PMM PI Meeting, 15 January, 2014, Tokyo

Improvement of GSMaP Microwave Radiometer Rainfall Retirevals over Land

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JAXA Collaborator:

Takuji Kubota and Misako Kachi

Research Activities of FY2013

- Implementation of orographic/non-orographic classification scheme into GSMaP MWR at-launch code
- Further research on orographic rainfall (with Chris Kummerow)
- Development of precipitation profile classification scheme from horizontal extent of rainfall system

Publication in FY2013

- Shige, S., S. Kida, H. Ashiwake, T. Kubota, and K. Aonashi, 2013: Improvement of TMI rain retrievals in mountainous areas. *J. Appl. Meteor. Climatol.*, **52**, 242-254.
- Taniguchi, A, S. Shige, M. K. Yamamoto, T. Mega, S. Kida, T. Kubota, M. Kachi, T. Ushio, and K. Aonashi, 2013: Improvement of high-resolution satellite rainfall product for Typhoon Morakot (2009) over Taiwan. *J. Hydrometeor.*, 14, 1859-1871.
- Shige, S., M. K. Yamamoto, A. Taniguchi, 2014： Improvement of TMI rain retrieval over the Indian subcontinent, *AGU Chapman Monograph for Remote Sensing*, accepted with minor revision. (Invited paper)

Shallow orographic heavy rainfall in the Asian monsoon region observed by TRMM PR

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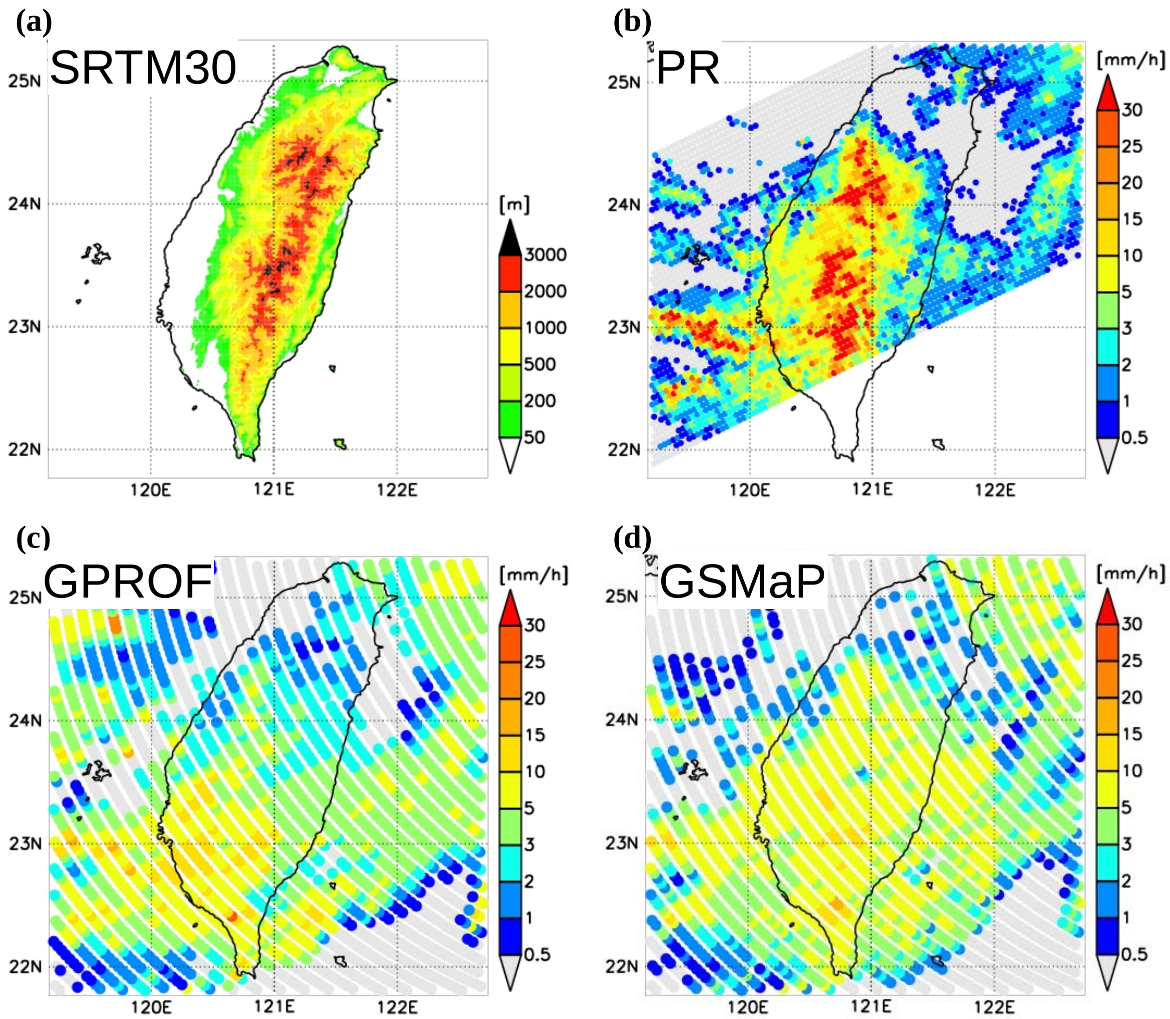
Acknowledgments: Chris, Dave, Greg, Wes, Paula, Mark, Paul, & many others!!!

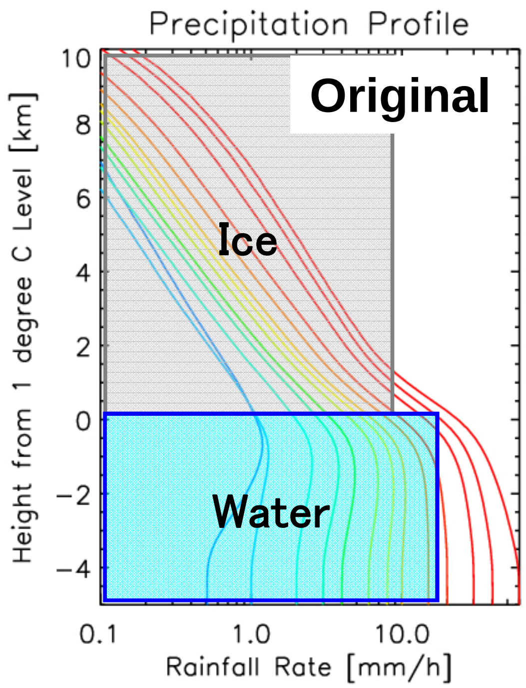
Introduction

- The dominant view that heavy rainfall results from deep clouds was formed based on observational studies in the United States, such as the pioneering work of Byers and Braham [1949].
- However, heavy rainfall can be caused by shallow orographic convection in moist Asian monsoon regions [i.e., Takeda et al., 1976; Takeda and Takase, 1980; Sakakibara, 1981].
- MWR rainfall algorithms, which assume that heavy rainfall results from deep clouds, underestimate rainfall associated with shallow orographic rain systems in Japan [Kubota et al. 2009; Shige et al. 2013], Taiwan [Taniguchi et al. 2013], Korea [Kwon et al. 2008; Sohn et al. 2013] and India [Shige et al. 2014].
- In this study, we examine dynamic and thermodynamic characters of the atmospheric environment which shallow orographic heavy rainfall in Asia may be linked to.

Typhoon Morakot (2009) over Taiwan

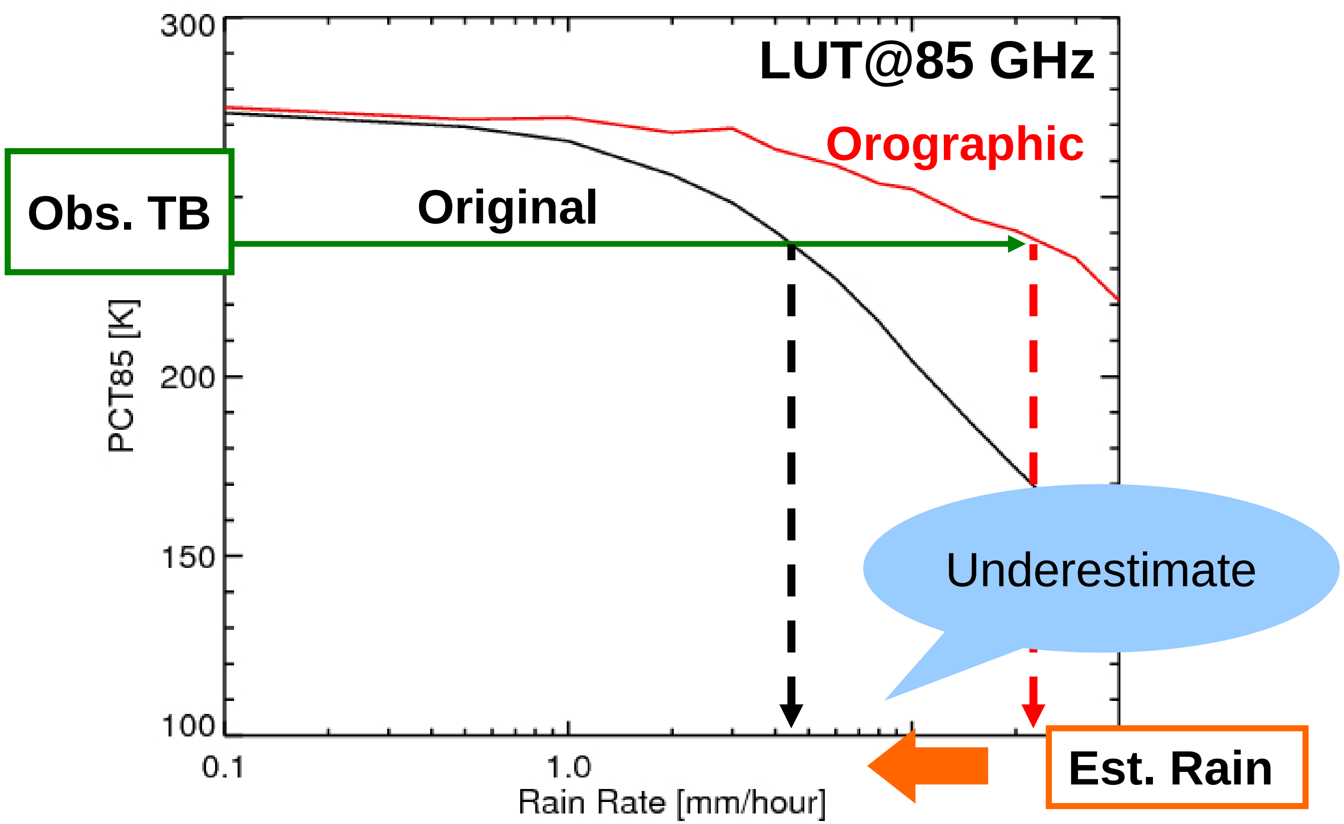
Taniguchi et al. (2013, JHM)

