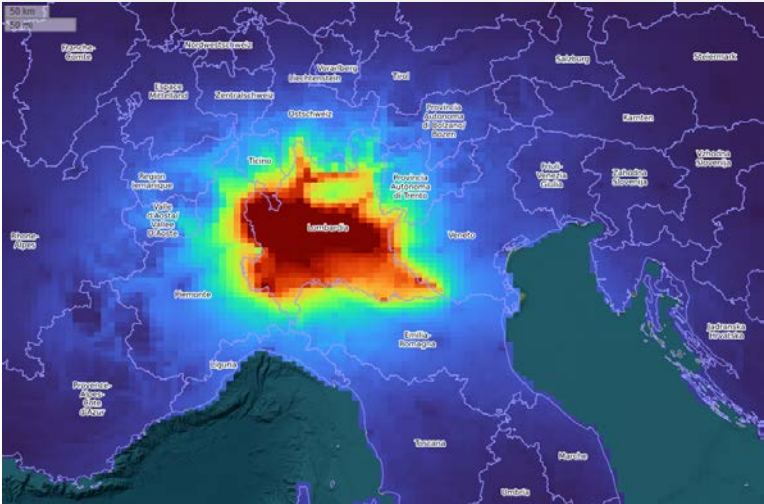


Future developments: downscaling

SHERPA presentation and training
November 5th, 2025

Need to improve the spatial resolution

PRECURSOR	GNFR_A	GNFR_B	GNFR_C	GNFR_D	GNFR_E	GNFR_F	GNFR_G	GNFR_H	GNFR_I	GNFR_J	GNFR_K	GNFR_L
NOx	50	50	50	50	50	50	50	50	50	50	50	50
NMVOG	0	0	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0	0
PPM25	0	0	0	0	0	0	0	0	0	0	0	0
SOx	0	0	0	0	0	0	0	0	0	0	0	0

