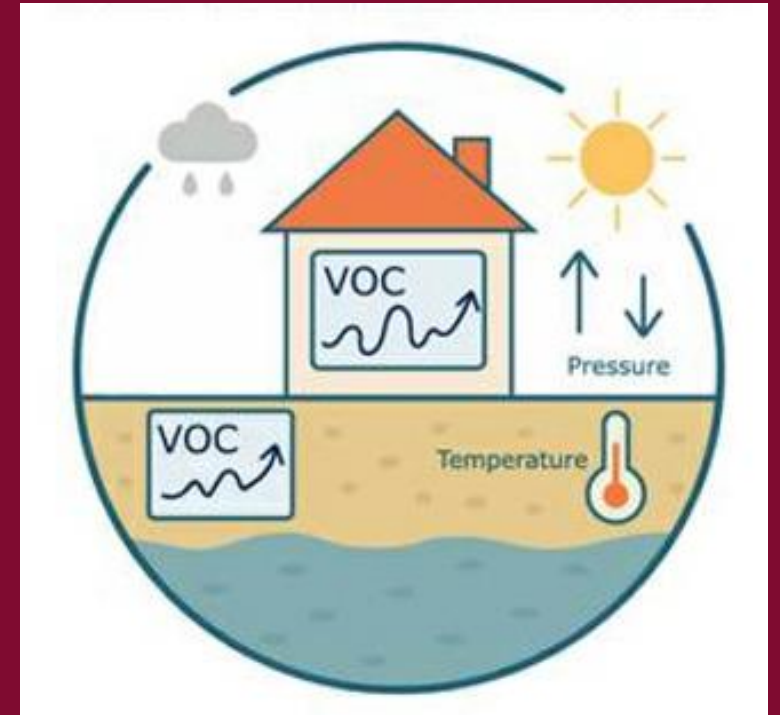


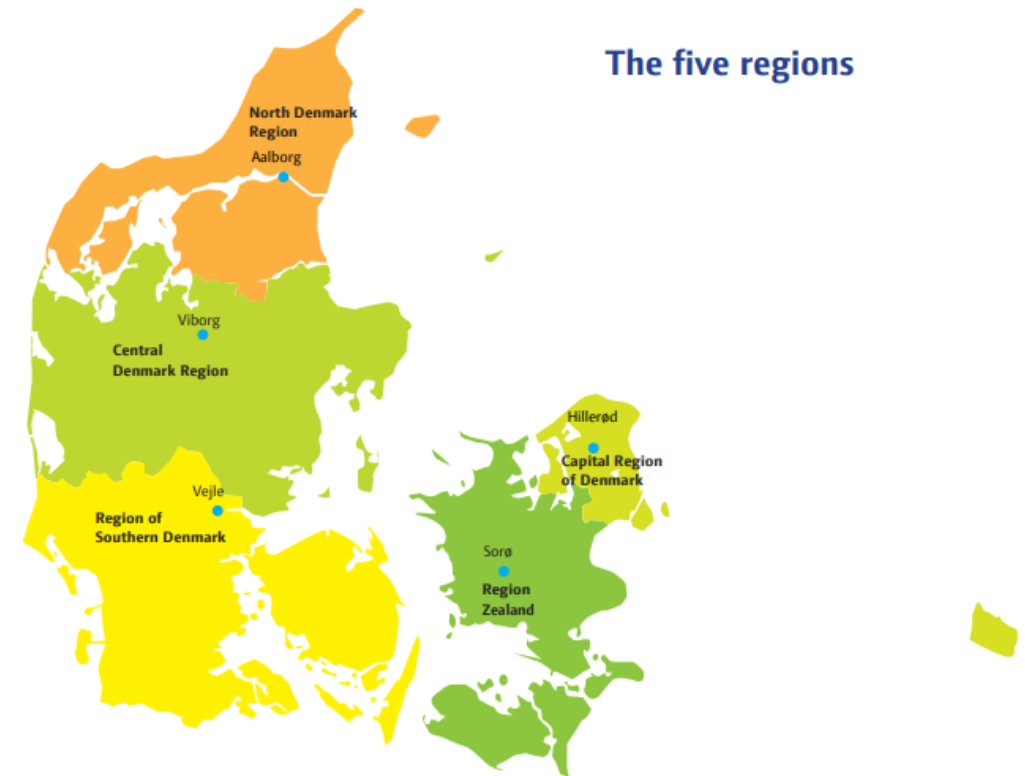


Temporal Variability of VOC Concentrations in Indoor Air and Sub-Slab Soil Vapour at a Former Dry Cleaner Site

Presented by Susanne Arentoft on behalf of Winnie Hyldegaard, Børge Hvidberg & Karin Birn Nielsen
Central Denmark Region, Denmark

Who We Are

- The Danish Regions manage contaminated land in Denmark.
- We investigate contaminated sites, assess risks, and implement remediation when necessary.
- Protecting human health and groundwater resources is our primary objective.



Why Conduct a Long-Term Study?

- Danish guidance recommends indoor-air measurements during winter.
- Winter measurements are assumed to provide conservative estimates.
- Limited evidence exists regarding long-term temporal variability.

