Surface Radiation Analyses from TWP-ICE

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Introduction

Surface data collected during Tropical Warm Pool-International Cloud Experiment (TWP-ICE) includes radiation and standard meteorological measurements at six remote sites, as well as those at the ARM Climate Research Facility (ACRF) Darwin site (Figure 1). Five of these remote sites include not only unshaded broadband hemispheric shortwave (SW) and longwave (LW) instruments, but also a multi-detector SW radiometer designed to simultaneously measure both the downwelling diffuse and total SW components. Having the SW component measurements, as well as the corresponding meteorological variables, allows the Flux Analysis methodology (Long and Ackerman 2000; Long and Gaustad 2004; Long 2004; Long et al. 2005; Long 2005) to be applied at these sites. Table 1 lists the latitude and longitude coordinates and start of data for each site.

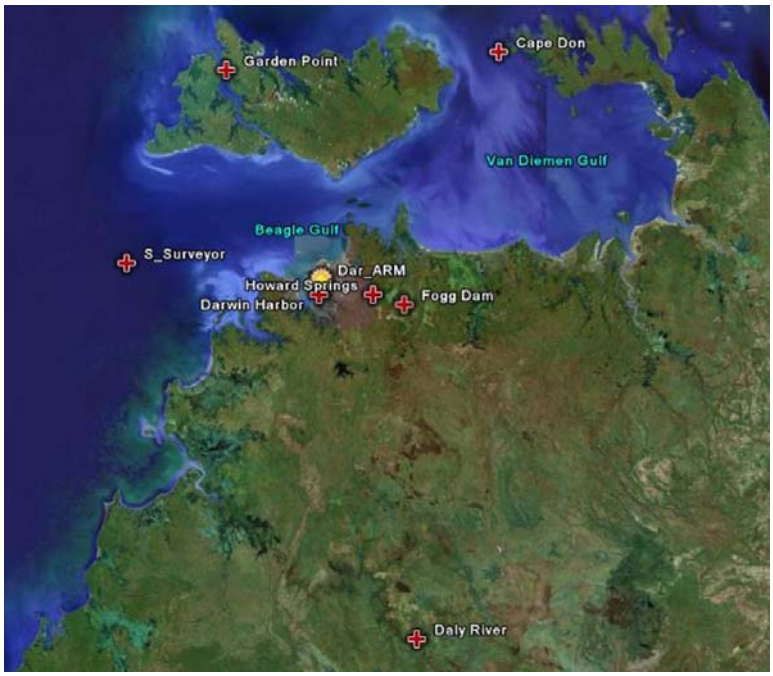

Figure 1. Map showing the location of the Darwin ARM site and the remote surface radiation sites during TWP-ICE.

Table 1. TWP-ICE radiation site locations and date of start of data collection.

Site	Lat. (S)	Long. (E)	Date start
Garden Point	11.4085	130.4167	9-Jan
Cape Don	11.3071	131.7654	11-Jan
Howard Springs	12.4943	131.1524	24-Jan
Darwin Harbor	12.499	130.8866	14-Jan
Fogg Dam	12.542	131.3069	25-Jan
Daly River	14.1593	131.388	28-Jan
RV S. Surveyor	~12.4	~130.0	22-Jan
Darwin ARM	12.4241	130.8912	from Mar 202

Daily Average Radiation

Daily average downwelling SW (Figure 2, top left) is generally greater at all sites during February of the TWP-ICE period than in January. Comparison of estimated clear-sky SW shows the Daly River SW is anomalously high (though it is likely correctable). Correspondingly, downwelling LW is lower in February (lower left), as is the daylight average sky cover (top right) illustrating the less cloudy conditions toward the end of the field experiment. The above decreasing cloudiness tendencies result in comparatively decreased magnitudes of both the SW and LW downwelling cloud effect (CE) in February.

