FACCEJPI

Agriculture, Food Security and Climate Change

FACCE-JPI Projects Booklet:

FACCE ERA-NET Plus, MACSUR and Multi-partner call on GHG mitigation

Compiled for FACCE ERA-NET Plus Mid-term meeting, 21-22 March 2017, Brussels, Belgium

www.faccejpi.com

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FACCE ERA-NET Plus on Climate Smart Agriculture

The main objective of this ERA-NET was to support interdisciplinary research and innovative approaches on the adaptation of European agriculture to: i) incremental climate change and ii) to increased climatic variability.

Under the ERA-NET Plus action "Climate Smart Agriculture: Adaptation of agricultural systems in Europe" co-funded by the Seventh Framework Programme (FP7) of the European Commission, this action aimed to address adaptation of European agriculture to climate change in its broad sense.

Four areas were highlighted as key to advancing research:

- Genetics and breeding of animals and plants to increase resilience to climate change;
- Pests and diseases of animals and plants linked to climate and posing significant risks;
- Adaptive management of water and soil resources
- Options for adapting agricultural systems.

11 projects were funded; teams come from 16 countries: Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Israel, Italy, the Netherlands, Romania, Spain, Sweden, Switzerland, United Kingdom and Australia.

FACCE-ERA-NET Plus has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 618105.

CAOS - Climate-Smart Agriculture on Organic Soils (January 2015 – December 2017)

Organic soils are hotspots of vulnerability, adaptation needs and greenhouse gas (GHG) emissions from agriculture in temperate and boreal Europe. We propose that wet organic soils could be used as risk insurance in dry periods and adapted water and soil management could prevent yield losses in very wet conditions. These measures will reduce GHG emissions.

OBJECTIVES	METHODS
• Synthesis of on-farm evidence of risks of conventional and success of semi-wet cultivation in six case study regions • Implementation of active soil and water management • Cultivation and evaluation of energy crops adapted to wet conditions • Quantification of the GHG emissions • Model-based synthesis of adaptation and mitigation potential • Bi-directional stakeholder involvement	• Combination of agro- and socio-economic farm surveys with water table data and soil properties • Plot scale on-farm experiments on soil and water management including the cultivation of different energy crops • Measurement of GHG emissions using manual chambers and of CO2 using autochambers • Coupling of a process-based hydrological model with a plant growth model • Questionnaires, expert and stakeholder workshops

KEY SCIENTIFIC FINDINGS

- Many farmers value organic soils as a risk insurance in dry years, which supports our main hypothesis, but there are country-specific barriers to wetter management.
- The net ecosystem carbon balance is around neutral for wet two-cut and three cut Festuca arundinacea and Festulolium energy crop systems, which is a strong improvement compared to conventional management.
- However, under very wet conditions, high methane emissions have to be accounted for.
- In The Netherlands, infiltration via submerged drains is widely accepted as a promising technique to combine intensive dairy farming and conservation of peat soils.
- The coupled SWAP-WOFOST model is able to depict yield differences caused by management-induced moisture conditions.

AMOUNT: 1 242 000€

CONSORTIUM PARTNERS:

- **Bärbel TIEMEYER, Thünen Institute of Climate-Smart Agriculture, Braunschweig, Germany**
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- **Norbert RÖDER, Thünen Institute of Rural Studies, Braunschweig, Germany**
- **Kerstin BERGLUND, Swedish University of Agricultural Sciences, Department of Soil and Environment, Uppsala, Sweden**
- **Jan VAN DEN AKKER, Wageningen Environmental Research (Alterra), Wageningen, The Netherlands**

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- ✓ Project homepage: http://www.caos-project.eu/
- ✓ European stakeholder workshop on climate smart peatland management (late 2017)
- ✓ Six regional stakeholder and expert workshops have been held in 2016
- ✓ CAOS provides important results for the EU Climate and energy package action and the COP21 follow-up regarding the development and evaluation of mitigation strategies especially in the LULUCF sector. For example, the update of the Finnish national energy and climate strategy is strongly based on the estimates of the efficiency and costs of measures for cultivated peat soils provided by the Natural Resources Institute Finland. Controlled drainage is part of the strategies selected for agriculture and LULUCF sectors.
- ✓ The project's results will be highly relevant to develop options to integrate mitigation measures for agriculturally used peatlands in the Common Agricultural Policy after 2020: Based on the results of the farm survey and the workshops, we will evaluate how adapted management could be implemented into the CAP and other existing European legal framework (e.g. ELER) in the different European regions.
- ✓ Consultation and policy support at different levels (e.g. Ministries of Agriculture)

CINDERELLA - Comparative analysis, INtegration anD ExemplaRy implEmentation of cLimate smart LAnd use practices on organic soils: Progressing paludicultures after centuries of peatland destruction and neglect (February 2015-January 2018)

The project CINDERELLA comprises a comparative analysis, integration and exemplary implementation of climate smart Land use practices on organic soils (peatlands). The aim is to progress paludicultures (agriculture on wet or rewetted peatlands) after centuries of peatland destruction and neglect. Means are field and lab investigations, desk studies and activities for dissemination and awareness raising for paludiculture.

OBJECTIVES	METHODS
• The main objective of the project is to extend the scientific base for a sustainable use of wetlands and making alternative uses accessible to farmers and land authorities. Aim is to advance wet agriculture (paludiculture) on peatlands by an integrated scientific approach. • Field investigations for establishing and optimizing biomass production in paludiculture • Find ways for minimising GHG emissions and nutrient release from organic soils • Incorporate ecosystem services • Develop management strategies and transfer them from lab to field and disseminate the innovative concept of paludiculture over Europe	• Field tests on paludiculture systems comprising ecologic and economic monitoring • Laboratory investigations, genetic analyses • Harvest- and use potentials in various European regions, Life Cycle Assessments for sustainability capability and the provision of ecosystem services. • Micro- and macro- economic analyses and assessment of ecosystem services of paludiculture • Review of political and legal boundary conditions to analyse current opportunities and constraints for large scale implementation of paludiculture

KEY SCIENTIFIC FINDINGS

As the project is not finalized yet, only general preliminary findings can be mentioned here:

- Framework conditions for optimizing land use and area potential for climate smart agriculture on organic soils in participating countries in Europe are analysed and recommendations for optimizing of cultivation of wet peatlands (paludiculture) developed
- Nutrient retention by paludiculture assessed by review and proven by lab and field investigations
- Genetics described for clones of *Phragmites australis* as well as *Typha latifolia*, *T. angustifolia* and *Arundo donax* correlated with information on productivity and preferred site conditions, factors controlling primary productivities assessed
- Analysis of management and productivity of paludiculture, assessing biomass utilization as fodder, building material or fuel for energy production

Photo: Partially mown reedbed on a wet peatland in Mecklenburg Western Pomerania, Germany (W. Wichtmann)

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- ✓ Cultivation of Reed and Cattail on wet peatlands shall be recognised as agricultural use of land and direct payments (CAP) should be available
- ✓ Funding schemes for paludiculture must be developed by agriculture authorities to give incentives for climate smart agriculture on organic soils
- ✓ Urgent needs to build up markets for products (construction and insulation material, bio-energy) from wet peatlands and incentives
- ✓ Counterproductive funding of drainage based land use on peatlands (like direct payments, rewards for organic farming, etc.) must be stopped.
- ✓ The polluter pays principle must be consequently applied to achieve the implementation of climate smart agriculture on organic soils
- ✓ Introduce accounting of GHG emissions from peatland use in the reporting of UNFCCC
- ✓ Peatlands have to be wet!

AMOUNT: 1 492 000€

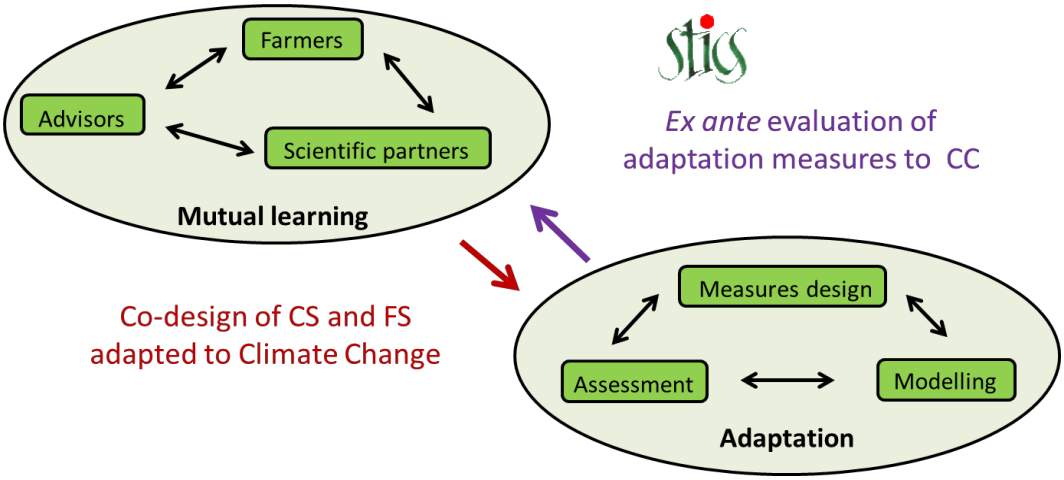
CONSORTIUM PARTNERS :

- **Leon Lamers, Radboud University Nijmegen (NL)**
- **Hans Brix, Aarhus University (DK)**
- **Stefan Weisner, Halmstad University (S)**
- **Hans Joosten, Greifswald University (D)**

Climate-CAFE - Climate Change Adaptability of cropping and Farming systems for Europe (February 2015-January 2018)

The Climate-CAFE project focuses on increasing the "adaptive capacity" of arable, forage crops to climate change (CC). Climate-CAFE is mobilizing an interdisciplinary approach to evaluate traditional and more novel regional adaptation and mitigation strategies along a North-South climate gradient in the EU. The evaluation includes synergies and trade-offs between strategies using different scales and indicators.

