Fog suppresses microclimate spatiotemporal variability by weakening land–atmosphere interactions

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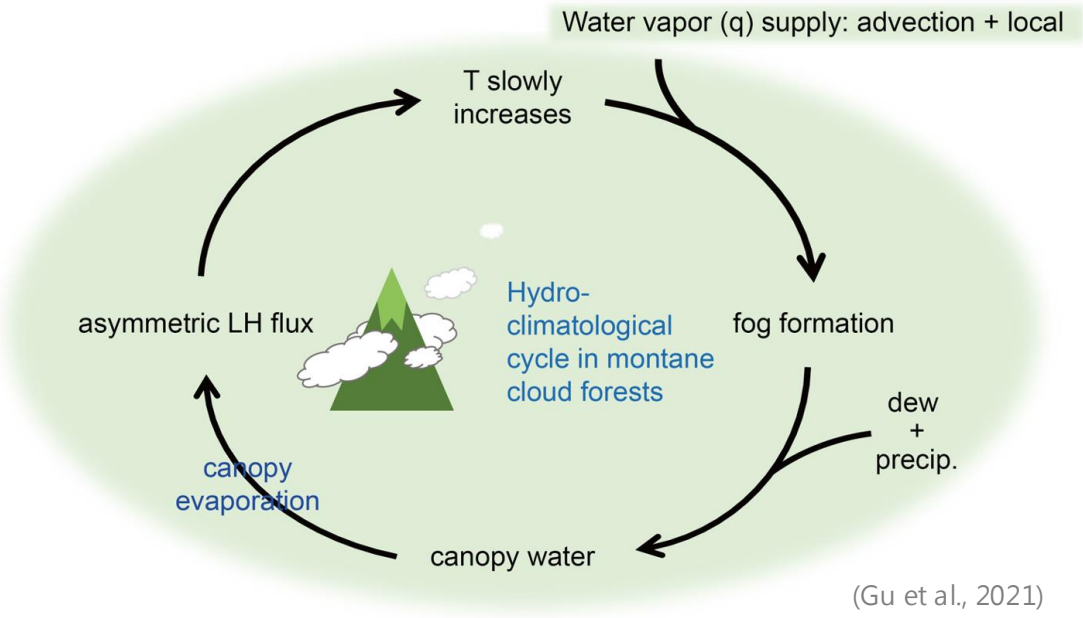
HydroClimatology Group

at Department of Atmospheric Sciences, National Taiwan University

The unique **diurnal cycle** of the montane cloud forests (MCFs)

Local evapotranspiration

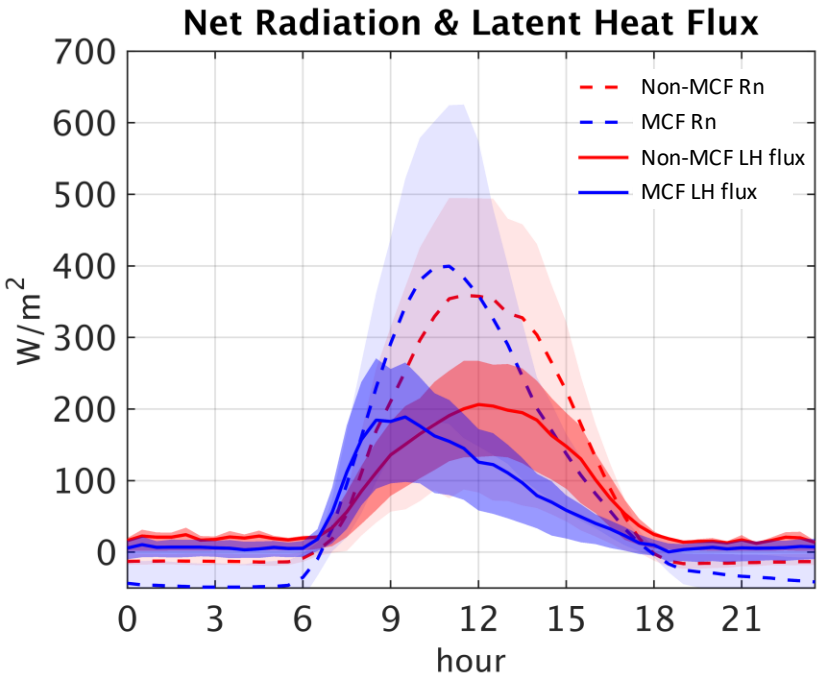
Valley wind advection

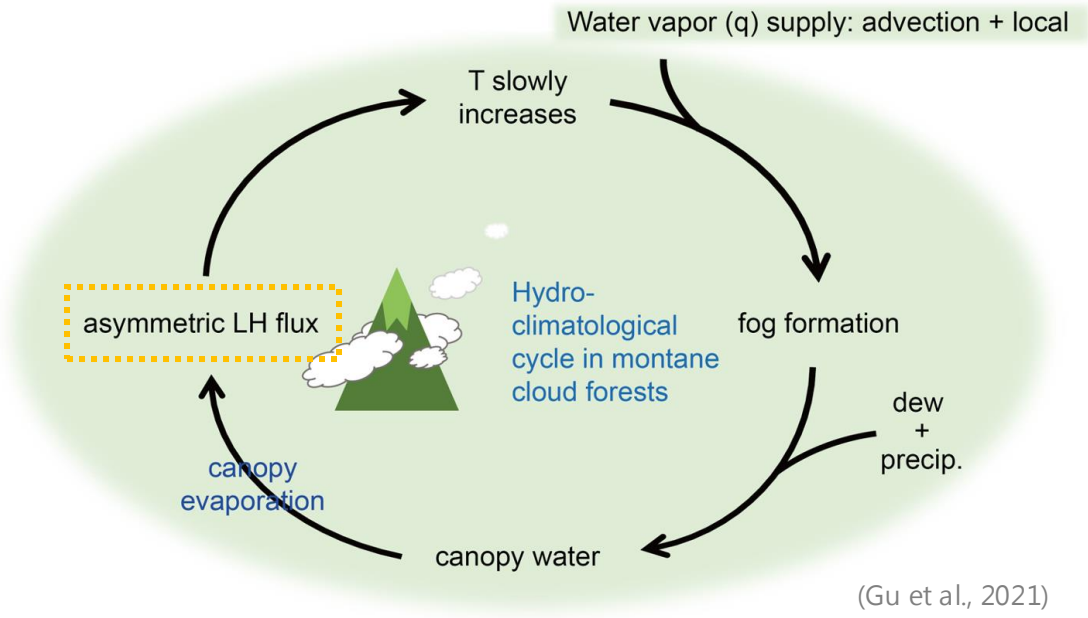


(Gu et al., 2021)

The unique **diurnal cycle** of the MCFs

Asymmetric diurnal cycle of latent heat (LH) flux with early peak



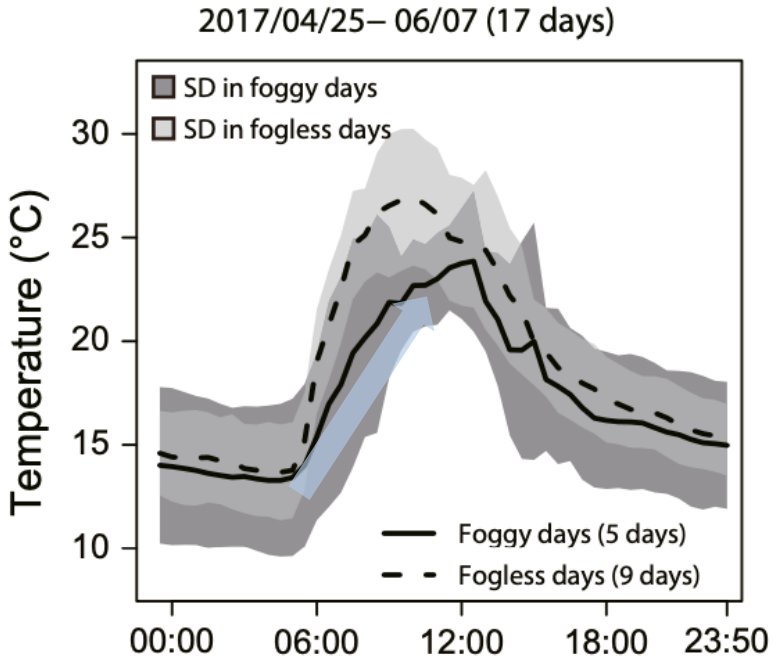


(Gu et al., 2021)

