

# High O<sub>3</sub> & UFP episodes around Madrid-July 2016



idæa<sup>a</sup>



MAPAMA, 25 de Mayo 2017

**EGAR** ENVIRONMENTAL  
GEOCHEMISTRY  
AND ATMOSPHERIC  
RESEARCH

# Institutions involved and authors



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# Contents and objectives

- Analysis of 2000-2016 O<sub>3</sub> data in Spain
- Focus on northern Barcelona & around Madrid, with 2 field campaigns on July 2015 & 2016
- **Identifying the origin of high O<sub>3</sub> & UFP episodes around Madrid July 2016**

The results presented here are from one submitted paper and another one in preparation:

## **ON THE ORIGIN OF THE HIGHEST OZONE EPISODES IN SPAIN, STOTEN 2016**

Querol X.<sup>1</sup>, Alastuey A.<sup>1</sup>, Orto A.<sup>2</sup>, Pallares M.<sup>2</sup>, Reina F.<sup>2</sup>, Dieguez J.J.<sup>3</sup>, Mantilla E.<sup>3</sup>, Escudero M.<sup>4</sup>, Alonso L.<sup>5</sup>, Gangoiti G.<sup>5</sup>, Millán M.<sup>3</sup>

<sup>1</sup>IDAEA-CSIC, <sup>2</sup>MAGRAMA, <sup>3</sup>CEAM, <sup>4</sup>UNIZAR, <sup>5</sup>UPV/EHU

## **ORIGIN OF HIGH OZONE EPISODES IN NE SPAIN, ACP 2017**

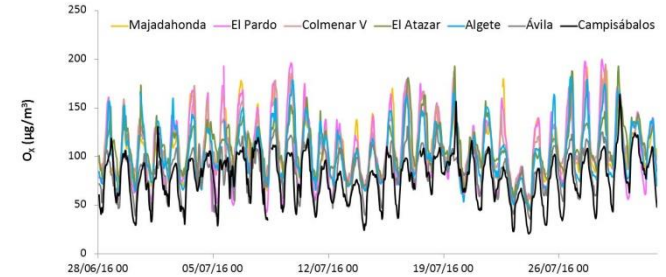
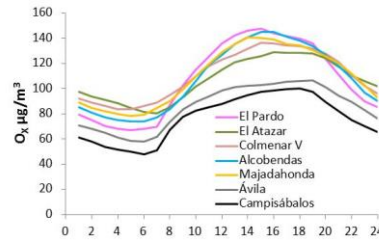
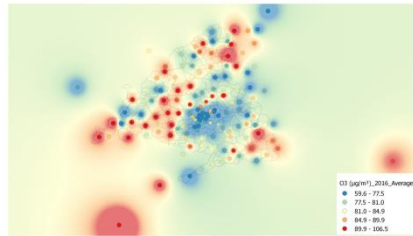
Querol X.<sup>1</sup>, Alastuey A.<sup>1</sup>, Minguillón M.C.<sup>1</sup>, Amato F.<sup>1</sup>, Reche C.<sup>1</sup>, Viana M.<sup>1</sup>, Karanasiou A.<sup>1</sup>, Rivas I.<sup>1</sup>, Pérez N.<sup>1</sup>, Ripoll A.<sup>1</sup>, Brines M.<sup>1</sup>, Ahn K.-H.<sup>2</sup>, Lee H.-K.<sup>2</sup>, Eun H.-R.<sup>2</sup>, Park Y.-H.<sup>2</sup>, Escudero M.<sup>2</sup>, Beddows N.<sup>4</sup>, Harrison R.M.<sup>4</sup>, Bertrand A.<sup>5</sup>, Temime-Roussel B.<sup>5</sup>, Marchand N.<sup>5</sup>, Soler R.M.<sup>6</sup>, Millán M.<sup>7</sup>

<sup>1</sup>IDAEA-CSIC, <sup>2</sup>Hanyang University South Korea, <sup>3</sup>UNIZAR, <sup>4</sup>University of Birmingham, UK, <sup>5</sup>CNRS-Marseille, France, <sup>6</sup>UB, <sup>7</sup>CEAM

## **RESULTS OF THE JULY 2016 CAMPAIGN AROUND MADRID**

# Methodology

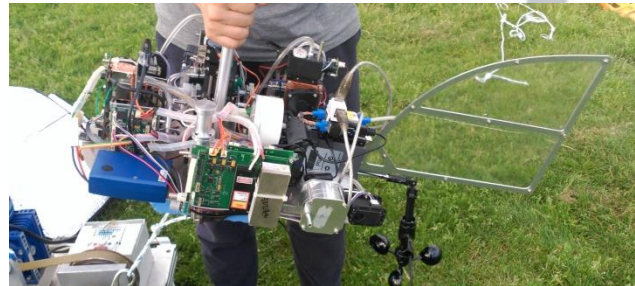
- Interpreting the spatial variability of  $O_3$  &  $NO_2$  in and around Madrid in July 2016 (29/06/2016-27/07/2016) and compare it with prior years



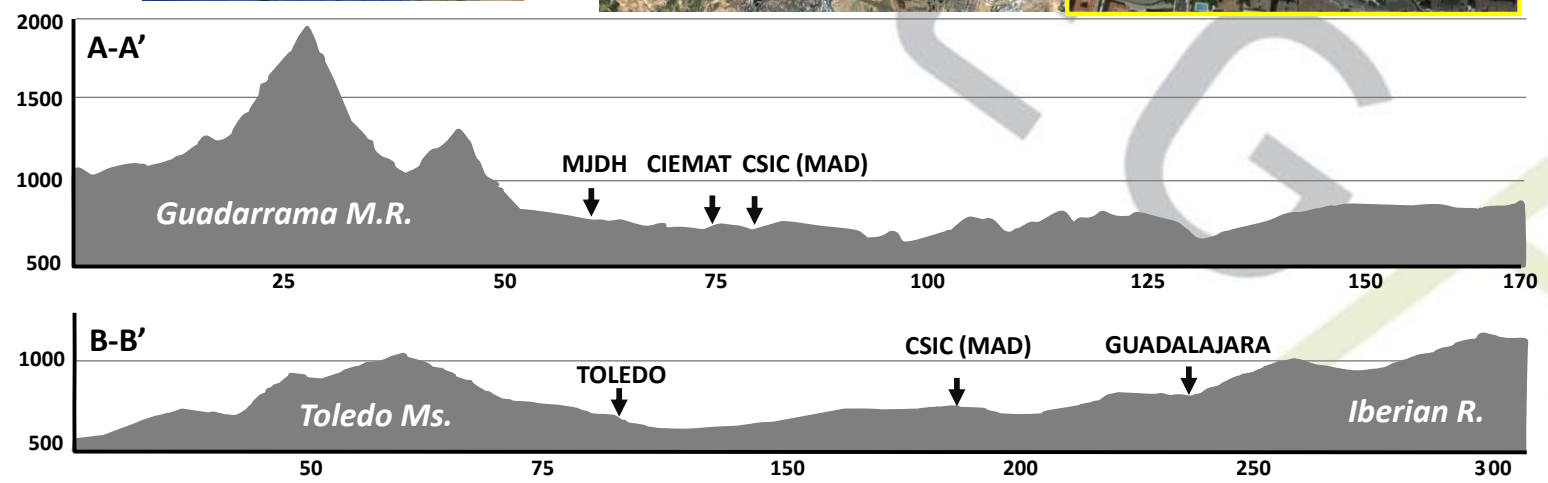
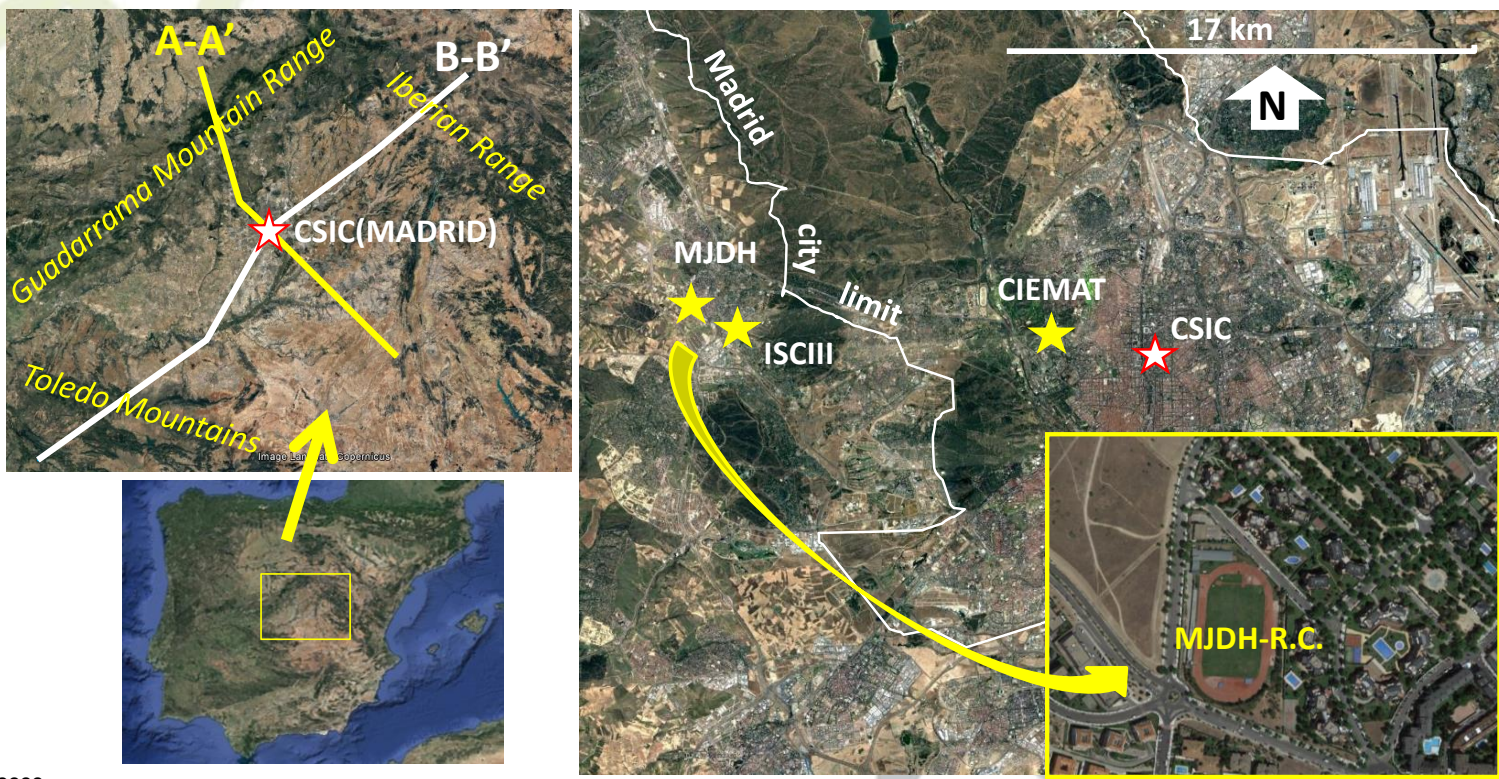
- Interpreting high resolution time variability of  $O_3$ , UFP,  $NO_x$  & VOCs at 3 supersites (04-20/07/2016): SMPS, CPC, PSM, BC, PM1/PM2.5, HR-TOF-PTRMS



- Interpreting vertical variability of  $O_3$  & UFP concentrations (11/07/2016)

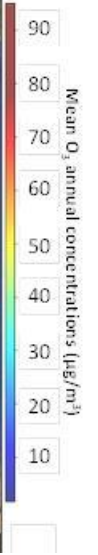
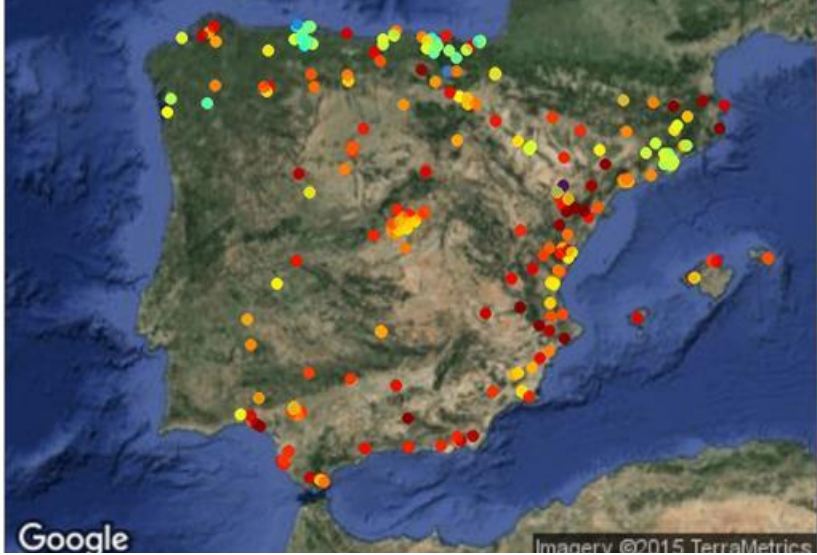


# Methodology



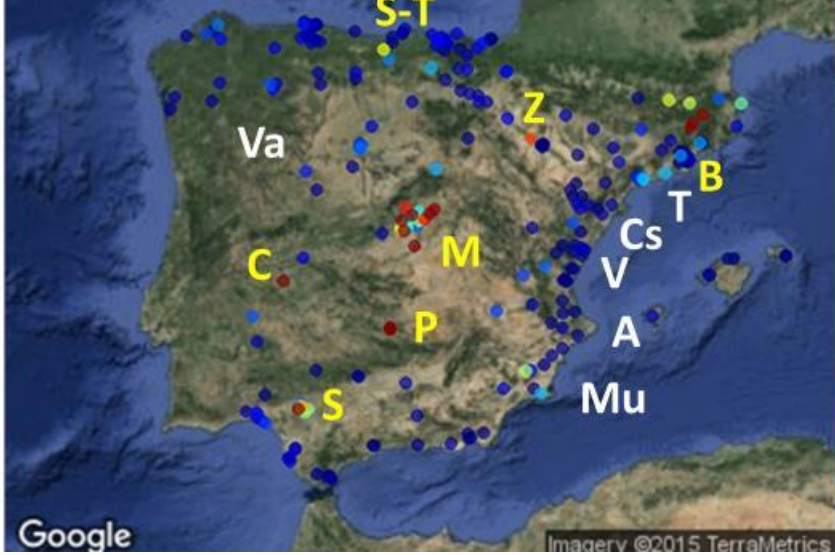
# 2000-2015 O<sub>3</sub> episodes in Spain

### Annual mean



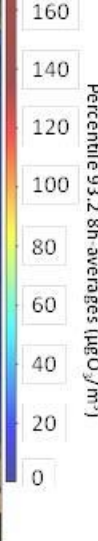
Google Imagery ©2015 TerraMetrics

### Exceedances of the information value



Google Imagery ©2015 TerraMetrics

### Percentile 93.2 max-8-h



Google Imagery ©2015 TerraMetrics

### AOT40 values

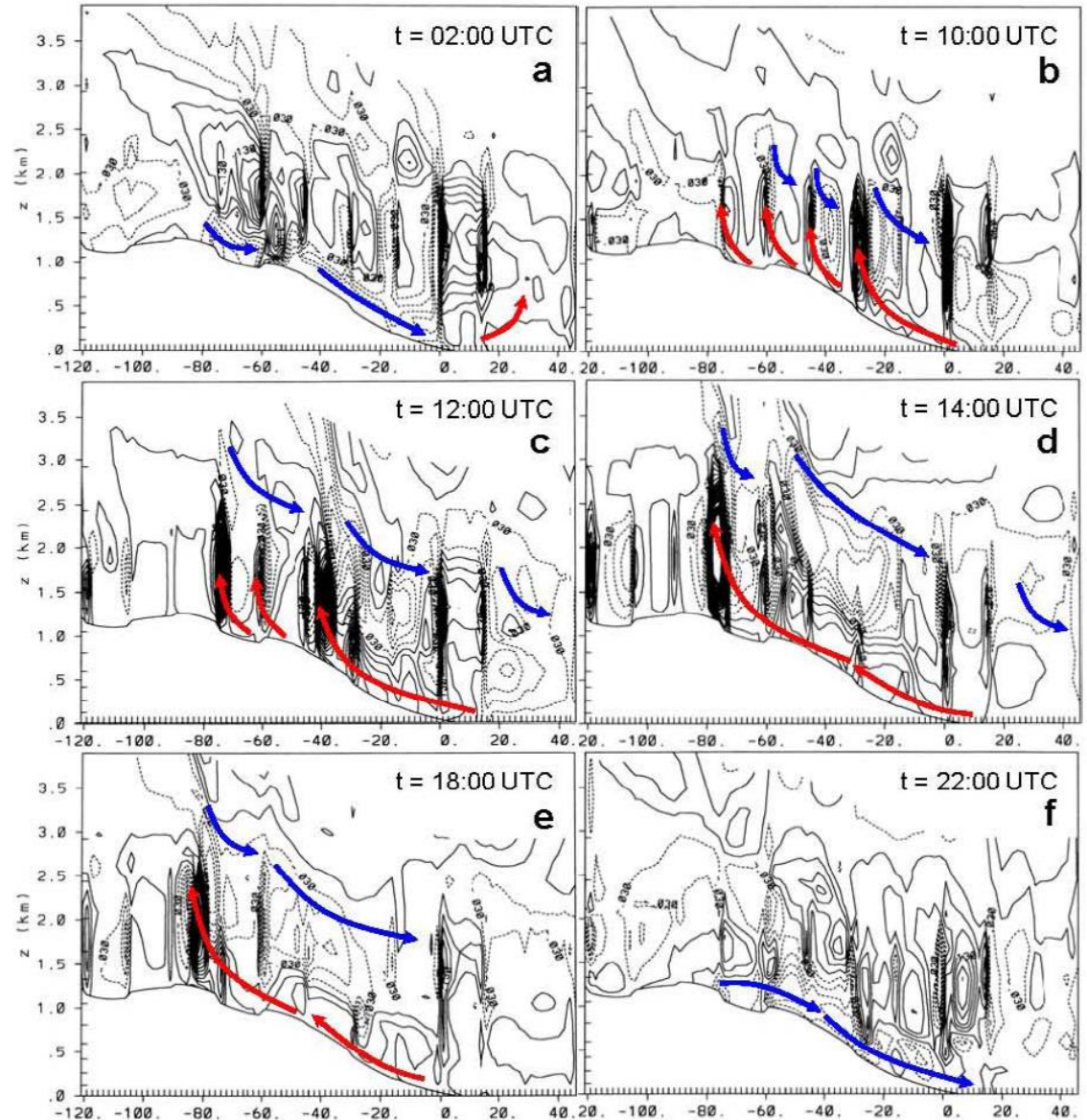
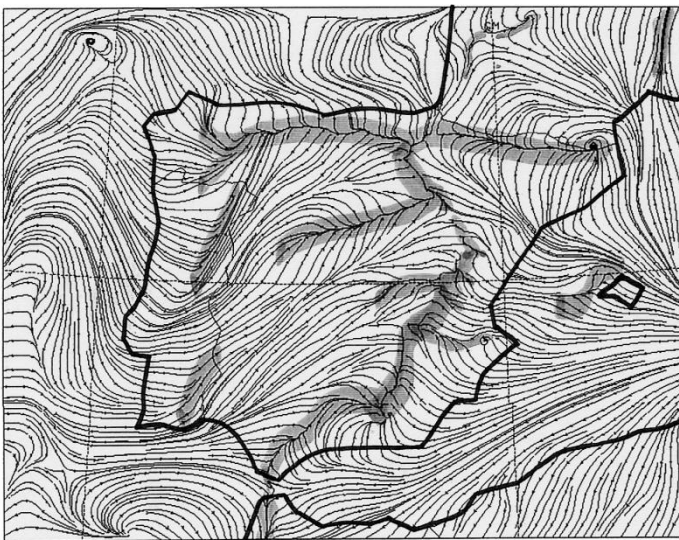
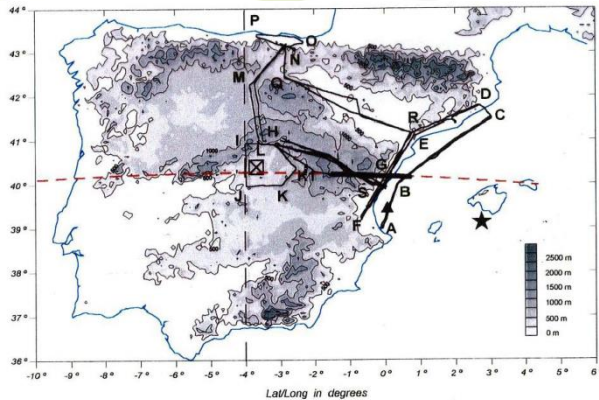


Google Imagery ©2015 TerraMetrics

# O<sub>3</sub> episodes in the Mediterranean

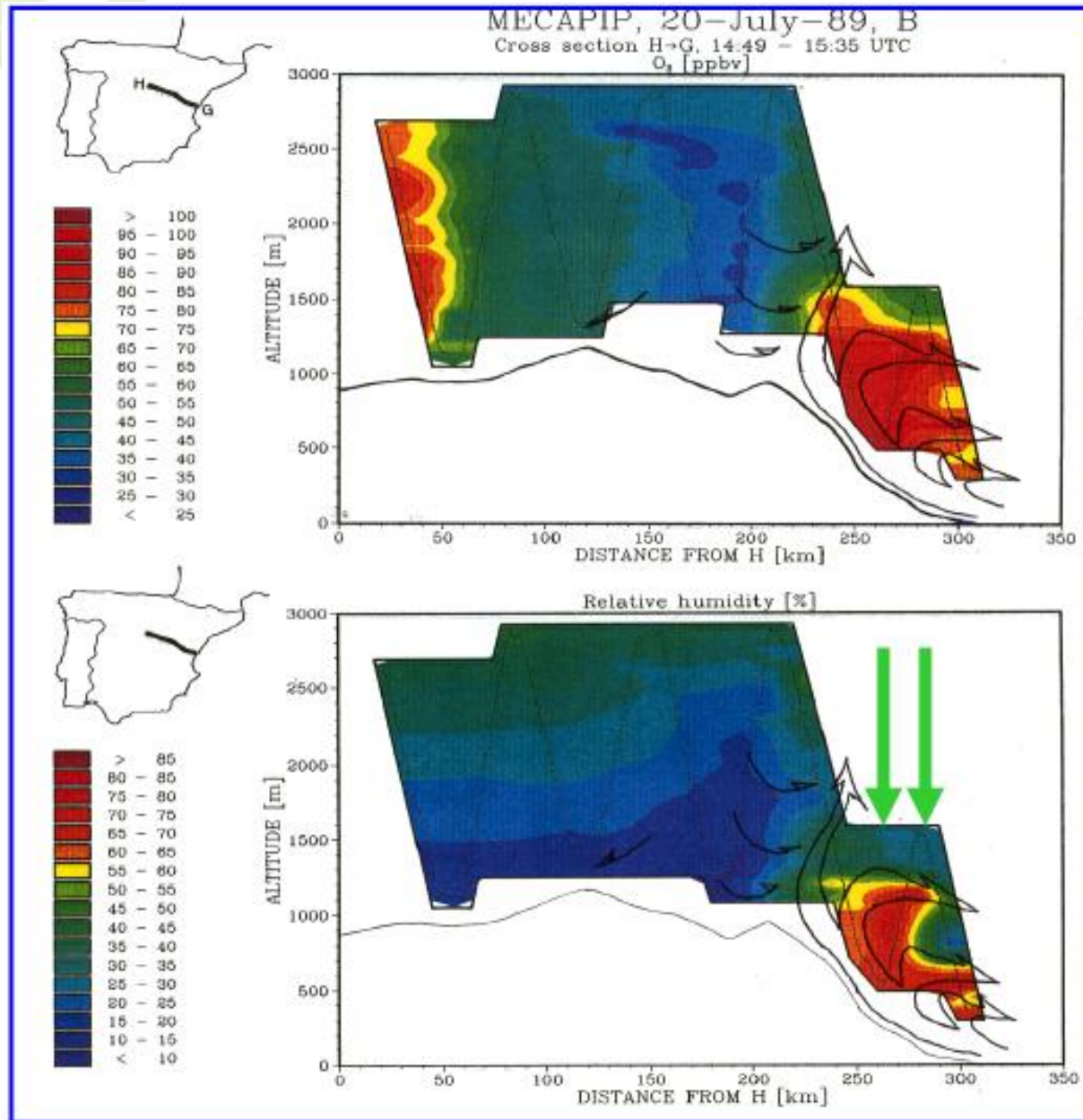
Salvador et al. (1997) Int. J. Env. Poll.  
MECAPIP 27 - July - 1989 ( $\omega$  Component)

Millán et al (2002) Environ Poll.