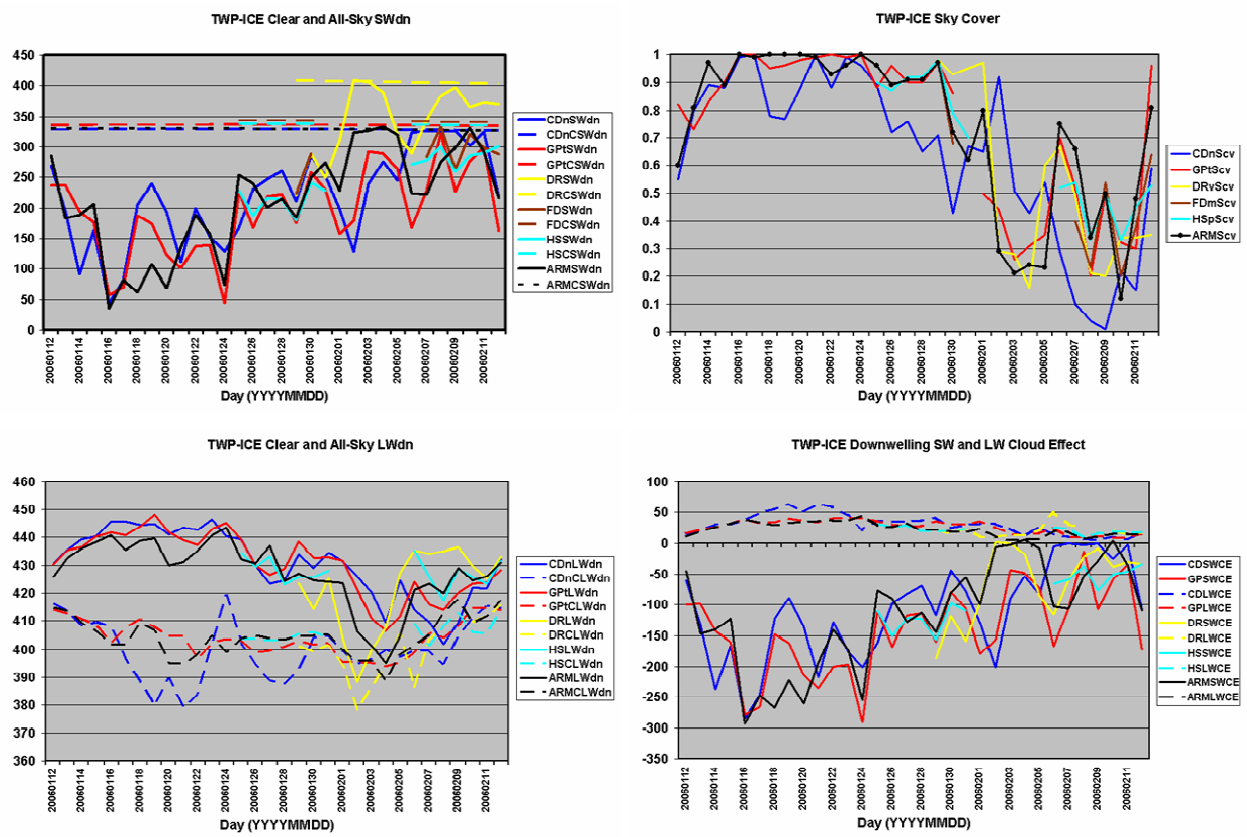

Figure 2. Daily average downwelling clear-sky (dashed) and all-sky (solid) SW (top left), downwelling clear-sky (dashed) and all-sky (solid) LW (bottom left), daylight average fractional sky cover (top right), and downwelling SW (solid) and LW (dashed) cloud effect (bottom right) for Cape Don (CDn, blue), Garden Point (GPt, red), Daly River (DR, yellow), Fogg Dam (FD, brown), Howard Springs (HS, light blue), and the Darwin ARM site (ARM, black) during TWP-ICE.

Diurnal Average Radiation and Sky Cover

Diurnal averages (Figure 3) show Garden Point downwelling SW (top left) tends to be more depressed in the afternoon in both the January and February portions of TWP-ICE, likely due to the frequent occurrence of the Hector convective cell over the Tiwis. Downwelling LW (top right) shows a more pronounced diurnal cycle in February than in January, both for clear-sky (dashed) and all-sky (solid). The LW in February is more correlated with the diurnal cycle of air temperature (lower left) than in January. But this is also caused by the influence of water vapor amounts. The diurnal cycle of relative humidity (RH, lower right) indicates that the air was often less moist in February, exhibiting about the same nighttime RH as the January period but at lower temperatures, and significantly lower RH during the daytime.

