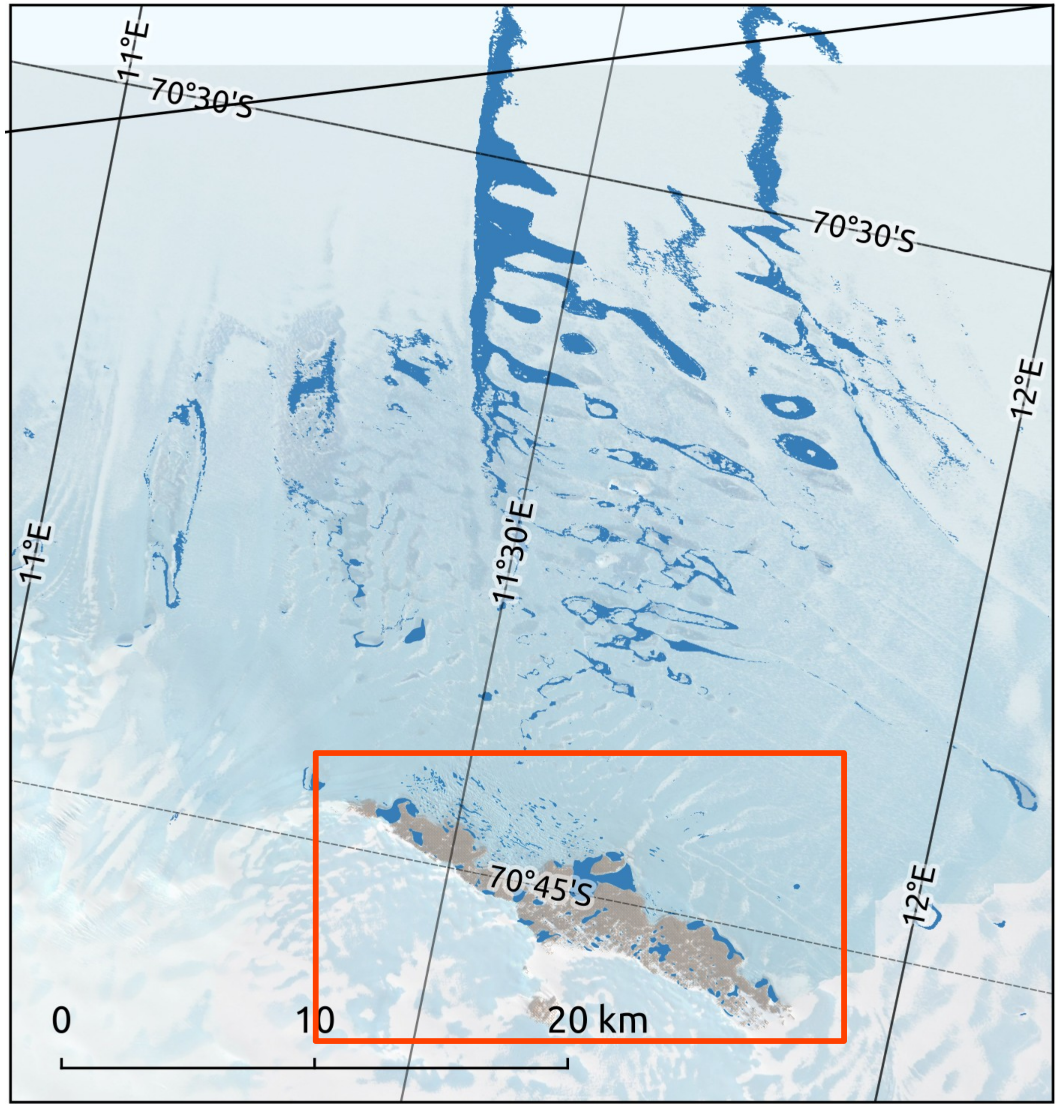

Summertime evaporation over two glacial lakes in the Schirmacher oasis East Antarctica

Elena Shevnina[1], Miguel Potes[2], Timo Vihma[1] and Tuomas Naakka[1,3]

[1] Finnish Meteorological Institute, Finland
[2] University of Évora, Portugal
[3] Stockholm University, Sweden

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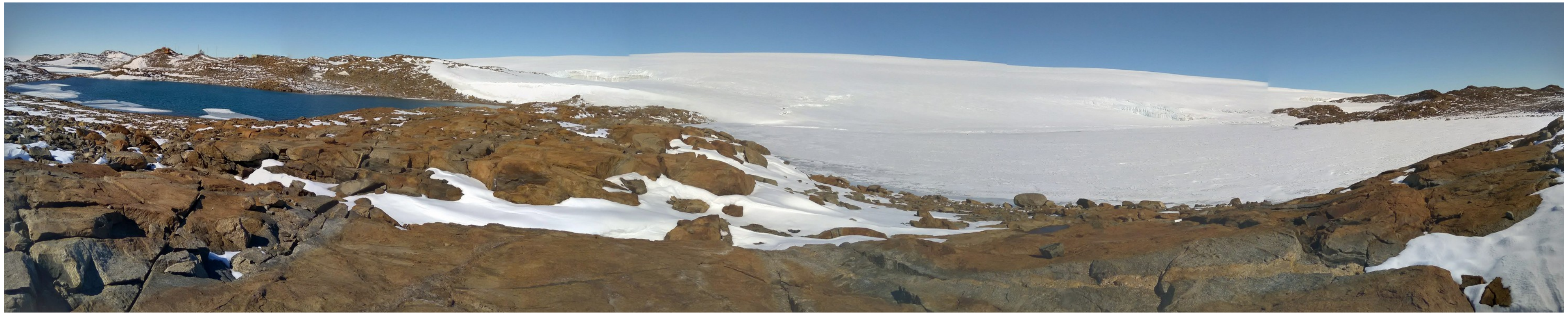
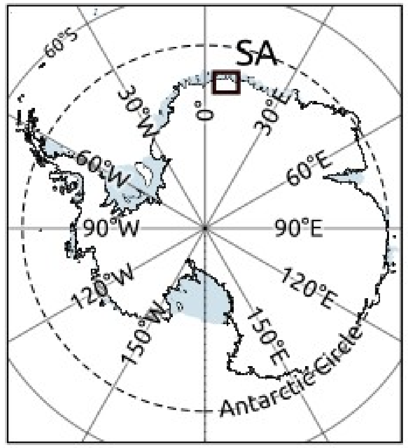
The Schimacher oasis [SA]: 80 km from the coast of Lazarev Sea, Dronning Maud Land.

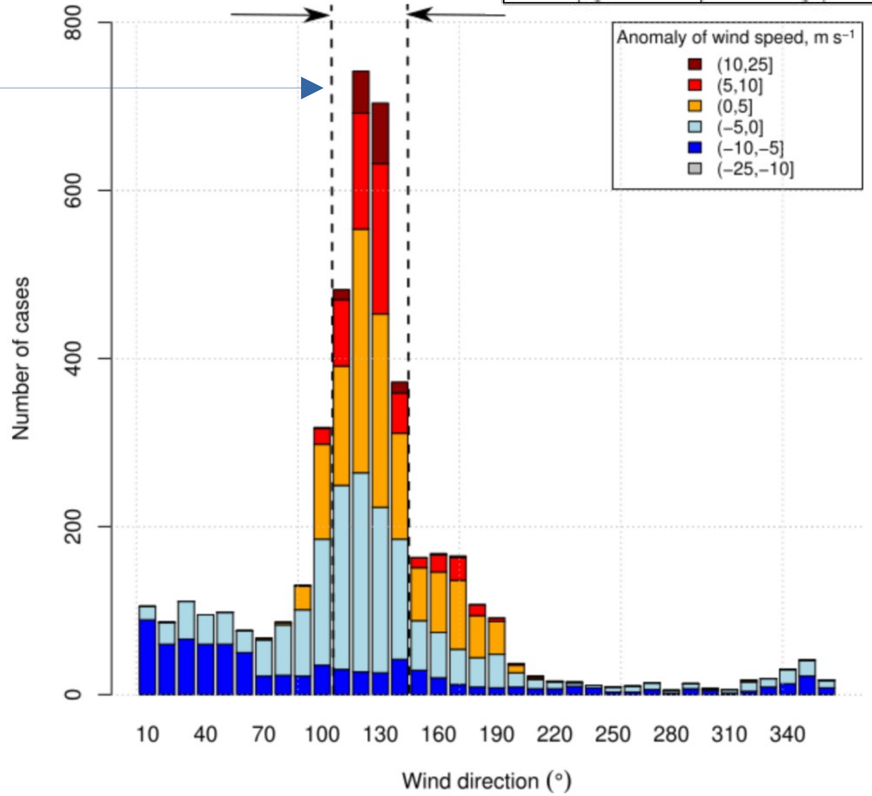




Climate: polar desert, katabatic winds

Meteorological parameter	1961–2010		
*	December	January	February
Air temperature, °C	−3.9/−1.0/1.5	−2.5/−0.4/1.4	−4.7/−3.3/−1.0
Relative humidity, %	47/56/69	49/56/66	41/49/59
Atmospheric pressure, Pa	965/975/991	964/976/986	964/973/987
Wind speed, m s^{-1}	4.3/7.4/10.3	3.1/7.0/10.4	5.8/9.4/13.1
Soil surface temperature, °C	3.0/6.7/10.0	3.0/6.7/11.0	−2.0/0.2/4.0
Precipitation, mm	0.0/5.3/54.8	0.0/2.6/38.0	0.0/2.9/25.9

