



# Meso-scale Mapping of Solar Resource

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<http://geomodelsolar.eu>

<http://www.crses.sun.ac.za/>

GeoModel  
SOLAR



# What is required?

PV



GHI (Global Horizontal Irradiation) or related e.g. GTI (Global Tilt Irradiation)

CSP/CPV

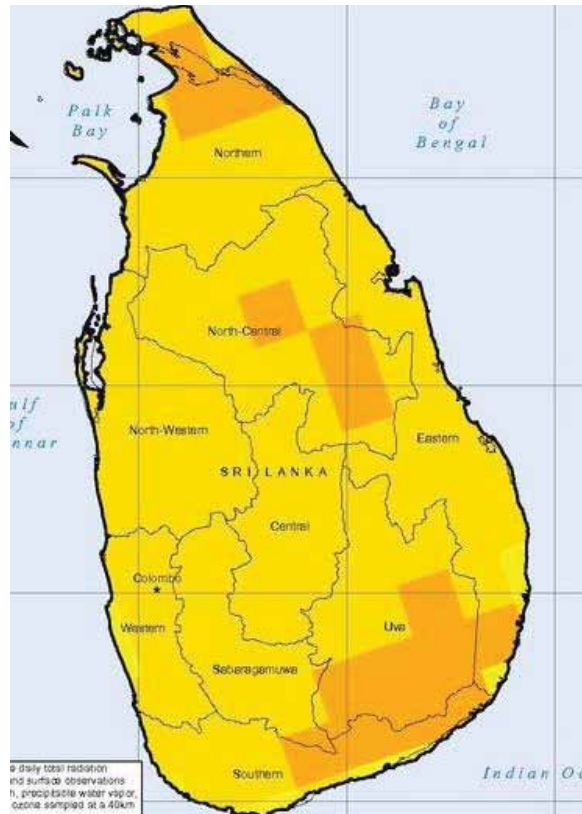


DNI (Direct Normal Irradiation)

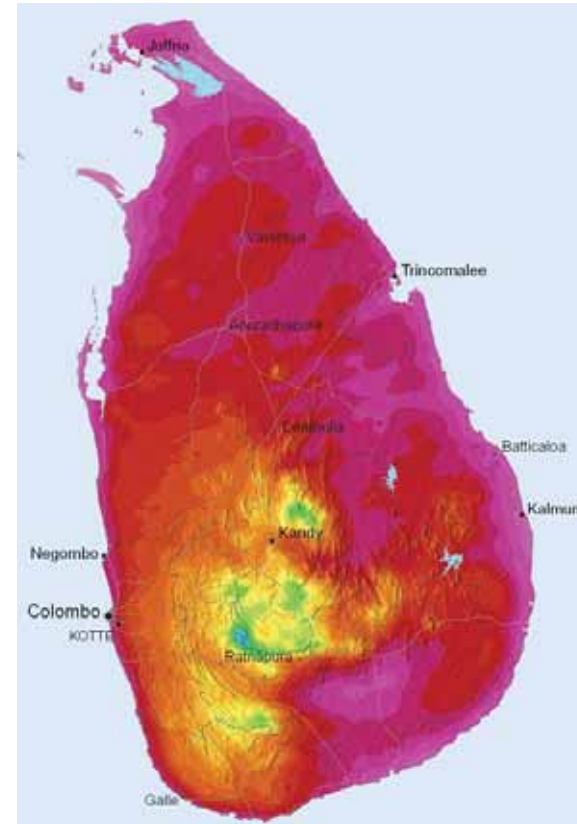
GeoModel  
SOLAR



# Traditionally Well-known Solar Resource Databases



# Modern Satellite-based Solar Resource Databases

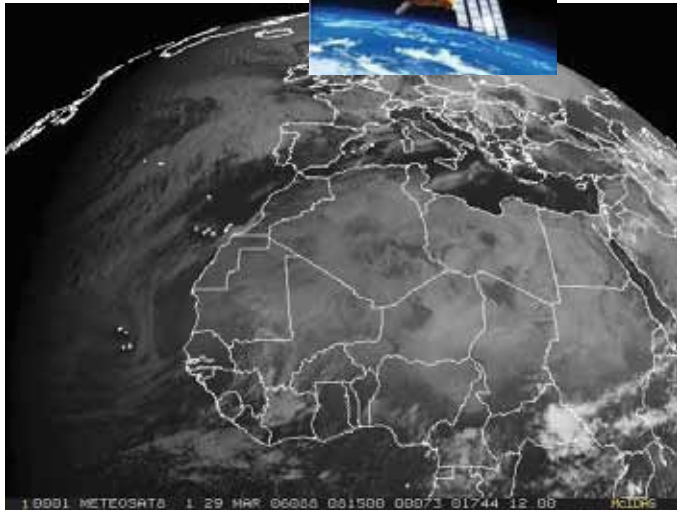


GeoModel  
SOLAR



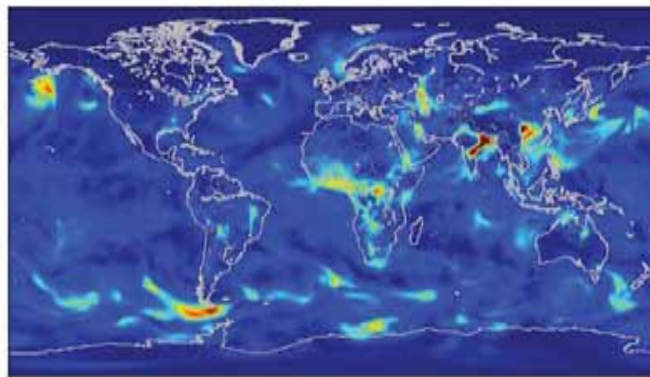
# Modern Solar database – inputs (real-time)

Satellite data



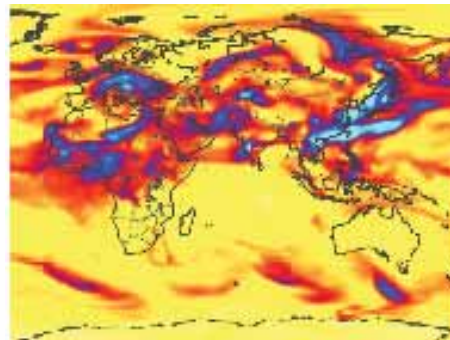
Temporal resolution: 15 or 30 min  
Spatial resolution: 3 km

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



Daily AOD

Water vapour  
35 km (6 hours)