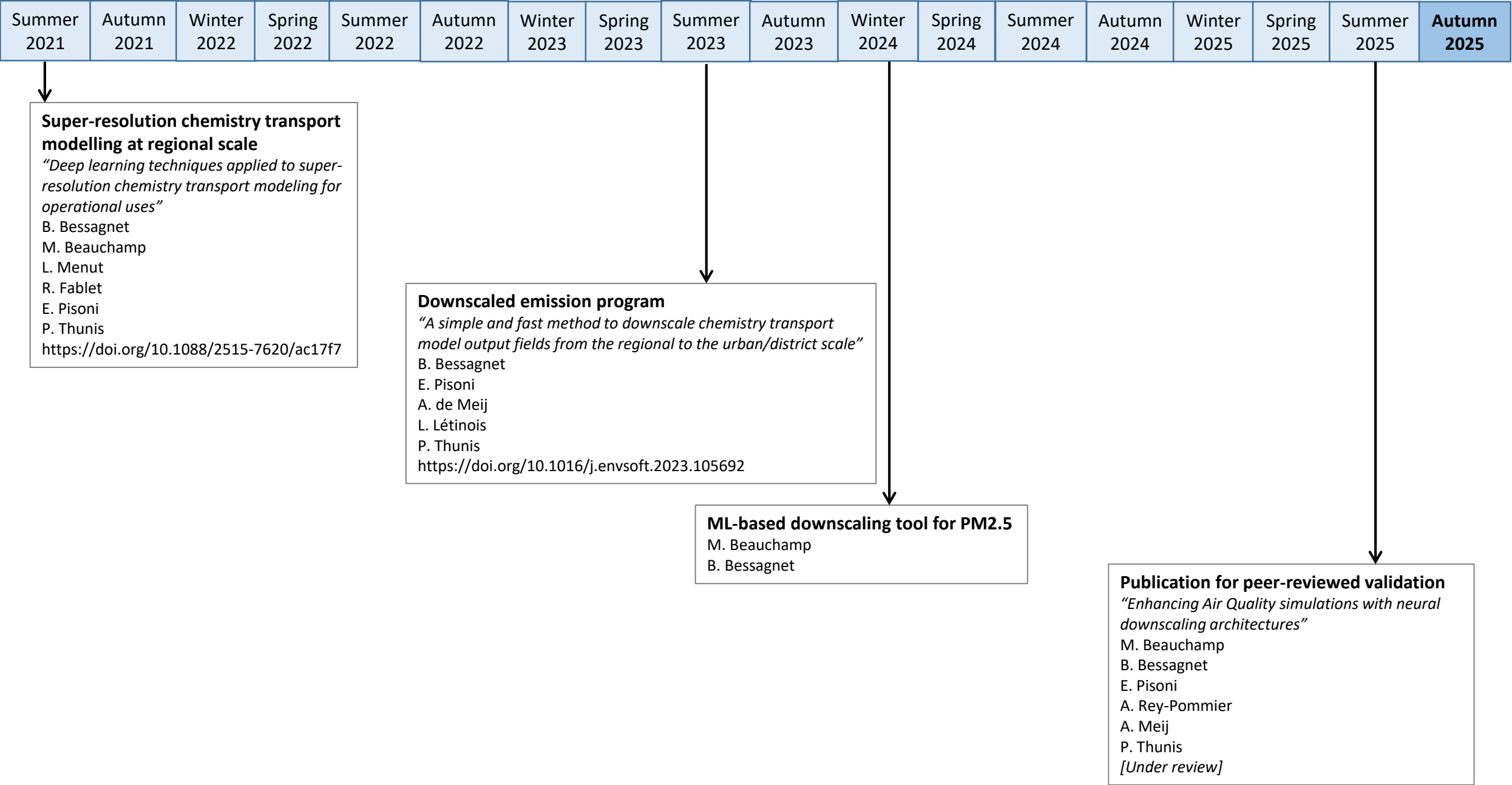


Original horizontal resolution: $0.05^{\circ} \times 0.1^{\circ} \approx 20\text{-}50 \text{ km}^2$

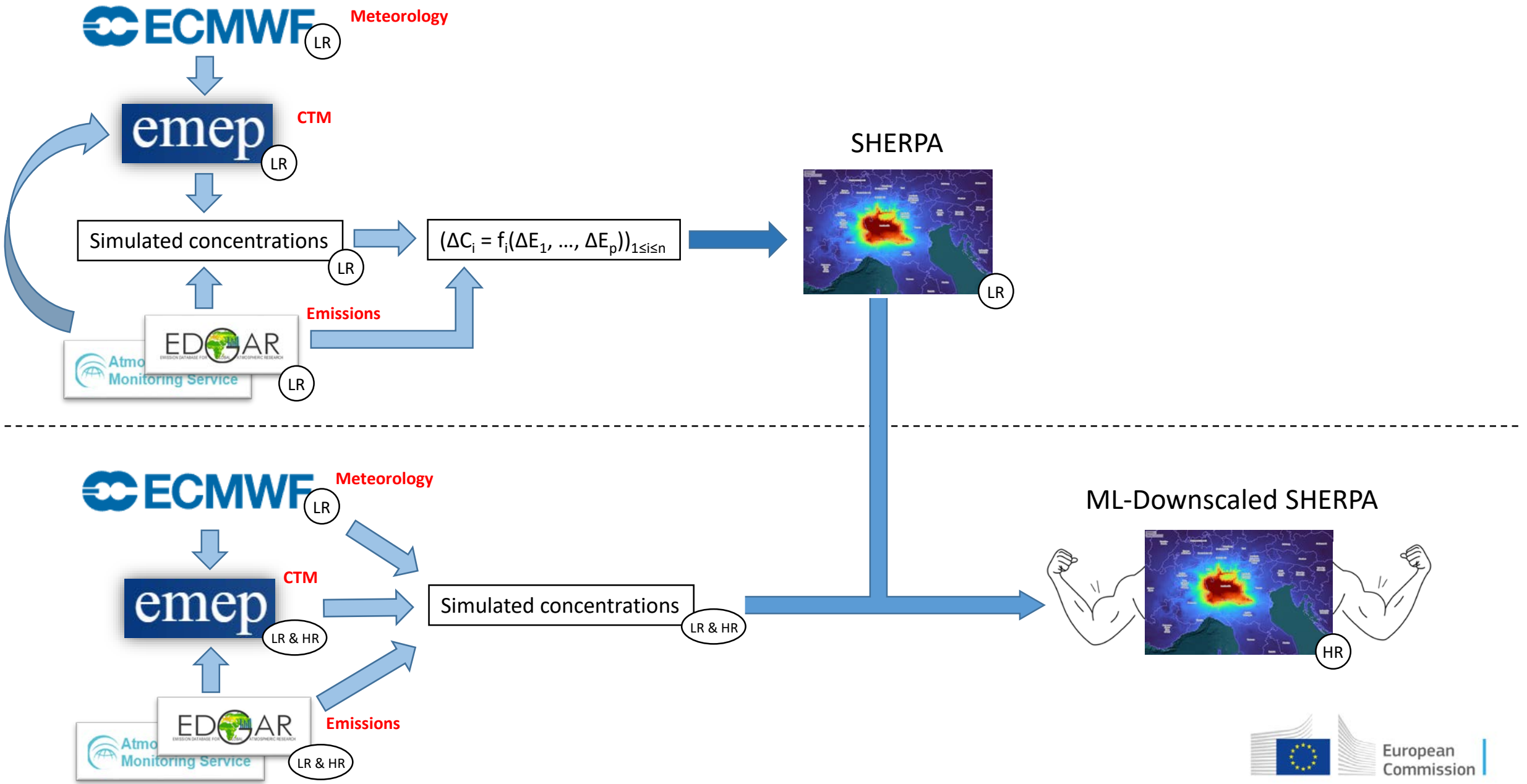
Computation time: 30-120 seconds

- Works well to have many pixels for NUTS1,2,3 level but not sufficient to describe impacts on smallest cities.
- Need for a SHERPA tool at higher resolution while keeping the low computation time.

