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Mapping Renewable energy potential in Lesotho using the WRF model

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CRESCO: Centro computazionale di RicErca sui Sistemi COmplessi

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INTRODUCTION

Here we present some preliminary results of the project «Building renewable potential maps for Lesotho», conducted by ENEA and funded by IMELS (Italian Ministry for Environment, Land and Sea) under the UNFCCC Paris agreement on climate change (https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement). The project started on March 2018 and will be completed at the beginning of 2020. The aim of the project is to build solar photovoltaic (PV) and wind energy potential maps, besides an hydrological map, for Lesotho. The final product will be a GIS based tool containing the maps and all the relevant information layers (roads, population distribution, electrical grid, etc.) useful to Lesotho Government for planning renewable energy exploitation. In addition, the project will promote capacity building and skills transfer so that the Lesotho Government will be able to manage the supplied tool. Here we illustrate the photovoltaic (PV) and wind energy potential maps produced for the test year 2015 by means of the WRF model.

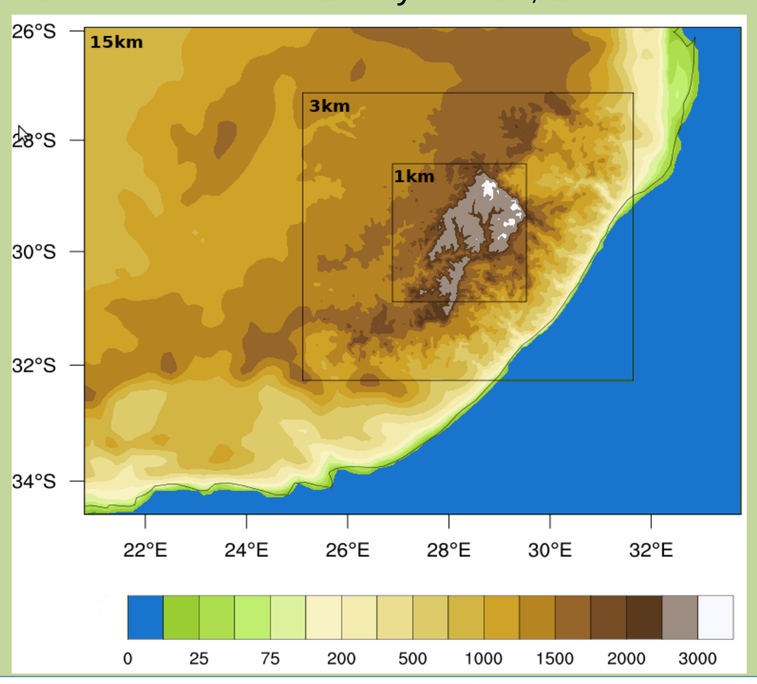
METHODOLOGY

Solar and wind energy potential maps were produced running WRF for the year 2015 with three different configurations (see Table below). The best performing simulation's hourly outputs of wind speed and air density, interpolated at 100m above ground, were used to produce Wind Power Density (WPD) map, while 10m wind, 2m temperature, diffuse and direct solar radiation were required to build the photovoltaic power potential map.

- WPD can be approximated as proportional to the cube of hourly wind speed: $$\mathrm{WPD} = \frac{1}{2}\, pv^3$$
- PV potential depends on solar radiation (both direct and diffuse), but also on panel efficiency (here cristalline silicon modules are considered), which is affected by panel temperature (higher the temperature, lower the efficiency) through air temperature and wind speed (see Huld et al., 2015 for reference).

MODEL SETUP

- Model version: WRF-solar 1.2.4 (based on WRF 6)
- Boundary conditions: ERA-5, 0.3° resolution
- Model domain: 3 domains 2-way nested, 15km -> 3km -> 1km



VALIDATION

Model configurations

	Sim1	Sim2	Sim3
Long wave	RRTMG (4)	RRTMG (4)	RRTM (1)
Short Wave	RRTMG (4)	RRTMG (4)	Dudhia Scheme (1)
Surface Layer	Eta Similarity (2)	MM5 similarity (91)	Eta Similarity (2)
Planetary Boundary Layer	Mellor-Yamada-Janjic (2)	Yonsei University scheme (1)	Mellor-Yamada Nakanishi and Niino (6)
Microphysics	WRF Single Moment 6-class (6)	WRF Single Moment 5-class (4)	New Thompson et al. scheme (8)
Land Surface Model	Noah (2)	Noah (2)	Noah (2)

