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IPSL SIRTA

Urban atmosphere dynamics for air quality applications

Atmospheric boundary layer height and wind profiles from ground-based remote sensing networks

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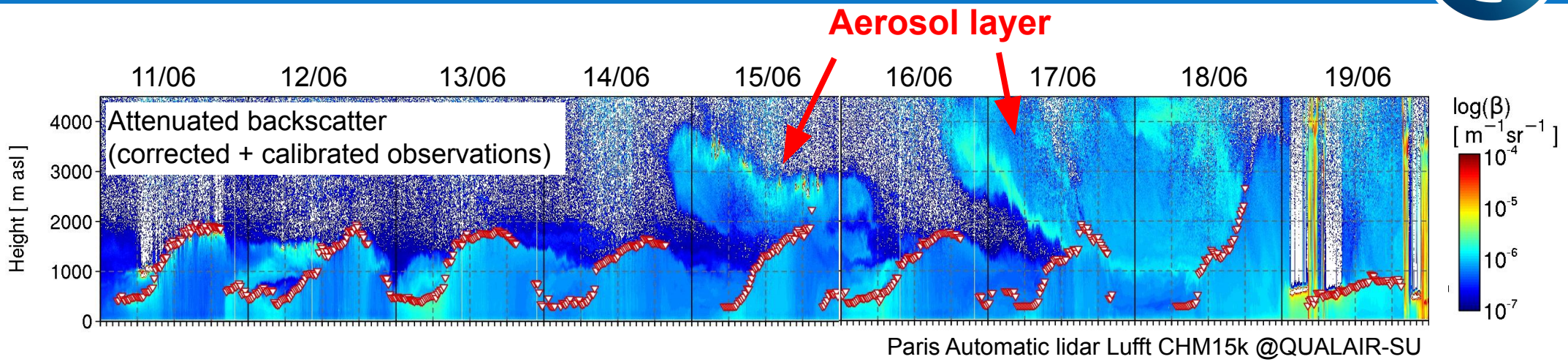
Atmospheric boundary layer profiling

- **Ground-based remote sensing:**
  - Automatic (depolarization) Aerosol Lidars
  - Doppler Wind Lidars
  - High vertical and temporal resolution
  - Continuous operation with low maintenance
  - Profile from near ground to top of the atmospheric boundary layer (ABL)

