

A11J-2895: Improved Accuracy in Shipborne Broadband Irradiance Measurements during MARCUS using New Tilt-Corrected SHIPRAD Systems

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SUMMARY

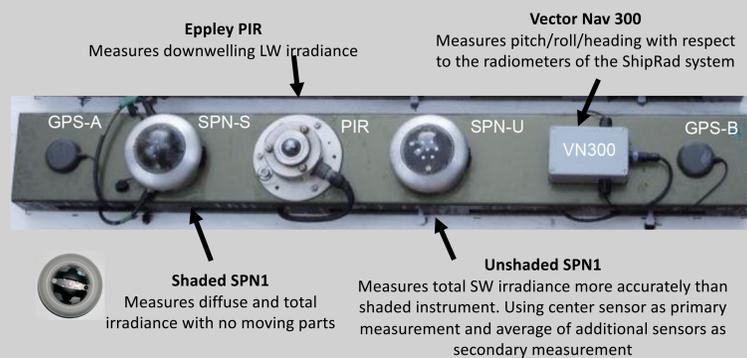
SHIPRAD Systems were developed to correct for measurement challenges of broadband irradiance on moving platforms. The instruments were first deployed during the MARCUS field campaign. These systems and data processing methodology corrects for:

1. Tilt from horizontal on moving platforms
2. Shading due to ship structures

Planned data products will be produced with 1-minute average best estimate data. Collaboration and feedback on accuracy and resolution requirements happily accepted.

Instrumentation: SHIPRAD SYSTEM

New ShipRad systems were designed to measure LW and SW broadband irradiance on ships. Deployed for the first time at the MARCUS field campaign, measurements of components of SW irradiance along with tilt and heading, allows for post processing to correct for tilt.



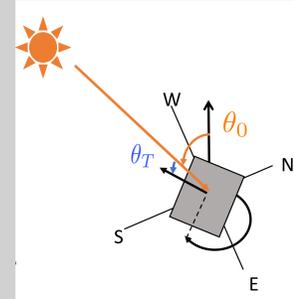
Tilt Correction Methodology

Direct SW Irradiance component is corrected for tilt up to 10° due to ship motion.

$$G = G_T \left(\frac{\mu_0 + D/N}{\mu_T + D_T/N} \right)$$

Equation for calculating horizontal SW (G) from tilted SW (GT). Tilted Diffuse is assumed to be equal to Diffuse for small tilt angles, the cosine of the tilt zenith angle (μ_T) is calculated as a function of pitch, roll, and heading.

Definition of terms

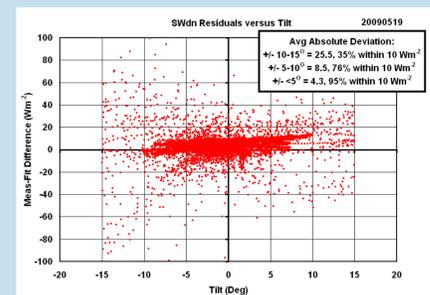


Cosine of solar zenith angle:
 $\mu_0 = \cos(\theta_0)$

Cosine of tilt zenith angle:
 $\mu_T = \cos(\theta_T)$

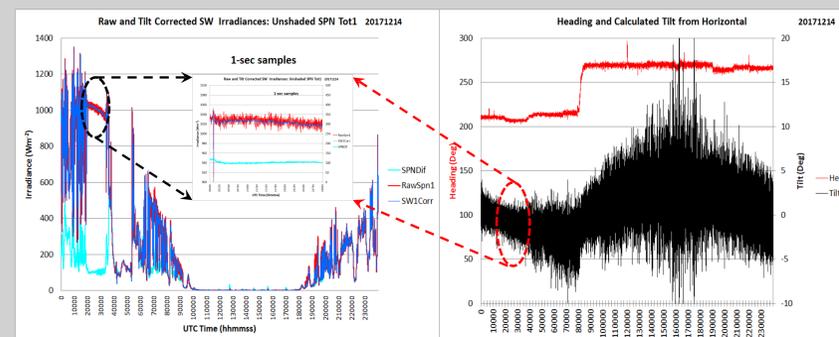
G : Total SW irradiance
 D : Diffuse SW irradiance
 N : Direct normal irradiance
 G_T : Total SW on tilted surf
 D_T : Diffuse SW on tilted surf

