Session 6: Experimental climate change – the case of a forest observatory (O_3HP) in Southern France

Ilja REITER
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Oak Observatory at the Observatoire de Haute-Provence

FR3098 ECCOREV (CNRS)

mission, installations & features

mission

- study the ecosystem of Pubescent (Downy) Oak and
- it’s evolution in the response to Global Change: climate change, pollution …

O3HP (OHP, CNRS)

Puechabon (CEFE, CNRS)

Fontblanche (INRA)

CLIMED (ANR/ IMBE)

- experimental treatments : rain exclusion plot & soon an irrigation plot
- sensing network, associated field & lab instruments

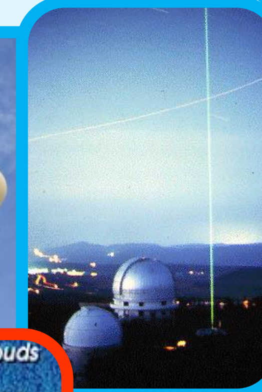
special features

- interfaced to atmospheric sciences at the OHP

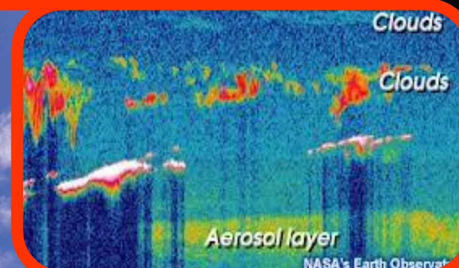
Research environment of the O3HP
vertical scaling

0 m – 35000 m

Station Gérard Mégie



10 km - 80 km



5 m - 20000 m

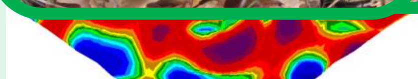
10 m -100 m

temporary installations

ANR CANOPEE

MEDEE

2 m -10 m



ANR SECPRIME²

-8 m to 6 m

mission, installations & features

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- experimental treatments : rain exclusion plot & soon an irrigation plot
- sensing network, associated field & lab instruments

special features

- interfaced to atmospheric sciences at the OHP
- expertise (OHP) for instrument development and metrology
- on-site conference facilities, hostel, restaurant
- field site with climatised laboratory, database, power & network
- 2 biologists (IR CDI & AI-CNRS CDD)

ECCOREV FR3098

ECosystèmes COntinentaux et Risques EnVironnementaux

- towards a dynamic interdisciplinarity in environmental research -

10 institutes
37 laboratories
2 observatories
O3HP, OHM

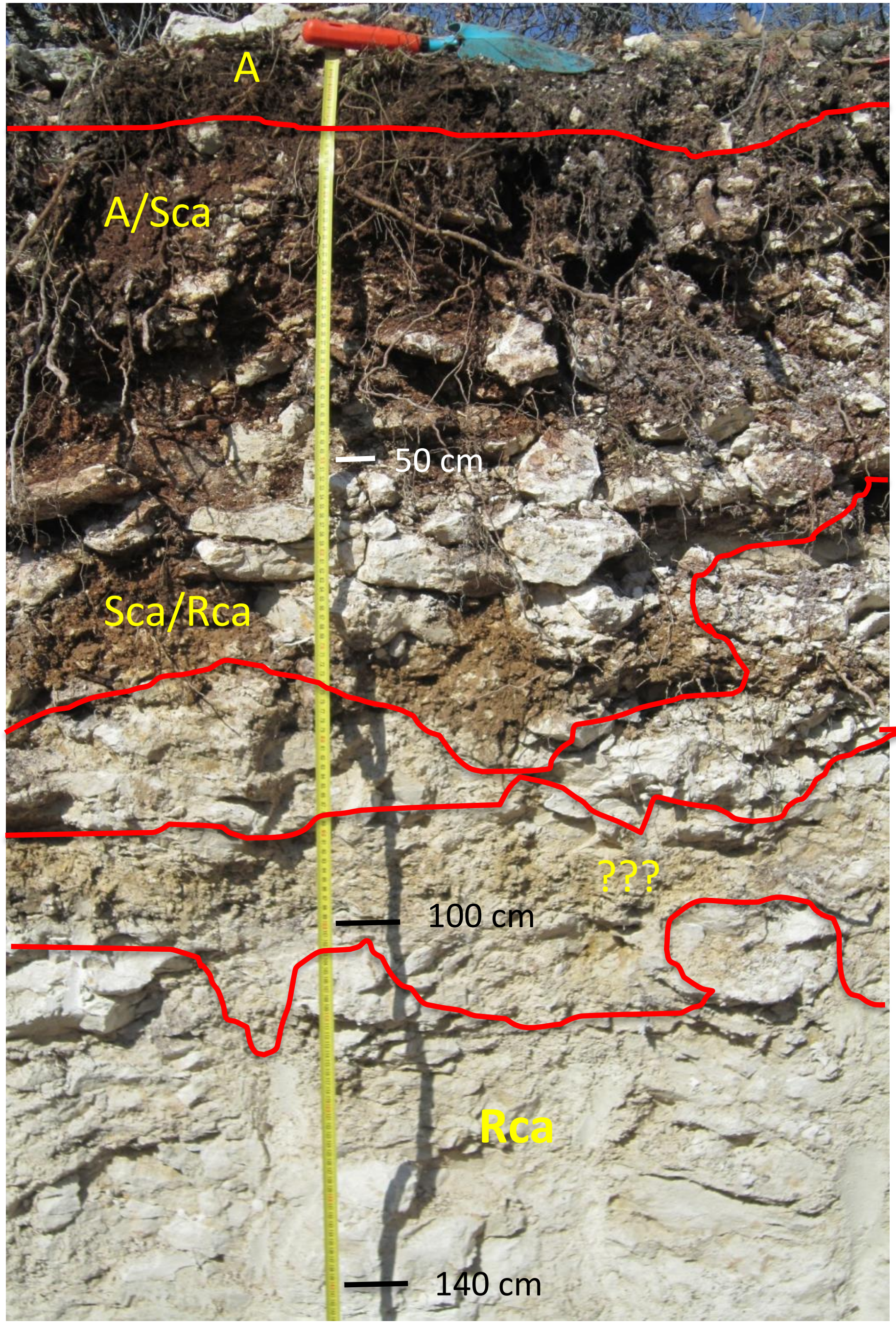
Principlal institutes of ECCOREV currently involved in the O_3HP :
OSU – Pytheas : **IMBE** – Institut Méditerranéen de Biodiversité et Ecologie marine et continentale / **OHP** - Observatoire de Haute-Provence/ **CEREGE** – Centre d'Etudes et de Recherche des Géosciences de l'Environnement
CEA / **IBEB** – Institut de Biologie Environnementale et de Biotechnologie

www.eccorev.fr

Calcosol OHP

(Saint Michel l'Observatoire)
Pubescent Oak ecosystem

- **between 80 cm & 110 cm clayey horizon**
- **penetration of Sca/Rca down to 70 cm in formof pockets**
- **Rca - calcarious bedrock, compact and hard, inpenetrable by rooting systems**



perspectives

- interdisciplinary research around biogenic particle (aerosols) formation and it’s relation to air pollution

- emphasis on research on soil-related processes
- nutrient – cycling

- near real-time modelling of tree and/or ecosystem physiology (+ visualisation), data shared with experimentators

