# Recent changes in hot and humid extreme over China

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# Wet-bulb temperature (TW) and humidity trends

- **Motivations**

Combined hot and humid conditions are potentially dangerous for human health. Indeed, at high hot-humid temperature, it becomes difficult for the body to cool down, no matter the physical condition of a person.

Here we investigated how such conditions have changed over China (a region already identified as vulnerable to hot-humid weather) during the past few decades, comparing station observation and ERA5 reanalysis.

- **A few key points**

- **Wet-bulb temperature** (**TW**): combined measurement of temperature and humidity.

**- High TW** → Health impact (***31°C*** *considered as dangerous;* ***35°C*** *deadly*).

- Empirical formulation (*Stull 2011*):

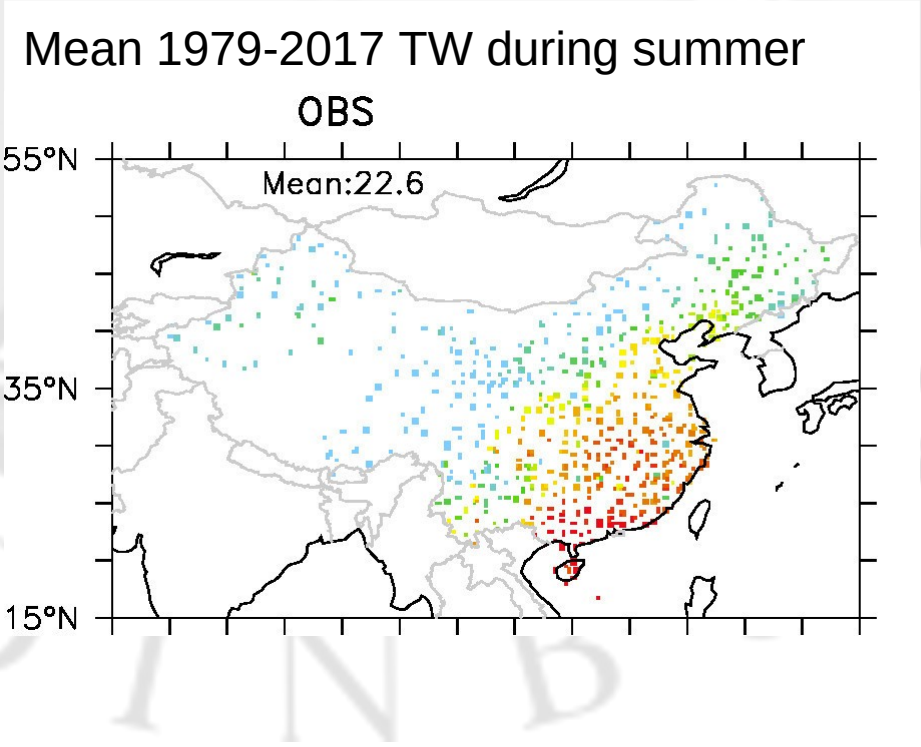
$$TW = T * \operatorname{atan}[0.151977 * (RH + 8.313659)^{1/2}] + \operatorname{atan}(T + RH) - \operatorname{atan}(RH - 1.676\,331) + 0.00391838*(RH)^{3/2} * \operatorname{atan}(0.023101*RH) - 4.686035$$

- Requires reliable temperature (T) and relative humidity (RH) datasets.

- Interaction between T and RH: Both can impact TW.

# Wet-bulb temperature (TW) and humidity trends

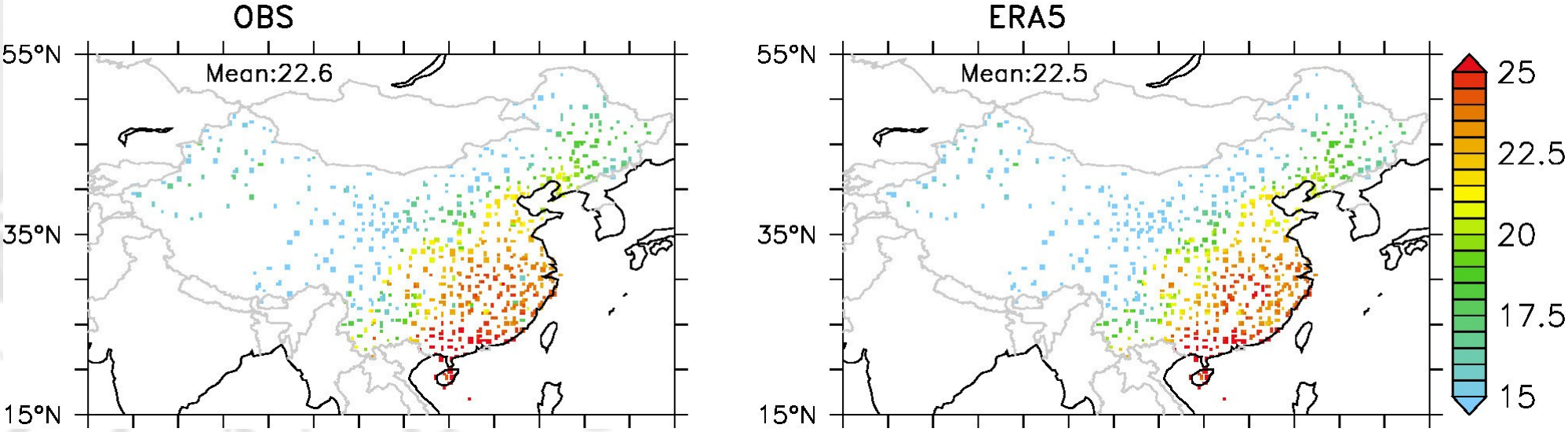
- **OBS** observation in-situ data (750+ stations over China), daily, 1960-2017



