Novel Perspectives on Diurnal Convection over Complex Topography through VVM Simulations

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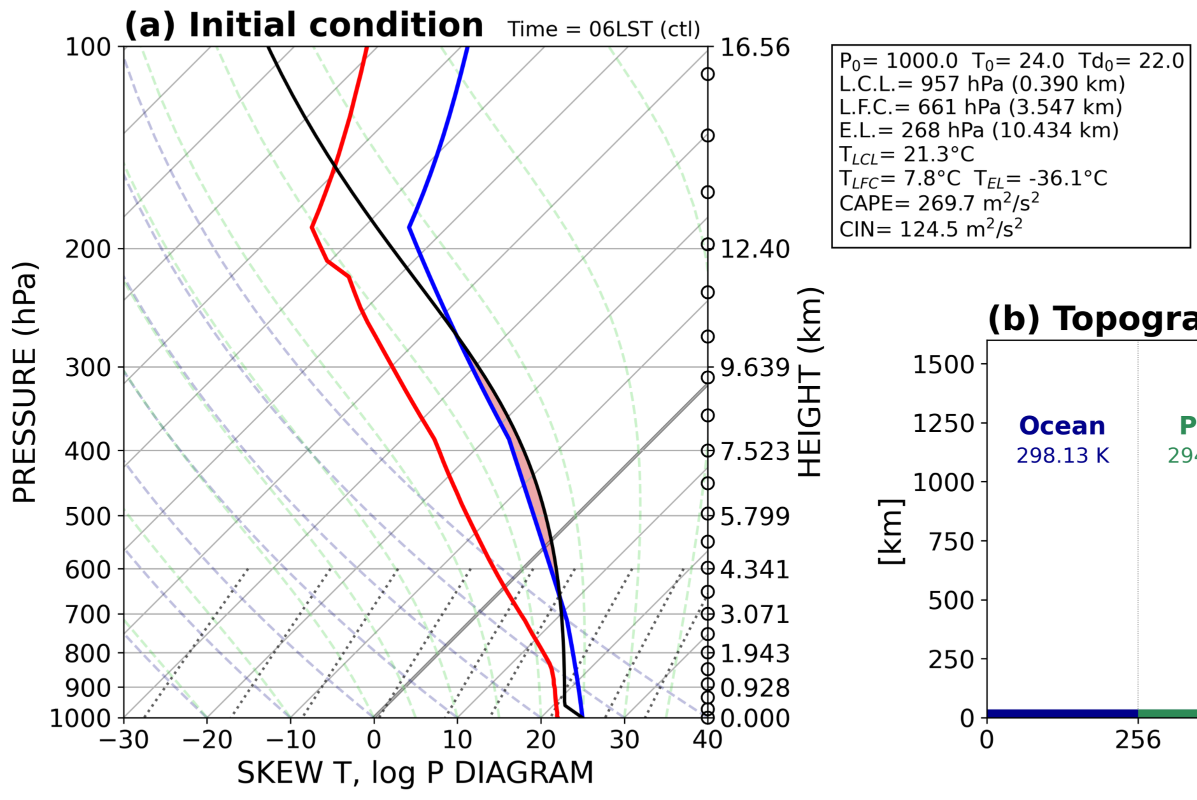
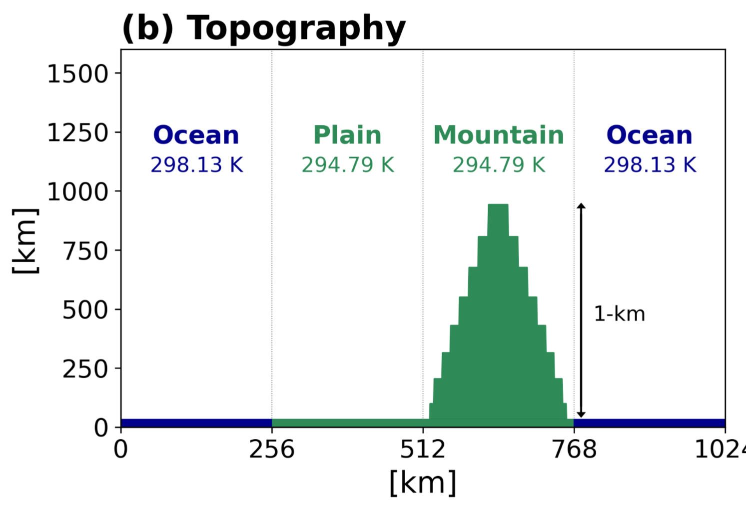
Introduction Schiro et al. (2018) introduced the concept of deep-inflow mixing approaches, suggesting that the moist static energy (MSE) required for convective development can be dynamically entrained from the environment through small-scale turbulence or coherent flow from the deep lateral inflow. Chang et al. (2023) applied this framework to complex topography in Taiwan, emphasizing the importance of local circulation-driven low-level upstream MSE transport as a key pathway for deep-inflow in transporting environmental MSE into convection. We used the VVM with an idealized terrain configuration and devised a scenario wherein local circulation plays a dominant role, while the influence of CAPE is relatively minor, to examine the responses of diurnal convection to varying environmental conditions. Through these idealized experiments that capture observational features, we can establish connections between simulation results and real-world observations.

