



Instituto Nacional de
Meteorología- **INM**

National Institute
for Meteorology



Origin and features of ultrafine particles in Barcelona

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1. Introduction: PM monitoring program in Barcelona 1999-2007

2. Daily cycles

3. Events and seasonal evolution

- local urban pollution events
- “clean” air events,
- ultrafine particles events

4. Summary

Studies on PM and urban air quality: since 1999



- ✓PM chemical characterization & mass closure
- ✓Time series analysis (back to 1995)
- ✓Modelling

BARCELONA { 1999-2000: L'HO site
2001-2002: SAGRERA site
2003-2007: IJA site

2003: number concentration measurements were added to the IJA aerosol program

ultrafine particle in Barcelona

IJA site: 2003-2007



ultrafine particle in Barcelona

IJA site: 2003-2007 – central urban background site

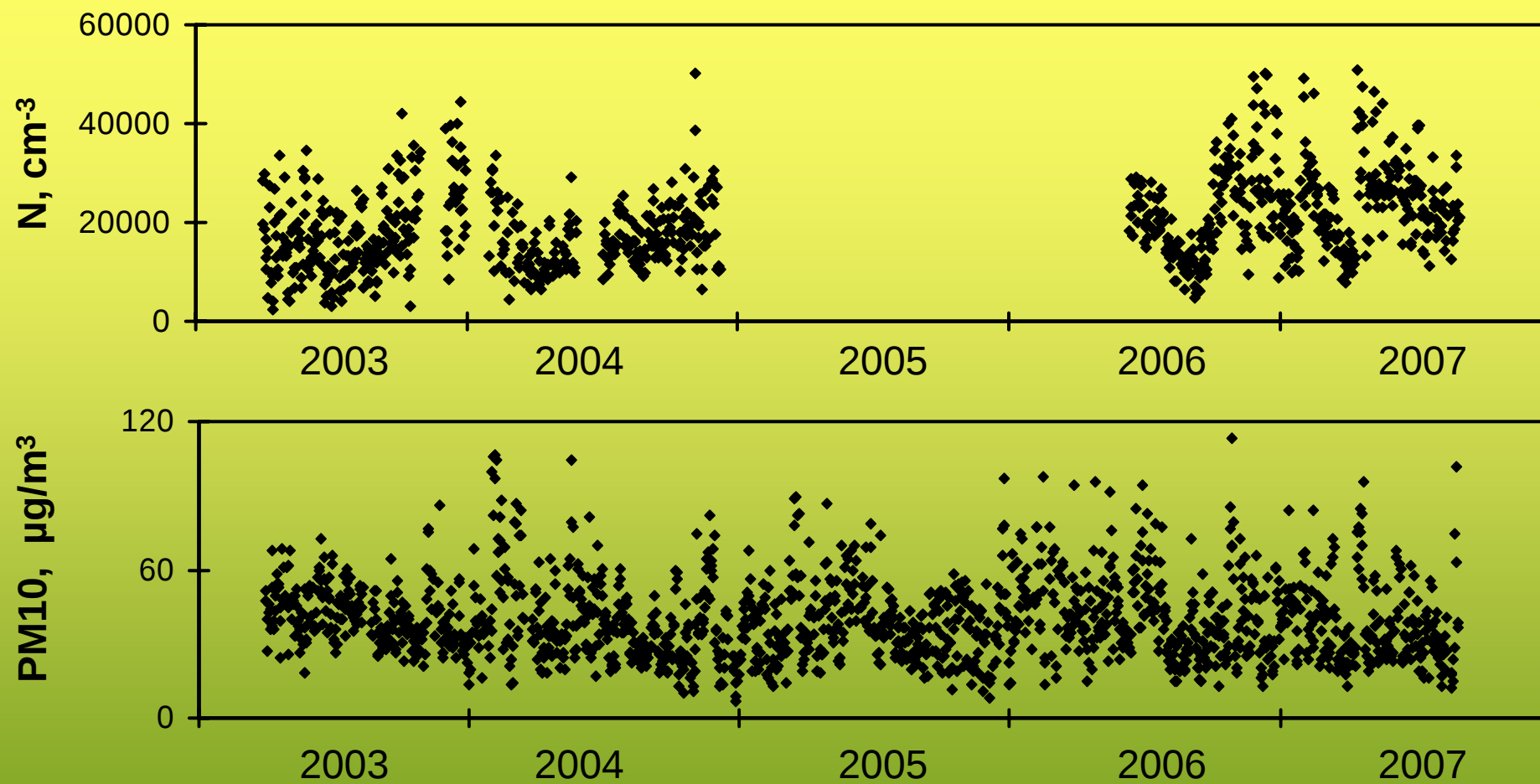
UNIVERSITY CAMPUS

Differential Mobility Particle Sizer 10-800nm