- OHP-collaborations in terms of technological development

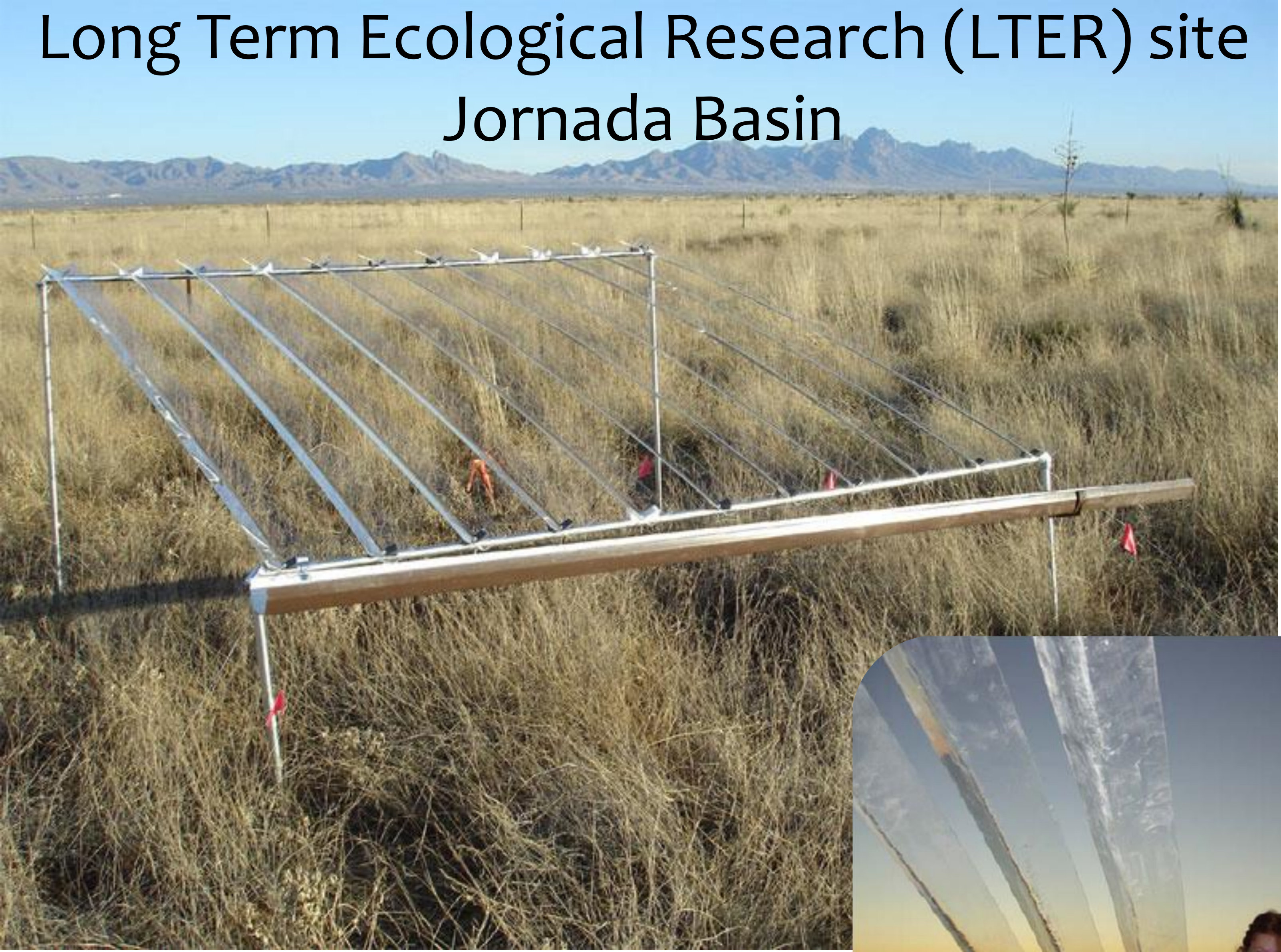
Precipitation manipulation experiments

Schwendenmann *et al.* 2010 – Indonesia – cacao agroforestry


Dispositif d'exclusion par des bâches polyéthylène d'un tiers des pluies.

- Brésil, Etat de Sao Paulo, Itatinga

Long Term Ecological Research (LTER) site Jornada Basin



- five levels of precipitation: 50% and 80% reduced precipitation, control (incoming precipitation), and 50% and 80% increased precipitation
- After the second year, the precipitation treatments are reversed to simulate high interannual precipitation variability typical of arid ecosystems

Rio Mayo, Chubut, Patagonia, Argentina

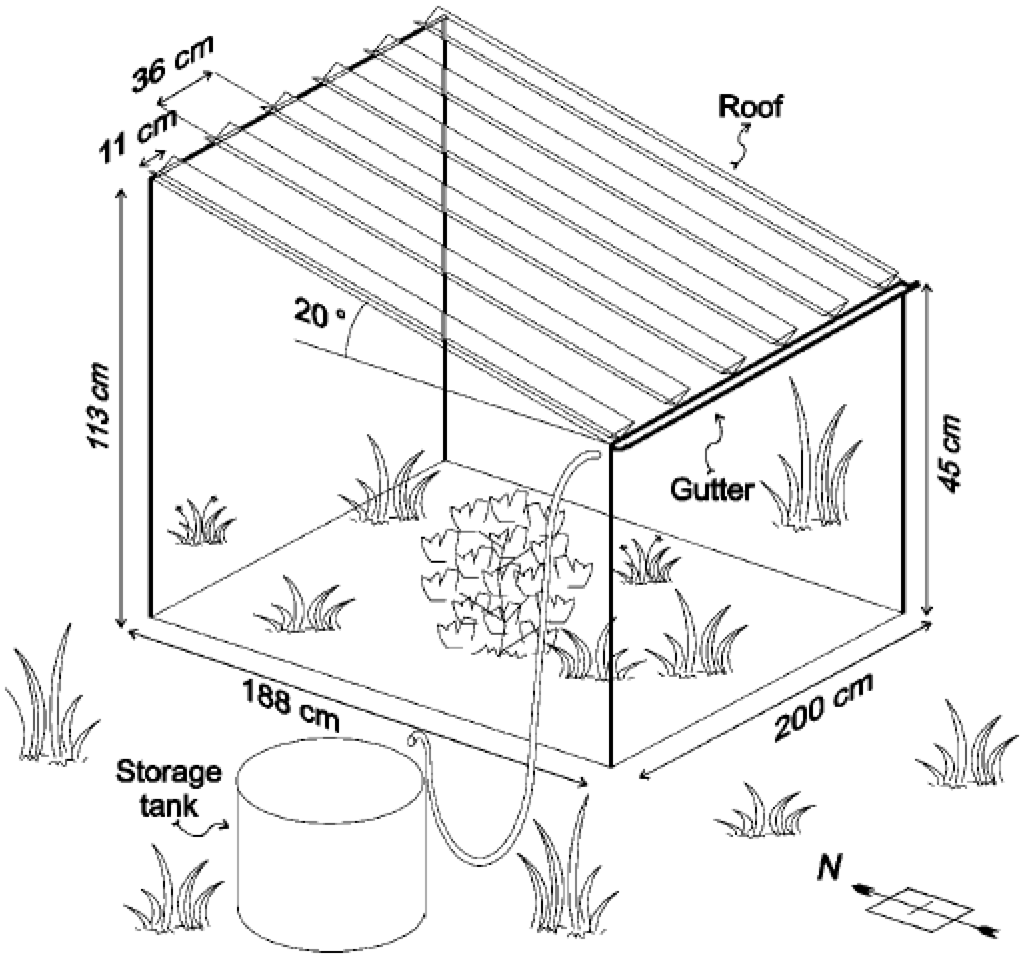


Fig. 1 Design of the rainout shelter that intercepts 30% of incoming precipitation

designed for shrubs

acrylic bands excluding 30%, 55%, 80% of rain,

surface 3.76 m²

tank for water storage

Yahdjian 2002, Oecologia

Coto Nacional de Quintos de Mora /Central Spain

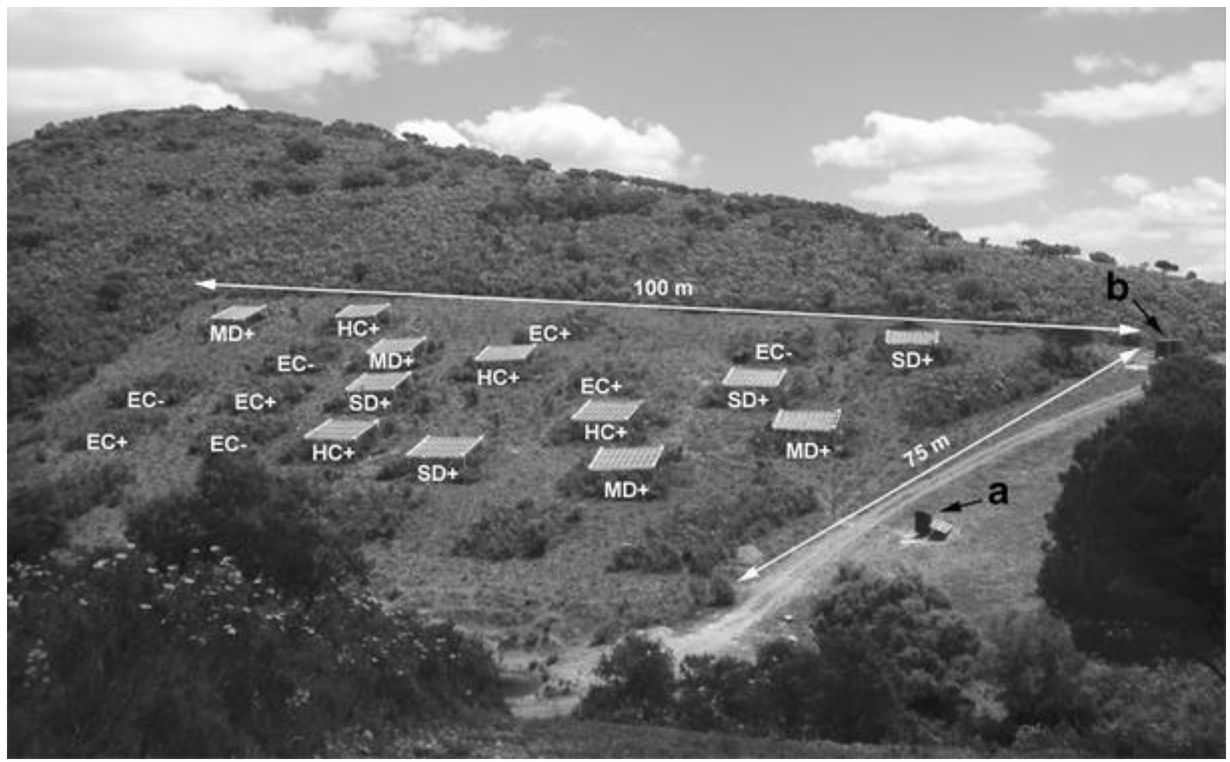
Stand view showing the experimental setup. The plots were subjected to the following treatments:

environmental control (EC), historical control (HC), moderate drought (MD), and severe drought (SD).

The areas between plots were cleared prior to the experimental fire in September 2009. Symbols + and – represent burned and unburned plots, respectively. **a** Solar panel connected to an electric accumulator. **b** Water containers for irrigation

Mean annual temperature is 14.9°C, with large daily and seasonal fluctuations.

Mean annual rainfall is 622 mm (7% in summer, 31% in autumn, 29% in spring, and 33% in winter), with high inter-annual variability but usually with two or three months of summer drought



Parra et al. 2012, Int J Biometeorol

- Throughfall exclusion panels, Tapajos National Forest. The throughfall exclusion panels drain into wooden gutters constructed in the forest understory. Photos from Nepstad et al., 2002.

