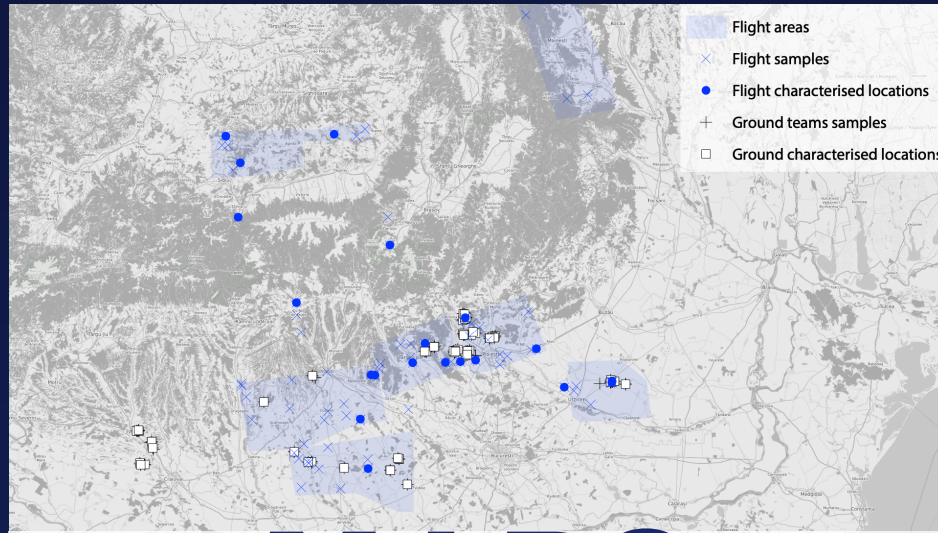


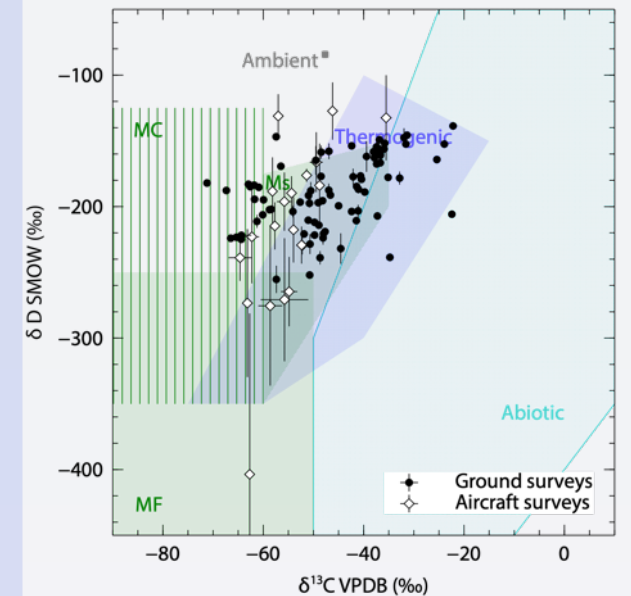
# CH<sub>4</sub> ISOTOPES DURING ROMEO

ISOTOPIC CHARACTERISATION OF METHANE EMISSIONS FROM OIL AND GAS OPERATION IN ROMANIA



## MAPS

## ISOTOPE DIAGRAMS



## PICTURES

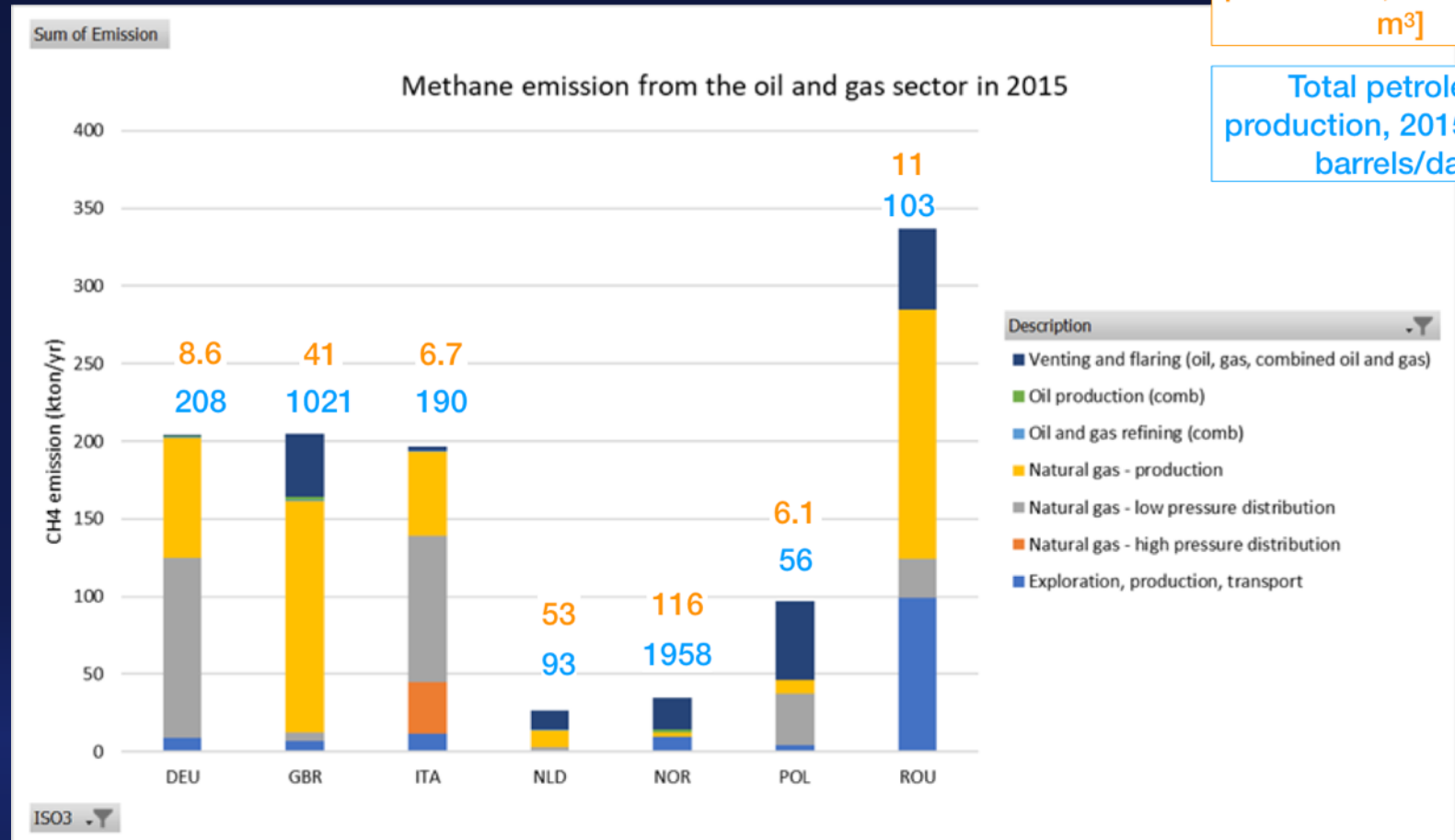


→ CONCLUSIONS  
→ CONTACT

- Oil and gas operations in Romania?
- 13 research teams
- Use of CH<sub>4</sub> isotopes
- From atmospheric samples to signatures

# CH<sub>4</sub> EMISSIONS IN ROMANIA?

- Historical oil and gas production
- Reported emissions are uncertain



Dry natural gas  
production, 2015, in [10<sup>9</sup>  
m<sup>3</sup>]

Total petroleum  
production, 2015, in [10<sup>3</sup>  
barrels/day]



# THE ROMEO CAMPAIGN

- Partners involved from UHEI (Heidelberg), AGH (Krakow), RUG (Groningen, NL), EMPA (Zürich), DTU (Copenhagen), LU (Lund), TNO (Netherlands), Scientific aviation (Boulder, CO), INCAS (Bucharest), UBB (Cluj)
- 21 days, 70 people:

**2 aircrafts**

**8 ground vehicles**

**2 drones**



# WHY INVESTIGATING CH<sub>4</sub> ISOTOPES DURING ROMEO?

- Confirm that emissions are from fossil fuel operations
- Characterise the source type
- Identify potential other sources, and not obvious sources
- Better understand the budget on a larger scale