Courtesy M. Millán, CEAM

# O<sub>3</sub> episodes in the Mediterranean



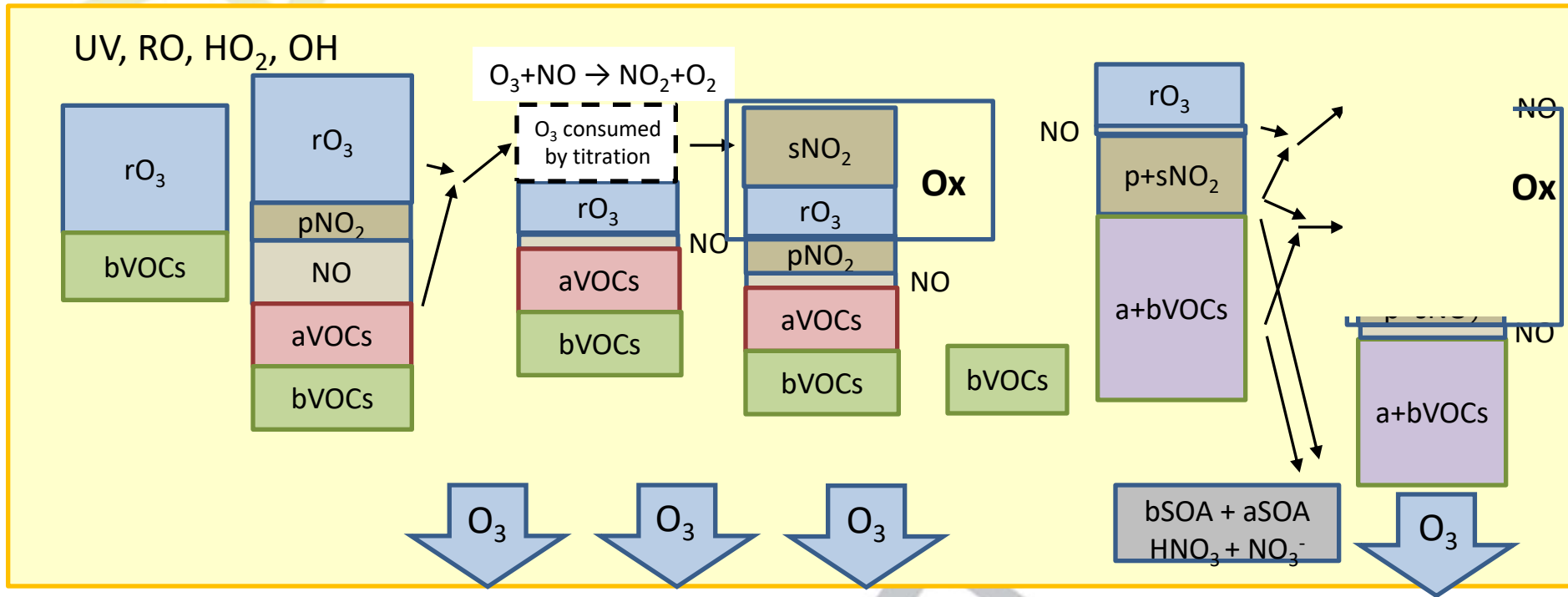
Courtesy  
M. Millán, CEAM

Millán et al (1996)  
Atmos Environ



# O<sub>3</sub> episodes in the Mediterranean

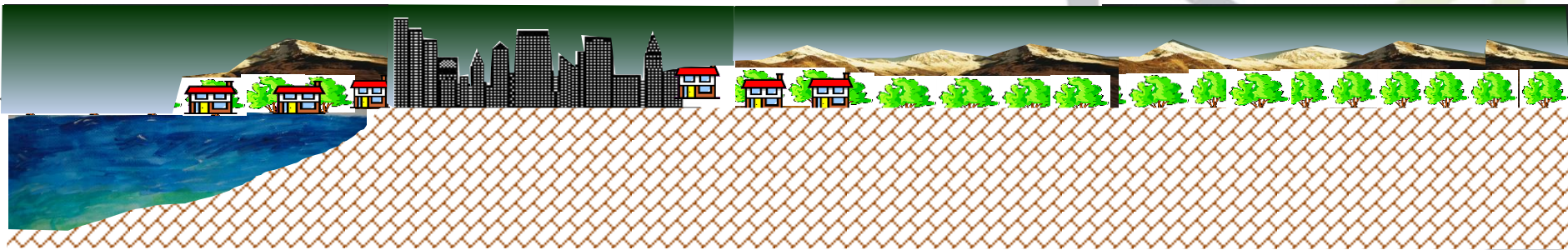
## The concepts of rOx & LOx



Ozone dry deposition (Monks et al., 2015):

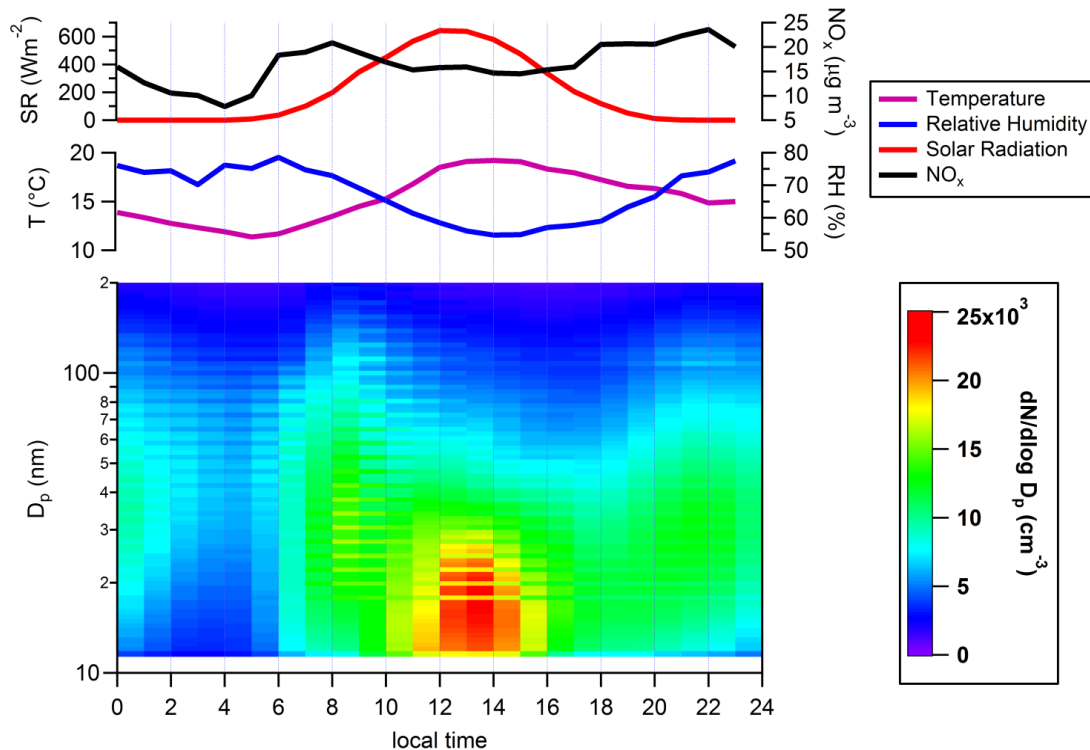
- Stomatal deposition
- Non stomatal deposition

- Radiation & surface-T reactions
- In-canopy chemistry (NO)
- Deposition to Water



# UFP episodes

## Daily average PNSD on a nucleation day at the main cities (BCN, MAD and BNE)



*Brines et al., 2015*

*Atmospheric Chemistry & Physics*

Attributed to the delay in the start of the new particle formation in urban environments due to the increase of the condensation sink (CS) during the morning and afternoon road traffic rush hours

- 55% of days nucleation for 2h
- 30% of days nucleation for 4h

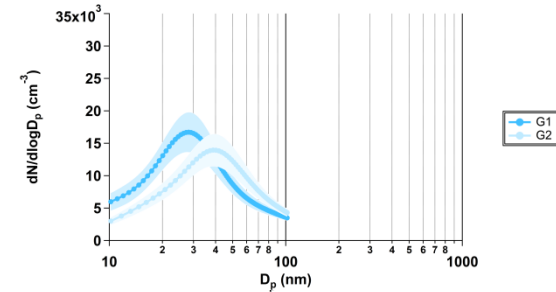
## OBJECTIVE OF THE PRESENT STUDY

- What is the vertical distribution of UFP over the city during nucleation days over Barcelona?
- Obtaining vertical profiles of PNC over the city during the growth of the mixing layer

## RESULTS

### SMPS cluster analysis: Barcelona, Madrid and Brisbane

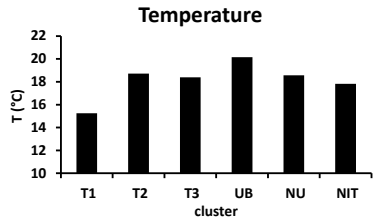
Brinest et al., 2016, ACP



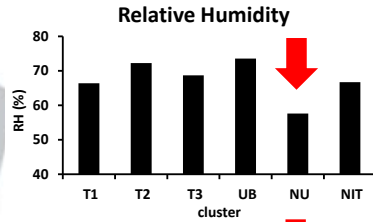
Cluster	% of time	Size distribution	Temporal trend	Characteristics
Traffic 1	27-24%	<b>20-40 nm</b> 70-130 nm	Traffic rush hour	Highest NO, NO <sub>2</sub> , BC and CO
Traffic 2	22-24%	20-40 nm <b>70-90 nm</b>	Evening and night	High NO, NO <sub>2</sub> , BC and CO
Traffic 3	11-20%	10-20 nm <b>50-90 nm</b>	Daytime	High NO, NO <sub>2</sub> , BC and CO

# UFP episodes

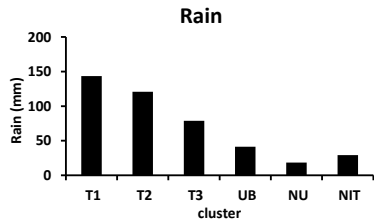
Brines M, 2015 PhD Thesis  
Barcelona, Madrid, Brisbane  
(Rome, Los Angeles)



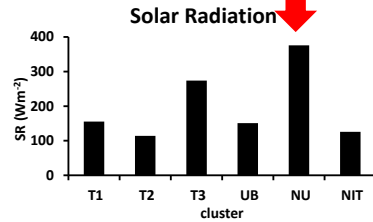
(a)



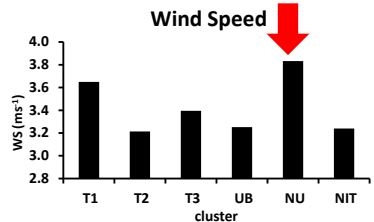
(b)



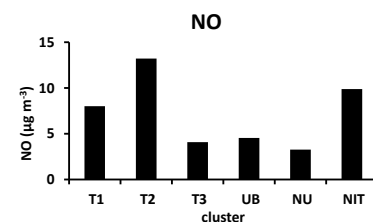
(c)



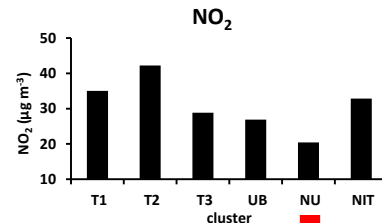
(d)



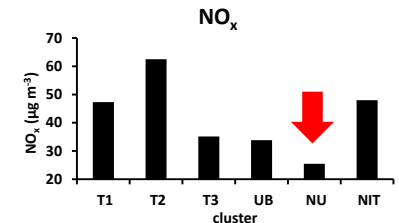
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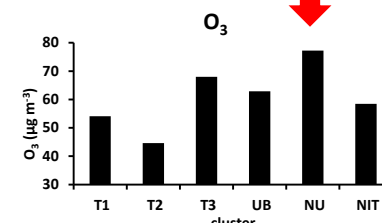
(f)



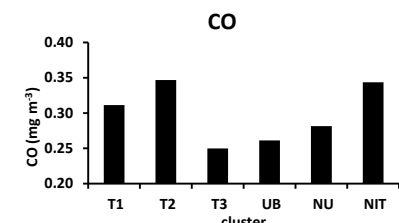
(g)



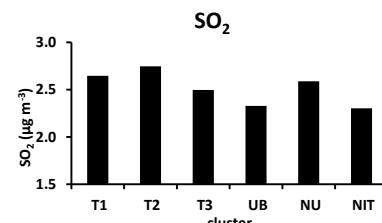
(h)



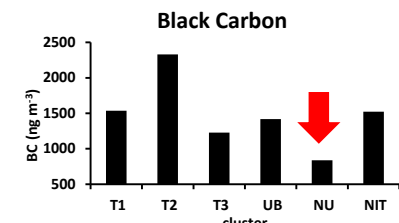
(i)



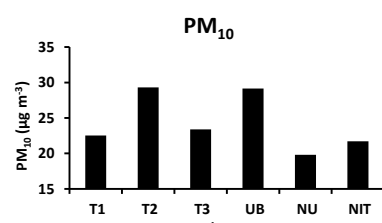
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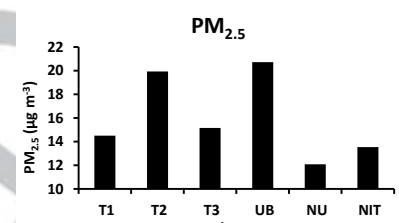
(k)



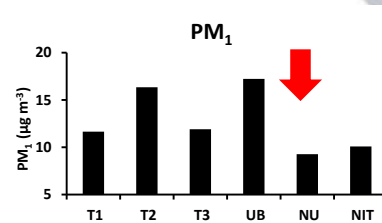
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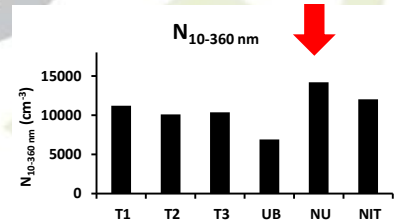
(m)



(n)



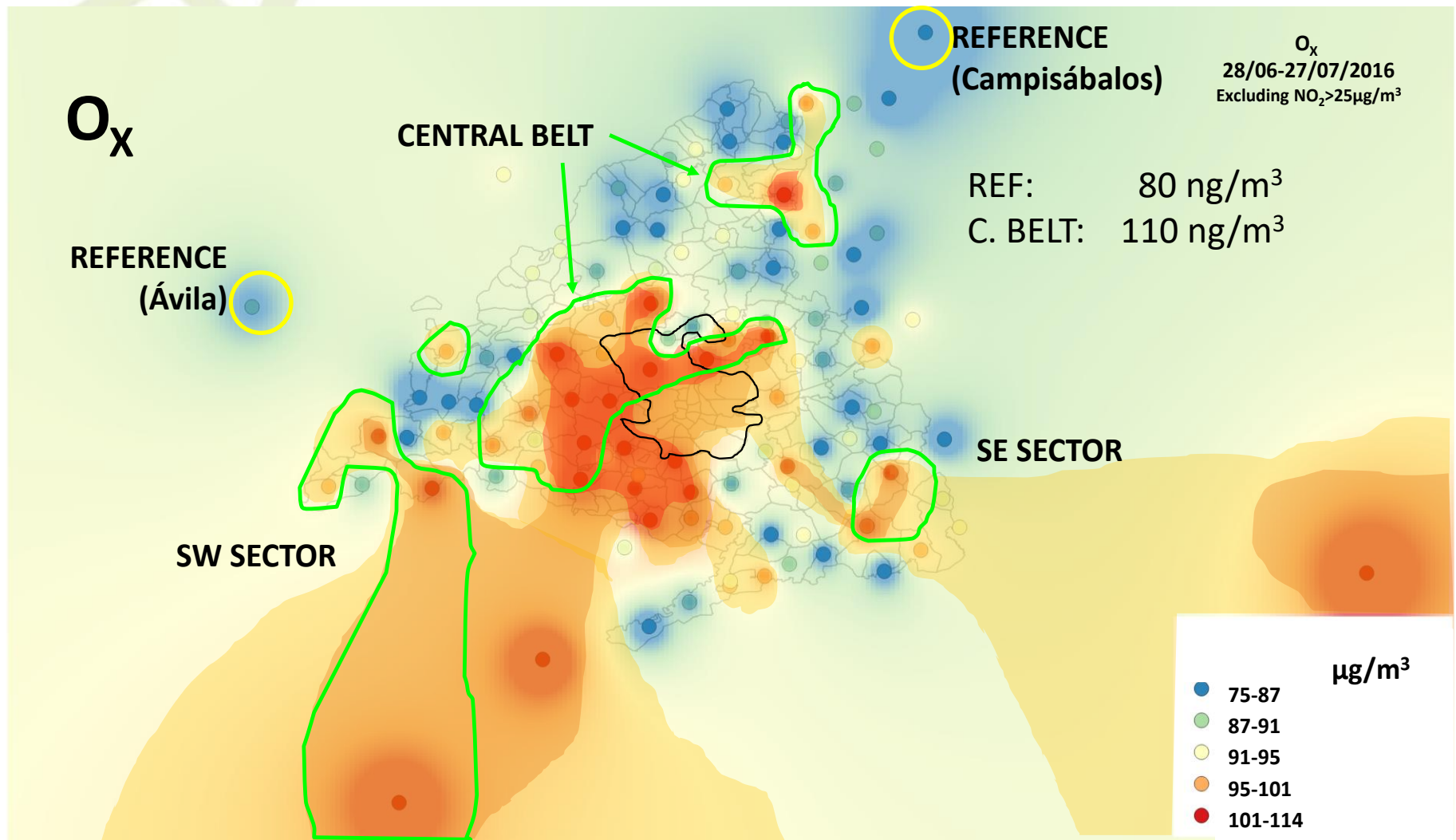
(o)