Timeline (1)



Main principle



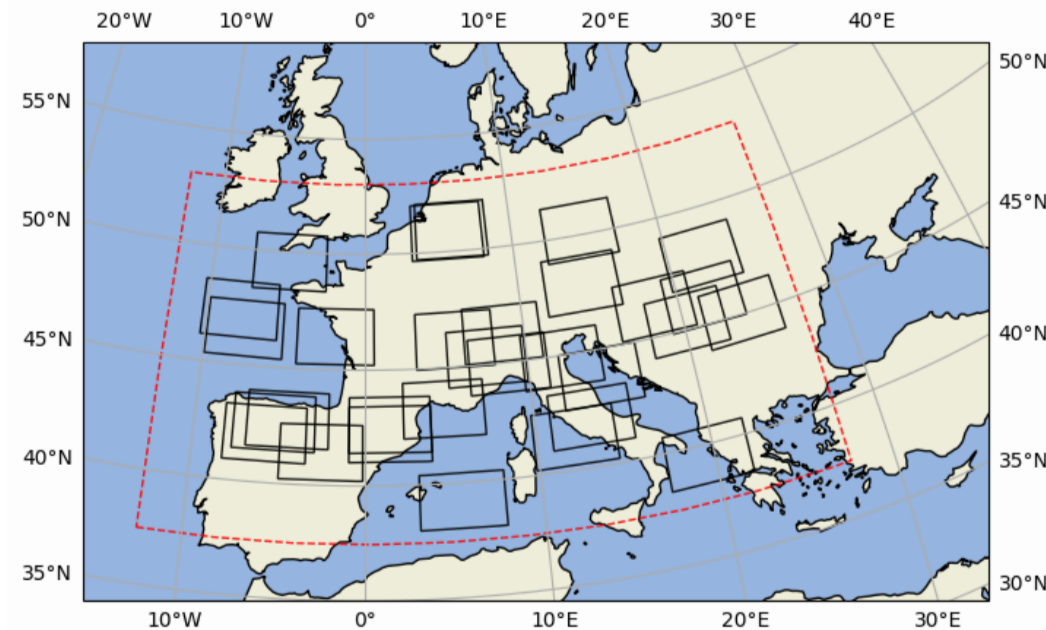
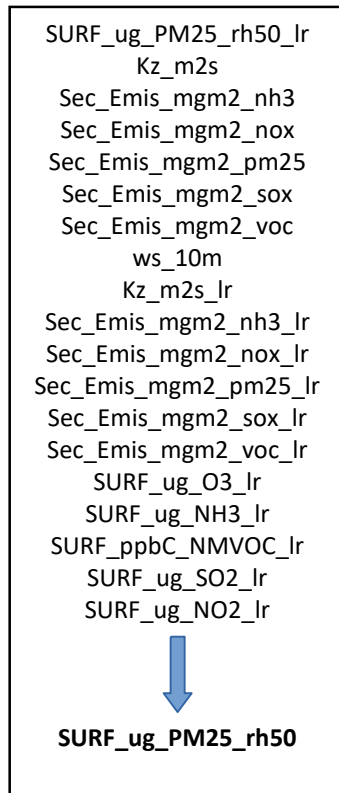
The spatial downscaling approach using machine learning

Approach: use of low-resolution pollution fields and high-resolution emission data to predict high-resolution pollution patterns

Main physical challenges:

- Account for secondary pollutants
- Capture different chemical regimes at different moments of the day
- Have a domain that is representative of physical-chemical conditions throughout Europe

→ All of this for different levels for emission abatements !



