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Towards the first circumarctic N_2O budget – Extrapolating to the landscape scale

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Significance of the **Arctic**

- Warming twice as fast as the rest of the globe (IPCC 2013)

Significance of **permafrost**

- Covers 23 million km^2 (Northern Hemisphere alone, Strauss et al. 2017)
- Large soil organic carbon (C) stock in the northern permafrost region of ~1500 Gt (Hugelius et al., 2014)
- Scarce data on circum-arctic nitrogen (N) stock

Significance of **nitrous oxide (N_2O)**

- ~300 times stronger greenhouse gas than carbon dioxide (CO_2) (IPCC 2013)
- Produced by microbial processes in the soil mostly associated with plant-available mineral N

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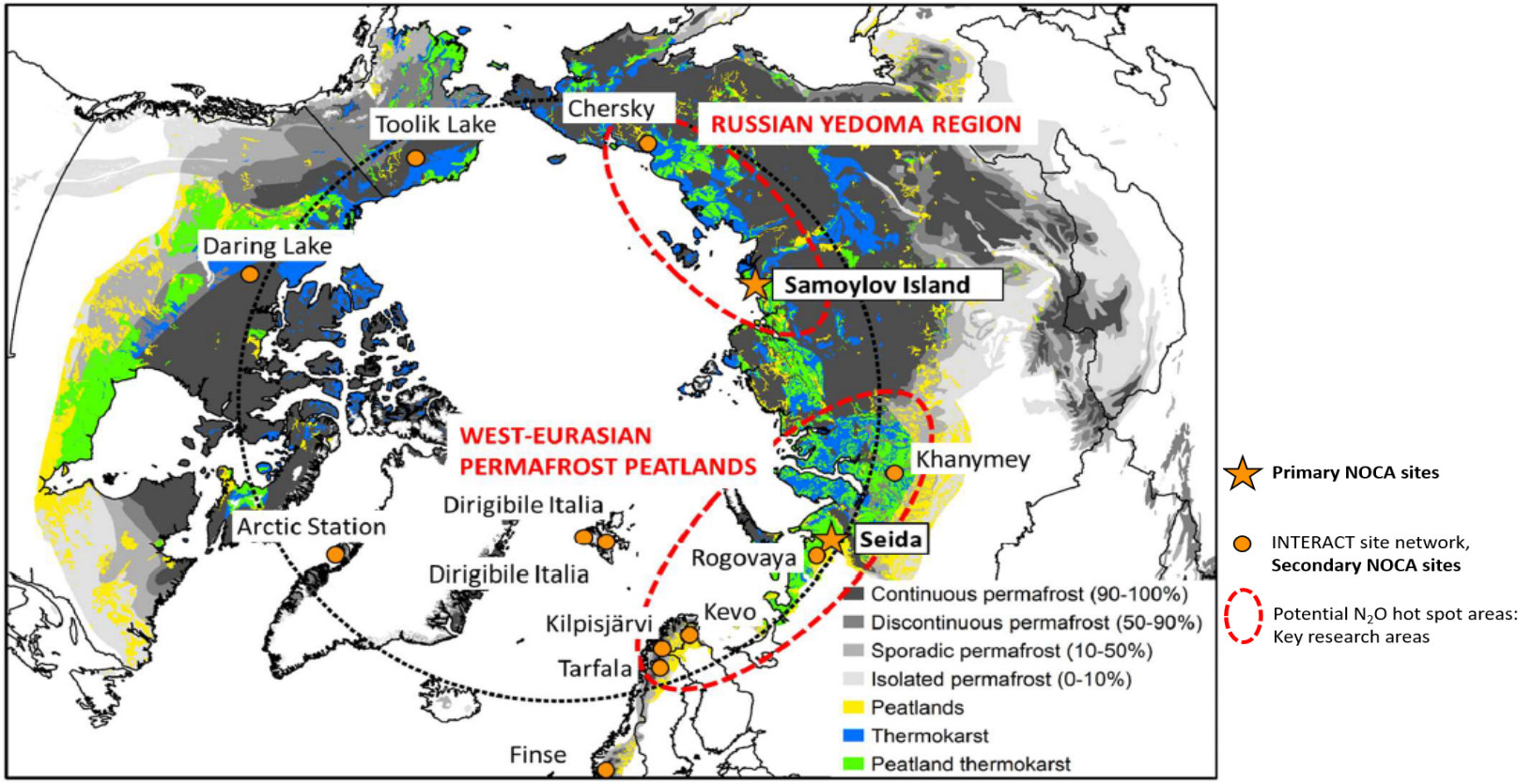
Ongoing **N_2O data acquisition** from static chamber and soil gas measurements (plot-scale data)

Data on **landcover-classes** from the literature, INTERACT cooperation partners & NOCA expeditions

Bottom-up upscaling approach to landscape, regional and finally circumarctic scale



Modified from Voigt *et al.* (2017), *PNAS*.

