



UNIVERSIDADE DE SÃO PAULO
INSTITUTO DE ASTRONOMIA, GEOFÍSICA E CIÊNCIAS ATMOSFÉRICAS
PAE – PROGRAMA DE APERFEIÇOAMENTO DE ENSINO
AGG0201 – GEOQUÍMICA DE AMBIENTES SUPERFICIAIS



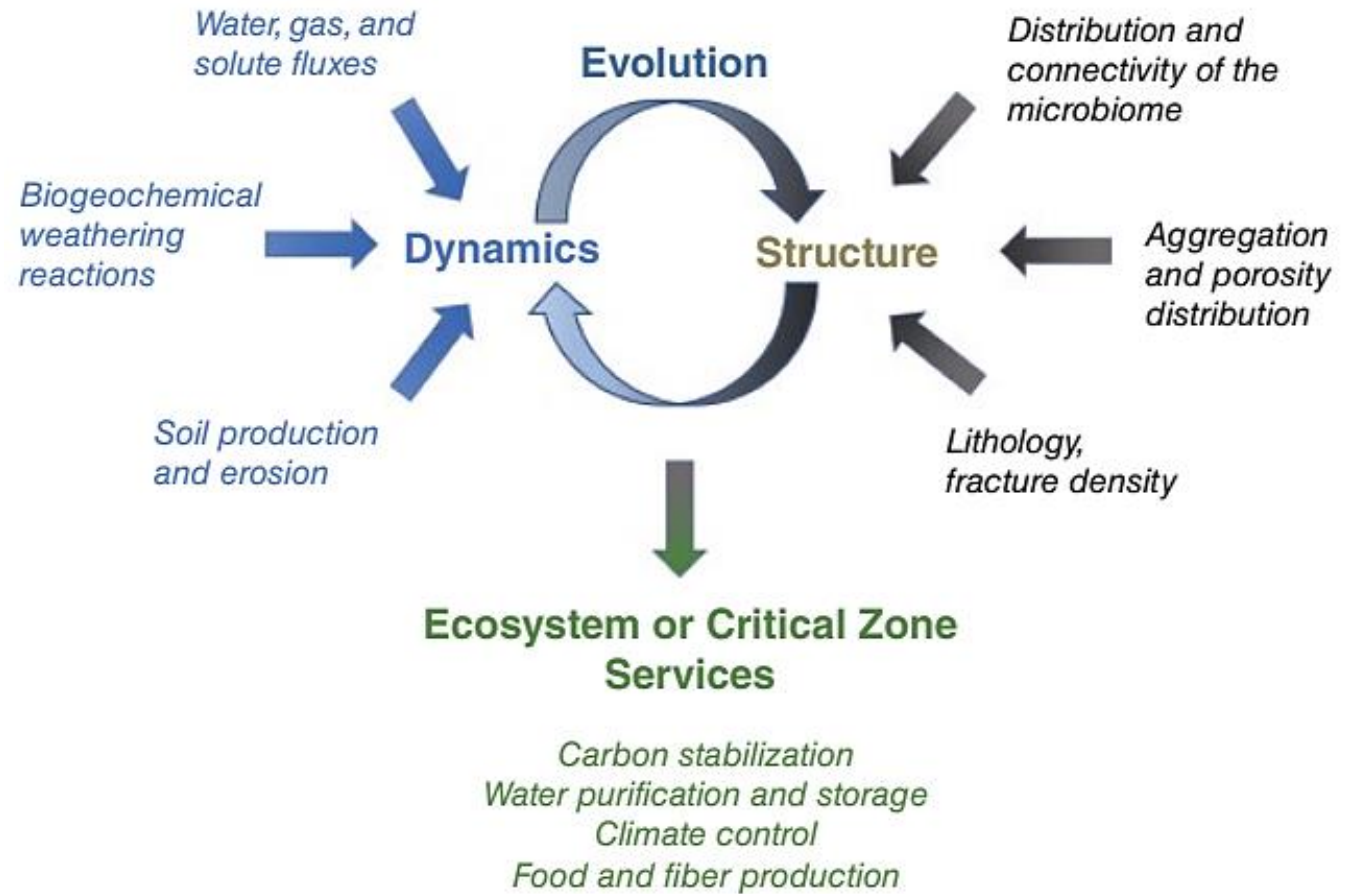
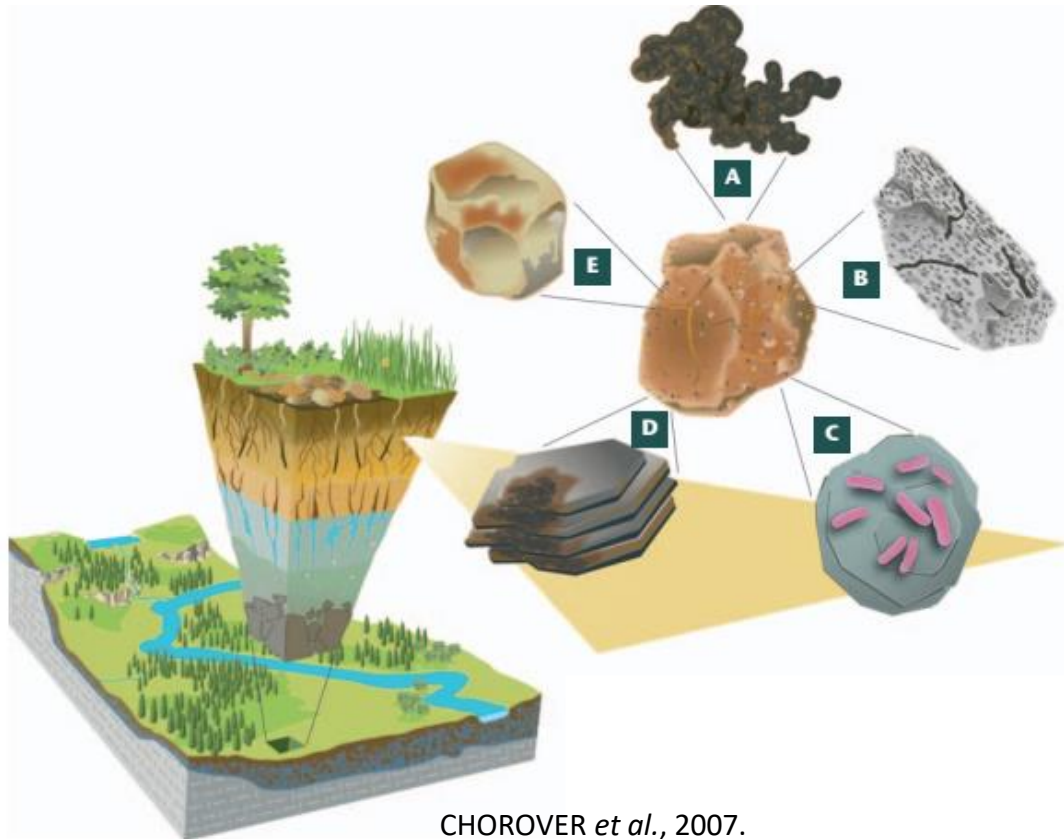
OBSERVATÓRIOS DE ZONA CRÍTICA

