A million dollar challenge to map Indonesian peatlands – A Digital Soil Mapping Approach

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Peatland in Indonesia


Image Landsat
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Soil C stock in Indonesia

- Land area: 190 Mha
- C stock mineral soil: 0-30 cm: 9.9 ± 0.4 Gt C (Sulaeman, 2015)
- Peatland: 33.7 Gt C (Wahyunto), area: 20.9 Mha

1997 Fire, released ~0.19-0.23 Gt C

2016 fire ~0.48 Gt C

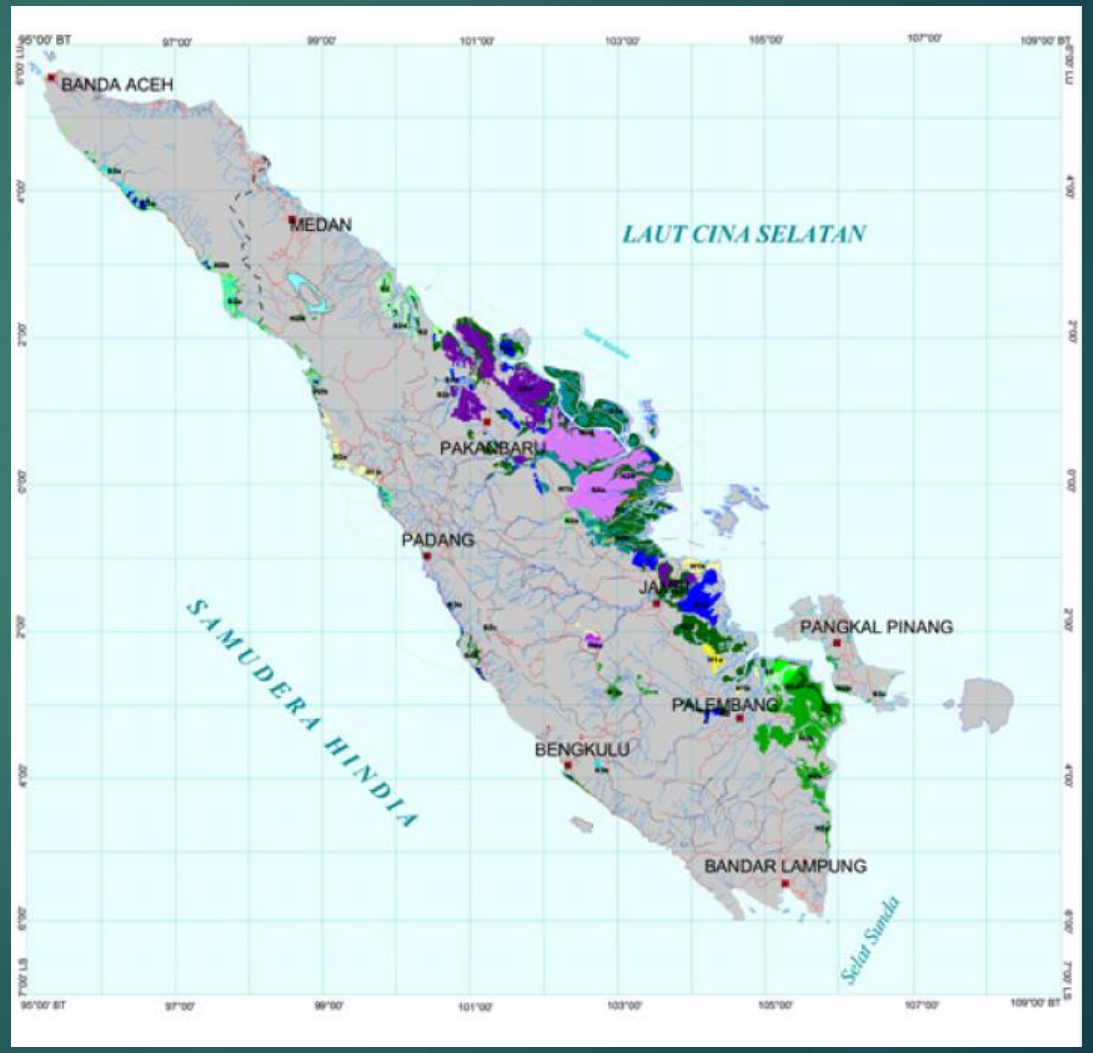
Indonesia's annual GHG emission (excluding land use) ~0.21 Gt C.

A million dollar prize

Current peat map

- Wetlands international

1:250,000 scale, peatland on 3 main islands: Sumatera, Kalimantan, Papua



Proposed Methodologies

- Using Remote & proximal sensing
  - LIDAR
  - Gamma Radiometrics (Ireland, Finland…)
  - EMI

