



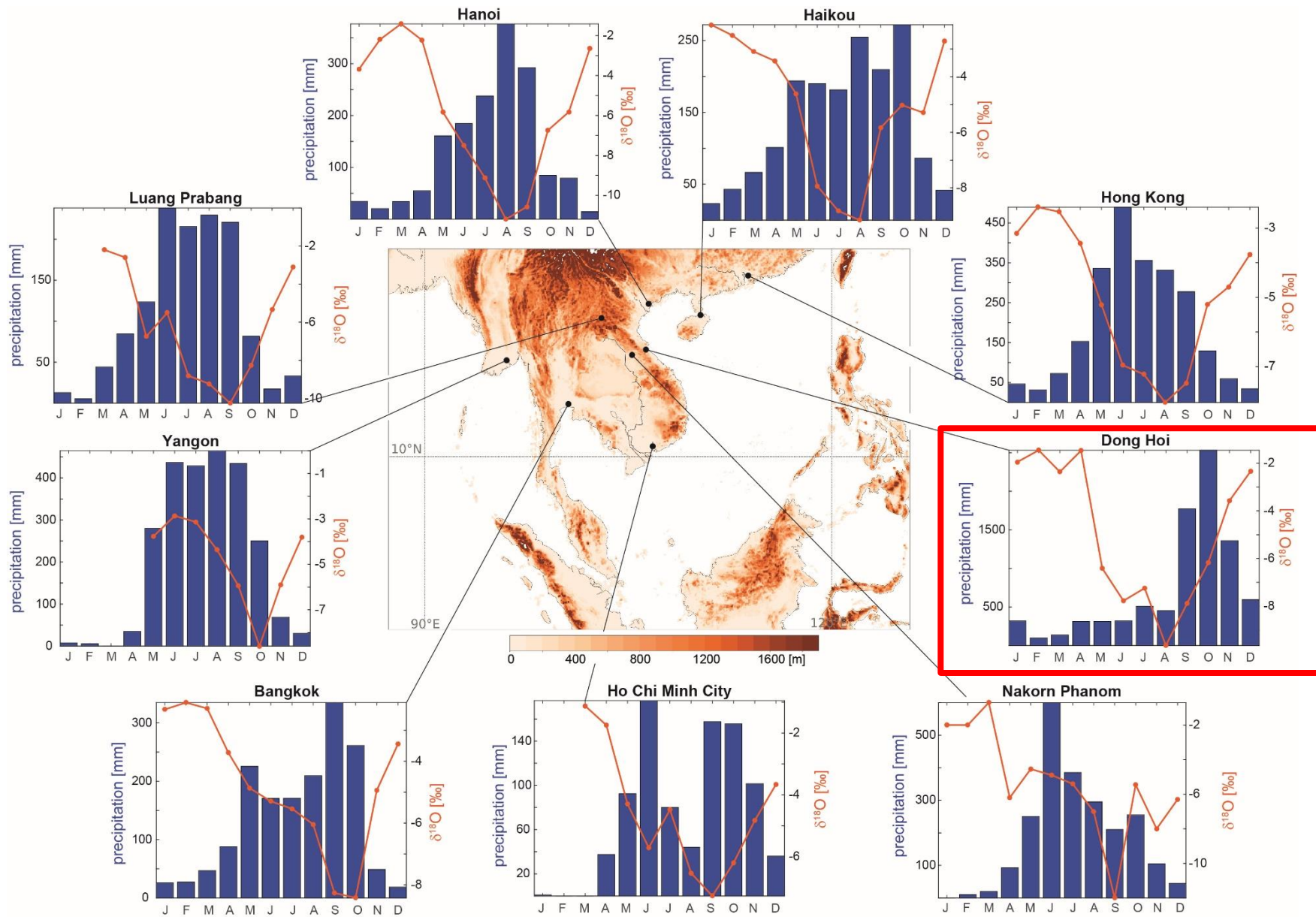
Rainwater isotopes in central Vietnam controlled by two oceanic moisture sources and rainout effects  
Annabel Wolf, William H. G. Roberts, Vasile Ersek, Kathleen R. Johnson, and Michael L. Griffith

# Motivation – why do we care about climate in Vietnam?

Monsoonal rainfalls and flooding related to tropical cyclones cause major damage to livelihood, infrastructure and the economy in Vietnam

Vietnam is located in the summer monsoonal realm but central Vietnam receives peak rainfall during autumn and winter. What does that mean for stable isotopes from this area?





