GLOBAL RENEWABLE ENERGY RESOURCE MAPPING

Global Wind Atlas Partnership

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ESMAP
Energy Sector Management Assistance Program

WORLD BANK GROUP
Energy & Extractives

INTRODUCTION TO ESMAP

- **Multi-donor trust fund** within The World Bank
- **Budget 40-50 MUSD/year** from 13 donor countries + World Bank
- **Operated** in over 100 countries **–** close to 1,000 activities since 1983
- Assist client countries in **managing** sustainable energy solutions

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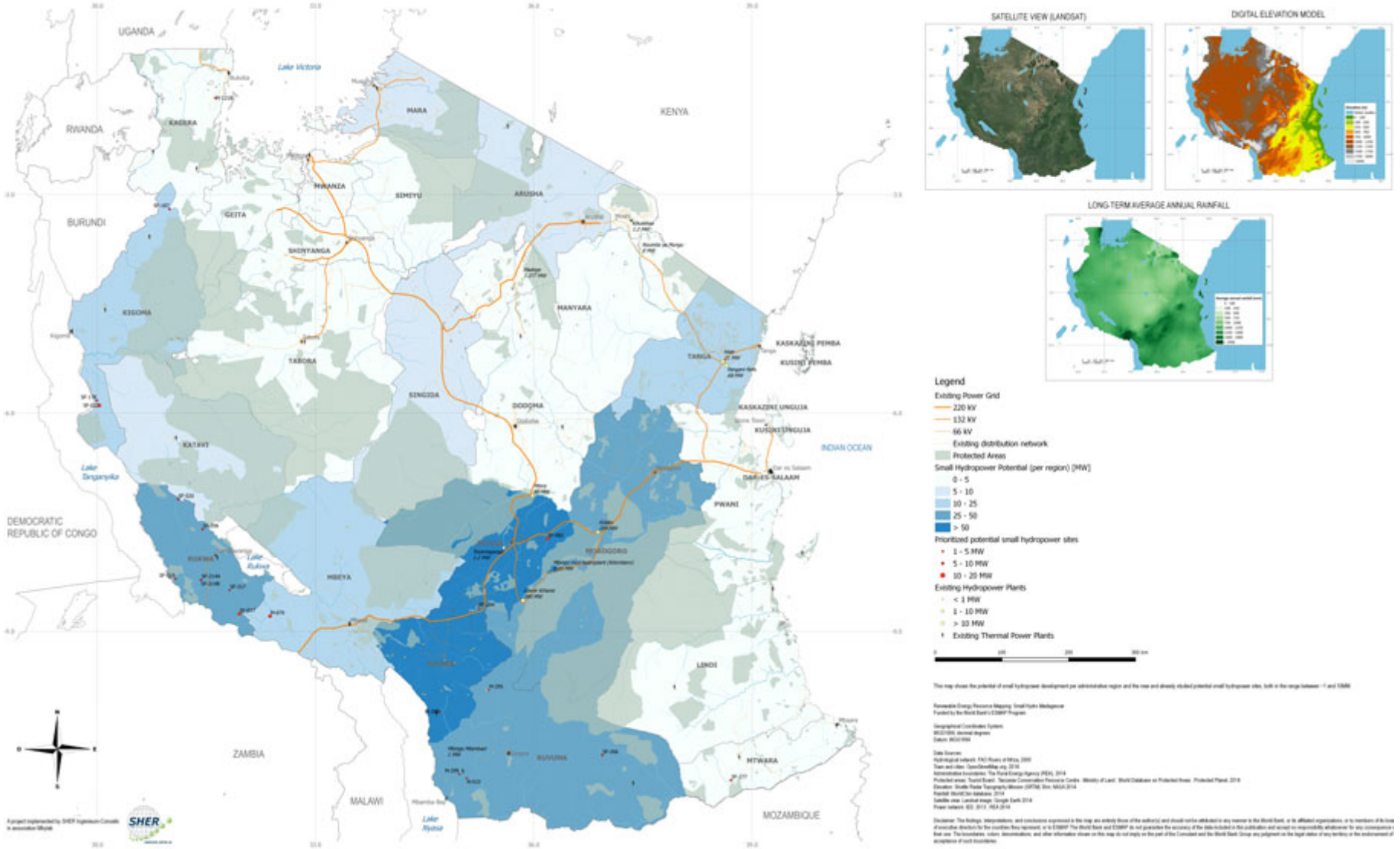
Why do it?

- **Demand** from low-income countries with scarce RE resource data to…
- Understand **resource potential,** strengthening public sector knowledge vis-à-vis private sector
- Develop **policy** and carry out geospatial **planning**
- Invest efficiently in supporting infrastructure such as **transmission**
- **Lower project risk** for commercial developers (= lower energy costs)