- This data set reports the results of a rainfall exclusion experiment in the Tapajos National Forest (Flona-Tapajos) at km 67 along the Santarem-Cuiaba BR-163 highway. From December 1999 through April 2005, following a one-year pre-treatment phase, rainfall was excluded from one of two 1-hectare plots of seasonally dry humid tropical forest. Soil emissions of carbon dioxide (CO_2), nitric oxide (NO), nitrous oxide (N_2O), and methane (CH_4) were monitored in order to determine the likely effect of increasingly frequent El Nino drought episodes in the Amazon basin. Soil trace gas flux data are provided in one comma-separated data file.

Fig. 1 Throughfall exclusion installation at Caxiuanã forest. One hectare (100 m × 100 m) of plastic panels draining into aqueducts intercepts incoming rain and drains it away from the soil, causing an artificial drought. The panels cover ~80% of the ground area and were in place throughout the whole duration of the experiment, with the exception of the 4–21 November 2002, when they were removed.

Fisher *et al.* 2007 – Eastern Amazonian rain forest

Arkansas Agricultural Research & Extension Center turfgrass

surface : 35 ft x 130 ft. x 17 ft. (422 m²),   rain-exclusion 100%

Konza Prairie Biological Station, near Manhattan, Kansas

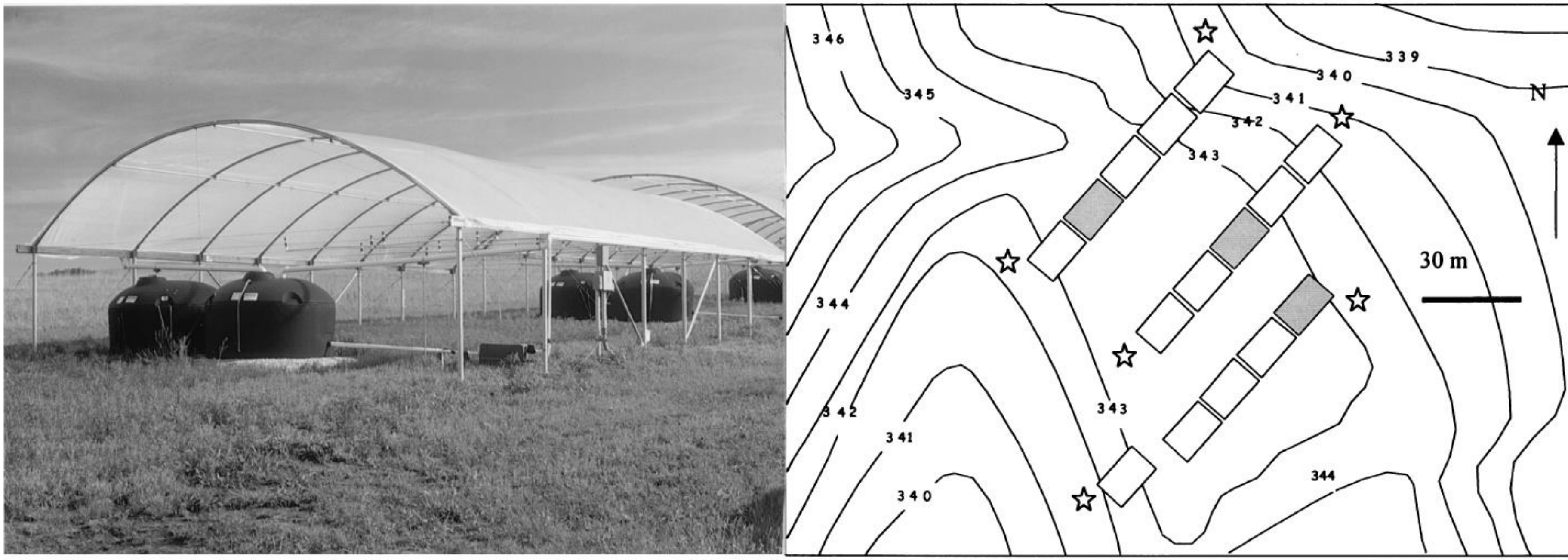


Figure 1. Left: One of 12 rain exclusion shelters, showing rainfall storage tanks and irrigation system erected for the rainfall manipulation plot study at Konza Prairie Biological Station in northeastern Kansas. See text for full description. **Right**: Map showing site topography and study plot layout. Rectangles denote perimeters of rain exclusion shelters. Shaded rectangles are no-shelter control plots. Stars indicate locations of rain gauges used to monitor natural rainfall and determine quantities for experimental application. Elevations in meters above mean sea level.

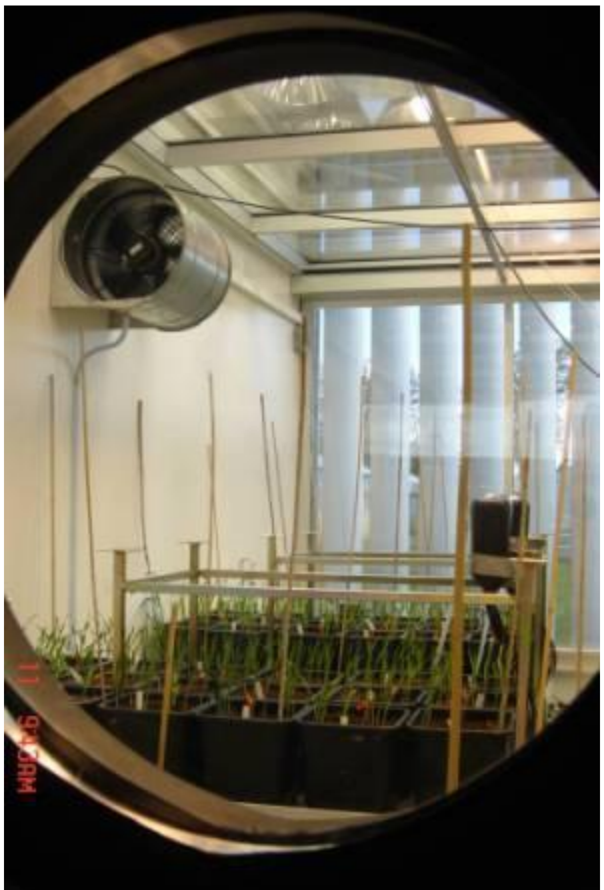
Fay et al. 2000, Ecosystems

Georgia – large rainout shelter

- Automatic rainout shelter at UGA Griffin Station turfgrass research, used to protect experiments performed in containers. However, the shelter is very dim.

- The Hawkesbury Forest Experiment (HFE) on the grounds of the University of Western Sydney’s Hawkesbury campus consists of whole tree chambers that simulate future climates and CO2 concentrations and rainout shelters that can simulate altered patterns of seasonal rainfall.

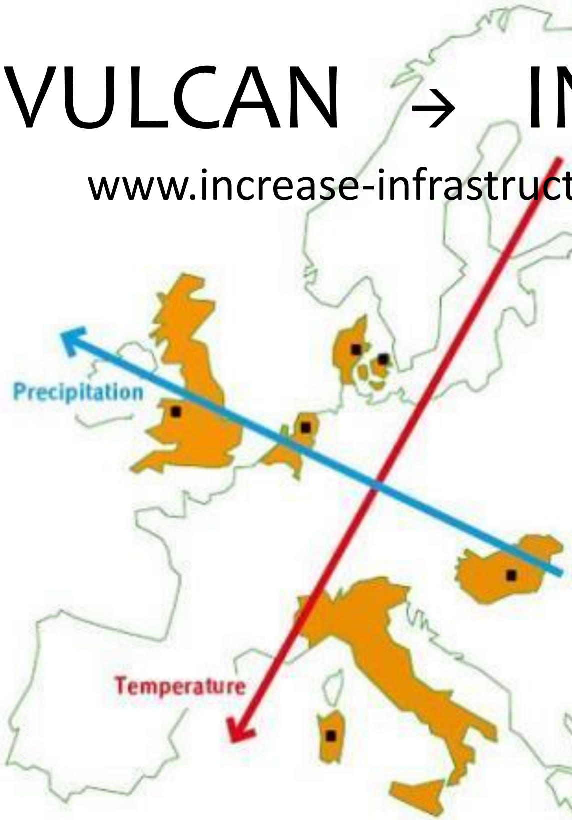
RERAF phytotrons, Denmark

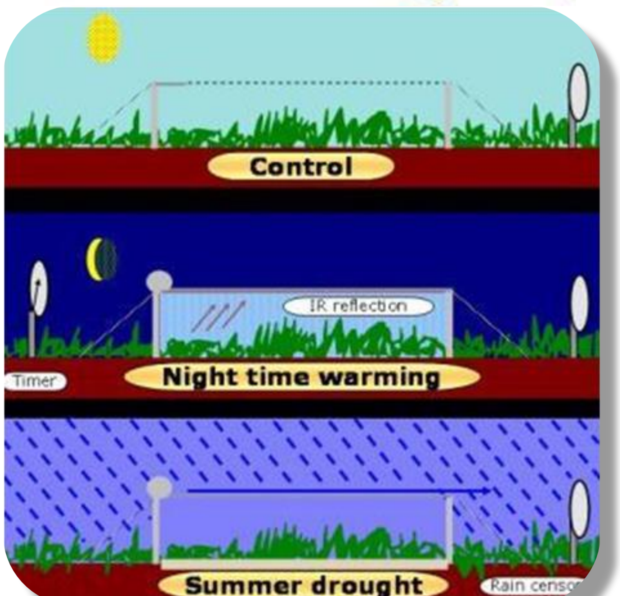


- RERAF is gas tight
  equipped with separate climate control and ventilation systems, which control the level of light, temperature and humidity. The control systems are also capable of simulating the diurnal and annual cycle
  Short duration peak values and long-term transients can be studied.
- Gases such as CO2 and O3 can be supplied separately or in combination to each chamber.

