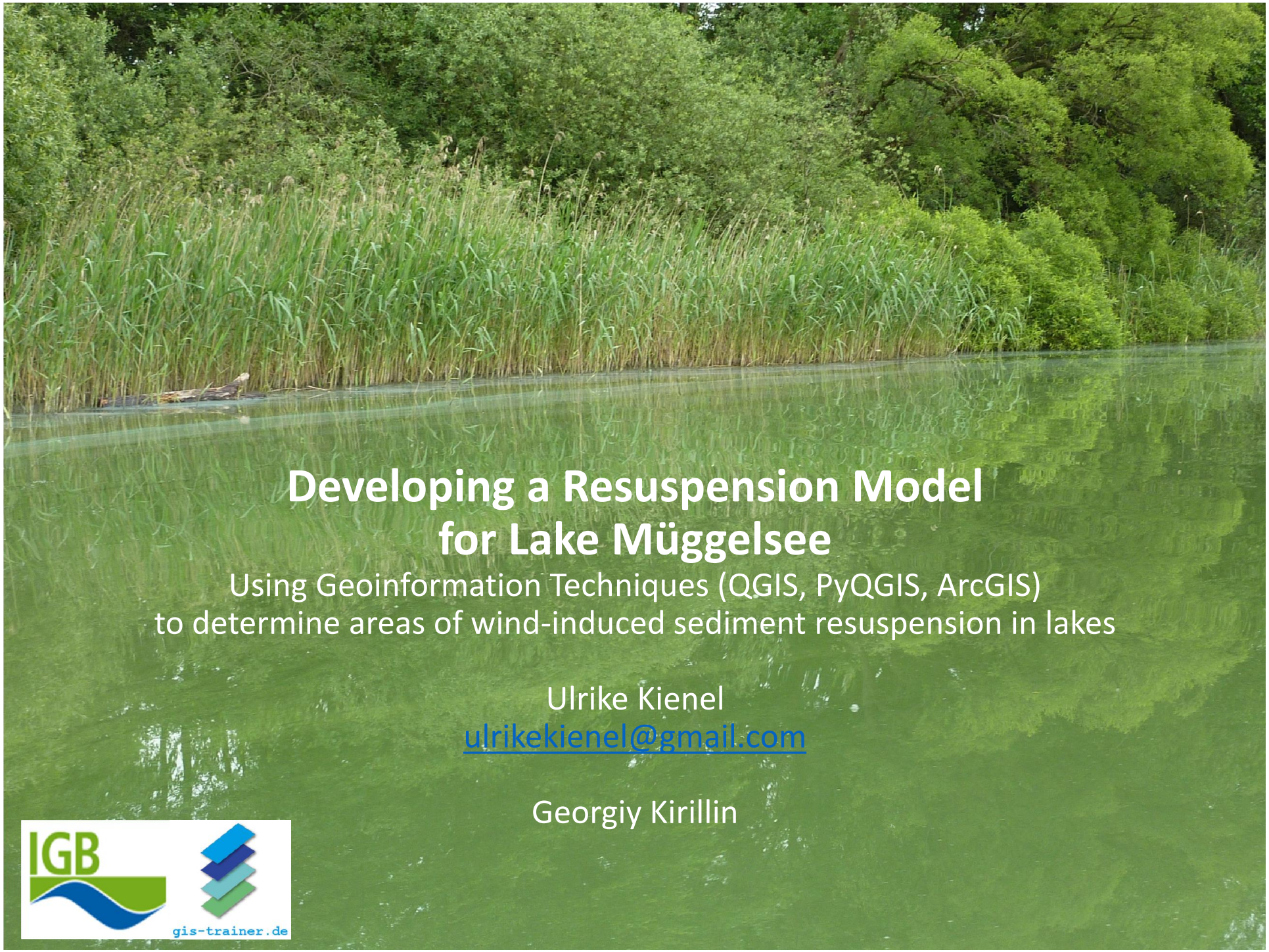

Developing a Resuspension Model for Lake Müggelsee

Using Geoinformation Techniques (QGIS, PyQGIS, ArcGIS)
to determine areas of wind-induced sediment resuspension in lakes

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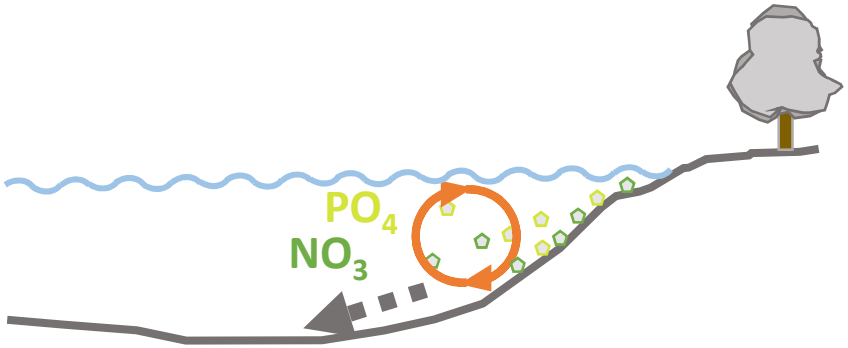
Motivation

Resuspension

of lake sediment

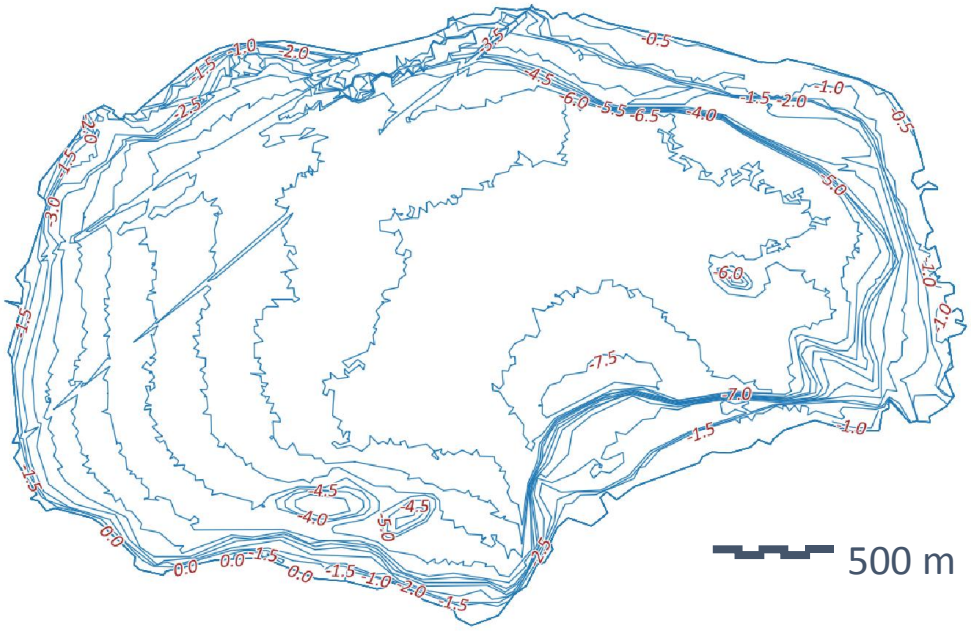


- Returns nutrients NO_3, PO_4 stored in sediments
  -> reinforcing blooms of algae and (toxic) cyanobacteria

- Increases the influence of nutrient input on water quality (land use, sewage, bathing, shipping traffic)


Müggelsee
Friedrichshagen
Waterworks
Public bathing
Public bathing beach
Müggelsee
Algal blooms
Algal blooms
52°26'13.64" N 13°38'56.30" O, Google Earth, image acquisition date 03/28/2017

Müggelsee (Data*)



Lake area	7.3 km²
Lake depth max.	8 m (Ø 4.9 m)
Water volume	36 x 10^6 m³
Nutrient input / year:	**20 t P**, **500 t N**

Algal blooms caused retreat of submersed plants

*IGB: Leibniz-Institute of Freshwater Ecology and Inland Fisheries Berlin

Methods

- **QGIS 2.14.18 - Essen**
- **PyQGIS**
- **ArcMap 10.4.1, ArcCatalog 10.4.1**

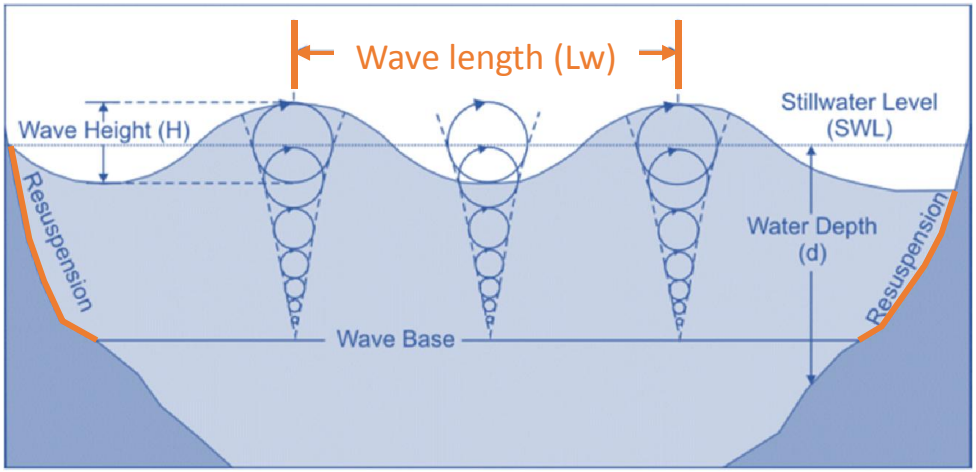
Data

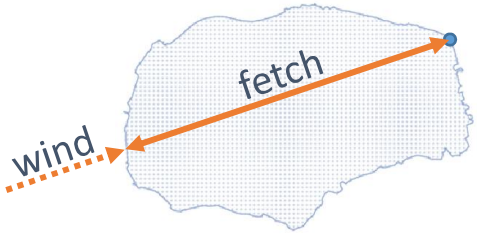
- Wind speed and direction DWD Station Schönefeld
  WEBWERDIS: *https://werdis.dwd.de/werdis/start_js_JSP.do*
- Bathymetry Müggelsee: IGB*
- Digital Surface Model (ATKIS) in 1-m resolution from FIS-Broker:
  http://www.stadtentwicklung.berlin.de/geoinformation/landesvermessung/atkis/de/dgm.shtml

