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South African Wind Energy Association

21 - 23 OCTOBER 2025
8:00 am – 5:00 pm

CAPE TOWN, SA
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2025 PRESENTATION

A Wind Turbines Dataset for South Africa: OpenStreetMap Data, Deep Learning Based Geo-Coordinate Correction and Capacity Analysis

Stefan Karamanski

22 October 2025

SPEAKER **OVERVIEW**

Stefan Karamanski

- **B.Eng Electrical and Electronics (Robotics) cum laude**
- **M.Eng Mechanical (Renewable and Sustainable Energy) cum laude**
- **Researcher within the Energy Centre at the Council for Scientific and Industrial Research (CSIR)**
- **Areas of expertise:**
  - **Wind energy (onshore and offshore)**
  - **Solar PV**
  - **Hydrogen energy**
  - **Smart grids**
  - **Battery energy storage systems**
  - **Spatial downscaling**
  - **Wind forecasting**
  - **Resource assessment**

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Article

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Maximilian Kleebauer, Stefan Karamanski, Doron Callies and Martin Braun

Special Issue

Advances in AI-Driven Geospatial Analysis and Data Generation (2nd Edition)

Edited by

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Article

A Wind Turbines Dataset for South Africa: OpenStreetMap Data, Deep Learning Based Geo-Coordinate Correction and Capacity Analysis

Maximilian Kleebauer [1,2,*], Stefan Karamanski [3], Doron Callies [1,2] and Martin Braun [1,2]

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2 Energy Meteorology and Geo Information System, Fraunhofer IEE, 34117 Kassel, Germany
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* Correspondence: maximilian.kleebauer@iee.fraunhofer.de

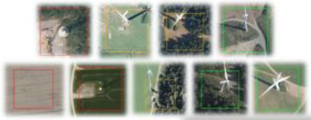
Abstract: Accurate and detailed spatial data on wind energy infrastructure is essential for renewable energy planning, grid integration, and system analysis. However, publicly available datasets often suffer from limited spatial accuracy, missing attributes, and inconsistent metadata. To address these challenges, this study presents a harmonized and spatially refined dataset of wind turbines in South Africa, combining OpenStreetMap (OSM) data with high-resolution satellite imagery, deep learning-based coordinate correction, and manual curation. The dataset includes 1487 turbines across 42 wind farms, representing over 3.9 GW of installed capacity as of 2025. Of this, more than 3.6 GW is currently operational. The Geo-Coordinates were validated and corrected using a RetinaNet-based object detection model applied to both Google and Bing satellite imagery. Instead of relying solely on spatial precision, the curation process emphasized attribute completeness and consistency. Through systematic verification and cross-referencing with multiple public sources, the final dataset achieves a high level of attribute completeness and internal consistency across all turbines, including turbine type, rated capacity, and commissioning year. The resulting dataset is the most accurate and comprehensive publicly available dataset on wind turbines in South Africa to date. It provides a robust foundation for spatial analysis, energy modeling, and policy assessment related to wind energy development. The dataset is publicly available.

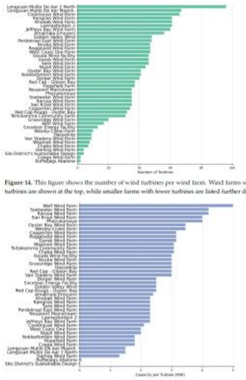
Keywords: wind turbine location; renewable energy; deep learning; geo-coordinate correction; OpenStreetMap

1. Introduction

Wind energy is one of the fastest-growing renewable energy so… In 2023, wind energy recorded its highest ever growth: in a single year, …

Figure 2. The method of the static cutting of the training images is shown. The black lines represent the cutting edges, the red dots the coordinates of the wind turbines.