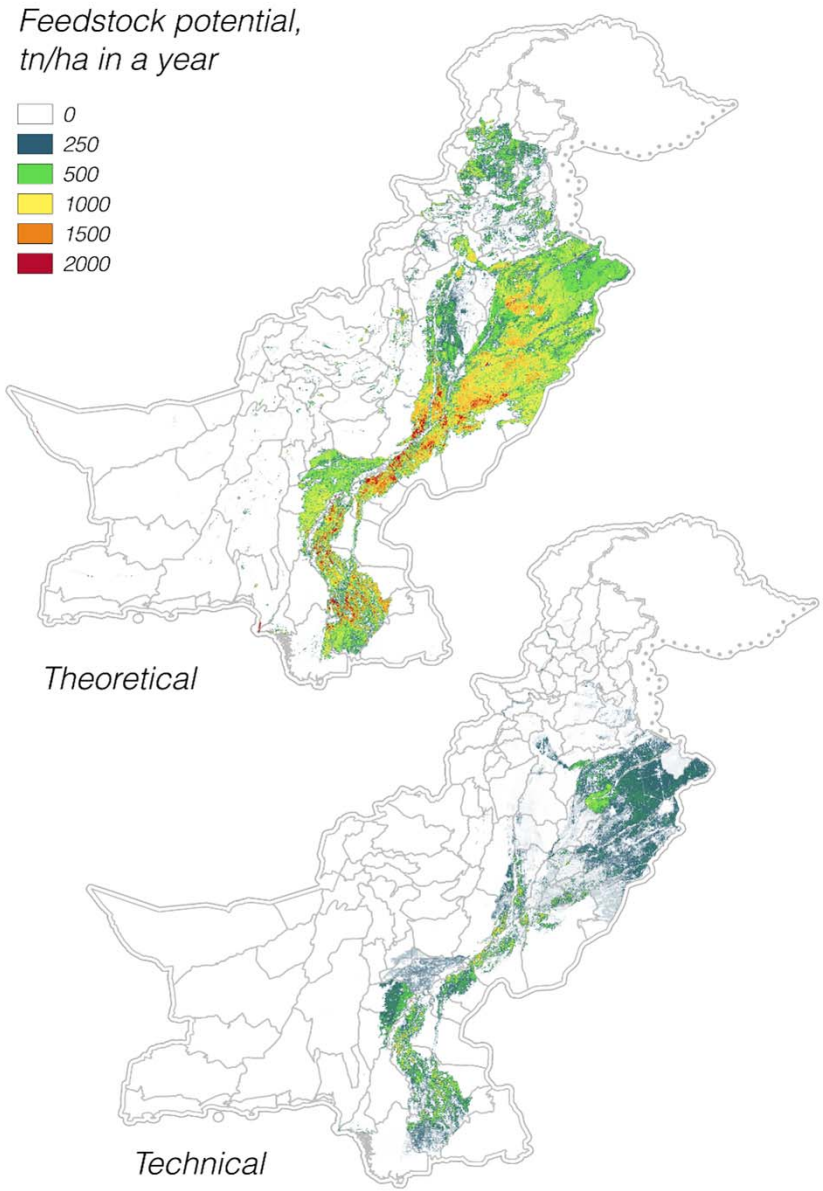
What does it involve?

- Assessment of technical resource potential using satellite data & weather model data **validated** by ground-based measurements

SAMPLE SMALL HYDRO MAP



Sample Biomass Map



SAMPLE SOLAR MAP

SOLAR RESOURCE MAP

GLOBAL HORIZONTAL IRRADIATION

LAO PEOPLE'S DEMOCRATIC REPUBLIC

DESCRIPTION

This solar resource map represents average daily/yearly sum of global horizontal irradiation (GHI) covering a period of nine recent years (2007-2015). The underlying Solargis database is calculated from atmospheric and satellite data with 10-minute and 30-minute time step respectively. The effects of terrain are considered at nominal spatial resolution of 250 m.
There is some uncertainty in the yearly GHI estimate as a result of limited potential for regional model validation due to a lack of high quality ground measurement data, which is estimated in this map to be approximately ±4%.
GHI is the most important parameter for energy yield calculation and performance assessment of flat-plate photovoltaic (PV) technologies.

ABOUT

The World Bank and the International Finance Corporation, collectively the World Bank Group, are publishing this solar resource map alongside a series of global, regional and country maps, to support the scale-up of solar power in our client countries. This work is funded by the Energy Sector Management Assistance Program (ESMAP), a multi-donor trust fund administered by The World Bank and supported by 13 official bilateral donors. It is part of a global ESMAP work program on Renewable Energy Resource Assessment and Mapping that includes biomass, small hydro, solar and wind. The World Bank Group has selected Solargis as its global provider of solar resource data and related services, and this map has been prepared by Solargis, under contract to the World Bank Group, based on a solar resource database that they own and maintain.

To obtain additional maps and information, please visit:
http://globalsolaratlas.info

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Considering the nature of climate fluctuations, inter-annual and long-term changes, as well as the uncertainty of measurements and applied methods, The World Bank, International Finance Corporation, and Solargis do not have any responsibility whatsoever, and do not give any warranty, on the accuracy of the data that were used to produce this map. Solargis has done its utmost to make an assessment of solar climate conditions based on the best available data, software, and knowledge. It is recommended that this map be used as a guide of solar resource potential rather than an instrument, in plan or develop solar power installations.

The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of the World Bank Group, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries.