Model configurations



- High RH (≥ 80) in low-lev
- Limited CAPE
- Presence of CIN
- No initial wind field



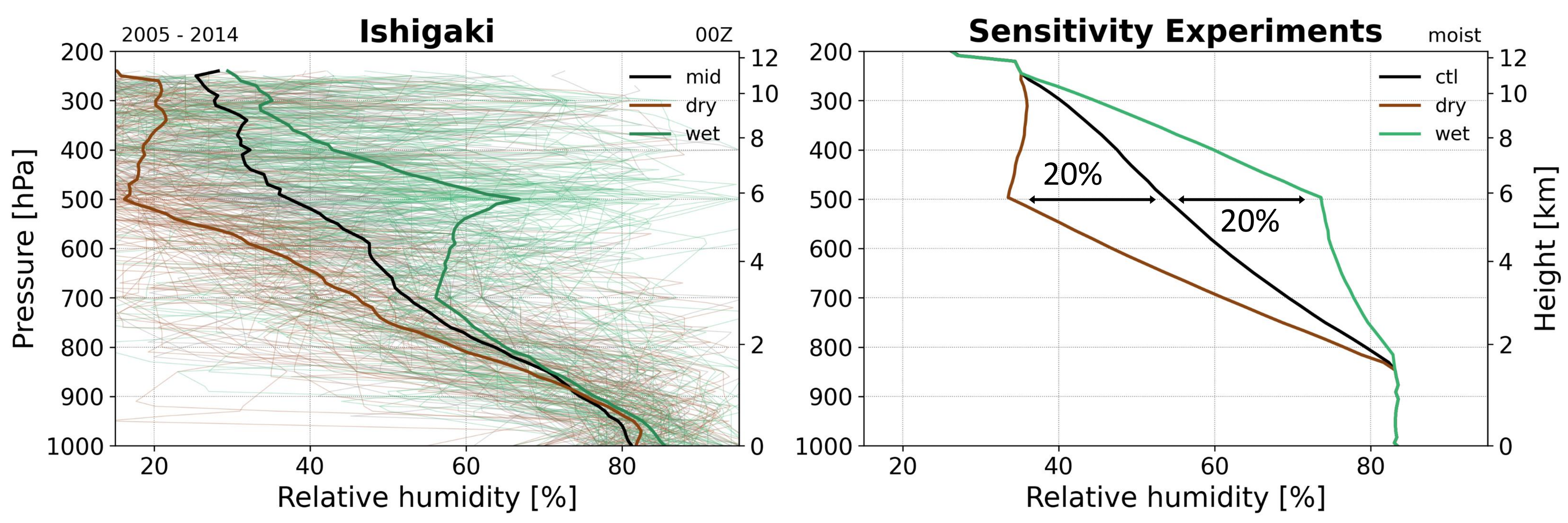
Vector Vorticity equation cloud resolving Model (VVM)

