Model-data fusion and FLUXNET

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Model-data fusion with EC data

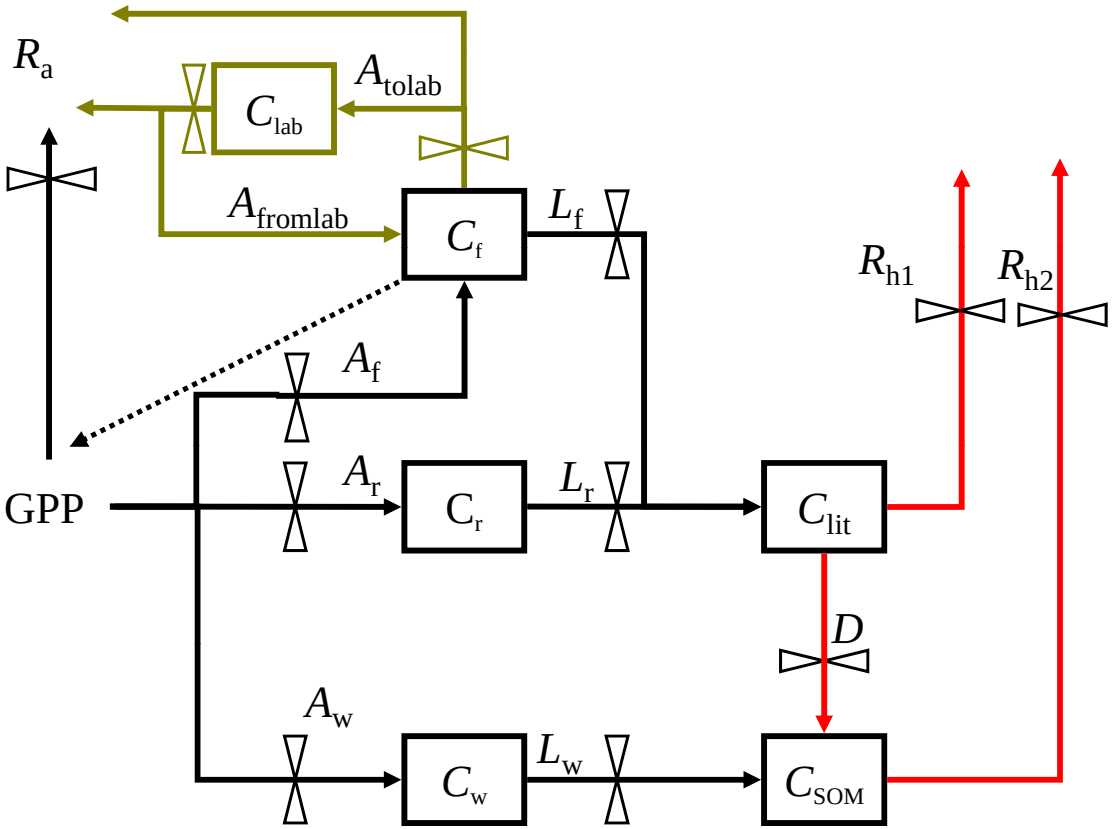
- Reviews
  - Raupach et al (2005, GCB)
  - FLUXLETTER Vol 1 No 4, Williams et al (2009)
  - Williams et al (BG Discussions, 2009)
- Site-based studies
  - Braswell et al. 2005, Williams et al 2005, Knorr & Kattge 2005, Wang et al 2007 etc
- REFLEX: Williams et al. (in review)
  - MDF intercomparison

REFLEX experiment

- Objectives: To compare the strengths and weaknesses of various model-data fusion techniques for estimating carbon model parameters and predicting carbon fluxes.
- Real and synthetic EC observations from evergreen and deciduous ecosystems
- A simple C model
- Focus on prediction uncertainty
- Multiple MDF techniques

