Bridging experimental and monitoring research for the assessment of ozone impacts on Mediterranean trees

26 October 2023

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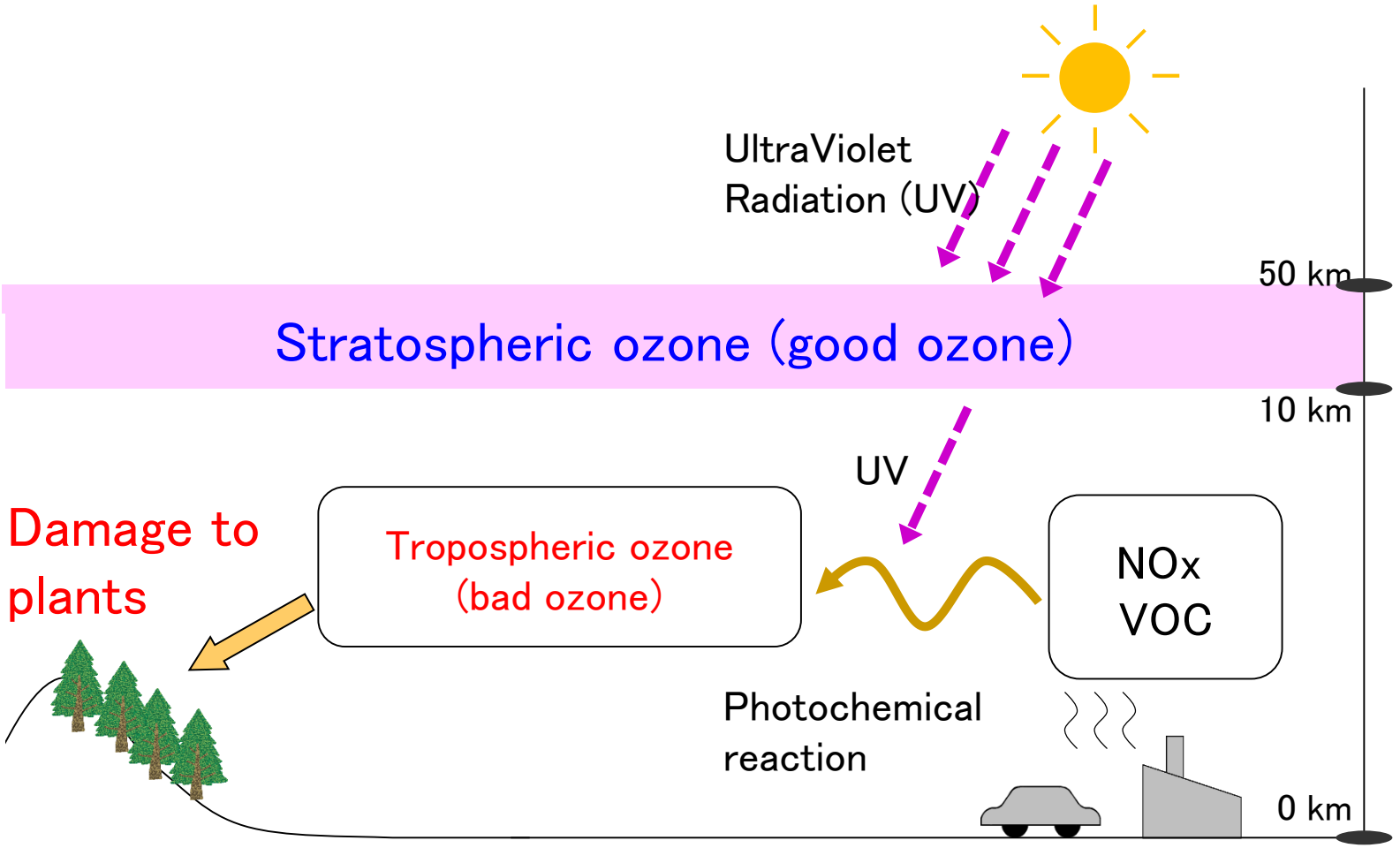
1. IRET-CNR, Italy; 2. UNIFI, Italy; 3.GIEFS, France; 4. ARGANS, France; 5. INCDS, Romania, 6. Transilvania University, Romania

Stratospheric ozone (good ozone)

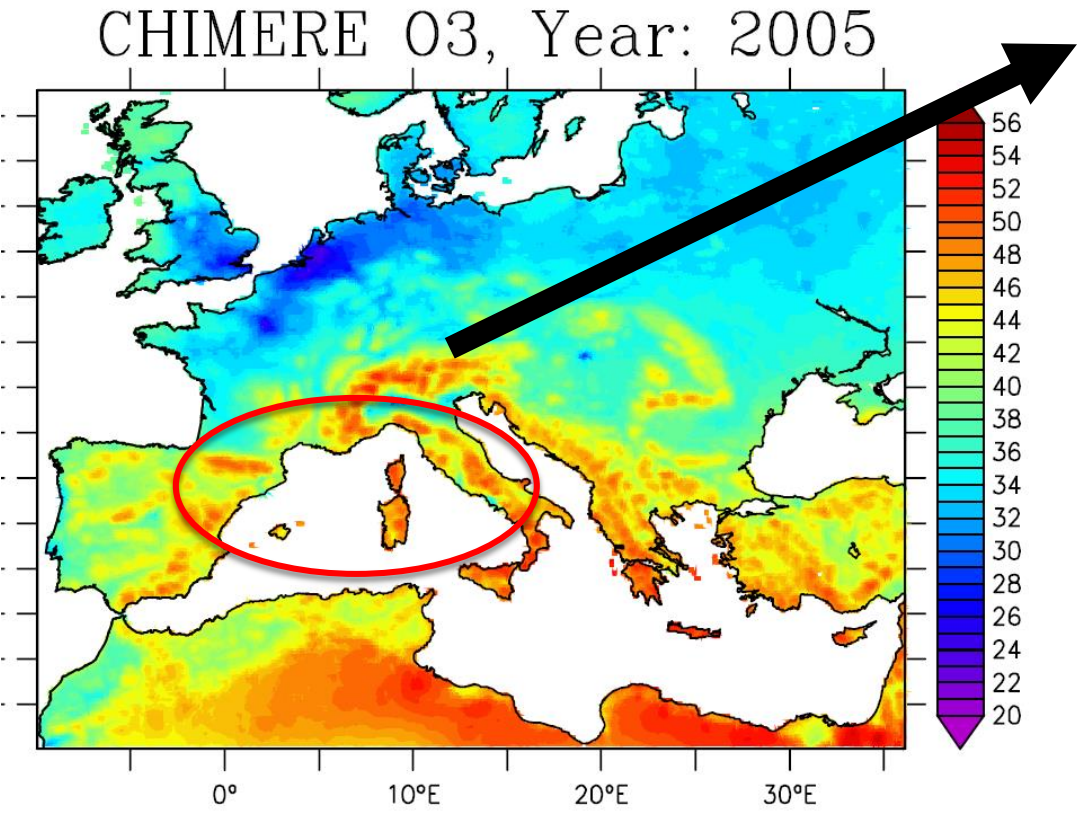
Protecting the organisms from UV as ozone layer.

