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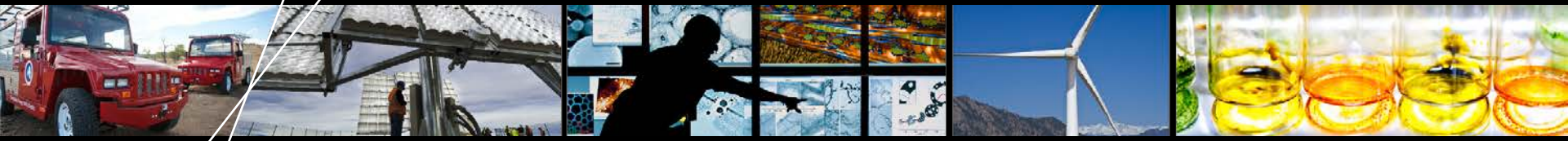
Delivering Data for the PV User from Physics-Based Satellite Models



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PV Solar Resource Workshop

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NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

How do satellites model surface radiation?

- **Empirical Approach: (original)**
  - –Build model relating satellite measurements and ground observations.
  - –Use those models to obtain solar radiation at the surface from satellite measurements.

- **Semi-Empirical Approach: (current industry standard)**
  - –Retrieve “cloud index” using counts from visible satellite measurements
  - –Relate “cloud index” to “clearness index”
  - –Scale clear sky radiative transfer model output by “clearness index”

- **Physical Approach: (the new approach)**
  - –Retrieve cloud and aerosol information from satellites
  - –Use the information in a radiative transfer model

The Gridded NSRDB Product

Satellite Input:

GOES data – 4 channels: 4 km : 30 min

Ancillary Input:

NWP Forecast or Reanalysis
Snow
Surface Emissivity
Surface Reflectance

RT Model Input:

Aerosol Product from MODIS/MISR satellite and AERONET ground measurements

Processing System:

PATMOS-x: Cloud Algorithms

Radiative Transfer:

Clear Sky: REST2
Cloudy Sky: SASRAB/NREL Fast All-sky Model

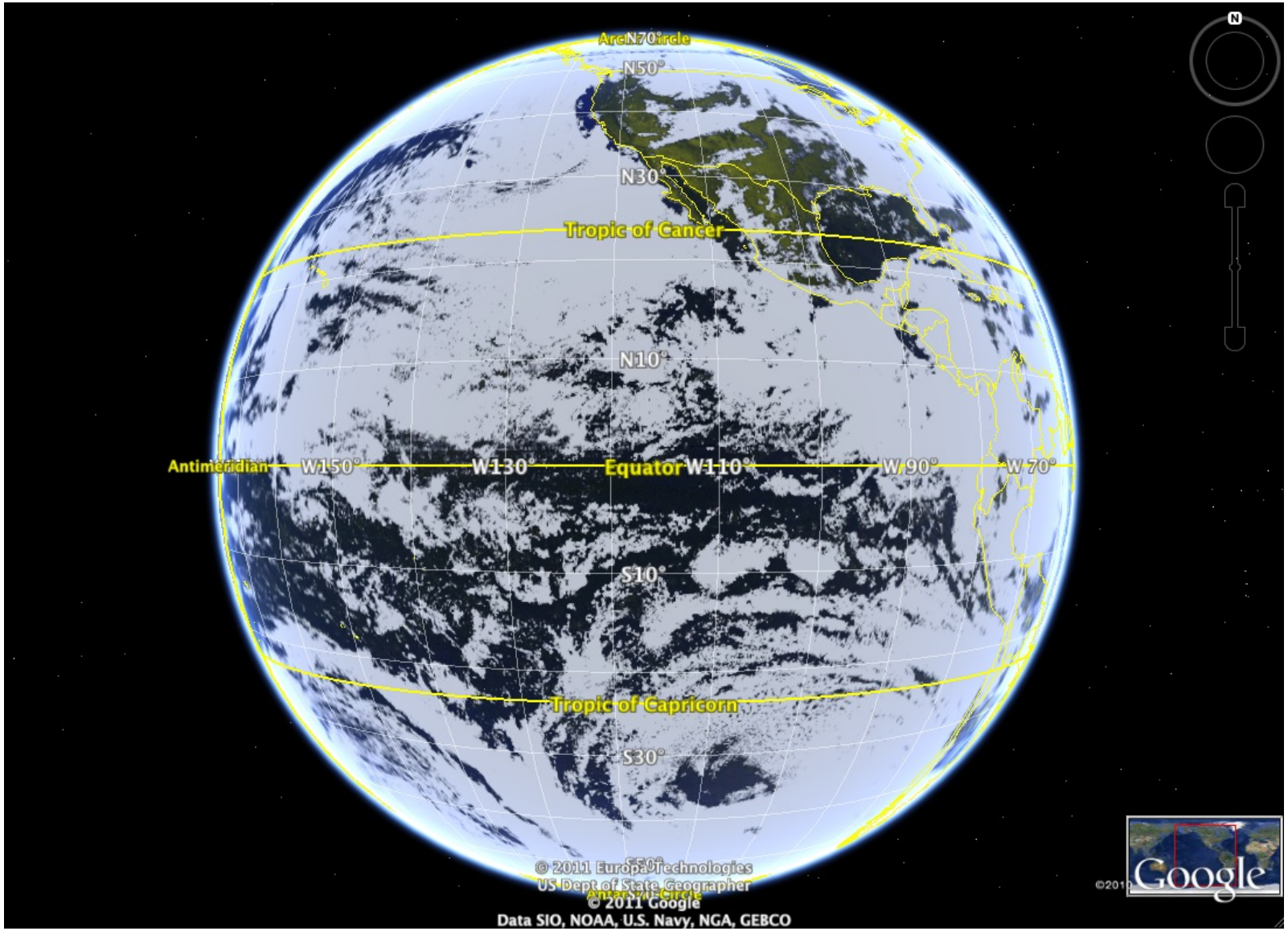
Cloud Products:

Cloud detection
Cloud type
Cloud height/temperature/pressure
Cloud optical depth
Cloud particle size
Cloud water path

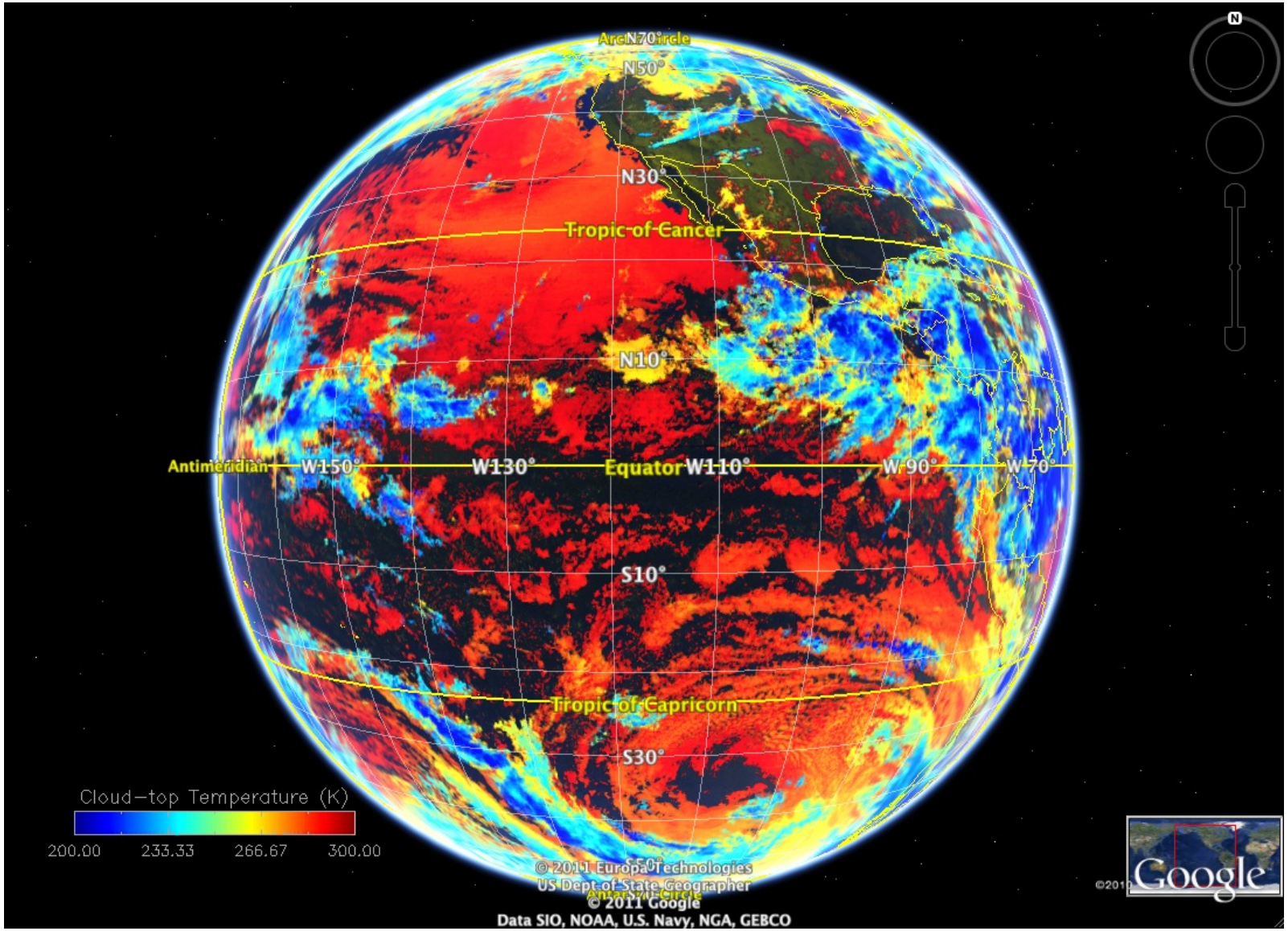
Irradiance Products

Global Horizontal Irradiance (GHI)
Direct Normal Irradiance (DNI)
Diffuse Horizontal Irradiance (DHI)