*IGB: Leibniz-Institute of Freshwater Ecology and Inland Fisheries Berlin

Computation of Resuspension

- Linear wave model (US Army Corps of Engineers 2002, Chamberlin 1994)
- Wave energy ~ wave length
- **Resuspension**: below SWL at **½ wave legth > water depth** (d)

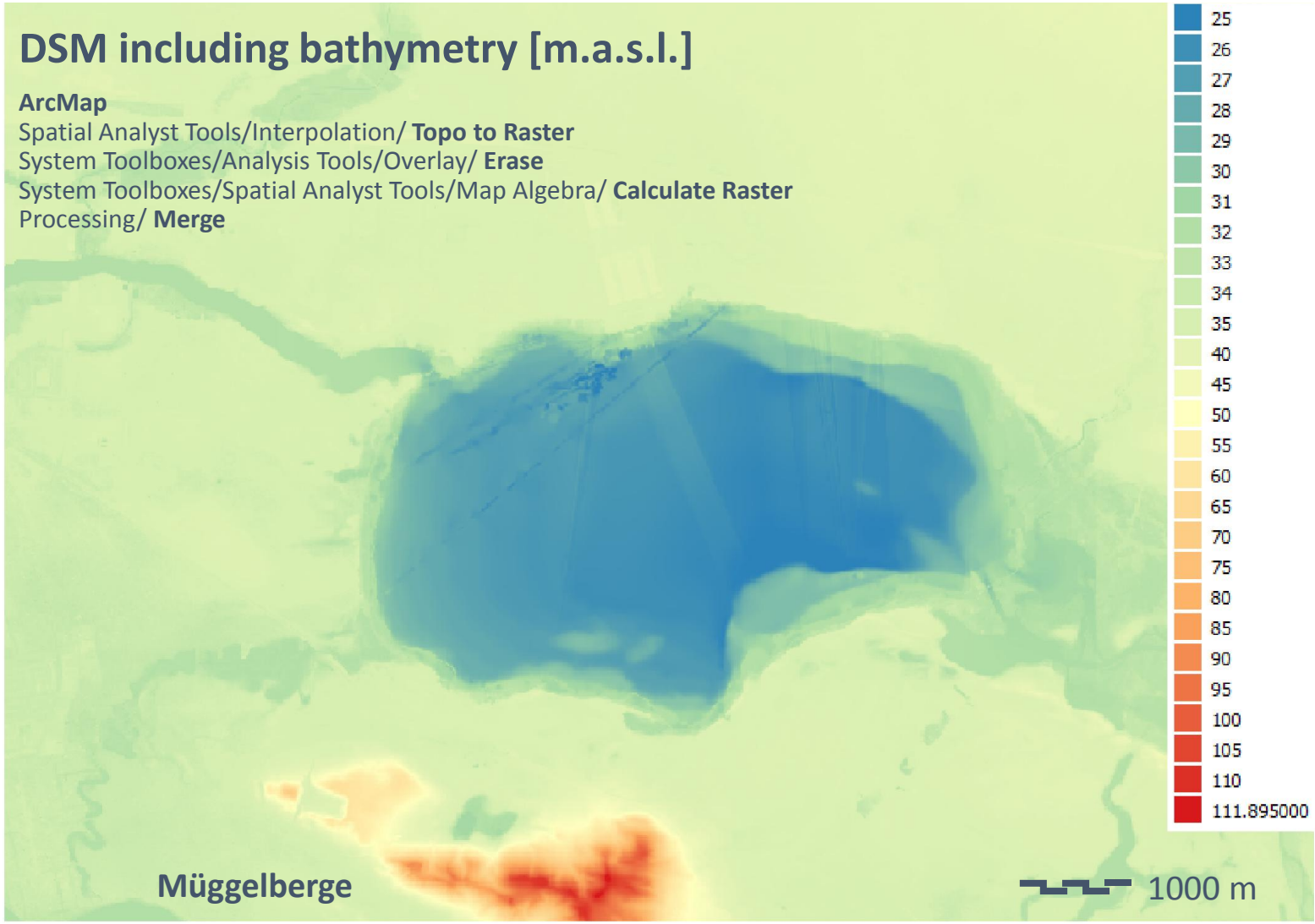




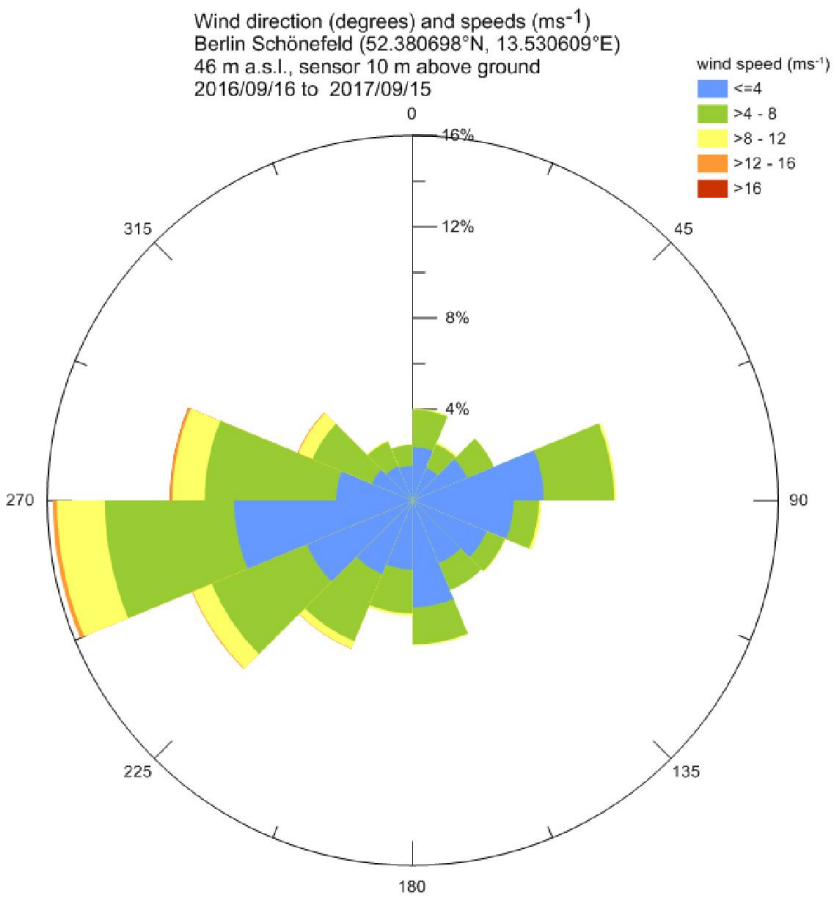
$$½\ L_w = 0.5 * (1.2 * (\tanh (0.077 * ((g * ((g * \mathbf{F}) / (((((\mathbf{U'} * 0.034) + 1.1) * 0.0001)^{0.5}) * \mathbf{U'})^2)) / \mathbf{U'}^2)^{0.25})))$$

U‘	**Wind speed** over water = U * 1.2
F	**Fetch**
g	Acceleration of gravity
L_w	Wave length