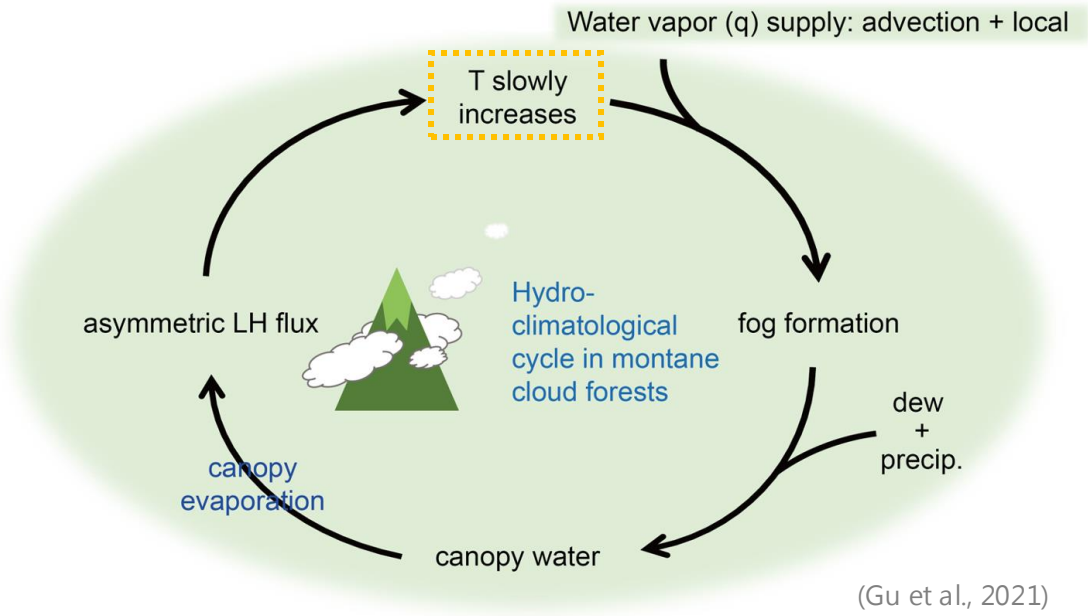
Canopy evaporation contributes to the early-morning LH flux.

The unique **diurnal cycle** of the MCFs

Slowly increasing morning temperature on foggy days



(Jang et al., 2022)



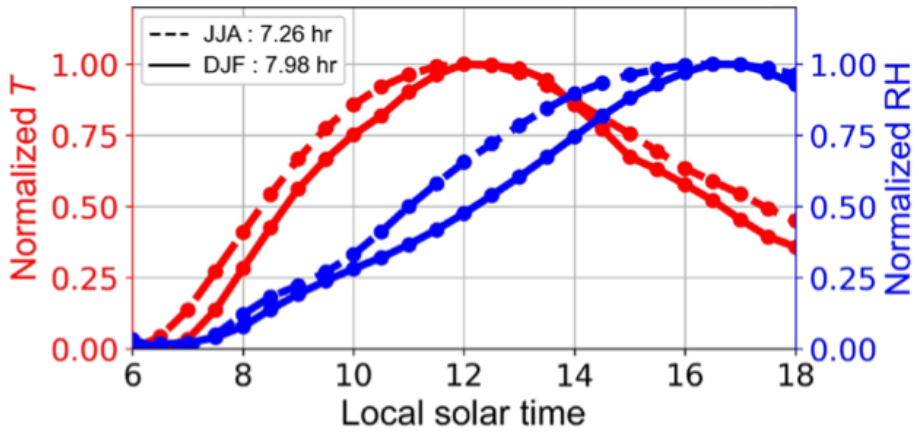
(Gu et al., 2021)

Slower daytime warming leads to stable diurnal temperature range.

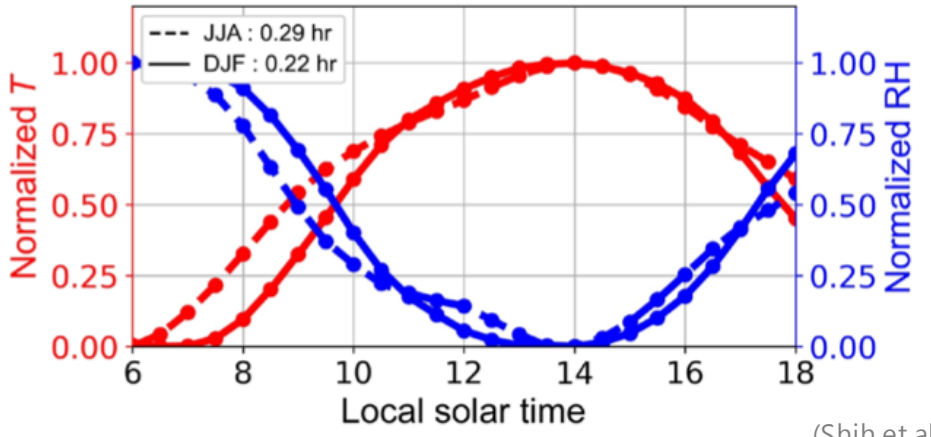
The unique **diurnal cycle** of the MCFs

Increasing *Q* and slow *Qs* growth results in the rising RH during the day.

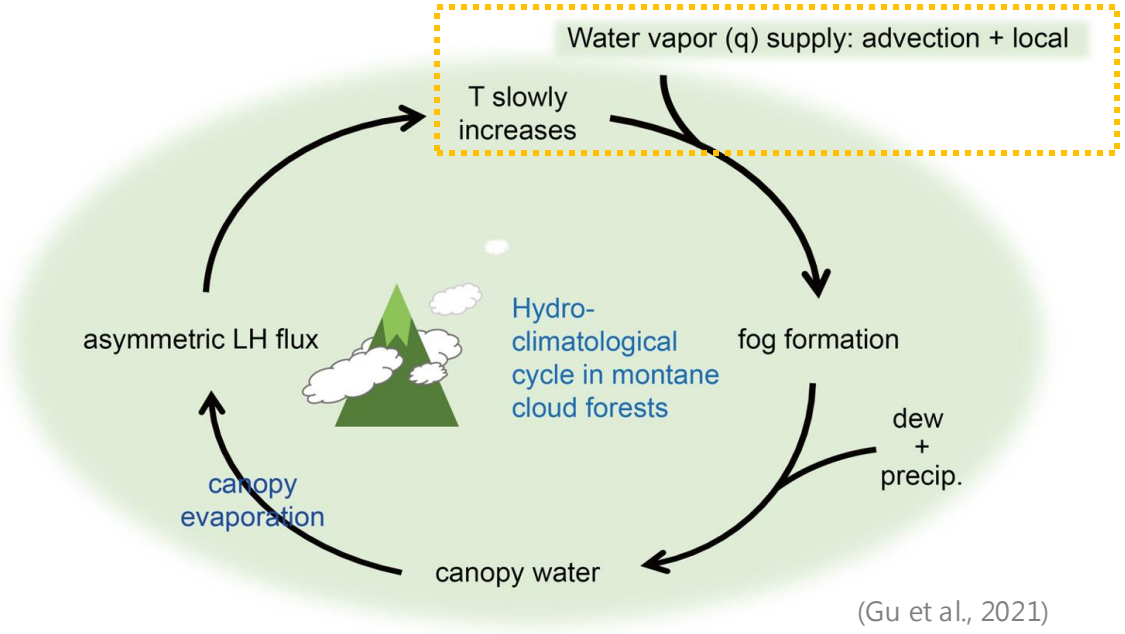
MCF



Non–MCF



(Shih et al., 2025)

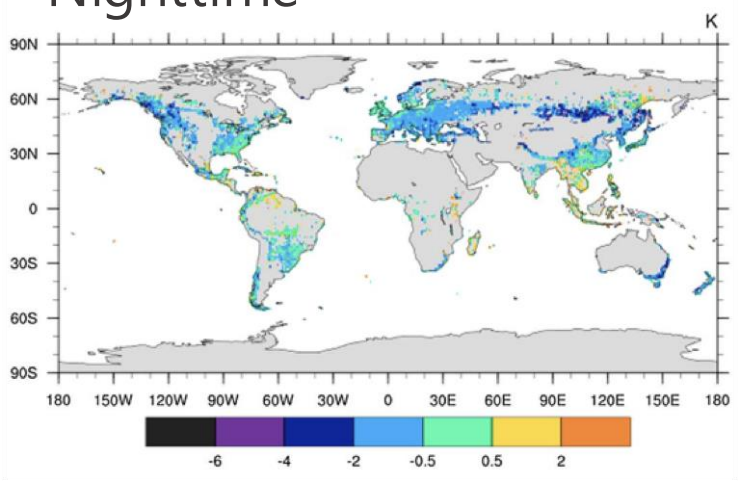


(Gu et al., 2021)