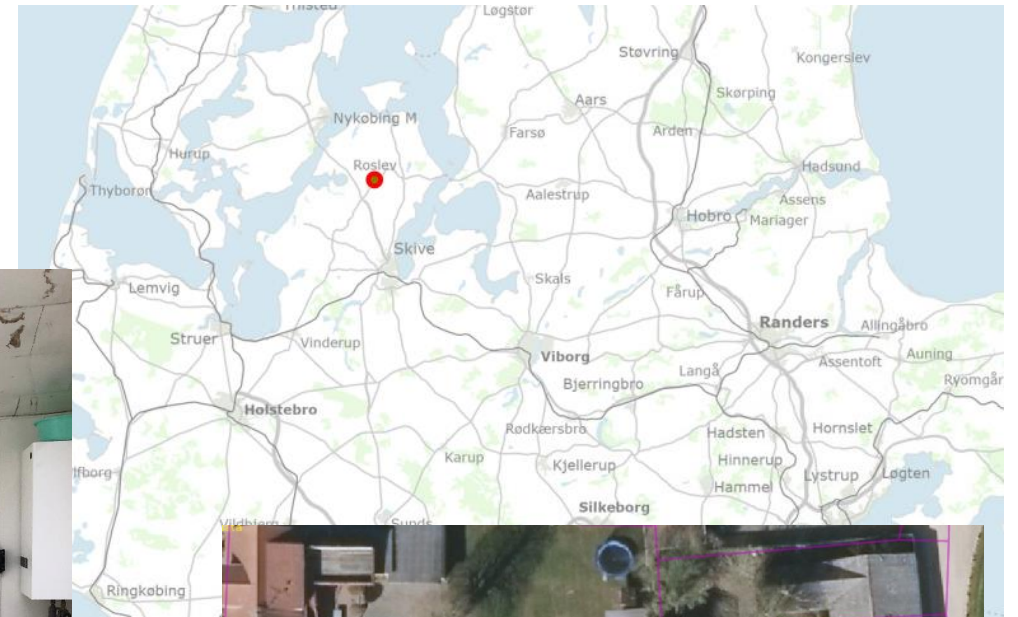


Study Objectives

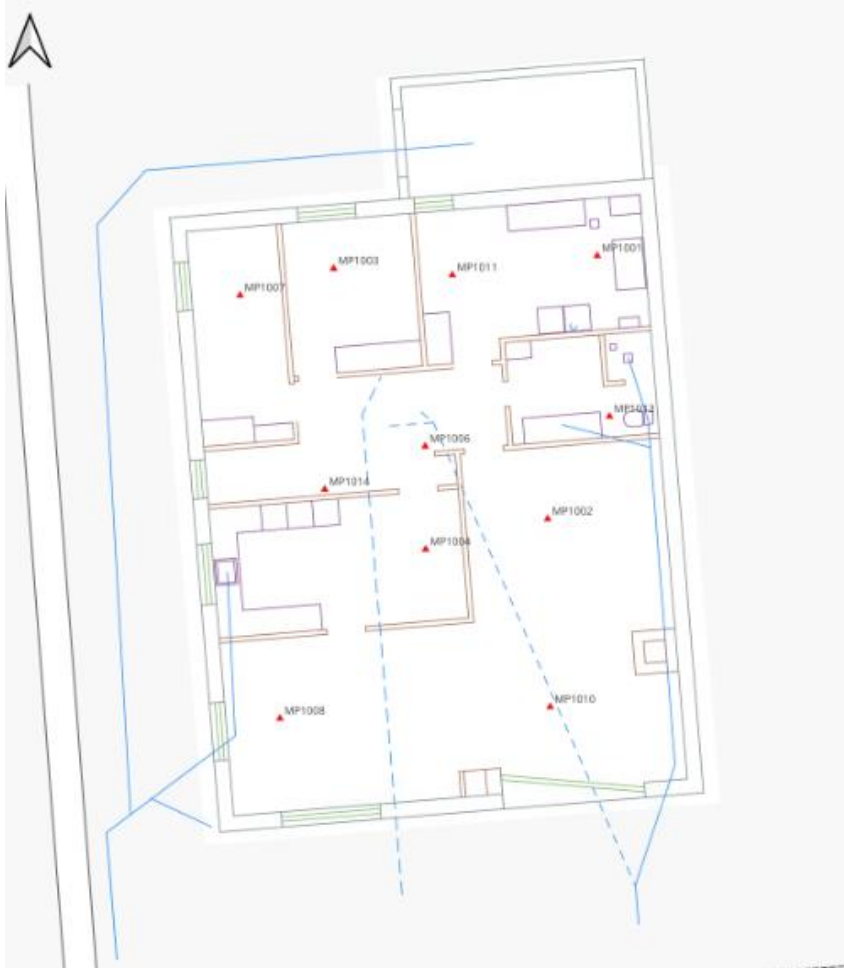
- Quantify temporal variability over two years.
- Identify optimal monitoring periods.
- Investigate environmental drivers.
- Improve confidence in vapour-intrusion risk assessments.

Test house - Roslev

- A former dry cleaner site
- Shallow groundwater table, 0.5-1.0 meters below ground level
- Contaminated with primarily Tetrachlorethylene (PCE)
- Old house, on the verge of being drafty but low venting because it is unoccupied
- Key message:
A near-surface source combined with shallow groundwater creates ideal conditions for studying temporal variation



Measurement points



Sub slab soil vapor – 11 permanent points



Indoor air – 8 permanent locations

Monitoring Programme

- Two-year study March 2020 - February 2022
- Measured parameters:
 - ❖ Sub-slab soil vapour and indoor air (TCE, PCE and others)

	Points	Method	Frequency	Period	Number of rounds	Number of measurements
Soil vapor	11	Dräger	Every 4th week	100 minutes	27	290
Indoor air	8	ORSA	Every 2nd week	14 days	49	390

- ❖ Radon
- ❖ Differential pressure
- ❖ Groundwater level
- ❖ Temperature
- ❖ Meteorological conditions

