



INGV



UNIVERSITY
of
OTAGO

SOURCE AND IMPACT OF GREENHOUSE GASSES IN ANTARCTICA

THE SENECA PROJECT

(financed by PNRA 2018)

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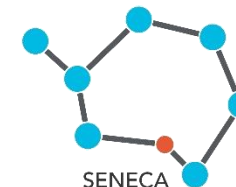
4 CEED University of Oslo

5 GNS - Otago University

6 University of Geneva

7 Geostudi Astier

8 CNR-IGAG, Italy



SENECA Project

source and impact of greenhouse gasses in Antarctica

PNRA / ANZ

Project duration: 24 months

Mission leagues & Targets:

I. December 2019 – January 2020

Taylor Valley

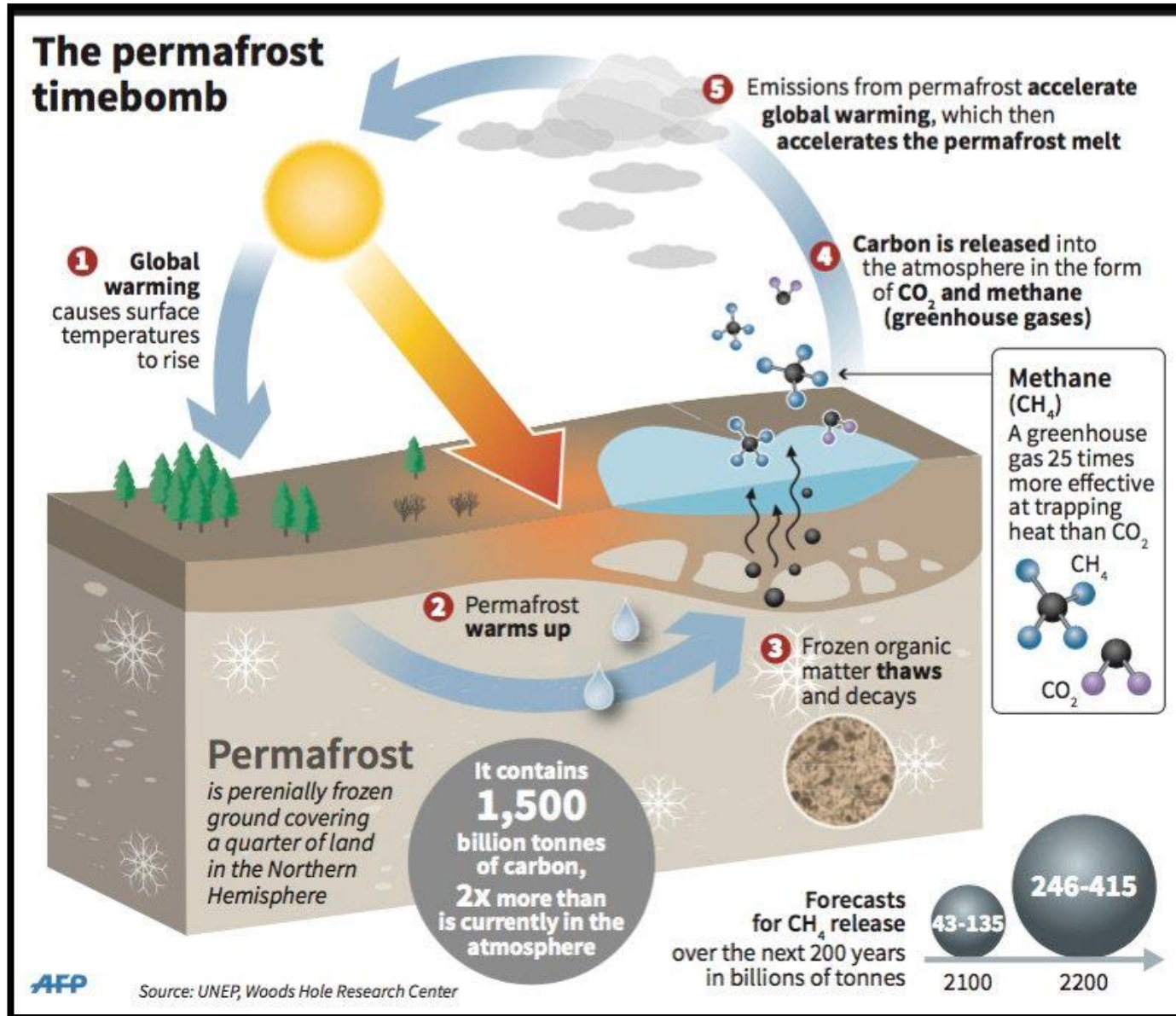
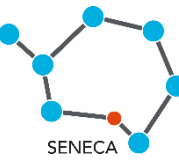
II. December 2020 – January 2021

Wright Valley

The project is developed along four major tasks:

- **Soil gas content and origin**
- **CO₂ and CH₄ degassing output**
- **Geophysics exploration and petrographic characterization of the soils**
- **Seasonal trend of CO₂ soil concentration**

Permafrost & climate change



Arctic and Antarctic regions store almost twice the carbon currently present in the atmosphere