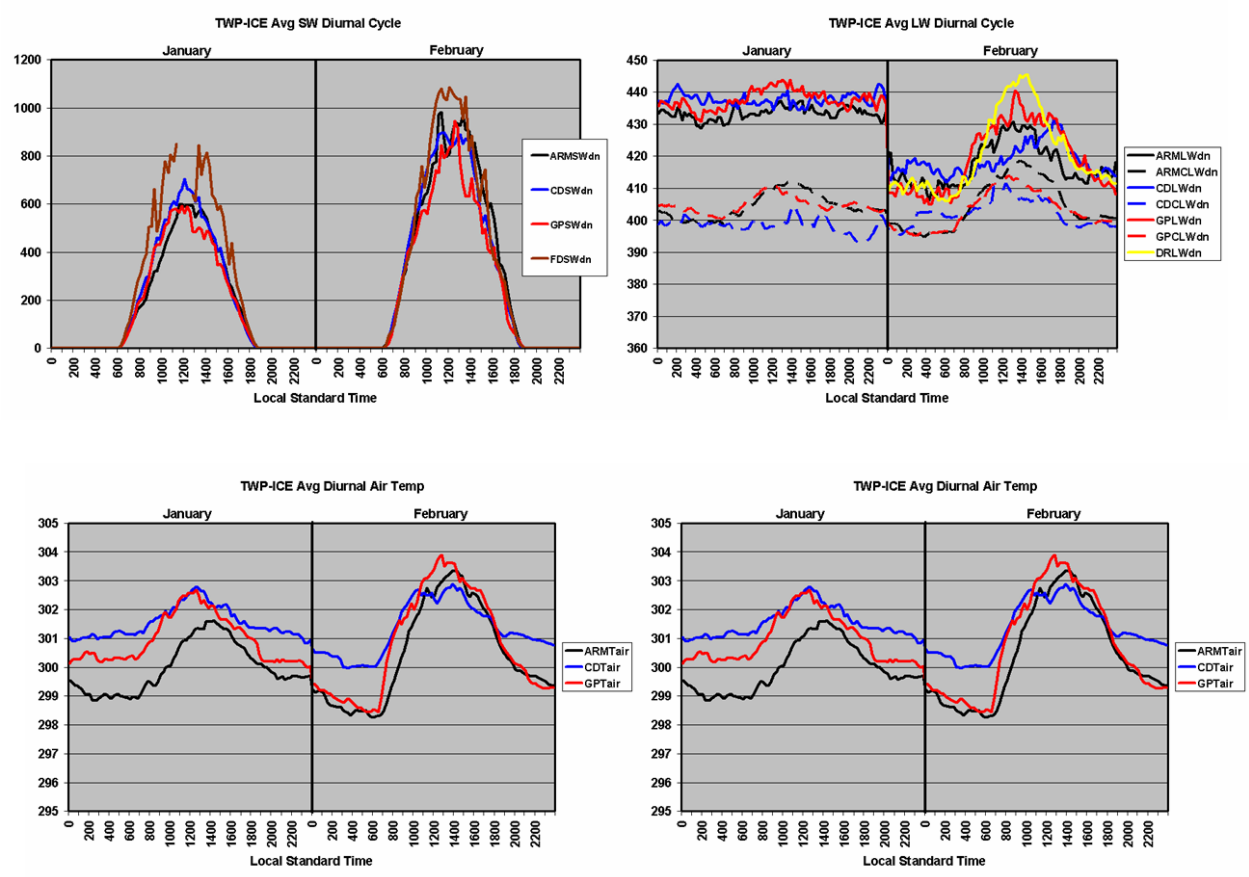

Figure 3. Composite average diurnal cycles for January and February portions of TWP-ICE for downwelling SW (top left), downwelling clear-sky (dashed) and all-sky (solid) LW (top right), air temperature (lower left) and relative humidity (lower right). Site abbreviations and line colors same as in Figure 2.

The daylight cycle of sky cover (Figure 4, left) shows an increasing tendency across the day for Cape Don and Garden Point in both months, though more pronounced in February. The ACRF site sky cover peaks at midday in February. The decreasing tendency at Daly River may be a manifestation of radiometer issues, and will be investigated further in the coming months. The diurnal LW effective sky cover (right) in general shows similar tendencies as the daylight SW sky cover, especially in February, indicating that most cloudiness had low to mid-level bases with corresponding significant impact on the downwelling LW measurements.

