

Positive Niche Construction: Incorporating Facilitative Microhabitat into Mechanistic Niche Modeling

Supplementary Material

<https://doi.org/10.26443/msurj.v1i1.216>

Dynamic Energy Budget Model in the Sea

Runs simulations of species in the AmP DEB parameter database as a function of sea surface temperature

choose a species (start typing and it will autocomplete)

Mytilus edulis (Blue mussel)

latitude
54

longitude
3

days
365

time step
hourly

start date
2020-01-31 13:00:00

body temp °C
18

f
1

☐ show food parameters

☒ constant Tb?

initial stage
egg

clutch size
1000000

mass unit
g

length unit
cm

z (size) multiplier - applies DEB covariation rules
0 4.2 10

kappa multiplier
0 0.95 2

☒ ageing?

☐ post-hatch respiration?

save output
debout.csv (version/00f286e50d4336652863e5b0e1464f/download/debout?w=)

Supplementary Figure 1. Example set up of [DEB Model in the Sea](#) simulation web tool.

Global Soil Microclimate Calculator

☒ RUN MODEL

load parameters ?

Browse...
 No file selected

latitude
 -42

longitude
 -79

height, cm
 1

month to plot:
 June

depths to plot:
☒ 0cm ☐ 2.5cm ☒ 5cm ☒ 10cm ☒ 15cm ☒ 20cm ☒ 30cm ☒ 50cm ☐ 100cm ☐ 200cm

°C offset
 0

☒ show terrain and soil parameters

Terrain and soil properties

% shade
 0 10 20 30 40 50 60 70 80 90 100

slope
 0 9 18 27 36 45 54 63 72 81 90

aspect
 0 36 72 144 146 216 288 359

horizon
 0 9 18 27 36 45 54 63 72 81 90

wind mult
 0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

% albedo
 0 10 20 30 40 50 60 70 80 90 100

% emissivity
 5 15 25 35 45 55 65 75 85 95 100

thermal conductivity
 0.027 1.6 2.5 3.6 5.4 7.2 9

heat capacity
 500 700 870 900 1,100 1,300 1,500

mineral density
 2.56

bulk density
 1.3

☒ organic surface layer?

☐ query soilgrids?