Tilt correction for 10° or less within 10 W m⁻²



Long et al. (2010) show that the tilt correction methodology corrected 90% of the data to within 10 W m^{-2} for tilt of $\pm 10^\circ$ or less, with an average absolute deviation of 5.2 W m^{-2} , and 95% if the data within 10 W m^{-2} for tilt of $\pm 5^\circ$ or less.

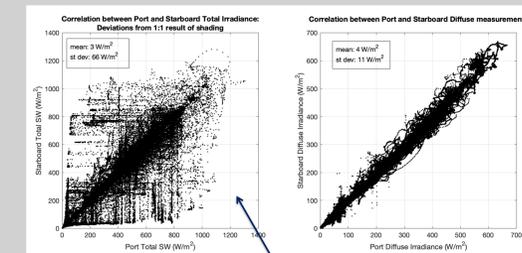
Example of tilt correction, Dec. 14, 2017:



Methodology from Long et al. (2010), *TOASI*, 4, pp.78-87, doi: 10.2174/1874282301004010078.

Removing Shading Due to Ship Structures

- Two ShipRad systems are placed on port and starboard
- Post Processing allows choice of unshaded measurements most of the time



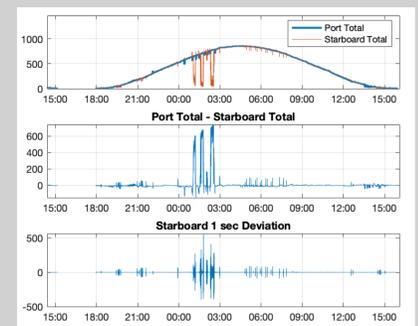
Comparison between port and starboard Total SW measurements shows large deviations due to shading that is not seen in diffuse SW irradiance

Methodology for creating best estimate irradiance to avoid shading:

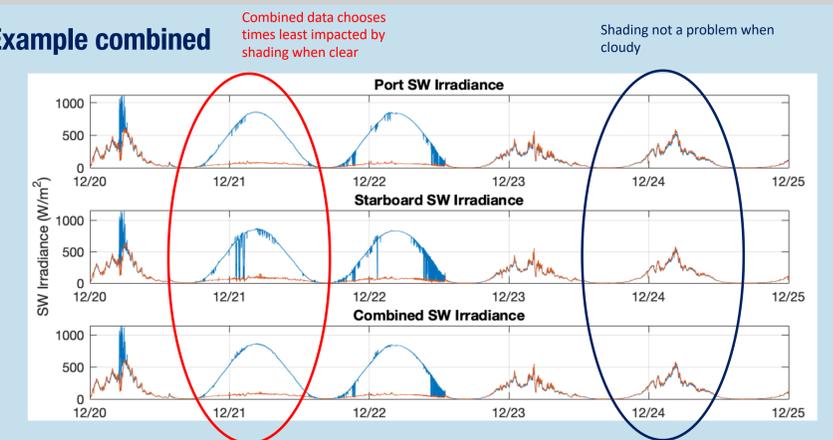
Downwelling LW and Diffuse SW: average of port and starboard measurements when tilt angle $< 10^\circ$

Total SW—use average of port and starboard unless shaded:

- When port/starboard total SW is $> 100 \text{ W m}^{-2}$ than starboard/port total
- When 1-sec deviation greater than 5 W m^{-2}



Example combined



Offset Characterization

Systems are characterized for offset from level compared to the VN300 to an accuracy of 0.1° to give the most accurate tilt correction possible.



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