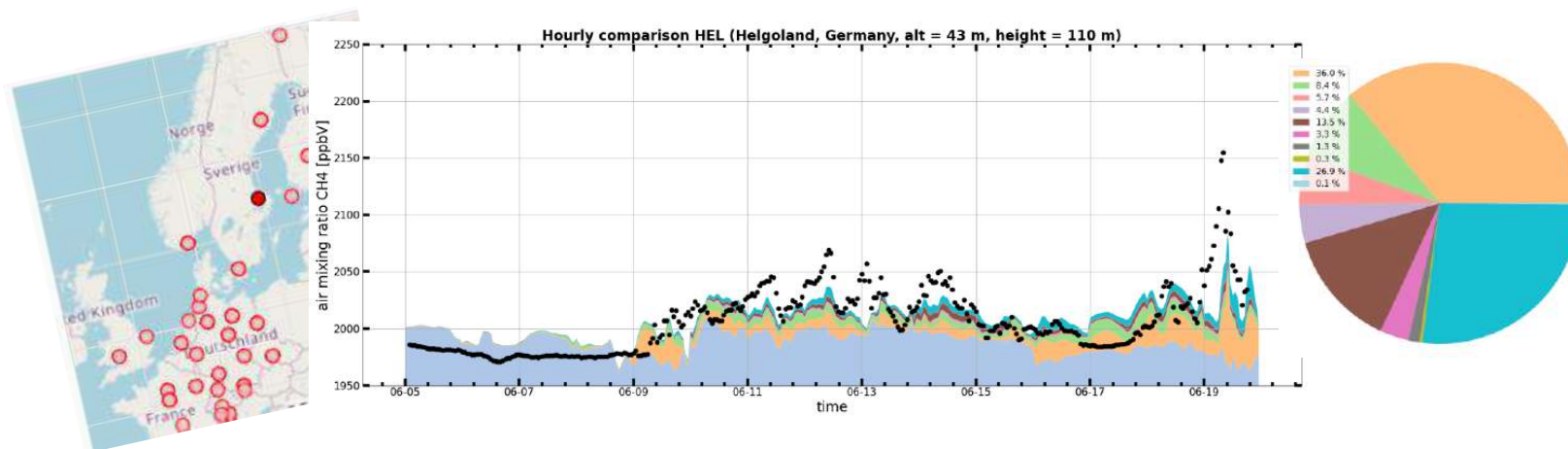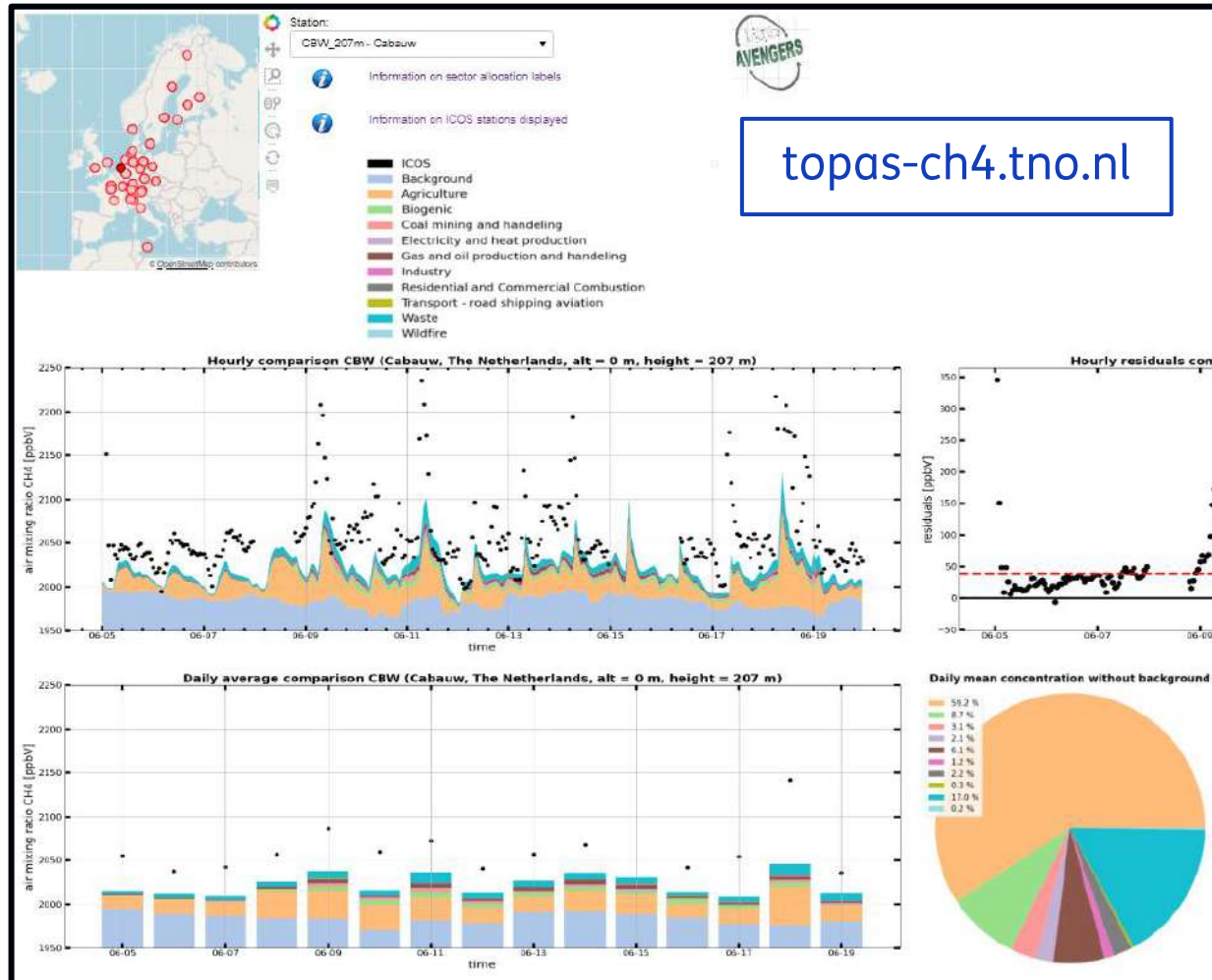# TOPAS-CH$_4$: A methane source attribution tool for policy support and scientific application

