Subseasonal-to-Seasonal S2S Prediction Project
WWRP World Weather Research Programme
WCRP World Climate Research Programme
Newsletter

In This Issue ...

News:

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

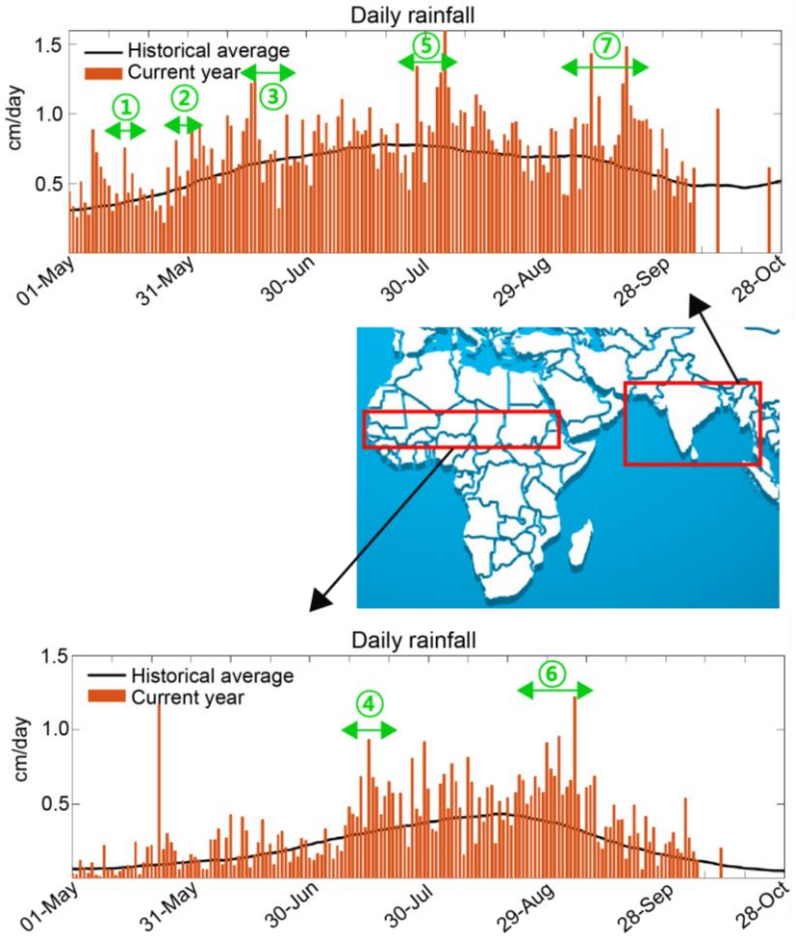


Fig. 1 : TRMM daily rainfall over the South Asian domain (top) and over the African monsoon domain (bottom). Corresponding domains are denoted with red rectangles (middle) (Source: W. Boos http://worldmonsoons.org).

The 2020 monsoon over Asia and Africa: *how well the S2S models performed*

Thierry Lefort and Philippe Peyrillé (*Meteo-France*)

The monsoon has been abundant over both Asian and African (Fig. 1) boxes (as defined by W. Boos), while the North American monsoon, covering a smaller area, was below average (not shown). Monsoon active periods and breaks are obvious on these large domains.

Seven episodes have been selected over both continents (plotted as double arrows on Figure 1). Following a chronological order, event 1 is the super cyclonic storm AMPHAN, event 2 the monsoon onset over Kerala early June, event 3 the intense Meiyu rainband in June, event 4 the first wet spell over the Sahel mid-July, event 5 is a change in the weather type over Asia late July, event 6 the second wet spell in the Sahel late August, and event 7 is the northward propagation of the Summer Boreal Intraseasonal Oscillation in September.

We intend to give a rapid overview of the role of the intraseasonal modes of variability, then examine the skills of S2S models on these specific events. In addition to classical S2S model outputs, we will give a few examples of operational expertized subseasonal production.

1) Super Cyclonic Storm AMPHAN – 16 May : MJO yes, but not as a precursor !

Observation

AMPHAN, the first tropical cyclone of the 2020 North Indian cyclone season, was powerful and catastrophic. It made landfall on 18 May as a very severe cyclonic storm in West Bengal, India. Storm surge and torrential rain caused floodings in West Bengal and Bangladesh.

The MJO RMM index was in phase 2 (Indian ocean) from 14 to 17 May (Fig. 2). But there was no MJO signal prior to 14 May, even seen through VP200. Indeed, the MJO seems to be emerging when the envelope of the Kelvin wave reaches the low frequency anomaly over the western Indian ocean on 12/13 May (Fig. 3). Then, the slightly wesward movement is the signature of an Equatorial Rossby (ER) wave that is found on VP200. When the Kelvin wave crosses the ER wave, the MJO RMM index becomes strong.

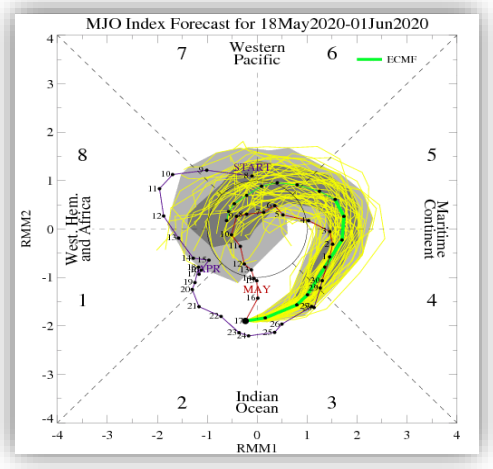


Fig. 2 : ECMWF MJO RMM index analysis and prediction on 17 May (source: NOAA/CPC).

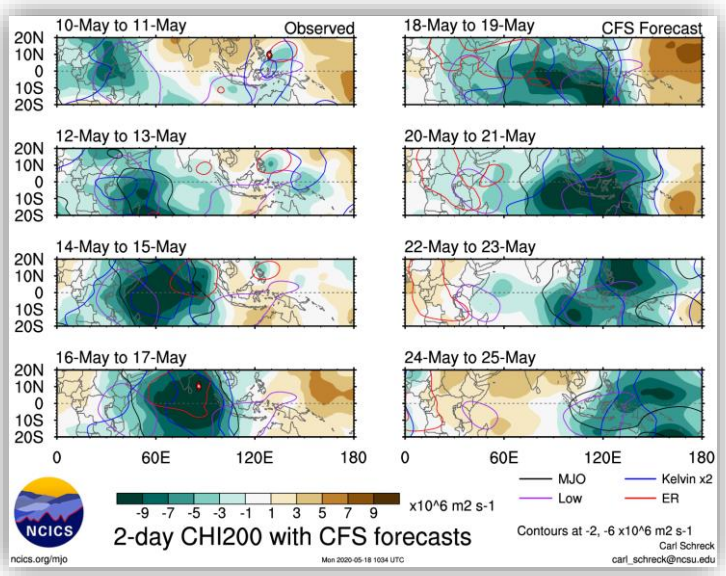


Fig. 3 : Velocity Potential at 200hPa with CFS (Source: C.Schreck).

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

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

• **S2S AI/ML Competition,** *2021, will be announced in S2S website. For more information, refer to page 14 in this Newletter.*

• **EGU General Assembly 2021,** *19–30 April 2021. Online.*
https://www.egu21.eu

• **2nd International Verification Challenge,** *The deadline for entries is 30 April 2021. The winner will be announced in May 2021, Online.*
https://www.emetsoc.org/second-international-verification-challenge/

• **WCRP Workshop on Extremes in Climate Prediction Ensembles (ExCPEns),** *2021, Pusan, Korea. Will be announced.*

• **EMS Annual Meeting 2021,** *06-10 September 2021, Historical University of Barcelona.*
https://www.emetsoc.org/events/ems-annual-meetings/

Prediction

With the absence of preexisting MJO, a very early signal could not be expected. It appeared in models at day 12-18 range (not shown). On May 4, the CPC MJO update mentioned that by late week 2, one of two Kelvin waves would trigger an new intraseasonal mode over the Indian Ocean.

Interestingly, a posteriori analysis of the event shows a clear signal of the MJO over the Indian Ocean while the operational forecast did not exhibit any clear propagative MJO signal that could be used as a precursor.

2) Monsoon onset over Kerala

The onset over Kerala was declared by the Indian Meteorological Department on 1 June, exactly the climatological date. There was no large scale pattern associated to the onset week. As mentioned by the CPC MJO update : "a robust Kelvin explained the quick transition of the MJO RMM index". Thus, not much predictability could be expected at subseasonal range.

3) Intense Meiyu-Baiu rainband in June: predictability provided by the low frequency state

Observation

Many provinces from southwestern, southern and central China were affected by intense rain, deadly floods and mudslides during several consecutive events.

The low frequency anomaly pattern observed in June is shown in Figure 4: a stronger Pacific subtropical ridge, much above average precipitable water and stronger westerly wind component in the Meiyu-Baiu band.

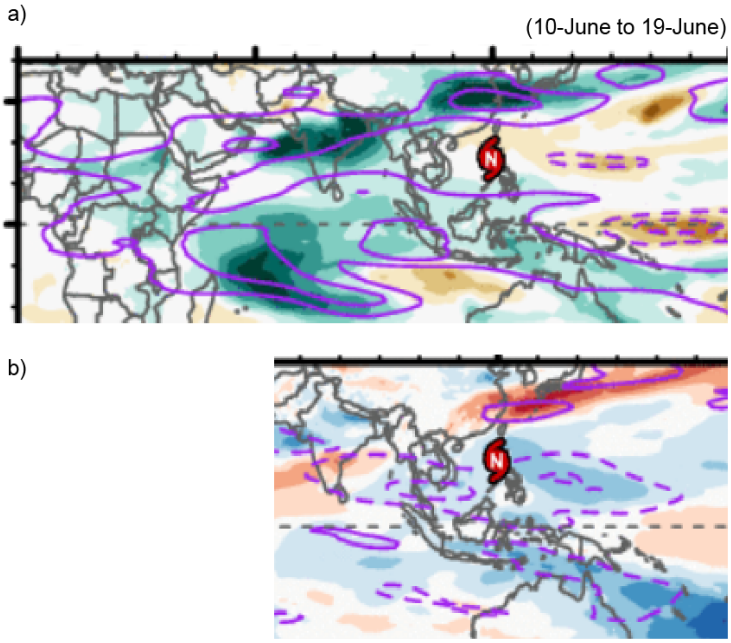


Fig. 4 : a) weekly anomaly predicted by CFS for precipitable water (green shading for moist anomaly) and b) zonal wind component (red shading for westerly anomaly) ; filtering of low frequency anomaly (120 days) in purple isolines (Source: C. Schreck).