Domain size	102.3 km x 102.3 km x18.6 km
Horizontal resolution	100 m x 100 m
Temporal resolution	2 minutes
Simulation duration	12 h (06 LST – 18 LST)
Lateral boundary condition	Double periodic

Sensitivity experiment setups

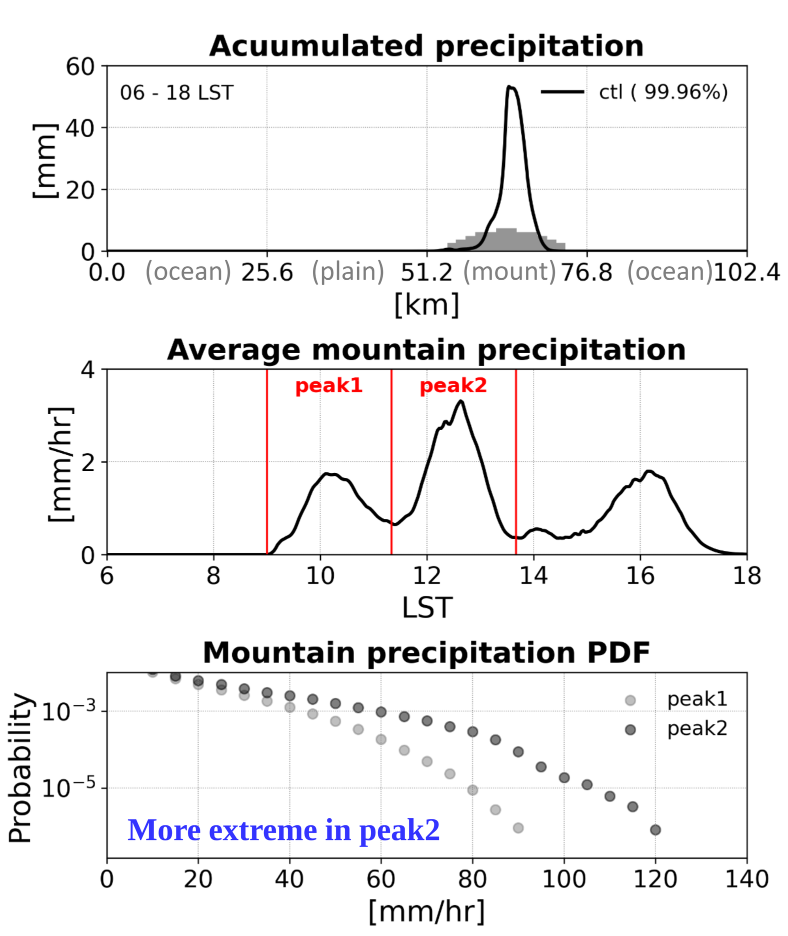
Change free atmosphere relative humidity (RH)

