

WORKSHOP ON “FORECASTING, BALANCING AND SCHEDULING OF RENEWABLE ENERGY IN INDIA”

Solar radiation resource assessment

**Dr. Ashvini Kumar
Director (Solar)**

**Solar Energy Corporation of India
New Delhi**

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Characteristics of solar radiation data

What kind of radiation data is needed?

DNI (Direct-Normal Irradiation)

GHI (Global-Horizontal Irradiation)

DHI (Diffuse-Horizontal Irradiation)

Source

Ground measurements

Satellite data

Ground measurements vs. satellite derived data

Ground measurements

Advantages

- high accuracy (sensor dependent)
- high time resolution

Disadvantages

- high costs for installation & O&M
- soiling of the sensors
- sometimes sensor failure
- no possibility to gain data of past

Satellite data

Advantages

- spatial resolution
- effectively no failures
- no soiling
- no ground site necessary
- low costs

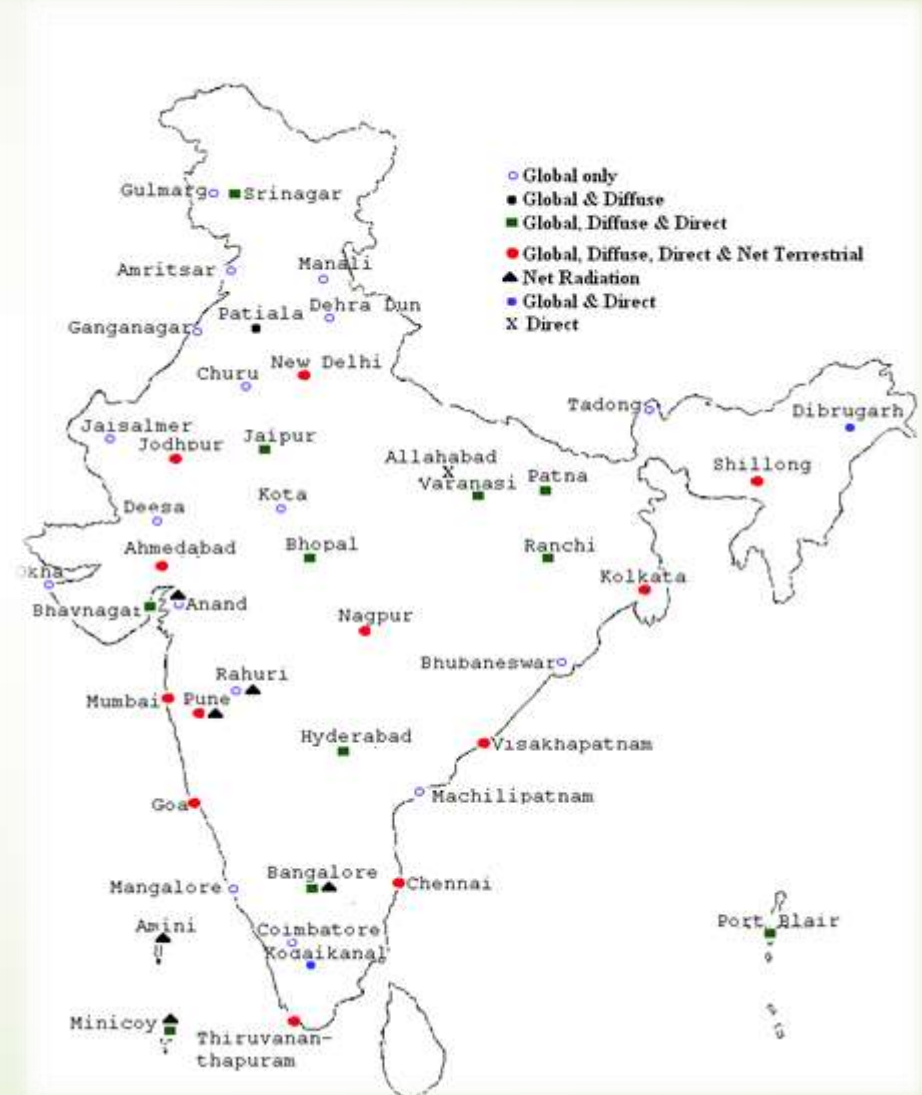
Disadvantages

- lower time resolution
- **low accuracy without ground measurement**

High quality ground measurement data is the basic ingredient for solar radiation mapping