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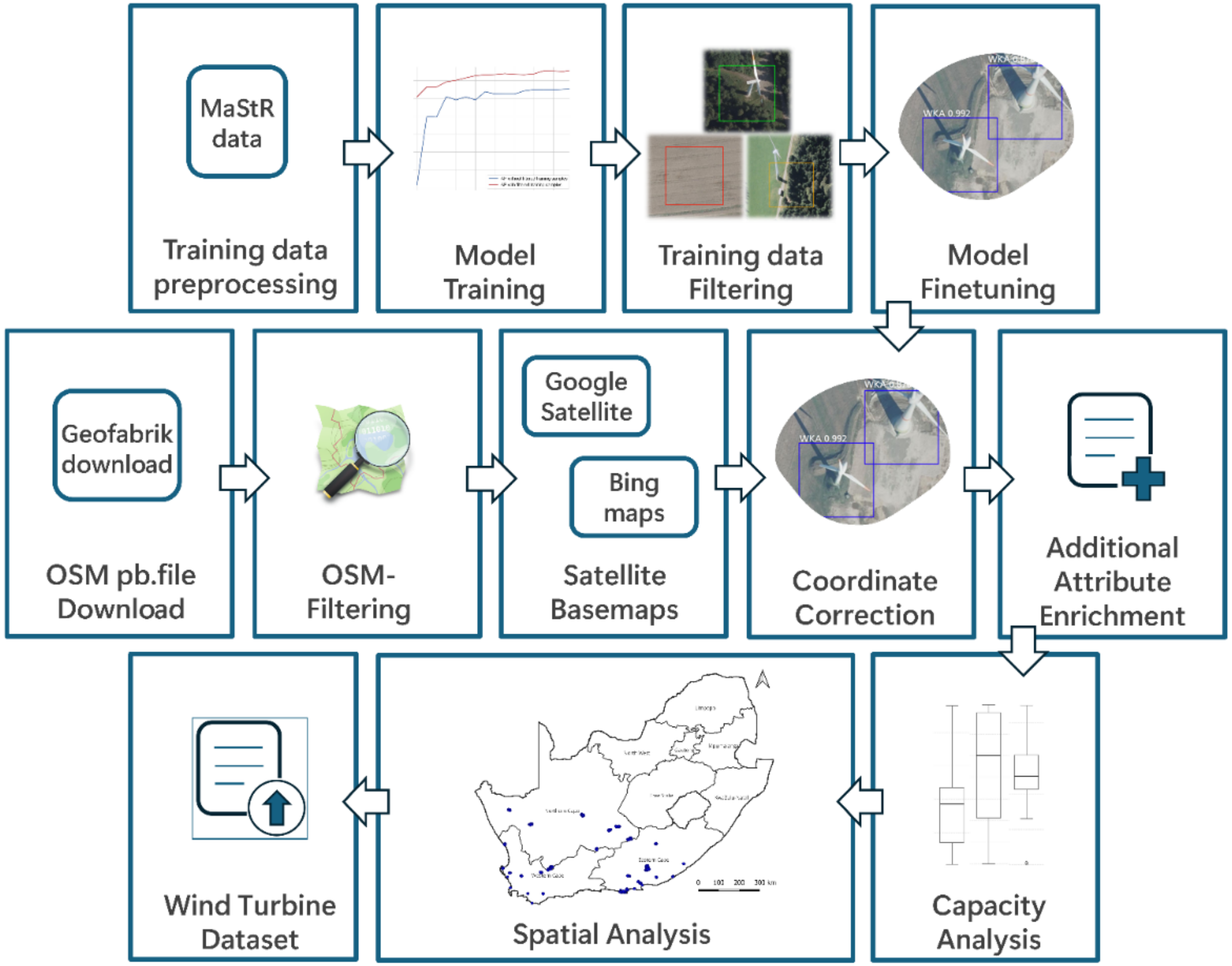
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Training data Filtering
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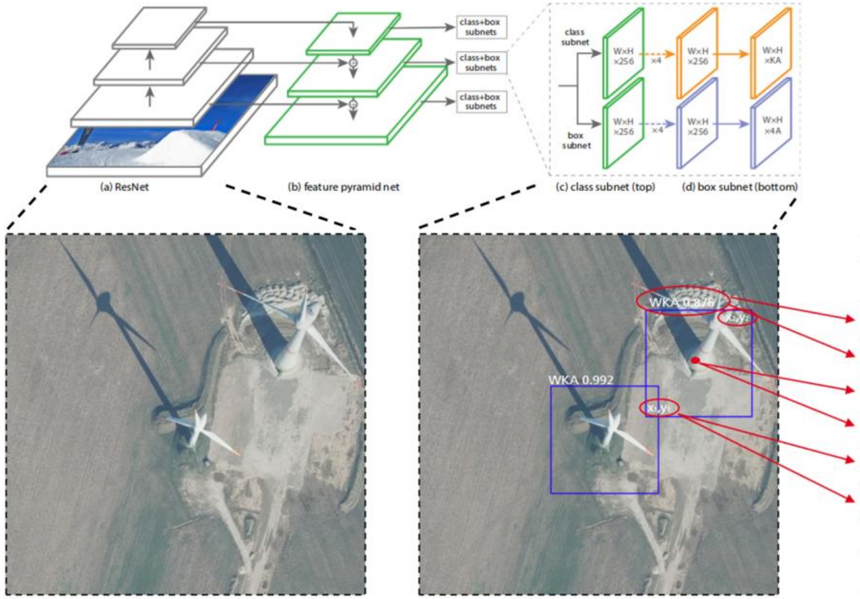
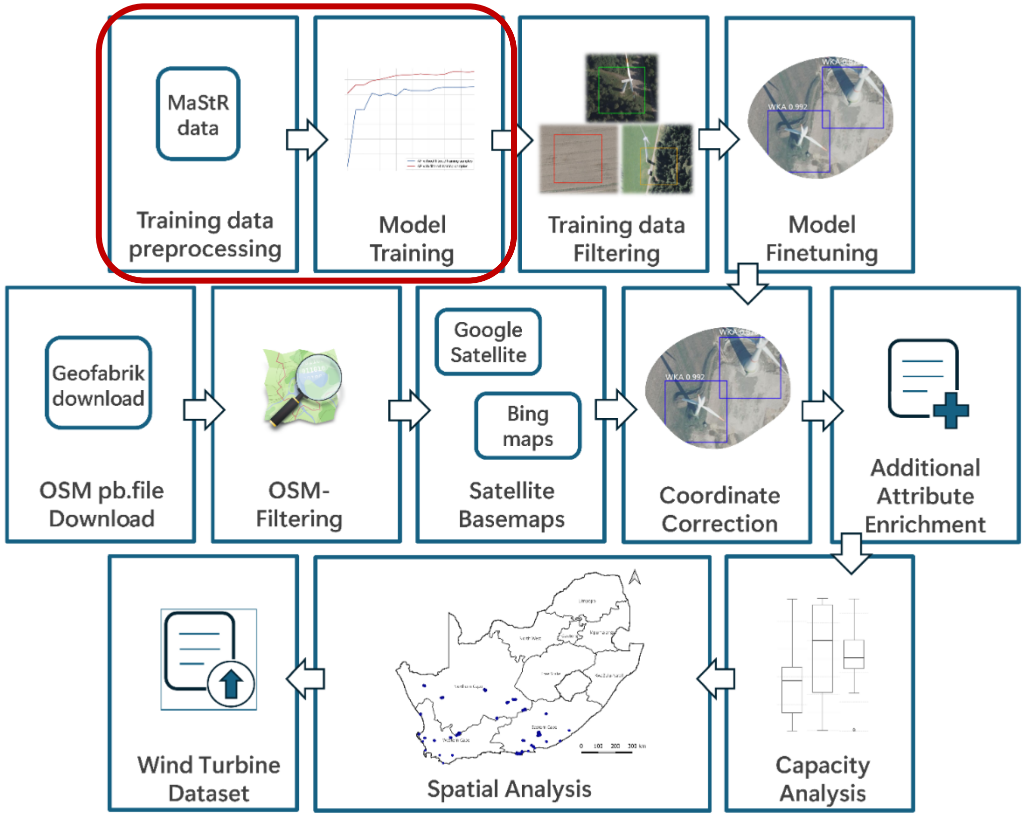


Objekttabelle
Bildname
Vorhersage-genauigket
Klassenname
Easting
Northing
X_1
Y_1
X_2
y_2



