

Foehn-like wind with a traditional foehn effect plus dry-diabatic heating from the ground surface contributing to high temperatures at the end of the leeward area

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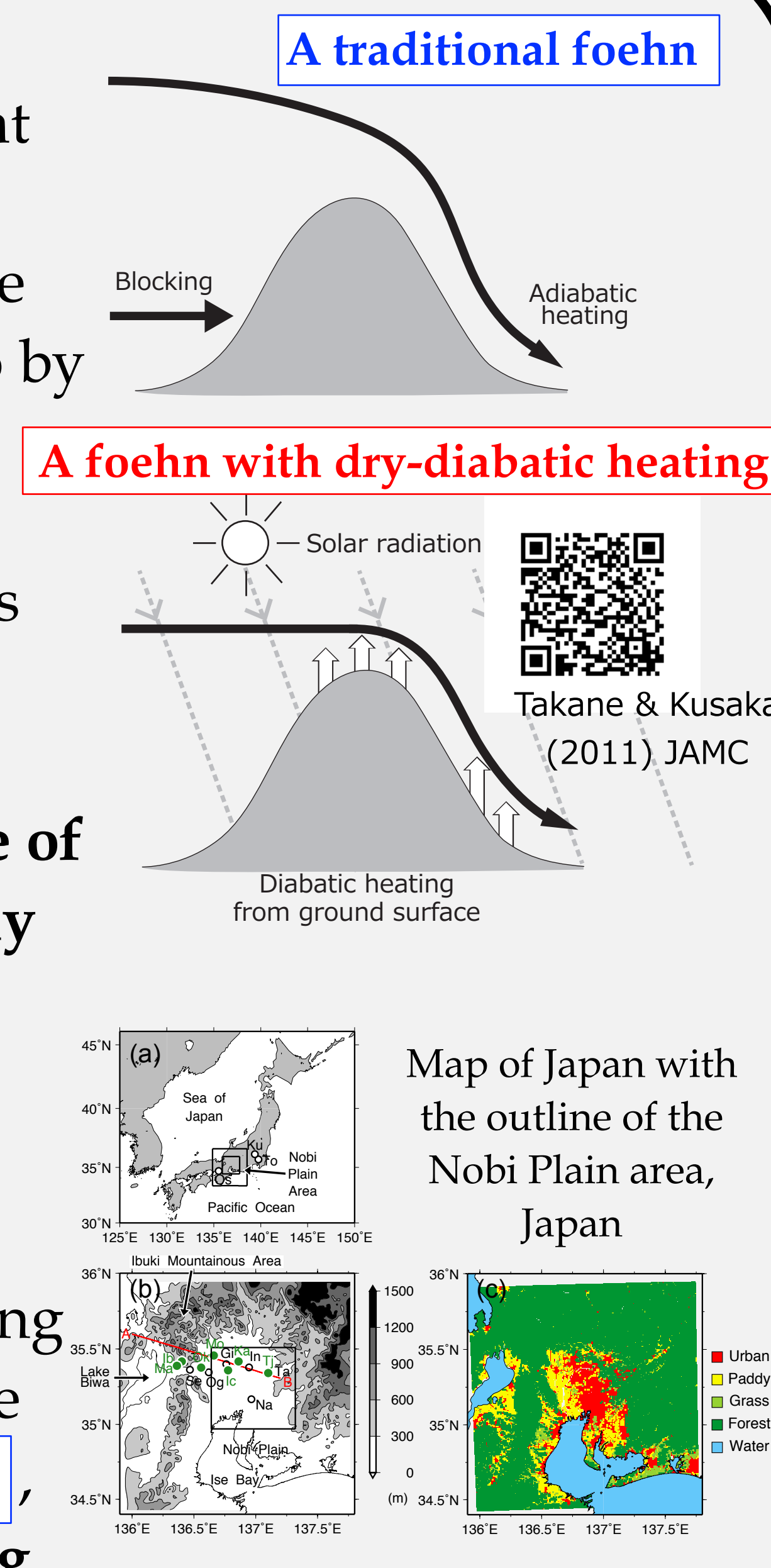
Acknowledgment