# Wet-bulb temperature (TW) and humidity trends

- **OBS** observation in-situ data (750+ stations over China), daily, 1960-2017
- **ERA5** reanalysis (0.25°, masked to fit OBS), hourly, 1979-2017

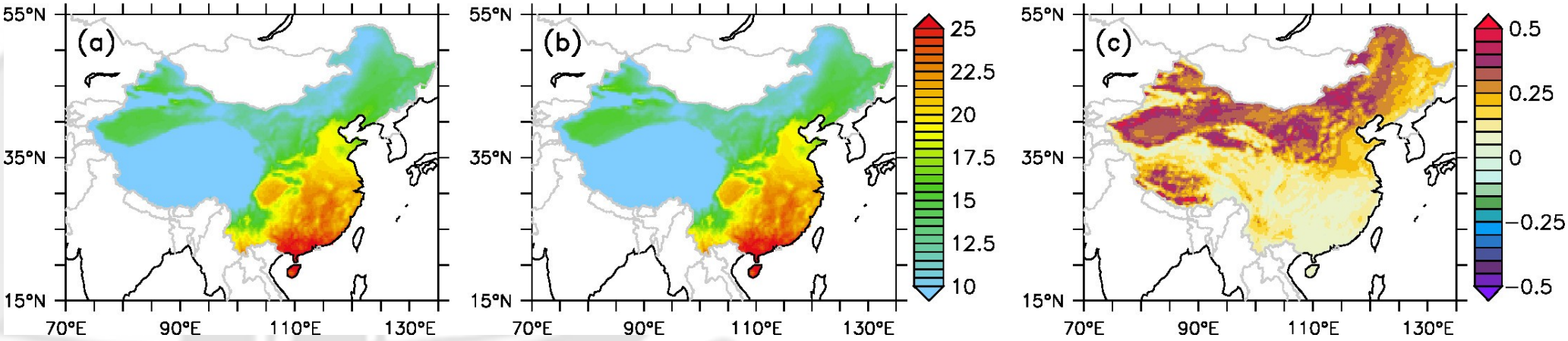
Mean 1979-2017 TW during summer



# Wet-bulb temperature (TW) and humidity trends

- **Does computing TW from hourly versus daily data makes a difference?**

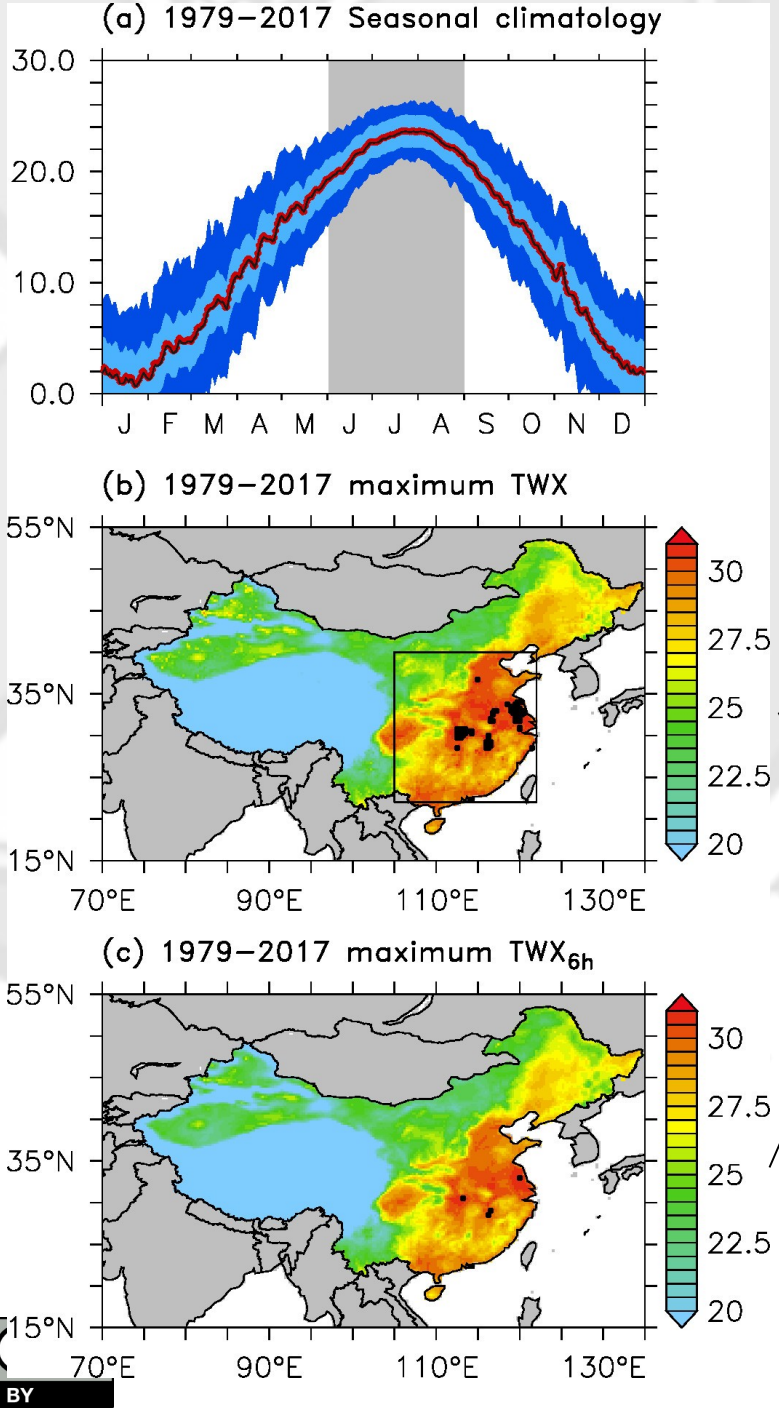
Daily TW from (a) hourly data and (b) daily mean data. (c) is the difference (b)-(a).




