Origins of the Summer 2002 Continental U.S. Drought

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The climatic conditions in the continental United States during spring and summer 2002 were dominated by severe drought across much of the country. In order to determine the origins of the drought, a number of general circulation model experiments were conducted. Ensembles of 4-month model integrations with the COLA atmospheric general circulation model (AGCM) were made, initialized at the end of each of the months from February through May 2002, using observed weekly sea surface temperature (SST, Reynolds and Smith, 1994) as a lower boundary condition. In each ensemble, both climatological and 2002 soil wetness data sets were used to initialize the model soil moisture fields. The results from the first set of ensembles initialized in late February 2002 are presented here.

The COLA AGCM used (version V2.2) includes NCAR CCM3 dynamics with triangular truncation at 63 wave numbers (T63), 18 sigma layers, Relaxed Arakawa-Schubert convection (RAS), and the Simplified Simple Biosphere Model. Two ensembles of 10 seasonal integrations were done from initial atmospheric states from 25 February to 1 March 2002. The monthly mean SST anomalies used in both ensembles are shown in Fig. 1. The equatorial Pacific SST transitioned from weak cold conditions during March, 2002 to warm conditions during June, 2002 (Fig. 1).

The first ensemble (SST) was initialized with climatological soil wetness The second ensemble (SST & SW) is identical except it was initialized with soil wetness that has 1 March 2002 soil wetness anomalies derived from the data set of Huang et. al (1996, HDK) imposed on the climatological soil wetness used in the first set of integrations. The HDK soil wetness anomalies were first adjusted for the differences in the monthly soil wetness variability between the HDK data set and the SiB soil wetness used in the COLA AGCM. The soil wetness anomalies used to initialize the SST&SW ensemble (Fig. 2b) are similar to those in the original HDK data set (Fig. 2a), although the magnitude of the negative anomalies across the eastern U.S. are larger than in HDK. After initialization, the soil wetness is predicted by SSiB in both sets of integrations.

The two ensembles are compared to an 18-year (1982-1999) 180-member MAMJ climatology of model integrations which used observed weekly SST (Reynolds and Smith, 1994) and the same climatological initial soil wetness as used in ensemble SST. The anomalously dry soil conditions across much of the U.S. on 1 March 2002 in the initial conditions (Fig. 2b) largely persist throughout the course of the MAMJ integrations (not shown

Large positive (negative) surface air temperature anomalies cover much of the southern two thirds of the US (northern US and southern Canada) in the MAMJ 2002 mean, as seen in the observed anomaly from the CAMS data set (Ropelewski et al., 1985, Fig. 3a). The MAMJ mean surface air temperature anomalies formed by subtracting the model climatology from the SST and SST&SW ensembles are shown in Figs. 3b and 3c, respectively. In Figs. 3b,3c (and 4b,4c) only anomalies significant at the 95% level are shown. The SST ensemble appears to get some of the warm anomaly in the western US, but completely misses the warm anomaly across the southern tier and the cold anomaly to the north. The SST&SW ensemble has a warm anomaly across the southern tier and a weak cold anomaly across southern Canada, and overall looks much more like that observed.

Large negative precipitation anomalies cover much of the central and southern US in the MAMJ 2002 mean, as seen in the observed precipitation anomaly from the CAMS_OPI data set (Janowiak and Xie, 1999, Fig. 4a). The MAMJ mean precipitation anomalies formed by subtracting the model climatology from the SST and SST&SW ensembles are shown in Figs. 4b and 4c, respectively. Both the SST and SST&SW ensembles have negative precipitation anomalies, but those in the SST&SW ensemble are larger in magnitude and extent and bear a closer resemblance to those observed (Fig 4a).

Thus, the results suggest that both the evolving SST and the antecedent soil wetness anomalies could help force the 2002 U.S. drought, though the impact of the antecedent soil wetness anomalies appears more significant.

REFERENCES

Huang, J., H. van den Dool and K. P. Georgakakos, 1996: Analysis of model-calculated soil moisture over the United States (1931-93) and application to long-range temperature forecasts. *J. Climate,* **9,** 1350-1362.