*austral summer (DJF)



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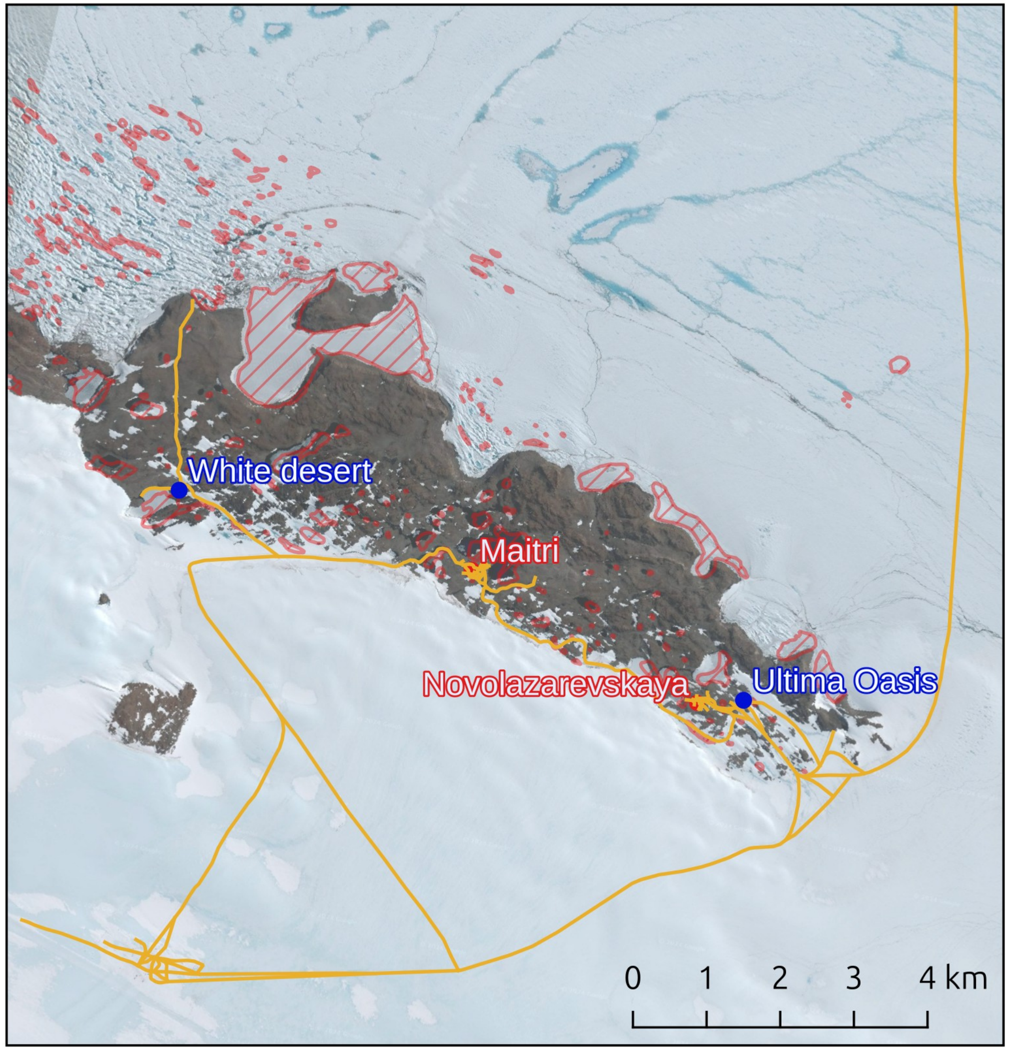


Lakes approx. 300 lakes (ADD):

- free of ice in 6-12 weeks
- no thermal stratification
- no snow on lake ice
- freshwater / saline

Infrastructure (ADD, Streetmap)**:** year-round bases(RED), seasonal camps (BLUE), ice airbase and roads(YELLOW)

Motivation

NO recommendations on what indirect method to apply

10 EXAMPLE VALUES OF LAKE EVAPORATION BY WMO REGION

See table on next four

WMO Regions:

- I Africa
- II Asia
- III South America
- IV North America, Central America and the Caribbean
- V South-West Pacific
- VI Europe

Methods for the quantification of evaporation from lakes

prepared for the World Meteorological Organization's Commission for Hydrology

Jon Finch and Ann Calver

2008

nature COMMUNICATIONS

2022

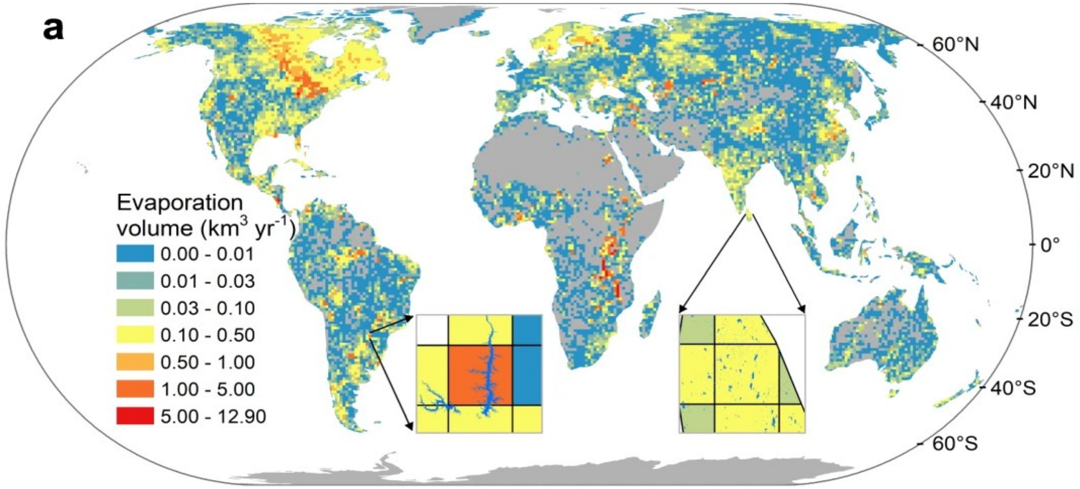
ARTICLE

Check for updates

https://doi.org/10.1038/s41467-022-31125-6 OPEN

Evaporative water loss of 1.42 million global lakes

Gang Zhao[1,2], Yao Li[2], Liming Zhou[3] & Huilin Gao[2]✉

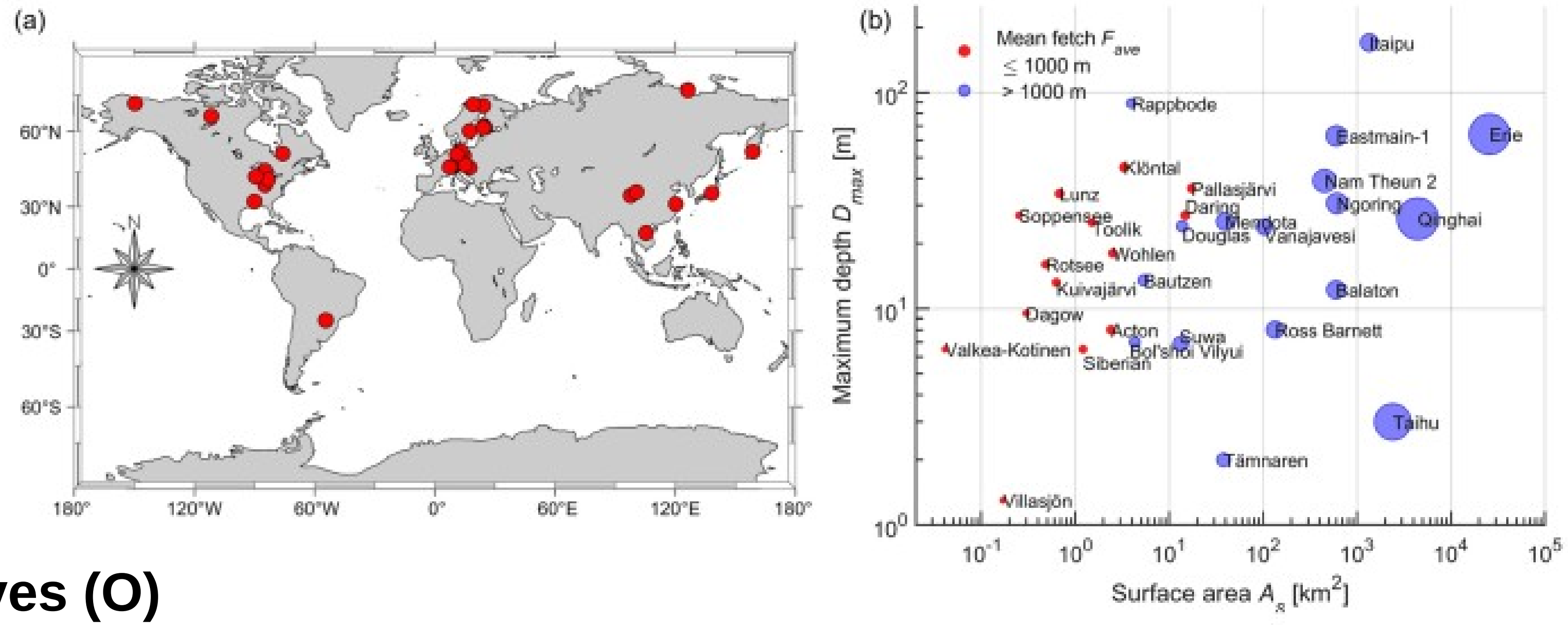


Motivation

AGU ADVANCING EARTH AND SPACE SCIENCES
Journal of Geophysical Research: Atmospheres
10.1029/2022JD037219

