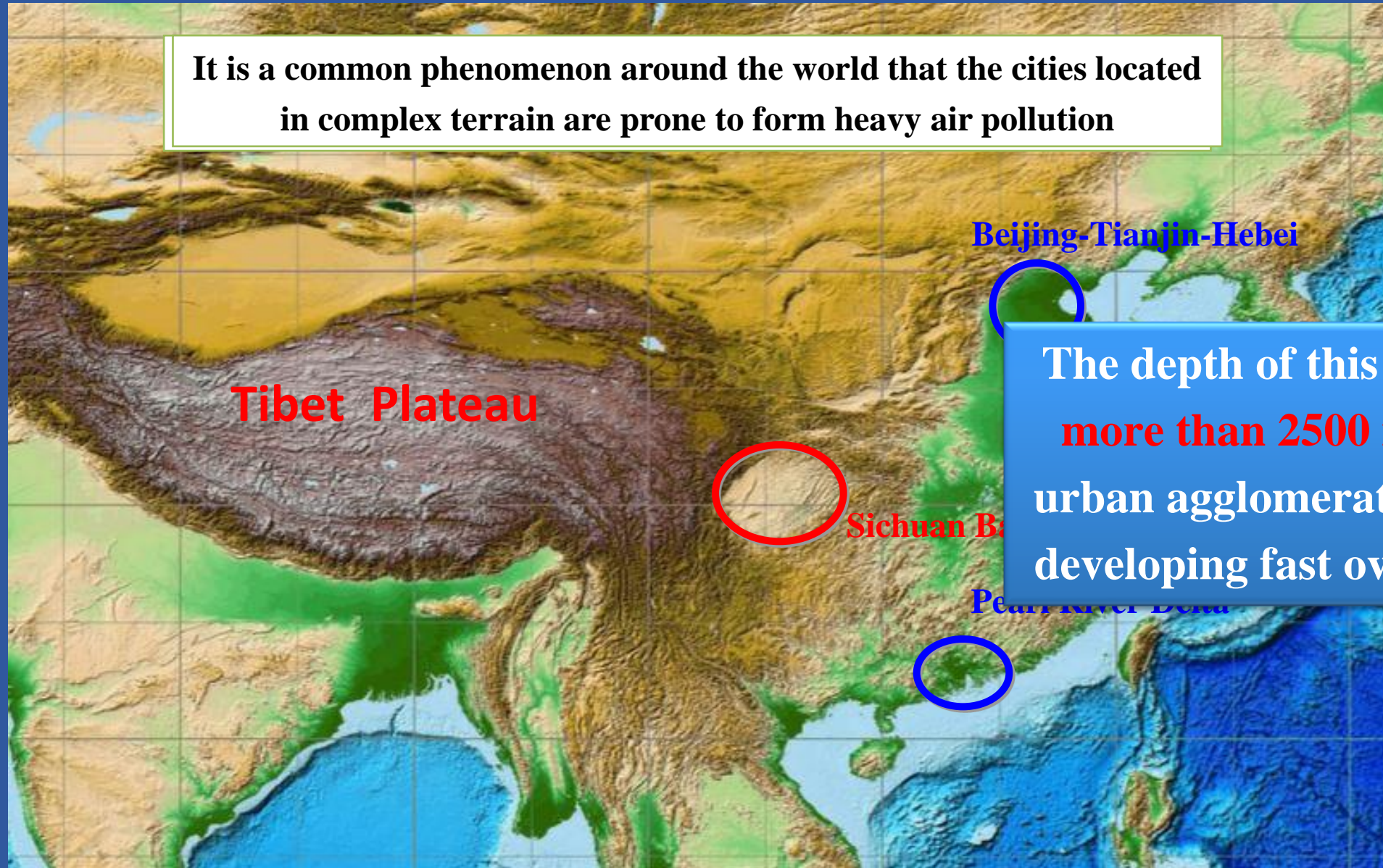# Factors influencing the boundary layer height and their relationship with air quality in the Sichuan Basin, China

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2020.4.20

It is a common phenomenon around the world that the cities located in complex terrain are prone to form heavy air pollution

Beijing-Tianjin-Hebei

Tibet Plateau

Sichuan Ba...

Pearl River Delta

The depth of this basin is more than 2500 m, and urban agglomerations are developing fast over there

Three-dimensional topographic map of Sichuan Basin

It is a common phenomenon around the world that the cities located in complex terrain are prone to form heavy air pollution

