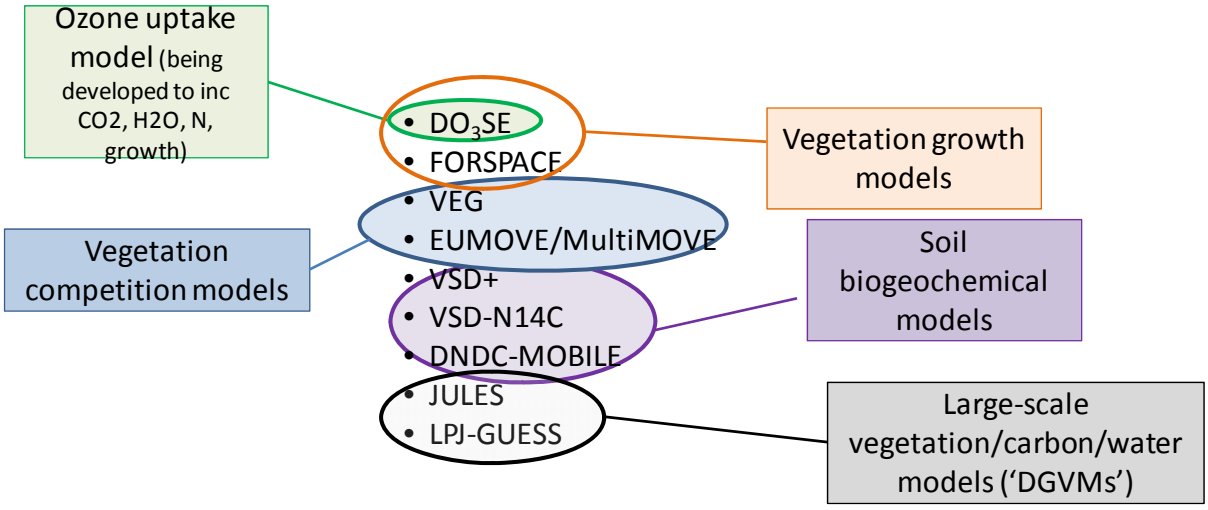
MS56 Identification of priorities for model development, final list of models for inclusion, and data requirements for parameterisation and testing

1. Description of Models used in C3

The ECLAIRE project has identified a number of models that will be used to improve our understanding of how pollutant deposition and climate change will impact biogeochemical cycling and vegetation, and specifically how GHG emissions, C stocks and biodiversity will be affected by these stresses.

Throughout this document, the models will be grouped into the categories indicated in **Figure 3.1** with further details being provided in **Table 3.1** which describes the main model aims, data requirements and key output variables.

Figure 3.1: Schematic of models being used within C3.



As well as providing the opportunity to scale information gathered in C3 from experiments and data mining, the C3 models will also be used to help design experiments (by identifying important uncertainties in existing modelling methods that can be answered by experimental investigation) and to interpret experimental results. For example, there is uncertainty as to how pollutants such as O_3 might affect key plant processes such as photosynthesis (An), stomatal conductance (gsto); by interaction with the modellers it will be possible to design experimental protocols that can be applied to collect new data to improve the representation of these processes within the models.

Modelling can also be used to further analyse experimental results, for example, the DO_3SE model, which is well suited to simulating experimental conditions, can be used to integrate experimental data e.g. use knowledge of O_3 concentrations, plant physiology and within chamber environmental

conditions to simulate g_{sto}, An and O_3 deposition. This type of approach can provide an interface between experimental data and some of the key model processes used by many of the ecosystem models (e.g. An, gsto, respiration (R) and carbon (C) allocation. Here, the meaning of the term 'interface' is to allow information gathered from experiments, describing e.g. the action of O_3 and drought on An, to be analysed and synthesised using DO_3SE leading to an improvement in how these key vegetation processes are modelled. Because each of the vegetation models will use the same, or very similar methods, to model these key processes, these modifications to DO3SE can then also be used to inform suggested modifications to these processes in other models. In addition, models within C3 will also be tested and further developed with appropriate ECLAIRE experimental data (i.e. those data collected from plot scale experimental campaigns) and with data identified through the data mining activities from other research Programmes. The more (semi-) qualitative data mining activities will also provide information that can be used for all model development as appropriate.