Guseva etal2023

NO measurements of lake evaporation



Aim (A) and objectives (O)

A: To quantify the uncertainties of the indirect methods applied to estimate the summertime evaporation over the lakes in Antarctica

O... to measure lake evaporation
O… to calculate the uncertanties of indirect methods

+methods

Indirect methods, E_{mod}

Evaporation E, mm d^{-1}

Methods for the quantification of evaporation from lakes

prepared for the World Meteorological Organization's Commission for Hydrology

Jon Finch and Ann Calver
2008

- Mass balance
- Energy budget
- Bulk or mass transfer → Heikinheimo et al., 1999
- Combination equations → Penman, 1948; Doorenbos and Pruitt, 1975; Odrova, 1979, Shuttleworth, 1993
- Equilibrium temperature method
- Empirical factors

Direct EC method, E_{EC}

Scopes: Pearson correlarion coefficent, Root Mean Square Error and s/σ criteria (Popov, 1976).

$$s = \sqrt{\sum_{i=1}^{n} \left(E_{EC}^{i} - E_{mod}^{i}\right)^2 / (n-m)} \qquad \sigma = \sqrt{\sum_{i=1}^{n} \left(E_{EC}^{i} - \bar{E}_{EC}\right)^2 / n}$$

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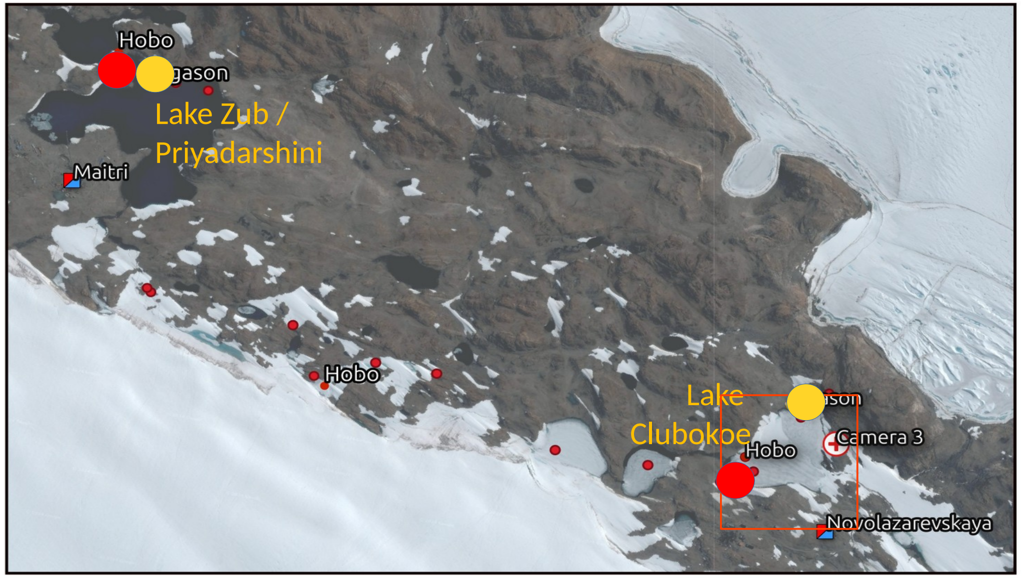
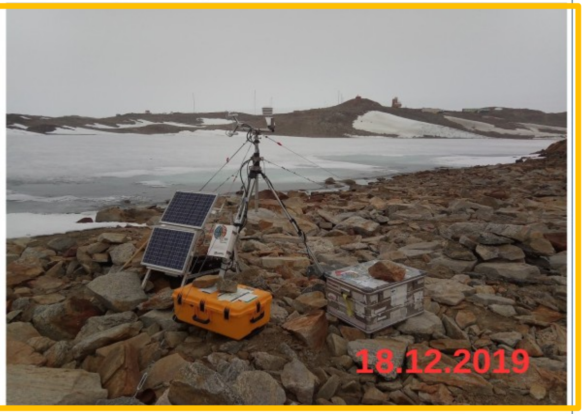
Field experiments:
2017 – 2018 and 2019 – 2020 summer (DJF)

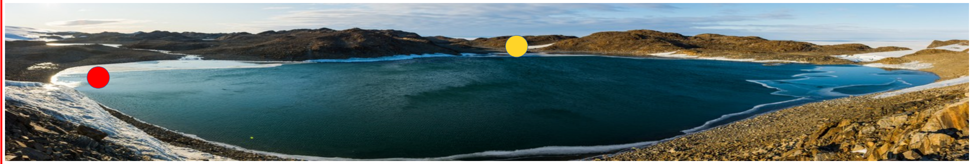


Lake	Mean/Max depth, m	Volume, 10^3 m^3	LSWT, °C
A: Zub Priyadarshini	2.9 /6.0	10	0.2 – 9.9
B: Glubokoe	13.1/34.5	1930	0.6 – 5.4

A

B



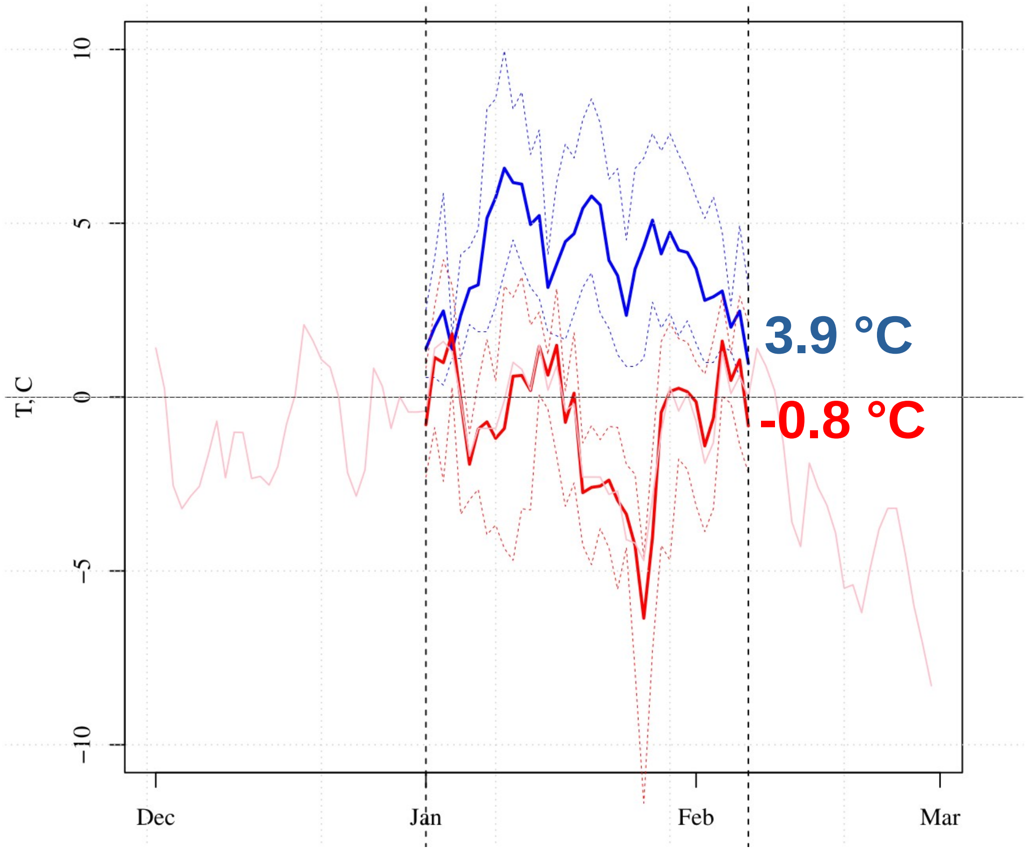

25.02.2020

Instrumentation

Site/sensor (Fig. 1c)	Elevation, m	Measured variables	Accuracy/ (precision)	Time series used in the analysis
IRGASON site	124.2	air temperature, °C; H_2O concentration, $g\,m^{-3}$; wind speed, $m\,s^{-1}$	±0.15/(0.025) ±0.037/(0.00350) –	30 min
HOBO	122.0	water temperature, °C	±0.44/(0.10)	daily average

