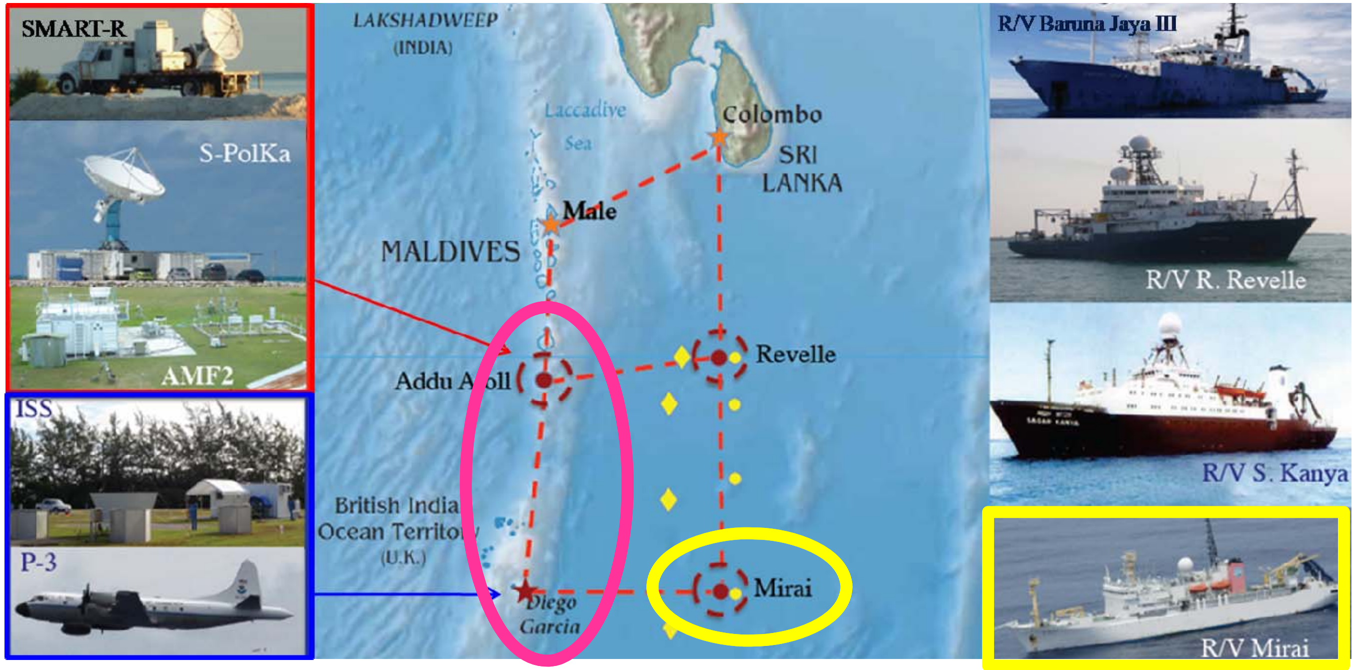
Characteristics of vertical moistening observed during CINDY/DYNAMO

Note.
Since the latter part of this presentation has been submitted and now under review, some results may be subject to change.

K. Yoneyama, H. Bellenger, M. Katsumata (JAMSTEC),
K. Yasunaga (U Toyama), and T. Nishizawa (NIES)

Outline

1. Moisture distribution in different MJO phases
2. Observational evidence of moistening by convection



Observing Period:

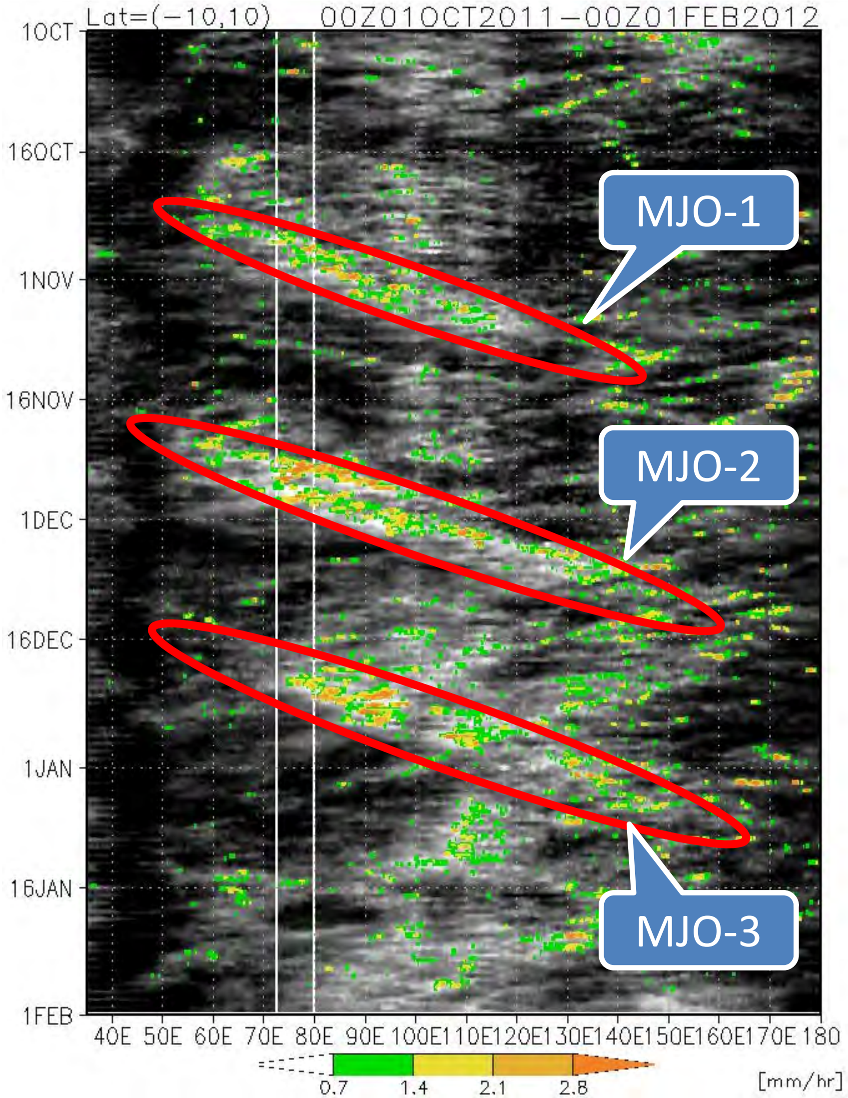
From Oct 2011

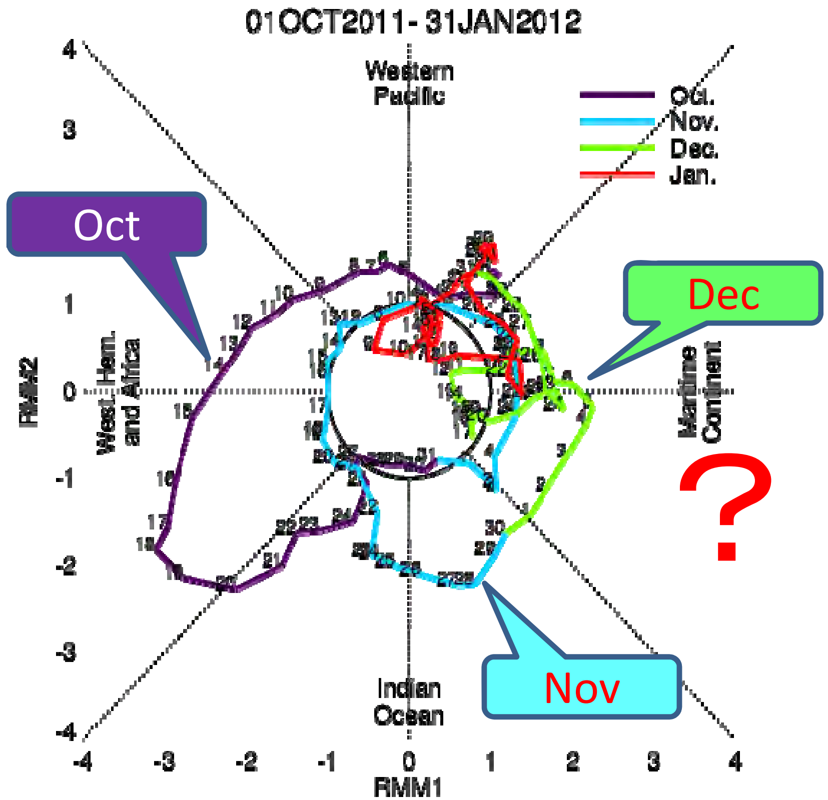
to Nov 2011 (SOP)

to Jan 2012 (IOP)

to Mar 2012 (EOP)

MJOs observed during CINDY/DYNAMO - IOP





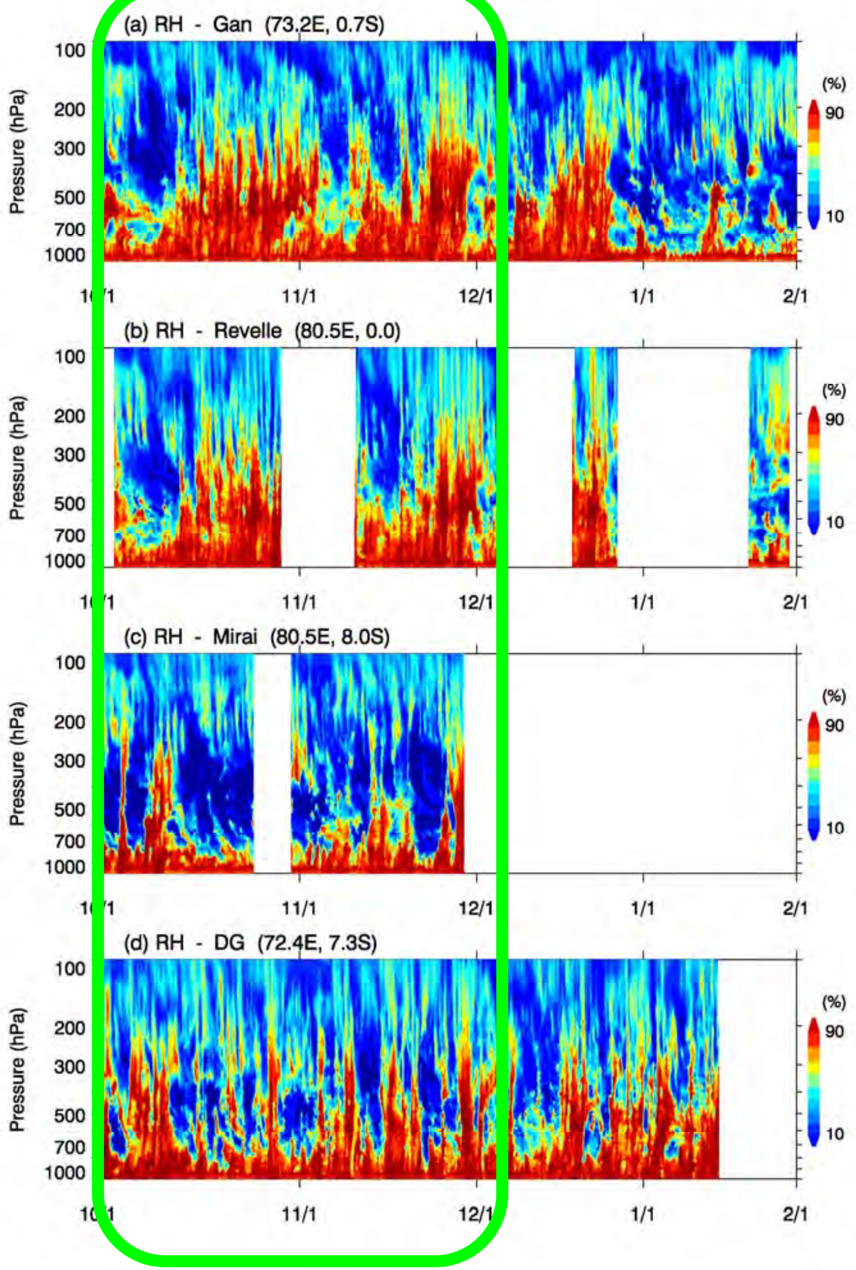
Relative Humidity during IOP (Oct – Jan)

