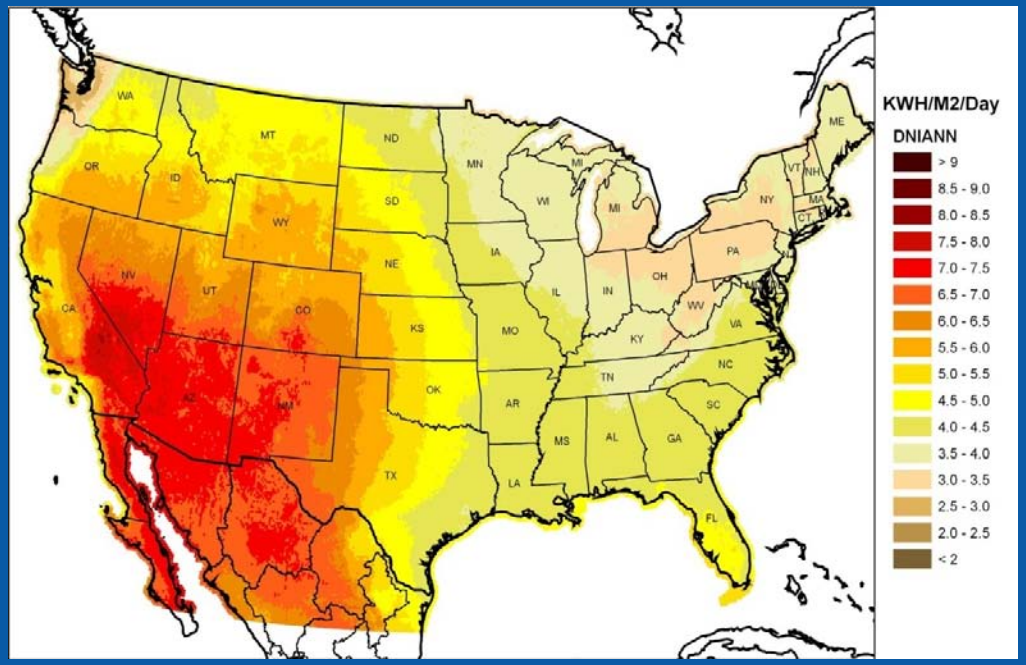
National Renewable Energy Laboratory
Innovation for Our Energy Future

National Solar Radiation Database (NSRDB) - 10 km Gridded Hourly Solar Database



Solar Resource Assessment Workshop
Denver, Colorado

Ray George, Steve Wilcox, Mary Anderberg

National Renewable Energy Laboratory

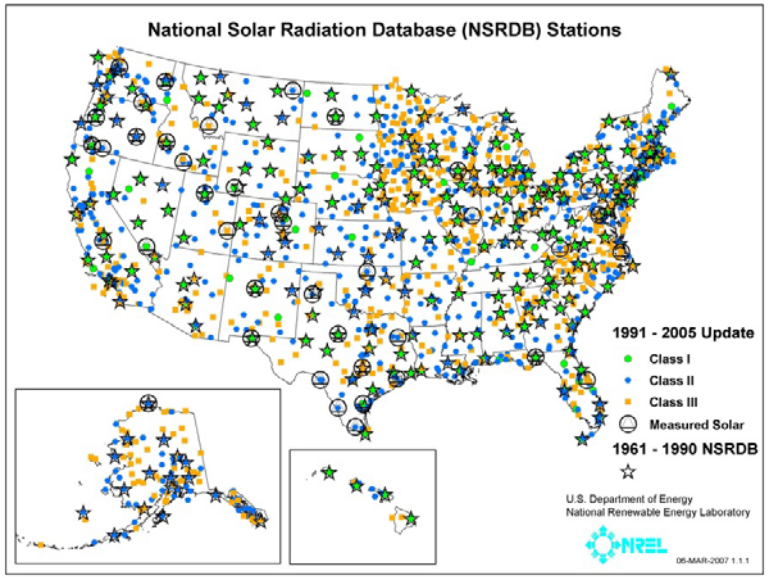
October 29, 2008

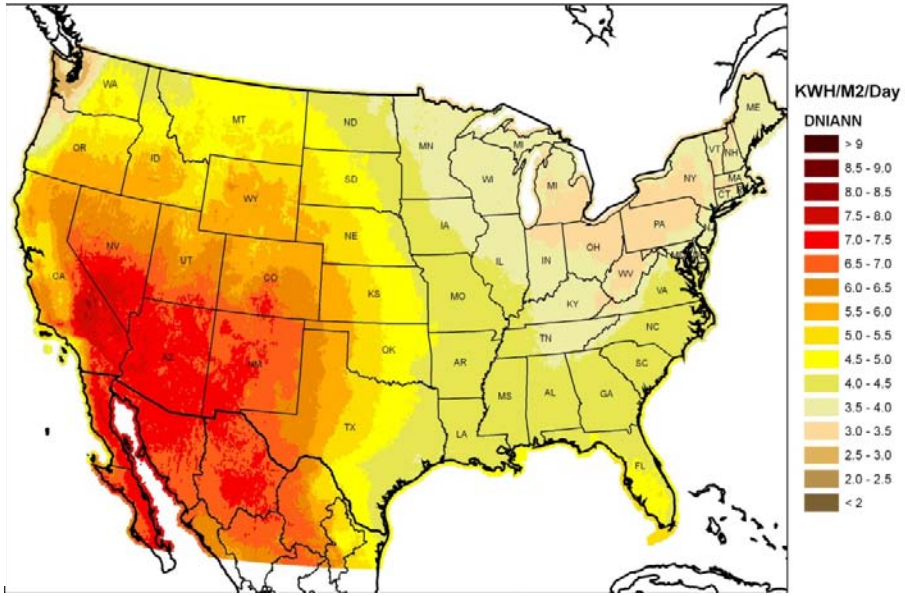
NREL/PR-550-44443

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

NSRDB Update – 1991-2005

Released in May 2007





NSRDB Station Data

Contains hourly solar and meteorological data for 1454 ground locations, 1991-2005

Distributed by National Climatic Data Center and NREL via web

NSRDB Gridded SUNY Data

Includes hourly satellite modeled solar data for years 1998-2005 on 10km grid

Hourly solar for any location can be combined with hourly met data for PV and CSP simulation.

www.nrel.gov/gis/cfm/input.cfm

New Satellite 10-km Data - Outline

Methodology

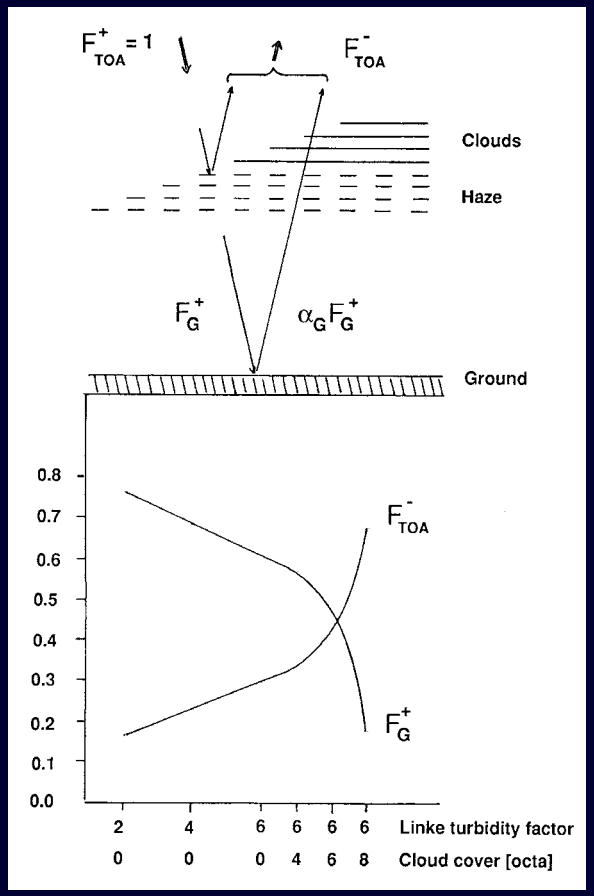
Map product description

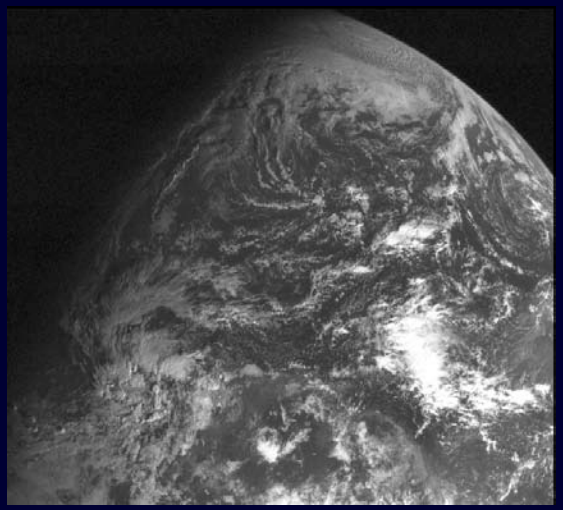
- Yearly Map Grids
- 8-year map “Climatological”
- Map adjustments
- How to obtain

Time Series Product

- Time shifting
- Diffuse editing
- How to obtain

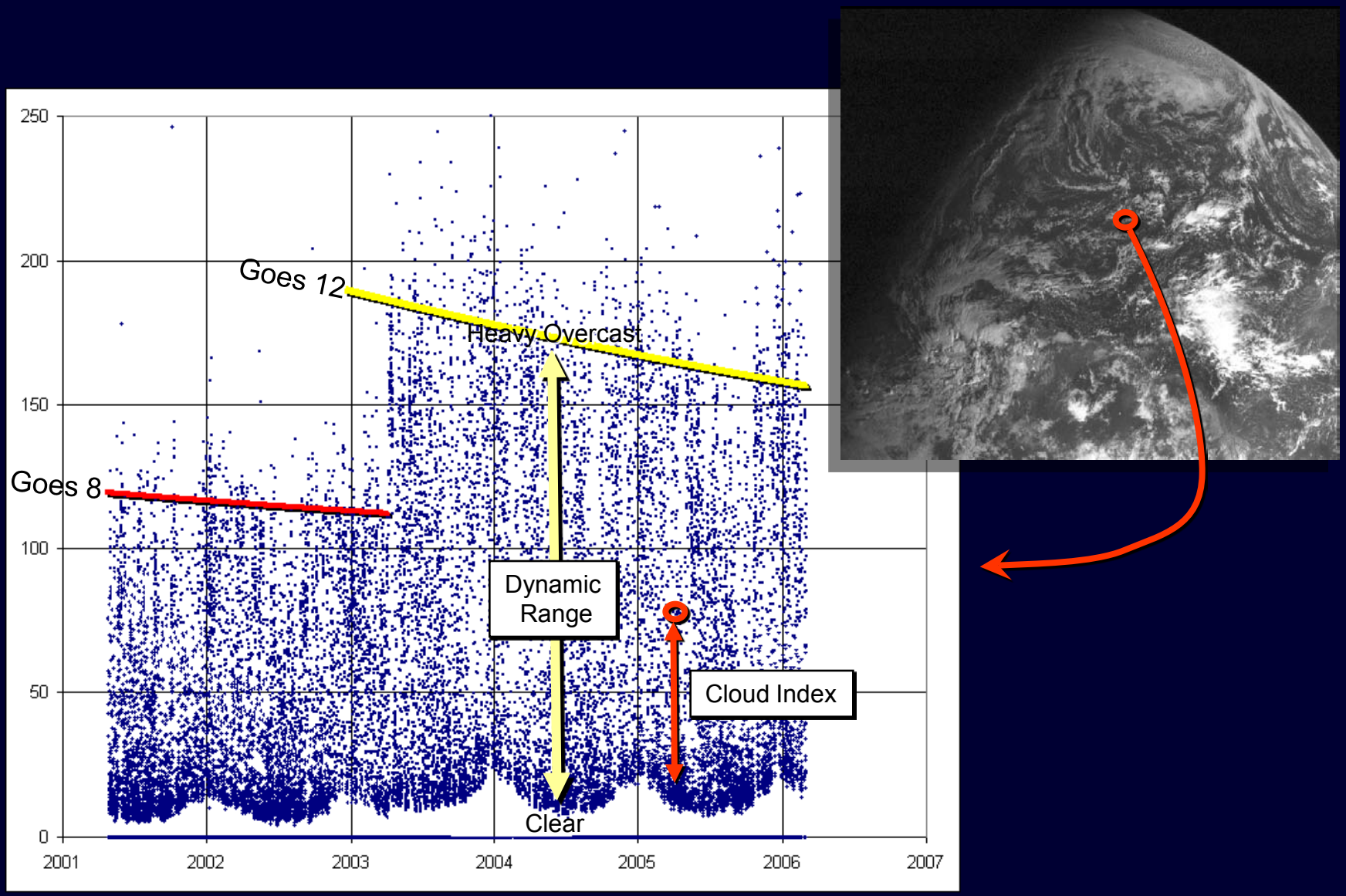
Basic principle





$$T = \frac{F^+_G}{F^+_{TOA}} = a - b\,\frac{F^-_{TOA}}{F^+_{TOA}}$$

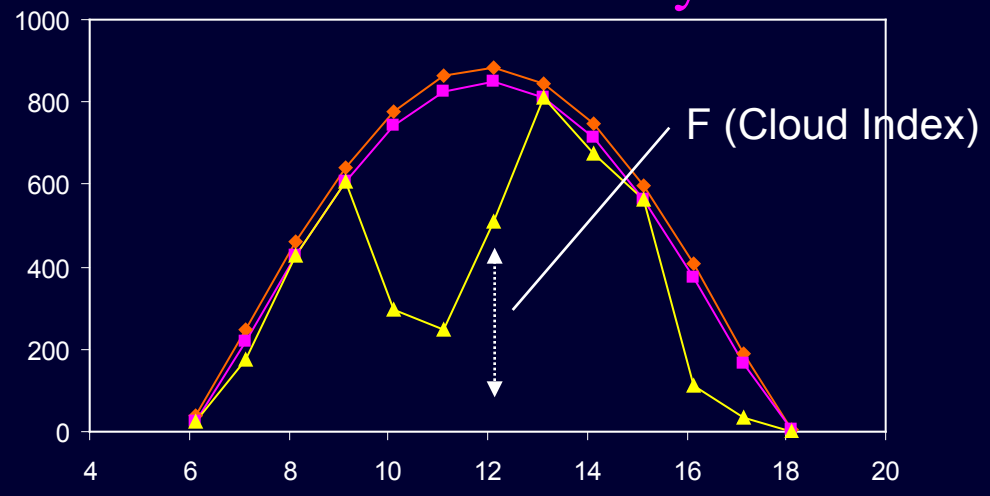
Richard Perez, et al.

