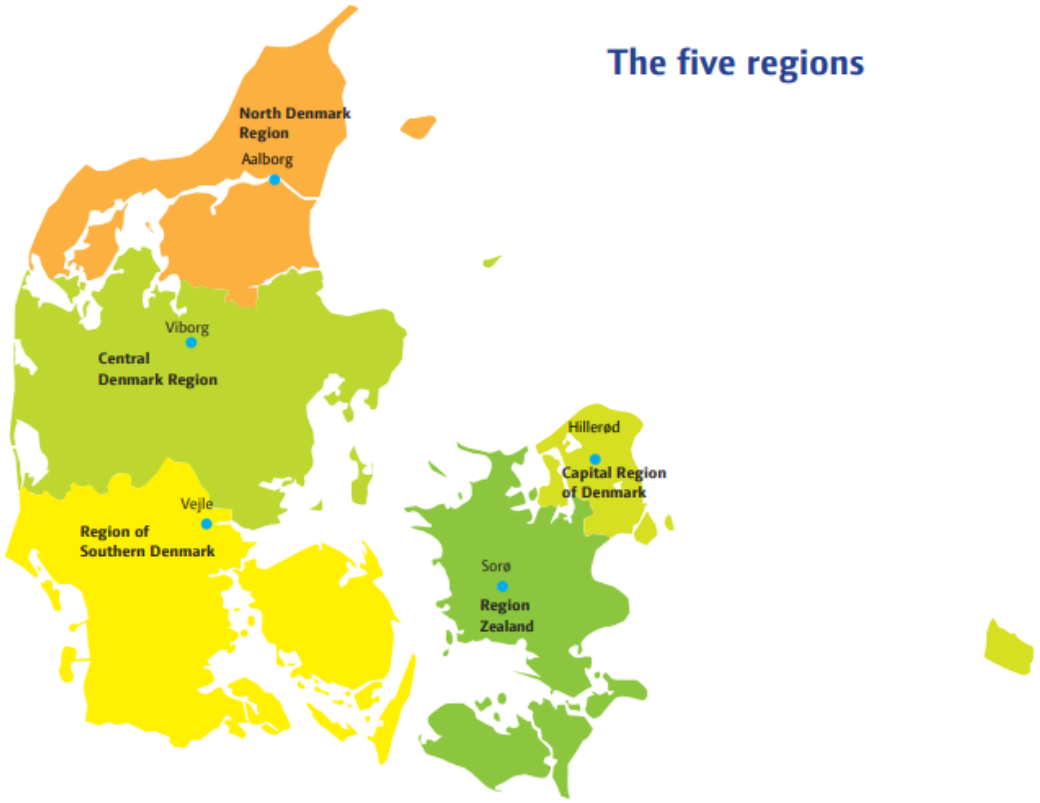
Variation in VOC concentration over time – results after a tow-year measurement period

Winnie Hyldegaard, Børge Hvidberg and Karin Birn Nielsen, Central Denmark Region
Presented by Susanne Arentoft, Central Denmark Region

Who we are and why do we care



- Denmark is divided into 5 administrative regions
- The regions map contaminated sites, make site investigations and risk assessments and ultimately mitigation were human health or drinking water supply is at risk under the polluter pays principle

Indoor air measurements

- In Denmark, the guidelines for measuring indoor air concentration of VOCs recommend a passive method over 2 14 days in the cold period of the year - October to March.

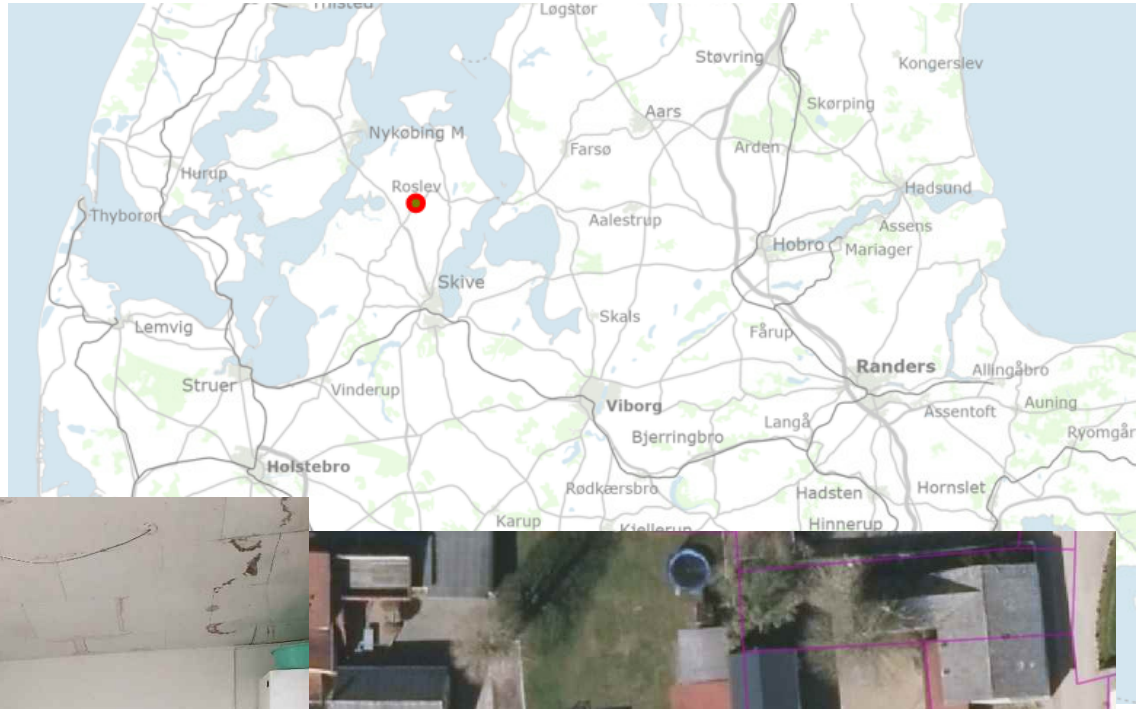
- Higher indoor air concentrations during the cold period in contrast to the summer period – thereby the result gives a more solid risk assessment and we wanted with our project to get a more solid risk assessment.