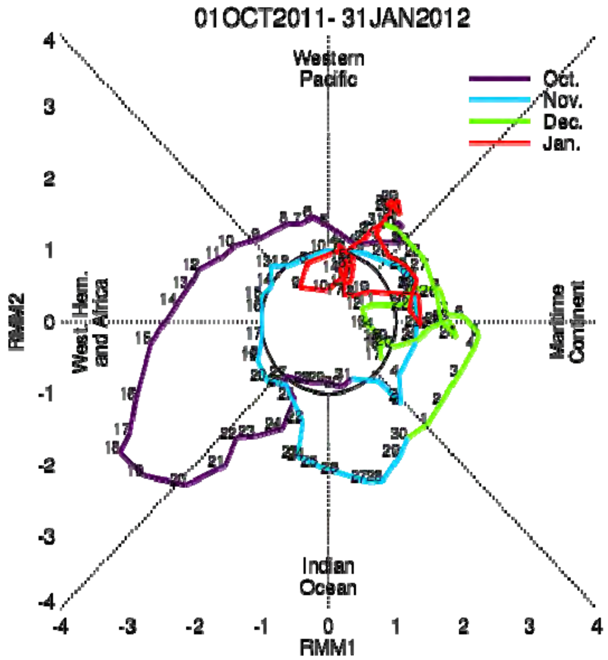
Gan

Revelle

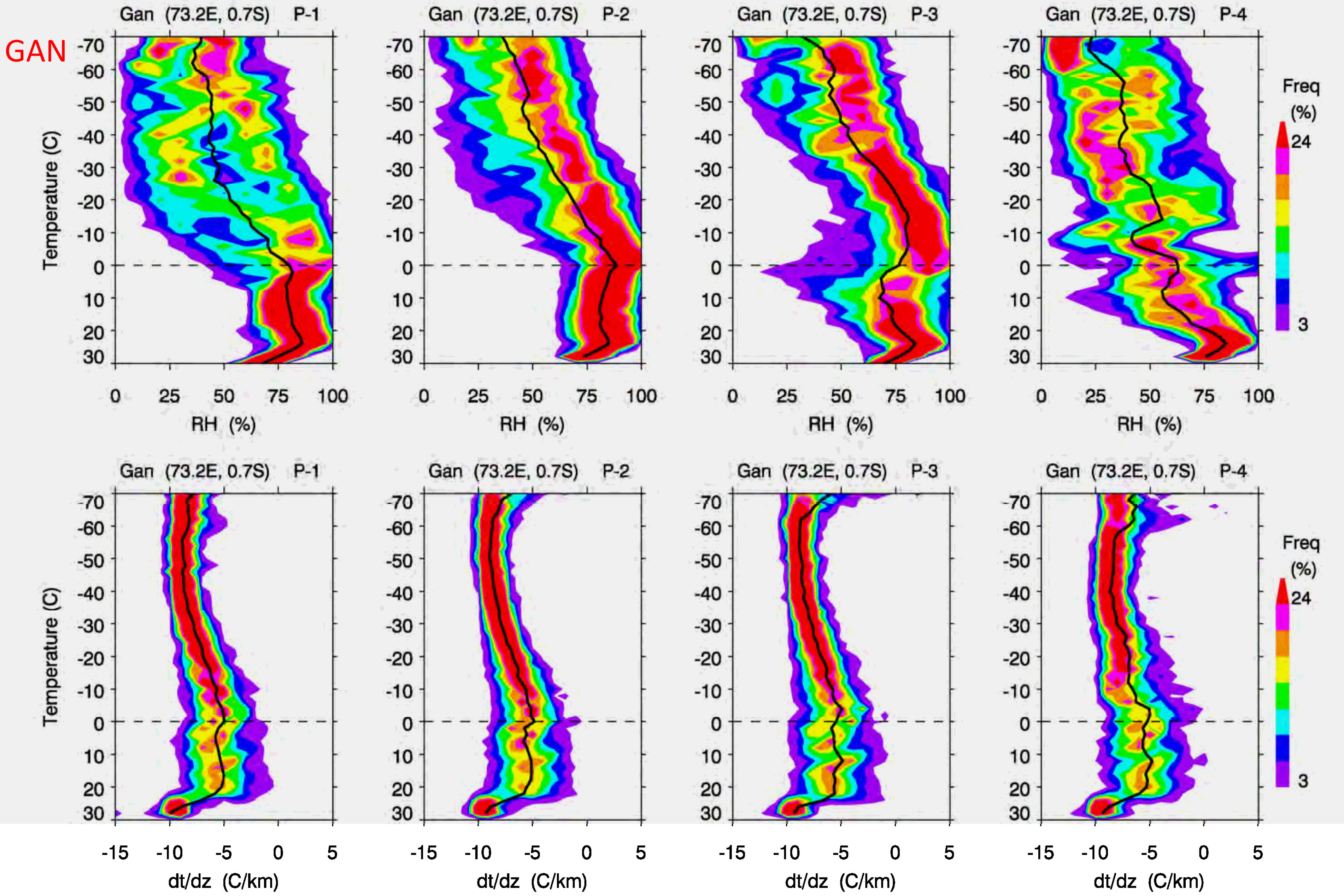
Mirai

Diego Garcia

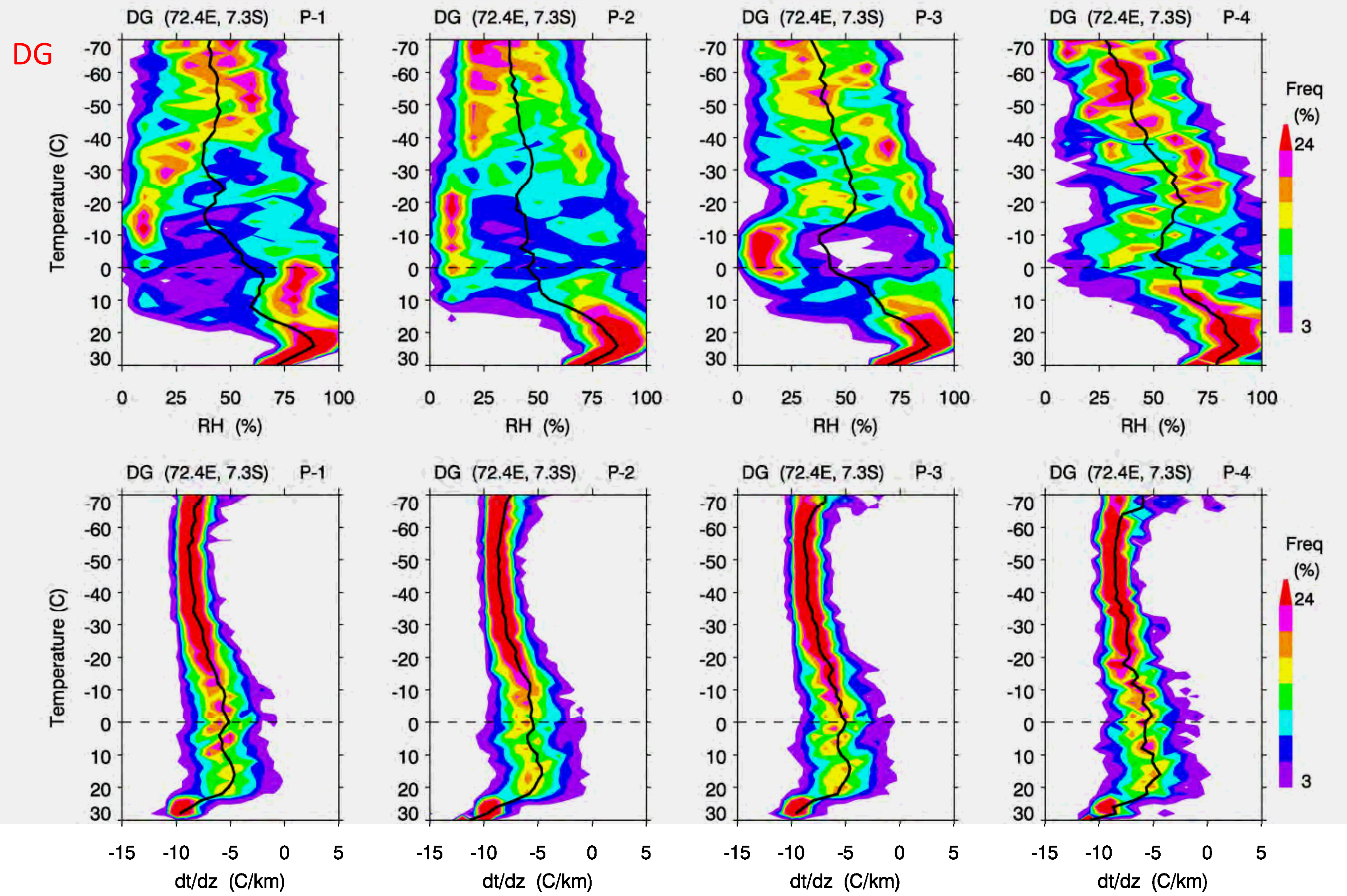




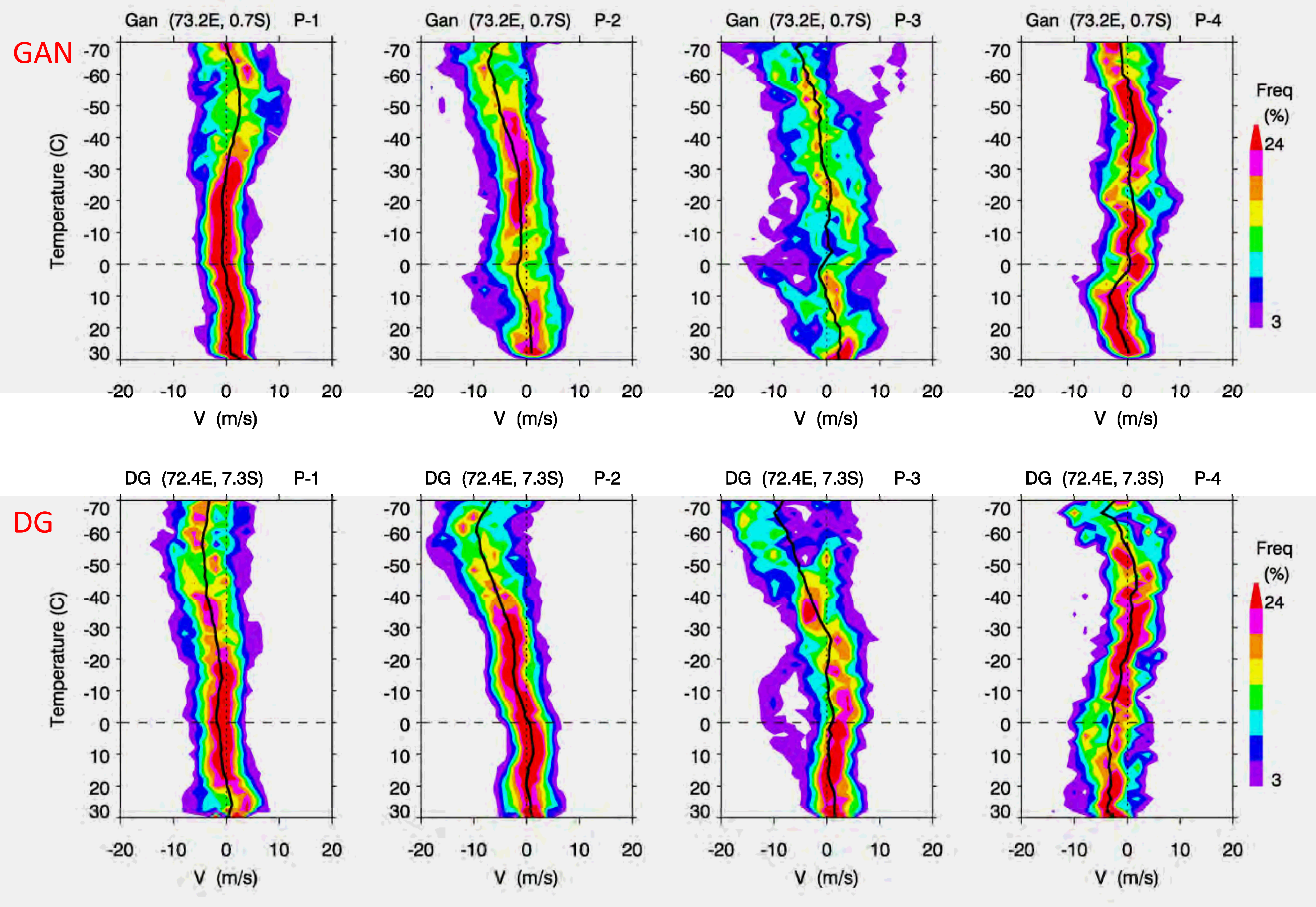
