A constrained depth-resolved artificial neural network model of marine phytoplankton primary production

Francesco Mattei, Michele Scardi

University of Rome ‘Tor Vergata’ & CoNISMa

francesco.mattei90@yahoo.it

mscardi@mclink.it

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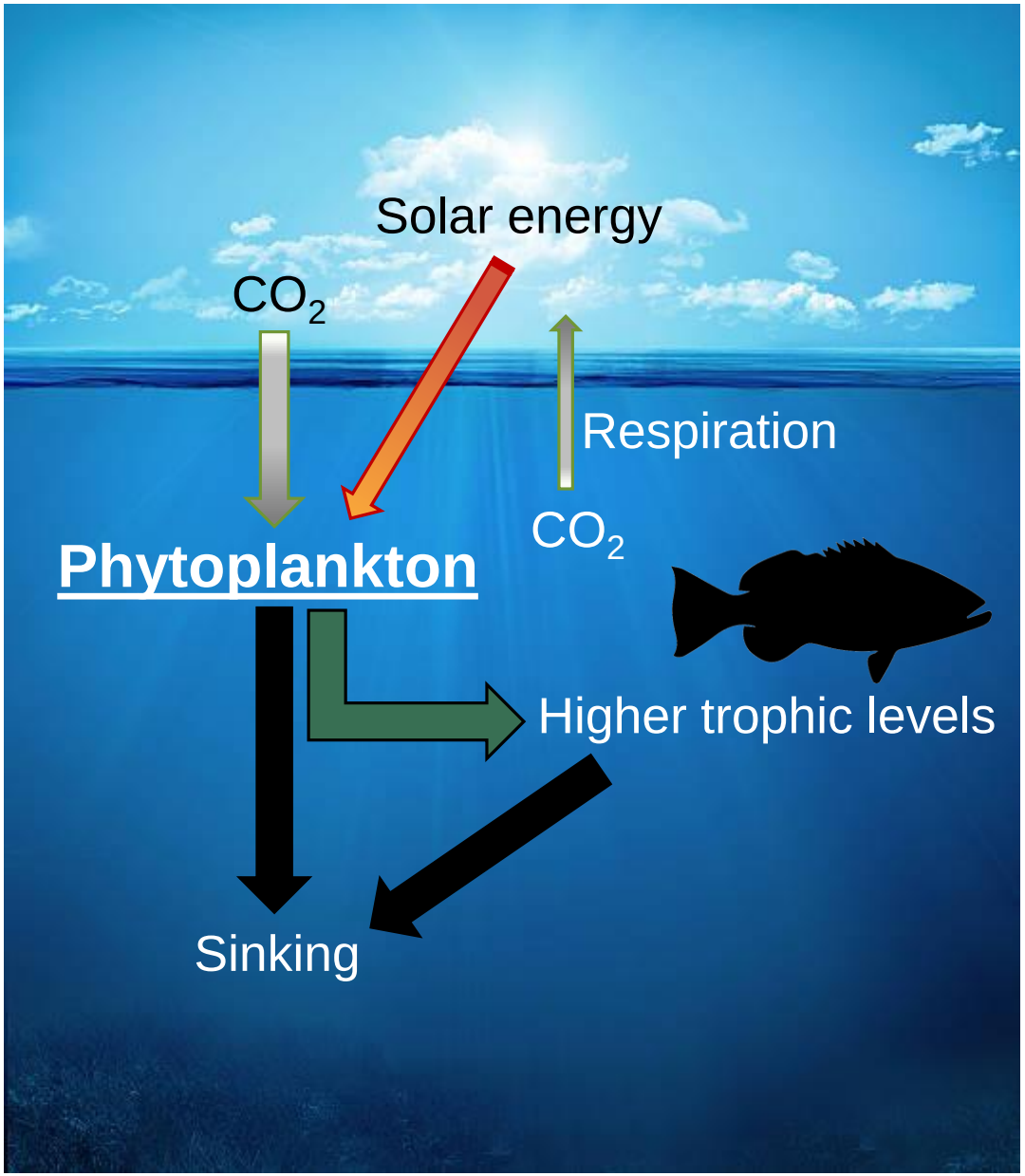
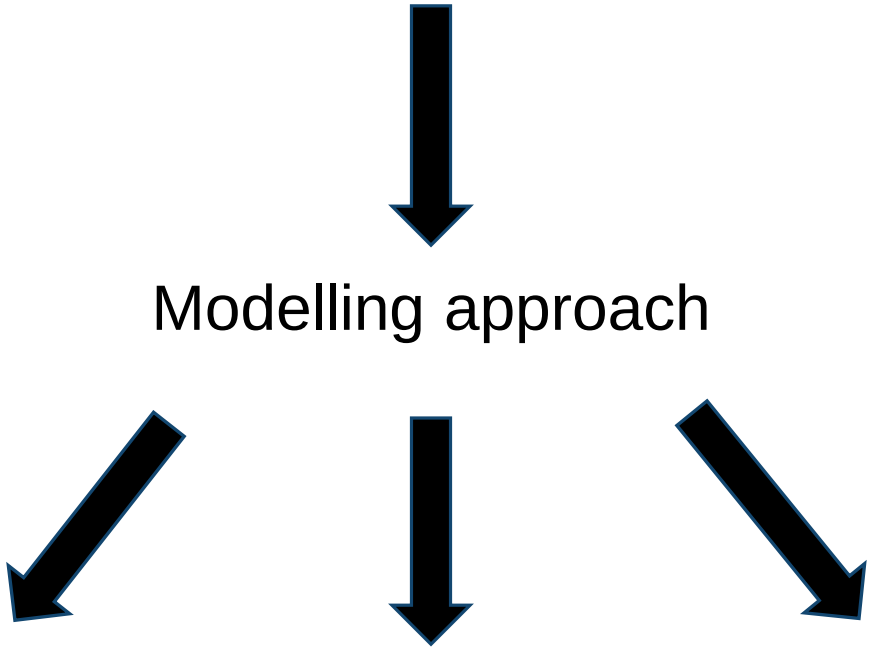
Phytoplankton primary production



