

Accuracy-Enhanced Solar Resource Maps of South Africa, Lesotho, Swaziland

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11-13 May 2015

GeoModel
S O L A R

UNIVERSITEIT
STELLENBOSCH
UNIVERSITY



GeoSUN
AFRICA

GeoModel Solar

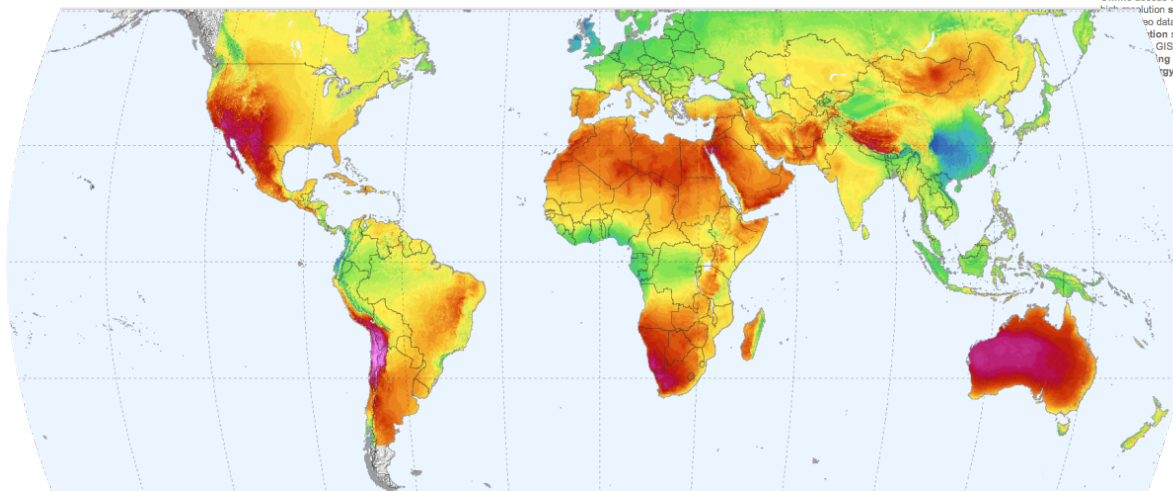
Development and operation of SolarGIS online system

Global solar resource and meteo database and maps

Software and data services for solar energy

Solar radiation SolarGIS database

- global database from 5 geostationary satellites,
- 15(30) minute time resolution
- 3 km (250m enhanced) spatial resolution
- up to 21 years into history, daily update



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solargis®

Online access to:
High resolution solar data,
no data,
Simulation software,
GIS database,
Engineering services
Technology.

iMaps
easy access to solar
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solarMaps
Maps for Google Earth
GIS data & digital maps
Poster maps
Free maps

dataServices
Real-time data delivery
Web-services

Model Solar s.r.o.

RELEASE NOTES
• 21 Aug Live database for pvSpot
extended to Namibia and south Botswana
• 16 Aug New tools for managing
your own account
• 3 Aug DNI, TEMP: More data and maps
freely accessible

NEWS
• 28 Jun Attend practical workshop
on validating and predicting
solar energy project viability
• 24 May SolarGIS awarded at SNEC
conference & exhibition in Shanghai

KEY MESSAGES
• SolarGIS lecture to download
• Our knowledge cited among top

SolarGIS
Best performing solar database
according to the international comparison

More News » Newsletter »

Meet us in Beijing (CHN), Marrakech (MOR), Graz (AUT), Abu Dhabi (UAE), Frankfurt (GER), Mumbai (IND) »
SolarGIS awarded at SNEC conference & exhibition in Shanghai »

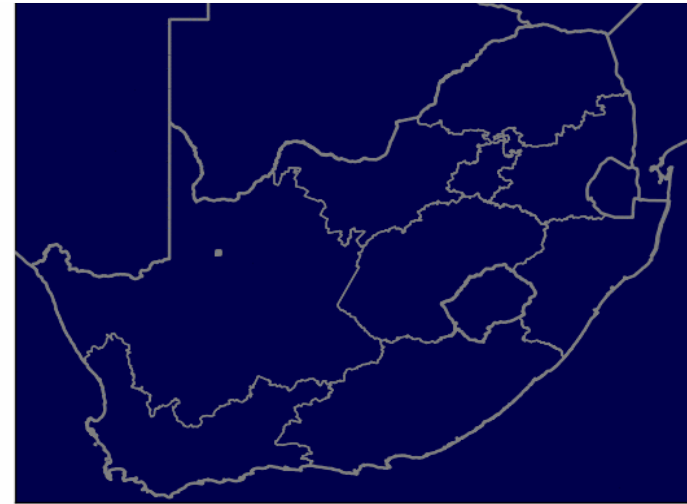
in Twitter YouTube

Project aim: improved data accuracy for South Africa

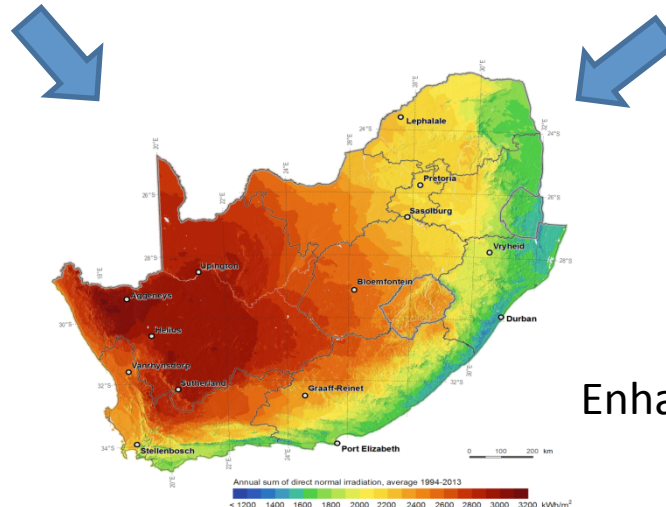


High quality ground measurements
+ Project management

Stellenbosch Uni. CRSES and GeoSun Africa



Satellite based solar radiation modelling
GeoModel Solar



Enhanced solar radiation database

Ground measurements vs. Satellite based models

Ground (on-site) measurements

ADVANTAGES

High frequency measurements (sec. to min.)

Higher accuracy, if properly managed

LIMITATIONS

Limited geographical representation

Limited time availability

Costs for acquisition and operation

Regular maintenance and calibration

Data quality control

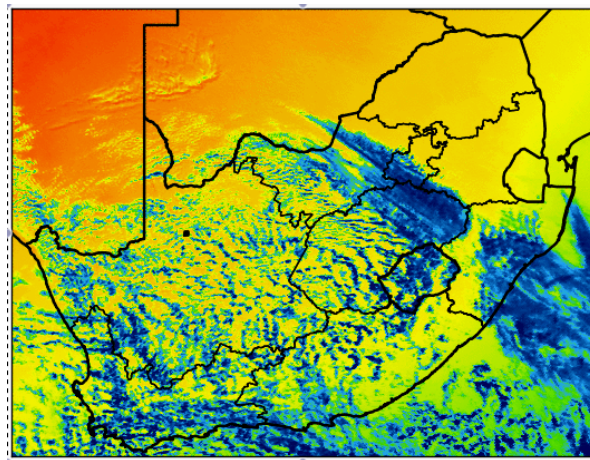


Source: GeoSUN Africa

Satellite-based models

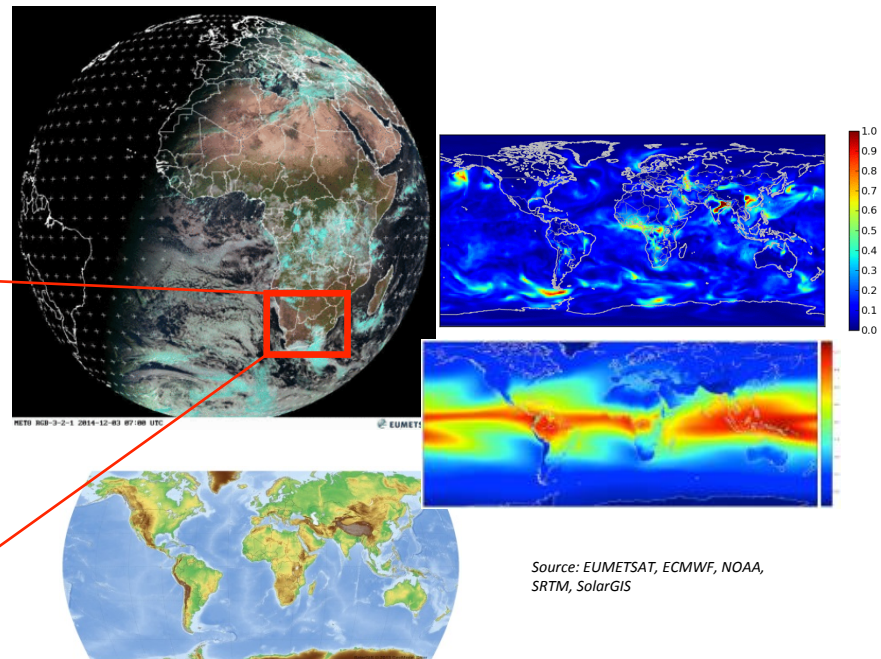
ADVANTAGES

- Continuous geographical coverage
- Spatial resolution approx. 3 km (250 m enhanc.)
- Frequency of measurements 15 and 30 minutes
- Spatial and temporal consistency
- Calibration stability
- High availability (minimum gaps)
- Up to 21+ years history – variability of weather



