REPUBLIKA HRVATSKA
MINISTARSTVO ZAŠTITE OKOLIŠA I ENERGETIKE

eptisa Adria d.o.o.

STRATEGIJA PRILAGODBE KLIMATSKIM PROMJENAMA

"Radionica za stručnjake za modeliranje klimatskih scenarija, procjenjivanje utjecaja klimatskih promjena temeljem rezultata dobivenih modeliranjem i procjenjivanje mjera prilagodbe klimatskim promjenama te upoznavanje s postojećim rješenjima i tehnologijama prilagodbe"

Radionica br. 4/10: ŠUMARSTVO

Ministarstvo poljoprivrede, Ulica grada Vukovara 78, Zagreb, 07. prosinca 2016. g.

HRVATSKI ŠUMARSKI INSTITUT

Modeliranje produktivnosti ekosustava biogeokemijskim modelom Biome-BGCMuSo u uvjetima promijenjene klime - Primjer šume hrasta lužnjaka *

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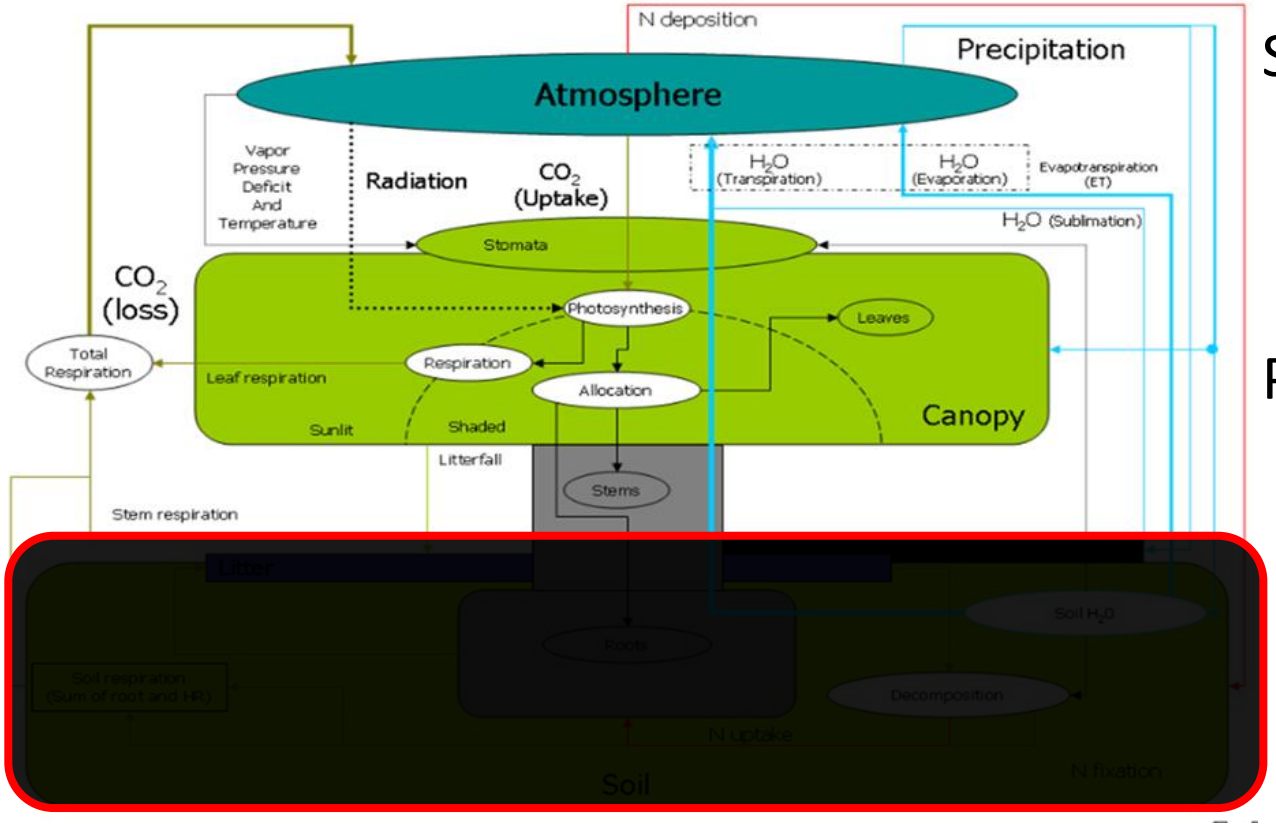
hrzz Hrvatska zaklada za znanost

*Rezultati prikazani u ovoj prezentaciji ostvareni su u okviru projekta "**EFFEctivity**" (HRZZ UIP-11-2013-2492).

