

13C and 14C implementation in the ORCHIDEE soil module a new constraint on the soil carbon dynamic

Journées de Modélisation des Surfaces Continentales, November 2019

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SOILS AND GLOBAL CHANGES

Anthropogenic
emissions

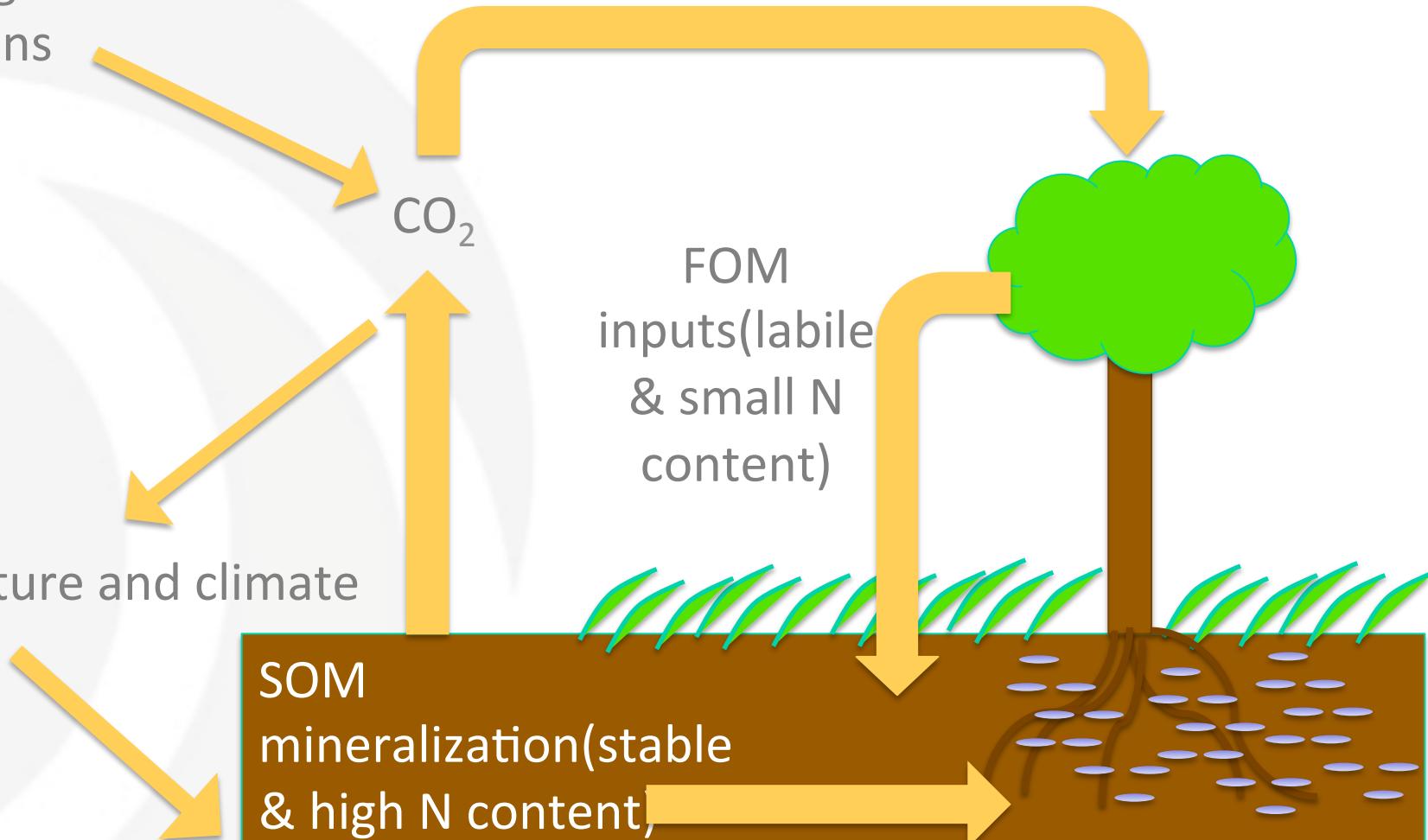
