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Probability of afternoon precipitation in eastern United States and Mexico enhanced by high evaporation

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Dataset Description and Validation

The NARR dataset is a dynamically consistent 3-hourly gridded dataset spanning 25 years (1979-2003) at roughly 30 km grid spacing[1] which we use to probe the physical connections between surface fluxes and subsequent precipitation. This dataset is derived from a data assimilation scheme (DAS) with near-surface observations ingested hourly, and atmospheric profiles of temperature, winds, and moisture from rawinsondes and dropsondes ingested every three hours. The NARR data were provided on a Lambert Conformal grid (3-hourly, approximately 32 km) in GRIB format. The data were interpolated using a bilinear interpolation scheme onto a 1/3° x 1/3° latitude-longitude grid in NetCDF format prior to all analyses performed here.

Assimilated precipitation data were provided by separate sources for the three nations falling within the NARR domain. Daily precipitation totals in the Continental United States (CONUS) were provided by National Climatic Data Center (NCDC) daily cooperative stations (16,139 total; 8,000 typically reported each day) and Climate Prediction Center River Forecast Center stations (15,622 total; 7,000 typically reported each day) [2]. Hourly totals were provided by NCDC's Hourly Precipitation Data stations (5,933 total; 2,500 typically reported each day)[2]. Prior to assimilation, daily precipitation totals were disaggregated into hourly values using temporal weights derived from a 2.5° gridded analysis of hourly rain gauge data over the CONUS and using hourly data from global reanalysis products where no hourly observations were available[1]. No hourly precipitation data were ingested from Mexico, so the quality of these data are not as high as in the CONUS. Though daily precipitation station density was similar in Mexico to the United States, relatively few stations exist in Canada, thereby limiting the benefits of precipitation assimilation there[1]. Blending of the datasets along the borders was used to reduce discrepancies between the different data sources. Figures S1 and S2, however, shows that this had the effect of reducing the likelihood of afternoon rain, the mean evaporative fraction (*EF*), the variability of *EF*, and the mean afternoon rainfall amount along national borders.

The objectives of the Regional Reanalysis project which led to the creation of the NARR data were to create a long-term, consistent, high-resolution climate dataset for North America which improved upon earlier global reanalysis datasets in both resolution and accuracy[1]. Numerous publications point to the success of this project. Many document significant progress in the components of the NARR system: the Eta model[3,4], the DAS[5], and the Noah land surface model[6]. Others detail clear improvements over two global reanalysis products in simulating seasons of dry and wet extremes[1,7], in matching radiosonde-based datasets of tropospheric winds and temperatures[1], in capturing the water and energy budgets in the Mississippi River Basin[8], and in capturing atmospheric moisture transport over the US and Mexico[9]. Surface water budgets in nine hydrologic basins in the CONUS and Mexico show relatively small residuals (about 0.2 mm/day) for most basins and slightly larger residuals for basins with complex terrain[10]. The NARR DAS does not directly assimilate precipitation; instead, hourly precipitation values are used to adjust the model's vertical profile of latent heating, water vapor and cloud water during the hourly assimilation intervals. A careful comparison of the precipitation, moisture flux convergence, and precipitable water characteristics of the NARR data to gridded observations showed very good correspondence between the two, albeit with a slight systematic bias toward more-frequent, light precipitation events, particularly in Florida[11].

Sensitivity to ENSO phase

For the sensitivity analysis to the phase of the El Niño/Southern Oscillation (ENSO), we first calculated the climatological cycle of average SSTs in the Niño 3.4 region, subtracted this from the corresponding time series, and then took a 5-month running mean. Using a definition of the El Niño/La Niña phase requiring 6 or more consecutive months to have a temperature anomaly in the Niño 3.4 region above 0.4 or below -0.4[12], a summer was included in either extreme if at least one month during JJA met this definition. While the latter reflects a rather non-restrictive definition of the phases, we wanted to ensure an adequate number of samples within each phase. Thus, 10 years (1982, 1983, 1986, 1987, 1991, 1992, 1993, 1994, 1997, and 2002) comprise the El Niño summers, while seven years (1984, 1985, 1988, 1989, 1998, 1999, and 2000) comprise the La Niña summers.