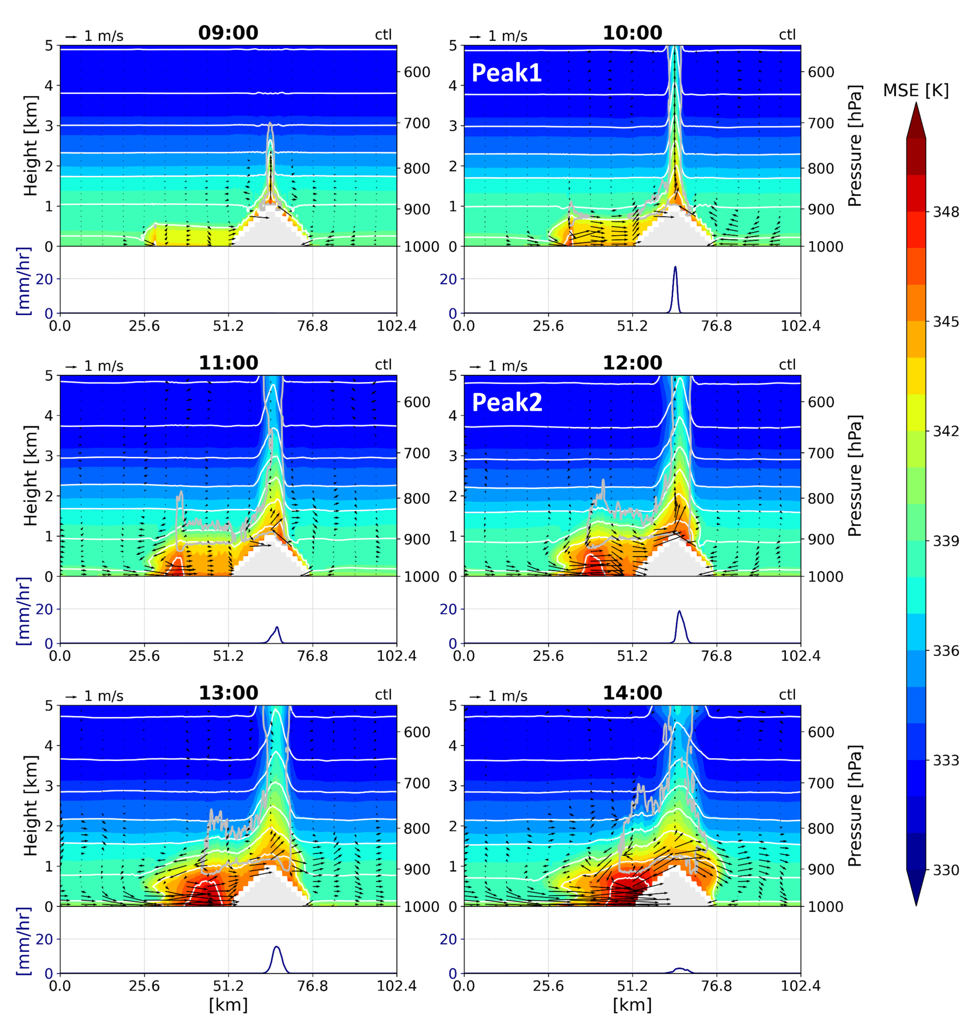
- RH ± 20% at 500 hPa (Ishigaki sounding; Chang et al., 2021)

