Vertical structure of latent heating in different types of precipitation features

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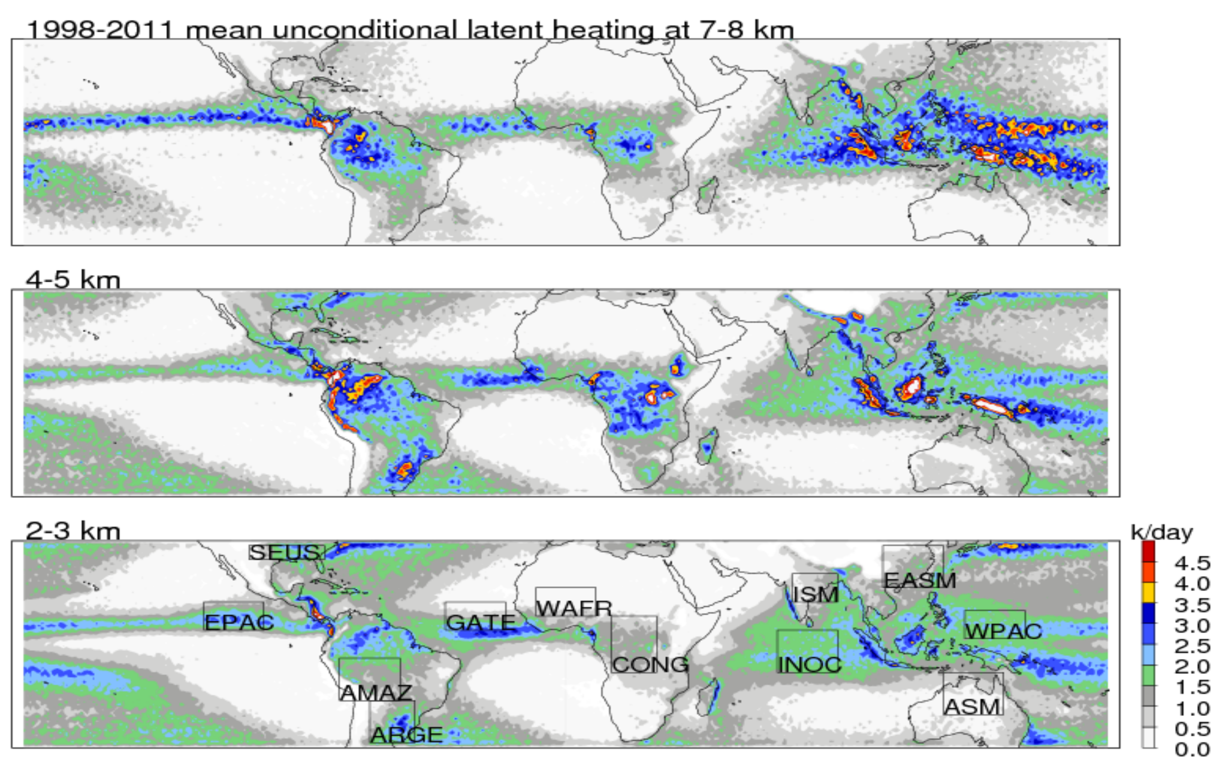
Motivation

