Solar and Wind Energy Resource Assessment (SWERA)

a UNEP/GEF project

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Division of

Technology Industry and Economics

United Nations Environment Programme

برنامج الأمم المتحدة للبيئة • 联合国环境规划署

PROGRAMME DES NATIONS UNIES POUR L'ENVIRONNEMENT • PROGRAMA DE LAS NACIONES UNIDAS PARA EL MEDIO AMBIENTE

ПРОГРАММА ОРГАНИЗАЦИИ ОБЪЕДИНЕННЫХ НАЦИЙ ПО ОКРУЖАЮЩЕЙ СРЕДЕ

GEF Operational Program 6

- promote the adoption of renewable energy
- accelerate deployment
- remove barriers

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SWERA Goals

- to accelerate and broaden the investment in solar and wind energy resource development through better quality and higher resolution resource information and assessment
- to demonstrate the benefits of mapping assessments through 13 country pilot activities in 3 major regions
    - to develop systems and tools for resource assessment & renewable energy planning

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SWERA Rationale

- A significant barrier to large-scale use of solar and wind energy technologies in much of the developing world is the lack of reliable and comprehensive information on renewable energy resources (awareness and confidence)
- The information is critical to the inclusion of solar and wind in energy planning

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Rationale

Most meteorological measurements are made for other purposes:

- high wind speed, gusting wind and wind direction is important for aviation
- weather balloon data (not surface wind speed) is used in weather prediction
- wind at the surface is important for evaporation , agriculture
- solar radiation data is often not of high priority for precision measurement

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Rationale

Meteorological measurements are sparse and information is needed for sites of useful energy potential

- **remote regions where rural electrification is needed**
- **arid regions for concentrating solar thermal plants**
- **ridges of hills and coastlines where wind energy may be of most interest**

Therefore, high resolution geo-spatial resource information covering these areas is needed.

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The SWERA Approach

- For wind assessment
  - **Use upper air pressure/ wind data combined with high resolution surface topology information to estimate surface wind potential.**
  - **Calibrate/ validate against surface measurements**
  - **most importantly the geospatial high resolution mapping identifies locations for further investigation and site specific measurement**

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The SWERA Approach

- Wind mapping models:
  - **WRAMS by US NREL**
    - **selects most favourable topology for wind, calculates wind power from upper air data (20 years), calibrates to ground data = 1 km resolution wind power to within 20% wind power for more than 80% of the areas estimated.**
  - **KAMM by Risø Denmark**
    - **mesoscale weather model using same input data but with full flow modeling = 5 to 10 km resolution maps with better wind prediction in valleys and offshore with water surface waves**
  - **MM5 by CBEE**
    - **mesoscale weather model using same input data = episodic weather/ wind prediction methods at 30 km resolution mapping**
  - **WA^{S}P by all national collaborating partners**

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The SWERA Approach

- Wind measurement

- **WA^{S}P by all national collaborating partners**
  - **correction of existing ground data for surrounding obstructions = calibration/validation data and time/frequency of wind**
- **GTZ TERNA Program**
  - **for grid connected prospects, funding for ground measurements and project planning**
- **World Bank, UNDP and Regional Development Bank projects**
- **other wind energy investors**

