Relationship between Clouds, Aerosols, the environment and the onset of Precipitation

Looking at other AMR sites in preparation for analyzing the AMF deployment in Shouxian

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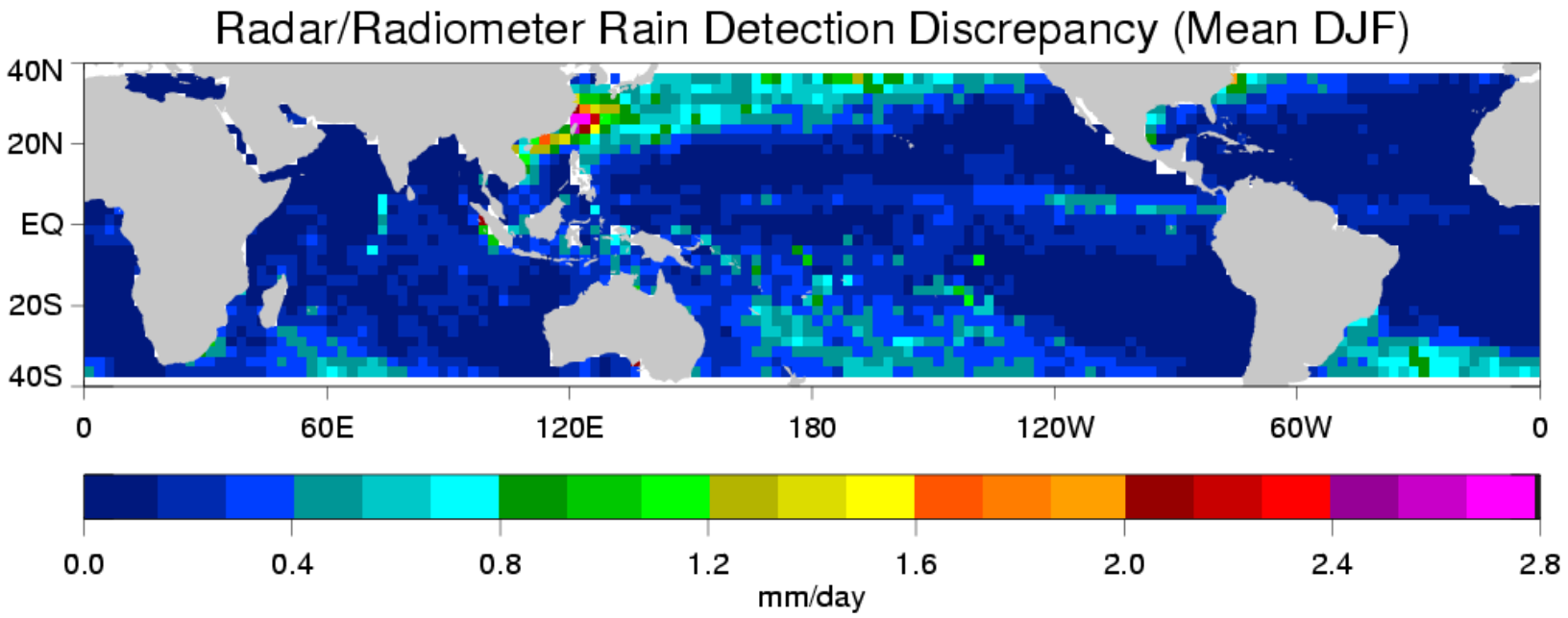
Motivation



Paper by Berg, Kummerow et al., (2006) speculated that discrepancy in TRMM products east of China was due to high aerosol concentrations modifying cloud processes assumed by the retrieval algorithms.

Background

- Irrespective of aerosols, we know little about the onset of precipitation. Passive microwave radiometers algorithms tend to have static thresholds for Liquid Water **Path** amounts after which point rainfall is assumed.

- TRMM Radar has detection threshold of 17 dBZ. This is too high to detect clouds or drizzle. Echoes appear at approximately 0.5 mm/hr.

- CloudSat can shed some light if reflectivity is used for rain detection and PIA is used for total liquid path inference - but rain water DSD causes ambiguity also.

