Relationship between climate variability indices and airborne pollination in Catalonia (NE Iberian Peninsula)

Marta Alarcón[1]
Jordina Belmonte[2,3]
Husam T. Maheed[1]
Cristina Periago[1]
Rebeca Izquierdo[1]

[1] Departament de Física i Enginyeria Nuclear, UPC, Barcelona, Spain

[2] Institut de Ciència i Tecnologia Ambientals (ICTA), Universitat Autònoma de Barcelona (UAB), Bellaterra, Spain

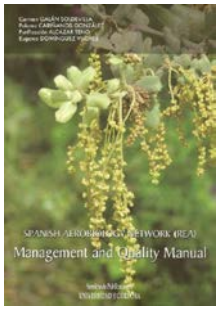
[3] Departament de Biologia Animal, Biologia Vegetal i Ecologia, Universitat Autònoma de Barcelona (UAB), Bellaterra, Spain

Aim

Explore the effect of the **NAO, WeMO** and **AO** climatic variability modes
on the airborne pollen series of **22 pollen types**
recorded at **6 stations of the Aerobiological Network of Catalonia**
during the 18-years **period 1994-2011**

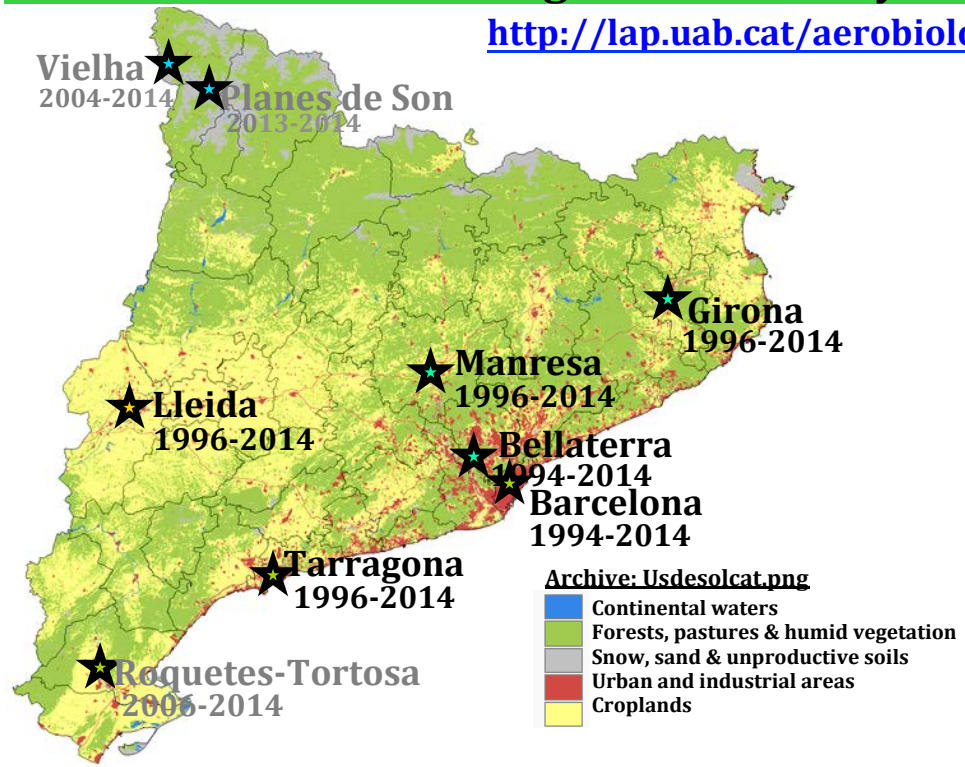
Area under study

Sampling & Analysing methods



Xarxa Aerobiològica de Catalunya

http://lap.uab.cat/aerobiologia



Geographical characteristics				Climatic characteristics (Allue Andrade 1990)		
Sampling stations	Altitude (m.a.s.l.)	Geographical Coordinates	Environment	Mean annual temperature (ºC)	Precipitation (mm)	Phytoclimates
Vielha	974	42º42' N, 00º47' E	Rural	9.9	899	Fresh-Continental Oriental- humid
Planes de Son	1542	42º37' N, 00º14' E	Rural	7.6	760	Fresh-Continental Oriental- humid
Girona	98	41º59' N, 02º50' E	Urban	15.0	740	Fresh-Continental Oriental-semihumid
Manresa	291	41º44' N, 01º30' E	Rural/Urban	13.6	619	Fresh-Continental Oriental-semihumid
Lleida	202	41º37' N, 00º35' E	Rural/Urban	15.1	385	Fresh-Transitional-semiarid
Bellaterra	245	41º34' N, 02º06' E	Rural/Urban	15.2	594	Fresh-Continental Oriental-semihumid
Barcelona	93	41º24' N, 02º09' E	Urban	16.4	593	Fresh-Tethyc-semiarid
Tarragona	44	41º07' N, 01º15' E	Urban	15.8	478	Fresh-Tethyc-semiarid
Roquetes-Tortosa	14	40º29' N, 00º58' E	Rural/Urban	16.8	576	Fresh-Tethyc-semiarid

Pollen taxa under study

TAXA	Plant type			Plant biogeography					Plant use			
	T	B	H	BA	ES	SM	M	Cm	S	R	C	O
Alnus	T				ES				S			(O)
Betula	T			BA	ES				S			O
Castanea	T					SM			S			(O)
CUPRESSACEAE/TAXACEAE	T	B			ES		M		S		C	O
Fagus	T				ES				S			(O)
Fraxinus	T				ES	SM			S			O
Olea	T						M		S		C	O
Pinus	T			BA	ES	SM	M		S		C	O
Platanus	T					SM	M		S		C	O
Quercus total	T	B			ES	SM	M		S			O
Quercus deciduous	T				ES	SM	M		S			O
Quercus evergreen	T	B					M		S			O
Ulmus	T				ES				S			O
Corylus		B			ES				S		C	
Pistacia		B					M		S			
Ambrosia t.			H				M		S	R		
Artemisia			H					Cm	S	R		
CHENOPODIACEAE-AMARANTHACEAE			H					Cm	S	R		
POACEAE			H					Cm	S		C	(O)
Plantago			H					Cm	S	R		
POLYGONACEAE			H					Cm	S			
URTICACEAE			H					Cm	S	R		