- *Riccardo Nanni, Teresa Steinke, Janot Tokaya, Richard Kranenburg, Arjo Segers, Antoon Visschedijk, Ilona Velzeboer, Arnoud Frumau, Renske Timmermans, Hugo Denier van der Gon, Martijn Schaap*

A methane source attribution tool

topas-ch4.tno.nl

- **TOPAS** services:
  TNO **O**perational **P**ollution **A**pportionment **S**ervices

- CH$_4$ service: daily updated simulations by LOTOS model of CH$_4$ and C$_2$H$_6$ concentrations over Europe

- Visualized on website

- part of **AVENGERS** project:
  Attributing and **V**erifying **E**uropean and **N**ational **G**reenhouse gas and aerosol **E**missions and **R**econciliation with **S**tatistical bottom-up estimates
  "To reconcile reported GHG emissions with independent information from atmospheric observations using top-down methods and process-based models, …"
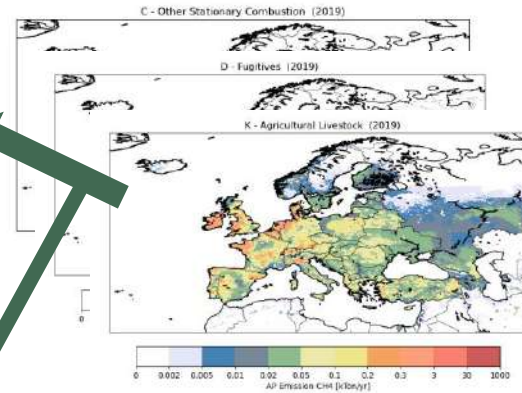
A methane source attribution tool

TOPAS full chemistry
source apportionment

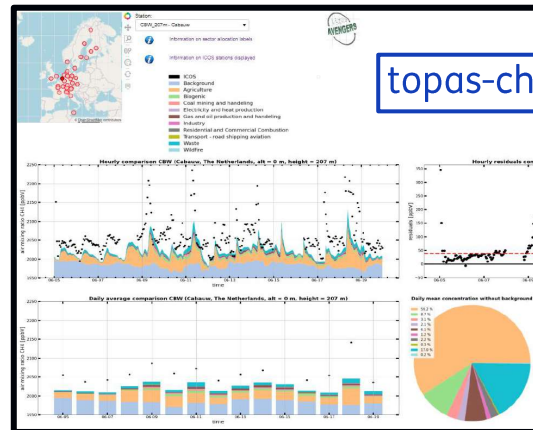topas.tno.nl

*boundary
conditions*

*OH
conc.*

CAMS global
reactive gasses
forecasts
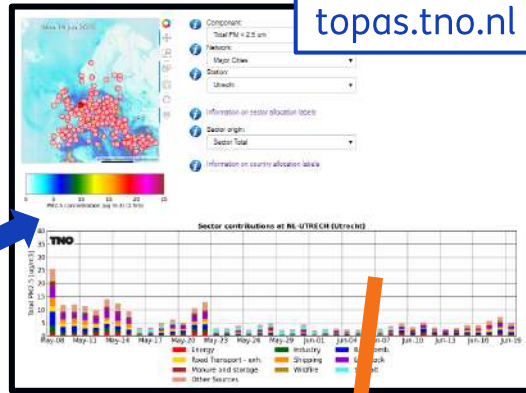
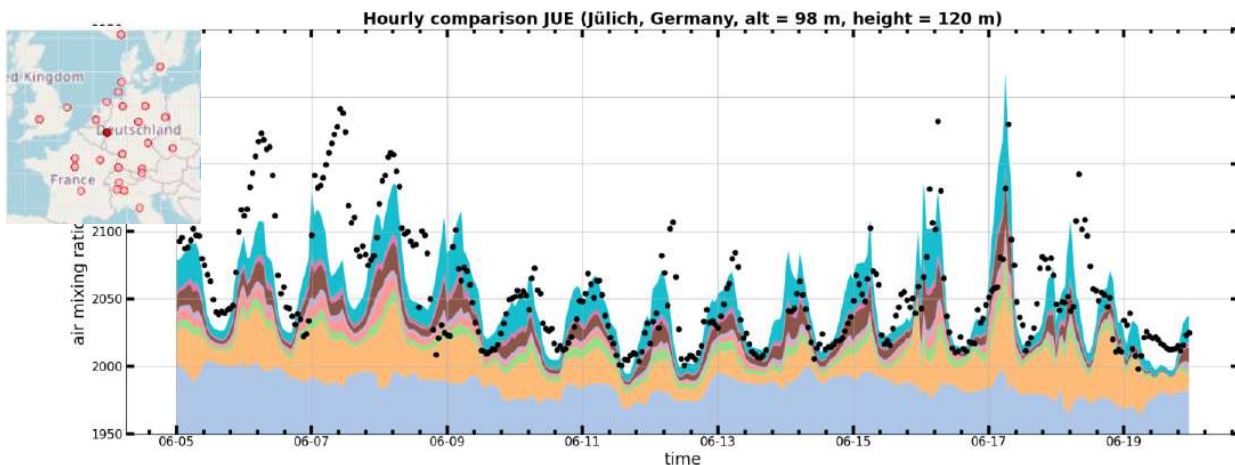TNO CAMS-REG emissions

topas-ch4.tno.nl

- LOTOS model configuration for CH$_4$ service:

  - European domain, ~ 25 km resolution

  - Emissions from CAMS-REG

  - Boundary conditions from CAMS global

  - CH$_4$ and C$_2$H$_6$ tracers,
    and for each 22 labelled fractions for
    emission source categories and
    boundaries

  - OH from TOPAS "full chemistry" service

- Observations daily updated from ICOS
  portal for plotting

ICOS Integrated Carbon Observation System

TNO innovation for life

Label definitions

Background
Agriculture
Biogenic
Coal mining and handeling
Electricity and heat production
Gas and oil production and handeling
Industry
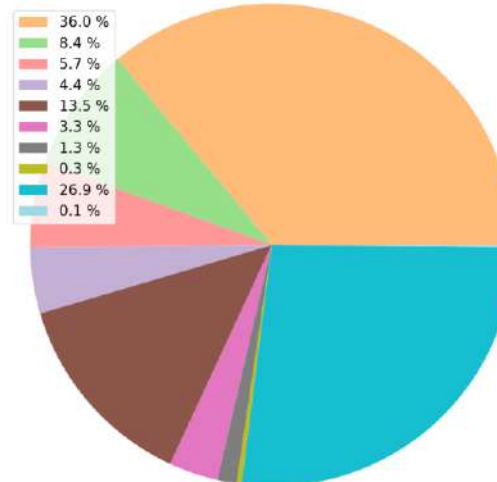Residential and Commercial Combustion
Transport - road shipping aviation
Waste
Wildfire

- Emission labels in model: 21 (GNFR sectors) + background

- In figures, aggregated to 10+1 categories
  (use these as labels too?)

- To be done: also labels for 5 focus countries of AVENGERS project
  (Sweden, Netherlands, Germany, Suisse, Italy) and "other countries"
  → total 61 labels?


Hourly comparison JUE (Jülich, Germany, alt = 98 m, height = 120 m)

Daily mean concentration without background

36.0 %
8.4 %
5.7 %
4.4 %
13.5 %
3.3 %
1.3 %
0.3 %
26.9 %
0.1 %

TNO innovation for life

Boundary conditions

- No influence on labelled fraction, but useful for comparison with observations

- Occasionally, stations seem to observe background only:

- For near-real-time simulations:

  - from CAMS global "reactive gasses" simulations, no CH4 observations assimilated ..

  - *use bias correction based on ICOS observations?*

- Alternatives for earlier time series:

  - CAMS ReAnalysis with assimilated CH$_4$ concentrations

  - CAMS CH$_4$ emission inversions

  - ..
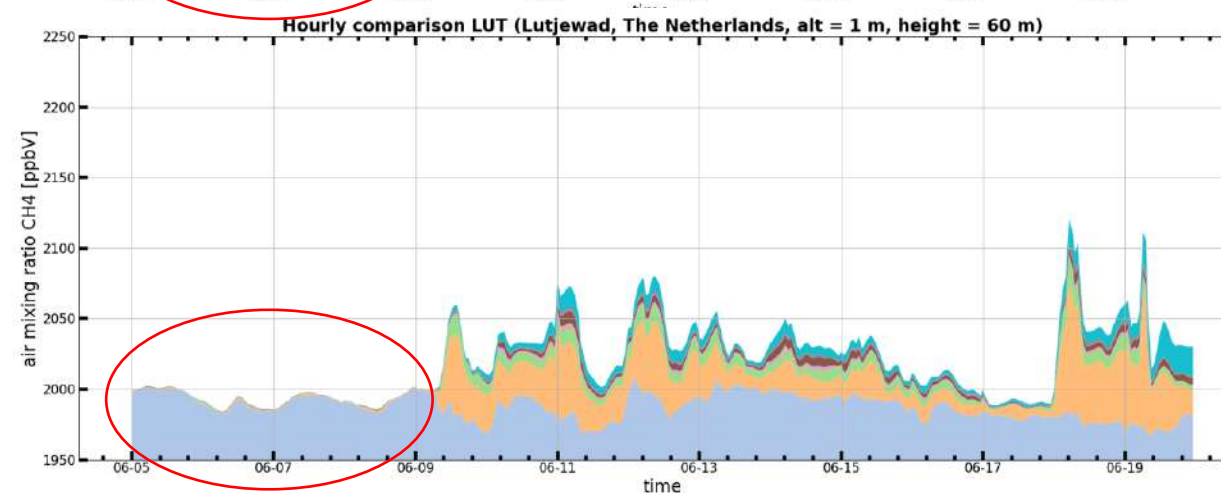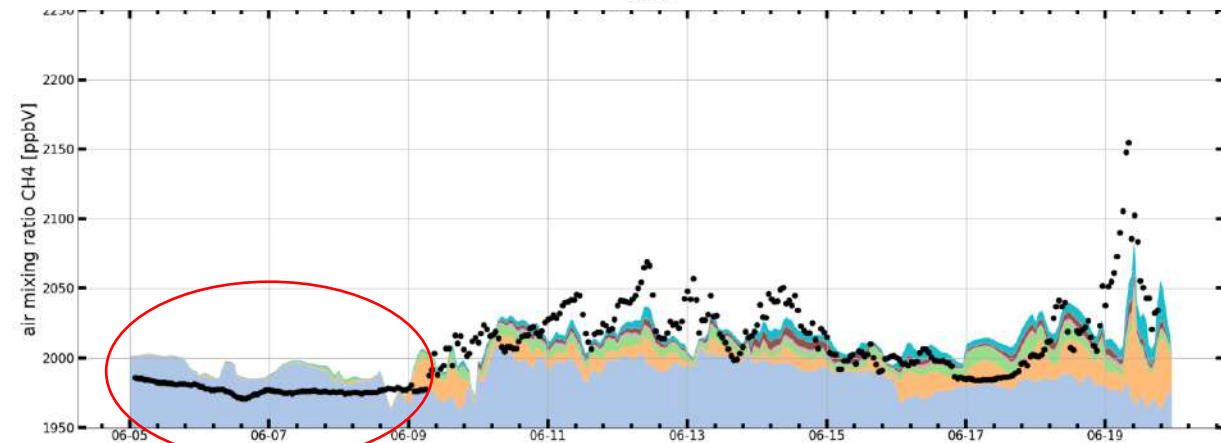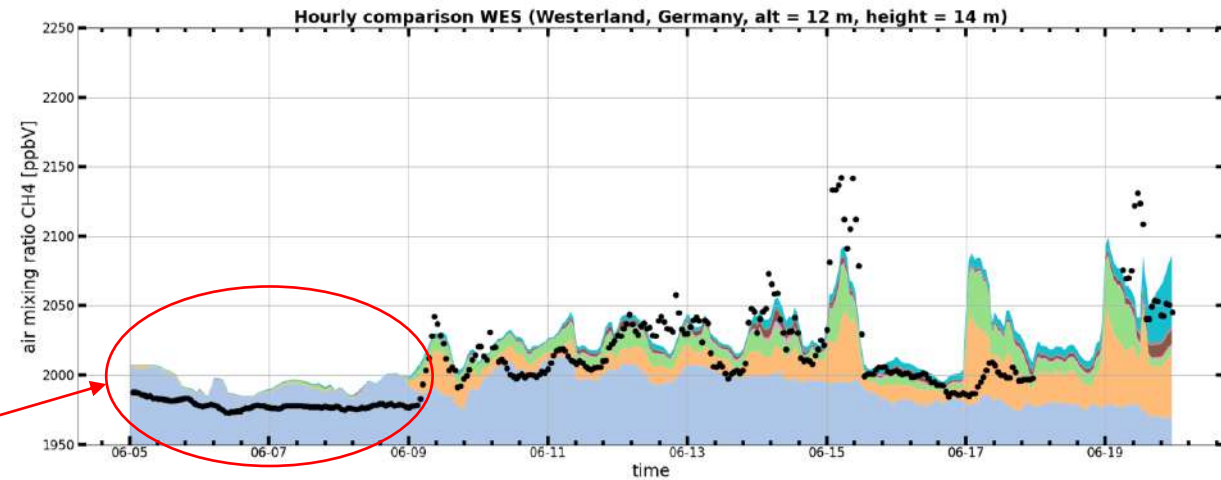
Time selection
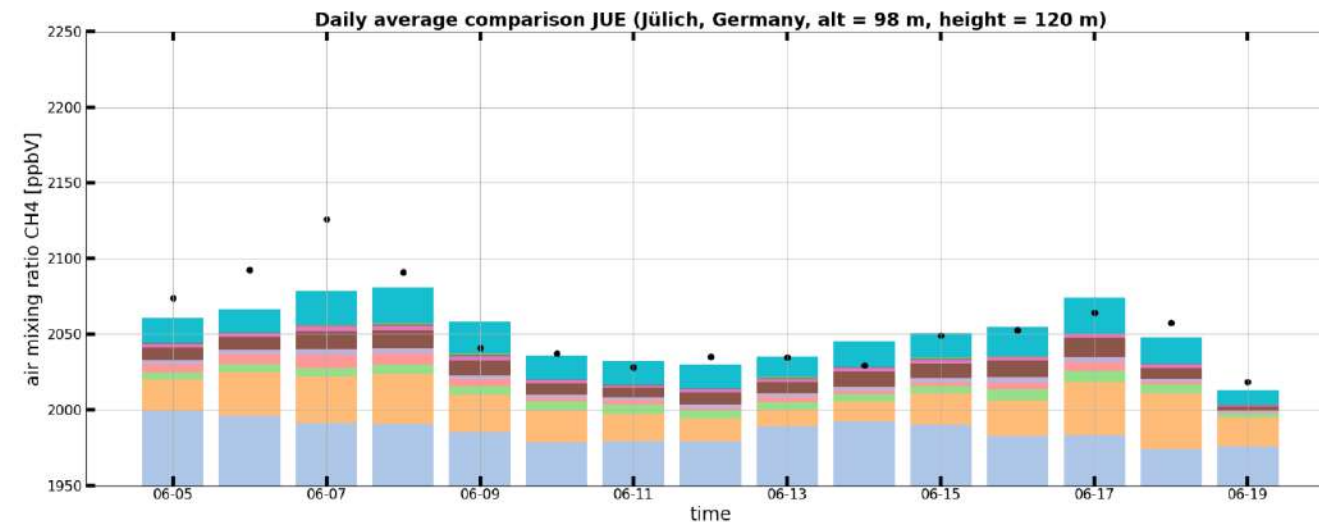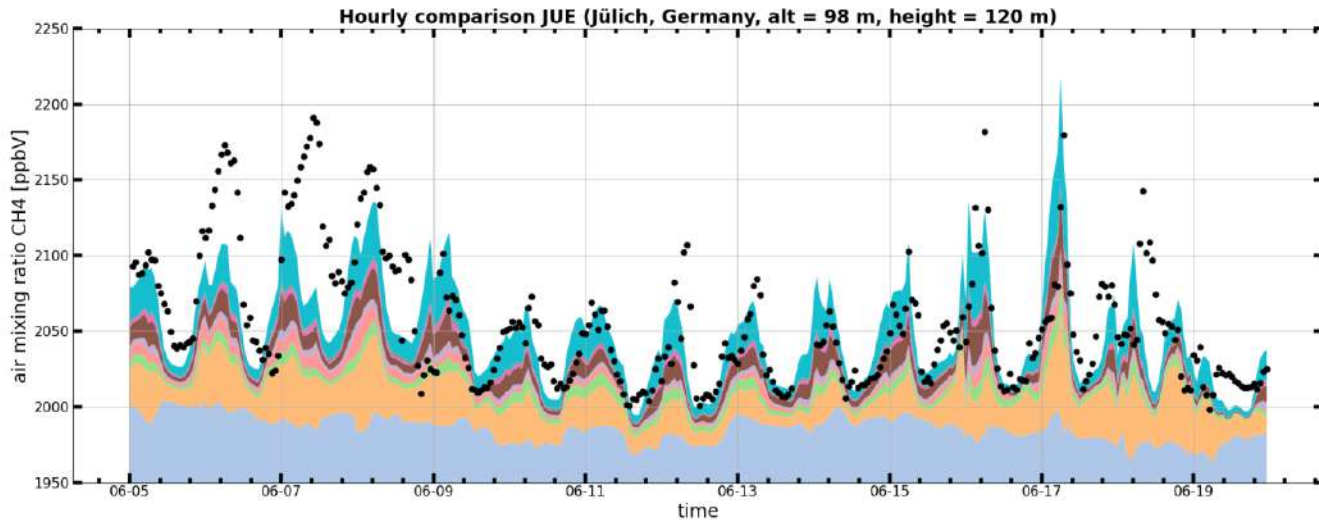