VULCAN → INCREASE

www.increase-infrastructure.eu





Grassland response (Shaw et al. 2002)

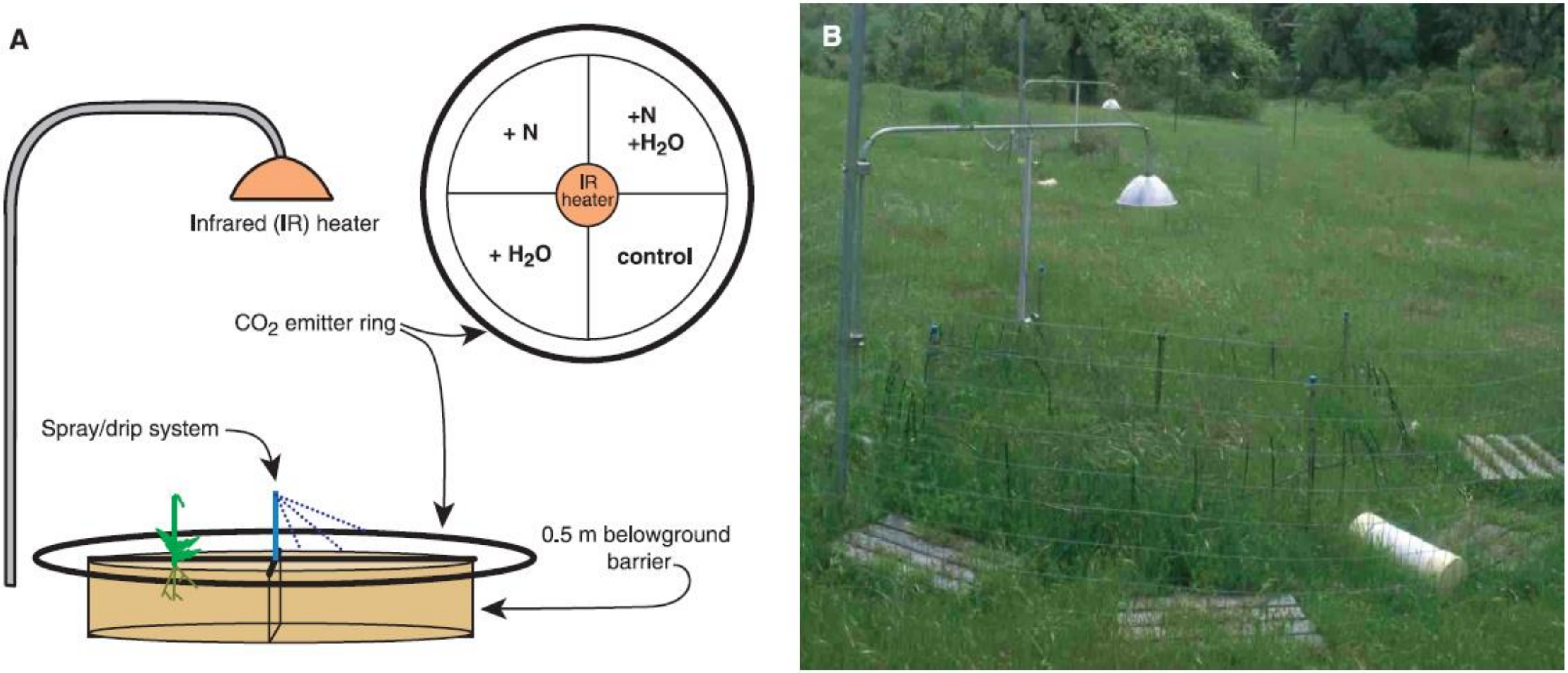
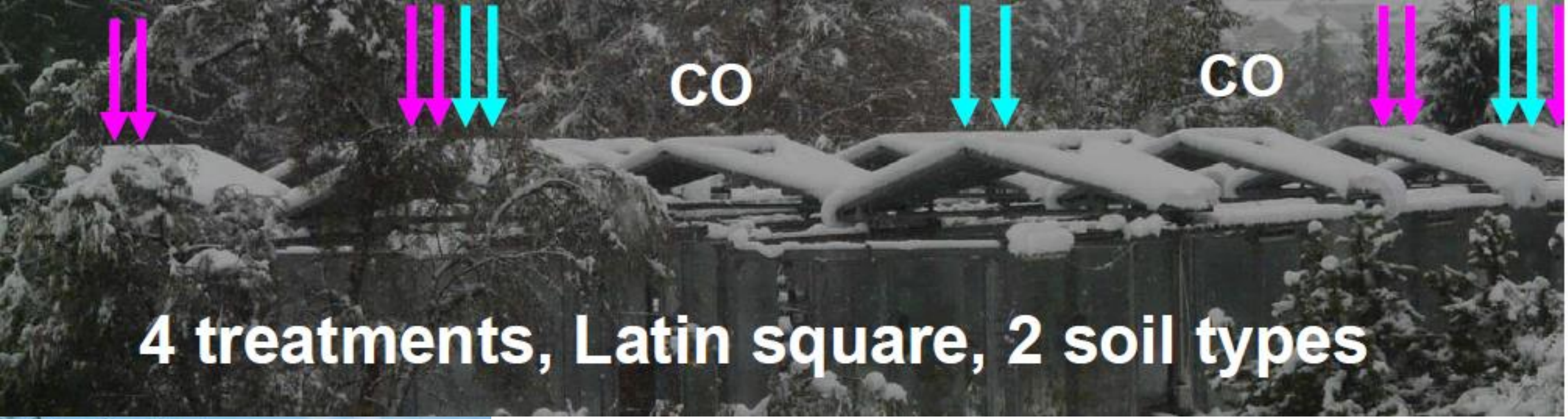
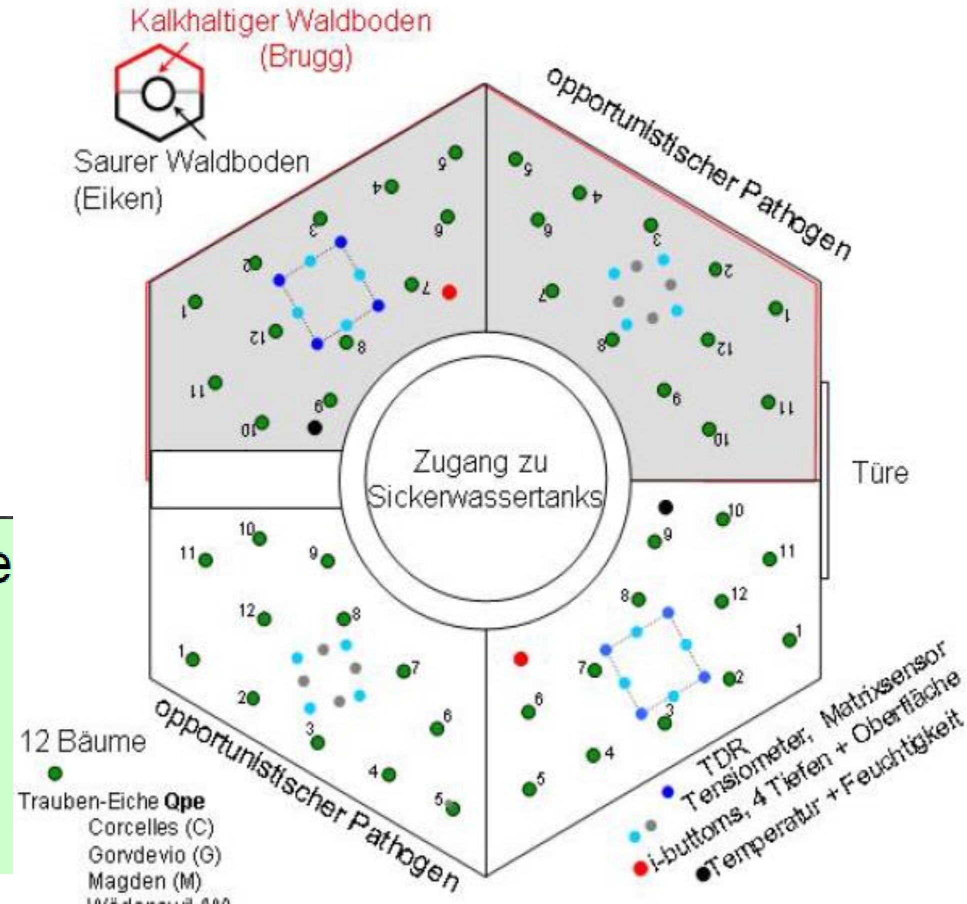


Fig. 1. (**A**) Schematic drawing of the study plots, side view (left) and top view (right). The plot is 2 m in diameter. (**B**) Photograph of a study plot.