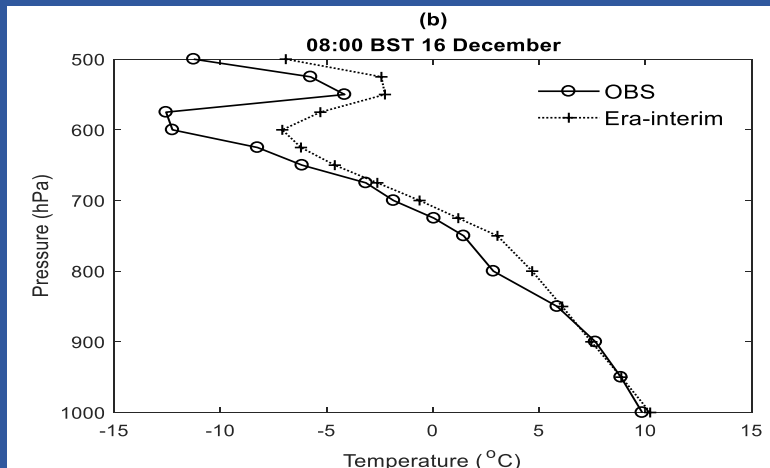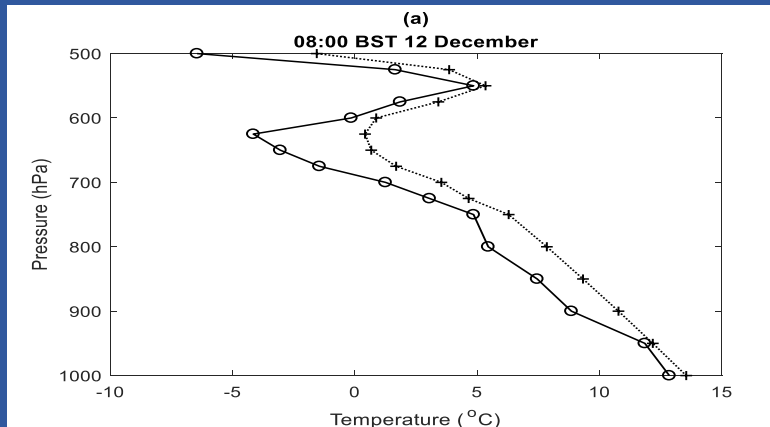Three-dimensional topographic map of Sichuan Basin
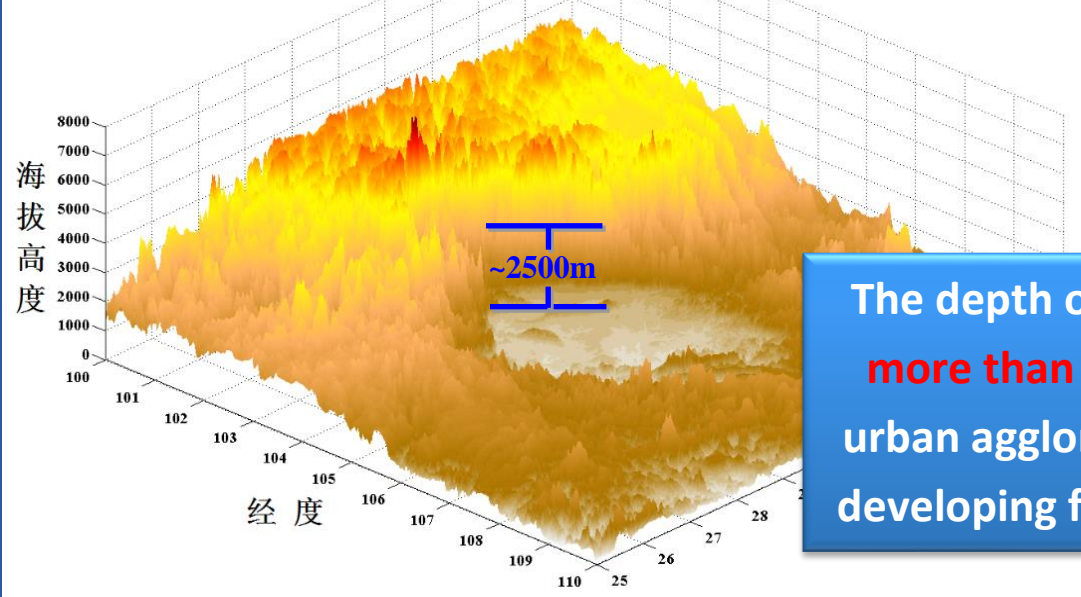
~2500m

海拔高度

经 度

The depth of this basin is more than 2500 m, and urban agglomerations are developing fast over there

Factors influencing the boundary layer height

1. the inversion temperature layer below the bottom of troposphere

(a) 08:00 BST 12 December

(b) 08:00 BST 16 December
OBS
Era-interim

The strong inversion layer in the lower troposphere over the Sichuan Basin leads to the accumulation of a large amount of water vapor below the inversion layer.
The inversion at the height of the plateau over eastern China is generated by the advection of warm air from the plateau, which provides favorable thermodynamic conditions for mid-level clouds
1. daytime: reflect and absorb a large amount of downward shortwave radiation, reducing the downward shortwave radiation to the basin surface. Then, the surface heating to the atmosphere is very slow
2. nighttime: stop the upward longwave radiation from the surface, the near surface temperature decreases slowly, the diurnal temperature range is small

Impact of inversion layer on the boundary layer height

Inversion temperature like a reverse pot cover

Sichuan Basin is like a basin

Pollutant concentration increases quickly because of limited atmospheric diffusion space.

Questions

1. How the impact of inversion layer on the boundary layer over the Sichuan Basin?
2. The traditional influencing factors on the boundary layer height is the surface sensible heat flux and wind shear. Are these factors would have effect on the boundary layer height over the Sichuan Basin?

Conclusion

- Factors affecting the boundary layer height (h_{max}) change in Sichuan Basin.

- The inversion layer in troposphere is the main factor affecting h_{max} on cloudy days.

- The vertical wind shear is the main factors affecting h_{max} on sunny days.