European domain

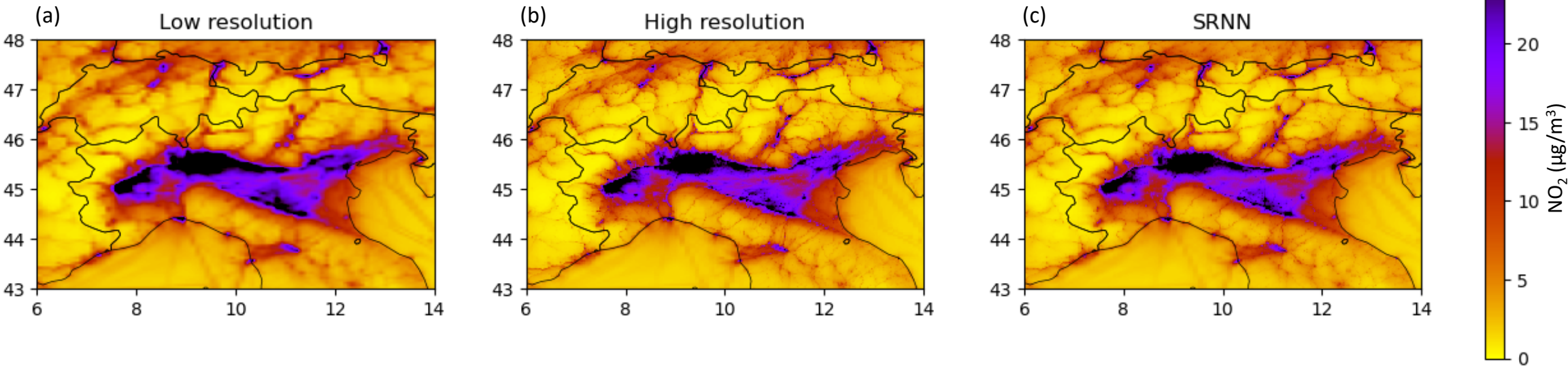
Training period: 01/01-25/01

Validation period: 25/01-31/01

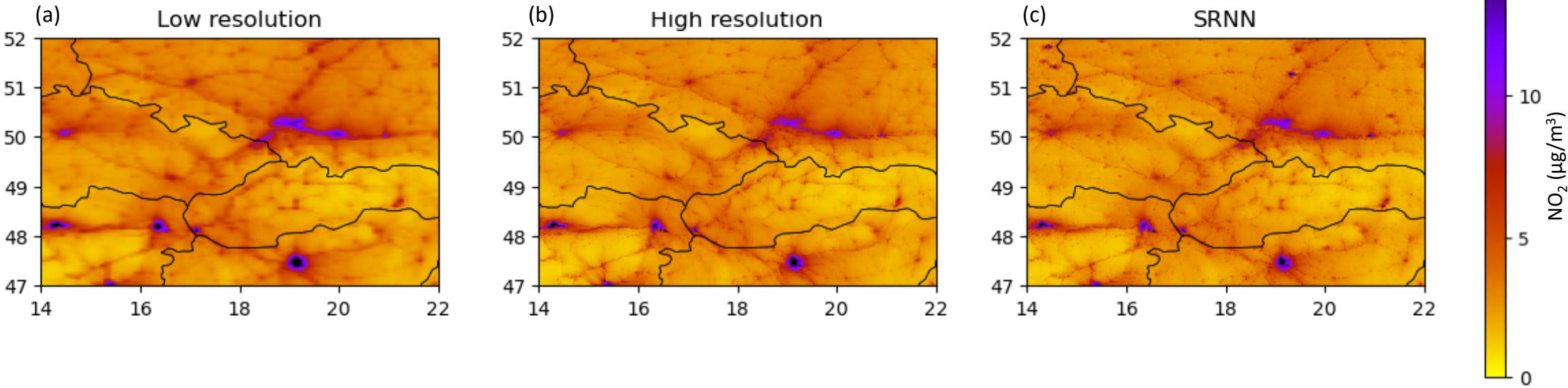
- Absolute concentrations
- 15 explanatory variables
- 50-150 training batches
- Dynamic use of patches for each period

First results

Example for NO₂ concentration downscaling: EMEP LR (a), EMEP HR (b), super-resolution model (c) in Po Valley and Alps. 5-day mean concentrations (Jan 26-31, 2021), Base Case.

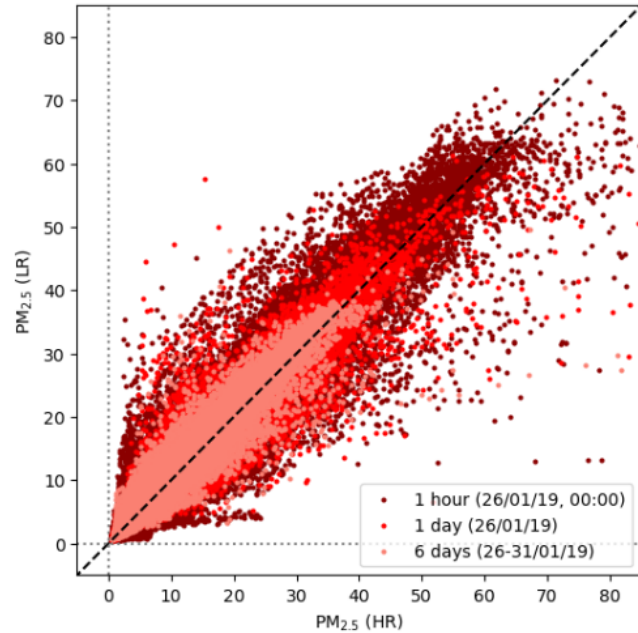


Example for NO₂ concentration downscaling: EMEP LR (a), EMEP HR (b), super-resolution model (c) in Central Europe. 5-day mean concentrations (Jan 26-31, 2021), -50%ALL scenario.