Influence of wind on Lake Müggelsee



Wind speed + direction

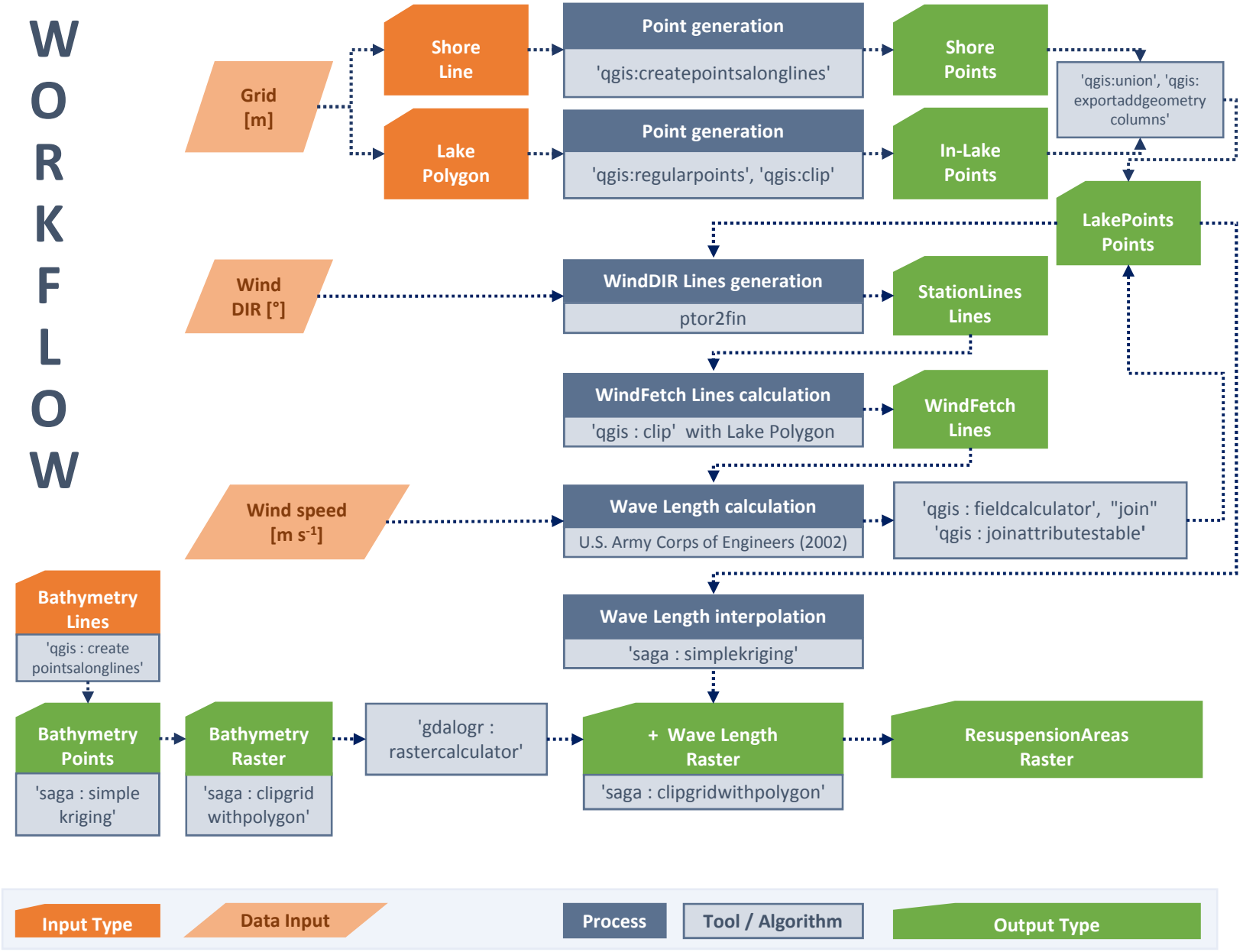


DWD Station Berlin Schönefeld

Annual mean (from hourly means)
(09/2016 – 09/2017)

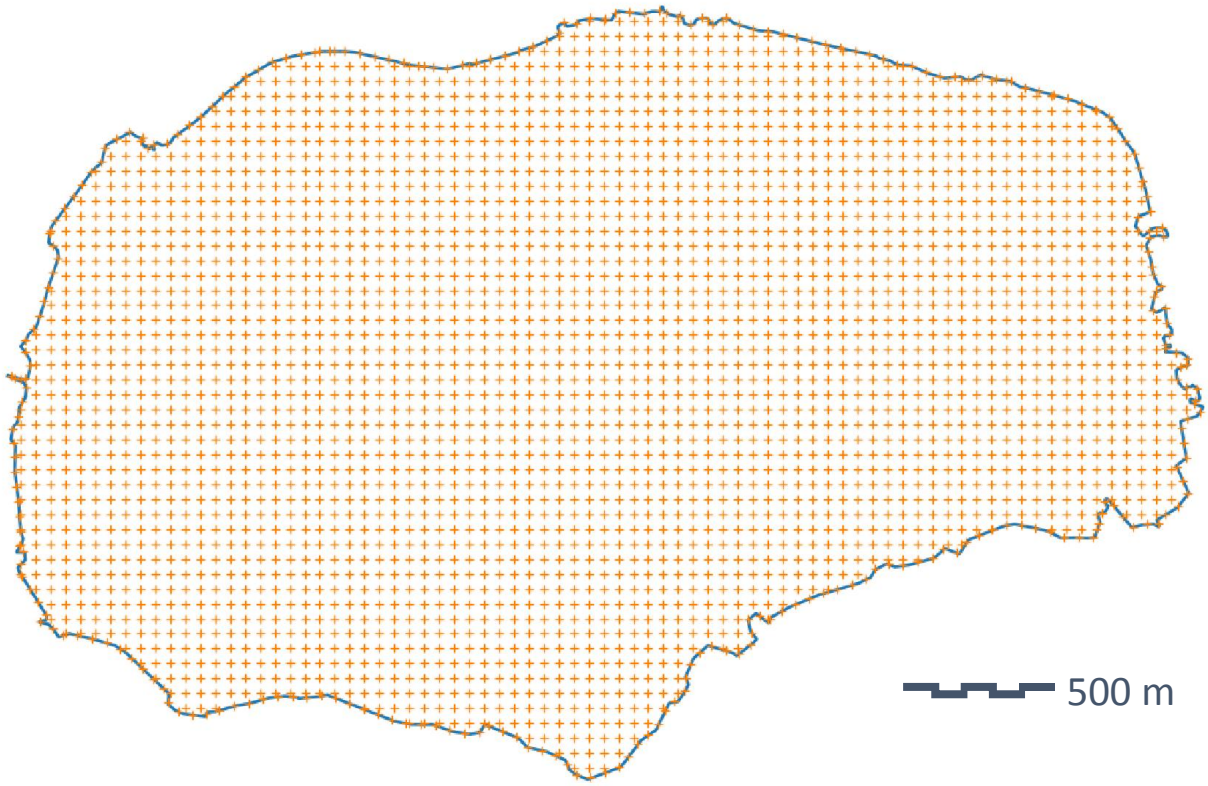
Wind speed
4.16 ms^{-1}
Wind direction WSW
238°

WORKFLOW


Grid [m]
Shore Line
Lake Polygon
Point generation
'qgis:createpointsalonglines'
Point generation
'qgis:regularpoints', 'qgis:clip'
Shore Points
In-Lake Points
'qgis:union', 'qgis: exportaddgeometry columns'
LakePoints Points
Wind DIR [°]
WindDIR Lines generation
ptor2fin
StationLines Lines
WindFetch Lines calculation
'qgis : clip' with Lake Polygon
WindFetch Lines
Wind speed [m s-1]
Wave Length calculation
U.S. Army Corps of Engineers (2002)
'qgis : fieldcalculator', "join"
'qgis : joinattributestable'
Bathymetry Lines
'qgis : create pointsalonglines'
Wave Length interpolation
'saga : simplekriging'
Bathymetry Points
'saga : simple kriging'
Bathymetry Raster
'saga : clipgrid withpolygon'
'gdalogr : rastercalculator'
+ Wave Length Raster
'saga : clipgridwithpolygon'
ResuspensionAreas Raster
Input Type
Data Input
Process
Tool / Algorithm
Output Type