  - These sensors require ground calibration, not cost effective over large extent

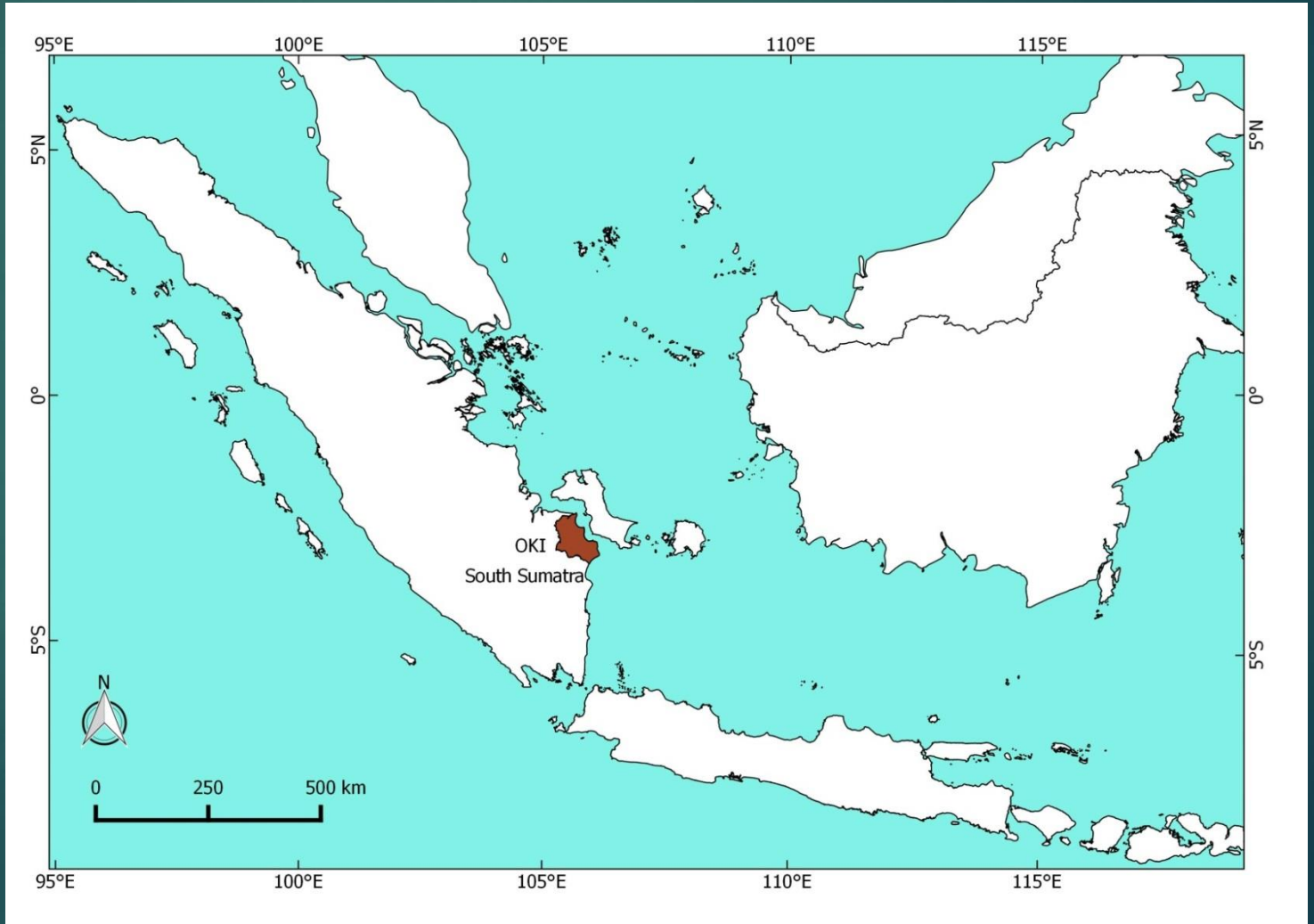
Digital Soil Mapping to the rescue

- $S = f(s,c,o,r,p,a,n)$ (McBratney et al. 2003)
  - s: soil, other properties of the soil at a point;
  - c: climate;
  - o: organisms, vegetation or human activity;
  - r: topography, landscape attributes;
  - p: parent material, lithology;
  - a: age, the time factor;
  - n: space, spatial position.

- Peat extent/ depth : $P = f(o,r,n)$

Mapping peat extent & depth

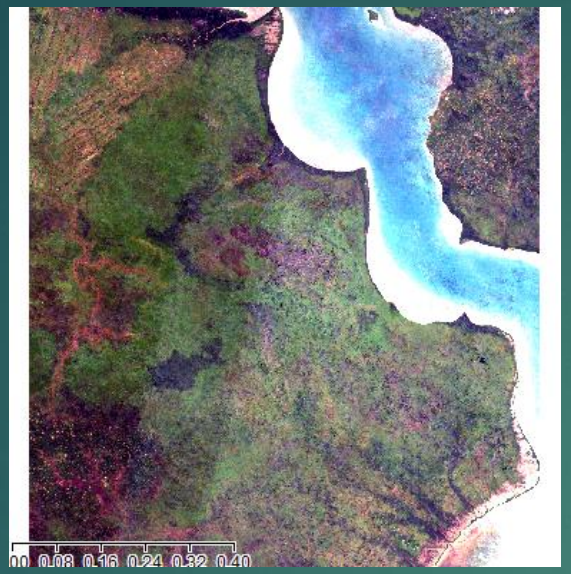
- Ogan Komering Ilir (OKI) South Sumatra



