WORKSHOP ON WEATHER AND CLIMATE SERVICES

Using weather and climate data to support decision-making in the energy sector

icem 2023 7th International Conference Energy & Meteorology:
Towards Climate-Resilient Energy Systems

Convenors: James Fallon, Jake Badger and Justin Sharp (remote)

https://linktr.ee/ICEM23ClimateServices

PROGRAMME

Tuesday 27th June 16:15-18:00 CEST

Panellists: Hiba Omrani, Falguni Patadia, Frank Kaspar, Gabriel Perez

Time	Activity	Speaker
16:15	Introduction	James
16:20	Overview of Climate Services	Jake, Panellists
16:40	Interactive Session: Climate Services Notebook	James
17:20	Discussion: the "Next Generation" of Climate Services	Panellists
17:55	Closing remarks	Justin

INTRODUCTION

WHAT IS A CLIMATE SERVICE?

A decision aide derived from climate information

Example slides and schematics here: https://www.wemcouncil.org/TALKS/EEA_Troccoli_Copenhagen_Sep2018.pdf

WMO Definition: https://public.wmo.int/en/bulletin/what-do-we-mean-climate-services

WHAT IS A CLIMATE SERVICE USED FOR?

WHAT WE WILL COVER TODAY?

- introduction from expert panellists
- how to **access and use** some climate services with python notebooks
- things to be aware of
- discussion on the next generation of weather & climate services

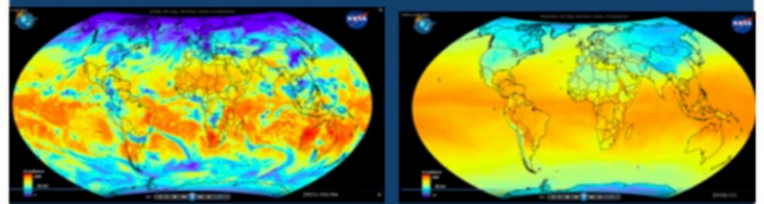
OVERVIEW OF LIVE CLIMATE SERVICES

Panellists:

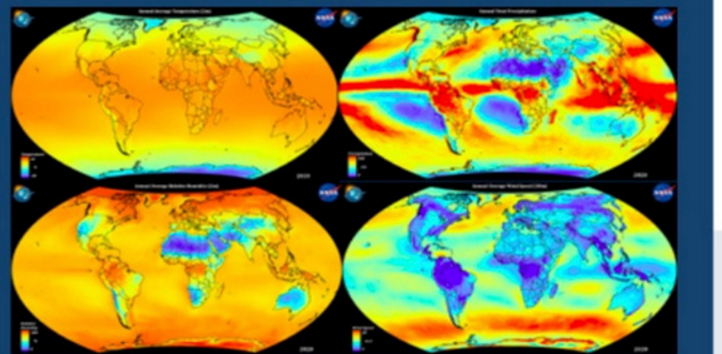
- Falguni Patadia (NASA POWER)
- Hiba Omrani (FOCUS-AFRICA)
- Gabriel Perez (Meteo IA)
- Frank Kaspar (DWD)

https://power.larc.nasa.gov/

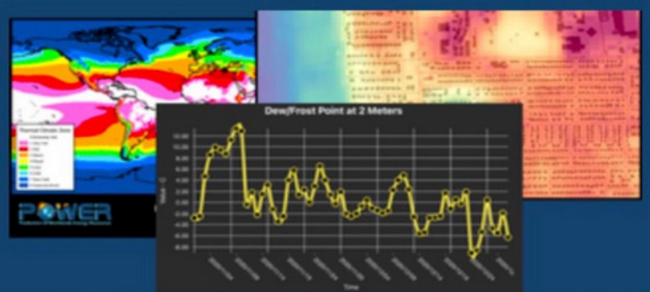
DATA PRODUCTS



Satellite based Hourly, Daily and Annual Average global **Surface Radiation data** at 1 Degree since July 1984 to-date



Hourly **Meteorological data** at 1/2 Degree from NASA MERRA-2 reanalysis since 1981 to-date along with several derived parameters



NASA data and **derived parameters** provided in formats for immediate adoption into solar energy, building systems planning and crop modeling decision support tools

National Aeronautics and Space Administration

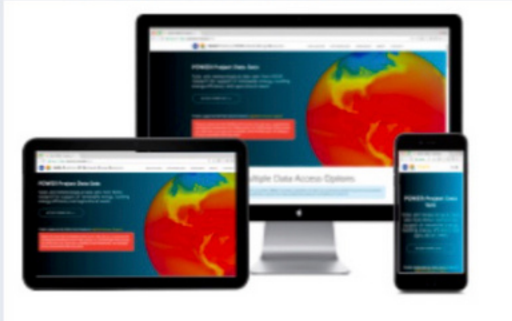
POWER

Prediction Of Worldwide Energy Resources

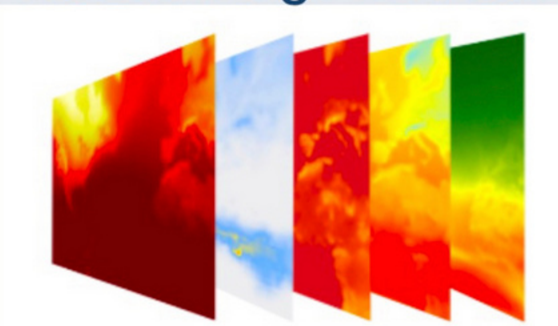
Our goal is to help improve decisions, learning and outcomes in renewable energy, sustainable infrastructure, and agroclimatology sectors, at any location in the world, through provision of freely available, easily accessible, high-quality, customized, and trusted solar and meteorological data from NASA for both current and future climates

SERVICES

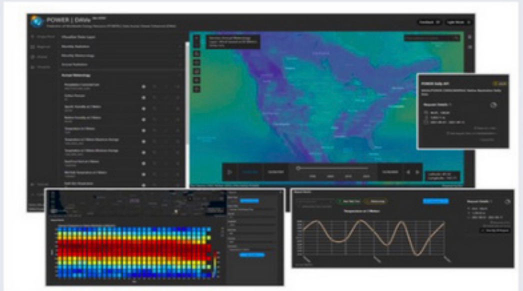
POWER Website



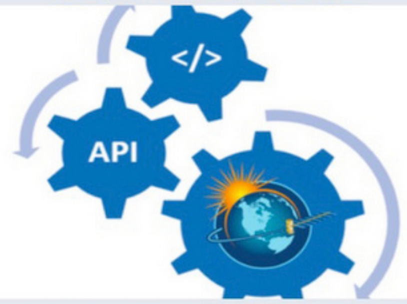
ArcGIS Image Services



Data Access Viewer

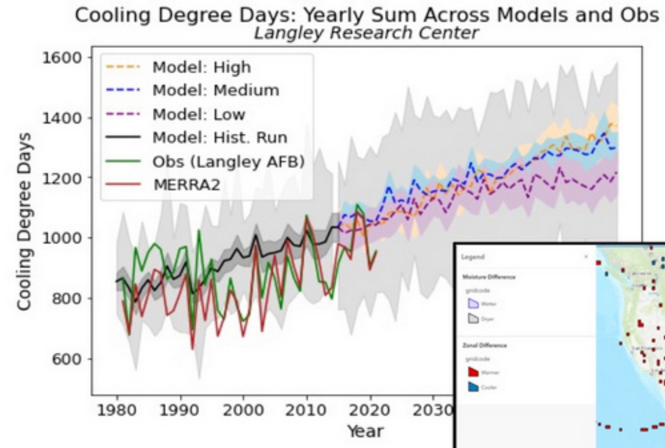


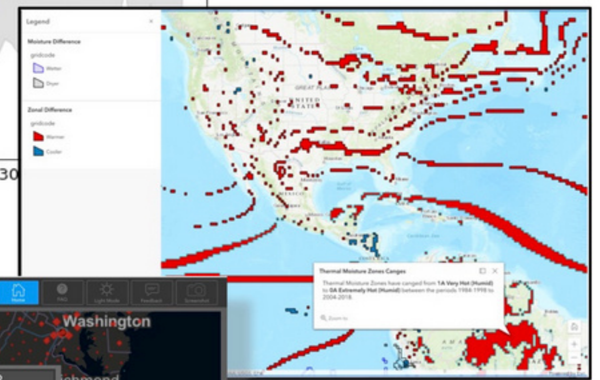
RESTful APIs

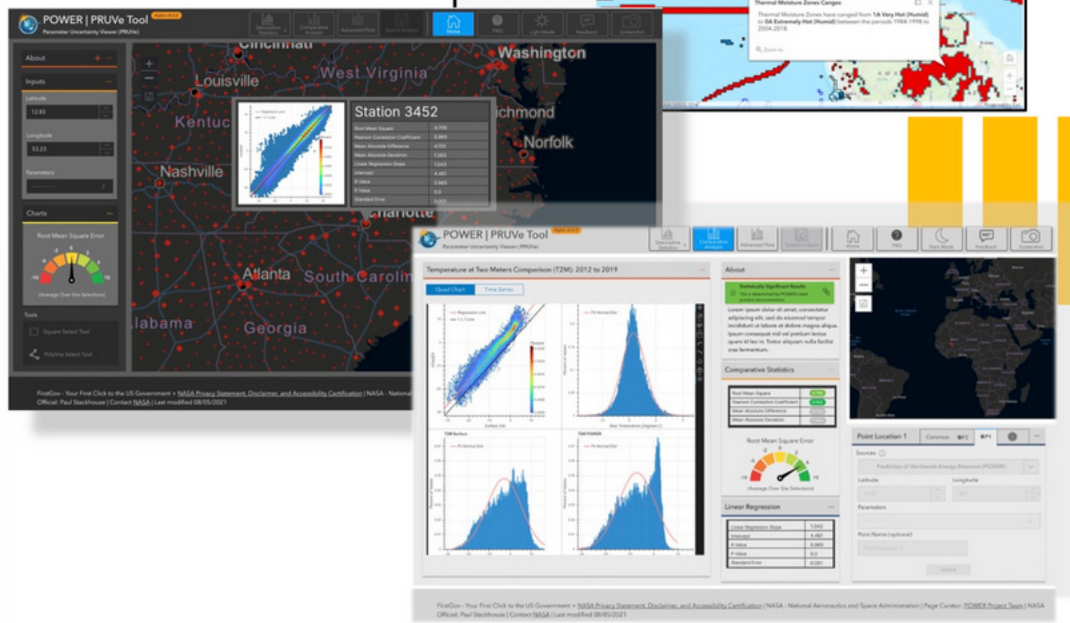


POWER provides multiple data access options. Check out details at: https://power.larc.nasa.gov/#dataaccess

