

Episodios de ozono en España

X. Querol¹, A. Alastuey¹, C. Carnerero¹, N. Pérez¹, J. Massagué¹, G. Gangoiti², L. Alonso²,
E.Mantilla³, J.J.Diéguez³, M.Escudero⁴, M.Hervás⁵, A.Campos⁵, I.Olivares⁵, M.B Larka⁵, J.R.Moreta⁶, M.Millán³

¹Instituto de Diagnóstico Ambiental y Estudios del Agua (IDAEA-CSIC), Barcelona

²E.T.S. Ingeniería de Bilbao, Dpto. Ingeniería Química y del Medio Ambiente, Universidad País Vasco UPV/EHU, Bilbao

³Centro de Estudios Ambientales del Mediterráneo, CEAM, Unidad Asociada al CSIC, Valencia

⁴Centro Universitario de la Defensa de Zaragoza, Academia General Militar, Zaragoza

⁵D.G. Calidad y Evaluación Ambiental, Ministerio para la Transición Ecológica, Madrid

⁶Agencia Estatal de Meteorología, AEMET, Madrid



Bases científico técnicas para la mejora de la calidad del aire en España
Valencia, 11-13 de junio 2019



Contenido

- Conceptos básicos del O_3
- Niveles de O_3 en España y tendencias temporales
- Origen de episodios de O_3 en España

house.

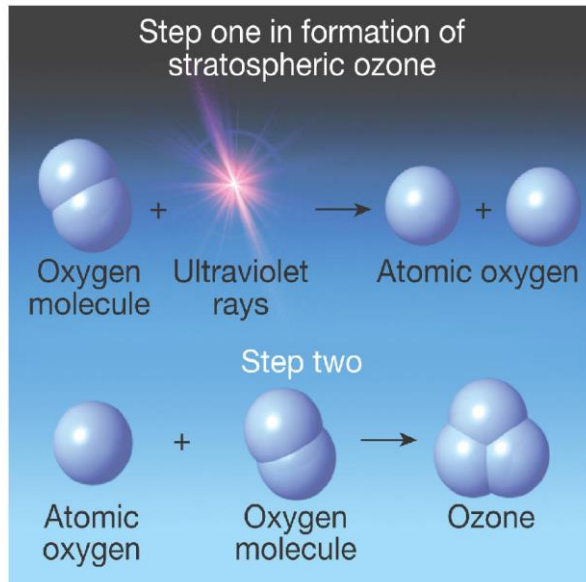
HIGH OZONE, ULTRAFINE PARTICLES AND
SECONDARY ORGANIC AEROSOLS
CGL2016-78594-R



Generalitat de Catalunya
Departament de Territori i Sostenibilitat

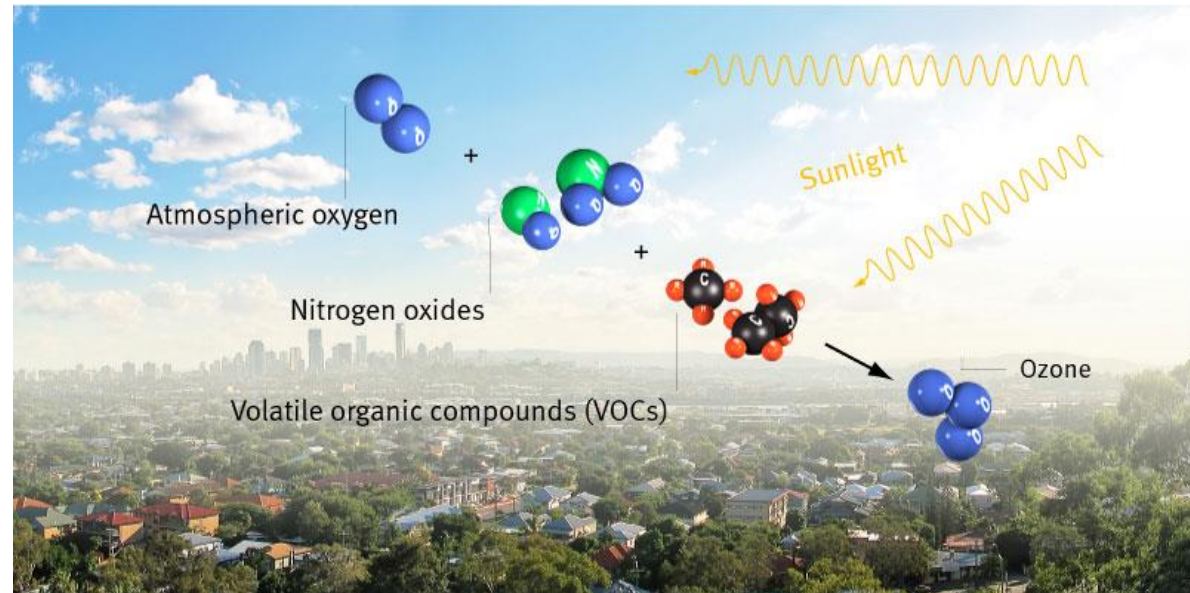


O_3 a la estratosfera



<http://www.geo.hunter.cuny.edu>

O_3 a la troposfera



<https://www.qld.gov.au/environment/pollution/monitoring/air-pollution/ozone/>

Queensland State Government, Australia

El O₃ troposférico

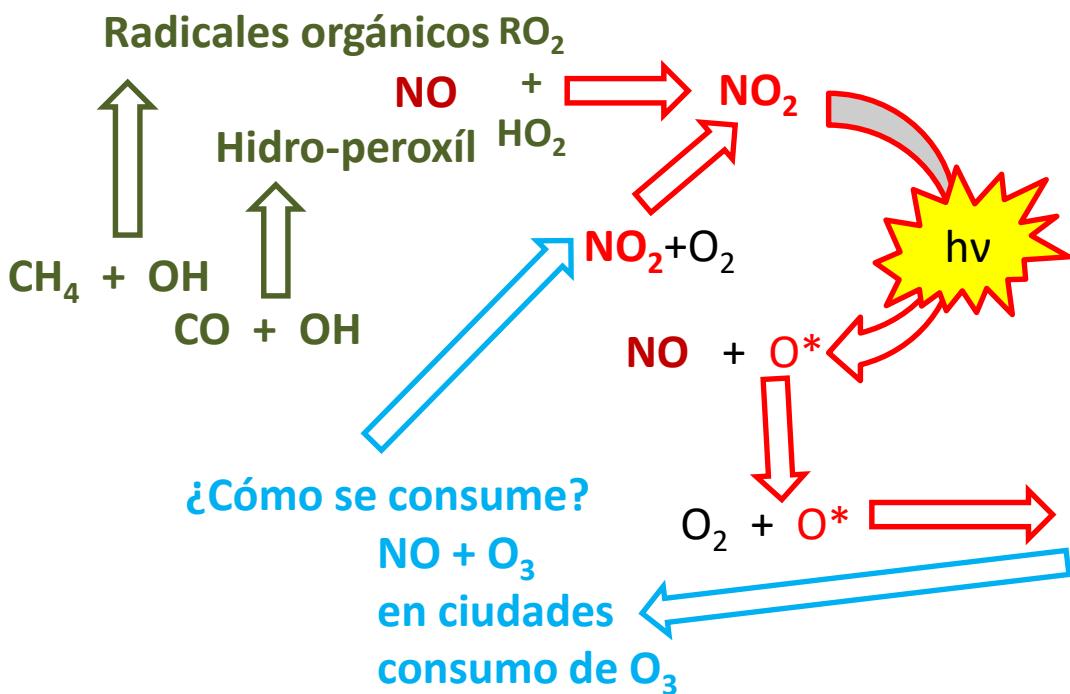
COVs relevantes para formar O₃

- Alcanos
- Alquenos
- Carbonilos (aldehídos y cetonas)
- HAP
- Alcoholes
- Peróxidos orgánicos
- COVs halogenados

Vida media en atmósfera

- Isopreno 1h
- Metano 10 años

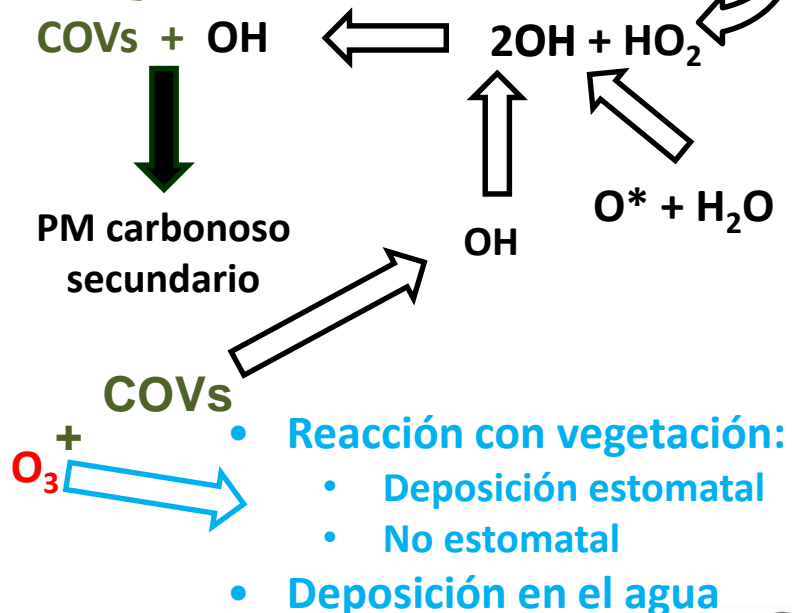
¿Cómo se genera O₃?



¿Cómo se consume?

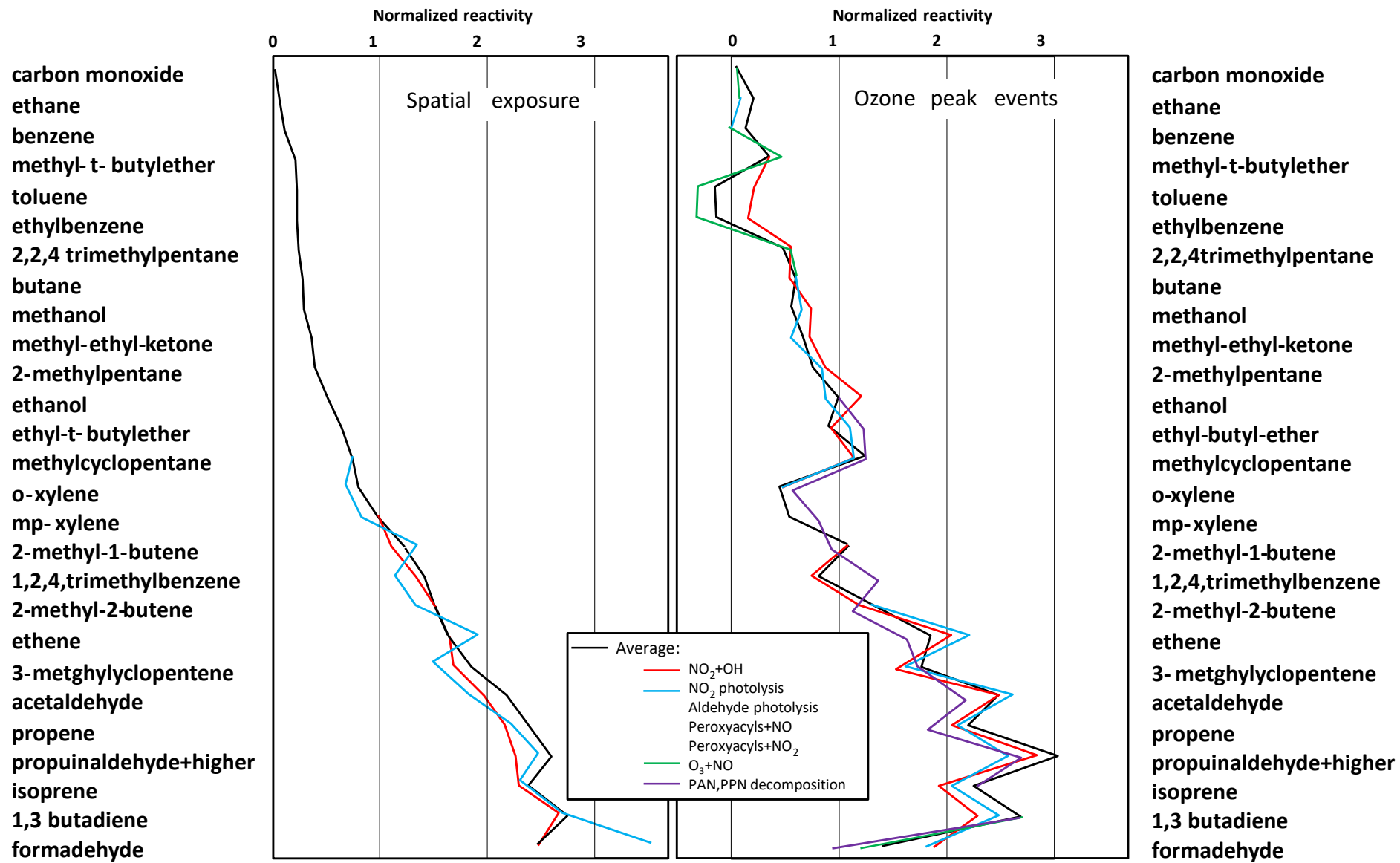
NO + O₃
en ciudades
consumo de O₃

Atmósferas contaminadas fotólisis de aldehídos, HONO y H₂O₂



El O₃ troposférico

Reactividad de los COVs



Potencial de formación de O₃ en base a COVs medidos con HR-ToF-PTRMS En Majadahonda (Madrid) Julio de 2016 (Querol X., et al., 2018, ACP)

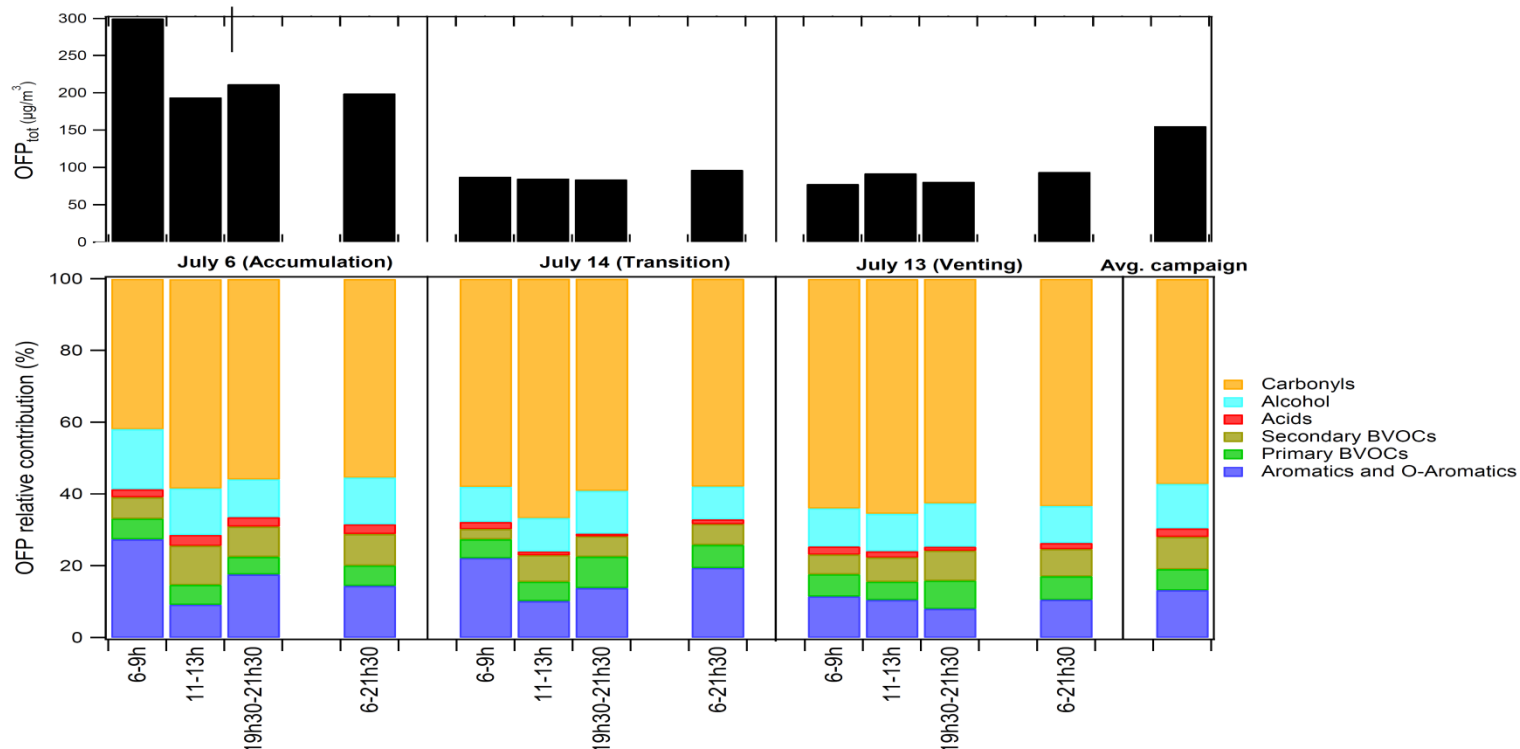
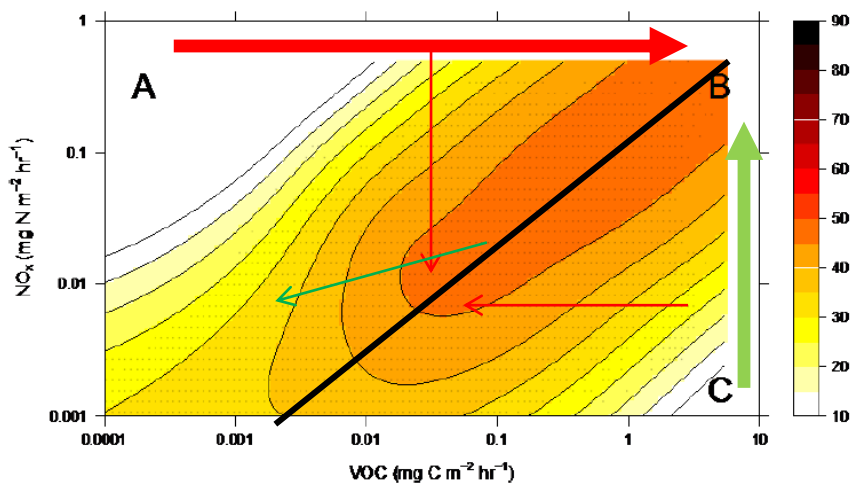