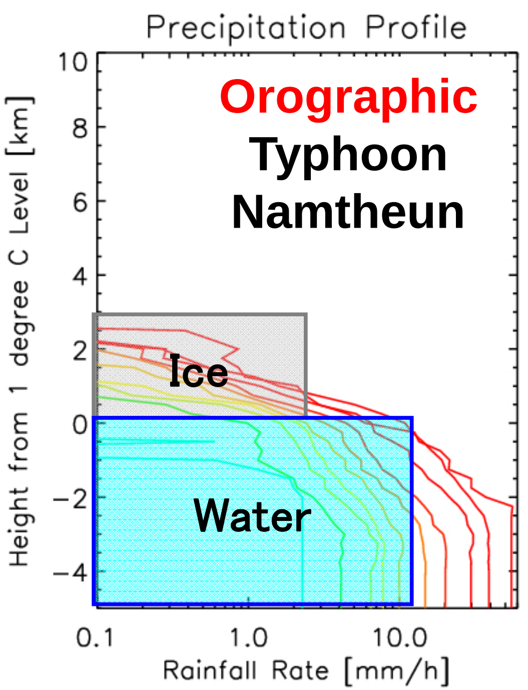




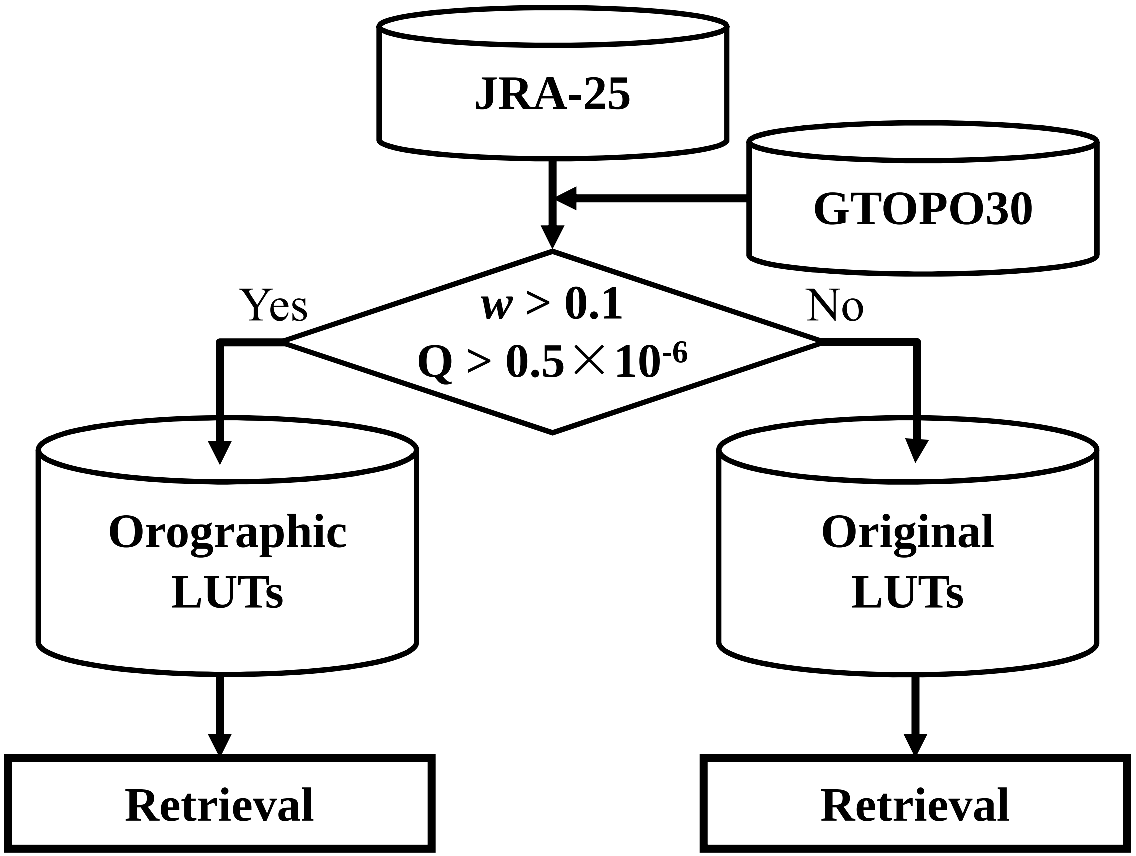
Look-up table:
Relationship between *Tbs* and rain rates

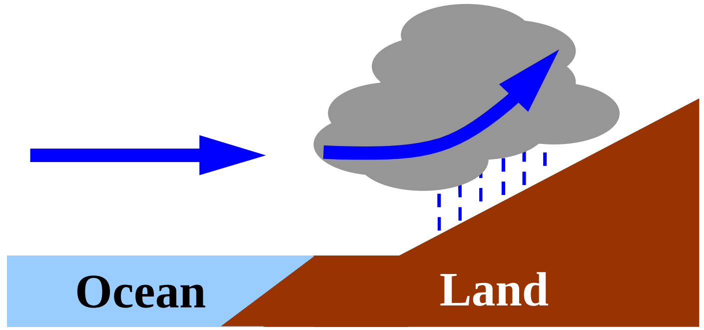
Shige et al. (2013, JAMC)





Orographic/Non-Orographic Rainfall Classification Scheme





Orographically Forced Upward Motion

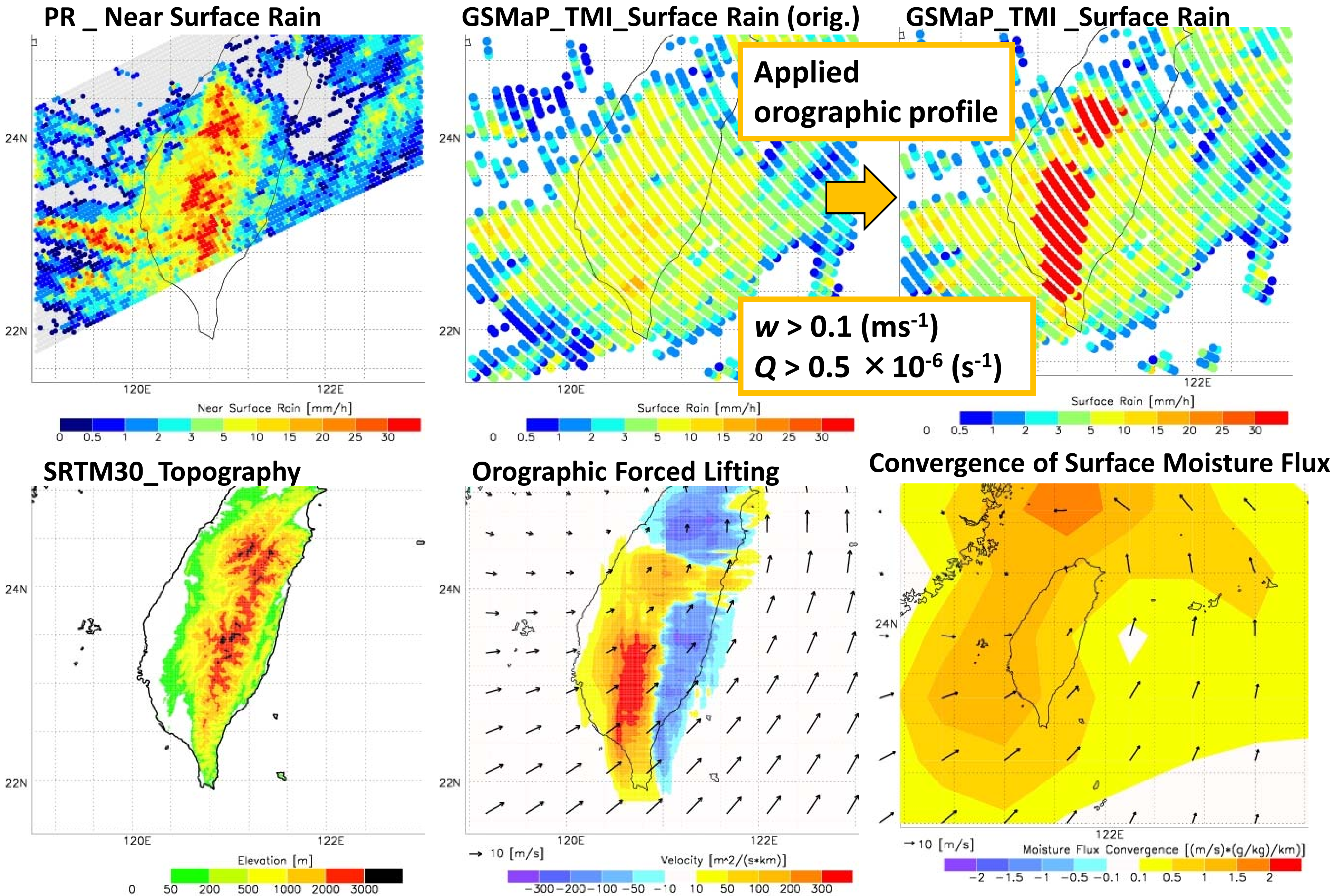
$$w = \frac{Dh}{Dt} = u\frac{\partial h}{\partial x} + v\frac{\partial h}{\partial y}$$

Convergence of Surface Moisture Flux

$$Q = -\left(\frac{\partial(uq)}{\partial x} + \frac{\partial(vq)}{\partial y}\right)$$

Shige et al. (2013, JAMC)

Typhoon Morakot (2009) over Taiwan
Taniguchi et al. (2013, JHM)



What determines deep or shallow?