Background

- India lies to the north of the equator between
 - $6^{\circ}44'$ and $35^{\circ}30'$ N latitude,
 - $68^{\circ}7'$ and $97^{\circ}25'$ E longitude
- Total land area is 3,287,263 sq. km.
- Historically, India Meteorological Department has been monitoring weather data in the country
- IMD has 45 stations where such measurements are taken.



Availability of solar resource data from IMD

- Two handbooks were published in 1980-81 to provide solar radiation data.
- Data books have been recently updated with latest data in a joint project of IMD and Solar Energy Centre
- This data is available on MNRE website.
- However, a need arose to monitor data at more sites where large capacity of solar projects is likely to be set up.
- Accuracy of data and DNI measurements became a necessity in view of high costs of solar power projects.

MNRE Programme

- ▶ **Jawaharlal Nehru National Solar Mission was launched in Jan 2010 to provide policy framework for promoting Grid and Off-grid solar applications**
- ▶ **Setting up of 20,000 MW capacity of solar power and 2000 MW equivalent of off-grid applications is envisaged by 2022.**
- ▶ **To support achieving JNNSM targets, MNRE initiated a programme for setting up additional solar radiation monitoring stations.**
- ▶ **C-WET was assigned the task. MNRE has sanctioned two Phases so far.**

SRRA Project

➤ Phase I

51 stations have been completed. These stations are located in areas of high potential for solar power generation

➤ Phase II

Additional 60 stations have been sanctioned covering all parts of the country.

➤ Basic Design

- Configuration of the sites was worked out in consultation with various stakeholders**
- Technical specifications were prepared and procurement carried out through international competitive bidding.**
- All data is collected centrally at a server installed at C-WET.**
- GIZ is supporting development of protocols for quality checks, data analysis and data processing.**

SRRA Stations Phase I & II



SRRA Stations – A Snapshot

Sl.No	State/UT	Number of Stations		
		Phase I	Phase II	Total
1	Andhra Pradesh	6	3	9
2	Bihar	-	3	3
3	Chhattisgarh	1	1	2
4	Gujarat	11	2	13
5	Haryana	1	1	2
6	Himachal Pradesh	-	2	2
7	Jammu & Kashmir	1	1	2
8	Jharkhand	-	2	2
9	Karnataka	5	1	6
10	Kerala	-	2	2
11	Madhya Pradesh	3	5	8
12	Maharashtra	3	6	9

SRRA Stations – A Snapshot

Sl.No	State/UT	Number of Stations		
		Phase I	Phase II	Total
13	Odisha	-	4	4
14	Punjab	-	2	2
15	Rajasthan	12	-	12
16	Tamil Nadu	7	-	7
17	Uttar Pradesh	-	5	5
18	Uttarakhand	-	2	2
19	West Bengal	-	3	3
20	North East	-	10	10
21	Union Territories	1	5	6
	Total	51	60	111

Configuration of SRRRA Stations

- Global Solar Irradiance
- Direct Normal Incident (DNI) Irradiance
- Diffuse Solar Irradiance
- Ambient Air Temperature
- Wind Speed and Direction
- Relative Humidity
- Atmospheric Pressure
- Precipitation
- Aerosol of the atmosphere (few sites)
- Data is collected through GPRS at C-WET



