Phosphorus in agricultural soils: drivers of the current distribution at global scale

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INRA SCIENCE & IMPACT

BORDEAUX SCIENCES AGRO

- Picture of the **current distribution of P in agricultural soils at global scale** required for :
  - identifying the areas of deficit/surplus
  - defining farming practices and policies towards a more sustainable management of P resource

- **Many drivers are involved** : geology (i.e. virgin soil properties) + farming practices + land-use change + soil erosion + ...

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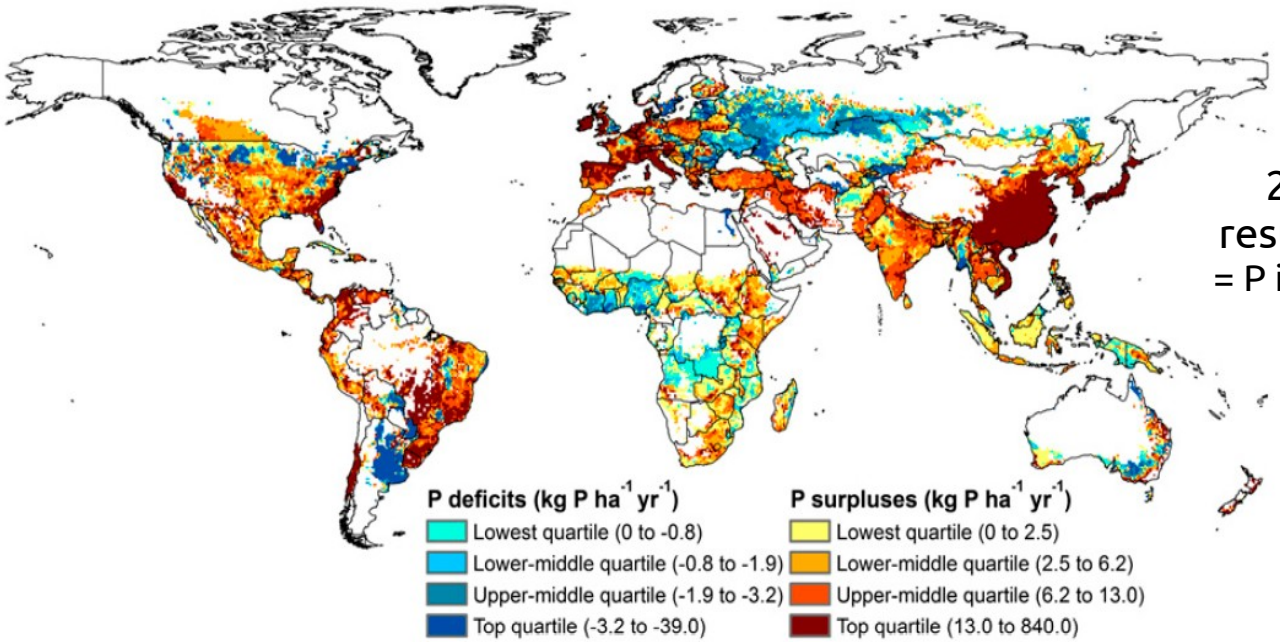
- Few studies focused on **separate** driver, e.g. :



2000 cropland soil P budget resulting from farming practices
= P in fertilizers – P in harvested crops
MacDonald et al. 2011

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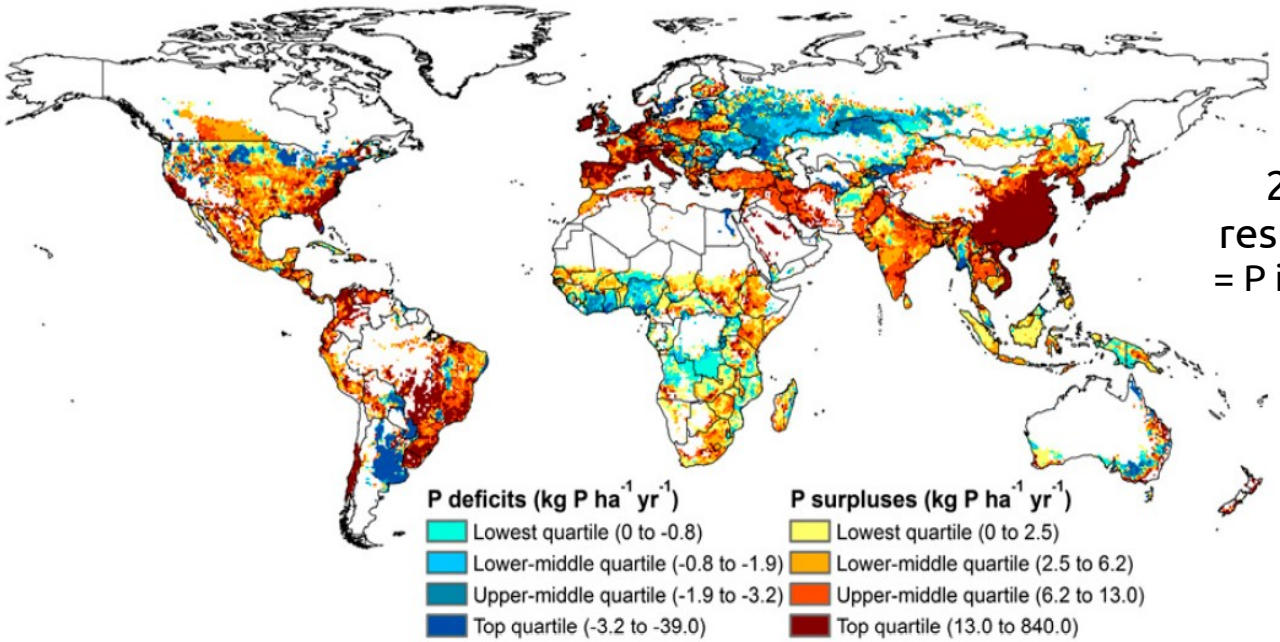

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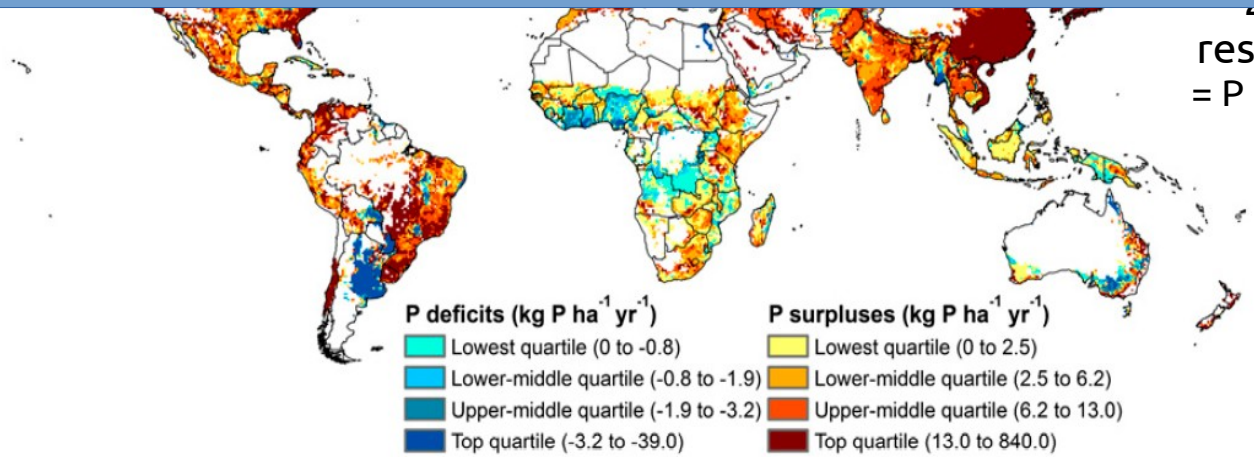
What is the contribution of the different drivers to the current distribution of P in agricultural soils at global scale ?



