Establishment of S2S Panel (or Task Group)

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Introduction / background

- WWRP/WCRP Sub-seasonal to Seasonal Prediction (S2S) Project officially ended at the end of 2023 and had remarkable success in fostering research on S2S prediction and predictability.
- During the project period, a lot of young scientists flourished.
  → We don't wish to lose the momentum!
- Recently, WMO established WMO Integrated Processing and Prediction System (WIPPS) centres for sub-seasonal prediction (GPC-SSP, LC-SSPMME). There are many unaddressed and emerging research and modeling questions.
- The follow-on WWRP project to S2S, SAGE (S2S Applications for aGriculture and Environment) Project, is going to focus primarily on its applications, with some relevant science themes (conditional predictability): SAGE Project Plan
- Here we propose an S2S panel (or task group) as an additional follow-on to WWRP/WCRP S2S

S2S Task group: Identified research topics

Two multi-faceted areas were determined with a few specific topics each.

(1) S2S predictability and prediction of the Earth System across scales

(a) Investigating atmospheric teleconnections and their links to Earth System components, including the use of XML to establish causal links (Yuhei, Hai Lin)

(b) Exploring seamless methods to identify optimal time and spatial scales for predictability and optimize signal to noise ratio (Andrea, ...)

(c) Developing and assessing ML/AI techniques for S2S prediction (e.g., calibration, downscaling, analogs, emulators to increase ensemble size, ML prediction models)(?)

S2S Task group: Identified research topics

(2) **Initialization and observation impacts**

Advancing techniques to obtain balanced initial states of the Earth system components and well-represented coupled modes, including coupled data assimilation (Andrea?, ...)

Exploring tendency adjustment methods to reduce biases and associated initial shocks/drifts (Andrea, Bill*, ...)

Assessing observation impacts, including OSEs, collaborating with Ocean Decade SynObs (Yuhei)

*as external contributor

Membership

Leads:
Dr. Yuhei Takaya (Meteorological Research Institute, Japan Meteorological Agency)
Dr. Andrea Molod (NASA/Goddard Global Modeling and Assimilation Office)

Members:
- 3-4 (?) additional members with expertise on the proposed research topics
- liaison member to the WWRP SAGE project
- ideally some members external to WGSIP (and possibly WCRP)
- we have some ideas, but suggestions and recommendations are welcome including ECS

Next steps

- Reach out to **potential members**, and develop a time frame.
- Finalize the plan in a given format to be submitted to ESMO.
- Continue organizing events (sessions in international conferences, EGU, EMS, AGU, AMS, AOGS, etc.)

Busan IAMAS-IACS-IAPSO Joint Assembly, 20-25 July 2025, Busan, Republic of Korea
The symposium "Monsoon systems: variability, processes, predictability, change and extremes" is proposed. http://www.baco-25.org/

AOGS2025, 27Jul.-1 Aug. 2025, Singapore
https://www.asiaoceania.org/aogs2025/

OCP-4 autumn 2025 (TBD)

Backup slides
(for more explanations of each topic)

(1a) Investigating atmospheric teleconnections and their links to Earth System components

Atmospheric teleconnections driven by slowly-varying tropical climate variability (such as ENSO and MJO) are recognized as crucial mechanisms facilitating S2S prediction in the extratropics. However, these teleconnections are not fully understood and often poorly represented in models. For example, the teleconnections of the MJO are often underestimated in S2S models (Stan et al. 2022). Thus, there is a need for more diagnostic study and for analysis of model error that leads to improvement in the representation of MJO-related teleconnections in S2S models. In addition, while local interactions in other Earth System components (e.g., between soil moisture and surface temperature/precipitation) are relatively well studied, their remote influence through teleconnections are less studied and understood. A comprehensive understanding of these teleconnections serves as a fundamental basis for predictive understanding in S2S forecasting. The S2S TG will explore such connections between Earth System components to better understand and exploit the full S2S predictability via these interactions.

(1b) Exploring seamless methods to identify optimal time and spatial scales for predictability

In the S2S timeframe, predictability significantly varies based on factors such as forecast lead time, season, region, and the state of the Earth system. Consequently, determining the optimal time and space scales (i.e., averaging scales to increase signal to noise ratio) to achieve the highest forecast skill is contingent upon these factors. Dirmeyer and Ford (2020), for example, introduced a technique for an ad hoc seamless forecast, but this does not account for the factors mentioned above. Understanding the optimal time and spatial scales of predictability is crucial for maximizing the utility of S2S prediction. However, our current knowledge in this area is limited; moreover, there is no consensus/guideline on how to define these optimal scales. To address this gap, the S2S TG will foster activities that analyze S2S data provided by the S2S Project contributors and others and propose an approach to define the optimal scales.

(1c) Developing ML/AI techniques for S2S prediction (e.g., calibration, downscaling, analogs)

The rapid advancement of Machine Learning (ML) and Artificial Intelligence (AI) techniques has found widespread application across various disciplines. There is a significant interest in leveraging these technologies for S2S prediction. For instance, within the S2S Project, the WMO coordinated a prize challenge in 2021 aimed at enhancing subseasonal prediction through ML/AI calibration methods to underscore the potential benefits of ML/AI in S2S prediction (Vitart et al., 2022). There is a growing demand for the development of innovative ML/AI techniques for calibration and downscaling in the context of operational S2S forecasting. ML/AI methods can also potentially play a crucial role in analyzing the processes involved in climate variability. In addition, ML based model emulators or analogs can substantially increase the ensemble size and potentially increase skill and/or the identification of extreme events. The S2S TG will embark on exploring the application of ML/AI techniques within the realm of S2S prediction and predictability studies.

(2a) Advancing techniques to obtain balanced initial states of the Earth system components and well-represented coupled modes, including coupled data assimilation

The majority of operational S2S models consist of atmosphere, ocean, sea-ice, and land components. These Earth System components are all coupled and solved in parallel in model integrations. Currently, initial conditions of these components are most often created separately using stand-alone models and analysis systems of the Earth System components. More advanced techniques of coupled data assimilation (CDA) potentially provide better-balanced initial states among the components, resulting in a better representation of coupled climate variability. The S2S TF aims to (i) promote awareness of and knowledge sharing relating to the many flavors of CDA that have been or are being developed; (2) recommend a set of diagnostics for assessing initial state balances within and across Earth system components.

(2b) Exploring tendency adjustment methods to reduce biases and associated drift

Model drift and systematic error, which grow rapidly on the S2S timescale (e.g. Saurral et al. 2021), have been one of the long-standing unresolved issues limiting the performance of S2S prediction. A tractable approach for reducing biases that has recently been implemented in some prediction models is to introduce tendency correction terms for the model prognostic variables that are estimated from data assimilation increments (e.g., Crawford et al. 2020). The approach and its influence on the skill of S2S predictions will be further explored and promoted by the S2S TG.

(2c) Assessing observation impacts, including OSEs, collaborating with Ocean Decade SynObs

A quantitative assessment of the impacts of observations on improving the quality of prediction is essential for better coordinating and planning observations of Earth System components. However, the impacts of observations on S2S prediction have not been adequately addressed in part due to the challenges of such studies, and so pose challenges for proposing optimal observational design (Subramanian et al. 2019). The SynObs Project of Ocean Decade is currently conducting coordinated Observation Sensitivity Experiments (OSEs) together with S2S prediction experiments using these OSEs (eg., Hackert et al., 2020). The S2S TG will assess the impacts of ocean observations collaborating with the SynObs group.