In order to facilitate the experimental design and model learning of C3 it is useful to describe in a little more detail the key vegetation processes that can be investigated further in this part of the ECLAIRE project.

Table 3.1. Brief overview of C3 models, their main aims, input data requirements, key output variables and the main point of contact within ECLAIRE. [An overview of all models used in ECLAIRE can be found at : http://www.eclaire-fp7.eu/research_components]

Model name	Class of model	Aim	Input data requirements	Key output variables	Scale	ECLAIRE contact name and e-mail
DO_3SE (Deposition of ozone for stomatal exchange)	Ozone uptake and growth	Estimates O_3 dry deposition and stomatal O_3 flux to estimate ecosystem damage. Also assesses CO_2 uptake via plant photosynthesis and soil-plant-atmosphere H_2O exchange. Deposition scheme will be further developed in C1 and a simple plant growth (C assimilation and allocation	Hourly met., hourly O_3 concentration, vegetation specific physiological parameters (e.g. max g_{sto}, J_{max}, Vc_{max}, and structural (e.g. LAI) parameters, site location details.	Leaf and canopy g_{sto}, leaf photosynthesis An, soil water, evapotranspiration, O_3 deposition, accumulated stomatal O_3 flux (PODy)	Site-specific + regional (e.g. European region) when coupled with EMEP (DO_3SE currently provides the O_3 deposition estimates for the EMEP photo-oxidant CTM)	Lisa Emberson (l.emberson@york.ac.uk)
FORSPACE (Forest dynamics in spatially changing environments)	Vegetation growth	Simulates forest dynamics in spatially changing environments, describing mechanistic interactions between C, N, P, H_2O, O_3 and temperature in vegetation and soil.	Climate, soil, cover per species (or PFT for non-forest species), management.	Forest data relating to process (i.e. evapotranspiration) and state (i.e. area, volume etc).	Vegetation model landscape	Koen Kramer (koen.kramer@wur.nl)
VSD + (awaiting)	Soil BGC	A dynamic soil model for simulation of the effects of atmospheric deposition and climate change on soil acidification, nutrient status, C&N pools and fluxes.				Gert Jan Reinds (gertjan.reinds@wur.nl)
VSD-N14C-MM	SOIL BGC	A plant-soil N and C cycling model to simulate long-term ecosystem enrichment by atmospheric N deposition. N14C is parameterised with basic plot-scale data available for a range of sites representing different plant types, and with different N deposition rates	See linked spreadsheet	Soil and biomass C & N pools (N14C); soil solution chemistry (VSD); Prevalence of individual species (MM).	Soil biogeochemical model, plot scale application?	Ed Rowe (ecro@ceh.ac.uk); Chris Evans (cev@ceh.ac.uk)
DNDC mobile	SOIL BGC	A biogeochemical model for simulating C & N turnover processes and associated biosphere-hydrosphere-atmosphere exchange of C and N compounds (e.g. GHG, NO, nitrate) at	Relevant information on meteorology and N deposition (daily), vegetation and soil properties.	Major C and fluxes, stock changes, GHG's/ NO fluxes, nitrate leaching	Soil biogeochemical and vegetation model, landscape scale	Klaus Butterbach-Bahl (klaus.butterbach-bahl@kit.edu);
VEG	Veg competition					
EUMOVE/Multi MOVE	Veg competition					
JULES	DGVM	Process based land surface model that principally estimates, energy, momentum, water and carbon	Climate, vegetation data.		Best et al. 2011; Clark et al. 2011	
LPJ-Guess	DGVM	DGVM for simulation of interactions between climate, atmospheric burdens of trace gases and vegetation, biogeochemical cycles and trace gas exchange.	Climate data, CO2 concentration, N deposition, land use type if used (crop mode only)	Forest and crop NPP or yield, soil and biomass C and N pools, trace gas emissions (BVOC, NOx, fire), forest potential natural	Landscape	Almut Arneth (almut.arneth@imk.fzk.de); Kirsti Ashworth (k.ashworth1@lancaster.ac.uk)

2. ECLAIRE C3 model requirements

It is first useful to identify the data requirements of the ECLAIRE models; this task has been aided by work conducted by Ed Rowe in WP13. **Table 7.1** provides an overview of the model quantities required; for full details please contact Ed Rowe (ecro@ceh.ac.uk). It will be important to establish which sites (experimental, WP10 and 11) and existing plot scale data available through the datamining activities in WP9 will be used by each model. **Table 7.1** Quantities required by the models that are available for use in C3. The importance of the quantity for each model is defined by 0=not required; 1=useful; 2=absolutely necessary. This list has been compiled from a 'Quantity requirements for ECLAIRE 3.5 models' collated by Ed Rowe.

