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):**
    \[
    \text{TW} = T \times \text{atan}[0.151977 \times (\text{RH} + 8.313659)^{1/2}] + \text{atan}(T + \text{RH}) - \text{atan}(\text{RH} - 1.676331) + 0.00391838 \times (\text{RH})^{3/2} \times \\
    \text{atan}(0.023101 \times \text{RH}) - 4.686035
    \]

  - 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

Mean 1979-2017 TW during summer

Mean: 22.6
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 make 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

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

**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??**

**Trends per decade**

**OBS ERA5**

**Legend**
- 95th
- 90th
- 75th
- 50th
- 25th
- 10th
- 05th

**TW changes much slower than T**

Wrong conclusion here
Wet-bulb temperature (TW) and humidity trends

- What happened?

**JJA RH mean anomalies relative to 2000-2017 period**

Decrease in relative humidity?
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 developed according to this new finding.
Wet-bulb temperature (TW) and humidity trends

**JJA RH mean anomalies relative to 2000-2017 period – after correction**

After homogenisation (solid lines), RH remains fairly constant. ERA5 has been corrected accordingly. TW has been recomputed using this corrected datasets.
After RH correction, TW increases as fast as T. Some differences for daily minimum and maximum.
What leads to the hottest TW conditions?

**Composite anomalies during the hottest TW cases (99th and 99.9th hottest days)**

Colours: TW$_{99}$ TWX$_{99}$

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**


THANKS