Photosynthesis

Temperature and climate

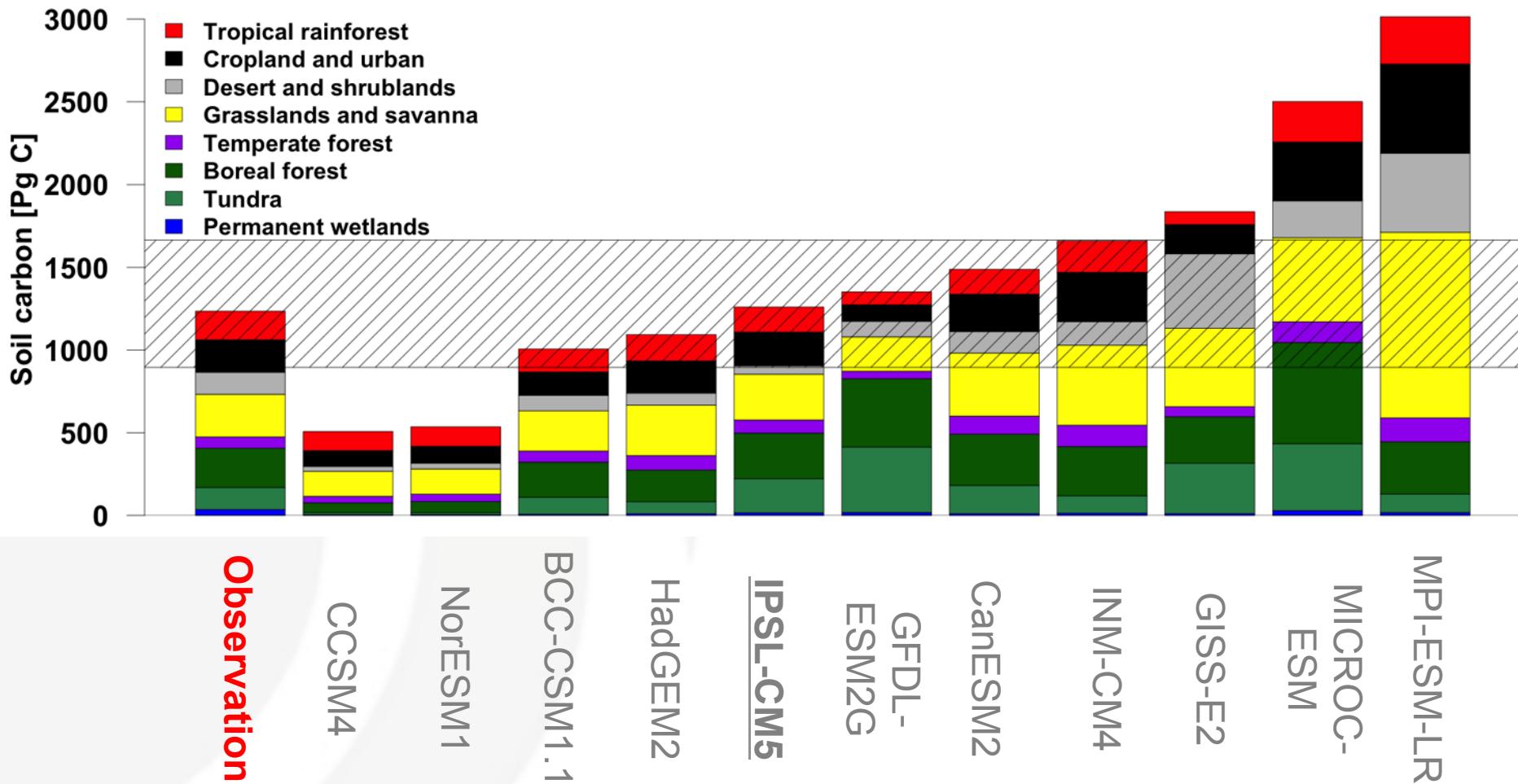
CO₂

FOM
inputs(labile
& small N
content)

SOM
mineralization(stable
& high N content)



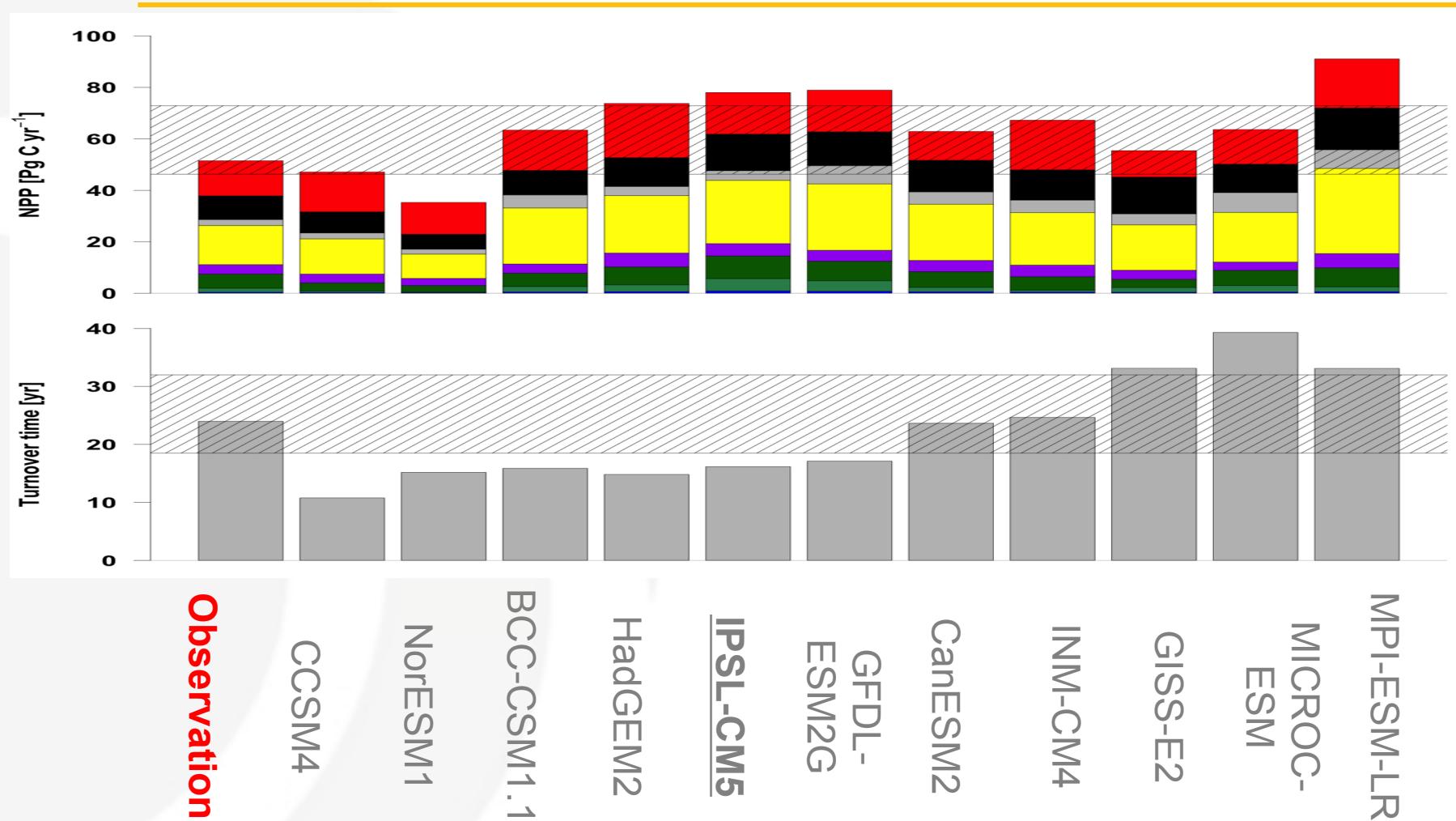
HOW GOOD ARE EARTH SYSTEM MODELS TO REPRESENT SOIL C STOCK



Todd-Brown et al. (2013)