From ERA5: [*daily mean of hourly TW*] vs [*TW from daily mean of hourly T/RH*]

→ only weak differences (slightly larger values when using daily means)

# Wet-bulb temperature (TW) and humidity trends




***OBS***

***ERA5***

***Diurnal range***

***Interannual variability***

Very good agreement between OBS and ERA5 for the mean climatology signal.

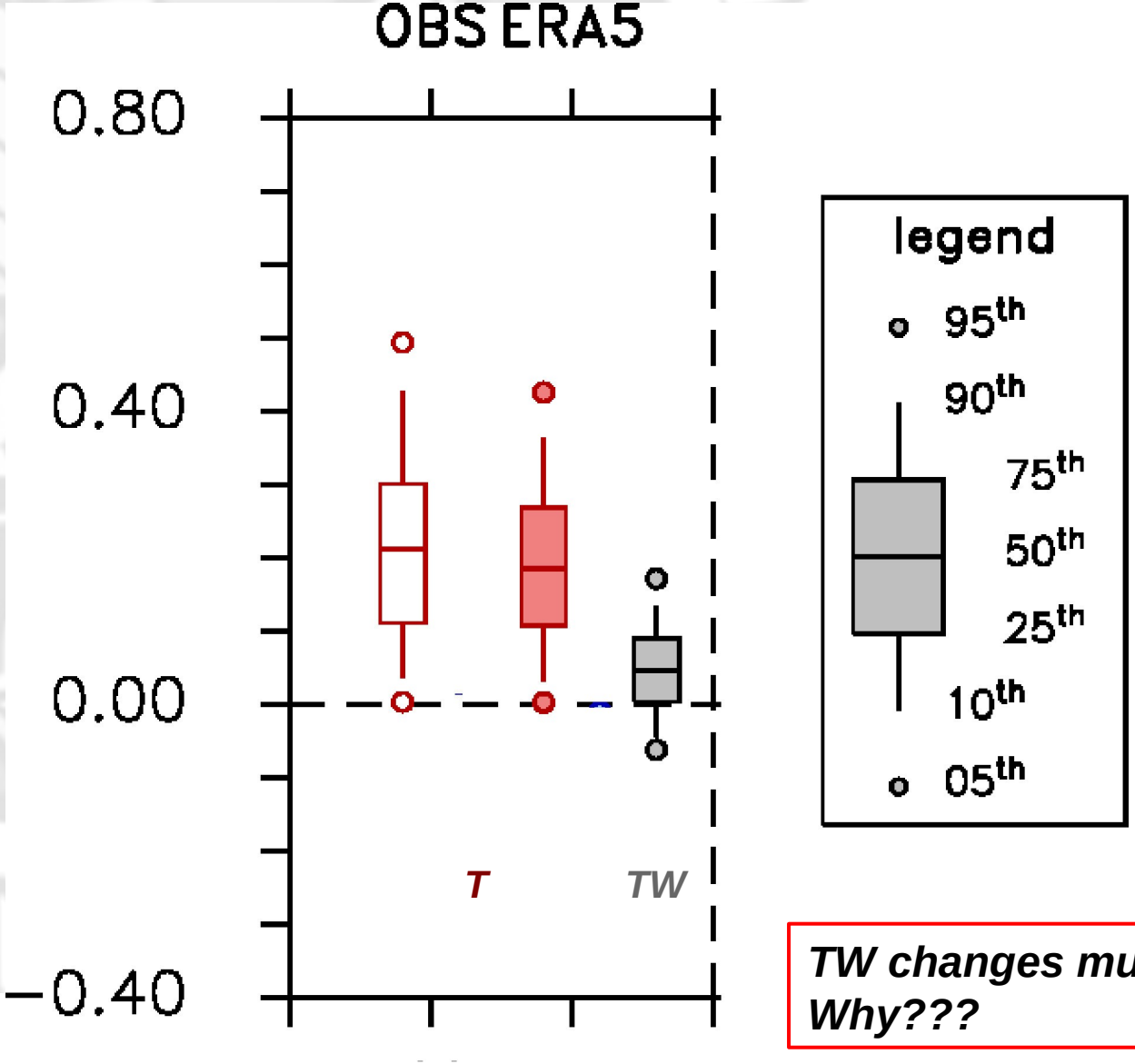
From ERA5 hourly TW we can estimate daily or 6h min/max TWX