Janowiak, J. E. and P. Xie, 1999: CAMS_OPI: A global satellite-rain gauge merged product for real-time precipitation. *J. Climate,* **12,** 3335-3342.

Reynolds, R. W. and T. M. Smith, 1994: Improved global sea surface temperature analyses using optimum interpolation. *J. Climate,* **7,** 929-948.

Ropelewski, C. F., J. E. Janowiak and M. F. Halpert, 1985: The analysis and display of real time surface climate data. *Mon. Wea. Rev.,* **113,** 1101-1107.

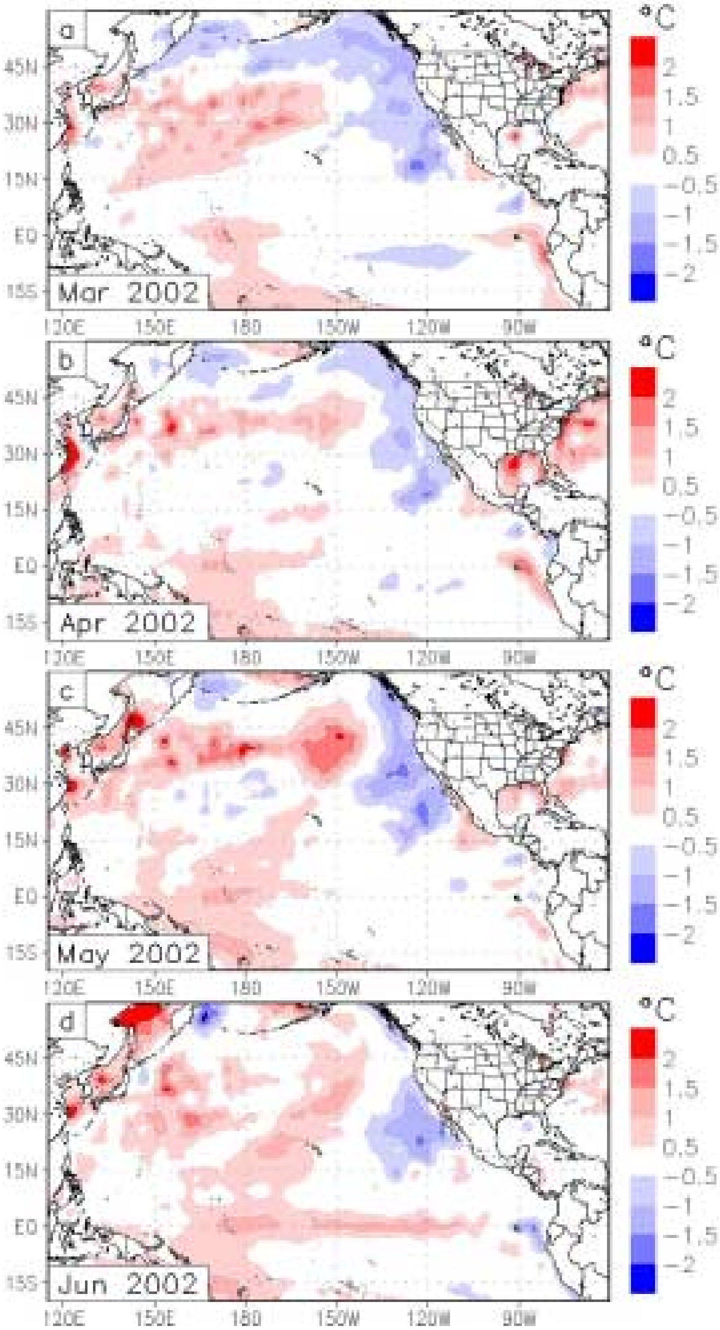

Fig. 1 Monthly mean SST anomalies from Reynolds and Smith (1994) relative to 1982-1999 climatology for a) March 2002, b) April 2002, c) May 2002 and d) June 2002.