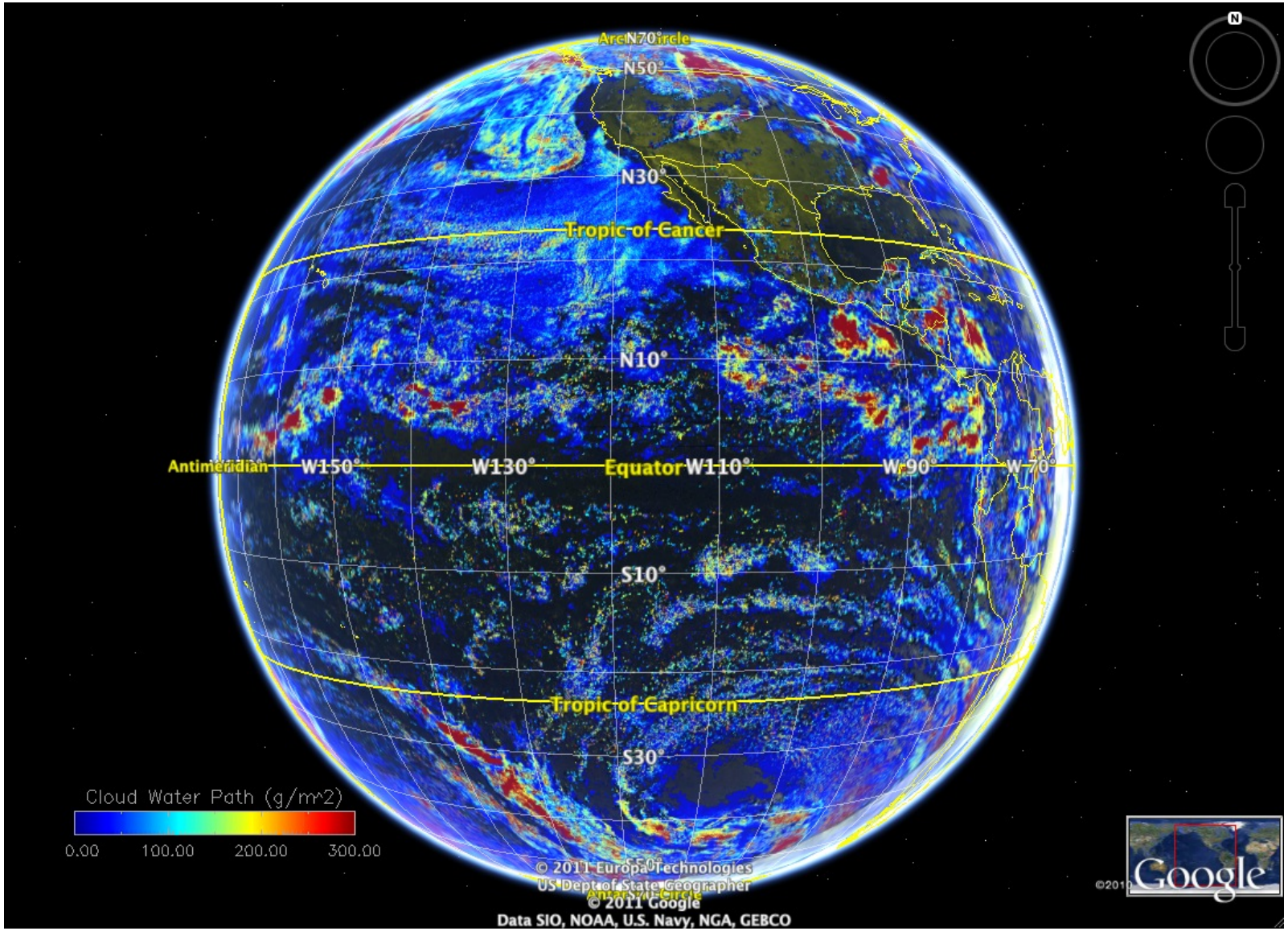
Cloud Algorithms: Cloud Mask



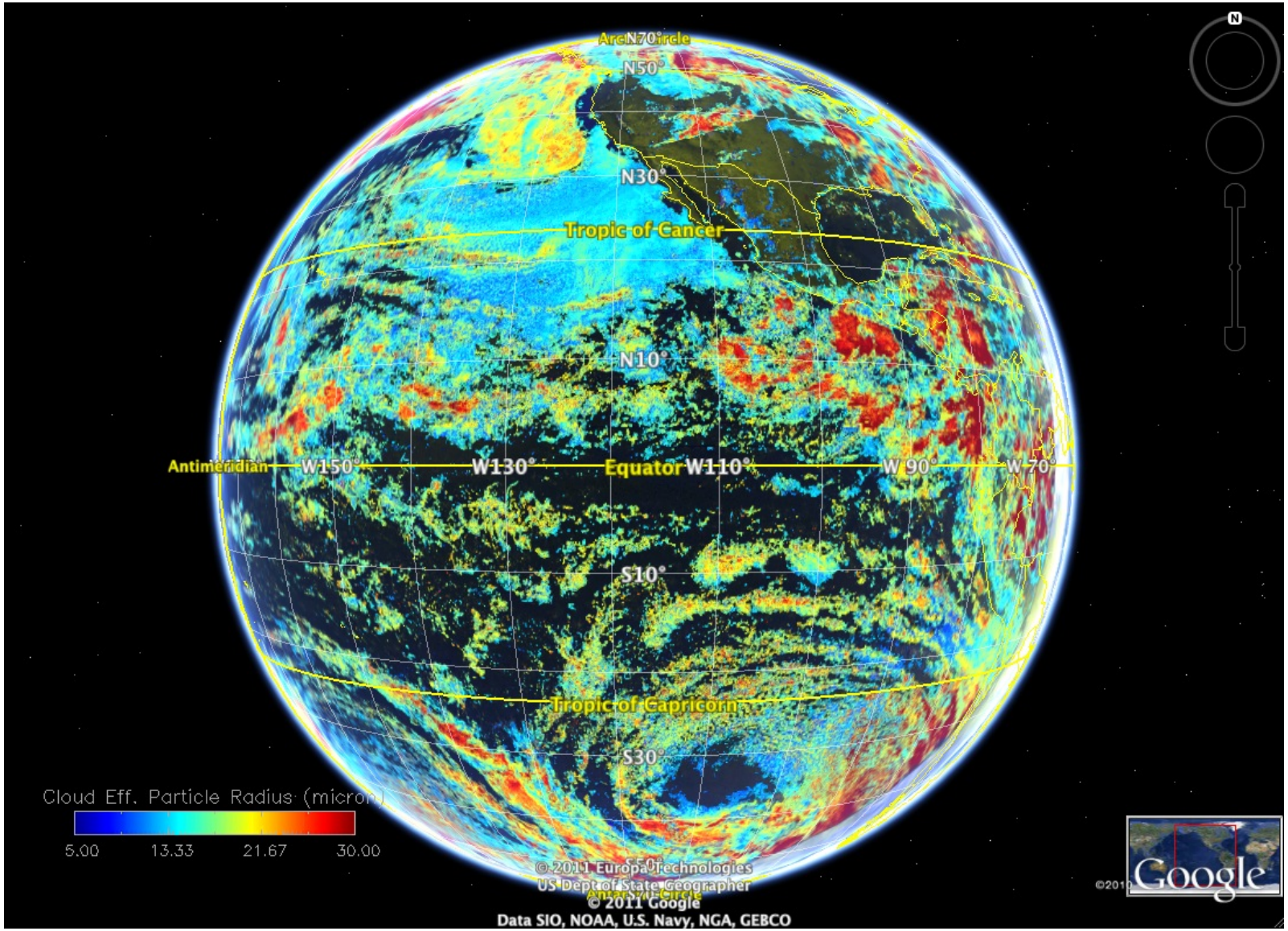
Cloud Algorithms: Cloud-top Temperature (K)