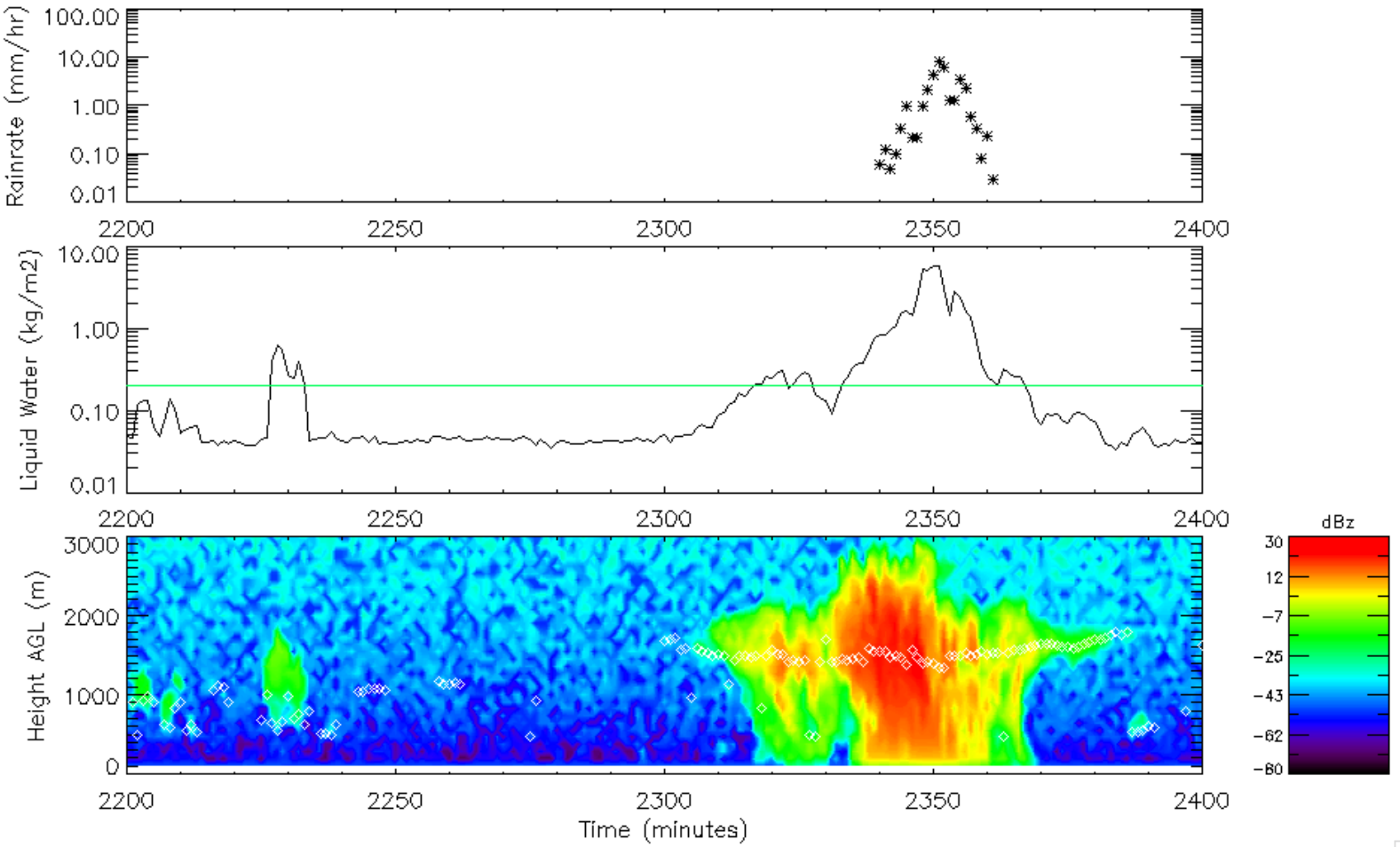
- ARM sites have cloud radar (for rain and cloud water) and microwave radiometer for LWP. Joint algorithm can be written to retrieve quantities related to cloud/rain onset. Must be very careful with rain on instruments.

- Nauru ARM facility is ideal for oceanic studies, but has very low and very uniform CCN concentrations. Observations are used to establish a baseline for the relationship between liquid water path, environmental conditions and surface rainfall.

- Niamey is ideally suited to study aerosol effects but lack of cloud radar observations make it difficult to separate water vapor effects from aerosol effects.

