Convocatorias 2017
Proyectos EXCELENCIA y Proyectos RETOS
AGENCIA ESTATAL DE INVESTIGACIÓN

AVISO IMPORTANTE

En virtud del artículo 16 de la convocatoria **NO SE ACEPTARÁN NI SERÁN SUBSANABLES MEMORIAS CIENTÍFICO-TÉCNICAS** que no se presenten en este formato.

Es obligatorio que la memoria contenga las tres partes (A, B y C). La parte C de la memoria no podrá exceder de 25 páginas.

Lea detenidamente las instrucciones para rellenar correctamente esta memoria, disponibles en la web de la convocatoria.

Parte A: RESUMEN DE LA PROPUESTA/SUMMARY OF THE PROPOSAL

A.1. DATOS DEL PROYECTO COORDINADO

INVESTIGADOR/ES COORDINADOR/ES:

INVESTIGADOR COORDINADOR PRINCIPAL 1 (Nombre y apellidos)**:**

Penélope Serrano Ortiz

INVESTIGADOR COORDINADOR PRINCIPAL 2 (Nombre y apellidos)**:**

Juan Luis Guerrero Rascado

TÍTULO GENERAL DEL PROYECTO COORDINADO: Estudio de los baLances de carbono y agua en EcosisteMas gEstioNados para su adapTAción al cambio cLimático

ACRÓNIMO DEL PROYECTO COORDINADO: ELEMENTAL

RESUMEN DEL PROYECTO COORDINADO Máximo 3500 caracteres (incluyendo espacios en blanco):

En el contexto del cambio climático, las prácticas de gestión agrícola y forestal destinadas a incrementar la captura de CO2 y optimizar la eficiencia del uso del agua adquieren gran relevancia en los ecosistemas mediterráneos (centro-sur de España) propensos a la sequía. Por otra parte, los altos niveles de concentración de O3 tienen un impacto negativo, pero de magnitud incierta, sobre la productividad, absorción de CO2 y uso del agua. Siendo crucial mejorar la comprensión y modelización de la deposición de O3. Los intercambios de CO2, H2O y O3 entre atmósfera y vegetación están intrínsecamente relacionados en estos ecosistemas, debido a que el estrés hídrico conduce a una regulación estomática afectando simultáneamente a estos intercambios.

El proyecto coordina 3 subproyectos que suman gran experiencia en la investigación sobre el intercambio de gases y energía en la interfaz biosfera-atmósfera usando la técnica de eddy covariance (torres de flujo). El subproyecto 1 es experto en intercambios de CO2 y caracterización de la capa límite atmosférica, el subproyecto 2 en mediciones de evapotranspiración y modelización del ciclo del agua y el subproyecto 3 en flujos de O3 y modelización de su deposición. El proyecto coordinado generará grandes sinergias agregando no sólo la experiencia, sino también la importante capacidad experimental e instrumental de los equipos, para crear un conjunto experimental único, compuesto de varias torres de flujo y diversas medidas complementarias que se desarrollará en 4 agro-sistemas de gran relevancia socioeconómica (olivares, cítricos, pinares de Alepo y "Dehesa"). Las bases de datos obtenidas tendrán un valor único debido a la interdependencia de los flujos de CO2, H2O y O3, utilizándose junto con herramientas de modelización para:

>Estudiar la partición de CO_2 y H_2O y con ello la eficiencia del uso del agua bajo distintos tratamientos de la cubierta herbácea

>Estudiar la contribución de la cubierta vegetal en la deposición de O_3 total y estomático mediante mediciones in situ y evaluar el estado de la técnica mediante la modelización de deposición de O_3 (DO3SE)

>Trabajar en la optimización de la técnica eddy covariance y ampliar la monitorización de variables complementarias para evaluar la calibración/validación de modelos

Además, como consecuencia de la creación de este conjunto experimental único y el logro de los objetivos propuestos, los hitos más notables del proyecto son:

- Cuantificación experimental del impacto de la retirada de la cubierta herbácea sobre los flujos de CO_2, H_2O y O_3 del olivar y el pinar. Donde además de las torres permanentes de flujo instaladas a nivel de ecosistema, se instalarán 2 torres más a niveles próximos a la superficie en ambos tratamientos (con y sin cubierta herbácea).
- Partición de los flujos de CO_2, H_2O y O_3 entre las distintas contribuciones del dosel y de la cubierta vegetal en aquellos agro-sistemas compuestos por dos capas de vegetación, desentrañando así las distintas estrategias empleadas por los árboles y la cubierta vegetal
- Nuevo enfoque para evaluar la aplicabilidad y exactitud de la técnica eddy covariance mediante la combinación de observaciones de la capa límite atmosférica
- Realizar una evaluación robusta de la eficiencia del uso del agua, la dinámica del ciclo del agua y su dependencia con condiciones climáticas, comparando las estimaciones independientes de los componentes de la evapotranspiración (HidroMORE) con mediciones in situ.

PALABRAS CLAVE DEL PROYECTO COORDINADO: eddy covariance, gases de efecto invernadero, gestión, O3, modelo HiDROMORE, monitoreo a largo plazo, teledetección

TITLE OF THE COORDINATED PROJECT: Enabling adaptation to cLimate changE by Management of Ecosystem carboN and water bALance

ACRONYMOF THE COORDINATED PROJECT: ELEMENTAL

SUMMARY OF THE COORDINATED PROJECT Maximum 3500 characters(including spaces):

In the context of climate change, agricultural and forestry management practices aimed at increasing C sequestration and optimizing water use efficiency have become of increasing interest for drought-prone ecosystems of central-south Mediterranean Spain. On other hand, high O_3 concentration levels in that area have a negative impact, but of still rather uncertain magnitude, onto plant productivity, CO_2 net uptake and water use. It is therefore also crucial to improve understanding and modeling of O_3 deposition for Mediterranean ecosystems. CO_2, H_2O and O_3 exchanges between atmosphere and vegetation are intrinsically related in Mediterranean ecosystems, as chronical conditions of water stress lead to stomatal down-regulation that affect simultaneously CO_2, H_2O and O_3 exchanges.

The project coordinates 3 subprojects, summing up great expertise in research about exchanges of trace gas and energy at biosphere-atmosphere interface, in particular using the eddy covariance (EC) technique. The team from subproject 1 is expert in CO_2 exchanges and characterization of atmospheric boundary layer; that from subproject 2 in evapotranspiration (ET) measurements and water cycle modeling, and that from subproject 3 in O_3 fluxes measurements and O_3 deposition modeling.

The coordinated project will generate great synergies by aggregating not only expertise, but also the important experimental and instrumental capacity of the 3 teams, to create a unique experimental set up including several flux-tower EC systems and various and diverse complementary measurements, that will be deployed in 4 ecosystems types of major relevance and socio-economic importance in Mediterranean Spain (Olive and Citrus crops,

Aleppo Pine forest and “Dehesa”). The collected datasets will be of unique value due to intrinsic interdependence of CO2, H2O and O3 fluxes, and will be used in conjunction with modeling tools to achieve the general objectives of the projects:

> Study water and CO2 flux partitioning together with the water use efficiency of representative Spanish ecosystems under different treatments

> Quantify the contribution of canopy and understory strata to total and stomatal ozone deposition for major relevant Mediterranean ecosystems by in-situ measurements and assess the state of the art regarding O3 deposition modelling (DO3SE) for these ecosystems.

> Optimize the eddy covariance technique and amplify complementary variable monitoring to assess model calibration/validation

Beside the unique experimental set up and the achievement of proposed objectives, the most remarkable features of the project are:

- Experimental quantification of the impact of understory vegetation management at the Olive and Pine sites, where double flux-tower sites (with and without understory vegetation) will allow to assess effect on CO2, H2O and O3 fluxes
- Partitioning of CO2, H2O and O3 ecosystem fluxes between canopy and understory contributions, for 3 agro-ecosystems composed by two vegetation layers, thereby disentangling the distinct strategies employed by trees and shrub/herbaceous vegetation
- Novel approach for assessing the applicability and accuracy of EC technique using combination of atmospheric boundary layer observations
- Perform robust assessment of water use efficiency and water cycle dynamics and their dependence to climatic conditions, by comparing independent estimates of ET components (model HidroMORE) and from a specific suite of in situ measurements.

KEY WORDSOF THE COORDINATED PROJECT: eddy covariance, greenhouse gases, management, O3, HiDROMORE model, long-term monitoring, remote sensing

A.2. DATOS DELOS SUBPROYECTOS

SUBPROYECTO 1 *(el investigador o investigadores principales del subproyecto 1 son los coordinadores del proyecto coordinado)***:**

TÍTULO: Improving Carbon sequestration in agro-ecosystems by management for adaptation to climate change

SUBPROYECTO 2:

INVESTIGADOR PRINCIPAL 1 (Nombre y apellidos)**:**

Eva María Rubio Caballero

INVESTIGADOR PRINCIPAL 2 (Nombre y apellidos)**:**

Francisco Antonio García Morote

TÍTULO: Improving the water uSe efficiency in Agro-ecosystems by management for Adaptation to Climate change

SUBPROYECTO 3:

INVESTIGADOR PRINCIPAL 1 (Nombre y apellidos)**:**

Arnaud Carrara

INVESTIGADOR PRINCIPAL 2 (Nombre y apellidos)**:**

Vicent Calatayud Llorente

TÍTULO: Ozone deposition partitioning in Mediterranean ecosystems: new approaches

Parte B: INFORMACIÓN ESPECÍFICA DEL EQUIPO

B.1. FINANCIACIÓN PÚBLICA Y PRIVADA (PROYECTOS Y/O CONTRATOS DE I+D+I) DEL EQUIPO DE INVESTIGACIÓN (repitala secuencia tantas veces como se precise en cada uno de los subproyectos participantes hasta un máximo de 5 proyectos y/o contratos por cada subproyecto)

SUBPROYECTO 1:

1.Investigador del equipo de investigación que participa en el proyecto/contrato (nombre y apellidos): Penélope Serrano Ortiz, Andrew S. Kowalski, Luis Villagarcía Sainz
Referencia del proyecto: CGL2014-52838-C2-1-R
Título: Hacia el balance integrado de gases de efecto invernadero en ecosistemas nacionales de alto impacto social y económico (GEISpain)
Investigador principal (nombre y apellidos): Penélope Serrano Ortiz y Andrew S. Kowalski
Entidad financiadora: Ministerio de Economía y Competitividad
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 01/01/2015-31/12/2017
Financiación recibida (en euros): 163.350€
Relación con el proyecto que se presenta: mismo tema
Estado del proyecto o contrato: concedido

2. Investigador del equipo de investigación que participa en el proyecto/contrato (nombre y apellidos): Penélope Serrano Ortiz (representante científica de la UGR)
Referencia del proyecto: Grant agreement No 284274
Título: InGOS— Integrated non-CO2 Greenhouse gas Observing System
Investigador principal (nombre y apellidos): Alex Vermeulen, P. Serrano Ortiz (IP de la UGR)
Entidad financiadora: European Commission, FP7-INFRASTRUCTURES-2011-1
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 01/10/2011-31/12/2015
Financiación recibida (en euros): 7.999.999€ (32.315€ para la UGR)
Relación con el proyecto que se presenta: mismo tema
Estado del proyecto o contrato: concedido

3. Investigador del equipo de investigación que participa en el proyecto/contrato (nombre y apellidos): Andrew S. Kowalski
Referencia del proyecto: Grant agreement No 244122
Título: Greenhouse gas management in European land use systems
Investigador principal (nombre y apellidos): Annette Freibauer, A. S. Kowalski (IP de la UGR)
Entidad financiadora: European Commission, FP7-ENV-2009-1.1.3.1
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 01/01/2010-30/06/2013
Financiación recibida (en euros): 8.928.864€ (75.000 para la UGR)
Relación con el proyecto que se presenta: mismo tema
Estado del proyecto o contrato: concedido

4. Investigador del equipo de investigación que participa en el proyecto/contrato (nombre y apellidos):
Referencia del proyecto: RNM-7186
Título: Balance de carbono en el olivar: efecto de la presencia de la cubierta vegetal
Investigador principal (nombre y apellidos): Andrew S. Kowalski
Entidad financiadora: Junta de Andalucía; Consejería de Economía, Innovación y Ciencia
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 01/06/2014-31/05/2014
Financiación recibida (en euros):169.185€
Relación con el proyecto que se presenta: mismo tema
Estado del proyecto o contrato: concedido

5.Investigador del equipo de investigación que participa en el proyecto/contrato (nombre y apellidos): Juan Luis Guerrero Rascado
Referencia del proyecto: Grant agreement No 654109

Título: Aerosols, Clouds, and Trace gases Research Infrastructure Network (ACTRIS-2 Integrating Activities)
Investigador principal (nombre y apellidos): Gelsomina Pappalardo
Entidad financiadora: European Union's Horizon 2020 research and innovation programme
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 01/05/2015-30/04/2019
Financiación recibida (en euros): 10.000.000€ (250000€ para la UGR)
Relación con el proyecto que se presenta: está muy relacionado
Estado del proyecto o contrato: concedido

SUBPROYECTO 2:

1. Investigador del equipo de investigación que participa en el proyecto/contrato: Eva Rubio, Francisco R. López-Serrano, Francisco A. García-Morote, Manuela Andrés Abellán
Referencia del proyecto: AGL2014-55658-R
Título: Propuestas de gestión forestal adaptativas para favorecer la resiliencia de bosques mediterráneos frente a los impactos del cambio climático (sequía e incendios) (FORESTRENGTH).
Investigador principal: Francisco R. López-Serrano y Eva Rubio
Entidad financiadora: Ministerio de Economía y Competitividad
Duración: 01/01/2015-31/12/2017
Financiación recibida (en euros): 145.200,00 €
Relación con el proyecto que se presenta: mismo tema
Estado del proyecto o contrato: concedido

