Recent changes in hot and humid extreme over China

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Wet bulb temperature 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*):

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

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

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

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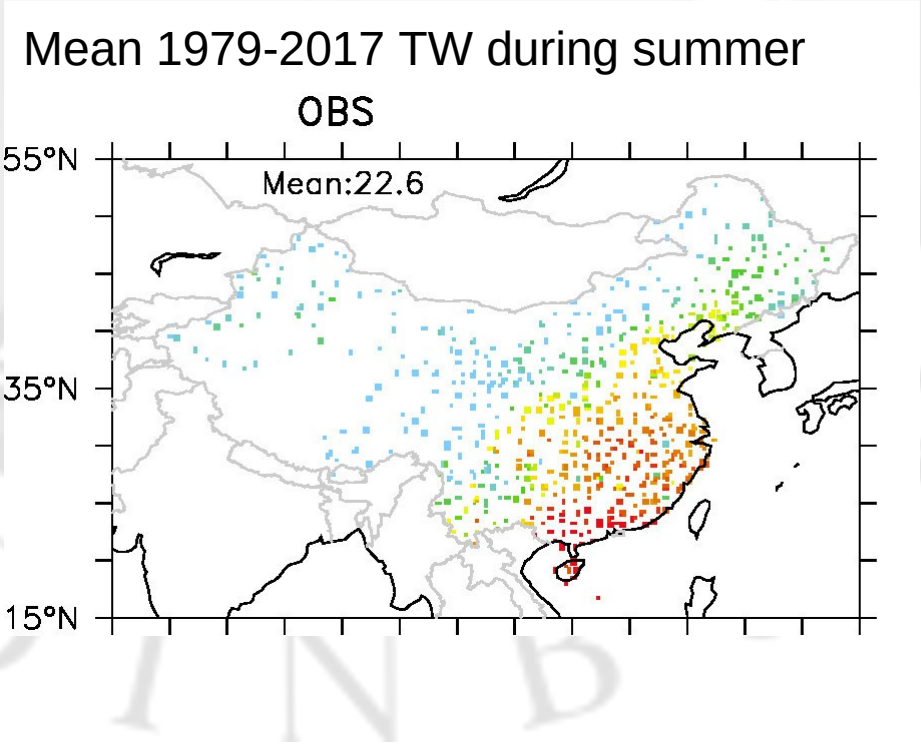
- **OBS** observation in-situ data (750+ stations over China), daily, 1960-2017



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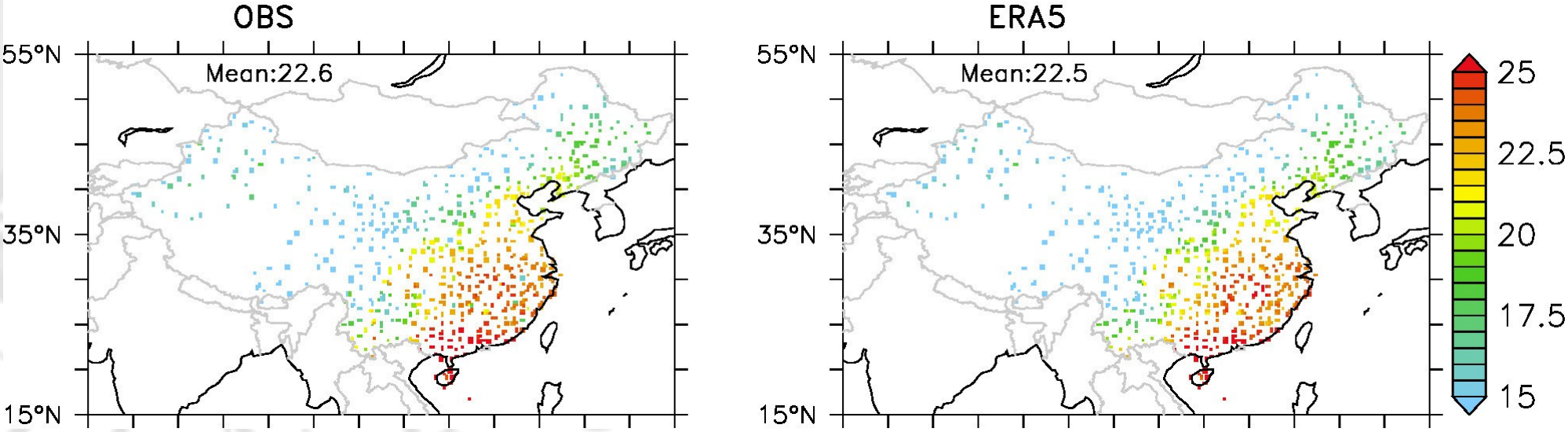
- **OBS** observation in-situ data (750+ stations over China), daily, 1960-2017
- **ERA5** reanalysis (0.25°, masked to fit OBS), hourly, 1979-2017

