

Preliminary look at MARCUS Tilt Corrected Broadband Radiation Data

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Correcting for Tilt from Horizontal

- For modest tilt, only the direct part of downwelling SW should be corrected for tilt.
 - Diffuse is assumed to be largely unaffected.
- In order to determine how much tilt there is, information on latitude, longitude, pitch, roll, and heading is needed.
- In order to properly apply the correction for tilt to the downwelling SW (essentially a multiplicative factor), knowledge of the partitioning between the direct and diffuse SW is needed.

Tilt Correction

- $G = D + N \cdot \mu_0$
horizontal

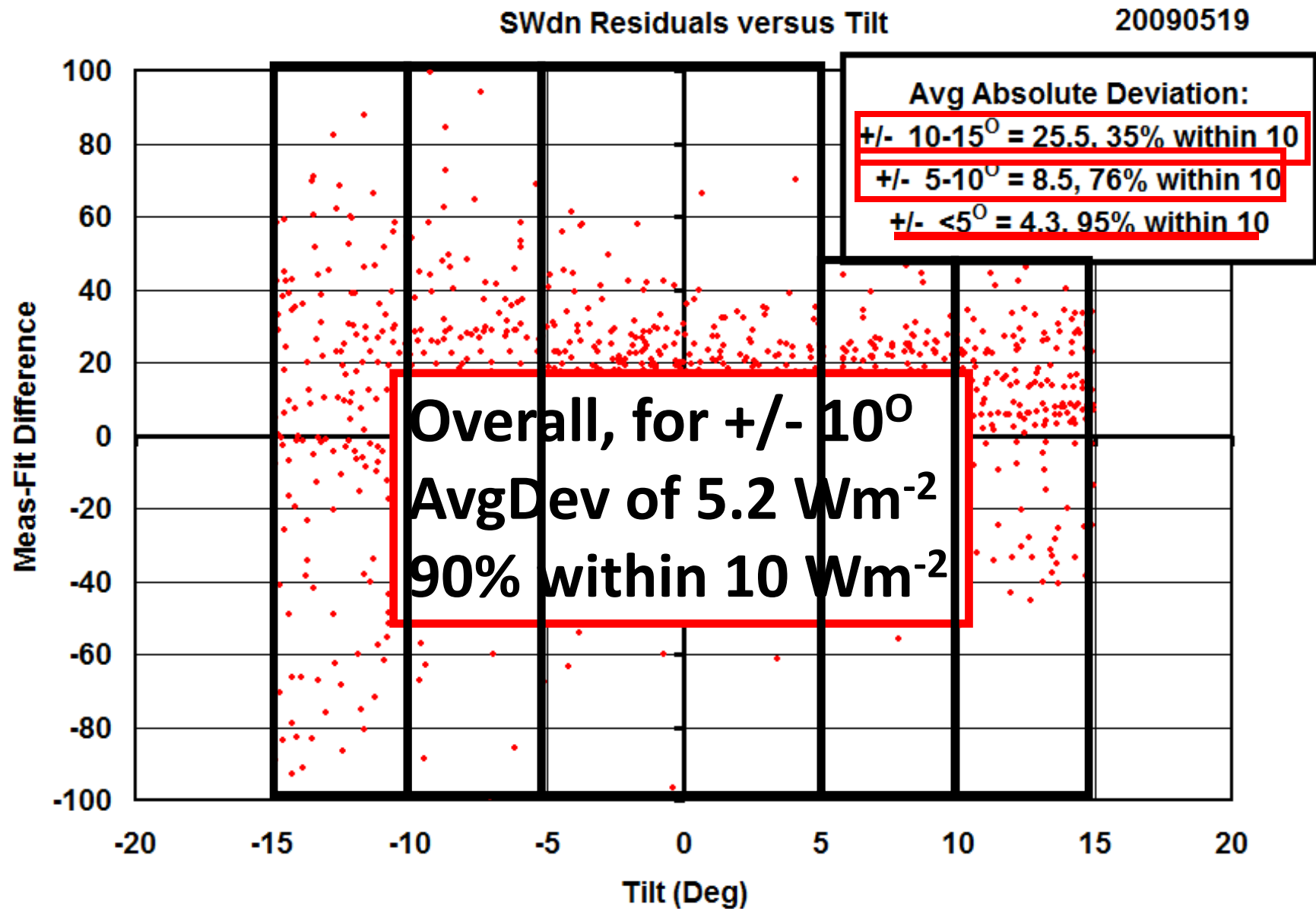
- $G_T = D_T + N \cdot \mu_T$
tilted

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

- Equation for calculating horizontal SW (G) from tilted SW (G_T), where
 - N = direct normal SW
 - D = diffuse SW
 - assumed to be equal for modest tilt
 - μ_0 = solar zenith angle
 - μ_T = tilt zenith angle
 - $f(\text{pitch, roll, heading})$

Long, C. N., A. Bucholtz, H. Jonsson, B. Schmid, A. Vogelmann, and J. Wood (2010): A Method of Correcting for Tilt from Horizontal in Downwelling SW Measurements on Moving Platforms, TOASJ, 4, pp.78-87, doi: 10.2174/1874282301004010078.