LIMITATIONS

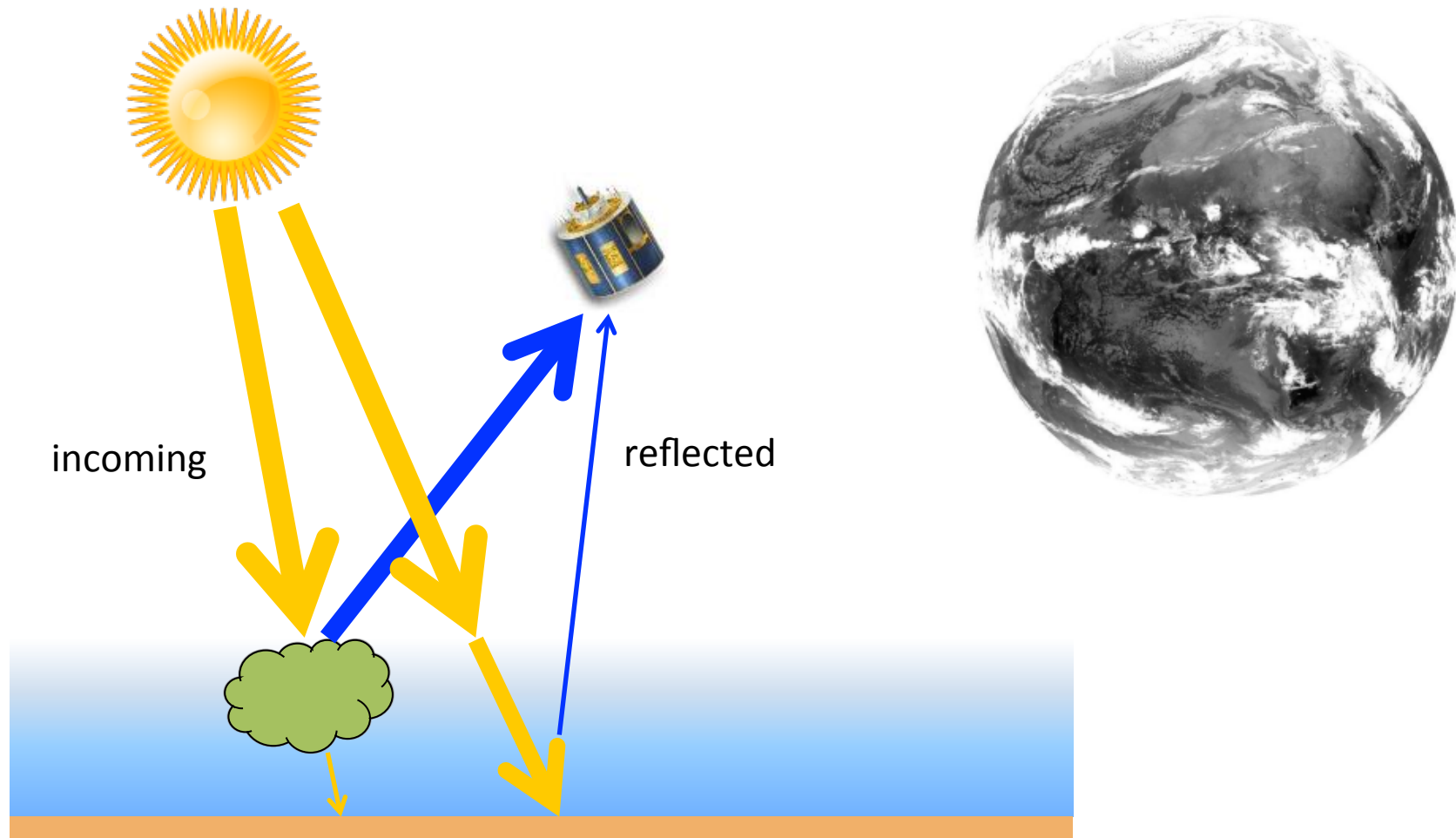
- Lower accuracy for the point estimate
(compared to high quality measurements)



Source: EUMETSAT, ECMWF, NOAA, SRTM, SolarGIS

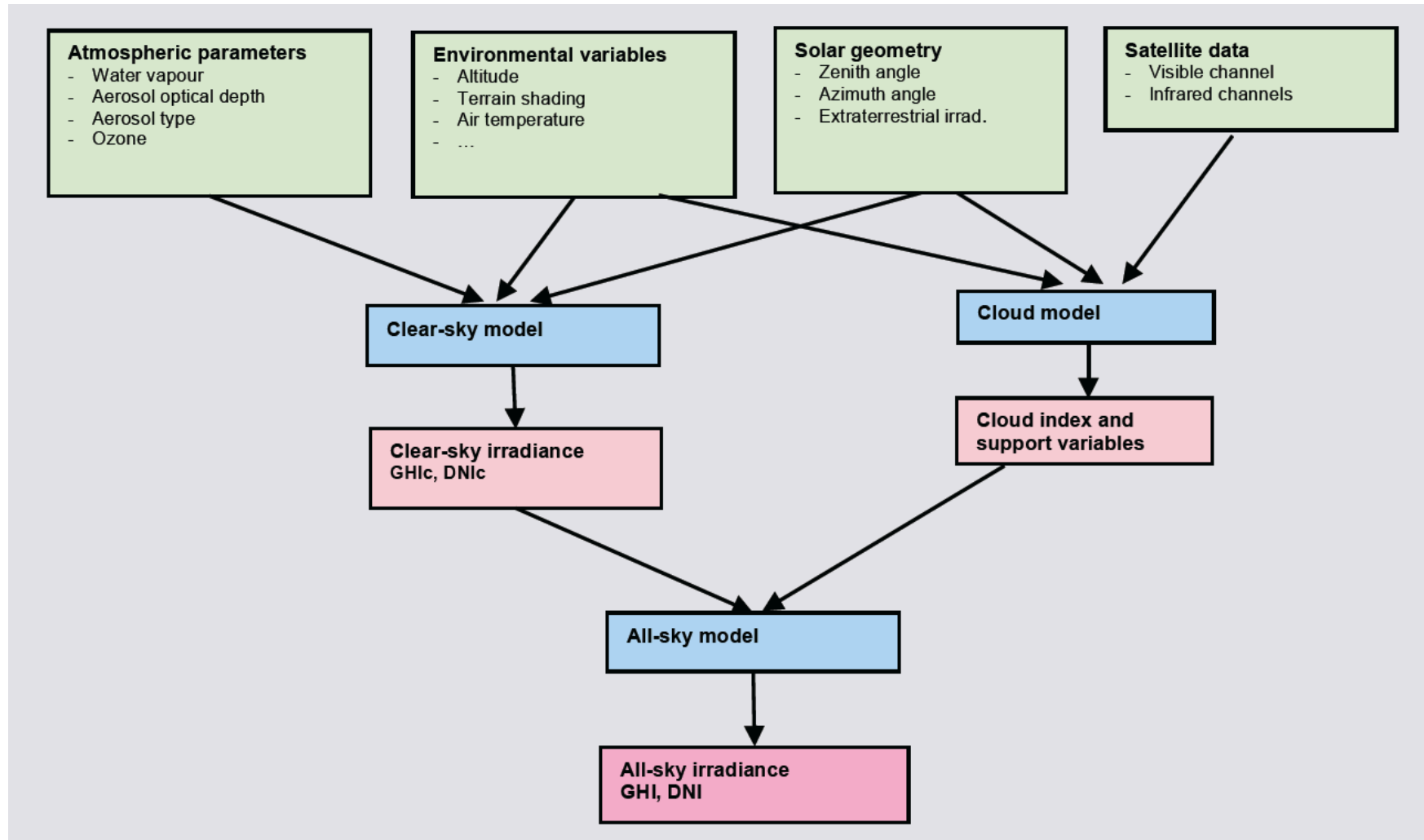
Satellite images – information on clouds