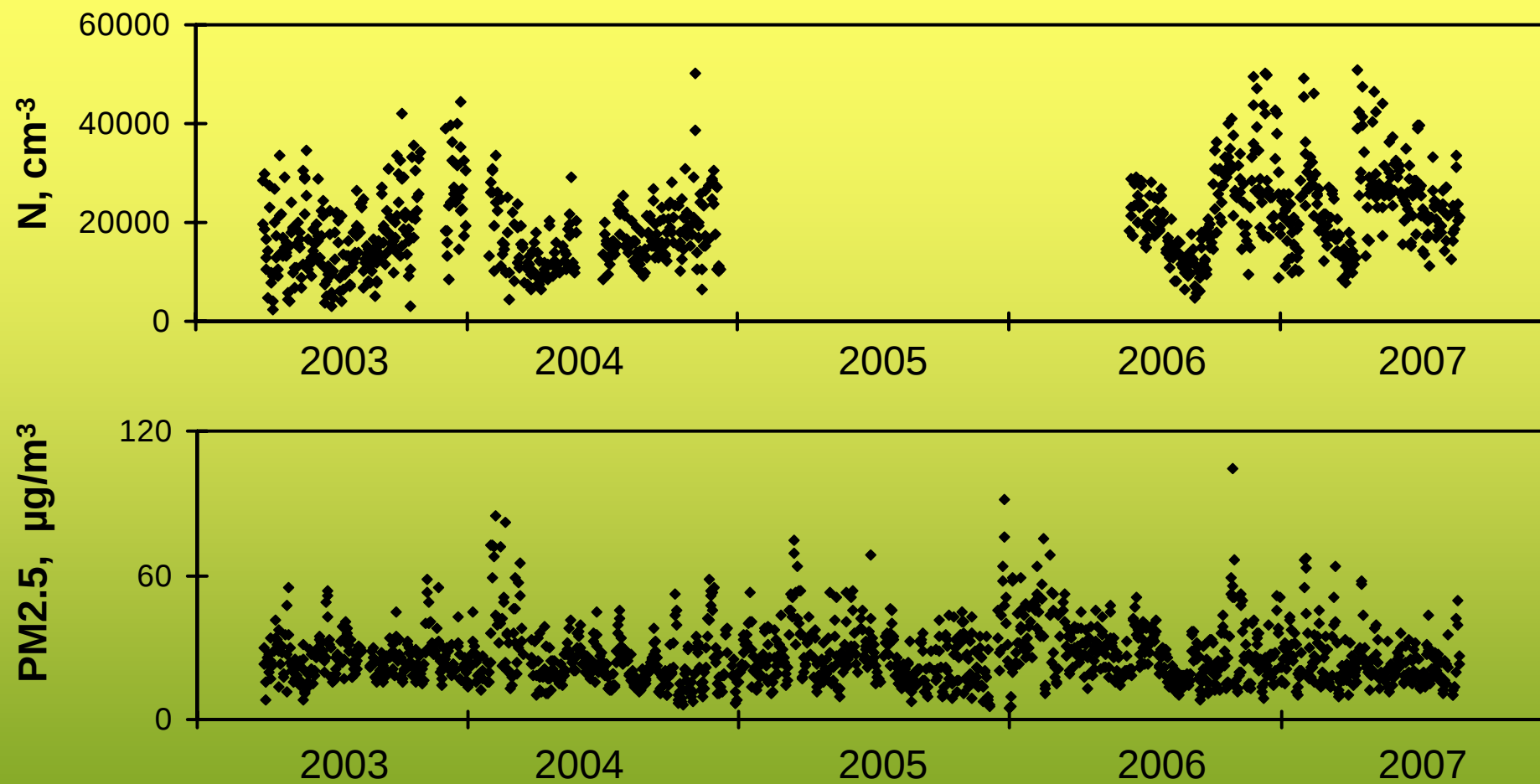
PM10 & PM2.5 sampling on filter



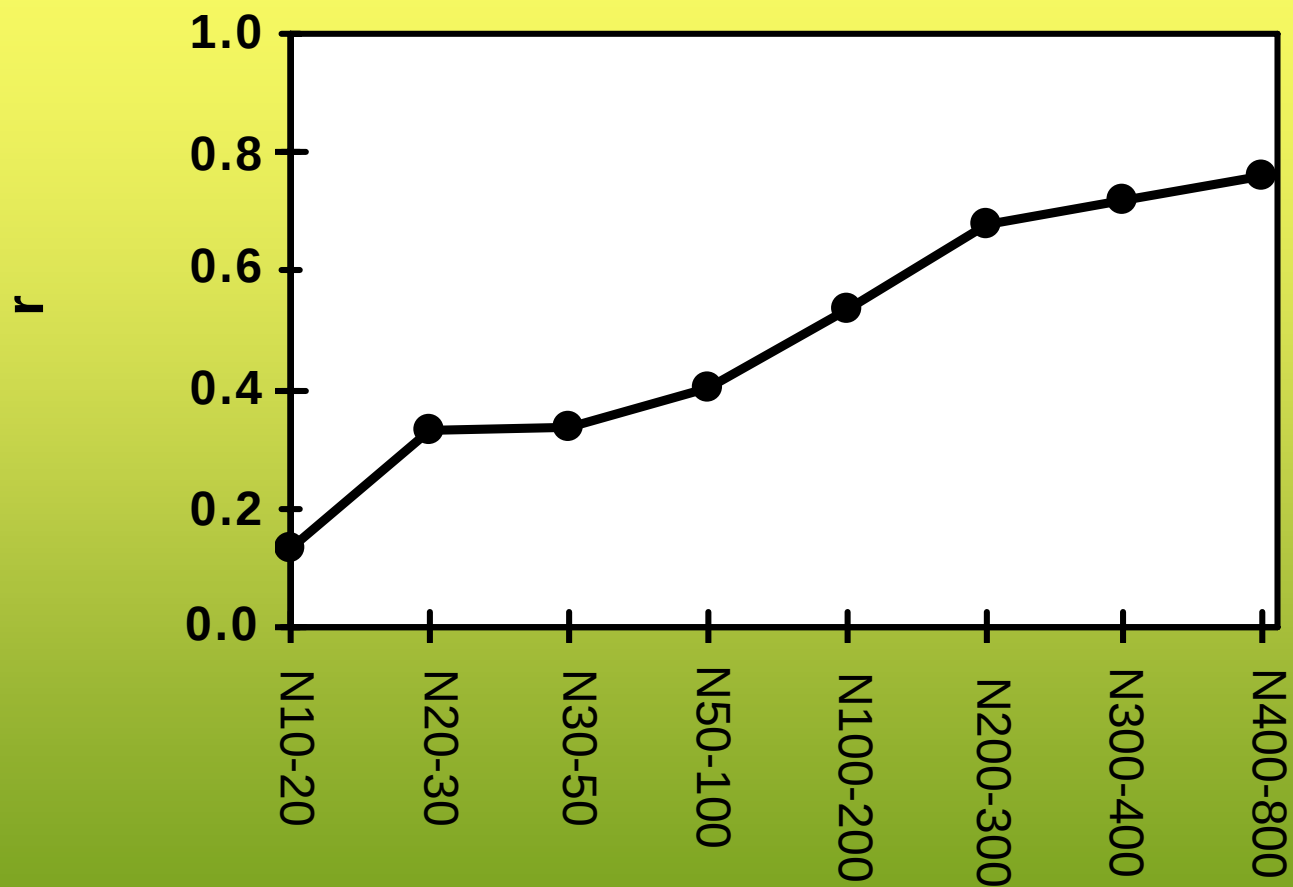
ultrafine particle in Barcelona



ultrafine particle in Barcelona

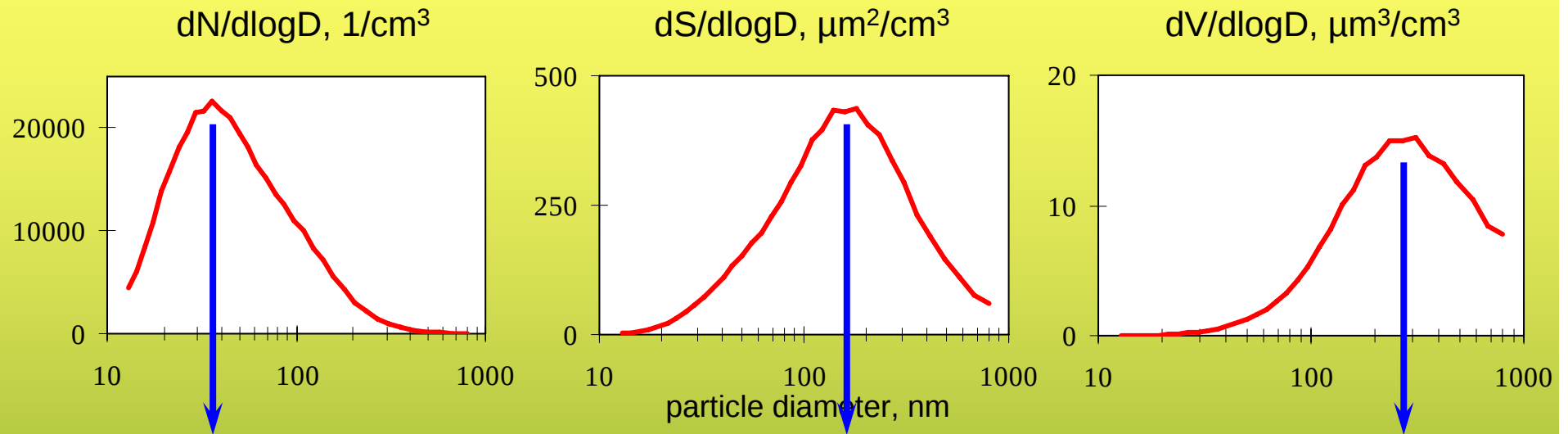


Correlation coefficient between number size distribution and PM2.5



ultrafine particle in Barcelona

Mean values



DpN: 36nm
DpN: peak diameter for $dN/d\log D$

DpS: 233nm

DpV: 309nm

N10-800: 16800cm^{-3}

N10-20: 1941cm^{-3}

N20-30: 3386cm^{-3}

N30-50: 3988cm^{-3}

N50-100: 5093cm^{-3}

N100-200: 1588cm^{-3}

N200-415: 496cm^{-3}

N415-800: 49cm^{-3}

86%: ultrafine

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2. Daily cycles

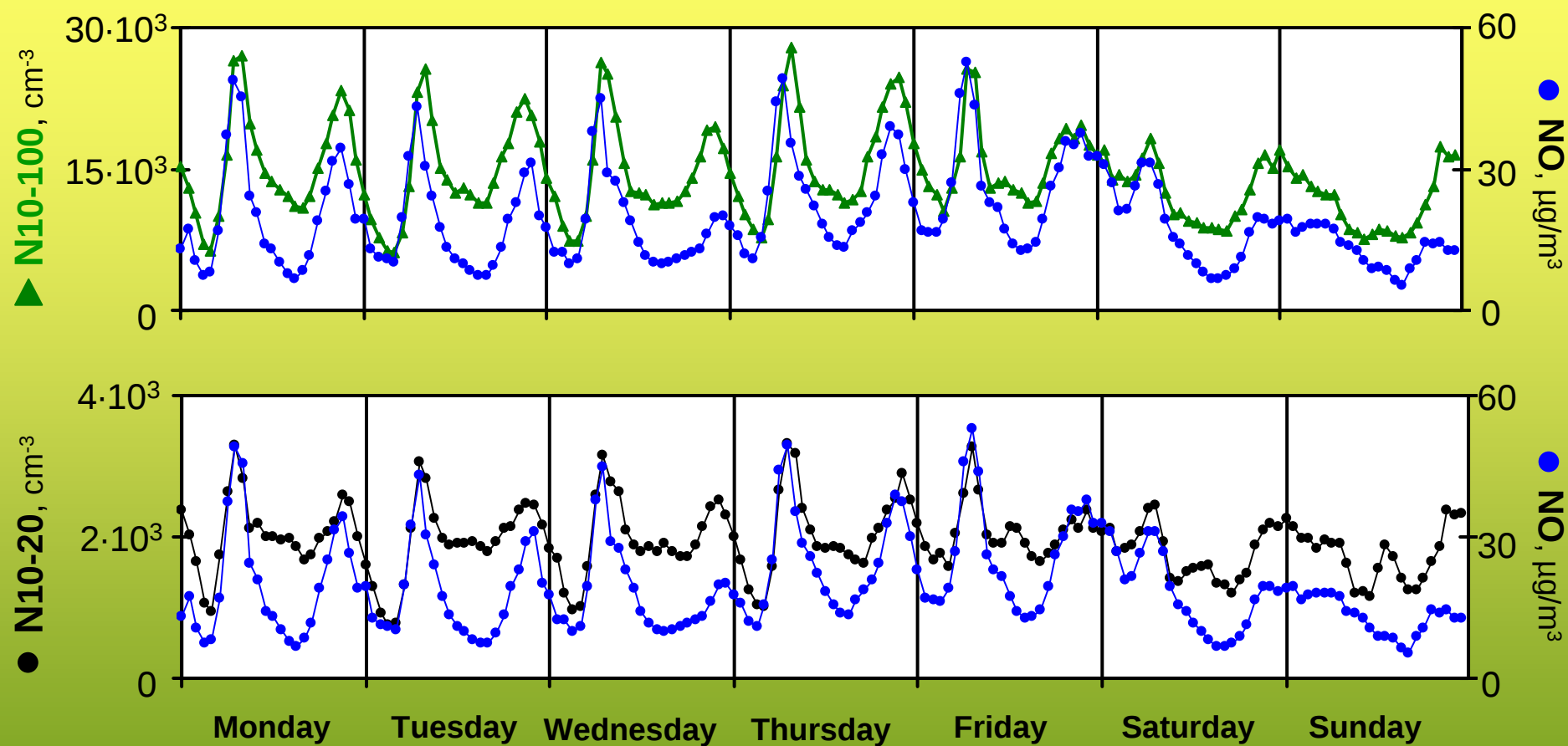
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- ultrafine particles events

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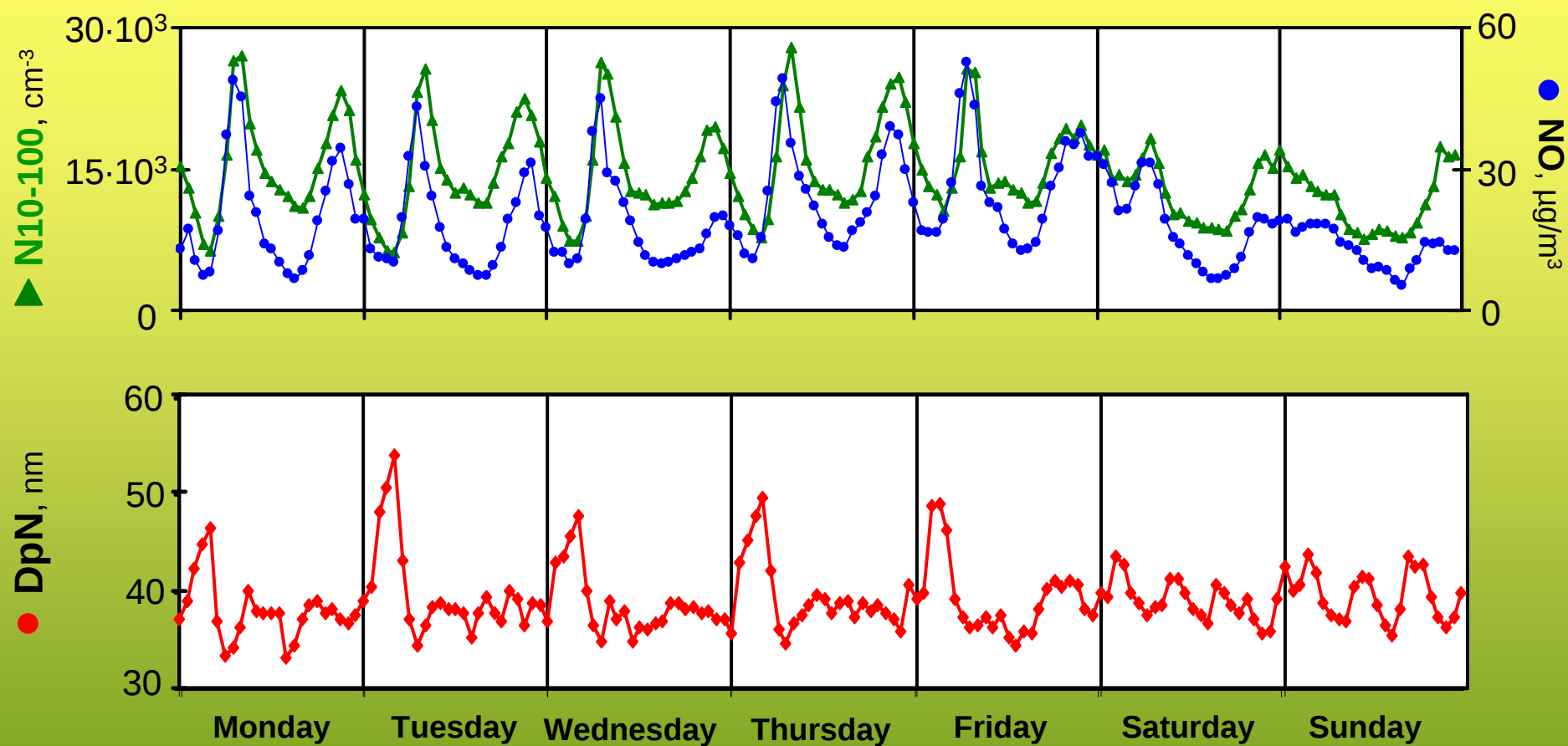
ultrafine particle in Barcelona

