

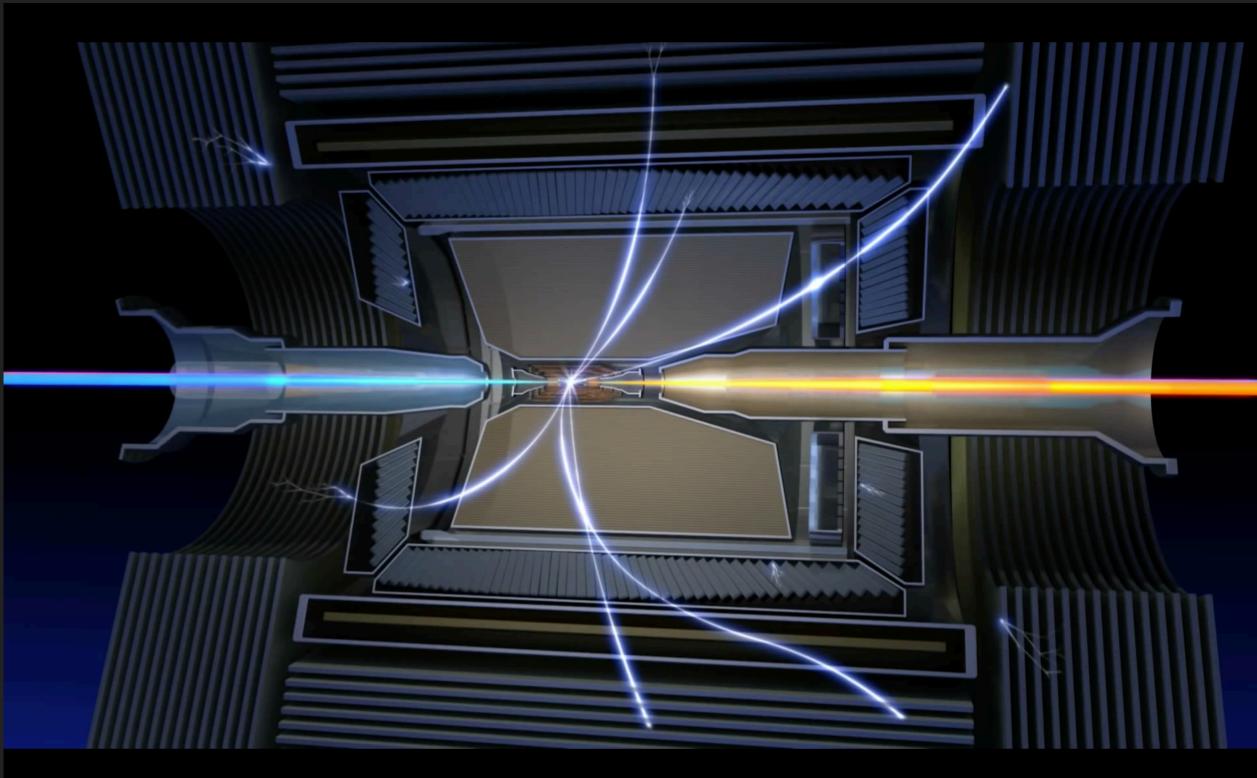
DR. ANŽE ZUPANC

SINERGISE

MONITORING WATER LEVELS FROM SPACE

MY BACKGROUND

- ▶ Researcher in the field of experimental high energy physics
 - ▶ Belle and Belle II at e+e- collider
 - ▶ looking for signatures of new particles or new types of interactions
- ▶ Joined Sinergise a few months ago
 - ▶ trying to extract valuable information from satellite imagery



SEVERE DRAUGHT IN SOUTH AFRICA

- ▶ Cape Town is dealing with severe water shortage due to several years long draught
- ▶ Their water reservoirs are getting empty

Pod prho minuto, splakovanje stranišča enkrat dnevno - boj Cape Towna s sušo

Več kot milijarda ljudi nima dostopa do tekoče vode

7. marec 2018 ob 07:50
Ljubljana - MMC RTV SLO

Cape Townu grozi, da bo postal prvo mesto v razvitem delu sveta, ki bo doživel "dan nič" - dan, ko zaradi hude suše iz pip ne bo pritekla niti kapljica vode. A Cape Town je le vrh ledene gore - do leta 2025 bosta dve tretjini Zemljanov živeli z občasnimi ali stalnimi prekinitvami dobave vode.

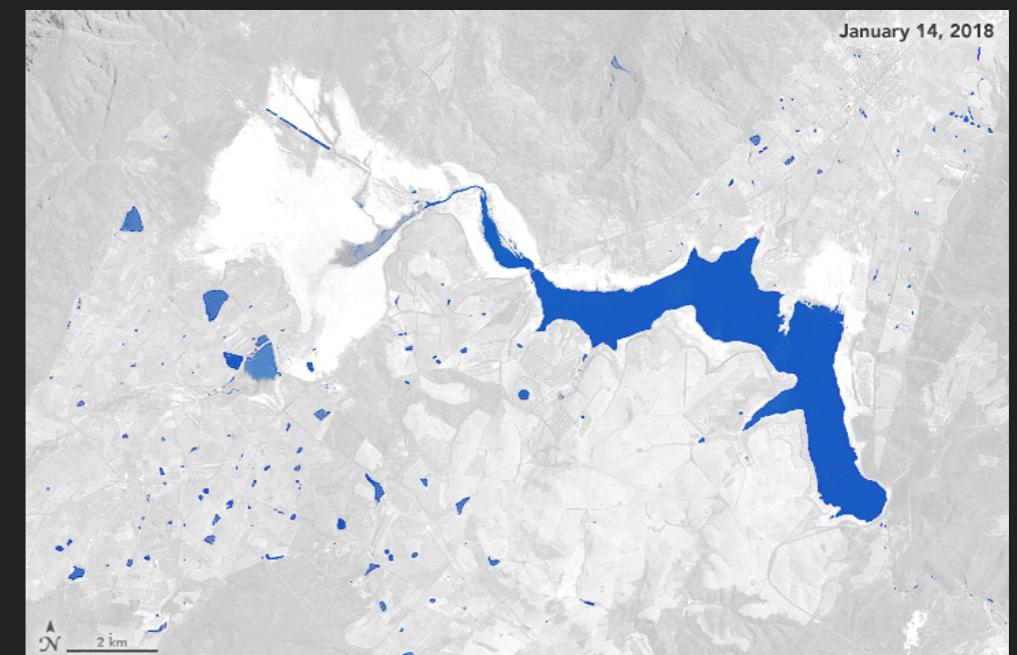
Cape Town, ki leži pod znamenito Mizasto goro na skrajnem jugu Afrike, je s štirimi milijoni prebivalcev drugo največje mesto v Južni Afriki in deseto največje na celini. V zadnjih mesecih se o njem govorí

Ocena novice: ★★★★
Ocena 4.0 od 47 glasov

Vaša ocena: ★★★★★
Ocenite to novico!



