Evaluation of mitigation effect from climate-change adapted forests

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IEA Bioenergy

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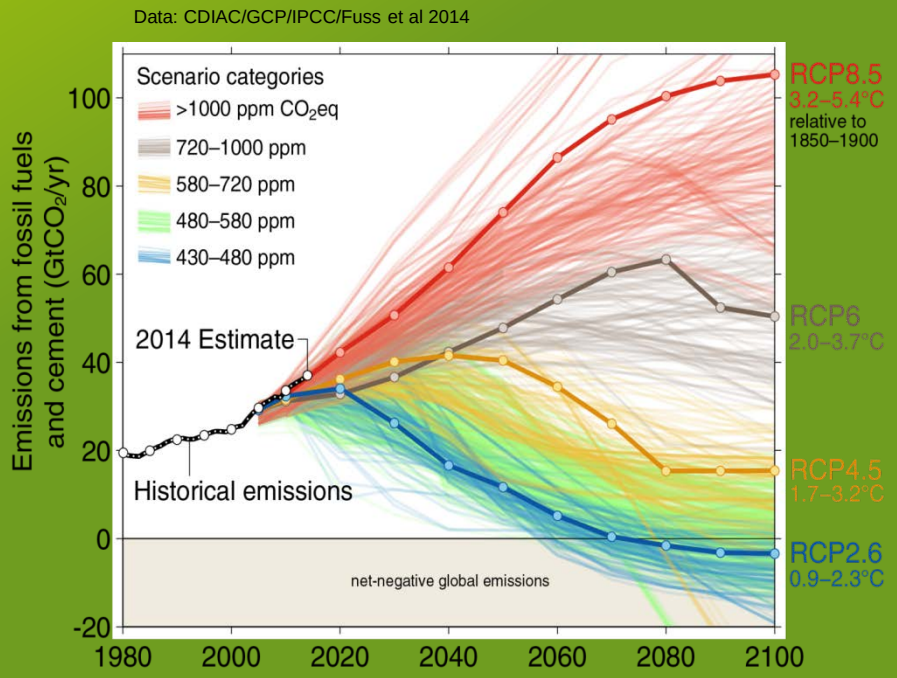
Adapted to … what ?



The future of the forests environment (atmosphere, soil, hydrology) is not determined
Forest management may rely upon:

- (i) versatility: optimal combination of forest alternatives
- (ii) diversity : species and provenances mixture ,…
- (iii) resilience : plasticity,

Criteria for biogeochemical and climatic sustainability

✓ Negative or neutral radiative forcing

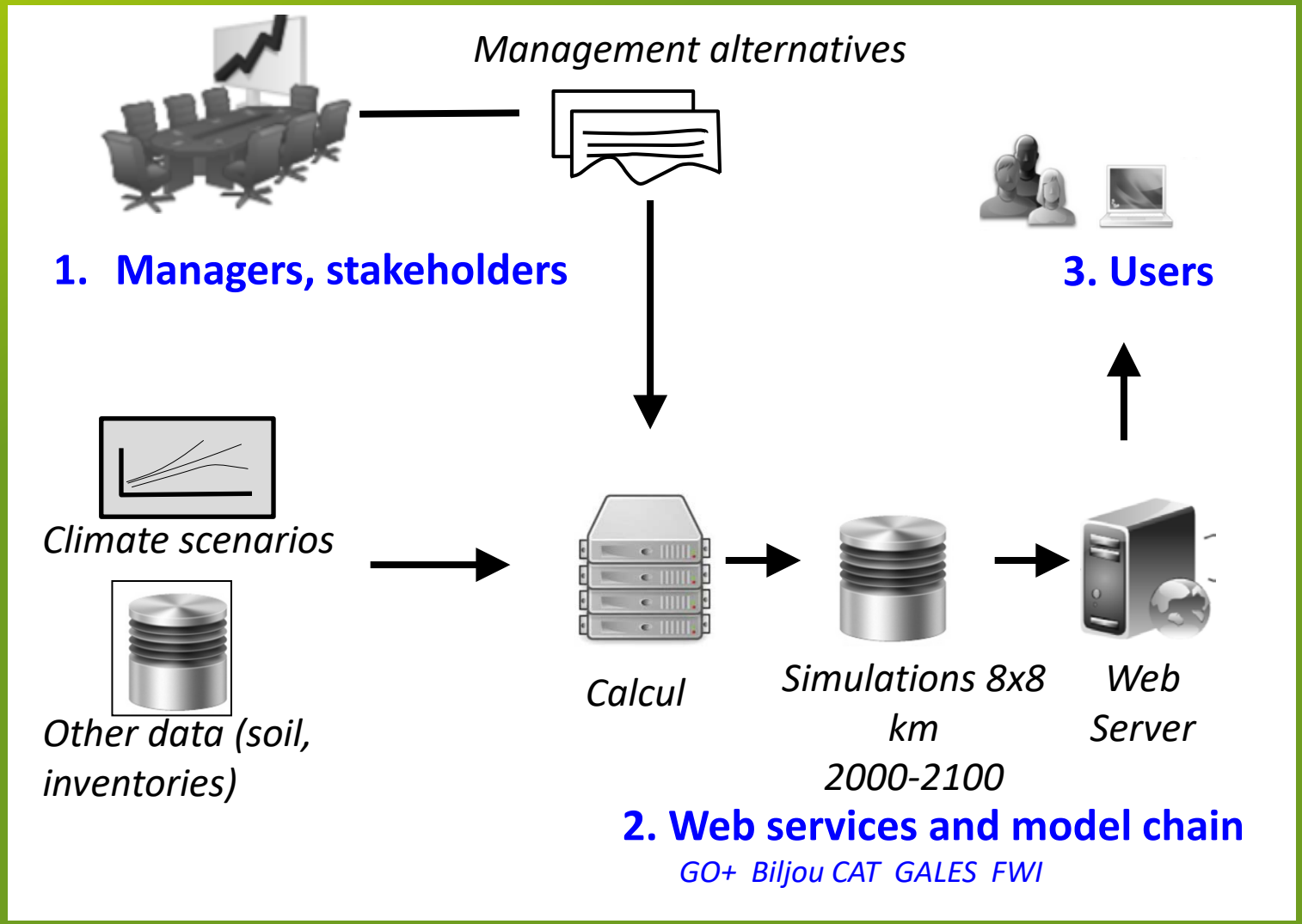
Radiative balance	« biophysical forcing »
Convective heat fluxes	« biophysical forcing »
Greenhouse effect	« biogeochemical forcing »