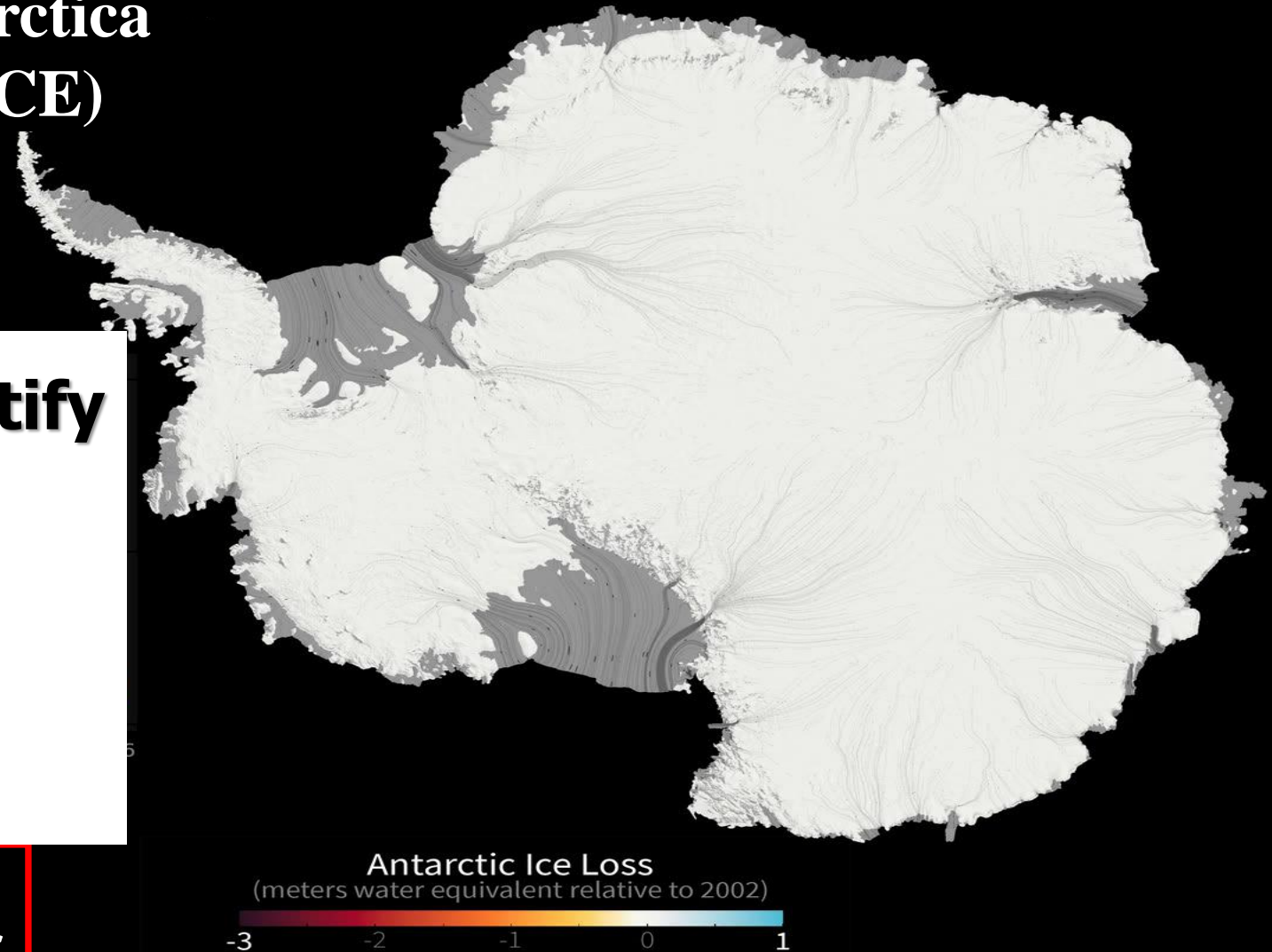
The SENECA expedition



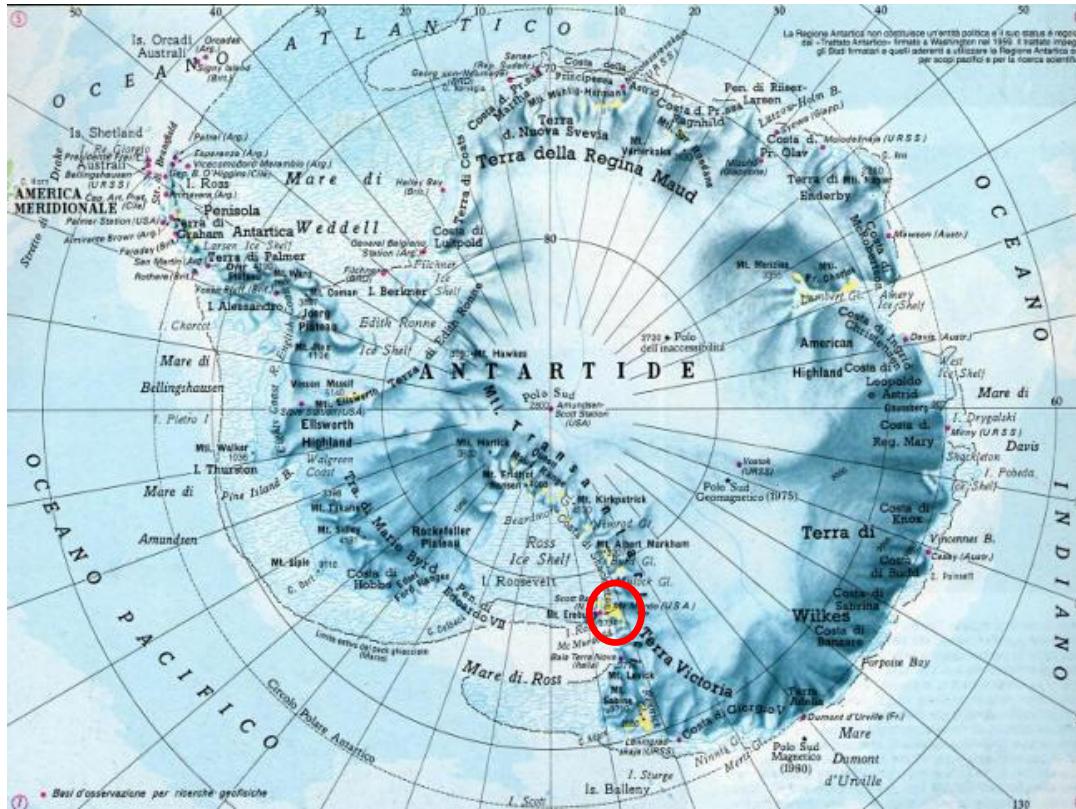
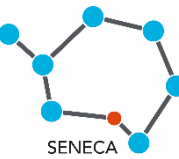
Ice Loss in Antarctica 2002-16 (GRACE)

- **NO investigations to quantify gas release in Antarctica**
- **Huge permafrost volumes**