Letícia Rangel Dantas

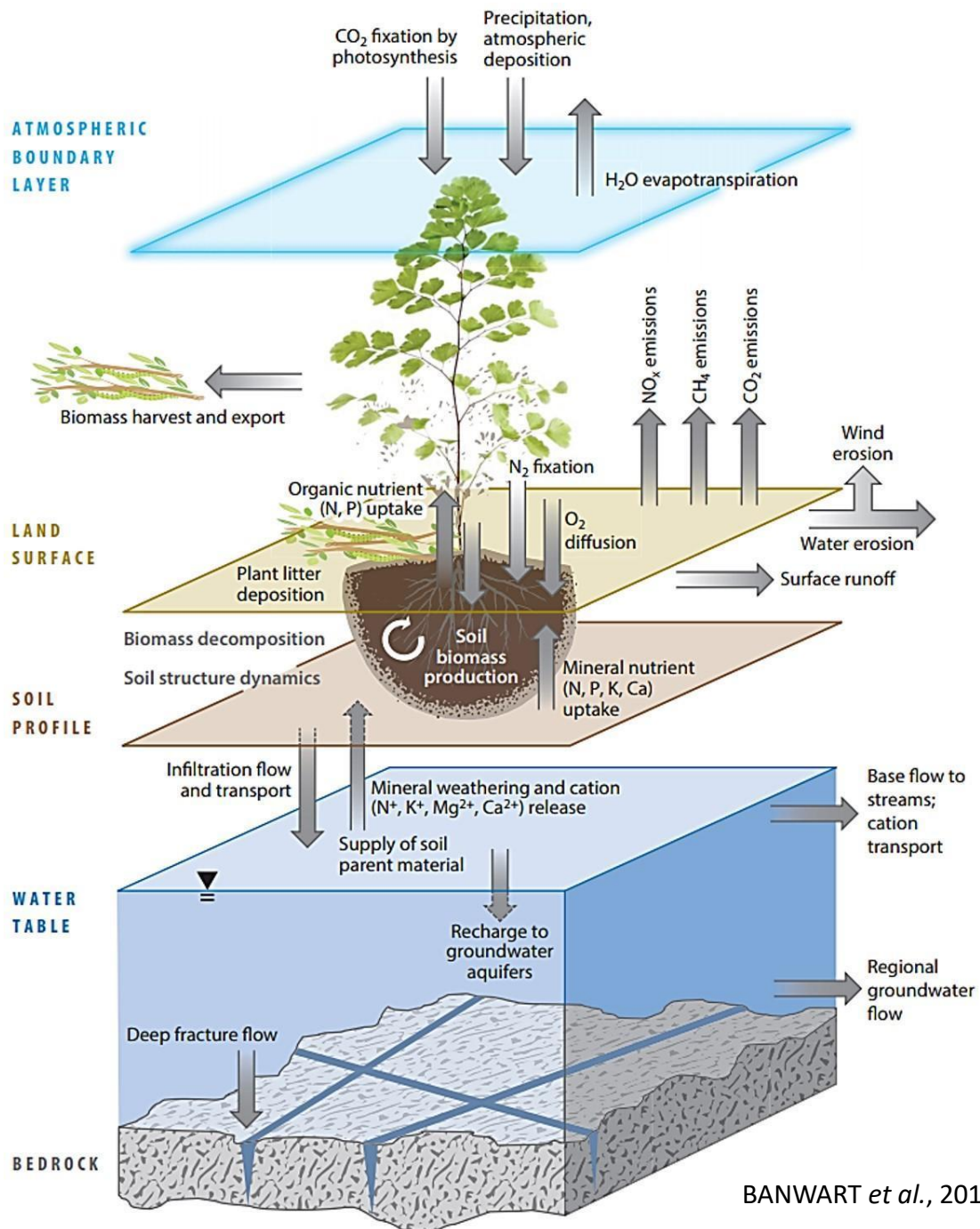
SÃO PAULO
20-09-2022

ZONA CRÍTICA

Região da superfície terrestre que se estende do topo da vegetação à zona de água subterrânea (NRC, 2001).



MORAVEC E CHOROVER, 2020.

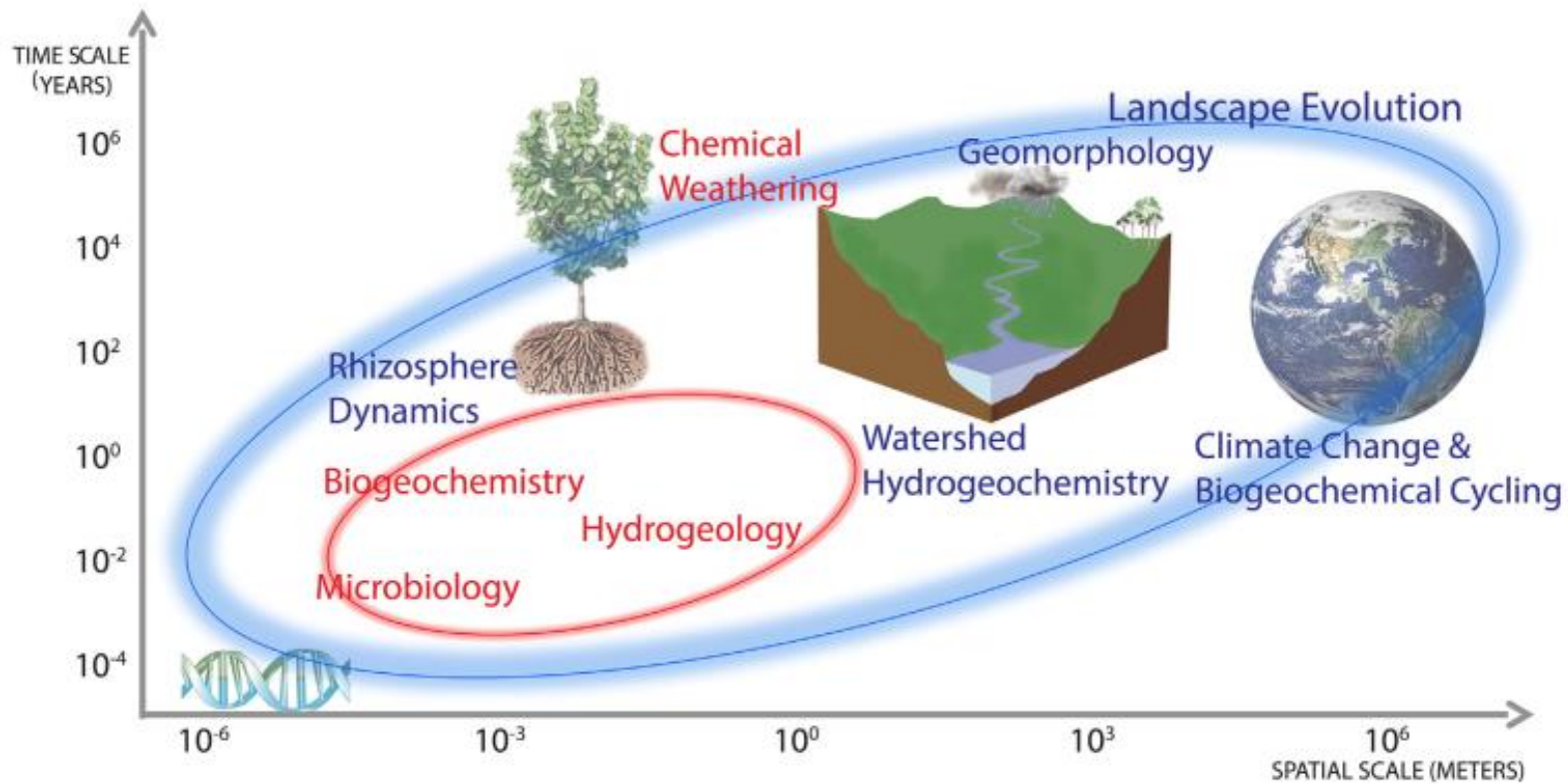


BANWART *et al.*, 2017.