Frequency Distribution of RH and Temp Lapse Rate as a function of Temp



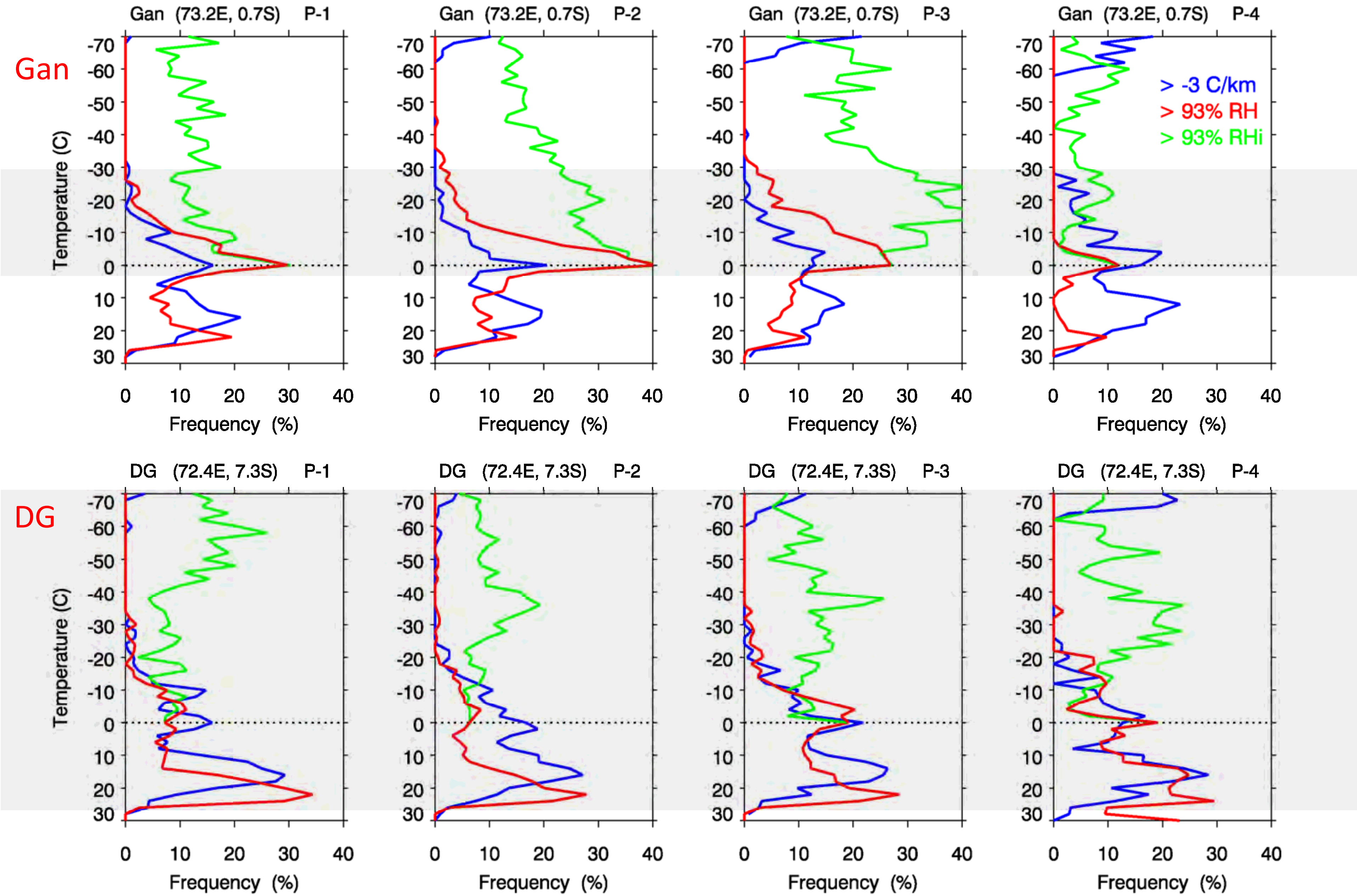
Frequency Distribution of RH and Temp Lapse Rate as a function of Temp