Cape Town doživlja sušo, ki nastopi le vsakih 384 let.
Foto: Reuters



Modified satellite images of Theewaterskloof Dam enhancing presence of water. [Landsat-8, NASA]

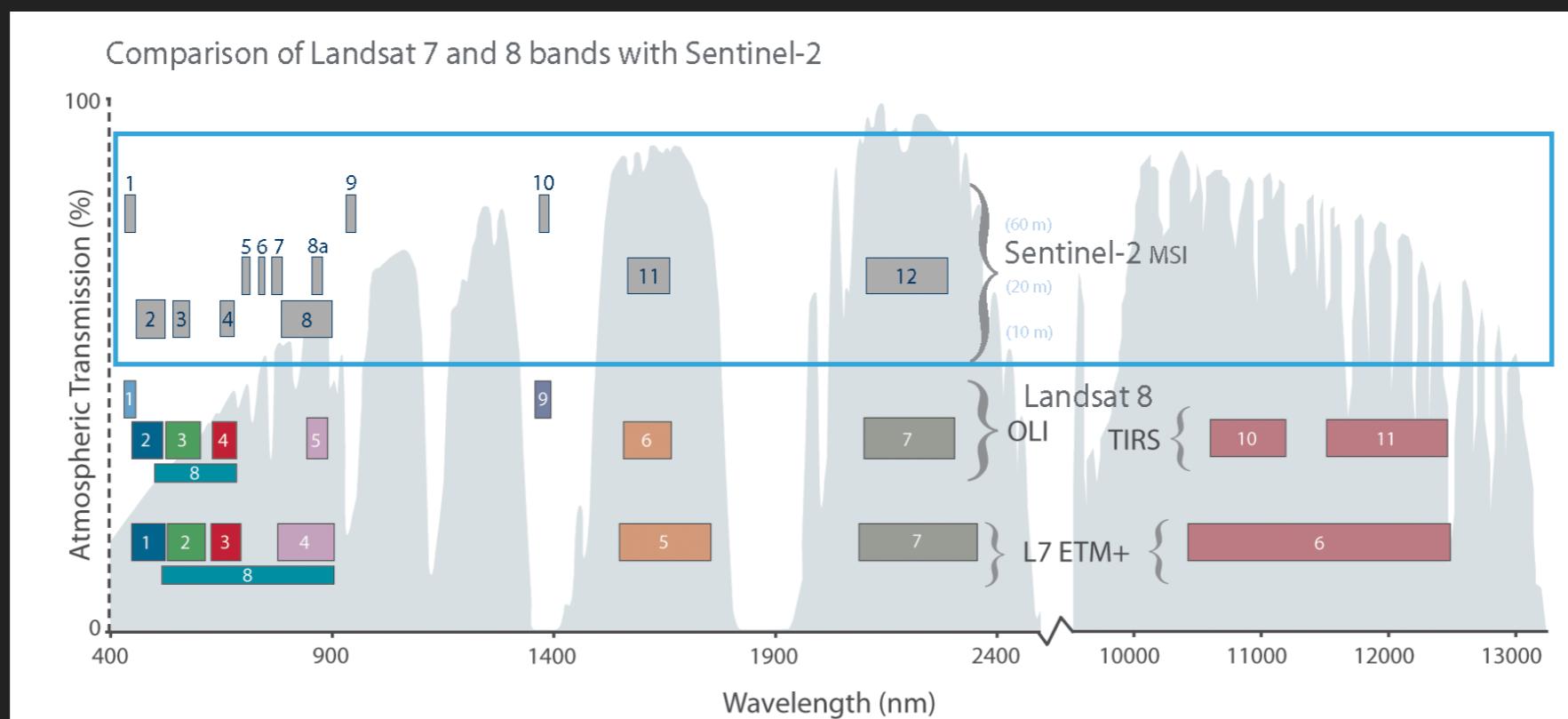
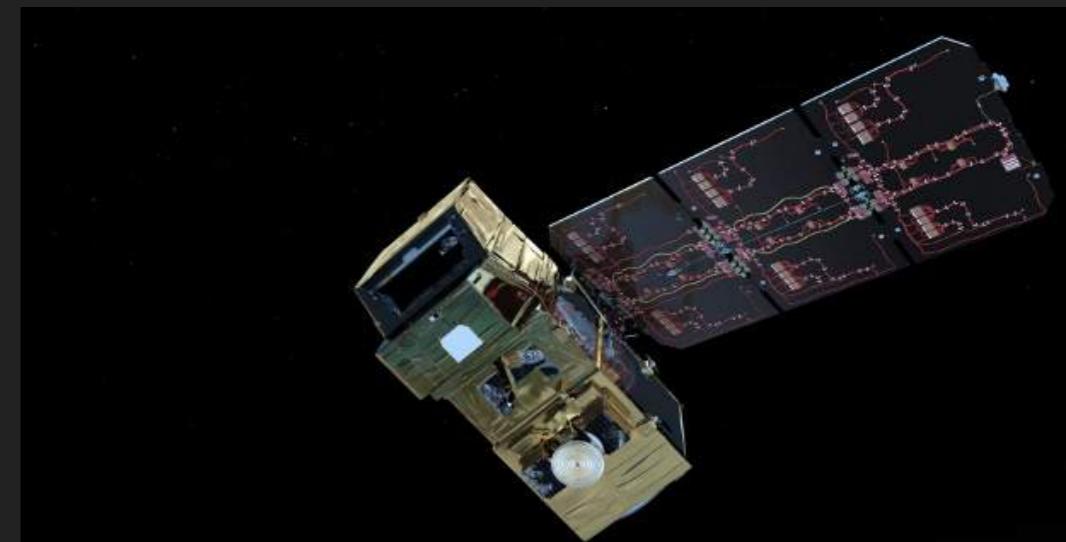
MONITORING WATER LEVELS FROM SPACE

- ▶ How can we quantitatively (and not only qualitatively) monitor the water levels from space for a given reservoir?
 - ▶ Measure water surface areas?
 - ▶ Measure water volume?
- ▶ What's the easiest way to extend the water level monitoring over all reservoirs in a given region, country, continent, or even on the entire globe?