Biome-BGCMuSo - općenito

Official website:http://nimbus.elte.hu/bbgc/



- Procesni model
  - Kruženje C, N i H_20
  - okolišni pogonitelji (temperatura, sunčevo zračenje, vlaga zraka, oborine, depozicija N ,…)

SASTAVNICE ES (*pools*):

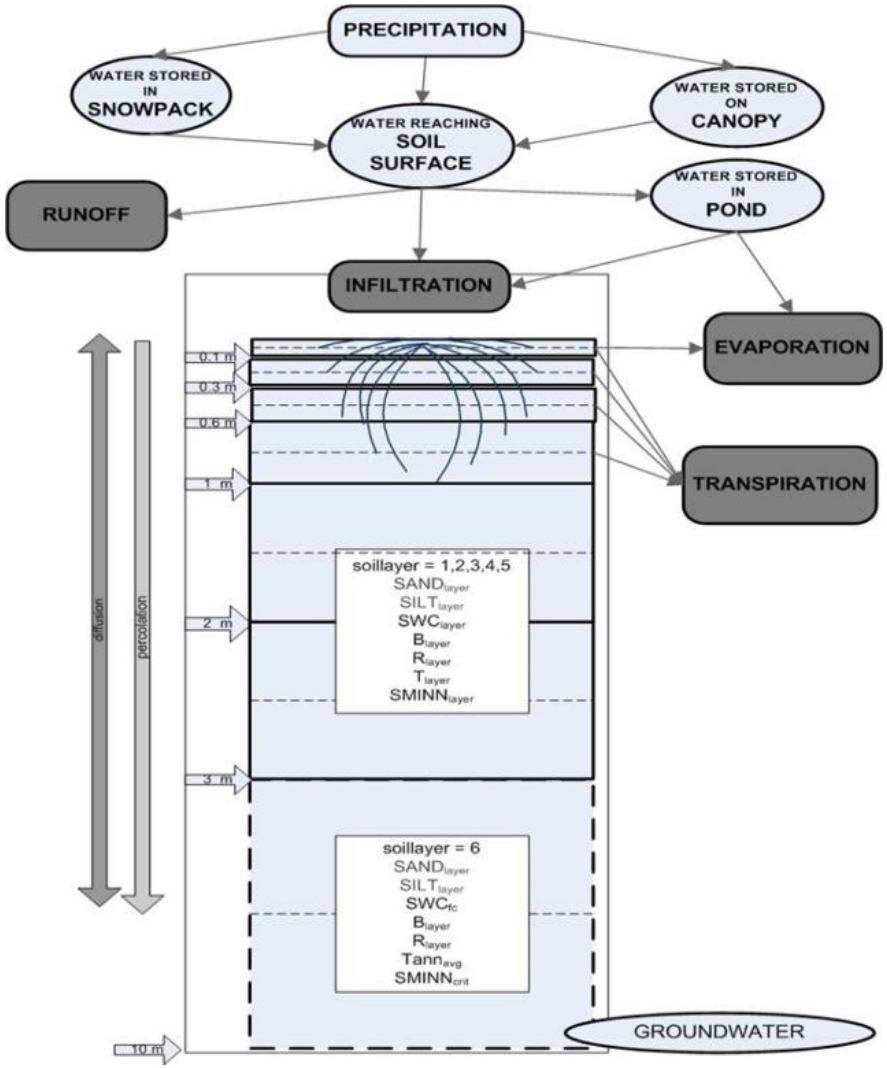
- Atmosfera
- Biljka
- Tlo

PROCESI ES (*fluxes*):

- Fotosinteza
- Alokacija
- Respiracija
- Dekompozicija
- Evapotranspiracija
- Fiksacija N

Biome-BGCMuSo - unaprjeđenje

- ***Mu**lti **So**il layer profile* (MuSo)
  - 7 slojeva
  - vertikalno kretanje vode (difuzija i perkolacija)
  - podzemna voda
  - kvazisaturacija – omogućeno otjecanje vode



