On source identification with footprints

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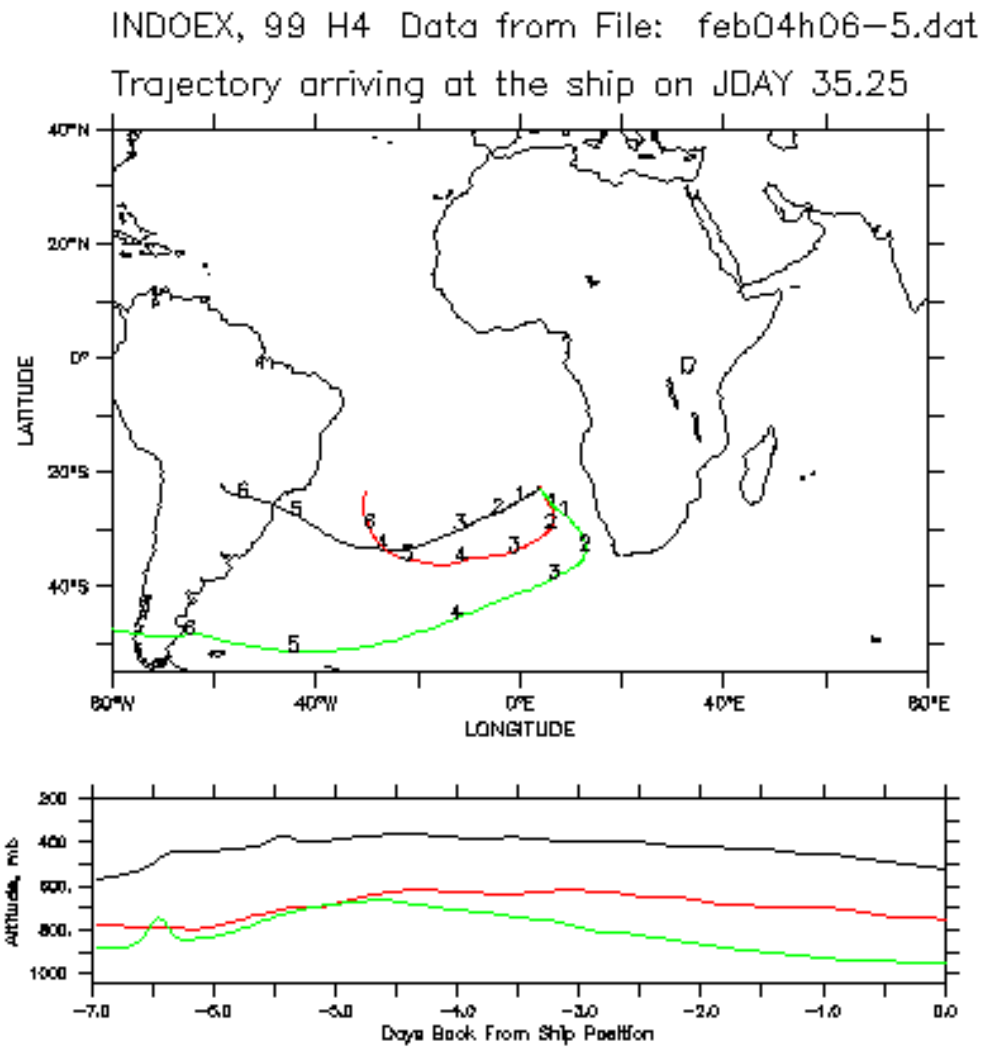
Outline:

- Footprints and source identification
- (4+1)D sensitivity patterns
- Example1: Soot in snow samples
- Example2: GHG monitoring in Tiksi

Trajectories



- Trajectory – back track of air parcel from receptor
- Very simple, intuitive and misleading
- Ignores diffusion, deposition, transformation
- Single or few trajectories provide little information
- No way to locate sources
- Density of trajectories is needed

Backwards modelling

- Reverse time
- Starts from the receptor
- It is NOT the way to inverse dispersion

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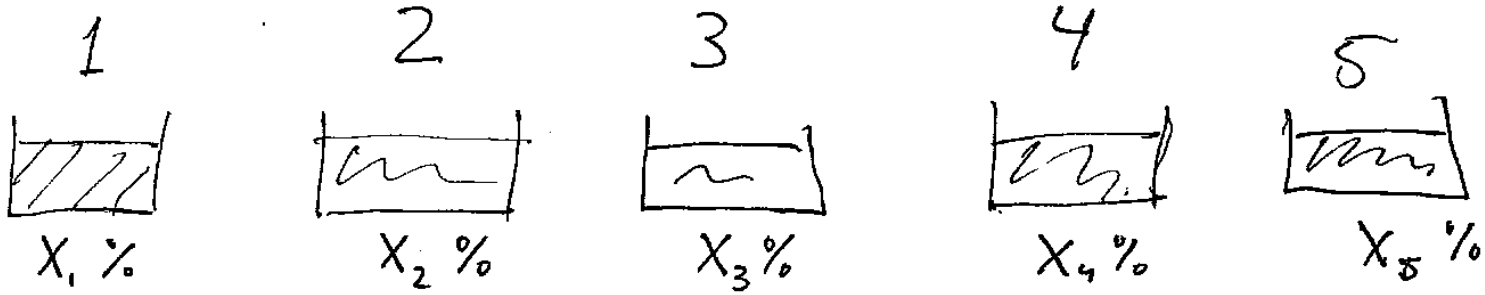
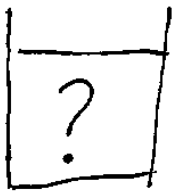
Can't meance the meat back...

Footprint





Forward:

X %

Inverse:

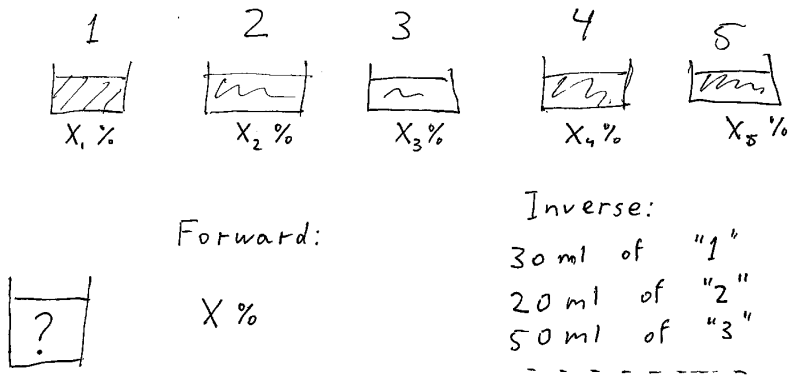
30 ml of "1"

20 ml of "2"

50 ml of "3"

Question: How strong each of initial liquids was?

Sensitivity



- Sensitivity does not tell where the source is
- It tells how sensitive particular sample is to emissions at different locations and times
- Footprint for each sample (number) is 4D field
- Can be used for source apportionment if some additional info is available

Example: Clean sample + assumption of persistent changing sources allows to exclude the area

Observations footprints

- Huge amount of data
- Constant sources: Can be integrated over footprint time
- Constant source height: Only expected source height can be taken
- Can be weighted/filtered/censored according to observational data

End up with observable amount of maps. . .