***East Asia → sensitive area***

*black dots: values > 31°C*

# Wet-bulb temperature (TW) and humidity trends

- **How much TW has changed recently?**

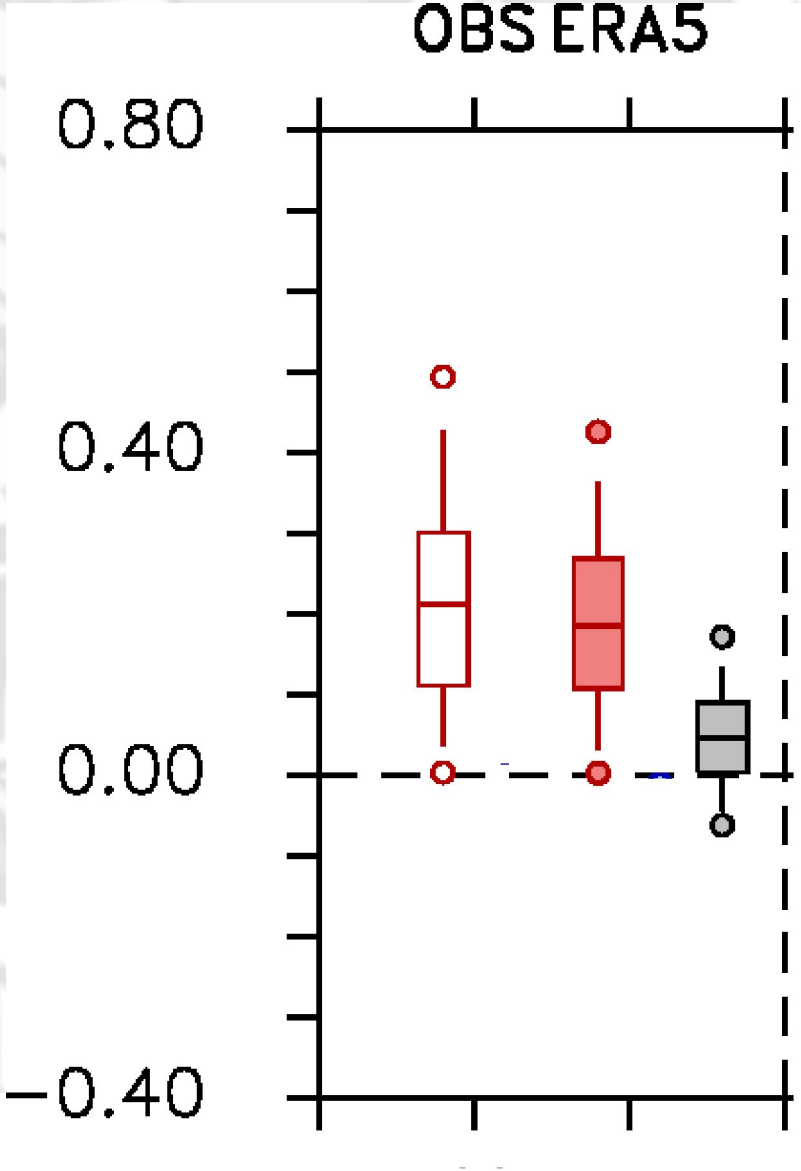


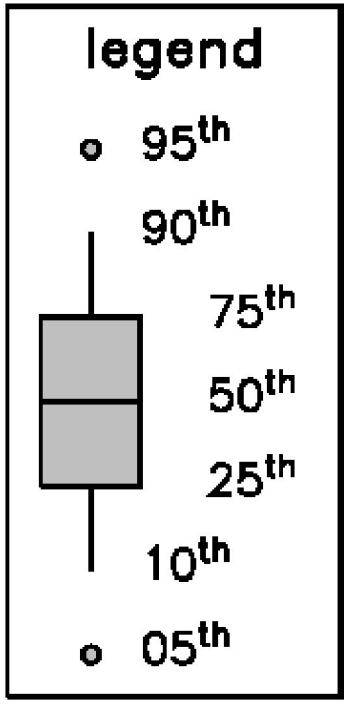