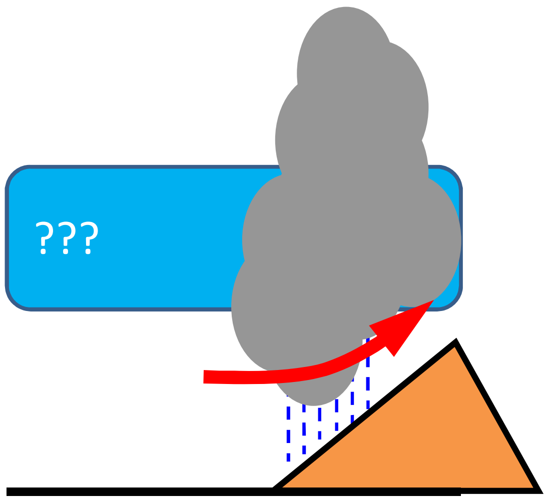
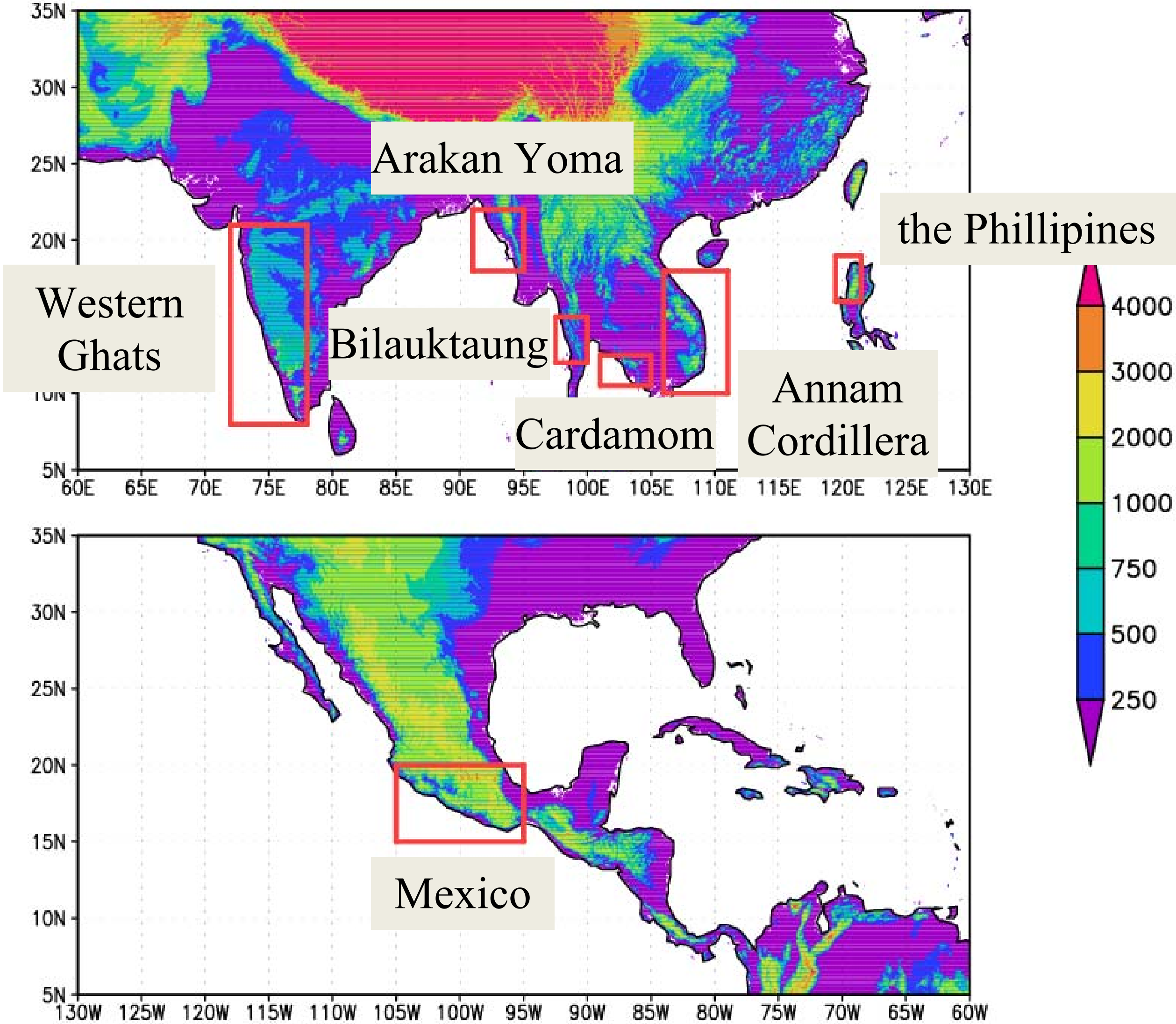


Fig. 1: Location of mesoscale mountain ranges (Western Ghats, Arakan Yoma, Bilauktaung, Cardamom, Annam Cordillera and the Phillipines) of the South Asian monsoon region (Fig 1a) and Mexico for comparison (Fig. 1b).