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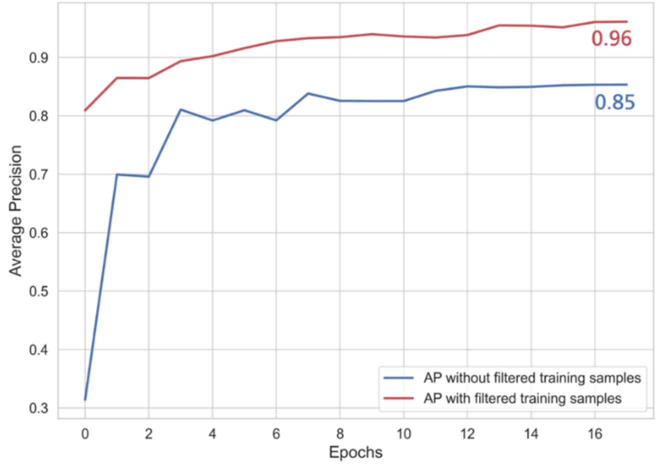
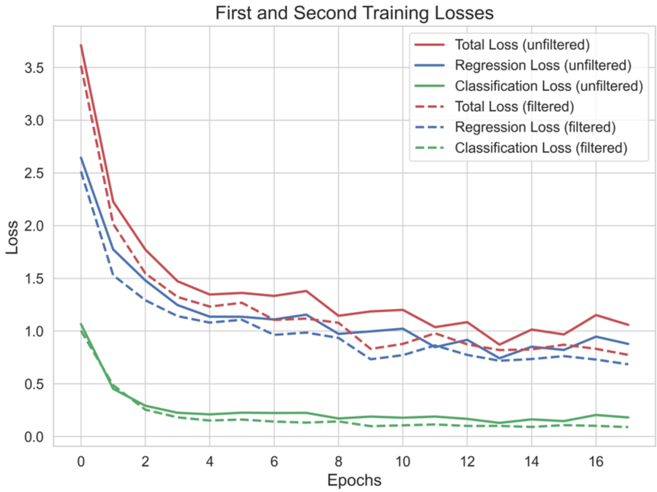
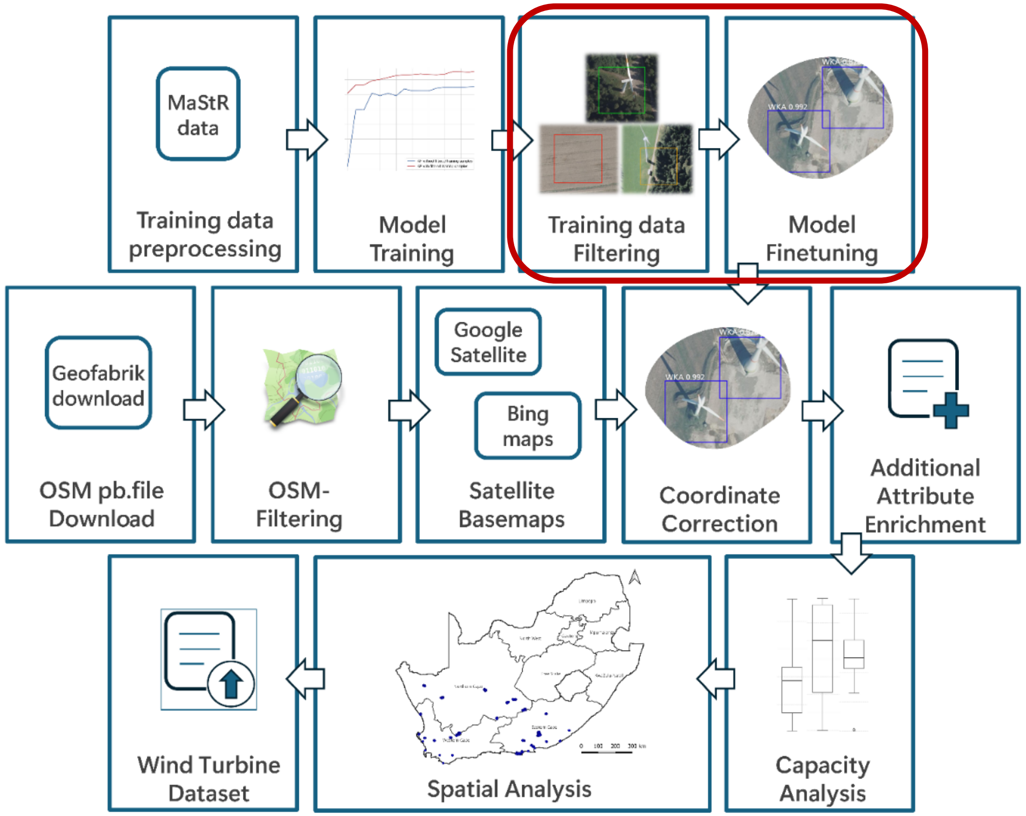

0.96
0.85
Average Precision
Epochs
AP without filtered training samples
AP with filtered training samples


First and Second Training Losses
Total Loss (unfiltered)
Regression Loss (unfiltered)
Classification Loss (unfiltered)
Total Loss (filtered)
Regression Loss (filtered)
Classification Loss (filtered)
Loss
Epochs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GEOFABRIK downloads

Download OpenStreetMap data for this region:

South Africa

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The OpenStreetMap data files provided on this server do **not** contain the user names, user IDs and changeset IDs of the OSM objects because these fields are assumed to contain personal information about the OpenStreetMap contributors and are therefore subject to data protection regulations in the European Union.
Extracts with full metadata are available to OpenStreetMap contributors only.

Commonly Used Formats

- south-africa-latest.osm.pbf, suitable for Osmium, Osmosis, imposm, osm2pgsql, mkgmap, and others. This file was last modified 1 day ago and contains all OSM data up to 2025-05-13T20:20:35Z. File size: 347 MB; MD5 sum: 7e63e92a842c8bd4f8ee3c8f49bb7f34.
- south-africa-latest-free.shp.zip, yields a number of ESRI compatible shape files when unzipped. (Format description PDF) This file was last modified 1 day ago. File size: 851 MB; MD5 sum: f9aaa56785fd9cdde1dcb9b9bf86d90a.