Tilt Correction Effectiveness

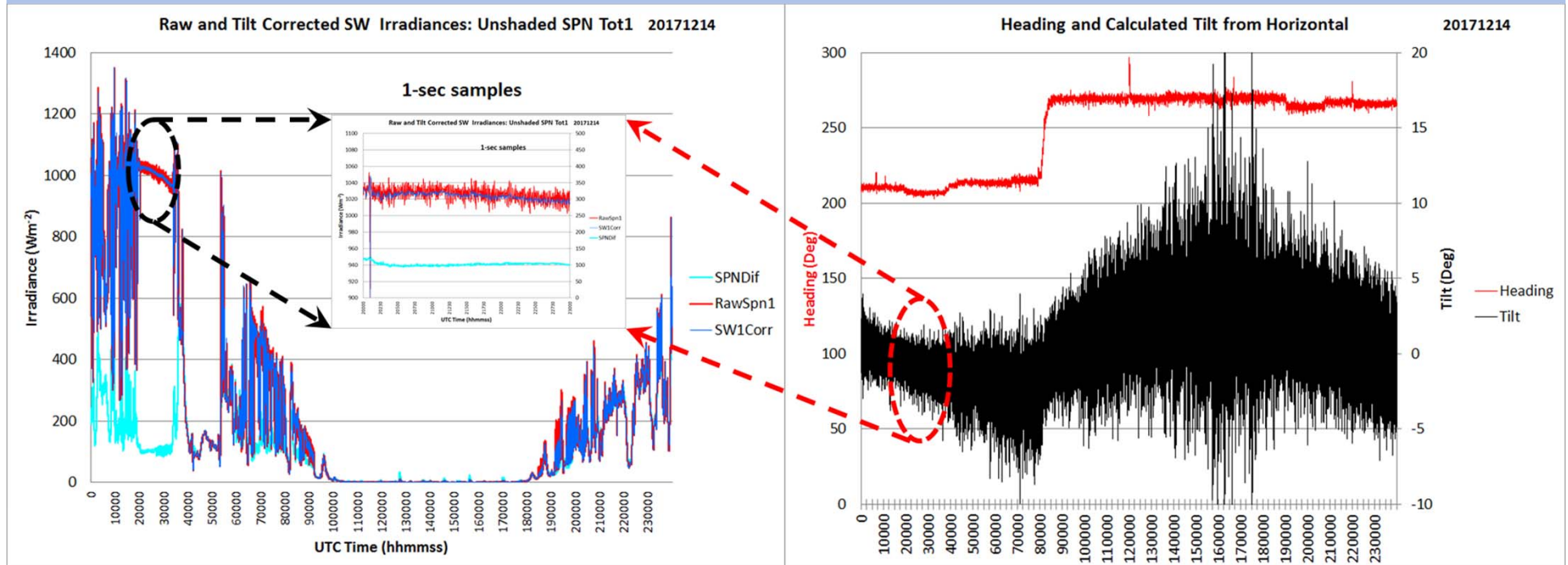


ShipRad Systems

- Tilt from horizontal on moving platforms can result in substantial downwelling shortwave (SW) and longwave (LW) errors
- ARM has developed ship-board radiation packages (ShipRad) similar to that designed for the ARM Aerial Facility G-1 aircraft
- The ShipRad set of instruments provides all the information that is needed to apply the correction for tilt from horizontal orientation developed by Long et al. (2010) to the downwelling SW measurements, as well as screen the longwave measurements for data likely contaminated by too large tilt.
- Three ShipRad systems were assembled affording one each on the starboard and port sides of the ship, and one spare system in case of failures.
- MARCUS is the maiden voyage for the ShipRad systems.