2000

2012

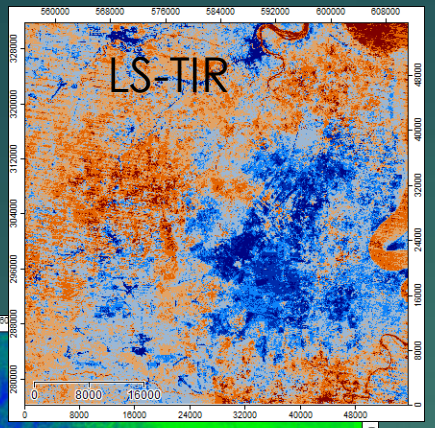
RGB

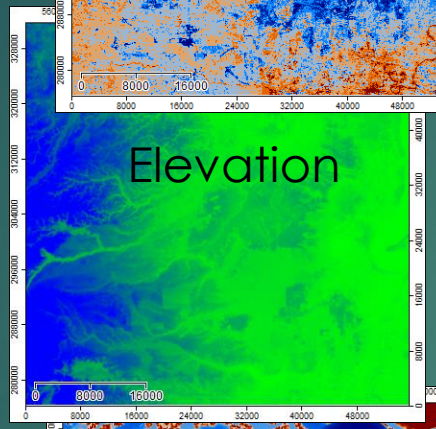


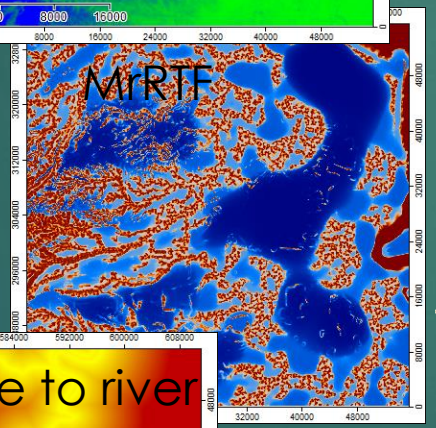
NIR

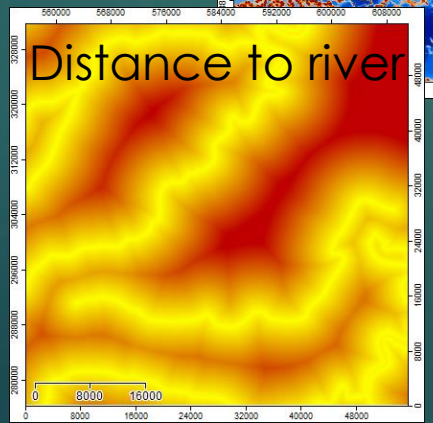
Mapping peat extent

Peat Information & Observations

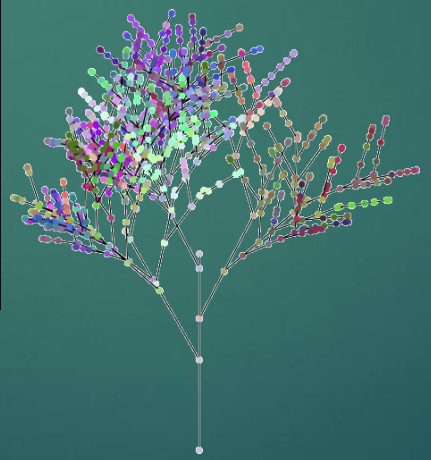




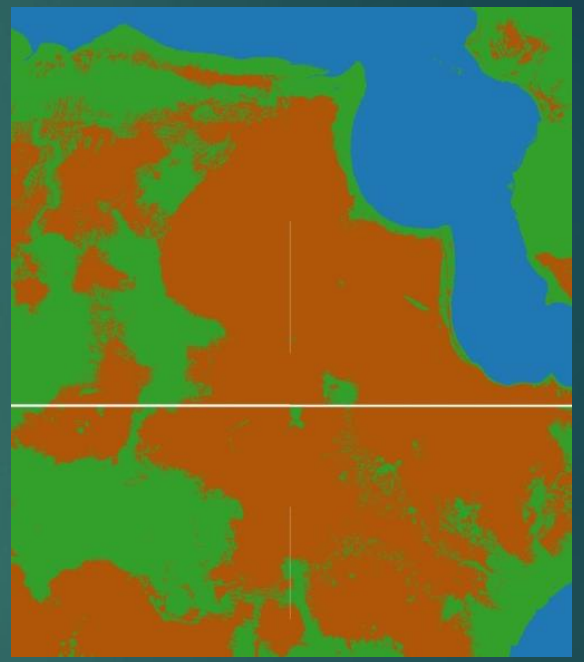




Random Forests



Peat extent

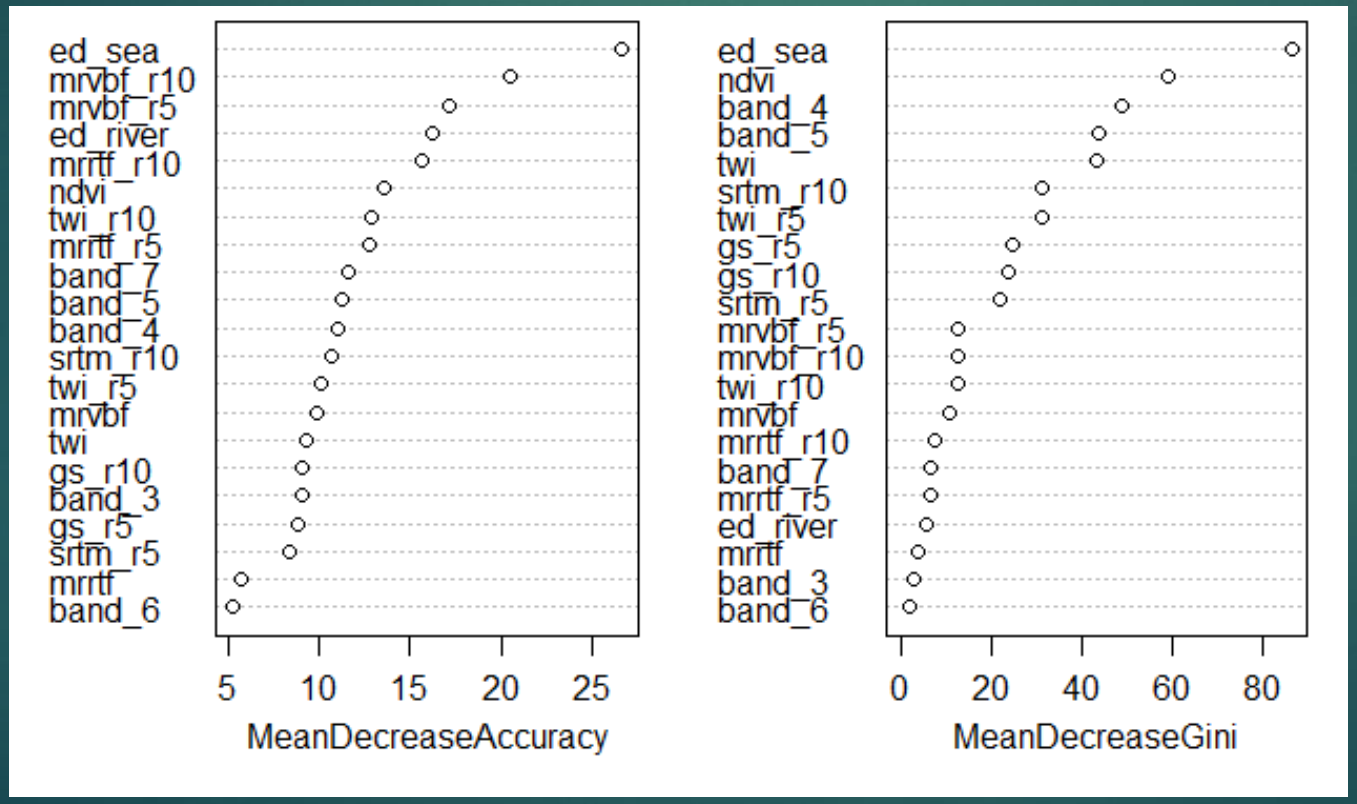


Peat extent

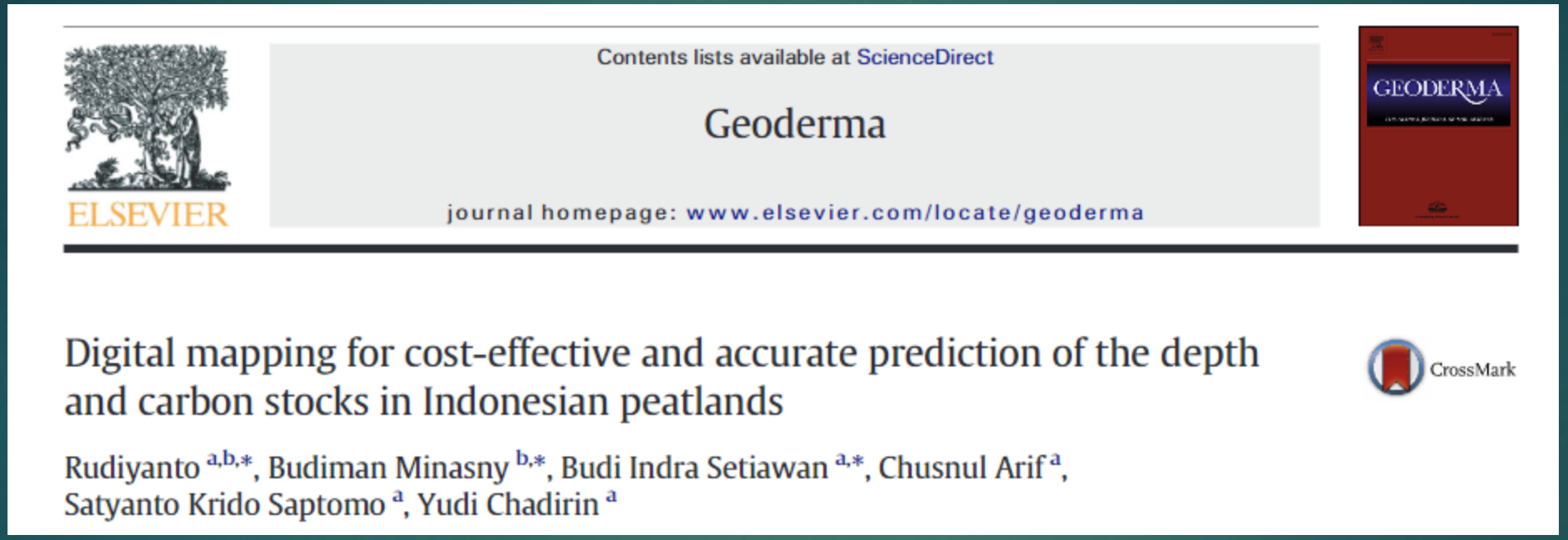
Plantation forest

Random? forest

RF: Accuracy : 0.94, Kappa : 0.8956



Mapping peat depth



Contents lists available at ScienceDirect

Geoderma

journal homepage: www.elsevier.com/locate/geoderma

Digital mapping for cost-effective and accurate prediction of the depth and carbon stocks in Indonesian peatlands

Rudiyanto [a,b,*], Budiman Minasny [b,*], Budi Indra Setiawan [a,*], Chusnul Arif [a], Satyanto Krido Saptomo [a], Yudi Chadirin [a]

Minasny, Budiman, Budi Indra Setiawan, Chusnul Arif, Satyanto Krido Saptomo, and Yudi Chadirin. "Digital mapping for cost-effective and accurate prediction of the depth and carbon stocks in Indonesian peatlands." Geoderma 272 (2016): 20-31.