# THE KEELING PLOT APPROACH

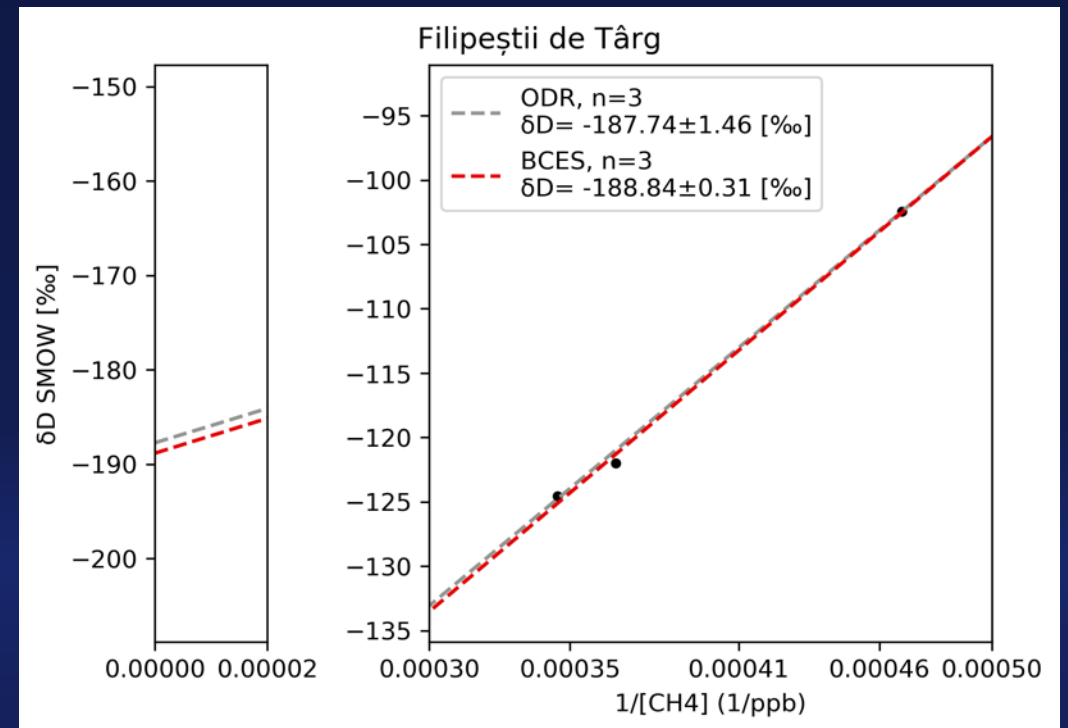
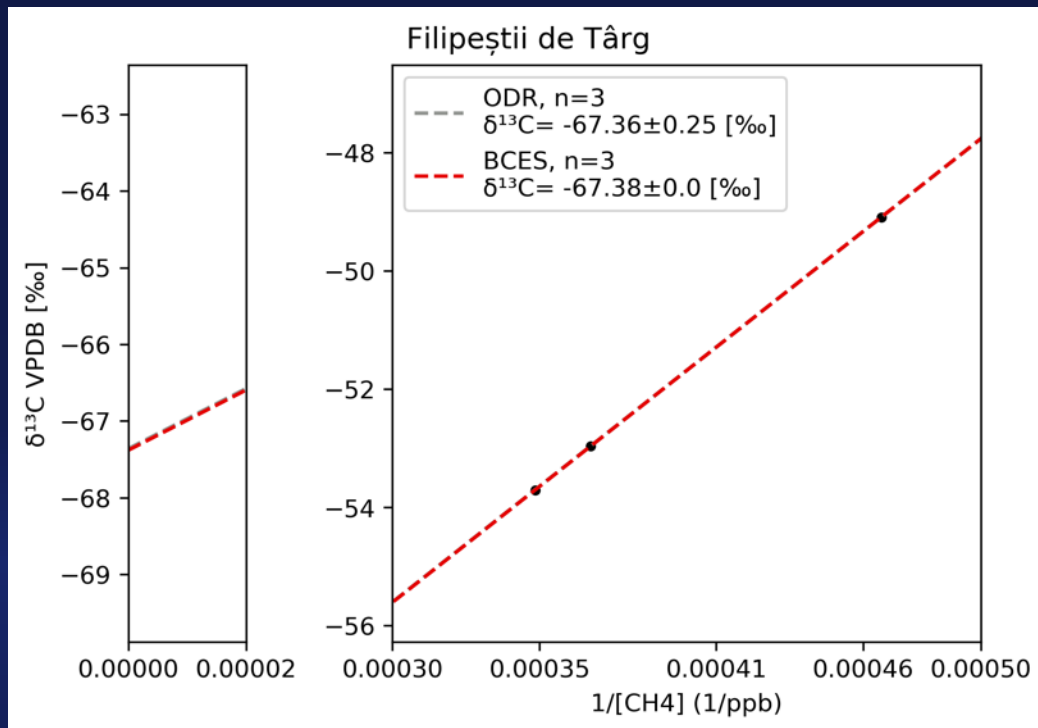
**Goal:** calculate the isotopic signature  $\delta^{13}\text{C}$  and  $\delta\text{D}$  of the  $\text{CH}_4$  source.

$$\delta_{\text{measured}} = C_{bg} (\delta_{bg} - \delta_{\text{source}}) (1/C_{\text{measured}}) + \delta_{\text{source}}$$

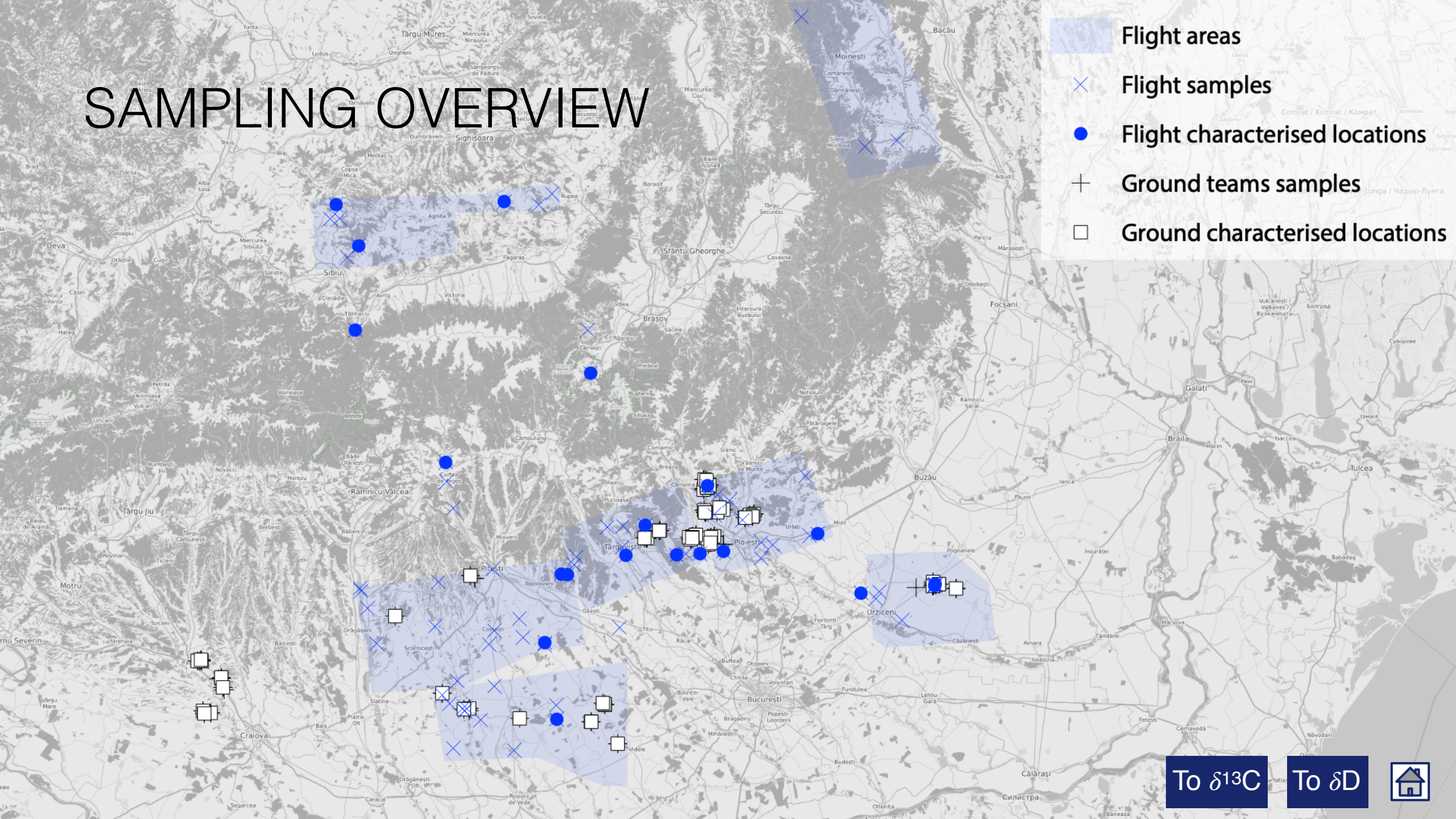
Example at one location:

$\delta^{13}\text{C} = -67.36 \text{ ‰ V-PDB}$

$\delta^{13}\text{C} = -187.7 \text{ ‰ V-SMOW}$



# SAMPLING OVERVIEW

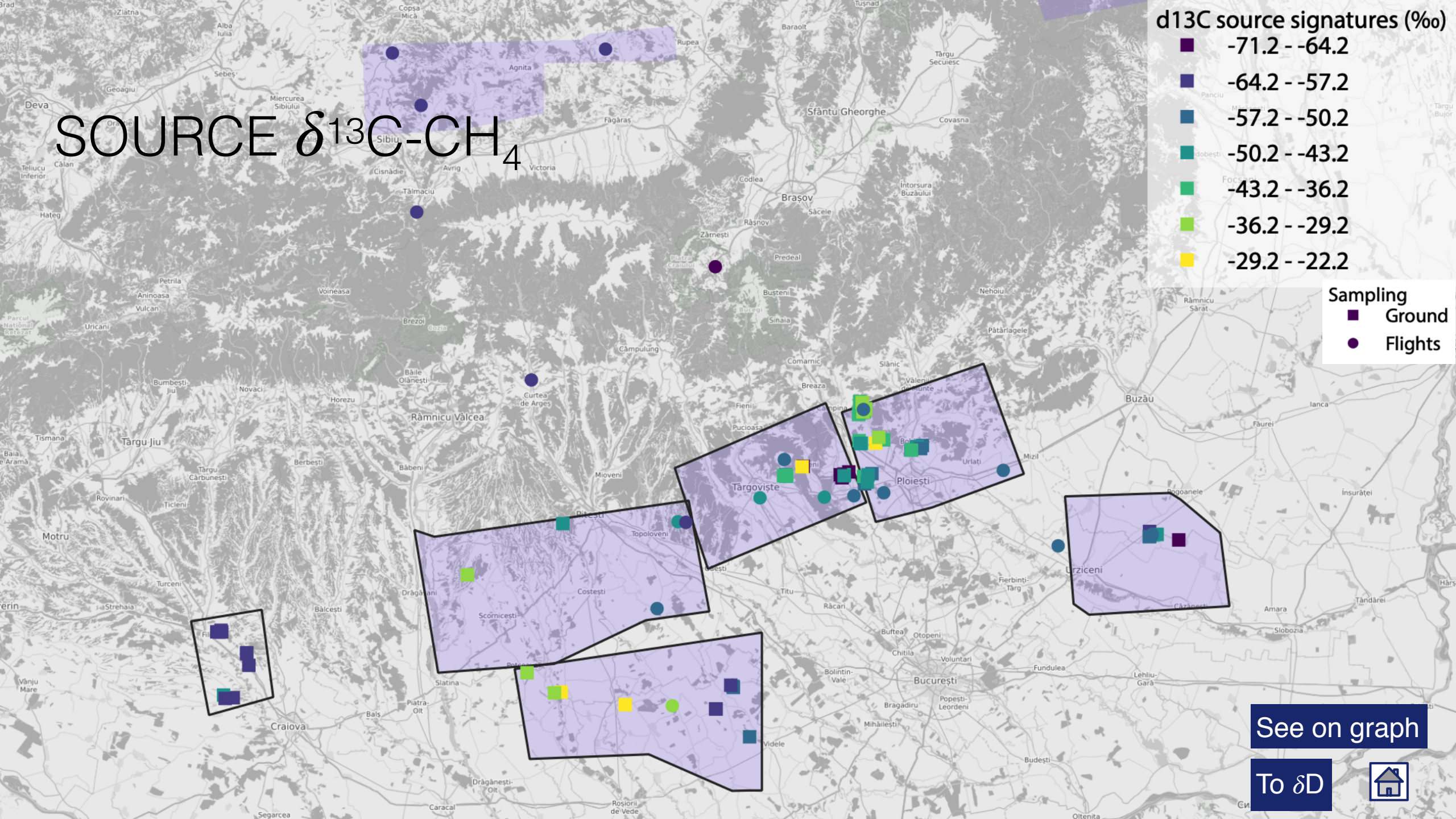
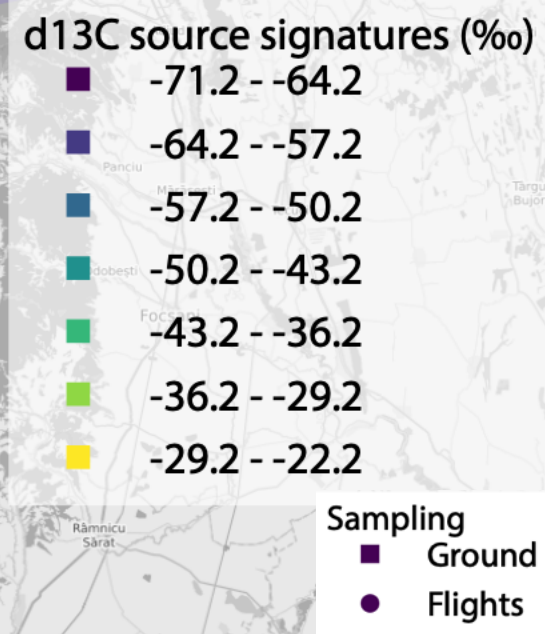