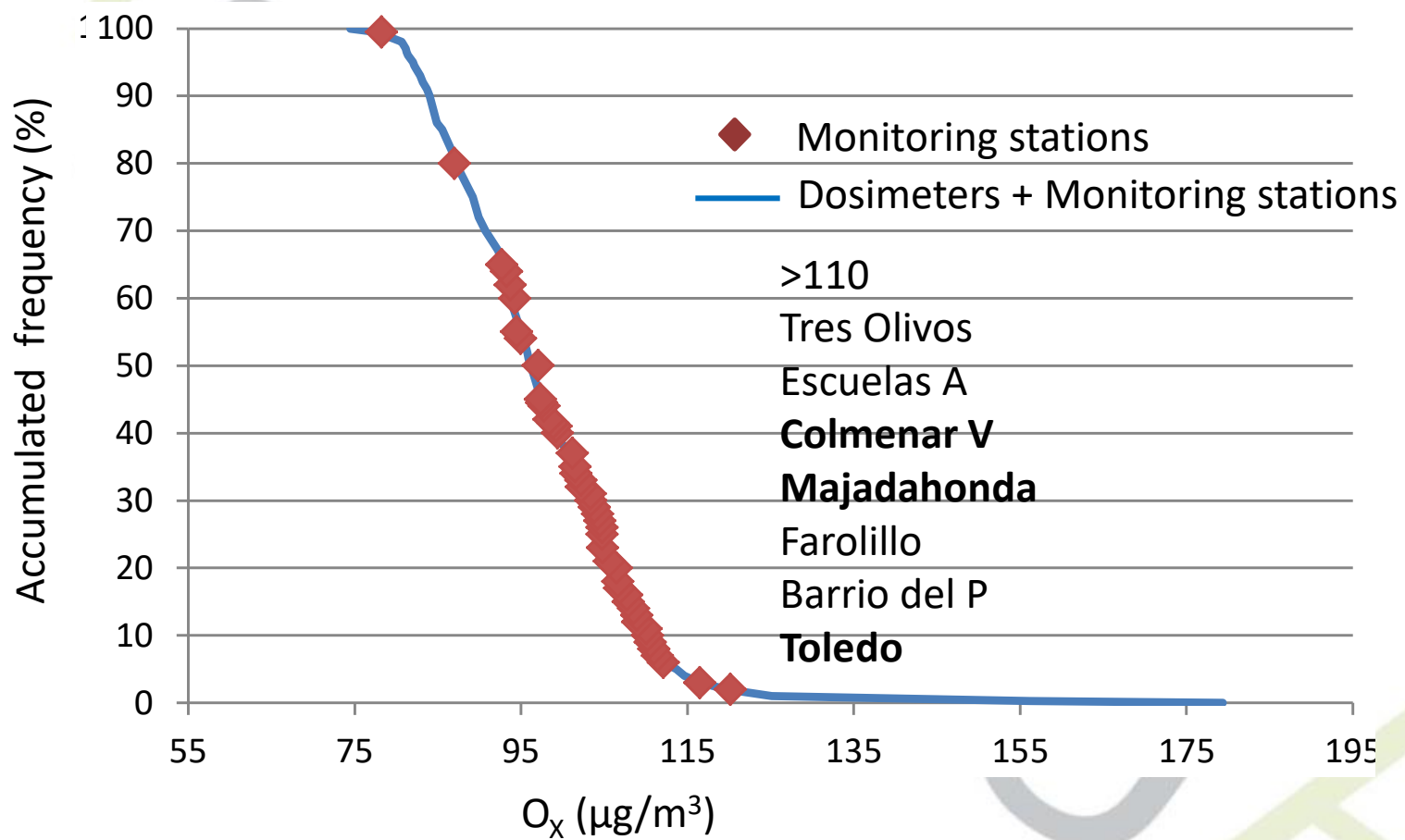
(p)

# UFP & O<sub>3</sub> Madrid campaign July 2016

Results: Mean variation (spatial)

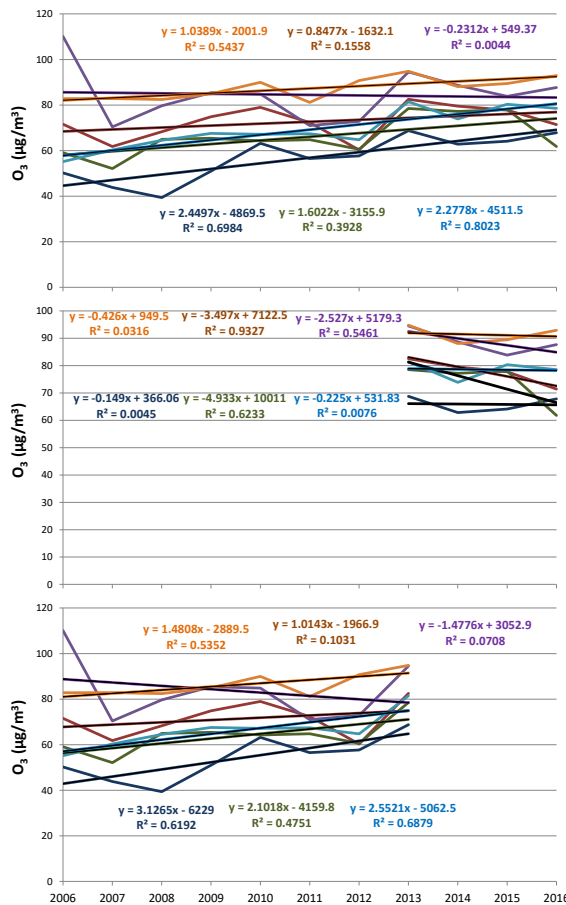


# UFP & O<sub>3</sub> Madrid campaign July 2016



# UFP & O<sub>3</sub> Madrid campaign July 2016

O<sub>3</sub>



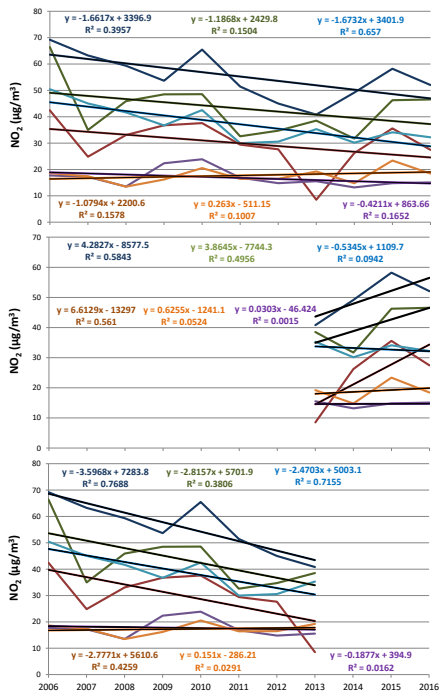
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- ARTURO SORIA
- PLAZA DEL CARMEN
- CASA DE CAMPO
- BARRIO DEL PILAR
- MAJADAHONDA

- ESCUELAS AGUIRRE
- ARTURO SORIA
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- CASA DE CAMPO
- BARRIO DEL PILAR
- MAJADAHONDA

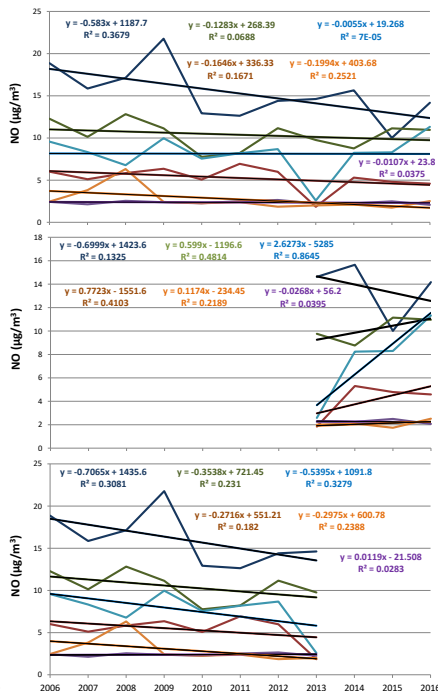
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- BARRIO DEL PILAR
- MAJADAHONDA

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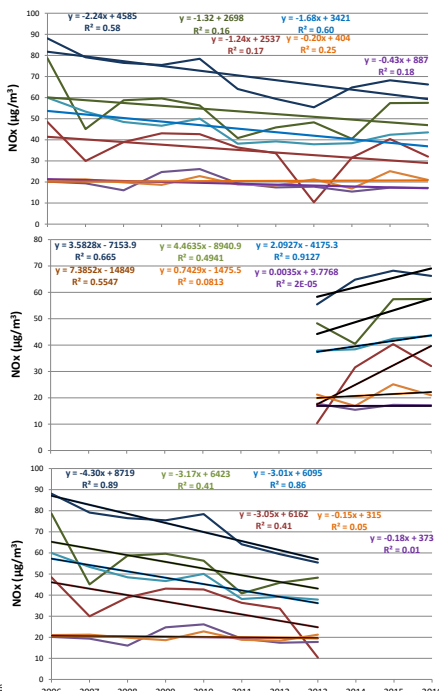
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## NO

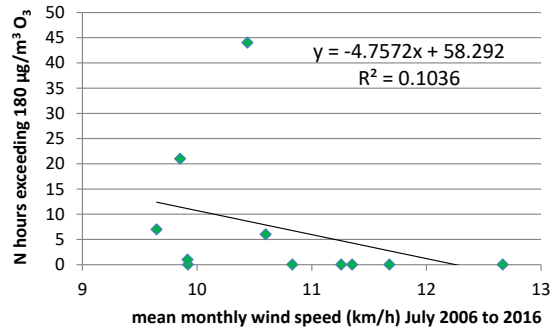
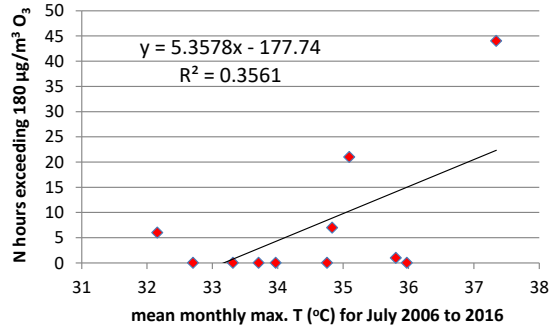
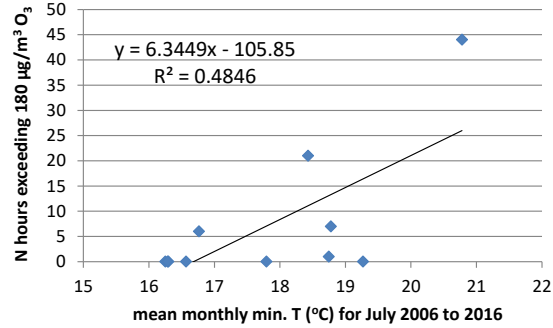
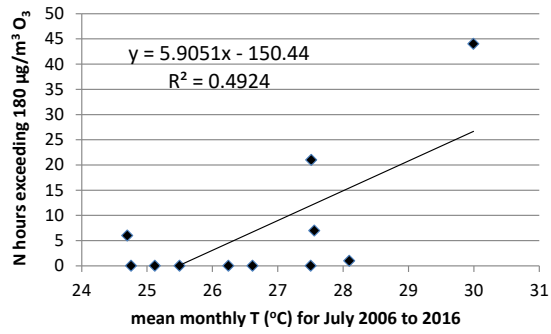


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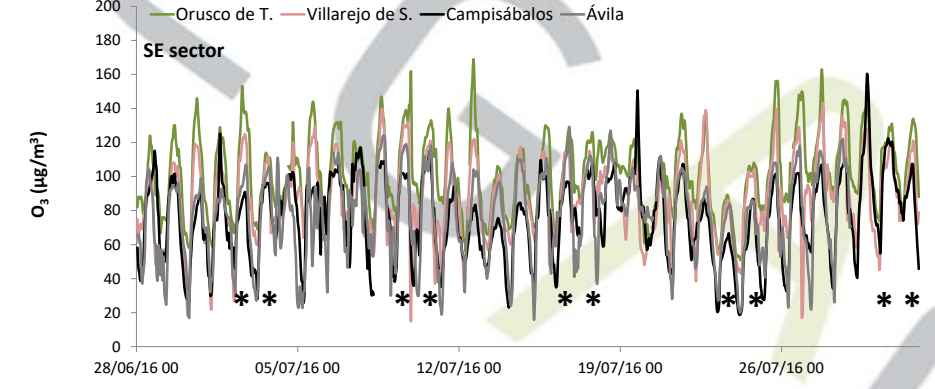
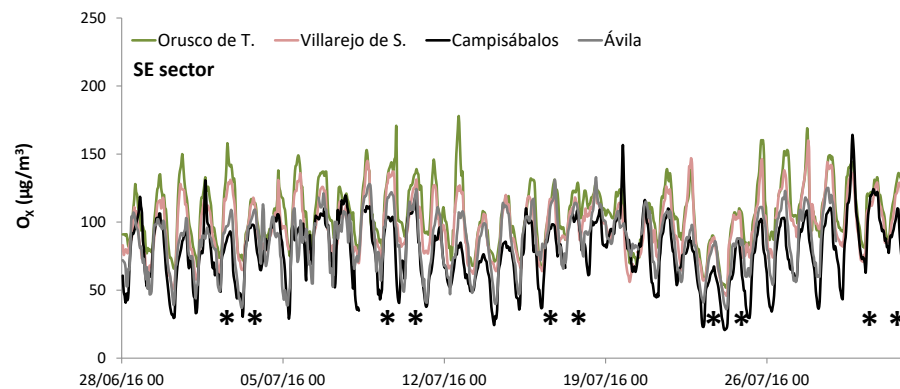
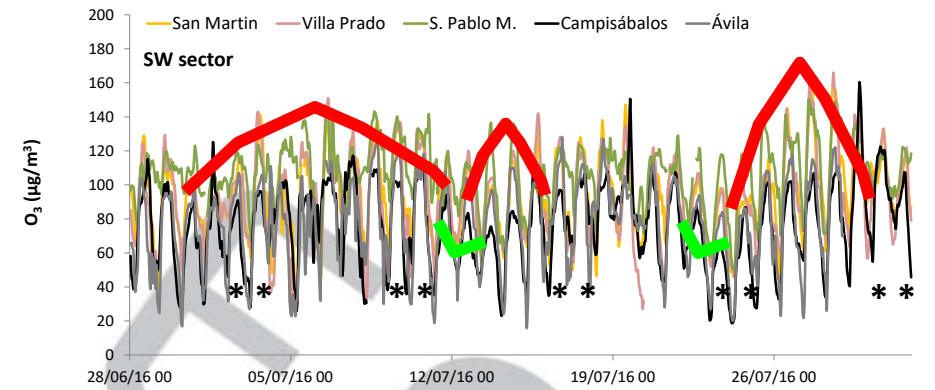
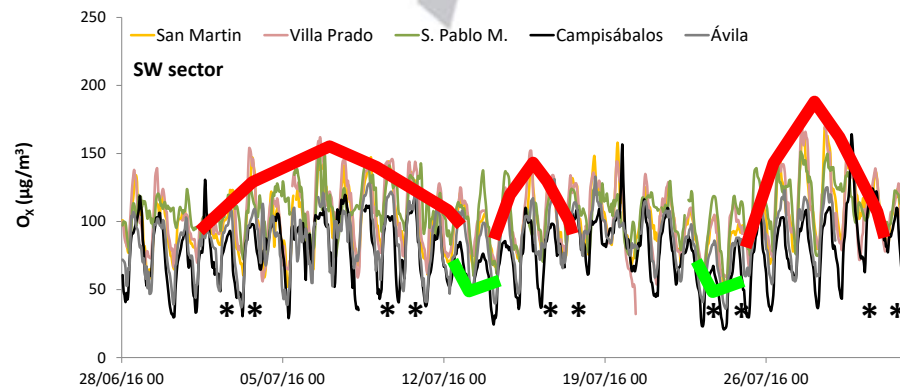
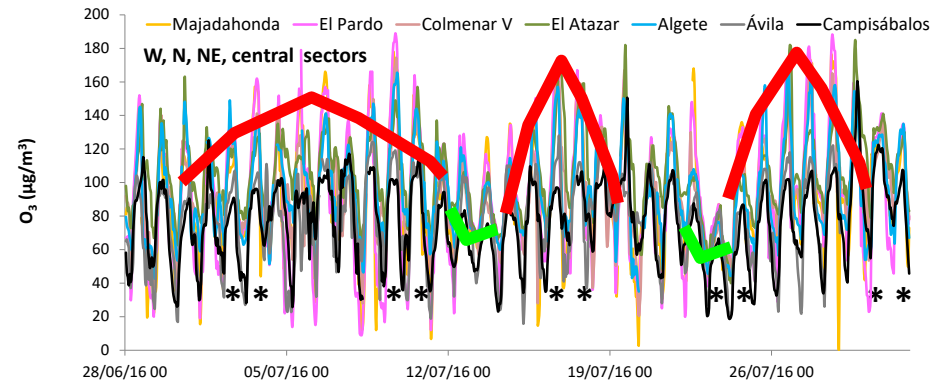
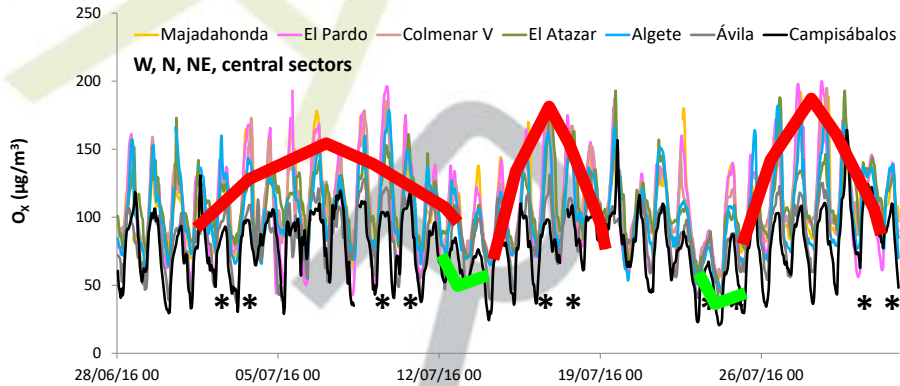




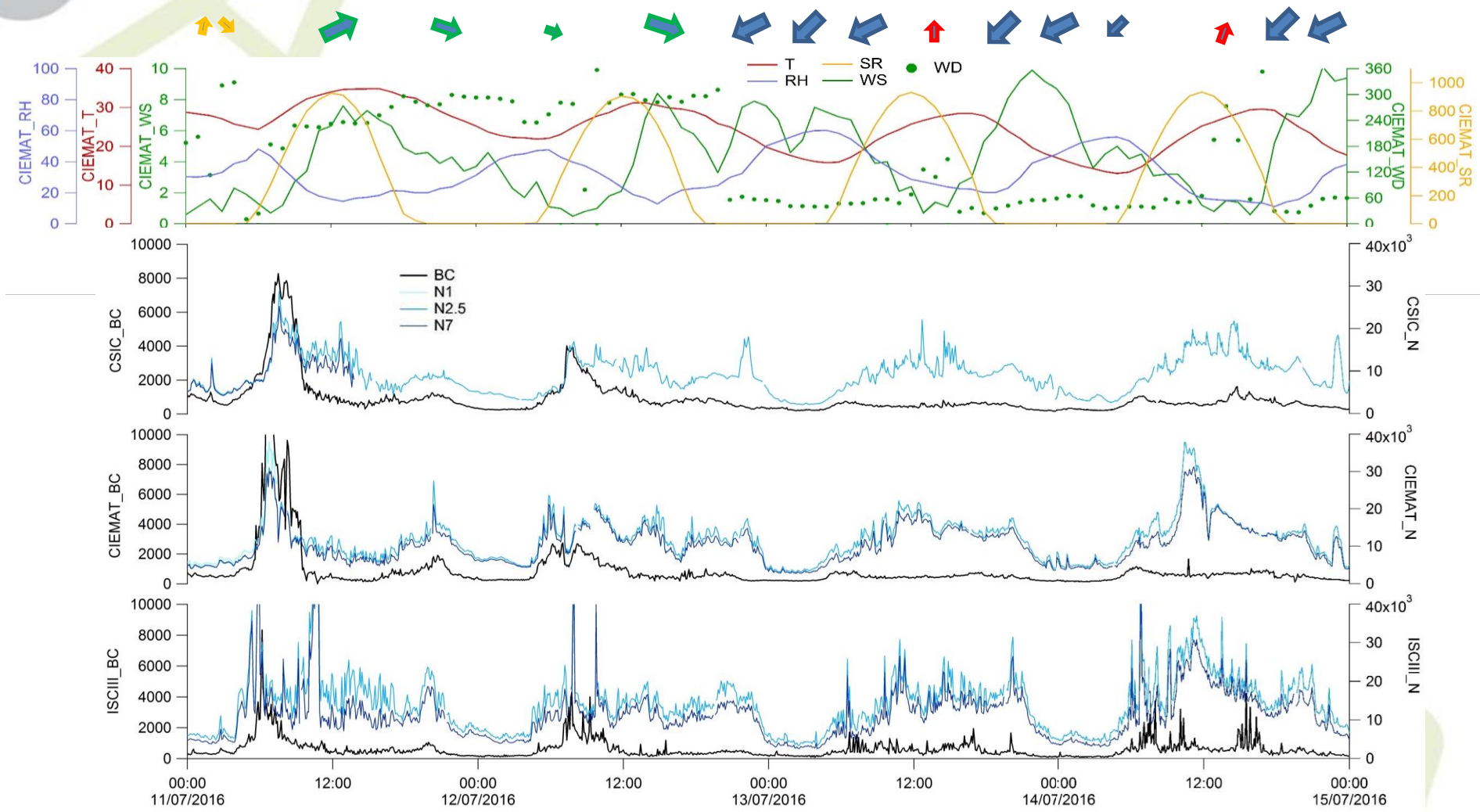
# UFP & O<sub>3</sub> Madrid campaign July 2016