NEW ANALYTICAL WEB-SERVICES







Contact Information

larc-power-project@mail.nasa.gov

https://power.larc.nasa.gov/

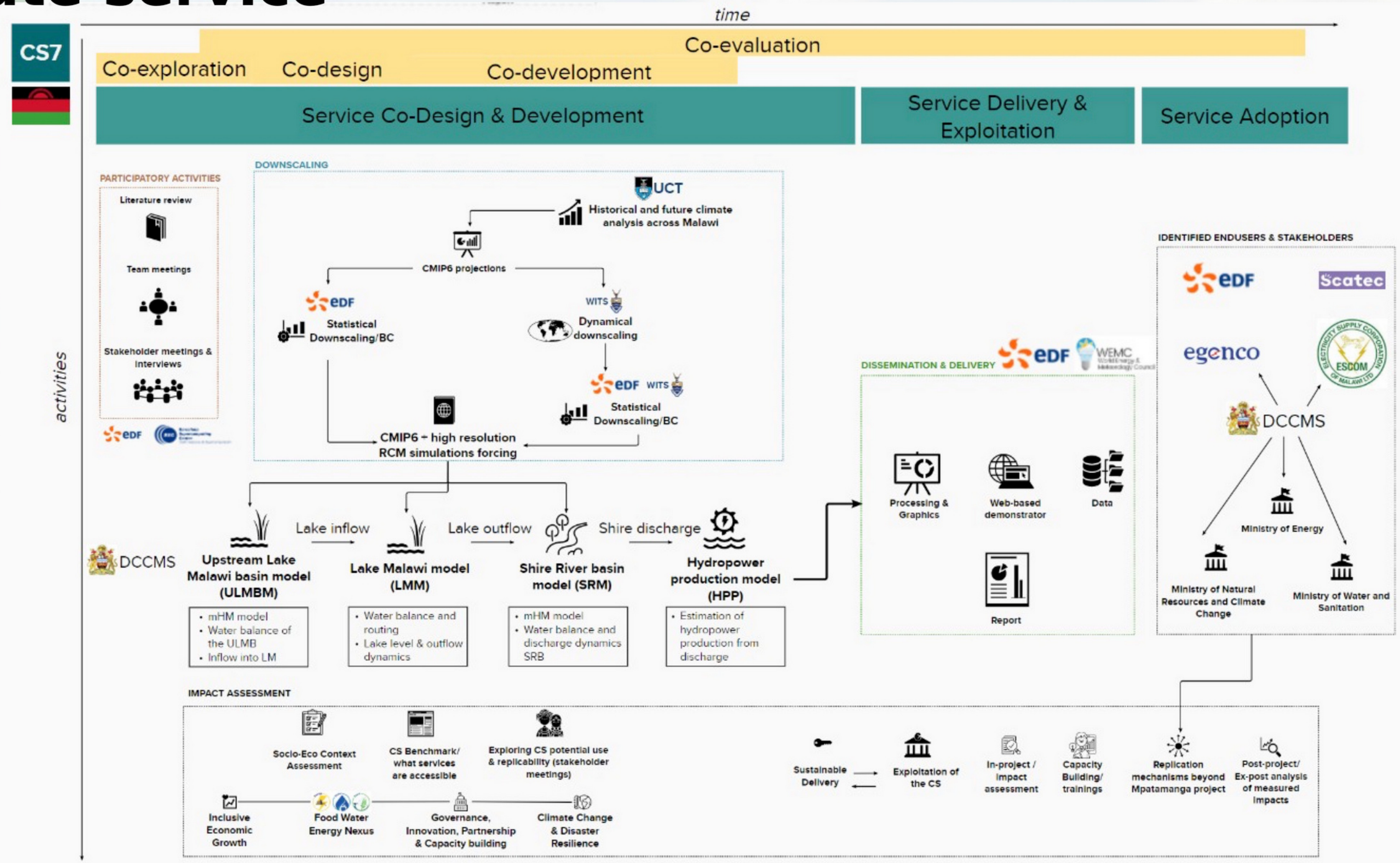
Key Differentiators for POWER Products & Services

- Numerous access options ranging from API, user interface & geospatial services
- Global coverage (fusion of LEO & GEO datasets)
- Multi-decadal, high-accuracy, community-specific datasets
- Customized data products, units & formats for specific user communities (improves usability & lowers adoption costs)

Building a climate service for hydro-power ressources: Application to Mpatamanga project in Malawi

Hiba Omrani, Lila Collet, Sara Octenjak, Roberta Boscolo, Lucy Mtilatila, Piotr Wolski, Omari Hamisi, Amos Mtonya, Audrey Valery, Charlotte Jouet, Patricia Nayeja, Alberto Troccoli

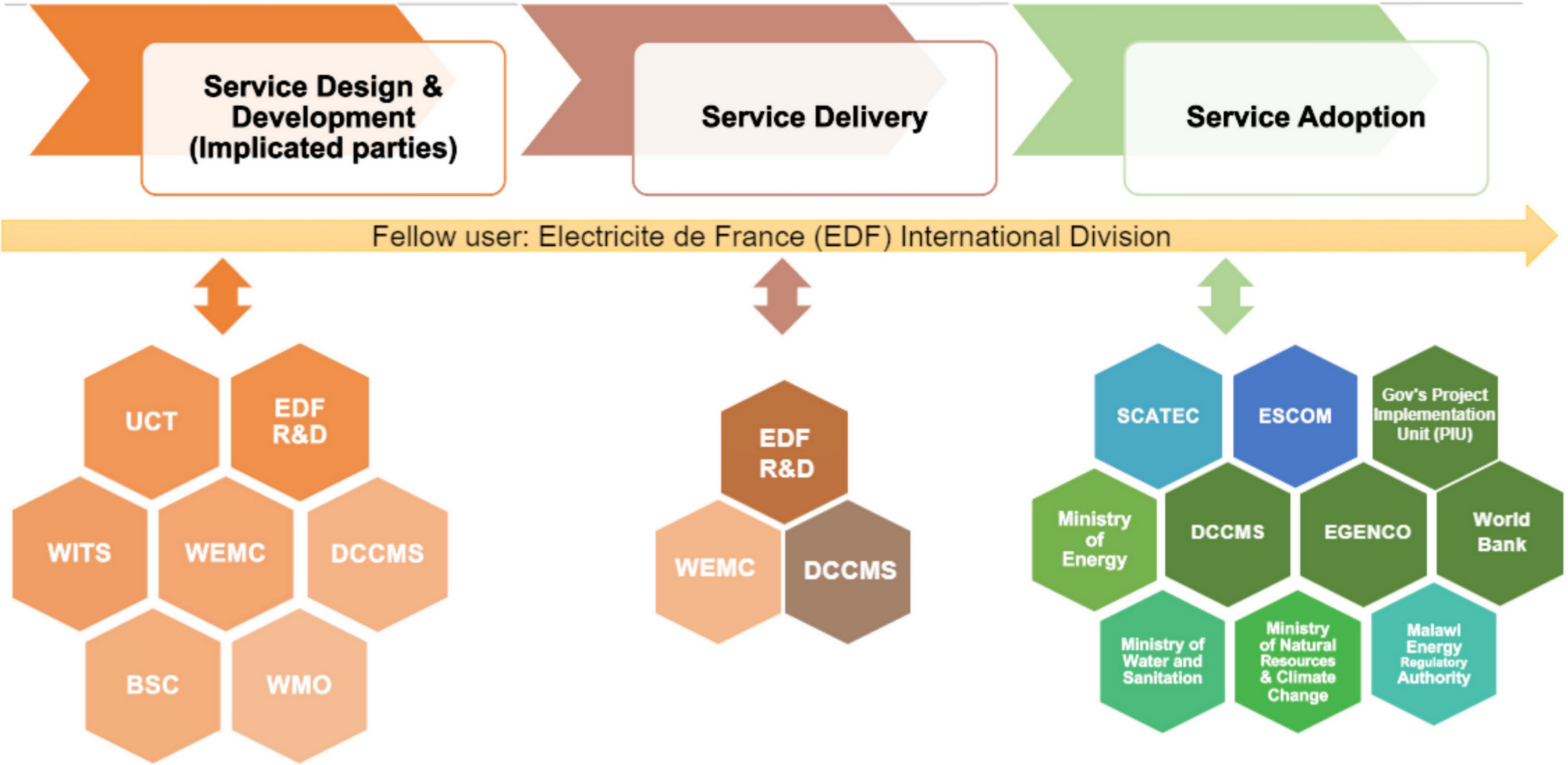
Energy & Water in Malawi
The climate service