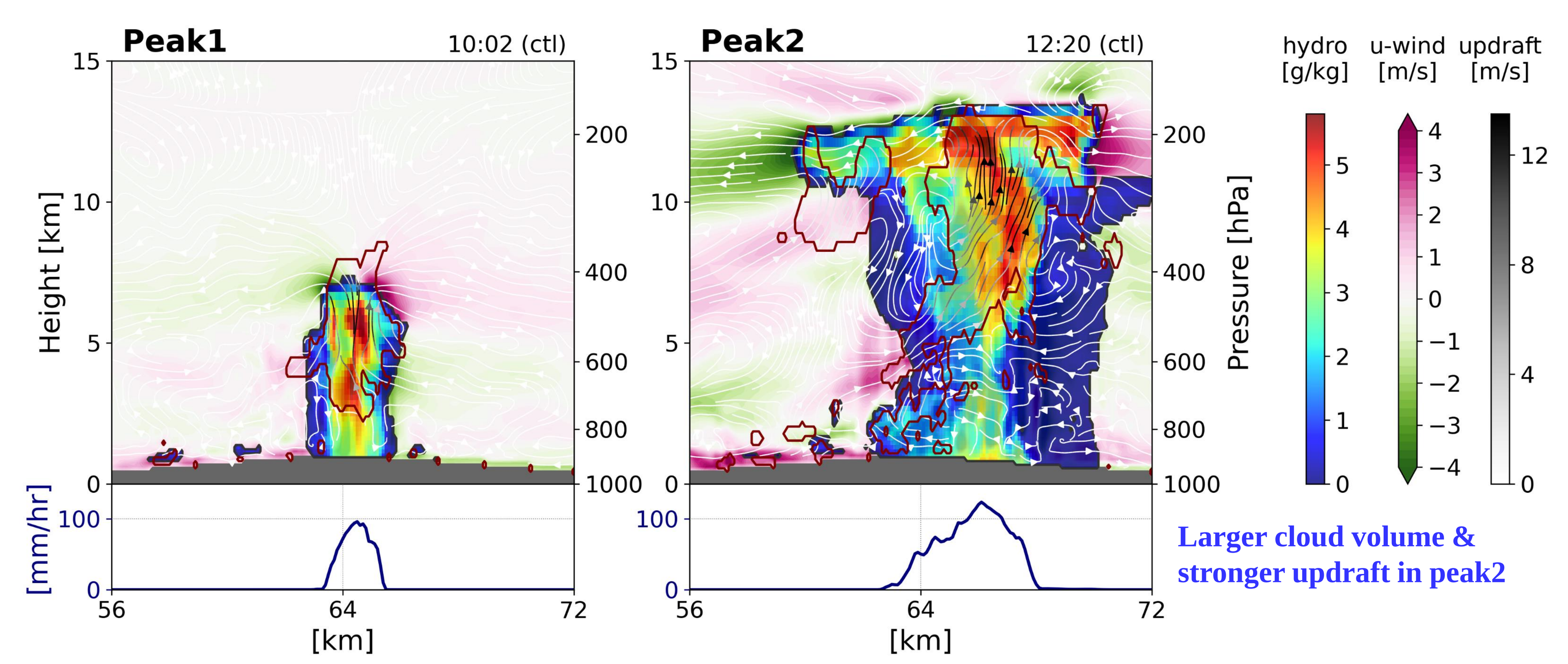


Results I

Precipitation and convection features



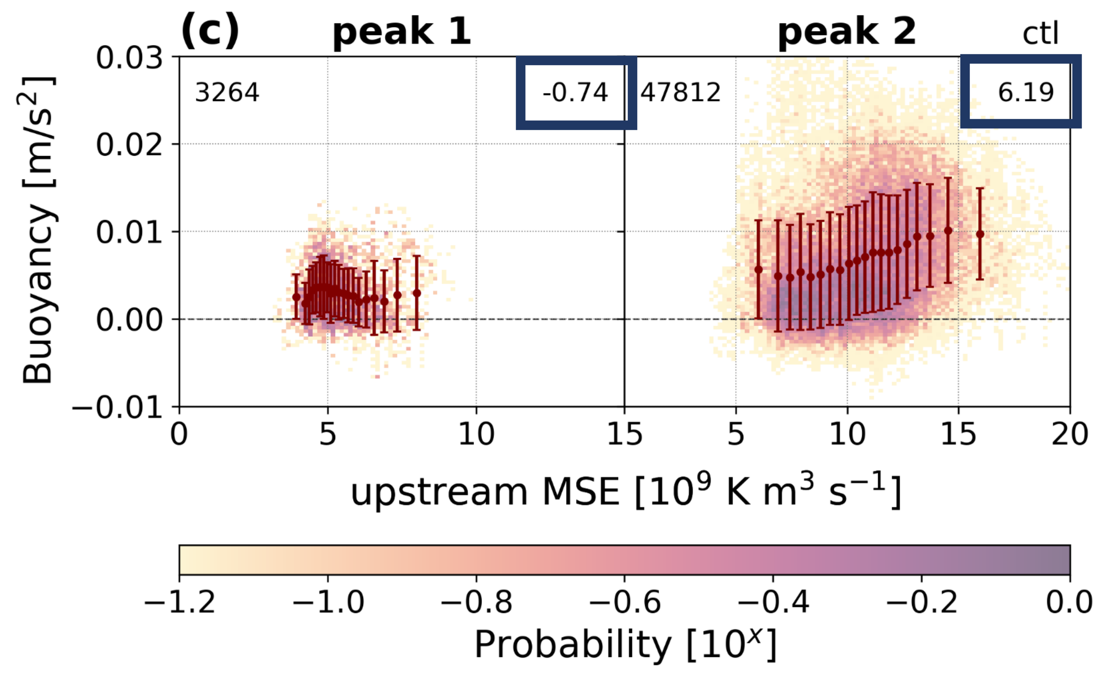




Local circulation features: We focus on the 1st (09:00 – 11:20) and 2nd (11:20 – 