Surface Albedo

Daily average surface albedo (Figure 5, left) exhibits larger change for the Darwin Harbor site than the land sites. Early Bay waters were visually murky, with persistent winds thereafter, followed by calmer winds toward the end of the period. Greater diurnal albedo signatures in February (right) attest to

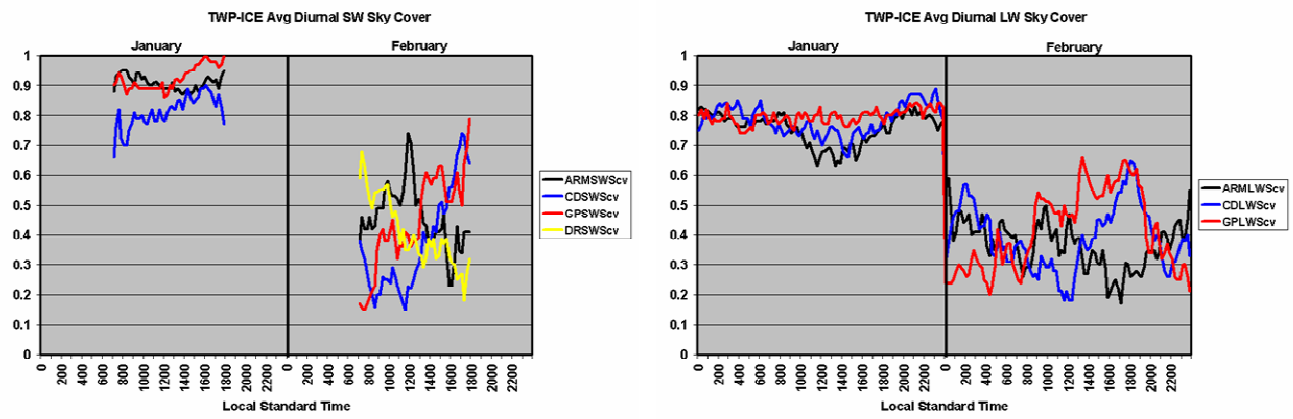

Figure 4. Composite average diurnal cycles for January and February portions of TWP-ICE for daylight SW-derived fractional sky cover (left) and effective LW sky cover (right). Site abbreviations and line colors same as in Figure 2.

decreased cloud amount and increased occurrence of direct (thus highly directional) sunlight. Note the exaggerated diurnal signatures of Fogg Dam and Darwin Harbor, which appear to be anomalously "v" shaped. Further investigation over the coming months will attempt to determine whether these albedo signatures are real or instrument issues.

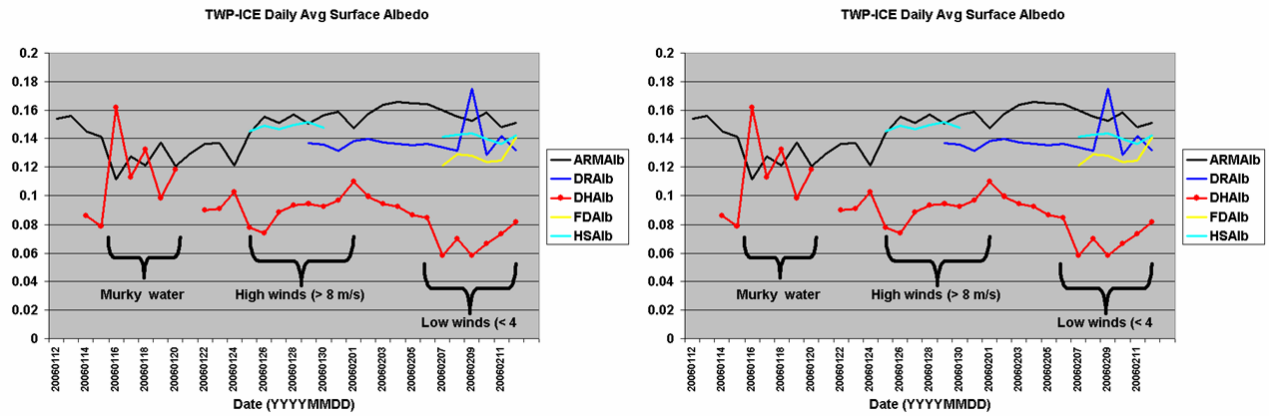

Figure 5. Daily average (left) and monthly diurnal (right) surface albedo for TWP-ICE. Site abbreviations and line colors same as in Figure 2.