Primary production estimation

In situ estimates are expensive and time-consuming



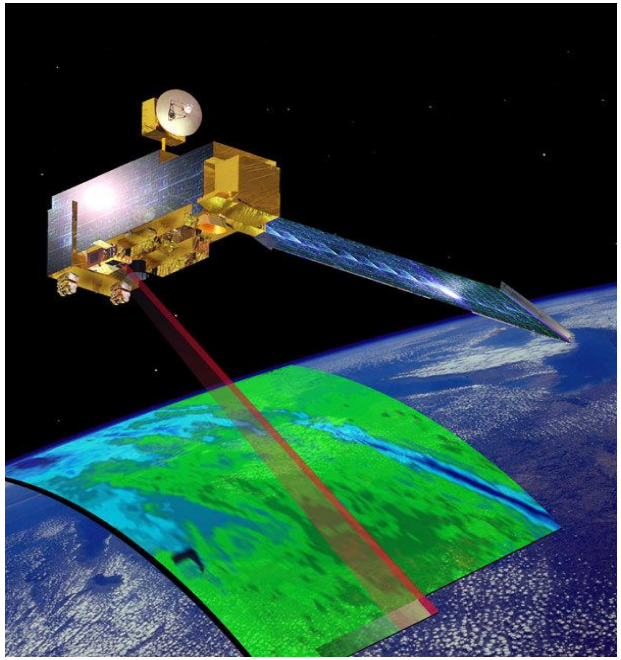
Modelling approach

Ryther & Yentsch
1957

VGPM
1997

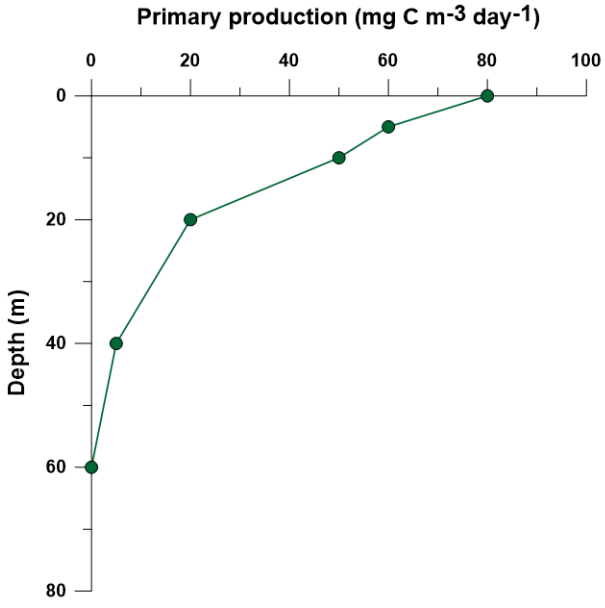
Machine learning
1996

Depth-resolution: from 2D predictors to 3D production profiles

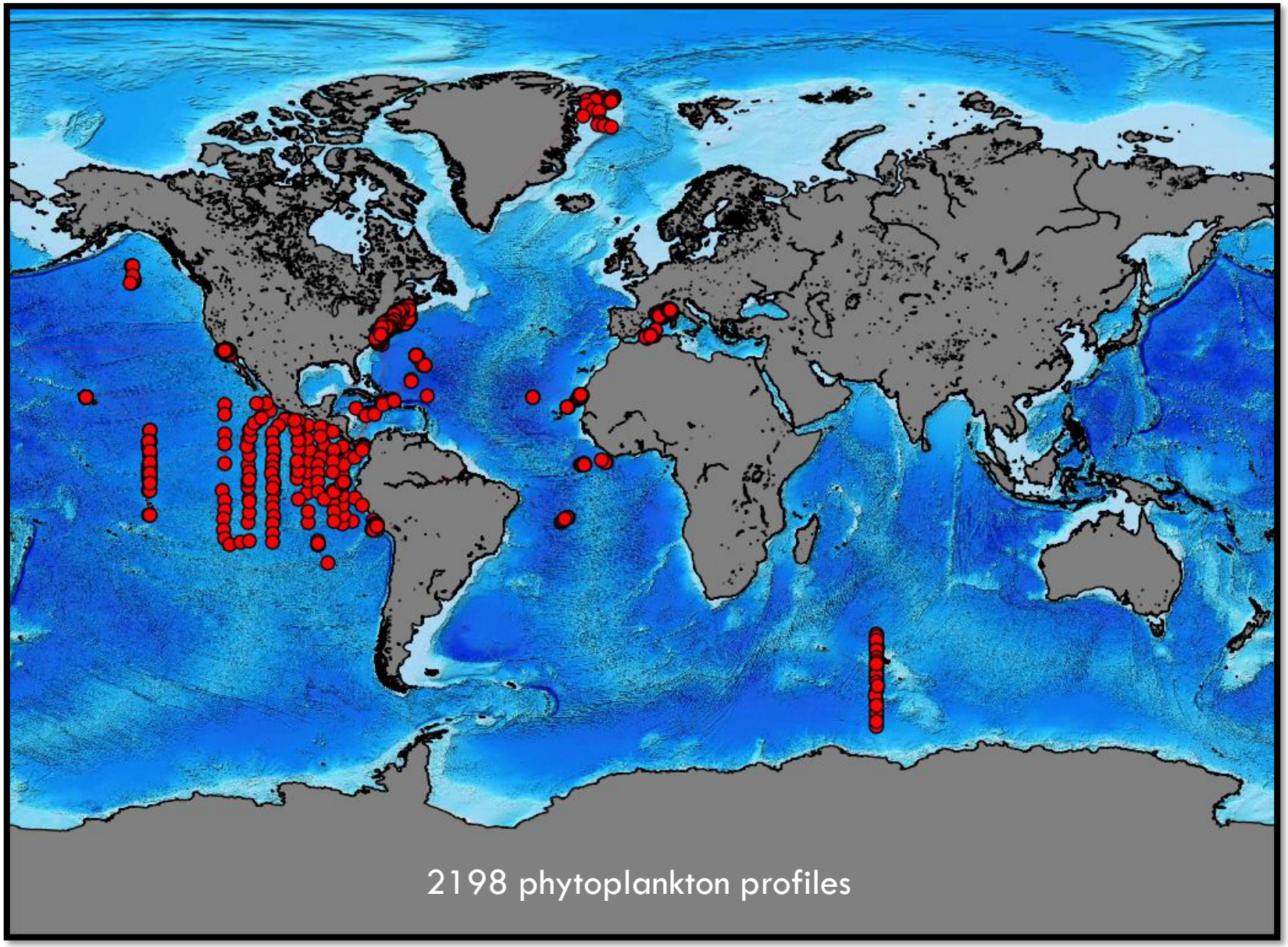


Predictors	Units
CHL-a 0 m	mg C m3
PAR 0 m	E m2 day
SST	°C
LAT	degrees
sin(LON)	-
cos(LON)	-
sin(date)	-
cos(date)	-

Depth-resolution



Available data



Depth-resolved artificial neural network

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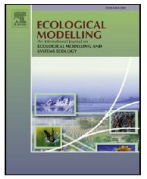

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F. Mattei[a,b,*], S. Franceschini[a,b], M. Scardi[a,b]