HOW GOOD ARE EARTH SYSTEM MODELS TO REPRESENT SOIL C STOCK



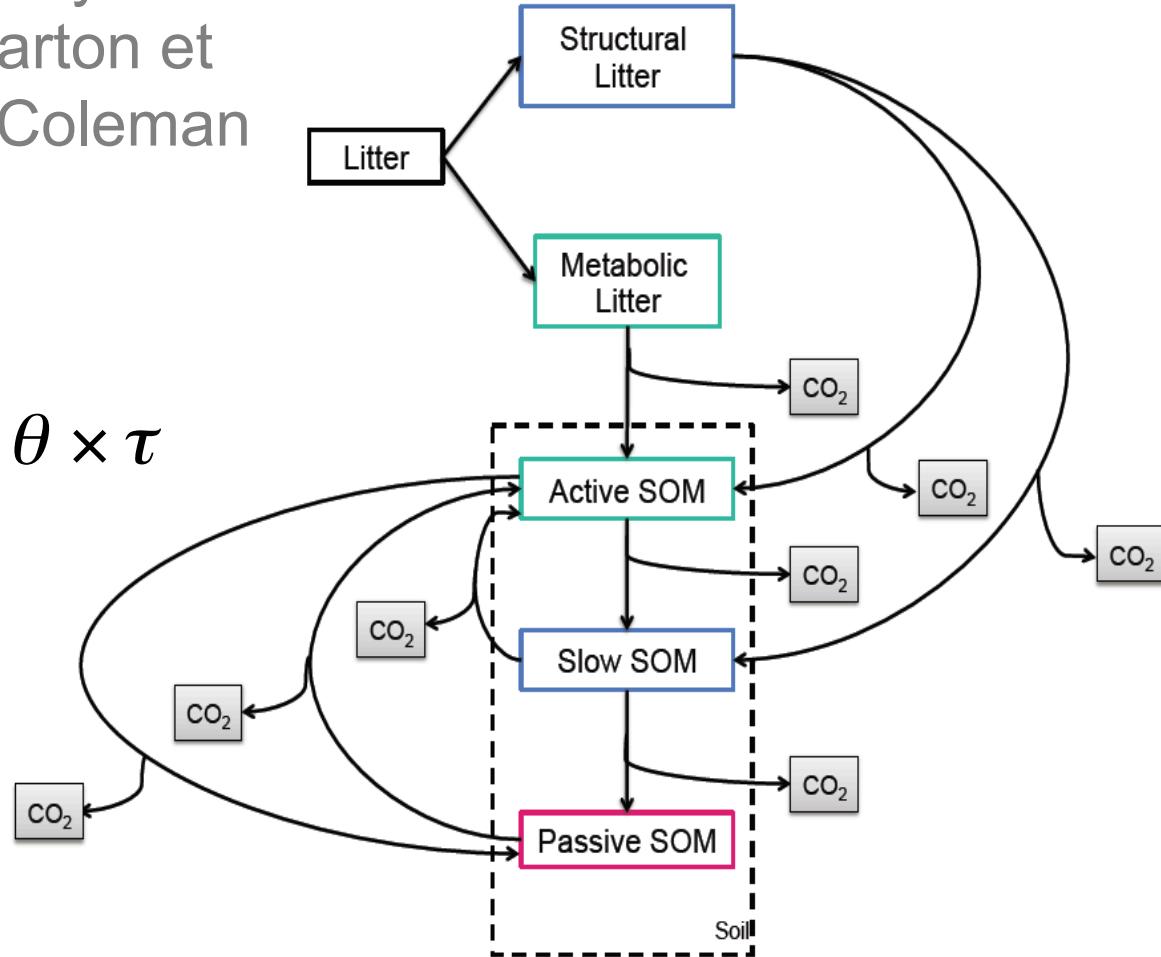
Todd-Brown et al. (2013)



THE SOIL C IN THE LAND SURFACE MODELS

- Soil representation mainly based on CENTURY (Parton et al., 1987) or on RothC (Coleman and Jenkinson, 1999)

$$\frac{\partial SOC}{\partial t} = I - k \times SOC \times \theta \times \tau$$



SEVERAL IMPORTANT MECHANISMS ARE STILL MISSING

Biology

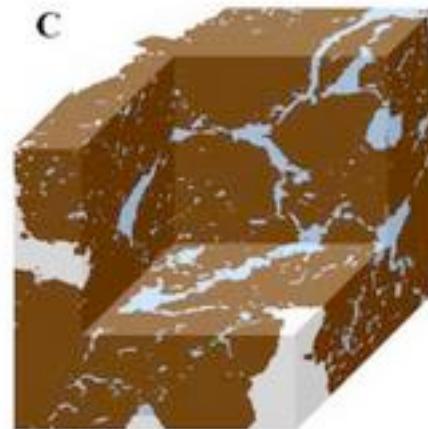


<http://cropandsoil.oregonstate.edu>

Chemistry

	p-Hydroxyl phenols	Vanillyl phenols	Syringyl phenols	Cinnamyl phenols
Aldehydes	<chem>O=Cc1ccc(O)cc1</chem> <i>p</i> -Hydroxybenzaldehyde	<chem>O=Cc1ccc(Oc2ccccc2)cc1</chem> Vanillin	<chem>O=Cc1ccc(Oc2ccccc2)cc1</chem> Syringaldehyde	<chem>O=C/C=C\c1ccc(O)cc1</chem> <i>p</i> -Coumaric acid
Ketones	<chem>O=Cc1ccc(Oc2ccccc2)cc1</chem> <i>p</i> -Hydroxyacetophenone	<chem>O=Cc1ccc(Oc2ccccc2)cc1</chem> Acetovanillone	<chem>O=Cc1ccc(Oc2ccccc2)cc1</chem> Acetosyringone	<chem>O=C/C=C\c1ccc(Oc2ccccc2)cc1</chem> Ferulic acid
Acids	<chem>Oc1ccc(O)cc1</chem> <i>p</i> -Hydroxybenzoic acid	<chem>Oc1ccc(Oc2ccccc2)cc1</chem> Vanillic acid	<chem>Oc1ccc(Oc2ccccc2)cc1</chem> Syringic acid	

