PSI

Characterization of Ultrafine Particles at a Rural Site in Switzerland

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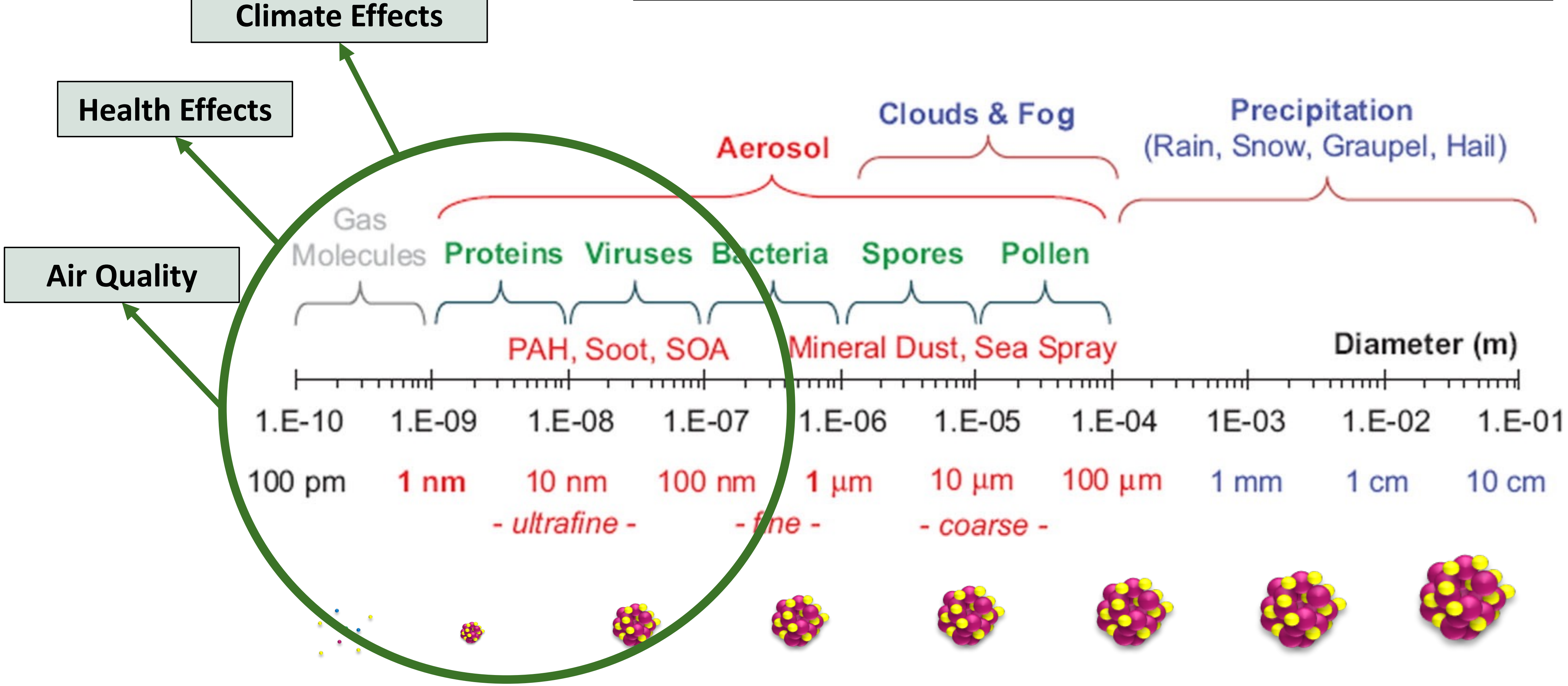
Size ranges of atmospheric aerosols

Focus of this talk: ultrafine particles <100 nm in diameter



Adapted from Shiraiwa et al. 2012

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Sources of Ultrafine Particles

UFP (D < 100 nm)