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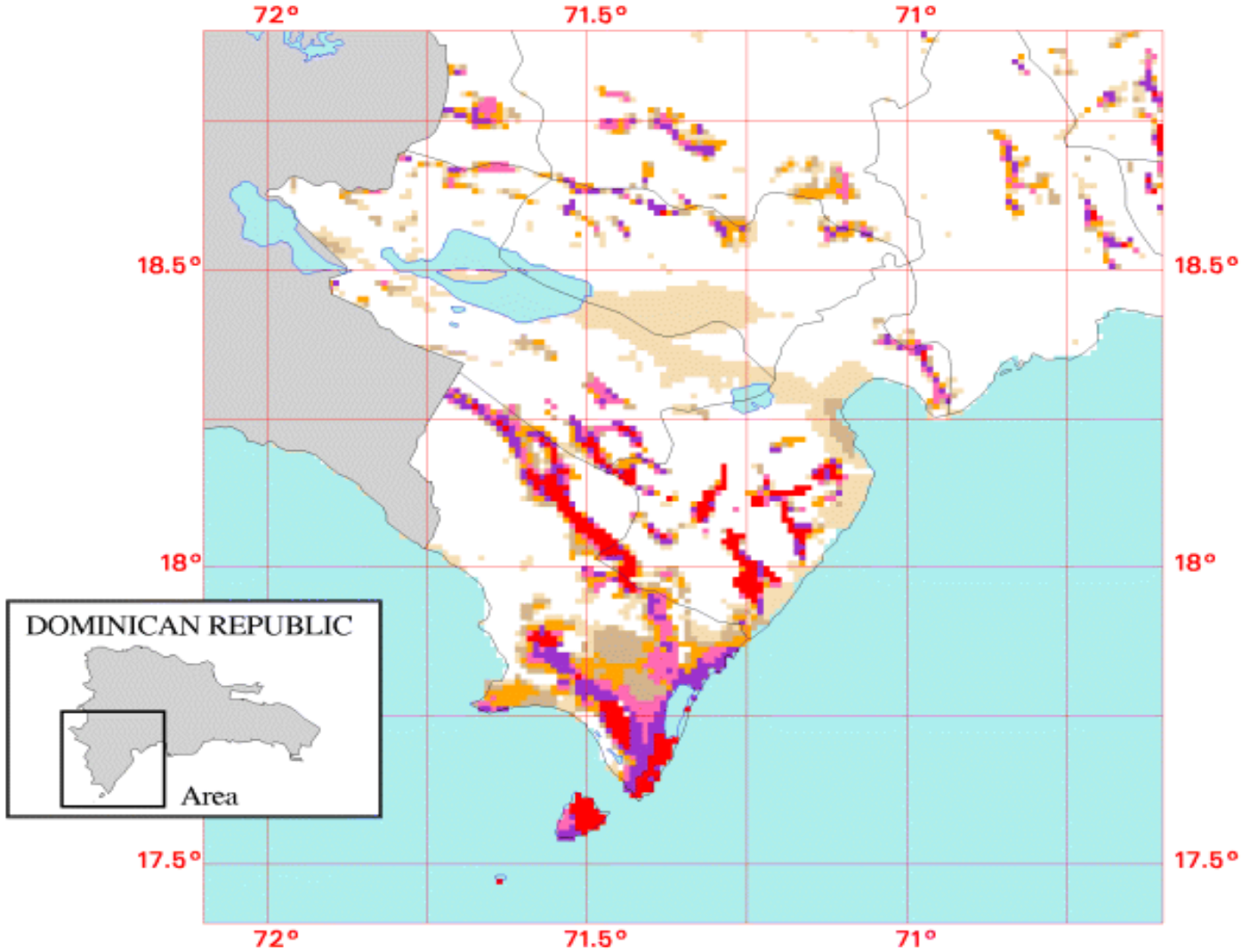
Dominican Republic - Southwestern Region
Most Favorable Wind Resource Areas



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The SWERA Approach

For solar: map the solar radiation from satellite imagery

- **models are either by statistical correlation or by physical modeling**
- **both types are calibrated to ground data**
- **microclimatic variations due to mountains, and wind/dust patterns can be detected often showing variations of more than 10% within 20 km distances**
- **most important for siting large installations but also useful for optimising the design of distributed systems**

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The SWERA Approach

- Solar mapping models:
  - **NASA/RETScreen**
    - **global low resolution ~220 km horizontal map (being upgraded) based on satellite data calibrated to ground sets**
  - **CSR by NREL and LABSOLAR (South America)**
    - **regional medium resolution 40 km with tilt and TMY calculators based on ~ 8 years satellite data (cloud cover)**
    - **Latin America, the Caribbean, Africa and South Asia**
  - **DLR Germany, State U. of New York, LABSOLAR**
    - **national high resolution 10-15 km seasonal maps from ~3 years satellite data**
    - **typical hourly values for specific locations**