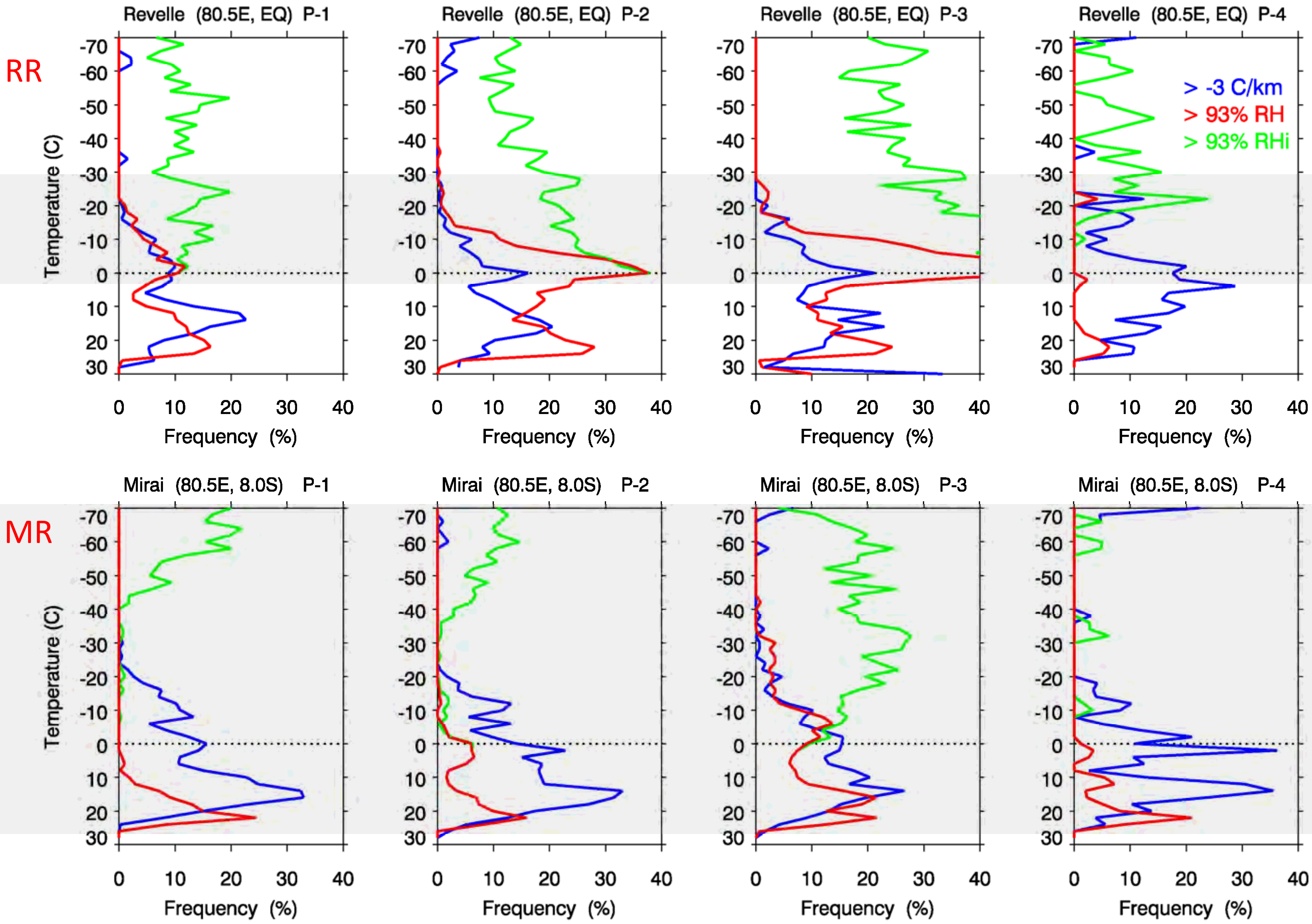
Frequency Distribution of V as a function of Temp



Cumulative Frequency of Clouds (>93%RH) and Stable Layer (>-3C/km)



Cumulative Frequency of Clouds (>93%RH) and Stable Layer (>-3C/km)



Does shallow convection/congestus moisten the atmosphere so that deep convection enhance ?

Recently, Hohenegger & Stevens (2013) questioned the importance of preconditioning by congestus for the onset of deep convection.

Data:

TBB from Meteosat

Radiosonde from ship	Apr 20 – May 20, 2011
GATE sounding network	Aug 30 – Sept 18, 1974

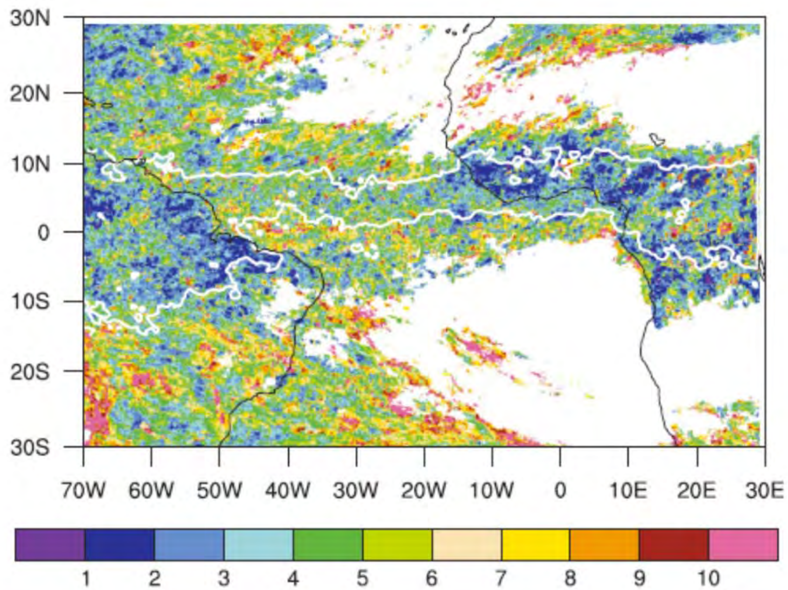
UCLA-LES

Method:

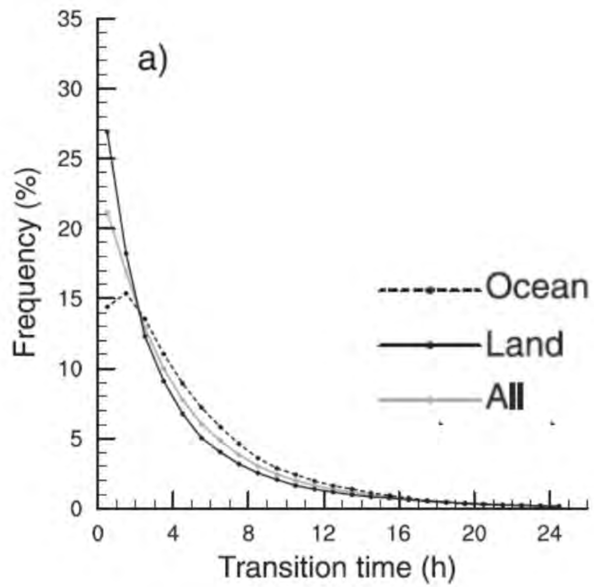
Evaluate time elapsed for congestus and cumulonimbi

1) Time-scale analysis indicates over 10 hr is needed to moisten the atmosphere by congestus, but obs shows only a few hrs.
2) A faster transition over land than over ocean.

