

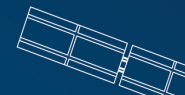


EUROPEAN SPACE SOLUTIONS

BRINGING SPACE TO EARTH

30 MAY - 03 JUNE, THE HAGUE, THE NETHERLANDS

#EUspace16 @SpaceSolutions_



How can Earth Observations assist the energy sector?

Alberto Troccoli

World Energy & Meteorology Council & University of East Anglia
with input from Copernicus' ECEM team

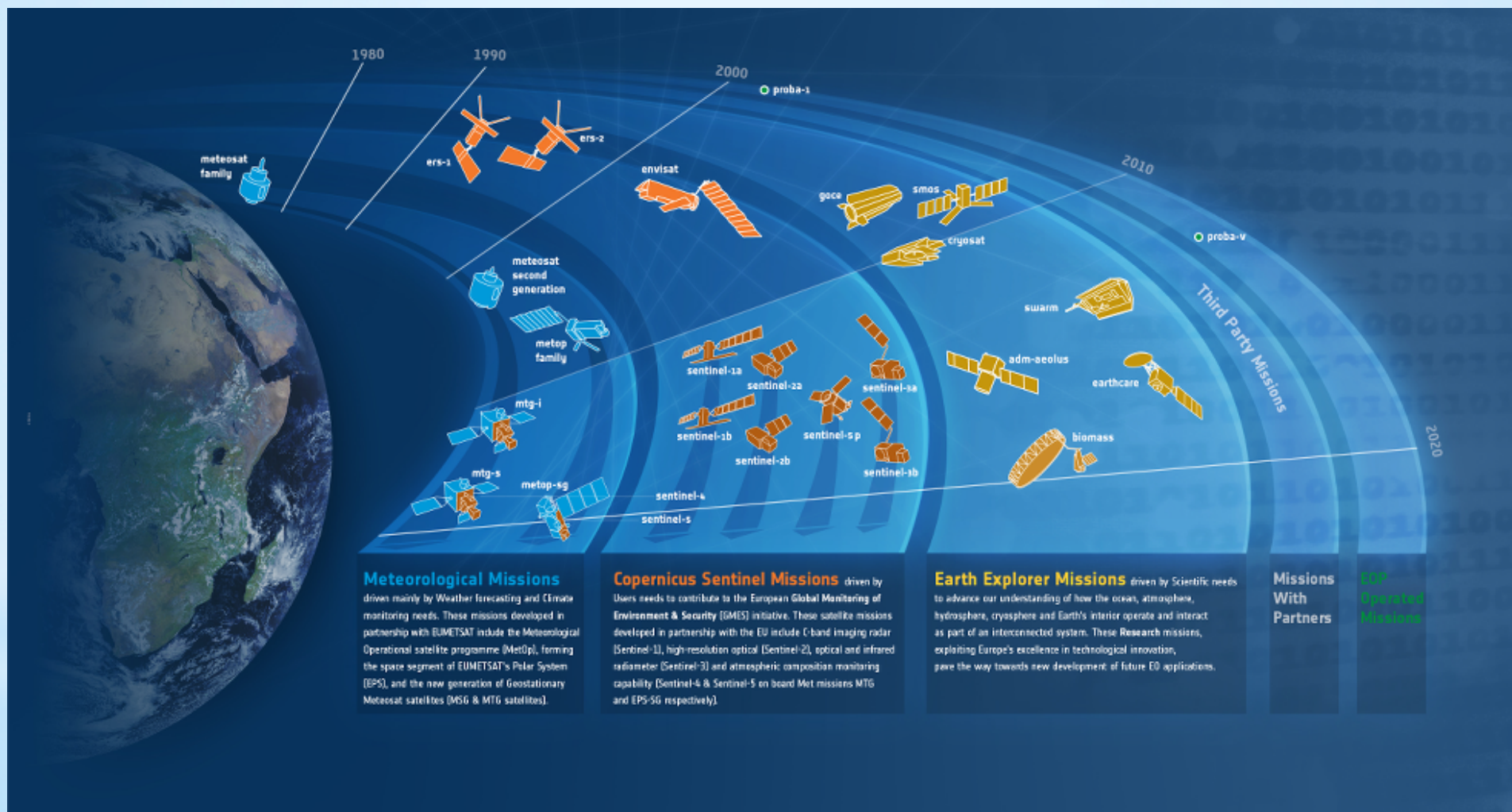
European Space Solutions, The Hague (NL), 3 June 2016

Outline

- It's a crowded space up there
 - Many energy-relevant ESA & NASA missions
 - A variety of (potentially) useful satellite EOs
- How are satellite EOs used for energy?
 - Many applications have been/are being developed
 - Understanding EOs limitations/complementarities
- Looking forward
 - Novel satellite EOs applications for energy
 - What's the uptake of satellite EOs energy applications?

