Tropical Western Pacific Island Cloud Trail Studies

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Introduction

Images and surface temperature measurements from the U.S. Department of Energy (DOE) Multi-spectral Thermal Imaging (MTI) satellite are combined with geostationary meteorological satellite (GMS) images during 2000 and 2001 to better understand cloud trail formation characteristics from the Atmospheric Radiation Measurement (ARM) Tropical Western Pacific (TWP) site. Figure 1 shows a comparison on two consecutive days in December 2000. The day for which a cloud trail developed was more moist and cooler at the altitude the cloud developed (about 600 m) and there was very little difference between the two days at the surface. The clear regions that were observed on each side of the island cloud trail in Figure 1 is very similar to ship trail clouds observed off the Coast of California (Porch et al. 1990).

These island cloud trails have been observed from both the islands of Nauru and Manus, Papua New Guinea. Figure 2 shows an island cloud at Manus observed from MTI and from the surface on two different days in 2001. Island clouds affect the site on Manus relatively infrequently compared to Nauru and the island cloud does not persist for long distances as the Nauru island cloud does. Though these island-generated clouds can affect ARM, they could represent a key to understanding boundary layer cloud formation in the tropics.

Except during El Niño periods, Nauru represents a divergent region of the ocean upwind from the convergent warm pool region. The boundary layer clouds formed by the island persist for great distances (over 100 km) and are sensitive to turbulence generated by the island. Convective turbulence is generated by the island during the day. Mechanical turbulence caused by the interception of the prevailing winds by the island is generated both day and night. The Nauru island clouds were observed on over 50% of the days in 1999 (Nordeen et al. 2001). Cloud condensation nucleii (CCN) generated by the island (particularly persistent sources such as sea salt) may play an important role in the clouds effect on solar radiation. Also, the sea surface temperatures often differ upwind and downwind of the island. During Nauru99, the ocean surface temperatures were observed to be about 0.3°C warmer upwind of the island during windy periods. This was also observed in the MTI surface temperatures (Figure 3).