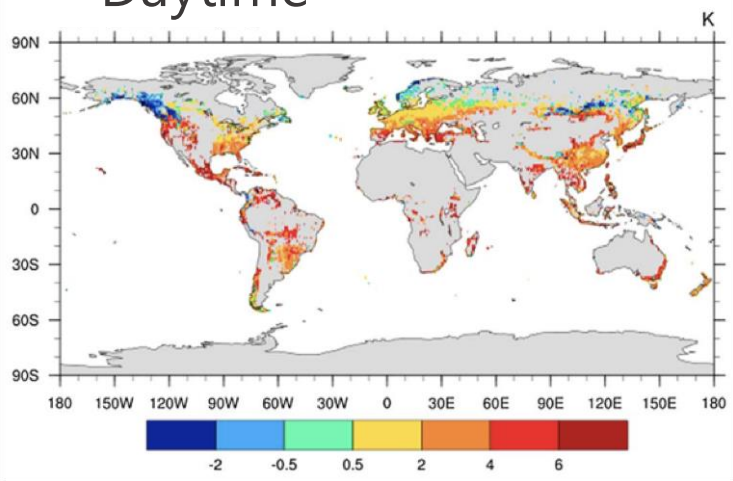
Heterogeneous land-use types in MCFs

Annual differences in surface temperature (open-forest)

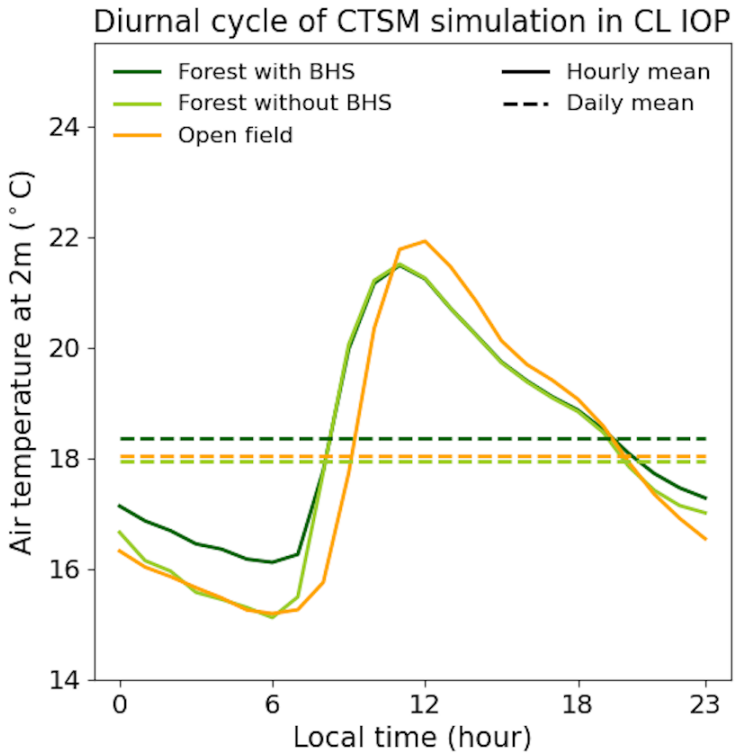
Nighttime



Daytime



(Schultz et al., 2017)

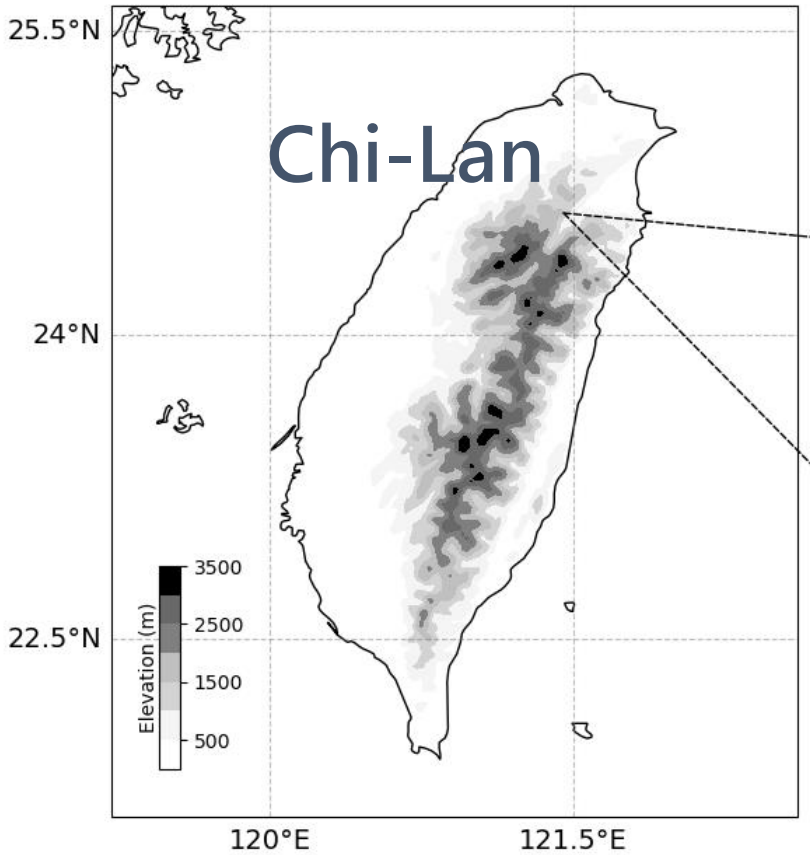


(Jang et al., 2017)

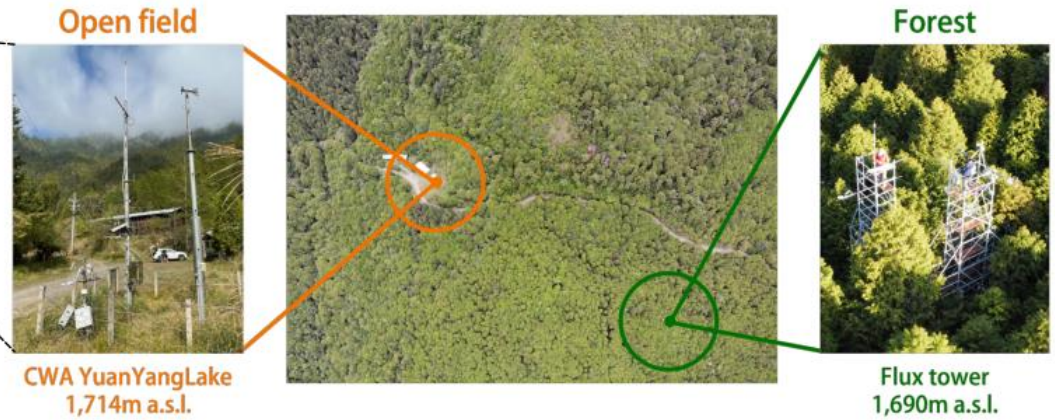
Forest surface temperature tends to be warmer during nighttime and cooler during daytime.