***TW changes much slower than T***
***Why???***

***Trends per decade***

# Wet bulb temperature and humidity trends

- **How much TW has changed recently?**



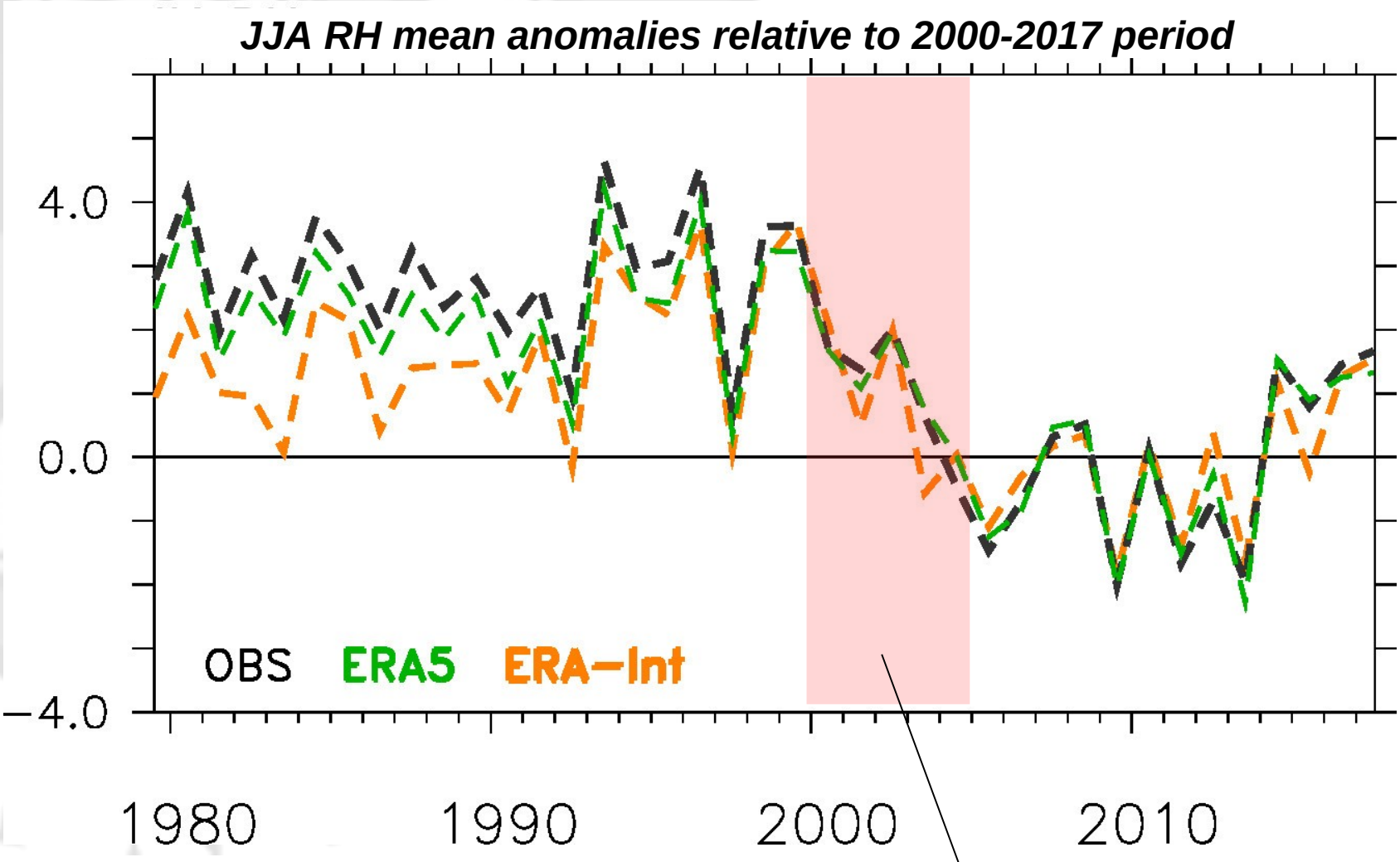

***TW changes much slower than T***
***Why???***

wrong conclusion here

***Trends per decade***

# Wet-bulb