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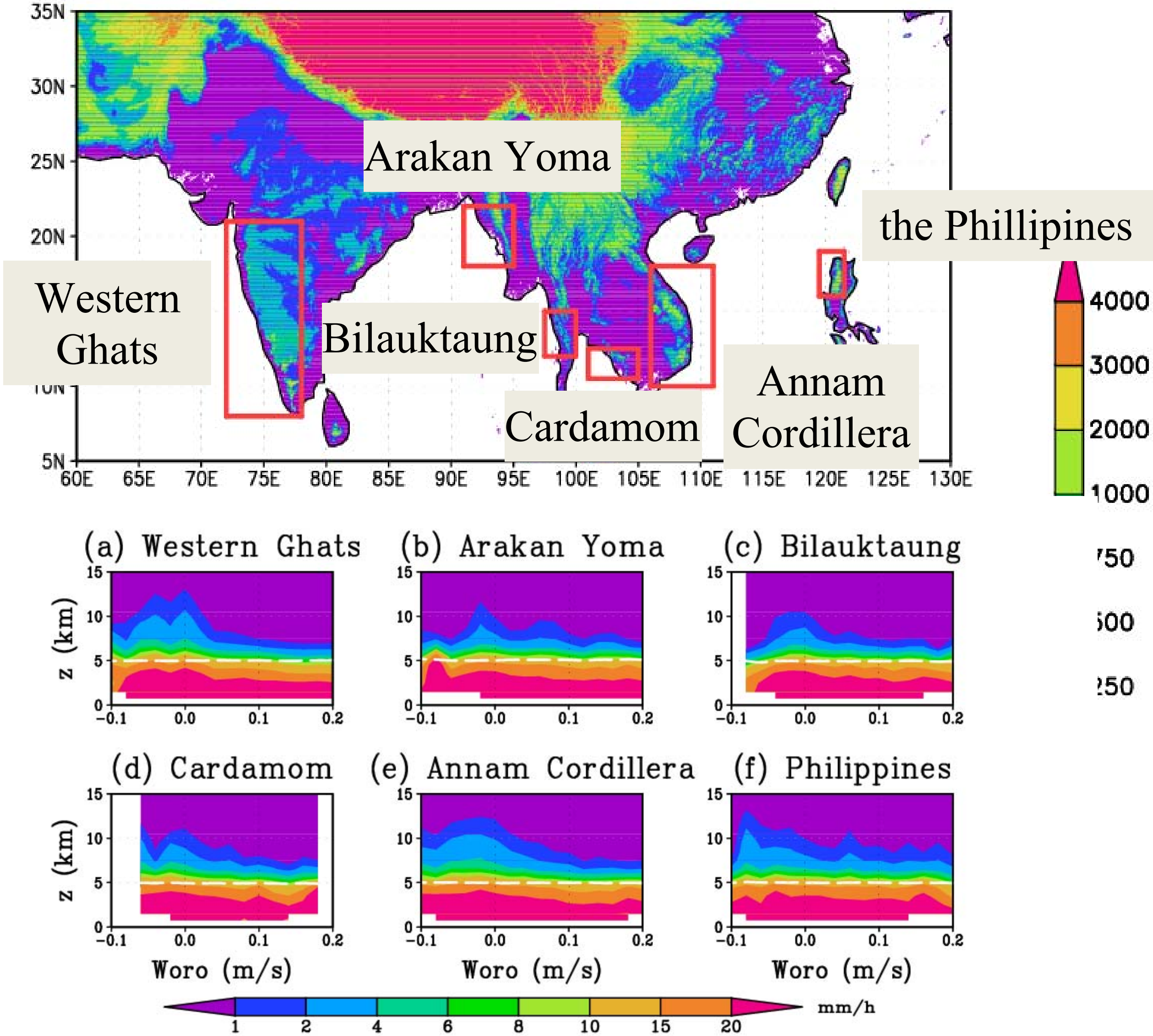
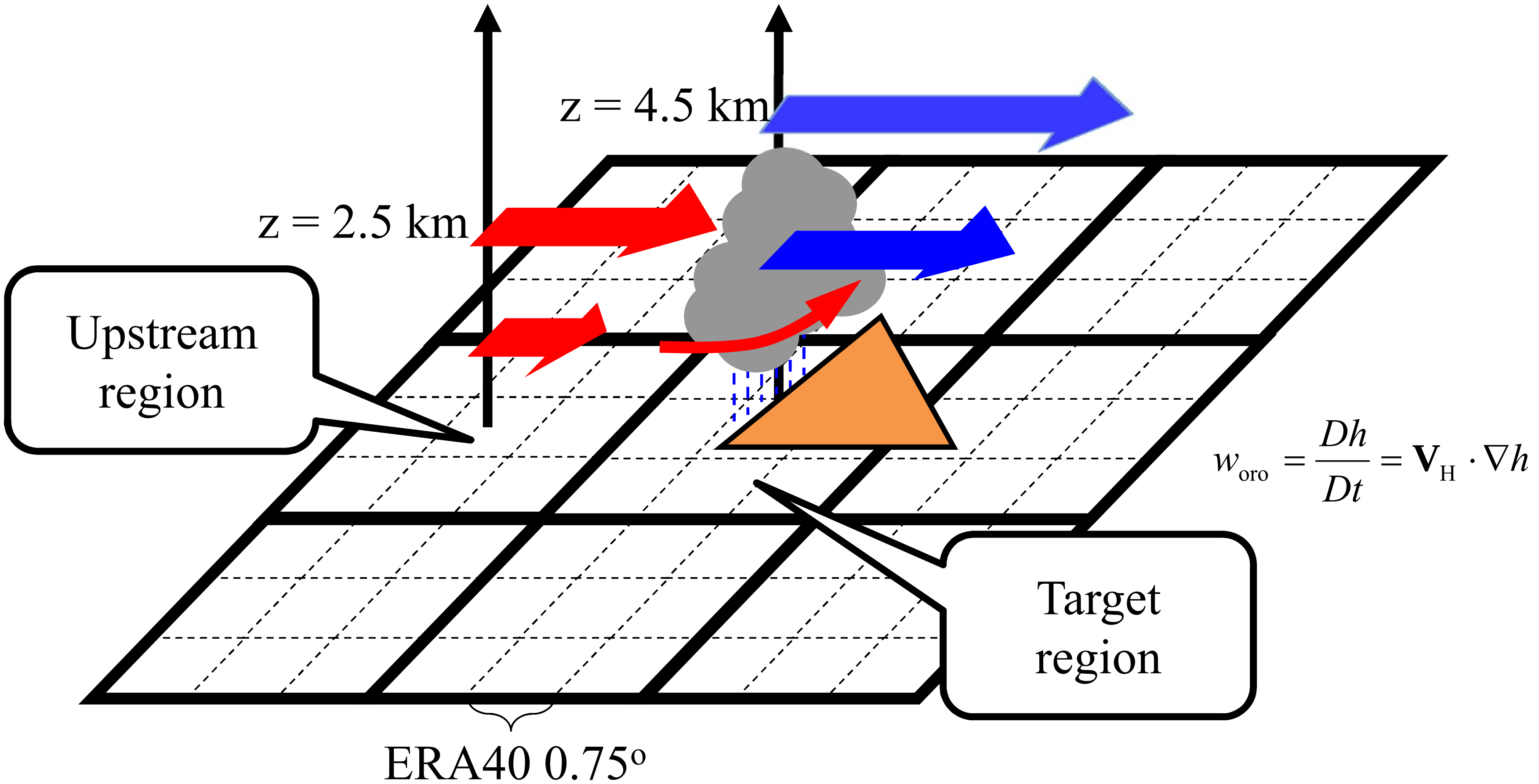


Fig. 2: Schematic of target region and upstream region.

TRMM PR: 0.05°
ERA-Interim: 0.75°
SRTM30: the original 1-km resolution data averaged within the horizontal length scale of 50km



Since we are interested primarily in heavy rainfall, we examine only the rain class of 20 < rain rate < 30mm h^{-1}.

Fig. 3: Precipitation profiles with heavy near-surface rain rates (20 mm h^{-1} < $R \leq$ 30 mm h^{-1}) as function of w_{oro} for mesoscale mountain ranges (Western Ghats, Arakan Yoma, Bilauktaung, Cardamom, Annam Cordillera and the Phillipines) of the South Asian monsoon region.

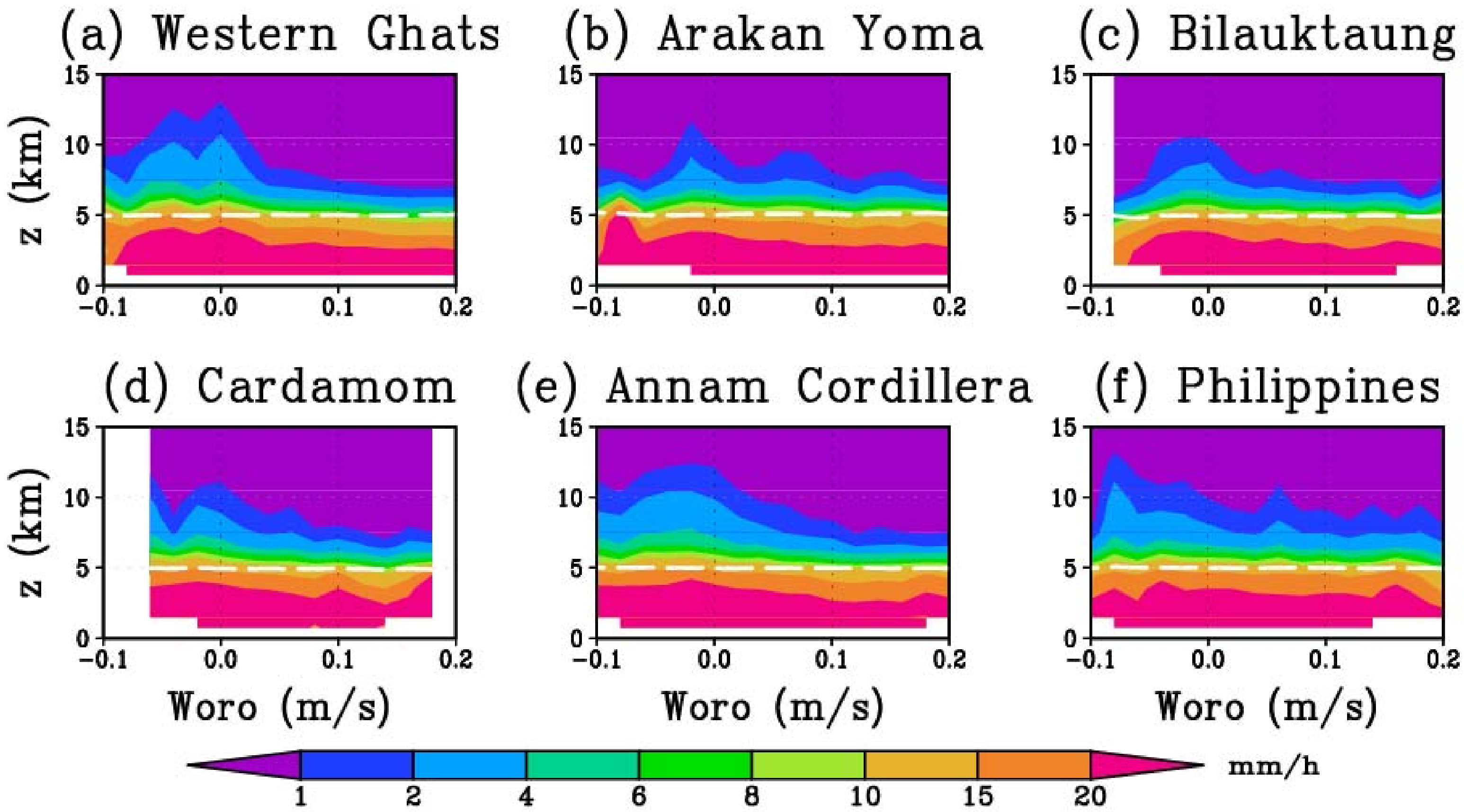
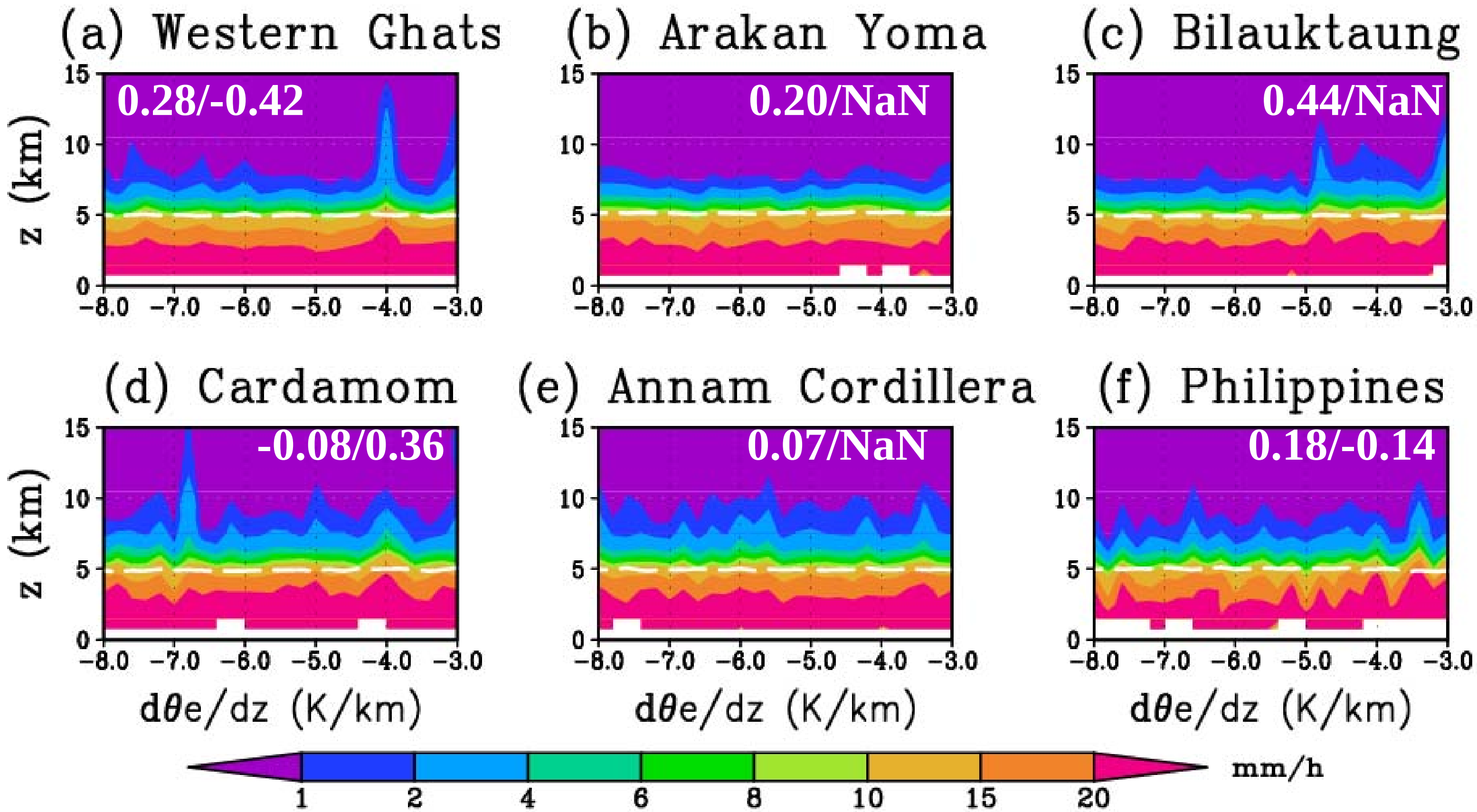