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Upscaling from plot to landscape scale

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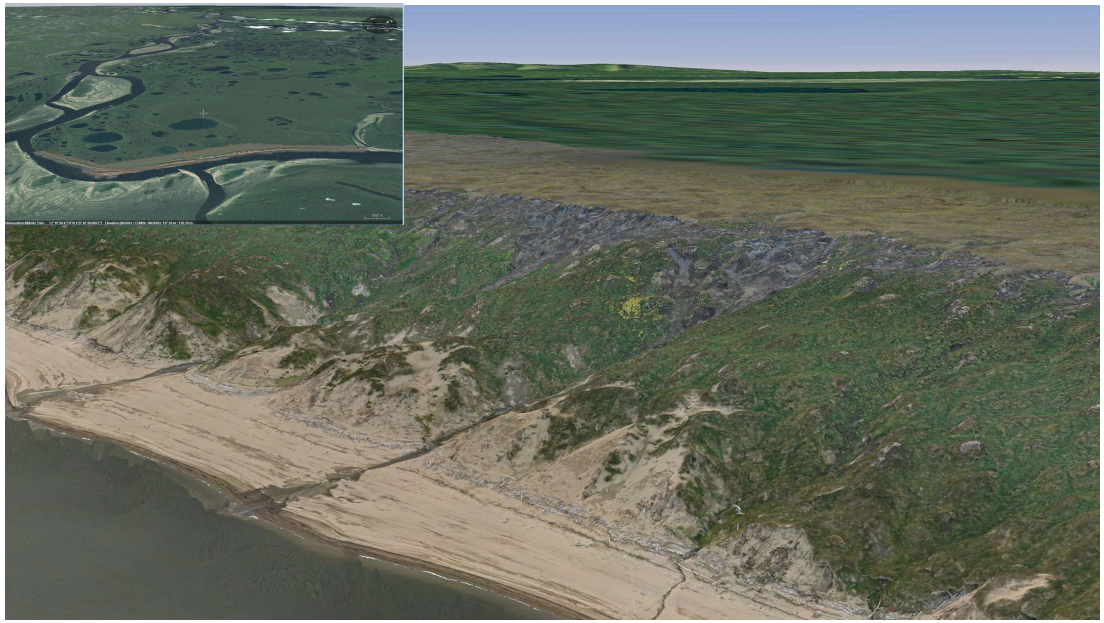
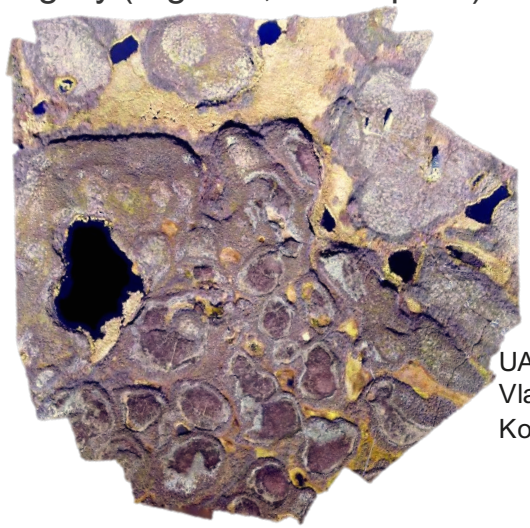
- **Plot-scale measurements**
- N_2O flux, soil, vegetation & micrometeorological data
- **Upscaling**
- Island cliff 3D model and vegetation maps based on unmanned aerial vehicle (UAV) imagery (landscape scale)
- Satellite imagery (regional, circumpolar)



3D model by Alexey Faguet, Russian Academy of Sciences



UAV image by Vladimir Elsakov, Komi Science Center

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2019 Expedition to the Lena River Delta