Solargis database version: 2.1
Map issue date: 2016-10-18

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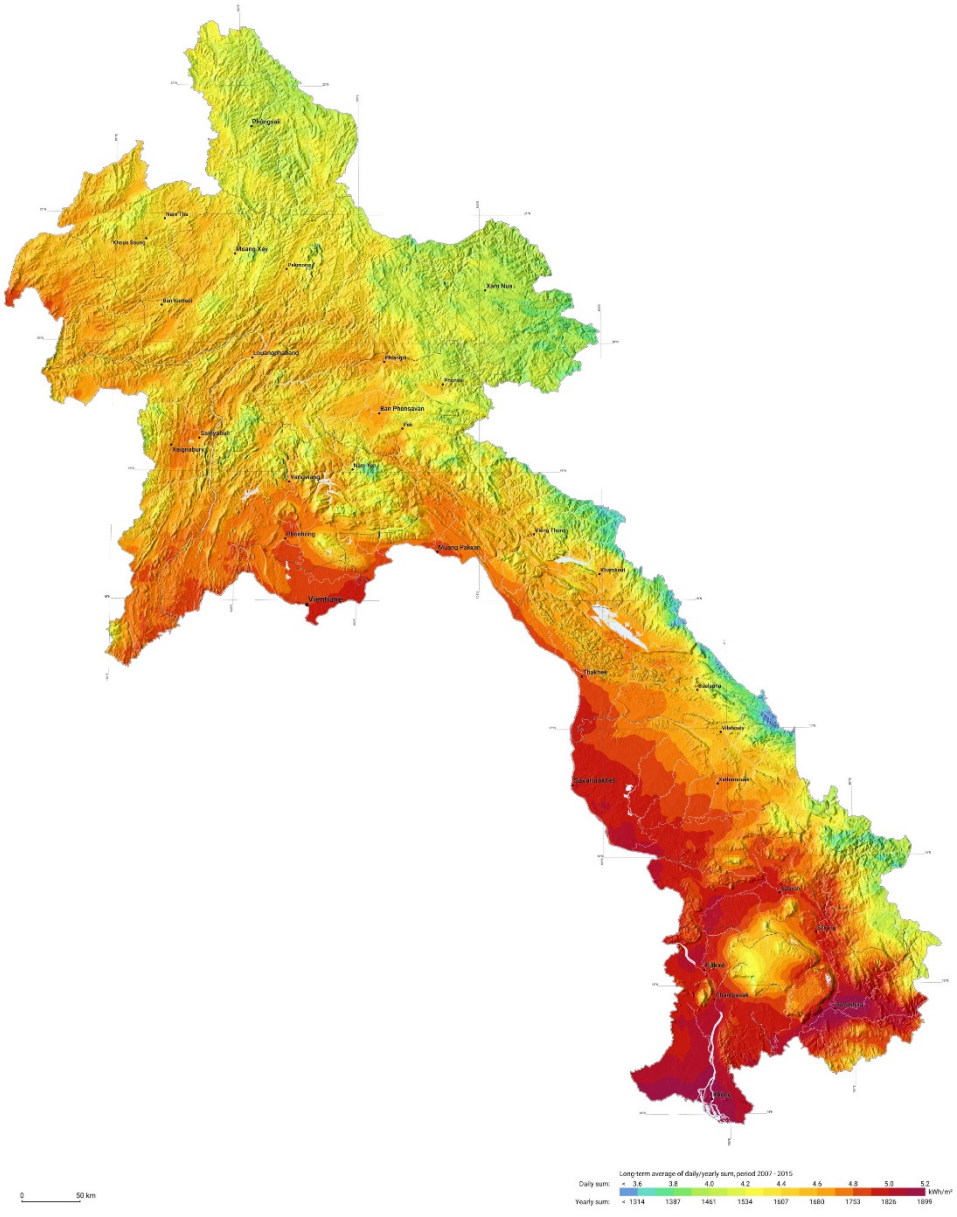
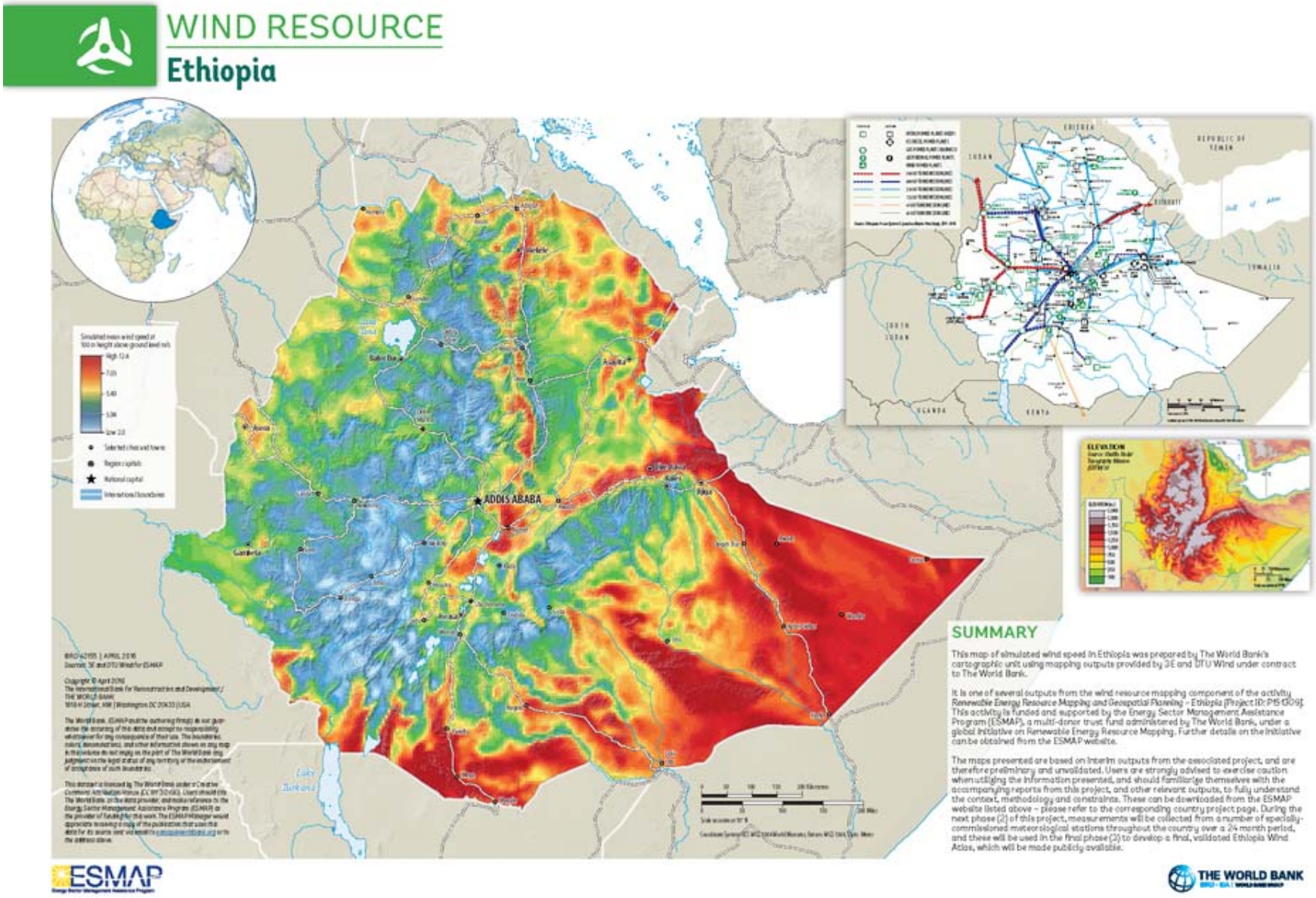
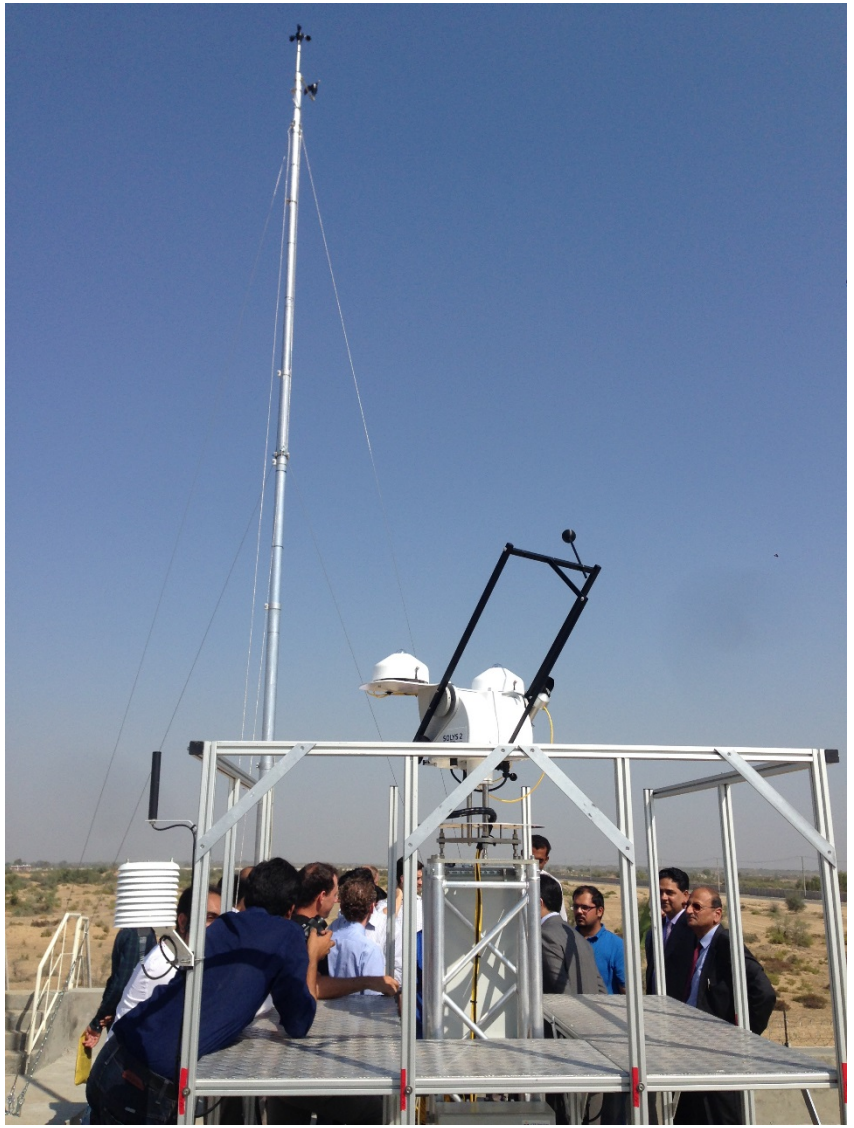