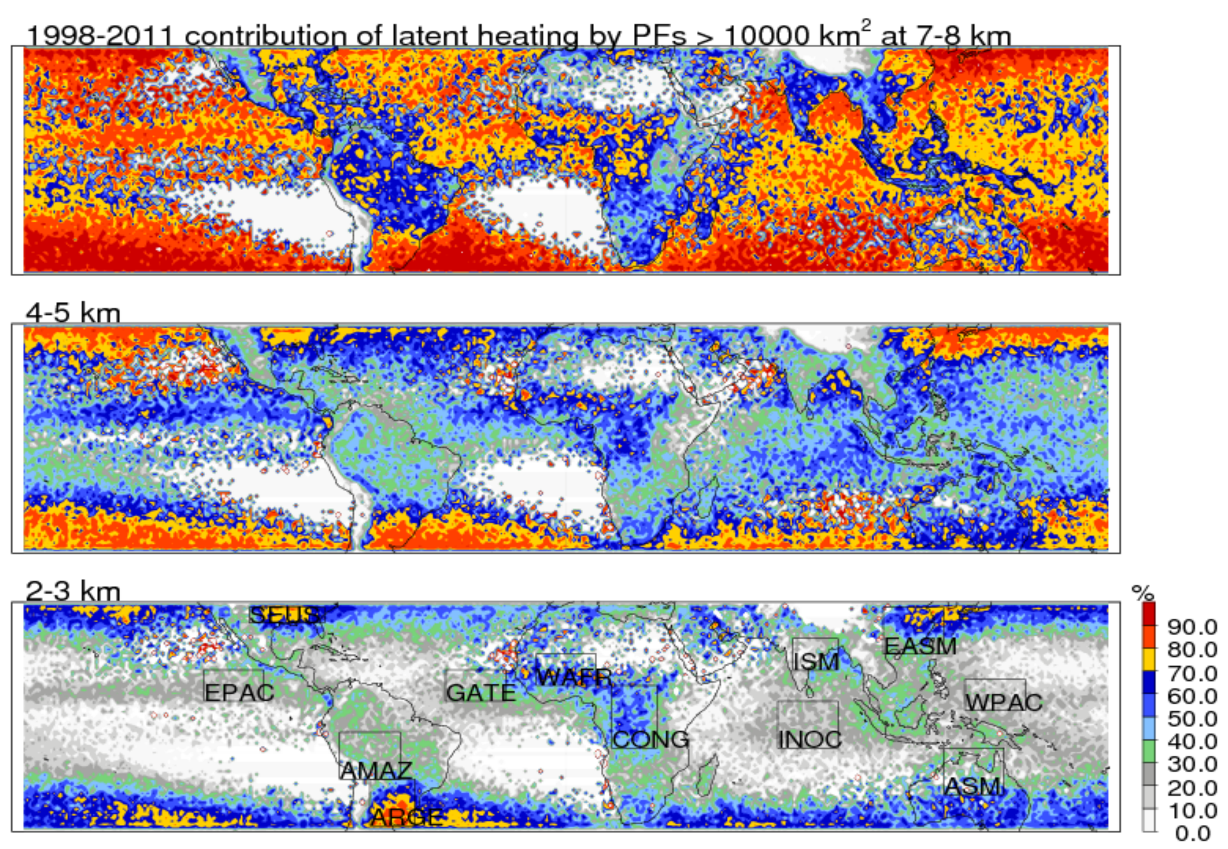
Latent heating is a primary component of the tropical convective heat engine. Correctly diagnosing the vertical profile of latent heating from convective systems is still a challenging problem. Organization of the precipitation is more and more realized as one important missing link in current cumulus parameterization schemes, so it becomes more important to understand the variations of latent heating structures in different types of precipitation systems.

Data and method

The University of Utah Precipitation Feature (PF) product summarizes the properties of precipitation systems, including the size, rain volume and convective intensity proxies from the PR, TMI and LIS observations (Liu et al. 2008). During the reprocessing of Version 7 TRMM product, the profiles of total latent heating and Q1-Qr in each PF (both convective and stratiform) are calculated from V7 TRMM 2H25 (SLH, Shige et al. 2007) products. As a result, it is possible to distinguish the latent heating contribution from PFs with different properties.