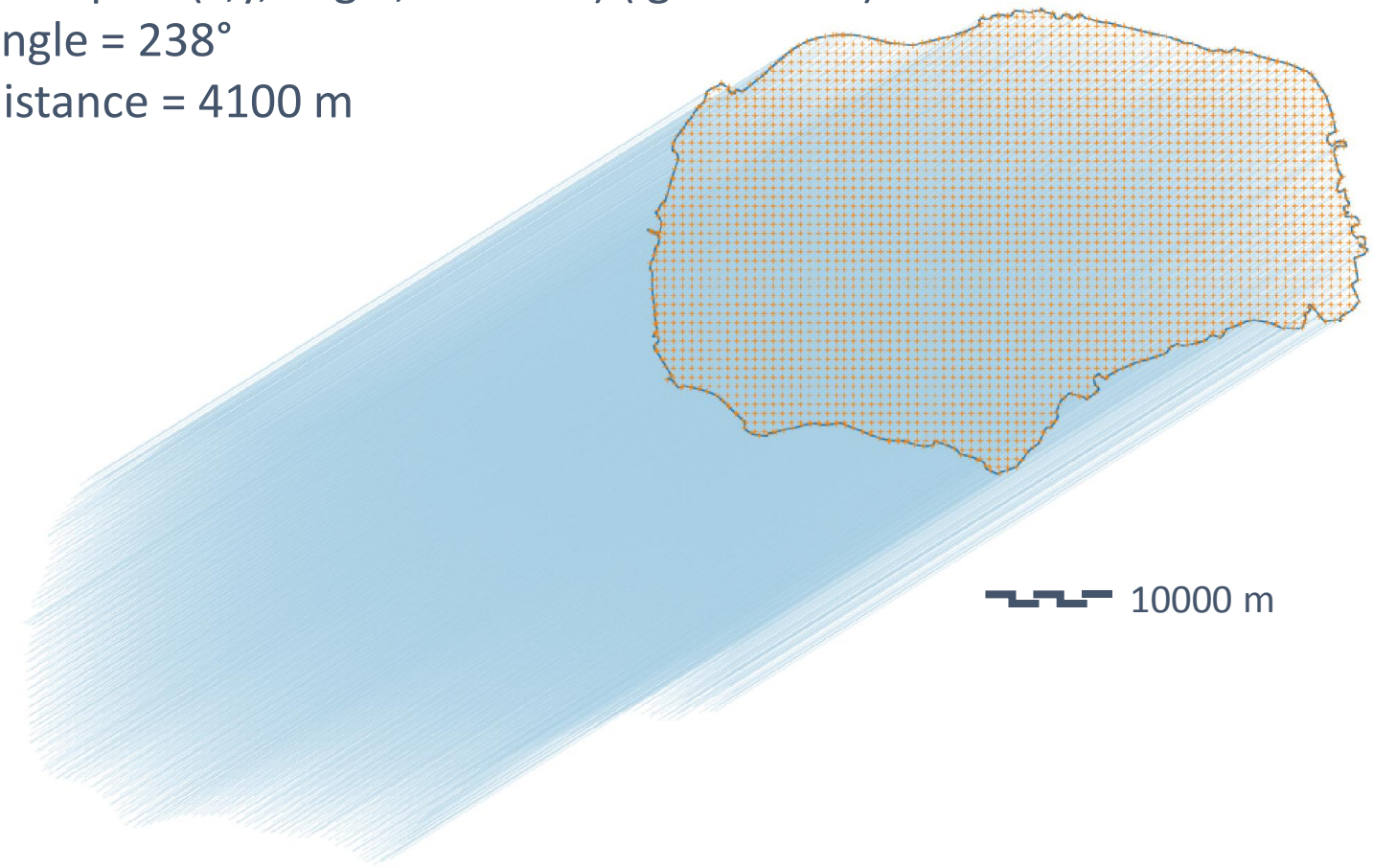
Point grid to append wind variables

- 'qgis:createpointsalonglines' → ShorePoints
- 'qgis:regularpoints', 'qgis:clip' → In-Lake Points
- 'qgis:union', 'qgis:exportaddgeometrycolumns' → LakePoints



StationLines in wind direction

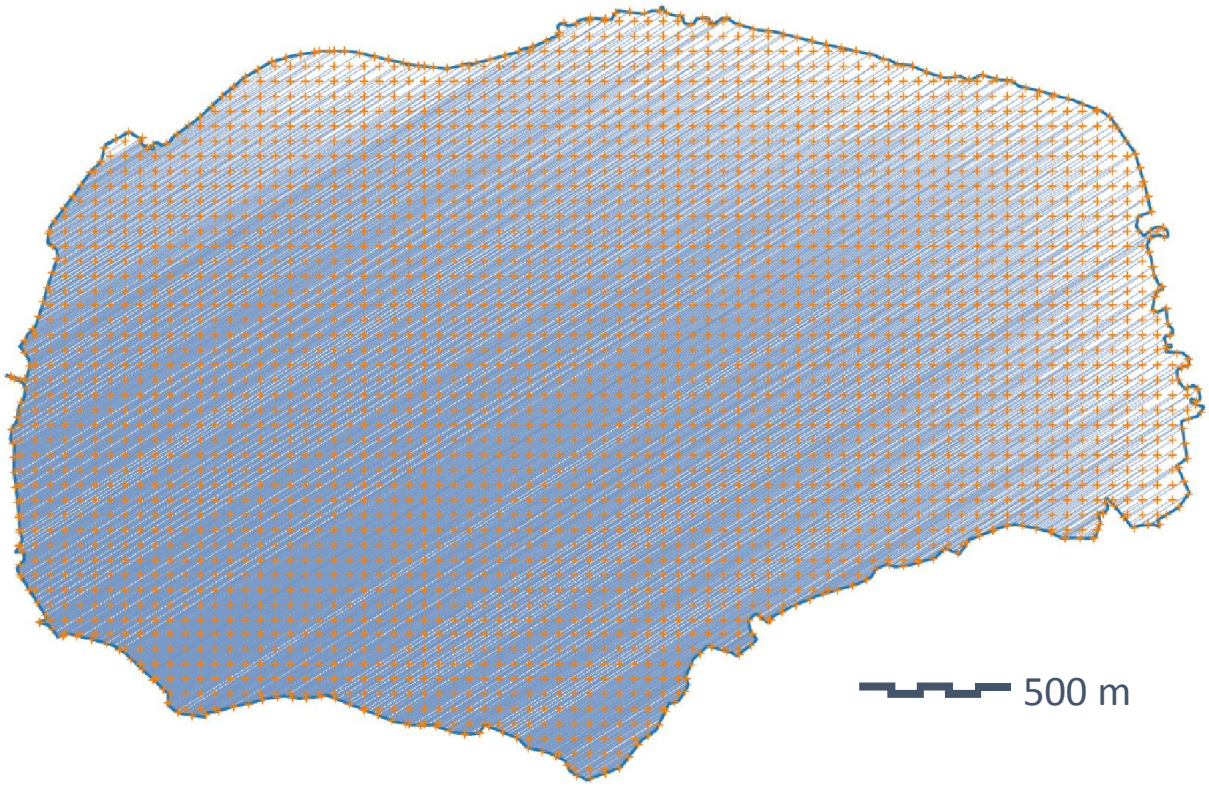
- ptor2ptfin(x,y, angle, distance) ('gene' on *) →
- angle = 238°
- distance = 4100 m



** http://osgeo-org.1560.x6.nabble.com/Digitize-Line-starting-at-a-point-vertex-with-a-defined-angle-and-distance-td5044921.html*