LEGEND

Plant type
- **T - tree**
- **B - bush**
- **H - herb**

Plant Biogeography
- **BA - Boreo-Alpine region**
- **ES - Euro-Siberian region**
- **SM - Sub-Mediterranean province**
- **M - Mediterranean region**
- **Cm - Cosmopolitan** (all regions & evironments)

Plant use
- **S - silvestre or wild** (not urban)
- **R - ruderal**
- **C - cultivated** (agricultura & forestry)
- **O - ornamental**

Pollen concepts under study

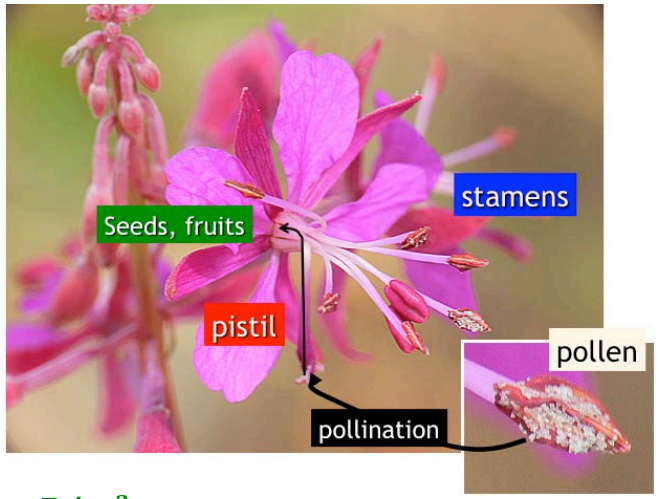
Annual Pollen Index (API)
Pollination start date (Start)
Pollination end date (End)
Pollination length (Length)

Climate concepts under study

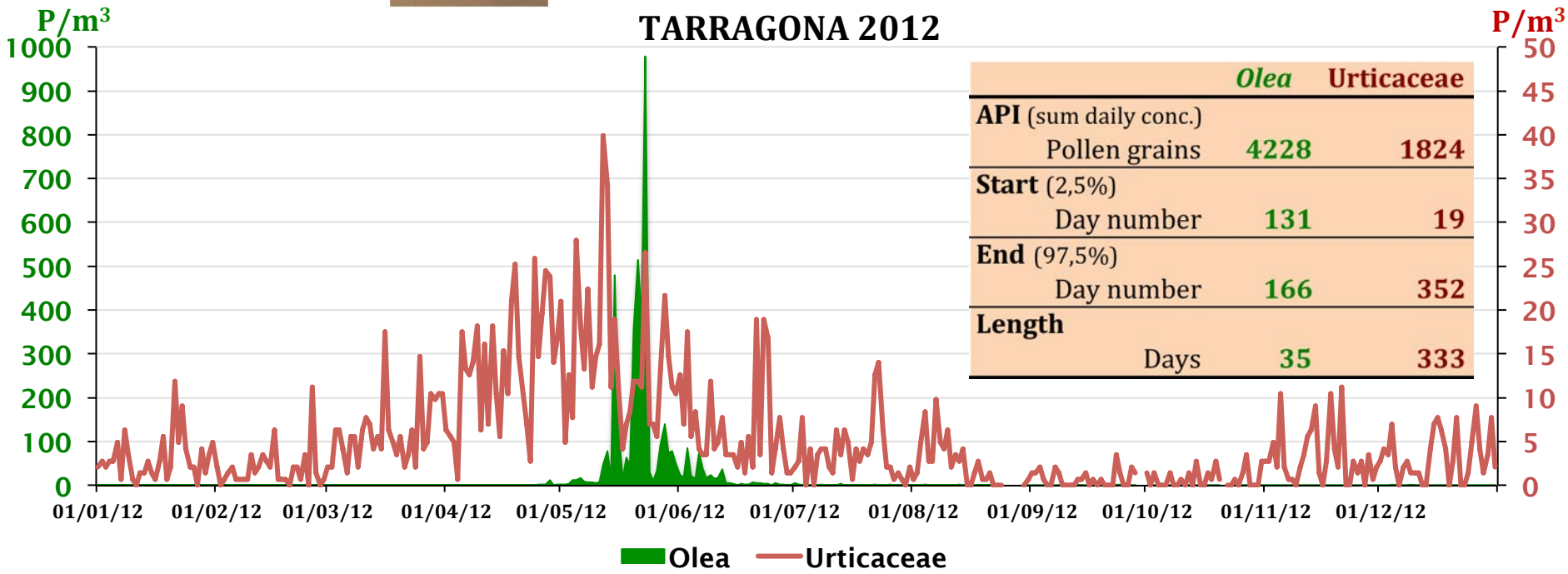
Annual and Winter (DJFM):
North Atlantic Oscillation index (NAOi)
West Mediterranean Oscillation index (WeMOi)
Artic Oscillation index (AOi)

Pollen taxa and concepts under study

Pollen concepts under study



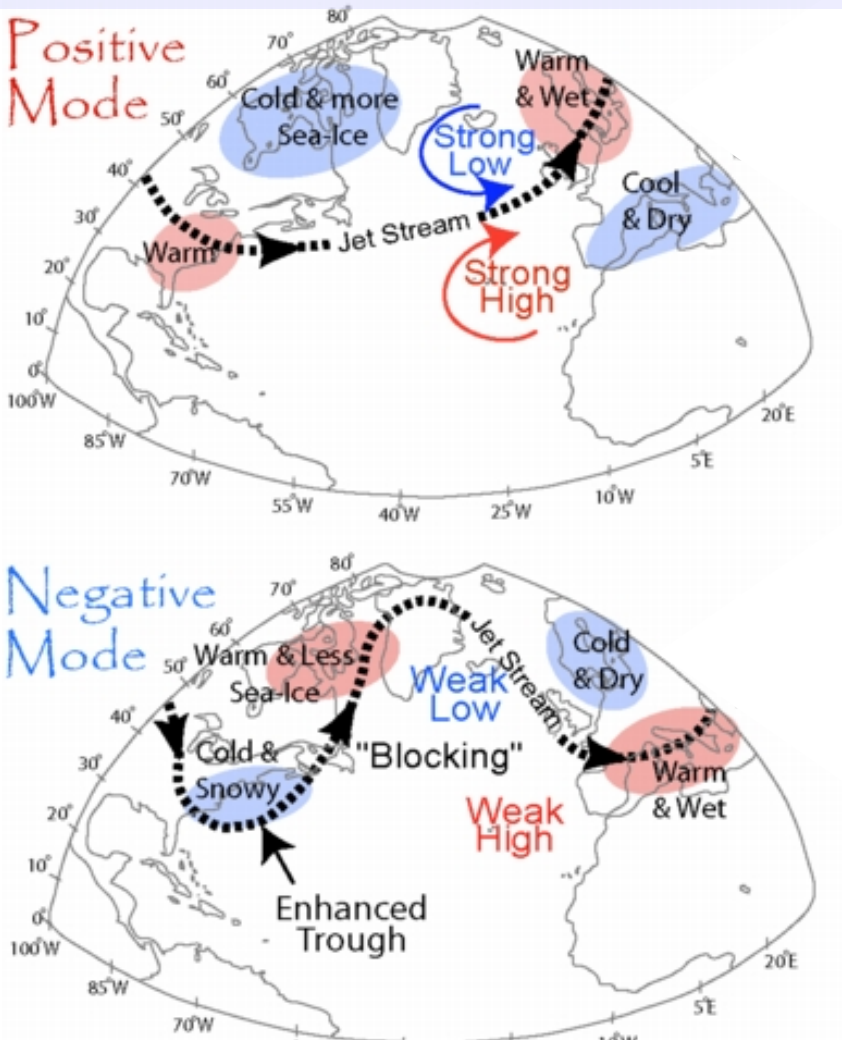
Annual Pollen Index (API)
Pollination start date (Start)
Pollination end date (End)
Pollination length (Length)