OBJECTIVES	METHODS
• Facilitates and assesses solutions to the adaptation of innovative European agricultural systems to climate change • Analyzes the levers and solutions which could be effective to adapt European culture systems to climate change • Formalizes scenarios of co-designed adaptation strategies in each adaptation pilot groups, and i) quantify the effect of CC on current systems, ii) predict the efficacy of co-designed adaptive measures • Evaluate by simulation the possible compromise between "mitigation" and "adaptation" of agricultural cropping systems at the plot level (CS) • Evaluates the socio-economic performance of European agricultural production systems at the farm level (FS) • Develops new simple and accessible tools in order to help farmers and advisors to predict the impact of CC on production and to simulate alternative scenarios • Communicates and disseminates on the works and results of the Climate-CAFÉ project	• Participatory research approach with 10 adaptation pilots in order to co-co-design adaptation measures • Synthesis of data from new and old experimental cropping system • Using the STICS soil-crop model, simulations of current and novel cropping systems are carried out for each adaptation pilot, called "quick scans" • Evaluation of DAYCENT and STICS models for simulating the agronomic and environmental performance in long-term experiments (large EU gradient) • Using MODAM and Farm-design models for calculation farm performances on economic and environmental criteria • Review the ability of some tools, namely ROTOR, Soil Explorer and AgRECalc at effectively assisting farmers and advisors to make robust decisions • Various social networks investigated: • Project web site, Twitter, Facebook, and Research_Gate page • Newsletters and Contacts with policy makers (Germany, The Netherlands,…)



KEY SCIENTIFIC FINDINGS

- An overview of potential adaptation measures characterised by the type of intervention tested. We will consider a wide range of adaptations of agricultural practices to CC from simple, no-cost adaptation options, to the use of a greater genetic diversity, e.g. balanced crop rotations and intercropping, novel technological options and technical practices, in terms of:
- Resistance strategies that seek to maintain the status quo over the near term through management actions that resist to CC disturbance;
- Resilience strategies requiring systemic adaptation for increasing the adaptive capacity after a climate disturbance with minimal management intervention;
- Transformation strategies for increasing adaptive capacity by facilitating transition to a new system.
- An overview of the prototypes designed to be resilient and environmentally sound and resource efficient crop and mixed livestock systems, while ensuring the dynamic conservation of soil, water and biodiversity that leads to beneficial outcomes in terms of C sequestration and reduced GHG emissions per unit product and area…
- A first quantitative evaluation based on simulation of these adaptive measures to CC and their ranking in terms of efficiency and costs.
- A first quantification of IPCC climatic scenarios -near future (2050) and far future (2100)- impact on European agricultural production, which represents a wide range of EU countries includes North-South climatic gradient.
- A first economic evaluation and a multi-criteria assessment of the CC impact on agricultural performances at the farm level for a sample of 10 representative adaptation pilots.

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- **Climate-CAFE web site:** http://www6.inra.fr/climate-cafe/ **Twitter:** https://twitter.com/EU_ClimateCAFE **Facebook:** https://www.facebook.com/climatecafeEU **ResearchGate:** https://www.researchgate.net/project/Climate-CAFE-Climate-change-adaptability-of-cropping-and- farming-systems

AMOUNT: 2 391 000 €

CONSORTIUM PARTNERS :

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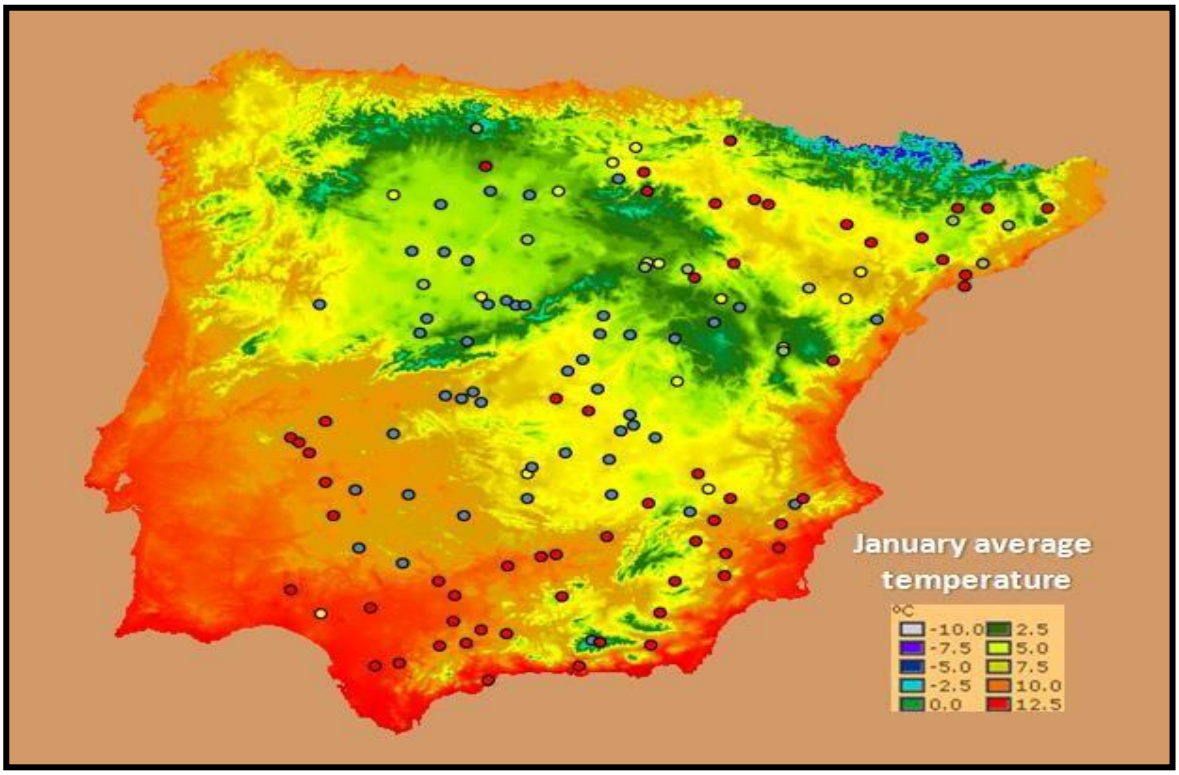
ClimBar - An integrated approach to evaluate and utilise genetic diversity for breeding climate-resilient barley (January 2015-February 2017)

The ClimBar goal is to identify genome regions, genes, and alleles conferring traits needed to breed resilient barley varieties adapted to the climatic conditions predicted for 2070 in different European environments.

OBJECTIVES	METHODS
• Determine phenotypes of a relevant germplasm diversity set under anticipated conditions of water and nutrient, CO2, and pathogen pressure • Field-phenotype the germplasm in different climatic zones; make precise physiological measurements in greenhouse • Connect phenotypes to genes and genome regions by GWAS using global gene variation, epigenome, and transcript data and by ecogeographic analysis • Formulate genomic selection (GS) and ideotype models for climate change to 2070 based on plant responses and climate predictions	• Field phenotyping • Seed quality analyses • Lysimeters for precision physiology • Exome data for GWAS • pathogen resistance screening • RNAseq and ChIP seq • high-CO_2 greenhouses • photosynthesis and leaf transpiration analyses

KEY SCIENTIFIC FINDINGS

- A set of agronomically important phenotypes linked to loci, chromosomal regions and alleles
- Detailed physiological profiles for the function of the alleles under climate-change scenarios
- High-precision disease responses versus alleles and climate change
- Llinkage between alleles, physiological response and the epigenetic and regulatory states genotype linked to phenotype and climate
- Agro-economic modelling for policy decisions
- Platform for incorporating allelic diversity into breeding programs



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- ✓ Agro-economic modelling for policy decisions
- ✓ Platform for incorporating allelic diversity into breeding programs
- ✓ Resilient germplasm for food-chain security, economic stability and environmental sustainability.

AMOUNT: 1 824 000€

CONSORTIUM PARTNERS :

- Alan Schulman	Natural Resources Institute Finland (Luke), FIN (coord)
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- Laura Rossini	University of Milan, IT
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ClimGen: Climate Genomics for farm animal adaptation (January 2015 – December 2017)

ClimGen uses 'omics methods to build livestock resilience to climate change by identifying biomarkers to predict climate adaptation. Using meta-analysis, on-farm experiments, and simulation, ClimGen is developing modified breeding strategies to more rapidly equip livestock with the resilience to withstand the effects of climate change in the short, medium and long-term.

OBJECTIVES	METHODS
• To carry out a data-mining and gap filling exercise for identifying genomic targets of selection in cattle, sheep and goat populations that occur in challenging climates throughout Europe and in northern and central Africa. • To carry out three case study experiments to find biomarkers of climate adaptation within the transcriptome and epigenome. These studies will analyse contrasting systems and seek to detect profile changes in 1) sheep and goats in contrasting thermal environments, 2) in pigs under thermal stress with controlled temperature environments and 3) in red-legged partridges under immune and thermal stress. • To use these data in an assessment of new strategies for breeding climate resilience into livestock populations using state-of-theart simulations, assuming different approaches such as admixture and genomic selection, which will be compared with more traditional breeding methods in terms of their comparative efficiency over short, medium and longer timescales.	• Bioinformatics approaches to abstracting and analyzing whole genome and SNP microarray data for livestock from north Africa to northern Europe. • 174 Turcana and Carpatina sheep/goats collected from Carpathians and genotyped using Illumina 50K SNP array. One sheep and one goat for genome sequencing. • Data gathered and analysed for environmental association study across latitudinal range. • Epigenetic studies on heat stress in commercial pigs ongoing. Data analysis for Moroccan livestock and partridge ongoing. New SNP tool for partridge under development. • Breeding simulation using the software QMSim.

KEY SCIENTIFIC FINDINGS

- We have carried out a data-mining and gap filling exercise for identifying genomic targets of selection in livestock populations in challenging climates.
- New samples have been collected and genotyped from the Carpathian region.

- Three experiments are finding biomarkers of climate adaptation in the transcriptome and epigenome in sheep and goats in contrasting thermal environments, 2) in pigs under thermal stress with controlled temperature environments and 3) in red-legged partridges under immune and thermal stress.
- In the next 6 months these data will be used to test new strategies for breeding climate resilience, using state-of-the-art simulations, assuming approaches including admixture and genomic selection.

FOCUS ON POLICY, END-USERS AND SOCIETY RELATED PRODUCTS

- ✓ 174 new sheep and goat 50k SNP array data
- ✓ First whole genomes sequences for Carpatina and Turcana sheep
- ✓ Genome-wide dataset assembled for European livestock across a latitudinal gradient

AMOUNT: 1 023 000€

CONSORTIUM PARTNERS :

- **Michael Bruford (coordinator), School of Biosciences, Cardiff University, Wales, UK**
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- **Francois Pompanon, Universite Joseph Fourier, Grenoble, France**
- **Augustin Vlaic, University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca, Romania**
- **Javier Canon, Universidad Complutense de Madrid, Spain**
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Genomite - New generation sustainable tools to control emerging mite pests under climate change (January 2015-December 2017)

The FACCE Genomite project has been focused on understanding the interactions between spider mites (*Tetranychus urticae/T. evansi*), their host plants and climate change (CC), combining genomics, climate change, metabolomics and computer modeling approaches to understand the impact of climate change on this major cosmopolitan chelicerate pest.

OBJECTIVES	METHODS
• Model species distribution and tritrophic interactions under CC • Reciprocal transcriptional responses of mites and plants (tomato and strawberries) under CC • Identification of plant and mite metabolites upon herbivory and CC • Identification of mite elicitors/effectors • Correlation of plant transcriptomics and metabolomic responses with tritrophic performance and mite transcriptome responses	• Determination of fitness and demographic parameters/computer modeling/validation • RNA sequencing (RNA-Seq) • Identification of metabolomic/lipidomic composition using GC-TOF MS and UPLC-Orbitrap MS • Transcriptomic and peptidomic analysis of mite salivome • Systems biology approaches

KEY SCIENTIFIC FINDINGS

- Drought increases the fecundity of *T. urticae* and *T. evansi* through changes in plant metabolic composition - climate change may have a profound impact on economic crop damage caused by mites.
- Spider mite population modeling revealed that the spider mite ecological niche will expand with climate change, especially expanding northwards in Europe representing an increasing threat to crop security.
- Feeding of tomato-adapted mites (*T. urticae* and *T. evansi)* is associated with similar patterns of tomato transcriptomic and metabolomic changes that reflect their ability to manipulate plant defenses.
- Spider mites manipulate the plant's defense response by injecting protein molecules into the host plants. A collection of secreted peptides have been identified as a starting point for the characterization of their function and identification of plant protein/processes they interact with.