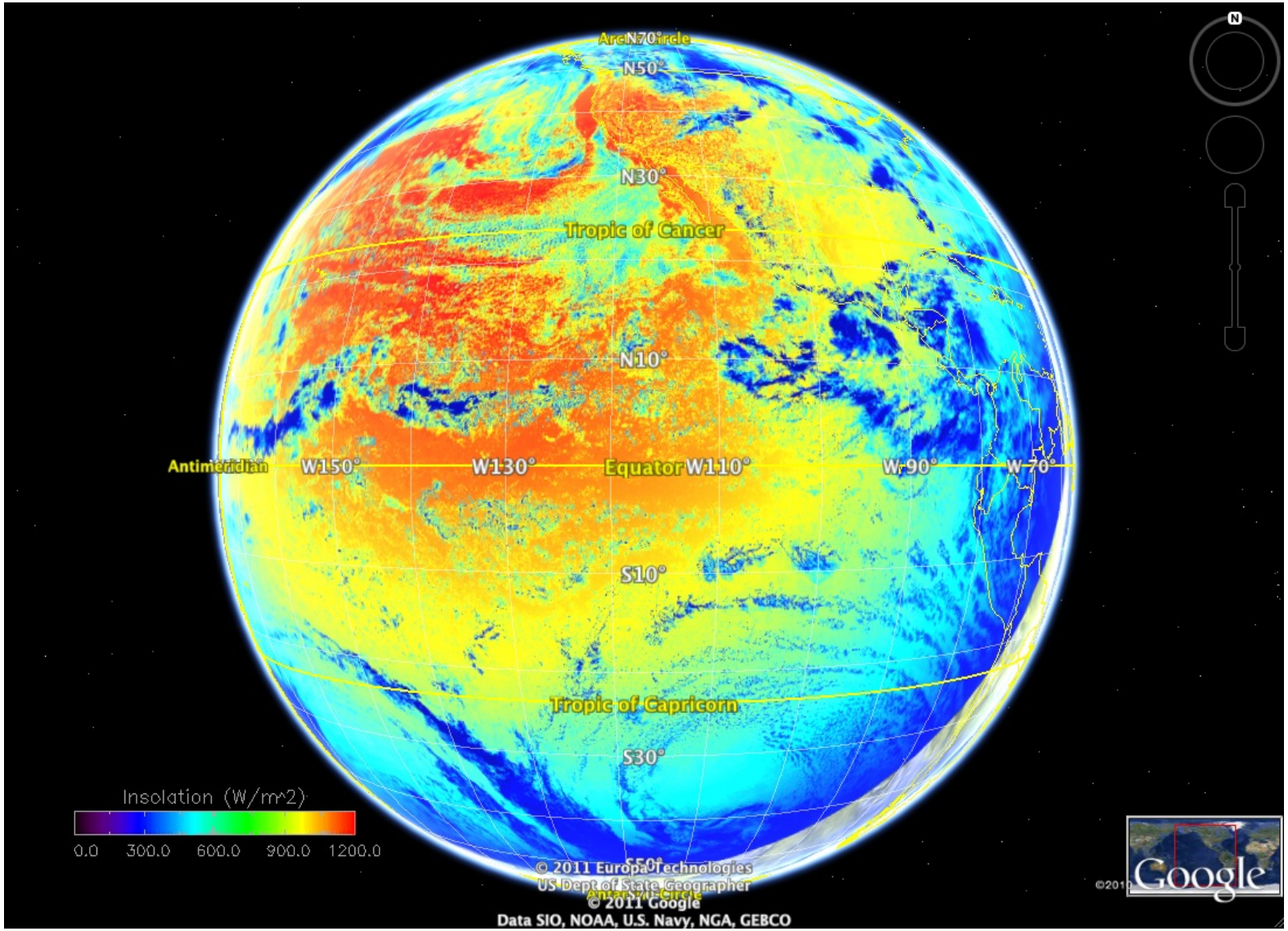
Cloud Algorithms: Cloud Water Path