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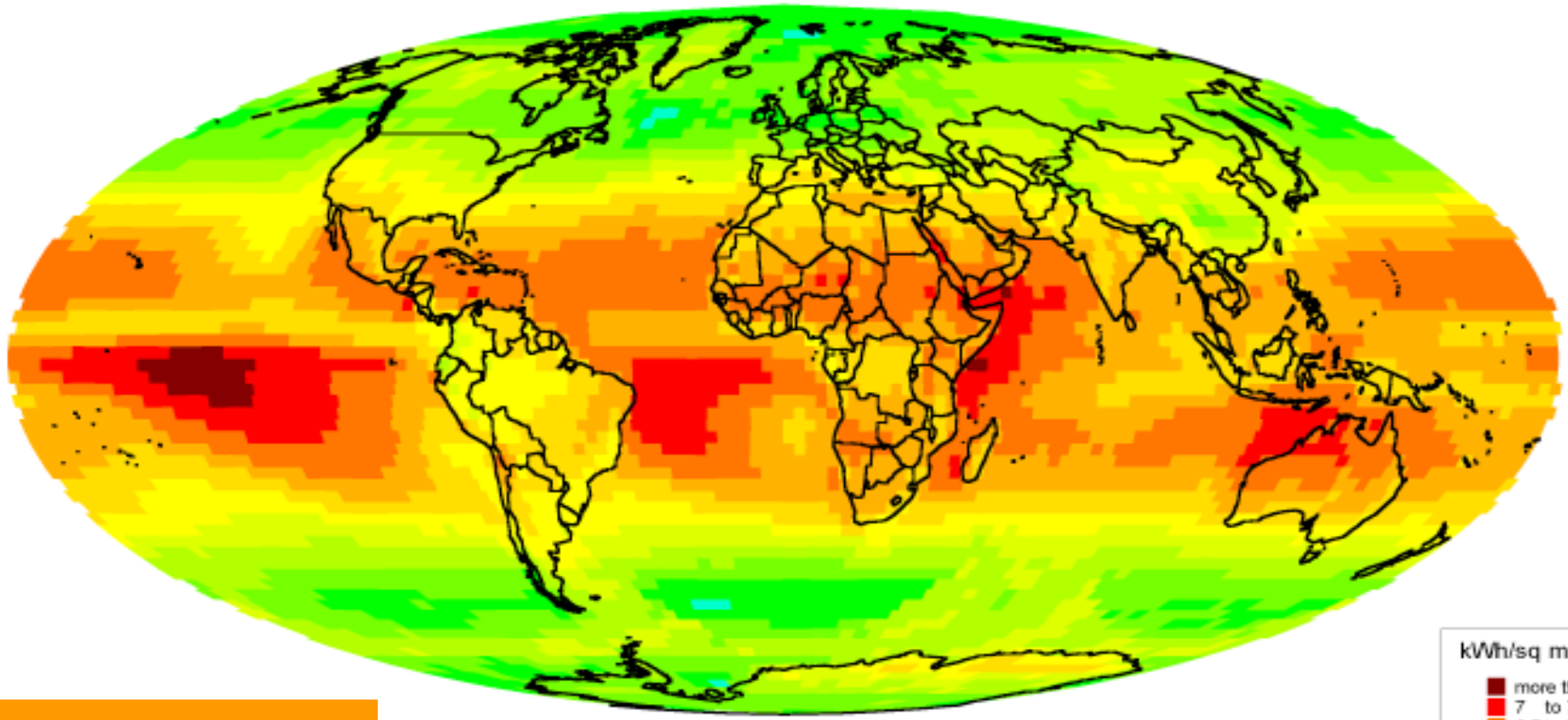
Estimated Global Horizontal Solar Radiation
1985 to 1988 Annual Average



kWh/sq m per day
- more than 7.5
- 7 to 7.5
- 6.5 to 7
- 6 to 6.5
- 5.5 to 6
- 5 to 5.5
- 4.5 to 5
- 4 to 4.5
- 3.5 to 4
- 3 to 3.5
- less than 3

US NASA

Preliminary satellite-derived estimates
based on the method of Dr. Rachel Pinker,
University of Maryland

Data source: World Climate Research Program data
available from the NASA Langley DAAC
NREL contact: Dave Renne (303) 275-4648
Date: December 14, 1994

The SWERA Approach

Integrating resource information with other data for into a geospatial analysis planning tool

