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Joined CanSIPS-CFSv2 Seasonal Forecast

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1. Introduction

The CanSIPS-CFSv2 seasonal forecast, or "The White Space Project," is a joint effort by Environment and Climate Change Canada (ECCC) and National Oceanic and Atmospheric Administration (NOAA) to deliver a geographically contineous seasonal forecast over the North American continent. At present, both ECCC and the Climate Prediction Center (CPC) of NOAA, perform their respective seasonal forecasts independently on a monthly basis. By doing this, each country applies a geographical mask over their counterpart leaving a "white space" to dominate for the seasonal forecast map of North America (see Fig. 1).

The principal goal of this project is to use the combined CanSIPS (Merryfield *et al.* 2013) and CFSv2 (Saha *et al.*, 2014) forecasts for the benefit of having a continuous forecast across the United States and Canada borders. One example of such a project is hydrological monitoring over the Great Lakes managed by the International Joint Commission, where the two countries have an agreement on the water quality (https://www.ijc.org/en/watersheds/great-lakes, accessed 27/12/2018).

Another significant goal of this project is an overall improvement of the seasonal forecasts stemming from the multi-model approach. Both countries will benefit from this approach with more skillful seasonal forecasts over the North American continent. Multi-model seasonal forecasting has been recognized to have better results than the single-model forecasting technique.

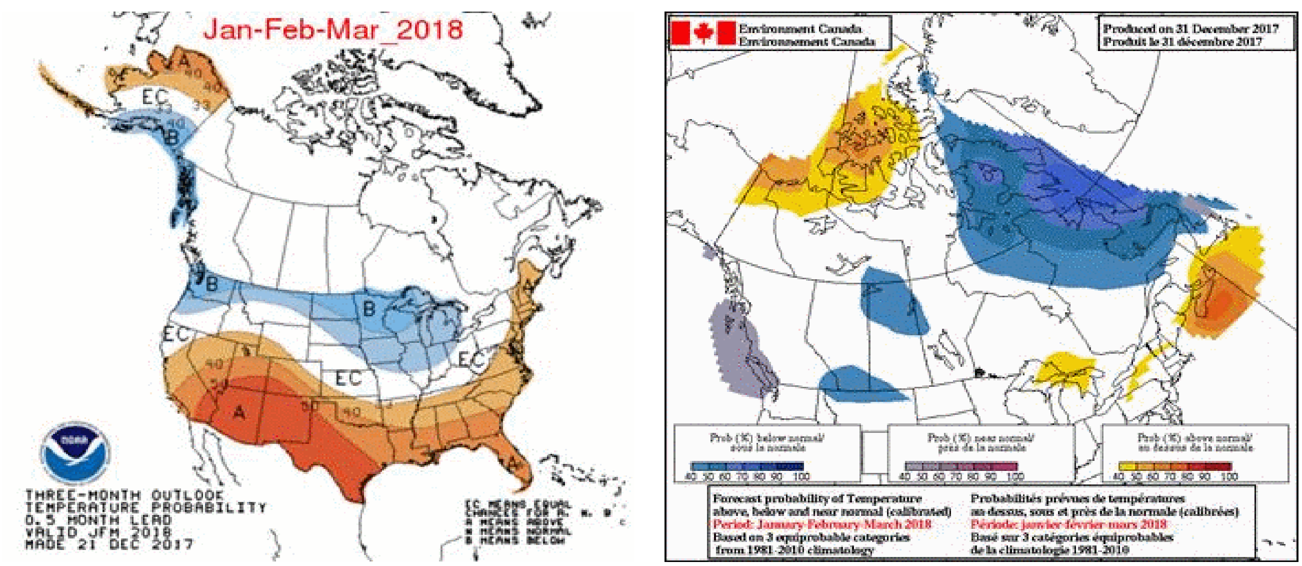

Fig. 1 On the left: Seasonal January-February-March 2018 lead 0 seasonal forecast, issued by the Climate Prediction Center. On the right: as on the left, but issued by Environment and Climate Change Canada.

2. Motivation for the zero-lead forecast

Motivation for this project comes from the fact that both ECCC and the CPC are the operational forecasting centres with an operational production cycle for dynamical seasonal forecasts on a particular day of the month.

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This is very important for the production of the "zero-lead month" (*i.e.* difference between the forecast target season and the forecast release is zero) seasonal forecasts, which are known to have better skill scores compared to the forecasts with longer leads (Wang *et al.*, 2010).

The North American Multi-Model Ensemble (NMME) is an example of a project that combines seasonal forecasts stemming from several North American climate models (Kirtman *et al.* 2014). Once per month, the NMME issues seasonal forecasts for North America targeting seasons having lead times of one to five months. The fact that the combined NMME forecast encompasses real-time seasonal forecasts from a number of production centres makes it very challenging to provide the zero-lead seasonal forecast. Therefore, the combined CanSIPS-CFSv2 real-time seasonal forecasts can be a complementary product to the North American Ensemble, filling the zero-lead gap. Figure 2 shows a comparison between the March-April-May (MAM) historical (1982-2010) percent correct skill scores of zero-lead and one-month lead time seasonal forecasts for near-surface temperature over Canada. Zero-lead forecast skill, calculated for only one model (*i.e.* CFSv2, Fig. 2a), is substantially higher than one-month lead time forecast skill from the Multi-Model Ensemble mean (Fig. 2b, six models in total), highlighting the importance of the shorter lead time forecasts over the longer lead multi-model ensemble forecasting approach. Globally performed analysis (not shown) of the percent correct score confirms the results over Canada in MAM and all other seasons.