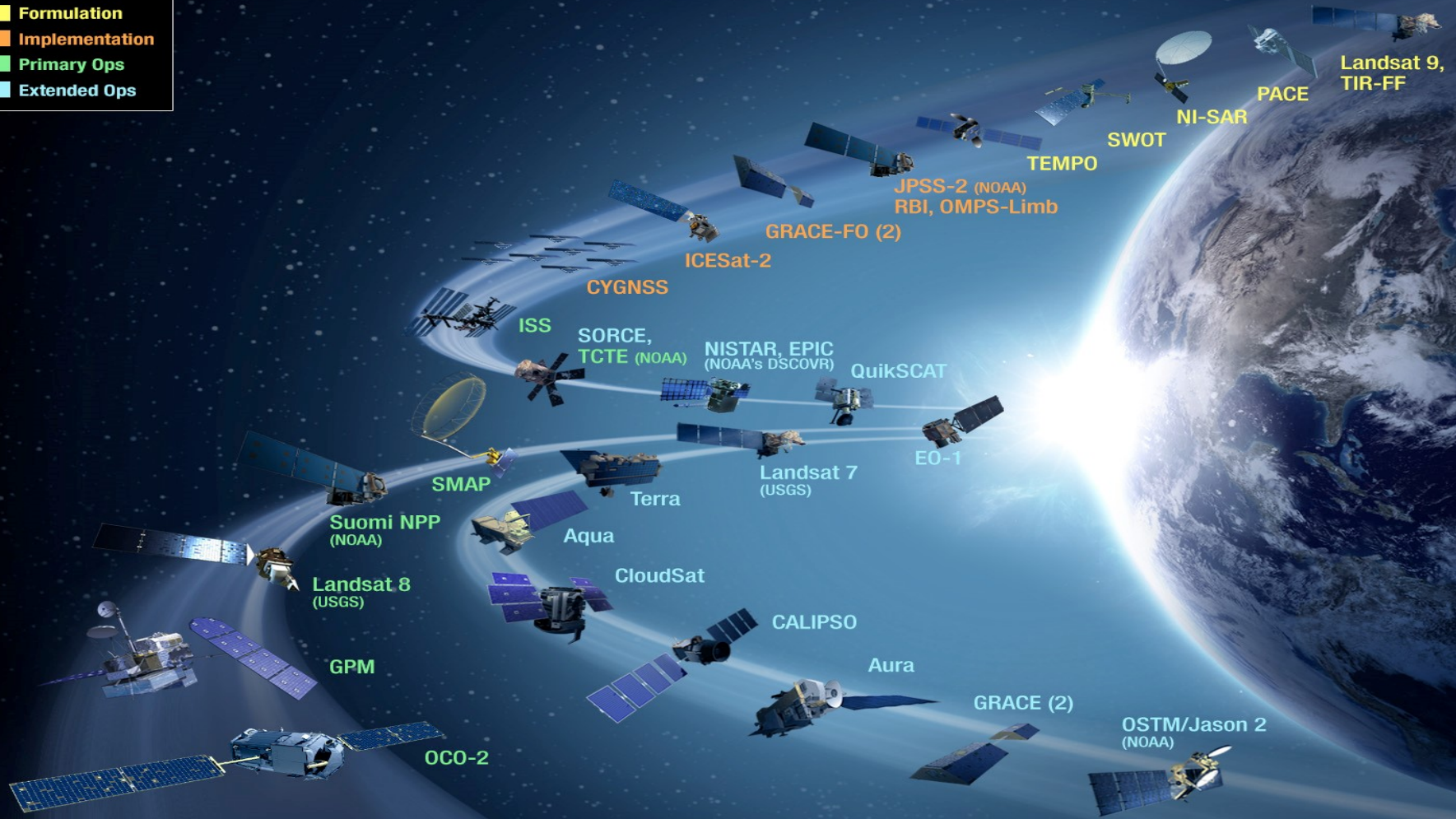
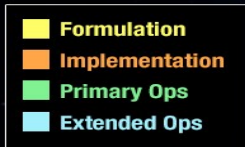


The ESA EO programme



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The NASA EO program



Satellite EO's & Energy 'pairing'

Demand

Air temperature
Cloud cover
Water vapour
Albedo
Nighttime lights

Hydro

Soil moisture
Precipitation
Snow cover
Elevation
River/lake par
Gravimetry

Solar

Solar irradiance
Cloud cover
Water vapour
Aerosols
Albedo
Air Temperature
Land cover
Elevation

Biomass

Solar irradiance
Air Temperature
Precipitation
Soil moisture
Land cover
Cloud cover
Albedo
Elevation

Wind

Elevation
Offshore winds
Wave/currents
Ocean altimetry

Marine

Offshore winds
Wave/currents
Ocean altimetry

Thermal

Air Temperature
River/lake par

Oil & Gas

Offshore winds
Wave/currents
Ocean altimetry



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Satellite EO Applications for Energy



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Snow cover measured from space