Primary particles

Emitted as particles

- **Traffic**
- **Domestic heating**
- **Airport emissions**
- **…..**

Anthropogenic dominant

Secondary particles

Formed in the atmosphere

New particle formation events from gas precursors

- Anthropogenic
- Biogenic

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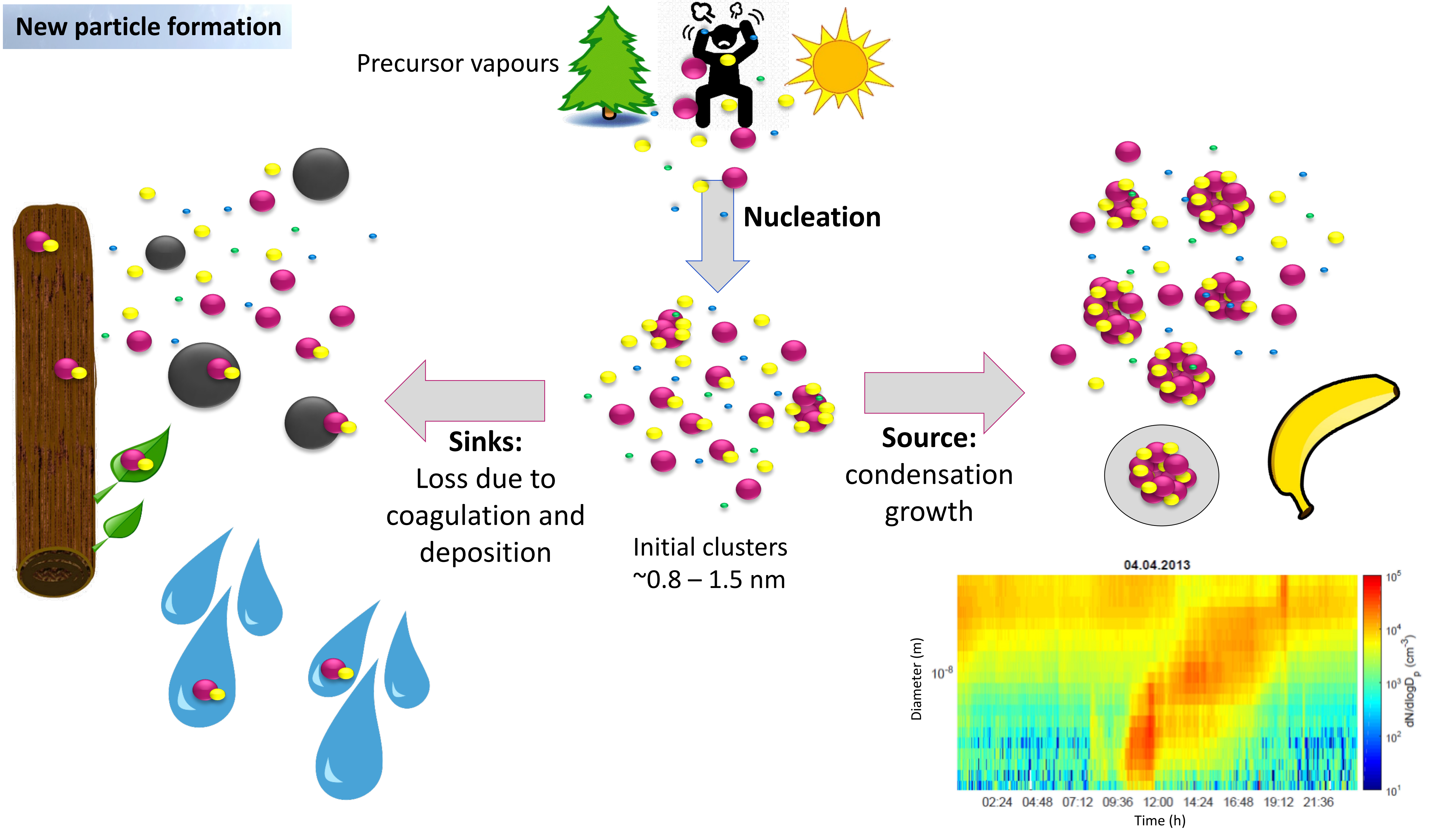
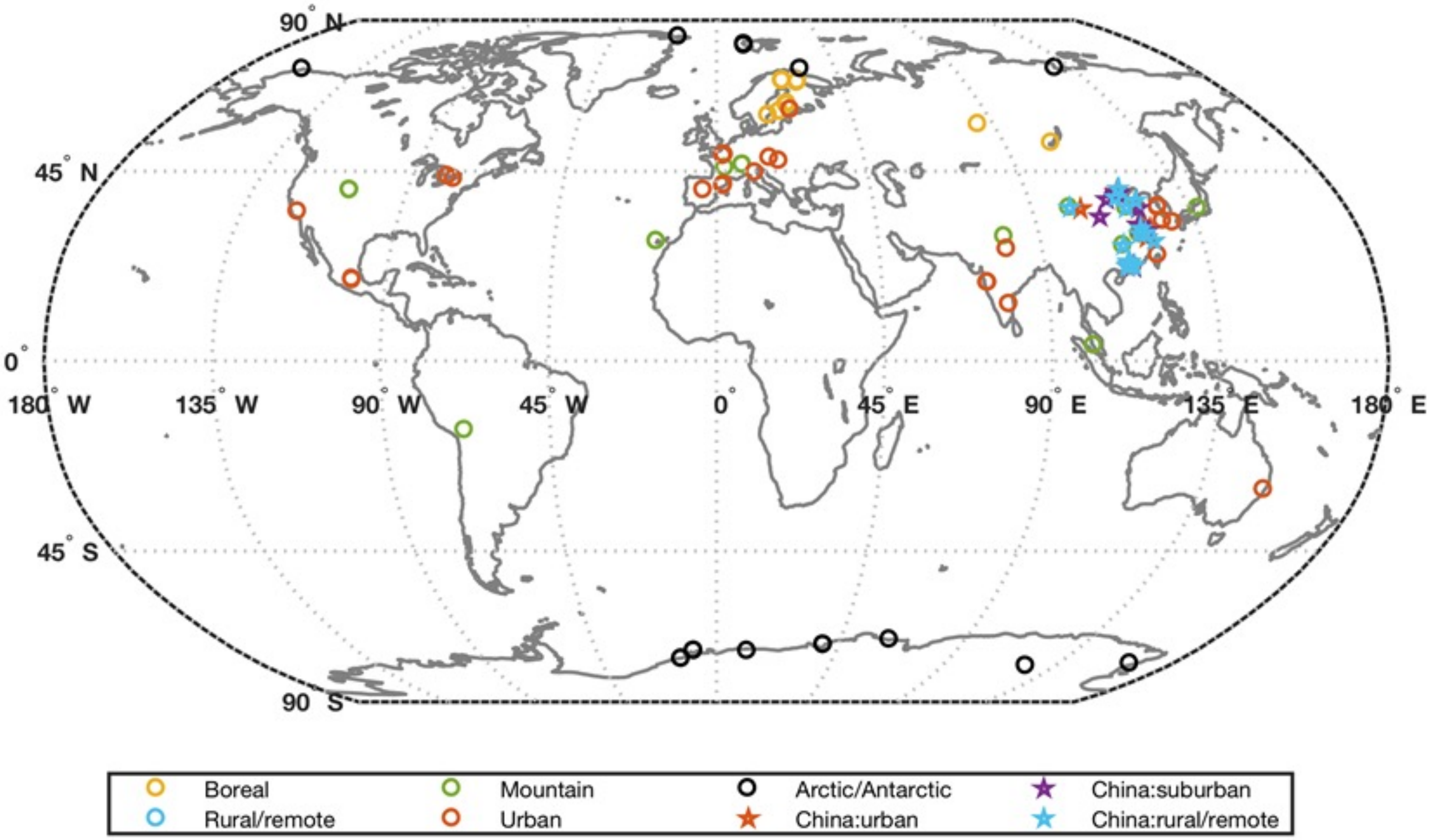
New particle formation



Regional NPF is observed in all environments.



However, we know only little about NPF in the rural environments in Europe especially within Swiss plains.

Kerminen et al. 2018

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Where in Switzerland?

Centre for Reactive Trace Gases In Situ Measurements (CiGas)
Operational support for trace gas measurements

PSI Atmospheric Chemistry Simulation Chambers (PACS)
Proccess studies of aerosols and gases

Centre for Aerosol Remote Sensing (CARS)
Reference center for aerosol optical depth measurements and calibration

BRM National Facility
In situ measurements of trace gases on the rural Swiss Plateau

JFJ National Facility
In situ measurements of aerosols, trace gases and clouds at remote, high altitude

PAY National Facility
In situ and remote sensing measurements of aerosols and clouds on the rural Swiss Plateau

What about primary and secondary UFP on the rural Swiss Plateau?
This study: One year of UFP and auxiliary measurements at Payerne observatory.

NPF events observed on top of the JFJ are found to be driven by both biogenic and anthropogenic precursors.
Manninen et al. 2010, Bianchi et al. 2016