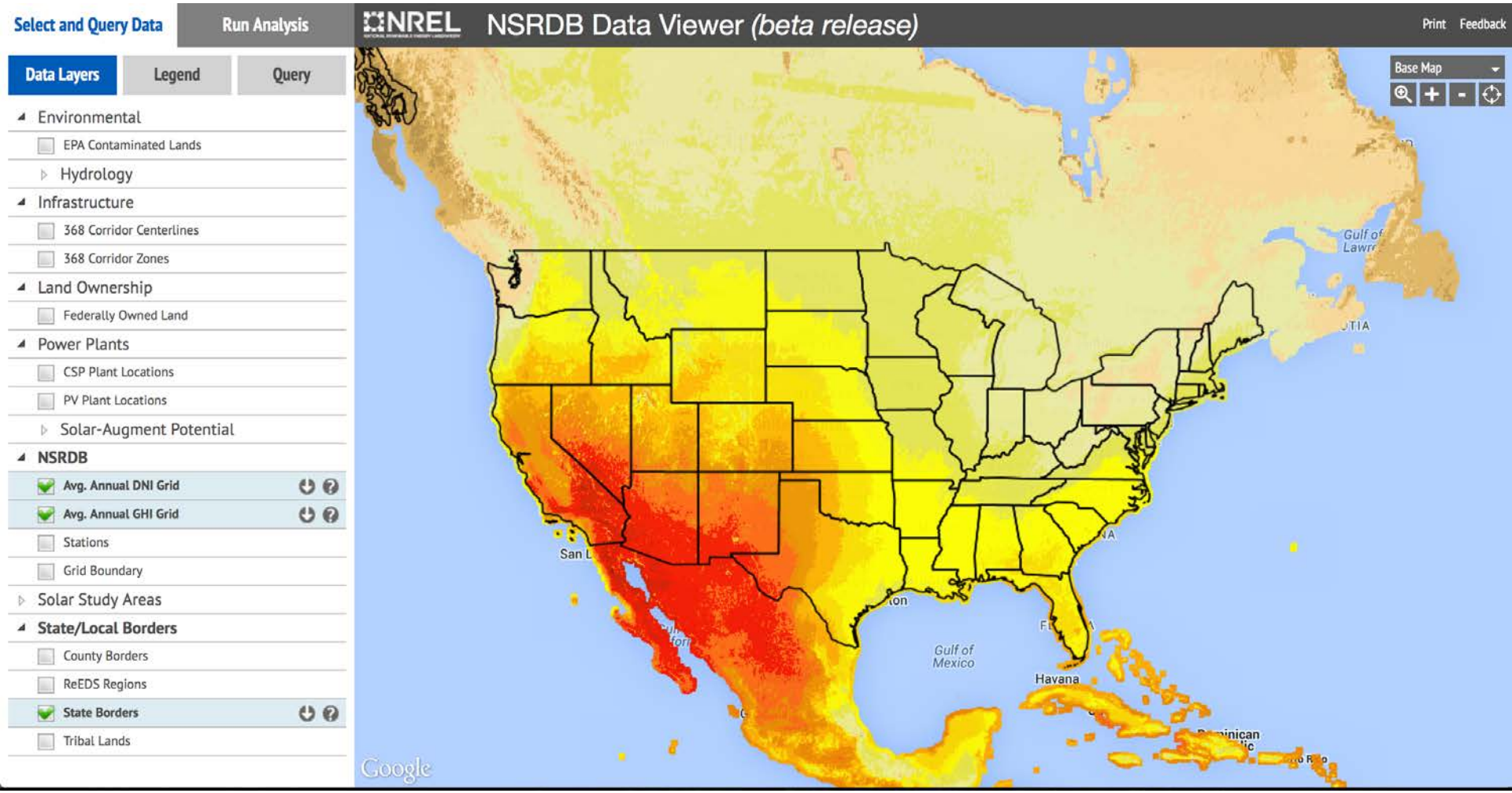
Cloud Algorithms: Cloud-top Particle Size