- satellite doesn't measure ground DNI, GHI
- complex modelling needed to get GHI, DNI



Solar models

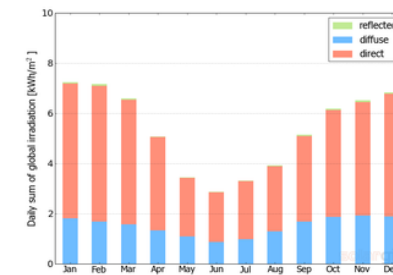
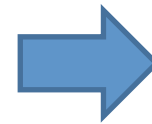
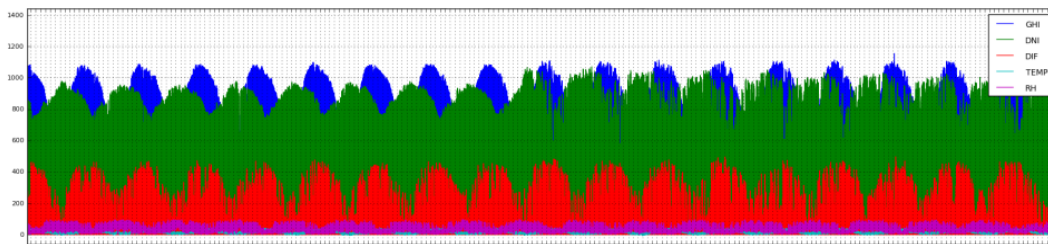
Semi-empirical approach: example SolarGIS



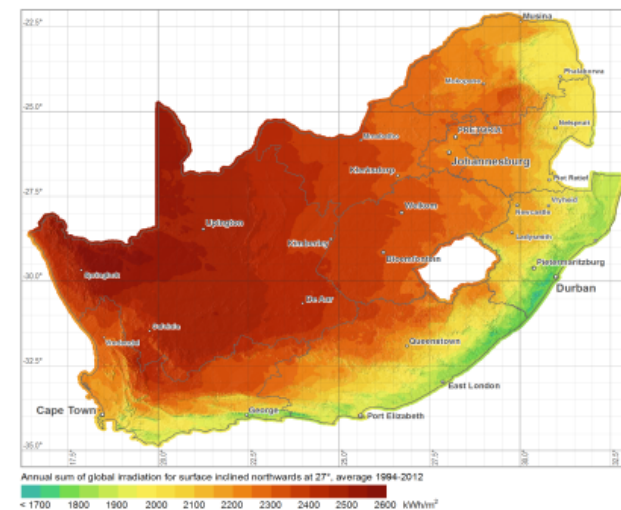
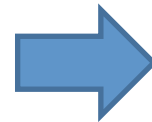
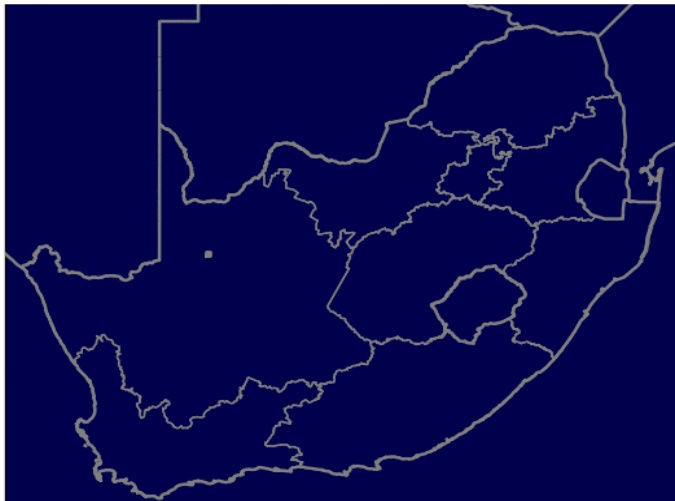
Solar maps

- satellite based models – ideal approach - measurements in spatial context
- solar maps – integration of time series :

21 (years) x 365 (days) x 96 (15 min values) = 735840 values per pixel >>> one (or 12) values



for each pixel in the map



Regional Enhancement of SolarGIS model

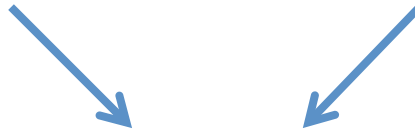
Regionally enhanced solar radiation database

Ground measurements

- high accuracy
- short period of measurement
- limited spatial context

Satellite based model

- lower accuracy
- long period of measurement
- continuous in space



Enhanced satellite based model

- improved accuracy
- long period of measurement
- continuous in space

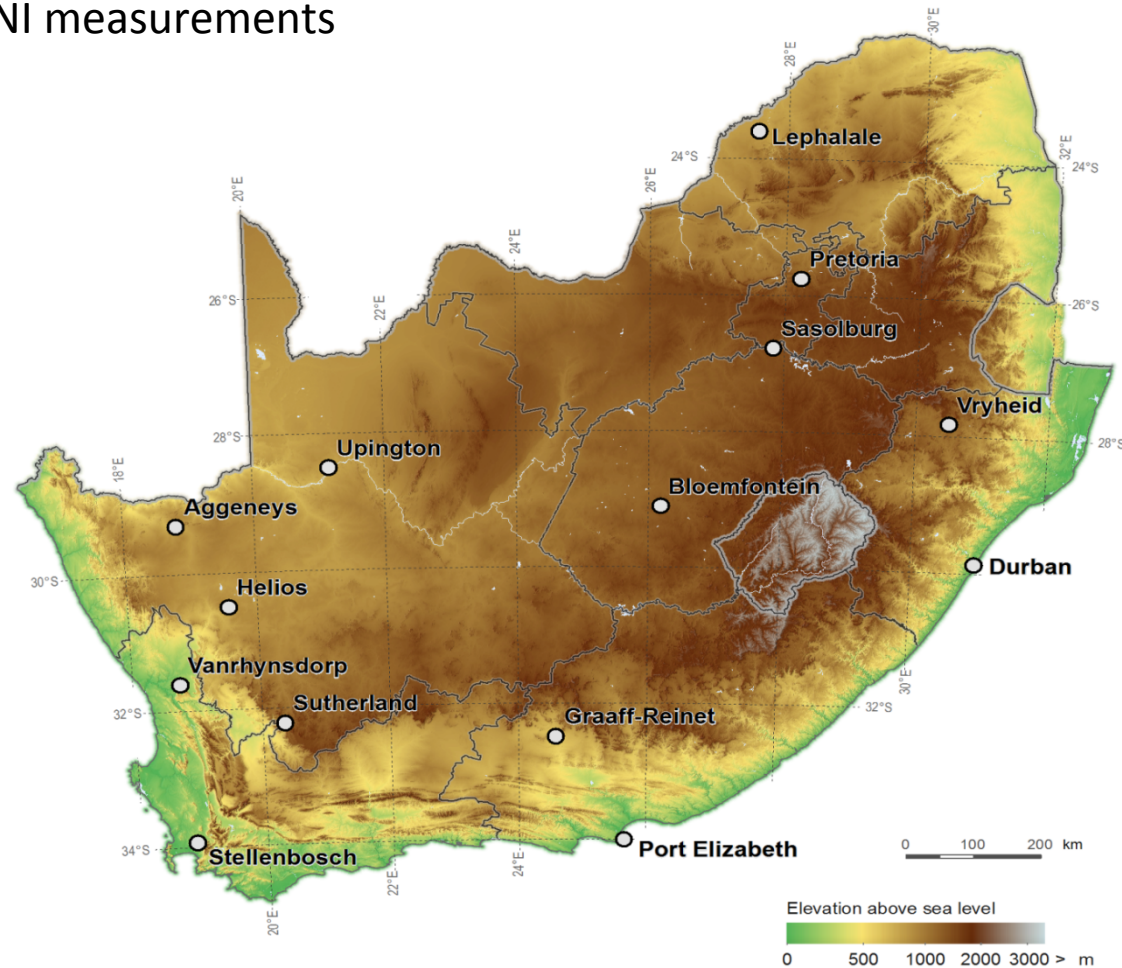
Regionally enhanced solar radiation database