Note 1: Acknowledging that not all experiments will provide each of these, Annex 3 provides a list of data required from each experiment

Note 2: The comparison data is not absolutely essential for model runs but is necessary for model evaluation so the '2' descriptor here should bear this in mind. In addition, a full complement of comparison data (e.g. where daily or hourly values are requested it is likely that these data will be useful even if there are large gaps in a seasonal time course) may often not be necessary. Some of the input data could possibly be described more as model parameterisation data and it may be that model defaults for these variables exist that could be used where local data are unavailable; as such unavailability of these data may still mean that the model can be run at a site.

Table 7.1 Inputs needed for the VEG, EU MOVE/multiMove and JULES models

Models & Quantities	Frequency	Units	DO_3SE	FORSPACE	VEG	EuMOVE/ MultiMOVE	VSD+	VSD-N14C-MM	DNDC-Mobile	JULES	LPJ-GUESS	ROMUL
Model type			gas uptake/growth	Veg growth	Veg compet.	Veg compet.	Soil BGC	Soil BGC	Soil BGC	DGVM	DGVM	
Location specific data												
Site name	Once	Text	2	1			2	2	2		2	2
Treatment name	Once	Text	2	1			2	2	2		2	2
Treatment period	Once	Year day(s)	2	0			1	0	0		0	1
Latitude & longitude	Once	degrees	2	2			1	2	0		2	2
Elevation	Once	m a.s.l.		0			2	0	0		0	1
Vegetation type	Annual	Text?	2	2			1	2	0		1	2
Management history	Annual	Text	2	2			1	2	2		1	2
Measurement height of meteorological and pollutant concentration variables	Once	m	2	0			0	0	0		0	0
INPUT DATA												
Meteorology												
Solar radiation (or derivatives) (hourly, daily or monthly)	(hourly (hr), daily (d)	W/m^2	2 (hr)	2 (d)			1 (d)	0	2 (d)		2 (d)	0
Precipitation	daily (d), annual (a)	m	2 (d)	2 (d)			2 (a), 1 (d)	2 (a)	1 (d)		2 (d)	2 (d)
Runoff	Annual	m	0	0			2	2	0		0	1
Air temperature	(hourly (hr), daily (d), monthly (m)), annual (a)	°C	2 (hr)	1 (d mean, 2, min, max)			1 (d)	1 (a), 2 (July max and Jan min)	1 (d mean, min, max)		2 (d mean, min, max)	2 (d mean, 1, min, max)
Air pressure	Hourly	Pa	2	0			0	0	0		0	0
Wind speed	Hourly (hr), daily (d)	m/s	2 (hr)	2 (d)			0	0	0		0	0
Vapour pressure Deficit (or derivatives, e.g.	Hourly	kPa	2	2			0	0	0		0	0
Soil temperature	Annual mean	°C	0	0			2	2	0		0	0
Soil temperature at 20 cm depth	Monthly mean	°C	0	0			0	0	0		0	2