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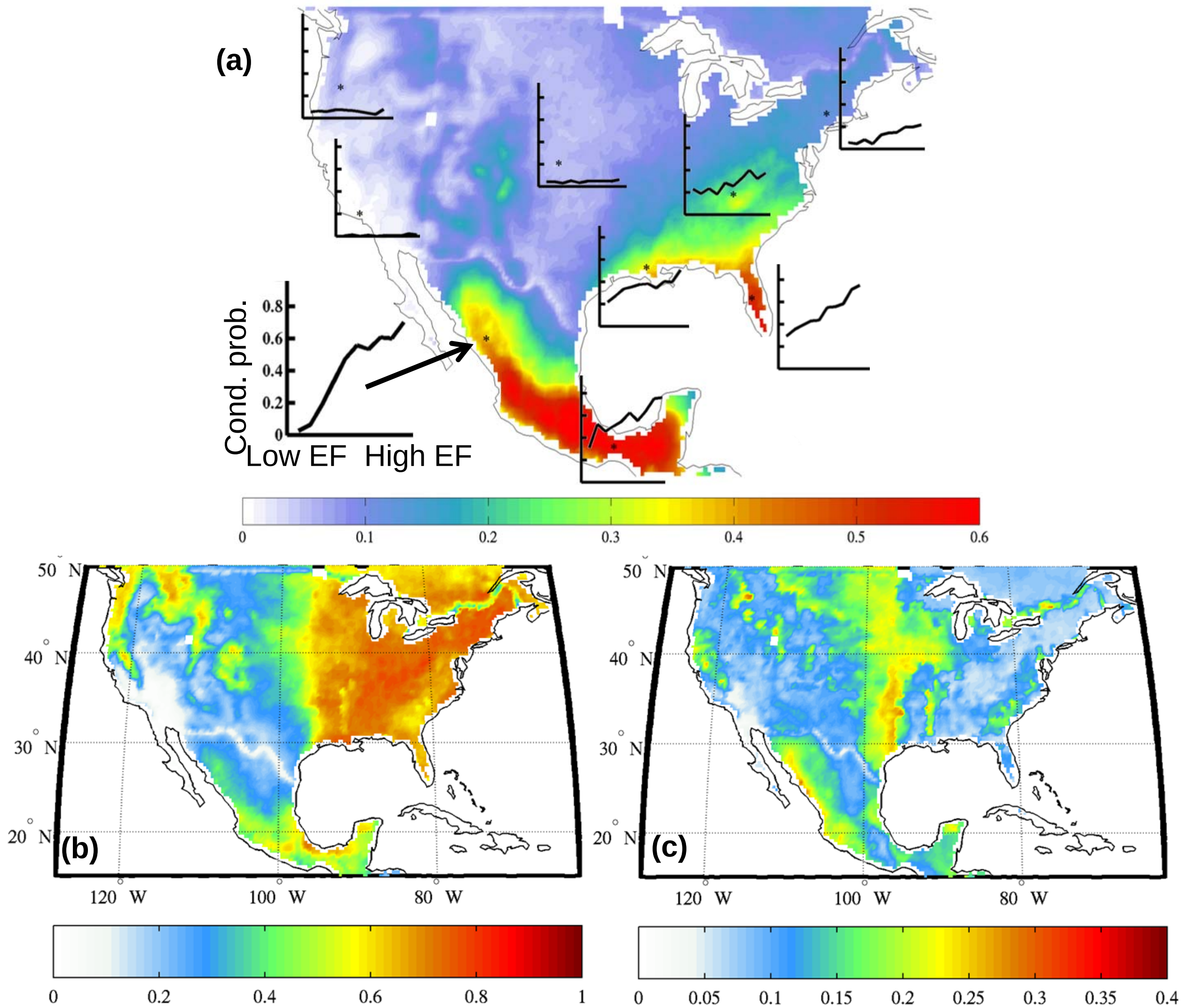

Figure S1: Mean afternoon rainfall probability and mean and standard deviation of evaporative fraction. (a) Mean probability of afternoon (noon-6pm) rainfall (color shading). Line plots indicate conditional probability of afternoon rainfall for ten evaporative fraction (*EF*) bins. *EF* bins are determined for each grid point, ensuring an equal number of observations in each bin. Black asterisks indicate precise location of data described by adjacent line plots. The probabilities are determined from all days, including those days removed from the *TFS* calculations. Mean values of the 50 bootstrap samples of the (b) mean and (c) standard deviation of daily noontime *EF*. Reduction of all three values along national borders results from the procedure used to blend datasets from different nations.

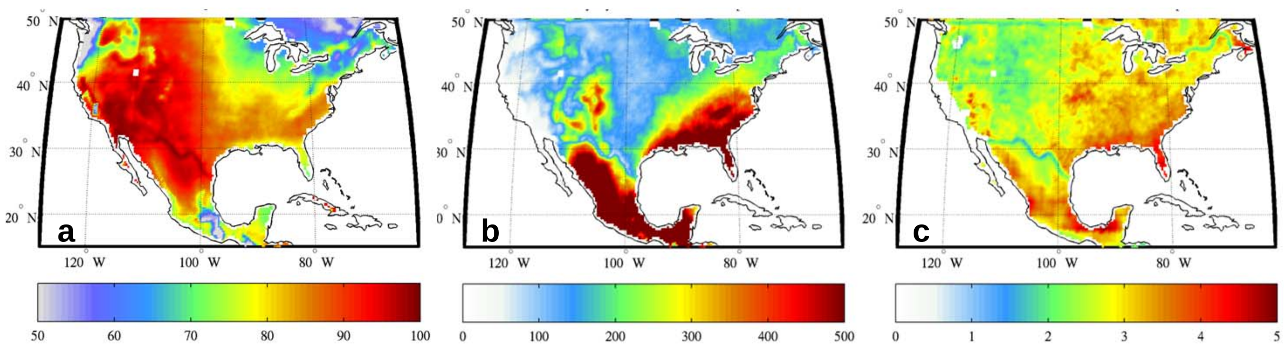

Figure S2: Characteristics of days included in *TFS* and *AFS* calculations. (a) Percent of days included in *TFS* calculation, after days with before-noon rainfall and days with negative *CTP* values are removed. (b) Number of rainy days contributing to *AFS* calculation. (c) Mean afternoon (noon-6 pm) rainfall amount (mm) when afternoon rainfall > 1 mm occurs.