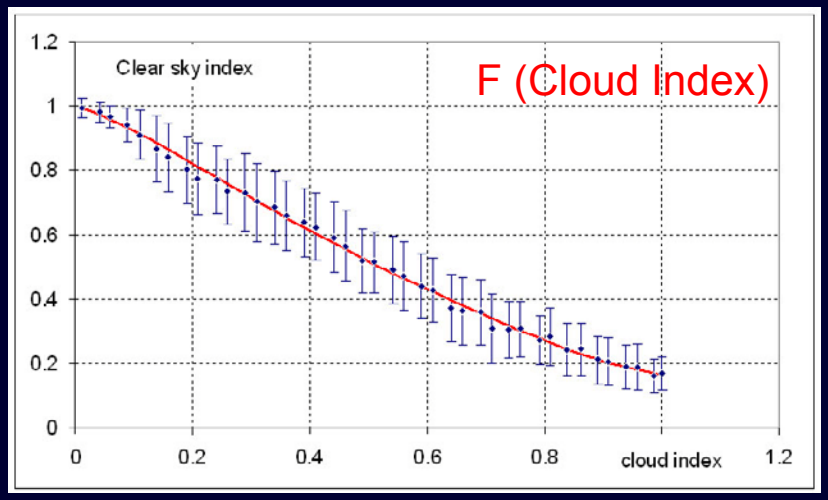


Richard Perez, et al.

GLOBAL IRRADIANCE

SOLIS clear sky model

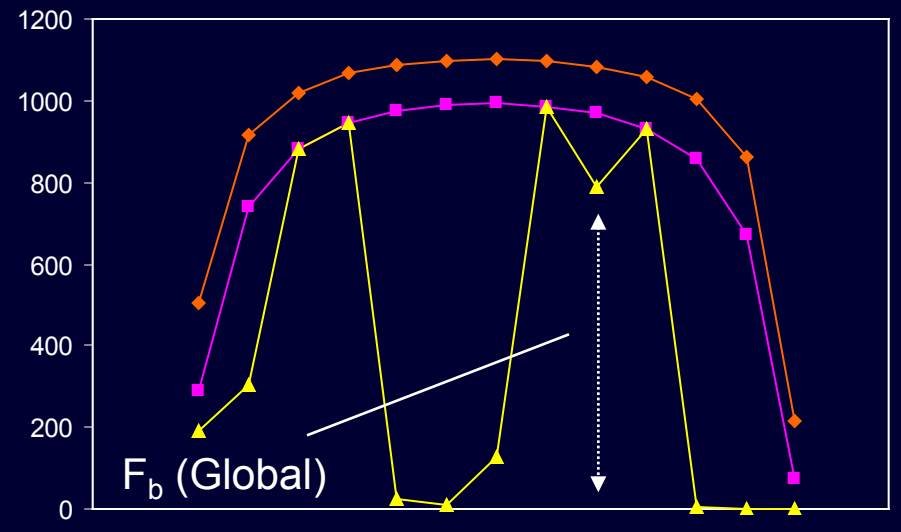




Richard Perez, et al.

Dirindex Model: DNI = Bird * f_b (GHI)

BIRD MODEL f (elevation, AOD, ozone, water vapor)

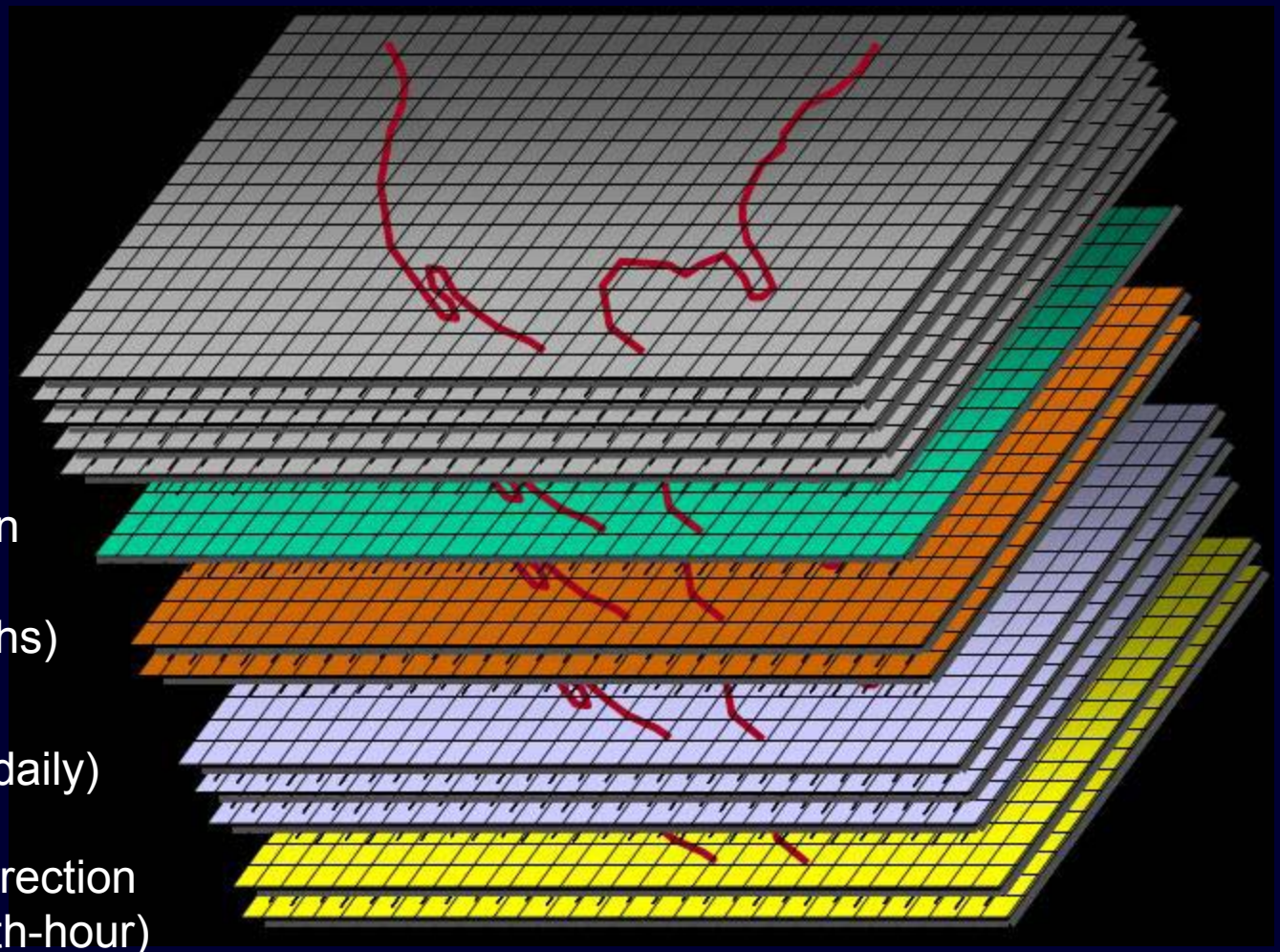


$$F_b = \frac{\text{Dirint (GHI)}}{\text{Dirint (GHI}_{clear})}$$

Dirint = NREL's DISC model modified per ASHRAE, 1993

Richard Perez, et al.

Operational Model



Pixels hourly

Terrain elevation

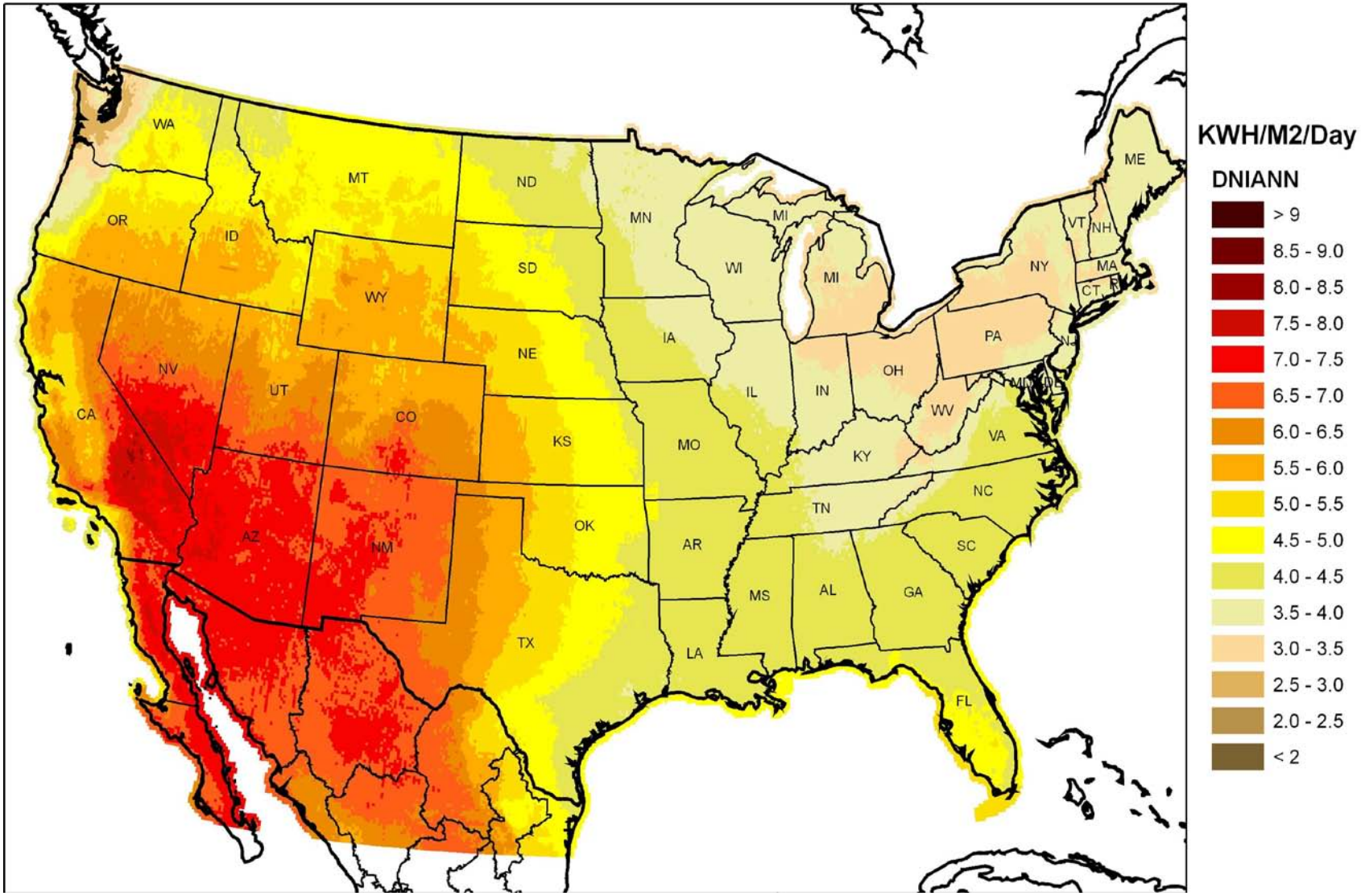
AOD, H_2O, O_3 (12 months)

Snow cover (daily)

Specular correction
(month-hour)

Richard Perez, et al.