www.carbonfusion.org

Model and parameters



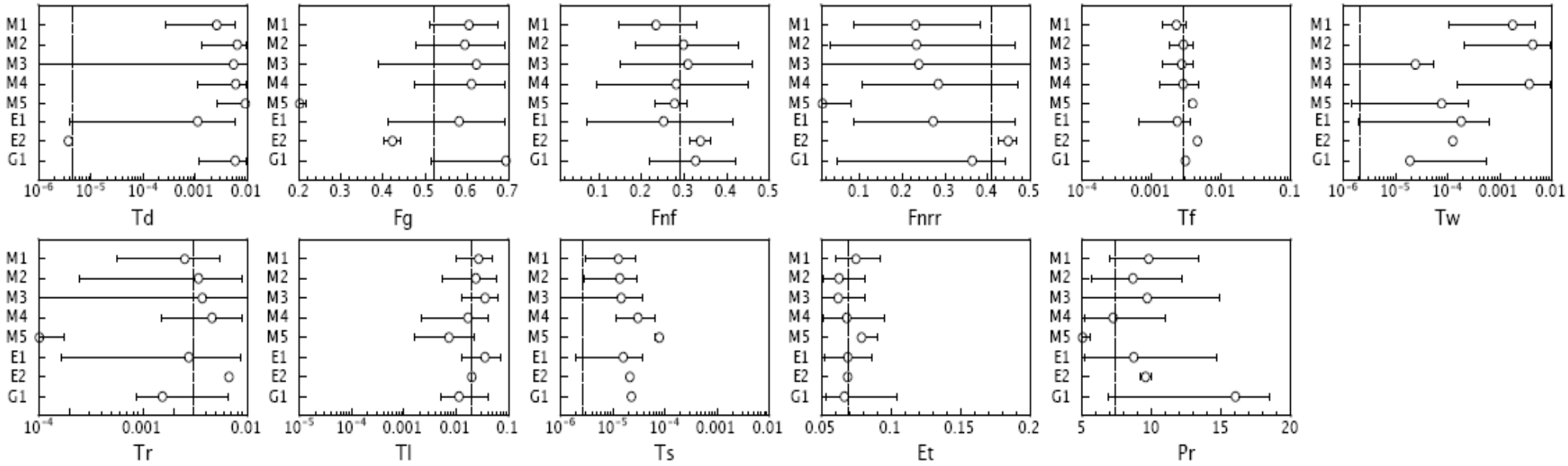
Parameters to be optimised:

	Description	Range (low/high)
p1	Decomposition rate (per day)	1 x 10^{-6}/0.01
p2	Fraction of GPP respired	0.2/0.7
p3	Fraction of NPP allocated to foliage	0.01/0.5
p4	Fraction of NPP2 allocated to roots	0.01/0.5
p5	Turnover rate of foliage (per day)	1 x 10^{-4}/0.1
p6	Turnover rate of wood (per day)	1 x 10^{-6}/0.01
p7	Turnover rate of roots (per day)	1 x 10^{-4}/0.01
p8	Mineralisation rate of litter (per day)	1 x 10^{-5}/0.1
p9	Mineralisation rate of SOM/CWD (per day)	1 x 10^{-6}/0.01
p10	Parameter in exponential term of temperature dependent rate parameter	0.05/0.2
p11	Nitrogen use efficiency parameter (a1) in ACM	5/20
p12 *	*GDD* value causing leaf out	200/400
p13 *	Minimum daily temperature causing leaf fall	8/15
p14 *	Fraction of leaf loss transferred to litter	0.2/0.7
p15 *	Turnover rate of labile carbon (per day)	1 x 10^{-4}/0.1
p16 *	Fraction of labile transfers respired	0.01/0.5
p17 *	Maximum C_f value (gC m^{-2})	100/500

Table A3. Model parameters requiring calibration. NPP_2 is NPP remaining after allocation to foliage.

