Irradiance Variability

The figure below shows an example of global horizontal irradiance recorded over two consecutive days in summer at a sampling rate of 10 Hz using a LiCor-200x sensor. Two key metrics can be used to analyse the variability of this irradiance:

- **Clear-sky Index (CSI)**: Ratio of global horizontal irradiance to clear-sky irradiance
  
  \[ \text{CSI} = \frac{G_{HI}}{G_{HI}^*} \]
  
  Where \( G_{HI} \) is the global horizontal irradiance and \( G_{HI}^* \) is the clear-sky irradiance.

- **Daily Variability Index (VI)**: Ratio of the total "length" of all global horizontal irradiance values to the "length" of clear-sky irradiance values over the time scale of analysis
  
  \[ \text{VI} = \frac{\sum_{i=1}^{n} |G_{HI,i} - G_{HI}^*|}{\sum_{i=1}^{n} |G_{HI}^*|} \]
  
  Where \( n \) is the total number of data points.

Localised Modelling

While solar irradiance is dependent on large-scale atmospheric conditions, the PV systems which convert this irradiance into electrical power can be strongly affected by local conditions. For example, the slope or orientation of a roof on which solar panels are mounted, and the position of nearby buildings and terrain all have an impact on the incident irradiance which is actually received and converted into usable energy. Consequently, there is a need to model not just the theoretical global horizontal irradiance that an area might receive, but the real-world irradiance on residential rooftops that is affected by shading and orientation.

With the increasing availability of high resolution lidar data for cities, it is possible to model the local buildings in 3D and accurately calculate shaded and reflected irradiance. This process involves the conversion of dense lidar point clouds to regular meshes, which can subsequently be passed into physically-based ray tracing software such as RADIANCE.

The disadvantage of this approach is that the ray tracing process is computationally expensive, particularly when evaluating large areas over extended periods of time. In addition, it does not directly yield any information about the roof topology, and the area available for PV systems. To address this, a Clustering Algorithm for Raytracing (CARTE) has been developed. CARTE is a fast, semi-automated method for extracting 3D polygons comprising each roof, using lidar and building footprint data. This can subsequently be used for estimating the orientation and maximum size of potential PV systems. An overview of the algorithm is provided in the panels to the right.

Data Collection

To accurately and fully characterise the variability of irradiance in New Zealand, extensive data is required across a range of different temporal and spatial resolutions. The figures below give an overview of the irradiance data that has been collected, as well as the process for extracting, cleaning, processing, and storing this data in a common format.