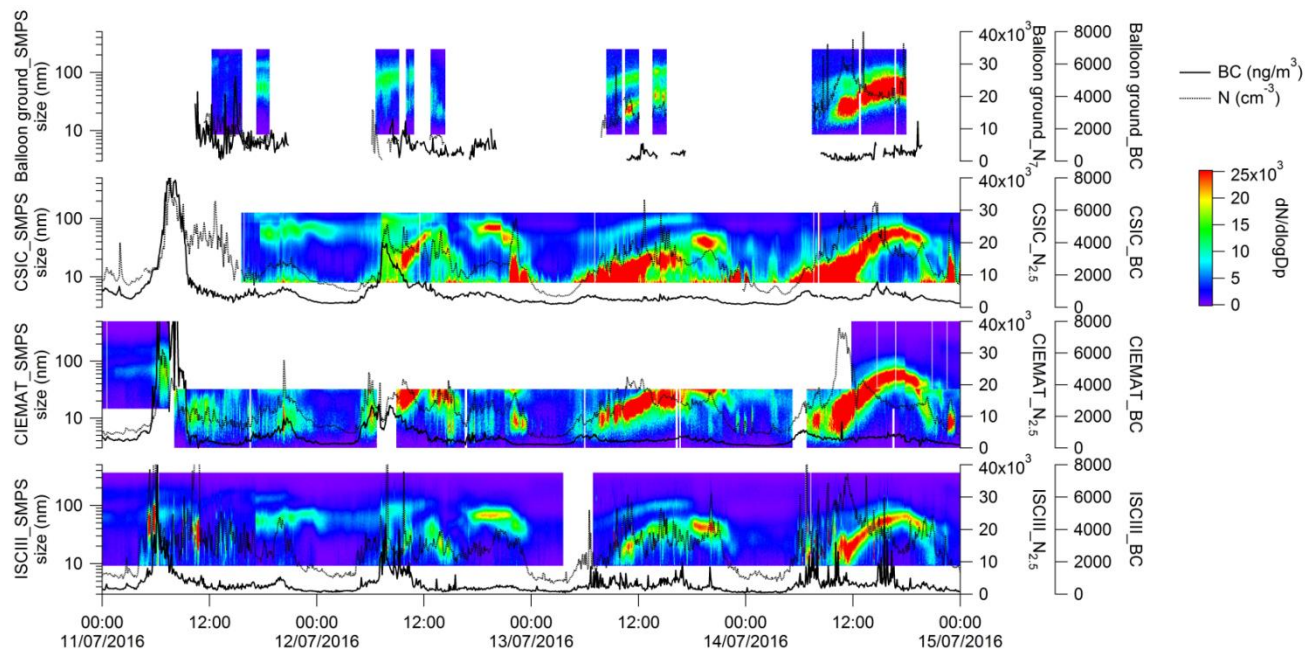
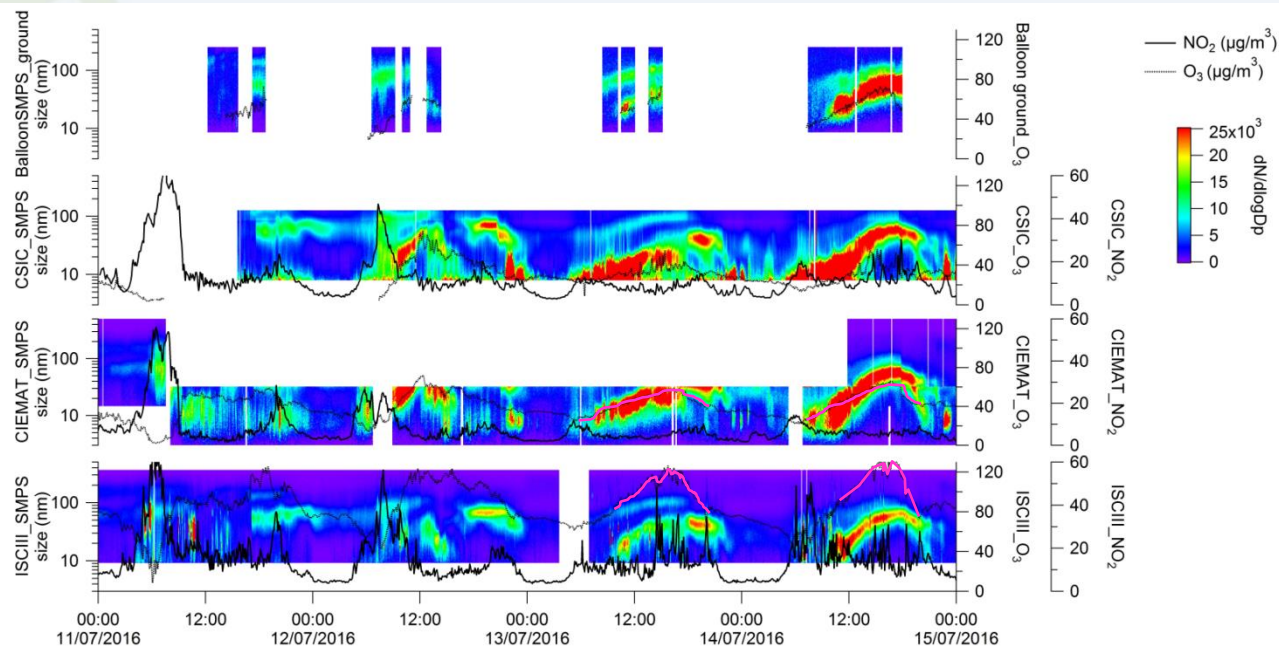
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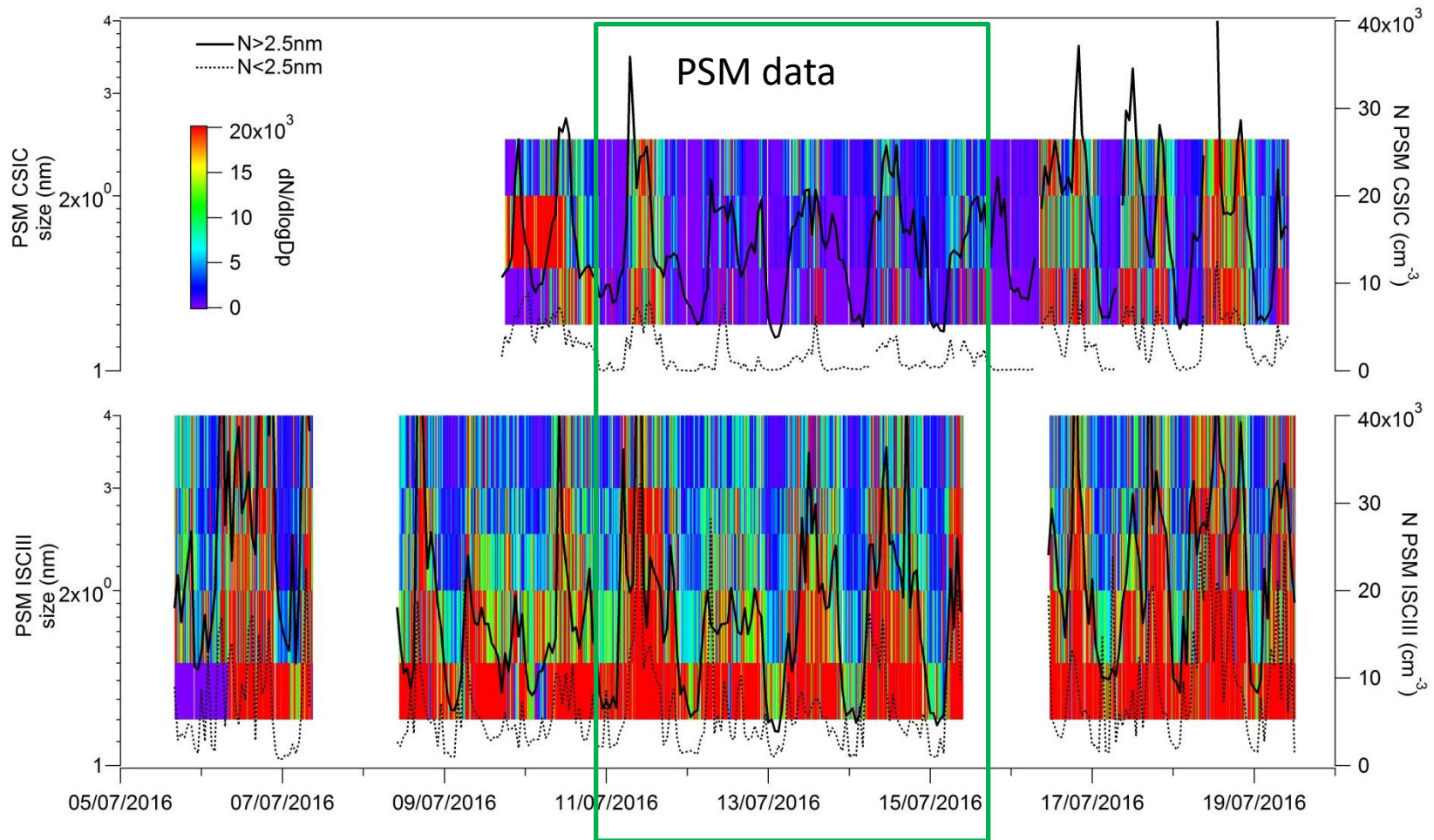
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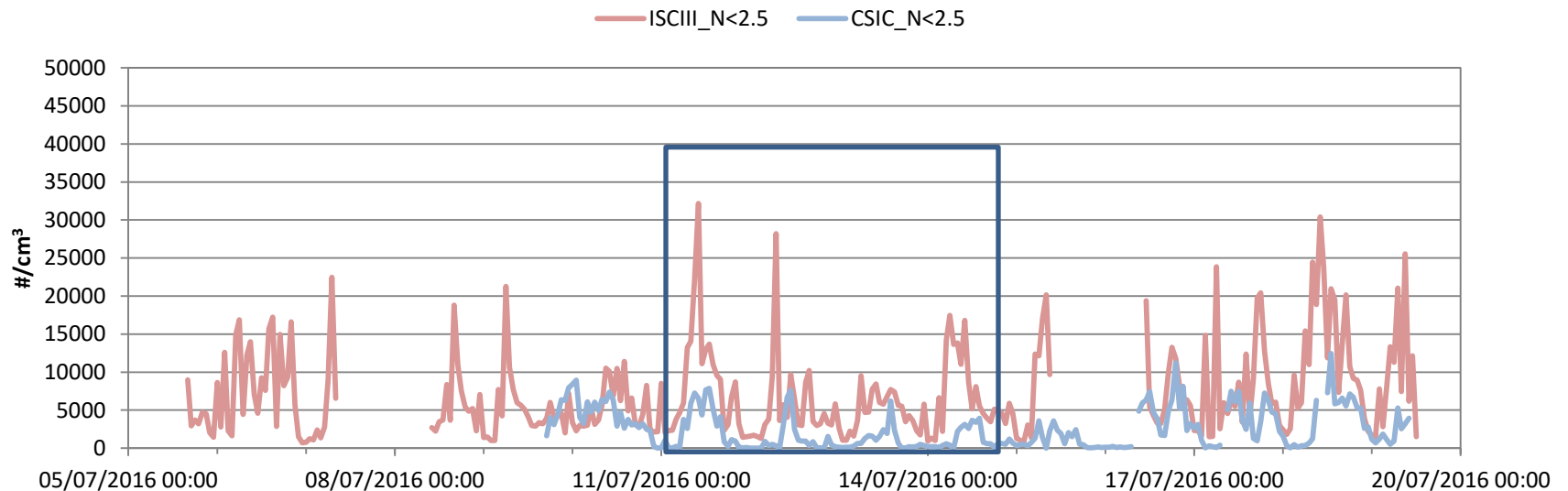
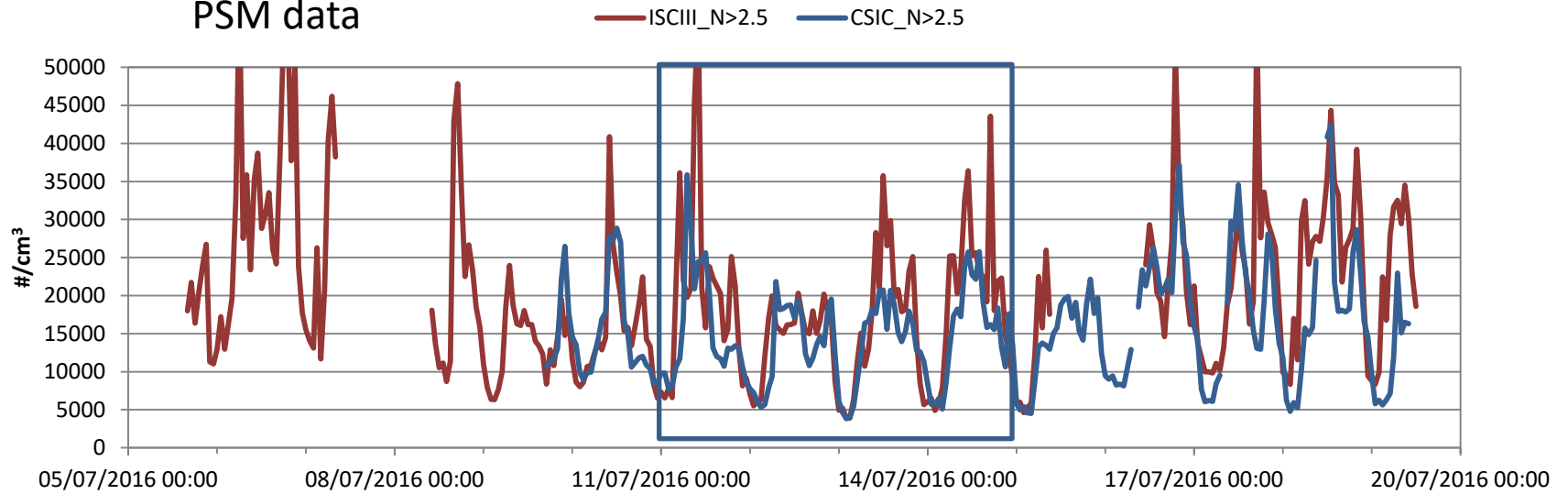


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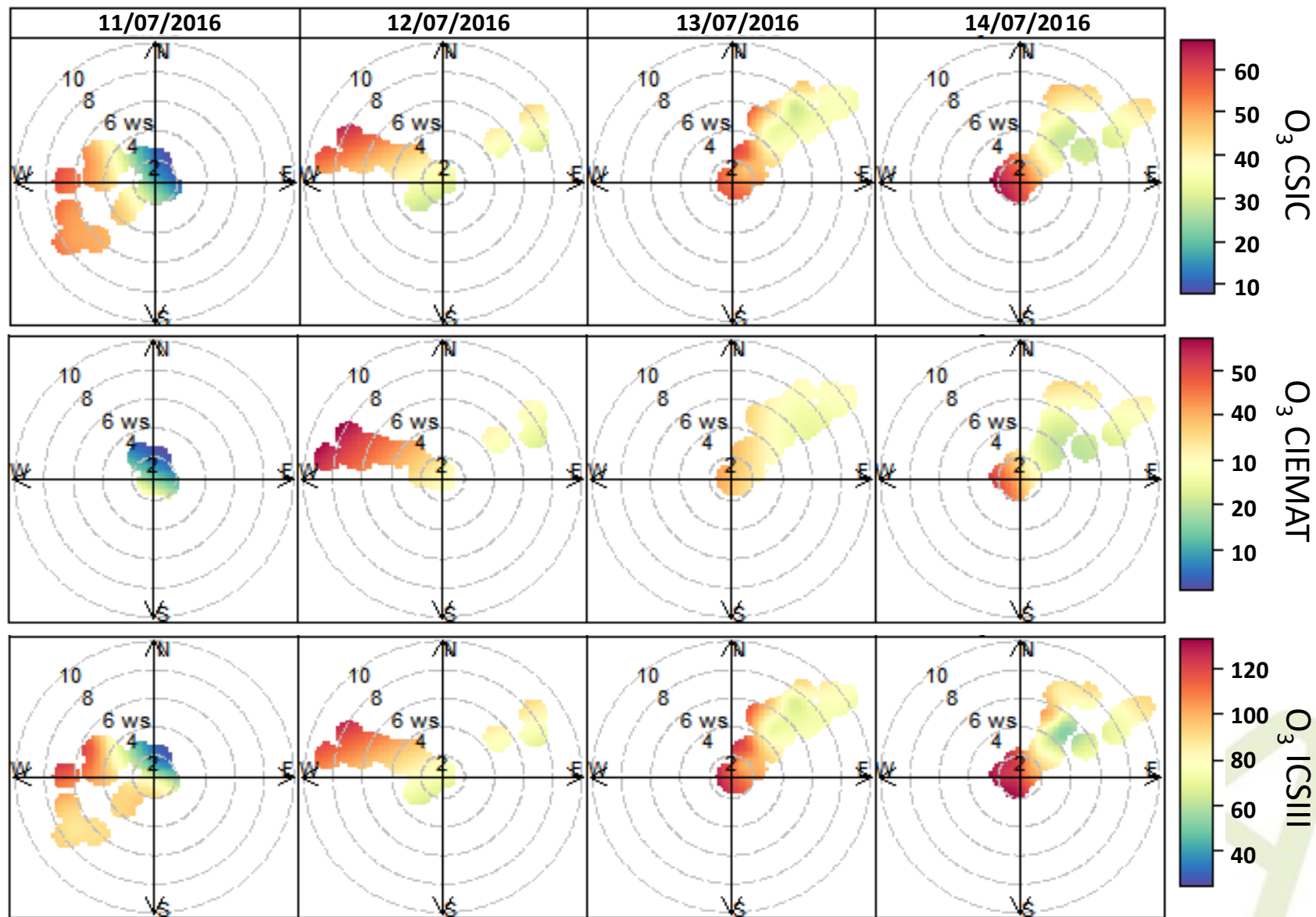


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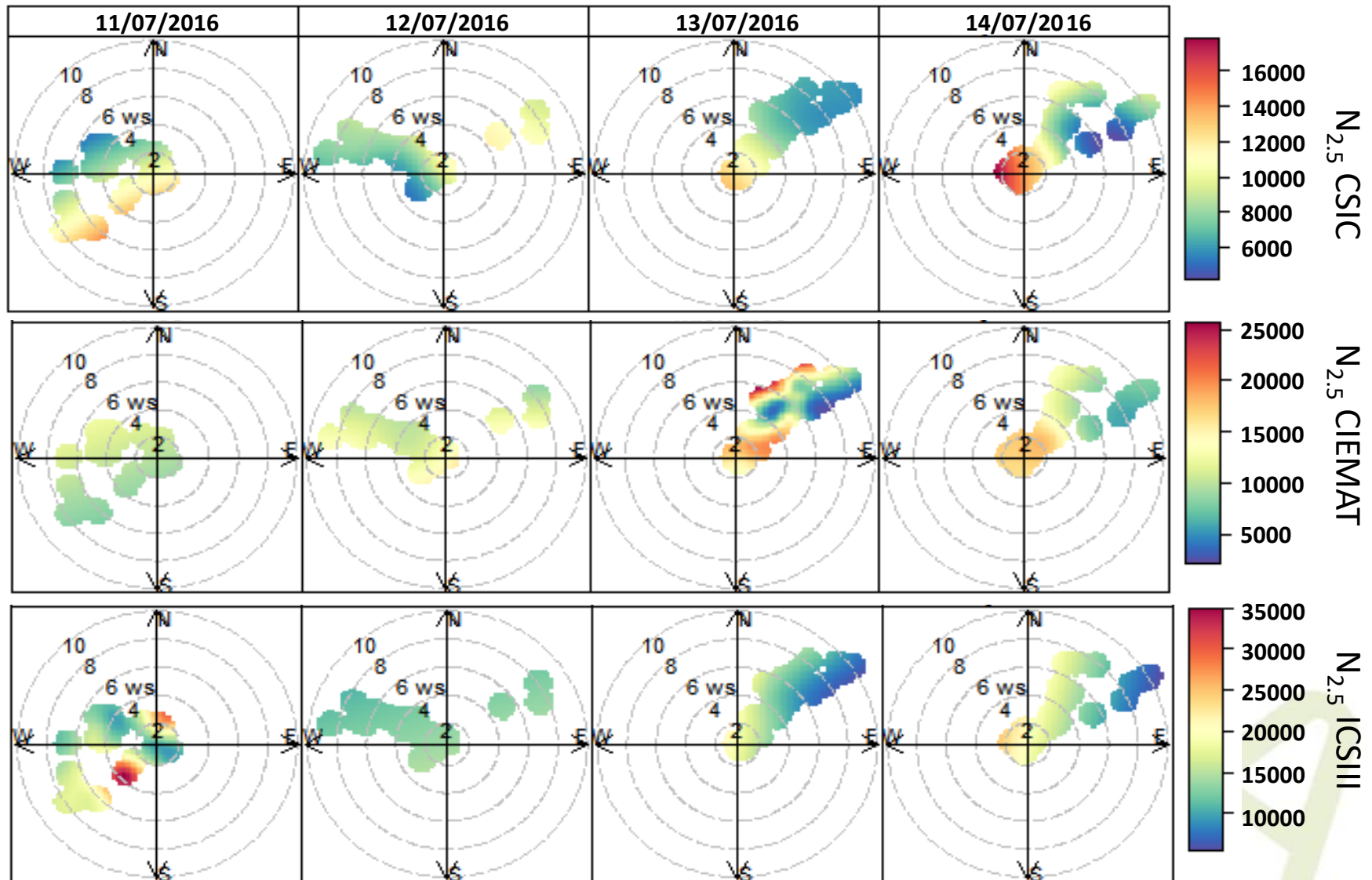
PSM data