Table 1 Candidate thermodynamic quantities

$d\theta e/dz$	Potential instability at 0.75 km.
dT/dz_{mlt}	Static stability near the $0^{o}C$ layer (Johnson et al. 1999)
RH	Relative humidity of the lower troposphere from 1.5 km to 4.5 km (Takayabu et al. 2010)
dT/dz_{low}	Static stability of the lower troposphere from 1.5 km to 4.5 km

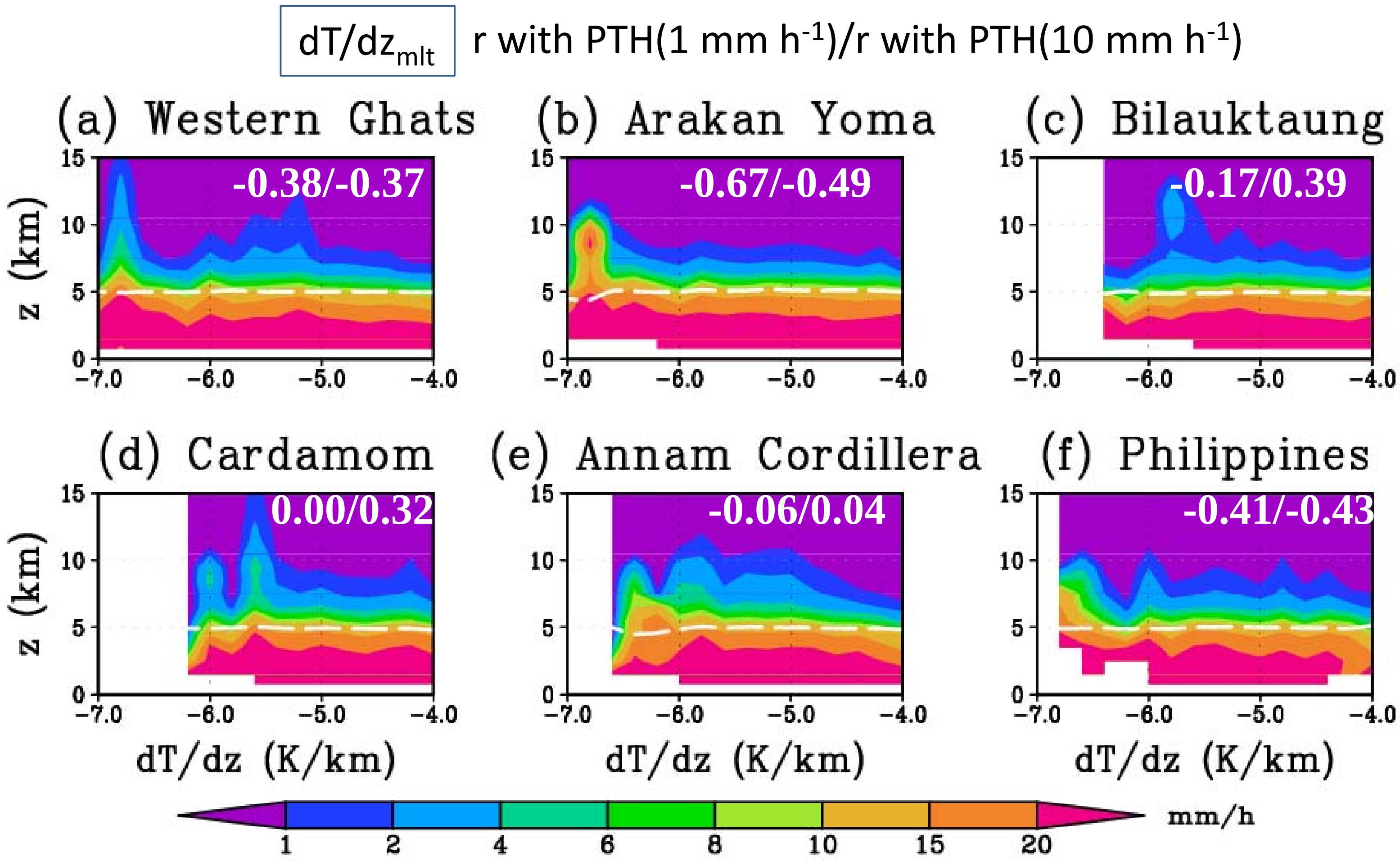
Fig. 4: As in Fig. 3 but for precipitation profiles with heavy near-surface rain rates (20 mm h^{-1} < $R \leq$ 30 mm h^{-1}) and upward motion (w_{oro} > 0 m s^{-1}) as function of $d\theta e/dz$ at z=0.75 km over the upstream region.

dθe/dz r with PTH(1 mm h^{-1})/r with PTH(10 mm h^{-1})



The results indicate that potential instability play no significant role in determining precipitation profiles.

Fig. 5: As in Fig. 3 but for precipitation profiles with heavy near-surface rain rates (20 mm h^{-1} < $R \leq 30$ mm h^{-1}) and upward motion ($w_{oro} > 0$ m s^{-1}) as function of static stability near the 0^{o}C layer.



The 7-yr conditional mean $Q_1 - Q_R$ profiles stratified with *dp/dt* at 500 hPa averaged over the ocean, associated with (a) all rain, for all rain averaged over the grids with SST of (a) 22.0° –23.0° , (b) 24.0° –25.0° , (c) 26.0° –27.0° , and (d) 28.0° –29.0° C. (Takayabu et al. 2010 JC)