resulting from farming practices
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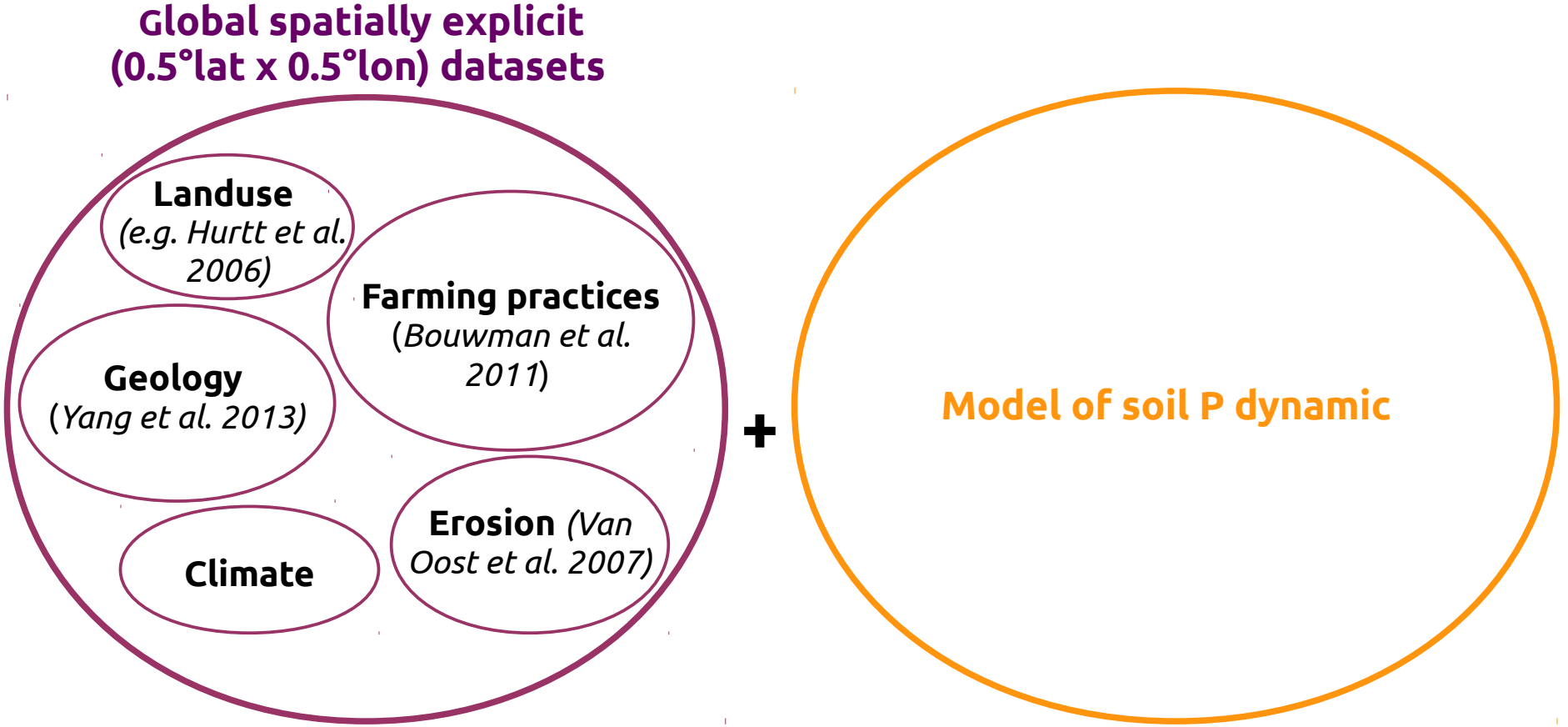
Method overview (1/2)

Aim : reconstruct the **temporal evolution of P in agricultural soils over the 20th century**

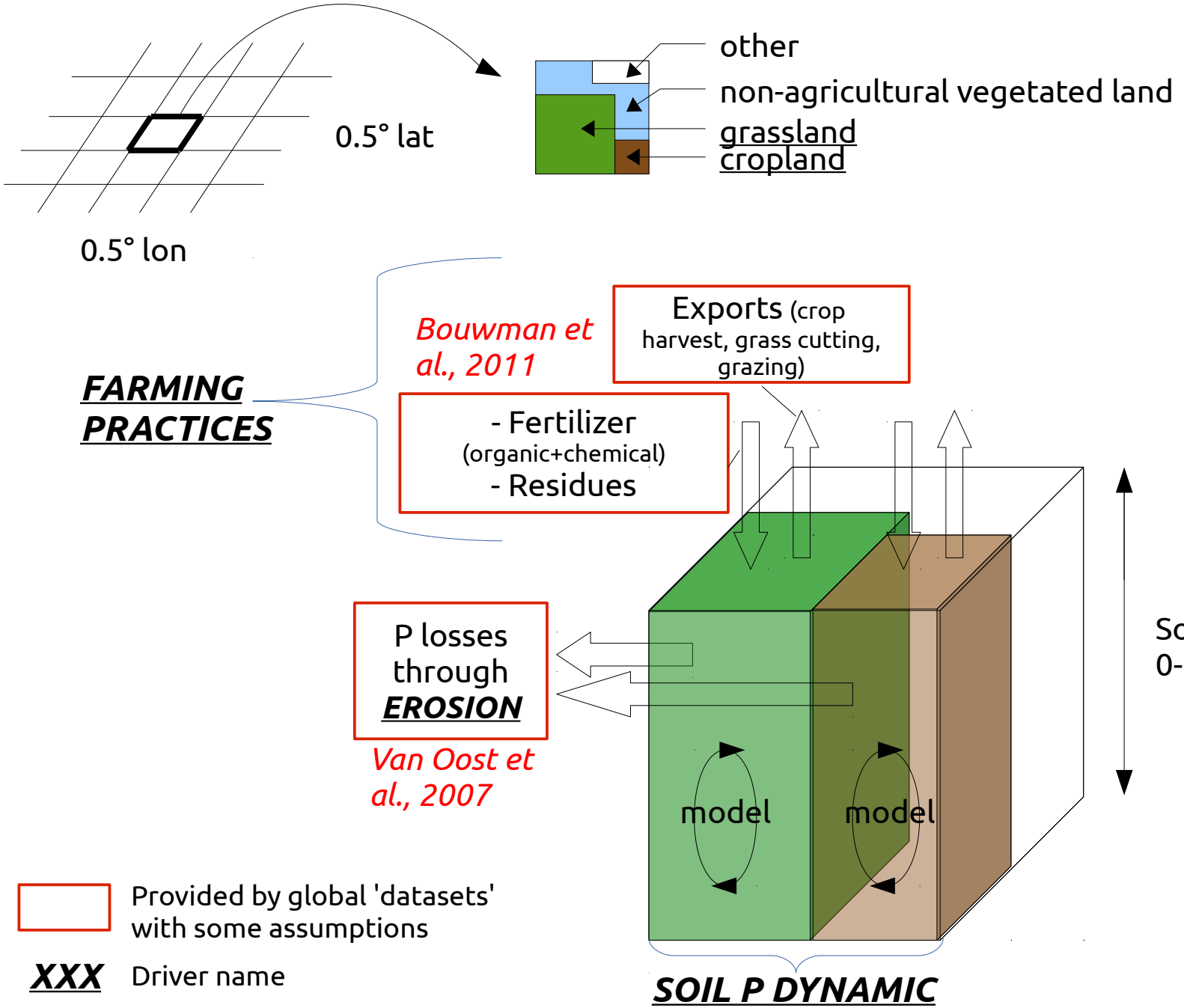


In total : 6 drivers (5 global datasets + 1 modeled)

Taking into account the **uncertainty** in each global dataset/model design :
→ 2 estimates of each driver (work in progress ; erosion, geology and soil dynamic).