Example 1: Soot in snow

Input:

- Mass concentration of soot in ∼50 samples of surface snow collected weekly

Problems:

- What is the concentrations are responsible for snow contamination?
- Effect of local sources?
- Effect of dry deposition?
- What PM soot is?
- Snow falls?

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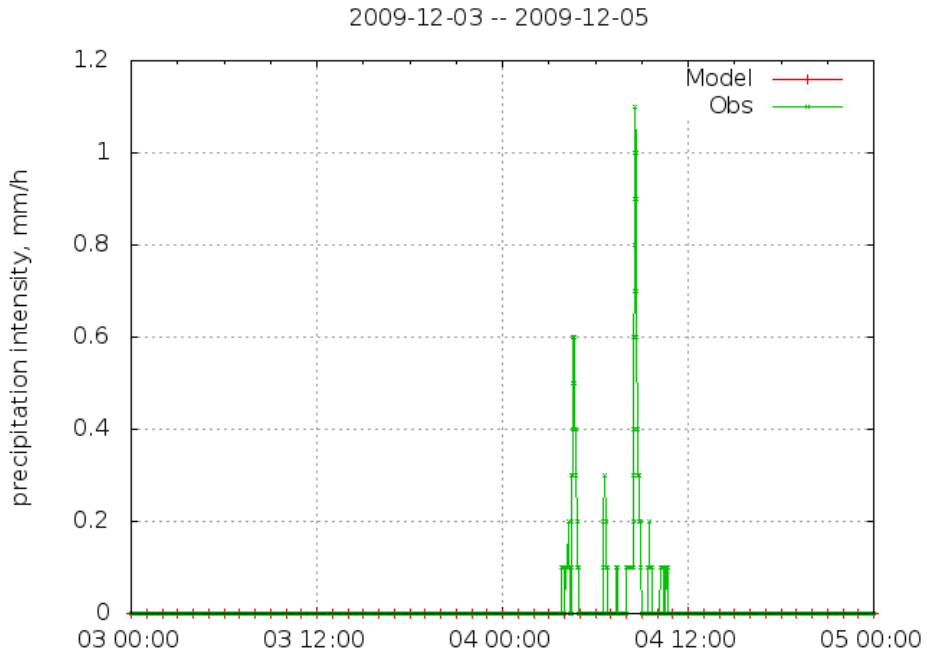
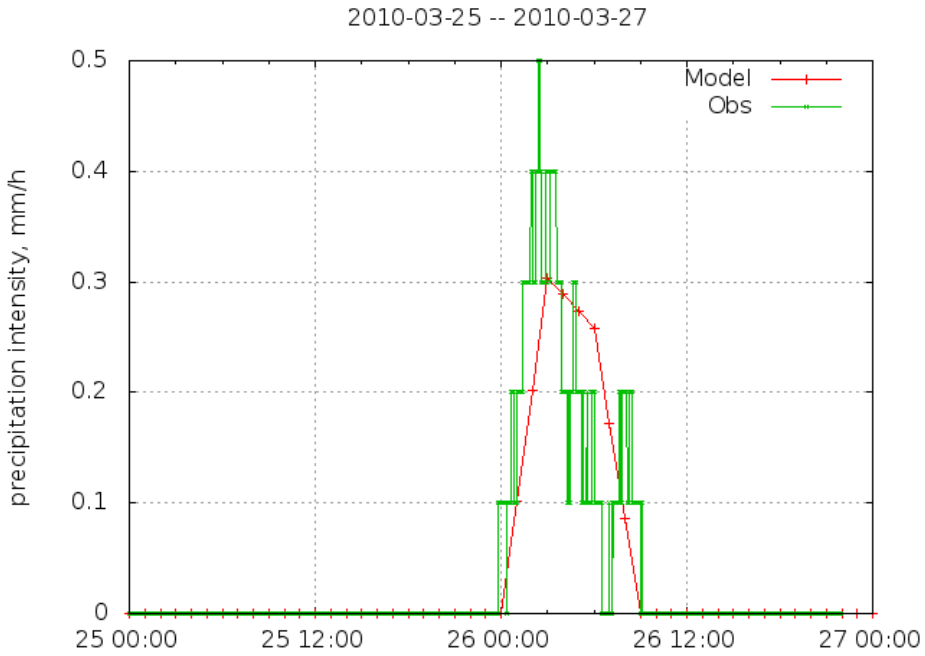
Solutions:

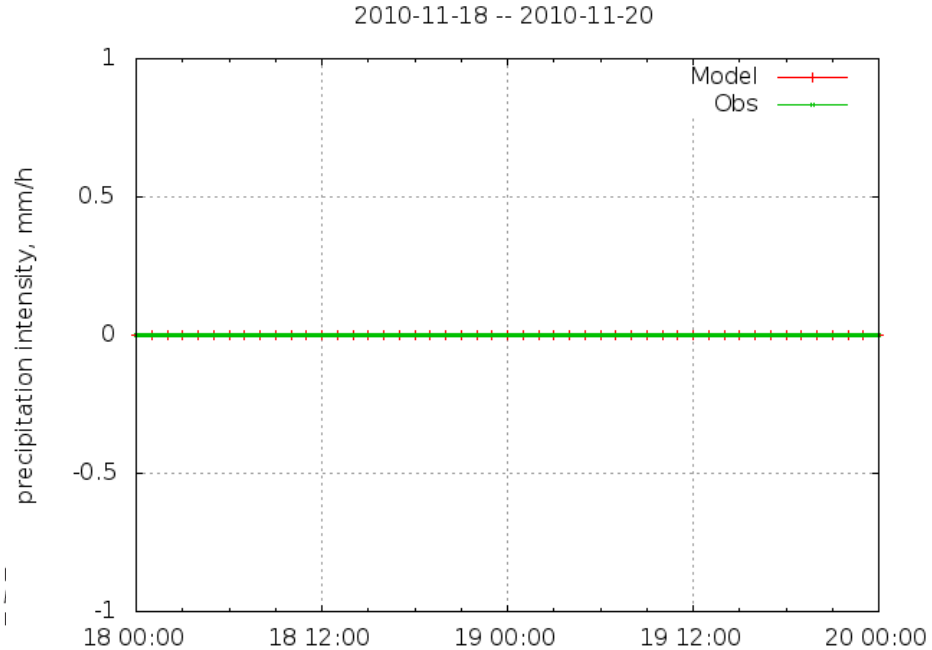
- Constant scavenging below cloud, none within cloud
- Friday samples
- Only after-snowfall samples
- Run passive gas, fine and coarse particles
- Only when meteo and observations reported snow

