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To Improve Hydrological Prediction: The Value of Medium Range Forecasts

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1. Introduction

In this study, we investigated the contribution of medium range forecasts (MRF) to hydroclimate seasonal CFSv2 forecast skill over the United States. The control experiment is the CFSv2 seasonal forecasts. The testing experiment is the MRF_CFSv2 merged forecasts. In the merged forecasts, the first 14 days of each CFSv2 temperature (T) and precipitation (P) forecasts were replaced by a member of the MRF forecasts. The merged T and P forcings were used to drive the Variable Infiltration Capacity (VIC) land model to obtain soil moisture (SM) and runoff (RO) seasonal forecasts. The MRF-CFSv2 merged forecasts were compared with the CFSv2 forecasts. The improvement is limited to lead-1 month. The merged forecasts show improvement of T. The P forecasts have low skill and only have limited improvement. Overall, the skill of the merged SM and RO forecasts are higher but the differences are not statistically significant for most areas.

2. Motivation

Shukla *et al.* (2012) showed that there is potential improvement of soil moisture and runoff forecasts over the Ensemble Stream Prediction (ESP) at lead-1 month by replacing the first 14 days of the ESP forecast by the MRF forecast. In this study, we assessed the improvement of the CFSv2 seasonal forecasts by the MRF-CFSv2 merged forecasts. For seasonal hydroclimate forecasts, the initial conditions play an important role. The initial conditions are the same for the CFSv2 only and the MRF-CFSv2 merged forecasts. The difference in skill comes from the Median Range weather forecasts.

3. Data & methods

3.1 CFSv2 control experiment

The daily CFSv2 temperature (T) and Precipitation (P) forecasts (Saha *et al.* 2014) were downscaled to 0.5 degrees and were error-corrected by using the BCSD method (Mo *et al.* 2012). The error-corrected T and P forecasts were then used to drive the VIC land surface model to obtain SM and runoff (RO) forecasts. Surface winds data were obtained from climatological CDAS dataset. Total 11 members of CFSv2 forecast were selected to match the MRF ensemble forecast. The initial conditions were taken from a VIC retrospective simulation VIC(SIM) by driving the VIC model with observed T and P. The SM and RO from the VIC(SIM) were then used for verification.

3.2 MRF_CFSv2 merged experiment

MRF temperature and precipitation reforecasts (Hamill *et al.* 2013) were interpolated to the same grid as the CFSv2 control experiment. The ensemble mean of 11 members of T and P forecast were bias corrected by using the previous 45-day training period. The corrections were evenly distributed to each member. The first 14 days of each member of the CFSv2 forecasts were replaced by a member of the error-corrected MRF forecasts. The transition period during day 15-16 is weighted with 2/3 and 1/3 accordingly. After day 16, only CFSv2 forecasts were used.

For each member, the MRF_CFSv2 merged T and P forecasts were used to drive a VIC simulation to obtain SM and Runoff forecasts. The surface winds are the same as the CFSv2 only experiment. We then took equally weighted ensemble average of all members.

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4. Verification

Total 26 year (1985-2010) forecasts at four representative initial dates (Jan 01, Apr 01, Jul 01 and Oct 01) were evaluated. The temperature and precipitation forecasts were verified against the objective analysis based on the gauge observations from the CPC unified dataset. The SM and RO forecasts were verified against the SM and RO from the retrospective simulation VIC(SIM). The runoff at grid points is further aggregated to the USGS 48 hydrological sections. Forecast skill is indicated by the Pearson correlation. The Fisher's Z test was used to assess the statistical significance of the forecast skill improvement.

5. Results

The impact of merging MRF_CFSv2 ensemble forecasts is limited to the forecasts at lead-1 month. The MRF_CFSv2 merged forecasts improve lead-1 month temperature CFSv2 forecasts overall with the largest impact over the western region. The forecast skill for P forecasts is very low for the lead-1 month. There is very little statistically significant improvement in P due to the MRF-CFSv2 merge.