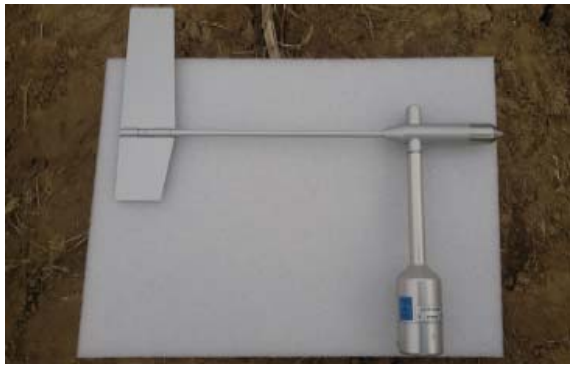
SAMPLE WIND MAP



Solar Measurement Campaign



WIND MEASUREMENT CAMPAIGN



COUNTRY PROJECT PIPELINE, ESMAP & OTHERS

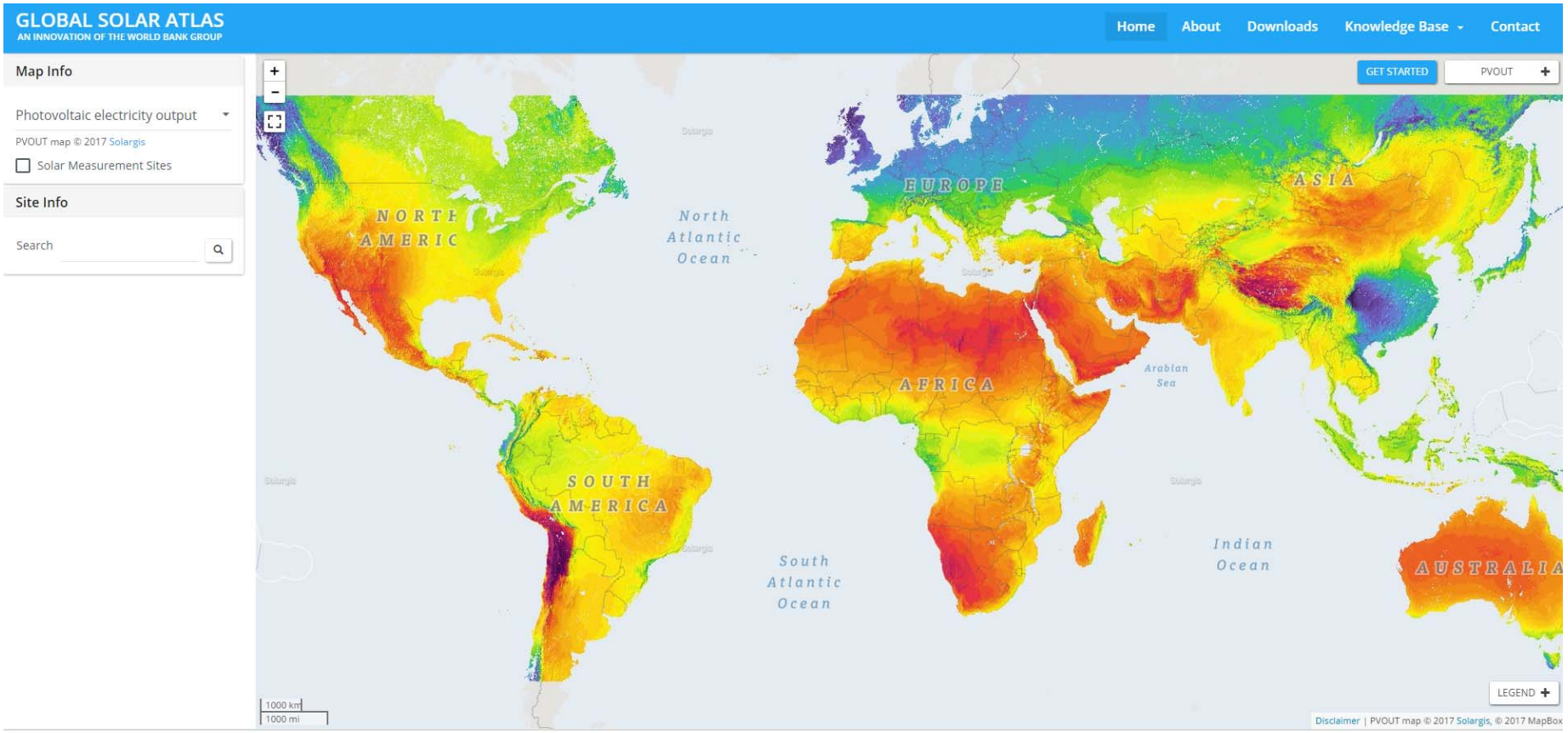
Country	Funding	Source	Biomass	Small Hydro	Solar	Wind
Bangladesh	$500,000	ESMAP / ASTAE			✓	✓
Burundi*	-	ESMAP			✓	
Ethiopia*	$1,600,000	ESMAP			✓	✓
Indonesia	$750,000	ESMAP		✓		
Kenya*	-	ESMAP			✓	
Madagascar	$1,350,000	ESMAP		✓		
Malawi	$710,000	ESMAP			✓	
Maldives	$2,415,000	ESMAP / ASTAE			✓	✓
Nepal	$1,800,000	ESMAP			✓	✓
Pacific Islands (10 countries)	$2,200,000	SIDS-DOCK			✓	✓
Pakistan	$4,350,000	ESMAP / ASTAE	✓		✓	✓
Papua New Guinea	$1,900,000	ESMAP / ASTAE			✓	✓
Rwanda*	-	ESMAP			✓	
Somalia	$1,000,000	In-country trust fund			✓	✓
Sudan*	-	ESMAP			✓	
Tanzania*	$2,350,000	ESMAP		✓	✓	✓
Uganda*	-	ESMAP			✓	

WORLD BANK APPROACH TO WIND AND SOLAR

- ESMAP initiative on Renewable Energy Resource Mapping launched in 2012; total budget of $25m up to FY16; projects in 19 countries
- Mapping outputs, for all developing countries are available for free
- All model output data and all measurement data in public domain, online
- Only transparent, peer-reviewed methodologies
- Outputs compatible with bankable, industry standard software
- Time-series based modeling to facilitate grid integration at least cost
- Uncertainty factors and variability analyzed and mapped
- Modeling validated, primarily in countries with high priority for RE
- Training, capacity building and additional tools for clients (planners)
- Create a new universal standard, enhance awareness, improve data access, support a consolidation of efforts, and remove wasteful duplication

GLOBAL SOLAR ATLAS

- Launched at World Future Energy Summit in partnership with ISA
- Around 1000 sessions a day since launch
- Poster maps disseminated to eight countries so far
- World Bank Group product – contract awarded in partnership with IFC