Prediction

The stationary signal was present in ECMWF model as soon as Day 26-32 (Fig. 5). This suggests that predictability was provided by the low frequency state. The pattern was rather well predicted by the ECMWF late May for the whole month of June (Fig. 6a). Note that the persistence of intense Meiyu-Baiu in July was not so well predicted (Fig. 6b).

The pattern for August was very well predicted: dry from Shanghai to Japan, a stronger Changma rain season for South Korea and North Korea, and wetter for northern China including Beijing (Fig. 6c).

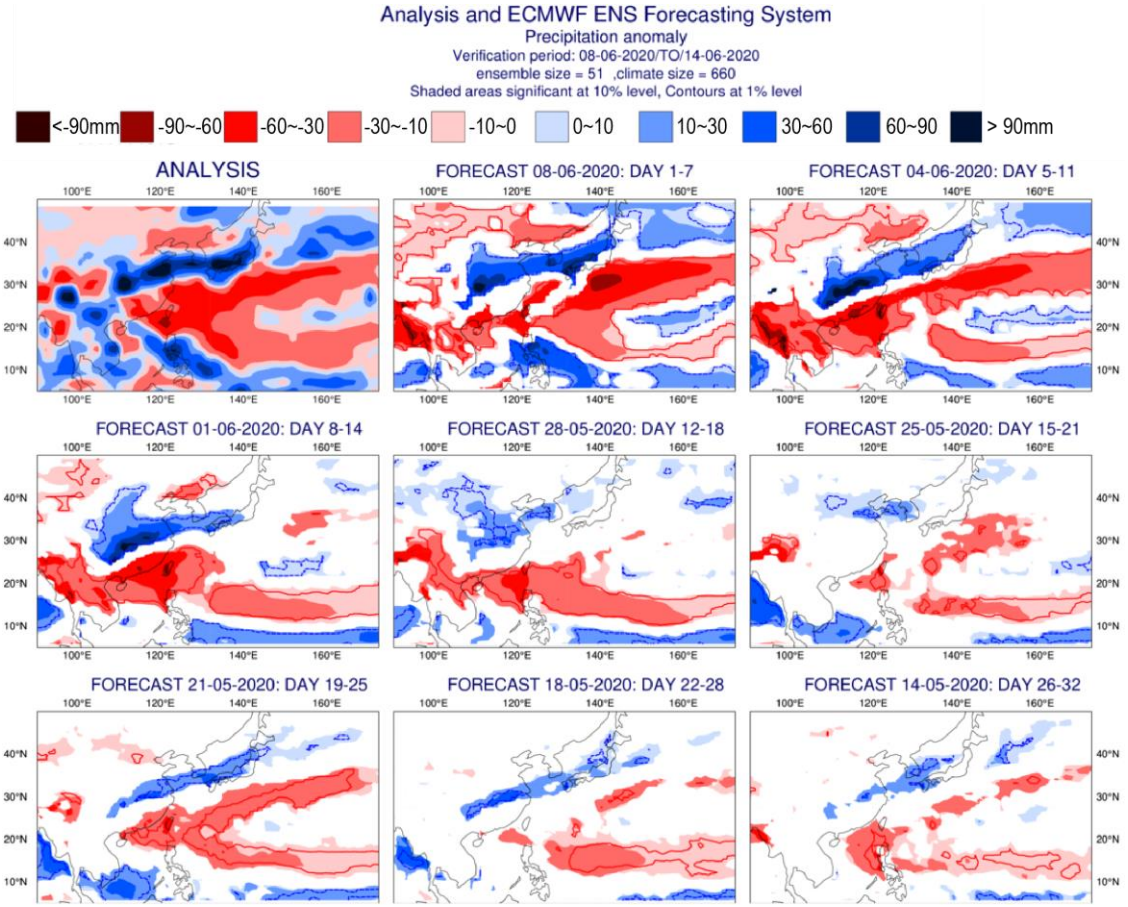


Fig. 5 : Verification for the week 08-14 June 2020 (source: ECMWF).

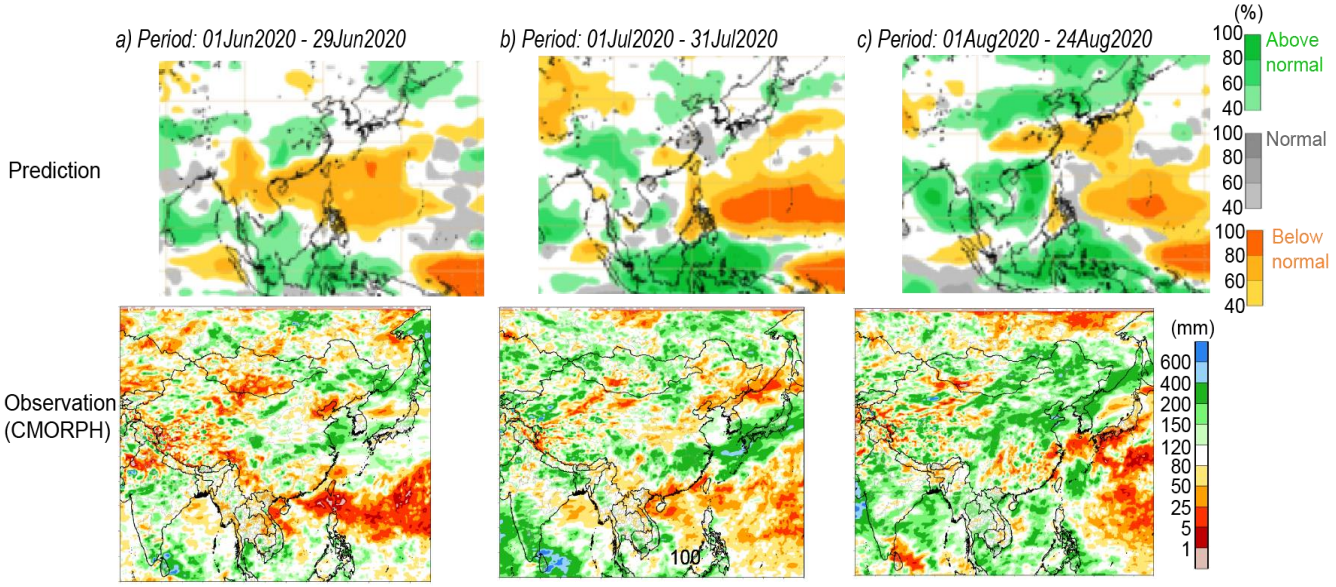


Fig. 6 : Prediction of ECMWF run (top panel, source: Meteo-France) and observed CMORPH anomaly (bottom panel, source: NOAA/CPC) a) for June with the run of 28 May, b) for July with the latest run of June, and c) for August with the latest run of July. Color scales show probabilities terciles for monthly forecast (top; white color area shows 'not statistically significant') and precipitation anomaly (bottom).

4) First wet spell over the Sahel

On Figure 1, a first wet spell is obvious around mid-July. Floods affected some areas of Nigeria, Niger and Mali.

Observation

No robust MJO was observed prior to the first spell in terms of RMM index. CPC MJO update stated on 29 June: "the RMM index is not characteristic of a singular, robust MJO event…this pattern is in line with the Kelvin wave over the Western Hemisphere at present slowing and possibly growing into a MJO event".

Prediction

Through the VP200 parameter (velocity potential at the tropopause), a propagative behaviour and a remarkably strong signal (shown in the red circle on Figure 7) was present in the ECMWF model as soon as Week 5 (Fig.7).

June had been rather dry over western and central Sahel. A change in the anomaly of precipitable water (from dry to wet) was predicted several weeks ahead (Fig. 8). It was associated to a clear contribution of the MJO to the total 850hPa westerly wind anomaly in filtering products (not shown).

The CREWS-Burkina Faso weekly video-conference (coordinated by Meteo-France with Senegal, Mali, Burkina Faso and Niger) held on 7 July concluded: "very favorable period due to the crossing of MJO/Kelvin and ER; Start of a wet spell around 9/10 July that will last approximately two weeks. We can consider filling the rainfall deficits observed since the start of the season".

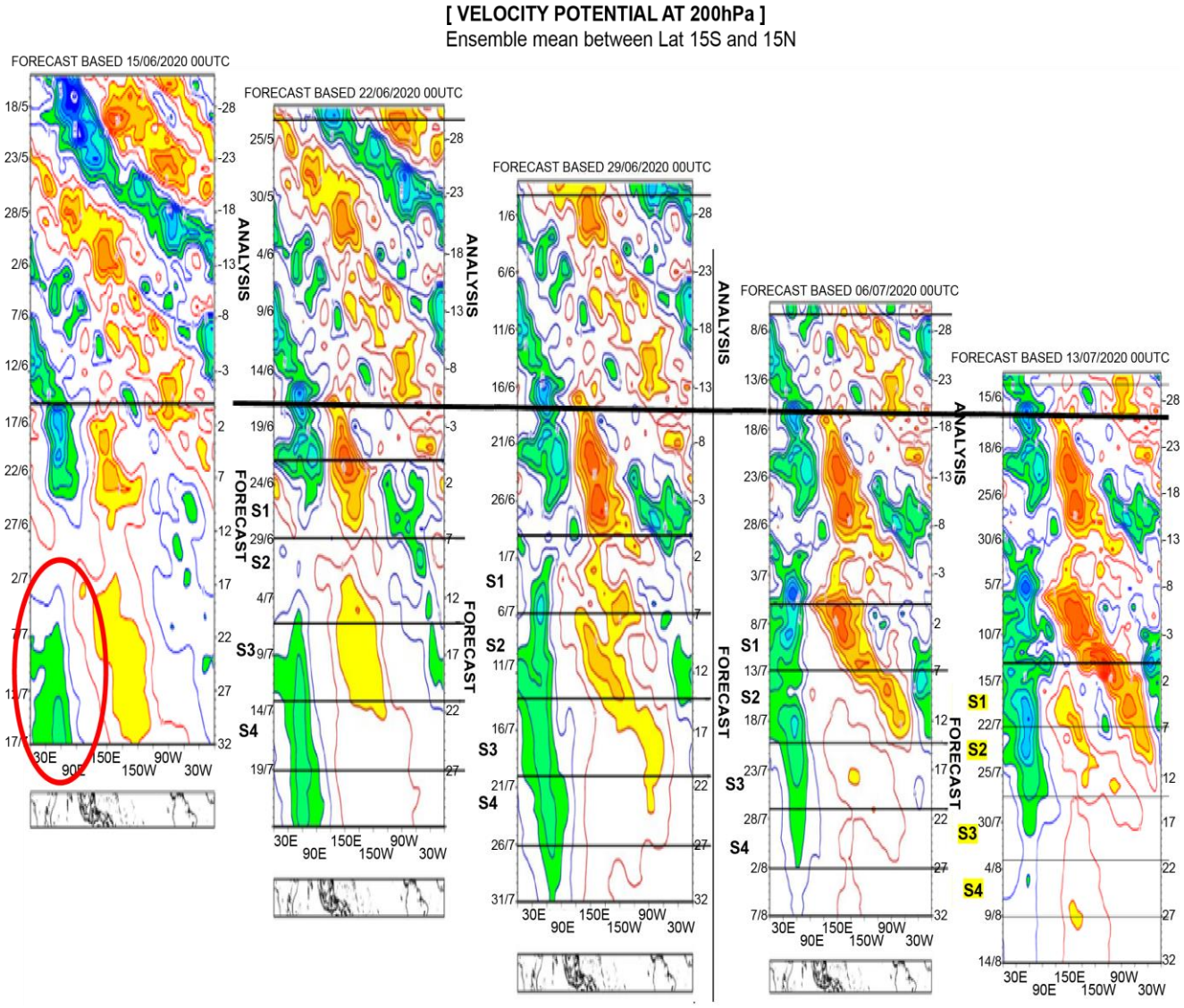


Fig. 7 : VP200 Hovmöller diagrams from ECMWF (from left to right : runs from 16, 23, 30 June, 7, 14 July). Green (resp. yellow shading) show divergent (convergent) anomalies.