Other Formats and Auxiliary Files

- south-africa-latest.osm.bz2, yields OSM XML when decompressed; use for programs that cannot process the .pbf format. Deprecated - not updated any more. MD5 sum:

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South Africa

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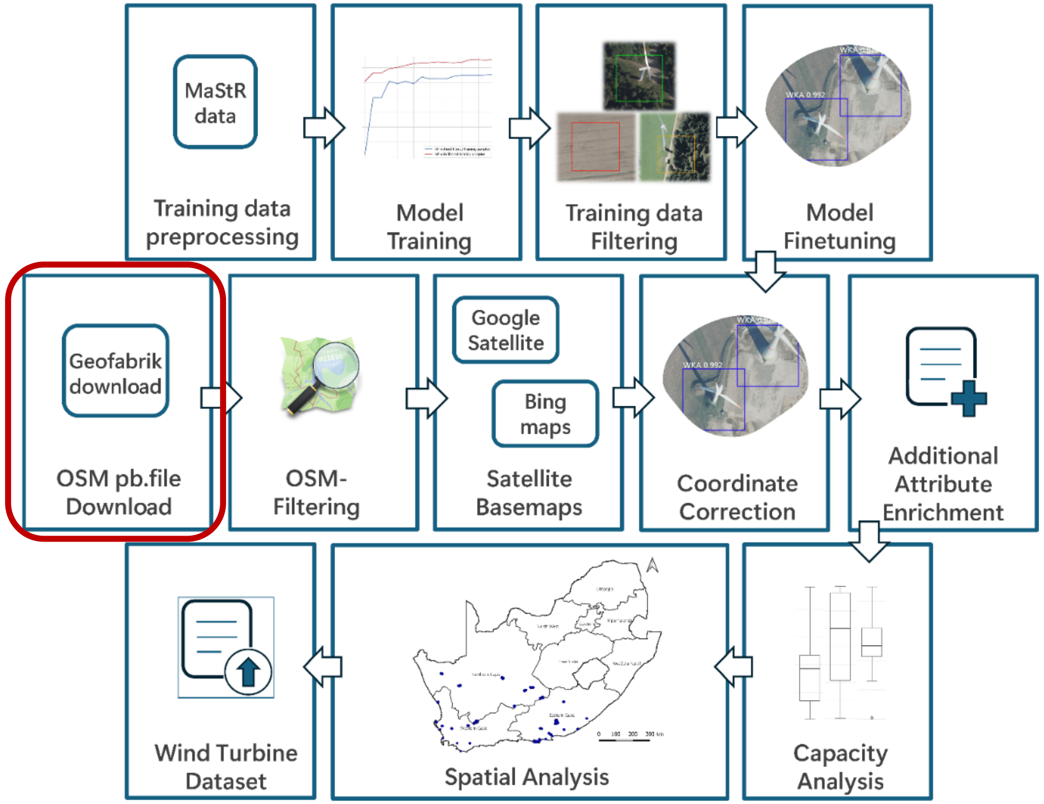


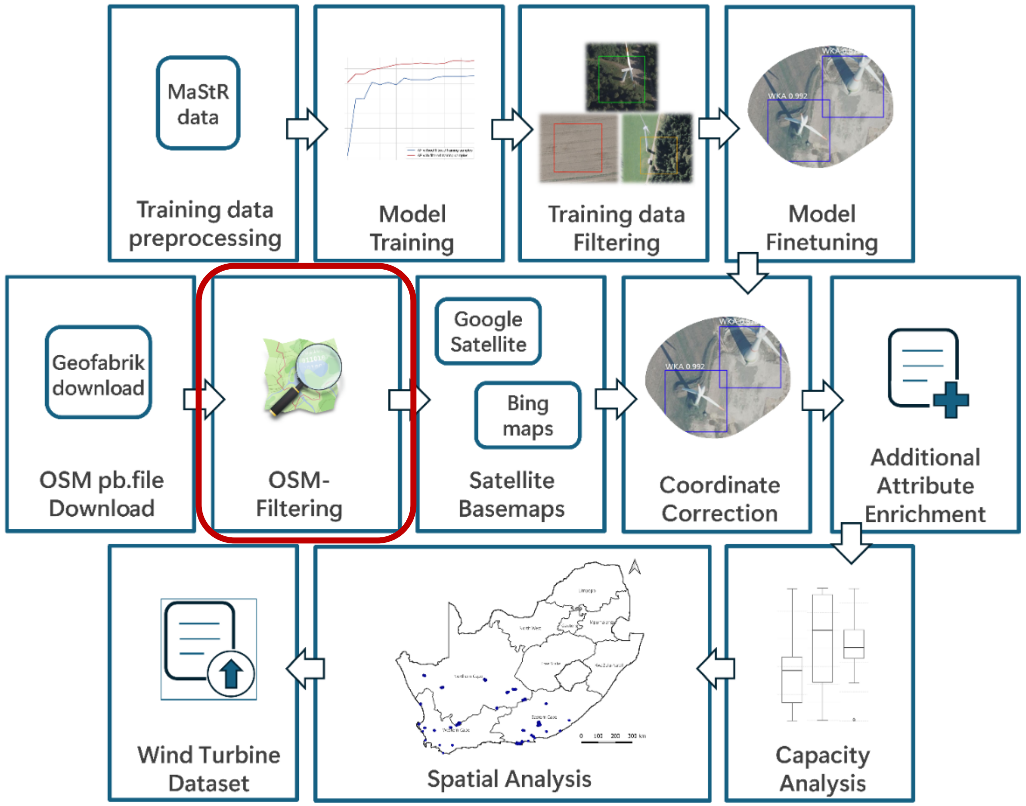
Software Metapapers

esy-osmfilter – A Python Library to Efficiently Extract OpenStreetMap Data

Adam Pluta, Ontje Lünsdorf

- **Prefilter**: The 'prefilter' is used to identify nodes, ways, and relations tagged with attributes like '"power": ["generator", "plant", "solar", "photovoltaic"]' to capture all relevant renewable energy installations.
- **Blackfilter**: A 'blackfilter' is applied to exclude certain types of infrastructure that are not of interest, such as those associated with fossil fuels or hydro-based generation. Examples include '("generator:source", "gas")', '("generator:method", "combustion")', and '("generator:source", "coal")'.
- **Whitefilter**: A 'whitefilter' is also used to ensure that elements explicitly tagged with '("power", "generator")' are retained in the dataset.

This process provides a refined dataset that filters out non-relevant elements and focuses on renewable energy facilities, improving the quality and relevance of the geospatial analysis.