High-resolution terrain  
90 meters



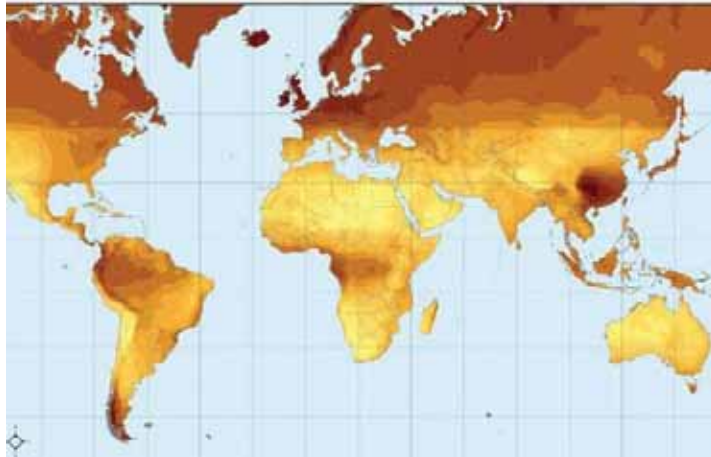
GeoModel  
SOLAR



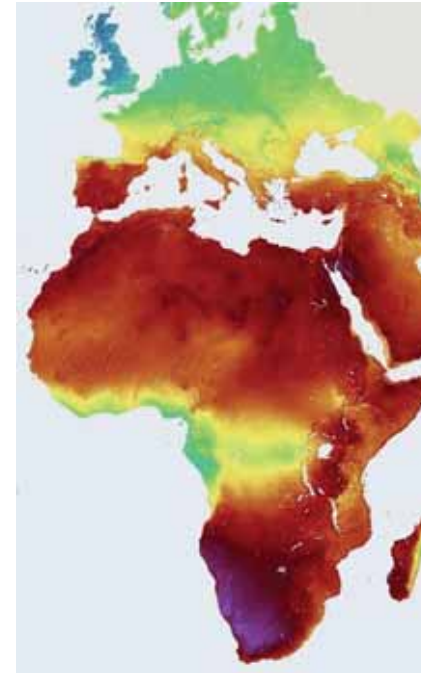
# Uncertainty? Which Data is Bankable?



1% - 4%



GHI – 5% to 12%  
DNI – 10% to 50%



GHI – 3% to 6%  
DNI – 6% to 12%

(Uncertainty of annual values)

# Satellite vs. ground measurements??



OR



# Satellite vs. ground measurements??



AND

~~OR~~



1 year  
**ground**  
data at 2%  
uncertainty



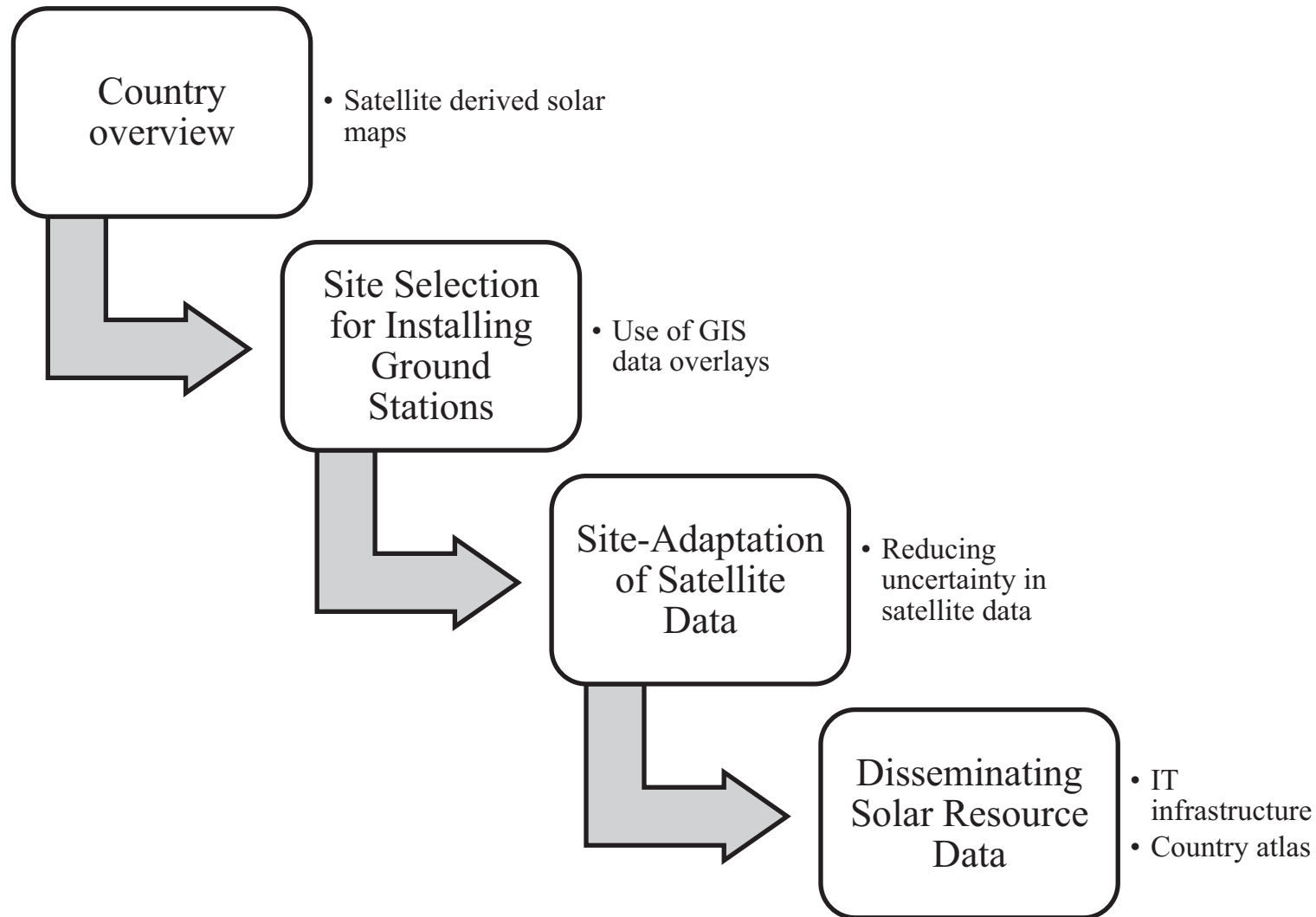
10+ years  
**satellite**  
data at 5%  
uncertainty