Mean 1979-2017 TW during summer



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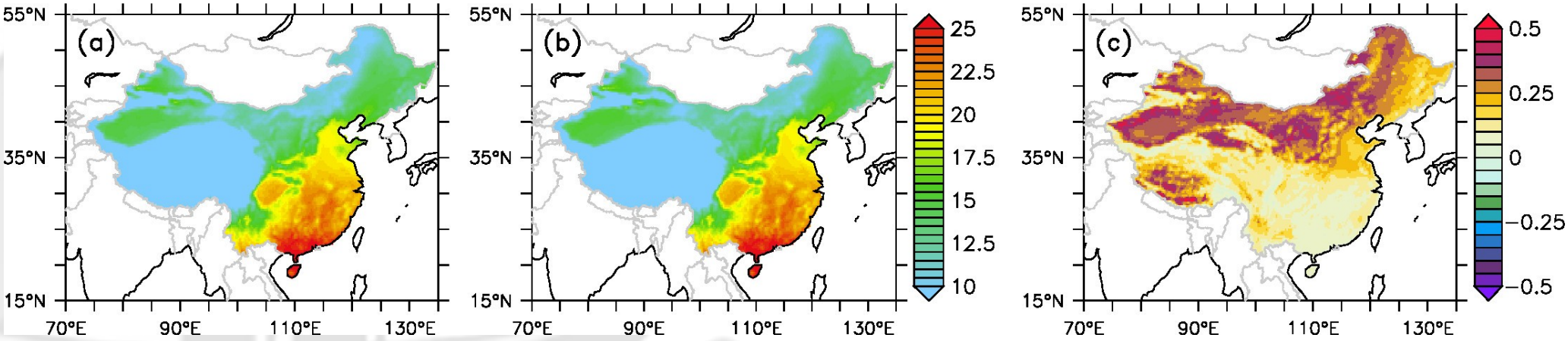
- **Does computing TW from hourly versus daily data makes a difference?**

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)

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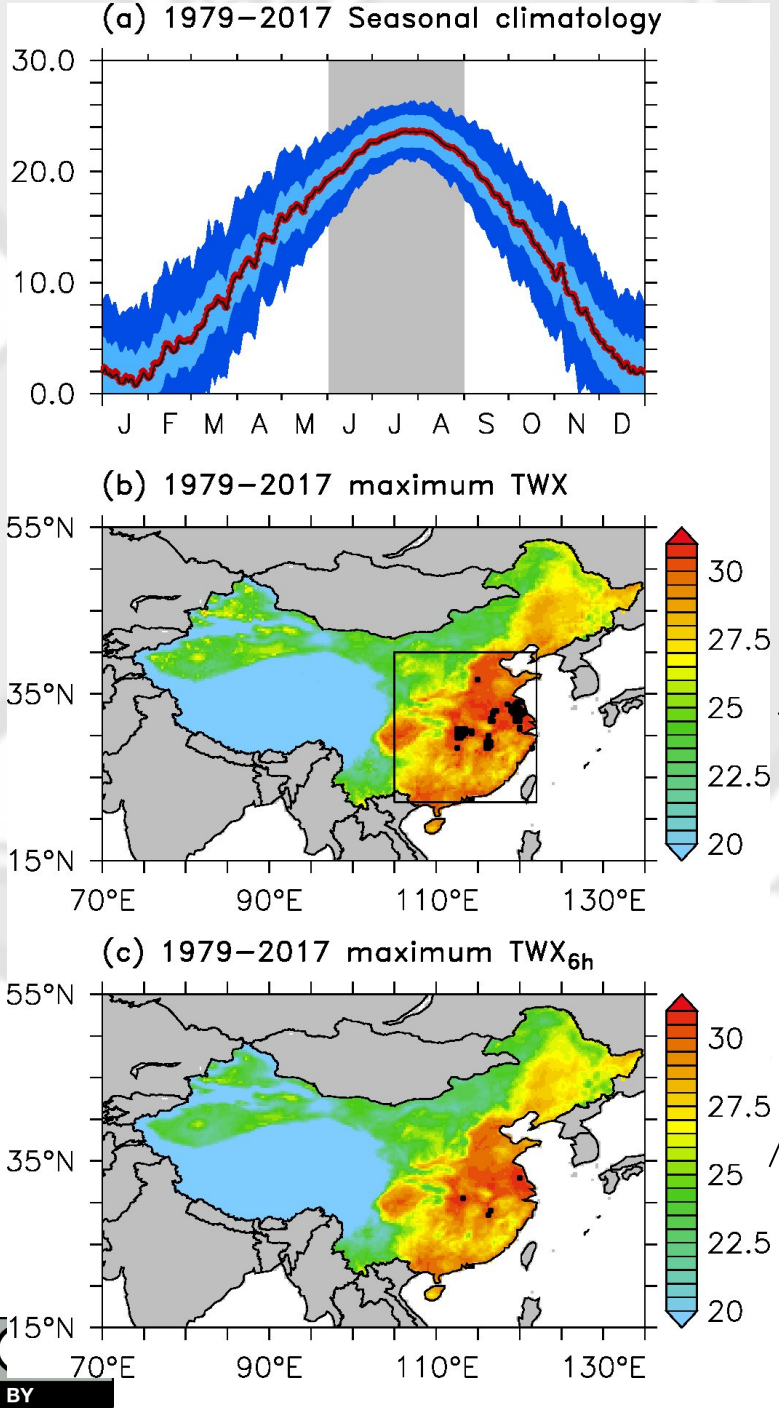