[a] Department of Biology, University of Rome "Tor Vergata", via della Ricerca Scientifica, 00133, Rome, Italy
[b] CoNISMa, Piazzale Flaminio, 9, 00196, Rome, Italy

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Ecological knowledge

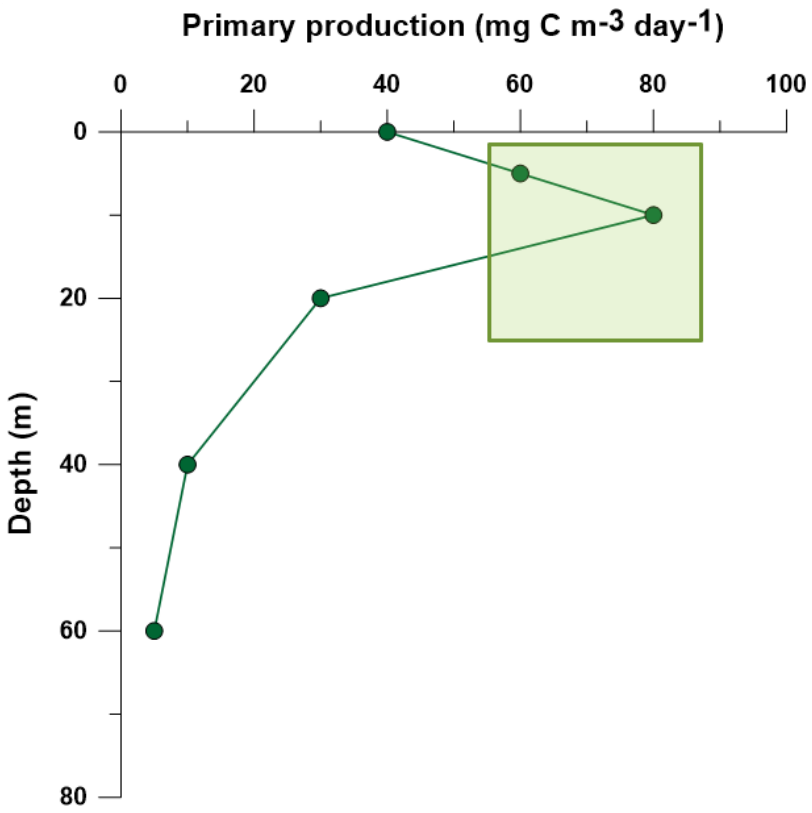
↓

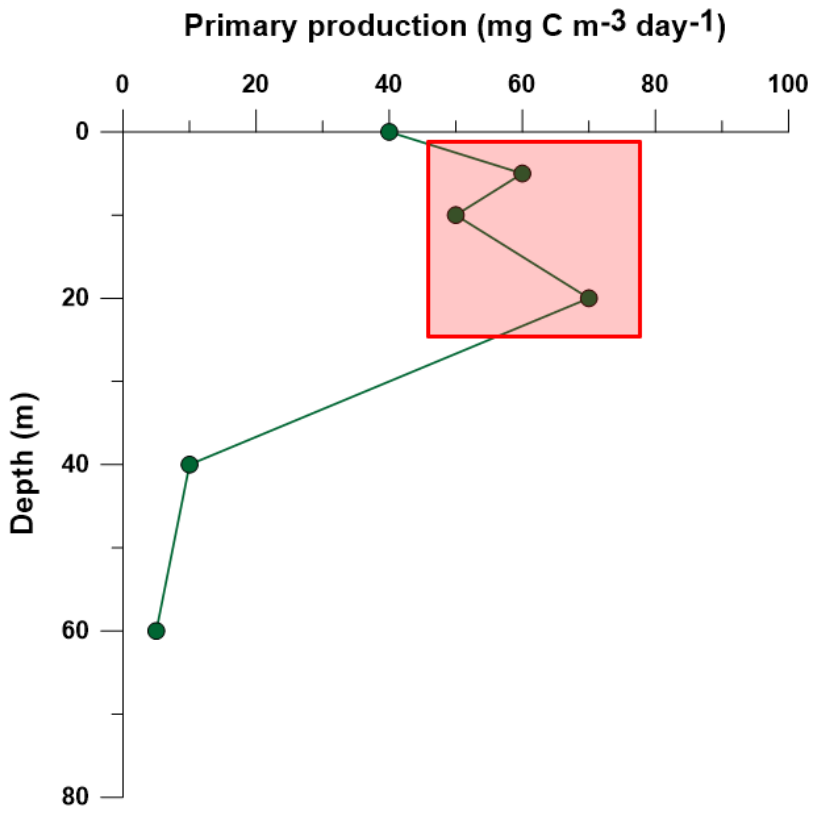
Ecologically sound model

↓

Better estimates?