AVAILABLE SATELLITE IMAGERY

SENTINEL-2 BY ESA

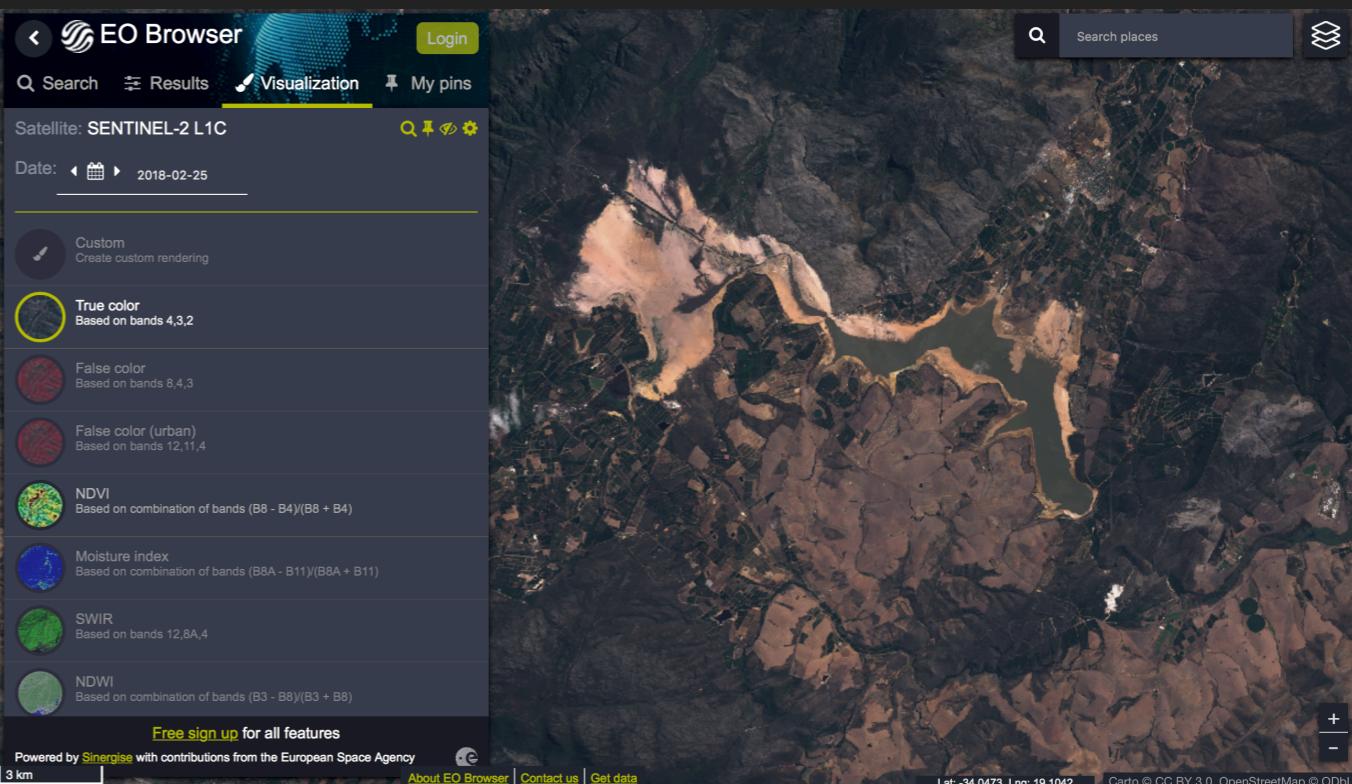
- ▶ Twin satellites in sun-synchronous orbits
- ▶ Have same orbits but separated by 180 degrees
- ▶ Each point on Earth's surface is recorded at least every five days
- ▶ A few TB per day
- ▶ All data freely available to anyone



BROWSING THROUGH THE ARCHIVE

EO BROWSER

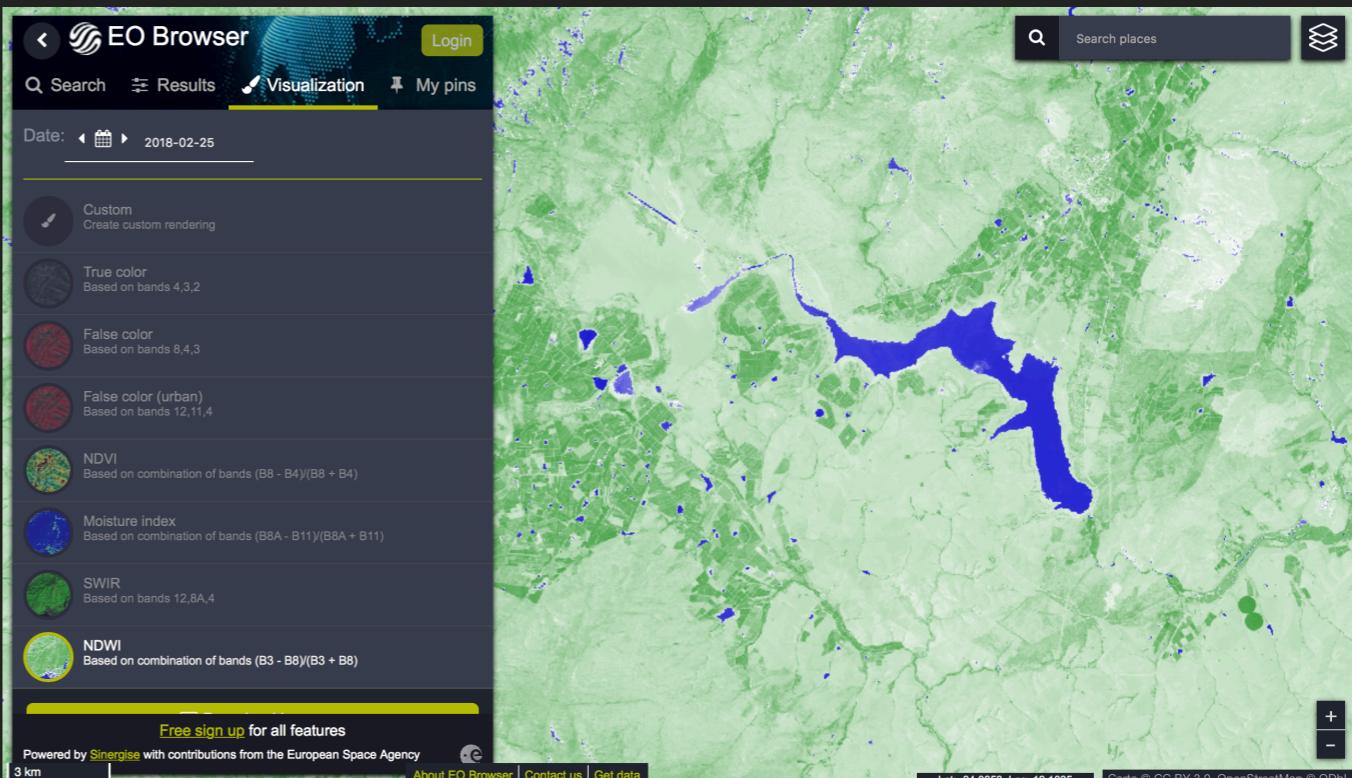
- ▶ Let's take a look at available imagery for Theewaterskloof Dam in South Africa [[link](#)]