z

7 . 1

The climate service
The frame work



z

The field mission

Malawi : 02-08 October 2022

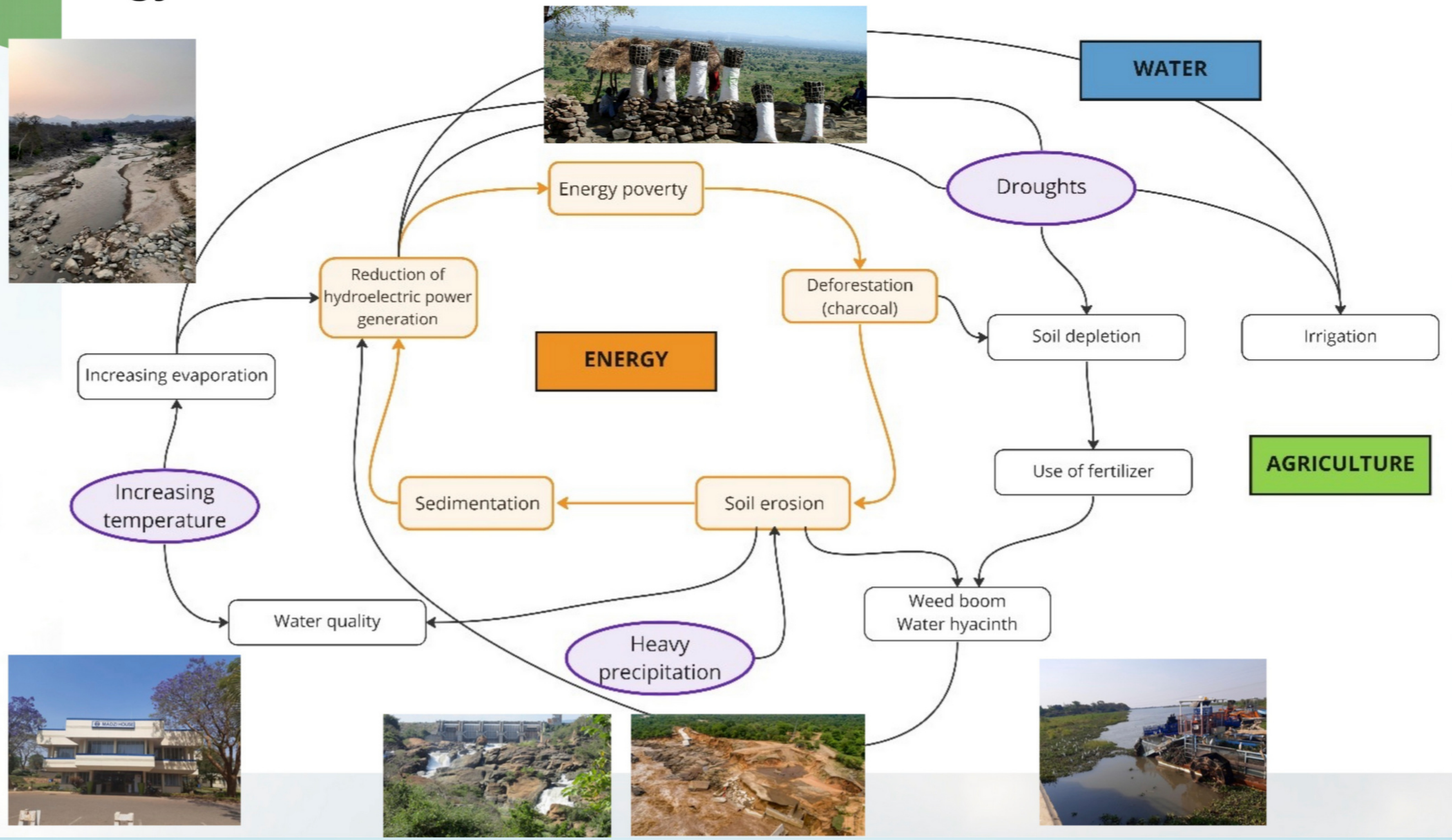
Meeting with stakeholders

Field visits

The Climate service

Water-Energy-Food nexus

Z



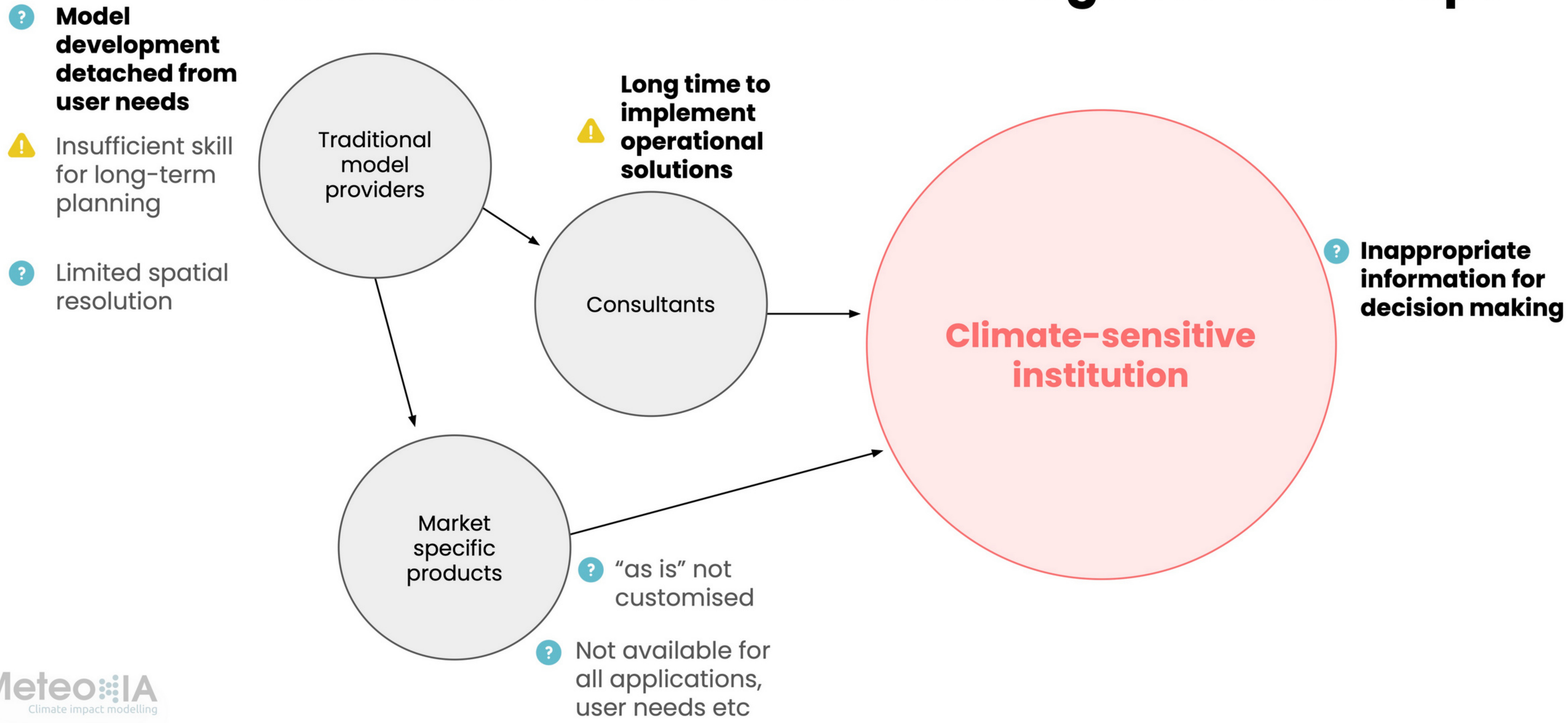
About us

MeteoIA is a startup focused on the development of AI models to predict the climate system and its impacts on climate sensitive institutions.

The company is structured around **MIA,** our centralised data-driven modelling system that enables developers and researchers to continuously build and deploy solutions.

www.meteoia.com

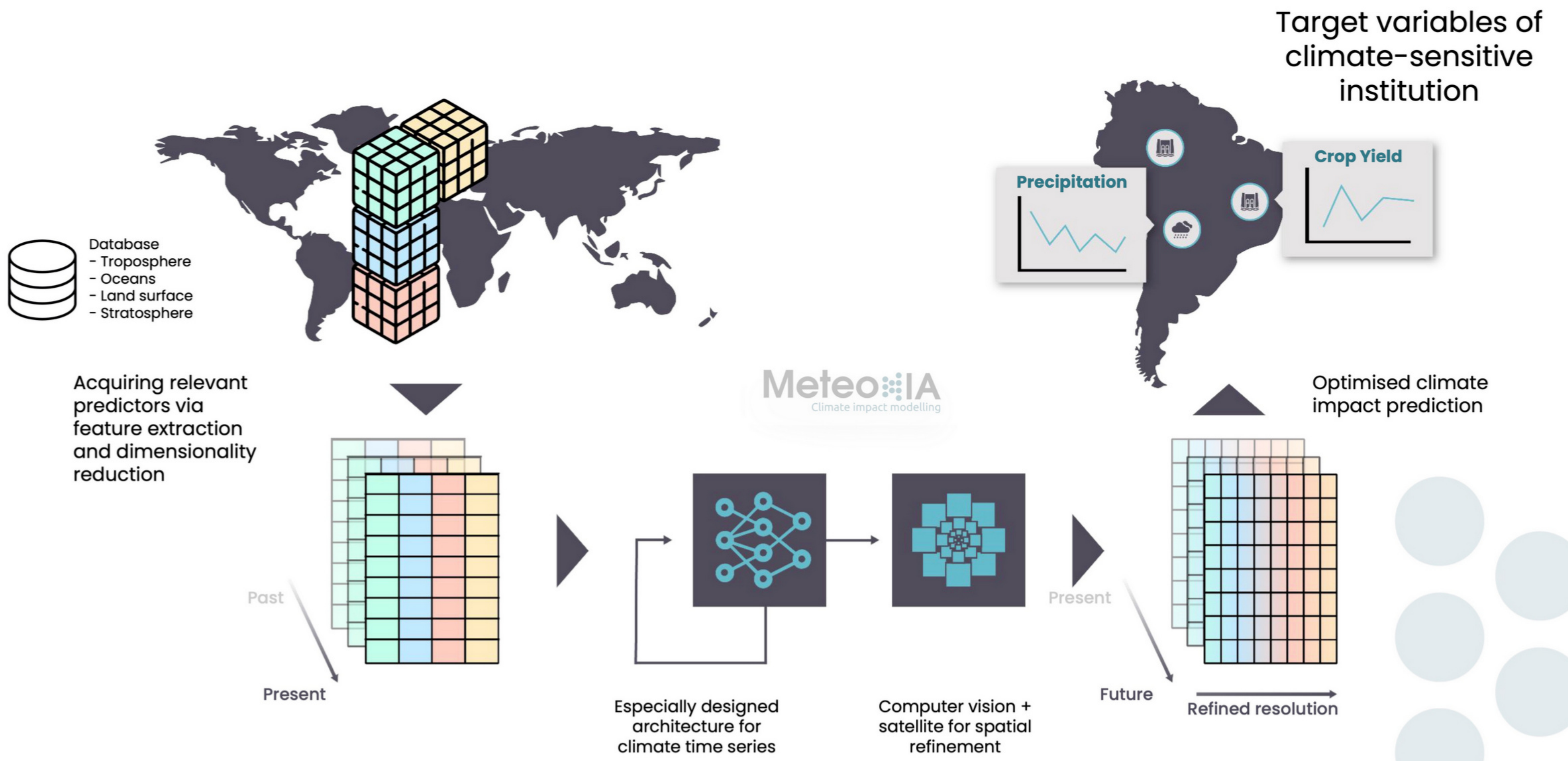
Limitations in the climate intelligence landscape



Increases operational risk

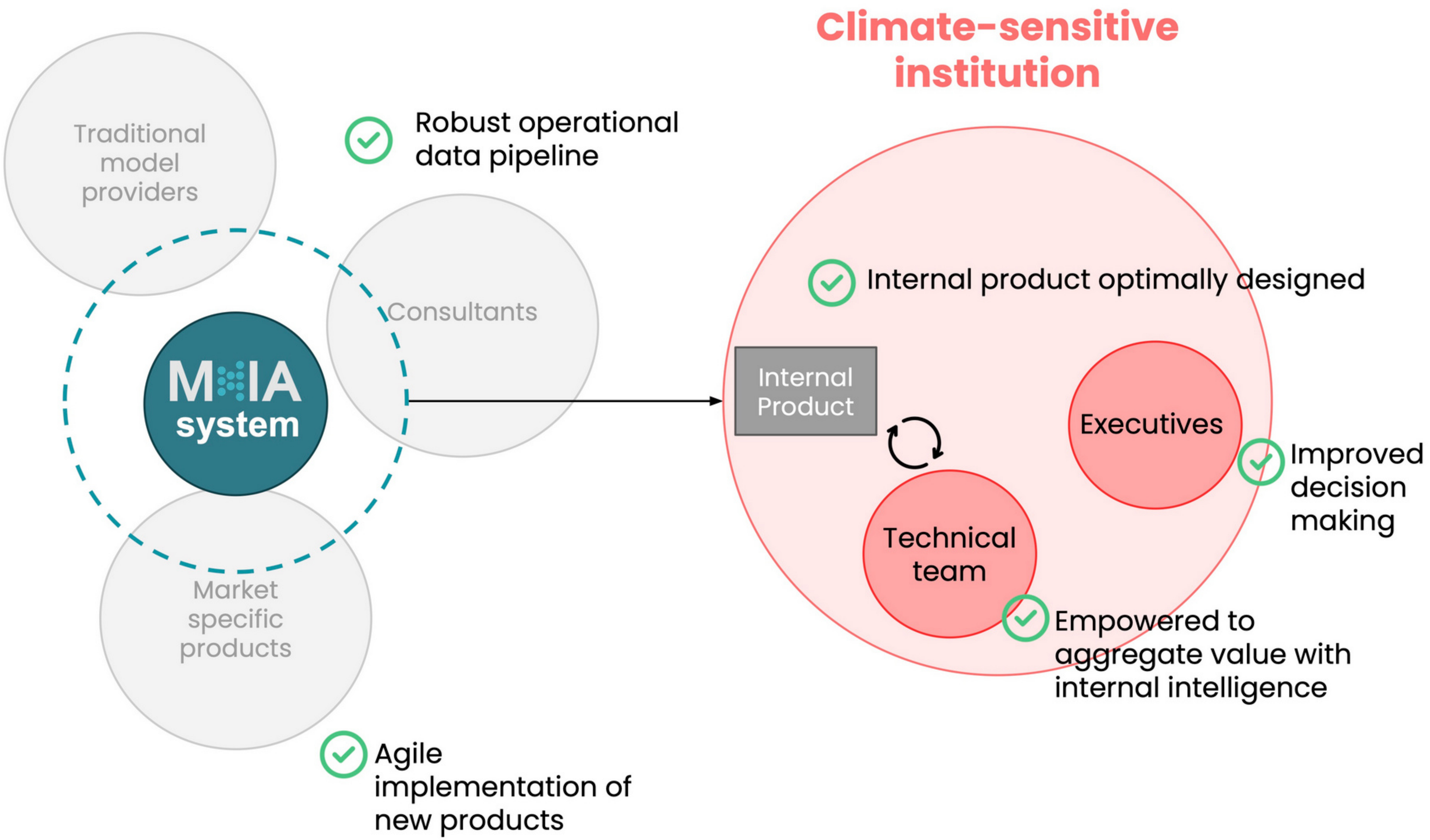
Decreases value for decision-making

A purely data-driven modelling pipeline optimised to user needs



Advantages for our clients

- On-demand model development
- High resolution forecast
- Flexible predictive horizon

