Greenhouse gas budgets of grassland systems: consideration to match sustainability, food security and energy production in a changing climate

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Greenhouse gas budgets of grassland systems: consideration to match sustainability, food security and energy production in a changing climate.

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The Artists of ART
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Arjan Hensen - ECN

Edinburgh, 12. April 2011

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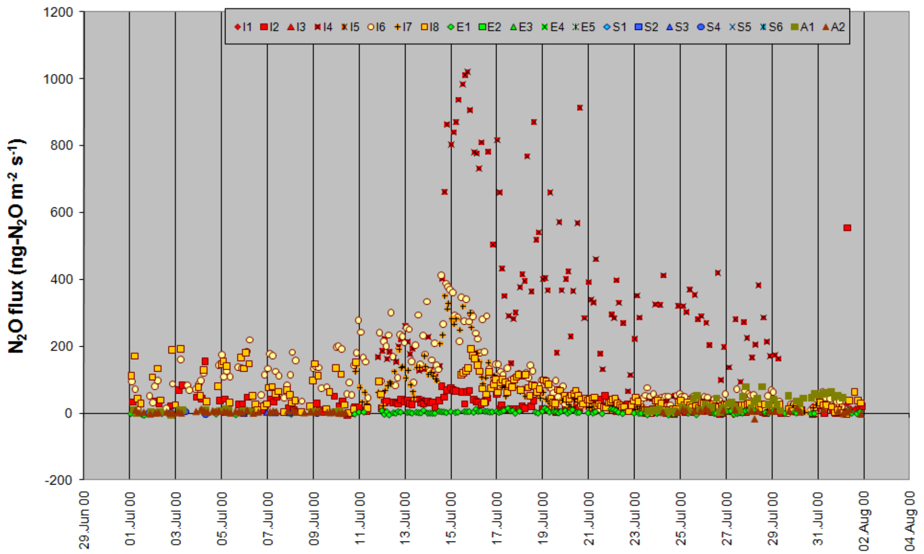
Preface

What a pitiable WP 1 scientists gets after a tremendous effort: numbers, numbers, numbers….



and he should go for the big picture…

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The modul race…

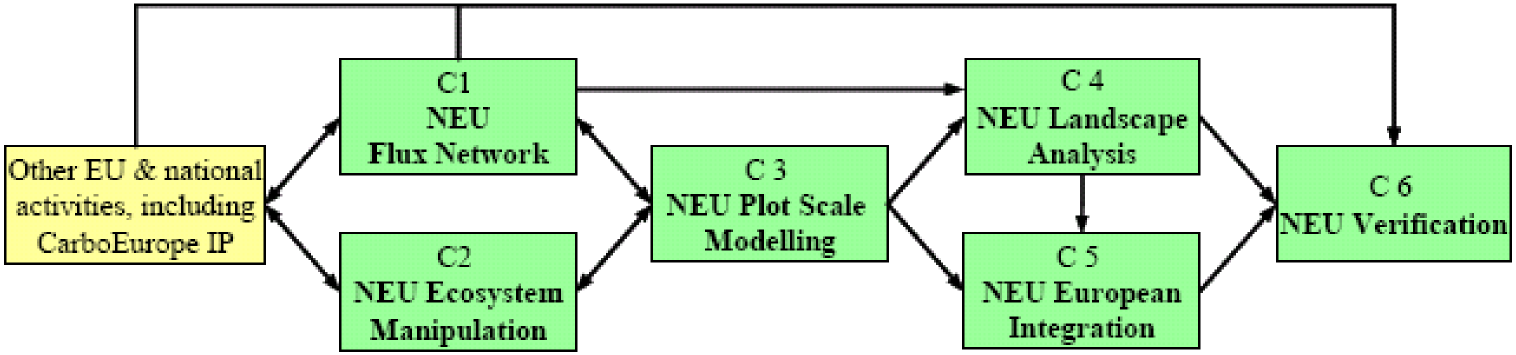

Figure 6.2. Information flow between the six main science Components of NitroEurope. The roles of four supporting Components (C7-10) are shown in Figure 6.4.

Let‘s do shortcuts during the next 15 minutes to contribute to the big picture

Outline: Grasslandsystems and GHG

- Yield variability and climate
- GHG emissions and grassland: N_2O versus C-sequestration
- Ecosystem services of grasslands
  - Food production
  - Ecosystem services
  - Energy production
- Orders of magnitude to keep in mind

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Role of grassland systems in European agriculture:

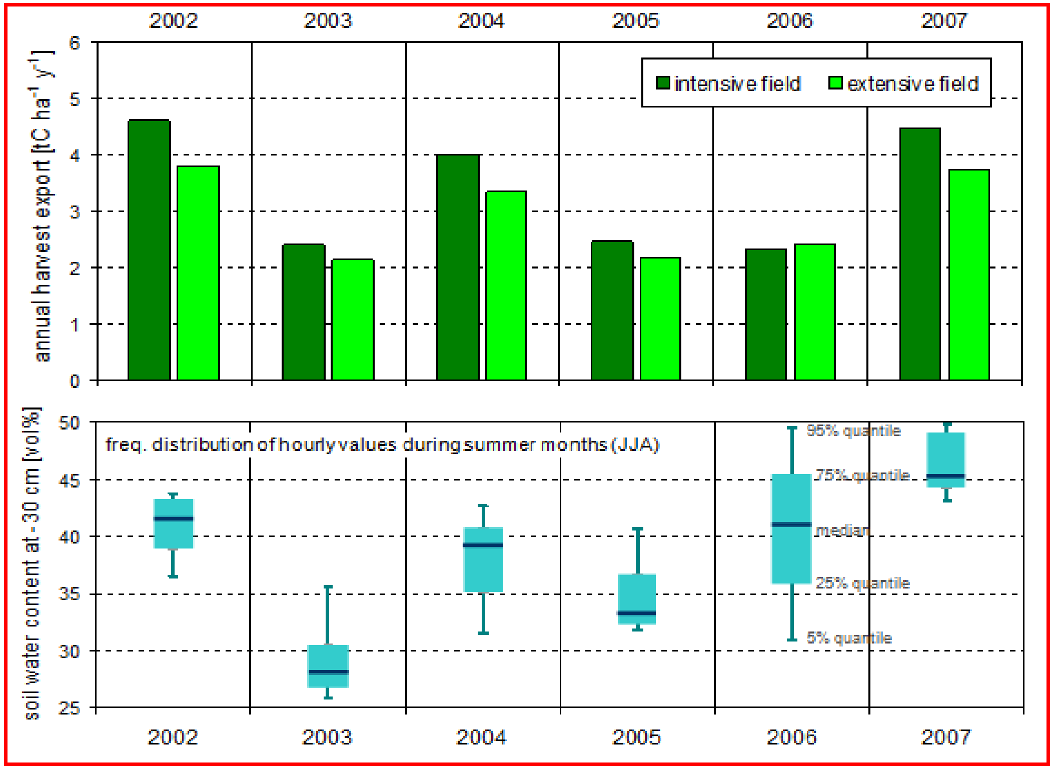
- Grasslands cover 0.6-1.5×10^6 km^2 that is 15% of the EU-25 territory, and 35% of the EU-25 agricultural lands.

- Switzerland: 60% of agricultural used land

- Grass is used by ruminants for dairy and meet production

Grass productivity and climate variability

Mown grasland in Oensingen: Soil water is important



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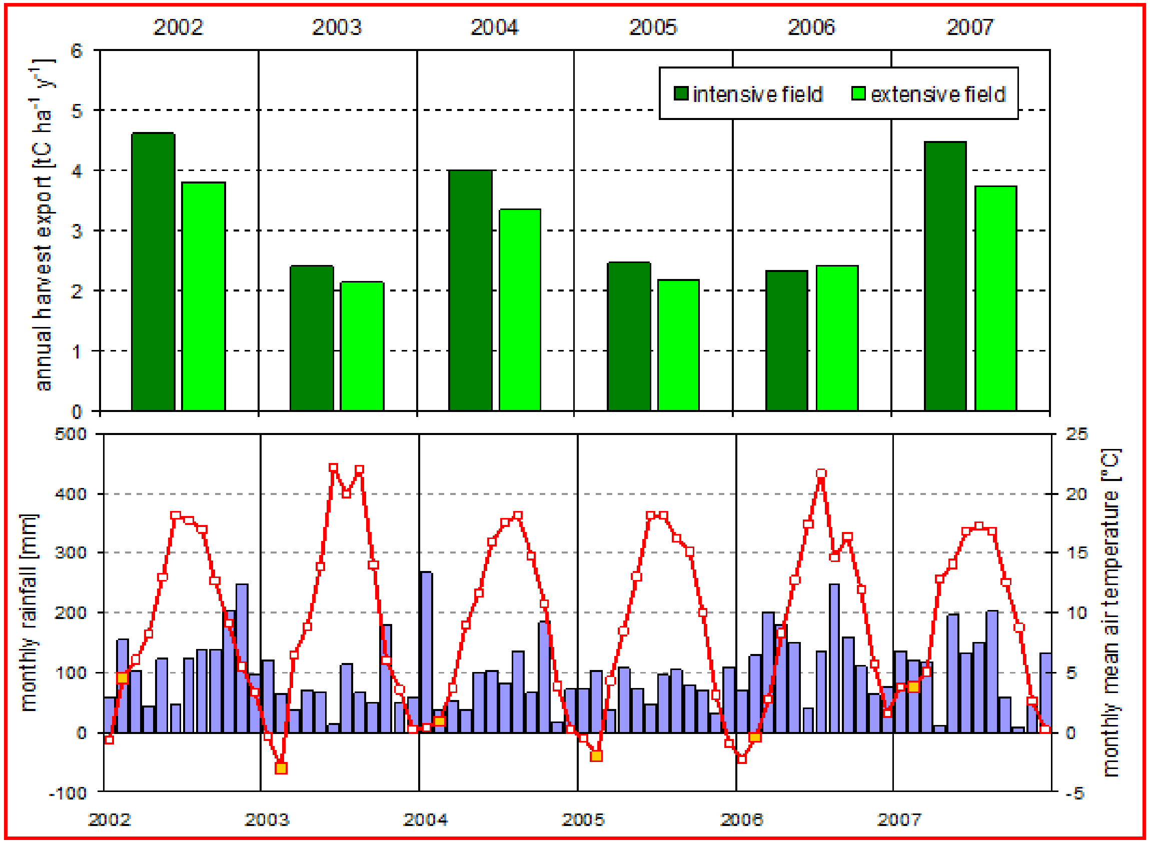
But apparently also the late winter/early spring temperature