Steps:

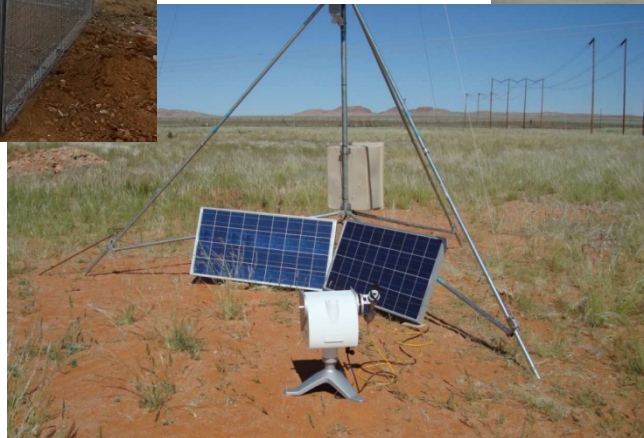
- QC of ground measurements
- Analysis of differences between sat. model and measured data for stations
- Analysis of spatial context of differences
- Derivation of the correction coefficients for given sites
- Harmonization of correction coefficient in a spatio-temporal context
- Interpolation of correction coefficients to whole territory
- Recalculation of the model (21 years, 15/30 min resolution)
- Integration of full time series to maps
- Assessment and evaluation

Ground measurements

- 14 stations in South Africa
- GeoSUN Africa, Eskom, SAURAN, STERG, GIZ and Ripasso Energy
- GHI and DNI measurements



Ground measurements



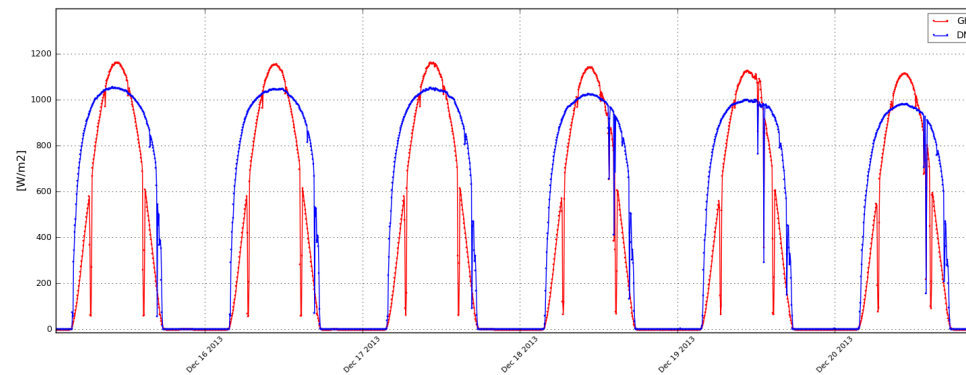
ID	Site name	2009					2010					2011					2012					2013					2014										
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1	Aggeneys																																				
2	Bloemfontein																																				
3	Durban																																				
4	Graaff-Reinet																																				
5	Helios																																				
6	Lephalale																																				
7	Port Elizabeth																																				
8	Pretoria																																				
9	Sasolburg																																				
10	Sonbesie																																				
11	Sutherland																																				
12	Uptington																																				
13	Vanrhynsdorp																																				
14	Vryheid																																				

GHI measurementsDNI measurements

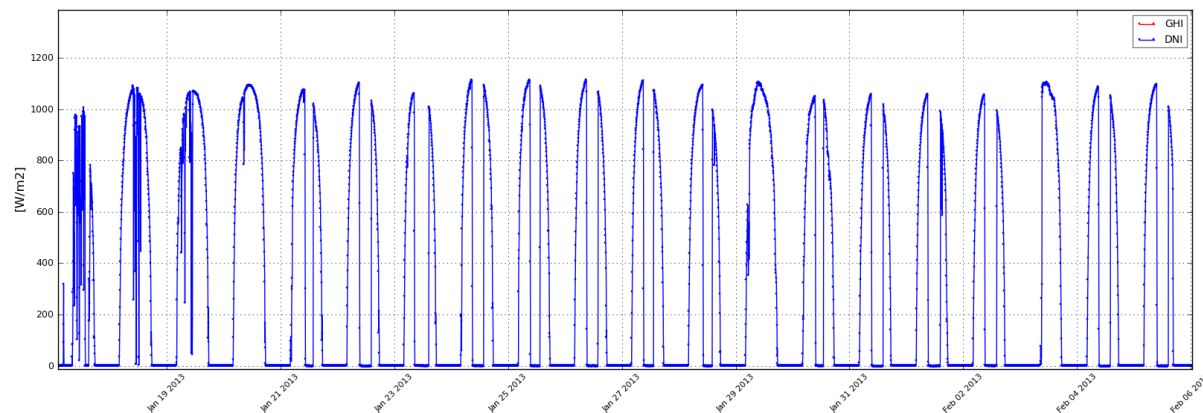
■ GHI measurements
 ■ DNI measurements

Ground measurements – quality control

- Identification of measurement problems
- Time harmonization, physical limits, consistency, shading, tracker malfunction, calibration....
- Exclusion of wrong and suspicious readings from further processing