Influence of fog on microclimate spatiotemporal variability

across heterogeneous land-use surfaces



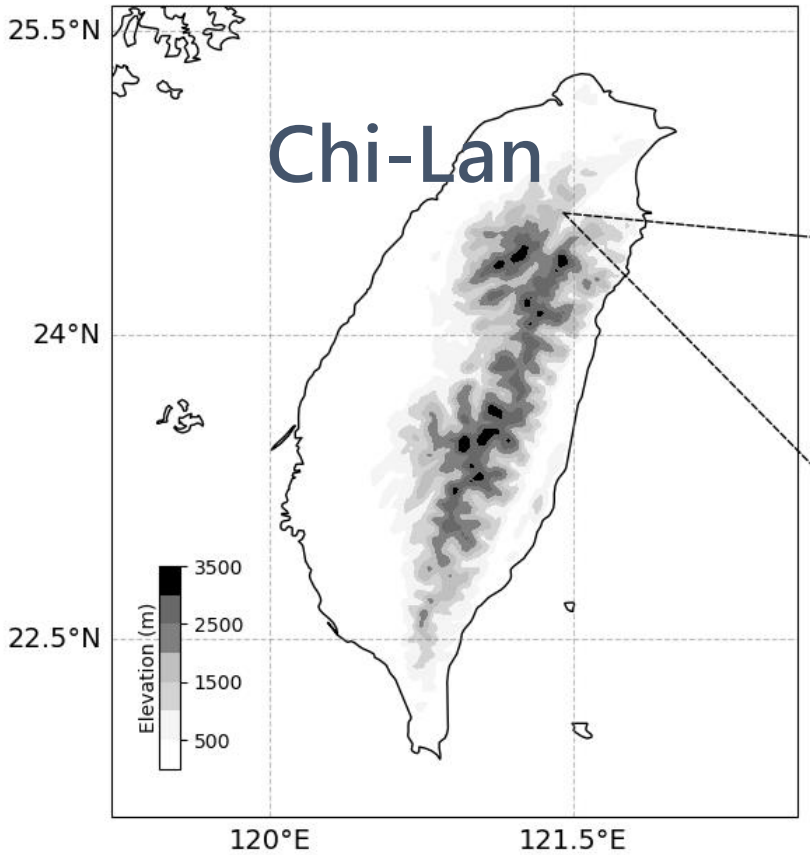
HORIZONTAL



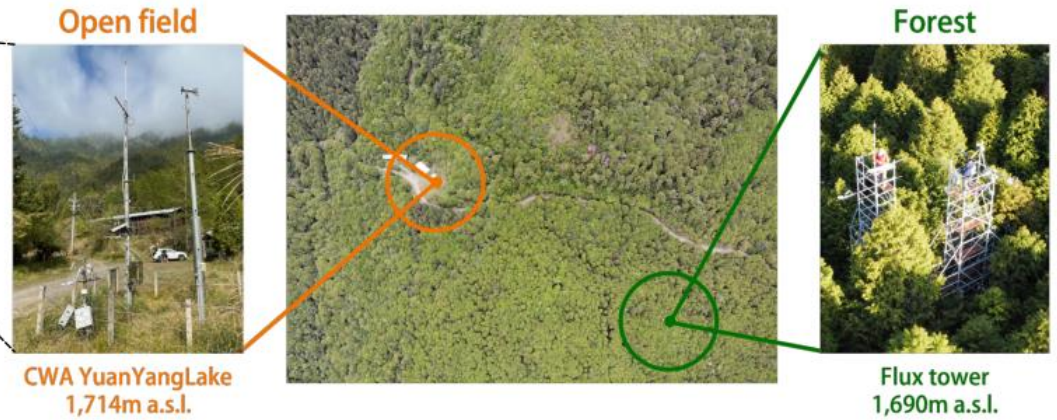
Paired comparison above canopy

Vertical extension of cloud–fog impacts

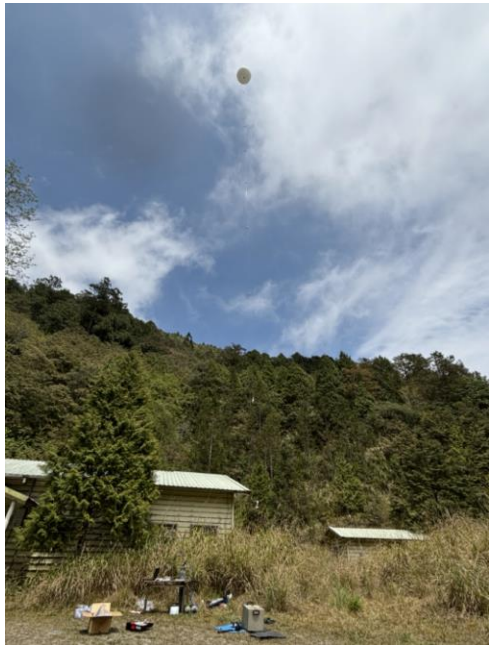
across heterogeneous land-use surfaces



HORIZONTAL

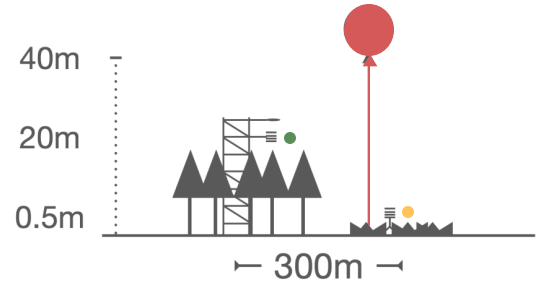


VERTICAL



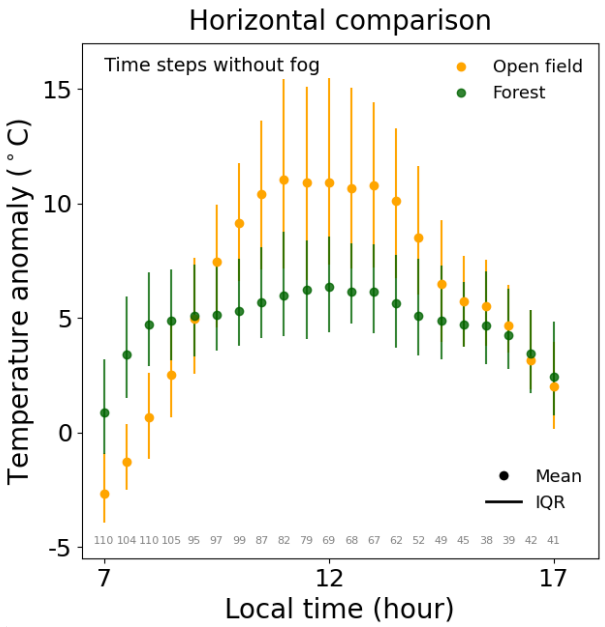
40m tethered balloon