- We have developed novel protocols for delivery of small molecules to spider mites that will provide a high-throughput platform for discovery of molecules with zero residues that can be efficient to control spider mites.

FOCUS ON POLICY, END-USERS AND SOCIETY RELATED PRODUCTS

- ✓ European Food and Nutrition Security Strategy – Food 2030
- ✓ The European Bioeconomy Strategy (published in 2012 and will be reviewed and updated by 2017)
- ✓ The EU Climate and energy package action and COP21 follow-up
- ✓ The Common Agricultural Policy (CAP) and CAP 2020+

AMOUNT: 1 559 318€

CONSORTIUM PARTNERS :

- **Jerry Cross, NIAB EMR, United Kingdom**
- **Maria Navajas, INRA, France**
- **Lothar Willmitzer, metaSysX GmbH, Germany**
- **Menelaos Stavrinides, Cyprus University of Technology, Cyprus**
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- **Isabel Diaz, Polytechnic University of Madrid, Spain**

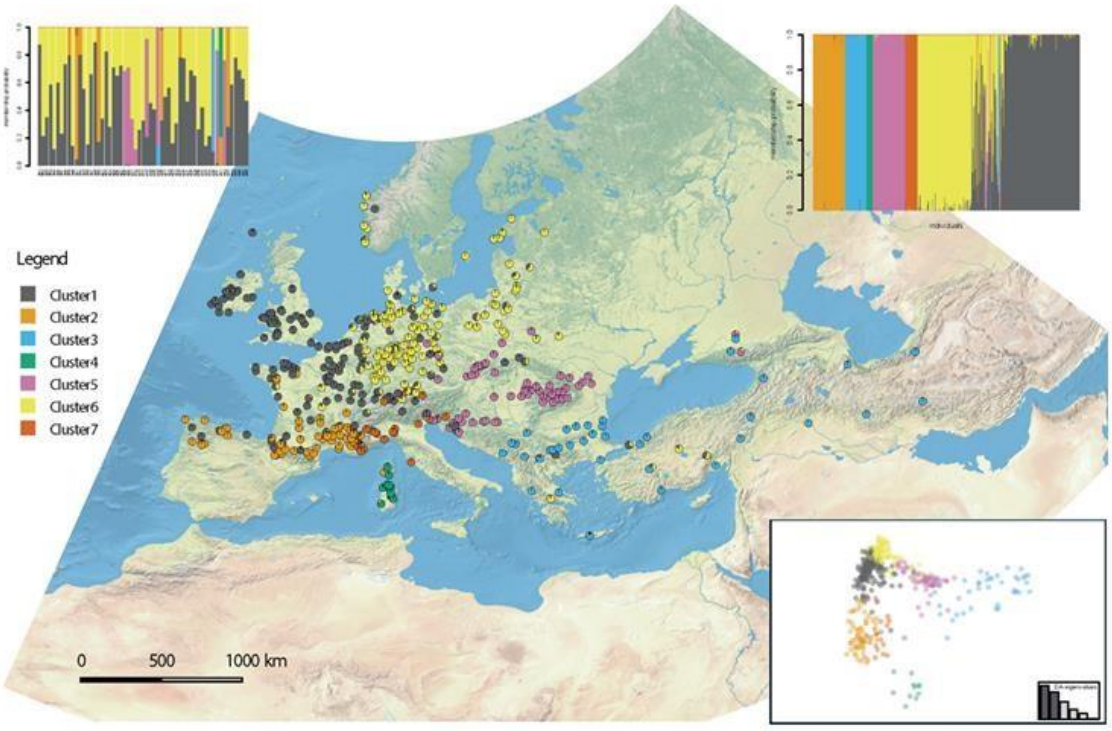
GrassLandscape - Bridging landscape genomics and quantitative genetics for a regional adaptation of European grasslands to climate change (January 2015- December 2017)

The GrassLandscape project aims to detect genomic markers of climatic adaptation in the natural diversity of perennial ryegrass using methodological tools from the Landscape genomics conceptual frame. Results will be used to set up strategies (assisted migration, breeding) for a regional adaptation of the diversity of this grassland species to the foreseen climate change throughout Europe.

OBJECTIVES	METHODS
Association models between genomic polymorphisms and environmental variations will be used to map the spatial distribution of genomic markers linked to adaptive diversity in present climatic conditions and to foresee possible shifts in the spatial range fitting these markers in the context of several climate change scenarios. We will define allelic profiles of perennial ryegrass expected to provide climatic adaptation at regional scale over Europe under the future climatic conditions. Strategies will be proposed to combine climatic adaptation and value for services by genetic recombination.	The project uses an innovative methodological frame (Landscape genomics) to screen the natural diversity of perennial ryegrass in order to discover genetic variability involved in environmental adaptation, and more specifically in climatic adaptation. This approach is based on the combined use of methods correlating genomic polymorphisms and environmental variations at sites of origin of genotypes and of tests of signature of selection. A genotyping method based on a NGS technology was applied to 550 populations sampled across the area of primary expansion of perennial ryegrass. Populations were furthermore phenotyped in fields and in controlled environment to record agronomic and eco- physiological traits.

KEY SCIENTIFIC FINDINGS

- A set of 330 000 SNPs marking out the natural diversity of perennial ryegrass
- An unprecedented overview of the spatial structure of perennial ryegrass diversity across its natural area of expansion
- First landscape genomics analyses proved that our experimental design enables to discover genomic markers associated with climatic adaptation.



Spatial structure of the natural diversity of perennial ryegrass across Europe

FOCUS ON POLICY, END-USERS AND SOCIETY RELATED PRODUCTS

- ✓ Delivery of a number of genetic pools to initiate breeding programs aiming to release improved populations adapted to future regional climates (to the benefit of breeding companies and/or participatory breeding initiatives)
- ✓ Delivery of Improved populations to restore grasslands degraded by future climatic disruptions (to the benefit of farmers, milk and meat industry and society)
- ✓ Contribution to policies intending to maintain or increase grassland acreage in Europe (and environmental benefits expected from grasslands)
- ✓ Innovative means for the preservation of the natural diversity of a grassland species in the face of climate change
- ✓ Identification of regions of Europe in which the natural diversity of temperate grass species is the most endangered by climate change

AMOUNT : 834 000€

- **Jean-Paul Sampoux, Institut National de la Recherche Agronomique (INRA), France**
- **Matthew Hegarty, Institute of Biological, Environmental and Rural Sciences (IBERS), Aberystwyth University, United Kingdom**
- **Klaus Dehmer, Leibniz Institut für Pflanzengenetik und Kulturpflanzenforschung (IPK), Germany**
- **Stéphanie Manel, Ecole Pratique des Hautes Etudes (EPHE – CEFE), France**
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GREENRICE - Sustainable and environmental friendly rice cultivation systems in Europe (December 2014-November2017)

Facing climate change and water scarcity in Europe, the GreenRice project will test the alternate wetting and drying system (AWDS) in Europe. AWDS is a rice production system based on intermittent irrigation that can save water (by 15-30%) while reducing greenhouse gas emission (up to 48%).

OBJECTIVES	METHODS
• The overall objective of GreenRice is to design and test an alternative water-saving rice production system for Europe ensuring sufficient productivity while reducing the negative impacts for the environment. • The four specific objectives are: • To evaluate the consequences of a shift from a permanently flooded system (PFS) to AWDS system on rice environment and productivity; • To identify varieties that maintain their productivity in AWDS; • To investigate plant traits determining adaption to AWDS; • 4) To disseminate the results of the projects to the main stakeholders (farmers and natural park authorities) and to the scientific community.	• The project uses a multidisciplinary approach bringing together agronomy, ecophysiology, breeding and ecology disciplines. • The methods used are: • Field varietal trials comparing PFS and AWDS and monitoring changes in productivity and on environmental elements such as water consumption, soil chemistry, soil salinity, and soil microbial community, and GHG emission (CH_4, N_2O, CO_2). • Identification of varieties adapted to AWDS through whole genome association mapping of a large panel of temperate varieties, followed by genomic selection. • Study of traits determining rice adaptation to AWDS (root traits, tolerance to salinity, resistance to nematode and blast infection) with the same panel. • Assessment of the potential of arbuscular mycorrhiza (AMF) symbiosis for the alleviation of biotic stress in AWD. • Role of soil microbial community in modulating GHG and cycling of C and N.

KEY SCIENTIFIC FINDINGS

➢ Field trials involving 12 varieties were conducted in Italy, France and Spain to compare PFS and AWDS. They showed a large water economy but contrasted varietal responses in term of productivity across countries depending on the irrigation management. In Italy, in 2015, a 43 % water usage saving in AWD conditions was observed, with generally no significant effect on the phenological, morphological and yield traits considered. In Camargue in 2016, AWD irrigation management proved to be too stressful for the crops, resulting in a significant yield reduction compared to PF (-37% on average). The adoption of less severe irrigation decision criteria is therefore forecasted for 2017. In Spain in 2016, a yield decline was observed in 4 of the 9 studied cultivars whereas no significant difference was observed in the rest of the cultivars.


Left: AWD experiment in Camargue in 2016 (France): visit of the participants to the 14th IRFGS

Right: AWD experiment in Ebro delta in 2016 (Spain): visit of the GreenRice partners

- In 2015, in Italy, AWDS reduced methane emissions by almost half. There was a significant difference in how the 12 varieties responded to a lower soil water depth. Overall, there was no
- significant difference observed in soil CO2 fluxes or carbon allocation between the two treatments, except for a few varieties. The data on GHG emission of the 2016 trials are still being analyzed.
- Under AWD treatment, rice plants showed an increased root branching, mostly involving the large lateral roots. The arbuscular mycorrhizal phenotype was nicely maintained, even if the colonization success was slightly more limited than under purely aerobic conditions. Molecular analysis revealed that a phosphate transporter was highly upregulated in AWD plants.
- GBS and bulk segregant analysis were used to map a major gene for complete nematode resistance to chr 11 by crossing a resistant Sri Lankan cultivar LD24 with an Italian variety Vialone Nano.
- The GreenRice panel of 240 European accessions was characterized for its salinity tolerance and GWAS used to map candidate genes for salinity tolerance.
- Field trials carried out at the Ebro Delta in 2016 showed an increase in productivity in mycorrhizal rice plants (30% increase) compared to non-mycorrhizal plants when grown under PFS. Under controlled greenhouse conditions, the mycorrhiza-induced protection against blast infection is dependent on the host genotype. Results on blast resistance in field-grown mycorrhizal rice plants were not conclusive due to a low blast incidence in the 2016 rice cropping season.

FOCUS ON POLICY, END-USERS AND SOCIETY RELATED PRODUCTS

- ✓ A project web site: http://www.greenrice.eu/ describing GreenRice activity.
- ✓ A tweeter account: @greenriceEU
- ✓ A leaflet presenting the project produced in 5 languages (English, French, Italian, Spanish and Catalan)
- ✓ Project presented at farmers' field day with field visit of the AWD experiments in France (09/09/15 and 07/09/16), Italy (04/09/15), and Spain (25/08/16).
- ✓ Field visit of the AWD experiment in Camargue organized for 100 participants of the International Rice Functional Genomics Symposium (29/09/16).Publications: 3 posters and 1 paper (doi: 10.4236/ajps.2015.612191). Several papers in preparation.

