A warming tropical central Pacific dries the lower stratosphere

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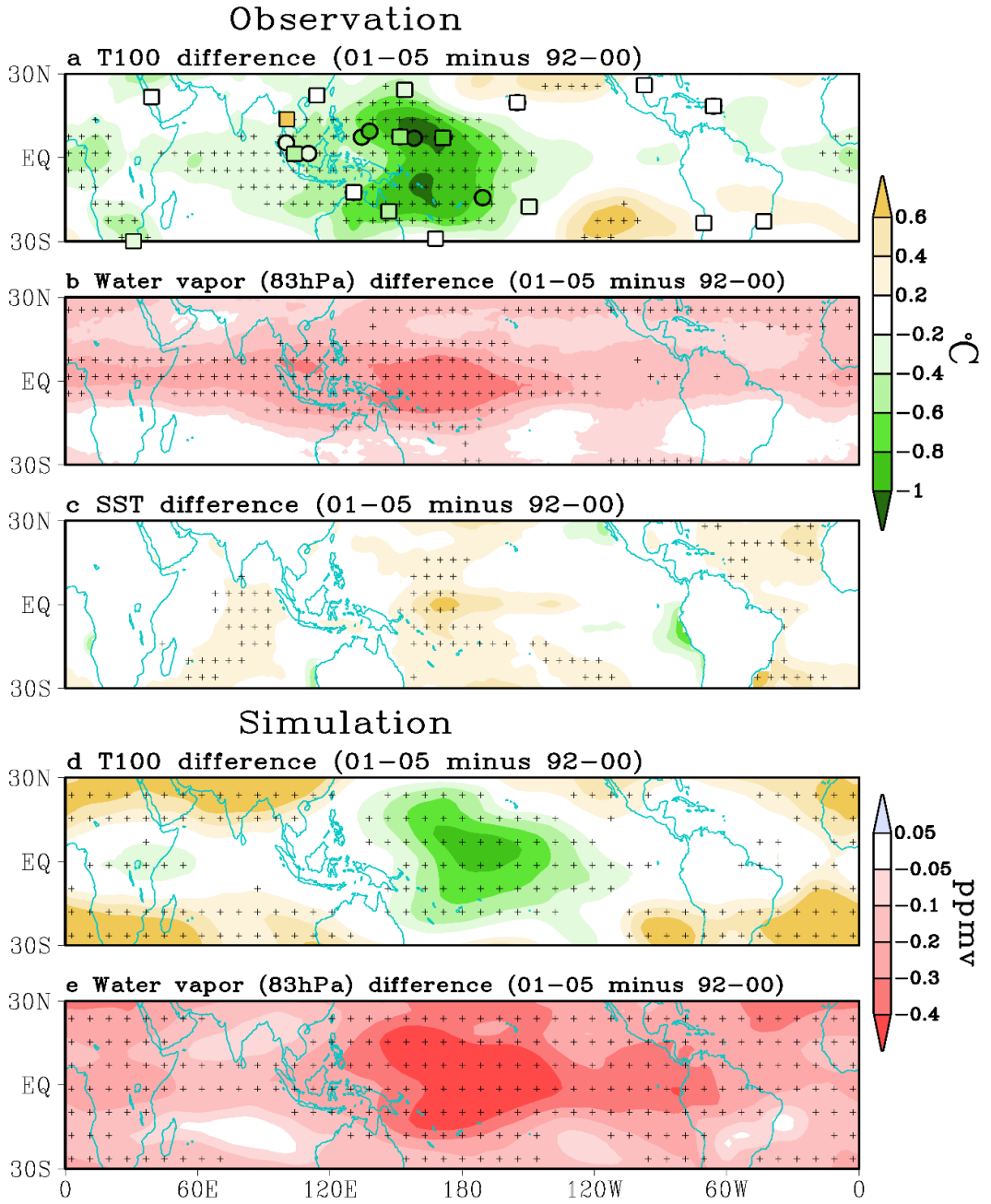
Background: The amount of water vapor in the tropical lower stratosphere (TLS), which has an important influence on the radiative energy budget of the climate system, is modulated by the temperature variability of the tropical tropopause layer (TTL). The TTL temperature variability is caused by a complex combination of the stratospheric quasi-biennial oscillation, tropospheric convective processes in the tropics, and the Brewer–Dobson circulation (BDC).

Objective and methods: In 2000, the TLS water vapor amount exhibited a stepwise transition to a dry phase, apparently caused by a change in the BDC. In this study, we examine the interdecadal-like transition from the pre-2000 period to the period after 2000 with a special focus on the role of tropical SST variability using a combination of the observational analysis and numerical model experiments.

Results and conclusion : We present observational and modeling evidence (see the figure on the right) that the epochal change of the TTL temperature and water vapor between the periods of 1992-2000 and 2001-2005 (a&b) is partly caused by a concurrent sea surface temperature (SST) warming in the tropical central Pacific (c). This SST warming cools the TTL above by enhancing the equatorial wave-induced upward motion near the tropopause, which consequently reduces the amount of water vapor entering the stratosphere. This study suggests that the tropical central Pacific SST is another driver of TLS water vapor variability on inter-decadal timescales. Our model simulation (d &e) suggests that the tropical SST changes from 1992-2000 to 2001-2005, which exhibit a significant warming in the Central Pacific (c), could contribute to about 30% of the step-wise drop of the lower stratospheric water vapor between the two periods. Thus, Future changes of different types of SST modes in the tropics represent a significant source of uncertainty for projections of the global radiation balance, and have important implications for global climate variability.

Figure caption. Observed and simulated 100 hPa temperature and 83 hPa water vapor variability associated with the 2000 "drying" event. Epochal differences (2001–2005 minus 1992–2000) of tropical (a) temperature at 100 hPa, (b) water vapor mixing ratio at 83 hPa and (c) SST, all derived from observations. For comparison, the differences (2001–2005 minus 1992–2000) of tropical (d) temperature at 100 hPa, and (e) water vapor mixing ratio at 83 hPa are derived from ECHAM5 simulations forced by observed tropical (30ºS–30ºN) SST (1992–2005) during the two periods (climatological mean during 2001-2005 and 1992-2000). In the extratropics, a slab ocean/sea ice model is coupled to the model. The differences of two 40-yr means is plotted. The squares and circles in a indicate the epochal difference of T100 (2001–2005 minus 1992–2000) derived from 17 RATPAC and 6 IGRA radiosonde stations, respectively. The small crosses in each plot indicate locations where the difference between the two periods is significant (above the 95% confidence level) by the two-sample T-test.



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