Aim

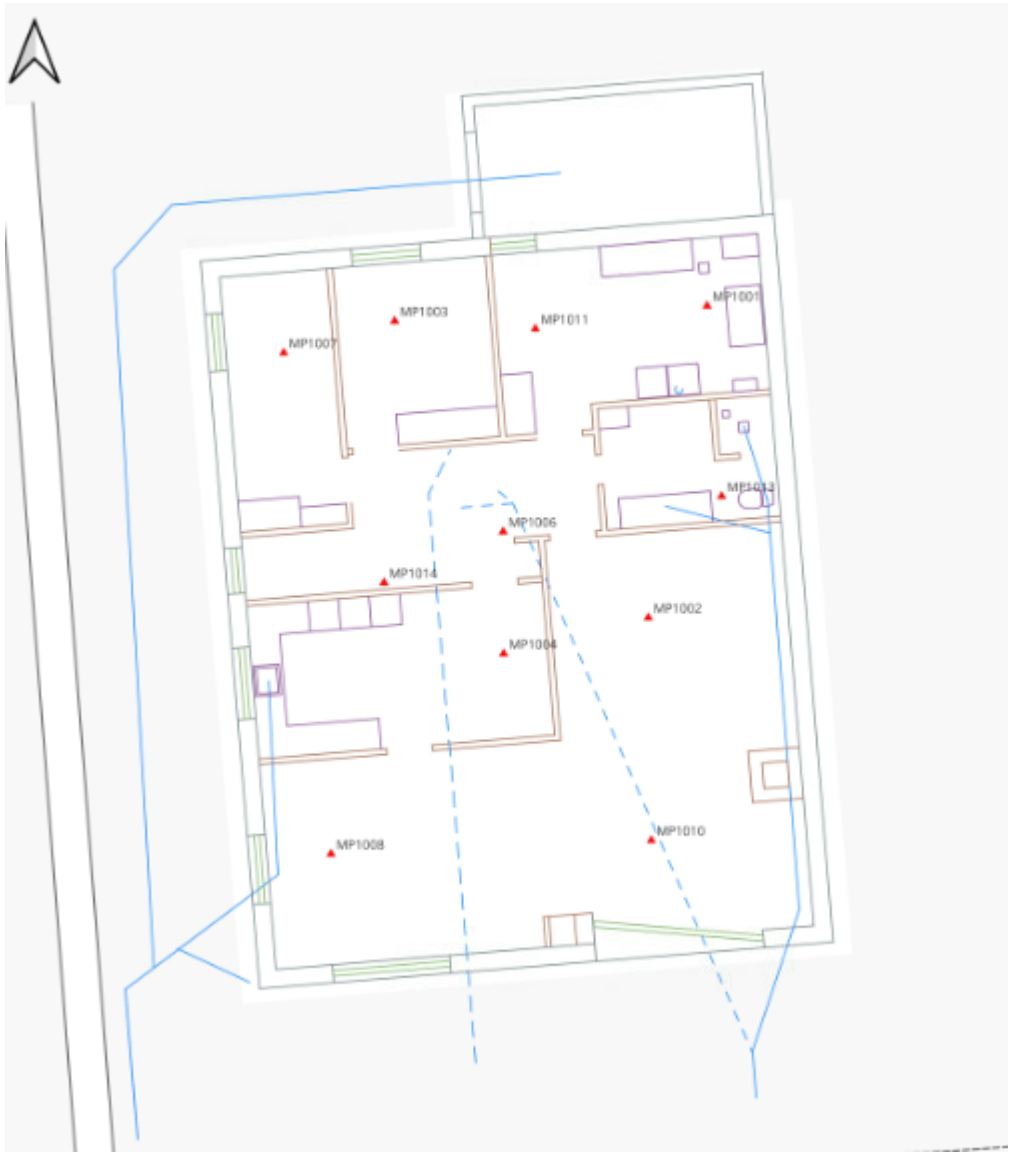
- To measure the variation in VOC concentration over a time period of two years in an unoccupied residence.
- To determine on the basis of the data when the conditions are most favorable for measuring in sub-slab soil vapor and indoor air to give a solid risk assessment.
- To investigate which parameters impact on the temporal variation of VOC concentrations in both sub-slab soil vapor and indoor air.

Test house - Roslev

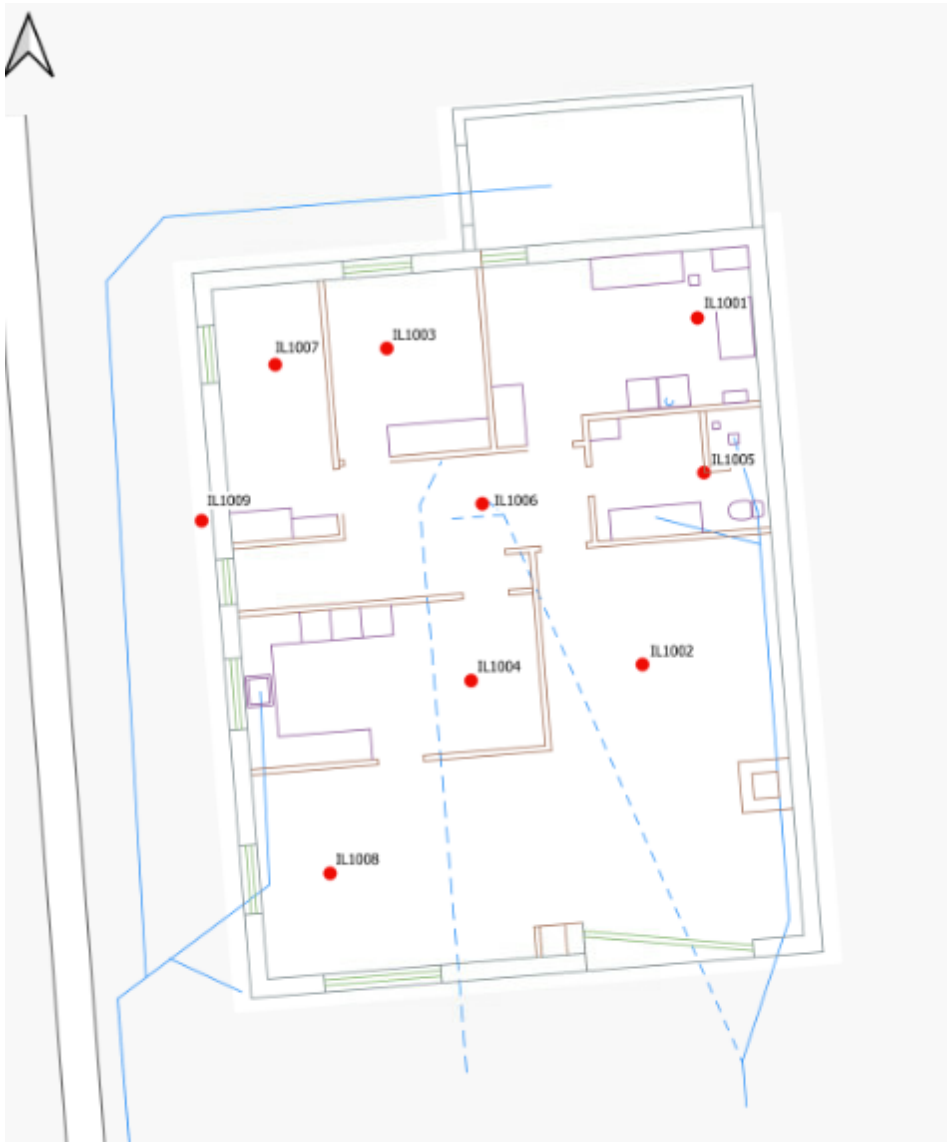
- A former dry cleaner site
- Shallow ground water table, 0.5-1.0 meter below ground level
- Contaminated with primarily Tetrachlorethylene (PCE)
- Old house, with low venting because it is unoccupied



