Sea Ice Initialization and Seasonal Prediction: a WGSIP experiment

Tremendous advance in improving and exploiting the initialization of the oceanic and atmospheric components of seasonal forecast systems has been made in the past decade, particularly with the advent of enhanced knowledge of the world's oceans through ARGO. Utilizing the increased knowledge of sea ice conditions within seasonal prediction systems remains an untapped and unknown reservoir of potential predictability. Current seasonal prediction systems range from prescribed sea ice climatologies to fully thermodynamic and dynamic interactive sea ice initialized from an observed state. To gain understanding of the potential impact of sea ice initialization on the atmosphere, it is necessary to perform model comparisons with and without sea ice initialization.

There have been suggestions that winter pre-conditioning and anomalous spring sea ice extent could influence Northern Hemisphere circulation. Effects on the location of the summertime North Atlantic Storm Track (Balmeseda et al., 2010) and the winter time circulation (e.g. Francis et al 2009) have both been suggested. However, it is not yet known if these effects are robust and in particular whether the initialisation of sea-ice can improve predictions of seasonal climate variability.

We suggest a concise set of multi-model sensitivity experiments to examine the effects of sea ice initialization in seasonal prediction systems. The experiments are a simple test of initializing sea ice conditions with the observed sea ice state versus initializing with a climatology. All other components of the seasonal prediction system would be initialized identically across the two experiments. As usual, no use of **any** future information should be allowed in any of the system components. Although the scope of this proposal favours the use of interactive ice models, it should not be seen as excluding simplistic statistical modelling of ice -- for instance the influence of prescribing persisted sea ice anomalies versus prescribing climatology. The primary goal of the study is to demonstrate the influence of proper initialization of sea ice on atmospheric circulation.

Detailed System Elements

The key component of this project will be the comparison of an experiment fully initialized to observed sea ice concentration with another experiment where sea ice initialization is climatological in nature:

- **Full Initialization Experiment:** This experiment should initialize the sea ice according to observational constraints. At a minimum, this should mean sea ice concentrations are initialized to be close to the observed full field as the corresponding assimilation system will allow. Any further initialization of the sea ice state (i.e. ice thickness) is up to the discretion and abilities of the individual participants. All further evolution of the sea ice field should be solely dependent on the sea ice model and its interaction with the other system components. In particular, **no** future knowledge of the observed sea ice state should be used in the experiment, but a simple persistence of the anomaly for example would be allowed.

- **Climatological Initialization Experiment:** This experiment should initialize the sea ice with no interannual variability – that is all experiments initialized in a given calendar month, should have the same initial sea ice. Further evolution of the sea ice would be solely determined by the ice model and its interaction with the other components of the system. In particular, again **no** information of the ice state, past or present should be used to evolve the model. The nature of the actual initialization will be left to the individual participants, however, we envisage that this would initialize with either an observed or model climatology (but not zero ice cover).

Initialization of other system components:

The initialization of the other components of the seasonal prediction system should be as close as possible between the observed and climatological ice initialization experiments, and in general, should be the fullest initialization available to the system. The experiment is designed to test the dependence on ice initialization on future predictability, and not the dependence of knowledge about sea ice conditions on the initialization of the other components. However, it is acknowledged, that in circumstances of a coupled initialization scheme, there may be some interdependence between the ice component and other components with regards to the use of ice observations in the system. Rather, than try and regulate this, it is left to individual participants to independently decide how best to proceed, however, it is **crucial** that each participant properly document how each of their system analysis are achieved.

Experiment Parameters:

Start Date: To properly assess the influence of sea ice initialization on summer and winter season predictions, as well as the autumn sea ice minimum, start dates for historical forecasts around a central analysis of May 1st, Aug. 1st, and Nov. 1st for the years 1996 and 2007 should be provided. The multi-model analysis will be performed using seasonal predictions of the summer (May 1st start), autumn (Aug 1st start), and winter (Nov. 1st start).