To  $\delta^{13}\text{C}$

To  $\delta\text{D}$



# SOURCE $\delta^{13}\text{C}$ -CH<sub>4</sub>

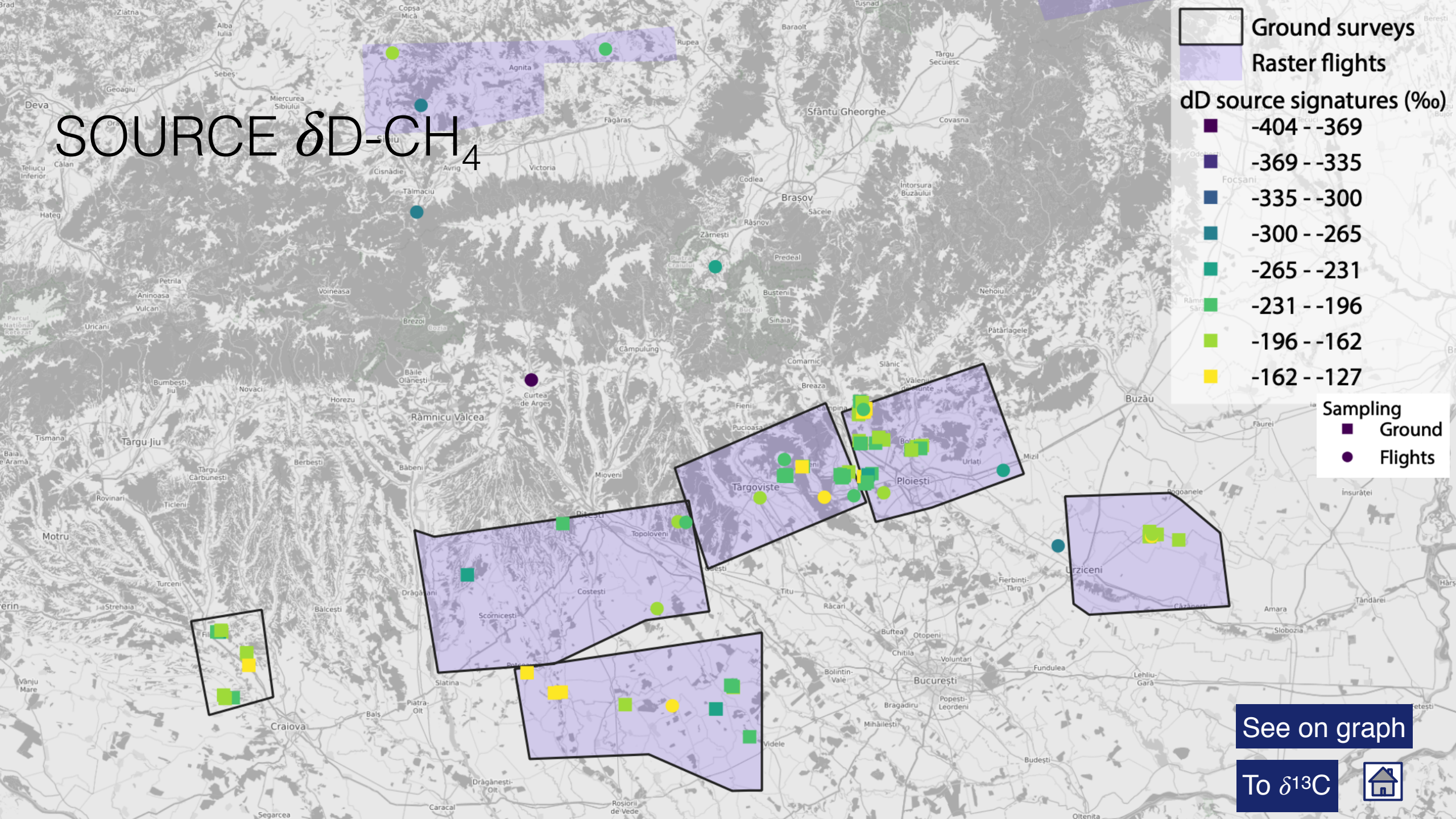
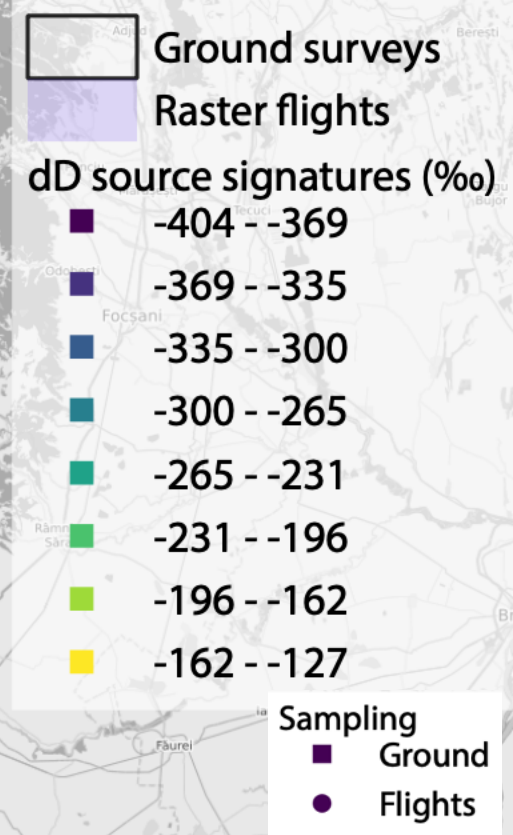


See on graph

To  $\delta\text{D}$



# SOURCE $\delta D-CH_4$

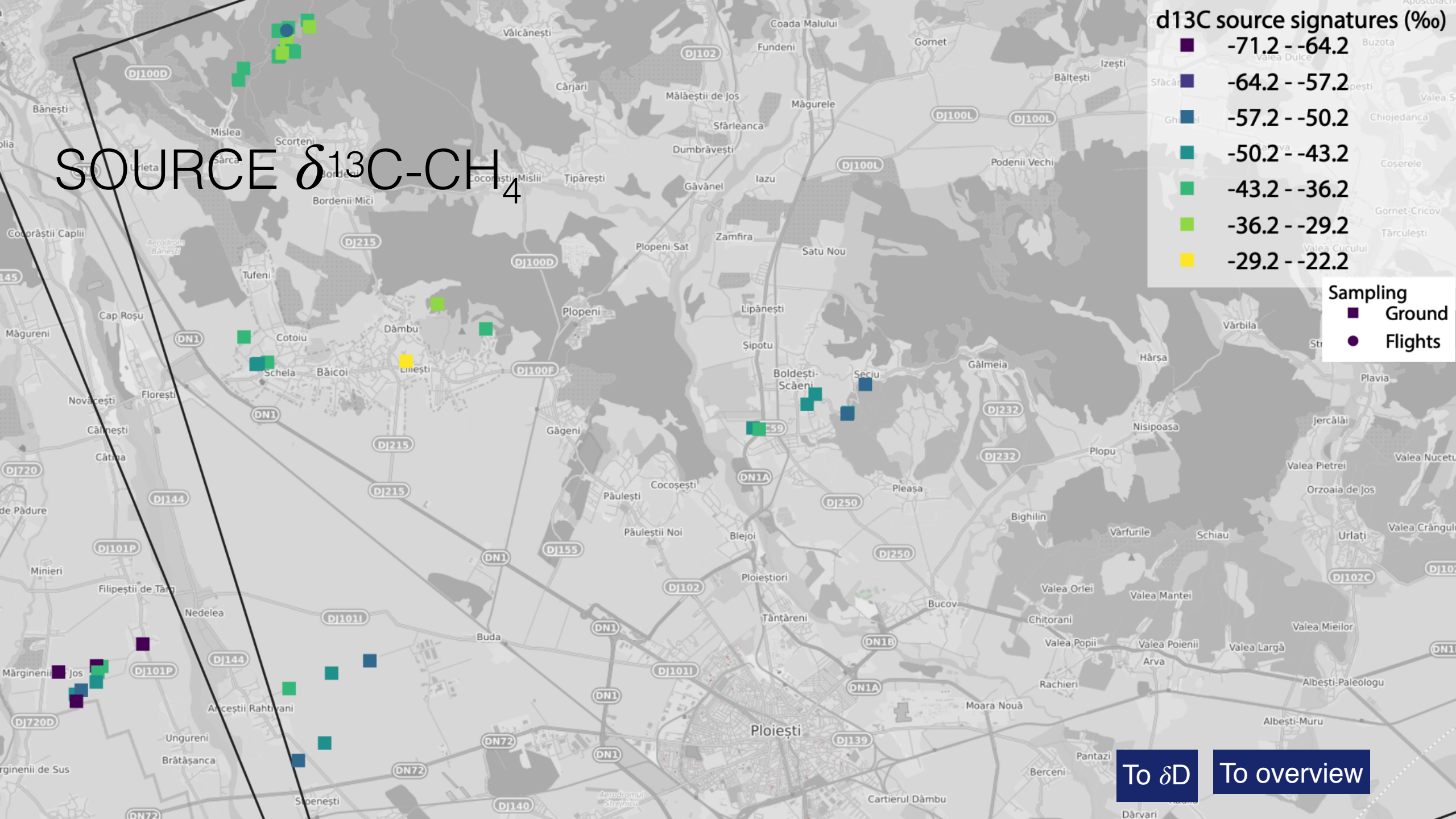
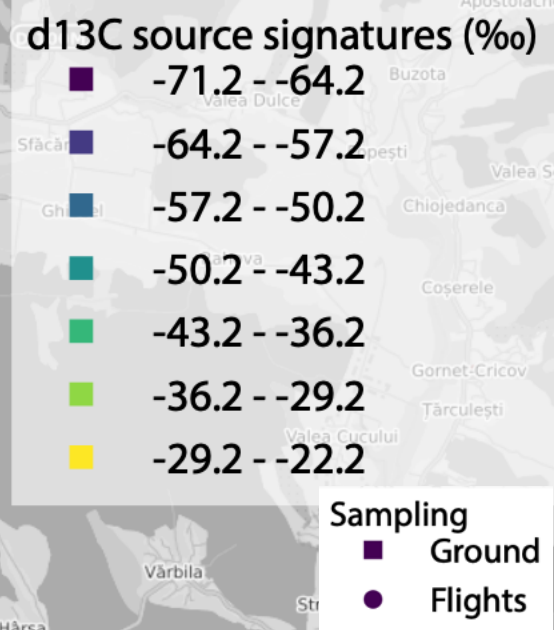