OBS
ERA5
Diurnal range
Interannual variability

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

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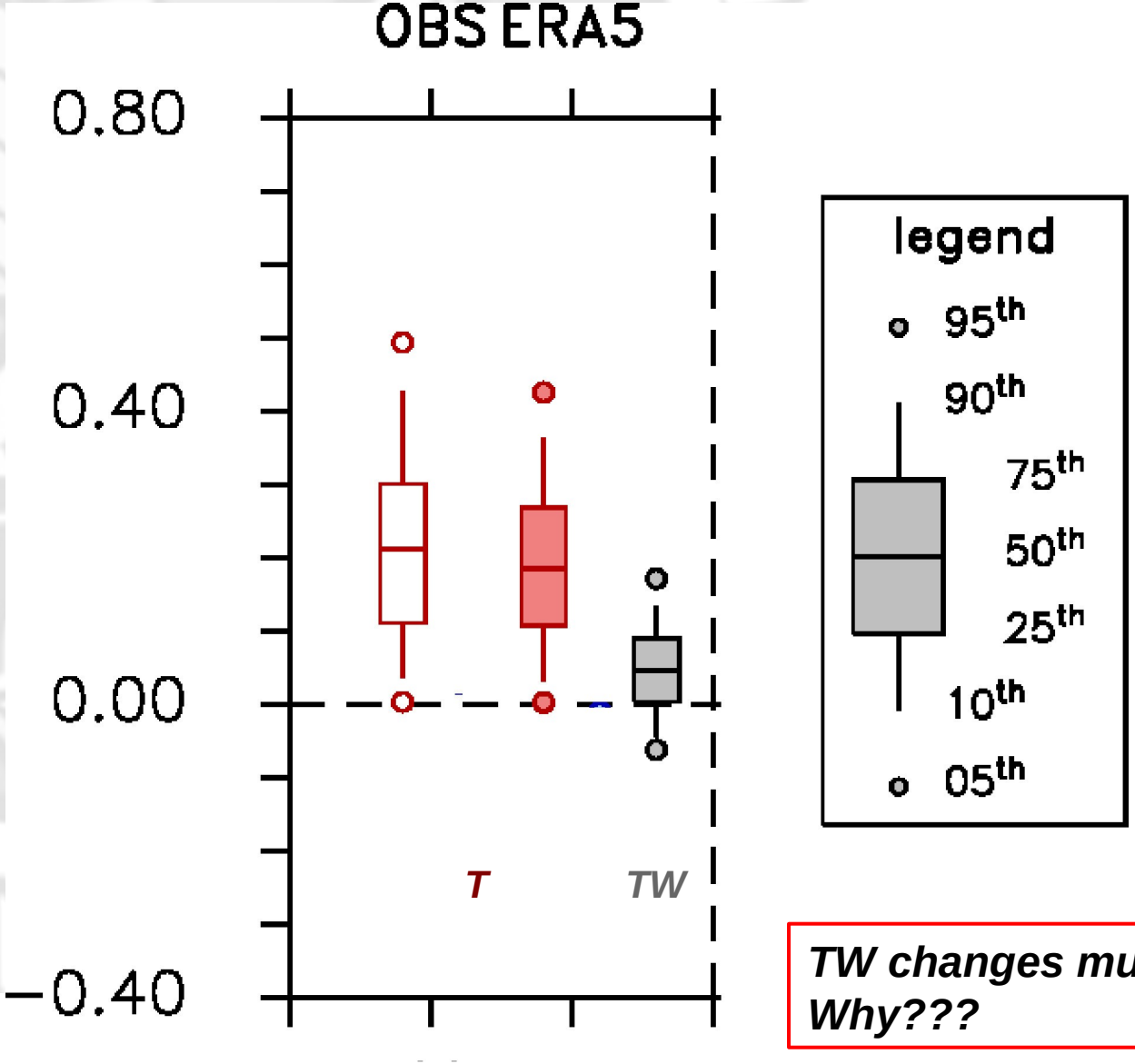
- **How much TW has changed recently?**



TW changes much slower than T
Why???