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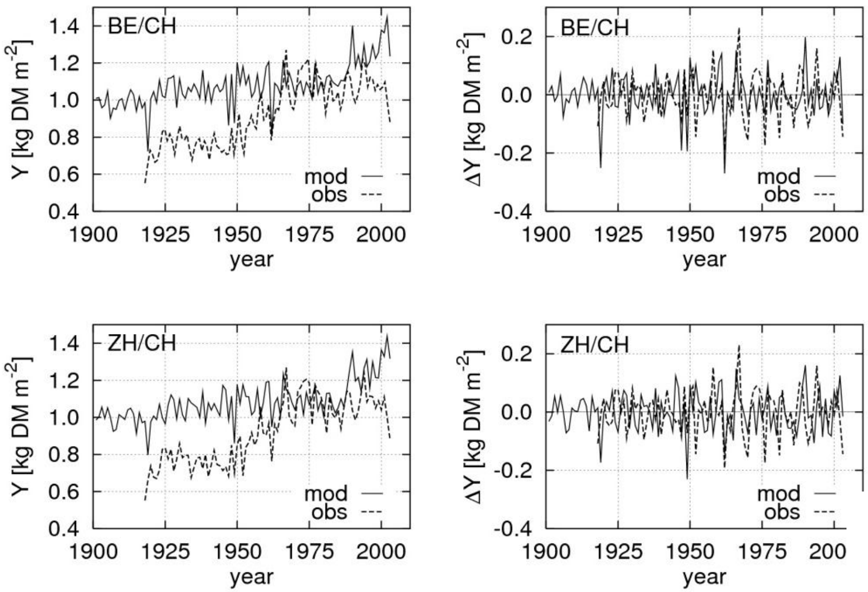
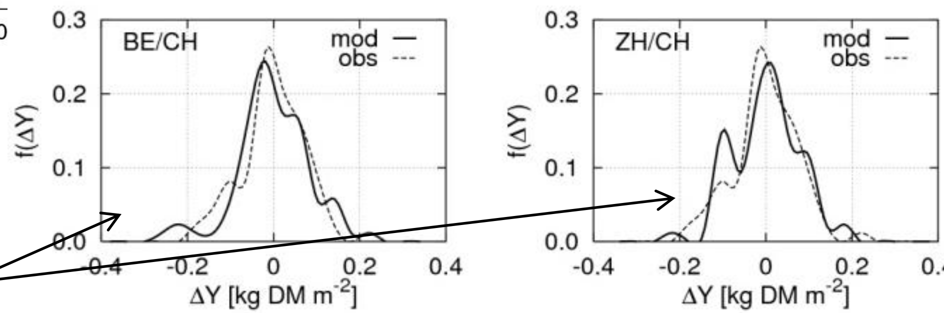
Is grass yield predictable based on simple meteorological drivers?



time series

detrended
time series and …
… distribution



In a statistical sense yes:

- T defines growing season length
- Solar Radiation defines pot. productivity
- Rain defines actual productivity

Empirical models tell us

- Meteorological related variability of the yield is in the order of 10% with largest deviation up to 20%

- Hypothesis: This variability will increase in the near future due to climate change

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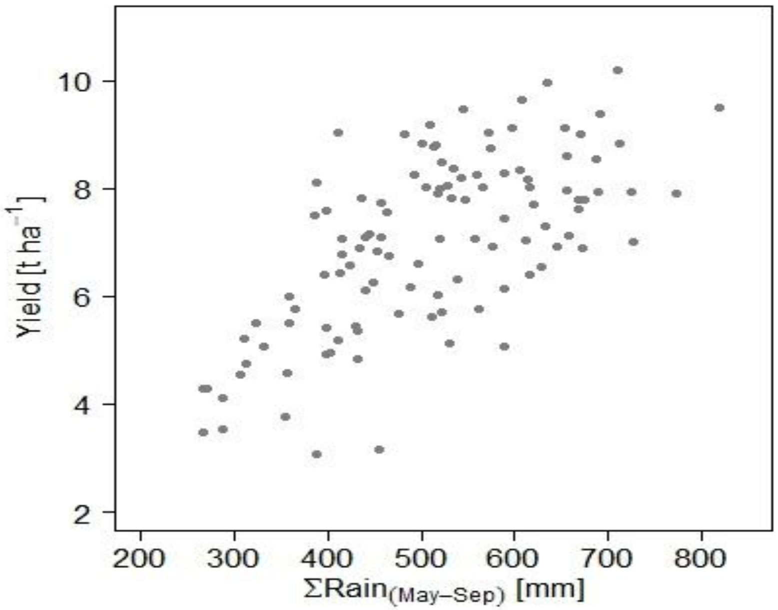
PROGRASS suggests a strong dependence on precipitation