- The secondary circulation is much weaker on cloudy days than on sunny days.
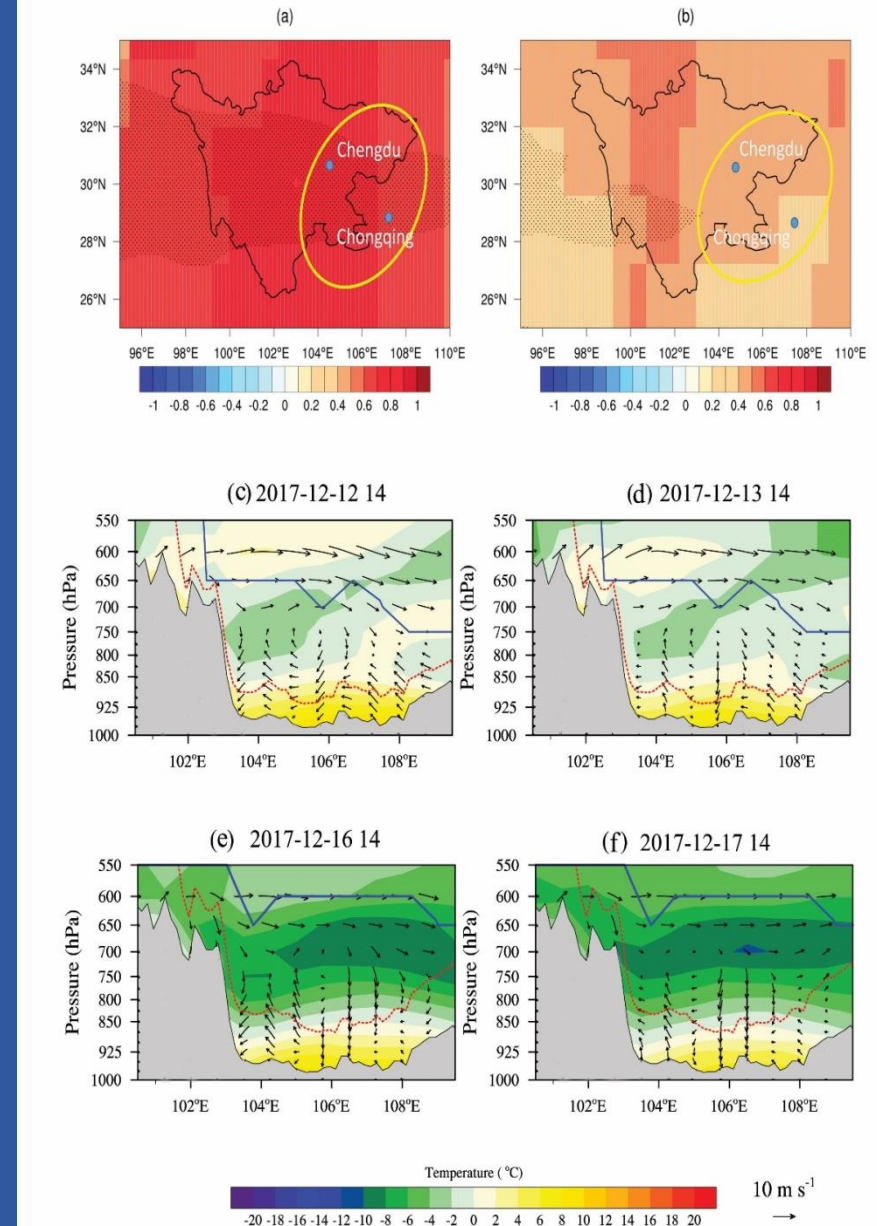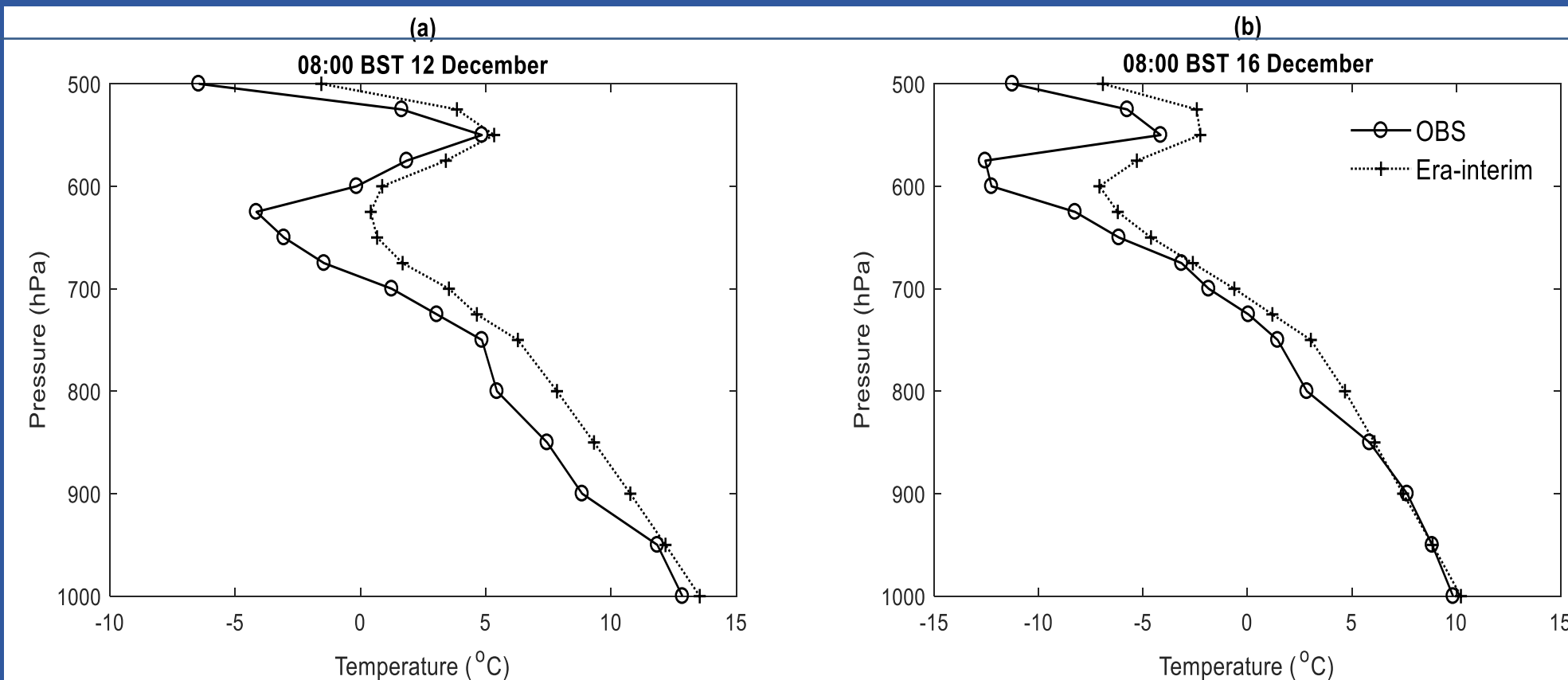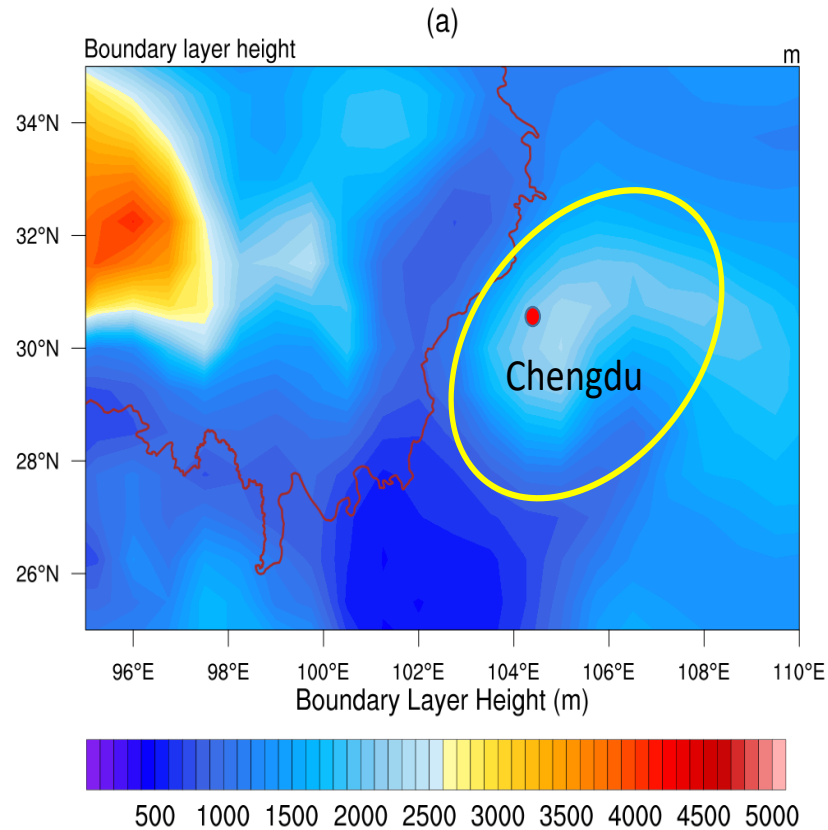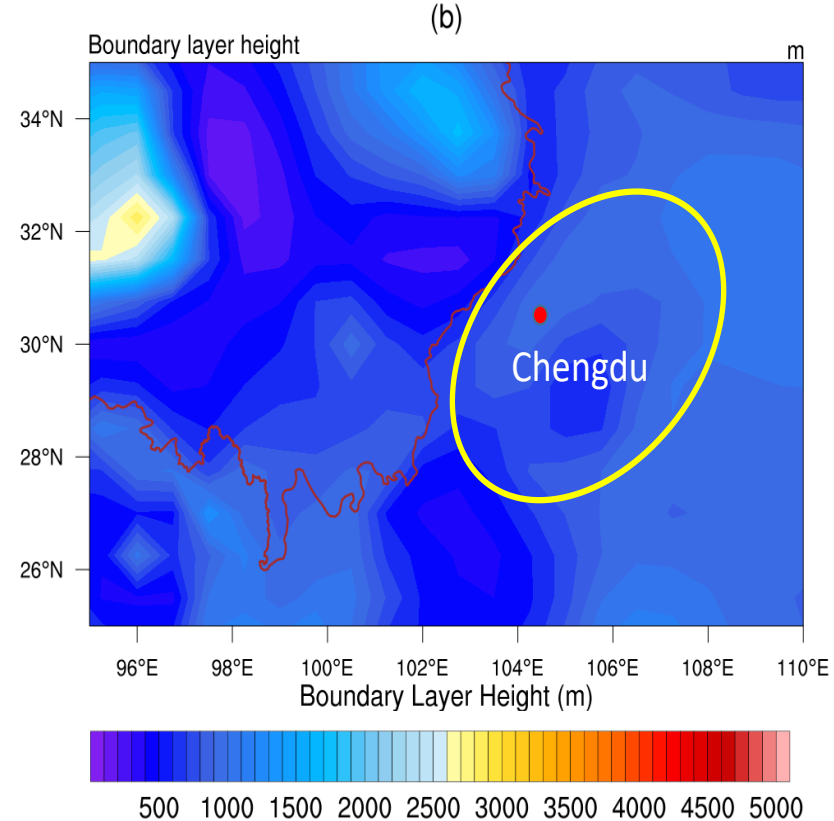
