Limites planétaires: concept et matière à réflexion pour un futur soutenable

Théo VISCHEL
Enseignant-Chercheur Professeur en Hydrologie
Université Grenoble Alpes – Institut des Géosciences de l'Environnement

Regards croisés sur les limites planétaires (environnement, droit, numérique) — 15/11/24 Grenoble

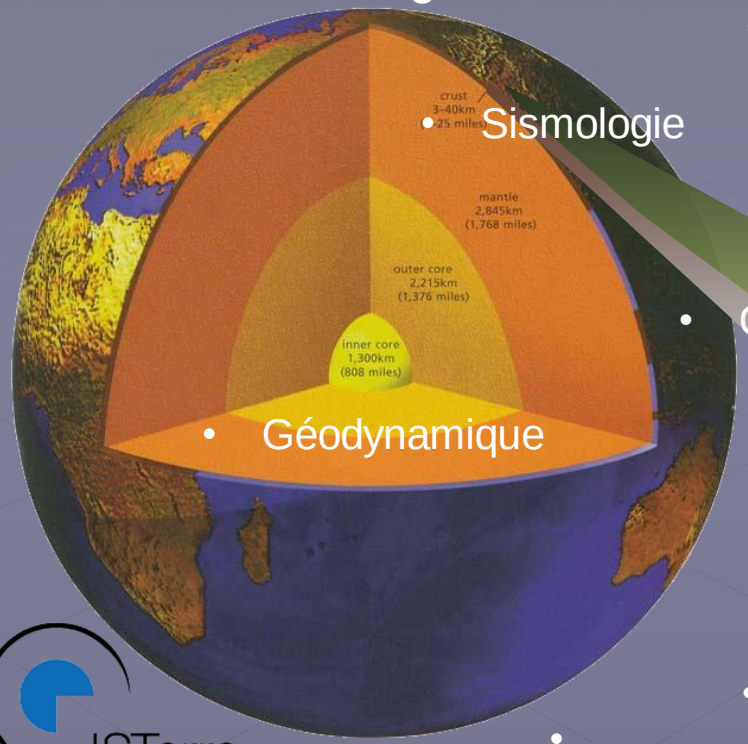
50 nuances de Greyosciences

Terre externe

- Climatologie
- Glaciologie
- Géomorphologie
- Océanographie
- Hydrologie
- Hydrogéologie
- …

