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What is the Potential Predictability of Seasonal Floods and Droughts?

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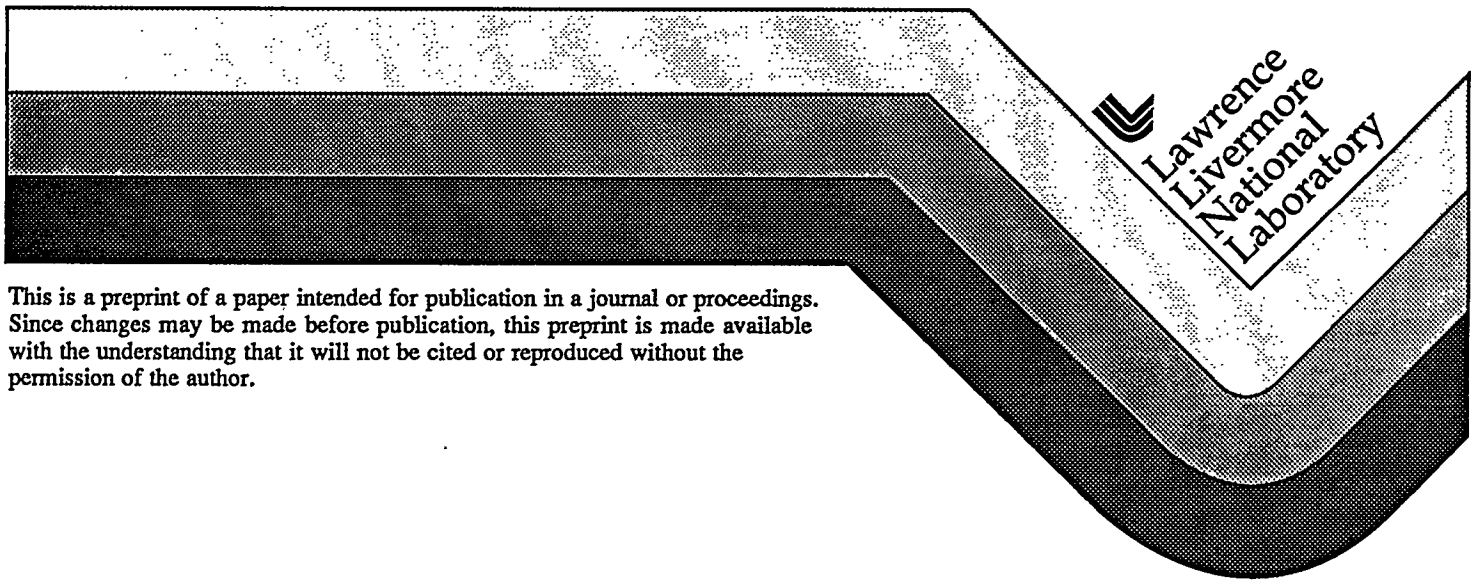

WHAT IS THE POTENTIAL PREDICTABILITY OF SEASONAL FLOODS AND DROUGHTS?

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The potential predictability (**PP**) of seasonal *anomalies* in continental hydrology (of which floods and droughts are but extreme examples) may be thought of as the upper bound in forecast accuracy to be expected when the state of the oceans is known "perfectly". We assume that the **PP** of the seasonal anomalies of continental hydrology is related to their degree of reproducibility (absence of initial-condition sensitivity) in the presence of identical ocean boundary conditions across a number of simulations. In this study, the **PP** of seasonal anomalies in surface hydrological variables is estimated from an ensemble of 6 decadal integrations of the ECMWF global atmospheric model coupled to a land-surface scheme which includes interception and transpiration by a simple vegetation canopy. Identical observed (AMIP) monthly sea surface temperatures (SST) are specified in each simulation, while the initial conditions of atmosphere and land surface are allowed to vary.

One approach to measuring the reproducibility of a simulation is to compute for each grid point (x, y) zero-lag temporal correlations of the time series of seasonal anomalies of like variables (e.g., 2 realizations of seasonal precipitation anomalies) drawn pairwise from the ensemble of n = 6 realizations. For each variable, a map of ensemble-mean temporal correlations **r**(x,y) then can be deduced by averaging the correlation maps obtained from all possible *independent* pairings--a total of N = n!/[(n-2)!2!] , or 15 maps, when n = 6.

Such an ensemble-mean map **r**(x,y) is shown for ECMWF model precipitation anomalies in Figure 1. Note that the correlations in the deep Tropics are generally larger than those in higher latitudes, where a number of negative correlations (anticorrelations) are obtained. However, even over northeast Brazil where the correlations are largest (**r** ~ 0.7), one simulation of precipitation anomalies explains, on average, only about 50% (i.e., $\mathbf{r}^2$) of the temporal variance of another simulation.