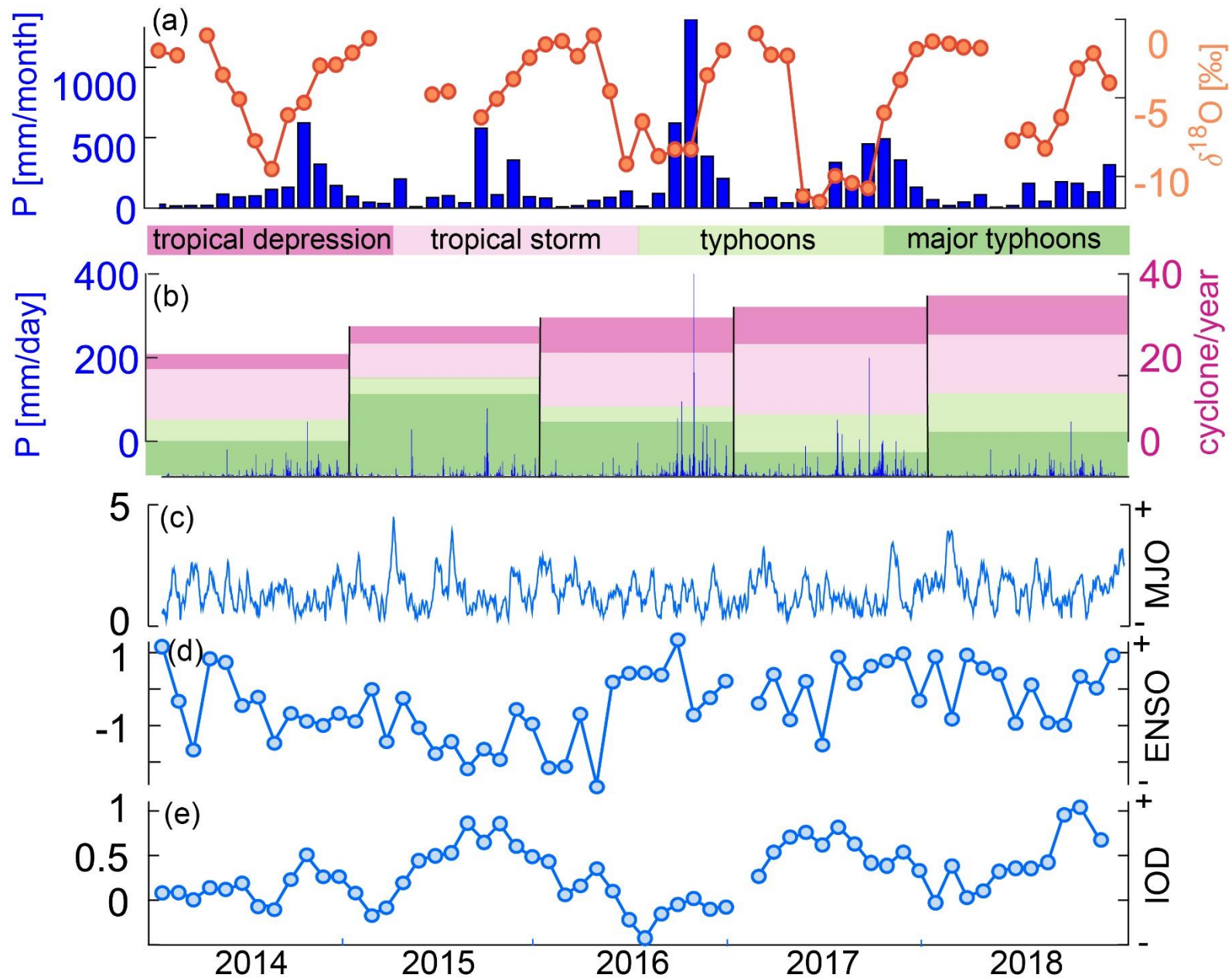
Data from the Global Network of Isotopes in Precipitation (GNIP) shows that central Vietnam (Dong Hoi station) is unique within Southeast Asia:

75% of total annual rainfall falls during autumn (September to November)

This is in contrast to typical summer monsoon rainfall

Despite this difference in peak rainfall,  $\delta^{18}\text{O}$  in central Vietnam follows the pattern typical for the summer monsoon region, with low  $\delta^{18}\text{O}$  during summer and high values during winter.