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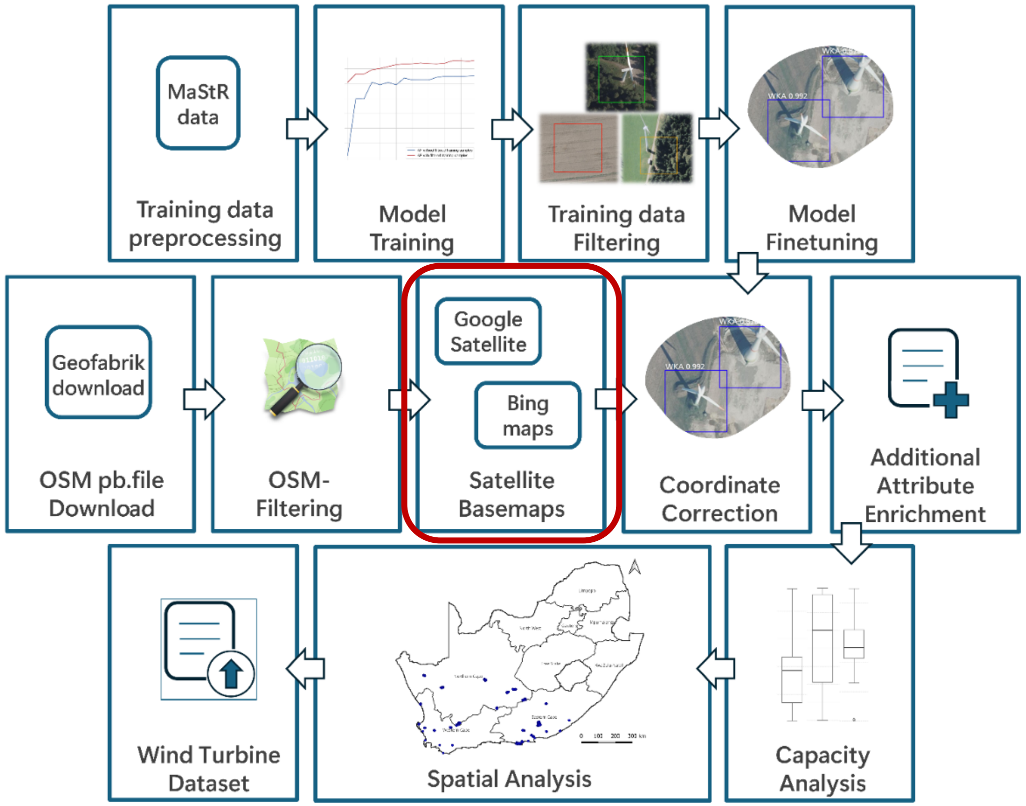
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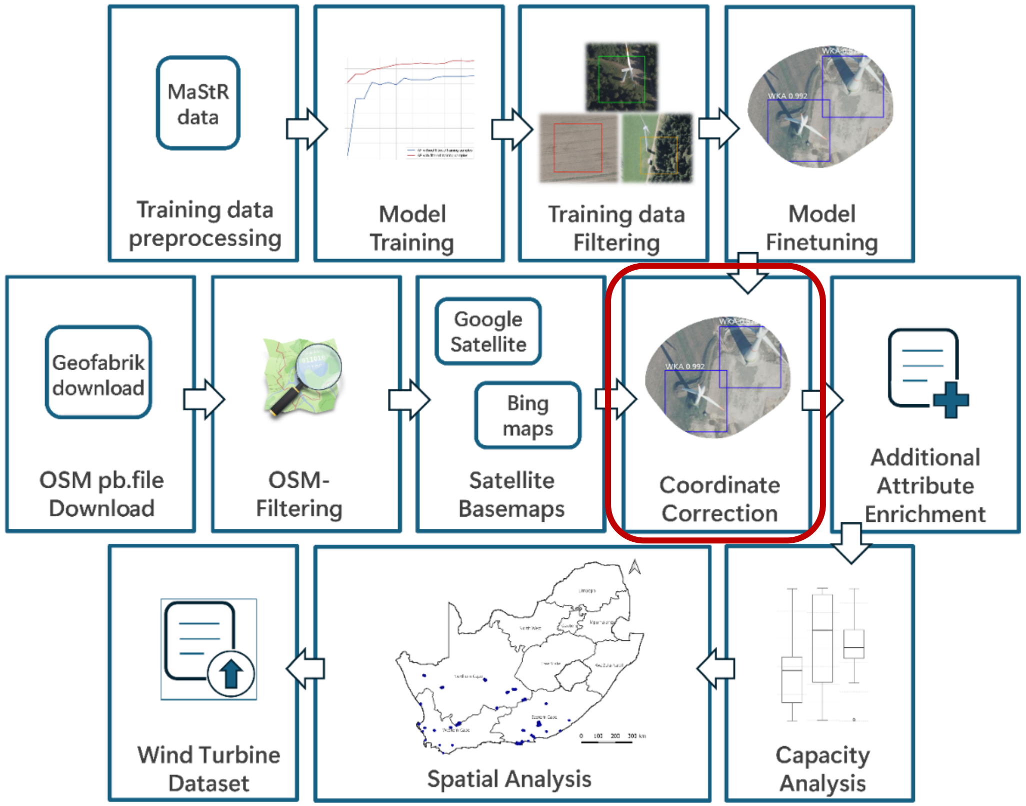
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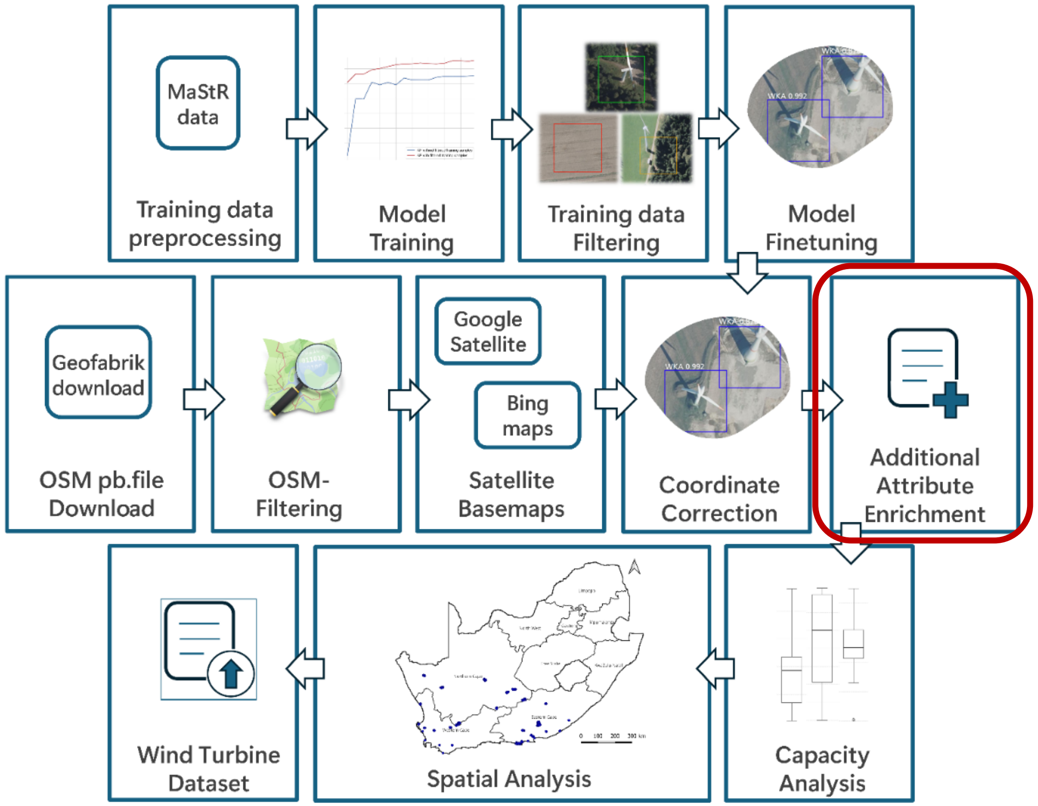
Table 3. Summary of Wind Turbines in South Africa, including the commissioning year, number of turbines, total capacity, capacity per turbine, and turbine type for each wind farm.