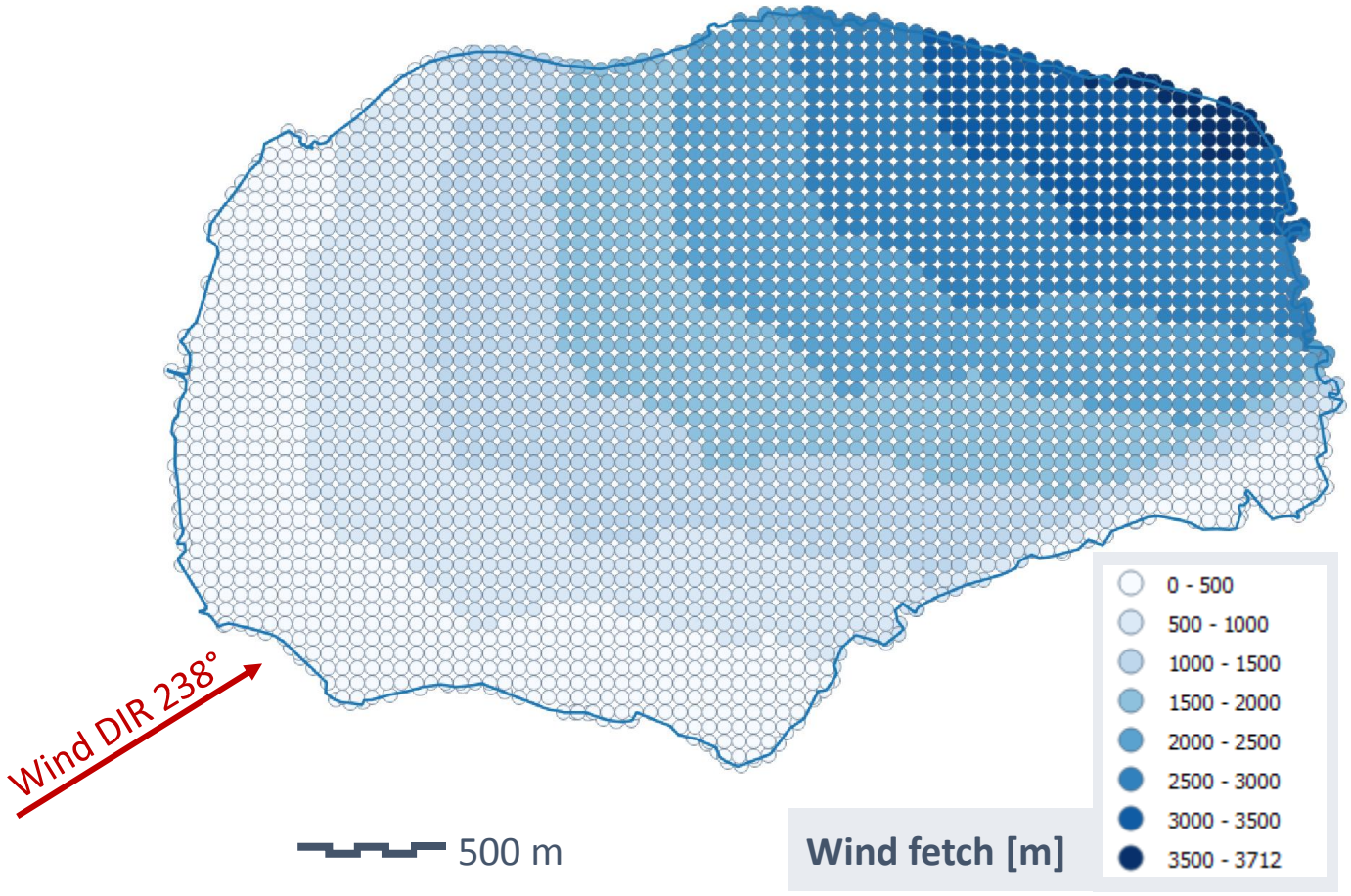
WindFetch for all LakePoints

- 'qgis : clip' with Lake Polygon → FetchLines



Fetch classification of LakePoints

- 'qgis : joinattributestable' of FetchLines with LakePoints

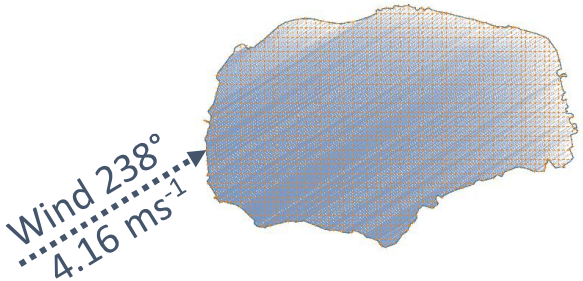


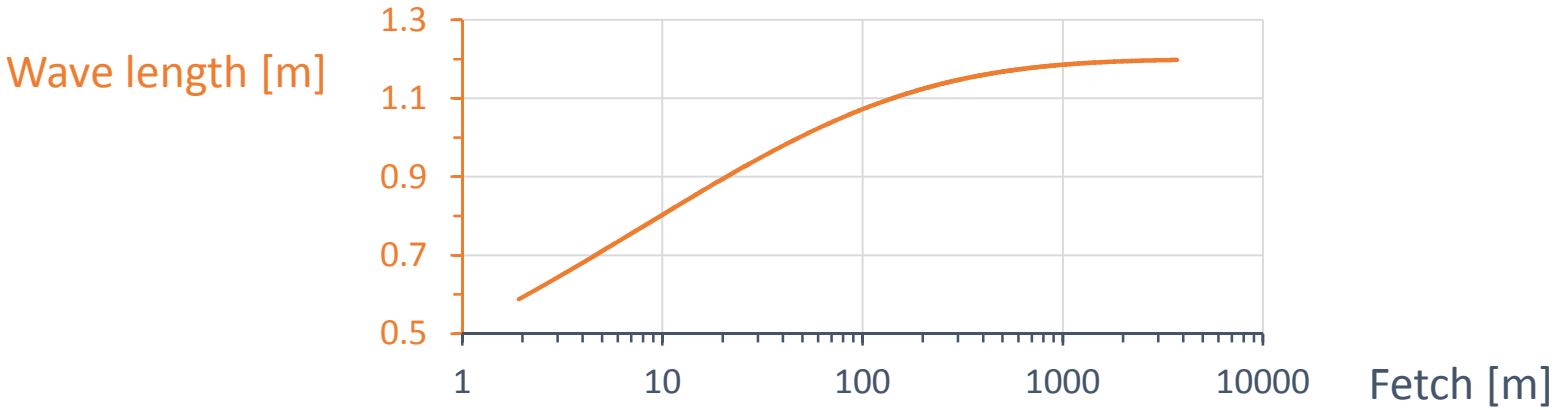
Wave length computation

- linear wave model (US Army Corps of Engineers 2002, Chamberlin 1994)
- Wave length

$$L_w = (1.2 * (\tanh (0.077 * ((g * ((g * \mathbf{F}) / (((((\mathbf{U'} * 0.034) + 1.1) * 0.0001)^{0.5}) * \mathbf{U'})^2)) / \mathbf{U'}^2)^{0.25})))$$

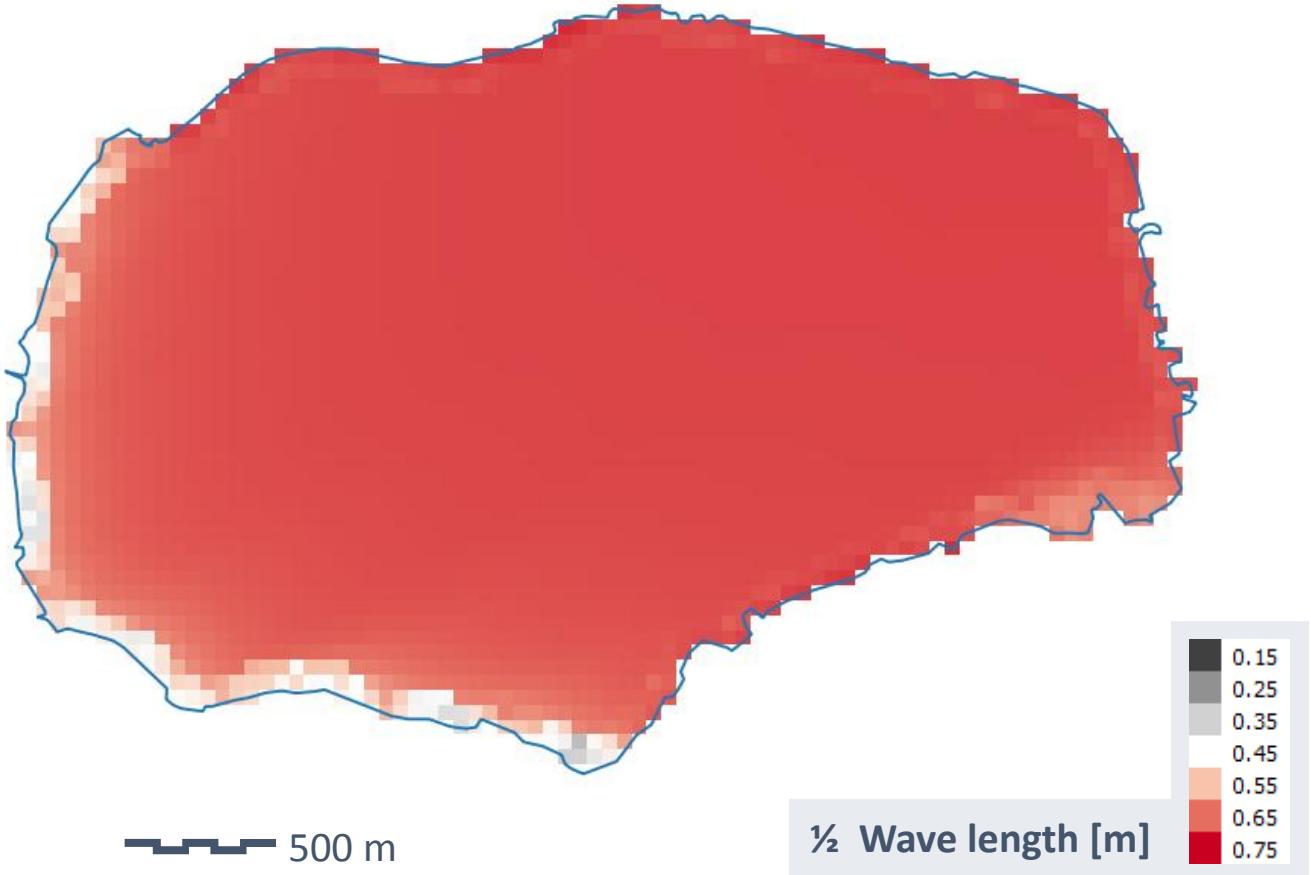
U‘ **Wind speed** over water = U * 1.2
F **Fetch**





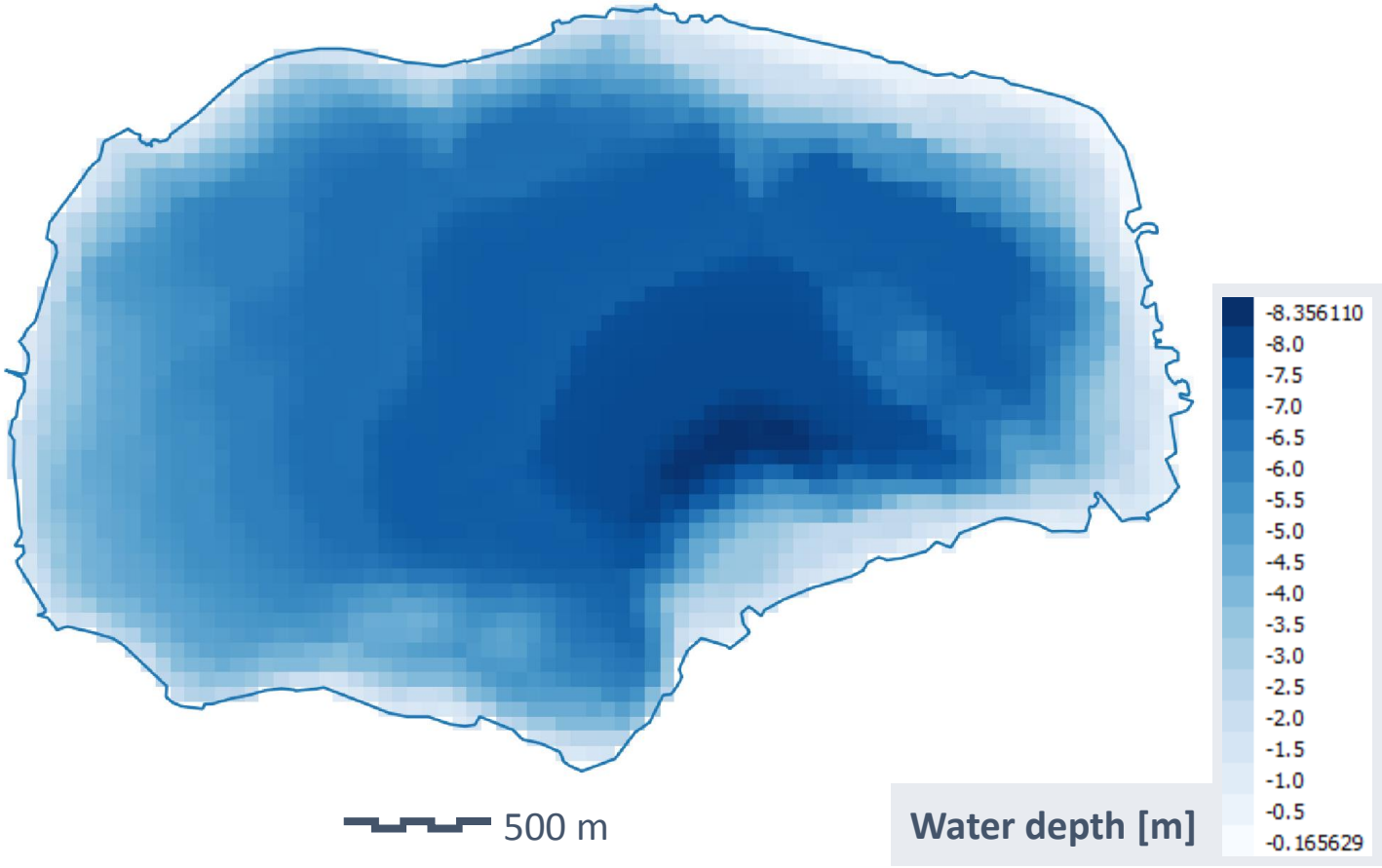
½ Wave-length Raster

- 'saga : simplekriging' of ½ WaveLengthPoints → ½ WaveLengthRaster
- 'saga : clipgridwithpolygon' → ½ WaveLengthRaster_clip