Figure S1. Ozone Formation Potential (OFP) and relative contribution of VOCs as measured by the PTR-ToF-MS (ISCIII site) to the total OFP for 3 selected days : 06/07/2016 (accumulation day), 14/07/2016 (transition day) and 13/07/2016 (venting day). For each day, we considered 3 distinct periods: Morning traffic peak (6:00-9:00 UTC), maximum insolation/biogenic VOC emissions period (11:00- 13:00 UTC), and evening traffic peak (19:30-21:30 UTC). Average daytime OFP (6:00-21:30 UTC) for each selected day as well as overall campaign average are also reported. PTR-MS measurements do not allow obtaining alkane/alkene concentrations and accordingly these are excluded in our OFP calculations.

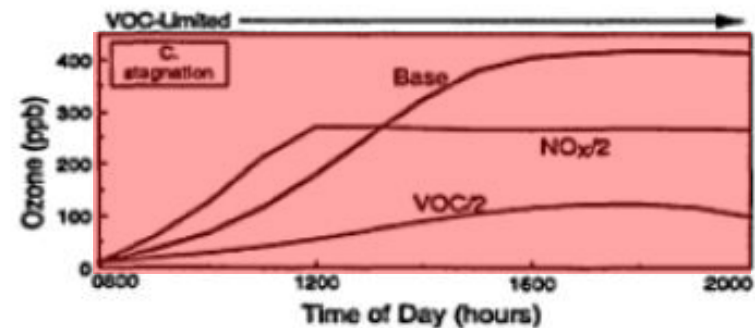
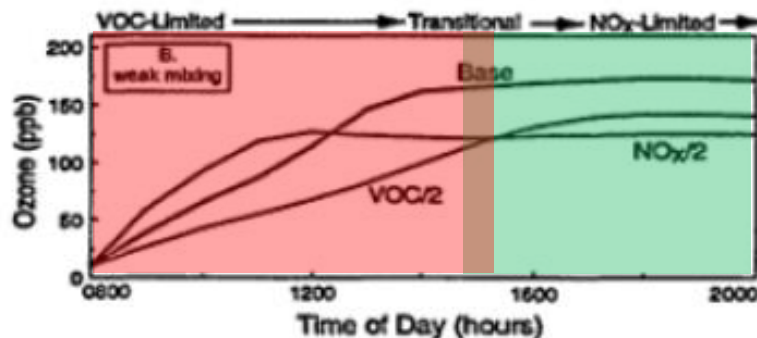
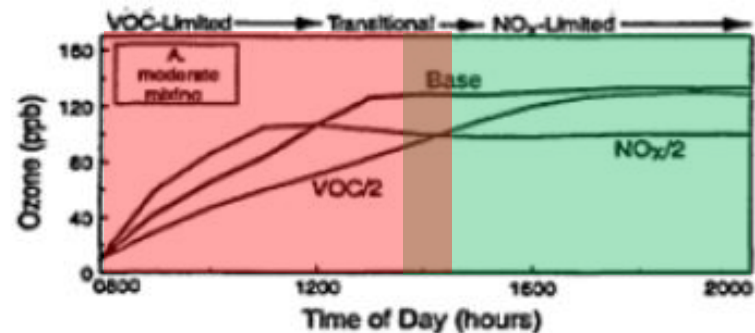
El O₃ troposférico

Sensitiva a los COVs Radicales OH < NO_x



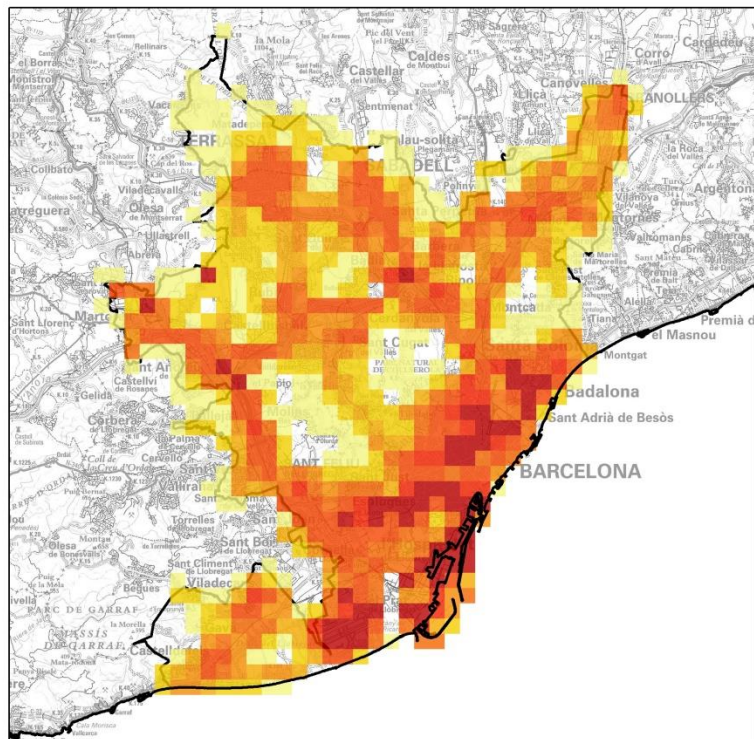
Monks et al., 2015, ACP

Sensitiva a los NO_x
Radicales OH > NO_x



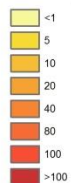
El O₃ troposférico

LOS PRECURSORES: NO_x



Emissions atmosfèriques de la ZPE

Emissions (t/any)



Emissions anuals de NO_x
totalts 2014

Direcció General de Qualitat Ambiental i Canvi Climàtic



Generalitat de Catalunya
Departament de Territori
i Sostenibilitat

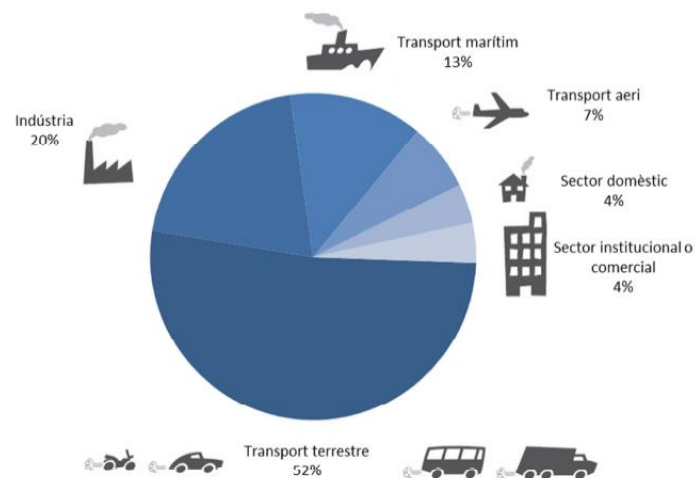
ETRS89

1:250.000



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Emissions NO_x 2014 (t/any)



2014

2011

Variació

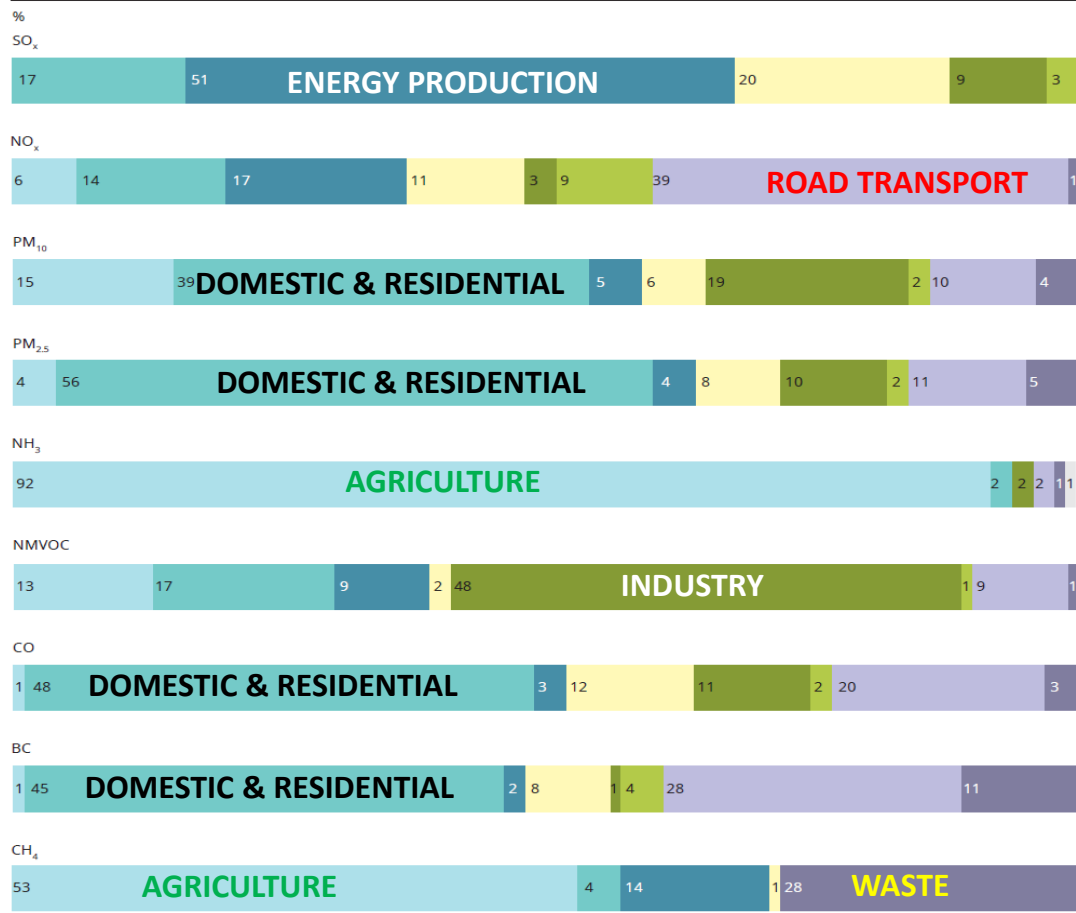
Sector	NO _x (t/any)	%NO _x	NO _x (t/any)	%NO _x	%NO _x
Transport terrestre	15.166	52	18.691	51	-19
Indústria	5.890	20	7.987	22	-26
Transport marítim	3.871	13	4.672	13	-17
Transport aeri	1.952	7	2.347	6	-17
Sector domèstic	1.142	4	1.292	4	-12
Sector institucional o comercial	1.141	4	1.497	4	-24
TOTAL	29.163	100	36.485	100	-20

El O₃ troposférico

EU-28 emisiones

LOS PRECURSORES: COVS

Figure 2.4 Contribution to EU-28 emissions from main source sectors in 2016 of SO_x, NO_x, primary PM₁₀, primary PM_{2.5}, NH₃, NMVOCs, CO, BC and CH₄



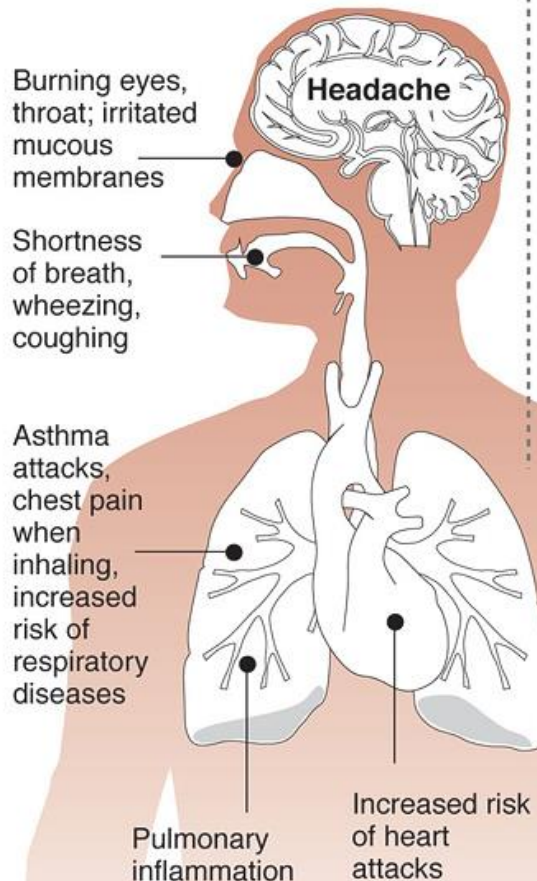
■ Agriculture
 ■ Commercial, institutional and households
 ■ Energy production and distribution
 ■ Energy use in industry
 ■ Industrial processes and product use
 ■ Non-road transport
 ■ Road transport
 ■ Waste
 ■ Other

Sources: EEA, 2018c, 2018e.

Why smog is harmful

Ozone, the main ingredient in smog, is one of the most widespread air pollutants and among the most dangerous.

Effects on health



How ozone forms

1 Oxygen in the atmosphere O₂

2 Nitric oxide, byproduct of combustion NO

3 Sunlight breaks up nitric oxide



4 Ozone formed by three oxygen atoms



U.S. ozone limits

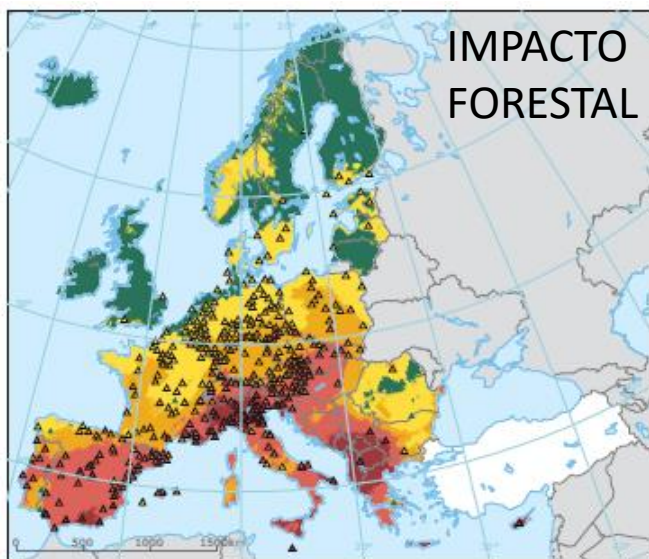
In parts per billion

• 1997-2008	84
• 2008-present	75
• New EPA proposal	60-70

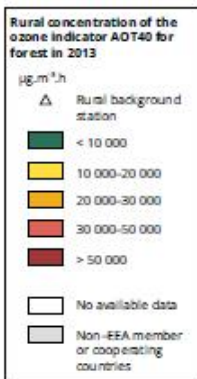
© 2010 MCT

Source: American Lung Association, State of the Air 2008, AP Graphic: Staff

El O₃ troposférico



IMPACTO FORESTAL



Source: ETC/ACM, 2016b.