Peat depth observations

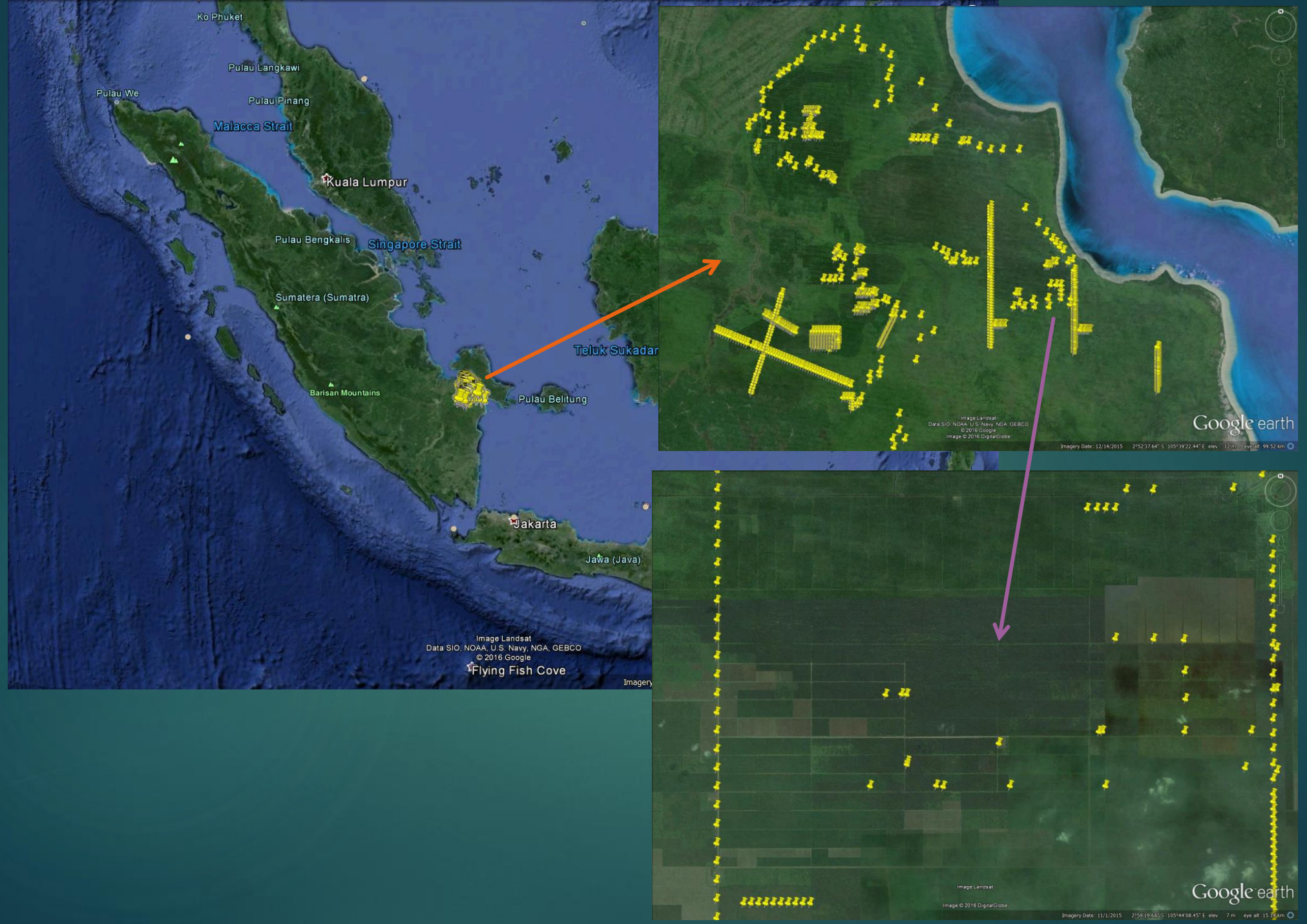
- Peat auger
- GPS

Peat depth drilling

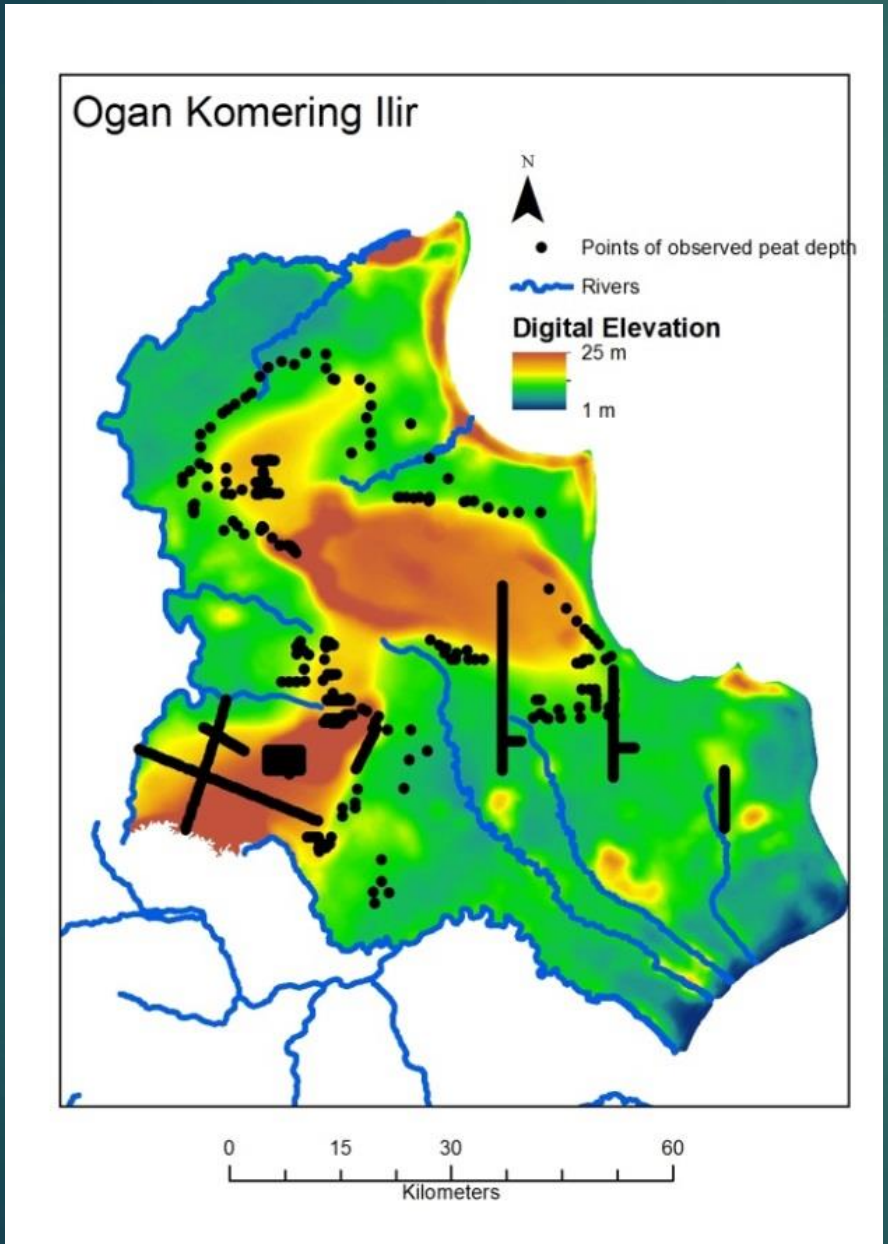
Around 10 m

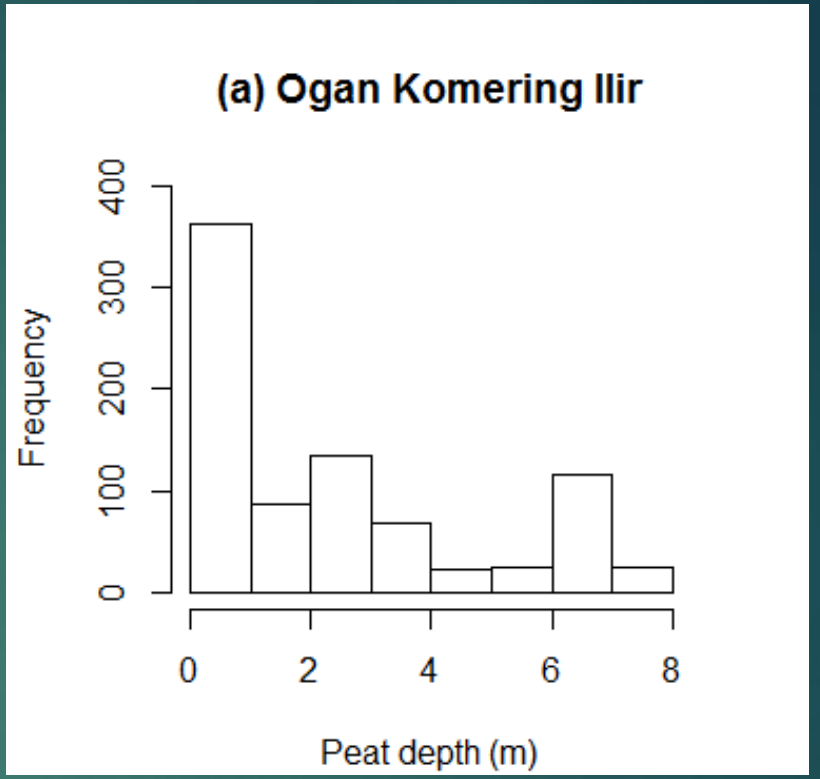
Peat

Marine clay


Ko Phuket
Pulau Langkawi
Pulau We
Pulau Pinang
Malacca Strait
Kuala Lumpur
Pulau Bengkalis
Singapore Strait
Sumatera (Sumatra)
Teluk Sukadar