From snow extent to snow water equivalent (using snow thickness in situ data), as a proxy for potential hydropower fuel stored in snow



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Mathieu (2015)

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- EnerGEO
- GEOSS Data CORE
- Global Atlas
- Global Atlas - App
- Global Atlas - Bioenergy

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Featured map

WIND POWERDENSITY MAP

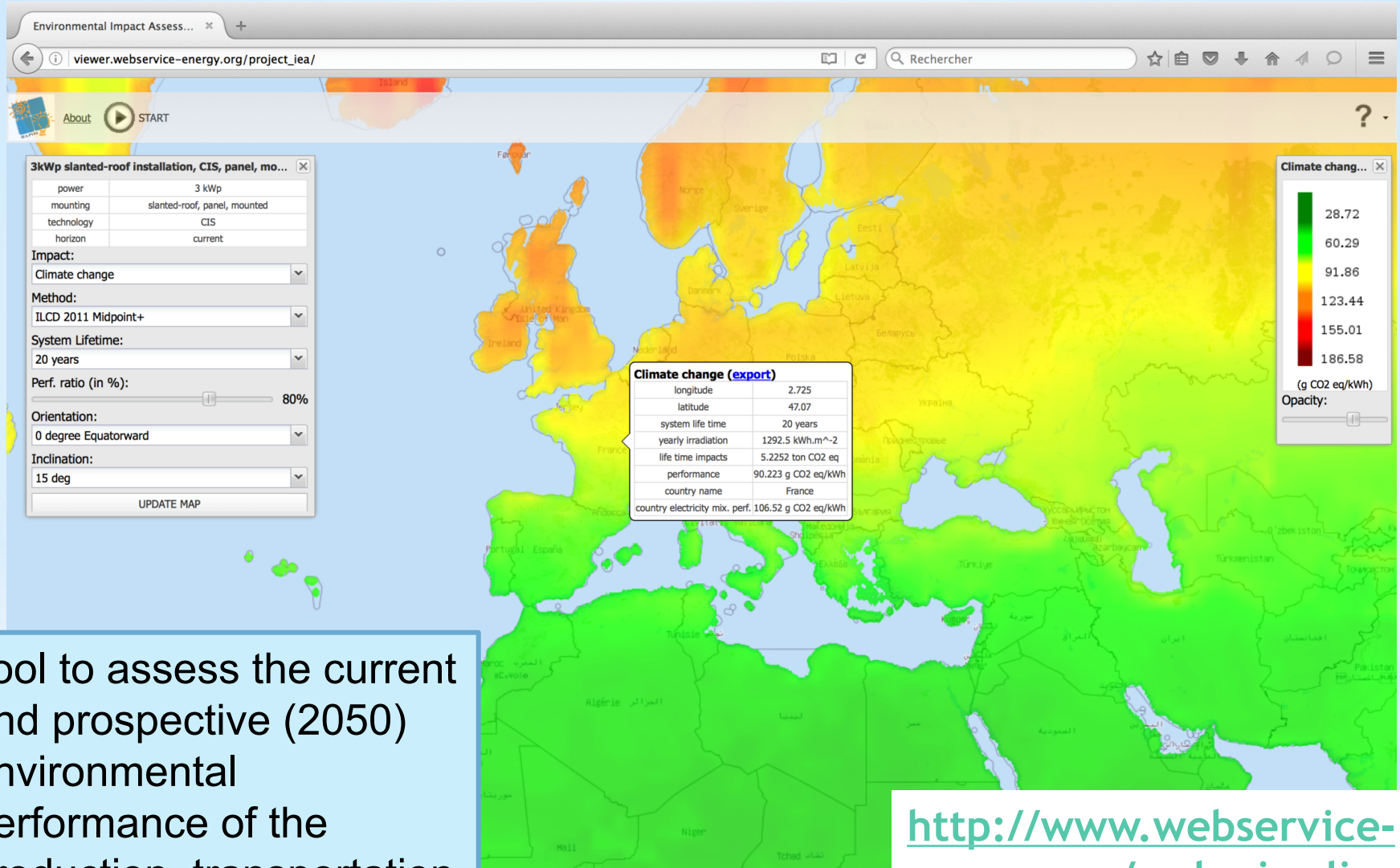


<http://www.webservice-energy.org>



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Environmental performance tool for PV



Tool to assess the current and prospective (2050) environmental performance of the production, transportation and use of PV systems



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<http://www.webservice-energy.org/web-gis-client>