2. Investigador del equipo de investigación que participa en el proyecto/contrato: Eva Rubio, Francisco R. López-Serrano, Francisco A. García-Morote
Referencia del proyecto: PEIC-2014-002-P
Título: Evaluación del balance de Carbono y Flujos de vapor de agua en sistemas agrícolas y forestales de Castilla-La Mancha (ECOFLUX III).
Investigador principal: Eva Rubio (coordinadora) y Francisco R. López-Serrano
Entidad financiadora: Consejería de Educación y Ciencia de Castilla-La Mancha
Duración: 27/09/2014-26/09/2017
Financiación recibida (en euros): 86.927 €
Relación con el proyecto que se presenta: mismo tema
Estado del proyecto o contrato: concedido

3. Investigador del equipo de investigación que participa en el proyecto/contrato: Eva Rubio, Francisco R. López-Serrano, Francisco A. García-Morote, Manuela Andrés Abellán
Referencia del proyecto: AGL2011-27747
Título: Manejo de montes mediterráneos tras incendio y cambio climático: resiliencia y productividad a tres escalas (FIREMED3L)
Investigador principal: Francisco R. López-Serrano
Entidad financiadora: Ministerio de Economía y Competitividad
Duración: 01/01/2012- 31/12/2014
Financiación recibida (en euros): 145.200,00 €
Relación con el proyecto que se presenta: está muy relacionado
Estado del proyecto o contrato: concedido

4. Investigador del equipo de investigación que participa en el proyecto/contrato: Eva Rubio, Francisco R. López-Serrano, Manuela Andrés Abellán.
Referencia del proyecto: CSD2008-00040
Título: Los montes españoles y el cambio global: amenazas y oportunidades (MONTES)
Investigador principal: Javier Retana (CREAF)
Entidad financiadora: CONSOLIDER-Ingenio 2010
Duración: 15/12/2008-14/12/2013
Financiación recibida (en euros): 4.000.000 € (228.507€ para la UCLM)
Relación con el proyecto que se presenta: está muy relacionado
Estado del proyecto o contrato: concedido

5. Investigador del equipo de investigación que participa en el proyecto/contrato: Eva Rubio,
Referencia del proyecto: GCL2008-04047
Título: Evapotranspiración, balance hídrico y estrés de la cubierta, EBHE
Investigador principal: Alfonso Calera
Entidad financiadora: Ministerio de Ciencia y Tecnología
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 01/01/2009-31/12/2011
Financiación recibida (en euros): 112.530,00 €
Relación con el proyecto que se presenta: mismo tema
Estado del proyecto o contrato: concedido

SUBPROYECTO 3:

1. Investigador del equipo de investigación que participa en el proyecto/contrato: Vicent Calatayud, Arnaud Carrara, Cristina Gimeno
Referencia del proyecto: CGL2014-52838-C2-2-R
Título: Assessment of ozone fluxes in relevant Mediterranean ecosystems (sub-proyecto del proyecto coordinado GEISpain “Hacia el balance integrado de gases de Efecto invernadero en ecosistemas nacionales de alto impacto social y económico”
Investigador principal: Vicent Calatayud
Entidad financiadora: MINECO: Proyectos I+D+i Retos Investigación
Duración (fecha inicio - fecha fin): 01/2015-12/2017
Financiación recibida (en euros): 130 000€ (cuantía CEAM)
Relación con el proyecto que se presenta: mismo tema
Estado del proyecto o contrato: concedido

2. Investigador del equipo de investigación que participa en el proyecto/contrato: Arnaud Carrara, Cristina Gimeno
Referencia del proyecto: G.A. no: 026188
Título: IMECC: “Infrastructure for Measurement of the European Carbon Cycle”
Investigador principal: Arnaud Carrara (CEAM), Coordinador: Peter Rayner (LSCE)
Entidad financiadora: European Commission (FP6)
Duración (fecha inicio - fecha fin): 01/2007-03/2011
Financiación recibida (en euros): 294 000€ (cuantía CEAM)
Relación con el proyecto que se presenta: está muy relacionado
Estado del proyecto o contrato: concedido

3. Investigador del equipo de investigación que participa en el proyecto/contrato: Arnaud Carrara, Cristina Gimeno
Referencia del proyecto: G.A. no: 313169
Título: ICOS-INWIRE: “ICOS improved sensors, network and interoperability for GMES "
Investigador principal: Arnaud. Carrara (IP CEAM): coordinador: Philippe Ciais
Entidad financiadora: European Commission (FP7)
Duración (fecha inicio - fecha fin): 12/2012-12/2015
Financiación recibida (en euros): 294 000€ (cuantía CEAM)
Relación con el proyecto que se presenta: está muy relacionado
Estado del proyecto o contrato: concedido

4. Investigador del equipo de investigación que participa en el proyecto/contrato: Arnaud Carrara, Cristina Gimeno
Referencia del proyecto: Carbored-II; CGL2010-22193-C04-01
Título: Red de monitorización de los flujos de carbono en ecosistemas mediterráneos españoles – cuantificación y estudio de procesos
Investigador principal: Arnaud Carrara, Coordinador Subproyecto 1
Entidad financiadora: Ministerio de Ciencia e Innovación
Duración (fecha inicio - fecha fin): 01/2011-12/2013
Financiación recibida (en euros): 120 000€ (cuantía CEAM, coordinador)
Relación con el proyecto que se presenta: mismo tema
Estado del proyecto o contrato: concedido

5. Investigador del equipo de investigación que participa en el proyecto/contrato: Vicent Calatayud, Arnaud Carrara, Cristina Gimeno
   Referencia del proyecto: CSD2007-00067
   Título: Equipo de Investigación Multidisciplinar sobre Cambios Climáticos Graduales y Abruptos, y sus Efectos Medioambientales (GRACCIE)
   Investigador principal: Profesor Joan Grimalt (CSIC)
   Entidad financiadora: CONSOLIDER-Ingenio 2010
   Duración (fecha inicio - fecha fin): 10/2007-10/2012
   Financiación recibida (en euros): 5.413.000,00 €
   Relación con el proyecto que se presenta: está muy relacionado
   Estado del proyecto o contrato: concedido

B.2. RELACIÓN DE LAS PERSONAS NO DOCTORES QUE COMPONEN EL EQUIPO DE TRABAJO (se recuerda que los datos de los doctores del equipo de trabajo y de los componentes del equipo de investigación no se solicitan aquí). Repita la siguiente secuencia tantas veces como precise para cada uno de los subproyectos.

1. Nombre y apellidos: Marta Isabel Picazo Córdoba.
   Titulación: Ingeniero Técnico Agrícola
   Tipo de contrato: Técnico de Laboratorio
   Subproyecto al que pertenece: Subproyecto 2

Parte C: DOCUMENTO CIENTÍFICO. Máximo 25 páginas.

C.1. JUSTIFICACIÓN DE LA COORDINACIÓN

A coordinated project is needed for two main reasons:

1. Integration of measurements and interpretation of results
Several specific objectives of the project will require the integration of different datasets of different natures (continuous data of eddy covariance fluxes, meteorological and environmental variables close to surface; CO2 fluxes derived from field campaign measurements with chambers (at leaf and soil level); soil CO2 profiles; vertical structure of atmospheric thermodynamic variables; diurnal data of aerosol columnar properties; measurements of high-resolution u-v-w wind profiles for characterization of the atmospheric boundary layer....) Therefore, it is crucial to have close collaboration between the subprojects which are responsible for the generation of different datasets, in order to achieve correct and robust interpretation of the results (e.g. carbon water annual budgets and partitioning) as well as for a correct parameterization and validation of the models to be employed (i.e. HidroMORE, DO3SE, associated photosynthetic or soil moisture module models). Additionally, since the studies will take place at existing experimental stations where important background knowledge has been accumulated, in particular regarding the C and H2O cycles, the background knowledge of the station PIs/teams will be essential, because of the complexity of the biogeochemical cycles and associated processes of the studied ecosystems, to interpret and discuss consistently the results.

2. To perform co-located experimental measurements
The proposed experimental approach will perform new measurements at existing CO2/H2O flux-tower stations to assess H2O/CO2 partitioning, model calibrations and improvements to the eddy covariance technique under different ecosystem managements operated by the different subprojects. In this regard, coordination is essential in order to benefit from the scientific potential and synergies between the new original collected data and the data routinely collected.
Measurements performed by the team of subproject 1 (field campaigns for the atmospheric boundary layer (ABL) or CO2 and H2O fluxes with chamber methods) will take place at flux-tower stations operated by the teams of subprojects 2 (Mediterranean forest with Stipa and Stipa free) and 3 (citrus grove and Dehesa). The HidroMORE model used in subproject 2 to estimate evaporation and transpiration at the ecosystem level and soil water content will be applied at flux-tower stations operated in subprojects 1 and 3. And measurements performed by the team of subproject 3 (O3 fluxes by eddy covariance, leaf scale gas exchange, fluorescence) will take place at flux-tower stations operated by subprojects 1 (Olive orchards) and 2 (forests). Therefore, the whole project will require a high degree of coordination for:
- Planning (timeline, design, set up issues) of experimental measurements.
- Installation, operation and calibration of the instrumentation.
- Integration of the different collected datasets and their processing.

C.2. PROPUESTA CIENTÍFICA

1. Antecedentes y estado actual

Eddy covariance flux-towers have made possible continuous, non-destructive, ecosystem-scale measurements of the ecosystem carbon and water balance over very short (half-hour) to long (multi-decadal) time scales (*1*) . Since 1996, eddy covariance flux-towers stations have been set up and aggregated into international networks that form the global FLUXNET (*2*). European Commission Framework Programs (FP6, FP7) addressed the lack of sampling for other ecosystem types, achieving continental-scale estimates. In the context of global representativeness of the ecosystem types, one of the regions with the greatest uncertainties lies in the Mediterranean (*3*). Since Mediterranean ecosystems are largely represented in Spain, which accounts for 62% of Mediterranean Europe, the applicants of the three subprojects have set up flux-towers in some of the major Mediterranean ecosystems in Spain over the last 15 years, supported by regional (BACAEMÁ, CARBOLIVAR, ECOFLUX I, ECOFLUX II, ECOFLUX III), national (BALANGEIs, CARBORED, CARBORED II, GEISpain, FIREMED3L, FORESTRENGTH) and European projects (CARBOMONT, CarboEurope-IP, IMECC, Carbo-Extreme, GHG-Europe, InGOS), creating the Spanish flux-tower network that attempts to fill the gap of a continuous and extensive set of measurement stations in Mediterranean ecosystems.

Part of this Spanish network was consolidated thanks to the coordinated national project GEISpain (2014-2017; teams from subprojects 1 and 3 of this proposal), whose main objective was to estimate their full greenhouse gas budget (CO2, CH4, N2O) and sensitivity to O3 in our agro-Mediterranean sites. The project is concluding with great scientific success (1 recent Thesis, 12 SCI papers and 12 conference contributions). As examples, our results have revealed the great contribution of rain pulses and ventilation processes in the annual C balance in the semi-arid Mediterranean ecosystems (*4-6*), improved and tested the approaches for calculating stomatal ozone fluxes (*7*) and enhanced the relevance of an accurate orientation of the sensor for an accurate evaluation of the consistency of the eddy covariance measurements (*8*). Notice that the coordinated project is still running (including an extension year) and the main results are still being processed.
The inclusion of the UCLM team (the subproject 2) in this new proposal represents new potential contributions and symbiosis in relation to Mediterranean forestry. Previous projects of the UCLM team, such as ECOFLUX and FORESTRENGTH, aimed to: i) the evaluate the CO2 and H2O fluxes on different natural forest ecosystems, ii) assess the combined effects of wildfires and forest management techniques (scrubbing and thinning) on fluxes and resiliency, and iii) assess the effect of rainfall restriction (a relevant form of climate change) on both productivity and resiliency of forest stands. The projects are still not concluded and, consequently, some goals are not achieved because results are still being processed. However, important conclusions have been reported, mainly regarding i) the dynamics of soil respiration depending on burn severity, post-fire burnt-wood management and thinning in different Mediterranean forest ecosystems, ii) the importance of carbon loss during early decomposition stages of tree stumps after wildfire, iii) net ecosystem production after low-burn severity and the significance of modeling approaches for estimating gross primary production and iv) characterizing the differential sensitivity of total and active soil microbial communities to drought and forest management. The inclusion of the UCLM team is furthermore essential achieve the proposed objectives (see below), and will increase coordination, synergies and therefore relevant results of the Spanish flux-tower community.

Background: Carbon and water cycles in the context of managed Mediterranean agroforestry ecosystems

In the agricultural context, management practices have modified gains and losses of soil C, altering the natural C balance and increasing greenhouse gas emissions. On other hand, observed and foreseen increases in Mediterranean drought demands more efficient water use by agricultural and forestry, and therefore adaptation of agricultural and forestry practices. Management practices aimed at increasing C sequestration and optimizing water use has become an increasingly relevant subject of interest, particularly in drought-prone ecosystems of central-south Spain, which present SOC contents frequently lower than 1% (*9*). In this context, the project will study agricultural and forest ecosystems of particular ecological and socio-economical relevance and representativeness in Mediterranean Spain.

Olive trees (*Olea europaea L.*) are one of the most important crops in the Mediterranean basin (9.5Mha), accounting for 98% of the world's olive cultivation area with relevant social and economic benefits. However, there is still scarce information (only during periods of less than one year) about CO2 exchange and ET at the ecosystem level (*10, 11*). One of the most widespread conservation practices is the maintenance of spontaneous resident vegetation cover (hereafter "weeds") in the alleys from autumn to spring (decreasing runoff, erosion rates and increasing soil organic carbon and soil fertility). Previous results from this research team (subproject 1) supported by the regional "CARBOLIVAR" project reveal that maintaining weed cover increased annual C uptake from 70±20 to 140±10 g C m^{-2} y^{-1} (*12*). However, there is as yet no information regarding ecosystem ET and the contribution of the different compartments (soil, trees and weed cover) into de C and water balances for both treatments. Additionally, thanks to the GEISpain project, the full spectrum of the GHG (CO2, N2O and CH4) is been measured. Preliminary results reveal that soil N2O emissions ranged from small N_2O consumption during the winter (-0.02 mg N_2O-N m-2 d-1) to 4.89 mg N_2O-N m-2 d-1 during the fertilization period, whereas the contribution of CH_4 exchange to the GHG budget is negligible in olive groves. However, no information about N_2O emissions has yet been reported for the weed cover treatment.