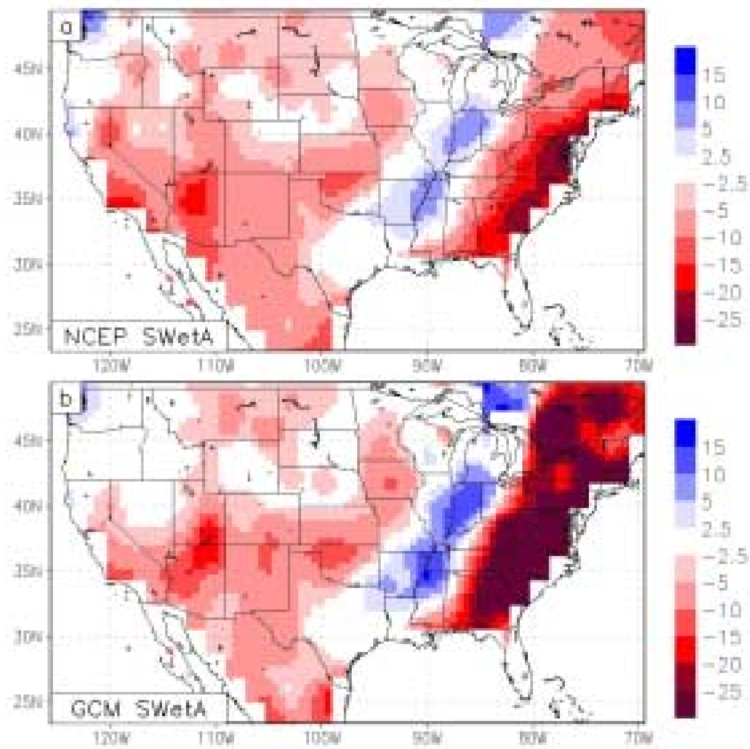

Fig. 2. March 1, 2002 soil wetness anomaly (percent of saturation) for a) Huang et al. (1996) and b) COLA GCM initial condition.