Tropospheric ozone (bad ozone)

Damaging plants as photochemical smog.



Concentration of ozone in Europe



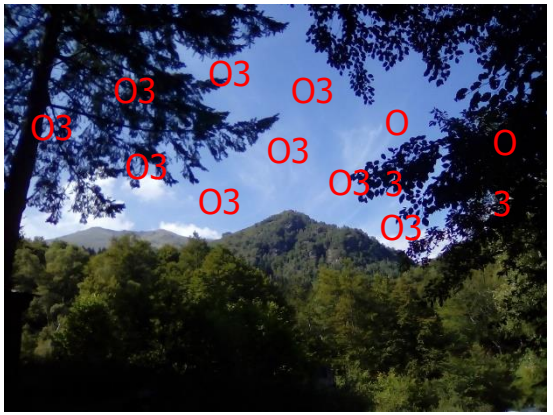
Anav et al. (2016, GCB)

Mediterranean Basin

→Ozone risks

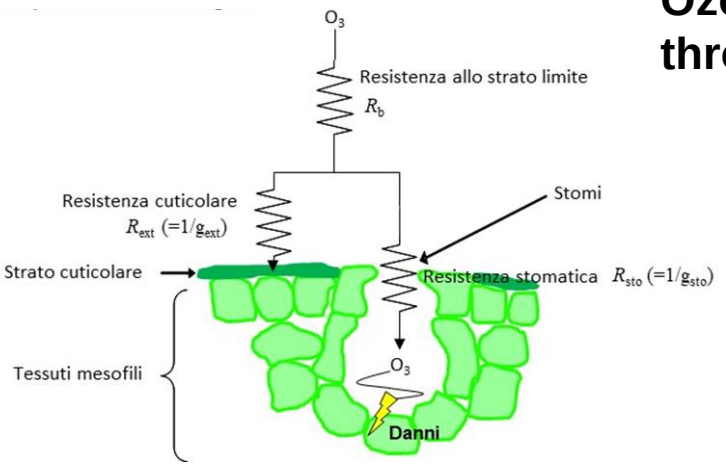
Forest monitoring

→Urgently needed



Assessment of ozone effects at national/regional level

New index POD ('Phytotoxic Ozone Dose')



Ozone enters through stomata

$$POD1 = \sum_{i=1}^{n} (F_{st,i} - 1) \cdot \Delta t$$

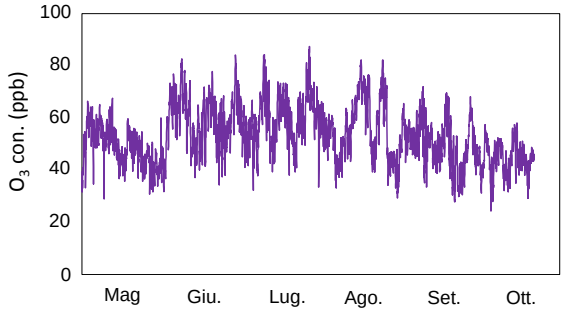
Jarvis stomatal model

$$g_{sO3} = g_{max} \cdot f_{phen} \cdot f_{O3} \cdot f_{light} \cdot \max\{f_{min}, (f_{temp} \cdot f_{VPD} \cdot f_{SWC})\}$$

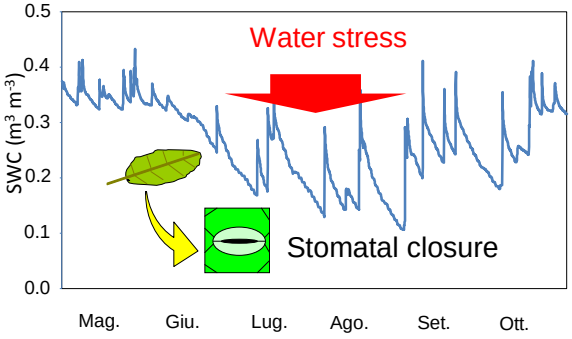
Considering species-specific parameters.

Effect of drought is essential.

