A1. Proposal Details

 Call Identifier
 Title. Give the title of your project (less than 200 characters).

impActs and feedbackS between climate and Soil affected by EroSion: cost in terms of carbon Storage in Mediterranean regions.

 Short Title or Acronym (max. 10 letters).

ASSESS

 Key-words: Supply key-words to specify your scientific subject.

Soils, erosion, climate change, future predictions, soil carbon storage

 Intended starting date: (Not earlier than... Not later than....)

Not earlier than December 1st 2016. Not later than February 1st 2017.

 Duration: In between 24 and 36 months.

36 months

 Total cost: Estimated overall budget of the project with breakdown per partner, including costs not covered by ERANETMED such as 'in kind' payments/contributions and other costs, which should be specified.

776 412€

 Requested funding: The total amount of funding requested from ERANETMED.

298 199€

 Participation of any research team involved in this Proposal in any other Proposal submit-ted within the framework of this Call.

For LISAH, Damien Raclot isinvolved in an other proposal called MET-LANDD (4 months on the 36 months for the project)
For INGREF Haithem Bahri is also involved in another project.
Other researchers involved in this project are not involved in other proposal within the framework of this call.

A2. Summary (max. 500 words)

Summarise the main questions and/or approach and objectives; give a short description of the activities and expected results of the project. This summary must be manually input into the relevant on-line section and cannot be uploaded as a Word document or PDF.

The soil organic carbon pool can strongly affect the carbon cycle and future global warming. However, the dependence of carbon storage on climate is currently not well understood. The uncertainties related to future soil C dynamics are relatively high and should be reduced. Different ways have been identified to improve the prediction of Earth system models. In particular, improving the role of texture and the representation of erosion on the soil organic carbon (SOC) balance are considered as important avenues of research. Both are in turn strongly dependant of the soil nature that evolves permanently throughout time under the action of climate on time scale as short as a few tens of years. Therefore **we propose, i) to evaluate the changes in soil carbon and associated properties at the 2100 horizon over Mediterranean regions; ii) to implement an erosion module into the land surface model ORCHIDEE-CROP to better represent the lateral carbon, nitrogen and phosphorous fluxes in croplands over this region due to erosion; iii) to perform experiments to better understand the C dynamics of eroded soils during transport.** To do so we will i) develop a statistical approach, to evaluate the link between soil classes and climate and to derive from this analysis the potential soil changes at Mediterranean scale; ii) derive the changes in carbon storage in soils for each grid cell from the obtained soil projections, and associated soil characteristics, using simulations by LPJmL and ORCHIDEE-CROP models over Mediterranean regions. iii) We will develop and evaluate an erosion module in ORCHIDEE-CROP based on the literature. Validation will be performed using a monitoring done on a site network around the Mediterranean Sea in the framework of the MASCC project. iv) Then, we will estimate, using the erosion module, the gain or the losses of nutrients and thus the quantify of inputs required to maintain fertility at those places undergoing a net decrease of nutrients due to erosion. v) To totally close the carbon budget of agricultural sector, we will estimate the C emissions due to fertiliser productions needed to compensate the effect of erosion or the modifications of fertility due to modifications of soil properties. We will also perform some experiments to better constraint the C emission from eroded soils during transport. Finally, based on these estimations, we will calculate the economic cost of inaction (nothing done to prevent soil erosion) vs. action (modification of practices to reduce erosion)

The main objective of the project is therefore to better understand the impact of soil erosion on the C balance of croplands over Mediterranean regions associated with its economic impacts. To do so, it **will bring together researchers from different disciplines (agronomists, economists, land surface modellers, soil scientists, life cycle assessment specialists)** and different countries (Tunisia, France, Algeria) to propose a broad view of the soil C cycle and its impact on other sectors.

A3. Background, Questions and Objectives (max. 1500 words)

Give a detailed justification of the objectives of the project within the context of the state-of-the art of the scientific area related to the project:

- *Present the research issues and, if applicable, also the main questions related to other actions addressed by the project (innovation, mobility).*
- *Precisely describe the scientific novelty of the project and, when applicable, innovation, and/or mobility objectives.*
- *Give the scientific basis of the project and related state-of-art and – where applicable - the basis for innovation and the need for mobility.*
- *Highlight the interdisciplinary character of the project and explain how its added value is to be exploited. Explain how these disciplines, and the combination thereof, are best suited to address the interface of the societal challenges identified.*
- *Explain the scientific added value and contribution of European-Mediterranean research networks and related transnational collaboration on the Research Question addressed.*
- *Explain the relevance and importance of the research and – when applicable - innovation, and mobility proposed, in terms of shared knowledge, applications (new products, services, processes, social innovations) and/or in terms of economic and societal impact.*

 If the proposal is part of a larger national or international project, explain its precise role and how it fits into this wider context.
 Explain the role and contribution of stakeholders in the project at all stages.

The SOC pool contains the equivalent of ca. 300 years of fossil fuel emissions. This is why small changes in its dynamics or land management patterns can strongly affect the flux of CO_2 exchanged with the atmosphere, and feed back on global warming. Recently, following the COP21, the French minister for agriculture launched an international program called "4 per mil" with the objective to propose soil management solutions able to mitigate climate at a rate of 4‰ year^{-1} which may fully compensate the anthropogenic emissions. However, the dependence of soil carbon storage on climate is still not well understood (Carvailhais et al., 2014) and the role of other factors such as texture, erosion, nutrients and changes in input is also important (Mathieu et al., 2015). Improving the simulation of texture in controlling the stability of SOC and the representation of erosion are considered as important avenues of research for improving SOC models (Luo et al., 2016).

Three types of approaches exist in the literature to document the relationship between soil properties and climate i) *Climatosequences*, generally latitudinal sequences (e.g. Tsai et al., 2010) or altitudinal sequences (e.g. Egli et al., 2003), demonstrated a significant impact of ambient climate on soil formation. This type of approach is mainly feasible on a local scale and for a few soil properties only. ii) *Simulation of the impact of climate change on soil evolution* with mechanistic models at millennium time scales such as SoilGen developed by Finke (2012), which is considered by Minasny et al. (2015) to be the most complete mechanistic model for soil. However this model can only be used to simulate a few soil types and cannot be applied on large scales yet. iii) and, last, a few *statistical approaches of pedogenesis at continental scales* on the basis of the Global soil data base demonstrated the relative controls of climatic and geologic attributes on some soil characteristics (pH, CEC, texture) at shorter time scales (decades). Rasmussen and Tabor (2007) established quantitative relationships between climate and soil classes at the continental scale (America) based upon the Runge (1973) energy model, which contains a synthetic representation of climatic parameters. We therefore hypothesize (i) that climate change will affect soil properties and not only carbon and (ii) that these changes may in turn impact future carbon storage and soil erodibility.