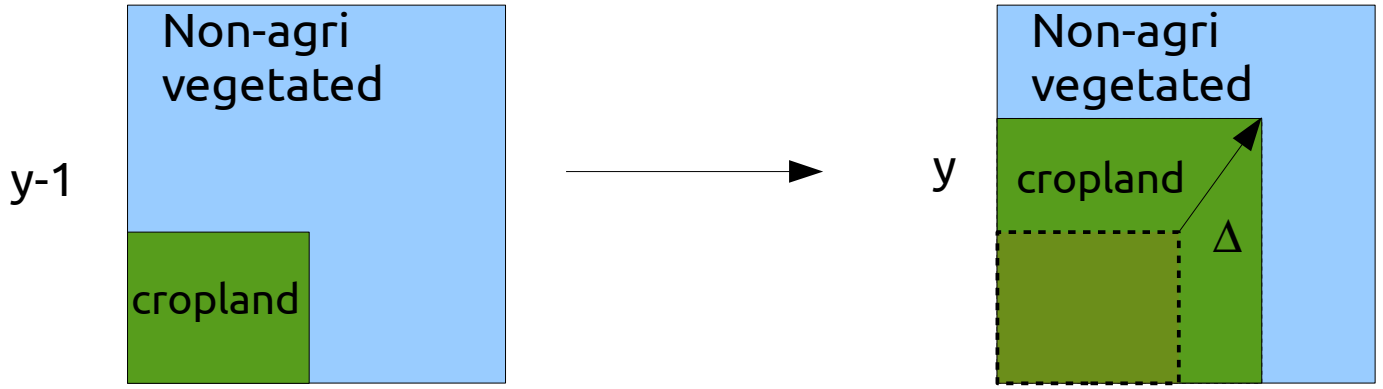
Method overview (2/2)

At any moment (1 year time intervals),



Method : land-use change and geology drivers

- Take into account the effect of land-use change from y-1 to y on soil P:



P(y-1)

P(y) = (**P**(y-1).[**f**(y-1)] + **P**(y-1).Δ) /**f**(y)

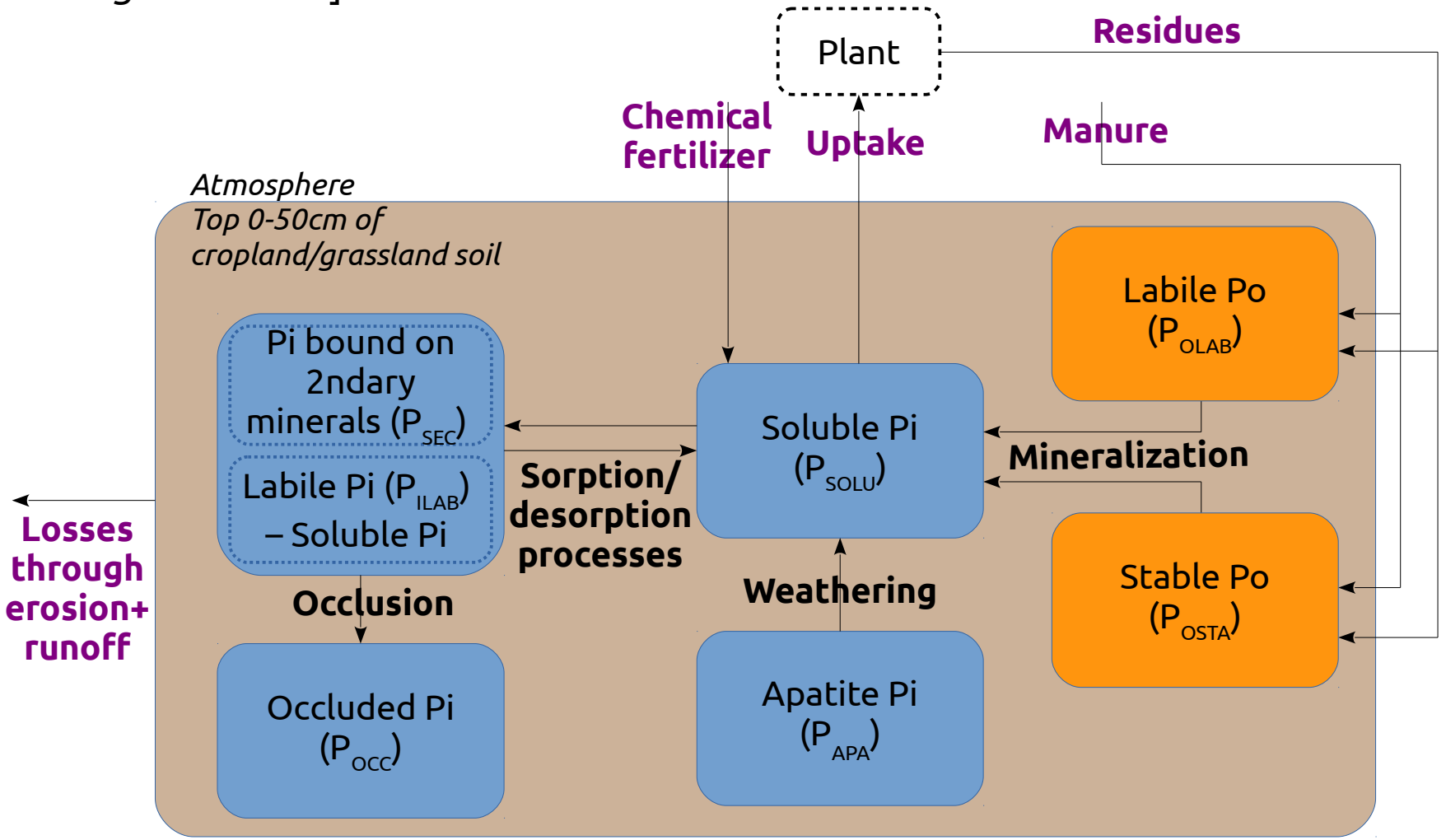
P: soil P pool; f: grid-cell fraction; Δ: land conversion

LAND-USE CHANGE *Hurtt et al., 2006*

- **For any y, P**(y) = P_{Yang} : **current P in unmanaged soil** [*Yang et al., 2013*], extrapolation of measures on sites thanks to soil properties ***GEOLOGY***

Method : model of soil P dynamic

- Soil pools based on **Hedley fractionation method**
- Flux parameterizations based on **Dynamic Global Vegetation Models** [*Goll et al.* 2012, *Wang et al.* 2010]



Fluxes :

xxx Derived from global datasets

xxx Simulated fluxes

Pools :