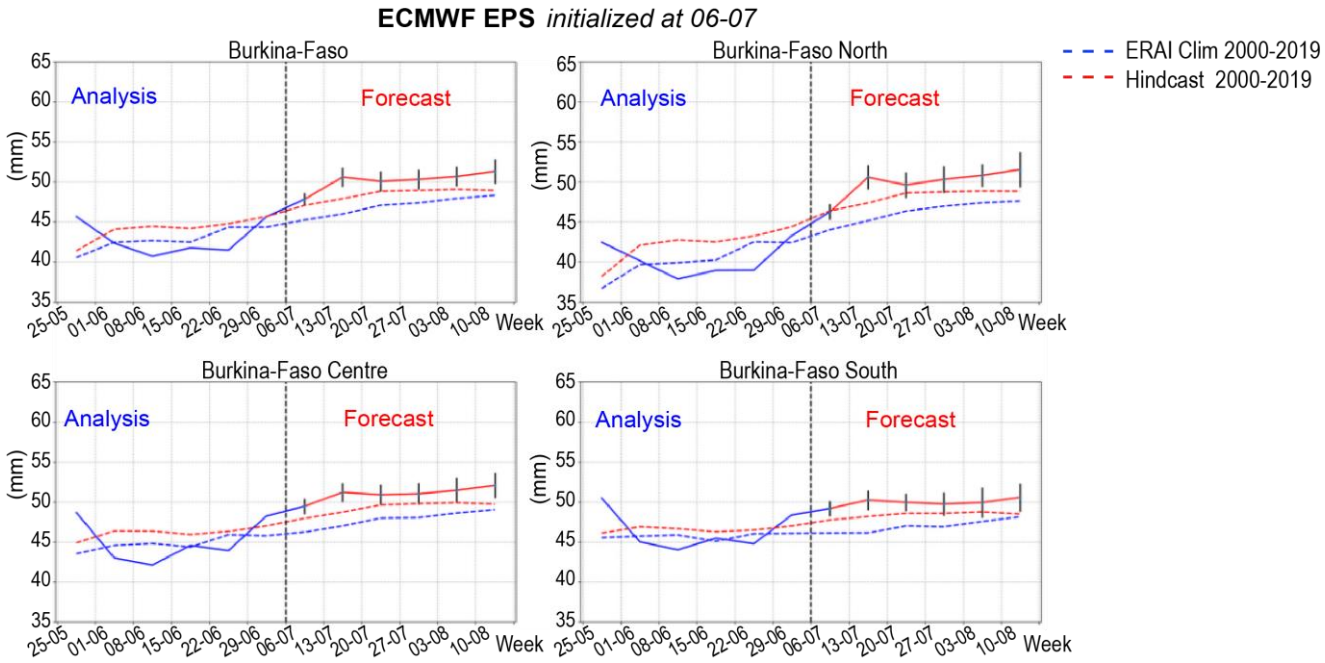


Fig. 8 : Weekly Precipitable Water anomaly from ECMWF model, run of 06 July (source: P. Peyrillé, from CREWS-Burkina Faso project, available on seasonal. meteo.fr).

5) Change of weather type in Asia between July and early August: MJO versus unfavorable background state

Observation

The low frequency anomaly (stronger Pacific subtropical ridge, low level easterly wind anomaly, dry from Guam to South China Sea and the Bay of Bengal) observed in July reversed during an intraseasonal event (Fig. 9). The same MJO that emerged over the western Indian ocean around mid July propagated across the Maritime Continent, as seen on Figure 9 and Figure 10.

TC Sinlaku (South China Sea) and TC Hagupit (south of Shanghai) formed and brought heavy rain to resp. northern Vietnam and Northern China.

Prediction

As stated on the forum on monsoons (Fig. 11) and CPC Tropics Hazards and Benefits Outlook and the Subseasonal forecast from the ASEAN Specialised Meteorological Center (Fig. 12), this event was well predicted several weeks ahead. The combination of MJO, CCKW and CCERW was stressed.

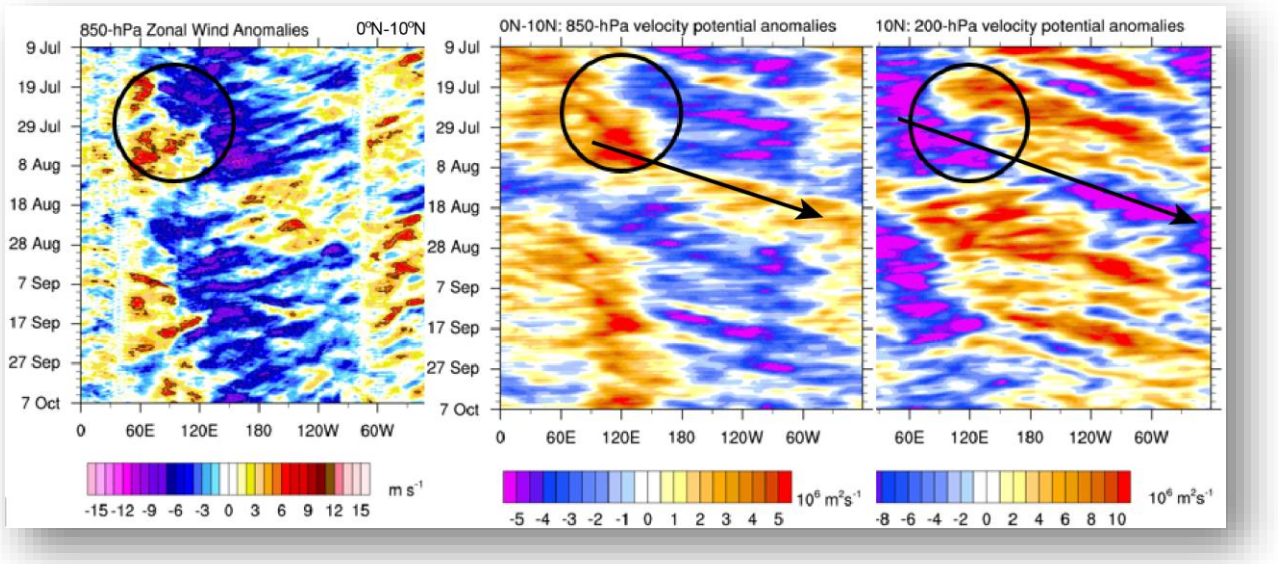


Fig. 9 : Hovmöller diagrams for anomalies of U850 (left), VP850 (middle), VP200 (right) (source: M.Ventrice).

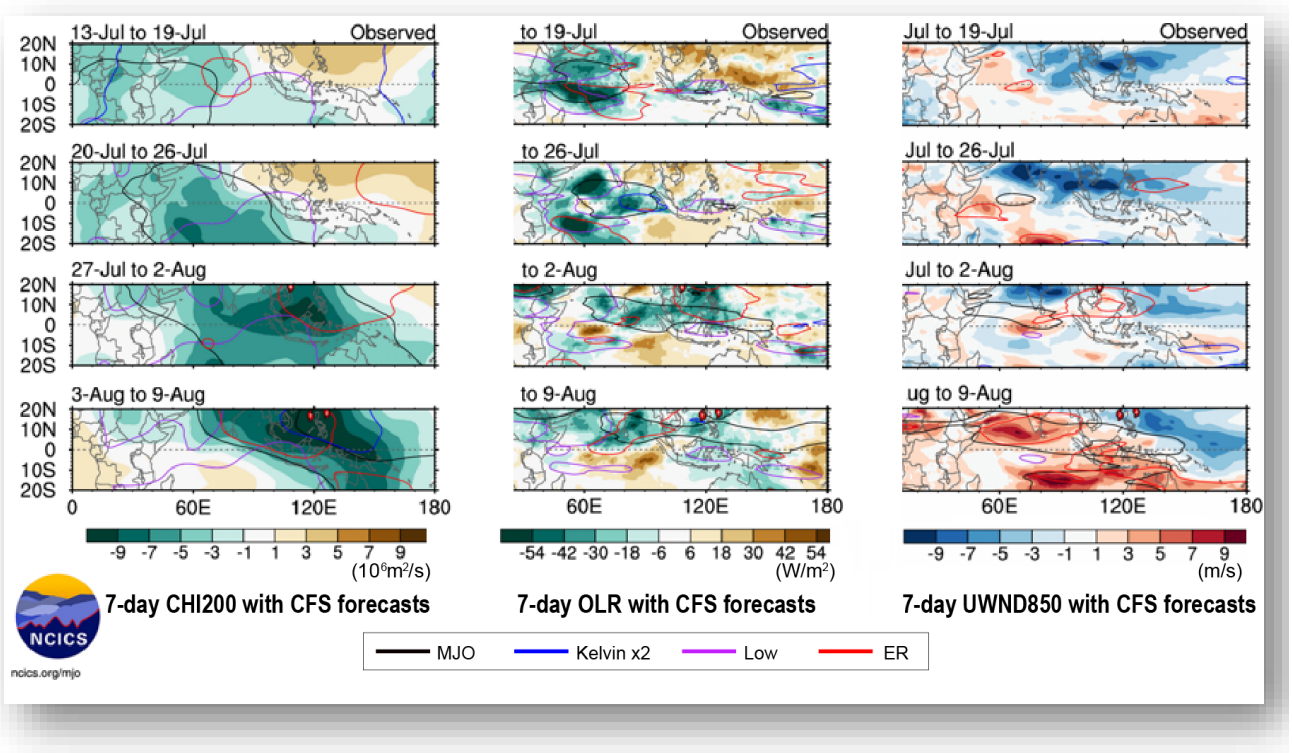


Fig. 10 : Observed 7 day-period anomalies of VP200 (left), OLR (middle), U850 (right) (Source: C. Schreck).