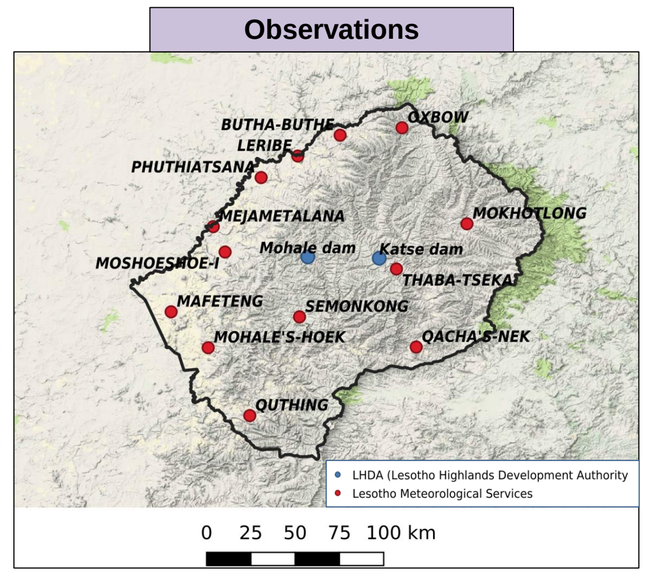
Global Irradiance scores

Simulation	NMB (%)	IOA	CORR	RMSE (W/m^2)
Sim1	9.3	0.87	0.92	140.5
Sim2	9.5	0.88	0.93	137.4
Sim3	9.9	0.88	0.93	138.6