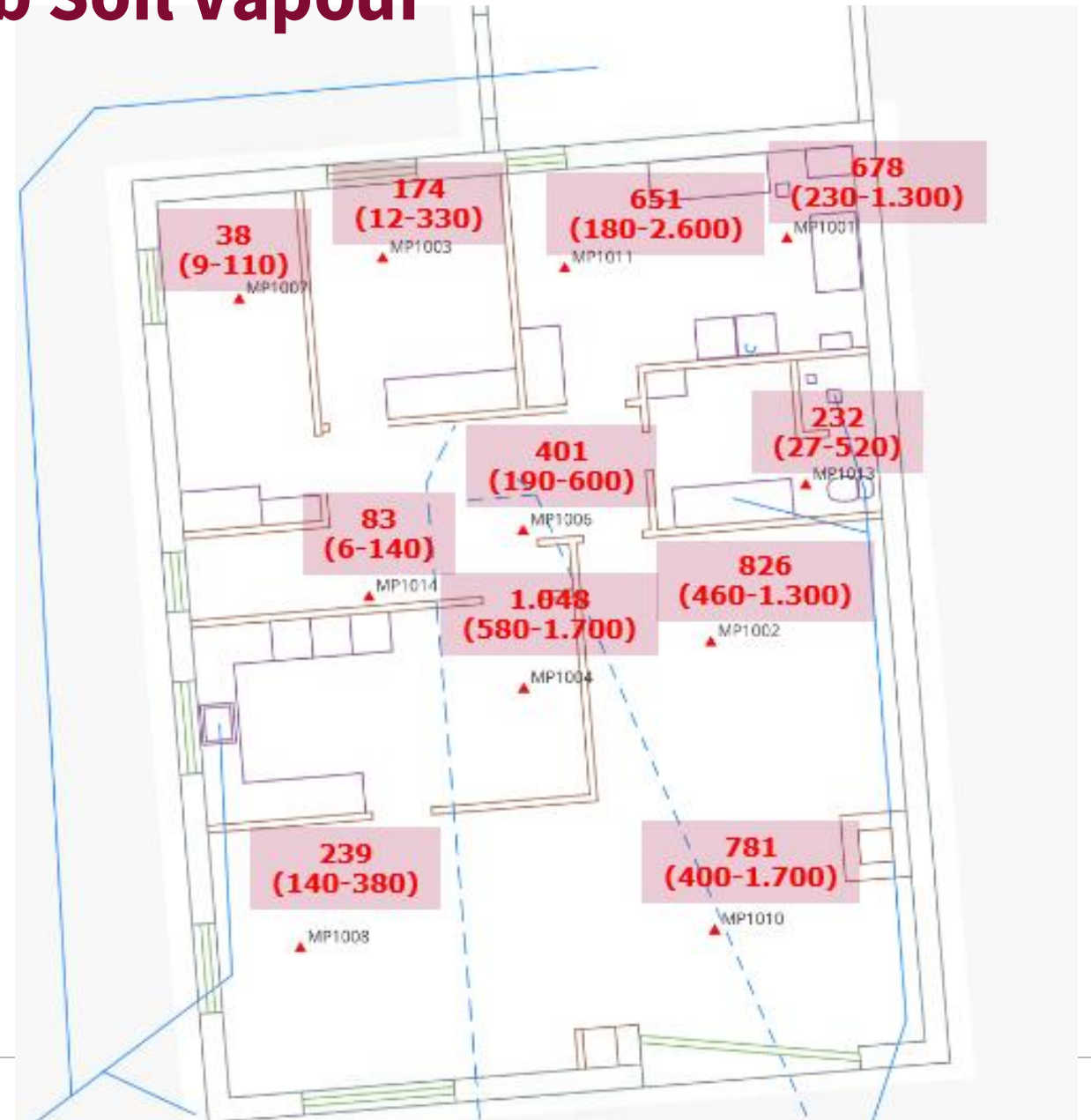
Spatial Variability in Sub-Slab Soil Vapour

Findings

- ❖ PCE concentrations ranged from 6.2 to 2,600 $\mu\text{g}/\text{m}^3$.
- ❖ Variability within a single monitoring round reached factor of up to 180.
- ❖ Highest concentrations occurred in the central and eastern parts of the building.

Key message:

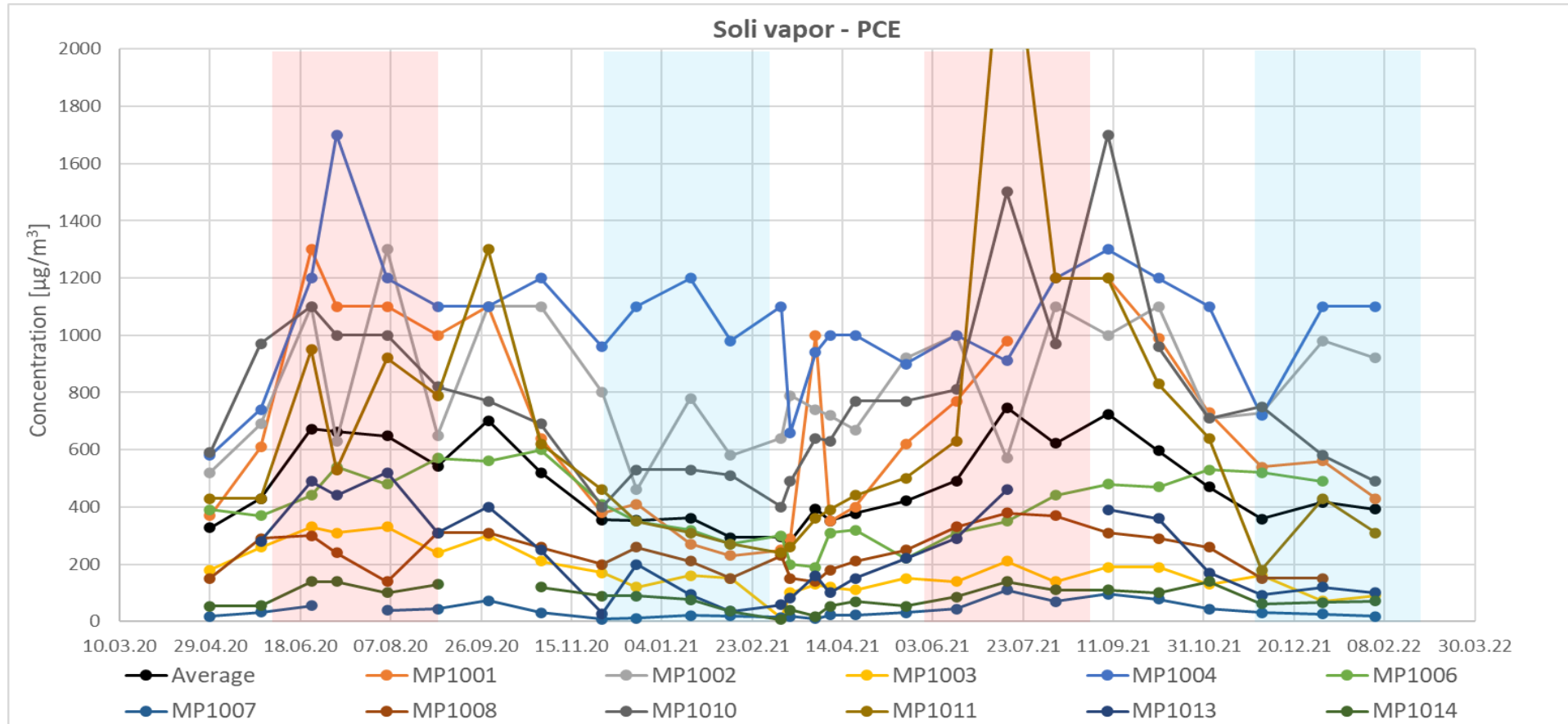
- ❖ Spatial variability was substantial and must be considered when designing monitoring programmes.