- For non-elevated stations with local sources:
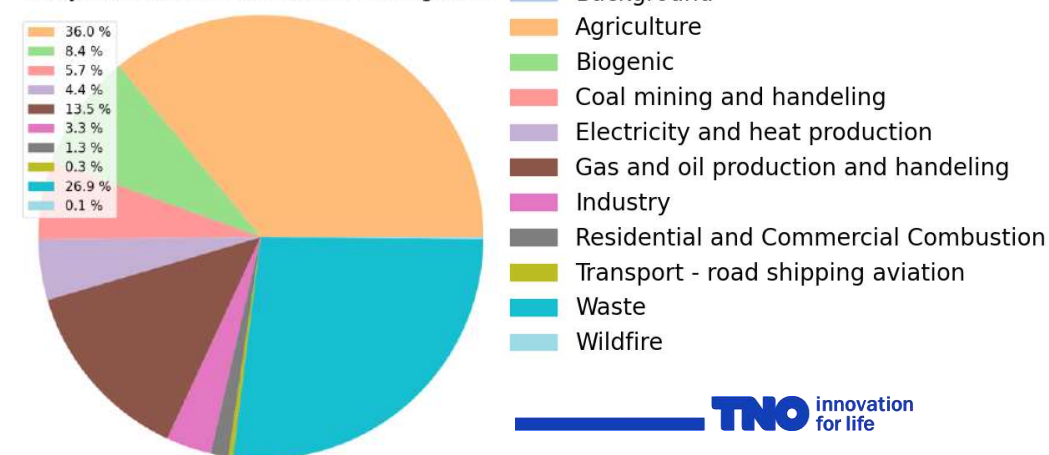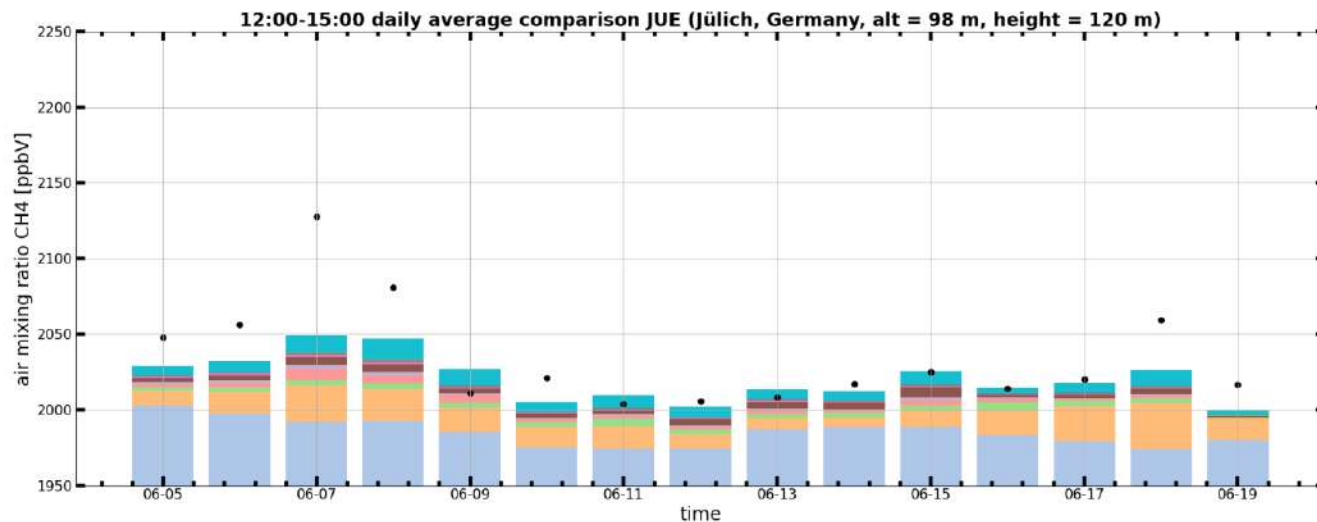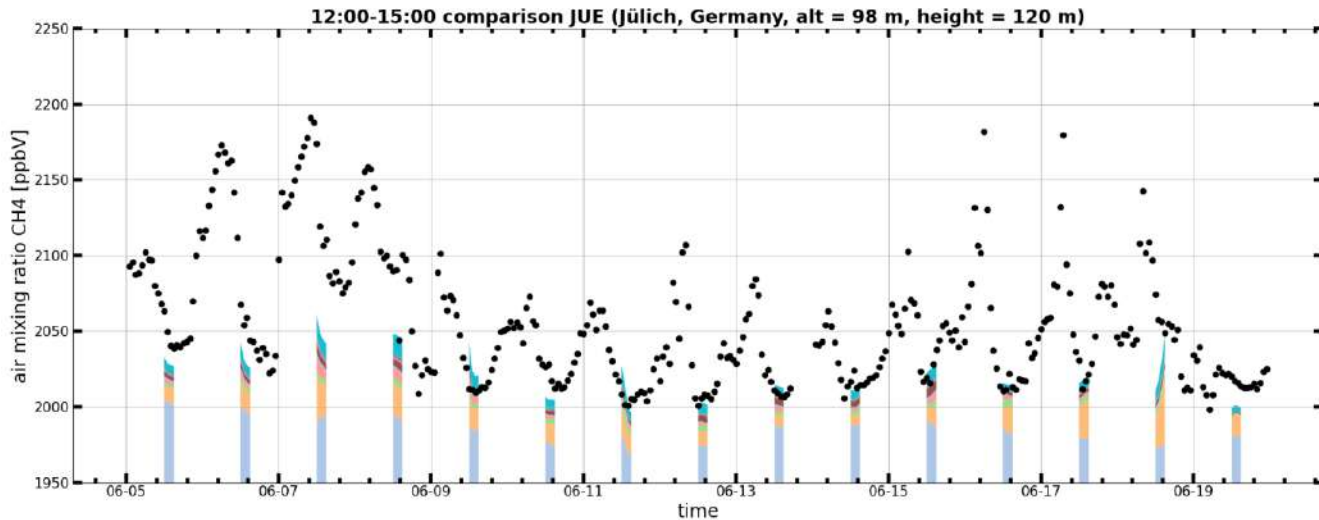 - highest concentrations at night: accumulation under stable conditions
  - daily averages are "biased" towards night time conditions