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  - Intenzitet i dinamika

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- sušni stres
  - intenzitet mortaliteta
  - kritični prag udjela vode u tlu
  - Kritični broj sušnih dana

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- denitrifikacija (… i fiksacija N)

EKOFIZIOLOŠKI PARAMETRI

VRIJEDNOST (MJ) OPIS PARAMETRA LIT.IZVOR

```
ECOPHYS      OAK (PIETSCH_2005) MuSo4
1       (flag)  biome type flag (1 = WOODY 0 = NON-WOODY)
0       (flag)  woody type flag (1 = EVERGREEN 0 = DECIDUOUS)
1       (flag)  photosyn. type flag (1 = C3 PSN 0 = C4 PSN)
0    *  (flag)  phenology flag (1 = MODEL PHENOLOGY 0 = USER-SPECIFIED PHENOLOGY)
1     dh(flag)  q10 flag (1 = temperature dependent q10 value; 0= constans q10 value)
1    *dh(flag)  acclimation flag (1 = acclimation 0 = no acclimation)
1     dh(flag)  CO2 conductance reduction flag (0: no effect, 1: multiplier)
1    *dh(flag)  soil hydrological calculation method (0: Richards, 1: DSSAT)
0     dh(int)   discretization level of SWC calculation (0: low, 1: medium, 2: high)
0     dh(flag)  soil temperature calculation method (0: Zheng, 1: DSSAT)
80     *(yday)  yearday to start new growth (when phenology flag = 0)          Field observations (H. Marjanović)
310    *(yday)  yearday to end litterfall (when phenology flag = 0)            Field observations (H. Marjanović)
0.30  *P(prop.) transfer growth period as fraction of growing season           149 doy
0.30  *P(prop.) litterfall as fraction of growing season                       241 doy
5     dh(Celsius) base temperature
1000  dh(Celsius) growing degree day for start of fruit allocation