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Introduction

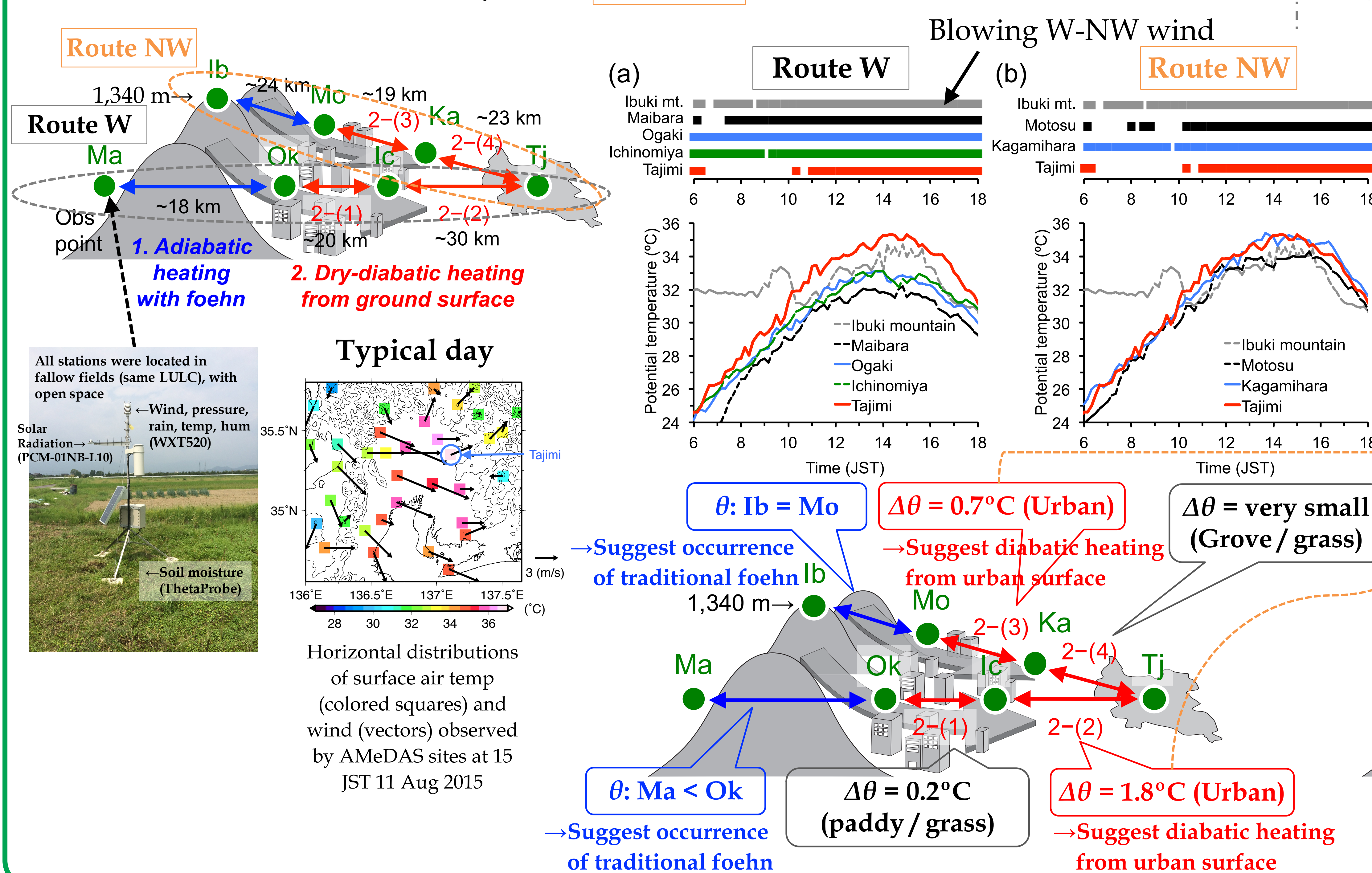
Extreme high-temperature (EHT) events, including heat waves relating to climate change, have recently occurred frequently in many parts in the world. The EHT events are triggered not only by global and synoptic factors, but also by meso- and microscale factors. In geographically complex regions, including near complex terrain, basins, seas, and urban areas, EHTs are influenced by many factors, such as Urban Heat Island, foehn winds, basin effects (including thermally induced local circulations), and sea breezes.