NORMALISED DIFFERENCE WATER INDEX

- ▶ Useful for mapping water bodies

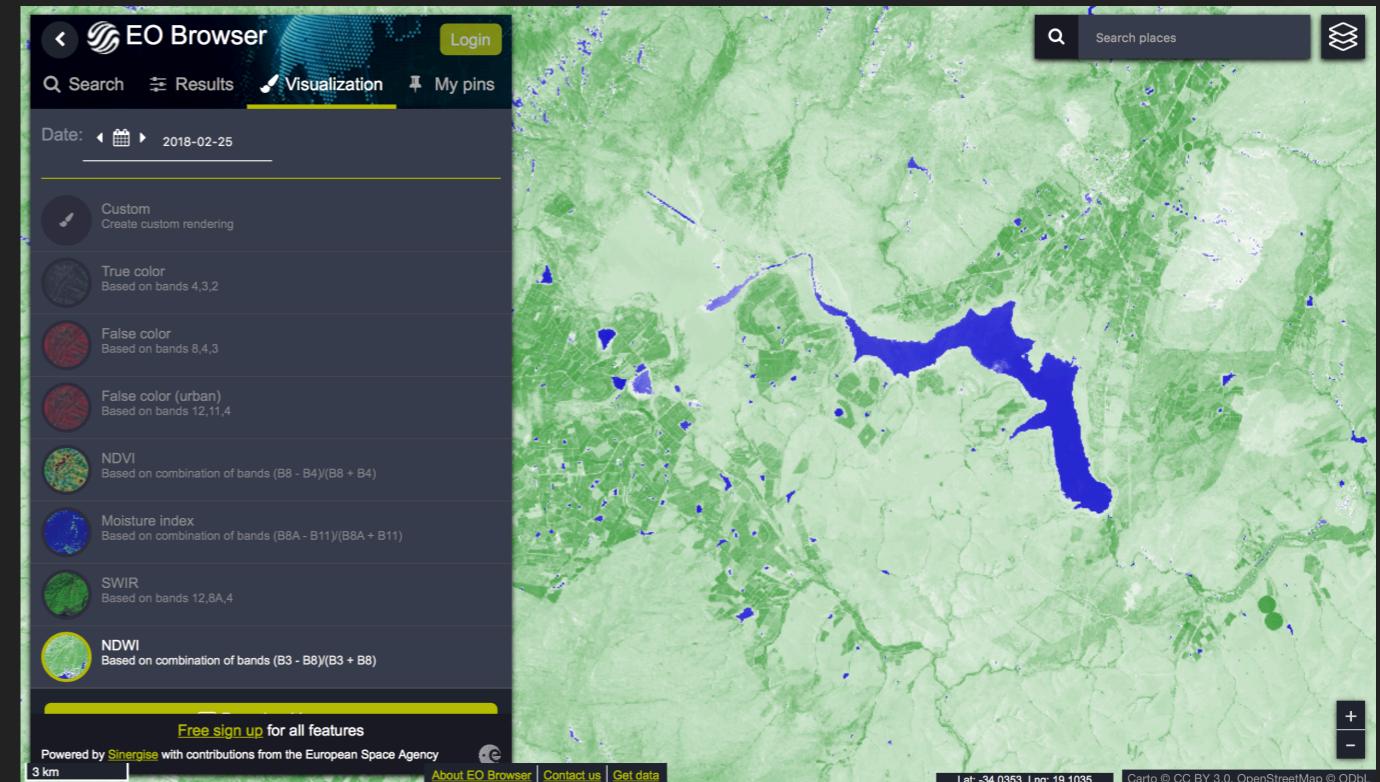
$$\text{NDWI} = \frac{\text{RED} - \text{NIR}}{\text{RED} + \text{NIR}}$$



BROWSING THROUGH THE ARCHIVE

EO BROWSER

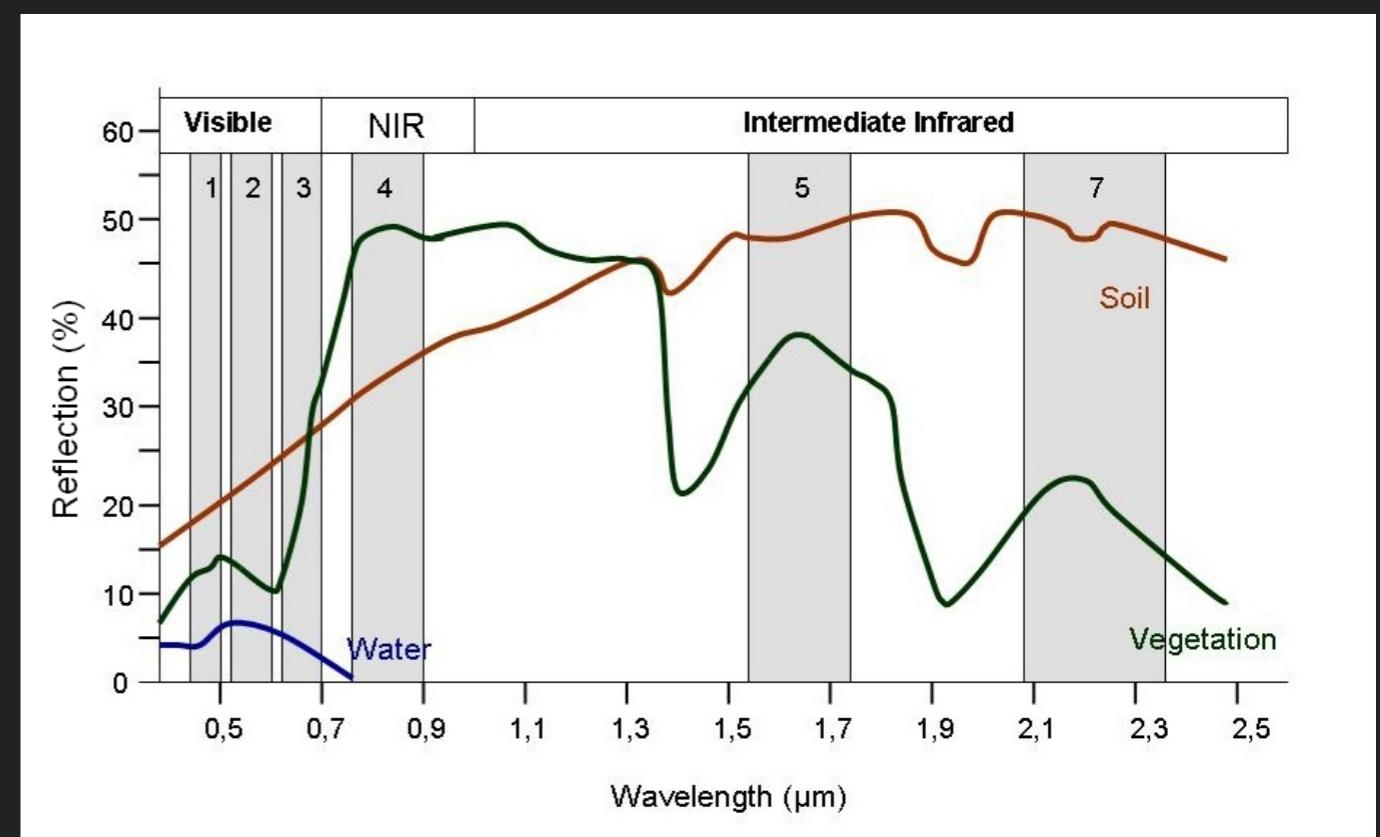
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NORMALISED DIFFERENCE WATER INDEX