2350  dh(Celsius) growing degree day for start of leaf senescence (0: no 1:yes)
1.0    P(1/yr)  annual leaf and fine root turnover fraction
0.7    P(1/yr)  annual live wood turnover fraction
0.02  *P(1/yr)  annual whole-plant mortality fraction                          Field observation (H. Marjanović)
0.00  *P(1/yr)  annual fire mortality fraction                                 Personal assasment
0.95  *P(ratio) (ALLOCATION) new fine root C : new leaf C                      Ostrogović, 2013
0.14  *dh(ratio)(ALLOCATION) new fruit c : leaf c (>0: yes, 0: no)             Ostrogović, 2013
0.0   dh(ratio) (ALLOCATION) soft stem c : leaf c (>0: yes, 0: no)
1.42   *P(ratio)(ALLOCATION) new woody stem C : new leaf C                    Ostrogović, 2013
0.16   P(ratio) (ALLOCATION) new live wood C : new total wood C
0.26   P(ratio) (ALLOCATION) new croot C : new stem C
0.50   P(prop.) (ALLOCATION) current growth proportion
24.5   *P(kgC/kgN)       C:N of leaves                                         Seletković, 2003
47.5  *P(kgC/kgN)       C:N of leaf litter, after retranslocation             Marjanović, LAB
43.   *P(kgC/kgN)       C:N of fine roots                                     Gordon and Jackson 2000, Zadworny et al. 2015
33.  *dh(kgC/kgN)       C:N of fruit                                          Toscano and Cimino, 2013
0     dh(kgC/kgN)       C:N of soft stem
73.5   P(kgC/kgN)       C:N of live wood
451    P(kgC/kgN)       C:N of dead wood
0.20   P(DIM)   leaf litter labile proportion
0.56   P(DIM)   leaf litter cellulose proportion
0.34   P(DIM)   fine root labile proportion
0.44   P(DIM)   fine root cellulose proportion