Table 7.1 continued

Models & Quantities	Frequency	Units	DO_3SE	FORSPACE	VEG	EuMOVE/ MultiMOVE	VSD+	VSD-N14C-MM	DNDC-Mobile	JULES	LPJ-GUESS	ROMUL
Model type			**gas uptake/growth**	**Veg growth**	**Veg compet.**	**Veg compet.**	**Soil BGC**	**Soil BGC**	**Soil BGC**	**DGVM**	**DGVM**	
Deposition												
Ozone concentration at leaf surface (l) or specified measurement height (sh)	Hourly (hr), daily (d), annual (a)	ppbv	2 (hr, sh)	2 (d, l)			1 (a)	2 (d, l)	0		2 (d, l)	0
NHy deposition flux	Annual	$gN/m^2/year$	0	0			1	2	1		2	1
NOx deposition flux	Annual	$gN/m^2/year$	0	0			1	2	1		2	1
S deposition flux	Annual	$meq/m^2/year$	0	0			1	1	0		0	0
CO_2 concentration	Hourly (hr), daily (d), annual (a)	ppmv	2 (hr)	0			1 (a)	1 (d)	2 (d)		2 (d)	0
Cl deposition flux	Annual	$meq/m^2/year$	0	0			1	1	0		0	0
Ca deposition flux	Annual	$meq/m^2/year$	0	0			1	1	0		0	2 ($kg/m^2/yr$)
Mg deposition flux	Annual	$meq/m^2/year$	0	0			1	1	0		0	2 ($kg/m^2/yr$)
K deposition flux	Annual	$meq/m^2/year$	0	0			1	1	0		0	0
Na deposition flux	Annual	$meq/m^2/year$	0	0			1	1	0		0	0
Soil												
Soil depth above which properties & stocks are recorded - e.g. solution sampling depth	Once	m	0	0			1	2	1 (must be 1 m)		0	1
Organic horizon thickness	Once	m	0	0			1	2	1		0	1
Initial soil N stock	Once	g/m^2	0	0			1	0	0		0	0
Soil porosity	Once	% vol	0	0			0	0	0		0	1
Soil bulk density	Once	g/cm^3	1	0			2	2	1		0	2
Soil texture	Once	Text (e.g. coarse, medium, fine)	2	0			1	0	1		1	1
Soil water content	Hourly (h), daily (d) or Annual (a)mean	g/g or m^3/m^3 or mm/layer	2	0			2	2(h)	1		0	1
Soil water content at PWP	Once	g/g or m^3/m^3 or mm/layer	1	0			0	0	0		0	2
Soil water content at FC	Once	g/g or m^3/m^3 or mm/layer	1	0			0	0	0		0	1
Cation exchange capacity	Once	Meq/kg dry	0	0			1	2	2		0	0
Cation exchange co-efficients and model type	Once		0	0			1	0	0		0	0
Al-hydroxide equilibrium constant	Once		0	0			1	0	0		0	0
Cation weathering rates	Once	$eq/m^3/yr$	0	0			1	0	0		0	0
N fixation rate	Once	$eq/m^3/yr$	0	0			1	0	0		0	0

Table 7.1 continued

Models & Quantities	Frequency	Units	DO_3SE	FORSPACE	VEG	EuMOVE/ MultiMOVE	VSD+	VSD-N14C-MM	DNDC-Mobile	JULES	LPJ-GUESS	ROMUL
Model type			**gas uptake/growth**	**Veg growth**	**Veg compet.**	**Veg compet.**	**Soil BGC**	**Soil BGC**	**Soil BGC**	**DGVM**	**DGVM**	
Vegetation												
Canopy height (annual)	Annual	m	2	2			0	2	1		1	0
Max rooting depth (annual)	Annual	m	2	2			2	0	1		1	0
Tree growth rates (default)	Depending on management	m^3/ha/yr	0	0			1	0	0		0	0
Tree biomass expansion factors	Per tree age class		0	0			1	0	0		0	0
Tree compartment turnover rates	Once	yr^{-1}	0	0			1	0	0		0	0
Tree compartment nutrient contents	Once	%	0	0			1	0	0		0	0
Floristics												
Mean Ellenberg R (pH) score (not cover-weighted)	Once	arbitrary	0	0			2	2	0		0	0
Mean Ellenberg F (wetness) score (not cover-weighted)	Once	arbitrary	0	0			2	2	0		0	0
COMPARISON or BIOLOGICAL EFFECT DATA												
LAI	Daily (d) or annual (a)	m^2/m^2	2 (d)	2 (a)			1 (a)	0	1 (a)		2 (a)	0
Wood and Root C stock	annual	g C or N/m^2/yr	0	2			1	1	1		2	0
Root N stock	annual	g N/m^2/yr	0	2			2	0	1		1	2
Litter C and N content	annual	%	0	2			1	0	1		2	2
Litter production C and N flux	annual	g N or C/m^2/yr	0	2			1	1	1		1	2
Photosynthesis net C flux (daily/monthly)	Hourly (hr), daily (d) monthly (m), annual (a)	g CO_2 /m^2/s	2 (hr)	2 (d)			0	0	1 (d, m)		2 (m, a)	0

