Remote sensing inputs needed for modeling global soil carbon sequestration in rangelands

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A renewed interest in grassland/ rangeland soil carbon

SDG 15.3 Soil carbon indicator

UNCCD Land degradation neutrality principle

UNFCCC Stabilizing climate below the 2° C global warming limit by reducing GHG emissions and using carbon sinks

4 per 1000 initiative on soils for food security and climate

Towards an international research program

An evidence based and policy relevant programme…

Aimed at providing options for countries, stakeholders and the private sector and at supporting the multi-partner initiative

… nested in existing international programmes

GRA – Integrative Research Group

CGIAR – CCAFS and WLE (Water, Land & Ecosystems) programmes

… well connected to other research & knowledge programmes

e.g. GSP, Geoglam, ELD, AgMIP, EU FACCE JPI…

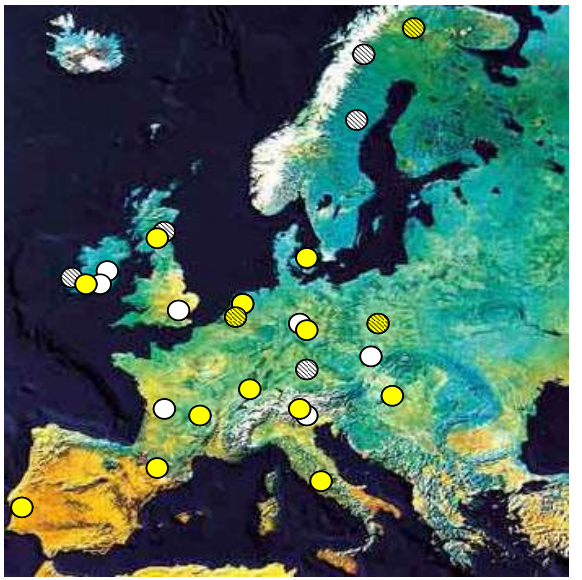
Seed funding provided by French Ministry for Research for 2016-2017

International Research Consortium (Coordination & Support Action by EC)

Themes of the international research programme

- Improving estimates of the baseline and of the potential of soil carbon sequestration (or loss) and of current soil carbon stocks;
- Design and co-construction of agronomic strategies and practices for soil carbon sequestration, including an assessment of their performances and of trade-offs among multiple objectives;
- Metrics and methods for monitoring, reporting and verification (MRV) of soil carbon sequestration (farm, landscape, region, country);
- Institutional arrangements and public policies, including financial mechanisms, that aim at promoting and rewarding relevant practices.

EU-Grasslands



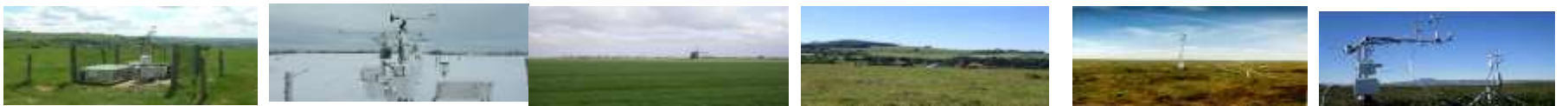
39 grassland flux tower sites (since 2002; ~210 site-years)
- 19 permanent grasslands (>5yrs and natural)
- 8 temporary sown grasslands
- 2 Savannah
- 4 wet grasslands

• Along a climatic gradient
MAT (2° C to 15C°) , MAP (260mm to 1349mm),
SOC (~4 to 72 kg C/m2)