Constraint #1: only one peak



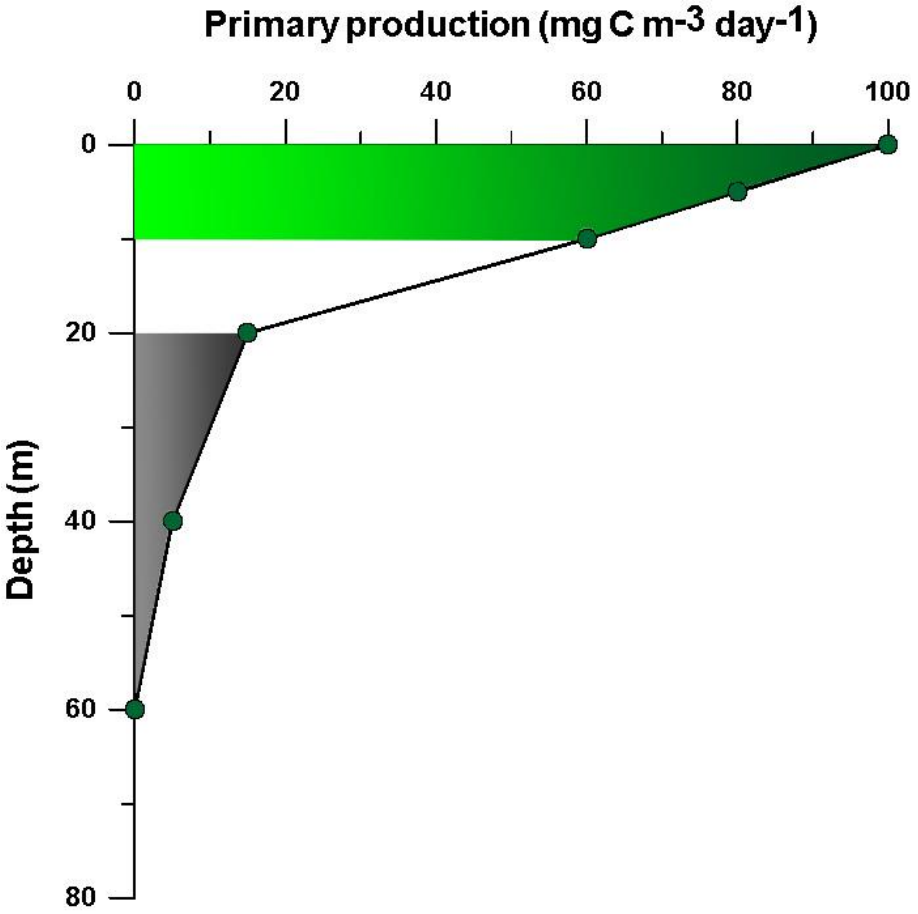


Selection after each training epoch

Constraint #2: depth-weighted error

Larger share of primary production is associated with the upper zone of the water column

Primary production between 0 and 10 m accounts for ~50% of the overall production