*** parameters p12-17 are used in DALEC-deciduous only.**

Parameter constraint

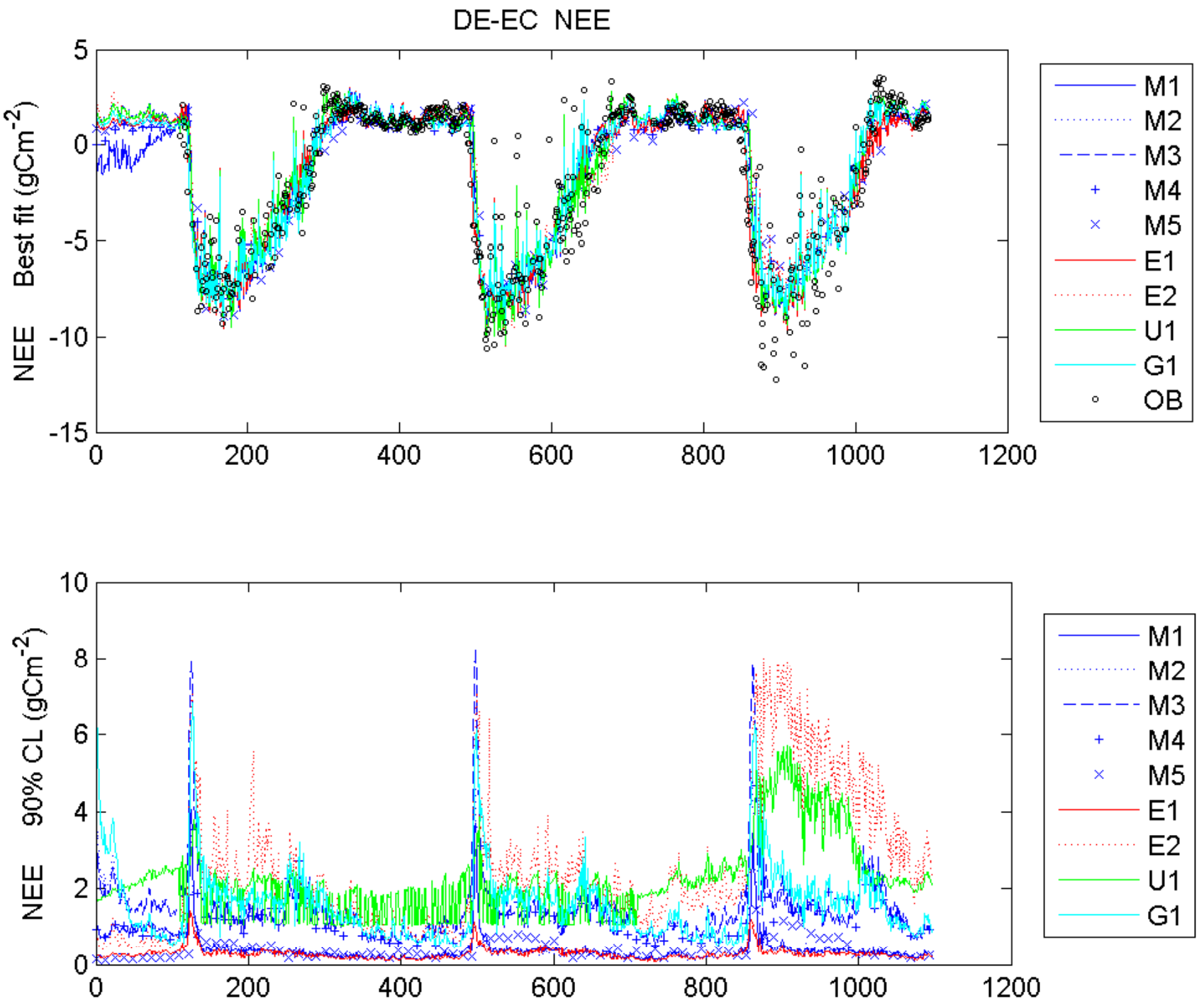


"truth"