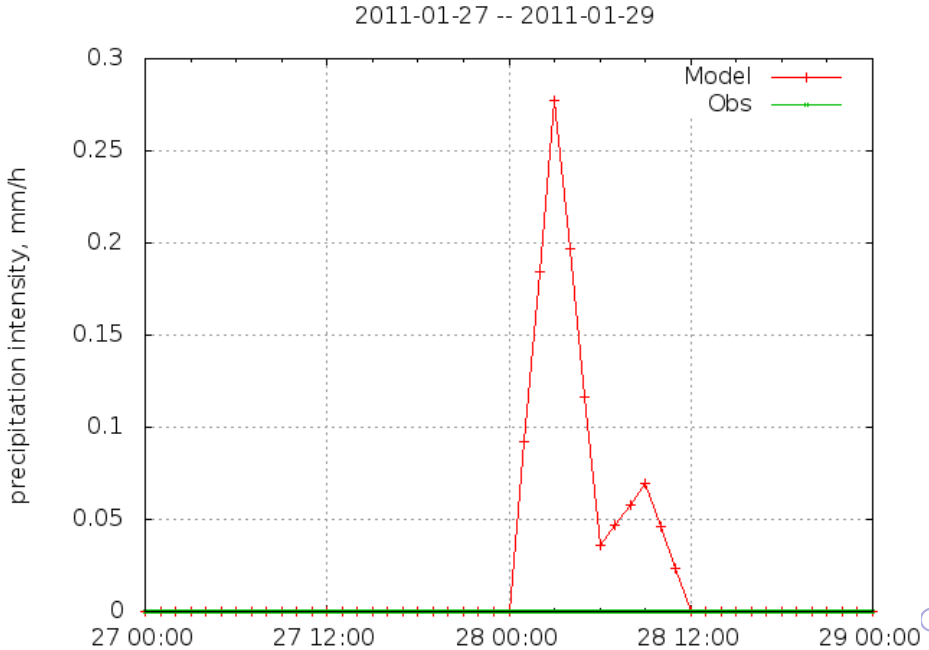
Compare average “clean” and “dirty” footprints.