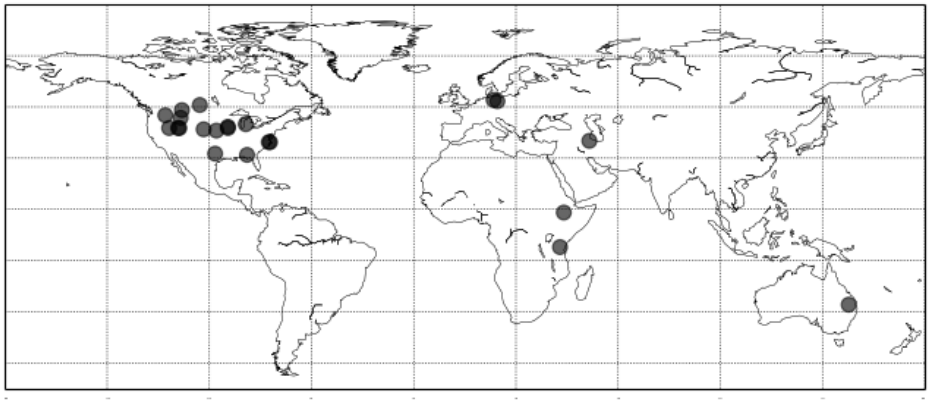
Organic soil P pool

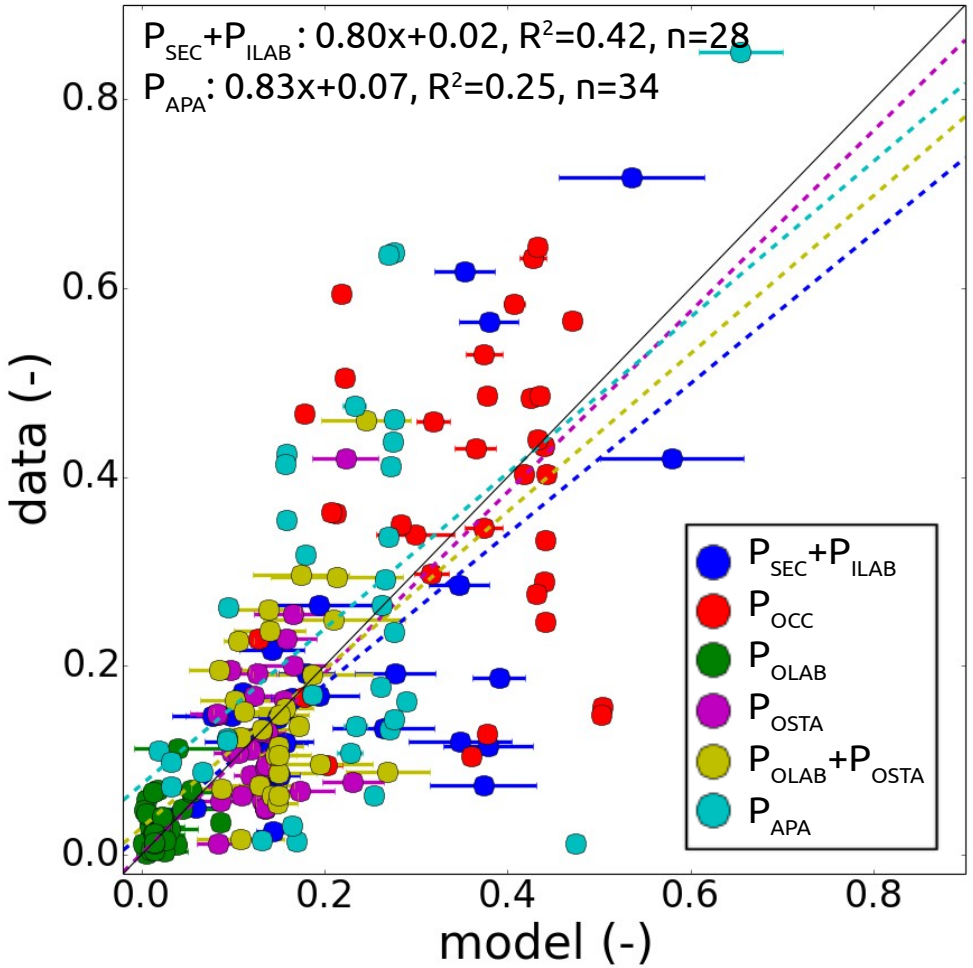
Inorganic (mineral) soil P pool

Non-explicitely represented pool

Evaluation

- Against compilation of **Hedley measurements on sites from litterature** (Augusto et al. *unpublished*)