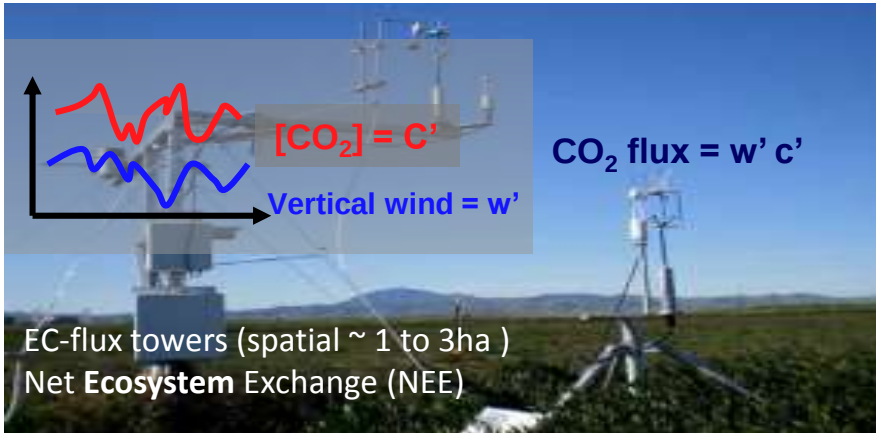
• With contrasted management
- high and low N input (0 to 320 kgN/ha/yr mineral and organic)
- mowing (C; 1 to 5 cuts),
- grazing (G; 0.2 to 2 LSU/ha.yr), mixed (G/C).

GHG EUROPE
Greenhouse gas management in European land use systems

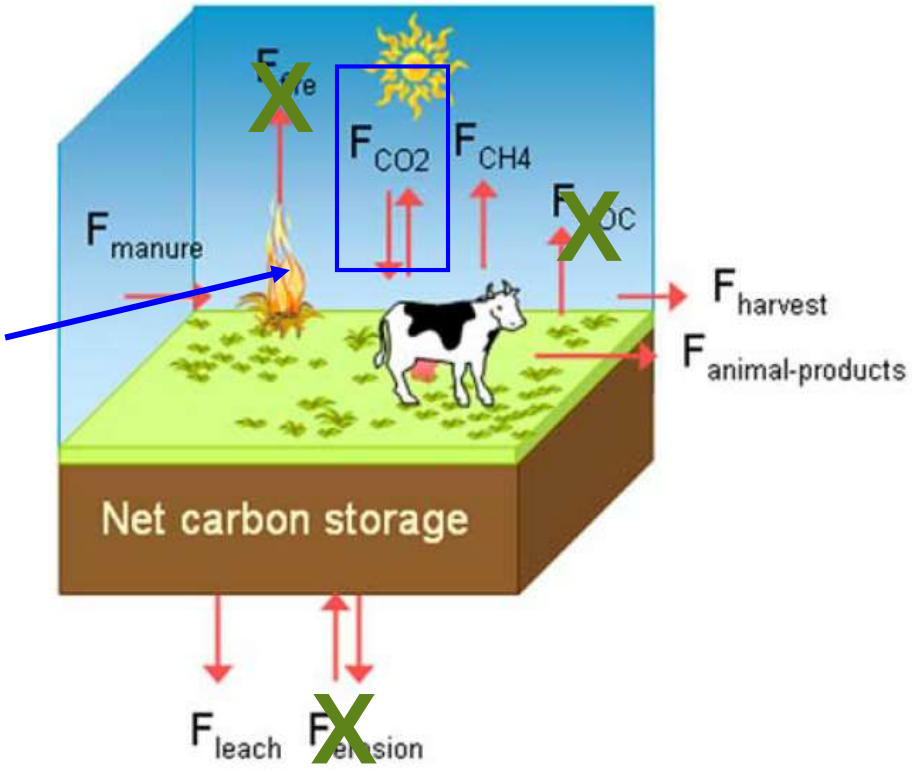
Analysis of C budget and GHG (N_2O, CH_4) emission in relation to management and climate



Carbon sink - Net Carbon Storage (NCS)



NEE=
Gross Primary Productivity (GPP)
- Ecosystem Respiration(Reco)