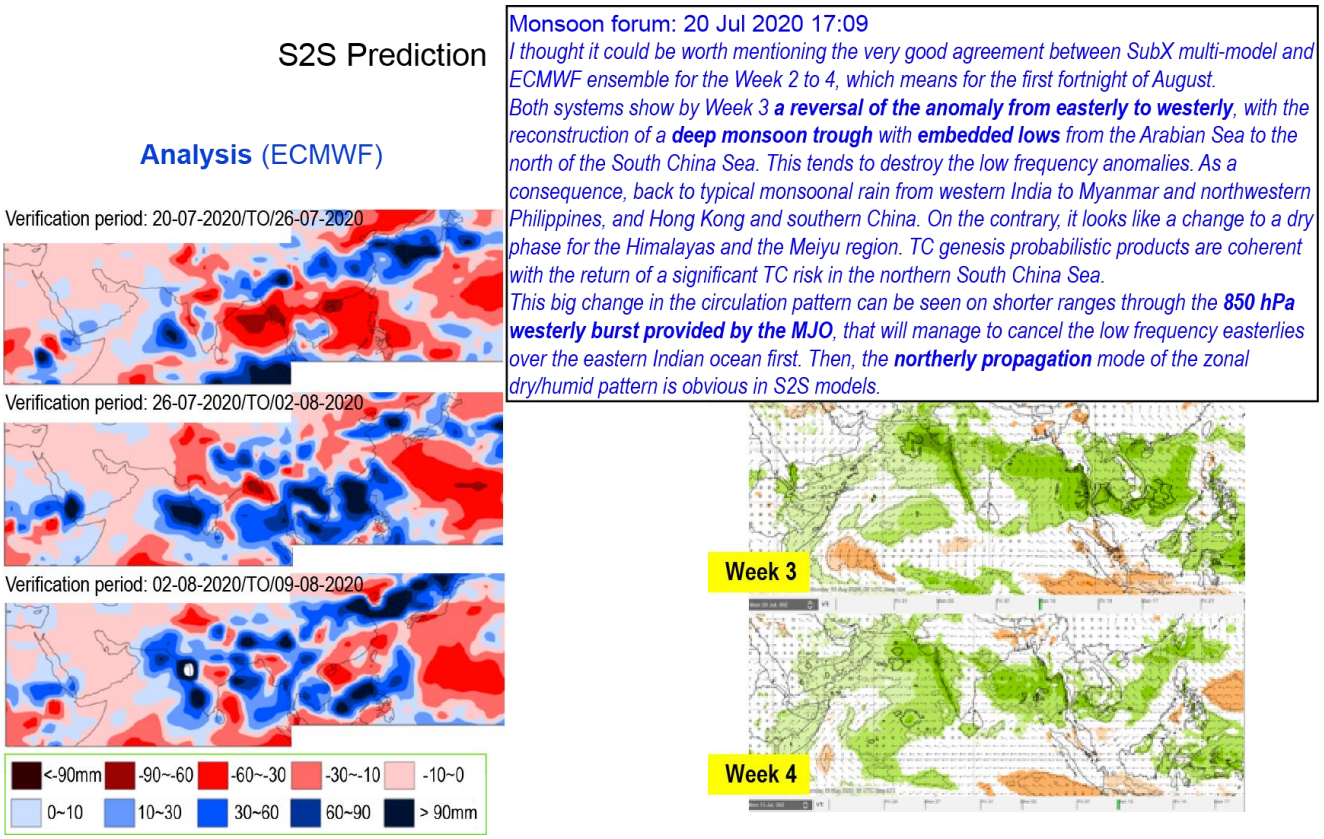


Fig. 11 : Left: Verification analysis of ECMWF for three consecutive weeks; right: prediction for the week ending 9 Aug (corresponding to bottom left) at Week 4 and Week 3 lead. Text: message on the monsoon forum on 20 July, by T. Lefort.

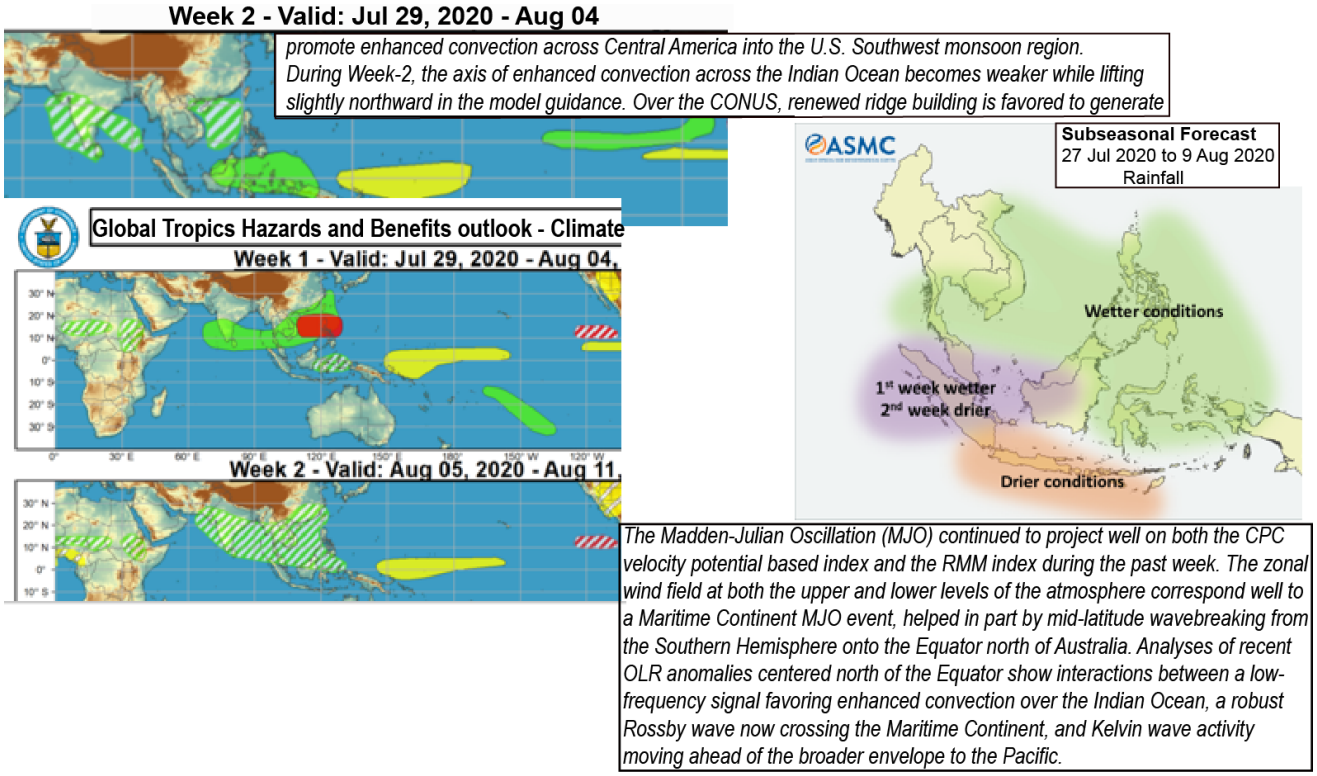


Fig. 12 : Routine expertized products (left: CPC, right: ASMC) for end July and early August. In text: extracted from the NOAA/CPC MJO briefings.

6) Second wet spell over the Sahel

Observation

After a relative dry spell over central and western Sahel in August, worrying for northern Senegal, a very active period took place during the last week of August and the first week of September. It coincided with a rare period with no rain at all along the Gulf of Guinea (Fig. 13).

Floods affected all countries in the Sahel: from Sudan to Senegal and Mauritania. Niamey in Niger was hit by a historical flooding as Niger river overflew.

Note that there is a remarkable correspondence between the relative break in the monsoon seen on Figure 1 and the propagative feature seen on Figure 9.

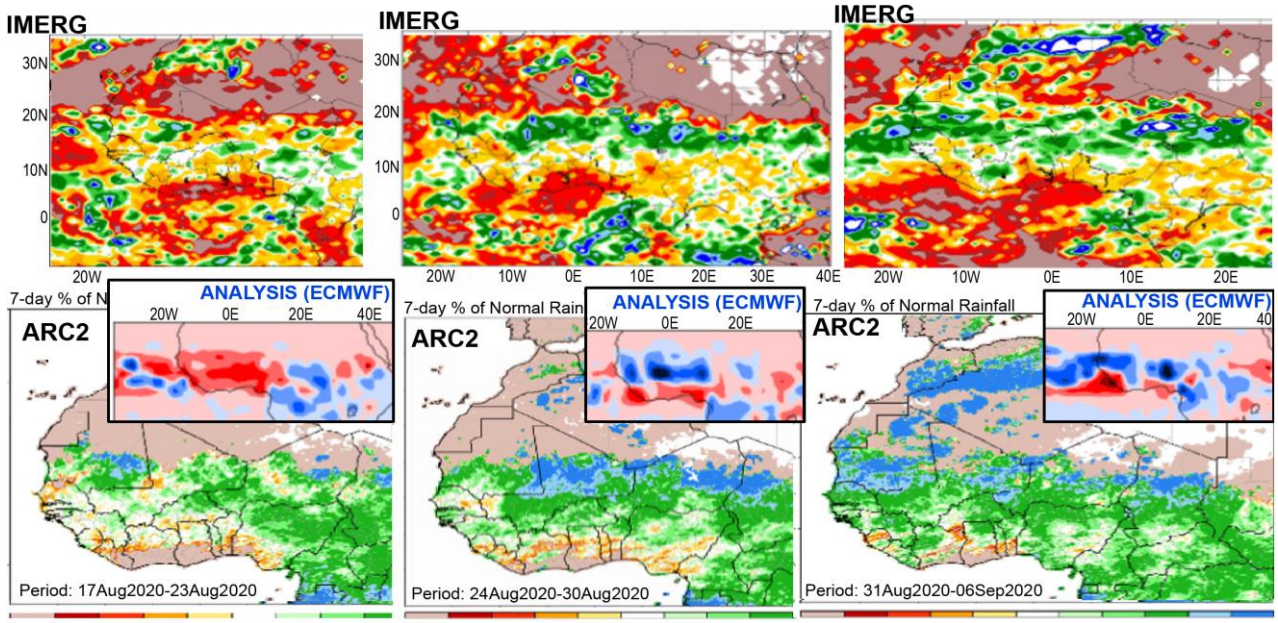


Fig. 13 : Weekly rainfall anomaly using IMERG satellite estimate (top, source P. Peyrillé, on seasonal.meteo.fr for CREWS-Burkina Faso, reference period 2000-2019), ARC2 data (bottom, source NOAA/CPC, reference period 1983-2005), and verification analysis from ECMWF (small rectangles).

