Mapping electrical towers in satellite imagery with smart-tracing

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Global Electricity Transmission Grid Mapping

ESMAP
Energy Sector Management Assistance Program

THE WORLD BANK

- ✓ Replicable
- ✓ Scalable
- ✓ Cost-effective

Already produced on:

- **Bangladesh**
- **Liberia**
- **Dominican Republic**

Likely to be followed by at least 12 more east African countries

Demo?

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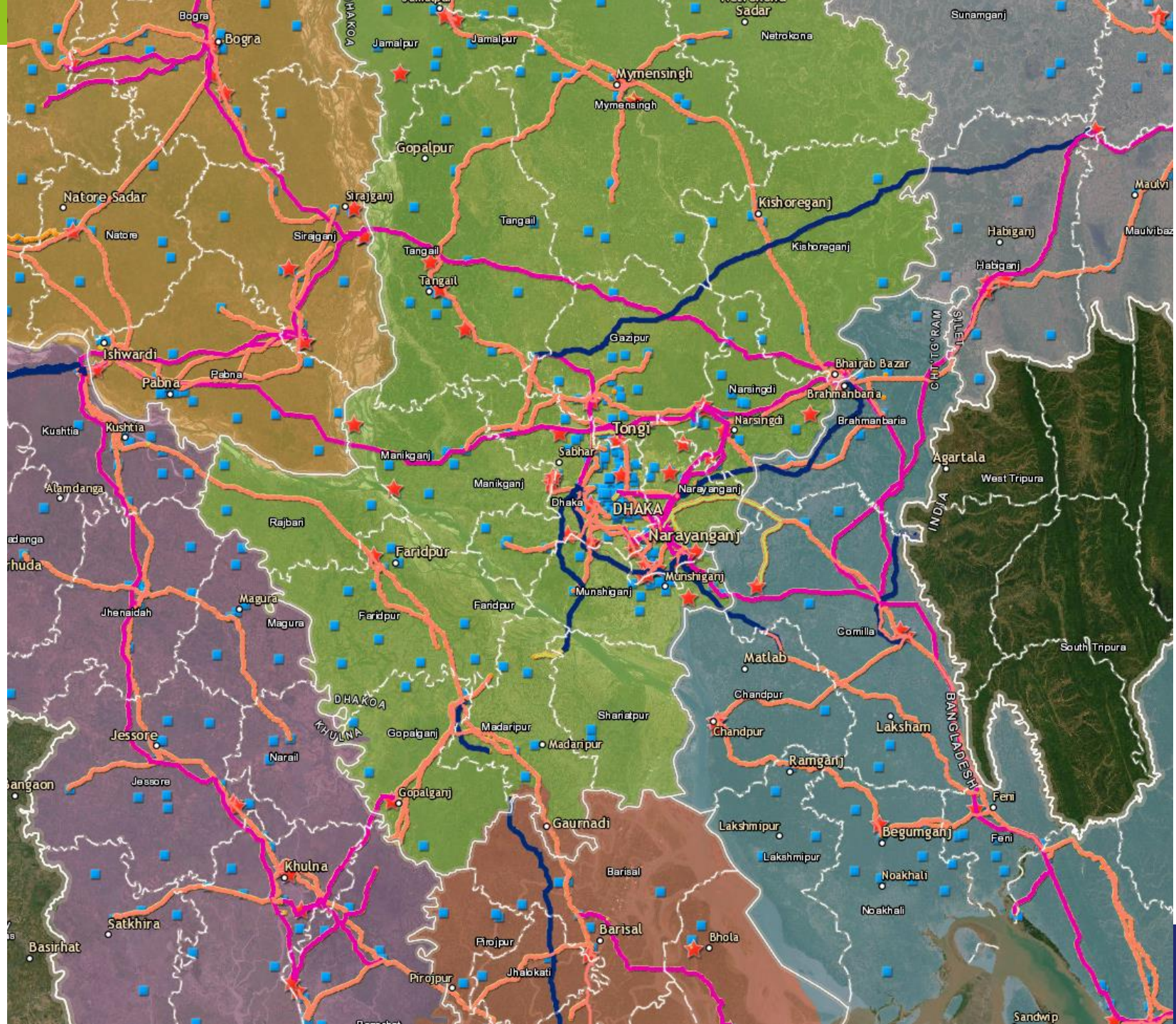
For earth observation


Bogra
Jamalpur
Sadar
Netrokona
Sunamganj
Mymensingh
Gopalpur
Natore Sadar
Natore
Sirajganj
Tangail
Kishoreganj
Habiganj
Maulvi
Ishwardi
Pabna
Gazipur
Bhairab Bazar
Narsingdi
Brahmanbaria
Tongi
Kushtia
Manikganj
Sabhar
Agartala
West Tripura
Alamdanga
Dhaka
DHAKA
Narayanganj
Rajbari
Faridpur
Munshiganj
Magura
Jhenaidah
Comilla
South Tripura
Matlab
Chandpur
Laksham
Ramganj
Shariatpur
Madaripur
Gopalganj
Jessore
Narail
Feni
Begumganj
Lakshmipur
Gaurnadi
Noakhali
Khulna
Barisal
Satkhira
Basirhat
Pirojpur
Bhola
Jhalokati
Sandwip
INDIA
BANGLADESH
CHITTAGONG
SYLHET
DHAKOA
KHULNA

Finding the electricity grid: 2 challenges

- Finding a powertower in an image
- Finding an image with a powertower

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Image tiles

Can be bought individually from mapbox, and other image providers.