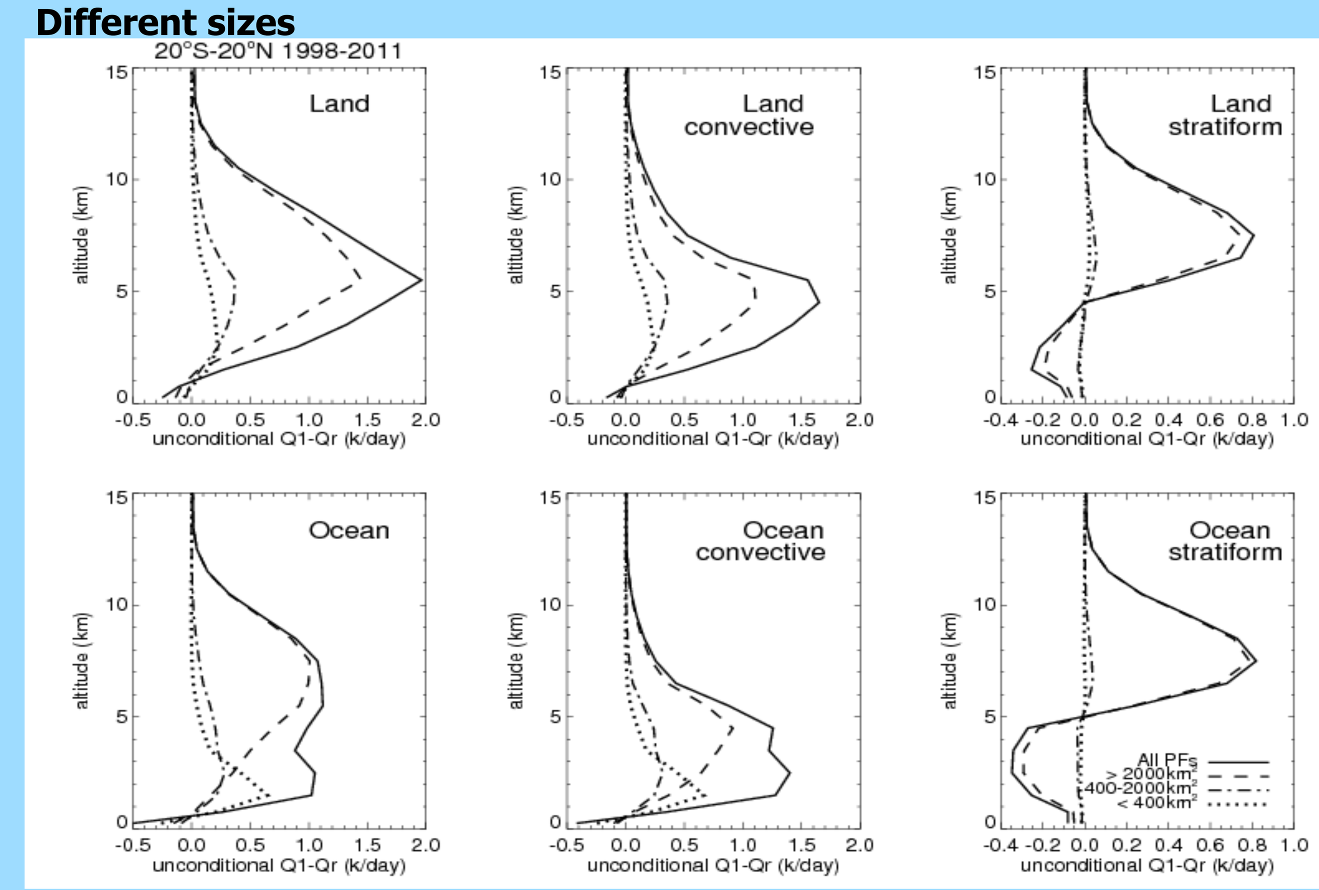
To validate the dataset, the mean unconditional latent heating rates at different region and altitudes are estimated by dividing the summations of total latent heating from precipitation features by total PR samples during 1998-2011. The geo-distribution of latent heating at different levels in top figure is similar to Figure 1 of Tao et al. 2004. At the same time, we are able to quantify the contribution of LH from large precipitation systems at different levels. (bottom figure). A major proportion of LH comes from large systems over ocean at high levels. This is consistent with more organized oceanic systems having a high fraction of stratiform precipitation.