Temporal Variability in Sub-Slab Soil Vapour

Key message:

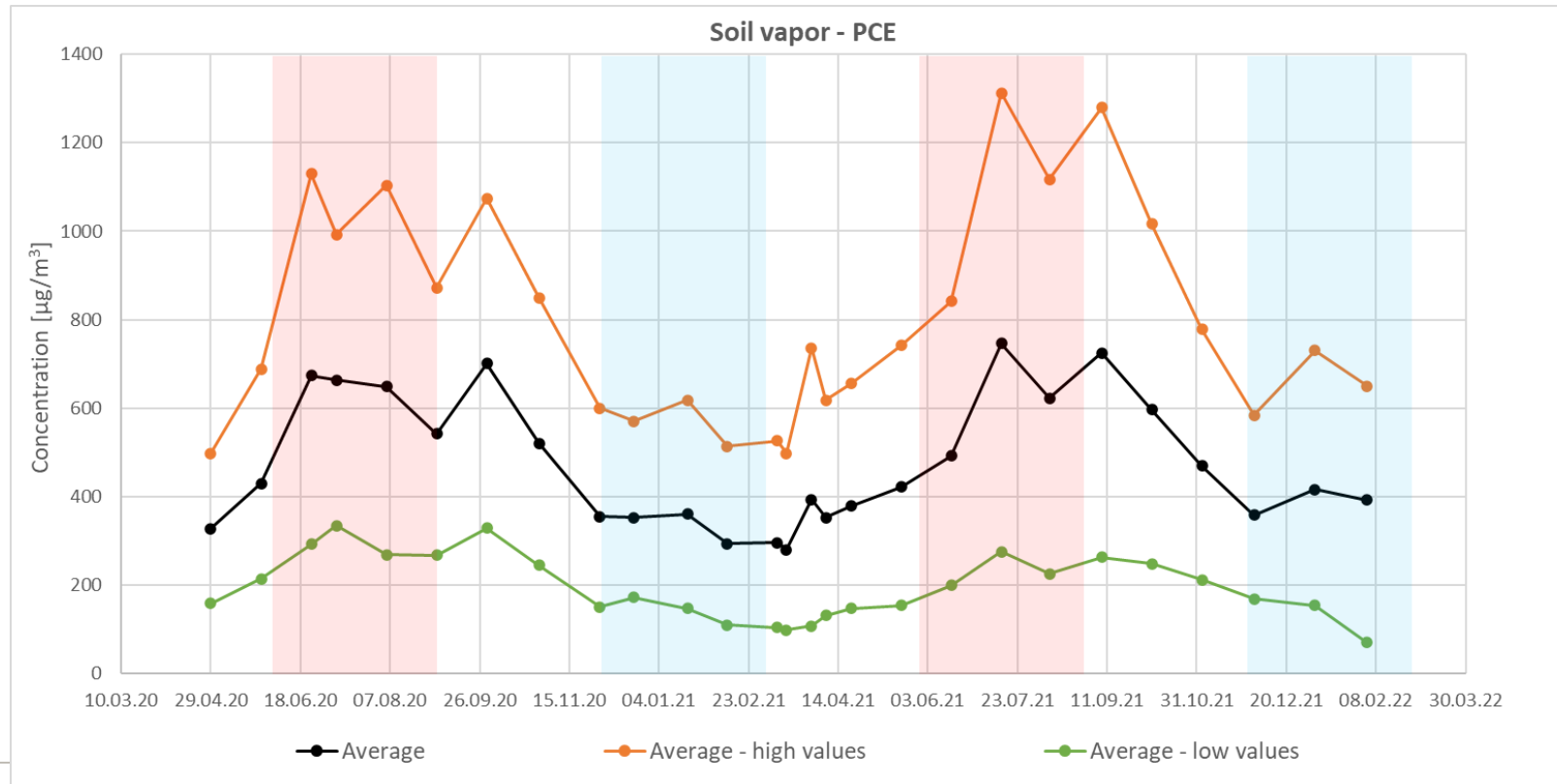
Spatial and temporal variability occurred simultaneously throughout the monitoring period.



Note: Red and blue markings, respectively indicate summer period (June-August) and winter periods (December to February)