Pérdidas globales para 2030 por disminución cosechas
17-35 billones \$/año

EU-28: 2020

Trigo 2.0 billones €/año

Tomate 0.6 billones €/año

EU-28: 2020:

0.1 billones €/año

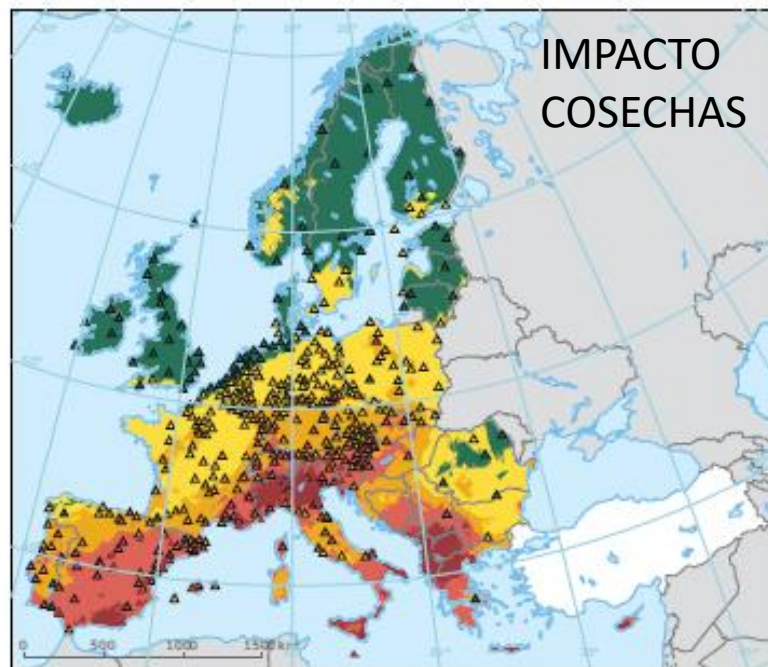
0.1 billones €/año

Funete: Ozone Pollution: A hidden threat for food security
WGE-ICP Vegetation, CEH, 2011, UK

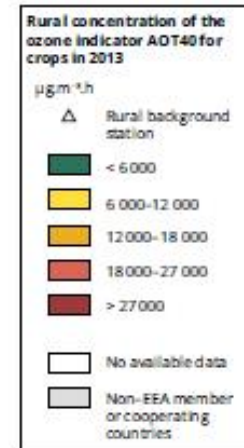
% bajada rendimiento producción por pasar de 60 µg/m³ a 120 µg/m³

Guisante y judía (-30%)	Alfalfa (-14%)
Boniato (-28%)	Sandía (-14%)
Naranja (-27%)	Tomate (-14%)
Cebolla (-23%)	Oliva (-13%)
Nabo (-22%)	Maíz (-10%)
Ciruela (-22%)	Arroz (-9%)
Lechuga (-19%)	Patata (-9%)
Trigo (-18%)	Cebada (-18%)
Soja (-18%)	Uva (-5%)

Fuente: Ozone Pollution: A hidden threat for food security
WGE-ICP Vegetation, CEH, 2011, UK



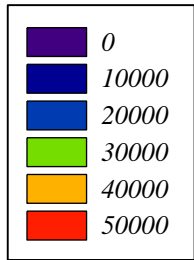
IMPACTO COSECHAS



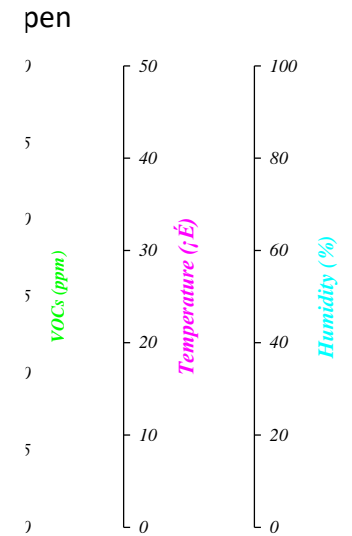
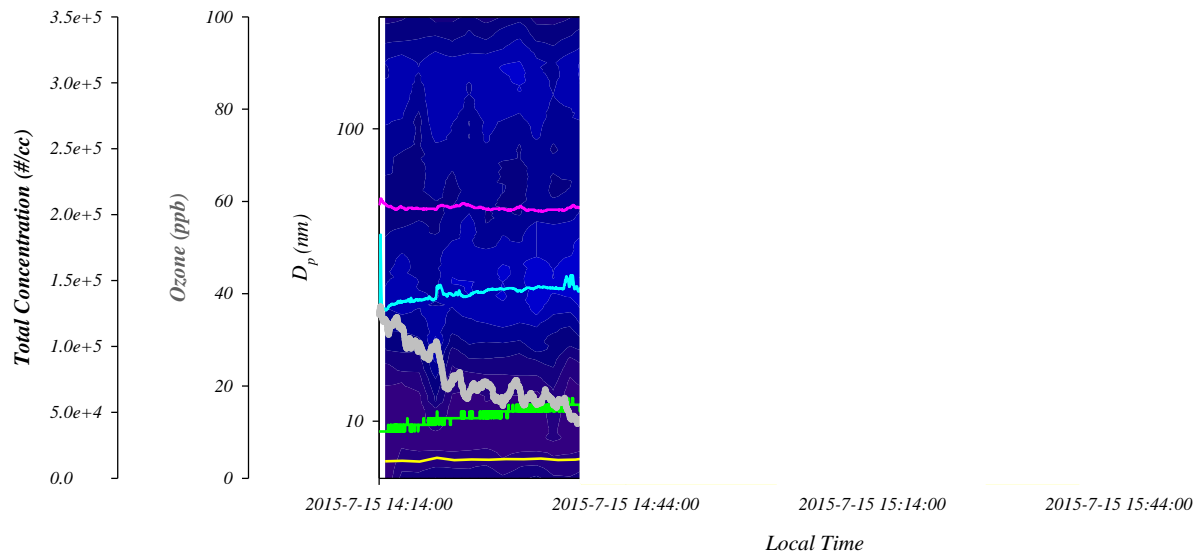
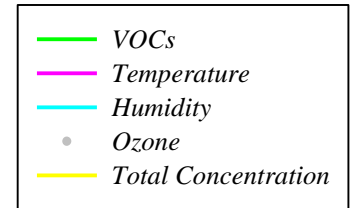
Source: ETC/ACM, 2016b.

El O₃ troposférico

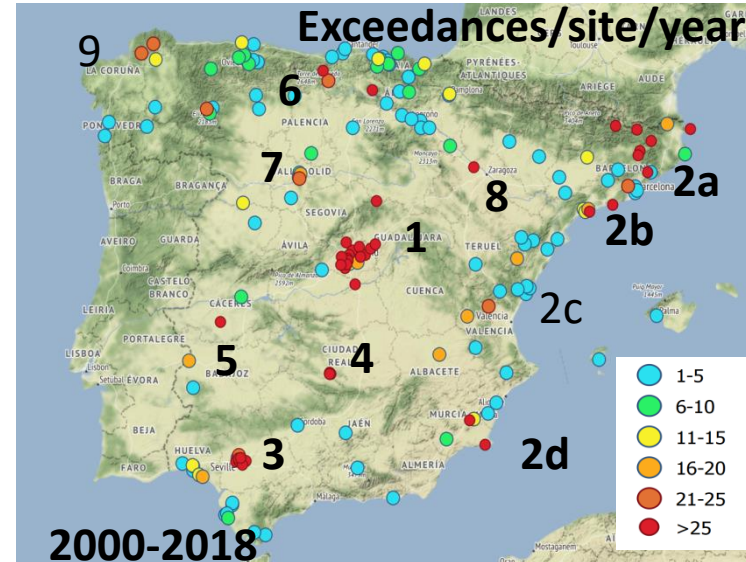
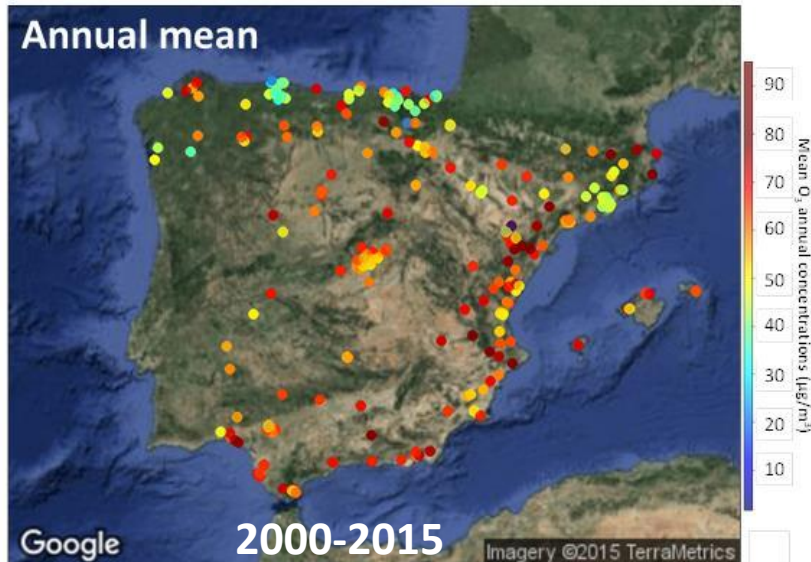
$dN/d\text{Log}D_p$ (#/cc)



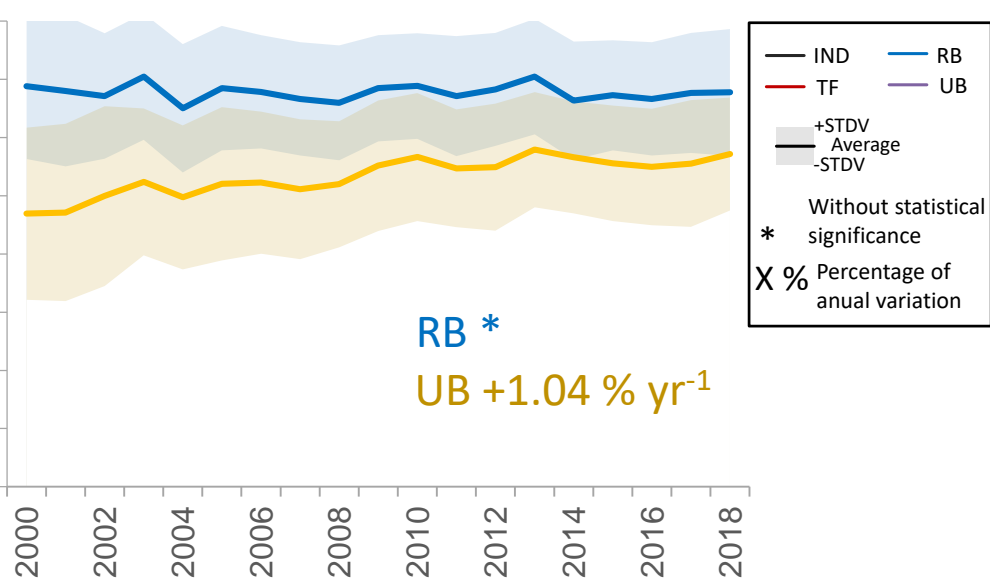
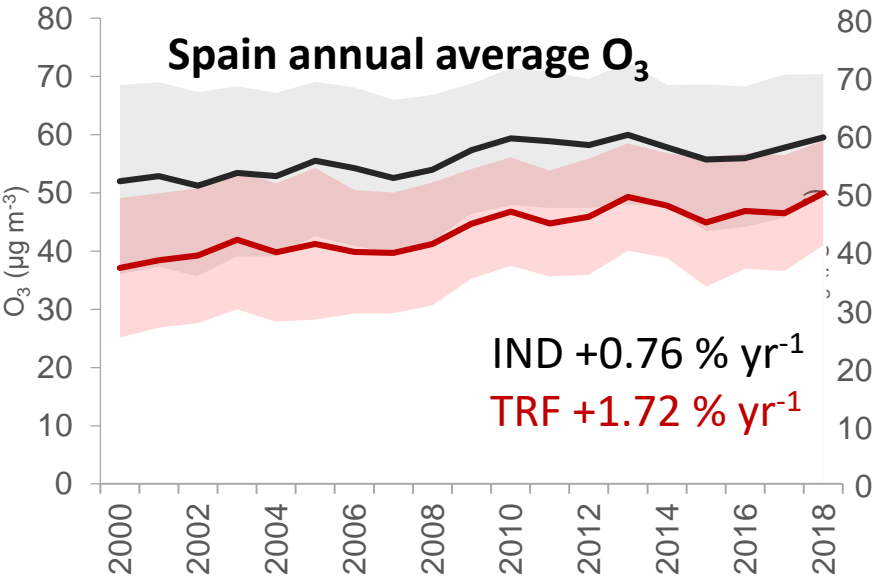
20150715_Classroom Test : w/ Ozone data



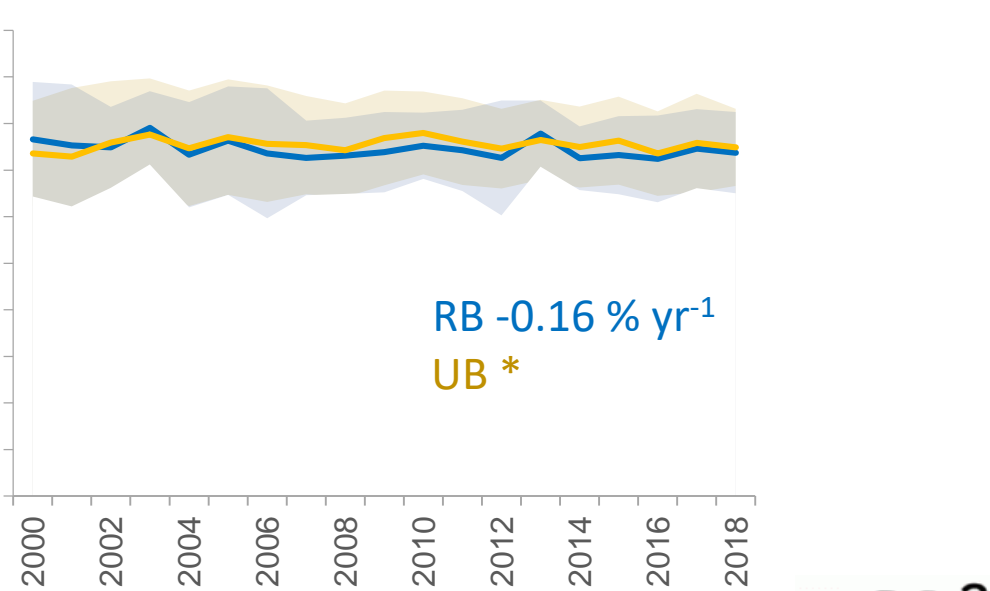
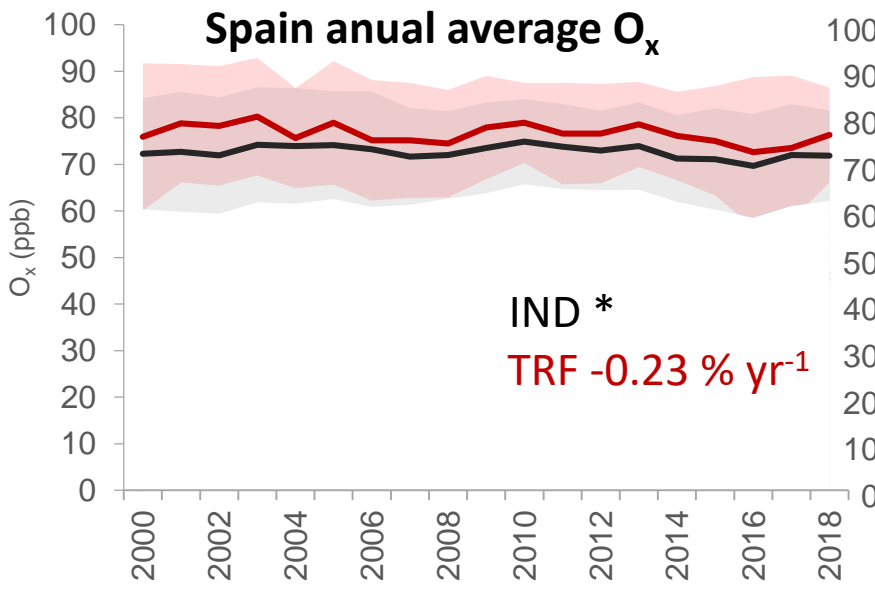
Niveles de O₃ en España