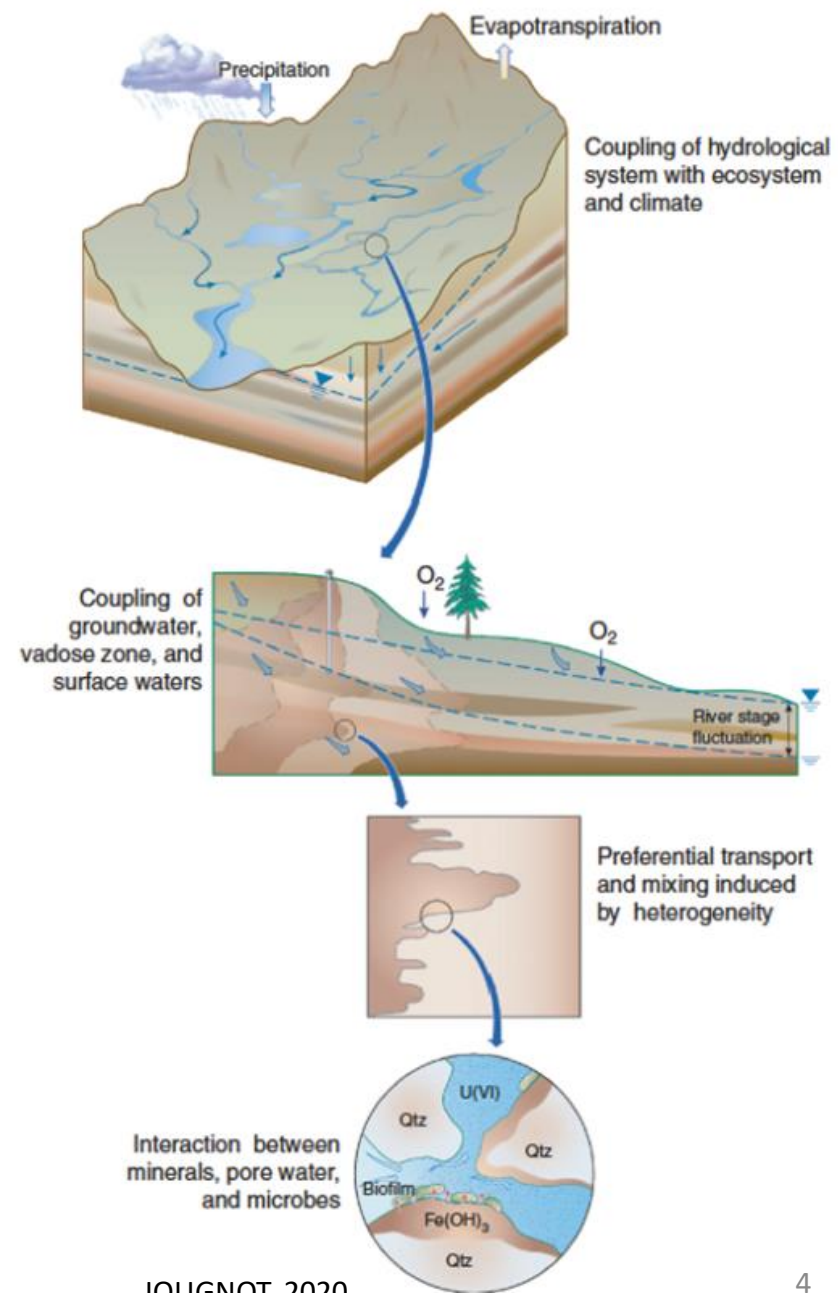
A zona crítica pode ser dividida em zonas menores com diferentes propriedades físicas, químicas e biológicas (LI *et al.*, 2017).

O solo funciona como um reator biogeoquímico (BANWART *et al.*, 2017).

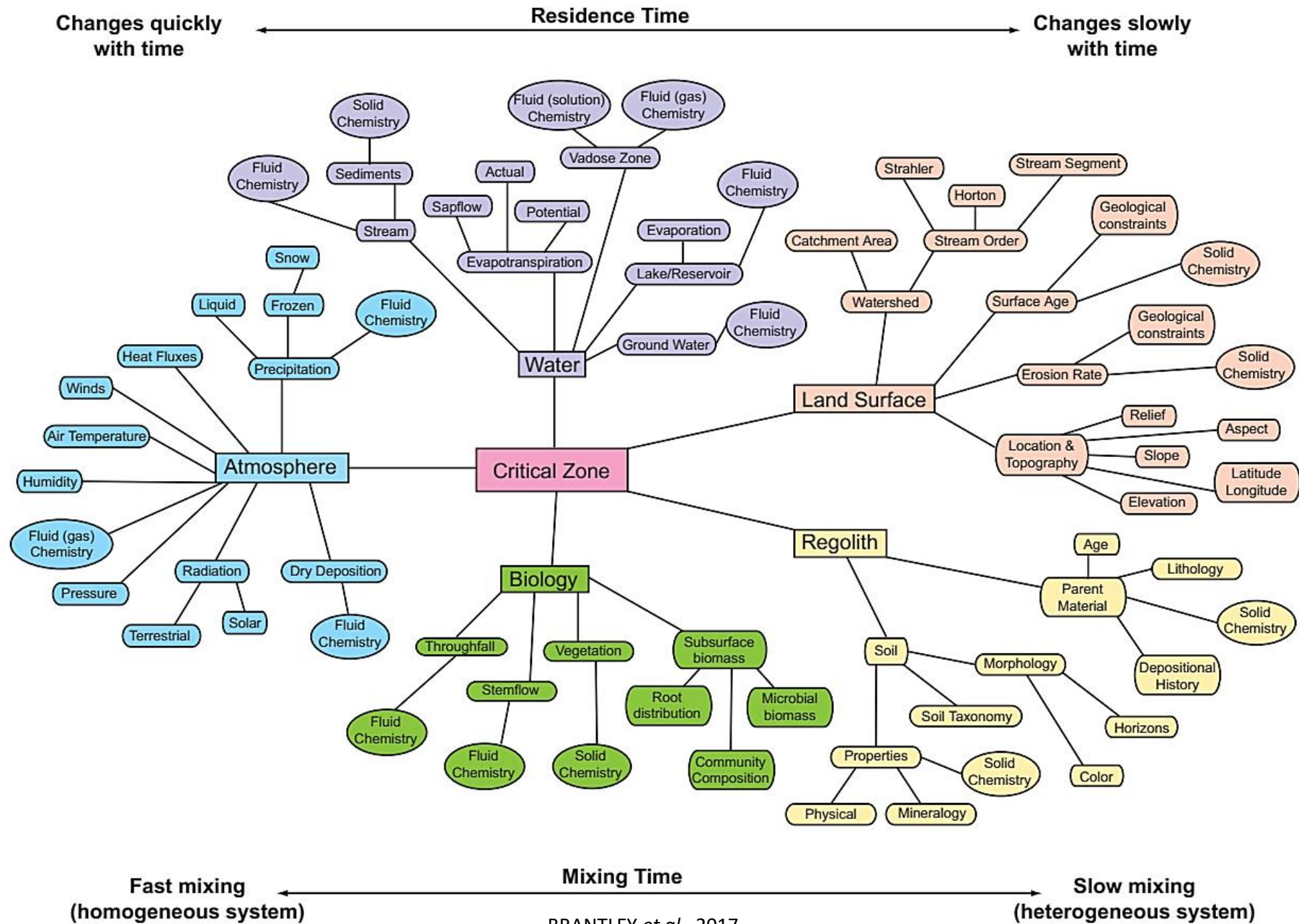
ESCALA DE PROCESSOS



LI *et al.*, 2017.



JOUGNOT, 2020.