Citrus crops represent about 300 000 ha in Spain, (2012, Source: Eurostat), mostly consisting of plantations with drip irrigation systems. Most of these are found in regions (Valencia, Andalusia) subjected to decreasing water availability and increasing water demands from various economic sectors. On other hand recent studies (Iglesias et al, 2013) suggest that citrus plantation presents a net carbon sequestration capacity (ca 10 T C /ha / year) comparable to forest ecosystems and could contribute to mitigation of climate change. Therefore the precise quantification, with state of the art methods, of productivity, net C uptake and water use efficiency of citrus crop and their sensitivity to abiotic environmental conditions (climate, soil, water availability) is of high relevance. It will allow evaluation of the vulnerability of Spanish citrus crop productivity to climate change and help define informed adaptation strategies in terms of agricultural practice for Citrus Orchards.

In the forestry context, climate change is anticipated to create novel environmental conditions and alter the set of organizing forces affecting forest structure and function. A potential tool to cope with the change could be the management of vegetation cover, because these changes will affect the water balance by perturbing evapotranspiration and interception rates (*13-15*), soil moisture dynamics (*16*), and aquifer recharge. Some published works show enduring effects of both thinning treatments (*17*), fire severity and post-fire wood management (*18*) on the total soil CO_2 fluxes. It also has been reported that thinning carried out at early stages (6-7 years old in post-fire regenerated forest stands) improved both the growth of the remaining trees and the probability of cone production (*19*). However, although some published works address the management effects on CO_2 and H_2O fluxes, scarce information exists. Adaptative Forest Management for Adaptation (AFM) in Mediterranean ecosystems seeks to couple the concept of ecophysiology with dryland forests management techniques, through the development of an ecosystem level water balance model (*15*). Thus, prediction of forest transpiration under different forest management scenarios represents a key factor for successful and appropriate AFM design in Mediterranean Spain. In addition, these management efforts, seeking to restore forest conditions to a state previous to the start of climatic change processes, would be less likely to succeed in providing desired ecosystem services than management based on resistance and resilience concepts. Because Aleppo pine forests (*Pinus halepensis* Mill.) are the most xerothermic and thermophilic Iberian pine species that shows a drought-avoidance strategy for survival, they could be used to cope with the climate change effects (mainly via forest ecosystems adaptation).

Aleppo Pine stands are among the most important forests in the Mediterranean area (3.5 Mha) and the most abundant species in Spain (2.08 Mha, i.e. 11.9 % of the total forest area). 96.6% of these stands are found in only 7 regions, Valencia, Cataluña, Castilla-La Mancha, Aragón, Andalucía, Murcia and Baleares (MAPAMA, 2015). Despite this, in the 19th century there was much more surface covered by pines than at present, due to thinning and felling in the early 20th century to implant *Stipa tenacissima* ("esparto"), an herbaceous species with great economic value until 1970 (used as natural fiber for making tools). This management caused important problems of erosion and loss of soil fertility in addition to a lack of natural pine regeneration. Thus, currently, a low density of trees is found in these stands (less than 260 trees/ha) with abundant understory cover (mainly, *Stipa tenacissima*). In addition, these forests are threatened by fires where "esparto" enables fire propagation (in fact, in 2012 July, a great fire occurred near the study site here selected). Consequently, these ecosystems have low productivities, due not only to climate reasons, but to management factors.

Partition and modeling of the compartments of H_2O and C fluxes.
Currently there is great concern and uncertainty regarding the long-term effectiveness of some management practices to improve the adaptation capacity of these Mediterranean agricultural and forestry systems (i.e. Mediterranean agro-systems) to climate change. Different strategies among trees, shrubs and herbaceous plants underline the need for studies on the partitioning of H_2O and C balances into their major compartments. This

includes identifying the role of the different vegetation strata in the ecosystem functioning, and the main drivers that determine the prevalence or dominancy of one strata. In other Mediterranean and semi-arid agro-systems, hydric and gas exchange parameters have successfully been used as indicators of the ecophysiological competence between species in a changing environment (*20*). To fully understand the C and H2O cycles, a precondition is to develop accurate models that will allow us to identify feedback mechanisms between trees and shrubs under changing climate. In recent research, models have been applied to predict the effects of forest management on semi-arid Aleppo pine stands. Models have been calibrated and evaluated with acceptable accuracy using sap flow, soil moisture and throughfall data collected in the field conditions in different agro-systems (*21*), among other techniques. Thus, predictive models should be applied to analyze the need for agro-ecosystem management in semi-arid climates, in order to achieve optimization of the hydrological cycle and consequently improve productivity and C-stocks.

In this context, the Hydrological Model for Operational estimates of Recharge and actual Evapotransporation (HidroMORE) represents a valuable tool for modeling the total ET and its partition into the main components of soil evaporation and transpiration. This model was developed by the University of Castilla-La Mancha (UCLM) in the 2000s, with direct implication of some of the members of Subproject 2. Since then, HidroMORE has been widely applied and validated in studies of ET and recharge for natural and agricultural systems, mainly under semi-arid Mediterranean environments, at different spatial (from plot to catchment) and temporal scales (from months to decades), using lysimeters and EC flux data (*22-29*). The model has been validated in terms of both ET and soil water content (SWC). The good performance that this model has shown in reproducing ET, but also SWC, (i.e. its capacity to reproduce the evolution in time of SWC with correlations coefficients around 0.9 (*24, 27, 29*), together with its operational character, were the reasons for its being selected for the Validation study of the SMOS L2 soil moisture data in the REMEDHUS Network (Spain) ((*22-24*). Also, results from the HidroMORE recharge module have been used as input data for modeling aquifer–river interactions under the influence of groundwater abstraction in the Mancha Oriental System (SE Spain) (7,260 km^2) (*26*).

HidroMORE is based on the soil water balance equation that provides daily estimates of deep percolation, water storage, ET, and the components of soil evaporation and canopy transpiration after considering effective precipitation, surface runoff and irrigation. The rationale of the ET estimation is the dual crop coefficient-reference ET methodology (*30*), where the atmospheric demand is calculated as the standarized ASCE-EWRI Penman Monteith reference evapotranspiration, ETo, and then, ETo is converted to ET by the use of two coefficients, the basal crop coefficient for transpiration (Kcb), which describes plant transpiration under no limiting factors such as water, salinity or environmental conditions, and a soil evaporation coefficient (Ke), which describes evaporation from the soil (*31*). In this model, water stress coefficients are estimated using two parallel daily water balances applied to the upper layer of the soil and to the vegetation root-zone. Kcb is calculated on the basis of the daily Normalized Vegetation Difference Index (NDVI), retrieved from temporal series of optical imagery (NDVI–Kcb approach).

Spatial scale	WUE	iWUE
Ecosystem	NEP/ET; GPP_{eco}/ET	GPP_{eco}/G_s
Plant	GPP_{tree}/T_{tree}	GPP_{tree}/g_{tree}
Leaf	A/T_{leaf}	$A_n/g_{leaf;}$

Water Use Efficiency (WUE) is defined by the ratio between carbon assimilation to transpiration, both integrated over a certain time period (*32*). WUE has been suggested to be crucial for characterizing the major relationships between plant structural and chemical–physiological traits and ecosystem functional properties related to carbon and water fluxes (*33*). However, its formulation depends on the technique utilized to measure its components as well as the operating spatial scales (see table).

In order to evaluate and identify the most convenient management practices, and be able to develop a criteria about the consequences of ecosystem management on water and carbon cycling of these Mediterranean ecosystems, previous knowledge is required of how biological and non-biological processes influence carbon assimilation and water loss to the atmosphere. In the case of agricultural ecosystems, there is a need to optimize the water use (irrigation) without affecting production, quality and CO2 sink capacity. In the case of natural ecosystems, we need to optimize water resources to assure stand sustainability, the long-term stability of the carbon pool, and to increase ecosystem productivity and resilience to perturbations

Background: Ozone (O3) and Mediterranean ecosystems

Tropospheric ozone (O3) is a pollutant affecting human heath, ecosystems and food security (*34*). Rural O3 concentrations have been increasing from a background of ca. 10–15 ppb to approximately 50 ppb (8-h summer seasonal average) since the end of the 19th century, due to increased emissions of O3 precursors from anthropogenic sources (*34, 35*). In plants, ozone exposure impairs CO2 assimilation reducing C sequestration, causes visible leaf injury, reductions in plant growth and yield, changes food nutrient properties and alters biomass partitioning. It may also change the species composition of natural plant communities (as sensitivity to this pollutant differs among species), reduce resilience to pests and diseases, and increase sensitivity to drought by reducing water use efficiency of the plants and by diminishing the capacity of the stomata to control water vapour exchange. Ozone is the third most important anthropogenic greenhouse contributing to the radiative forcing, directly as GHG, and indirectly by suppressing the global land-carbon sink giving rise to additional accumulation of anthropogenic CO2 emissions in the atmosphere (*36*). Given its adverse effects on biomass production and the consequences for the global carbon and water cycles, its inclusion in global climate modelling is needed. The empirical model DO3SE (Deposition of Ozone for Stomatal Exchange) is a dry deposition model designed to estimate the total and stomatal deposition (or flux) of ozone (O3) for selected European land-cover types and plant species. Through the inclusion of DO3SE algorithms in EMEP photo-oxidant model, ozone risk maps for vegetation that incorporate the modifying influence of environmental factors including meteorological, soil water content and plant phenological variables are produced for Europe. EMEP models are instrumental for developing air quality policies in Europe, mainly in support of the Convention on Long-range Transboundary Air Pollution (CLRTAP).

Despite its importance for risk assessment in Europe (and more recently in Asia where it has started to be applied, e.g., (*37*)), DO3SE model has rarely been validated with field measurements, and direct measurements of O3 fluxes with fast sensors and micrometeorological techniques are still very scarce. Sites with eddy covariance measurements are ideal platforms for the validation of O3 flux models, as stomatal conductance (as inferred from latent heat flux) among many other environmental variables are continuously measured. Under Mediterranean conditions a better understanding of the partitioning between stomatal and non-stomatal ozone deposition in different ecosystems is fundamental, as drought conditions have an important effect on stomatal O3 uptake by the plants. While deposition rates are partly governed by stomatal uptake over a plant canopy, this only accounts for ca 40–60% of total deposition on average and the non-stomatal component is not constant (*38*). Furthermore, as ecosystems are frequently multilayered, it is also of great interest to consider O3 flux partitioning among layers. So far, very few studies have addressed this issue, and never before in Spain. During the implementation of ELEMENTAL project, two ecosystems representative of Mediterranean vegetation with arboreal and grass layers (Aleppo pine with an understory of *Stipa tenacissima*, and a Holm oak dehesa) will be studies in order to be able to understand the mechanisms of ozone deposition in them. Both trees are key species for risk assessment in the Mediterranean area, through their inclusion in the Mapping Manual of the CLRTAP (*39*), and furthermore Aleppo pine is an O3 sensitive species (*40*). The results of the present study will allow comparing modelled O3 fluxes with measured O3 fluxes and will provide DO3SE parameterizations on adult trees under real field conditions, taking into account the role of understory vegetation in O3 flux partitioning. Annual pastures of the Spanish Dehesa ecosystem are known to be particularly sensitive to O3 and are threatened by current ambient O3 levels (*41*). As pasture plants responses to O3 are strongly modulated by water availability, the performance of models used to estimate water availability in pastures will be tested against eddy covariance, lysimeter and SWC probes measurements. This will importantly improve risk assessment for this economically important and diverse component of the Dehesa ecosystem. Finally, a parameterization of DO3SE model will be provided for citrus trees, a representative tree of Mediterranean fruitculture which is also sensitive to ozone (*42*).

Background: Eddy covariance limitations and uncertainties

The correct application of the eddy covariance technique requires micrometeorological expertise and advanced technology (*43*). Fluxes, to or from the surface of interest, are then estimated by the covariance between the scalar concentration and the vertical wind speed. Such a one-dimensional interpretation of turbulent transport is predicated on numerous assumptions/hypotheses including but not limited to surface uniformity, stationarity of atmospheric conditions, homogeneity of the turbulence, instrument time response, and sufficient length of the statistical averaging period to capture all transporting eddies. While this may appear to be prohibitive, such assumptions are verified by various types of micrometeorological analyses, many on a half-hourly basis (*44-47*). However, despite standardization of eddy covariance methodologies across large-scale research infrastructures worldwide (*48*) evidence is accumulating against the exactness of this micrometeorological technique as currently applied.

Closure of the surface energy balance is often used as a validation criterion, but rarely if ever achieved (*49*). This quality control criterion consists of comparing the sum of the latent and sensible heat fluxes, measured with the eddy-covariance method, to the available energy consisting of net radiation minus the soil heat flux. This outstanding problem has been known for decades. Regarding carbon fluxes, eddy covariance studies are now reaching durations whose integrations can be compared with ecology-based biometric assessments of carbon stock changes, but validation remains elusive (*48*). Additionally, validity checking of eddy covariance water fluxes has equally yielded disappointing results (*50*). A number of causes have been proposed to explain the surface energy balance non closure (mismatch in instrument footprint, measurement errors, advective flux divergence, or inadequate sampling of low frequency turbulent motions (*51*), to name few). However, even taking into account many of these causes, a surface energy imbalance was still reported (*52*). A recent discussion concluded that large eddies are likely to be one of the primary contributors to the underestimated turbulent (*53*). Enlarged phase difference of large eddies linked to entrainment or advection occurrence leads to increased residuals of the surface energy balance (*54*). Therefore, a detailed knowledge on all features of the atmospheric boundary layer (ABL) is mandatory for a physical understanding of the energy and mass fluxes. Additionally, a recent study by one member of the proposing team (*55*) found that micrometeorology has systematically neglected the role of non-diffusive transport - independent of turbulent eddies - in estimating exchanges of mass and heat with the surface. Therefore, new methodologies based on this pioneering paper, to account exactly for both turbulent and non-turbulent forms of transport, and determine whether precision can be improved in this way, are needed and will be tested within our proposed project. The only choice is indirect measurements by ground-based remote sensing methods that offers sufficient vertical resolution and temporal coverage for detailed boundary layer studies (*56*).