Simulation with processed oriented model PROGRASS

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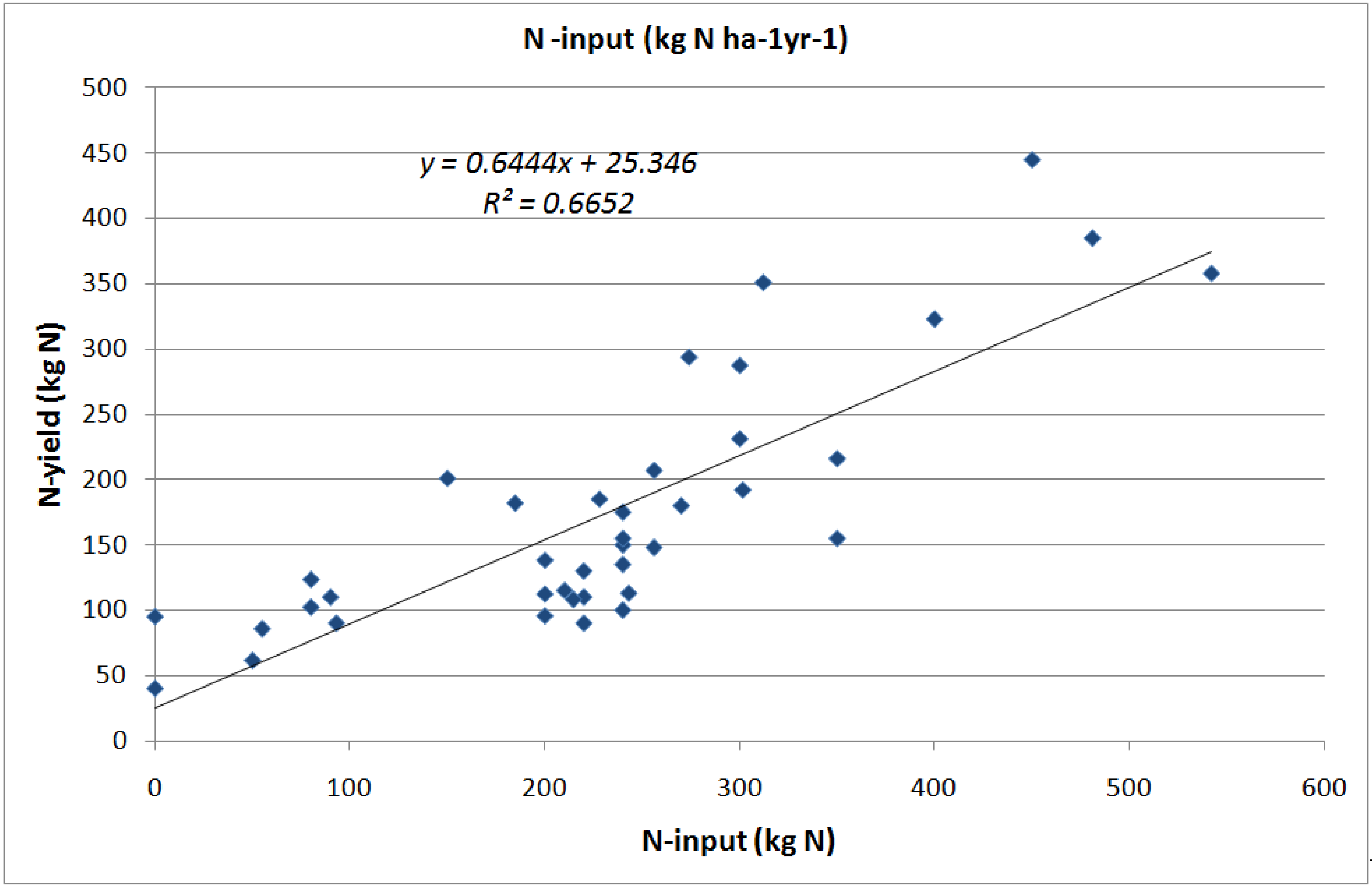
Relation between N-input and productivity of European grassland systems



