Report from the working group 2:

Design of Sub-Seasonal Forecast Systems

At present, not much thought has been given in the designing of an optimal S2S prediction system. Current systems are generally inherited from weather or seasonal prediction systems. There is no adequate scientific justification to corroborate various options that are currently in use.

The ideal sub-seasonal to seasonal prediction system should have a consistent assimilation and forecast system across reforecasts and real time forecasts, **BUT** given the computing and human resource constraints one has to make compromises. Currently, the scientific basis for making such decisions is limited. S2S database could be used to investigate these questions.

The discussion was organized around the following main questions:

- Considering that the computer resources allocated for the sub-seasonal operational predictions are defined, what is the optimal design of a sub-seasonal forecast system?
- At sub-seasonal range the reforecast data set is an integral part of the forecast system. Ideally the re-forecast and real-time runs should have exactly the same configuration. In reality this is not trivial to achieve. What are the important aspects to take care in the transition from reforecasts to forecasts?
- What are the advantages of using a forecast system valid for a medium to a seasonal predictions (seamlessness system) versus a tailored system that address specifically the predictions on sub-seasonal time scales?
- What is the optimal method to generate initial conditions for sub-seasonal predictions?

General recommendations:

Considering the large variety of present configurations used for the operational S2S forecasts the working group recommends sharing information on rationale behind design of current forecast system on S2S project pages (possibly alongside the current model description). It is important to document whether the current forecast configuration was chosen on the basis of scientific rationale or just for convenience.

Resources Allocations:

For a given amount of computer resources, what should be the priority? We discussed the importance of spatial resolution versus ensemble size and more generally the importance of introducing model complexity.

We agreed that this is a rather complex issue. We know that the horizontal resolution is not so critical for MJO predictions but it is relevant for a variety of processes at sub seasonal time scales such as mid-latitude teleconnections, blocking activity etc.

What should be the relative cost of real-time forecasts and re-forecasts (e.g., should real-time and re-forecasts have the same ensemble size?)

This depends on the use of the reforecast data. If detailed calibration (e.g. based on skill), estimates of conditional skill etc. are desired, then there is a need of close match of the

ensemble size between reforecast and forecast. For just a basic bias correction (based on mean climate) the size of reforecast ensemble can be modest (e.g. 3-10 members).

What should be the relative cost of the atmosphere and ocean components for sub-seasonal prediction?

As high atmospheric resolution as affordable; matching ocean resolution may not be critical for sub-seasonal. It may not be necessary to have full ocean model. We had divergent opinions on this latter statement. We also discussed the dependence of the answer on the evaluation metrics used for assessment.

How frequent should the sub-seasonal forecasts be?

We didn't reach a definitive answer. We can suggest to use the S2S database to examine some choices and understand relative merits (ensemble size vs. frequency of start times). Currently the most popular approach seems to combine lagged forecasts and perturbed forecasts to achieve sufficiently large sample from each start time.

Encourage experimentation with the idea that bias correction may not be a linear problem in sub-seasonal predictions. Would a different protocol for reforecast generation be more appropriate for sub-seasonal? (e.g. sample phases of drivers of predictability). If a large reforecast is available, this may just be a matter of sampling it in a suitable way.

Lagged vs. burst ensemble: Need perturbations for initial conditions to achieve sufficient sample from each day? Either way, need enough members to be able to quantify reliability of forecast.

Transitioning from reforecasts to forecasts by maintaining consistency:

How consistent initial conditions between reforecasts and real-time forecasts need to be?

Getting it wrong is a big source of errors in variables relevant to users, and should be monitored in real-time forecasts. The fact that it is important to have consistency in inputs of observational data, is an argument to keep the reforecast period relatively short (approx. 10 years). On the other hand there are other factors that need to be considered, for example we need to have a sufficient number of samples for extremes.

How can we make real-time and re-forecasts initial conditions more consistent?

Running off line systems should be considered as a back up to the full coupled system reanalysis for generating initial conditions for reforecast and real-time forecasts. Nudging of surface conditions is another option. If resources are available, run re-analysis to match the analysis in the forecast would be the ideal solution.

Is it better to use a seamless or a tailored system for S2S predictions?

Should the ocean model have a specific configuration for sub-seasonal prediction (e.g. different vertical resolution than for long-range and climate forecasting)?

If operational constraints are not an issue, targeted configuration would be an advantage for this time-scale (e.g. higher resolution in upper ocean only; mixed layer ocean may even be sufficient).

Should the perturbation strategy target specifically the sub-seasonal time-range (e.g., MJO, upper ocean)?

The group agreed that further investigation is needed to address this point. Studies exploring the use of bred vectors and singular vectors in the ocean would be very valuable.

Regarding methods for initial conditions generation we discussed the relevance of consistency between analysis and forecast systems.

We agreed that consistency in atmospheric initial conditions may not be problematic, but is more important in slowly varying surface components, e.g., land, snow. The S2S database should be used to quantify this statement further. Consistency across reforecast should also be taken into account.

How could we reduce the initialization shock (coupled data assimilation or relaxation techniques)?

We don't know the consequences from deviating from the ideal system. Techniques are being used to minimize initial shocks, and more studies are needed to investigate this issue further.

How to best generate perturbations in surface conditions?

Ideal should be consistent within the coupled system, but we don't know which approach will be the best, e.g., coupled EnKF or (weakly) coupled 4DVAR.

The group also discussed the benefit of producing the reforecast on the fly versus producing a static reforecasts. Each approach has different advantages and weaknesses. Decision depends on user requirements. For example if the reforecast is used to recalibrate application models (e.g., hydrological models, crop models) the production on the fly might require more computation for the users.

The group also commented on the provision of consistent information across different time-ranges. Currently some institutions have made efforts in merging information on sub-seasonal and seasonal time-scale. Such an activity should be encouraged further.