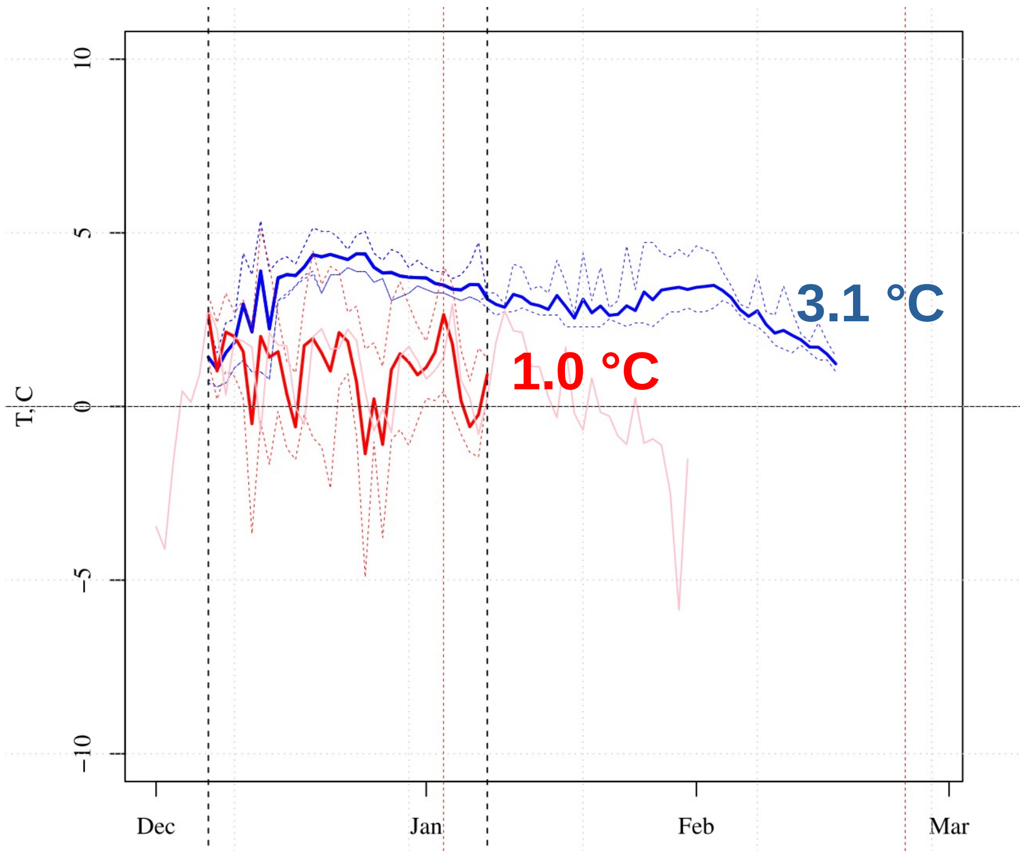
Daily minimum, average and maximum air temperature, T °C (red) and lake surface water temperature, LSWT °C (blue).

Lake Zub/Priyadarshini



30.12.2017 – 8.02.2018 (38 days)

Lake Glubokoe



8.12.2019 – 13.01.2020 (32 days)

The lakes are warmer than the ambient air

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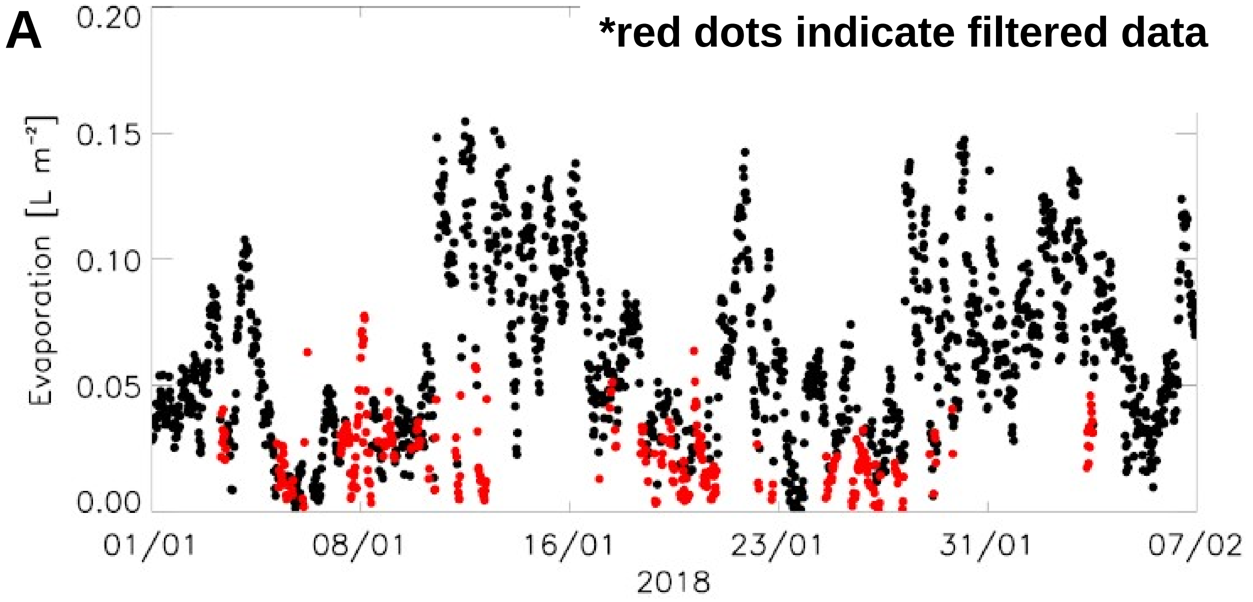
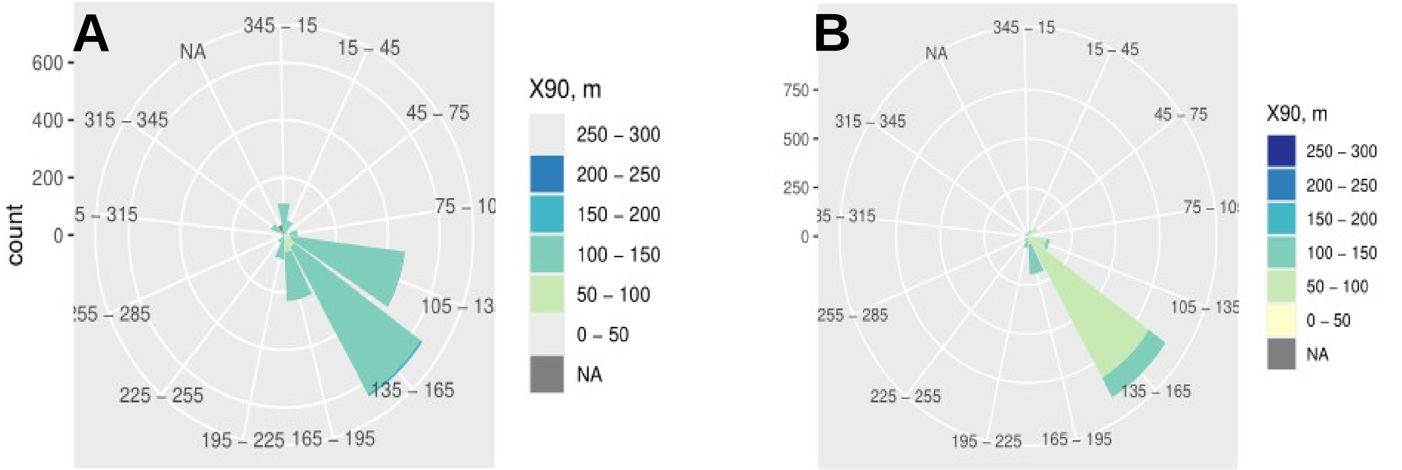
+ **EC method**

Data processing:

- **excluding the intervals with less than 50 % of total measurements;**
- **excluding the data with non zero values in the flags and with gas signal strength less than 0.7;**
- **Excluding the data outside the footprint (lake surface)**

Data quality: good (>80%).





The footprint of the EC measurements

The evaporation over the lakes varied from 0.3 to 5.0 mm d^{-1}. It takes on average 1.7 mm d^{-1} in December and 3.0 mm d^{-1} in January-February.