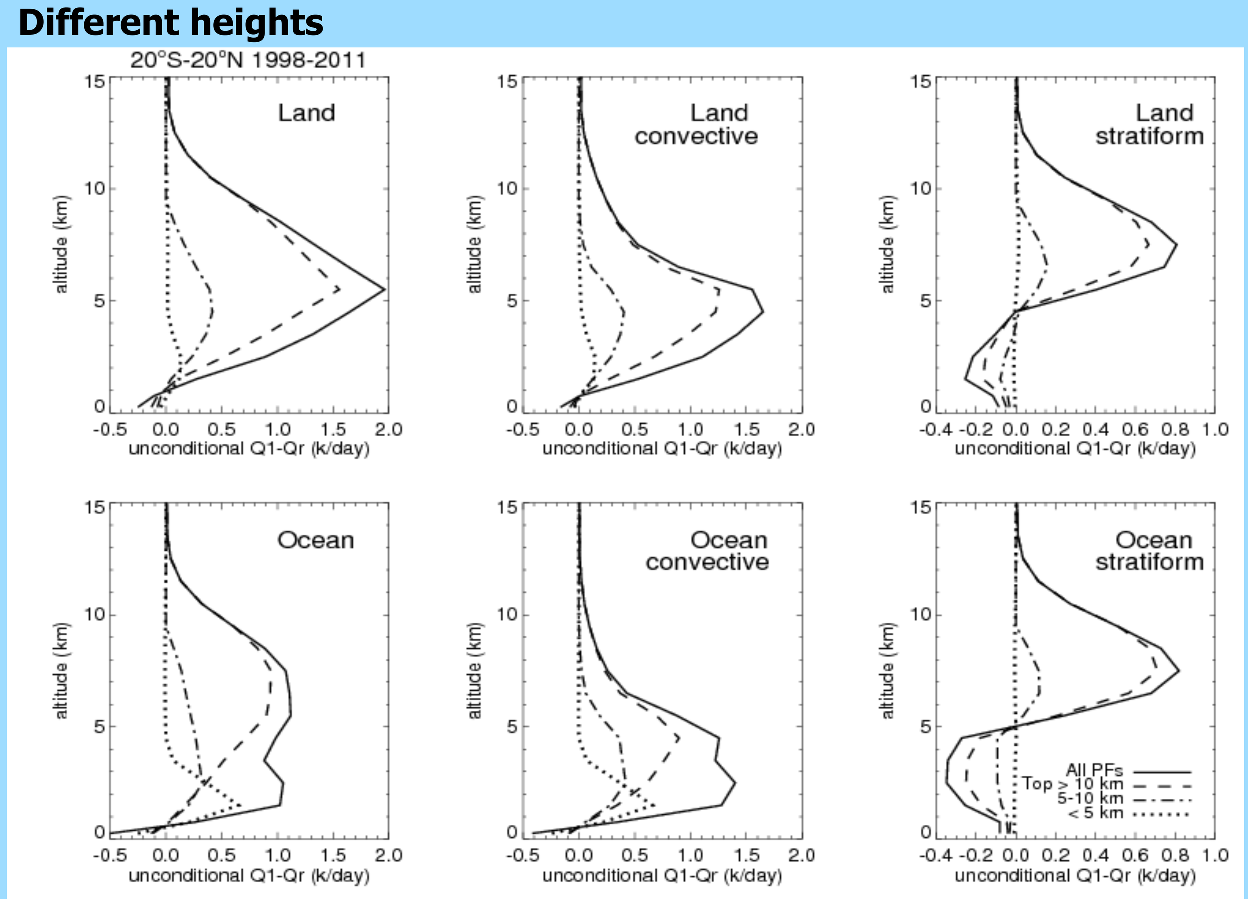


Latent heating contribution from PFs with different properties

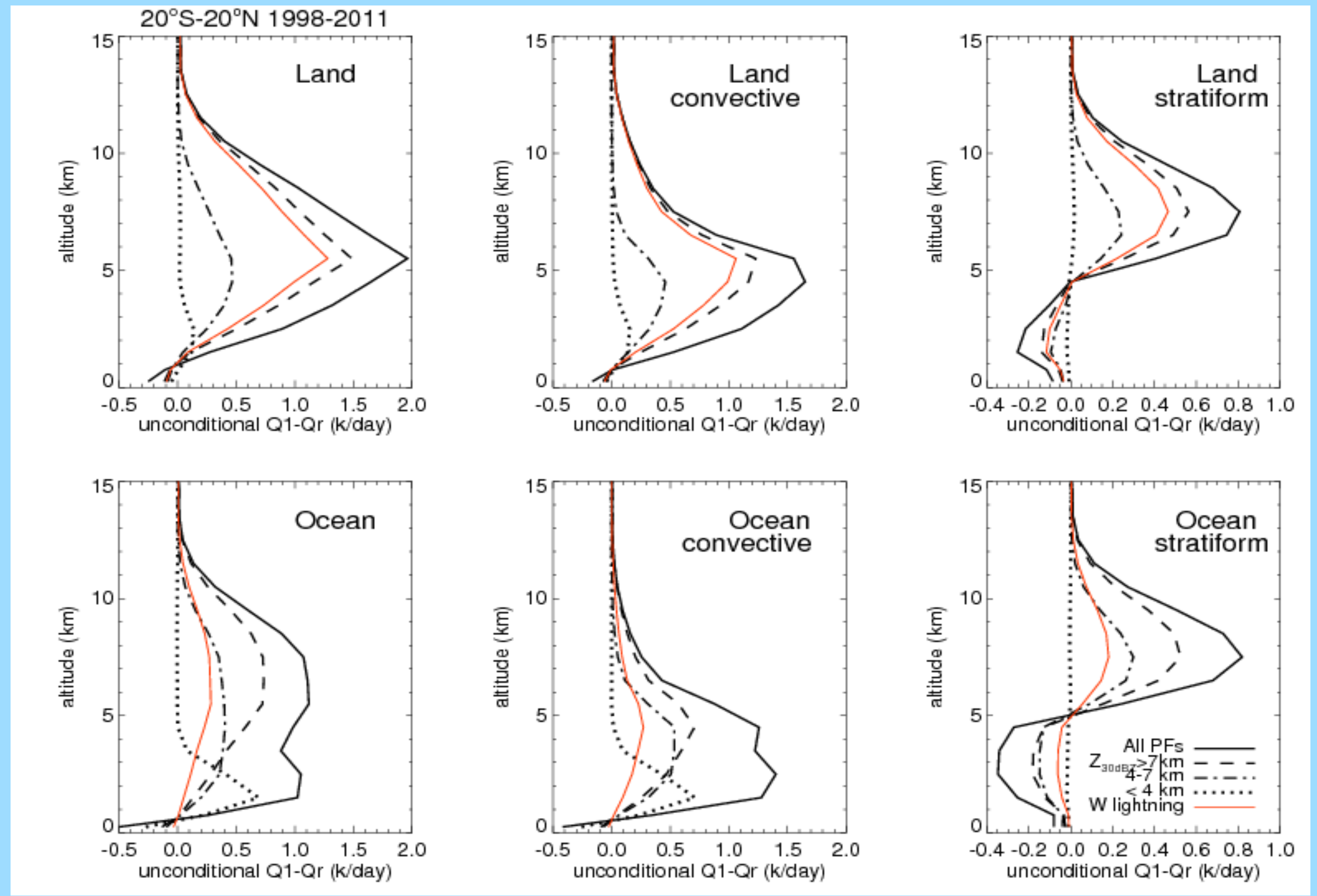
Different sizes



Different heights



Different convective intensities

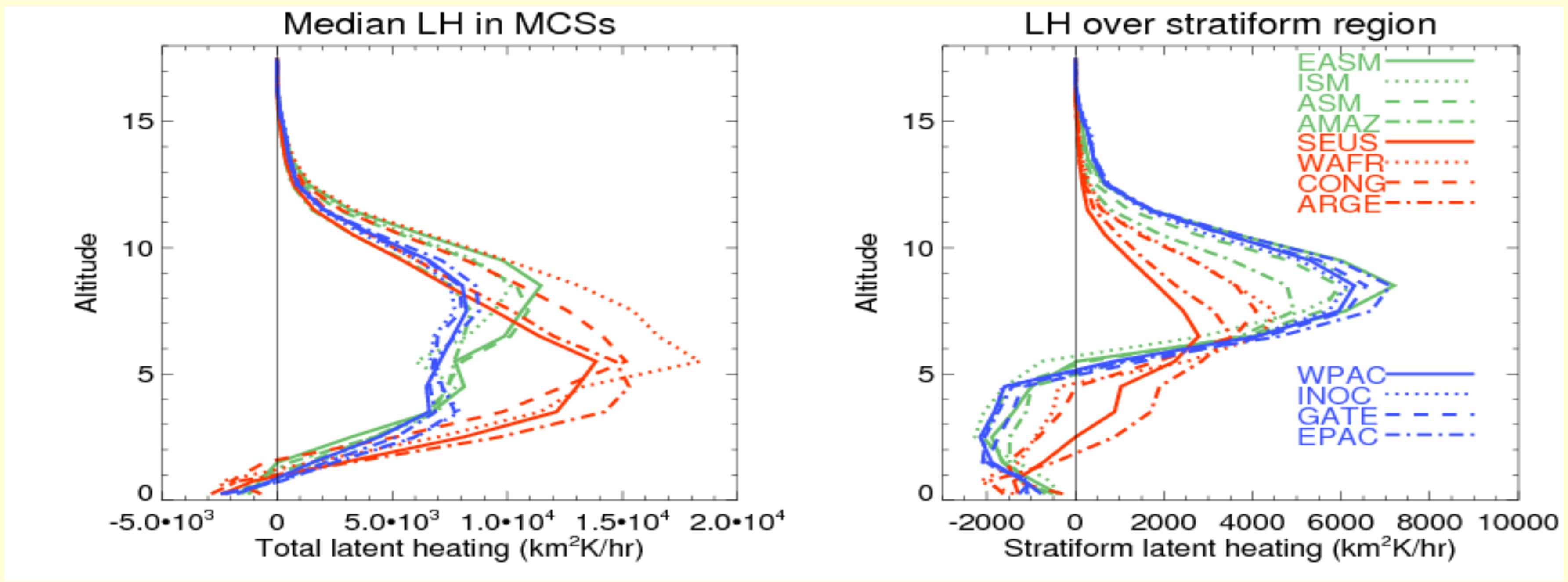


- MCSs (PFs with size > 2000 km²) are the main contributors of latent heating from stratifrom regions everywhere. MCSs over land have a dominating contribution to the latent heating above 2 km. Over ocean, small PFs have a large contribution of latent heating from convective regions at low levels (< 3 km).
- Most of the small PFs are shallow as well. The lower peak of latent heating over ocean is mainly contributed by these small and shallow systems.
- PFs with intense convection (30 dBZ echo top > 7 km) dominate the latent heating contribution at all levels over land. However, the oceanic PFs with less intense convection (30 dBZ echo top between 4-7 km) have large contributions at low levels.
- As expected, thunderstorms have a large contribution to total latent heating over land, but a smaller contribution over ocean.