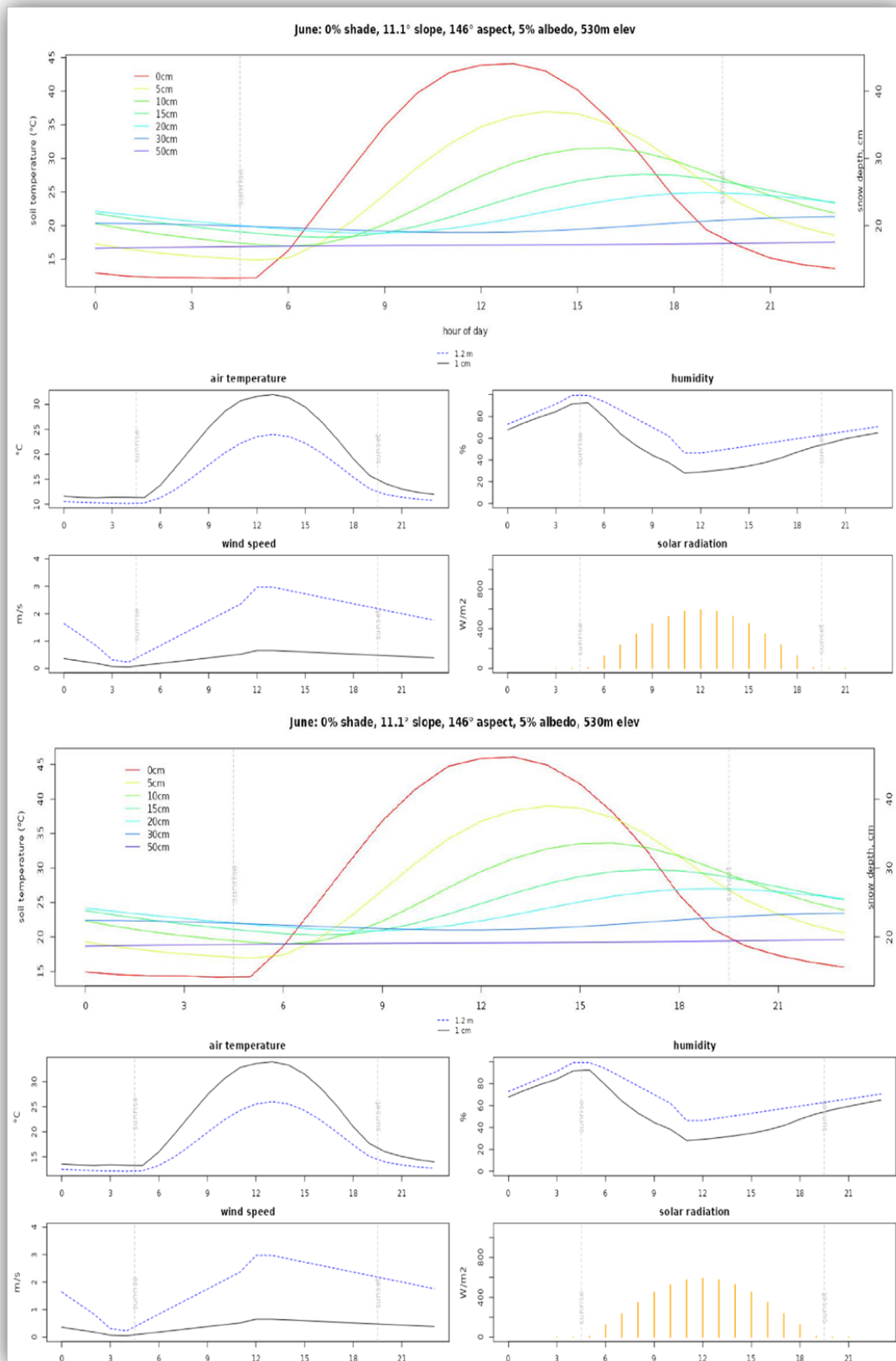
☒ fine-scale topography?

RESET

resolution
 30

pixels
 50

Supplementary Figure 2. Example set up of [Global Soil Microclimate Calculator](#) simulation web tool.



Supplementary Figure 3. Example output of [Global Soil Microclimate Calculator](#) simulation web tool.

Supplementary 4: [Link](#) to Compiled DEB Parameters for *Mytilus Edulis* and DEB Model in the Sea Assumptions.

“Figure 4 shows the mass budget scheme used in the DEB theory. The symbol $\dot{J}$ means mass, the symbol $\dot{p}$ represents energy flow (power), and the dot above means a flux (per time). The elemental composition of the different molecules is represented by $n_{1,2}$ where 1 represents the element (C, H, O or N) and 2 represents the ‘molecule’ (e.g. V for structure or C for CO_2). The fluxes (moles per time) of food, structure, reserve and feces.”

$$\begin{array}{c} \text{Food} \quad \text{Structure} \quad \text{Reserve} \quad \text{Faeces} \\ \left(\begin{array}{cccc} n_{CX} & n_{CV} & n_{CE} & n_{CP} \\ n_{HX} & n_{HV} & n_{HE} & n_{HP} \\ n_{OX} & n_{OV} & n_{OE} & n_{OP} \\ n_{NX} & n_{NV} & n_{NE} & n_{NP} \end{array} \right) \left(\begin{array}{c} \dot{J}_X \\ \dot{J}_V \\ \dot{J}_E + \dot{J}_{ER} \\ \dot{J}_P \end{array} \right) \begin{array}{l} \text{Food} \\ \text{Structure} \\ \text{Reserve} \\ \text{Faeces} \end{array} + \left(\begin{array}{cccc} 1 & 0 & 0 & n_{CN} \\ 0 & 2 & 0 & n_{HN} \\ 2 & 1 & 2 & n_{ON} \\ 0 & 0 & 0 & n_{NN} \end{array} \right) \left(\begin{array}{c} \dot{J}_C \\ \dot{J}_H \\ \dot{J}_O \\ \dot{J}_N \end{array} \right) \begin{array}{l} CO_2 \\ H_2O \\ O_2 \\ N \text{ waste} \end{array} = \left(\begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \end{array} \right)
 \end{array}$$