Measurement points



Sub-slap



Indoor air

Measurement program

The measurements in the test house have been carried out over 2 years from March 2020 to February 2022

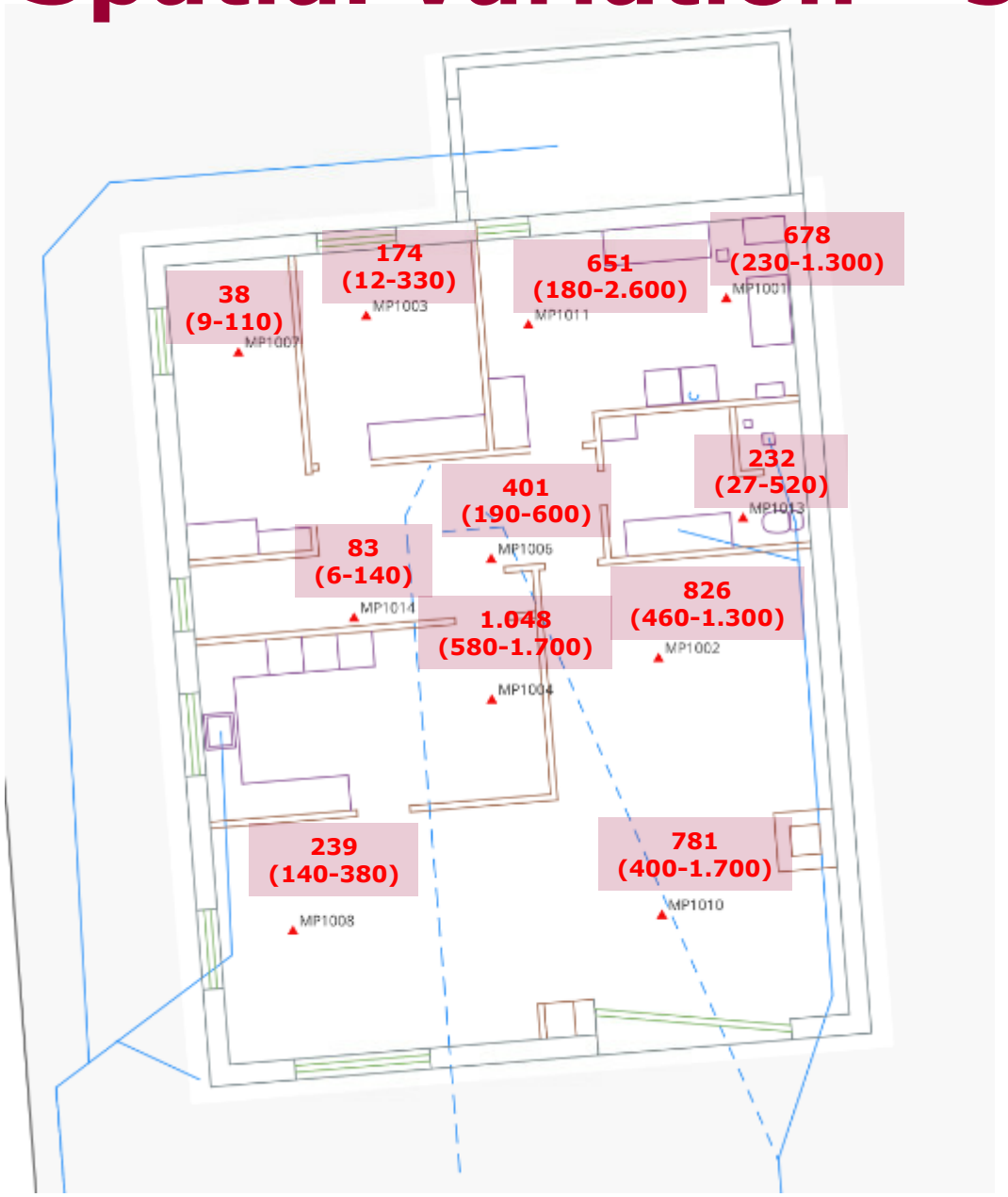
Measurements of soil vapor and indoor air (PCE, TCE and others):

	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

Additional:

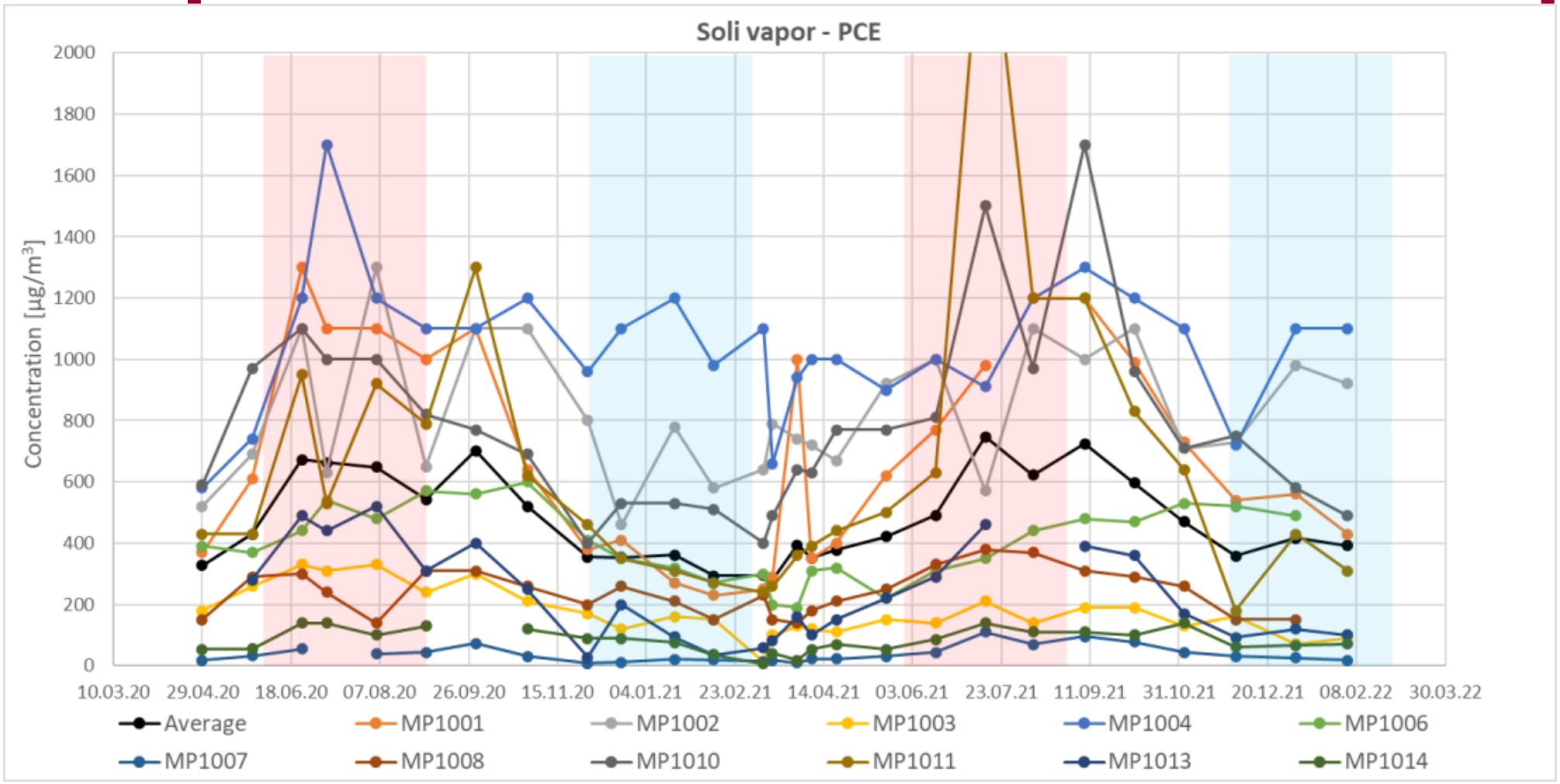
- Radon
- Differential pressure
- Temperature
- Groundwater level
- Groundwater temperature
- Rain
- Wind
- Etc.