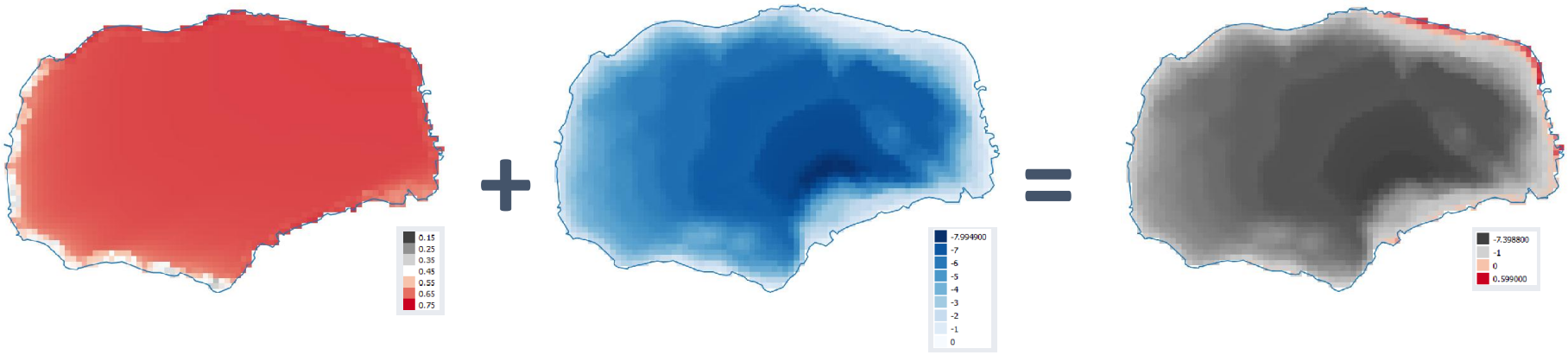
Bathymetry Raster

- Input: Bathymetry Lines
- 'qgis:createpointsalonglines' → Bathymetry Points
- 'saga : clipgridwithpolygon' → BathymetryRaster with Lake Polygon



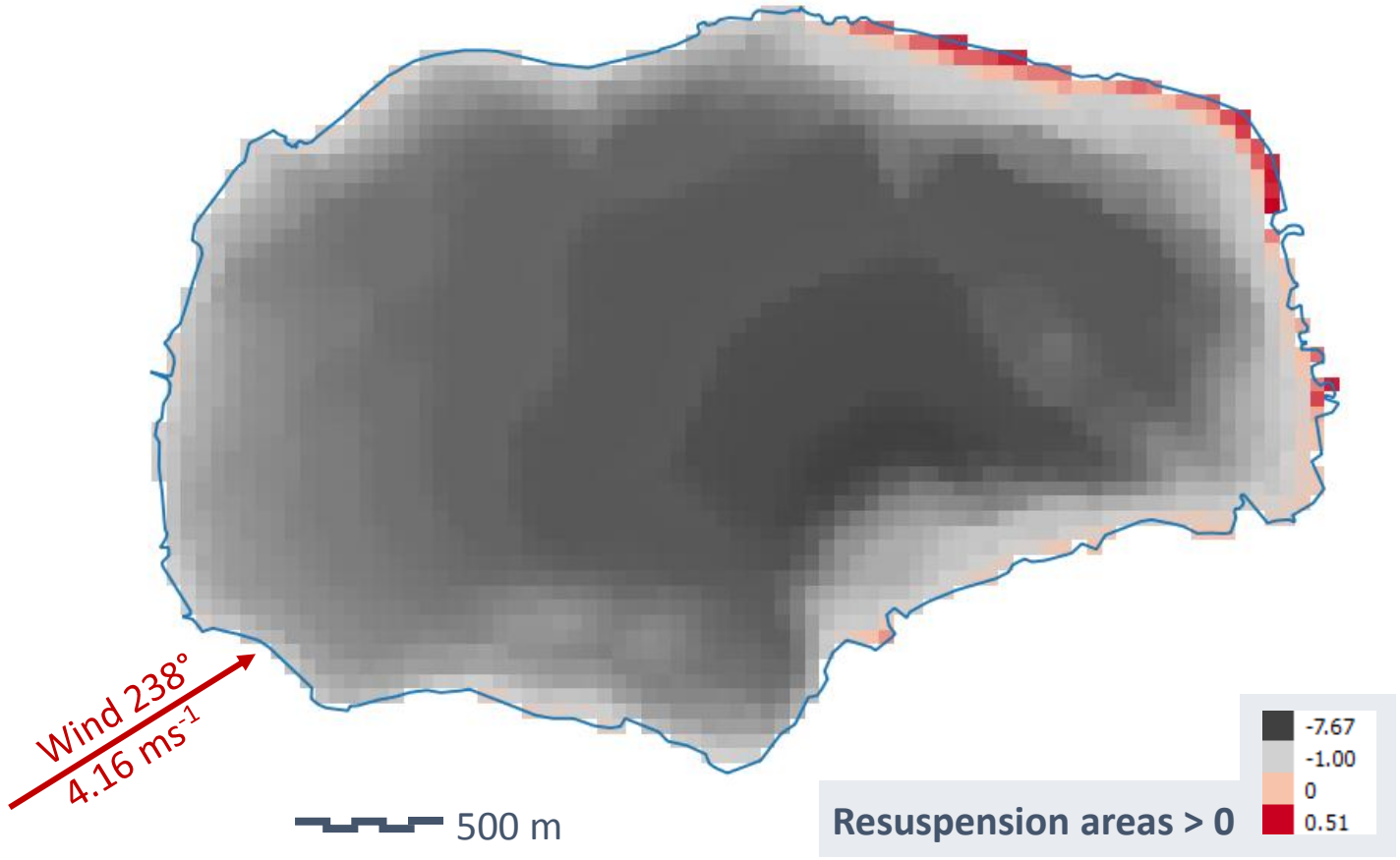
(½ Wave length + Water depth) > 0 = Resuspension

- 'gdalogr : rastercalculator'