- **Contribution of each P form to the total P** on cropland sites

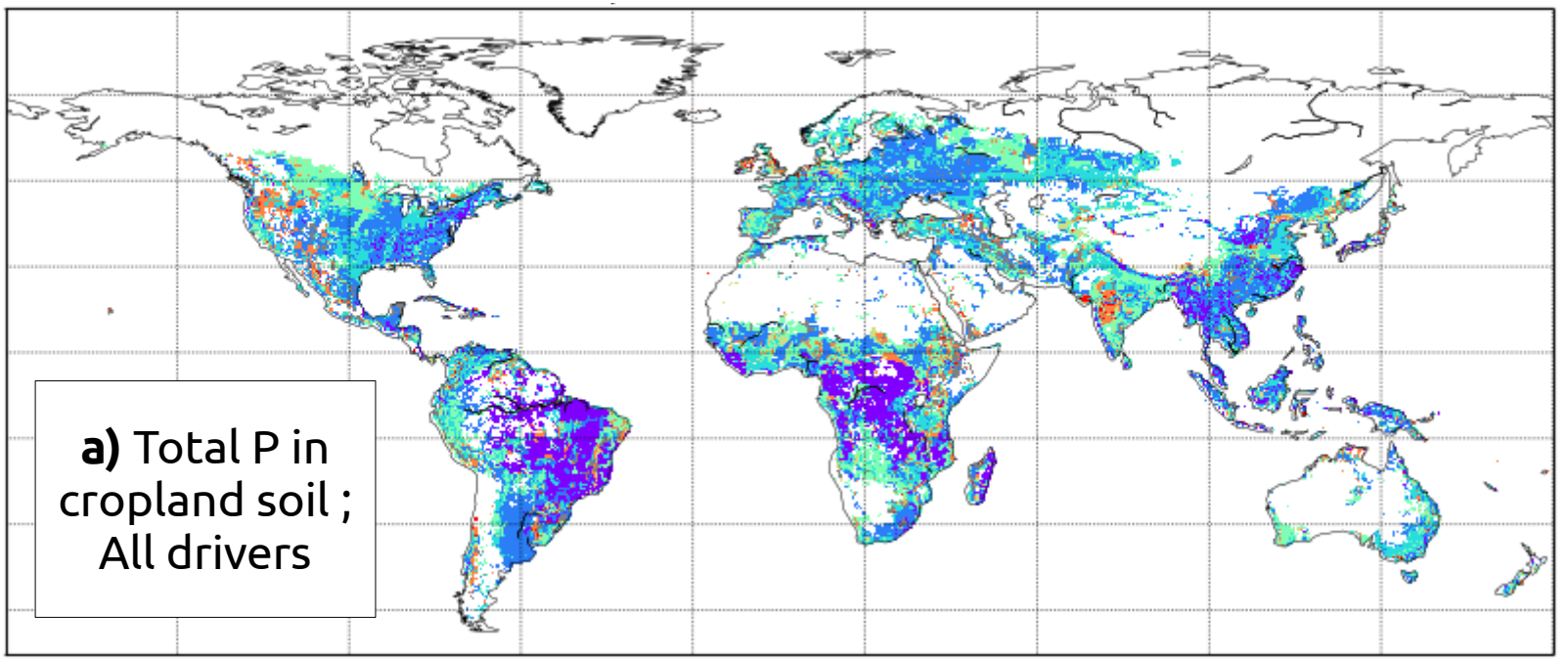
  - Relatively well captured

- **More difficult to capture the absolute value of total soil P**

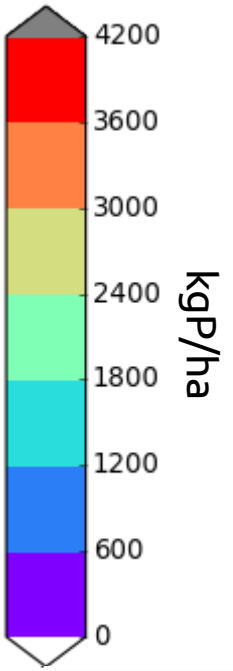
Results

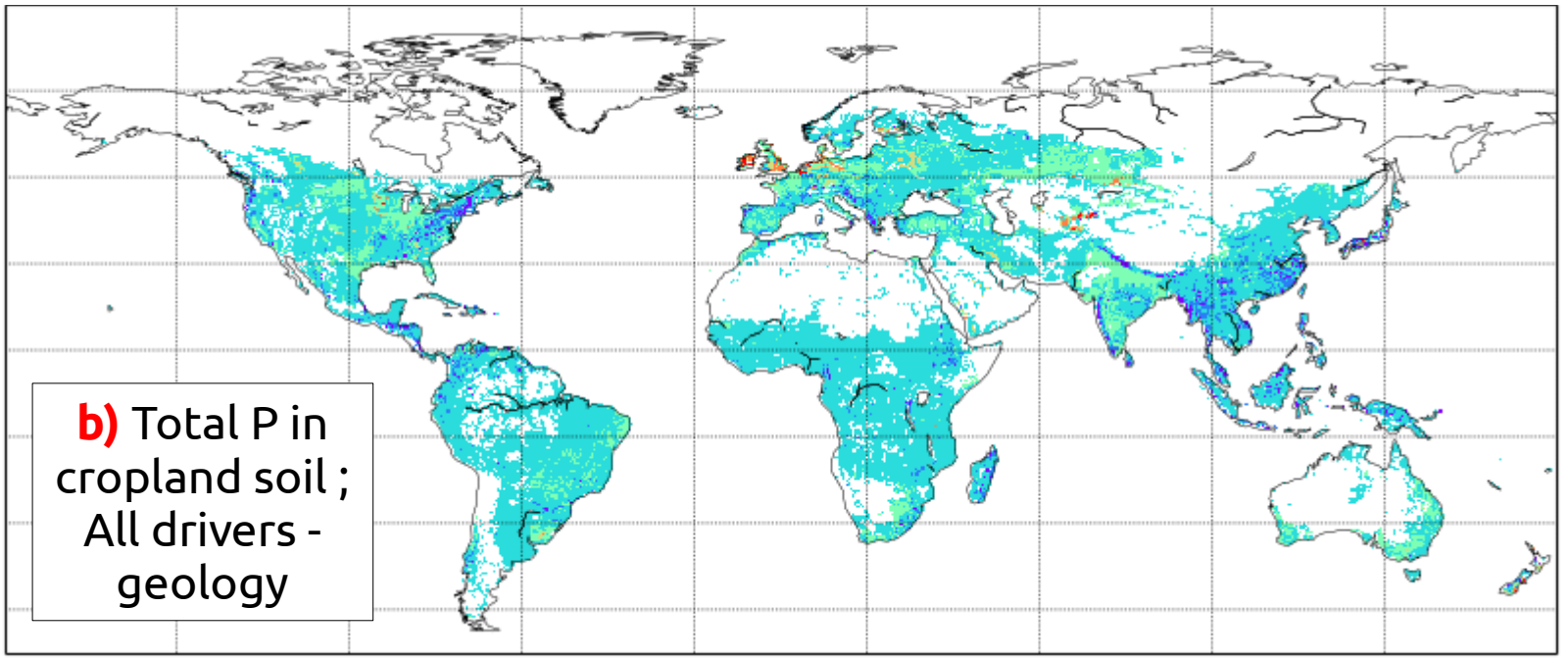
Drivers of the current spatial variability (1/2)

- E.g. : effect of removing spatial variability in 'geology'

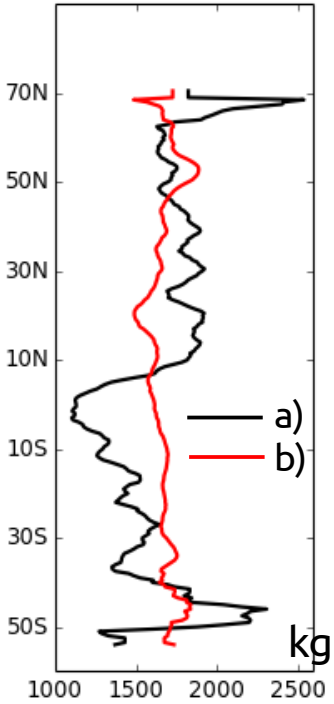


a) Total P in cropland soil ; All drivers





b) Total P in cropland soil ; All drivers - geology



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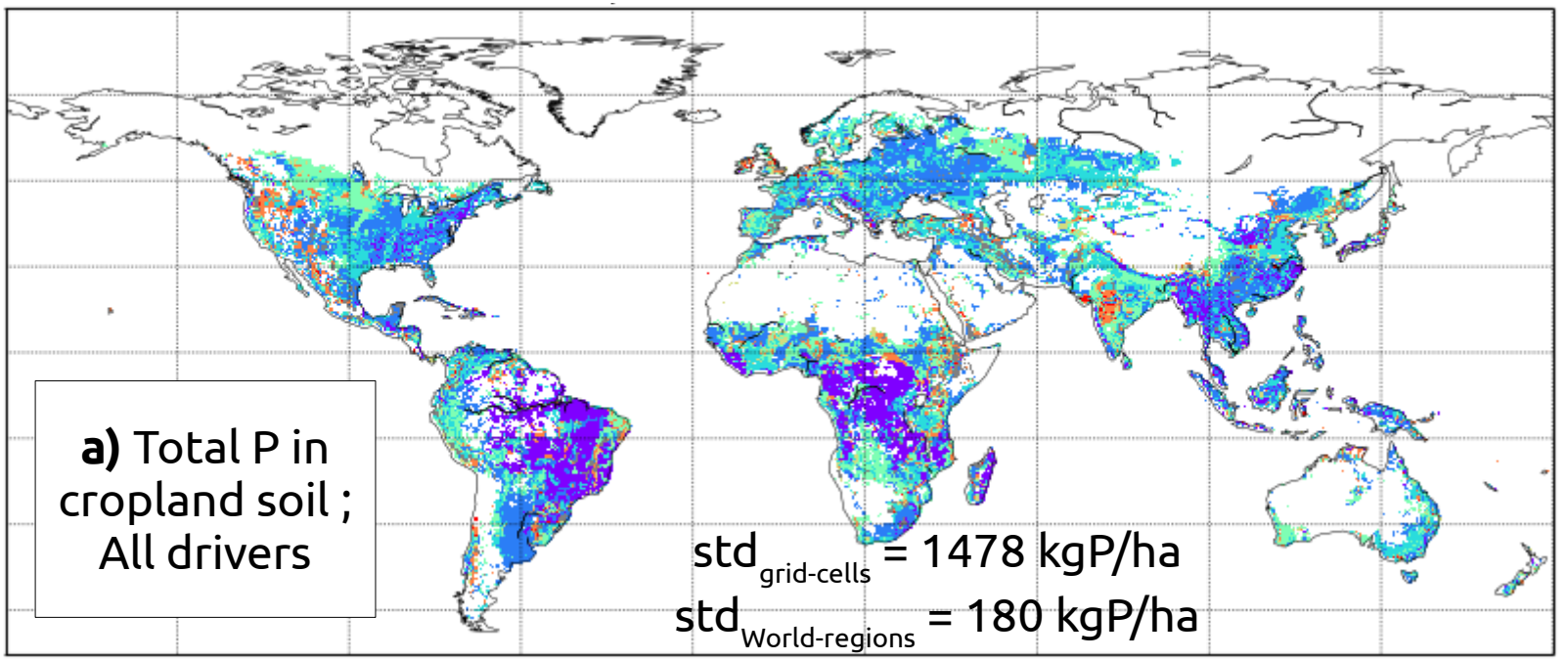