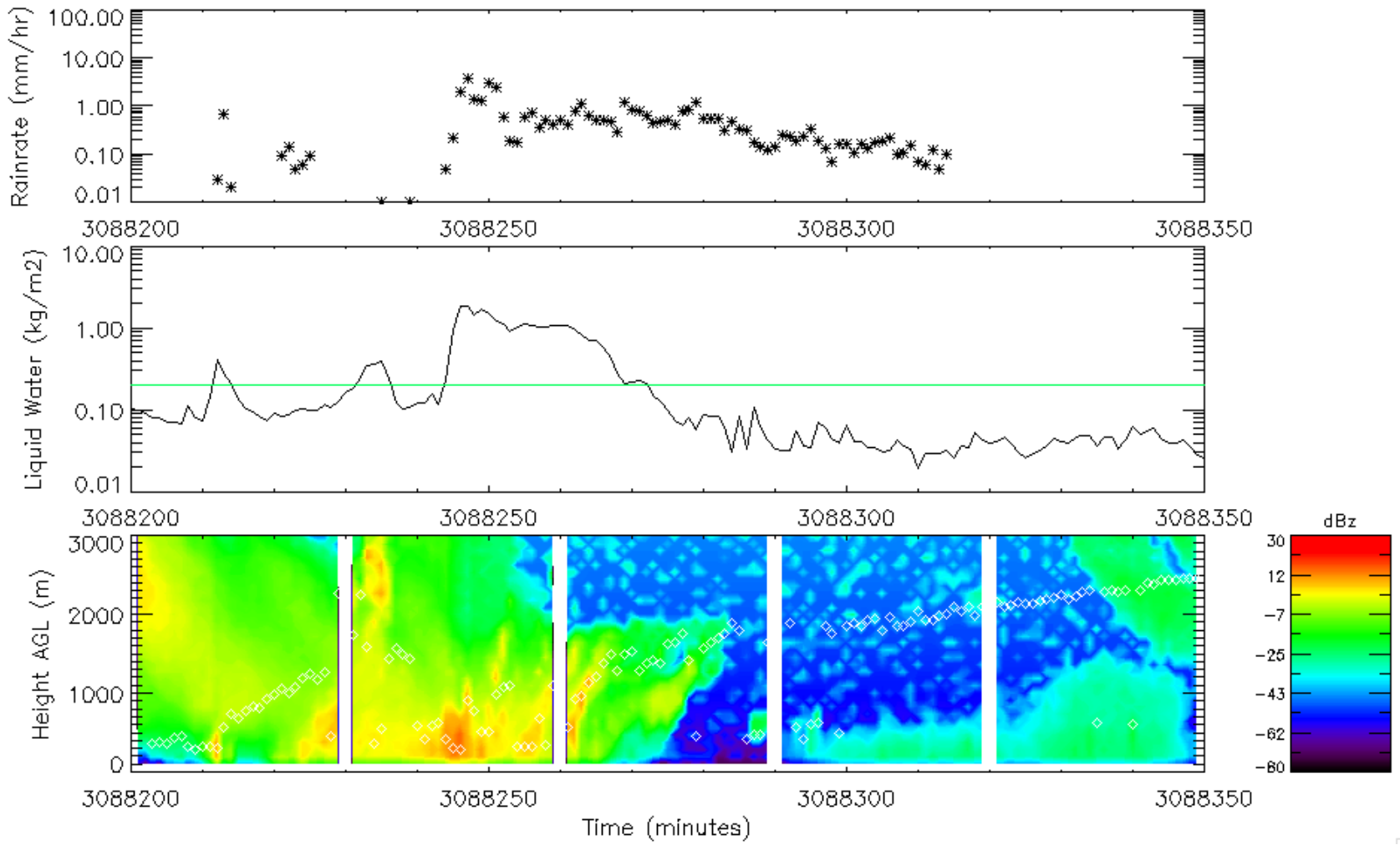
Nauru ARM facility

A straightforward example from Nauru



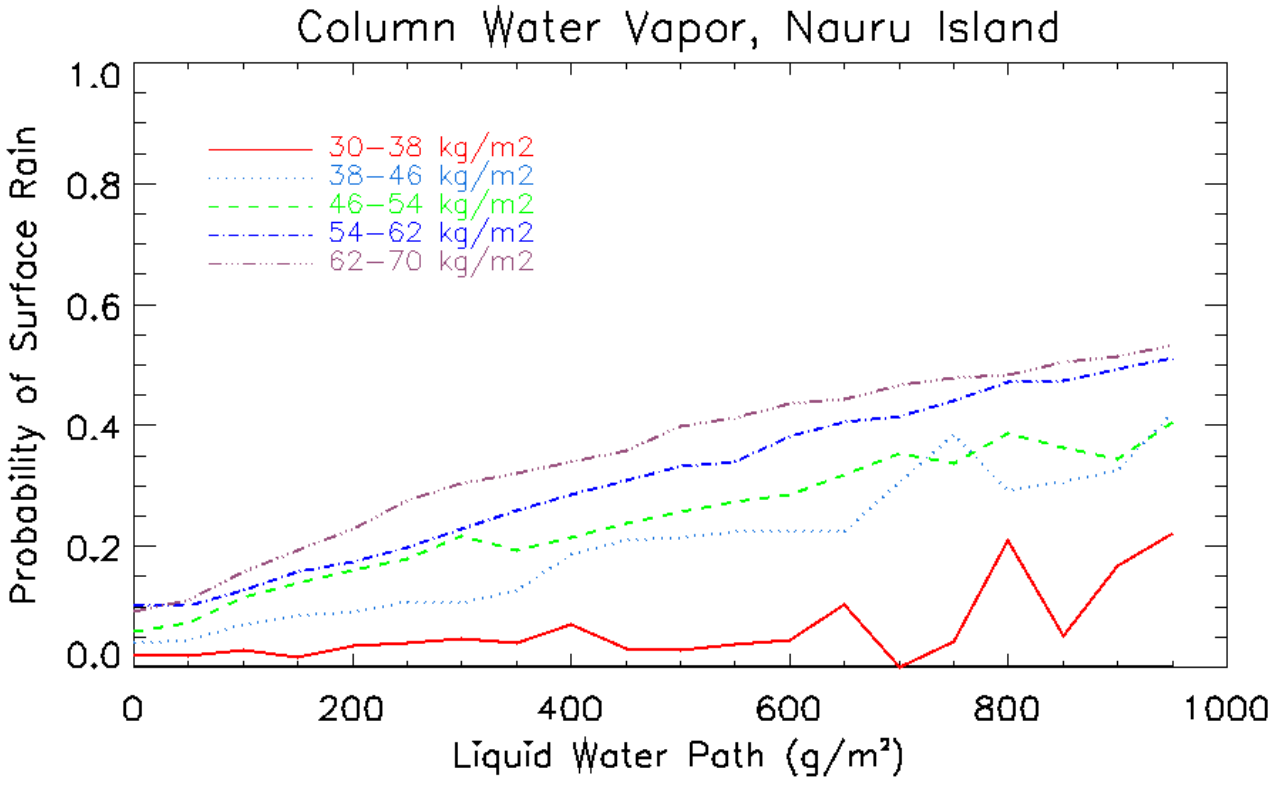
Surface rainfall (top), cloud liquid water (middle) and radar reflectivity (bottom) for 3 hours on 25 Nov. 1998.