2. Daily cycles

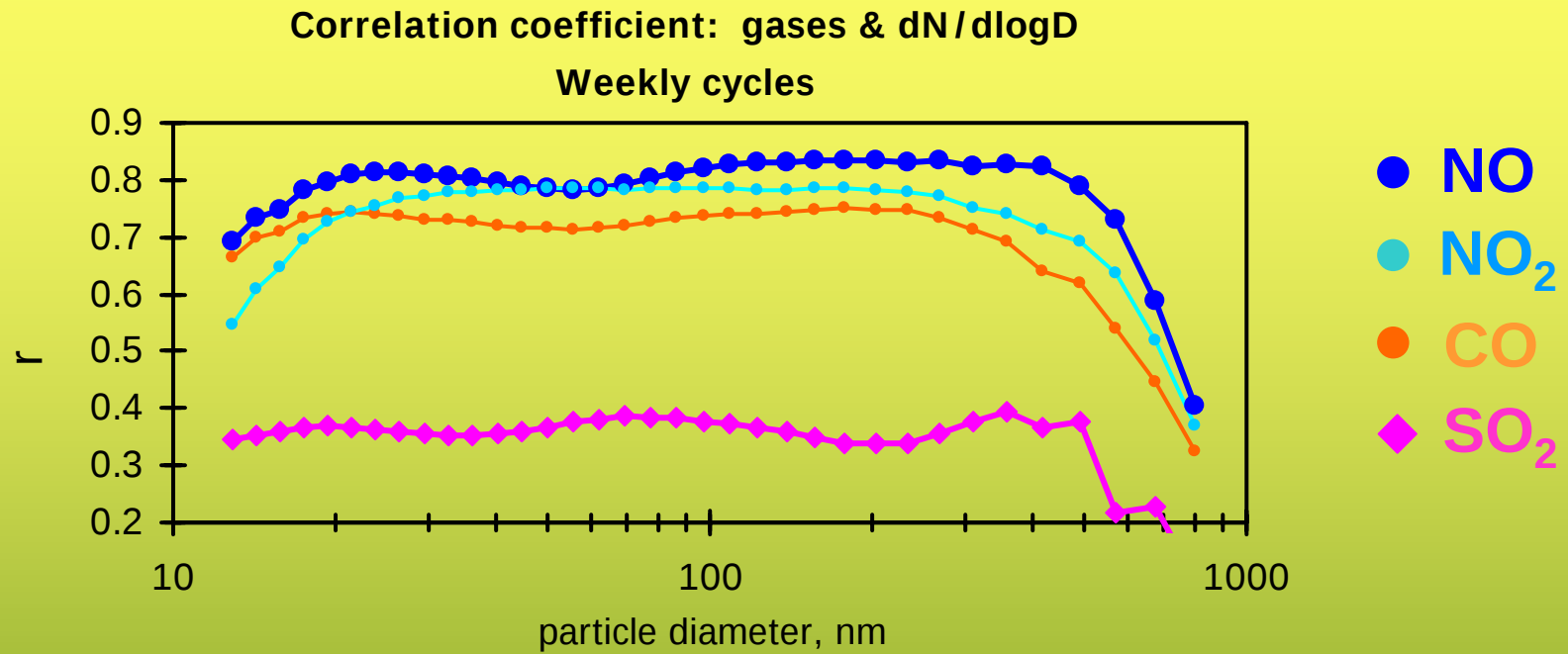


ultrafine particle in Barcelona

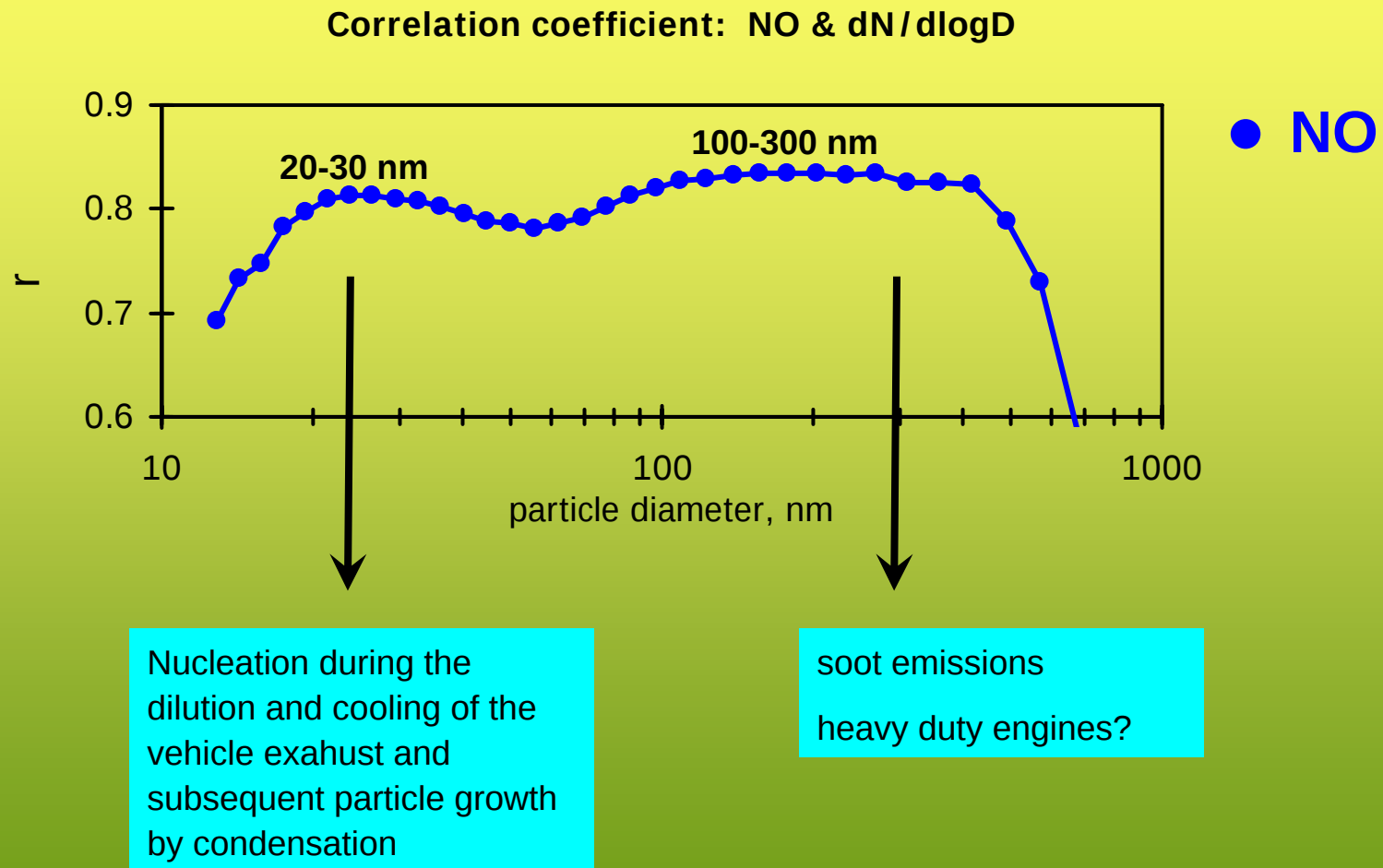
2. Daily cycles



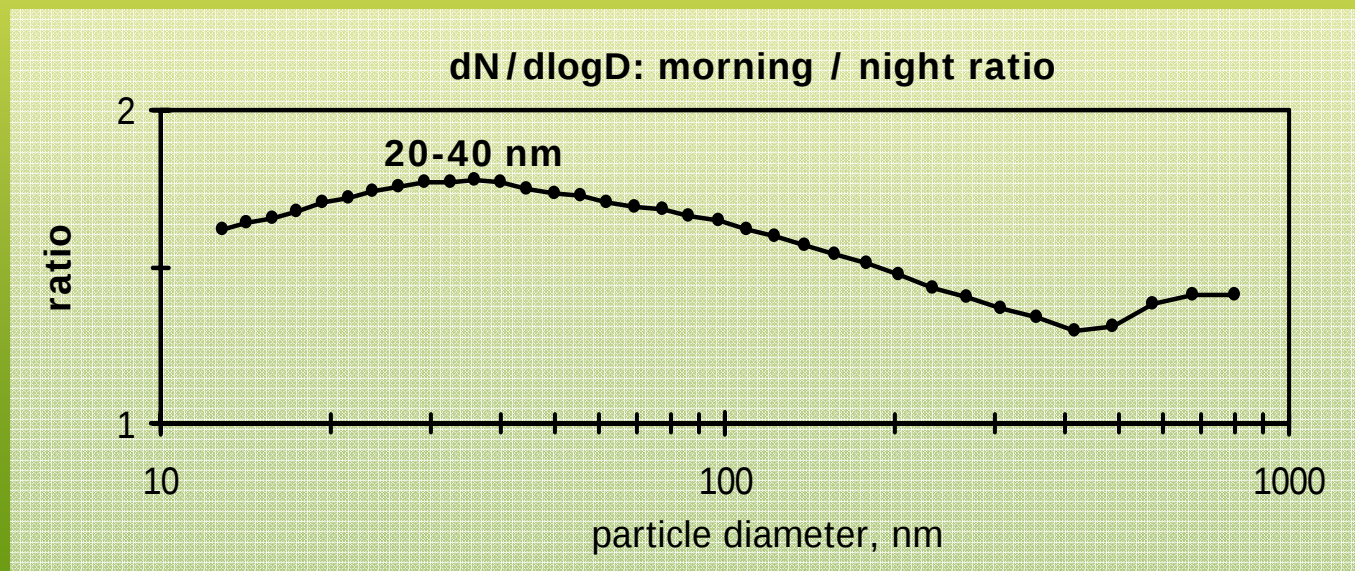
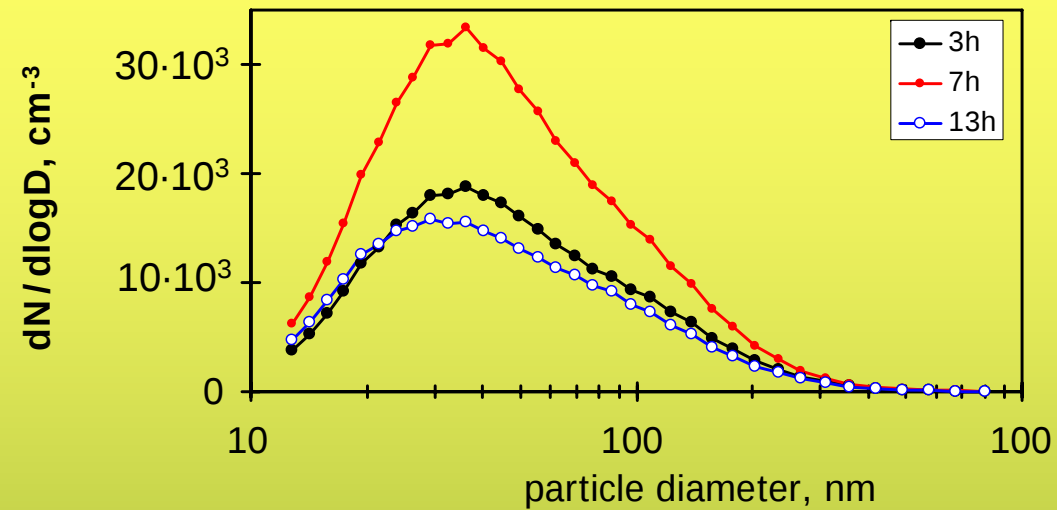
2. Daily cycles



2. Daily cycles



2. Daily cycles



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3. Events and seasonal evolution

-local urban pollution (winter)

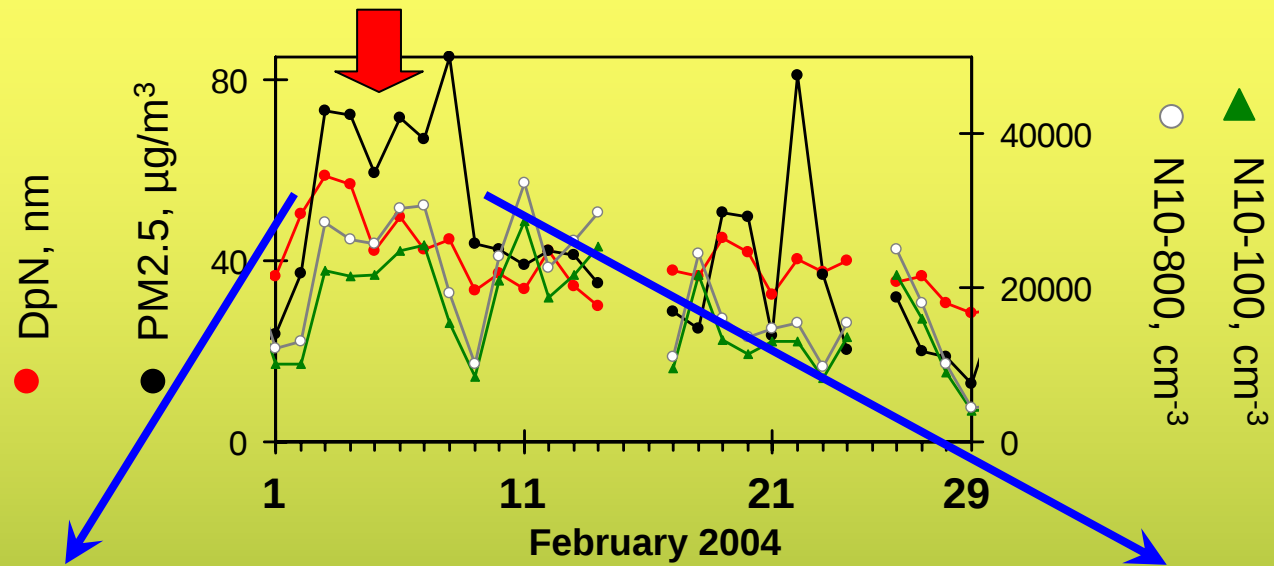
concatenations of:

- Local urban pollution
- Atlantic air masses advections

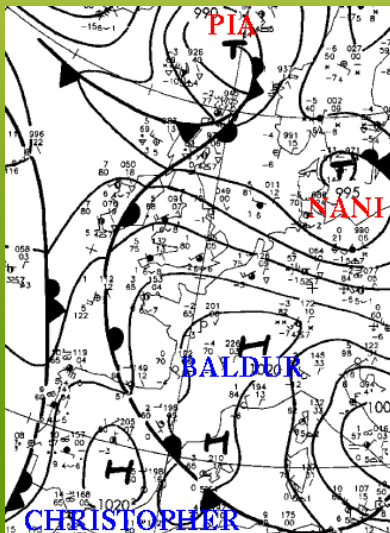


correlated day-to-day variations in the daily mean values of **N10-100**, **DpN** & **PM2.5**

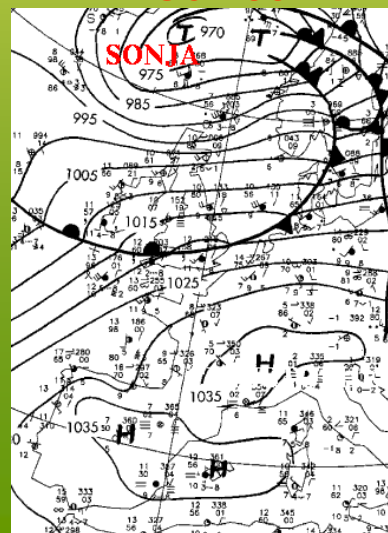
3. Events and seasonal evolution: local urban pollution