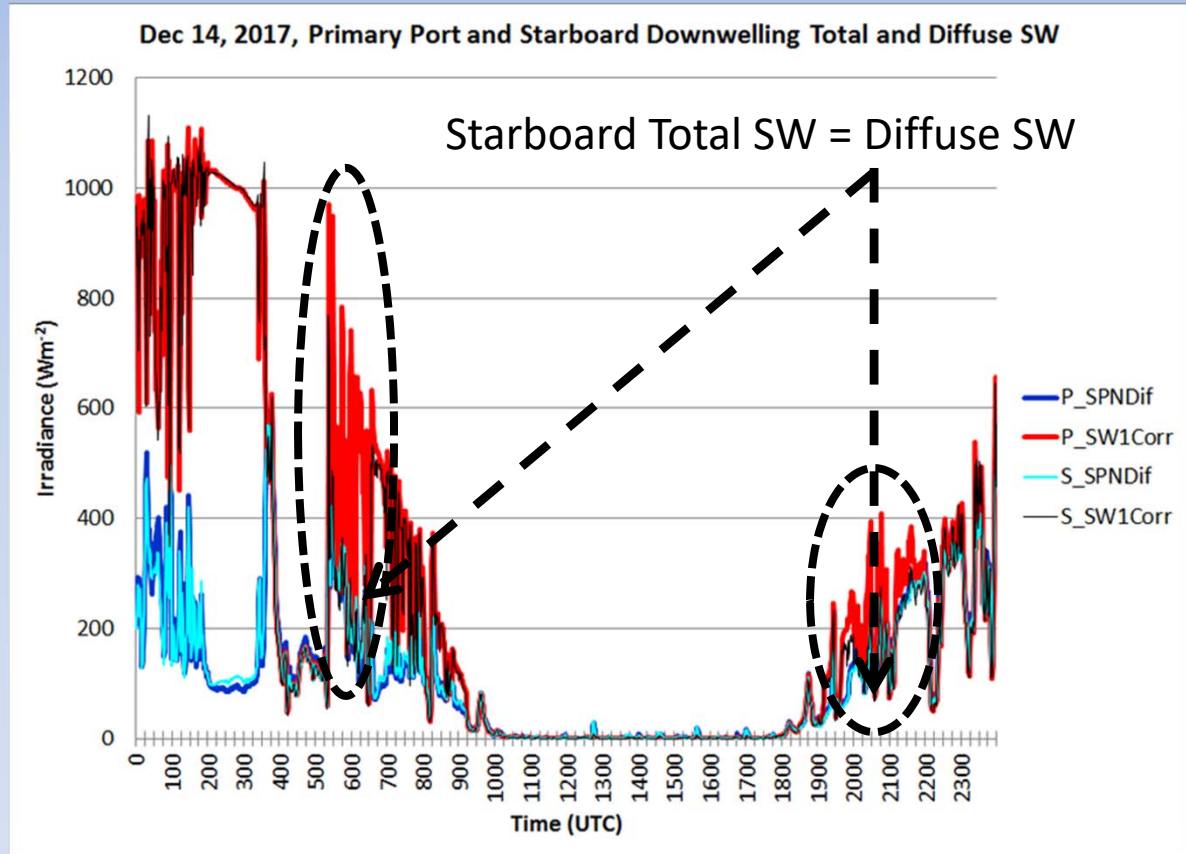


Example of tilt correction, Dec. 14, 2017

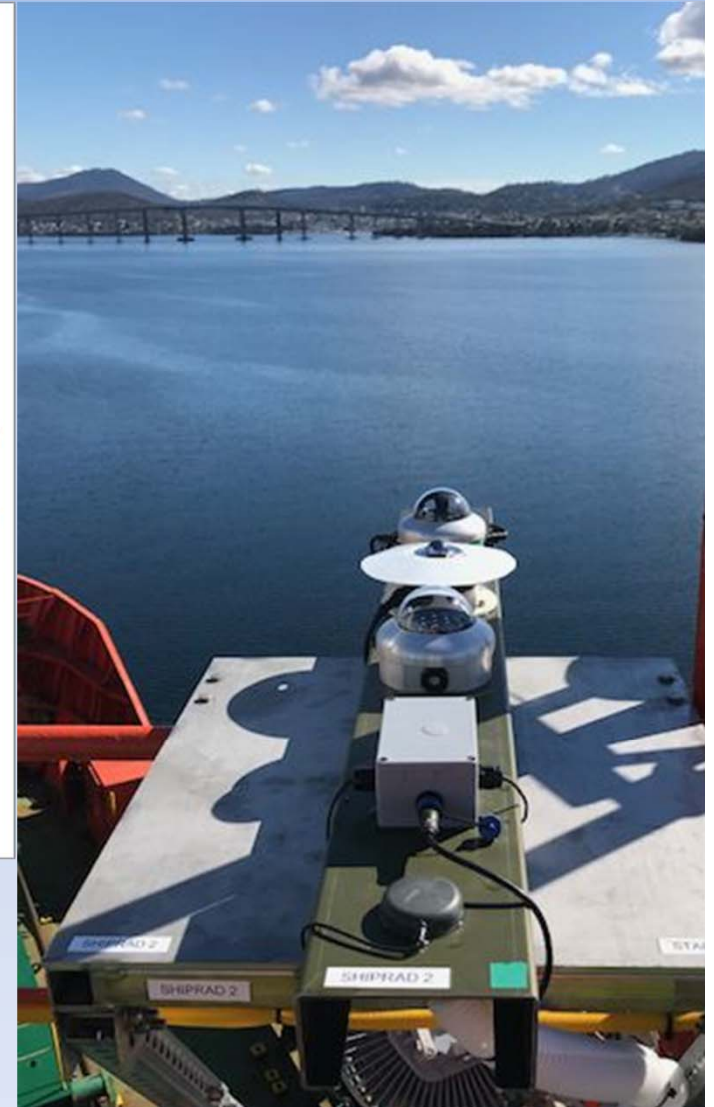


- A brief nearly clear-sky period (dashed circle) shows the effectiveness of the preliminary tilt correction. As the zoom plot shows, even without refined detector angular offset from nav correction, the noise in the 1-second samples is decreased from a spread of $30-40 Wm^{-2}$ to only a few Wm^{-2} . This despite the rapidly changing tilt from horizontal (black) shown in the right hand plot.

Why Port & Starboard Systems?