	Olea	Urticaceae
API (sum daily conc.) Pollen grains	4228	1824
Start (2,5%) Day number	131	19
End (97,5%) Day number	166	352
Length Days	35	333

Climatic index: North Atlantic Oscillation (NAO)

Represents the state of the atmospheric circulation **in the North Atlantic**
(dipole Reykjavik and Gibraltar)
Regulates the cyclone trajectories and cyclogenesis in the Euro-Mediterranean region

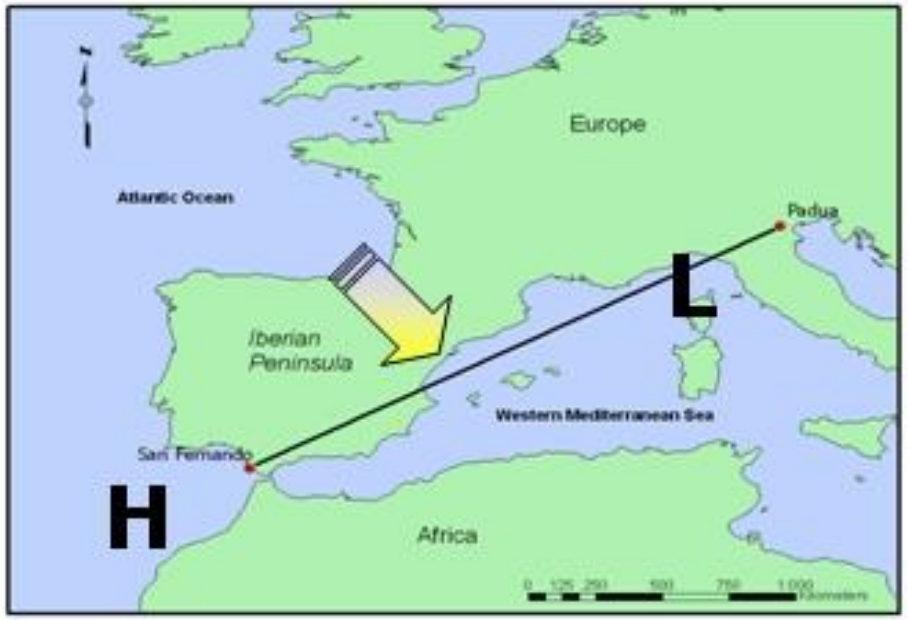


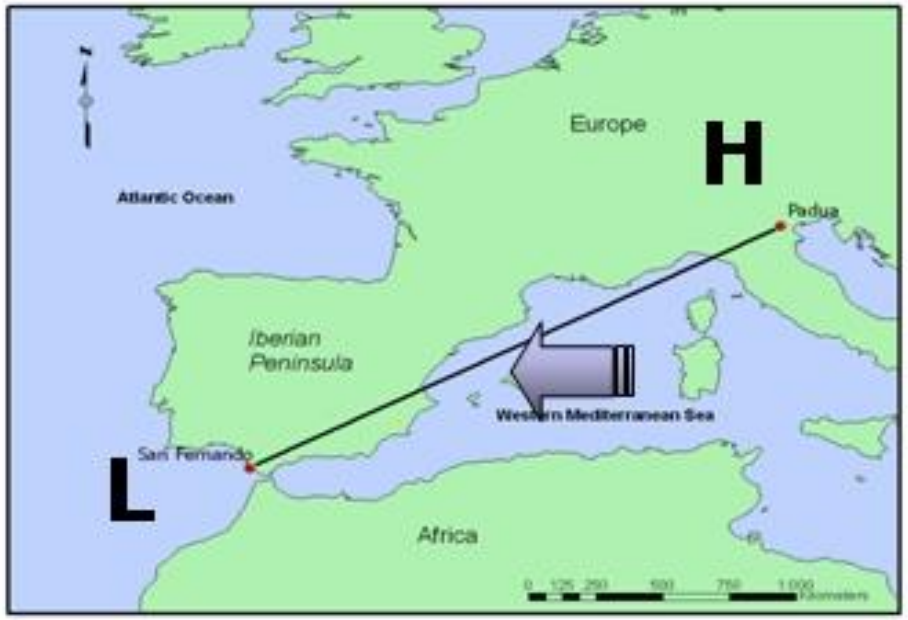
NAO +
Lower Precipitation and higher Insolation
in southern Europe and western Mediterranean
due to the increase of air masses from W and SW (N Africa)

NAO -
Higher Precipitation and lower Insolation
in southern Europe and western Mediterranean
due to the increase of air masses from the NW (Atlantic)

Climatic index: Western Mediterranean Oscillation (WeMO)

New secondary oscillation form which determines the atmospheric circulation
in the western Mediterranean basin
(dipole Padova and Cádiz)