Snowfalls in met.model

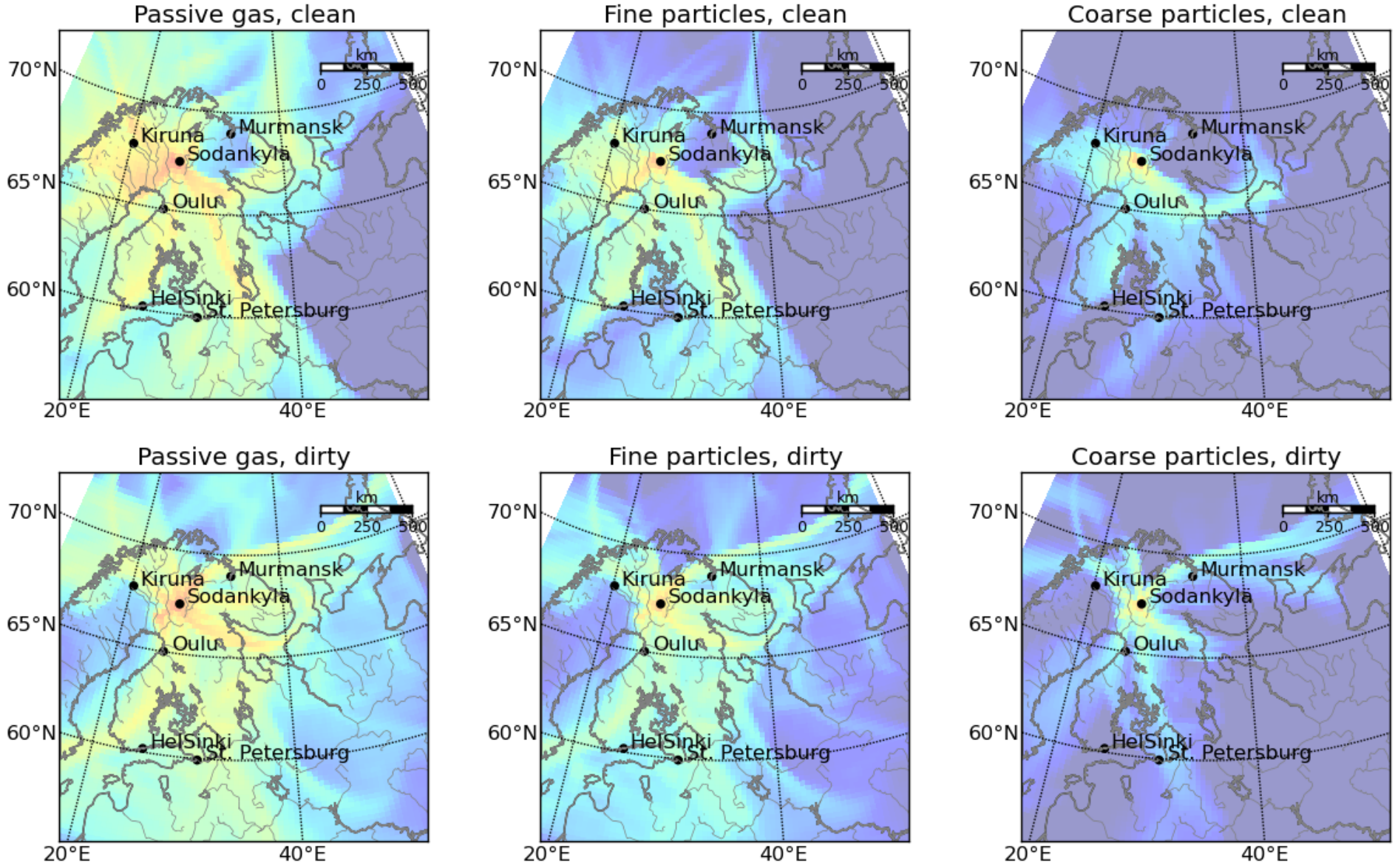






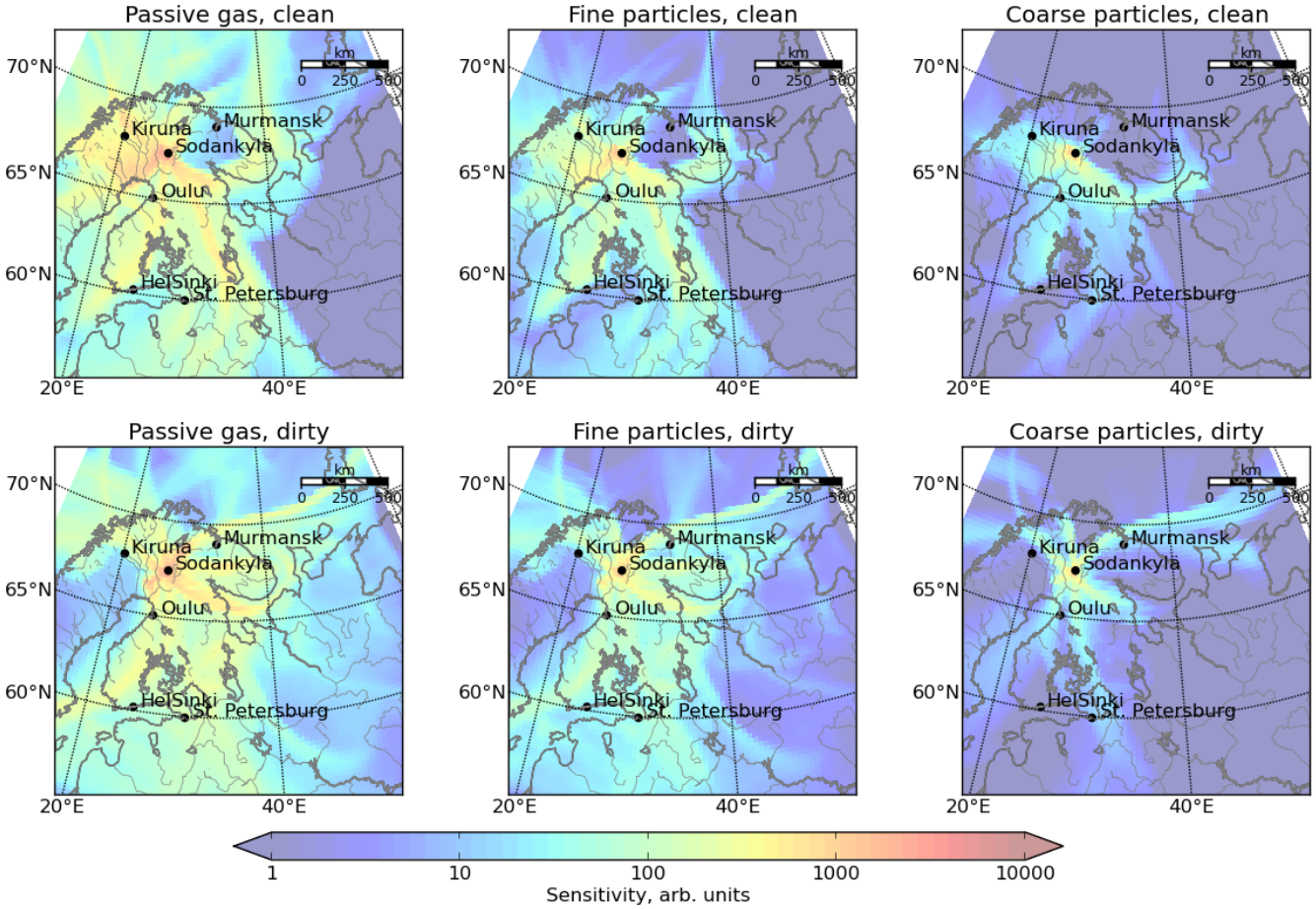


Clean and dirty footprints



Exercise results

- Stronger washout – more compact footprint
- Kola peninsula contributes to “dirty” samples, but does not contribute to “clean”



Example 2: CH4 from the sea bed?

Input:

- Hourly time series of CH4 and CO2 concentrations at Tiksi

Problems:

- No constant background
- What is “clean” and what is “dirty”?

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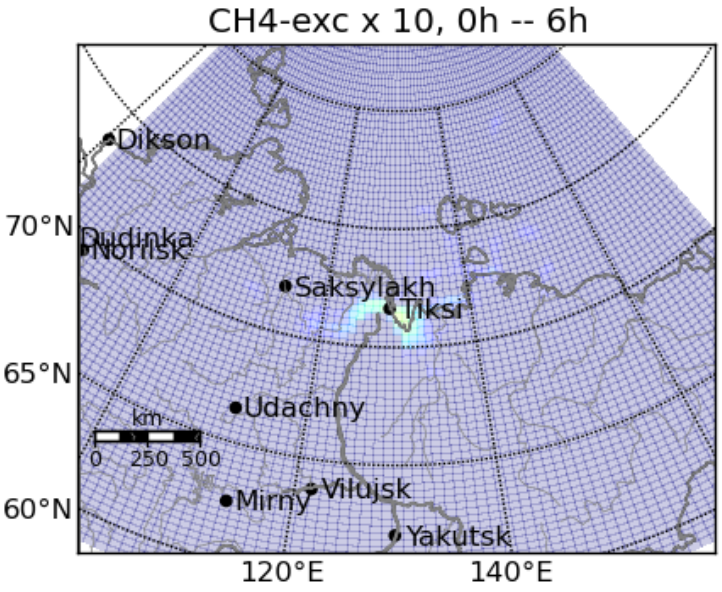
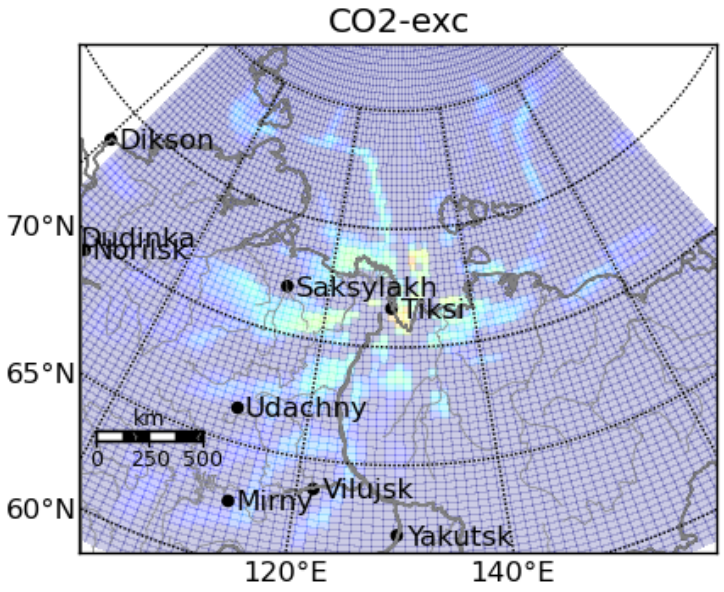
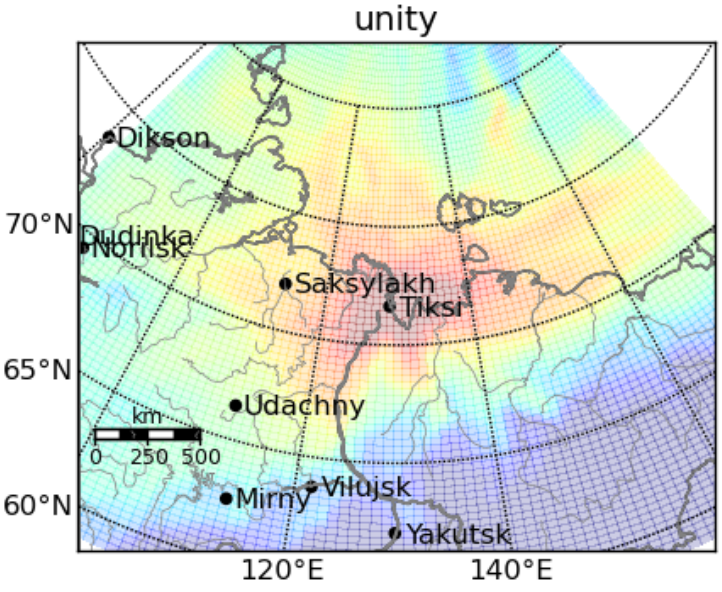
Solution:

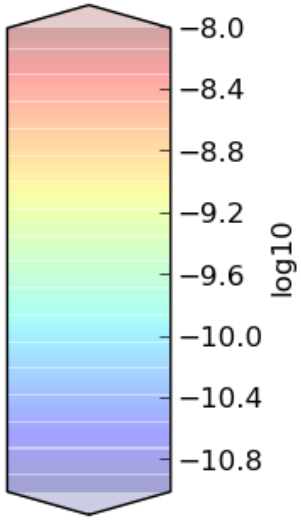
- Band-pass filter time series
- Weight footprints according to signal components

Weighted footprints









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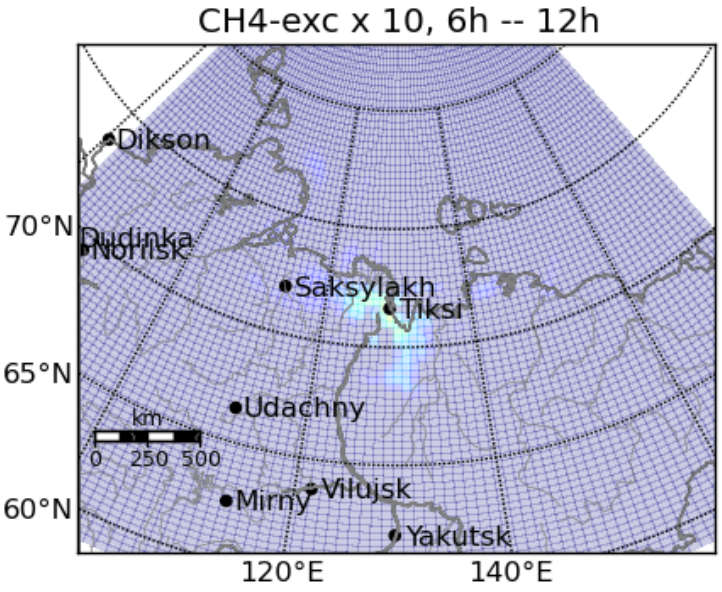

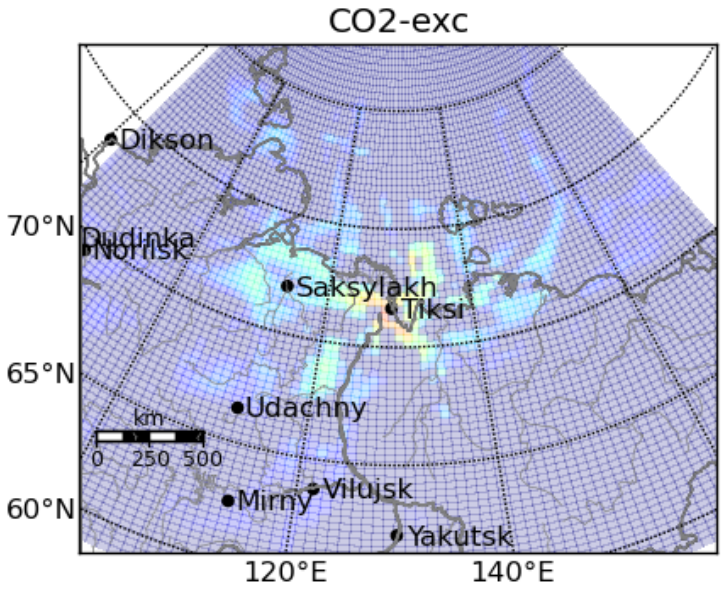

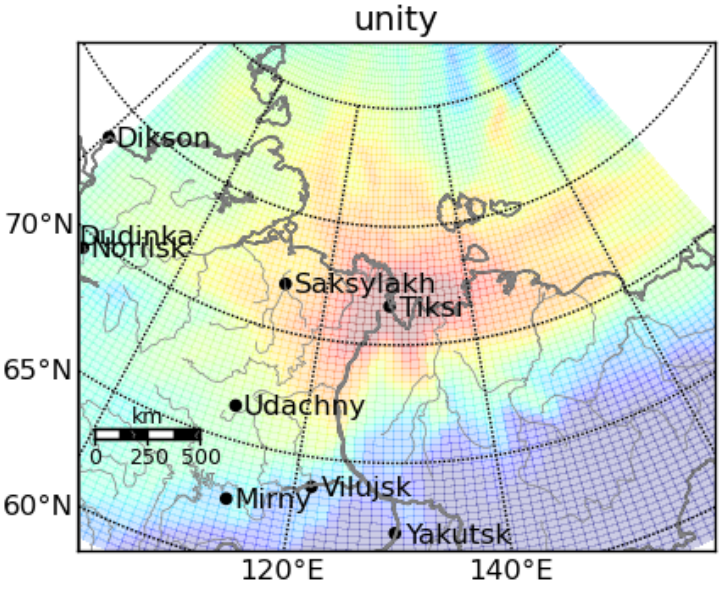

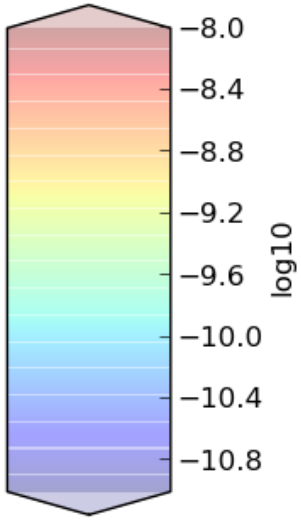

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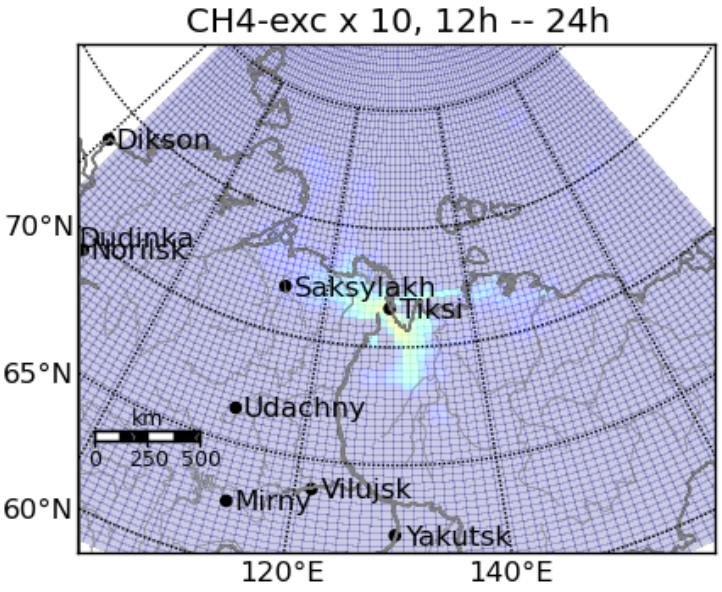