A foehn wind is an important factor in the occurrence of many extreme high-temperature events in geographically complex regions. In this study, we verified the hypothesis that a foehn-like wind contributes to high temperatures at the end of the leeward (eastward) area using three difference approaches: **field experiments**, **numerical experiments**, and **statistical analyses**. According to the hypothesis, a foehn-like wind has the features of the sum of **a traditional foehn effect with adiabatic heating**, plus **dry-diabatic heating from the ground surface** along the fetch of the wind.



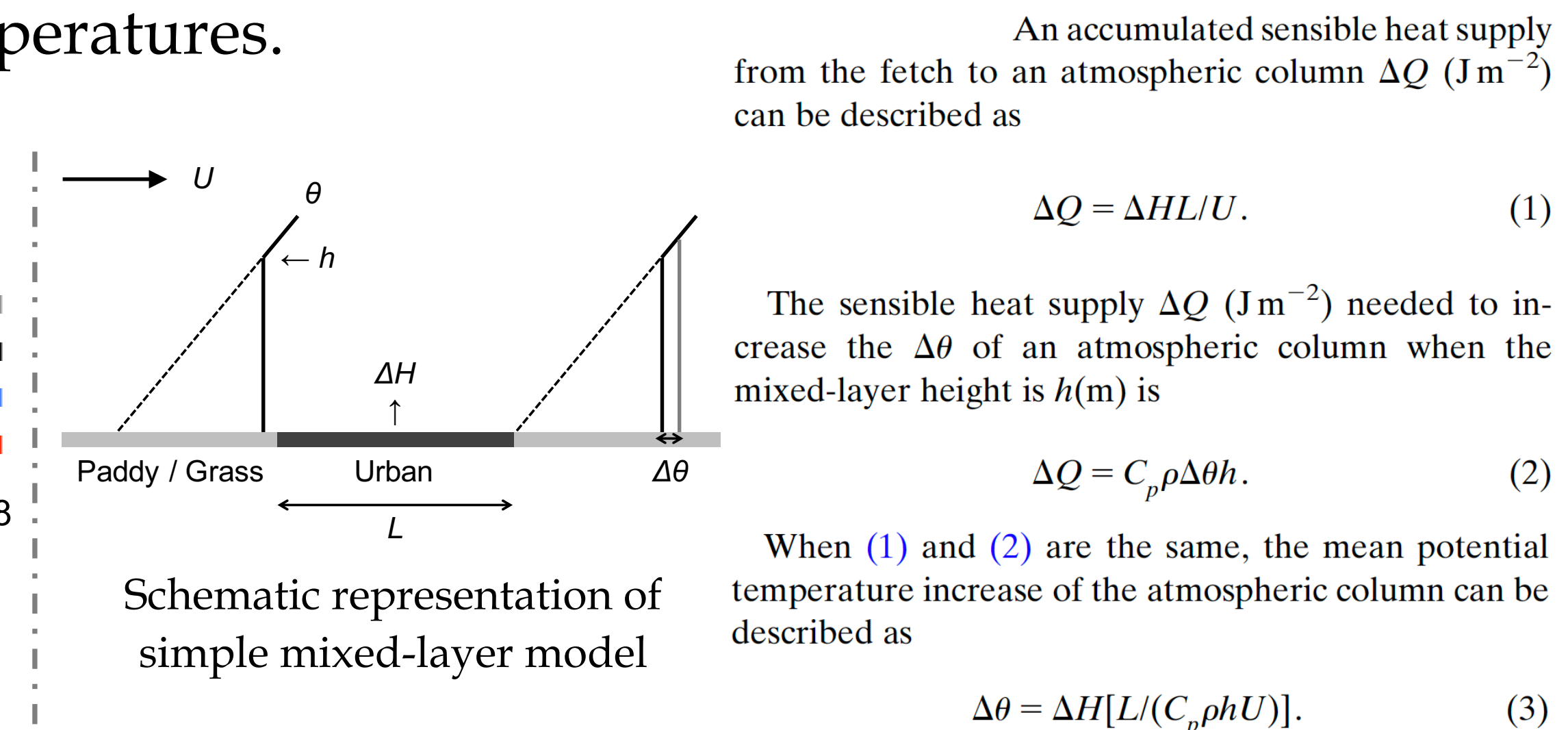
Field experiment (Observation)