Name of Farm	Comm. Year	Turbines	Tot. Cap. (MW)	Cap./Turbine (MW)	Turbine Type
Amakhala Emoyeni	2016	56	134.4	2.4	Nordex N117/2400
Buffeljags Abalone	2012	2	0.13	0.065	Horizontal Axis Turbine
Chaba Wind Farm	2015	7	21.5	3.075	Vestas V112-3.075
Coega Wind Farm	2010	2	3.6	1.8	General Electric GE2.5XL
Cookhouse Wind Farm	2014	66	138.6	2.1	Suzlon S88/2100
Copperton Wind Farm	2021	34	102	3.15	Acciona AW-3150/125
Darling Wind Farm	2008	4	5.2	1.3	Fuhrländer FL 1250/62
Dassieklip	2015	9	27	3	Sinovel SL 3000/90
Dorper Wind Farm	2014	40	100	2.5	Nordex N100/2500
Excelsior Energy Facility	2020	13	32.5	2.5	Goldwind GW121/2500
Garob Wind Farm	2021	46	145	3.15	Nordex AW125/3150
Golden Valley Wind	2020	48	120	2.5	Goldwind GW121/2500
Gouda Wind Facility	2015	46	138	3	Acciona AW-3000/100
Grassridge Wind Farm	2016	20	60	3	Vestas V112/3000
Hopefield Farm	2014	37	66.6	1.8	Vestas V100-1.8
Jeffreys Bay Wind Farm	2014	60	138	2.3	Siemens SWT-2.3-101
Kangnas Wind Farm	2020	61	140	2.3	Siemens SWT-2.3-108
Karusa Wind Farm	2021	35	147	4.2	Vestas V136-4.2
Khobab Wind Farm	2017	61	140	2.3	Siemens SWT-2.3-108
Loeriesfontein 2	2017	61	140	2.3	Siemens SWT-2.3-108
Longyuan Mulilo De Aar 2 North	2017	96	144	1.5	Guodian UP86/1500
Longyuan Mulilo De Aar Maanh.	2016	67	100	1.5	Guodian UP86/1500
Noblesfontein Wind Farm	2014	41	73.8	1.8	Vestas V100-1.8
Nojoli Wind Farm	2016	44	88	2	Vestas V100-2.0
Noupoort Mainstream	2016	35	80.5	2.3	Siemens SWT-2.3-108
Nxuba Wind Farm	2020	47	140	3	Nordex AW 125/3150
Oyster Bay Wind Farm	2021	41	140	3.45	Vestas V117-3.45
Perdekraal East Wind Farm	2020	48	110	2.3	Siemens SWT-2.3-108
Phezukomoya	2025*	35**	140	4	Vestas V136-4.0



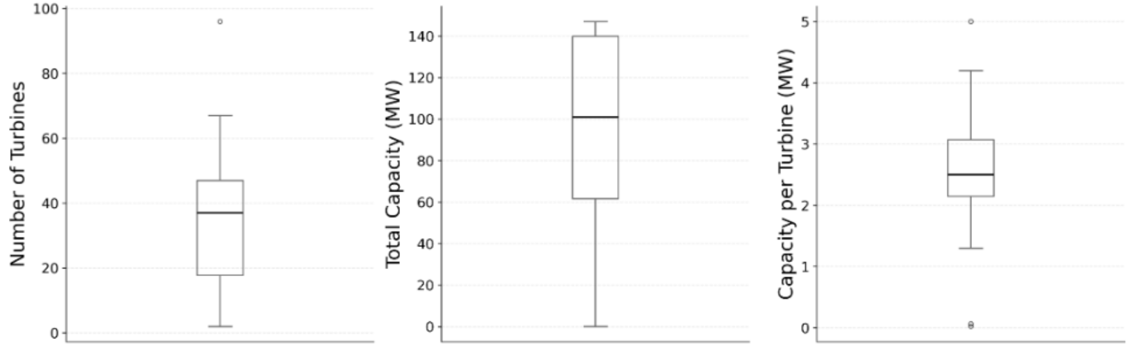


Figure 11. Summary statistics of key parameters of South African wind farms. Number of turbines per wind farm (left side), total installed capacity (MW) per wind farm (in the middle), and capacity per turbine (MW) (on the left). The boxplots contains the median, interquartile range, and outliers in the dataset

