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CSP & Solar Resource Assessment

CSP Today South Africa 2013

2nd Concentrated Solar Thermal Power Conference and Expo

4 - 5 February, Pretoria, Southern Sun Pretoria Hotel

Mr Riaan Meyer

On behalf of

Centre for Renewable and Sustainable Energy Studies – University of Stellenbosch

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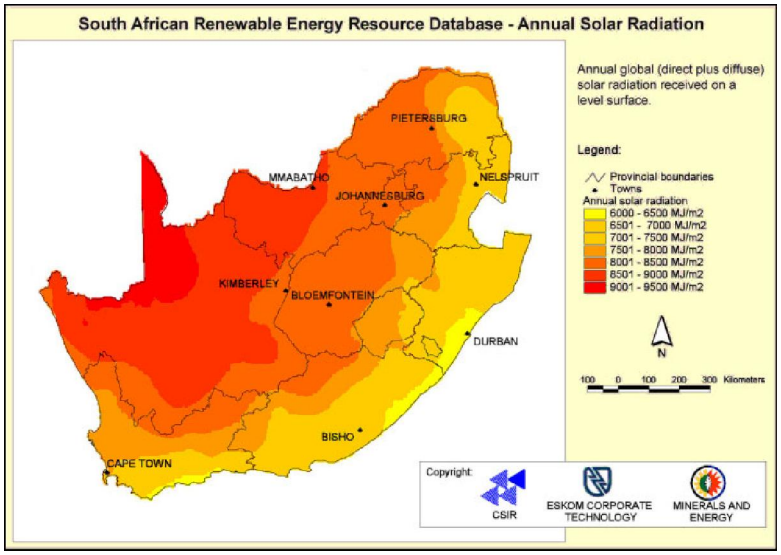
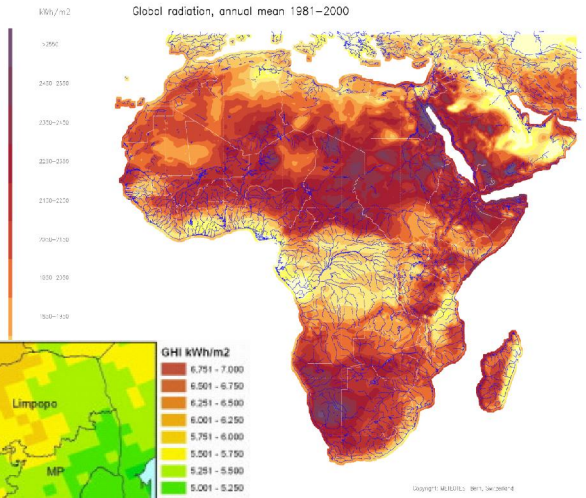
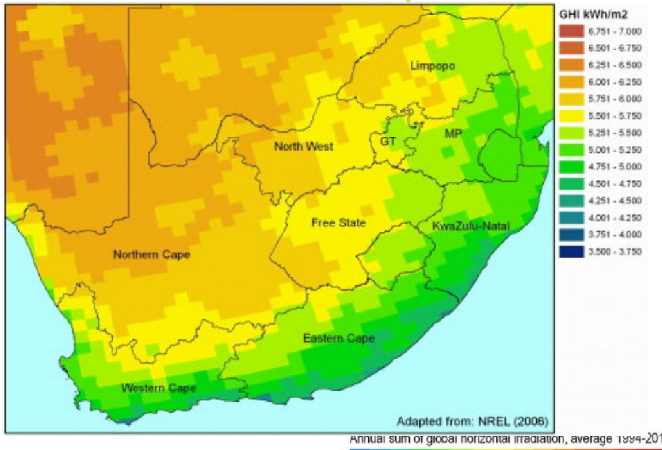
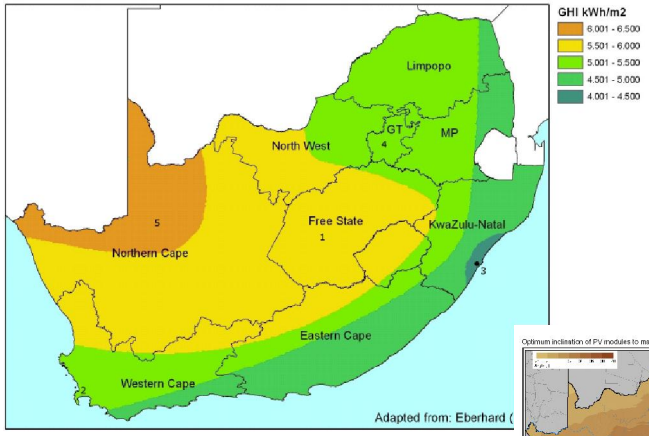
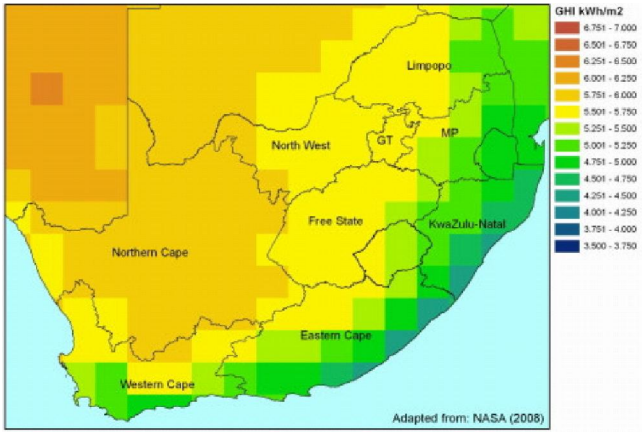
Solar Maps for South Africa