Each tile is 0.001°x 0.001°

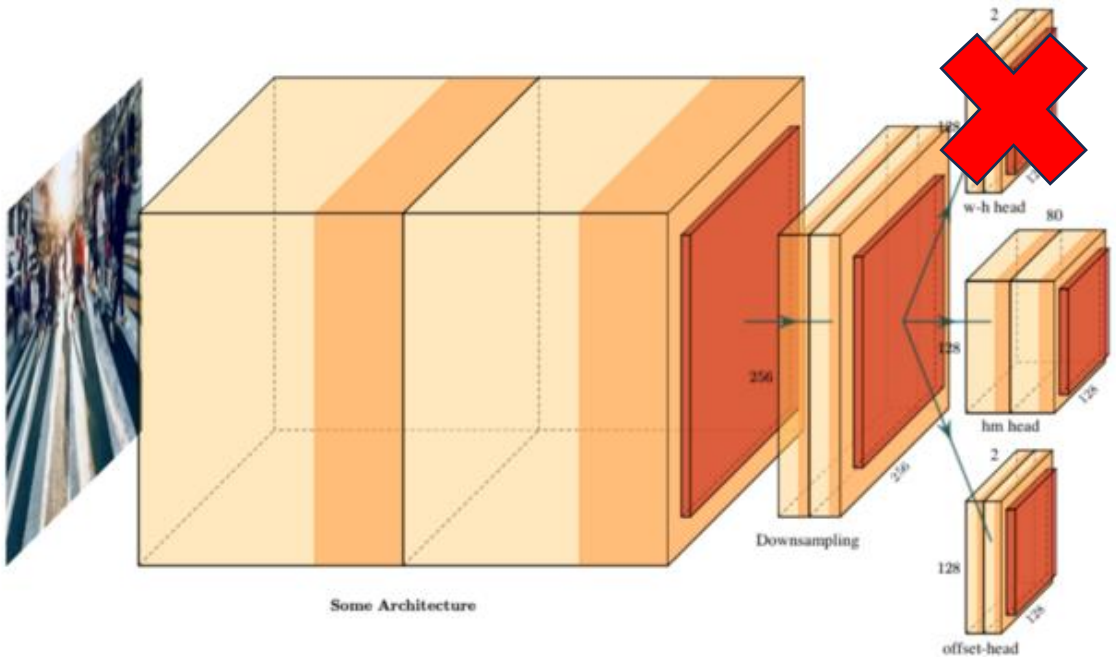
~0.5m resolution

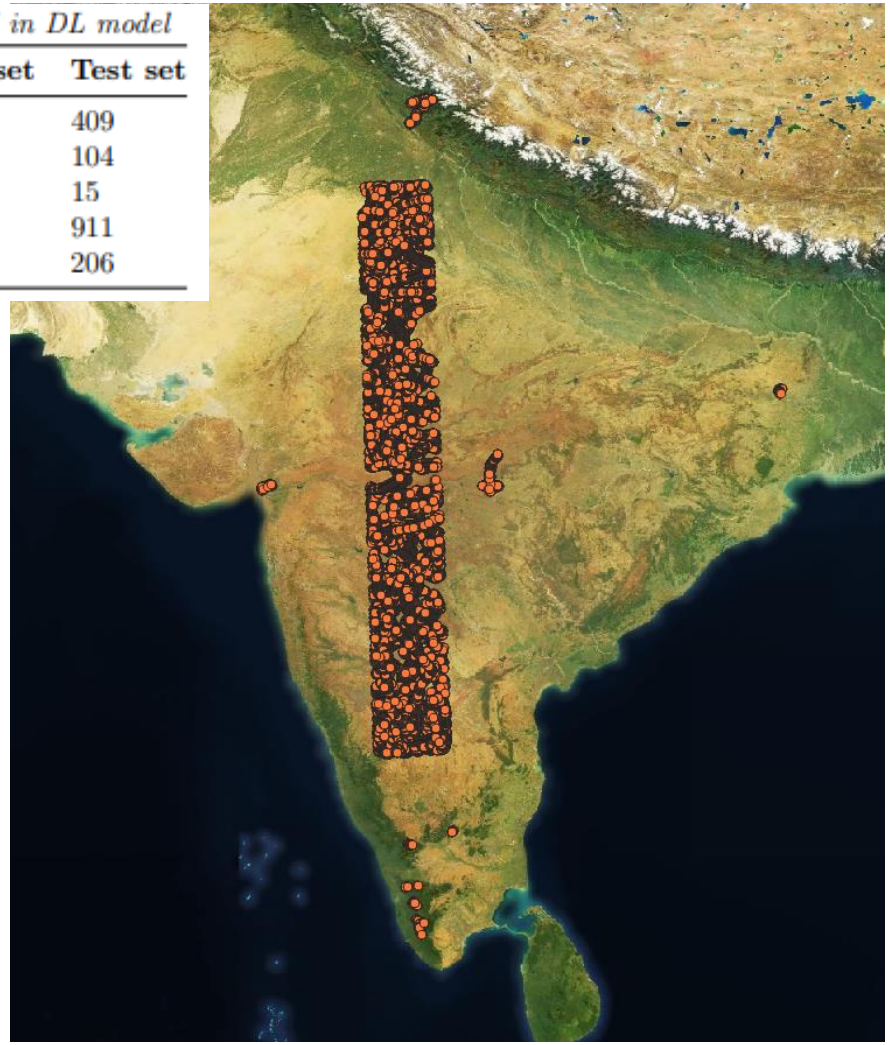
The deeplearning model

Table 1: Training data used in DL model

Country	Train set	Test set
India	178,620	409
Yemen	3,437	104
Liberia	240	15
Bangladesh	6763	911
Dominican Republic	1897	206

- Object detection as a point with a modified Centernet model
- Trainingsdata obtained from OSM

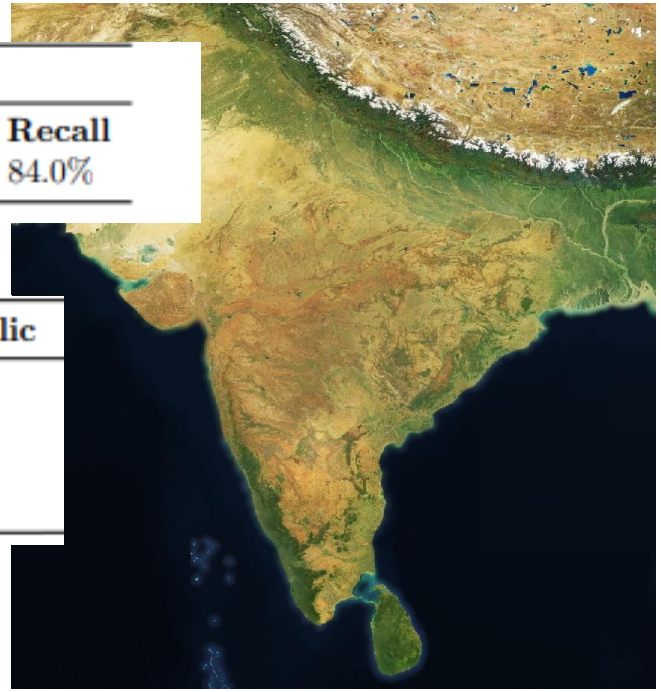




Training data in India sampled from OSM

Finding the electricity grid

- Finding a powertower in an image
- Finding an image with a powertower



	Total		Bangladesh		Dominican Republic	
	Precision	Recall	Precision	Recall	Precision	Recall
Mapbox	81.7%	83.7%	80.1%	83.6%	85.2%	84.0%

	Bangladesh	Dominican Republic
Country size (km^2)	148,460	48,671
Tiles needed for full coverage	6,780,588	2,222,942
Number of tiles bought by smart-tracing	876,021	180,345
Percentage of image tile saving	87%	91%

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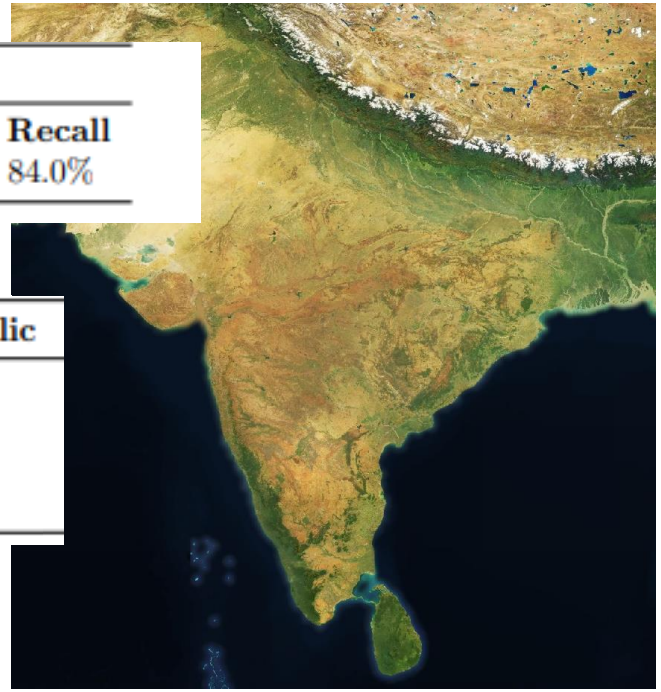
Finding the electricity grid