AMOUNT: 1447 000€

CONSORTIUM PARTNERS :

- **Brigitte Courtois, Tuong-Vi Cao Bang, and Chantal Hamelin, CIRAD, France**
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- **Giampiero Valè, Stefano Monaco and Andrea Volante, CREA, Italy**
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- **Blanca DSan Segundo and Sonia Campos, CRAG, Spain**
- **Maite Martinez-Eixarch and Maria del Mar Català, IRTA Spain**
- **Adam Price, Yit Arn The, Roshi Shresta and Victoria Oliver, University of Aberdeen, Uk**

MODCARBOSTRESS - Improving models and plant phenotyping pipelines for a smart agriculture under abiotic stress combination and elevated CO2 (January 2015 – December 2017)

Crop models are essential tools to support the choice of varieties, species and cropping systems but also to orientate breeding in front of the many intertwinned challenges of climate change. However, crop models predictions widely diverge under combination of stresses such as those associated with climate change (temperature increases, drought, elevated CO2). MODCARBOSTRESS revisits some of the hypotheses on which crop models are based and explores avenues for their improvement.

OBJECTIVES	METHODS
• Evaluate the performance of crop models which are based on contrasted views of plant function when crops are challenged by stress combinations • Evaluate the importance of acclimation to temperature increases and elevated CO2 • Evaluate the benefits of incorporating this biological knowledge into both types of models • Propose low-cost improvements in CO_2 control in phenotyping set-up	• Retained wheat and oilseed rape as crops and identified a list of 15-20 cultivars with contrasted behaviors in the field • Chose 2 contrasted crop models either photosynthesis driven (GECROS) or both source • / sink driven (SYRIUS-Q) • Focused on leaf development, leaf expansion, photosynthesis, grain abortion • Performed experiments under stress combination • Identified field data sets under various stress combinations to run crop models before and after improvement

KEY SCIENTIFIC FINDINGS

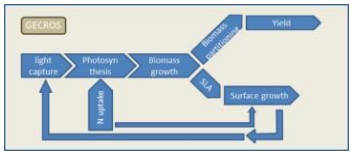
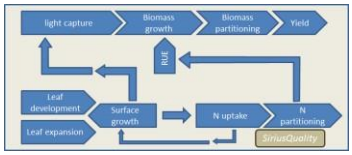
- There are massive changes in phyllochron (rate of leaf emission) induced by low or high temperature, probably linked to C staus that could induce major biases in models
- Plants achieve photosynthesis acclimation to temperature via optimising nitrogen partitioning among various fractions in charge of the photosynthetic machineries
- Acclimation of photosynthesis is much more rapid than previsouly expected and it does not depend on new organs
- Models have been improved but simulations still need to be run against field data

MODCARBOSTRESS

Improving crop models for better prediction of agriculture performance under climate change

3 CLIMATIC STRESSES  X  X 

2 CROPS  **WHEAT**  **OILSEED RAPE**

2 MODELS  

2 ORIGINS OF DATA  **PHENOTYPING PLATFORMS** **FIELD** 

7 EUROPEAN GROUPS

PRIFYSGOL ABERYSTWYTH UNIVERSITY · UNIVERSITY OF COPENHAGEN · JÜLICH FORSCHUNGSZENTRUM · cnrs · AARHUS UNIVERSITY · WAGENINGEN UR For quality of life · INRA SCIENCE & IMPACT · cea

AN ERA-NET + PROJECT ON CLIMATE SMART AGRICULTURE

FOCUS ON POLICY, END-USERS AND SOCIETY RELATED PRODUCTS

- ✓ MODCARBOSTRESS contributes to improving large scale simulations of crop production in Europe (done in the frame of other consortia such as MACSUR) and thus to policy making. Simulations based on improved models could be relevant to policy makers involved in the set-up of CAP by encouraging both productive and climate resilient solutions, in terms of varieties, species, rotations, cropping systems.
- ✓ Because it will help to more reliably identify climate smart agricultural solutions, MODCARBOSTRESS will also contribute to environmentally sustainable food systems and thus to Food 2030.

AMOUNT: 1 137 000€

CONSORTIUM PARTNERS :

- **Bertrand Muller, Pierre Martre, INRA, UMR LEPSE, Montpellier**
- **Fabio Fiorani, Forschungszentrum Juelich GmbH, Germany**
- **Carl-Otto Ottosen, Aarhus University, Denmark**
- **Eva Rosenqvist, Copenhagen University, Denmark**
- **Bernard Genty, CNRS/CEA, France**
- **Xinyou Yin, Wageningen University and Research Centre, The Netherlands**
- **John Doonan, Aberystwyth University, United Kingdom**

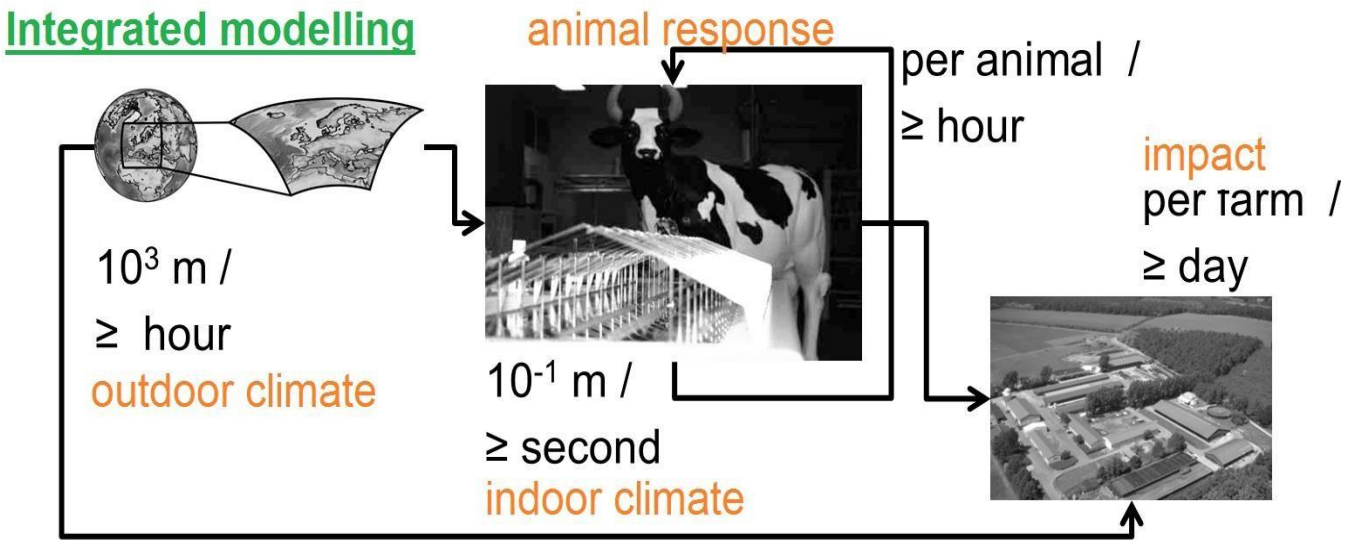
OptiBarn - Optimized animal-specific barn climatisation facing temperature rise and increased climate variability (December 2014–November 2017)

Naturally ventilated buildings (NVB), as often used for dairy cattle housing, are particularly vulnerable to climate change since the microclimatic conditions inside strongly depend on the outdoor weather conditions. Without sound adaptation strategies, increased climate variability will result in a sub- optimal thermal environment impairing production and welfare of animals and increasing emission rates.

OBJECTIVES	METHODS
• Assessing the influence of outdoor climate on the indoor climate in NVB • Region-specific risk analysis on how often critical weather situations will occur under conditions of climate change • Assessing cow-individual stress reactions in different climate zones • Assessing engineering solutions to control indoor climate conditions • Assessing environmental and economic effects of climate change on dairy cattle husbandry in NVB • Propose region-specific, sustainable adaptation strategies for dairy housing	• High resolution measurements (on-farm) , physical modelling at lab-scale, numeric simulation & statistic modelling • Indoor measurements of temperature, humidity and air flow, local and regional weather station data; statistical and regional climate modelling • Monitoring of physiological and behavioral response of cows, statistic modeling • Gas concentration measurements, milk yield monitoring, Farm-scale modelling • Linking of different temporal and spatial scales by statistical models & extrapolation to other barns / regions

KEY SCIENTIFIC FINDINGS

- Spatial variations of up to +/- 3°C, and up to +/- 20% relative humidity can be observed inside a NVB
- Air speed inside NVB is increased in the first third and decreased in the last third of the main flow through the building compared to the inflow air speed; the inflow angle determines the orientation of the main flow and the cows adapt their positions in the barn accordingly if possible
- Indoor THI mainly depends on outdoor THI, horizontal air flow and insolation
- Assessing climate related stress in cattle only by the temperature-humidity index (THI) based on point measurements results in an uncertainty in THI score of up to +/-4 corresponding to up to 8 kg difference in milk yield loss per cow
- The amplitude of the responses to climatic stress (e.g. changes in body posture or rumination activity) varies during the day and has its maximum in the afternoon



FOCUS ON POLICY, END-USERS AND SOCIETY RELATED PRODUCTS

- ✓ Transparent monitoring of climate-related stress (as precursor for a heat stress app)
- ✓ Assessment of housing technologies and management strategies to reduce heat stress
- ✓ Regional evaluation of risks of economic losses in the dairy cattle sector under climate change
- ✓ Emission scenarios under climate change with and without adaptation of cattle housing
- ✓ Support of a continuous production of high-quality milk with increased animal welfare and health

AMOUNT: 1 074 000€

CONSORTIUM PARTNERS :

- **Sabrina Hempel, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)**
- **Christoph Menz, Potsdam Institute for Climate Impact Research (PIK)**
- **Ilan Halachmi, Agricultural Research Organisation of Israel (ARO)**
- **Guoqiang Zhang, Aarhus University (AU)**
- **Agustin del Prado, Basque Centre For Climate Change (BC3)**
- **Fernando Estelles, Polytechnic University of Valencia (UPV)**

SYBRACLIM: Securing yield stability of Brassica crops in changing climate conditions (November 2014–October 2017)

Crop yield stability is greatly dependent on the response of key developmental programs including flowering time, root development and pod shattering to stress conditions. SYBRACLIM aims at understanding the mechanisms of adaptability to suboptimal environmental conditions of oilseed rape (*B. napus*) by uncovering the genetic, physiological and molecular bases of the regulation of these developmental traits in relation to environmental factors such as temperature or drought and their impact on crop yield.

OBJECTIVES	METHODS
• Identification of new breeding targets for high temperature and drought tolerance of oilseed rape • Assessment of the impact that high temperature and water stress have on yield parameters in genotypes of oilseed rape. • Identification of genetic determinants for high temperature and water stress tolerance in oilseed rape. • Identification of oilseed rape climatic stress tolerance genes suitable for entering breeding programmes. • Development of predictive models for crop adaptation to climate conditions based on climate and oilseed rape genomic data. • Identification of better strategies to adapt agricultural systems to climate conditions to secure yield of oilseed rape crops.	• Deep phenotyping of the influence of high temperature on fruit dehiscence, flowering time and root development as well as the effect of water stress in shoot and root development and senescence. • Analysis of seed yield and seed quality parameters (oil and protein contents and composition) in oilseed rape varieties. • Genome-wide (RNA-seq) and *B. napus* 60k SNP array approaches to uncover the genetic determinants for high temperature and water stress tolerance. • Associative transcriptomic analysis to identify candidate genes that control pod shattering in response to higher temperatures. • Development of newer regression techniques to identify and predict the important climate variables contributing to oilseed rape yield.