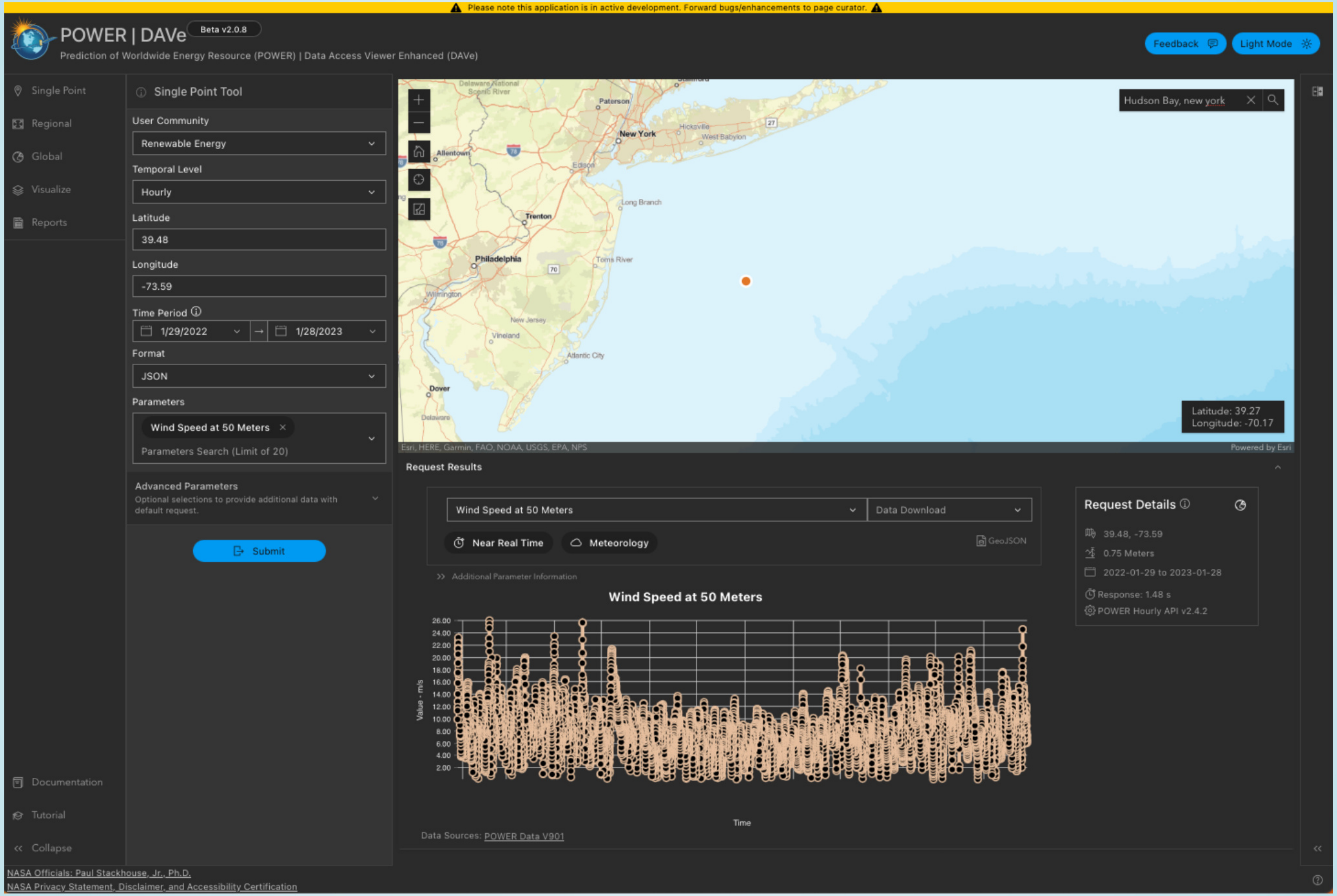


MeteoIA

INTERACTIVE SESSION PART 1: WORKING WITH METEOROLOGICAL DATA

DOWNLOADING DATA...

In this example, we use the **NASA POWER DAVe** tool to extract **1 month of hourly 50m wind speed data** from **Hudson Bay**



Please note this application is in active development. Forward bugs/enhancements to page curator.
POWER | DAVe
Beta v2.0.8
Prediction of Worldwide Energy Resource (POWER) | Data Access Viewer Enhanced (DAVe)
Feedback
Light Mode
Single Point
Regional
Global
Visualize
Reports
Single Point Tool
User Community
Renewable Energy
Temporal Level
Hourly
Latitude
39.48
Longitude
-73.59
Time Period
1/29/2022
1/28/2023
Format
JSON
Parameters
Wind Speed at 50 Meters
Parameters Search (Limit of 20)
Advanced Parameters
Optional selections to provide additional data with default request.
Submit
Documentation
Tutorial
Collapse
Hudson Bay, new york
New York
Philadelphia
Trenton
Allentown
Paterson
Long Branch
Toms River
Atlantic City
Dover
Latitude: 39.27
Longitude: -70.17
Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS
Powered by Esri
Request Results
Wind Speed at 50 Meters
Data Download
Near Real Time
Meteorology
GeoJSON
Additional Parameter Information
Request Details
39.48, -73.59
0.75 Meters
2022-01-29 to 2023-01-28
Response: 1.48 s
POWER Hourly API v2.4.2
Wind Speed at 50 Meters
Value - m/s
Time
Data Sources: POWER Data V901
NASA Officials: Paul Stackhouse, Jr., Ph.D.
NASA Privacy Statement, Disclaimer, and Accessibility Certification

READ IN A REANALYSIS DATASET

Now that we have downloaded our data, we use `xarray` to open the dataset

In [5]:
```
# read in the dataset
wind50m_reanalysis = xr.open_dataset("datasets/reanalysis/POWER_Point_Hourly_20220129_20230128
```

In [6]:
```
# dataset overview
wind50m_reanalysis
```

Out[6]:
```
<xarray.DataArray 'WS50M' (time: 8760, lat: 1, lon: 1)>
[8760 values with dtype=float32]
Coordinates:
  * time     (time) datetime64[ns] 2022-01-28T19:00:00 ... 2023-01-28T18:00:00
  * lat      (lat) float32 39.48
  * lon      (lon) float32 -73.59
Attributes:
    units:          m/s
    long_name:      Wind_Speed_at_50_Meters
    standard_name:  Wind Speed at 50 Meters
```

xarray.DataArray 'WS50M' (**time**: 8760, **lat**: 1, **lon**: 1)

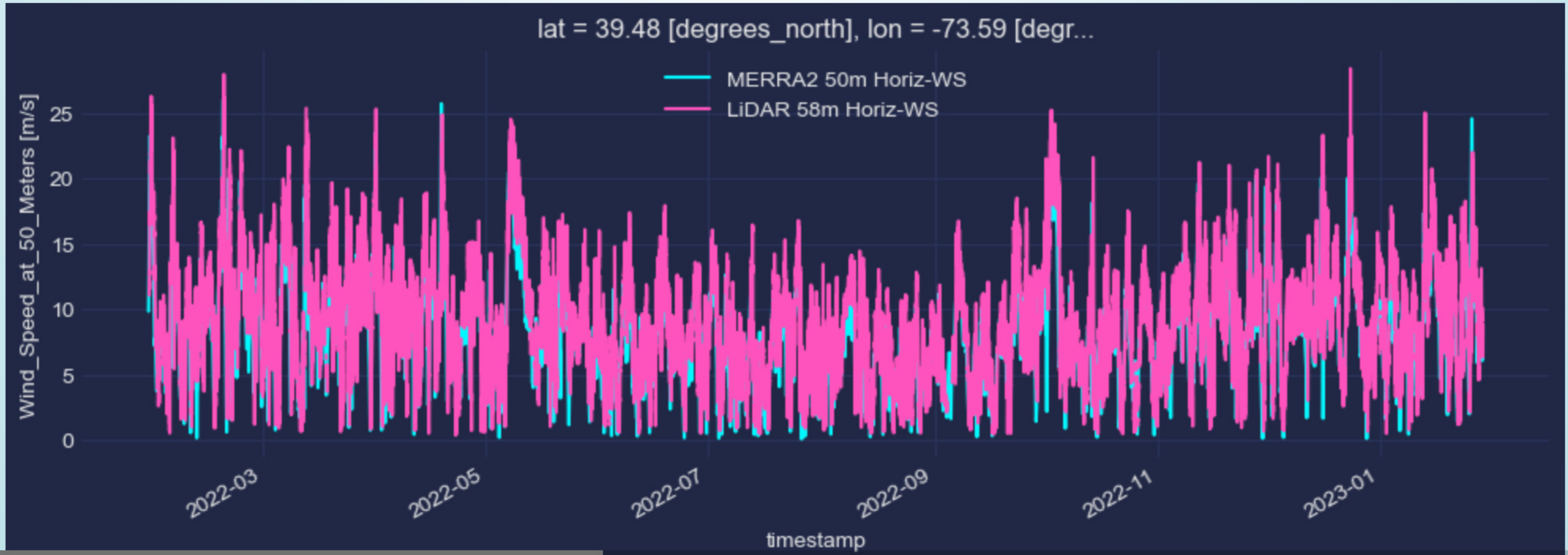
[8760 values with dtype=float32]

OBSERVATIONS DATASET

In [8]:
```
# read in a lidar dataset
## New York Bight LiDAR Buoy data
## https://oswbuoysny.resourcepanorama.dnv.com
fname = "datasets/NYSERDA Floating LiDAR Buoy Data/E05_Hudson_South_West_10_min_avg_20220129_2
wind58m_lidar = read_csv_lidar(fname, "lidar_lidar58m_Z10_HorizWS")
```

PLOT WINDSPEEDS

In [9]:
```
# plot each timeseries
fig, ax = plt.subplots()
wind50m_reanalysis.plot(ax=ax)
lines = wind58m_lidar.plot(ax=ax).lines

# add x and y limit code here
#plt.gca().set_xlim("2022-04-15", "2022-05-01")
#plt.gca().set_xlim("2022-11-01", "2022-11-15")

plt.legend(lines, ["MERRA2 50m Horiz-WS", "LiDAR 58m Horiz-WS"]);
```



INTERACTIVE SESSION PART 2: SPATIAL DATA

APIs to access ready made geotiff files on DTU's Global Wind Atlas

See video tutorial: https://globalwindatlas.info/en/about/VideoTutorials

In [13]:
```
# JABA: examples of APIs to access ready made geotiff files on DTU's Global Wind Atlas
#mmap_name = 'https://globalwindatlas.info/api/gis/country/DNK/wind-speed/100'
#mmap_name = 'https://globalwindatlas.info/api/gis/country/DNK/elevation_w_bathymetry/'
#mmap_name = 'https://globalwindatlas.info/api/gis/country/ITA/wind-speed/100'
```

