Isotopic Signal of Earlier Summer Monsoon Onset over the Bay of Bengal

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THE onset of the Asian summer monsoon is noticeably controversial. Stable oxygen isotope ($\delta^{18}O$) in precipitation has long been used to trace present water vapor source, particularly to catch up the summer monsoon precipitation signal. The abrupt depletion of $\delta^{18}O$ in precipitation in the Asian summer monsoon region is a clear signal that summer monsoon rainfall starts. Two stations were set up in the East Asian summer monsoon dominated Guangzhou and Lulang to clarify the dates of the Asian summer monsoon onset. Generally earlier appearance of the more depleted ^{18}O in Lulang precipitation confirms an earlier summer monsoon onset in the Bay of Bengal. The earlier appearance and late disappearance of more depleted $\delta^{18}O$ at Lulang implies a longer duration of the BOB summer monsoon influence on southeast Tibetan Plateau than the SCS summer monsoon influence on southeast coastal China. Isotopically identified summer monsoon evolutions from precipitation $\delta^{18}O$ at both stations are verifiable with NCEP/NCAR reanalysis data, indicating an alternative approach in studying the summer monsoon circulation from precipitation $\delta^{18}O$.

Research Background

China is influenced by the Asian monsoon, not only at present, but also during the past, with south and southeast China prevailed by the East Asian monsoon, while southeast Tibetan Plateau dominated by the influence of the Indian monsoon. Study of the GNIP data enables scientists to realize the close correlation between stable isotope variation with moisture sources and transportation processes. ^{18}O in precipitation is even proposed to have a positive relation with monsoon strength. There is thus a potentiality to study monsoon evolution from $\delta^{18}O$ in precipitation, which is simpler and also bears directly on the interpretation of such paleo-climate record as speleothem, tree rings and ice cores, etc.

Sampling and data processing

Since the beginning of 2007, precipitation with event-based amount larger than 0.1mm has been collected in 15-mL PET bottles and sealed tightly before cool storage. Meteorological data was kept simultaneously, including temperature, precipitation amount, relative humidity, air pressure and wind speed. Light rainfall sometimes failed to fill up the sampling bottles, therefore was particularly noted before measurement on a Finnigan MAT 253, with precision being $\pm 0.05‰$.

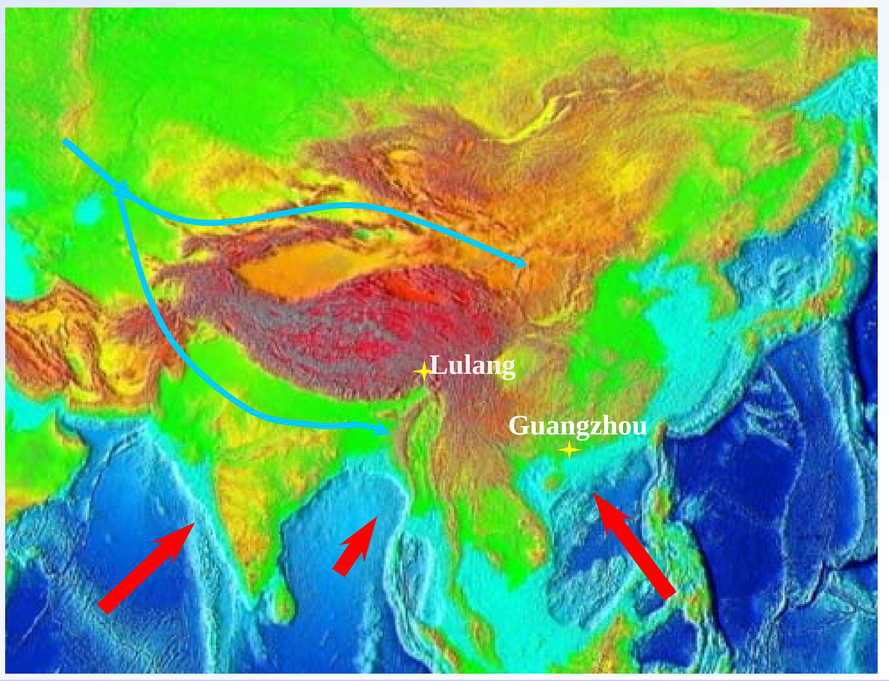

Figure 1 Location of Lulang Station in southeast Tibetan Plateau and Guangzhou Station off the coast of South China Sea.