See on graph

To  $\delta^{13}C$



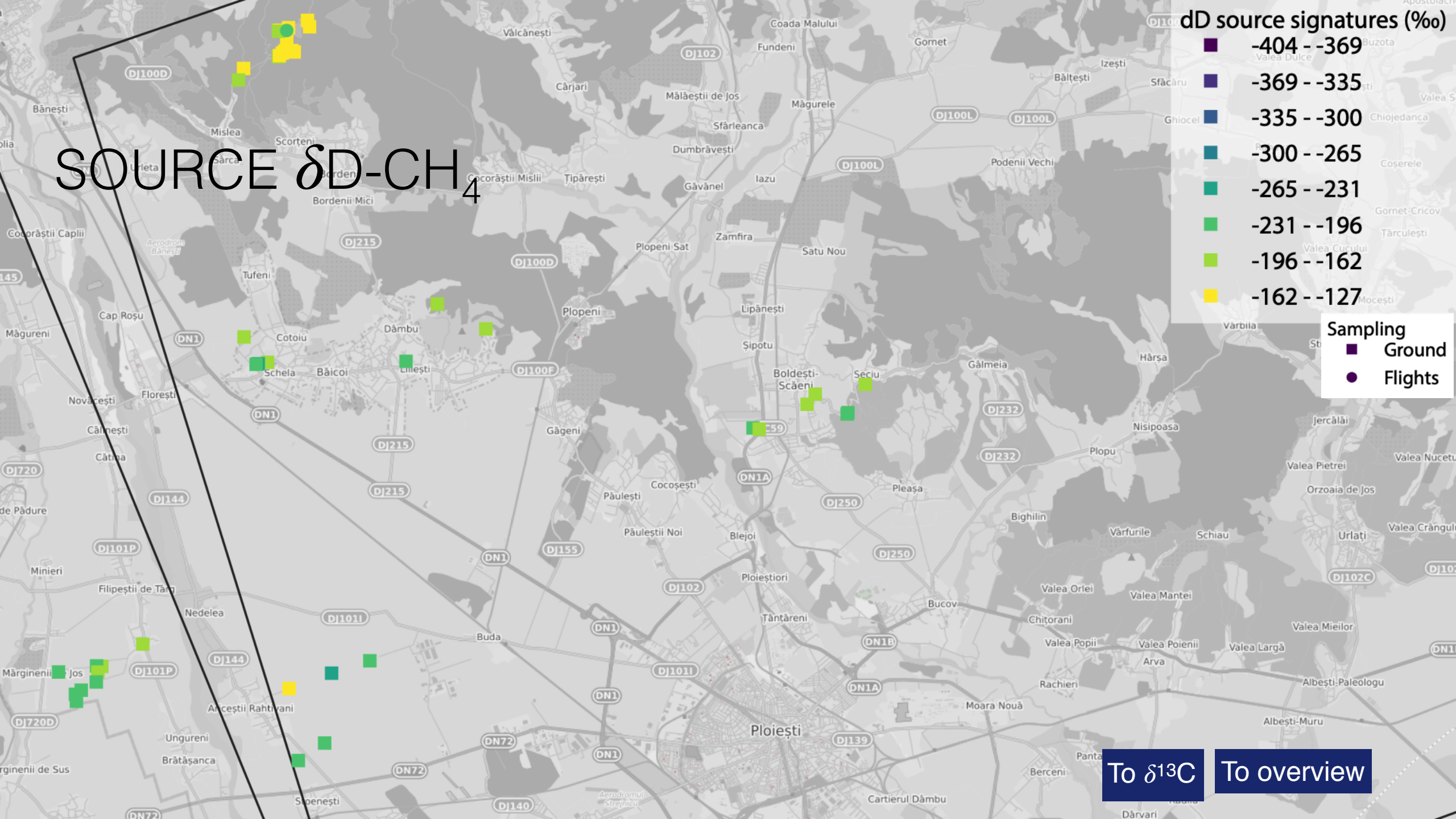
# SOURCE $\delta^{13}\text{C}-\text{CH}_4$



To  $\delta\text{D}$

To overview

# SOURCE $\delta D-CH_4$



# SOURCE $\delta^{13}\text{C}-\text{CH}_4$

## d13C source signatures (‰)

- -71.2 - -64.2
- -64.2 - -57.2
- -57.2 - -50.2
- -50.2 - -43.2
- -43.2 - -36.2
- -36.2 - -29.2
- -29.2 - -22.2

## Sampling

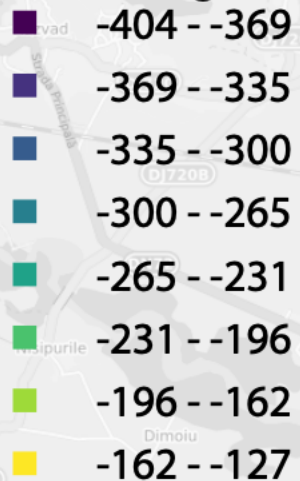
- Ground
- Flights

To  $\delta\text{D}$

To overview

# SOURCE $\delta D-CH_4$

## dD source signatures (‰)

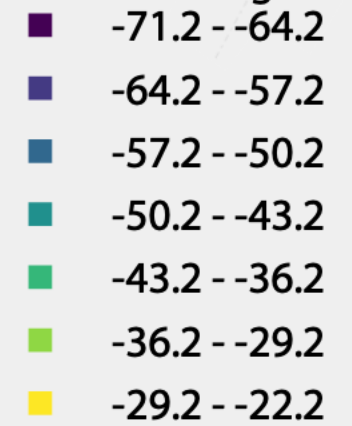


Sampling  
■ Ground  
● Flights

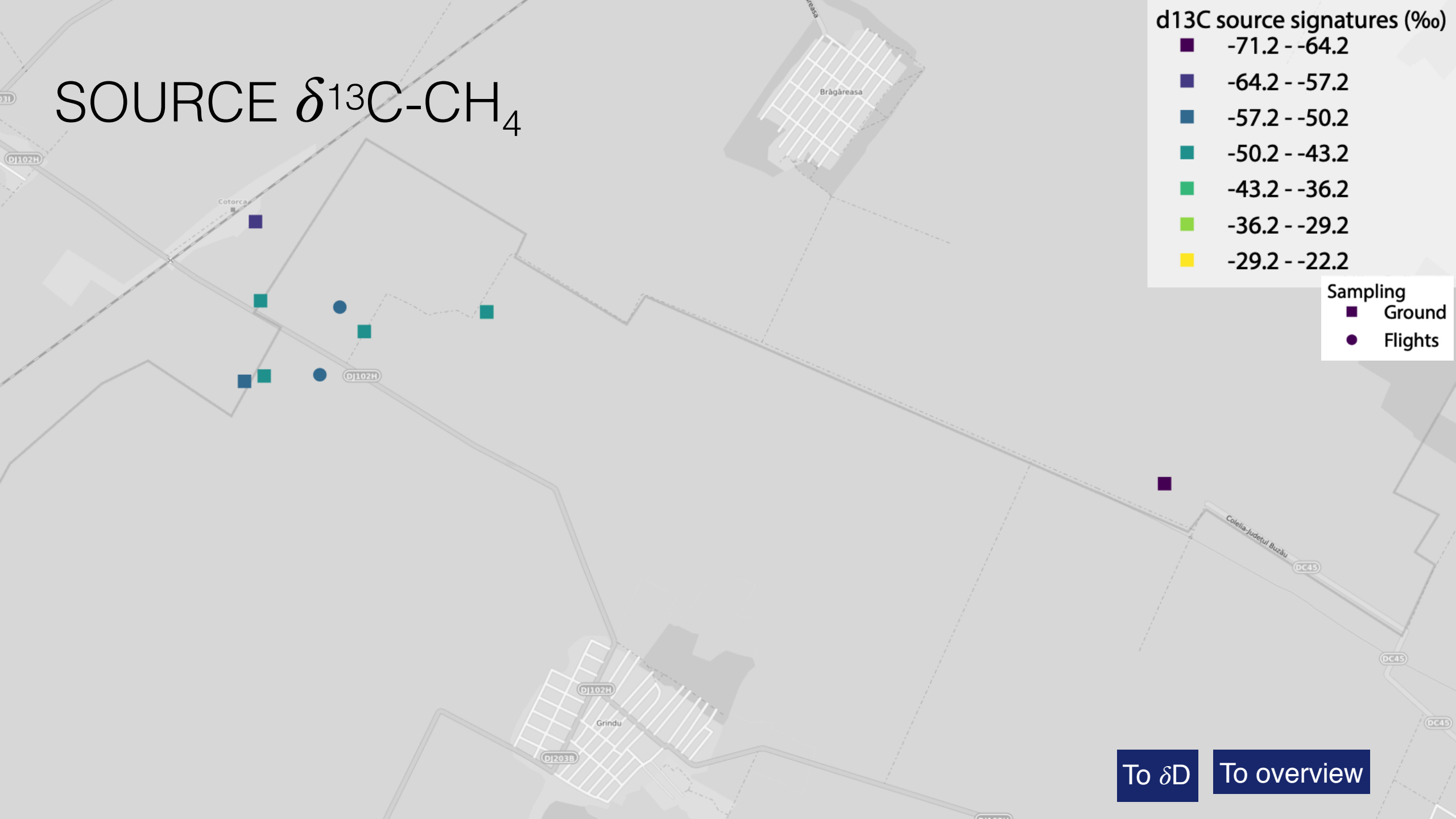
[To  \$\delta^{13}C\$](#)  [To overview](#)

