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CanStoc: a merged CanSIPS-StocSIPS macroweather forecasting system

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Many atmospheric fields, in particular temperature, respect statistical symmetries that characterize the macroweather regime (time-scales longer than the lifetime of planetary sized structures (about 10 days) and the scale at which the anthropogenic forcings begin to dominate the natural variability (currently 10 – 20 years). The scale-invariance of the fluctuations implies the existence a huge memory in the system that can be exploited for macroweather forecasts. The space-time statistical factorization (STSF) of the correlation function is another statistical symmetry. STSF relates space and time and implies that at a specific place, when long enough time series are available, spatial correlations cannot be used to improve the forecast. This is because the correlation information from (for example) teleconnections is already contained in the past values of the series.
The Stochastic Seasonal and Interannual Prediction System (StocSIPS[1,2]) is a stochastic model that exploits these symmetries to perform long-term forecasts. Compared to traditional global circulation models (GCM) it has the advantage of forcing predictions to converge to the real-world climate (not the model climate). It extracts the internal variability (weather noise) directly from past data and does not suffer from model drift. Some other practical advantages include much lower computational cost, no need for downscaling and no ad hoc postprocessing.
In the macroweather regimes GCMs become stochastic with internal variability having scaling fluctuations over wide ranges. From a forecast point of view, GCMs can be seen as an initial value problem for generating many “stochastic” realizations of the state of the atmosphere, while StocSIPS is effectively a past value problem that estimates the most probable future state. This difference in approach assures the lack of direct correlation between the purely stochastic predictions of StocSIPS and the deterministic-stochastic predictions of GCMs. In this work we show how this can be used in the least square framework to obtain an optimal predictor, effectively a hybrid between GCMs and a Stochastic model. The resulting hybrid, “CanStoc”, is a merger of StocSIPS and the Canadian Seasonal to Interannual prediction System (CanSIPS[3]) GCM. CanSIPS is a long-term multi-model ensemble (MME) system using two climate models developed by the Canadian Centre for Climate Modelling and Analysis (CCCma).
The optimal linear combination of CanSIPS and StocSIPS was based on minimizing the square error of the final predictor in the common hindcast period 1981-2010. The stability of the coefficients used was verified using training periods with different lengths. Global time series and regional maps at 2.5ºx2.5º resolution show that the skill of CanStoc is better than that of each individual model for most of the regions when non-overlapping training and verification periods are used.

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[3] Merryfield WJ, Denis B, Fontecilla JS, Lee WS, Kharin S, Hodgson J, Archambault B (2011) Rep., 51pp, Environment Canada.