Spatial variation - sub-slab soil vapor



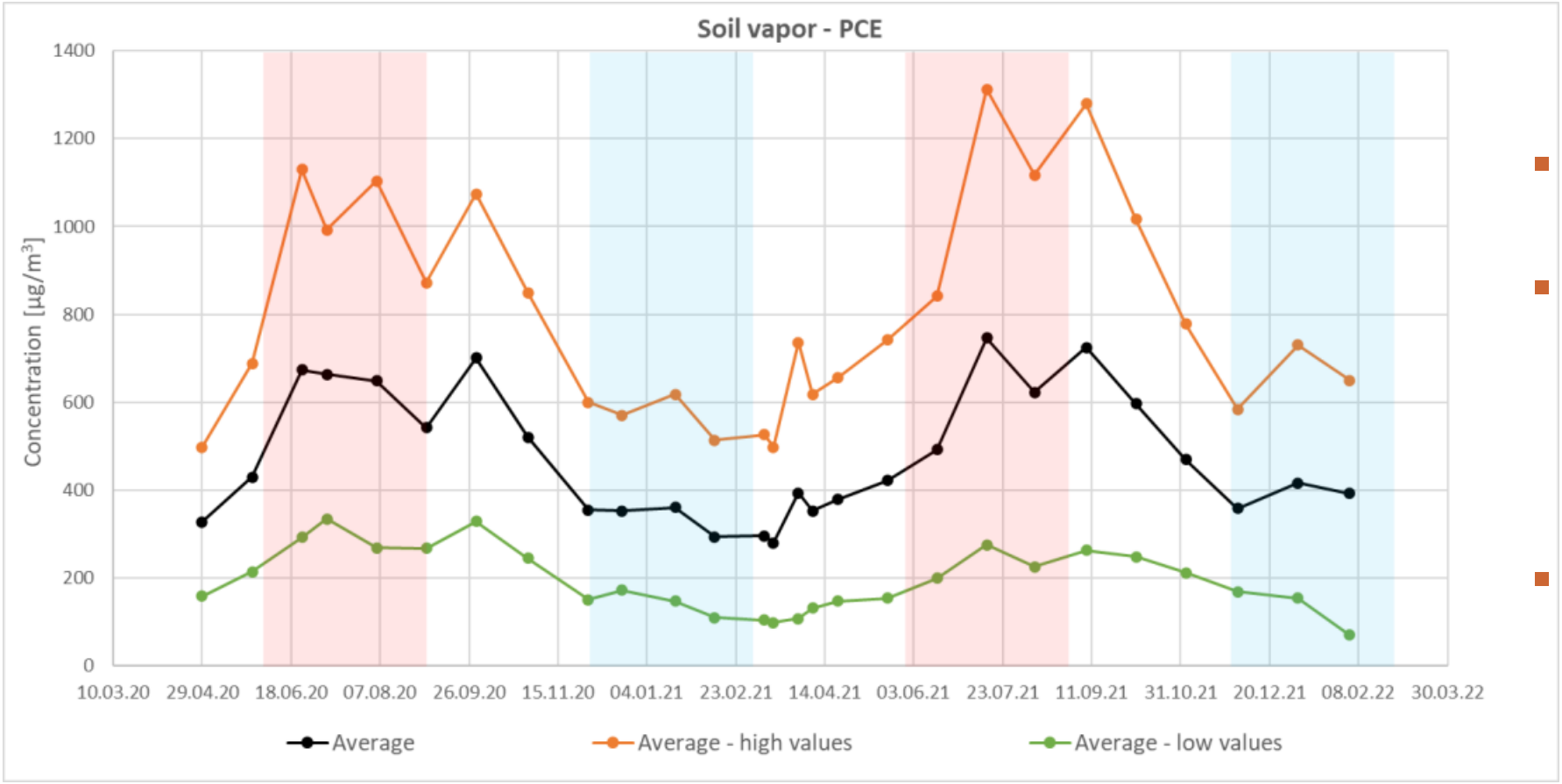
- PCE 6.2-2,600 µg/m^3.
- During the same measurement round, 6.2-1,100 µg/m^3 PCE were found - factor approx. 180.
- One explanation may be that there seems to be foundations under many internal walls as well as high groundwater levels.