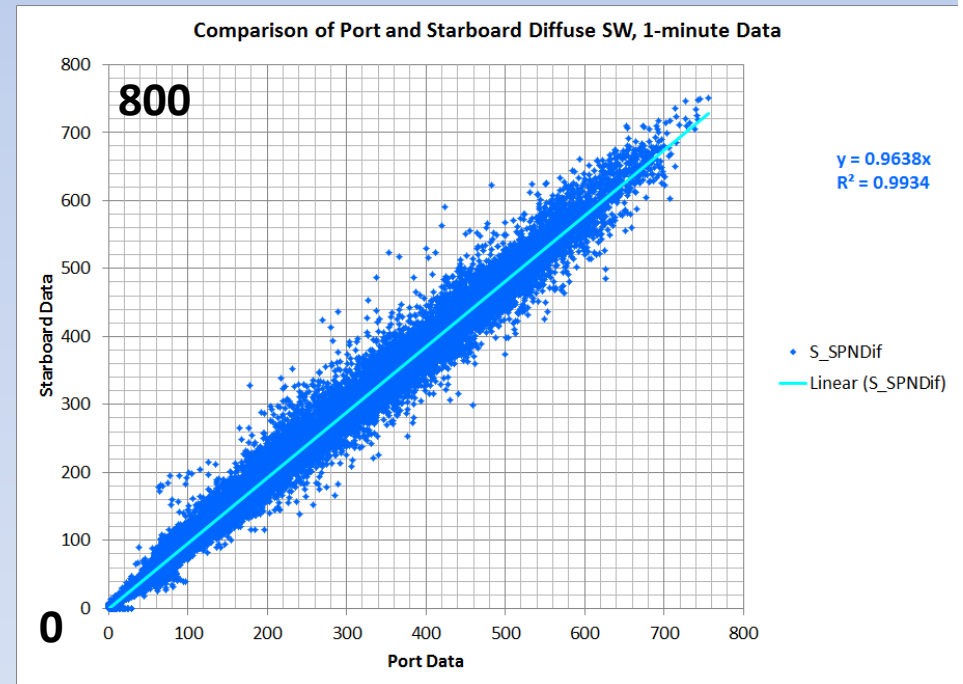
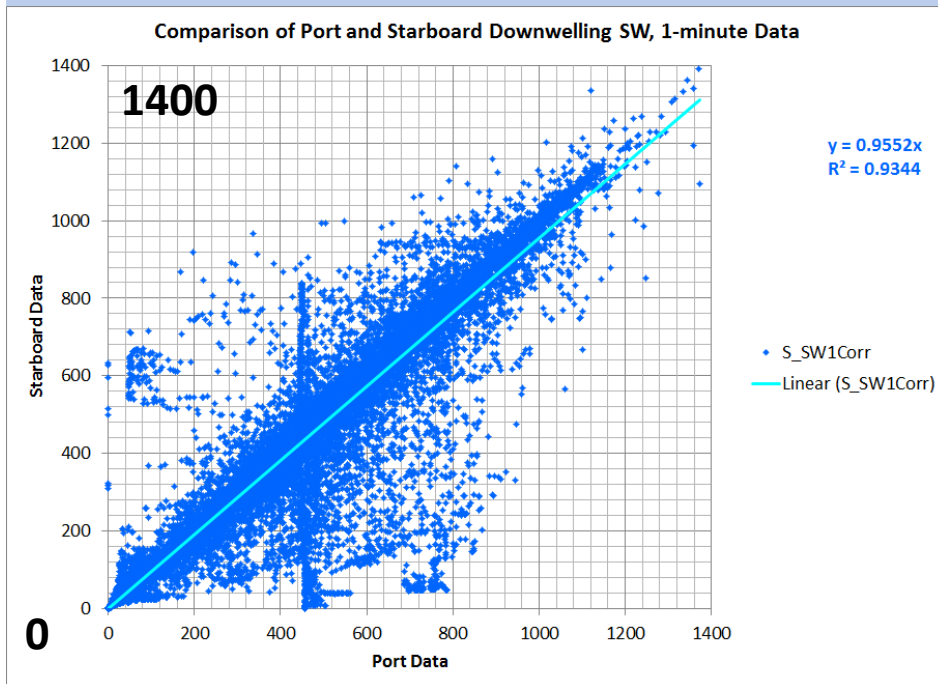
- **Shadowing from ship structure and nearby obstructions**