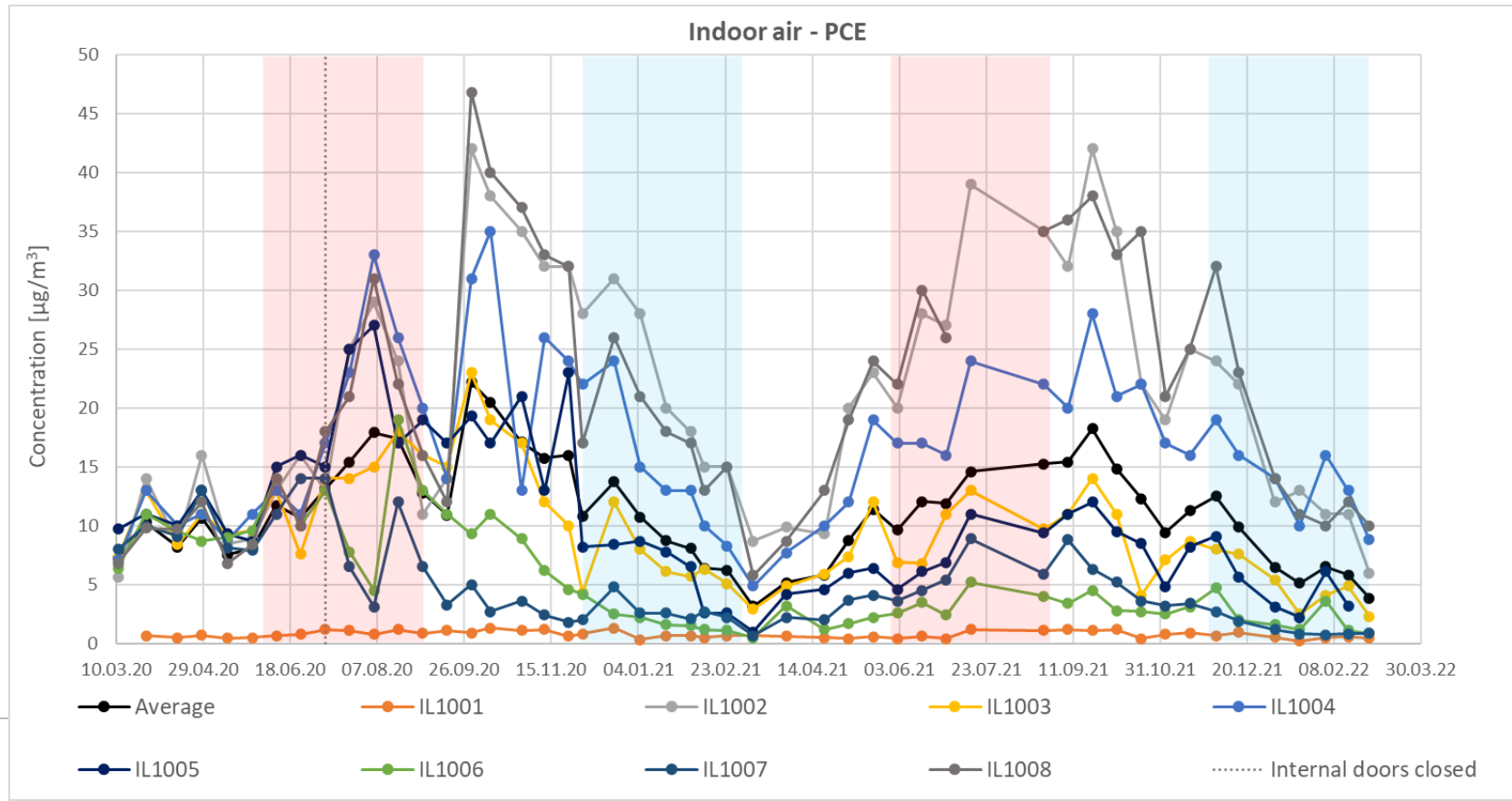
Seasonal Trends in Sub-Slab Soil Vapour

- Temporal variability up to a factor of 30.
- Highest concentrations observed during summer. Summer concentrations typically 2-3 times higher than winter.
- Key message:
Contrary to expectations, the highest vapour concentrations occurred during summer.



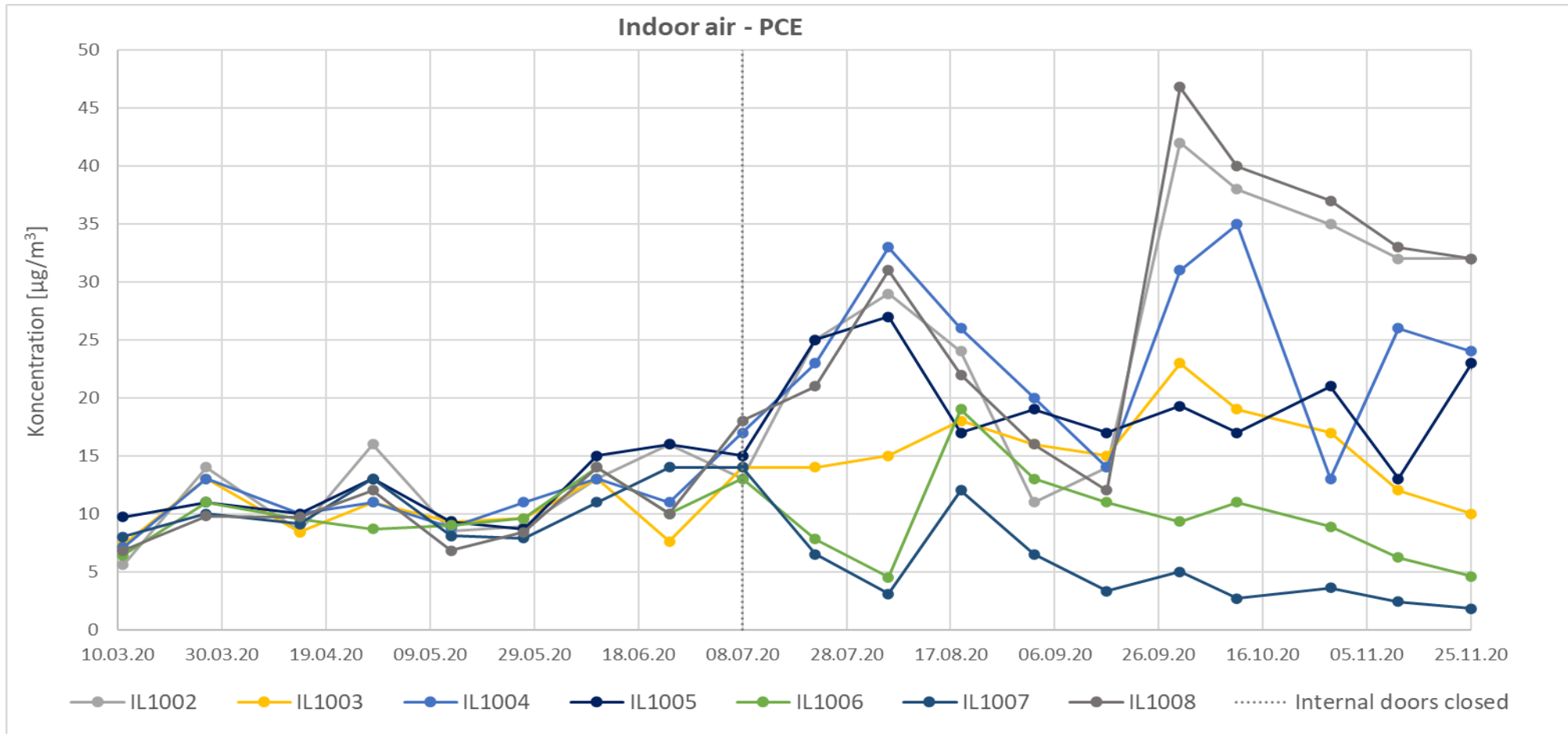
Seasonal Trends in Indoor Air

- Temporal variability up to a factor of 40.
- Highest concentrations observed between July and October.
- Similar trends observed as in sub-slab vapour.
- Key message
Indoor-air concentrations followed the same overall seasonal pattern as sub-slab vapour.



Influence of Internal Doors

- Key message:
Building layout and door positions significantly influenced indoor-air distribution.