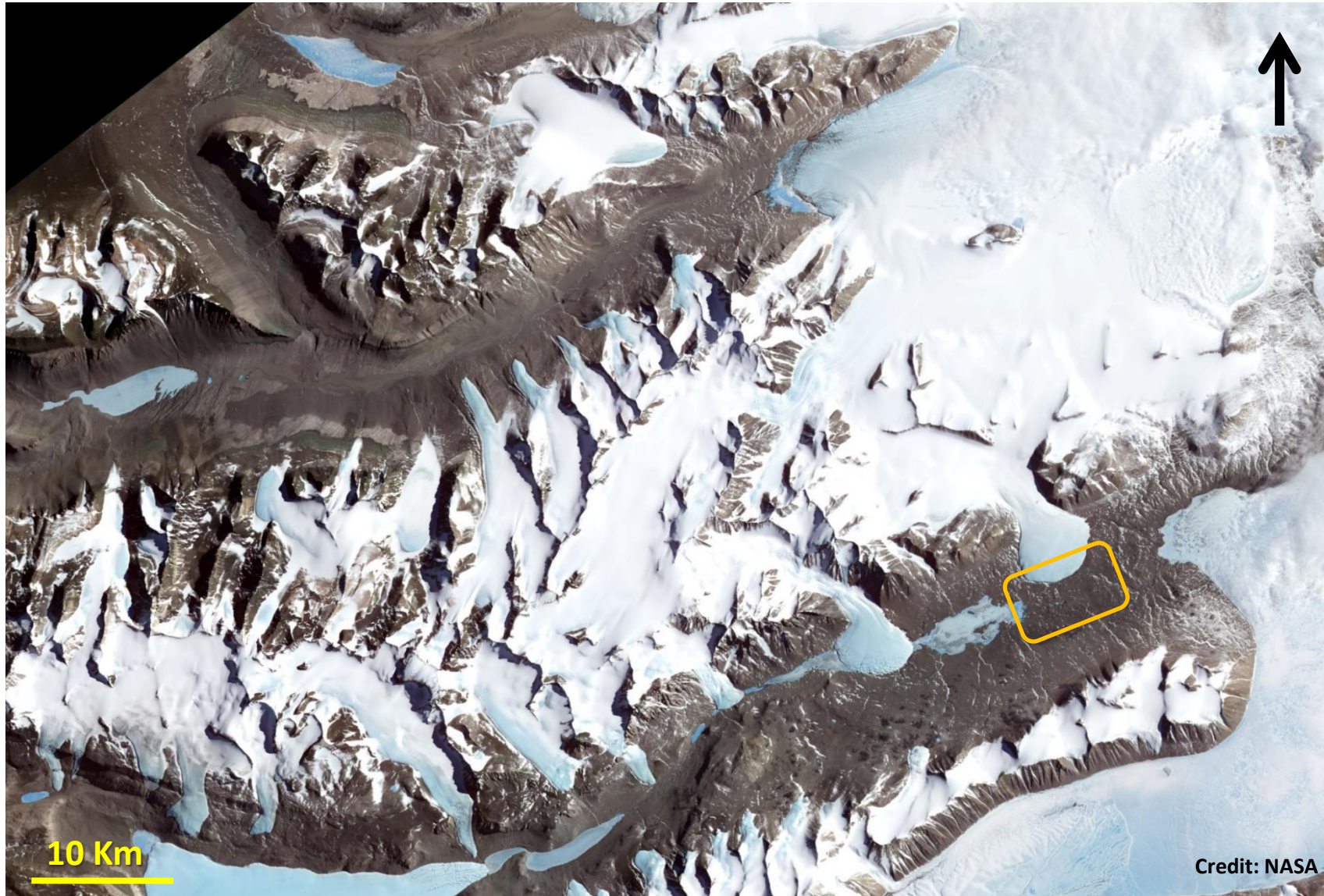
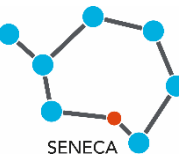
**125 gigatons of ice per year
sea level to rise by 0.35 mm/yr**



Mc Murdo Dry valleys Antarctica



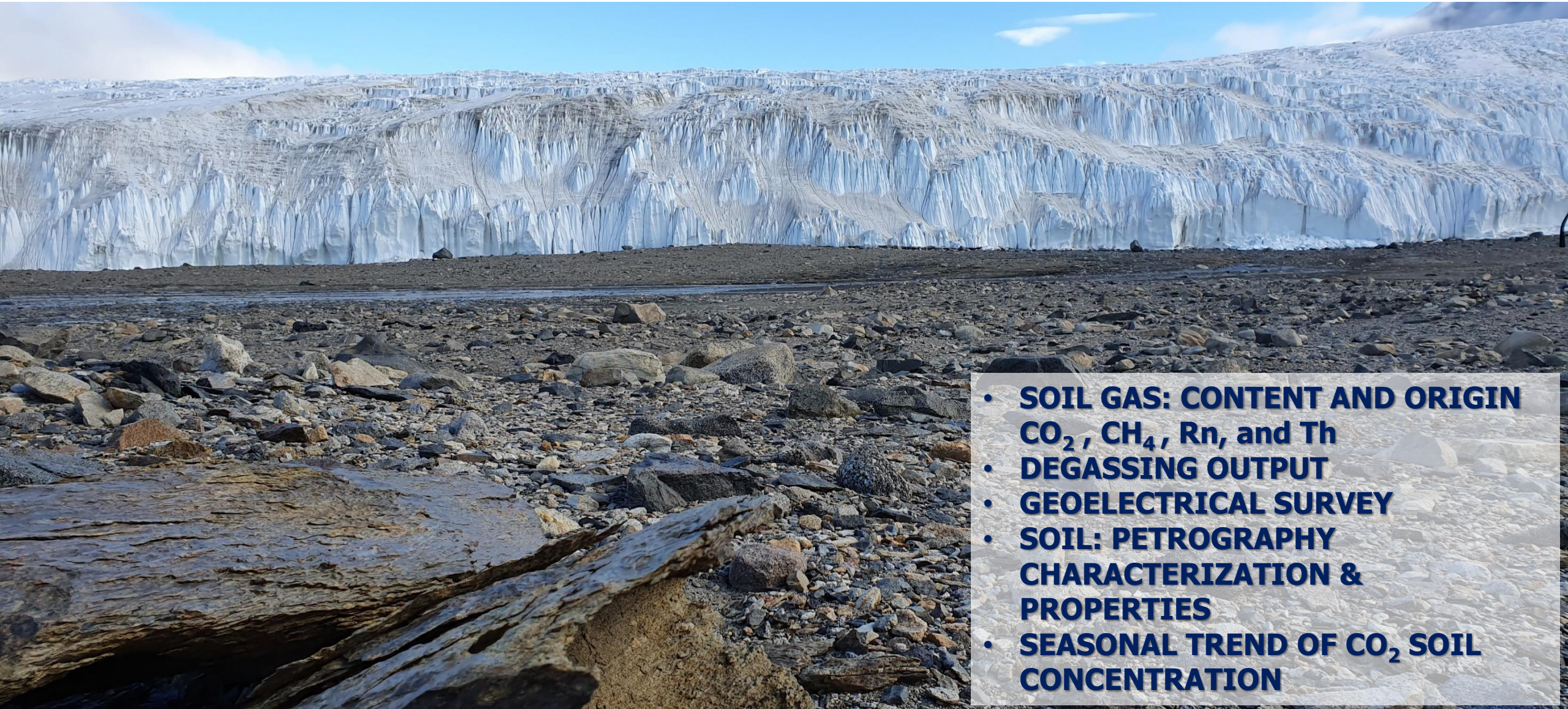
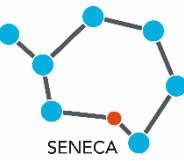
Mc Murdo Dry valleys Antarctica