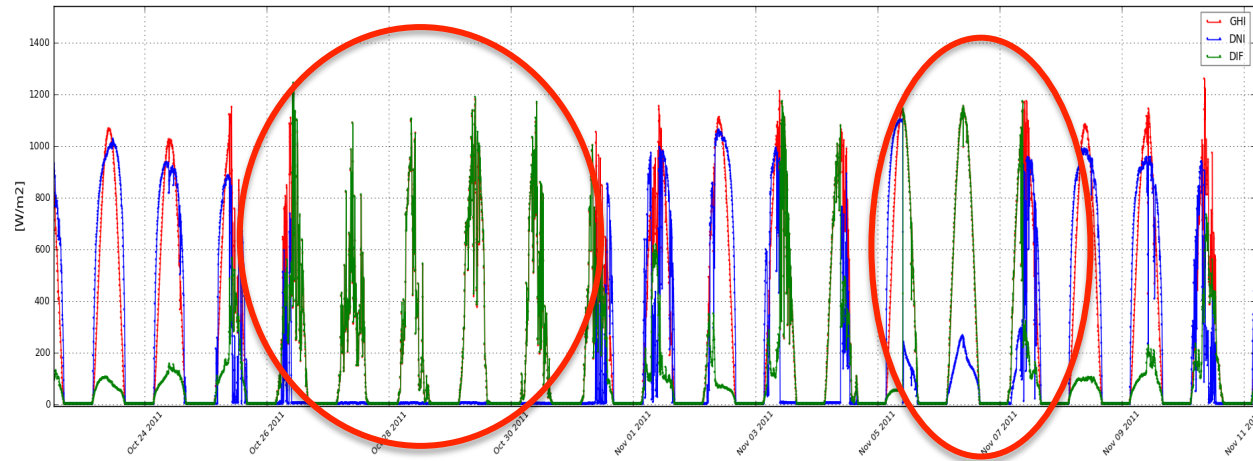


shading

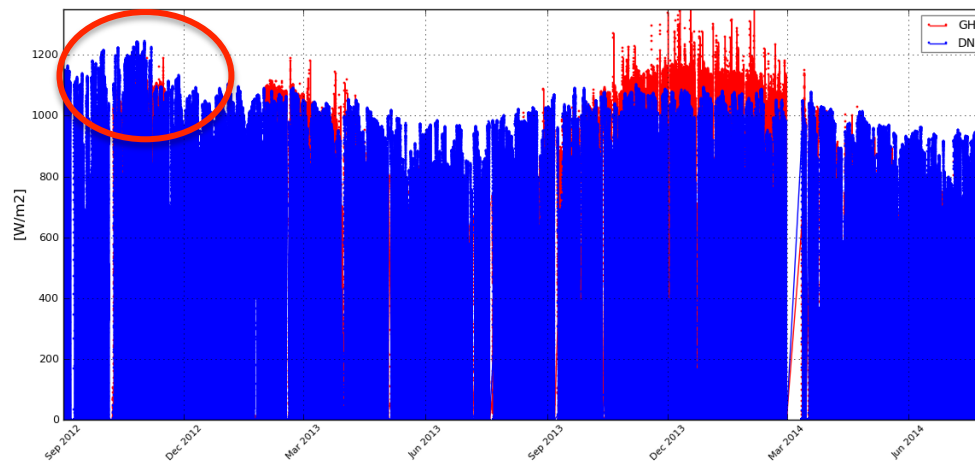


DNI sun tracking

Ground measurements – quality control

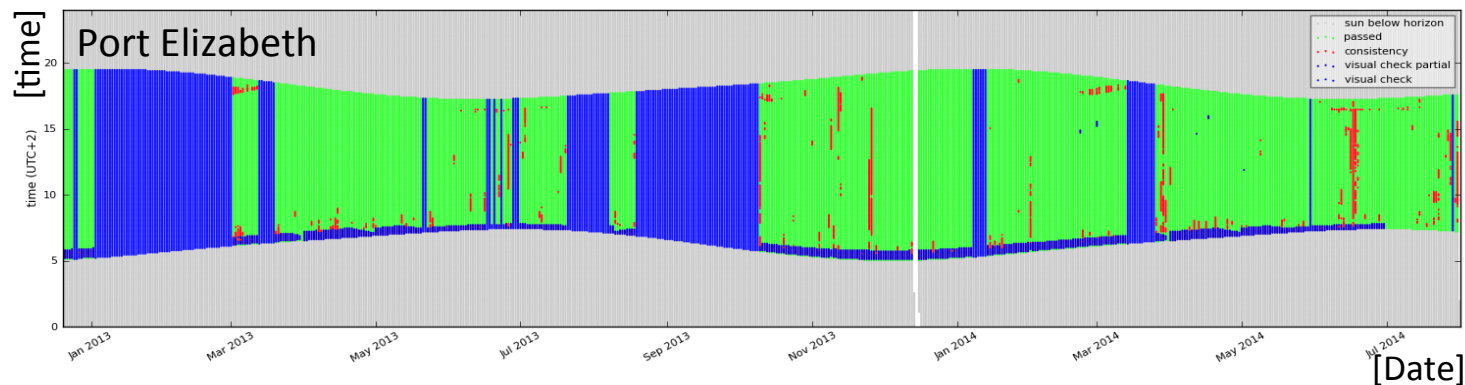
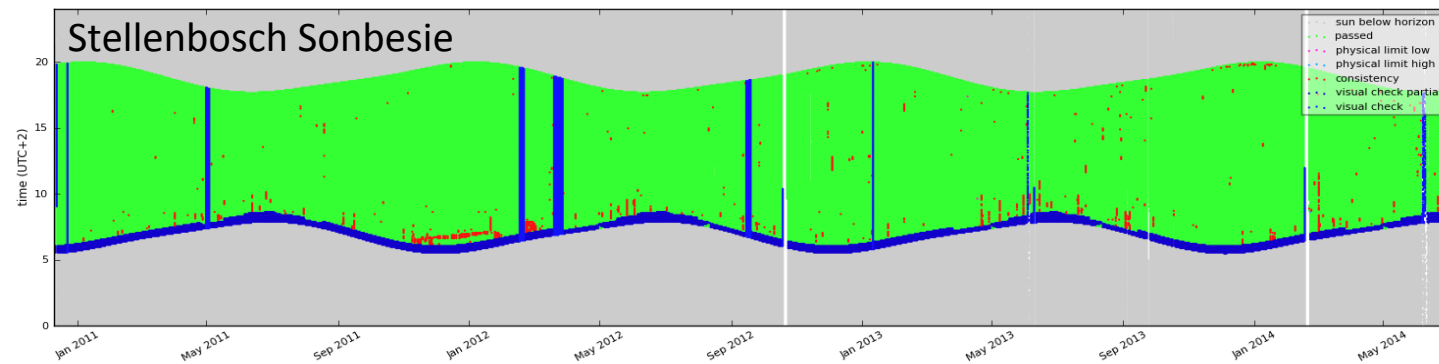
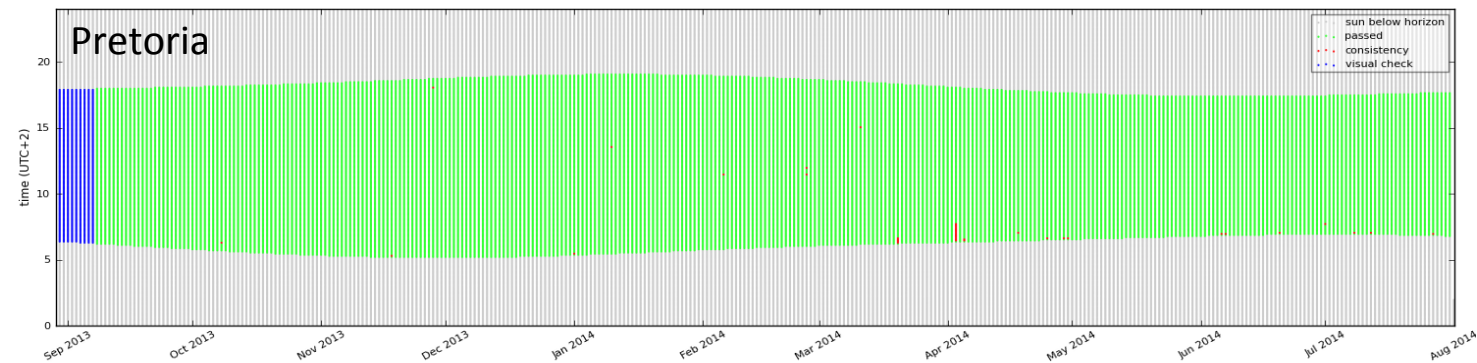