$$\left(\begin{array}{c} \dot{J}_X \\ \dot{J}_V \\ \dot{J}_E + \dot{J}_{ER} \\ \dot{J}_P \end{array} \right) \begin{array}{l} \text{Food} \\ \text{Structure} \\ \text{Reserve} \\ \text{Faeces} \end{array} = \left(\begin{array}{ccc} -\eta_{XA} & 0 & 0 \\ 0 & 0 & \eta_{VG} \\ \mu_E^{-1} & -\mu_E^{-1} & -\mu_E^{-1} \\ \eta_{PA} & \eta_{PD} & \eta_{PG} \end{array} \right) \left(\begin{array}{c} \dot{p}_A \\ \dot{p}_D \\ \dot{p}_G \end{array} \right) \begin{array}{l} \text{assimilation} \\ \text{dissipation} \\ \text{growth} \end{array}$$

$$\mu = \text{energy} - \text{mass converter, J/C-mol}$$

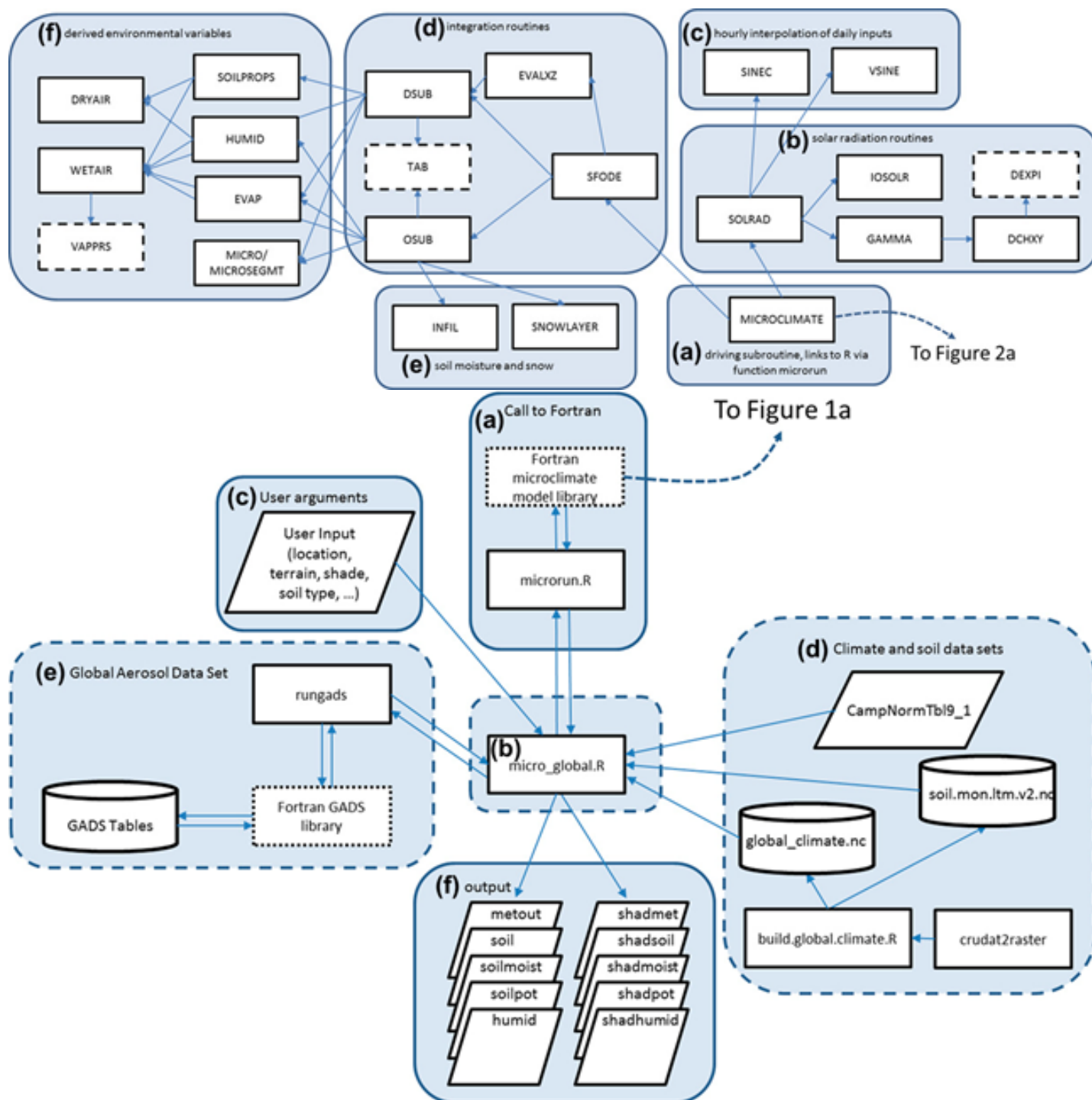
$$\eta = \text{mass} - \text{energy converter, C-mol/J}$$