Prediction

With the robust MJO event (both in RMM index and VP200), we could expect enhanced predictability in the extended range. Indeed, the MJO-like VP200 pattern was present at Week 4 in the CFS model (Fig. 14). In the ECMWF model, the wet pattern was present at Day 12-18 for the first week of the event, at Day 19-25 for the second week (Fig. 15).

On 18 August, both teleconferences from NOAA/CPC and CREWS-Burkina Faso stressed the likely active period for Africa for the next two to three weeks: "substantial event likely", "the supersposition of a Kelvin wave, an Equatorial Rossby wave and the MJO in phases 8 to 2 is very favorable for convection and African Easterly Waves".

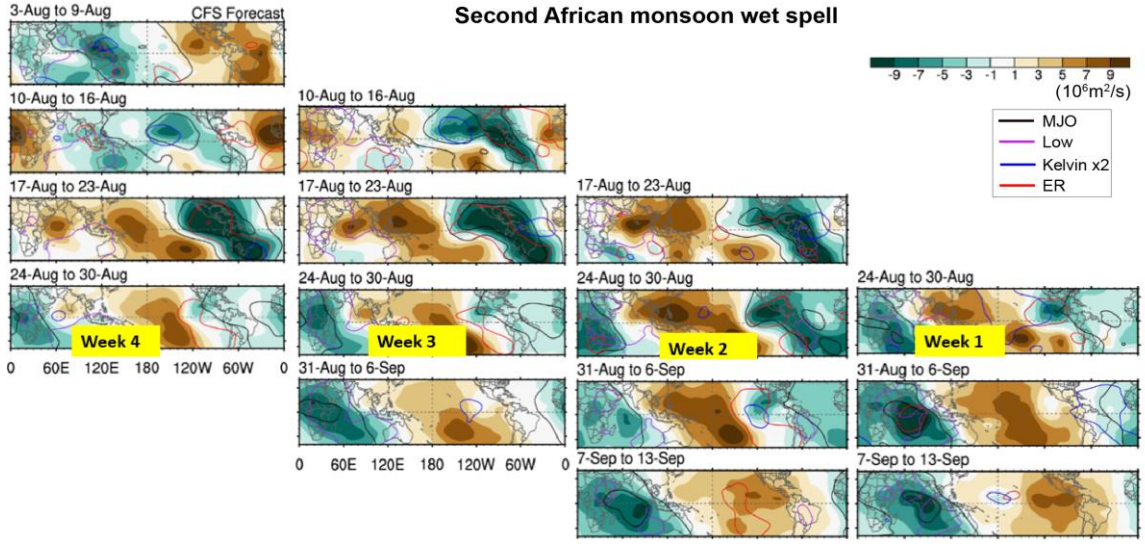


Fig. 14 : CFS forecast for VP200 (source: C. Schreck).

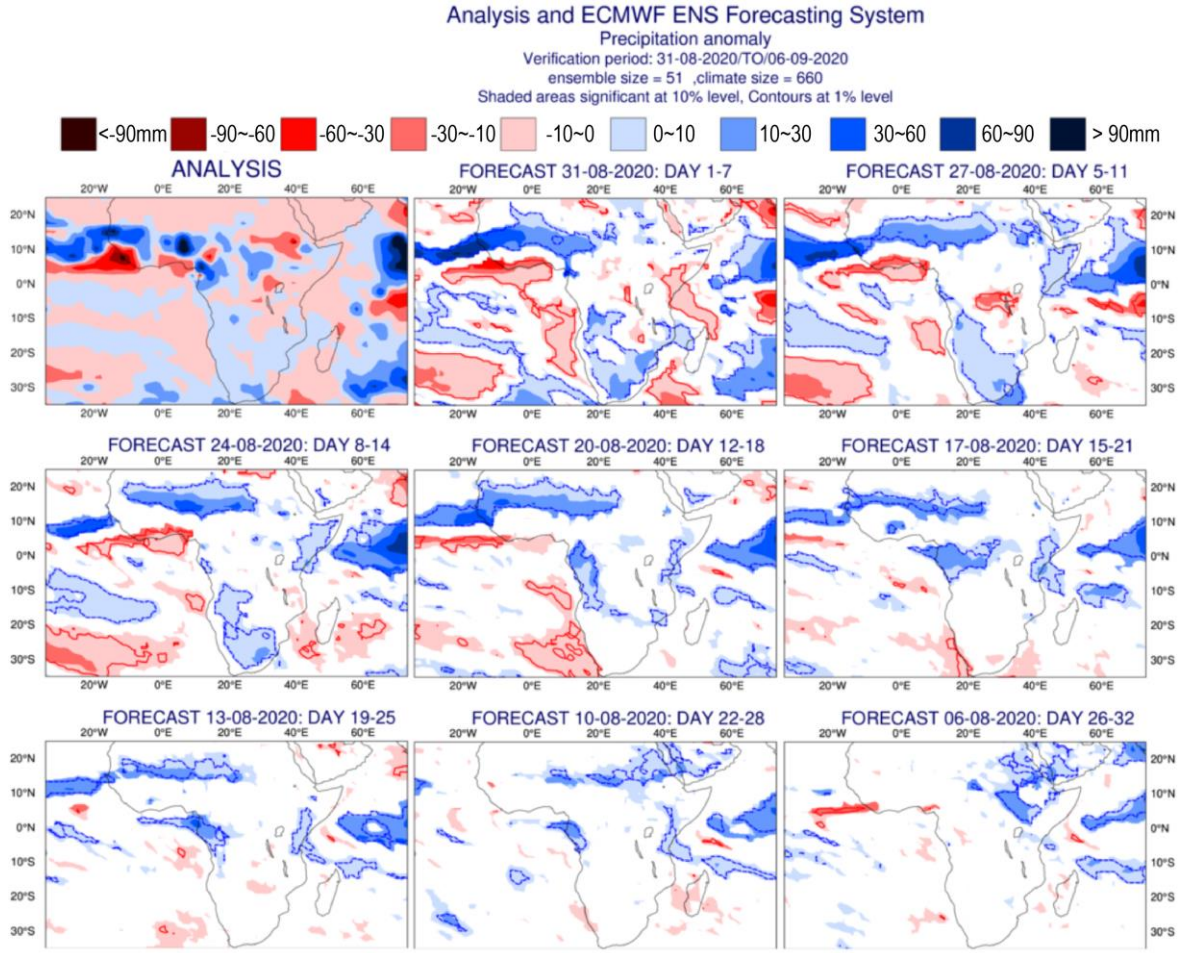


Fig. 15 : Verification of weekly rainfall for the Week 31 Aug. - 06 Sep.

7) September: northward propagation of the Boreal Summer Intra Seasonal Oscillation

Observation

On Figure 9, the VP200 field shows the continuation of the propagative pattern toward the Maritime Continent.

Let's focus on the northward propagation now. The BSISO 1 index (APEC Climate Center) remained mostly active all the way from phase 7 to phase 5. It means there was a clear northward propagation of NW-SE elongated wet anomaly pattern (Fig. 16).

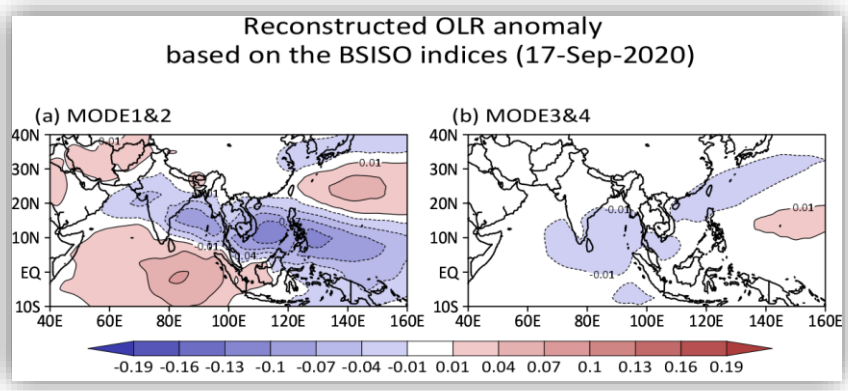


Fig. 16 : Reconstructed OLR anomaly based on BSISO indices on 17 September (source: APEC Climate Center).

Prediction

There was a remarkable agreement among S2S models: SubX multi-model and IMD are shown on Figure 17, ECMWF on Figure 18.

See also the very good prediction of the eastward propagation of the westerly wind anomaly linked to the envelope of the MJO in the European model (Fig. 18 and 19). Floods observed in Sri Lanka (6-9 Sep.) and Indonesia (6-16 Sep.) were not a surprise. In this case, SubX multi-model seems better at Week 3 for the Eastern Himalayas. On Week 5 (Fig. 19), floods observed in India (Karnataka, Mumbai) and coastal Cambodia (Preah Sihanouk) were possible according to the pattern predicted at Week 5. TC Noul that formed in the northern South China Sea was also not incoherent with the pattern of a cyclonic anomaly.

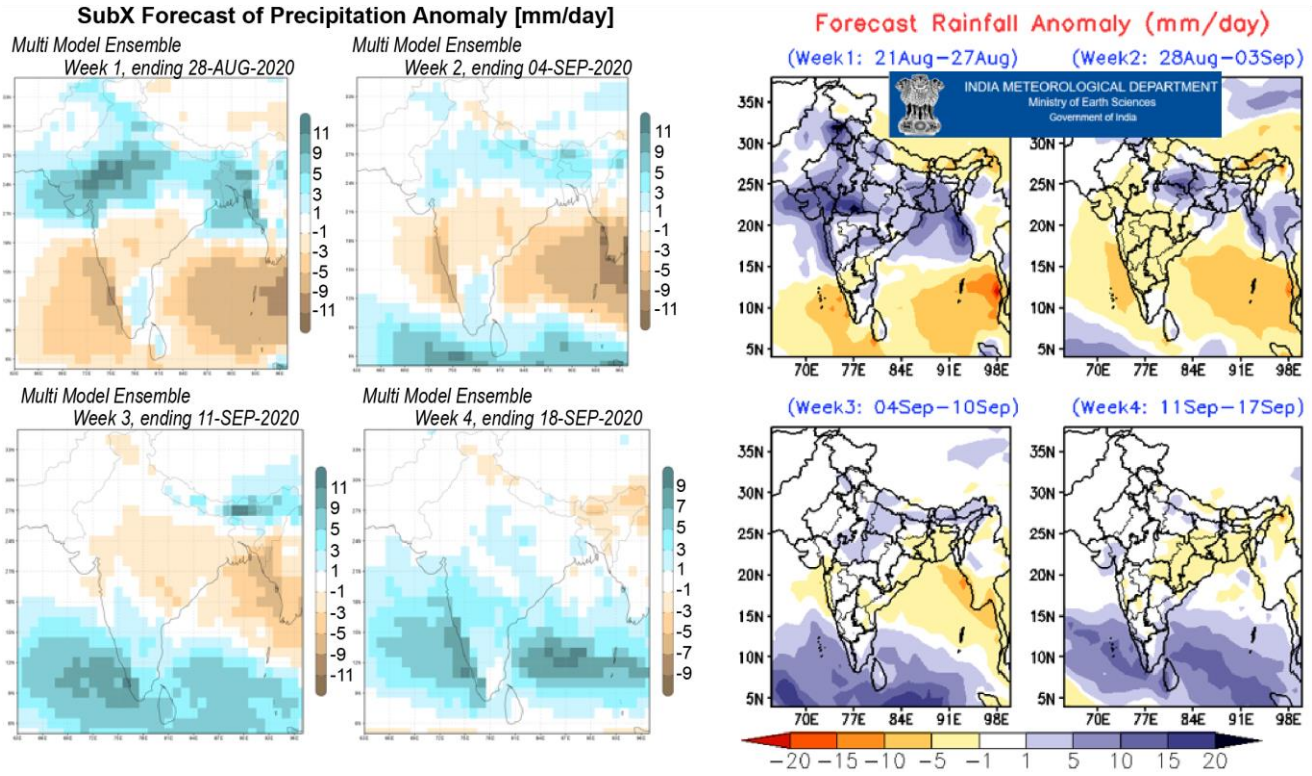


Fig. 17 : Weekly Rainfall anomaly for Week 1 to Week 4 in SubX multimodel (left) and IMD model (right).