Satellite Global and DNI 8 Year Maps



Satellite Solar Map Products

0.1 degree grid – nominal 10 km spacing

Coverage CONUS, Northern Mexico, HI

8 year average, 12 months + annual = 13 grids

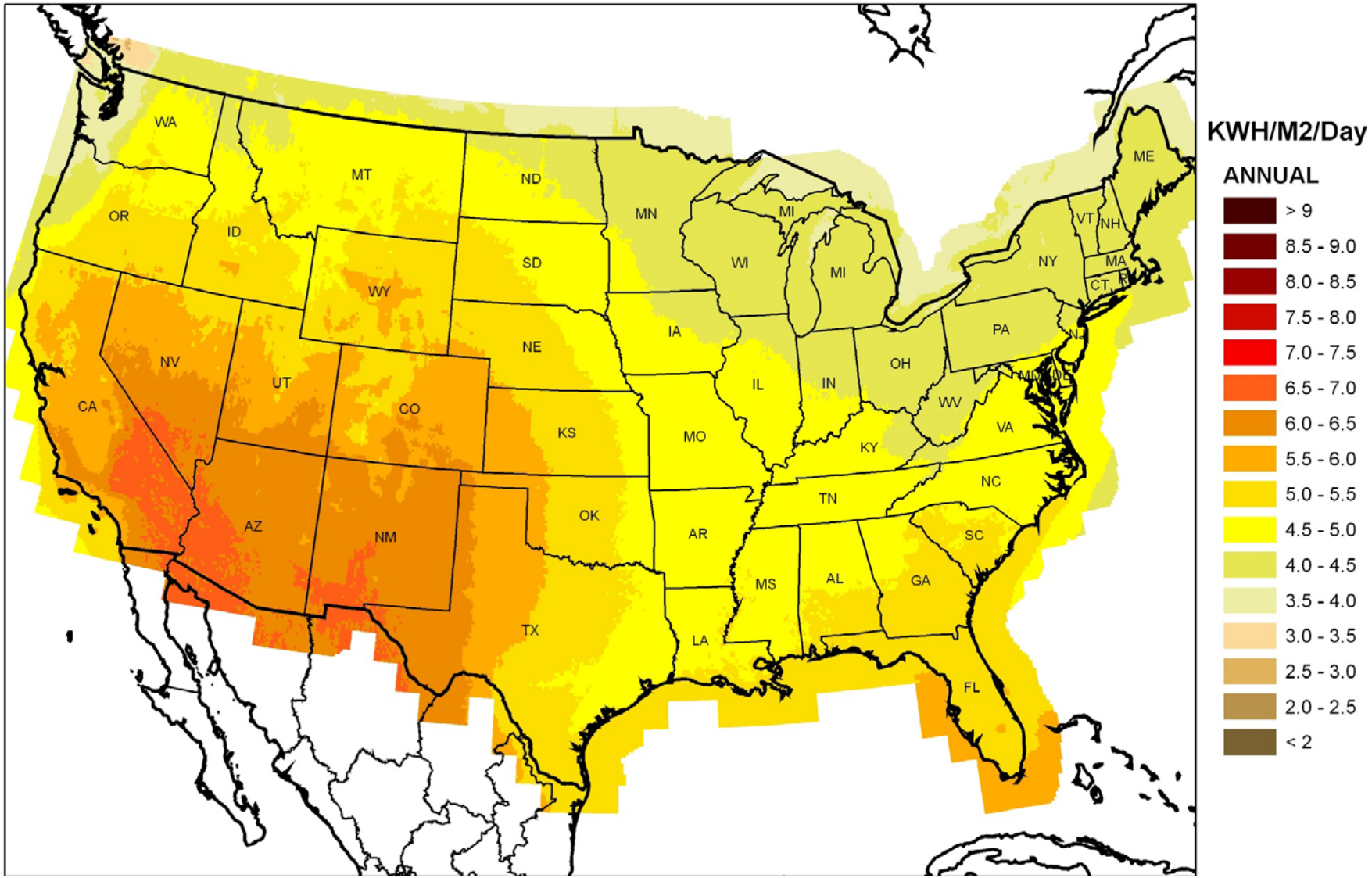
DNI data adjusted to eliminate low anomalies

- (caused by very bright backgrounds)
- Adjusted to match a smoothed map

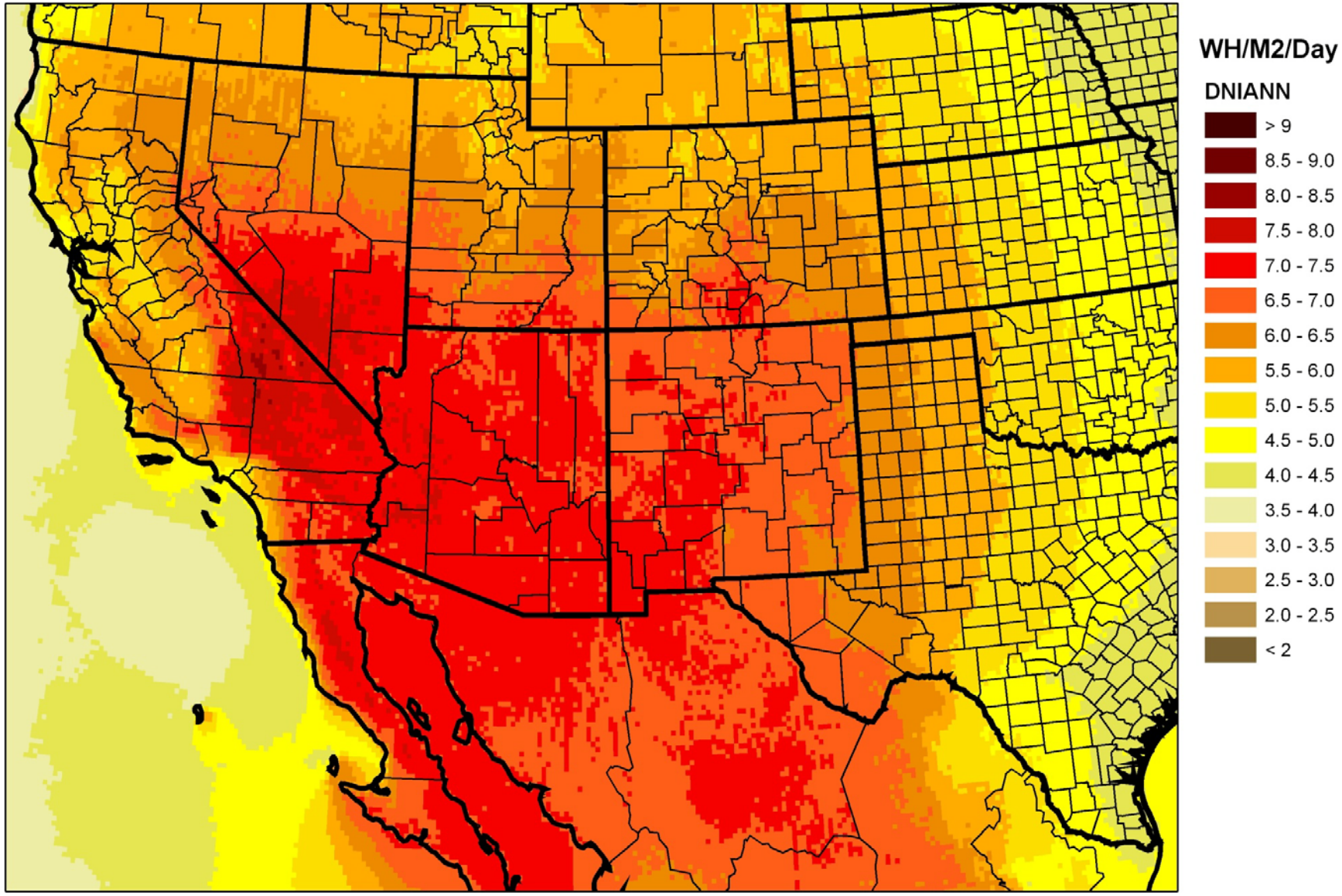
DNI and PV (Latitude Tilt) 8-year mean monthly data can be downloaded from www.nrel.gov/gis/cfm/input.cfm .

Data Fields in ".dbf" file – can be loaded into Excel, Access, etc.

Satellite Global Latitude Tilt Maps



NSRDB/SUNY DNI - Annual Average 1998-2005



Uncertainty in Solar Radiation Estimates can Directly Influence Success of Concentrating Solar Projects

Direct Normal Irradiance (DNI) modeled estimates have an uncertainty that ranges up to +/- 20%

Break-even annual DNI for Concentrating Solar Power (CSP) plants is generally considered to be DNI = 7000 whr/m^2/day

DNI values are highly dependent on AOD (Aerosol Optical Depth), which is hard to measure.

Clean air prospecting with better aerosol data will reduce uncertainty of DNI estimates.

Sources of Uncertainty in DNI

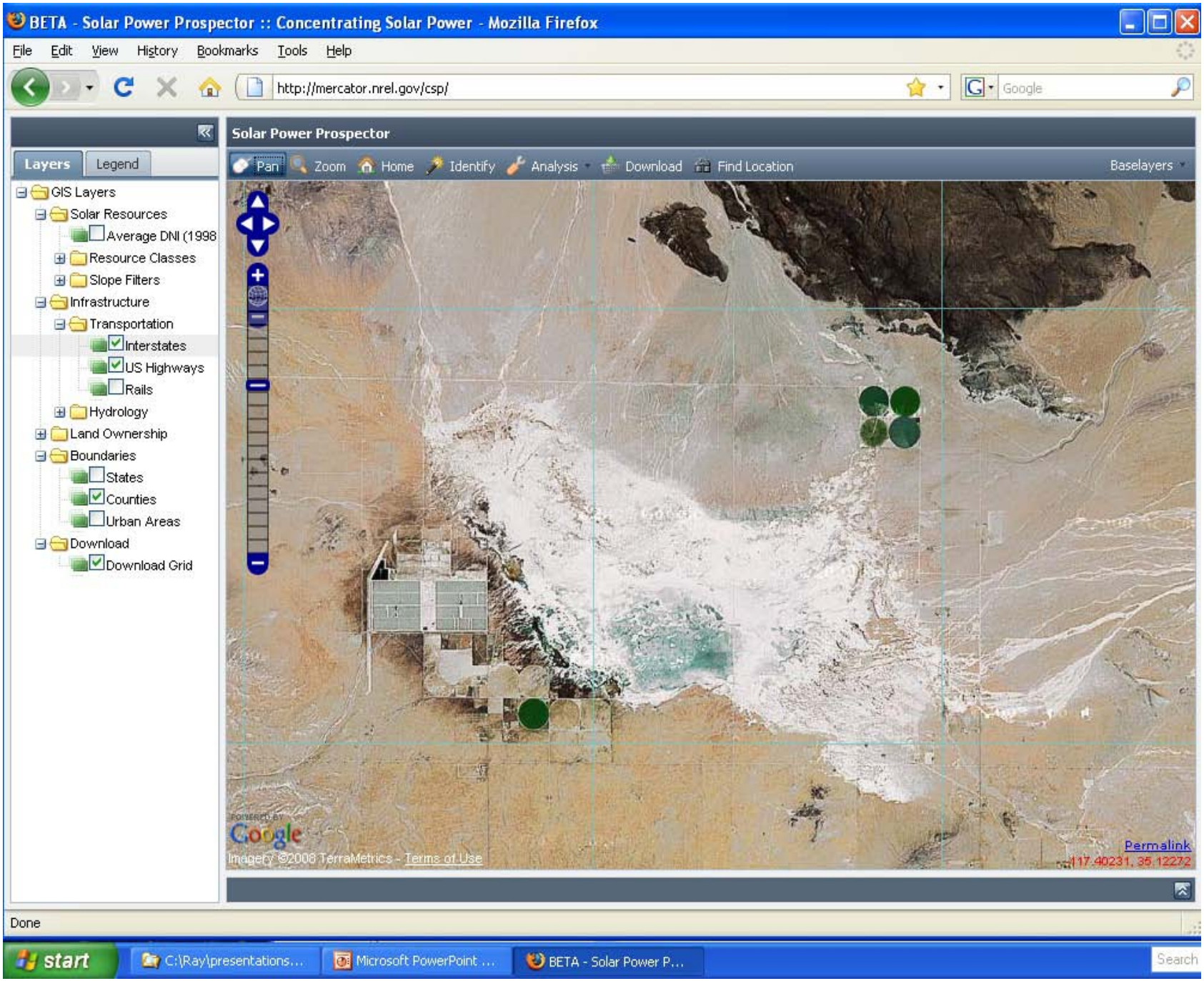
High Surface Albedo

Unrealistic Aerosol Optical Depth

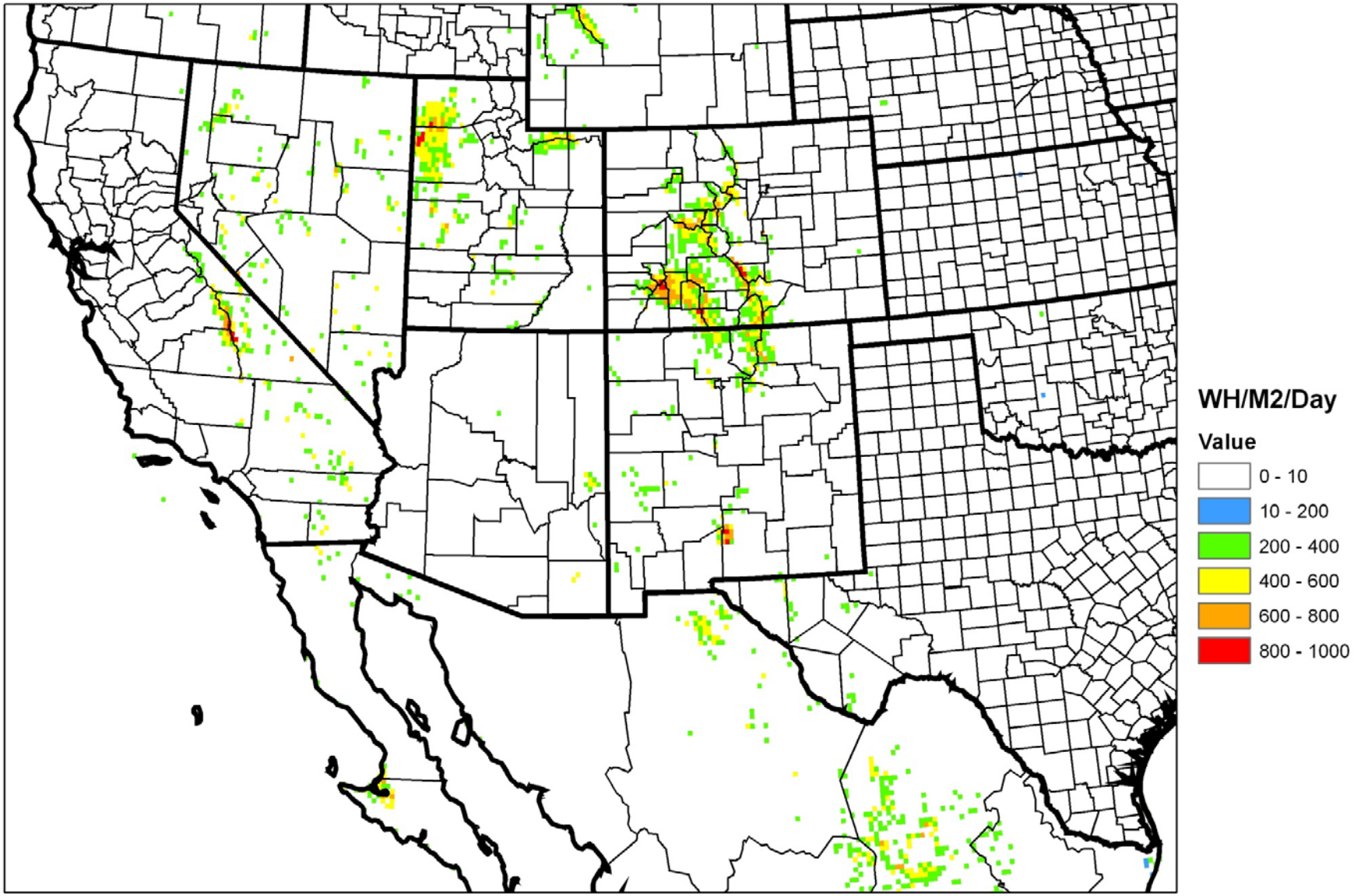
- Monthly and Annual Means
- Daily or Weekly Patterns