Fog suppresses microclimate spatiotemporal variability

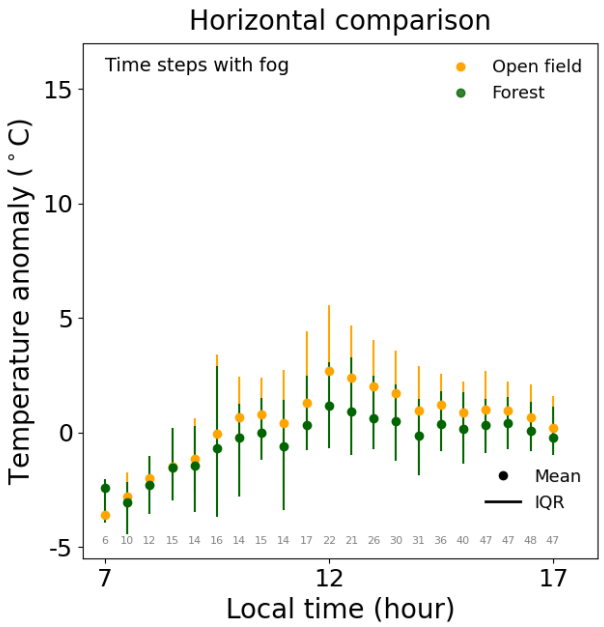


Temporal and **HORIZONTALLY** spatial variation

Fogless

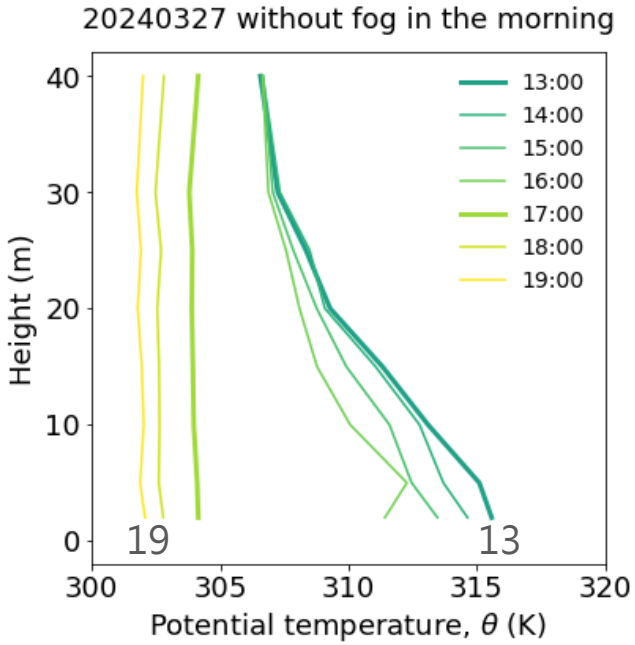


Fog

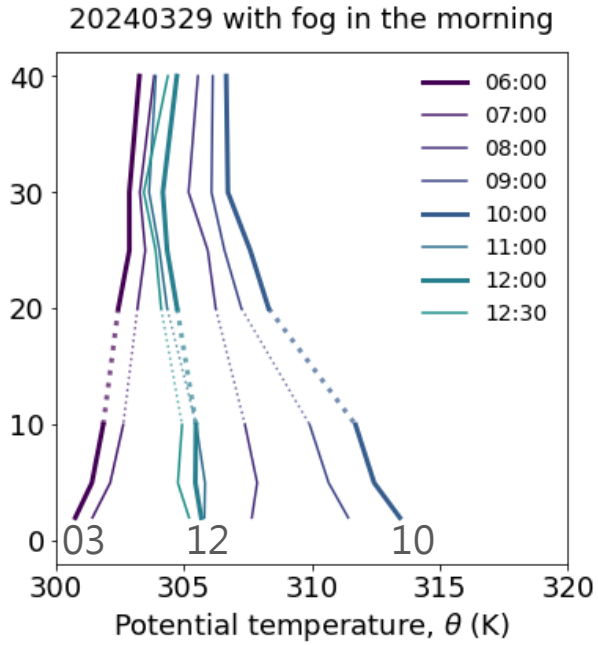


Temporal and **VERTICALLY** spatial variation

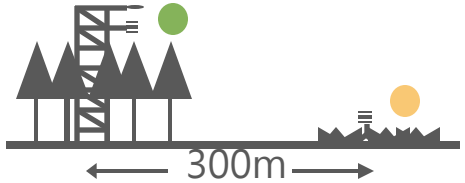
Fogless

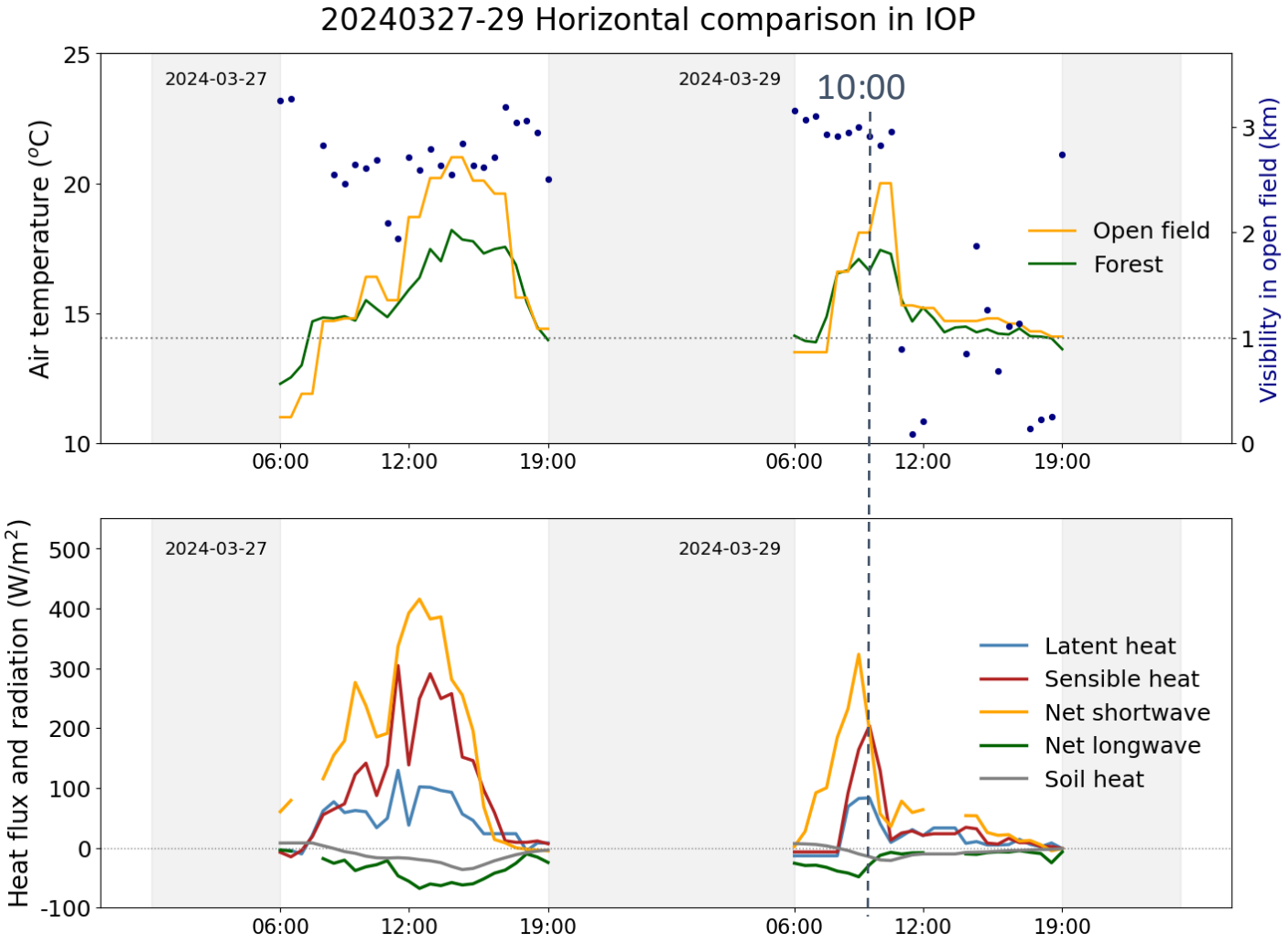


Fog (11-19)

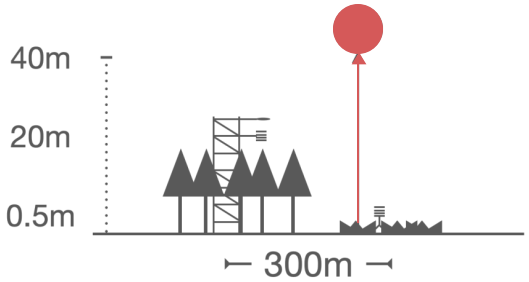


Decreasing net radiation is associated with a significant reduction in air temperature