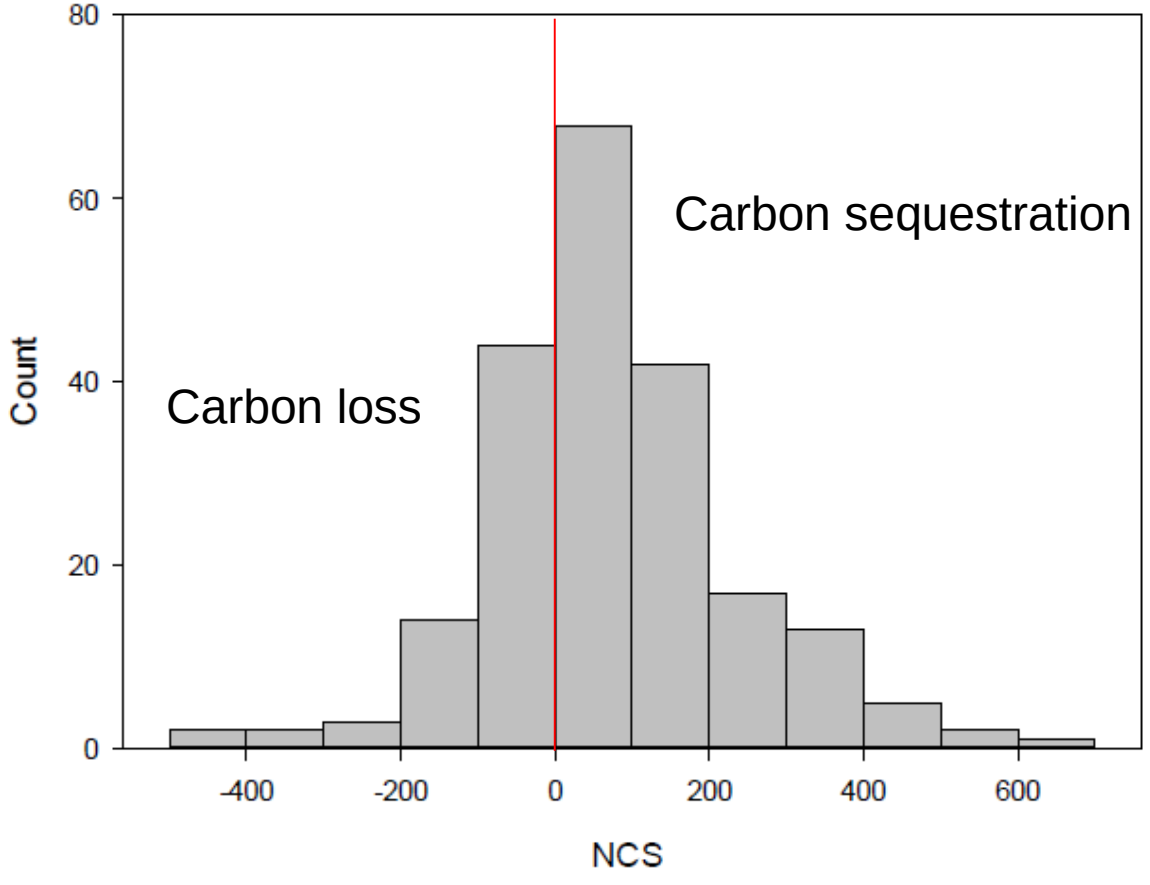


Simplified balance for temperate managed grasslands

$$NCS = F_{CO2} - F_{CH4\text{-}C} + F_{manure} + F_{harvest} + F_{animal\text{-}products} + F_{leach}$$

(Allard et al. 2007, Soussana et al 2010):

Frequency distribution of annual net carbon storage (NCS, g C m^{-2} yr^{-1})



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Collaboration with GEOGLAM

GSP, Digital Soil Map
FAO Global Land Cover /GAEZ

Satellite/ Model

- GPP
- NPP

Model intercomparison (GRA)

Statistics/ Models

- Carbon use (rangelands: FAO grazing density, IGLEAM also)
- Ecosystem C balance