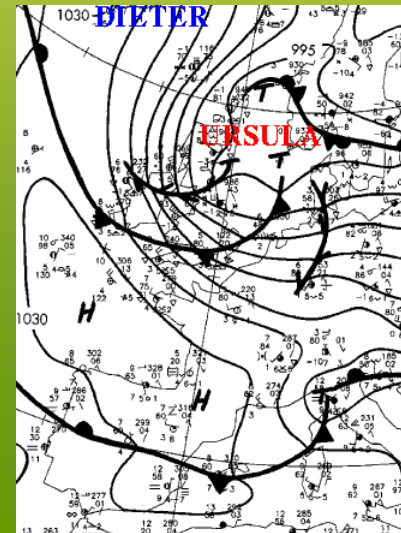
“clean air”
1-Feb-2004



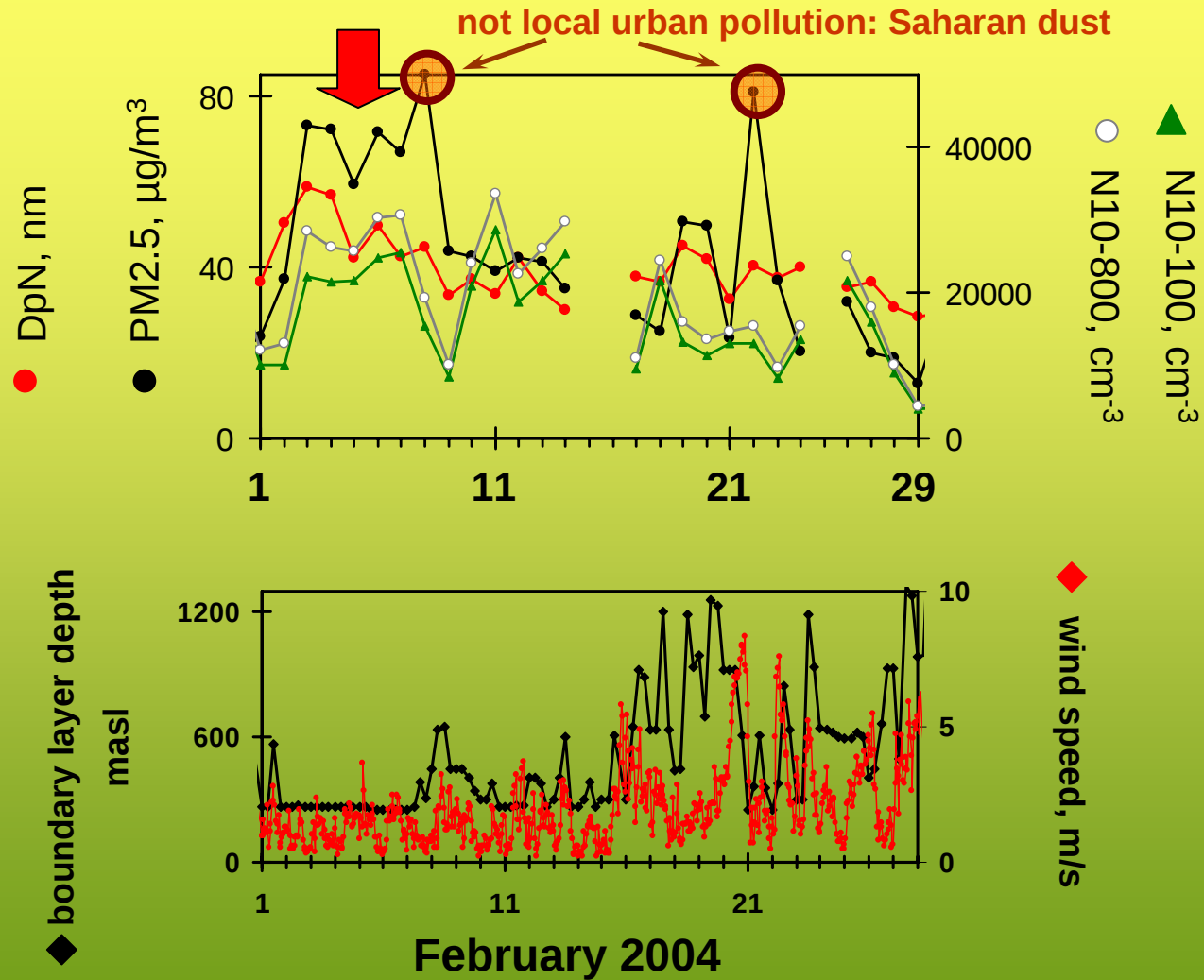
Local urban pollution
4-Feb-2004



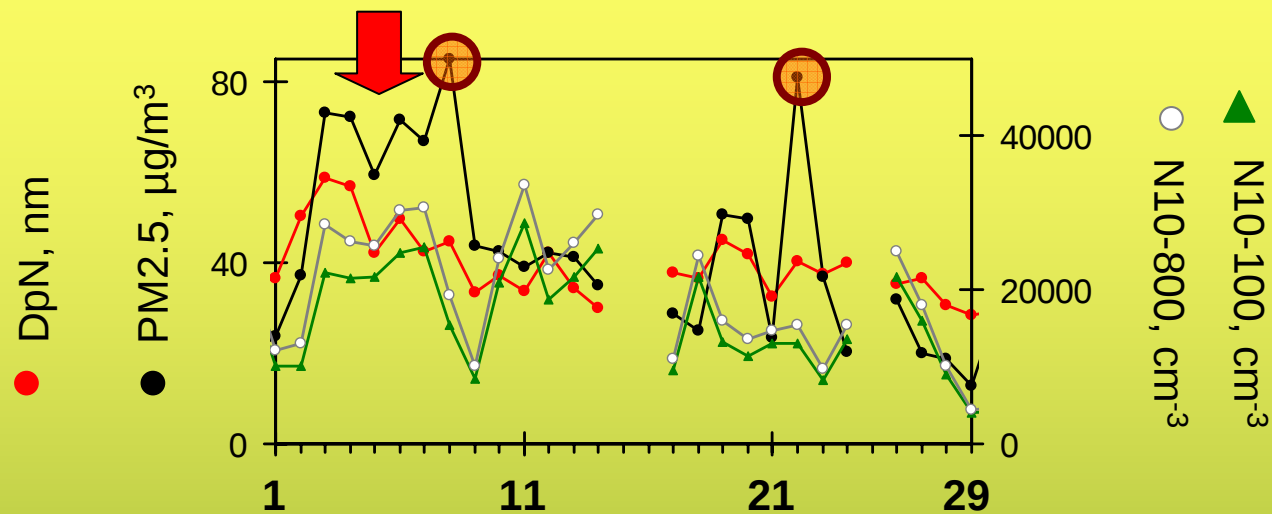
“clean air”
9-Feb-2004



3. Events and seasonal evolution: local urban pollution



3. Events and seasonal evolution: local urban pollution

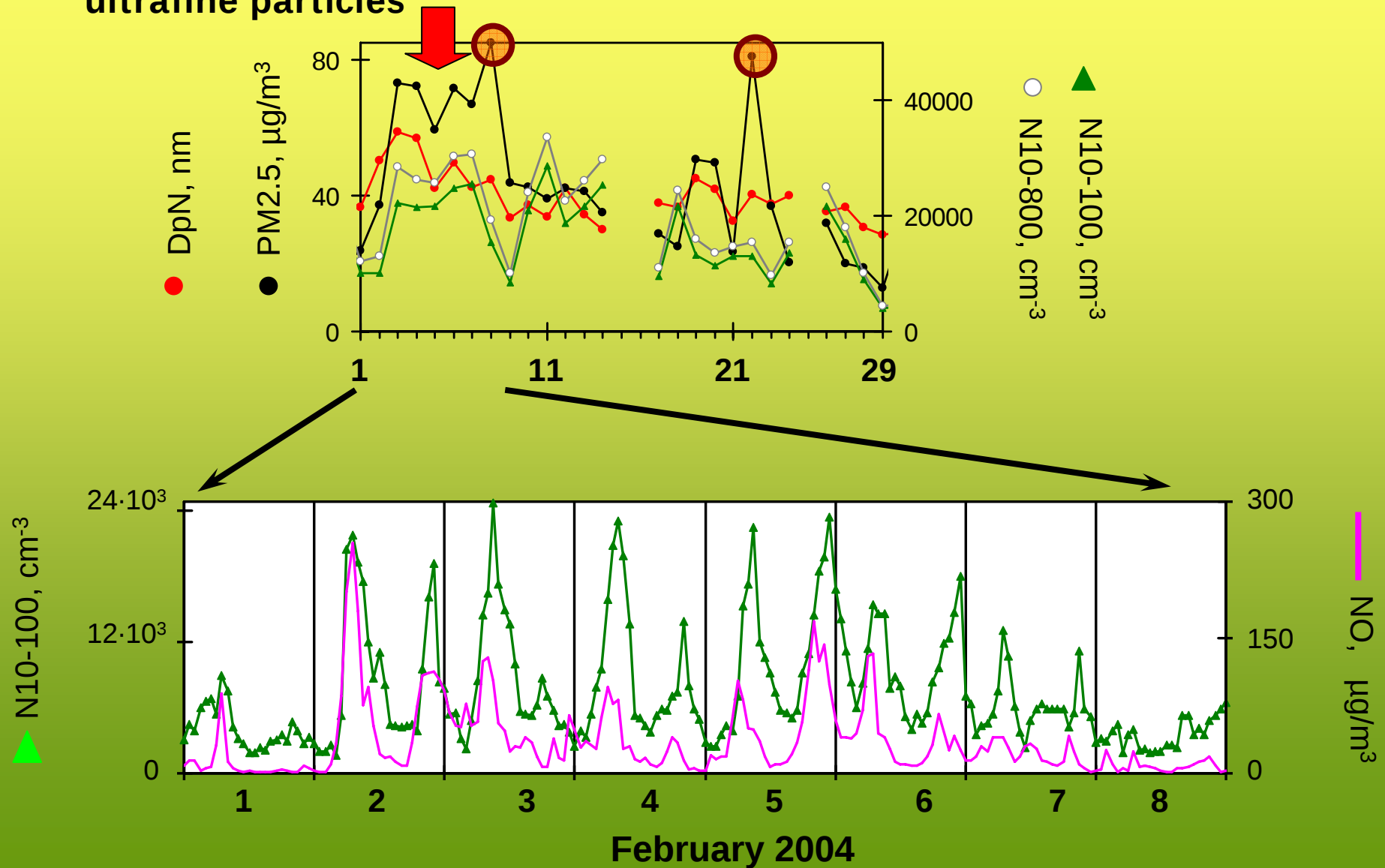


Both ultrafine and PM2.5 particles increase during local urban pollution events, however they behave in deferent ways



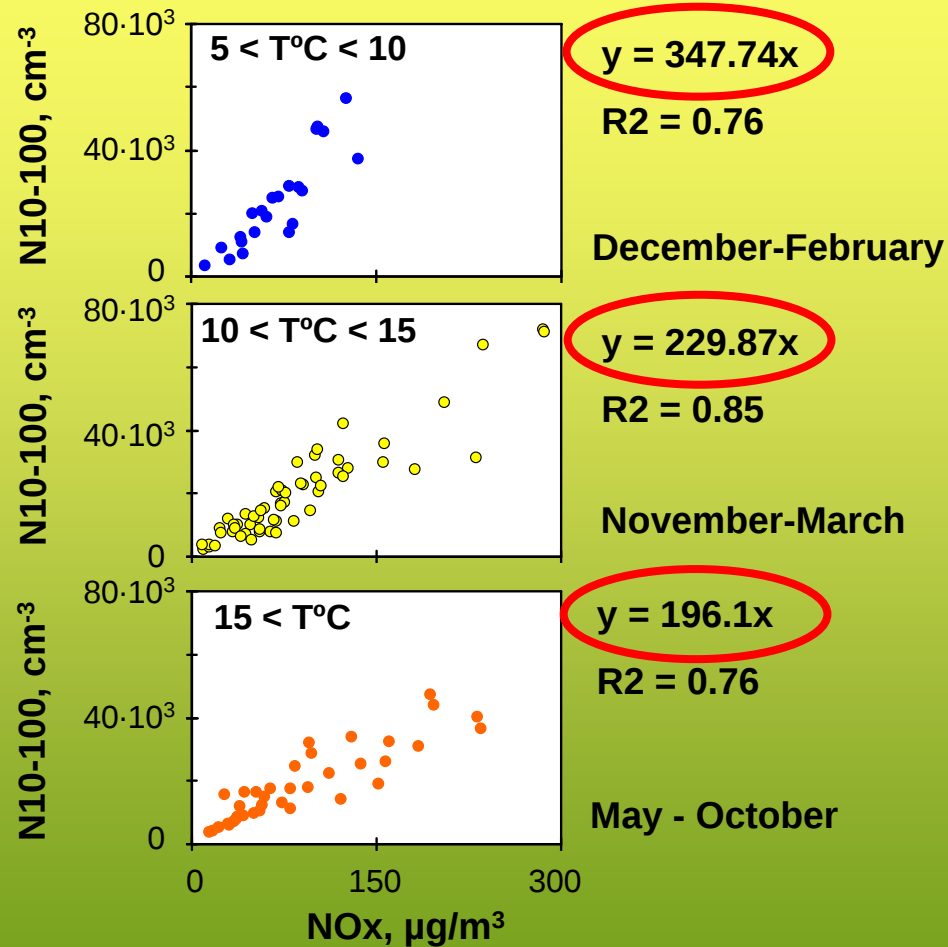
3. Events and seasonal evolution: local urban pollution

ultrafine particles



ultrafine particle in Barcelona

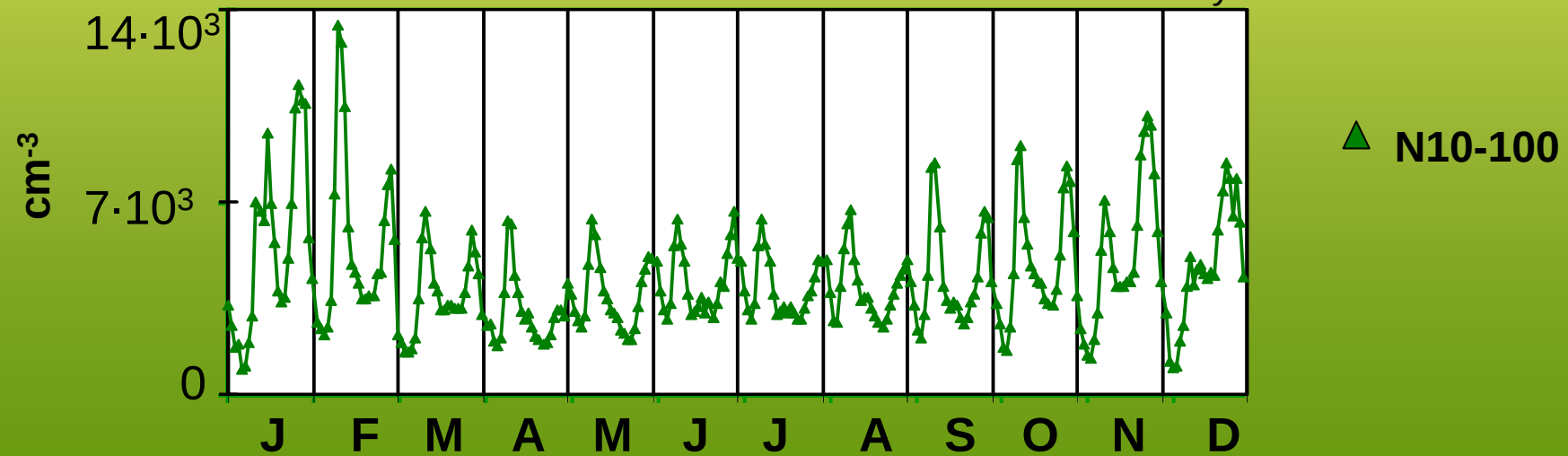
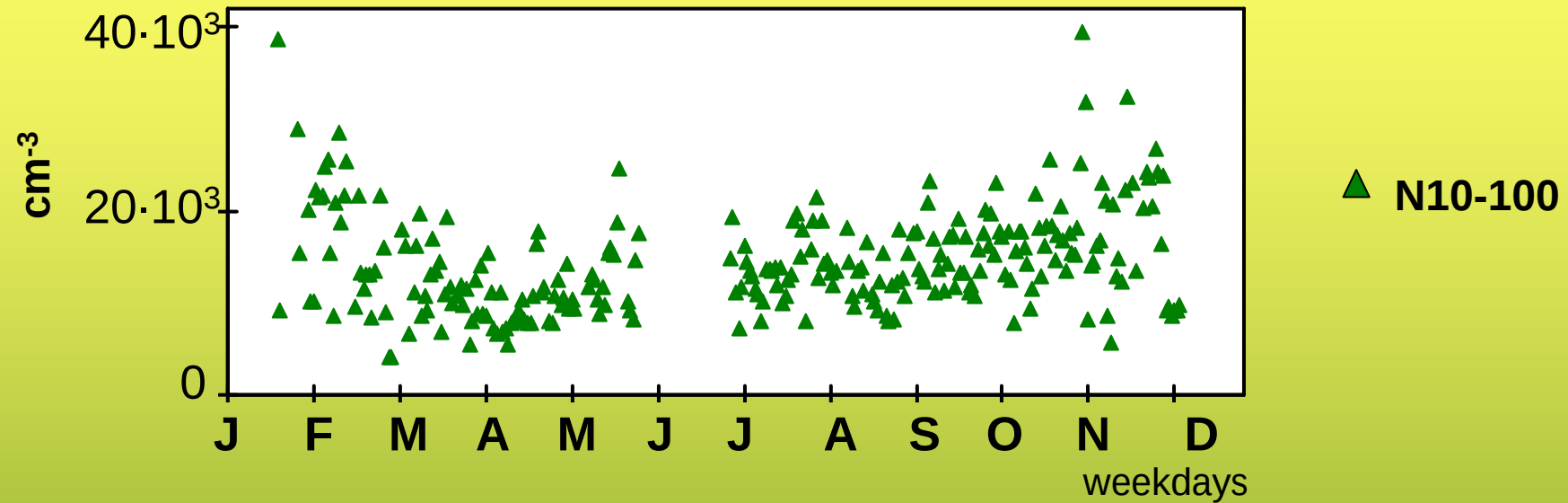
Relationship between N10-100 and NO_x
Morning rush hours (7-9h)



Ultrafine particles
formation is enhanced
under low
temperatures: winter
maximum during
morning rush hours