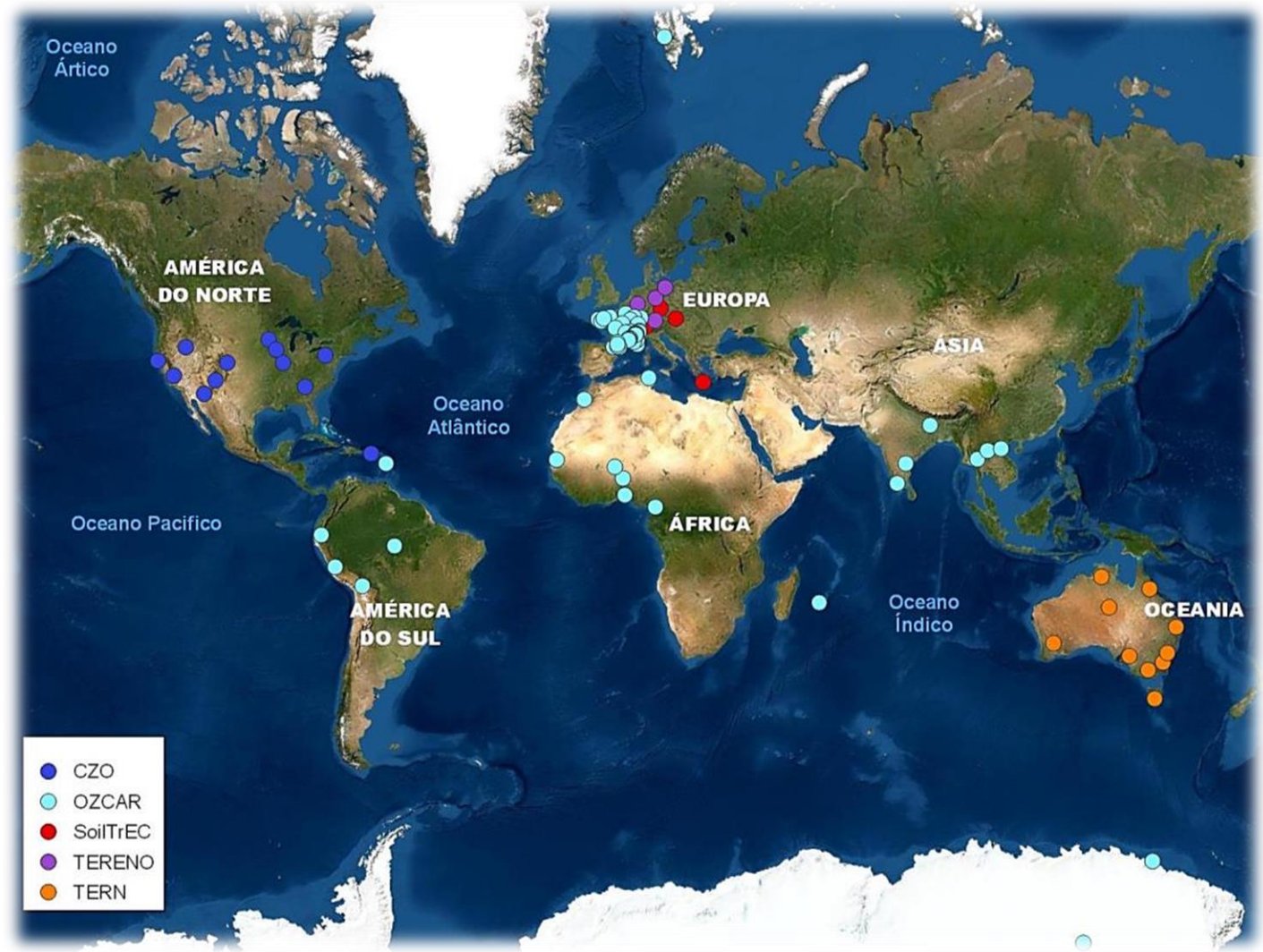
DESAFIOS CIENTÍFICOS

Captura de padrões em diferentes locais de zona crítica para investigações destes sistemas em resposta a perturbações naturais e antropogênicas (ARORA *et al.*, 2021).

Identificação do comportamento de diferentes sítios de zona crítica em resposta aos mesmos estressores ou de sítios semelhantes a estressores diferentes.

OBSERVATÓRIOS DE ZONA CRÍTICA




Sítios ou conjuntos de sítios conectados sem tamanho mínimo ou intervalo específico de condições, definidos apenas por questões fundamentais que impulsionam a sua implementação (BRANTLEY *et al.*, 2017).



Adaptado de ZACHARIAS *et al.*, 2011; KARAN *et al.*, 2016; BRANTLEY *et al.*, 2017; GAILLARDET *et al.*, 2018.

TERN (Australia)



-  13 sites
-  > 750 plots
-  16 supersites (10 – 200 km)

<https://www.tern.org.au/>

CZO (USA)

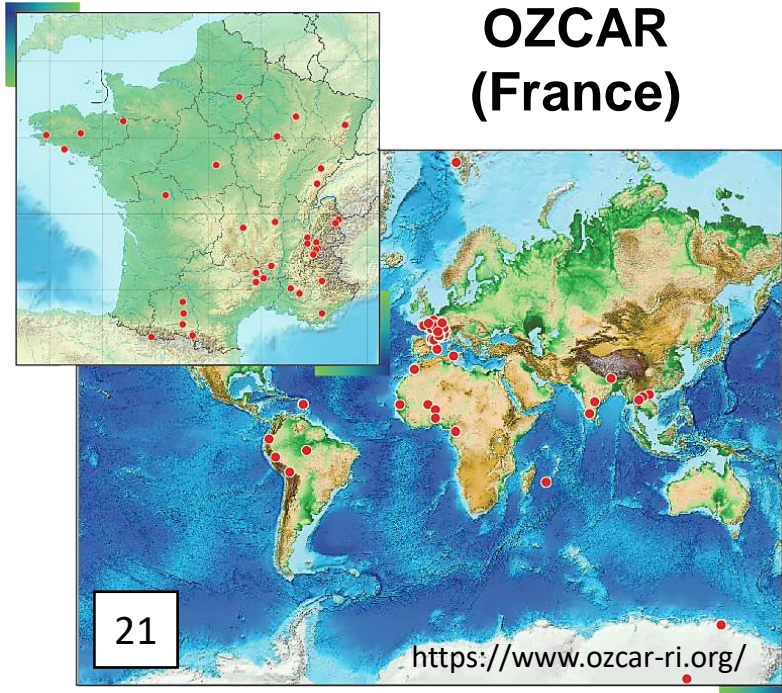


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<https://czo-archive.criticalzone.org/national/>

Redes de observatórios

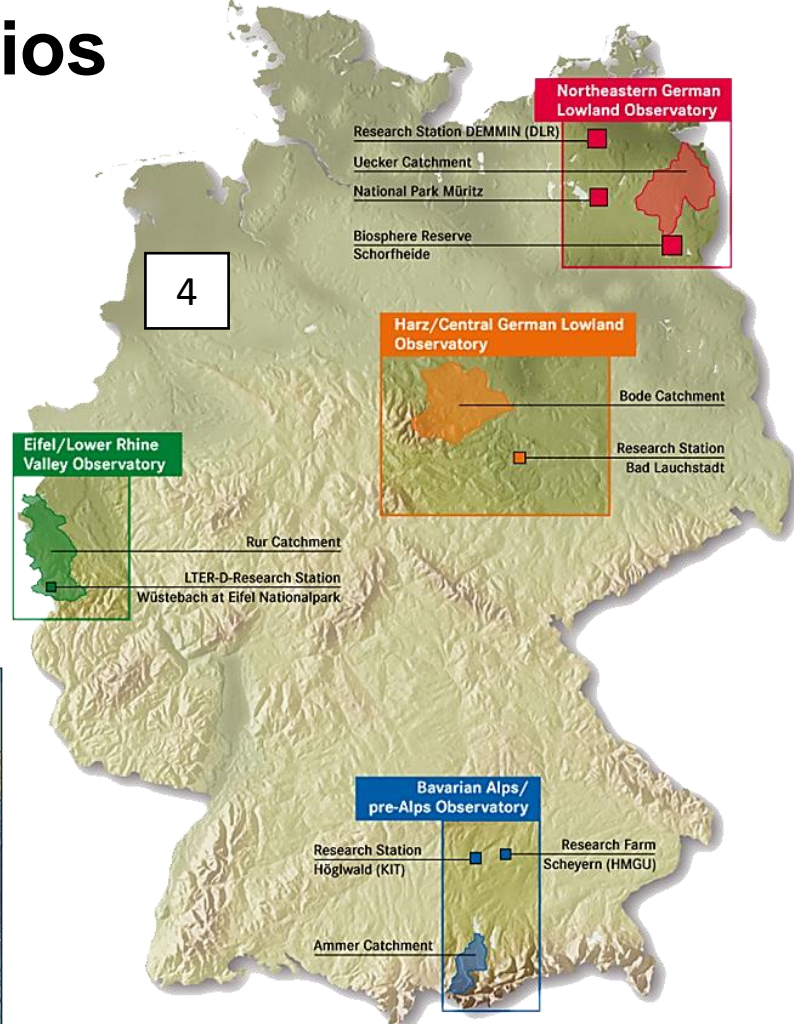
OZCAR (France)