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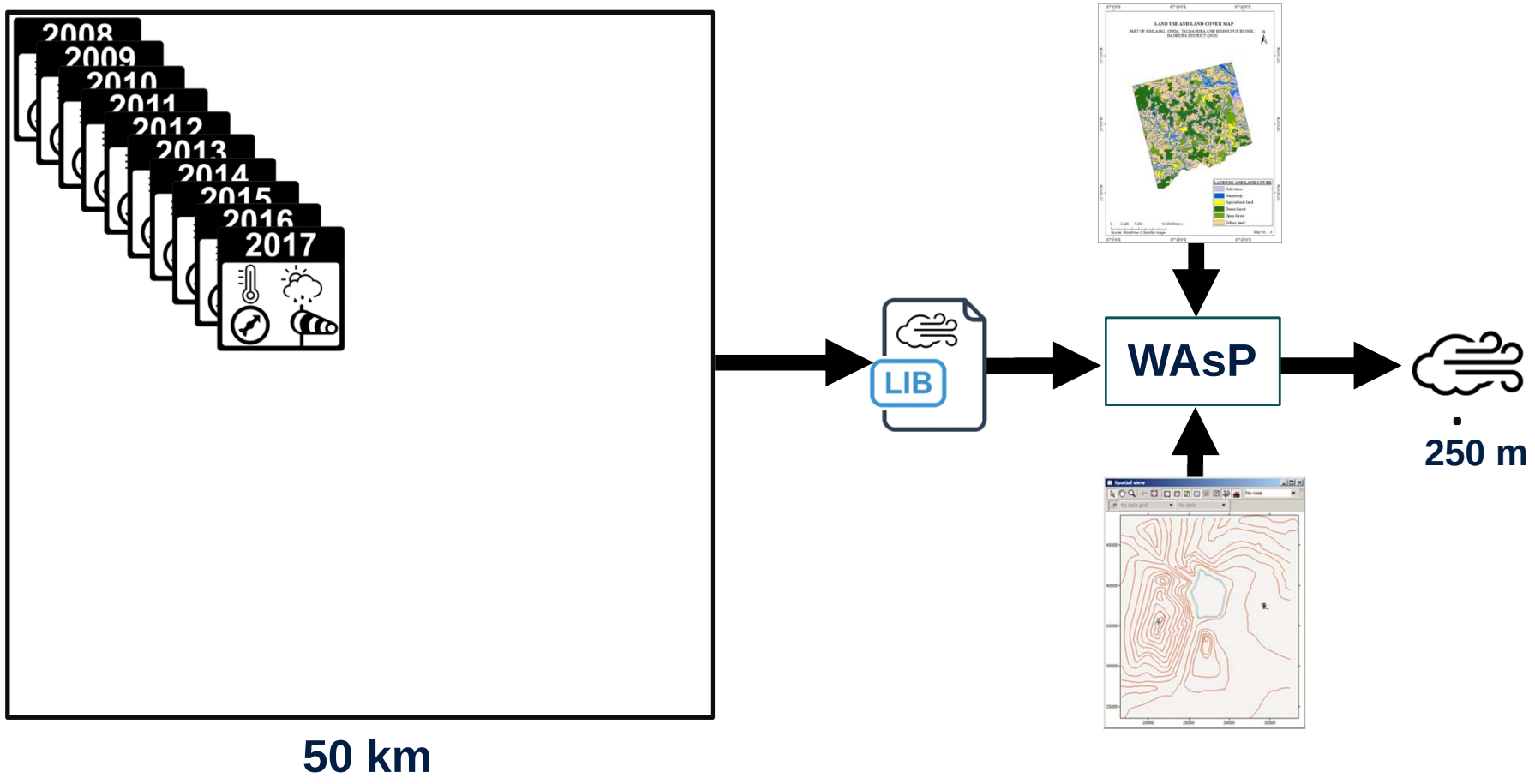
PLANS FOR 2017-2018

- Disseminate and promote **Global Solar Atlas**
- Promote new **solar data services** within WBG and to clients in support of solar scale-up
- Partner with DTU Wind Energy to improve and relaunch **Global Wind Atlas**
- Award WBG Master Agreement for **wind mapping and data services** and commission a global mesoscale mapping as input into GWA (Vortex & Everoze)
- Explore **Global Hydropower Atlas** as a concept
- Develop online **measurement data visualization platform**
- Explore global **transmission line mapping** program with other teams
- Develop tools to achieve greater value-added, such as **geospatial analysis tools**