temperature (TW) and humidity trends

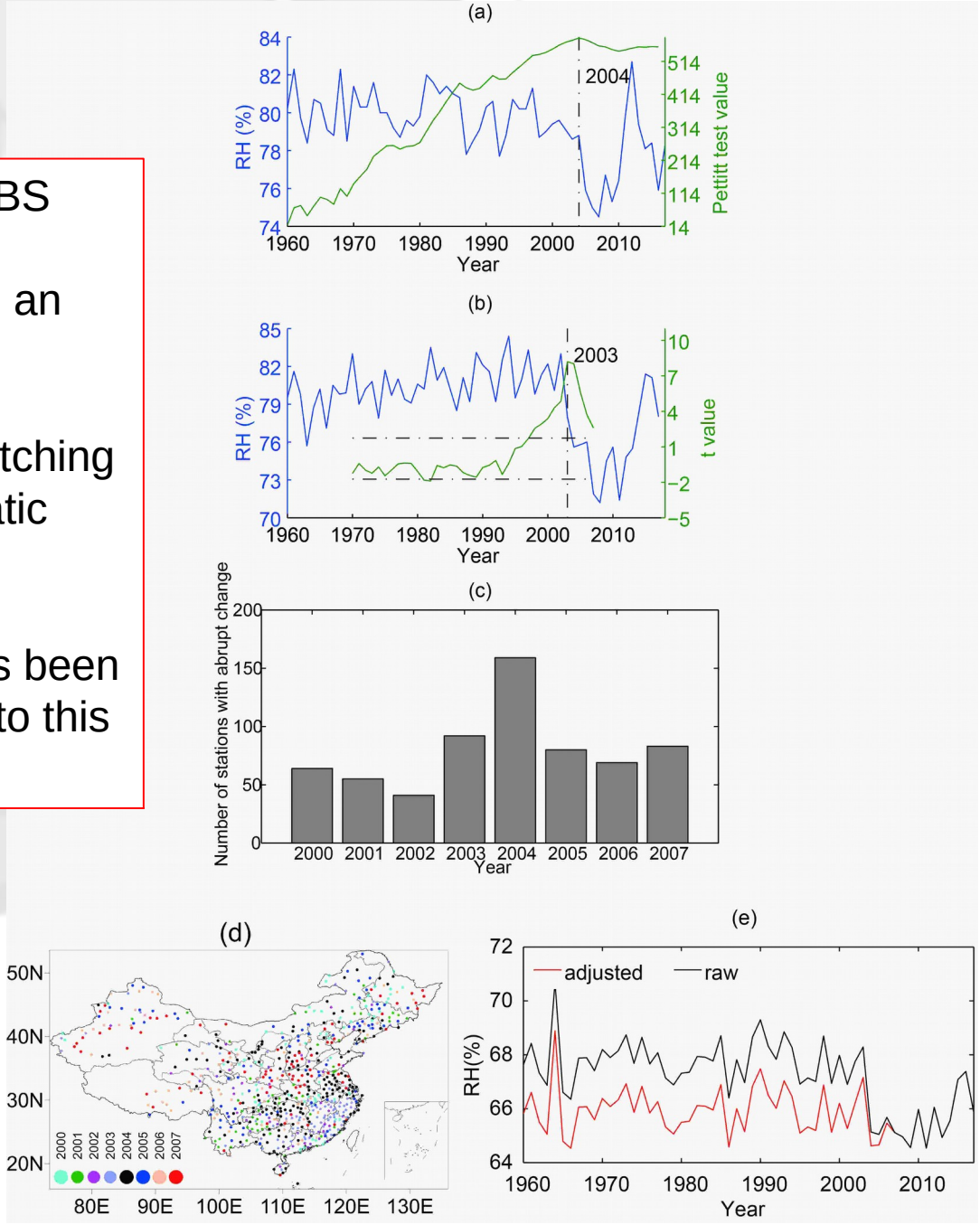
- **What happened?**



# Wet-bulb temperature (TW) and humidity trends

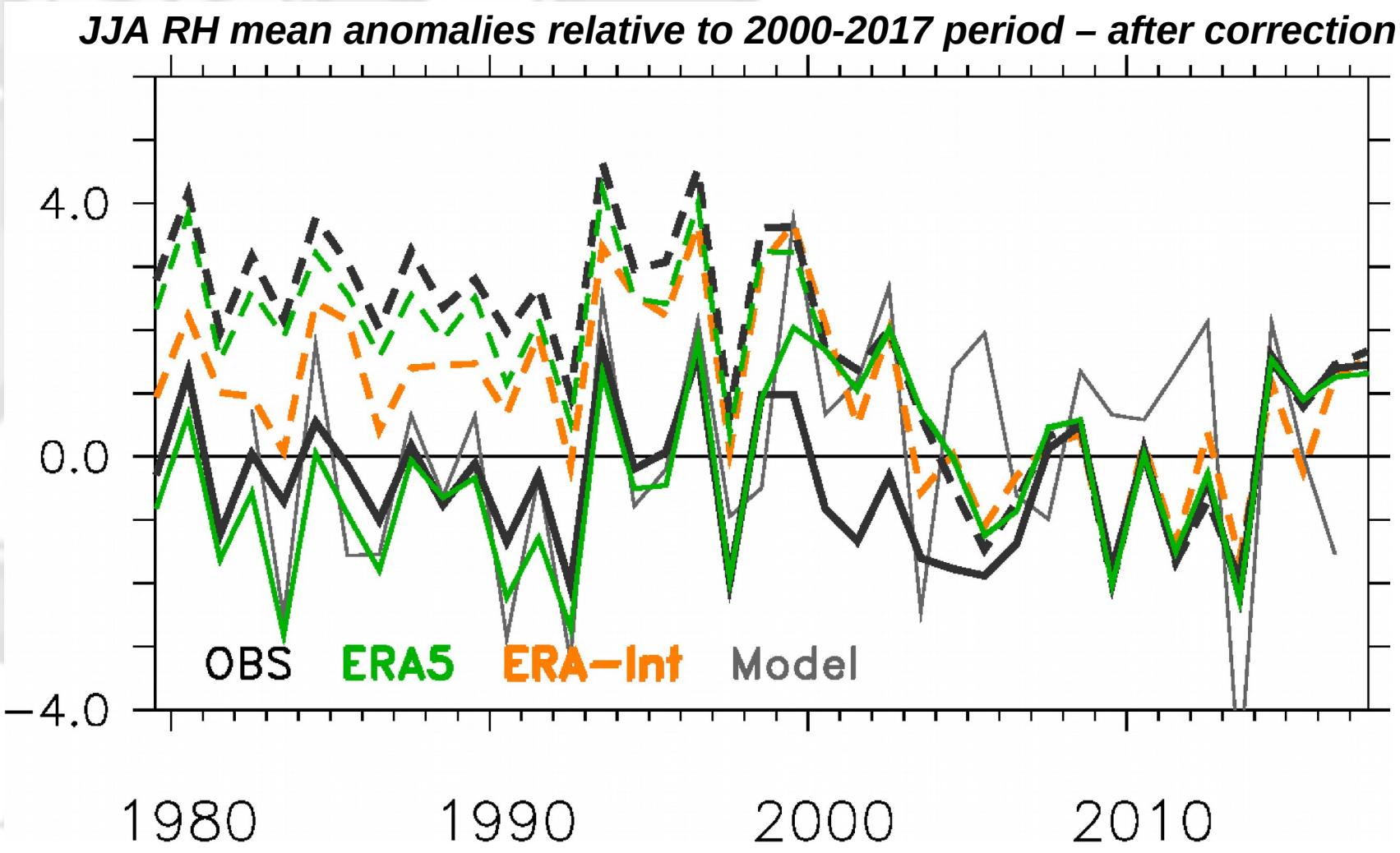
A careful analysis of OBS has concluded that the decrease in 2000s was an artifact due to a