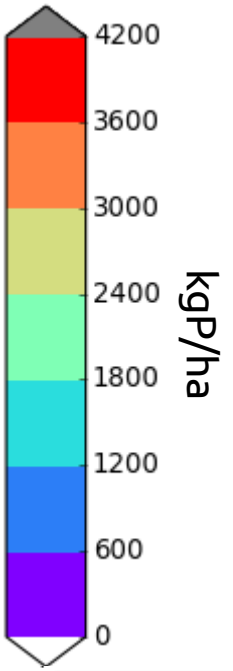

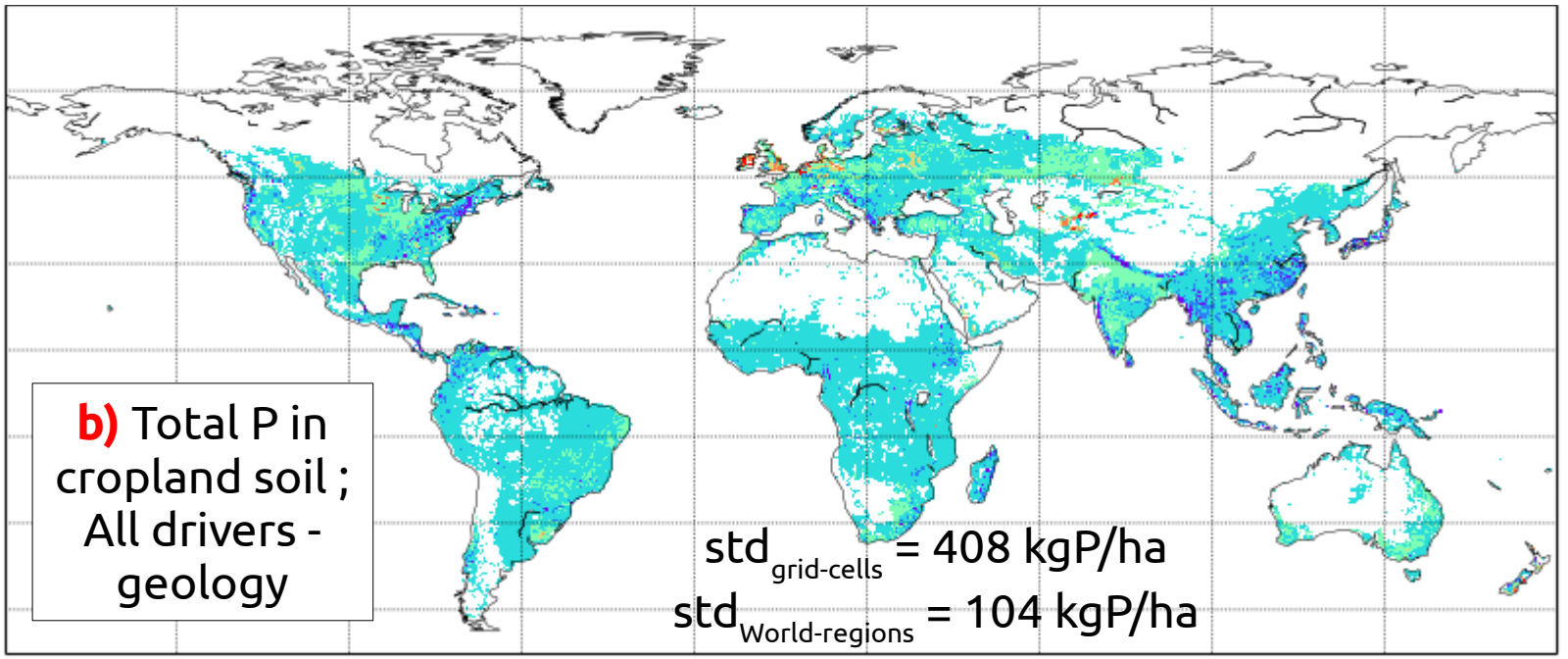

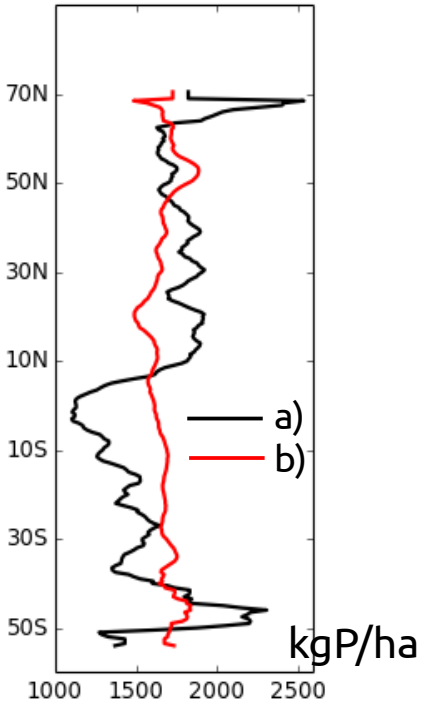

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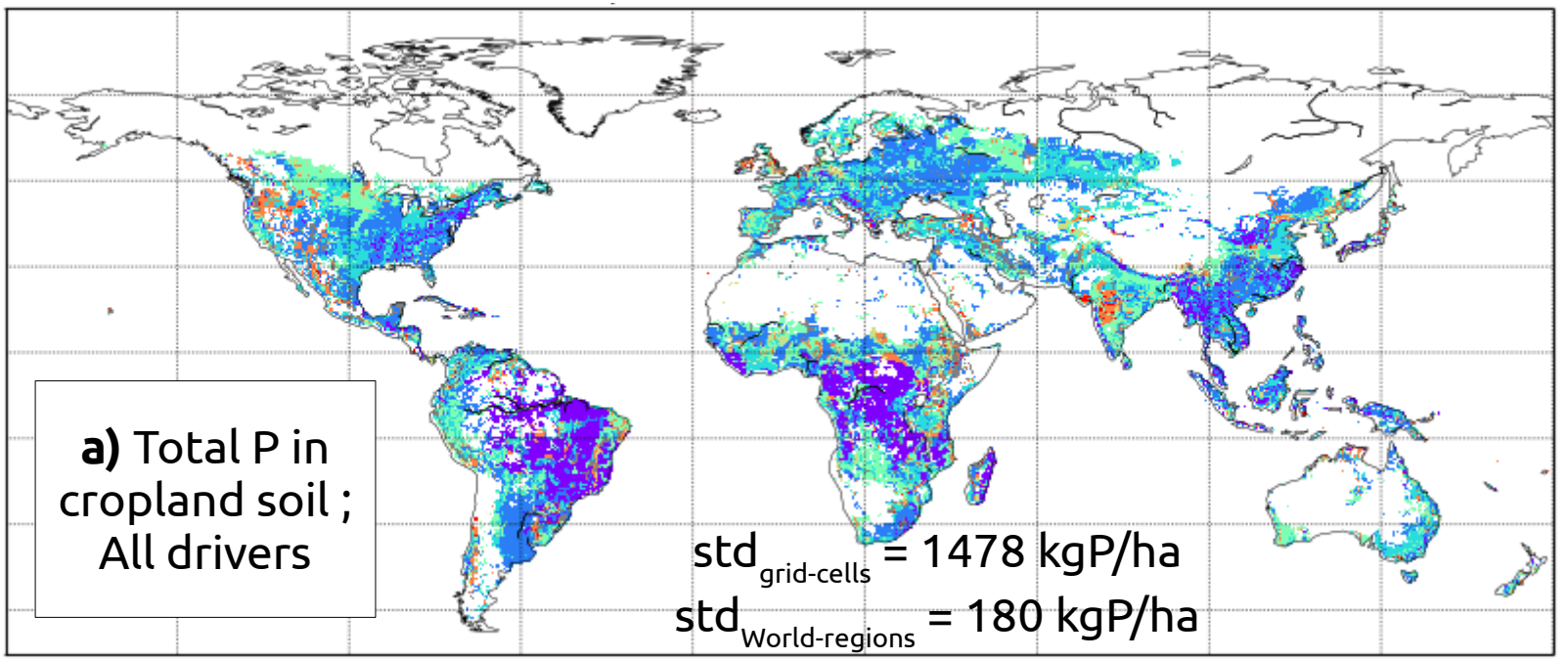
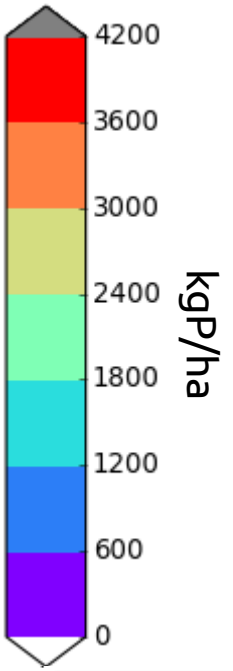