8 Years (1998-2005) Not Representative of Climate

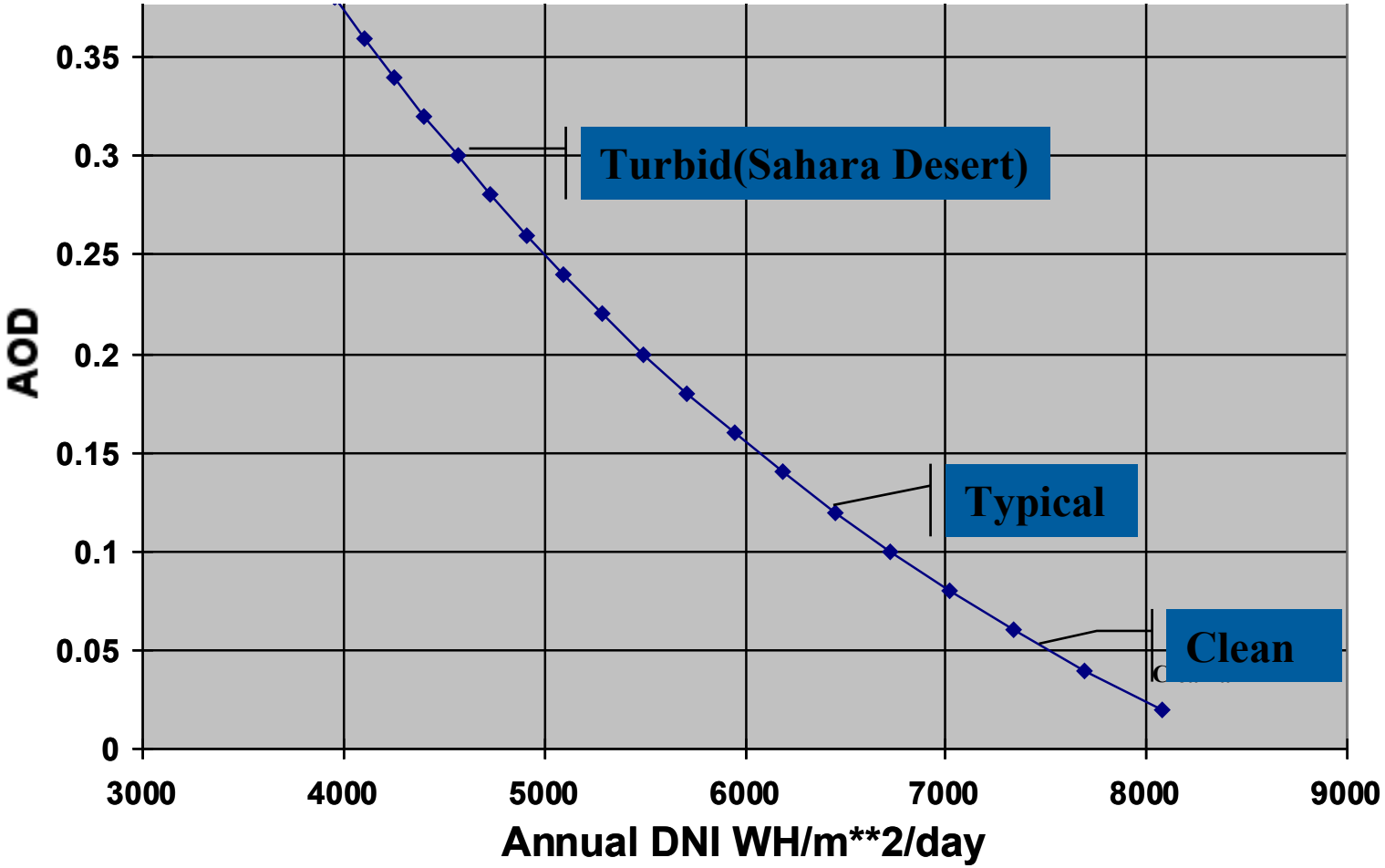
Spatial Variation Below 10 Km. Grid


BETA - Solar Power Prospector :: Concentrating Solar Power - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://mercator.nrel.gov/csp/
Google
Solar Power Prospector
Layers
Legend
GIS Layers
Solar Resources
Average DNI (1998
Resource Classes
Slope Filters
Infrastructure
Transportation
Interstates
US Highways
Rails
Hydrology
Land Ownership
Boundaries
States
Counties
Urban Areas
Download
Download Grid
Pan
Zoom
Home
Identify
Analysis
Download
Find Location
Baselayers
Google
Imagery ©2008 TerraMetrics - Terms of Use
Permalink
-117.40231, 35.12272
Done
start
C:\Ray\presentations...
Microsoft PowerPoint ...
BETA - Solar Power P...
Search

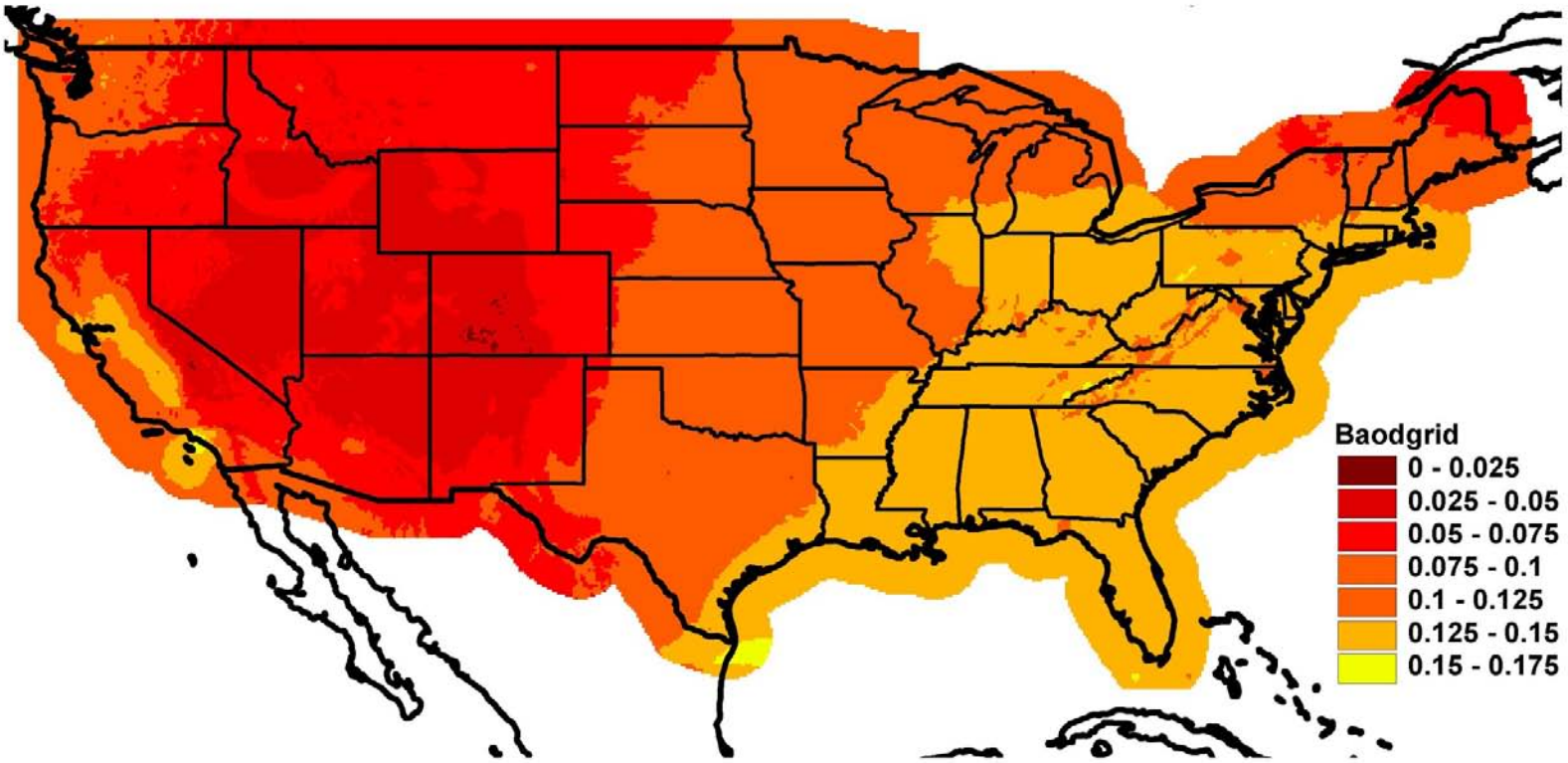
NSRDB/SUNY DNI - Corrections to Annual Average 1998-2005



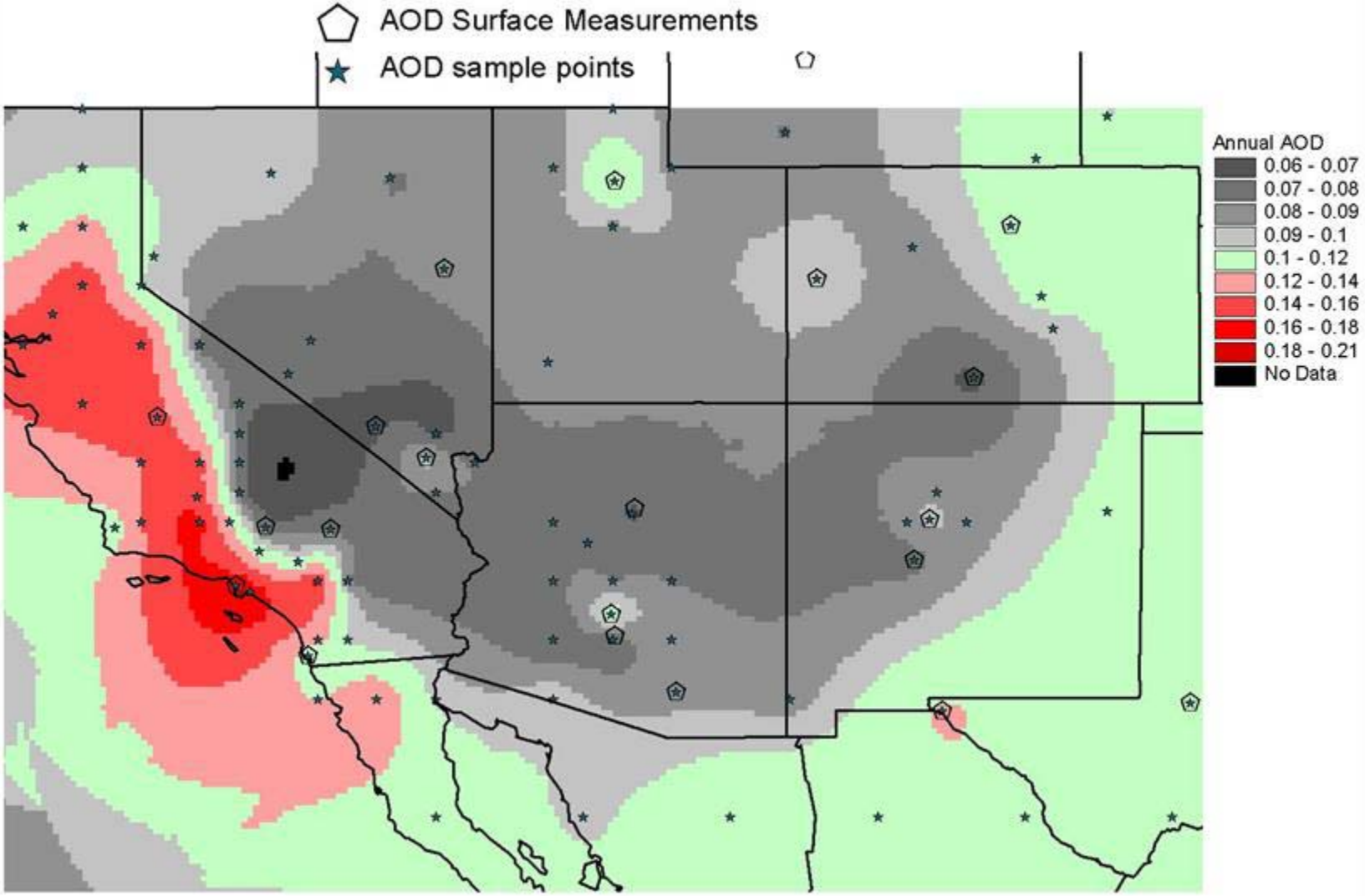
DNI very Sensitive to Aerosol Optical Depth (AOD)