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<https://www.ozcar-ri.org/>

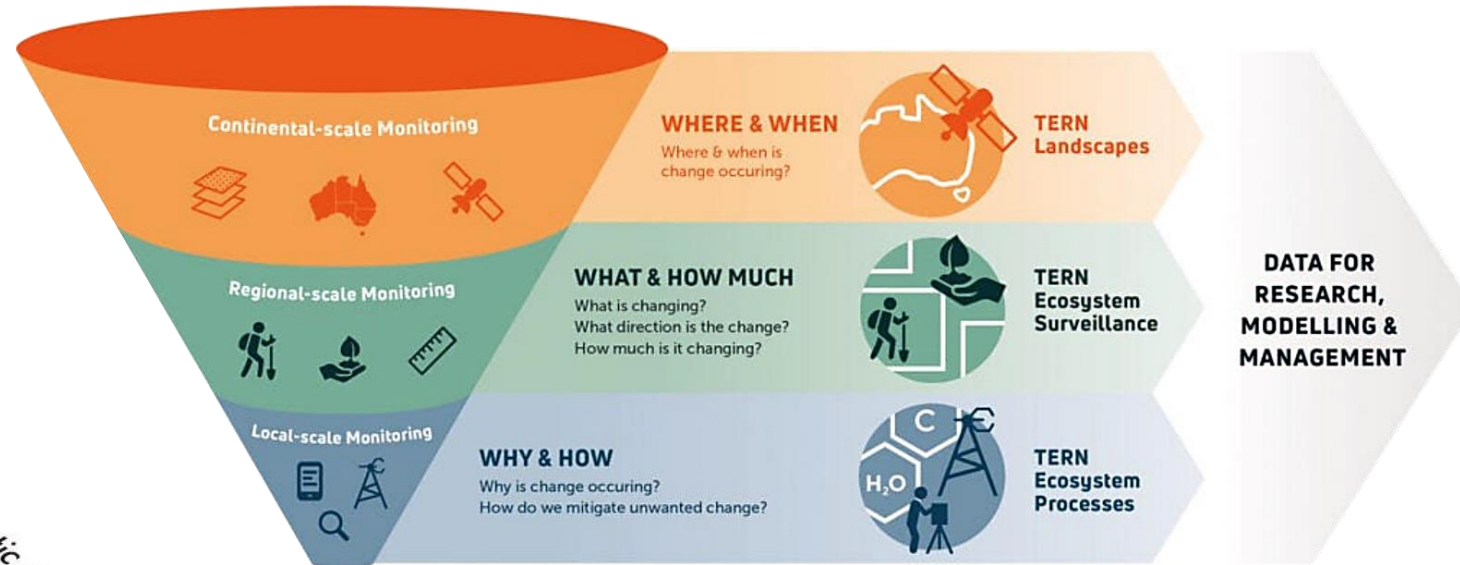
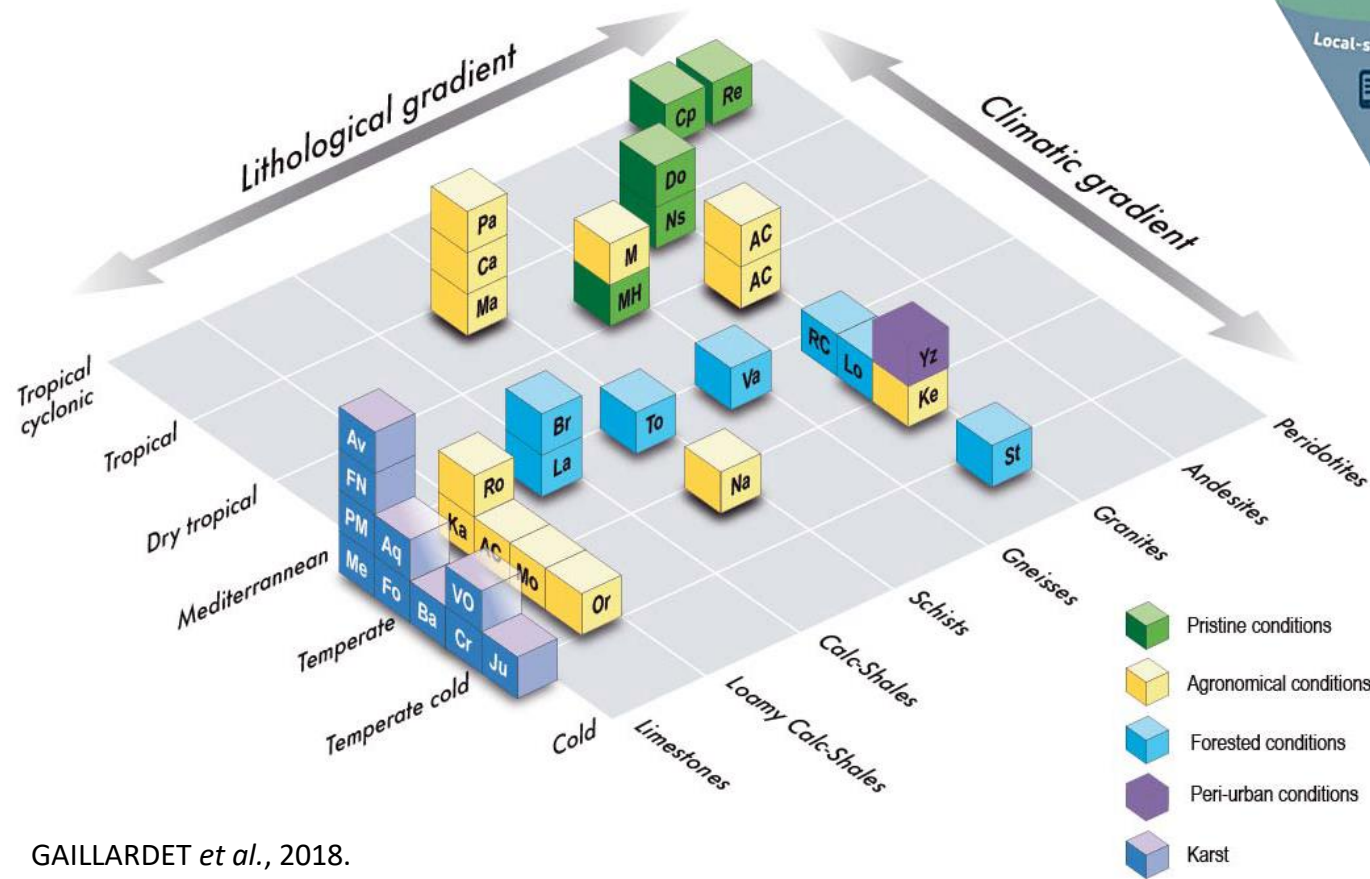
TERENO (Germany)



4

<https://www.tereno.net/>

OZCs estão presentes em diferentes gradientes litológicos, climáticos e de uso do solo.