- **Largest ice-free surface in Antarctica 4,800 km².**
- **Mean annual $-30 < T < -5^{\circ}\text{C}$**
- **Annual precipitation < 100 mm water equivalent**
- **One of windiest places on Earth: Katabatic 320 km/h**
- **Climate: cold and extremely arid**

Studied area $\approx 20 \text{ km}^2$

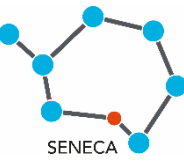
Planned activities



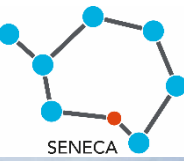
- **SOIL GAS: CONTENT AND ORIGIN**
CO₂, CH₄, Rn, and Th
- **DEGASSING OUTPUT**
- **GEOELECTRICAL SURVEY**
- **SOIL: PETROGRAPHY**
CHARACTERIZATION &
PROPERTIES
- **SEASONAL TREND OF CO₂ SOIL**
CONCENTRATION



Geochemical activities

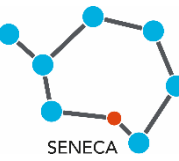


Water sampling and in situ measurements



- Isotopes (O, D)
- Anions
- Cations
- pH from 7.2 to 10.3
- Conductivity 93.2 to 4340 μS
- Microbial colonies thriving at stagnating waters

Monitoring probes installation

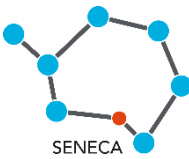


Long range winter monitoring

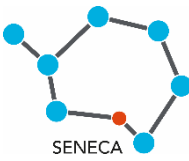
- CO₂
- Temp
- Atmospheric pressure



Soil CO₂ – CH₄ flux survey



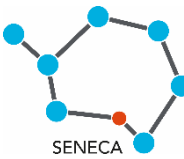
Soil and Permafrost sampling



- **Sampled sediments for grainsize and petrography**
- **Sampled permafrost for TOC**
- **Permafrost contains CO₂ and CH₄ after thawing**



Gas sampling + Radon-Thoron Survey



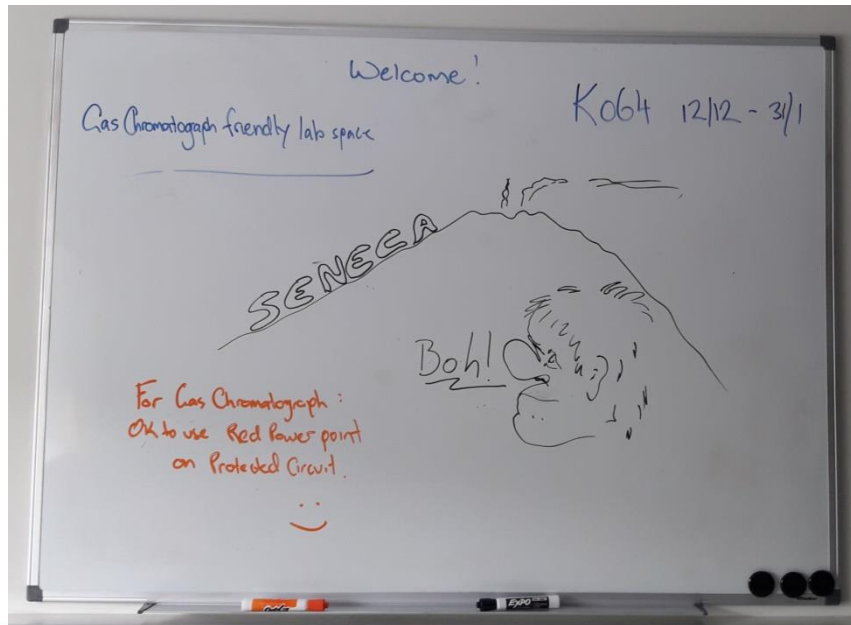
Gas samples from 30-40 cm depth analysed in the laboratory in Antarctica

- **Predominant gas CO_2 + CH_4**
- **Presence of Rn emissions from shallow regions**