- GeoSpatial planning tool
- **allows site specific and area specific assessment of potential based on**
  - **proximity to electrical grid substations**
  - **non electrified areas**
  - **population density and cities/towns**
  - **roads, land classification**
- SWERA.UNEP.net
  - **web accessible archive**
  - **CDROM distribution format**
  - **links to other sites**

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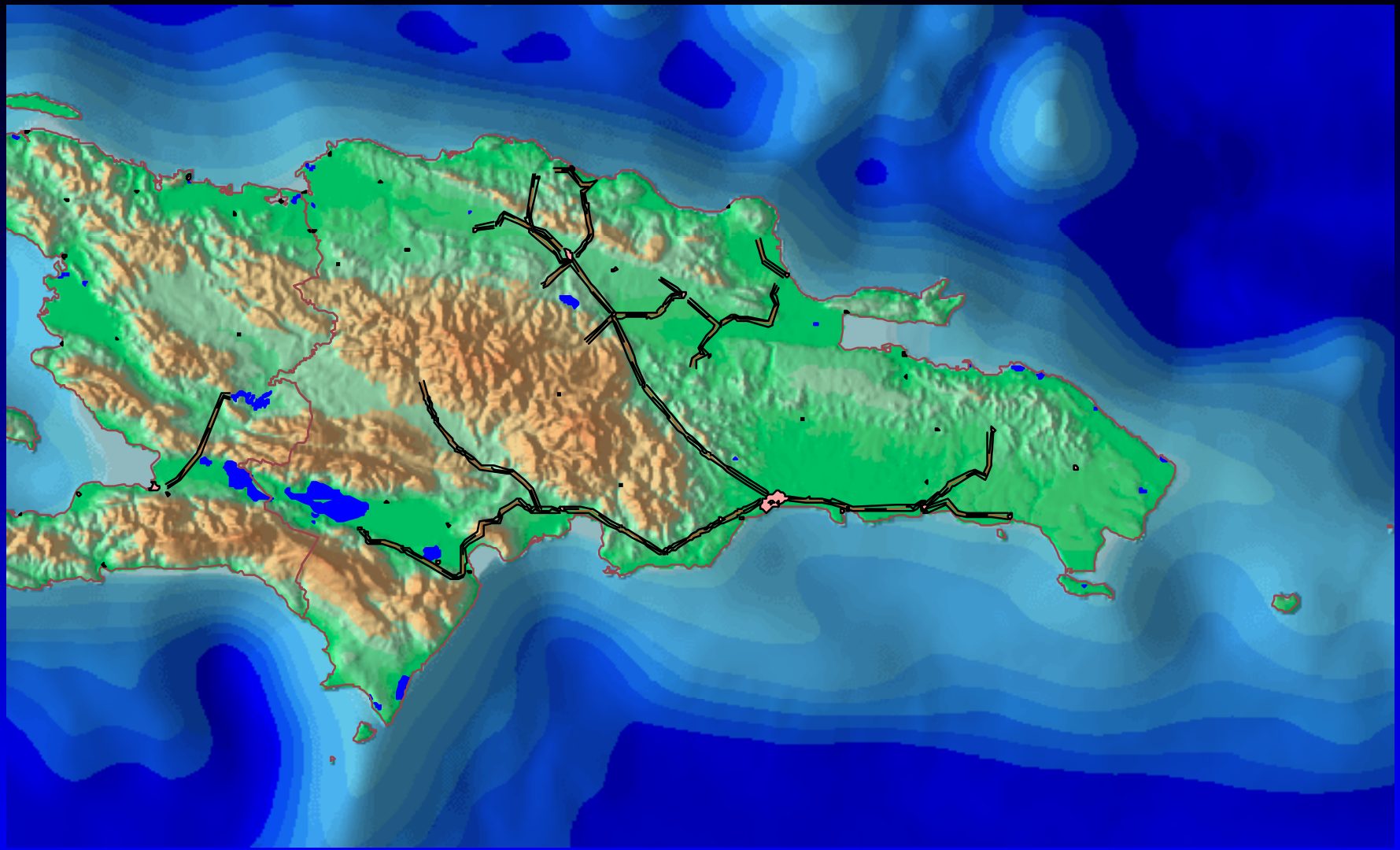