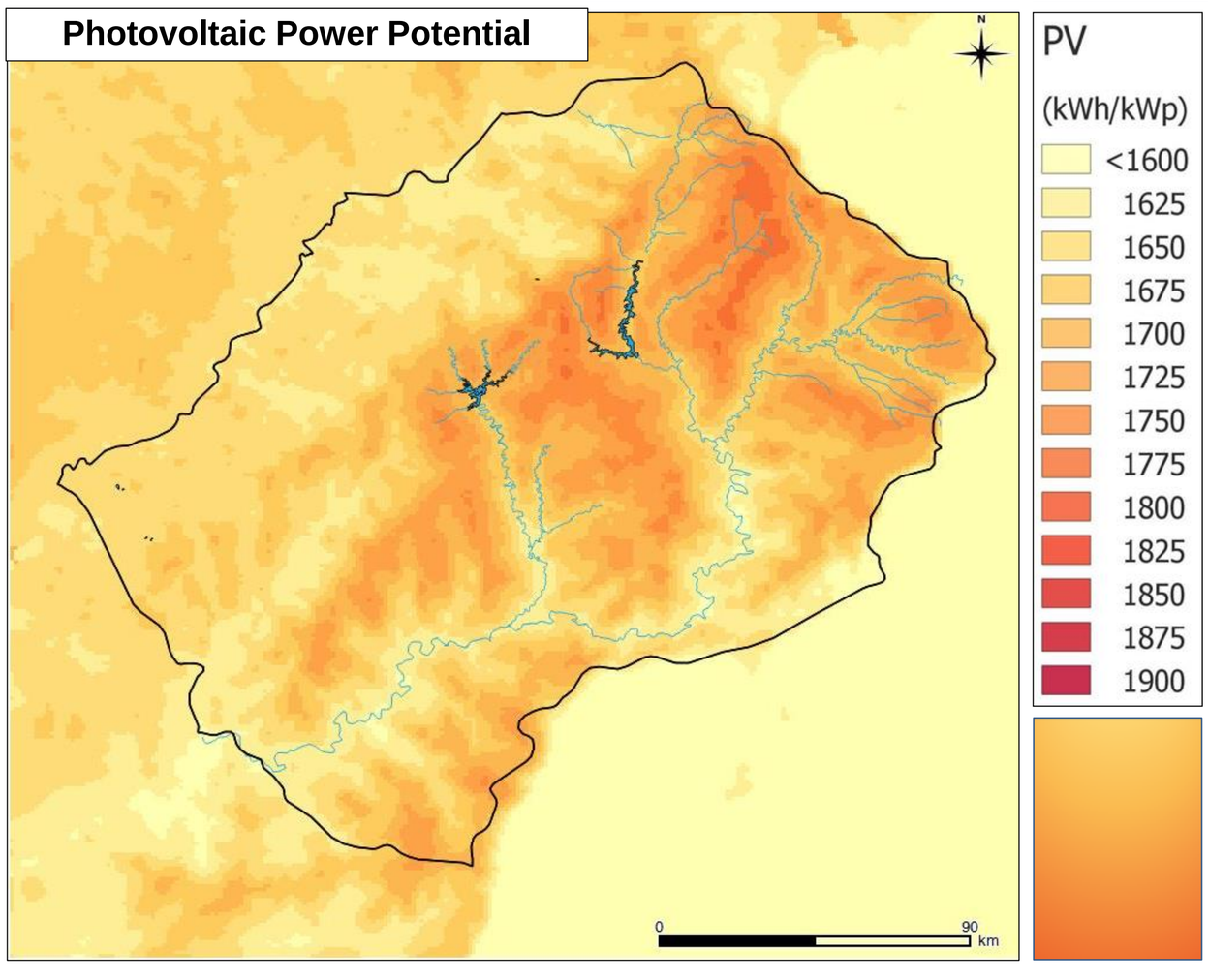
Wind speed scores

Simulation	MB (m/s)	IOA	CORR	RMSE (m/s)
Sim1	1.7	0.56	0.68	2.48
Sim2	0.5	0.63	0.66	2.05
Sim3	1.11	0.58	0.69	2.38

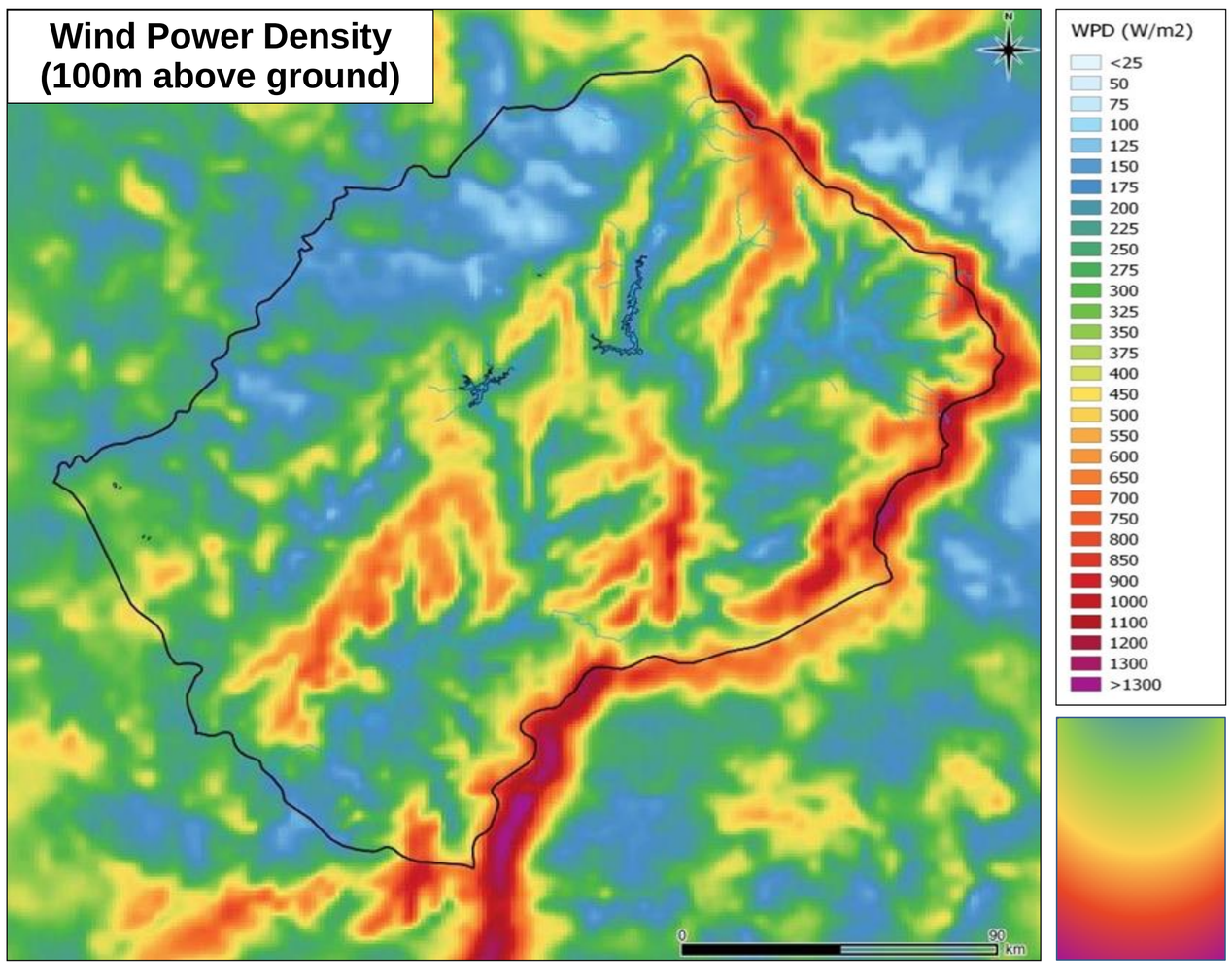
Observations



Photovoltaic Power Potential



Wind Power Density (100m above ground)



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