→ large-scale vertical advection is essential



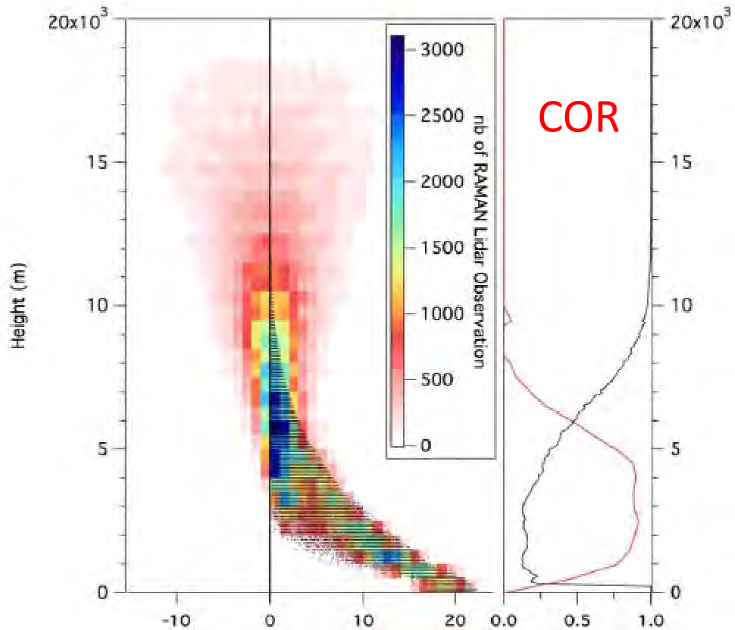
Average Time (hr) elapsed btwn first appearance of Cg & first Cb.



From Hohenegger and Stevens (2013)

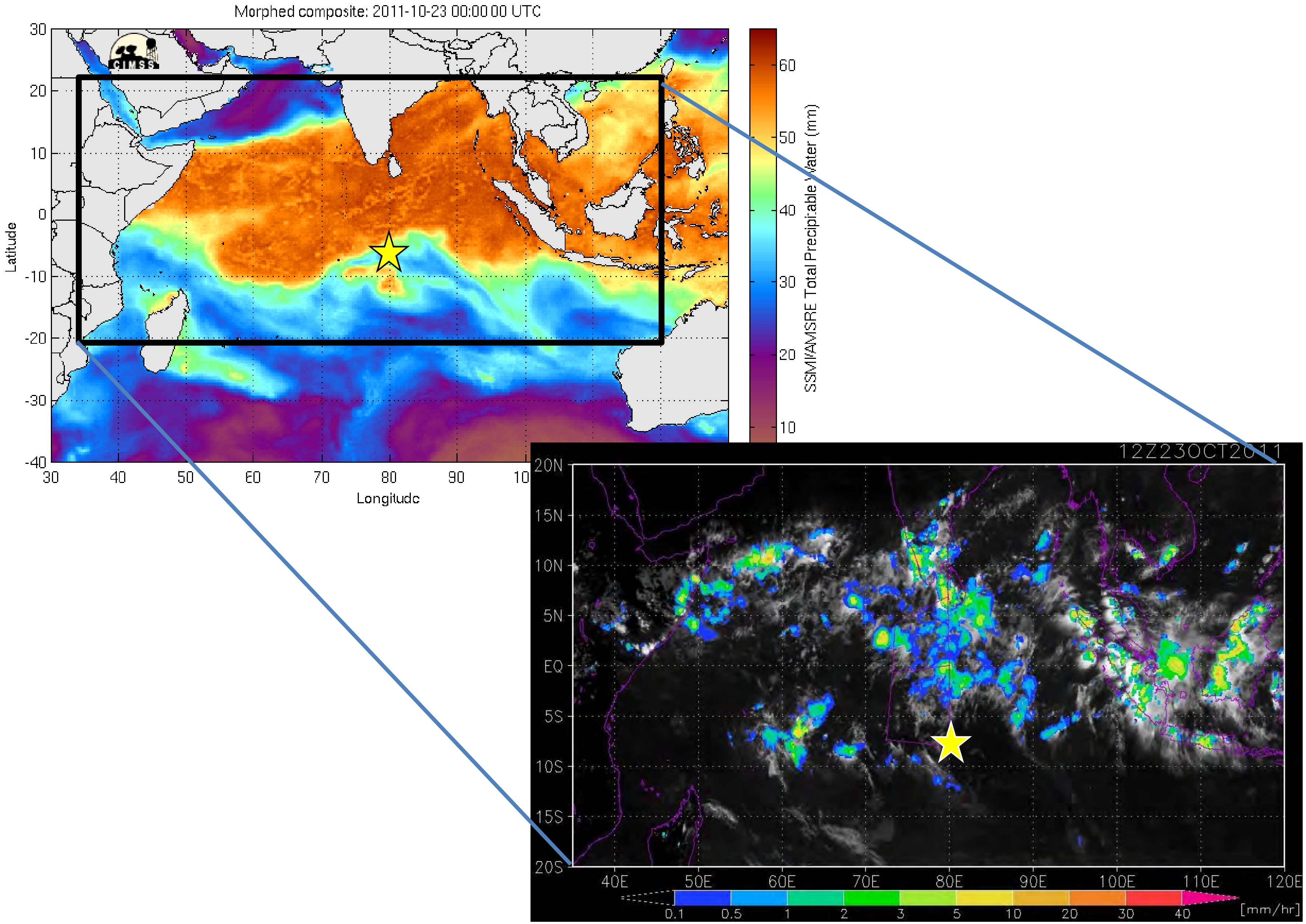
Moisture Observations on-board the *MIRAI*

Raman Lidar	Water vapor density * only nighttime, 90 m resolution available for 0.5 – 5 km	1-min / 10-min
Ceilometer	Cloud base height	1-min
C-band Doppler radar	10dBZ Echo-top height	10-min
Radiosonde	Large-scale / Validation	3-hourly