Physics



<http://www.abdn.ac.uk>

Thevenot et al., 2010



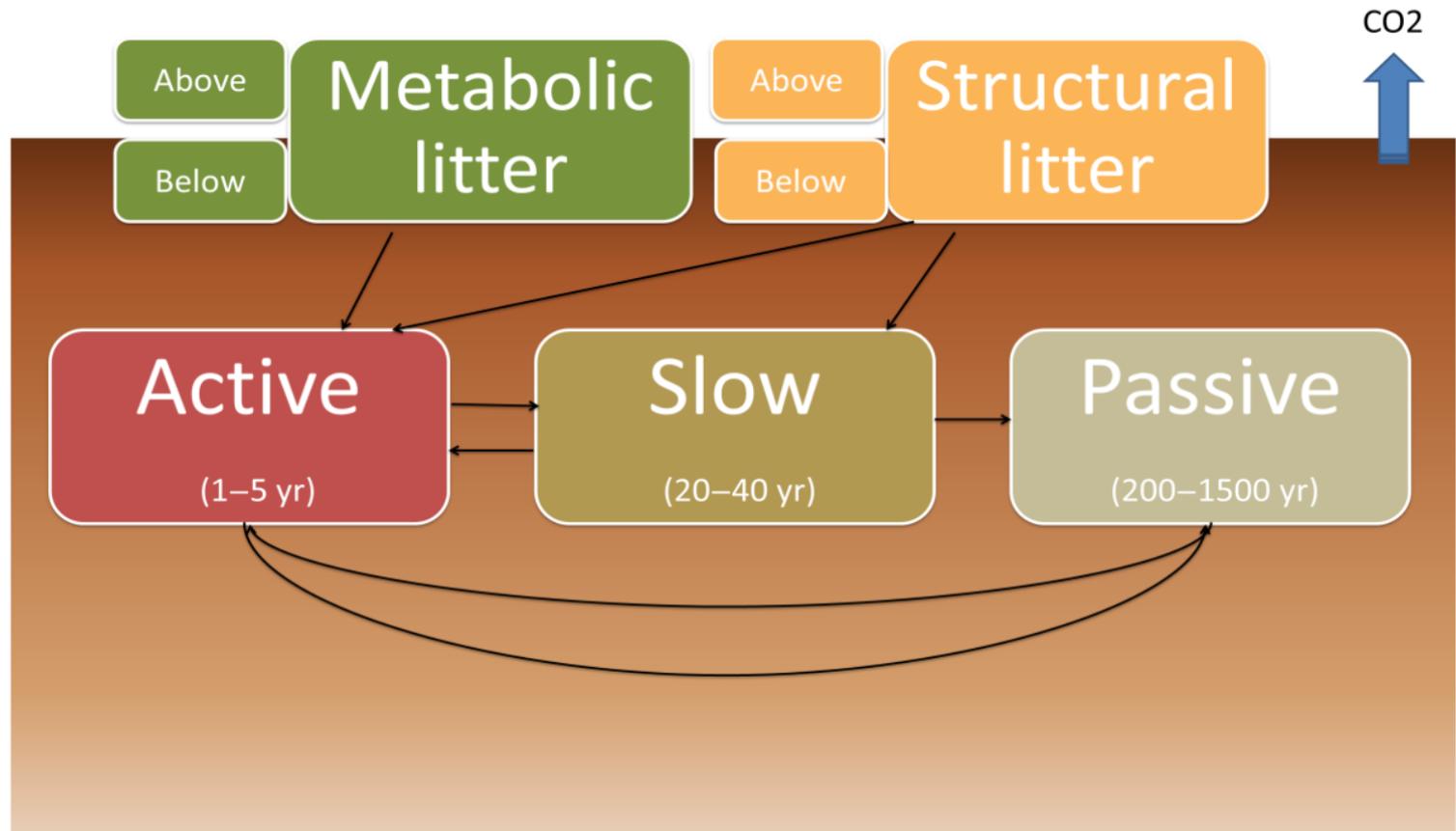
SOIL CARBON DISCRETIZATION

- Any models used for CMIP5 represent the soil C profiles.
- A substantial part of the soil C stored in deep layers (Jobbagy and Jackson, 2000)
- Deep C dynamic different from surface C (Fontaine et al., 2007)
- In ORCHIDEE any C is lost by drainage or runoff instead of the importance of allochthonous C in the aquatic ecosystems functioning (Cole et al., 2007, Bianchi et al., 2011)