10+ years  
time series  
at 2.5%  
uncertainty

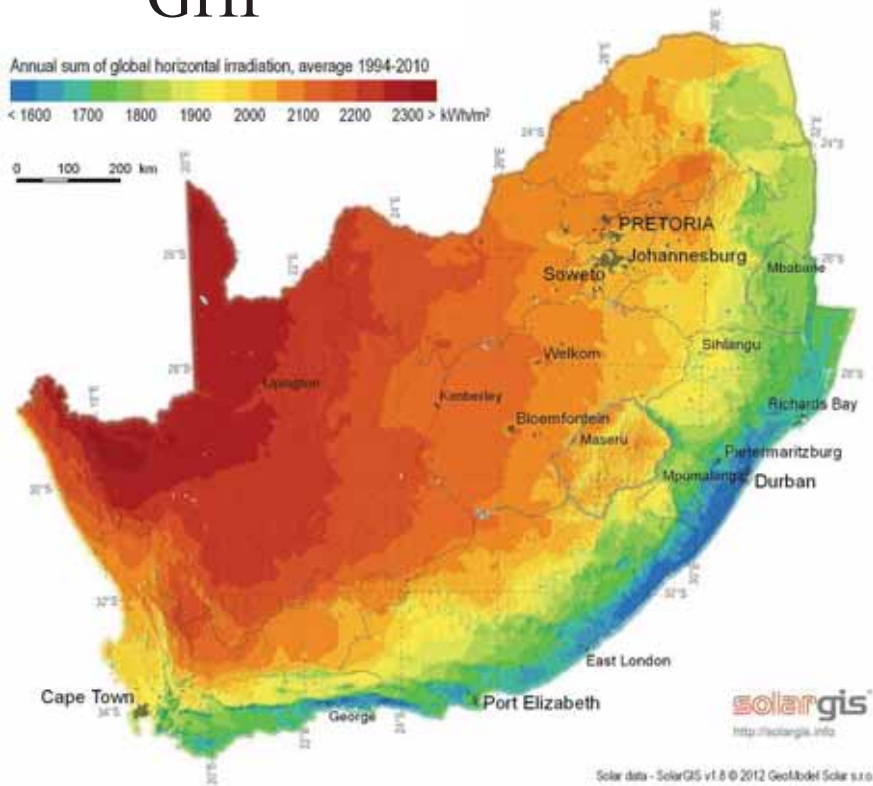


# Meso-scale Solar Resource Mapping in 4 Steps

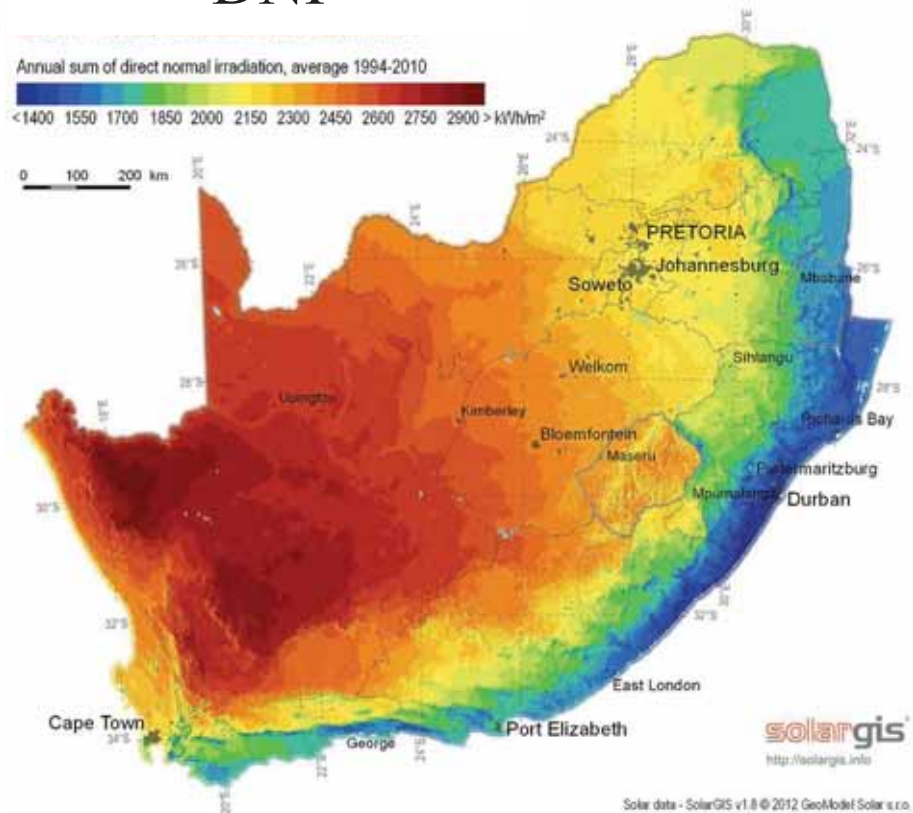


# Step 1: Country overview

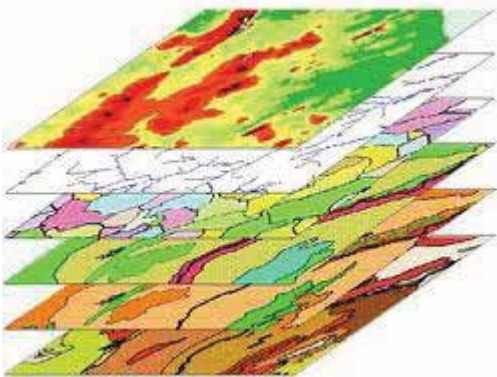
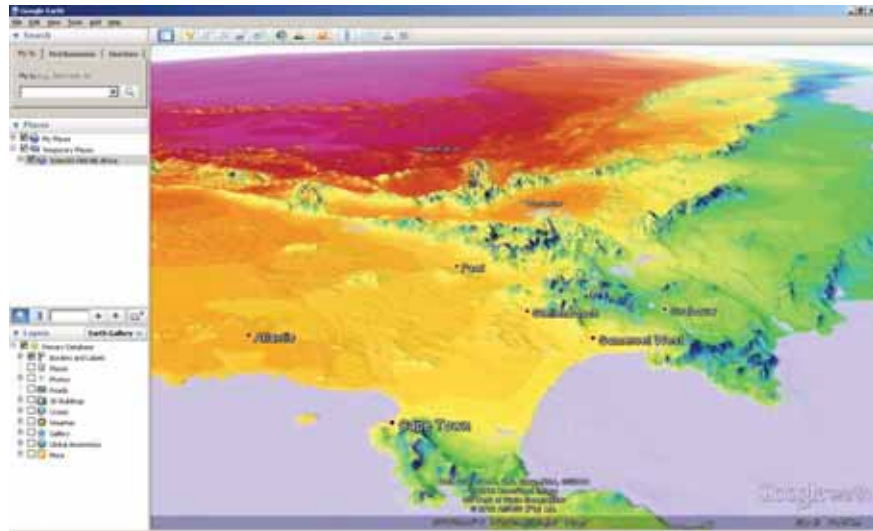
## GHI