Soil erosion leads to the redistribution of SOC stock within a landscape or a region, and causes both a release of CO_2 during the decomposition of eroded material and a C storage from input tending to increase the SOC in redeposition areas. The role of erosion on the carbon balance is thus complex and still not well understood. **An intense debate continues on whether soil erosion is a net source or sink** with respect to the atmospheric CO_2 reservoir (Van Oost et al., 2007, Lal et al., 2005). One of the central questions of this debate is **whether eroded soils are mineralized faster or slower when they are transported compared to the mineralization rates of non-eroded material**. Moreover, within this debate, it is **often ignored that erosion also modifies the net primary production** (NPP) as shown by Kirkels et al. (2014). At last both SOC storage and erosion are a function of soil characteristics like soil texture, pH, etc. (Antoni et al., 2006; Mathieu et al., 2015) which evolve permanently through time, notably in response to climate change on time scales ranging from decades to centuries (Rounsevell et al. 1999; Guo et al., 2010; Montagne and Cornu, 2010; Cornu et al., 2012).

One of the most striking consequences of erosion is the loss of fine-sized mineral particles, of organic matter and of the associated nutrients with eroded soil downslope, i.e., a major loss of soil fertility. Hence, **the C emissions related to the production of fertiliser that must be increased** (for net nutrient lost) **or decreased** (for net nutrient gain) due to erosion have to be considered, in order **to balance the C global budget.** This has never been done. Finally, **the costs associated to fertilizers application are quite important to price agricultural products** (Lecuyer et al., 2014) and the economic cost of soil fertility modification due to erosion or to changes in soil properties should be carefully estimated by comparing the cost of action (innovative practices to reduce erosion and/or climate change impact on soil properties: i.e. intermediate cropping, direct seedlings, mulch) vs. the cost of inaction (modification of the amount of fertilisers amended).

Mediterranean regions are particularly prone to erosion because of the climatic conditions, soil types present in these areas and vegetation cover. The Era net med call is a unique opportunity to put together different groups studying soils and soil erosion with very different tools and methods (land surface models, catchment models, microcosms experiment, isotopic tracers). The project ASSESS aims to study the soil C balance of croplands over the Mediterranean regions by tacking into account different drivers of the soil C dynamic and their feedbacks: climate change, soil properties (texture, pH, etc.), soil water erosion. The main novelty of this project is to tackle the question of soil C balance with different aspects and tools. The project will benefit from the expertise of partners coming from different fields or research (agronomist, soil scientists, biogeochemists, land surface modellers, economists, etc.) and will open exciting avenues of research aiming as considered the soil erosion under different aspects. During the project, we will encourage visit and long stay of different partners in the different institutions involved to promote synergy between the partners.

A4. Project Description (max. 2500 words)

Give an overall description of the project and justify the methodology chosen to reach the objectives.
 Give an overall description and the general approach and methodology chosen to achieve the project objectives. Highlight the particular advantages of the methodology chosen; specify the expected project results (in quantitative terms where appropriate).
Explain where there might exist a potential for synergy between different tasks of the project and how this is going to be exploited.

In this project, we aim to **evaluate the soil C balance in Mediterranean croplands under future climate change with a particular focus on the impact of erosion**. We decided to focus on lateral fluxes because they are still ignored by Earth System Models despite their relative importance (Regnier et al., 2013). A great uncertainty on the impact of soil erosion on soil C balance is observed in the literature (Van Oost et al., 2007, Lal et al., 2005) mainly due to two aspects: i) **it is still unknown whether the decomposition rate of organic matter from eroded soil is impacted its by transport** ii) the C emissions of **the necessary external inputs of fertilizers to maintain NPP on eroded areas are still not accounted for.** Moreover, the impacts of climate change on soil properties controlling soil erodibility are also ignored. In addition, we aim to go a step forward by associating an economic evaluation of such changes to finally come up with a more detailed evaluation of co-benefits and trade-offs relevant for policy makers and stakeholders.

The proposed work is organised in five WPs. A very fist WP will consist of project management with regular meetings to promote synergy between the partners (described in section C). The others consisting in: (i) evaluating the impact of climate change at the 2100 horizon on the soil characteristics; (ii) implementation of soil erosion in ORCHIDEE-CROP; (iii) evaluating the C emission related to the production of the necessary fertilisers to maintain NPP; (iv) estimating the decomposition rate of eroded material during transport and the C, N, P fluxes leaving the catchment area using soil incubations in controlled environments and site monitoring, respectively (vi) evaluating the economic costs of erosion.

Each WP corresponds to one or more deliverables. When WP is not split by tasks one deliverable per WP is expected. If a WP is divided by task each task corresponds to one deliverable.