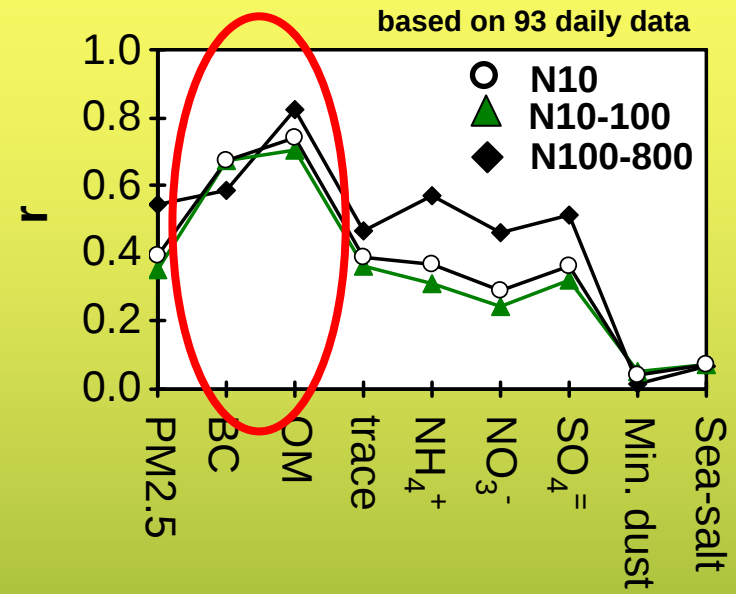
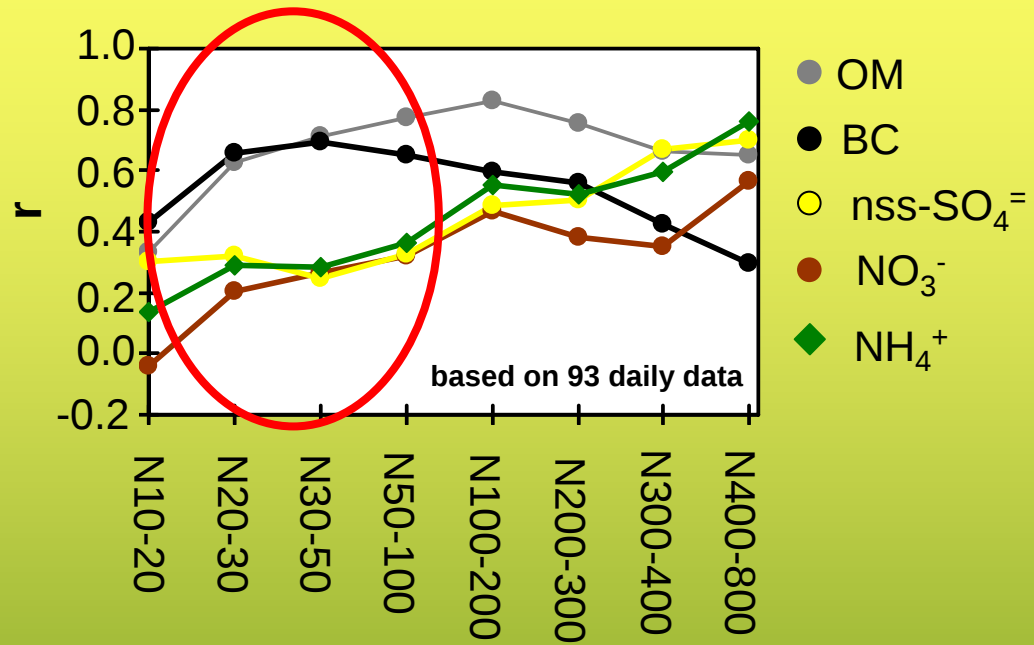
3. Events and seasonal evolution: local urban pollution

ultrafine particles



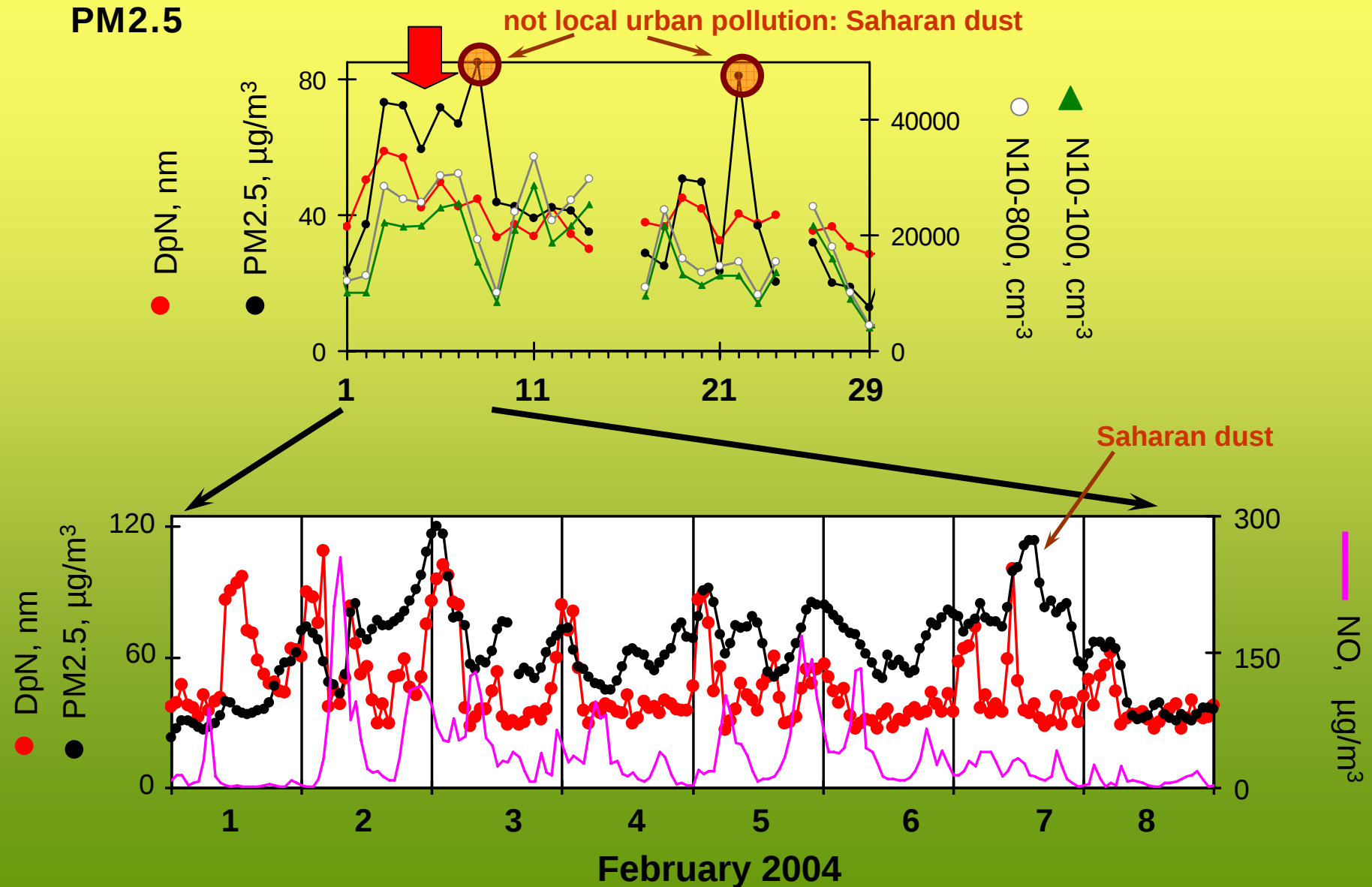
3. Events and seasonal evolution: local urban pollution

ultrafine particles



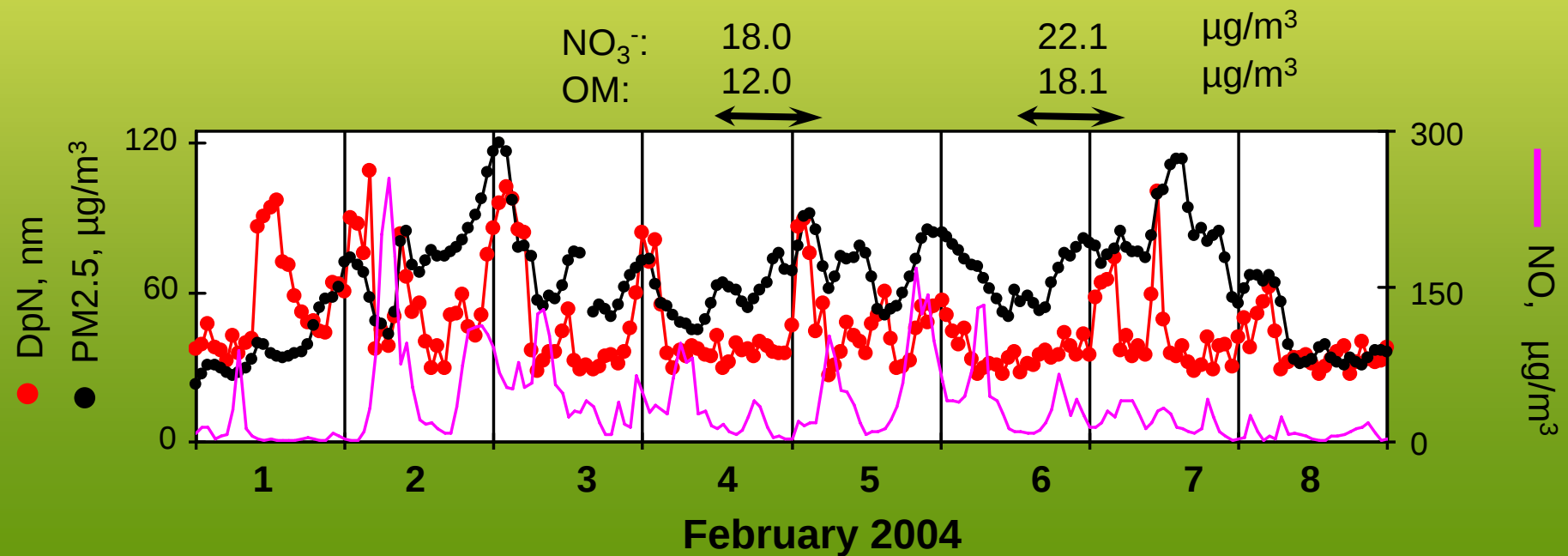
3. Events and seasonal evolution: local urban pollution

PM2.5



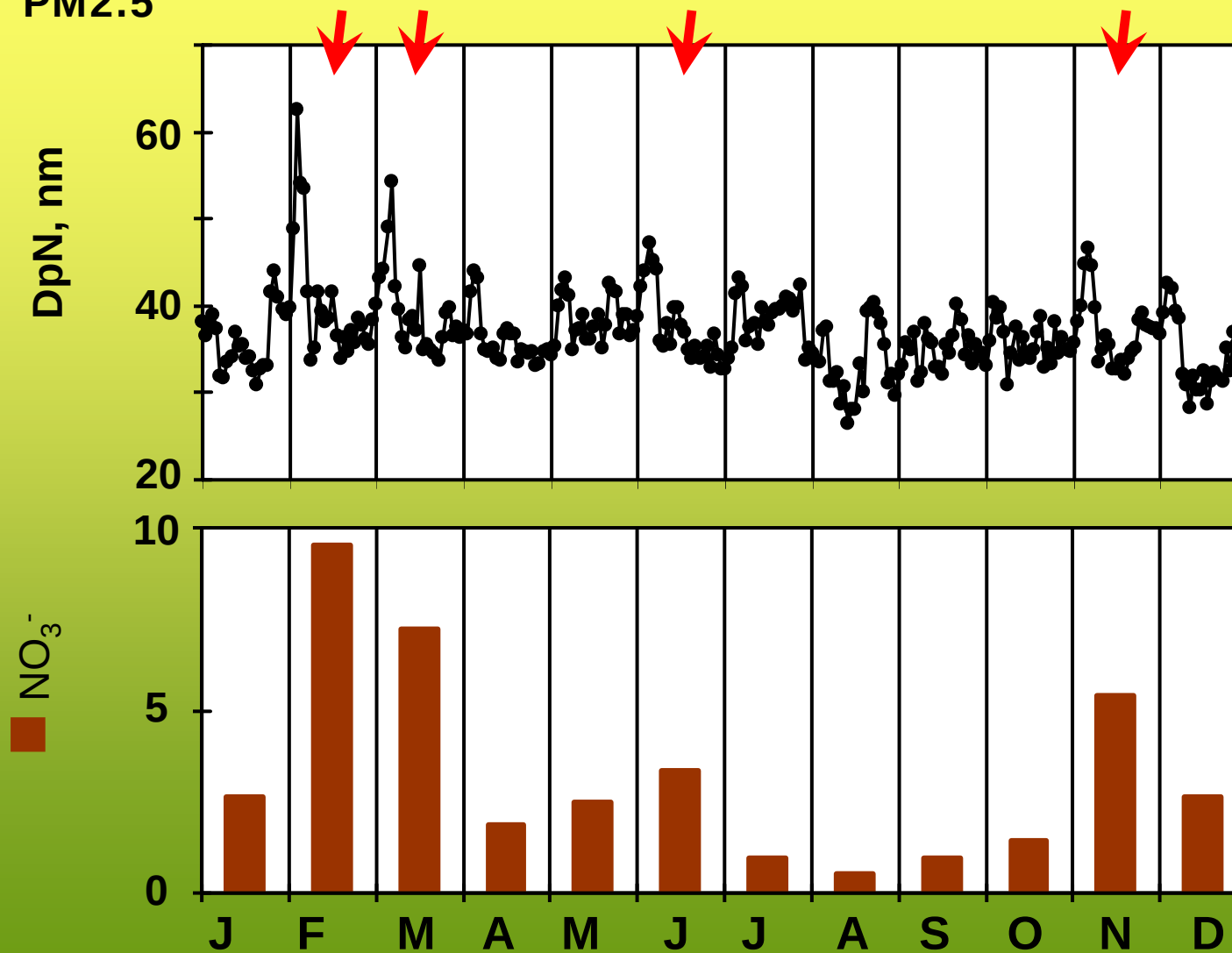
3. Events and seasonal evolution: local urban pollution