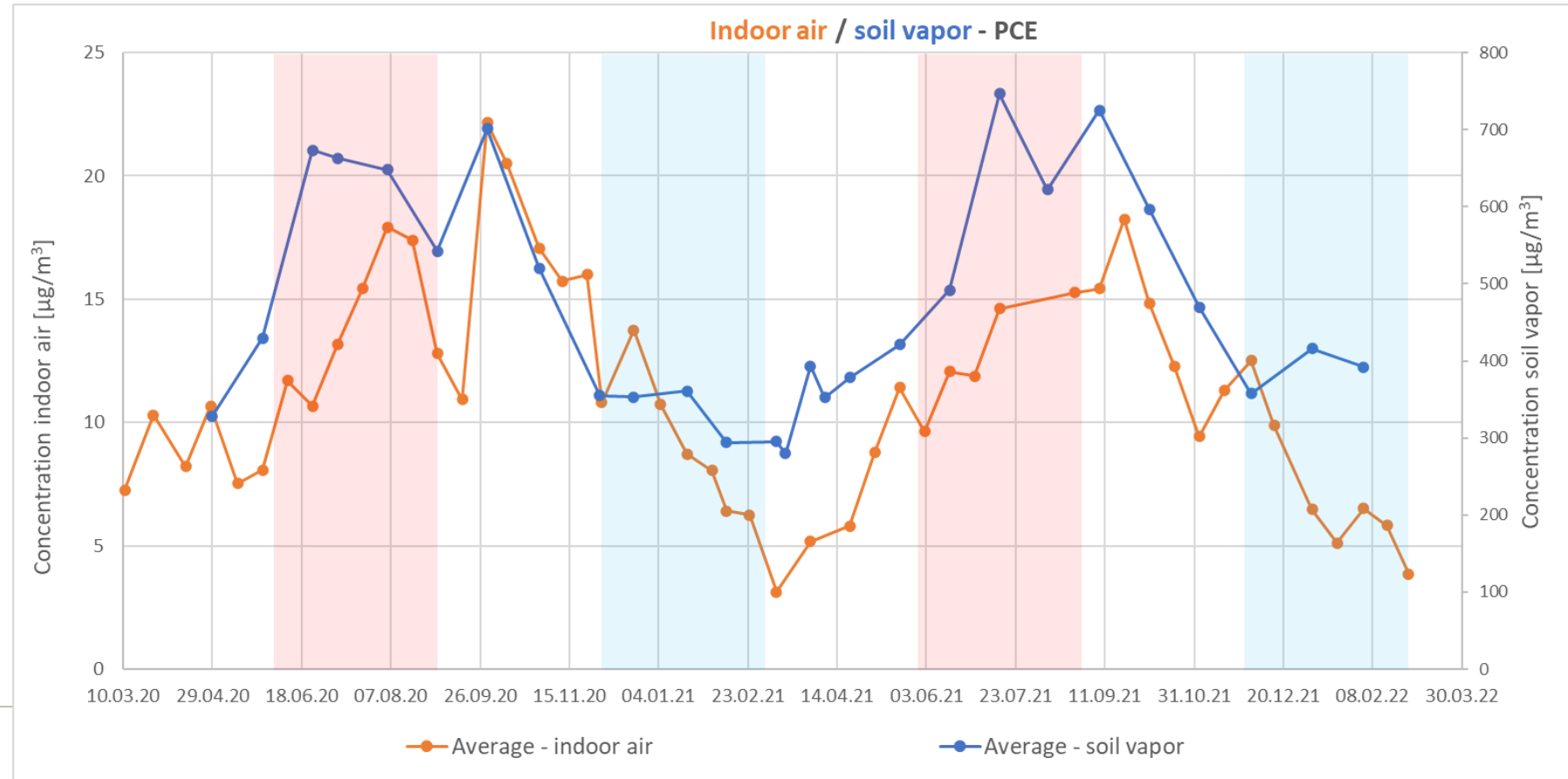


Indoor Air vs Sub-Slab Soil Vapour

- ❖ Similar seasonal trends.
- ❖ Indoor-air concentrations lagged slightly behind sub-slab concentrations.

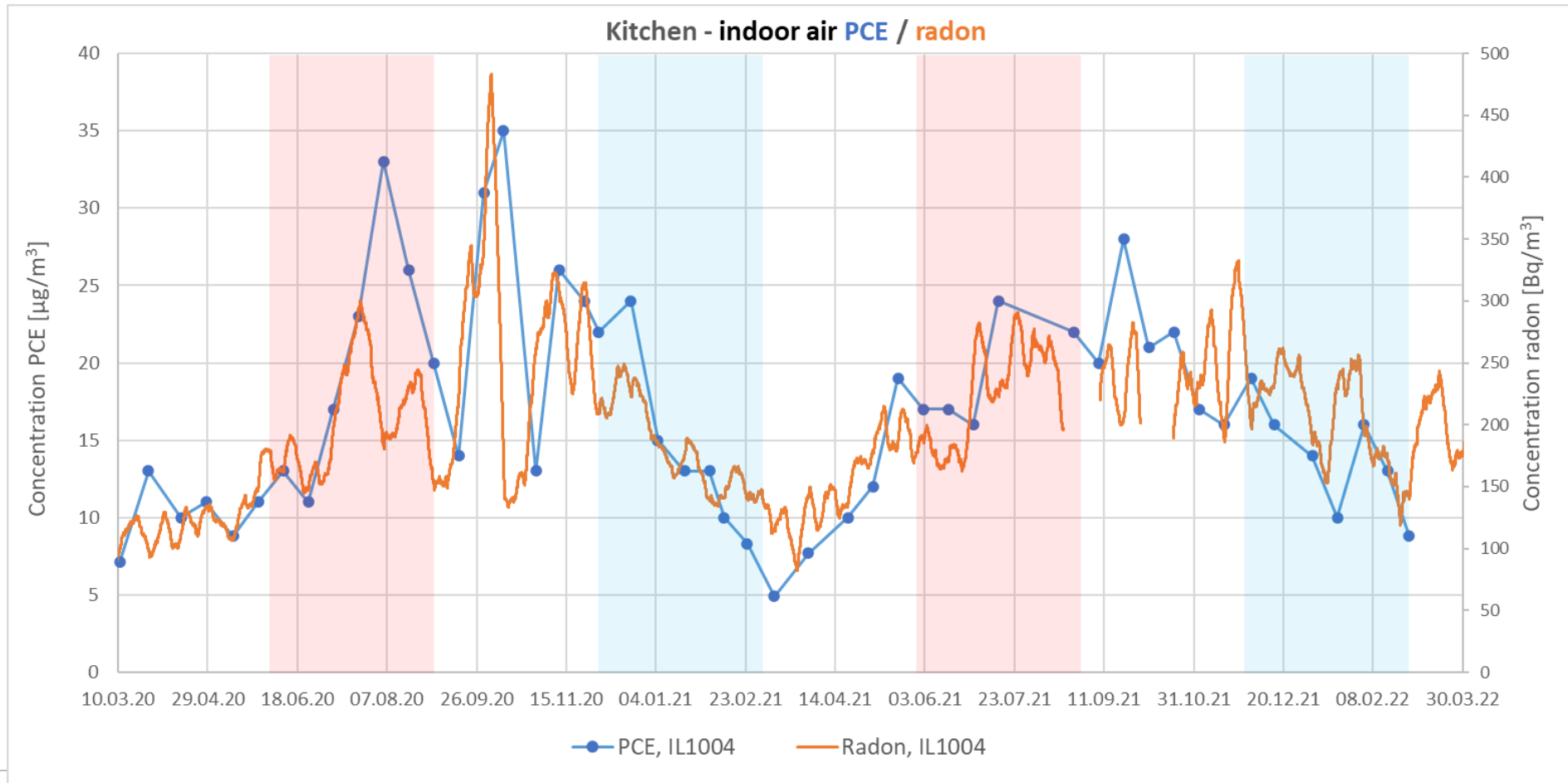
Key message

- ❖ Indoor-air concentrations were largely controlled by concentrations beneath the floor slab.