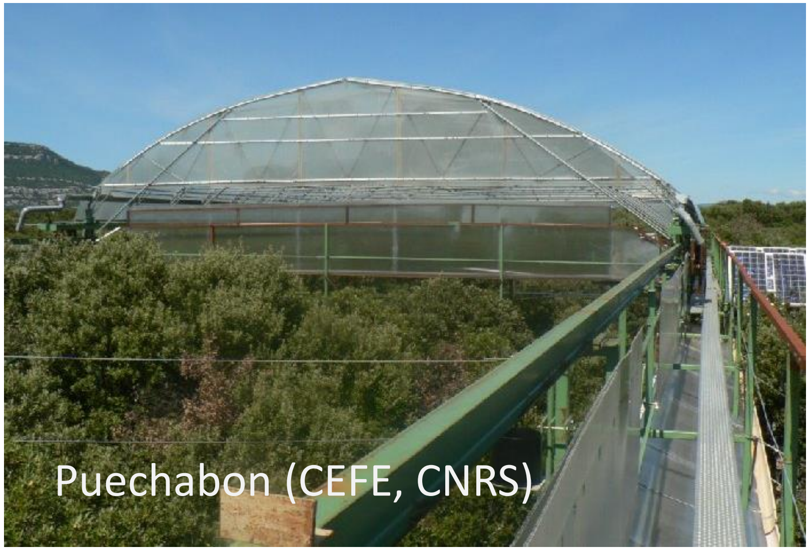
→ responses to simple combinations of single factors differ greatly from single factor responses



Experiment Querco 2007-2009 (Proje
CO control,
AW air warming,
D drought,
AWD drought and air warming



Experimental field sites in Southern France with rain exclusion systems



summary rain exclusion setups

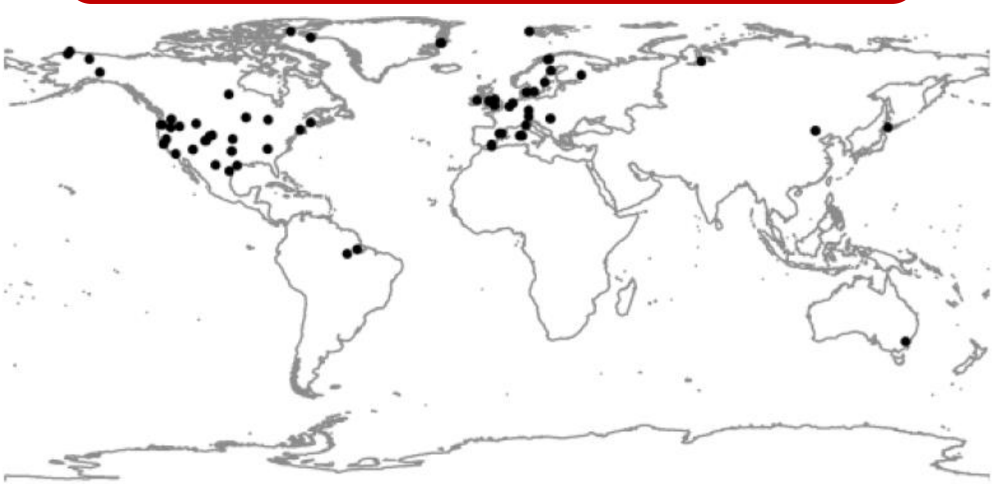
- Class « static exclusion »
  - rain gutter type
  - tent type
- Class « dynamic exclusion »
  - displacable roof
  - rollable covers
- Class « controlled water availability »
  - greenhouses
  - phytotrons
  - chambers

systems below and above the canopy, interception changes,
border effects
microclimatic effects: shading, temperature, …
litterfall effects
physical impact of installation (not exhaustive, see Beier et al. 2012)

Temperature and precipitation response – meta-analyses

(1) Measure total and belowground biomass and productivity in addition to aboveground biomass and productivity. Aboveground biomass and productivity are commonly used to estimate responses of plant growth to climate change. However, belowground biomass and productivity play an important role in such responses, with which total biomass and productivity can be calculated to quantify ecosystem level responses to climate change.

(2) Conduct more experiments manipulating precipitation. Because of the variability and unpredictability of future precipitation projections, more precipitation manipulation experiments are needed to elucidate the impacts of wide range of possible scenarios. These experiments should manipulate not only precipitation quantity, but also alter precipitation timing, frequency, intensity as well as seasonality.



(3) Design multifactorial experiments in a wide range of ecosystems. Temperature and precipitation effects could be additive, so single-factor experiments can be very informative and provide the basic mechanisms for ecosystem responses. However, complex interactions do exist and may not be consistent among ecosystems or treatments. In this sense, a single factor experiment is not adequate to illustrate the responses of ecosystem under interactive climate change effects.

(4) Establish experiments in underrepresented biomes and environments. Multiple-factor experiments have been limited to herbaceous ecosystems. Yet, given the greater biomass, soil microbial biomass, soil C pools, and high C fluxes in woody communities, it is crucial to include more woody systems in multifactor manipulation experiments. However, the technological and cost constrains make mature forest ecosystem warming experiments very difficult. In addition, most manipulation experiments have been in mid-to-high latitudes in northern hemisphere, and new experiments are needed in low latitude and tropical systems to identify a systematic variation of responses across ecosystems.

Wu et al. (2011) Global Change Biology

ECOLOGY LETTERS
Ecology Letters, (2012) **15**: 899–911 doi: 10.1111/j.1461-0248.2012.01793.x

REVIEW AND SYNTHESIS

Precipitation manipulation experiments – challenges and recommendations for the future

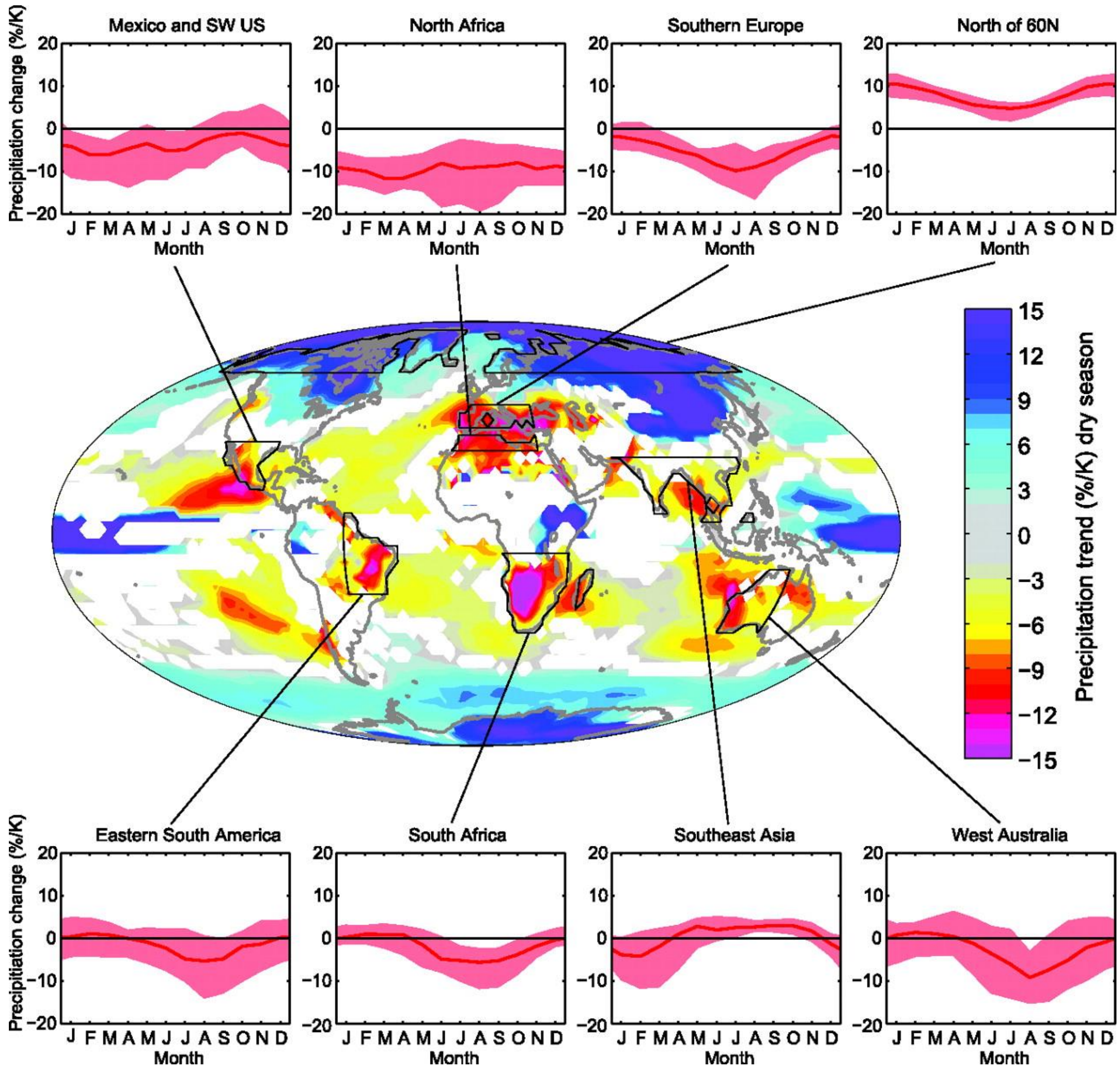
Claus Beier,[1]* Carl Beierkuhnlein,[2] Thomas Wohlgemuth,[3] Josep Penuelas,[4] Bridget Emmett,[5] Christian Körner,[6] Hans de Boeck,[7] Jens Hesselbjerg Christensen,[8,9] Sebastian Leuzinger[10] Ivan A. Janssens[7] and Karin Hansen[11]