O_3 concentration



Soil water content



O_3 levels are high in the period in which stomata close due to water stress

EU LIFE project MOTTLES [2016-2020]

(MOnitoring ozone injury for seTTing new critical LEvelS)

MOTTLES
LIFE15 ENV/IT/000183

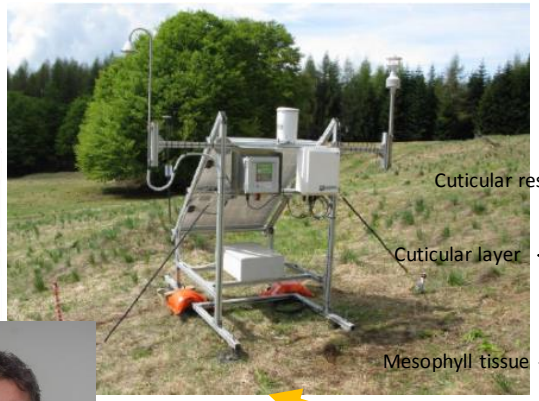
EU LIFE MODERn NEC [2021-2025]

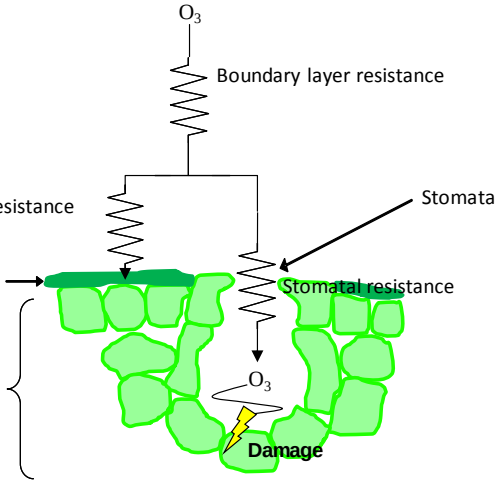
(new MOnitoring system to Detect the Effects of Reduced pollutants emissions resulting from NEC Directive adoption

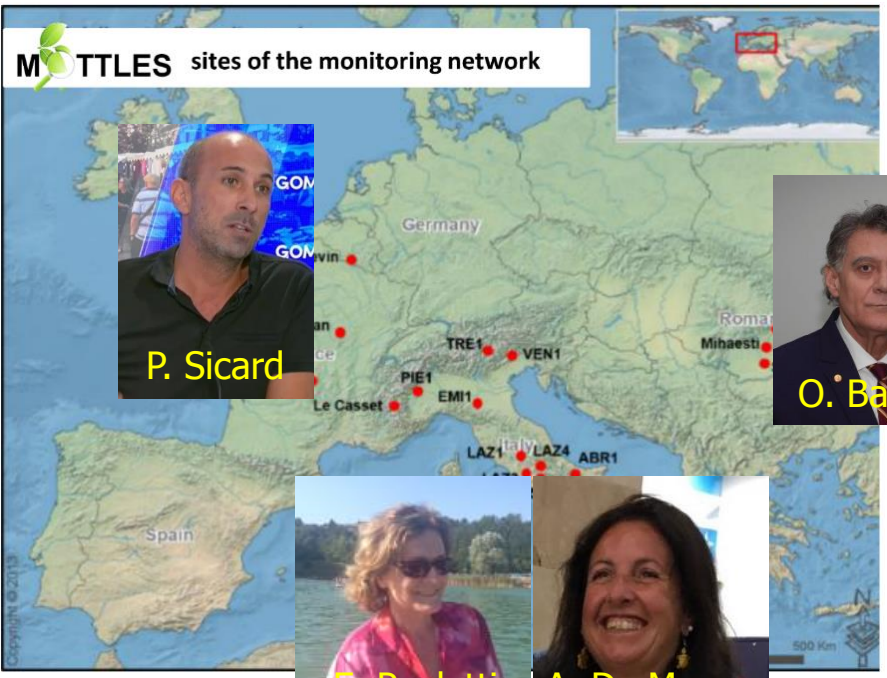
LIFE MODERN NEC
Qualità dell'aria, la risposta degli ecosistemi

E. Paoletti G. Papitto

Active ozone monitoring -> Stomatal ozone uptake calculation







P. Sicard

O. Badea

E. Paoletti

A. De Marco

Ogawa passive sampler

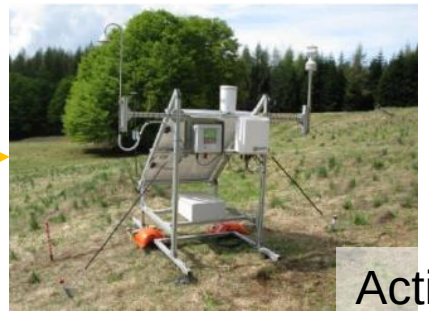
Active ozone monitoring station in forests

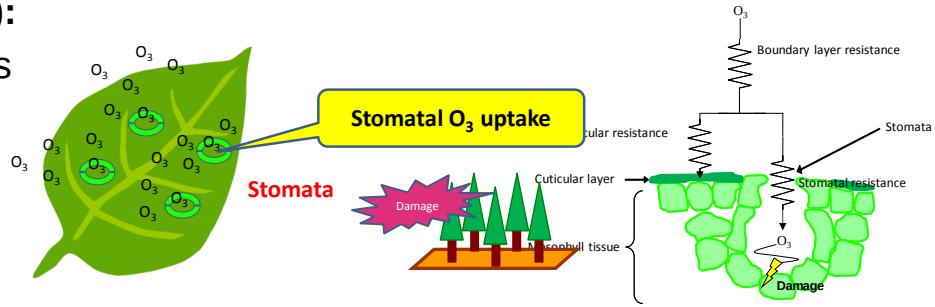
Stomatal ozone uptake calculation

Ozone and meteorological data (hourly):