Niveles de O₃ en España



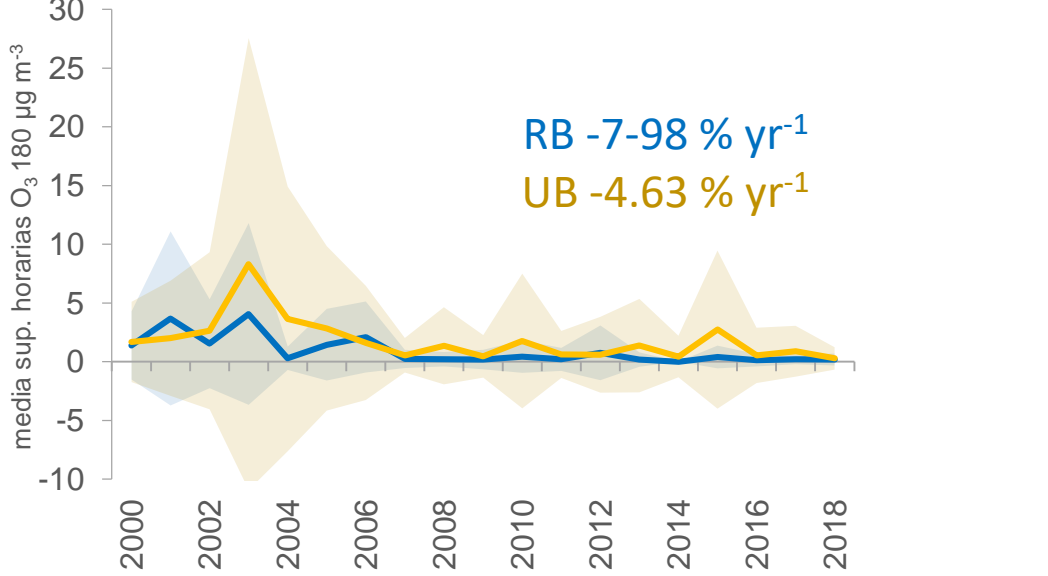
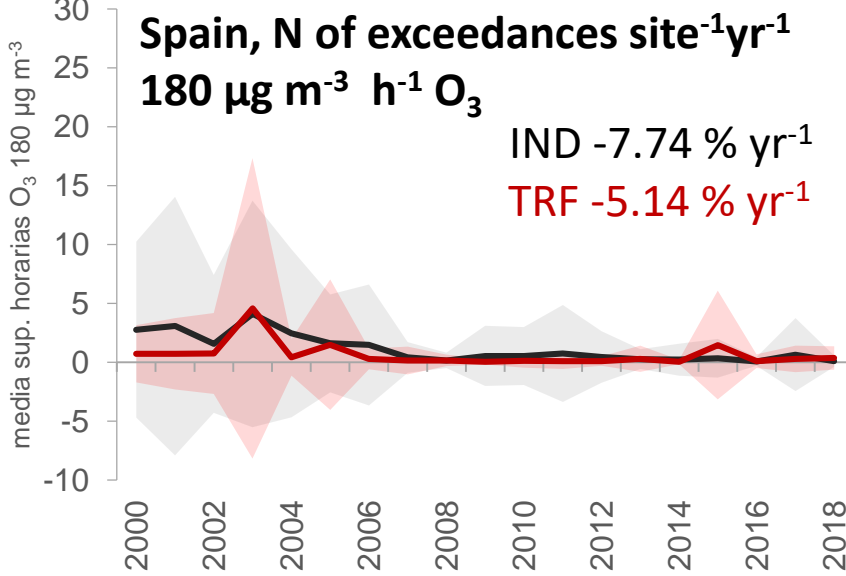
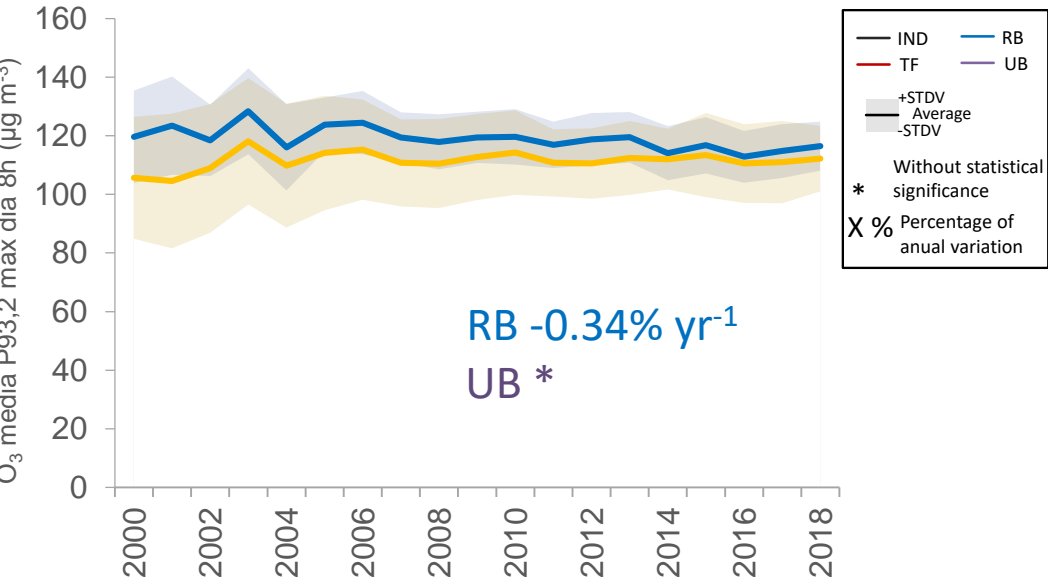
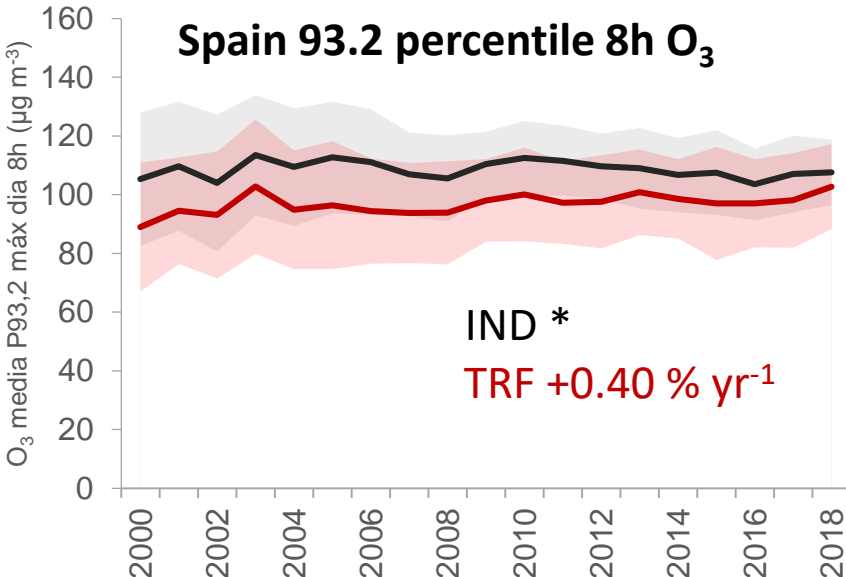
O_x=O₃+NO₂, reduces the effect of O₃ titration by NO



Updated from Querol X. et al., Science of the Total Environment 572 (2016) 379–389



Niveles de O₃ en España

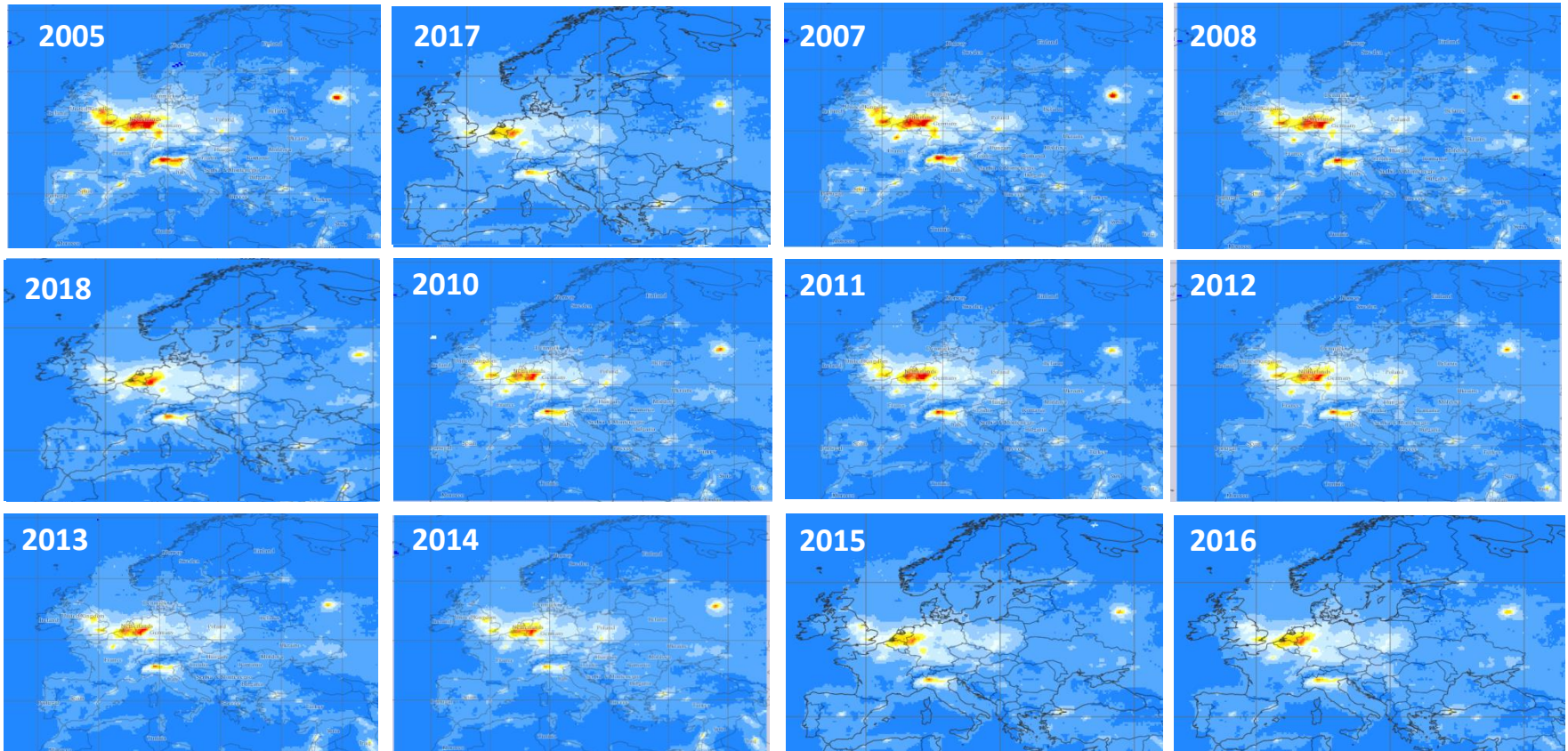
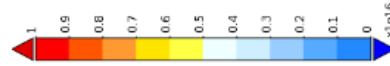


- IND — RB
- TF — UB
- +STDV — Average
- -STDV
- Without statistical significance
- * Percentage of annual variation

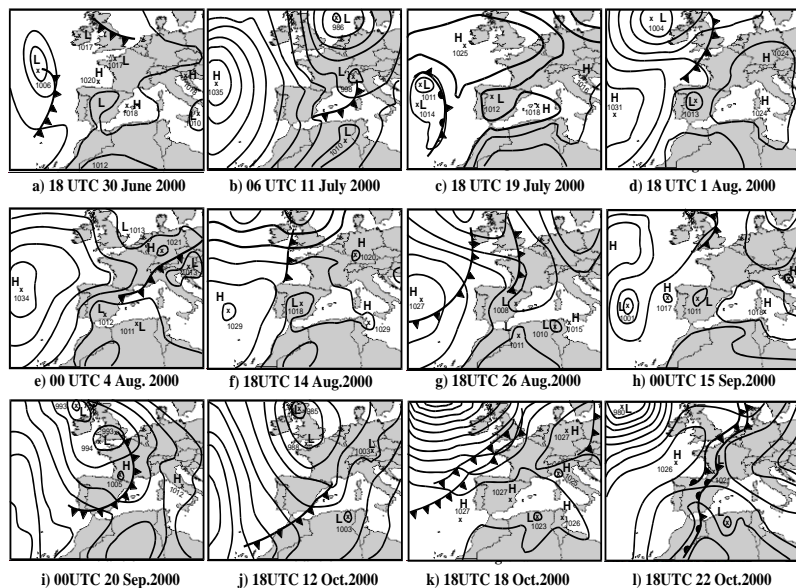
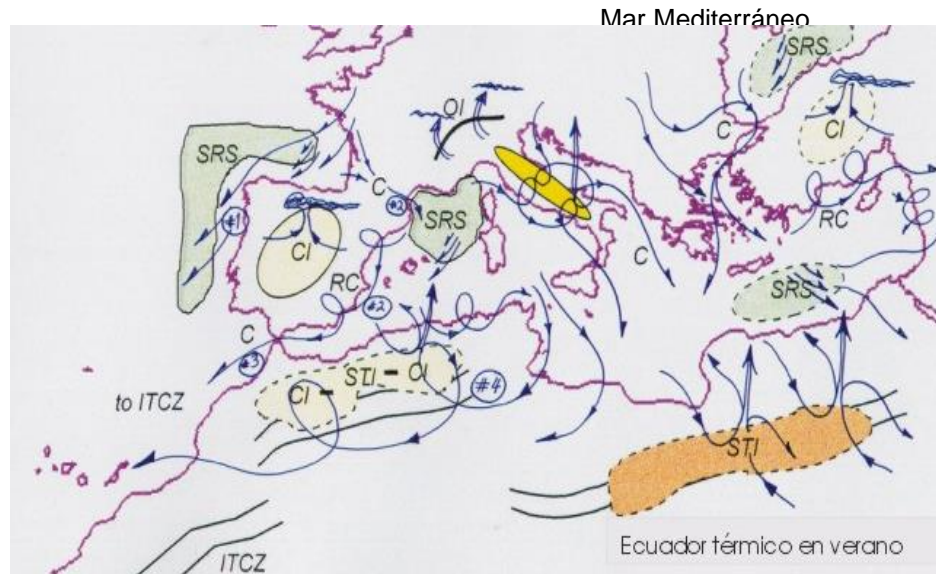
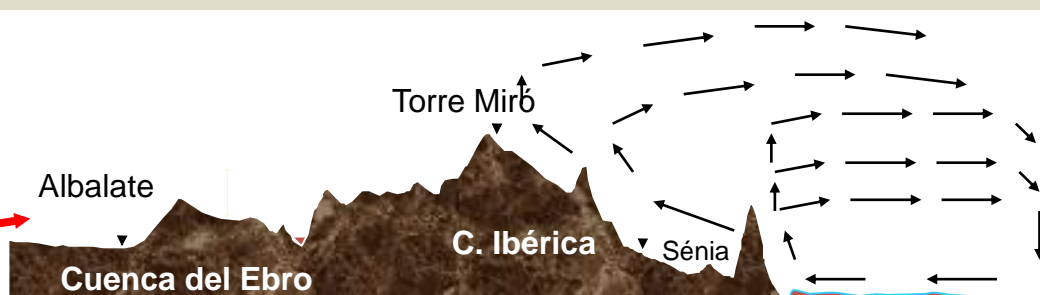
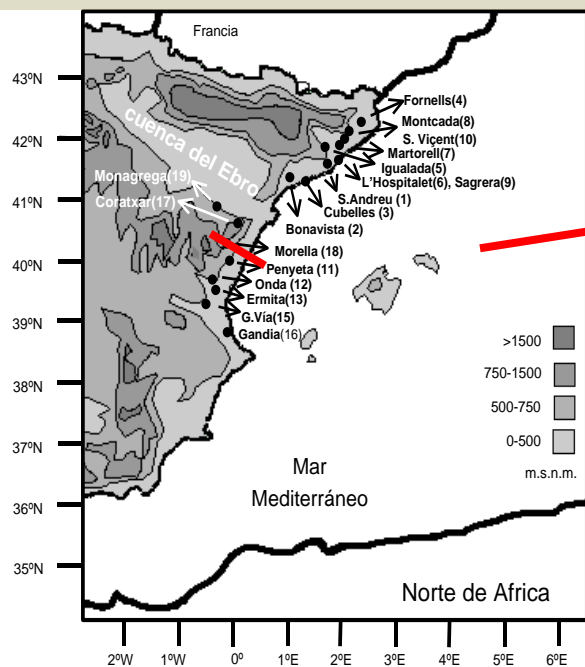