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- 2019 NOCA primary study site: **Kurungnakh Island** is located within the Lena River Delta in Eastern Siberia
- Yedoma deposits: Pleistocene ice-rich permafrost with ice-wedges covering > 1 million km^2 of the northern permafrost zone (Grosse et al., 2011)
- Thawed by fluvial thermo-erosion forming retrogressive thaw slumps
- ~130 Gt organic carbon in Yedoma (Strauss et al., 2017)

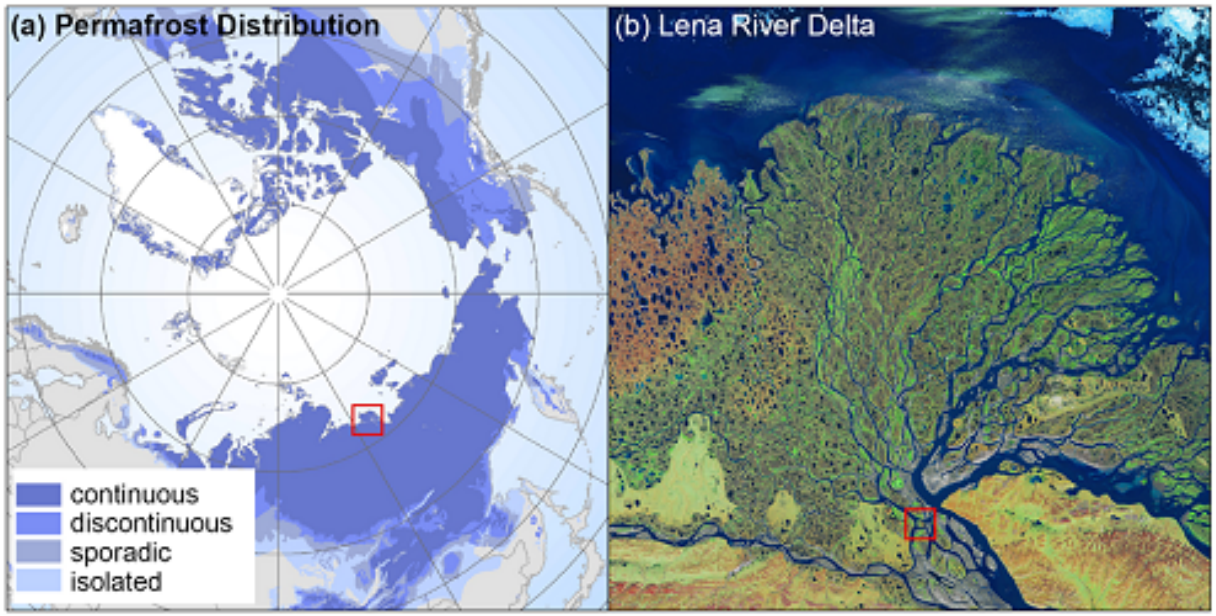

Figure by Boike et al. (2012):
(a) Circumpolar permafrost distribution (Brown et al., 1998) and the Lena River Delta.
(b) Location of the Kurungnakh Island within the Lena River Delta, Eastern Siberia, Russia (NASA, 2000).

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2019 Expedition to the Lena River Delta

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20 sites (5 repl. each):

- Yedoma outcrop with 7 vegetation types
- 3 topographic transects (island plateau, long dried-out thermokarst lake basin, lake rim) with 3 sites each following a moisture gradient
- 3 sites within ‘recently’ dried-out thermokarst lake
- 1 exposed and freshly vegetated lake rim site with meltwater run-off

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Yedoma outcrop (A) with 7 vegetation types

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- Yedoma with Holocene vegetation cover (~30cm, moss dominated)
- Freshly thawed, wet and bare Yedoma
- Dry and bare Yedoma
- Yedoma with young mosses (D)
- Yedoma with young grasses (B)
- Yedoma with the yellow flowering Senecio palustris (C)
- Yedoma with grass and Senecio palustris