13:40) precipitation peaks in which the developments are closely related to the evolution of sea-valley breeze circulations.

Results II

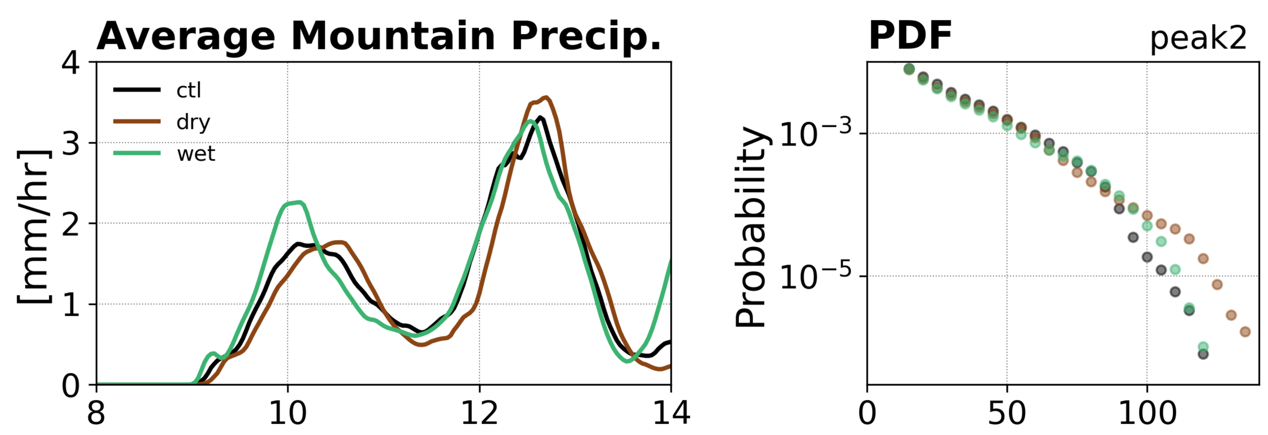
Local circulation-driven low-level upstream MSE transport