Fig. 2. Temperature profiles from the ERA-Interim Reanalysis and the observational datasets on (a) cloudy and (b) sunny days.
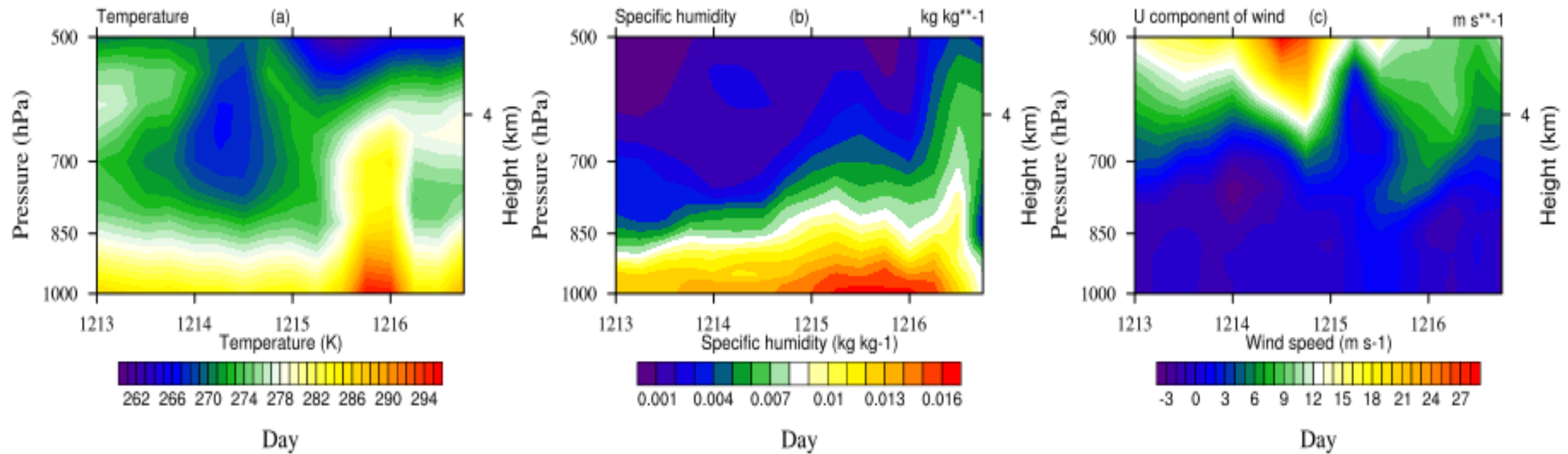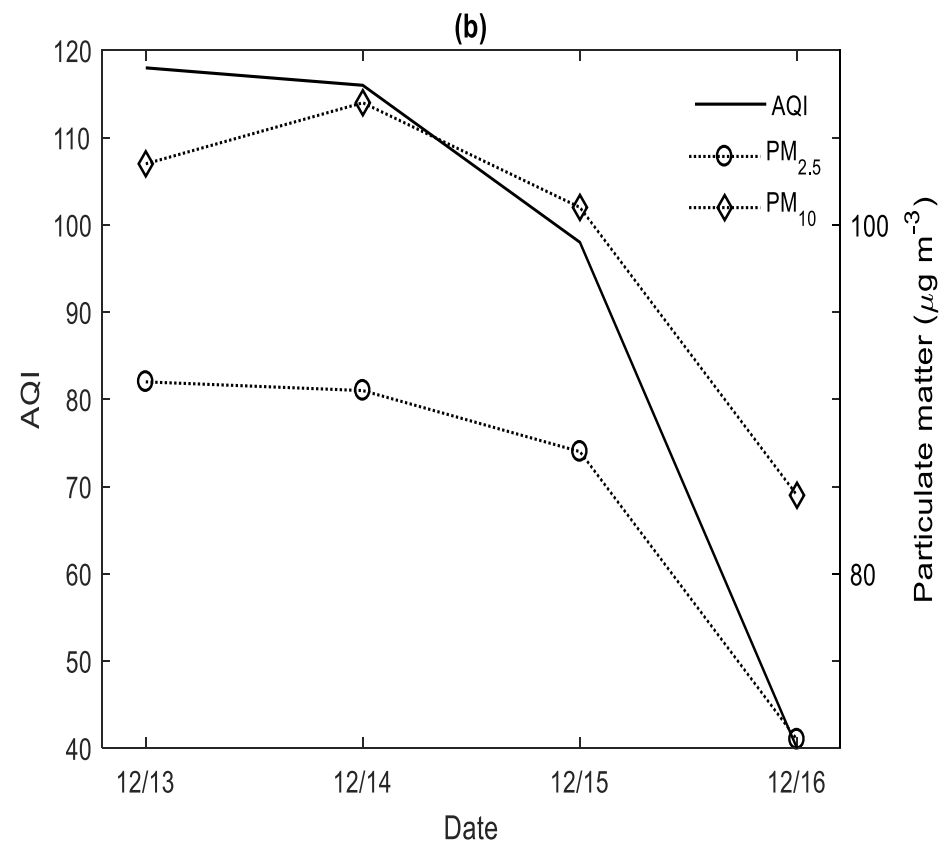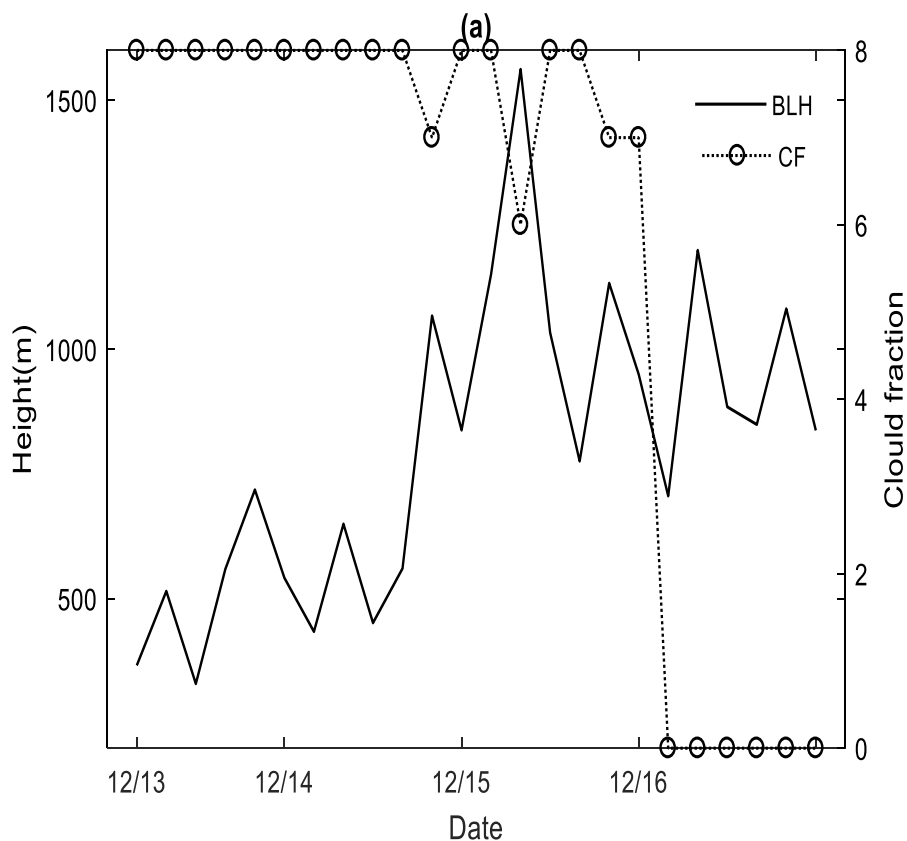
Sunny day