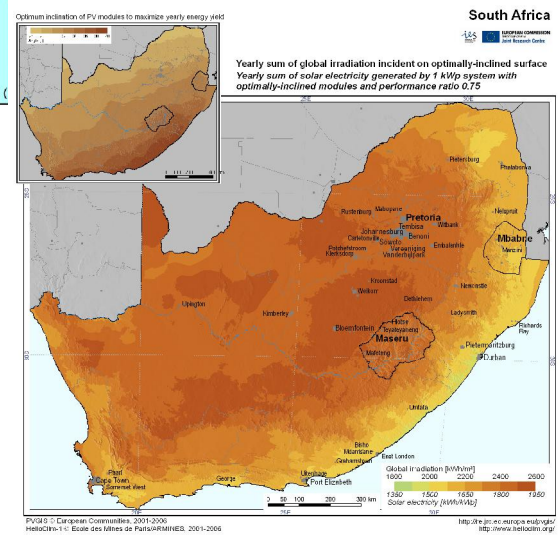


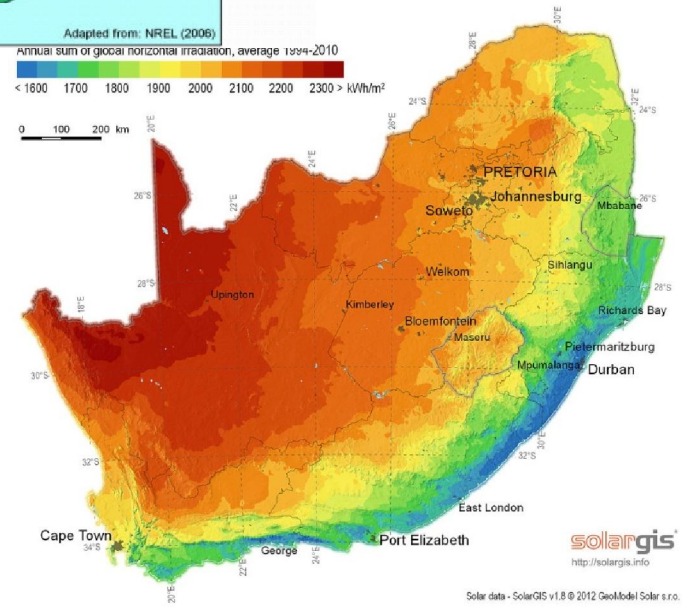


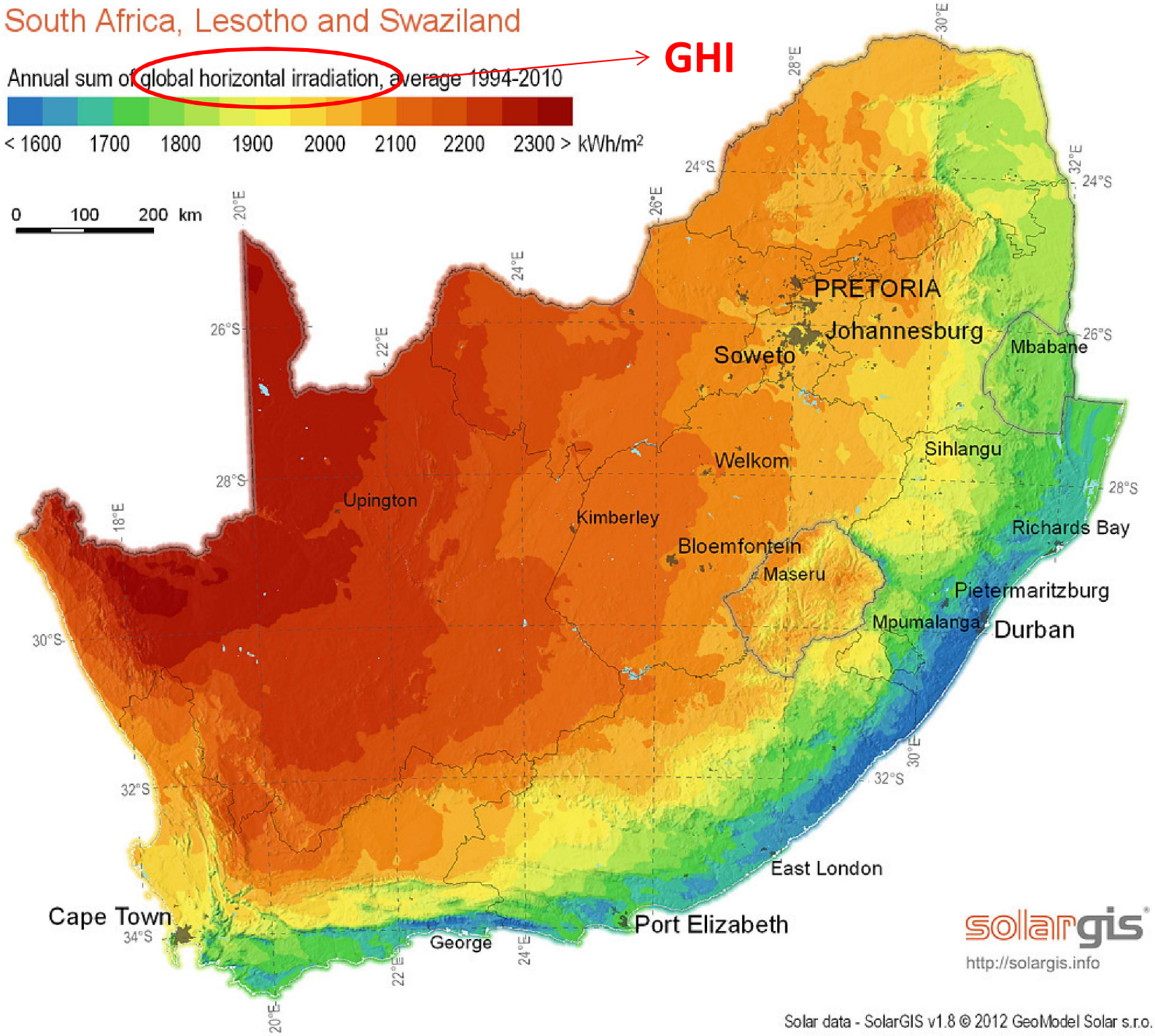




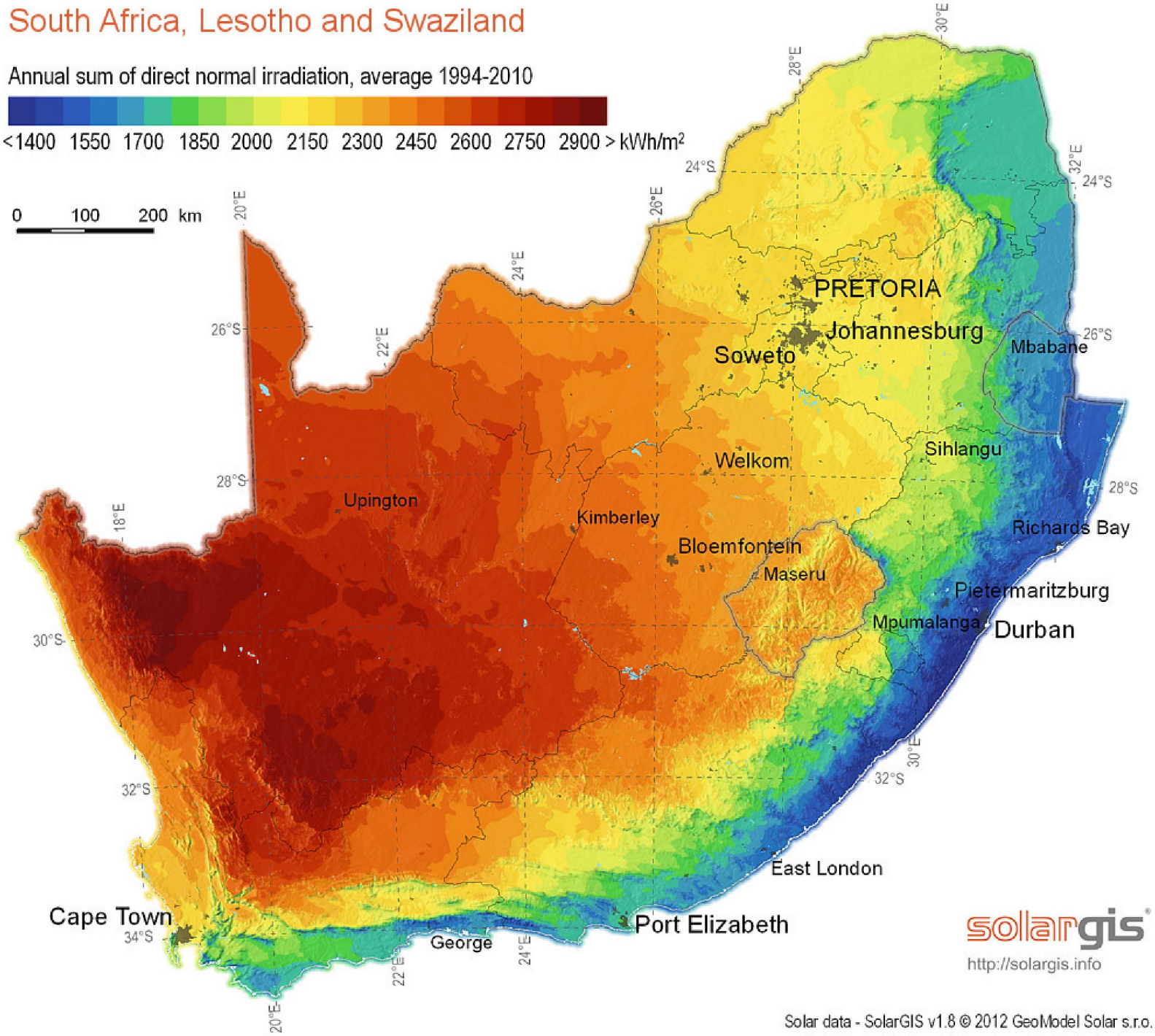







South Africa, Lesotho and Swaziland
Annual sum of global horizontal irradiation, average 1994-2010
GHI
< 1600 1700 1800 1900 2000 2100 2200 2300 > kWh/m²
0 100 200 km
PRETORIA
Johannesburg
Soweto
Mbabane
Welkom
Sihlangu
Upington
Kimberley
Richards Bay
Bloemfontein
Maseru
Pietermaritzburg
Mpumalanga
Durban
East London
Cape Town
George
Port Elizabeth
solargis
http://solargis.info
Solar data - SolarGIS v1.8 © 2012 GeoModel Solar s.r.o.

South Africa, Lesotho and Swaziland

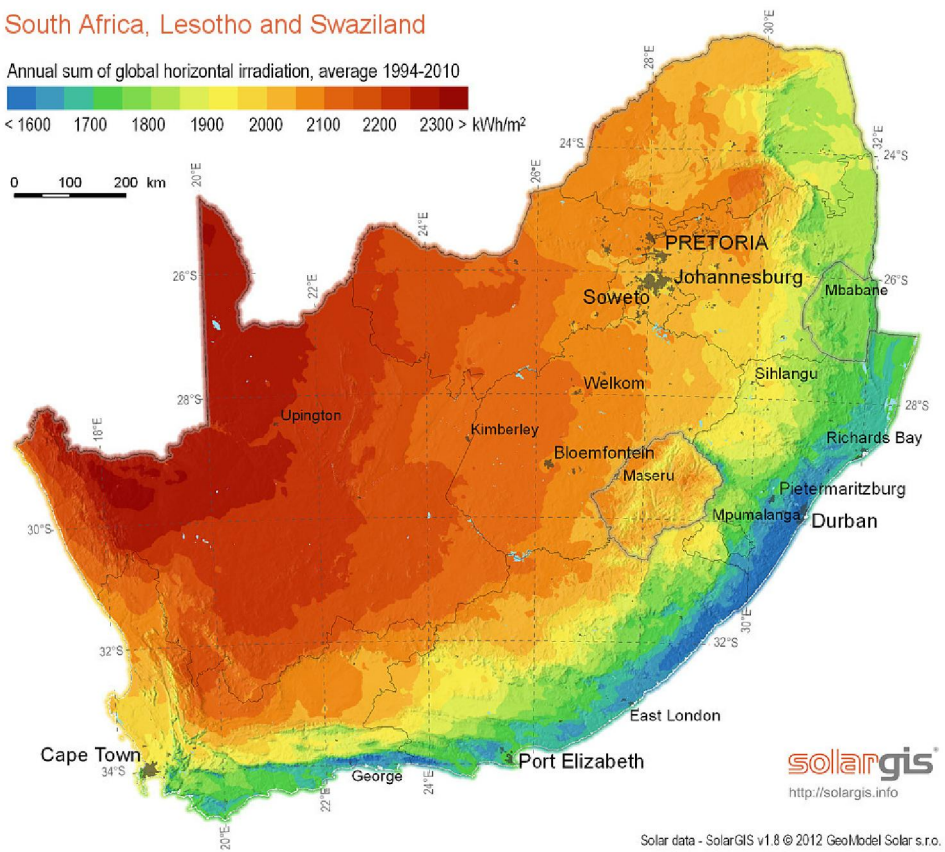


Solar data - SolarGIS v1.8 © 2012 GeoModel Solar s.r.o.