PM2.5



3. Events and seasonal evolution: local urban pollution

PM_{2.5}



3. Events and seasonal evolution: local urban pollution

local urban pollution: WINTER

- PM2.5 particles events (night) due enhancements in the condensation of semi-volatile species at night: low temperatures, low dilution (low wind speed and low boundary layer depth),

- ultrafine particles events (rush hours) due enhancements in the “ultrafine particles formation” in the morning rush hours during the vehicle exhaust dilution and cooling: low temperatures, low dilution (low wind speed and low boundary layer depth),

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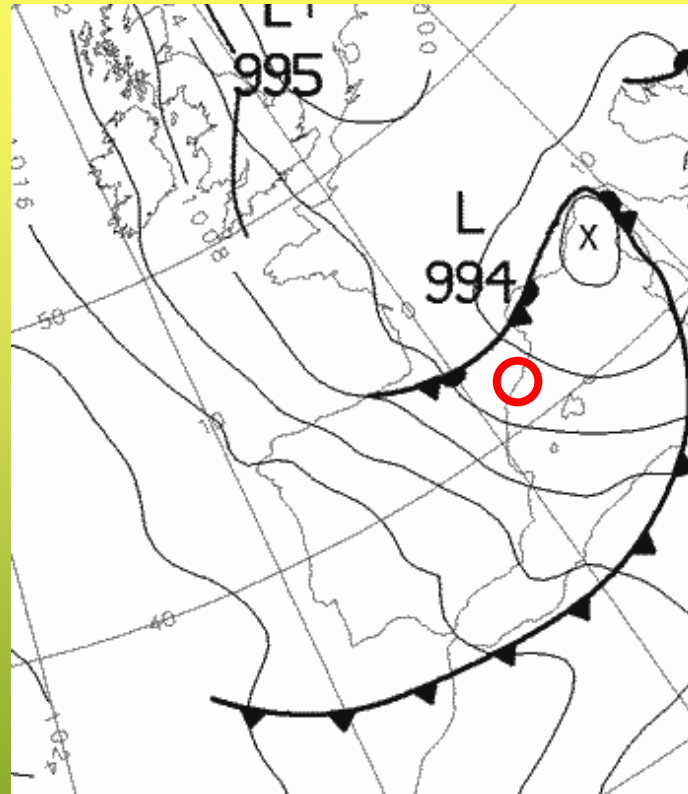
2. Daily cycles

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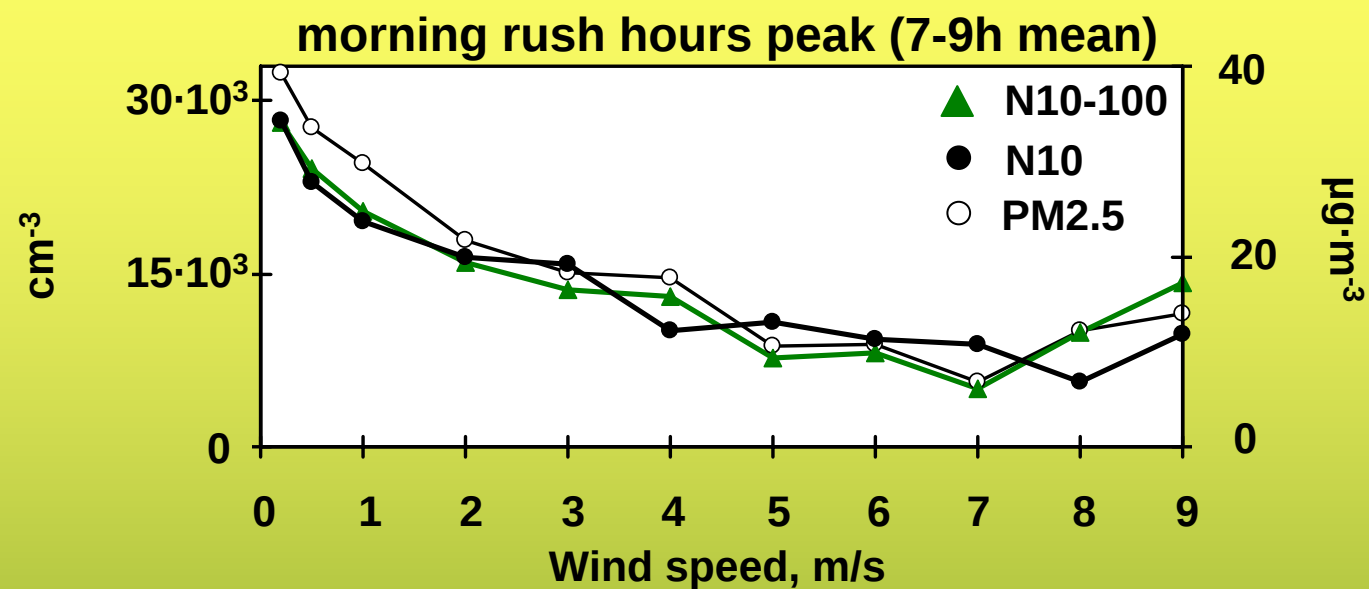
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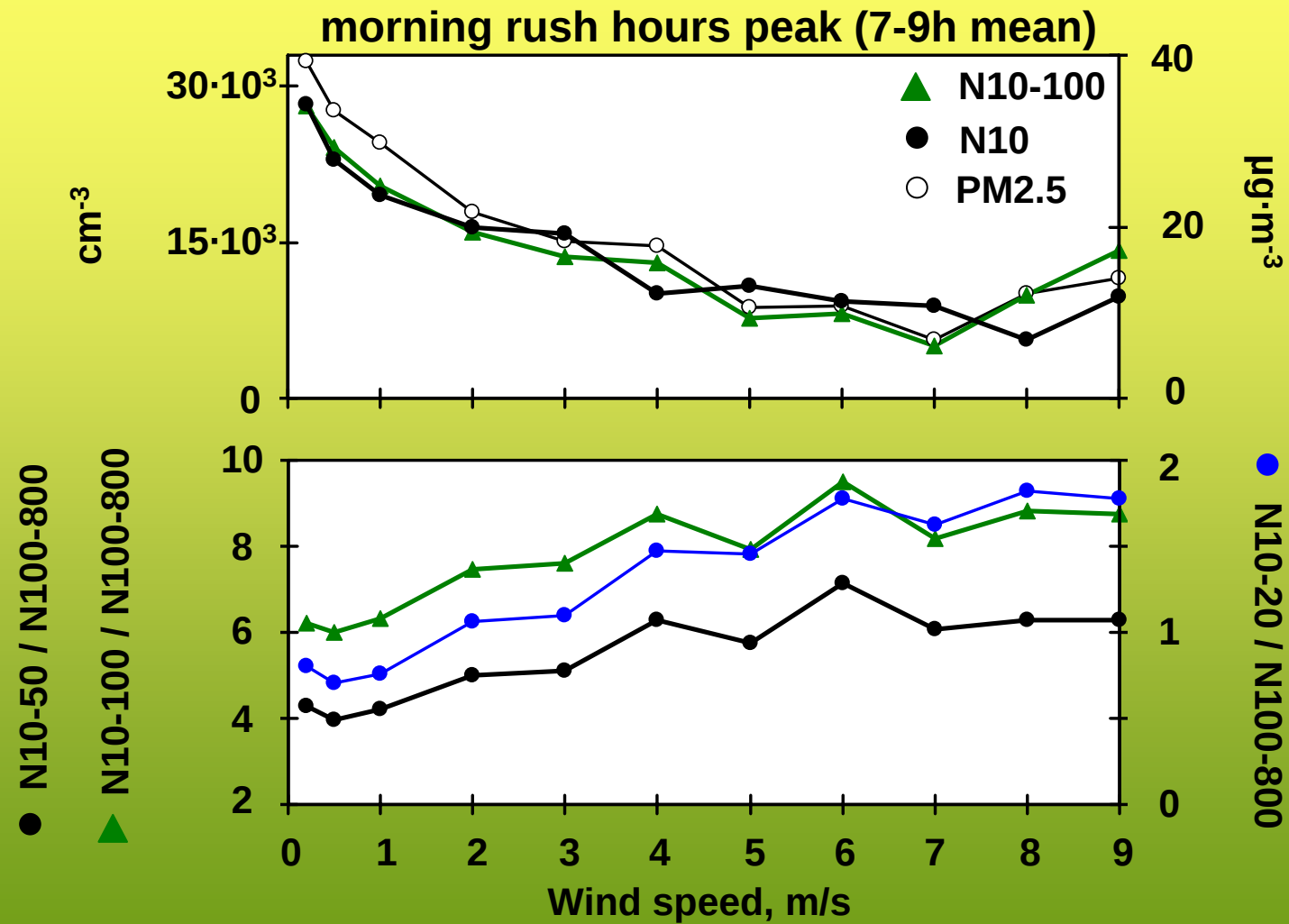
3. Events and seasonal evolution: clean air events



3. Events and seasonal evolution

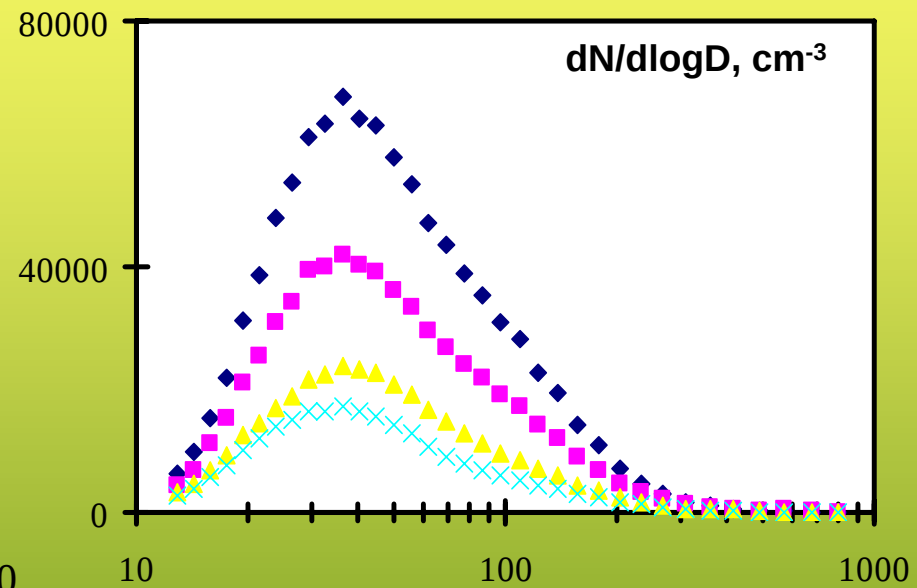
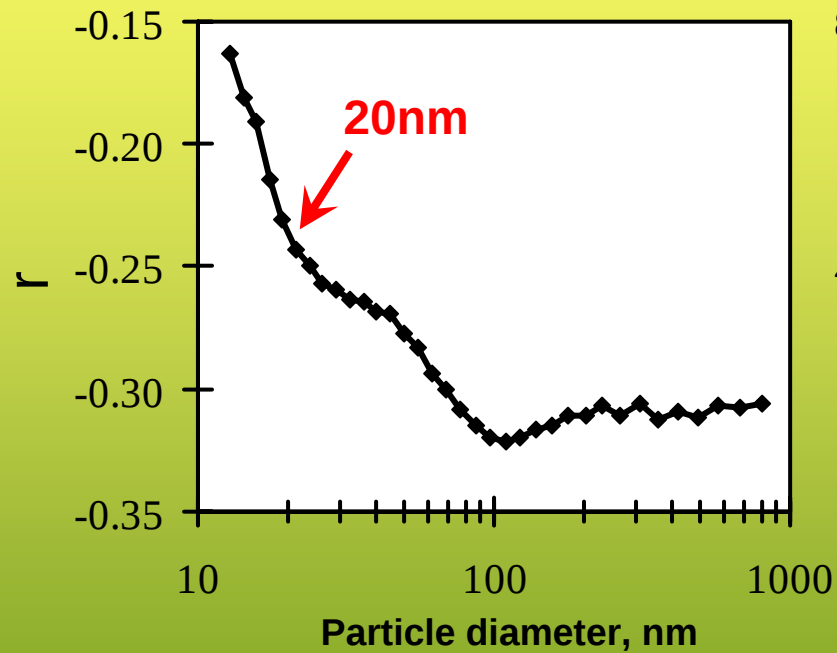