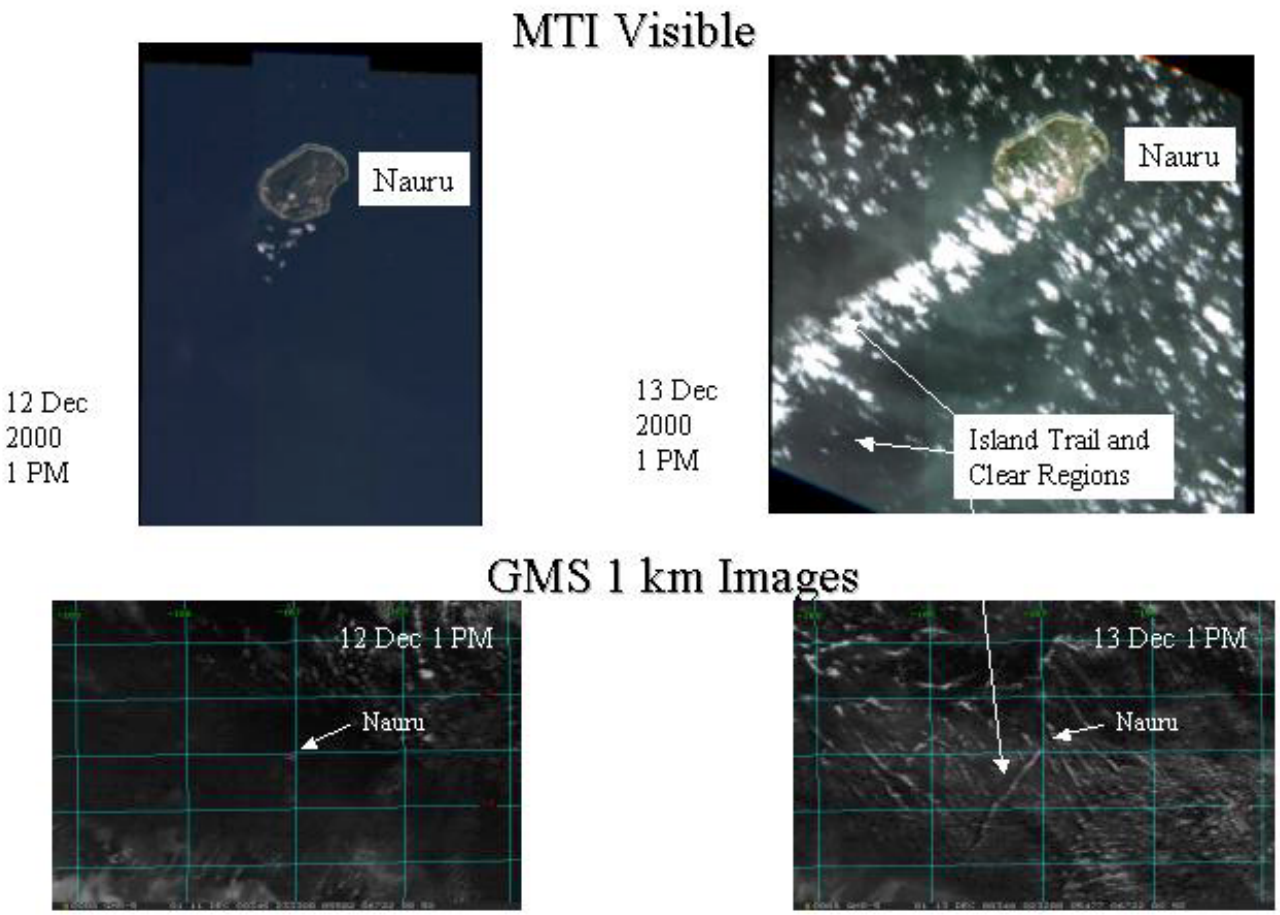

Figure 1. Comparison of DOE MTI satellite and GMS 1km resolution images on December 12, 2000, (no island cloud trail) and December 13, 2000, (fully developed island cloud trail).

The current El Niño began in 2002. This has caused the character of the measurements at Nauru to change. Figure 4 shows that precipitable water vapor and cloud liquid water measured with the microwave radiometer (MWR) increased over Nauru to levels similar to those observed over Manus. The character of the wind