Cloudy day

h_{max} was higher on sunny days than on cloudy days

Fig. 3. Distribution of the boundary layer height in the Sichuan Basin on (a) sunny and (b) cloudy days in winter 2017–2018. The oval outline is the Sichuan Basin and the red line is the border of the Tibetan Plateau.

Transitional period from cloudy day to sunny day:
temperature-the inversion temperature layer disappears
relative humidity-the inversion layer in the specific humidity disappears
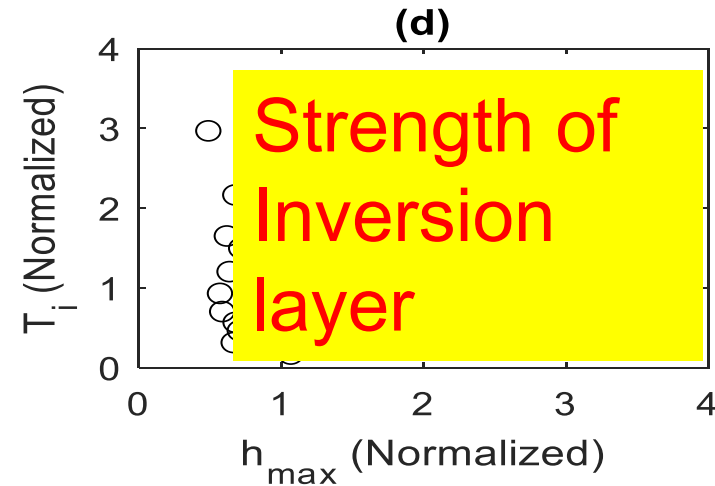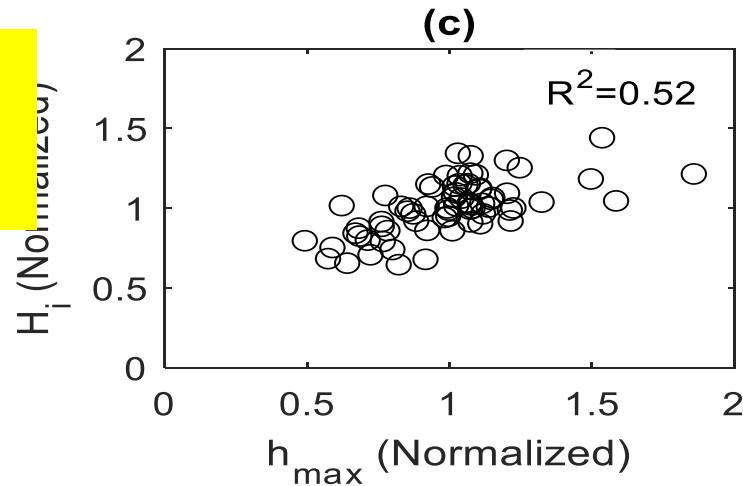horizon wind speed-the wind speed increases