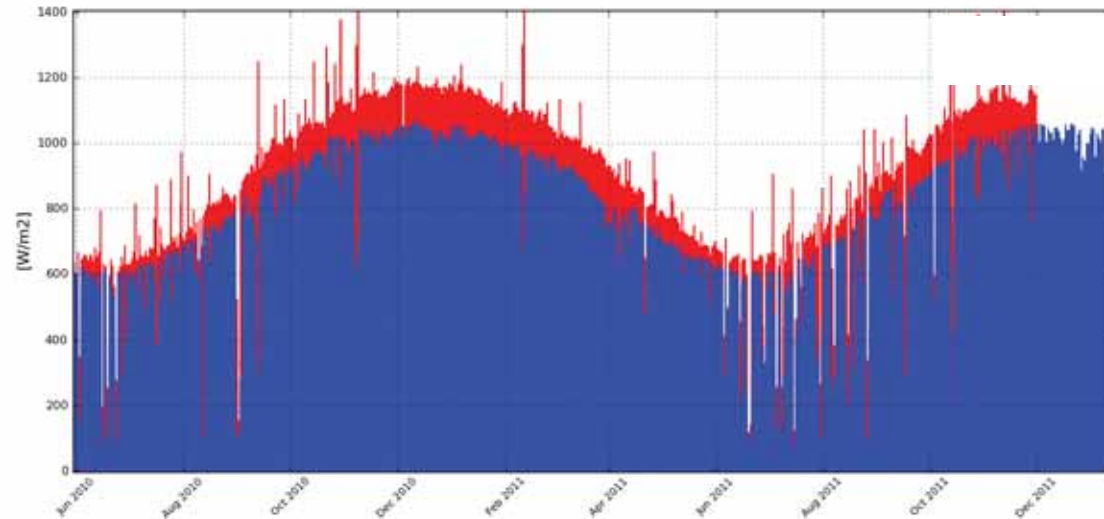
## DNI



# Step 2: Site Selection for Installing Ground Meteo Stations

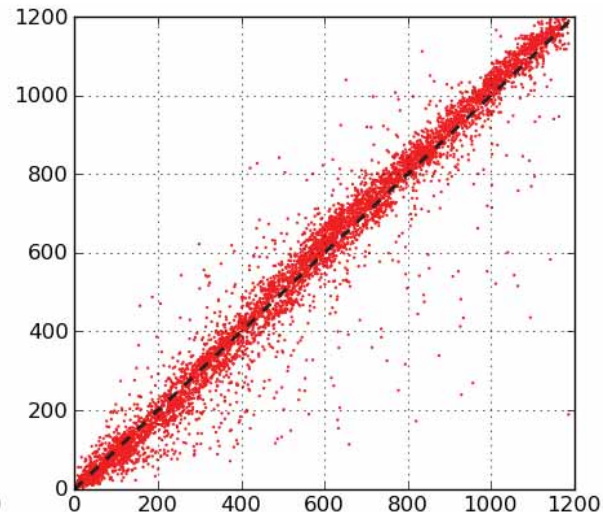
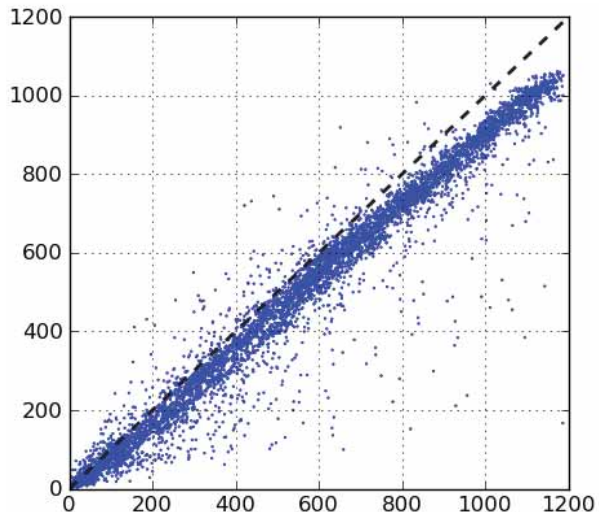


# Step 3: Site-Adaptation of Satellite Data

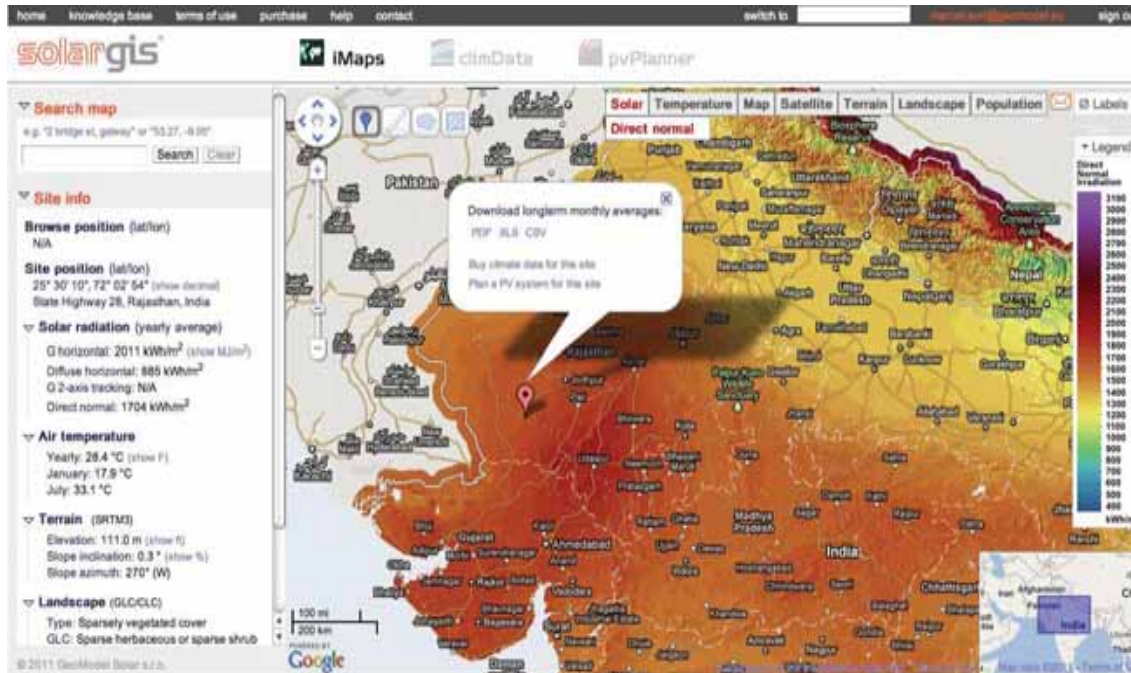


...before data correlation

...after data correlation



# Step 4: Disseminating Investor-Grade Solar Resource Data



**LONG-TERM MONTHLY AVERAGES OF SOLAR RADIATION AND AIR TEMPERATURE**

Report number: 09876-0-1234-22  
Date: 12 August 2011 02:08:03 (GMT+5:30)