Time selection

12:00-15:00 comparison JUE (Jülich, Germany, alt = 98 m, height = 120 m)

12:00-15:00 daily average comparison JUE (Jülich, Germany, alt = 98 m, height = 120 m)

- For non-elevated stations with local sources:
  - better use afternoon hours only?
  - averages over [12:00,15:00] local-time

12-15 mean concentration without background

43.0 %	
9.6 %	
7.0 %	
3.9 %	
9.7 %	
2.5 %	
2.0 %	
0.4 %	
21.6 %	
0.3 %	

- Background
- Agriculture
- Biogenic
- Coal mining and handeling
- Electricity and heat production
- Gas and oil production and handeling
- Industry
- Residential and Commercial Combustion
- Transport - road shipping aviation
- Waste
- Wildfire
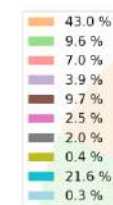
Simulations over 2021-2022
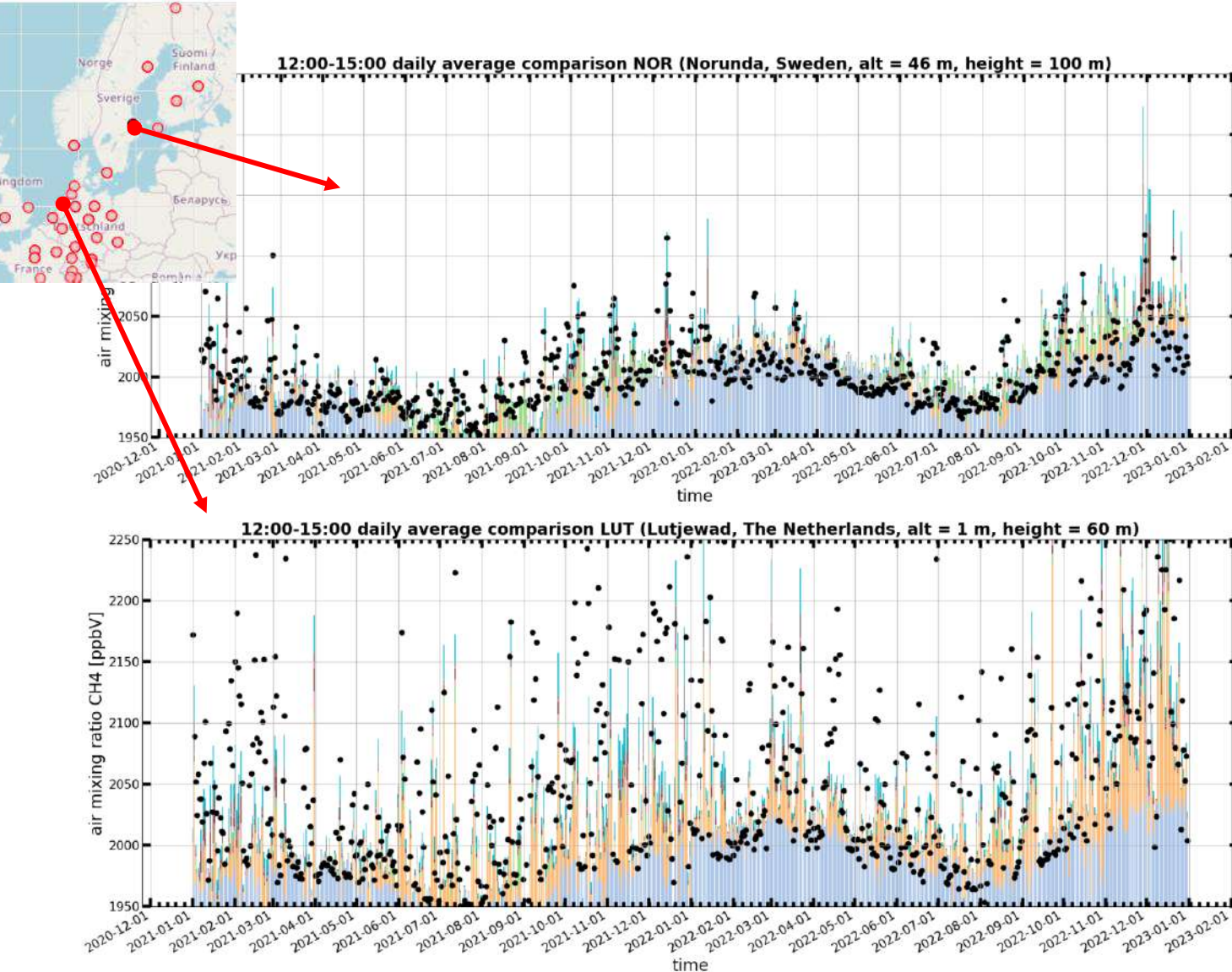
- Example of two sites that (occasionally) receive background concentrations only:
  - Norda (SWE)
  - Lutjewad (NLD)
- Local contributions (especially in Lutjewad), on top of increasing background
- Background is important to infer trends in local emission