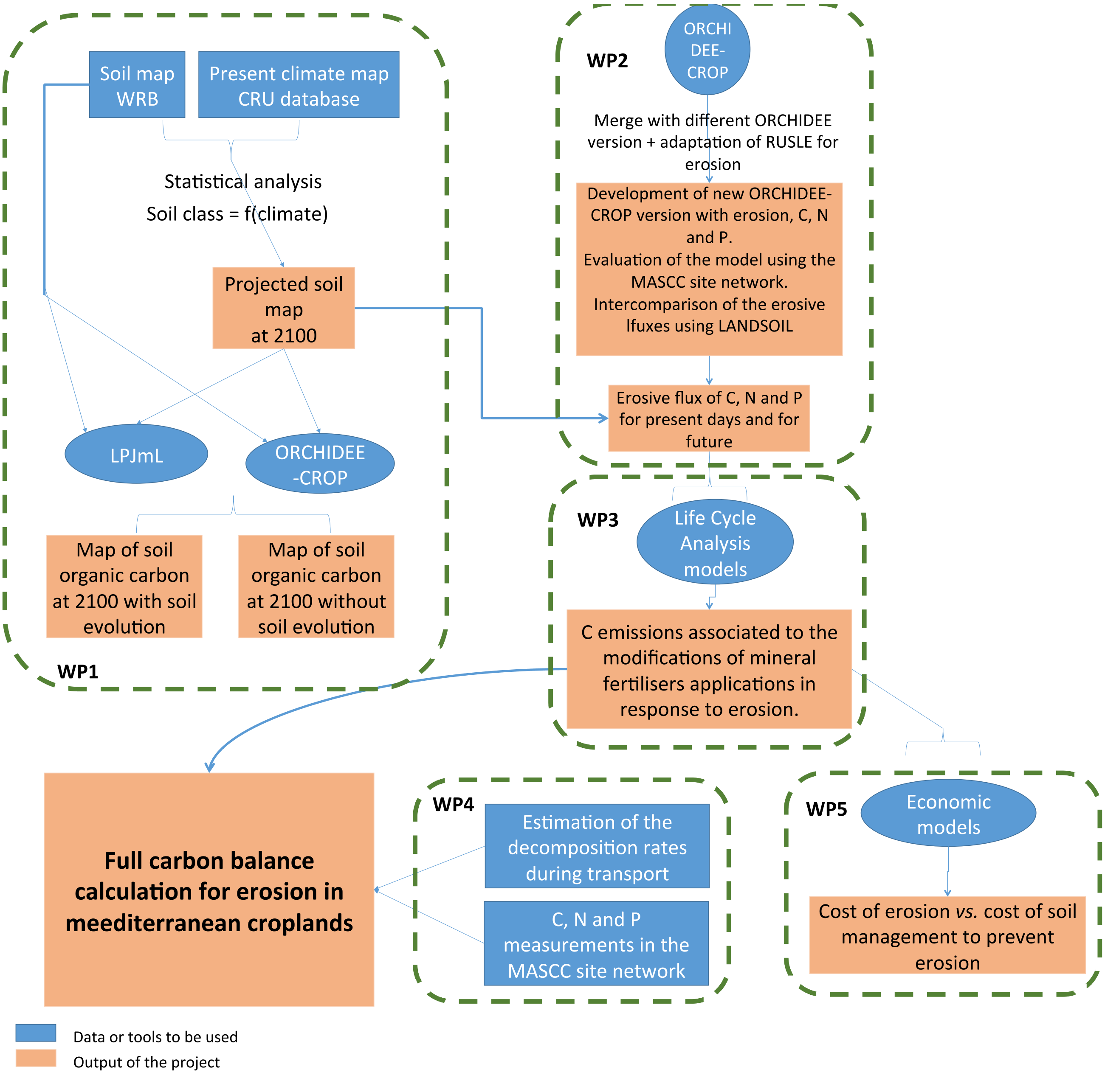

Figure 1: Flow sheet of the project

WP1: Evaluating the impact of climate change by 2100 horizon on soil characteristics

Task 1: Statistical relations among soil classes and climatic descriptors

To calibrate our statistical model, we will use data coming from the global soil map of the International Centre for Soil Reference and Information (ISRIC) (Batjes, 2005) providing at 5' resolution the dominant soil class and 22 soil characteristics for two depth layers (0-30 cm and 30-100 cm). We will also use climate data for historical period provided by the Climatic Research Unit (CRU). Since grid scales of climatic and soil databases do not coincide. A prerequisite will be to set them in coherence using statistical methods. Various methods are available (Vrac & Naveau, 2007; Lavaysse et al, 2012) in several R packages (http://www.lsce.ipsl.fr/Pisp/mathieu.vrac/). They will be tested to select optimal methods in function of the climatic field.

Then, different statistical methods, as logistic regression (e.g. Kempen et al., 2009), classification trees (e.g. Gray et al., 2009; Lacarce et al., 2012) or random forest (Cutler et al., 2007), artificial neural networks (Guiot et al, 1996), and various Bayesian approaches of non-linear modelling (Mathieu et al, 2015), will be tested to determine the relationship among soils classes and climatic descriptors. This work will be done at global scale to address both the Mediterranean basin and the global scale. The Mediterranean Basin is of specific interest because it encounters climatic (hydric) thresholds that may severely affect soils. Moreover, the sensus stricto Mediterranean climate could extend towards the north in the future. Therefore considering the global scale will strengthen the model.

Task 2: Projection of the soil changes induced by the different climatic projections

To project the soil changes from the different RCP's, we will apply the statistical model obtained in task 1 to the climate projections for the 21st century (using outputs from the ISIMIP project, Warszawski et al. 2014) and then consider, for each soil pixel, which related soil class should be present with an associated probability. GIS treatment of the results will allow determining, for each soil class, the surface areas, the location that will be concerned by a potential soil change by the horizon 2100. The nature of this change will also be discussed.

Task 3: Verification of the obtained projections for soil changes

We propose, to confront the results of the statistical model to two independent approaches for verification of the obtained projections: i) comparison to observations performed on a well characterised soil network using the chrono-climate-sequence developed in the project Life Regadiox (http://life-regadiox.es/en/) in NE Spain; ii) comparison of the obtained projection with those obtained by the SoilGen2 (Finke, 2012) model. This will be performed for Mediterranean soils only.

The network in NE Spain includes a series of irrigated plots on which soils from different series are monitored in several aspects since their transformation from dryland to irrigation. The series includes actual agricultural plots and one experimental field. This allows for studying in detail the evolution of soil properties in time after a major consequence of climate change that is the adoption of irrigation. It offers a unique opportunity for gathering Mediterranean soil data and their evolution in time for different soil series in relation to a change in climate.

WP2: Implementation of new features to the original ORCHIDEE-CROP model

Task 1: A more mechanistic soil module associated with explicit N and P cycles.

ORCHIDEE-CROP (Xu et al., 2015) is a process-based model representing the exchange of C, water and energy between the land surface and the atmosphere with a more detailed representation of the croplands based on the STICS model (http://www6.paca.inra.fr/stics/) compared to the standard version of ORCHIDEE. A version incorporating the dynamics of N and P is under development and will be available early 2016. ORCHIDEE-CROP includes a specific description of major crops (winter wheat, corn, soybean with a summer crop to be added), based on phenological and carbon allocation equations from the STICS model. ORCHIDEE-CROP was evaluated at sites for winter wheat and maize in Europe with flux tower measurements, and participated in international model intercomparisons exercise like AgMIP and ISIMIP GGCMI globally.

Task 2: Erosion process implementation

We propose to implement into this new ORCHIDEE-CROP version the "Revised Universal Soil Loss Equation (RUSLE)." This equation was developed and calibrated by the US Department of Agriculture (USDA) for cultivated soils in North America. It has been used extensively since then and was applied to very different situations such as in Europe or in China (Panagos et al., 2015, Pan and Wen 2014). Despite the mechanisms description is over simplified its application seems to be the best way to estimate large-scale fluxes (Doetterl et al., 2016). Nevertheless, its direct application to spatially-distributed models is not straightforward. Naipal et al., (2015) developed a generic approach adapting the RUSLE settings to allow simulations with a typical spatial resolution of surface models such as ORCHIDEE-CROP (10 to 50 km). The RUSLE model is fed by spatial data on rainfall characteristics, topography, crops and other soil cover, erosion control strategies, and soil erodibility data. These last can be modified according to the results of WP1 on the potential evolution of soils under climate change. The erodibility factor *K* of RUSLE mostly depends on soil texture, organic matter, structure, permeability and stoniness and will be affected by climate change. Moreover the C factor of the RUSLE equation related to primary production will be also affected by climate change. This equation only covers splash and runoff-induced erosion, so we will focus in this project only on this source of erosion.

Task 3: ORCHIDEE-CROP model evaluation

Since RUSLE was first developed for an environmental context very different from the Mediterranean one, we will conduct an evaluation of its applicability to Mediterranean soils on a number of on-site evaluations using the site network managed by the project MASCC started in 2016 and coordinated by Damien Raclot. The MASCC sites network is the mid- to long-term monitoring of catchments acquired in six Mediterranean countries (France, Spain, Portugal, Tunisia, Morocco and Italy) and is the following step of the R_OSMED project (https://sites.google.com/site/rosmedsicmed/home/study-sites-title/study-sites). The database including rainfall/runoff/erosion, land uses and agricultural practices for all sites has being elaborated during previous projects by the teams participating to MASCC. This database contains about 100 years of continuous monitoring of runoff and erosion in a wide range of contrasted Mediterranean environments. During the ASSESS project we will mainly focus on three catchment areas located in France (Roujan-Peyne), Morocco (Tleta) and Tunisia (Kamech-Lebna) where C,N,P outflow monitoring will be performed (*c.f.* WP 4).

