Estimating Solar Radiation Using Daily Maximum and Minimum Temperature

Solar radiation was estimated using the Hargreaves and Samani (1982, 1985) equation for each township center using interpolated daily maximum and minimum temperature measurements. This equation estimates solar radiation as a function of the difference between the daily maximum and minimum temperatures with an adjustment coefficient of 0.16. Additionally, it uses Julian jay, Latitude and elevation to estimate the suns position relative to the point of interest on the earth's surface. This methodology as has shown good agreement (r^2 = 0.87) with measured daily solar radiation data at several of the ARD's meteorological stations.

The equation is given by:

(1) $$Rs = Kt * Ra * (T\max - T\min)^{0.5}$$

Where:

Rs	=	estimated solar radiation in [MJ $m^{-2}day^{-1}$],
Ra	=	extraterrestrial radiation [MJ $m^{-2}day^{-1}$],
Tmax	=	daily maximum air temperature (^oC)
Tmin	=	daily minimum air temperature (^oC)
Kt	=	adjustment coefficient = 0.16

(2) $$Ra = \frac{1440}{\pi} Gsc * drf \left(nws * \sin(lat) * \sin(ndec) + \cos(lat) * \cos(ndec) * \sin(nws) \right)$$

(3) $$Gsc = 0.082$$

(4) $$dfr = 1 + 0.033 * \cos(2 * \pi * Jday / Ndays)$$

(5) $$nws = ar\cos(-\tan(lat)\tan(ndec))$$

(6) $$ndec = 0.409 \sin\left(\frac{2\pi Jday}{365} - 1.39 \right)$$

Where,

elev	=	station elevation [m]
Jday	=	Julian day
Ndays	=	Number of days in a year (366 in a leap year)
Gsc	=	solar constant [MJ $m^{-2}day^{-1}$],
dfr	=	inverse relative distance
ndec	=	solar declination angle
nws	=	sunset hour angle
lat	=	station latitude in radian
Rso	=	clear sky solar radiation [MJ $m^{-2}day^{-1}$],
T	=	mean daily temperature at 1.5 to 2.5 m height from the ground [^oC],
P	=	mean atmospheric pressure at station elevation {m],

Results:

Solar Radiation estimates were tested against measure solar radiation data taken from five meteorological stations widely across the province, ranging in in latitude from 58.38 degrees north to 49.49 degrees north (Figure 1).

From each station an entire year (2009) of total daily incoming measured solar radiation measurements were plotted against solar radiation estimated using equation 1 (Figure 1, Figure 2, Figure 3, Figure 4, Figure 5, Figure 6).

For these five stations, the R^2 values ranged from 0.87 to 0.89 with slopes of the regression equations ranging from 0.87 to 1.0 with intercepts ranging from 1.17 to 1.46. These results suggest that that the method employed here adequately estimates solar radiation for individual stations across the province with minimal bias using only maximum and minimum daily temperatures, date and station location.

In order to provide continuous estimates of solar radiation for each township center, the estimated solar radiation values presented here were derived from interpolated temperature values, estimated using linear inverse distance weighting interpolation algorithms using all available station data on a given day, from the closest eight stations, up to a maximum radius of 200km. Note, the interpolation process rarely needed to use station data from stations on the fringes of the maximum interpolation radius (200 km). For those data users that require having insight into the interpolation radius, flags are available along with the interpolated temperature estimates that describe the interpolation radius. An example of a data flag is as follows:

N=8, C=26.02, F= 48.95

Where:

N = the number of stations used in the interpolation
C= distance to the closest station (km)
D = distance to the farthest station (km)

Notes:

Users of this data are cautioned that this is only an estimation of total daily solar radiation. On any given day, large discrepancies between estimated and actual measurements can and do occur. There are several reasons for this of which the main ones are:

1. The equations use the difference between maximum and minimum temperatures to proxy cloud cover, assuming that days with large variations between maximum and minimum temperatures tend to be clear days, and days with less variation between minimum and maximum temperatures tend to be cloudy days.

2. The interpolation scheme tends to have more errors where station density is low and/or were large differences in elevation occur over short distances (eg, though the mountains, foot hills, Swan Hills, Cypress hills, and other major topographical features as well as near large water bodies). Data users can get a very good idea of the interpolation neighborhoods, by downloading the maximum and minimum temperature flags that can be used to screen estimates that were based on low station density.