3. Events and seasonal evolution



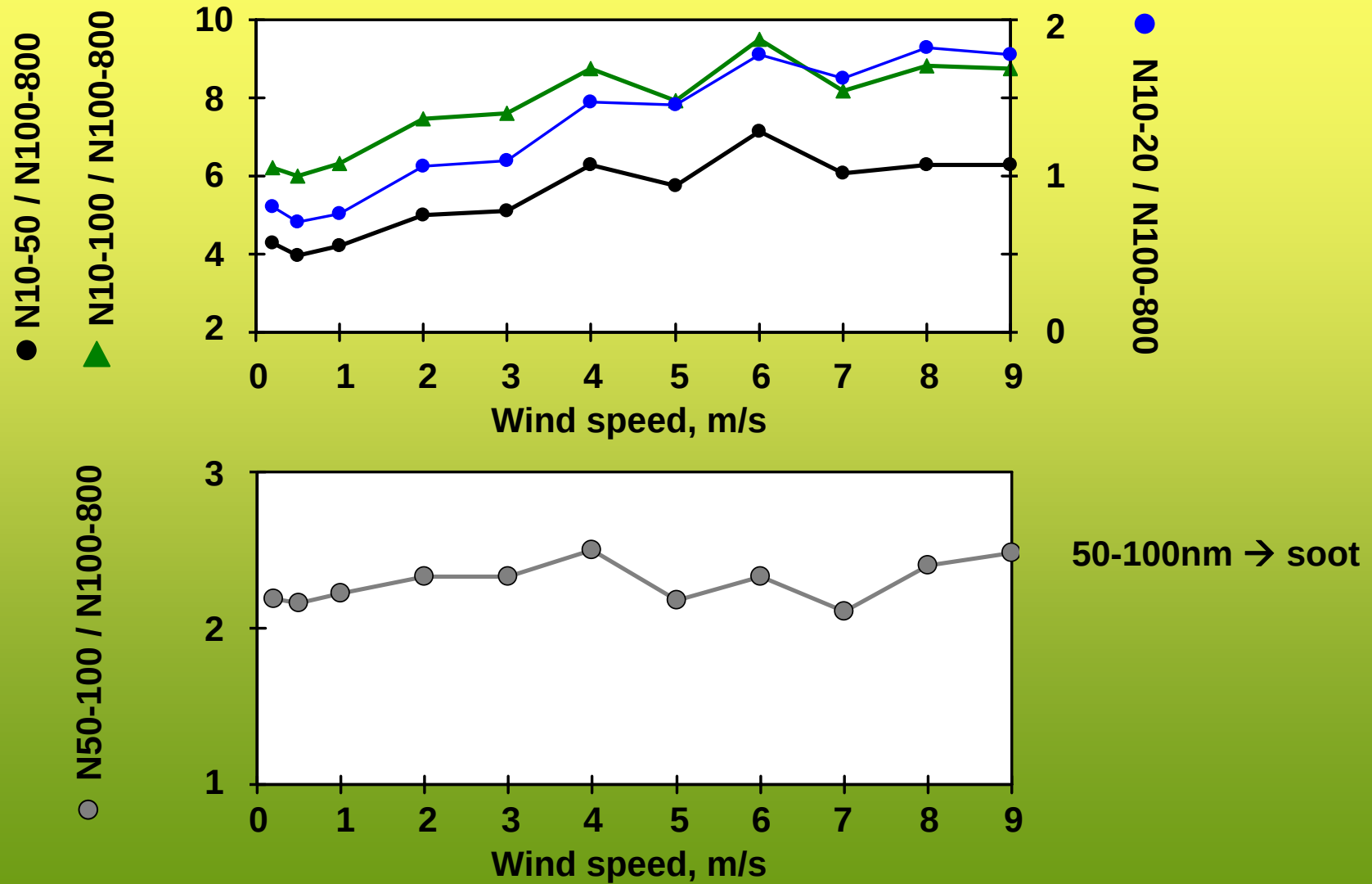
3. Events and seasonal evolution

Correlation coefficient:
wind speed vs. $dN/d\log D$



- ◆ 0.1-0.6 m/s (1-10th)
- 1.0-1.7 m/s (25-50th)
- ▲ 2.0-4.0 m/s (75-90th)
- × 5.0-10 m/s (95-100th)

3. Events and seasonal evolution



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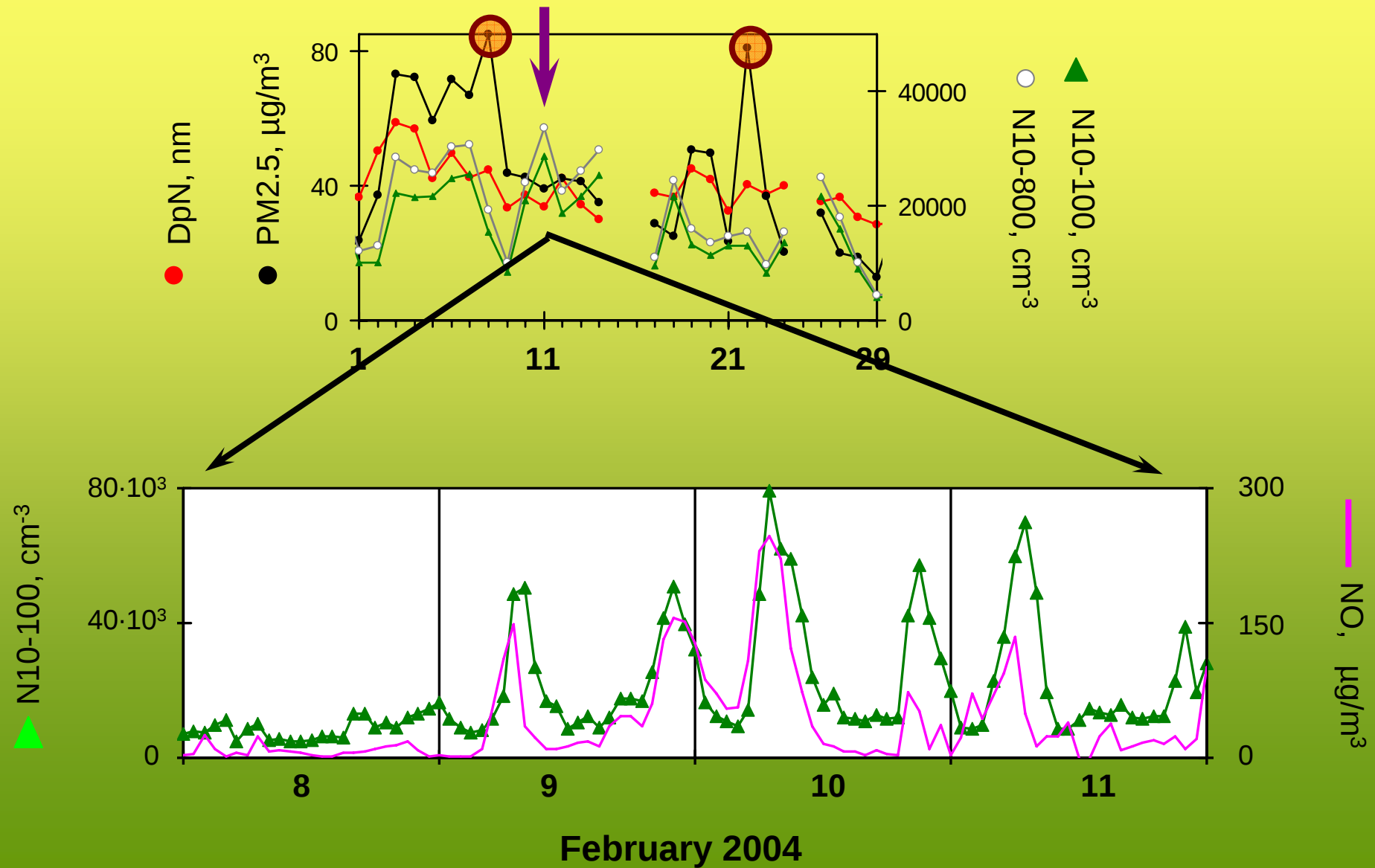
2. Daily cycles

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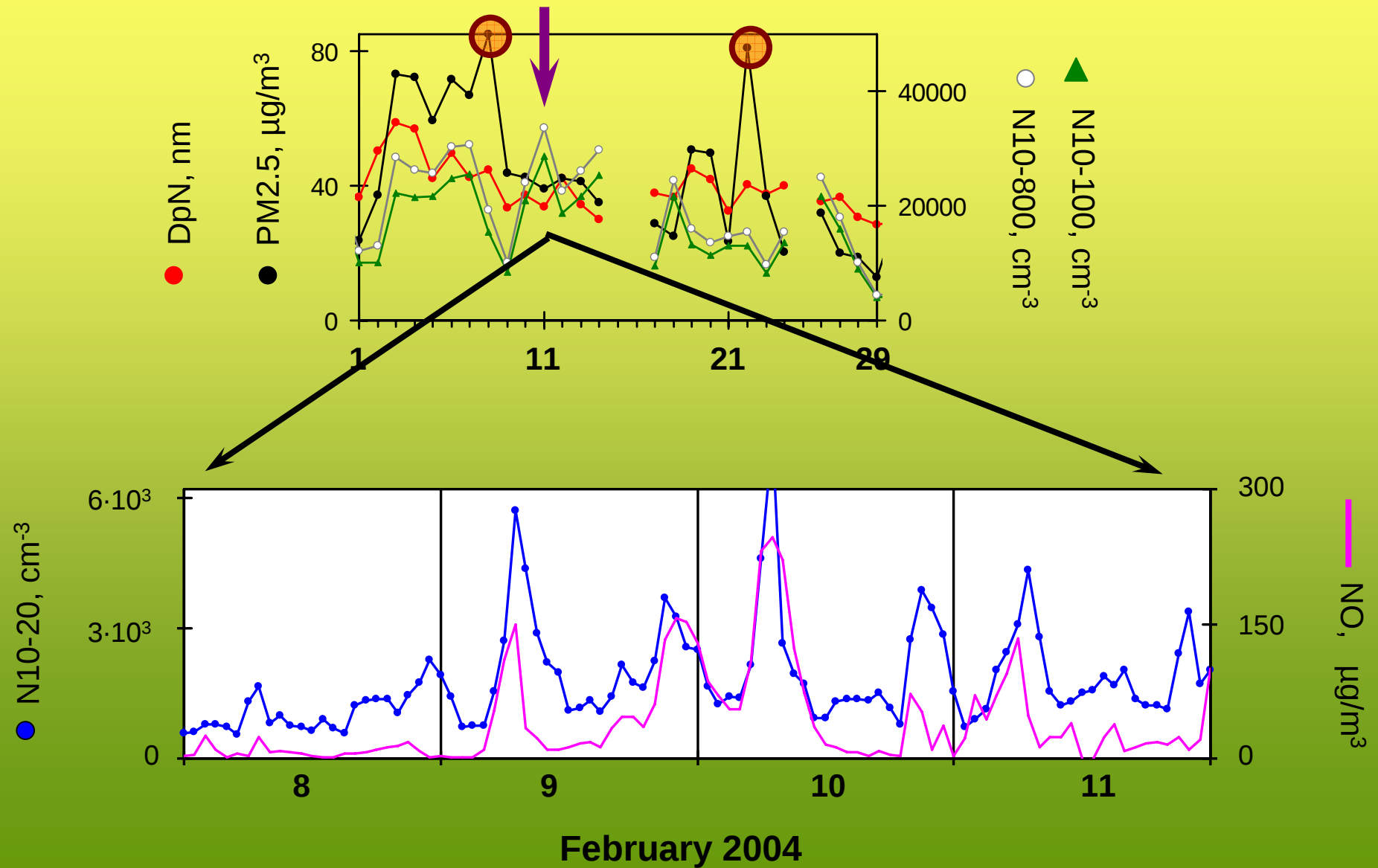
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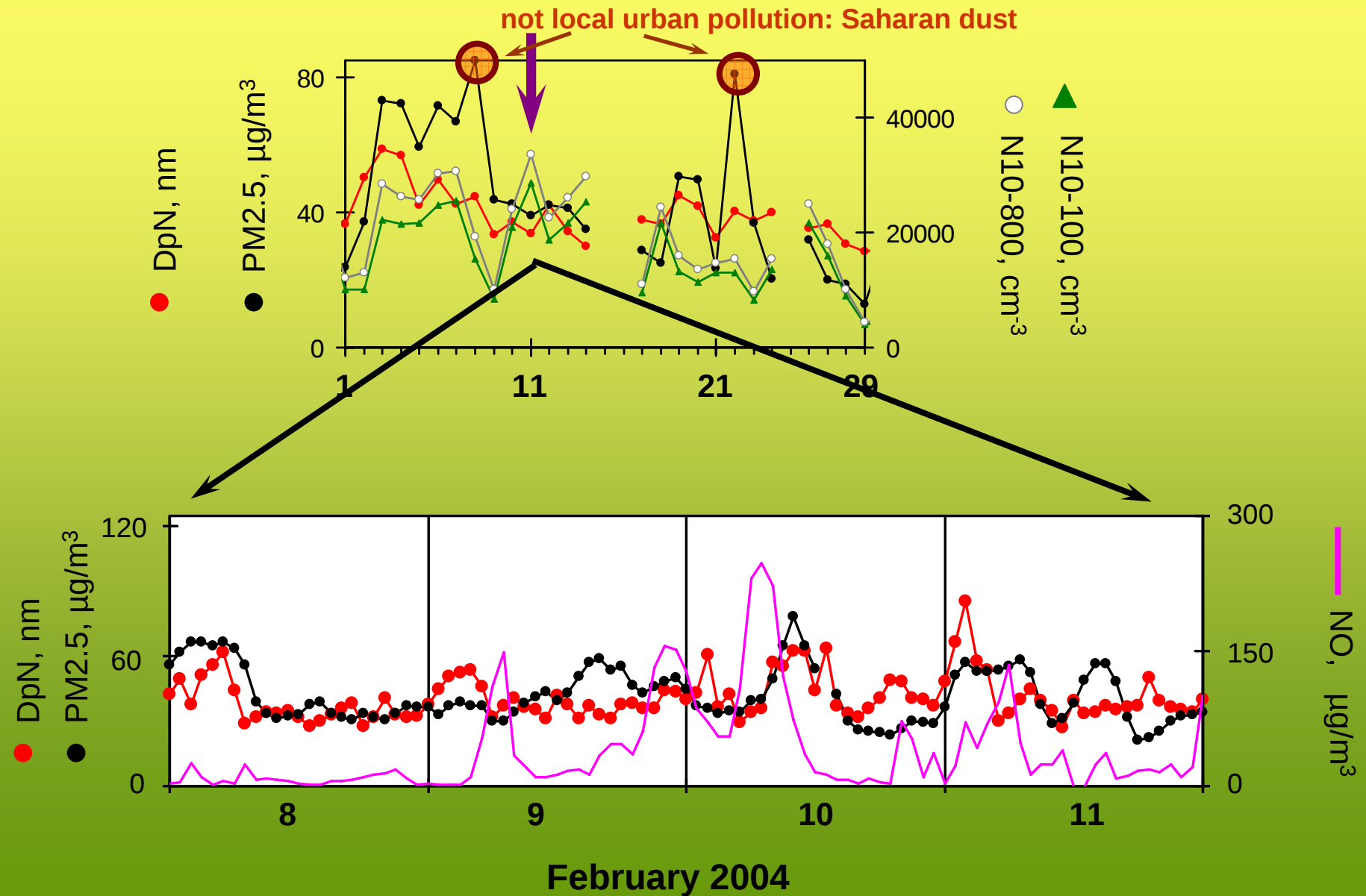
3. Events and seasonal evolution: ultrafine particles events



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3. Events and seasonal evolution: ultrafine particles events