Niveles de O₃ en España

NASA NO₂ OMI level 3 Plotted using the Giovanni online data system, developed and maintained by the NASA GES DISC
Mean annual tropospheric NO₂ column (clear, 0-30% cloud) (10¹⁴ molec/cm²)



Origen de los episodios de O₃ en España

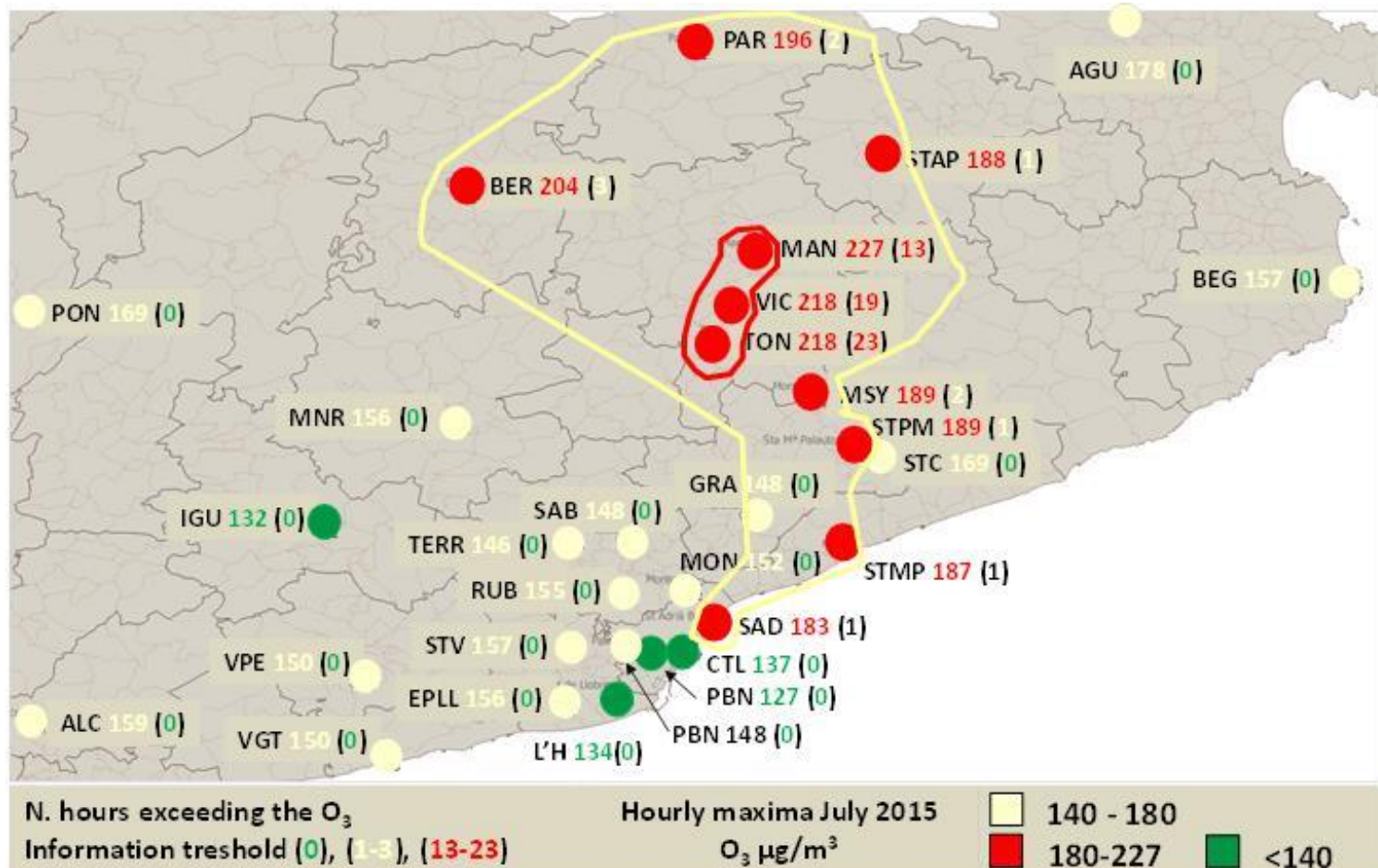


Millán et al., 1991, 1996a, 1996b, 1996c, 2000, 2002, 2014; Millán, 2002a; Millán and Sanz, 1999; Mantilla et al., 1997; Salvador et al., 1997, 1999; Gangoiti et al., 2001; Stein et al., 2004, 2005; Castell et al., 2008a, 2008b, 2012; Dieguez et al., 2009, 2014, Plaza et al., 1997

Origen de los episodios de O₃ en España

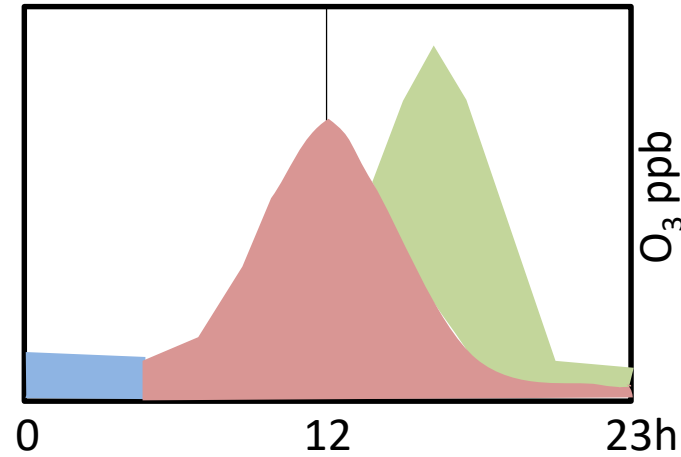
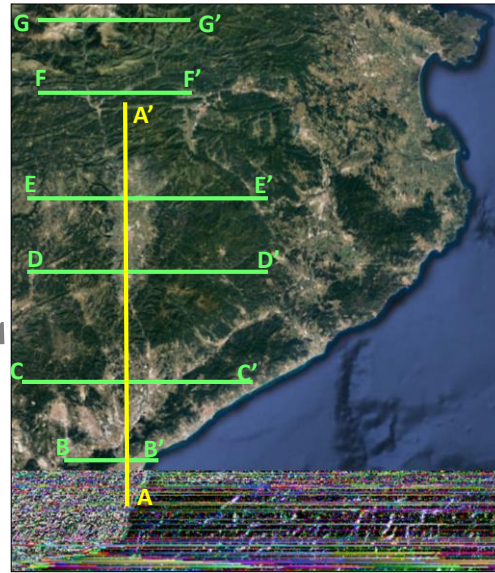
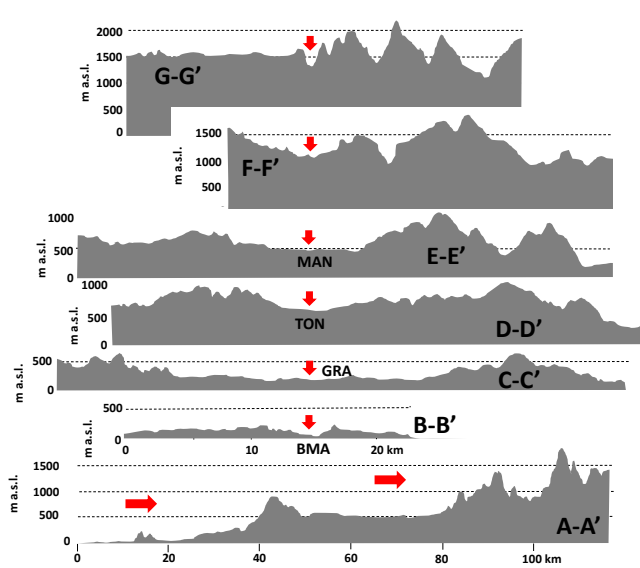
Case study 1: N of Barcelona-Vic