Trends per decade

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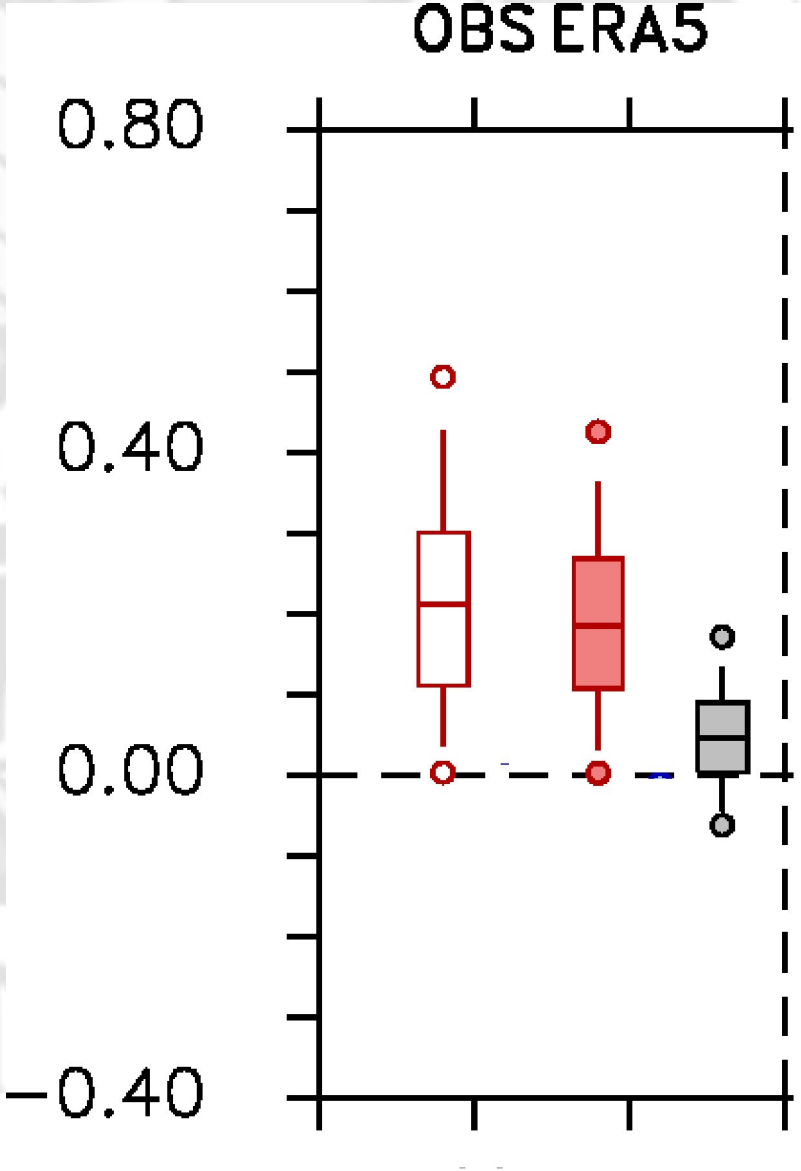
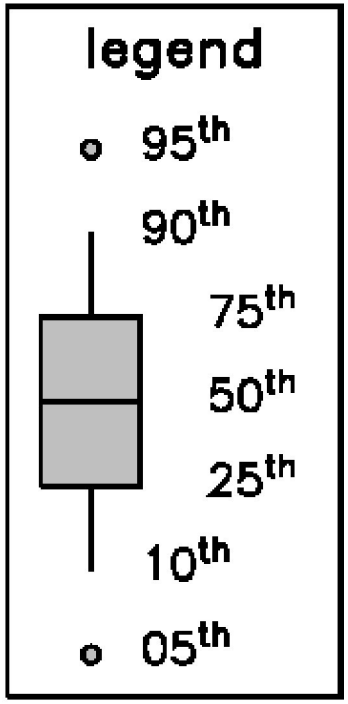
- **How much TW has changed recently?**





TW changes much slower than T
Why???