- Finding a powertower in an image
- Finding an image with a powertower



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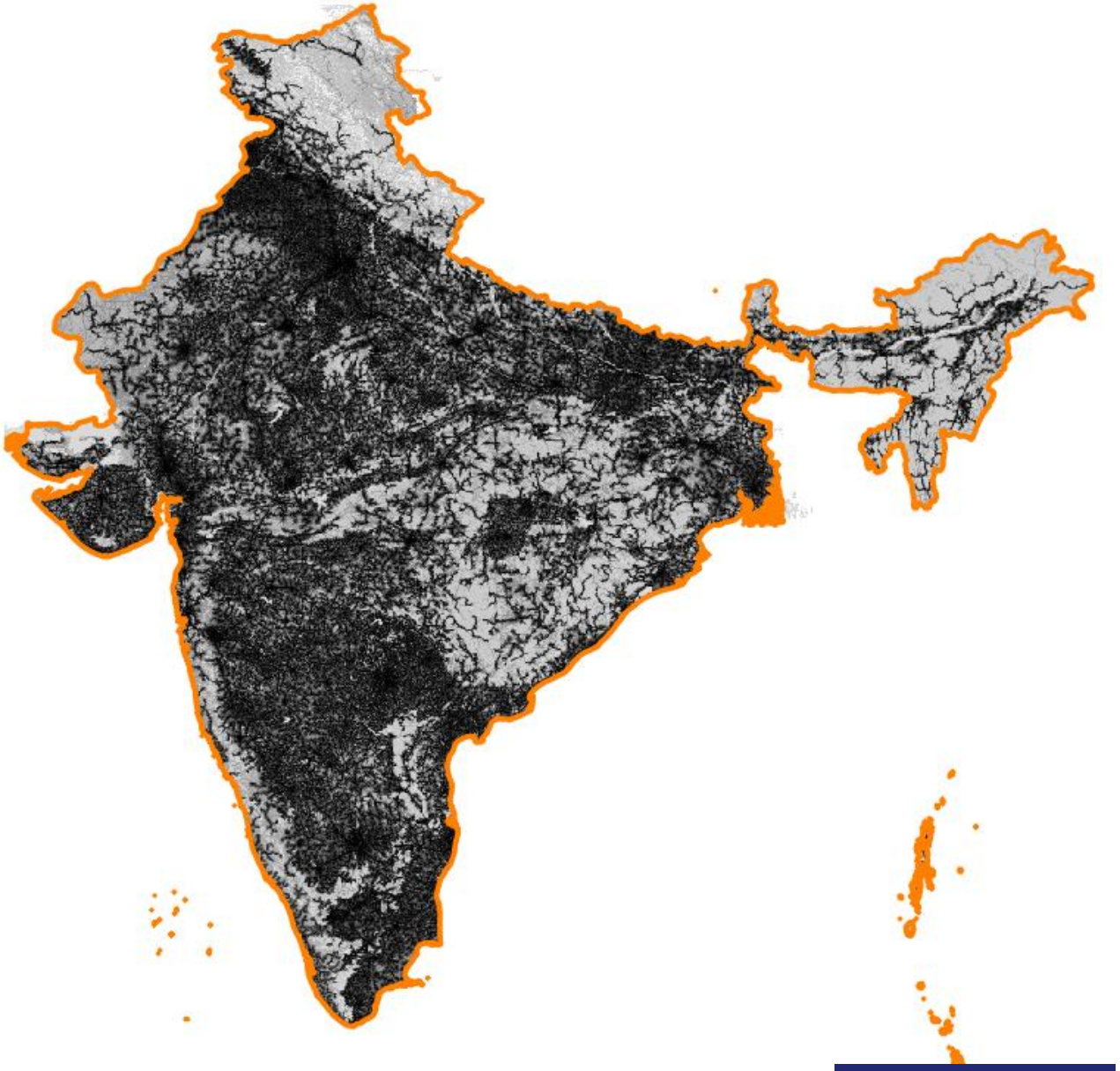
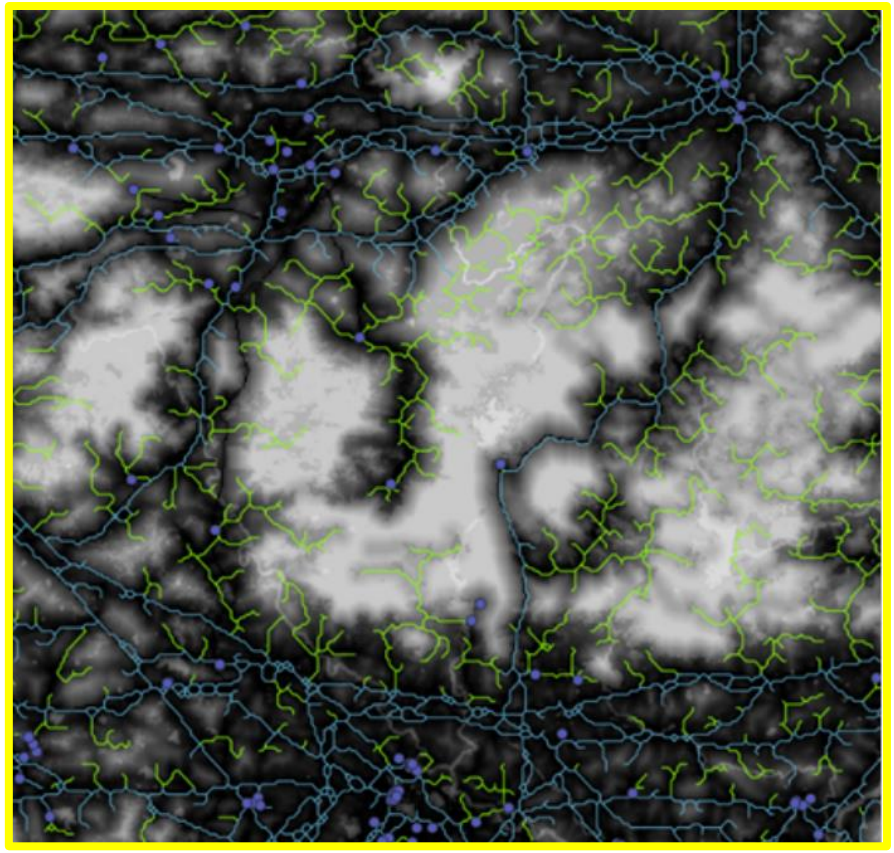
Finding an image with a powertower

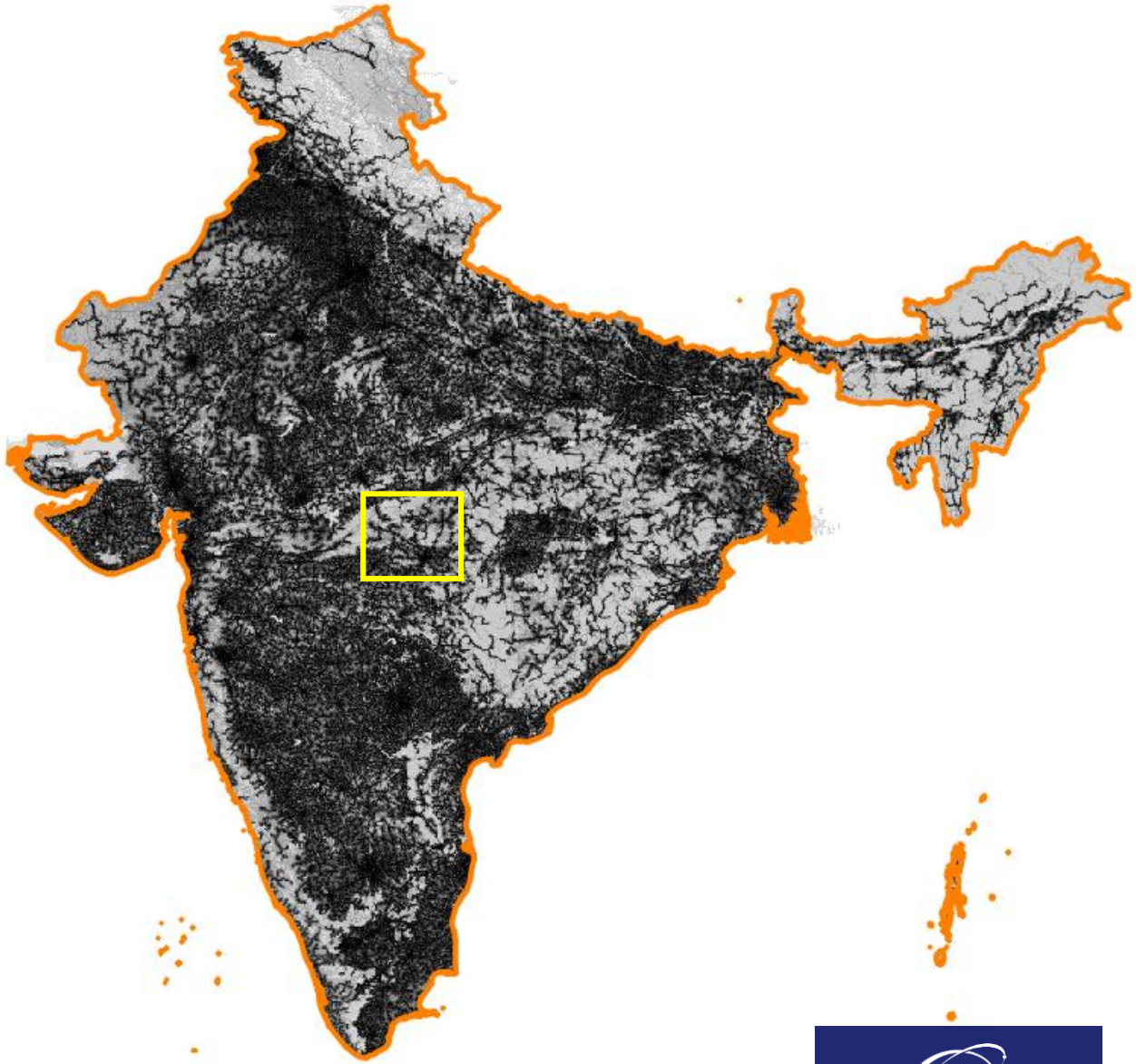
- A country can be large
- Probability map based on gridfinder approach, combines:
  - Nightlight imagery
  - Settlement map
  - OSM roads/railways
  - Slope map
  - Land use map
  - Open source powerplants and substations