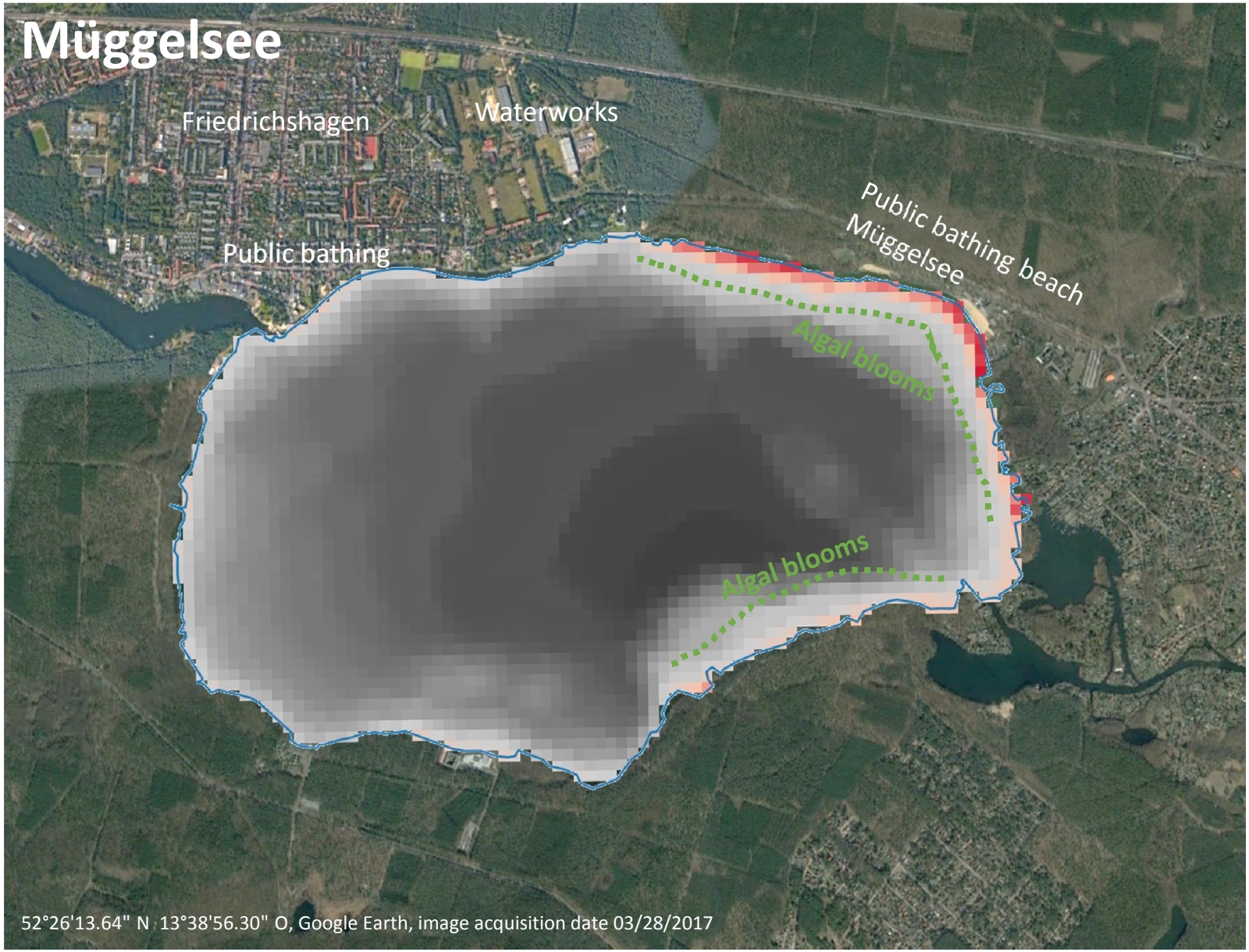


Resuspension areas Lake Müggelsee (annual mean)

- 'gdalogr : rastercalculator' (½ WaveLengthRaster + BathymetryRaster)




Müggelsee
Friedrichshagen
Waterworks
Public bathing
Public bathing beach
Müggelsee
Algal blooms
Algal blooms
52°26'13.64" N 13°38'56.30" O, Google Earth, image acquisition date 03/28/2017


Müggelsee
Friedrichshagen
Waterworks
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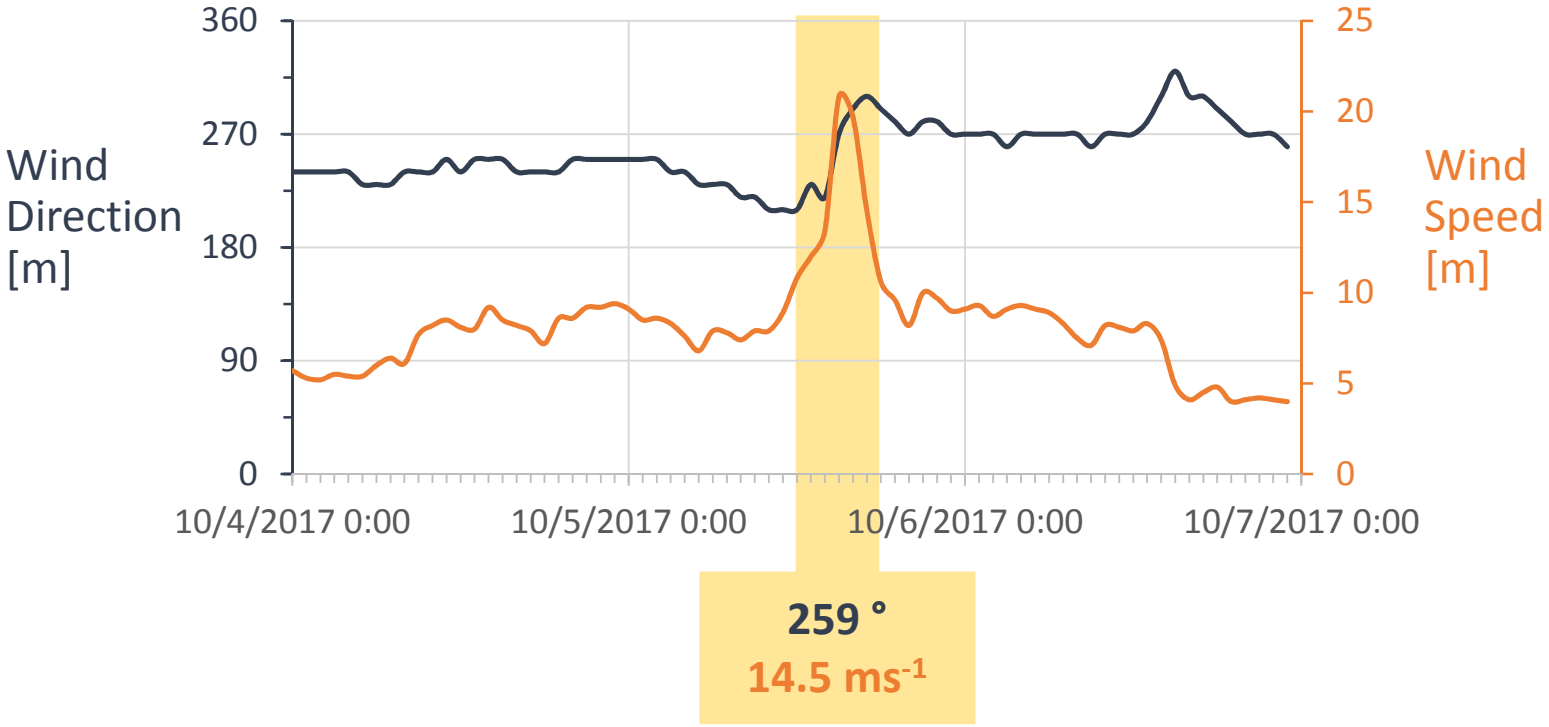
Public bathing beach Müggelsee
Algal blooms
Algal blooms
52°26'13.64" N 13°38'56.30" O, Google Earth, image acquisition date 03/28/2017

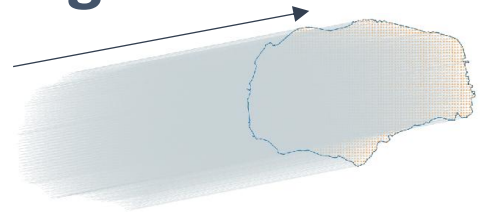
Storm Xavier (2017-10-5)

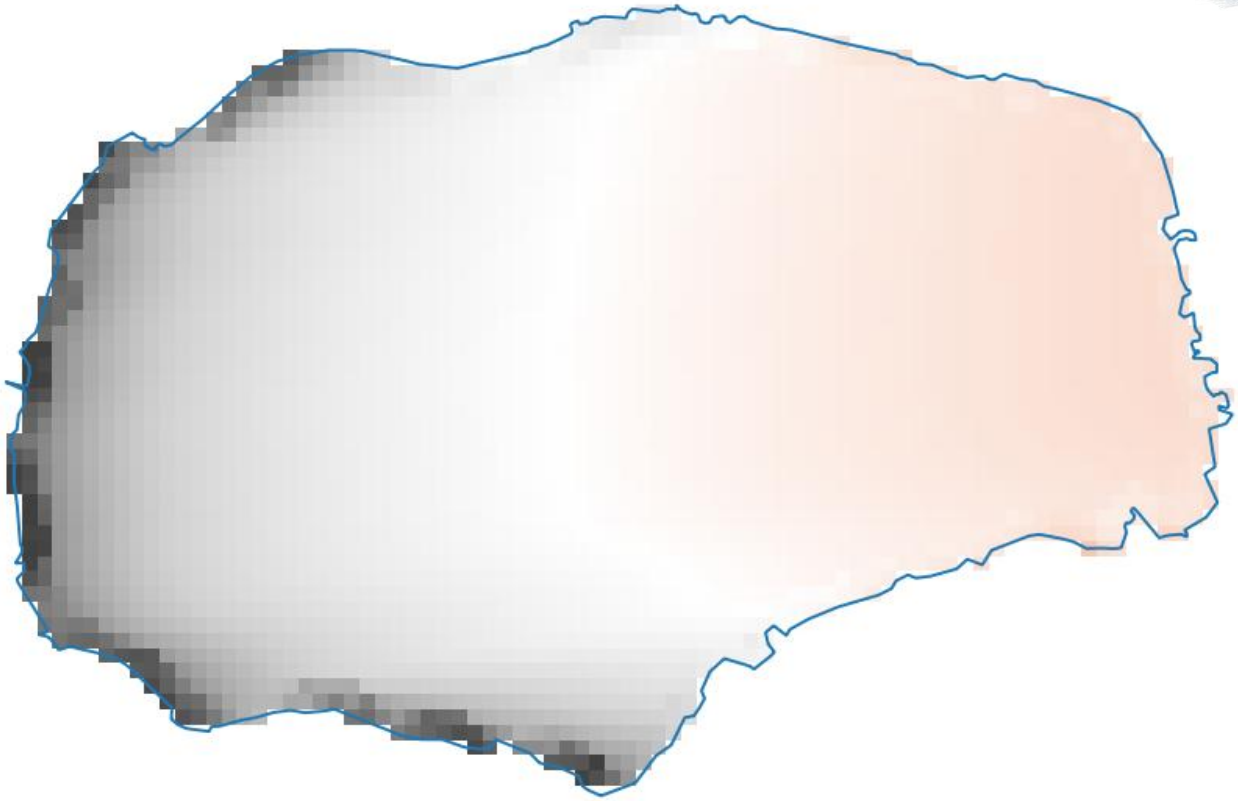
- 12 – 06 pm
- wind SSW → WNW
- wind speed 10 → 21 ms^{-1} (hourly average)