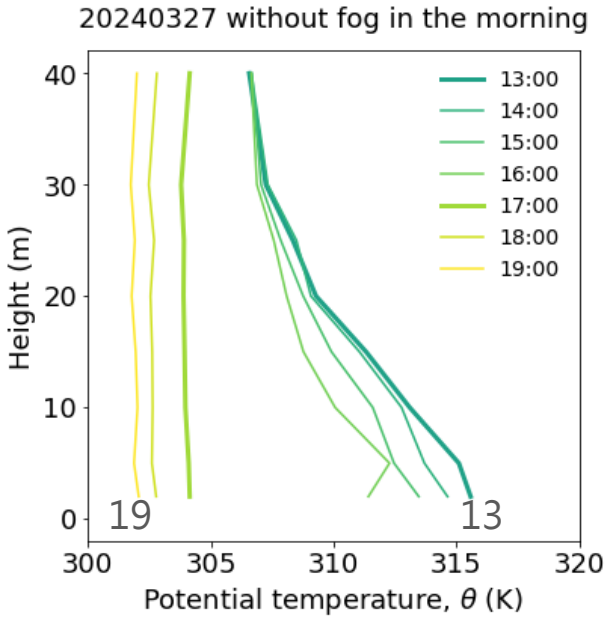


Cooling environments support the persistence of fog

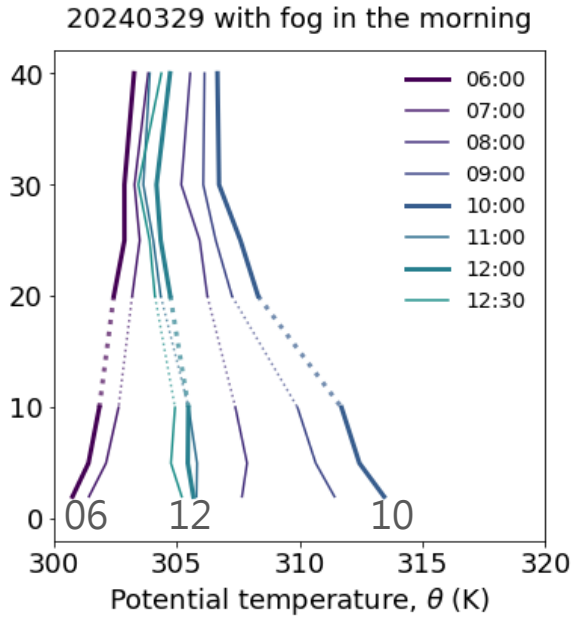


Potential temperature

Fogless

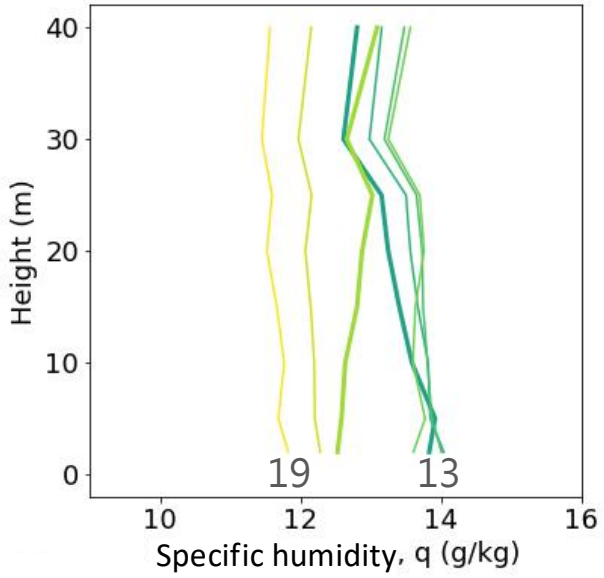


Fog (11-19)

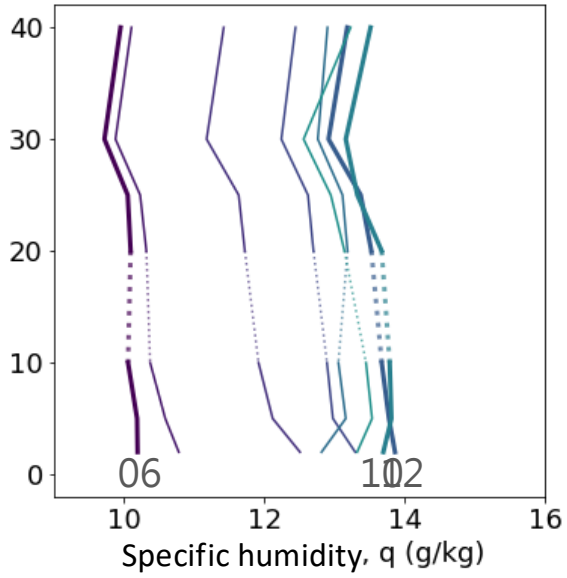


Specific humidity

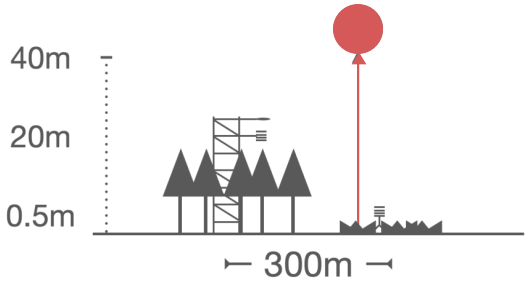
Fogless



Fog (11-19)

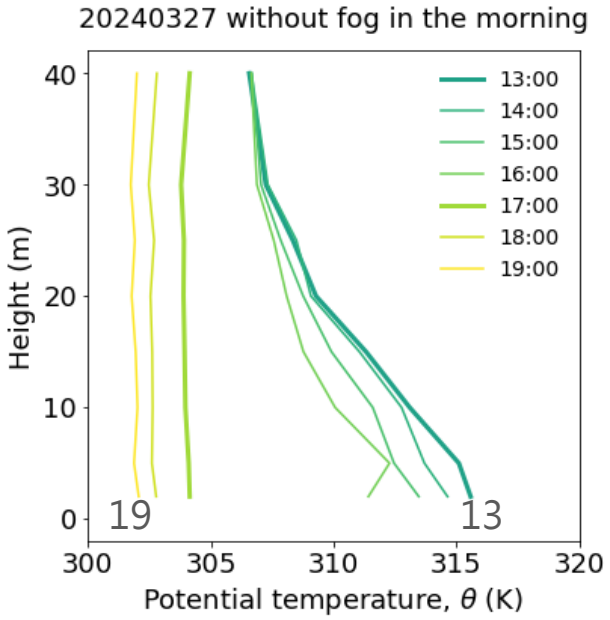


Cooling environments support the persistence of fog

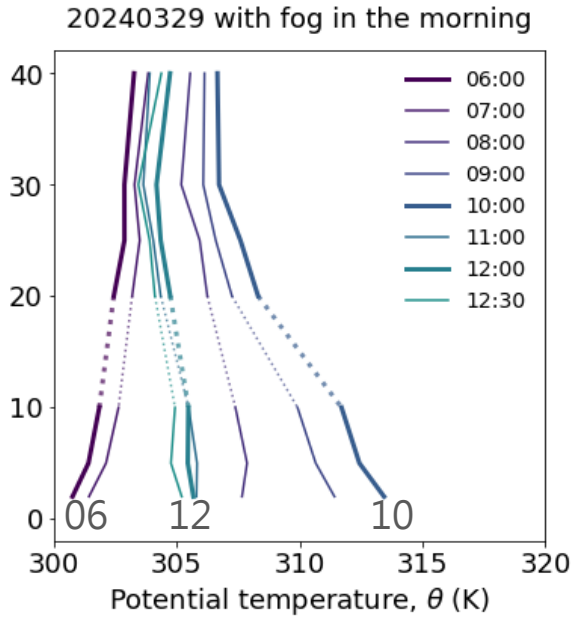


Potential temperature

Fogless

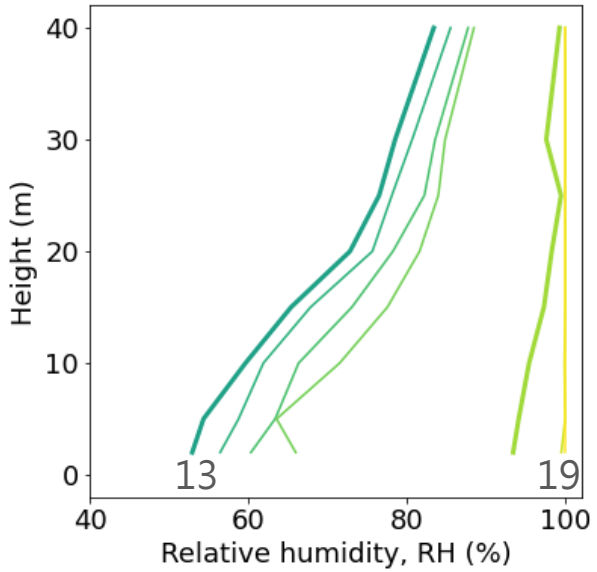


Fog (11-19)

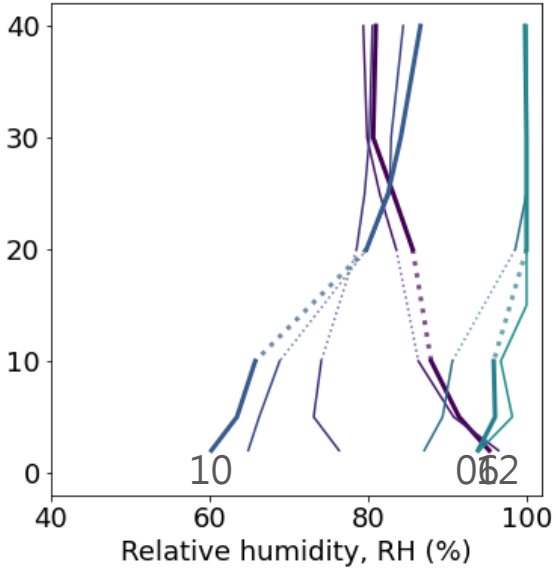


Relative humidity

Fogless



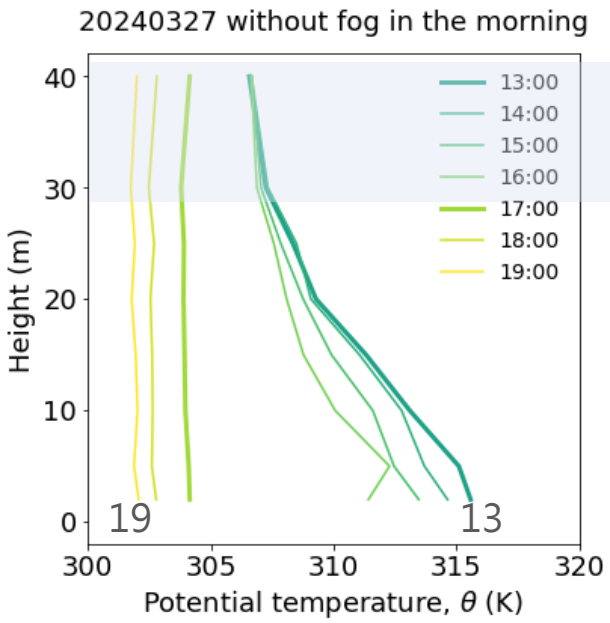
Fog (11-19)