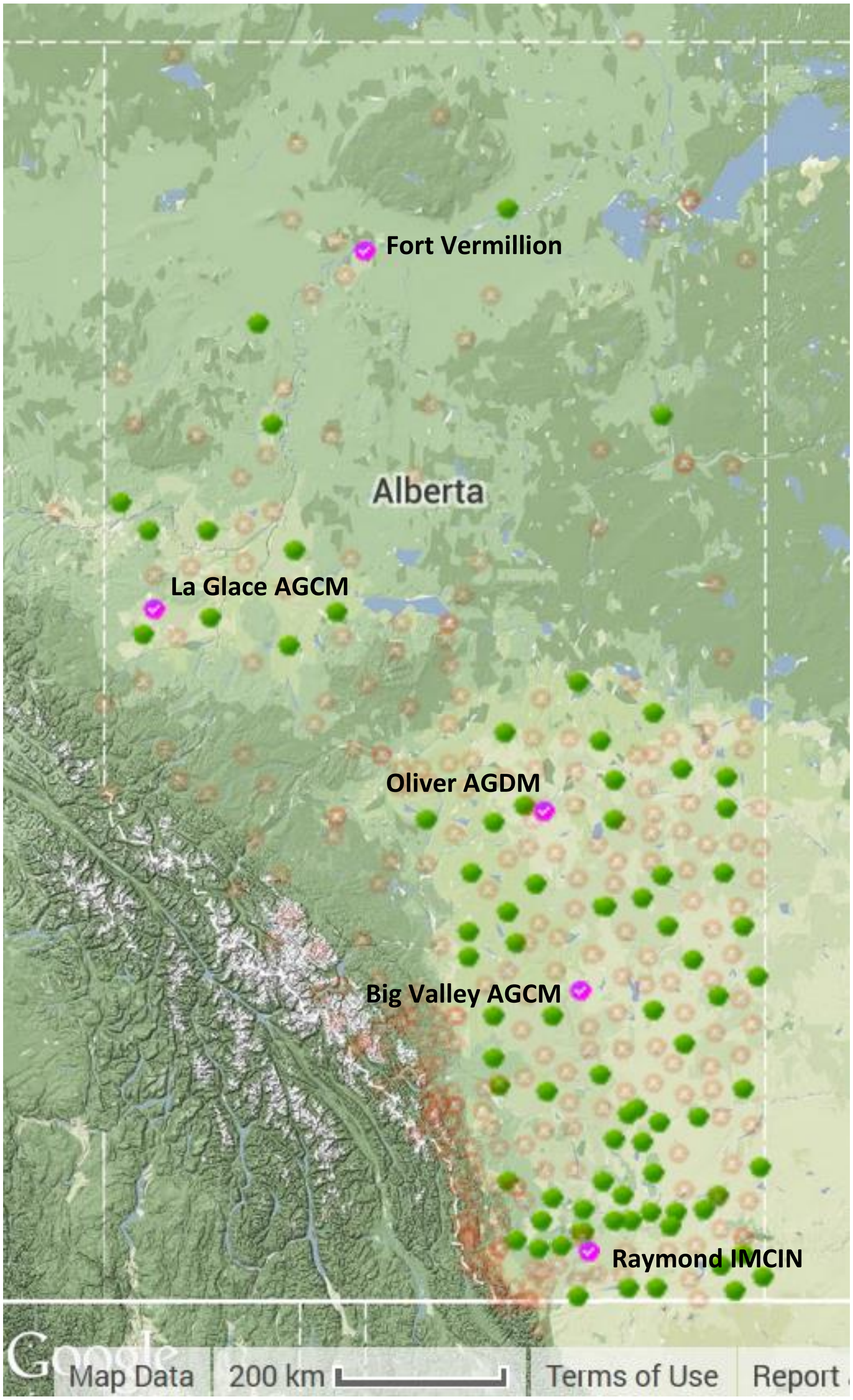

Figure 1. Locations of stations used for investigating the performance of the Hargreaves and Samani Equation**.**