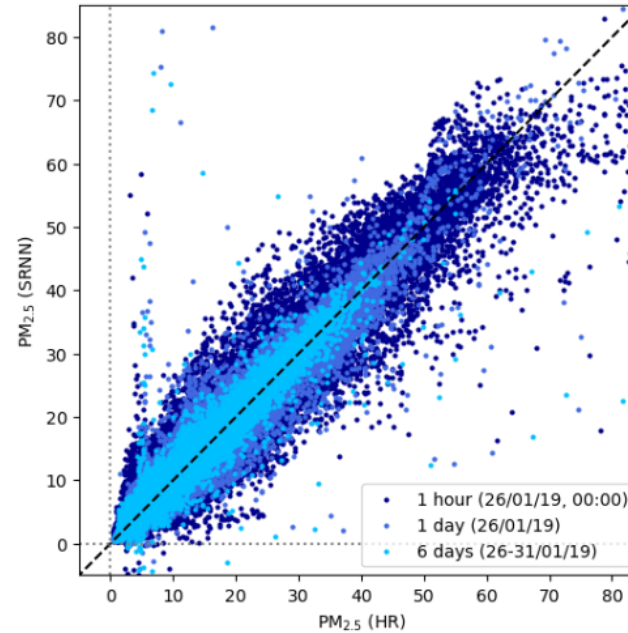


Metrics

Simulated HR vs. Simulated LR for PM_{2.5}



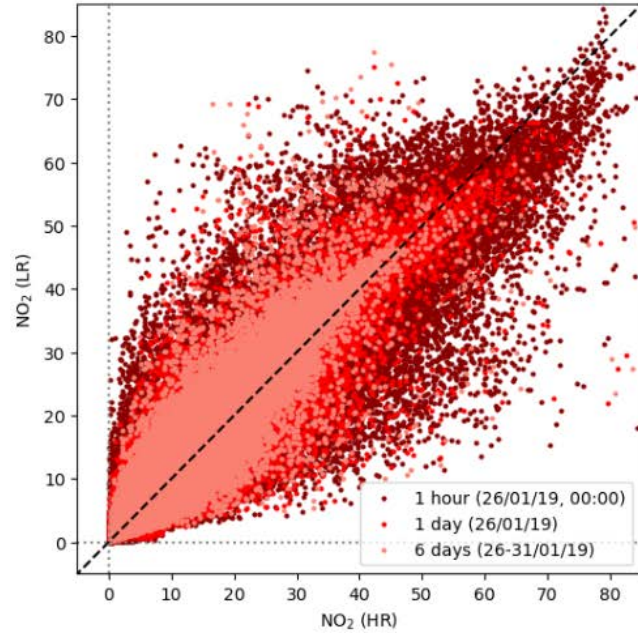
Simulated HR vs. Super-resolution (NN) for PM_{2.5}



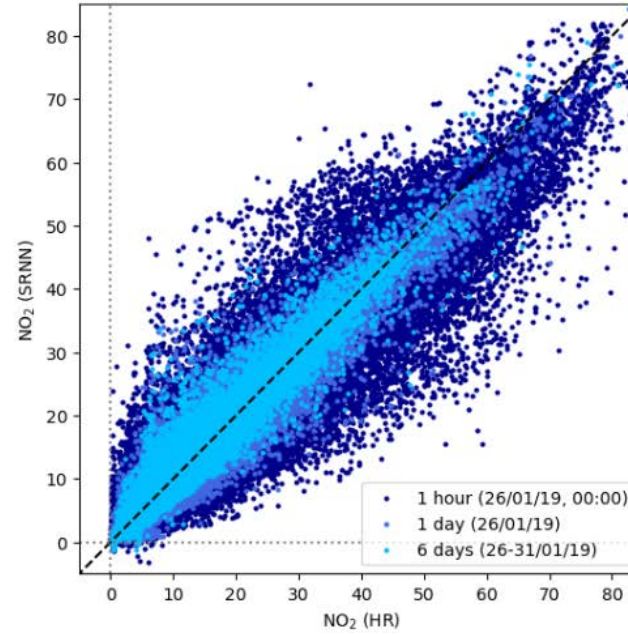
Observations:

- Good performance overall despite outliers for both PM_{2.5} and NO₂ models.
- Highest performances are found at around 12:00-14:00, lowest performances at around 6:00 and 20:00, illustrating chemical relationships not entirely captured by the model - The effect is more pronounced for NO₂ and for scenarios where secondary pollutants are involved.
- Performance plateau is reached after about 1 day of averaging.
- Too much importance to secondary sources of PM_{2.5}.