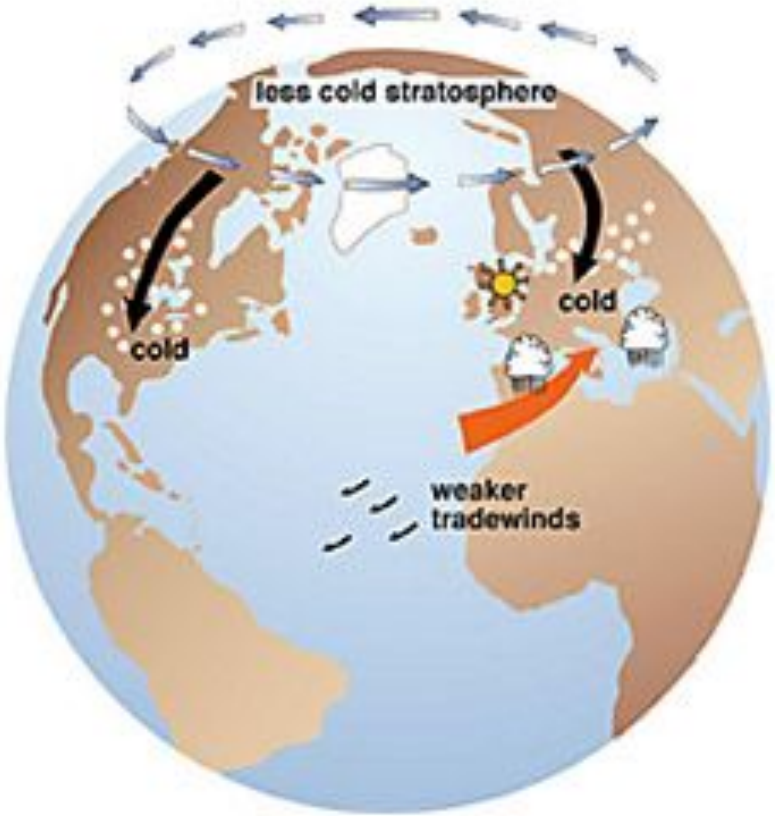


WeMO +
Lower Precipitation
in the Mediterranean coast of Iberian Peninsula
due to increase of air masses from the Atlantic

WeMO -
Higher Precipitation
in the Mediterranean coast of Iberian Peninsula
due to increase of air from the Mediterranean

Climatic index: Artic Oscillation (AO)

Represents the state of the atmospheric circulation **over the Arctic**



AO +
Lower Precipitation
in the western Mediterranean regions
due to the increase of air masses from the Atlantic

AO -
Higher Precipitation
in the western Mediterranean regions
due to the increase of air masses from N Europe

Statistical methods

Spearman's Rank Correlation Coefficient

between the ***normalized*** pollen data for **API**, **Start**, **End** and **Length**

and the **NAO**, **WeMO** and **AO** **annual** and **winter (DJFM) indices**

using SPSS 19.0

Key to the interpretation of the results

NAO + WeMO + AO +	Lower Precipitation and higher Insolation in the Mediterranean
NAO - WeMO - AO -	Higher Precipitation and lower Insolation in the Mediterranean

A **Positive** Rank Correlation between NAO/WeMO /AO and

- API means that **lower Precipitations in the Mediterranean coincide with high API and viceversa.**
- Start/End/Length mean that **lower Precipitations in the Mediterranean coincide with later/longer pollination and viceversa.**

A **Negative** Rank Correlation between NAO/WeMO /AO and

- API means that **lower Precipitations in the Mediterranean coincide with low API and viceversa**
- Start/End/Length mean that **lower Precipitations in the Mediterranean coincide with earlier/shorter pollination and viceversa.**

Results

Number of significant Spearman's rank correlations between API/Start/End/Length and climatic indices

			Barcelona	Bellaterra	Tarragona	Girona	Lleida	Manresa	Total	Total	Total
NAO	API	W	4	5	1	0	1	0	11		
		A	0	2	1	0	2	1	6	17	
	Start	W	2	3	2	1	1	2	11		
		A	2	1	3	3	0	0	9	20	62
	End	W	0	2	0	0	1	1	4		
		A	0	3	1	1	0	0	5	9	
	Length	W	1	5	0	2	1	1	10		
		A	1	1	2	0	1	1	6	16	
WeMO	API	W	6	5	1	0	1	2	15		
		A	3	6	1	2	2	5	19	34	
	Start	W	1	1	1	0	0	0	3		
		A	4	5	2	1	3	4	19	22	118
	End	W	0	5	1	0	1	1	8		
		A	1	5	0	1	7	7	21	29	
	Length	W	2	4	1	0	2	2	11		
		A	3	6	0	0	6	7	22	33	
AO	API	W	0	1	0	0	2	0	3		
		A	0	0	0	2	2	0	4	7	
	Start	W	1	1	3	2	1	2	10		
		A	2	0	1	4	1	1	9	19	45
	End	W	0	1	3	2	0	0	6		
		A	2	1	0	0	1	1	5	11	
	Length	W	0	1	0	0	0	0	1		
		A	2	0	0	0	2	3	7	8	
Total nr correlations			37	64	24	21	38	41			225

Results

Number of significant Spearman's correlations between API/Start/End/Length and climatic indices

Concept	Nr (%) sig. cor.	Nr (%) sig. cor.
Climatic indices period	**Anual** 132 (58,7%)	**Winter** 93 (41,3%)

Concept	Nr (%) sig. cor.	Nr (%) sig. cor.	Nr (%) sig. cor.
Climatic indices	**WeMO** 118 (52,4%)	**NAO** 62 (27,6%)	**AO** 41 (20,0%)

Concept	Nr (%) sig. cor.	Nr (%) sig. cor.	Nr (%) sig. cor.	Nr (%) sig. cor.	Nr (%) sig. cor.	Nr (%) sig. cor.
Sampling station	**Bellaterra** 64 (28,4%)	**Manresa** 41 (18,2%)	**Lleida** 38 (16,9%)	**Barcelona** 37 (16,4%)	**Tarragona** 24 (10,7%)	**Girona** 21 (9,3%)

Concept	Nr (%) sig. cor.	Nr (%) sig. cor.	Nr (%) sig. cor.	Nr (%) sig. cor.
Pollination	**Start** 61 (27,4%)	**API** 58 (25,8%)	**Length** 57 (25,3%)	**End** 49 (21,8%)

Results

Results of Spearman's rank correlation analysis between **API and climatic indices**