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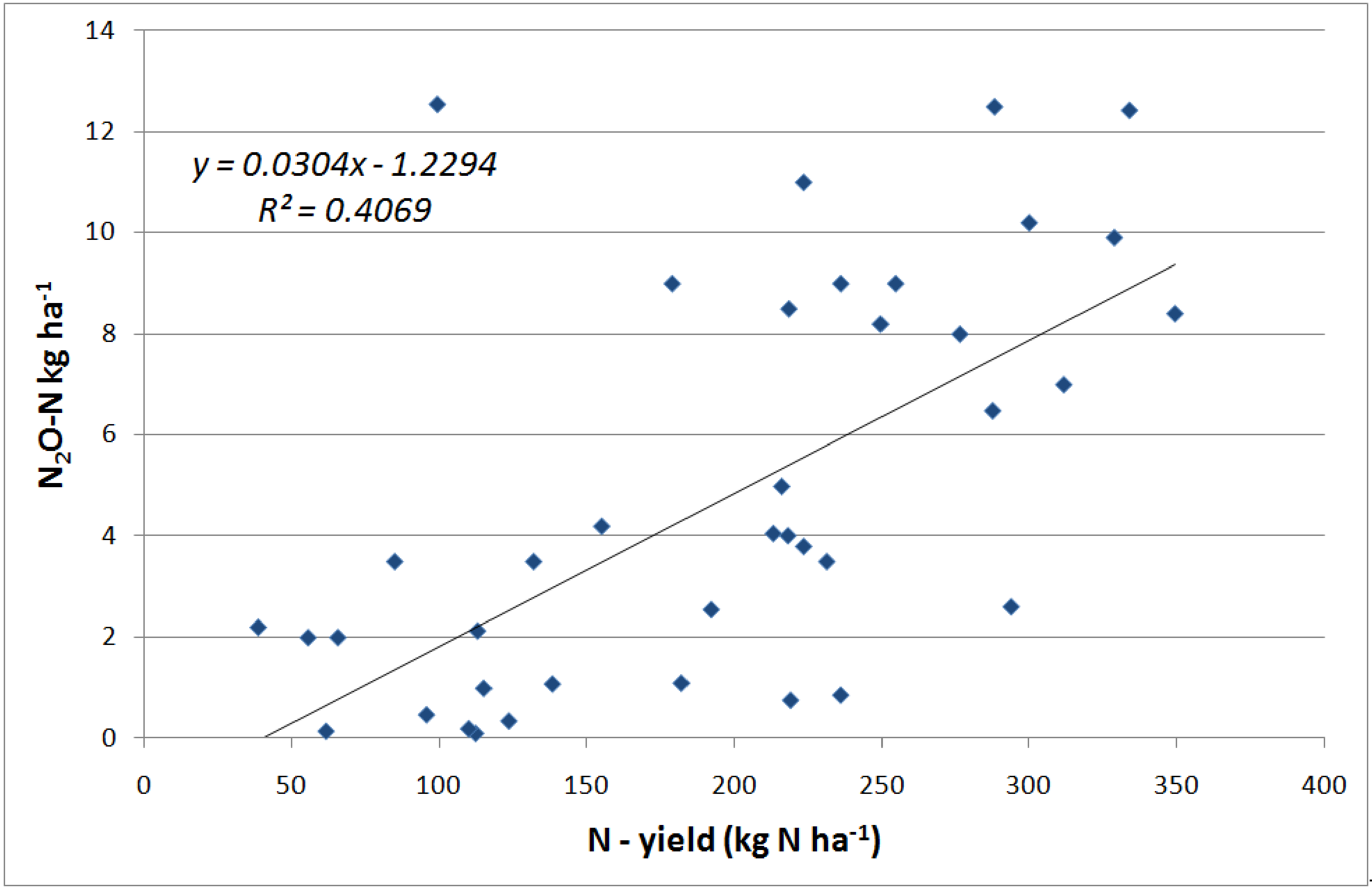
N_2O emission and N-yield



Increasing pressure on extending grasslands to serve higher ranking societal needs:

- Mitigation of GHG emissions by C-sequestration
  - “The carbon sequestration efficiency of grasslands, defined as the ratio of NBP to NPP, amounts to 0.09±0.10. Therefore, per unit of carbon input, grasslands sequester 3–4 times more carbon in the soil than forests do, making them a good candidate for managing onsite carbon sinks. Ciais et al. (Biogeosciences Discuss., 7, 5997–6050, 2010)