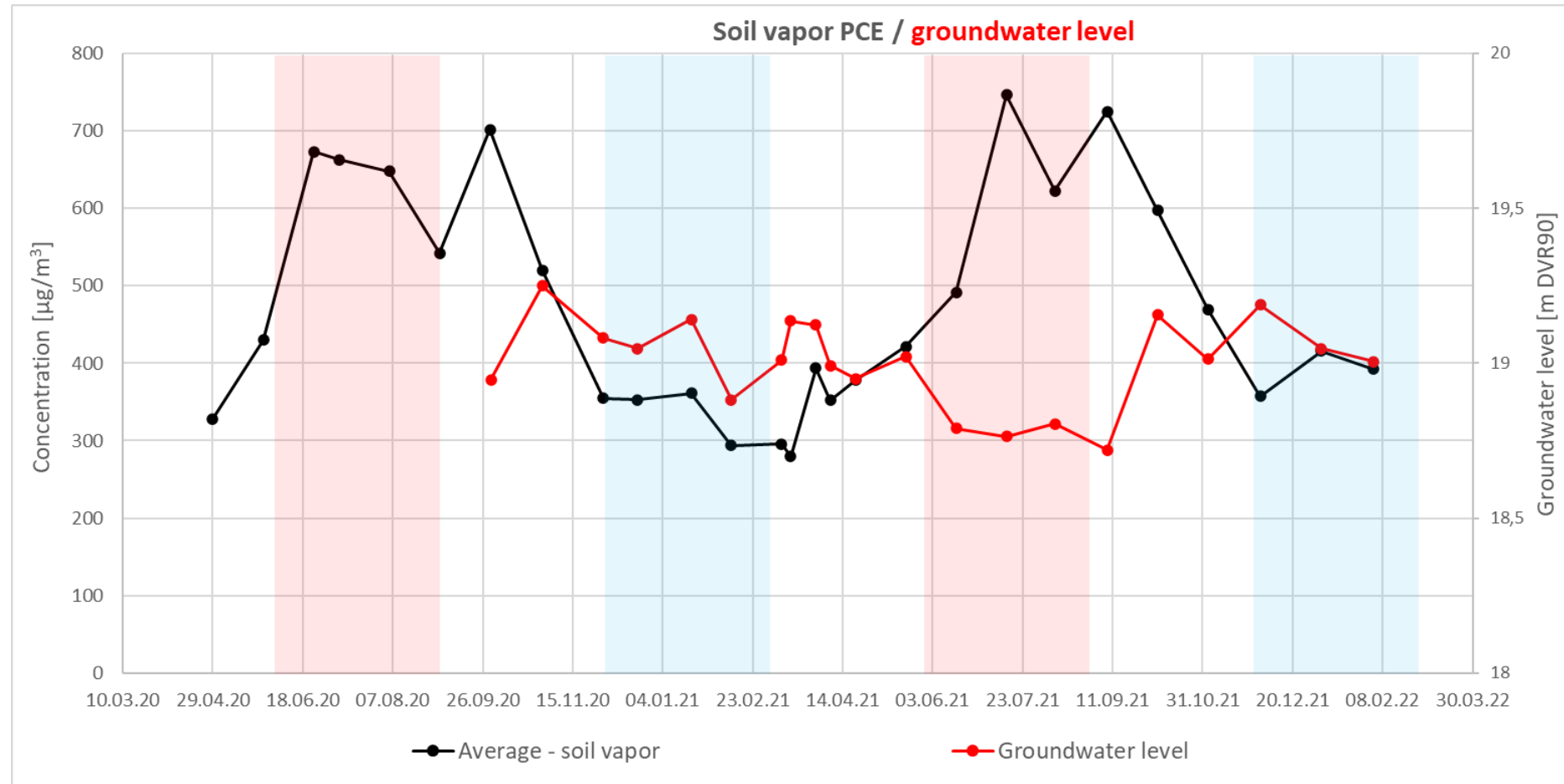
Radon as an Indicator

- Strong correlation between radon and PCE.
- Continuous radon monitoring is simple and inexpensive.
- Key message:
Radon may be a valuable indicator of temporal changes in vapour intrusion.