Port and Starboard Agreement

1-minute averages

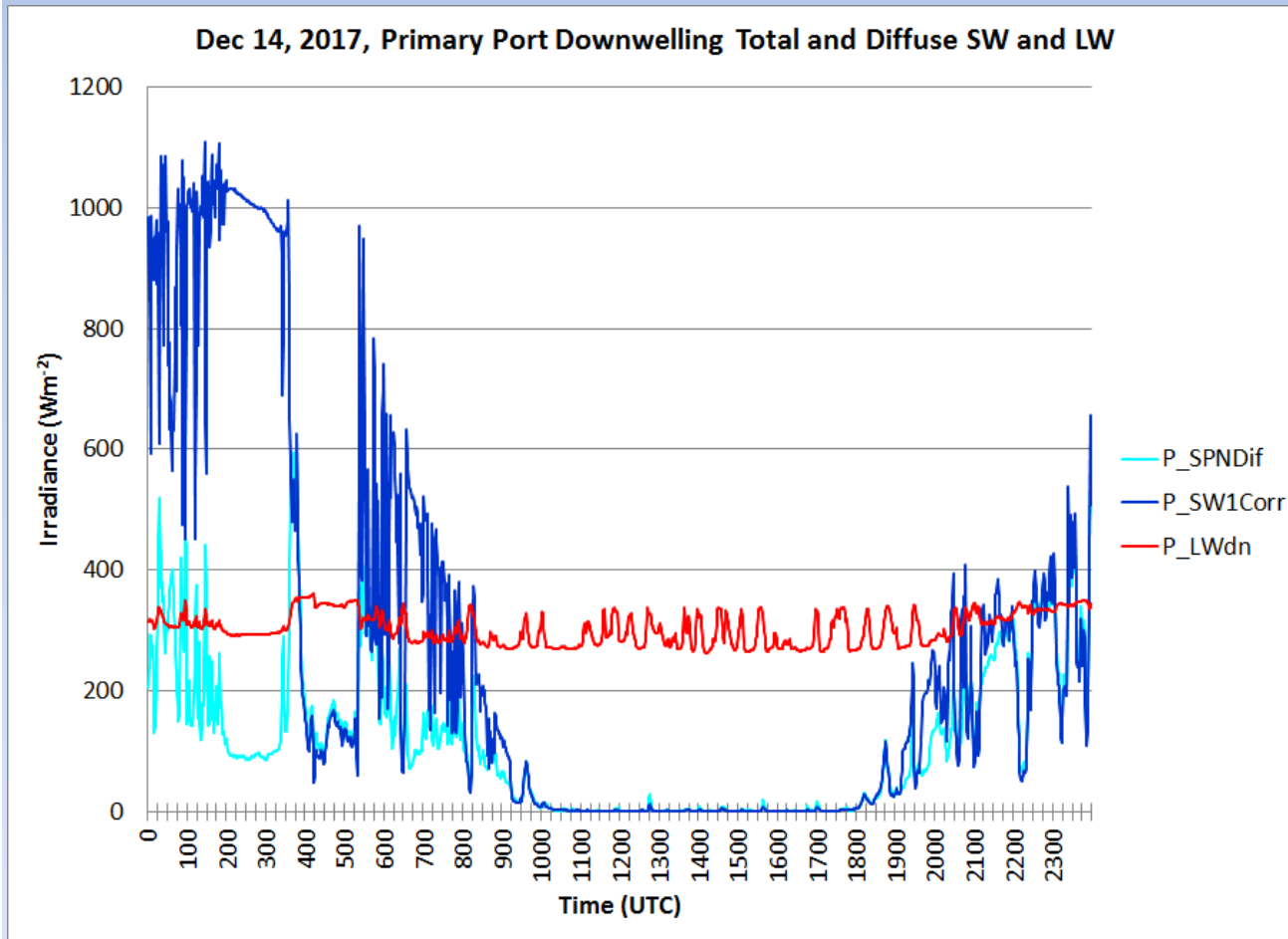
Total SW Diffuse SW



Port vs Starboard Total SW shows significant disagreements due to shading of one side.

Port vs Starboard Diffuse SW does not show similar disagreements because they are shaded measurements already.

Best Estimate Irradiances



- Look for times when one side has diffuse about equal to the total SW but the other side shows the total SW significantly greater than the diffuse, and choosing the one with smaller “diffuse ratio”
- Average the 2 diffuse SW and 2 LW