# SOURCE $\delta^{13}\text{C}\text{-CH}_4$

d13C source signatures (‰)



Sampling  
■ Ground  
● Flights



[To  \$\delta\text{D}\$](#)

[To overview](#)

# SOURCE $\delta D-CH_4$

dD source signatures (‰)

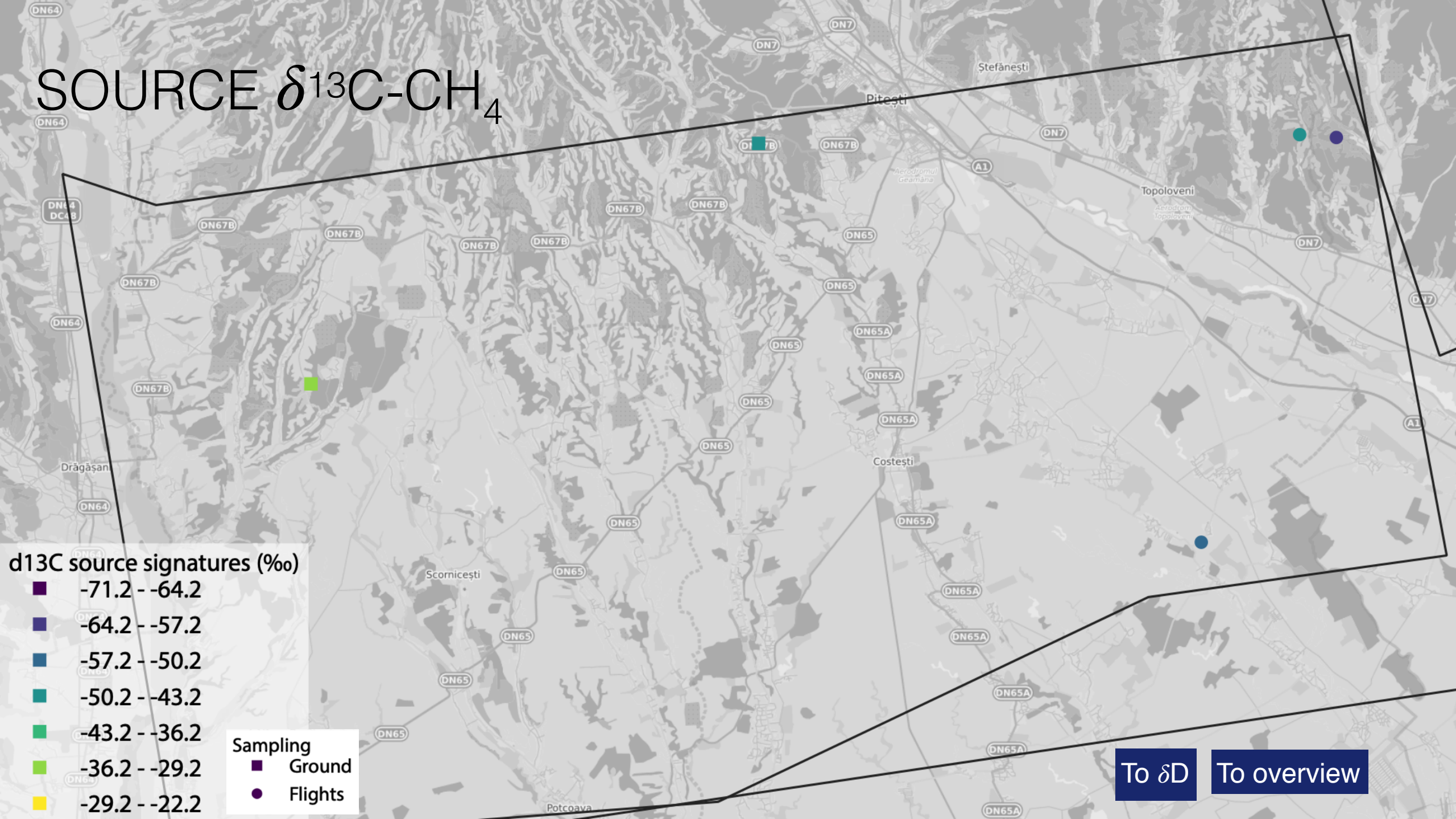
- -404 -- -369
- -369 -- -335
- -335 -- -300
- -300 -- -265
- -265 -- -231
- -231 -- -196
- -196 -- -162
- -162 -- -127

Sampling  
■ Ground  
● Flights

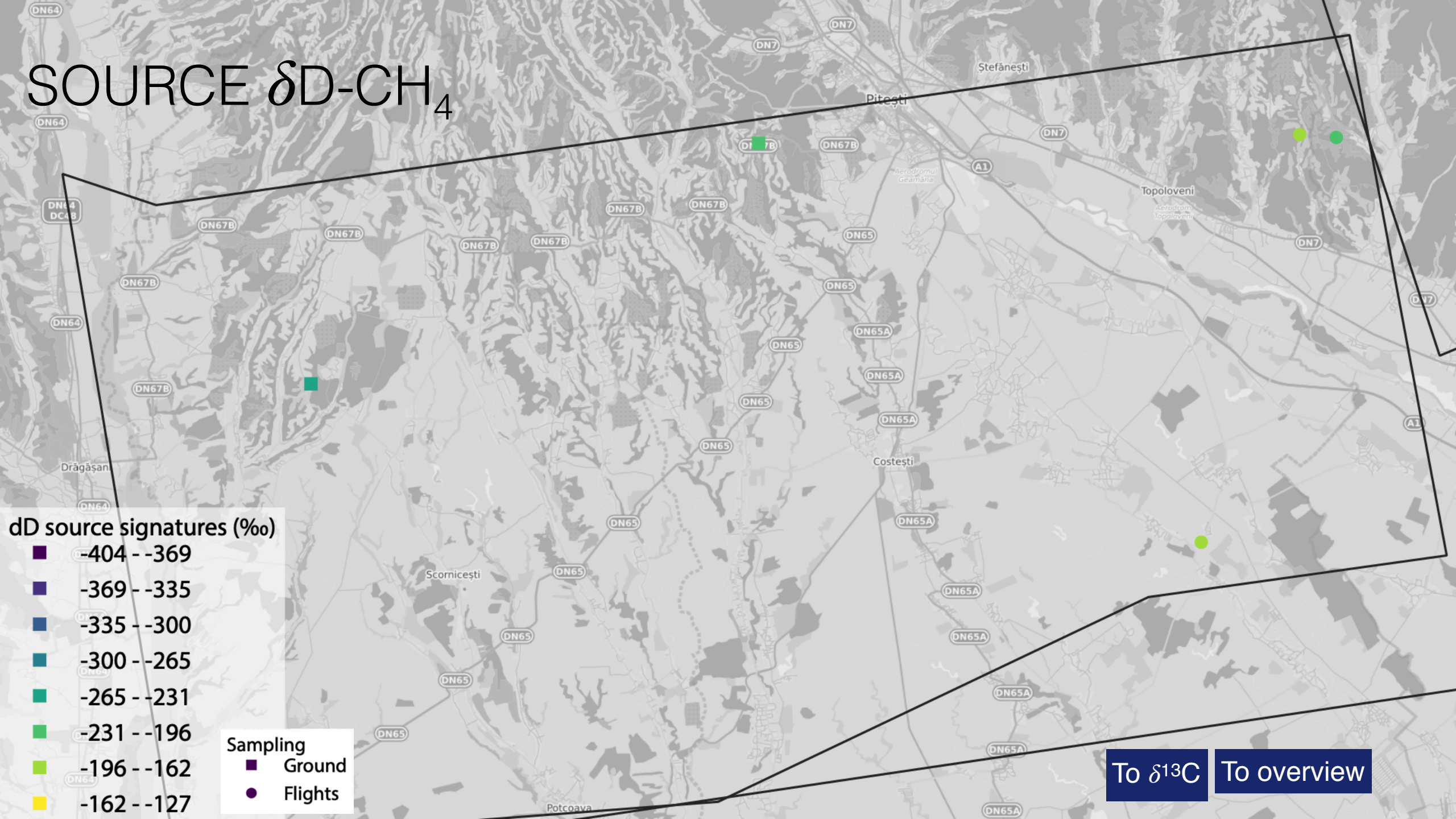
[To  \$\delta^{13}C\$](#)

[To overview](#)