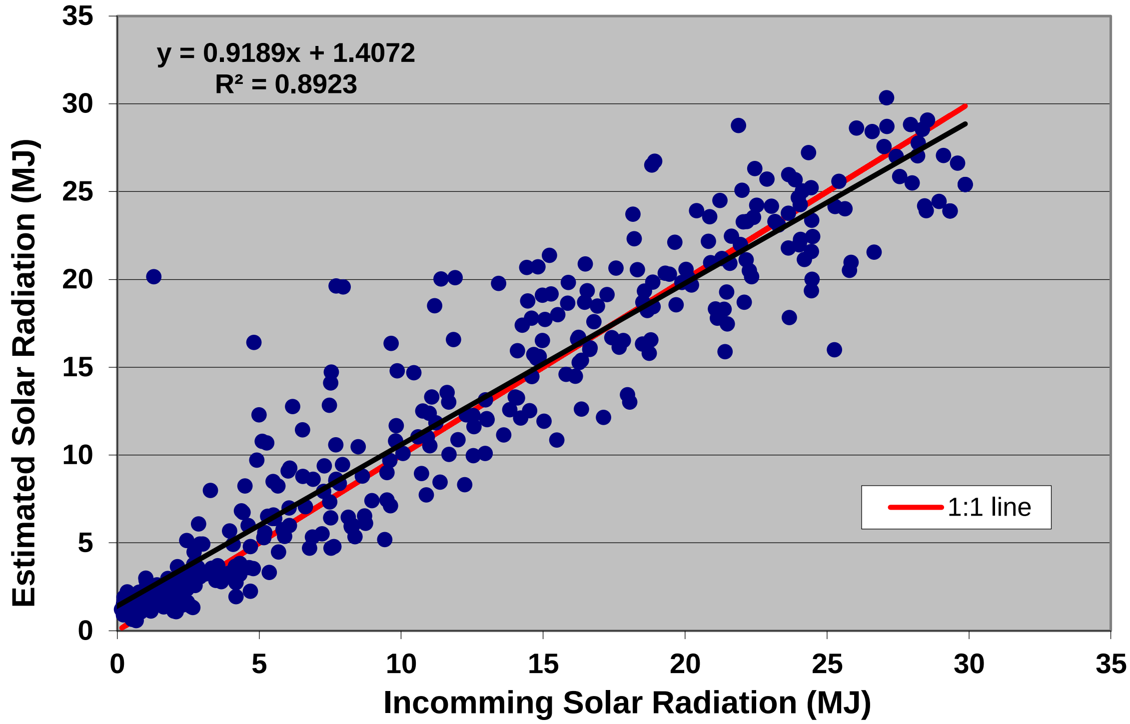

Figure 2 Solar Radiation measured vs. Solar Radiation Estimated for Fort Vermillion

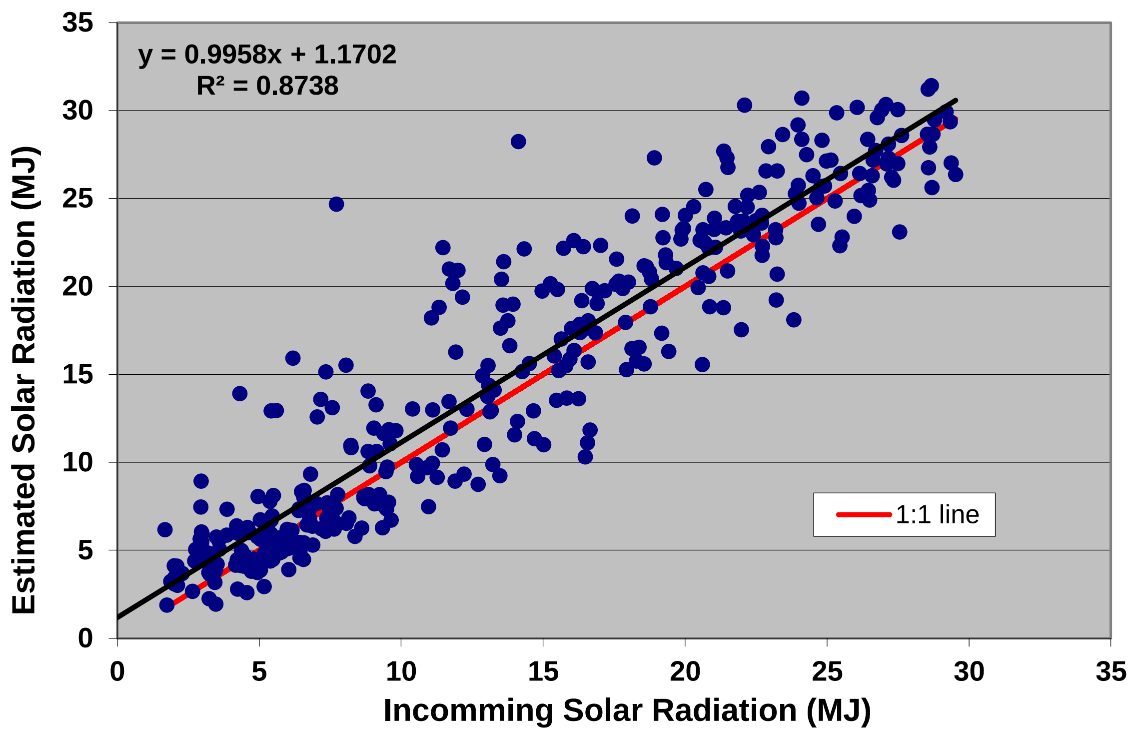

Figure 3. Solar radiation measured vs. solar radiation estimated for Raymond IMCIN