GHI (Global Horizontal Irradiance)

PV (Photovoltaic)
SWH (Solar Water Heaters)

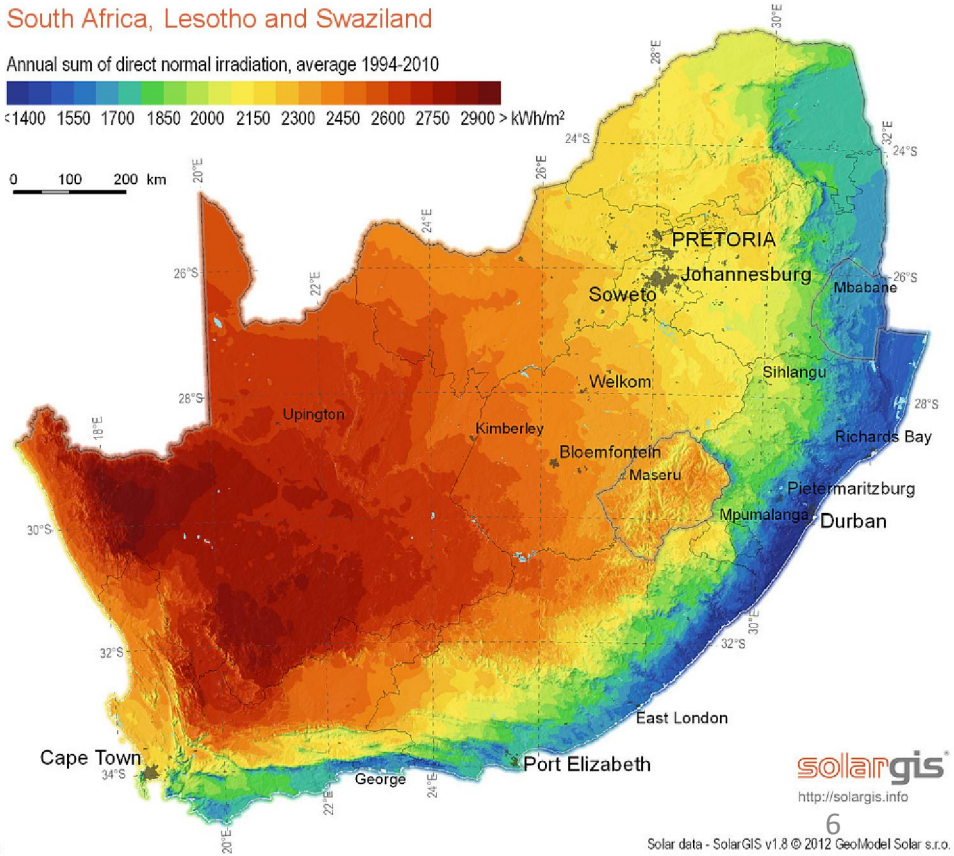
Upington = 2228 kWh/m^2/a
Bloemfontein = 2078 kWh/m^2/a
Cape Town = 1897 kWh/m^2/a
Durban = 1637 kWh/m^2/a



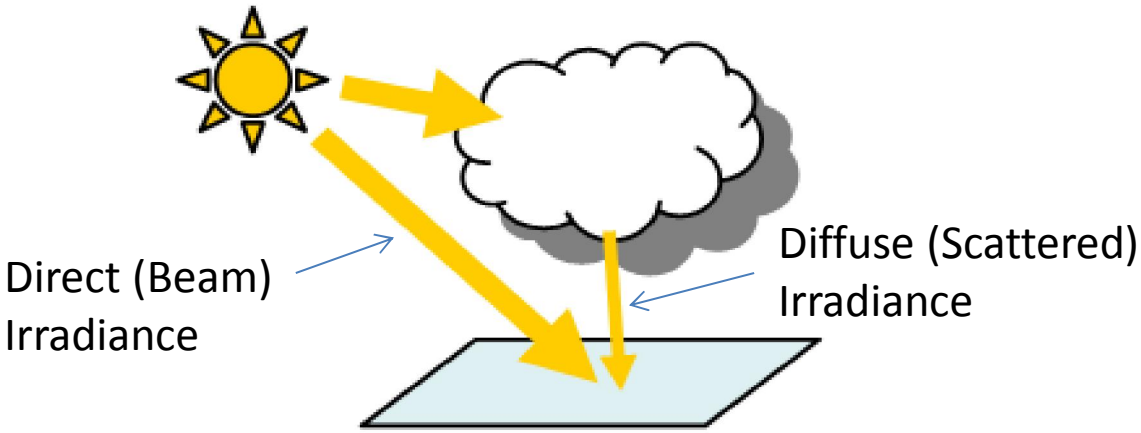
DNI (Direct Normal Irradiance)

CPV (Concentrating Photovoltaic)
CSP (Concentrating Solar Power)

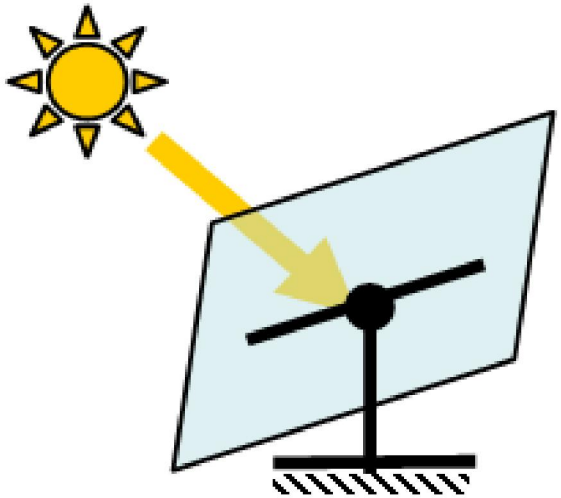
Upington = 2601 kWh/m^2/a
Bloemfontein = 2375 kWh/m^2/a
Cape Town = 2114 kWh/m^2/a
Durban = 1454 kWh/m^2/a



Global horizontal irradiation
GHI

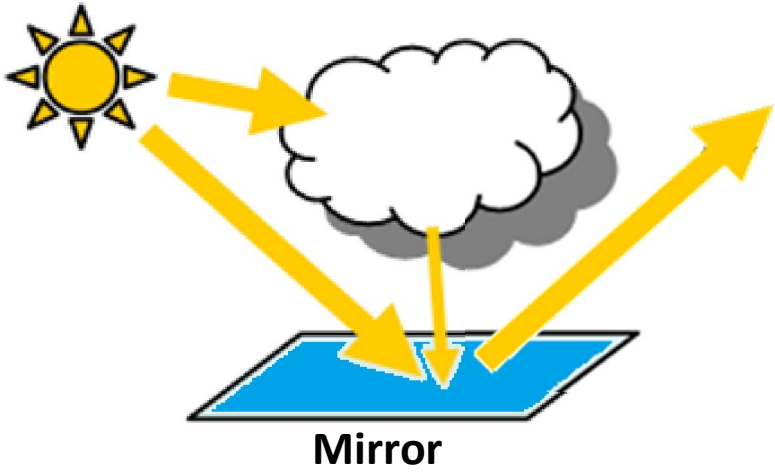


Direct normal irradiation
DNI



GHI – Combination of Direct and Diffuse Irradiance measured on a horizontal plane (and applies to PV and SWH)

DNI – This is only the direct (beam) component of the sun (i.e. excluding the Diffuse Irradiance) and measured in a plane normal to the rays of the sun (and applies to CSP and CPV).