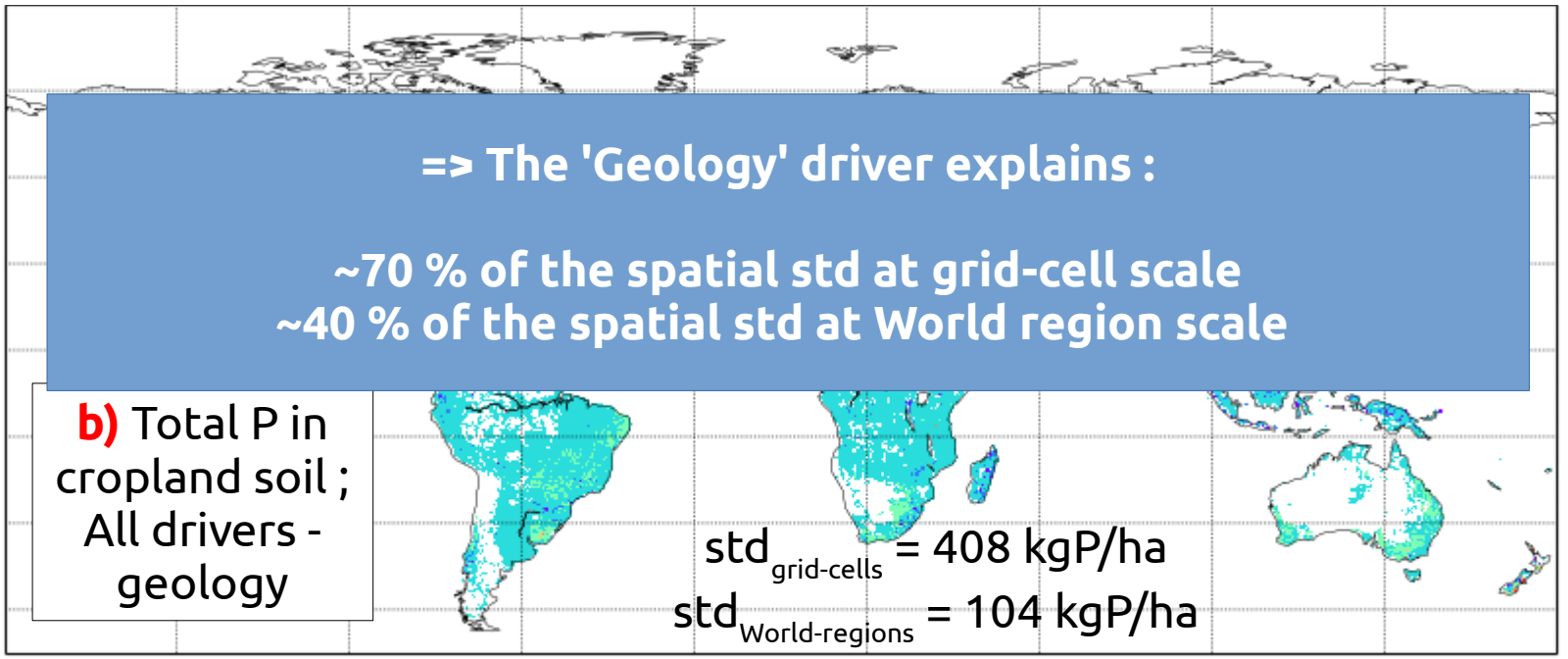


a) Total P in cropland soil ; All drivers

$std_{grid\text{-}cells}$ = 1478 kgP/ha

$std_{World\text{-}regions}$ = 180 kgP/ha





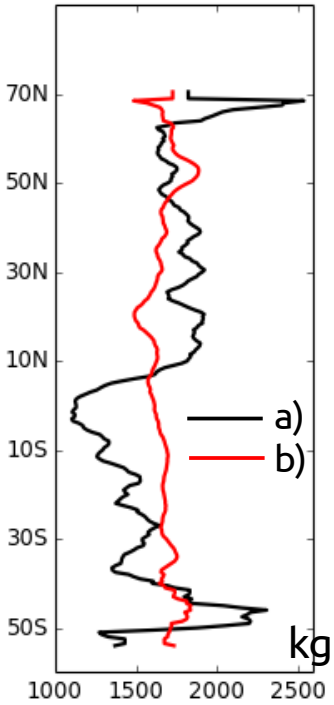
=> The 'Geology' driver explains :