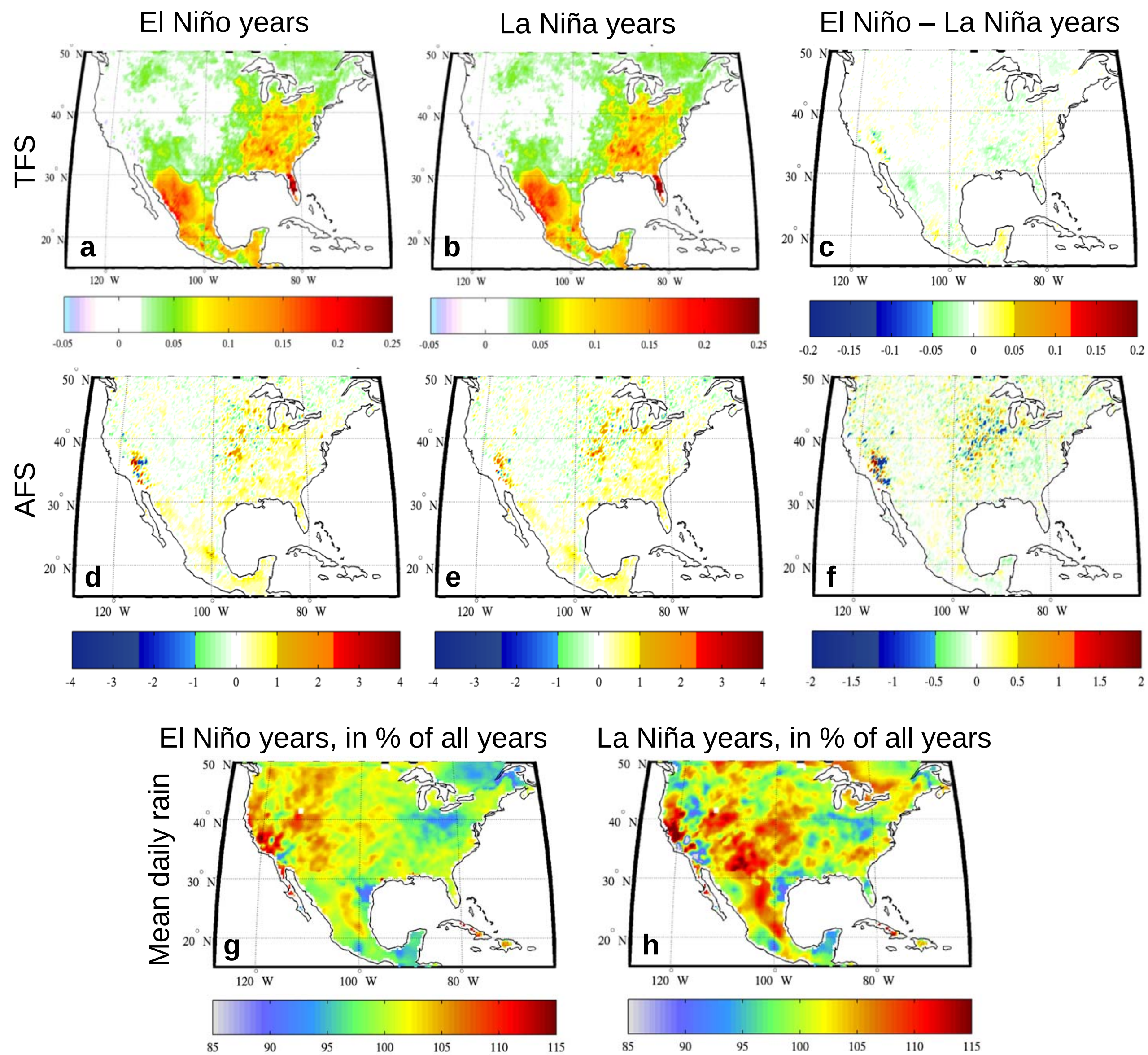

Figure S3: Sensitivity of *TFS* and *AFS* to ENSO forcing. *TFS* (a)-(c) (units of probability of afternoon [noon-6pm] rain) and *AFS* (d)-(f) (units of mm of afternoon rain) values for the El Niño years (left column), La Niña years (middle column), and El Niño – La Niña differences (right column). Shading details for (a)-(f) as in Figure 1. Ratio of mean daily rain in El Niño (g) and La Niña (h) years to mean daily rain in all years.