Summary

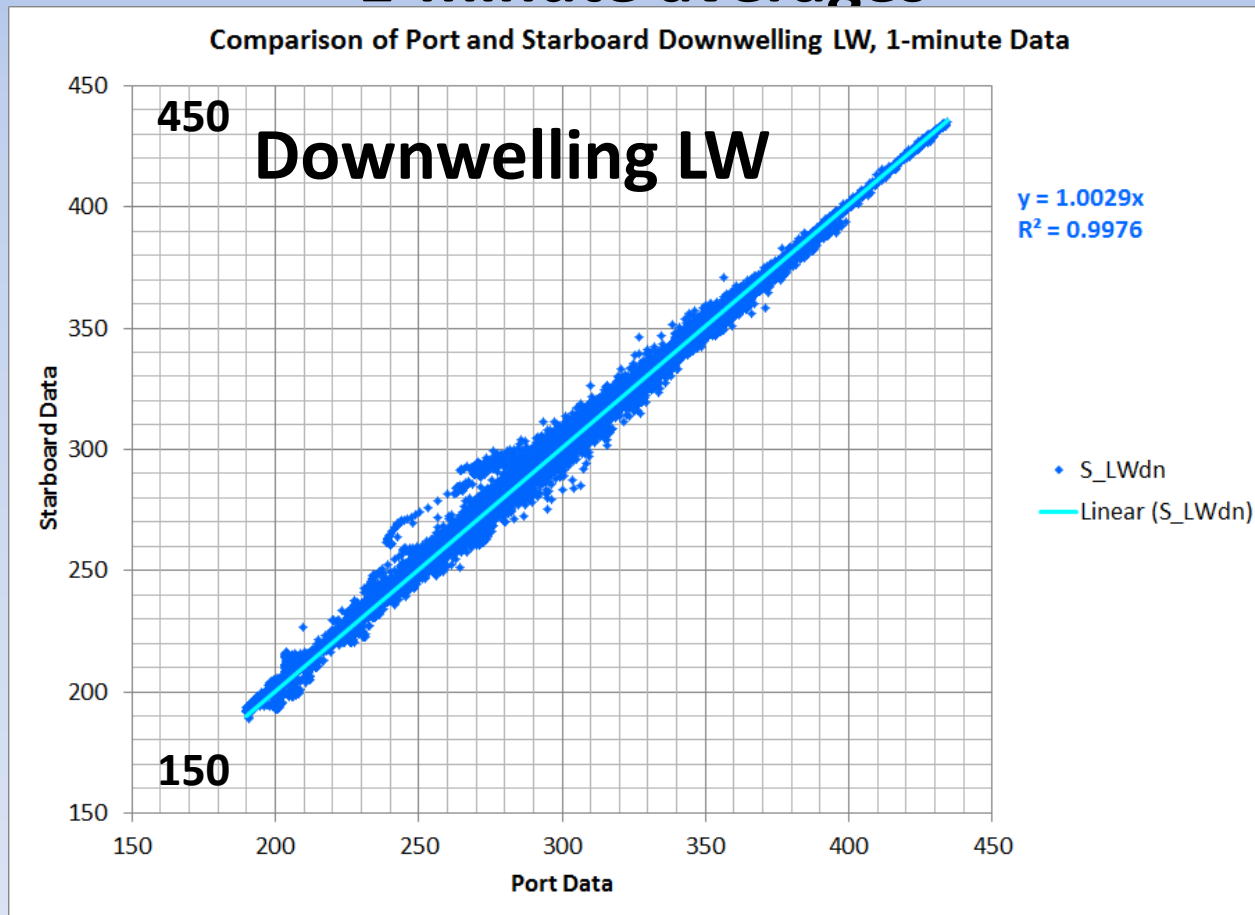
- Making accurate downwelling shortwave irradiance measurements on moving platforms such as ships and aircraft requires correction of the data for tilt from horizontal orientation. ARM has developed ship-board radiation systems (ShipRad) similar to the radiation package developed for the AAF G-1 aircraft.
- The maiden deployment of the ShipRad systems is for the MARCUS campaign with both a port and a starboard system to help mitigate shading by the ship structure and other close-by obstructions.
- Preliminary data indicate the systems are functioning reasonably well after a few initial hiccups, and will provide more accurate, tilt corrected data for use in developing a “best estimate” radiation product for ship campaigns.

Thanks for Listening!

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Extra

Port and Starboard Agreement 1-minute averages



Port vs Starboard Total SW shows little disagreement since LW is an emission regime not readily susceptible to interference.