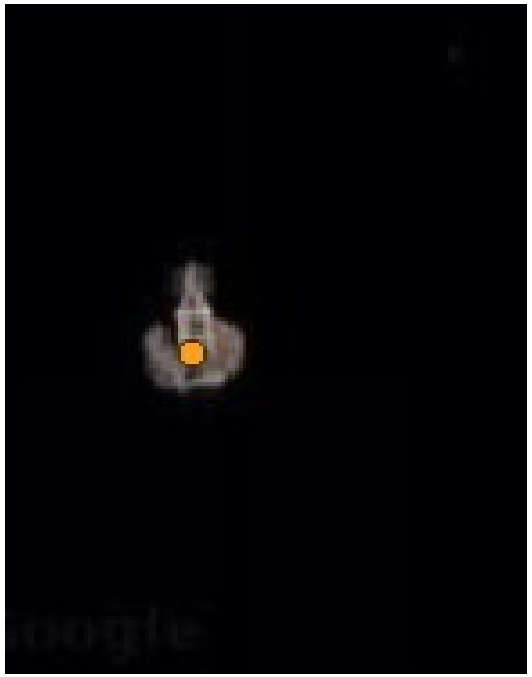
Probability map - India



Darker = higher probability
Gridfinder predicted powerlines in green&blue



Not all towers are probable…



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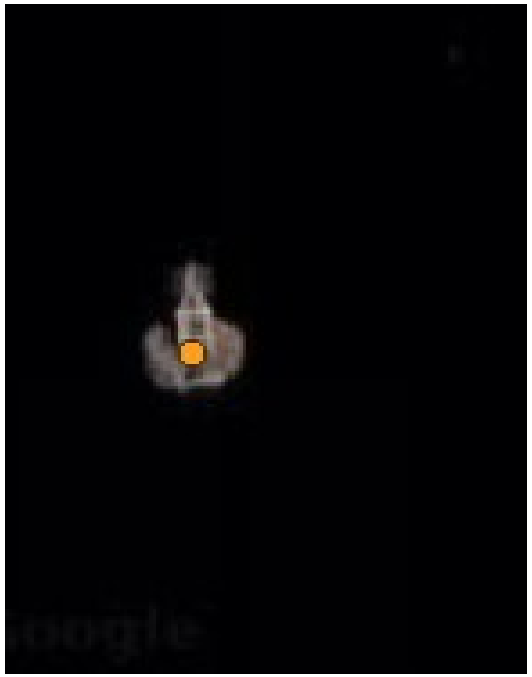
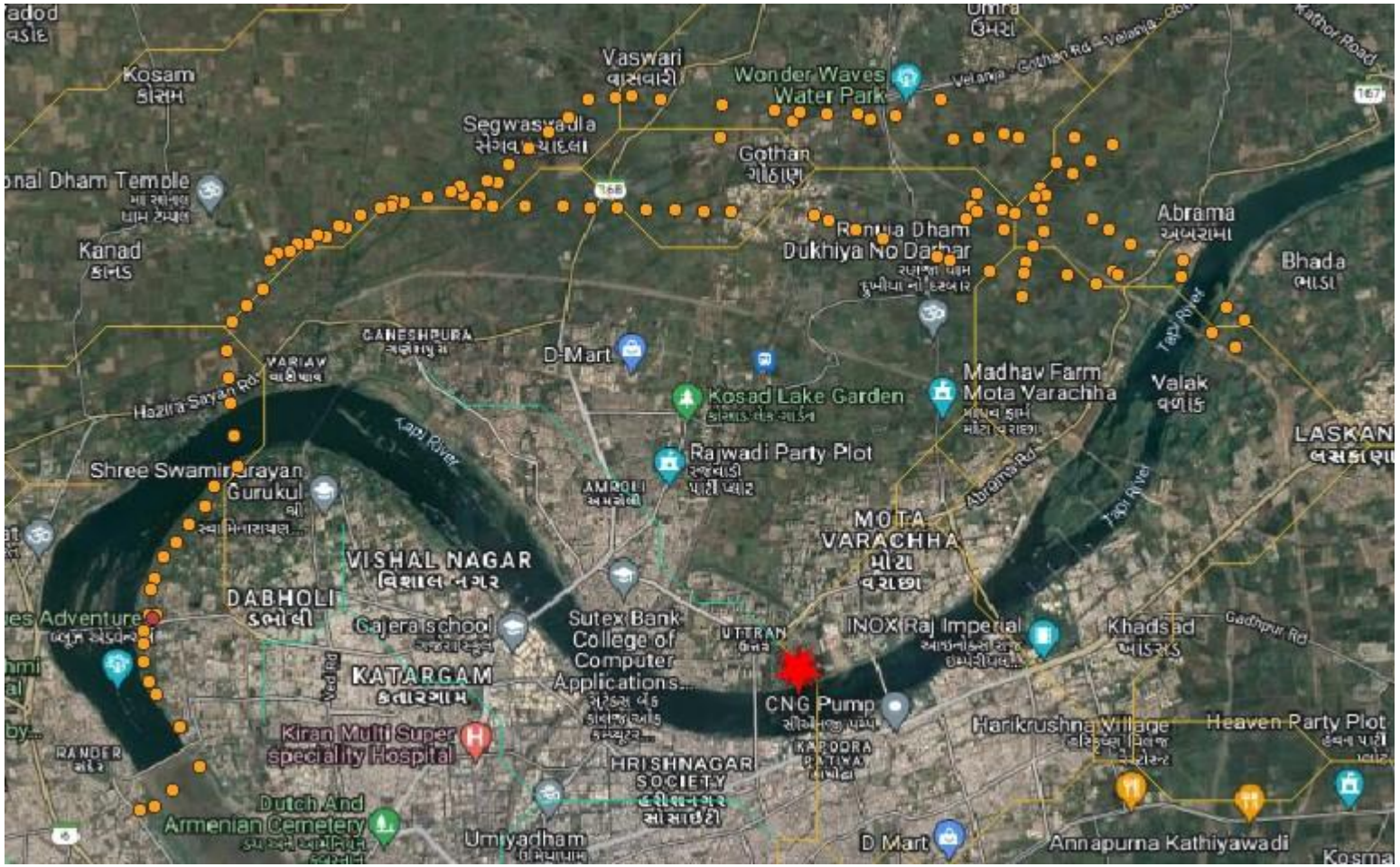