Only the direct (beam) component of the sun can be reflected (or concentrated)

GHI ≈ 800 W/m^2
DNI ≈ 900 W/m^2

Note the blue sky and distinct shadows


2
CG 3750
GHI ≈ 600 W/m²
DNI ≈ 250 W/m²
Note the grey sky and weak shadows

GHI ≈ 400 W/m^2
DNI ≈ 0 W/m^2

Note the grey sky and no shadows

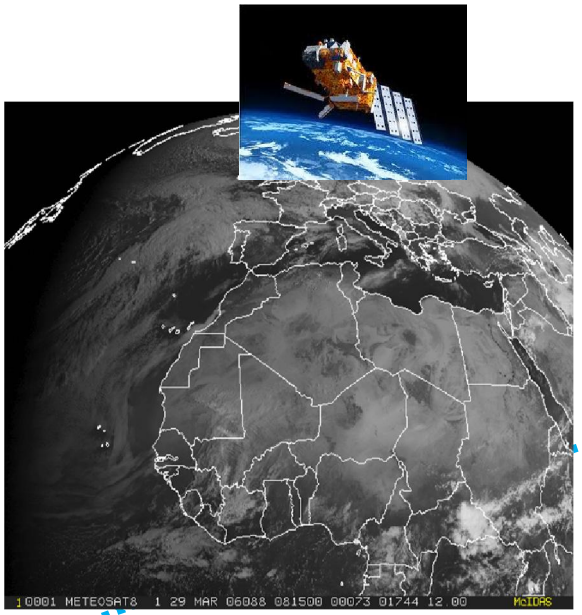
GHI (PV) vs. DNI (CSP)

Global Horizontal Irradiance

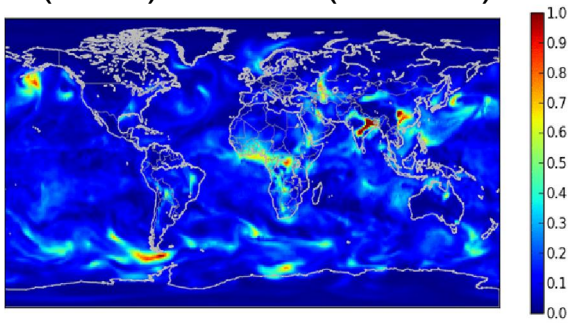
- GHI is the most common solar map
- GHI is the most commonly measured solar data parameter
- The cost of a GHI based solar measurement station is significantly lower than that of DNI
- Satellite derived GHI data is available at a lower cost than DNI data
- Satellite derived GHI data has lower uncertainty than DNI

Direct Normal Irradiance

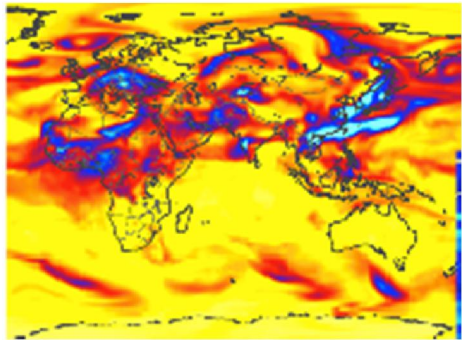
- Few DNI maps are available
- Few DNI measurements are available, especially in the public domain
- The cost of a DNI solar measurement station is significantly higher than that of a GHI/GTI based station
- Satellite derived DNI data is more expensive than GHI/GTI data
- Satellite derived DNI data has higher uncertainties than GHI/GTI

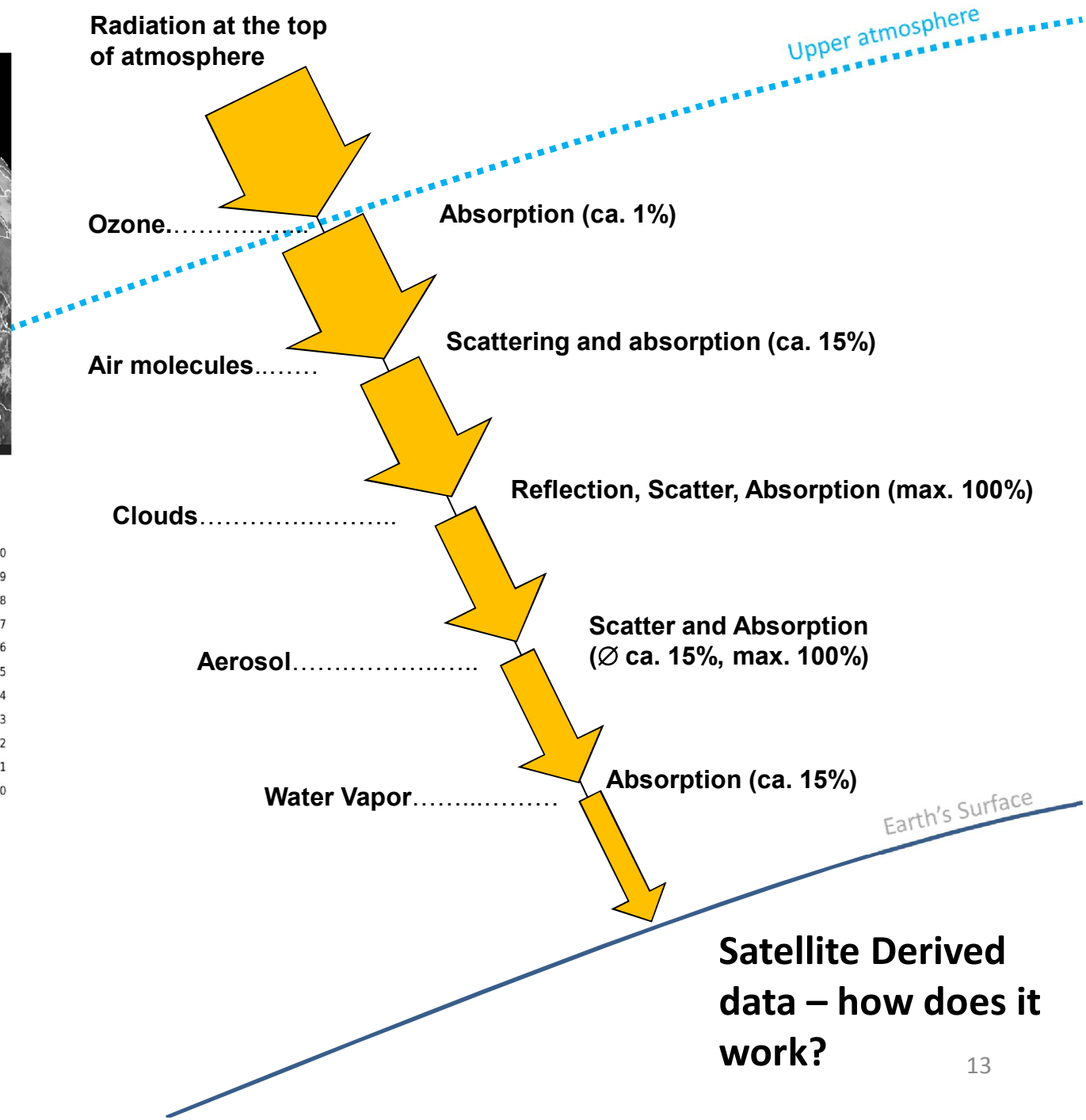


Aerosol Optical Depth (AOD) 125 km (6 hours)



Water vapour 35 km (6 h)

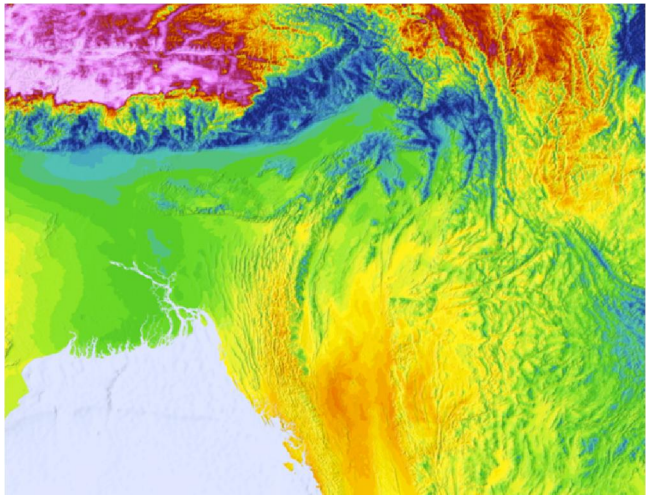




Satellite Derived data – how does it work?