Electricity Grid

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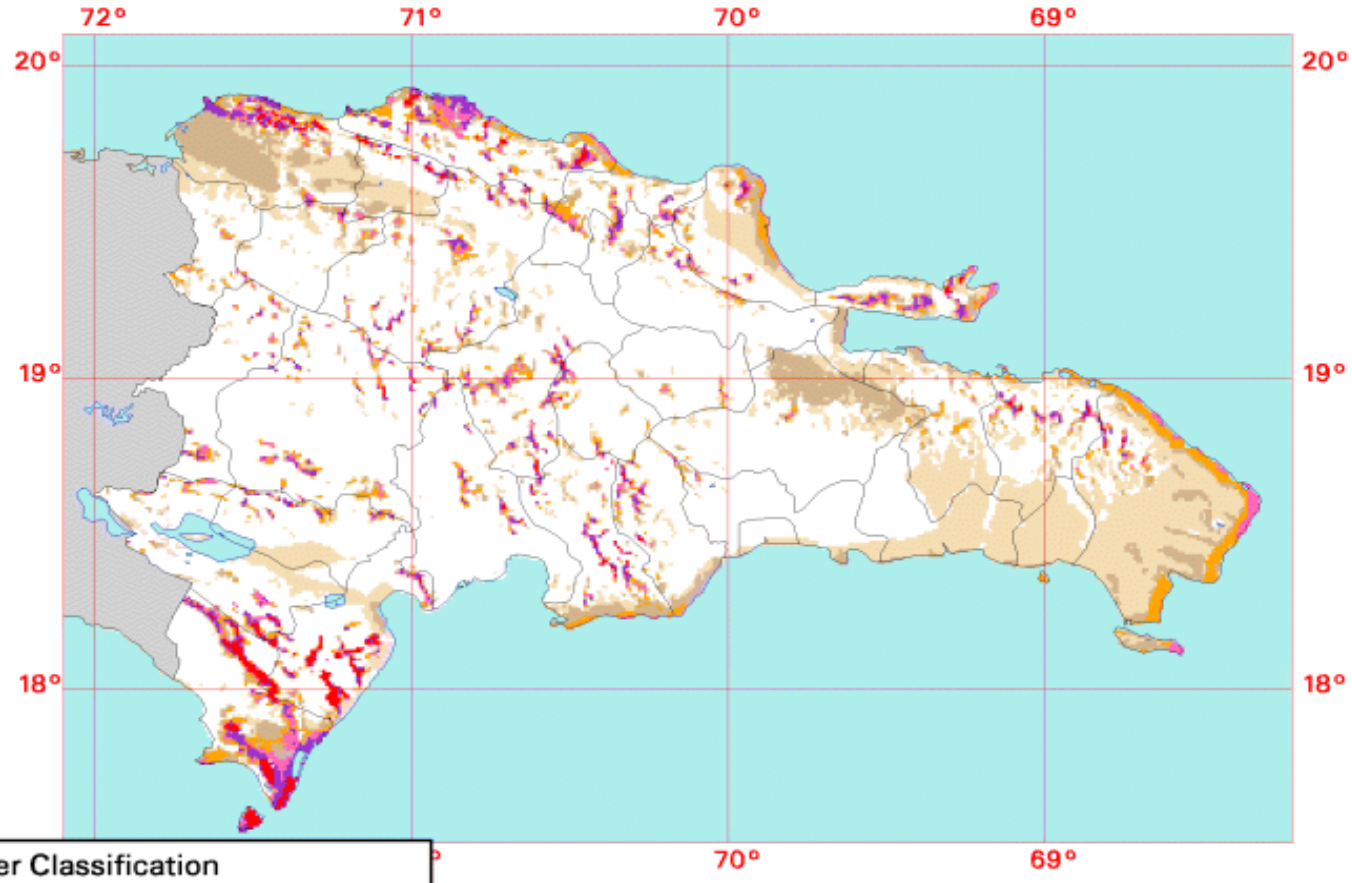
Dominican Republic - Most Favorable Wind Resource Areas



Wind Power Classification

Resource Potential		Wind Power Density at 30 m W/m^2	Wind Speed[a] at 30 m m/s
Utility	Rural		
Marginal	Moderate	100 - 150	4.9 - 5.6
		150 - 200	5.6 - 6.1
Moderate	Good	200 - 250	6.1 - 6.6
		250 - 300	6.6 - 7.0
Good	Excellent	300 - 400	7.0 - 7.7
Excellent		400 - 1000	7.7 - 10.5

[a] Wind speeds are based on a Weibull k value of 3.0

The wind resource classification is specific for both utility scale and rural applications and applies to areas with low surface roughness.