Smart tracing

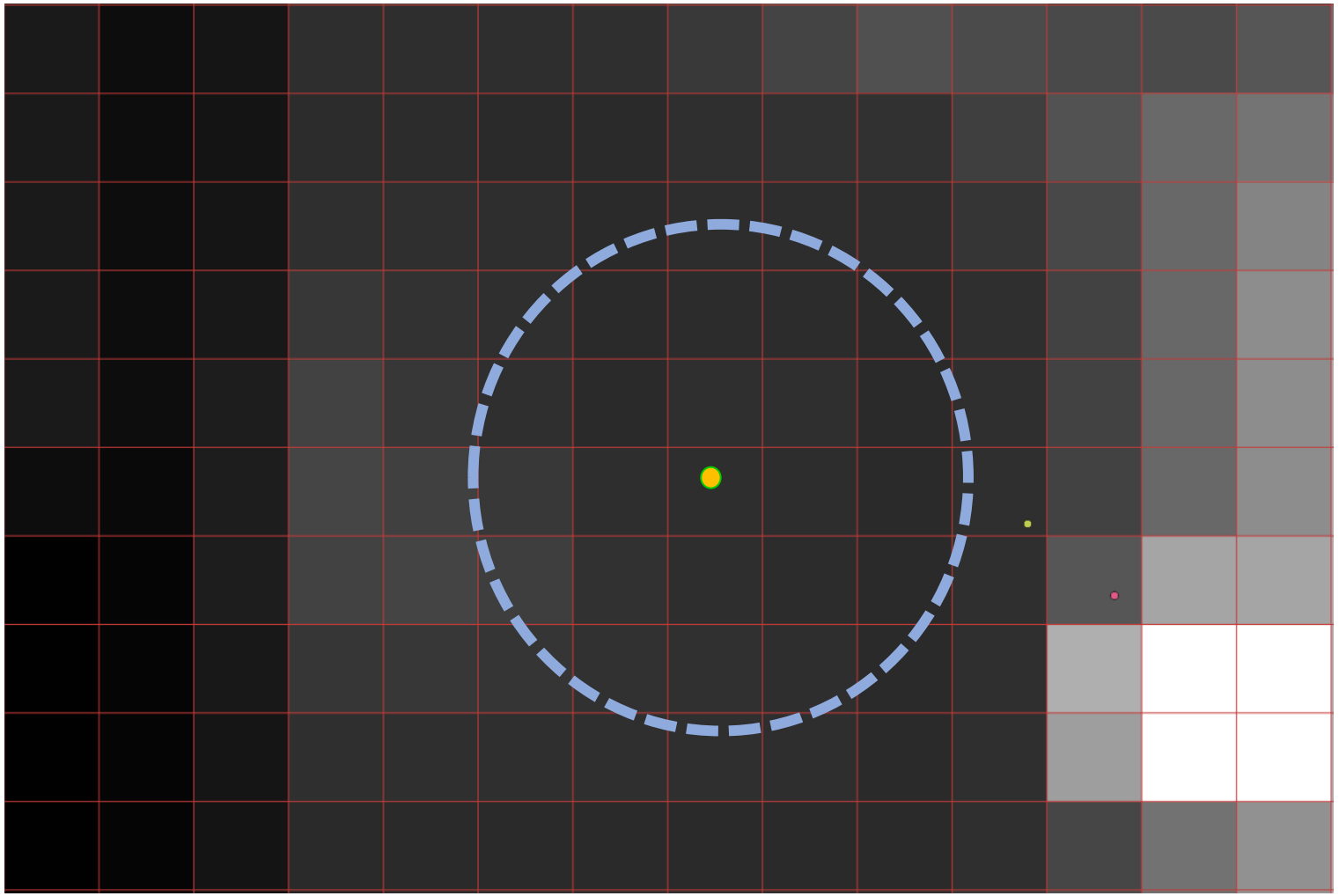
If we know of two consecutive towers, we should be able to find the next?

Smart tracing

- Start from substations & powerplants

Smart tracing

- Start from substations & powerplants
- Get global costmap



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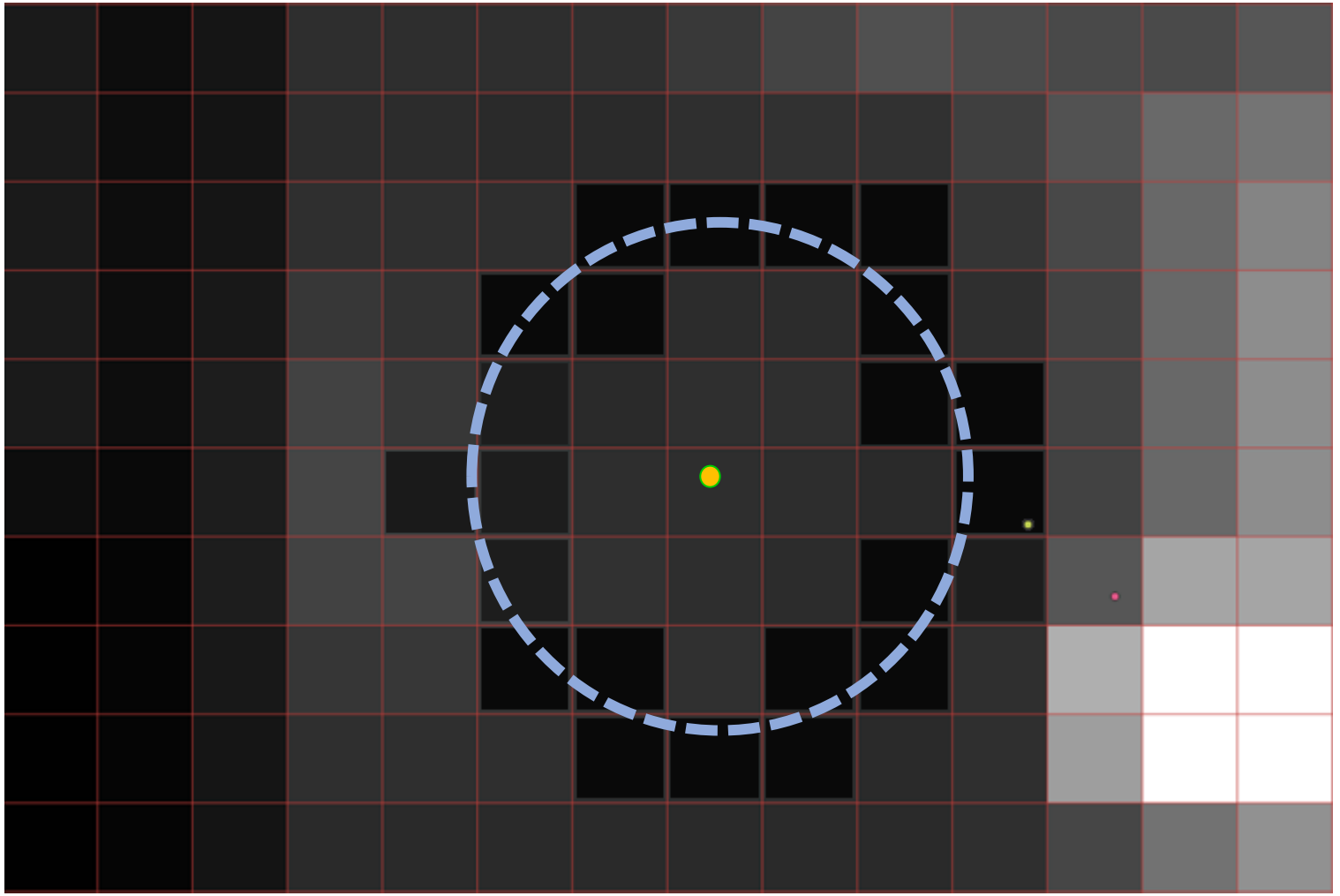
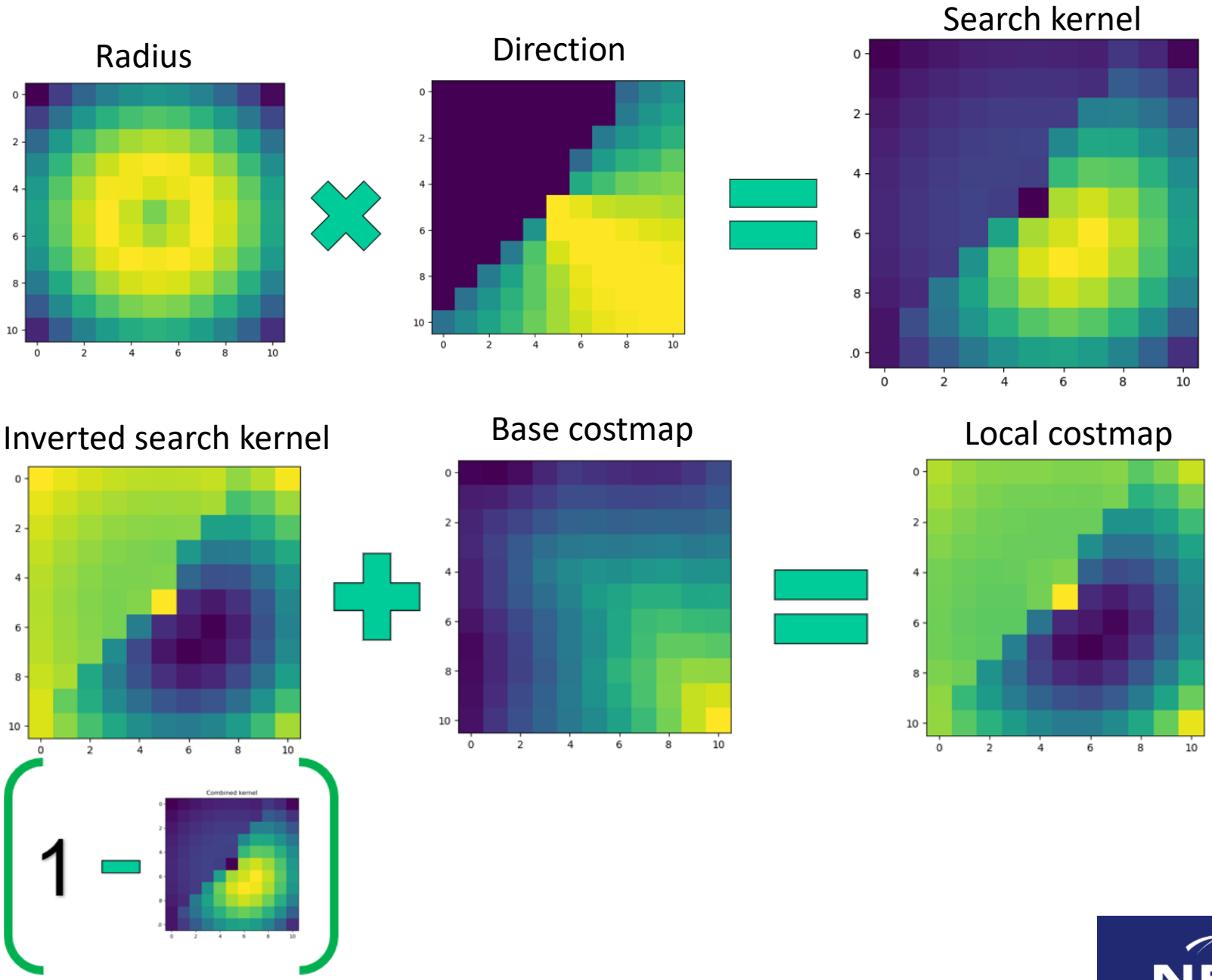
Smart tracing