→Active monitor powered by solar panels

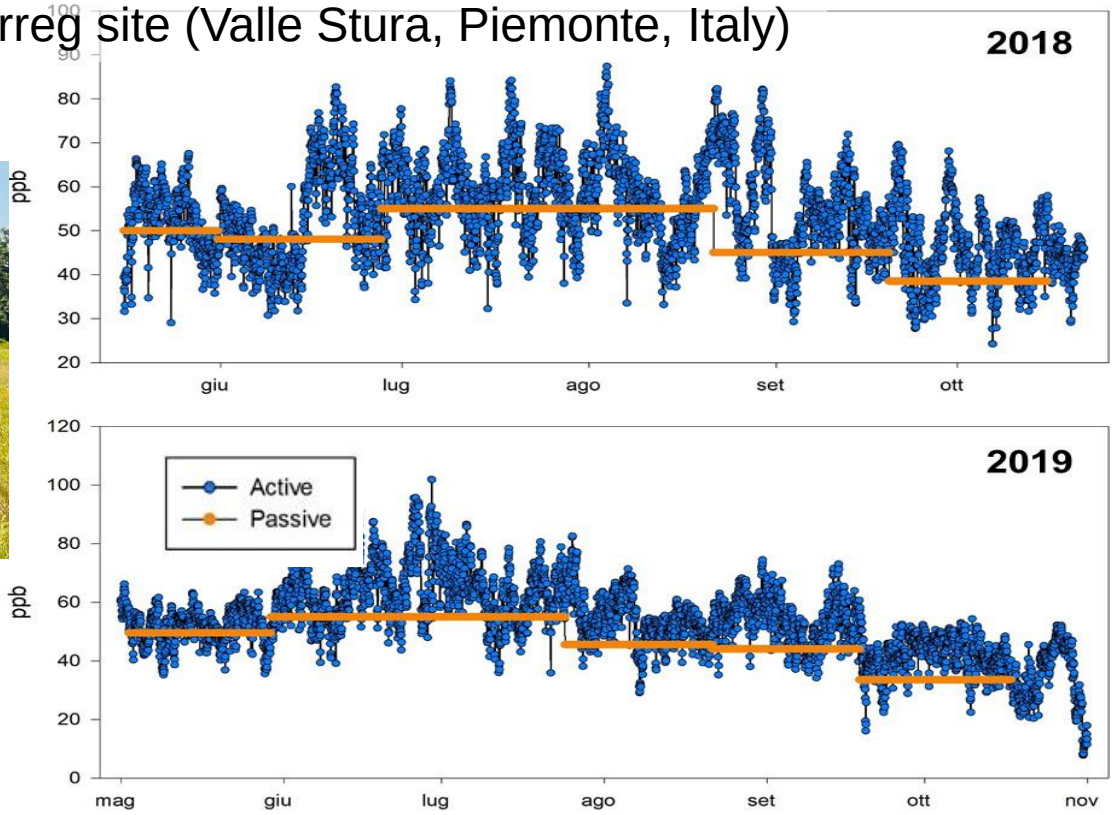
Ogawa
passive sampler



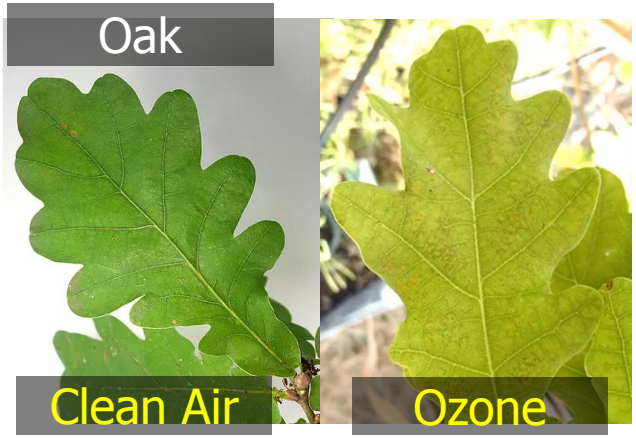


Active vs. Passive
Interreg site (Valle Stura, Piemonte, Italy)

New Italian site in 2023
VEN2 (Bosco Fontana)



Visible foliar injury induced by ozone



Age effect

Young leaves

Old leaves

(more damage)

Shade effect

Shaded portions of the leaves usually do not show any injury

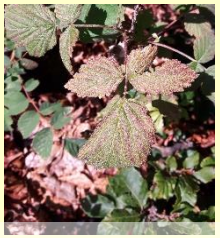
Data collection at forest sites

The field protocols followed the ICP-Forests manual

Problems

1) Need of the validation of field-observed ozone like symptoms

V. myrtillus



Rubus sp.

S. aucuparia

We found ozone-like visible injuries at forest sites.

However, the validation is still needed.

2) Lack of the information of g_s model parameters for POD calculation

Alnus glutinosa
Carpinus betulus
Fraxinus excelsior
Pinus cembra
Rubus sp.
Sorbus aucuparia
Vaccinium myrtillus

We can get stomatal conductance (g_s) parameters for some dominant tree species (from the ICP mapping manual).

However, the parameters for several symptomatic species are still needed.

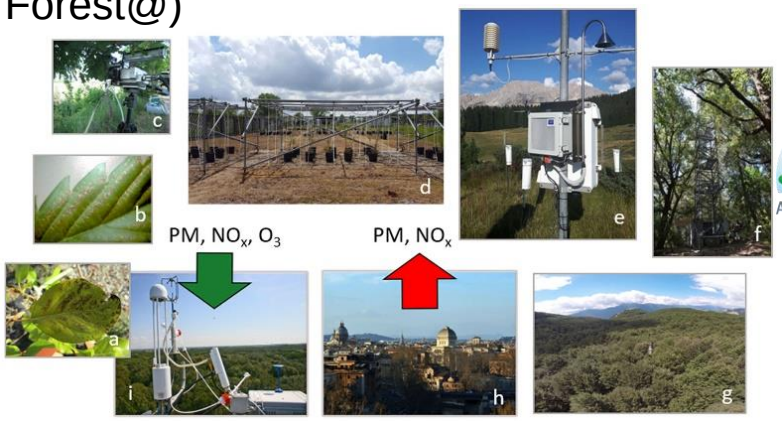
FO_3X Free-air O_3 eXposure

Web Site within AnaEE: https://platforms.anaee.eu/research-platform-index/fo3x/

1) Need of the validation of field-observed ozone like symptoms

2) Lack of the information of g_s model parameters for POD calculation

Forest monitoring + Manipulative Experiments (Fares and Paoletti 2019, Forest@)