Simulated HR vs Simulated LR for NO₂



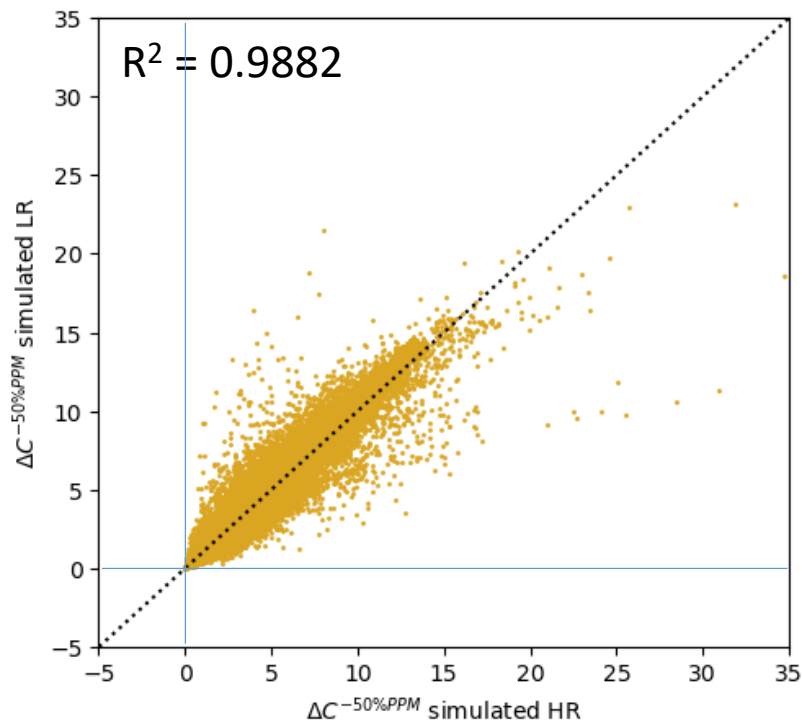
Simulated HR vs Super-resolution (NN) for NO₂



Target variable

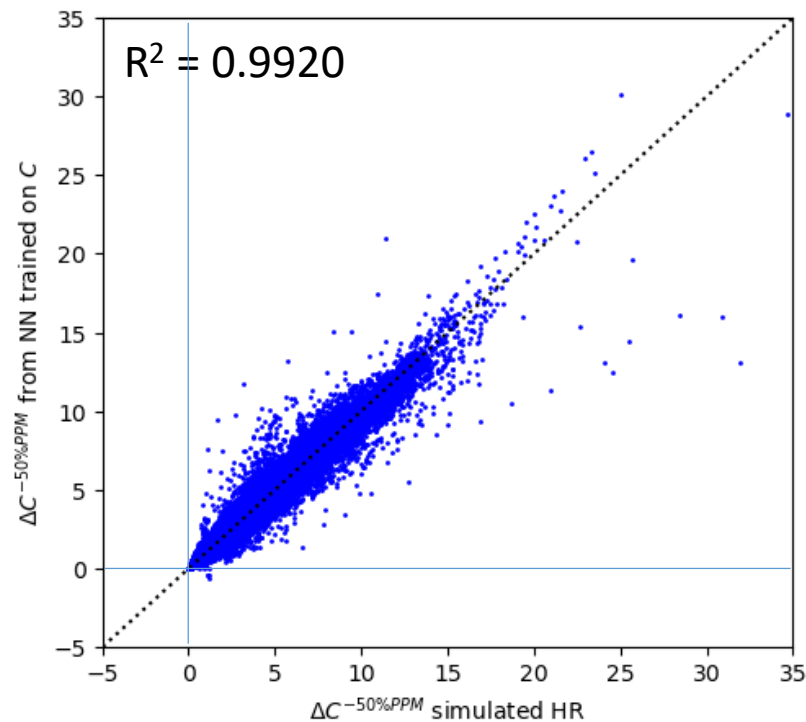
X: $\Delta C, -50\%PPM$ (HR)

Y: $\Delta C, -50\%PPM$ (LR)



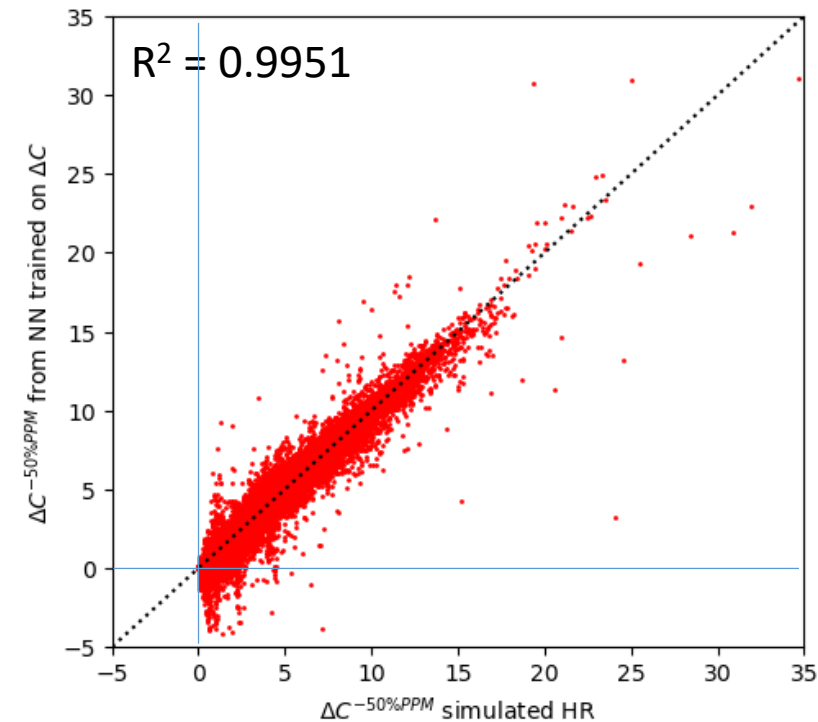
X: $\Delta C, -50\%PPM$ (HR)