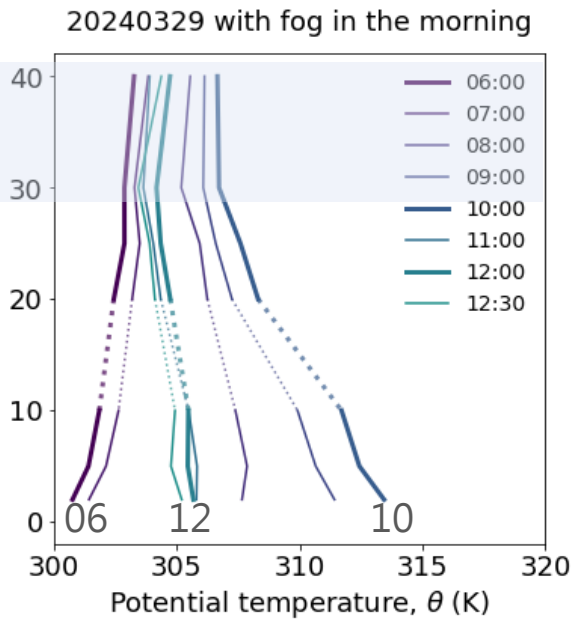
Influenced depth of land surface process?

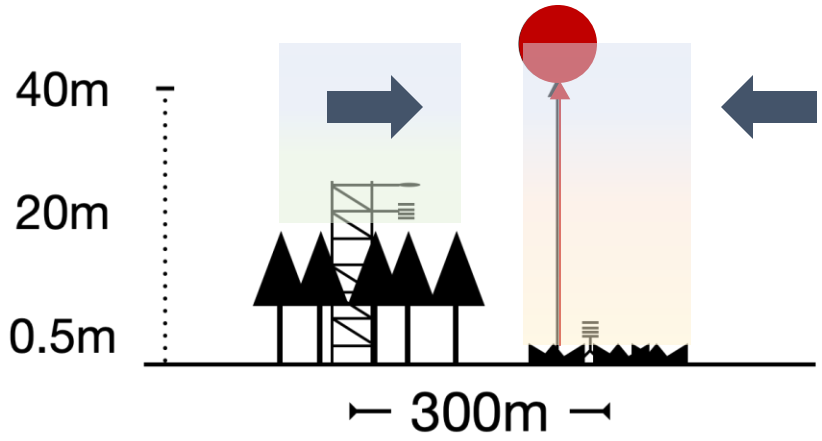
Potential temperature

Fogless



Fog (11-19)

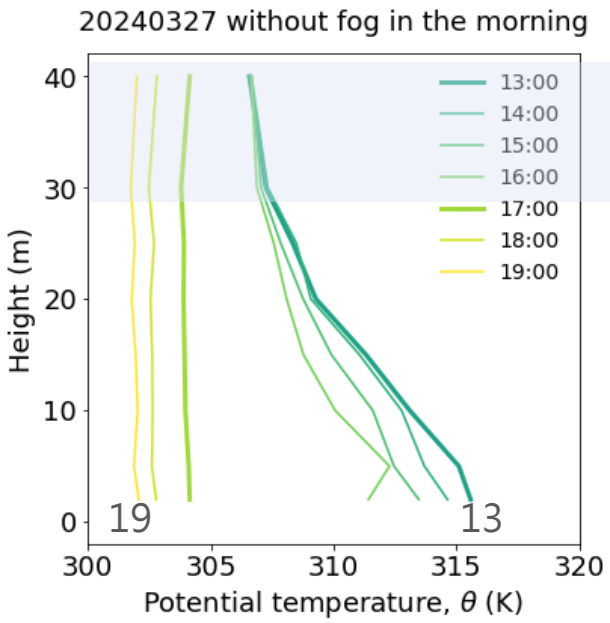




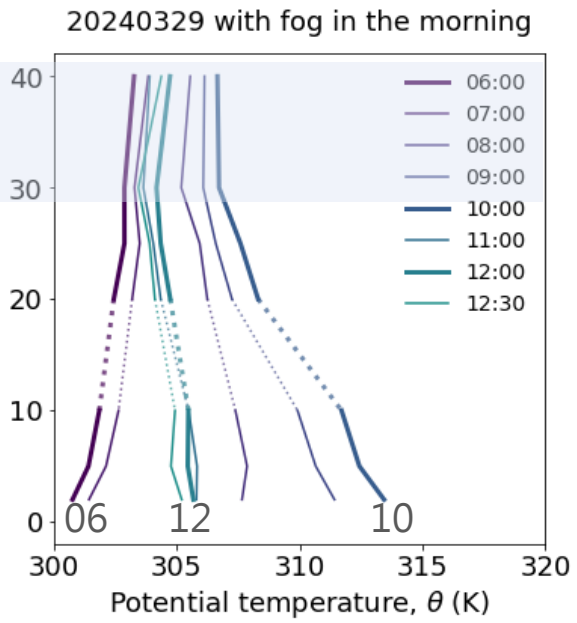
Ongoing work: Influenced depth of land surface process

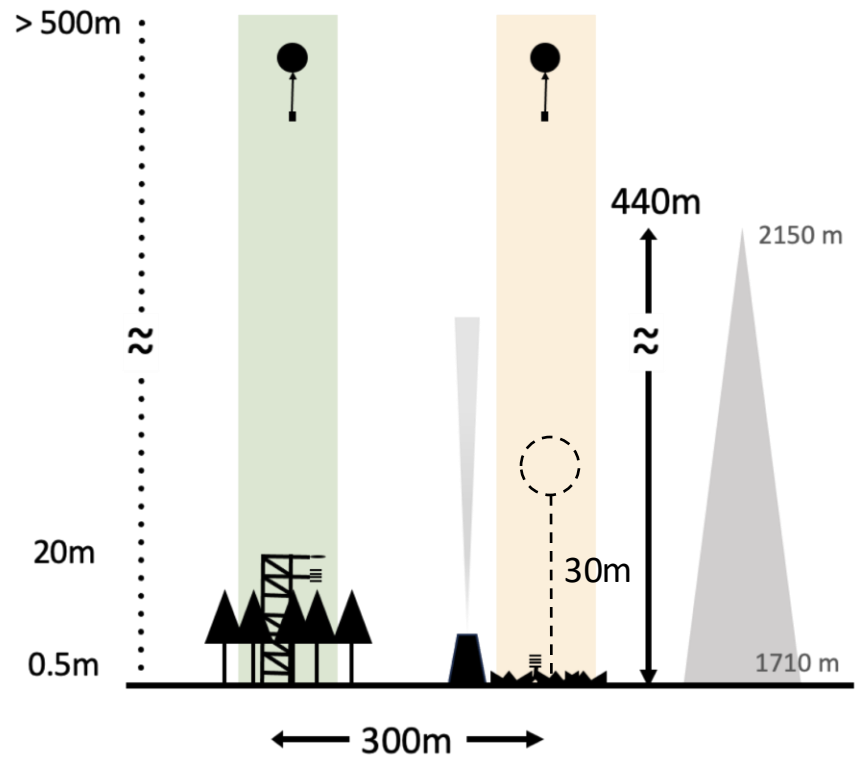
Potential temperature

Fogless



Fog





Ongoing work: Contribution of land surface process

Total Change

$$F_{total}(t) = C_p \Delta\theta(t)$$

$$M_{total}(t) = L_v \Delta q(t)$$

(Seo and Dirmeyer, 2022)