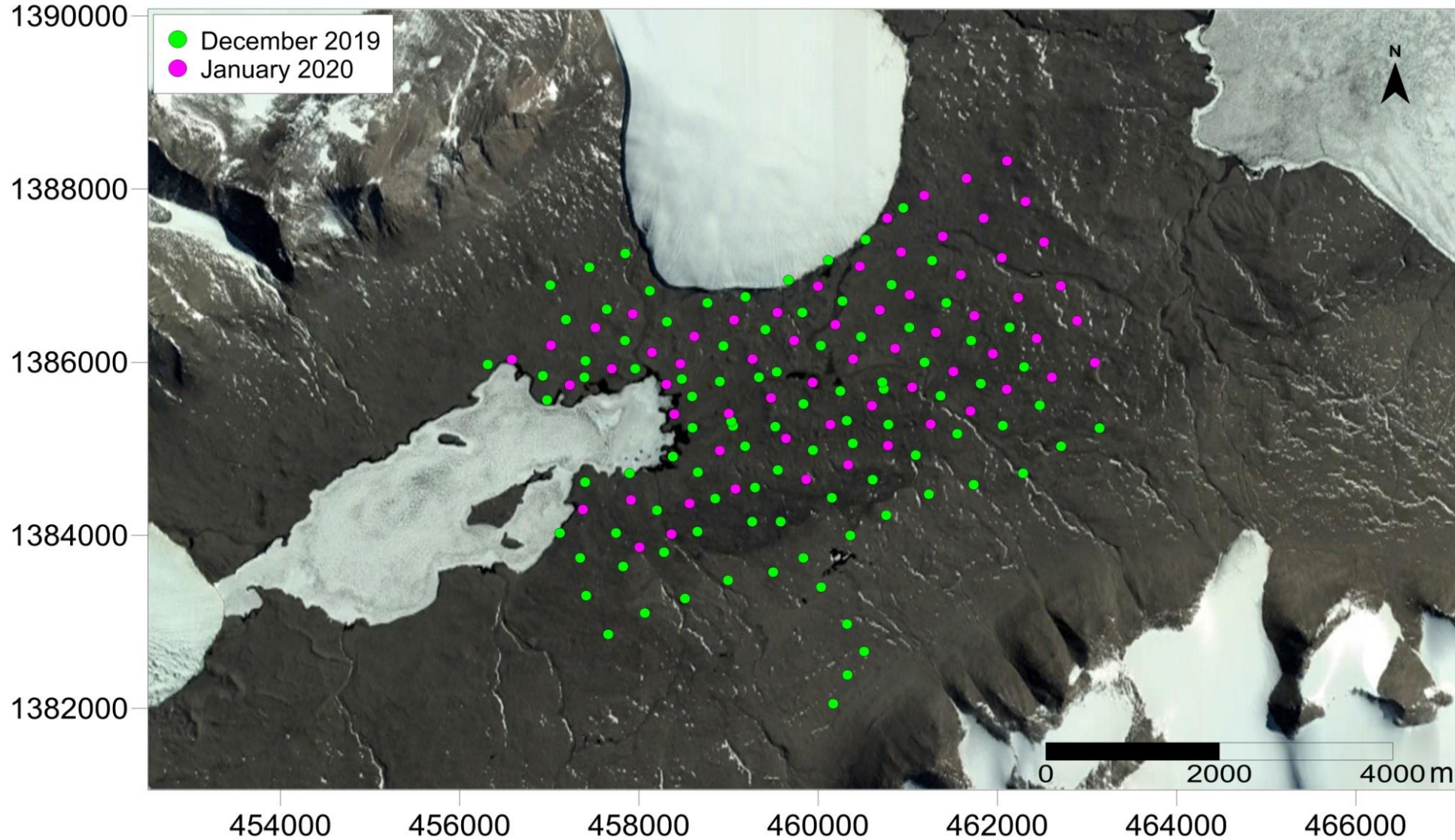
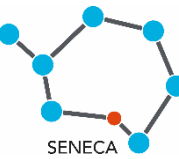


Scott Base lab

Gas samples, dissolved gas in the waters and permafrost are analysed directly in the Scott Base laboratory in Antarctica



Soil gas survey

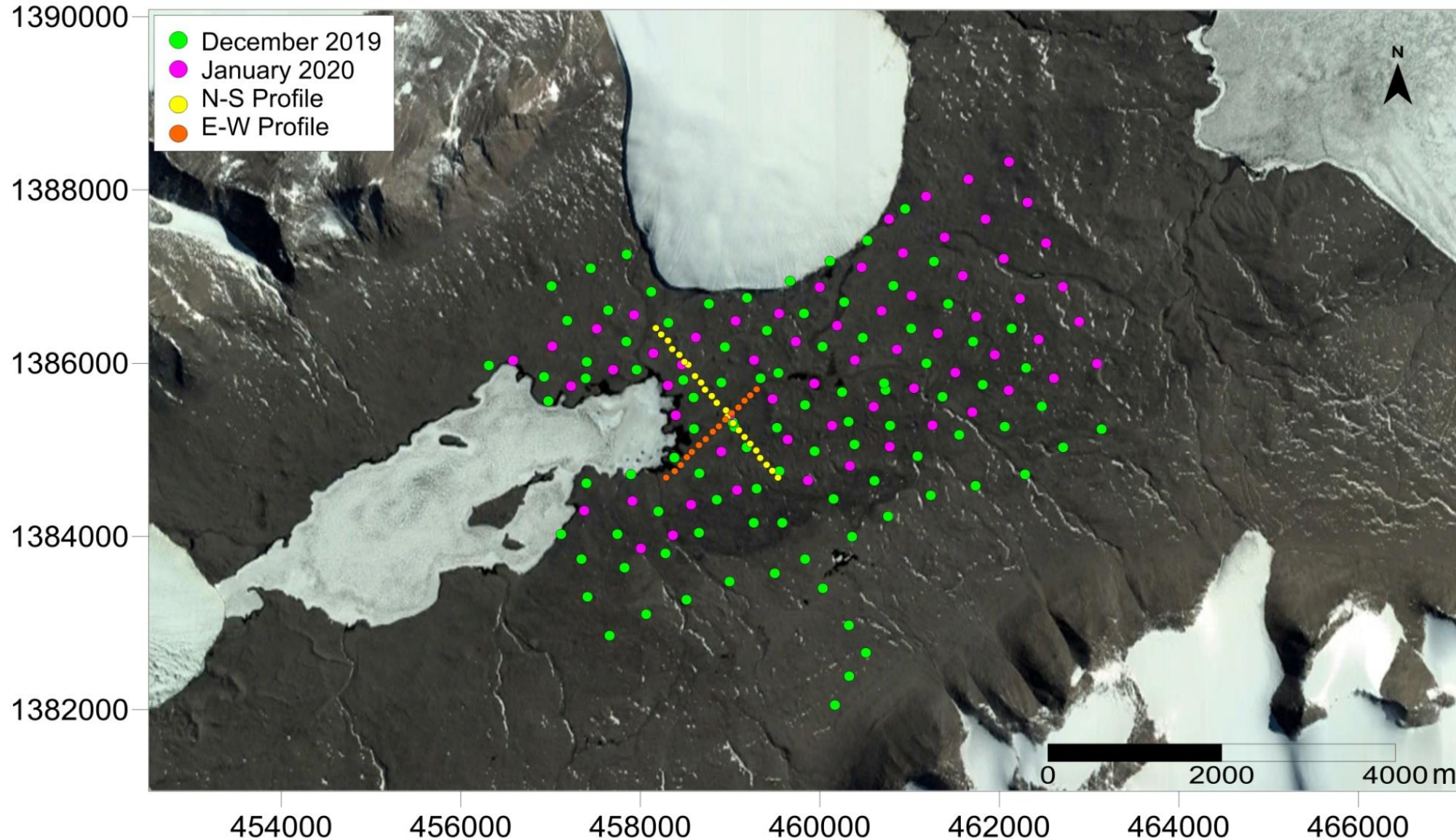
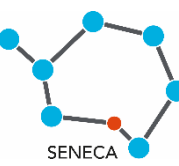