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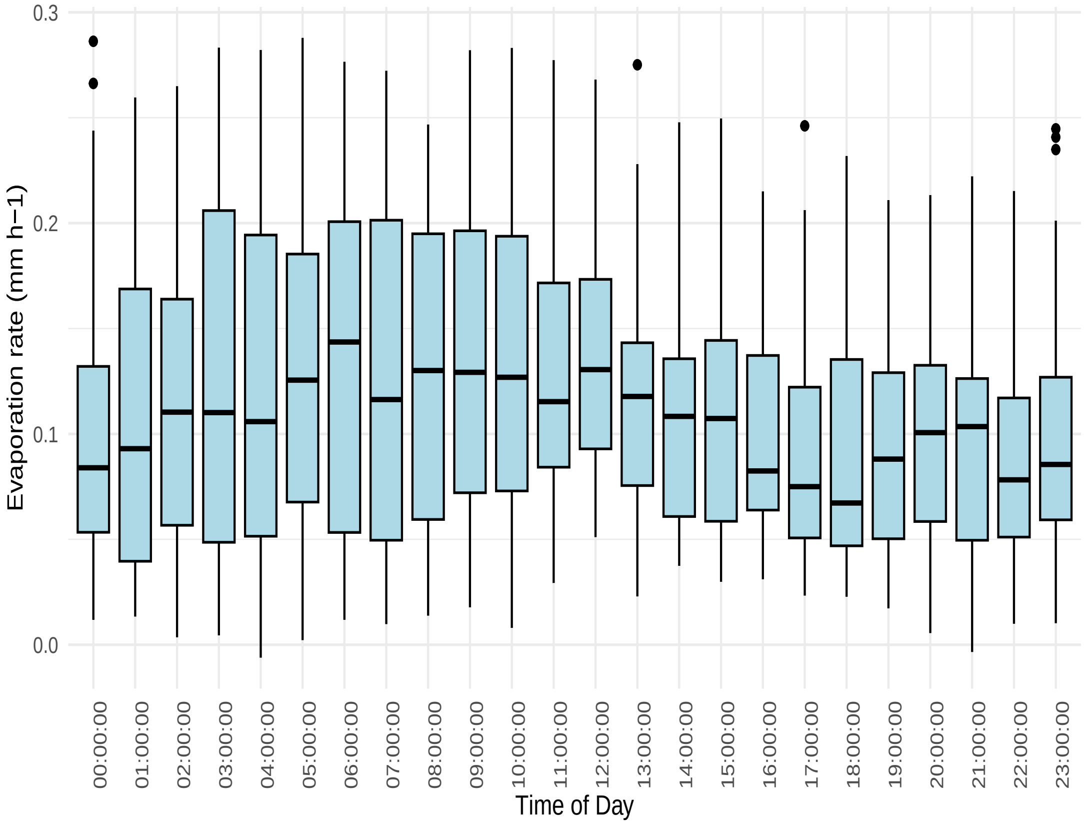
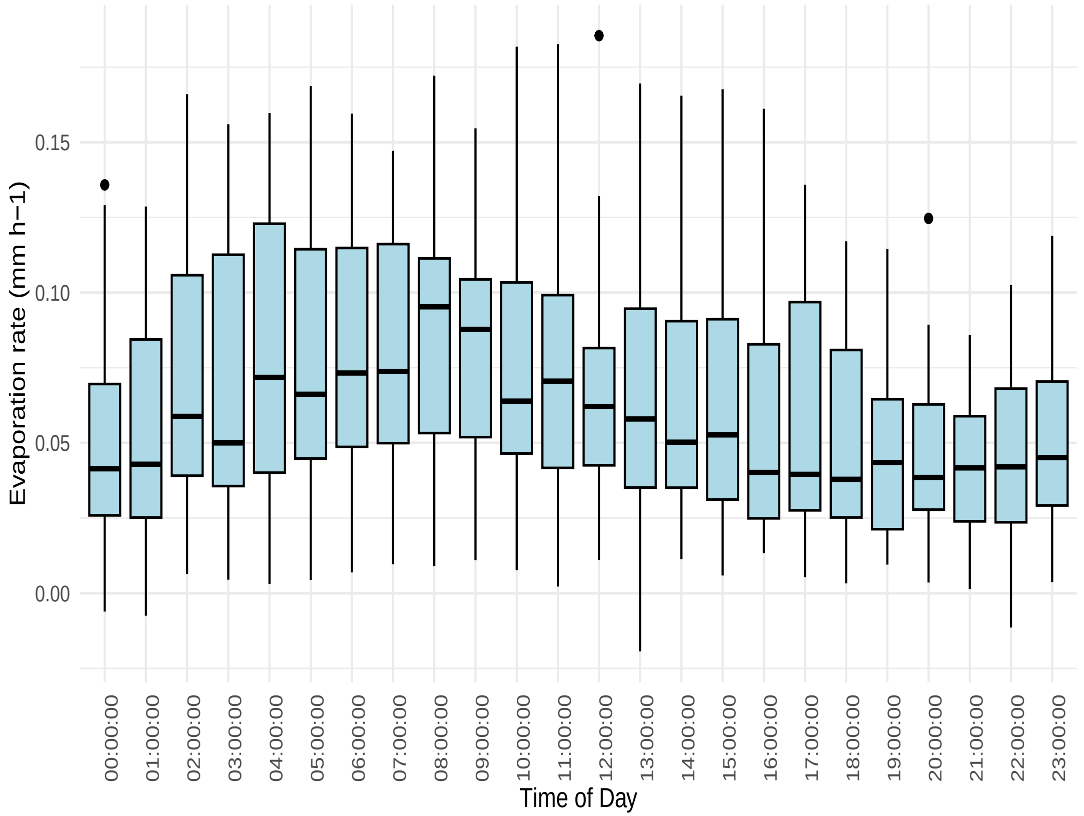
+intra daily cycle

Lake Zub/Priyadarshini



Lake Glubokoe



The evaporation peaks in the early morning (6:00 – 8:00 AM); and then, it gradually decreased until late evening (9:00 and 11:00 PM)

Indirect methods: Estimates and Scopes

E_{EC}	3.0 mm d^{-1} in January-February	1.7 mm d^{-1} in December

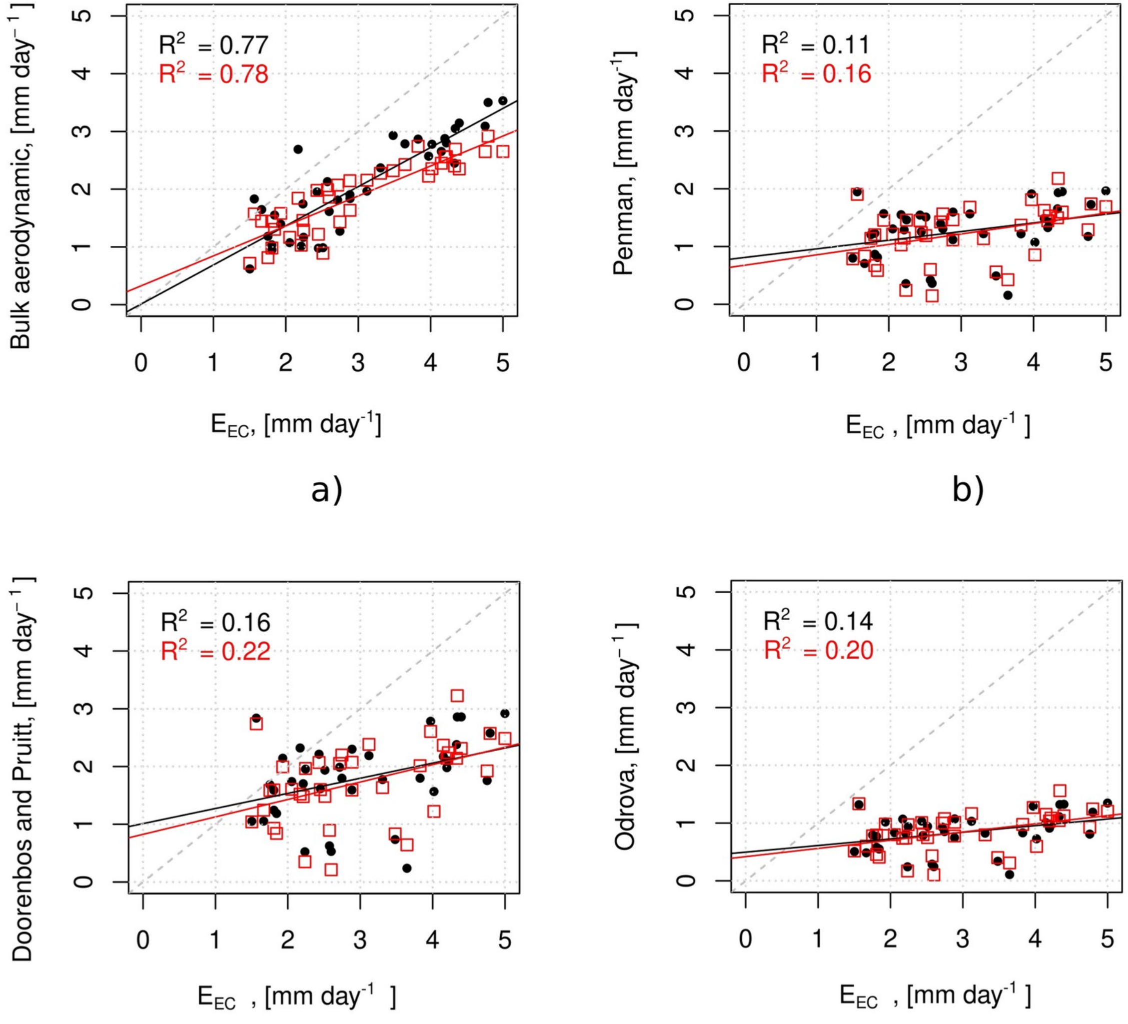
Methods	Lake Zub/Priyadarshini		s/σ	Lake Glubokoe		s/σ
	E_{mod}	RMSE		E_{mod}	RMSE	
BA:Heikinheimo etal.(1999)	2.0 / 3.5*	1.0	1.1	–	–	–
Penman (1948)	1.3 / 2.0	1.8	2.0	0.6 /1.7	1.1	2.2
Doorenbos and Pruitt (1975)	1.8 / 2.9	1.3	1.6	0.8 / 2.4	1.0	2.1
Odrova (1979)	0.8 / 1.3	2.2	2.4	0.4 / 1.1	1.1	2.4
Shuttleworth (1993)	1.0 / 1.8	2.1	2.3	–	–	–
Shevnina etal. (2022)	–	–	–	1.5 / 5.1	1.2	2.5