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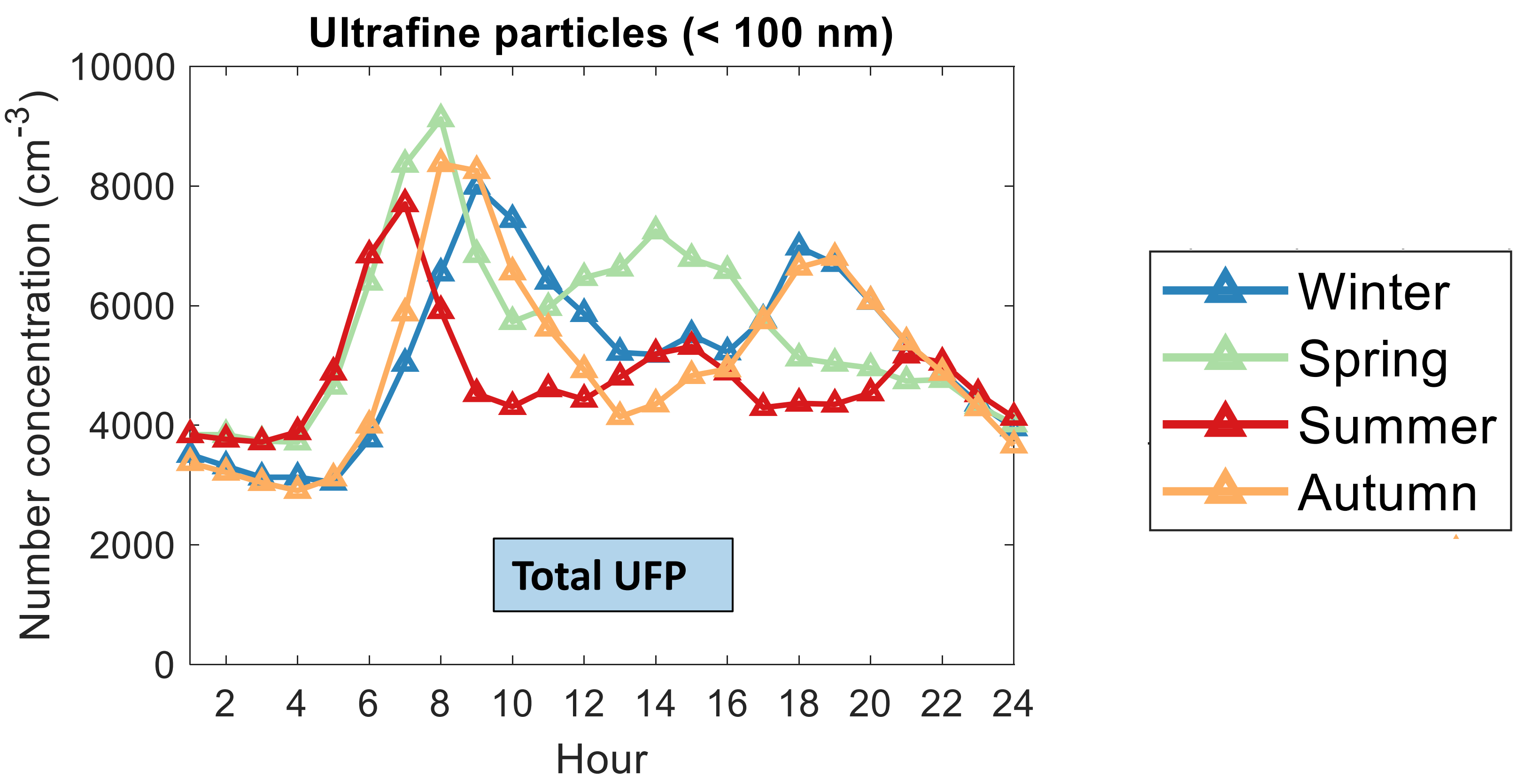
Diurnal pattern UFP number concentration



Total UFP:
➔ **Pretty constant background of ~4’000 cm-3.**
➔ **Distinct diurnal pattern on top of background suggests considerable contribution from local UFP sources (<~1h transport).**

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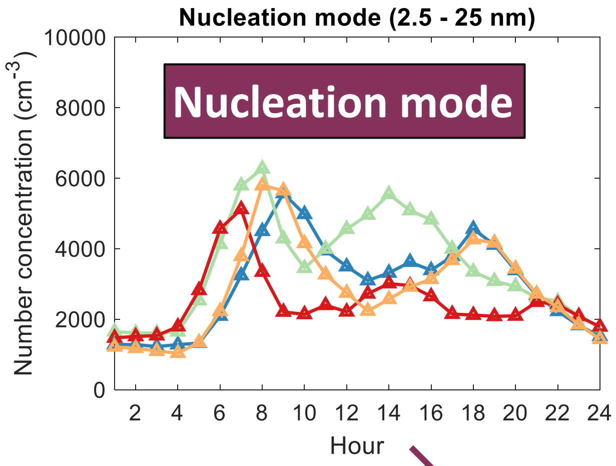
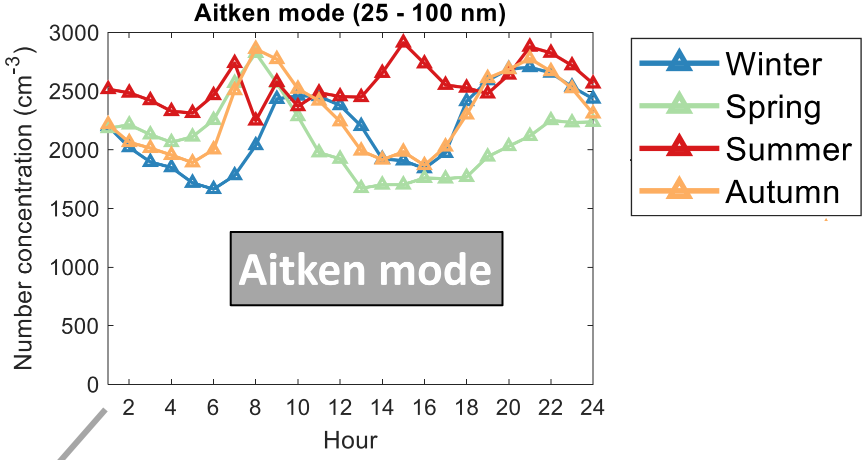
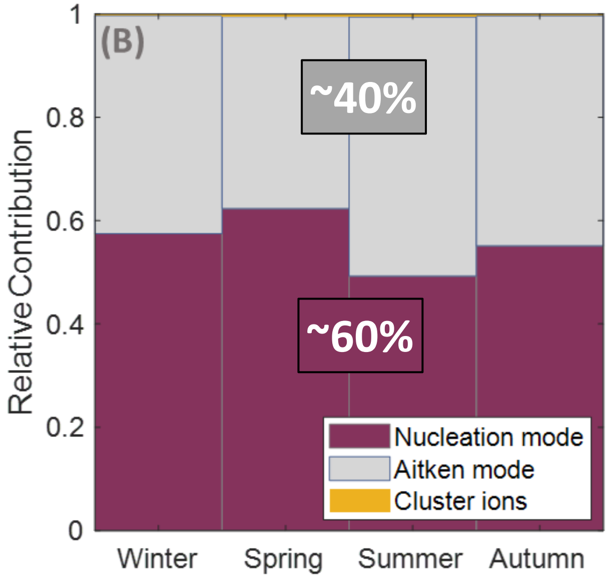
Diurnal pattern and size fractions of UFP

Drives diurnal variability of UFP
→ high ratio of nearby emissions/production compared to contribution from advection