<https://www.tern.org.au/>

Instrumentação

High frequency exploration

WP1 : soil-atmosphere exchanges

- ★ 1.1 : microwave scintillometry
- 1.2 : flux tower and IR scintillometry

WP2 : pulsation of water in the ZC

- 2.1 : hydrogravimetry
- 2.2 : hydrogeodesy
- ★ 2.3 : water sensors

WP3 : temperature monitoring

Fiber optic for temperature and gas

WP4 : high temporal monitoring

- ★ 4.1 : extreme event monitoring
- ★ 4.2 : the River Lab
- ★ 4.3 : innovative chemical sensors

Hot-spot and hot-moments

WP5 : scanning the surface

image drone exploration

WP6 : geophysical tools of exploration

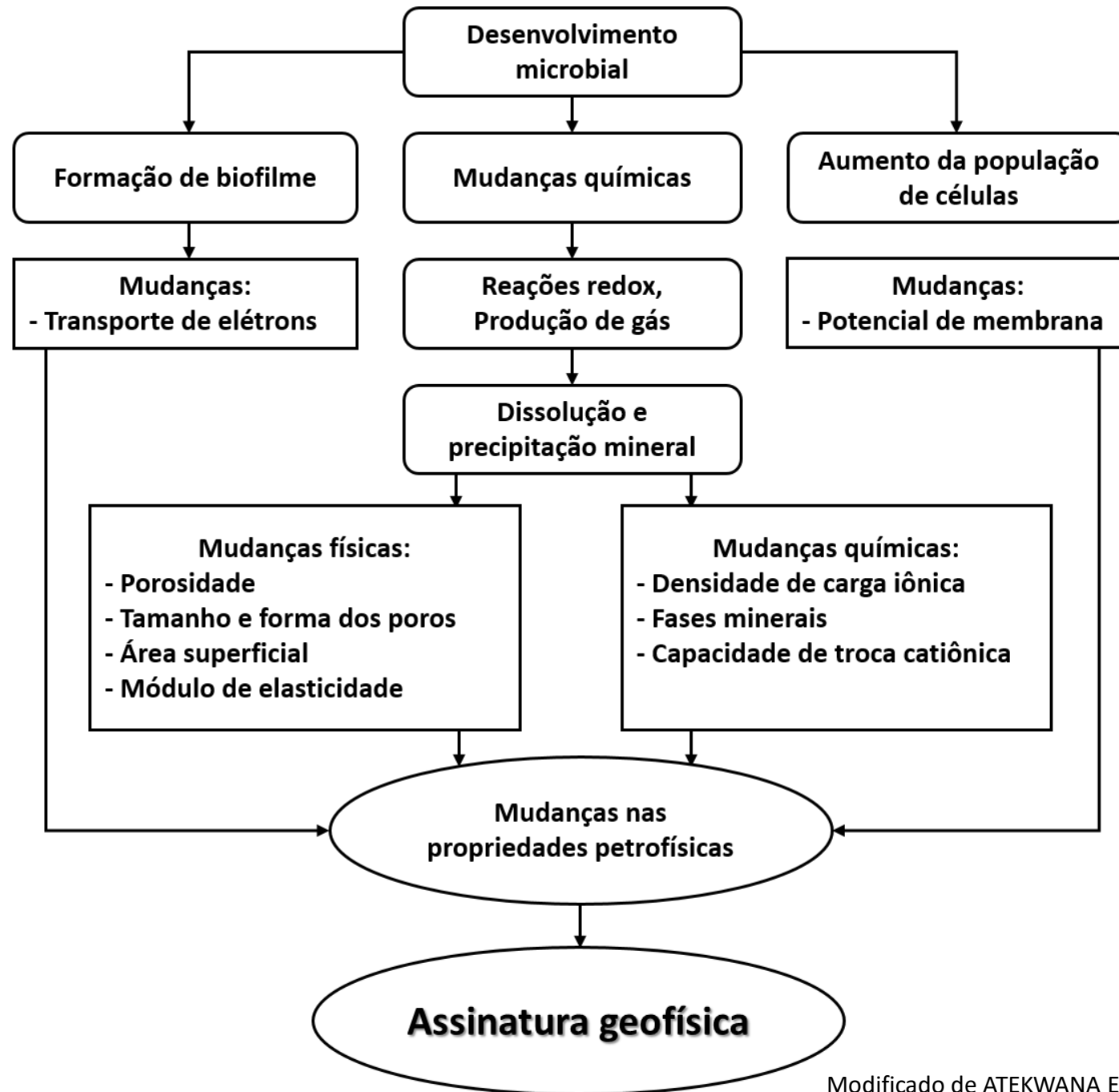
- 6.1 : seismic methods
- ★ 6.2 : MSR
- 6.3 : electrical methods
- 6.4 : polarization
- 6.5 : CS-AMT

WP7 : inaccessible groundwaters

- 7.1 : well equipment
- 7.2 : well monitoring
- 7.3 : reactive and inert tracer test experiments