Regression slopes

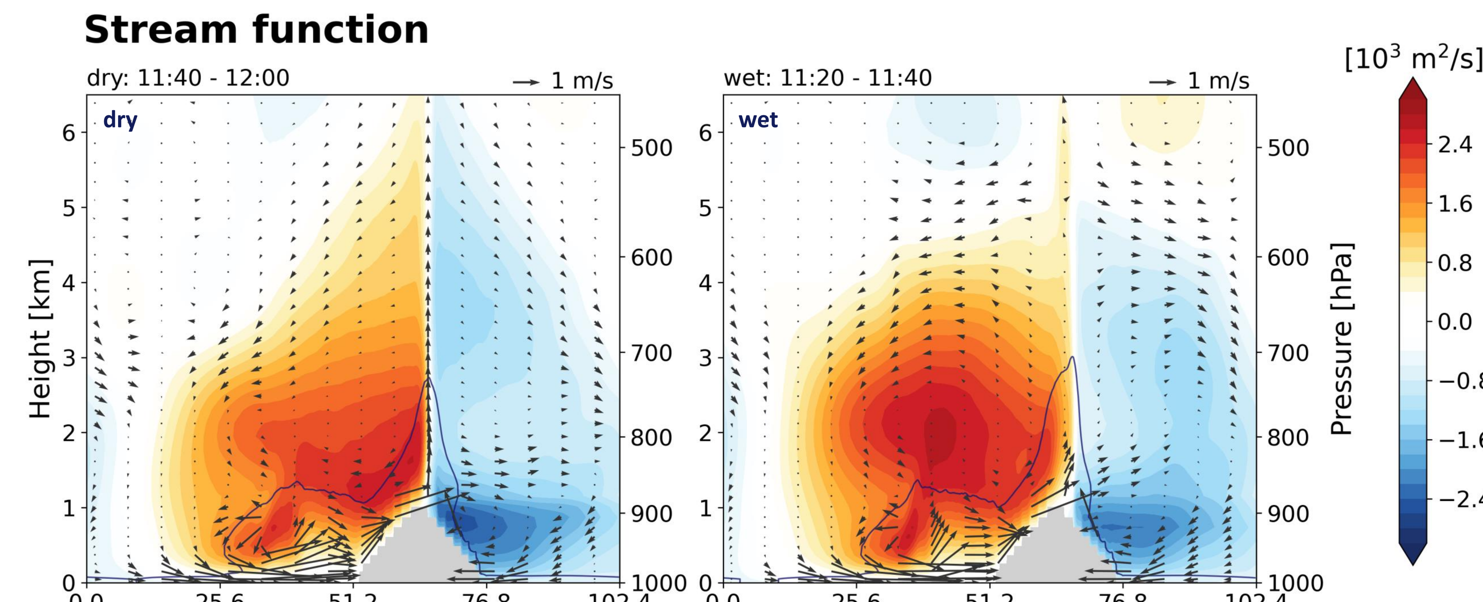
The contribution of upstream MSE refers to how much buoyancy increases for a unit of upstream MSE.

Environmental variabilities



Regression slope

dry	wet
7.33	4.31



Role of local circulation: Its structures and strengths influence the contribution of upstream MSE.

Conclusions

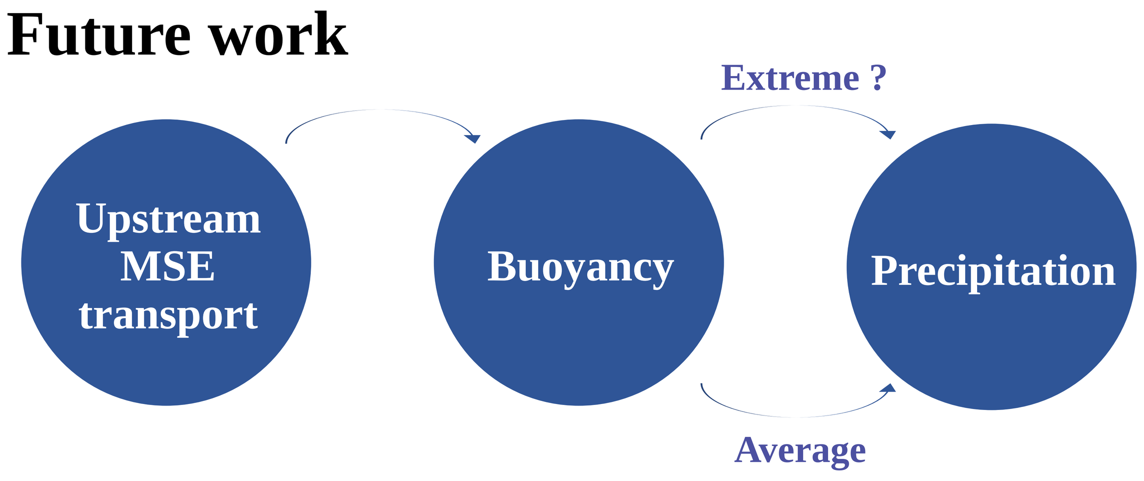
Peak1
Lower regression slope

Peak2
Larger regression slope

Peak3

Depends on **background environmental conditions** and **the scale of local circulation establishment.**

Future work



Specifically explore **convection structure** and the role of **cold pools** in extreme precipitation.

References

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Acknowledgements

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