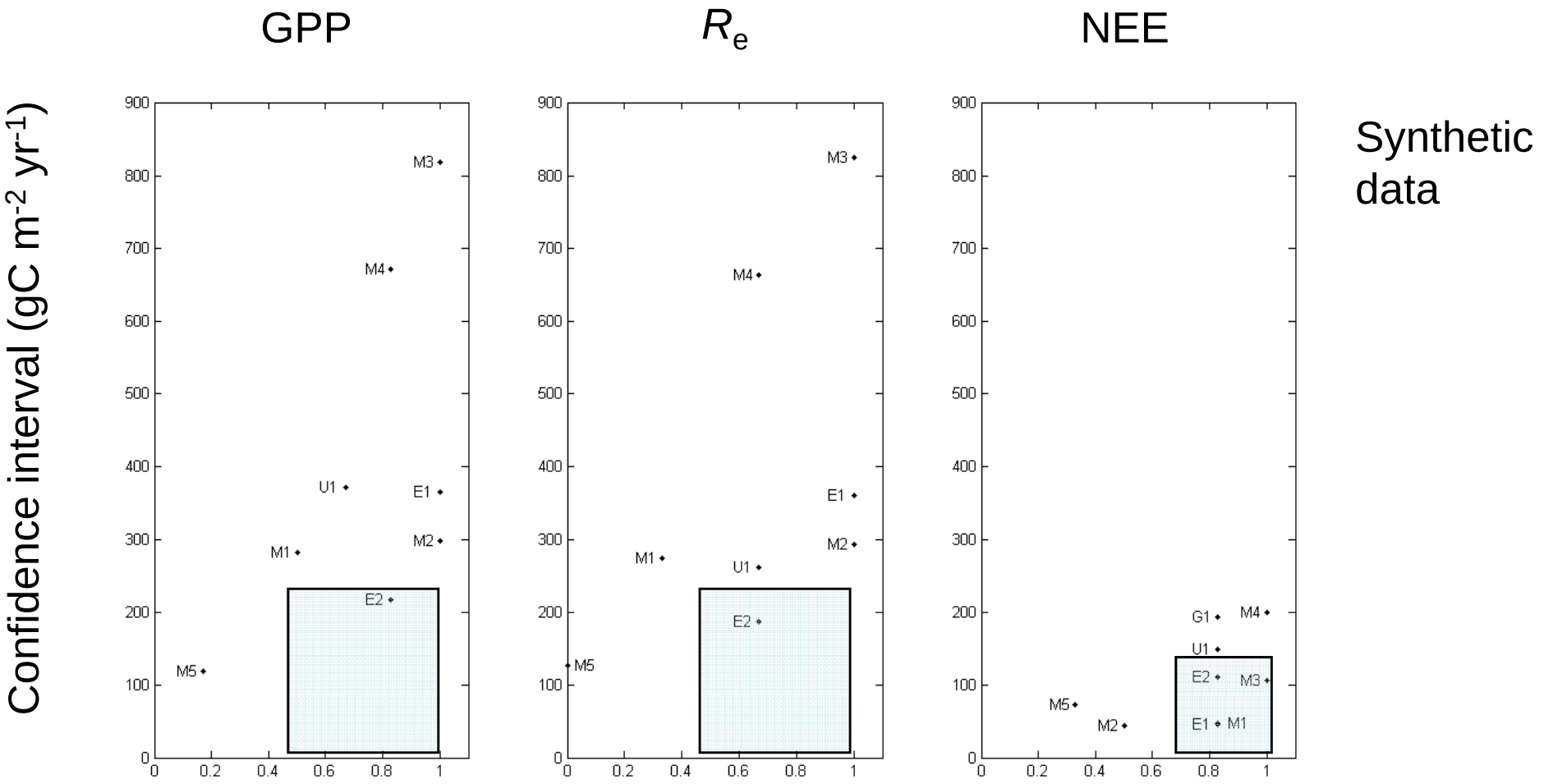
Consistency among methods
Confidence intervals constrained by the data
Consistent with known "truth"

Parameter summary

- Parameters closely associated with foliage and gas exchange are better constrained
- Parameters for wood and roots poorly constrained and even biased
- Similar parameter consistency values for synthetic and EC data
- Divergence among methods in estimates of parameter CIs