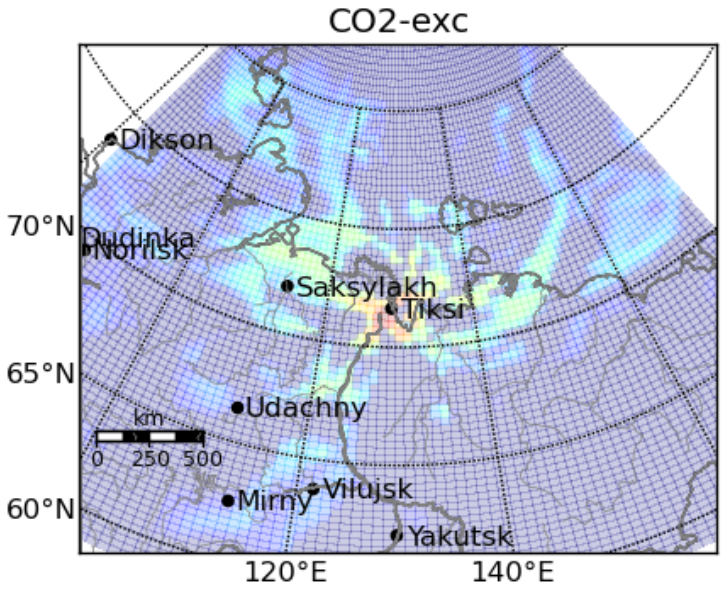

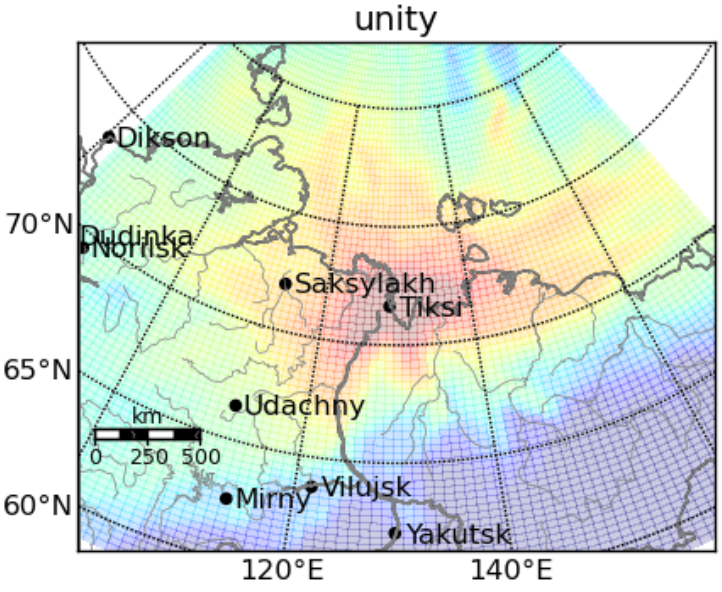

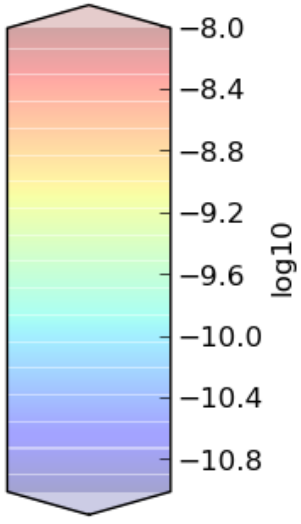

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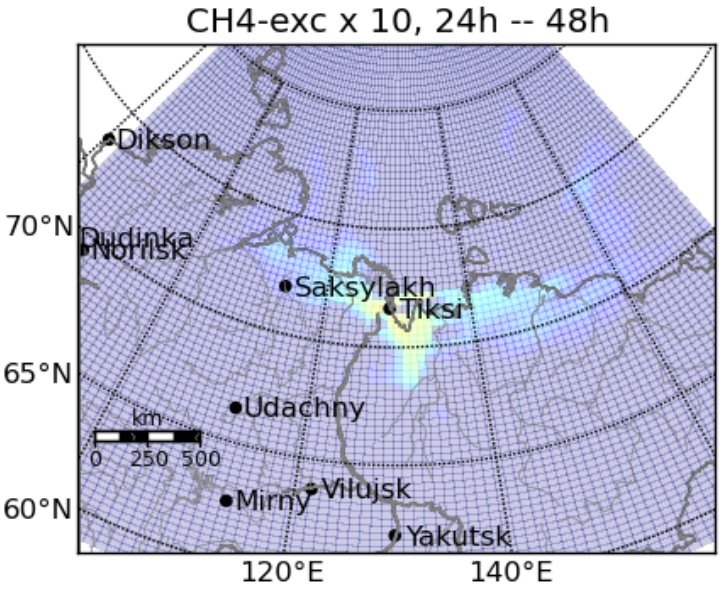