Relación con otros grupos de investigación Nacionales y Extranjeros

At national level, other groups related to ecosystem scale carbon fluxes measurements are the EEZA (CSIC) which, in collaboration with the subproject 1 team, is running several stations in Almería province since 2004; Doñana Biological Station (EBD), which is running eddy covariance stations since 2008 and part of the proposing team are advising them in the calculation of the eddy covariance fluxes according to the international standards. Additionally, the proposed team collaborates with different groups in the context of database optimization for validation of models of gross primary production and evapotranspiration estimates, such as the "Departament de Física de la Terra i Termodinàmica (Universitat de València)", IFAPA (Centro Alameda del Obispo, Córdoba) and the "Dinámica fluvial e hidráulica group" (IISTA-Universidad de Córdoba). Regarding atmospheric characterization the subproject 1 team collaborates with the Remote Sensing Laboratory (Universitat Politècnica de Catalunya), Instituto Nacional de Técnica Aeroespacial (INTA), Dpt. Earth Physics and Thermodynamics (University of Valencia), to name a few. The group of the

subproject 2 has participated together the subproject 1 in some calls for projects (National Parks, MINECO). In addition, subproject 2 has collaborated with the Centre de la Recerca Ecológica i Aplicacions Forestals (CREAF) and Autonomous of Barcelona University (Dr. Gracia, Dr. Peñuelas), with the Global Change Unit of Dept. Termodinamic Dept, Univ. Valencia (JA Sobrino), theLaboratory of Earth Observation, Dep. de Termodinámica, Univ. Valencia (J. Moreno), Fundación CEAM, (M.J. Sanz), the Laboratori de Fisiologia Vegetal, Dpt de Biologia, Universitat de les Illes Balears, (Dr. Medrano and Dr Flexas). Regarding O3, we highlight collaborations with: the CIEMAT, el Instituto de Diagnóstico Ambiental y Estudios del Agua (IDAEA), Barcelona Supercomputer Center.
At the European level, most significant research groups using eddy covariance for measuring CO_2/H_2O gases to quantity, are involved in the current European projects such as ICOS, where the Spanish team collaborates (without funding). Groups involved in these projects include the Max Planck Institute for Biogeochemistry (GE), Johann Heinrich von Thünen-Institut (GE), Center for Ecology and Hydrology (UK), University of Edinburgh (UK), University of Antwerp (BE), Alterra (NE) University of Tuscia (IT), Laboratoire des Science s du Climat et de l'Environnement (FR), Gembloux Agricultural University (BE), University of Helsinki(FI), University of Hamburg (GE), and Global Change Research Centre (Czech Republic) to name a few. Regarding to the atmospheric Boundary Layer (ABL) and atmospheric characterization the subproject 1 team collaborates with Institute Pierre Simon Laplace (LMD), Institue of Methodologies for Environmental Monitoring (IMAA/CNR, IT), Finnish Meteorological Institute (FMI, FI), Instituto de Ciências da Terra (ICT-Évora, PT) and Centerof Lasers and Applications of the Institute of Energy and Nuclear Research (IPEN, BR), among others. For O3, we highlight collaborations with the following Institutions: Swish Federal Institute for Forest, Snow and Landscape (WSL, CH), (Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (ENEA, IT), Centre for Ecology & Hydrology (UK), University of Florence (IT), CNR (IT), Research Center for Eco-Environment Science (RCEES, China) to name few.

2. Hipótesis de partida, objetivos generales y adecuación del proyecto

In the context of the effect of managements in the carbon and water balance of relevant Mediterranean agro-systems, we hypothesize that:

(a) Different managements applied to relevant Mediterranean agro-systems (such as Olive Orchard with and without weed cover or Aleppo Pine Forest with and without *Stipa tenacisima*) provide great differences in the carbon and water balance. The partitioning of these two fluxes into their main components (Figure 1a) will allow us to understand and improve the carbon sequestration as well as the water use efficiency. The proposed experimental measurements and modeling approaches of ELEMENTAL will provide the best design for such quantification. In this regard, the research team (subproject 1) has demonstrated the increase in the C uptake in olive orchards with weed cover (2 times higher than weed free treatment; (*12*)). However, limiting water increases competition for soil resources between weed cover and trees (*57*), increasing evapotranspiration and therefore, could modify the water balance.

(b) For water limited agro-systems, the water balance at ecosystem level, and the subsequent partitioning of ET into transpiration and evaporation can be performed with acceptable accuracy by using models like HidroMORE, and neglecting effects from O3 or CO_2 atmospheric gases. In this sense we start from the basic hypothesis that CO_2, water vapor and ozone fluxes are coupled through plant stomata interface. On one hand, atmospheric CO_2 is absorbed by plants through photosynthesis and utilized for biomass growth. Simultaneously, an outward water vapor flux leaves stomata, which corresponds to transpiration. Plants control stomata to optimally satisfy the trade-off between the amount of carbon assimilated and the amount of water transpired (*58*). On the other hand, ozone is taken up by the plant through stomata as well, and, as an air pollutant, can provoke direct leaf injury. Consequently, plant CO_2 uptake (as well as transpiration) can be adversely affected by ozone, resulting in a potential reduction in water use efficiency (Fig 1a).

(c) According also to the above explanation, HidroMORE estimates of soil water content, evapotranspiration components of transpiration and evaporation, as well as water stress conditions, are valuable data to analyze the effect of water stress on the regulation of O3 and CO2 fluxes at stomatic level, plant and ecosystem levels (Fig 1a).

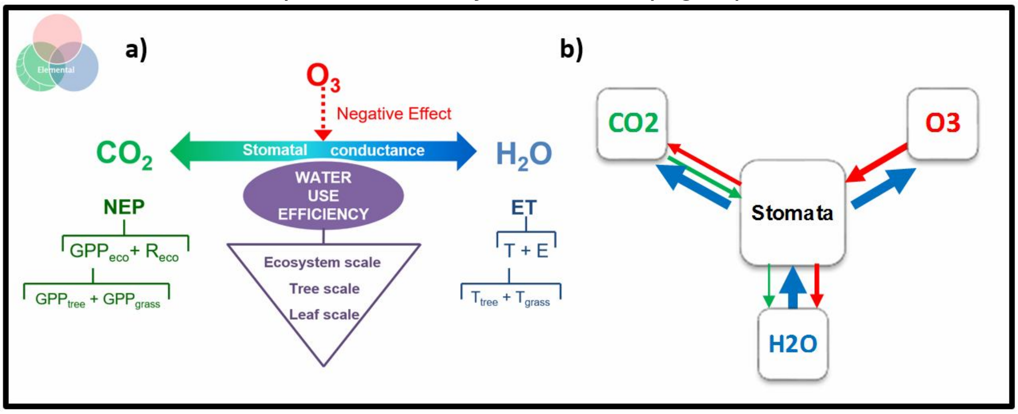


Figure 1. Schema to illustrate (a) The partition of CO2 and water vapor fluxes and its interaction with ozone fluxes. (b) interactions between CO2, H2O and O3 fluxes through stomata, and the major control that water availability to plants exerts on the stomata control

(d) Regarding the energy balance closure, we anticipate that continuous monitoring of the atmospheric boundary layer height will allow us to establish relationships between the energy balance closure and boundary layer evolution, and thereby improve characterizations of the surface energy budget. The energy balance closure, as measured by the flux tower, will vary according to the evolution of the boundary layer height. Flux towers measure near the surface, and are intended to describe fluxes imposed on the atmosphere's lower boundary. However, there are times of day and synoptic situations during which the upper boundary of the layer in which the tower measures (entrainment zone) similarly influences the tower fluxes. Boundary layer growth into an overlying inversion, as typically caps the mixed layer, requires energy to break atmospheric stability, and the buoyancy fluxes associated with such energy requirements may influence the tower measurements. In 2016, the team of the subproject 1 detected a preliminary improvement (from 76 to 81%) in the energy balance closure in the ABL-growth phase during the short term AMAPOLA field campaign in the olive orchard.

(e) Finally, for the ozone fluxes study we hypothesize that:
1) the DO3SE model is able to estimate satisfactorily ozone stomatal fluxes, at least in terms of accumulated fluxes along a growing season in three relevant Mediterranean ecosystems.
2) It is possible to estimate both stomatal and non-stomatal contributions to total ozone deposition flux using a combination of experimental techniques including eddy covariance measurements at whole ecosystem and subcanopy levels, sap-flow and leaf-level measurements.
3) Understory vegetation plays a significant role in O3 deposition in ecosystems with two layers of vegetation.

Objetivos generales

In this regard, the general objectives of the proposed coordinated project are:
1- To study the water and CO2 flux partitioning together with the water use efficiency of our study sites under different treatments
2- To optimize the eddy covariance technique and complementary variables monitoring to assess model calibration/validation
3-To quantify the contribution of canopy and understorey to total and stomatal ozone deposition for major relevant Mediterranean ecosystems by in-situ measurements and assess the state of the art standard O3 deposition model (DO3SE) for these ecosystems.

Adecuación

The proposed general objectives are strongly linked with "RETO DE LA SOCIEDAD 5: Acción sobre el cambio climático y eficiencia en la utilización de recursos y materias primas". ELEMENTAL will provide scientific knowledge of the processes and mechanisms of managed terrestrial ecosystem functioning under different treatments to promote policies for adaptation to climate change. Quantifying the contribution of the different components (soil, trees, understory) in the carbon and water balance of the selected agro-systems and managements, along with the long-term high quality monitoring of the fluxes of CO2 / H2O via improving the eddy covariance technique, will provide essential information to adapt managed Mediterranean agro-systems, that are especially relevant in given their high vulnerability, to the effects of climate changes. Additionally, carbon and water balance and its partitioning in agricultural ecosystems will be essential to evaluate the water use efficiency and how the impacts of climate change can influence their productivity and other services and functions.

Similarly, synergies between ELEMENTAL and other European research programs about monitoring and mitigation of agricultural and forestry GHG (cf. ESFRI project ICOS (H2020); the past GHG-Europe (FP7)) are evident. The objectives of ELEMENTAL will reduce uncertainties to improve carbon sequestration and optimize water use. The database generated by ELEMENTAL will be integrated into existing European Fluxes Databases Cluster (http://www.europe-fluxdata.eu/), filling knowledge gaps in continental networks and providing a better characterization of ecosystem services in the Mediterranean area.

3. Objetivos específicos de cada uno de los subproyectos

Subproject 1
Obj 1.1. To quantify net CO2 exchange of the total ecosystem and the soil/grass layer using continuous eddy covariance measurements (a permanent and a portable flux tower) in the 4 studied agro-systems under different management of understorey vegetation. *Responsible: P. Serrano Ortiz*
Obj. 1.2 To separate the contributions of tree canopy and soil/grass vegetation layers to overall ecosystem net CO2 exchange, including their partitioning into photosynthetic uptake and respiratory processes, by combining EC measurements, additional C flux measurements (i.e. continuous measurements of horizontal soil CO2 profiles and soil chamber systems) and modeling. *Responsible: P. Serrano Ortiz*
Obj 1.3. To improve energy balance closure by co-located remote sensing data of the atmospheric boundary layer (vertical profiles of horizontal and vertical wind components using Dopler lidar) for improving eddy covariance measurements. *Responsible: J. L. Guerrero-Rascado*
Obj 1.4. To improve modeling applicability in our study sites by measurements of the atmospheric boundary layer properties (temperature, pressure, relative humidity and aerosol properties profiles using a co-located Sun-photometer) and by upgrading continuous measurements of NDVI, phenology and soil water content profiles. *Responsible: J. L. Guerrero-Rascado*

Subproject 2:
Obj 2.1. To quantify total ecosystem Evapotranspiration and the soil/grass layer using continuous eddy covariance measurements (a permanent and a portable flux tower) in the 4 studied agro-systems under different management of understory vegetation. *Responsible: E. Rubio*
Obj. 2.2 To partition total Evapotranspiration measured with the flux towers into soil evaporation, tree transpiration and the soil/grass layer contributions using additional measurements (lysimeters, sap flow meters and chamber systems). *Responsible: F. A. García*
Obj 2.3 To model total ecosystem ET and its partitioning into soil evaporation and canopy transpiration at our study sites. *Responsible: E. Rubio*
Obj. 2.4 To evaluate the effectiveness of the management practices applied to the agro-systems for adaptation to climate change, by using different formulations of Water Use Efficiency (WUE). *Responsible: F. A. García*

Subproject 3

Obj 3.1. To perform continuous eddy covariance measurements of ozone fluxes at ecosystem level over a full phenological year in a Aleppo Pine Forest, a Olive Plantation, a Citrus Orchard and a Holm Oak dehesa. *Responsible: A. Carrara*

Obj 3.2. To quantify separately O3 uptake by the tree canopy and understorey/grass layer at the ecosystems presenting two vegetation layers (i.e. Aleppo Pine Forest, Olive Plantation, Holm Oak dehesa) by performing subcanopy EC O3 fluxes measurements. *Responsible: A. Carrara*

Obj 3.3. To partition between stomatal and non-stomatal components of ozone deposition, its temporal variation and its dependence onto abiotic factors and management of understorey vegetation for the 4 studied ecosystems. *Responsible: A. Carrara*

Obj 3.4. To parameterize DO3SE model, including its photosynthetic component (DO3SE_C), for Citrus Orchard and Aleppo Pine Forest. *Responsible: V. Calatayud*

Obj 3.5. To validate modeled stomatal ozone fluxes (DO3SE) and total ozone deposition fluxes using O3 and H2O eddy covariance fluxes measurements. *Responsible: V. Calatayud*

4. Metodología

To achieve the objectives of proposed coordinated project we propose to measure CO2/H2O and O3 fluxes at different levels using different available techniques: the eddy covariance technique (ecosystem and subcanopy levels), chambers systems (soil and plant level: field campaigns), soil CO2 profiles, lysimeters (soil level: continuous measurements) and sap flow meters (tree level: continuous measurements) in 4 relevant Spanish Mediterranean ecosystems: an olive Orchard and a Semiarid Forest under two different managements (with plant cover and plant free), a Dehesa and an citric orchard (6 flux-tower stations in total). Such flux measurements will be complemented by the monitoring of environmental parameters (temperature, humidity, radiative fluxes, precipitation) that determine the magnitude and direction of surface atmosphere exchanges, and allow the filling (when necessary) of inevitable gaps in flux measurements via empirical modeling techniques. Additionally, Atmospheric Boundary Layer (ABL) characterization campaigns at each study site (Tair profile, P profile, RHair profile, u-v-w wind profiles, aerosol optical and microphysical properties, phenology (digital camera) will be provided to complete the requirements to assess the second general objectives.