A not so straightforward example from Nauru

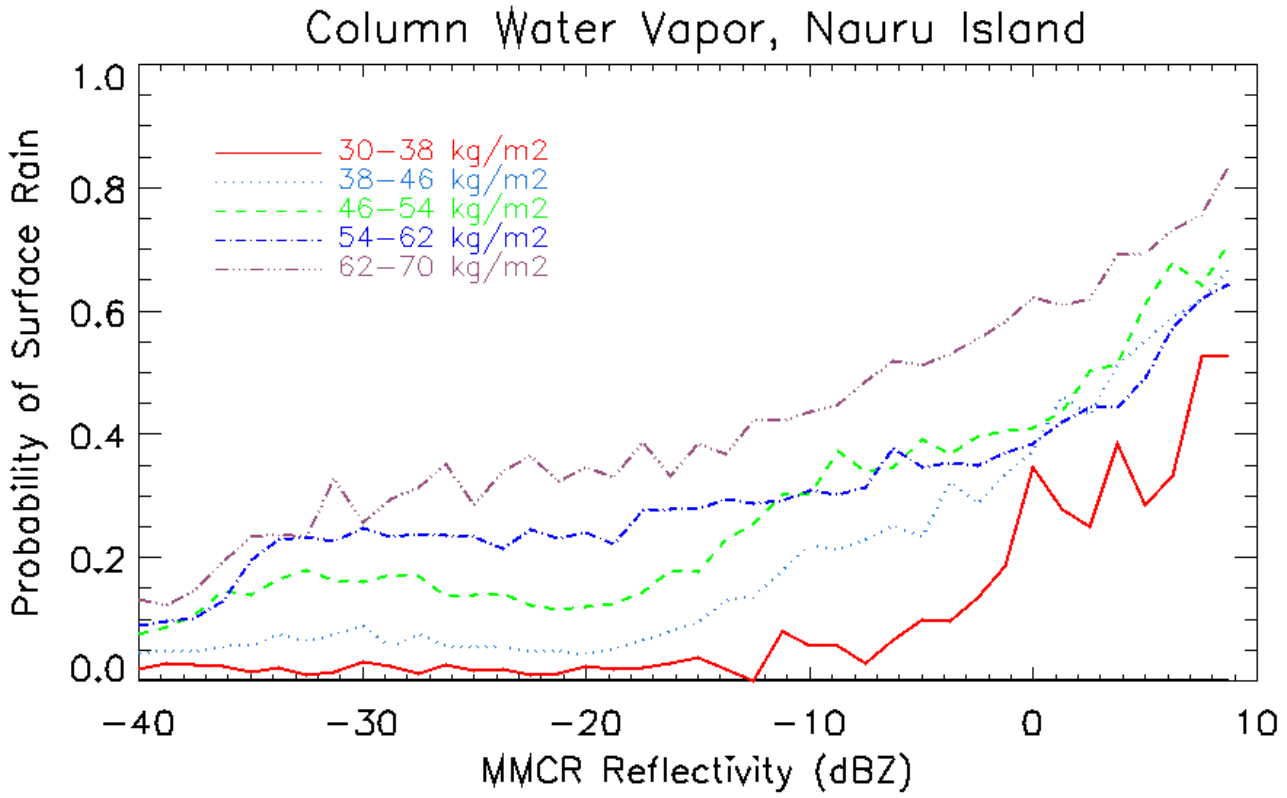


Surface rainfall (top), cloud liquid water (middle) and radar reflectivity (bottom) for 3 hours on 07 Oct. 2004.

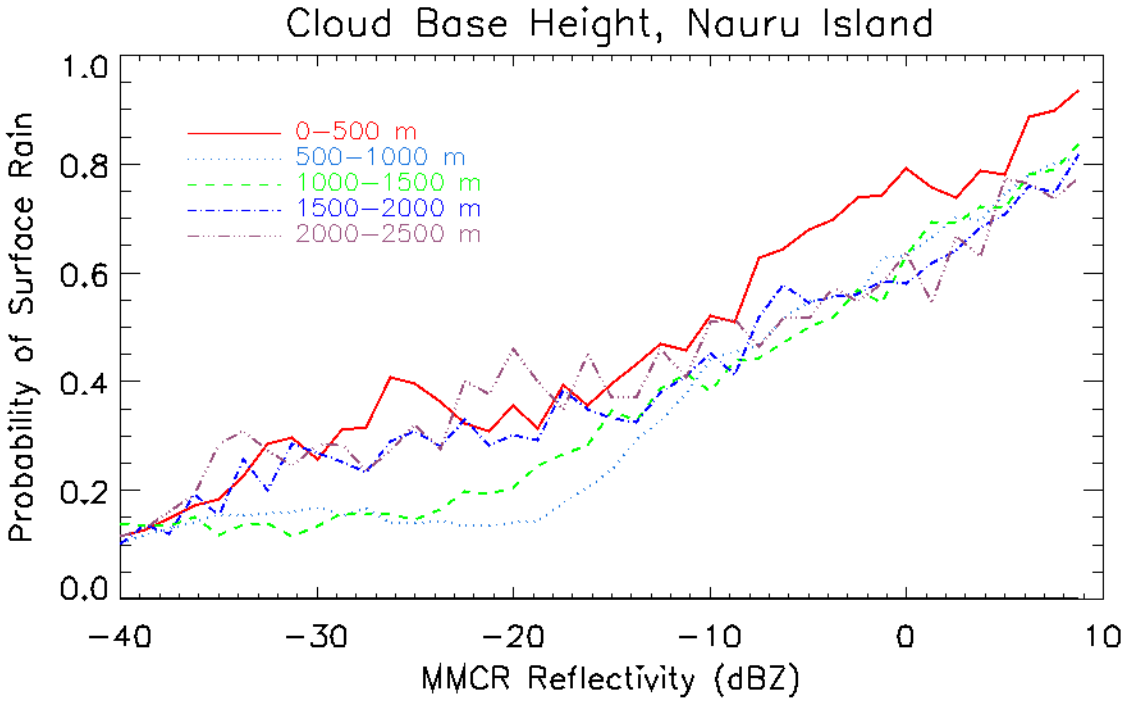
The probability of rainfall increases for the same liquid water path in more humid environments.



