



Sub-seasonal to Seasonal Prediction Project (S2S)

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WMO OMM

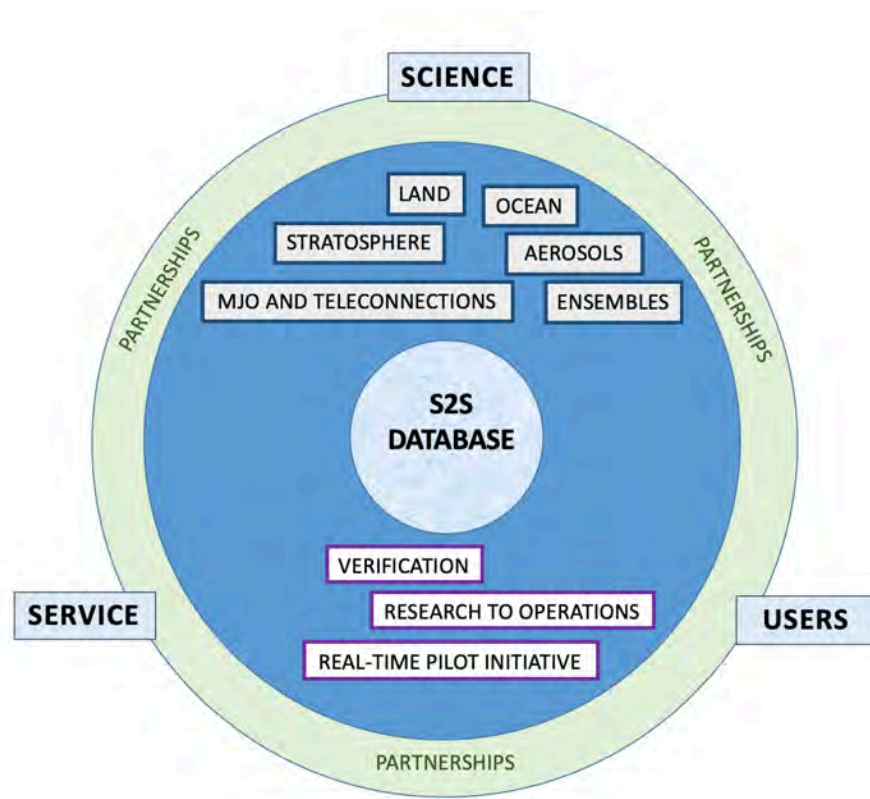




Subseasonal-to-Seasonal
S2S
Prediction Project

2014–
2023

- Improve forecast skill and understanding on the sub-seasonal to seasonal timescale **between 2 weeks and a season** with special emphasis on high-impact weather events
- Promote the initiative's uptake by operational centres and exploitation by the applications community
- Capitalize on the expertise of the weather and climate research communities to address issues of importance to the Global Framework for Climate Services



S2Sprediction.net

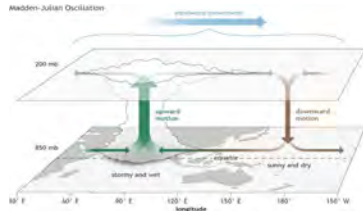
Science sub-project activities

Four initiatives have been launched which involve coordination with operational and research centres in order to improve S2S operational prediction:

- Evaluating the Impact (direct and indirect) of Aerosols on NWP and Subseasonal Prediction (WGNE-S2S-GAW Coordinated experiment). 5 centres have run the experiments - evaluation started
- Coordinated experiment to better understand stratosphere-troposphere interaction in NWP and climate models (SNAPSI, Collaboration with SPARC/SNAP)
- Ocean observing system experiments to better understand the impact of ocean observations on sub-seasonal forecasts, with specific focus on the evaluation of the upcoming Tropical Pacific Observing System (TPOS)
- LS4P (led by GEWEX): impact of initialized land surface and snowpack over Tibetan Plateau on S2S prediction.

S2S Forecast skill: “Are we progressing?”