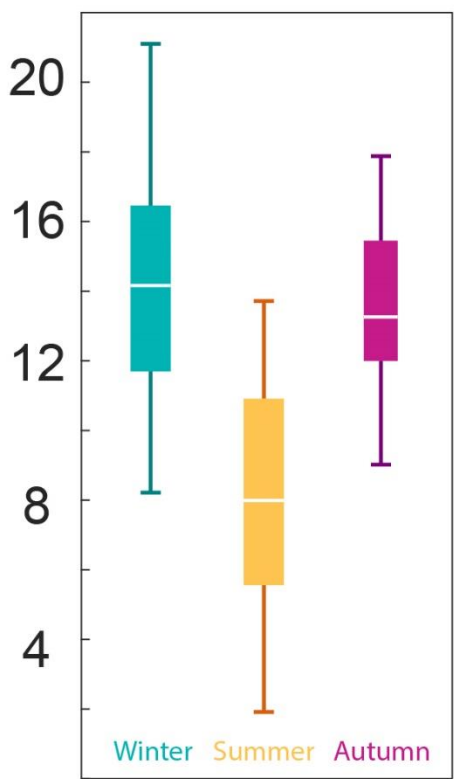
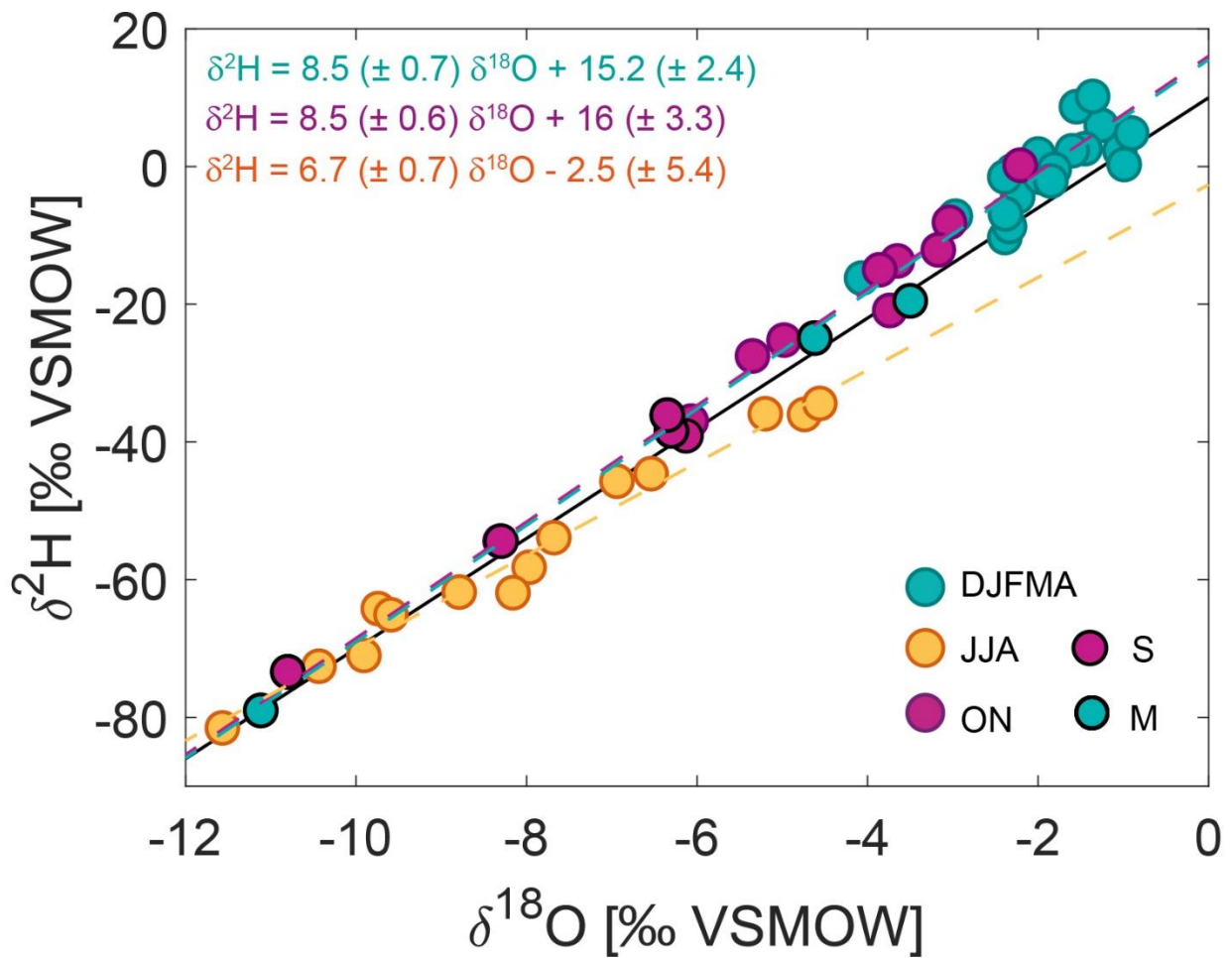
- why?