AnaEE Eric
Analysis and Experimentation on Ecosystems

FO_3X

FO_3X (Ozone FACE)

Further development

ECOSYSTEM HEALTH AND SUSTAINABILITY
2022, VOL. 8, NO. 1, 2144466
https://doi.org/10.1080/20964129.2022.2144466

Bridging experimental and monitoring research for visible foliar injury as bio-indicator of ozone impacts on forests

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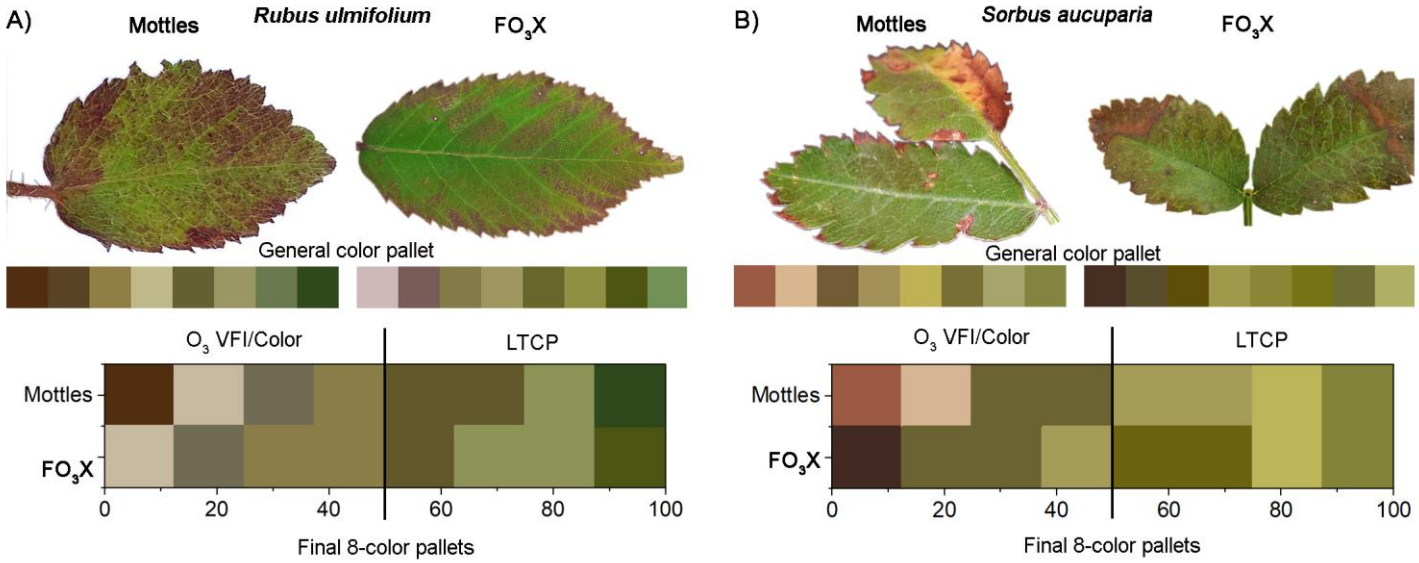
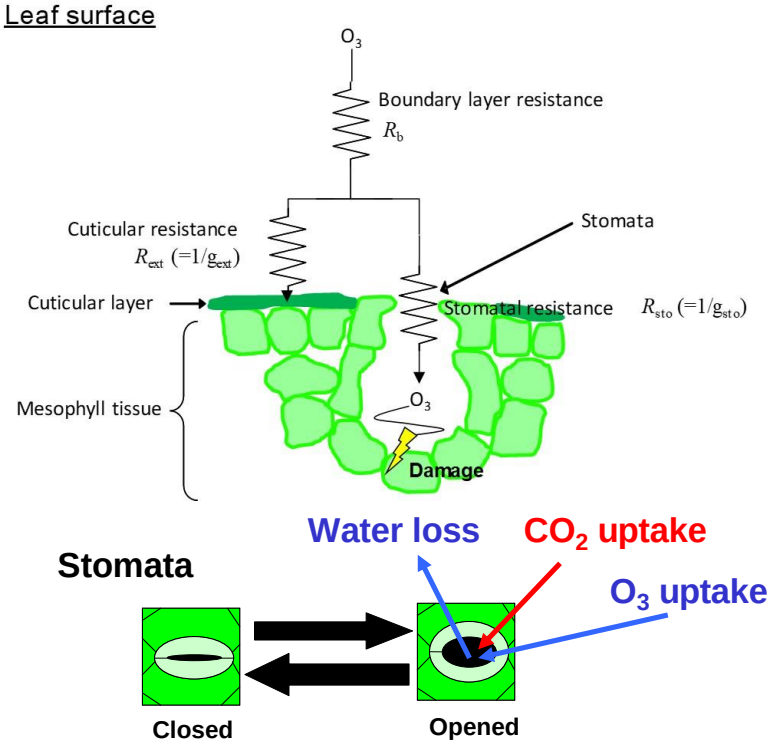
Moura et al. (2022, EHS)