The measure **r**(x,y) accounts only for the overall *temporal* reproducibililty of the seasonal anomalies of different realizations. To obtain a measure of the *spatial* reproducibility of these anomalies, we consider the time series of global *pattern* correlations for each independent pairing of the 6 realizations. In Figure 2, the ensemble-mean time series s(t) of the pattern correlations (solid line) and the average intraensemble scatter about this mean (dashed line) are shown for seasonal precipitation anomalies. It can be seen that the global *spatial* reproducibility of the precipitation anomalies increases markedly following the development of ENSO events (e.g., in boreal spring of 1983 and 1987). More predictable global precipitation anomaly patterns apparently are associated with ENSO sea surface temperature anomalies. (Note, however, that even in ENSO years only about 40% of the global spatial variance of precipitation in one simulation is explained by another.) Qualitatively similar behavior is observed in other ECMWF surface hydrological variables such as soil moisture and surface evaporation (not shown).

We also have calculated more conventional measures of **PP**, such as the fraction of the total temporal variance of the anomalies of continental hydrology in each season that is explained by the common ocean boundary forcing conditions of 6 realizations. Maps of **PP** so computed (not shown) suggest a somewhat more optimistic assessment of the predictability of seasonal continental hydrology in the extratropics--at least in certain seasons. The more optimistic estimate of **PP** probably results from use of the ensemble mean obtained by averaging over all 6 realizations, instead of computing the average correlation of two realizations, as in Figure 1. (That is, any single realization is likely to resemble the ensemble-mean state more than it does another realization.). Accurate estimation of the ensemble mean (the most likely state of the climate system) is therefore important for successful forecasting of seasonal anomalies, especially outside the Tropics.

We conclude that skillful prediction of seasonal floods and droughts is more feasible in the Tropics, but is possible to some degree in the extratropics as well. To successfully predict extratropical anomalies, the forecaster must generate sufficient realizations to yield a good estimate of the ensemble mean. (There is evidence that as many as 10 realizations may be required.) The likelihood of a successful extratropical seasonal forecast also depends greatly on whether there are antecedent ENSO events, and to some extent on the forecast season as well.

Figure 1

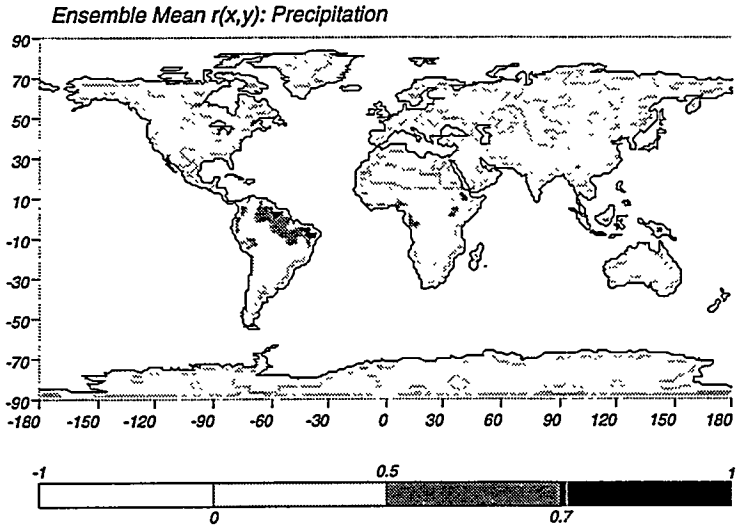
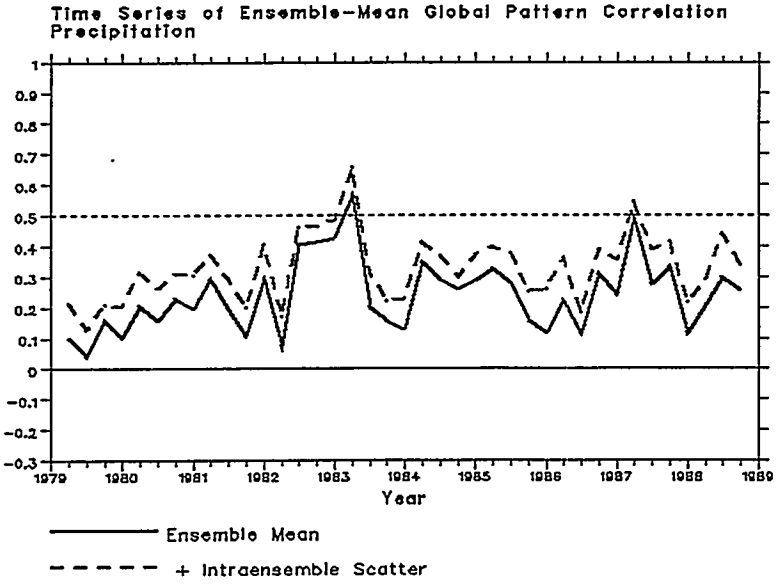


Figure 2



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