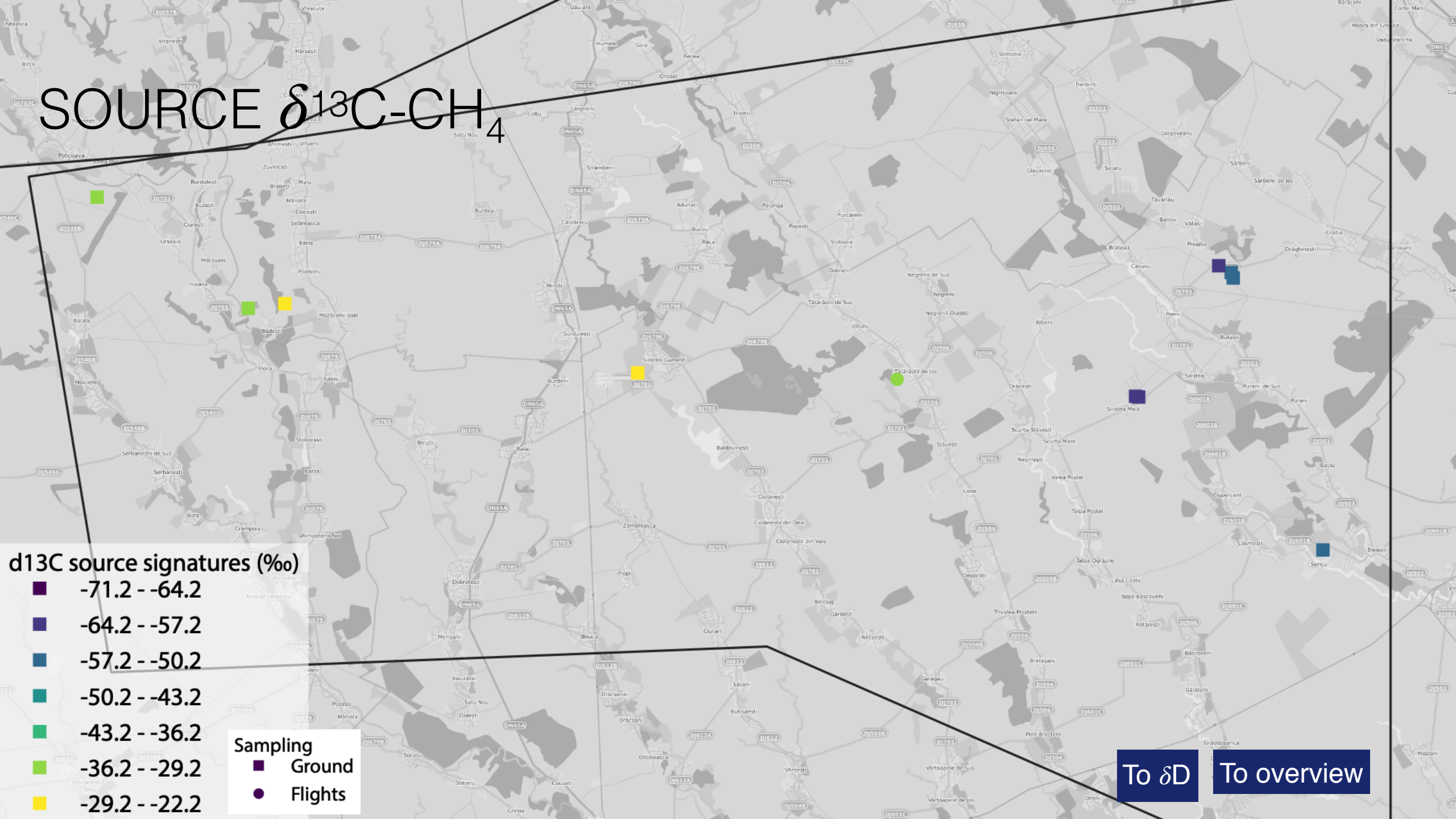
# SOURCE $\delta^{13}\text{C}$ -CH<sub>4</sub>



# SOURCE $\delta D-CH_4$



# SOURCE $\delta^{13}\text{C}$ -CH<sub>4</sub>



# SOURCE $\delta D-CH_4$

## dD source signatures (‰)

- -404 -- -369
- -369 -- -335
- -335 -- -300
- -300 -- -265
- -265 -- -231
- -231 -- -196
- -196 -- -162
- -162 -- -127

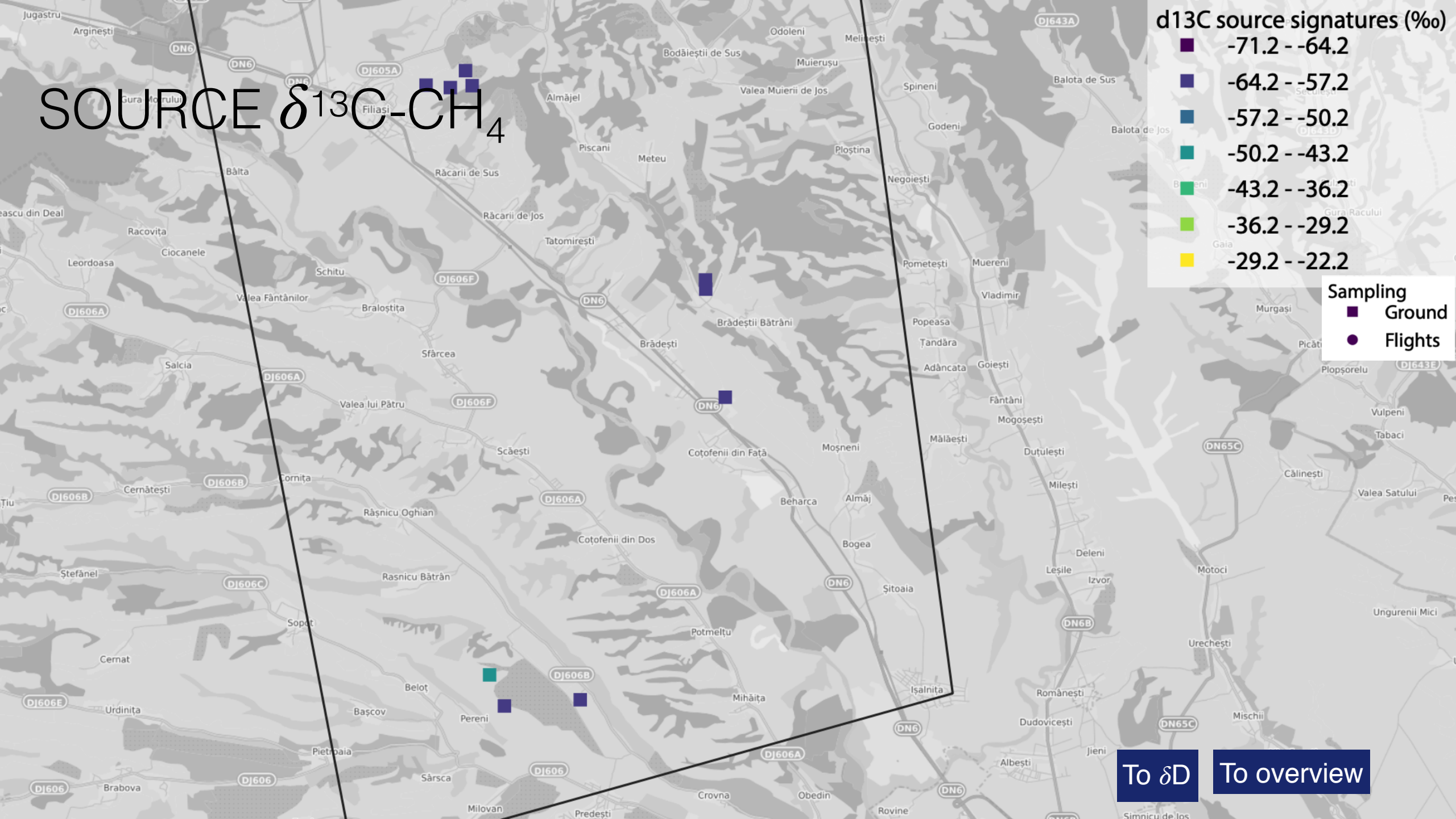
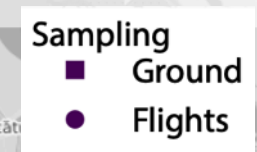
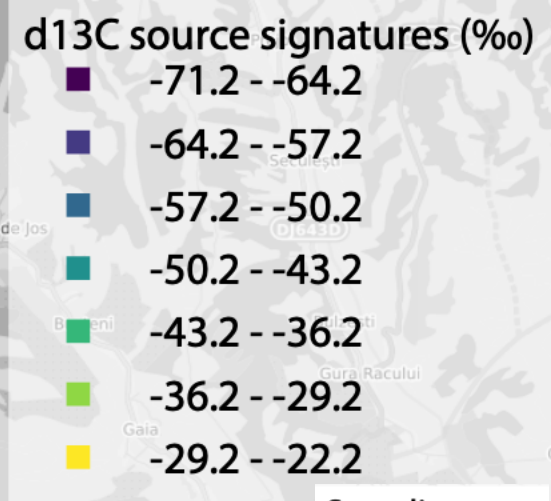
### Sampling