✓ Negative (C) or neutral (N, P etc.) mass balance

Carbon
Water
Nutrients

✓ Of the whole forest – wood products chain

Concerting management alternatives
(projects: FOREVER, MACCAC, Evafora, Forêts-21)



Forest management alternatives for biomass production

Species selection

- Coniferous: *Pinus p. , Pseudotsuga m., Pinus s. Pinus n.*
- Broadleaved : *Fagus, Quercus,*

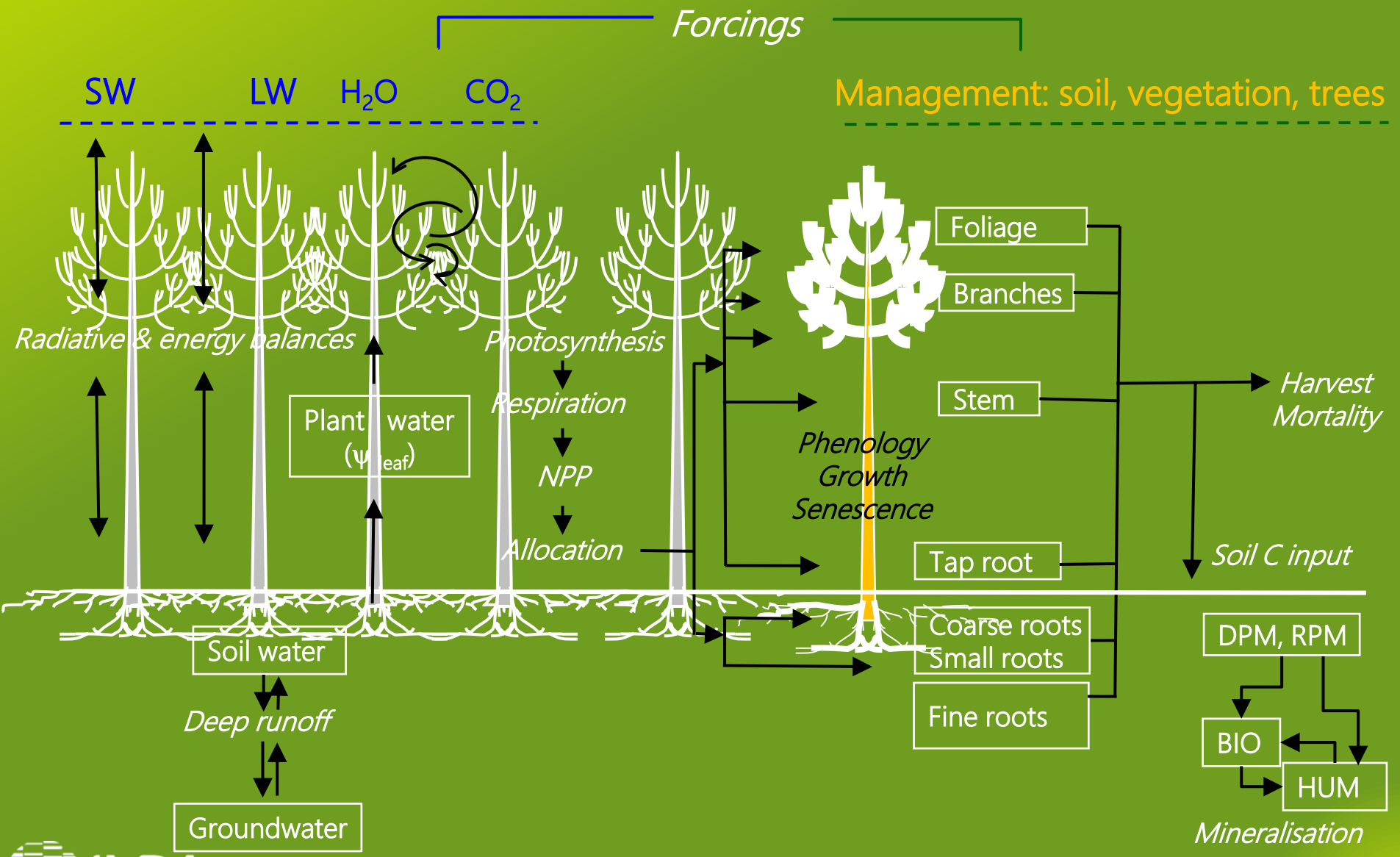
Soil and stand management:

- Soil preparation
- Stand regeneration
- Thinning regime
- Rotation duration

Species and age mixtures

(Agroforestry)

Predictive tool: process model of Forest WP chain Go+CAT



Go+ model in short

Vegetation

- Hourly time step / ha spatial unit,
- 2 layers : Sun–Shade / Farquhar' – Jarvis' – Hydraulics –
- Phenology, Allocation, Growth, Mortality

Soil

- Roth-C,
- 3 Soil layers,
- Bucket model + Groundwater

Management

- Soil preparation,
- Vegetation management,
- Tree stand management

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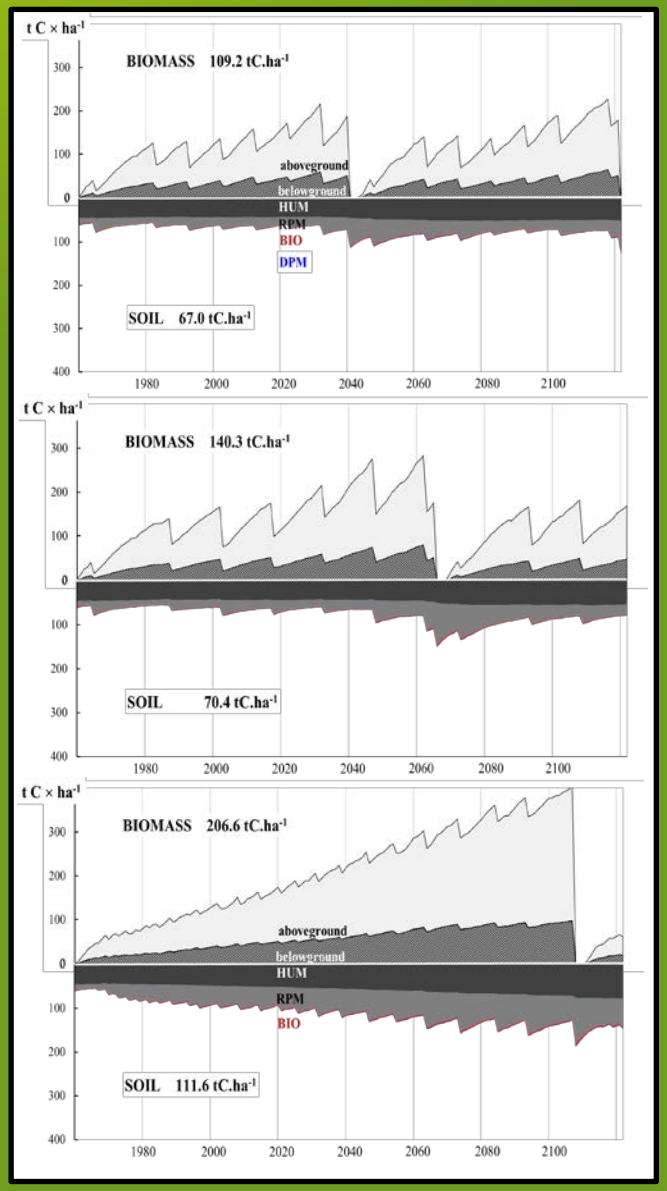
Management alternatives – 1. European Beech Standards.

