Impact of the Atlantic Warm Pool on the Summer Climate of the Western Hemisphere

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Abstract: The North Atlantic subtropical high (NASH), being the strongest during the summer, determines the strength of the tropical easterly trade winds at its southern flank. The easterly trade winds carry moisture from the tropical North Atlantic into the Caribbean Sea where the flow intensifies forming the Caribbean low-level jet (CLLJ). The CLLJ then splits into two branches: one turning northward and connecting with the Great Plains low-level jet (GPLLJ), and the other one continuing westward across Central America into the eastern North Pacific. This paper discovers that the easterly CLLJ is maximized in the summer and winter, whereas it is minimized in the fall and spring. The semi-annual feature of the CLLJ results from the semi-annual variation of sea level pressure in the Caribbean region owing to the westward extension and eastward retreat of the NASH.

The Atlantic warm pool (AWP) with a large area of warm water is comprised of the Gulf of Mexico, the Caribbean Sea, and the western tropical North Atlantic. The NCAR community atmospheric model and observational data are used to investigate the impact of the AWP on the summer climate of the Western Hemisphere. Two groups of the model ensemble runs with and without the AWP are performed and compared. The model results show that the AWP's effect is to weaken the summertime NASH, especially at its southwestern edge. The AWP also strengthens the summertime continental low over the North American monsoon region. In response to these pressure changes, the CLLJ's strength is weakened, but its semi-annual feature does not change. The weakening of the CLLJ decreases the westward moisture transport from the AWP and thus suppresses rainfall in the eastern North Pacific. The AWP's impact on the GPLLJ is to strengthen (weaken) its northward moisture transport for summer (fall) rainfall over the central United States.

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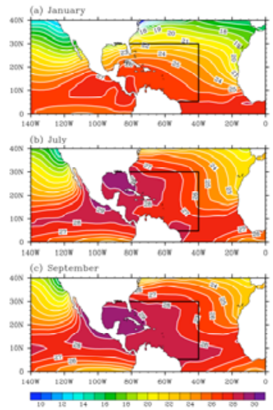

Figure 1. SST distributions near the Atlantic warm pool (AWP) region in (a) January, (b) July, and (c) September. The NCAR Community Atmospheric Model (CAM3) is used to investigate the impact of the AWP on the summer climate of the Western Hemisphere. Two sets of 20-member ensemble simulations are conducted. In the control (CTRL) run, the monthly climatological SST is prescribed globally. In the second set of run (NO_AWP), we hold SST in the AWP region (from 5°N to 30°N between 40°W and the coast of the Americas) to its January value while the twelve-monthly SST climatology is specified for the rest of global ocean.

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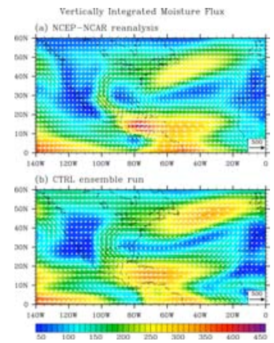

Figure 2. The summer (JJA) vertically integrated moisture flux (kg m^{-1} s^{-1}) calculated from (a) the NCEP-NCAR reanalysis and (b) the CTRL ensemble model run. Arrows indicate the moisture flux vector and colors represent the amplitude of the moisture flux. During the summer, the easterly trade winds carry moisture from the tropical North Atlantic into the Caribbean Sea where the flow intensifies forming the Caribbean low-level jet (CLLJ). The CLLJ then splits into two branches: one turning northward and connecting with the Great Plains low-level jet (GPLLJ), and the other one continuing westward across Central America into the eastern North Pacific. These two branches of moisture transport act to bridge a linkage between the AWP and precipitation over the central United States and the eastern North Pacific.

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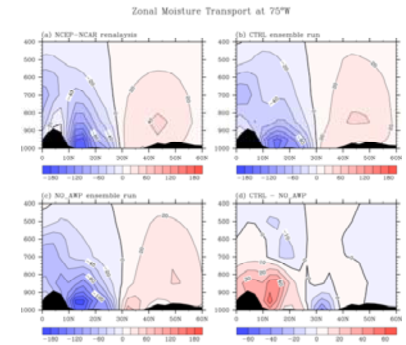

Figure 3. The meridional-vertical sections of the zonal moisture transport (g kg^{-1} m s^{-1}) at 75°W during the summer (JJA) from (a) the NCEP-NCAR reanalysis, (b) the CTRL ensemble model run, (c) the NO_AWP ensemble model run, and (d) the difference between the CTRL and NO_AWP ensemble model runs. The AWP is inversely related to the CLLJ; that is, the AWP's effect is to weaken the CLLJ.