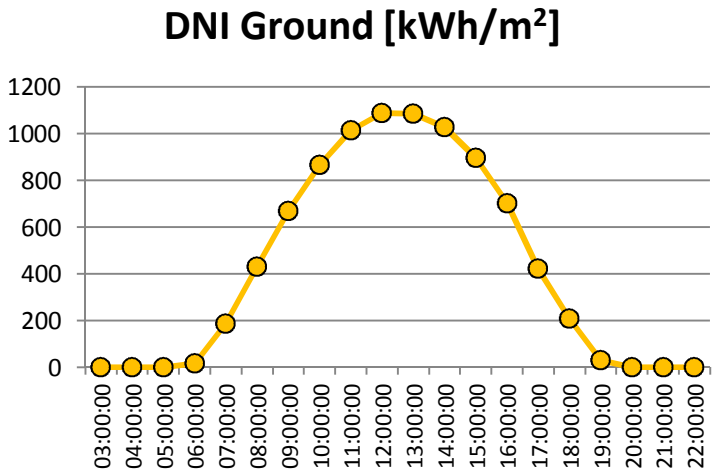
Satellite Derived Data

Date/Time	GHI Ground [kWh/m2]
2012/11/03 05:00	0
2012/11/03 06:00	0
2012/11/03 07:00	16
2012/11/03 08:00	186
2012/11/03 09:00	431
2012/11/03 10:00	669
2012/11/03 11:00	866
2012/11/03 12:00	1012
2012/11/03 13:00	1087
2012/11/03 14:00	1085
2012/11/03 15:00	1028
2012/11/03 16:00	896
2012/11/03 17:00	702
2012/11/03 18:00	421
2012/11/03 19:00	209
2012/11/03 20:00	29
2012/11/03 21:00	0
2012/11/03 22:00	0



SolarGIS

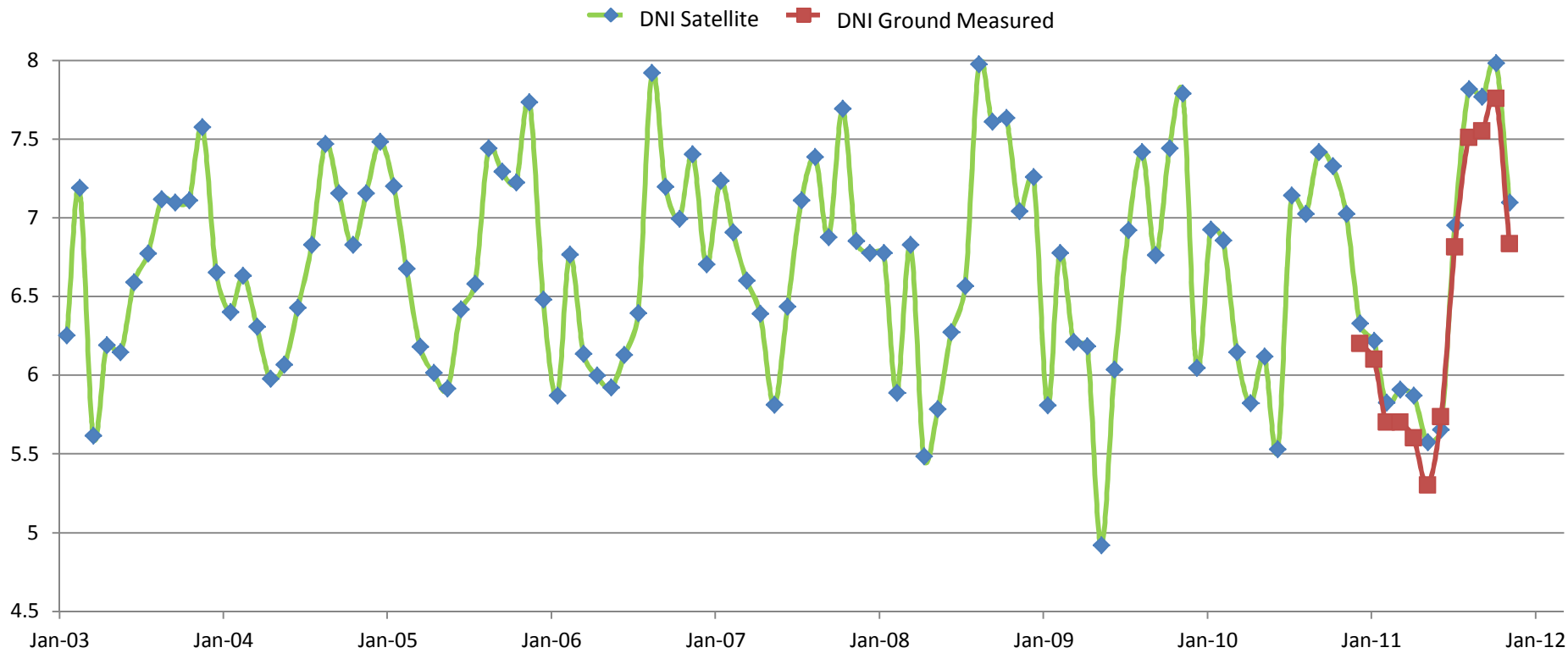
GHI – 3% to 6%
DNI – 6% to 12%
(Uncertainty of annual values)

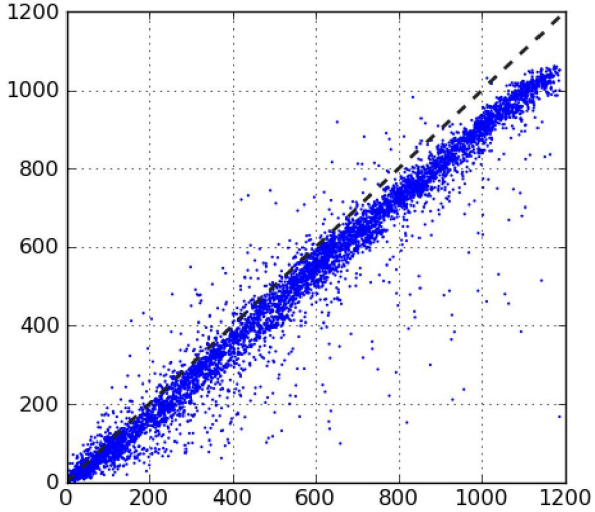


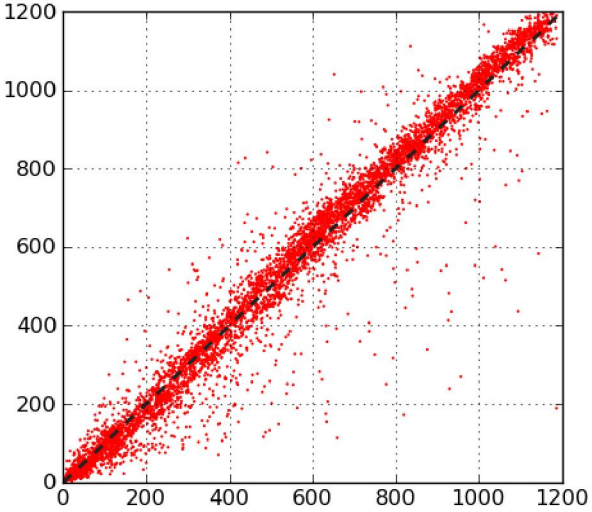
GHI – 12% to 45%
DNI – higher than GHI
(Uncertainty of hourly values)

How to bring a project to bankability from a solar resource perspective

- You install a high quality solar measurement station with the best instruments you can get and you measure for 20 years.
- During this period you maintain the station well by keeping the instruments clean and performing regular calibration.
- At the end of 20 years you will have a bankable time series.







1 year **ground** data at 1% uncertainty

+

18+ years **satellite** data at 10% uncertainty

→

18+ years time series < 5% uncertainty

(Uncertainty of annual values)

DNI measurements

Thermopile Pyrheliometer

RSR (RSP/RSI)

DNI measurements

Thermopile Pyrheliometer

Advantages

- Accurate DNI data - directly measured DNI - requires no post processing. Uncertainties: Daily sums < 1%, Hourly <2%.
- Additional DNI values (Calculated DNI from GHI and Diffuse)

Disadvantages

- High cost
- Higher maintenance

RSR (RSP/RSI)