# UFP & O<sub>3</sub> Madrid campaign July 2016

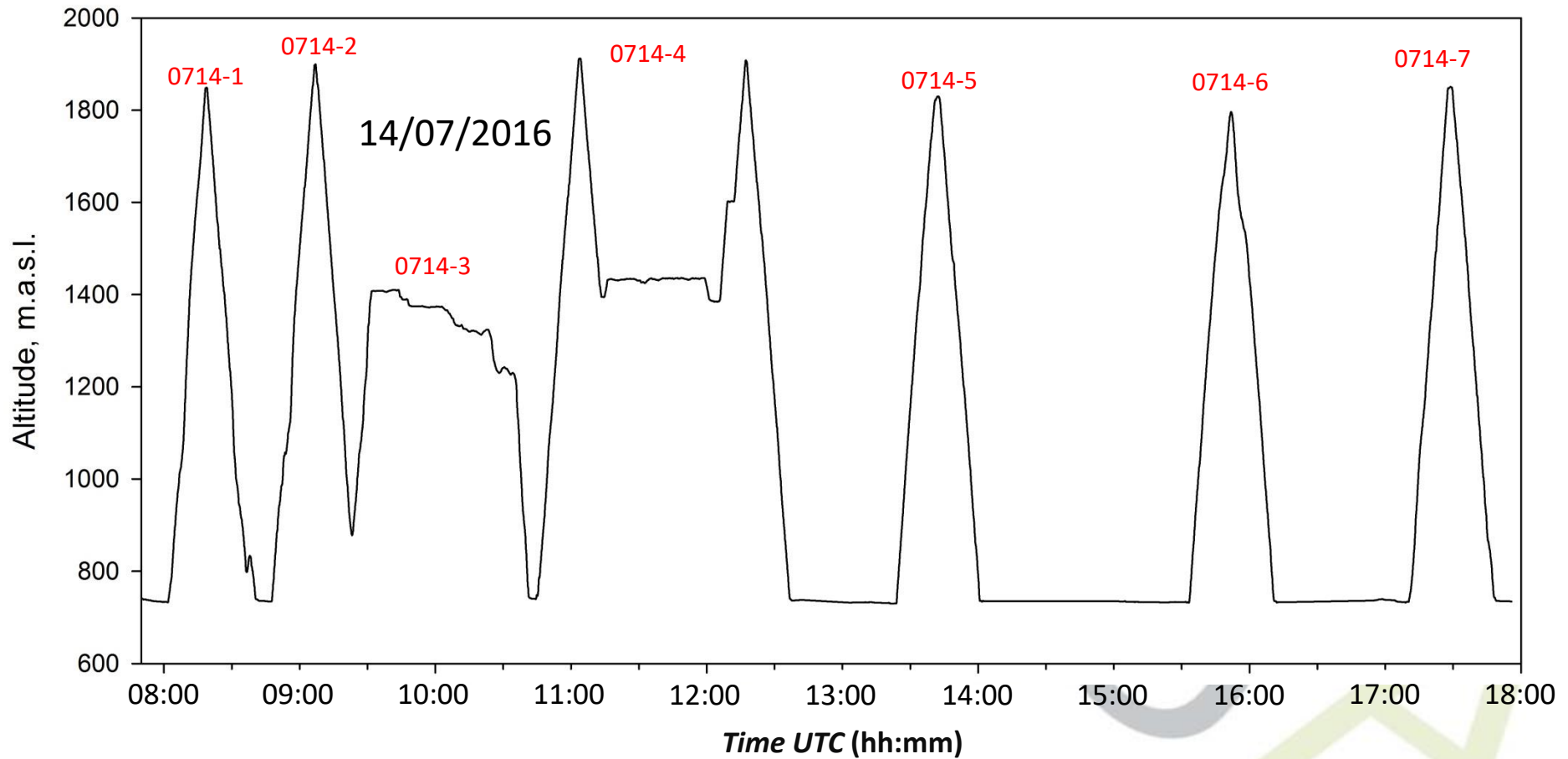


# UFP & O<sub>3</sub> Madrid campaign July 2016



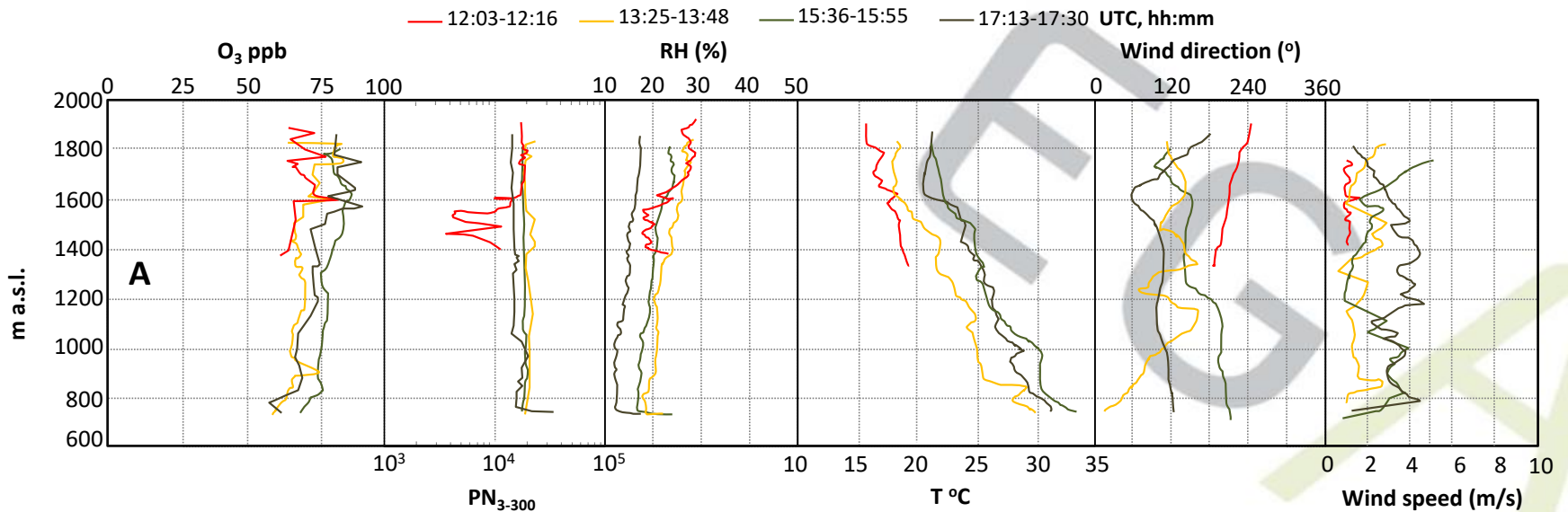
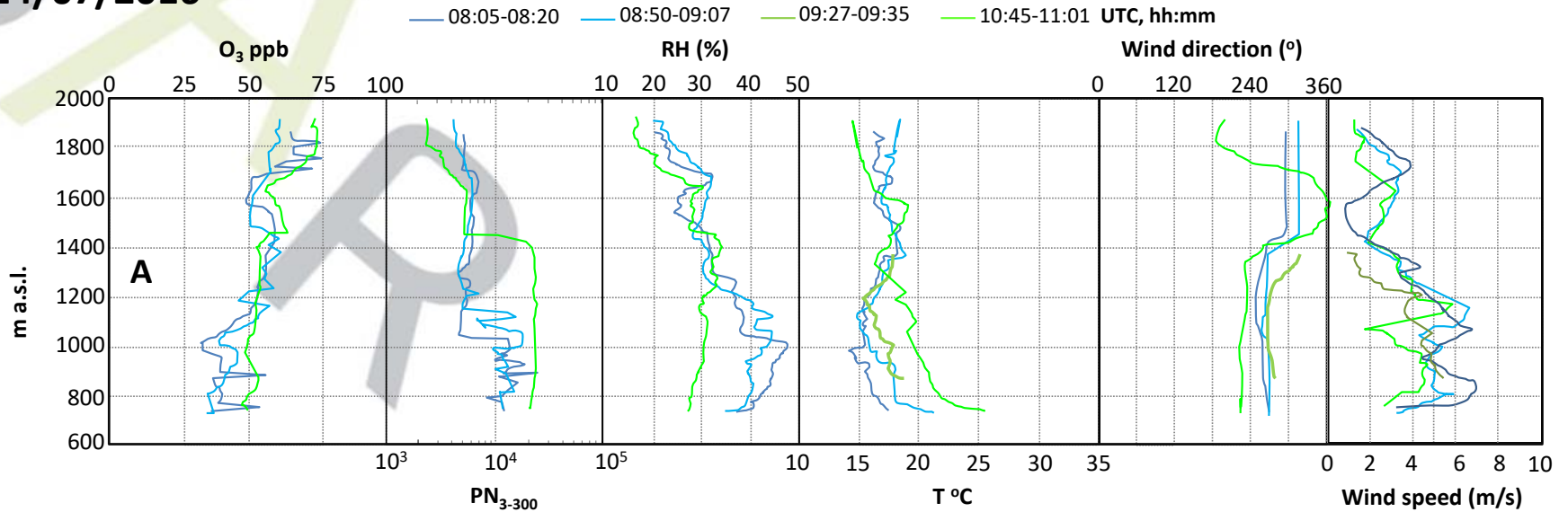


# UFP & O<sub>3</sub> Madrid campaign July 2016



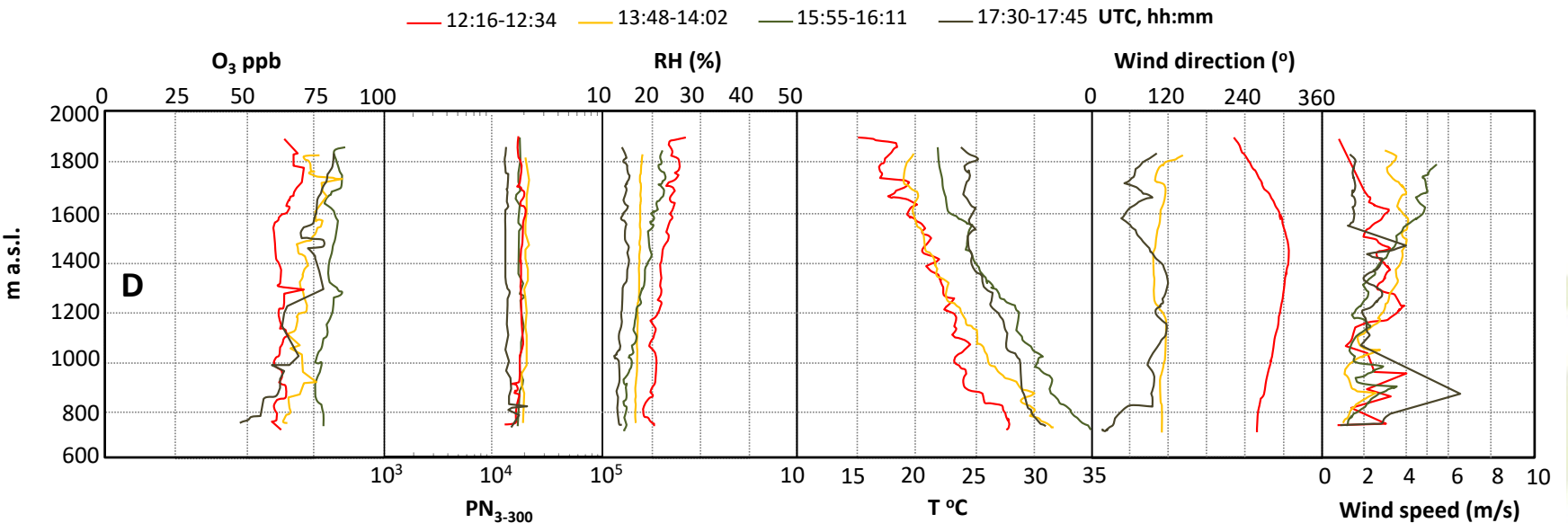
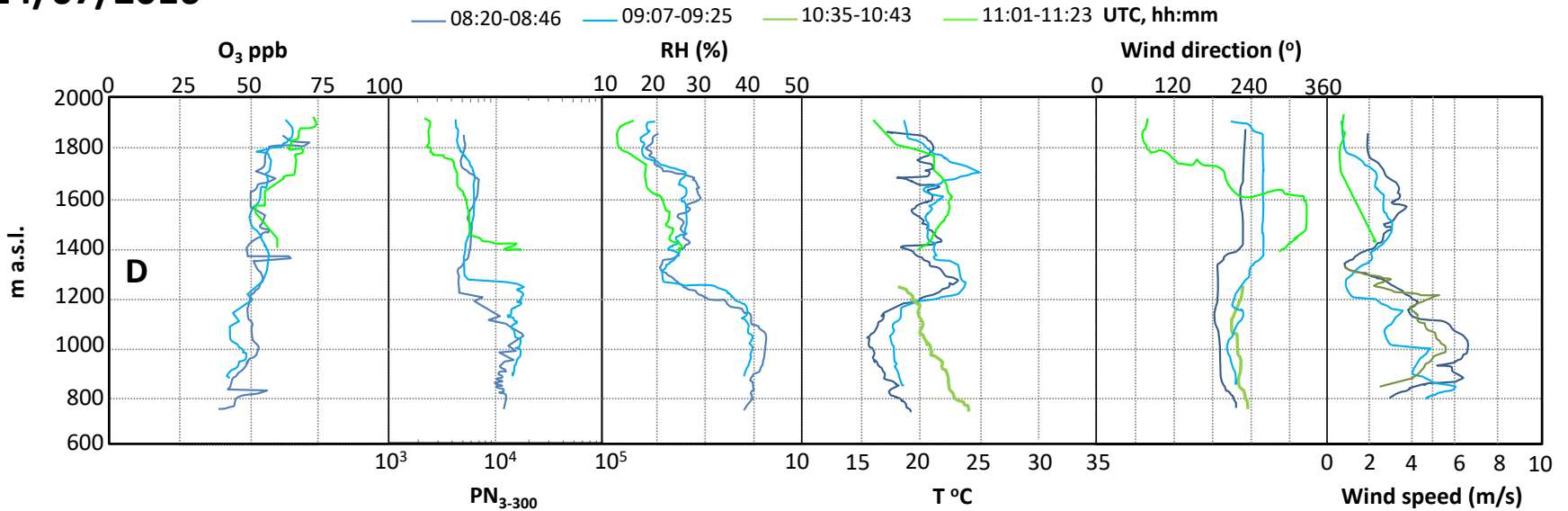
# UFP & O<sub>3</sub> Madrid campaign July 2016

14/07/2016



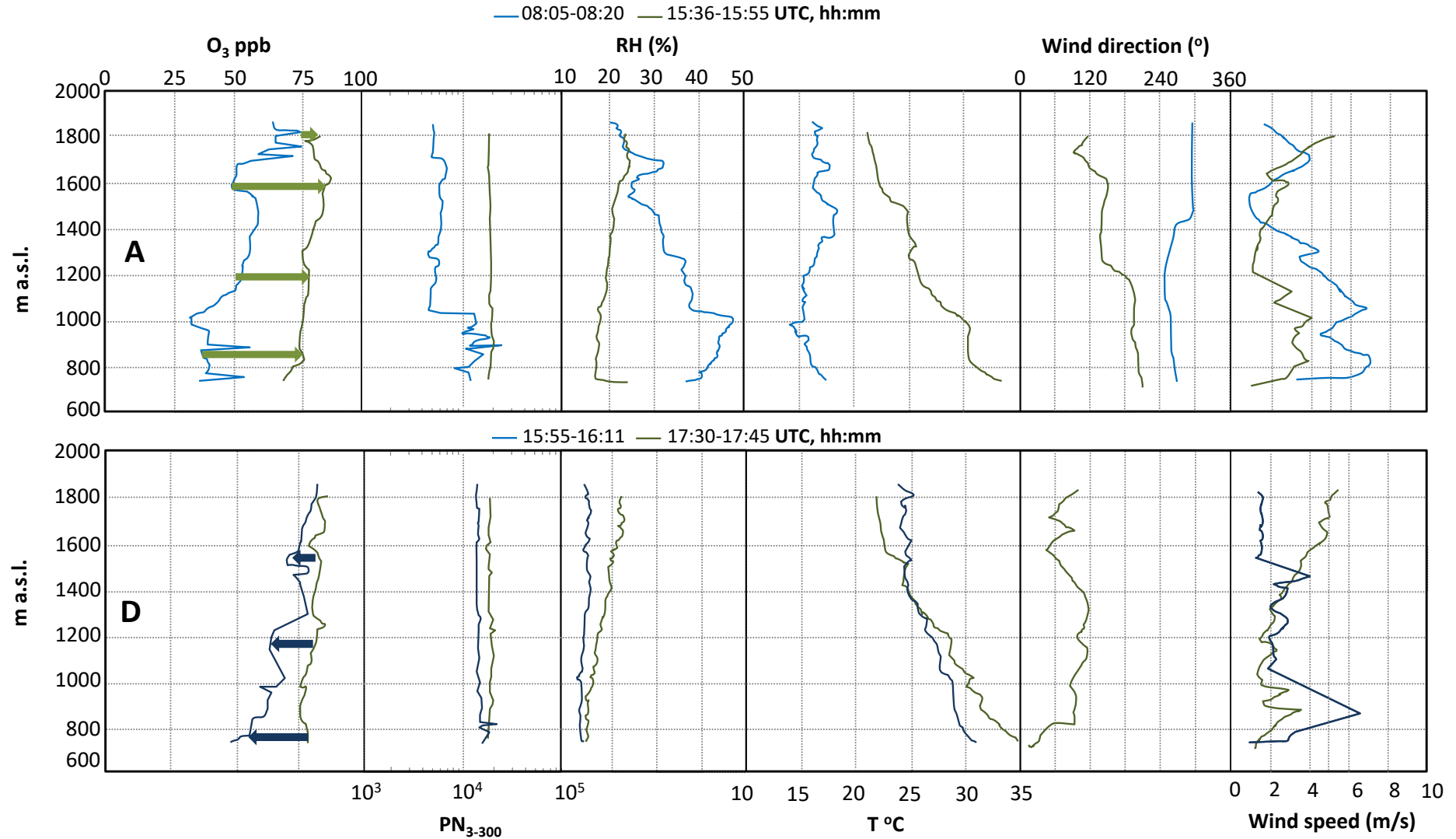
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14/07/2016



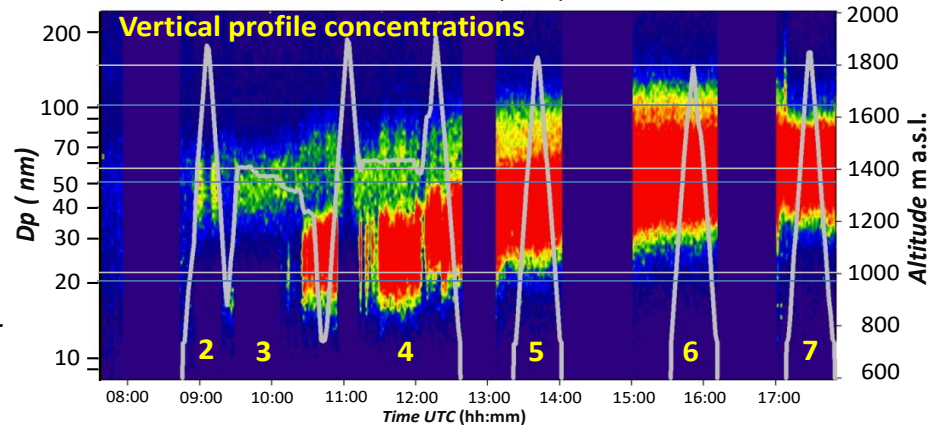
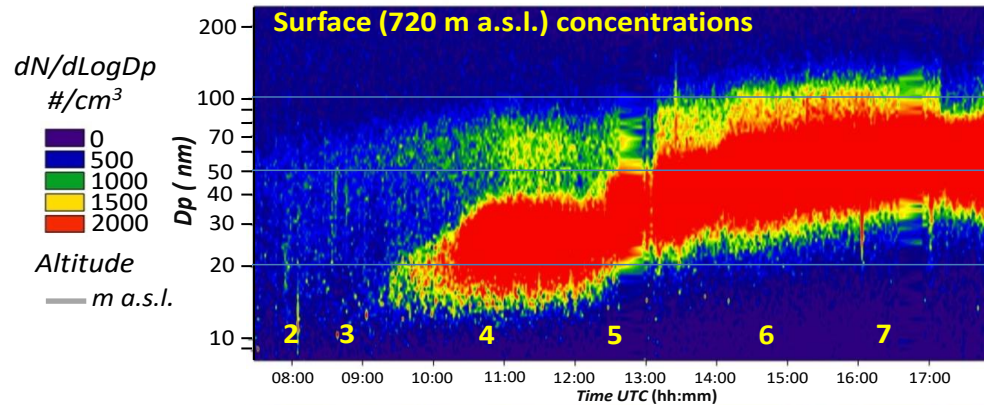
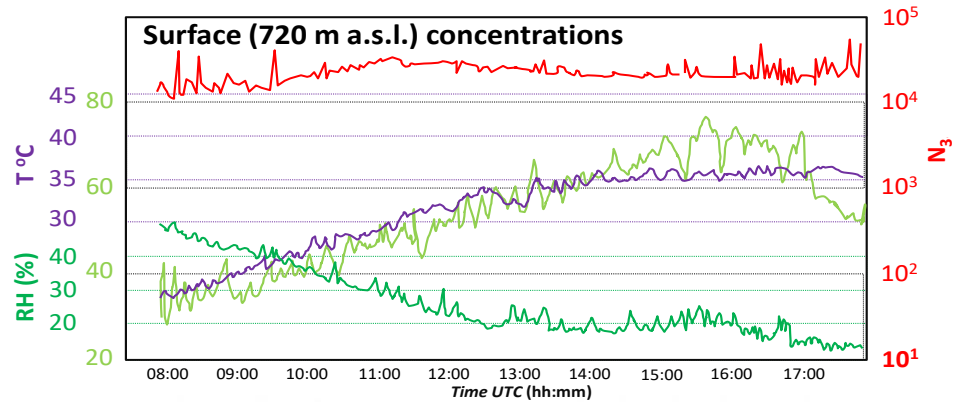
# UFP & O<sub>3</sub> Madrid campaign July 2016

14/07/2016



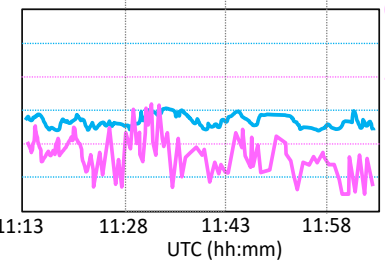
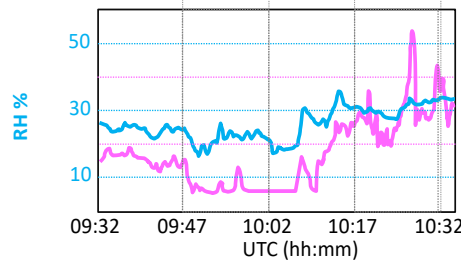
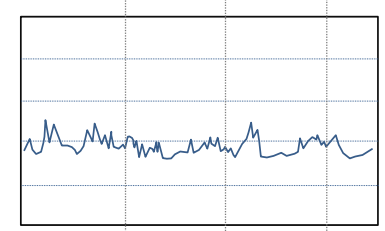
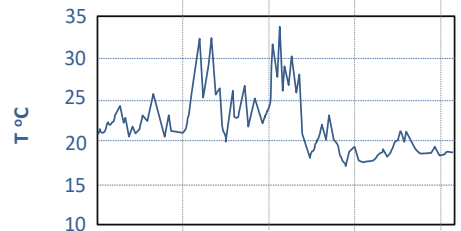
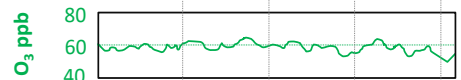
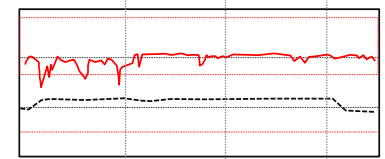
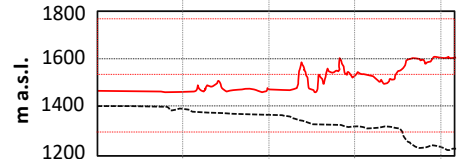
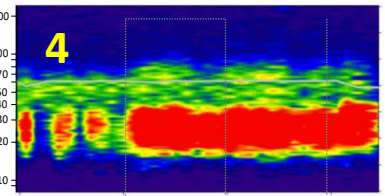
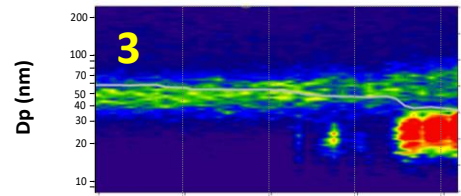
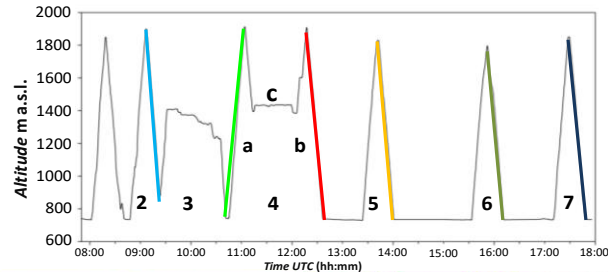
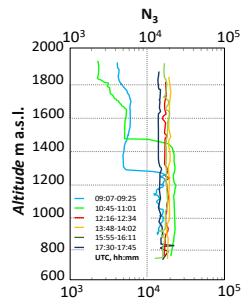
# UFP & O<sub>3</sub> Madrid campaign July 2016