Transitional period from cloudy day to sunny day:
the boundary layer height increases
the cloud cover decreases
the air quality becomes better

Factors influencing the boundary layer height

Inversion layer height

Strength of Inversion layer

Inversion layer height

Strength of Inversion layer
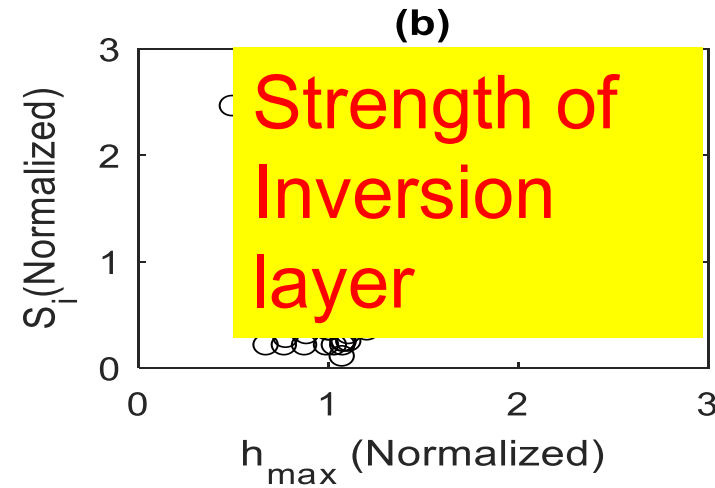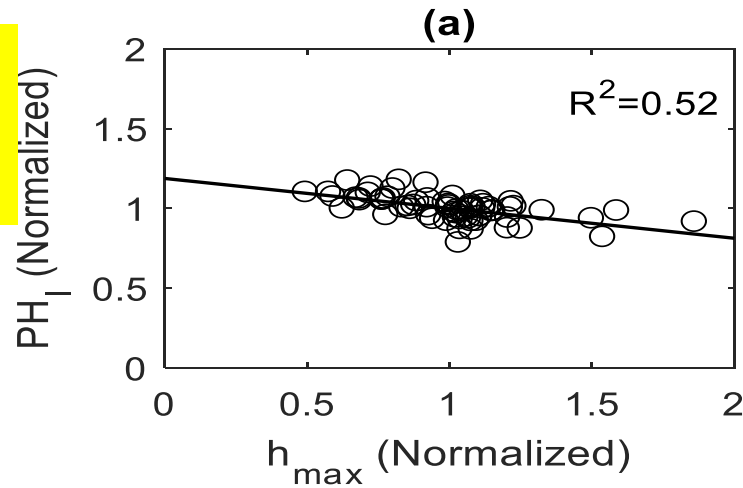
During cloudy days, strong correlation between PH_i and h_{max} with a correlation coefficient , The correlation between S_i and h_{max} was lower than that of PH_i

Fig. 6. Relation between the height of the base of the inversion layer and (a) PH_i and (c) H_i, (b) the inversion temperature (S_i) and (d) the thickness of the inversion layer (T_i) and the boundary layer height on cloudy days.

Inversion temperature like a reverse pot cover

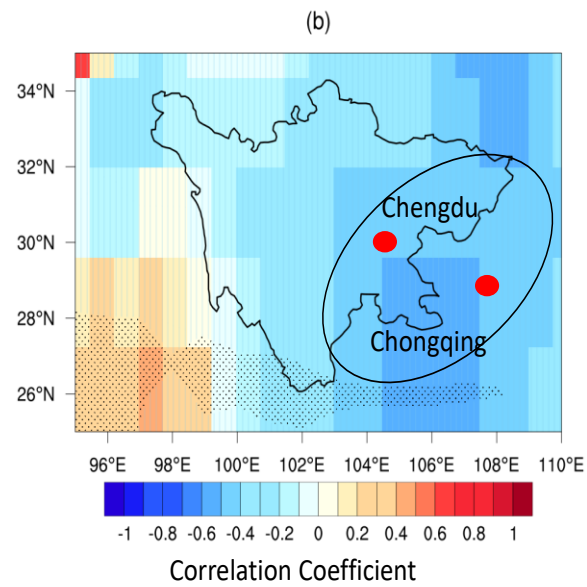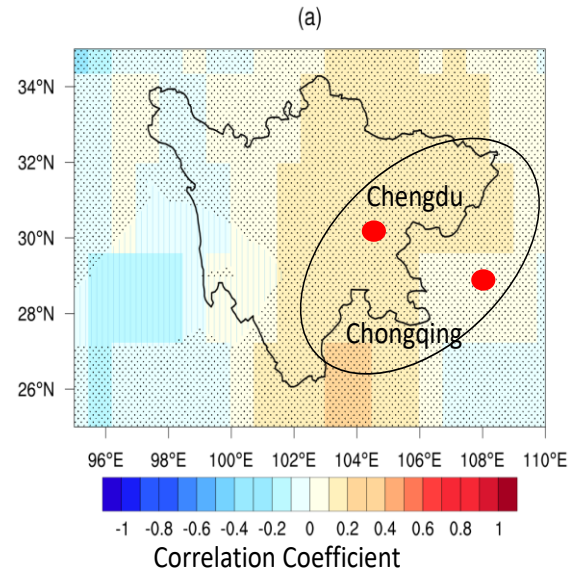Sichuan Basin is like a basin

Pollutant concentration increases quickly because of limited atmospheric diffusion space.