- Ground
- Flights

To  $\delta^{13}C$

To overview

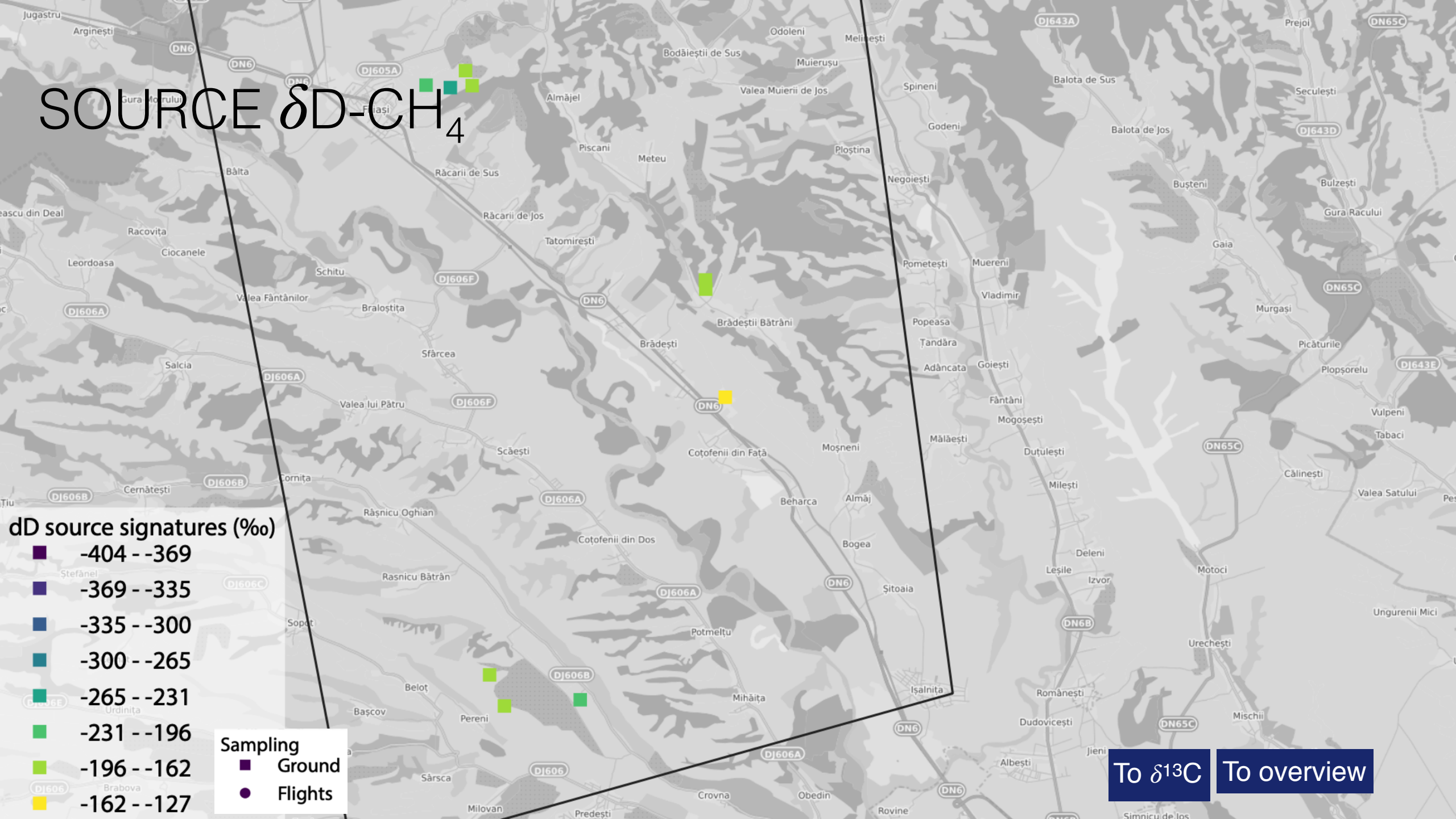
# SOURCE $\delta^{13}\text{C}$ -CH<sub>4</sub>



To  $\delta\text{D}$

To overview

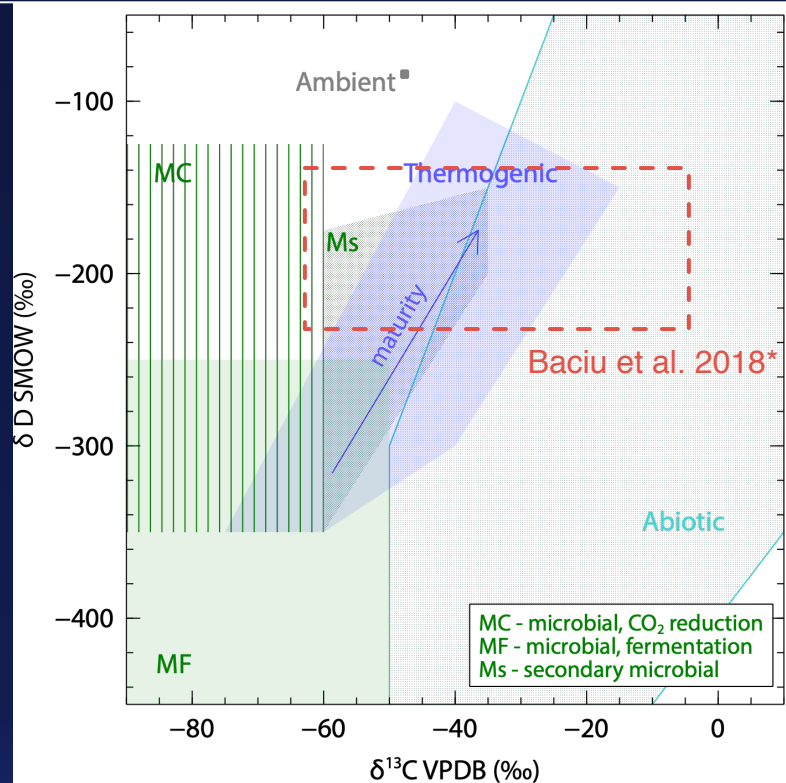
# SOURCE $\delta D-CH_4$



To  $\delta^{13}C$  To overview

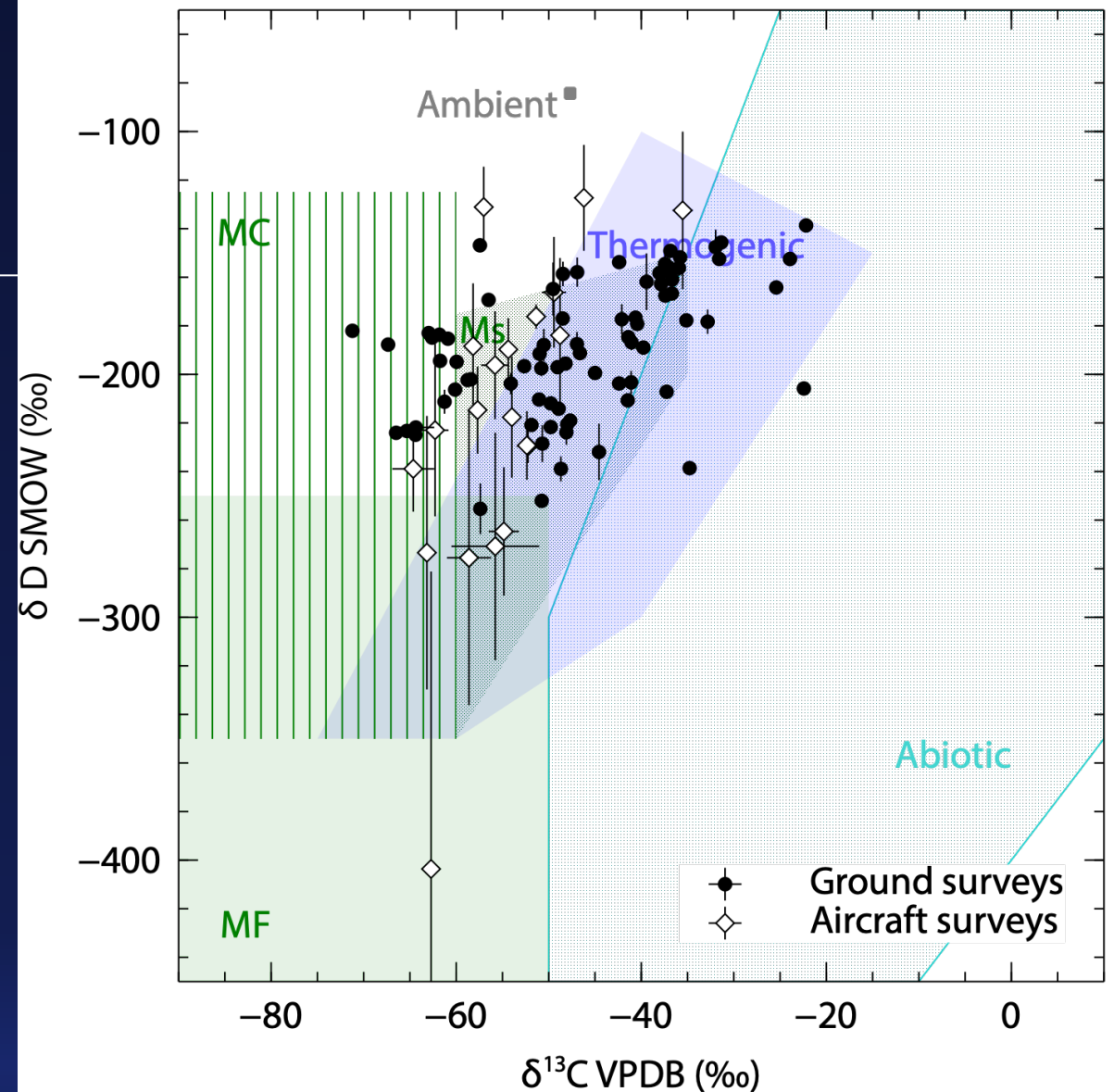
# ISOTOPE RESULTS

- Agreement with previously reported geological sources in Romania
- Fossil fuel  $\text{CH}_4$  measured from aircraft, but not only