**Site info**  
Site name: **Karnar, Rajasthan**  
Name: Rajghat, India

**Coordinates**  
Location UTM: 111 m  
Slope inclination: 0°  
Slope azimuth: 270° west

Location on the map: [http://www.solarGIS.com/31\\_500794948/72-0407084/6x-Geogm\\_Satellite.html](http://www.solarGIS.com/31_500794948/72-0407084/6x-Geogm_Satellite.html)

**Geographic position**

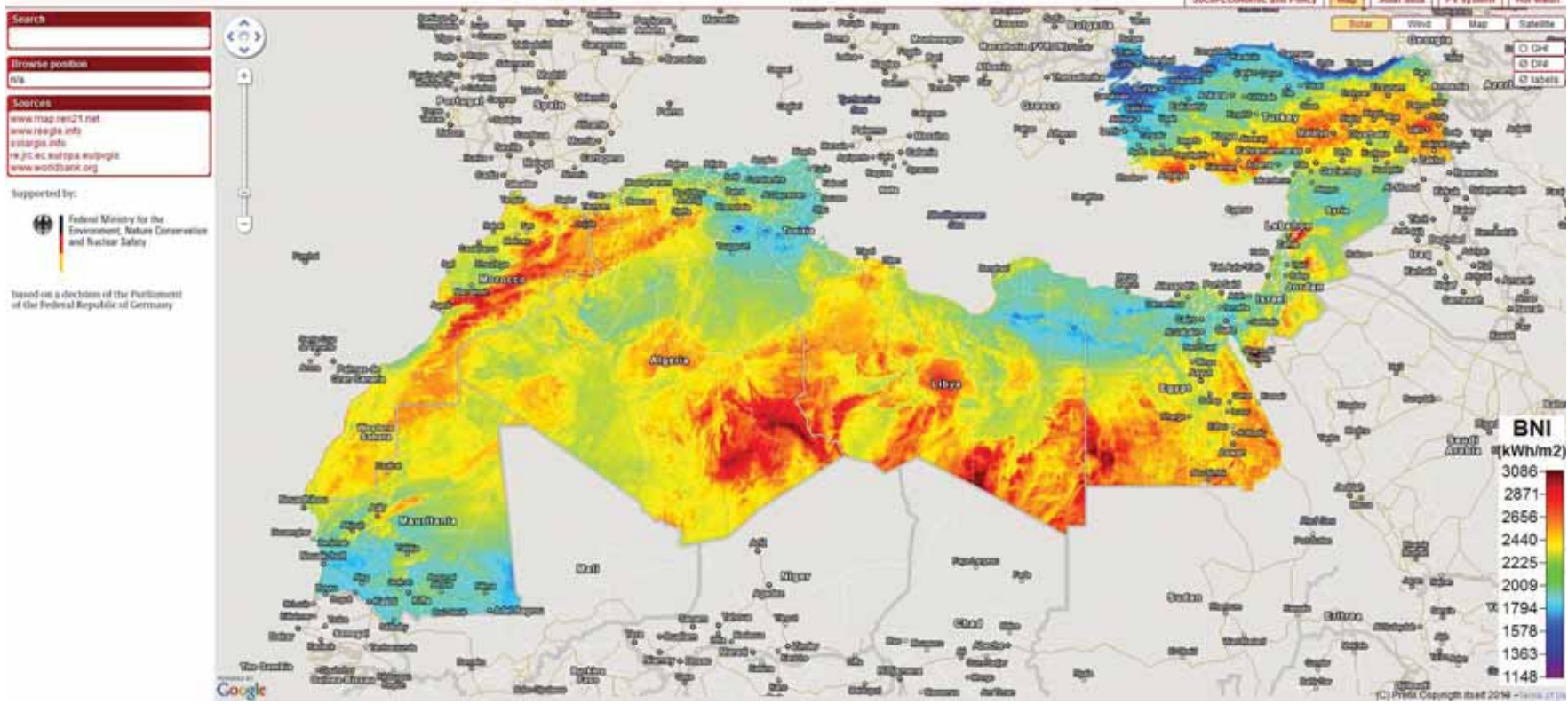
Google Maps © 2010 Google

**Climate data**

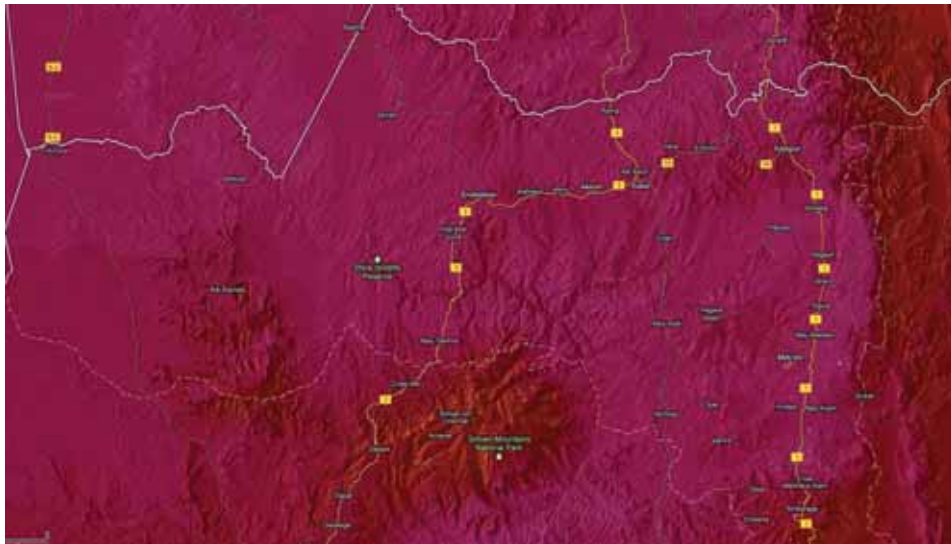
Month	G <sub>h</sub>	G <sub>d</sub>	D <sub>h</sub>	D <sub>d</sub>	D <sub>n</sub>	G <sub>t</sub>	T <sub>a</sub>
Jan	5.26	1.36	1.86	35	5.07	161	12.9
Feb	5.29	1.46	1.95	52	5.29	182	13.8
Mar	6.34	1.67	2.22	69	6.34	187	16.5
Apr	7.12	2.04	2.71	81	6.89	179	18.9
May	7.20	2.09	3.22	102	5.52	159	26.7
Jun	6.93	1.92	3.71	89	3.78	103	34.1
Jul	6.90	1.82	3.28	102	1.30	88	32.8
Aug	6.76	1.68	2.88	83	1.18	88	31.2
Sep	6.79	1.76	2.69	77	1.41	100	30.9
Oct	6.88	1.75	2.36	62	1.89	121	28.2
Nov	6.46	1.34	1.90	54	4.92	149	23.8
Dec	6.10	1.27	1.53	41	5.36	157	19.4
<b>Year</b>	<b>6.15</b>	<b>20.12</b>	<b>2.42</b>	<b>888</b>	<b>4.07</b>	<b>1704</b>	<b>26.4</b>