Sunny day

Cloudy day

good correlation between h_{max} and the sensible heat flux in the central Sichuan Basin on sunny days than that on the cloudy days
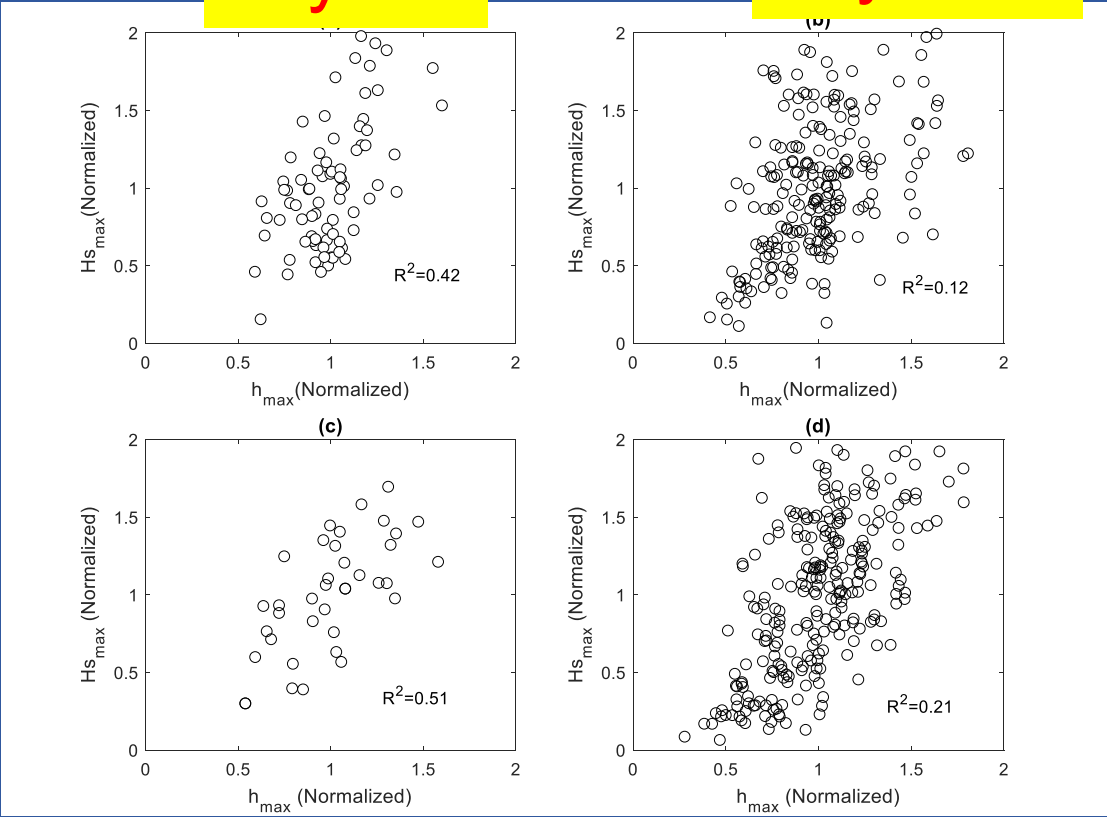

Fig. 7. Significance test of the correlation between the sensible heat flux and h_{max} on (a) sunny and (b) cloudy days in Sichuan Province. The leftmost red dot is Chengdu and the rightmost red dot is Chongqing. The oval shape reflects the outline of the Sichuan Basin.

Sunny day

Cloudy day

Chengdu

Chongqing

good correlation between h_{max} and the sensible heat flux in the central Sichuan Basin on sunny days than that on the cloudy days

Fig. 8. Correlation between the sensible heat flux and h_{max} at Chengdu on (a) clear and (b) cloudy days and at Chongqing on (c) clear and (d) cloudy days.
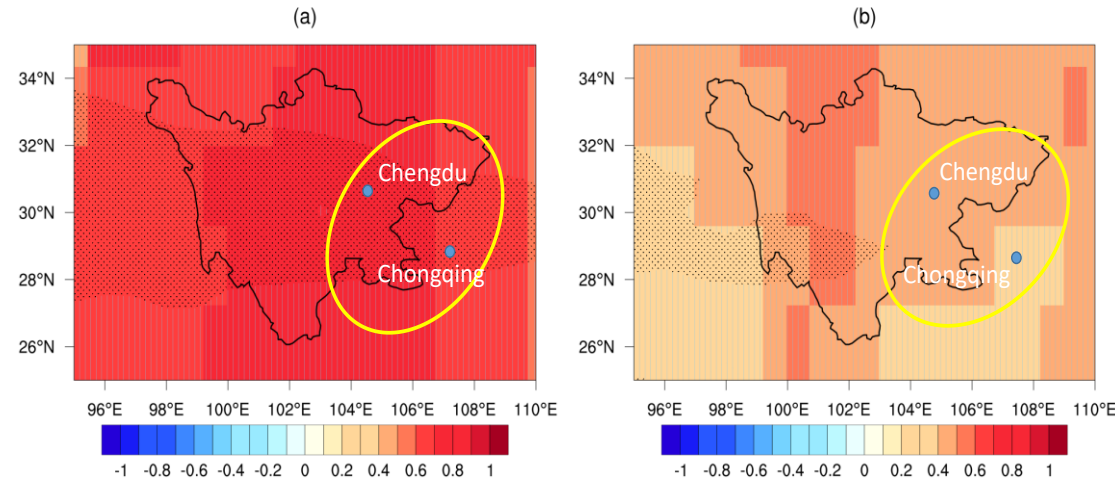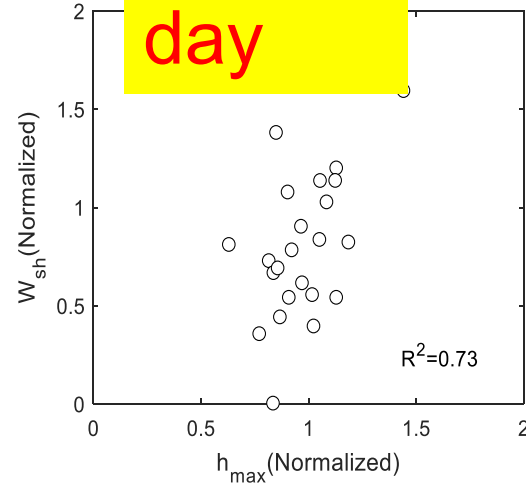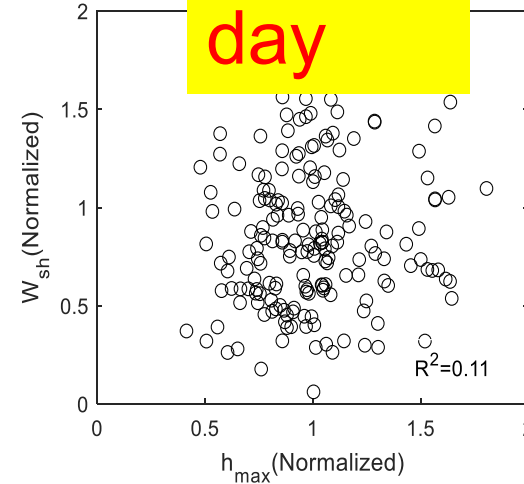
Sunny day

Cloudy day

The correlation between h_{max} and the turbulent surface stress in the central region of the Sichuan Basin was excellent on sunny days than that on cloudy days