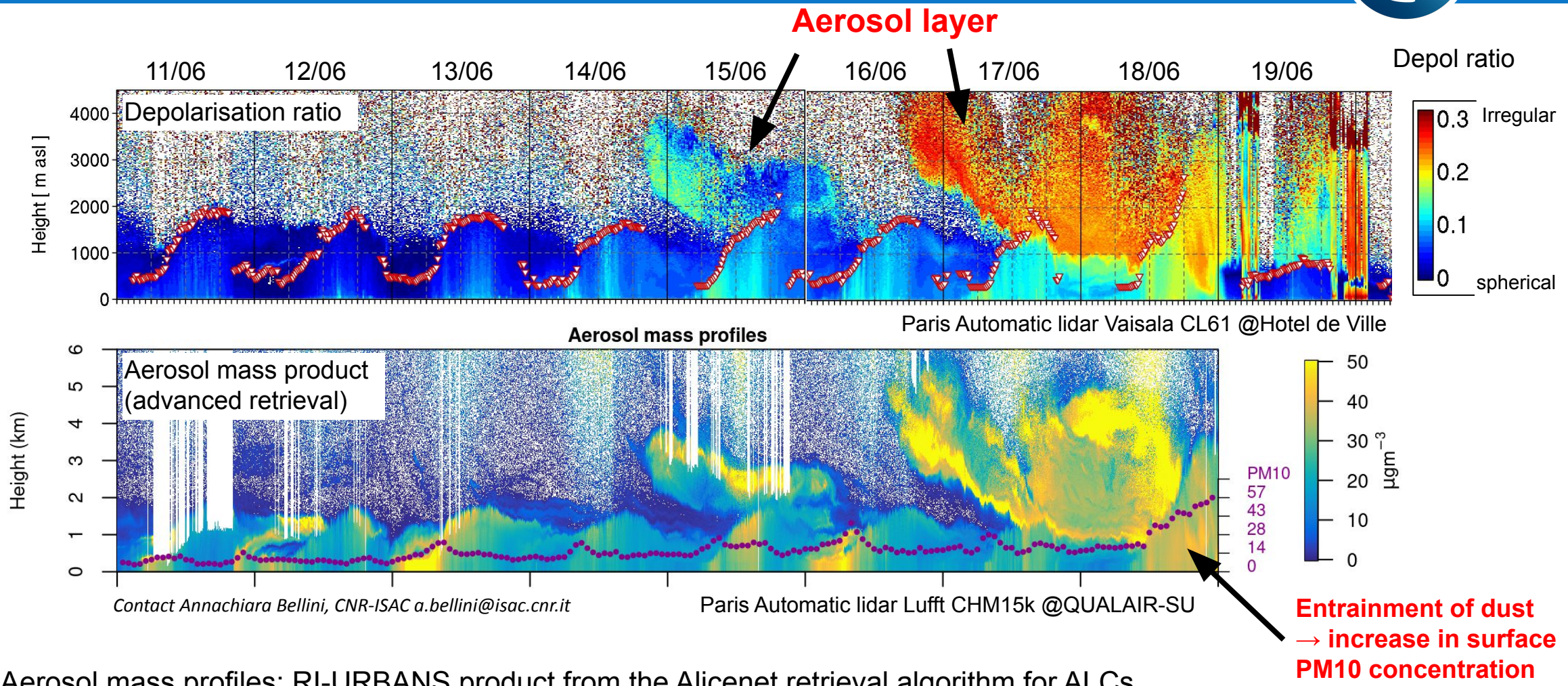
- **Advanced products from diverse sensor networks:**
  - Calibration and correction (e.g. Kotthaus et al. 2016; Hervo et al 2016)
  - Aerosol mass and extinction (e.g. Dionisi et al. 2018; Bellini et al. 2023, in prep)
  - Boundary layer height (e.g. Kotthaus et al. 2020; Kotthaus et al. 2023)
  - Wind and turbulence profiling
  - Detection of low-level jet (e.g. Cespedes et al., in prep)

