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Comparison of Satellite Estimated Hourly Solar Data with Coincident Ground Based Measurements and their Applications in Industry and Commerce

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Abstract

This project aims to analyse the difference between Australian Bureau of Meteorology (BOM) gridded hourly satellite-estimated data and coincident ground based measurements of both Global Horizontal Irradiance (GHI) and Direct Normal Irradiance (DNI), and determine what the difference means in practice to the building and renewable energy industries.

From these comparisons, Real Time Year (RTY) weather data was applied to the prediction and management of PV, building-integrated PV, other renewable energy generators and building field performance. This was done using energy simulation software – System Advisor Model (SAM) for renewable energy systems and EnergyPlus and the house energy rating and evaluation software BERS-Pro and NatHERS Analyser for buildings. In this way, an understanding of data accuracy for the renewable energy and building industries was developed.

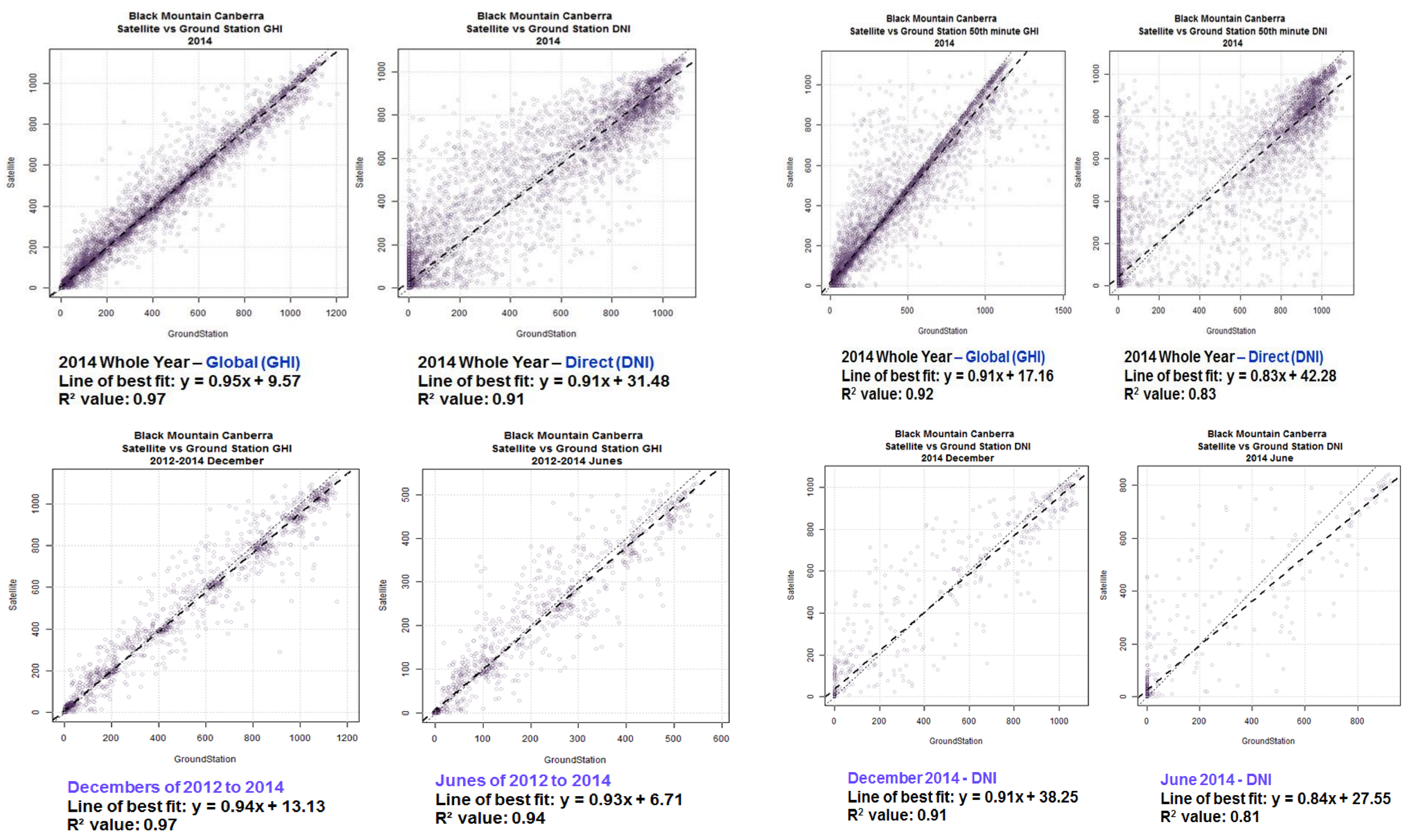


Figure 1. Coincident Solar Data Comparison

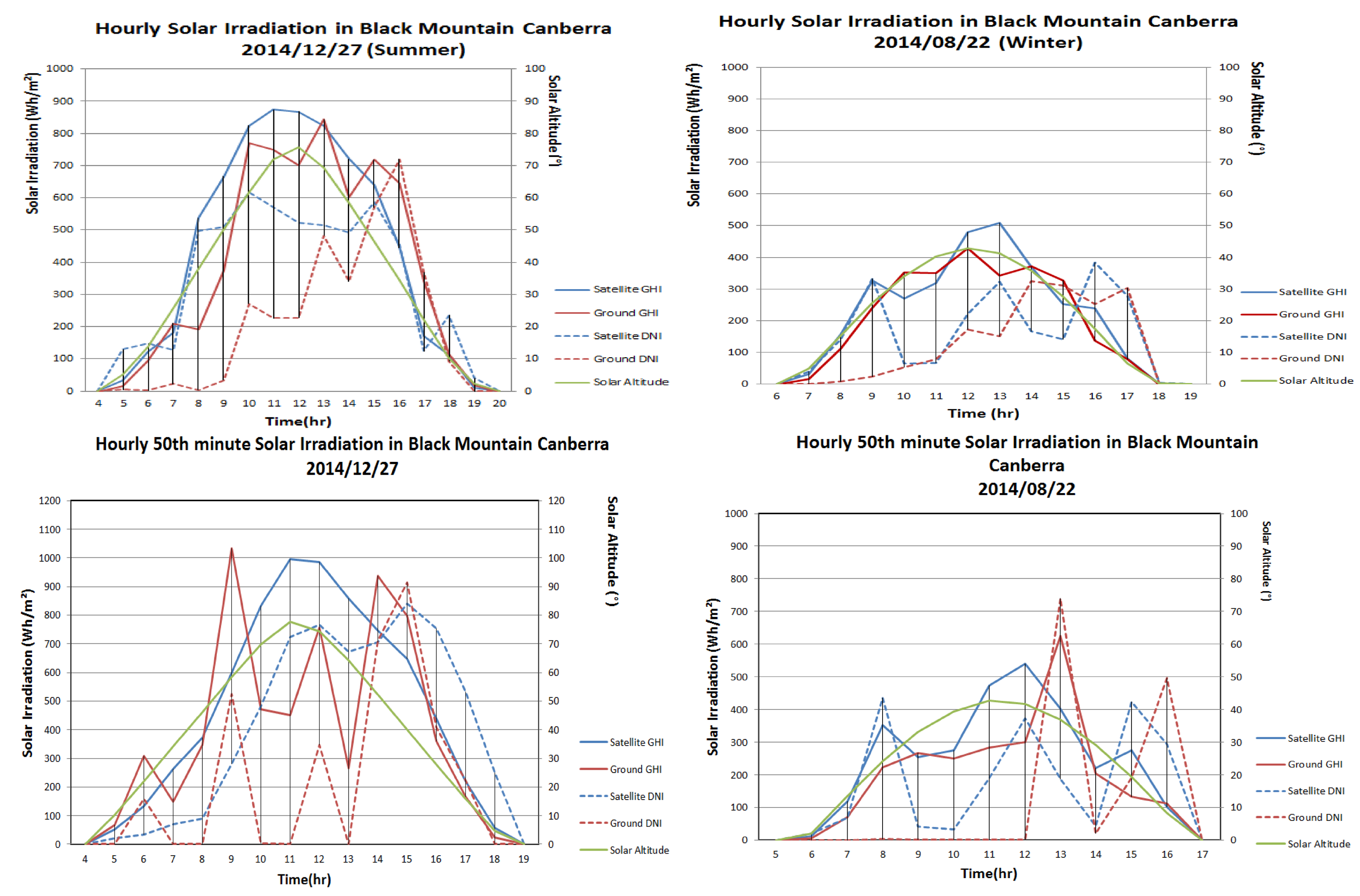
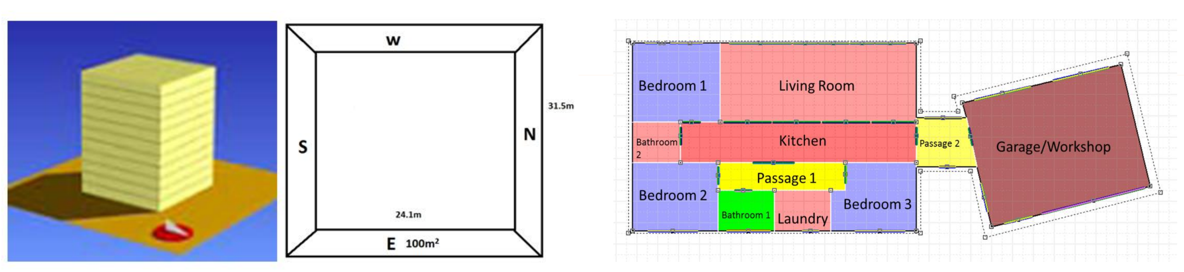


Figure 2. Solar Radiation profiles for some extreme-difference days

Effect on Industrial Applications

Apply the satellite and ground station data to the simulation of a 10 storey commercial office building and a passive solar residence and observe the difference in energy consumptions.