The GSNIP station at Dong Hoi recorded over five years

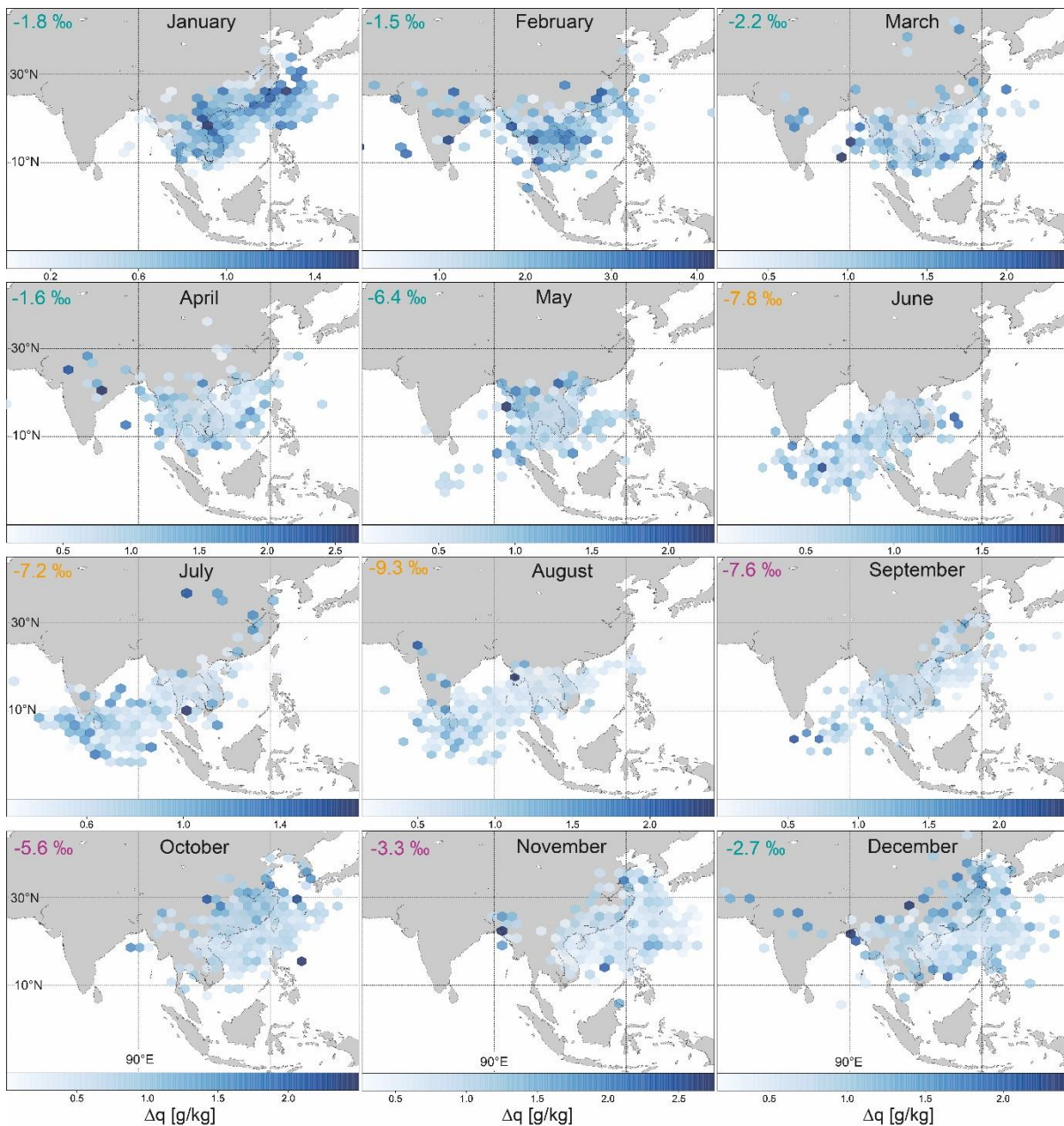
The seasonal cycle in  $\delta^{18}\text{O}$  is evident in all years recorded

- What is driving the seasonal cycle in  $\delta^{18}\text{O}$  in central Vietnam?