By running simulation on those sites, we will parameterize and evaluate the ability of the ORCHIDEE-CROP to reproduce fluxes of C, N and P related to erosion.

Task 4: ORCHIDEE-CROP model application over the Mediterranean regions

After model evaluation, we will conduct simulations over Mediterranean regions for the 1950-2015 period with a resolution of 50 km to estimate the flux of C, N and P. Finally, we will use climate and land uses scenarios to perform future simulations over the period 2015-2100. We will use classical land use scenarios such as developed by the TRENDY project (http://dgvm.ceh.ac.uk/node/21) and future climate scenarios corresponding to different RCP scenarios defined by the IPCC.

Moreover, for futures simulations, we will use fixed soil parameters given by ISRIC and time dependent parameters using the statistical equations developed in WP1. To better tackle the uncertainties related to modification of soil properties on soil C balance, we will do this sensitivity test using both LPJmL and ORCHIDEE-CROP. The comparison of the results provided by the two models will help to identify trends that are model dependent and trends that are similar in both model and therefore more consistent. For this part, we will use the Mediterranean version of LPJmL that includes perennial crops (agricultural trees).

WP3: CO_2 emissions associated to increased synthetic fertilizer production to compensate erosion effects

One of the major impacts of erosion is the modification of productivity of agricultural systems concerned. To compensate for these losses and maintain crop productivity, it is necessary to increase the mineral fertilizers application. However, in areas where eroded material is re-deposited, the mineral fertilizers use might also be reduced. Such modifications of the mineral fertilizers inputs will result in variations of the fossil C emissions necessary to produce such fertilisers and therefore alter the overall balance of C in eroded agricultural systems. Indeed, in the current debate on the role of source or sink of C of erosion, most studies assume a constant primary productivity without taking into account the emissions of C associated with the use of additional inputs (Fig. 2).

We therefore propose an integrated analysis to estimate the associated C fluxes. Based on estimates of erosive fluxes of N and P calculated in the WP2 at national and European scale, we will calculate the necessary fertilisers inputs for their compensation and the C fluxes associated with the application of these inputs surplus. This will take into account the C emissions related to fertilizer production, their transport and their applications. This may involve the use of ad hoc spreadsheets and LCA databases (as EcoInvent) or more complex tools like SimaPro. Nevertheless, considerable uncertainties remain about the availability of the redeposited eroded N and P to plants. Indeed, the whole N and P content in soils is not necessarily available in the short term for plants and for estimating these uncertainties we consider different scenarios: (i) the total loss of N and P must be compensated (ii) only the loss of N and P mineral and organic present in the labile fractions of soil must be compensated and (iii) only the loss of mineral N and P must be compensated.

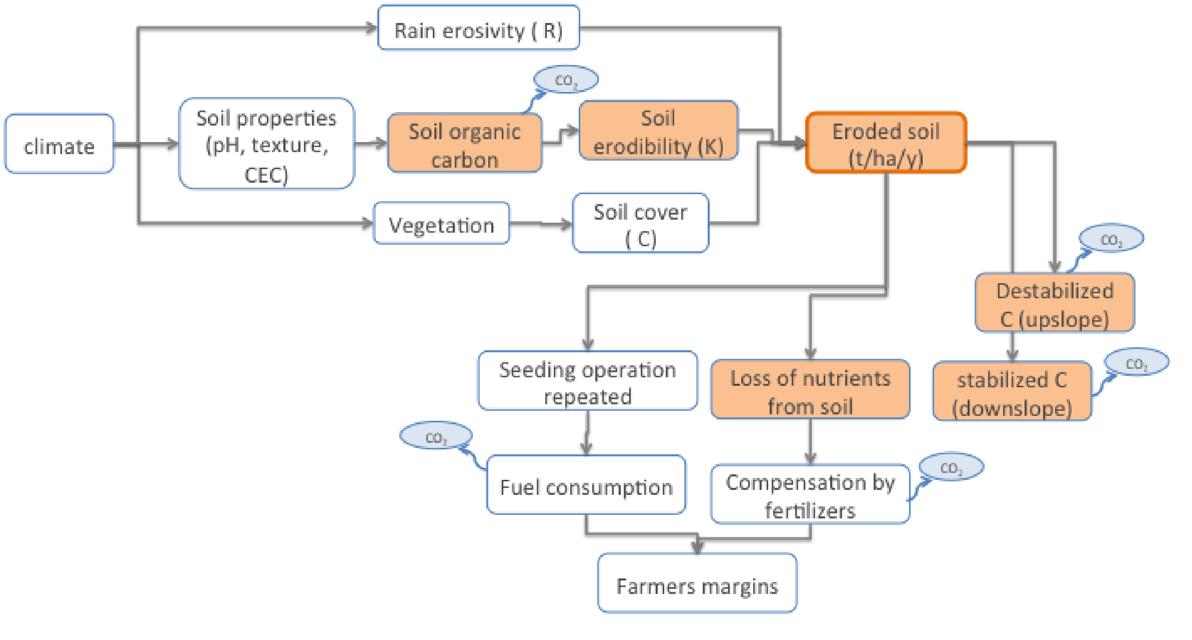

Figure 2: Impact of erosion on C balance and on farmers' margins.

WP4: Decomposition of eroded material during transport: two different approaches

The question whether erosion is a net sink or source of C is intensively debated in the literature (Van Oost et al., 2007, Berhe et al., 2005, Lal et al. 2005) and the main question within this debate is the dynamics of eroded C during transport. Indeed, if the decomposition rate of eroded C is lower than non-eroded C because of oxygen availability for instance, erosion is a sink. But, if decomposition rate of eroded C is higher than non-eroded C because of aggregates breakdown or priming effect, erosion is a source of C. In this WP we want to estimate the decomposition rate of eroded soil by two complementary approaches: i)using soil incubations in controlled conditions simulating conditions during transport and ii) measuring C, N and P fluxes at the outlet of catchment areas selected from the MASCC site network (France (Roujan-Peyne), Morocco (Tleta) and Tunisia (Kamech-Lebna)).

Task1: Soil incubations to better understand the mechanisms

We will use the facilities available at INGREF to incubate eroded material sampled in the different sites of the MASCC site network to evaluate their decomposition rates in aquatic environments. The experience duration will be two months and each microcosm will simulate a water column in shallow aquatic environment. Microcosms will be filled with air without CO_2 and the accumulated CO_2 production will be measured using by titration of the NaOH excess with 0.1MHCl using the phenolphthalein indicator (Zibilske, 1994). Half of the microcosms will receive an addition of mineral NPK whereas the other hal will be used as controls. This experiment will help to better understand how the trophic state of an aquatic environment might affect the SOC dynamic in an aquatic context. The decomposition rates of SOC in aquatic context and its sensitivity to erosion will be estimated by incubated both eroded material sampled in the outflow of the catchment area and in places of the catchment area not affect by erosion.