The constraint influences the deltas computation during the training phase

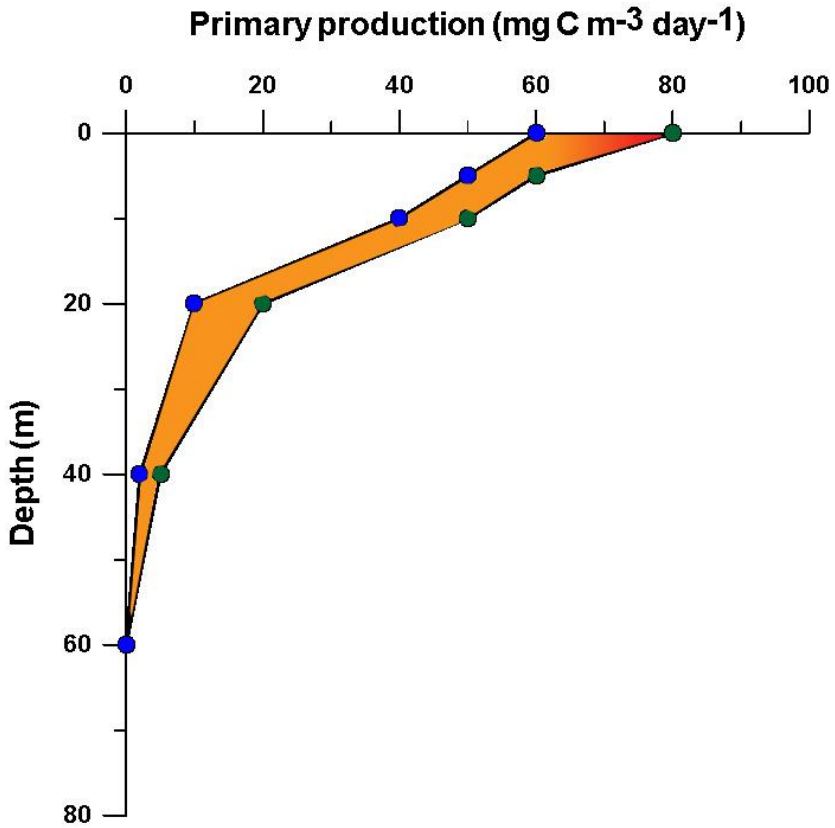
Constraint #3: variable learning rate & momentum

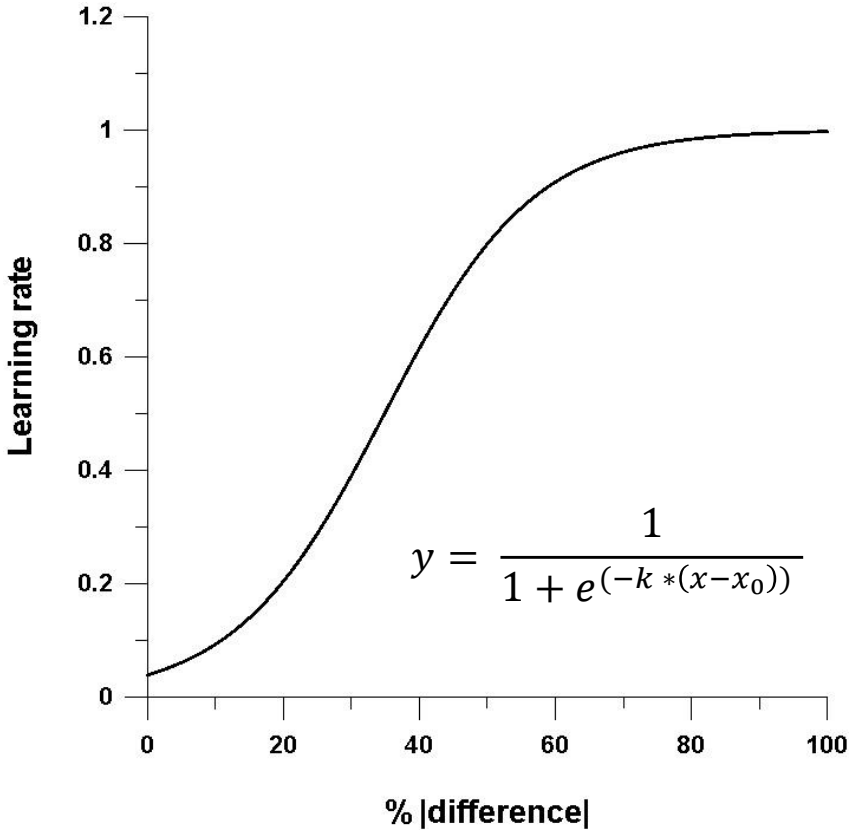
$$difference = Observed - Estimated$$

$$x = \frac{|difference| * 100}{Observed}$$

$$Learning\ rate = \frac{1}{1 + e^{(-k*(x-x_0))}}$$

$$Momentum = 1 - Learning\ rate$$





Constraints performances

Constraint	Overall R^2 gain	IPP R^2 gain
Single peak (selection)	+2%	+3%
Depth (deltas)	+2%	+4%
IPP (learning rate & momentum)	+3%	+6%
Single peak + Depth	+1%	+3%
Single peak + IPP	+2%	+2%
Depth + IPP	+2%	+5%

Aim carefully!

- Machine learning algorithms are tools
- Customization for ecological modeling
- Enhanced estimates accuracy

Conclusions

- Enhanced exploitation of the available information
- 2D predictors converted in 3D profiles
- Ecologically and data driven training

Thank you for the attention!

Francesco Mattei, Michele Scardi

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