4.1 Experimental sites

A) Olive orchard (PI of the station: P. Serrano Ortiz -Subproject 1-)

The selected olive orchard (37º 54'39.30''N, 3º13'42.4''W; Úbeda, Jaén) is fully representative of the surrounding olive plantations. The climate is warm-hot Mediterranean, with hot dry summers and mild winters, and a mean annual temperature of 15.5 °C. Mean annual precipitation is 650mm, accumulated mostly during spring and autumn. The olive tree plantation is ca. 20 years old, with a density of 70 trees ha^{-1} and has been cultivated following organic farming practices for more than 60 years. The entire area is equipped with two pressure-compensating drippers per tree that maintain a constant flow of 8 $l\ h^{-1}$ and is irrigated with an average of 130 $m^3\ ha^{-1}\ day^{-1}$ from May to September. The area is daily fertilized with NPK from April to October. The flux-tower stations are located in two areas selected in the olive orchard with two different treatments: weed-free treatment (A1), in which a glyphosate-based herbicide is been applying to avoid spontaneous weed growth and weed-cover treatment (A2), which is the management commonly applied in the orchard and consists of maintenance of spontaneous weed cover in the alleys from autumn to spring.

B) Pine Forest: Semiarid Aleppo pine forest (PI of the station: E. Rubio -Subproject 2-)

Two different zones of 90 ha each, in a representative Aleppo pine forest stand into the MUP nº 82 "Los Donceles" (38º 25' 05''N, 1º 42' 10''W; Hellín, Albacete), was selected as study site. The site has semiarid ombroclimate located in the low Mesomediterranean belt (Rivas Martínez, 1987). The average rainfall and temperature values were 340 mm and 16.5 ºC, respectively. Potential natural vegetation was a kermes oak forest of *Quercus coccifera* L. (*Rhamno-Querceto cocciferae sigmetum*, Rivas Martínez 1987). Actual overstory vegetation was Aleppo pine and, as the main understory, was *Stipa tenacissima*. In this stand, two zones, control (B1) and managed (B2) sites, have been identified (about 90 ha each one). Both zones presented similar topographic and soil characteristics (carbonate substratum, pH value of about 8.5, low slope (<4 %)). The control site is already equipped with an EC flux tower (working since 2012) and other soil and biometric sensors (dendrometers) that have provided significant information on the low productivity and water stress conditions of this ecosystem. Besides, reduced-area experiments consisting in applying the scrubbing of sparto, have revealed the benefits for the Aleppo pine of this treatment in terms of number of naturally regenerated individuals, and of the diameter growth of their trunks. Also, for the Aleppo pine, Del Campo et al. (2014), showed that thinning have positive effects on the water cycle (transpiration, soil water and interception) and growth of this pine, because enhanced a lower dependence of growth on climate fluctuations. According to the working plan envisaged in this Project a treatment, consisting on a scrubbing of esparto by strips (10 m wide at 30 m spaced) will be carried out at the managed site. The size of this treatment (90 ha) will allow us to capture the effect of this management practice on water and CO2 fluxes by EC flux towers.

C) Dehesa: Las Majadas (PI of the station: A. Carrara -Subproject 3-)
The station is located at 39º 56’ 26’’ N and 5º 46’ 29’’ W (Majadas del Tiétar, Cáceres), at approximately 260 m a.s.l. Climate is Mediterranean with hot and dry summer but with relatively cold winter due to rather continental location. Mean annual temperature is 16.7 ºC and Annual precipitation is ca 650 mm. The long-term historical management at the site has resulted in a holm oak (Quercus Ilex) savanna known in Spain as a “dehesa”, with an understory dominated by annual herbaceous species. Tree density is about 20-25 trees per hectare, with a mean height of 8 m and a mean DBH of 43 cm. The management consists of continuous grazing by cattle and regular pruning (each 20- 30 years) of the trees. The soil type is classified (FAO) as Cambisol (Dystric). The site is an Intensive Monitoring Plot (Level II) of the ICP Forest network. The site is the most comprehensive and complete eddy covariance flux tower site in the Iberian Peninsula, has contributed to 8 EU projects, 4 national projects, has been demonstration site for the ICOS “ESFRI” infrastructure, and currently contribute to one national project (SynerTGE) and one EU project (ICOSINWIRE).

D) Citrus orchard: Valencia (PI of the station: A. Carrara -Subproject 3-)
The station is located at 39º 35’ 17’’ N and 0º 23’ 59’’ W (Moncada, Valencia), about 70 m a.s.l, within a young citrus orchard. The studied orchard is submitted to management practices, including drip irrigation, representative of the 180 000 ha of citrus plantations located within the region Communidad Valenciana, which constitute about 60% of total Spanish citric production. Climate is Mediterranean with hot and dry summer, mean annual temperature is 18.5 ºC and mean annual precipitation is about 550 mm. The flux tower station was built in 2017 thanks to project “*Equipamiento para la implementación de estaciones ICOS de monitoreo de flujos de carbono y de agua en cultivos Mediterráneos*” (CEAM15-EE-3709, MINECO/FEDER, UE). It includes the standard suite of measurement and respond to instrumental and set up requirements of ICOS level 2 ecosystem stations.

4.2 Working Plan

To achieve the proposed objectives, the following tasks, structured by objectives of each subgroup, will be performed (See also the Cronogram for additional information).

Task 1. Continuous measurements of ecosystem scale fluxes of CO2, H2O, O3 and environmental variables

Task 1.1. Continuous operation of ecosystem "flux-tower station" (CO2/H2O EC fluxes + environmental variables)

The project includes 6 experimental sites: Olive Orchard with weed cover, Olive Orchard without cover, Pine Forest with Stipa understorey, Pine Forest without Stipa understorey, Dehesa, and Citrus Orchard). All sites are already equipped with flux-towers stations at the ecosystem level measuring continuously CO2 and water vapor fluxes by eddy covariance together with a standard suite of environmental variables (meteo, variables, radiation, soil water content and temperature, etc.). This task consists of ensuring the continuity of the stations operation and data processing following procedures (including quality check, corrections, gap filling, flux partitioning) established as result of the Spanish project (CARBORED II) following the state-of-the-art international standards, guidelines and protocols (Carboeurope, Fluxnet, ICOS).

Task 1.2. Application of management treatments to the agro-systems
Only for site B, the execution of the treatment is required. Site B2, will correspond to a homogeneous Aleppo pine stand (90 ha approx.), which is located near to Site B1, a not treated stand, where an EC was installed in 2014. The sylvicultural treatment (scrubbing) will be carried out at the end of 2018, in order to capture the effects of clearing shrubs with the EC flux-towers and complementary setups. The scrubbing will be carried out by removing 33% of shrub cover in the experimental area (90 ha). This sylvicultural treatment will clear the invasive grass and shrubs (mainly *Stipa tenacissima*) by uprooting and shredding. To prepare the stand in the treatment of clearing shrubs, we will use a forestry tractor equipped with brush shredder (>200 CV power; cutting width 2 m; cutting height 0-50 mm) which greatly improve site restoration. This mechanical treatment will be realized by strips of 10 m width in the experimental area following level curves, and spaced about 30 m each. The clearing will be done close to larger trees, in order to stimulate their growth due to the expected increase of nutrients and water availability, while providing space to favor natural regeneration.

Task 1.3. Measurement of ecosystem scale fluxes of O3
Measurements of ozone fluxes will be performed at ecosystem scale by eddy covariance using fast response ozone sensors (FOS, Sextant Technology Ltd.) that will be integrated to existing CO2/H2O EC stations. O3 absolute concentrations will be measured simultaneously with an ozone slow response analyser (Europe, ML9810B, 2BTech) for calibration of O3 turbulent fluctuations measured by the fast response O3 analyzers.
The measurements will be performed at both Olive Orchard sites (with/without weed cover) during the first year of the project, and at both Pine Forest sites (with/without *Stipa* understorey) during the second year, and at both the Dehesa and Citrus Orchard sites during the third year.

Milestones for Task 1: Continuous long term data of CO2, water vapor and energy fluxes *for the studied agro-systems with different understory managements. O3 fluxes covering main phenological phases* at the ecosystem level.

Task 2. Measurements of subcanopy EC fluxes of CO2, H2O and O3
At the beginning of the project two additional portable EC flux systems with be built and tested by putting in common instrumentation (anemometers CSAT and R3-50, IRGAs LI7500, FOS, data loggers and mast structures) from the different teams (CEAM, UGR, UCLM). These flux-towers will be installed at both stations (with/without weed cover) of Olive Orchard site during the first year of the project, and at both stations of the Pine Forest site (with/without *Stipa* understorey) during the second year, for measuring CO2/H2O/O3 exchange at the subcanopy/soil level (hereafter "subcanopy fluxes"). Note that the Dehesa site is already equipped with a subcanopy CO2/H2O flux tower, so only O3 fluxes measurements will be implemented there during the third year of the project.

Milestones: Installation of Subcanopy EC systems to measure CO2, H2O, and O3 fluxes at Olive orchard, Pine forest, and Dehesa sites (month 2, 14, 26, respectively)

Task 3. Complementary biometric measurements of the canopy
In order to understand local processes and interpret spatial (inter-site) variability of carbon water budgets and their components, a number of variables characterizing the studied ecosystems are needed. Therefore all the sites will harmonize their ancillary data set to fulfil the objectives of the project. Subproject PI's will be responsible for producing a coherent and consistent ancillary data for the flux-tower stations on its supervision, by collecting existing data and performing additional measurements. From the information that will be systematically collected at some sites, of particular relevance are the inventories (using the Zebrevo device –movil terrestrial lidar-), combined with destructive sampling of both trees

and scrubs (only for Forest site) to obtain estimations of biomass (above and belowground biomass). In addition, we will measure the litterfall using traps and the LAI for both under and overstory (following Martínez et al. 2017). Finally, data from soil such as soil classification, texture, carbon, macro and micronutrient and microbial contents), that represent crucial information in the context of carbon and water cycles studies, will be taken. Data from the different sites will be centrally collected, checked for consistency and their format will be standardized to build a comprehensive and consistent ancillary database of the project.
Milestones: a comprehensive and consistent biometric database from the whole sites

Task 4. Partitioning of CO2 fluxes into its dominant components and processes. Complementary CO2 measurements

Task 4.1 Horizontal Soil CO2 profiles

Each site (and treatment) will be equipped with continuous measurements of soil CO2 molar fraction to provide estimations of soil respiration based on Fick's law of diffusion (*59*). Each profile depth will has 20 meters of high porosity PTFE tubing that is air permeable and waterproof (10m coming and 10m going) covering high and heterogeneous areas and allowing sampling an extensive area with only a CO2 gas analyzer and some port manifolds (*60*). The system is composed by a low pressure pump that circulates air through a closed system, which is measured by a CO2 sensor (LI-840, LI-COR). This system will provide a large sampling area and avoid possible pressure effects caused by installation of these sensors on surface. For estimating soil CO2 fluxes we will determine the soil gas diffusivity (requested by the calculation of soil respiration) using the methodology as described Sánchez-Cañete et al., 2017. The system will be installed in the Olive Orchard, Pine Forest and Dehesa from the sixth to the ninth month of the project and will be measuring continuously since then.

Task 4.2 Intercomparison of soil respiration from CO2 profile with Chamber measurements

Soil respiration will be also measured in several field campaigns using different standard commercialized CO2 analyzer systems available for each subproject team: EGM-4/SRC-1 (PP-Systems, Hitchin, UK), Li-Cor 8100 and Li-Cor 8150 multiplexer (Lincoln, NE, USA). For each site (only treatments with two vegetation layers) a field campaign will be performed every two months, sampling at least 8 soil plots limited by PVC collars (diameter 10.5cm or 19 cm height 9 cm) already in the soil to ca. 5 cm depth at the beginning of the project. This measurements will be compare with the soil respiration estimations using horizontal CO2 profile. Although each subproject will be responsible for measuring the sites for which they are responsible, the subproject 1 will be responsible for data analysis and intercomparison.

Task 4.3. Separation of CO2 fluxes into GPP and respiratory components for different vegetation layers from multiple complementary datasets (intercomparison)

Task 4.3.1. CO2 partitioning from canopy flux-tower, subcanopy flux-tower and soil CO2 profiles (intercomparison)

Ensuing Task 1.1, continuous fluxes measurements will be carried out using one flux-tower along the 3 years and at each one of the sites and treatments. Data obtained will permit to estimate directly the Net Ecosystem Productivity (NEP) and, indirectly, the Gross Primary Productivity (GPP) and the total Ecosystem Respiration (Reco) by standard partitioning methodologies (*61*). In addition, at olive and forest sites two subcanopy flux-towers will be installed per treatment for a period of one year, with the goal to obtain a more detailed CO2 partitioning in compartments. In the agro-systems with two vegetation strata, the partition of the subcanopy NEP will provide the grass productivity, GPP_{grass} and the subcanopy respiration ($R_{subcanopy}$), which includes the autotrophic respiration of roots of trees. In the agro-systems with only one vegetation strata, the partition of the subcanopy NEP will provide the total soil respiration. Besides, combining NEP fluxes from both ecosystem and subcanopy towers, and integrating the complementary measurements of soil respiration (soil profiles and chambers in different cover types), then the Net Primary Productivity of trees (NPPtrees) will be obtained.

A intercomparison between the described methodological approach for NEP and its partitioning and others methodological approaches (i.e. carbon-mass balance, and whole-canopy photosynthesis-modelling approach (*62*) will be done.