GSP, Digital Soil Map

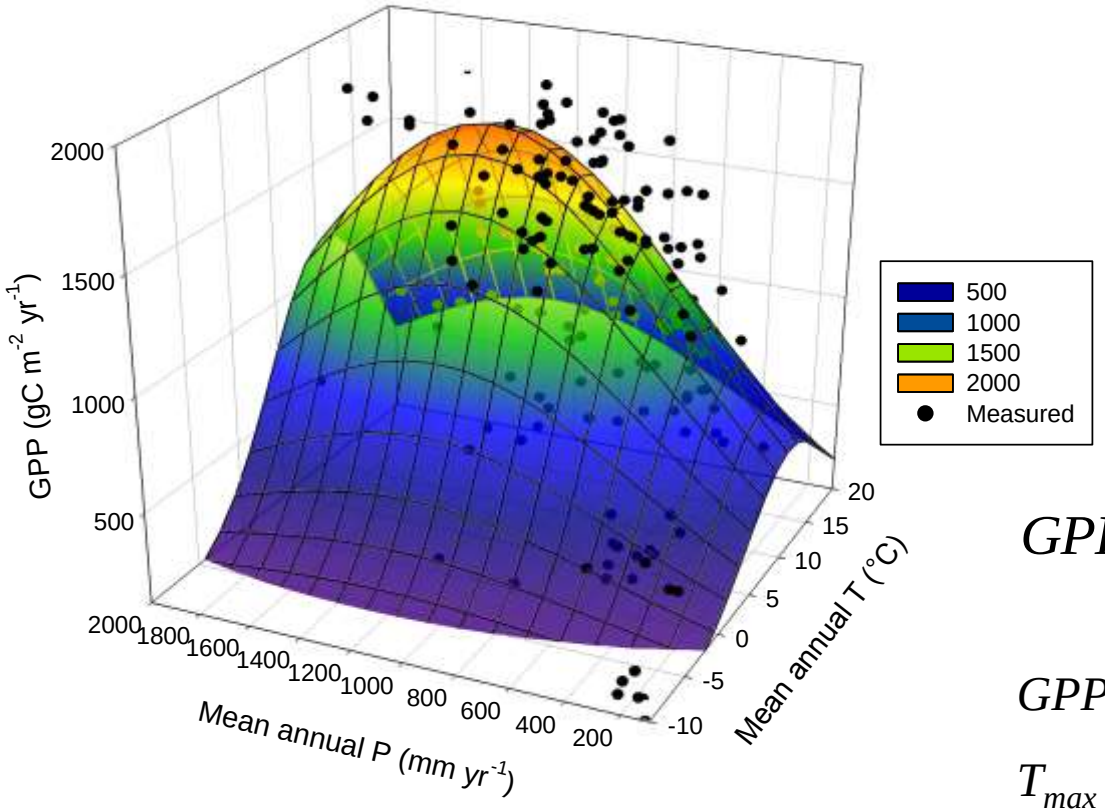
Model intercomparison (GRA)

Models

- Soil C maps; LIDAR for above-ground C
- Soil C sequestration

The plan is to build a data/model infrastructure and co-branded products
Can this work?

Annual Gross Primary Productivity (i.e. photosynthesis)



$$GPP = GPP_{\max}.e^{-0.5.\left(\frac{T-T\max}{b}\right)\left(\frac{P-P_{\max}}{c}\right)}$$

GPP_{max} = 1770 ± 70 gC m^{-2} yr^{-1}

T_{max} = 11.0 ± 0.5 ° C

P_{max} = 1280 ± 60 mm

Gaussian model (r^2=0.65, P<0.0001)

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How does NCS vary with management?

$$NCS = (f_2 + k_N.N_s).GPP + k_C.L_C$$

with:

Ns, Nitrogen supply (kg N ha^{-1} yr^{-1})

Lc = Manure – Digestible intake - Harvest

f_2 = 0.0901 ± 0.0141

k_N = 2.0 10^{-4} ± 8.44 10^{-5}

k_C = 0.660 ± 0.110

Multiple linear regression model

(r^2=0.65, P<0.001)

A simple statistical approach…

with low predictive ability at site scale

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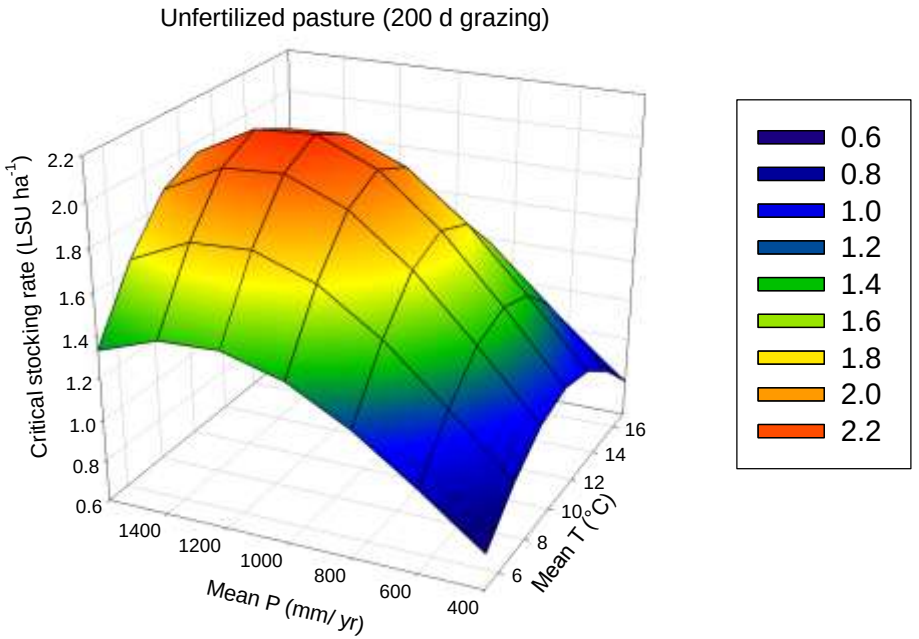
Critical stocking rate (SR*) for zero carbon storage