Task 2: Measurement of accumulation rates in the catchment areas outflow.

The ASSESS project will benefit from the sampling effort of the MASCC on the three catchment area selected. C N and P will be measured using classical elementary analysis methods and the different measurements during the period of the project will help us to calculate fluxes at the outlet for C, N and P in the catchment area outflow. This is central information for model evaluation. Since those measurements were not planned within the MASCC project, the ASSESS project will also provide useful information to the MASCC partners.

WP5: Economic costs of erosion

The economic weight of the use of mineral fertilizers is about 10% of production (Lecuyer et al., 2014) and because of the fertilizer prices increase, more and more "parsimonious" management of these inputs are conceived to adjust fertilizer applications (with tools such as direct measurement of N concentration in leaves, fertilizer run by GPS, etc.). Soil management procedures aiming at prevent erosion are generally not considered as a possibility to reduce the externality of erosion. At least, soil erosion is not seen as a possible increase of this externality. Preventing erosion also means controlling the amount of fertilizer applied. Based on the quantities of inputs provided to offset the effect of erosion on primary production calculated in WP3 and the yield calculated during WP2 for the different sites, we will evaluate the economic cost of erosion for the farmers. Moreover, we will study management solutions enabling economic compromise between investments to protect the soil against erosion and additional costs related to the compensation of losses for N and P. In particular, we want to compute the cost of action vs. the cost of inaction using cost/benefit analyze tools, hence being able to propose economic incentives in order to promote more efficient practices for some given contexts (pedoclimatic, socioeconomic and institutional).

SECTION B: TEAM INFORMATION (max. 500 words per partner)

 Identify the participating teams and the institutions to which they belong.
 Identify the Project Coordinator

For each team, the following information should be given:
 Team Details:
- Give the total number of team members. The size of each team should be limited to those people actually needed for performing the tasks.
- Describe the background and particular expertise of the team in relation to the tasks to be performed. Describe how the teams complement each other in the execution of the project.
- If relevant, provide a maximum of five references of relevant, recent scientific publications or patents which best show the capability of the team to perform the work proposed. Indicate for each the name of the authors, the title of the article, the journal or other publication, the date and place of issue. If a publication exists on a website, give its address.
- Describe the relevant instrumentation and infrastructure available in view of the tasks assigned to the team.
- Describe the specific contribution of each project partner.
- Describe prospects for establishing efficient and sustainable partnerships within the network, including transfer of know-how and experience.

Contact details of the Proposal Coordinator

Proposal Coordinator:
Bertrand Guenet
Laboratoire des Sciences du Climat et l'Environnement (LSCE)
UMR 8212
L'Orme des Merisiers-bat.712
91190 Gif-sur-Yvette - France
Tel: +331 69 08 53 20
Fax: +331 69 08 30 73
Bertrand.guenet@lsce.ipsl.fr

(LSCE, UMR 8212 – CNRS – CEA –Université de Versailles St Quentin, Gif-sur Yvette, Saclay)
LSCE is a leader in Biogeocheochemical and Climate modelling and assimilation of land surface properties. The lab also investigates terrestrial systems using original techniques (gamma spectrometry, geochemical elemental and isotopic analyses through the GeoTrAc (Geochronology Tracer Archeometry) team. LSCE and LMD have developed the ORCHIDEE land surface model. ORCHIDEE is now used by numerous groups at the international level and is involved in more than 20 scientific papers in international journals including Nature and Science.
For the ASSESS project 6 scientists (including one post doc) from LSCE will be involved. The LSCE partners are all well experienced in land surface modelling and/or in erosion assessments. Nicolas Vuichard is a land surface modeller specialized in cropland areas. Nicolas Viovy is also a land surface modeller. His main speciality is the response of vegetation to climate change. He was one of the original developers of the ORCHIDEE model. Philippe Ciais is biogeochimist with special interest on feedbacks between climate and carbon cycle. He has been Convening Lead Author in the 5th IPCC Assessment Report. Olivier Evrard is an internationally recognized expert in erosion flux assessment. Bertrand Guenet (the project coordinator) is a

soil scientist with double expertise on soil experiments and measurements and on SOC modelling in land surface models.
LSCE will be the lead group for WP2. The expertise of the different LSCE partners will help to link with other WP's. In particular, Olivier Evrard and Bertrand Guenet already had successful collaborations with other partners involved in WP1 and WP4.

Recent relevant publications:

Evrard O, Nord G, Cerdan O, Souchère V, Le Bissonnais Y, Bonté P (2010) Modelling the impact of land use change and rainfall seasonality on sediment export from an agricultural catchment of the northwestern European loess belt. *Agriculture, Ecosystems and Environment*, **138**, 83–94.

Guenet B, Moyano FE, Peylin P, Ciais P, Janssens IA (2016) Towards a representation of priming on soil carbon decomposition in the global land biosphere model ORCHIDEE (version 1.9.5.2). *Geoscientific Model Development*, **9**, 841–855.

Guenet B, Danger M, Harrault L et al. (2014) Fast mineralization of land-born C in inland waters: First experimental evidences of aquatic priming effect. *Hydrobiologia*, **721**, 35–44.

Yue Y, Ni J, Ciais P, Piao S et al. (*in press)* Lateral transport of soil carbon and land−atmosphere CO_2 flux induced by water erosion in China. *Proceedings of the National Academy of Sciences*

Wu X, Vuichard N, Ciais P et al. (2015) ORCHIDEE-CROP (v0), a new process based Agro-Land Surface Model: model description and evaluation over Europe. *Geoscientific Model Development Discussions*, **8**, 4653–4696.

(LISAH, UMR 144 INRA – IRD – Montpellier SupAgro, Montpellier)
The main objectives of UMR LISAH research team are: i) to increase basic understanding for processes about water, erosive and pollutant transports in soils and farmed catchments as a function of spatiotemporal variabilities, both natural and anthropogenic, ii) to develop new methods and tools for detecting and preventing risks to soil and water resources and flooding events, and iii) to define sustainable management strategies for rural landscapes. UMR LISAH is highly involved in mid to long-term environmental research observatory in the Mediterranean area by managing the OMERE Observatory (http://www.obs-omere.org/) and coordinating a R_Osmed Mediterranean network devoted to catchment soil erosion monitoring. These investigations have strongly relied on transmediterranean partnerships that involved research institutes, universities and graduate school.
The main participants will include Stéphane Follain (Assistant Professor HDR in Soil Sciences at Montpellier SupAgro, European expert for Mediterranean soils) specialized in modelling long-term soil resource evolution in agricultural landscapes in relation to global changes, Yves Le Bissonnais (research director at INRA) as a specialist of soil erosion processes and modelling, and Damien Raclot (researcher at IRD) as a specialist of soil erosion monitoring and modelling.
These participants have developed several erosion models as the STREAM/LANDSOIL, MESALES, PESERA and MHYDAS-erosion models. They have led and/or been significantly involved in several ANR projects such as MESOEROS [MEditerranean Soils EROSion and vulnerability to global change during the 21st century, Projet ANR, 2007-2010], LANDSOIL [Landscape design for soil conservation under land use and climate changes, 2009-2012], ALMIRA [Adapting Landscape Mosaics of Mediterranean Rainfed Agrosystems for a sustainable management of crop production, water and soil resources, Projet ANR Transmed, 2014-2017] and MASCC [Mediterranean Agricultural Soil Conservation under global Change, ARIMNET2, 2016-2019].