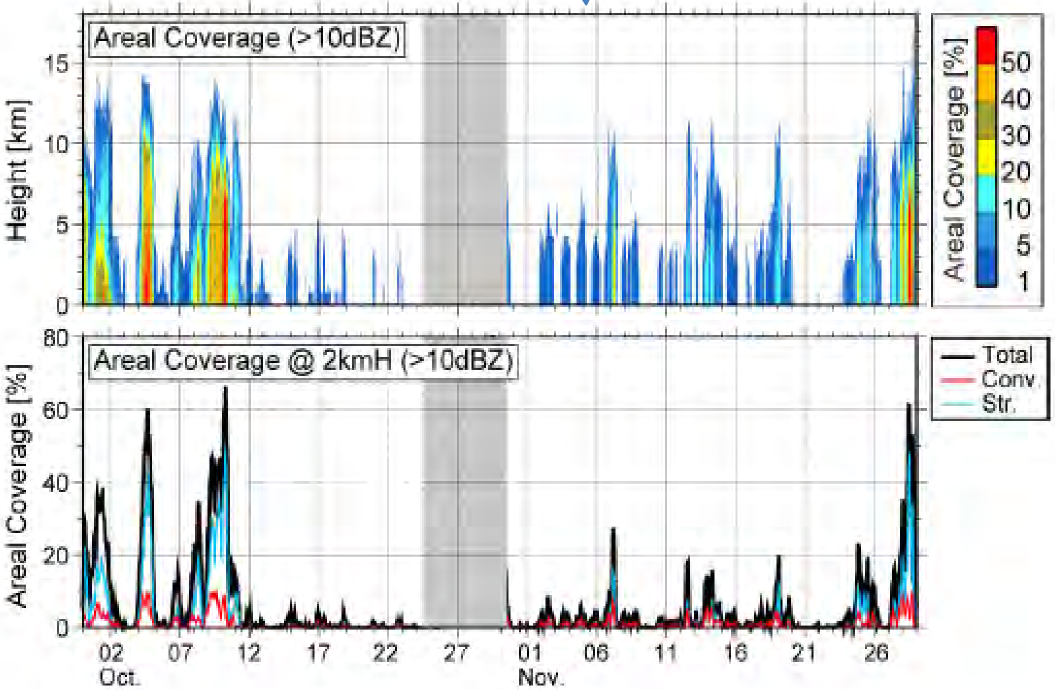
From Bellenger et al. (2014, submitted)

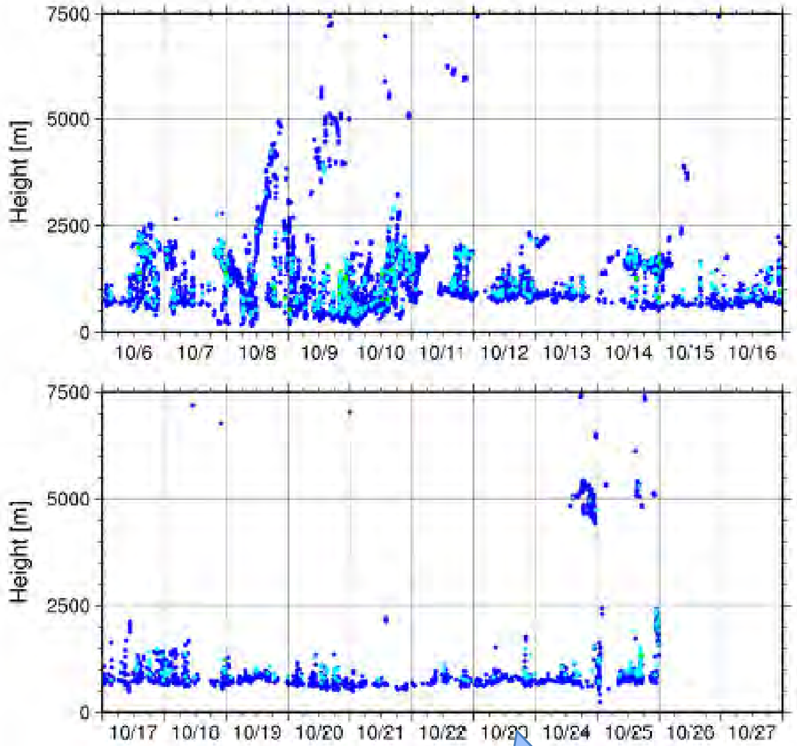
Distributions of TPW, OLR, Rain at 12:00 UTC on Oct. 23, 2011



Moisture Observations on-board the *MIRAI*

C-band Doppler Radar
Areal coverage (>10dBZ)
(Top) Vertical profiles
(Btm) at 2km height