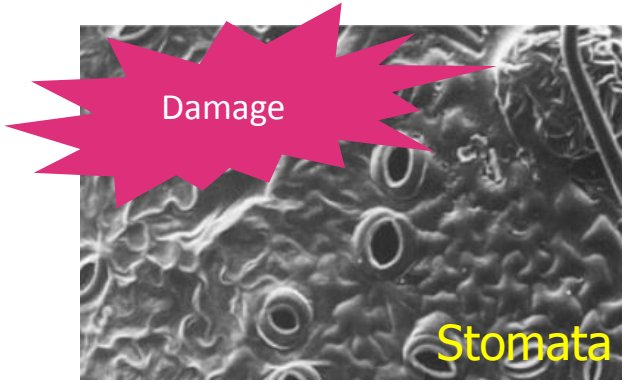


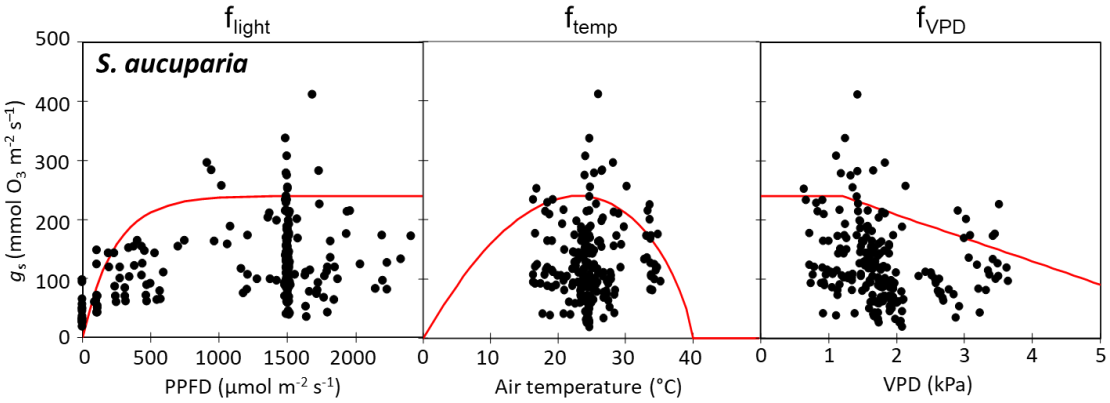
Specie	Color code	name
R. ulmifolius	512E10	Bracken
	C7BAA1	Coral Reef
	726B53	Peat
	8A7D47	Pesto
	62582B	Costa Del Sol
	8E9457	Green Smoke
	4C5513	Saratoga
	2F481C	Clover
S. aucuparia	9B5A42	Sepia Skin
	472D22	Saddle
	D7B690	Tan
	6C6133	Yellow Metal
	A29A5A	Husk
	6B6110	Spicy Mustard
	B9B05E	Olive Green
	86853B	Sycamore

Imaging analysis (color composition) ->Automatic detection?

Stomatal conductance measurements and modeling





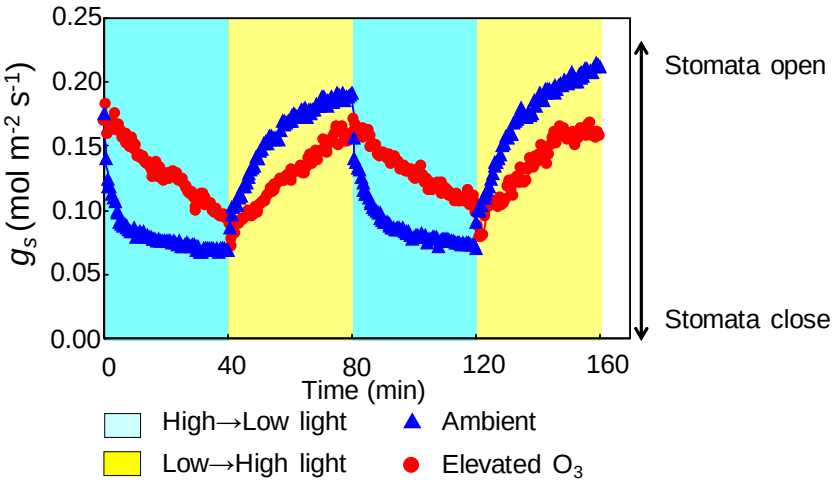


$$g_{sO3} = g_{max} \cdot f_{phen} \cdot f_{O3} \cdot f_{light} \cdot \max\{f_{min}, (f_{temp} \cdot f_{VPD} \cdot f_{SWC})\}$$

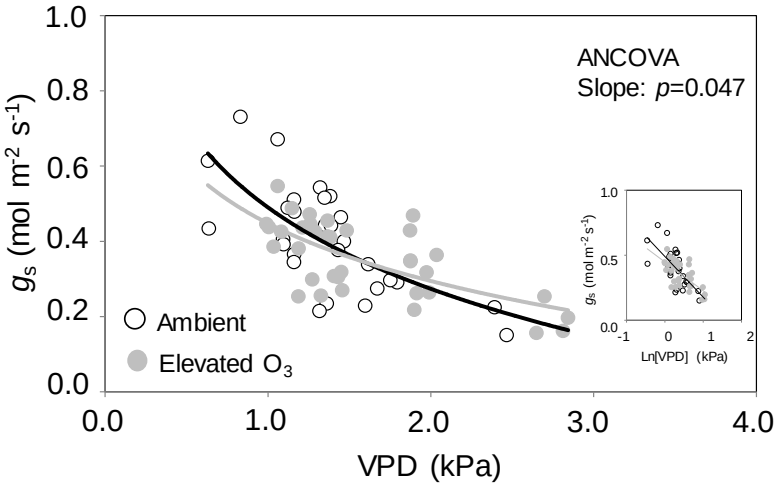
Ozone induces not only stomatal closure but also "**Stomatal sluggishness**" (Paoletti 2005, *Env Pol*).