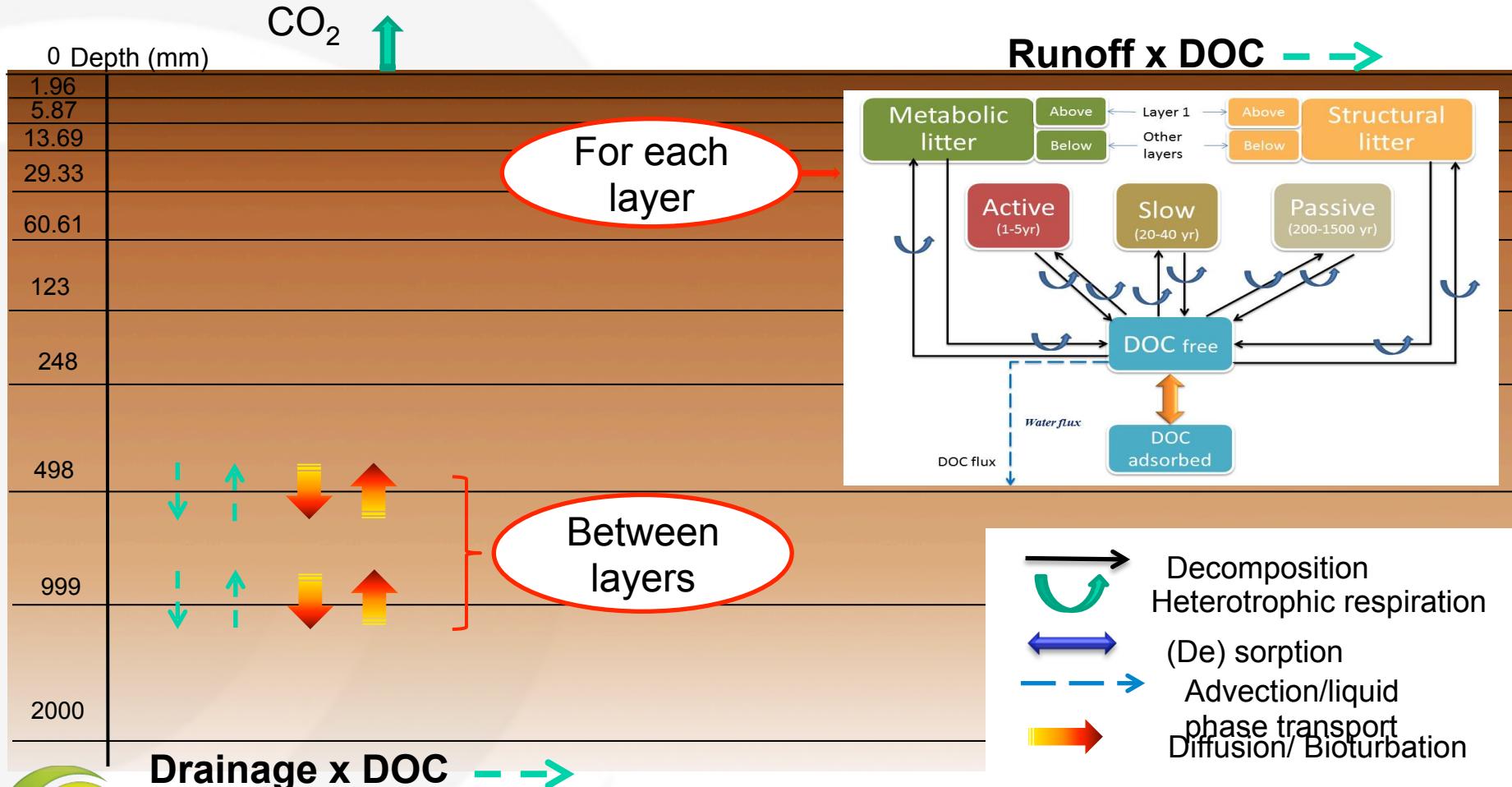
SOIL CARBON DISCRETIZATION

ORCHIDEE SVN r3340



SOIL CARBON DISCRETIZATION

Soil C discretized using the same layers than hydrology scheme (11 layers). A new pool introduced (DOC)



¹⁴C INCORPORATIONS

All processes that apply to total soil carbon in ORCHIDEE are now represented for ¹⁴C :

$$\text{litter (carbon14)} = \mathbf{F^{14}C_{Litter}} * \text{litter(carbon)}$$

$$\mathbf{F^{14}C_{Litter}} = \mathbf{F^{14}C_{atmosphere}}$$

flux_decrease= **k_decrease** * carbon (K_decrease=Ln2/5730 , radioactive decay constant)

$$F_{Mean} = F_{\downarrow active} * Carbon14_{\downarrow active} + F_{\downarrow slow} * Carbon14_{\downarrow slow} + F_{\downarrow passive} * Carbon14_{\downarrow passive} / (Carbon14_{\downarrow active} + Carbon14_{\downarrow slow} + Carbon14_{\downarrow passive})$$

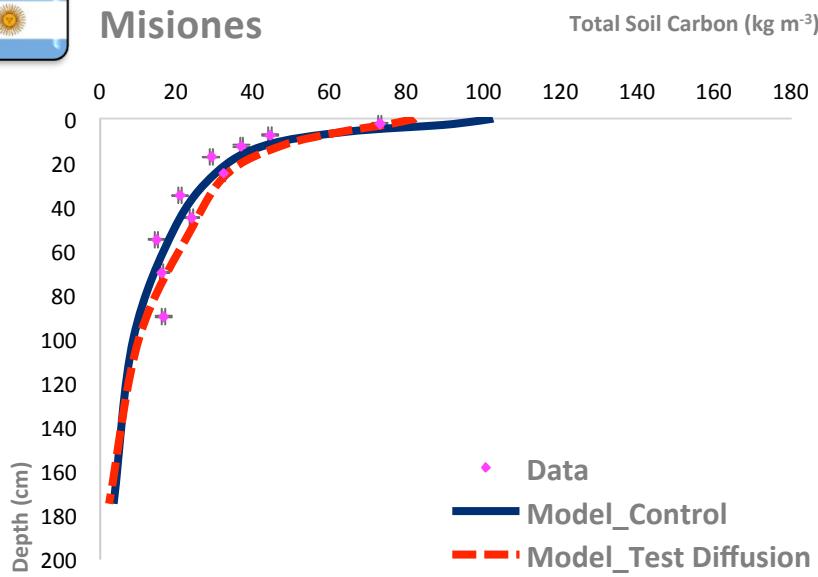
Tifafi et al., (2018)