large change in the network around that period (switching from manual to automatic stations).

Homogenised OBS has been developped according to this new finding.




*Li et al., 2020*

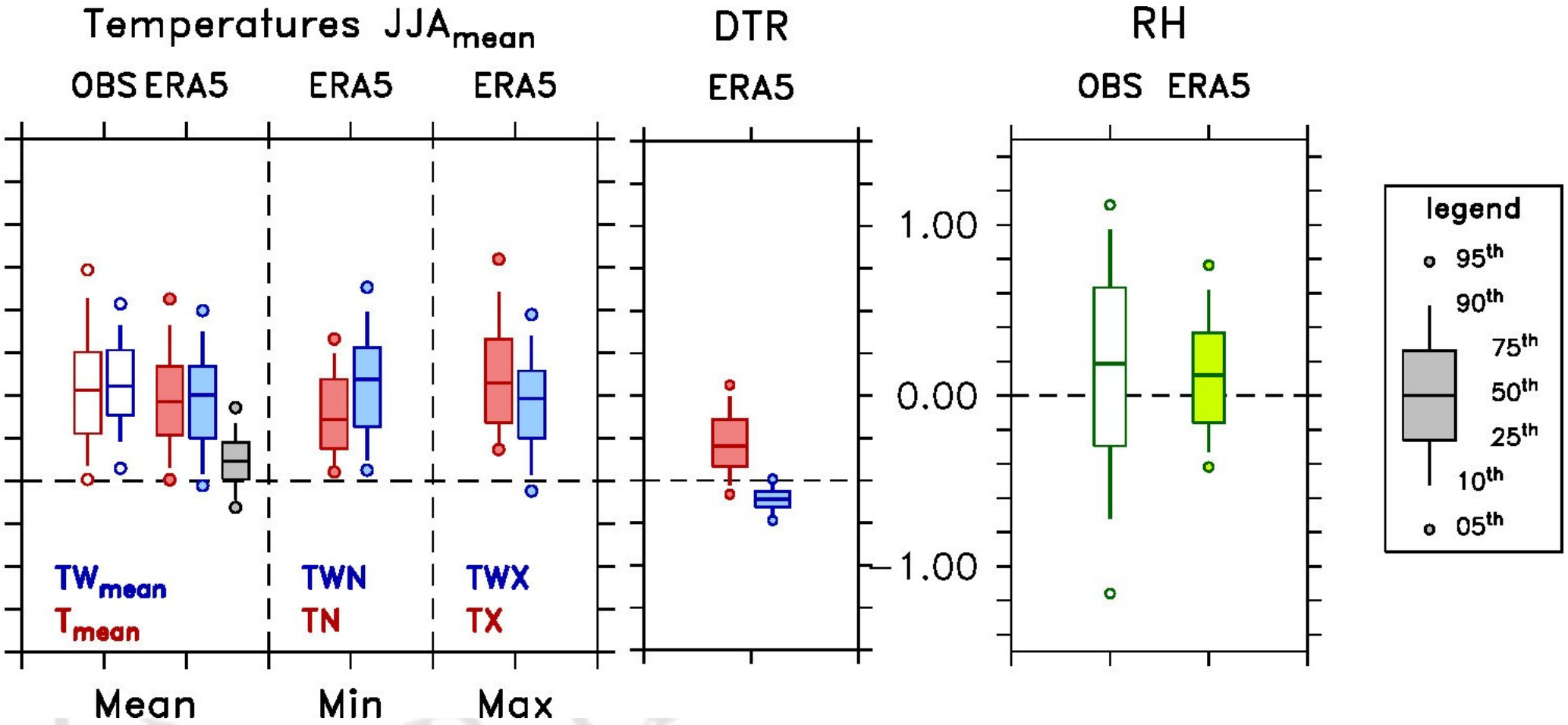
# Wet-bulb temperature (TW) and humidity trends