0.30 *dh(DIM)   fruit litter labile proportion                                 Toscano and Cimino, 2013
0.29 *dh(DIM)   fruit litter cellulose proportion                              Toscano and Cimino, 2013
0.00  dh(DIM)   soft stem litter labile proportion
0.00  dh(DIM)   soft stem litter cellulose proportion
0.75   P(DIM)   dead wood cellulose proportion
0.038  P(1/LAI/d)       canopy water interception coefficient
0.54   P(DIM)   canopy light extinction coefficient
2.0    P(DIM)   all-sided to projected leaf area ratio
34.5   P(m2/kgC)        canopy average specific leaf area (projected area basis)
2.0    P(DIM)   ratio of shaded SLA:sunlit SLA
0.088  P(DIM)   fraction of leaf N in Rubisco
0.00   dh(DIM)  fraction of leaf N in PEP Carboxylase
0.0024  P(m/s)  maximum stomatal conductance (projected area basis)
0.00006 P(m/s)  cuticular conductance (projected area basis)
0.005   P(m/s)  boundary layer conductance (projected area basis)
0.9   *dh(prop) relative SWC (prop. to FC)  to calc. soil moisture limit 1 (-9999: not used)   Heavy clay soil, optimal soil moisture condition below FC
0.985 *dh(prop) relative SWC (prop. to SAT) to calc. soil moisture limit 2 (-9999: not used)  Heavy clay soil, stress due to excess water starts before SAT
-9999  dh(prop) relative PSI (prop. to FC)  to calc. soil moisture limit 1 (-9999: not used)
-9999  dh(prop) relative PSI (prop. to SAT) to calc. soil moisture limit 2 (-9999: not used)
200     P(Pa)   vapor pressure deficit: start of conductance reduction
2550    P(Pa)   vapor pressure deficit: complete conductance reduction
0.01 dh(prop.) senescence mortality coefficient of aboveground plant material  Personal assasment