Terre interne

Géologie



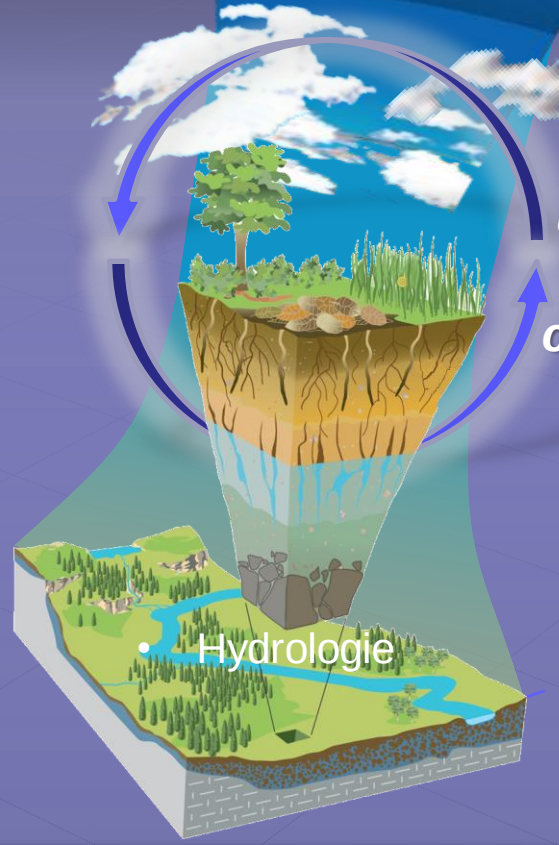
- Sismologie
- Géodynamique

ISTerre

IGE
Institut des géosciences de l'environnement

Mon domaine de recherche

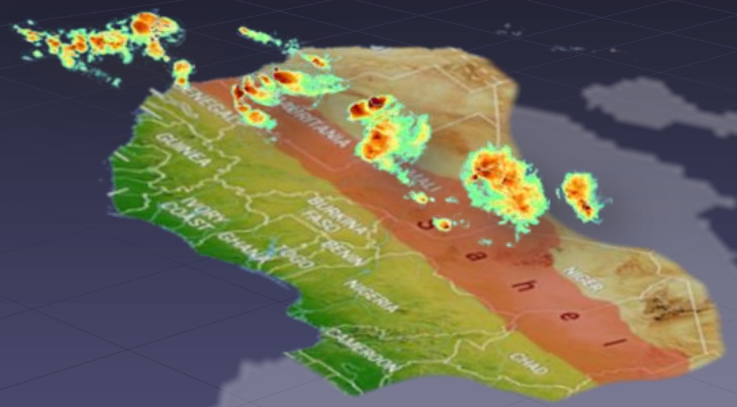
- Climatologie

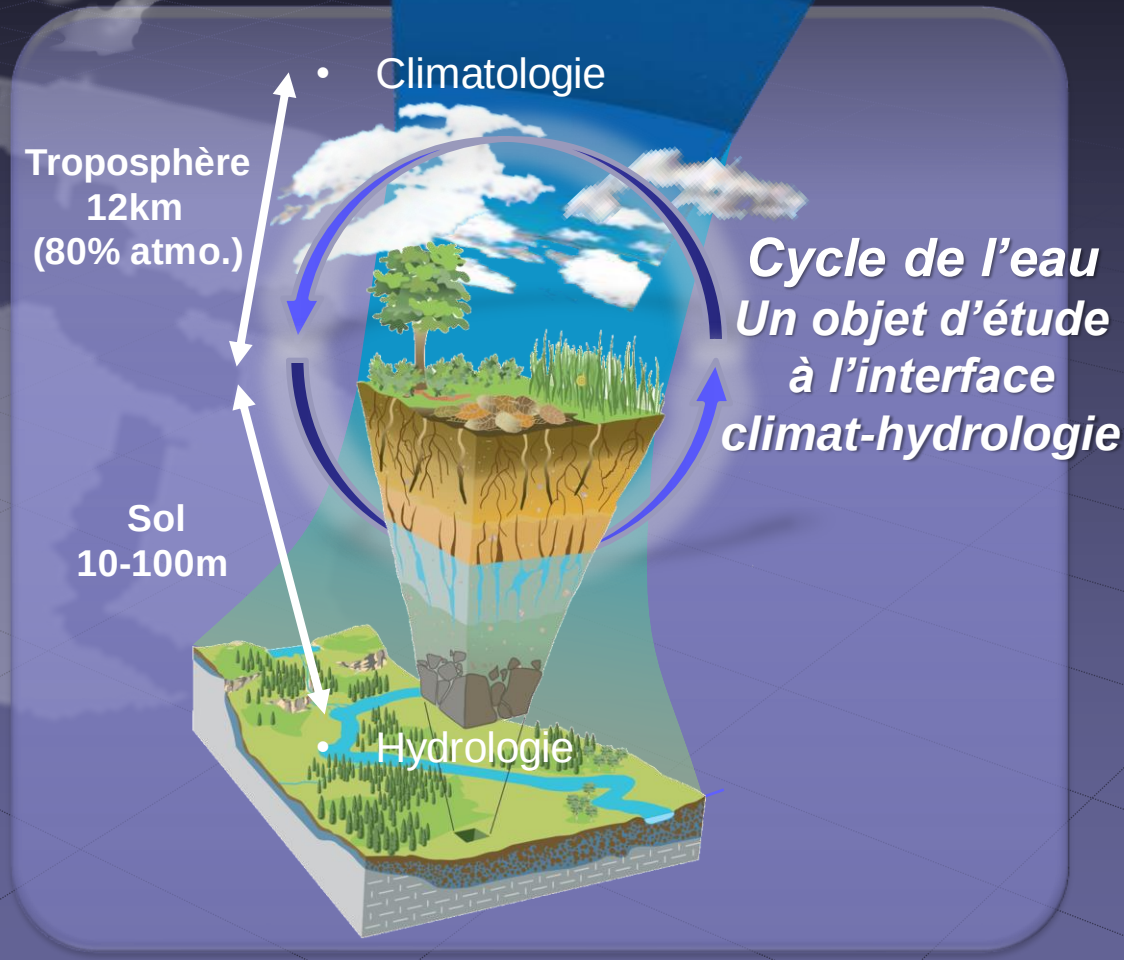


Cycle de l'eau
Un objet d'étude
à l'interface
climat-hydrologie

- Hydrologie

Mon domaine de recherche

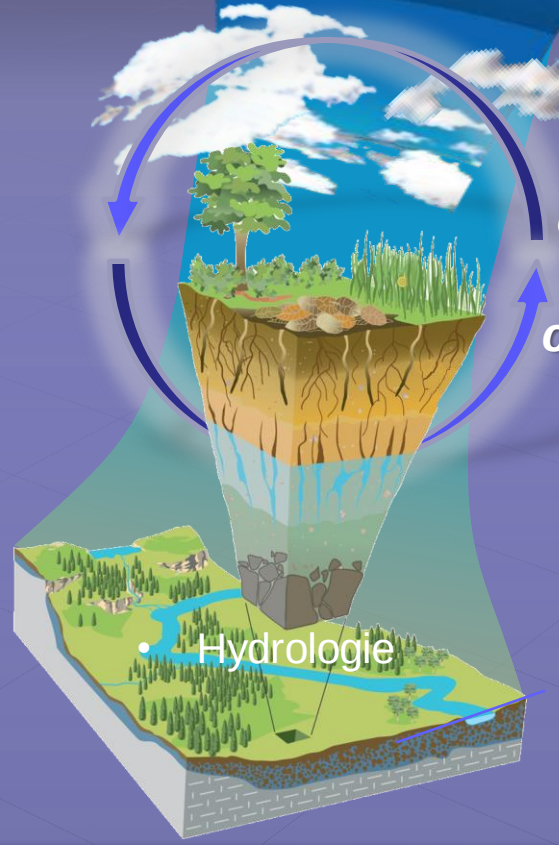