Task 4.3.2. CO2 fluxes from subcanopy flux towers vs Chamber measurements (intercomparison)
A transparent handmade closed chamber will be used to measure the subcanopy (or soil) net CO2 exchange and ET in several plots. Chamber dimensions are 0.5x0.5x0.6 m and chamber walls consists in transparent film sheets (NRS90 clear, Llumar®, Solutia Inc., Düsseldorf, Germany) of 75 µm thick that were attached to the structural aluminum frame. The chamber system includes an Infrared Gas Analyzer (IRGA; Li-840, Li-cor, Lincoln, NE, USA) to measure the CO2 and water vapor molar fractions, two small fans (8.9 cm diameter) to homogenize the air within the chamber volume, a thermocouple (PT100) to measure the confined air temperature and a datalogger (CR1000, Campbell Sci., Logan, UT, USA) to record all measured variables at a frequency of 1 Hz (*5*). For each site (an treatments) three field campaign will be performed coinciding with the year where the subcanopy flux-tower is installed in that site. We will sampling at least 4 soil plots limited by an structural aluminum frame. The fluxes will be calculated following standard procedures (*63*). The obtained values of CO2 exchange and ET are equivalent to what subcanopy flux-towers measures but at a smaller spatial scale and hence, results can be compared.

Milestones for Task 4: Continuous values of ecosystem, grass and soil respiration, and ecosystem and trees gross primary productivity for the studied agro-systems with different understory managements

Task 5. Partitioning H2O exchange into its dominant processes. Complementary measurements

Task 5.1. Sap-flow measurements
Additionally, tree transpiration can be estimated using sap flow measurements based on the use of heat as a tracer for sap flow. Common approaches include the heat ratio method (*64*), (SFM1 Sap Flow Meter, ICT International) or the tissue heat balance (*65*), (EMS81 Sap Flow Meter, EMSBRNO). In the olive orchard five sap-flow units at each treatment, will be installed. In the forest sites, due to the larger heterogeneity of the trees, a total of 12 sap-flow units per treatment will be used. An in the Dehesa there are already five sap-flow units. The trees will be selected in accordance with stem diameter at breast height (DBH) to cover the range of the distribution found within the footprint of the EC tower. Continuous measurements of sap-flow along the three years of study will be recorded, together with additional data of the individuals, regarding to: DBH, plant height and age, cross-sectional sapwood area, sapwood depth and plant bark thickness and leaf area. Sap flow values representative of the whole tree will be calculated by radial integrating the punctual measurements following Nadezha et al., 2002 . To up scaling the sap flux to stand level, and obtain and independent estimate of the stand transpiration, to be comparable to ET from EC flux-towers the approach following Perez-Priego et al., 2017 by will be used.

Task 5.2. Lysimeter measurements
For the particular case of heterogeneous surfaces composed by trees and understory vegetation (such as our study sites), lysimeter measurements are particularly relevant to quantify the contribution of the understory layer into the ecosystem ET measured by eddy covariance (*50*).Therefore a lysimeter will be installed at the beginning of the project in each experimental site and managements to continuously measured evaporation (in the agro-systems with one vegetation strata) or evapotranspiration (In the agro-systems with two vegetation strata).

Task 5.3. Separation of ET fluxes into evaporative and transpiration components for different vegetation layers from multiple complementary datasets
This task addresses the concomitant use of three well-established techniques to measure ET and its compartments, eddy covariance (both above and below canopy), sap flow, and

lysimeter measurements. Table 2 shows a summary of the methods proposed in this project, to estimate evapotranspiration and its components.

Multi-year comparison of these three independent techniques for continuous (half-hour data) estimates of evapotranspiration and its components are scarce, and even more unusual when the vegetation has a complex structure (tree + grass).Thus, biotic and abiotic processes controlling evapotranspiration and its separation into components will be examined with a spatial and temporal detail not available when only a single measurement technique is used.

Method	Component	Spatial scale (m^2)
EC (above canopy)	$T_{trees}+T_{grass}+E_{soil}$	10^4
EC (below canopy with grass)	$T_{grass} + E_{soil}$	10^2
EC (below canopy without grass)	E_{soil}	10^2
Sap flow	T_{trees}	10^2
Lysimeter (soil with grass)	$T_{grass} + E_{soil}$	10^0
Lysimeter (bare soil)	E_{soil}	10^0

Summary of ET methods (T_{trees}, trees transpiration, Tgrass grass transpiration, Esoil, soil evaporation)

It has been hypothesized that changes on the structure and composition of the canopy (e.g. from a management practice), will modify the partition evaporation / transpiration that may be associated with changes in plant productivity and soil carbon processes. These processes combine to affect the ecosystem carbon budget. For this reason, data on the partitioning of ET coupled with carbon exchange characteristics at a sufficient temporal and spatial scale are crucial in order to better understand this challenging question.

Milestones for Task 5: Continuous values of soil evaporation, and tree and grass transpiration for the studied agro-systems with different understory managements

Task 6. Parameterization and validation of the DO3SE and DO3SE_C models

Task 6.1. In-situ data collection for DO3SE model parametrization

Several measurements campaigns will be performed at the Pinus Halepensis Forest and Citrus Orchard sites to collect in-situ data necessary for DO3SE model parametrization.
Leaf scale measurements of CO2, H2O fluxes and stomatal conductance will be carried out with a portable photosynthesis system (LI-6400, LiCor) under different meteorological conditions in order to capture the daily and seasonal variation in gas exchange parameters with regard to changes in phenology, radiation, T, VPD, and SWC (the parameters used for deriving the functions used in DO3SE model). A/Ci curves will also be carried out for modelling the maximum rate of carboxylation (Vcmax) and electron transport (Jmax), according to Long and Bernacchi (2003). Leaf water potential will be measured at each campaign with a Scholander chamber (Digital Model, Skye Instruments).

Several campaigns will be carried out along the year in order to account for the seasonal variations of these parameters with both environmental conditions and phonological stages, an issue of great relevance for Mediterranean ecosystems (e.g, (51, 52)).

Task 6.2 Parametrization the DO3SE and DO3SE_C models

This task aims at providing novel parameterizations both for the multiplicative and for the photosynthetic algorithms of DO3SE model.
Using both data collected by task 6.1 and meteorological and soil water content (SWC) data available at flux tower sites, species-specific functions relating the changes of stomatal conductance (gsto) in relation with phenology, radiation, air temperature, atmospheric vapor pressure deficit, and SWC will be built for both Citrus and Pinus Halepensis vegetation, and parameterization will be obtained according to the methodology described in the Mapping Manual of the Convention on Long-Range Transboundary Air Pollution (LRTAP, 2015).

For the DO3SE_C model, the main parameters needed are Vcmax, Jmax, and the parameter m describing the relationship between An and gsto (calculated according to Müller et al., 2005(53)).

Task 6.3 Validation / Intercomparison of modelled stomatal ozone fluxes (DO3SE) with EC ozone fluxes

Stomatal ozone fluxes will be modelled for all study sites with the DO3SE model applying existing site specific parameterizations for Olive Orchard (from GEISpain project), Pine Forest and Citrus Orchard (from task 6.2), and default parametrization for Dehesa.
The vegetation stomatal ozone fluxes modelled with DO3SE will then be compared to estimates of total and stomatal deposition inferred from O3 EC measurements (Tasks 1.2, 2, and 9) for their validation and to understand the DO3SE models potential inconsistencies or pitfalls. A statistical analysis of the results will be performed and of the discrepancies will be analysed in term of seasonal patterns and potential environmental drivers (e.g. soil moisture, temperature, radiation). A sensitivity analysis modifying the key model parameters will be carried in order to test how they affect ozone flux estimates (cf. (52)).

The EC measurements at both ecosystem and subcanopy level performed in the project for 3 ecosystem types will allow to validate modeled canopy stomatal fluxes versus direct in-situ experimental estimates of bulk canopy O3 deposition and stomatal conductance.
Milestones: Parameters for modeling calculated. Modeled O3 fluxes compared with measured fluxes with eddy covariance

Task 7. WUE from different perspectives as a tool for better understanding of CO2 and H2O cycle interaction and evaluating adaptation strategies.
The partitioning of both water and carbon fluxes by using several experimental techniques (eddy covariance profiles, leaf chambers, sap flow sensors) together with modeling approaches will permit the estimation of the WUE and iWUE at ecosystem, tree and leaf spatial scales. Furthermore, the experimental design will allow the assessment of the ozone negative effects on WUE and iWUE and will elucidate the role of management in Mediterranean ecosystems, where the optimization of the water-use is fundamental. In particular, WUE and intrinsic WUE (iWUE) will be calculated at leaf level, by relating the measured net C assimilation (An) to the transpiration (Tleaf) flux and stomatal conductance (gs), respectively. Similarly, WUE at ecosystem level (WUEeco) will be obtained to either the ratio between NEE or GPP to ET, while intrinsic WUE (iWUEeco) will be estimated as the ratio between GPP and the surface conductance (Gs), which is derived from meteorological variables and the latent energy flux by inverting the Penman-Monteith equation (Beer et al. 2009).
Milestones: Several values of WUE at different spatial and time scales

Task 8. Partitioning of O3 deposition flux between vegetation layers and stomatal and non stomatal processes
Task 8.1 Partitioning of O3 deposition flux between vegetation layers
EC measurements of O3 deposition fluxes performed from whole ecosystem flux towers (Task 1.2) and from subcanopy flux-towers (Task 2) will be combined to quantify the contributions of canopy and understorey (i.e. understorey vegetation + soil) to overall ecosystem O3 deposition fluxes at the following sites: Olive Plantation, Aleppo Pine Forest, Holm Oak dehesa.
We will estimate the daily and seasonal patterns of the O3 flux partitioning among the different vegetation layers of the ecosystems, and analyse the abiotic (e.g. meteorological variables) and biotic (e.g. biophysical vegetation parameters) factors that govern these patterns.
In addition, at the Olive Plantation site, we will quantify and analyse the effect of management practice (weed cover or bare soil) onto olive tree canopy O3 flux as well as onto the overall removal of O3 from atmosphere by olive plantation.
Similarly, for the Pine Forest site, we will quantify and analyse the effect of understorey vegetation onto Pine canopy O3 flux and overall ecosystem O3 deposition.

Task 8.2 Partitioning of O3 deposition flux between stomatal and nonstomatal removal processes
The contribution of stomatal and non-stomatal processes to total measured ozone fluxes by eddy covariance will be estimated using different complementary approaches. Bulk stomatal conductance of vegetation will be estimated using different methods depending on the ecosystem type.
Bulk stomatal conductance (and related stomatal ozone fluxes) will be firstly estimated for all ecosystems from available H2O fluxes measured by eddy covariance using Penman-Monteith approach for periods during which evaporation can be considered negligible. Both SWC and precipitation in combination with lysimeter data will be used to define such periods.
In addition, sap flow measurements will be used to further assess the canopy bulk stomatal conductance and the stomatal ozone flux of tree canopy, since transpiration and O3 influx are coupled through stomatal regulation. Canopy-level stomatal conductance and related ozone fluxes inferred from these sap-flow measurements will be compared to Canopy scale ozone deposition fluxes estimated in Task 9.1.

We will perform a critical assessment of both stomatal O3 deposition patterns and the most usual standard methods (either experimental or model) to estimate it for Mediterranean ecosystems. This will achieved by comparing independent estimates of ozone canopy stomatal fluxes: (a) estimates from various independent experimental approach (EC and sapflow); (b) modelled values using site specific parametrization from in-situ measurement at leaf scale.

Milestones: O3 Fluxes calculated for each layer. Stomal and non-stomatal O3 deposition calculated

Task 9. Upgrading flux-tower sites with Webcam, NDVI, SWC
All the flux tower sites of the project will be upgraded in order to increase both (a) the quality and relevance of their measurement suite in the context of the present project, and (b) their future research potential in a wider context.

Soil Water Content (SWC)
Ensuring robust and representative SWC measurements is very critical for flux-tower stations located in arid and semiarid Mediterranean ecosystems, because the soil water availability for vegetation is a critical driver of both CO2, H2O exchanges at ecosystem level. On other hand, SWC often present strong spatial variations in Mediterranean ecosystems due to various possible reasons (strong evaporative demand, rocky soils, patchy vegetation, irrigation, etc.) and it is therefore often results challenging to get SWC measurements representative of the spatially average SWC of the studied ecosystem. Since this variable is highly critical for both modeling and analysis of CO2 and H2O fluxes in Mediterranean ecosystems, new additionalSWC measurements will be set up following the ICOS level 2 stations requirements (5-depths SWC profile + 4 superficial SWC sensors) at the sites not meeting these requirements.

Optical observations (Webcam and NDVI)
Optical sensors for continuous measurement of NDVI and RGB+IR Webcams will provide automated, near-surface remote sensing of ecosystem/vegetation characteristics.
The NDVI data will be used in the project (Task 11.1) for ET modelling, and will allow to assess RS NDVI products largely used for driving the RS driven light use efficiency models used to estimate CO2 assimilation at regional and global scale.
The Webcams will be installed and operated according to ICOS Phenocam protocol guidelines, and all the flux-tower sites of the projects will integrate the PhenoCam network (https://phenocam.sr.unh.edu/webcam/about/) by sharing the collected images.