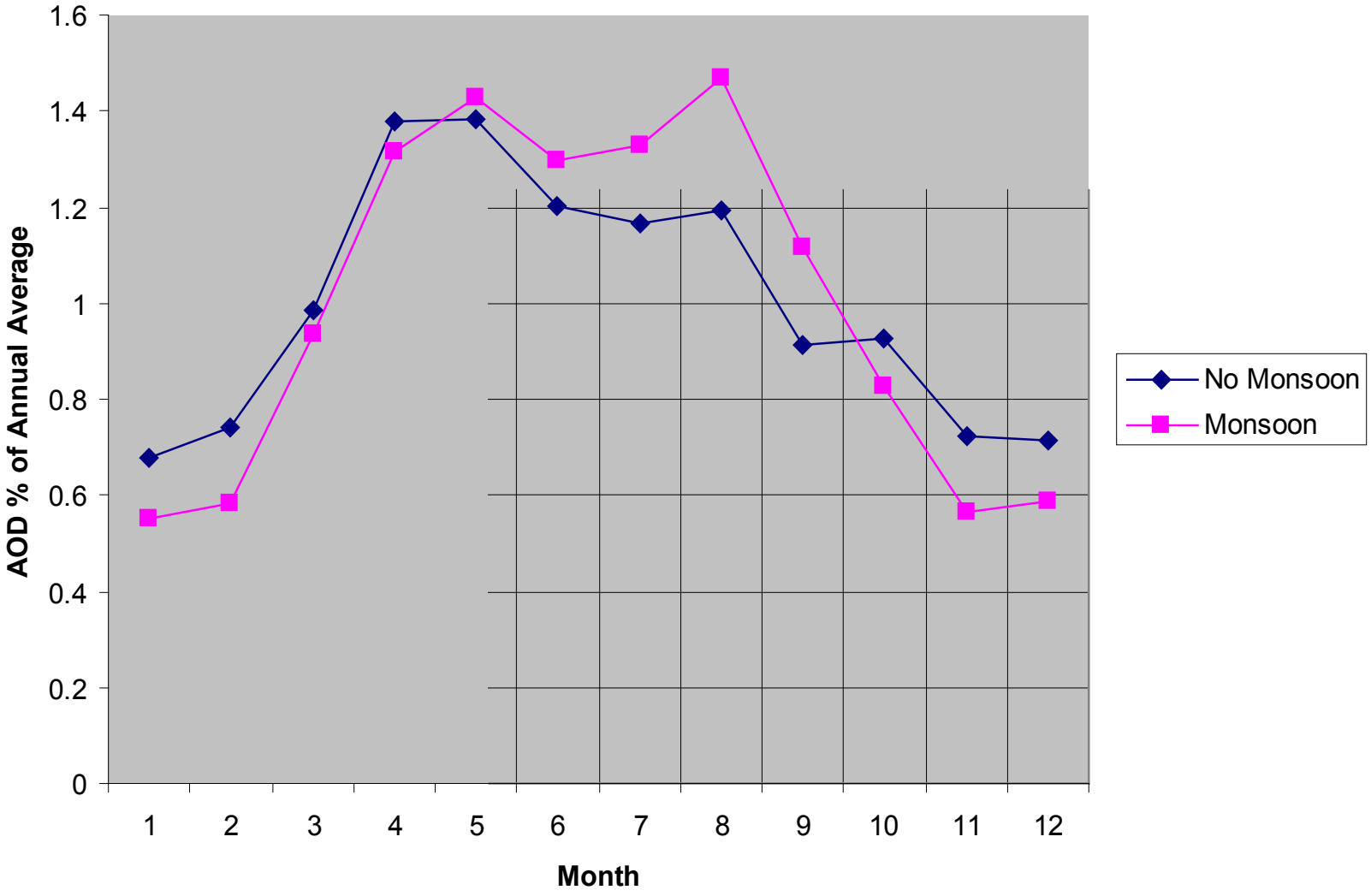
NSRDB - Annual Average BAOD



Annual AOD Adjusted to Sea Level

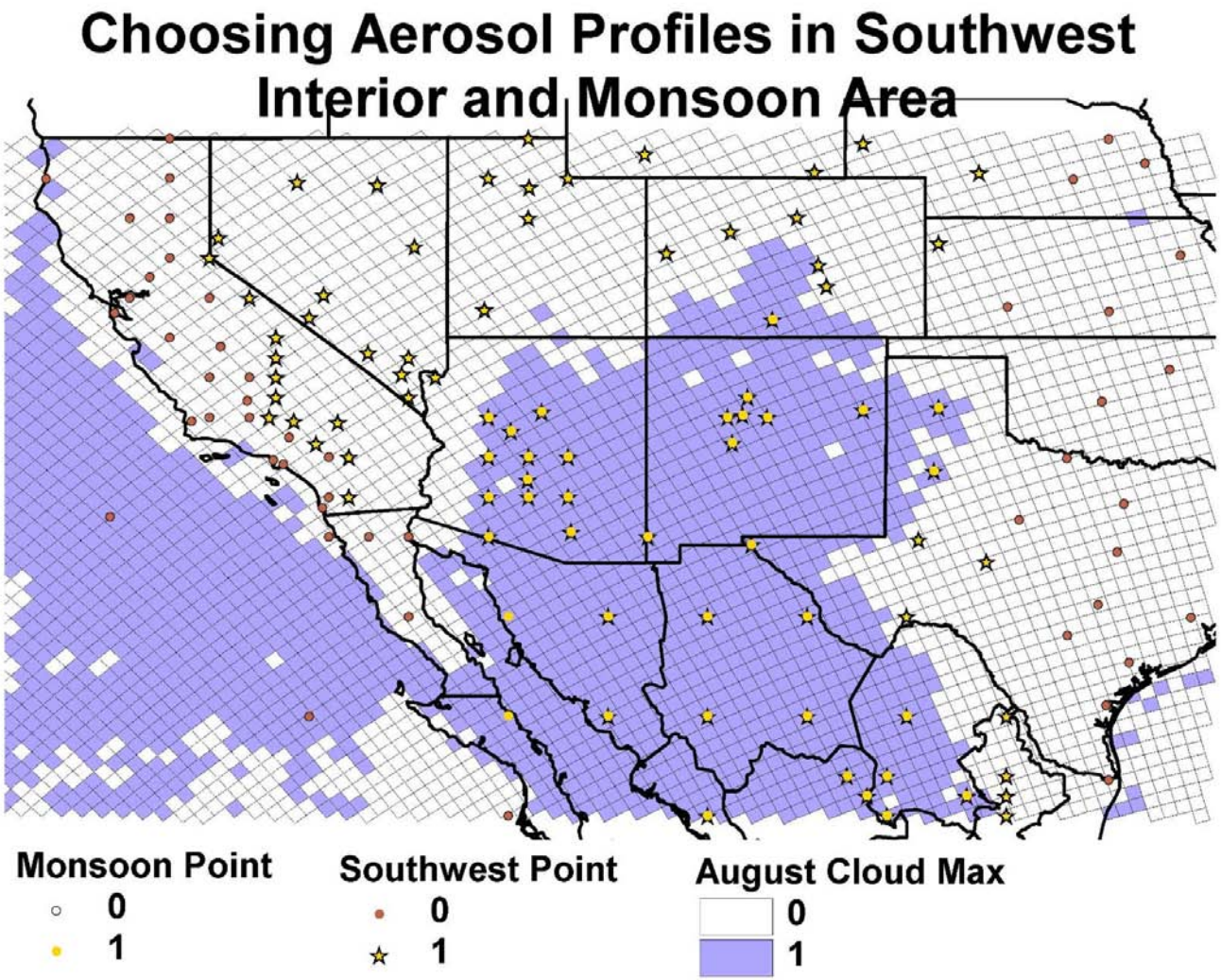


Southwestern Seasonal Aerosol Patterns

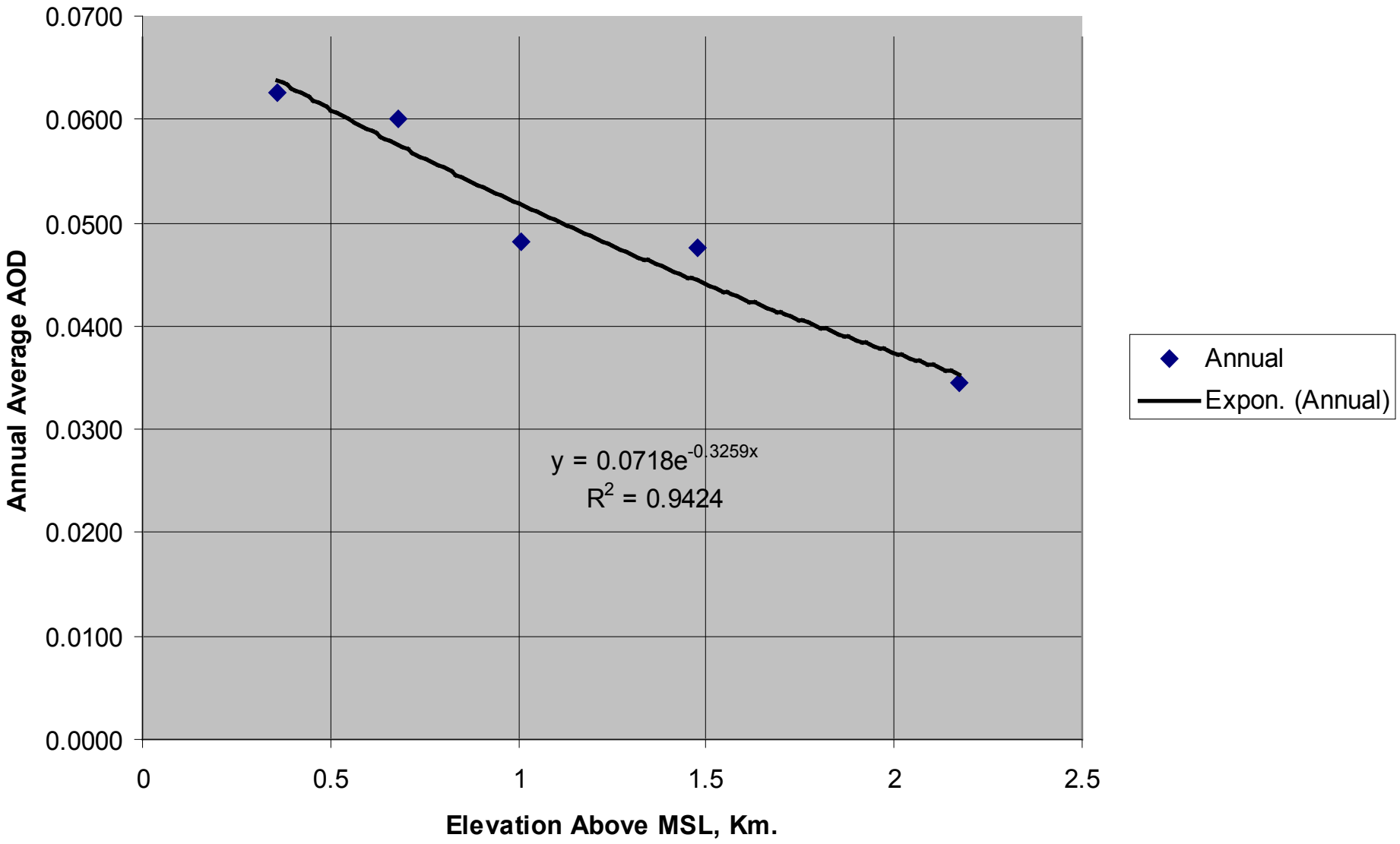


Use Real and Bogus Surface Points, Outside Monsoon Zone

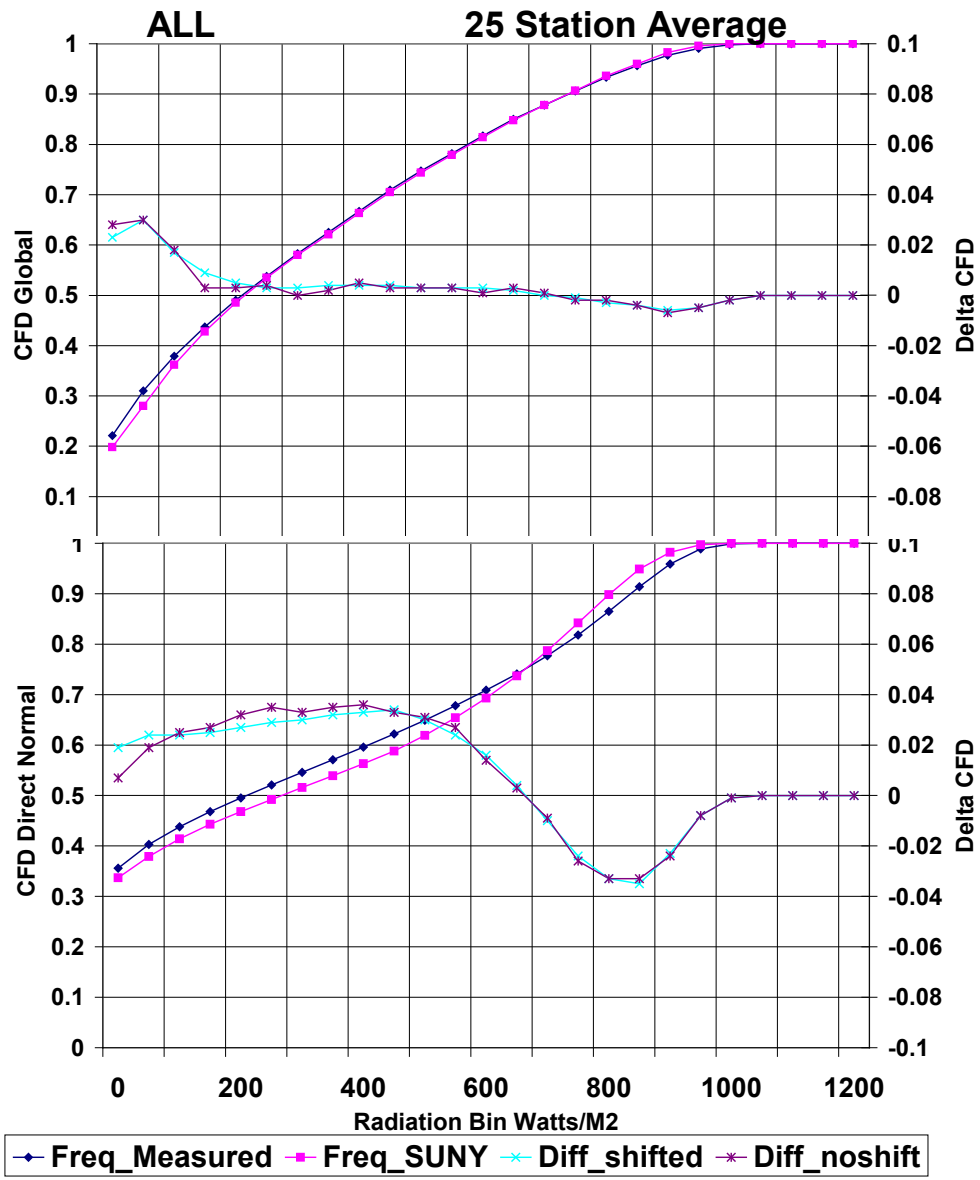
(Clouds in August > annual average)