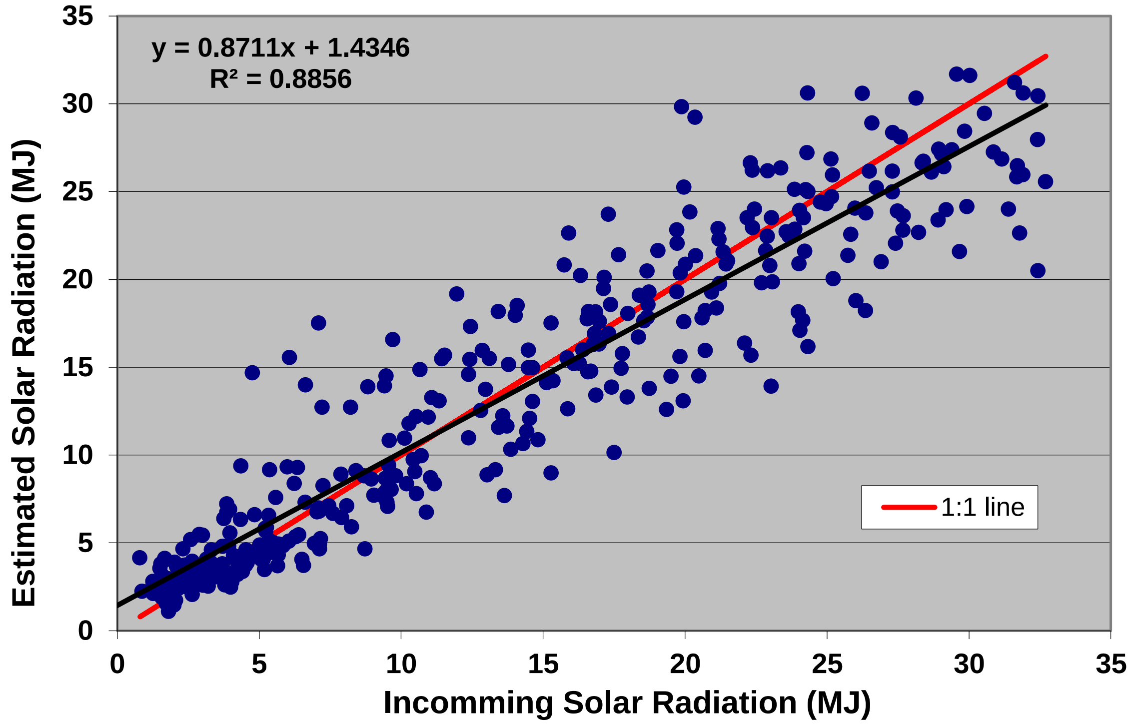

Figure 4 Solar radiation measured vs. solar radiation estimated for La Glace AGCM