Abstract

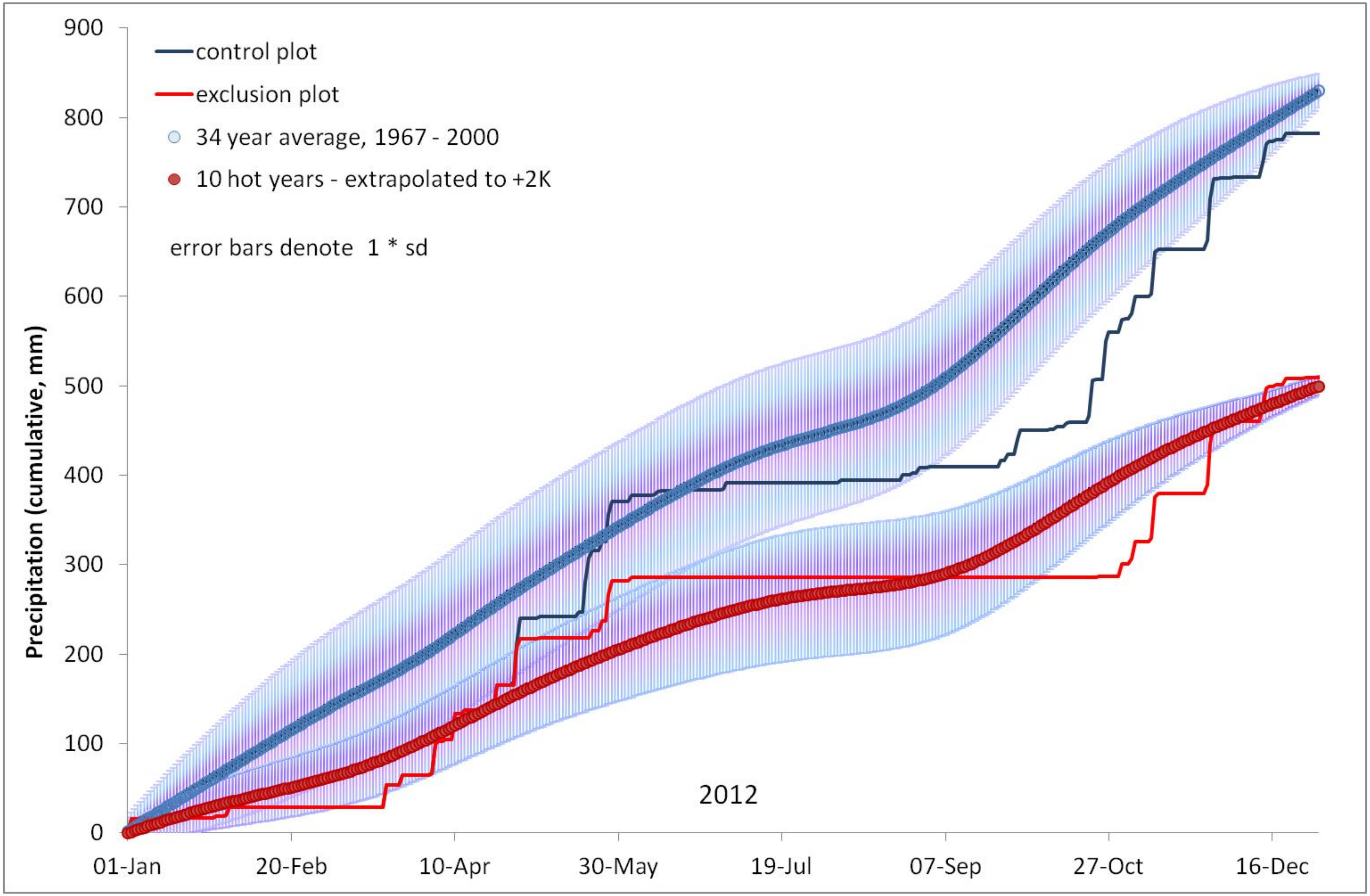
Climatic changes, including altered precipitation regimes, will affect key ecosystem processes, such as plant productivity and biodiversity for many terrestrial ecosystems. Past and ongoing precipitation experiments have been conducted to quantify these potential changes. An analysis of these experiments indicates that they have provided important information on how water regulates ecosystem processes. However, they do not adequately represent global biomes nor forecasted precipitation scenarios and their potential contribution to advance our understanding of ecosystem responses to precipitation changes is therefore limited, as is their potential value for the development and testing of ecosystem models. This highlights the need for

Expected decadally averaged changes in the global distribution of precipitation per degree of warming (relative to 1900–1950), based upon 22 AOGCMs for a midrange future scenario A1B

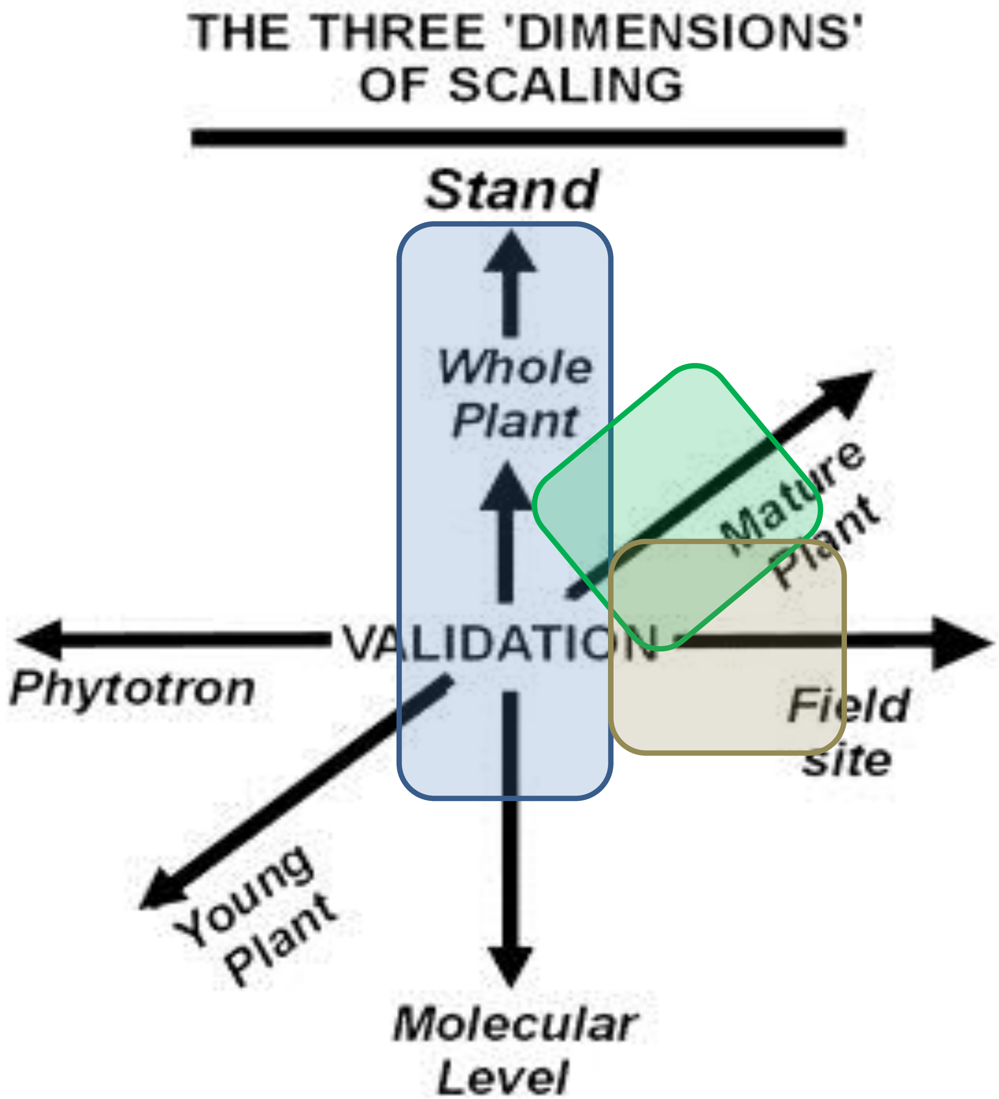
Solomon S et al. PNAS 2009;106:1704-1709



Rain exclusion piloting O_3HP



Common database for field sites dedicated to experimental studies on climate change in Southern France



Matyssek et al. (2012) Environmental Pollution 160: 57 - 65

Ecosystems vary

- species diversity
- spatial climate variability
- site variability
- …

- « changes in precipitation and temperature characteristics »
- « precipitation & temperature interaction »

notion: we might have never had this before

→ experimentally it's a huge challenge

→ need to work together at multiple scales & across disciplines, and on the long-term, i.e. Cooperate