Annual AOD vs Elevation



Global and Direct CFD for 25 Stations



Global Horizontal

Modeled Matches Measured

Direct Normal

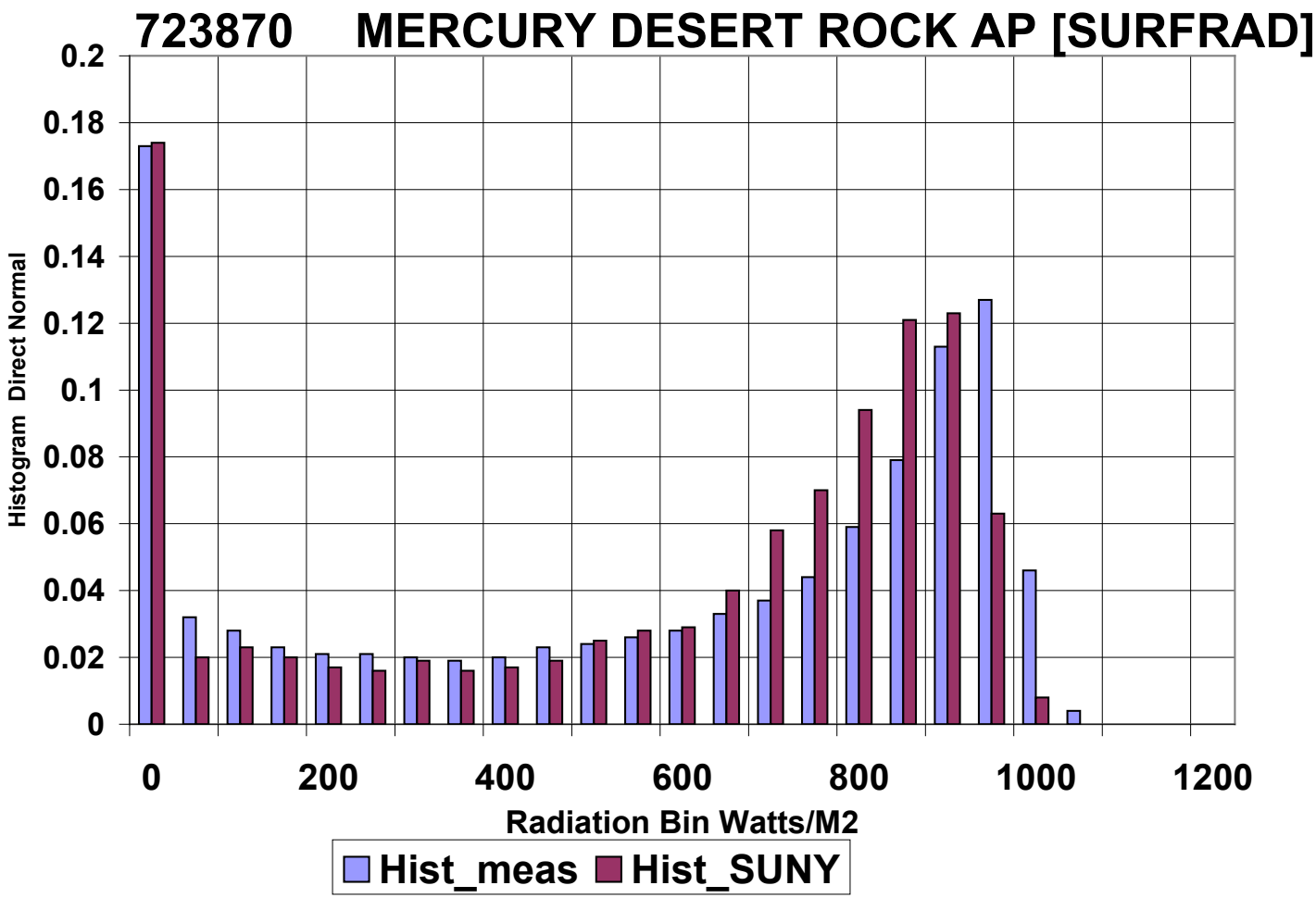
Modeled Lower than Measured

(lower bins)

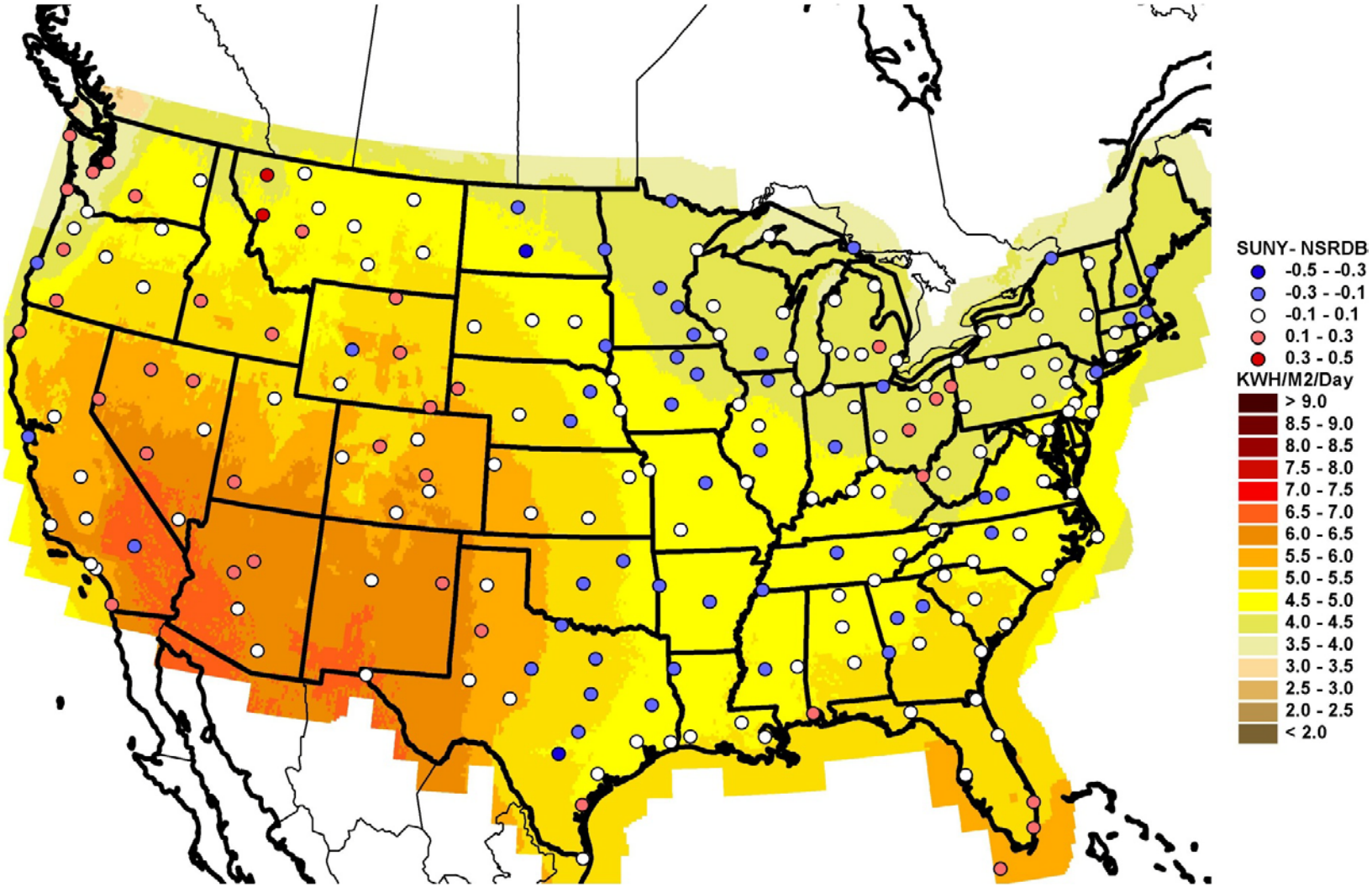
Modeled Higher than Measured

(higher bins)

Histogram of DNI, Desert Rock



Annual Latitude Tilt from Perez Data 1998-2005
Points = Perez-NSRDB 1961-1990, Watt-Hr/M2/Day



Obtaining Satellite Time Series

NSRDB – combined with weather data for 1452 sites – from NCDC

NSRDB/SUNY – shifted and unshifted radiation, no WX – from NCDC – free at: ftp://ftp.ncdc.noaa.gov/pub/data/nsrdb-solar

NSRDB/SUNY map files from NREL – ESRI Shapefile format - free at: www.nrel.gov/gis/cfm/input.cfm

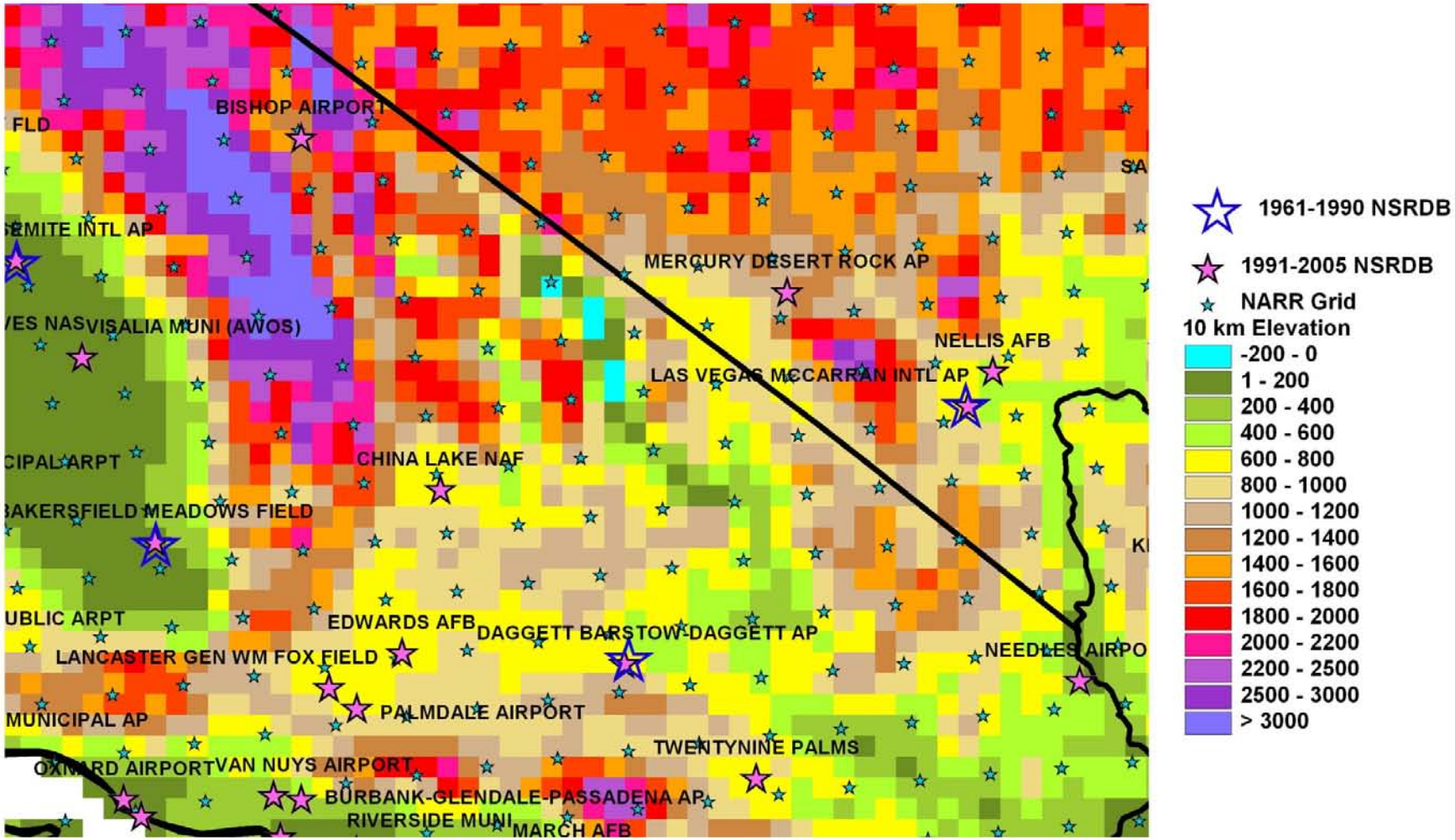
Gridded Satellite and Weather Data

Weather Data from NSRDB (surface measured) or NARR

NARR = North American Regional Reanalysis, 32 km grid, 3 hourly data.