*mean/max

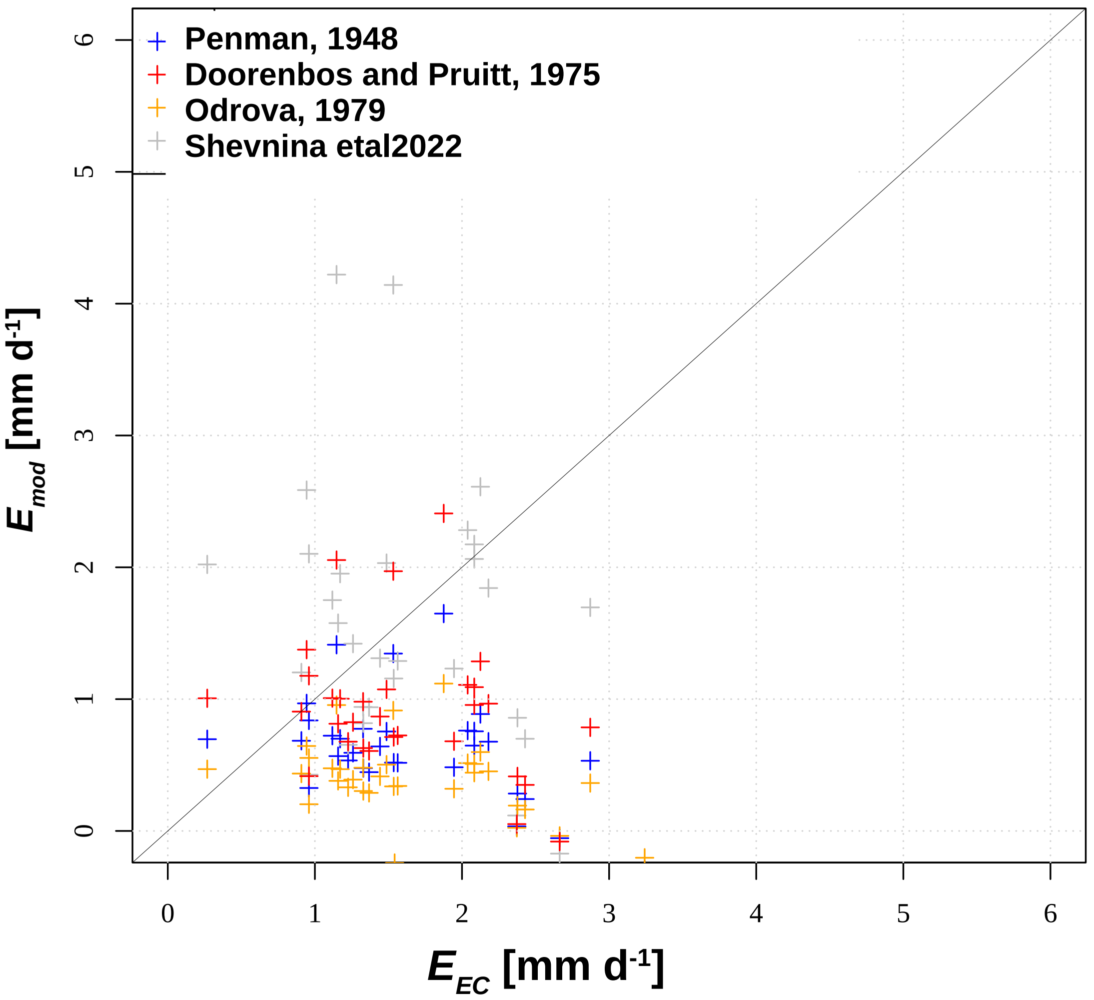
On average, the methods underestimated the evaporation for 32–72 %.
The bulk aerodynamic method demonstrates the best scopes.

+ im

Lake Zub/Priyadarshini



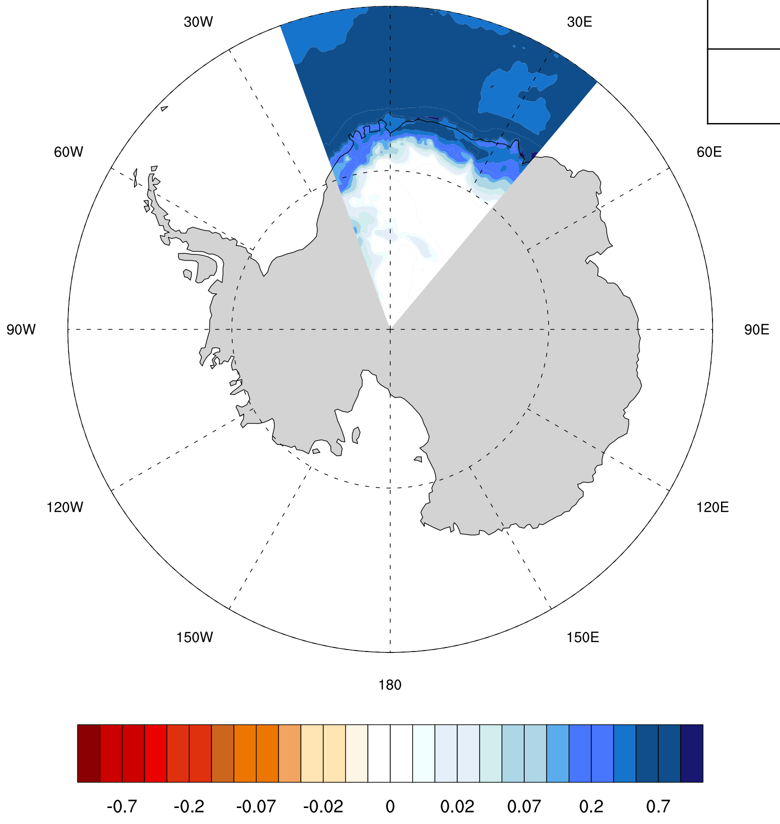
Lake Glubokoe



The bulk- aerodynamic method and combination formulas are weak in simulation of day-by-day evaporation.