Temporal variation - sub-slab soil vapor



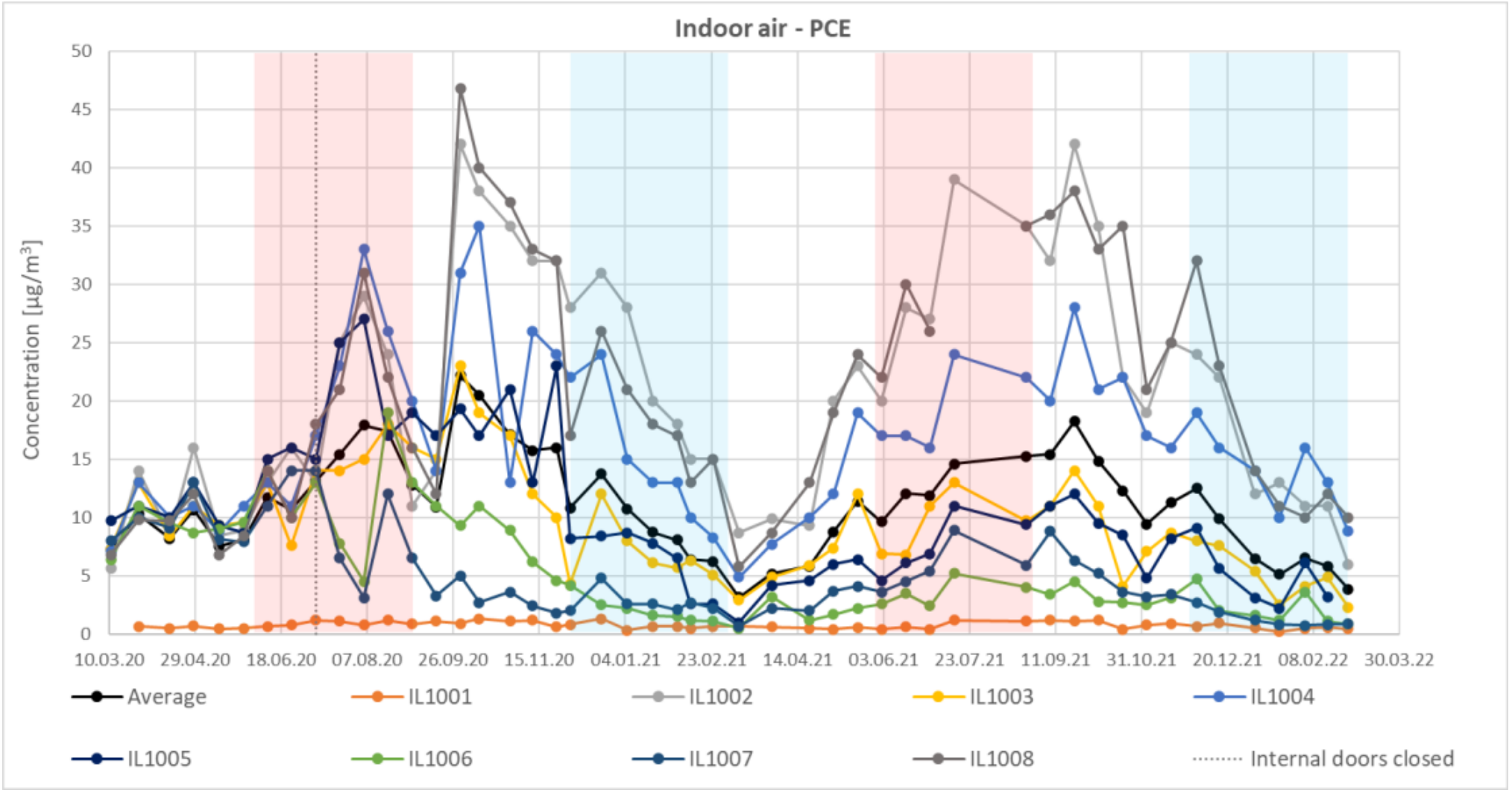
Note: Red and blue markings, respectively indicate summer period (June-August) and winter periods (December to February)

Temporal variation - sub-slab soil vapor

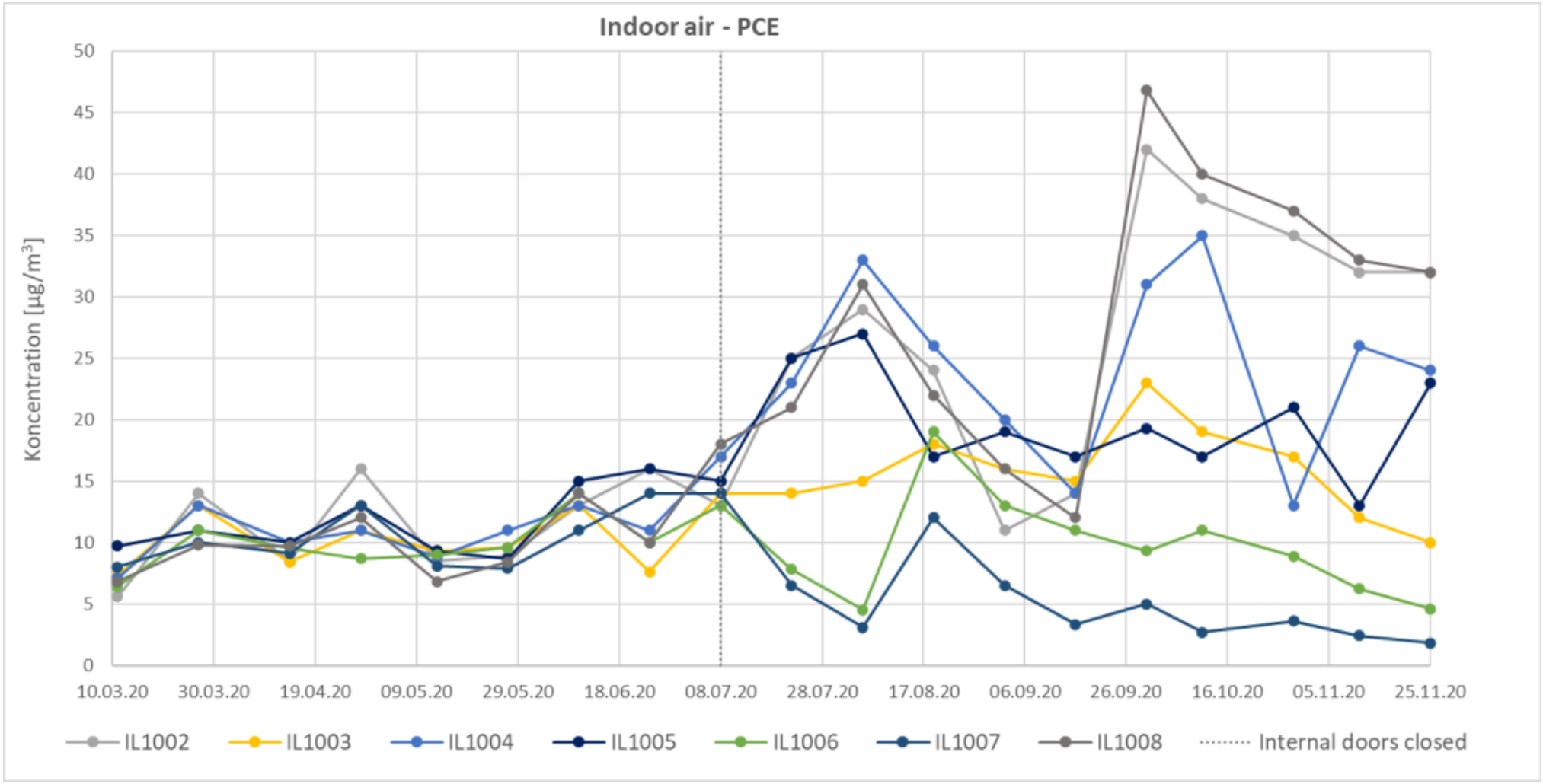


- Relatively large temporal variation in sub-slab soil vapor.
- In the same point, a factor of approx. 30.
- Clear seasonal variation with the highest concentrations in June-September and lowest in December-March
- In the summer periods, the average concentrations are approx. a factor of 2-3 above the values measured in winter