Advantages

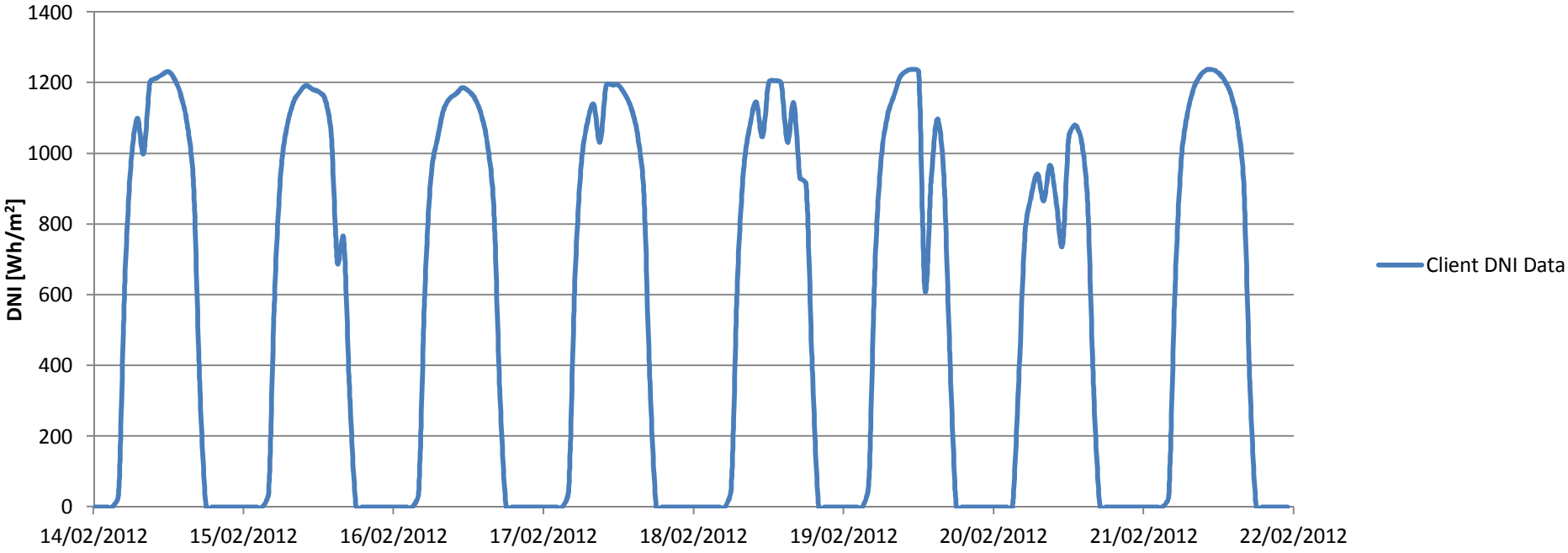
- Lower Cost
- Lower Maintenance

Disadvantages

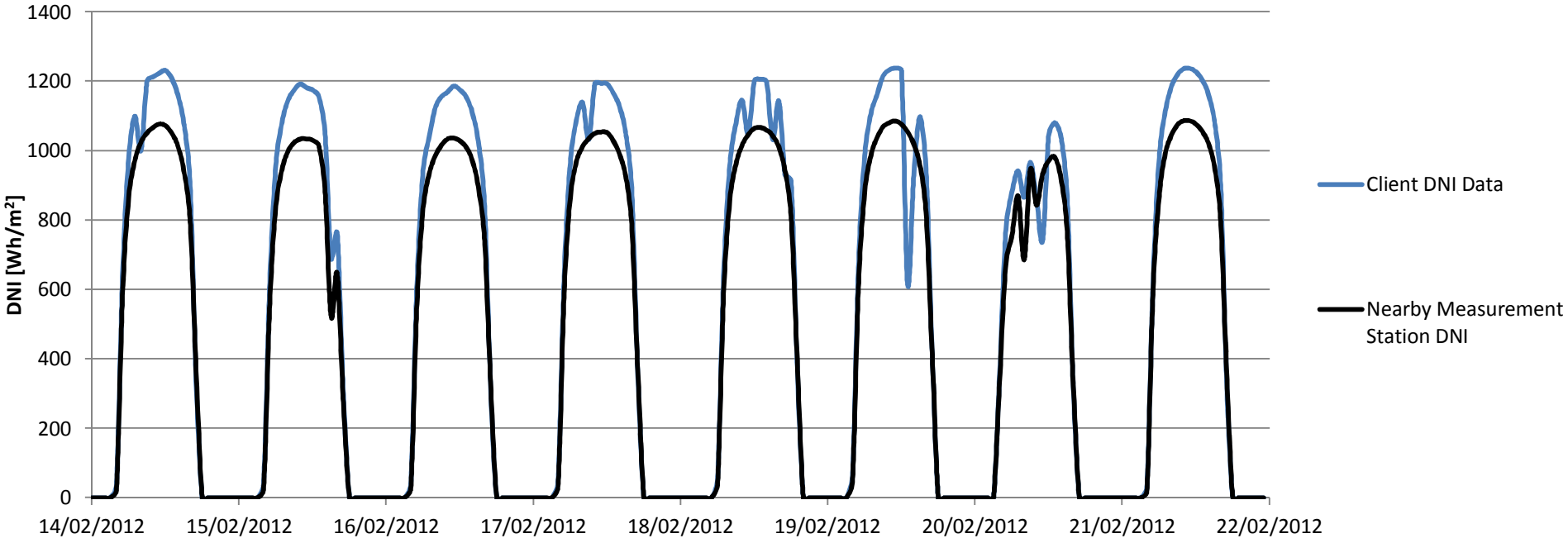
- Less Accurate DNI (DNI is calculated)
- Requires calibration – ideally in country – prior to installation
- Post-processing of data is required
- Only one set of DNI readings – no data checks are possible

What if I am uncertain about my DNI measurements?

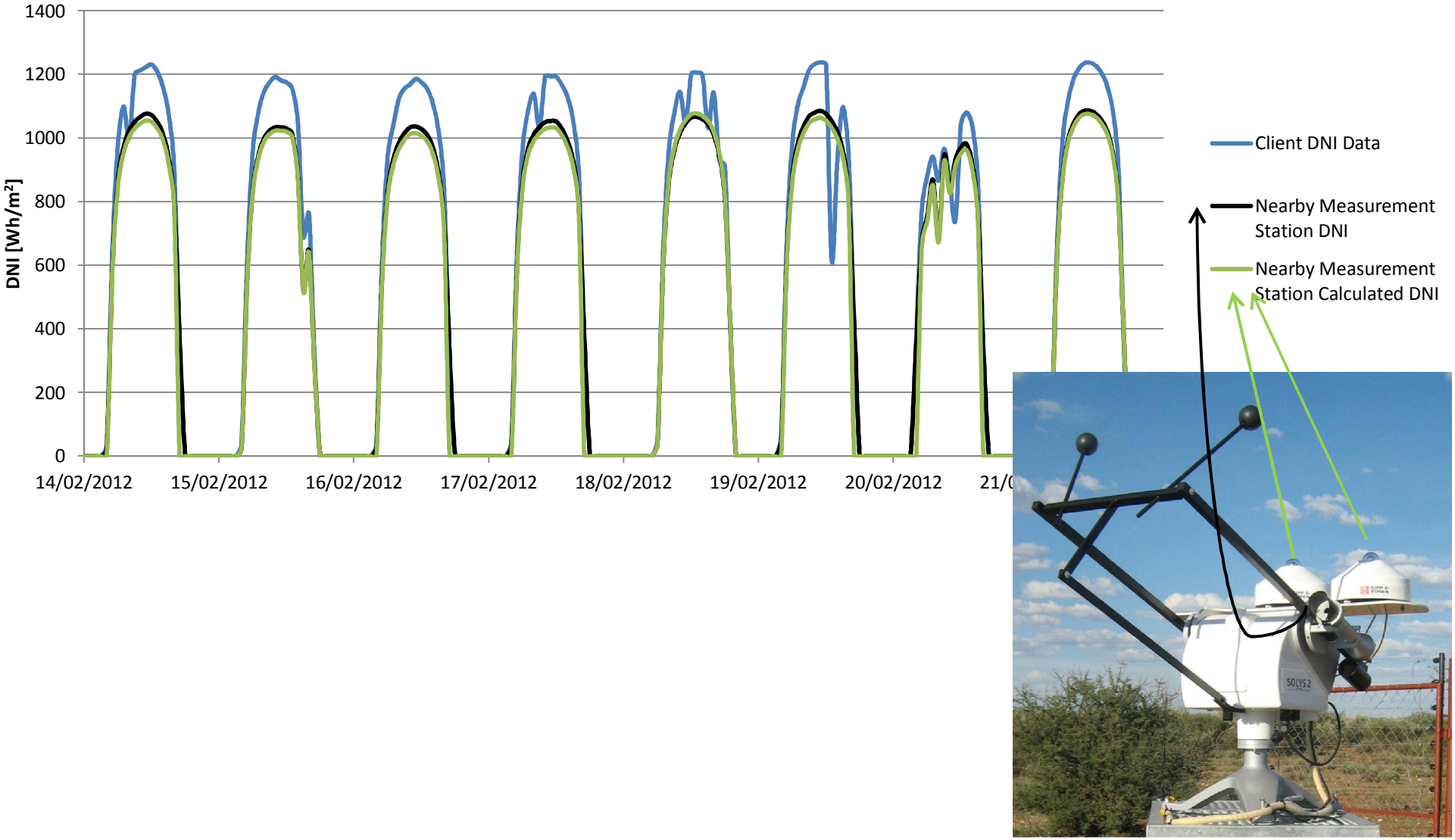
What if I am uncertain about my DNI measurements?