0.01 dh(prop.) senescence mortality coefficient of belowground plant material  Personal assasment
0.025 *dh(prop.) senescence mortality coefficient of leaf (after maturity)     Field observations of litterfall dynamics (app 40 days)
0.01   dh(prop.) turnover rate of wilted standing biomass to litter
0.05   dh(prop.) turnover rate of cut-down non-woody biomass to litter
0.01    (prop.) N denitrification proportion
0.02  *dh(prop.) bulk N denitrification proportion (WET)                       Personal assasment
0.01   dh(prop.) bulk N denitrification proportion (DRY)
0.1     (prop.) N mobilen proportion
0.0036  *(kgN/m2/yr) symbiotic+asymbiotic fixation of N                        N fix rate in pure Alnus sp. stand is 0.01 - 0.02 kgN/m2/yr, average 0.015 (Binkley et al. 1994). Volume share (%) of Alnus on eddy site is around 24% (Marjanović et al 2011).
0.9   *dh(prop.) ratio of the storage and the actual pool mortalitay due to management  Assumption that 10% of harvested trees resprouts into coppice (Alnus, Carpinus)
0.5   dh(prop.) critical value of soil stress coefficient
90    *dh(days) critical number of stress days after which senescence mortality is complete  Personal assasment
1.0    *(m) maximum depth of rooting zone                                      Personal assasment
3.67    (DIM) root distribution parameter
0.5     (prop.) maturity coefficient
0.3     (prop.) growth resp per unit of C grown
4.0     (DIM) c parameter of DSSAT TSOIL estimation_____FURTHER ARE MODEL CODE PARAMETERS_____
0.4   *(kgC/kgN/d) maintenance respiration in kgC/day per kg of tissue N      Cannell and Thornley 2000