Storm Xavier (2017-10-5) – ½ Wave-length

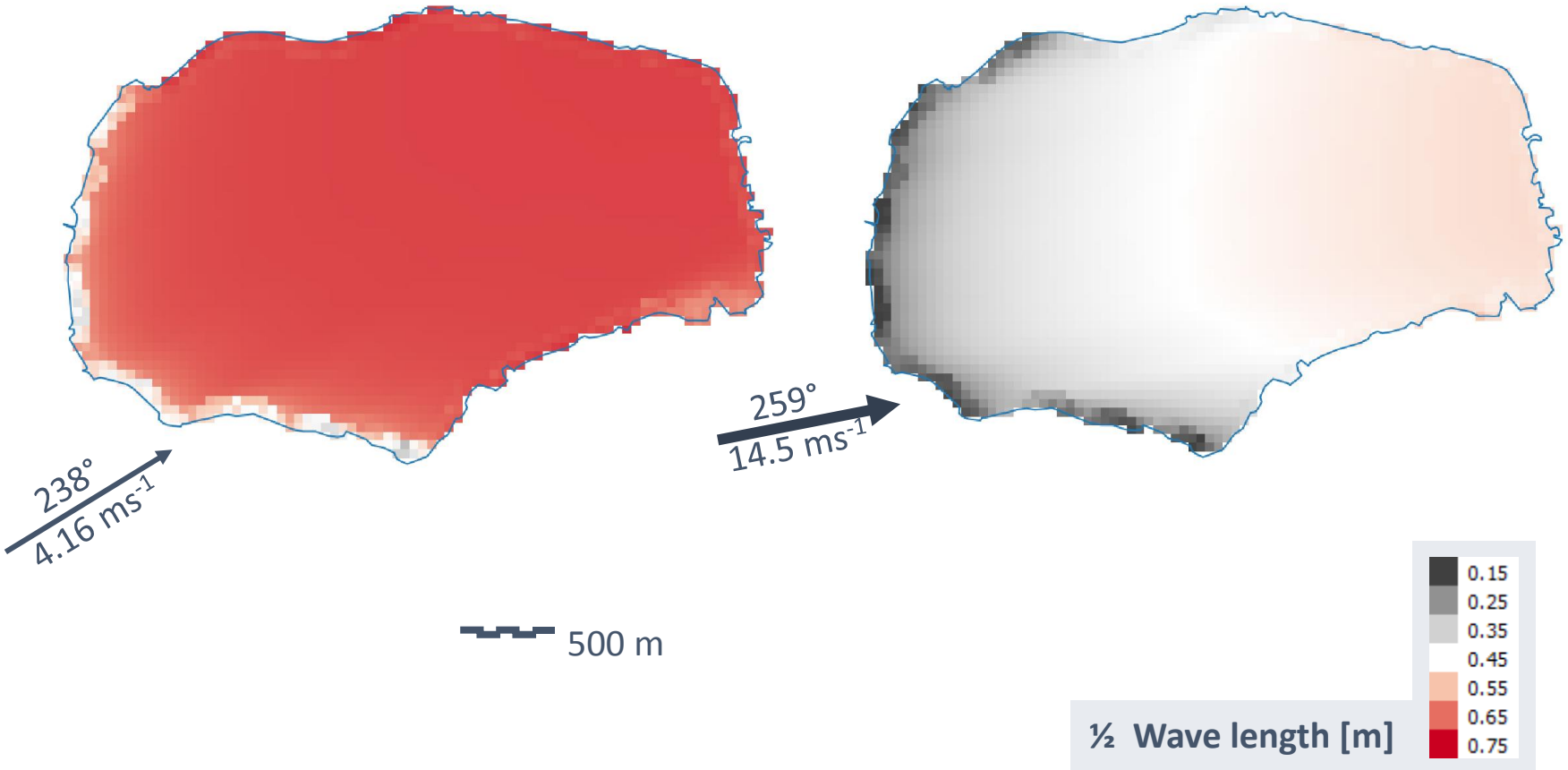
$L_w = 1.20 \tanh \{0.077[g F_n / U'^2]^{0.25}\}$





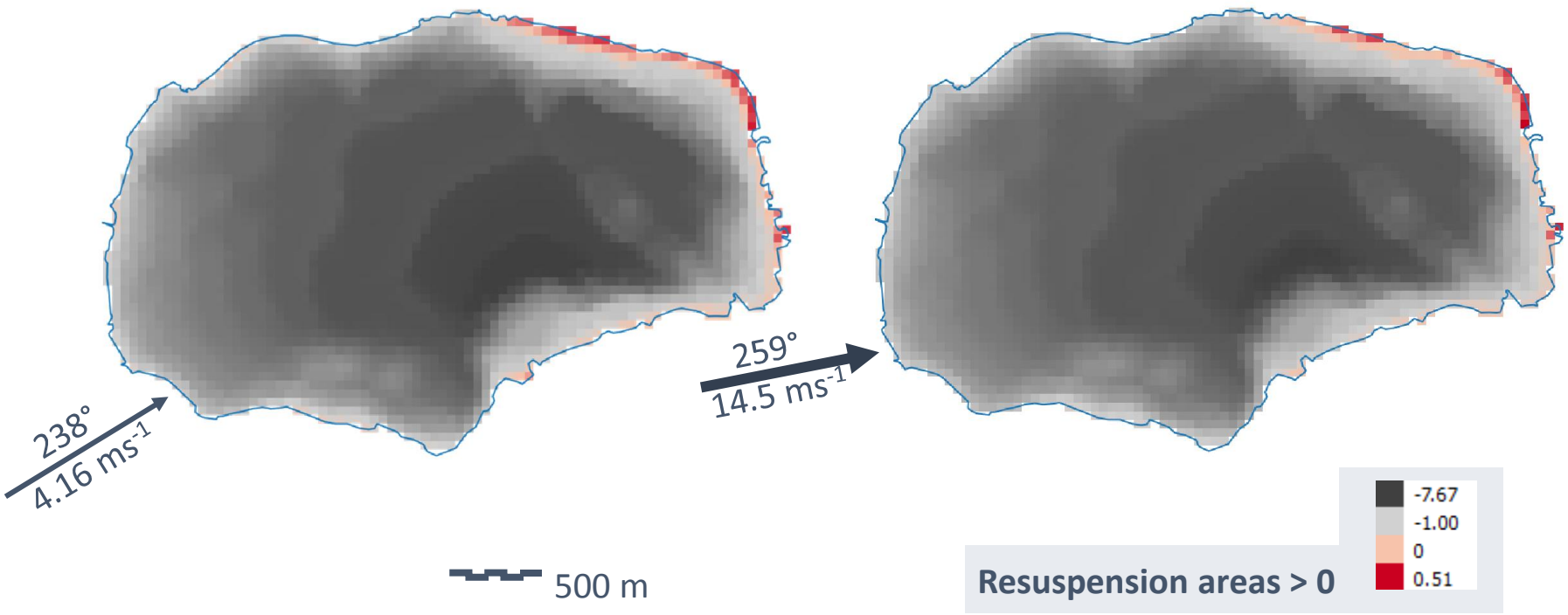
½ Wave legths

Annual average vs. Storm Xavier



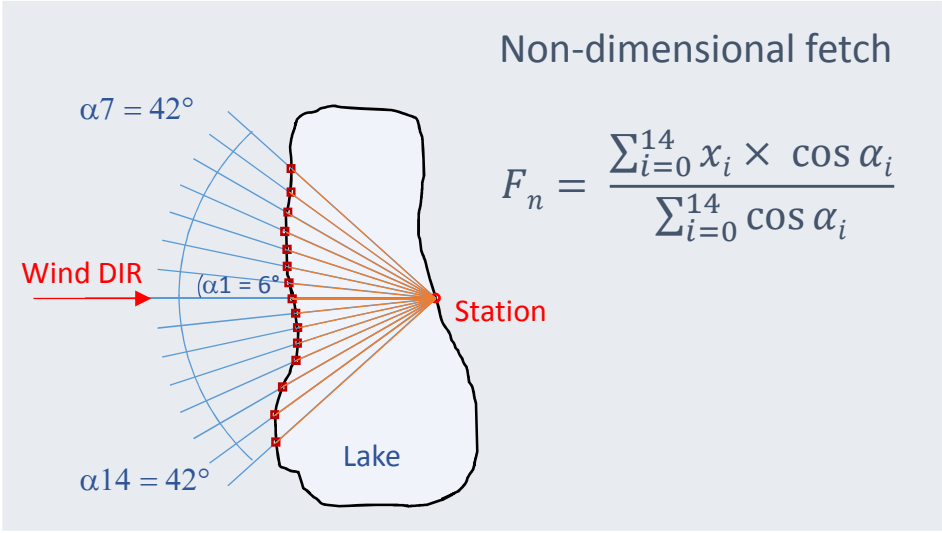
Resuspension areas

Annual average vs. Storm Xavier



Outlook – Internship at IGB

- Improve computation of non-dimensional fetch (US Army Corps of Engineers 2002)



- Adjust wind speed using on-site wind data
- All computations in Python script -> QGISplugin

Thank You!

- GIS Trainer Martin Dresen & Co.
- GISsis ☺
- Georgiy Kirillin (IGB Berlin)