Barisan Mountains
Pulau Belitung
Jakarta
Jawa (Java)
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2016 Google
Flying Fish Cove
Google earth

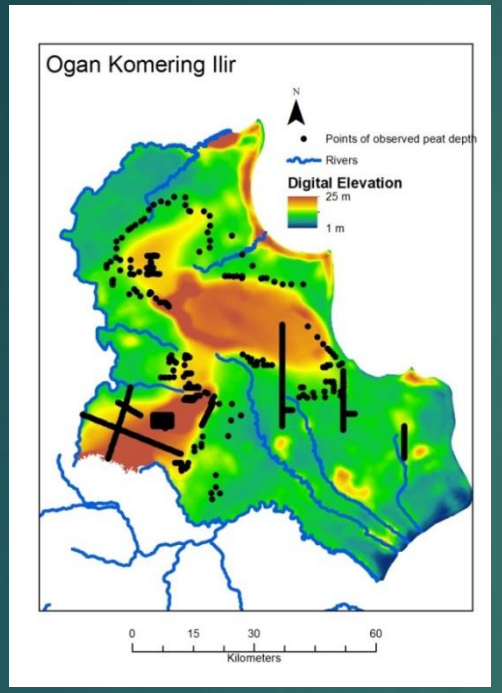
610,311 ha



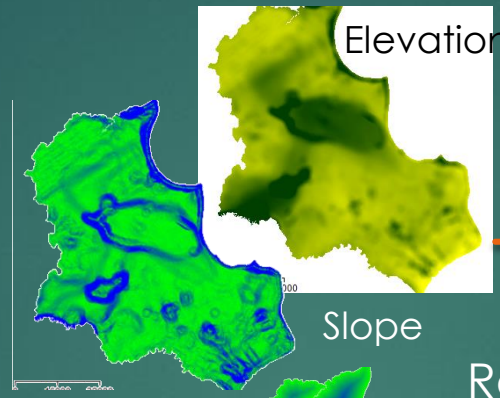


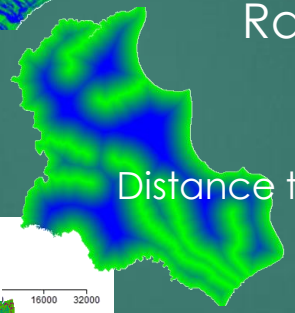
Peat depth = *f*(elevation, distance to rivers, wetness index…)