**Two grids
mesh 500 m
each**

**December
'warmer'**

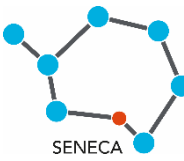
**January
'colder'**

Soil gas survey



**Additional 100
m spacing
profiles to
compare with
geoelectric
profiles**

Preliminary Results – Geochemical activities



Soil gas concentration survey

DECEMBER

CO₂ up to 34.389 ppm **CH₄** up to 3977 ppm

JANUARY

CO₂ up to 13.259 ppm **CH₄** up to 18446 ppm

CH₄ and **CO₂** are **present** in the sediments both during warmer and colder survey

Soil CO₂ – CH₄ flux survey

DECEMBER

CO₂ up to 4.35 g/m²d **CH₄** up to 40.2 mg/m²d

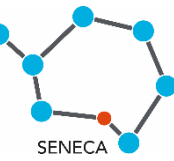
JANUARY

CO₂ up to 11.6 g/m²d **CH₄** up to 40.8 mg/m²d

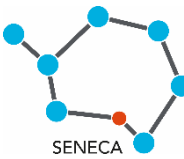
Increase in **CO₂** flux in January (colder survey).
Stable flux of **CH₄** in December & January (warmer survey)



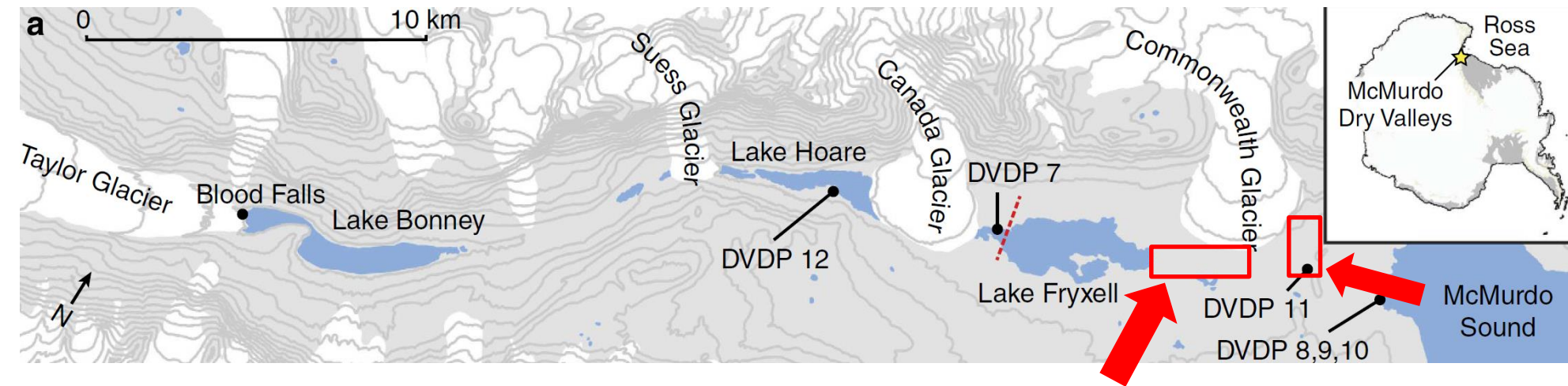
Geoelectrics activities



GEOELECTRICAL SURVEY IN THE TAYLOR VALLEY (ANTARCTICA)



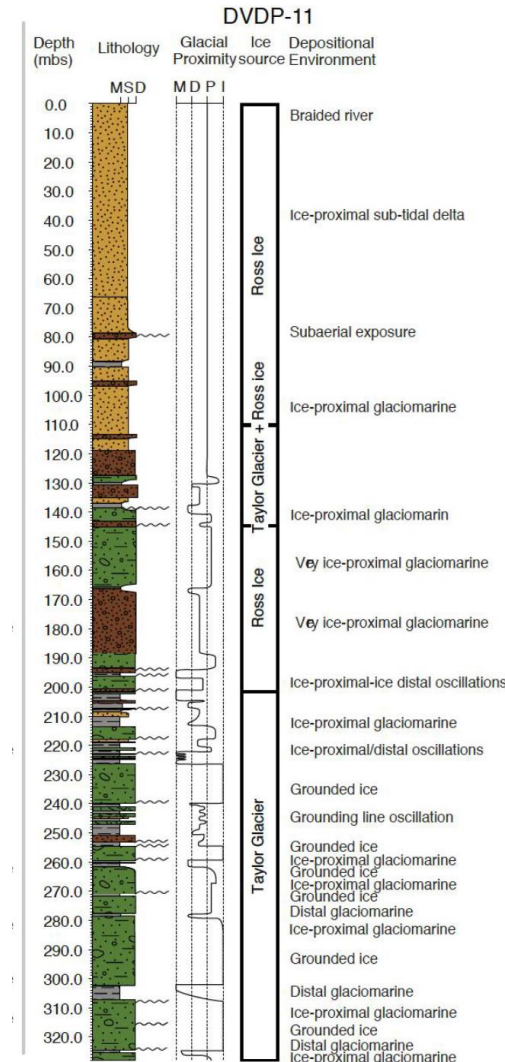
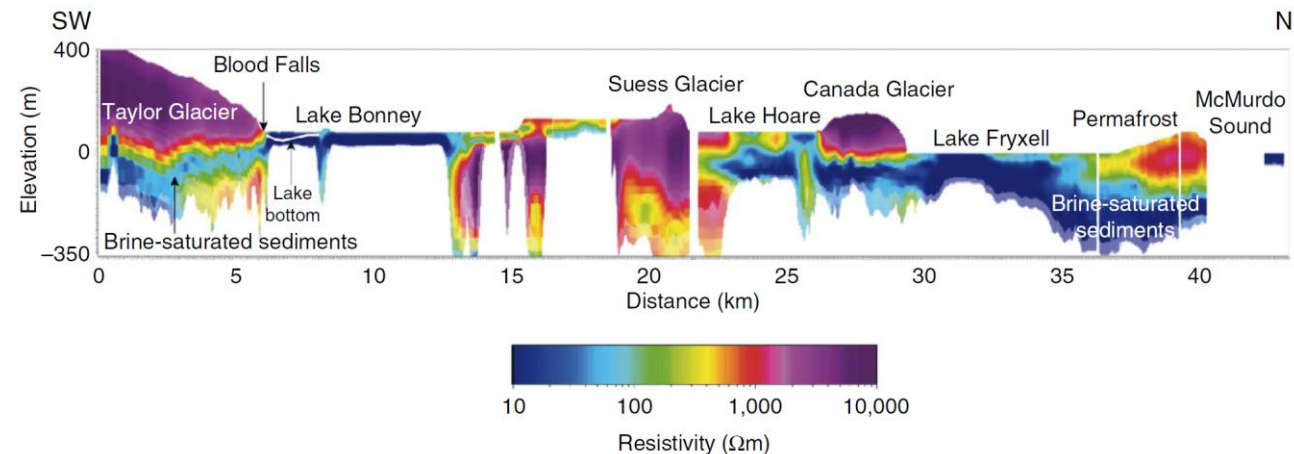
We performed a 2D geoelectrical survey to map the depth of the permafrost and the electrical properties of the subsurface