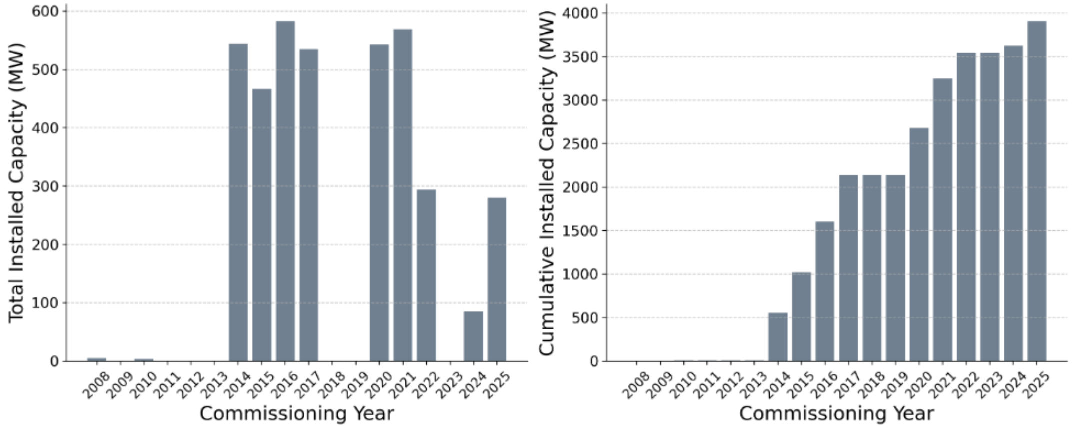
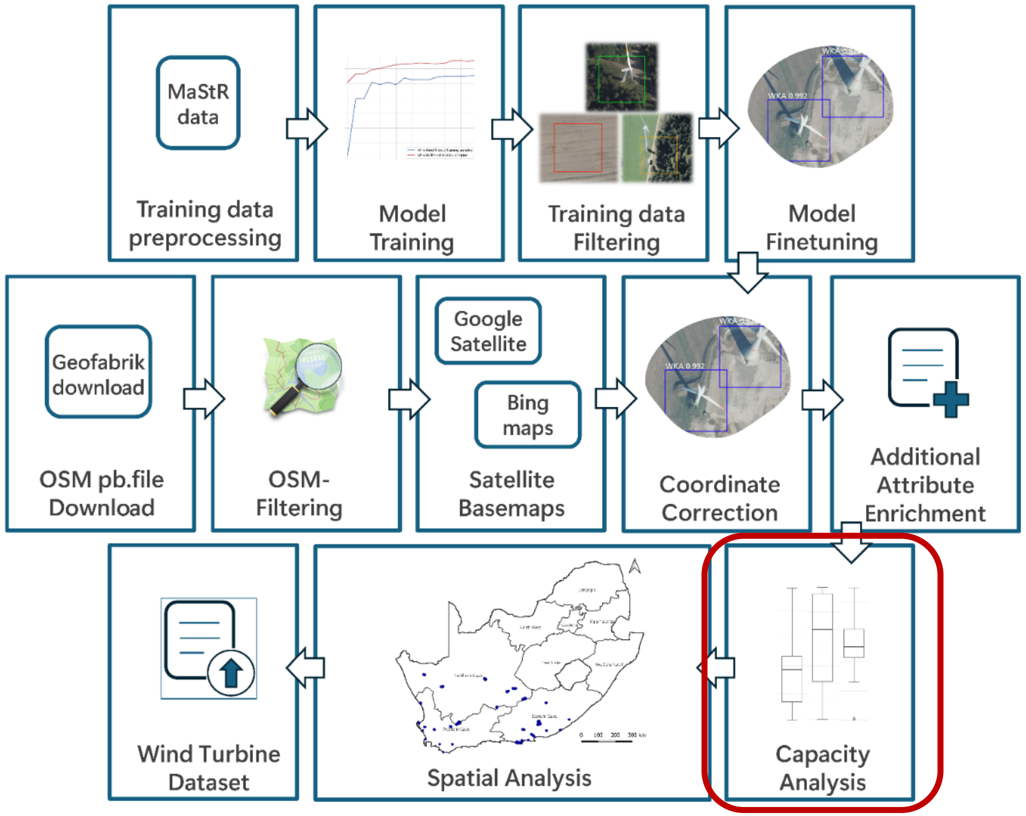


Figure 12. Development of wind power capacity in South Africa by year. The annual installed wind power capacity from 2008 to 2025 is shown on the left-hand side, and the cumulative installed capacity on the right-hand side.



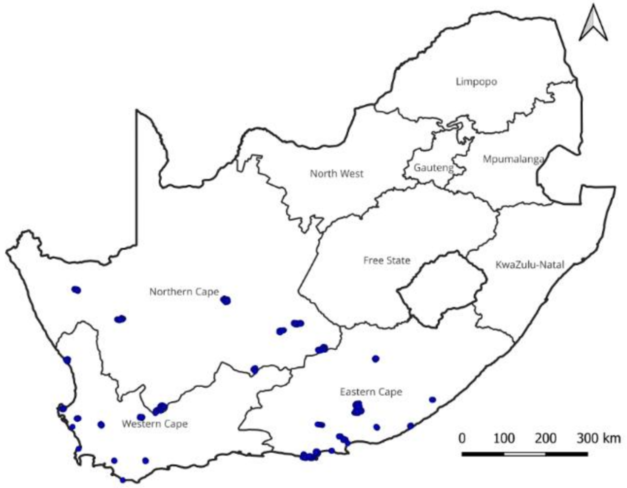


Figure 16. Spatial distribution of all existing wind turbines in South Africa, marked in blue, highlighting their locations across the country.