We conducted field experiments at seven points around the Nobi Plain, Japan from 1 to 31 August 2015 to observe surface meteorological elements in the locations at which the mesoscale westerly wind blew over the Nobi Plain. The Maibara (Ma), Ogaki (Ok), Ichinomiya (Ic), and Tajimi (Tj) stations were located along the track of the mesoscale westerly wind (**Route W**). In addition, the Motosu (Mo), Kakamigahara (Ka), and Tajimi (Tj) stations were located along the track of the mesoscale northwesterly wind (**Route NW**).



Diabatic heating derived using a mixed-layer model

To confirm **the diabatic heating from the urban surface**, the simplified estimate of the effect of this on the potential temperature increase on the leeward area was obtained using a **simple mixed-layer model**, and the results were compared to the observed potential temperatures.



The W and NW winds were influenced by dry-diabatic heating from the ground surface (especially from an urban surface) over the fetch of the wind

Numerical experiment

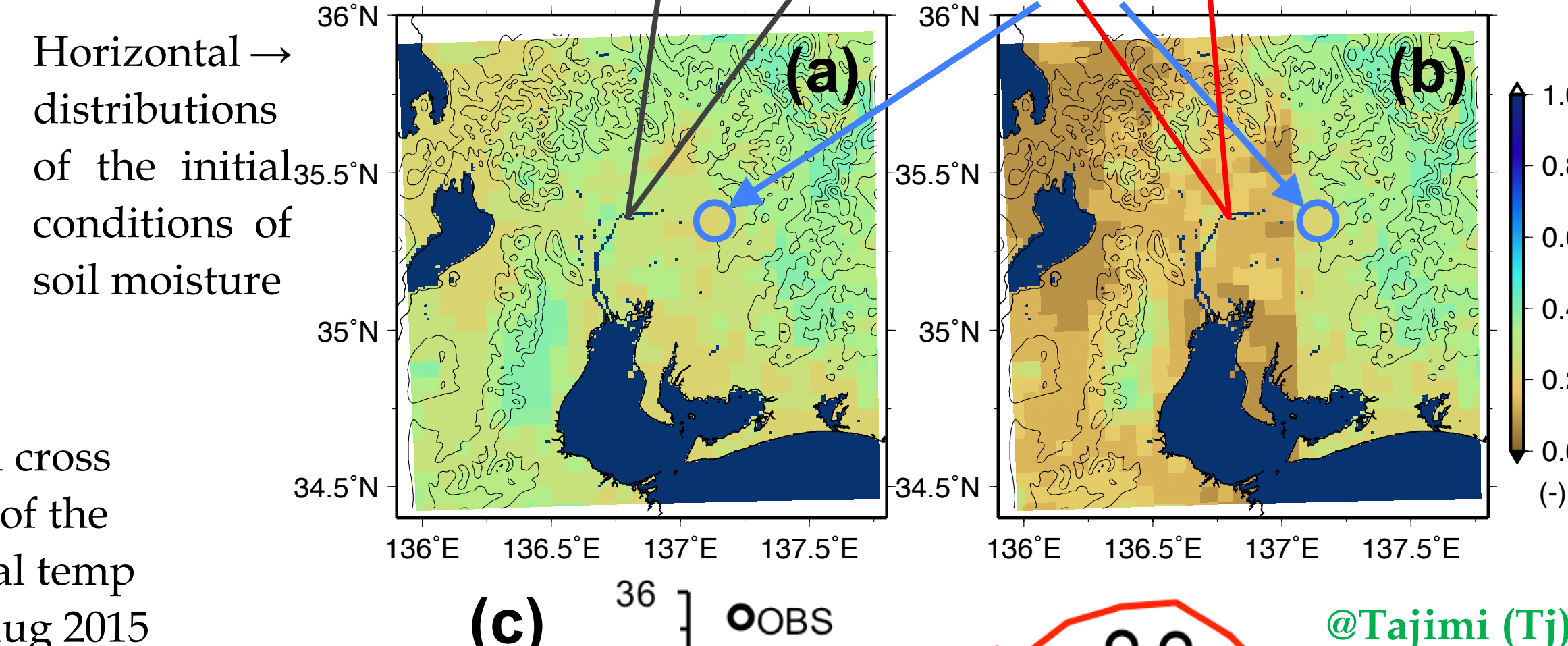
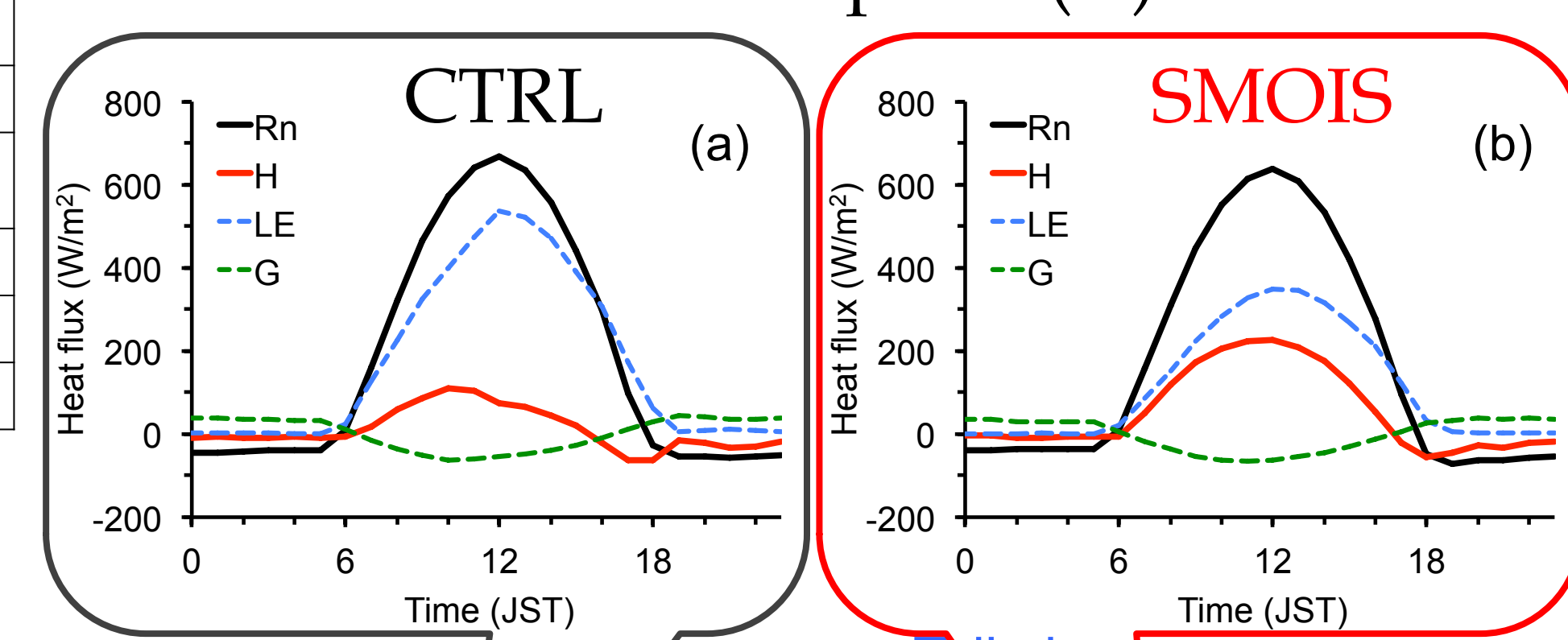
We used the WRF model to determine (recheck) dry-diabatic heating from the windward ground surface.