20 10 0 20 40 60 80 100 Kilometers

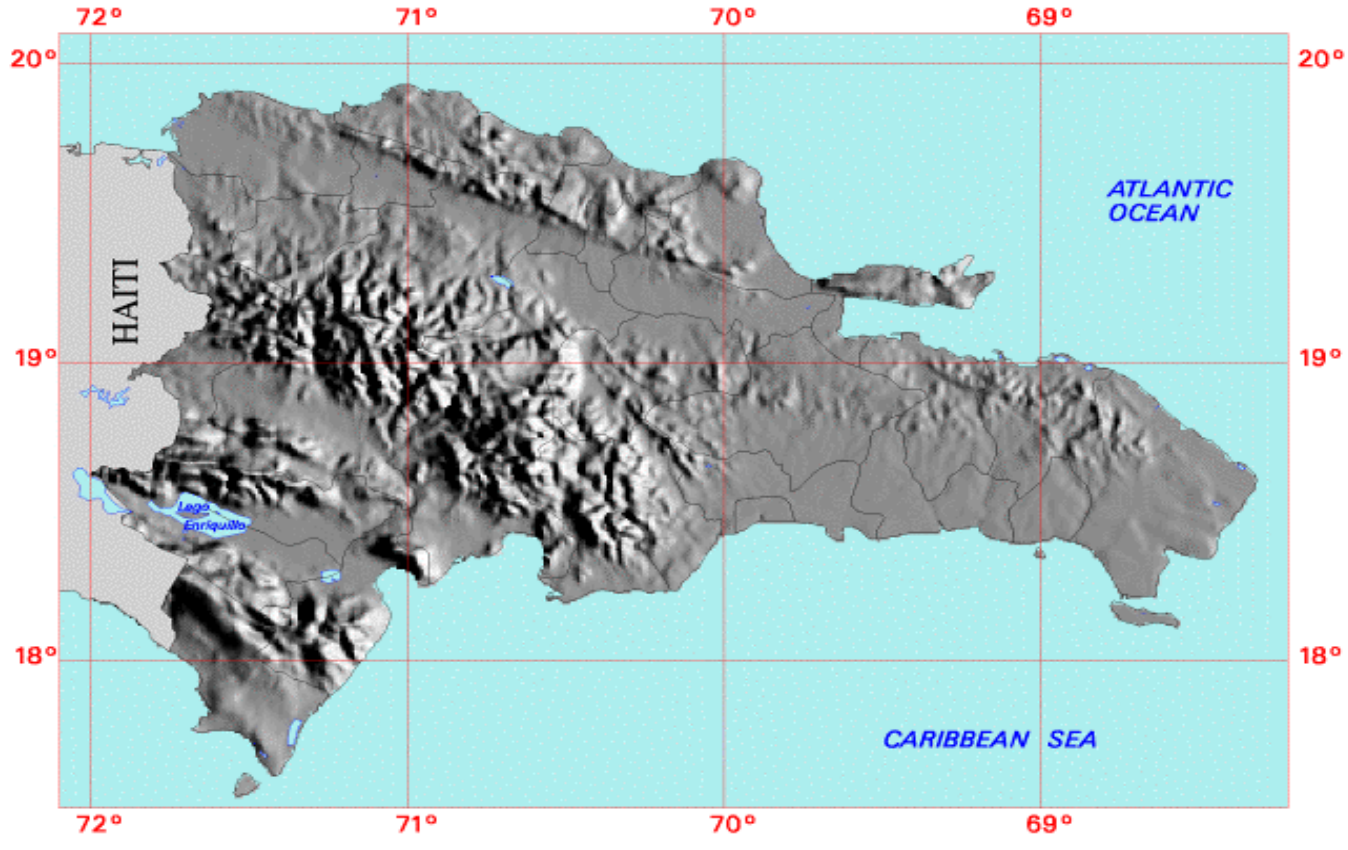
US Dept. of Energy - National Renewable Energy Laboratory