LOAD DATASETS

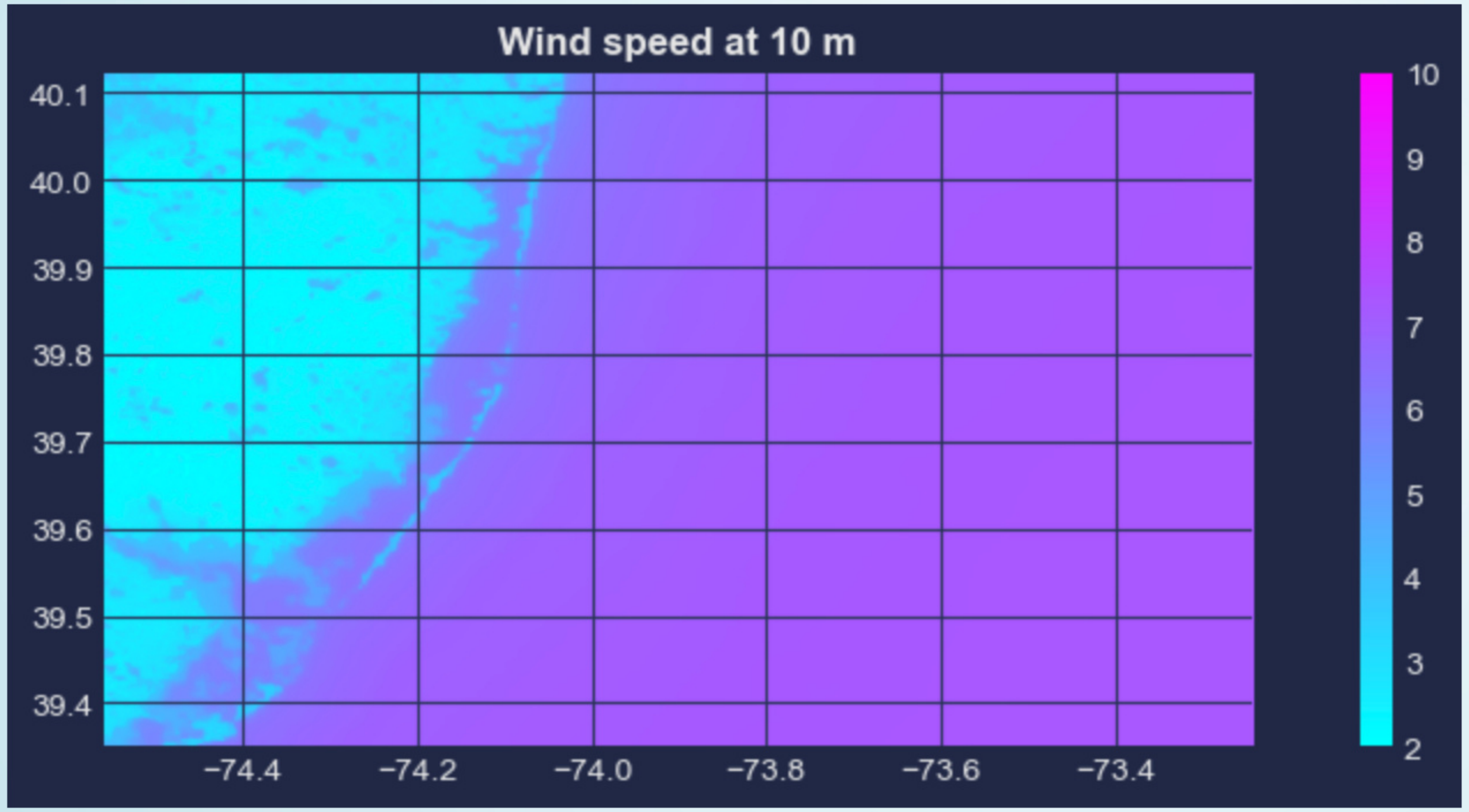
```
In [14]: # JABA: example custom region of interest ("area-1") defined on GWA webpage,
         # JABA: and wind speed at different heights above surface made as geostiff data and downloaded
         mmap_name10 = "datasets/GWA/area_1_wind-speed_10m.tif"
         mmap_name50 = "datasets/GWA/area_1_wind-speed_50m.tif"
         mmap_name100 = "datasets/GWA/area_1_wind-speed_100m.tif"
         mmap_name150 = "datasets/GWA/area_1_wind-speed_150m.tif"
```

In [14]:

```python
# JABA: example custom region of interest ("area-1") defined on GWA webpage,
# JABA: and wind speed at different heights above surface made as geostiff data and downloaded
mmap_name10 = "datasets/GWA/area_1_wind-speed_10m.tif"
mmap_name50 = "datasets/GWA/area_1_wind-speed_50m.tif"
mmap_name100 = "datasets/GWA/area_1_wind-speed_100m.tif"
mmap_name150 = "datasets/GWA/area_1_wind-speed_150m.tif"
mmap_name200 = "datasets/GWA/area_1_wind-speed_200m.tif"
```

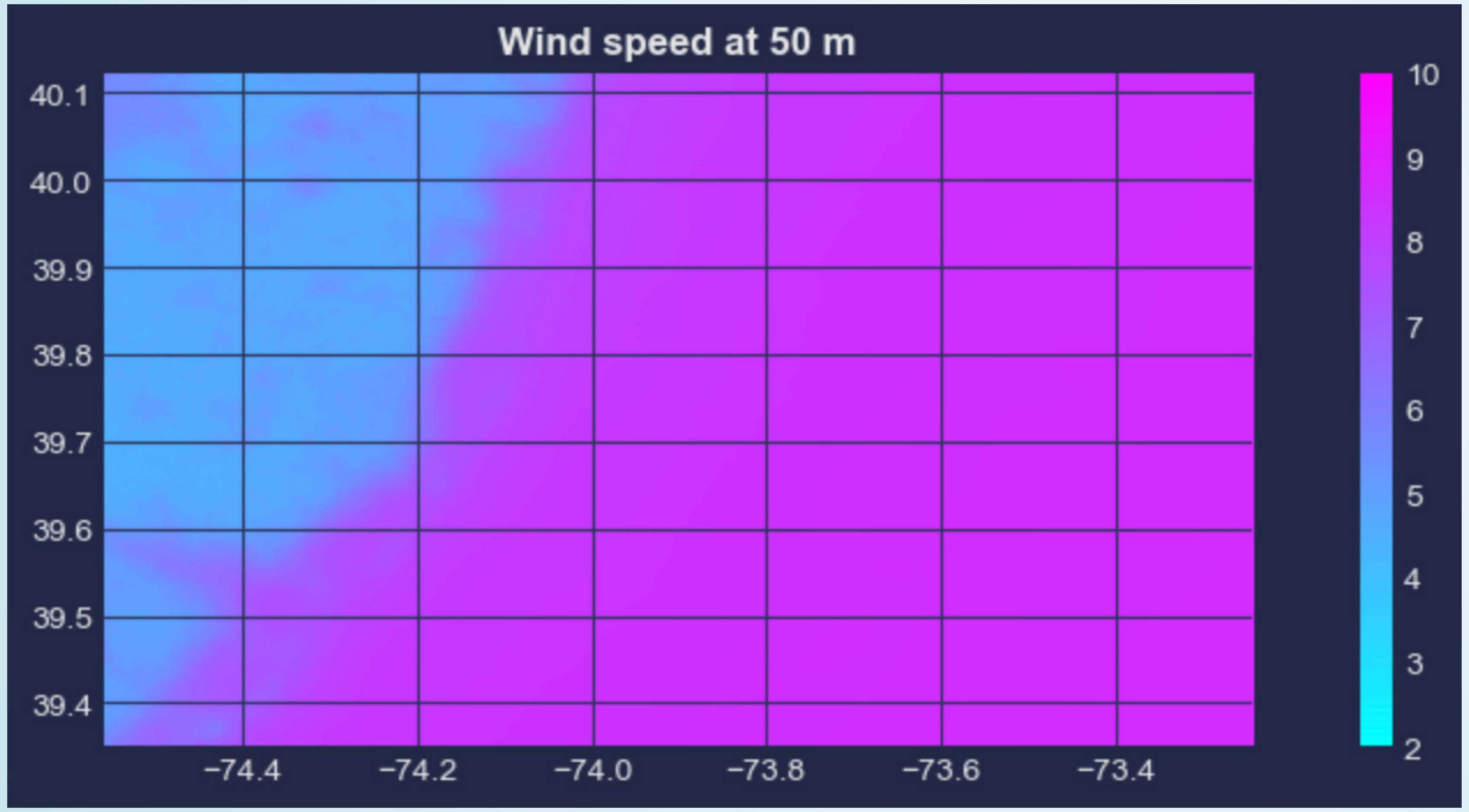
VISUALISE DATASETS

In [15]:
```python
# JABA: 10 m data
fig, ax = plt.subplots()
dataset10 = rasterio.open(mmap_name10)
im = show((dataset10, 1), ax=ax, title='Wind speed at 10 m', vmin=2, vmax=10)
fig.colorbar(im.get_images()[0], ax=ax);
```



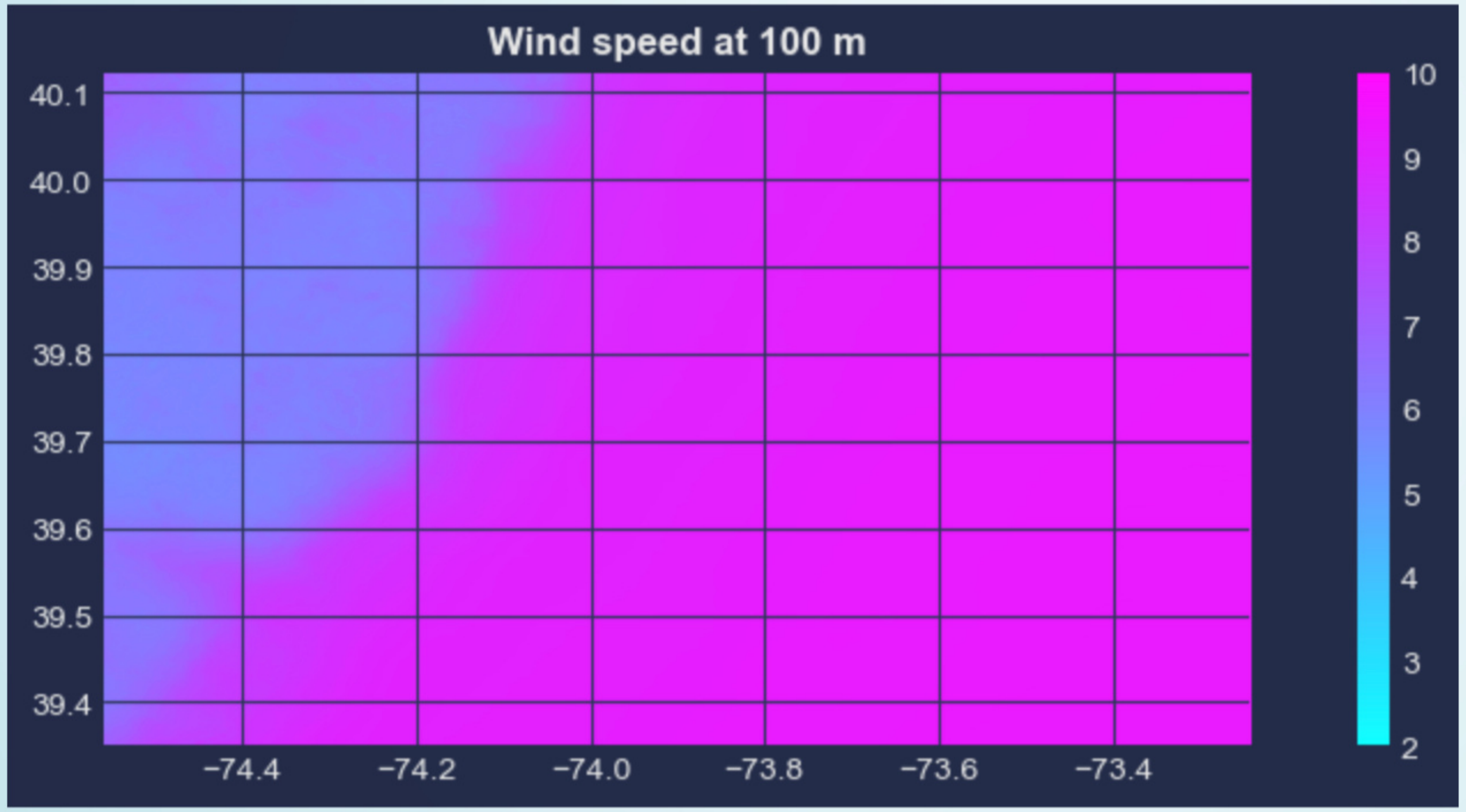
In [16]:

```
# JABA: 50 m data
fig, ax = plt.subplots()
dataset50 = rasterio.open(mmap_name50)
im = show((dataset50,1), ax=ax, title='Wind speed at 50 m', vmin=2, vmax=10)
fig.colorbar(im.get_images()[0], ax=ax);
```