Small variability
→ advection dominates over nearby emissions/production





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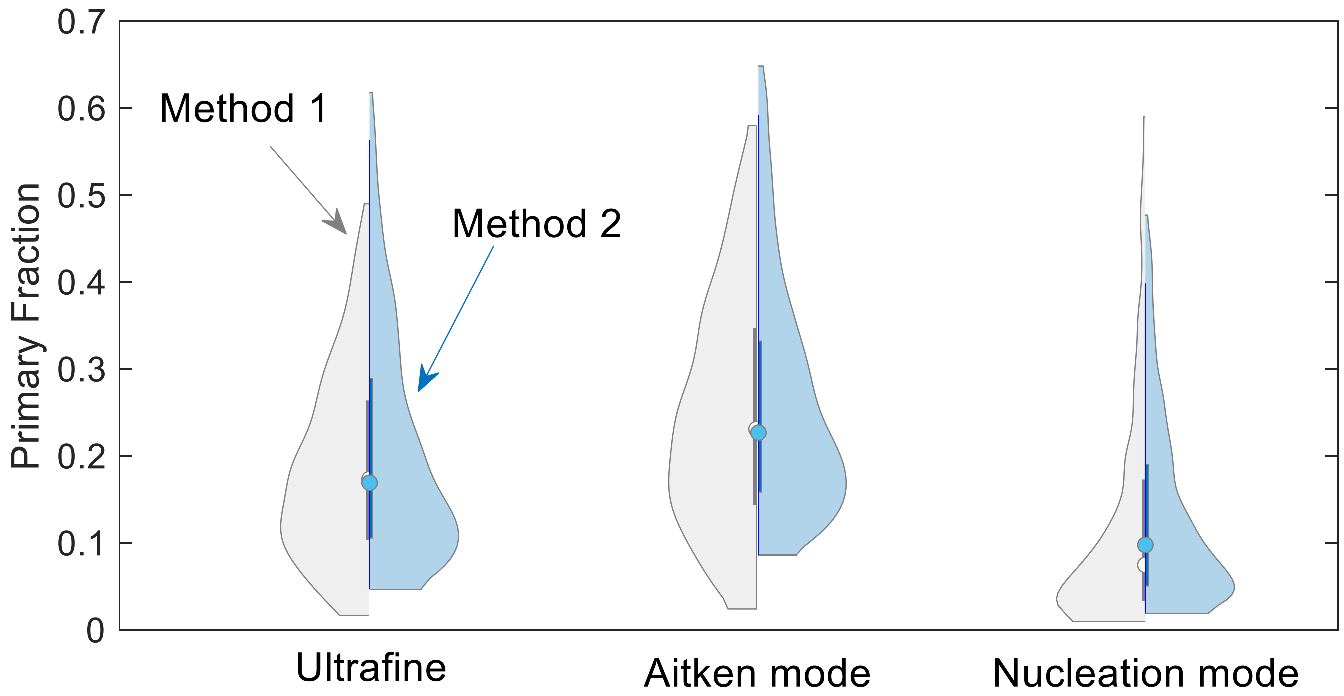
Two methods to determine the primary UFP

Non-volatile particle number as proxy
- Use Catalytic Stripper
- Measure number (and size distribution) of non-volatile particles

Black carbon as a tracer
- Assume fixed emission ratio for primary particle number to BC mass
- Estimate this ratio from lower edge of correlation plot.



1) Both methods agree nicely for the overlapping measurement period

2) Secondary particles dominate the number concentration of UFP.

3) Primary fraction higher in Aitken mode compared to nucleation mode.

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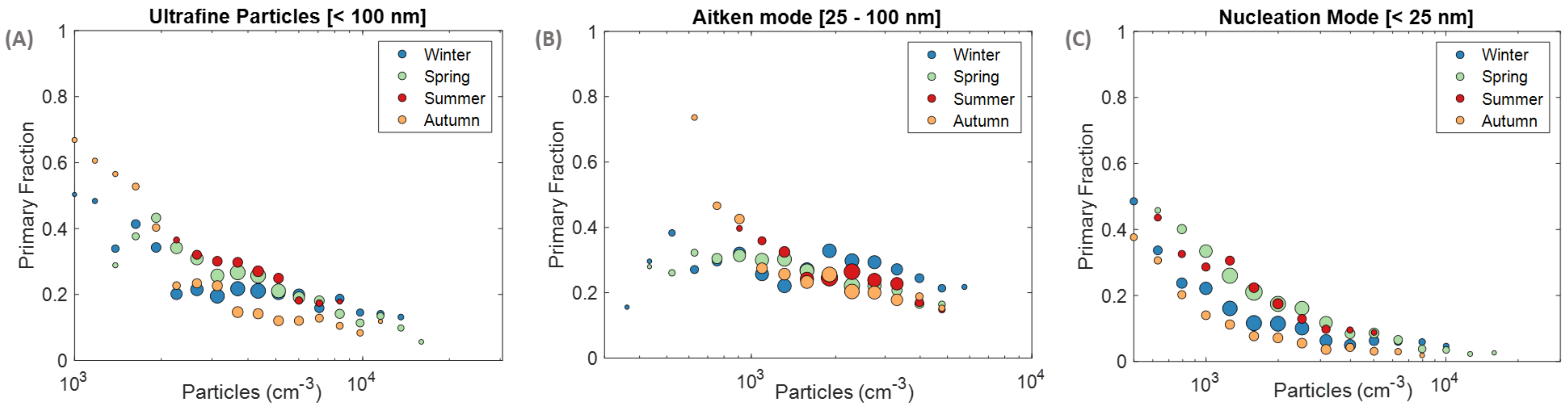
Contribution of primary and secondary UFP



1) Comparable contribution of primary particles across seasons.

2) The larger the number concentration, the smaller the primary fraction.
➔ Secondary particles originating from new particle formation events dominate high UFP concentration events, particularly for the nucleation mode.