wrong conclusion here

Trends per decade

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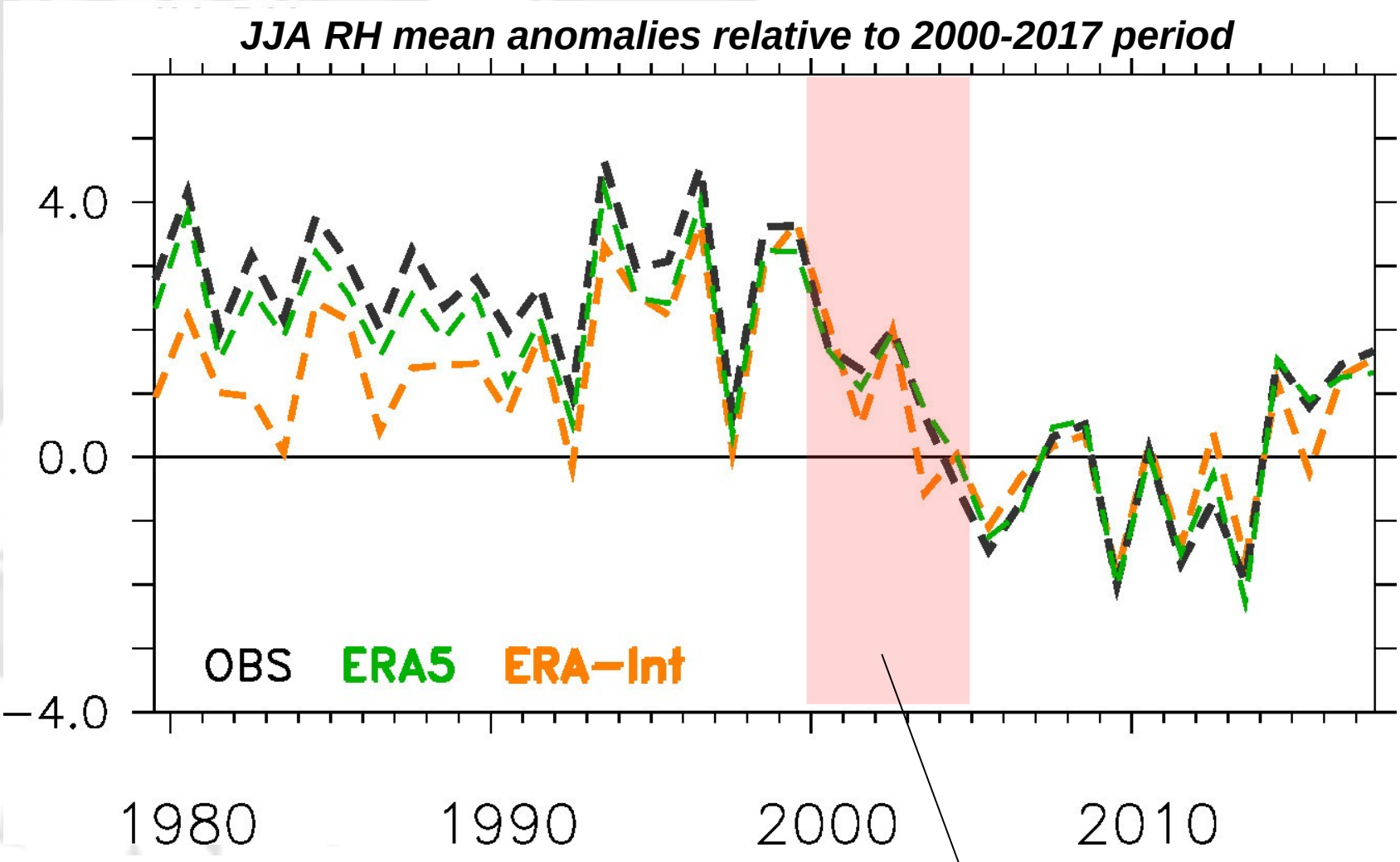
- **What happened?**