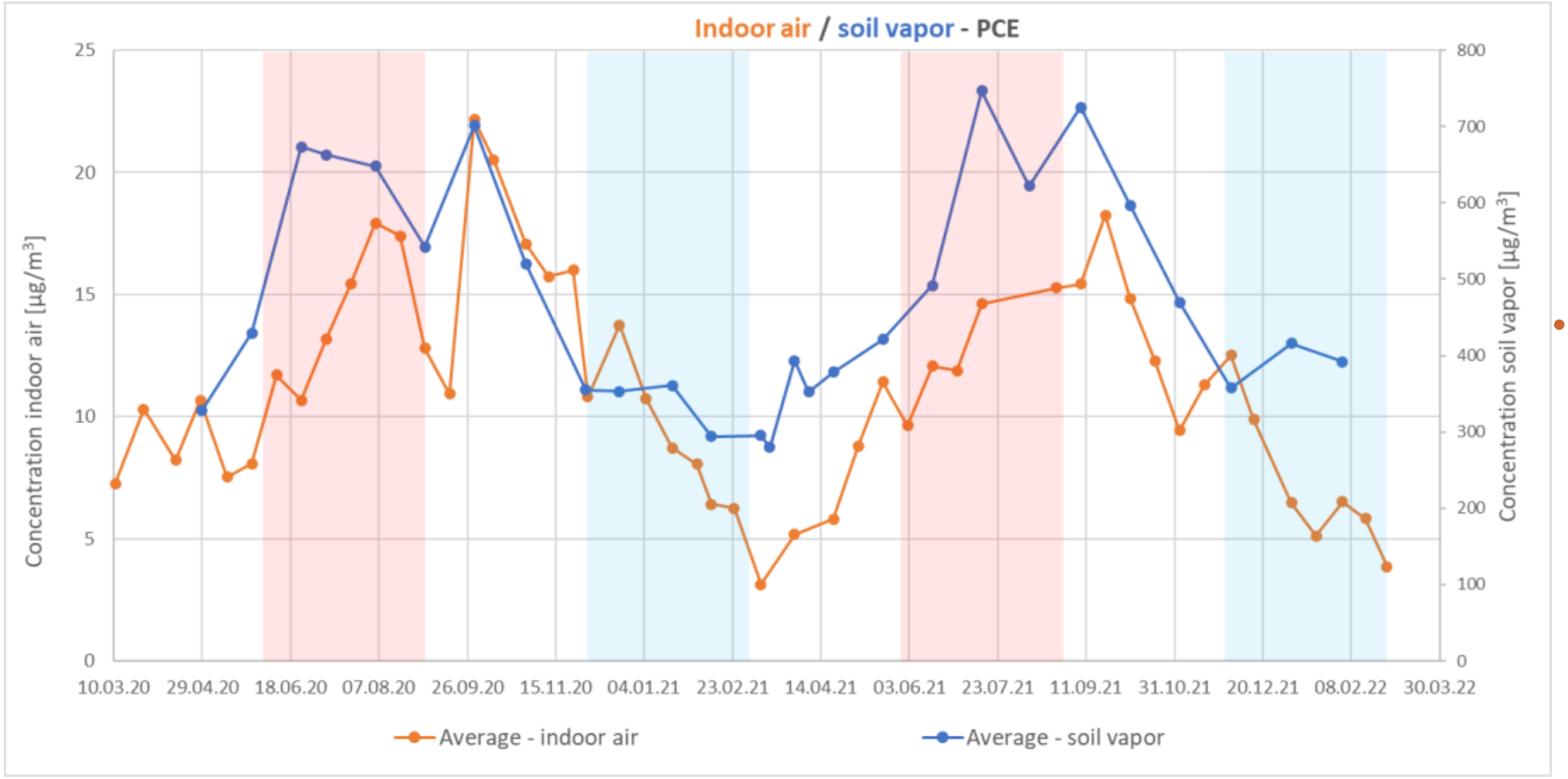
Temporal variation – indoor air



Temporal variation - closing of doors

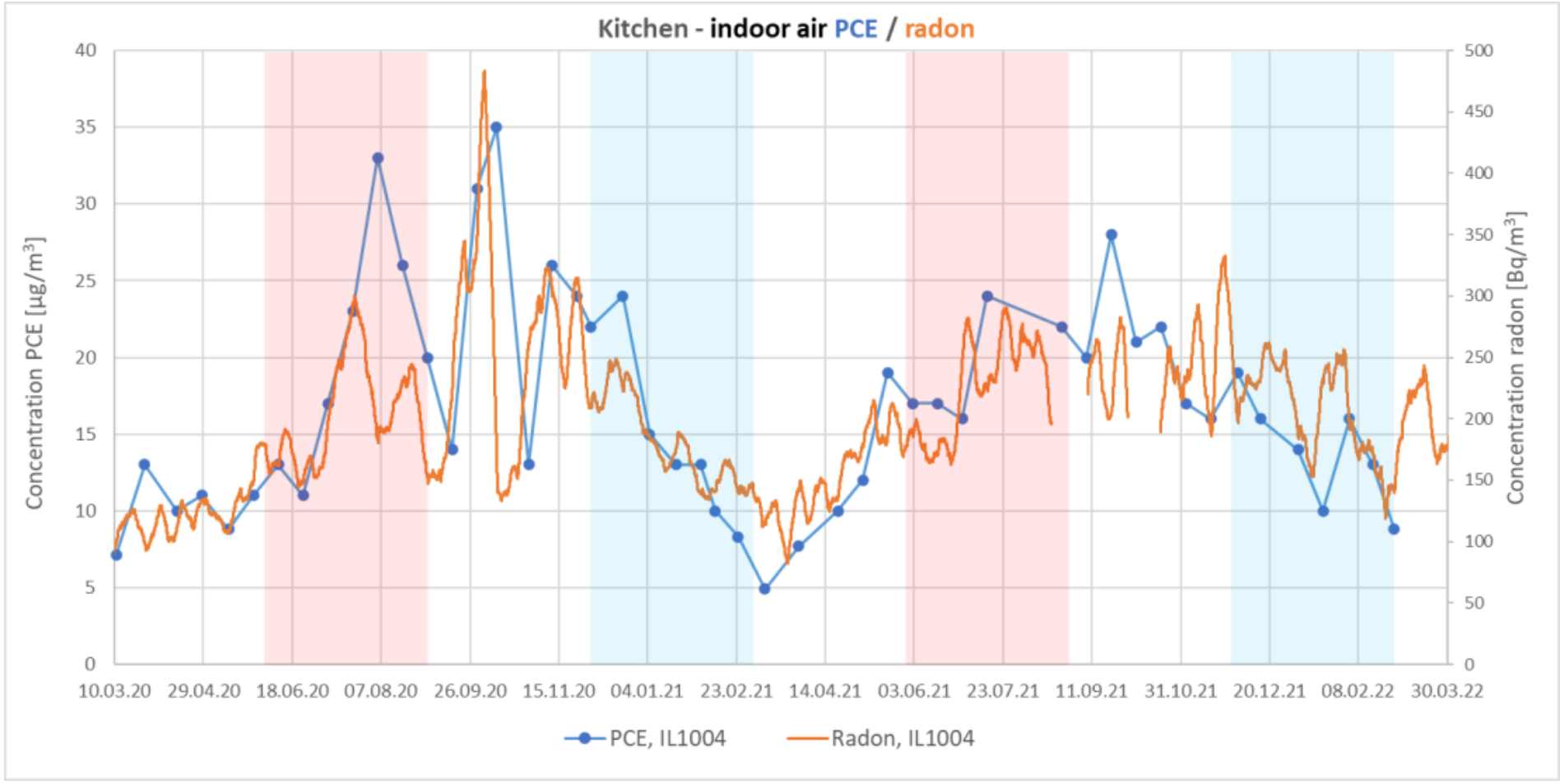


Indoor air and sub-slab soil vapor