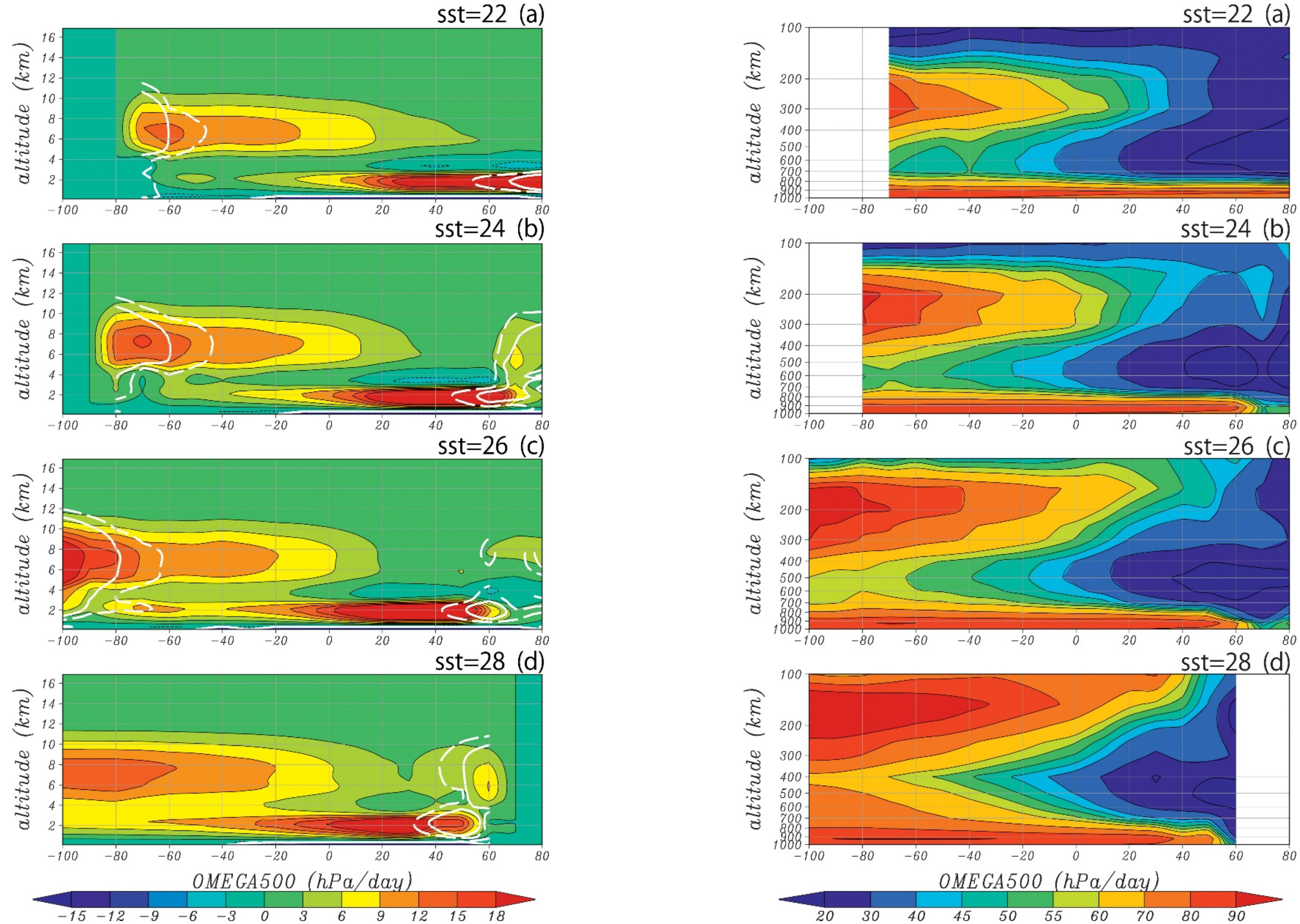


Fig. 6: As in Fig. 3 but for precipitation profiles with heavy near-surface rain rates (20 mm h-1 < R ≤ 30 mm h-1) and upward motion (woro > 0 m s-1) as RH.

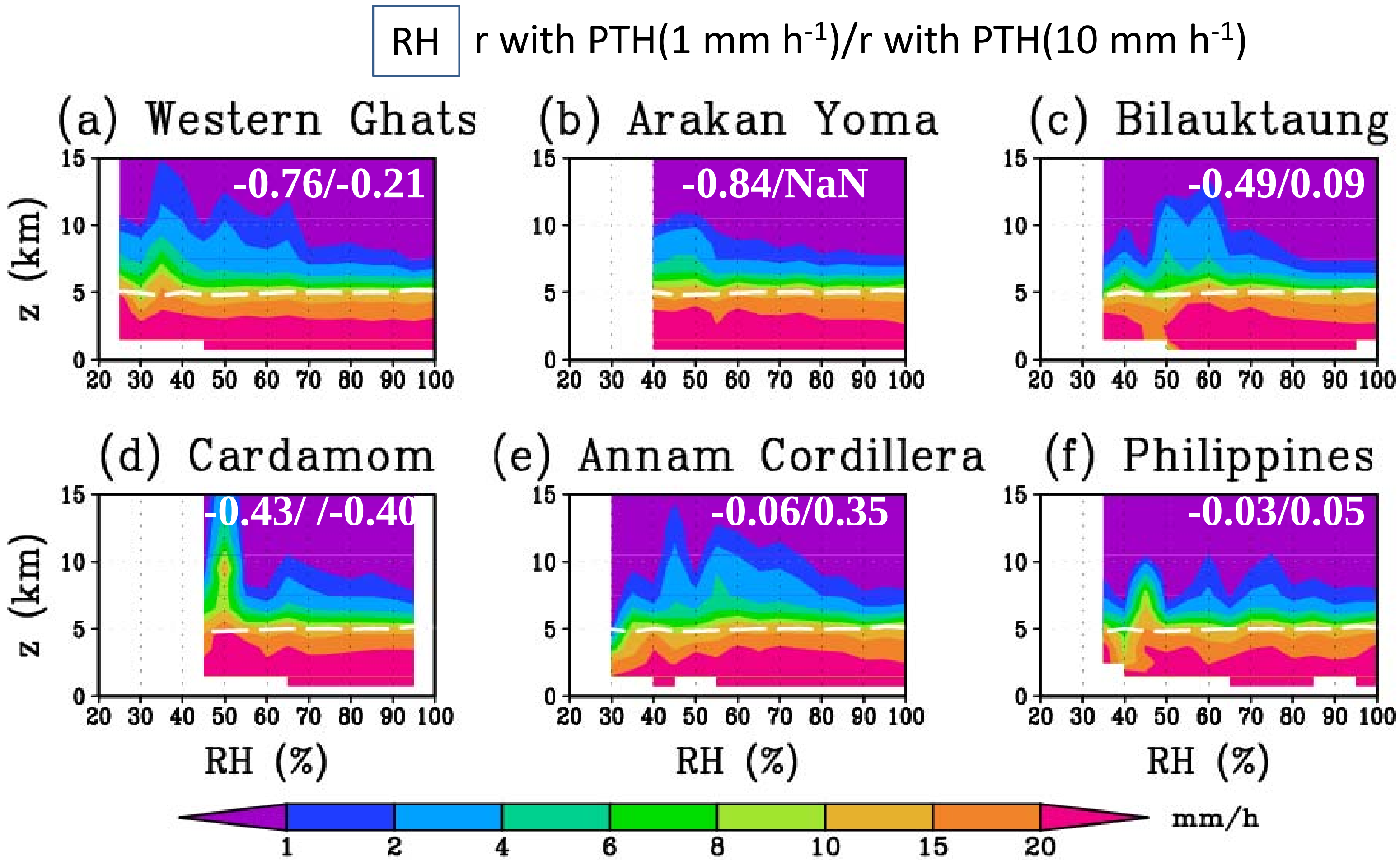
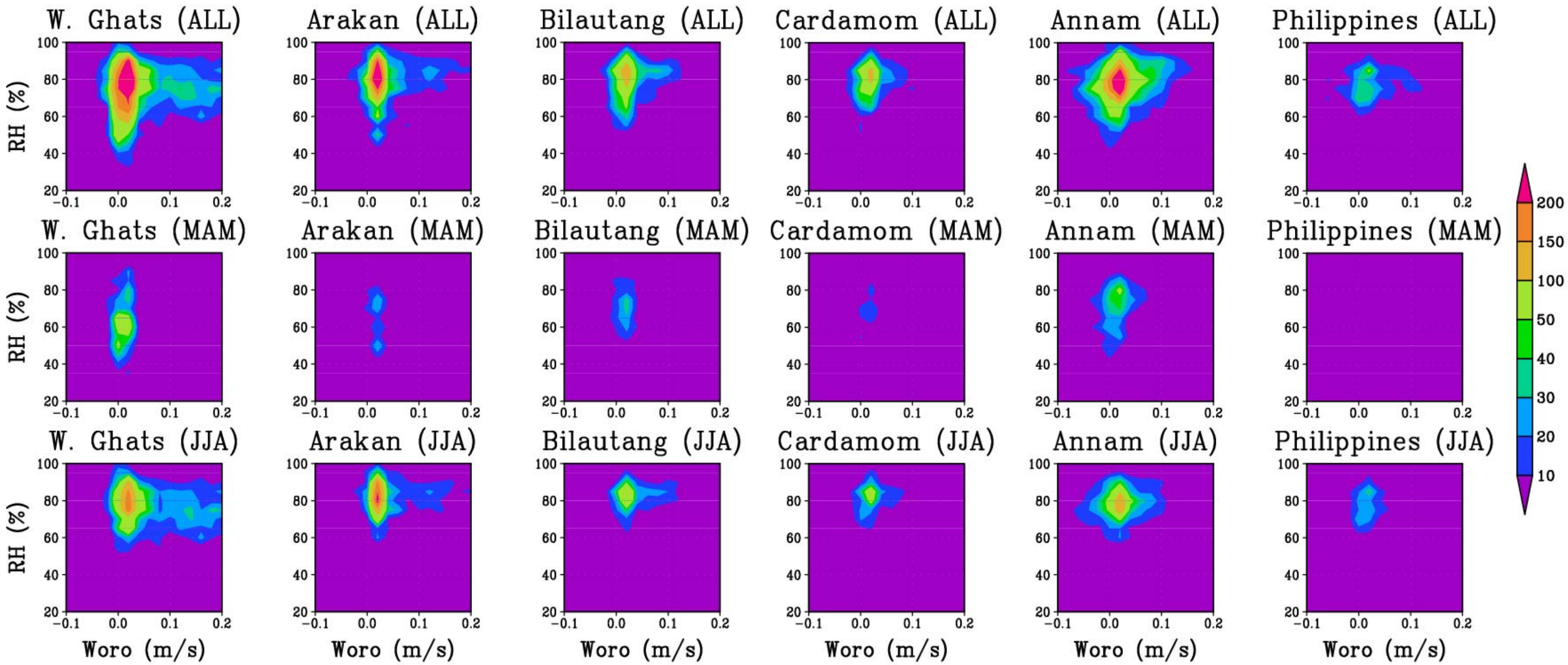