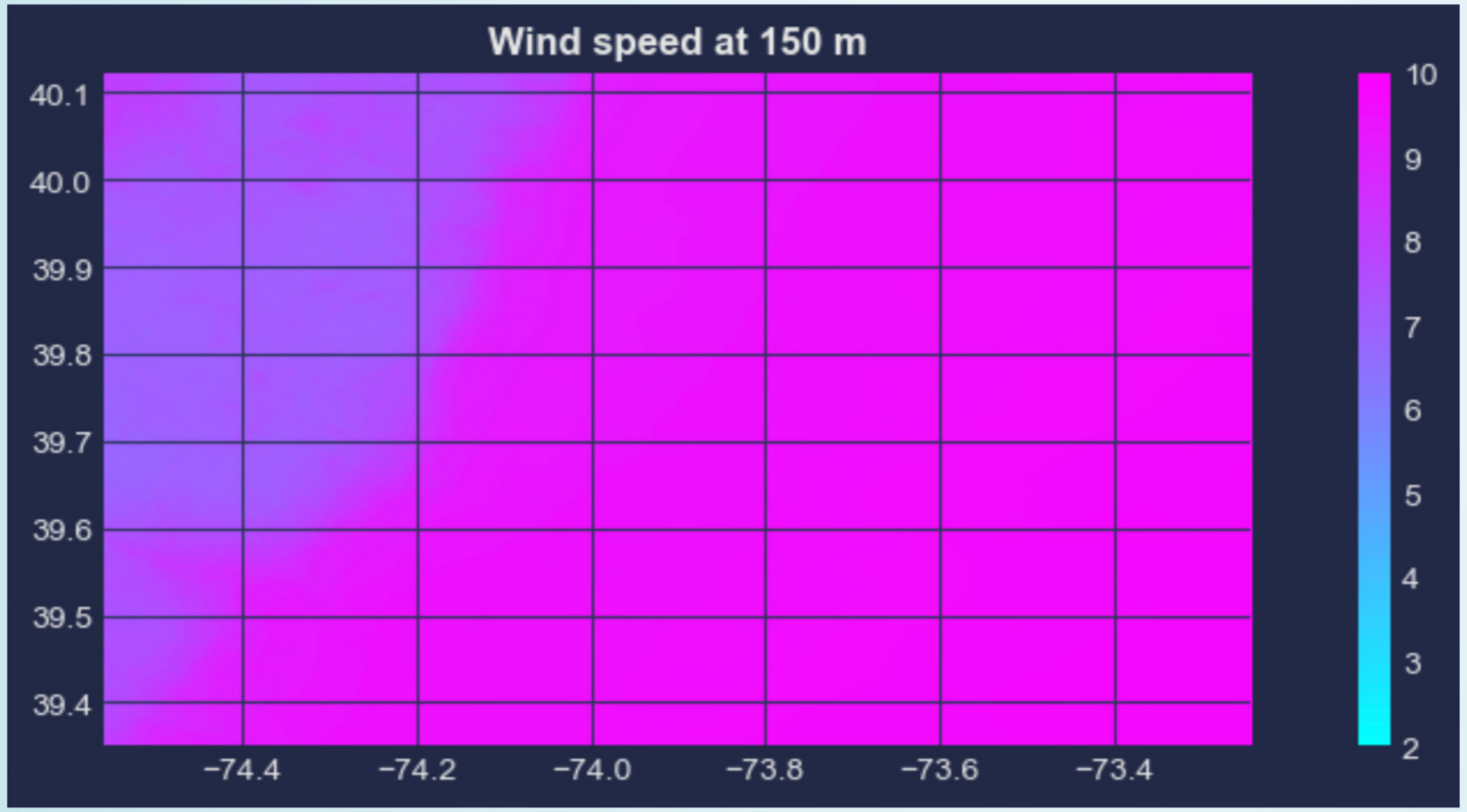
In [17]:

```python
# JABA: 100 m data
fig, ax = plt.subplots()
dataset100 = rasterio.open(mmap_name100)
im = show((dataset100,1), ax=ax, title='Wind speed at 100 m', vmin=2, vmax=10)
fig.colorbar(im.get_images()[0], ax=ax);
```

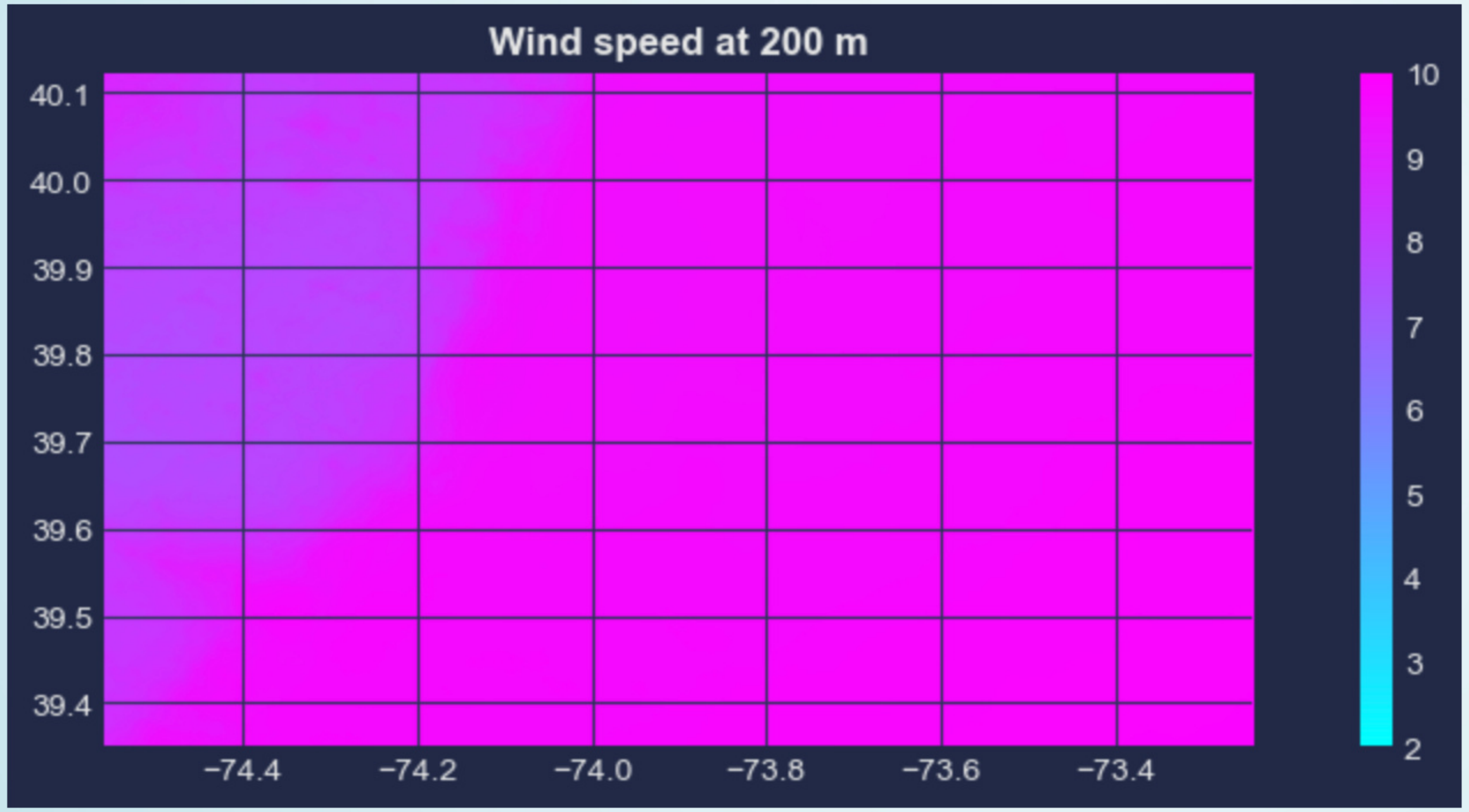


In [18]:

```python
# JABA: 150 m data
fig, ax = plt.subplots()
dataset150 = rasterio.open(mmap_name150)
im = show((dataset150,1), ax=ax, title='Wind speed at 150 m', vmin=2, vmax=10)
fig.colorbar(im.get_images()[0], ax=ax);
```



In [19]:
```
# JABA: 200 m data
fig, ax = plt.subplots()
dataset200 = rasterio.open(mmap_name200)
im = show((dataset200, 1), ax=ax, title='Wind speed at 200 m', vmin=2, vmax=10)
fig.colorbar(im.get_images()[0], ax=ax);
```

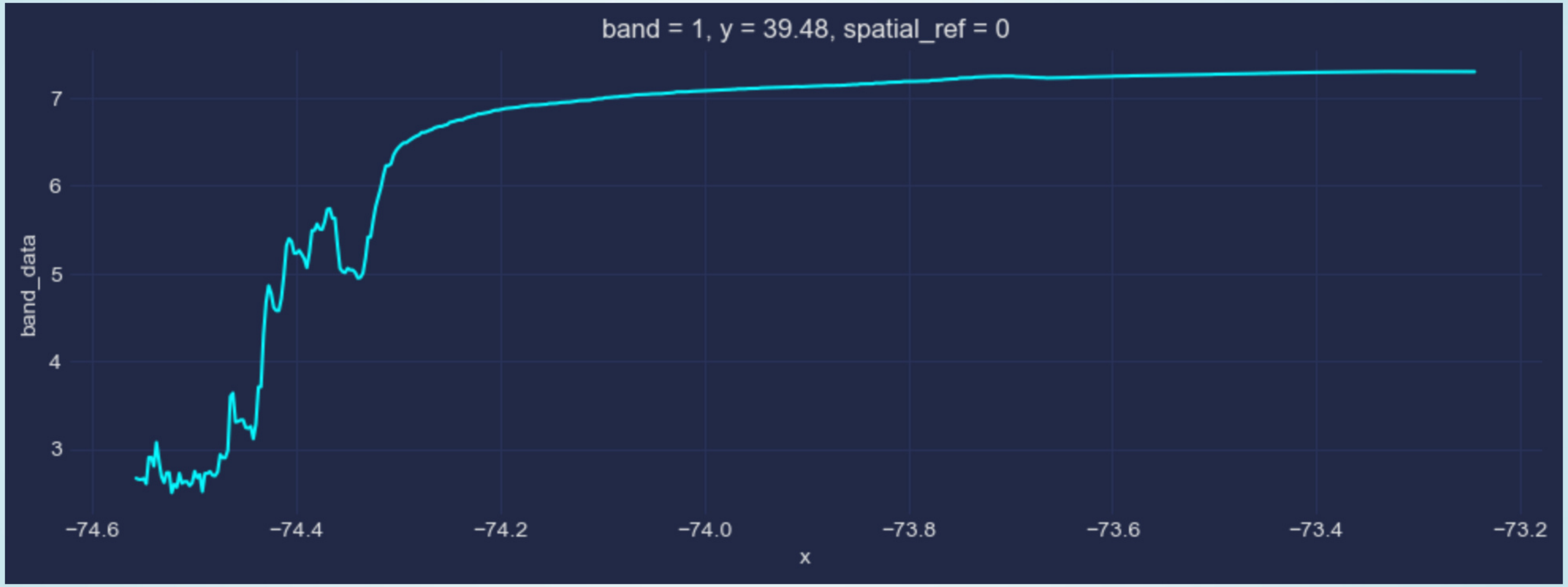


MAKE TRANSECT MEASUREMENT

In [20]:
```
# open datasets with xarray
ds10 = xr.open_dataset(mmap_name10, engine='rasterio')
ds50 = xr.open_dataset(mmap_name50, engine='rasterio')
ds100 = xr.open_dataset(mmap_name100, engine='rasterio')
ds150 = xr.open_dataset(mmap_name150, engine='rasterio')
ds200 = xr.open_dataset(mmap_name200, engine='rasterio')
```