Significant Positive SW Cloud Effect

Downwelling SW significantly greater than clear-sky amount is not unusual in the TWP. This positive CE occurred at all sites during TWP-ICE (Figure 6). During January, CE greater than 20 Wm^{-2} occurred about 3% of the daylight hours, compared to about 20% of the time in February at Garden Point (Figure 7, left), 13% at Cape Don and 28% at the Darwin site. This positive CE offset the negative CE by an amount ≤1% of the total CE in January, but by 9% at Garden Point, 11% at Cape Don, and 22% at Darwin ARM during the February portion of TWP-ICE. The positive CE is produced by

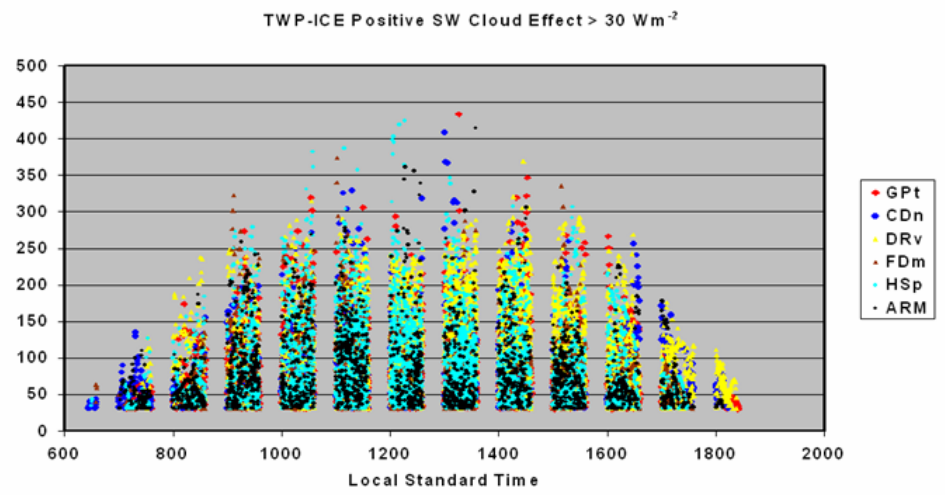

Figure 6. Composite plot of positive downwelling SW cloud effect greater than 30 Wm^{-2} during TWP-ICE. Site abbreviations and line colors same as in Figure 2.

three-dimensional cloud-radiation interactions, and occurs when clouds enhance the diffuse SW while at the same time the direct sun is not blocked by cloud. For Positive CE > 30 Wm^{-2} in February, sky cover amounts are 50% or less for 85% of the occurrences (Figure 7, right). For positive CE > 50 Wm^{-2}, peak sky cover amount is slightly greater.

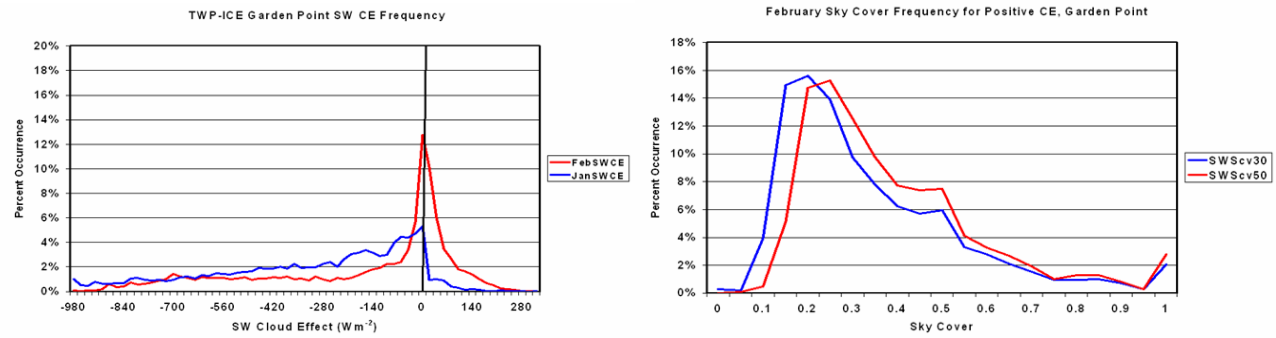

Figure 7. Frequency of occurrence of downwelling SW CE by CE magnitude (left) for Garden Point for January (blue) and February (red). Fractional sky cover frequency (right) for positive CE greater than 30 Wm^{-2} (blue) and greater than 50 Wm^{-2} (red) for February at Garden Point.

Summary

TWP-ICE exhibited less cloudiness in February than in the January portions of the experiment. The change in cloudiness resulted in a decrease in magnitude of SW and LW CEs. Downwelling SW shows an afternoon decrease at Garden Point likely due to Hector, while the downwelling LW generally increases during daylight hours at all sites. Surface Albedo at the Darwin Harbor site

significantly decreased over the TWP-ICE period. Substantial positive SW CE significantly offsets negative CE during February and occurs largely when sky cover amounts are 50% or less.

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