	Barcelona						Bellaterra						Girona						Lleida						Manresa						Tarragona						CATALONIA					
	WeMO		NAO		AO		WeMO		NAO		AO		WeMO		NAO		AO		WeMO		NAO		AO		WeMO		NAO		AO		WeMO		NAO		AO		WeMO		NAO		AO	
Pollen taxa	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a
Alnus																																											
Betula																																											
Castanea								P																																		
Cupressaceae	N																			N																	N	N	N			
Fagus																																										
Fraxinus																							N	N		N						N										
Olea			N						N												N	N		N													N		N		
Pinus	N		N																																	N	N					
Platanus		P						N		P				N				P	N							N																
Quercus	N		N				N		N																												N		N			
Quercus **deciduous t.**			N						N															N						N		N				N		N			
Quercus **evergreen t.**	N						N	N																												N						
Ulmus								N																N													N					
Corylus							P			P	P							P				P	P				P						P					P		P		P
Pistacia									P																																	
Ambrosia **t.**																																										
Artemisia	N						N																		N												N					
Chenop./Amaranthaceae		P							P																												N		N			
Plantago	N																									N												N					
Poaceae								P																N															N			
Polygonaceae																																					N					
Urticaceae		P												N																												
Total Pollen							N	N												N																	N	N	N			

P: positive correlation
N: negative correlation
w: winter (DJFM)
a: annual
**** significant at the level 0,01**
*** significant at the level 0,05**

Results

Results of Spearman's rank correlation analysis between **API and climatic indices**

	Barcelona						Bellaterra						Girona						Lleida						Manresa						Tarragona						CATALONIA					
	WeMO		NAO		AO		WeMO		NAO		AO		WeMO		NAO		AO		WeMO		NAO		AO		WeMO		NAO		AO		WeMO		NAO		AO		WeMO		NAO		AO	
Pollen taxa	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a
Alnus																																											
Betula																																											
Castanea								P																																		
Cupressaceae	N																			N																	N	N	N			
Fagus																																											
Fraxinus																							N	N		N						N											
Olea			N						N												N	N				N												N		N			
Pinus	N		N																																		N	N					
Platanus		P						N		P				N				P	N							N																	
Quercus	N		N				N		N																												N		N			
Quercus **deciduous t.**			N						N																N						N		N				N		N			
Quercus **evergreen t.**	N						N	N																													N						
Ulmus								N																		N												N					
Corylus							P			P	P							P				P	P				P						P						P		P	
Pistacia									P																																	
Ambrosia t.																																											
Artemisia	N						N																		N												N					
Chenop./Amaranthaceae		P							P																												N		N			
Plantago	N																									N												N					
Poaceae								P																N															N			
Polygonaceae																																					N						
Urticaceae		P												N																													
Total Pollen							N	N												N																	N	N	N			

P: positive correlation
N: negative correlation
w: winter (DJFM)
a: annual
** **significant at the level 0,01**
* **significant at the level 0,05**

Results

Results of Spearman's rank correlation analysis between **API and climatic indices**

	Barcelona						Bellaterra						Girona						Lleida						Manresa						Tarragona						CATALONIA										
	WeMO		NAO		AO		WeMO		NAO		AO		WeMO		NAO		AO		WeMO		NAO		AO		WeMO		NAO		AO		WeMO		NAO		AO		WeMO		NAO		AO		Total	N*	N**	P*	P**
Pollen taxa	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a	w	a					
Castanea								P																																	1			1	
Cupressaceae	N																			N																	N	N	N				5	3	2		
Fraxinus																					N	N				N							N										4	3	1		
Olea			N						N												N	N				N												N		N			7	4	3		
Pinus	N		N																																		N	N					4	3	1		
Platanus		P						N		P				N				P	N							N																	7	2	2	2	1
Quercus	N		N				N		N																													N		N			6	6			
Quercus deciduous t.			N						N																N						N		N				N		N			7	5		2	
Quercus evergreen t.	N						N	N																		N											N					4	4			
Ulmus								N																		N												N					3	2	1		
Corylus							P			P	P					P						P	P				P					P							P		P		10			10	
Pistacia									P																																		1			1	
Artemisia	N						N																		N													N					4	4			
Chenop./Amaranthaceae		P							P																													N		N			4	1	1	2	
Plantago	N																									N												N					3	2	1		
Poaceae								P														N																	N				3	2		1	
Polygonaceae																																					N						1	1			
Urticaceae		P											N																														2		1	1	
Total Pollen							N	N												N																	N	N	N				6	5	1		
19 taxa over 23	6	3	4	0	0	0	5	6	5	2	1	0	0	2	0	0	0	2	1	2	1	2	2	2	2	5	0	1	0	0	1	1	1	1	0	0	9	6	6	2	0	1					
N*	4		4				4	4	3										1	1	1		1	2	2	2					1		1				5	5	5	1							
N**	2													2						1		1				3						1					4	1	1								
P*		2					1	2	2	2	1							2				1	1				1							1							1	1							
P**		1																																														