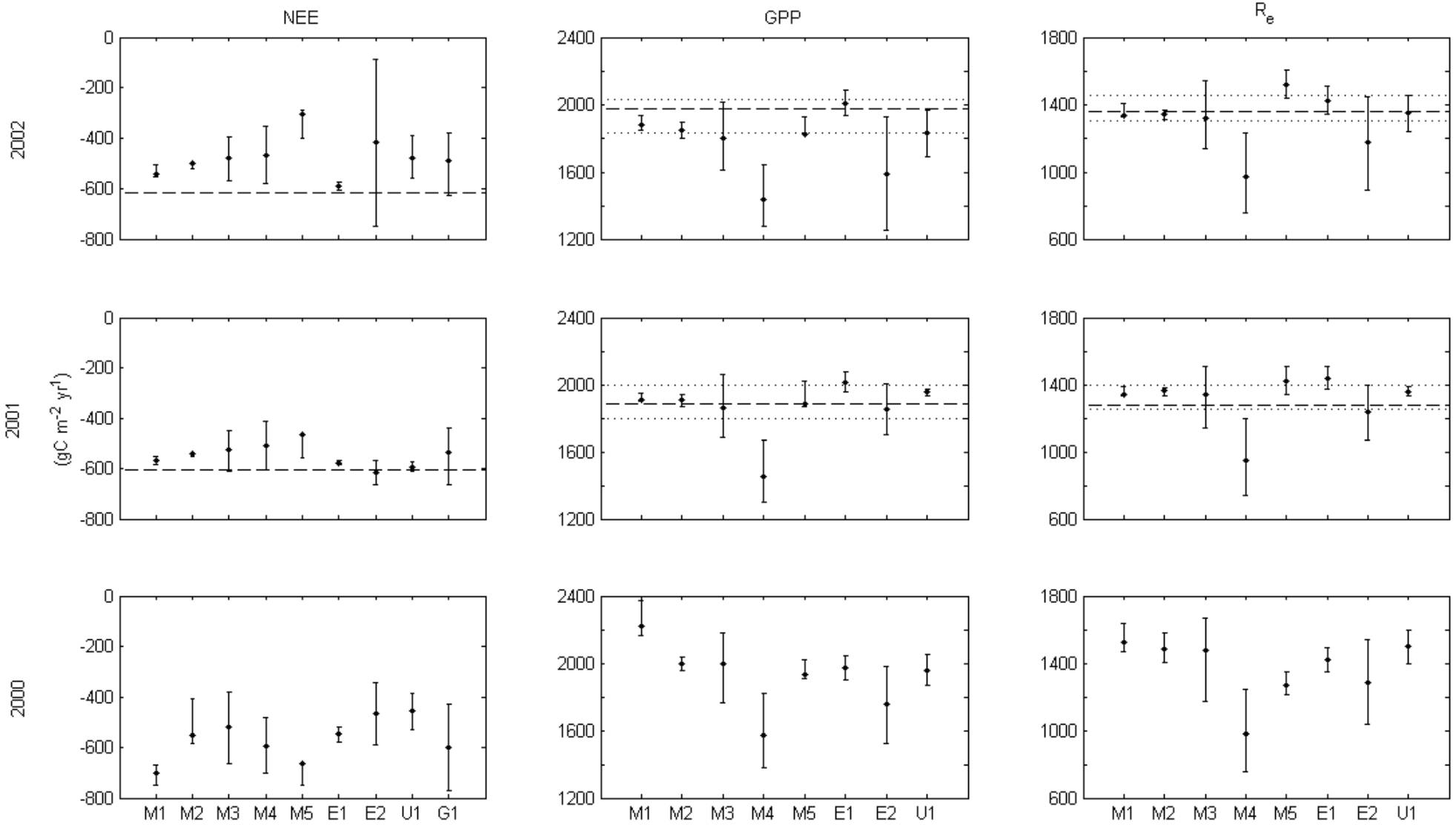

DE-EC NEE
NEE Best fit (gCm-2)
5
0
-5
-10
-15
0
200
400
600
800
1000
1200
M1
M2
M3
M4
M5
E1
E2
U1
G1
OB
NEE 90% CL (gCm-2)
10
8
6
4
2
0
0
200
400
600
800
1000
1200
M1
M2
M3
M4
M5
E1
E2
U1
G1

Testing algorithms – synthetic data



Fraction of successful annual flux tests (3 years x 2 sites, *n*=6)