Model setting

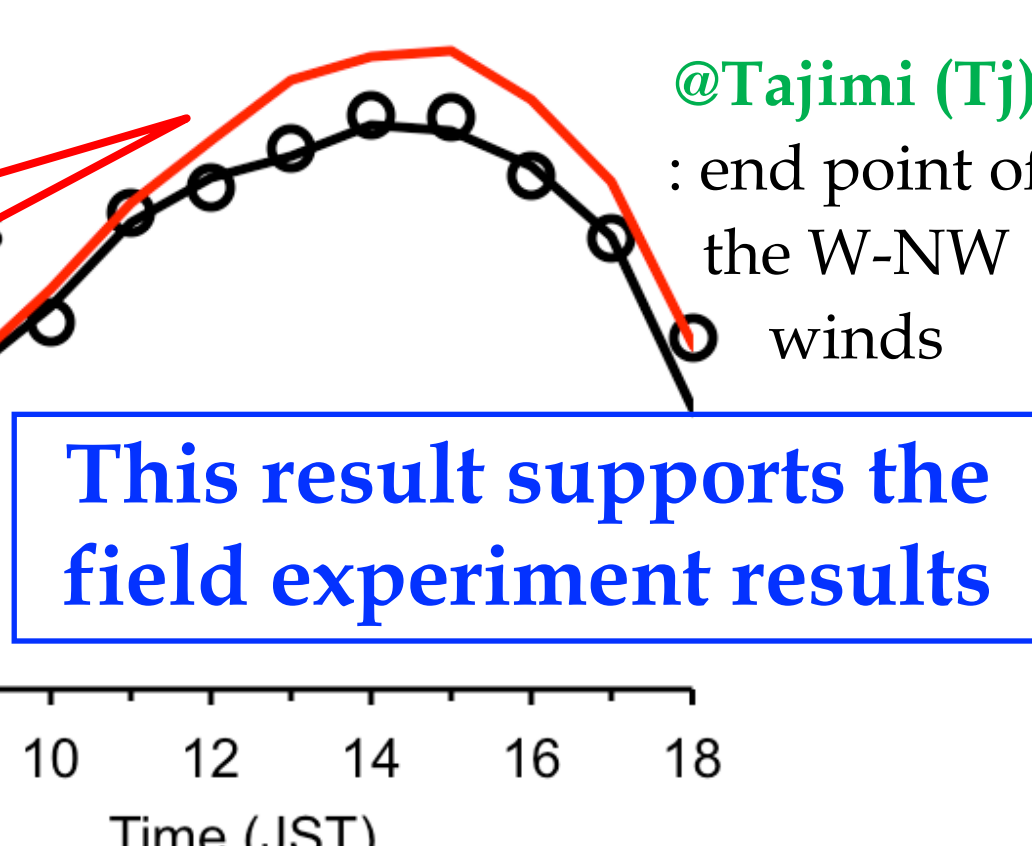
Model	WRF ver. 3.1.1
Boundary data	NCEP-NCAR reanalysis
Integration period	9 – 12 August 2015
Horizontal resolution	2.7 (d01), 0.9 (d02), 0.3 km (d03)
Vertical levels	42 layers
Land scheme	Noah land surface model
Urban scheme	Single-layer urban canopy model

Sensitivity experiment of soil moisture over the windward area

Windward point (Ic)

