The role of urbanization on the temperature, RH and wind in Taiwan in July

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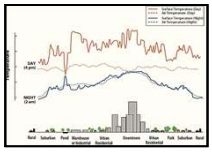
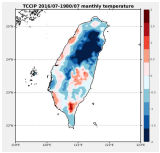
Abstract

This work investigates the impacts of land cover changes on the changes of surface environments in Taiwan in July. By using high-resolution regional WRF model experiments, we compare the changes of monthly mean of temperature (T), relative humidity (RH), and winds due to land cover changes between 1980 and 2016 in Taiwan (Chen et al., 2019). Changes of diurnal changes of T, RH, and land sea breeze are also investigated with the CWB station data of Taipei, Taichung, and Taitung. While model simulations have biases over the northern Taiwan, they seems to capture the patterns of temperature changes over the western Taiwan. It is found that, the temperature increase due to built-up land can be up to 2 degree over the urban area, which covers the cooling effects due to large-scale atmospheric changes.

Motivation:

- Urban heat island(UHI) is an urban area that is obviously warmer than its surrounding rural area.
- T : July 2016 was hotter than July 1980 in urban area in Taiwan from TCCIP.





https://www.usgs.gov/media/images/urban-heat-islands

Observation:

Station data from the Central Weather Bureau

Hourly ; July 1980 and July 2016

Model :

Model : WRF

Horizontal resolution : ~2.07km

Initial data : EXP1 : 1980 yr Atm + 1980 yr Land

EXP2 : 1980 yr Atm + 2016 yr Land

EXP3 : 2016 yr Atm + 1980 yr Land

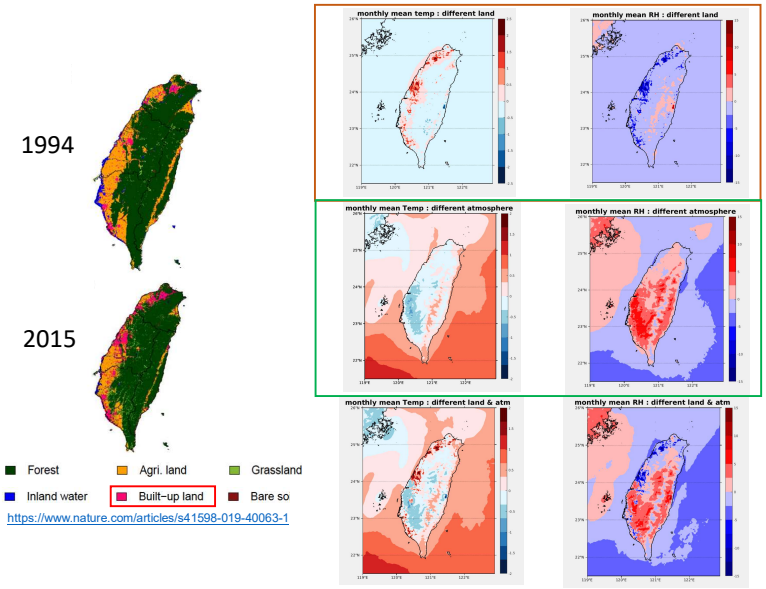
EXP4 : 2016 yr Atm + 2016 yr Land

Methodology:

In order to estimate the impact of the urbanization on T, RH and WS, the WRF simulation were mainly divided into difference between 1980 and 2016's (1) land forcing and (2) atmospheric forcing.The details are shown bellow:

- Different surface forcing:
  [(EXP2-EXP1) + (EXP4-EXP3)]/2 → average Atm but different land
- Different atmosphere forcing:
  [(EXP3-EXP1) + (EXP4-EXP2)]/2 → average land but different Atm