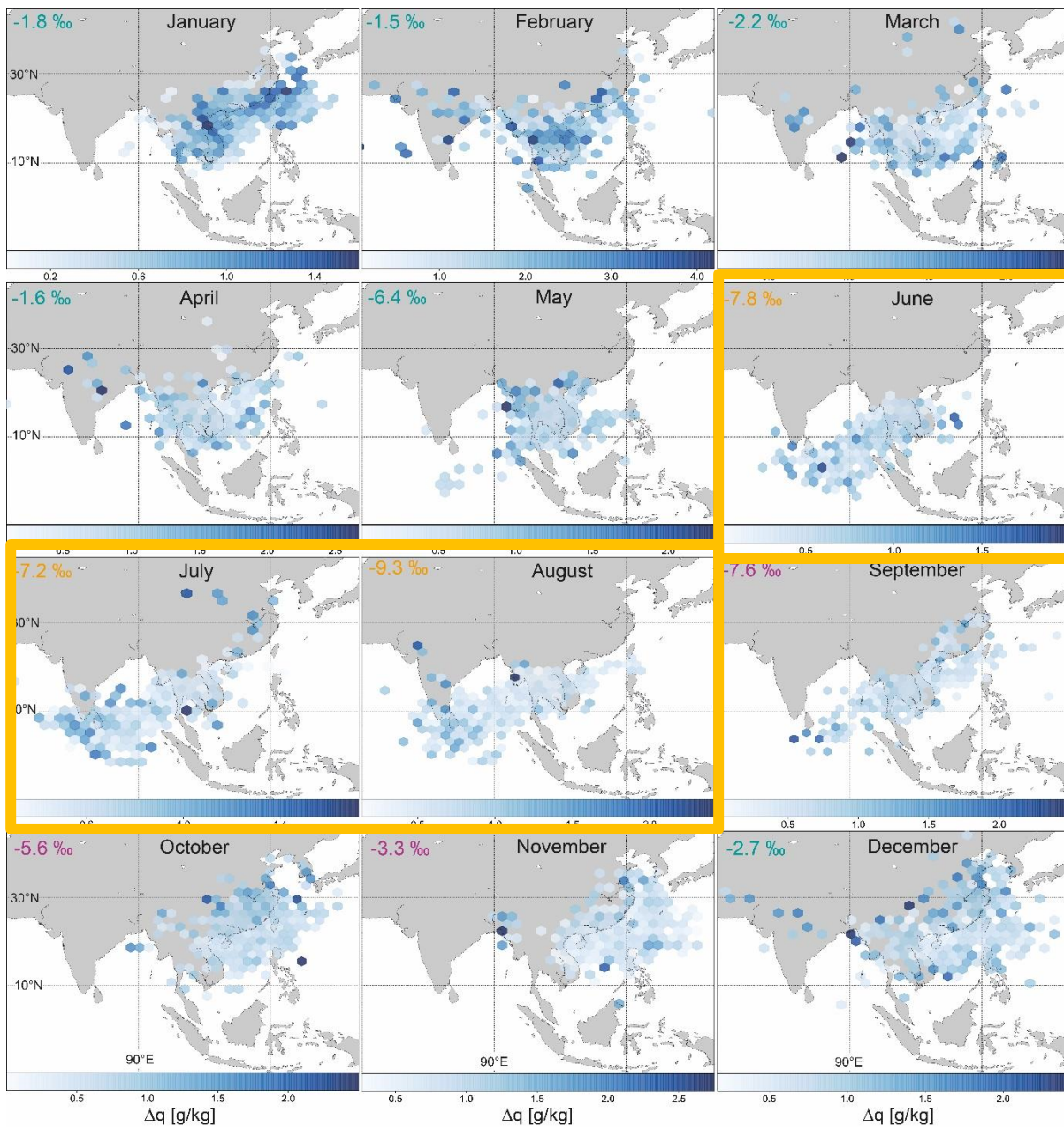
The deuterium excess recorded at Dong Hoi station shows that summer strongly differs from the rest of the year.

- Could this be related to the moisture source?



Moisture flux simulated using PySplit for each month from 2014 to 2018, corresponding to the years of data collected at Dong Hoi station.