- Start from substations & powerplants
- Get global costmap
- Combine with local search kernel

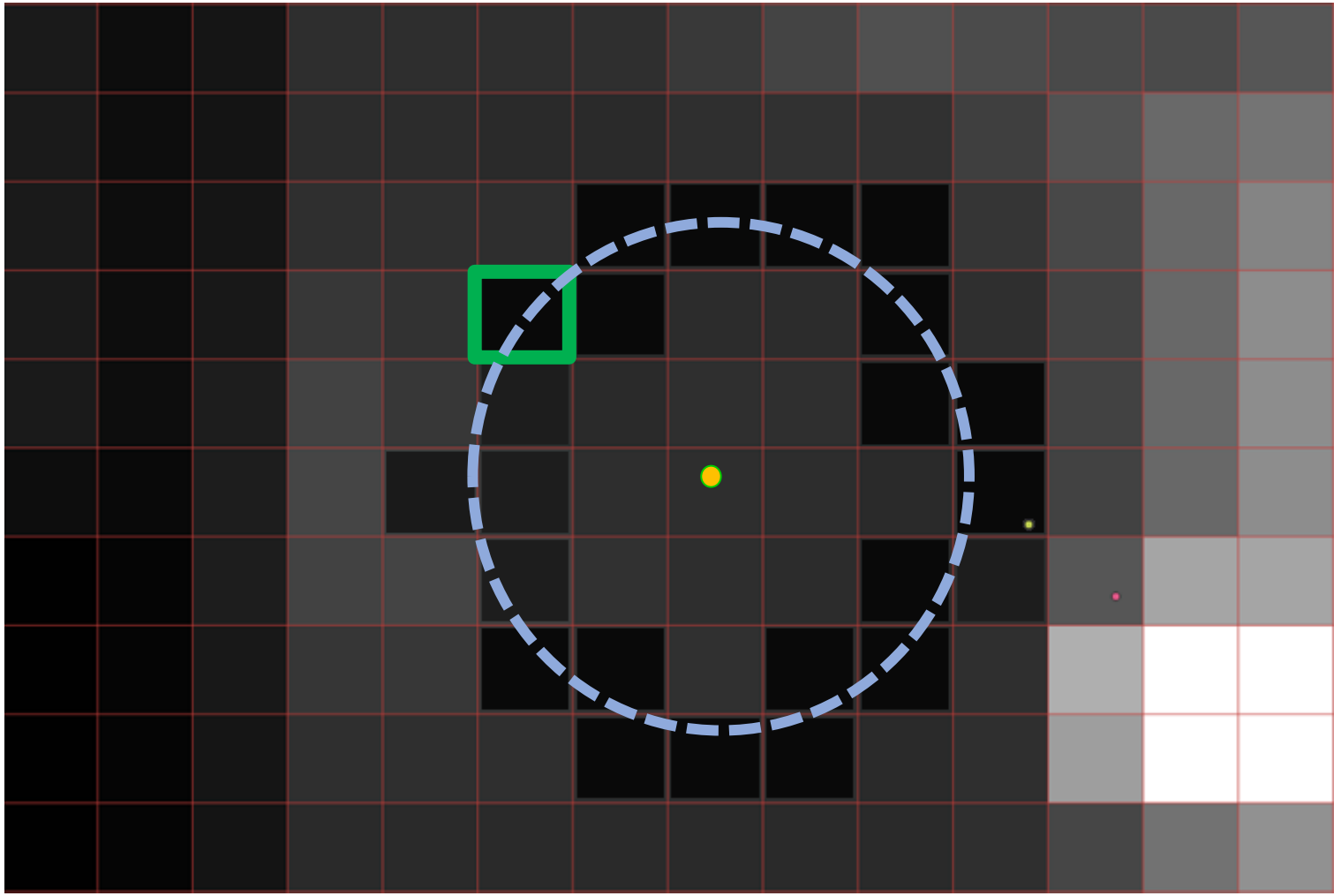


Local search kernel



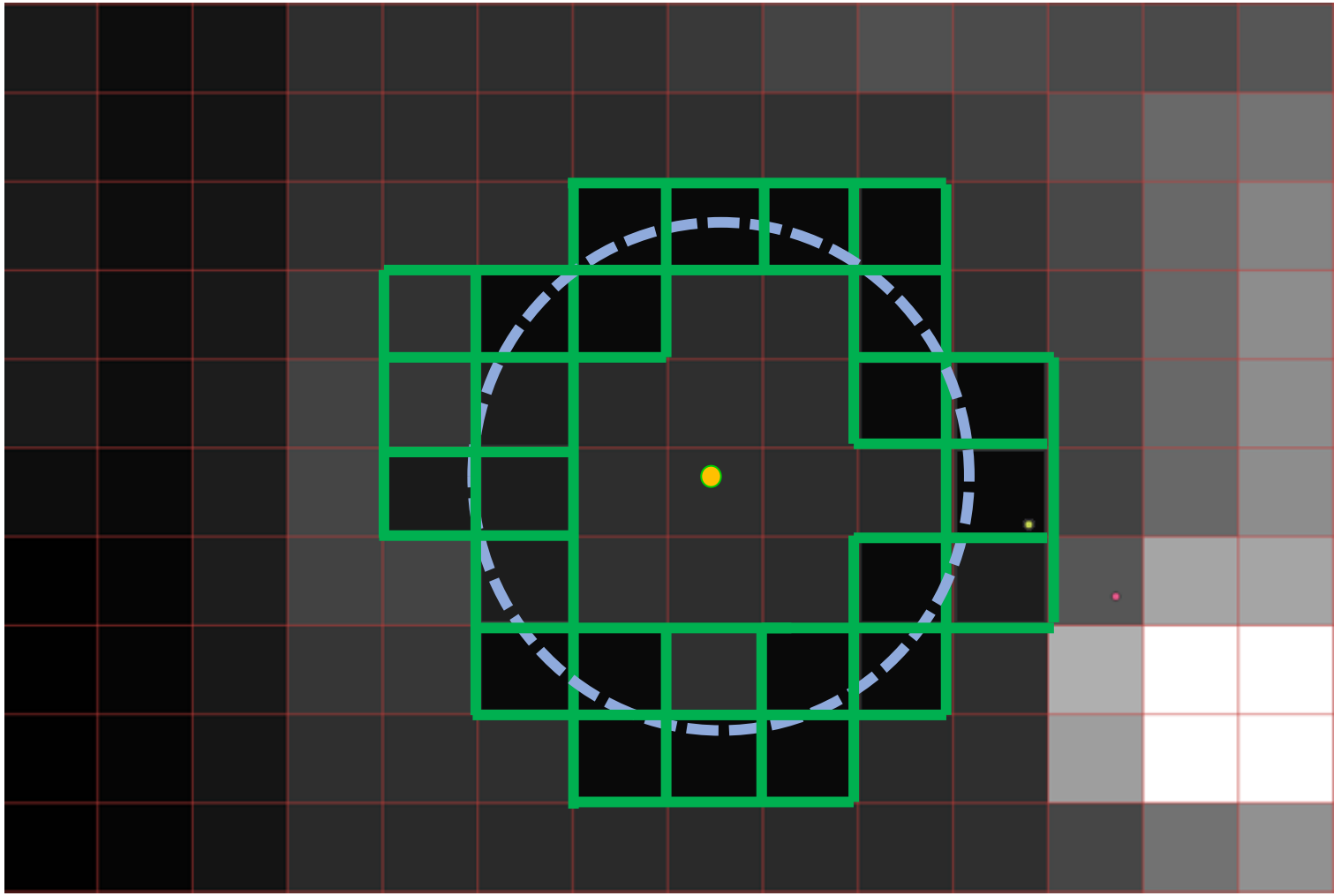
Smart tracing

- Start from substations & powerplants
- Get global costmap
- Combine with local search kernel
- Buy “cheapest” tile first



Smart tracing

- Start from substations & powerplants
- Get global costmap
- Combine with local search kernel