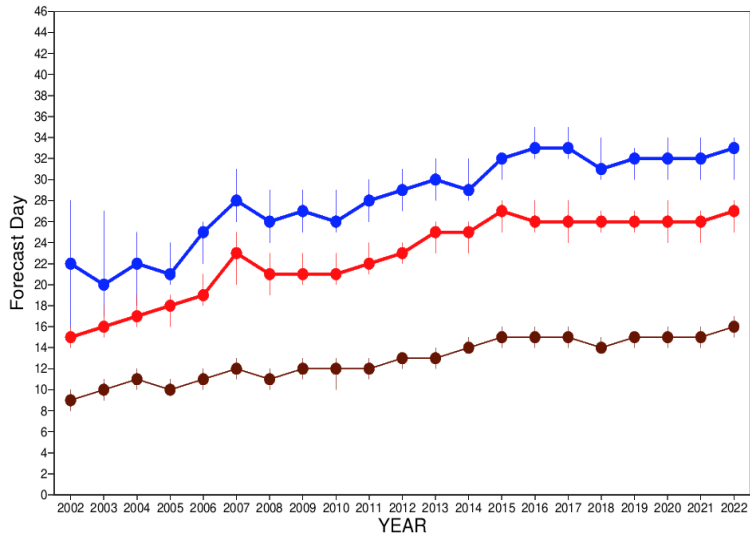
ECMWF Forecast Skill



Madden Julian Oscillation (MJO)

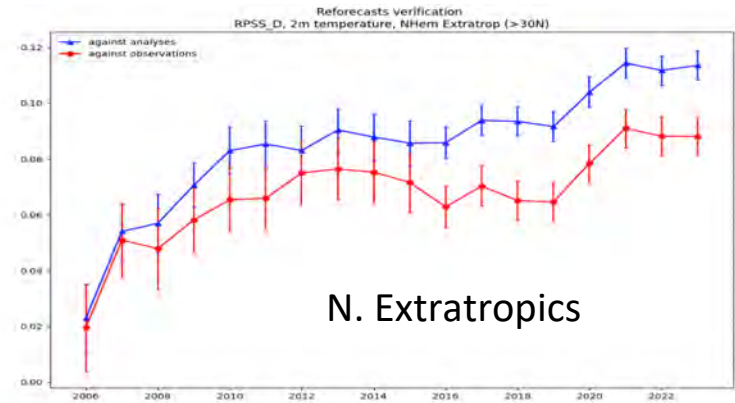
MJO Bivariate Correlation

● 0.5 ● 0.6 ● 0.8

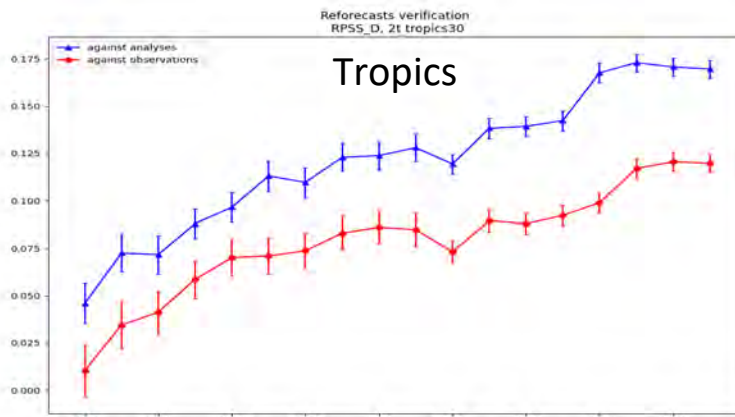


Week 3 2m temperature

Ranked probabilistic skill Score



N. Extratropics



Tropics

Significant Improvements in recent years. Gain of 2-weeks of MJO predictive skill over the past 20 years!