As a result, the merged MRF_CFSv2 forecasts improve the SM and accumulated runoff forecasts, but the differences in skill are overall not statistically significant (Fig.1). There is some statistically improvement for lead-1 month runoff forecasts (Fig.2) due to the slightly improved soil moisture. The enhancements in skill are regional and seasonal dependent. For hydroclimate forecasts at lead-1 month, skill is largely contributed

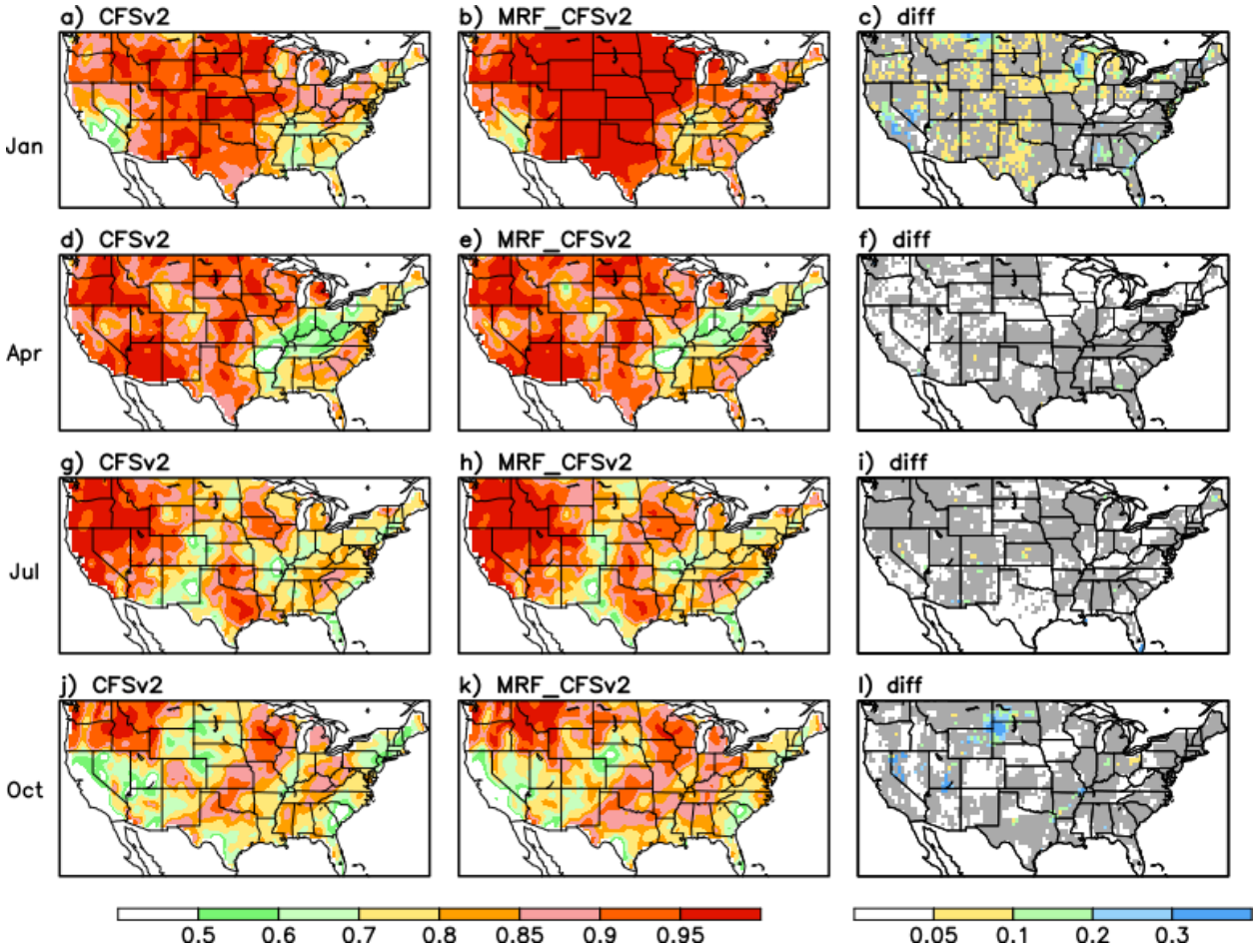

Fig. 1 Forecast skill for January (a) CFSV2 forecasts, (b) MRF_CFSv2 merged forecasts for lead-1 month as measured by the Pearson correlation. Areas where values are significance at the 5% level are sheded. (c) difference between (a) and (b). Grey shading indicated improvement. Areas where difference is statistically significant at the 5% confidence level are colored. (d) - (f), (g) - (i) and (j) - (l) are the same as (a) – (c), but for April, July and October, respectively.