If carbon storage declines with grazing pressure, can we calculate a critical stocking rate leading to zero carbon storage?

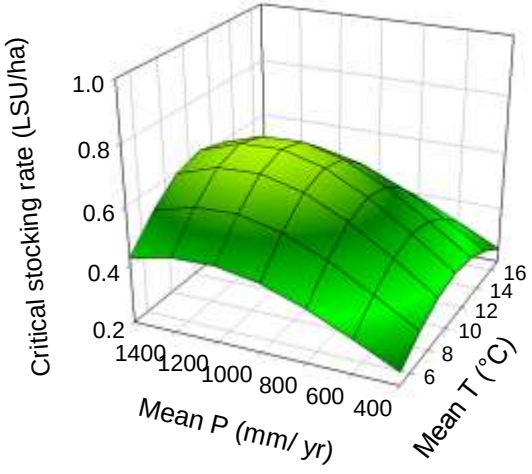


Carbon sequestration occurs frequently, even in intensive pastures

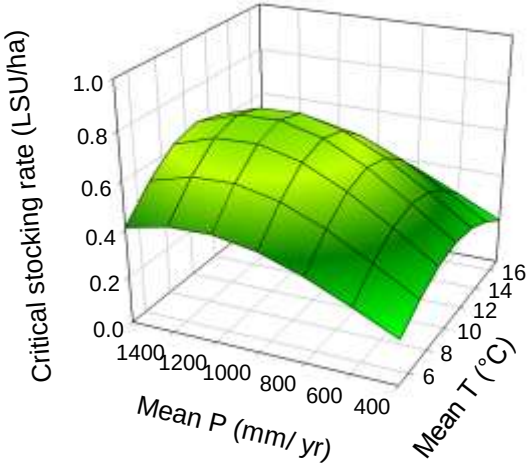
Critical animal stocking density for ‘zero carbon’ pastures

- **Does C sequestration compensate for non CO_2 emissions (CH_4, N_2O) on-site?**

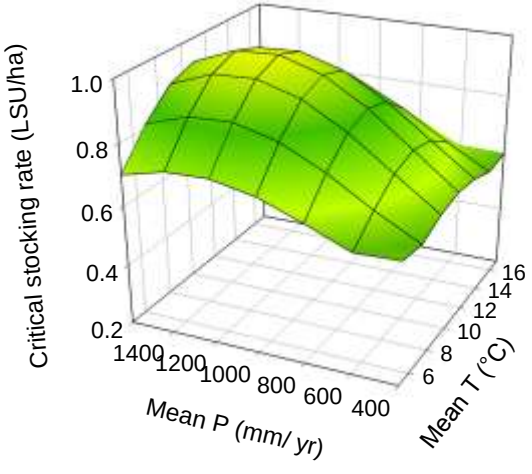
a. Unfertilized pasture (200 d grazing)



b. Mineral N fertilized pasture (200 d grazing)



c. Manure fertilized pasture (200 d grazing)



Questions

How to improve GPP estimates on pastures?

Which spatial grid?

Start with pixels, with flux sites (e.g. Europe, Australia)

Collaborations planned:

FAO and LEAP

INRA

GEOGLAM RAPP (CSIRO)

IIASA

A postdoc with modeling/remote sensing experience will be hired (ask Anne Mottet or Jean-Francois Soussana for further information)

Thank you for your attention !