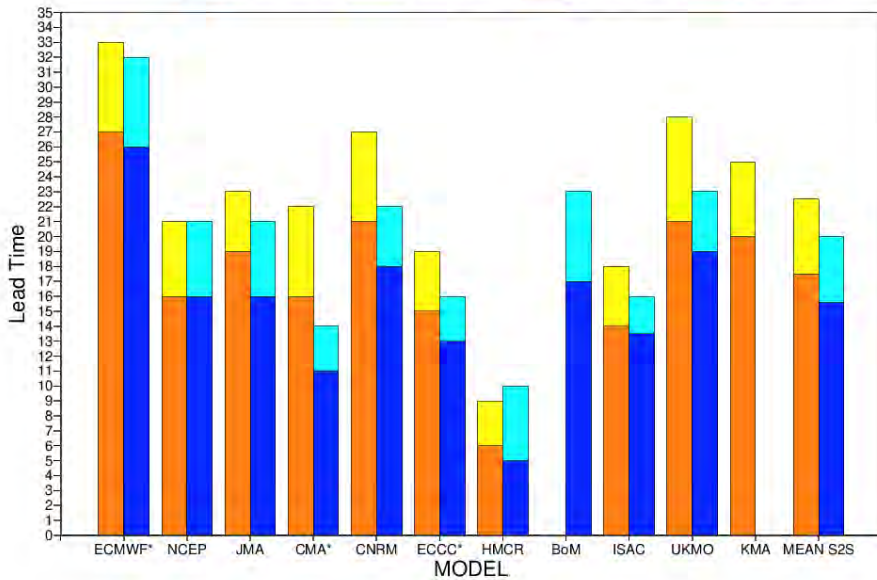
S2S Forecast skill: "Are we progressing?"

S2S Models Hindcast Skill

MJO Bivariate index

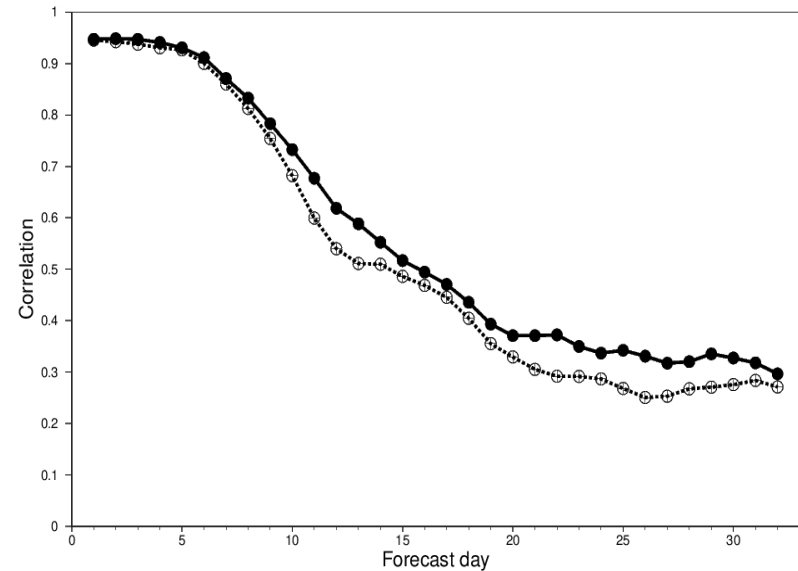
MJO Bivariate Correlation
2022 vs 2015 - S2S REFORECASTS 1999-2010

0.6 cor(2022) 0.5 cor(2022) 0.6 cor(2015) 0.5 cor(2015)