IRENA Global Atlas

United Arab Emirates ✕



Maps



Tools



Solar



Hydro



Biomass



Geothermal



Marine

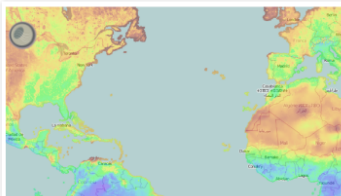


Wind



Advanced search

Published Maps - 4/8

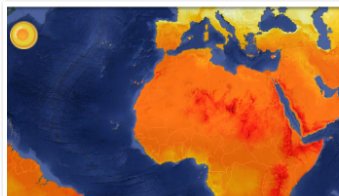


DTU Global Wind Atlas

Best use: Potential, +Business

5 Comments 200

Preview

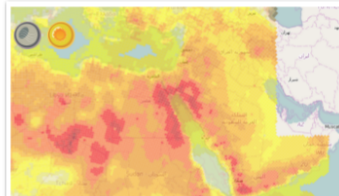


Solar Map from HelioClim3v4-MC for 2005

Best use: Potential, +Business

5 Comments 200

Preview

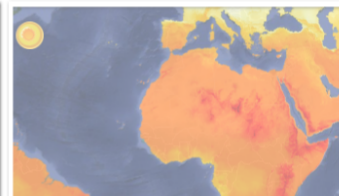


Saudi Arabia map - analysis by DLR - demonstration of zoning for Concentrated Solar Power (CSP)

Best use: Education

5 Comments 200

Preview



Solar Map from HelioClim3v4-MC for 2005

Best use: Potential, +Business

5 Comments 200

Preview

Published Tools - 4/6

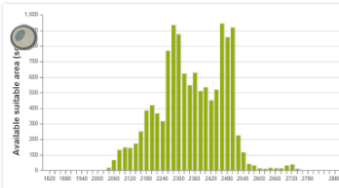


Photovoltaic (PV) System generation calculator for the countries in the Mediterranean region from SolarMED

Best use: Potential

5 Comments 200

Preview

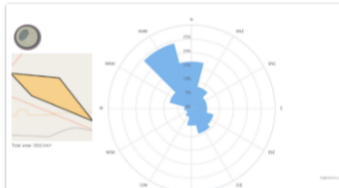


Concentrated Solar Power (CSP) potential calculator for Morocco by Energy Downstream Services (ENDORSE)

Best use: Potential

5 Comments 200

Preview

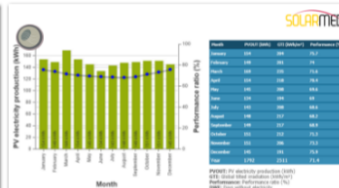


Wind statistics generator from DTU's Global Wind Atlas

Best use: Potential

5 Comments 200

Preview



Photovoltaic (PV) System generation calculator for the countries in the Mediterranean region from SolarMED

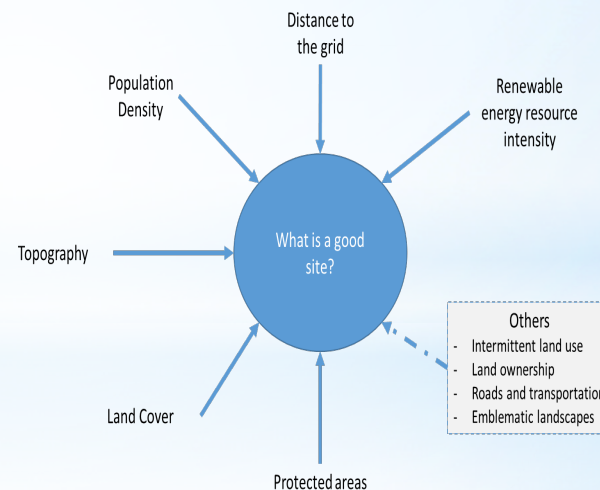
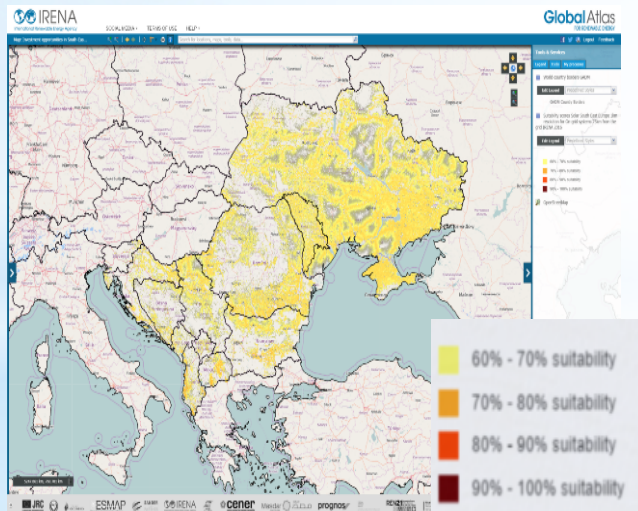
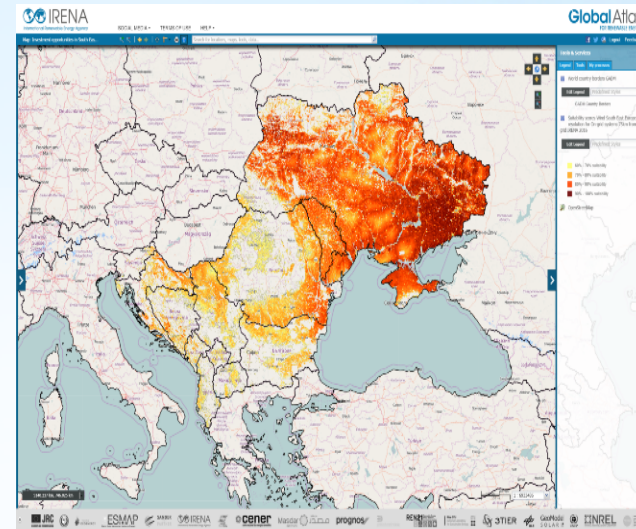
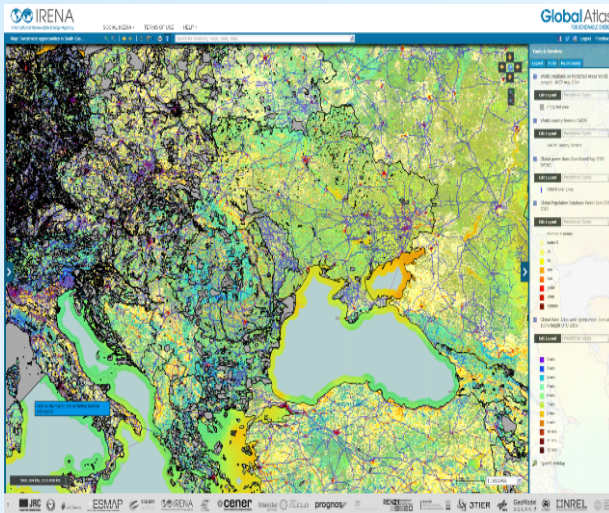
Best use: Potential