Simulations over 2021-2022

- Characterization of stations:
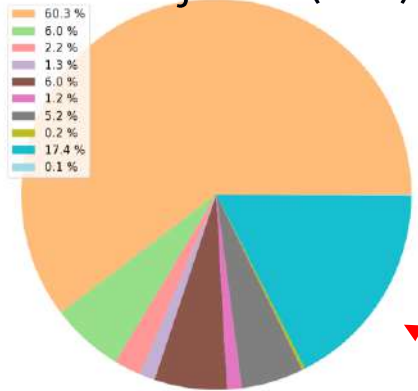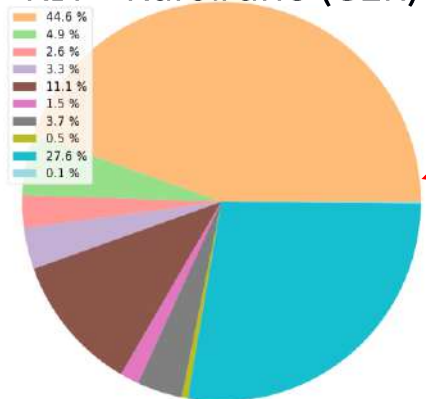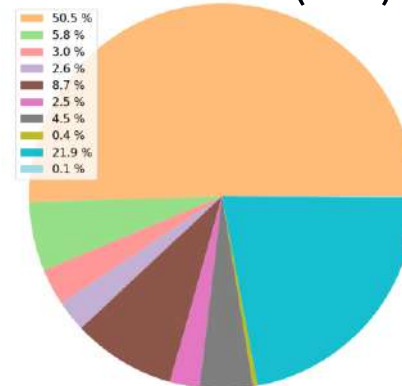 stations in north-west Europe most influenced by local **agriculture** and **waste treatment** ;

- other sector have more stable contribution

LUT – Lutjewad (NLD)

60.3 %	
6.0 %	
2.2 %	
1.3 %	
6.0 %	
1.2 %	
5.2 %	
0.2 %	
17.4 %	
0.1 %	

KIT – Karslruhe (GER)

44.6 %	
4.9 %	
2.6 %	
3.3 %	
11.1 %	
1.5 %	
3.7 %	
0.5 %	
27.6 %	
0.1 %	

JUE – Julich (GER)

50.5 %	
5.8 %	
3.0 %	
2.6 %	
8.7 %	
2.5 %	
4.5 %	
0.4 %	
21.9 %	
0.1 %	

- Background
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Ethane as tracer for fossil methane

preliminary results!

Total (2018)

- Ethane (C$_2$H$_6$) is emitted during extraction and use of fossil methane (CH$_4$), and has almost no biogenic source
  → use ethane as tracer for fossil methane?