Stations assigned to each 10km solar grid point as a function of proximity and elevation.

Grid = Perez 10 Km. Elevation, Meters
Points = NSRDB and NARR Weather Data



CSV Hourly Files

114953475	34.75	-114.95	587.9	-8	91151	20.6	-115.08	34.599	708.2		
2005	1	1	1	0	0	0	7.2	3.3	932.4	215	3.65
2005	1	1	2	0	0	0	6.87	3.07	932.1	215	3.33
2005	1	1	3	0	0	0	6.53	2.83	931.9	197	3.01
2005	1	1	4	0	0	0	6.2	2.6	931.6	197	2.69
2005	1	1	5	0	0	0	5.97	2.03	931.4	197	2.51
2005	1	1	6	0	0	0	5.73	1.47	931.3	224	2.32
2005	1	1	7	0	0	0	5.5	0.9	931.1	224	2.14
2005	1	1	8	59	253	29	6.93	1.03	932.8	224	1.89
2005	1	1	9	198	356	98	8.37	1.17	934.5	222	1.65
2005	1	1	10	367	595	123	9.8	1.3	936.2	222	1.4
2005	1	1	11	417	432	202	10.6	0.93	935.3	222	1.49
2005	1	1	12	379	228	257	11.4	0.57	934.3	156	1.59
2005	1	1	13	314	97	264	12.2	0.2	933.4	156	1.68

International DNI Data

SWERA – Solar and Wind Eneregy Resource Assessment

CSR 40 km modeled DNI over large regions.

Higher resolution (SUNY, DLR) DNI over smaller areas

TMYs for selected countries.

Swera.unep.net

SWERA.UNEP.NET – Download Data and Maps

Main Menu

Home Page
About SWERA
About Solar and Wind
Products
Countries
Business
Calendar
Links
Search
Mapping Help
SWERA Intranet

Welcome To SWERA

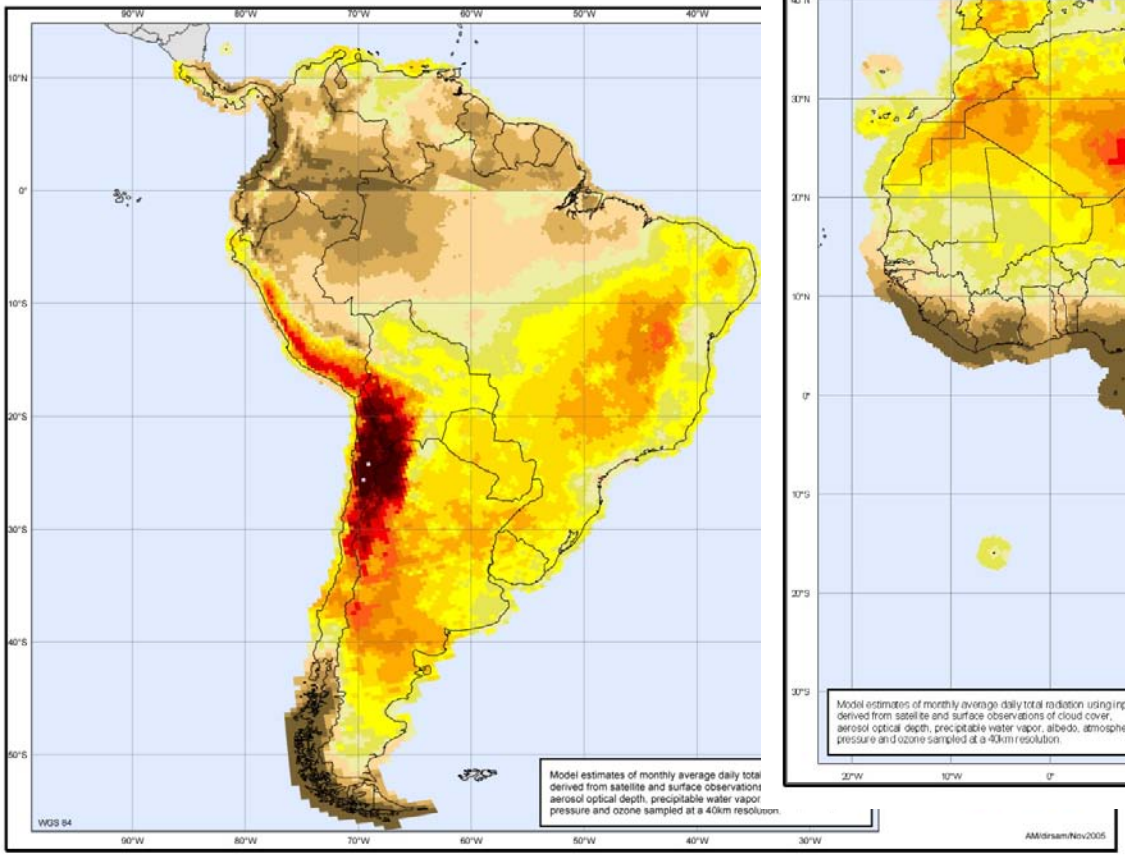
The SWERA website provides information about solar and wind energy resources in thirteen partner countries around the world. Products held in the SWERA archive include data on wind and solar energy potential, plus detailed country energy analyses. To learn more about renewable energy in each country or the partner agencies, click on the map or the menu. SWERA is a UNEP (United Nations Environment Programme) project with co-financing from GEF. The goal is to provide solar and wind energy assessments to potential investors and the public to promote more effective use of alternative energy resources.

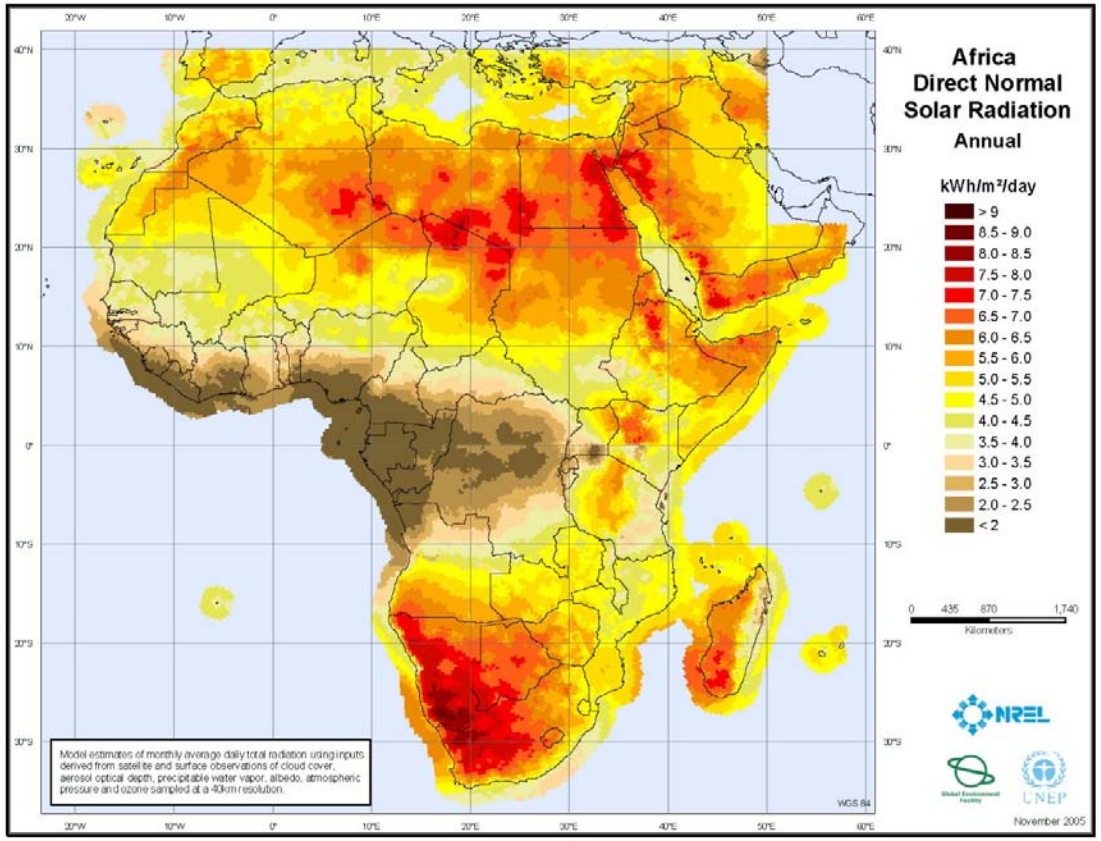
Now with the completion of the successful pilot project, SWERA is being expanded into a full Programme offering resource information and mapping tools across the spectrum of renewable energy sources. All information and tools can be found in one on-line location with a common user interface... click here for more details.

Languages

SWERA DNI Regional Maps

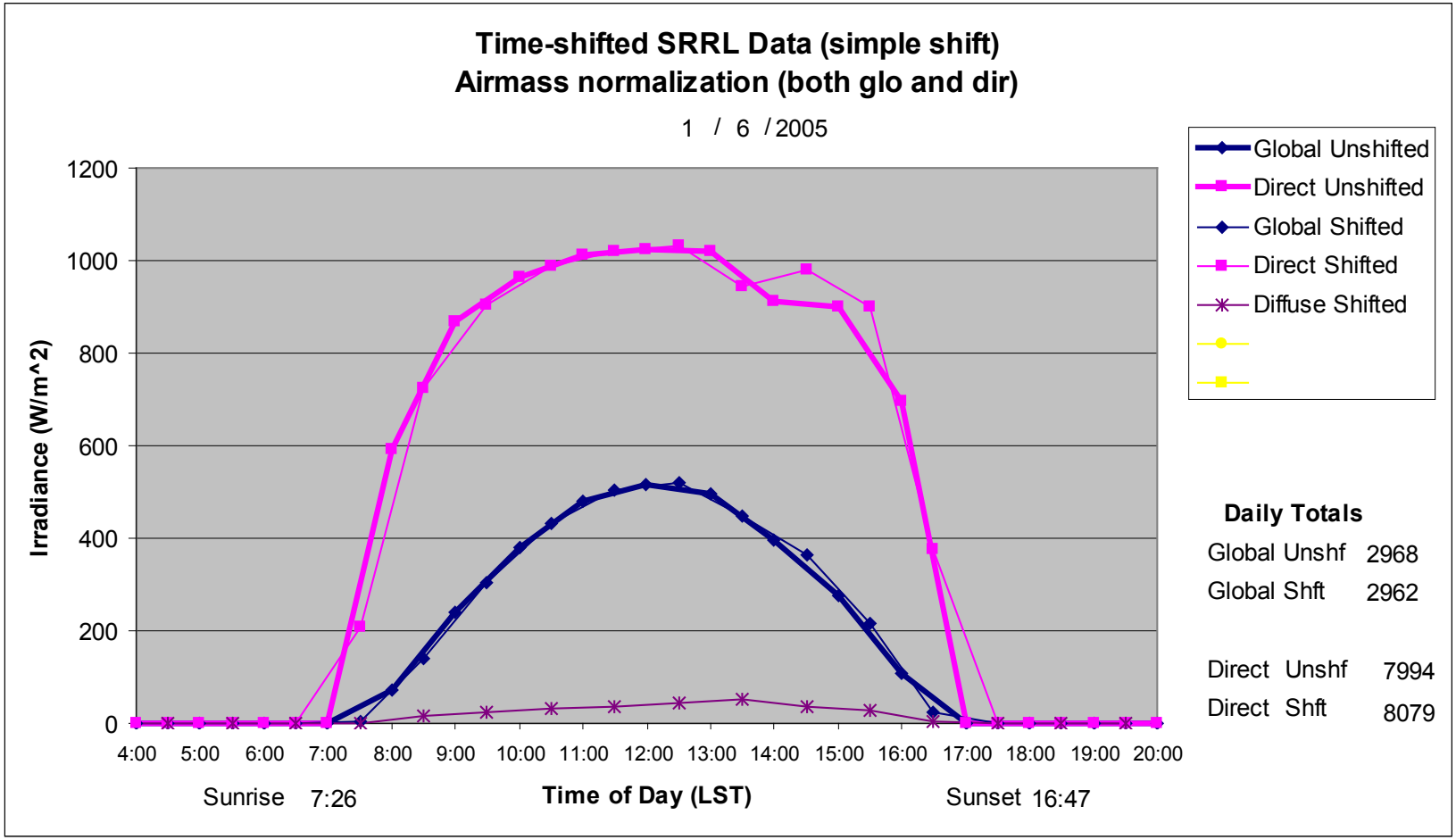
Africa, South America, East Asia, Mexico