1. Different land and Atm forcing of monthly mean T and RH :

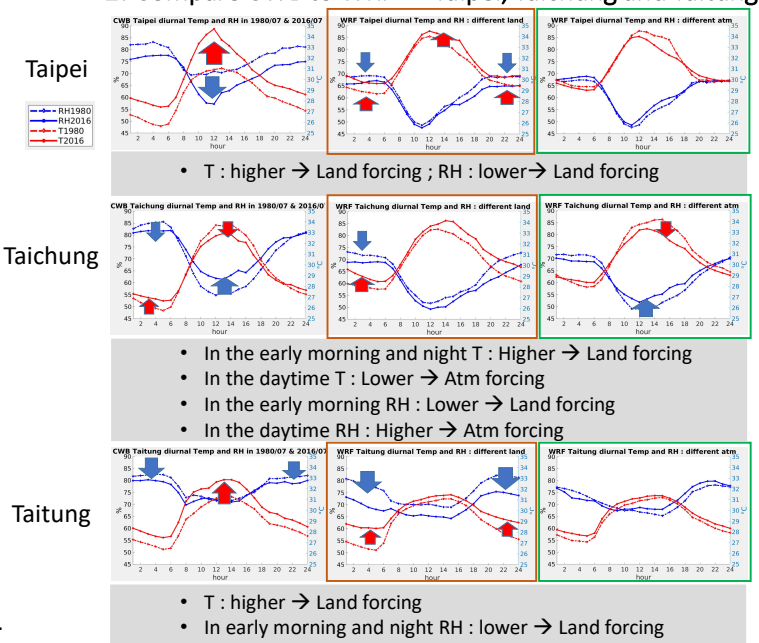


https://www.nature.com/articles/s41598-019-40063-1

Fig.1 Columns from left to right are the anomaly of monthly mean T and RH.

- Land forcing in the urban area : T → hotter ; RH→ lower
- Atm forcing in the urban area : T → lower ; RH → lower
- In the urban area : Land forcing > Atm forcing

2. Compare CWB to WRF --- Taipei, Taichung and Taitung:



- T : higher → Land forcing ; RH : lower→ Land forcing
- In the early morning and night T : Higher → Land forcing
- In the daytime T : Lower → Atm forcing
- In the early morning RH : Lower → Land forcing
- In the daytime RH : Higher → Atm forcing
- T : higher → Land forcing
- In early morning and night RH : lower → Land forcing

Fig.2 Diurnal variation of T. and RH in July 1980 (dotted line) and July 2016 (Solid line). Columns from left to right are CWB, WRF land forcing, and WRF atmospheric forcing.

3. Changes of Land-Sea Breeze & diurnal cycle :

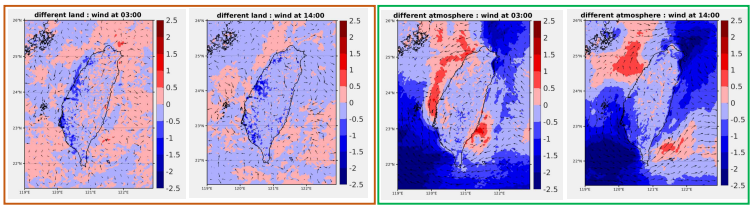
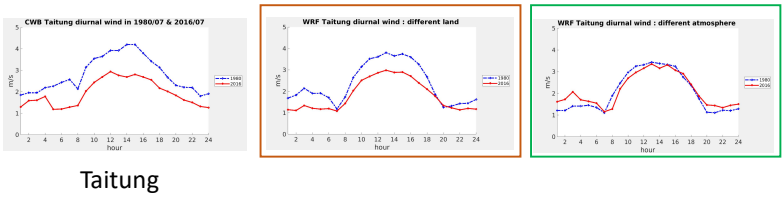


Fig.3 WRF simulated WS and wind direction at 3:00 and 14:00. Figures from left to right are WRF's land forcing and atmospheric forcing

- Land & Atm forcing → wind speed in urban area : lower
- Land & Atm forcing → wind direction in urban area : same



Taitung

Fig.4 The variation of diurnal WS in Taitung. However, WRF models bad in Taipei and Taichung so the two places are skipped here.

- Wind speed : lower → different land forcing

Discussion:

(a) T and RH were opposite in phase no matter the monthly mean or diurnal cycle. Because of RH highly react to the temperature and moisture content, the result may just show the increase or decrease of the T .

(b) Station data had the most largest variation in the noon in the diurnal cycle part; however, WRF data show large variation in the earthly morning and night. It means WRF still have some bias comparing with CWB.