European network

Entrainment of elevated layers



Entrainment of elevated aerosol

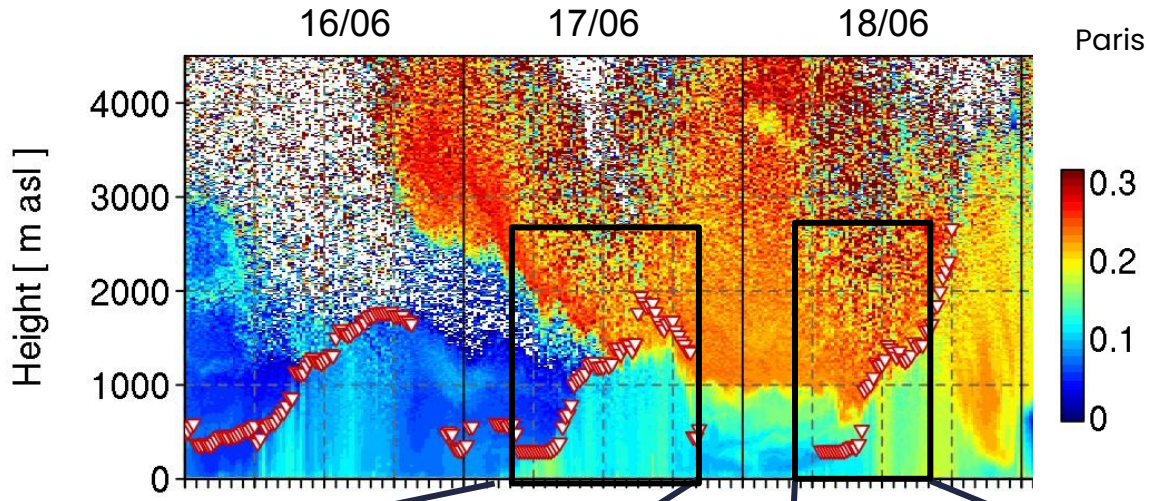


- Aerosol mass profiles: RI-URBANS product from the Alicenet retrieval algorithm for ALCs
- Observations in central Paris (Qualair CHM15k) - IPSL-SIRTA
- Surface PM10 concentrations (Vitry-Sur-Seine, Airparif)

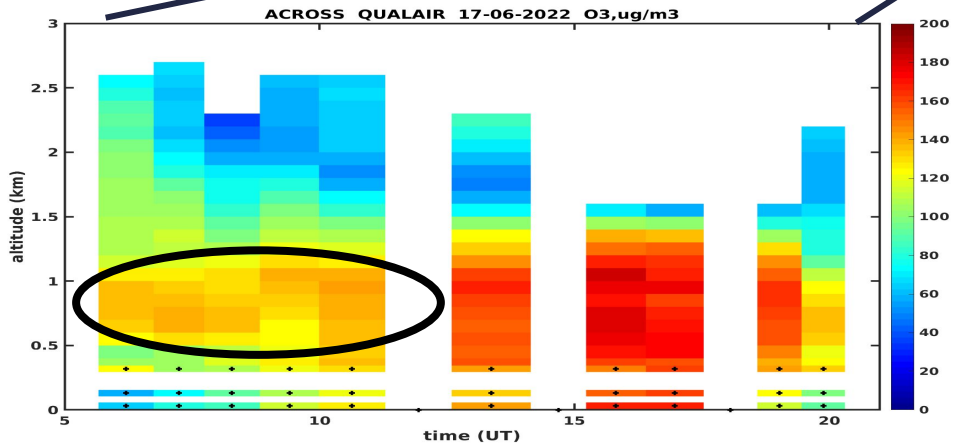
Ozone profile observations

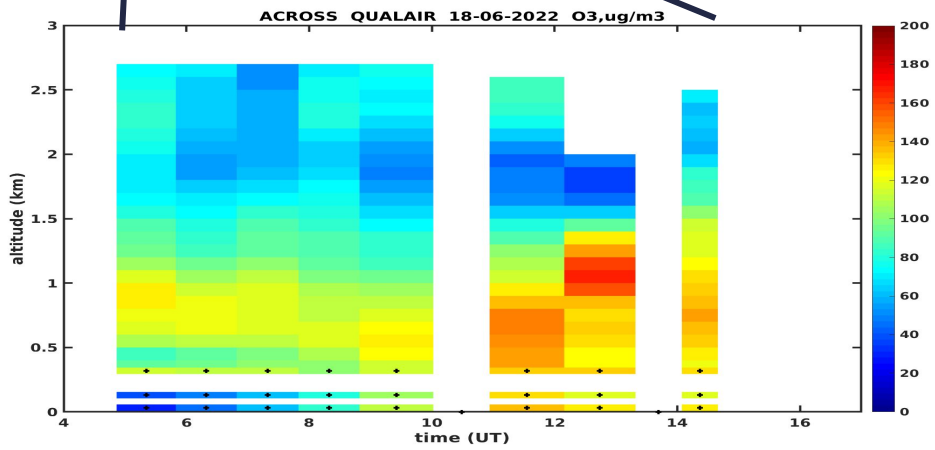
Paris Automatic lidar Vaisala CL61 @Hotel de Ville

17th June
High ozone (>140 ug/m3) in residual layer
→ daytime ozone peak exceeds 180 ug/m3