- Buy “cheapest” tile first
- Continue until budget is spent

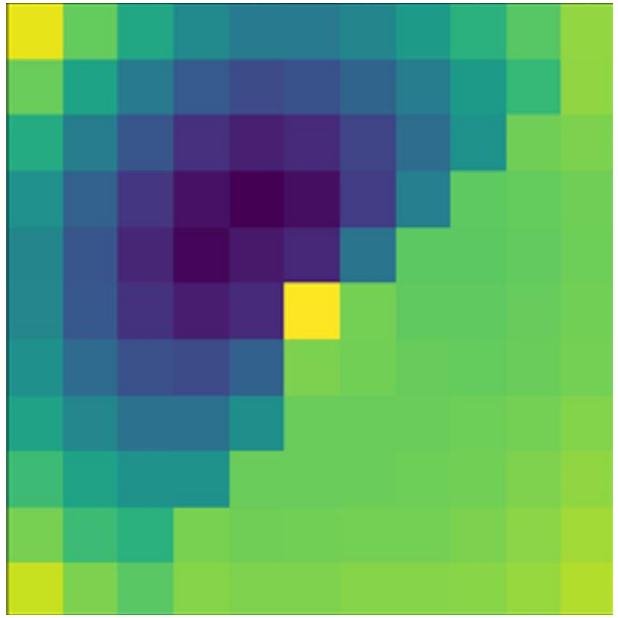


Smart tracing

- Start from substations & powerplants
- Get global costmap
- Combine with local search kernel
- Buy “cheapest” tile first
- Continue until budget is spent
- Spawn new tracer for each line found

Smart tracing

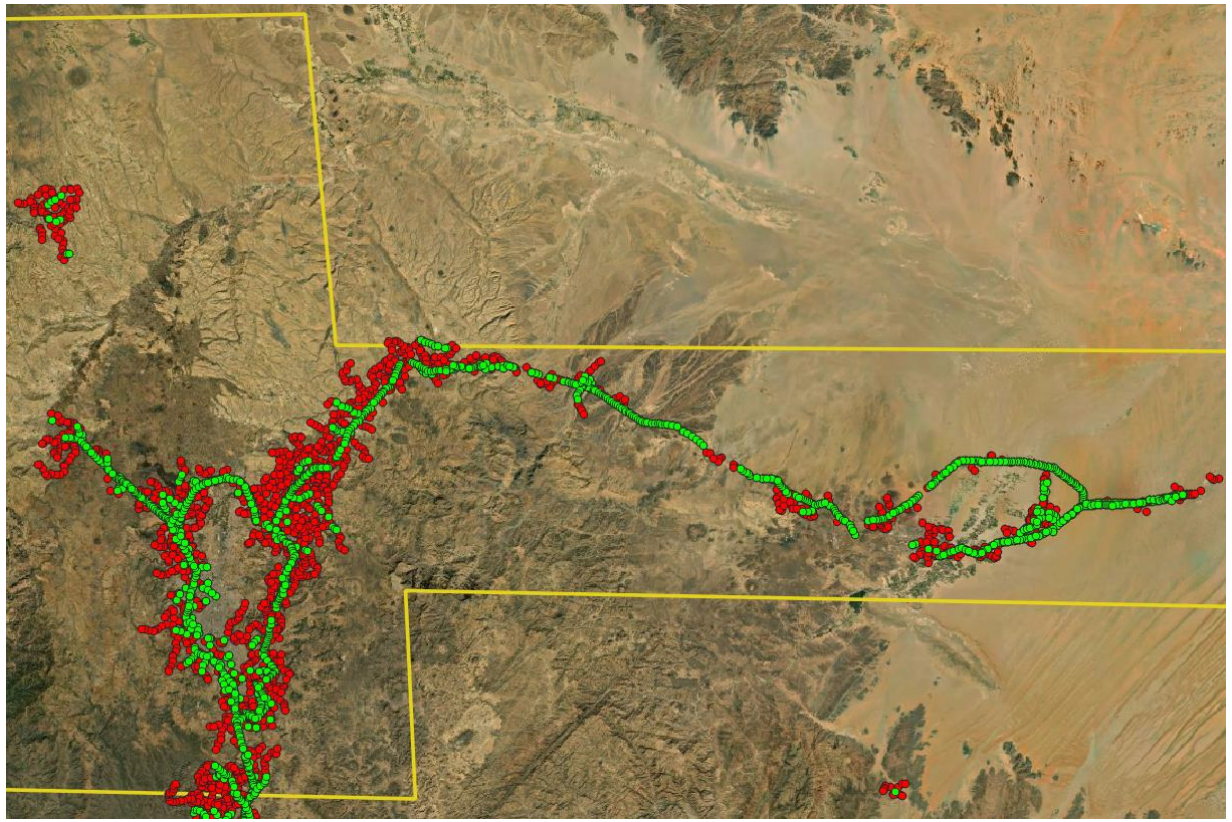
- Each tracer follows a single line
- Expected angle is known
- Again buy cheapest tile first