**Long term averages:**  
 G<sub>h</sub>: Daily sum of global horizontal irradiation (kWh/m<sup>2</sup>)  
 G<sub>d</sub>: Monthly sum (annual) of global horizontal irradiation (kWh/m<sup>2</sup>)  
 D<sub>h</sub>: Daily sum of diffuse horizontal irradiation (kWh/m<sup>2</sup>)  
 D<sub>d</sub>: Monthly sum (annual) of diffuse horizontal irradiation (kWh/m<sup>2</sup>)  
 D<sub>n</sub>: Daily sum of direct normal irradiation (kWh/m<sup>2</sup>)  
 D<sub>n</sub>: Monthly sum (annual) of direct normal irradiation (kWh/m<sup>2</sup>)  
 T<sub>a</sub>: Daily (annual) air temperature (°C)

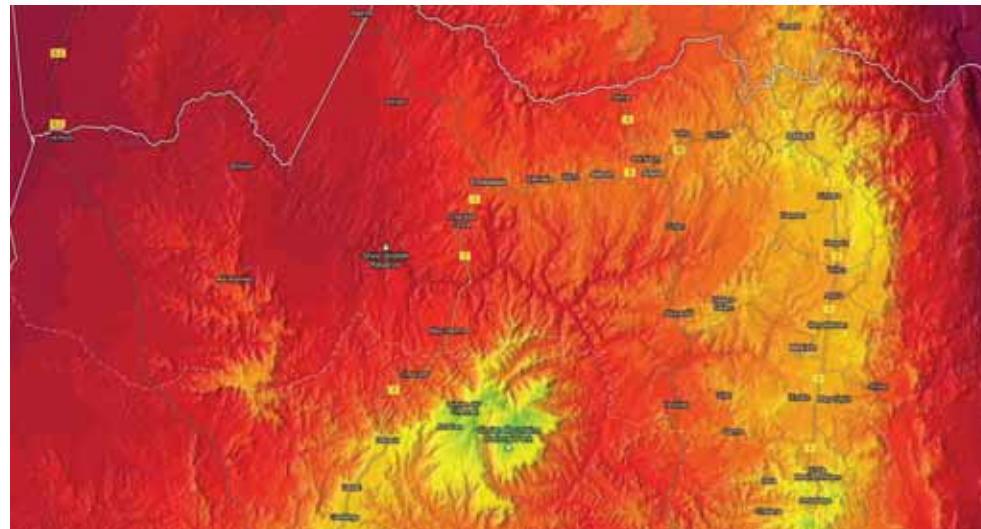
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# GHI and DNI is only part of the information required