- ▶ Useful for mapping water bodies

$$NDWI = \frac{RED - NIR}{RED + NIR}$$



JUPYTER NOTEBOOK EXAMPLE #1

FROM SATELLITE IMAGE TO RESERVOIR'S WATER LEVEL

1. Download satellite image (NDWI)

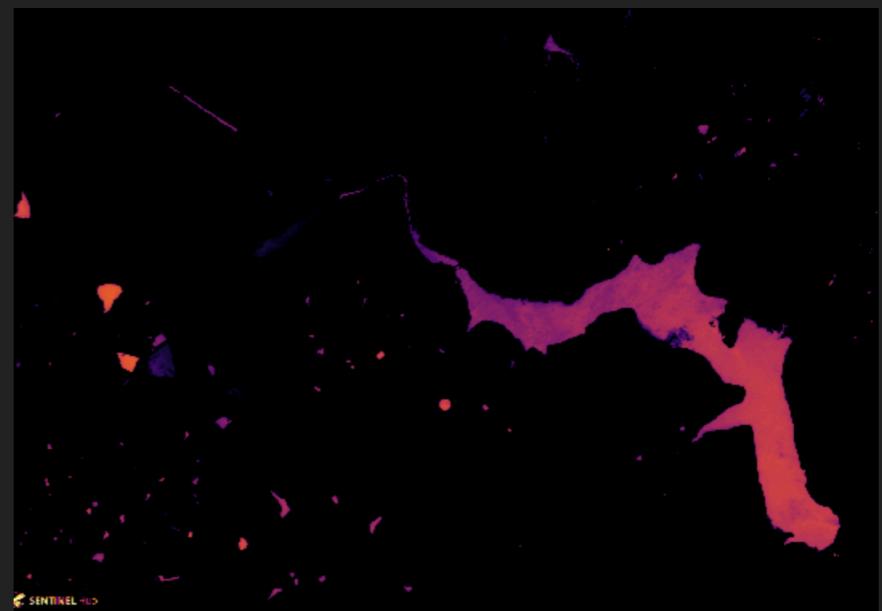
2. Perform Water Detection

- ▶ apply [Otsu's method](#) to reduce a graylevel image to a binary image (water / no water)

3. Calculate Water Level

- ▶ the method above can measure water surface area

$$\text{Water Level} = \frac{\text{Current Water Surface Area}}{\text{Water Surface Area when full}}$$