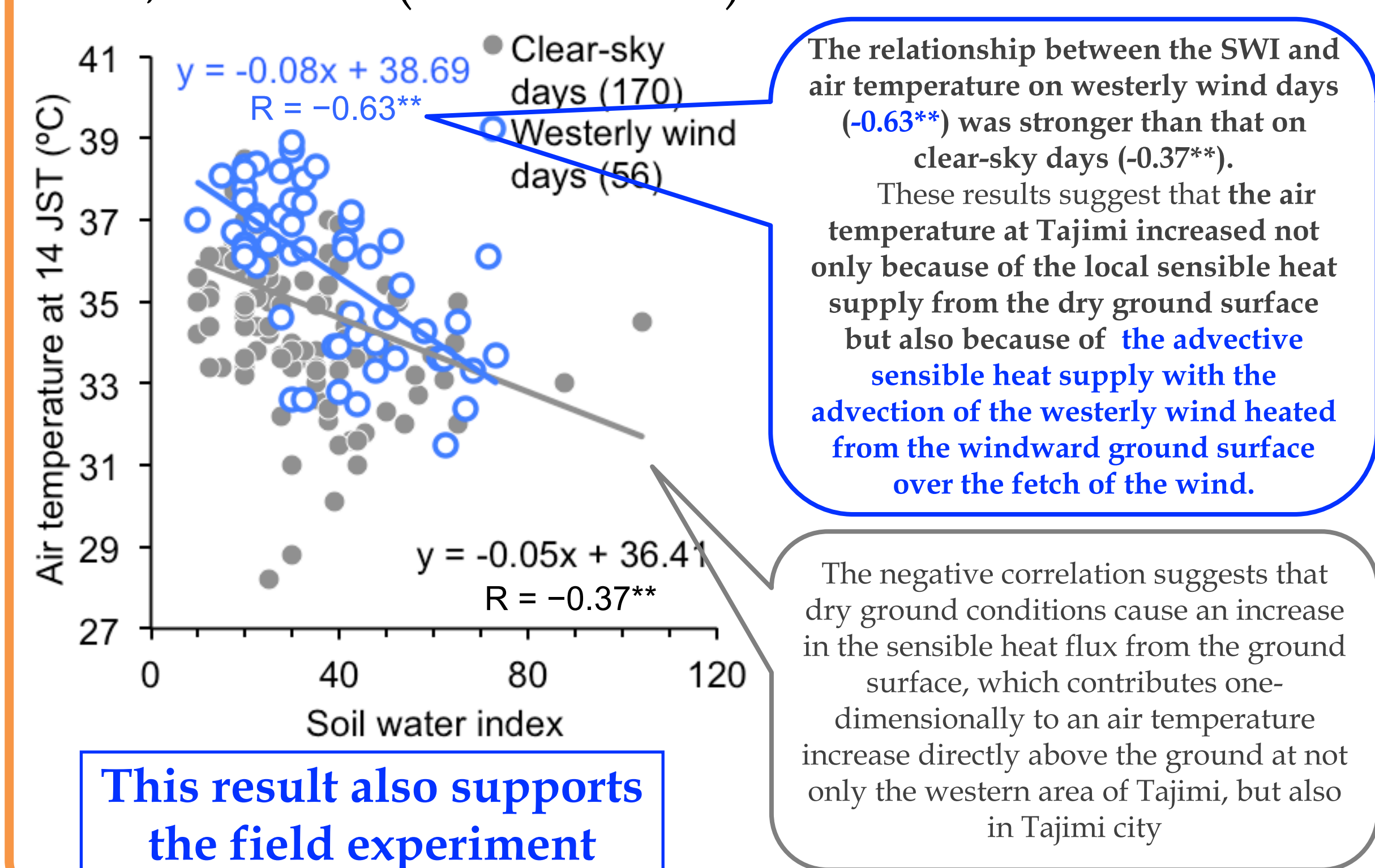


The SMOIS was clearly higher than that of CTRL after around 11 JST when the westerly wind began to blow at Tajimi



Statistical analysis

The effect of diabatic heating from the ground surface on air temperature in the leeward area was also assessed by a statistical analysis using observational data, and SWI (soil moisture) data



Summary

- Field experiments** conducted at seven observational points on Nobi Plain, Japan, where a mesoscale westerly wind blew, revealed that **the westerly wind clearly had the features of a traditional foehn effect** in the western part of the Nobi Plain.
- In addition to **field experiments**, a simplified estimate using a **simple mixed-layer model** demonstrated that **the wind was further heated by dry-diabatic heating (sensible heat supply) from the ground surface** along the fetch (especially in urbanized areas in the eastern region of the Nobi Plain) of the wind.
- This diabatic heating effect** along the fetch of the wind on the high temperature at the end of the leeward area **was also supported by both additional numerical experiments and a statistical analysis**.
- These results proved that **the hypothesis is correct** and indicated that ground conditions and the land use and land cover (LULC) in the windward area were strongly related to air temperature at the end of the leeward area, where an extremely high temperature was observed.