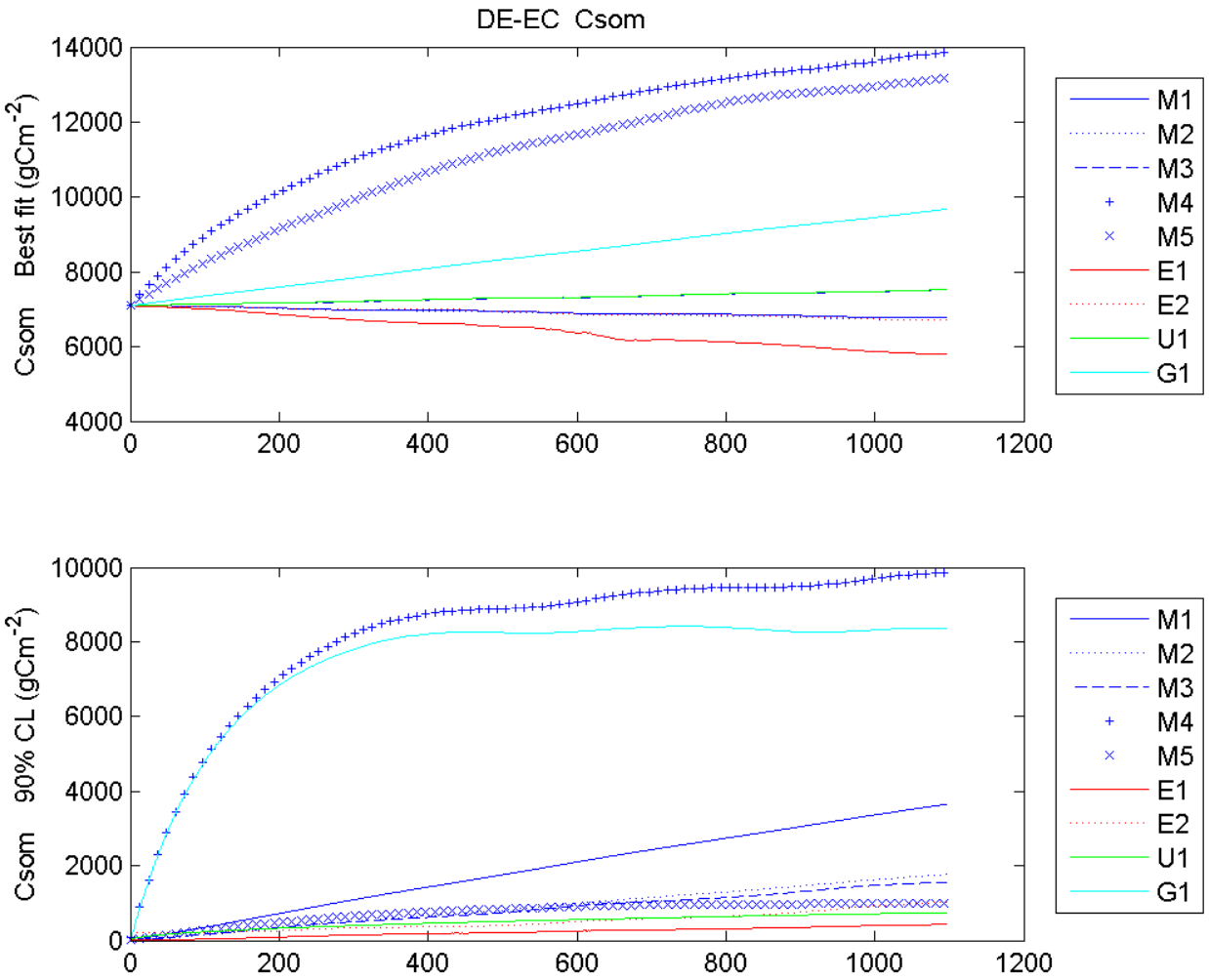
Testing algorithms – Hesse FLUXNET data



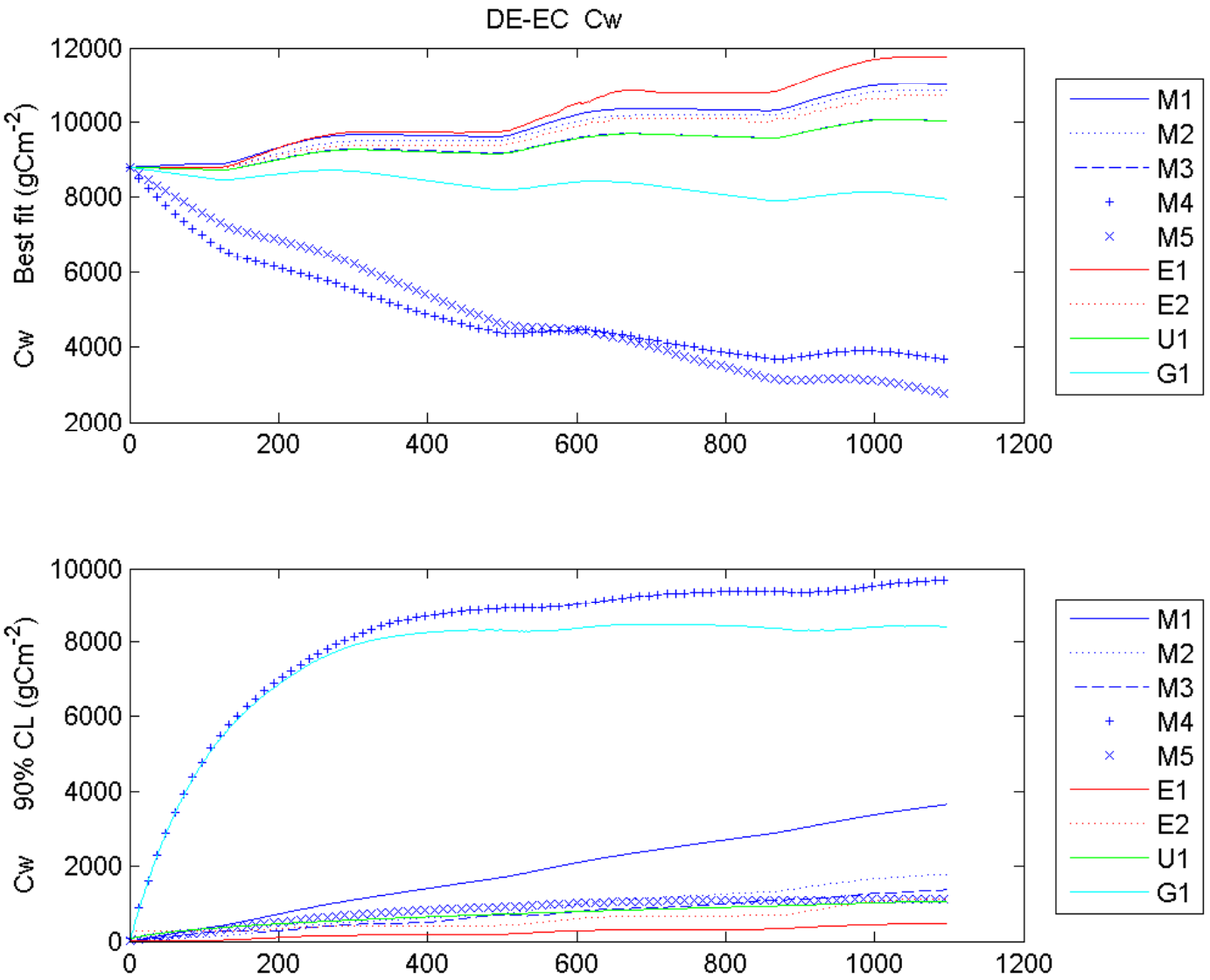
------FLUXNET gap filled data – Desai et al 2008

| 90% confidence interval on annual analysis

Problems with soil organic matter…



And with woody C



State retrieval summary

- Confidence interval estimates differed widely
- Some techniques balanced success with narrow confidence intervals
- Some techniques allowed large slow pools to diverge unrealistically
- Decomposition of NEE into GPP/R_e was generally successful using daily data
- Model error = 88%
- Prediction error = 31%

REFLEX 2?

- Objectives: to compare how different land surface models can learn from FLUXNET data
- Real and synthetic observations from evergreen and deciduous ecosystems
- 2 years of FLUXNET data supplied from 2 forest sites
- Synthetic data
- A range of LSMs and multiple MDF techniques
- Model predictions then compared to multiple years of succeeding FLUXNET data
- C and water cycles
- Managed by LSCE, University of Edinburgh & ?
  - Partners welcomed

REFLEX 2 includes:

- Multiple LSMs and MDF schemes
- Model time-steps from hourly to daily.
- Model testing (NEE, LE, H) against longer EC time-series (explaining inter-annual variation?)
- Comparison of model outputs with biometric data – LAI, C stocks
- Comparison of model process rates with empirical decomposition – GPP, Ra, Rh.

Other data constraints?

- Tree rings
- FPAR, NDVI, EVI time series
- Stem inventories
- chronosequences
- Phenology observations
- Soil moisture, LE, stream-flow
- Surface temperature (IRT)

Acknowledgements:
REFLEX team:
Andy Fox
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New expt:
Philippe Peylin
Hans Verbeecks
Philippe Ciais

Thank you

Estimating NEE model error

Dataset	Year 1 (data)	Year 2 (data)	Year 3 (prediction)
DE-EC	181	97	186
EV-EC	119	93	169
DE-SYN	139	94	149
EV-SYN	95	58	118