Mikucki et al., (2014)

We selected two survey areas according to:

- The distribution of the resistivity values from previous studies
- Correlation with borehole data (DVDP 11, ~320 m deep)
- Logistic constraints



Field apparatus

We used the Fullwaver system (Gance et al., 2018, Lajaunie et al., 2018).

Current is injected through an induced polarization transmitter, (VIP 5000, IRIS Instruments). An external generator provides current for the VIP. The receiving nodes record continuously the electrical field and the injection electrodes can be moved inside and outside the receiving nodes with any type of electrode array configuration. Injected current is recorded on real time on the I-Fullwaver.



a) Transmitter-VIP



b) I-fullwaver

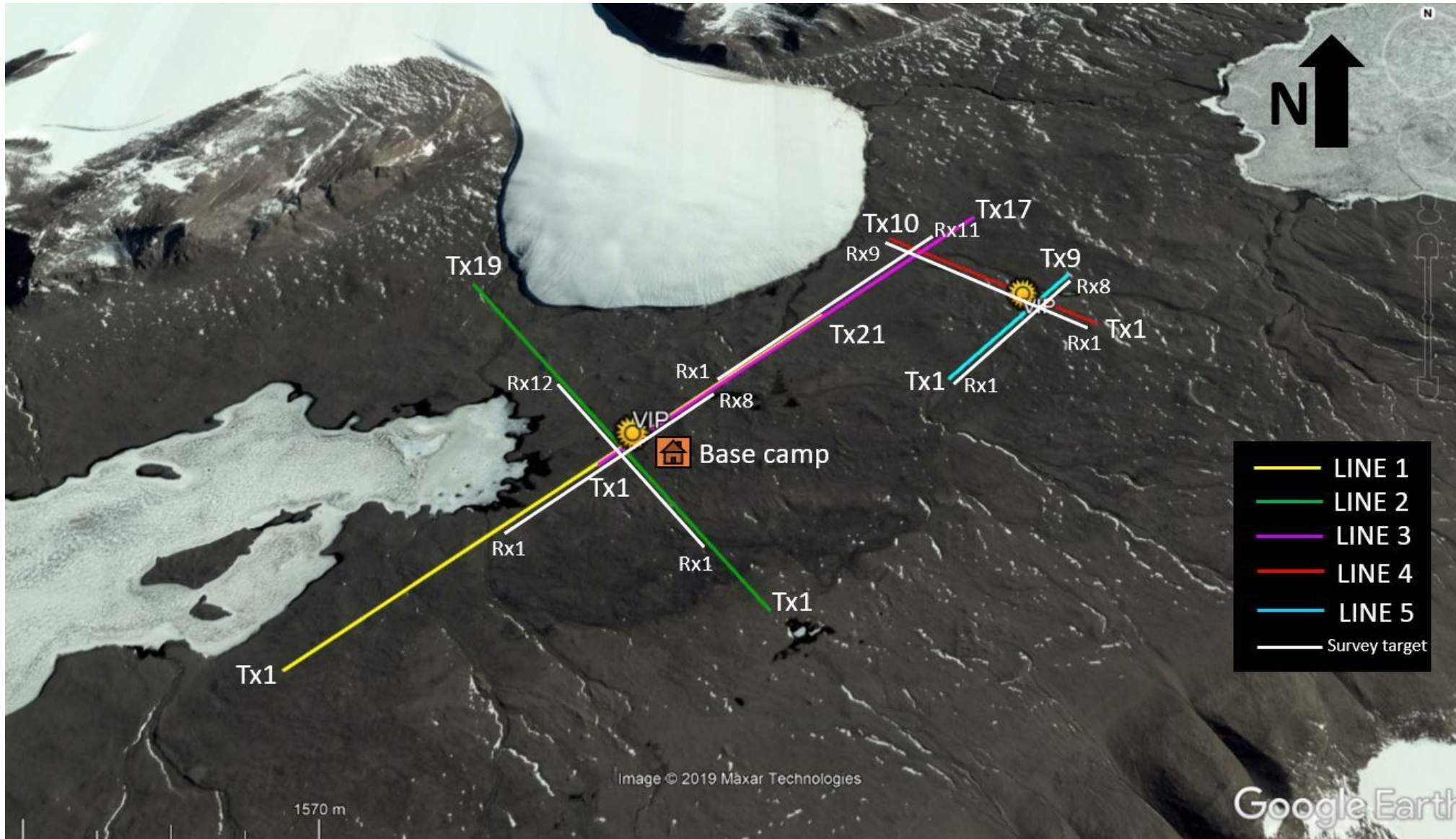
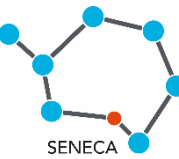


c) V-fullwaver



- one induced polarization transmitter (VIP)
- one current measurement unit called I-Fullwaver
- a set of 2-channels independent receiving nodes called V-Fullwavers
- a motor generator