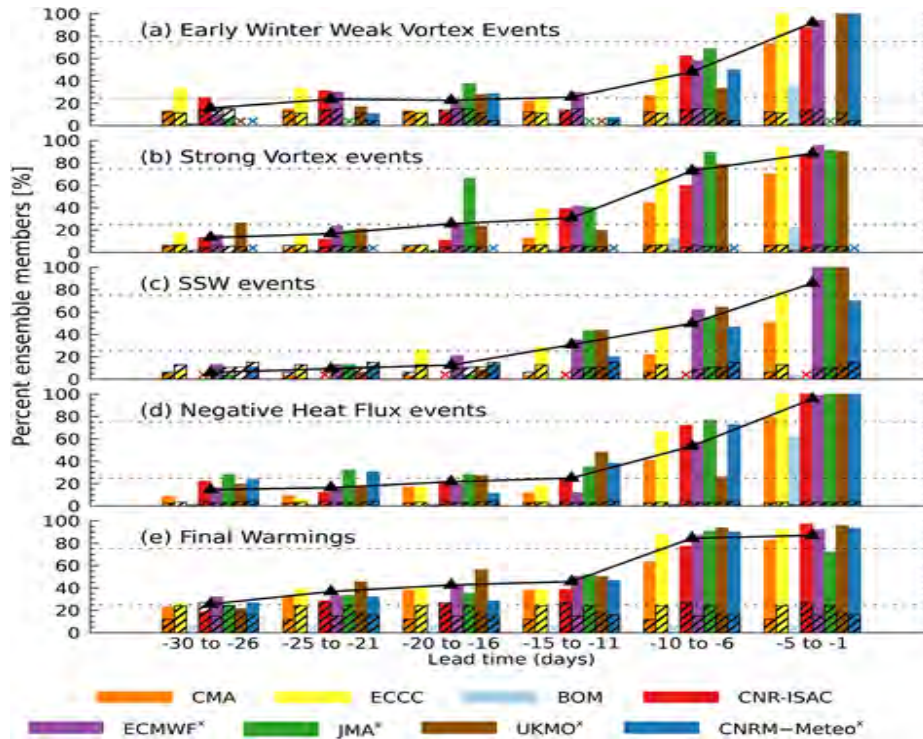
NAO Index

2017 2023



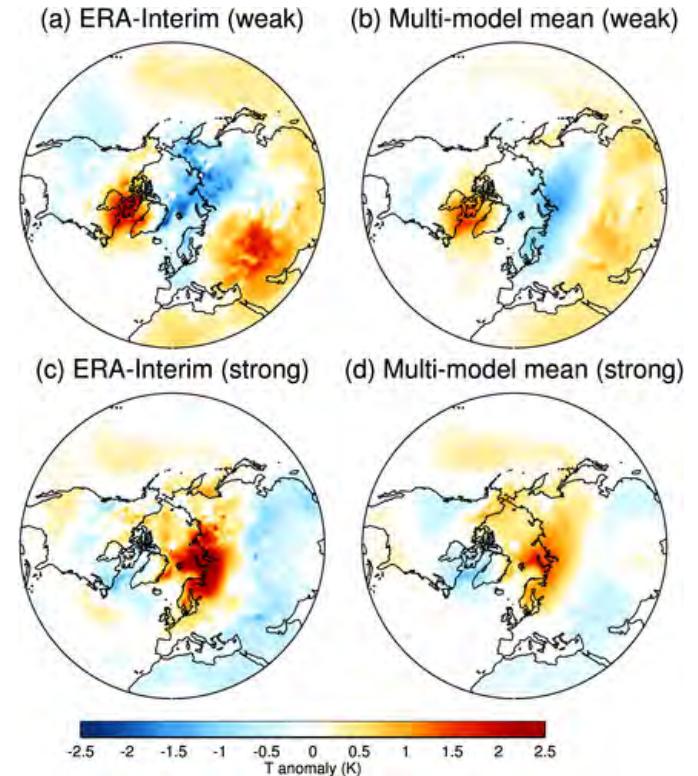
S2S Stratosphere sub-project: SSW predictability