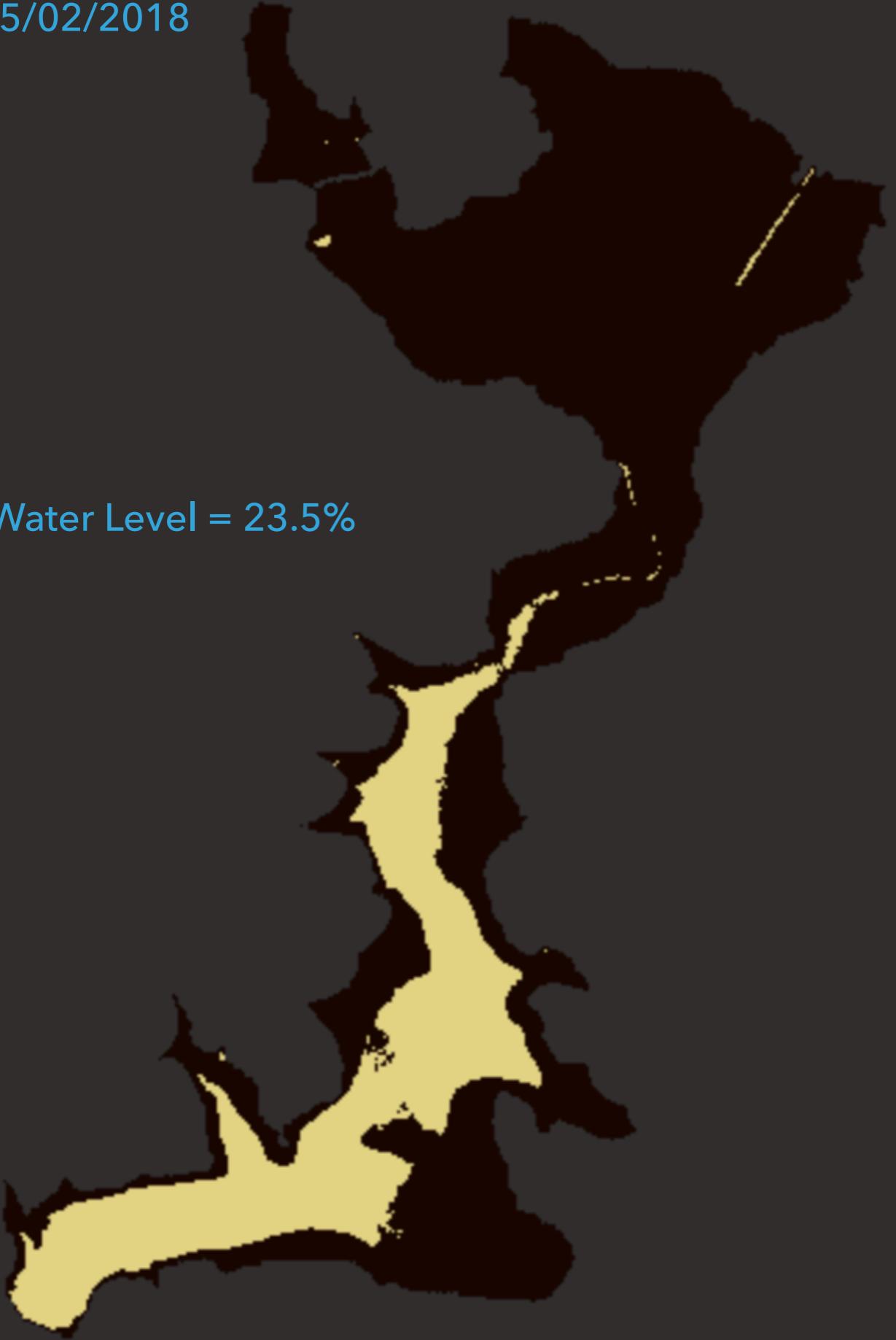




Theewaterskloof Dam

25/02/2018

Water Level = 23.5%



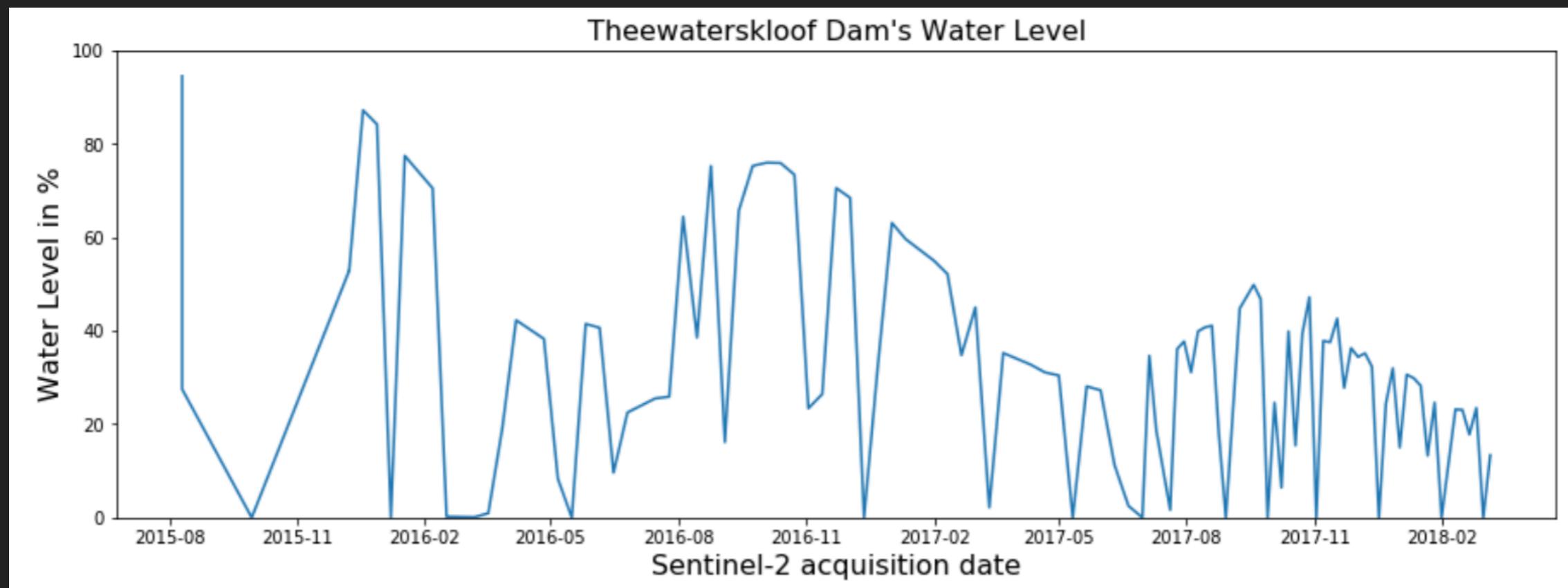
DON'T LET THE
PERFECT BE THE
ENEMY OF THE
GOOD.

Voltaire

HISTORIC WATER LEVELS

HOW DID THE WATER LEVEL CHANGE HISTORICALLY?

- ▶ Repeat the procedure on all available Sentinel-2 images of Theewaterskloof Dam
- ▶ available since mid 2015, 103 in total



THIS IS UNACCEPTABLE

GeoDev Meetup's Audience

CLOUDS

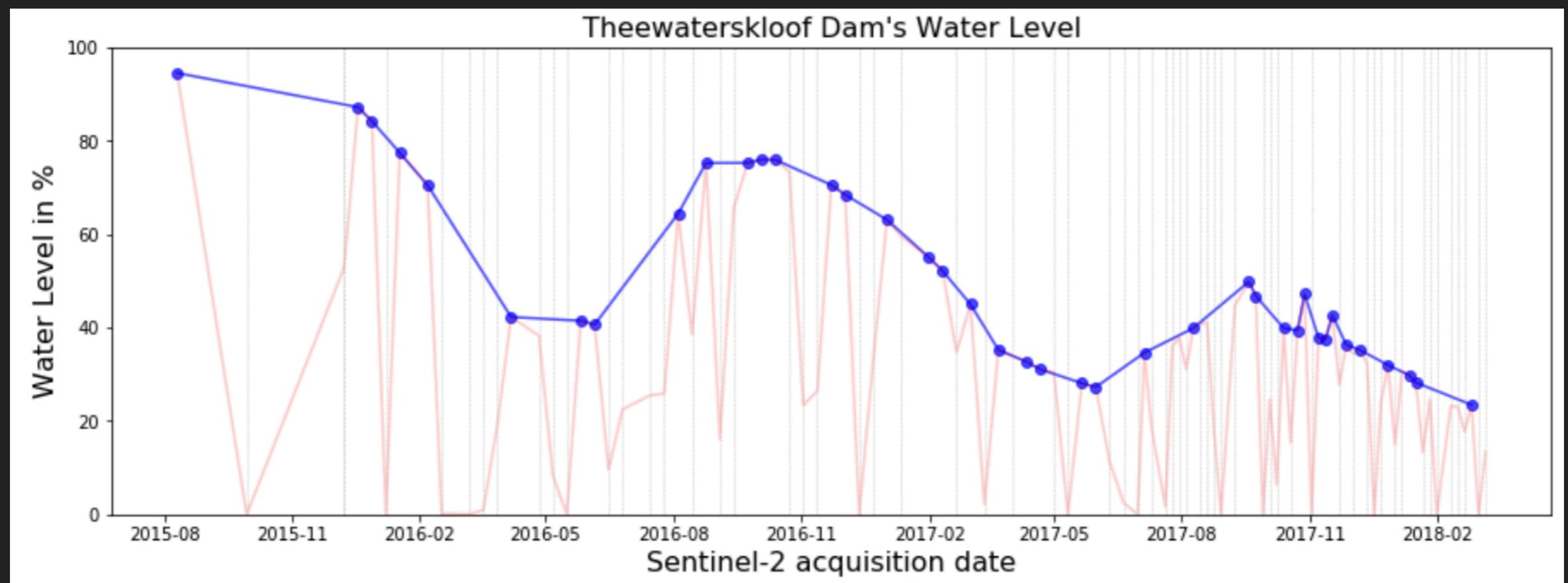
- ▶ The procedure doesn't work if the clouds are obscuring the view of the ground, water surface, everything
- ▶ Need to mask cloudy images



HISTORIC WATER LEVELS

HOW DID THE WATER LEVEL CHANGE HISTORICALLY?

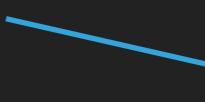
- ▶ Repeat the procedure on all available Sentinel-2 images of Theewaterskloof Dam
 - ▶ available since mid 2015, 103 in total
 - ▶ mask all cloudy images



WHAT ARE THE WATER LEVELS OF OTHER RESERVOIRS IN SOUTH AFRICA?