After homogenisation (solid lines), RH remains fairly constant.
ERA5 has been corrected accordingly.
TW has been recomputed using this corrected datasets.

# Wet-bulb temperature (TW) and humidity trends

***Trends per decade*** *after RH correction (coloured symbols) and before correction (gray symbols)*

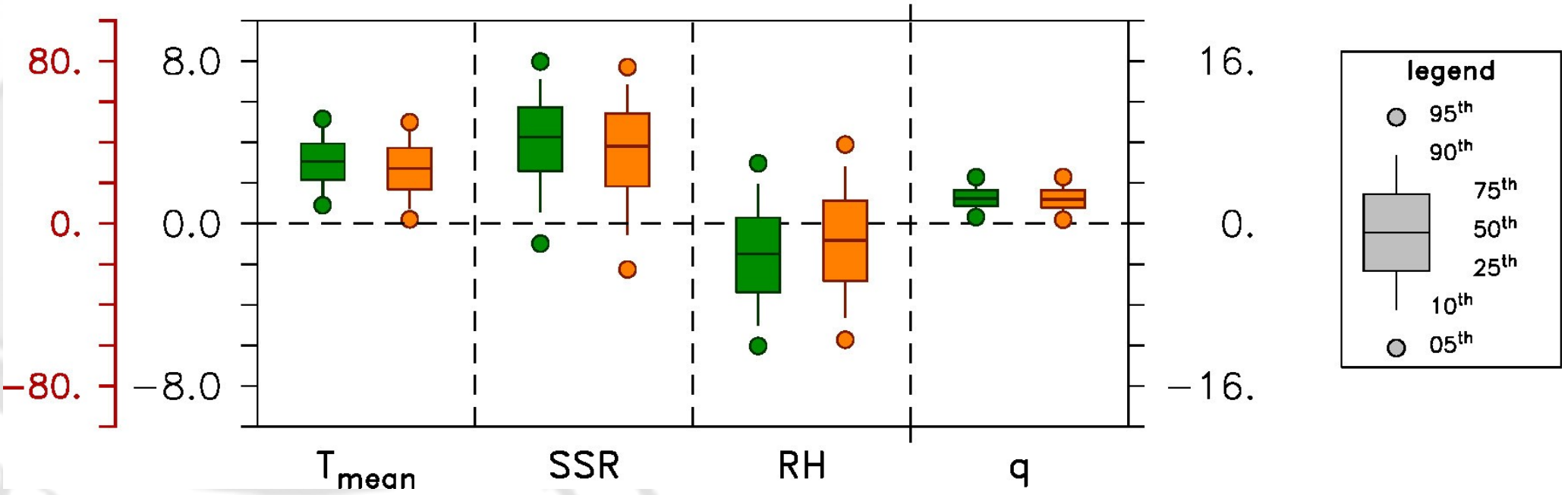



***After RH correction, TW increases as fast as T.***
***Some differences for daily minimum and maximum.***

# Wet-bulb temperature (TW) and humidity trends

- **What leads to the hottest TW conditions?**

***Composite anomalies during the hotest TW cases (99$^{th}$ and 99.9$^{th}$ hostest days)***




***Extreme TW days are due mainly to increased in T. However, specific humidity q also increases, limiting the decrease in RH.***

# Wet-bulb temperature (TW) and humidity trends

- **Key Points**

- We detected a significant bias in RH over China in both observation (work done by our collaborators from IAP, Beijing) and ERA5 reanalysis.

- This bias previously lead to underestimate changes in TW.

- After RH correction, TW trends became more consistent with changes in T.

- As TW increases at the same rate as T, this implies that humidity q can also increase, to maintain similar RH levels. This is also the case for the warmest TW days, with clear q positive anomaly (thus weater conditions, in a specific humidity way).

- **References**

- Freychet, N., Tett, S. F. B., Yan, Z., & Li, Z. (2020). Underestimated change of wet-bulb temperatures over East and South China. Geophysical Research Letters, 47(3), e2019GL086140.

- Li, Zhen, et al. "Homogenized daily relative humidity series in China during 1960–2017." Advances in Atmospheric Sciences 37 (2020): 318-327.

# THANKS