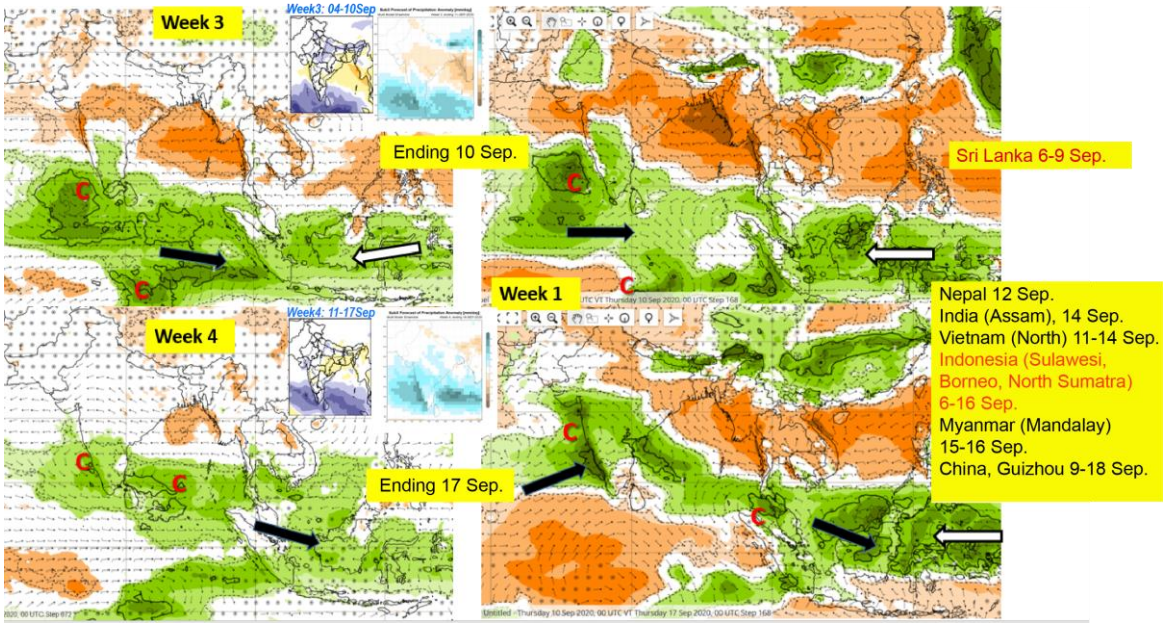


Fig. 18 : Anomalies of weekly rainfall and 850 hPa wind predicted by ECMWF model, run from 20 Aug for Week 3 upper left) and Week 4 (bottom left). Week 1 prediction used as proxy for verification (right). Black isolines are the Shift Of Tails of the Extreme Forecast Index for rainfall (Source: eccharts). Added by the author: Cyclonic circulation anomalies are shown by "C" letters in red. Black (resp. white) arrows show the westerly (resp. easterly) wind anomalies, red text reports the floods that occurred and that could be expected (Source: floodlist.com).

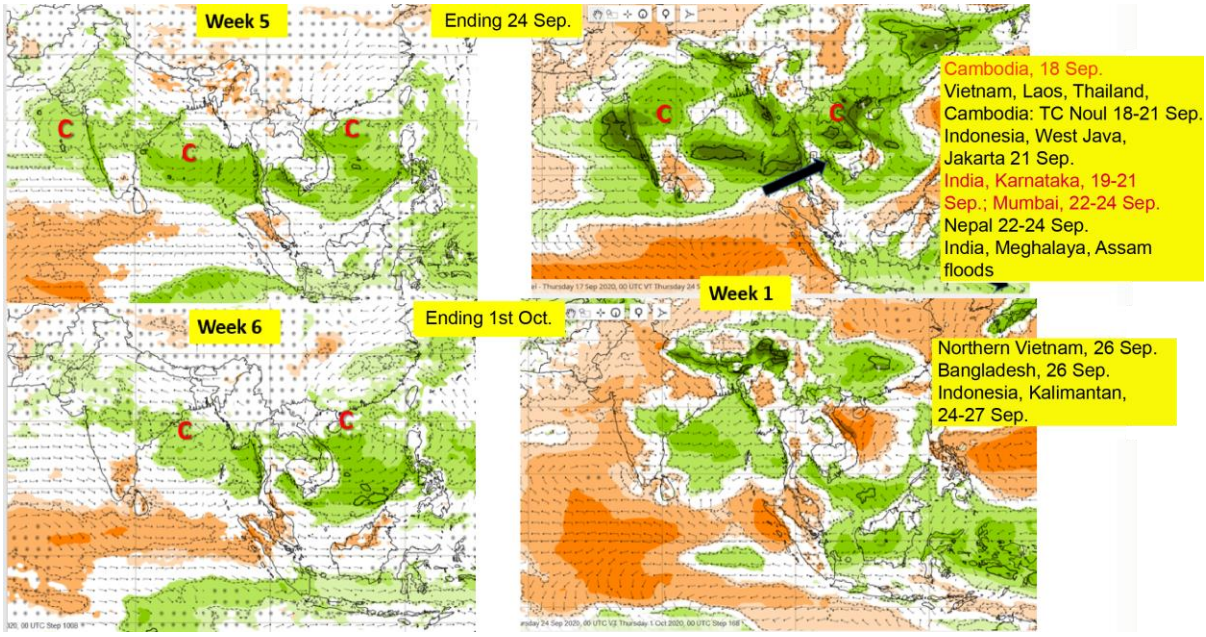


Fig. 19 : Same as Figure 18, but for Week 5 and Week 6.

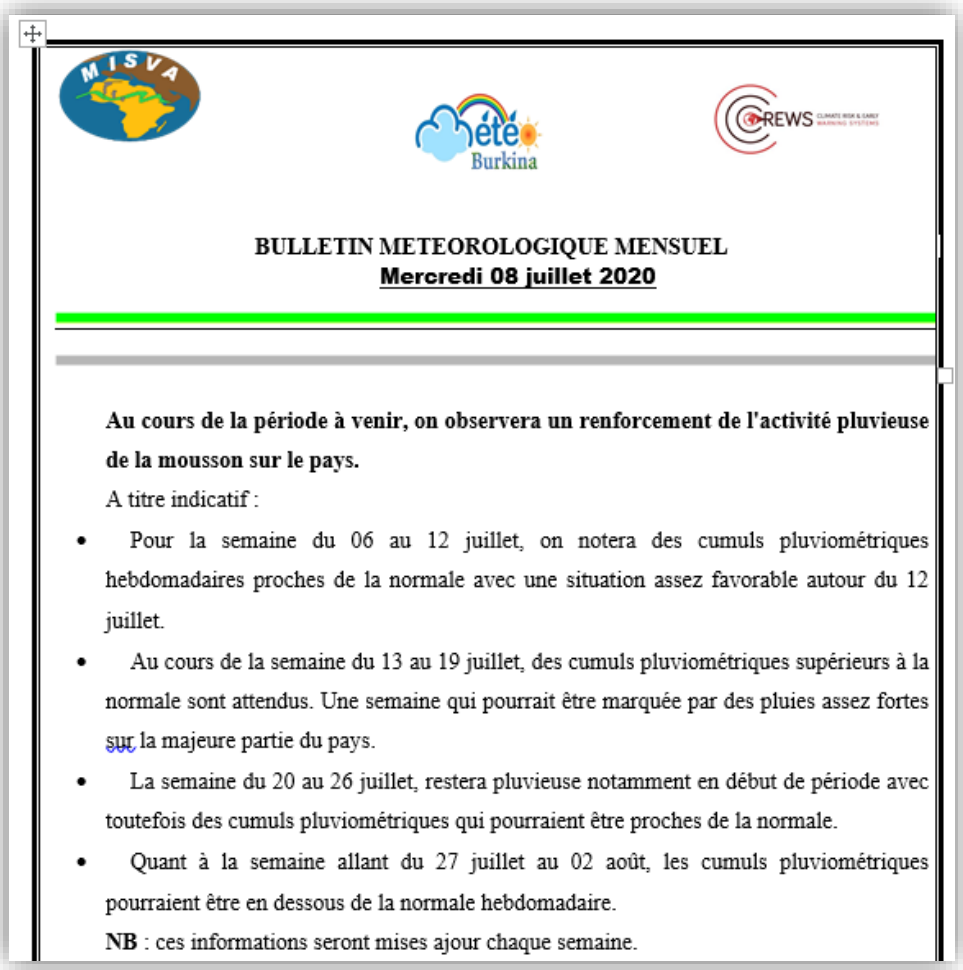
Discussion

We could see that at first order, the propagative VP200 MJO circumnavigation is a remarkable predictor of wet spells and breaks of the monsoon several weeks ahead. On the meantime, the OLR structure might not project very well onto the RMM index, for example when the background state is strong. Moreover, even through VP200, propagation is not always the rule: non-pre-existing MJO sometimes emerges out of the crossing of a Kelvin wave and an Equatorial wave. When the propagative signal is clear, S2S models provide forecasters with very useful indication of wet

In the framework of CREWS – Burkina Faso project, the National Meteorological Service ANAM has experimented a four-week period outlook bulletin, after a specific training with Meteo-France experts within the project. Figure 20 shows the bulletin issued on 8 July, shortly before the first wet spell.

Acknowledgments:

Many thanks to the staff behind all these great websites (and others related to S2S not cited here). Special thanks to the staff of Climate Services at Meteo-France.