Radiative Transfer: Global Horizontal Irradiance



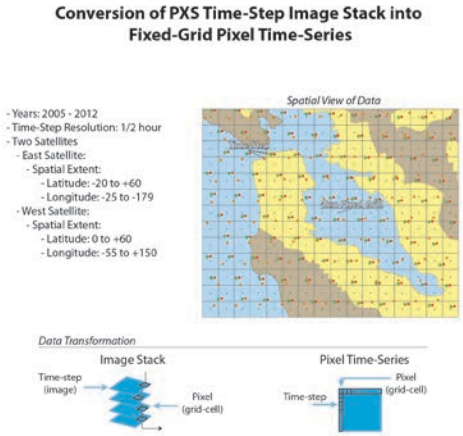
Accessing the NSRDB Data

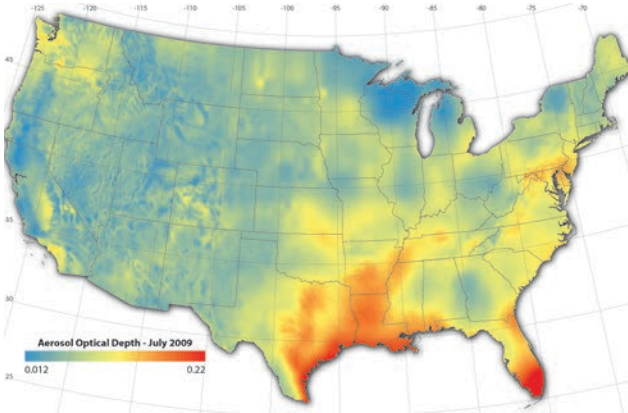


GIS based data access with web-service for multi-pixel download

Timeline

- **Beta product (2005-2012) available by March 2015**
- **Final Product (1998-2014) available by September 2015**
- **Typical Meteorological Year (TMY) product by September 2015**
- **Intermediate monthly update available after September 2015 (possible daily product)**
- **Annual dataset by following March (2015 onward) .**





Clear Sky Model Inputs- Measured at SURFRAD sites

7 sites – Data from 2009 used for the study

Aerosol	Water Vapor
Climatological	Climatological
Daily	**Climatological**
Daily	**Daily**

Not shown

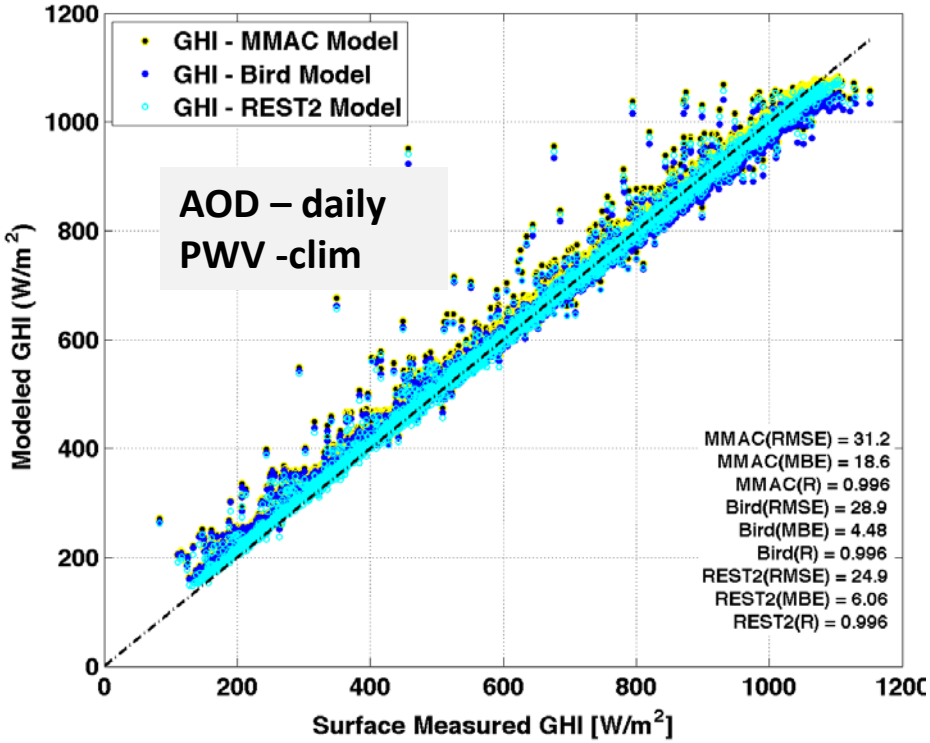
Climatological Values are annual averages