14/07/2016



# UFP & O<sub>3</sub> Madrid campaign July 2016

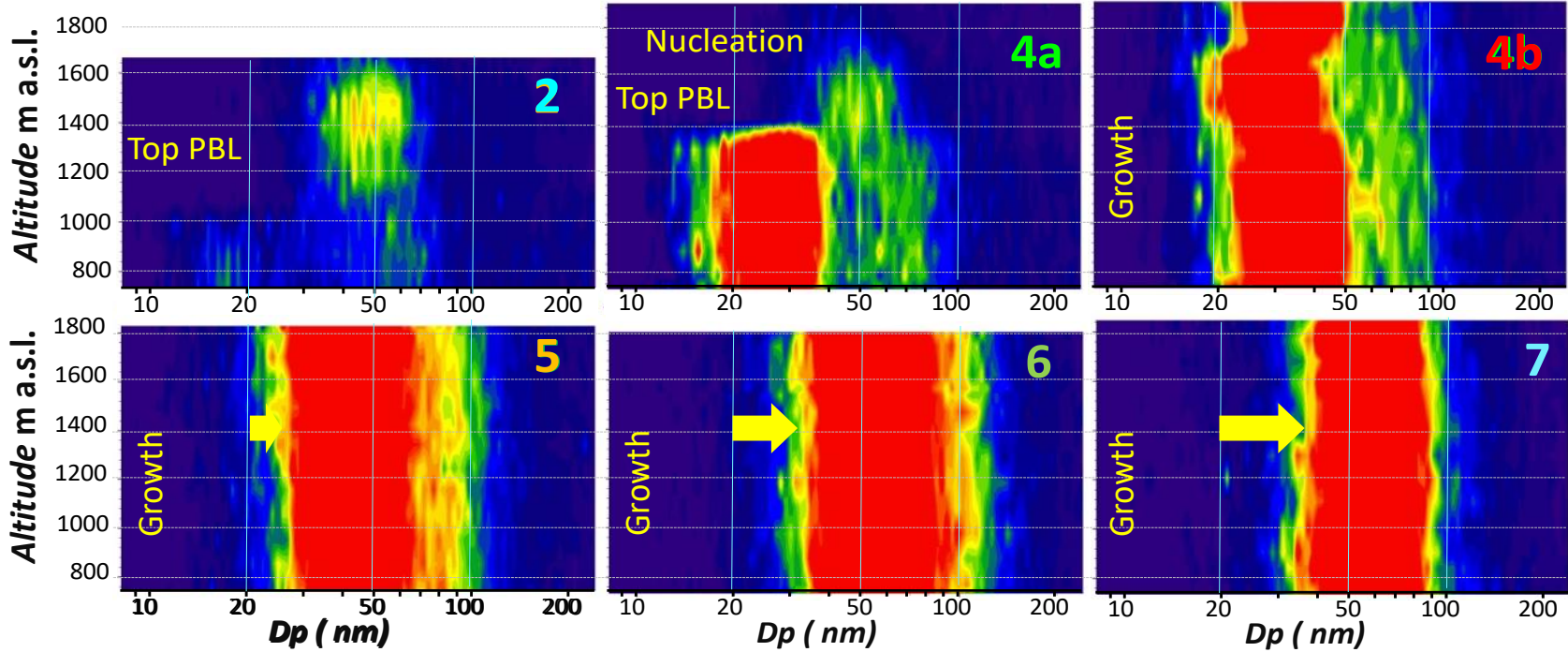
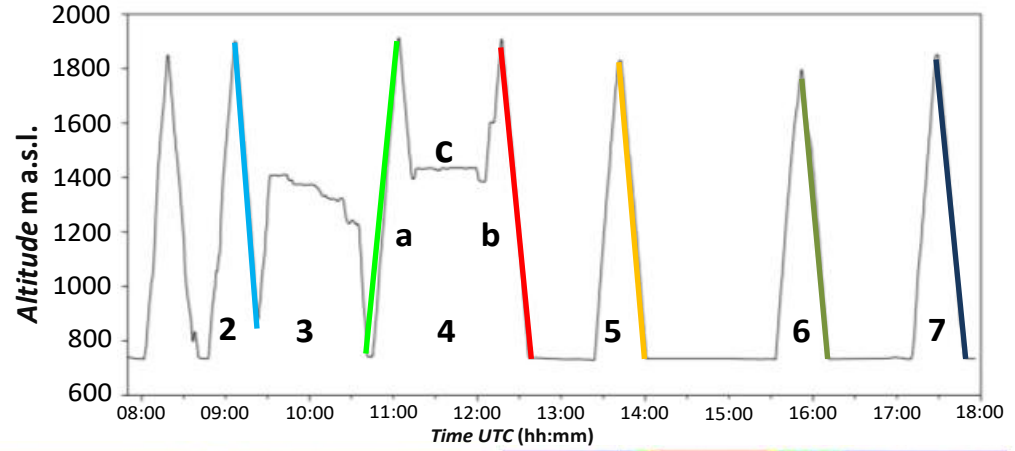
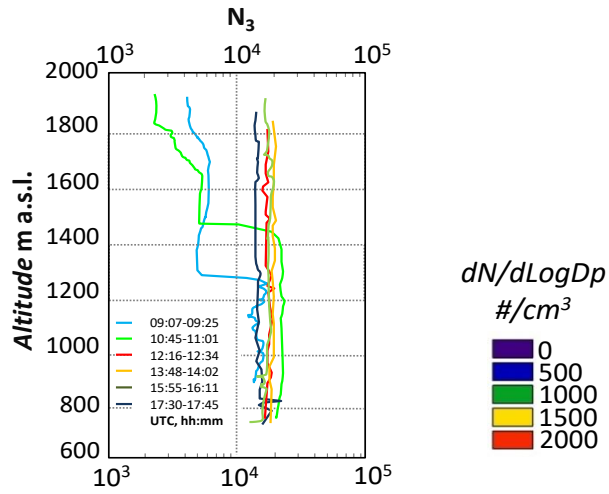
14/07/2016



Wind speed m/s

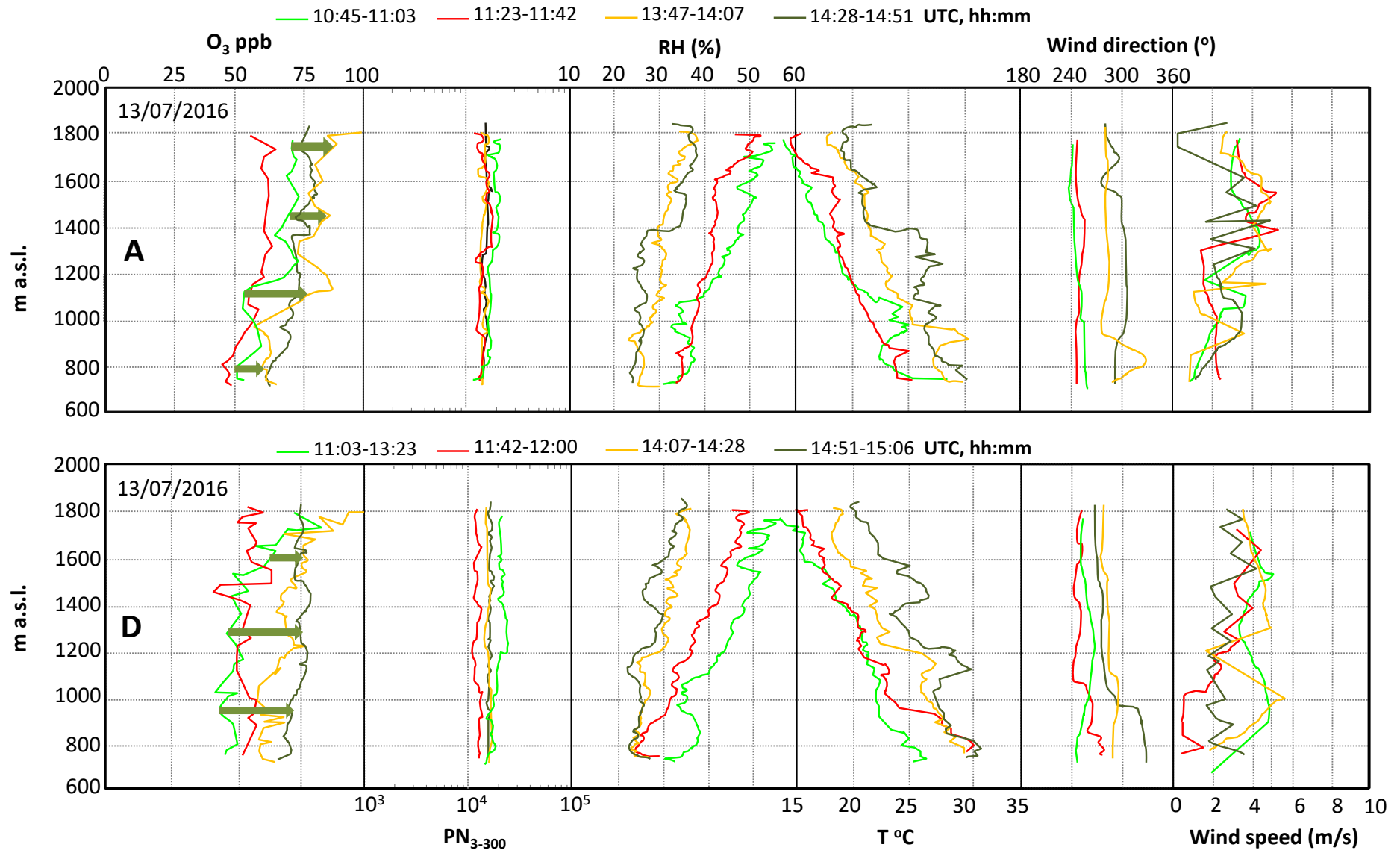
$PN_{3-300}$

# UFP & O<sub>3</sub> Madrid campaign July 2016



# UFP & O<sub>3</sub> Madrid campaign July 2016

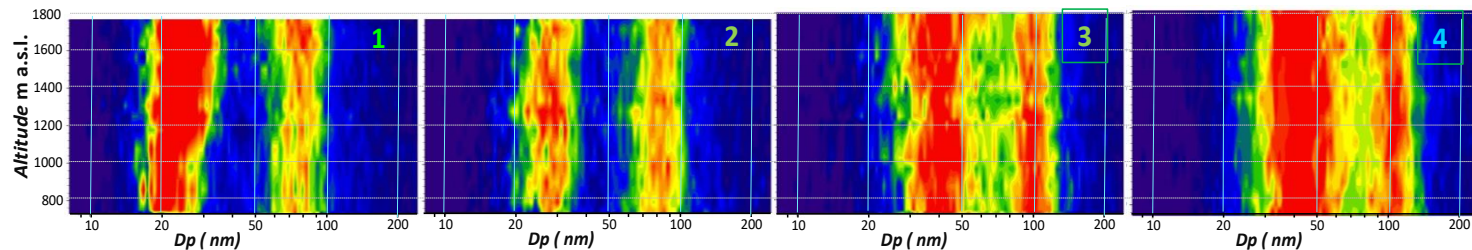
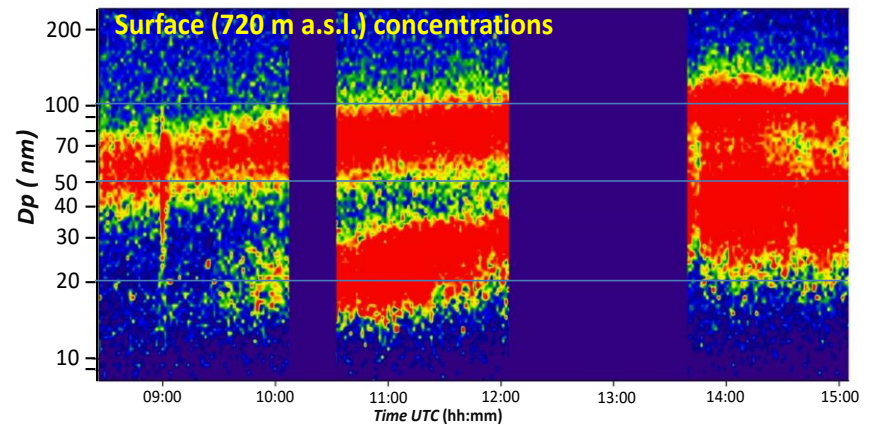
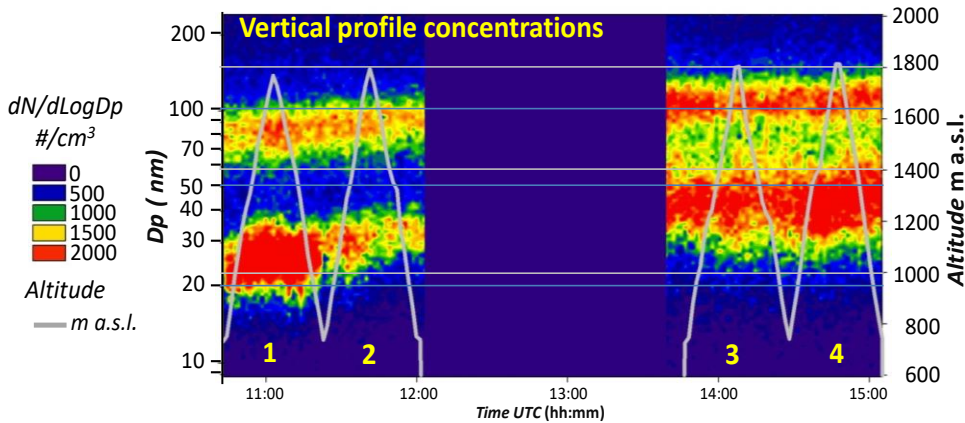
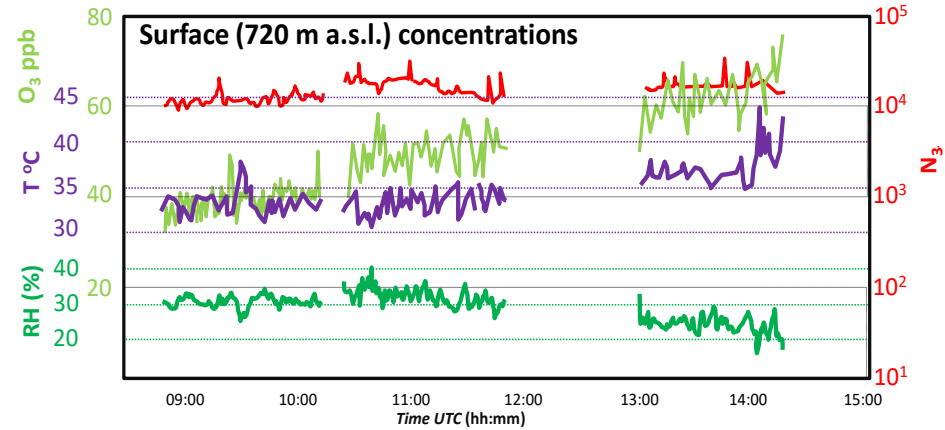
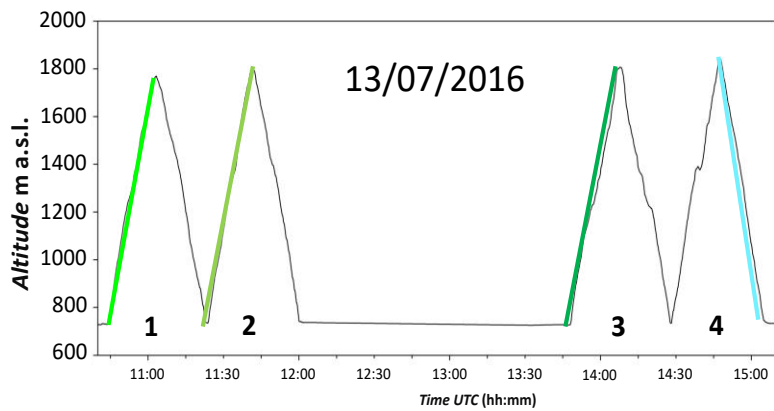
13/07/2016





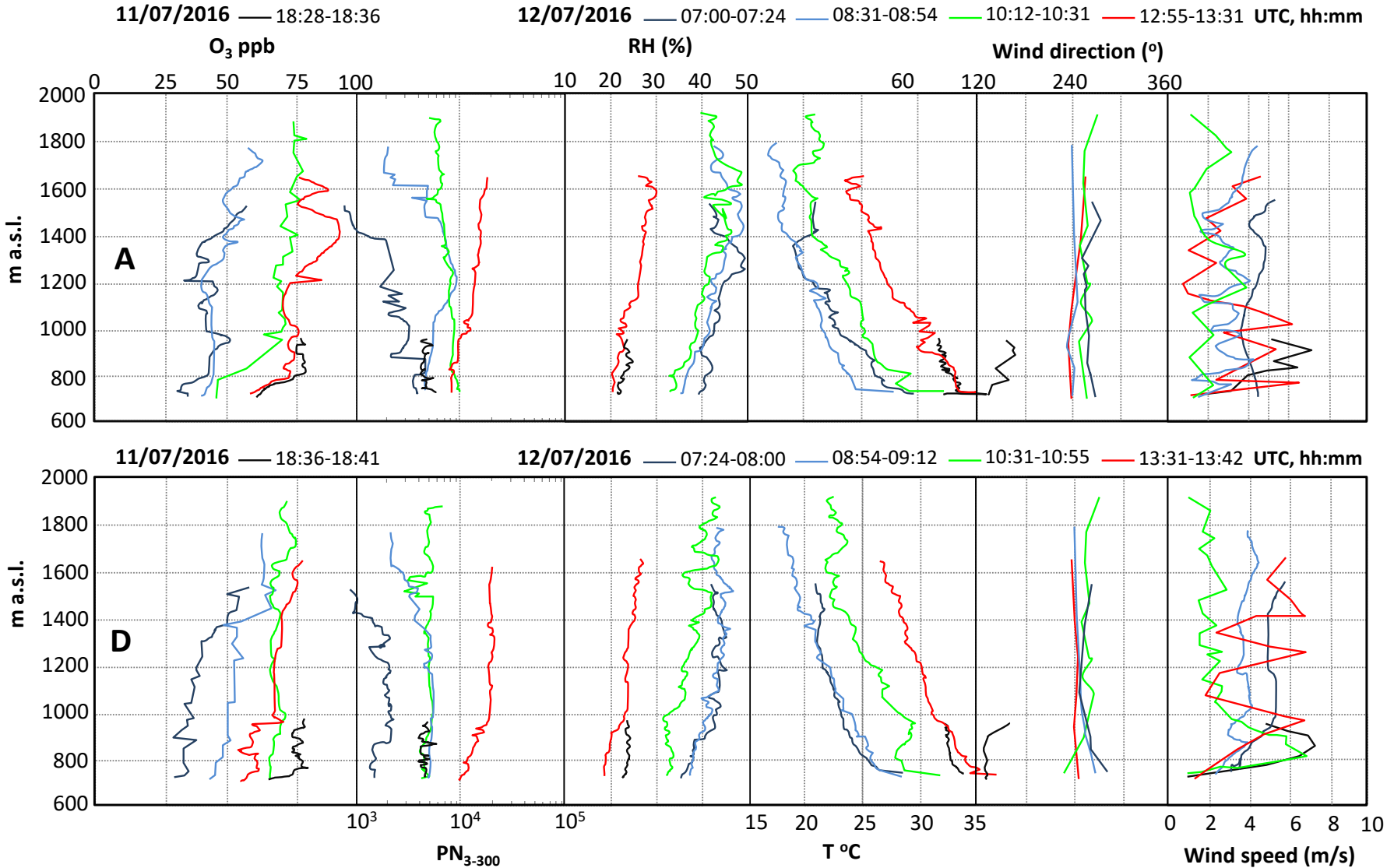
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13/07/2016