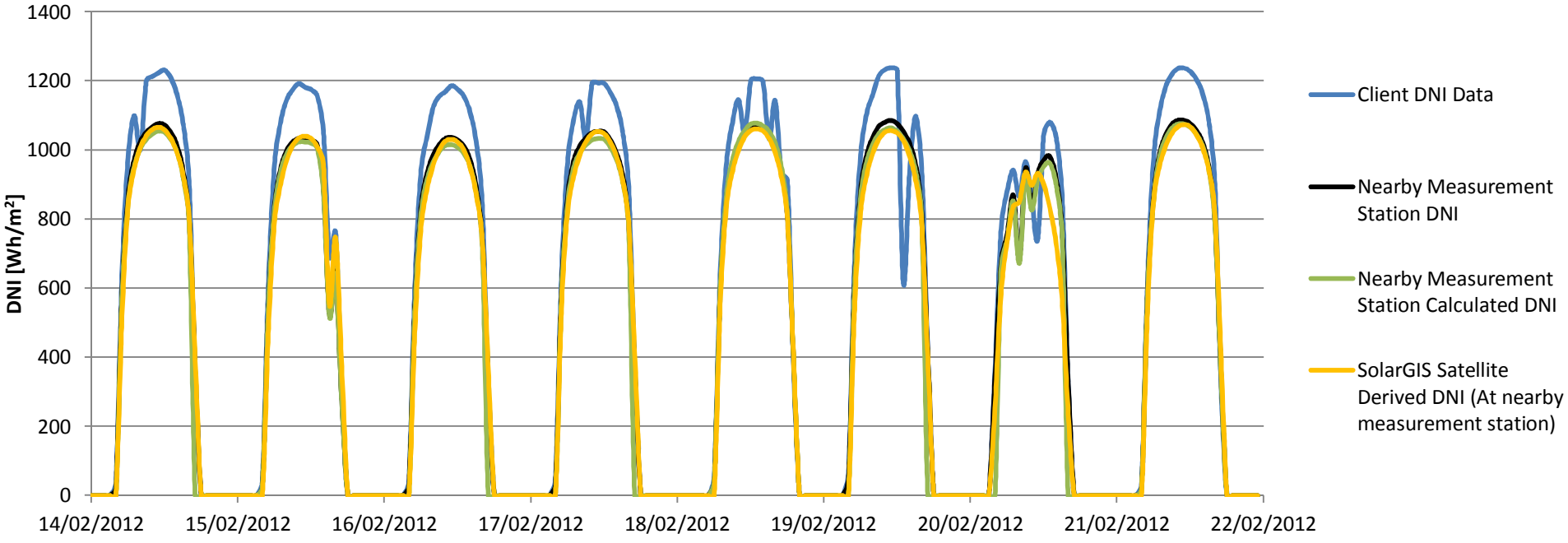
Compare it to measured DNI obtained from a station with accurate readings – local nearby



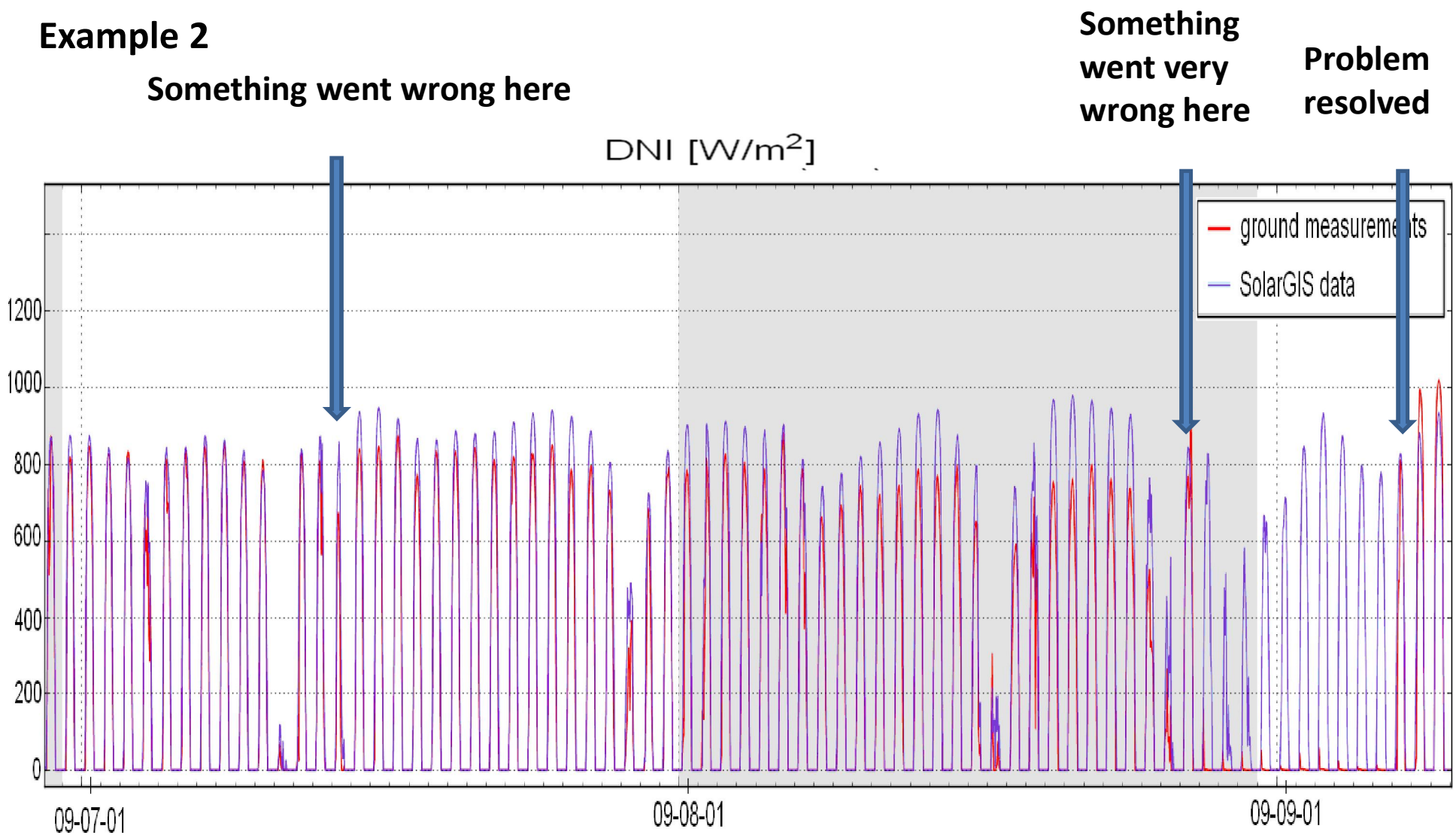
Compare it to calculated DNI obtained from the same station with accurate readings – local nearby



Compare it to satellite derived data (known to be good in that Area) as an additional check