direction also changed in 2002 from predominant winds from the east to a more even mixture of east and westerly winds. Nauru is presently being used as a validation site for the atmospheric infrared sounder (AIRS) on the Aqua satellite. More information on the character on the Nauru island cloud trail will help us understand more about the sensitivity of boundary layer clouds in the Tropical Pacific to perturbations in turbulence and CCN.

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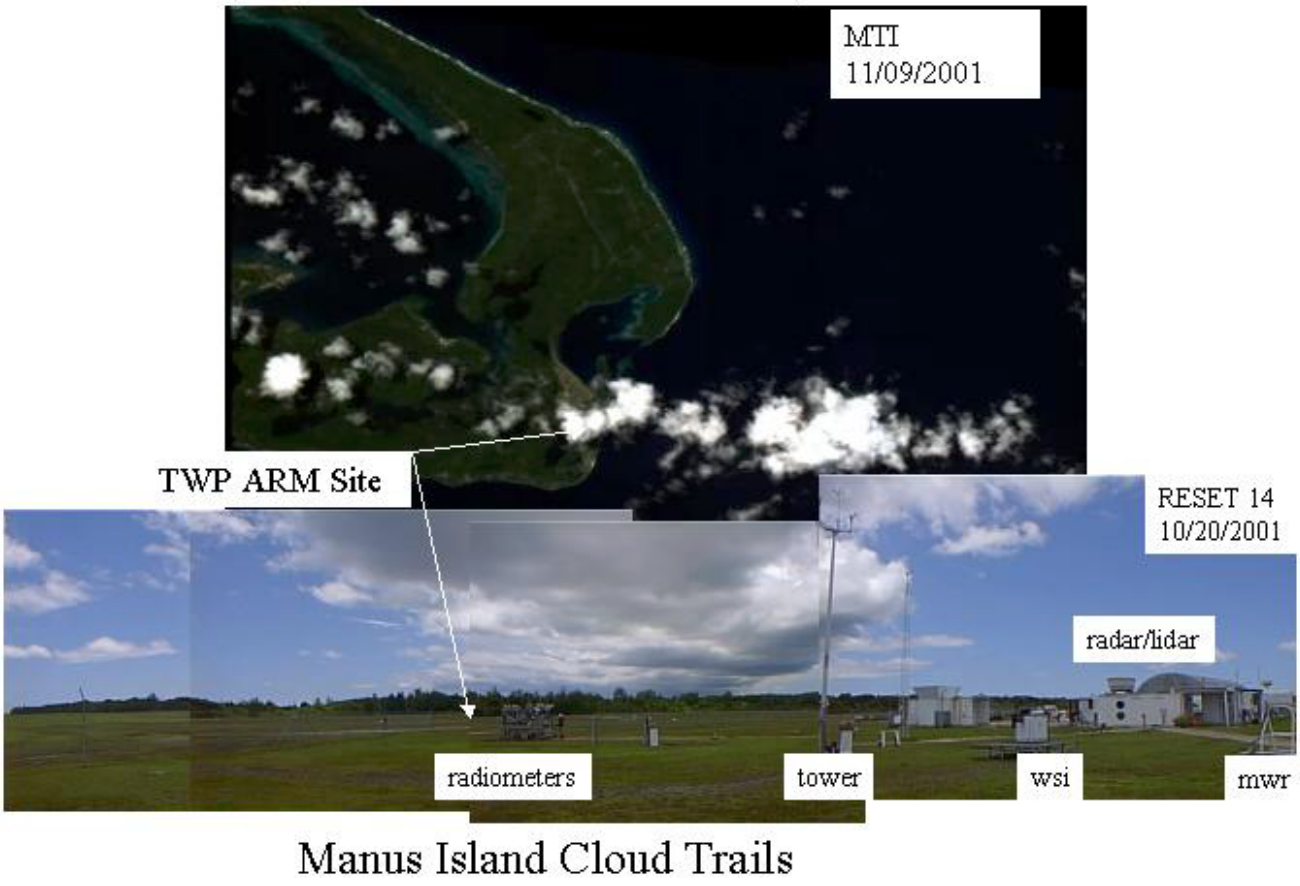

