.

A total of 8 forecast verification group projects were developed during the workshop, providing the participants the opportunity to learn and apply methods for ensemble forecast verification, deterministic forecast verification, spatial verification, sub-seasonal forecast verification and high resolution wind speed forecast verification.

The second part of the workshop featured the science conference (May 8-11), including keynote talks along with contributed presentations and posters addressing the following topics: Verification of high impact weather and extremes, user-oriented verification and estimation of forecast value, meta-verification (properties of verification methods), methods for verification of probability and ensemble forecast, spatial verification methods and verification approaches, observation uncertainty in forecast verification, climate and sub-seasonal to seasonal (S2S) forecast verification. The workshop had a dedicated session on S2S verification, with a keynote talk by the S2S co-chair (Frederic Vitart) on verification methods and procedures used in sub-seasonal verification.

Some of the science conference highlights of relevance for S2S include: Extreme value theory is still under initial stages of usage in forecast verification with potential for novel developments and applications. Accounting for observational uncertainty in forecast verification is an emerging area where new research developments are needed. Spatial verification methods have potential to provide information about how well models represent spatial features/structures.

Photo 2: Participants of the science conference on forecast verification methods (Berlin, May 8-11 2017, photo: Pertti Nurmi).

The science conference also provided the opportunity to the tutorial participants of the first part of the workshop to present their forecast verification group project results to the entire workshop audience. Additionally, the science conference also featured the result of the "Forecast Verification Challenge" for development of a user-oriented verification method https://www.wmo.int/pages/prog/arep/wwrp/new/FcstVerChallenge.html. The winner of the challenge, Helge Goessling, from the Alfred Wegener Institute, Bremerhaven, Germany, who developed a novel verification approach for ice edge verification presented a key note talk entitled "Verification of user-relevant contours with the Integrated Ice Edge Error and the Spatial Probability Score". Additional information about the workshop including some of the presentations is available at http://www.7thverificationworkshop.de/.

S2S Special Session at the 5th WGNE workshop on systematic errors in weather and climate models

The WCRP-JSC/CAS Working Group on Numerical Experimentation (WGNE) organized a workshop on systematic errors in weather and climate models, hosted by Environment and Climate Change Canada (ECCC) in Montreal during 19-23 June 2017.

The workshop included a special session on the Year of Tropics-Midlatitude Interactions and Tele-connections (YTMIT) organized in collaboration with the S2S Teleconnection sub-project. The purpose of this session was to launch the YTMIT international project that will be carried out between mid-2017 and mid-2019.

The Teleconnections session included two keynote speakers (John Fyfe and David Straus), two oral presentations and eight posters. The keynote speakers reviewed tropical-extratropical interactions related to the Madden-Julian Oscillation (MJO) in boreal winter (D. Straus) and the links between low, mid, and high latitudes with an impact on the recent warming slow down (J. Fyfe).

The phase speed of the MJO plays an important role in modulating the teleconnection patterns in the North Atlantic. It is important to understand the response to cyclic and pulse heating. Intervention experiments have shown that cycle of MJO heating leads to propagating, not stationary response.

On longer time scales, the recent warming slowdown combines a global response to variability in the tropical Pacific, with a cooling impact from tropical volcanic eruptions. Errors in external forcing may contribute to overestimation of recent tropospheric warming simulated by the CMIP3 and CMIP5 models. Arctic sea ice loss may have contributed to changes in midlatitude weather and climate. Some climate models support this notion while others do not.

A modest improvement in teleconnection patterns in Northern Hemisphere is seen after introducing a higher resolution ocean component in the ECMWF coupled model used for ensemble predictions. 30% reduction is seen in frequency of blocking over the North Atlantic, which is consistent with the weak 500hPa geopotential height teleconnections (F. Molteni).

A number of results presented in the poster section indicate that model biases (e.g., SST, upper tropospheric jet stream, tropical diabatic heating) have impacts on simulation of teleconnections.

The extra-tropics also influences the variability of the tropics on S2S time scales, extratropical Rossby wave breaking shows a strong negative correlation with the Atlantic tropical cyclone activity.

The session concluded with discussions and recommendations, which include: a) the role of stratosphere should also be considered in the evaluation of biases involved in the simulation of atmospheric teleconnections (vertical resolution in lower stratosphere may be effective); b) the role of mean state biases (e.g., double ITCZ) in simulating the large-scale circulation regimes;

c) development of diagnostic and metrics for forecast skill evaluation; d) more studies should evaluate the role of teleconnections during summer season and Southern Hemisphere; e) the role of the subtropics should be also be explored because there may be some interactions between Rossby waves propagation and dynamics of regimes.

In case it's of interest, Advanced School on Tropical-Extratropical Interactions on Intraseasonal Timescales will be held in Trieste, Italy, 16-27 October, 2017. You can find details on the advanced school at http://indico.ictp.it/event/7998/material/poster/0.pdf.

Subseasonal prediction of the heat wave of December 2013 in Southern South America by the POAMA and BCC-CPS models

Marisol Osman · Mariano S. Alvarez

Abstract The prediction skill of subseasonal forecast models is evaluated for a strong and long lasting heat wave occurred in December 2013 over Southern South America. Reforecasts from two models participating in the WCRP/WWRP Subseasonal to Seasonal project, the Bureau of Meteorology POAMA and Beijing Climate Center model BCC-CPS were considered to evaluate their skill in forecasting temperature and circulation anomalies during that event. The POAMA reforecast of 32 member ensemble size, initialized every five days, and BCC-CPS reforecast of 4 member ensemble size for the same date of POAMA plus the previous 4 days were considered. Weekly ensemble mean forecasts were computed with leadtimes from 2 days up to 24 days every 5 days. Weekly anomalies were calculated for observations from 13th of December to 31st of December 2013. Anomalies for both observations and reforecast were calculated with respect to their own climatology. Results show that the ensemble mean warm anomalies forecasted for week 1 and 2 of the heat wave resulted more similar to the observations for the POAMA model, especially for longer leads. The BCC-CPS performed better for leads shorter than 7 (14) for week 1 (2). For week 3 the BCC-CPS outperformed the POAMA model, particularly at shorter leads, locating more accurately the maxima of the anomalies. In a probabilistic approach, POAMA predicted with a higher chance than BCC-CPS the excess of the upper tercile of temperature anomalies for almost every week and leadtime. The forecast of the circulation anomalies over South America could be used to explain the location of the highest temperature anomalies. In summary, for this case, models skill in forecasting surface temperature in a context of a heat wave resulted moderate at leadtimes longer than the fortnight. However, this study is limited to model-to-model analysis and a multi model ensemble strategy might increase the skill.

Keywords S2S · South America · SACZ · Heat wave

Full version of this paper can be found at http://link.springer.com/article/10.1007/s00382-017-3582-4.

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