principal ideas

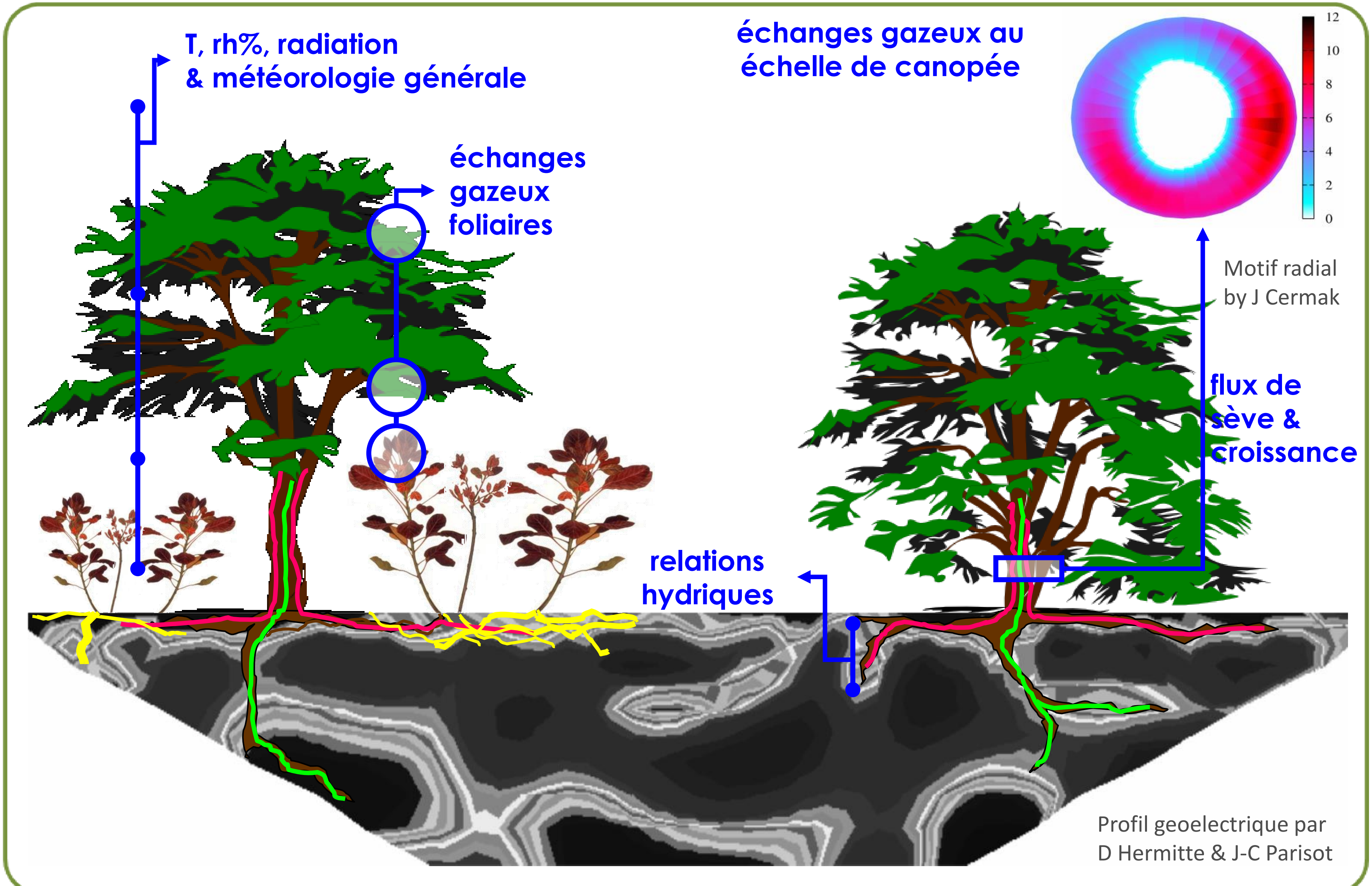
- management of data
  - continuous/long-term monitoring
  - short-term experiments
  - data export
  - data visualisation
- manipulate data
  - perform calculations
  - verify , correct, interpolate data
- be attractive to other field sites
  - include user-friendly interfaces
  - develop helpful tools
- assess actual research activity related to a site and it's history
  - number, and type of person involved
  - projects having run/ running on the site
  - scientific output
- interfacing experimentations and modelers
  - visualize plant/ecosystem physiology, state of stress, … close to real time
- identify user needs and evolve

---➔ facilitate and assure cooperation and collaboration for the long-term

principal idea

- management of data
- manipulate data
- be attractive to users
- identify user needs
- be attractive to ‘partner’ field sites
- assess actual research activity related to a site and it’s history
- interface experimentators and modelers

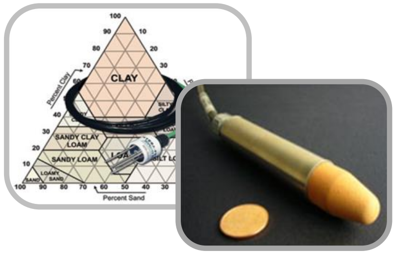
Mesures


T, rh%, radiation
& météorologie générale
échanges
gazeux
foliaires
échanges gazeux au
échelle de canopée
12
10
8
6
4
2
0
Motif radial
by J Cermak
flux de
sève &
croissance
relations
hydriques
Profil geoelectrique par
D Hermitte & J-C Parisot