Y: $\Delta C, -50\%PPM$ (NN_C) (NN trained on BC concentrations)



X: $\Delta C, -50\%PPM$ (HR)

Y: $\Delta C, -50\%PPM$ (NN _{ΔC}) (NN trained on -50%ALL ΔC)



Each point correspond to a pixel of the European domain for the quantity (ΔC) under study averaged from 26 to 31 January

Features of the final product

Domain: Western & Central Europe >>> All Europe and neighboring regions

Spatial resolution: $0.01^{\circ} \times 0.02^{\circ} \approx 1 \times 2 \text{ km}^2$ (from $0.05^{\circ} \times 0.1^{\circ} \approx 1\text{-}2 \text{ km}^2$)

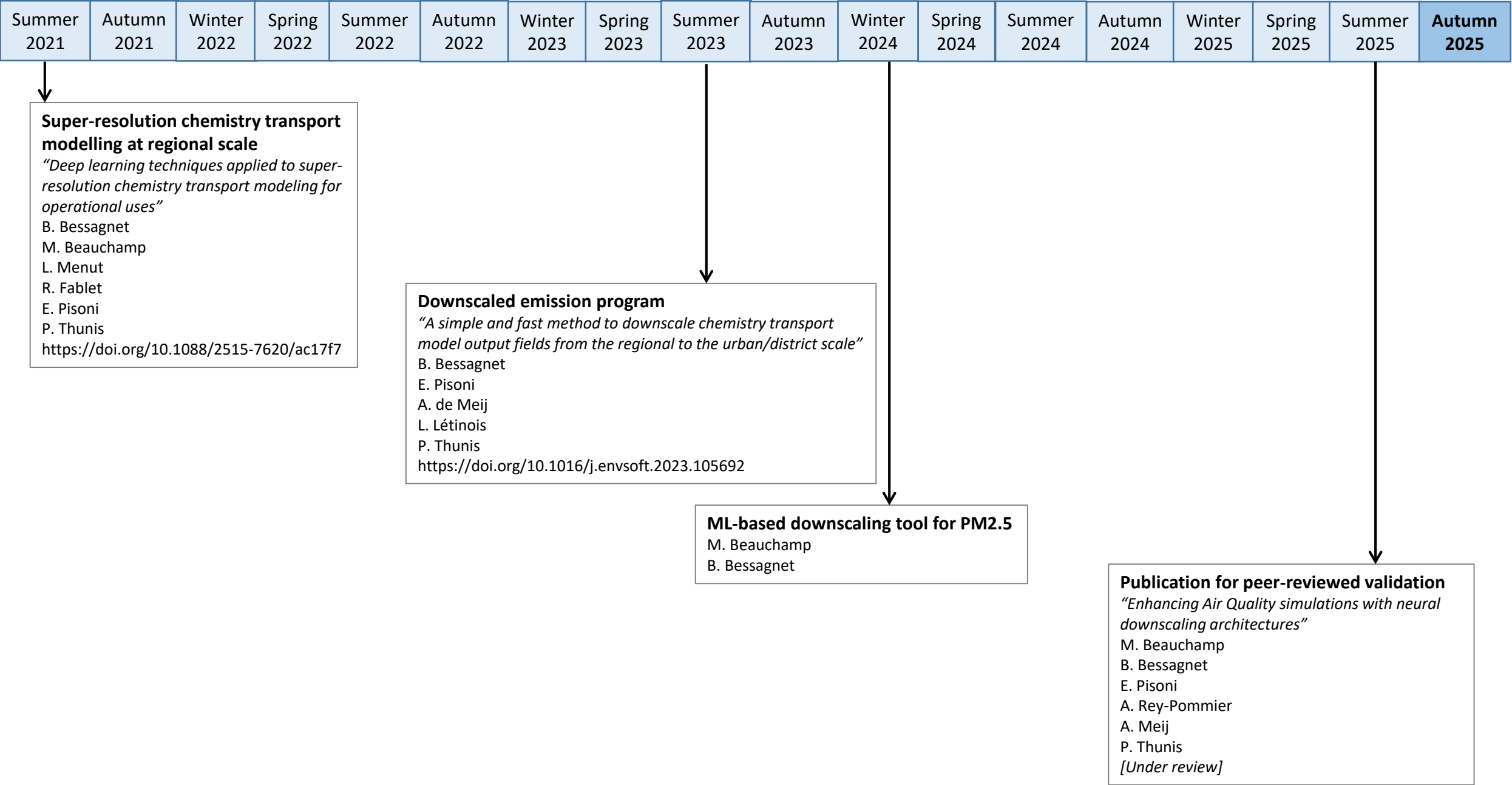
Temporal resolution: to be defined, trade-off between performance and frequency