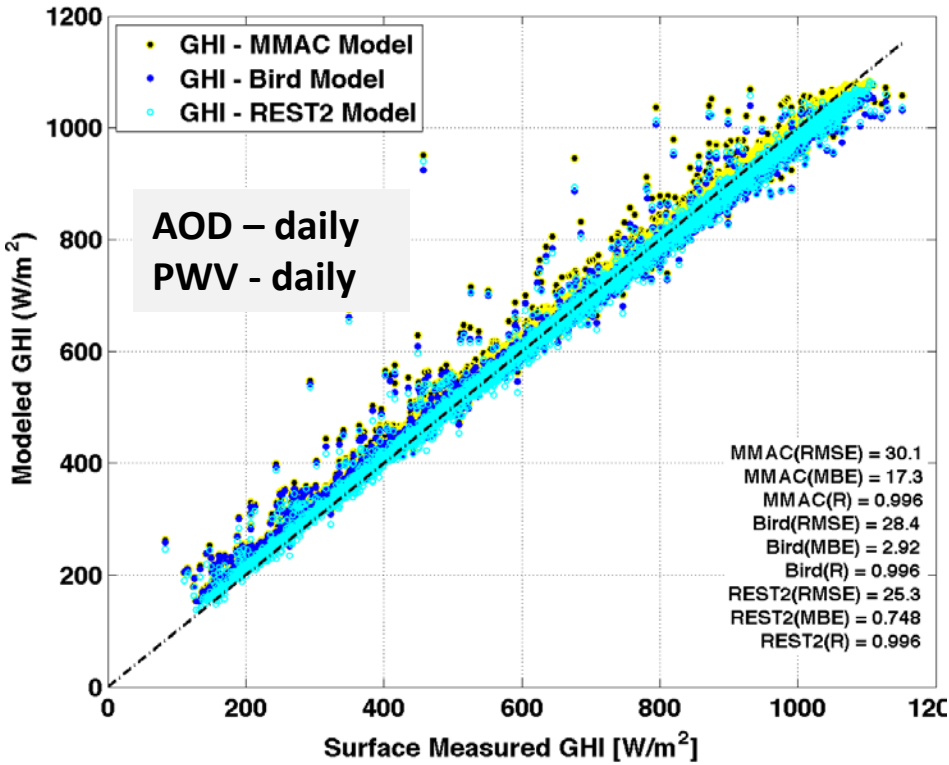
<u>Source of Inputs:</u>

AOD from MODIS/MISR/Aeronet

Water Vapor from CFSR

GHI -Desert Rock – NV - Clear Sky Comparison

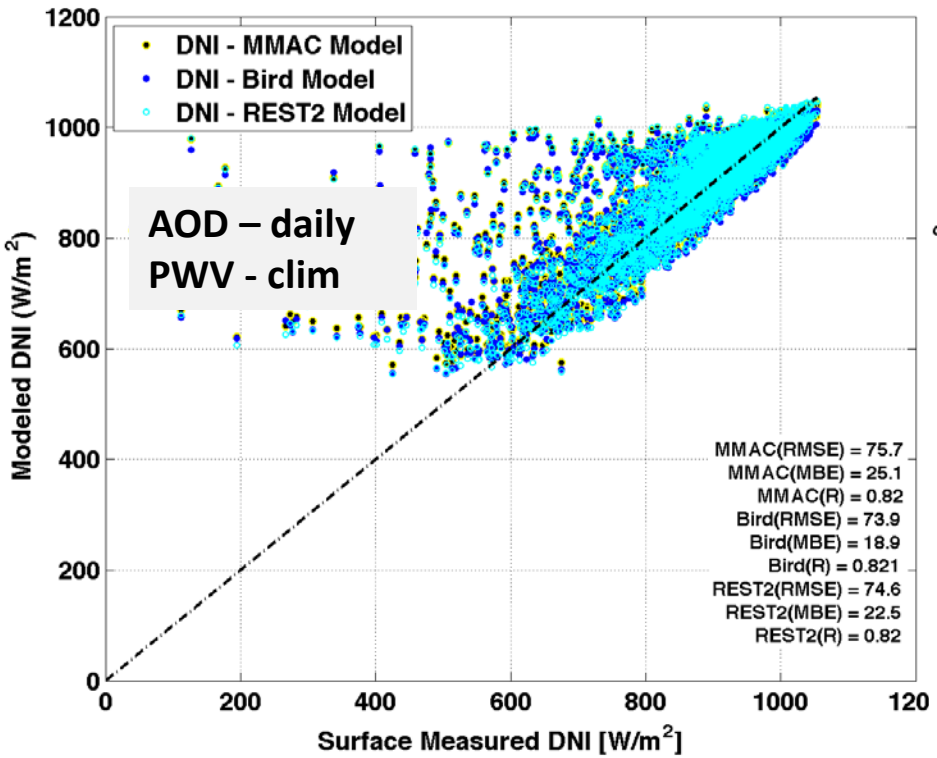


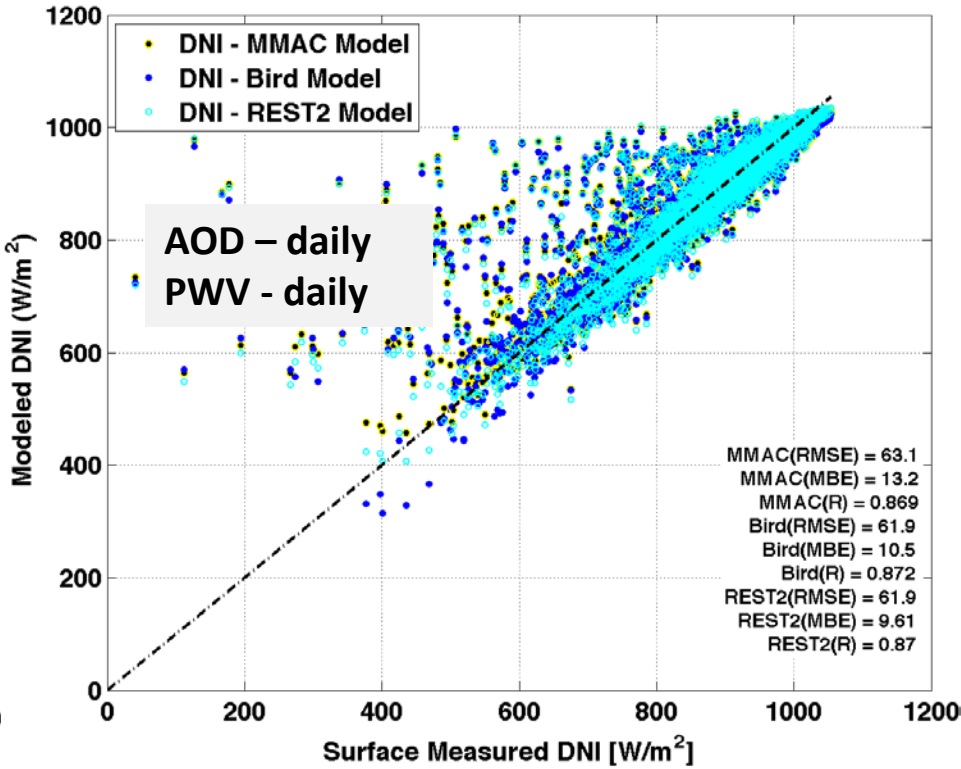


	RMSE (W/m^2)	MBE (W/m^2)	R
MMAC	31	19	0.996
Bird	29	4	0.996
REST2	25	6	0.996

	RMSE (W/m^2)	MBE (W/m^2)	R
MMAC	30	17	0.996
Bird	28	3	0.996
REST2	25	1	0.996

DNI -Desert Rock – NV Clear Sky Comparison



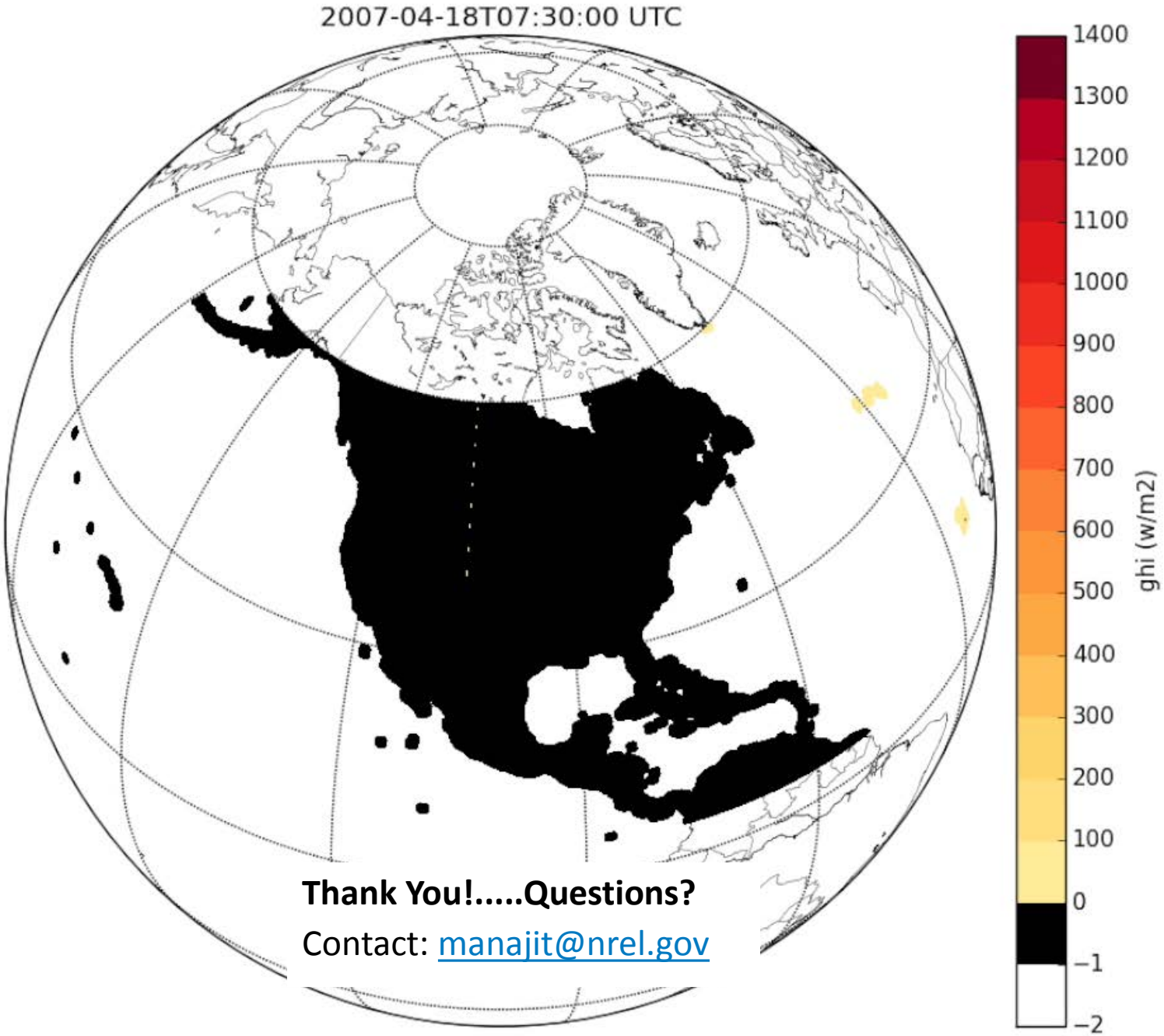


	RMSE (W/m^2)	MBE (W/m^2)	R
MMAC	76	25	0.82
Bird	74	19	0.82
REST2	75	23	0.82

	RMSE (W/m^2)	MBE (W/m^2)	R
MMAC	63	13	0.87
Bird	62	10	0.87
REST2	62	10	0.87

Conclusions

- **Clear sky GHI and DNI from the satellite is significantly accurate whether MMAC, REST2 or Bird models is used.**
- **Accurate aerosol and water vapor information is critical in properly modeling clear sky GHI and DNI.**
- **Accurate spatial and temporal satellite based spectral aerosol data are found to be the most important model input but most difficult to get right.**
- **MMAC is used in the beta version but we plan to use REST2 in future versions.**



Thank You!.....Questions?

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