Réseau des capteurs

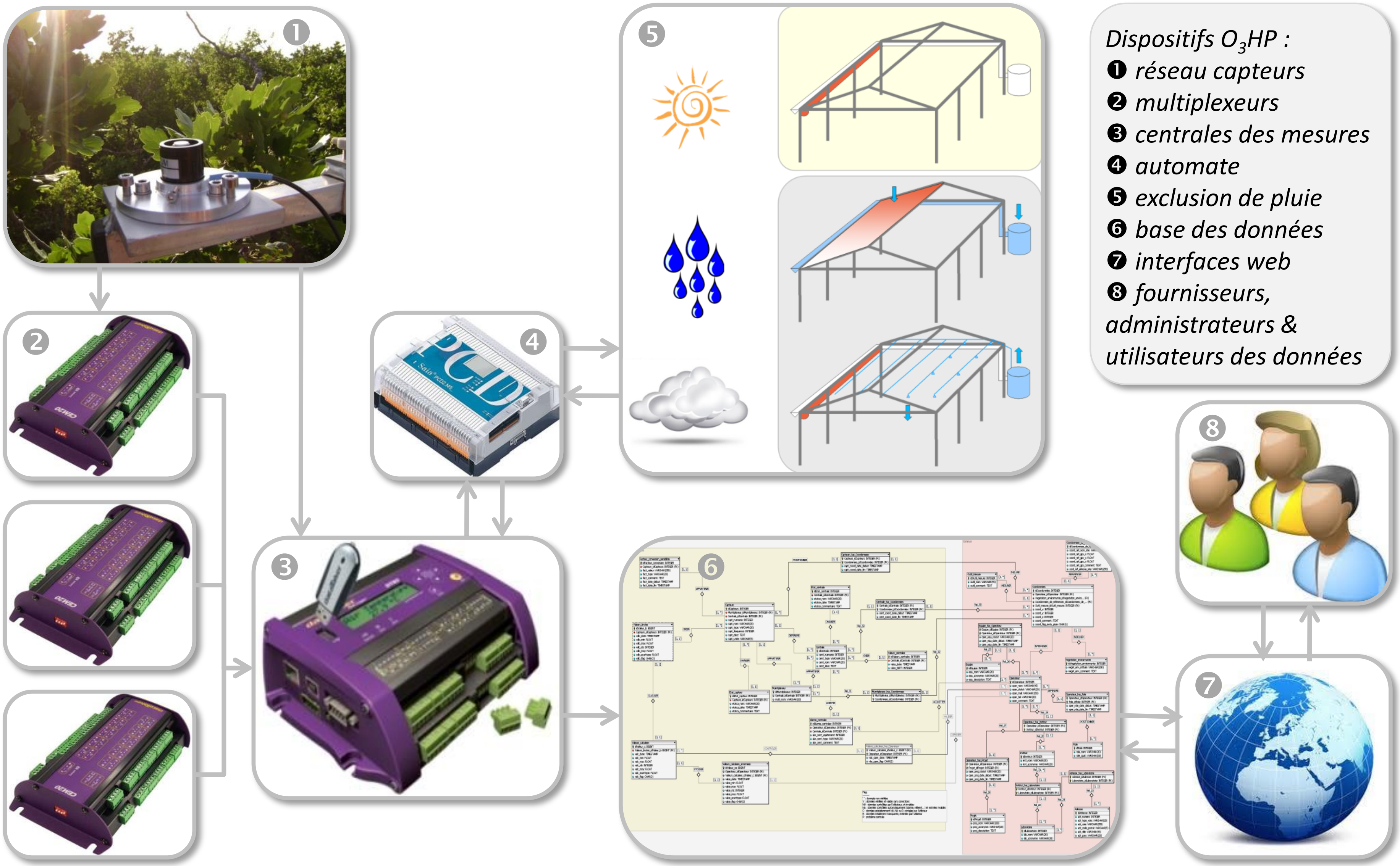




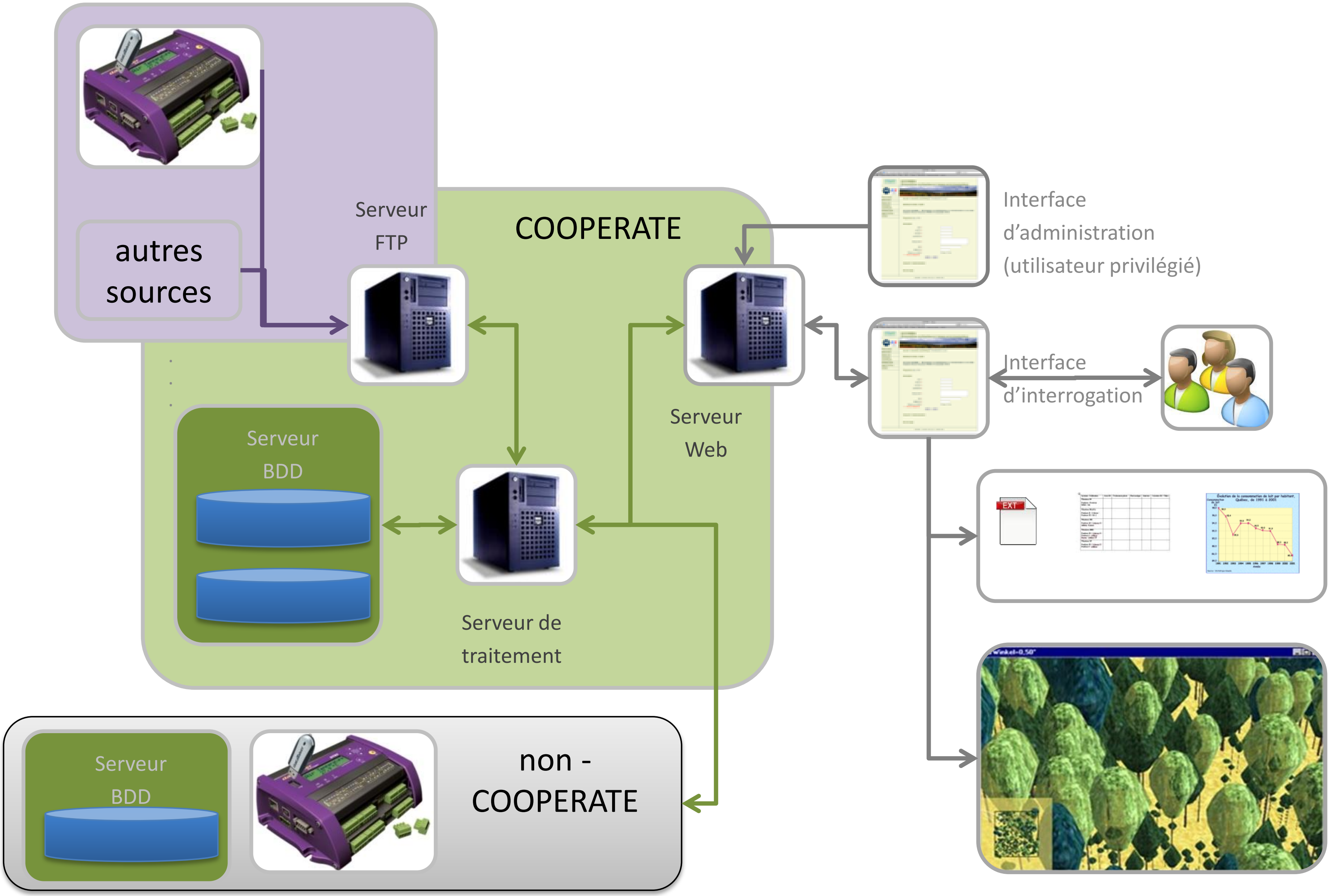


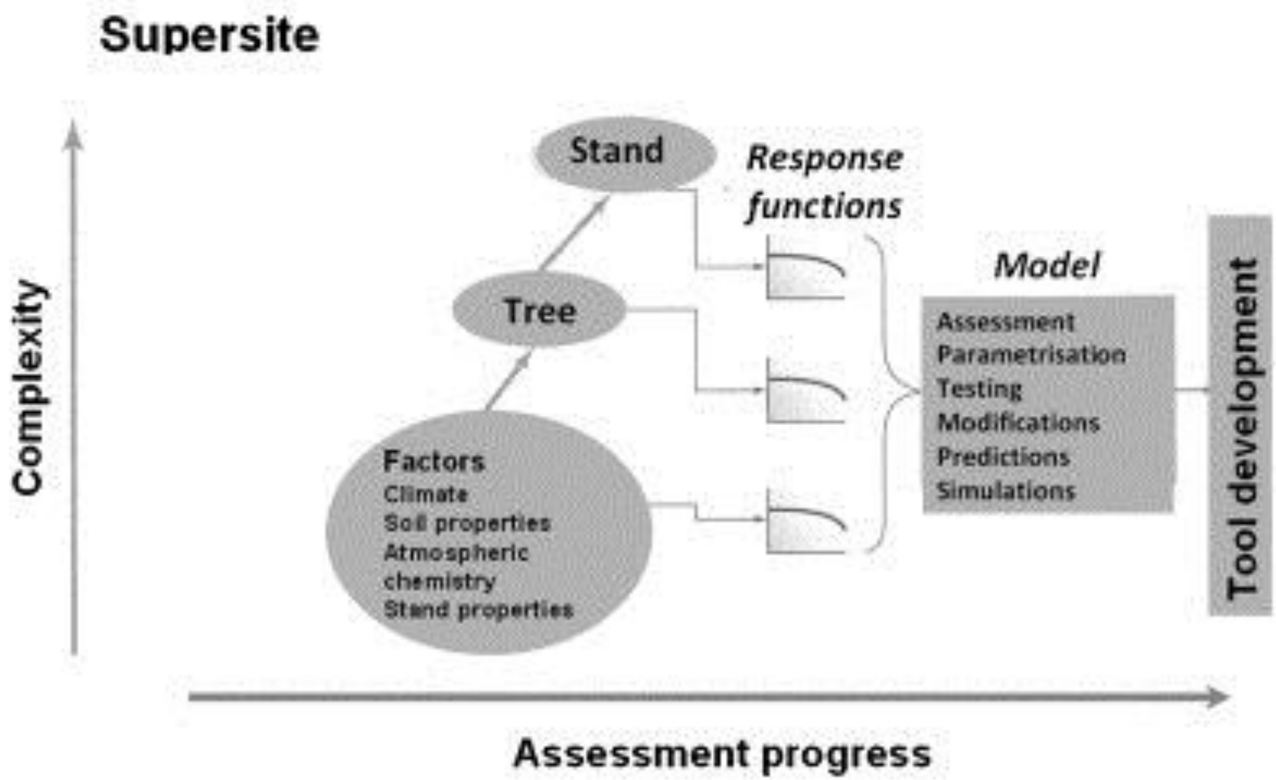

capteurs	signale	fourchette	quantité	canaux	pas de temps
pyranomètre	tension	0-15 mV	2	2	1 s
PAR-mètre	tension	0-15 mV	9	18	1 s
T & rh% atmospherique	SDI12	numérique	10	1	120 s
precipitation	compteur	tension, valeur seuil	1	1	even.
vent vitesse & dir.	tension	0-2.5 V	1+1	2	1 s
T & H_2O% & conductivité du sol	SDI12	numérique	20	2	300 s
T & potentielle hydrique du sol	SDI12	numérique	8	1	900 s
moiteur foliaire	tension	0-2.5 V	2	1	
dendromètre	résistance	0-20 kΩ	12	24	+10 s
flux de sève 1(3)-points, fabrication interne	tension	0-0.1 mV	x	2x (6x)	+10 s
flux de sève 6-points	tension	0-0.1 mV	7	84	+10 s

schematic of data flow in the O_3HP program



Base(s) des Données COOPERATE





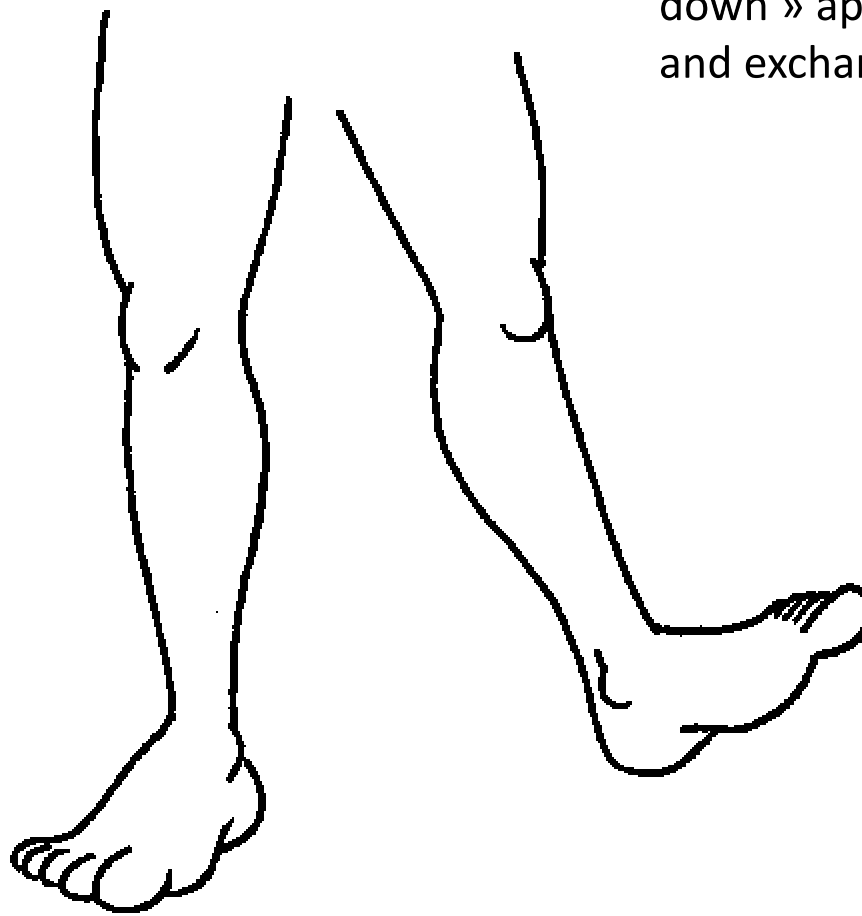
"Supersite" – a new kind of research site in forest ecosystems, integrating experimentation within the soil-plant-atmosphere interface and model development

Matyssek et al. (2012) Environmental Pollution 160: 57 - 65

Studies should include close collaboration of ecologists and modellers in the phase of the project design as well as in its evaluation (Beier et al. 2012)

towards a dynamic interdisciplinarity in environmental research

share data, and
integrate in networking
to fascilitate « top-down » approaches
and exchange



« bottom-up » approach
animation of
observational and
experimental research
around an oak forest
ecosystem, with
emphasis on
environmental drivers,
and linking to
atmospheric processes

how to get to work in the O3HP-program

- open to all national and international collaborators
- contact the PI (Thierry Gauquelin), internal check to resolve potential conflicts of interest
- plan your experimental approach and activities with the site manager (me)
- make use of the local ressources
- participate in an adapted way in site maintenance and consumables
- make your data available to the O_3HP research community after appropriate delay (database).
- acknowledge ECCOREV in publications of site-related research

Funding and support by

cnrs
dépasser les frontières

imbe
institut méditerranéen de biodiversité et d'écologie marine et continentale

cea

Région PACA

Agence Nationale de la Recherche
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Aix-Marseille Université

Thanks for your attention