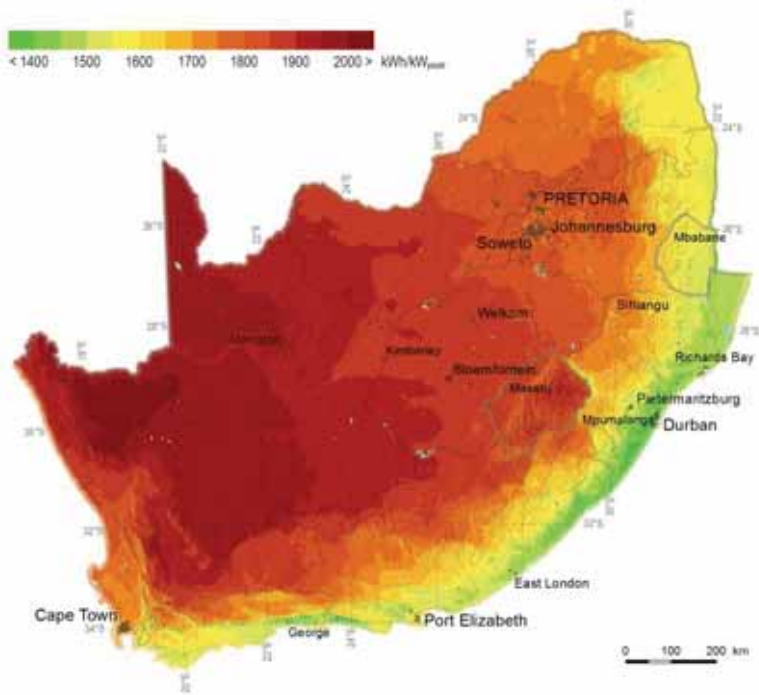


GHI

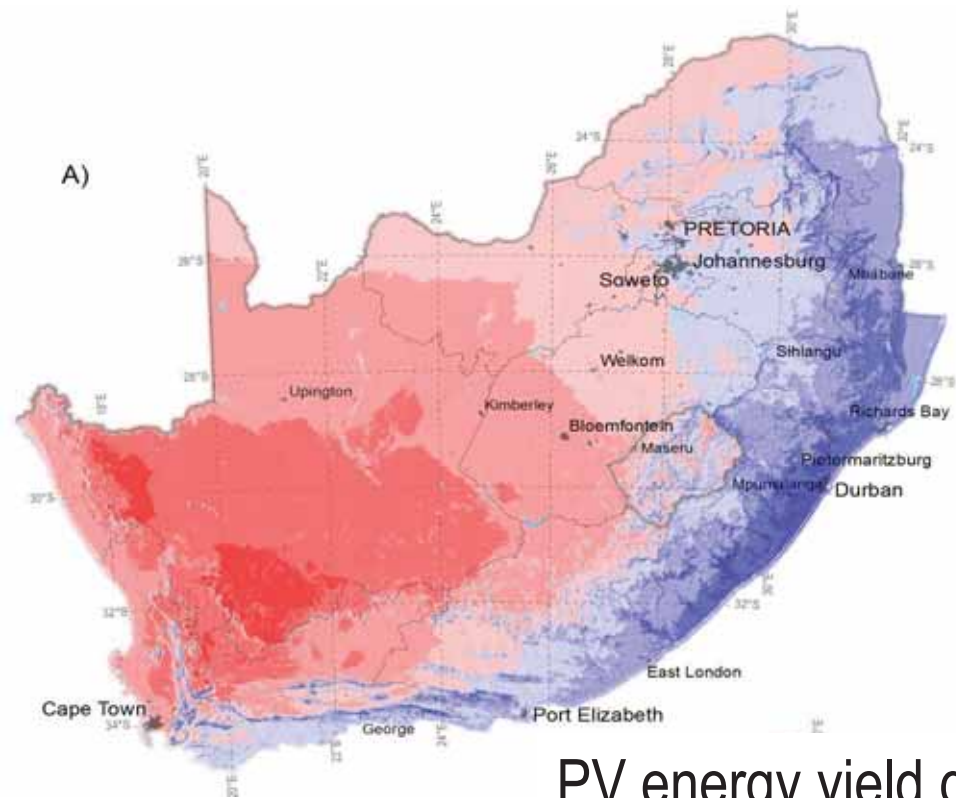


TEMP

# PV yield output, GTI for tracker systems, etc.



PV for fixed panels



PV energy yield gain from 1-axis tracker

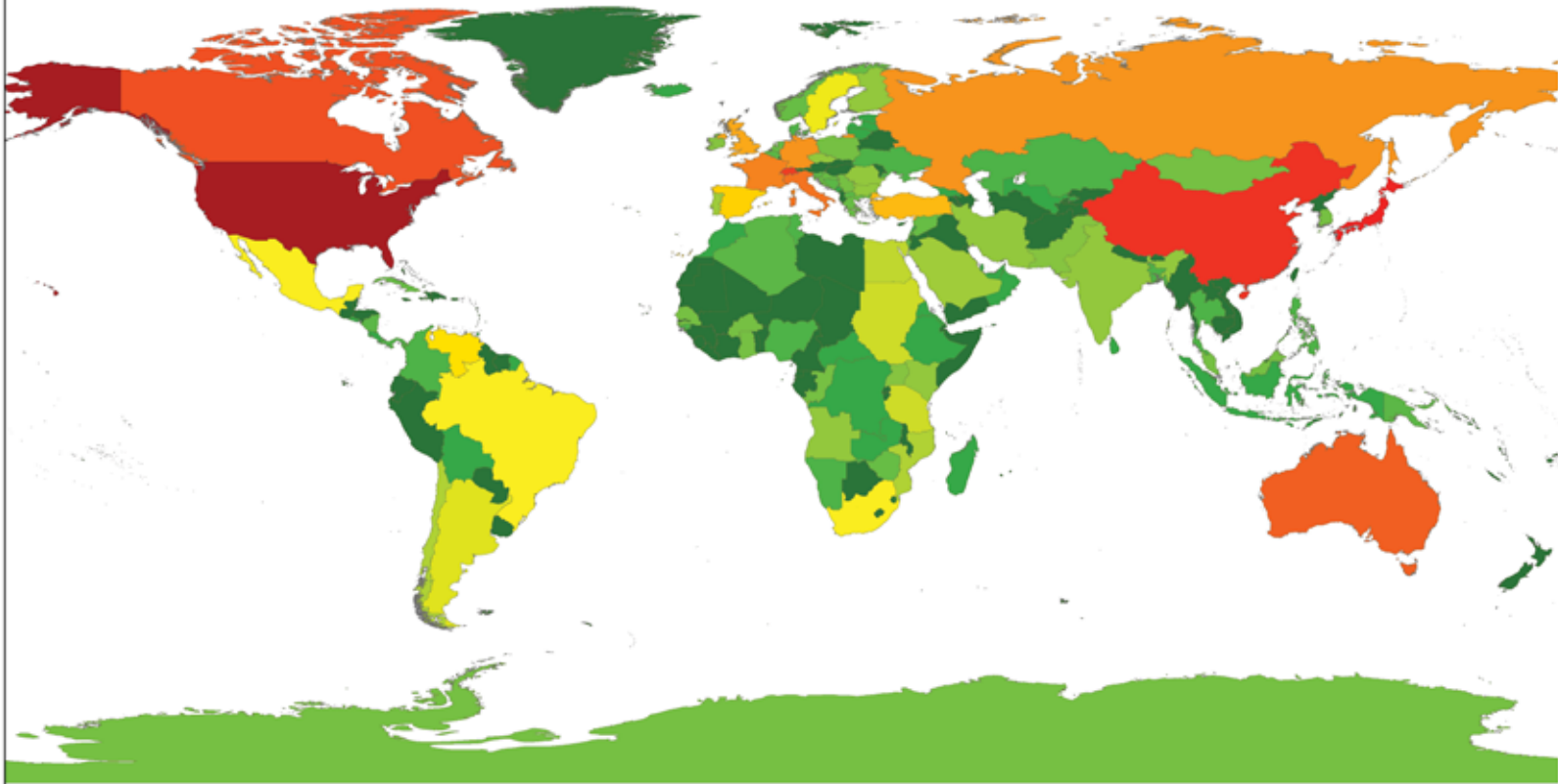


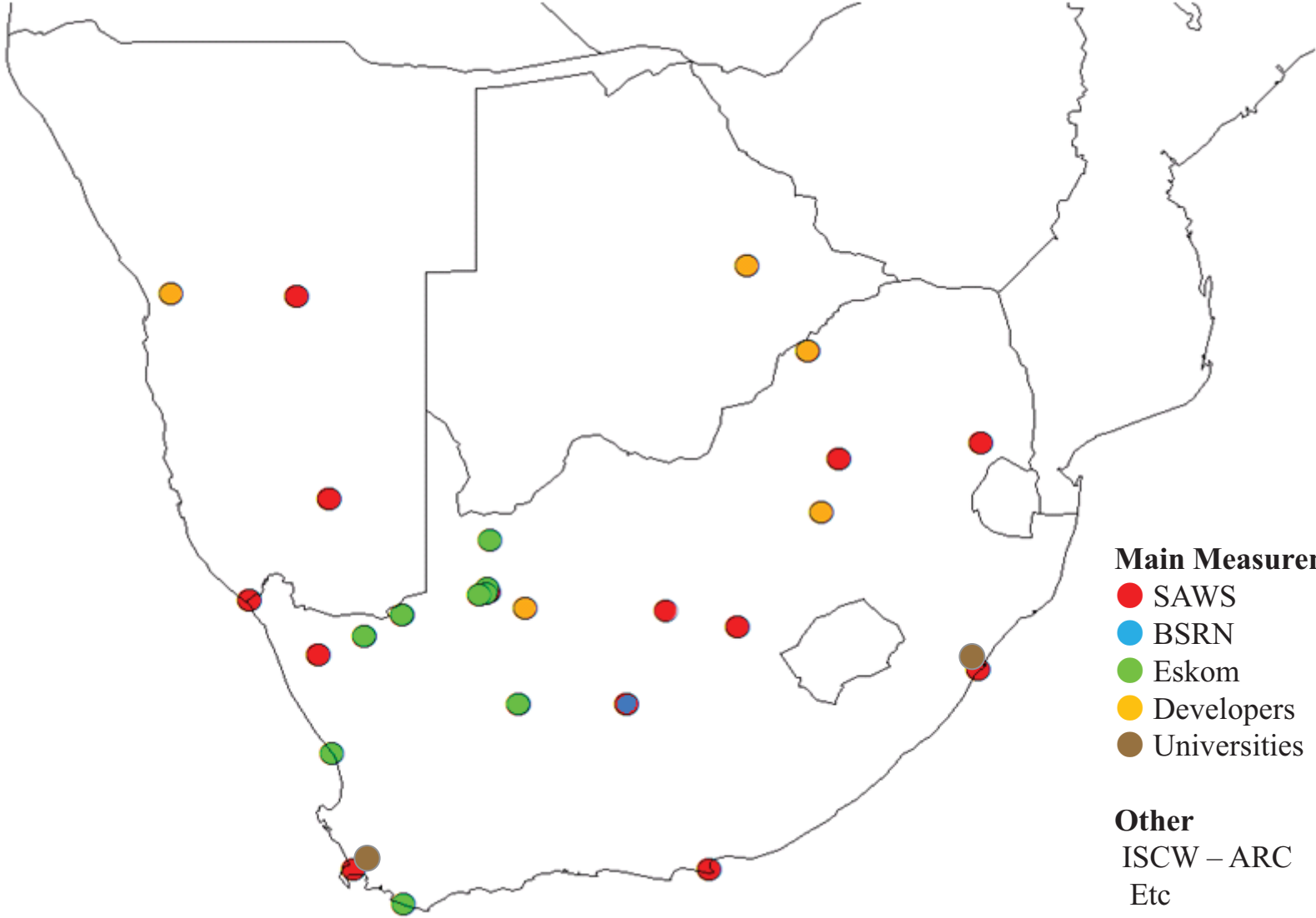
Satellite data/maps are really only good if they have been validated with high quality ground measurements