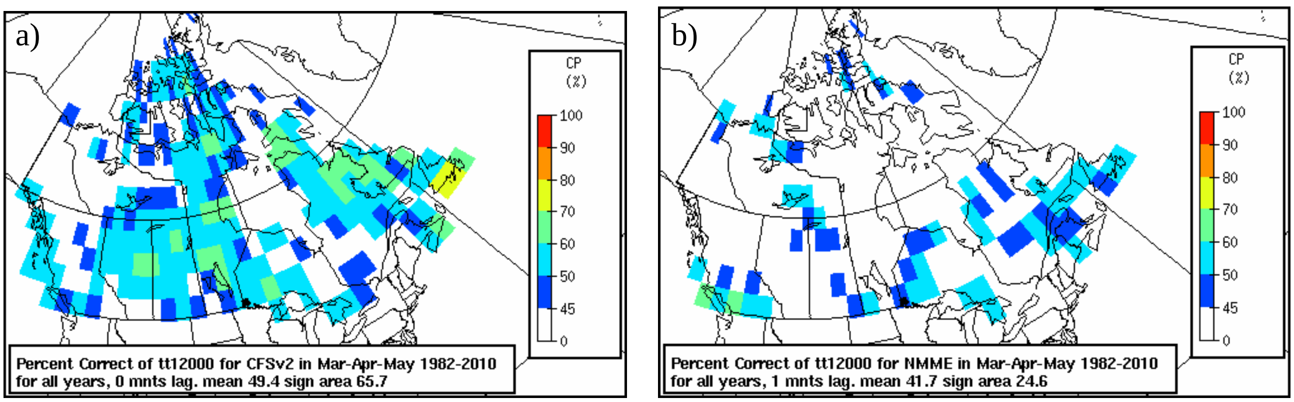


Fig. 2 Historical (1982-2010) percent correct score for MAM season for a) CFSv2 ensemble mean lead 0, and b) North American Multi-Model Ensemble mean, lead 1.

3. Experimental setup of the joined CanSIPS-CFSv2 real-time forecasts

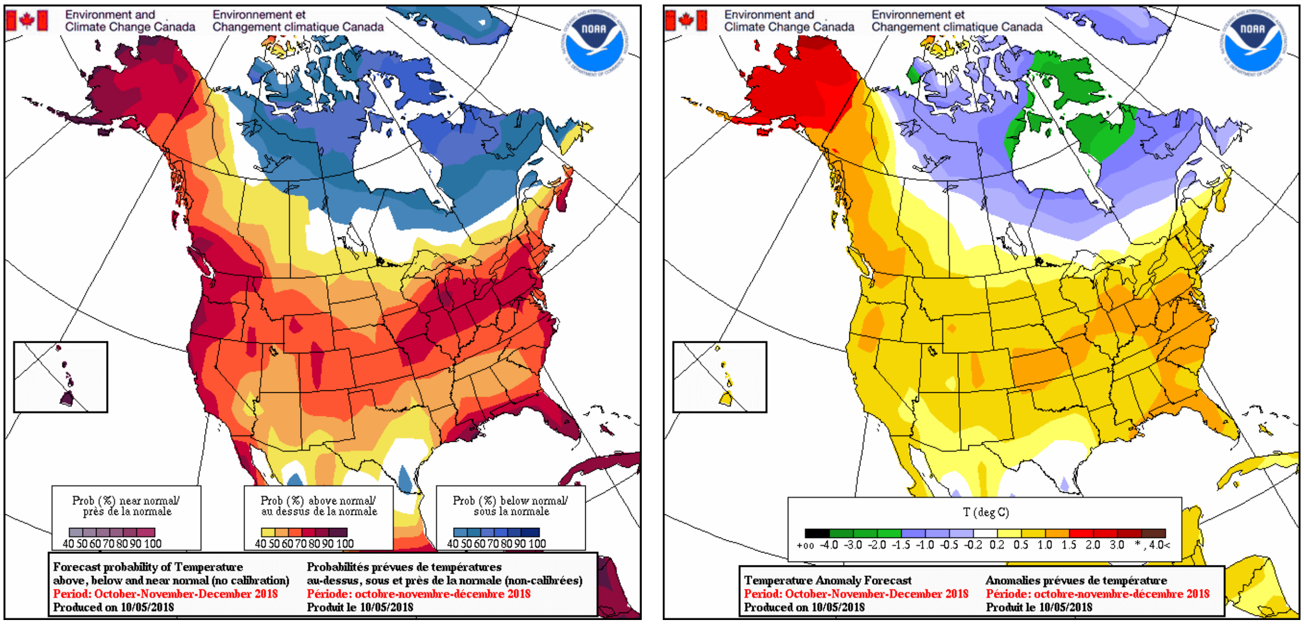
Since the CanSIPS and CFSv2 models use different methods to initialize their respective real-time seasonal forecasts, we used the following configuration, which has been found to be the most suitable for this type of product. To construct the combined seasonal forecast, we have used 20 ensemble members of the CanSIPS system having the "burst initialization" (*i.e.* all ensemble members are launched at the same time) executed on the last day of each calendar month and the 20 ensemble members of the CFSv2 model that have lagged initial conditions. As the combined CanSIPS-CFSv2 real-time forecast is constructed on the first day of each calendar month, we have used the 20 CFSv2 ensemble members executed with lags closest to the end of the month. This configuration enables the combined system to be as close as possible to zero-lag. The combined forecast is an ensemble prediction using 40 ensemble members that are given equal weight. The ensemble members for the historical CanSIPS and CFSv2 ensembles, needed for the estimation of the system's climatology and historical forecast skill, are selected using a similar approach as for the real-time forecast ensembles.