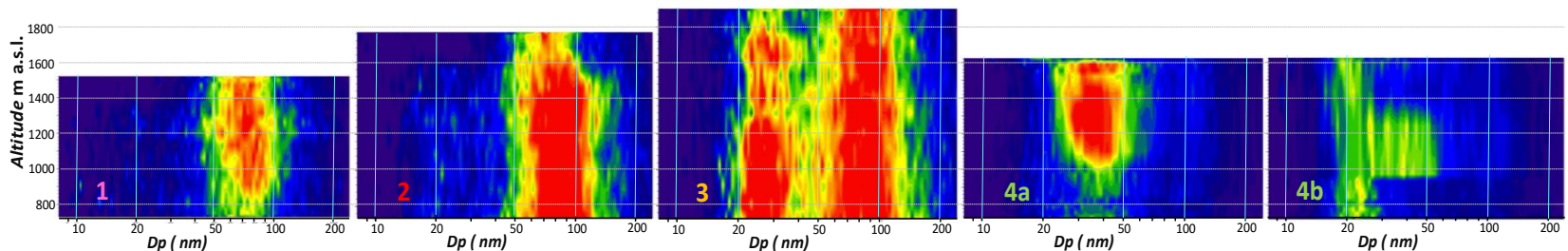
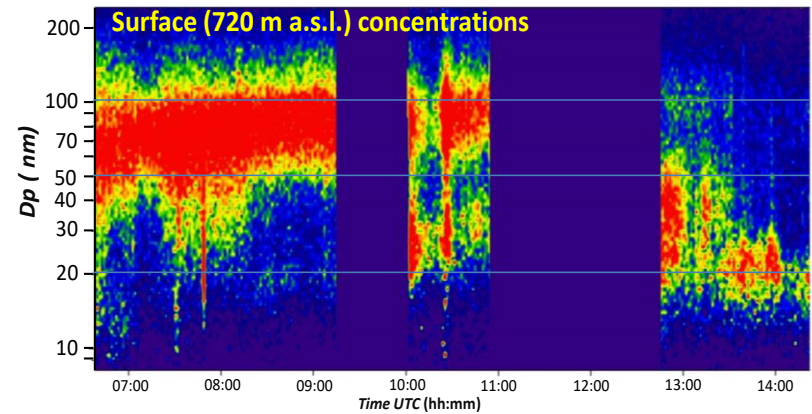
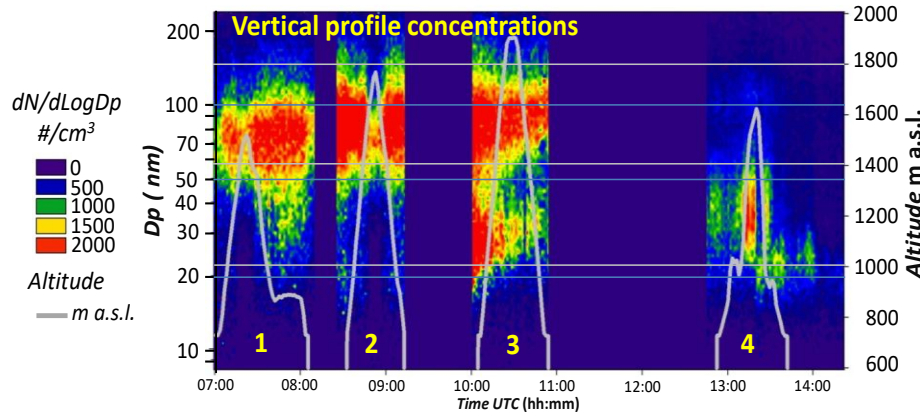
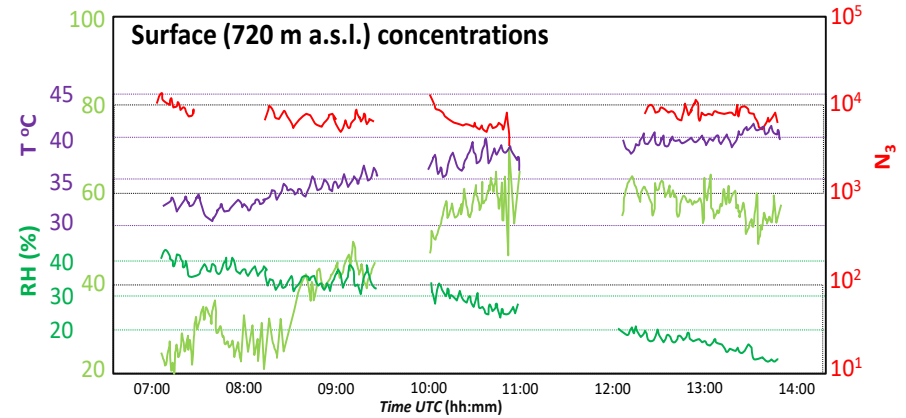
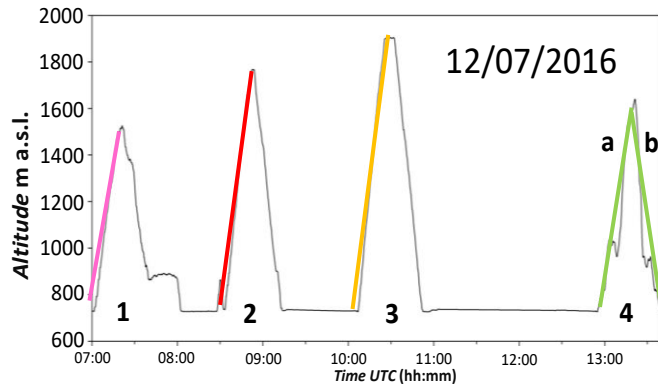
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11-12/07/2016

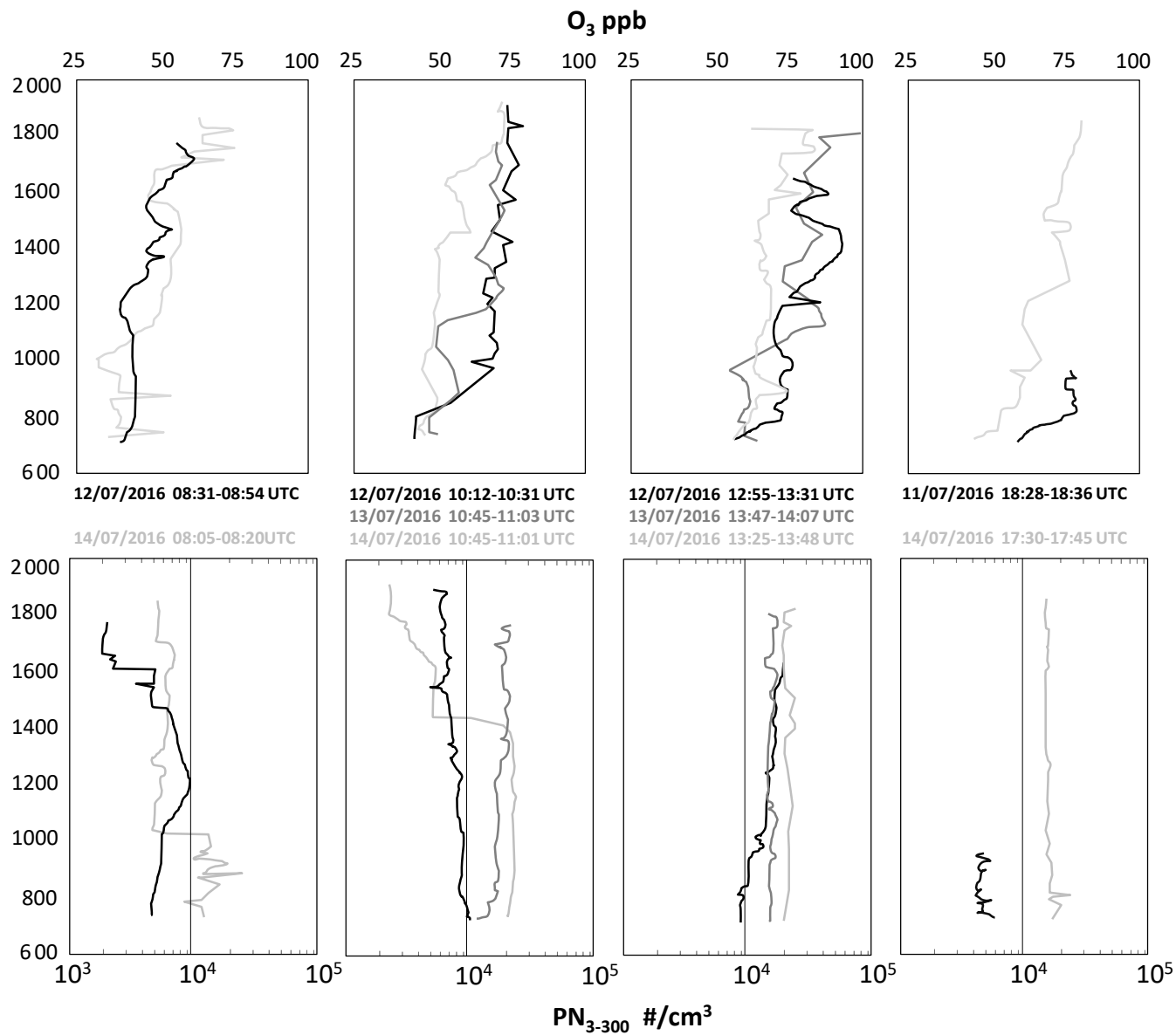


# UFP & O<sub>3</sub> Madrid campaign July 2016

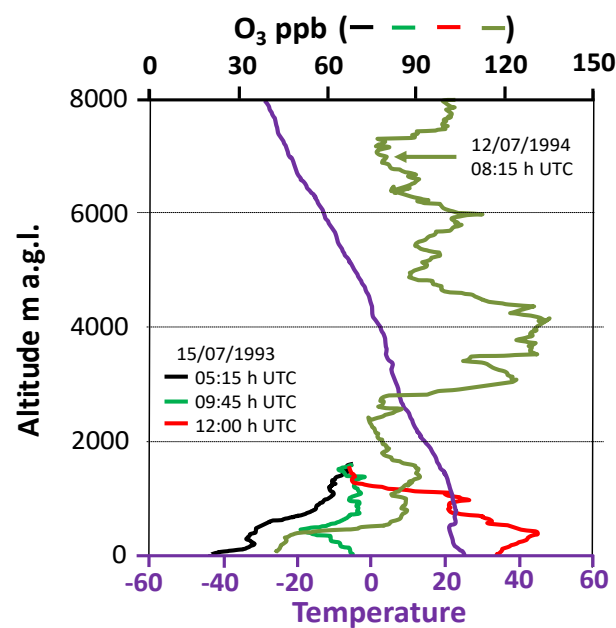
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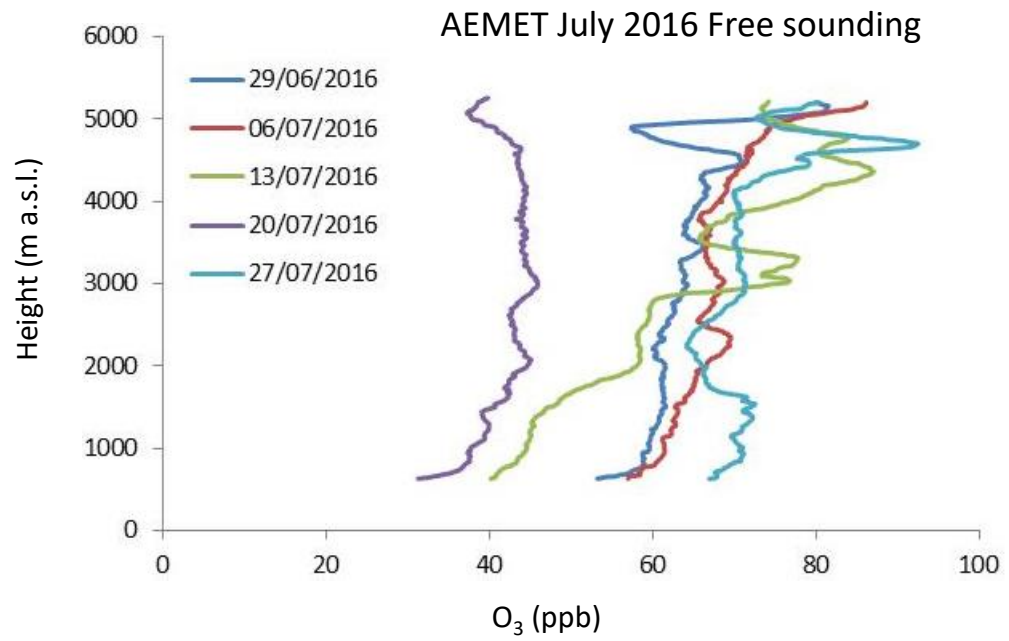
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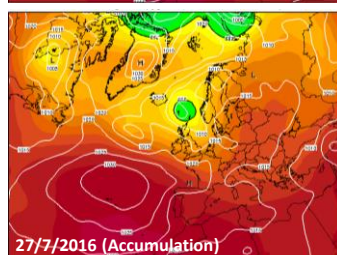
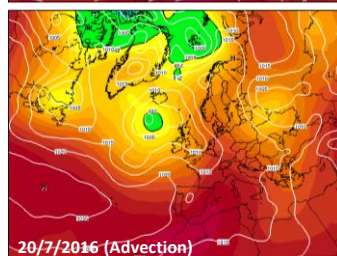
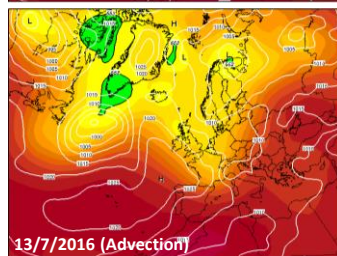
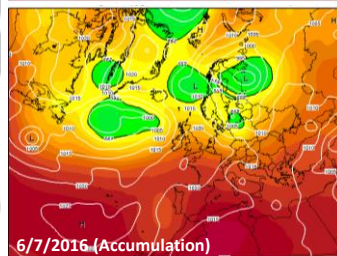
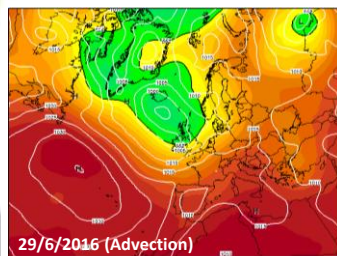
# UFP & O<sub>3</sub> Madrid campaign July 2016



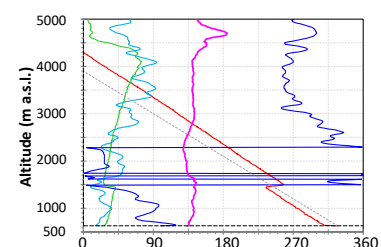
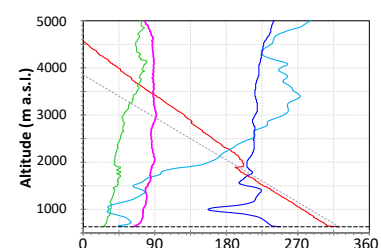
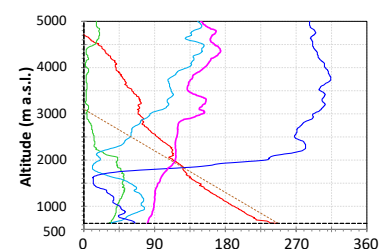
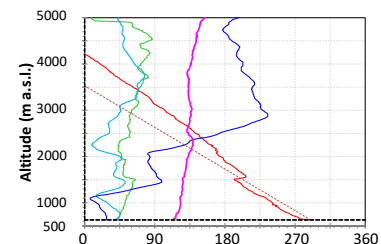
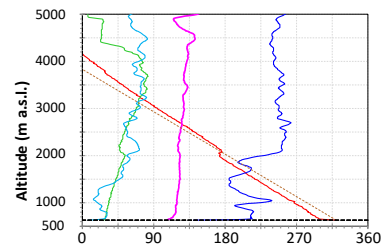
Plaza et al., 1997

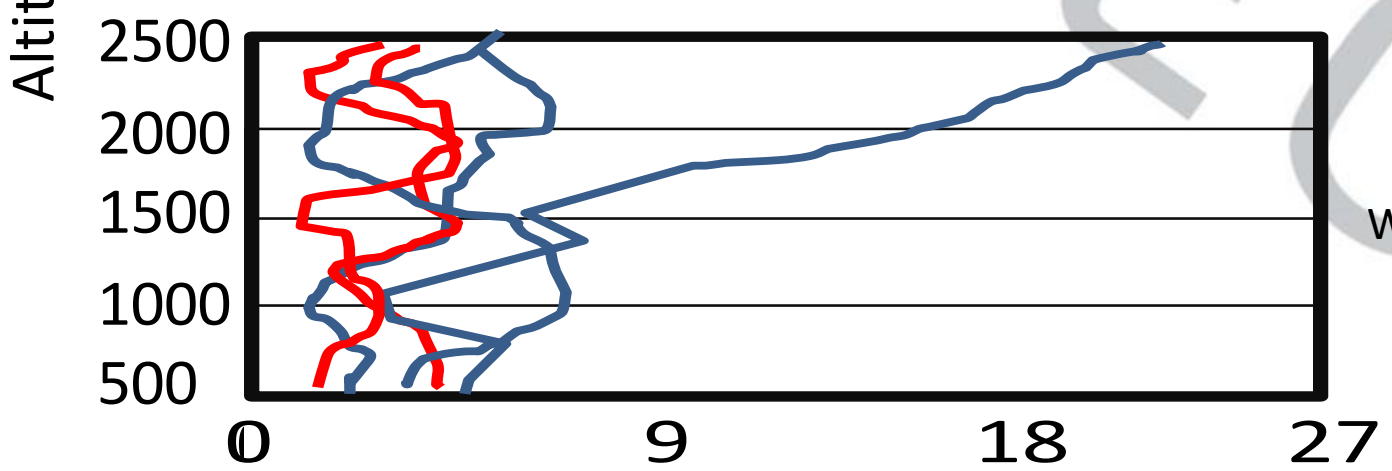
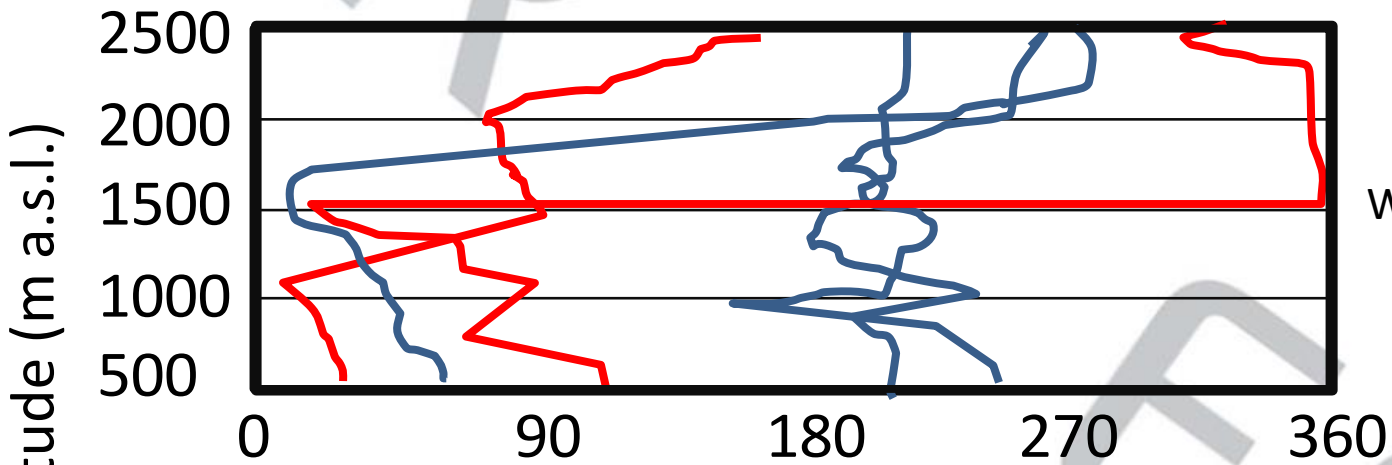
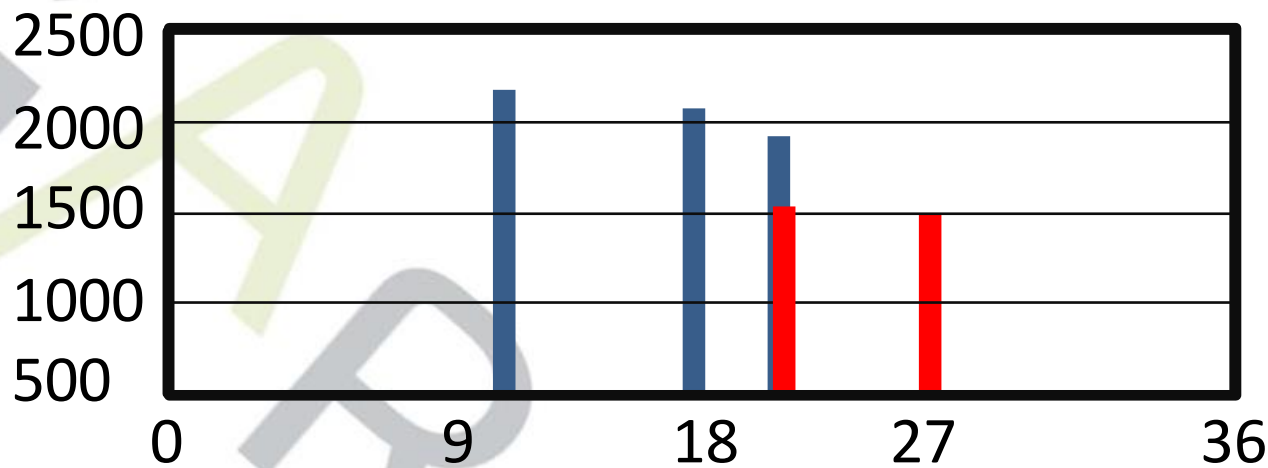