DNI and DIF sun tracking



DNI calibration

Ground measurements – quality control results



Night-time

Data passed QC

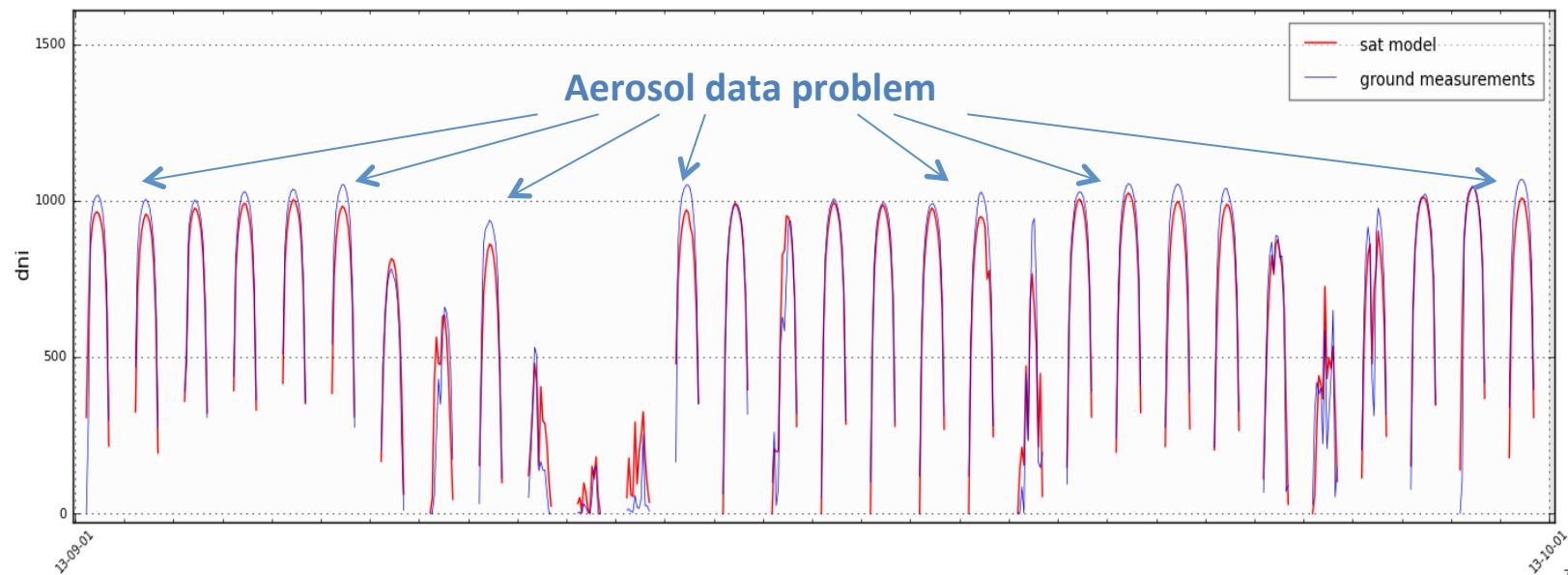
Shading

Physical limits,
Consistency

Other problem

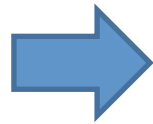
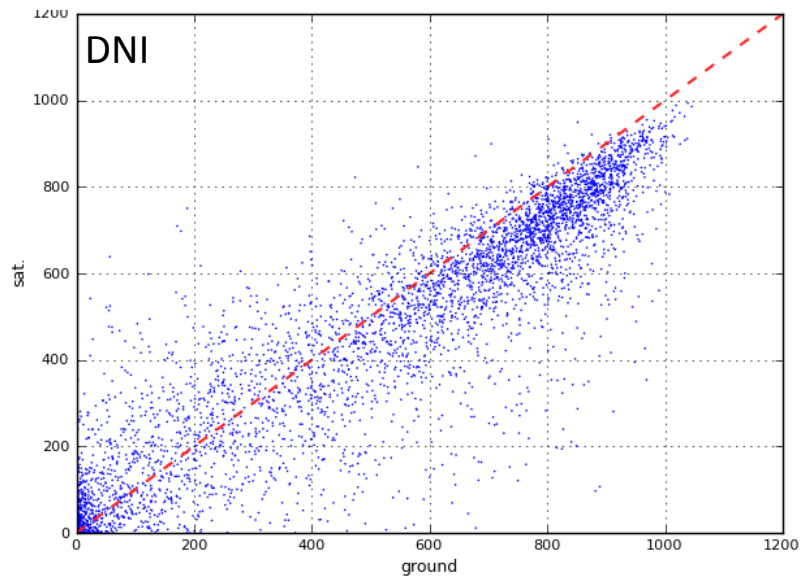
Analysis of ground – model data differences

- identification of differences
- analysis of potential sources – input data (aerosols), model (cloud identification), ...
- proposal of correction for individual sites (+ seasonal effect)