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- osnovne postavke modela
- parametri specifični za pojedini ekosustav
  - Omjeri alokacije C
  - C/N u pojedinim sastavnicama
  - kemijski sastav pojedinih sastavnica
  - mortalitet uslijed sušnog stresa
  - denitrifikacija i fiksacija N

Biome-BGCMuSo vs. originalni model

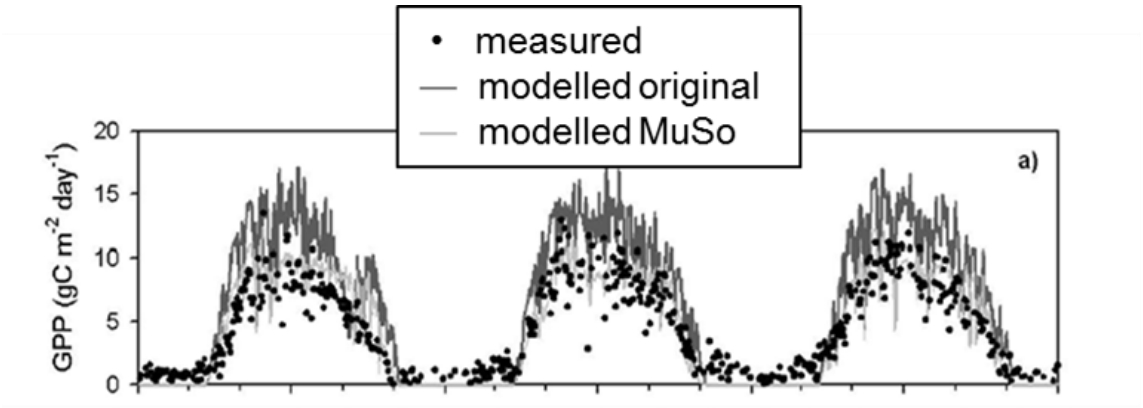


Table 5: Quantitative model evaluation of simulation for deciduous broad-leaved forest for the Jastrebarsko forest site using different error metrics. ORIG means the original Biome-BGC, while MuSo refers to the BBGCMuSo. See text for the definition on the error metrics.

	R^2		RMSE		NRMSE		NSE		BIAS	
	ORIG	MuSo	ORIG	MuSo	ORIG	MuSo	ORIG	MuSo	ORIG	MuSo
GPP	0.84	0.84	3.67	1.77	27.3	13.1	-0.13	0.74	2.27	0.33
TER	0.81	0.83	2.5	1.31	27.4	14.4	-0.51	0.59	2.13	0.82
SWC	0.83*	0.67	0.11*	0.08	27.1*	21.2	0.06*	0.42	-0.08*	0.02
NPP	0.99	0.99	240.9	70.3	30.5	8.9	-0.03	0.91	220.3	-52.3

* SWC simulated by the original Biome-BGC represents constant value within the entire root zone

Hidy, D., Barcza, Z., Marjanović, H., Ostrogović Sever, M. Z., Dobor, L., Gelybó, G., Fodor, N., Pintér, K., Churkina, G., Running, S., Thornton, P., Bellocchi, G., Haszpra, L., Horváth, F., Suyker, A., Nagy, Z.: Terrestrial Ecosystem Process Model Biome-BGCMuSo: Summary of improvements and new modeling possibilities, Geosci. Model Dev. Discuss., 2016.

PREDIKCIJE
- primjer šume hrasta lužnjaka -

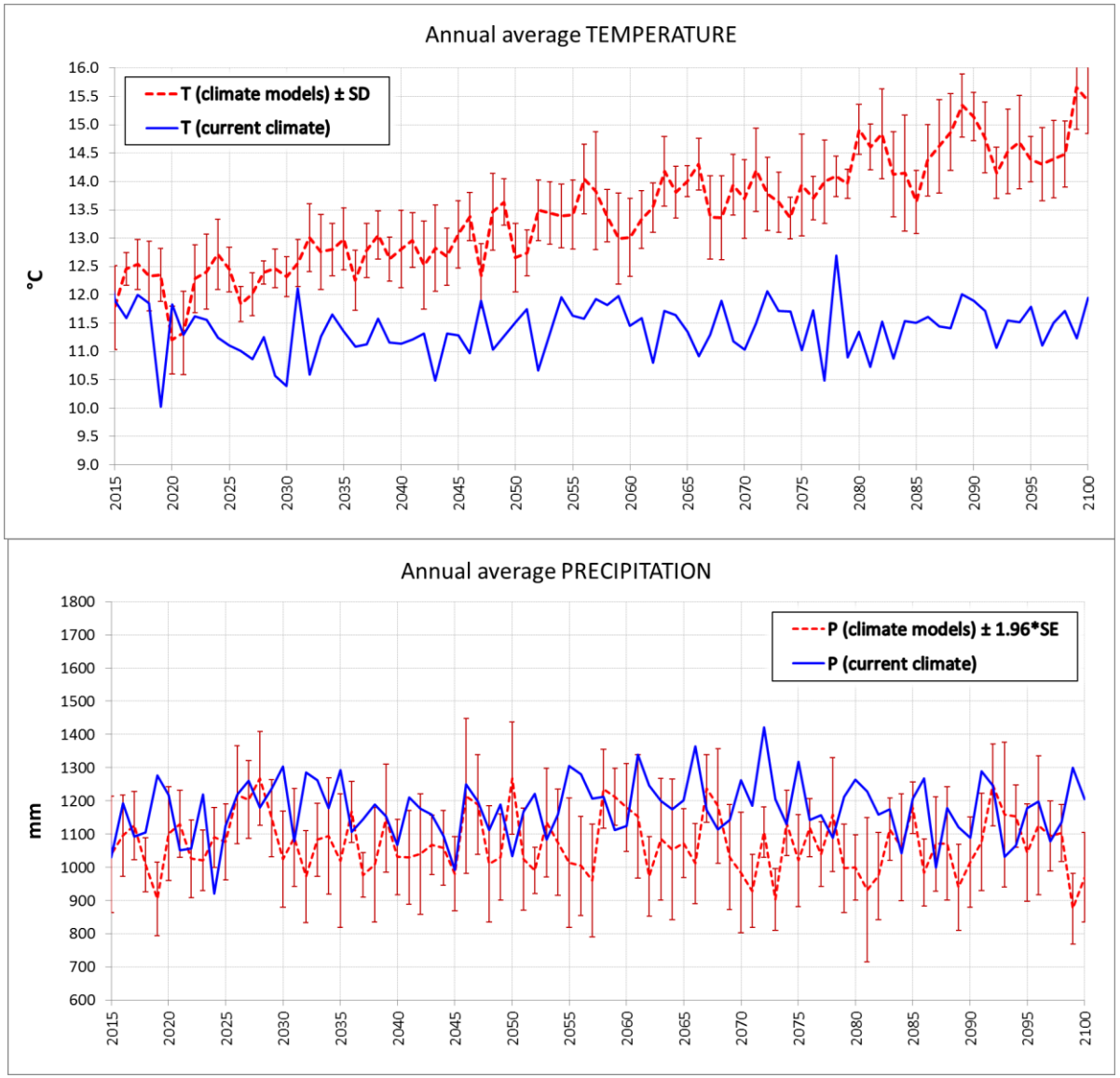
- 2015.-2100. (spin-up 1900.-1999.)

- meteo data
  - FORESEE baza (http://nimbus.elte.hu/FORESEE/map_query/index.html)
  - 1951.-2014. – prošla i sadašnja klima