Figure 2. Island clouds do affect radiation measurements on Manus, Papua New Guinea (though less often than on the Island of Nauru).

References

Nordeen, M. L., P. Minnis, D. R. Doelling, D. Pethick, and L. Nguyen, 2001: Satellite observations of cloud plumes generated by Nauru. *Geophys. Res. Let*., **28**(4) 631-634.

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MTI Water Temperatures

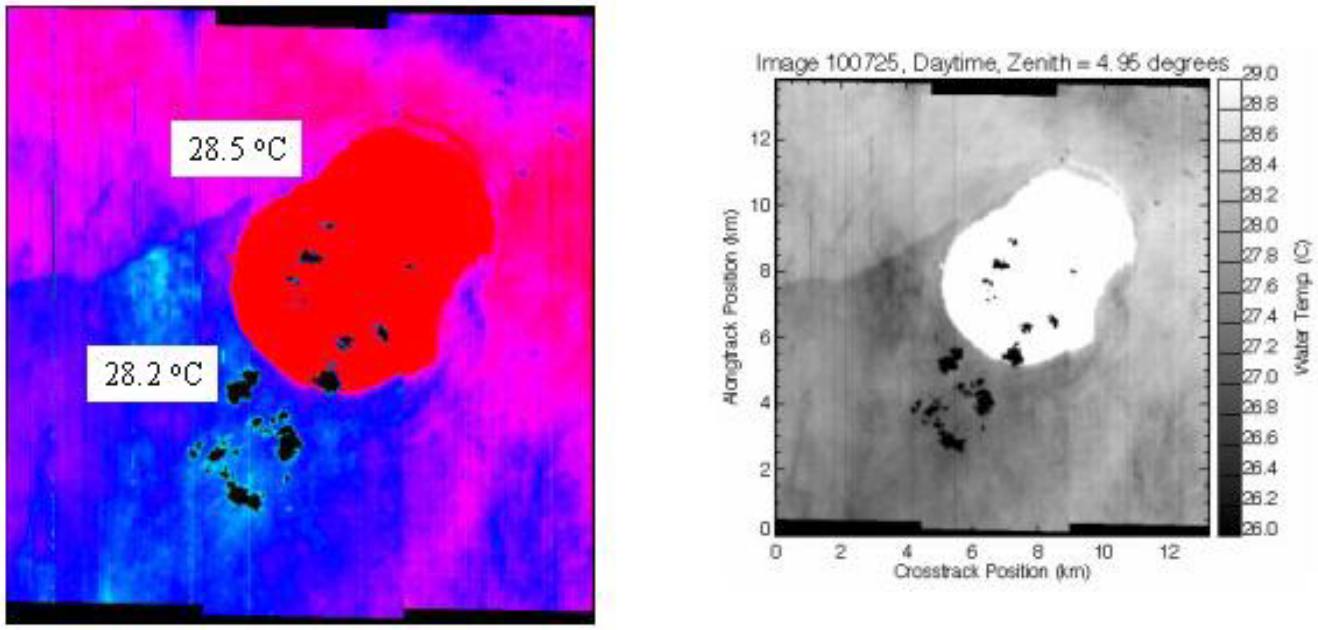

Figure 3. The MTI derived surface water temperature appears to be about 0.3°C warmer upwind of the island.

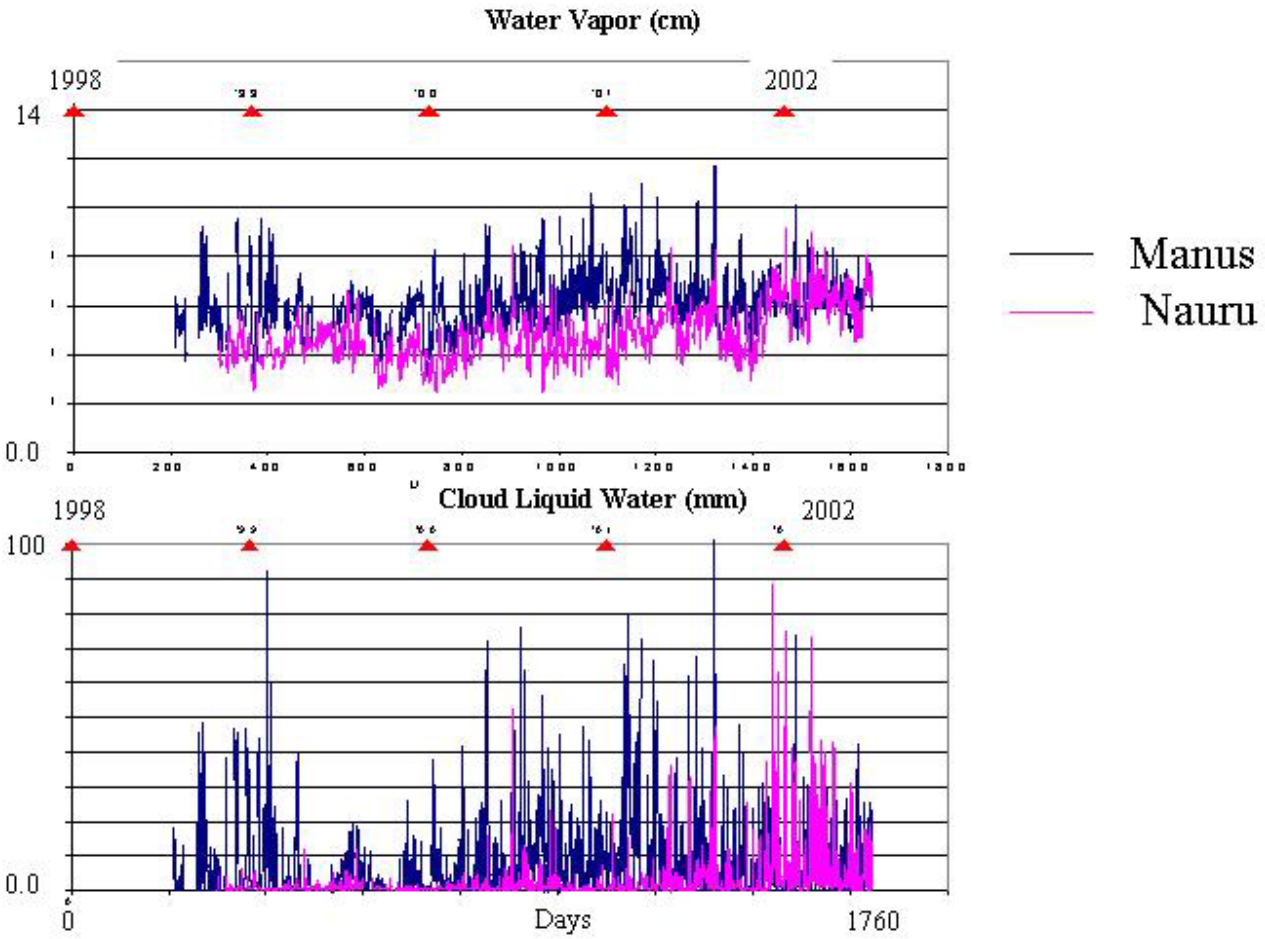

Figure 4. There is a higher level of water vapor and rain over Nauru after the El Niño began in 2002.