Recent relevant publications:

Cerdan, O.,Govers G., Le Bissonnais Y., Van Oost K., Poesen J., Saby N., Gobin A., Vacca A., Quinton J., Auerswald K., Klik A., Kwaad F.J.P.M., Raclot D., Ionita I., Rejman J., Rousseva S., Muxart T., Roxo M.J., Dostal T. (2010).The rate and spatial variation of soil erosion in Europe: a study based on erosion plot data. *Geomorphology*, 122: 167-177.

Paroissien, J-B, Darboux, F, Couturier, A, Devillers, B, Mouillot, F, Raclot, D, Le Bissonnais, Y. (2014). Assessment of the effects of water erosion and global change on sustainability of Mediterranean soils. *Journal of environmental management*. Doi: 10.1016/j.jenvman.2014.10.034.

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(ECOSYS, UMR INRA – AgroParisTech, Thiverval-Grignon)
The ECOSYS Joint Research Unit INRA/AgroParisTech is the result of the merger in 2015 between several research groups from Versailles-Grignon area close to Paris (Environment and Arable Crops ; Physical Chemistry and Ecotoxicology of the Soil of Contaminated Agrosystems and part of Bioemco). The work of the new ECOSYS unit aims to treat in an integrated way the functioning of agroecosystems and their relationship with the environment. Agroecosystems are created as a result of external constraints and drivers and internal ones. To understand this functioning, the ECOSYS unit works with concepts of functional ecology and ecotoxicology, taking into account the flux of matter and energy and the functions of isolated organisms and the interaction with their environment. For the ASSESS project the expertise of Benoit Gabrielle and Nathalie Gagnaire on life cycle assessment tools will be used for WP3. The expertise of Claire Chenu, an internationally recognized soil scientist (ambassador for FAO during the year of soil in 2015), will be quite useful to link the work of the different WP

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(ECOPUB, UMR UMR INRA – AgroParisTech, Thiverval-Grignon/Paris)
Founded in 2000, the Joint Research Unit (UMR) "Public Economics" (UMR INRA 210) involves researchers from INRA and AgroParisTech conducting research on agricultural policies and agri-environment on the food trade, and the development of agriculture, with the aim to assess the economic effects of public policies.
This UMR is attached to the department of Social Sciences, Agriculture and Food, and Environment (SAE2) of INRA. Its activities are focused on "Agriculture, Environment, Natural Resources and Public Policy" and "Location, trade, climate change and public policy." ECOPUB is particularly involved in the

scientific priorities "farm Adaptation to changing circumstances", "Protection and management of natural resources", "Markets and trade of agricultural, agro-industrial and food" and "Dynamic economic, land use and climate change ".

Directed by Professor Jean-Christophe Bureau, UMR Public Economics is also attached to the Department "Economics, Social and Management" (SESG) AgroParisTech. The UMR faculty members belong to the Unit training and research "Economics, Public Management and Policy" of this department. UMR Public Economics participated in a number of European projects: GENEDEC (FP6), and AgFoodTRAde FACEPA (FP7). The UMR is participating in the Eranet TRUSTEE and FoodSecure projects (FP7) and Susfan (H2020). Since 2012, the UMR is part of the Laboratory of Excellence in Biodiversity, Agroecosystems, Society, Climate (BASC) of which it is a founding member.

Desbois, D. ; Butault, J.-P. ; Surry, Y. (2013) Estimation des coûts de production en phytosanitaires pour les grandes cultures. Une approche par la régression quantile, *Economie Rurale*, n° 333. pp.27-49.

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Disdier, A-C.; Marette, S. The Combination of Gravity and Welfare Approaches for Evaluating Non-Tariff Measures in **: *American Journal of Agricultural Economics***, (2010), vol. 92, n° 3. pp. 713-726.

The Laboratory of Rural Engineering of the National Institute for Research in Rural Engineering, Water and Forests (LGR / INRGREF)

INGREF was created in 2011 to support the national policy in the fields of management and development of resources water and soil. The laboratory program was developed following the identification of new p riority themes in order to reflect emerging needs of development actors. The Laboratory of Agricultural Engineering brings together multidisciplinary teams of renowned national and international researchers. It has (18) researchers, (4) full-time engineers and (5) university teachers and expert associates.

The team involved in this project has access to all locals of laboratory for soil and crop measurements. Besides, Tunisian team has scientific equipment allowing it to perform all proposed tasks for example: Equipment for measuring soil organic matter and soil nitrogen and soil incubation under laboratory conditions

Tunisian team has access to the site of Kamech experimental watershed (sub-catchment of Lebna catchment) located in Cap Bon peninsula. It is a small agricultural catchment (263 ha) in a Mediterranean environment with 20 years of data: impact of global change (climate and anthropogenic activities as agricultural practices) on water and erosion balance, fluxes and quality. Soils: Calcic Cambisols (63.5%), Regosols (25.5%), Eutric Regosols (9.6%) and Chronic Vertisols (1.4%). Main cultures: cereals and leguminous. Continuous automatic measurements at nested scales from plot to catchment outlet (surface runoff, shallow groundwaters, surface-atmosphere fluxes) and continuous monitoring of anthropogenic activities. More information available on http://www.obs-omere.org. Kamech experimental catchment belongs to the French SOERE-RBV Network.

The results can be extrapolate to the Lebna catchment, the team have access to his database. The Lebna catchment (210 km2) is 90% rural; and depicts a steep hilly relief. The Jebel Abderrahmane is the western limit and the upstream part of the Lebna Catchment. It is covered by scrubland and forest (maximum altitude 650 m). The central part of the catchment depicts hilly reliefs and is mainly covered by associations of mixed cultures and rangelands (average altitude 350 m). The eastern and downstream part of the catchment is a quite flat area and is covered by annual crops and orchards (altitude around sea level).

The Lebna watershed is located within an agricultural region that includes intensive vegetable farming and fruit cultivation. The region spreads over 4% of the Tunisian agricultural lands, and it provides around 16% of the agricultural production.

In terms of landscape mosaics, the Lebna watershed is characterized by (1) a typical land use with mixed cultures and rangelands, and (2) several hydro-agricultural infrastructures for preserving water and soil resources. When dealing with land use, we note field crops (cereals, legumes), fodder crops, grazing lands, and olive growing.