- ▶ The procedure can easily be applied to any water reservoir anywhere on Earth
 - ▶ but manual queries, setting the bounding box is not the way to go
- ▶ Use existing maps of selected OSM features
 - ▶ for example by <https://www.geofabrik.de>

Theewaterskloof Dam



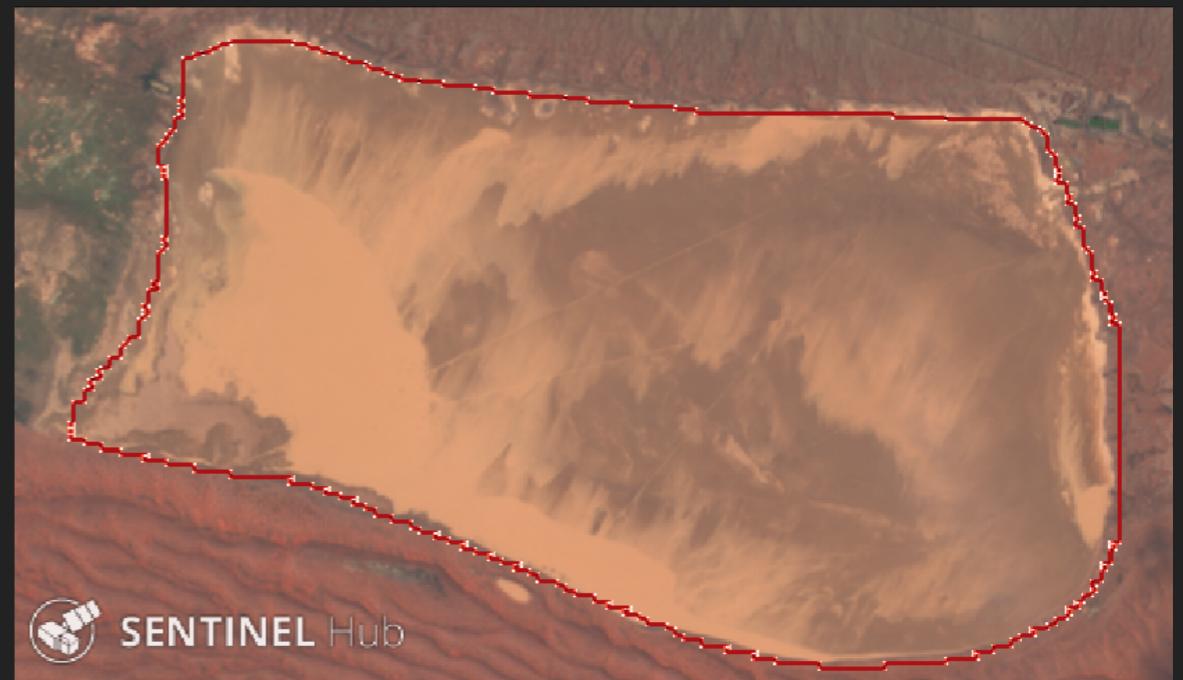
MAPPING THE WATER LEVELS OF ALL WATER RESERVOIRS IN SOUTH AFRICA

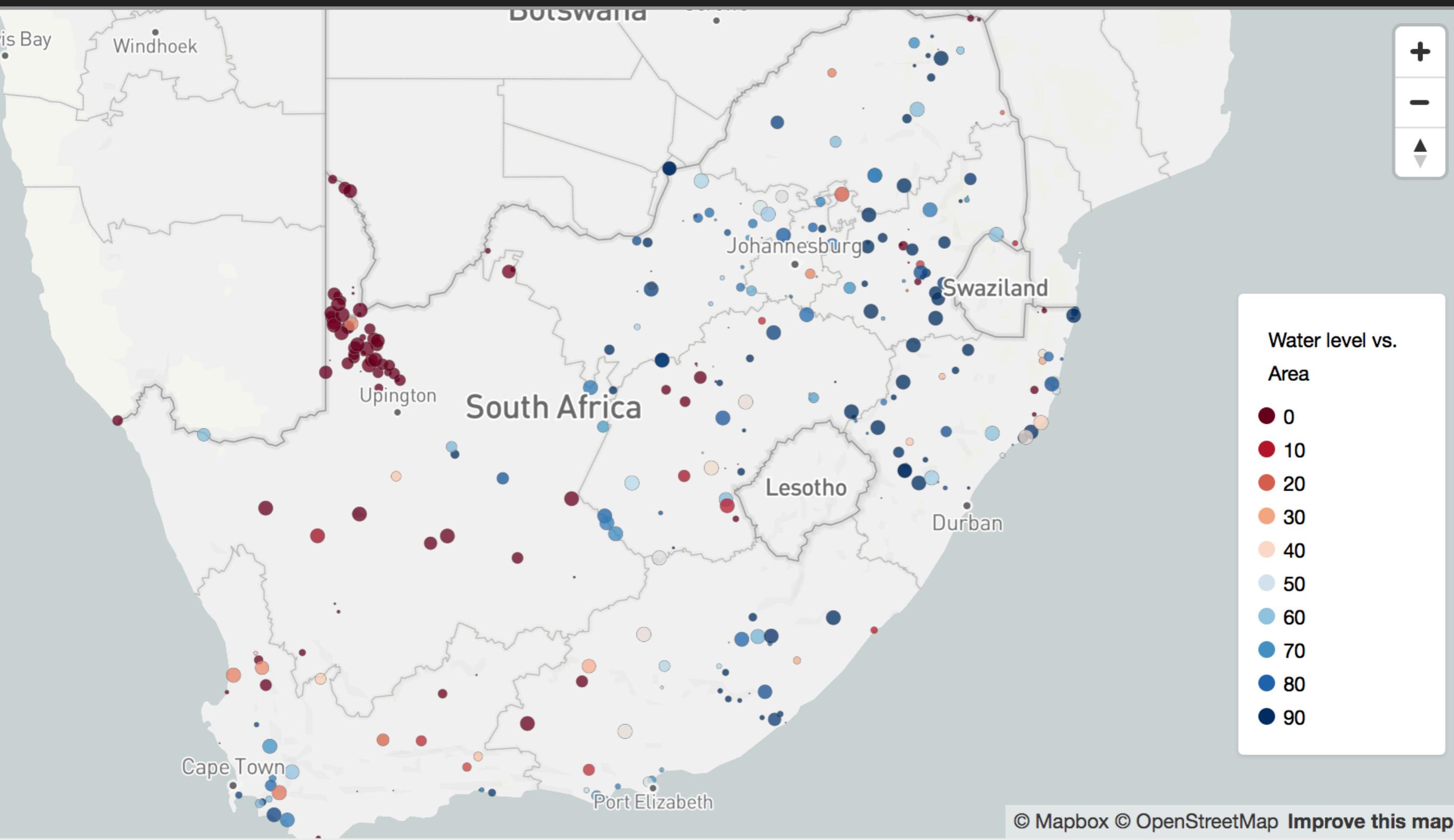
- ▶ For each water reservoir in OSM
 - ▶ find the most recent cloudless acquisition
 - ▶ determine the water level using the same approach
 - ▶ save the results in the 'DB'
- ▶ Show results on the map