GLOBAL WIND ATLAS VERSION 1, 2015



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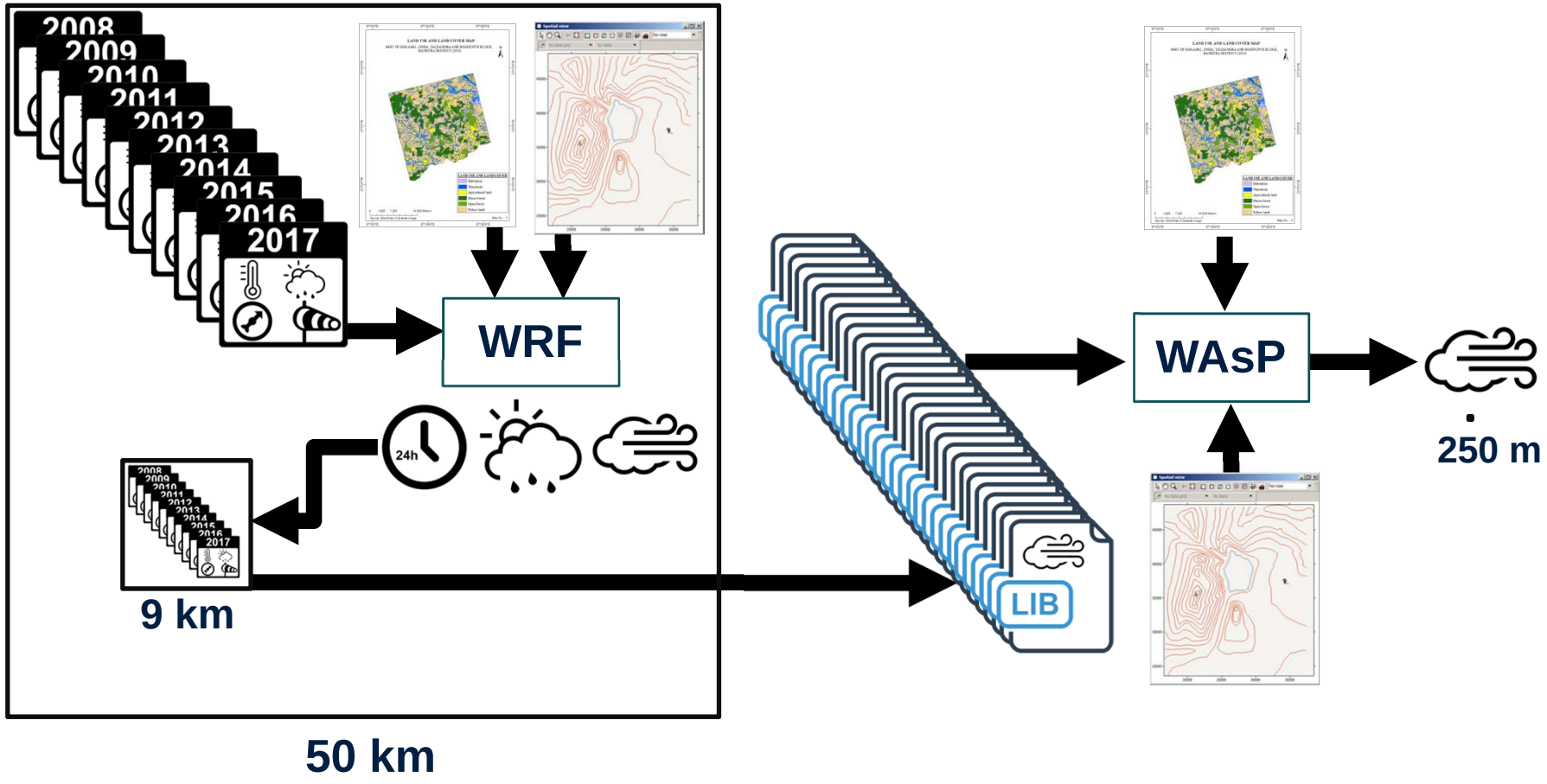
GLOBAL WIND ATLAS VERSION 2, 2017

Same method used by Risø for South Africa etc., but applied globally



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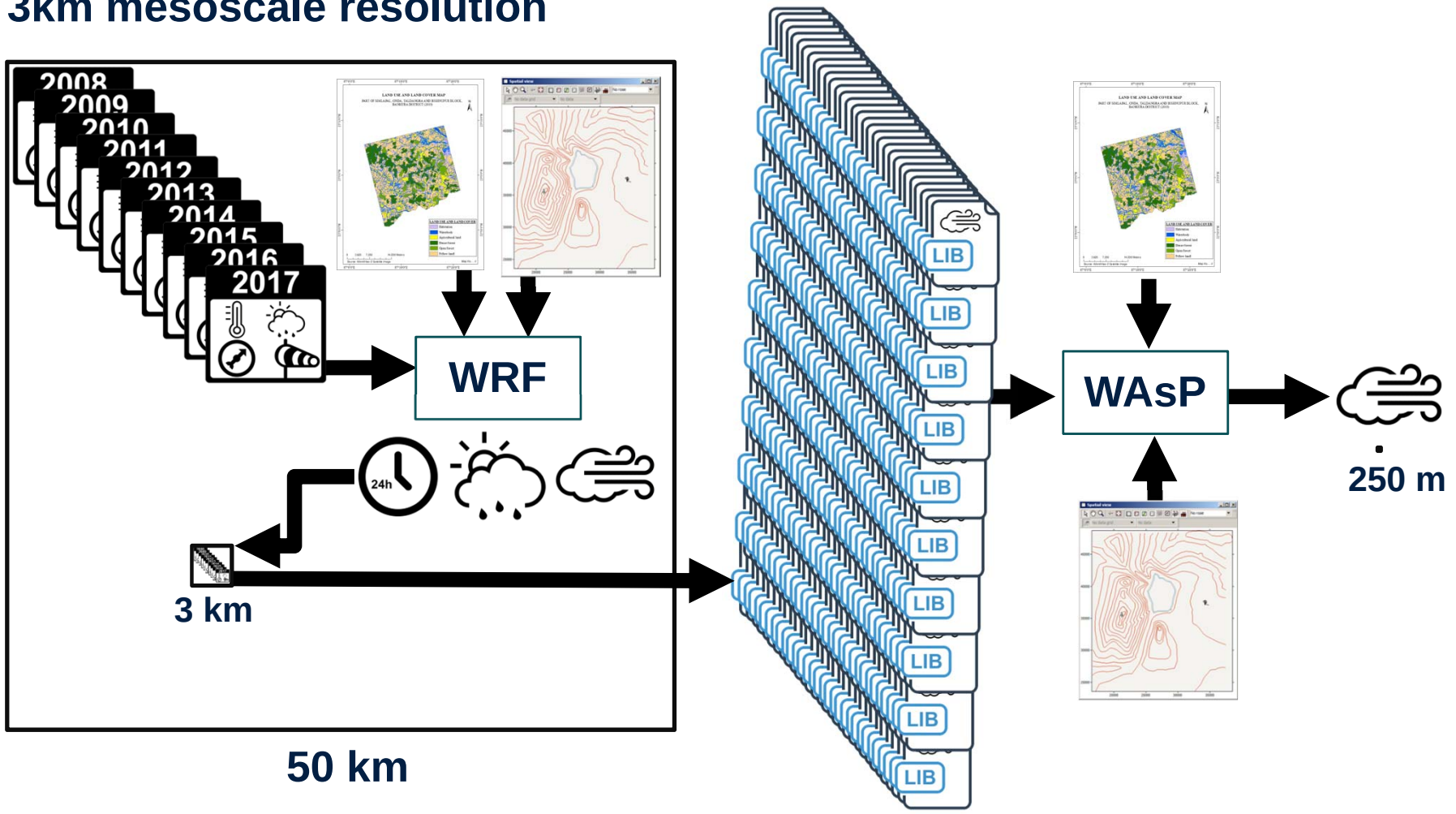
GLOBAL WIND ATLAS VERSION 3, 2018