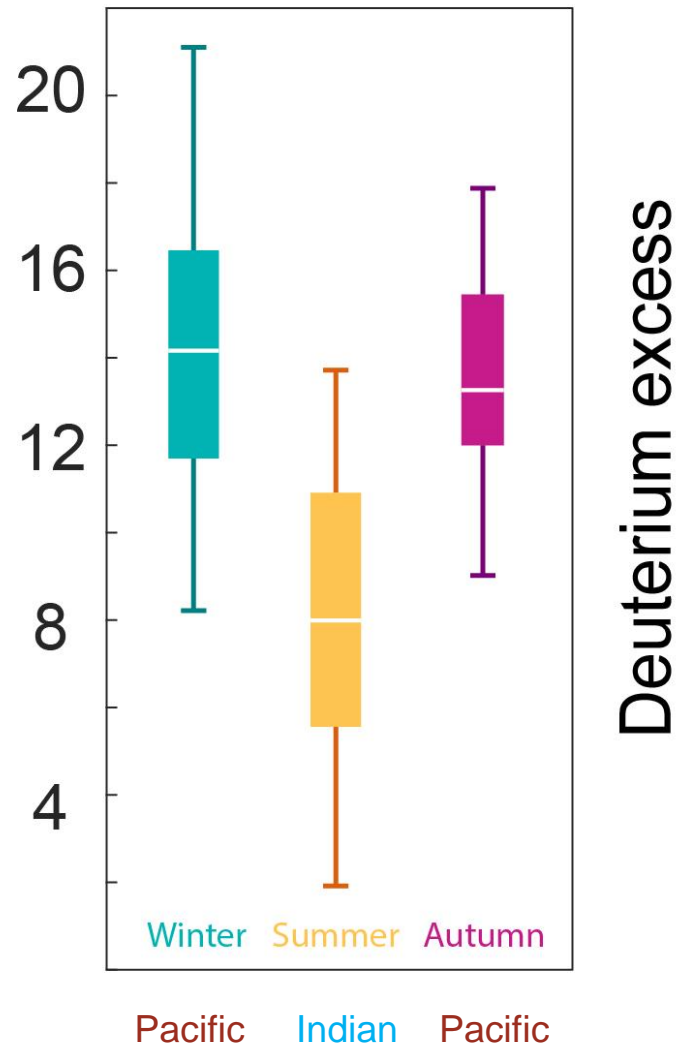
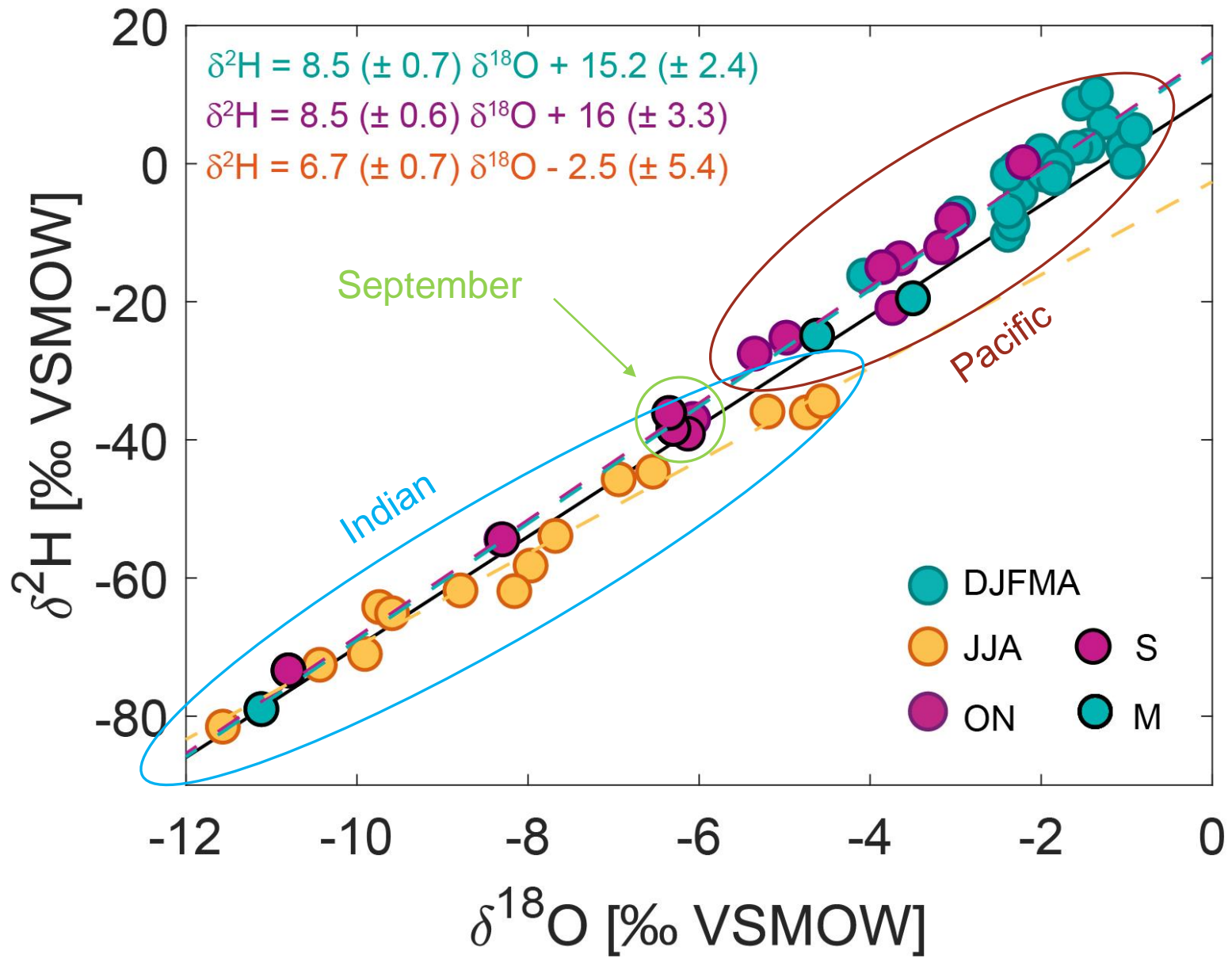
The dark blue shading indicates increased moisture uptake



Low  $\delta^{18}\text{O}$  values in summer corresponds to moisture arriving from the eastern Indian Ocean