NREL contacts:
Dennis Elliott
Marc Schwartz

NREL

SR Haymes 04-MAY-1999 5.3

Dominican Republic - Shaded Relief Map



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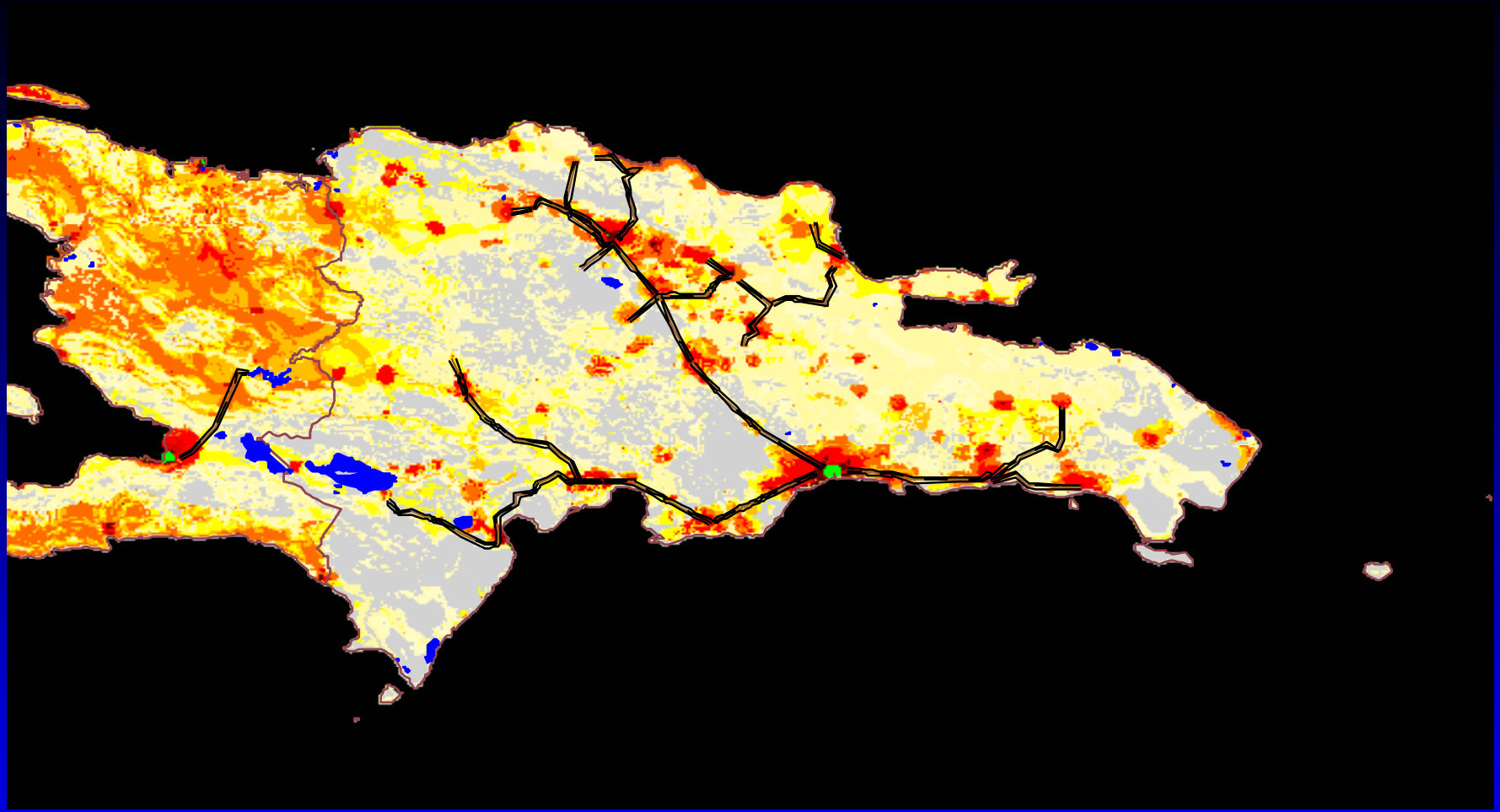
SR Haymes and DM Heimiller 10-MAY-1999 1.1