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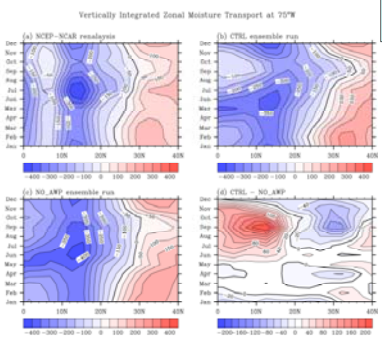

Figure 4. The time-latitude sections of the vertically integrated zonal moisture transport (kg m^{-1} s^{-1}) at 75°W from (a) the NCEP-NCAR reanalysis, (b) the CTRL ensemble model run, (c) the NO_AWP ensemble model run, and (d) the difference between the CTRL and NO_AWP ensemble model runs. The westward moisture transport of the Caribbean low-level jet (CLLJ) is maximized in the summer and winter, whereas it is minimized in the spring and fall. The semi-annual feature of the CLLJ follows the semi-annual cycle of sea level pressure in the region of the Caribbean that results from the east-west extension and development of the North Atlantic subtropical high (NASH).

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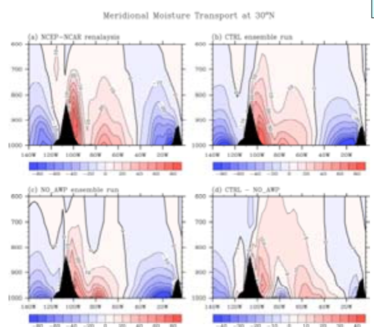

Figure 5. The zonal-vertical sections of the meridional moisture transport (g kg^{-1} m s^{-1}) at 30°N during the summer (JJA) from (a) the NCEP-NCAR reanalysis, (b) the CTRL ensemble model run, (c) the NO_AWP ensemble model run, and (d) the difference between the CTRL and NO_AWP ensemble model runs. During the summer, the AWP strengthens the northward moisture transport of the Great Plains low-level jet (GPLLJ), whereas it weakens the moisture transport of the southeast jet.

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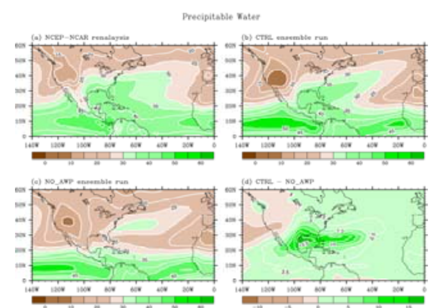

Figure 6. The summer (JJA) precipitable water content (kg m^{-2}) from (a) the NCEP-NCAR reanalysis, (b) the CTRL ensemble model run, (c) the NO_AWP ensemble model run, and (d) the difference between the CTRL and NO_AWP ensemble model runs. The AWP contributes to a large amount of the precipitable water over the AWP and its surrounding regions.

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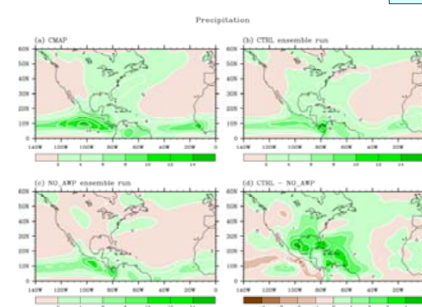

Figure 7. The summer (JJA) rainfall (mm day^{-1}) distribution from (a) the CMAP product, (b) the CTRL ensemble model run, (c) the NO_AWP ensemble model run, and (d) the difference between the CTRL and NO_AWP ensemble model runs. The impacts of the AWP on summertime rainfall are to increase rainfall over the AWP region, the United States Gulf Coast region, and the central United States and to decrease rainfall west of Central America.