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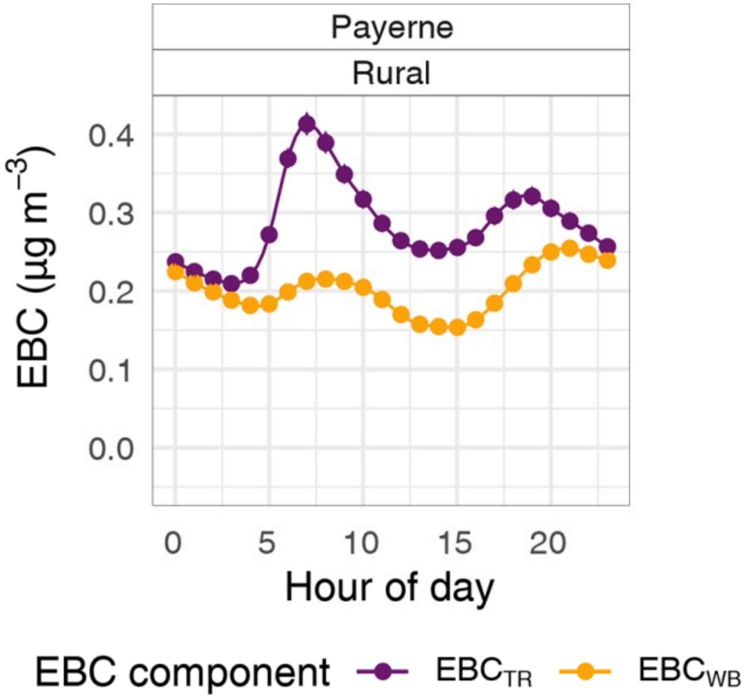
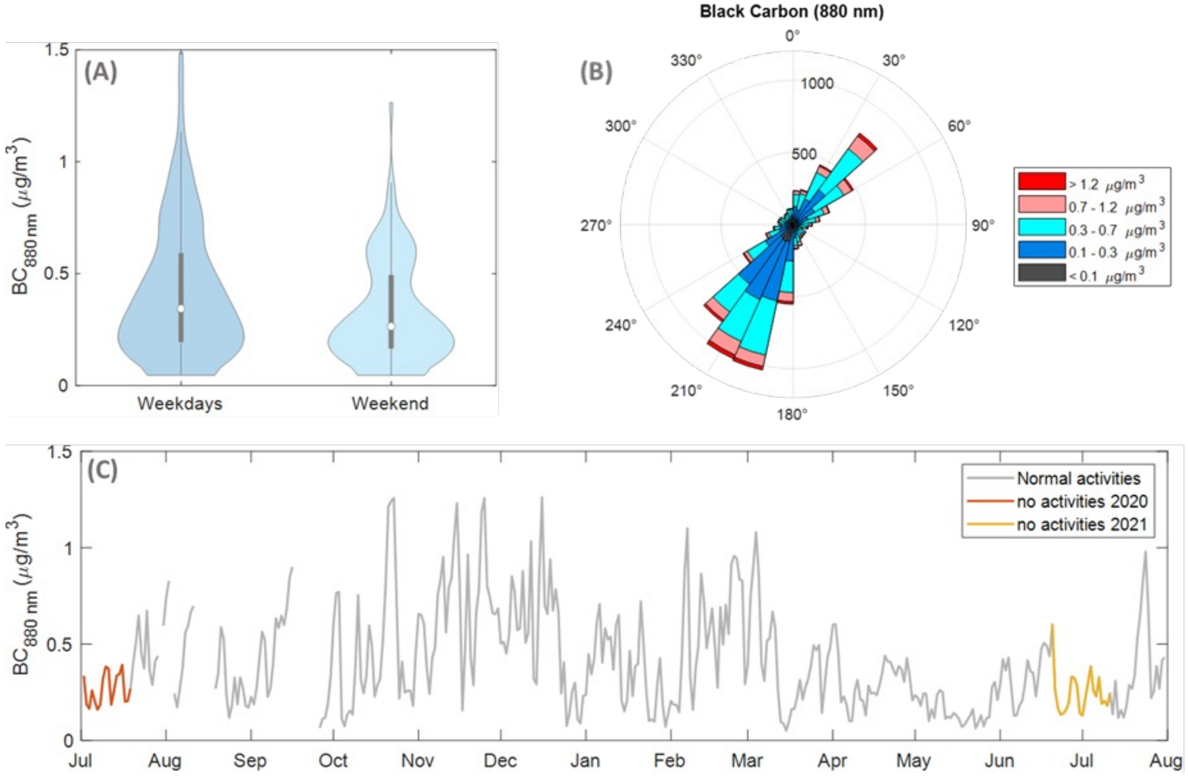
Primary particles at Payerne





Previous studies have shown traffic and wood burning dominate the BC (proxy for primary particles) at Payerne.
Grange et al. 2020

Our results show little evidence of airport direct contributions to BC concentrations in Payerne.

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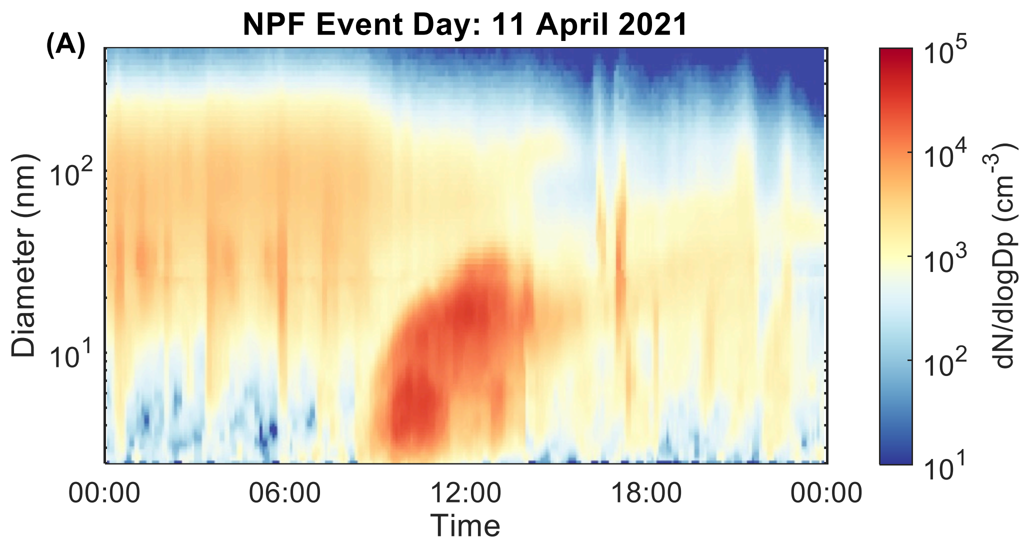
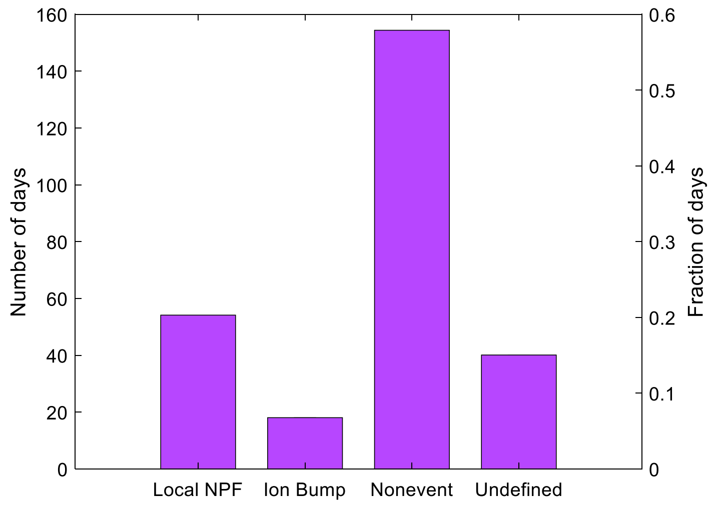
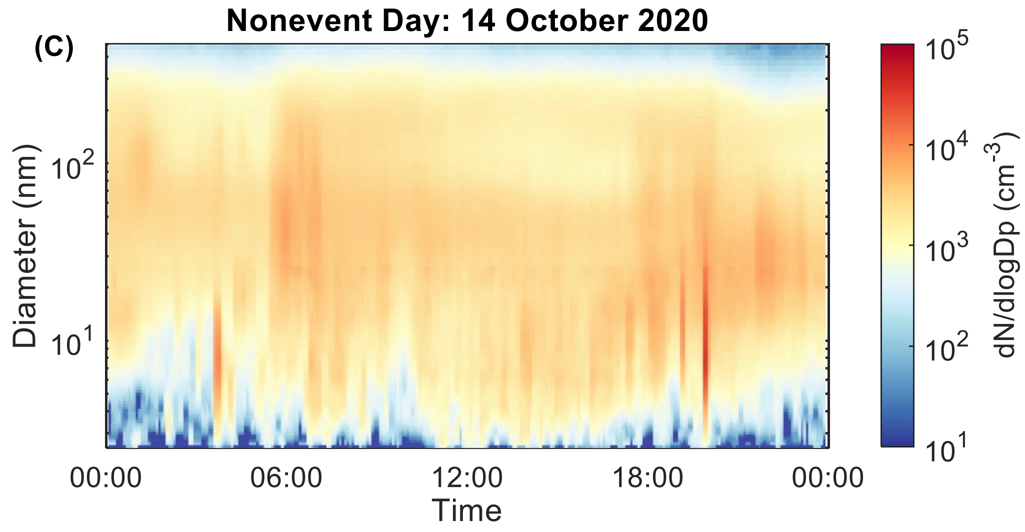
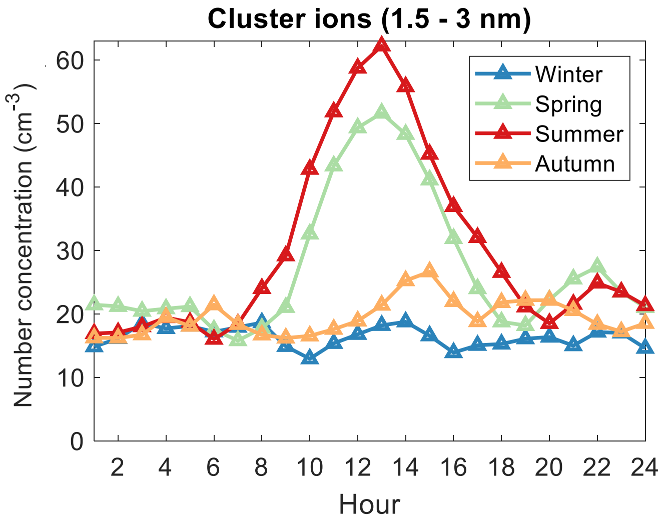
Secondary particles: NPF at Payerne