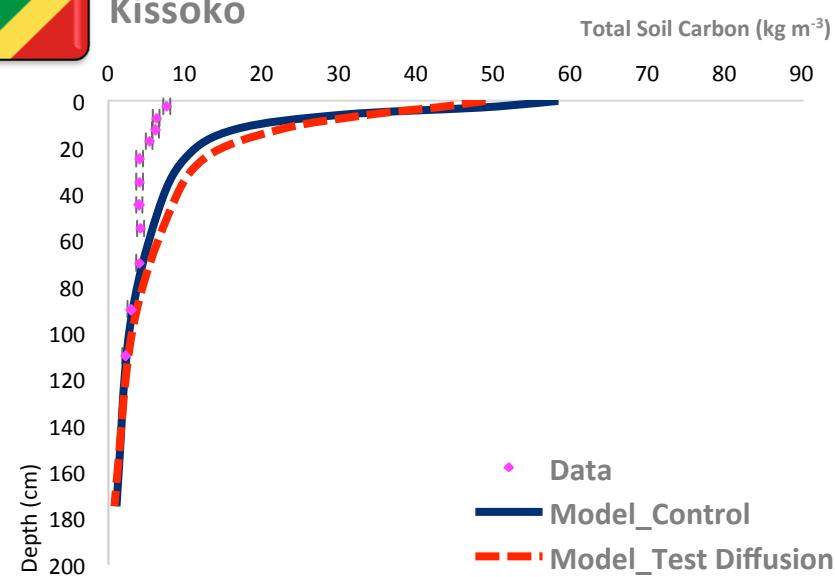
TOTAL SOC PROFILES



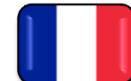
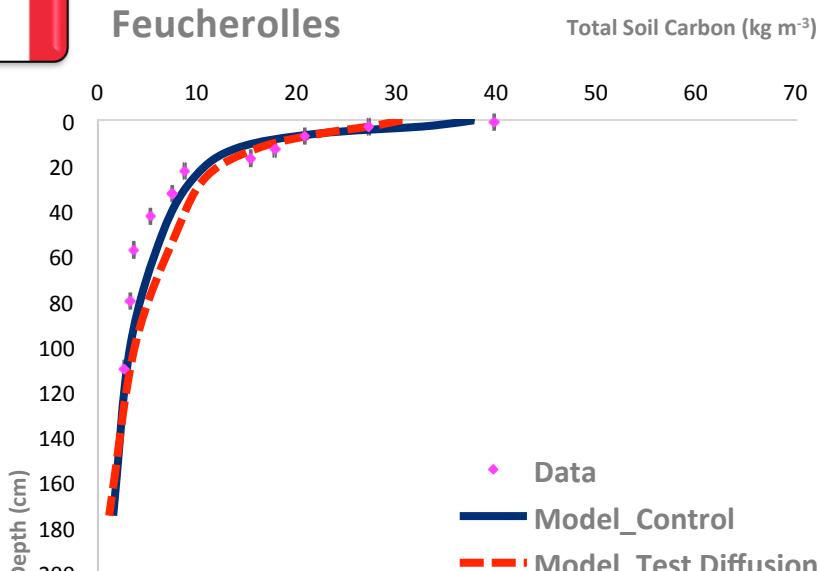
Misiones



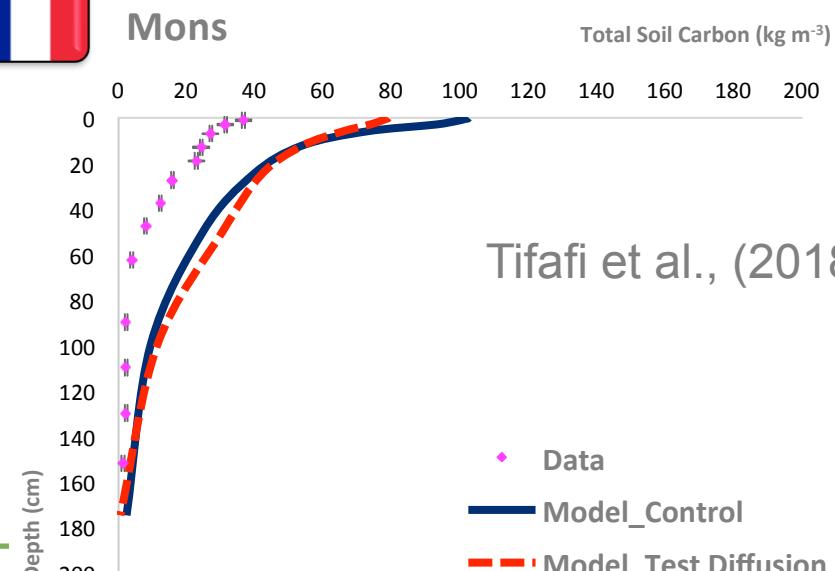
Kissoko



Feucherolles



Mons



Tifafi et al., (2018)



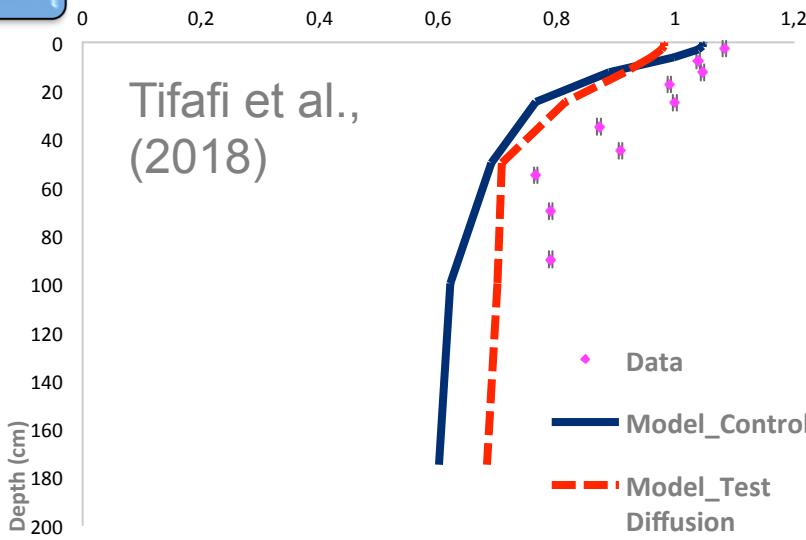
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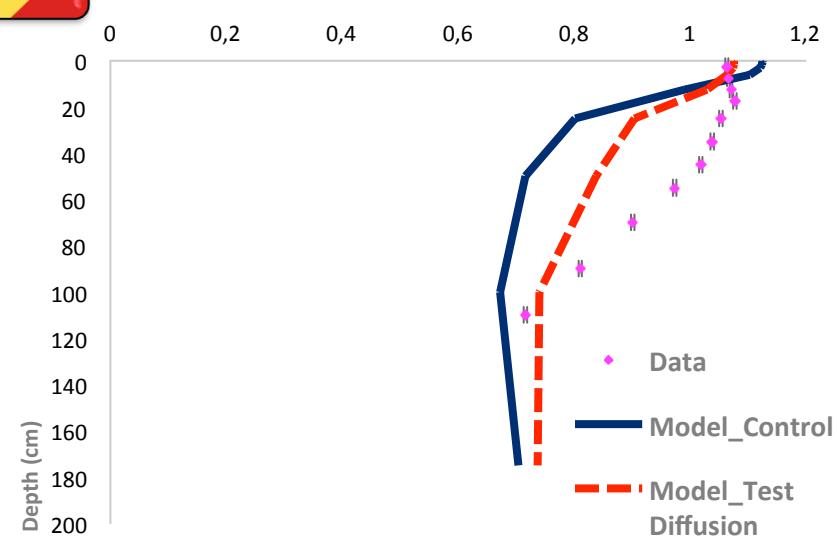
MODERN FRACTION