Model Integration: The model should run through at least a 4 month integration. Models initiated with the central analysis date of May (Aug/Nov) 1st should at least cover through the completion of Aug (Nov/Feb).

Ensemble Members: A minimum of 8 ensemble members per start date should be achieved.

Model Output: These experiments are primarily intended to test the usefulness of sea ice initialization in seasonal prediction systems; therefore, it should be sufficient to provide monthly averaged output for the multi-model comparison. That being said, it would be in individual participants interest to have some subset of the data available as daily means, which they could provide to other interested parties if requested (with due consideration of data and human resources). **All data should be provided in netcdf format following the CHFP output LINK. Futhermore, all data should be provided on the native (horizontal) grid for the system** (spectral data on a Gaussian grid) with appropriate CF compliant grid labelling. However, all participants should be prepared to provide the data on a 1^{o} latitude and longitude grid if requested, although we strongly recommend against performing any detailed analysis with this (possibly) strongly interpolated data, particularly since we wish to focus on the polar regions.

- Atmospheric (Monthly Mean)
  - Surface Monthly Mean: 2m temperature, sea surface temperature, surface radiative temperature, 2m specific humidity, (10m) velocity, mean sea level pressure, surface pressure.
  - Surface Monthly Accumulation: Total precipitation, downward surface solar radiation, net surface longwave radiation, latent and sensible heat flux.
  - Monthly Pressure Level Mean: geopotential height, temperature and velocity at 850, 500, 200 and 100 hPa.
- Oceanic Monthly Mean:
  - Sea Surface (top level) temperature and salinity.
  - Sea level height.
  - Depth averaged temperature, salinity, and velocity over top 10m, 100m, 400m – or alternatively full temperature, salinity and velocity information down to at least 400m.
  - Surface heat, freshwater and momentum fluxes.
- Sea Ice Monthly Mean:
  - Ice concentration
  - Ice thickness and snow thickness
  - Velocity
  - Top and bottom boundary heat, freshwater and momentum fluxes.
  - Top and bottom boundary temperature.
- Land Surface Monthly Mean:
  - Snow cover and snow depth
  - Soil wetness
- Daily Atmospheric Output (suggested)
  - Daily max/min 2m temperature.
  - Daily geopotential height and temperature at 850, 500, 200 and 100hPa at 00Z and 12Z.
- Daily mean ocean output (suggested)
  - Top level temperature and salinity.
  - Top 10m average temperature (if multiple layers in top 10m).
- Daily mean sea ice output (suggested)
  - Ice concentration and ice thickness
- Initial Conditions (suggested) – to better understand differences between systems.
  - Instantaneous sea ice concentration and thickness.
  - Instantaneous temperature, salinity and velocity of ocean in top 400m
  - Instantaneous 2m temperature and specific humidity
  - Instantaneous 10m (or appropriate proxy) winds

Potential Analysis and Diagnostics

We will carry out analysis of the 2 cases and include all participants in any published scientific studies.

Time Scale of Project

Project Data should be provided by individual projects by July 1, 2011. Initial multi-model analysis would be complete by Jan. 2012.

Project Contact

For further information on the project, contact the coordinator Drew Peterson (drew.peterson@metoffice.gov.uk) or WGSIP co-chairs Ben Kirtman (bkirtman@rsmas.miami.edu) and Adam Scaife (adam.scaife@metoffice.gov.uk). Details for data sharing, and data storage will be forthcoming as the project evolves.

References

Balmeseda, M.A., L. Ferranti, F. Molteni and T. Palmer; Impact of 2007 and 2008 Arctic ice anomalies on the atmospheric circulation: Implications for long-range predictions. QJMRS DOI:10.1002/qj.661

Francis J.A., W. Chan, D.J. Leathers, J.R. Miller and D.E. Veron 2009: Winter Northern Hemisphere weather patterns remember summer Arctic sea-ice extent, Geophys. Res. Lett., vol. 36, L07503.

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