In data processing, we remove those data with higher-than-1.5‰ and amount lower-than 0.3 mm, considering them to be subjected to evaporation during storage. Till January, 2009, out of the 359 samples collected at the Guangzhou Station, data of 11 samples was considered unreliable, thus removed to avoid any bias. Out of the 390 samples collected at the Lulang Station, no data is considered to be subjected to evaporation.

Conclusions and implications

◆Stable isotopic criteria have been set up to identify the evolution of East Asian summer monsoon, the results verifiable with synoptic observations, confirming the coincidence of precipitation $\delta^{18}O$ variation with monsoon onset, withdrawal and the active-break cycle.

◆Precipitation $\delta\ ^{18}O_{wt}$ indicates that the BOB monsoon onsets earlier, and withdraws later than the East Asian monsoon, with a longer duration.

These results will help in the verification of GCM model using water isotopes.

Results

- Event-based precipitation $\delta^{18}O$ values were processed daily, showing amount-weighted $\delta^{18}O$ (i.e. $\delta^{18}O_{wt}$). Precipitation $\delta^{18}O_{wt}$ at Lulang shows a wider variation range and generally lower values than Guangzhou.
- Precipitation $\delta^{18}O_{wt}$ values at both stations are enriched in winters and depleted in summers. During May-October, $\delta^{18}O_{wt}$ demonstrates four obvious depletions annually at both sites, with a 20-40-day interval, attributive to amount effect and therefore suggestive of the coincidence with the Madden-Julian Oscillation.
- Asian monsoon evolution can be studied by some isotopic criteria, thus precipitation $\delta^{18}O_{wt}$ presents a precise-to-date monsoon evolution processes that are identical with reconstructed wind pattern from NCEP reanalysis data.

Isotopic criteria for

The monsoon influence onset:

✓threshold=precipitation $\delta^{18}O$ simple mean from February to March in respective year, substantially lower-than-threshold daily precipitation $\delta^{18}O_{wt}$ value (by a margin ≥1.5‰);

✓abrupt decrease followed by at least three more days of lower-than-threshold $\delta^{18}O_{wt}$ values within a week's time.

& withdrawal

■the last extreme $\delta^{18}O_{wt}$ depletion at relatively high temperature

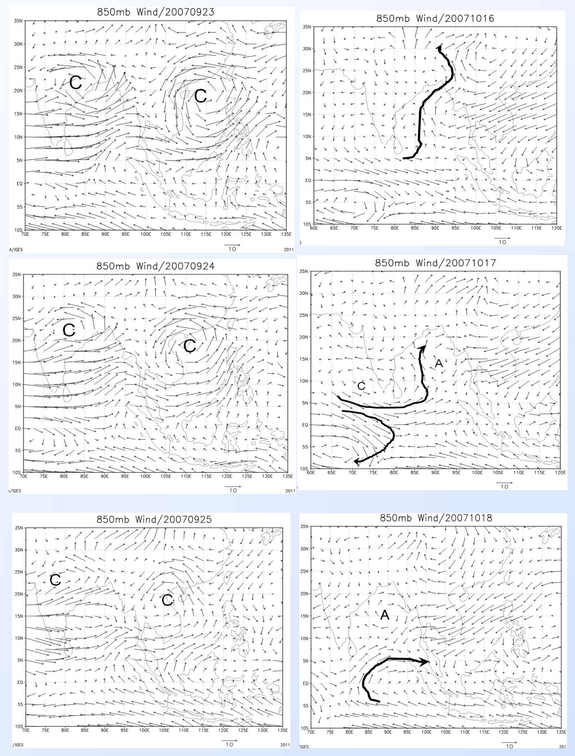

Figure 2 Variation of daily precipitation $\delta\ ^{18}O_{wt}$ and corresponding daily amount at a) Lulang and b) Guangzhou during 2007-2009. Summer monsoon durations in respective year are marked by arrow-with-bars. Wind patterns and corresponding Outgoing Long-wave Radiation are shown on the two sides, demonstrating simultaneous atmospheric circulations.