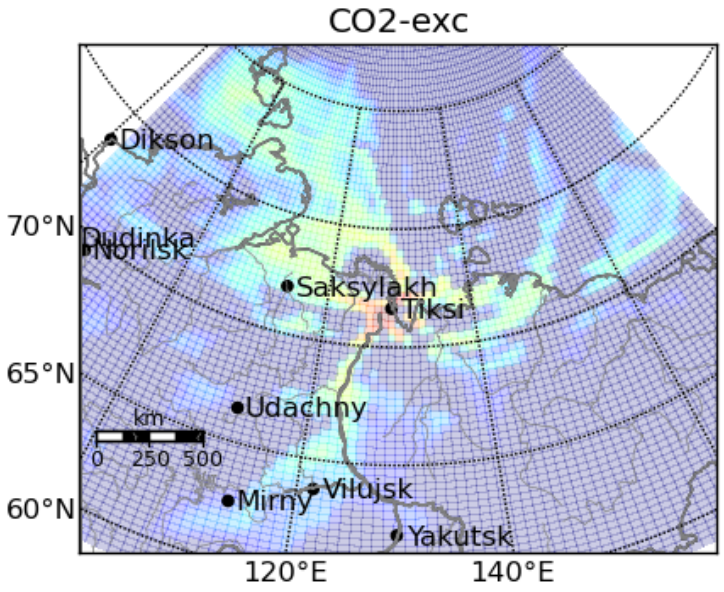

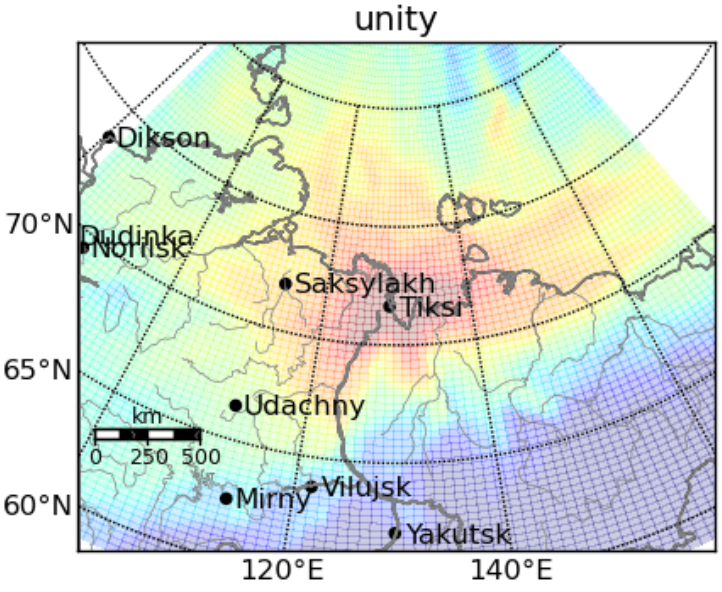

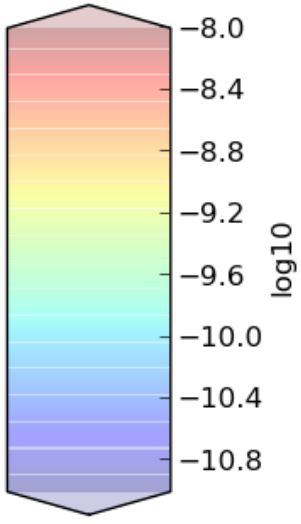

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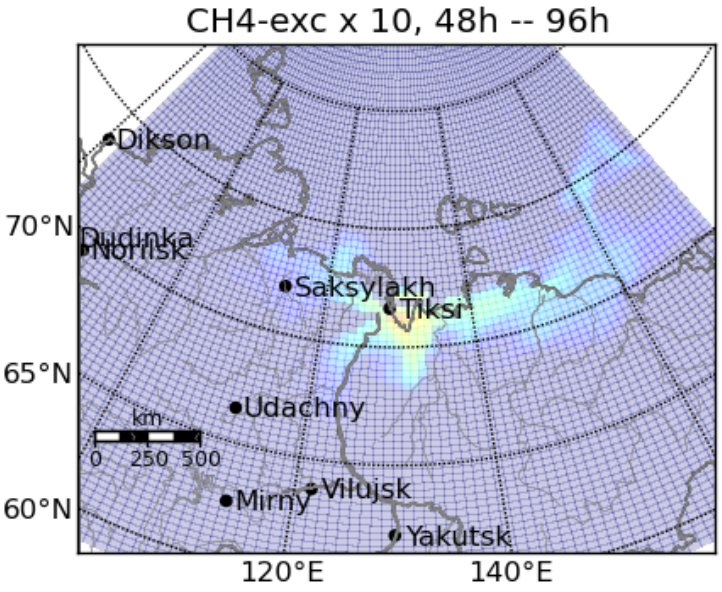