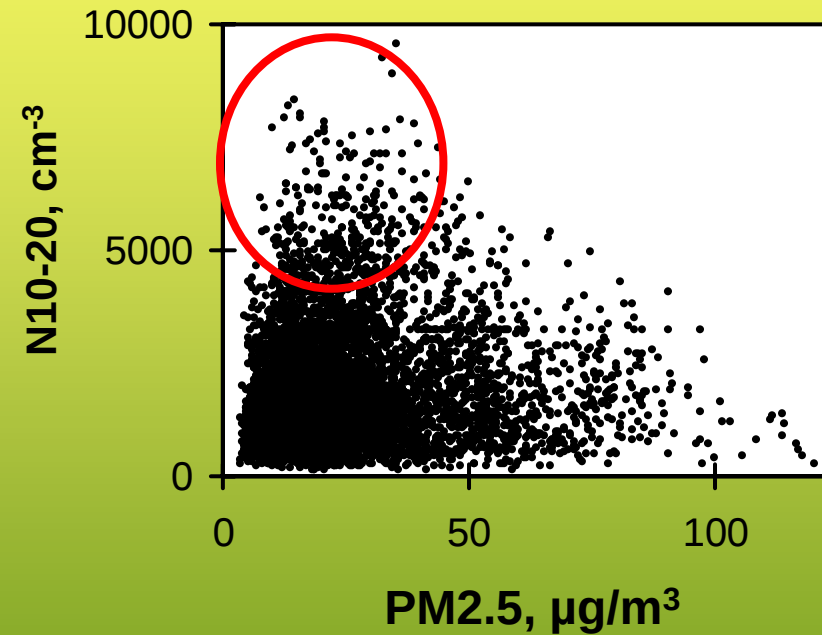


3. Events and seasonal evolution: ultrafine particles events

- primary vehicle exhaust emissions,**
- role of nucleation in “ambient air” ?**

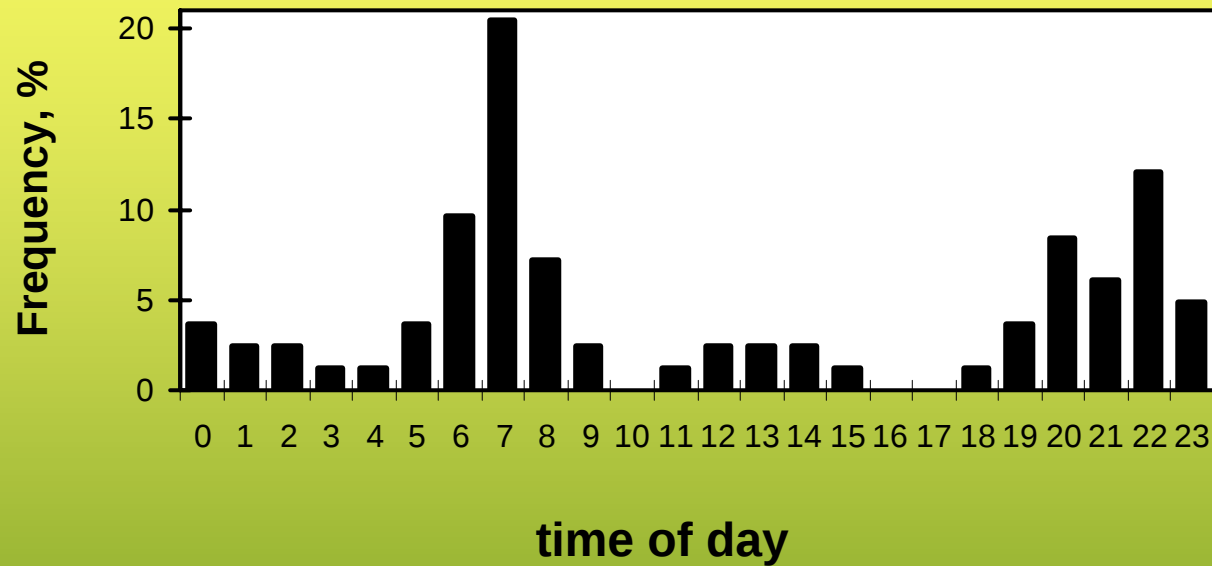
3. Events and seasonal evolution: ultrafine particles events

$N_{10-20} > 6000 \text{ cm}^{-3}$ & $\text{PM}_{2.5} < 40 \mu\text{g/m}^3$
~80 hourly events/year



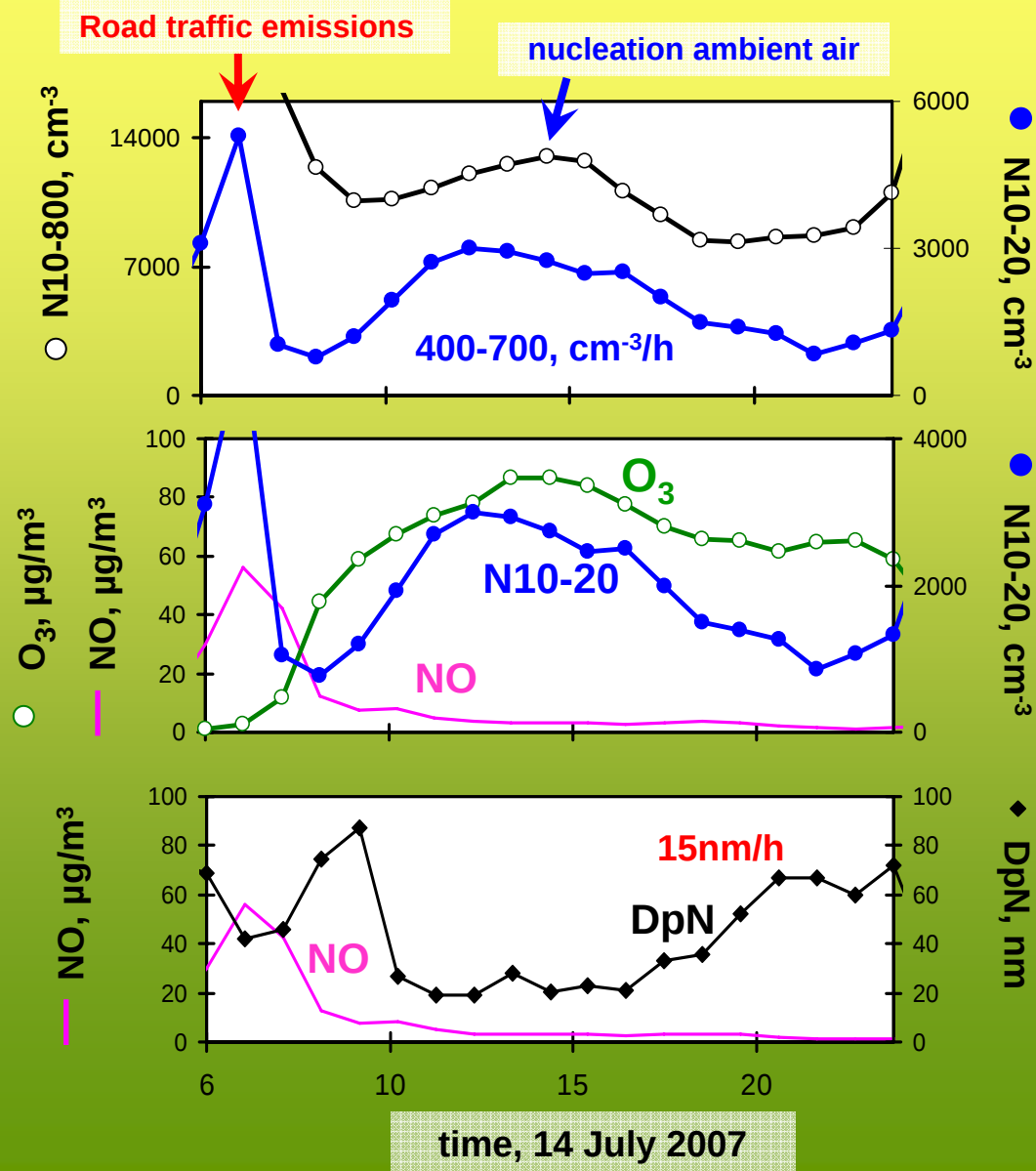
3. Events and seasonal evolution: ultrafine particles events

Hourly $N_{10-20} > 6000 \text{ cm}^{-3}$ & $\text{PM}_{2.5} < 40 \mu\text{g/m}^3$
~80 events/year

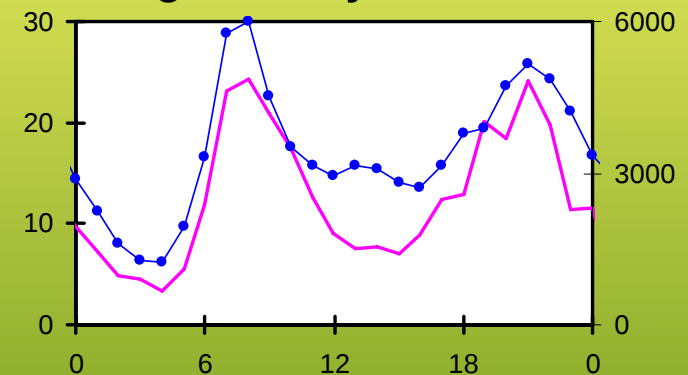


3. Events and seasonal evolution: ultrafine particles events

Ambient air nucleation event



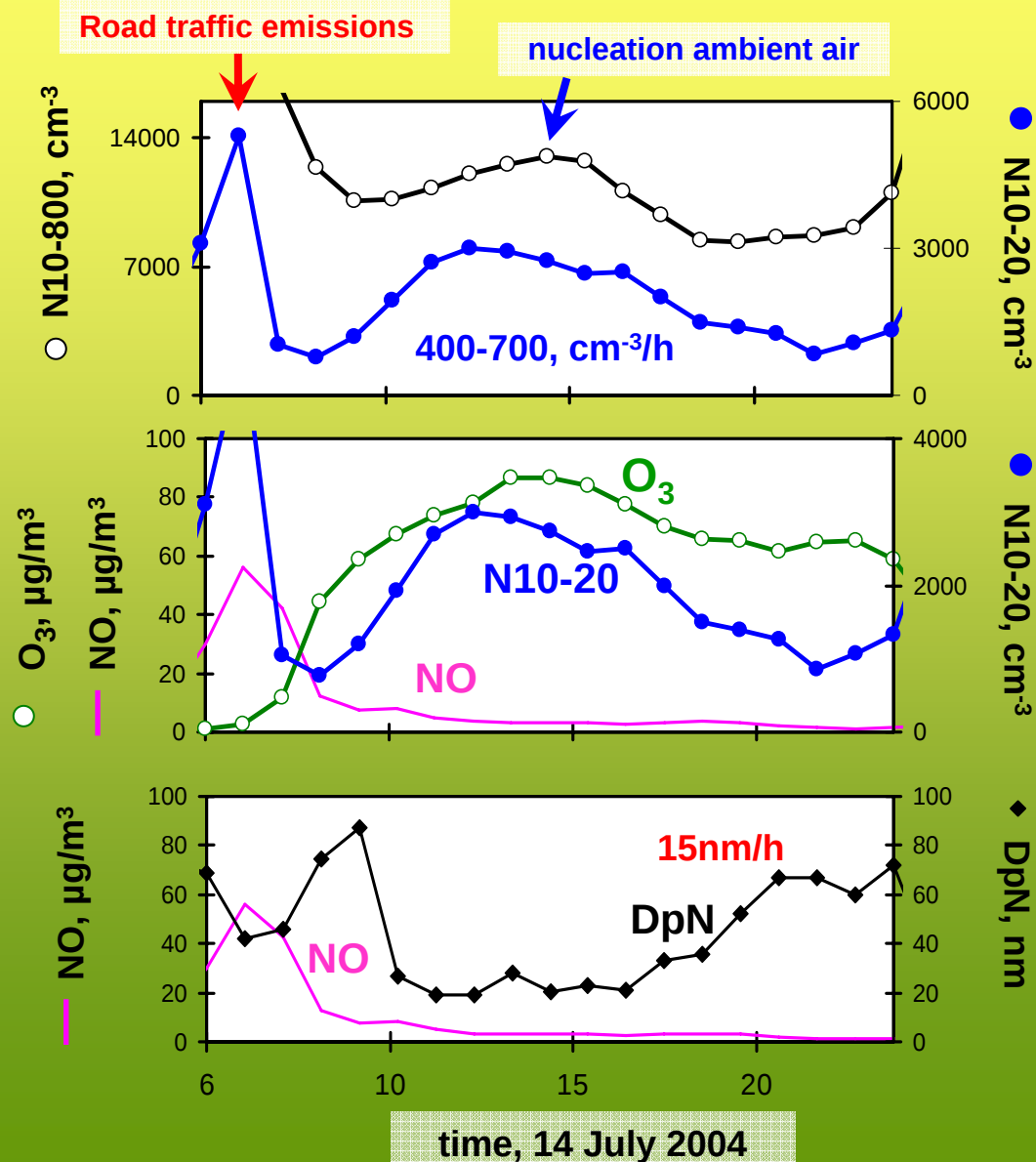
regular daily evolution



ultrafine particle in Barcelona

3. Events and seasonal evolution: ultrafine particles events

New particle formation in ambient air (nucleation events)



2-4 “ambient air nucleation”
events / year,

Nucleation ambient air

N10-20

$2 \cdot 10^3 - 6 \cdot 10^3 \text{ cm}^{-3}$

N10-100

$10 \cdot 10^3 - 15 \cdot 10^3 \text{ cm}^{-3}$

Nucleation exhaust
Primary emission

N10-20

$2 \cdot 10^3 - 8 \cdot 10^3 \text{ cm}^{-3}$

N10-100

$10 \cdot 10^3 - 80 \cdot 10^3 \text{ cm}^{-3}$

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Summary

Main features of ultrafine particles in Barcelona:

- road traffic: the most important source of ultrafine particles,
10-800nm: 86 % of the particles are ultrafine,
dN/dlogD: mode 36nm
- temperature influences on the ultrafine particles formation.
Maximum in “ultrafine particle concentrations” in winter during the morning rush hours.
- “classical winter PM2.5 pollution events” → ultrafine particle pollution,
 - PM2.5 formation → enhanced at night “condensation of semi-volatile material”,
 - Ultrafine particles formation → fresh emissions morning,
- additional “ultrafine particles pollution events” not associated with the “classical winter PM2.5 episodes”
- very low frequency of nucleation events in ambient air (2-4 events/year),

ultrafine particle in Barcelona