The Pacific is moisture source during the rest of the year

September is the month of transition





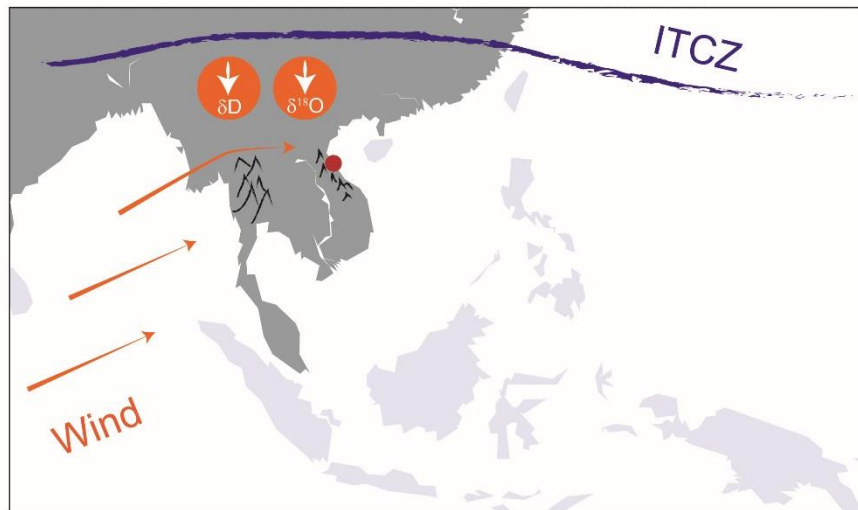
(a) Spring, autumn, winter



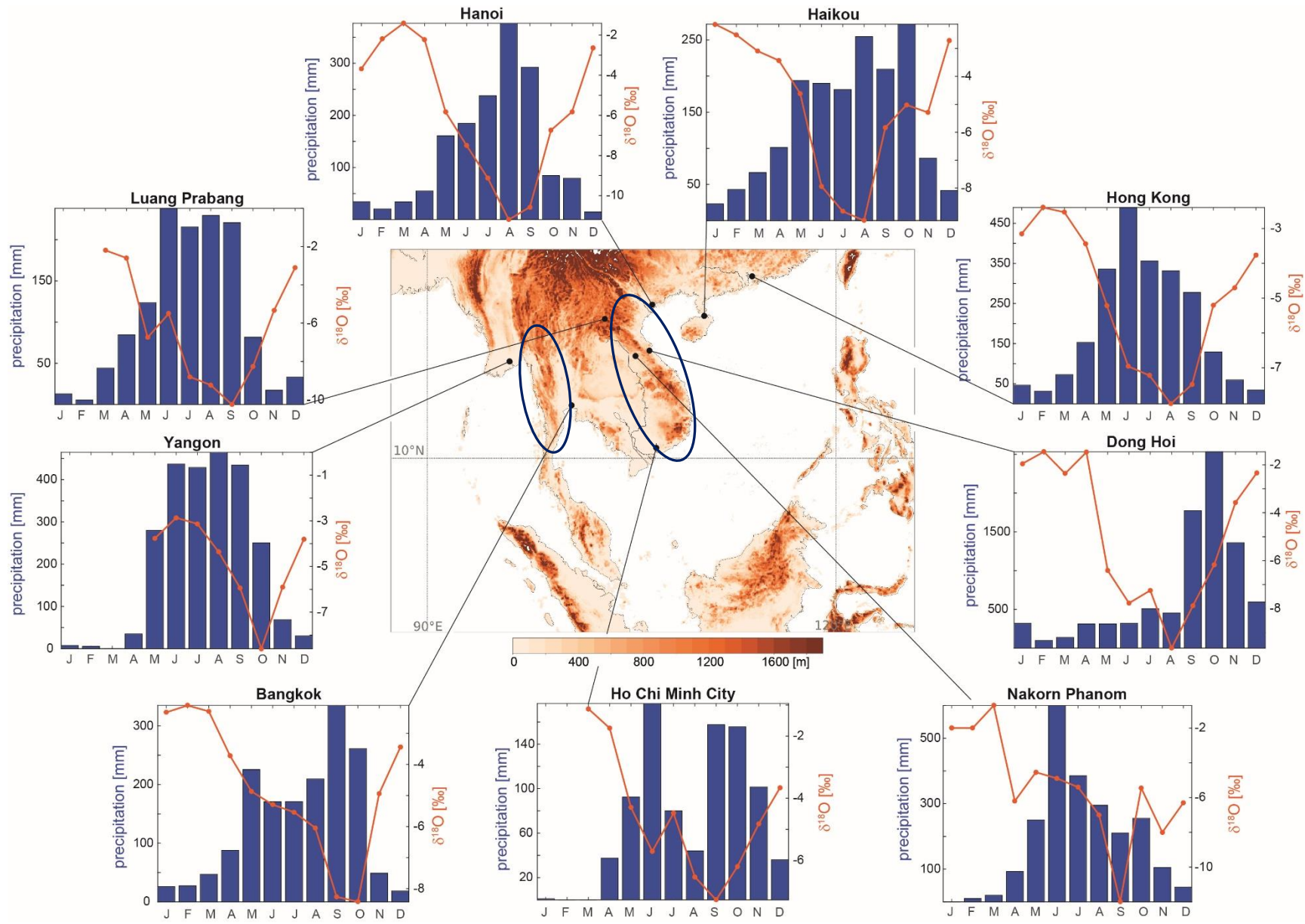
Shift in moisture source is caused by the seasonal migration of the ITCZ:

During winter the ITCZ is located close to the equator and moisture derives from the Pacific