Sun tracker with solar radiation measurement equipment

Meteorological Sensors



**Ultrasonic
Anemometer**



**Rain
Gauge**



Barometer



**Temperature &
Humidity sensor**

Operation and Maintenance

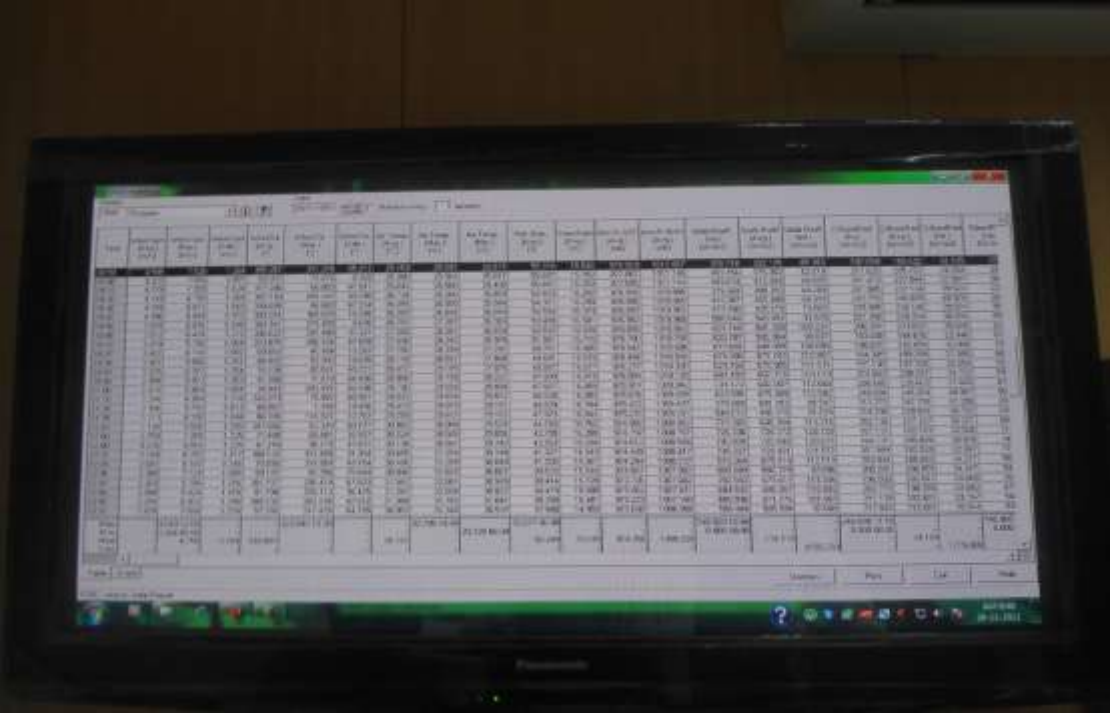
- Solar PV modules for electricity autonomy
- Arrangement at local level for daily cleaning
- Training of the local people
- Maintenance of equipment through vendor for a period of 5 years
- On-site calibration for solar radiation sensors
- Traceability of measurements through calibration facility at IMD and/or CWET
- Arrangement of regular visits by CWET staff for inspection