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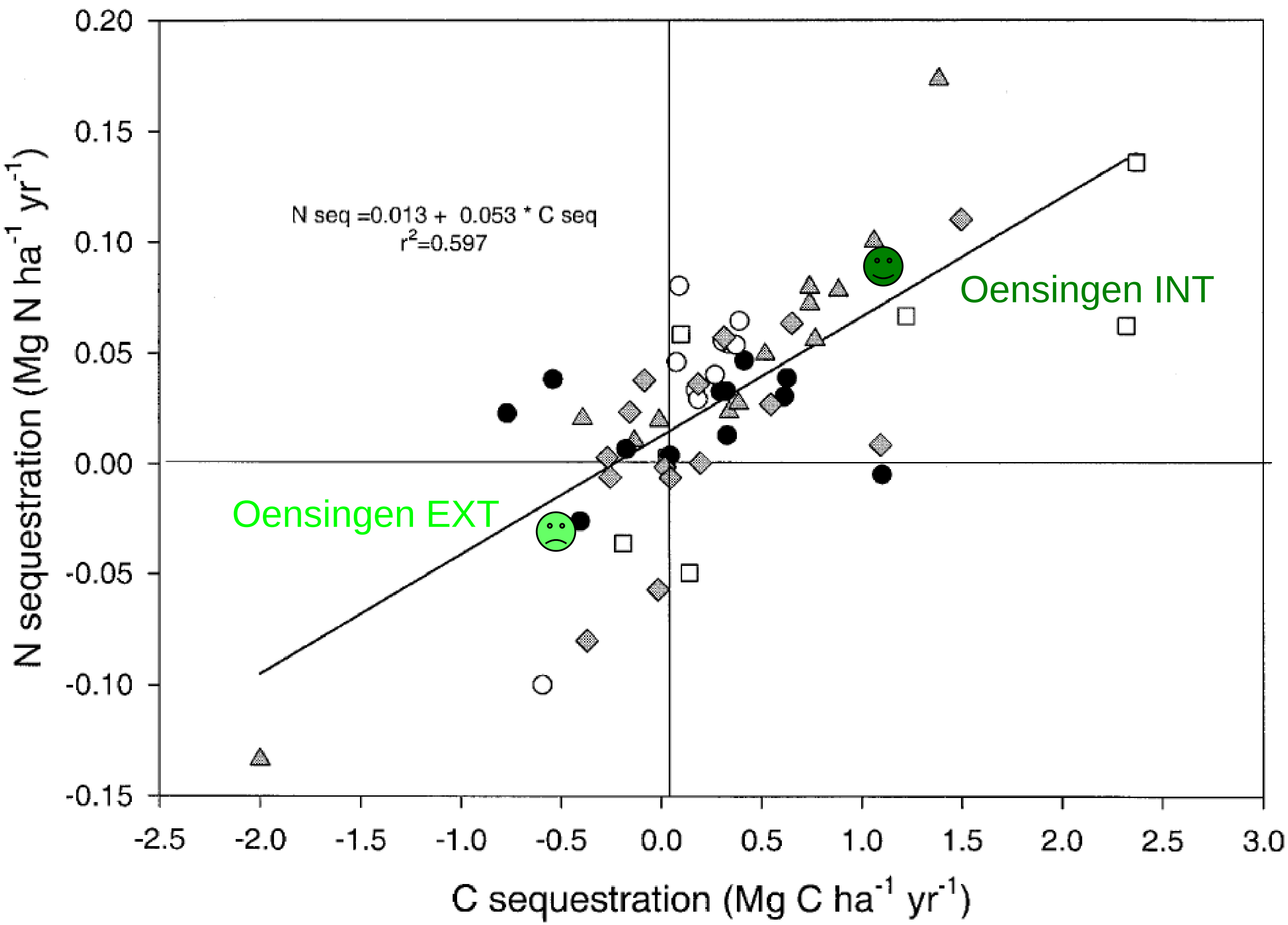
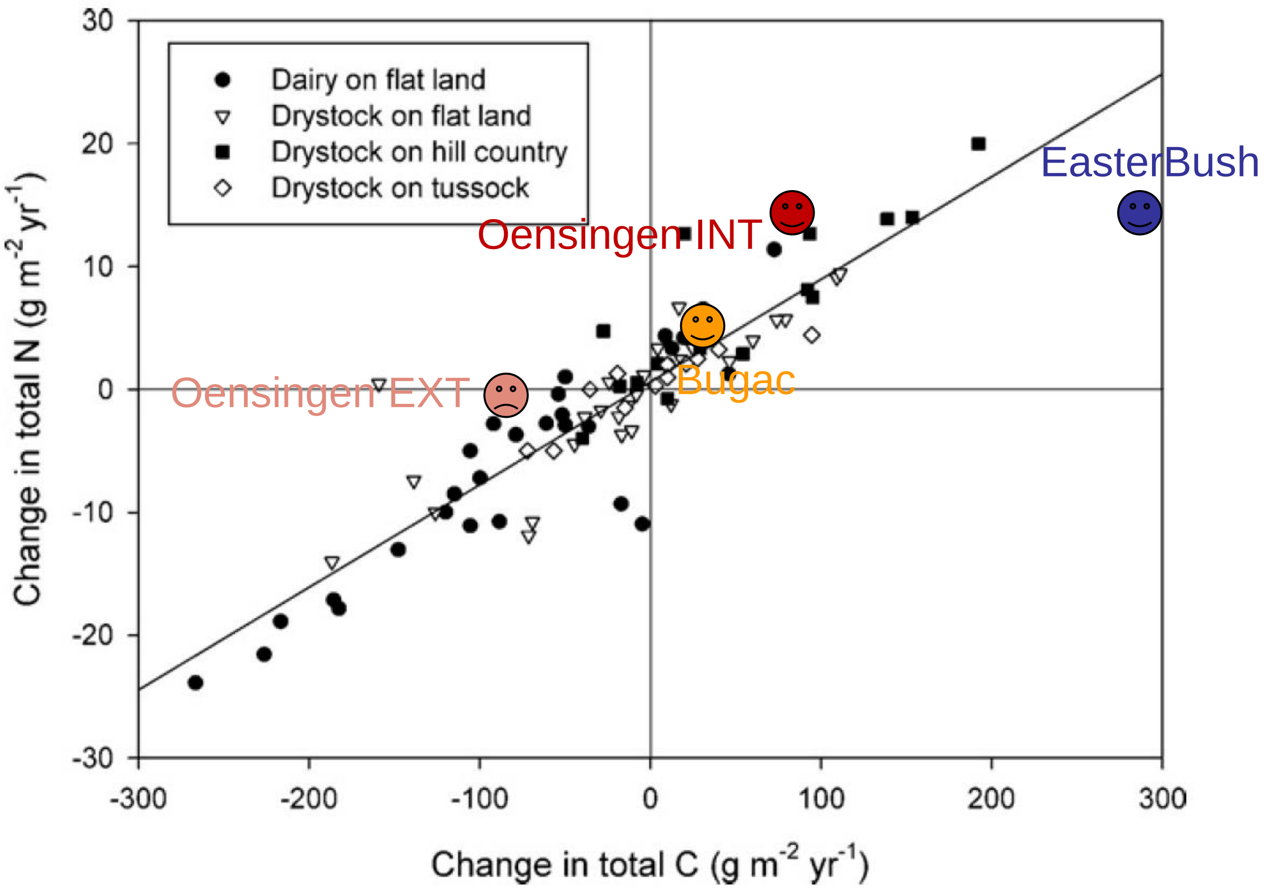
Literature overview from Conant et al. (2005, Nutr.Cycl.Agroecosys.)