Milestones: SWC sensors, NDVI sensors and Webcam installed and operating at all sites (Month 6)

Tasks	Oli.	For.	Deh	Cit.	Subprojects	Objectives	Persons	First Year	Second Year	Third Year
0. Coordination					1,2,3	all	**PSO**	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
1. Continuous measurements of ecosystem scale fluxes of CO2, H2O, O3 and environmental variables										
1.1. Continuous operation of ecosystem "flux-tower station"	X	X	X		1,2,3	all	**PSO**, AMO, PD1, PhDs1; **ER**, PD2, AL; **AC**,	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
1.2. Application of management treatments to the agro-ecosystems		X			2	1.1, 2.1, 2.4	**FRL**, PhDs2, MA	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
1.3. Measurement of ecosystem scale fluxes of O3	year1	year2	year3	year3	3	3.1	**AC**, PD3	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
2. Measurements of subcanopy EC fluxes of CO2/H2O/O3	year1	year2	year3	year3	1,2,3	1.1, 2.1, 3.2	**PSO**, AMO, PD1, PhDs1; **ER**, PD2, PhDs2, AL; **AC**, PD3	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
3. Complementary biometric measurements of the canopy	X	X	X	X	1,2,3	1.2, 2.2, 2.3, 2.4, 3.3	**JLGR**, LVS, Tech1; **FAG**, FRL, MA, PhDs2; **AC**	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
4. Partitioning of CO_2 fluxes into its dominant components and processes										
4.1 Horizontal Soil CO2 profiles	X	X	X		1	1.2	**ASK**, EPSC, PD1	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
4.2 Intercomparison of soil respiration from CO2 profile with Chamber measurements	year1	year2	year3		1	1.2	**PSO**, EPSC; PD1; PhDs2; RL	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
4.3. Separation of CO_2 fluxes into GPP and respiratory components										
4.3.1 CO2 partitioning	year1	year2	year3		1	1.2	**PSO**, PD1; **FRL**, PD2; AC	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
4.3.2 CO2 from subcanopy flux towers vs chambers (intercomparison)	year1	year2	year3		1	1.2	**PSO**, PD1; **FAG**, PhDs2	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
5. Partitioning H_2O exchange into its dominant processes. Complementary measurements										
5.1. Sap-flow measurements	X	X	X		1,2,3	2.2	LVS, AR; **FAG**, PhDs2; AC, OPP	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
5.2. Lysimeter measurements	X	X	X		1,2,3	2.2	LVS, AR; **FRL**, PD2; OPP	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
5.3. Separation of ET fluxes into evaporative and transpiration components	X	X	X		2	2.2, 3.3	LVS, AR; **FAG**, ER, PhDs2; AC, OPP	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
6. Parameterization and validation of the DO3SE and DO3SE_C models										
6.1. In-situ data collection for DO3SE model parametrization		year2		year3	3	3.4	**VC**, CG, PD3	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
6.2 Parametrization the DO3SE and DO3SE_C models		year2		year3	3	3.4	**VC**, ZF, PD3	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
6.3 Validation / Intercomparison of modelled stomatal ozone fluxes (DO3SE) with EC ozone fluxes	X	X	X	X	3	3.5, 3.3	**VC**, HGG, IGF, AC	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
7. WUE from different perspectives	X	X	X	X	2	2.4	AMO, AR; **FAG**, MA, ER, AL	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
8. Partitioning of O3 deposition flux between vegetation layers and stomatal and non stomatal processes										
8.1 Partitioning of O3 deposition flux between vegetation layers	X	X	X		3	3.2	**AC**, VC, PD3	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
8.2 Partitioning of O3 deposition flux between stomatal and nonstomatal removal processes	X	X	X	X	3	3.3	**AC**, VC, PD3	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
9. Upgrading flux-tower sites with Webcam NDVI SWC	X	X	X	X	1,2,3	1.4	**JLGR**, EPSC, PD1; **ER**, MA, PD2	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
10. Atmospheric Measurements										
10.1 ABL structure monitoring	year1	year2	year3		1	1.3, 1.4	**JLGR**, HL, PhDs1	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
10.2 Atmospheric measurements for modeling improvement	year1	year2	year3		1	1.3, 1.4	**JLGR**, HL, PhDs1	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
11. Modeling ET and its components (HIDROMORE)										
11.1 Generation of input variables from remote sensing data and modelling of ET using	X	X	X	X	2	2.3, 3.3, 3.5	**ER**, PD2, PhDs2,	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX
11.2 Validation/Intercomparison of Modeled estimates with estimates from experimental measurements (Tasks 1, 2, 5)	X	X	X	X	2	2.4	**ER**, PD2, PhDs2	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX

***Each color correspond to the different studied sites: Olive Orchard (Oli; yellow), Aleppo Pine Forest (For; Green); Oak Holm Dehesa and Citrus Orchard (Deh and Cit; Reed)**

***Persons. Subproject 1. Principal Investigators: PSO (P. Serrano Ortiz), JLGR (J. L. Guerrero Rascado; Research team: ASK (A. S. Kowalski, LVS (L. Villagarcía Saiz),PhDs1 (PhD student) requested), PD1 (contracted post-doc researcher); Work team: EPSC (E. P. Sánchez Cañete), AMO (A. Meijide Orive), AR (Alexander Roll), HL (Hassan Lyamani). Subproject 2. Principal Investigators: ER (Eva Rubio), FAG (Francisco A. García Morote); Research team: FRL (F. R. López Serrano), MA (Manuela Andrés Abellán); Work team: AL (Dr. Ana López Ballesteros); PhDs2 (PhD student requested), PD2 (contracted post-doc research).Subproject 3. Principal Investigators: VC (V. Calatayud), AC (A. Carrara), Research team: CG (Cristina Gimeno), PD3 (contracted researcher); Work team: OPP (Dr. Oscar Pérez Priego), HGG (Dr. Héctor García Gómez), IGF (Dr. Ignacio González Fernández), ZF (Zhaozhong Feng). The underlined person will be responsible**

Task 10. Atmospheric Measurements

Task 10.1 ABL structure monitoring
The ABL structure will be continuously monitored (24 h) during 2 mouths at each site (and treatment) using a Doppler lidar co-located to the flux-towers. The Halo Photonics pulsed Doppler lidar system is a unique, state-of-the-art autonomous instrument for atmospheric remote sensing. This Doppler lidar is able to provide wind profiles in all three components with full hemispherical coverage with 0.01°resolution in both axes. The system collect data to 10 km with raw data storage, using a minimum range around 60m. The temporal resolution is selectable in range 0.1–30 s. The ABL height is detected assuming that the ABL height is demarcated by a strong gradient of aerosol content where there is a transition between the ABL with high aerosol concentration and a relatively clean free atmosphere, and therefore the ABL height corresponds to the height at which the variance of the carrier to noise ratio (CNR) is maximum (*66*). Given the high power supply requirements of this instrument, the electricity for each site is needed. Since for the Forest site the electricity is not available, we will need an electric generator.
Milestones: Identification of main dynamic processes of ABL for all sites

Task 10.2 Atmospheric measurements for modeling improvement
The characterization of the scenarios for atmospheric correction will be obtained by radiosonde data through launches a GRAW DFM-06 radiosonde (GRAW Radiosondes, Germany) few meters far from the flux-towers and simultaneous to LandSat 8 overpasses over our study sites. It is a lightweight weather radiosonde that provides profiles of temperature (resolution 0.01ºC, accuracy 0.2ºC), pressure (resolution 0.1 hPa, accuracy 0.5 hPa), relative humidity (resolution 1%, accuracy 2%) and wind (accuracy 0.2 m/s). Data acquisition and processing will be performed by Grawmet5 software and a GS-E ground station from the same manufacturer. For each site 10 radiosondes will be launched coinciding with the field campaigns for monitoring the ABL structure (task 10.1).
In addition, the selection of aerosol model will be done through column integrated characterization of the atmospheric aerosol by means of an automatic sun tracking photometer Cimel CE - 318 - 4, also co-located to the flux-towers. This instrument makes direct Sun irradiance measurements with a 1.2º full field of view every 15 min at 340, 380, 440, 670, 870, 940 and 1020 nm. These solar extinction measurements are then used to compute aerosol optical depth (AOD) at each wavelength except for the 940 nm channel, which is used to retrieve total column water vapor. The AOD is derived from the total optical depth obtained from direct Sun - photometer measurements data. The sky radiance measurements, performed at the almucantar and principal planes at 440, 675,870, and 1020 nm together with solar direct irradiance measurements at the same wavelengths, are used to retrieve the aerosols ingle - scattering albedo, phase function and the volume size distribution.

Milestones: Values of atmospheric vertical profiles of T, P and RH and columnar aerosol properties at all sites

Task 11. Modeling ET and its components (HidroMORE)

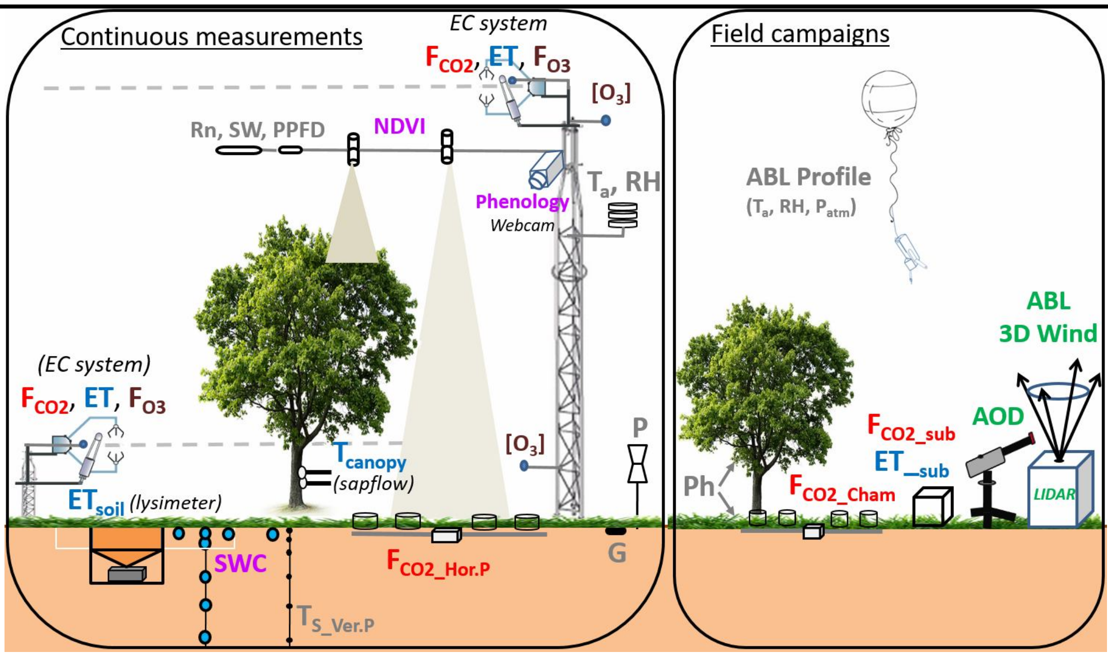
Task 11.1. Generation of input variables from field and remote sensing data. Application of HidroMORE for the studied sites
In order to apply HidroMORE for each one of the sites, a set of input data is required. Notice that the model is a distributed model that can be applied at different spatial scales; it is also versatile in terms of the nature and quality of the input data (from field data to remotely sensed imagery, and from specific data to vague and generic one). Then, when some input data are missing about the soil and/or vegetation, the model uses internal tables to reproduce generic information on some typical agro-systems. Here, HidroMORE will be used by integrating high quality input data measured at field, such as precipitation and meteorological variables (wind speed, solar radiation, air temperature and relative humidity) recorded at the flux-tower setups. Also, soil data for texture, depth, soil water content at field capacity, soil water content at wilting point, and soil water at saturation, obtained from soil analyses of the study site, will be integrated. Root depth is a critical factor for calculating soil

water content on the definition of the limits of water storage and availability. Finally, for the kcb-NDVI series, two approaches will be considered: (i) to use imagery data from satellites with the appropriate spatial and temporal resolutions; (ii) to use NDVI series measured in situ with the NDVI sensors integrated into the flux-tower equipment.

Task 11.2 Validation/Intercomparison of Modeled estimates of total ET, canopy transpiration, soil evaporation and SWC with estimates from experimental measurements (Tasks 1, 2, 5)
HidroMORE provides daily estimates of ET, SWC, transpiration from the whole canopy and soil evaporation. In previous studies, this model has been validated in terms of recharge, total ET and SWC, showing a good performance against EC flux and lysimeters (see Background section). However, the model has not yet been evaluated in terms of the components transpiration and evaporation. The singular opportunity that constitutes the concurrent continuous measure of transpiration, and evaporation will allow to check its performance to model ET partition. The advantages of having a model that has been proved to provide accurate T and E for the relevant agro-systems of this proposal are evident since, in general, no SWC measurement are available.

Milestones: Daily estimates of ET, Tcanopy, Esoil, SWC from HidroMORE

The following figure illustrate all the measurements that will be carried out to get the objectives of ELEMENTAL



Measurements in red, blue and brown are related with fluxes of CO2, H2O and O3, respectively. Measurements for upgrading flux-towers are in purple and measurements used for improving the eddy covariance technique are shown in green. Continuous measurements: Ecosystem fluxes of CO2 (F_{CO2}), evapotranspiration (ET) and Ozone (O3) measured by IRGAs and a 3D sonic anemometer. Phenology measured by a Phenological camera. Normalized Difference Vegetation Index (NDVI, 2-channel sensors) of tree canopy and understorey. Photon flux density (PPFD, up & down, Quantum PAR sensors). 4 component Net radiation (Rn, SW, LW, up and down, 4-components net radiometer). Air temperature and relative humidity (RH, thermohigrometer). Precipitation (P, Rain Gauge). soil evapotranspiration ($ET_{\_soil}$, Lisymeter). Soil Water Content (SWC, humidity probe). Vertical profile of temperature ($T_{S\_Ver.P}$, thermistor). Soil heat flux (G, heat flux plate). Horizontal profile of soil CO2 respiration ($F_{CO2\_Hor.P}$, IRGA). Transpiration (T, Sap flow sensors). Field campaigns: CO2 and H2O exchange at leaf level from trees and grass (Ph, IRGA LI6400). Soil CO2 respiration measured by a portable chamber (F_{CO2_Cham}, IRGA). Subcanopy fluxes of CO2 and H2O measured with a whole-plant chamber ($F_{CO2\_sub,}$ $ET_{\_sub}$). Aerosol optical depth (AOD, Sun photometer). Atmospheric boundary layer temperature , humidity and pressure profile (ABL Profile), 3D wind direction and wind speed (Lidar Doppler). Variables measured by the radiosonde.