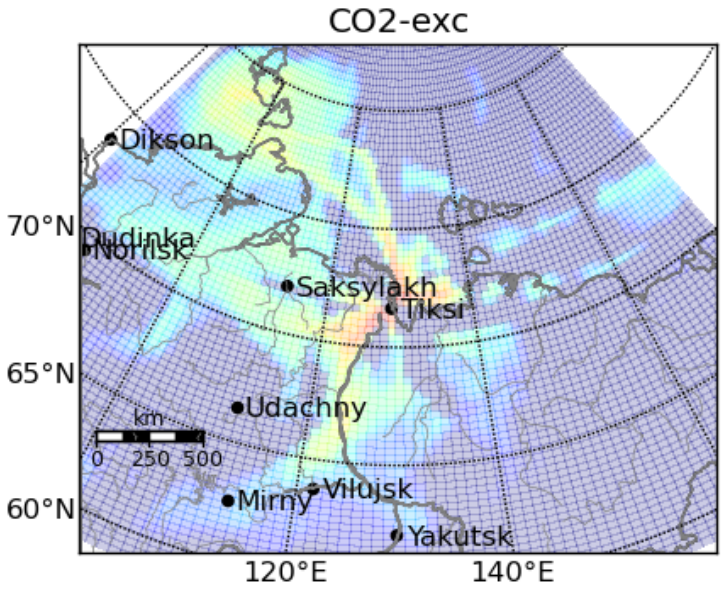

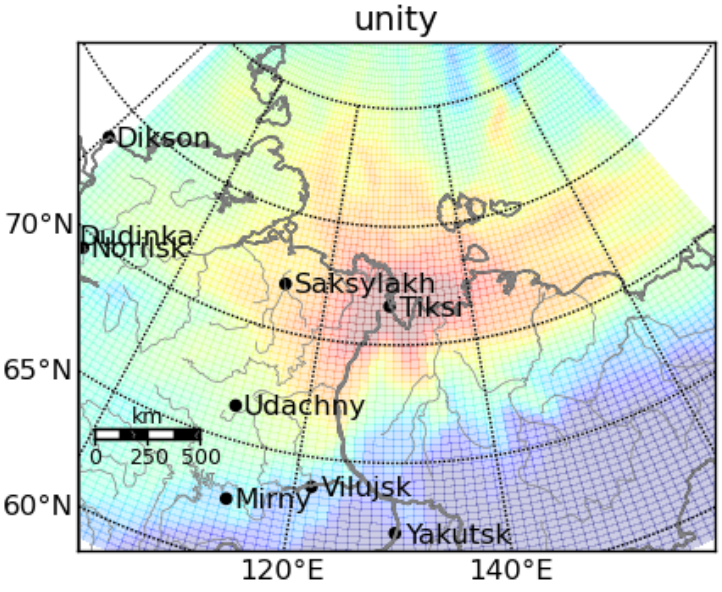

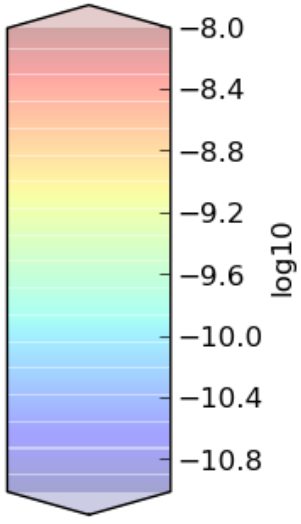

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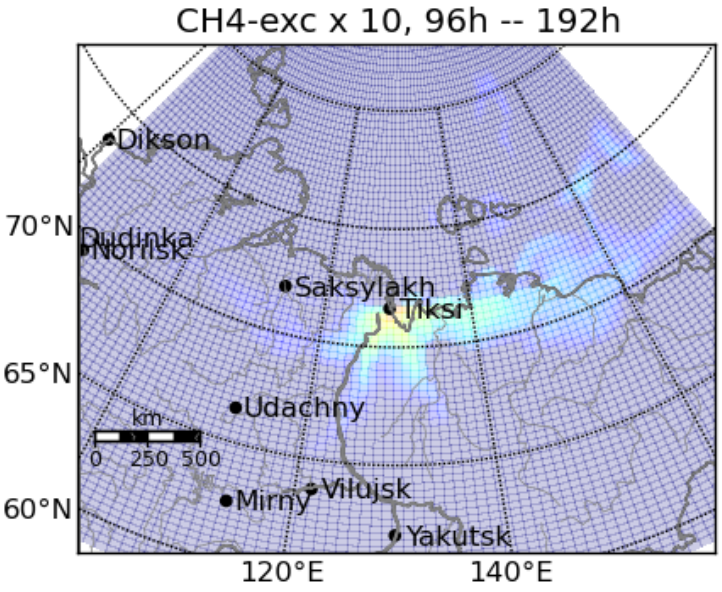
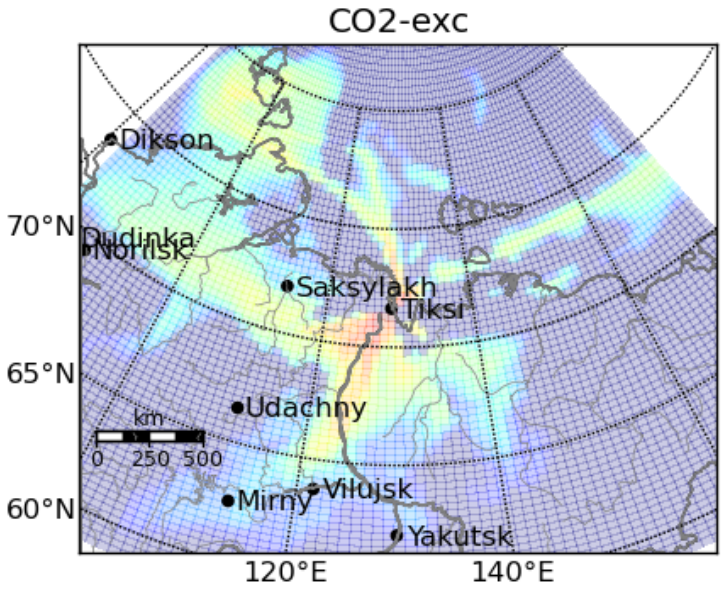
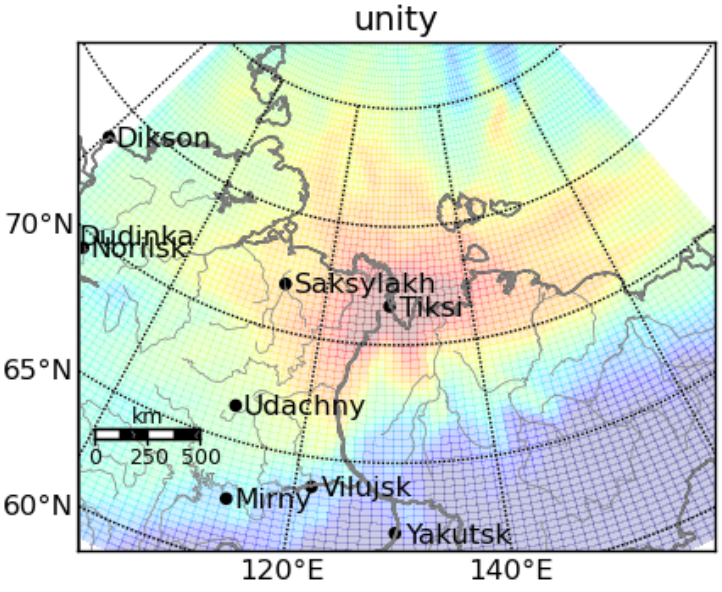
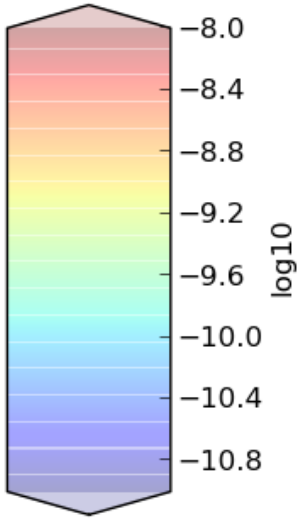


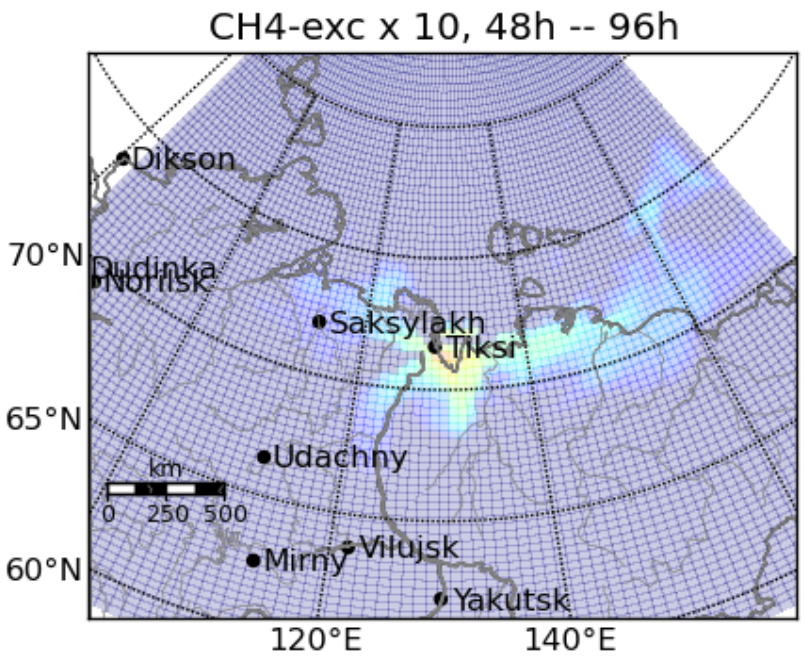


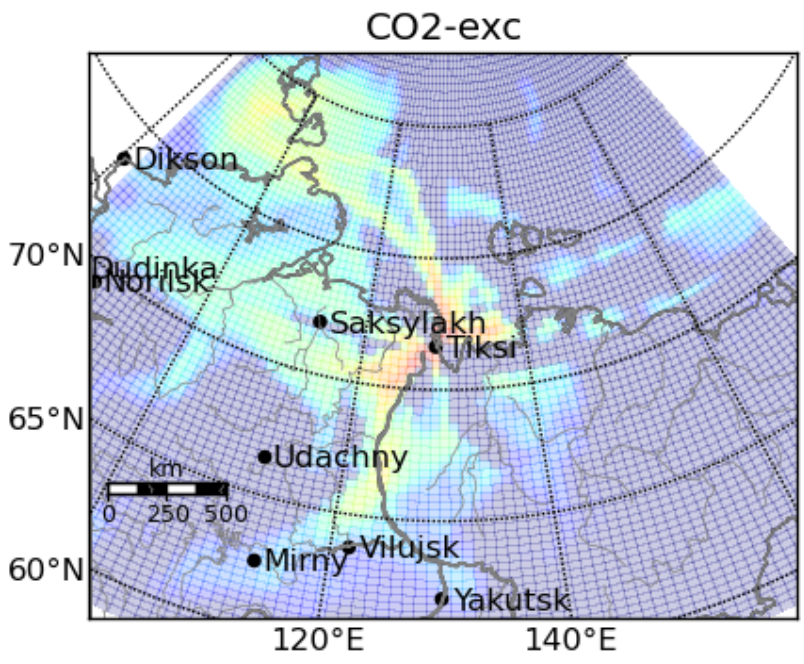




Exercise results

- CH4 has more compact footprint
- Sources of CO2 can be clearly traced (shipping, industries)
- Band-pass decomposition works when background is unknown





Summary

- Footprints are better than trajectories
- It is not the way to do “inverse” dispersion
- Require data reduction and interpretation
- Powerful tool for source identification (works for isolated sources)