Stoichiometric equations of the standard model of Dynamic Energy Budget theory, taken from Kooijman (2010).

Supplementary Figure 4. Overview of stoichiometric equations of the standard model of Dynamic Energy Budget theory, explained by Dr. Kearney in documentation of NicheMapR package¹.

“The first equation in Figure 4 is simply a statement of the conservation of mass; the flows of all the elements in the different metabolic processes, when added together, must sum to zero. The second equation states the relationship between the four organic mass fluxes and the three energy fluxes of assimilation, growth and ‘dissipation’ (maturation and its maintenance, somatic maintenance, any heating or osmoregulation costs, and reproduction overhead costs), given the conversion coefficient matrix for energy/mass.

The key point is that knowing the energy fluxes, computed from the DEB model as it evolves through time, and the stoichiometric composition of food, structure, reserve and feces, one can compute the oxygen, carbon dioxide, metabolic water and nitrogenous waste fluxes. Although we don’t usually have explicit data on these elemental compositions, the default values [based on general estimates of organismal stoichiometry, e.g. Roels (1983)] give good predictions in practice. Thus, by producing a DEB model we can get realistic dynamics of development, growth and reproduction under fluctuating temperature and food scenarios, and we also get estimates of the fluxes of food, feces, metabolic water, respiratory gases and nitrogenous waste production ‘for free’, as shown in Figure 5 for *Eulamprus quoyii*. This is one of the many pay-offs for abstracting biomass into pools of reserve and structure.”



Supplementary Figure 5. Figure 1 (Top). Structure of the Fortran library of the NicheMapR microclimate model. Solid boxes represent Fortran subroutines and dashed boxes represent Fortran functions. Figure 2 (Bottom). Structure of the R functions used to run the NicheMapR microclimate model with the global databases on climate, soil moisture and aerosols. User input data are represented by the trapezoid boxes and databases are indicated by cylinders. Fortran libraries are indicated by dashed boxes. Curved shaded boxes represent scripts specific to the application of the model with the global climate database and can be substituted with user-created R scripts for customization to alternative environmental data sources. From documentation of NicheMapR package¹.

References

1. Kearney, M. R. & Porter, W. P. NicheMapR – an R package for biophysical modelling: the ectotherm and Dynamic Energy Budget models. *Ecography* **43**, 85–96 (2020). <https://doi.org/10.1111/ecog.04680>