WP8 : chemical and isotopic fingerprinting

- ★ 8.1 : gas tracing
- 8.2 : water isotopes
- ★ 8.3 : integrative sensors



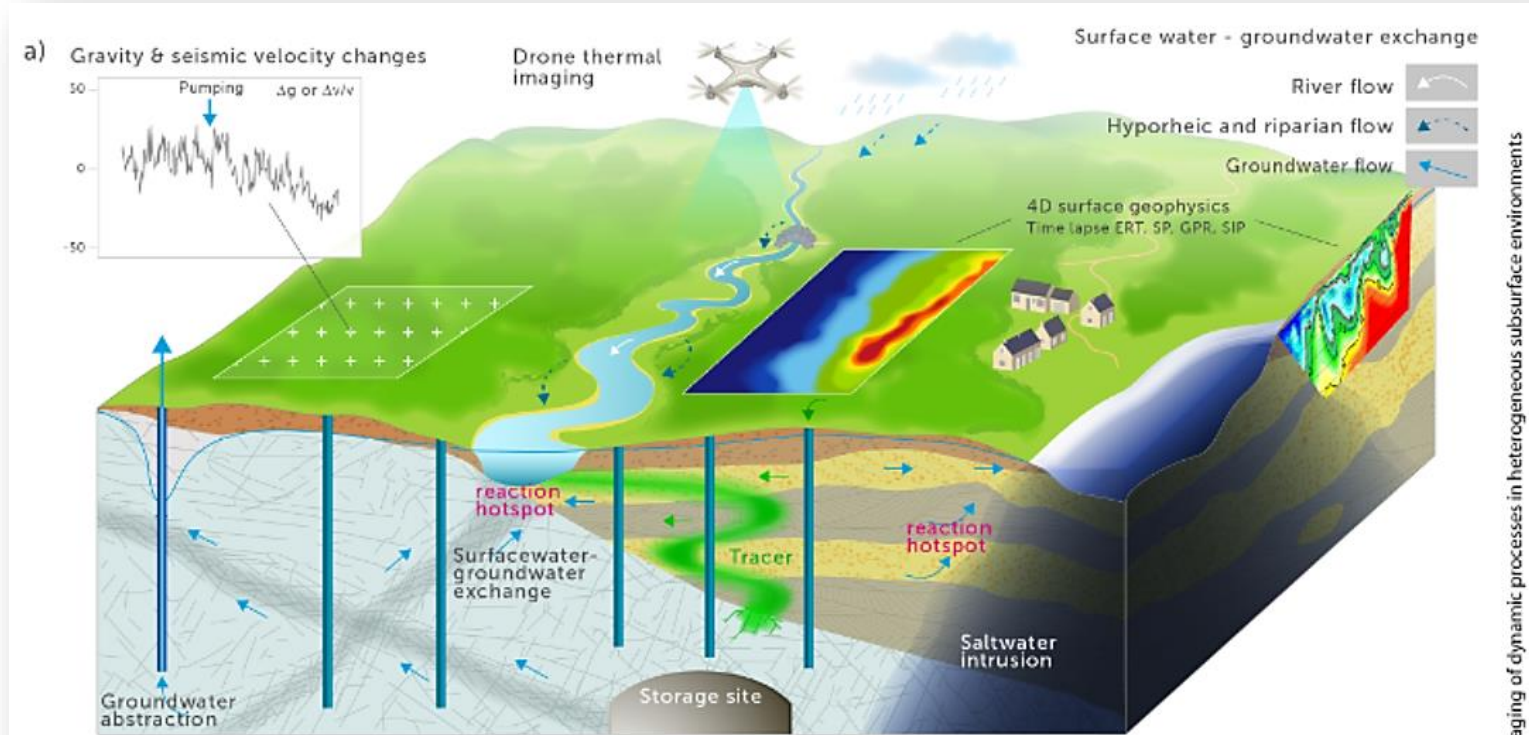


Image designed by ENIGMA: European training network for in-situ imaging of dynamic processes in heterogeneous subsurface environments

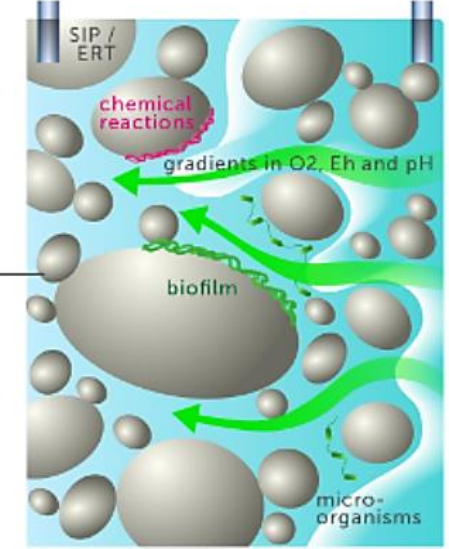
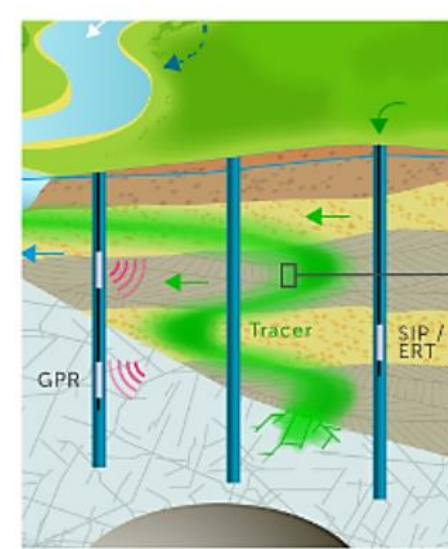
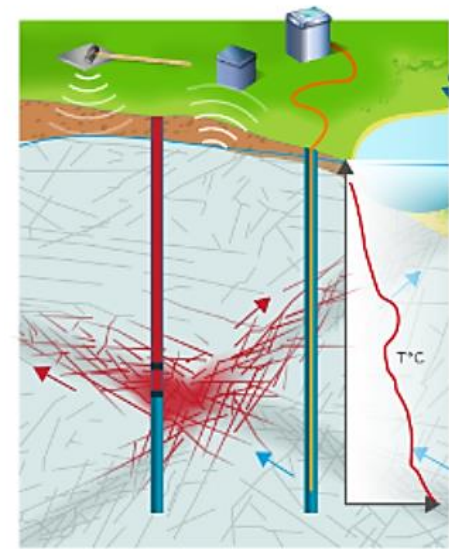
Medições diretas e amostragem pontual podem não ser suficientes para identificar e quantificar processos da zona crítica (RIEBE *et al.*, 2017).

Métodos geofísicos são menos invasivos, repetíveis (lapso de tempo) e apresentam maior cobertura espacial e menor custo em comparação com medições diretas (PARSEKIAN *et al.*, 2015).

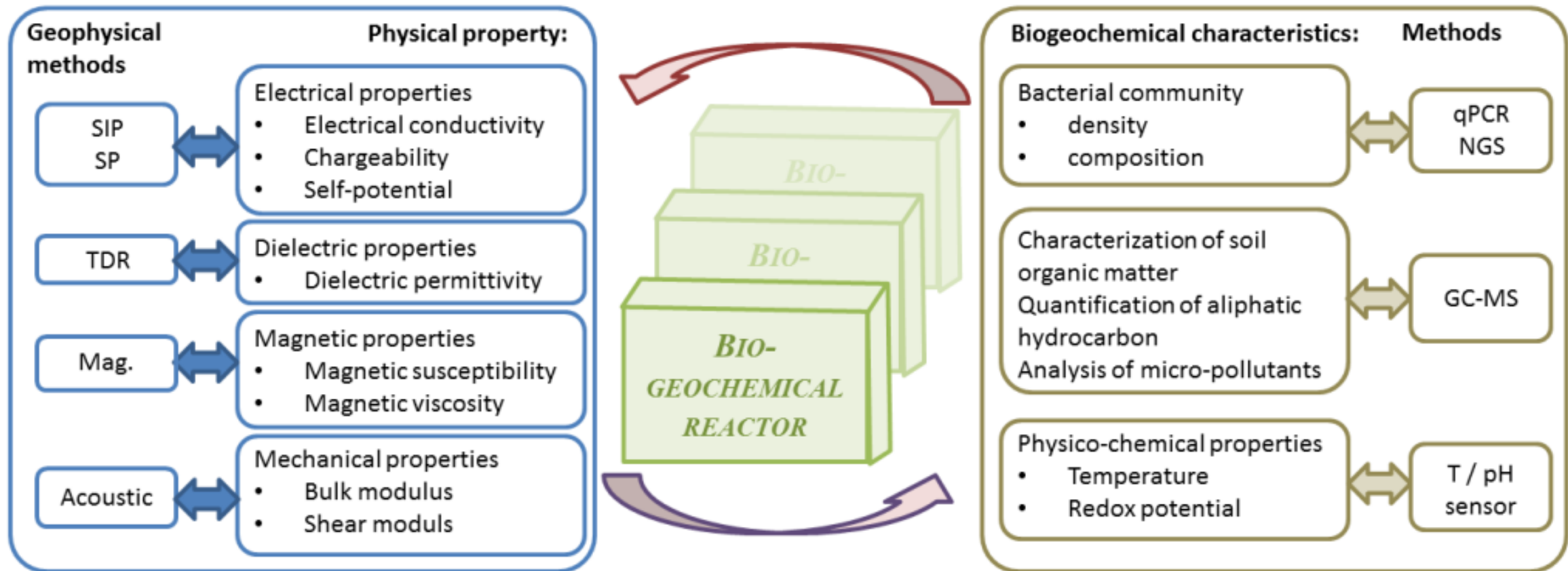
b) Monitoring temporal dynamics and spatial distribution of fluxes and water content

c) Process based geophysical imaging of transport phenomena

d) Quantifying geophysical signatures of mixing, reactions and biofilms



©



JOUGNOT, 2020.