Units: gC m^{-2} yr^{-1}

CI in FLUXNET analyses are ~31% larger than in synthetic studies

Estimating NEE prediction error

Dataset	Year 1 (data)	Year 2 (data)	Year 3 (prediction)
DE-EC	181	97	186
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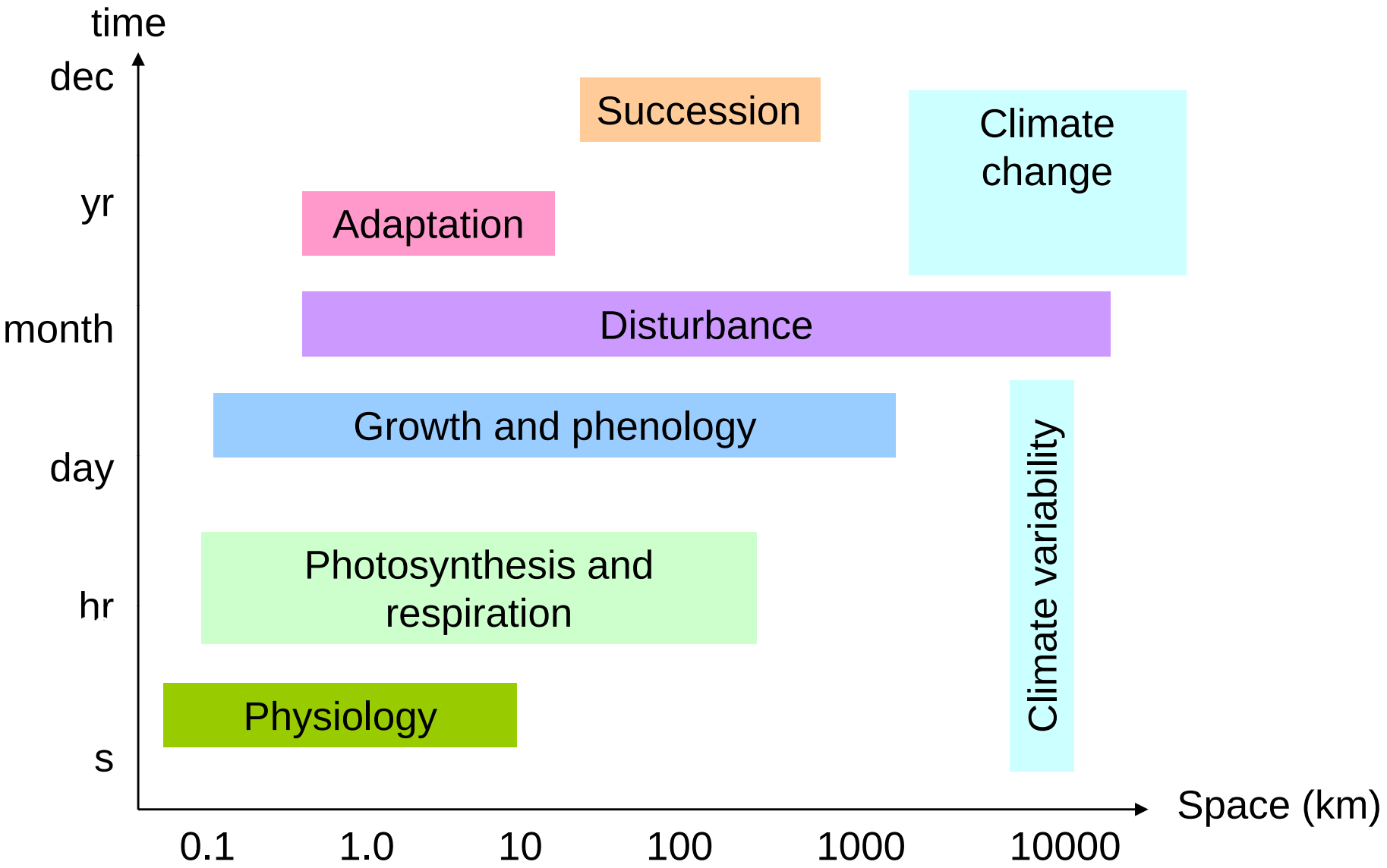
Units: gC m^{-2} yr^{-1}

CI drop in year 2 as initial condition errors are reduced
CI increase by 88% in prediction year, compared to year 3

Time and space scales in ecological processes



Time and space scales in ecological observations