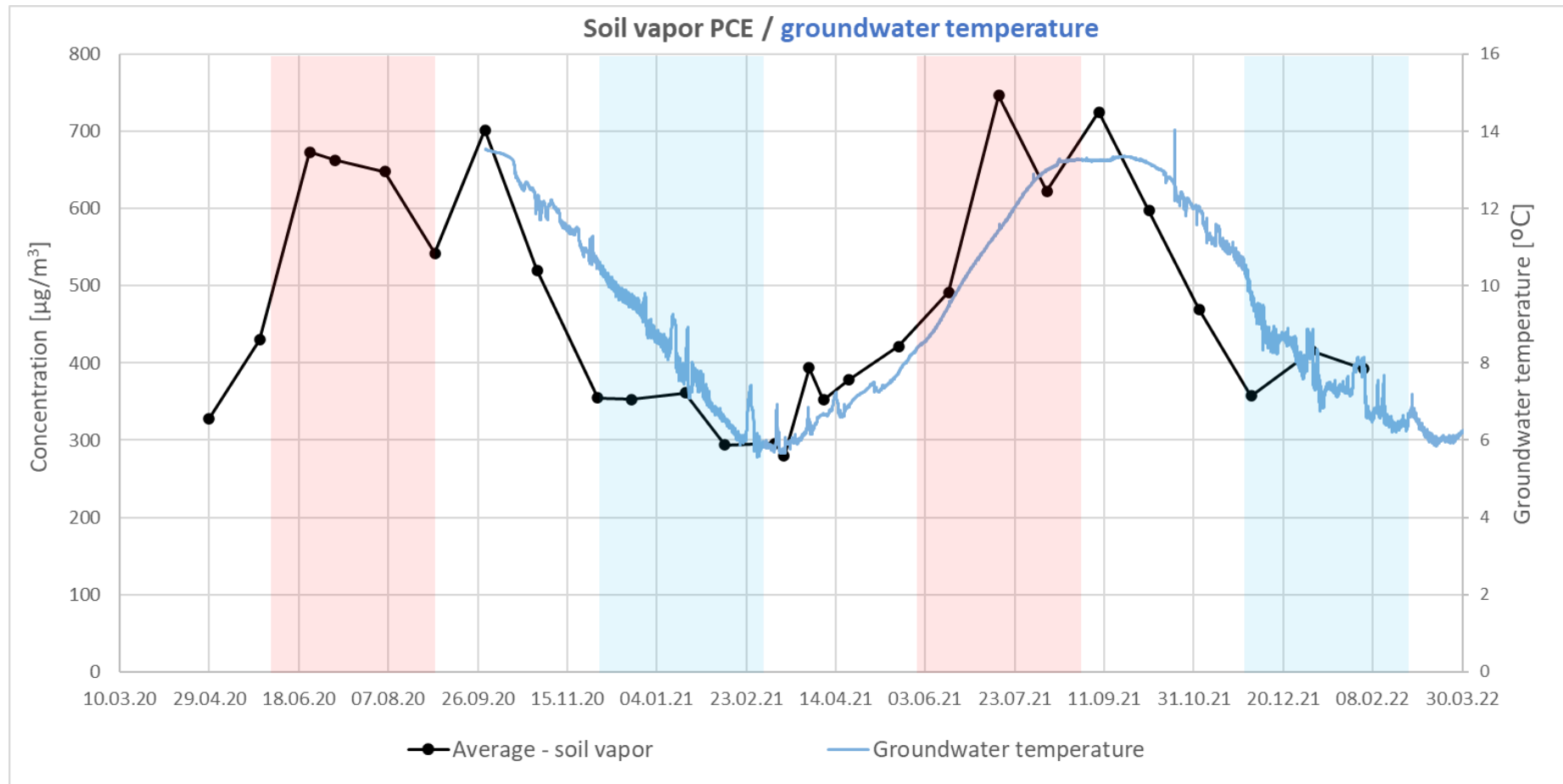
Influence of Groundwater Level

- Key message
Lower groundwater levels coincided with higher vapour concentrations.



Influence of Temperature

- Key message
Groundwater and soil temperature were strongly associated with concentration changes.



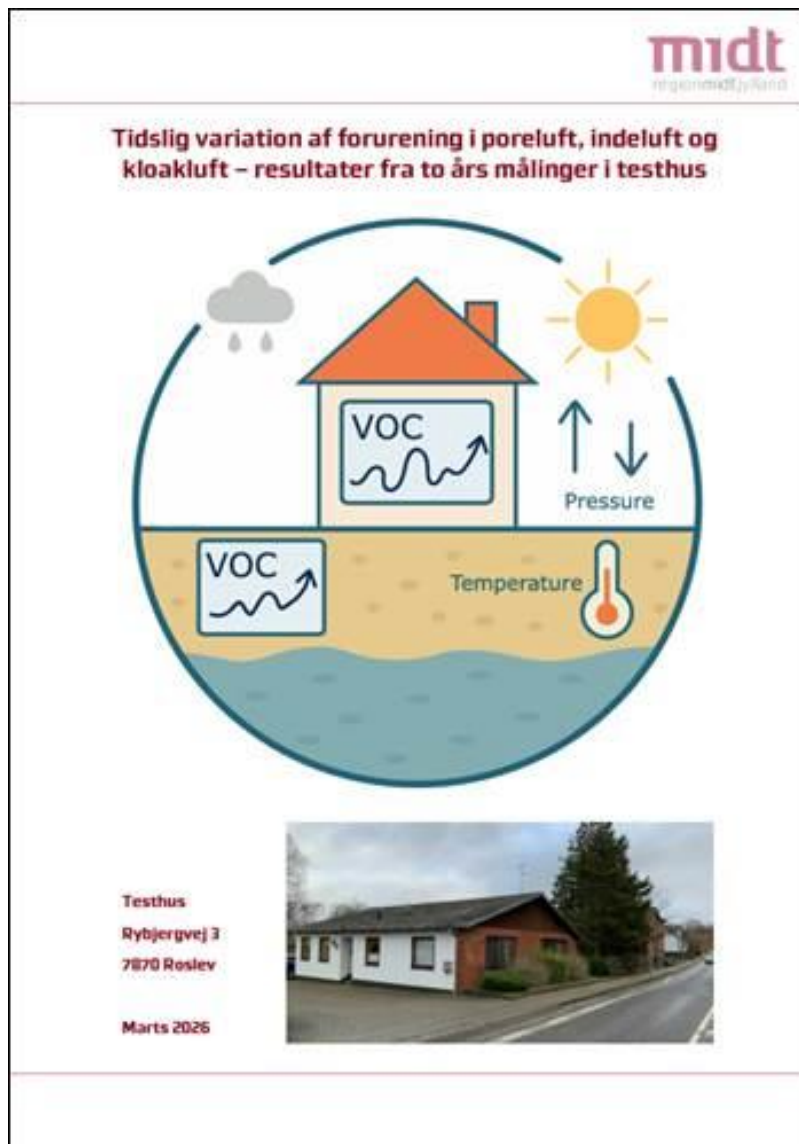
Conclusions: Sub-Slab Soil Vapour

- Spatial variability exceeded a factor of 180.
- Temporal variability exceeded a factor of 30.
- Highest concentrations occurred during summer.
- Temperature and groundwater level were key drivers.
- Winter sampling may underestimate vapour concentrations at sites with shallow contamination sources

Conclusions: Indoor Air

- Temporal variability exceeded a factor of 40.
- Indoor-air concentrations followed sub-slab trends.
- Internal doors strongly influenced distribution.
- Radon was a useful indicator.
- Winter monitoring may not always represent worst-case exposure.

For further information



[Link to report](#)

**Thank you for your
attention
Questions?**

**Susanne Arentoft, Central Denmark
Region
susare@rm.dk**