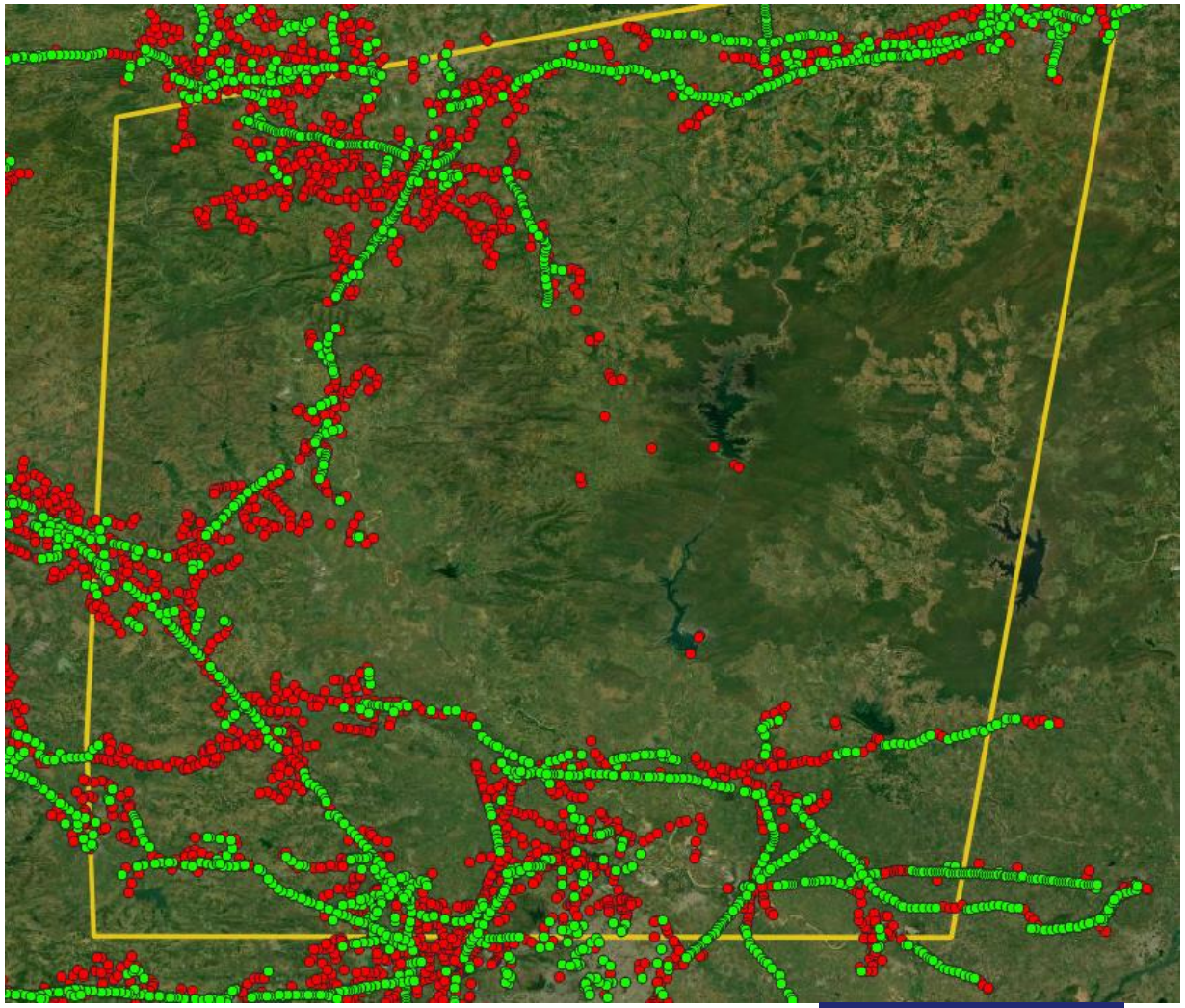


Smart tracing

- Each tracer follows a single line
- Expected angle is known
- Again buy cheapest tile first
- Until a new tower is found
- (But a minimum of three tiles of exploration)

After post processing





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Outlook / Summary

- Smart tracing is a very flexible method to trace regular-interval objects
- Validated 88.83% of OSM towers in Bangladesh and 19.88% of all found towers were new, while only buying 13% of all tiles
- Validated 76,50% of OSM towers in the Dominican Republic and 11,31% of all found towers were new, while only buying 9% of all tiles
- Better imagery would lead to better results

Dominican Republic		
	Raw result	**Post processed results**
Total detected power towers	10140	8607
Correct detected power towers	6584	6584
False positives	3556	2023
Correctness	64.93%	76.50%

Bangladesh		
	Raw result	**Post processed result**
Total detected power towers	29945	20447
Correct detected power towers	18164	18164
False positives	11781	2283
Correctness	60.66%	88.83%

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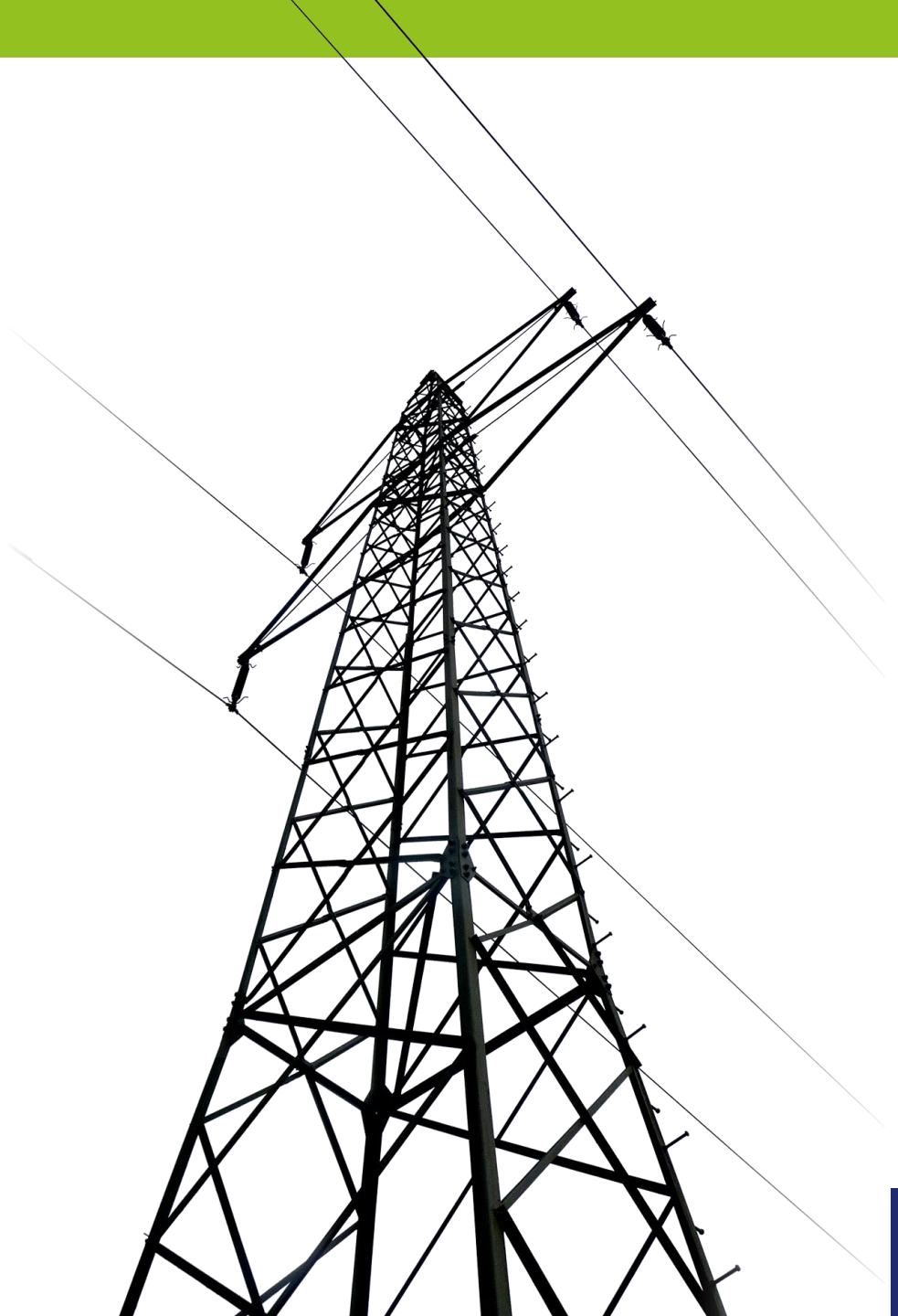
Questions?



Thanks to:
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And:
Fiona Gallagher, Fang Fang, Geert Koster and Cornelis Valk from NEO

Mapbox

Google

NEO
For earth observation

Mapbox

Google

post processing

Before

Straight line segments