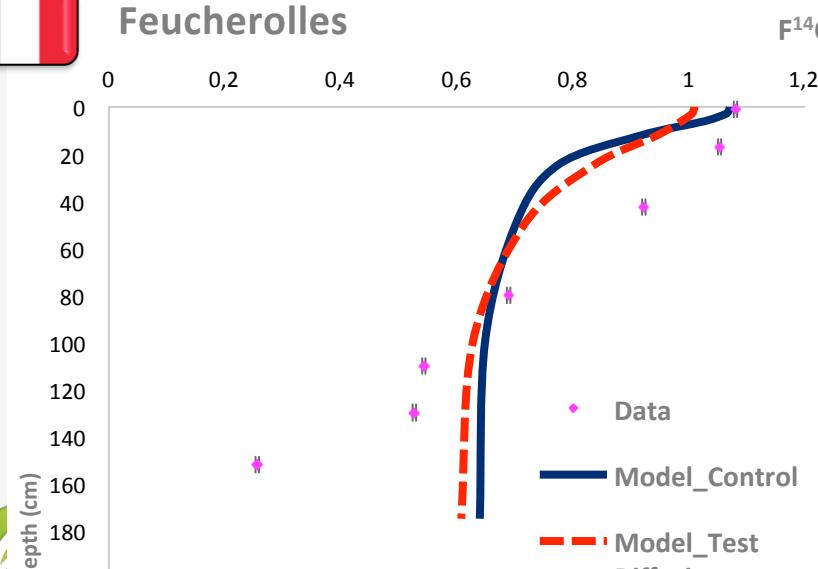
Misiones



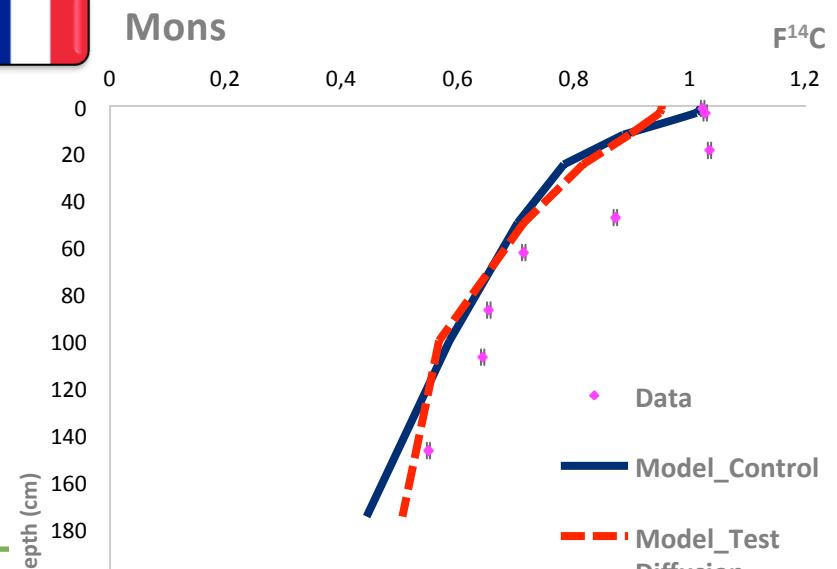
Kissoko



Feucherolles



Mons

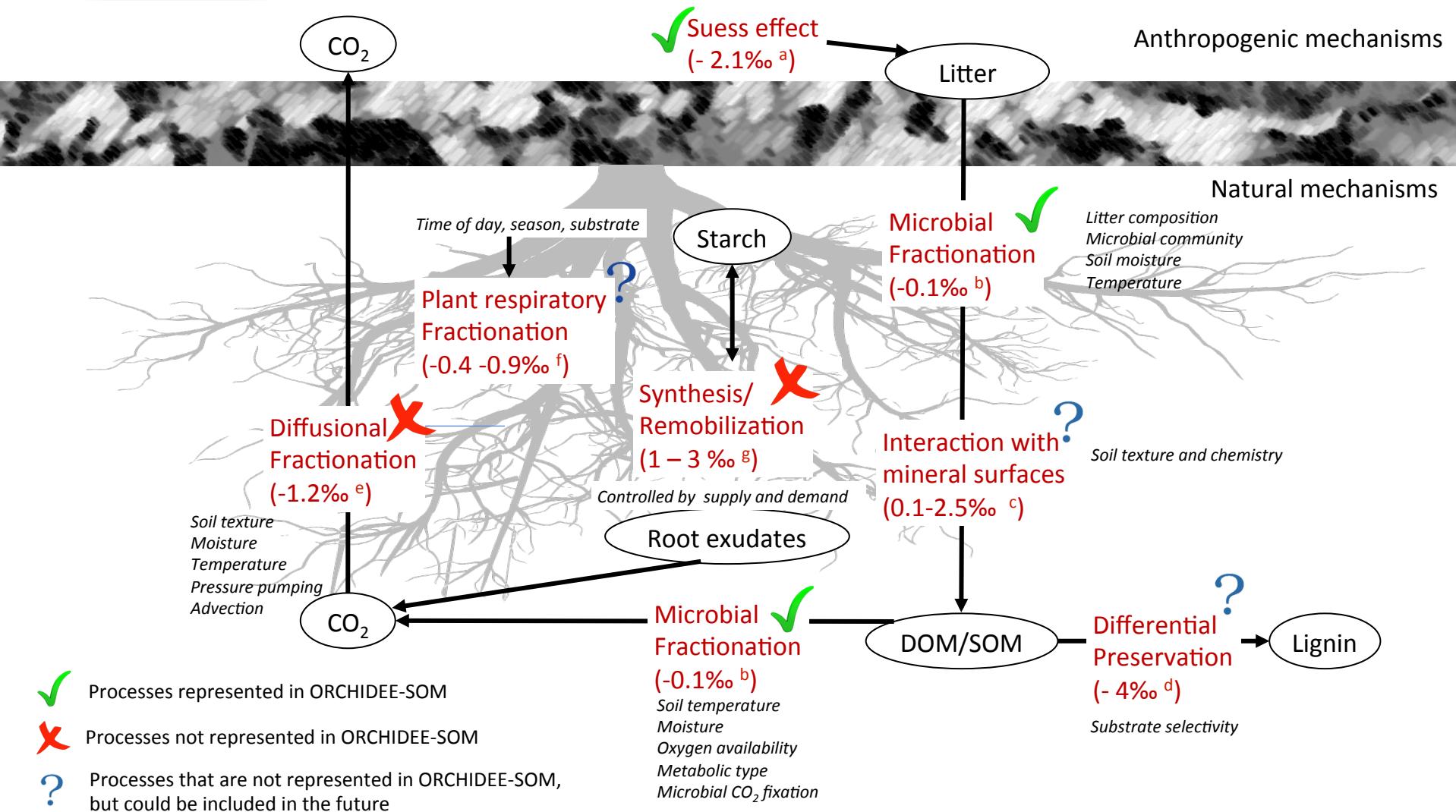


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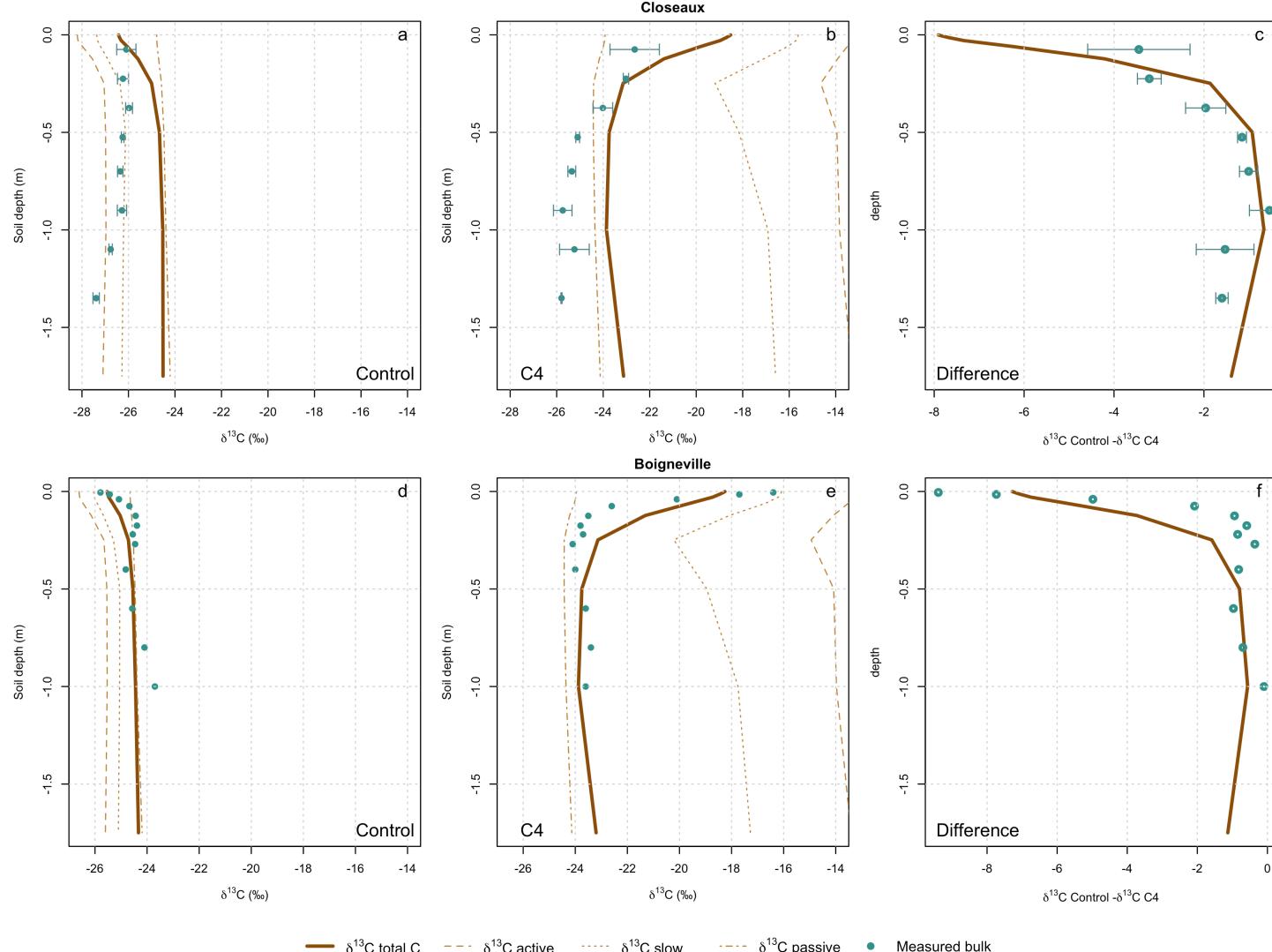
13C INCORPORATIONS



Camino-Serrano et al., (In prep)



C3/C4 SUCCESSION



Camino-Serrano et al., (2019)



SUMMARY

- A **substantial part** of the soil C stored in deep layers
- ORCHIDEE-SOM is able to **reproduce the soil C profiles** and the soil DOC in mineral soils
- ORCHIDEE-SOM fairly represent carbon isotopes dynamic too.
- A coupling with the vegetation modules is needed



THANKS FOR YOUR ATTENTION!



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