Figure 3. 10 Storey office building (left), Passive solar house (right)



Analysis

Table 1. Annual Average Hourly Energy Consumption for Office building 2014

	Heating Energy Consumption (SAT Data)					Heating Energy Consumption (GND Data)			
	West	North	East	South		West	North	East	South
Max (kWh)	8.00	7.11	6.83	8.28	Max (kWh)	8.17	7.44	7.17	8.50
Average (kWh)	1.69	**1.50**	**1.28**	1.61	Average (kWh)	1.69	**1.61**	**1.44**	1.61
Std Dev (kWh)	2.00	1.92	1.75	2.00	Std Dev (kWh)	2.06	2.01	1.89	2.03
	Cooling Energy Consumption (SAT Data)					Cooling Energy Consumption (GND Data)			
	West	North	East	South		West	North	East	South
Max (kWh)	16.69	11.79	13.47	10.39	Max (kWh)	16.53	11.72	13.44	10.39
Average (kWh)	4.39	4.50	4.17	3.47	Average (kWh)	4.36	4.47	4.14	3.44
Std Dev (kWh)	3.31	2.67	2.89	2.33	Std Dev (kWh)	3.28	2.64	2.89	2.31

Heating consumption was more inconsistent within the building than cooling consumption, especially for the East and North facing areas. The differences in average hourly consumption reached 6.83% and 11.11% in the North and East respectively. Overall, values of satellite data simulated heating consumption were smaller than the ground station simulation in all categories. More specifically, the standard deviations of satellite data simulations were between 1.48% and 7.41% smaller than ground station data.

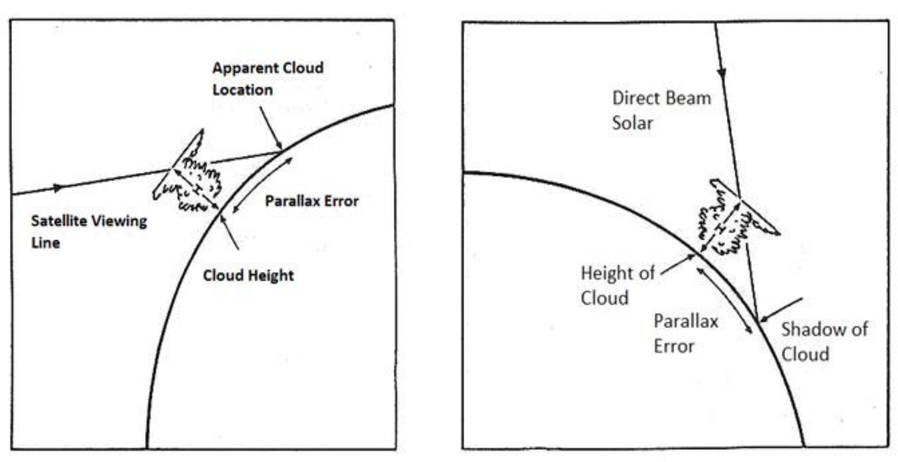
Table 2. Passive Solar House with PV - Consumption and Cost Comparison 2014

Canberra		PV Delivery (kWh)	Cooling (kWh)	Heating (kWh)	HVAC-PV (kWh)	Feed in Tariff Incentive ($)	Cost of Grid Electricity ($)	Final Electricity Cost ($)
Heavyweight	Satellite data	6288.91	1281.60	6397.30	1389.99	354.80	1018.07	663.27
	Ground data	6195.71	1206.50	7162.10	2172.89	351.91	1141.78	789.87
Lightweight	Satellite data	6288.91	4755.80	13879.30	12346.19	291.13	2699.04	2407.91
	Ground data	6195.71	4634.30	14894.90	13333.49	289.17	2858.88	2569.71

Simulations based on satellite data gave 6.22% and 2.62% increases in cooling consumption for heavyweight and lightweight respectively, in the heavyweight version, heating consumption as simulated using satellite data was 10.68% lower than when using the ground station data. The substantially lower heating energy consumption also decreased the final electricity cost, it was reduced from $789.87 (ground) to $663.27 (satellite), a 16.03% lower result.

Prime cause of big individual-hour differences

Figure 3. Satellite Parallax error (left) and solar parallax error (right)



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