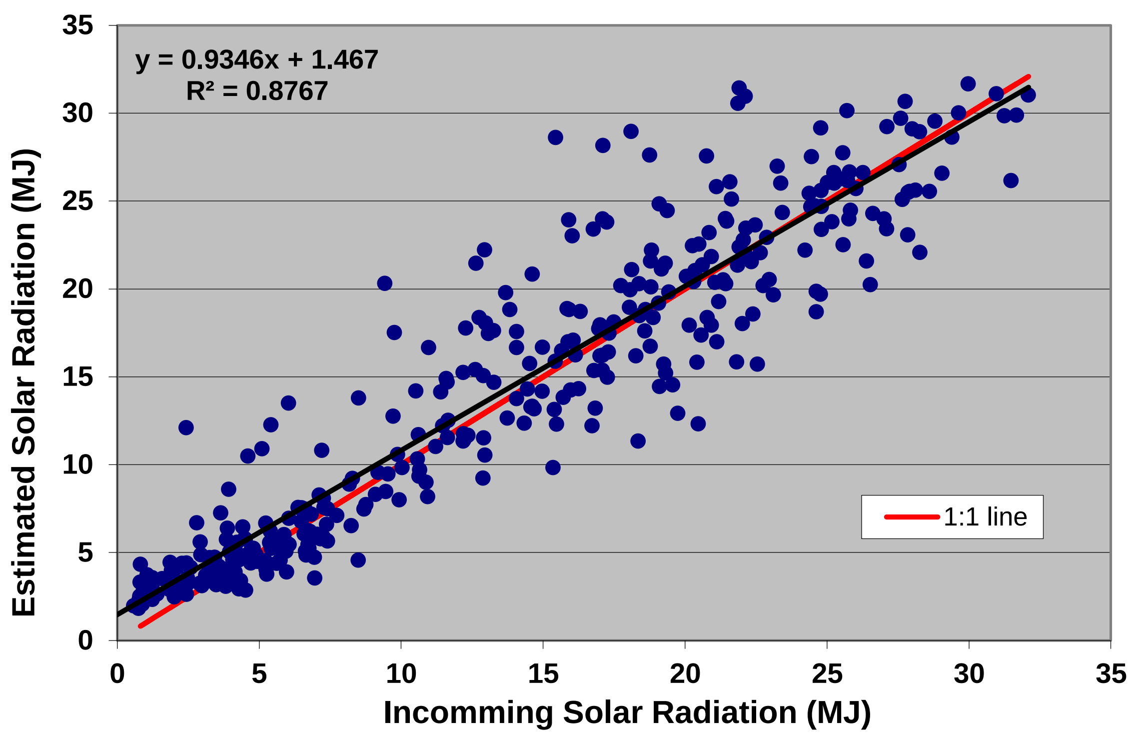

Figure 5 Solar radiation measured vs. solar radiation estimated for Oliver AGDM

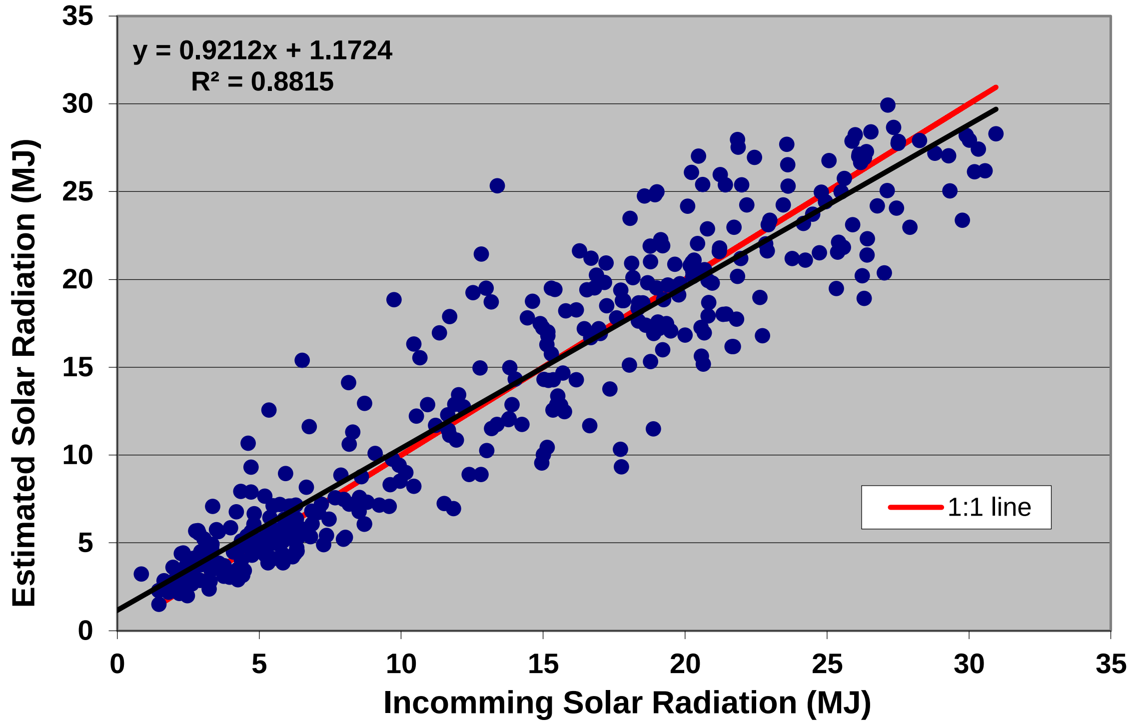

Figure 6 Solar radiation measured vs. solar radiation estimated for Big Valley AGCM