Describe the specific contribution of each project partner.

The main contribution of Tunisian team is, using different approaches, to understand the impact of erosion on soil carbon sequestration at catchment scale.

Tunisian team has a fairly rich database and very representative sites of the mediterranean area. The scientists have developed good knowledge on the field work

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2. Mekki I., Jacob F., Biarnès A., Gana A., Chehata N., Grünberger O., Bouceffa W., Blanca Y., Chebbi H., Jenhaoui Z., Motto A., Ponchant L., Trabelsi E. 2015. Characterizing land and water use across different spatial scales within rural areas over the Cap Bon region (Tunisia). Poster presentation in the SICMED international conference, 20-21 October, Marseille, France.
3. H Cheikh M'hamed, M Rezig & M Ben Naceur. 2015. Water Use Efficiency of Durum Wheat (Triticum durum Desf) Under Deficit Irrigation. Journal of Agricultural Science. Vol. 7, No. 8. 238-249 pp.
4. Annabi M., Bahri H., Béhi O., Sfayhi D., Cheikh Mhamed H., 2013. Wheat nitrogen fertilization in Tunisia: trends and main determinants. In French. Tropicultura 31,4: 247-252.
5. Taoufik Hermassi, Mohamed Amine Cherif, Hamadi Habaieb, 2014. Etude du transport solide au niveau du bassin versant de Merguellil, Tunisie Centrale : Cas des bassins versants d'Ettiour et de Rajela".The International Water Journal La Houille Blanche. Issue Number 4, 2014. pp. 88 - 96. DOI : http://dx.doi.org/10.1051/lhb/2014043.

Research Laboratory « PRAVDURN - Production Agricole et Valorisation Durable des Ressources Naturelles » Aims and research topics

In order to council both agricultural development and long term environmental quality, environmental degradation mitigation ought to be considered right now as a main challenge for coming decades. Here the operational objective is to maintain ecosystems functioning and therefore the sustainability of agricultural production systems.

To achieve this goal, the PRAVDURN laboratory is scientifically organised to analyse and propose innovative and integrative management of environmental resources: soil and water resources. For this, the main study site of the PRAVDURN lab is located in the Chéliff plains, where yield objectives and ecosystem services could generate antagonist management strategies.

Research teams:

- Cropping systems and Biotechnologies

- Soil resource management

- Water resource management

- Environmental impact assessment and modelling

Main research topics of the PRAVDURN lab:

- Soil quality and soil degradation evaluation

- Soil salinization processes

- Soil erosion and transport

- GIS, remote and proxy detection for space and time analysis of soil surface properties

- Qualitative and quantitative analysis of water resource

- Irrigation and water quality

- Water re-use and Environmental impact assessment

- Water pollution: N cycles

Selected publications:

Douaoui A., Yahiaoui I. Combination of remote sensing and kriging to improve soil salinity mapping in the Hmadna plain (Algeria). Toprak Su Dergisi - Soil-Water Journal, 2015, Special Issue, 1-5.

Douaoui A., Lépinard Ph. : Télédétection et salinité- Cartographie de la salinité des sols de la plaine algérienne du Bas-Chéliff. Géomatique expert 76 (2010).

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Douaoui A., Gascuel-Odoux C., Walter Ch. : Infiltrabilité et érodibilité de sols salinisés de la plaine du Bas Chéliff (Algérie). Mesures au laboratoire sous simulation de pluie. EGS, Vol. 11, N°4, 379-39, 2004.

Yahiaoui I., Douaoui A., Zhang Q., Ziane A. Soil salinity prediction in the Lower Cheliff plain (Algeria) based on remote sensing and topographic feature analysis. Journal of Arid Land, Vol 7 (6), 794-805 (2015).

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Harkat S., Boukharouba K., Douaoui A. Multi-site modeling and prediction of annual and monthly precipitation in the watershed of Cheliff (Algeria). Desalination and Water Treatment, 12-1, 2014.

Aubert M., Baghdadi N., Zribi M., Douaoui A., Loumagne C., Baup F., El Hajj M., Garrigues S. : Analysis of TerraSAR-X data sensitivity to bare soil moisture, roughness, composition and soil crust. Remote sensing of environment, 115, 2011, 1801-1810.

Bouarfa S, Marlet S, Douaoui A, Hartani T, Mekki I, Ghazouani W, Benaissa I, Vincent B, Hassani F, Kuper M. : Salinity patterns in irrigation systems: a threat to be demystified, a constraint to be managed: Field evidence from Algeria and Tunisia. Irrigation and Drainage, 58: S273-S284, 2009.

SECTION C: PROJECT MANAGEMENT (max. 1000 words)

 Describe how the overall coordination and monitoring of the project will be implemented. Provide if possible a project organisational chart. Indicate the decision-making bodies and processes foreseen as part of the project execution (decision boards, coordination meetings).

 If appropriate, set up a Gantt chart or detailed diagram giving the time schedule of the tasks and mark their interrelations; add milestones where important goals will be reached and/or decisions on further approach will have to be made; indicate a critical path marking those events which directly influence the overall time schedule in case of delays.

 Explain how information flow and communication will be enhanced within the project (e.g. via the use of communication software, through consortium- and task meetings, by the temporary placement of project participants at other partner institutions). Provide detail of specific planned meetings and exchanges, and highlight factors likely to lend additional value to these, such as the involvement of young researchers.

 Risk management: Indicate where there are risks of not achieving the objectives and fallback positions, if applicable.

In this section, we describe the WP 0 related to project management.

WP0: Project management

The project will be coordinated by Bertrand Guenet from CNRS, UMR 8212 LSCE. He has been involved in several national and international projects sometimes as PI or coPI. He has a double expertise in land surface modelling and in laboratory incubations. One of the main objective of the project is to share ideas, concepts and data to be able to provide a large overview of erosion impacts on Mediterranean croplands. Therefore, several coordination meetings will be organized during the project with all the tasks leaders (twice a year) to share progress made by each groups and to promote synergy between the partners. As most as possible these meetings will be without video-conferences to have more time to interact outside classical meeting times. In addition to this a kick off meeting and a closure meeting will also be organized where all the project participants will be invited. We also want to organize a mid term meeting with all the participants to present on-going work and promote collaborations. Finally, regular meeting will be also organized for each WP where the project coordinator will attend to discuss the protocols, the results and to check for delay and/or complications. Three WP meetings will be organized per year, for WP meetings videoconference will be used.

To promote collaborations we will create a dedicated space in the LSCE cloud where all the participants will share documents, publications etc. In particular, we will create a dedicated document to list the intended papers with a title, a short abstract and the contact person to promote collaborations and let the people share some data and ideas. This document will benefit to all the participants by promoting all the partners to give significant inputs in the studies of the others.