General relationship between C and N sequestration of grazed grasslands

New Zealand study by Schipper et al. (2010, Agric. Ecosys. Environ.)



Listen to the talk by Christof Ammann tomorrow 12:00 Carrik 2&3

N-cost of C sequestration in a fertile soil

- typical C:N ratio in fertile soil is 10.
- Sequestring 1.0 t C means sequestring 0.1 t N
- 1 t N costs $ 800 (if applied as mineral fertiliser)
- 45 % of applied N is lost to atmosphere and water.
- 1 t sequestered C needs $ 145 worth of N (= $ 40 / t CO_2)

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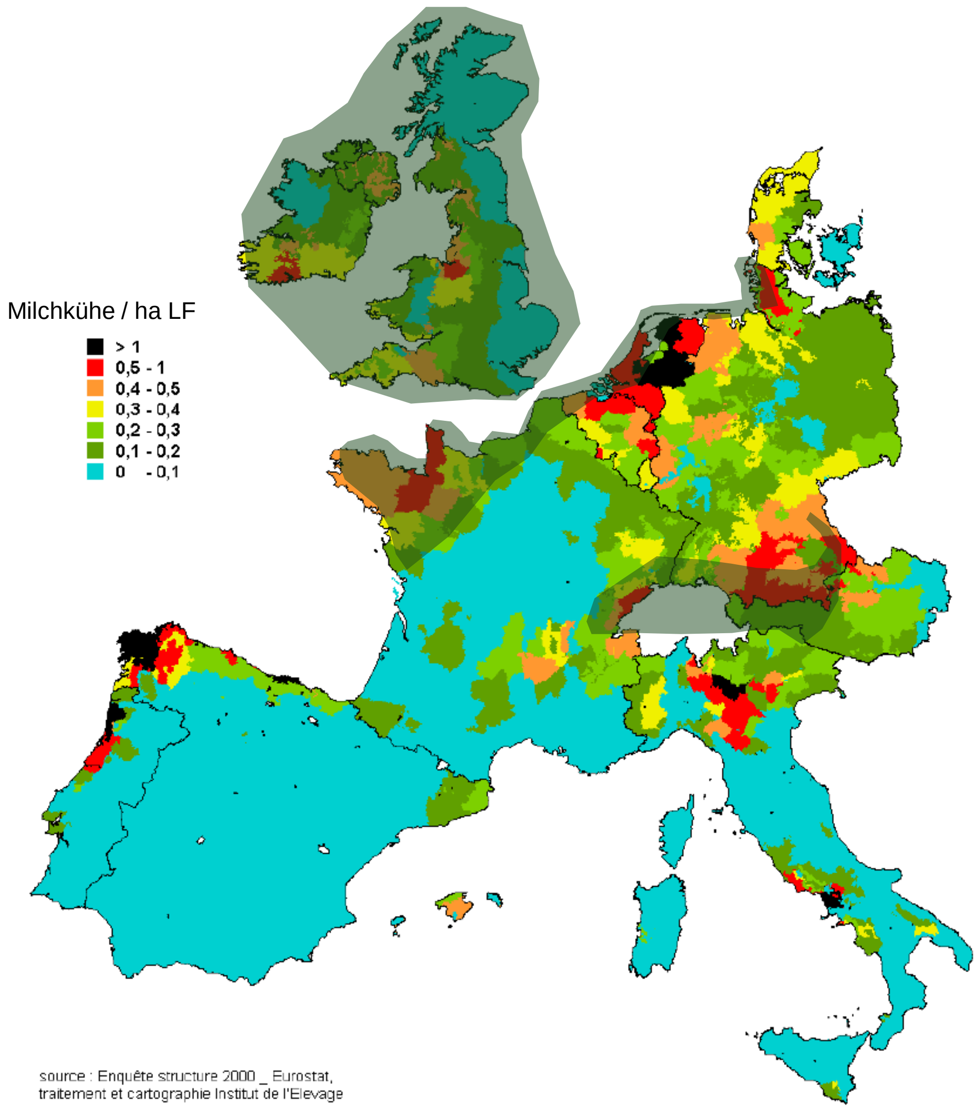
Main food product of grassland: Dairy product (milk and meet)

- Green milk: Feeding of animals based > 85% on roughage (gras, hay , etc…)

Currently only about 10 to 20% of the European milk is green milk



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Additional ecosystem services of grasslands

- Extensively managed hay meadows are a large biodiversity reservoir
- Species rich pastures have a higher yield
- Grassland process organic manure that originate from diary production and meet production in general
- Grassland are sinks for reactive trace gases such as NO_y, O_3, NH_3 etc