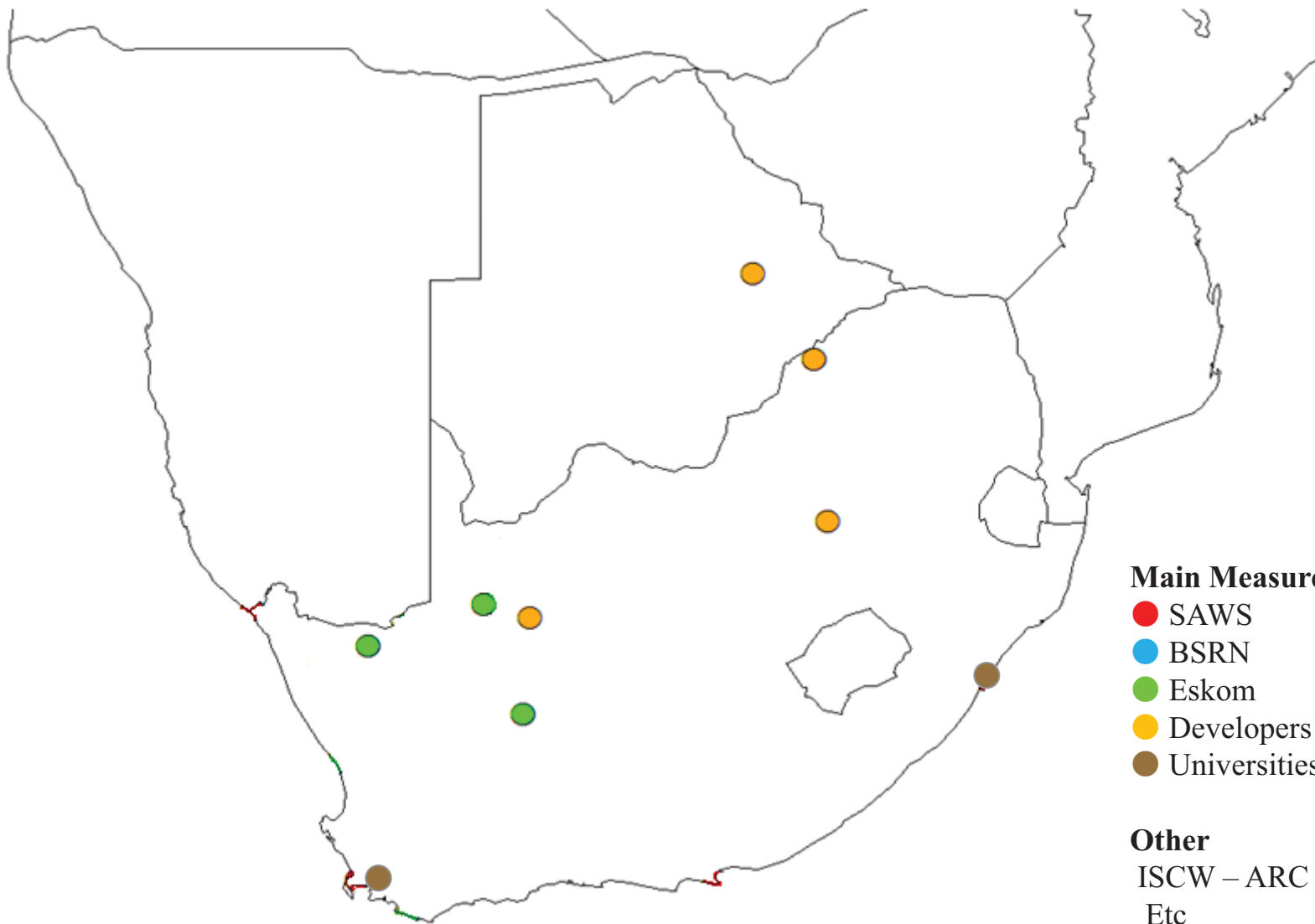


Solar Measurement Stations

Source: Meteornorm







**Main Measurements**

- SAWS
- BSRN
- Eskom
- Developers
- Universities

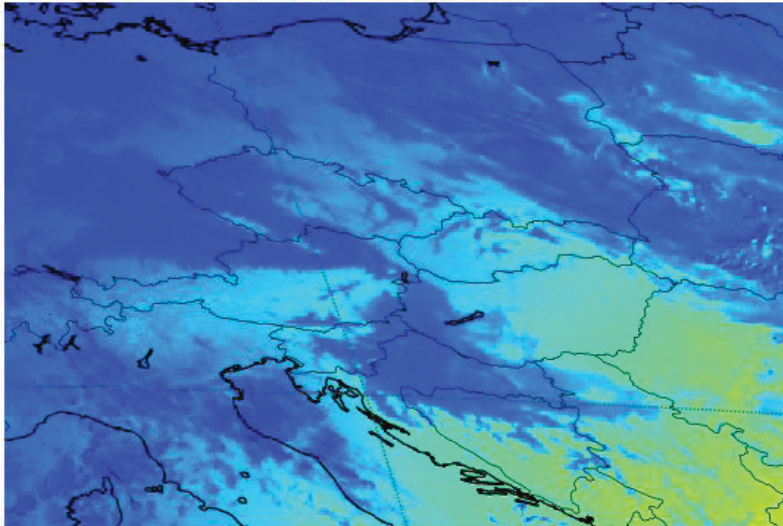
**Other**

ISCW – ARC  
Etc



# Next steps...

2011-11-01 06:45:00



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Solar Resource Forecasting



Grid Management

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Thank You

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