+ reanalyses

November – March

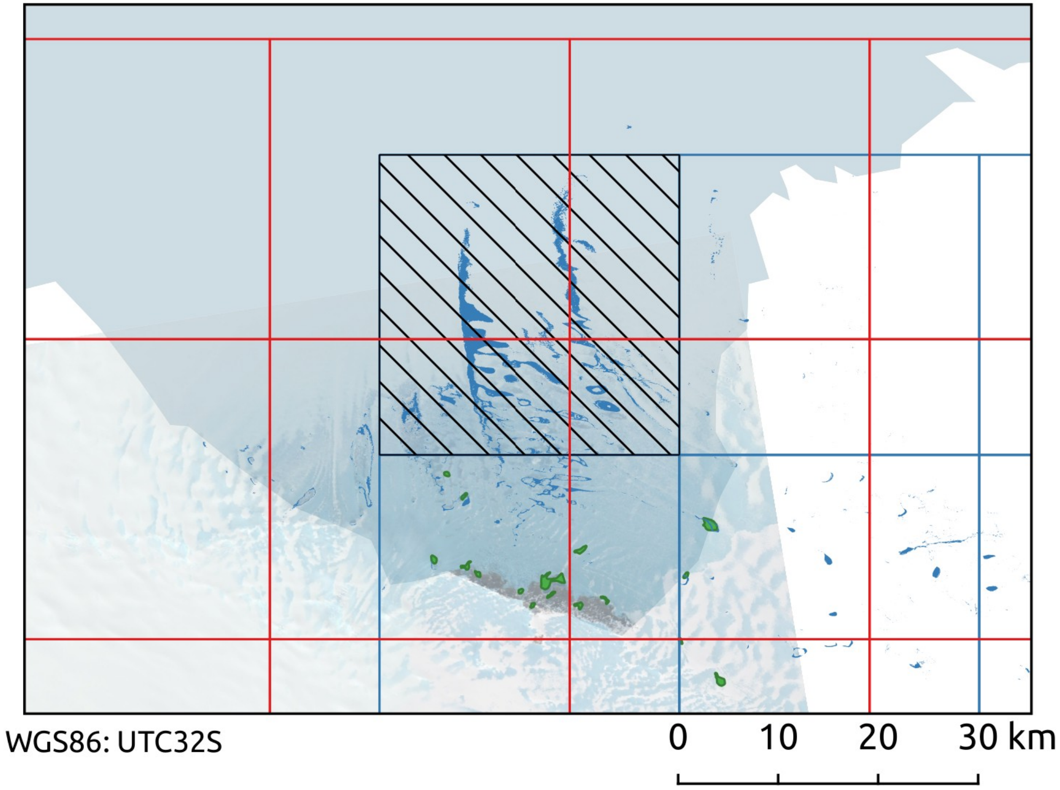


Evaporation, mm d^{-1}

Evaporation, mm d^{-1}

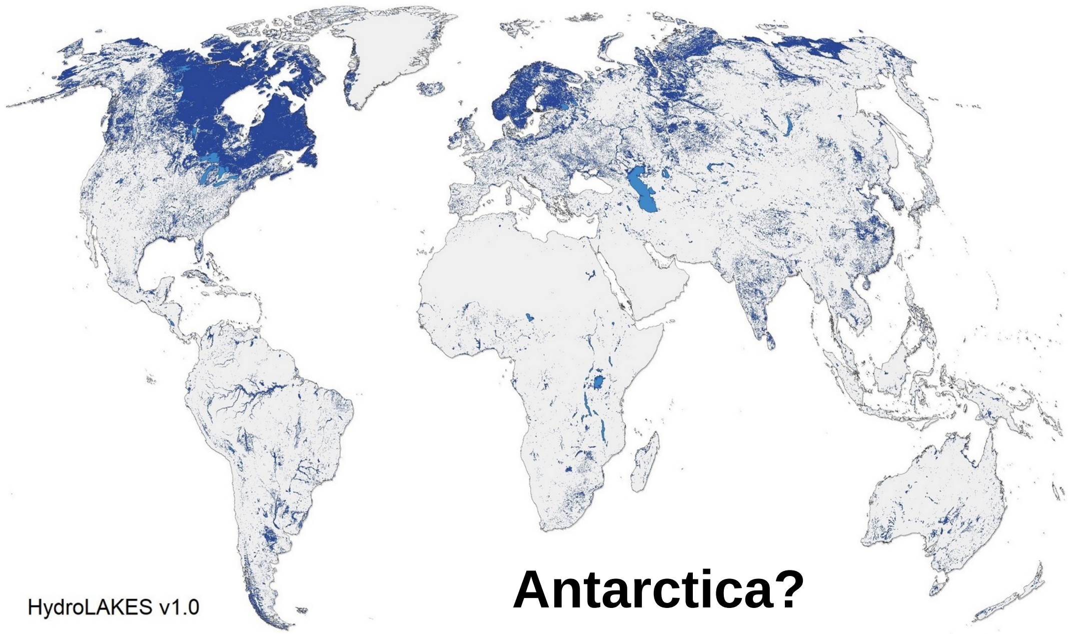
Open ocean (ice < 50%)	Sea ice (ice > 50 %)	Slopes (el > 2000 m)	Plateau (el > 2000 m)
0.71	0.85	0.25	0.00

Bulk-aerodynamic method is implemented in NWPs: the surface moisture flux [evaporation/ sublimation]



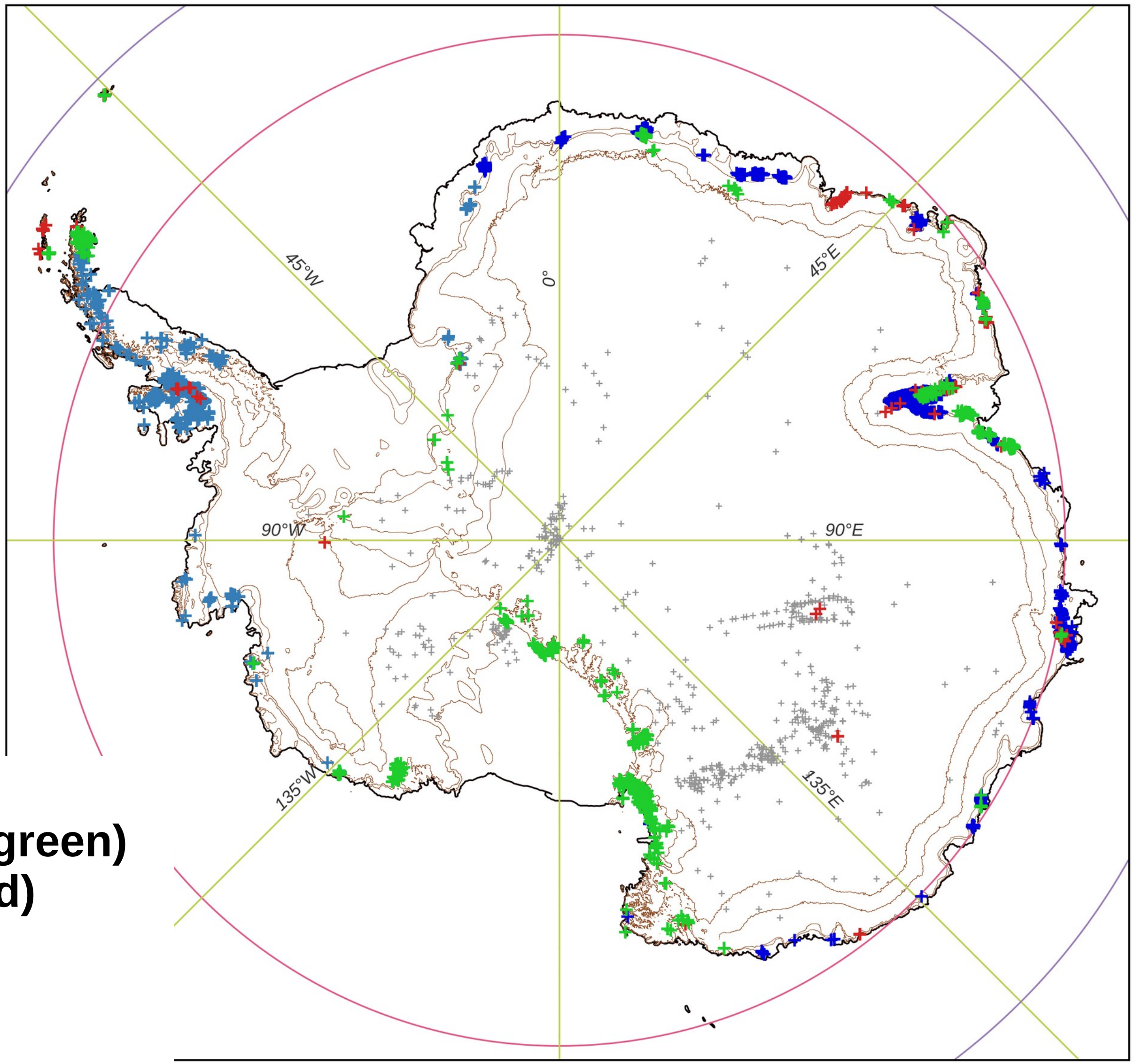
ERA5>> Land cover map in NWPs: NO LAKES
ERA6>> revised land cover maps in NWPs: YES LAKES **+ FLake model**

+ permanent/seasonal water in NWPs



Antarctica?

Messager, M.L., Lehner, B., Grill, G., Nedeva, I., Schmitt, O. (2016). Estimating the volume and age of water stored in global lakes using a geo-statistical approach. Nature Communications, 7: 13603. https://doi.org/10.1038/ncomms13603



- **Antarctic Digital Database: Gerrish etal2020 (green)**
- **Composite Antarctic Gazetteer: CAG 2019 (red)**
- **Qantarctica: Matsuoka etal 2021: (grey)**
- **Stokes etal2019 (blue)**
- **Corr etal2022 (light blue)**