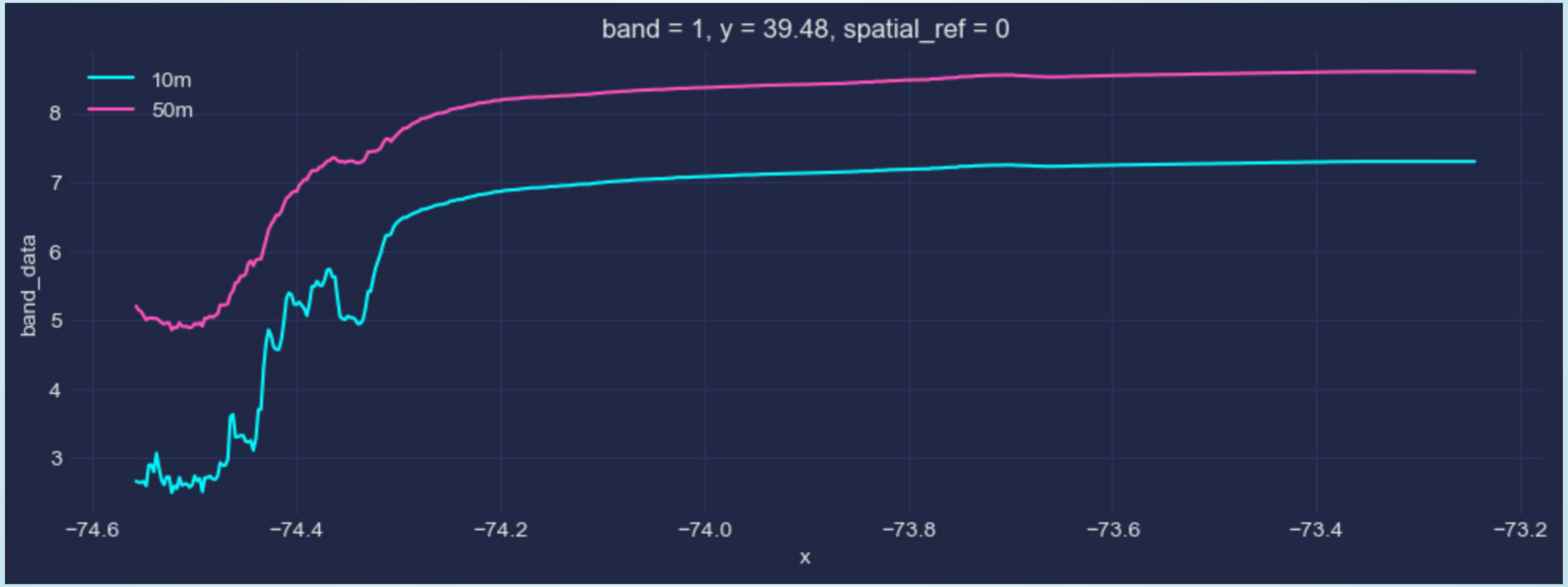
In [23]:
```
# Make transect at measurement latitude.
windspeed10 = ds10.band_data
windspeed50 = ds50.band_data
windspeed100 = ds100.band_data
windspeed150 = ds150.band_data
windspeed200 = ds200.band_data

# calculate mean of reanlsysis data, this will be used in the transect plot
wind50m_reanalysis_mean=np.mean(wind50m_reanalysis)
#wind50m_reanalysis_mean

# calculate mean of lidar data, this will be used in the transect plot
wind58m_lidar_mean=np.mean(wind58m_lidar)
#wind58m_lidar_mean


# JABA: create a transect at the measurement location (lon_meas, lat_meas)
#lon_meas = -74.0 # teest
#lat_meas = 40.0 # test
lon_meas=-73.59
lat_meas=39.48


# JABA: put in the mean value here for the measured and reanalysis data
#data_meas = 6.0
#data_rean = 6.9
data_meas = wind58m_lidar_mean
data_rean = wind50m_reanalysis_mean
```

In [24]:
```
# plot 10m windspeed
windspeed10_1d=windspeed10.sel(band=1, y=lat_trans, method='nearest')
windspeed10_1d.plot();
```



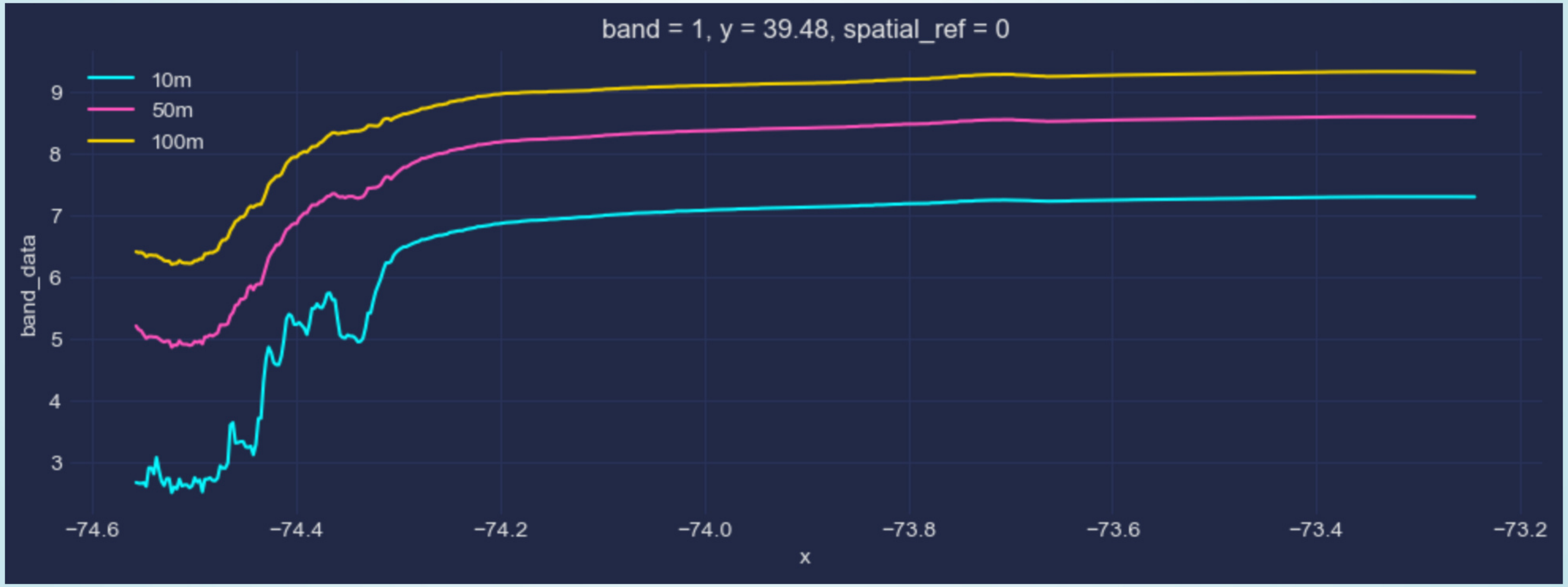
In [25]:

```
# add 50m windspeed
windspeed50_1d=windspeed50.sel(band=1, y=lat_trans, method='nearest')

windspeed10_1d.plot(label="10m")
windspeed50_1d.plot(label="50m")

plt.legend();
```

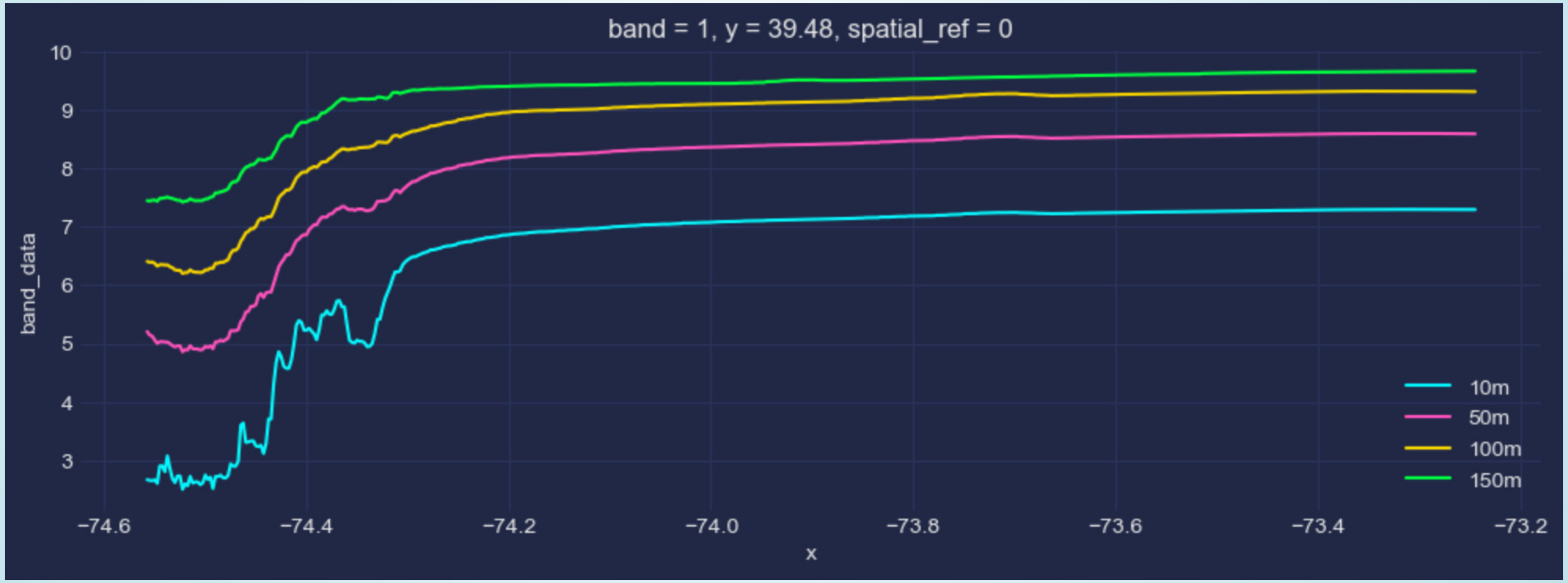


In [26]:

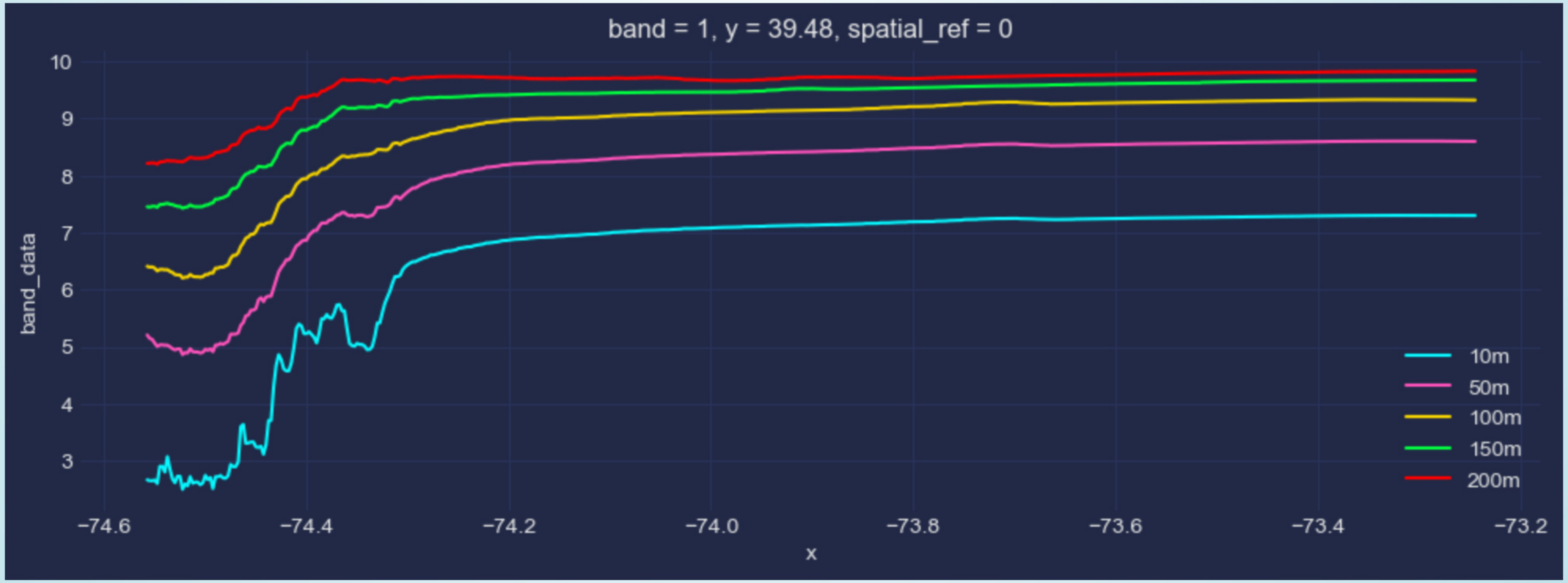
```python
# add 100m windspeed
windspeed100_1d=windspeed100.sel(band=1, y=lat_trans, method='nearest')

windspeed10_1d.plot(label="10m")
windspeed50_1d.plot(label="50m")
windspeed100_1d.plot(label="100m")

plt.legend();
```



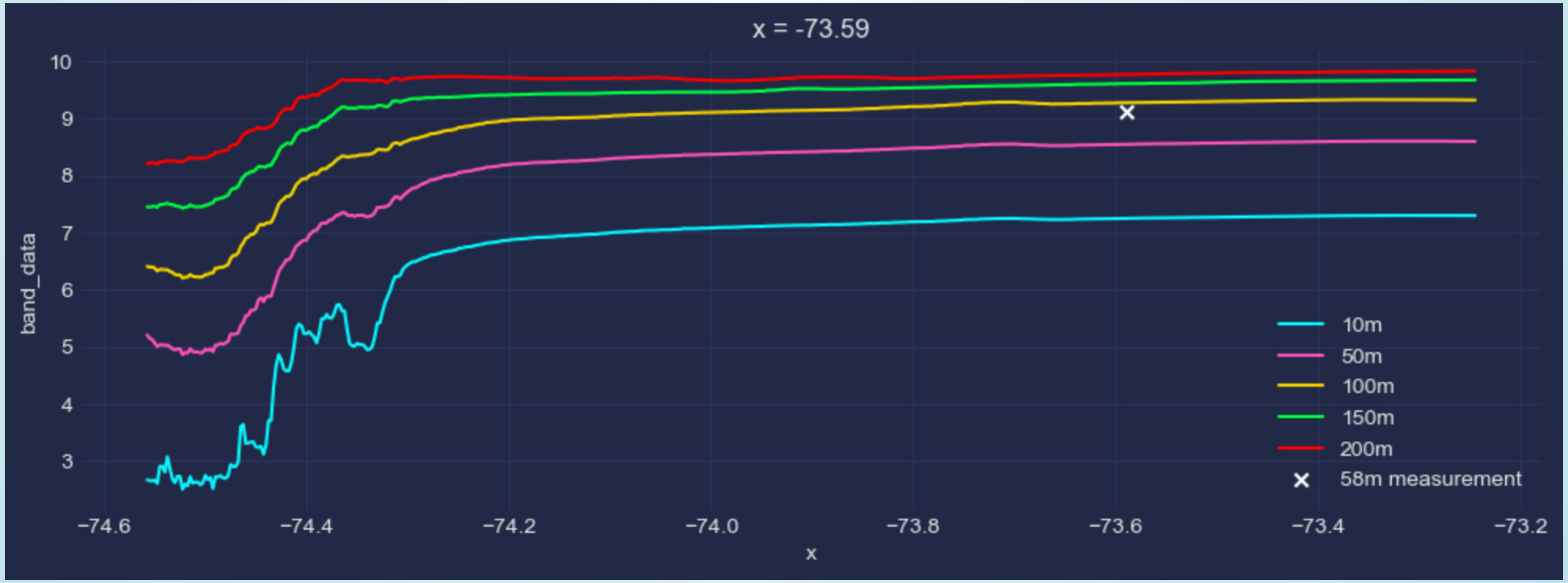
In [27]:
```
# add 150m windspeed
windspeed150_1d=windspeed150.sel(band=1, y=lat_trans, method='nearest')

windspeed10_1d.plot(label="10m")
windspeed50_1d.plot(label="50m")
windspeed100_1d.plot(label="100m")
windspeed150_1d.plot(label="150m")

plt.legend();
```



In [28]:
```python
# add 200m windspeed
windspeed200_1d=windspeed200.sel(band=1, y=lat_trans, method='nearest')

windspeed10_1d.plot(label="10m")
windspeed50_1d.plot(label="50m")
windspeed100_1d.plot(label="100m")
windspeed150_1d.plot(label="150m")
windspeed200_1d.plot(label="200m")

plt.legend();
```

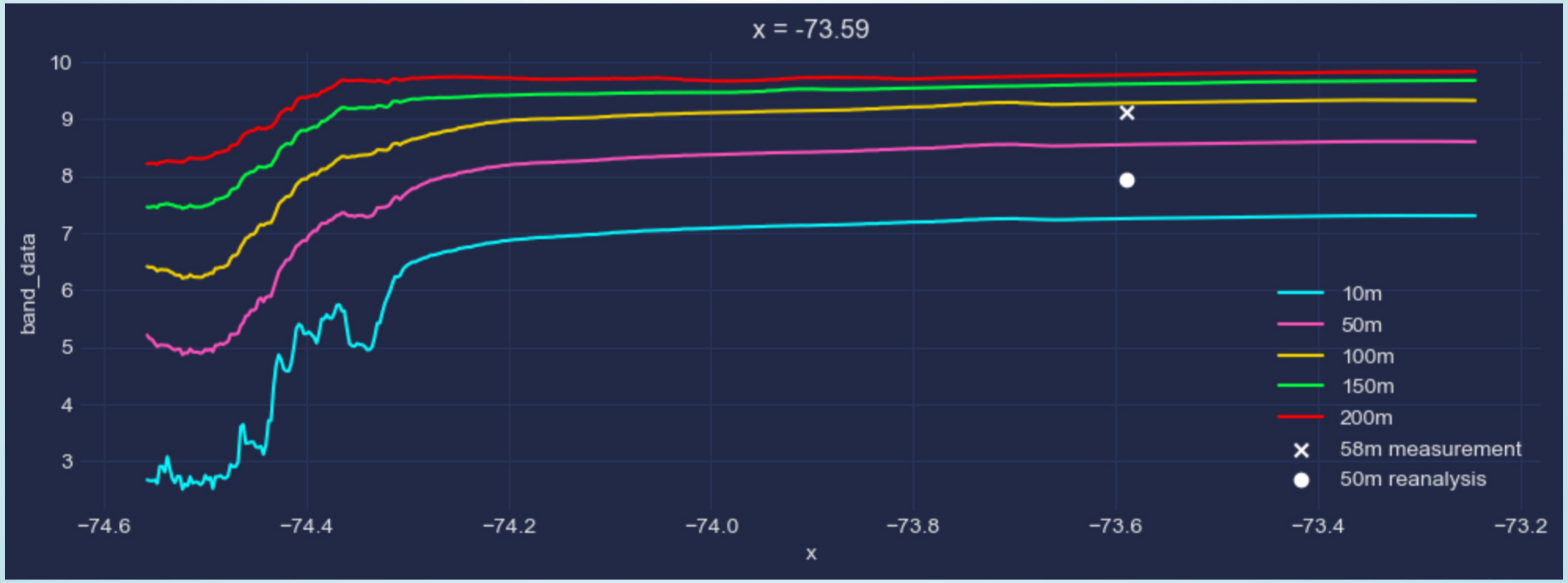


In [29]:
```python
# add measurement data
windspeed_meas_1d=xr.DataArray([data_meas], name="band_data",dims={"x"}, coords={"x":[lon_meas

windspeed10_1d.plot(label="10m")
windspeed50_1d.plot(label="50m")
windspeed100_1d.plot(label="100m")
windspeed150_1d.plot(label="150m")
windspeed200_1d.plot(label="200m")
windspeed_meas_1d.plot.scatter(label="58m measurement", color="white", marker="x")

plt.legend();
```



In [30]:

```python
# add reanalysis data
windspeed_rean_1d=xr.DataArray([data_rean], name="band_data",dims={"x"}, coords={"x":[lon_meas

windspeed10_1d.plot(label="10m")
windspeed50_1d.plot(label="50m")
windspeed100_1d.plot(label="100m")
windspeed150_1d.plot(label="150m")
windspeed200_1d.plot(label="200m")
windspeed_meas_1d.plot.scatter(label="58m measurement", color="white", marker="x")
windspeed_rean_1d.plot.scatter(label="50m reanalysis", color="white", marker="o")

plt.legend();
```



LEARN TO DRIVE BEFORE TAKING OFF IN A FERRARI!

DISCUSSION: NEXT GENERATION CLIMATE SERVICES

SHOULD AN EMPHASIS BE PLACED ON PRODUCING DATA ON REGULAR SPATIO-TEMPORAL GRIDS THAT CAN EASILY BE PROCESSED BY END USERS?

A VAST AMOUNT OF METEOROLOGICAL AND ENERGY GENERATION DATA IS CURRENTLY PROPRIETARY: IS IT POSSIBLE TO USE THIS DATA FOR THE BROADER GOOD?

WHAT ARE SOME OF THE LIMITATIONS OF CURRENT NWP/GCM BASED PRODUCTS USED BY THE ENERGY SECTOR?

HOW MIGHT NEW POST-PROCESSING METHODS CHANGE THE QUALITY AND QUANTITY OF DATA IN THE CLIMATE SERVICES ARENA?

HOW MIGHT AI METHODS CHANGE HOW DATA IS PROVIDED TO USERS?

- Will we end up with ChatGPT type interfaces where we specify the attributes of the data we need, and a climate service returns the data it deems most appropriate?
- What other changes might AI method bring to how users interface with data?
- What are some of the pros and cons that you see in the nexus of the AI revolution and large climate datasets?

WRAP UP

THANK YOU

Thank you kindly to the panellists for their contributions, and to the audience for taking part!

ABOUT THESE SLIDES

View as `PDF` / `html` or run `ipynb` with instructions at:

https://linktr.ee/ICEM23ClimateServices

https://github.com/jfallon1997/ICEM-2023-ClimateServicesWorkshop