A typical SRRA station

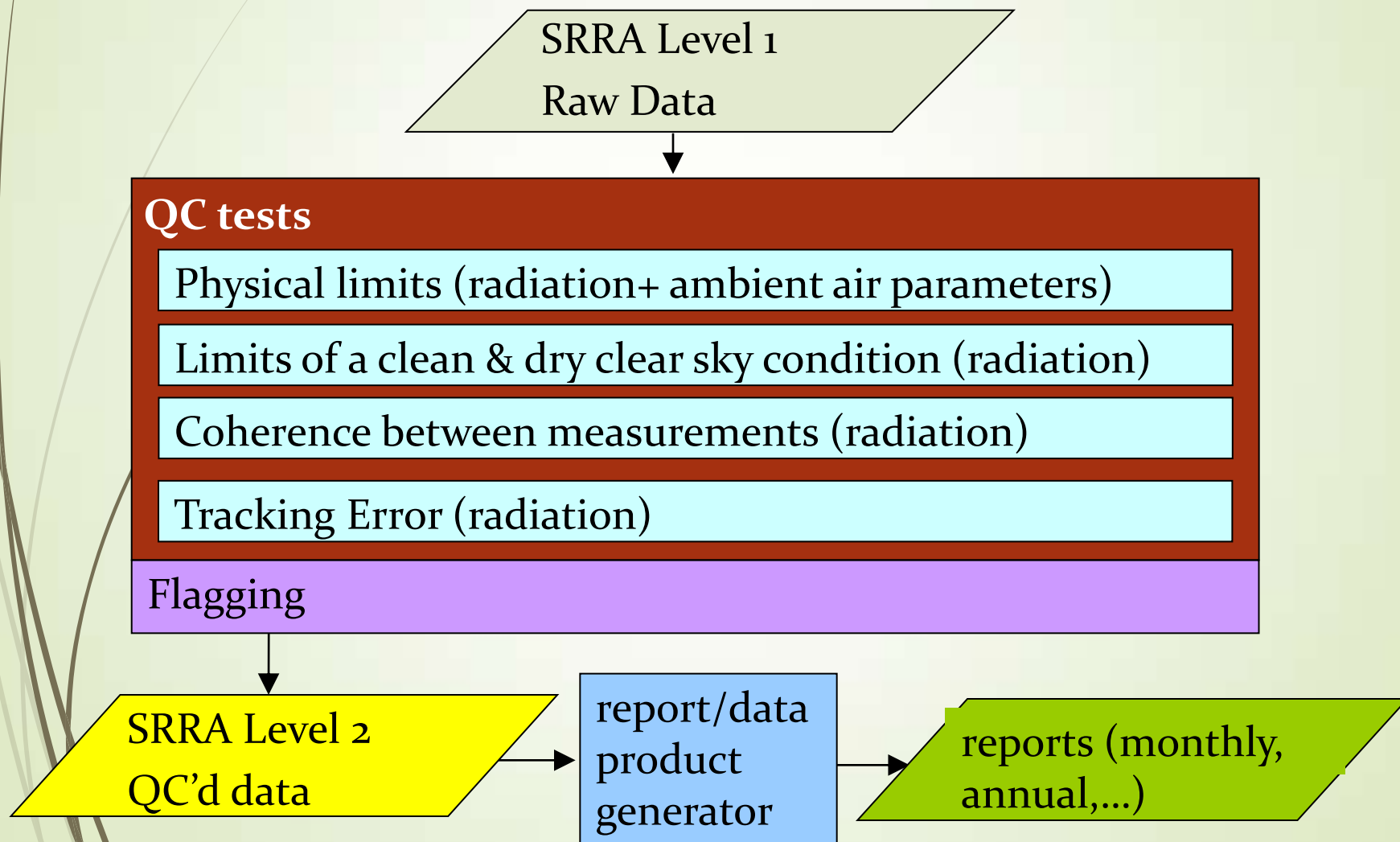


At CWET, Chennai

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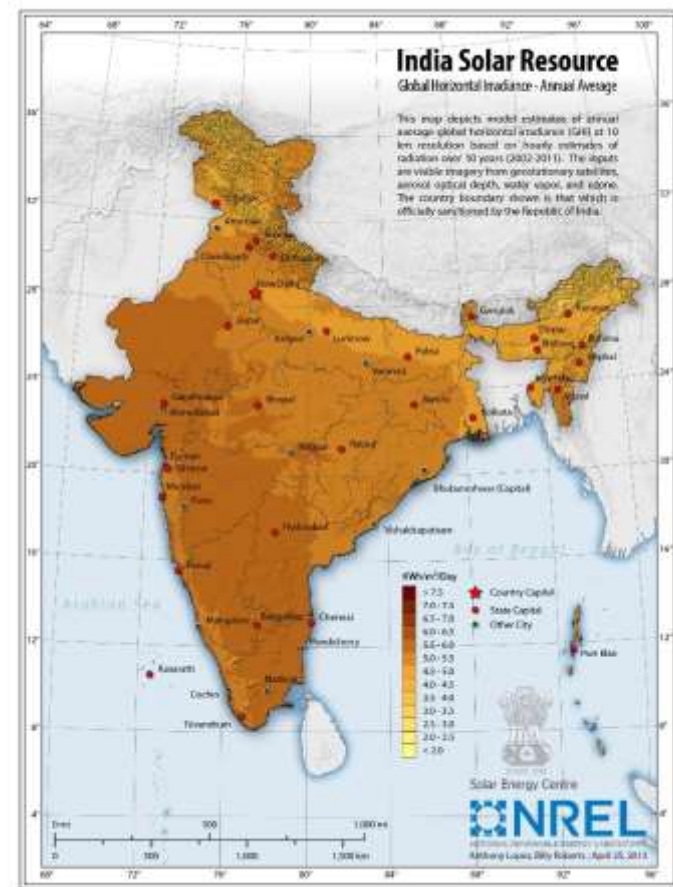
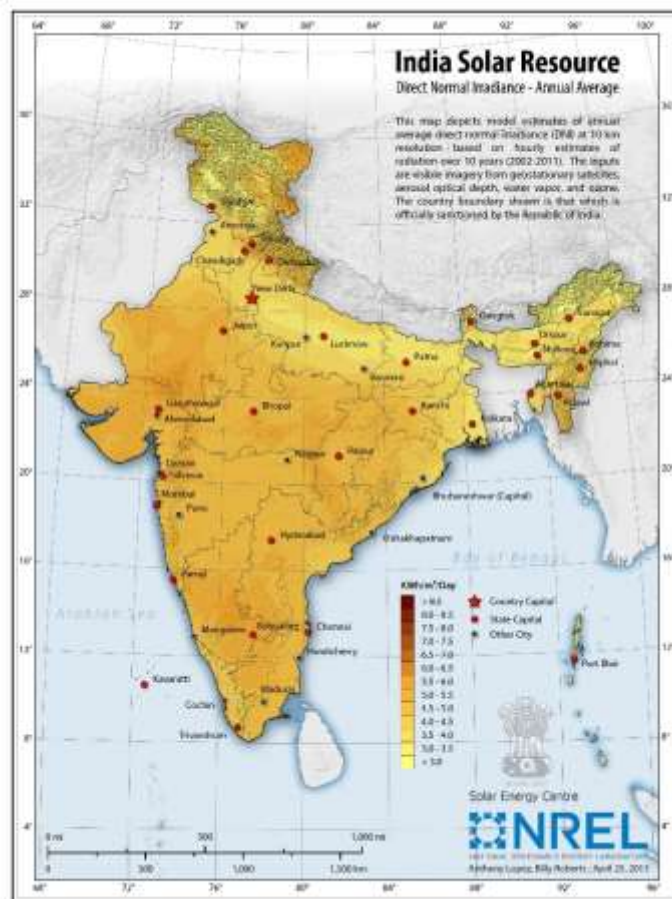
SRRRA QC data flow



Solar Energy Corporation of India

- Jointly working with Solar Energy Centre
- Review of automatic on-line check protocols is aimed
- Calibration lab is being developed at Solar Energy Centre, Gurgaon
- Data products for investors, bankers and other stakeholders to be developed
- Capability building is strengthened in collaboration with NREL, USA and GIZ, Germany.
- A National Group is envisaged to further pursue solar radiation activities.
- Performance benchmarking of solar PV projects is being carried out, where developers are requested to provide solar radiation data as recorded by them along with performance data of the plant.

Solar radiation data from other sources (Long term series)



Forecasting of Solar Resource: Issues

- Presently, a large variation is observed in data estimated from satellite images with reference to ground surface measurements, especially for DNI.
- Availability of good quality solar resource data from ground surface measurement stations over sufficiently long duration
- Development of simulation models that are able to consider atmospheric attenuation at local/ regional levels
- Satellite images at appropriate spatial resolution and frequency of time
- High quality aerosol measurement data to fine-tune estimation of solar radiation from satellite images

Thank You !