NPF events are observed on ~25% of the days.





Indicates NPF in warmer season around noon-time.
➔ also seen in nucleation mode

Intense NPF events are observed at Payerne, starting from the smallest sizes.

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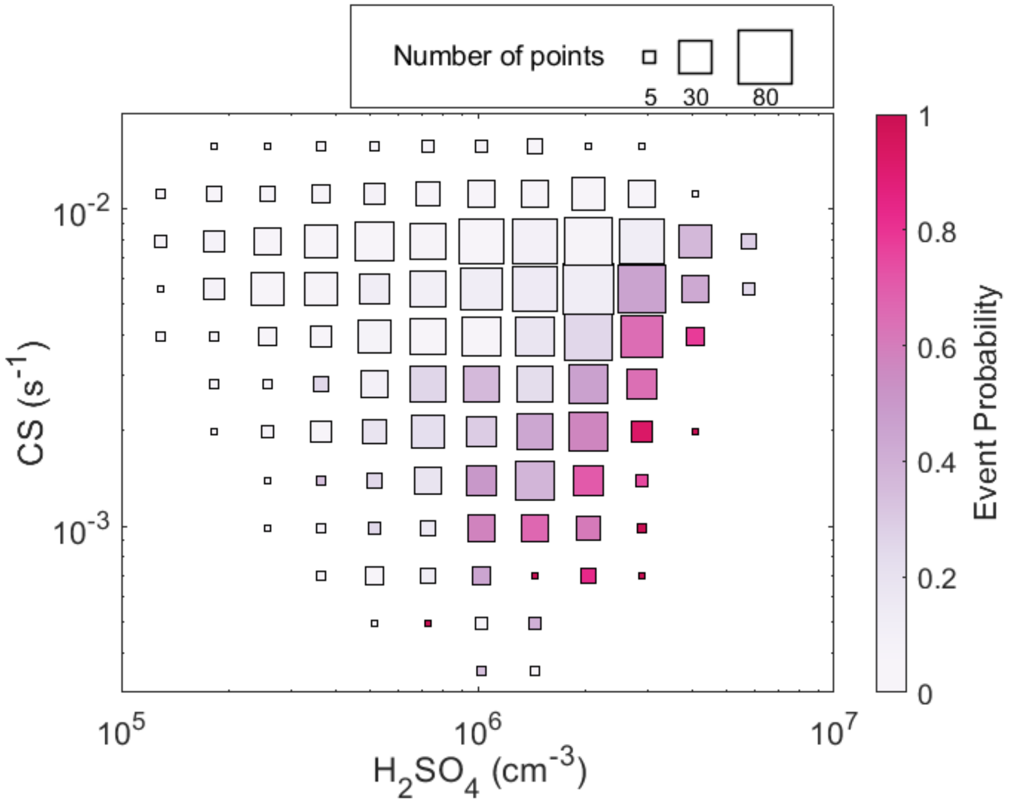
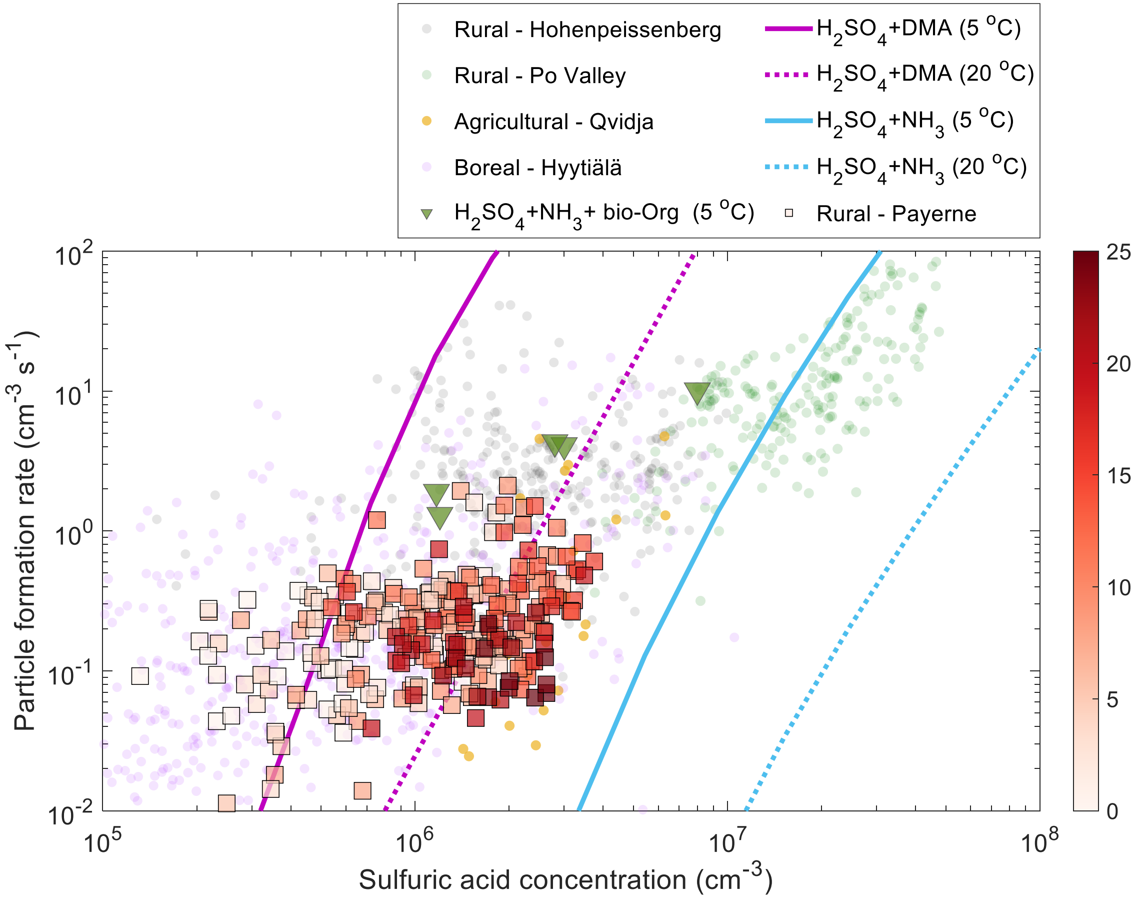
NPF occurrence and precursors