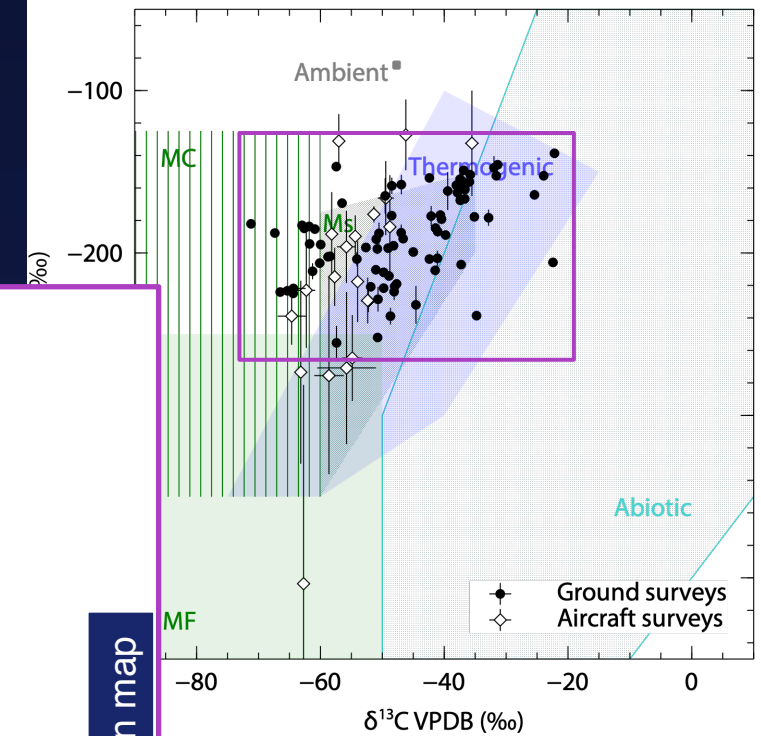
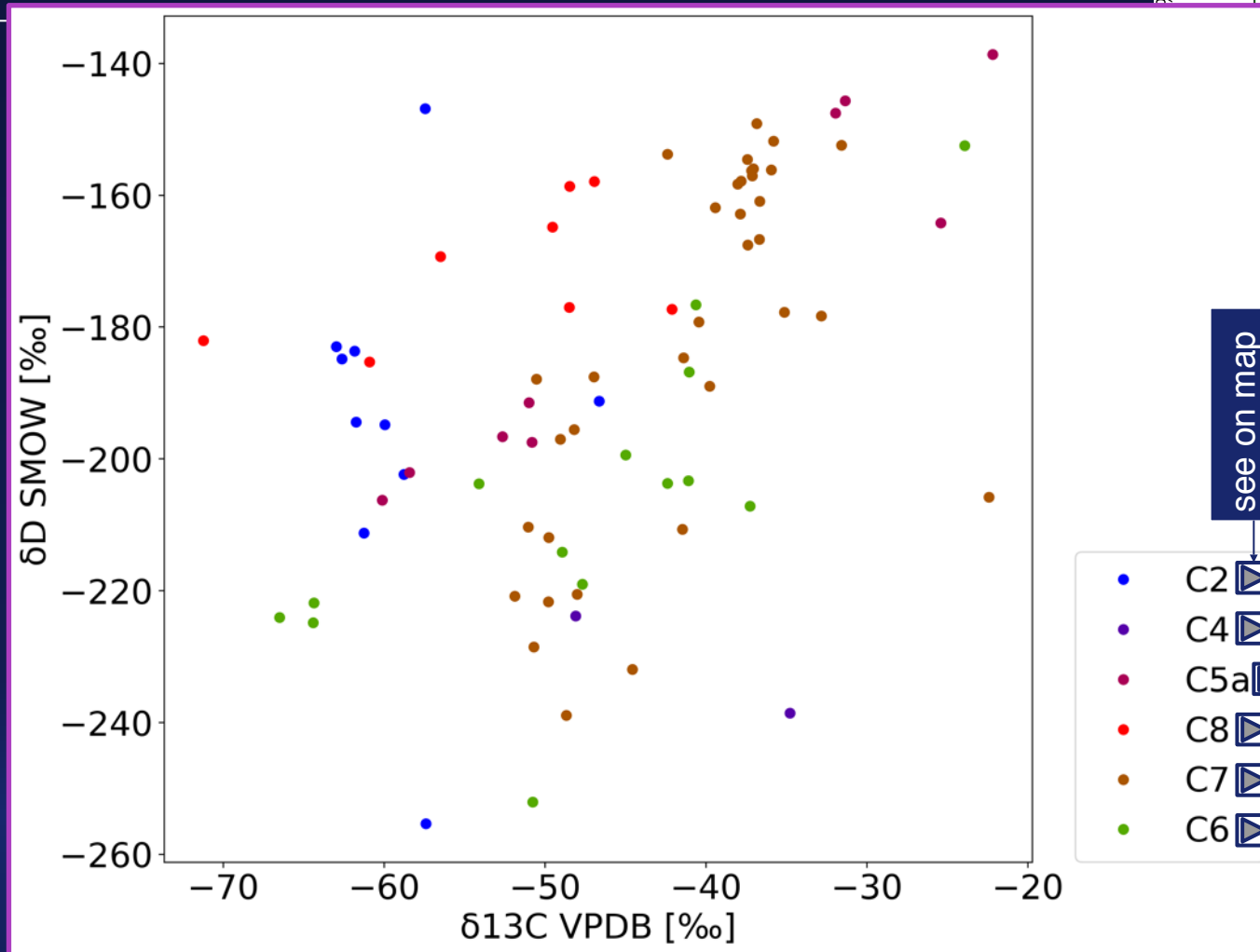
\* Baciu, C., Ionescu, A., Etiope, G., 2018. Hydrocarbon seeps in Romania: Gas origin and release to the atmosphere. *Marine and Petroleum Geology* 89, 130–143.

Graph: Milkov, A.V., Etiope, G., 2018. Revised genetic diagrams for natural gases based on a global dataset of >20,000 samples. *Organic Geochemistry* 125, 109–120.



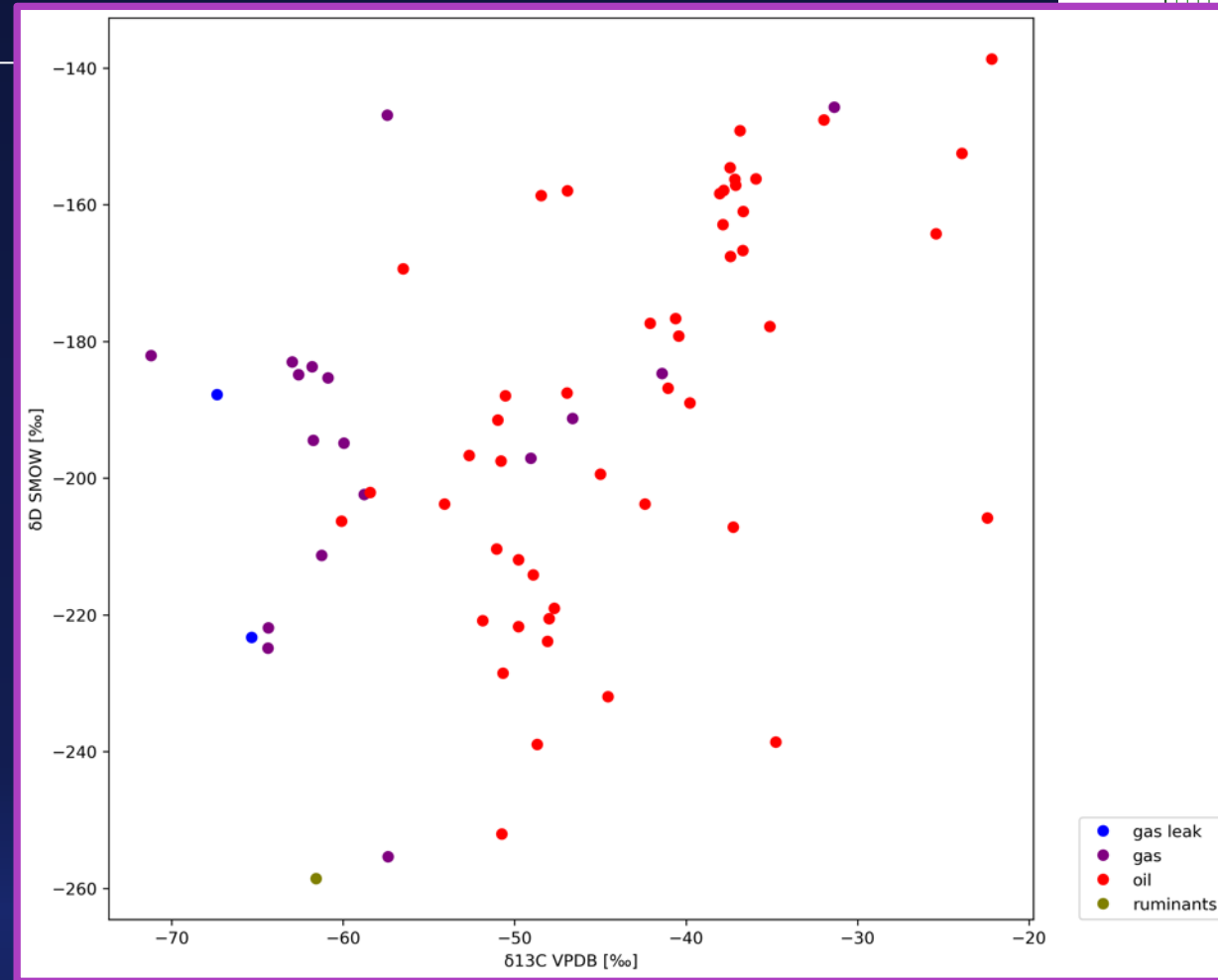
ROMEO results – all signatures

# ISOTOPE RESULTS – geography

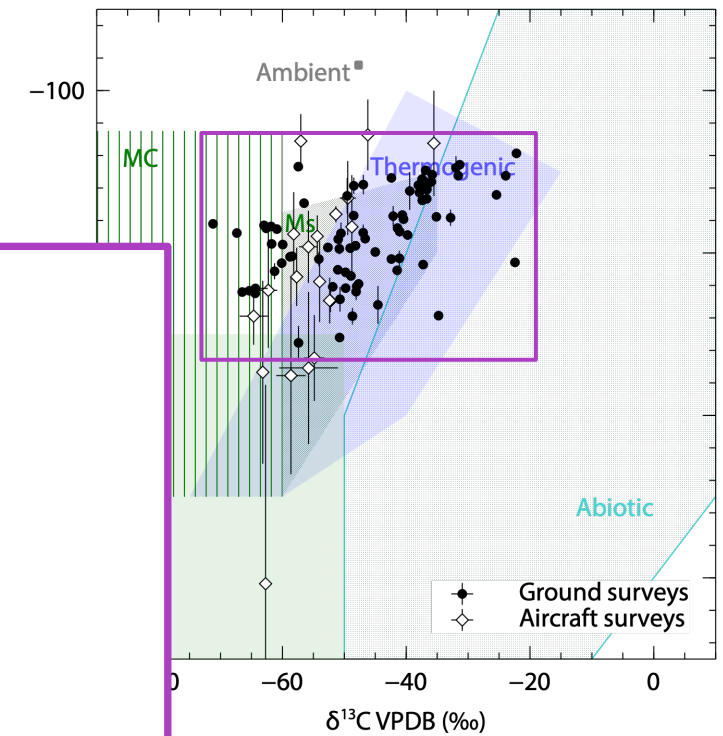


# ISOTOPE RESULTS - oil vs gas

- $\delta D$  allows to distinguish between  $CH_4$  from agriculture & waste sources and fossil fuel operations
- Extraction of microbial gas



ROMEEO results – ground surveys



## KEY FINDINGS $\text{CH}_4$ isotopes from Romanian oil and gas industry

- Importance of measuring the 2 isotopes
- Oil and gas emissions were measured from the aircraft
- A significant benefit for European methane isotopic signatures data





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# DON'T HESITATE TO CONTACT ME

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