# UFP & O<sub>3</sub> Madrid campaign July 2016

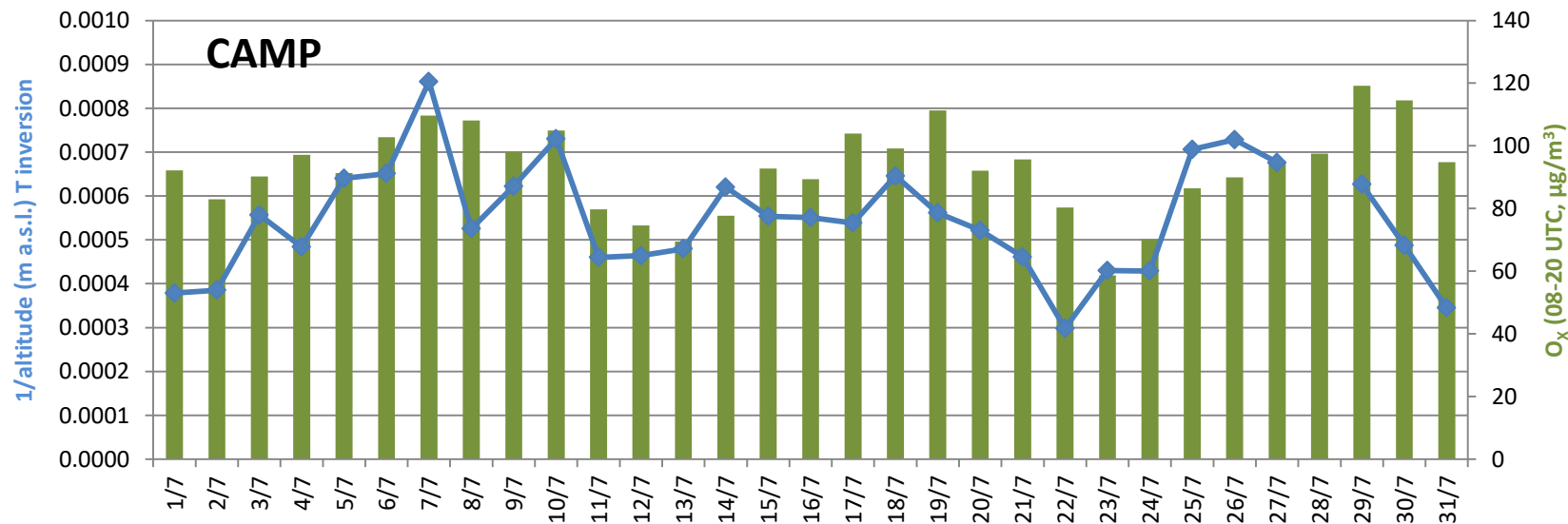
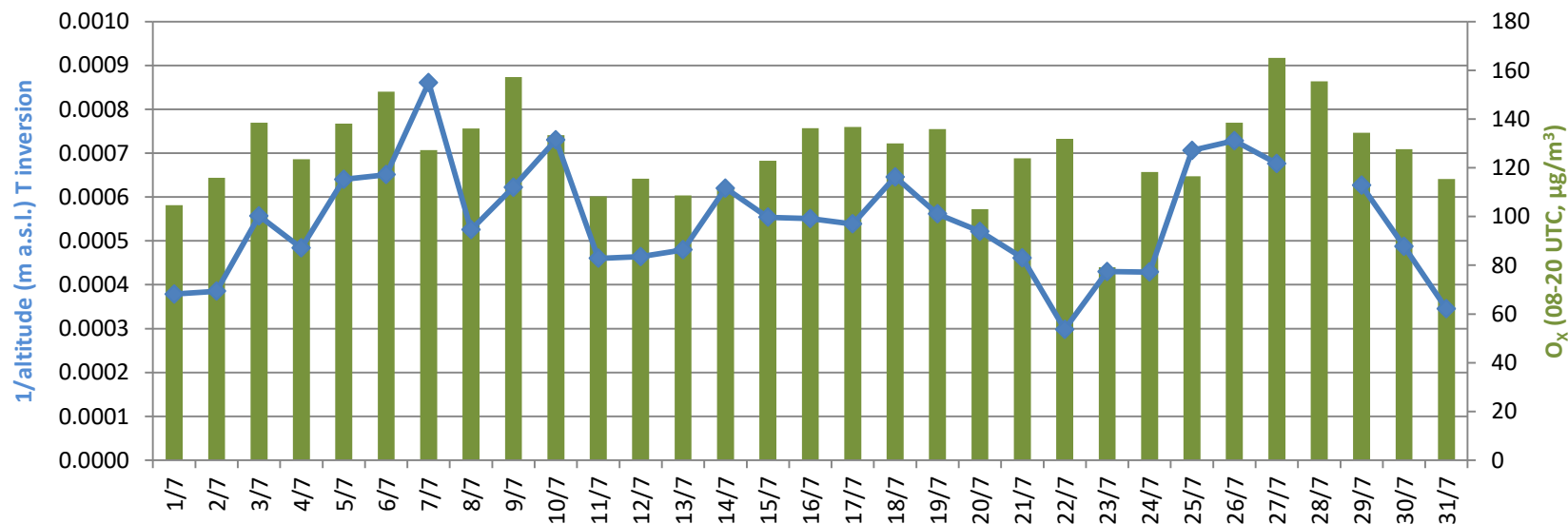


- T (x10°C)
- RH (%)
- WVEL (x10m/s)
- WDIR (deg)
- O<sub>3</sub> (x2ppb)



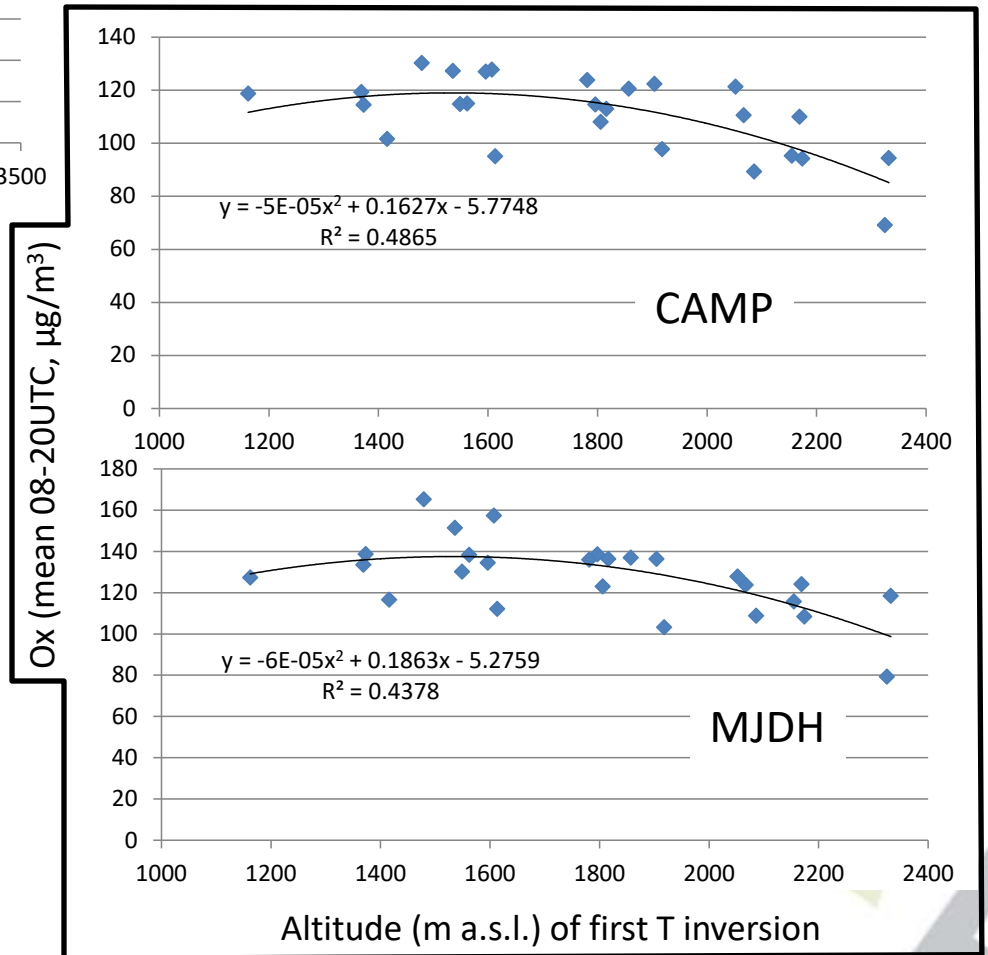
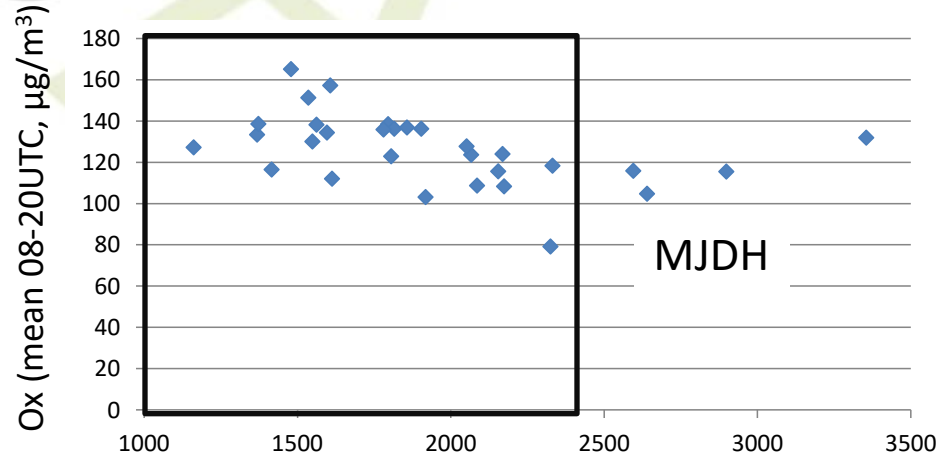


# UFP & O<sub>3</sub> Madrid campaign July 2016



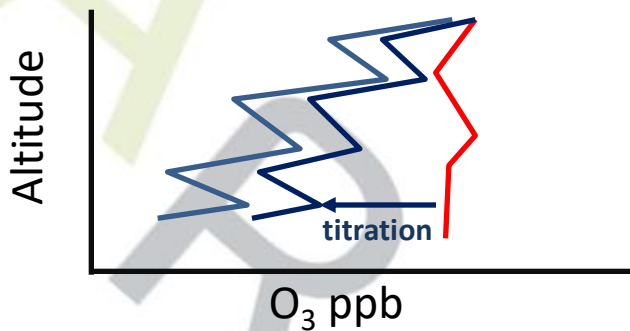


# UFP & O<sub>3</sub> Madrid campaign July 2016



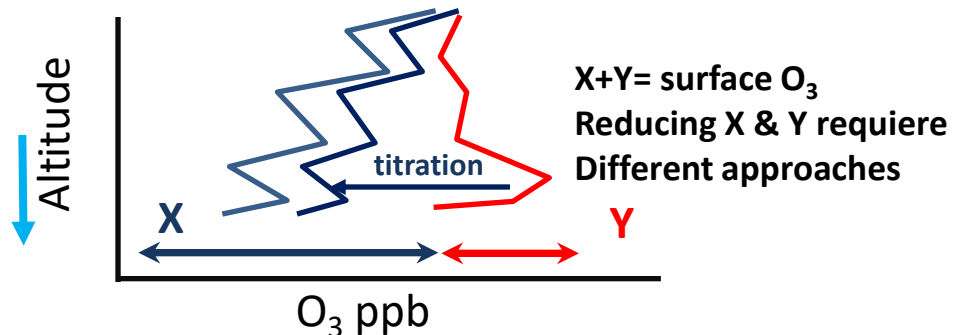
# UFP & O<sub>3</sub> Madrid campaign July 2016

## ADVECTIVE EPISODE



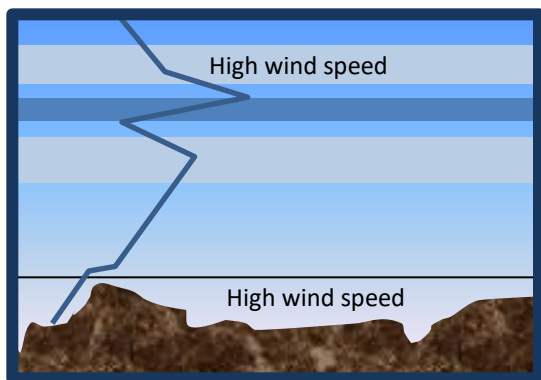
Night-midday

## ACCUMULATIVE EPISODE



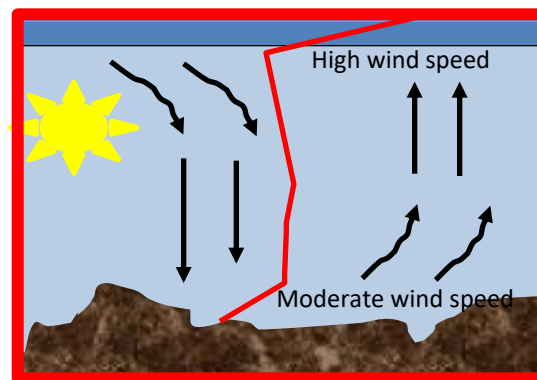
Midday-afternoon

afternoon-night



Reserve strata  
high O<sub>3</sub> (external????)

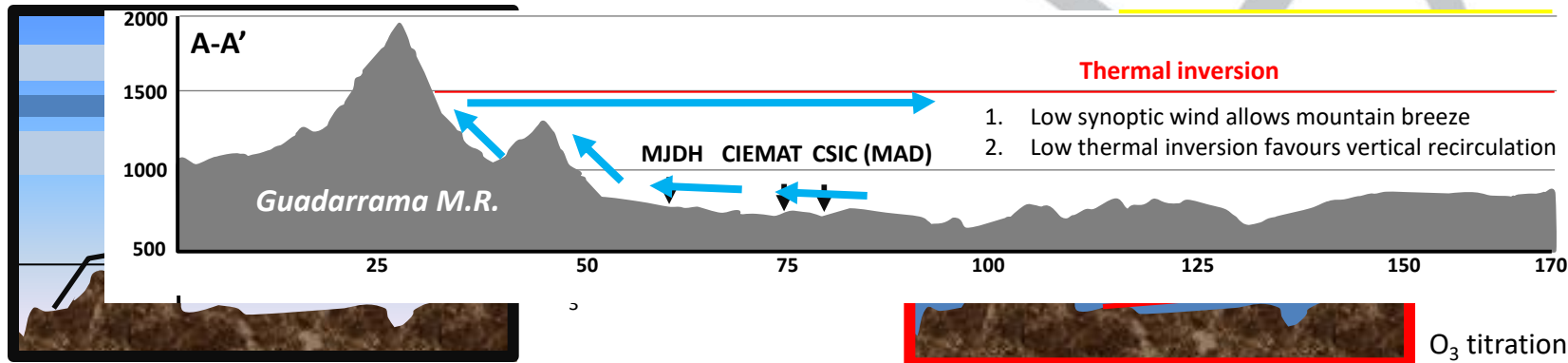
PBL  
O<sub>3</sub> nocturnal titration



High PBL thickness:  
mixing and fumigation

**Advective conditions**  
at surface avoiding  
accumulation

O<sub>3</sub> titration at lower levels

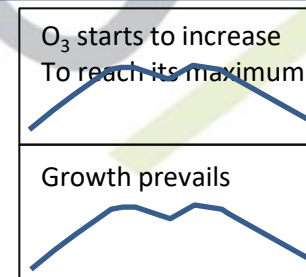
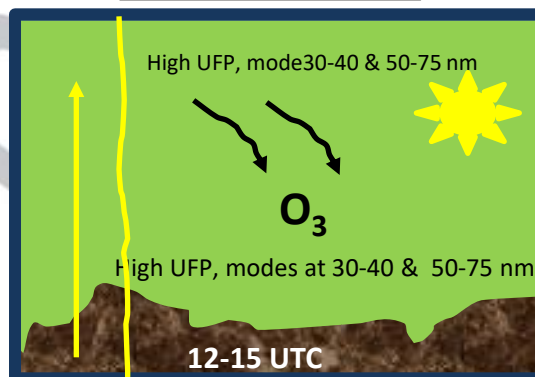
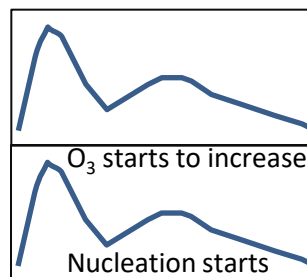
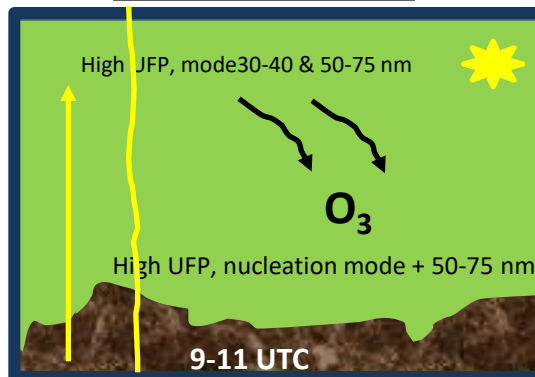
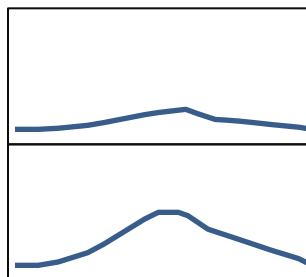
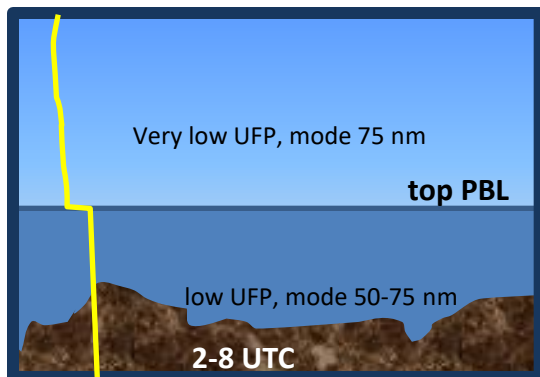
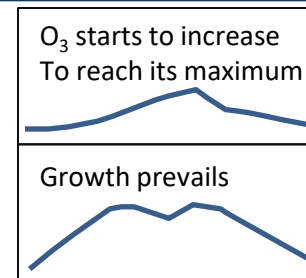
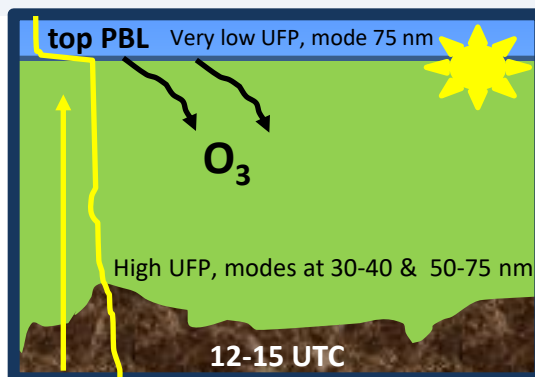
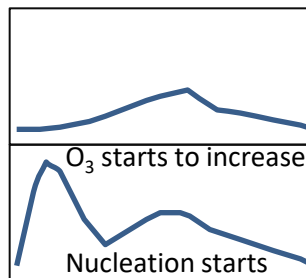
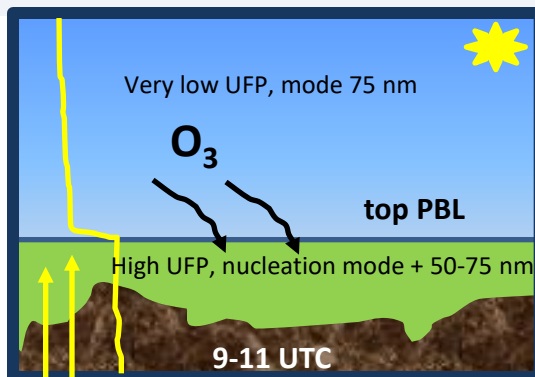
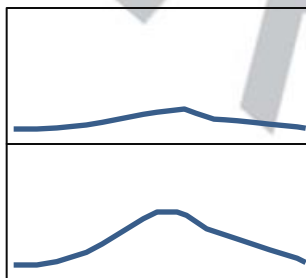
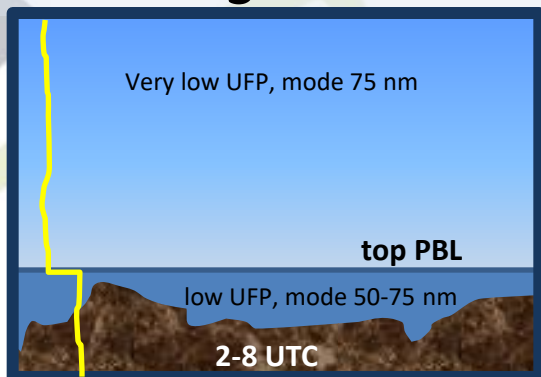


- Thermal inversion**
1. Low synoptic wind allows mountain breeze
  2. Low thermal inversion favours vertical recirculation

ickness:  
migation  
**accumulation**  
Madrid plume  
cal production

O<sub>3</sub> titration at lower levels

# UFP & O<sub>3</sub> Madrid campaign July 2016



# Concluding remarks

- The highest O<sub>3</sub> episodes (>180µg/m<sup>3</sup> hourly O<sub>3</sub>) have both regional-long range transport and regional-local components, the latter being prevalent in specific periods around Madrid and Barcelona
- We showed that using AQ data we can determine when the latter is prevalent
- However, the regional contribution is very complex because is determined by vertical recirculations cycles (Millán et al., 1997 and 2000) accumulating O<sub>3</sub>
- To evaluate possible effect of mitigation actions for these intense pollution episodes we need to:
  - Be able to forecast the episodes of synoptic stagnation dominated by vertical recirculation cycles , PBL height and external high altitude O<sub>3</sub> strata.
  - Carrying out sensitivity analysis for abatement of NO<sub>x</sub> and AVOCs for these specifically
- Obviously the O<sub>3</sub> problem is not only concerned to the exceedances of the information threshold value, but also the human protection and AOT40 targets. These are exceeded around Madrid and in the Southern and Mediterranean sides
- The fact that we found a clear OMI 2005-2015 NO<sub>2</sub> decrease at regional scale with low effect on mean regional O<sub>3</sub> (constantly high along the period) points to the complexity of abating mean O<sub>3</sub> levels, but we should study also the peak episodes

# Acknowledgements

Thank you very much for your attention!!!!  
[xavier.querol@idaea.csic.es](mailto:xavier.querol@idaea.csic.es)