5. Infraestructura y equipamientos singulares disponibles

Each experimental site is equipped (or has available and already to install) with standardized high-performance instruments to measure fluxes of CO2, water vapor and energy between terrestrial ecosystems and atmosphere (flux-tower). Each flux-tower consists of an infrared gas analyzer that measures densities of CO2 and H2O, a three-axis sonic anemometer that measures wind speed and sonic temperature, a tower structure supporting the instrumentation at the required height to measure fluxes properly, and a data logger to record and process data. The total average cost of each flux tower is around 60.000€ (55.000 x[2 (Olive) +2(Forest) + 1 (Citric)+ 1(Dehesa)] total=360.000€) (instrumentation to be used in all tasks). Together with fluxes, the experimental sites are also equipped with complementary instrumentation to measure meteorological and other environmental variables. The cost of the complementary instrumentation varies for the different sites, but average cost of basic core instrumentation is about 20.000€ (20.000 x 6 sites EC systems=120.000€) (instrumentation to be used in task 1)

Subproject 1 (UGR) partners operate the two flux towers of the olive orchard, subproject 2 (UCLM) partners operate the two flux towers of the pine forest and Subproject 3 (CEAM) partners operate the dehesa and the citric orchard site.
Additionally, the different subproject teams have additional instrumentation (anemometers, IRGAs, data loggers and tower structures) to compose two additional flux-towers (70.000€) (instrumentation to be use for task 2).
Note that several of the proposed sites have been (or are) part of different national (CARBORED) and international networks (FLUXNET, CarboEurope, ICOS) and contributed to EU projects such as FP6 projects MIND, CARBOMONT, NitroEurope-IP, CarboEurope-IP, and FP7 projects IMECC, GHG-Europe, CARBO-Extreme, ICOS-PP and InGOS.
Additional relevant equipment that will be used for the project for field campaign measurements:

Subproject 1: A Portable Photosynthesis System (LI6800, LiCor) equipped for measuring leaf gas exchange (35.000€),Two portable soil CO2 efflux systems (LI-8100,LiCor (30.000€) and EGM4/SRC1, PPsystem (14.000€)). A Halo Photonics Doppler lidar to monitor the structure of ABL (200.000€), a Sun-photometer (Cimel 318-4) (50.000 €) to derive aerosol optical and microphysical properties and a GRAW MET station with GRAW DFM-06 radiosondes to measure meteorological profiles (7000 €)

Subproject 2: 10 complete forestry measuring equipments consisting of the following dendrometers: digital calipers, laser hypsometers, laser distance meters, bark gauges, Pressler dendrometers, and metric tapes. We also have a complete equipment for biomass sampling (destructive inventory). Complementary, high precision instrumentation to measure the main variables which permit us characterize both trees and forest stand: 1 Ultrasonic hypsometer and distance meter model VERTEX III DME; 2 laser dendrometer CRITERION RD 1000 (LASER TECHNOLOGY INC.), 2 LAI measuring equipment (LAI-2000 (LICOR)); 12 sap flow measuring equipment; and 60 automatic dendrometers model DRL Equipment utilized for gas exchange measurements at tree level: 2 Analyzers for measurement of CO2 and H2O by IRGA (LICOR), models LI-6400 and LI-6400 XT, measuring chambers of chlorophyll fluorescence (LI 6400-40), photosynthesis in conifers (LI 6400-05) and needles (LI 6400-07). To measure soil CO2 we also dispose of 1 LI 6400-09, and 2 Portable gas exchange analyzers, model LI-COR 8100 and LI-COR 8150 Multiplexer. Recently, we have acquired a terrestrial manual laser scanner model ZEBREVO (latest technology in Terrestrial Lidar) including the Geoslam and Geomagic Wrap data analysis software. Our laboratory is well equipped with additional instrumentation to measure C and mineral nutrients in vegetal biomass and forest soils. Finally, we have other additional equipment, essential for fieldwork: 2 all-terrain vehicles (Nissan and Toyota models), 1 Trailer towing platform (MATILSA, Parma 12 m) and 1 Trailer 1000 kg.

Subproject 3:A Portable Photosynthesis System (LI6400, LiCor) equipped for measuring leaf gas exchange (35.000€). An ozone analyzer (Europe) (9000€). A leaf area meter (LAI2000, LiCor) (3000€). A Scholander pressure chamber (Skye) (3000€) for measurement of leaf water potential. A gas chromatograph-MS (LC/MS Thermo), (60000€). A gas chromatograph-MS (Agilen), fitted with SPME and TD (144.595€). Liquid chromatograph-MS (Thermo) (120.000€). A PTRMS (Ionikon) (2400.000€).

7. Contratación de personal: justificación

Subproject 1

We request a contract with a level of PhD in Sciences for 2 years.The post-doc contract requested is clearly justified in the Chronogram given the temporal situation of some of the post-docs (Ana Meijide and Enrique P. Sánchez-Cañete) with only 1 or 2 years of contract when this project starts.The post-doc will be strongly involved in the tasks related to measurements of CO2/H2O with eddy covariance, soil profiles and chambers in all the exprimental sites and treatments (except the citric Orchard). Task 1.1 and 2 regarding continuous operation of ecosystem and subcanopy "flux-tower station"systems, task 4.1 regarding horizontal Soil CO2 profiles and task 4.3 for separation of CO2 fluxes into GPP and respiratory components.

We also request a contract with a level of degree in Sciences and expertise as technician. The technician contract requested for the first two years of the project is clearly relevant given the intensive field work (field campaigns and installation of new instruments). The University of Granada do not account for technicians dedicated to field research. In this regard, despite the technician is not included in the Chronogram (he/she will be in the tasks with requirements of field activities (mostly all), his/her contract will ensure an efficient field work optimizing the time of researchers of subproject 1.

Subproject 2

We request a contract with a level of PhD or Master in Forestry sciences. This professional should have important knowledge on forest ecology, forest restoration, micrometeorology and C and H2O cycles. The candidate should also have relevant training on experimental design, database management and advanced statistical analysis. Its main function would be twofold: first, executing the field work and carried out the data inventory (in each of the tasks defined above), thus creating and analyzing the associated databases, and second, writing scientific papers. This broad function is justified by the number of working days scheduled in the methodology section (1 person / 3 years).

Subproject 3:

We request a contract with a level of PhD in Sciences. The post-doc contract requested will support experimental activities (in particular field campaigns at Pine Forest site and Citrus Orchard), data treatment and analysis (both flux-tower data and leaf scale gaz exchange campaigns data). The project has a strong component of experimental activities, with several field measurements campaigns during 2 years of the project. Therefore the contract is requested for a 2 year period.

Ecophysiological measurements and eddy covariance technique are rather complex and requires advanced knowledge of trace gaz flux measurements techniques and experience with measuring protocols quality control and data processing for the type of instrumentation used (IRGA analyzers, wide variety of sensors ...), which requires as specialized personnel, with some solid knowledge and previous experience in order he can perform part of planned work in independent way. Therefore it is requested to contract a PhD post-doctoral researcher. The contracted PhD postdoc will be involved in the following tasks: Task 1.2, Task 2, Task 6.1, Task 6.2

C.3. IMPACTO ESPERADO DE LOS RESULTADOS

The results of this project will provide scientific knowledge of the processes and mechanisms of terrestrial ecosystems functioning to promote policies for adaptation to climate change. Quantifying the components of the carbon and water balance as well as the full GHG exchanges and their sensitivity to O3 in term of productivity, along with the long-term monitoring of the flows of CO2 / H2O, will provide essential information to enable mitigation ofclimate change, as well as adaptation which is especially relevant in Mediterranean ecosystems given their high vulnerability. Additionally, GHG measurements in managed ecosystems under different treatments will provide essential information to evaluate how the impacts of climate change can influence their productivity and other services and functions. Similarly, synergies between ELEMENTAL and other European research programs about monitoring and mitigation of agricultural and forestry GHG (cf. ESFRI project ICOS (H2020);

the past GHG-Europe (FP7)) and research programs and networks about monitoring of vertical profiles of wind and aerosols properties (ACTRIS-2(H2020), AERONET, Cost Action TOPROF(ES1303) (H2020), E-PROFILE)will allow us to integrate our database into existing European Fluxes Databases Cluster (http://www.europe-fluxdata.eu/) and ACTRIS-2 database (http://actris.nilu.no/), filling knowledge gaps in continental networks and providing a better characterization of ecosystem services in the Mediterranean area and ABL characterization. In addition, the results of ELEMENTAL, will reduce uncertainties in GHG Mediterranean inventories to improve carbon sequestration and to reduce GHG emissions.
As can be seen in the CVs, the reasearch team maintains high production capacity of articles in national and international journals, as well as active participation in congresses. The plan for disseminating the results of this project includes publication in journals such as Agricultural and Forest Meteorology, Agriculture, Ecosystem and Environment, Atmospheric Chemistry and Physics, Atmospheric Research and even Science or Nature, all included in the Science Citation Index and characterized by their relevance in the field of study in which this project falls. The results also will be presented at international meetings and conferences, such as the ICOS, FLUXNET or ACTRIS meetings, and the European Geosciences Union, the American Geophysical Union Assembly meetings, the International Laser Radar Conference, European Lidar Conference and European AerosolConference, to name few.
The DO3SE model provides the method by which the EMEP model estimates ozone deposition and stomatal ozone flux. Since the 1990s, the EMEP models have been the reference tools for atmospheric dispersion calculations as input to the Integrated Assessment Modelling (IAM), which supports the development of air quality polices in the European Union. As stated in LRTAP (2015), species-specific O3 flux-effect relationships and critical levels for cropscan be used to estimate yieldlosses, including economic valuations, while for trees, they can be used as a starting point for calculation ofimpacts on carbon sequestration, hydrology and tree diversity.Therefore, the improvement of models for a correct estimation of the O3 fluxes and associated impacts under Mediterranean conditions have important economic implications, and they are relevant for climate change and biodiversity as well. Given that O3 is a key air pollution problem for Spain, with increasing presence in the media, model estimations of the O3 impacts on vegetation must be sound enough to support realistic air quality policies on this topic in Spain. In contrast, the impacts of O3 on Mediterranean areas were largely overestimatedin the past for some types of vegetation, as they were based on O3 exposure metrics which did not take into account the modifying effect of meteorological and SWC conditions on O3 uptake, i.e. there was a mismatch between expected and observed effects.
The fact that we focus on two important Mediterranean olive and orange trees, providing ad-hoc parameterizations for the DO3SE modelwill have an important impact in the United Nations ICP-Vegetation community, which leads ozone research in Europe. CEAM researchers are integrated in this community. The project is also of great interest for Chinese researchers as the ozone flux methods is now recognized as superior to exposure-based methods also in Asia. Dr. Zhaozhong Feng (RCEES, Beijing) is included in the working team. The IP of this subproject has been awarded two times with a Grant from the Chinese Academy of Sciences for Visiting Senior Researcher, ensuring the continuity of a fruitful collaboration. All these synergies ensure that the project will have an important international impact, and many SCI scientific publications may be anticipated. As the IP of this proposal participates in the EP on Ambient Air Quality of ICP-Forest (and indeed he was co-chairman of this group from 2008 to 2015), in which ozone is also considered a priority topic, the project will also have an important diffusion in this community. Also in the flux-tower community, ozone flux is starting to be considered a relevant topic, and it increasingly measured. Furthermore, the concept of “supersites”, platforms integrating long term measurements and research, is currently taking shape, and measurement of ozone fluxes is one of the frequent requirements for a place to be considered a supersite. The development of this project can importantly contribute to positioning some of the Spanish eddy covariance sites into this new type of platforms, providing even more international visibility. Additionally, the team will develop a webpage including a description of the project, emerging results, and ongoing activities.

C.4. CAPACIDAD FORMATIVA DEL EQUIPO SOLICITANTE

Subproject 1

The reasearch team is composed oft wo PIs that, thanks to their mature research careers, have great experience supervising PhD and Master students, and two professors with long experience in research direction and teaching activities.The team has presented 10 PhD theses (5 of them directed by the PIs) and numerous Final career projects and Masters, including 3 European masters programs (University of Bordeaux , University of Hamburg andUniversity of Montpellier 2).The team highly interdisciplinary (ecologist, atmospheric physics and ecophisiology) ensuring a high quality training capacity in several areas relevants for the proposed objectives. In this context, of the hundreds of research teams operating flux-towers worldwide to estimate carbon and water fluxes, the vast majority areecologists with little background in atmospheric physics, and so only dozens are contributing to the evolving methodology of such measurements. The two PIs of this subproject belong to the Atmospheric Physics Group (GFAT) of the UGR, but with complementary backgrounds: while Penélope has contributed to defining ecological applications of micrometeorological methodologies since the earliest days of Spanish flux-tower research, Juan Luis has dedicated to establish one of the first remote sensing supersites over the Iberian Peninsula and is contributing into an international initiative to address the structure of the atmospheric boundary layer with a focus on ground-based atmospheric profiling techniques. Members have participated in the first publications of (EUROFLUX) methodologies for eddy covariance application, gap-filling and complementary measurements for purposes of validation. The group has produced results describing the source/sink behavior and functional ecology of Mediterranean ecosystems, improving the correct application of the eddy covariance technique, as well as, has developed methods to improve the knowledge of the different internal layers of the ABL by different remote sensing techniques, including synergies. This publication history frames the group’s training capacity, furthermore reflected by numerous theses directed by the group mentioned above (see CVs).

Subproject 2

The research group is composed of 4 PDI (at full time) that due to its different multidisciplinary training, have great experience supervising PhD and Master students in different themes related to forest ecology and forest management, such as biomass estimation in Mediterranean forest, forest regeneration, post-fire treatments, forest soils, and CO2 and H2O fluxes in Mediterranean ecosystems. This ensures a high training capacity in diverse areas which are included in the proposed objectives of this project. In this sense, our research group has directed 8 PhD theses in the last 10 years (see CV), and numerous Degree and Master Projects (more than 50 in the last ten years). The teaching and research career of our graduates is highly positive, which demonstrates the formative capacity of our group: 3 PDI, and 5 postdoctoral contracts in prestigious universities such as University of Navarra, University of Arizona, University of Lleida, University of Edinburgh, and University of Castilla-La Mancha.

C.5.IMPLICACIONES ÉTICAS Y/O DE BIOSEGURIDAD

Not applicable

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