Intensive
(« Biomass and Energy »)

Standard
(« Timber »)

Self Thinning
(« theoretical reference »)



Target D = 60 cm
Revolution = 10 y
Competition Index = 0.35

D = 80 cm
R = 15 y
C = 0.35

Age = 150y
R = 3 y
C = 1.0

Historical climate

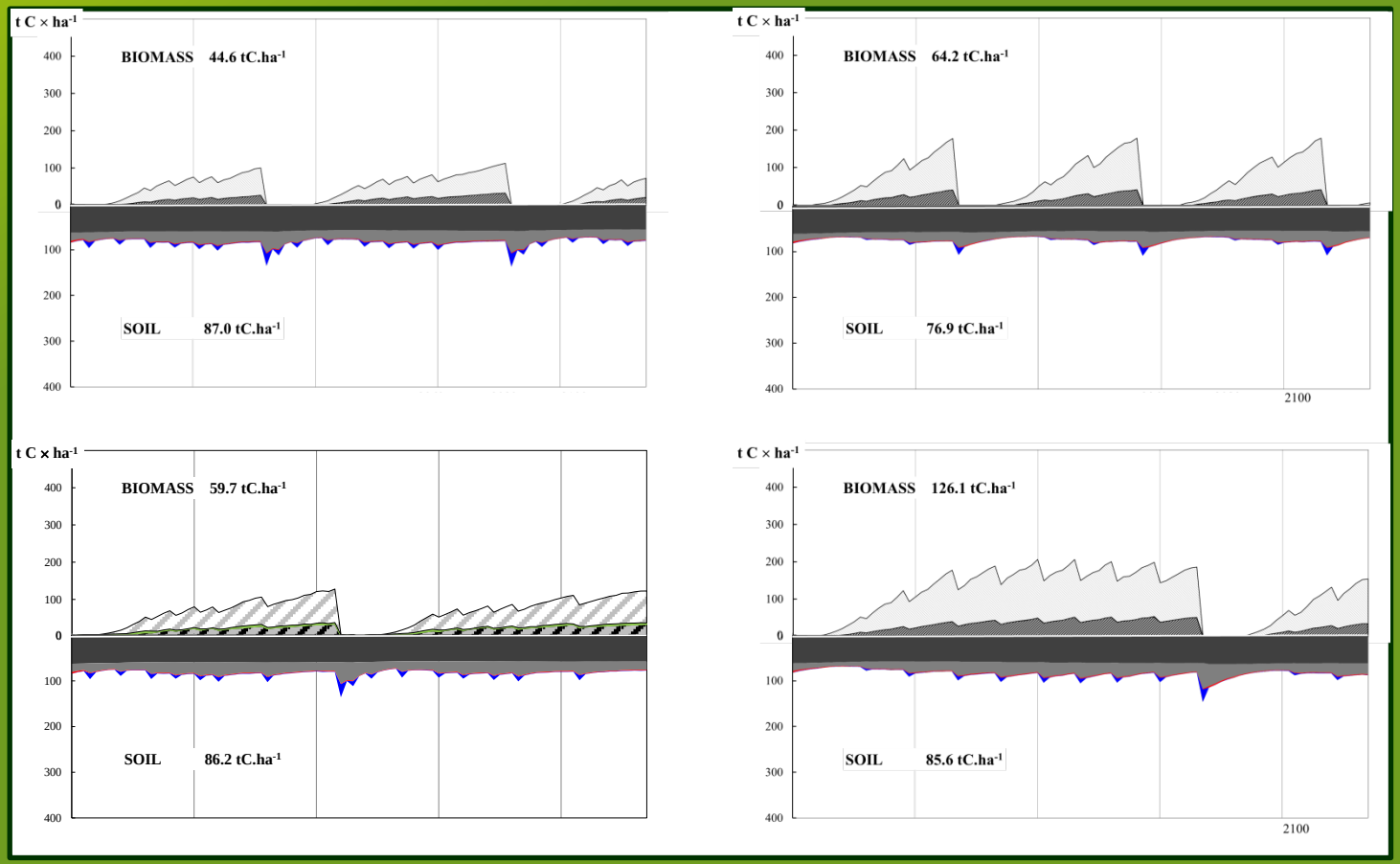
Management Alternatives – 2. Coniferous Standards.

Pinus pinaster

Douglas Fir

Intensive (« Biomass and Energy »)

Standard (« Timber »)



(Historical climate)

Results 1. 2000-2100 radiative forcing of management alternatives at regional level

- Aquitaine French Region (1Mha)
- Impacts :
  - Albedo (8x8 km) (SW ↓ RCP,s α predicted by GO+, monthly τ_{atm} from NASA)
  - Biogenic carbon sequestration
    - in situ: soil, tree and vegetation biomass (GO+ model)
    - C stored in 8 wood products categories (CAT model)
  - Fossil carbon
    - Forest operations (Gonzalez Garcia et al. 2014)
    - Products transformations (CAT model)
  - Fossil carbon substitution (Sathre et O'Connor, 2010)
    - *f* from 0.5 (energy) to 3.0 (timber)
- Attenuation of atmospheric variations by Earth model (Forster et al. 2007)
- Radiative forcing of CO_2= *f* (concentration en CO_2) (Boucher et al. 2007)