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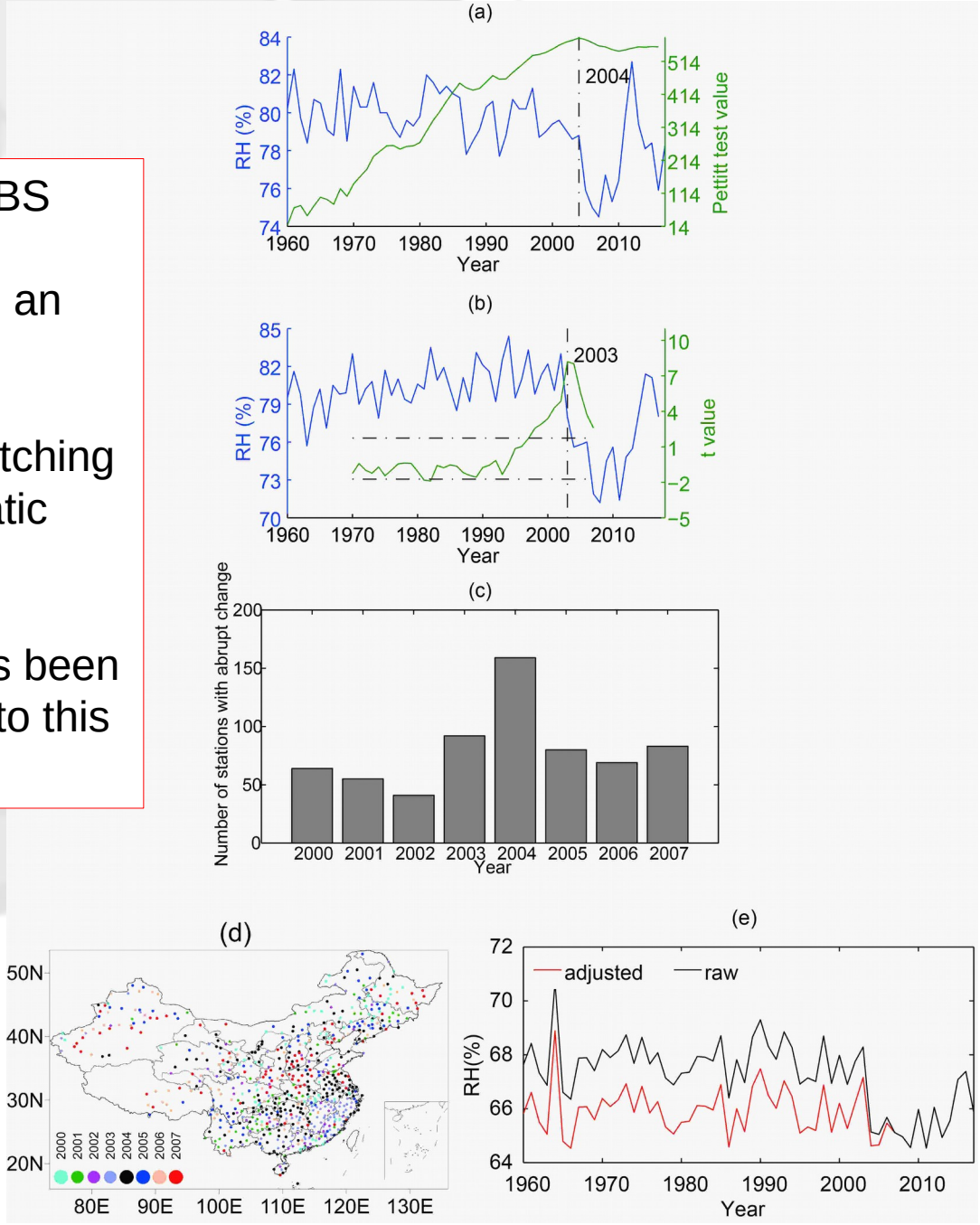
A careful analysis of OBS has concluded that the decrease in 2000s was an artifact due to a large change in the network around that period (switching from manual to automatic stations).

Homogenised OBS has been developped according to this new finding.