Stomatal sluggishness

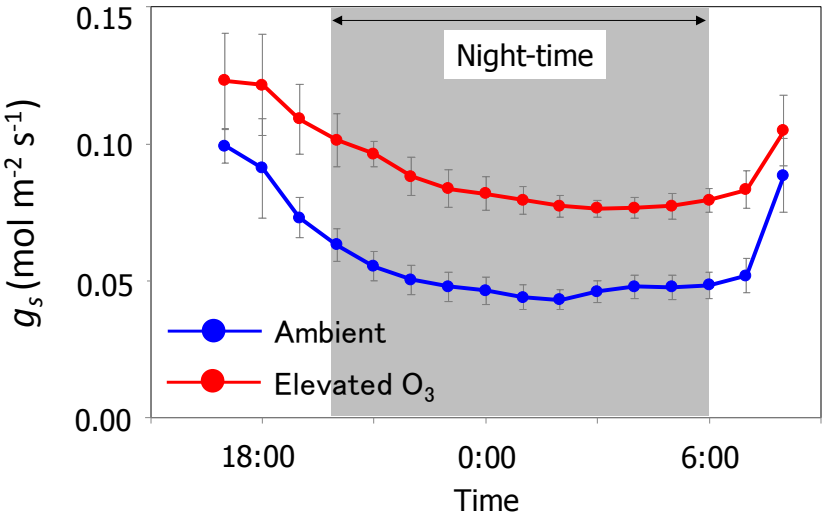
Light variation (Japanese Siebold's beech: Hoshika et al. 2012, Env Pol)



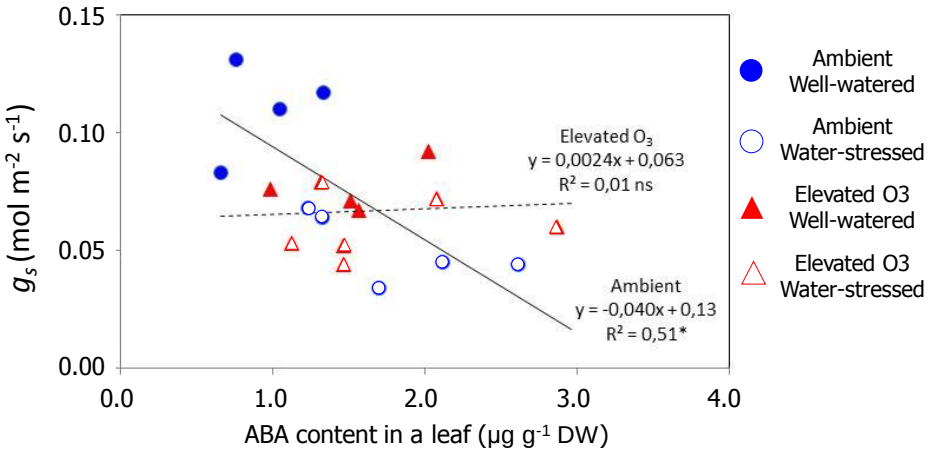
VPD (Japanese white birch: Hoshika et al. 2018, Plant Biol)



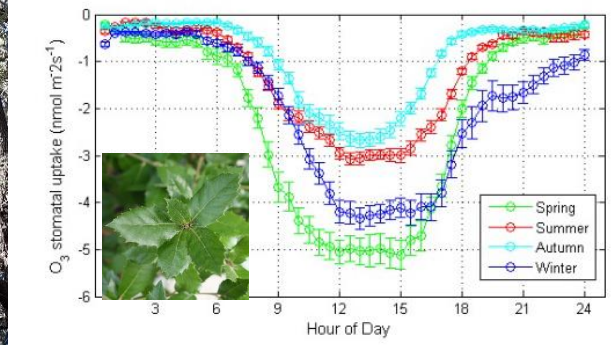
Night-time g_s (Oxford poplar: Hoshika et al. 2019, STOTEN)



ABA (Mediterranean deciduous oak: Hoshika et al. 2022, Physiol Plant)



How about the effects of O_3 on g_s in actual field sites?



Q. ilex forest

S. Fares

A. Conte

O_3 x water stress

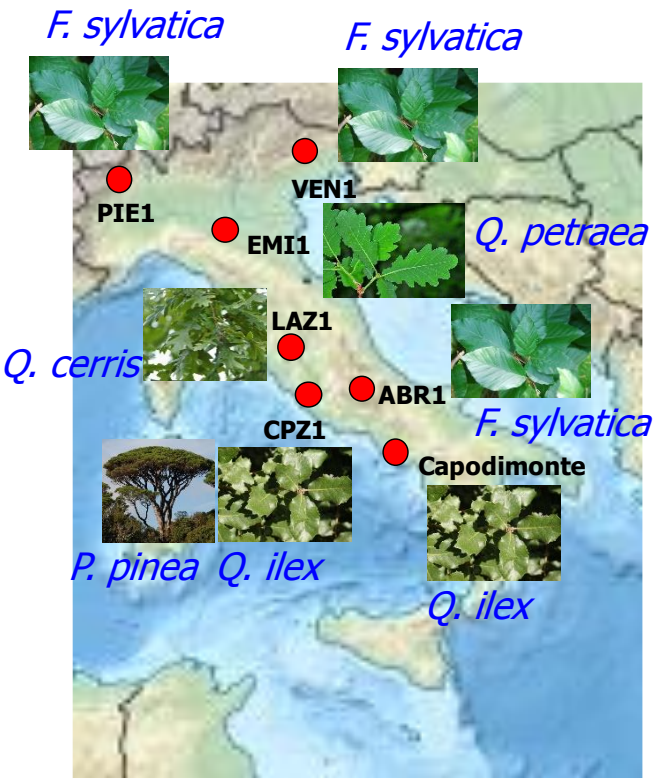
Water loss? Carbon uptake?