  - 2015.-2100. – rezultat 10 regionalnih klimatskih modela (ispravljenih za pristranost)

- CO2
  - Mauna Loa Observatorij (http://www.esrl.noaa.gov/gmd/obop/mlo/) i Etheridge i dr. 1998 (http://cdiac.ornl.gov/trends/co2/lawdome.html)
  - A1B emisijski scenarij (IPCC 2000)

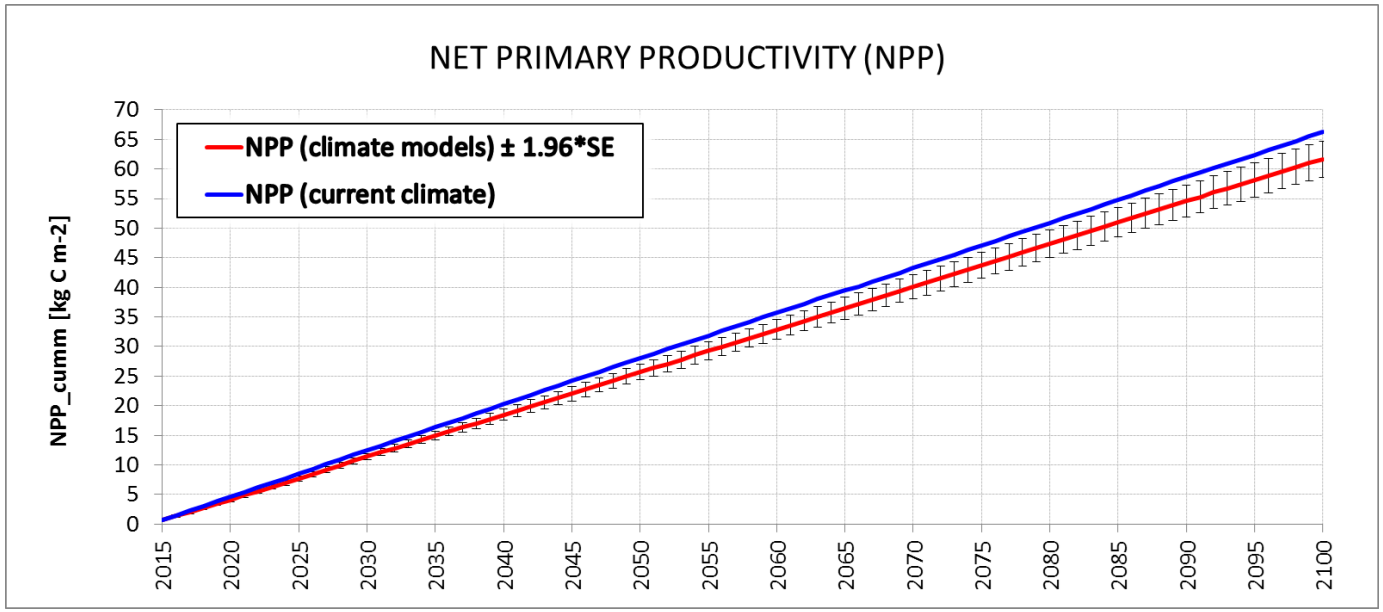
- gospodarenje: sadašnje = buduće (15% V/10 g.), ophodnja 140 g.

REZULTATI – promjena klime



- *Current climate* (sadašnja klima) - procijenjena klima u budućnost na temelju nasumičnog izbora klime prethodnih godina (1951.-2014.) i sa fiksnim CO2 od 400ppm (N=3)
- *Climate models* (klimatski modeli) - prosjek rezultata dobivenih primjenom 10 reg. klim. modela

REZULTATI – utjecaj na šumski ekosustav

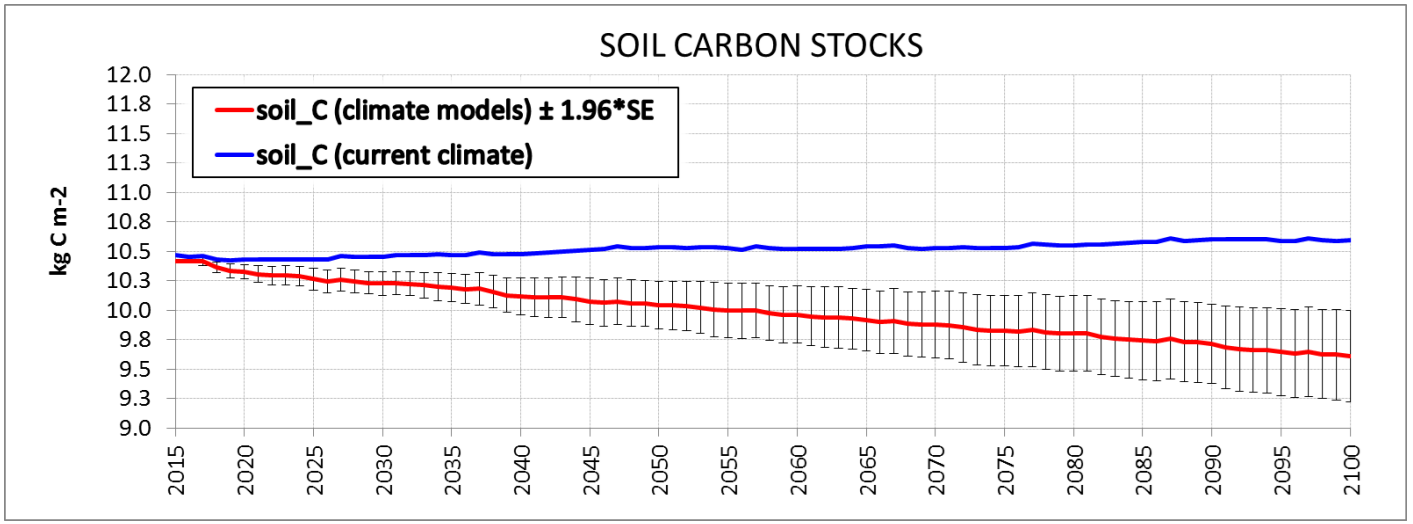


NPP = GPP – Ra

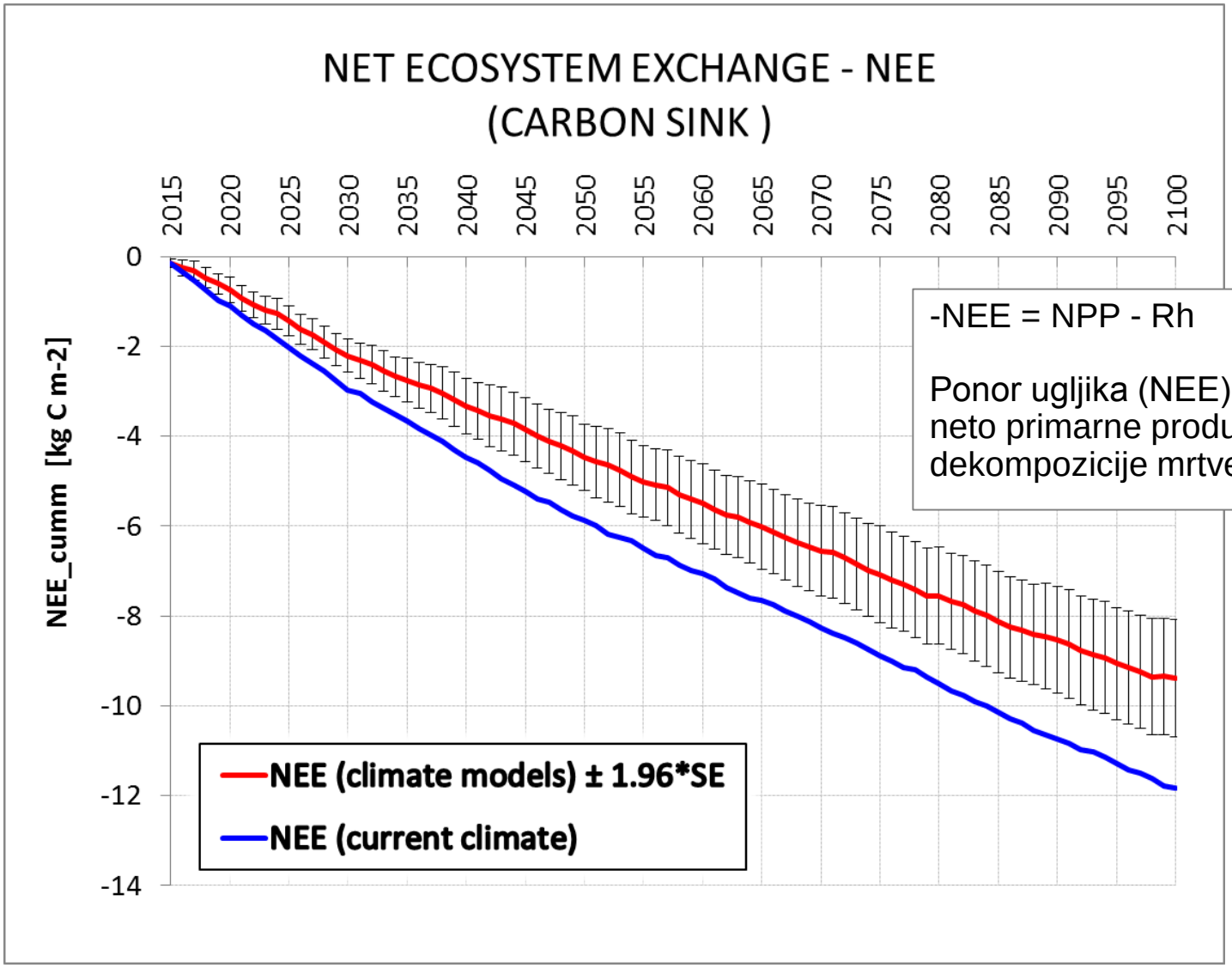
Neto primarna produktivnost (NPP) je razlika između ukupne asimilacije (GPP) i respiracije biljaka (Ra)

Soil C stocks - zalihe ugljika u tlu

Smanjenje zaliha predstavlja oslobađanje C iz tla, odnosno dekompoziciju mrtve organske tvari tla (Rh).



REZULTATI – utjecaj na ponor ugljika



-NEE = NPP - Rh

Ponor ugljika (NEE) je razlika između neto primarne produkcije (NPP) i dekompozicije mrtve organske tvari (Rh)

ZAKLJUČAK

- uočen **negativan trend ponora ugljika** u lužnjakovim šumama u uvjetima promijenjene klime u razdoblju 2015. – 2100. godine

  Uzrok - negativan trend produktivnosti (u manjoj mjeri)

  pozitivan trend oslobađanja ugljika iz tla (u većoj mjeri)

- Za predikcije na području čitave RH potrebna parametrizacija modela za ostale ekosustave (moguća iz literature), ali za validaciju sa potrebni terenski podaci.