+ to (re-)inventor of the surface lakes in Droning Maud Land

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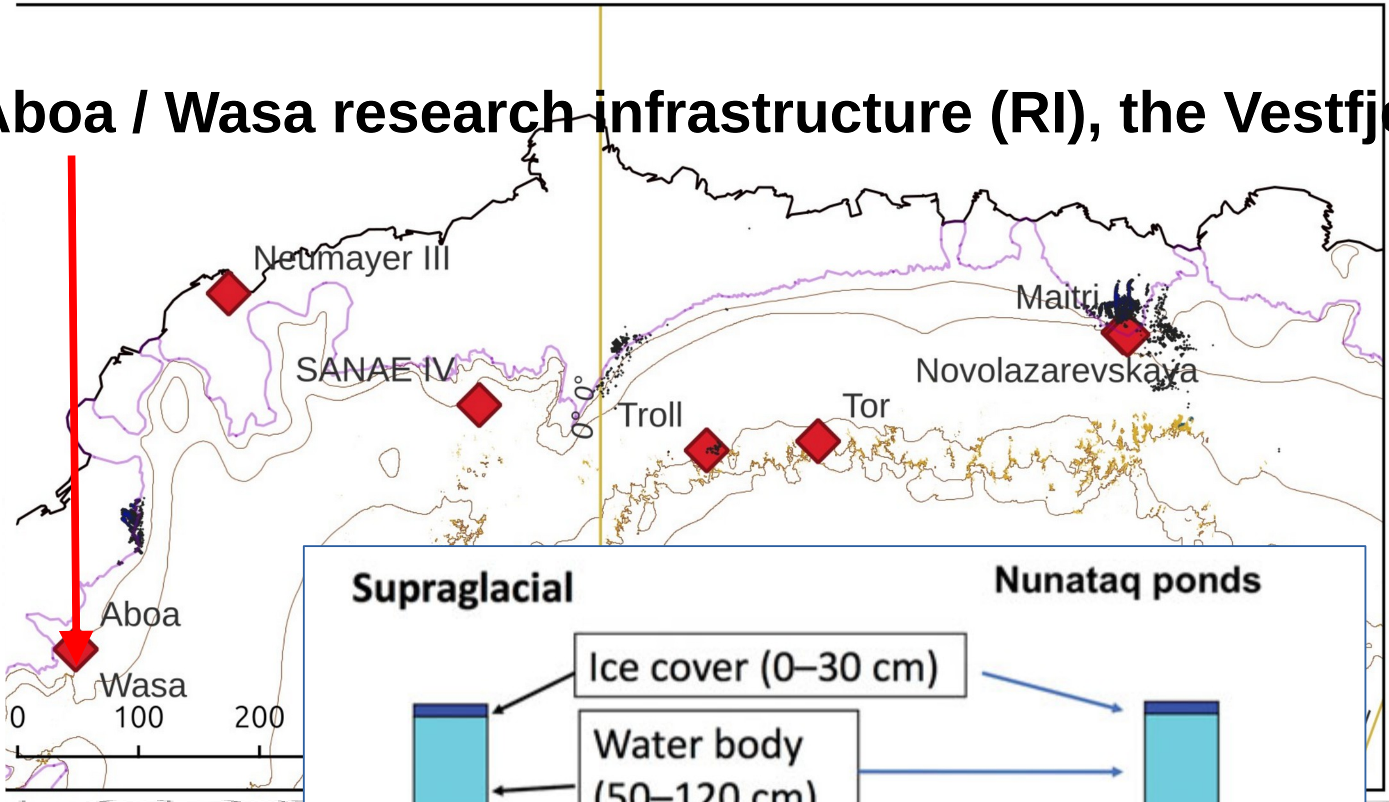
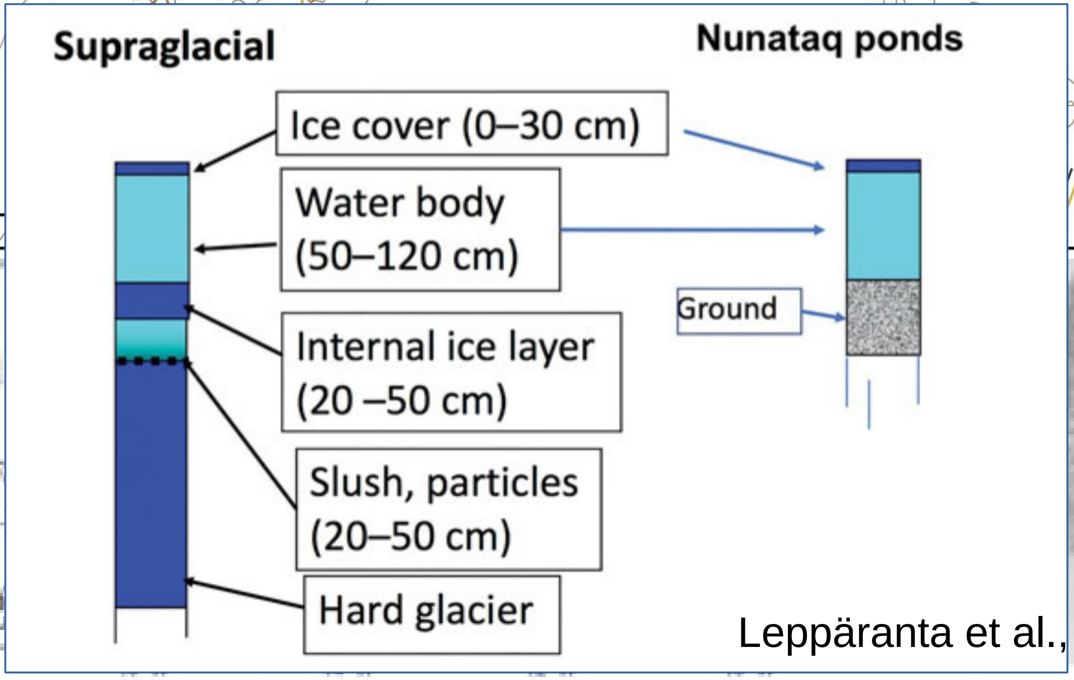
+ [permanent / seasonal water] land cover maps in NWPs: revision for Antarctica

- **Antarctic Digital Database, (ADD) approx. 1300 lakes mixed the surface and subsurface lakes;**
- **ADD misses approx. 450 surface lakes in Dronning Maud Land, Enderby Land and Mary Byrd Land;**
- **Composite Antarctic Gazetteer, CAG: sourced the ancillary data for the lakes (depth) for approx. 700 surface lakes;**
- **Quantarctica: replicated lakes from the ADD and extended the information on the subsurface lakes;**
- **Approx. 95 % of the surface lakes are not included in the land cover map (lakes of the supraglacial type).**

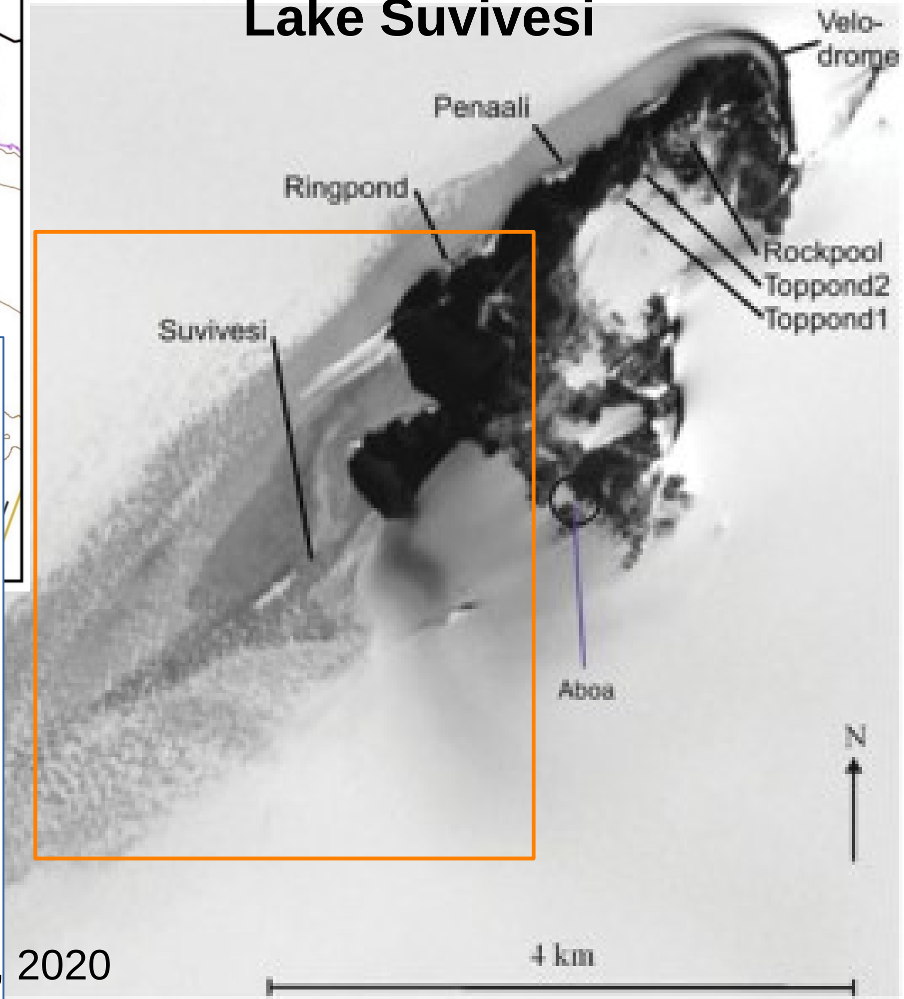
+ to develop new scheme for the supraglacial lakes

Aboa / Wasa research infrastructure (RI), the Vestfjella Mountains, DML





Lake Suvivesi



Leppäranta et al., 2020

The Cryosphere, 16, 3101–3121, 2022
https://doi.org/10.5194/tc-16-3101-2022

The Cryosphere

Thanks for the attention!

Evaporation over a glacial lake in Antarctica

Elena Shevnina[1], Miguel Potes[2,3], Timo Vihma[1], Tuomas Naakka[1], Pankaj Ramji Dhote[4], and Praveen Kumar Thakur[4]

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