5 Comments 200

Preview



Combining sources of information



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IRENA

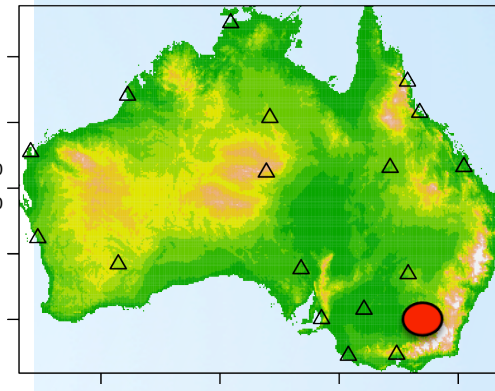
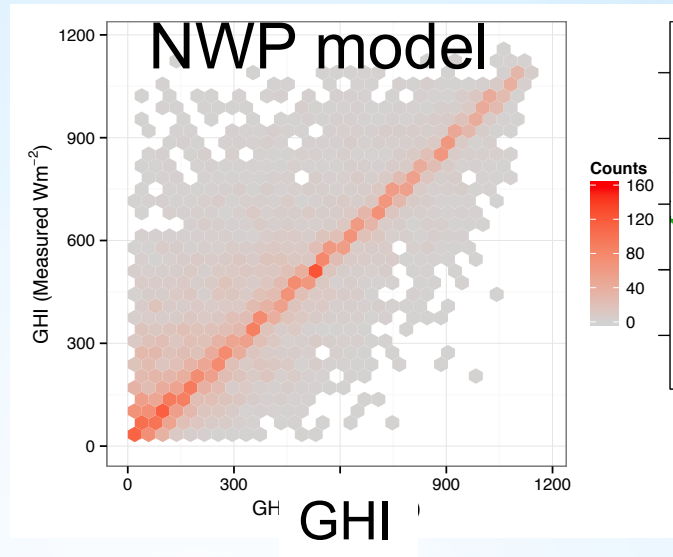
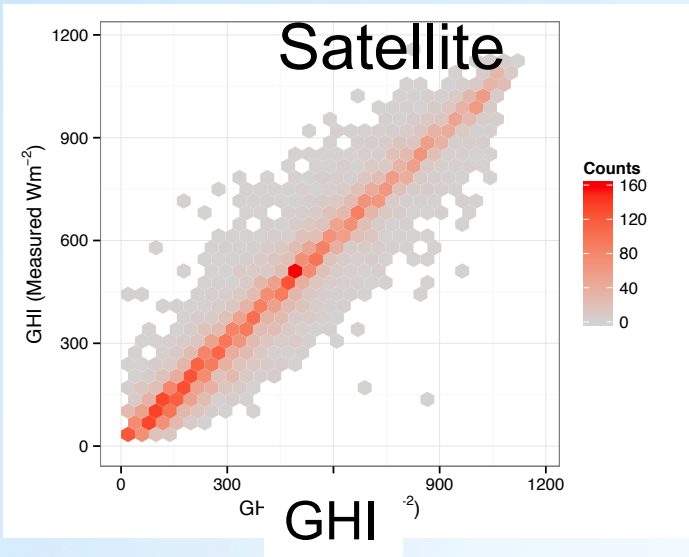
International Renewable Energy Agency