OBSERVATÓRIO-PILOTO DE ZONA CRÍTICA EACH-PET

PET

EACH-USP

SP-070

Rod. Ayrton Senna

Av. Dr. Assis Ribeiro

Rua Ribeira do Amparo

R. Col. Leopoldina

R. Seta Verde

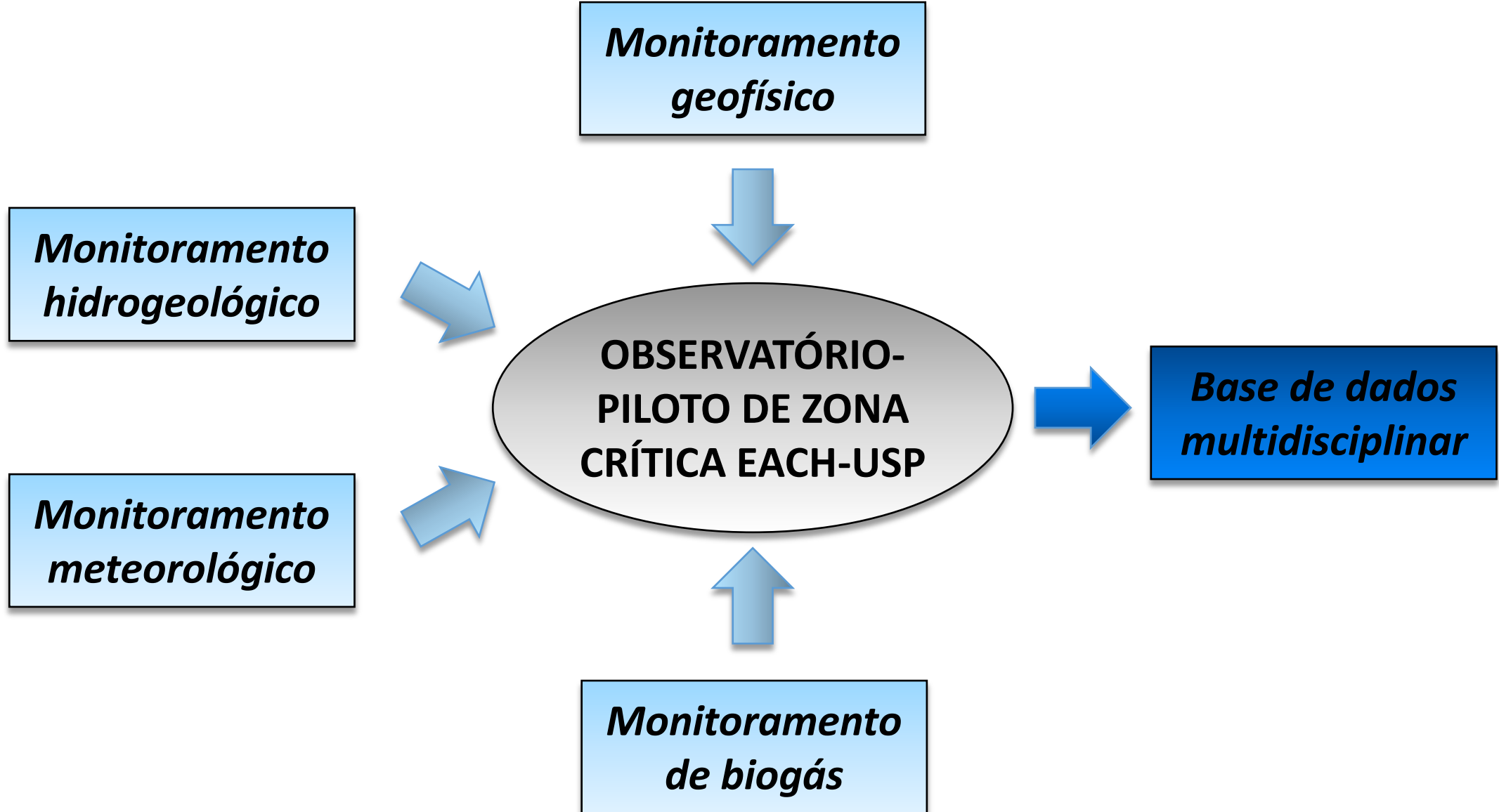
R. Novo Oriente do Piauí

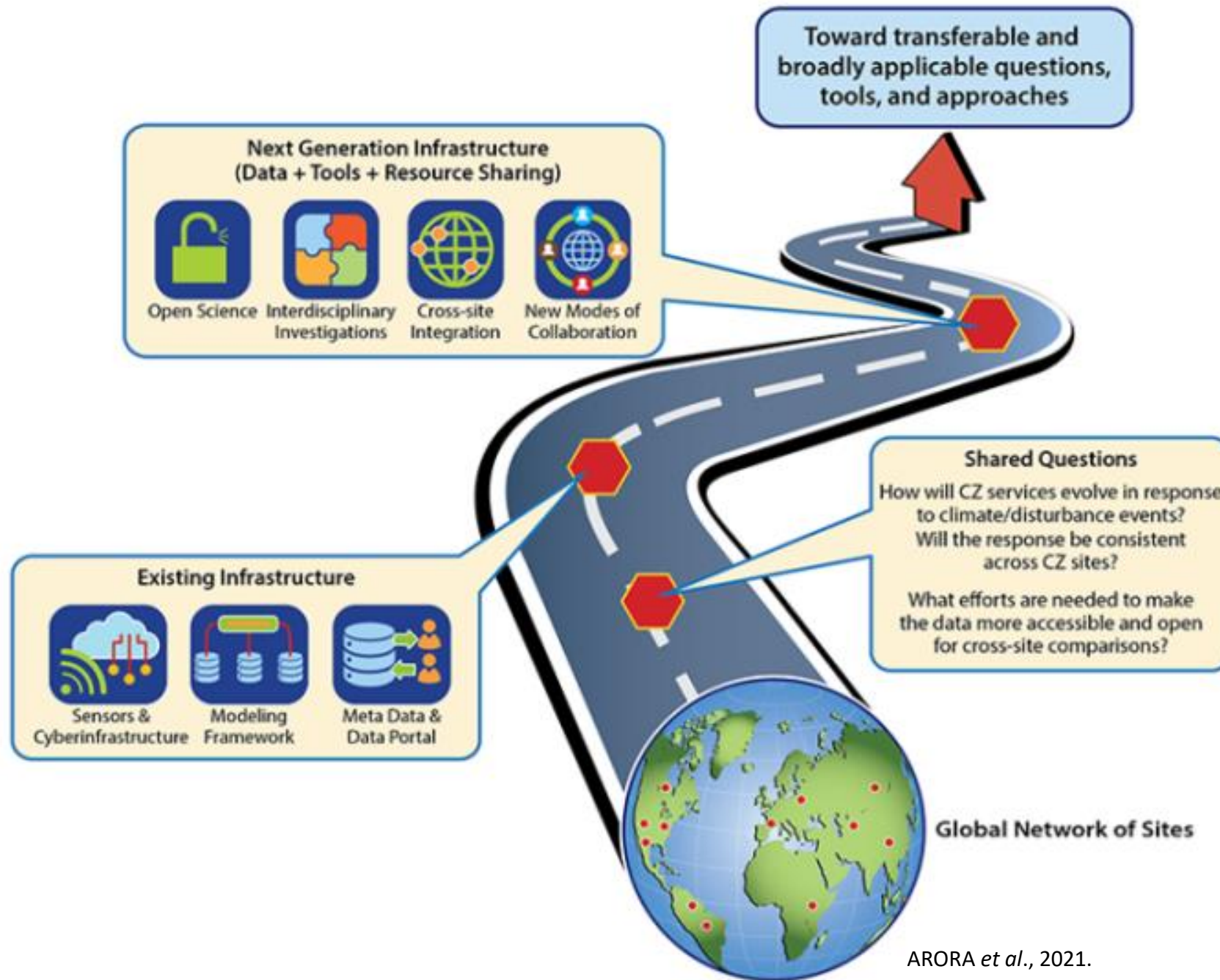


Compreender padrões de evolução sazonal de assinaturas biogeofísicas e propriedades magnéticas em área urbana com um complexo histórico de uso do solo.

PET

EACH-USP





ARORA *et al.*, 2021.

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