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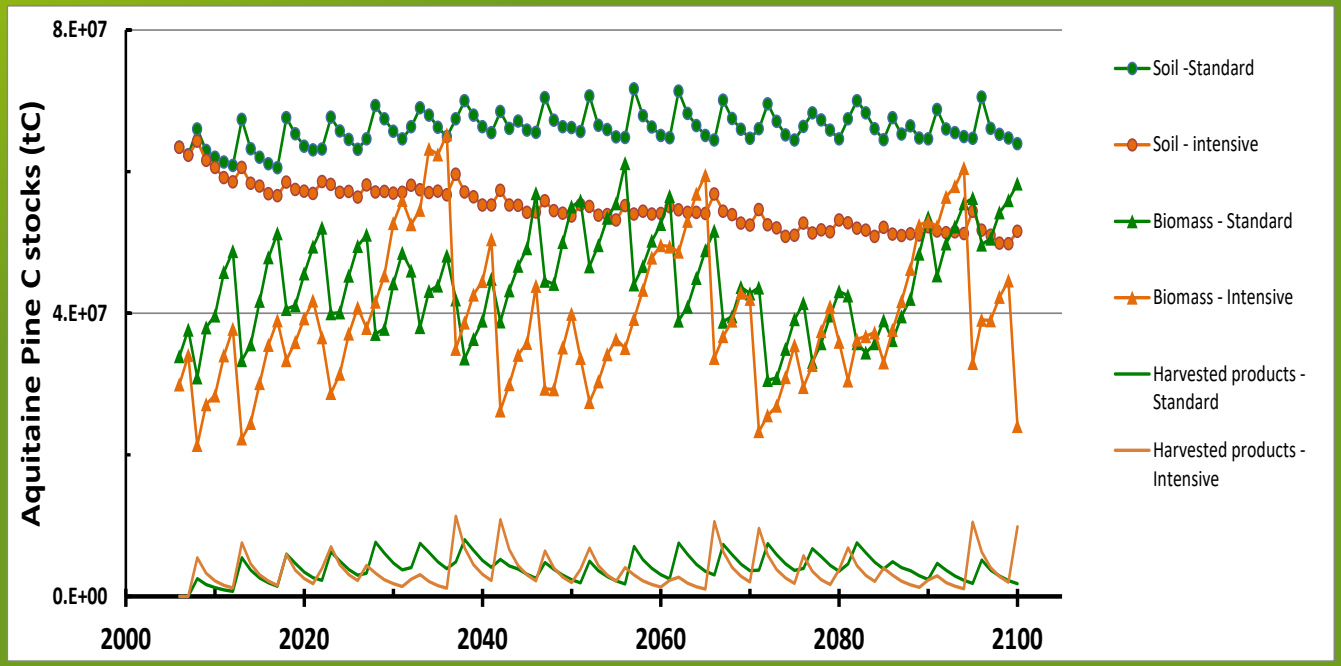
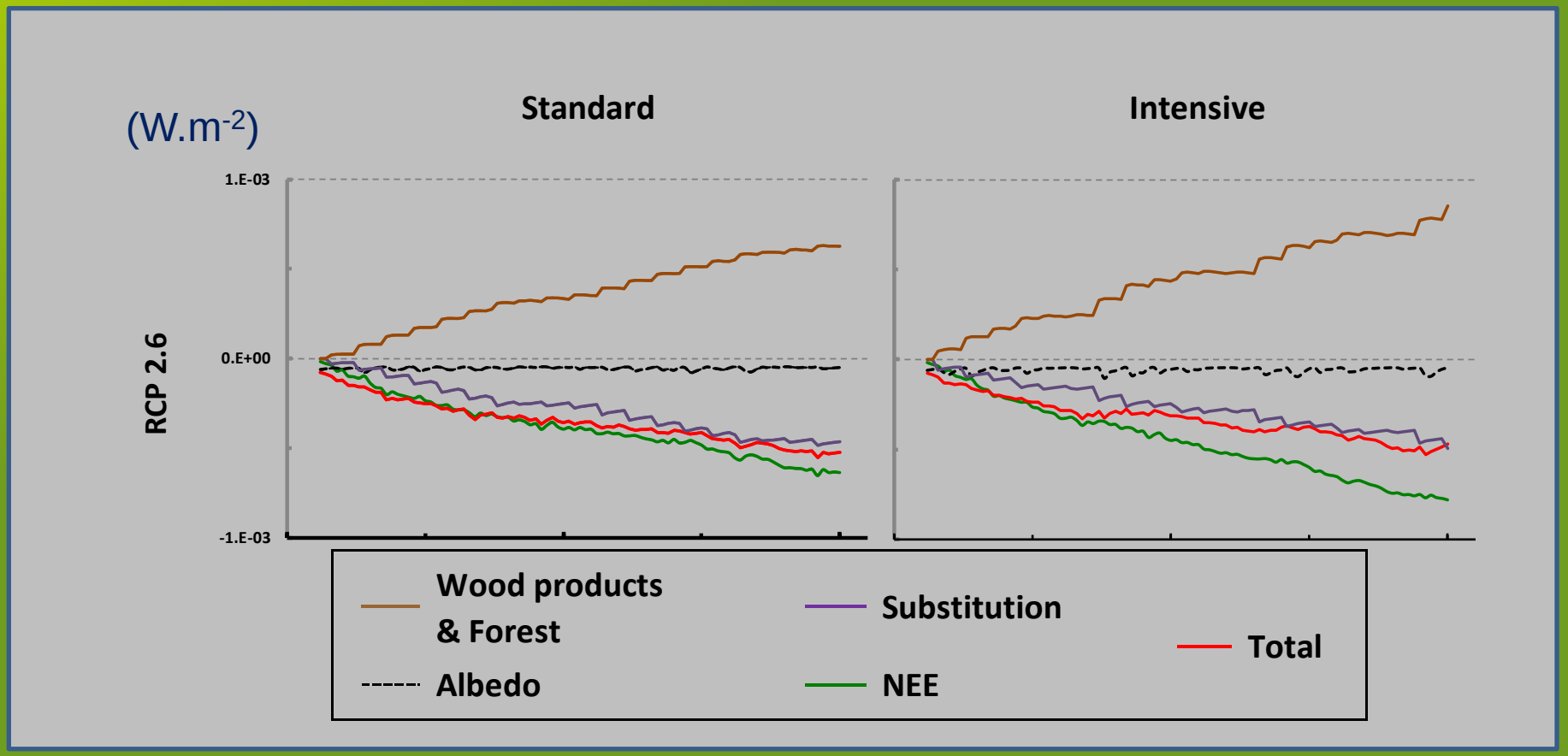
1. Carbon stocks *in situ* and in wood products