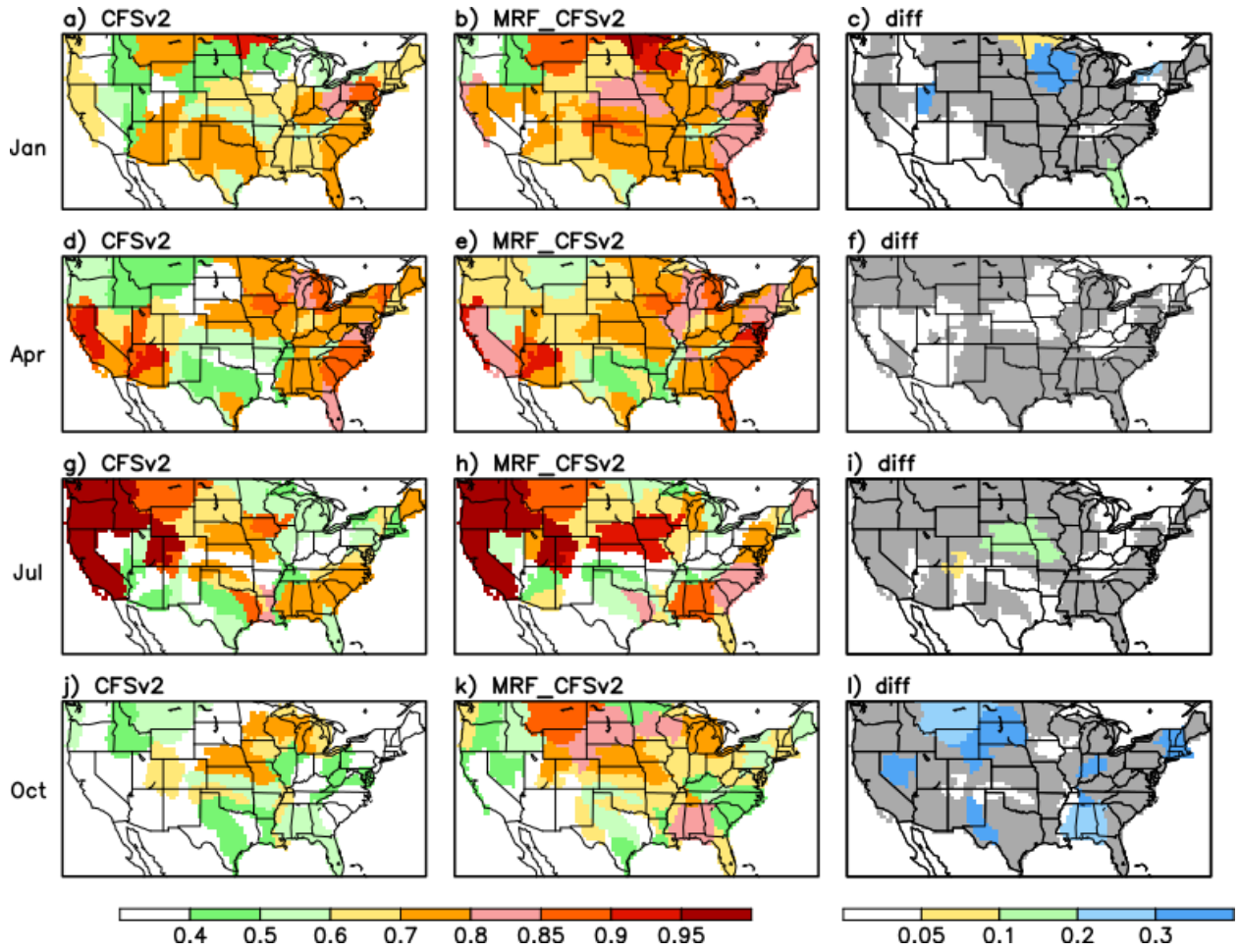

Fig. 2 Same as Fig. 1, but for the forecast skill of accumulated runoff at 48 hydrological sub-sections.

by the initial conditions. At longer leads, climate forcing becomes important, but the skill is too low to make any realistic difference.

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