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3 topographic transects

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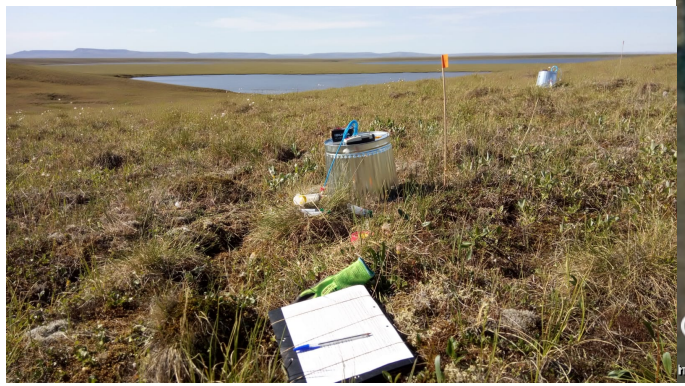
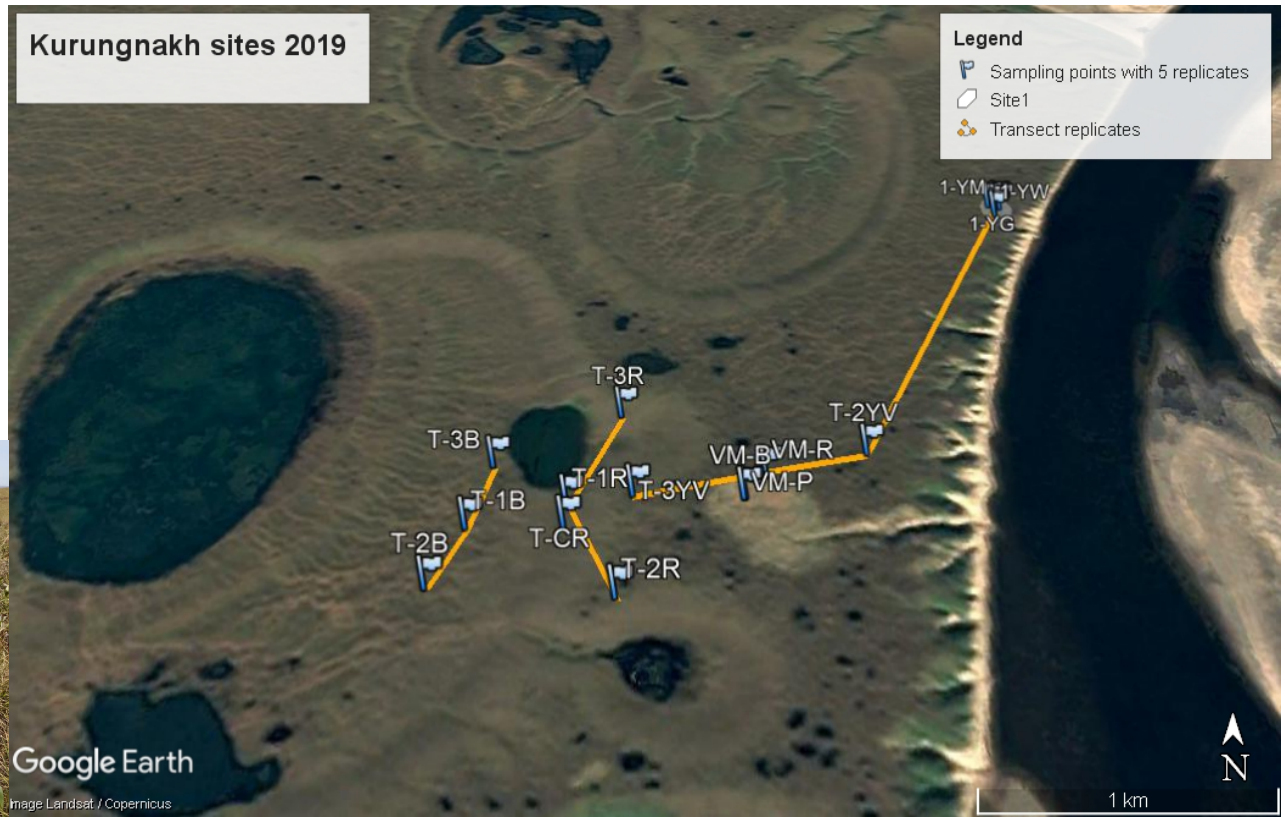
- Island **plateau** with Holocene cover and typical tundra vegetation
- Long dried-out thermokarst **lake basin** with polygon tundra
- Long dried-out thermokarst **lake rim**





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‘Recently’ dried-out thermokarst lake