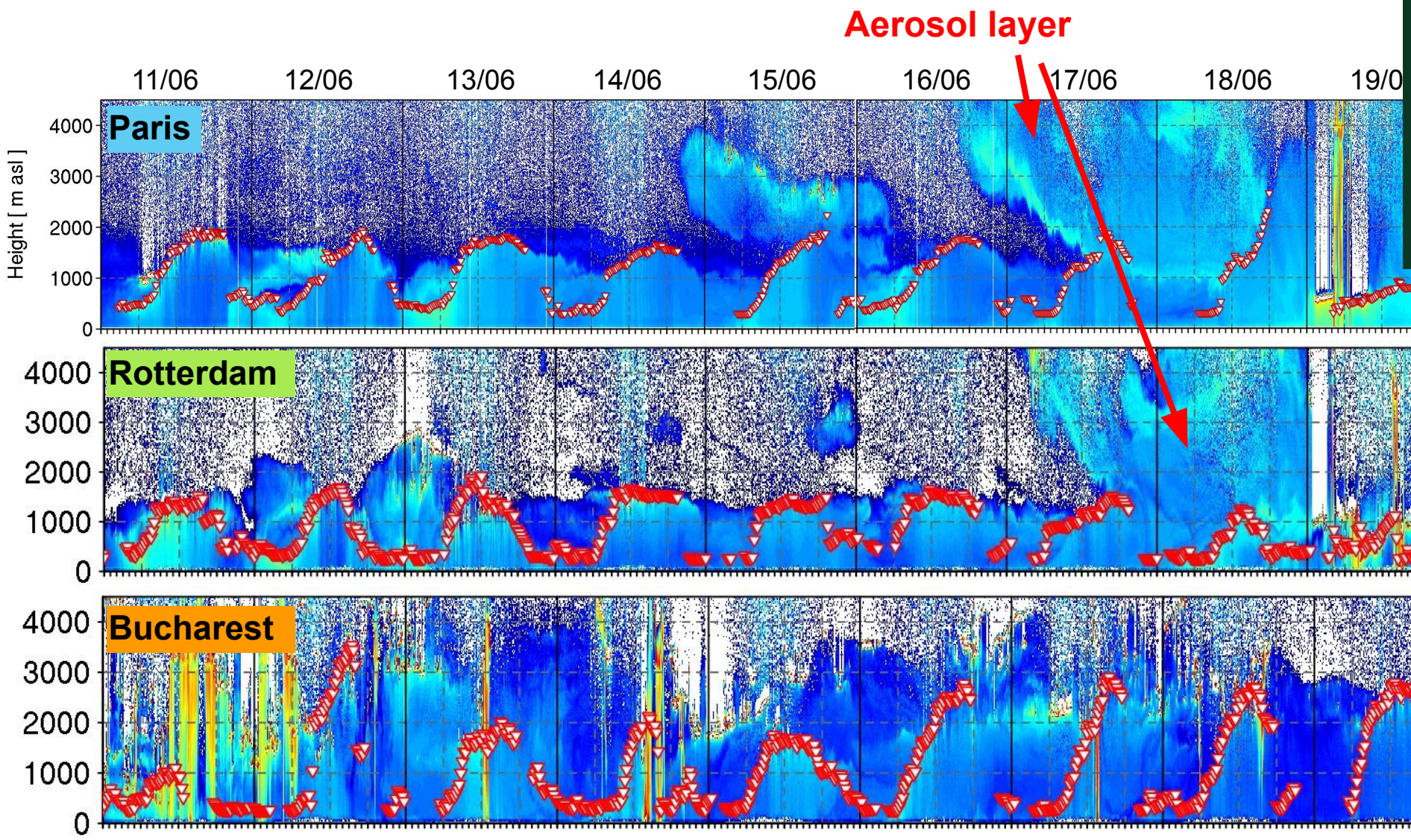
18th June
Lower ozone in transported layer + dust
→ reduced photolysis and lower ozone concentrations





