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Diffuse and direct components of solar radiation in ground-based and satellite-derived data

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Many applications of solar radiation data require values for the separate diffuse (F) and direct (R) components of global radiation (G). Accurate measurement of these has been difficult, and beyond the scope of many meteorological and climate networks. Here I describe the use of high-quality data from a Baseline Surface Radiation Network (BSRN) site to assess and enhance the quality and utility of surface irradiance data both from ground-based networks and inferred from satellite measurements.

As a primary station of the Network for the Detection of Atmospheric Composition Change and, more recently, the Total Column Carbon Observing Network, the NIWA Lauder site in New Zealand measures numerous atmospheric constituents to the exacting demands of these networks. The Lauder station has also operated as a BSRN site since August 1999, with GFR data recorded every minute to the high calibration standards of the BSRN. These data are supported by simultaneous measurements of aerosol optical depth (AOD), which show the site to be of rare atmospheric clarity (AOD at 500 nm typically 0.02 – 0.05).

Plotting the diffuse and down-welling direct proportions of measured irradiance against the clear-sky clearness index (measured/model G) shows compact distributions that are useful in several ways. In the first instance, departures can be used to detect errors including contamination, misalignment, or timing errors in the GFR measurements themselves. The familiar phenomenon of cloud enhancement can be recognised and explored.

By integrating the one-minute data over ten minutes or an hour, the effect of cloud on typical meteorological network measurements is shown. Enhancement largely compensates for shading by broken cloud to preserve the compact relationships of the finer data into hourly integrals. Consequently, a robust algorithm to separate the F and R components of measured G is derived.

Several applications of this analysis are shown. An application on NIWA's web pages shows average solar energy availability by hour anywhere in New Zealand. It is readily extensible elsewhere, depending on data sources for solar radiation. In the Australian region, high-quality GFR measurements are made at only nine sites, including three BSRN stations, and the extension of radiation data to other locations makes use of hourly images from geostationary satellites. The satellite images are instantaneous, but the data product is shown from the above analysis to approximate time integrals of ground-based data.