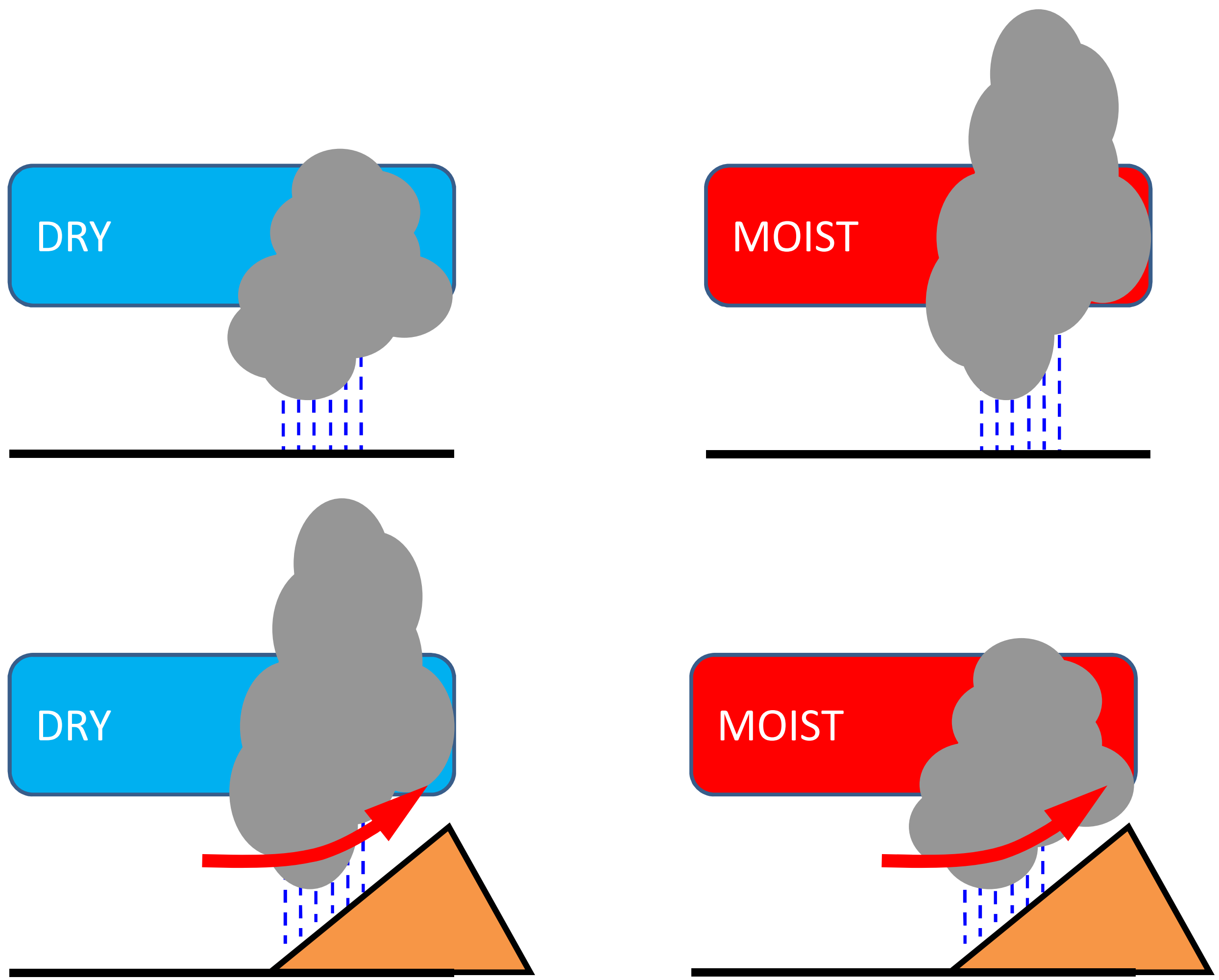
Fig. 7: Two dimensional histogram of grid with heavy rain rates (20 mm h^{-1} < $R \leq 30$ mm h^{-1}) as function of w_{oro} and RH for mesoscale mountain ranges (Western Ghats, Arakan Yoma, Bilauktaung, Cardamom, Annam Cordillera and the Phillipines) of the South Asian monsoon region.



What determines deep or shallow?

Ocean

Mountain



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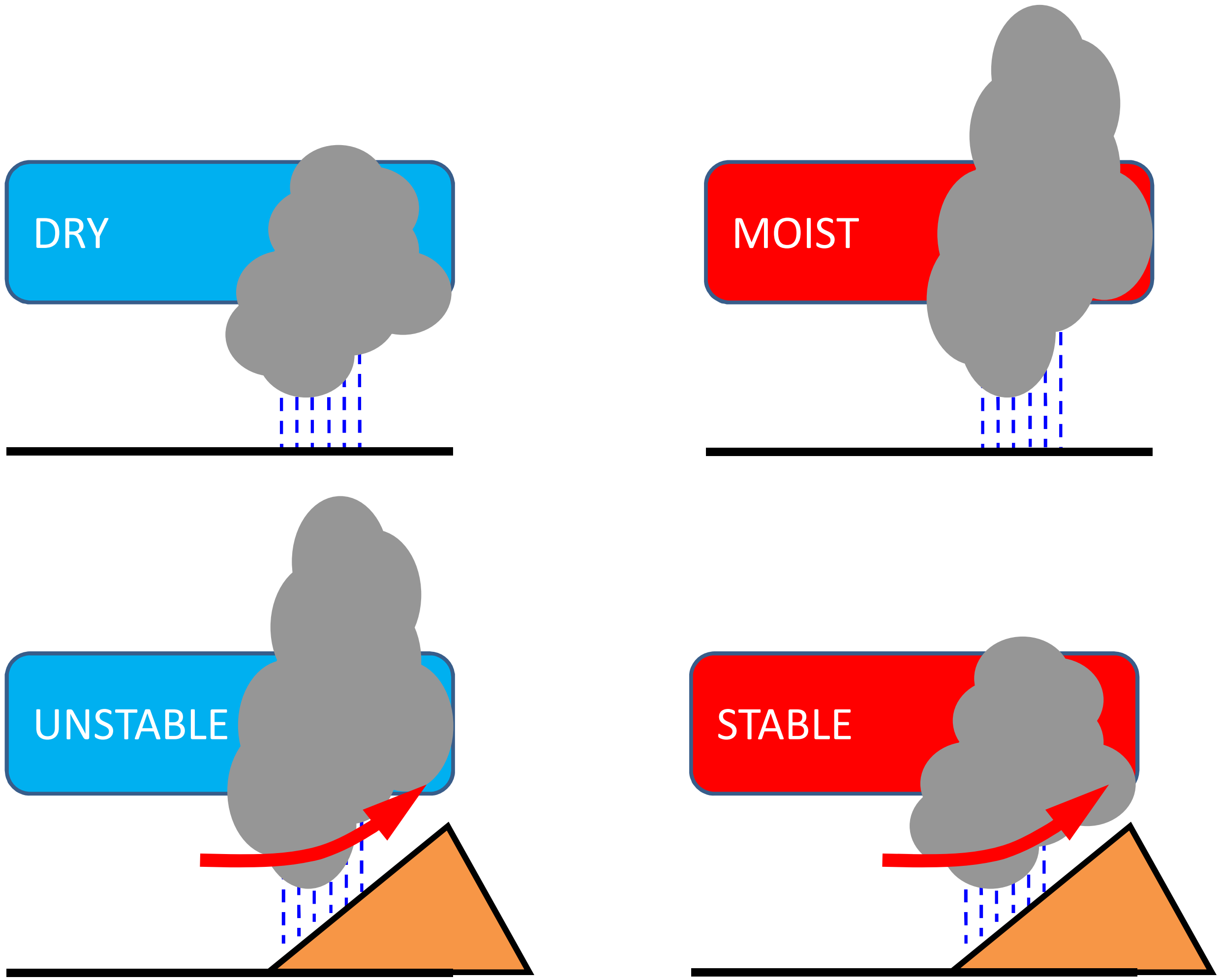


Fig. 8: As in Fig. 3 but for precipitation profiles with heavy near-surface rain rates (20 mm h^{-1} < $R \leq$ 30 mm h^{-1}) and upward motion (w_{oro} > 0 m s^{-1}) as dT/dz_{low}.