~70 % of the spatial std at grid-cell scale
~40 % of the spatial std at World region scale

b) Total P in cropland soil ; All drivers - geology

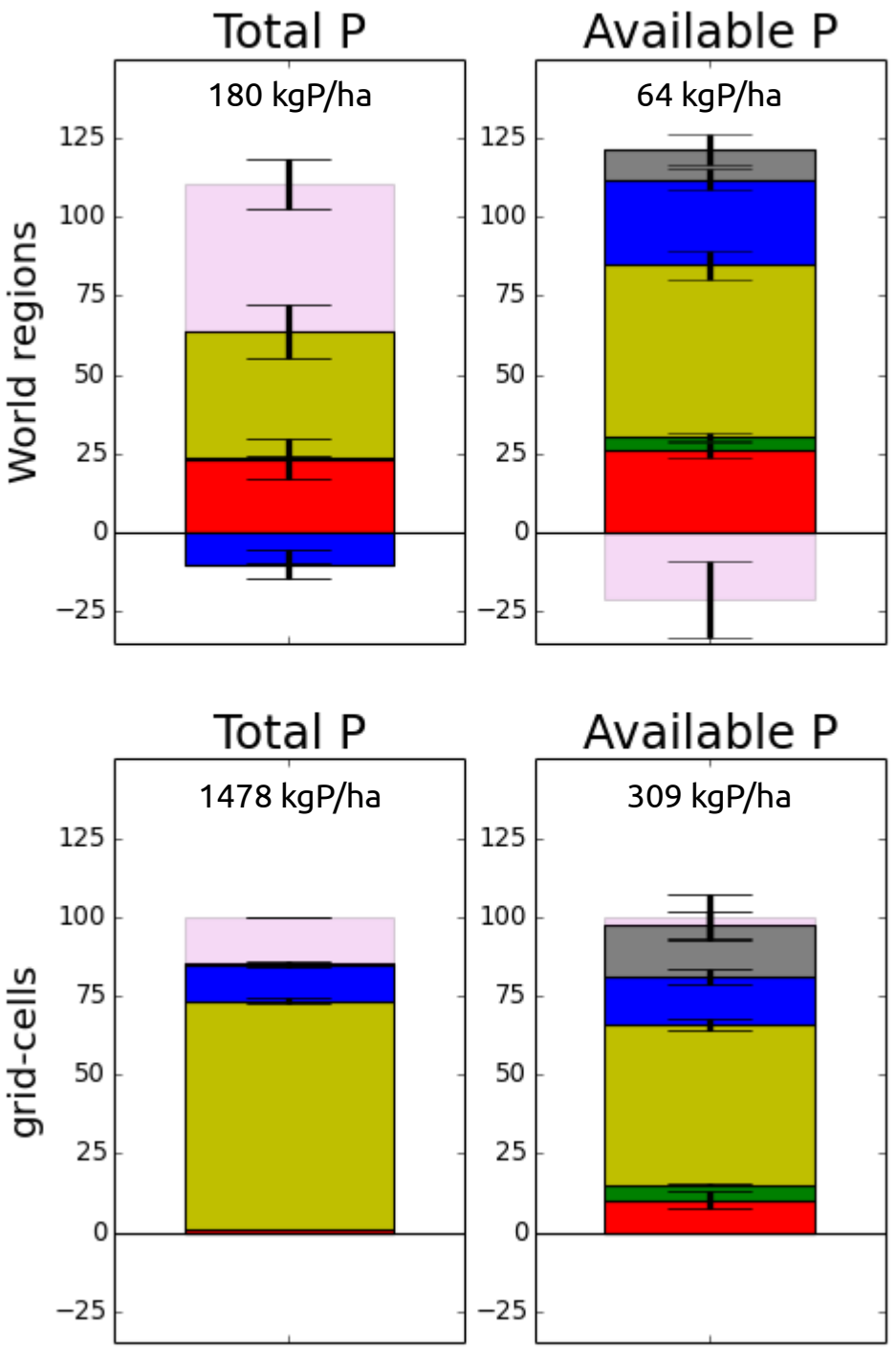
$std_{grid\text{-}cells}$ = 408 kgP/ha

$std_{World\text{-}regions}$ = 104 kgP/ha



Drivers of the current spatial variability (2/2)

Contribution to the spatial standard deviation (%) computed between :



Preliminary key-results:

- **key-role** played by the **'geology'** even for the **available P**
- for available P : **farming practices ~ erosion**
- for total P : contribution varies if or World-regions or grid-cells

Conclusion

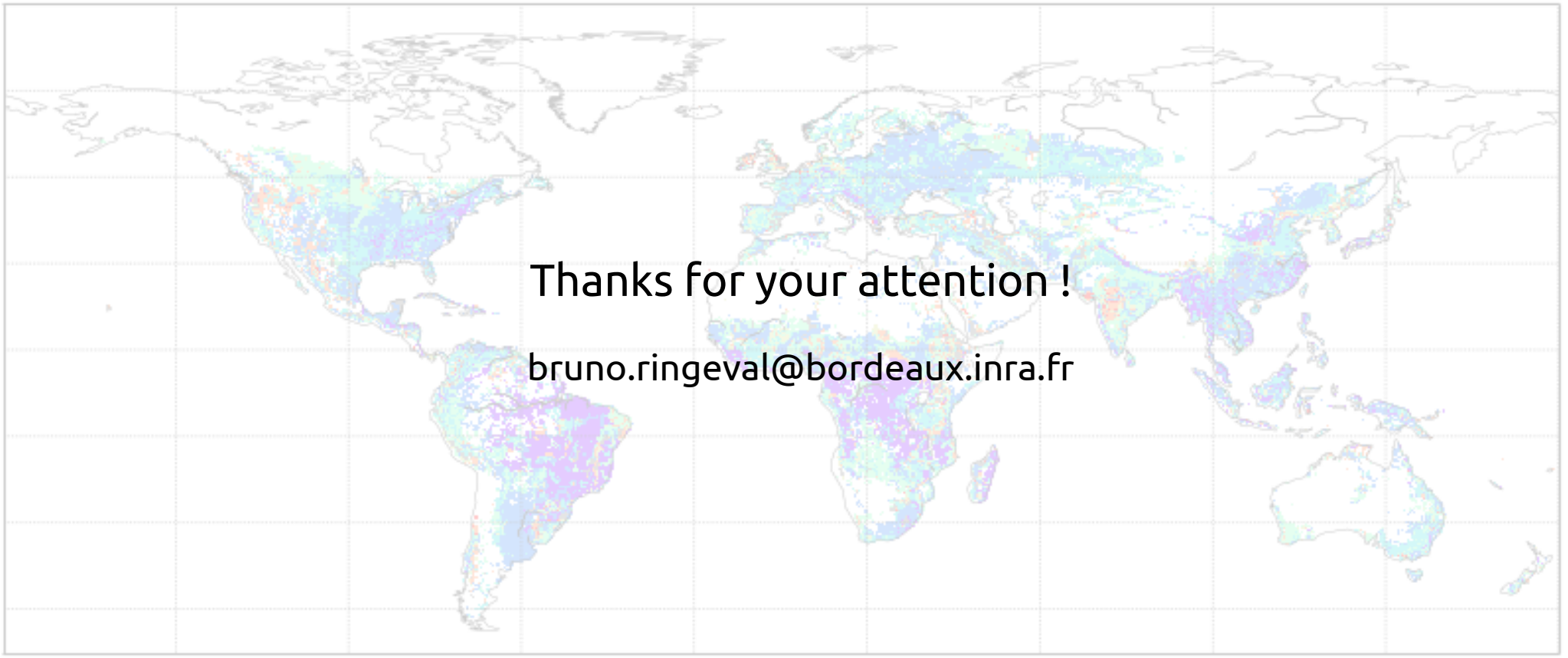
Thanks to our approach, we are able to assess the contribution of the different drivers to the current distribution of P in agricultural soils at global scale.

Preliminary key-results:

- **Key-role** played by the **'geology'** for **both total and available P**
- For available P : **farming practices ~ erosion**
- Difference in driver contribution as function of the spatial scale (grid-cells vs regions)

Work in progress:

- Difficulties in **evaluation** (number of sites, depth, mismatch about soilorder between observations and global datasets)
- The **uncertainty in all datasets** (farming practices, land-use) has to be taken into account



Thanks for your attention !

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Method : initial conditions

- Initial conditions (i.e. soil P content of agricultural soils in 1900) :

P_{Yang} prescribed to agricultural soils in 1700

then **200 years of simulation** with :

- constant soil input/output (=1900 level)
- land-use change