Paris Ozone lidar @QUALAIR-SU by Gérard Ancellet, LATMOS-IPSL

ABL variations at European scale



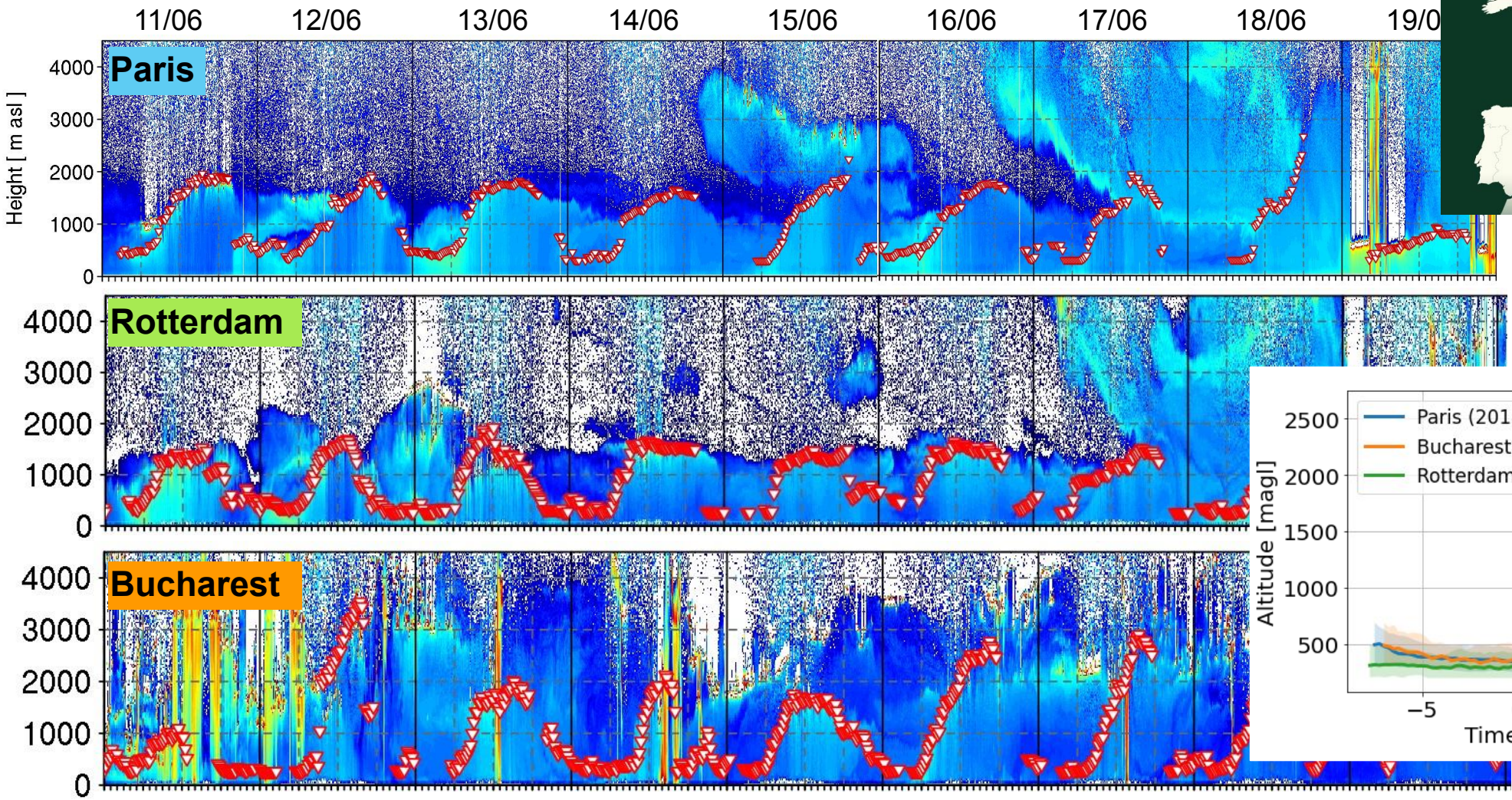
Paris Automatic lidar Lufft CHM15k @QUALAIR-SU