Target variable: Concentrations >>> absolute Deltas

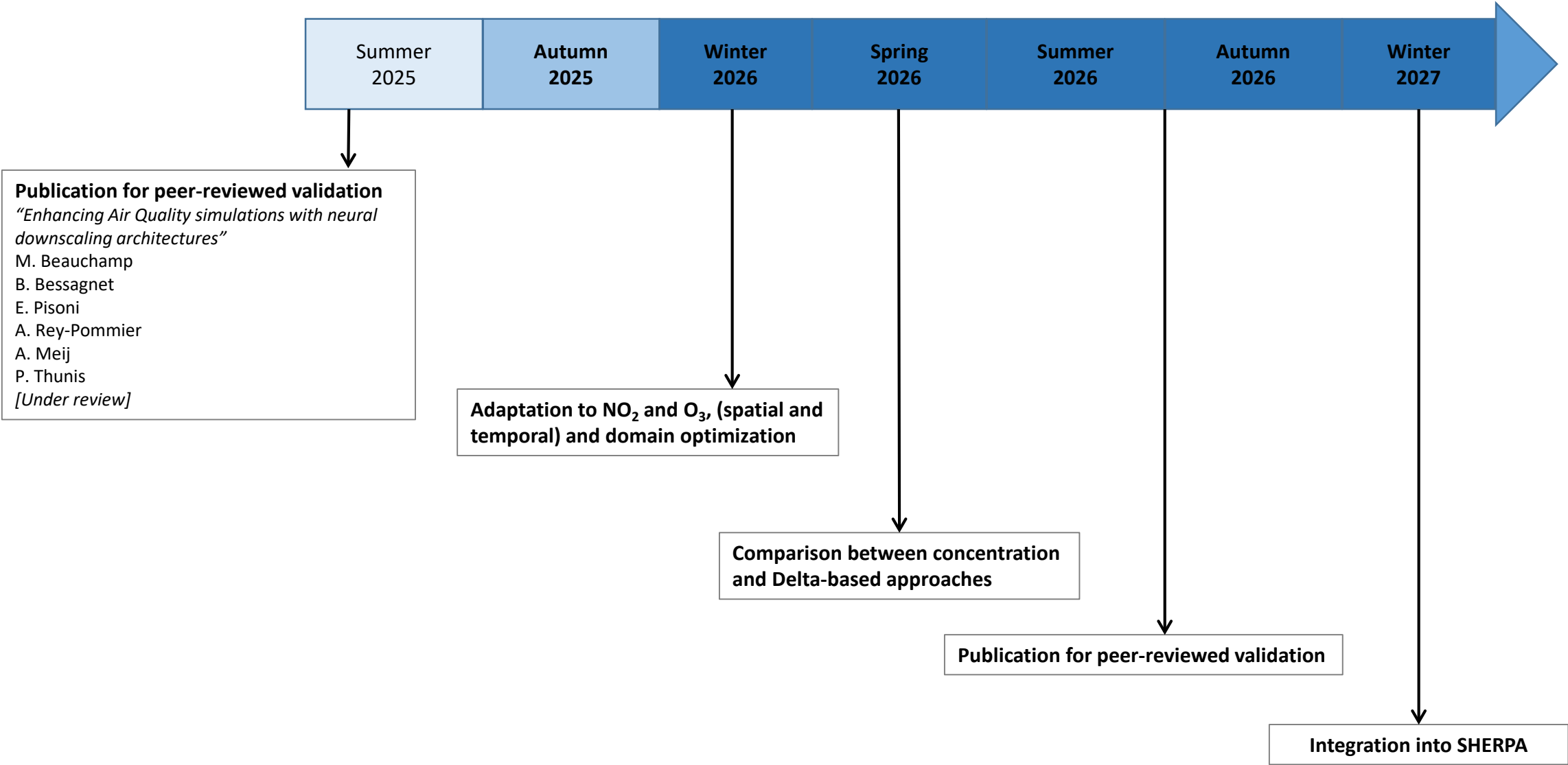
Species: $\text{PM}_{2.5}$, NO_2 ... and O_3 ?

Execution time: a few minutes for one month of hourly fields

Timeline (1)



Timeline (2)



Please ask your questions

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