To limit the risks related to this kind of multi-partners project and be sure that synergy between participants will be a priority for all, we will encourage co-supervising of post doc and students. In particular, in WP 5, the master student will be co-supervised by Dominique Desbois and Bertrand Guenet. The main tasks of the student will to provide an economic evaluation of the cost of erosion in terms of extra fertilisers inputs. The student will probably have an economic background and therefore Dominique Desbois will be the main supervisor but to help the student to better understand the context of the project, Bertrand Guenet will co supervise to give him (her) an overview of the erosion related issues. The post doc affected to WP2 will be mainly supervised by LSCE partners but also by LISAH partners. The post doc will benefit from the expertise of each group (land surface modelling for LSCE and erosion process for LISAH) to succeed in the representation of the erosion mechanisms in ORCHIDEE-CROP and its evaluation. One of the main difficulties for WP2 and therefore for the post doc is to be able to work at multi spatiotemporal scales. Both groups are used to work at very different scales and we are therefore quite confident in our ability to collaborate.

Finally, we want to invite a group of external scientists recognized for their skills in aspects related to the project to be part of the scientific board of the project that will be invited to each coordination meeting between task leaders. We will make this board as international as possible.

Months	0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	27-30	30-33	33-36
WP0: Project management	KOM		CoM		CoM		MTM		CoM		CoM	ClM
WP1: Evaluating the impact of climate change by 2100 horizon on soil characteristics	Task 1			Task 2		Task 3						
WP2: Implementation of new features to the original ORCHIDEE-CROP model	Task 1			Task 2		Task 3		Task 4				
WP3: CO2 emissions associated to increased synthetic fertilizer production to compensate erosion effects												
WP4: Decomposition of eroded material during transport: two different approaches			Task 1	Task 2								
WP5: Economic costs of erosion												
Valorisation of the project												
Paper writing							WP1	WP2 (until task 3) + WP4	WP2 task 4		WP3 + WP5	WP3 + WP5
Implementation of a module of soil/climate in MineCraft												

Each WP corresponds to one or more deliverables. When WP is not split by tasks one deliverable per WP is expected. If a WP is divided by task each task corresponds to one deliverable.

KOM: Kick off meeting
CoM: coordination meeting
ClM: Closure meeting

SECTION D: BREAKDOWN OF COSTS

□ *For each team, give the cost breakdown and a brief justification for all allowable costs. All costs should be given in Euros. The cost breakdown should follow the template provided in the Guide for Applicants.*

SECTION E: IMPACT OF PROJECT RESULTS (max. 1000 words)

□ *Describe the expected results of the project and their utilisation potential.*

□ *Describe the expected impact of the project on the societal challenges addressed in the project as well as on cross-cutting issues.*

□ *Describe the expected impact of the project on the scientific disciplines involved in the project.*

□ *Describe the expected impact of the project results in terms of economic and societal needs of the Euro-Mediterranean Region.*

□ *Sketch out a result exploitation plan which explains:*

i. How the new knowledge generated through the project and other deliverables of the project will be exploited (apart from publications and other information-sharing activities, also including databases, problem solving concepts, computer codes, technical solutions, etc.);
ii. The appropriateness of measures for the dissemination and/or exploitation of transnational projects results;
iii. If relevant: how innovative results will be further exploited through an implementation plan for the project results;
iv. How intellectual property, including foreground knowledge, patents, copyrights, license agreements and any other arrangements will be managed.

Expected results

Each task presented in section A4 (if a WP is divided in task subsection it means that the considered WP is a task itself) will be published in international scientific journals. The results from WP1 will have a particular impact in the community working with Earth System Models since it will test for the very first time the impact of climate change on soil properties. The absence of such an effect is an implicit assumption done by all the Earth system modellers that has never been deeply evaluated. One of the outcomes of this WP will be a set of maps with soil properties depending on climate conditions in the future. This might be a major input to better constraint the boundaries conditions of the Earth system models and thus reduce the uncertainties on future climate predictions.

The main objective of the ASSESS project is to estimate the flux of C, N and P lost by erosion in croplands in a future climate change context. This goal will be mainly achieved with WP2. To our knowledge it will be the first time that such fluxes will be estimated for future period. It will be a major input in the scientific community working on erosion and would provide important insights to policy makers to design innovative land management dealing with soil preservation in Mediterranean regions. Moreover, associated to the results from WP3, we will be able to produce a complete C balance of erosion at the Mediterranean scale. This might also give important elements to stakeholders to calculate the C balance for each country. Moreover the results of the WP3 will be a first estimation of the fertilizers needs to compensate erosion in the future for Mediterranean countries. This aspect is also important to design agronomical policies.

The WP4 has the particularity to benefit from a sampling effort performed within the MASCC project to be started in September 2016. In return, the ASSESS project will produce data not planned by the MASCC project (fluxes of C, N and P in the outflows). This synergy between projects is a very good opportunity to better understand different aspect of erosion, in particular the relationship between the flux of sediments and the flux of elements like C, N or P. The knowledge that will be produce thanks to this synergy would not have been possible within the framework of a unique project. Moreover, the WP4 will produce important results to better understand the process occurring during the transport of eroded material. This is still one of the major gaps of knowledge for the scientific communities interested in erosion and carbon flux. The WP4 will therefore improve the understanding of the C balance related to erosion.

The WP5 will produce an estimation of the economic cost of action vs. inaction in terms of erosion prevention. This is estimation will be an important tools for stakeholders to anticipate the economic weight of the use of mineral fertilizers in the future. Depending on this economic weight, the cost of soil protection policies might be reevaluated to take into account the money saved by those policies. Thus, the money invested in soil protection might be presented as an investment to decrease the cost of production within a climate change context.

Project result exploitation

Beside classical scientific dissemination through publications (estimated between 6 and 8) in scientific journals and conferences, and student training (2 M2 internships), we propose a dissemination of the results towards the stakeholders and the society. We will create a website presenting the project and the main results. We will use this website to promote communication for large audience in all the countries involved (radio program, newspapers, etc.).

Moreover we want to implement the module relating soil and climate in the very popular video game Minecraft© with simplified feedbacks between soil and climate but based on the project results. This video game is a resource management game that aims at creating worlds in order to protect nocturnal monsters. In its present state, it includes climate and two types of soils: podzols and clayey soils that allows different agricultural productions. The objective of the implemented module would be to educate youth to the environmental constraints on soils.

Finally, all the codes developed during the project will be freely available upon request for scientific use.

SECTION F: ETHICS, GENDER, YOUNG RESEARCHERS (max. 500 words)

 If applicable: Clearly explain the way(s) in which the project intends to deal with ethical issues that may be associated with the project.
 If applicable: Explain how gender is taken into account in the project.
 If applicable: Explain how young researchers are supported through the project activities

During this project no particular ethic issues will be face. Nevertheless, we will pay attention in the gender balance of the young researchers hired by the project. Furthermore, all young researchers hired by the project will be invited to each WP meetings, to the kick-off, mid term and closure meeting. Finally, we will promote professional networking for young researchers to let them benefit from the large consortium involved in this project.