Koninklijk Nederlands Meteorologisch Instituut
Ministerie van Infrastructuur en Waterstaat

Rotterdam Automatic lidar Lufft CHM15k @Cabauw

Bucharest Automatic lidar Lufft CHM15k @Magurele

ABL variations at European scale



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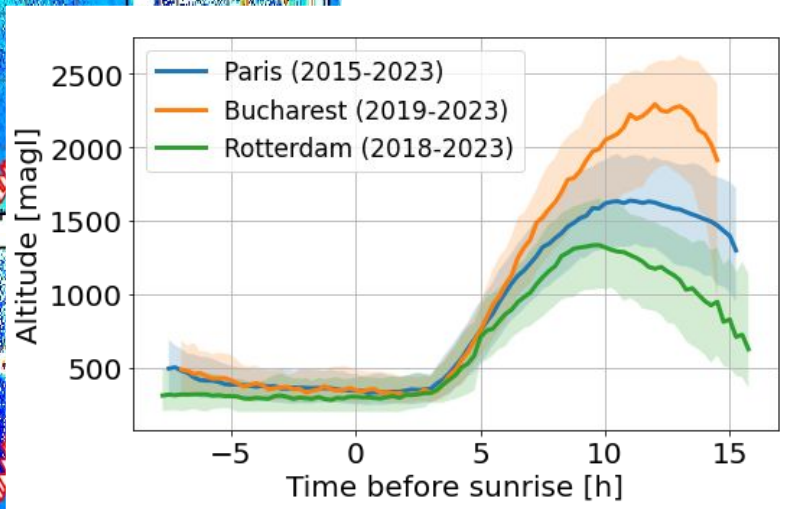
ABL testbed