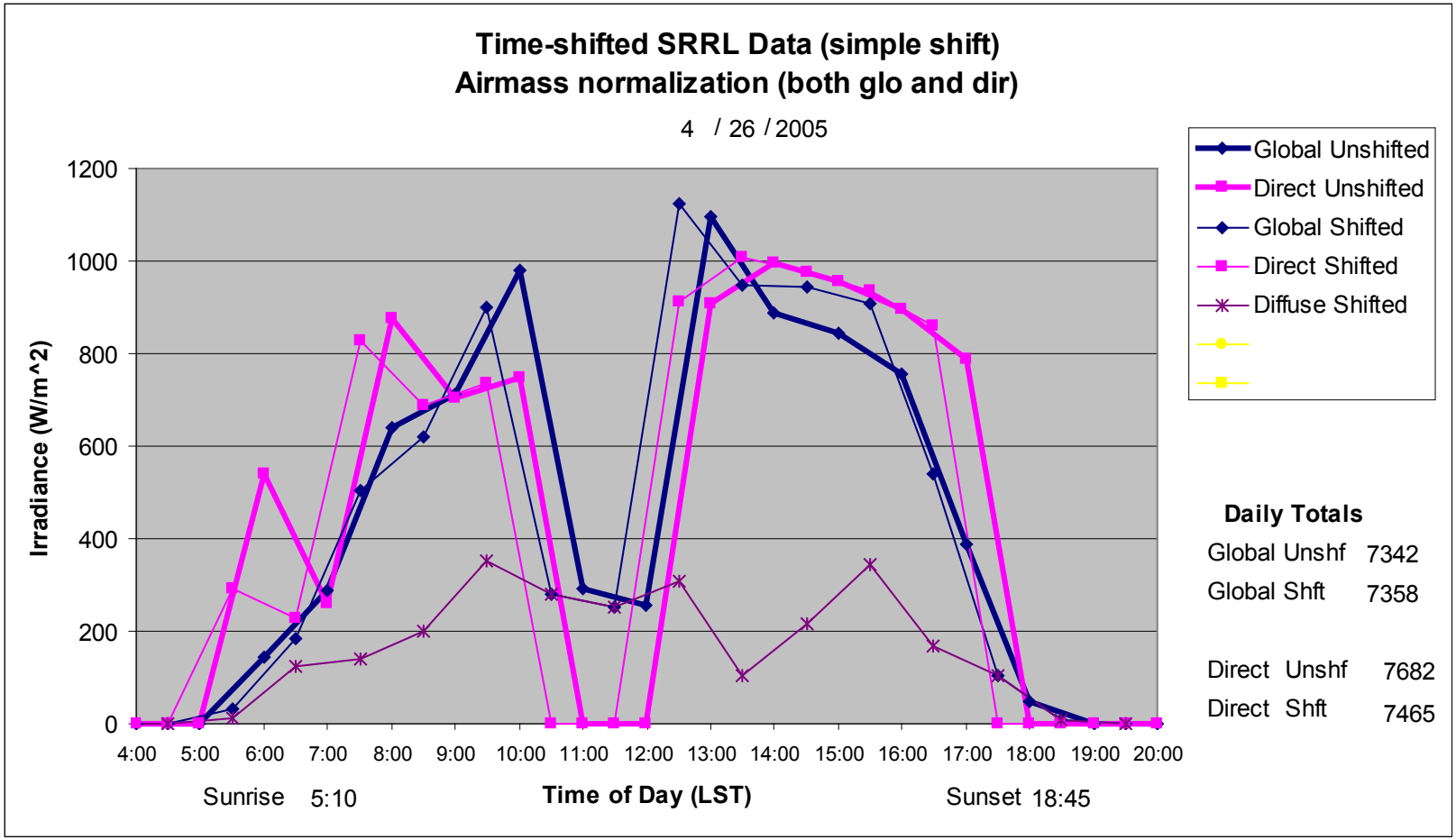


BACKUP SLIDES

Time Shifting – Clear Day



Time Shifting – Partly Cloudy



Corrections for Low Diffuse

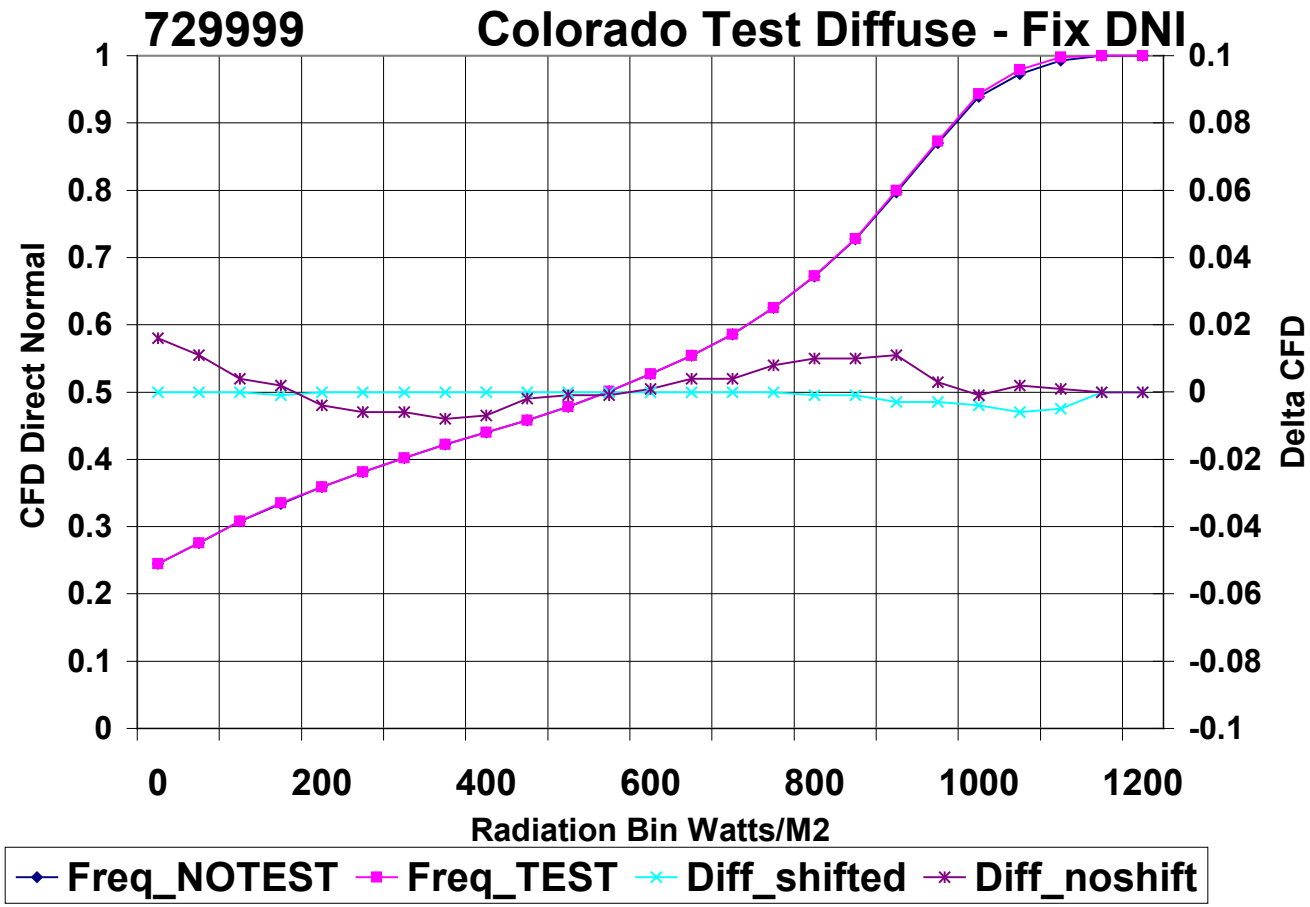
Calculate Minimum Diffuse Using GHI, AOD, Water Vapor

If 0.85*(Minimum Diffuse) is greater than Model Diffuse…

Set Diffuse = Minimum Diffuse

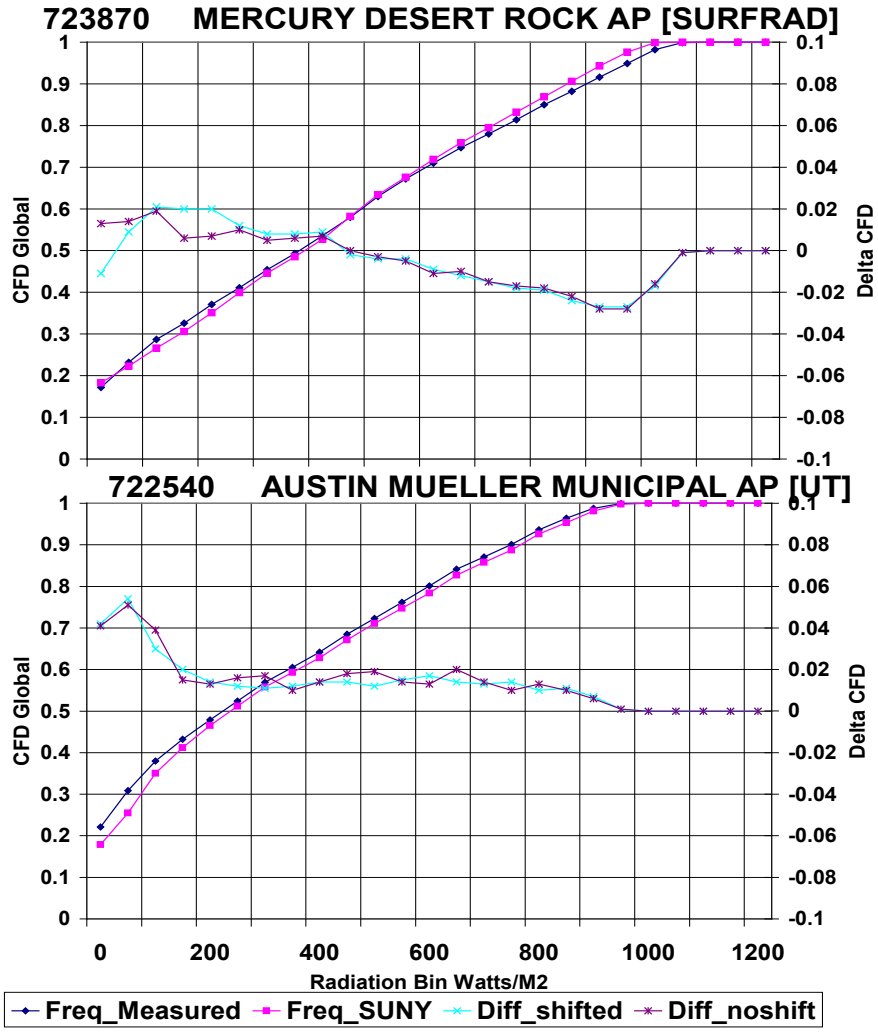
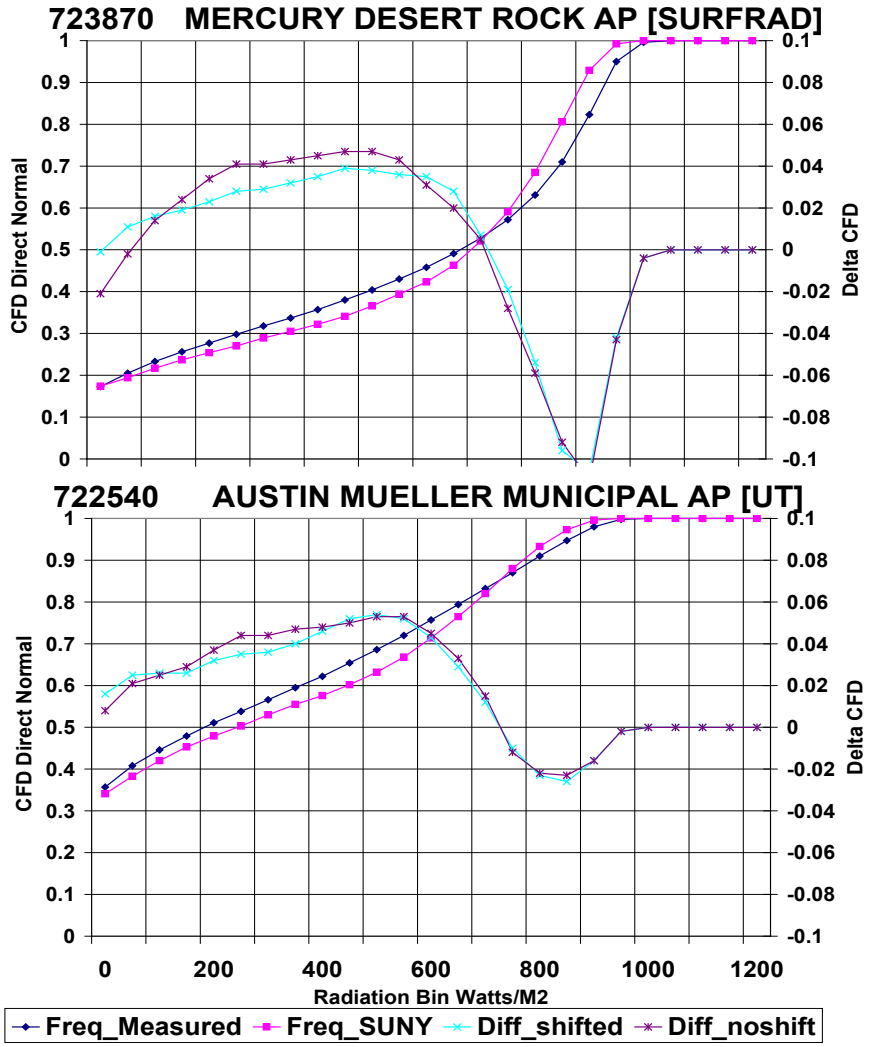
Recalculate DNI from Global, Diffuse

DNI Distributions Not Affected by Diffuse Test



Cumulative Frequency Distribution

Global Horiz



Direct Normal