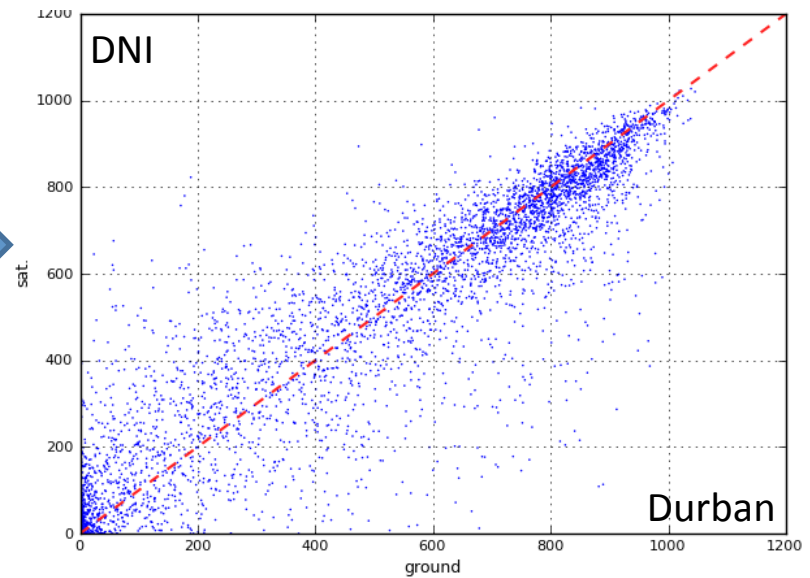


Correction coefficients for individual sites

Original data

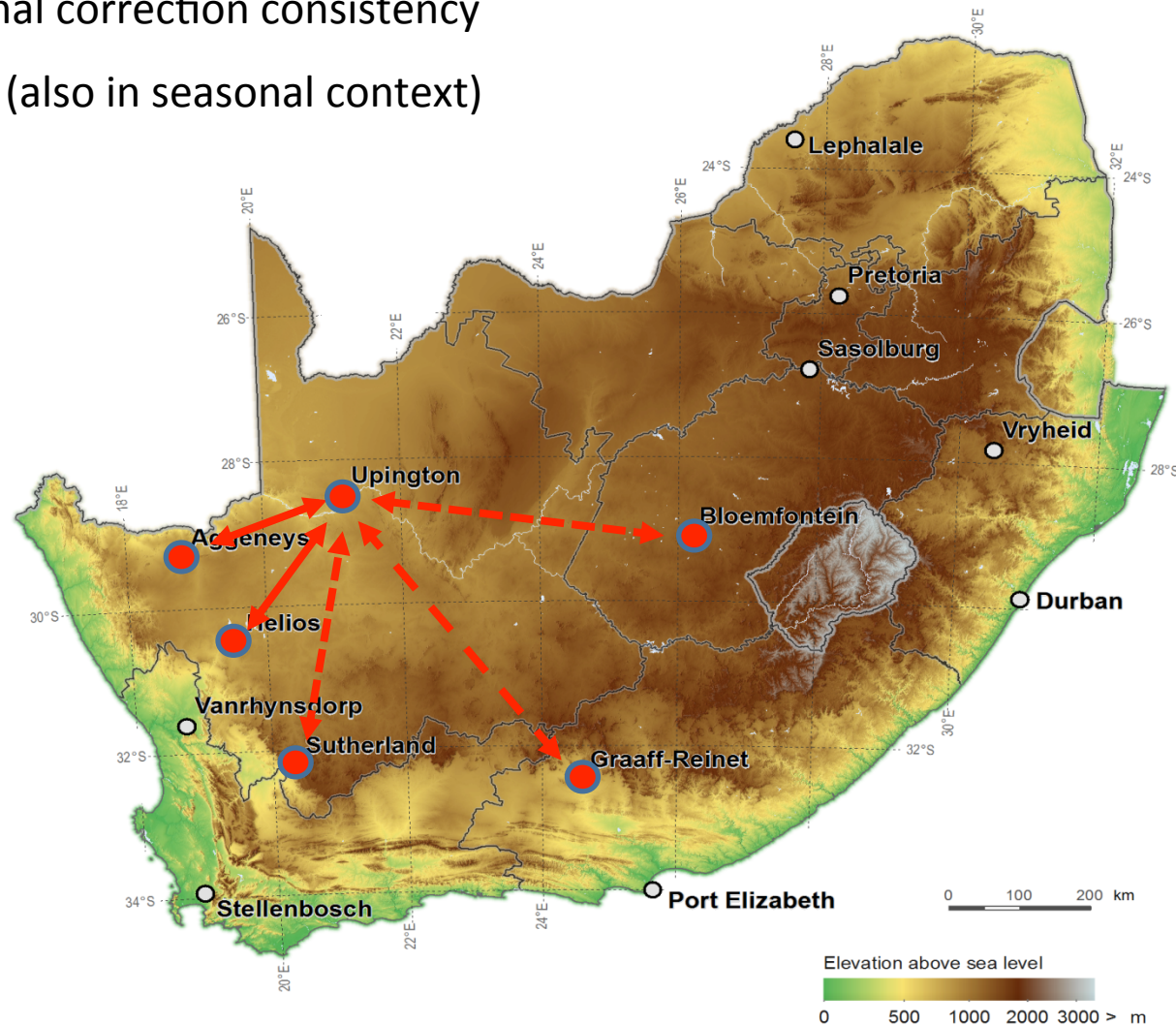


Enhanced data



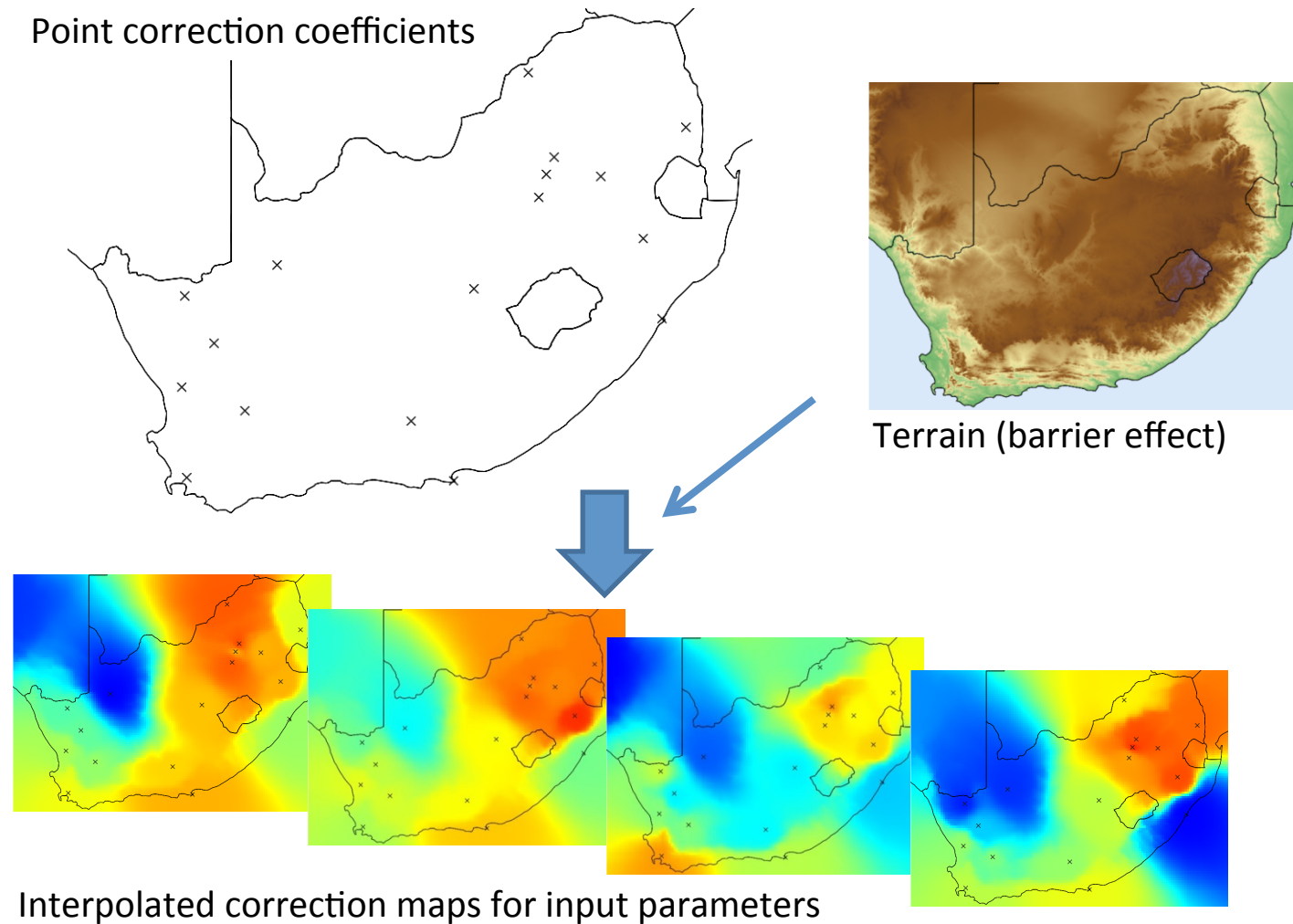
Correction coefficients- spatial harmonization

- ground measurements from different periods – potential problem
- analysis of regional correction consistency
- check of outliers (also in seasonal context)



Correction coefficients interpolation

- creation of spatial layers of correction coefficients



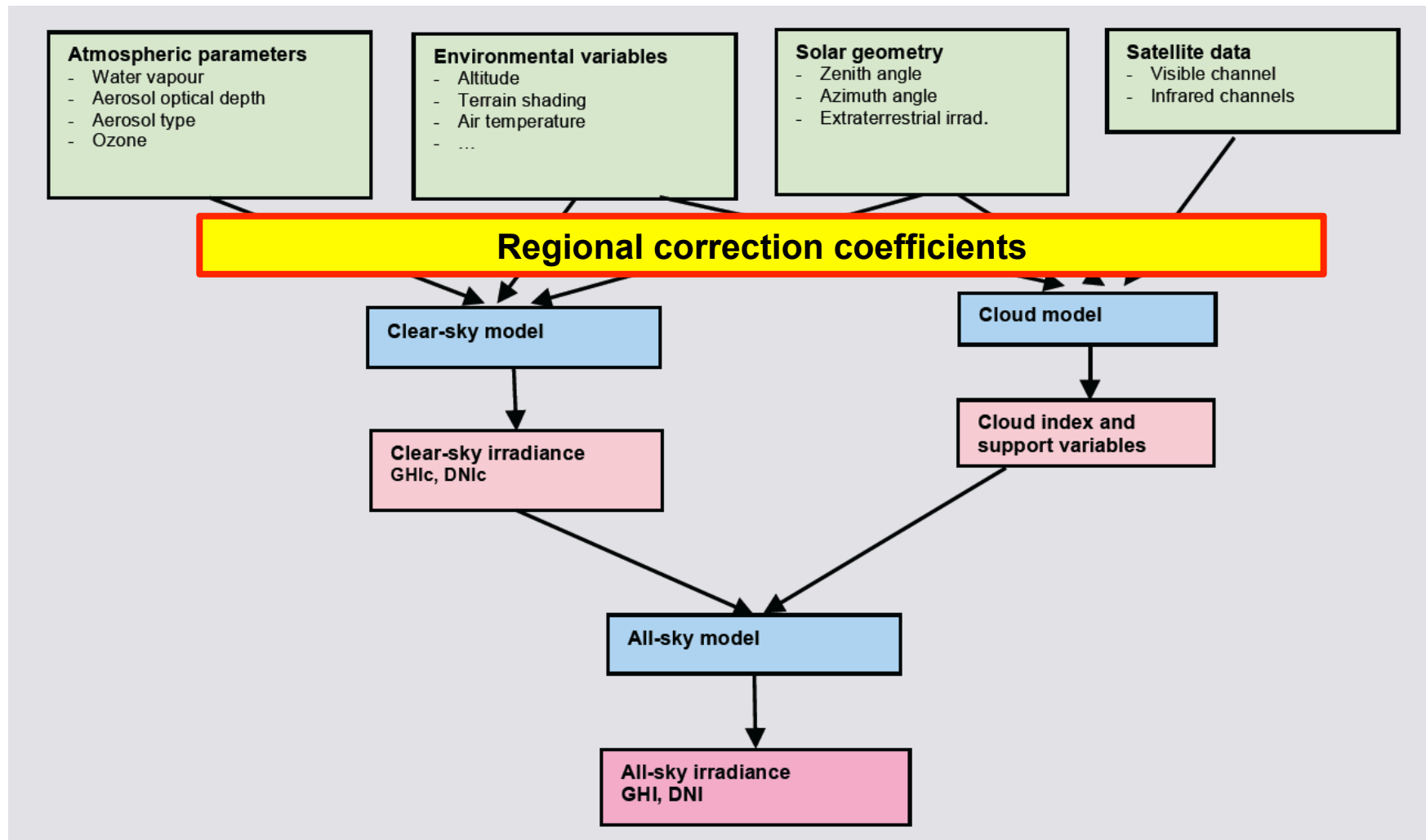
Results

- DNI annual value: -1.5 – +12.2%
- GHI annual value: -0.2 – +2.0%

Meteo station	DNI annual values			GHI annual values		
	Original	Adapted	Difference	Original	Adapted	Difference
	[kWh/m ²]	[kWh/m ²]	[%]	[kWh/m ²]	[kWh/m ²]	[%]
Aggeneys	2845	3019	6.1	2290	2313	1.0
Bloemfontein	2390	2546	6.5	2070	2094	1.2
Durban	1404	1574	12.2	1607	1638	2.0
Graaff-Reinet	2200	2346	6.6	1939	1959	1.0
Helios	2739	2918	6.5	2210	2231	1.0
Lephalale	2127	2183	2.6	2057	2067	0.4
Port Elizabeth	1700	1765	3.8	1718	1729	0.6
Pretoria	2077	2078	0.0	1994	1996	0.1
Sasolburg	2165	2178	0.6	2032	2035	0.2
Stellenbosch	2127	2231	4.9	1883	1898	0.8
Sutherland	2796	2915	4.3	2151	2165	0.7
Upington	2612	2894	10.8	2230	2266	1.6
Vanrhynsdorp	2441	2570	5.3	2072	2090	0.8
Vryheid	1967	1937	-1.5	1902	1898	-0.2