Max-h (N. h >180 µg/m³ O₃) July 2015



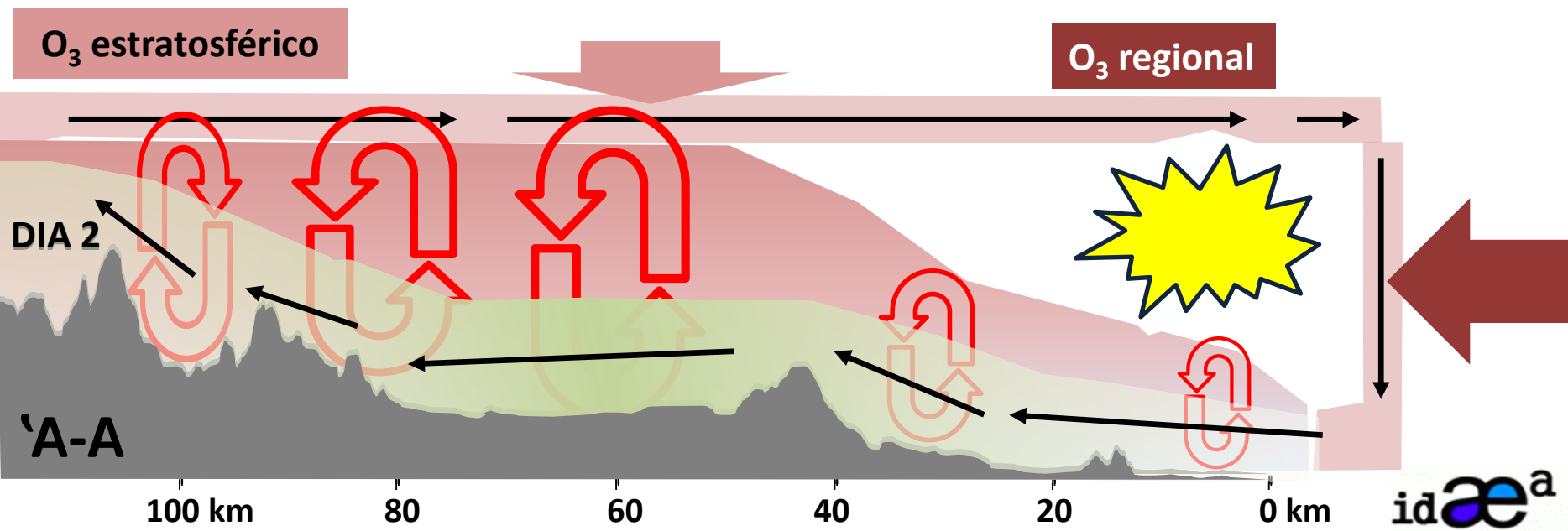
Origen de los episodios de O₃ en España

Case study 1: N of Barcelona-Vic



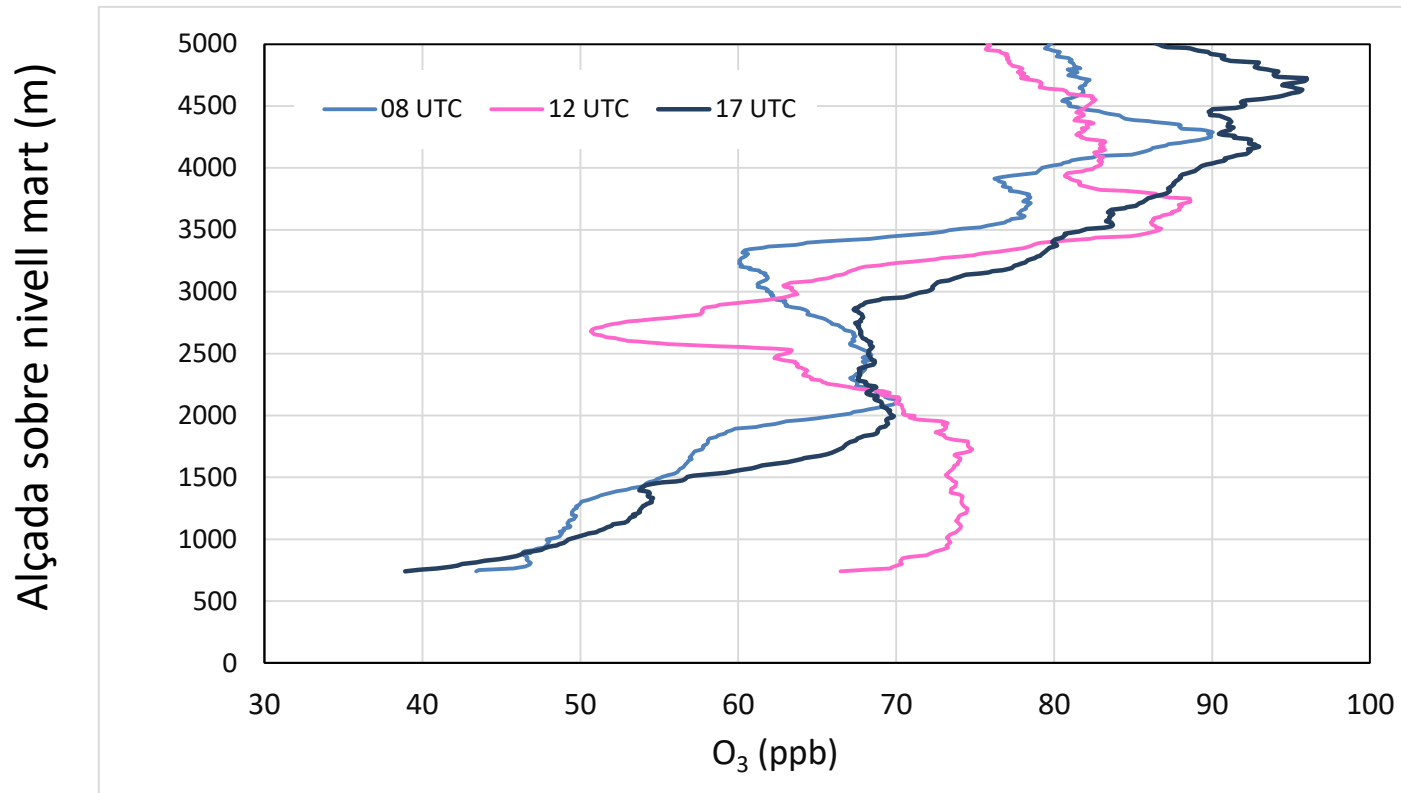
O₃ estratosférico

O₃ regional



Origen de los episodios de O₃ en España

Case study 1: N of Barcelona-Vic

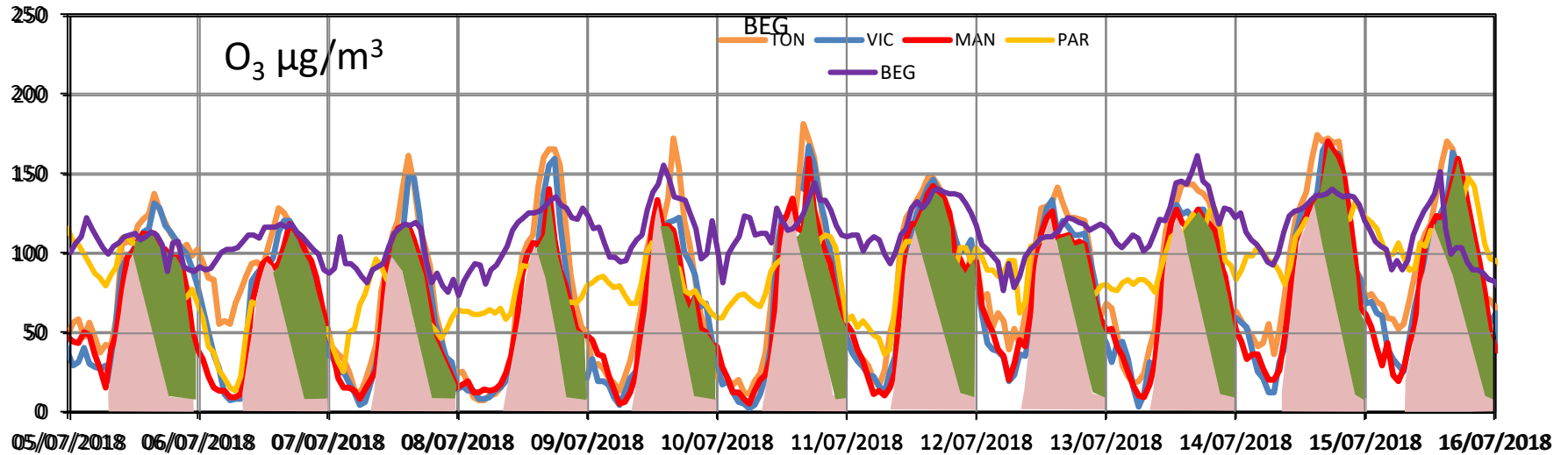


Montseny 13/07/2018

Fuente: Colaboración AEMET

Origen de los episodios de O₃ en España

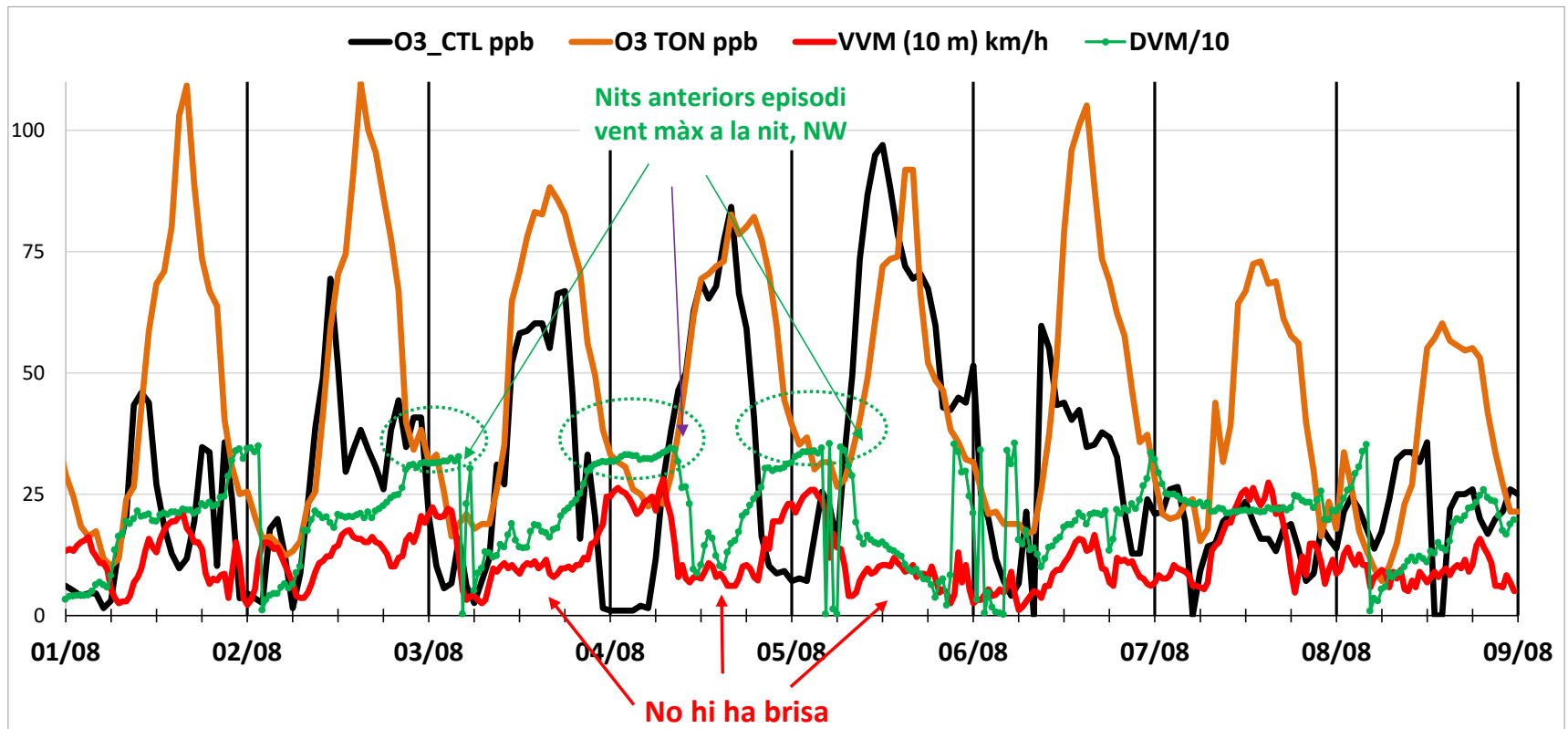
Case study 1: N of Barcelona-Vic



Origen de los episodios de O₃ en España

Case study 1: N of Barcelona-Vic

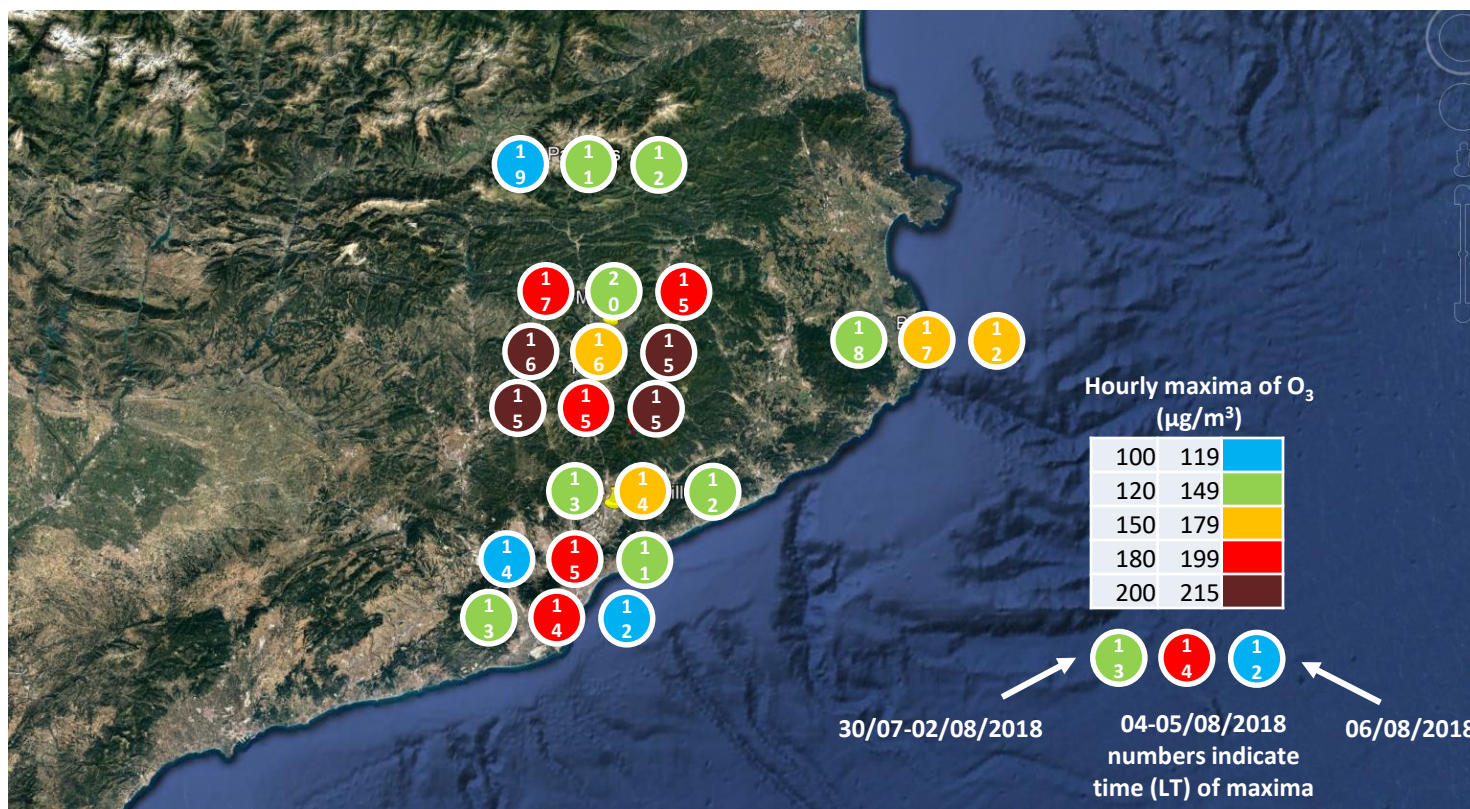
BARCELONA CITY JULY-AUGUST 2018



Origen de los episodios de O₃ en España

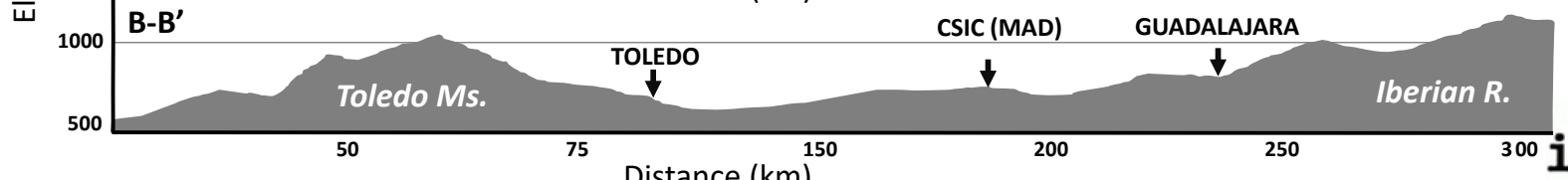
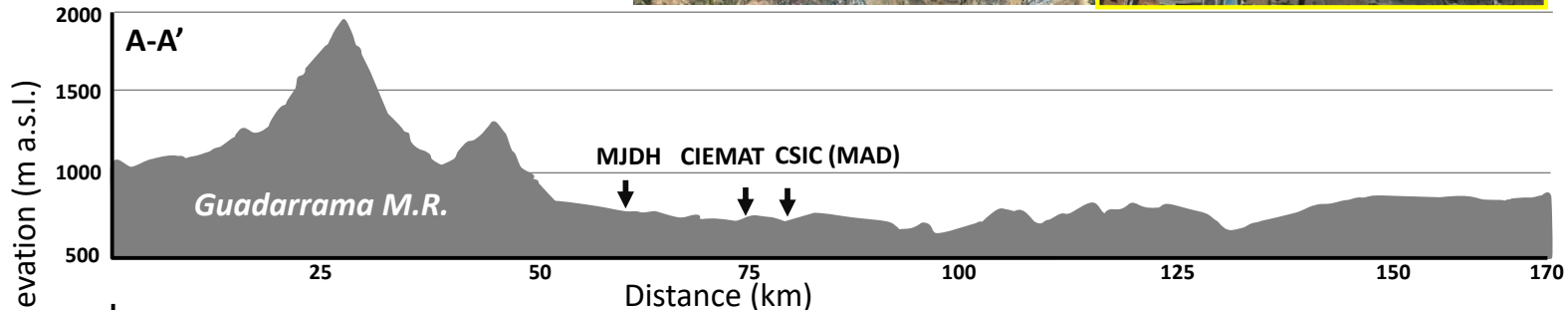
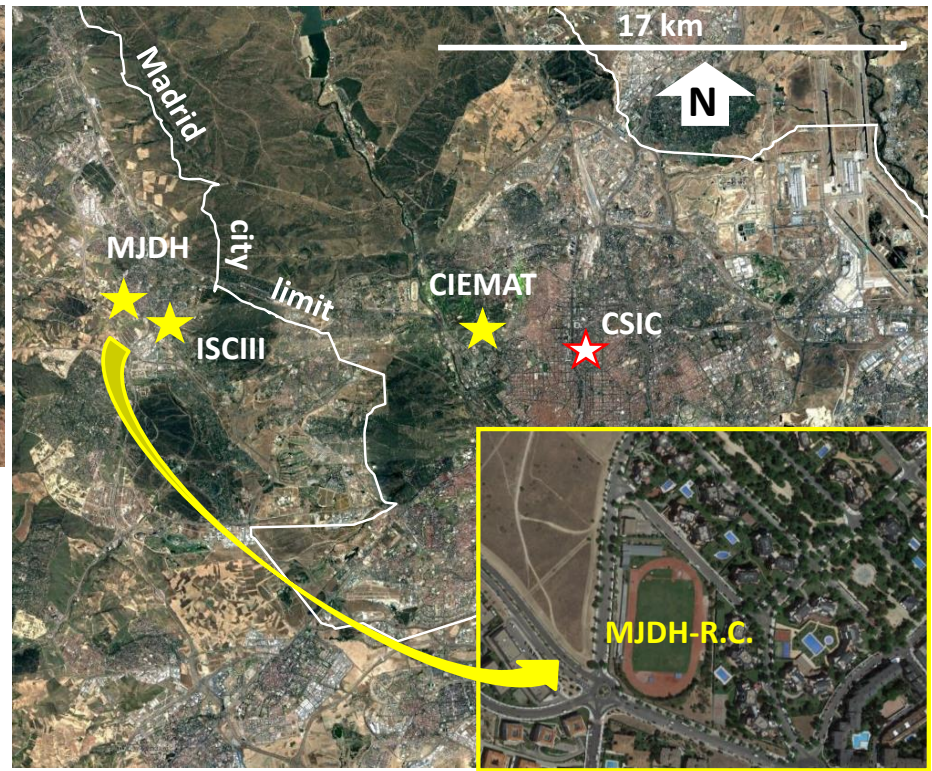
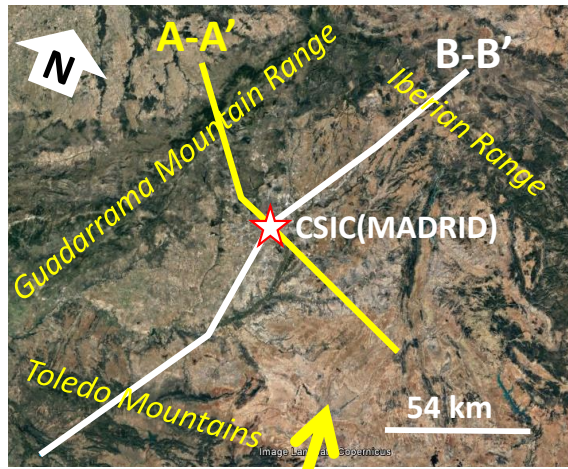
Case study 1: N of Barcelona-Vic