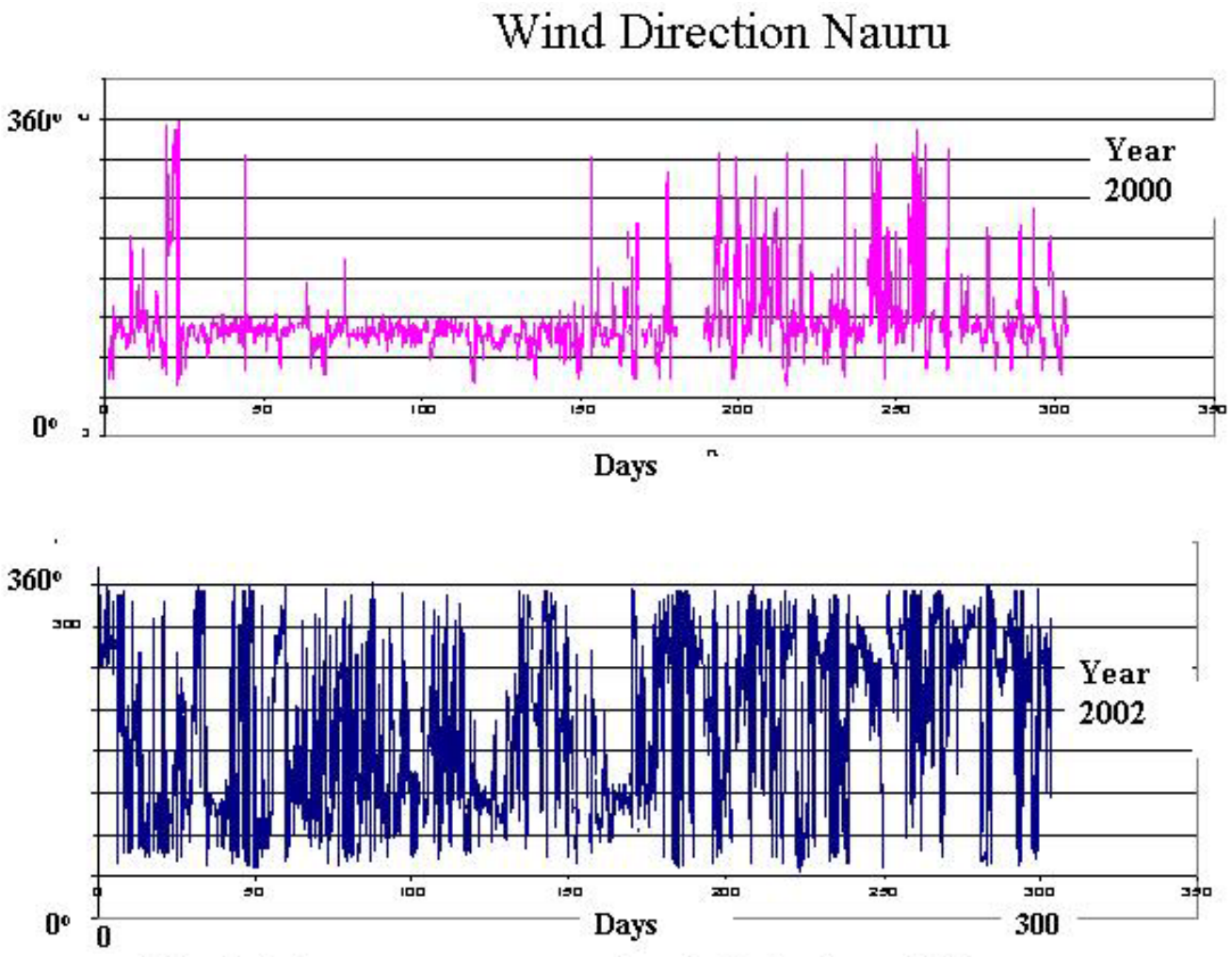

Figure 5. There are more easterly winds during El Niño year.