RCP 2.6

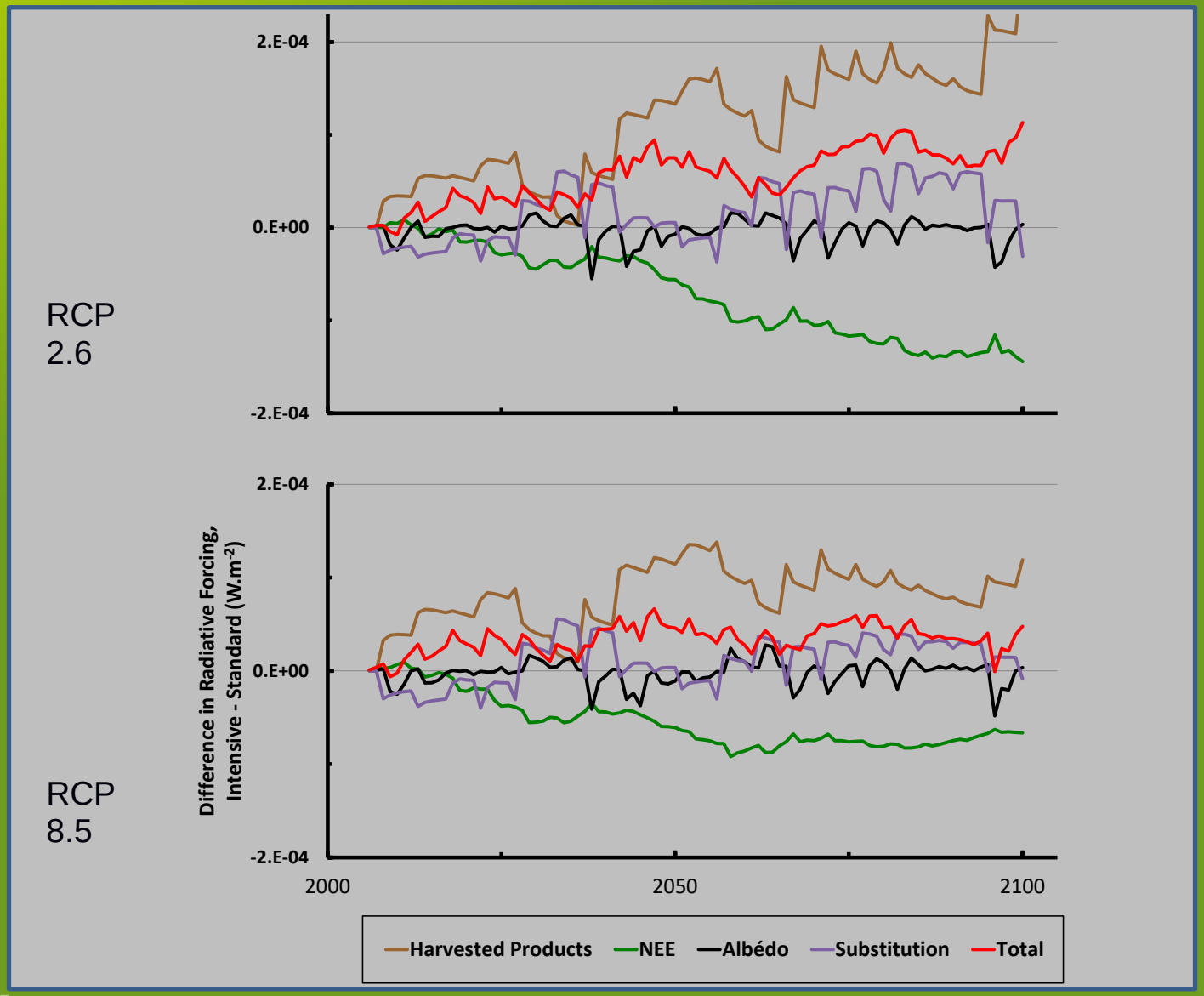


✓ Soil and biomass stocks depleted in intensive aternatives

2. Radiative forcing is negative only if substitution is accounted for.

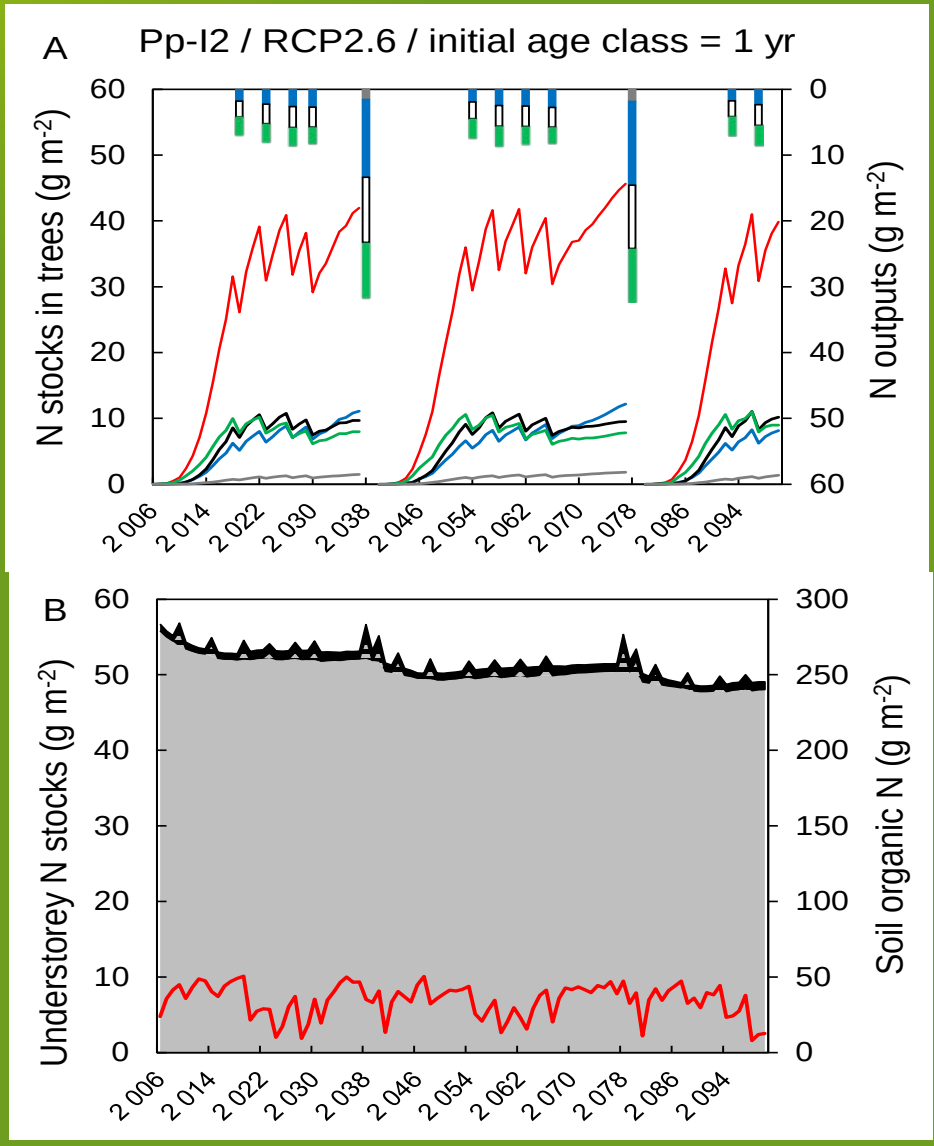


3. The overall radiative forcing of standard management is cooler in colder scenarios



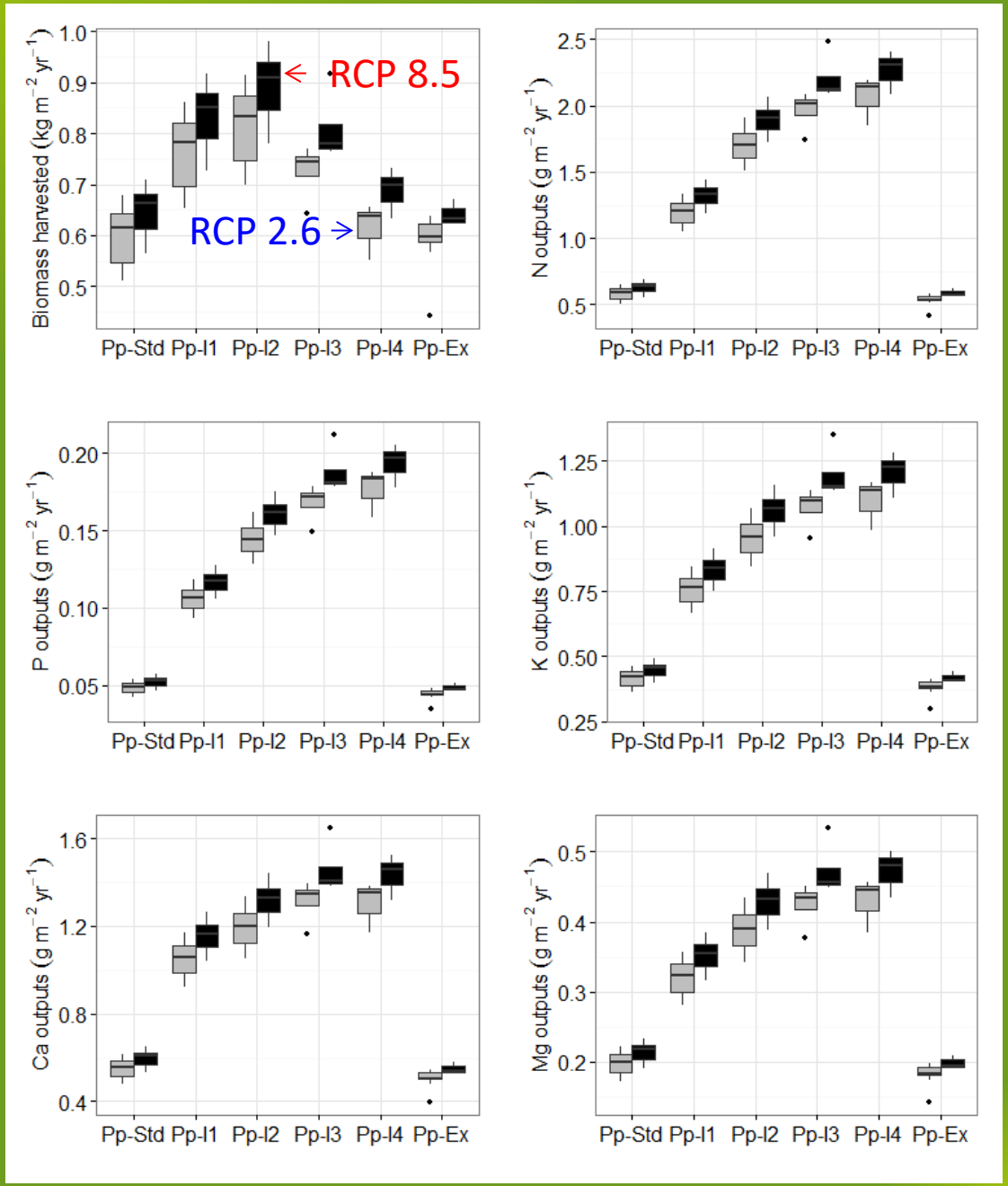
4. Dynamics of nutrients stocks in soil and biomass for different management alternatives predicted by Go+ (V. 26.51).

- Experiments at stand scale
- *Pinus, Fagus, Pseudotsuga*
- 4 to 8 management schemes tested



5. Biomass harvested and nutrients export over a 95 year period:

Intensification has a cost !



Few lessons from recent and ongoing R&D projects with ANR, ADEME, CNRS

- The best management scheme is the one that can be implemented by managers
- Intensification has environmental costs (climate, water, nutrients)
- Climate-management interaction is substantial

Thank you for attention

Acknowledgements

Recent projects having supported the Go+ model development:

- *ORACLE* (French ANR, N. De Noblet, CNRS, coord.)
- *MACCAC* (French ANR, O. Roupsard, CIRAD, coord.)
- *Forever* (CNRS, A. Dufour, coord.)
- *Evafora* (Ademe, O. Picard coord.)
- *PROFOUND* Cost action (COST, C. Reyer coord.)

Evaluation (1/4). Fluxes and stocks of energy, C and water.