Once operational then at the end of each calendar month, we will be issuing a joined CanSIPS-CFSv2 ensemble seasonal forecast for zero and one-month lead times.

4. Products of the joined system

The CanSIPS and CFSv2 models are combined to form a multi-model ensemble mean where each ensemble member is equally weighted. The flagship product of the joined CanSIPS-CFSv2 forecasting system is the probabilistic forecast for near-surface temperature (Fig.3 on the top left), precipitation and sea-surface temperature. In addition to the probabilistic forecast, we also provide an anomaly forecast (Fig. 3 in the top right for temperature) and a deterministic seasonal forecast (Fig. 3 on the bottom left for temperature). The anomaly forecast is an important complement to the probabilistic seasonal forecasting approach, which makes it possible to associate the probability value with the magnitude of an anomaly. The deterministic approach is useful for seasonal forecast evaluation using simple and understandable skill score measures, such as the correlation coefficient or the percent correct skill score. The joined system seasonal forecasts may be accessed at the following web page:

http://collaboration.cmc.ec.gc.ca/cmc/saison/Joined_CanSIPS_CFSv2/site_web/#t/11/2018/m123/on (username and password available upon request to marko.markovic@canada.ca).



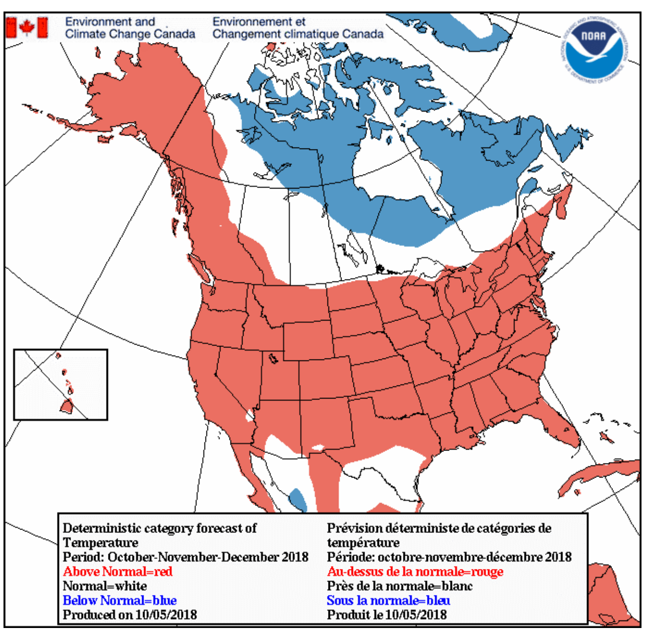


Fig. 3 Zero-lead seasonal forecast for October-November-December 2018 from joined CanSIPS-CFSv2 seasonal forecasting system. Top Left: probabilistic approach; Top Right: anomaly forecast; Bottom Left: deterministic approach.

This project highlights the importance of the shorter lead time seasonal forecasts in comparison to longer lead multi-model methodology. The International Alaska-Northwestern Canada Joined Bulletin is the first user of the joined CanSIPS-CFSv2 seasonal forecast (https://www.canada.ca/en/environment-climate-change/services/climate-change/science-research-data/climate-trends-variability/quarterly-bulletins/alaska-northwest-june-2018.html, accessed 28.12.2018). This quarterly publication studies the seasonal climate and the impact of temperature, precipitation and sea ice on the region.

In order to finalize the joined CanSIPS-CFSv2 seasonal forecast project, we need to perform the forecast calibration. This technique is known to improve seasonal forecasts by mitigating forecast biases, such as overall overconfidence, that most of the forecasting systems possess, especially for the higher observational frequencies (Kharin and Zwiers, 2003). Seasonal climate assessments in the northern regions of North America (*e.g.* Alaska, Yukon) would greatly benefit from seasonal forecasts of sea ice. Therefore, our next step will be the inclusion of the real-time sea-ice forecasts in our forecasting system. Verification of the previous CanSIPS-CFSv2 seasonal forecast should also be included as an important component of the forecasting system. This step would shed light on the system's overall performance and would also build the "forecasting confidence" of the new forecasting system.

References

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