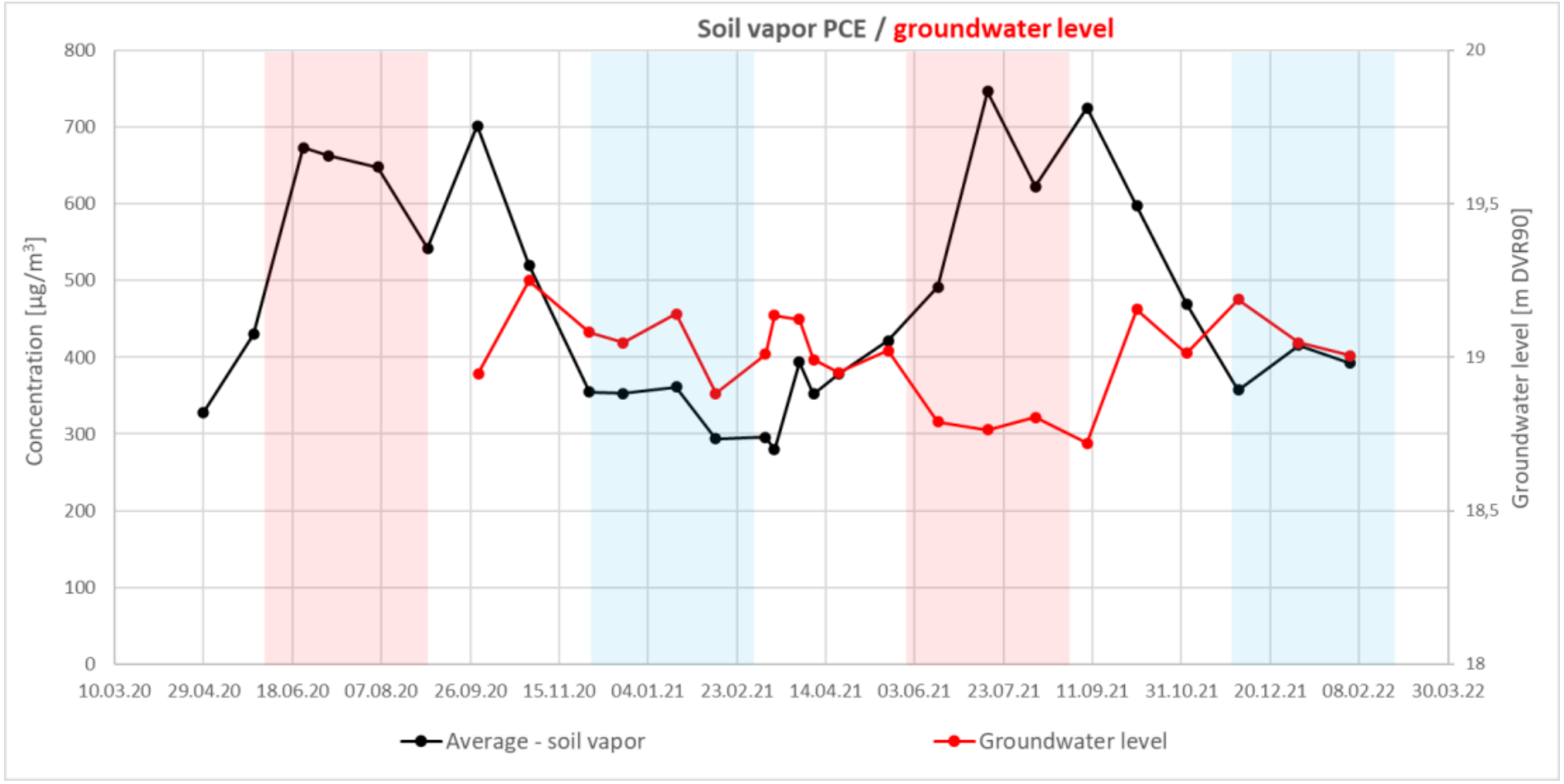
- Same seasonal variation for sub-slab soil vapor and indoor air.
- Indoor air concentrations are controlled by concentrations in the sub-slab soil vapor – with a slight delay.