Latent heating in MCSs under different regimes

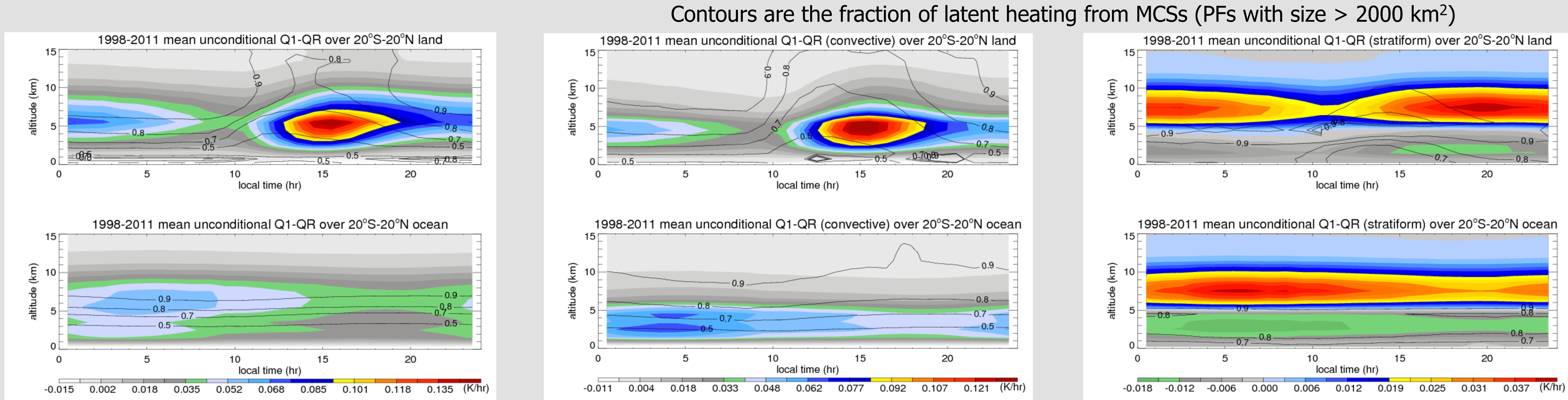
Because of different sizes and fractions of stratifrom precipitation, MCSs under different weather regimes have different latent heating structures. In general, MCSs over land have stronger latent heating in the mid troposphere than over ocean. With higher fractions of stratiform precipitation, MCSs over ocean have larger latent heating contributions than those over land at 7-10 km. MCSs during active monsoon precipitation regimes tend to have latent heating intermediate between those over land and ocean.

Region	Season	Type	Rain from MCSs (> 2000km²)	Percent of stratiform precipitation in MCSs	Percent of latent heating at 7-10 km from stratiform region
EASM	JJA	Monsoon	79%	55%	77%
ISM	JJA	Monsoon	76%	48%	76%
ASM	DJF	Monsoon	79%	51%	75%
AMAZ	DJF	Monsoon	76%	54%	79%
SEUS	JJA	Land	72%	39%	46%
WAFR	JJA	Land	84%	41%	52%
CONG	MAM	Land	77%	43%	58%
ARGE	DJF	Land	86%	44%	51%
WPAC	JJA	Ocean	77%	57%	85%
INOC	JJA	Ocean	74%	54%	88%
GATE	JJA	Ocean	79%	56%	87%
EPAC	JJA	Ocean	81%	58%	87%



Diurnal variation of latent heating

Contours are the fraction of latent heating from MCSs (PFs with size > 2000 km²)



- Following the typical diurnal cycle of precipitation, latent heating peaks in the afternoon over land. Latent heating over ocean has only a small diurnal variation, with a broad peak at night and early morning.
- Slightly tilted latent heating vs. local time structure in the afternoon over land is consistent with the typical development of afternoon convective systems, increasing in size and maturity with time.
- In the afternoon, smaller systems (< 2000 km²) have considerable (> 30%) contribution of latent heating at high levels (> 5 km) over land, while smaller systems contribute < 20% over ocean at all times.
- At 3-6 km, MCSs contribute even higher proportion of latent heating over land than over ocean during night and early evening.
- When raining, the conditional latent heating rate in the convective region over land is higher than over ocean, which is consistent with more intense convective rainrate over land. However, the stratiform heating rate is higher over ocean at high levels, also with stronger cooling at low levels than that over land.

Acknowledgements:

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