Removal of greenhouse gases and pollutants in periurban Mediterranean forest ecosystems described by the **Aggregated Interpretation of the Energy balance and water dynamics for Ecosystem services assessment (AIRTREE) model**

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AIRTREE- multi-layer model parameterization with ground-level and proximally sensed data

Proximally sensed data, in situ gradient measurement

Measurements on site
Photosynthetic parameters, e.g. Vcmax, Basal Emission Factors for BVOC, LAI

Literature
Air pollutants deposition, carbon fluxes and ecosystem services

Pollutant concentrations, meteorological parameters, vegetation type

Radiative transfers: Leaf temperature and solar irradiation

Photosynthesis & stomatal conductances

Validation with EC data

BVOC emission

Turbulent transport

Canopy profile

Soil processes
Leaf/canopy level measurements for compilation of a database

- Meteorology (air temperature, precipitation, solar radiation)
- Photosynthetic parameters (A\text{max}, G\text{sto}, Vc\text{max}, J\text{max}) and BVOC basal emissions by single-leaf gas exchange measurements

- Tree architecture and LAI by stereometric methods
- Database on mediterranean tree structural and physiological parameters nested in AIRTREE
Model validation: Continuous Eddy Covariance flux measurements

Fluxes are measured from the eddy covariance (EC) between vertical wind speed and gas concentration ($O_3$, VOC, $CO_2$, $H_2O$), with observations 10 times per second

$$\Phi_x = w'X'$$
Model calibrated for energy fluxes
Target gas measured at Castelporziano: CO2

- About 600 g CO2 m\(^{-2}\) per year removed by the forest
- Tot. GPP in 2013: 1566 g (C) m\(^{-2}\) (894 mm precip.)
- Tot. GPP in 2014: 1768 g (C) m\(^{-2}\) (1100 mm precip.)
The model will soon incorporate more advanced mechanisms to take into account VPD limitation during summer months.
Target gas: ozone

Ozone fluxes are higher during late spring, when stomatal conductance is high. Up to $8 \text{ g O}_3 \text{ m}^{-2} \text{ yr}^{-1}$.

- Evaporative/resistive method for the stomatal component:
  \[
  \lambda E = \frac{\rho c_p [e_s(T_0) - e(z_m)]}{\gamma (R_a + R_b + R_{sto})}
  \]

- Soil sink:
  \[
  R_{ac} = \frac{14 \times \text{LAI} \times z_c}{u^*}
  \]

- Cuticoles:
  \[
  R_{g} = R_{g1} + R_{g2} \cdot \frac{\text{SWC10}}{\text{SWC}_{fc}} \]
  \[
  R_{\text{cut(dry)}} = \frac{R_{\text{cut(dry)}_0}}{e^{0.03 RH} \times \text{LAI}^{1/4} \times u^*}
  \]
  \[
  R_{\text{cut(wet)}} = \frac{R_{\text{cut(wet)}_0}}{\text{LAI}^{1/2} \times u^*}
  \]

(Fares et al., 2014. Agr. For Met.)
Measured vs simulated ozone fluxes

Multi-level deposition affected by the proportion of leaf biomass at each level

Underestimated gas phase chemistry
Target gases: PM1 and PM2.5

Few weeks of measurement:

- Positive fluxes of PM2.5 represent the quota of intercepted PM resuspended into the atmosphere

- PM1: some captured particles can be absorbed into the tree, though most particles that are intercepted are retained on the plant surface

Modelled PM fluxes:

Existing models still do not consider that the quota of resuspension is quite high and may equal deposition for PM 2.5 and PM10

Model sensitivity: major effects of soil properties and drought on photosynthetic parameters

Optimization routines by PEST (Doherty, 2016).
PEST is a nonlinear parameter estimation and optimization package based on the Gauss-Marquardt-Levenberg algorithm.

- Unrealistic predictions when soil water content is not included among the parameters driving stomatal regulation.

Soil porosity

Velocity of carboxilation changing over the vegetative season
Spatial distribution of green ozone sinks in Rome

Use of Earth Engine to derive tree cover and LAI by supervised classification using high resolution remotely sensed data (Sentinel 2).

2.6 tons(O3) year-1
Spatial distribution of green PM sinks in Rome

Use of Earth Engine to mask tree cover and LAI by supervised classification using high resolution remotely sensed data (Sentinel 2).
User-friendly and open access web-gis application to estimate ecosystems services

Try online on:
www.air-tree.org!
BVOC emitted by urban vegetation: Castelporziano as a test site

- Nested in AIRTREE: Model of Emissions of Gases and Aerosols from Nature - MEGAN

\[ F_{\text{BVOC}} = B_0 \cdot \exp(\theta_0 \cdot (P_a - P_f) \cdot (P_a)^\theta) \cdot \frac{[\theta_0 - \frac{\ln(P_d)}{T_{\text{air}}}] \cdot \text{PAR}}{[\theta_0 - \frac{\ln(P_d)}{T_{\text{air}}}]} \cdot \exp(\theta_0 \cdot (T_{\text{av}} - 297)) \cdot \exp(h_0 \cdot (T_{\text{av}} - 297)) \cdot \exp(h_0 \cdot (T_{\text{av}} - 297)) \]

- Temperature-dependent BVOC emissions uncoupled from carbon assimilation
VOC emissions & effects for air quality

- New Basal Emission factors calculated for key Mediterranean urban forest ecosystems were used to run MEGAN for estimating BVOC emissions in central Italy from the main plant functional types coupled with a Community Land Model.

- The global model run with realistic BEF from prevailing MT emitting species predicted lower concentrations of tropospheric ozone compared with an isoprene emitting scenario used in the previous MEGAN version.

\[O_3\] concentration, median values (12:00 to 14:00)

*Fares et al. Env. Sc. Tech. 2013*
Conclusions:

- AIRTREE is a promising model to predict pollutants sequestration by urban forests with a proper parameterization
- Great potential for interactions with new open access tools for air quality and remotely sensed data
- Existing network to assess long term ecophysiological parameters of vegetation may be used for model validation
- A user friendly web-Gis interface has been released
- Future work: test possible ozone damage to vegetation with semi-empirical models
Thank you for the attention!

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