WeMO	NAO	AO	
49	25	8	Total
24	17	3	winter
25	8	5	annual

P: positive correlation
N: negative correlation

w: winter (DJFM)
a: annual

**** significant at the level 0,01**
*** significant at the level 0,05**

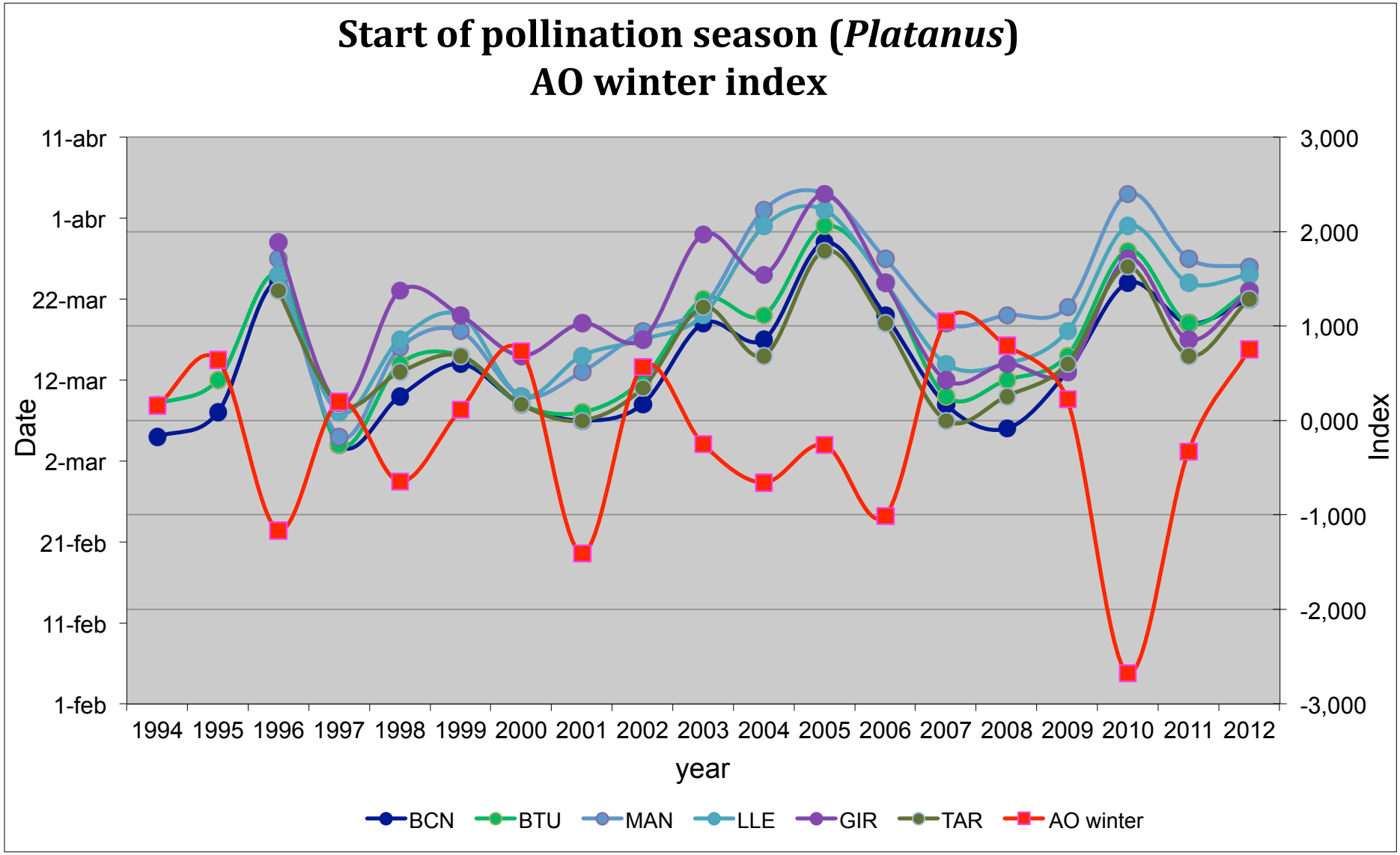
Results

Results of Spearman's rank correlation analysis between **Start of pollination and climatic indices**

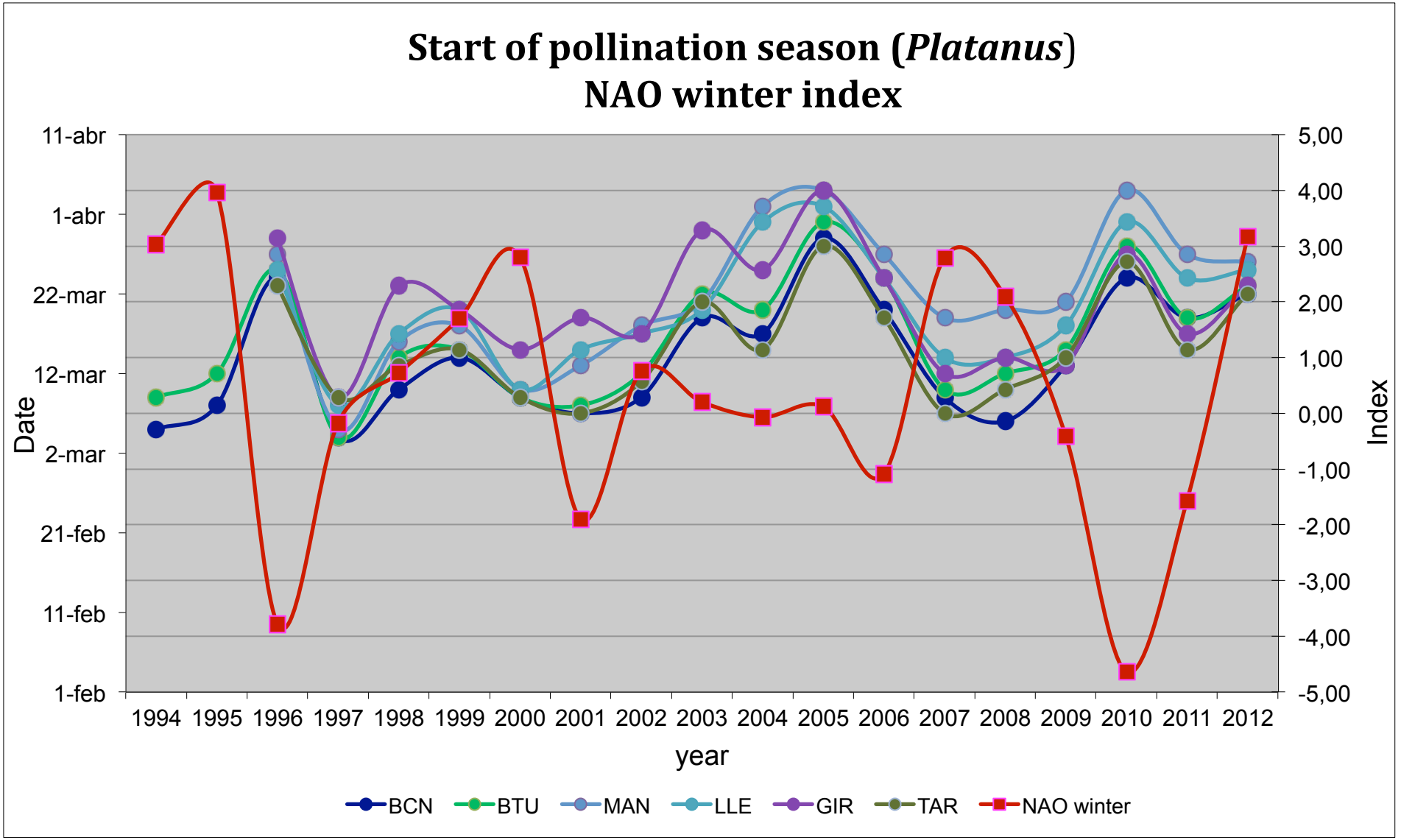
Pollen taxa	Barcelona WeMO w	Barcelona WeMO a	Barcelona NAO w	Barcelona NAO a	Barcelona AO w	Barcelona AO a	Bellaterra WeMO w	Bellaterra WeMO a	Bellaterra NAO w	Bellaterra NAO a	Bellaterra AO w	Bellaterra AO a	Girona WeMO w	Girona WeMO a	Girona NAO w	Girona NAO a	Girona AO w	Girona AO a	Lleida WeMO w	Lleida WeMO a	Lleida NAO w	Lleida NAO a	Lleida AO w	Lleida AO a	Manresa WeMO w	Manresa WeMO a	Manresa NAO w	Manresa NAO a	Manresa AO w	Manresa AO a	Tarragona WeMO w	Tarragona WeMO a	Tarragona NAO w	Tarragona NAO a	Tarragona AO w	Tarragona AO a	Total	N*	N**	P*	P**
Alnus																						N						N									2	2			
Ambrosia							P			P																											2			2	
Artemisia														N			N															N			N		4	3	1		
Betula																															P						1			1	
castanea													P																					P			2			2	
Chenopod/ Amaranthaceae																																					0				
Corylus														N				N																			2	2			
Cupressaceae		N						N						N				N													N	N			N		7	5	2		
Fagus																P																					1			1	
Fraxinus																																					0				
Olea																							N			N	N			N						N	3	3			
Pinus				N			N			N																		N									4	3	1	1	
Pistacia				N						N									N			N			N				N					N			7	5	2		
Plantago						N																															1			1	
Platanus	N			N	N		N			N	N						N								N				N						N		10	8	2		
Poaceae																																					0				
Polygonaceae	N		N																																		2	2			
Quercus Deciduous type				N																							N	P									1	1			
Quercus Evergreen type										N																											1	1			
Quercus Total																	N																				1	1			
Ulmus																					N						N					N					3	1	2		
Urticaceae		N				N			N								N				N						N						N				7	4	3		
20 taxa over 23	2	2	1	4	1	2	3	1	1	5	1	0	1	3	0	1	2	4	1	0	0	3	1	1	2	0	0	4	2	1	2	3	1	2	3	1					
N*	2	2	1	2	1		2		1	4	1			3			1	4	1			1		1	2			1		1		2	1	1	3	1					
N**						2		1										1				2	1					3	2		1	1									
P*							1		1				1			1		2													1			1								
P**																																										