KEY SCIENTIFIC FINDINGS

- Genome-wide association study for drought resistance in oilseed rape have found only weak correlations between the experimental repetitions and low heritability values for biomass productivity under drought conditions within a semi-controlled greenhouse experiment.
- Different flowering and root development responses to high temperature of a panel of *B. napus* varieties have demonstrated that complex regulatory networks are involved in the adaptation to this environmental cue associated with climate change.
- Characterization of *B. napus* TILLING lines with altered pod shatter resistance using the Random Impact Test have identified genetic determinants associated to this adaptive trait.
- Obtention and molecular and genetic characterization of *B. napus* varieties with resilience to pod shattering and water stress resistance that can be used for selection in breeding programmes.

- Determination that classical regression techniques, based on ordinary least square and stepwise selection, were less accurate in predicting the crop yields than newer regression techniques based on regularization method.
- Based on prediction models; precipitation was found to have an adverse effect on yield during autumn and winter. Soil type was also important for crop yields with lower yields on sandy soils compared to loamy soils.

FOCUS ON POLICY, END-USERS AND SOCIETY RELATED PRODUCTS

- ✓ SYBRACLIM will significantly contribute to the development of climate adapted and flexible oilseed rape cultivars due to the uncovering of new physiological strategies and mechanisms as well as genetic components involved in drought and high temperature resistance in Brassica crops, and their role in crop yield stability.
- ✓ SYBRACLIM aims to understand the genetic mechanisms regulating pod shattering. Pod shattering causes a yield reduction to an average grain loss of 15-20% per year (in extreme weather conditions the losses are even around 70%). An improvement in pod shattering resistance as under high temperatures can not only lead to an increase in grain yield but also to increase the income of farms.
- ✓ A better understanding of the physiological and genetic components of enhanced drought and high temperature resilience will lead to the identification of reliable physiological, morphological and genetic markers that can be used in the selection process and integrated in commercial breeding programs for the establishment of stable cultivars which can cope with climate change.
- ✓ SYBRACLIM will also help to assess the effects of climate change on plant-based production. As a result a forecast of possible risks associated with climate change and provision of measures that can be initiated in time will be defined and therefore agricultural production systems can be adapted at an early stage to prevent crop losses.
- ✓ Identification of oilseed rape varieties with a better resilience to increasing temperature and water deficiency will help to define a more efficient use of natural resources like water and soil nutrients that are crucial to achieve a sustainable European agriculture.
- ✓ Finally, since lower and more variable yields may also be expected to enhance greenhouse gas emissions through lower carbon returns to the soils and less efficient use of applied fertilisers, securing yield stability of Brassica crops in changing climate conditions will help to obtain a more sustainable crop production and efficient use of European natural resources.

AMOUNT : 167 000€

CONSORTIUM PARTNERS :

- **Coordinator: Dr. Mónica Pernas, Centre for Plant Biotechnology and Genomics (CBGP) , UPM-INIA, Spain.**
- **Dr. Alain Bouchereau, Institute for Genetics, Environment and Plant Protection, INRA, Rennes, France.**
- **Dr. Leckband Gunhild, NPZ-Innovation GmbH, Germany.**
- **Prof. Olesen, Department of Agroecology and Environment, Fac. of Agricultural Sci., Aarhus University, DK.**
- **Prof. Lars Østergaard, Department of Crops Genetic, John Innes Centre, United Kingdom.**
- **Prof. Rod Snowdon, IFZ-Research Centre fo Biosystems, Land Use and Nutrition, Justus Liebig University, Giessen, Germany.**
- **Dr. Mirek Trnka, Institute of Agriculture Systems and Bioclimatology Mendel University, & Global Change Research Centre, Brno, Czech Republic.**

FACCE-JPI Knowledge Hub MACSUR - Modelling European Agriculture with Climate Change for Food Security

MACSUR is the pilot FACCE-JPI action, which started in June 2012 for 3 years (MACSUR1). It was extended for a further 2 years (MACSUR2) until May 2017. The Knowledge Hub MACSUR community consists of around 300 researchers in 18 countries.

MACSUR consists of 3 coordinated and integrated networks on 1) crops (Crop M); 2) grasslands and livestock (Live M) and 3) economics and trade (Trade M).

The strategic objective of MACSUR was to create a coordinated and visible European network bringing together the major European research groups to join forces, share expertise and data resources, and address this urgent issue in a timely and concerted fashion. In addition to the scientific outcomes expected, the benefits of this pilot action have included:

- fostering interaction and synergy between European modellers in the areas of crops, livestock and trade;
- allowing long lasting and large base research and tools and methods for capitalising on results;
- providing European critical mass in the international context and JPI branding;
- establishing and reinforcing links between national programmes and supercomputing facilities.

The aim of a FACCE Knowledge Hub; a tailor-made instrument, conceived by FACCE-JPI, was to:

- perform excellent joint research in the particular field to respond to questions in the Strategic Research Agenda;
- increase and facilitate transnational cooperation and coordination between excellent researchers and research organisations, building a progressive and long-lasting network;
- to provide the opportunity to develop research capacity in the particular field, to join learning/training activities (e.g. mobility) and to share infrastructures.

MACSUR - Modelling European Agriculture with Climate Change for Food Security (2012–2017)

MACSUR is a European knowledge hub comprising >300 scientists. Its goal is to improve the European capacity in modelling climate change impacts on crops, livestock systems, and soci-economy for conducting assessments for adaptation and mitigation options.

OBJECTIVES	METHODS
• Improve individual AgSyst models • Crop and livestock production, farms, and national & international agri-food markets • Model integration & linking of models for selected farming systems and regions • Provide hands-on training to junior and experienced researchers in integrative modeling • Assess climate-induced risks/ opportunities & the consequences of adaptation and mitigation in agriculture for better avail-ability, accessibility & affordability of food	• Cataloging of models • Standardized model comparisons • Improvements in modelling methodology (scaling, response surfaces, uncertainty, crop rotations, disease vectors, breeding options, model linking) • Scenario development • Integrated regional case studies • Specialist workshops • Global collaboration in ensemble modelling • Good-practice approaches & guidelines • Impact assessments

KEY SCIENTIFIC PRODUCTS

- c. 200 scientific articles important review papers defining the challenges and priorities for modelling
- Several special issues by CropM, LiveM, TradeM
- Integrated view of CC impacts on agriculture across disciplines and scales
- Modelling activities now include pests & diseases, breeding, livestock health, farm-scale modelling
- Understanding of data/model demands of other disciplines
- Establishment of a network in Europe that is on par with other international networks
- Open Data Journal for Agricultural Research (ODJAR): supported its development, publication of data sets
- Gobal significance through conferences, collaboration, and committees, e.g. iCropM-2016 (>350 participants from all over the world, all leading international crop modelling groups represented)

AMOUNT: 6 000 000€

CONSORTIUM PARTNERS : http://macsur.eu/index.php/about/partners

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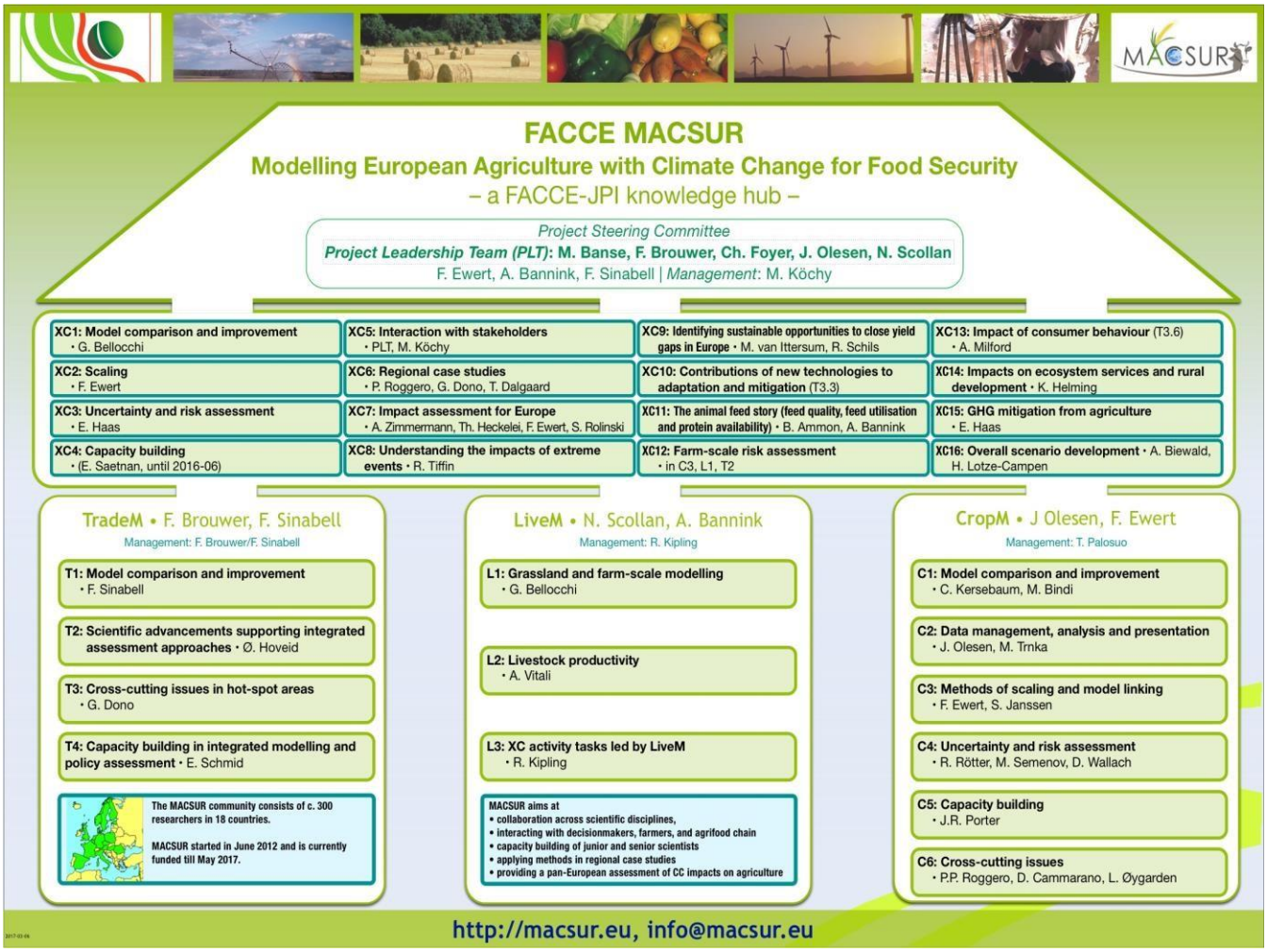
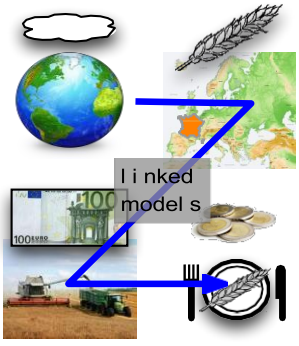
- **70 institutions in Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Israel, Italy, Norway, Poland, Romania, Spain, Sweden, The Netherlands, United Kingdom**



FOCUS ON POLICY, END-USERS AND SOCIETY RELATED PRODUCTS

- ✓ Policy briefs on crop modelling and livestock research for policy support
- ✓ Regional case studies with participation of stakeholders
- ✓ Workshops for decision makers in Brussels
- ✓ State-of-the-art articles
- ✓ National MACSUR results flyers: http://macsur.eu/index.php/output/country-flyers
- ✓ Interaction with decision makers, researchers, food value chain actors
- ✓ Participation in international networks
- ✓ Contributions to EEA report 'Climate change, impacts and vulnerability in Europe 2016
- ✓ Contributions to EU and national consultations, research policy advice
- ✓ Input to IPCC AR 5 (cited papers), articles for IPCC AR 6 in pipeline



Multi-partner Call on Agricultural Greenhouse Gas Research

FACCE – JPI launched this call in January 2013 bringing together 11 FACCE member countries as well as Canada, New Zealand and the United States.