Prediction of SSW events



Domeisen et al, 2019

SSW teleconnections

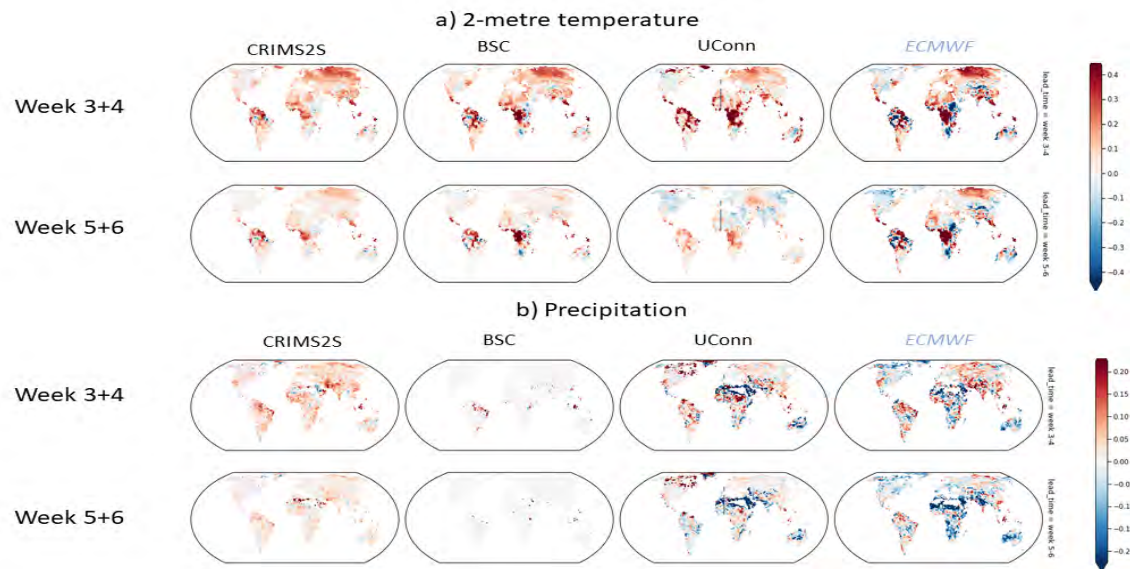


Domeisen et al, 2019

S2S AI/ML Competition

- Challenge: Provide forecasts of near surface temperature and precipitation for weeks 3+4 and 5+6 more skilful than ECMWF operational forecasts for every Thursday of the year 2020.
- Hosted by Swiss Data Science Center at ETH Zürich, with ECMWF support through the new European Weather Cloud for data access to S2S forecasts.
- 49 registered teams ,only 5 succeeded in providing better forecasts than the Benchmark (ECMWF S2S operational forecasts). Top 3 teams got rewarded a prize.