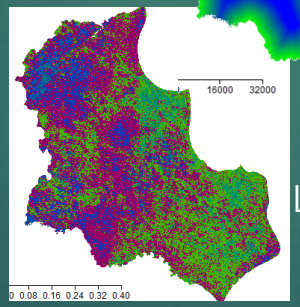
Input
Ground observations



+ Covariates

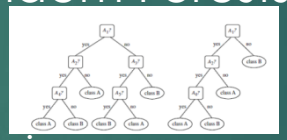


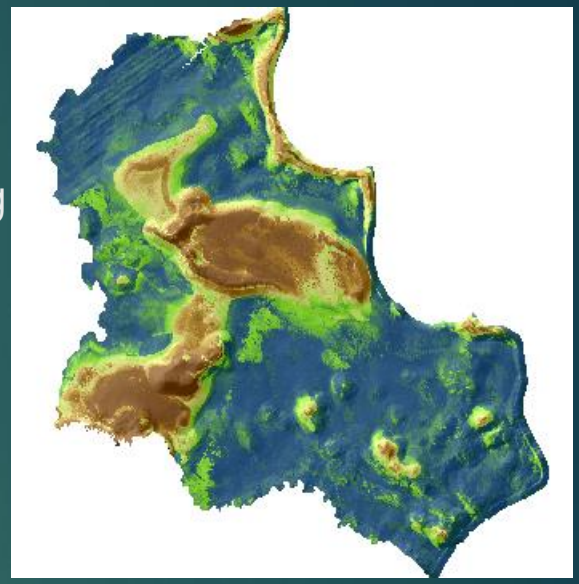




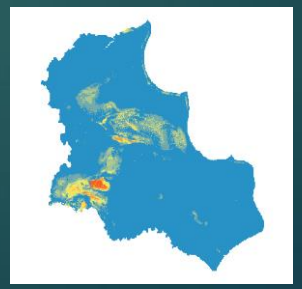
Machine Learning

Cubist
Random Forests

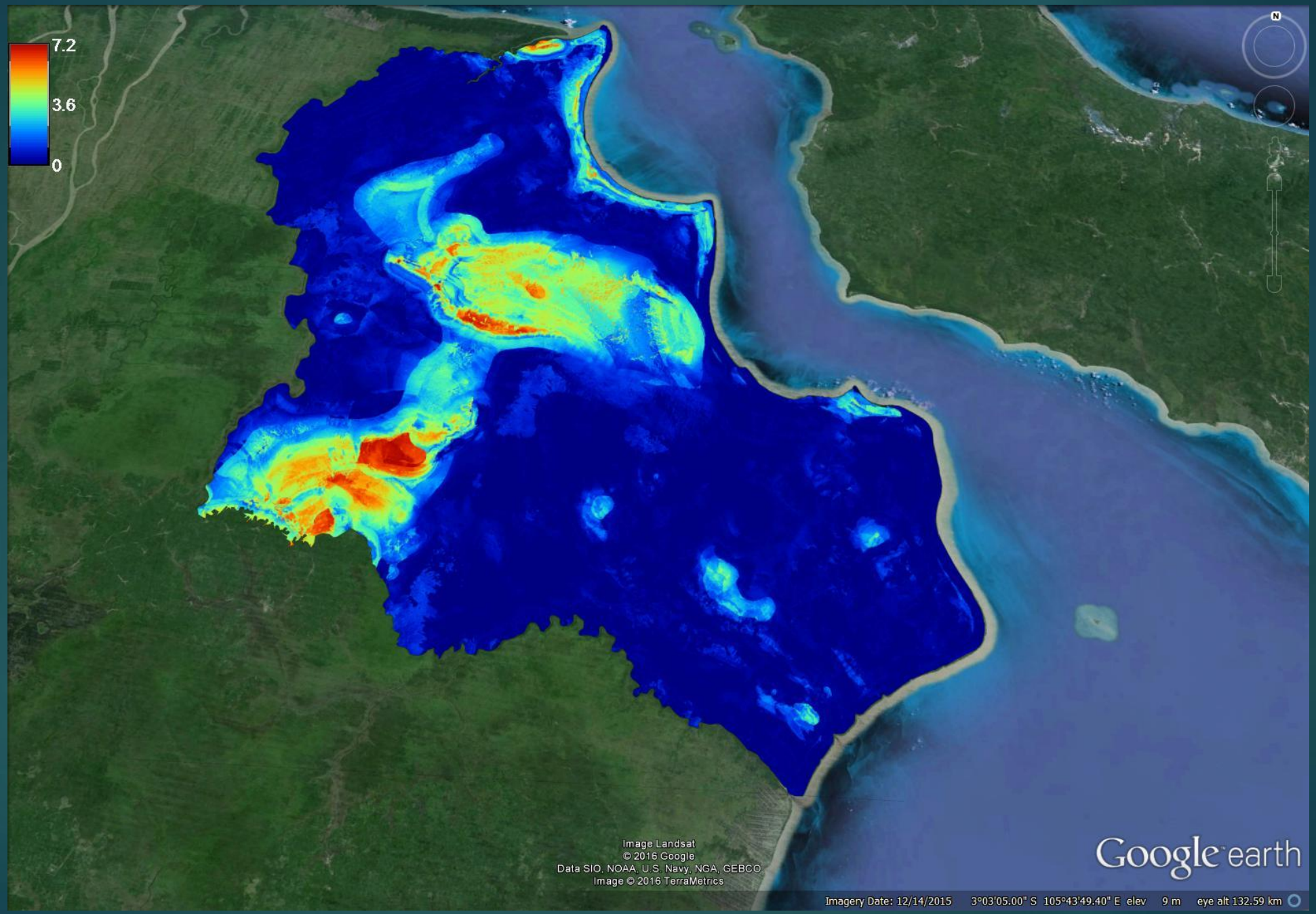




Peat depth map



Confidence in prediction


7.2
3.6
0
Image Landsat
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2016 TerraMetrics
Google earth
Imagery Date: 12/14/2015 3°03'05.00" S 105°43'49.40" E elev 9 m eye alt 132.59 km