Ceilometer
Cloud detection
(Top) Oct. 6-16
(Btm) Oct. 17-27

Instantaneous Moisture Variations associated with Shallow Convection

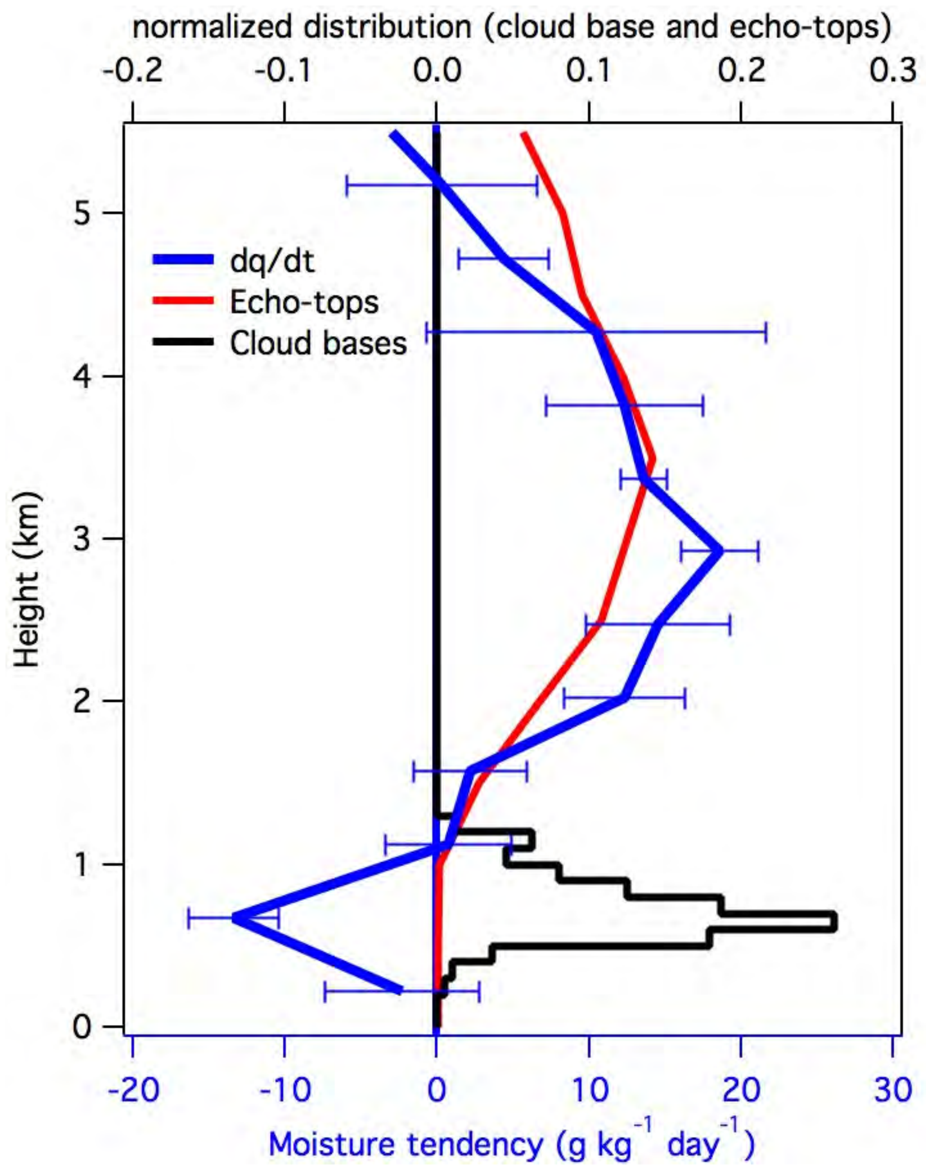
Moisture Tendency dq/dt

is calculated in the vicinity of shallow convection within 25 min from the peak

Shallow Convection ≡
Cloud base < 1.2 km
10 dBZ Echo top < 4 km

Cloud Coverage = 10 %

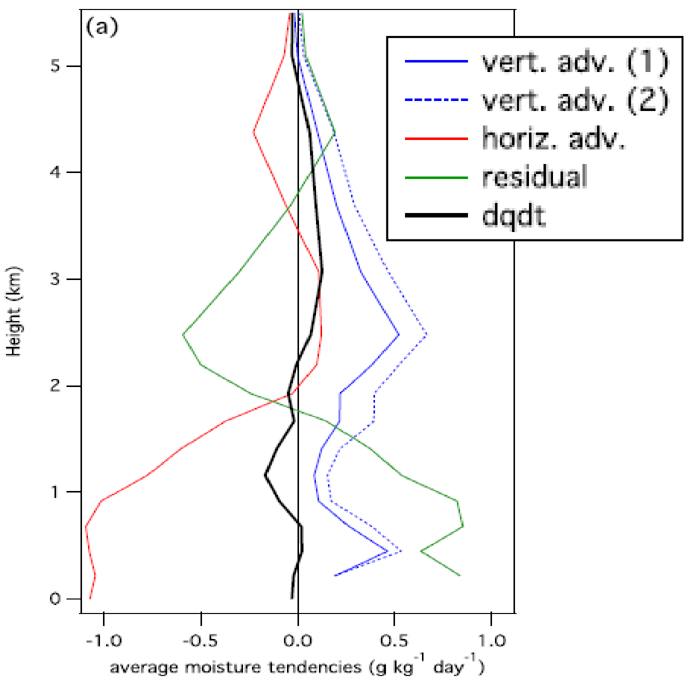
10〜20 g kg^{-1} day^{-1}
→ 1〜2 g kg^{-1} day^{-1}

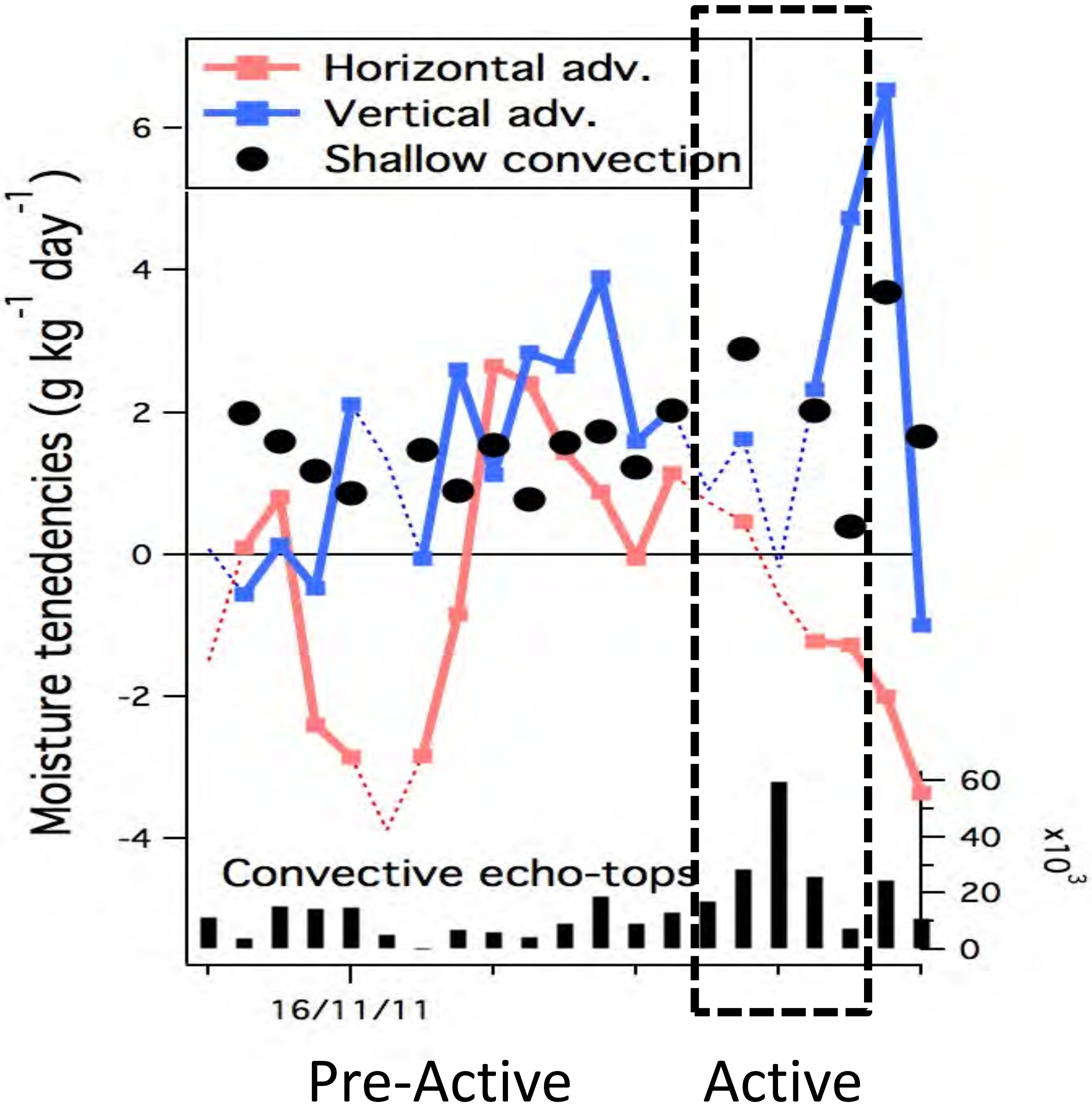


From Bellenger et al (2014, submitted)

Preconditioning : Shallow Convection vs. Large-scale Advection

ERA-Interim
200 x 200 km
centered on Mirai
Averaged btwn 1.5-5km
during shallow conv.





From Bellenger et al (2014, submitted)

Summary

(1) Frequency distributions of RH and temperature lapse rate show the features depending on the different MJO phases.

  (a) While 0C stable layer exists during Phase 1-2 (prior to convective peak), it is strengthened in Phase 3-4 and upward shift is confirmed.
  (b) After the passage of convective peak (Phase 3), dry condition dominates just above trade inversion and 0C stable layer.

(2) Based on moisture observations on-board the Mirai using Raman Lidar, Ceilometer, C-band scanning Doppler radar, and Radiosonde sounding, we confirmed;

  (a) Moisture tendency associated with shallow convection is comparable with large-scale advection during the shallow convective situations.
  (b) Moisture tendency from shallow convection is always positive. Thus, the mean effect of convective transport is stronger than large-scale advection tendencies.

Namely, despite its role has recently been questioned, convection seems to play an important role in pre-conditioning the atmosphere prior to deep convection.

Finally, we'd like to encourage you (in particular numerical model guys) to use those observation data, which are available from CINDY and/or DYNAMO data archive centers;

http://www.jamstec.go.jp/iorgc/cindy/
https://www.eol.ucar.edu/field_projects/dynamo/