RPSS Score – YEAR 2020

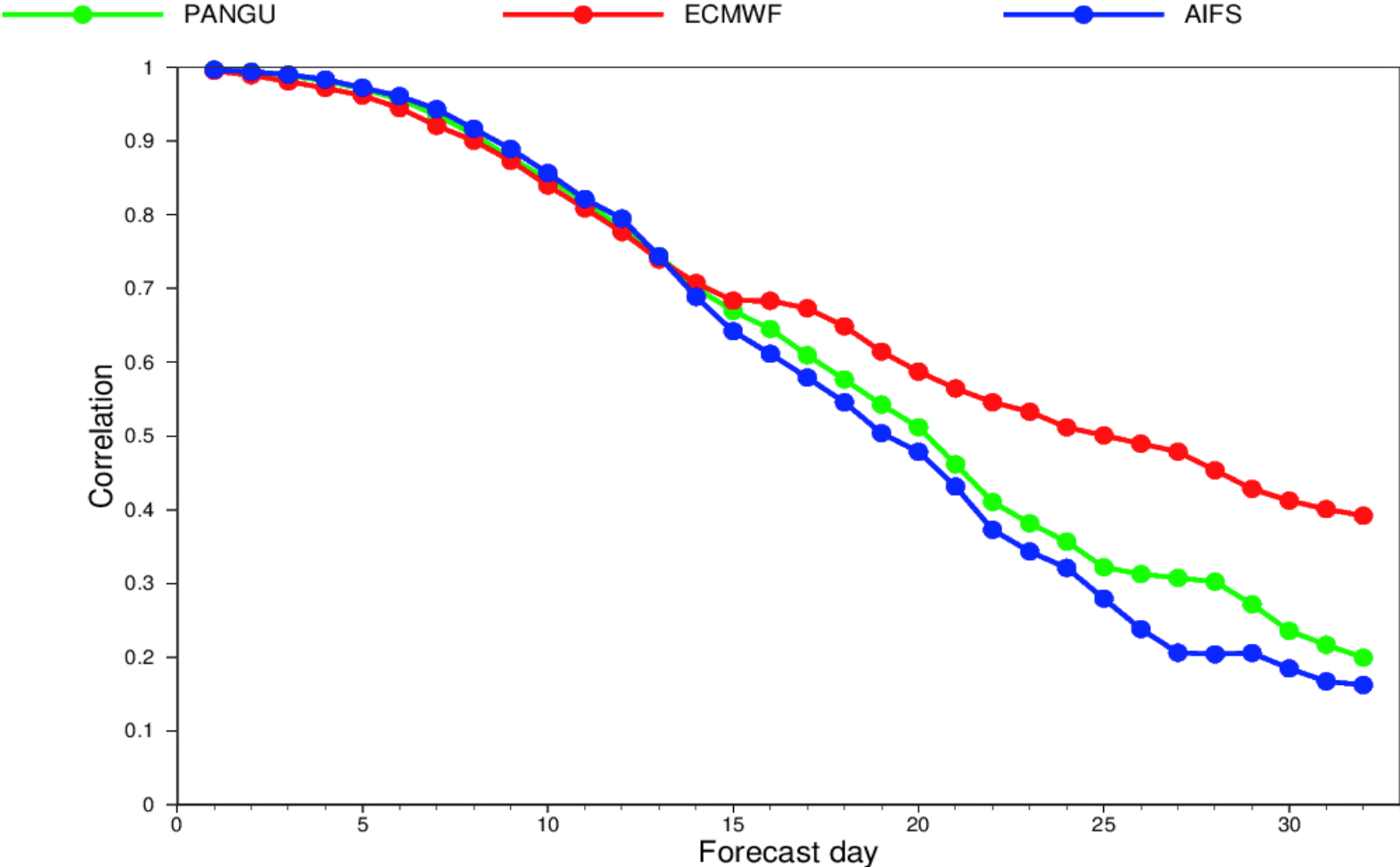


Verification score (RPSS) for the top 3 teams and the ECMWF benchmark. The higher the better. Blue colors indicate scores worse than climatology. Red color indicate better scores than climatology.

Vitart, F., A.W. Robertson, A. Spring, F. Pinault, R. Roskar, W. Cao, S. Bech, A. Bienkowski, N. Caltabiano, E. De Coning, B. Denis, A. Dirkson, J. Dramsch, P. Dueben, J. Gierschendorf, H.S. Kim, K. Nowak, D. Landry, L. Lledo, L. Palma, S. Rasp, and S. Zhou 2022: Outcomes of the WMO Prize Challenge to Improve Subseasonal to Seasonal Predictions Using Artificial Intelligence. *Bull. Amer. Meteor. Soc.*, 103, 2878-2886