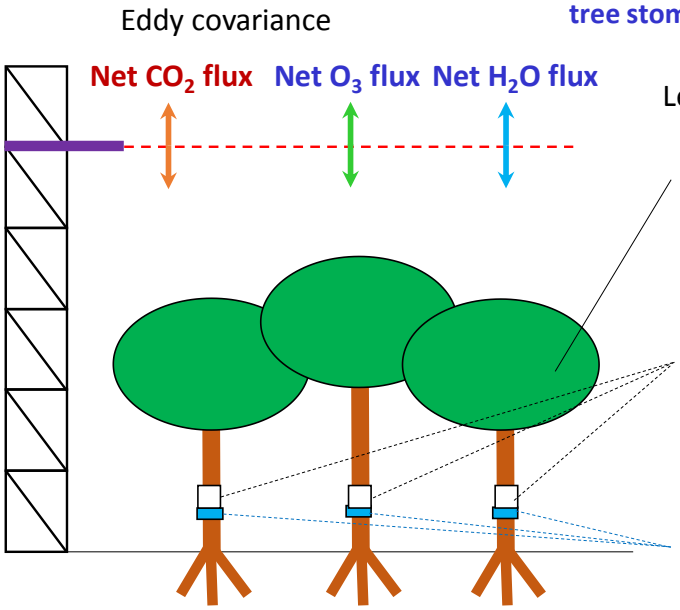
➡ Current and ongoing research!

4ClimAir (Italian National Project@CNR) [2022-2024]

IRET-CNR (coordinator: Yasutomo Hoshika; Alessio Giovannelli; Gabriele Guidolotti), IBE-CNR (Rita Baraldi), ENEA (Alessandra De Marco), INCDS (Ovidiu Badea), NUIST (Zhaozhong Feng)

4ClimAir
Ozone Drought





Calculation of tree stomatal conductance

Leaf gas exchange

Sap flow (TreeTalker)

Dendrometer

TreeTalker

Acknowledgement

We thank for the financial support to

PNRR ITINERIS (Mission 4, Comp. 2, Notice 3264/2021, IR0000032)

PNRR NBFC (Mission 4 Comp 2 Inv. 1.4 - Call No. 3138 of 16)

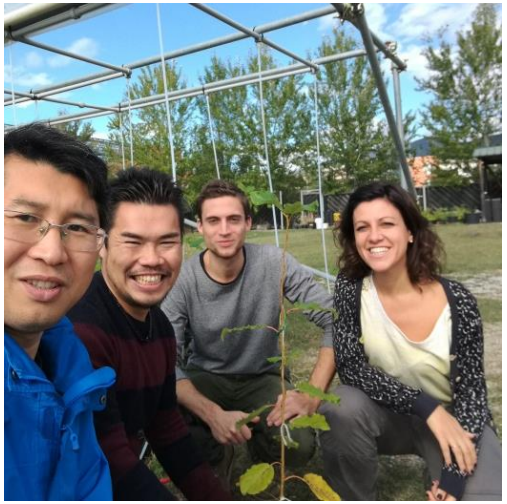
MODERn NEC (LIFE20-GIE_IT_000091), AIRFRESH (LIFE19 ENV/FR/000086), Mottles program (LIFE15 ENV/IT/000183),

CNR project 4ClimAir (SAC.AD002.173)

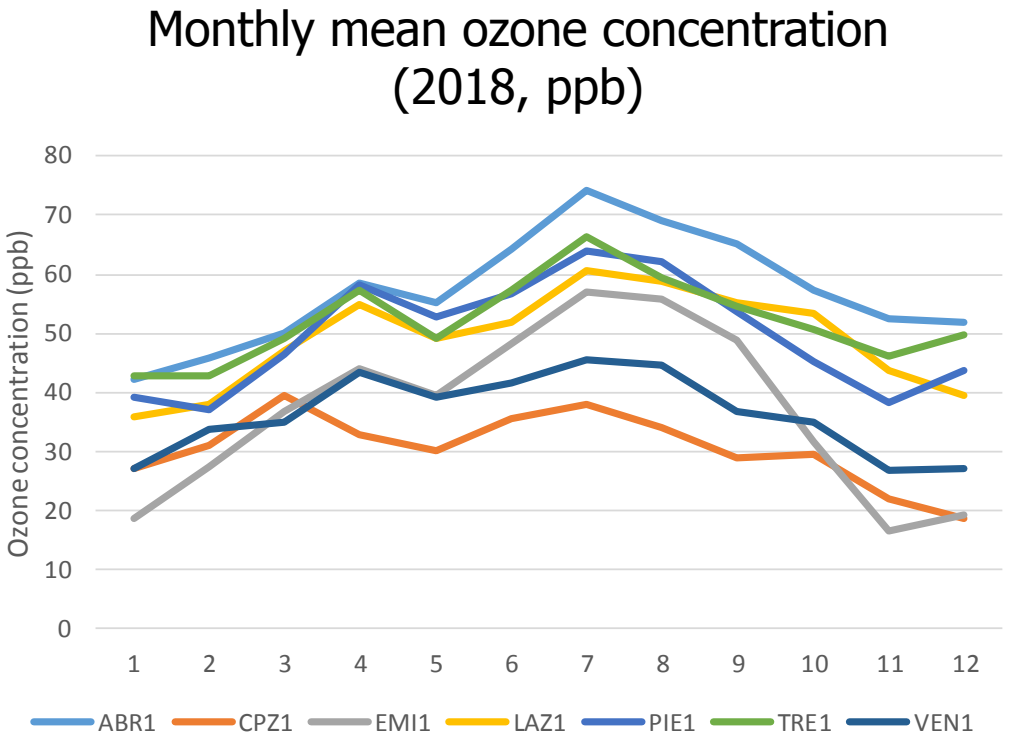
Fondazione Cassa di Risparmio di Firenze (2013/7956)

AnaEE (Analysis and experimentation on ecosystems) Eric

Thank you for your attention!!



Situation of ozone pollution in forest area



Situation of ozone pollution in forest area

Annual mean ozone concentration (ppb)
(2018-2022)

	Year				
	2018	2019	2020	2021	2022
ABR1	58.1	53.3	46.7	48.2	54.3
CPZ1	30.7	34.2	33.3	27.3	22.4
EMI1	38.1	37.9	31.3	32.2	43.0
LAZ1	49.3	46.3	41.7	42.4	48.2
PIE1	50.6	50.8	46.7	49.5	53.4
TRE1	52.2	46.6	40.6	43.7	46.0
VEN1	36.5	35.6	31.2	33.4	33.2