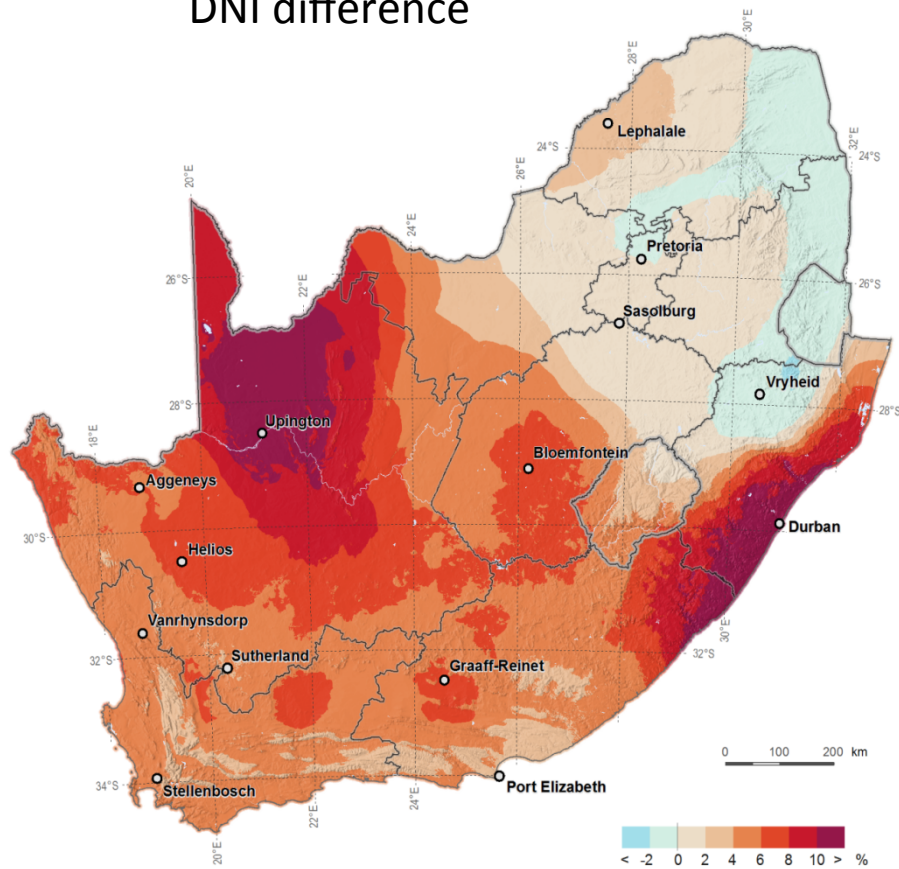
Calculation of enhanced model

- New solar radiation database (20 years, 15/30 min values)

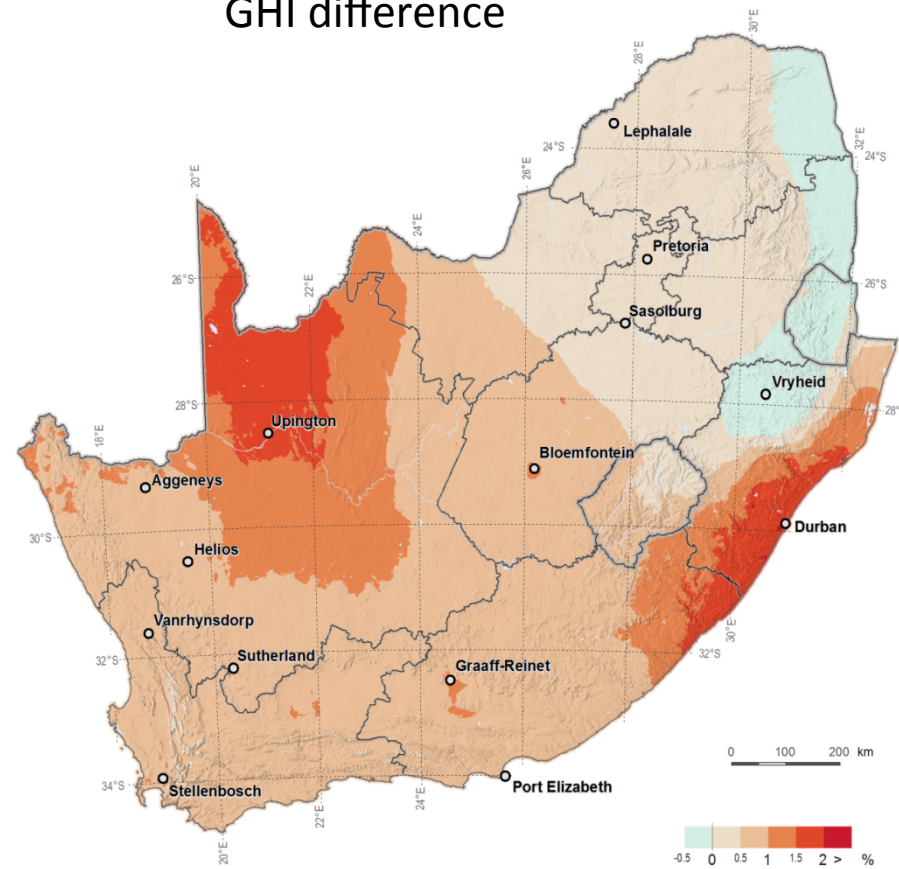


Results

DNI difference



GHI difference



Results

User's uncertainty of yearly estimated in South Africa [%]

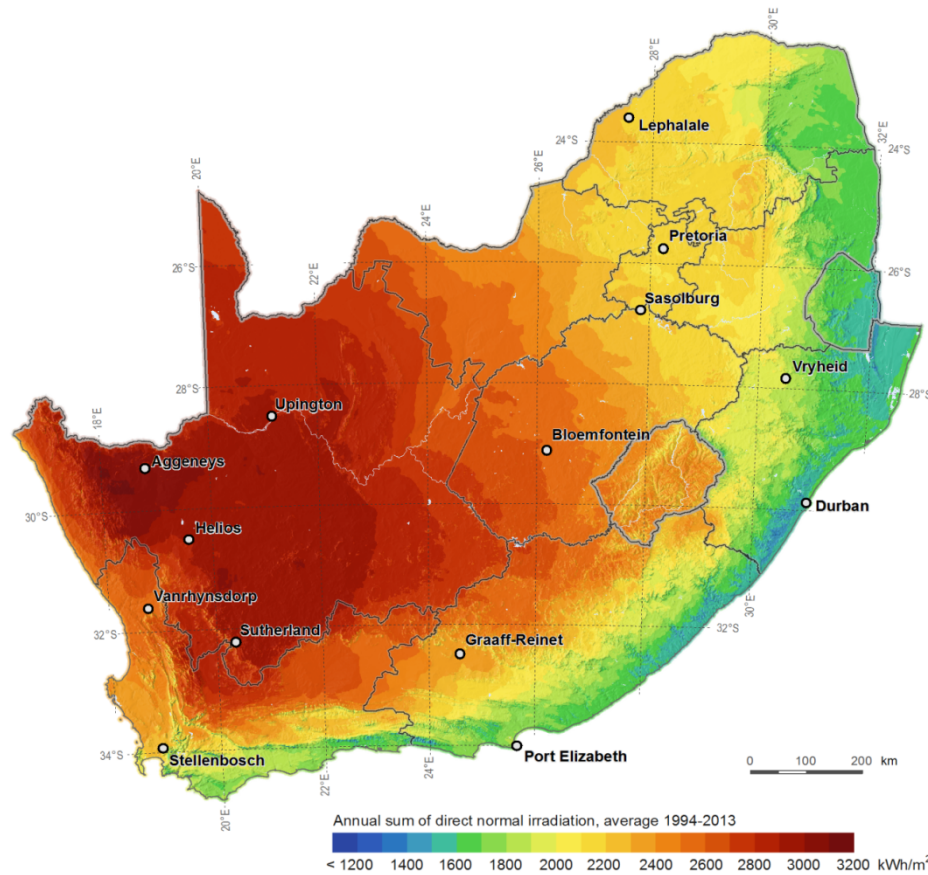
DNI	Lower	Higher	Exceptional
Original data	8.0	10.0	11.5
After enhancement	5.0	6.0	7.5

GHI	Lower	Higher	Exceptional
Original data	3.5	4.0	5.0
After enhancement	3.0	3.5	4.0

Results

Enhanced SolarGIS database for South Africa, Lesotho and Swaziland

Direct normal irradiation



Global horizontal irradiation