Li et al., 2020

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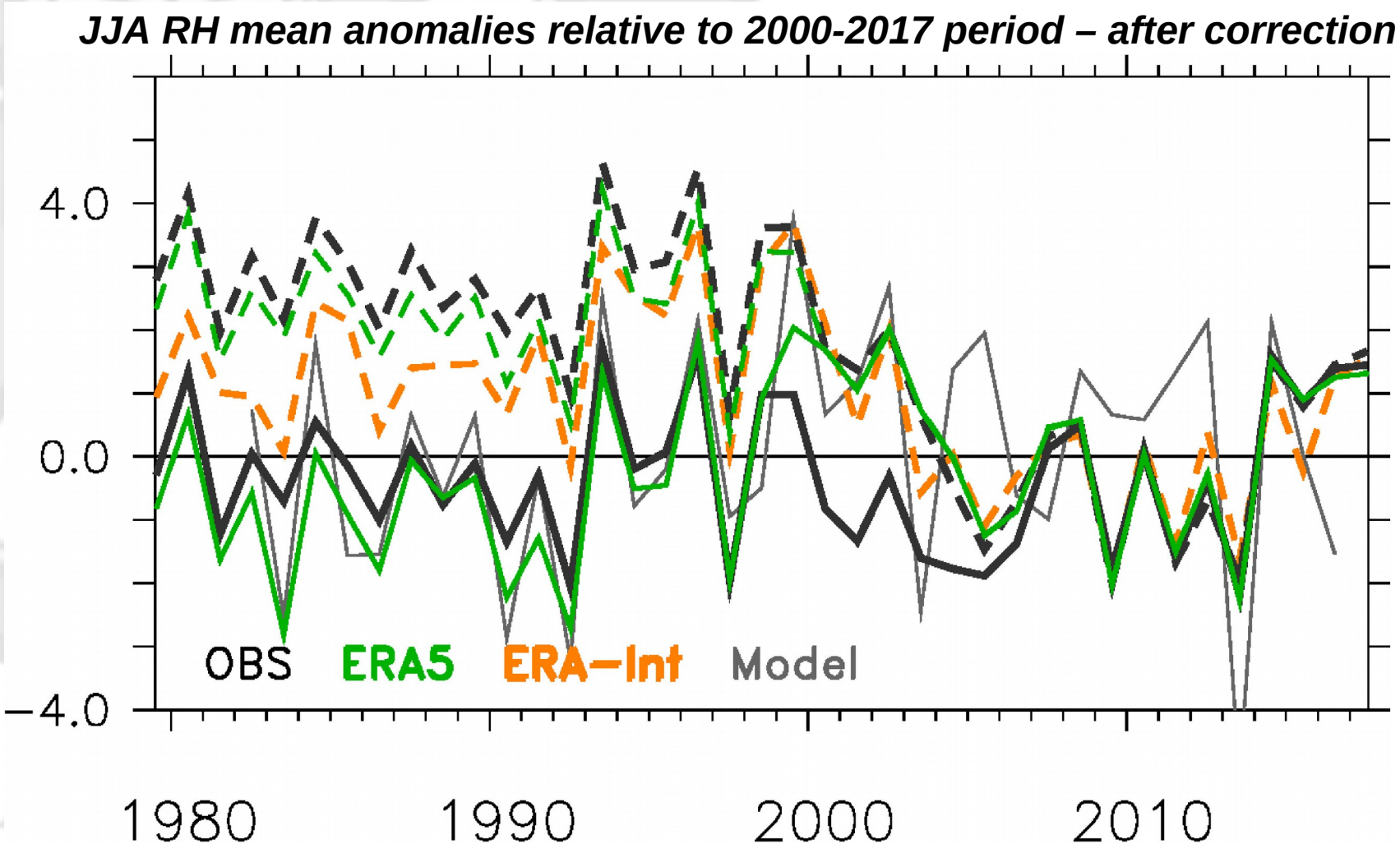

After homogenisation (solid lines), RH remains fairly constant.
ERA5 has been corrected accordingly.
TW has been recomputed using this corrected datasets.

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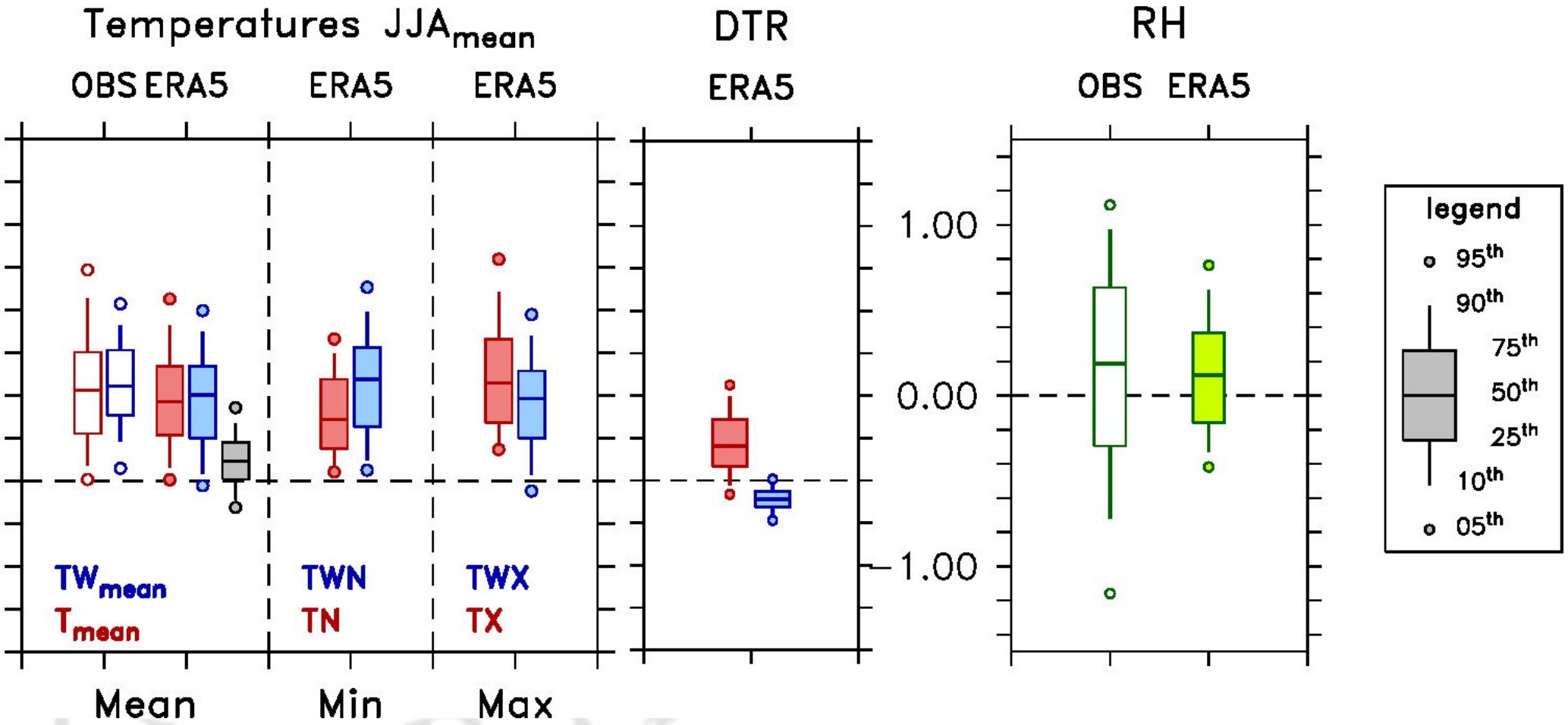
Trends per decade *after RH correction (coloured symbols) and before correction (gray symbols)*