COLLELONGO SITE

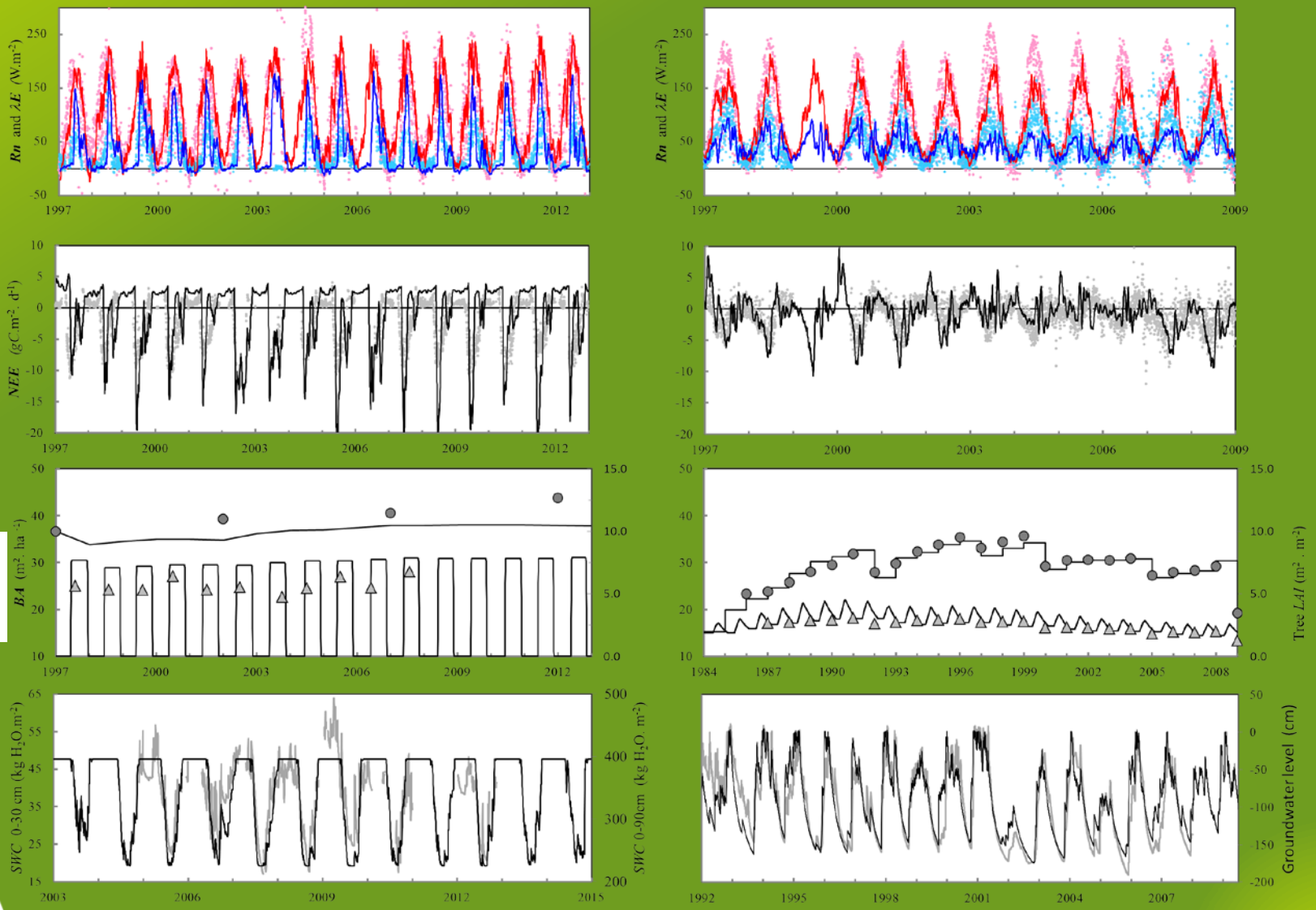
LE BRAY SITE

R_n, λE

NEE

Basal area
LAI

Soil water



Evaluation (2/4)

Daily fluxes at FLUXNET Sites. Statistics :

- R^2, RMSE

	Rn (Watts.m^{-2})		λE (Watts.m^{-2})		NEE (gC . d^{-1} m^{-2})	
	R^2	RMSE	R^2	RMSE	R^2	RMSE
BC Campbell 49	0.97	13.1	0.76	13.5	0.67	1.7
BC Campbell 88	0.95	15.6	0.69	13.3	0.26	1.8
Collelongo	0.60	54.8	0.41	41.7	0.30	5.5
Hesse	0.75	41.4	0.70	28.2	0.2	3.0
Soroe	0.59	58.0	0.65	56.8	0.51	4.0
Le Bray	0.61	44.3	0.26	23.0	0.22	2.9

- Systematic & Unsystematic errors

	Rn (Watts.m^{-2})		λE (Watts.m^{-2})		NEE (gC . d^{-1} m^{-2})	
	s	u	s	u	s	u
BC Campbell 49	3.8	13.1	8.5	13.5	1.2	1.7
BC Campbell 88	2.8	15.6	6.2	13.3	1.6	1.8
Collelongo	13.3	53.1	8.4	41.7	0.7	5.5
Hesse	10.6	41.4	17.0	28.2	0.2	2.9
Soroe	12.6	55.4.	43.3	56.8	1.8	4.0
Le Bray	18.0	41.0	22.1	23.0	0.6	2.9

s: systematic error; u: unsystematic error;