=

Land Contributions

$$F_{sfc}(t) = \frac{\overline{SH}(t)}{\overline{\rho}(t) Z_{PBL}(t)} \Delta t$$

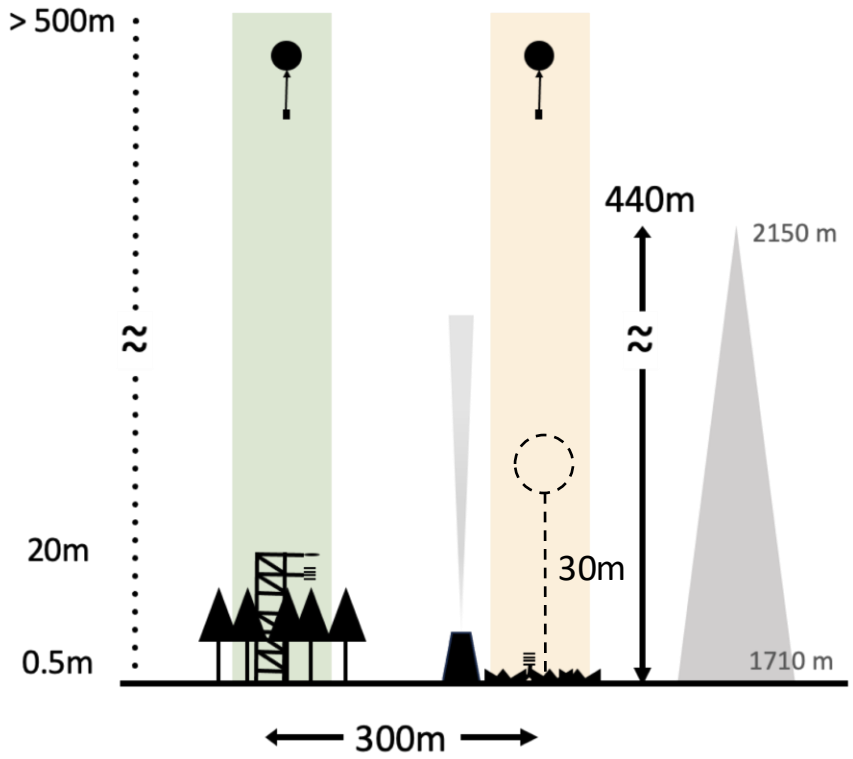
$$M_{sfc}(t) = \frac{\overline{LH}(t)}{\overline{\rho}(t) Z_{PBL}(t)} \Delta t$$

+

Atmosphere Contributions

$$F_{atm}(t) = C_p \Delta\theta(t) - F_{sfc}(t)$$

$$M_{atm}(t) = L_v \Delta q(t) - M_{sfc}(t)$$



Courtesy of Ching-Hung Shih

Conclusions and ongoing works

- Fog and cloud effectively dampens the microclimatic spatiotemporal variation by suppresses the land-atmosphere interactions.

- Spatial heterogeneity in near-surface microclimate across different land types may represent strength in land-leg of land–atmosphere interactions.

- Influenced depth of land surface process & contribution of land surface process

Thanks for listening and I will take any questions here.

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Contribution of land surface process

Land Contributions

$$F_{sfc}(t) = \frac{\overline{SH}(t)}{\overline{\rho}(t) Z_{PBL}(t)} \Delta t$$

$$M_{sfc}(t) = \frac{\overline{LH}(t)}{\overline{\rho}(t) Z_{PBL}(t)} \Delta t$$

+

Atmosphere Contributions

$$F_{atm}(t) = C_p \Delta\theta(t) - F_{sfc}(t)$$

i.e. entrainment at top of PBL, radiative heating, cooling, and frictional warming

$$M_{atm}(t) = L_v \Delta q(t) - M_{sfc}(t)$$

i.e. entrainment at top of PBL, horizontal advection, and phase changes of water in the ML

=

Total Change

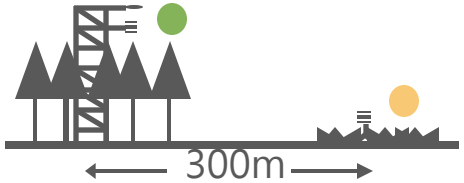
$$F_{total}(t) = C_p \Delta\theta(t)$$

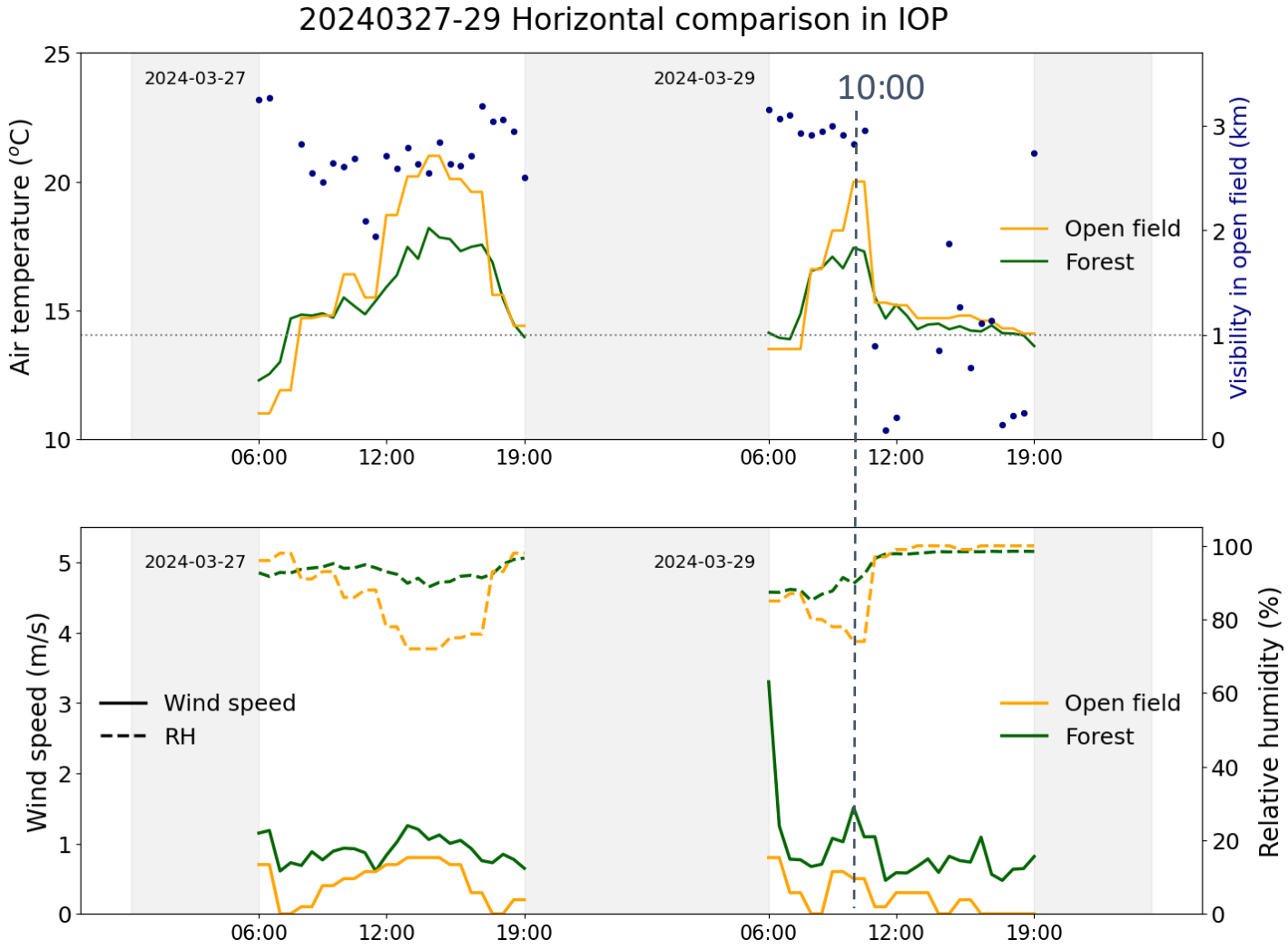
$$M_{total}(t) = L_v \Delta q(t)$$

(Seo and Dirmeyer, 2022)

Courtesy of Ching-Hung Shih

Investigating how fog events influence microclimatic spatiotemporal variability





Intensive Observation Periods
20240327- 20240329