Evaporation below cloud base?

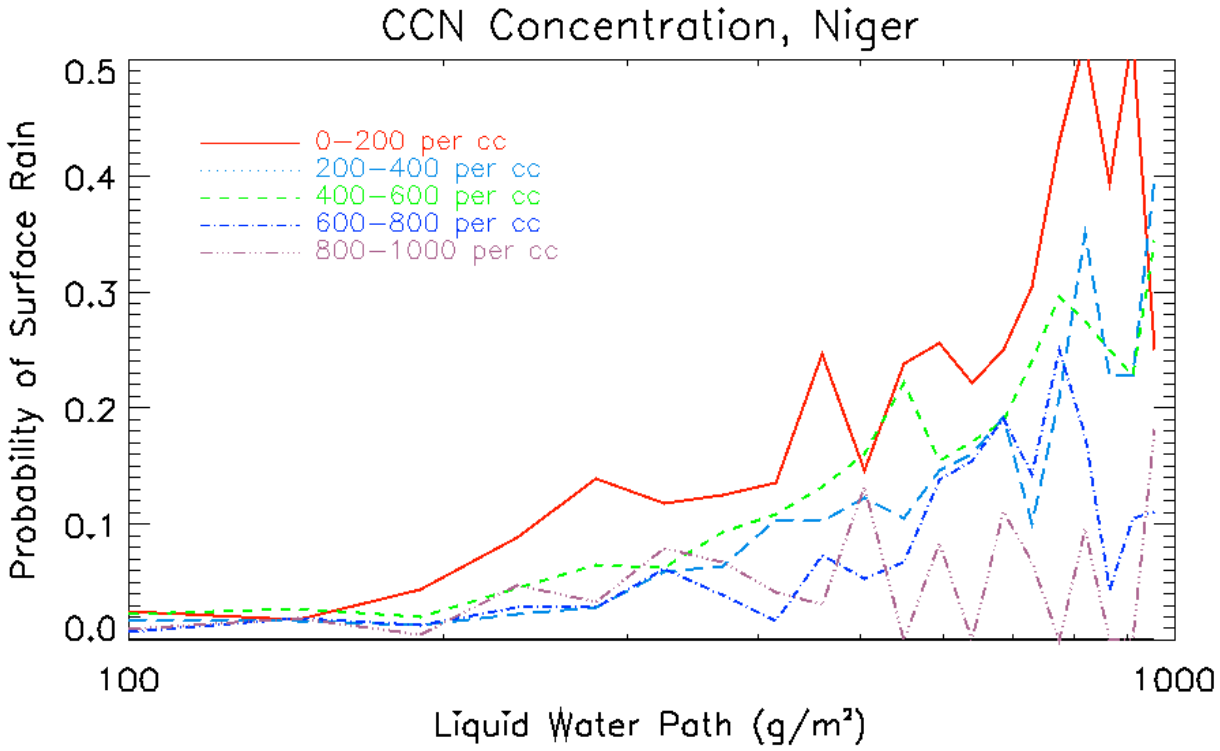


For a given reflectivity at cloud base, the humid environment is more likely to report rain on the ground.