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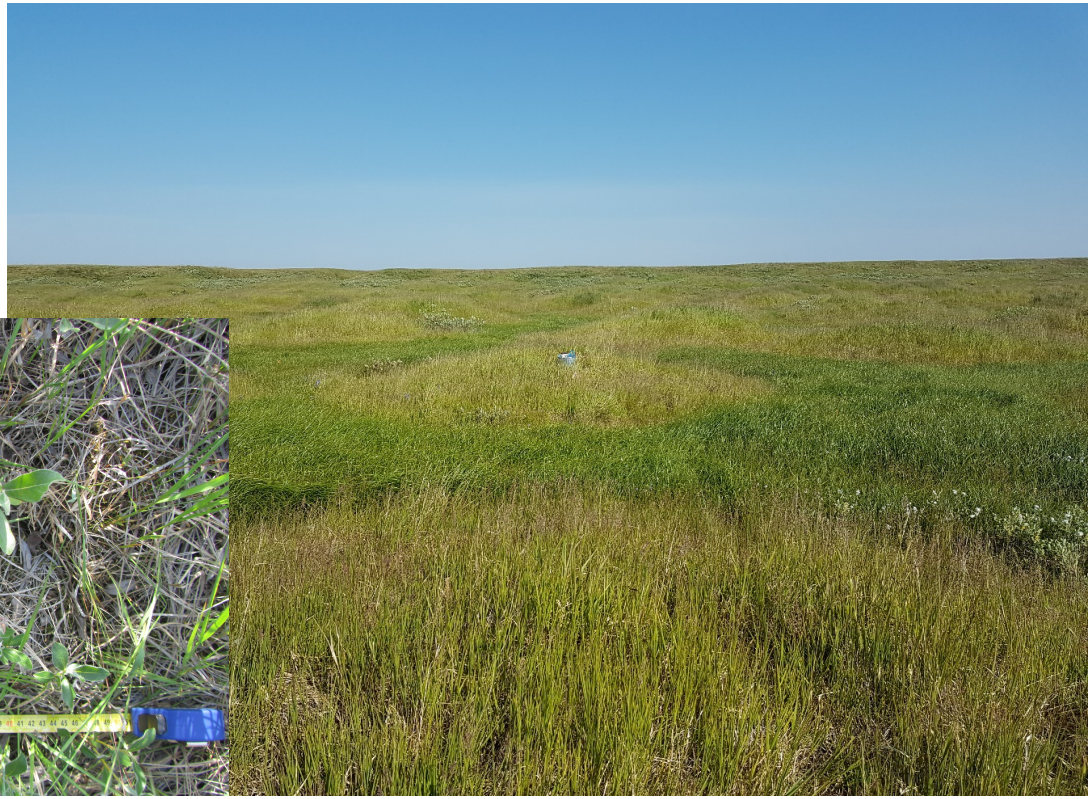
- Wet and partially waterlogged **basin** with deep green grass
- Small ice **elevations** (5-10m^2) vegetated with grass
- **Rim** with soft slope, vegetated by moss, grass and small shrubs



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Exposed and freshly vegetated lake rim site

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- Characterized by broken Holocene cover and melt water run off
- Thawed Yedoma mixed with sand and organic matter
- Young, tall and deep green grasses and small shrubs
- Partially water logged and/or bare soil towards the lower slope

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Upscaling from plot to landscape scale

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- High-resolution imagery (5cm per pixel)
- 3D model calculation of surface area (B) more accurate than area estimate by plane view (A)
- N_2O flux measurements extrapolated for each outcrop vegetation category

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Outlook

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- **Vegetation maps** for the inland and transect sites (in preparation) categorize the 2019 NOCA primary study site Kurungnakh Island **based on 2D and 3D UAV imagery**
- Measured N_2O fluxes will be extrapolated for each vegetation category area and growing season duration → **Landscape N_2O budget**
- Underlying **N_2O production processes** investigated and **main drivers** identified with auxiliary measurements and further incubation studies in the future

Hypotheses:

- Inland, Yedoma with Holocene cover, is a small N_2O emitter covering a large aera of the study site
- Outcrop, thawed Yedoma is a large N_2O emitter covering a small aera of the study site (i.e. hot spot)

N_2O hot spots, due to their intensity, are significant for the permafrost–climate warming feedback loop.

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N_2O caught your interest? Stay tuned, coming soon:

- Voigt C, Marushchak ME, Abbott BW, Biasi C, Elberling B, Siciliano SD, Sonnentag O, Stewart KJ, Yang Y, Martikainen PJ: **Nitrous oxide emissions from permafrost-affected soils**. In final revision, Nature Reviews Earth and Environment.
- **NOCA database** submitted to PANGAEA® Data Publisher