Condensation sink





NPF only occurs if:

- **Sulfuric acid concentrations are sufficiently high.**
- **Condensation sink is sufficiently low.**

By comparing to other locations in Europe, and to chamber experiments and modeling results, we infer that NPF events in Payerne are driven by sulfuric acid and stabilizing bases such as ammonia and amines.

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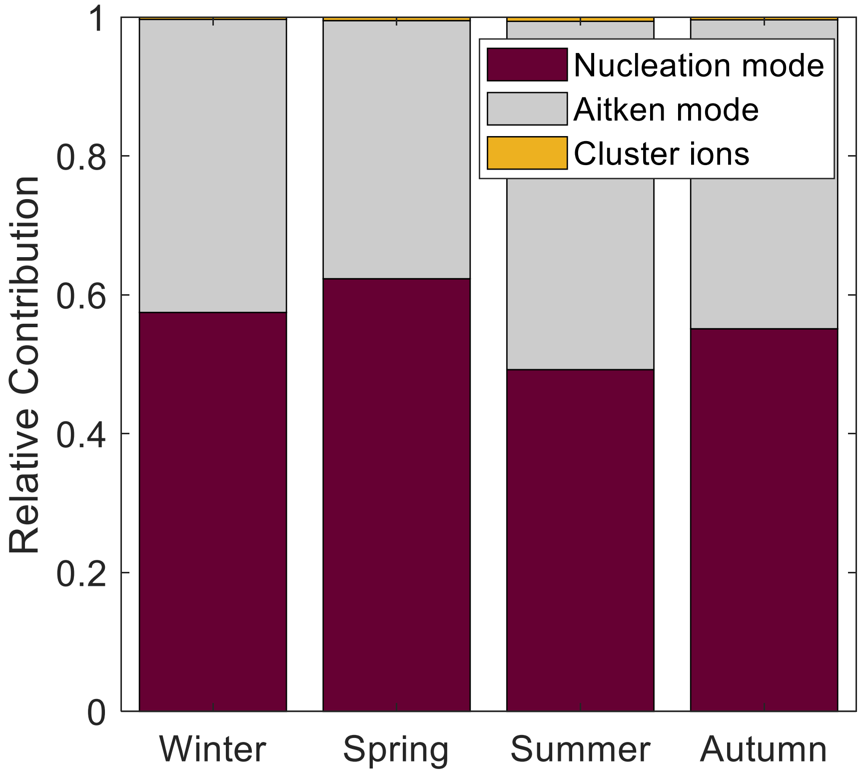
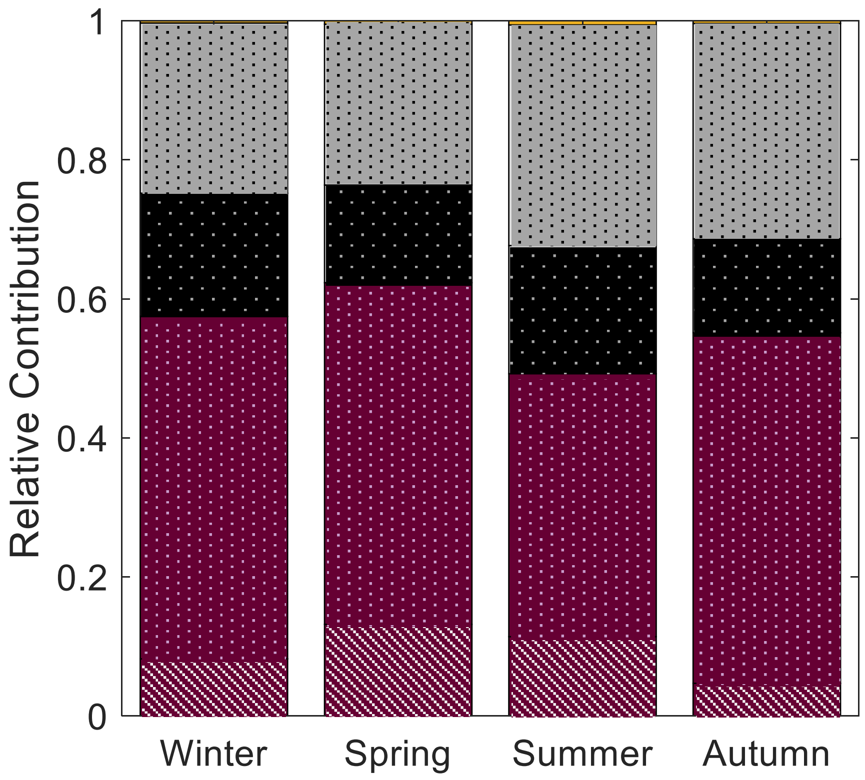
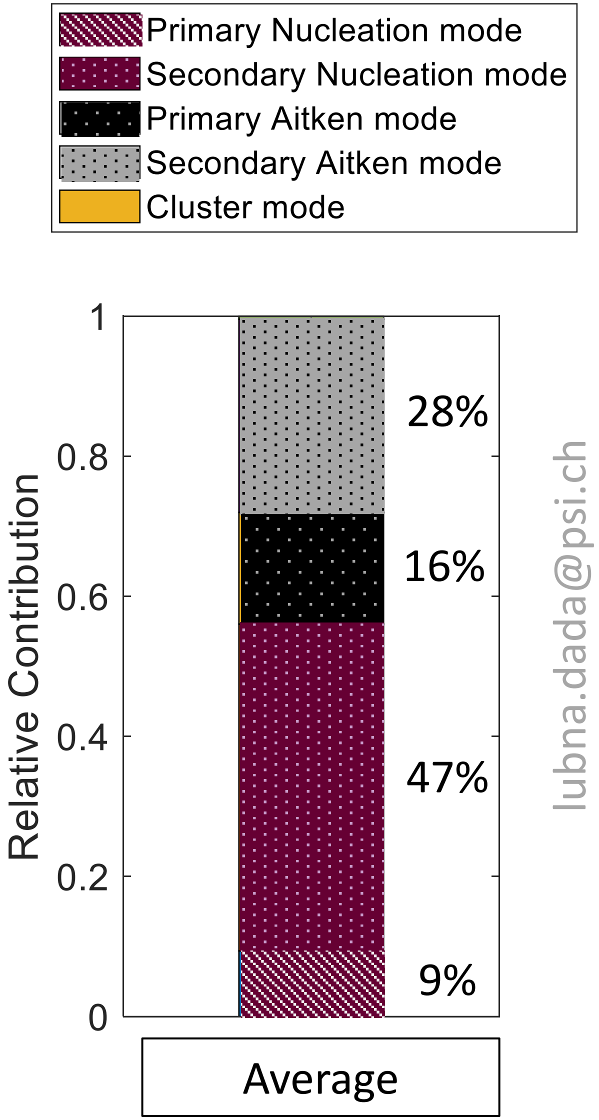
Secondary UFPs matter, a lot!