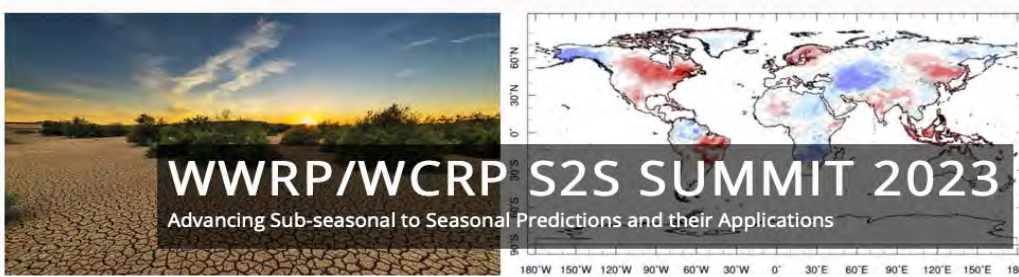
ECMWF ML MJO skill - JAS

MJO Bivariate Correlation 1999-2010 re-forecasts



S2S (2013-2023) Legacy

- Development of the S2S database and services around the database (IRI DL, pre-computed weather indices, S2S product websites).
- Bringing together a varied geographical and multidisciplinary community of scientists, spanning a wide range of regions and subjects (more than 600 registrations to the S2S mailing list)
- Advancing understanding of predictability drivers, teleconnections and model deficiencies on different processes and areas.
- Encouraging S2S research funding: > 16 funded S2S research projects by NOAA
- 25 training courses , 49 workshops/sessions and 17 webinars (organized during COVID)
- 22 articles, 1 book, 22 newsletters



03 - 07 July 2023

University of Reading, UK



- 191 attendees + about 40 online from 29 countries
- ½ attendees were Early career scientists
- 85 oral presentations + 109 posters around 3 themes: S2S processes/modelling/R2O
- 8 breakout groups

Main recommendations:

1. Need for international coordination of pan S2S activities that connect predictability research, modelling and observational needs as well as impact after the end of the WWRP/WCRP S2S project (end of 2023).
2. **Need for real-time access of S2S database**, in particular ECMWF S2S data (removal of the 3-week embargo).
3. The research and coordinated experimentation should be supported with adequate research databases and cloud infrastructure.
4. There is a wish for operational services to offer cloud capabilities for processing data.
5. Promote exchanges between ML and Met communities: Hold regular events for updates and training.

Lessons learned and Remaining Challenges

- Improved linkages with several other groups in WWRP and WCRP is needed and between the weather and climate communities. To address issues like S2S prediction and attribution in the context of a changing climate which has become an urgent priority for better resilience.
- Need to further develop S2S prediction for climate services and applications through coordinated engagement with user and applications communities.
- S2S database: Need to address huge disparity in the configuration of S2S re-forecasts, making the use of the S2S database for multi-model evaluation very difficult.
- Science: Address model errors responsible for the too weak tropical-extratropical teleconnections. Need for longer re-forecasts to better understand interactions between sources of predictability.

After 2023

Follow up of S2S project:

- WWRP/SAGE
- S2S activities in WCRP
- Lead Centre for sub-seasonal to seasonal Forecast (LC-LSSFMME)

S2S database:

- S2S data providers and archiving centres have been asked to renew their commitment for another 5 years (WMO letter sent in July)
- Plans to ask data providers **to reduce real-time data embargo** from 3 weeks to 2 days.

S2S Website (www.s2sprediction.net) hosted by APCC:

- Will be maintained online for another 2 years

WWRP/WCRP Sub-seasonal to Seasonal prediction (S2S) database

	Time-range	Resol.	Ens. Size	Freq.	Hcsts	Hcst length	Hcst Freq	Hcst Size
ECMWF	D 0-46	Tco639L137	100	Daily	On the fly	Past 20y	2/weekly	11
UKMO	D 0-60	N216L85	4	daily	On the fly	1993-2015	4/month	7
NCEP	D 0-44	N126L64	4	4/daily	Fix	1999-2010	4/daily	1
ECCC	D 0-32	~39 km 85 levels	21	weekly	On the fly	2001-2020	weekly	4
BoM	D 0-60	T47L17	33	2/weekly	Fix	1981-2013	6/month	33
JMA	D 0-34	TL319L100	5	daily	Fix	1991-2020	2/month	5
KMA	D 0-60	N216L85	8	daily	On the fly	1993-2009	4/month	7
CMA	D 0-60	T266L56	4	2/week	On the fly	Past 15y	2/week	4
CNRM	D 0-47	T359L91	25	weekly	Fix	1993-2017	weekly	10
CNR-ISAC	D 0-32	0.75x0.56 L54	40	weekly	Fix	1981-2010	6/month	5
HMCR	D 0-63	1.1x1.4 L28	20	weekly	Fix	1990-2015	weekly	10
IAP-CAS	D0-65	C96L32	16	daily	Fix	1999-2018	daily	4