Population Density and Electricity Grid

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Promoting the Alternative

- Development of energy planning documents
- Least Cost Power Production vs diversified resources
- supplement Hydro where drought prone
- Assessment of the potential for rural electrification by PV/wind versus grid extension
- Assessment of the potential for grid supply by wind/ solar
  - **project specific economic analysis of feasibility**
  - **proposal preparation**

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Global Significance

- UNEP/WMO/IPCC reports wind power production potential between 20,000 TWh/yr and 53,000 TWh/yr subject to assumptions of land availability, efficiency and resource
- WEC assumes 27% of the surface has wind speed >5.1 m/s @10m
- High resolution assessment is expected to better estimate the resource potential
- The acceleration and broadening of investment through **high resolution assessment**

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Project Feasibility Studies

- Rural remote power from a RETSCo:
  - Solar radiation intensity from medium or long term maps
  - Assumption of solar home systems per person (economic factor)
  - efficiency/size of systems
  - total cost per household electrified
  - compare solar home system rates versus grid extension/ distribution losses and cost (subsidies equal)

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Project Feasibility Studies

- Grid connected wind farm:
  - Distance from electrical substation (line cost)
  - Existence of road access
  - Turbine density, efficiency
  - annual wind power
  - total cost per kwh
  - cost versus fossil fuel systems (subsidies equal)

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Project Feasibility Studies

- Solar thermal/biomass plant:
  - Siting of solar “hot spots” using high resolution map
  - hour by hour analysis/ combination plant sizing
  - distance to grid/ distribution loss
  - iterative analysis of sites to achieve lowest overall cost per kwh
  - cost versus fossil fuel systems (subsidies equal)

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Project Feasibility Studies

- Wind mini-grid/ fuel cell storage (or diesel hybrid):
  - locate closest wind power production location (including transmission) to load centre/village using high and medium resolution maps and geospatial analysis
  - seasonal and hour by hour analysis/ combination plant sizing using best ground data
  - cost versus diesel only systems (subsidies equal)

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Project Data Availability/Distribution

- High-resolution solar and wind energy resource data bases and maps will be made widely available by UNEP/ Global Resource Information Database facilities and by host country agencies
  - CD-ROM with or without a simplified Geospatial Planning tool
  - Internet wesite
- Partners: CBEE, INPE, LABSolar (Brazil), DLR (Germany), Risoe (Denmark), NREL (US), TERI (India), UNEP/GRID, GTZ, CRED (China) and many others

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Policy and Planning for Solar and Wind

- Advance planning for renewables
  - **diesel generators are the cheap fast fix for power shortages**
- **Diversify energy supply sources**
  - **El Niño drought cycles will likely increase**
  - **precipitation, biomass, wind and solar can have seasonal complementarity**
- Perform integrated analysis
  - **avoid subsidies biased toward grid extension or diesel generation**
  - **integrate enterprise development planning**
- **CO_2 emission reduction credits**

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Technology “bright spots”

- Wind Turbine technology cost is dropping
- UNEP/GEF with IFC, KfW are seeking opportunities to replicate large scale PV deployments to reduce cost
- Fuel Cells are expected to drop significantly in cost
  - **remote applications of Wind/Fuel Cells can use the same technology as cars with hydrogen storage**
  - **higher efficiency fuel cells running on natural gas or methanol can achieve reduced emissions in the near term and switch to Renewable Energy Technology generated Hydrogen in the long term**
  - **low environmental impact cogeneration of heat/power/cooling sited at loads with modular sizing**

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UNEP GEF info

- "Fuel Cell Market Prospects and Intervention Strategies" **www.unep.org/gef/download/fc**
- **"Solar and Wind Energy Resource Assessment" Project Document www.gefweb.org project documents for CEO endorsement**
- **swera.unep.net (launching early 2002)**
- **contacts:**

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