JULY-AUGUST 2018



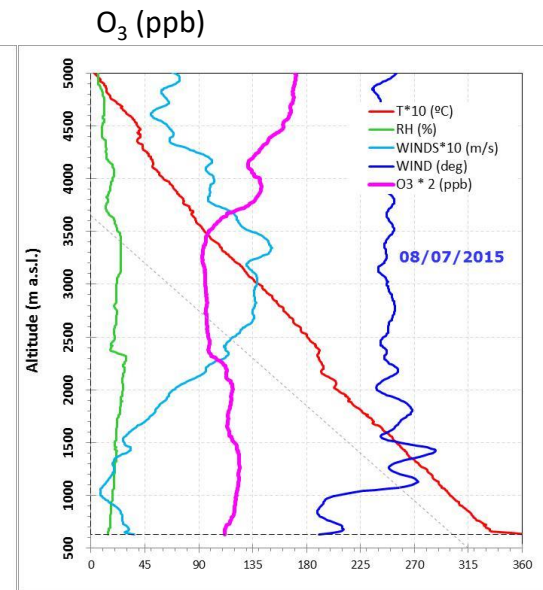
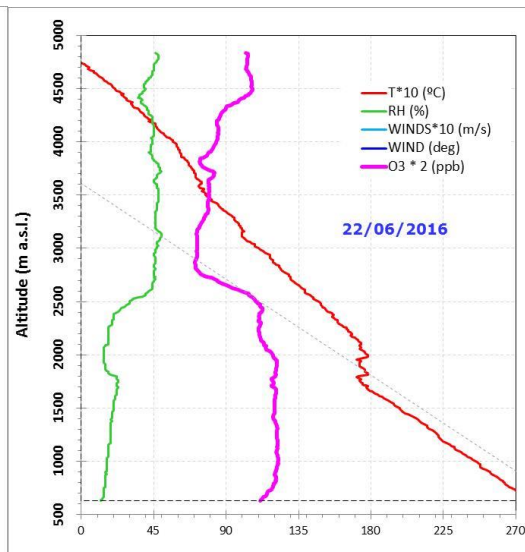
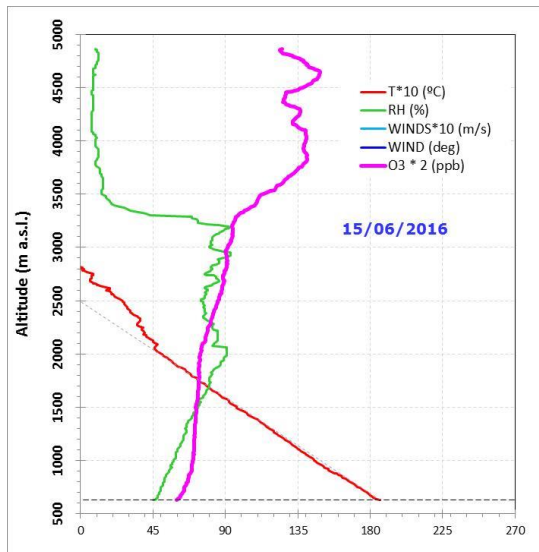
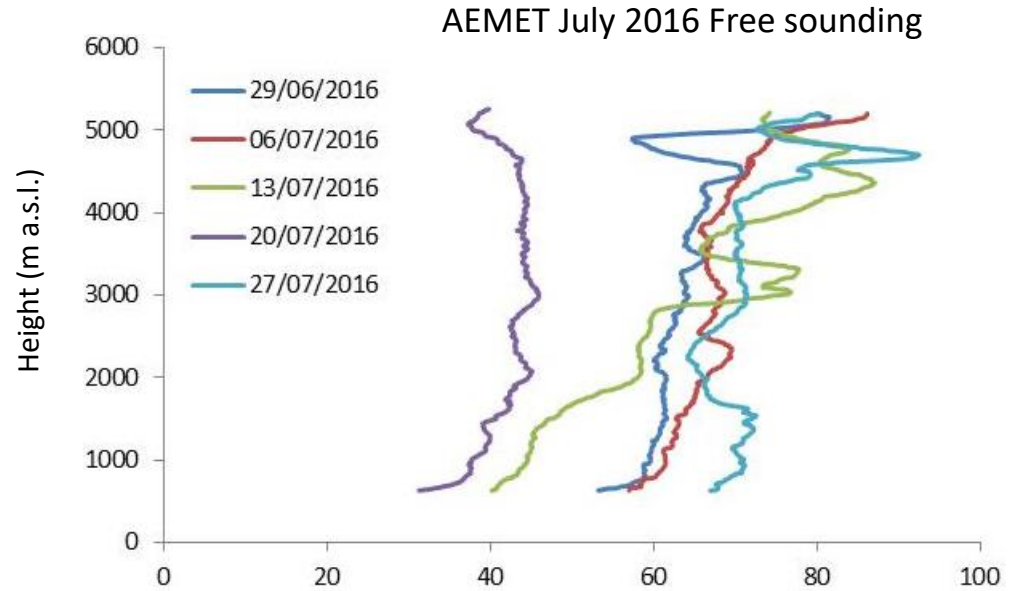
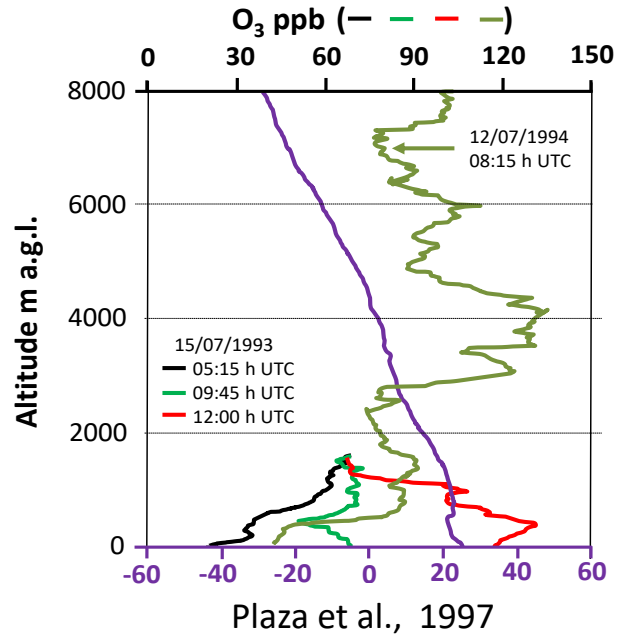
Origen de los episodios de O₃ en España

Case study 2: Madrid



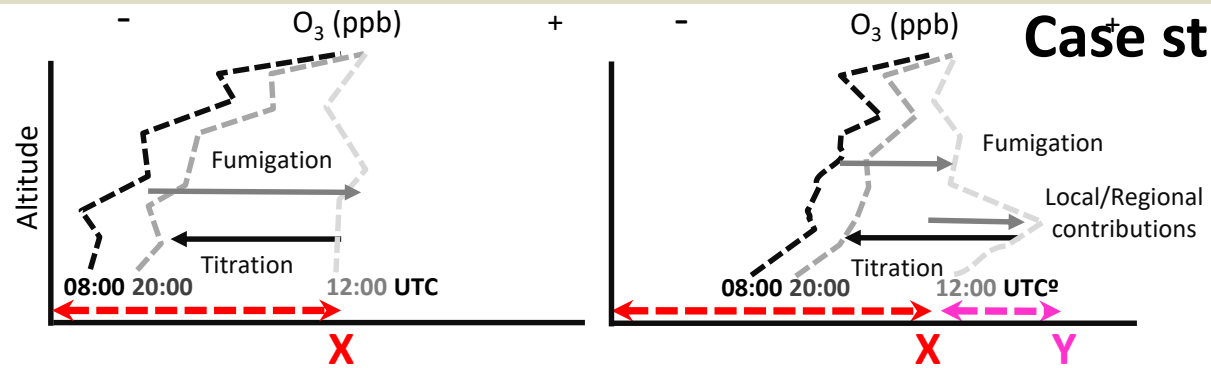
Origen de los episodios de O₃ en España

Case study 2: Madrid



Origen de los episodios de O₃ en España

Case study 2: Madrid

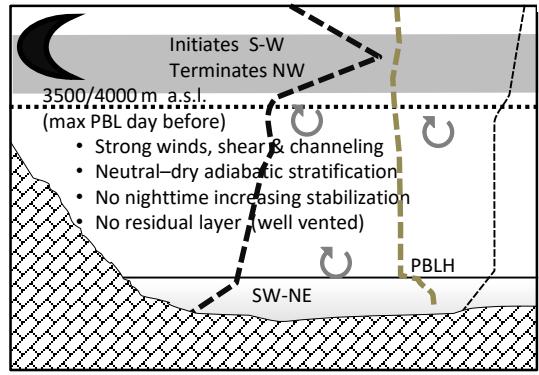


VENTING/TROUGHING (VT EVENT) ACCUMULATING/RIDGING (AR EVENT)

Free troposphere. Strong winds
Occasional high O₃ strata (regional-external, free-troposphere O₃)

Low O₃ (mixed, more external)
Intense ventilation, no accumulation from the day before
Mechanical Turbulence

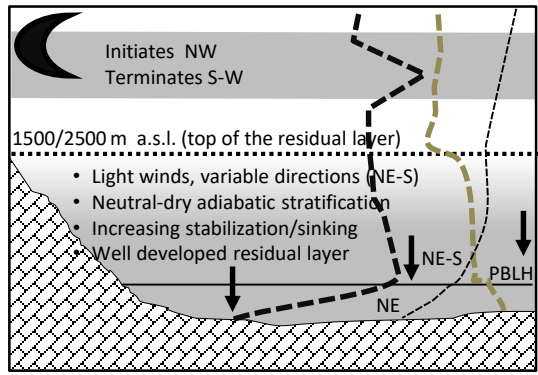
Surface layer, occasionally stably stratified
Low O₃ concentrations, titration
Strong winds SW-NE



Free troposphere. Light winds
Occasional high O₃ peaks (regional-external, free-troposphere O₃)

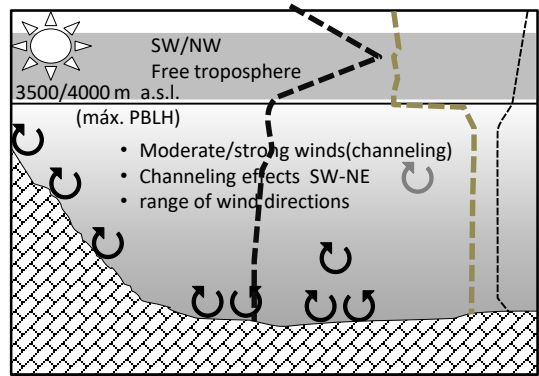
Higher O₃ (mixed external + Local)
Low ventilation, re-circulatory winds, accumulation from the day before
No Turbulence

NE'ly jet over stably stratified surface layer
Low O₃ concentrations, titration
Light winds (NE).



Strong winds
No O₃ accumulation in the PBL
No re-circulatory winds
New O₃ /UFP formation
O₃ fumigation

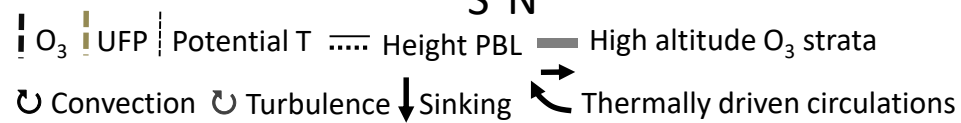
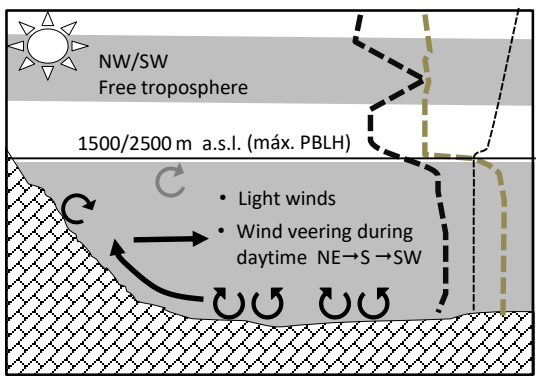
Thicker PBL: > 2000-2500 m a.s.l. at 12:00 UTC
Rapid growing up to 3500/4000 m
Intense mechanical & convective turbulence; Intense convection



Light winds

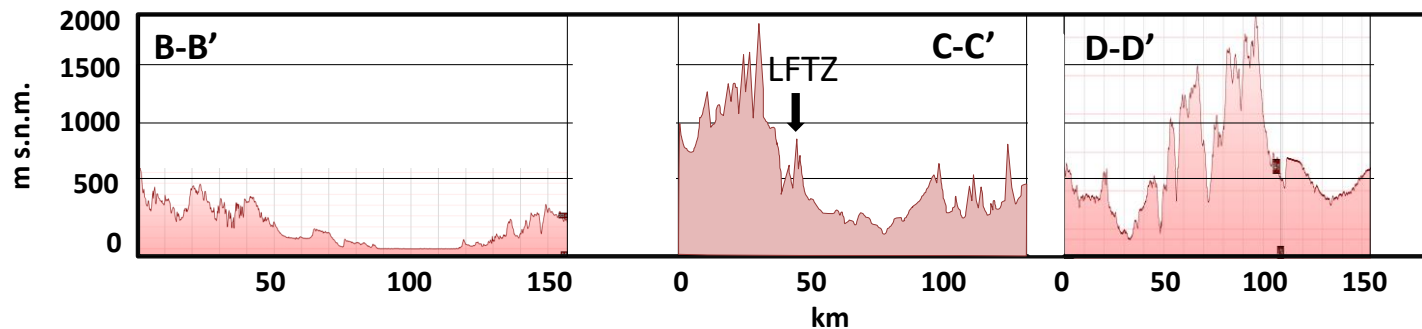
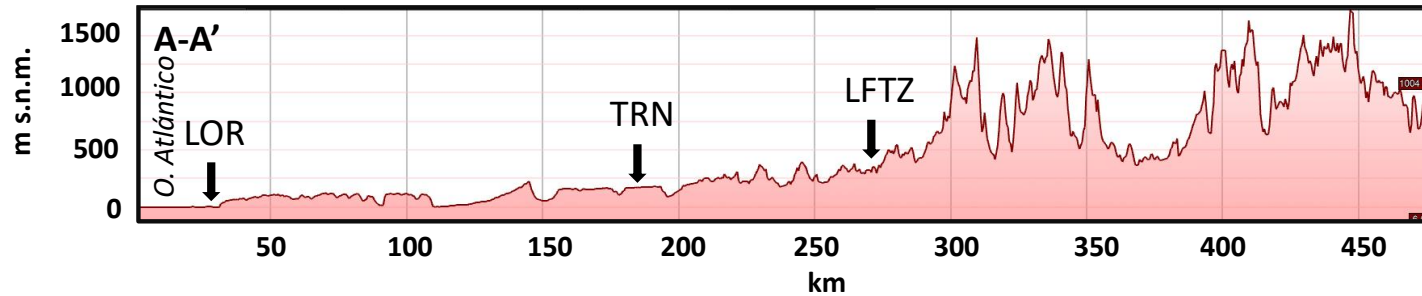
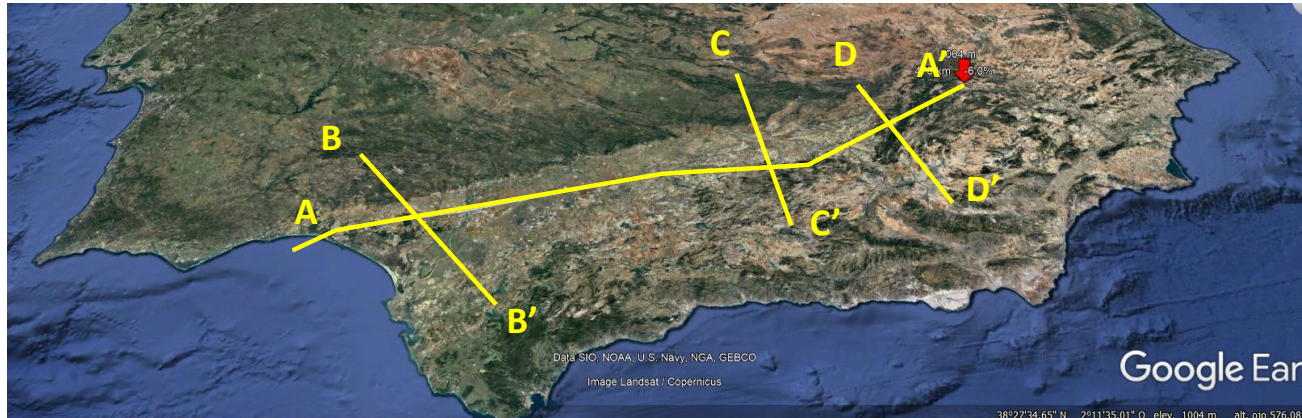
O₃ accumulation in the PBL
Re-circulation over the MMA basin
New ozone/UFP formation, O₃ fumigation

Thinner PBL: < 1500 m a.s.l. at 12:00 UTC
Slower deepening to 1500/2500 m
Intense convective turbulence
Additional O₃ formation of local origin
Thermally driven wind veering NE→S→SW
Intense convection