BULLETIN METEOROLOGIQUE MENSUEL
Mercredi 08 juillet 2020

Au cours de la période à venir, on observera un renforcement de l'activité pluvieuse de la mousson sur le pays.

A titre indicatif :

- Pour la semaine du 06 au 12 juillet, on notera des cumuls pluviométriques hebdomadaires proches de la normale avec une situation assez favorable autour du 12 juillet.
- Au cours de la semaine du 13 au 19 juillet, des cumuls pluviométriques supérieurs à la normale sont attendus. Une semaine qui pourrait être marquée par des pluies assez fortes sur la majeure partie du pays.
- La semaine du 20 au 26 juillet, restera pluvieuse notamment en début de période avec toutefois des cumuls pluviométriques qui pourraient être proches de la normale.
- Quant à la semaine allant du 27 juillet au 02 août, les cumuls pluviométriques pourraient être en dessous de la normale hebdomadaire.

NB : ces informations seront mises ajour chaque semaine.

Fig. 20 : Experimental Meteo-Burkina (ANAM) subseasonal outlook issued on 8 July. In French. Published with authorisation from ANAM.

Data, products, method

The sources of the figures shown hereafter are listed as follows:

- http://worldmonsoons.org created by William Boos at UC Berkeley
- http://floodlist.com/ is an excellent database for major floods that occur worldwide, funded by Copernicus, a European Union programme.
- https://www.ecmwf.int/ and https://www.ecmwf.int/en/forecasts/eccharts
- http://wxmaps.org/subx_custom.php for charts of the SubX project (but of course, see also : https://iridl.ldeo.columbia.edu/maproom/Global/ForecastsS2S/index.html)
- https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml provides weekly expert discussions on MJO and Tropics hazards outlooks.
- https://www.cpc.ncep.noaa.gov/products/international/easia/easia.shtml
- https://ncics.org/portfolio/monitor/mjo/ created and maintained by Carl Schreck
- http://mikeventrice.weebly.com/ created and maintained by Michael Ventrice
- http://seasonal.meteo.fr/CREWS created by Meteo-France (P. Peyrillé and Direction of Climate Services, with login/passwd)
- http://misva.sedoo.fr created by CNRM at Meteo-France, where you can find weekly briefings with public access
- https://mausam.imd.gov.in/imd_latest/contents/extendedrangeforecast.php
- http://asmc.asean.org/subseasonal-weather-outlook-19-october-1-november-2020/
- https://www.apcc21.org/ser/moni.do?lang=en for the monitoring of the BSISO
- http://www.tstorms.org/monsoon/ discussion mailing list around the monsoons. Endorsed by WMO, provided by Bill Thorson and John McBride

Key to predict heatwaves over the Yangtze River basin 20 days in advance

Pang-Chi Hsu, Jiehong Xie, Jinhua Yu, Haishan Chen
Key Laboratory of Meteorological Disaster of Ministry of Education, NUIST, China

1. Purpose

This study evaluates the subseasonal prediction skill of heatwaves over the Yangtze River basin (YRB)—one of the most densely populated and economically important regions in China—in the current subseasonal-to-seasonal prediction systems and identifies the crucial processes influencing the fidelity in predicting YRB heatwaves at subseasonal timescale.

2. Data

The reforecast data (1999–2010) of three operational models [the China Meteorological Administration (CMA), the National Centers for Environmental Prediction of the U.S. (NCEP) and the European Centre for Medium-Range Weather Forecasts (ECMWF)] that participated in the Subseasonal to Seasonal Prediction (S2S) project were collected. The verification datasets include the gridded daily-mean near-surface air temperature (SAT) at 2 m from the CN05 database and the large-scale circulations, surface heat fluxes and soil moisture from the ERA-Interim reanalysis. A heatwave is defined to occur when the SAT exceeds a relative criterion of the 90th percentile for at least three consecutive days.

3. Results

Fig. 1 shows the three S2S models' Heidke Skill Scores (HSSs) estimated by the fraction of correct predictions for heatwave days in the YRB during the summer seasons after eliminating the corrected predictions due to random chance. In both the individual members' and the ensemble predictions, the HSS drops quickly as the forecast lead increases from 5 to 15 days in all three models. The model predictions show no skill (HSS of ~0) beyond the 15-day lead. Among the three models, the ensemble prediction of ECMWF is superior at the lead time of 5–20 days.

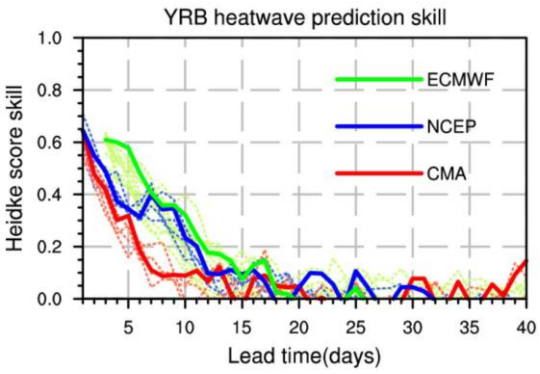


Fig. 1. Heidke Skill Score (y-axis) of heatwave predictions at different forecast leads from 1 to 40 days (x-axis) for the individual members (dashed curves) and the ensemble predictions (solid curves) of CMA (red), NCEP (blue) and ECMWF (green) models during summers of 1999–2010.

The superior skill in predicting the occurrence, intensity and duration of YRB heatwaves can be attributed to the model's fidelity in capturing the phase evolution and amplitude of high-pressure anomalies associated with the intraseasonal oscillation. Fig. 2 quantitatively compares the biases in the strength of 500-hPa geopotential (H500) anomalies associated with the 10–30-day quasi-biweekly oscillation (orange dots) and 30–90-day Madden-Julian oscillation (blue dots) against the biases in SAT anomalies for all YRB heatwave days in the observation. At shorter forecast leads (10 days), the effects of 10–30-day and 30–90-day circulation prediction skills on heatwave predictions are comparable with similar correlation coefficients between SAT biases and intraseasonal H500 biases. As the lead times become longer (over 15–20 days), the 30–90 day H500 biases show a tighter connection with SAT biases (with a higher correlation coefficient). This implies that the activity of 30–90-day Madden-Julian oscillation provides a source of YRB heatwave prediction skill at the subseasonal timescale beyond a 20-day forecast lead.

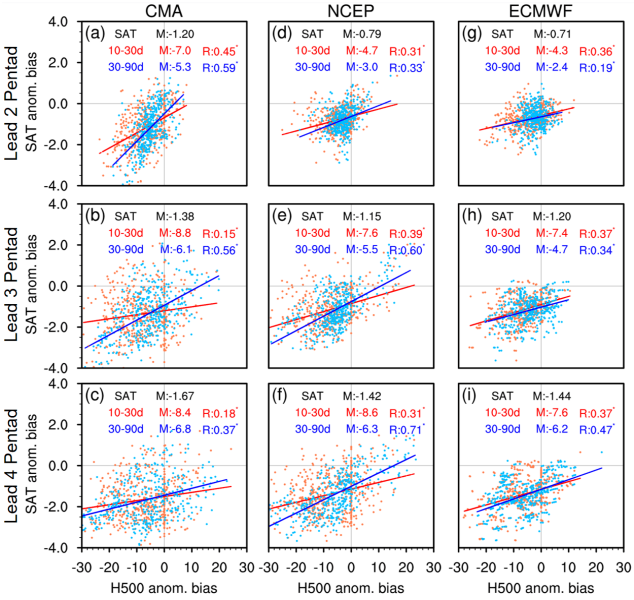


Fig. 2. Scatterplots for (a–c) CMA, (d–f) NCEP and (g–i) ECMWF model prediction biases in SAT anomalies (units: °C, y-axis) against the intraseasonal H500 anomalies (units: gpm, x-axis) associated with the 30–90-day oscillation (blue dots) and 10–30-day oscillation (orange dots) for all heatwave days over the YRB during 1999–2010: predictions at lead times of (a, d, g) 6–10 days, (b, e, h) 11–15 days, and (c, f, i) 16–20 days. The linear fit curves for blue and orange dots are presented in dark blue and red, respectively. The average of biases (M) for each variable and the correlation coefficient (R) between SAT biases and H500 biases are given in each panel. R with an asterisk indicates the correlation coefficients are significant at the 95% confidence level based on the Student's t-test.

Through the land–atmosphere interaction, the prediction errors in soil moisture induced by precipitation anomalies are also a factor influencing the prediction skill of SAT anomalies (Fig. 3). When the models successfully predicted soil moisture anomalies and precipitation changes, which are largely influenced by the intraseasonal circulation anomalies, before the heatwave occurrence, they could also better predict the amplitude and duration of SAT anomalies associated with the heatwave.

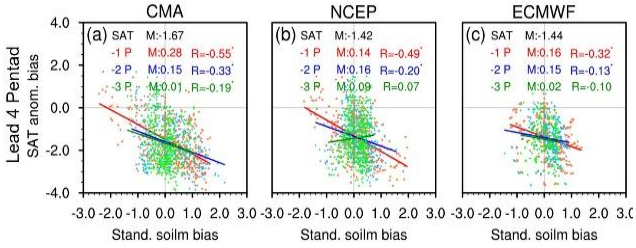


Fig. 3. As in Figs. 2c, f and i but showing scatterplots between the SAT biases during heatwave days against the soil moisture biases at 1–5 days (orange dots), 6–10 days (blue dots) and 11–15 days (green dots) in advance of YRB heatwave occurrence.

4. Conclusions

The major sources of subseasonal prediction skill for heatwaves over the YRB were identified based on the reforecast data from three operational models participated the S2S project. Models with superior skill of heatwave prediction show higher fidelity in predicting both the 10-30-day and 30-90-day circulation anomalies. Furthermore, the capability of the models in predicting heatwave occurrence at a longer lead time (15–20 days in advance) is closely related to their fidelity in capturing the evolution and amplitude of 30–90-day intraseasonal circulation rather than the 10–30-day quasi-biweekly circulation. The land conditions modulated by circulation anomalies also contribute to the prediction skill of heatwave duration and intensity.

This article is extracted from Xie et al. (2020) published in Adv. Atmos. Sci., 37, 1435–1450. http://doi.org/10.1007/s00376-020-0144-1.

S2S AI/ML Competition in 2021

Frédéric Vitart and Andrew Robertson

Artificial Intelligence (AI) or Machine Learning (ML) methods for weather forecasting have recently generated a huge interest in the research community. These methods could be used to improve data assimilation methods, physical parameterizations or the post-processing of model outputs. Research on using AI/ML methods as an alternative to dynamical models is also ongoing. The newly formed WMO Research Board has identified Artificial Intelligence (AI) as a key research topic in weather and climate science for the upcoming years. The World Meteorological Organization (WMO) Science & Innovation Department, in collaboration with the Services and Infrastructure, has encouraged holding an open competition to explore new services based on AI methods and applied to the WWRP/WCRP Sub-seasonal to Seasonal S2S project database. Following this recommendation, the WWRP/WCRP S2S Project is planning to organize an Artificial Intelligence (AI)/Machine Learning (ML) competition in 2021. The innovation coming out of this competition will support the goals and actions areas of the S2S and WWRP implementation plans as well as the WCRP strategic plan.