The call aimed to bring together excellent research consortia to enhance international collaboration in the face of the global issue of climate change mitigation. The call aimed to cross three scientific themes by three cross-cutting topics:

Scientific themes:

Theme 1: Improved methodologies for quantifying GHG emissions and removals in agricultural systems and in national inventories.

Theme 2: Study of mitigation options at the field, animal and manure management scales with quantification of their technical potential for a range of agricultural systems and regions.

Theme 3: Quantification of the costs and benefits and of the impacts for food production and for the environment of GHG mitigation options.

Cross-cutting topics:

Topic 1: Greenhouse gas emissions in the agriculture sector arising from agricultural soils including crops and grasslands, domestic livestock and waste management systems.

Topic 2: Greenhouse gas removals, e.g. through carbon sequestration in agricultural soils.

Topic 3: Lifecycle of agricultural and food products. GHG mitigation studies taking account of other sectors such as industry, transport, energy and land use change that add to the net greenhouse gas emissions.

MODELS4PASTURES: Robust models for assessing the effectiveness of technologies and managements to reduce N2O emissions from grazed pastures (January 2013- December 2017)

Models4Pastures aims to test and improve the ability of simulation models to provide robust assessments of N2O mitigation options in grassland systems across a large geographic and climatic range. In addition to N2O emissions, pasture growth, leaching, soil carbon and other gases will be tested, including the biophysical and management flow-on effects.

OBJECTIVES	METHODS
• Assessing models against experimental data for their estimations of N_2O emissions, pasture growth and soil C stock changes (WP2 : Model intercomparison) • Using models to test the impact of agricultural practices in GHG emissions and removals (WP3: Mitigation strategies) • Improving models by using a new high-quality dataset (Swiss site) (WP4: New data at a Swiss site, eddy covariance, all gases)	• Collaboration within international coordinated efforts, especially linked to the Integrative Research Group (IRG) of the Global Research Alliance (GRA) and CN-MIP project (FACCE-JPI) • Compare models using a 5-stage protocol; • Mitigation modelling with scenarios → Models: APSIM; DayCent; DayCent (two versions); PaSim; SPACSYS (WP2 only) • →Datasets from sites in NZ, UK, CH and FR • →Validation against new Swiss data and for management chosen to challenge models

KEY SCIENTIFIC FINDINGS

- Without site-specific information (blind test), the median prediction of the ensemble of models for grasslands N_2O emissions ranged within one standard deviation of the mean of the observations at individual sites (local scale) and all sites together (global scale). However, the uncertainties in the N_2O measurements were high. The ensemble was better at assessing changes than absolute values.
- Grasslands above-ground net primary production (ANPP) was generally poorly estimated by either individual or the ensemble of models and was usually overestimated. There was considerable uncertainty in the measurements and those data limitations have contributed to the underestimation by the models. We recommend that methods of measurement should be standardized and highly recommend the development of a global network of experiments in grassland sites. Moreover, models should be improved regarding their representativeness of spatial heterogeneity (trampling, vegetation composition, dung and urine patches) and

the methods by which they simulate grazing offtake (which is often represented as mowing or a fractional harvest rather than more realistic grazing).

- Reducing the number of models within the ensemble (down to three models) resulted in a better performance of the model ensemble against plausible median estimates for ANPP.
- No single model simultaneously had the lowest prediction error (RRMSE) for ANPP and N_2O emissions.

Fig.1 *Field measurements of GHG emissions at Laqueuille site (France). Site (a), flux tower for C fluxes measurements (b), grazing exclosure cage (c) and automatic chambers for N_2O measurements (d). Photograph credits: F. Ehrhardt, July 2016.*

FOCUS ON POLICY, END-USERS AND SOCIETY RELATED PRODUCTS

- Tier 3 methodologies could be developed for assessing N_2O regional emissions based on the median of a set of models. This methodology would require an ensemble of models that can be used to assess the effectiveness of management options for mitigation and a streamlined mechanism to robustly run the ensemble.
- Additional information will become available once the mitigation scenario modelling is completed.

AMOUNT: 483 010 €

CONSORTIUM PARTNERS :

- **Val SNOW (coordinator), Mark LIEFFERING, Paul NEWTON, Russel MCAULIFFE; AgResearch (New Zealand)**
- **Pete SMITH, Nuala FITTON; University of Aberdeen (UK)**
- **Kairsty TOPP, Bob REES, Vasileios MYRGIOTIS, Stephanie JONES; SRUC (UK)**
- **Laura CARDENAS, Lianhai WU; Rothamsted Research (UK)**
- **Katja KLUMPP, Renata SÁNDOR, Raphael MARTIN; INRA (France)**
- **Marco Bindi, Lorenzo BRILLI; University of Florence (Italy)**
- **Lutz MERBOLD, Kathrin FUCHS; ETH Zurich (Switzerland)**
- **Fiona EHRHARDT; INRA, coordination with GRA and CN-MIP**

DesignChar4food - Enhancing both soil carbon sequestration and fertility while reducing soil greenhouse gas emissions through designer biochar application (July 2014-July 2017)

Our project goal is to design biochar with characteristics that will improve soil fertility, increase soil carbon sequestration, and make nitrogen more available for plant uptake by reducing N entrapment and nitrous oxide formation. Developing collaborative research between US and European colleagues will expedite guidelines for designer biochar production and soil use.

OBJECTIVES	METHODS
• Conduct a meta-analysis of recent biochar literature and identify if biochars influence nitrous oxide formation and biochar characteristics that influence N availability and denitrification; • Using information from the meta-analysis, design biochars using different parent feedstocks, pyrolysis temperatures, and biochar morphology to possess these characteristics; • Conduct laboratory experiments to determine the interaction of nitrogen and these designer biochars that regulates nitrogen availability (sorption, entrapment, etc.); • Examine the influence of agricultural chemicals on nitrogen availability when biochar is co-applied; • Develop an electronic program called "CHARnet" to facilitate collaboration and data sharing between d4f team members and biochar stakeholders.	• Reviewed results from over 70 published articles, established a spreadsheet that identified key salient biochar properties and soil conditions with N availability and nitrous oxide formation; • Using statistics and meta-analysis techniques, determined which of these properties had a significant impact on N availability and nitrous oxide formation; • Used traditional laboratory sorption experiments between N solutions and biochars; • Using laboratory and field experiments, subjected biochar and N containing solutions to different forms of nitrification inhibition chemicals and measured nitrous oxide formation.

KEY SCIENTIFIC FINDINGS

- The meta-analysis revealed a relationship between biochar and nitrous oxide emissions with about 40% of the studies observing a decrease in nitrous oxide formation following biochar application;
- Biochar characteristics (high C/N ratios, pore sizes, and air dried moisture content) were hypothesized to be indicators of its ability to trap N ions and reduce immediate N availability.
- Observed conflicting response of biochars ability to reduce nitrous oxide formation using specific chemical inhibitors to track microbial mechanistic pathways.
- CHARnet was formed as a means to facilitate communication, sharing equipment, and collaboration between d4f scientists and additional collaborators from other countries.

CONSORTIUM PARTNERS :

- **Jeff Novak, Kurt Spokas, Gilbert Sigua, USDA-ARS ; and Jim Ippolito, Colorado State University, USA**
- **Claudia Kammann, Hochschule Geisenheim University, Germany**
- **Nils Borchard, Center for International Forestry and Research, Indonesia**
- **MariaLuz Cayuela, CEBAS, Spain**
- **J.M. Estavillo, Sergio Menedez, and Teresa Fuertes-Mendizabal, University of Basque, Spain**
- **Nicole Wrage-Monnig, University of Rostock, Germany**
- **Michael Schirrmann, Leibniz Institute, Germany**

CN-MIP - C and N models intercomparison and improvement to assess management options for GHG mitigation in agrosystems worldwide (January 2013-December 2017)

CN-MIP is an international study coordinated together with IRG group of the Global Alliance for GHG (GRA) which aims at benchmarking simulation models of yield, N2O and C fluxes, for a wide range of grassland and cropland situations, and test agricultural mitigation options. The objective is to improve national GHG inventories through Tier 3 method.

OBJECTIVES	METHODS
• Large variability in GHG emissions within and across sites make difficult the evaluation of the intensity of emissions at the year and regional scales. The project examined whether the use of modeling can provide a credible and generalizable estimation method for these emissions (Tier 3). • Developing Tier3 approach for wide diversity of cropping systems and climate, worldwide • Investigating the effect of agricultural mitigation options on GHG emissions under various climates and systems • CN-MIP project with 10 teams and 9 models joined the IRG group of the GRA to achieve these objectives	• A coordinated action of unprecedented scale with the GRA (16 models for croplands, 12 models for grasslands and 4 models for both, • 45 teams from 11 countries) focused on benchmarking and evaluation of simulations models using data from 10 international sites over 4 continents. • Experimental strategy implied double blind modelling (anonymous data sites and anonymous models), which a five-step modelling involving gradual release of site information to modelers to improve calibration of the models. • Calibrated models are then used to assess the response of GHG to reduction of fertilization, irrigation, OM management (numerical experimentation)

KEY SCIENTIFIC FINDINGS

(As the project is not finalized yet, not all findings can be mentioned here)

- None of the 24 models tested has superior performance in all circumstances. Median prediction of models is a plausible estimator of yields, N2O emissions and C storage and provides a more robust estimator than individual models. A set of models (ensemble approach) allows unbiased estimate for main crops (maize, wheat, rice and grassland).
- Tier 3 methodologies could be developed for assessing N2O regional emissions based on the median of a set of models. Such ensemble of models can be used to assess effectiveness of management options for mitigation

FOCUS ON POLICY, END-USERS AND SOCIETY RELATED PRODUCTS

- ✓ This exercise has improved the simulation models structure and parameterization and has extended their range of validity
- ✓ This work has several implications at a range of scales (local, regional, global) including improvement of national inventories from IPCC Tier 1 or 2 methods to Tier 3 methods : (i) ability of modelling approach to provide credible and generalizable estimation method for GHG emissions; (ii) set of models uncalibrated for specific conditions which provide an unbiased estimate using the range of experimental errors for the main three crops (maize, wheat, rice); (iii) possibility to develop Tier 3 methodology for assessing N2O regional emissions, through the construction of a meta-model
- ✓ This work contributes to the international research program 4 per 1000, by evaluating the performance of soil C models to predict evolution of soil C stocks in response to agricultural practices.