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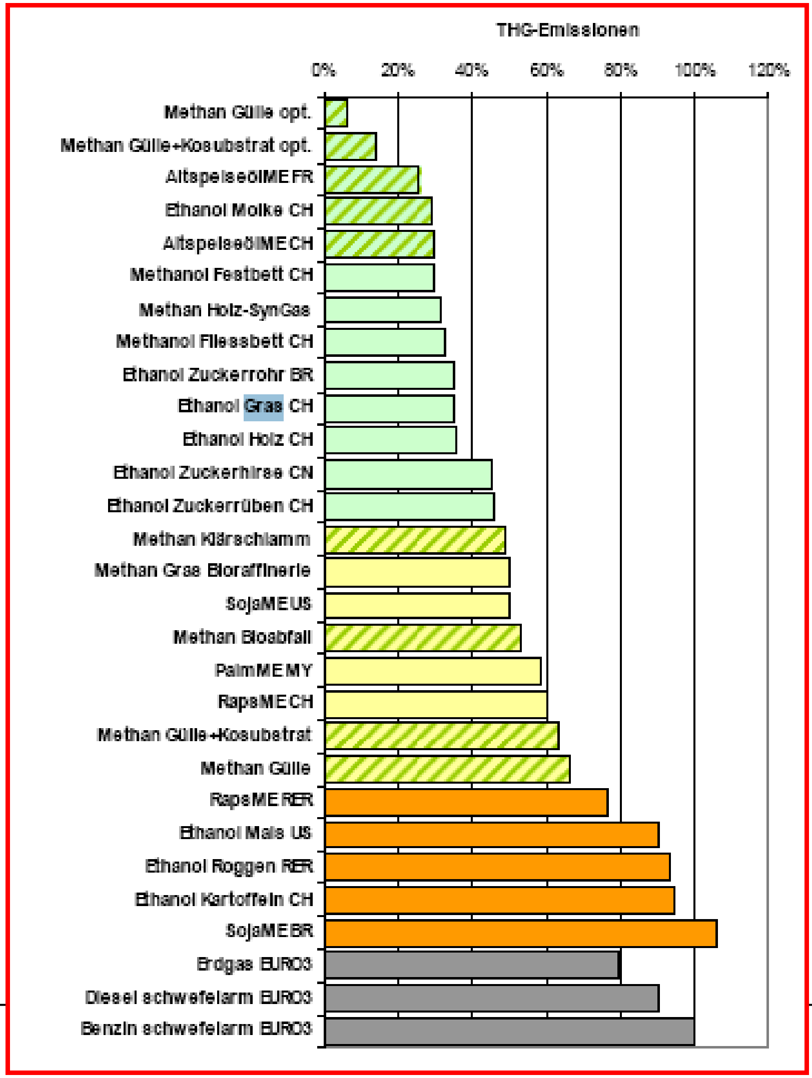
Gras based energy production

- Mean yield: 10 t DM ha^{-1} $year^{-1}$
- 1 kg DM yields 1.0 … 4 kWh
- We use througout the presentation a value of 1.0 kWh based on the report „Ökobilanz von Energieprodukten: Ökologische Bewertung von Biotreibstoffen, R. Zah et al., Empa (2007)“
- 1 ha might produce: 10‘000 kWh or 1‘000 liter gasoline

LCA biofuel Gras is a reasonable biofuel in the GHG context



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Energy use related to management of Golf courses

From Thumm et al: University Hohenheim „Energetische Verwertung des Schnittguts von Golfanlagen

- A 65 ha 18 hole golf course potentially produces 65’000 liter biogasoline per year
- 1000 members driving cars with an average mileage of 10 l 100 km^{-1} can drive 650 km $year^{-1}$
- *(Alternatively you could feed 400 citizen)*

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GHG aspects of Bioenergy:

- Per hectare 1000 Liter gasoline can be gained. This corresponds to 2320 kg CO_2 or 632 kg C
  (conversion factor used: 1 liter gasoline yields 2.32 kg CO_2 or 0.632 kg C).
- The production is associated with an emission of 4.5 kg N_2O –N.
- With a GWP of 127 this corresponds to 571 kg $C_{equivalent}$ or 91% of the “saved” CO_2 emissions
  (1 kg N_2O – N corresponds to 127 kg CO_2 -C $_{equivalents}$)

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Further hypothesis: Dairy and meat production will decline by 20% due to:

- Adaption of production level to larger grass and crop yield variability
- Due to NEU the demiterian idea becomes a big societal success
- Awareness of the urgent need to reduce GHG emissions is increasing

But average grass yield stays constant

- Total grassland production in Switzerland: 5.4 Mt DM year^{-1}
- 20% corresponds to 1.08 MT DM year^{-1}
- Associated energy production potential: 1100 GWh year^{-1} or 3960 TJ
- Total energy consumption Switzerland: 865250 TJ
- Potential grassland contribution: 0.45%
- *With bankers words: Peanuts!*

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What happens if a Porsche Cayenne owner becomes a demiterian?

- Average meet consumption: 100 kg per capita and year
- Cut in half
- With this 250 kg CO_2 equivalent are saved
- This allows to drive about 500 - 800 km

Conclusions

- Grass should primarily be used to feed ruminants that in turn feed humans
- Bioenergy from grassland system cannot solve any energy supply problem.
- It can only be an option as a surplus/waste management in connection with conservation or increase of biodiversity and potential C-sequestration.
- Increased grassland productivity for energy production only will be the wrong way to go!

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Thank you!

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