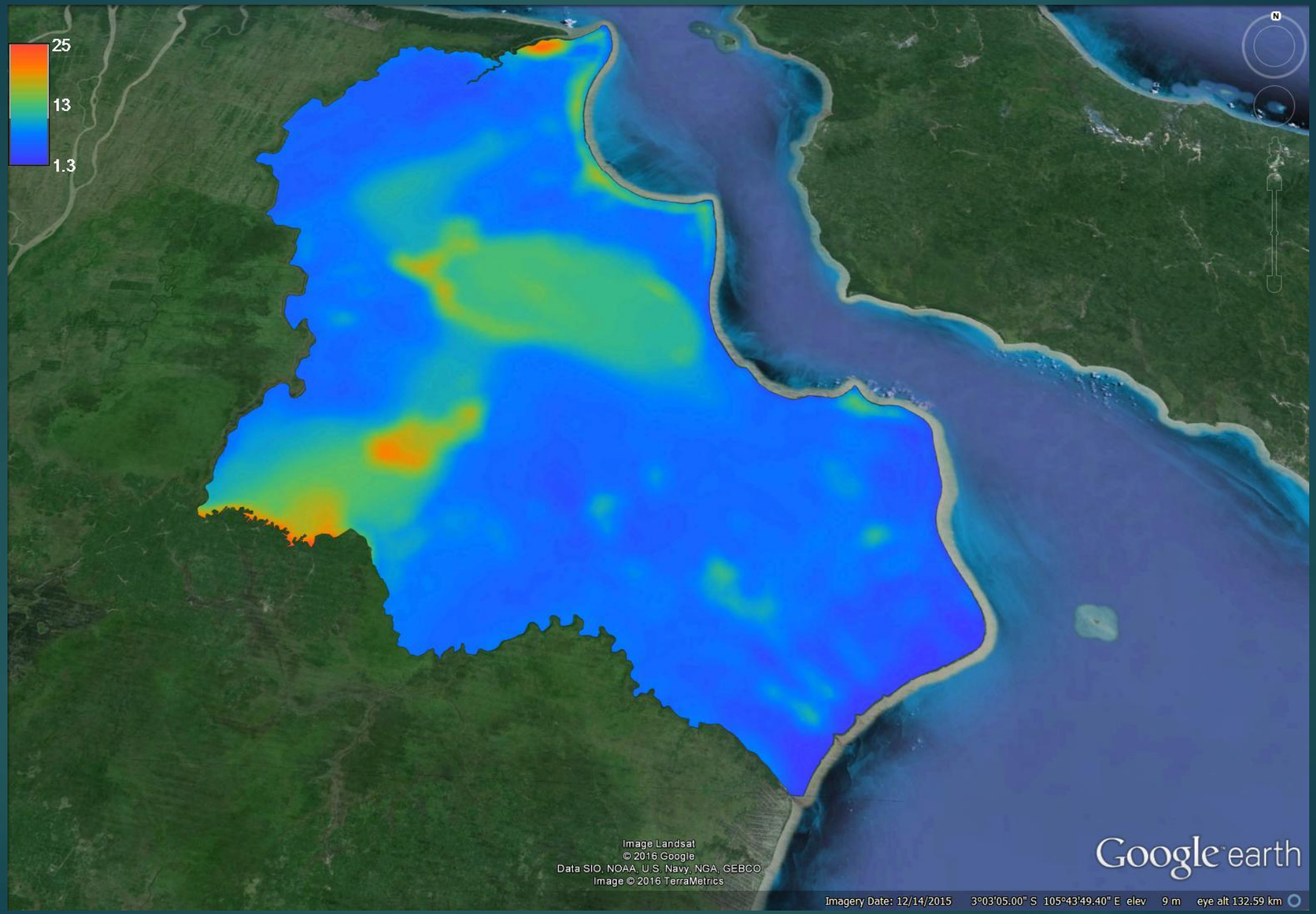
25
13
1.3
Image Landsat
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Image © 2016 TerraMetrics
Google earth
Imagery Date: 12/14/2015 3°03'05.00" S 105°43'49.40" E elev 9 m eye alt 132.59 km