Bloemhof



Uitsakpan



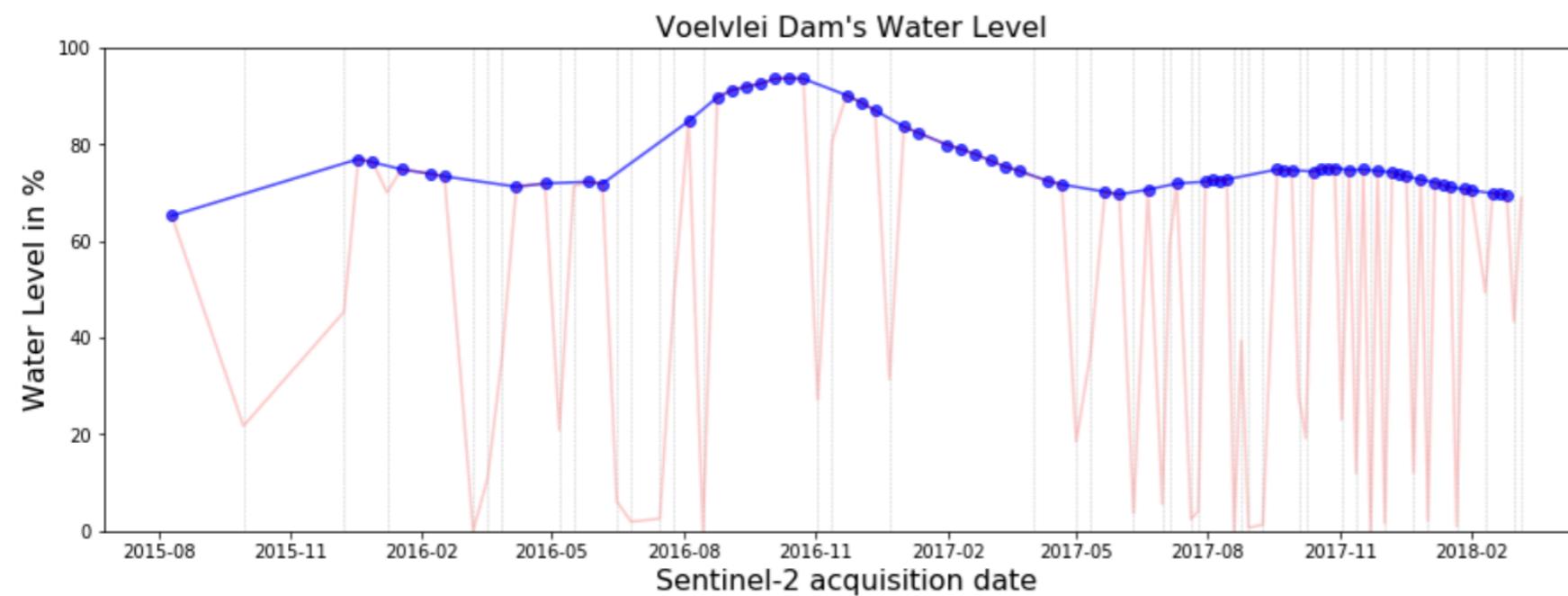
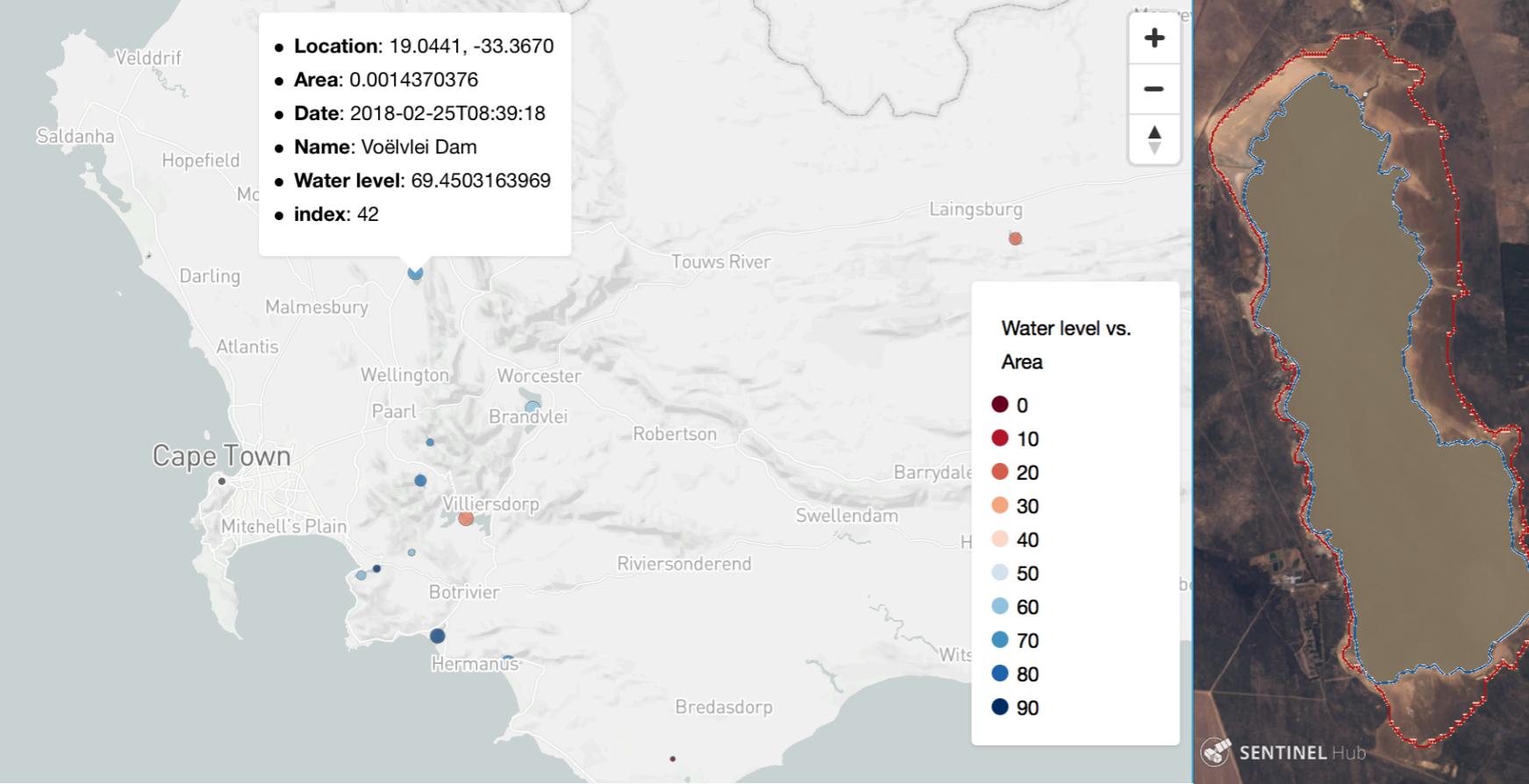


MY ENVIRONMENT

- ▶ Python 3.6
 - ▶ NumPy, SciPy, scikit-image, ...
- ▶ JupyterLab, Jupyter Notebook
- ▶ Data Gateway
 - ▶ <https://github.com/sentinel-hub/sentinelhub-py>
- ▶ Cloud Detection
 - ▶ <https://github.com/sentinel-hub/sentinel2-cloud-detector>
- ▶ Vector data manipulation
 - ▶ <http://geopandas.org>
 - ▶ <https://github.com/Toblerity/Shapely>
- ▶ Open Street Map
 - ▶ Maps of selected features prepared by <https://www.geofabrik.de>
- ▶ Map Visualisation
 - ▶ <https://github.com/mapbox/mapboxgl-jupyter>

Brandvlei Dam





THANK YOU



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