	WeMO	NAO	AO	
	20	22	19	Total
	11	3	10	winter
	9	19	9	annual

Results


Start of pollination season (*Platanus*)
AO winter index
11-abr
1-abr
22-mar
12-mar
2-mar
21-feb
11-feb
1-feb
Date
3,000
2,000
1,000
0,000
-1,000
-2,000
-3,000
Index
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
year
BCN
BTU
MAN
LLE
GIR
TAR
AO winter

Results


Start of pollination season (*Platanus*)
NAO winter index
Date
11-abr
1-abr
22-mar
12-mar
2-mar
21-feb
11-feb
1-feb
Index
5,00
4,00
3,00
2,00
1,00
0,00
-1,00
-2,00
-3,00
-4,00
-5,00
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
year
BCN
BTU
MAN
LLE
GIR
TAR
NAO winter

CONCLUSIONS

API/Climatic indices - most of the taxa **significant negative correlations**

The **wetter conditions** associated with the negative mode of the climatic indices in Catalonia coincide with **higher API values**.

The only exception was *Corylus* which showed positive significant correlations for all stations.

Start/Climatic indices - most of the taxa **significant negative correlations**

The **dryer and more insolated conditions** associated with the positive mode of the climatic indices in Catalonia coincide with an **advance in the pollination start**.

The only exception were *Ambrosia*, *Castanea, Fagus* and *Betula* which are Eurosiberian taxa often long range transported.

End/Climatic indices - most of the taxa **significant positive correlations**

The **rainy conditions** associated with the negative mode of the climatic indices in Catalonia favors the cleaning of the atmosphere and the **advance in the pollination end**.

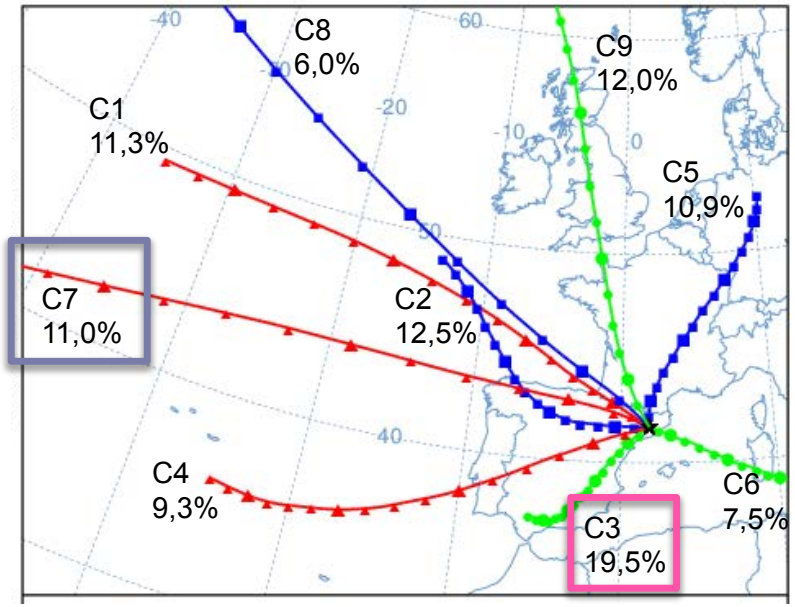
The most **vulnerable** taxa (more significant correlations) with regard to API were ***Corylus*, *Olea*, *Platanus* and *Quercus* deciduous type.**

WeMO is the index showing more significant correlations with **API**.
NAO is the index showing more significant correlations with **End of pollination**.
AO, closely followed by NAO and WeMO, is the index showing more significant correlations with **Pollination Start.**