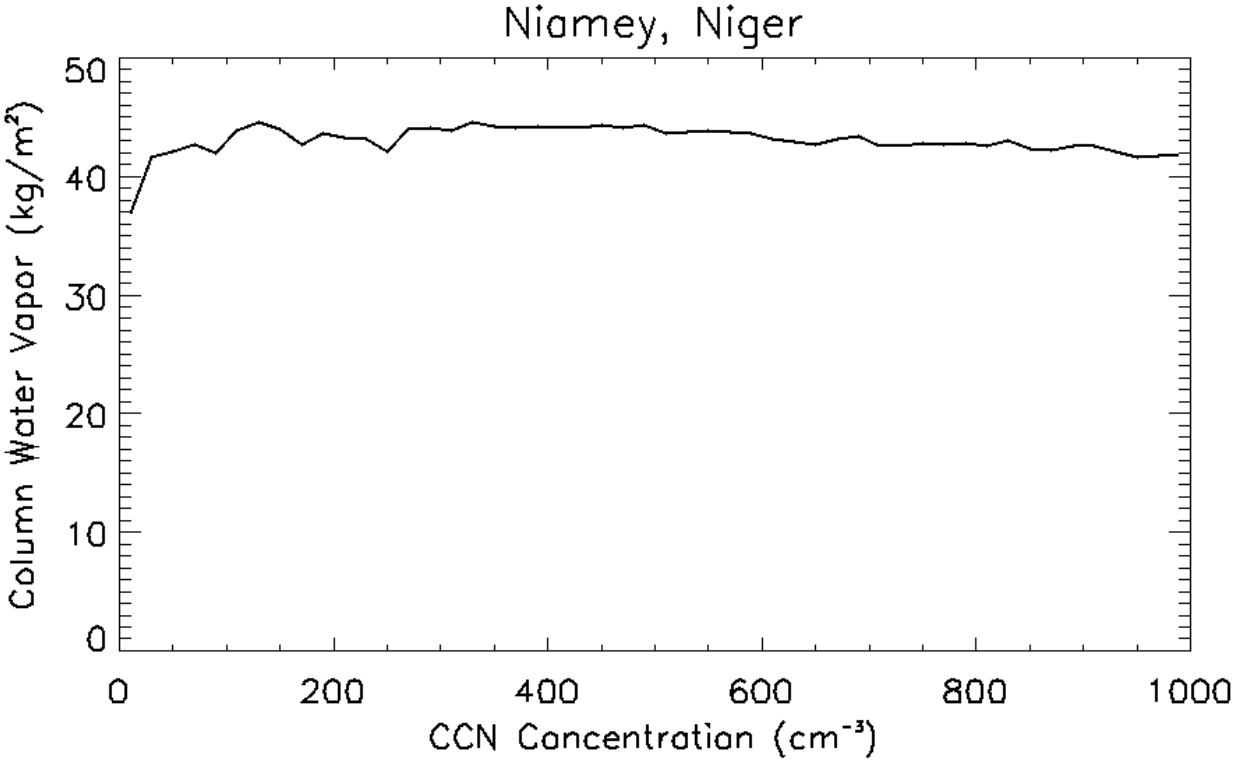


Cloud base height (from radar) does not appear to impact probability of surface precipitation. Cloud base is related to humidity.

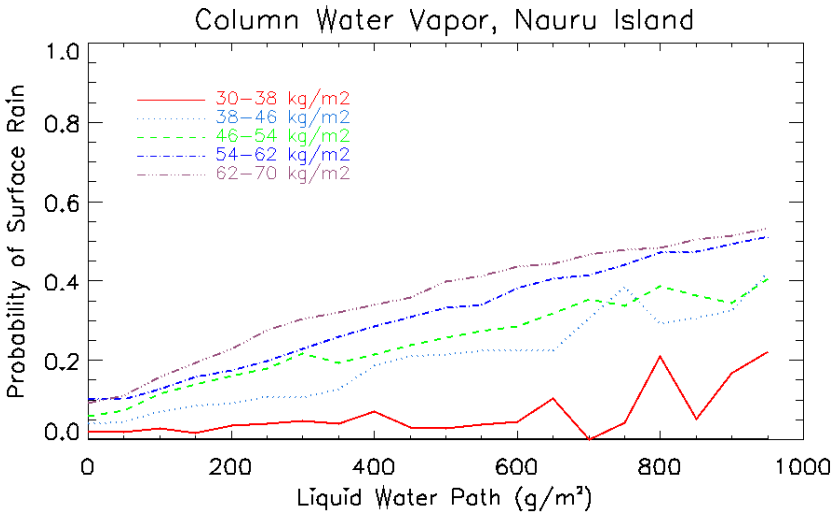
Figure 2.7. Map showing location of ARM Mobile Facility at Niamey, Niger (blue marker).

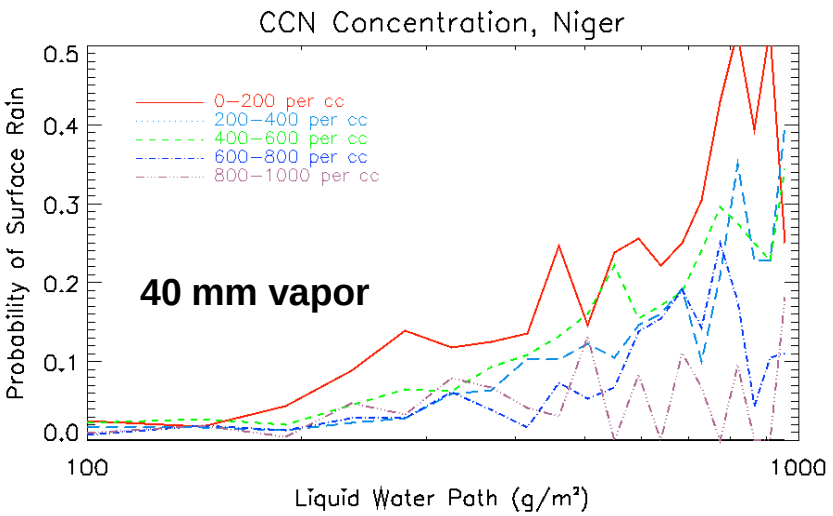


Niamey shows striking relation between cloud liquid water and surface precipitation in varying aerosol environments.