AMOUNT: ~ 1 343 530 €

CONSORTIUM PARTNERS :

- **Sylvie RECOUS & Fiona EHRHARDT, INRA (France), coordinator**
- **Pete SMITH, University Court of the University of Aberdeen, UK**
- **Marco BINDI, University of Florence, Italy**
- **Roberta FARINA, CREA, Roma, Italy**
- **Luca BECHINI, Università degli Studi di Milano, Italy**
- **Pier Paolo ROGGERO, Università degli studi di Sassari, Italy**
- **Joana SHARP, The New Zealand Institute for Plant and Food Research, NZ**
- **Richard CONANT, University of Colorado, USA**
- **Emma SUDDICK, Woods Hole Research Center, USA**
- **Peter GRACE, Queensland University of Technology, Australia**

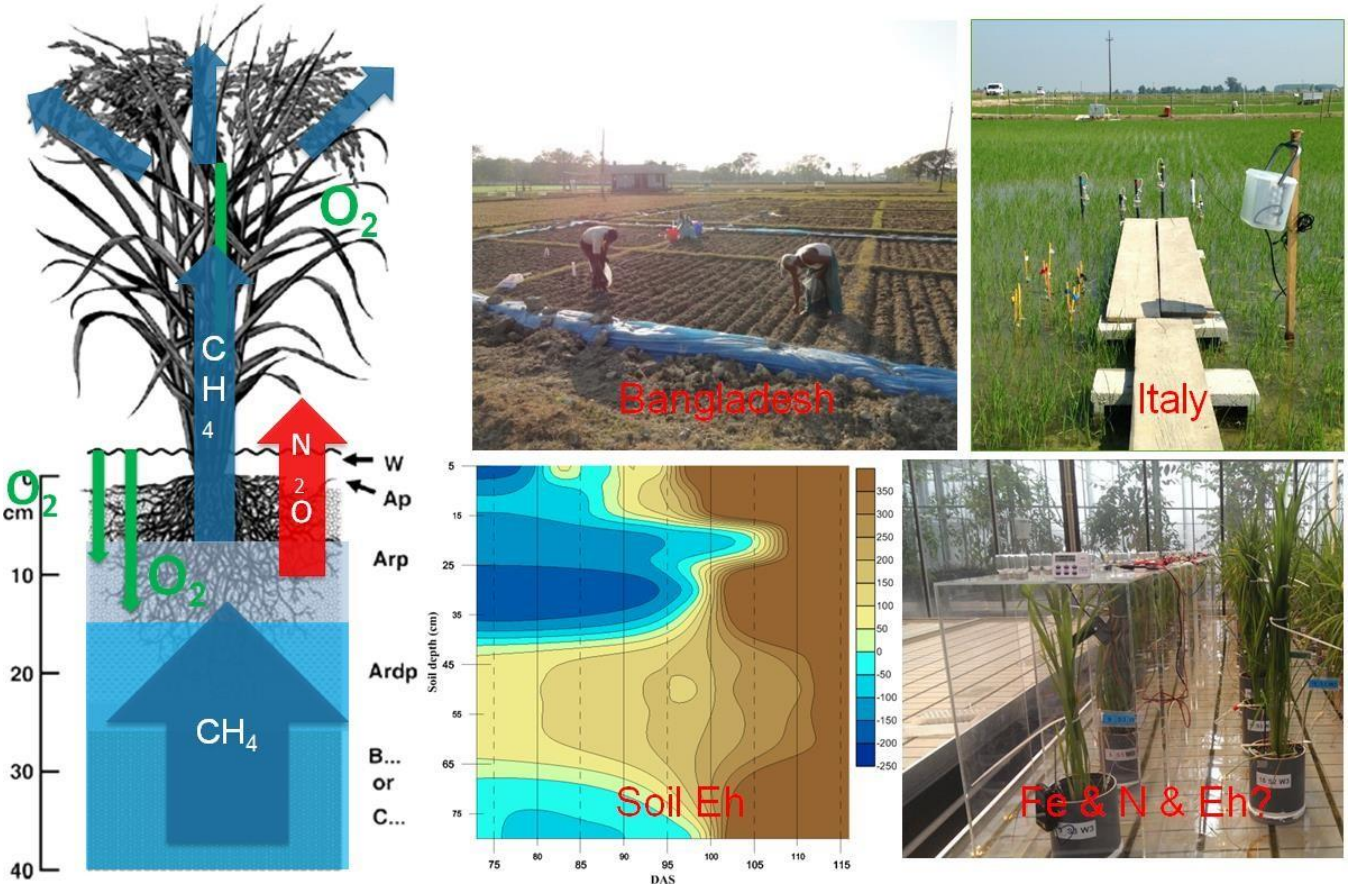
GreenRice: Greenhouse gas emissions from paddy rice soils under alternative irrigation management (March 2014-February2018)

We aim to forward our knowledge on key paddy soil biogeochemical processes involved in CH_4 and N_2O emission that gain importance in cropping systems with non-continuous flooding. These insights then need to be synthesized in the mechanistic DNDC biogeochemical model. We have set up and monitored a field experiment in Bangladesh and in Italy and conduct pot experiments.

OBJECTIVES	METHODS
• To reveal determining factors controlling the rate of change of the soil redox potential in young floodplain paddy soils. • To further our insight how CH_4 production in paddy soils under continuous flooding (CF) as compared to alternative irrigation management (AIM) results from the net result of CH_4 genesis and oxidation • To quantify the release of fixed-NH_4^+, expected to be substantial in floodplain soils. • To examine the contribution of different N sources to N_2O production under AIM. • To translate new knowledge generated in GreenRice on specific effects of AIM on GHG emissions in floodplain soils into the DNDC biogeochemical model.	• Monitoring of microbial activity, Fe and Mn reduction and changes in Eh in Bangladeshi soils; intensive sampling of heterogenous • 2 years North-Italian field experiment where we used two methodologies to quantify the influence of AIM on CH_4 oxidation in situ & monitored CH_4 and N_2O emissions and soil solution levels over depth gradients • Field setup with gas-samplers, soil solution samplers and stable isotope measurements to discover the provenance of emitted N_2O • Collaboration with National Agriculture and Food Research Organization's 'DNDC-rice' C and N simulation model

KEY SCIENTIFIC FINDINGS

- Fe-reductive dissolution is in synergy with soil mineral N buildup and Fe-reduction is the major e^-- capturing process in young floodplain paddy soils.
- Pedogenic oxides cannot be the sole e^--acceptor, and silicate Fe^{3+} appears crucial
- AIM irrigation impacts moisture level, redox potential, only till 10-15cm depth
- CH_4 emission reduction by water saving irrigation results mainly from inhibited methanogenesis and not from enhanced CH_4-oxidation
- Under near saturation or flooded conditions soil pore water may serve as a reservoir for produced N2O which cannot diffuse out.



- Significant N_2O emissions only occurred early in the growing season and were highest in dry-seeded treatments and were related to mineralization and nitrification pathways.
- Ammonium levels following fertilization appear to be driven by pre-fertilization water management, with rapid uptake, loss, or fixation in water seeded treatments

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- ✓ We aim to forward our knowledge on key paddy soil biogeochemical processes that gain importance in cropping systems with non-continuous flooding. These insights then will be synthesized in the mechanistic DNDC-rice biogeochemical model
- ✓ The updated DNDC-rice forms a valuable tool for scenario analysis: water-saving irrigation vs. BAU, to support agricultural policy-making in rice growing areas in river delta's
- ✓ Italian partners have important interaction with the various irrigation consortia feeding the rice cropping area in Northern Italy; Bangladeshi partners disseminate knowledge via BRRI
- ✓ After project completion and publication in peer-reviewed papers, datasets produced as part of GreenRice will be opened up.

AMOUNT: 605 758€

CONSORTIUM PARTNERS :

- **Steven Sleutel, Heleen Deroo, Masuda Akter & Pascal Boeckx - Ghent University (Belgium)**
- **Johan Six, Elizabeth Verhoeven, Charlotte De Cock - ETH Zurich (Switzerland)**
- **Luisella Celi, Daniel-Said Pullicino, University of Torino (Italy)**
- **Marco Romani, Ente Nazionale Risi (Italy)**
- **Changsheng Li (†22-10-2015), University of New Hampshire (US)**

EndoGas: Manipulating grass - fungal endophyte symbioses to reduce greenhouse gas emissions and increase soil carbon sequestration in grasslands of Finland, Spain, and the United States (July 2014-June 2017)

Meadow and tall fescue support significant livestock industries, and red fescue is an important turf species in the Northern Hemisphere. All of these grasses associate with fungal endophytes. The aim of this research is to identify grass-endophyte combinations that stimulate soil carbon sequestration, reduce GHG emissions, and support other ecosystem services.

OBJECTIVES	METHODS
• Quantify endophyte presence and strain effects on grassland GHG emissions. • Quantify endophyte presence and strain effects on grassland soil carbon sequestration. • Build a database of these results and make publicly available. • Build international, long-term collaborations through networking.	• We quantified fungal endophyte presence effects on soil- to-atmosphere trace gas fluxes in meadow fescue stands in southern Finland, and endophyte presence and strain effects on trace gas fluxes in tall fescue stands in central USA using standard GRACEnet protocol for chamber-based measurements. • We evaluated endophyte presence effects on meadow, tall, and red fescue soil C pools (0-10cm) at multiple locations: three different sites in Finland, the Faroe Islands, Spain, and the USA. Standard soil C assessment protocols were followed.

KEY SCIENTIFIC FINDINGS

- In Finland, fungal endophyte presence appears to reduce nitrous oxide fluxes in by ~16%, reduce carbon dioxide fluxes by 6%, and reduce methane by 160% in meadow fescue stands (Fig. 1).
- Effects of fungal endophyte presence and strain on GHG fluxes in Kentucky are more subtle.
- Soil C data are in the process of being worked up.