(b) Summer

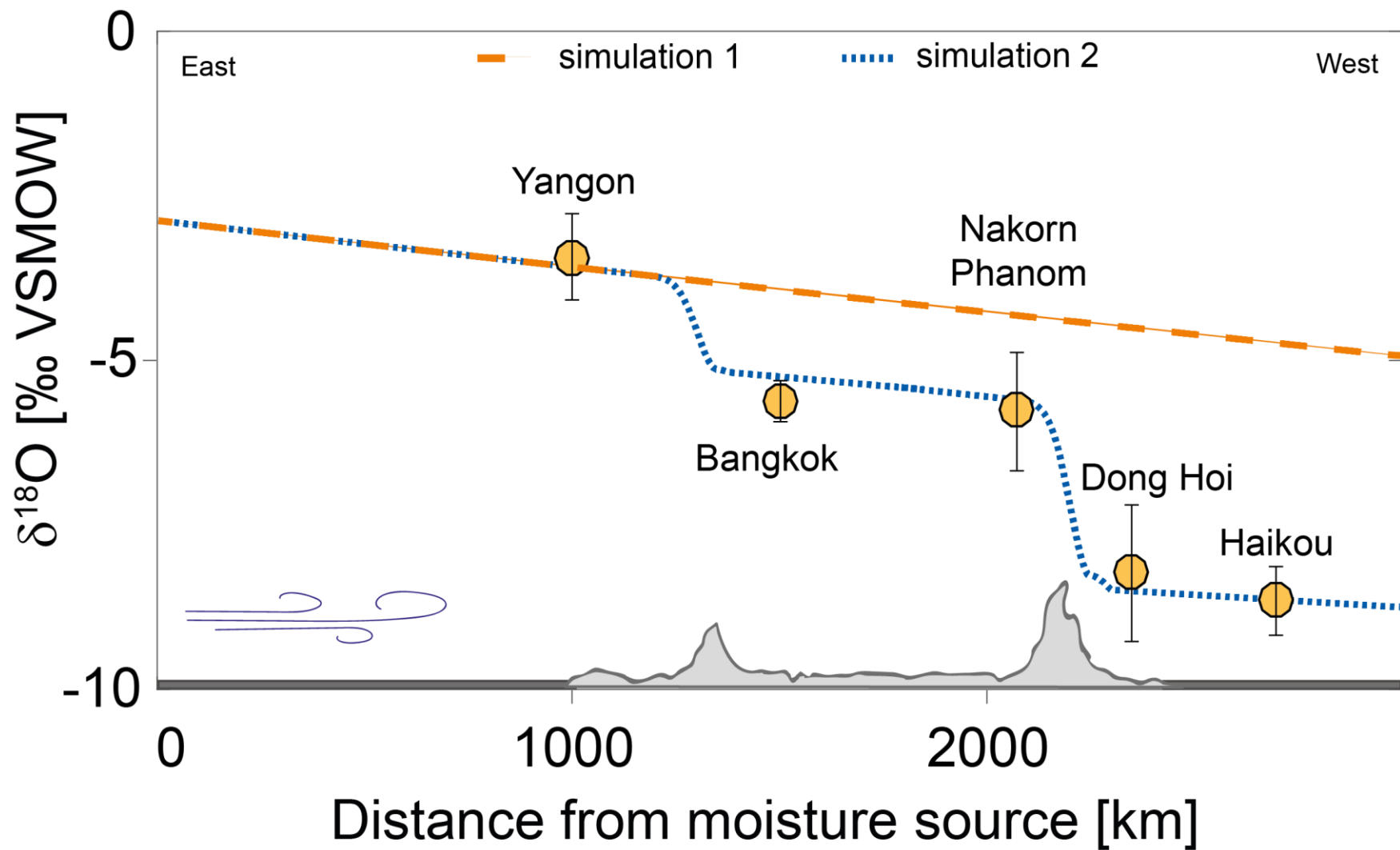


During summer the ITCZ is located north of central Vietnam and moisture derives from the Indian Ocean



Two mountain ranges are located between the Indian Ocean and Vietnam

- How do they affect  $\delta^{18}\text{O}$  along the way?



Simulation 1: rainout effects on  $\delta^{18}\text{O}$  across mainland Southeast Asia not considering topography

Simulation 2: considers topography

Results:  
70% of the spatial variability in summer rainfall  $\delta^{18}\text{O}$  is explained by local topography

## Summary

- Seasonal variability in rainwater isotopes in central Vietnam shows low values during summer and high values during winter
- This pattern is typical for the summer monsoon regions, but central Vietnam receives most rainfall in autumn and winter
- The seasonal cycle in rainwater isotopes is control by a shift in moisture source between Indian and Pacific Ocean
- Spatial variability can be explained by orographic rainout effects, when moisture passes mainland Southeast Asia, before reaching Vietnam

## Interested in more?

Wolf, A., Roberts, W.H.G., Ersek, V., Kathleen R. Johnson & Michael L. Griffiths. Rainwater isotopes in central Vietnam controlled by two oceanic moisture sources and rainout effects. *Sci Rep* 10, 16482 (2020).  
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