The main goal of the competition is to encourage the use of AI/ML tools to extract valuable information from the S2S database. The S2S database contains a huge amount of data (more than 100 TBs) which makes it a potentially powerful resource for AI/ML methods to explore possibilities of improving current S2S forecasts through, for instance, improved bias correction and multi-model combination. The competition should provide us more insight on the potential benefit of S2S/AI methods for S2S prediction.

The current proposal for this competition is to provide the "best possible" forecast of 2-metre temperature and precipitation, at forecast lead times of weeks 3-4 using biweekly averages. The forecast domain will be global (on the 1.5-degree spatial grid resolution of the S2S database but limited to land gridpoints) and the forecasts must be issued as tercile probabilities. The verification will be performed using the Ranked Probability Skill Score (RPSS) on 3 domains: Northern Extratropics, tropics and Southern Extratropics. The verification data will come from CPC 2-metre temperature and gridded data. The created software, code, documentation and results will be required to be open source and open access.

It is envisaged to have 2 rounds. During the first round, hindcasts from all the Thursdays of a given year (e.g. 2020) will be produced. The benchmark will be the ECMWF hindcasts after simple calibration. No data more recent than the forecasts start date should be used. During the second round, the most highly ranked teams from round 1, will compete on real-time forecasts. The competition will be open to AI/ML methods using data from the S2S database, but it will also be open to AI/ML methods using other types of input data, such as large climate model ensembles or reanalysis data. There will be a monetary prize from WMO for the winners.

The competition is planned to take place in 2021 and will be advertised via the S2S mailing list. Depending on the platform which will be used to run the competition, some of the aspects of the competition, as described above, may be modified

WMO S2S 9th Steering/Liaison Group Meeting

The 9th S2S Steering/Liaison Group meeting took place online on 22-24 September 2020. 33 people, including Steering Group and Liaison Group members, WMO and ICO members and several guests from linked projects or groups, attended the meeting.

Day 1: *WMO updates, S2S Database & Linkages with other groups*

Michel Rixen (WMO WCRP) gave the presentation about new strategic and implantation plans of WMO, WCRP and WWRP and briefed new constituent bodies and structures. Regarding S2S database, current status, future plans and products for exploitation by the research and application communities was presented by Ángel Munoz (IRI S2S Database), Tongwen Wu (CMA S2S database), Manuel Fuentes (ECMWF S2S database), and John Methven (TIGGE).

Talks from the other groups linked to S2S were followed. Hyung Jin Kim (APCC) mentioned that APCC activities focus on adding value to direct model outputs and summarized activities of WMO LC-LRFMME. Arun Kumar (NCEP) reported the activities of this group changed its name to IPET-OPSLS after the WMO reorganization. John Methven (U. of Reading) listed the main PDEF activities which are relevant to S2S. Phil Klotzbach (CSU) and Zhuo Wang (U. of Illinois) gave the presentation on WGTMR focusing seasonal prediction of tropical storms. Andy Moore (UC Santa Cruz) presented an overview of recent DAOS activities such as coupled data assimilation and forecast sensitivity intercom-parison. Bill Merryfield (EC) presented the WGSIP activities on predictability on intraseasonal to decadal time scales.

Day 2: *Six S2S Subprojects reports & Other activities*

Cristiana Stan (George Mason University) presented the MJO Teleconnection sub-project activities. She addressed scientific studies addressing the research topics and questions and communicated via a wiki page in S2S website and webinar. It was suggested to promote the use the real-time OLR MJO index (ROMI), in addition to RMM indices, in order to try to better characterize the tropical forcing.

Paul Dirmeyer (George Mason University) presented the Land sub-project activities. The Land sub-project is strongly connected to the Land Surface for Prediction (LS4P), which is a multi-model project lead by YongKang Xue (UCLA). A special issue in Climate Dynamics will be organized to report various LS4P research results and other S2S prediction research.

Charlotte DeMott (CSU) highlighted recent MJO studies on S2S prediction and the ocean, suggesting that ocean feedbacks to mean state moisture may be key, and also that ocean evolution is important for some MJO events. The differences between model ocean initialization with real world ocean initial state and ocean model drift were discussed.

Angela Benedetti (ECMWF) introduced the second Phase of the WGNE Aerosol project: Evaluating the impact of aerosols on Medium-Range and Sub-seasonal Numerical Weather Prediction. This project is a joint collaboration between WGNE, S2S and GAW. The aims are: To identify and quantify the importance of aerosols for the predictability of the atmosphere at short-range and subseasonal time scales.

Yuhei Takaya (JMA) presented the Ensembles sub-project activities. He pointed out the sub-project wiki page including the scientific objectives and proposed activities. He mentioned results of a study from ECMWF showing the lagged-ensemble approach can improve skill of weeks 3 and 4 forecasts and theoretical results from Yuhei using a Monte Carlo Method.

Daniela Domeisen (ETH Zürich) presented the report on the Stratosphere sub-project. She started by introducing the SPARC/SNAP project. She summarized two community papers related to S2S and then outlined the two ongoing projects: 1) stratospheric bias in S2S models, and 2) stratospheric damping experiments.

Day 3: *Other S2S Activities & Opportunities going forward*

Caio Coelho (CPTEC) presented R2O and Verification project which is not a S2S Phase II subproject per se. The project has two objectives (a) Scientific & (b) Operational, and linked to other WMO activities such as WGSIP, IPET-OPSLS, and JWGFVR. Joanne Robbins (UK MetOffice) presented the real-time pilot initiative for the development of end-to-end S2S applications (Nov. 2019 ~ Oct. 2021). Its desired outcomes are to create a legacy for continued uptake and use of S2S forecasts in various sectors. WWRP's SEAR and WCRP's CORA are involved and there are 15 projects at present.

Frédéric Vitart (ECMWF) described the proposed AI/ML competition for S2S forecasts. The competition is proposed to start in Feb. 2021 and run for 6 months, using 2020 gridded precipitation and T_{2m} RPSS as the target. Andrew Robertson (IRI) summarized recently proposed activity to make a quasi real-time verification of S2S forecasts, such as every quarter to review both skill scores and significant case studies over the previous season. It could be synchronized with the newsletter.

Seung-On Hwang (S2S ICO) reported on current ICO activities. Andrew Robertson presented various WMO projects focused on West Africa with an S2S component. Michel Rixen (WMO WCRP) mentioned an EU call on preventing and fighting extreme wildfires with integration and demonstration of innovative means. Zhuo Wang said that a monsoon project could be started if there is enough interest in the monsoon topic in the S2S community. There was final discussion on S2S objectives and plans for 2020-2023.

S2S Webinar Series (Sep., Oct., and Nov.)

S2S ICO

WMO S2S Prediction Project organized monthly S2S project webinar series. S2S online webinars have been held as follows.

1. The 4th webinar (Sep 16th) on *Land subproject*. Dr. Paul Dirmeyer chaired and 70 people attended.

- **Judah Cohen** (AER): Eurasian Snow Cover Variability Links with Stratosphere-Troposphere Coupling and its Potential Use in Subseasonal to Seasonal Predictions.
- **Kristi R. Arsenault** (NASA): NASA's seasonal hydrologic forecasting system for improved food insecurity early warning in Africa.
- **David Gochis** (NCAR): A status update on current and planned activities in coupled S2S work with the WRF-Hydro model and its National Water Model implementation.
- **Yongkang Xue** (UCLA): The Remote Effects of Tibetan Plateau Spring Land Temperature on Global Summer Precipitation- The GEWEX/GASS/LS4P First Phase Activity.

2. The 5th webinar (October 28th) on *Research-to-Operations and Forecast Verification.* Dr. Caio Augusto dos Santos Coelho at CPTEC chaired and 79 people attended.

- **Paul Dirmeyer** (George Mason Univ.) and **Trent Ford** (U. of Illinois): Seamless forecast construction and validation across subseasonal time scales
- **Andrea Manrique-Suñén** (Barcelona Supercomputing Center): Choices in the Verification of S2S Forecasts and Their Implications for Climate Services.
- **Ángel G. Muñoz** (IRI): Sub-Seasonal Forecast Skill: When, Where and How to Find it.

3. The 6th webinar (November 25th) on *Real-Time Pilot*, Dr. Joanne Robbins chaired and 48 people attended.

- **Joanne Robbins** (UK Met Office): Initial synthesis of S2S real-time pilot questionnaires: progress, findings and next steps.
- **Thea Turkington** (Centre for Climate Research Singapore, Meteorological Service Singapore): S2S Southeast Asia Pilot Project
- **Steve Woolnough** (Univ. of Reading): Sub-seasonal Prediction for Africa: Examples from the African-SWIFT Real-Time Pilot Project
- **Michael J. DeFlorio** (Scripps Institution of Oceanography, University of California): Subseasonal-to-Seasonal (S2S) Research and Experimental Forecast Product Development at CW3E/NASA JPL

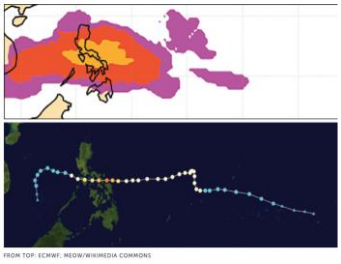
The movie files and abstracts of all presentations in S2S webinar are available at WMO S2S homepage http://s2sprediction.net/static/documents#presentations. Upcoming S2S webinar will be about 'Machine learning' next January. We are looking forward to seeing you on-line.

A news article on S2S forecasts

S2S Prediction Project is pleased to introduce a news article about S2S forecasts to Newsletter subscribers. The title is "Improved three-week weather forecasts could save lives from disaster- accurate predictions could help people prepare for extreme weather".

This article, written by Alexandra Witze, appeared in the ScienceNews on AUGUST 27, 2020. WMO S2S Co-chairs, Frédéric Vitart and Andrew Robertson was interviewed.

To read the full text, go to the following website.
https://www.sciencenews.org/article/climate-weather-forecast-three-week-disaster-storms



On target
A forecast made in the second week of November (top) foresaw heavy rains coming more than three weeks later over the Philippines, which did indeed arrive as Typhoon Kammuri (actual path shown, bottom). (Extracted from the news)

New S2S LG members

Dr. **Kunio Yoneyama**, a director of Dynamic Coupling of Ocean-Atmosphere-Land Research Program (DCOP), JAMSTEC, Japan. He also belongs to WWRP WGNE.

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.