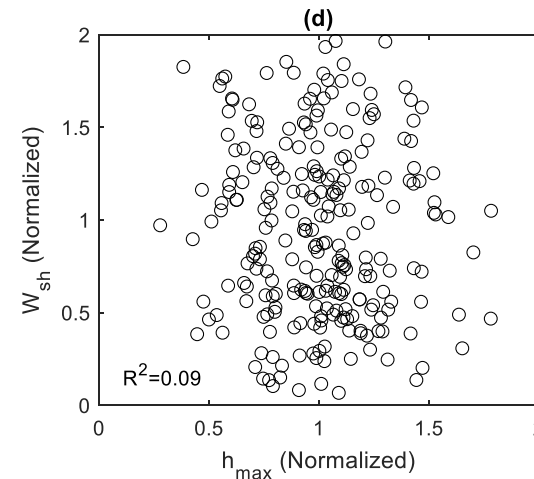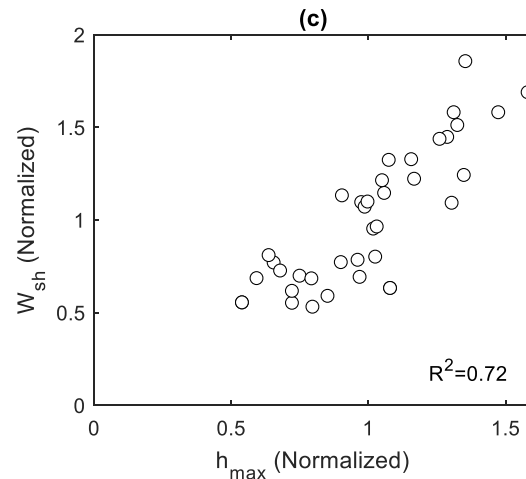Fig. 9. Significance test of correlation between the wind shear and the boundary lay[er] cloudy and (b) sunny days in Sichuan Province. The oval shape reflects the outline o[f] Basin.

Fig. 10. Relationship between wind shear and the boundary layer height at Chengdu on (a) clear and (b) cloudy days and at Chongqing Station on (c) clear and (d) cloudy days.

Cloudy day

Sunny day

Inversion layer height

Boundary layer height
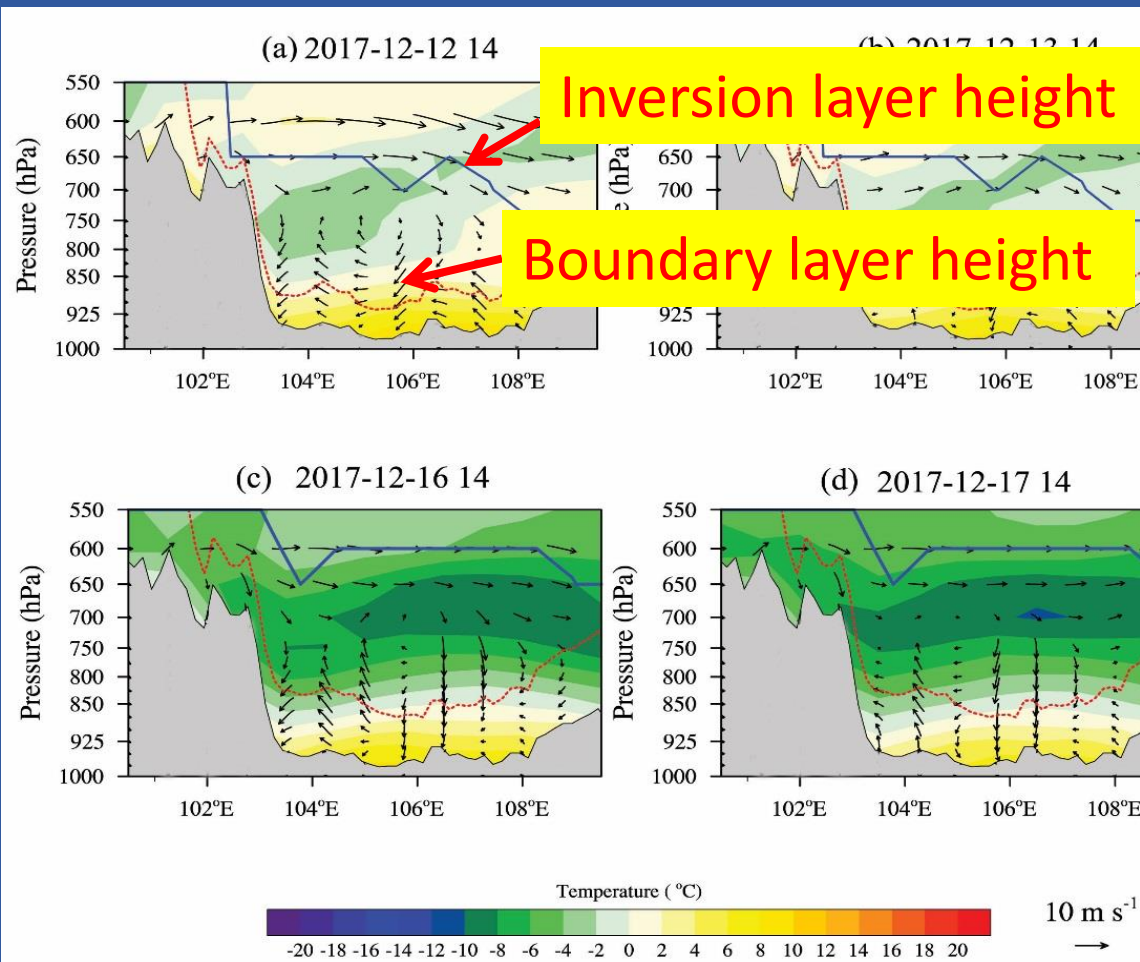
The secondary circulation in the boundary layer was stronger on sunny days than on cloudy days. This stronger secondary circulation increased the wind shear and turbulent mixing and provided the energy required to increase h_{max}.

Fig. 11. West–east vertical cross-sections of temperature (shading; units: °C) and wind vectors (synthesized by u and w) through the Sichuan Basin (30.75° N) on sunny days at (a) 14:00 BST on December 12, 2019, (b) 08:00 BST on December 13, 2017 and on cloudy days at (c) 14:00 BST on December 16, 2017 and (d) 14:00 BST on December 17, 2017. The vertical velocity is multiplied by 100 when plotting the wind vectors. The most polluted area is marked by red dots . The gray shading represents the terrain. The solid line represents the base of the inversion layer and the red dotted line represents h_{max}. This area is not clearly visible.

Thank you!