AP Emission C2H6 [kTon/yr]

12:00-15:00 daily average comparison NOR (Norunda, Sweden, alt = 46 m, height = 100 m)
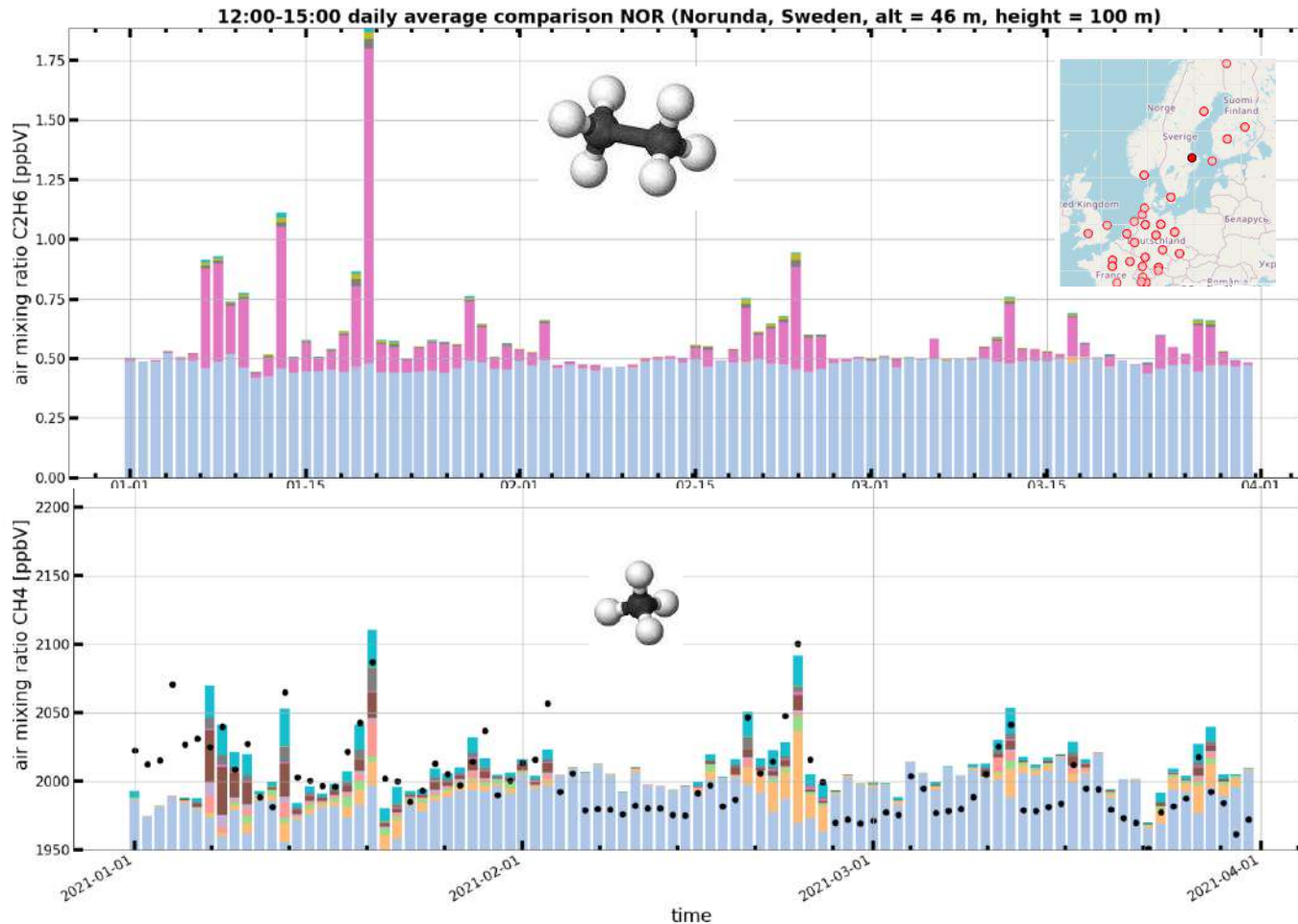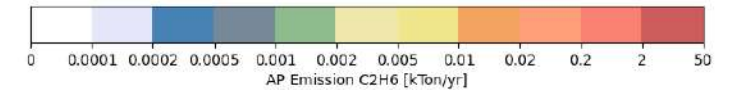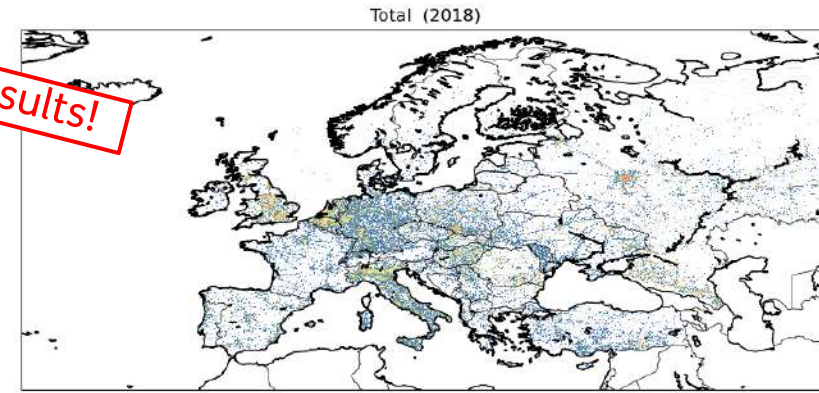
- First simulations of ethane:

  - background rather stable ... *(correct?)*

  - source "Industry" is dominant ... *(correct?)*

  - no observations collected yet

- No correlation with methane source "Industry", but indication for importance of local sources?

Legend:
- Background
- Agriculture
- Biogenic
- Coal mining and handeling
- Electricity and heat production
- Gas and oil production and handeling
- Industry
- Residential and Commercial Combustion
- Transport - road shipping aviation
- Waste
- Wildfire

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Outlook

- Daily updated source apportionment service for methane:
  topas-ch4.tno.nl

- On the action list:

  - improve boundary conditions *(use more than one?)*

  - (selected) country specific labels

  - figure selection, figure tuning, …

  - provide data *(on ICOS portal?)*

- Ethane tracer and observations

- Long term evaluation:

  - multi-year simulations

  - evaluate sampling strategies (temporal averages, sampling heights, …)