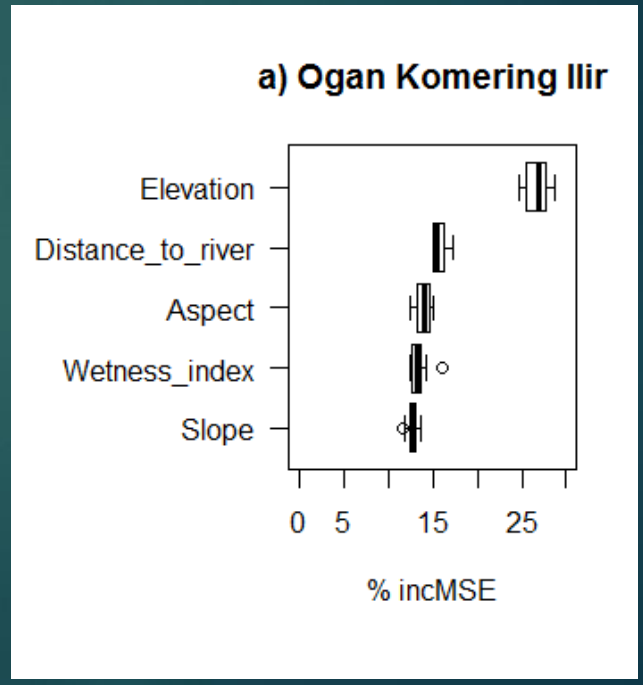
Important Covariates

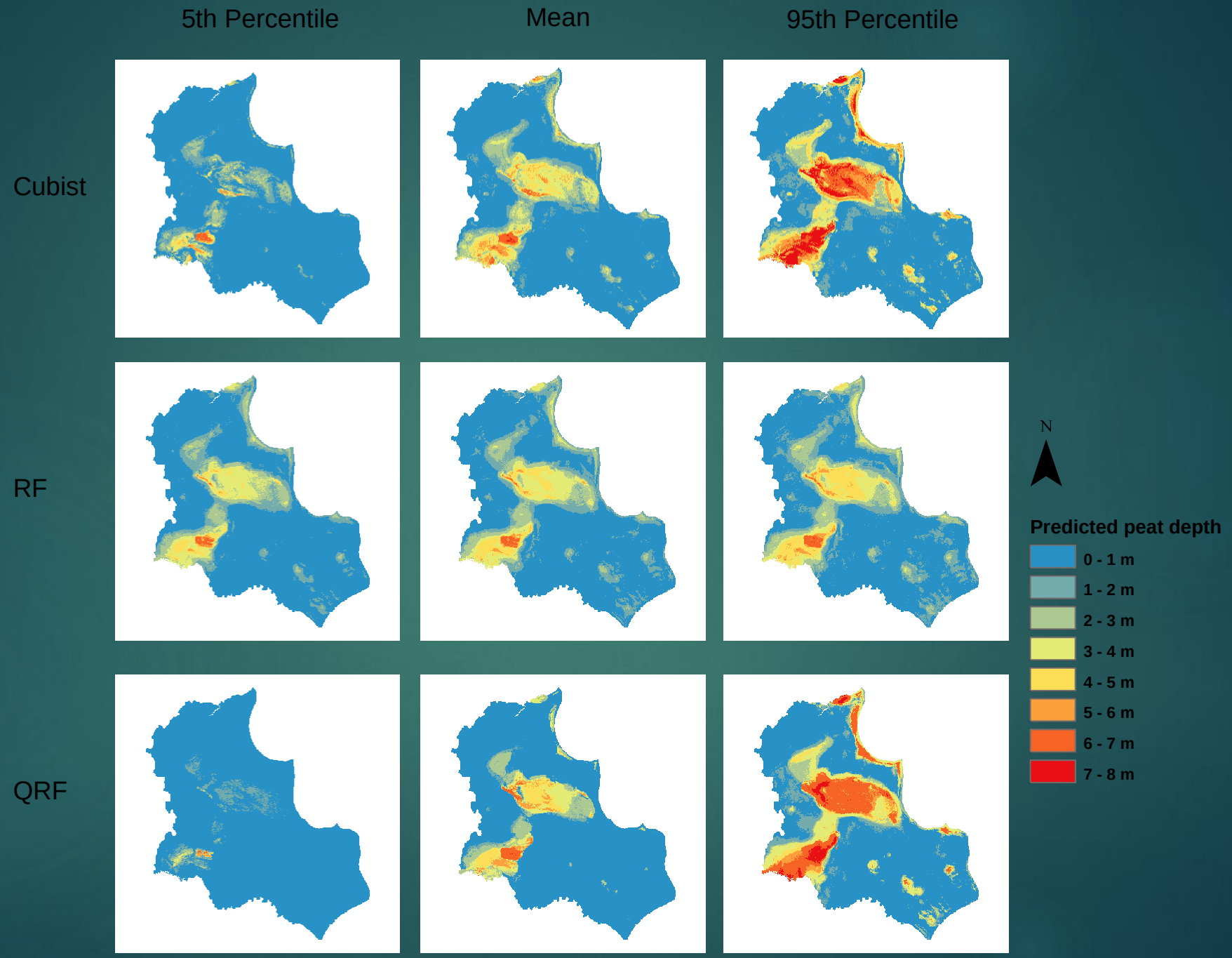
Percent of times covariates used in a Cubist model

Condition	Model	
92	94	Elevation
45	78	Wetness Index
22	25	Slope
14	46	Distance to River
8	50	Aspect
	44	Band 4 (NIR)
	22	Band 7 (SWIR)
	18	Band 5 (SWIR)

R^2	RMSE	bias
0.95	0.51	-0.078

Random Forests




5th Percentile
Mean
95th Percentile
Cubist
RF
QRF
N
Predicted peat depth
0 - 1 m
1 - 2 m
2 - 3 m
3 - 4 m
4 - 5 m
5 - 6 m
6 - 7 m
7 - 8 m

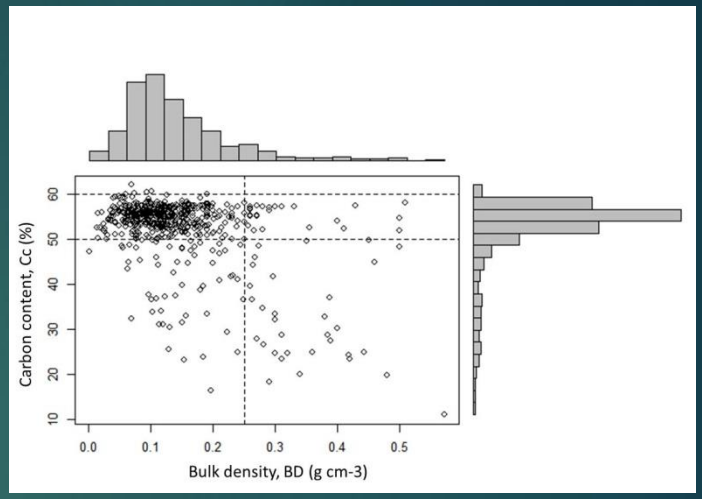
Peat Volume

Whole Area: 6103 km^2

$$V_p = \left(\sum_{i=1}^{m} T_i\right) A_{cell} = \left(\sum_{i=1}^{m} T_i\right) (\Delta X\, \Delta Y)$$

Peat C stock

$$C_p = V_p \times BD \times C_c$$



Rudiyanto et al. 2015

	Prediction of peat volume (x 10^9 m^3)			Prediction of Carbon stock (x 10^9 tonnes = Giga tonnes)			C stock (t C/ha)
	5th percentile	Mean	95th percentile	5th percentile	Mean	95th percentile	Mean
Cubist	2.6	6.3	10.4	0.1	0.5	0.9	816
RF	6.1	7.3	8.6	0.3	0.6	0.9	945
QRF	0.8	4.6	13.0	0.1	0.4	1.5	595

Conclusions

- DSM can facilitate the delivery of fine resolution peat maps accurately and cost-effectively.

Update:
Peat Prize Competing teams

- 1. Bell Geospace and PT Rubotori Petrotech Indonesia
- 2. Duke University and PT Greencap NAA Indonesia
- 3. Deltares and Bandung Institute of Technology (ITB)
- 4. DRYAS, a team of independent Indonesian researchers
- 5. Bogor Institute of Agriculture (IPB) and the University of Sydney
- 6. Remote Sensing Solutions GmbH (RSS), Agency of the Assessment and Application of Technology (BPPT) and Sriwijaya University
- 7. UGM (Gadjah Mada University) Indonesian Peat Mapping Team
- 8. Applied GeoSolutions and National Institute of Aeronautics and Space (LAPAN)
- 9. PT EXSA Internasional/Forest Inform Pty Ltd
- 10. Stanford University and Tanjungpura University
- 11. NARIC Forest Research Institute