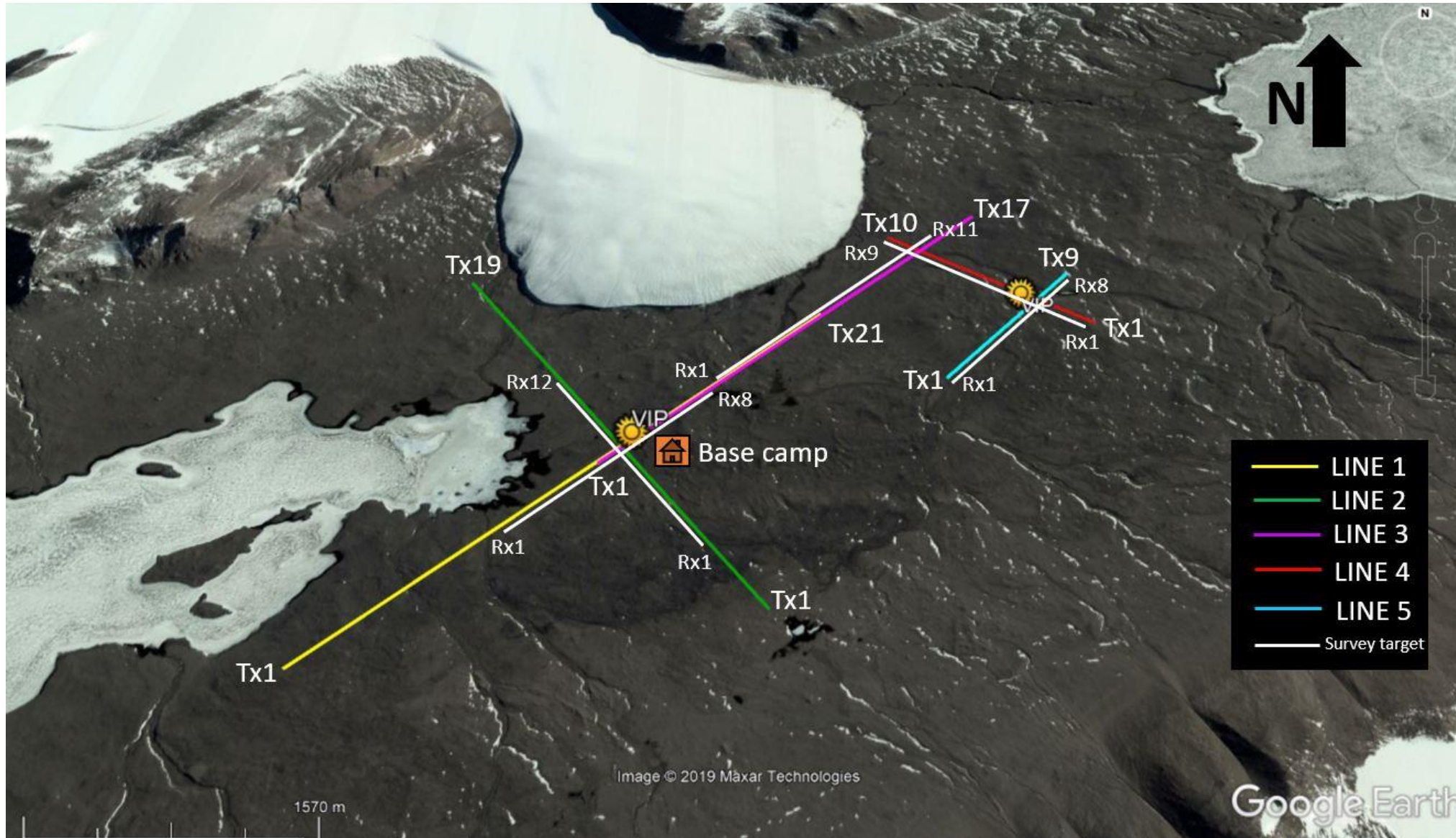
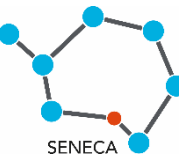
Geoelectrical survey



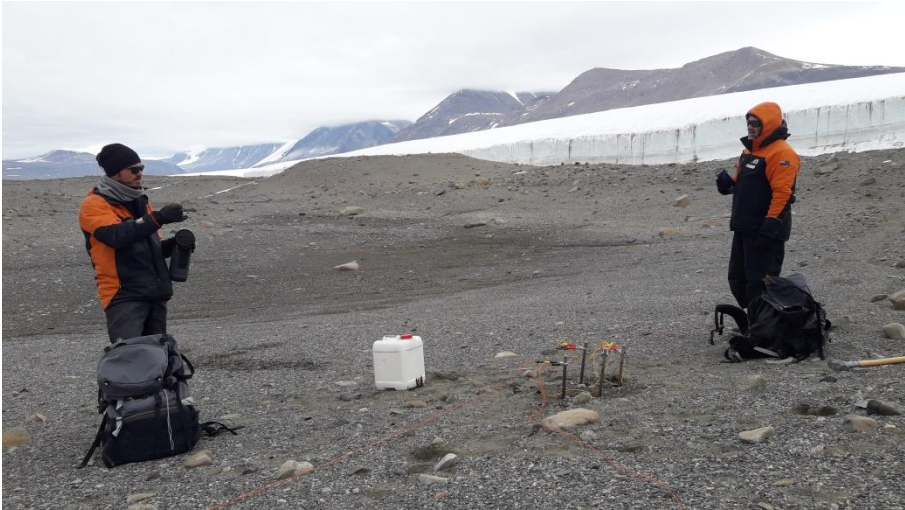
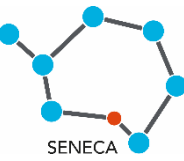
AIMS

- Investigate sediments properties
- Define permafrost base
- Calibrate results with available boreholes

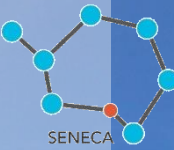
Survey design



Geoelectrics deployment



Conclusions



- **CH₄ and CO₂** present in the thawed permafrost
- Emission rates **dependant** on **T variations**
- First ever **emission estimate** for CH₄ and CO₂ in Southern Polar Hemisphere
- **Benchmark** for future measurements
- Map preferential gas release **pathways**
- Define **thickness of permafrost** using geoelectrical data
- Investigate **mechanisms** of gas migration through the shallow sediments



Thank you