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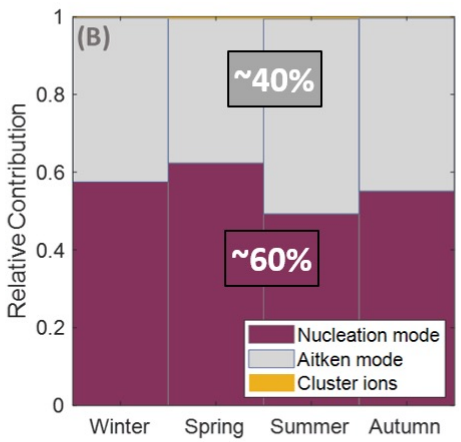
Conclusions

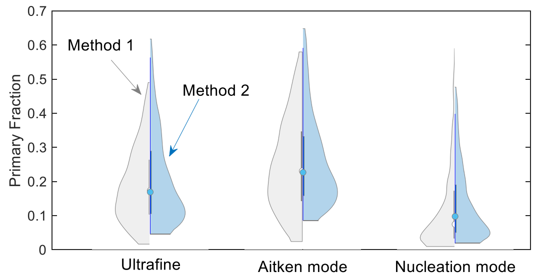
1) **Nucleation mode and Aitken mode contribute ~60% and 40% to total particle number**, respectively.

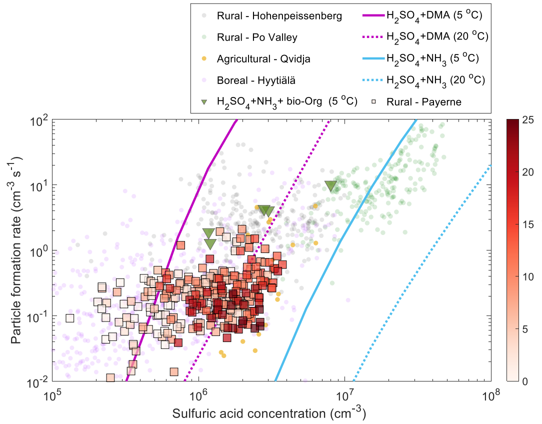
2) Variability of UFP is driven by variability of nucleation mode. Aitken mode concentration remains quite stable.
   ➔ **Much shorter lifetime of small primary particles leads to pronounced impact of local/regional emission** as opposed to larger diameters.

3) Two methods for quantifying the relative contributions of primary and secondary particles agree that **secondary particles dominate over primary particles**.

4) NPF events are driven by **sulfuric acid**, with the help of stabilizing bases such are **ammonia** and **amines**.







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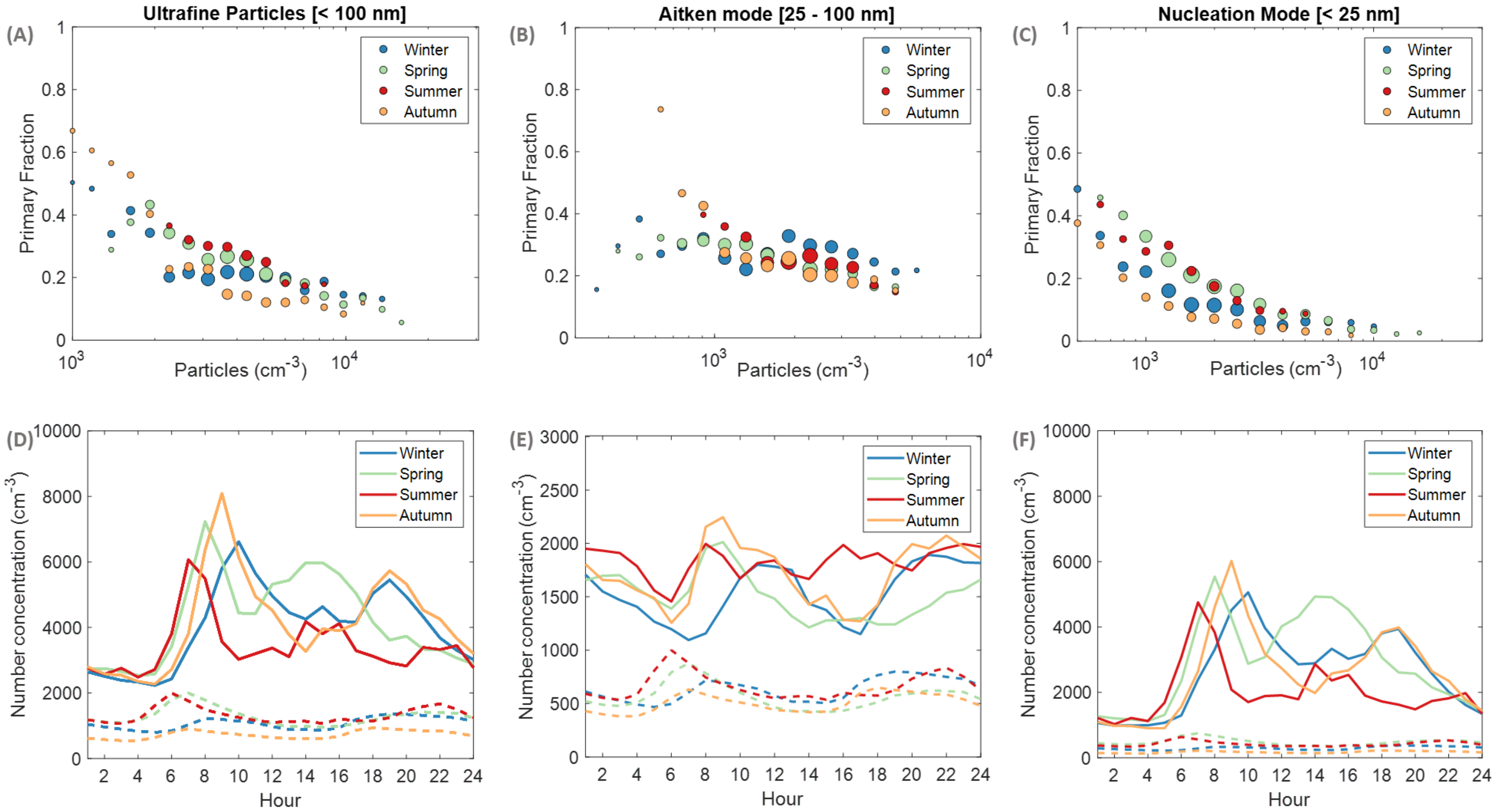
Contribution of primary and secondary UFP



1) Comparable contribution of primary particles across seasons.

2) The larger the number concentration, the smaller the primary fraction.

➔

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