Table 7.1 continued

Models & Quantities	Frequency	Units	DO_3SE	FORSPACE	VEG	EuMOVE/ MultiMOVE	VSD+	VSD-N14C-MM	DNDC-Mobile	JULES	LPJ-GUESS	ROMUL
Model type			gas uptake/growth	Veg growth	Veg compet.	Veg compet.	Soil BGC	Soil BGC	Soil BGC	DGVM	DGVM	
Plant respiration	Hourly	g CO_2 /m^2/s	1	0			0	0	0		0	0
Whole plant biomass	Annual	g C /m^2	2	0			0	0	0		0	0
Leaf biomass	annual	g C /m^2	1	0			2	0	0		0	1
Root biomass	Annual	g C /m^2	2	0			2	0	0		0	2
Shoot total peak C & N stock	Annual	g C or N /m^2	2	2 (by plant functional type)			0	2	1		0	0
Crop yield	Annual	g C/m^2/yr	2	0			0	0	1		2	0
Wood C:N	annual	ratio	0	2			1	0	1		2	0
Leaf C:N	annual	ratio	0	2			2	0	1		2	2
Root C:N	annual	ratio	0	2			2	0	1		2	2
Leaf C stock	Annual	g C/m^2/yr	0	2			2	0	1		2	2
Leaf & root C:N (annual)			0	2				2	1		0	
Leaf temperature		^oC	1	0			0	0	0		0	0
Reference evapotranspiration (grass)	Annual	mm/yr	0	0			2	0	1		0	0
Evapotranspiration	daily, annual	mm/d or mm/yr	2 (mm/d)	1 (mm/d or mm/yr)			2 (mm/yr)	0	1 (mm/d)		2 (mm/yr)	1 (mm/yr)
Stomatal conductance	Hourly	mmol H_2O m^{-2} PLA s^{-1}	2	0			0	0	0		0	0
Sap flow data	Daily	mm/day	2									
Leaf water potential	Hourly	MPa	1	0			0	0	0		0	0
Pre-dawn leaf water potential	Daily	MPa	2	0			0	0	0		0	0
Floristics												
Species present	Annual	Text	0	1			1	2	0		0	0
Cover of present species	Annual	%	0	2			1	0	0		0	0
Mean Ellenberg N (fertility) score (not cover-weighted)	Once	Arbitrary	0	0			1	2	0		0	0
Tree type/composition	Once		0	2 (#trees/ha)			1 (no. trees/ha)	0	0		1 (relative LAI)	2 (text)
Soil												
Soil temperature at 20 cm depth	Daily (d) or monthly (m)	^oC	0	0			0	0	0		0	2
Forest floor temperature	Daily (d) or monthly (m)	^oC	0	0			0	0	0		0	1
Cation exchange capacity (once)			0	0				2	2		0	
Soil solution major ion concentration (annual mean)	Annual	meq/m^3	0	0			1	2	2		0	2
Soil solution pH	Annual	pH units	0	0			1	2	1		0	1
Soil slurry pH	Annual	pH units	0	0			0	1	0		0	0
Base saturation (once)	Once	meq [Ca+Mg+K+Na] / 100meq CEC	0	0			1	2	2		0	0
Soil C and N stock	Once	g C or N /m2	0	0			1	2	1		1	2
Soil respiration C flux	Bi-weekly	g C/m^2/yr	0	0			2	1	1		0	0
Mineral N leaching	Monthly	g N/m^2/yr	0	0			2	2	1		1	1
Dissolved organic N and C flux	Annual	g N or C/m^2/yr	0	0			2	1	1		0	0
Soil evaporation	Daily	mm/day	1	0			2	0	0		0	0
Parameterisation data												
gmax /g0	Once	mmol H_2O m^{-2} s^{-1}	2	1			0	0	0		1	0
Vcmax	Once	µmol CO_2 m^{-2} s^{-1}	2	1			0	0	0		1	0
Jmax	Once	µmol electrons m^{-2} s^{-1}	2	1			0	0	0		1	0
m	Once	dimensionless										