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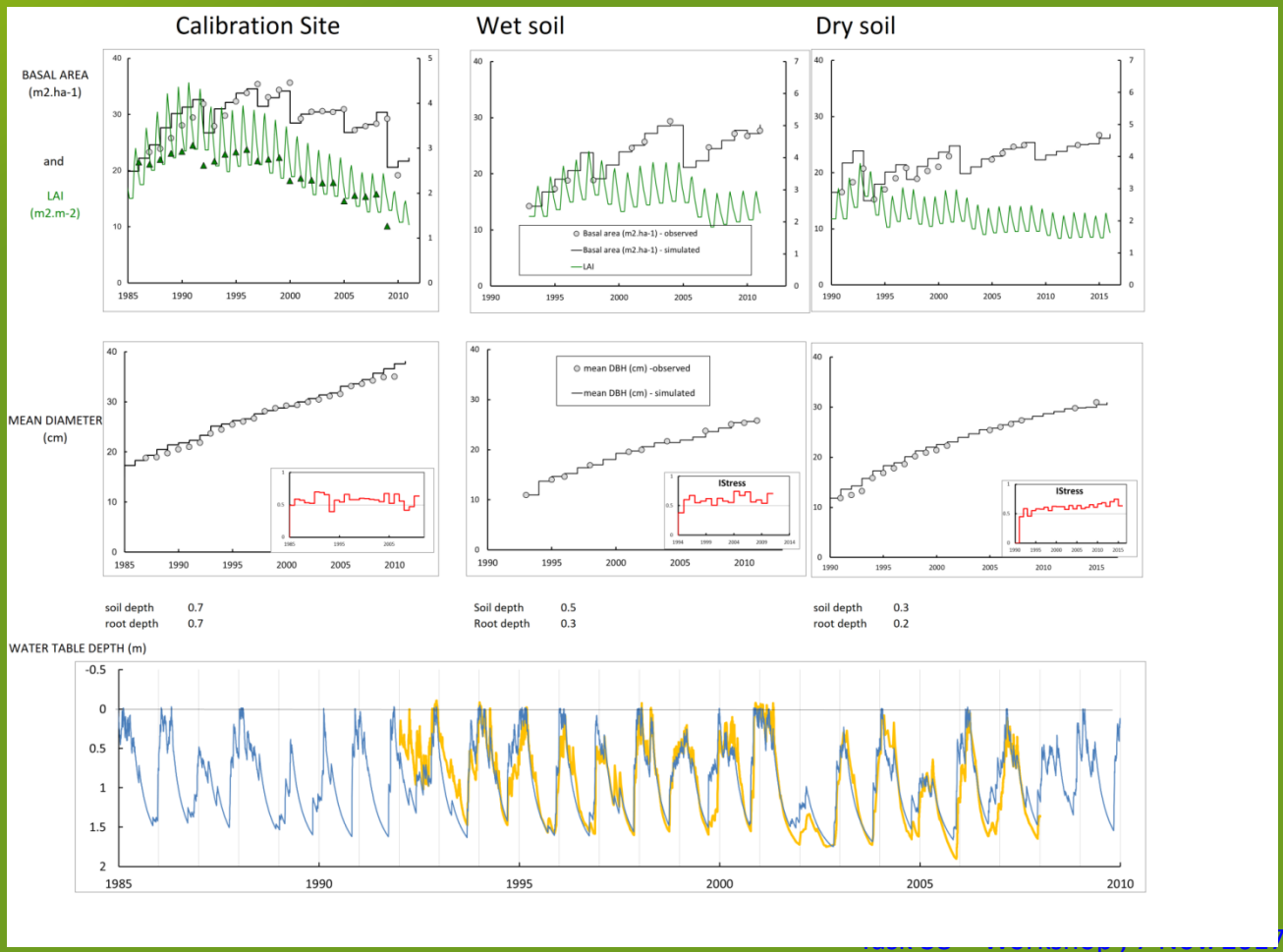
Evaluation (3/4)

Growth, production and soil groundwater trajectories.

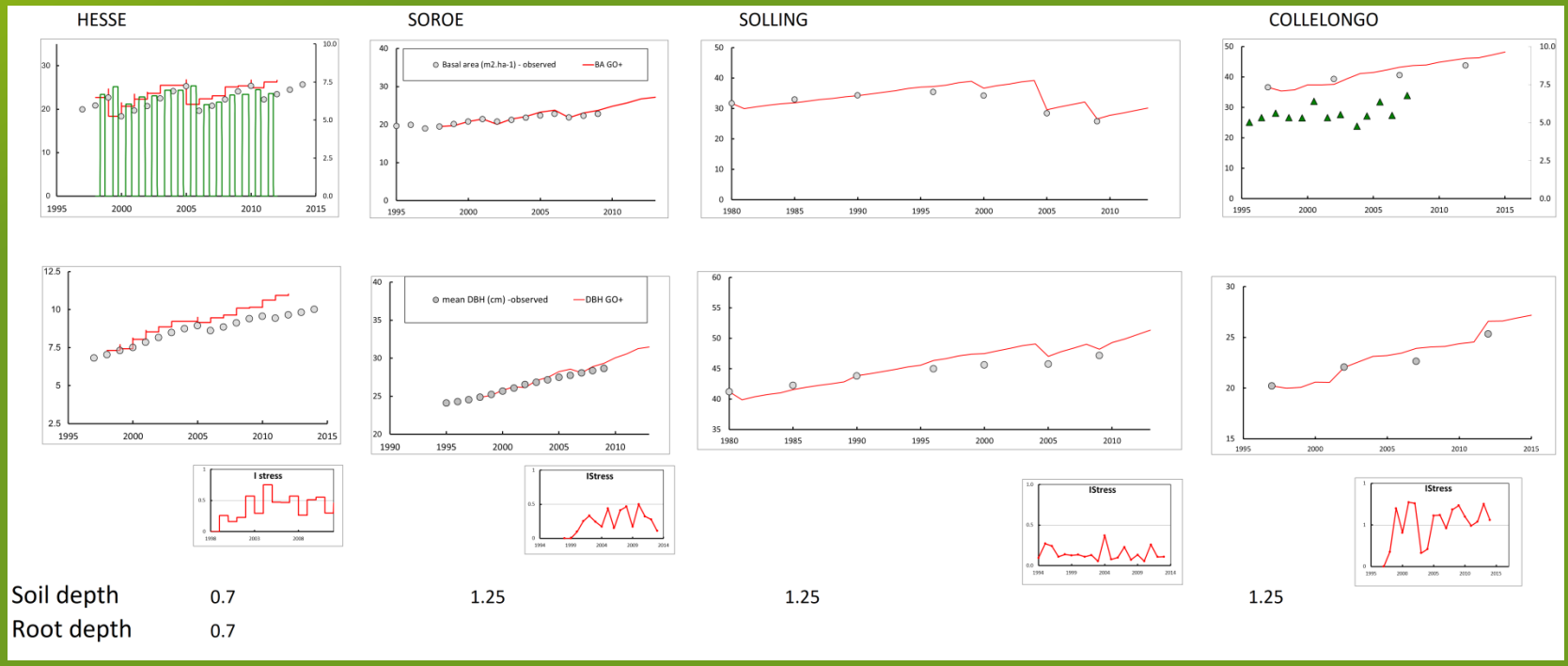
1. Coniferous



Evaluation (4/4)

Growth and production trajectories.

2. Broadleaved



Soil depth	0.7	1.25	1.25	1.25
Root depth	0.7			

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- *Evafora* (Ademe, O. Picard coord.)
- *PROFOUND* Cost action (COST, C. Reyer coord.)

Data used for calibration or evaluation :

- *European carbon* data cluster (L3 and L4 data from FR-Hes, FR-LBr, IT-Col, DK-Sor)
- *Fluxnet* (Vancouver Douglas fir chronosequence, A.T. Black)
- ISIMIP database (Solling, Collelongo, Soroe, Le Bray sites)
- *GIS Coop de données* (*Pompogne* site, D. Merzeau)
- INRA long-term forest inventory data (*Vielle* site, C. Meredieu et al.)
- Forest Soil database (V. Badeau, INRA Nancy)
- Historical series of meteorological data (Météo-France)