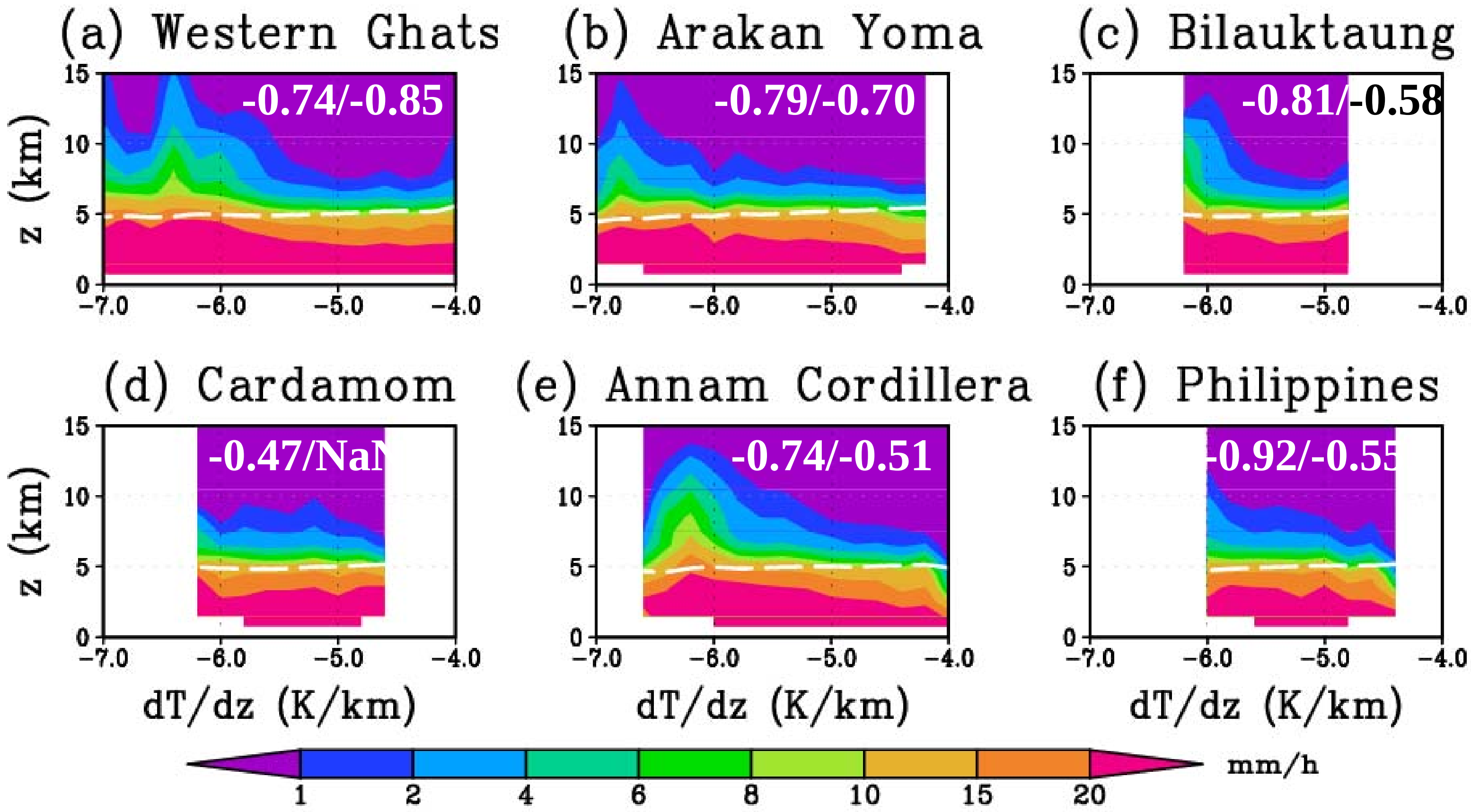
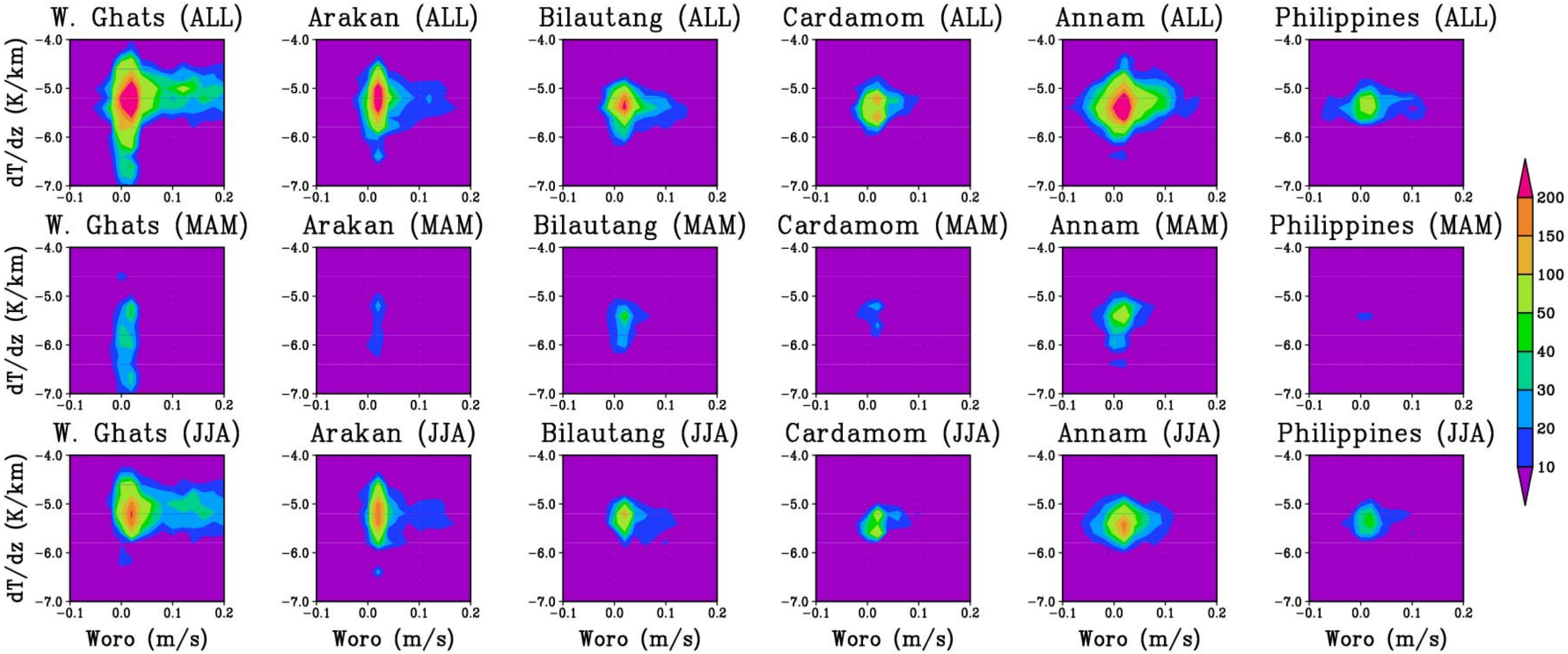
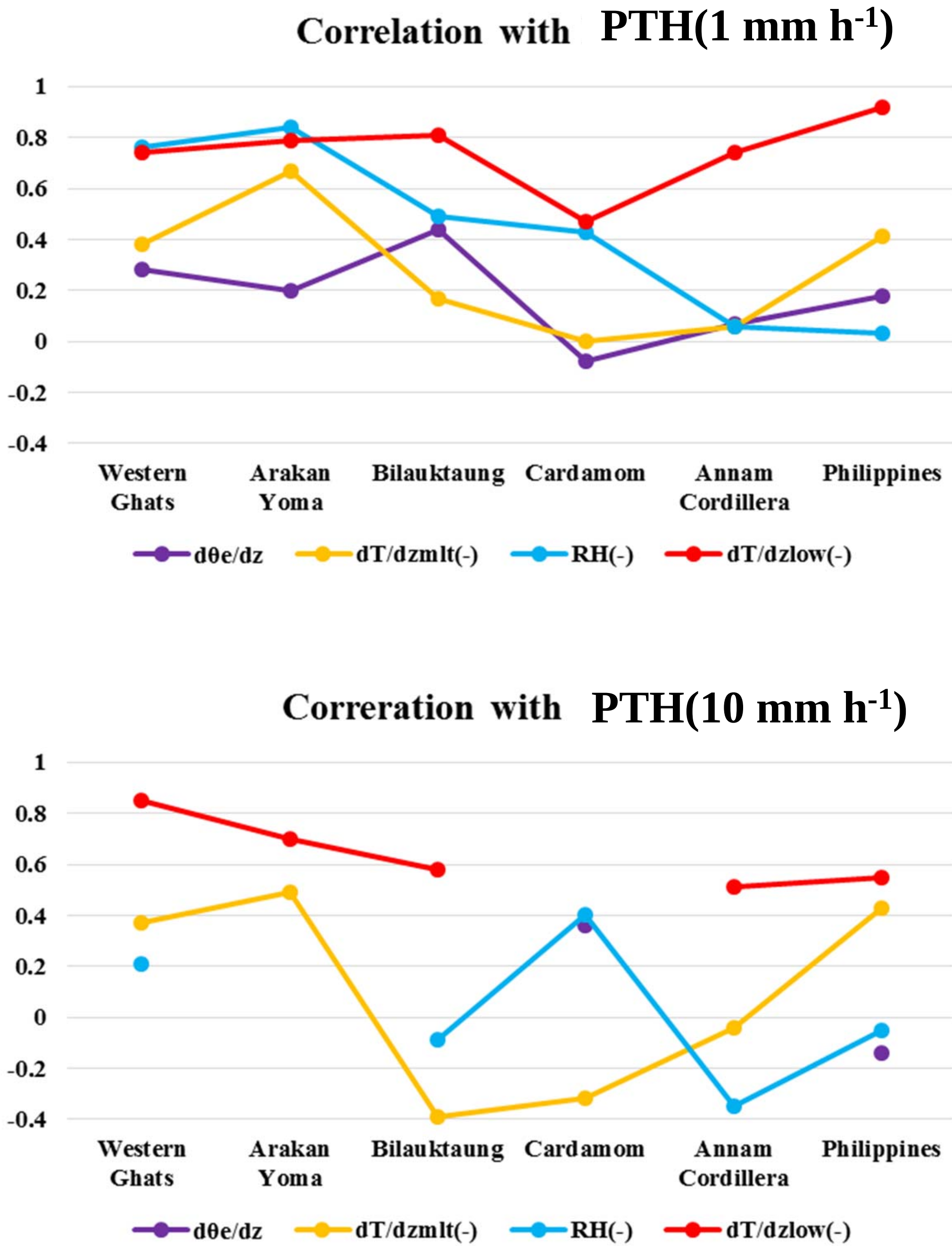


Fig. 9: As in Fig. 7 but for two dimensional histogram of grid with heavy rain rates (20 mm h^{-1} < $R \leq$ 30 mm h^{-1}) as function of w_{oro} and dT/dz_{low}



Correlation coefficients of the static stability of lower troposphere with depth of heavy orographic rainfall are higher than those of other candidate thermodynamic quantities.



Summary

- Depth of heavy orographic rainfall decreases with RH, especially western parts of the Asian monsoon region, in opposite to what were observed for oceanic convection.
- In contrast to transient and ubiquitous occurrence of oceanic convection, orographic convection occurs stationary and thus strongly stabilize their environment.
- Correlation coefficients of the static stability of lower troposphere with depth of heavy orographic rainfall are higher than those of other candidate thermodynamic quantities.