AMOUNT: 325 182€

CONSORTIUM PARTNERS :

- **Rebecca McCulley, University of Kentucky, U.S.A.**
- **Kari Saikkonen & Marjo Helander, Luke & University of Turku, Finalnd**
- **Inigo Zabalgogeazcoa & Beatriz Vazquez de Aldana, IRNASA – CSIC, Spain**

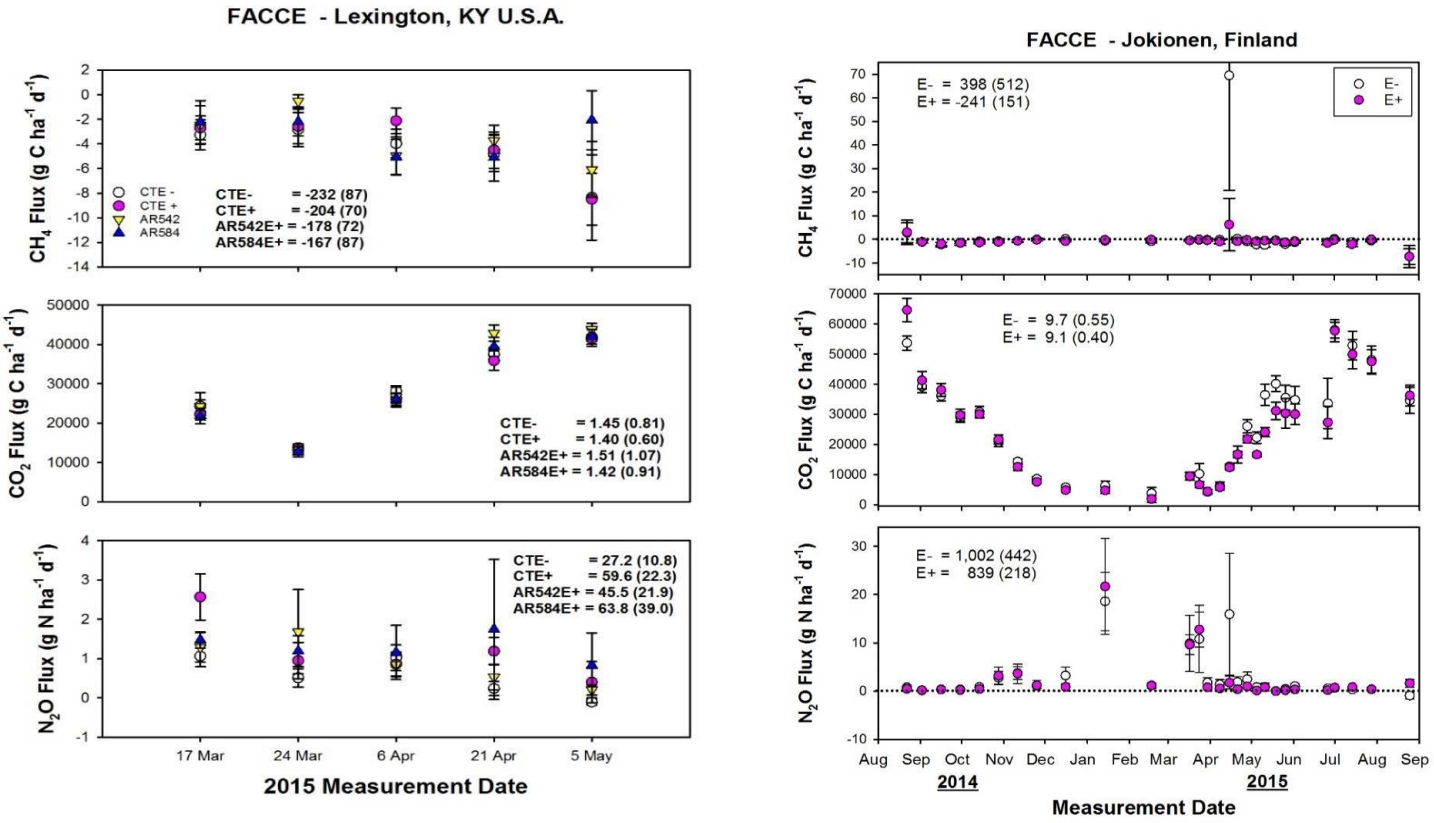

Figure: Finnish GHG fluxes from meadow fescue stands endophyte-infected (E+) or endophyte-free (E-), with Kentucky data from tall fescue stands that were either endophyte-free (CTE-), infected with the common toxic endophyte strain (CTE+) or infected with one of two novel endophyte strains (AR542E+ and AR584E+). Annual for Finland and 50-day totals for Kentucky are shown in inset (for CO_2 annual total is in Mg CO_2-C ha ; for all other gases, units are the same as on the y-axis).

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- ✓ Our website and database have been initiated: www.mcculleylab.org/endogasactivities
- ✓ We presented a poster on our project at the 2015 International Symposium on Fungal Endophytes of Grasses (ISFEG), held at the Centre for AgriBioscience at La Trobe University in Melbourne, Australia, where ~150 grass-endophyte researchers, students, and industry representatives were present. Citation: McCulley, R.L., K. Saikkonen, M. Helander, I. Zabalgogeazcoa, and B.R. Vazquez de Aldana. 2015. EndoGas: Manipulating grass-fungal endophyte symbioses to reduce GHG emissions & increase soil carbon sequestration in grasslands of Finland, Spain, and the US.
- ✓ Our FACCE project led to Drs. Saikkonen and Helander receiving OECD Fellowships to come to my lab in the US for 6 months in 2014, which has strengthened our collaborations. It also led to Dr. McCulley receiving a GRASS award from the NZAGRC in New Zealand and researching similar questions for 4 months in Palmerston North, New Zealand in 2016, which has led to a pending NZ-GPLER proposal.

Barriers to Adoption of No-Cost Mitigation Options (July 2015 – Jun 2018)

Motu, in collaboration with AgResearch and Landcare, is engaged in a three year project that seeks to better understand why some apparent 'no-cost' options for agricultural mitigation (reduction of biological GHG emissions) remain non- or under-adopted in practice. This work is conducted in collaboration with INRA (France), Teagasc (Ireland) and SRUC (Scotland) research partners.

OBJECTIVES	METHODS
• To develop a typology of possible reasons (barriers) why under-adoption of no-cost mitigation options occurs • To test and verify the no-cost status of selected mitigation options using farm-scale empirical analysis • To explore with farmers (using interviews and a survey) if 'no-cost' options do exist, what are the barriers to their adoption and how these could be addressed	• The initial 'typology of barriers' of Objective 1 is already available online. Based on this typology we are investigating what are the main barriers to adoption that farmers face in NZ and how these can be overcome to facilitate the uptake of mitigation options. Thus, based on a combination of empirical analysis employing secondary data (farm-level data) and primary data (interviews and survey), we will provide insights to improve our understating on what sort of policies and/or market interventions can be implemented to foment the adoption of GHG mitigation options that could maintain an economically viable, while emissions-friendly, agricultural sector in NZ.

KEY SCIENTIFIC FINDINGS

Work in progress. Publication so far:

1. Jaffe. Adam. 2017. "Barriers to Adoption of No-Cost Options for Mitigation of Agricultural Emissions: A Typology". Motu Note #24. Available online at: http://motu.nz/our-work/environment-and-resources

AMOUNT : $320,000 NZD

CONSORTIUM PARTNERS :

- **David Fleming, Suzi Kerr, Edmund Lou, Sally Owen and Loic Henry – Motu Economic and Public Policy Research**
- **Robyn Dimes, Cecile DeKlein and Bruce Small - AgResearch**
- **Pike Brown - Landcare**

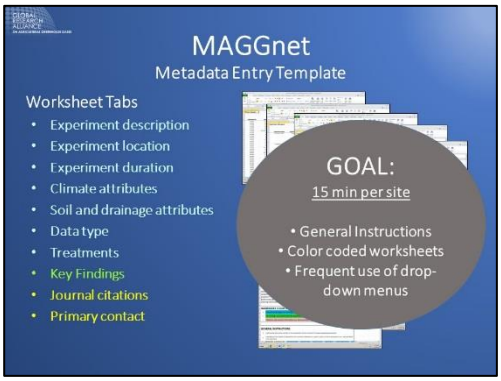
MAGGnet – Quantifying Greenhouse Gas Mitigation Effectiveness through the GRA Croplands Greenhouse Gas Network

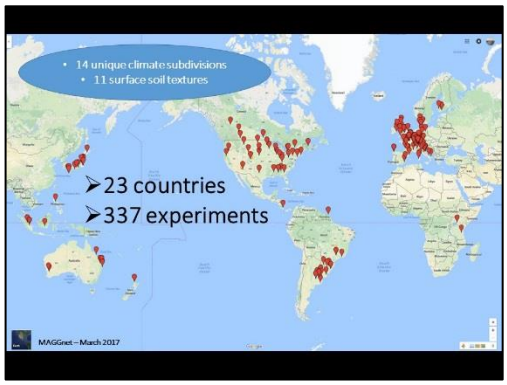
MAGGnet was established to foster the development of coordinated, multi-national approaches for inventory and analysis of greenhouse gas mitigation research. Since 2012, MAGGnet has compiled metadata from over 300 experimental sites throughout the world. Metadata contributors include scientists actively engaged in the GRA Croplands Research Group.

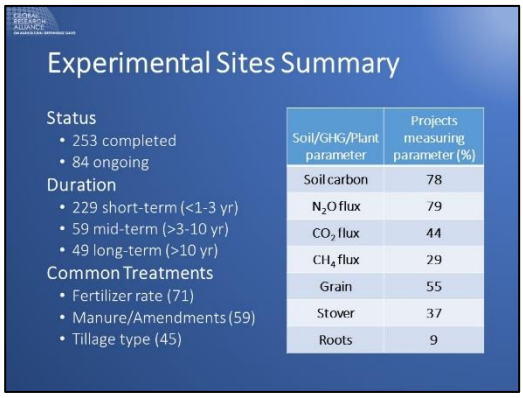
OBJECTIVES	METHODS
• Quantify the effectiveness of specific mitigation practices (e.g., fertilizer type/rate, tillage, crop rotation, residue management, cover crop, livestock integration, etc.) for arable-annual crops throughout the world using meta-analysis. • Quantify potential tradeoffs in GHG mitigation and crop yield. • Identify and communicate critical data gaps. • Facilitate communication and cooperation among member countries in GRA Research Groups to improve predictive capabilities of process-based models.	• Retrieve GHG emissions and SOC stock change data from published studies conducted by member countries. • Validate data and conduct analyses across >200 experimental sites. • Disseminate results to GRA partners and the public. • Interface with a C-and-N-modeling team in the Croplands and Soil C/N Crosscutting Research Groups to validate and improve predictive capabilities of process-based models for estimating GHG emissions from multiple agroecoregions represented by member and non-member GRA countries.

KEY SCIENTIFIC FINDINGS

- Data from over 300 sites were reviewed and partitioned into 'alternative' and 'business as usual' management practices associated with N fertilization, N source, crop rotation, and tillage treatments.
- Among management variables evaluated for their effect on N_2O emission, only N fertilization differed significantly between 'alternative' and 'business as usual' practices.
- Moreover, no differences between treatments were observed for yield-scaled emissions.
- As data for the evaluation were compiled globally, outcomes suggested a need for additional site data to allow for statistically robust analyses within similar production regions







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- MAGGnet used to help identify sites for model inter-comparison exercise (INRA, 2014-present)
- MAGGnet metadata template adapted by GRA Paddy Rice Research Group to document rice production research sites in Japan, Indonesia, Philippines, Thailand, and Vietnam (2015-present).
- MAGGnet metadata, site map, and sharing agreement made available online through GRA and GRAMP websites (globalresearchalliance.org/maggnet/; www.gramp.org.uk/).

MAGGnet overview published in *Carbon Management*
(http://dx.doi.org/10.1080/17583004.2016.1180586

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- **Ayaka Kishimoto-Mo, National Institute for Agro-Environmental Sciences, Japan**
- **Yasuhito Shirato, National Institute for Agro-Environmental Sciences, Japan**
- **Gervasio Piñeiro, Universidad de Buenos Aires, Argentina**

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