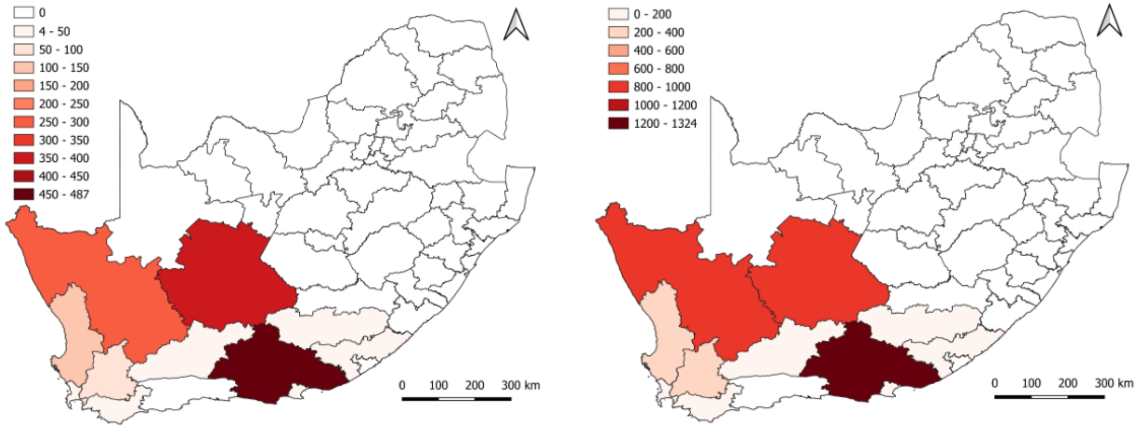
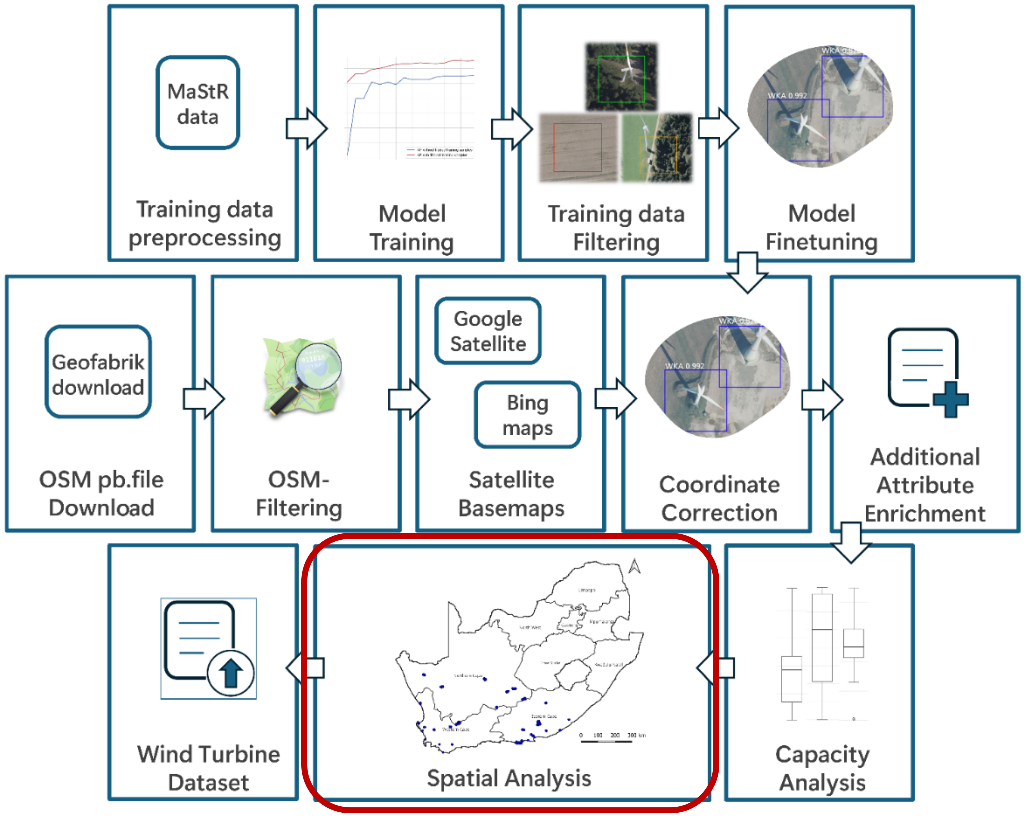


Figure 17. Spatial distribution of wind energy infrastructure by municipality. Map (on the left side) displays the number of wind turbines, while map (on the right side) shows the total installed wind capacity (MW). The patterns reveal significant regional clustering, with a small number of municipalities concentrating the majority of infrastructure.



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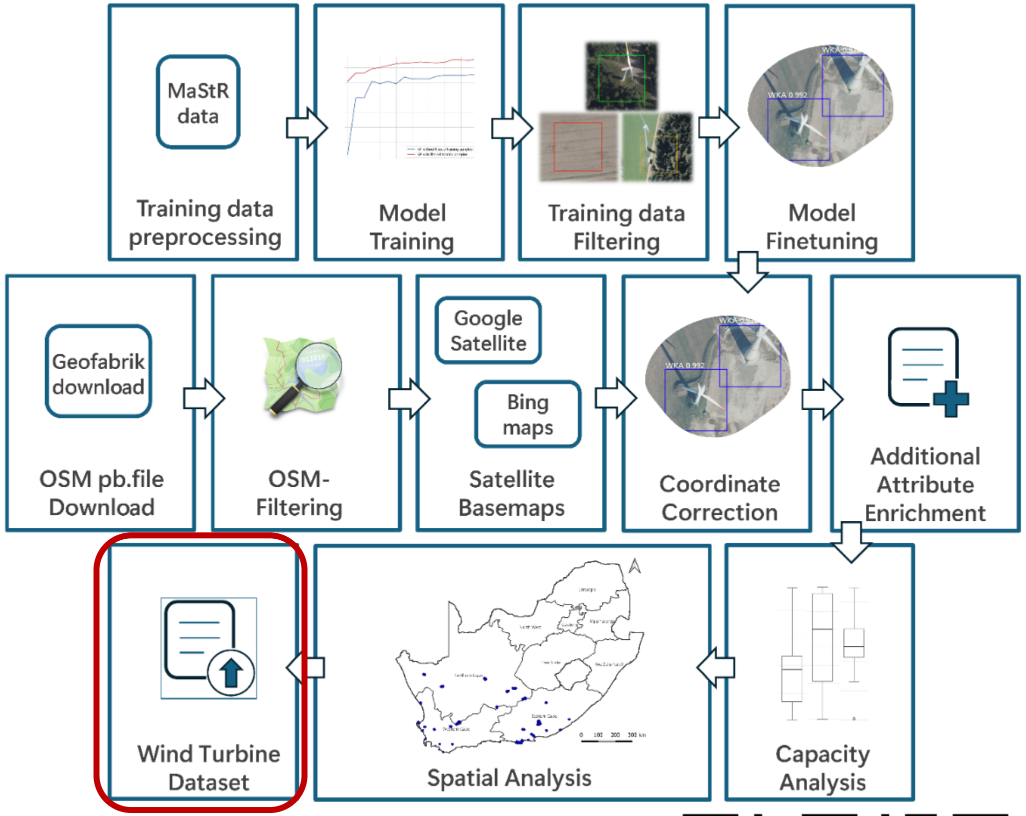

Online Dataset:

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CONTACT DETAILS

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Researcher

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