S2S report
(draft 1)

1. Highlights for JSC

- Real-time Pilot Initiative begun in Nov 2019 for two years, making the S2S forecasts available in real time to 16 climate-service demonstration projects, spanning developing and developed countries and a application sectors (Energy, agriculture, health, civil protection, humanitarian, water, forestry, fishing, media, etc).
- New S2S website created for Phase II of S2S (2019-2023), including collaboration wikis on new since sub-projects (Aerosols, Ensembles, Land, MJO/teleconnections, Ocean, Stratosphere), RTO, the Real-Time Pilot, as well as for the emerging area of machine learning (s2sprediction.net).
- Ocean/Sea-Ice fields are now being added to the S2S database, which is archived at ECMWF, CMA, as well as IRI Data Library which enables server-side computing and visualization.
- As of April 1, 2020, 130 articles have been published in the peer-reviewed literature using the S2S database, which now includes over 100TB of data.

2. Primary science issues (looking ahead, 3 to 5 years)

- MJO prediction and teleconnections in collaboration with the Working Group for Numerical Experimentation (WGNE) MJO Task Force with focus on MJO/high-impact weather relationships and tropical-extratropical interactions;
- Land initialization and configuration, to investigate the fidelity of model representations of land-atmosphere interactions, and how S2S forecasts may be improved by taking better advantage of the information contained in land surface states;
- Ocean and sea ice initialization and configuration to improve subseasonal predictions though improved initialization of the ocean-sea ice state and depiction of key ocean and sea ice processes that provide predictability at subseasonal time scales;
- The stratosphere, with focus on quantification and understanding of stratosphere/troposphere coupling, model biases, initial conditions and ensemble generation, and whole atmosphere diagnostics;
- Atmospheric composition, to assess the benefits of using prognostic aerosols rather than the climatology used in the current operational S2S models, identify the level of aerosol model complexity needed, and assess the predictability of aerosols (e.g. dust) at the S2S time scale and potential forecast value for applications;
- Ensemble generation, to determine (on the S2S scale) the optimal initial-perturbation strategies on S2S scale, sources of overconfident forecasts, importance of initial perturbations of the ocean, and stochastic parameterization schemes.
- Improving research-to-operations methodologies for calibration, multi-model combination, verification and generation of forecast products, especially for forecasts of precipitation and weather extremes over land.
- Connecting science to society through co-development of forecast-value demonstration projects involving climate scientists, forecasters and sectorial decision makers (Real Time Pilot Initiative)

3. Issues and challenges, for example:

- How do you work with other WCRP activities and partners outside of WCRP?
    - The stratosphere, in collaboration with the WCRP Stratosphere-troposphere Processes And their Role in Climate (SPARC) initiative on Stratospheric Network for the Assessment of Predictability (SNAP).
    - Atmospheric composition is in collaboration with WGNE and Global Atmospheric Watch (GAW).
    - Land initialization and configuration, in coordination with the Global Energy and Water Exchange/Global Land Atmosphere System Study (GEWEX/GLASS), Data Assimilation and Observing Systems (DAOS), EartH2Observe, and Working Group for Sub-Seasonal to Interdecadal Prediction (WGSIP) SNOWGLACE project.
    - Ocean and sea ice initialization and configuration is in coordination with WGSIP, DAOS, and PDEF (Predictability, Dynamics, Ensemble Forecasting) Working Groups.
    - Ensemble generation, is in collaboration with PDEF and WGNE.
    - Verification research activities of S2S forecasts is in collaboration with the Joint Working Group on Forecast Verification Research (JWGFVR).
    - Research to Operation activities of S2S forecasts is in collaboration with the WMO Inter-Programme Expert Team on Operational Predictions from Sub-seasonal to Longer-Time Scales (IPET-OPSLS).
    - We have begun discussion with CORA to integrate the S2S Real-Time Pilot initiative across WCRP time scales toward Objective 4: Connecting Climate Science with Society.
    - Discussions have been held with CORDEX, to develop a demonstration for the added value of dynamical downscaling of S2S forecasts over regions that combine good S2S skill at large scale, with complex small time & space scale climate dynamics, such as the maritime continent
    - Potential to link with WDAC on Data infrastructure: integration needed between S2S database, research S2S datasets (eg NCAR), and with CMIP data. There is already integration of S2S thru IRI Data Library to NMME, EU-C3S, SubX

- How you see your community evolving?
    - S2S is now in its second phase (2019–2023), by the end of which we envisage S2S forecasting - as part of climate services - being a routine component of operational forecasting carried out by global producing centers, with forecasts exchanged through WMO Lead Centers for multi-model sub-seasonal forecasts, and disseminated by national meteorological services (NMSs) throughout the world. This Research to Operations objective is well underway through the WMO's Expert Team (IPET-OPSLS).
    - By filling the gap between medium range weather forecasts and seasonal climate predictions, S2S provides a concrete example of one part of a broader evolution toward provision of seamless weather/climate information across scales from days to decades and local to global scale, with weather forecasting at one end and climate-change projections at the other.
    - S2S is focusing research on model and forecast improvement through the set of science sub-projects described above. But there will be no silver bullet and S2S predictability over land for precipitation and weather extremes is likely to remain low in general. We see further evolution toward identifying (in advance) windows of forecasts of opportunity when and where particular sources of predictability are strong, enabling useful probabilistic forecasts.

This demand requires climate science research (WCRP core projects) to improve climate services (as part of WCRP Objective 4), from days to decades.

- Expanding data infrastructure, enabled through the TIGGE, S2S, SubX, NMME, EU-C3S, and CMIP databases has created a new opportunity for machine learning/artificial intelligence to improve forecasts and attribute extremes to weather/climate phenomena. Cloud computing is expected to play a key role in enabling these ML approaches as well as to allow researchers to connect these still-disparate databases together through rapidly-evolving python tools like Pangeo.
- Downscaling/regional modelling, and cloud-resolving modelling are future areas for S2S evolution (with the focus so far on "getting the synoptic scale right"), and naturally fit within the seamless forecasting concept.

- How does current funding affect your community, your activities, your service?
  - S2S is reliant on critical in-kind contributions such as ECMWF, CMA, the contributing forecast providers, as well as national/regional science funding agencies
  - In the arena of big data, there are potential opportunities to engage big tech companies and their philanthropic wings. To date, support has mostly been restricted to cloud computing credits, rather than grant funding essential for salary supported.