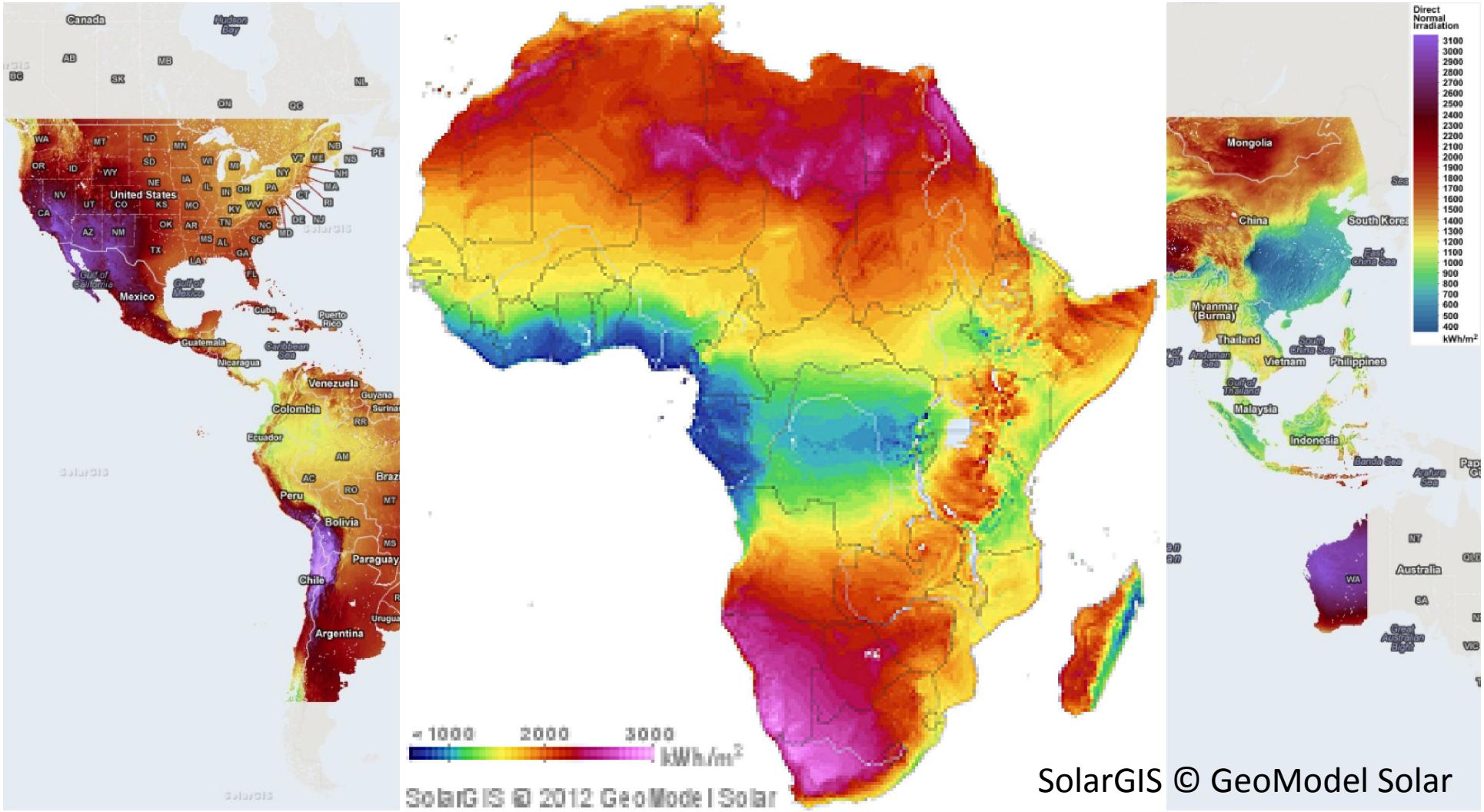
Example 2



Typical problems

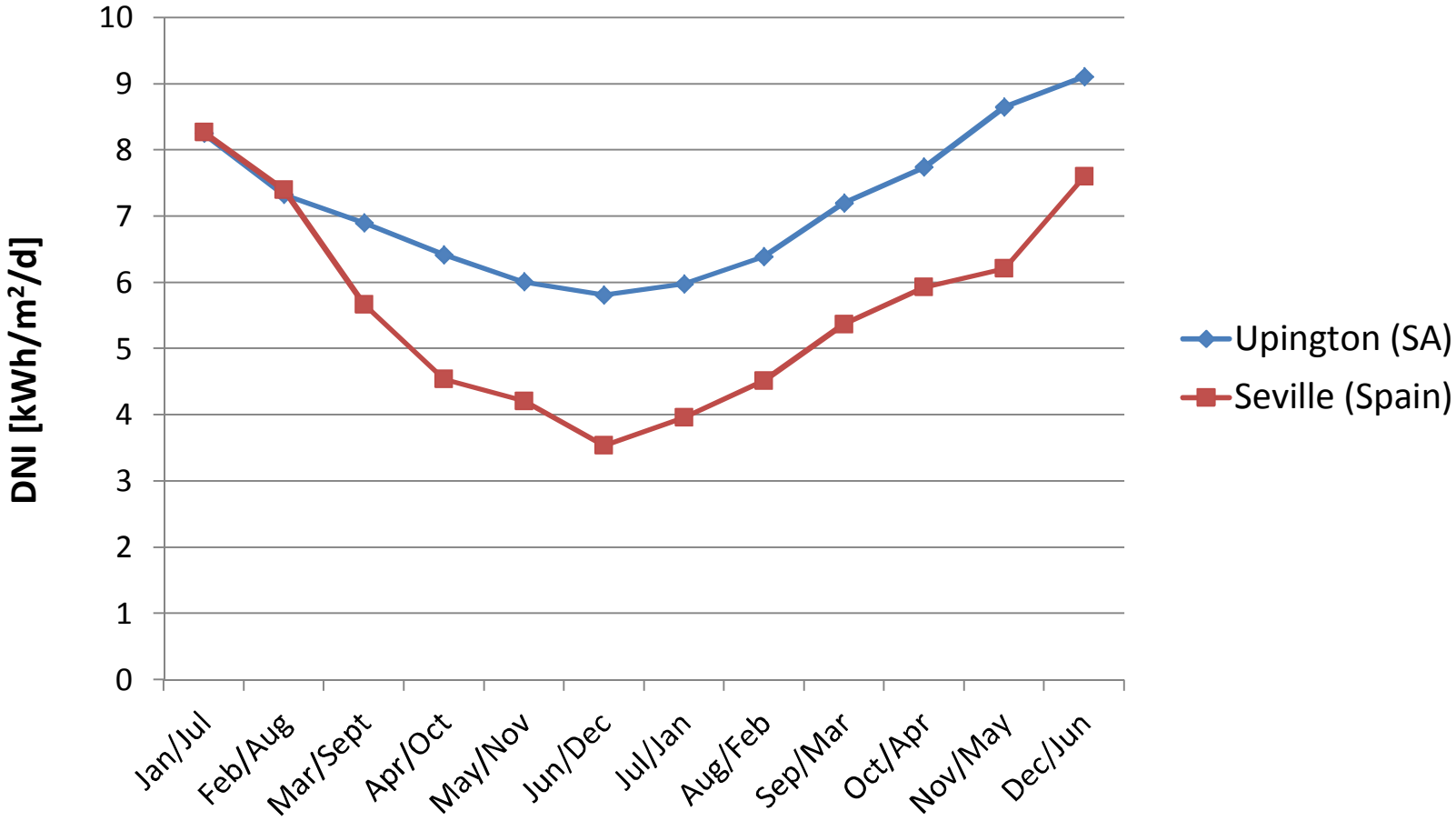
- **Tracker slight miss-alignment**
- **Tracker total miss alignment or not tracking**
- **Instruments not cleaned**

World DNI Map (SolarGIS)



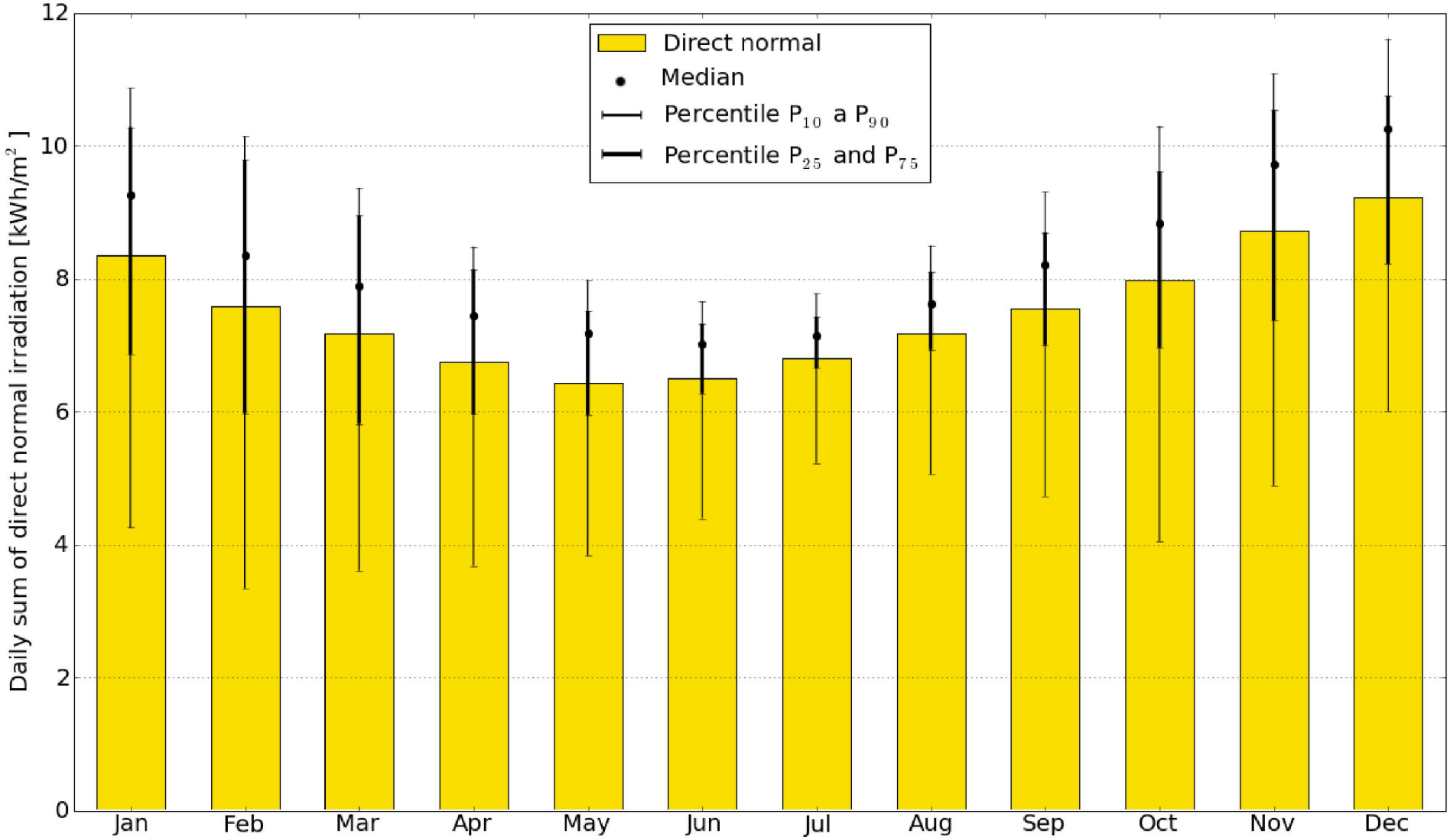
www.solargis.info/imaps

Upington vs. Seville



Seville has a Mediterranean climate = bad winters
Upington has a summer rainfall climate = great winters

Upington Solar Park: Bankable Resource Report



http://www.crses.sun.ac.za/files/research/publications/technical-reports/GeoModelSolar_SolarResRep_58-01-2011_Upington_rev2.pdf

CSP related research at Stellenbosch University

UNIVERSITEIT STELLENBOSCH UNIVERSITY

Department of Mechanical and Mechatronic Engineering
University of Stellenbosch

SOLAR THERMAL ENERGY RESEARCH GROUP

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