Limitations satellite-based EO & possible complementarities

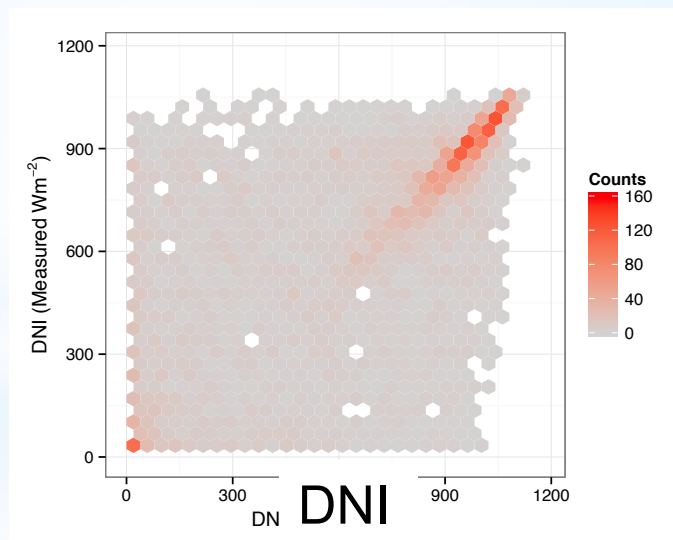
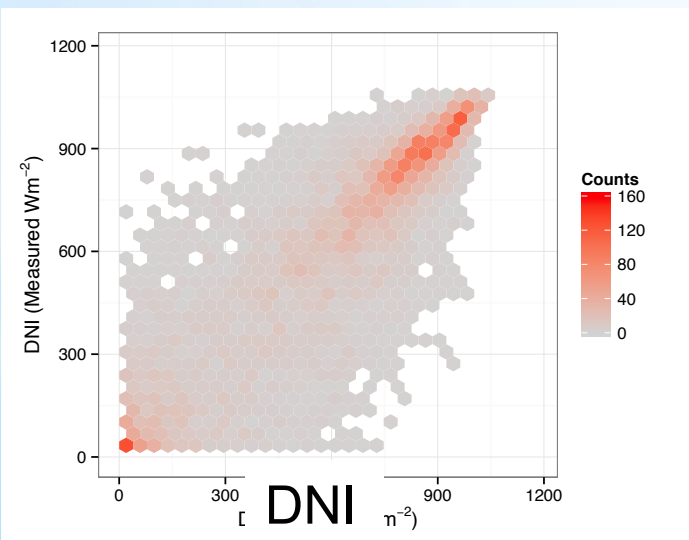


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Solar irradiance assessment



d)



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Davy et al (2016)

Combining satellite with NWP model

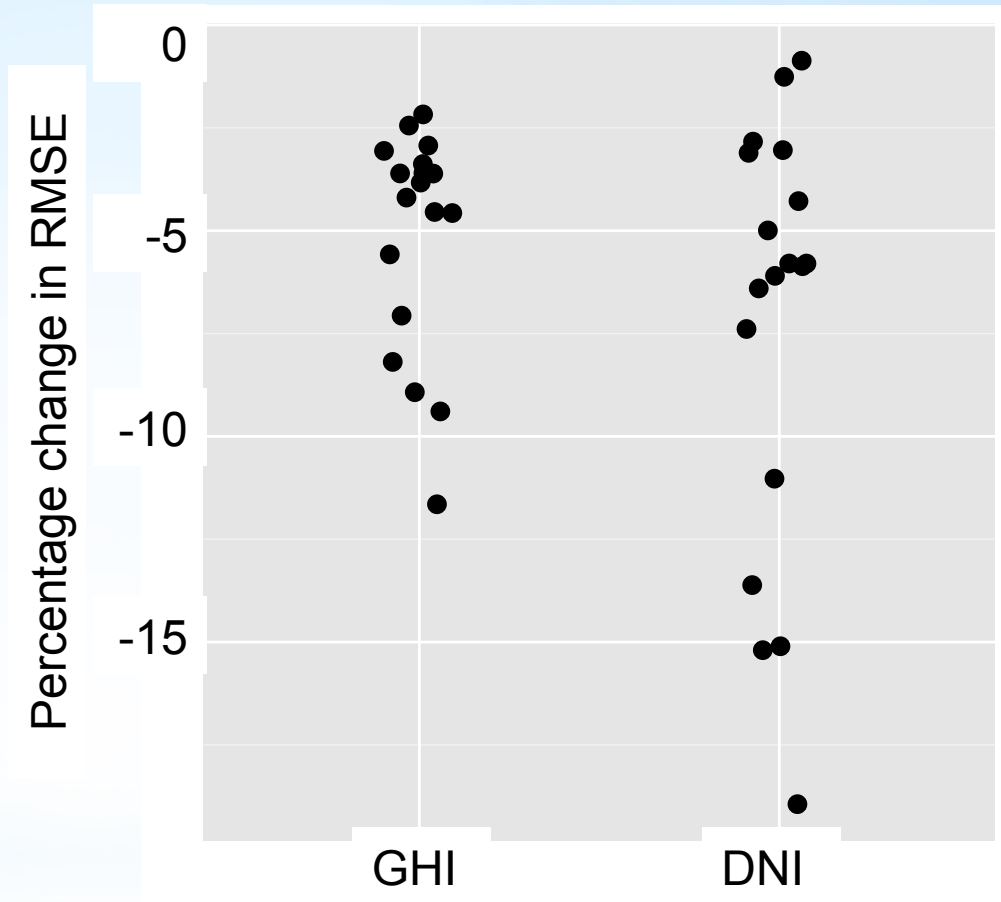
Nonlinear fit to hourly ground station data:

$$k_m \sim f(k_s, k_c, \cos(\theta_z))$$

Generalised additive model (GAM)

Baseline model, satellite GAM:

$$k_m \sim f(k_s, \cos(\theta_z))$$



RMSE change when using NWP model in combination to satellite irradiance, compared to satellite irradiance alone.

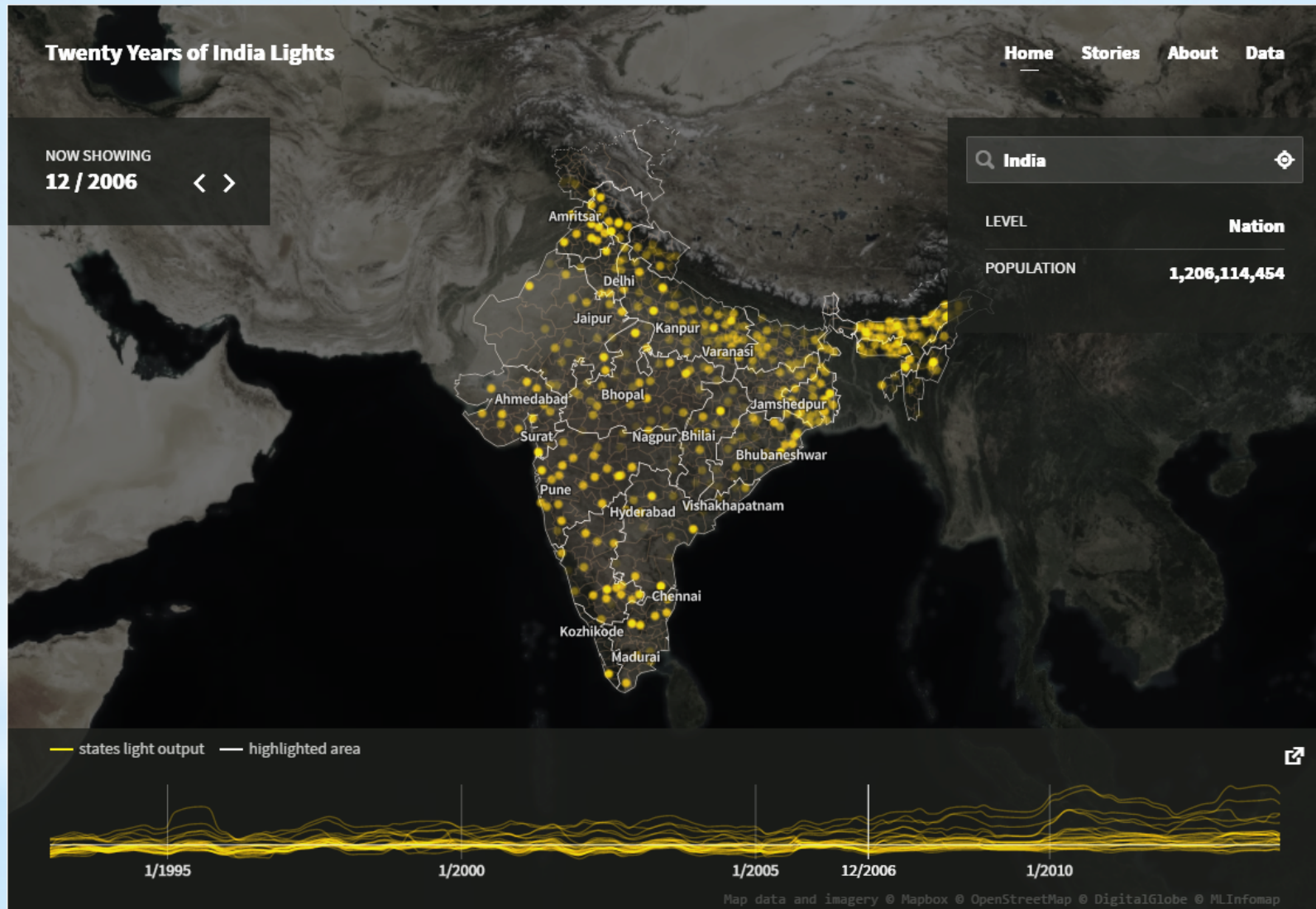


Novel EO applications



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Eyes in the sky help track rural electrification