Aerosol concentration were correlated with column water vapor to ensure that presumed aerosol effects were not cross-correlated. Little correlation is evident.





With apologies for liner *vs* log scales

For 40 mm of vapor and low CCN concentrations, Niamey shows some resemblance to Nauru.

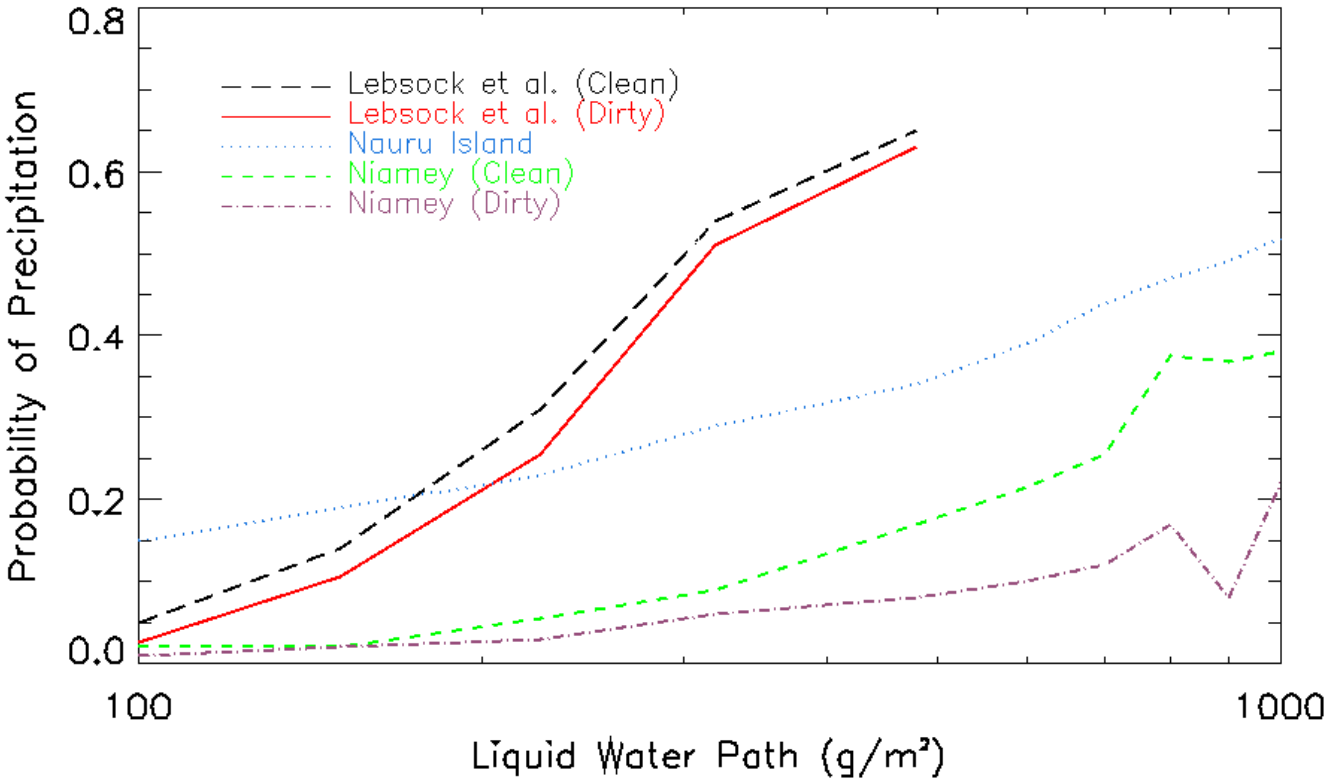


Figure 5.1. Cloud Liquid Water vs. Probability of Surface Precipitation from this study and Lebsock et al. (2008).

AMF objective is to study precipitation onset at cloud base and surface - and to relate this to CCN and water vapor environment. Work to begin in earnest in May 2009.