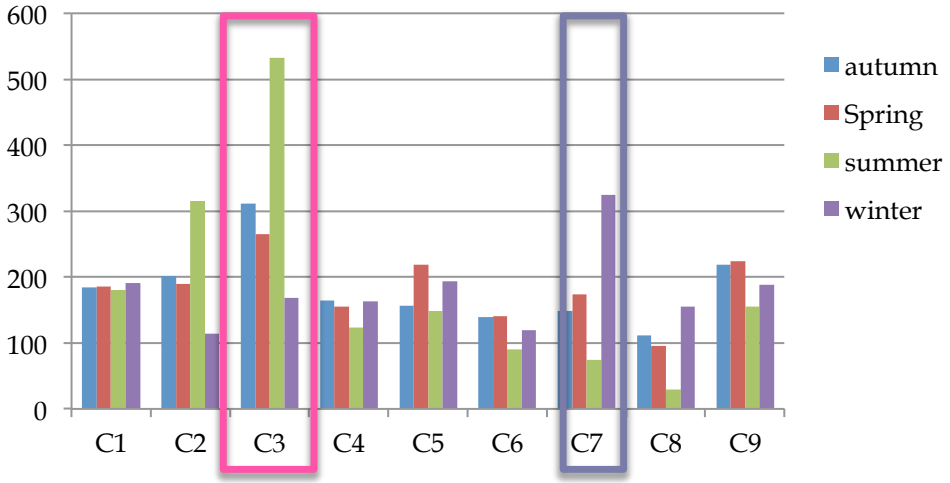
CONTINUATION: Daily back-trajectories cluster analysis

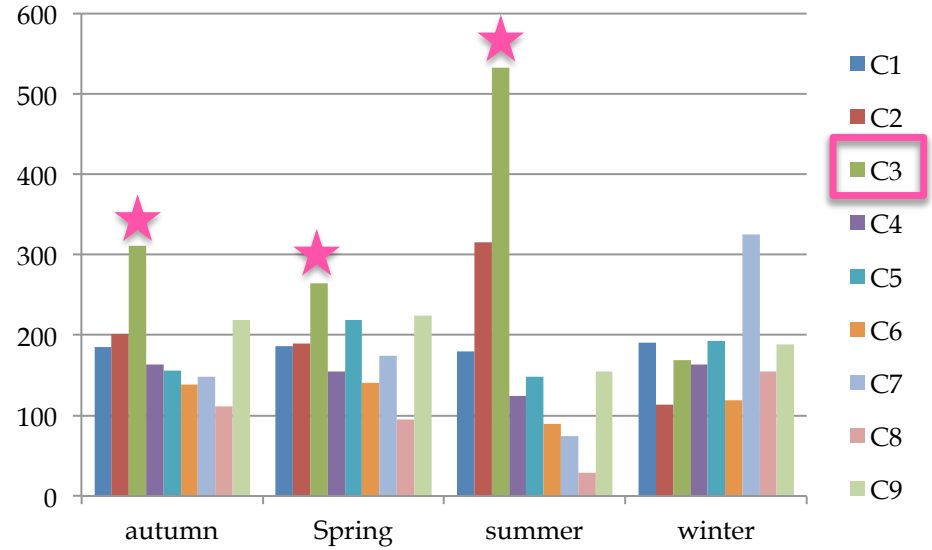
Period 1994-2011: 96-h isosigma back-trajectories at 12:00 UTC and 1.500 m.a.s.l.
(HYSPLIT 4.0 at http://www.arl.noaa.gov/ready/hysplit4.html, Draxler and Rolf 2003)

9 Clusters (each 24h)



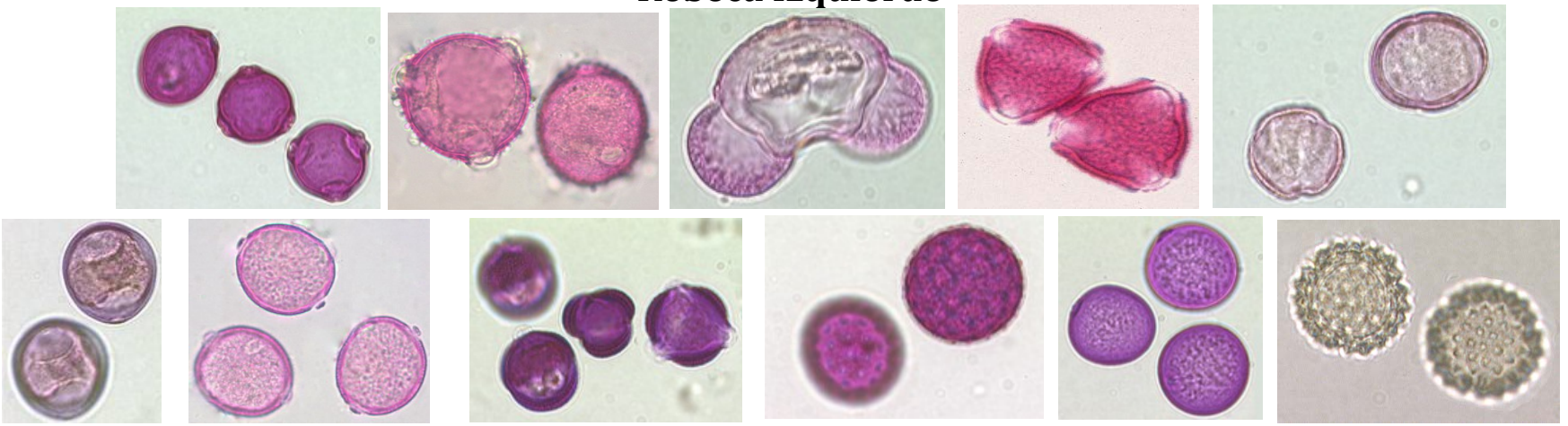
C1, C7 and C8 **Atlantic** *mean* and *long distance* (28,3%)
C4 **Atlantic** *mean distance* (and Iberian Peninsula) (9,3%)
C9 **Europe** (N) *long distance* (12,0%)
C5 **Europe** (NE) *short distance* (10,9%)
C6 **Mediterranean** and **S Europa** (7,5%)
C2 and C3 **Iberian Peninsula** recirculation (32,0%)





Work in progress…

Thanks for your attention

Relationship between climate variability indices and airborne pollination in Catalonia (NE Iberian Peninsula)

Marta Alarcón[1]
Jordina Belmonte[2,3]
Husam T. Maheed[1]
Cristina Periago[1]
Rebeca Izquierdo[1]