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

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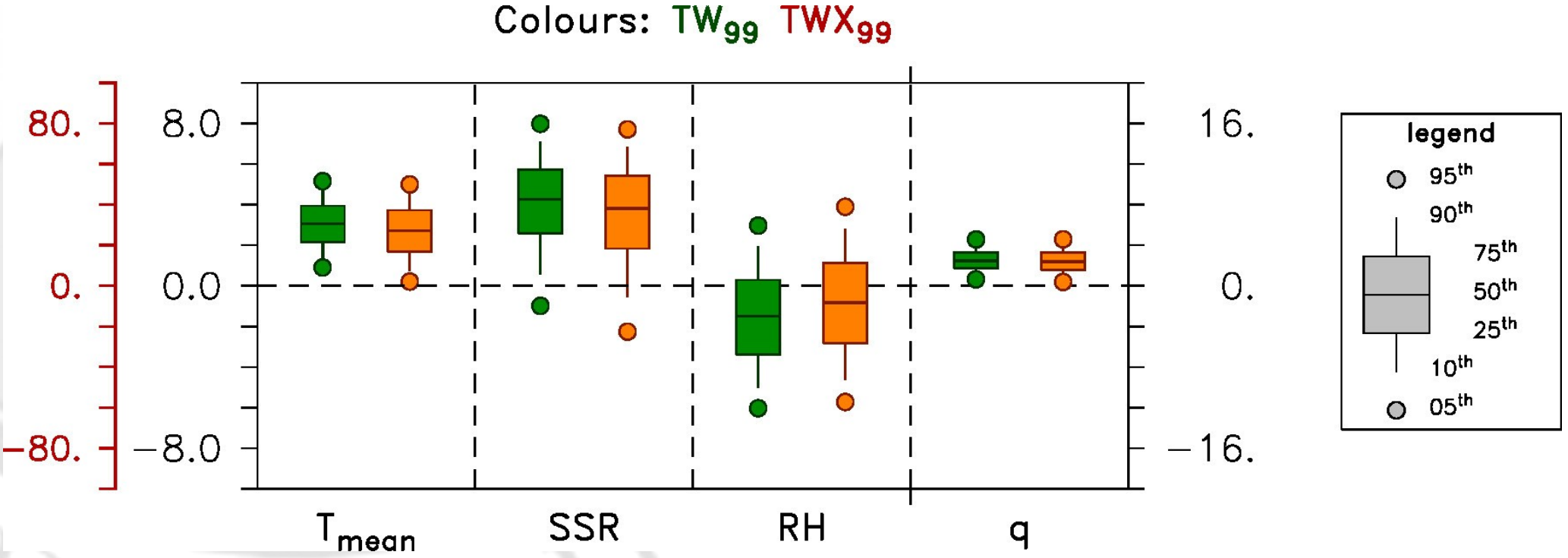
- **What leads to the hottest TW conditions?**

Composite anomalies during the hotest TW cases (99th and 99.9th hostest days)



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

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- **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.

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THANKS

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