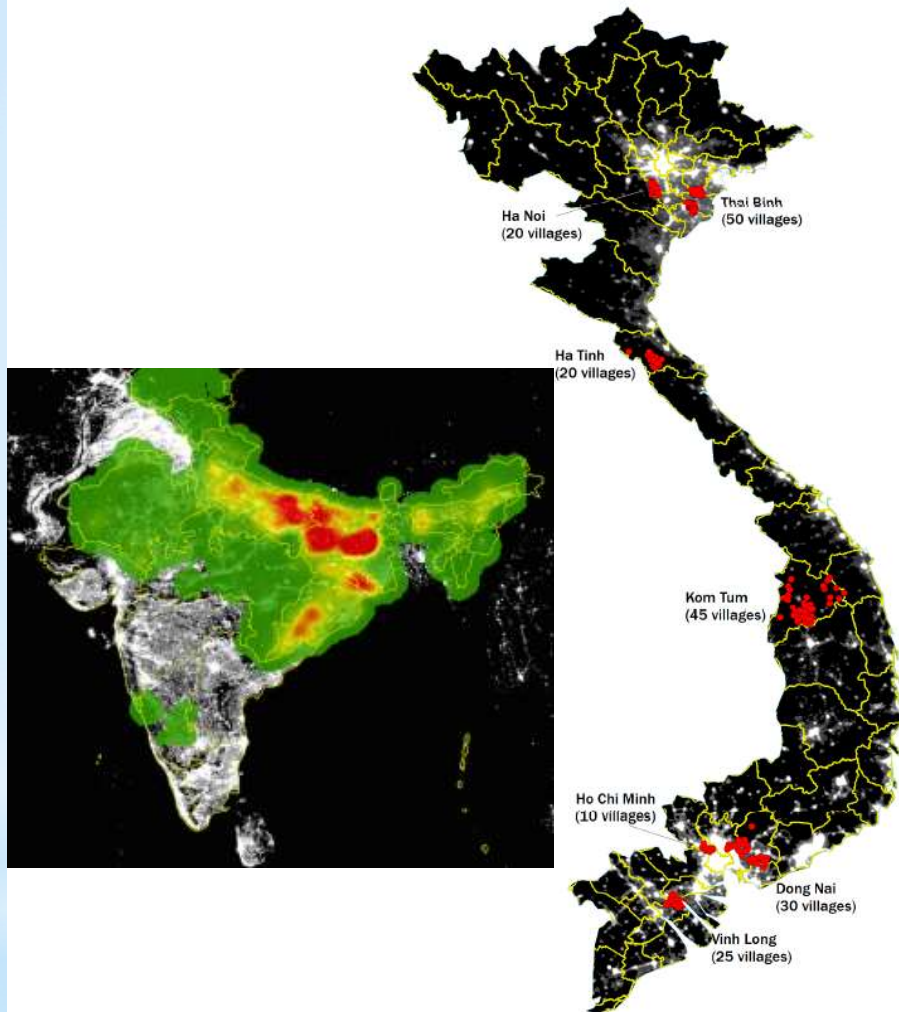


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<http://blogs.worldbank.org/energy/eyes-sky-help-track-rural-electrification>

MONITORING RURAL ELECTRIFICATION FROM SPACE

Figure 3. Location of surveyed villages.



- The Tracking Light From the Sky WB Project works in collaboration with National Oceanic and Atmospheric Administration (NOAA), University of Michigan, and Development Seed.
- Data-intensive strategy to improve the monitoring of electricity service provision to rural areas in India, following the successful demonstration of the effectiveness of night-time lights satellite imagery for rural electrification monitoring in Africa (Mali, Senegal) and East Asia (Vietnam).
- The project collected and analyzed a unique historical archive of nighttime satellite imagery to track the supply of electricity service at the village level spanning nearly 8,000 nights since 1993 in 600,000 villages in India.



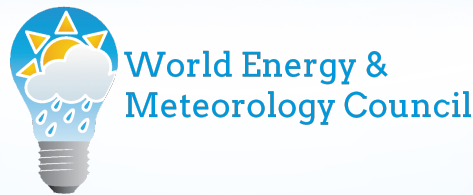
**But what is the
uptake of these
applications?**



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Some considerations

- Several organisations are developing EO-based applications (ESA, NASA, Copernicus, ARMINES, ...)
- ... with a varying degrees of co-ordination/ dissemination (IRENA, WBG, GEO, GFCS, ...)
- EO data normally used for pre-feasibility assessments – but only a limited number of variables are fully exploited (e.g. irradiance)
- Private companies develop their own tools ... but level of uptake is poorly documented
- What about a catalogue of EO success stories with guidance on best practice for energy applications?



Thank you