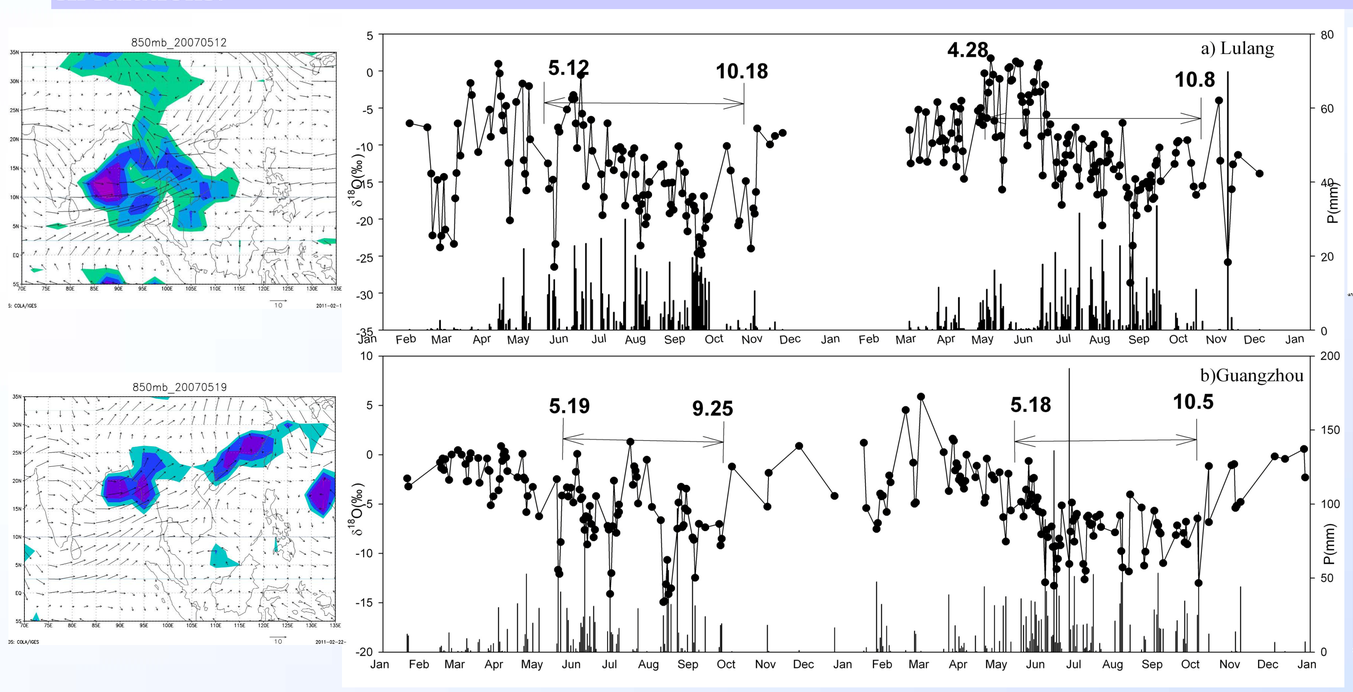

Figure 3 Low-level wind patterns around the BOB monsoon withdrawal on October 16-18, 2007, and around the SCS monsoon withdrawal during September 23-25, 2007, based on NCEP/NCAR reanalysis data. "A" stands for anticyclone and "C" for cyclone. Black arrowed-curve indicates the prevailing wind pattern.

Reference:

X.X. Yang, T. D. Yao, W. L. Yang, and B. Q. Xu, 2011. Isotopic signal of earlier summer monsoon onset in the Bay of Bengal, *J Climate* (in review).

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