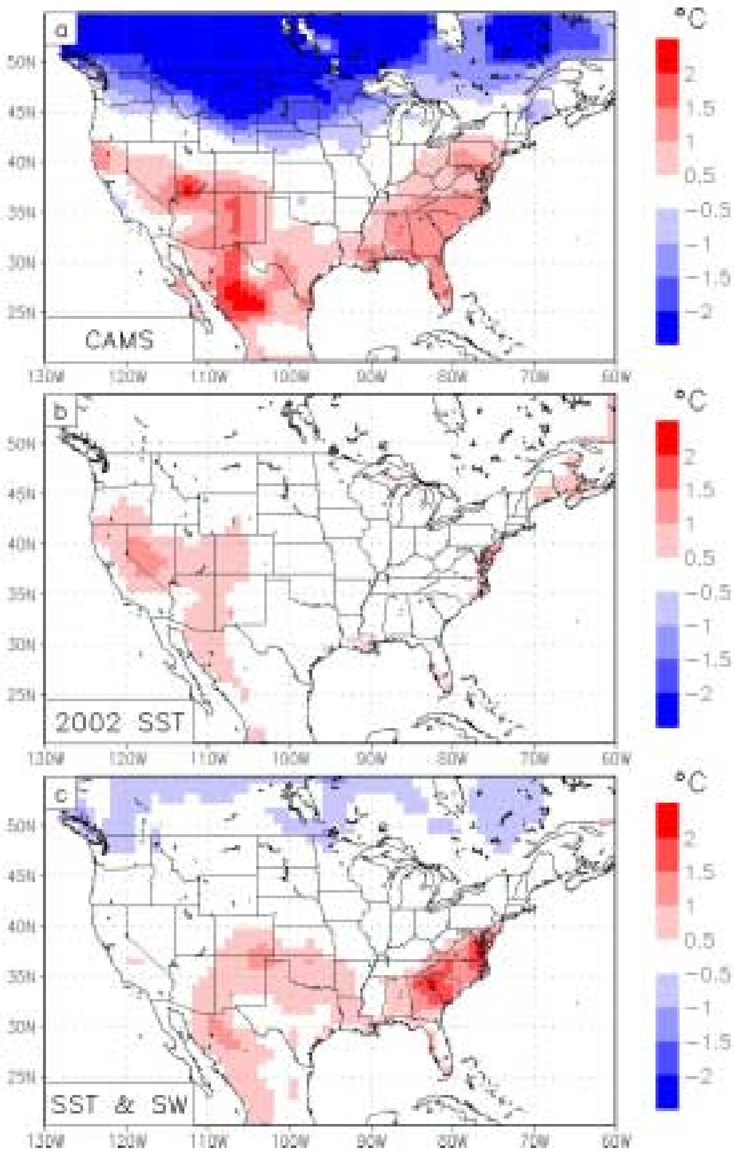

Fig. 3. Surface air temperature anomalies for March-April-May-June 2002 mean relative to 1982-1999 mean for a) CAMS observations, b) SST ensemble and c) SST&SW ensemble.

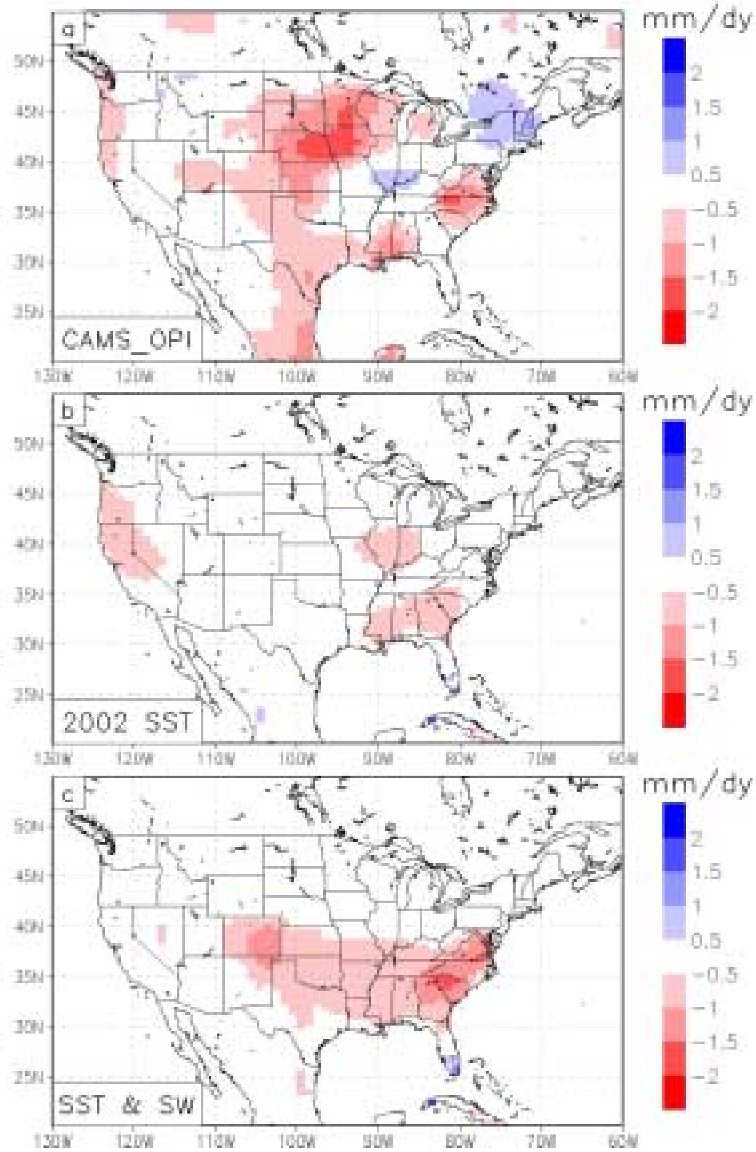

Fig. 4. Precipitation anomalies for March-April-May-June 2002 mean relative to 1982-1999 mean for a) CAMS_OPI observations, b) SST ensemble and c) SST&SW ensemble.