Origen de los episodios de O₃ en España

Case study 3: Guadalquivir Valley

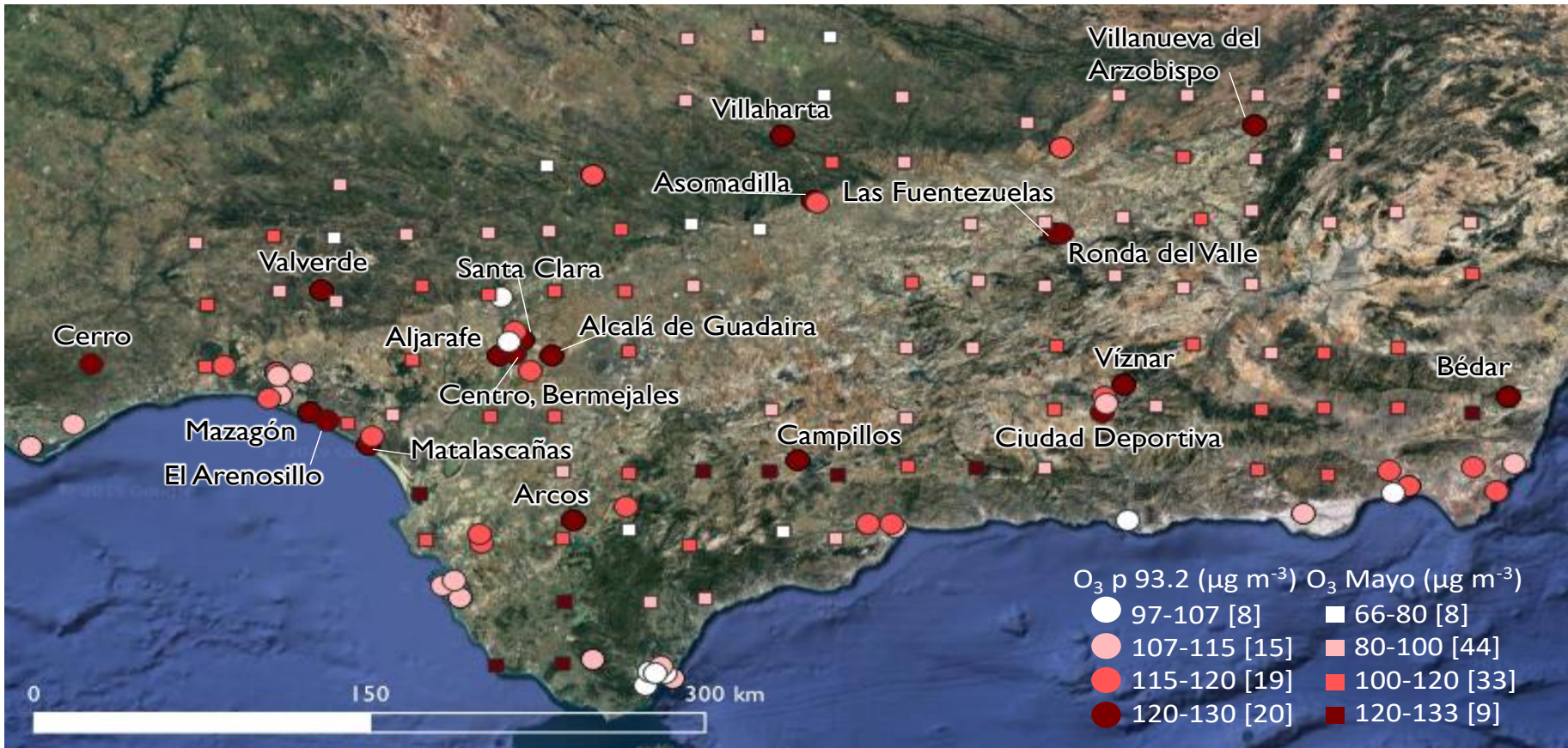


Origen de los episodios de O₃ en España

Case study 3: Guadalquivir Valley

Average percentile 93.2 O₃ 2005-2018, dossimetres average of May 2006-2017

Minimum 6 years of valid data: (minimum of 75% APR-SEP of O₃ hourly data availability)

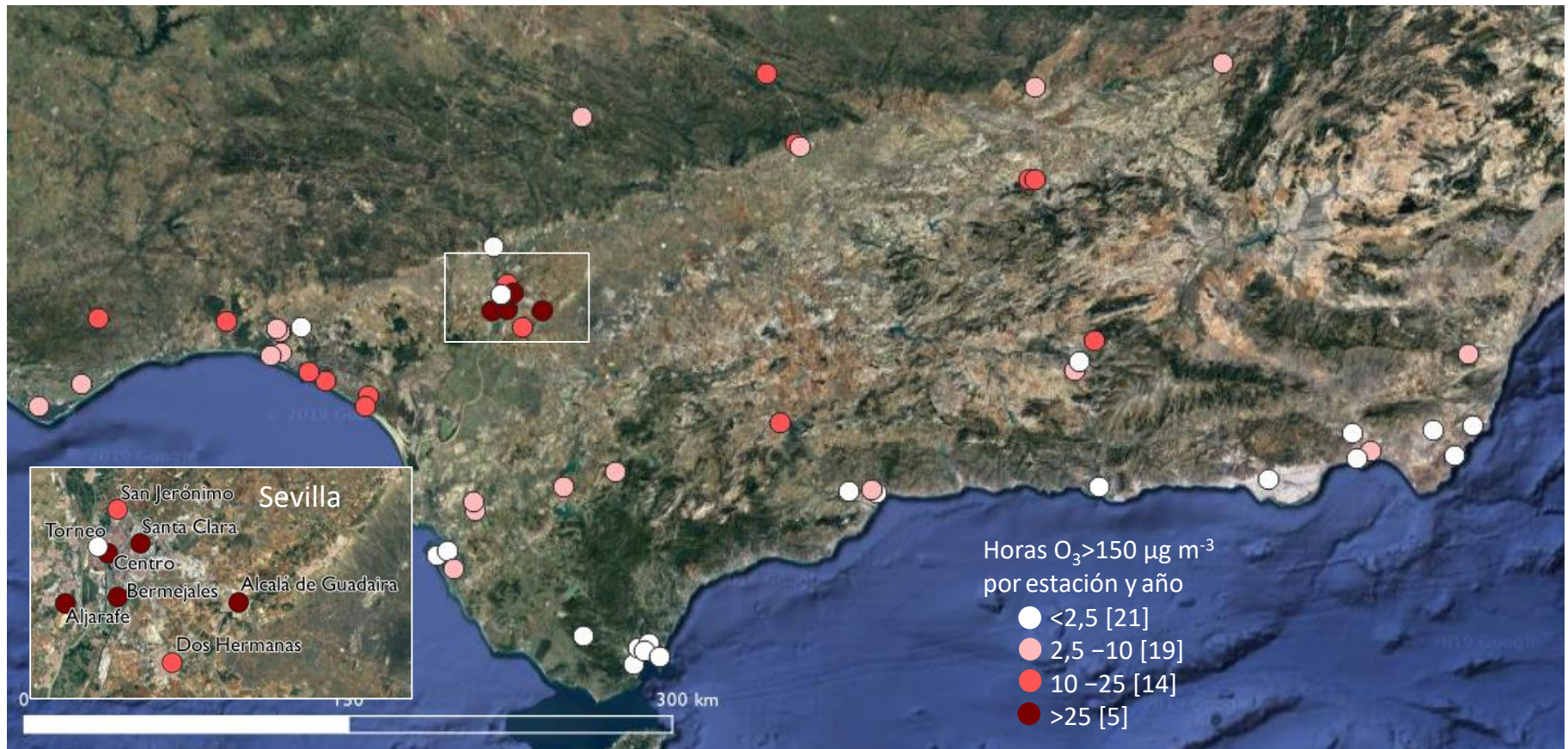


Origen de los episodios de O₃ en España

Case study 3: Guadalquivir Valley

Average number of h exceedances > 150 $\mu\text{g m}^{-3}$ O₃ per site per year 2005-2018

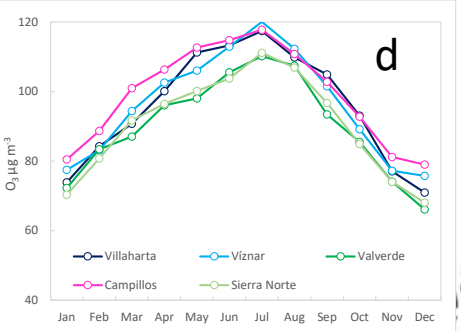
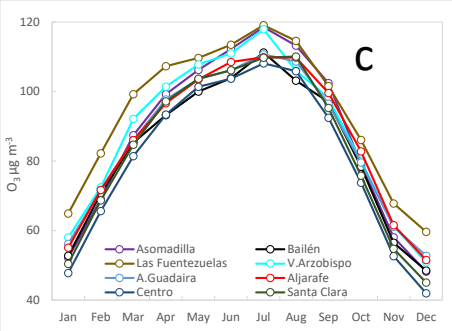
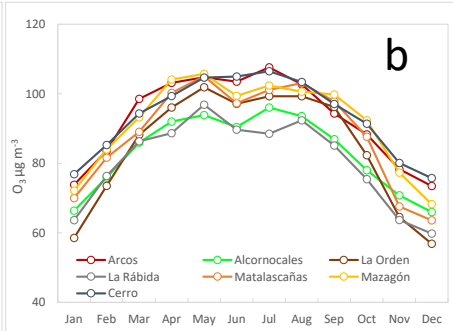
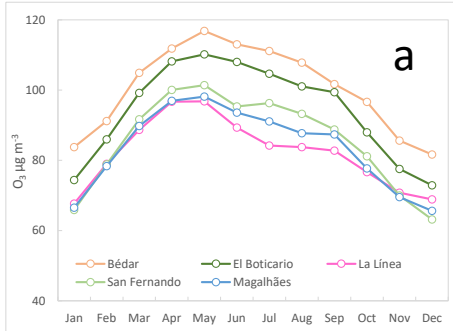
Years with minimum of 75% APR-SEP hourly data availability. Minimum of 7 years of valid data within 2005-2018



Origen de los episodios de O₃ en España

Case study 3: Guadalquivir Valley

Montly means daily O₃ máxima of 8-h moving averages, 2005 – 2018

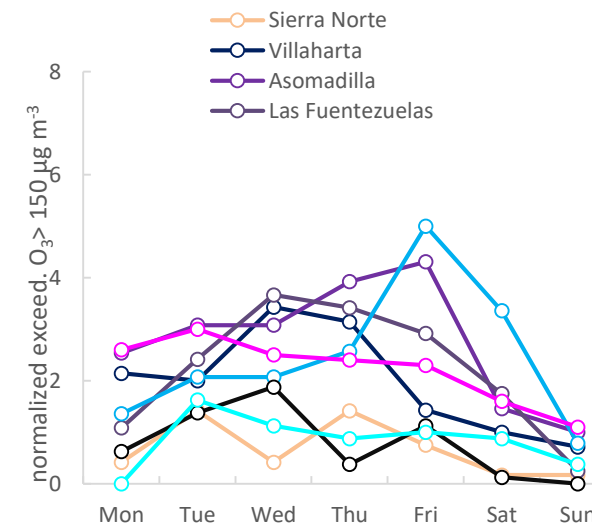
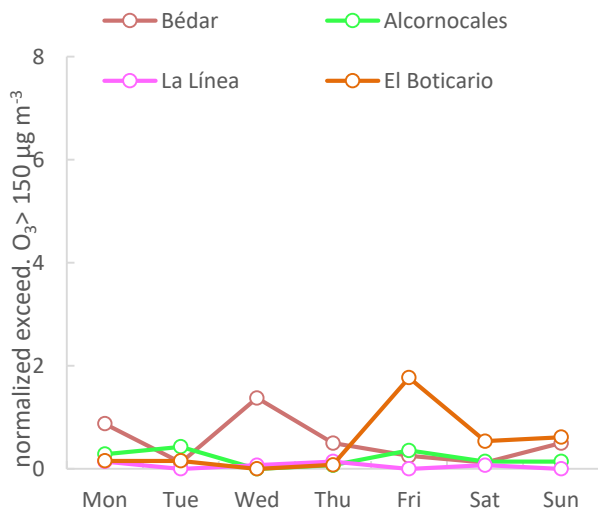
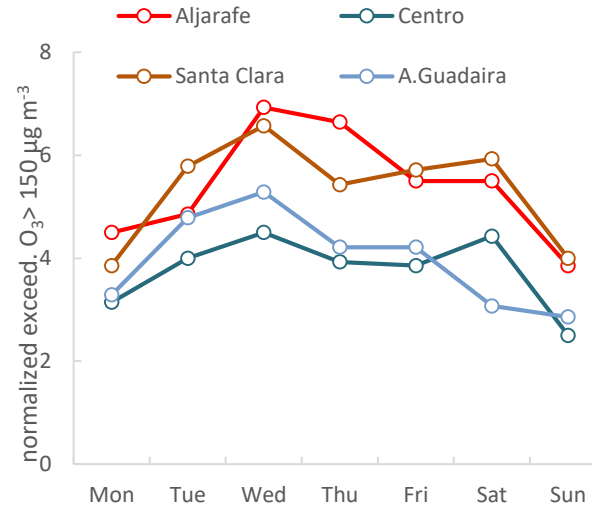
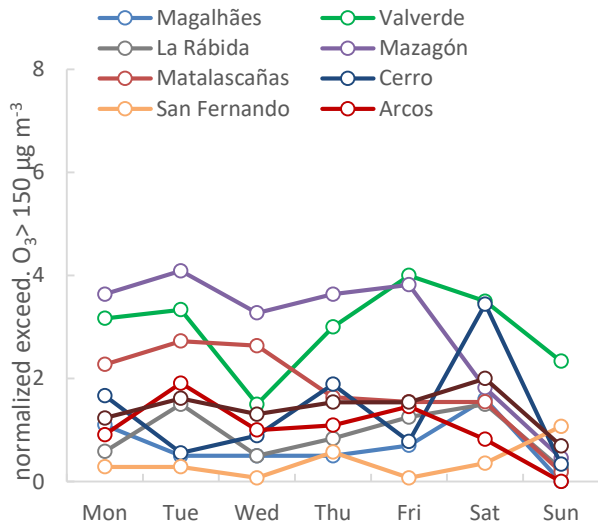


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Origen de los episodios de O₃ en España

Case study 3: Guadalquivir Valley

2005-2018 montly averages of hourly exceedances site⁻¹ yr⁻¹ of O₃ 150 µg m⁻³



Consideraciones finales

- El problema del O_3 es uno de los más complejos en la calidad del aire; las soluciones serán por tanto complejas también
- Las superaciones de $180 \mu\text{g m}^{-3}$ de h- O_3 se registran en 7 áreas específicas de España y tienen contribuciones locales, regionales y de larga distancia. Se necesitan políticas a 3 escalas, PERO LA LOCAL / REGIONAL ES MUY IMPORTANTE para reducir los episodios más agudos
- La contribución de las 3 escalas al O_3 varía en las diferentes cuencas y en el tiempo
- Las diferentes cuencas aéreas requieren un estudio individualizado pero teniendo en cuenta aportes externos a diferentes escalas
- Para reducir el O_3 es necesario disminuir los precursores estructuralmente (mayo-agosto), además de aplicar medidas episódicas; para ello son necesarios estudios de modelización-sensibilidad
- Muy IMPORTANTE TENER EN CUENTA CONCEPTOS DE CARGA CRÍTICA: Muchos focos en una zona, todos cumpliendo la legislación en misiones de precursores pueden dar problemas grandes de O_3 .
- Las medidas episódicas pueden ser efectivas para los episodios más agudos si:
 - Se llevan a cabo pronósticos meteorológicos de episodios de recirculación y profundidad de la capa de mezcla (Millán et al., 1997 y 2000)
 - Estudios de sensibilidad específicos para reducciones de COV y NOX.
- Los episodios máximos disminuyeron en la última década y el O_3 urbano está creciendo y el impacto en el aumento de los radicales (y PM_{2.5} y OVOCs) ya está demostrado

Agradecimientos



UIMP



Generalitat de Catalunya
**Departament de Territori
i Sostenibilitat**



house.

HIGH OZONE, ULTRAFINE PARTICLES AND
SECONDARY ORGANIC AEROSOLS
CGL2016-78594-R

¡Muchas gracias por su atención!
Xavier.querol@idaea.csic.es