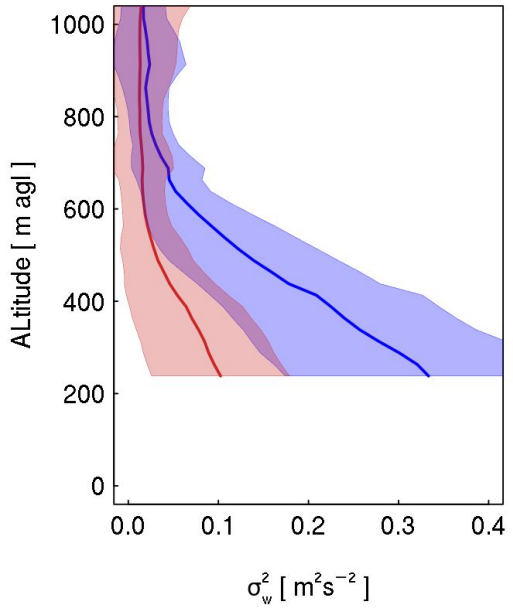


Wind and turbulence profiling

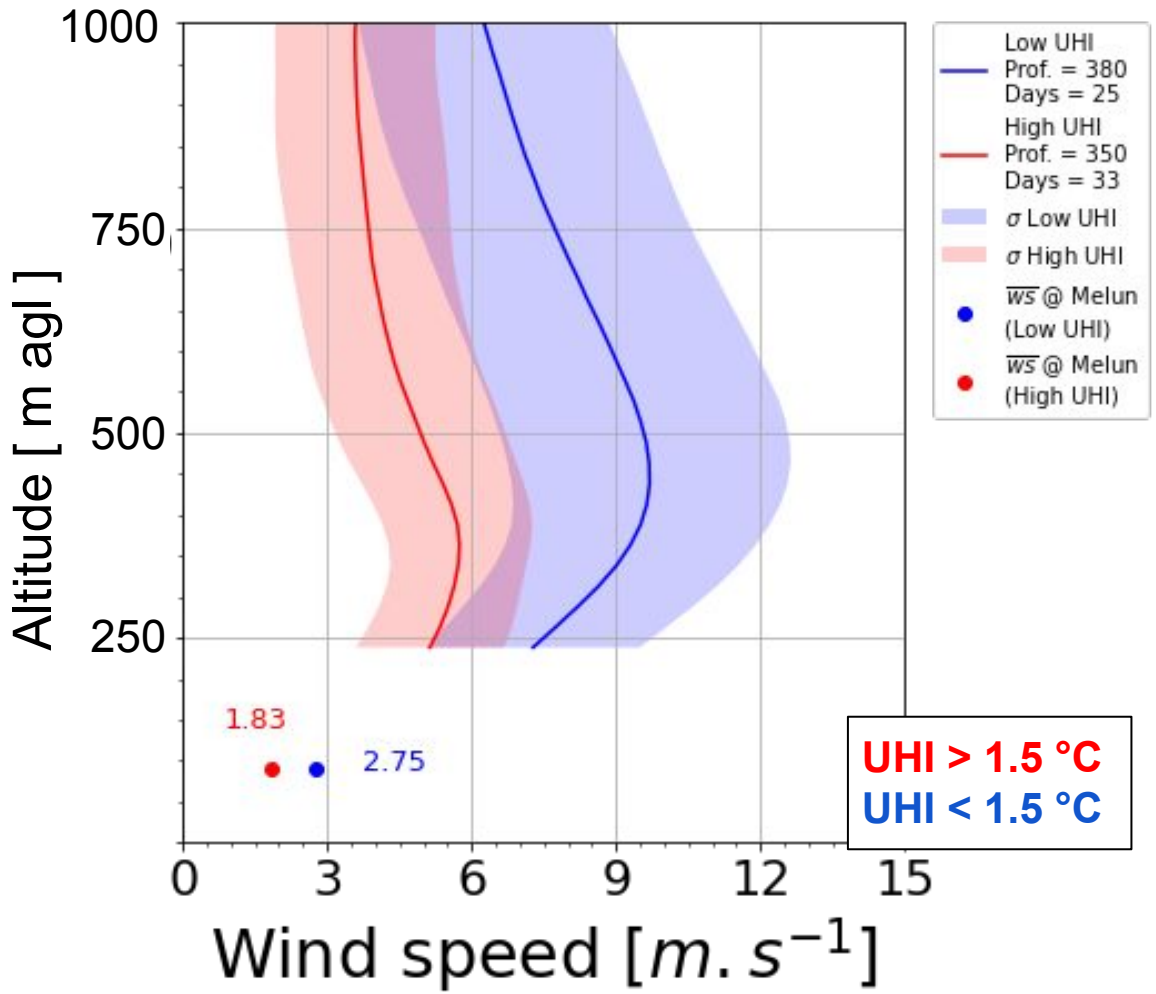
- Nocturnal low-level jet (LLJ) frequent in Paris region: 70% of summer nights
- Mostly anticyclonic flow: cloud-free nights with winds from northeast

Increased thermal stratification:

- LLJ core at lower altitude
- Suppressed vertical mixing
- Lower surface wind speed
- Strong urban heat island (UHI)



Vertical velocity variance



Vaisala Doppler wind lidar @QUALAIR-SU; Paris Region PhD @LMD: Jonnathan Cespedes

Conclusions

Novel ground-based remote sensing observations from automatic aerosol lidars and Doppler wind lidars provide valuable insights on dynamics of the urban atmosphere:

- Novel profile data reveal impact of **stratification** and **entrainment** from elevated layers
  - Dust, heat and composition influence near-surface concentrations

- Significant **temporal and spatial variations in boundary layer heights**
  - Average summer ABL height over Bucharest ~ 1.5 x height over Rotterdam
  - Peak heights can vary by factor of 3 from one day to the next

- At night, **low-level jet** can be a frequent phenomenon (70% of summer nights in Paris)
  - Impact on spatial heterogeneity (e.g. urban heat island) via mixing and advection

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