3km mesoscale resolution



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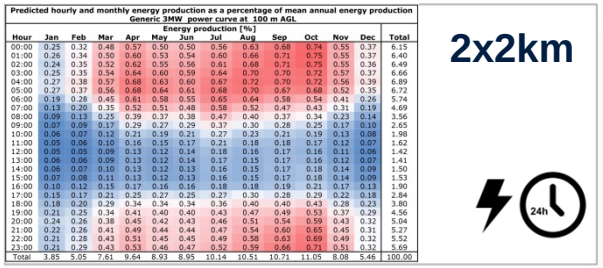
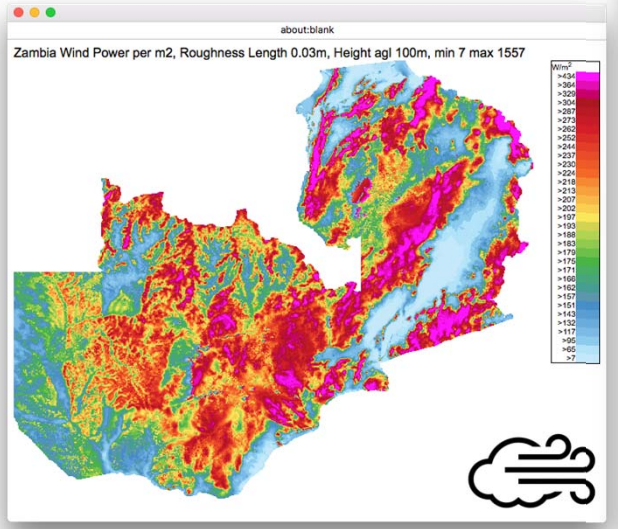
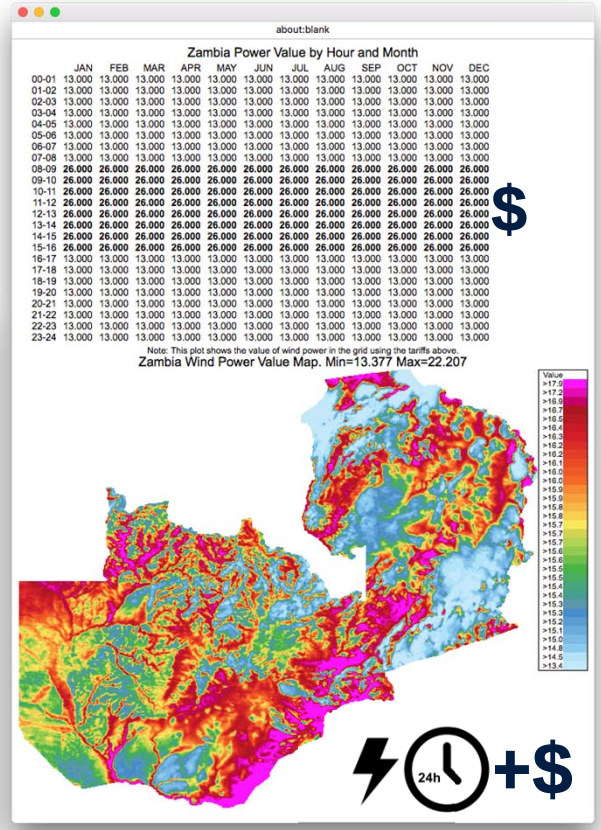
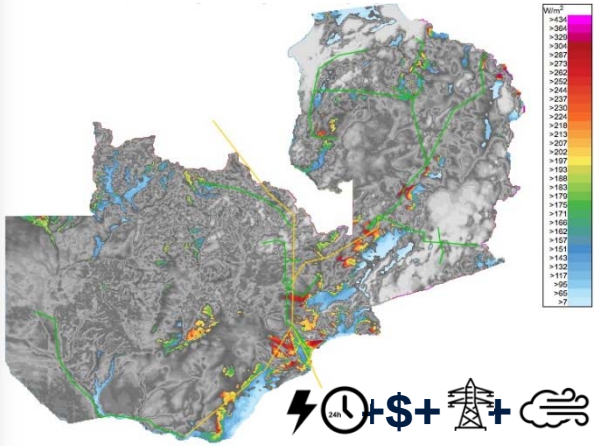
LOAD-FOLLOWING SITING IN ZAMBIA USING HOURLY AND MONTHLY POWER GENERATION









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Contact Details

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RESULTS SO FAR

- Zambia measurement data being picked up by Scaling Solar developers to finalize their bids
- Interim results from Tanzania small hydro mapping has identified sites unknown to REA
- Discussion of potential wind farm development in PNG – possibility for WB operation
- Interim wind mapping results in Ethiopia being used by Government for aggressive wind power expansion plan
- Interim wind and solar maps in Pakistan have highlighted huge resource in Balochistan, and potential for longer term development
- Interim wind mapping in Vietnam 'discovered' resources in the center and north of the country that were not previously visible – will be investigated further
- Open access measurement data being regularly downloaded by modeling firms to improve global resource estimates