Indoor air and radon



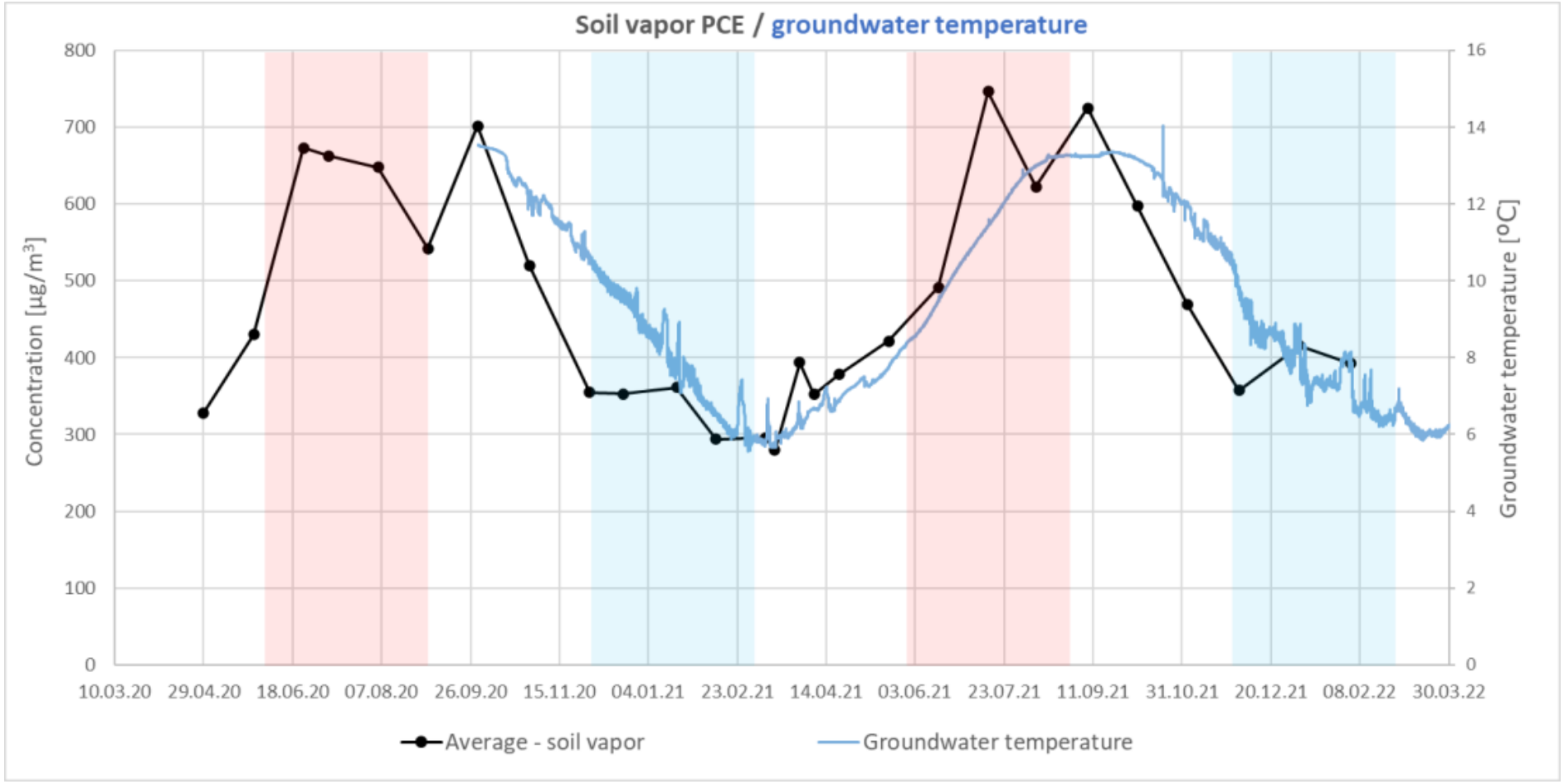
- Very good correlation between PCE measurements and radon content.
- Radon measurements are a good indicator for the temporal variations in the concentration of PCE in indoor air

Sub-slab soil vapor and groundwater level



- There is a correlation between a slightly lower groundwater table (0.3-0.4 m) in the summer of 2021 and increasing sub-slab soil vapor concentrations

Sub-slab soil vapor and groundwater temperature



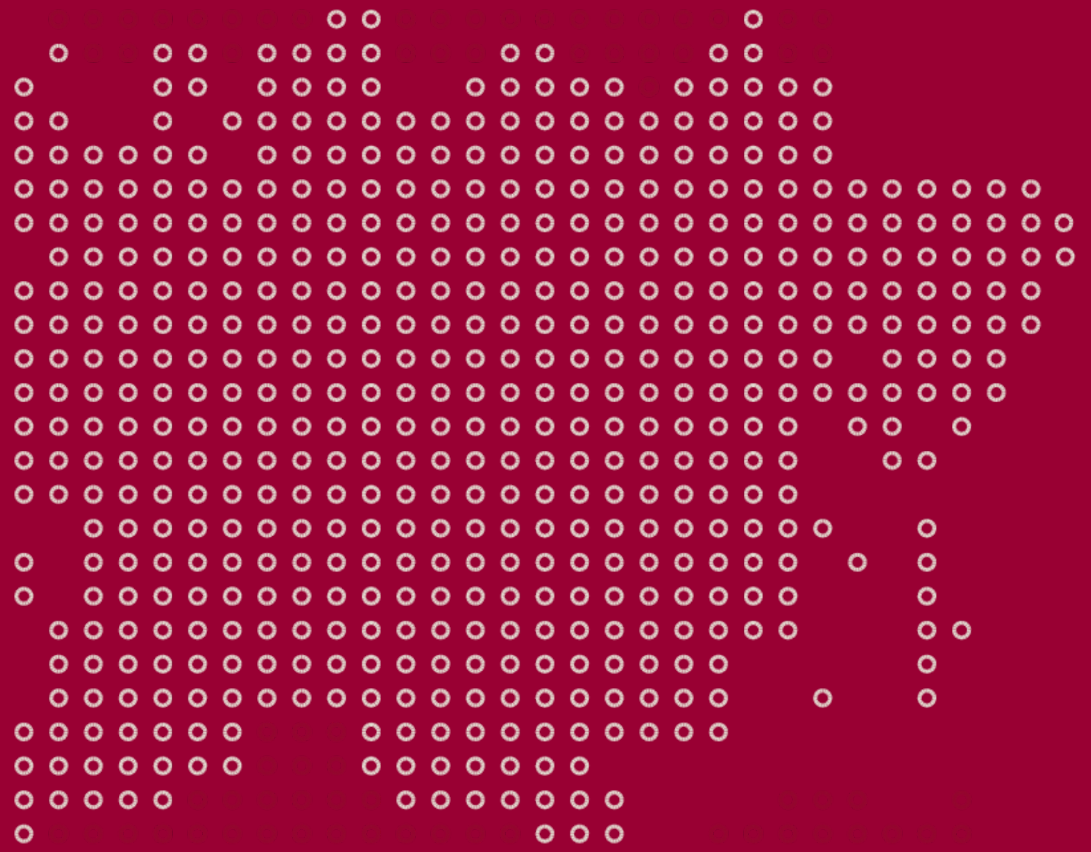
- There is a good correlation between variation in groundwater temperature and sub-slab soil vapor concentration.
- Soil and groundwater temperatures appear to have a major impact on the content of PCE in the sub-slab soil vapor

Conclusion, sub-slab soil vapor

- Spatial variation up to factor approx. 180 in the same measuring round
- Temporal variation up to factor approx. 30 at the same point
- Clear seasonal variation with the highest concentrations in June-September
- Sub-slab soil vapor concentration seems to be controlled by groundwater and soil temperatures and groundwater level:
  - High temperature results in an increase of evaporation of VOC
  - Lower groundwater results in larger unsaturated zone leading to risk of an increase in evaporation of VOC
- We estimate that seasonal variations in sub-slab soil vapor concentrations can be significant if the pollution source is near-terrain
- There is a risk of underestimating the sub-slab soil vapor concentration if the measurements are only made during the winter period at locations with a near-terrain pollution source.

Conclusion, indoor air

- Spatial variation up to factor approx. 20 in the same measurement round
- Temporal variation up to factor approx. 40 in the same point
- Clear seasonal variation with the highest concentrations in July-October
- Indoor air concentration is controlled by content in the sub-slab soil vapor
- It is of great importance whether internal doors are open or closed
- We observed no correlation with differential pressure and air temperatures at our test location
- Radon measurements provide good information about temporal variations in VOC concentrations
- There is a risk of underestimating the risk of pollution impact if indoor air measurements are only carried out during the winter season in homes similar to the test house (pollution source near-terrain and low air exchange).



Thank you for your attention

Winnie Hyldegaard,
Karin Birn Nielsen, karsve@rm.dk
Susanne Arentoft, susare@rm.dk