Cycle de l'eau
Un objet d'étude
à l'interface
climat-hydrologie

Ma légitimité sur le sujet des limites planétaires

- Climatologie

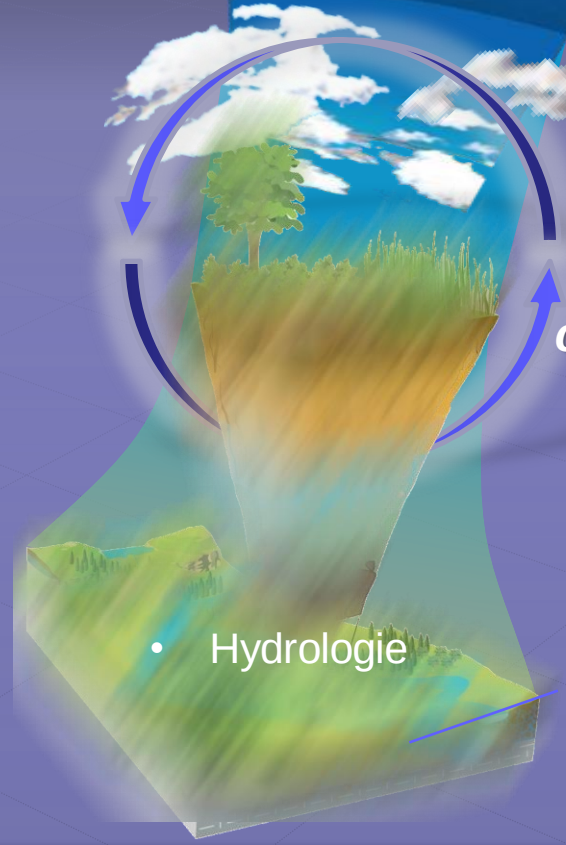


Cycle de l'eau
Un objet d'étude
à l'interface
climat-hydrologie

- Hydrologie

Ma légitimité sur le sujet des limites planétaires

- Climatologie

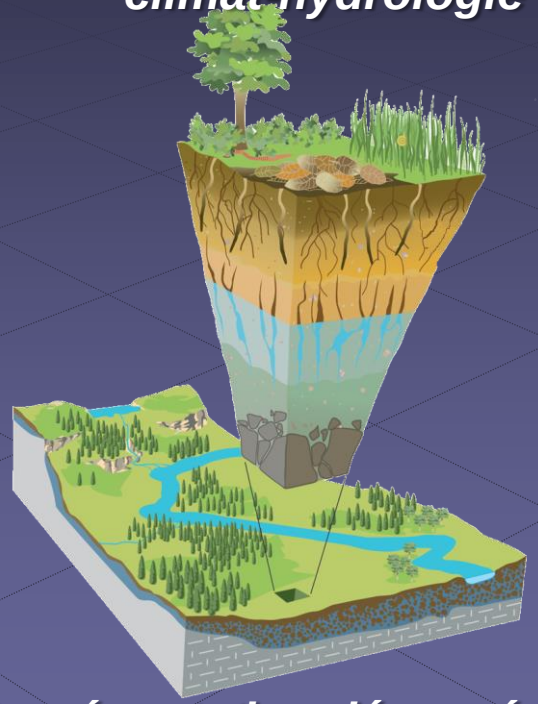


Cycle de l'eau
Un objet d'étude
à l'interface
climat-hydrologie

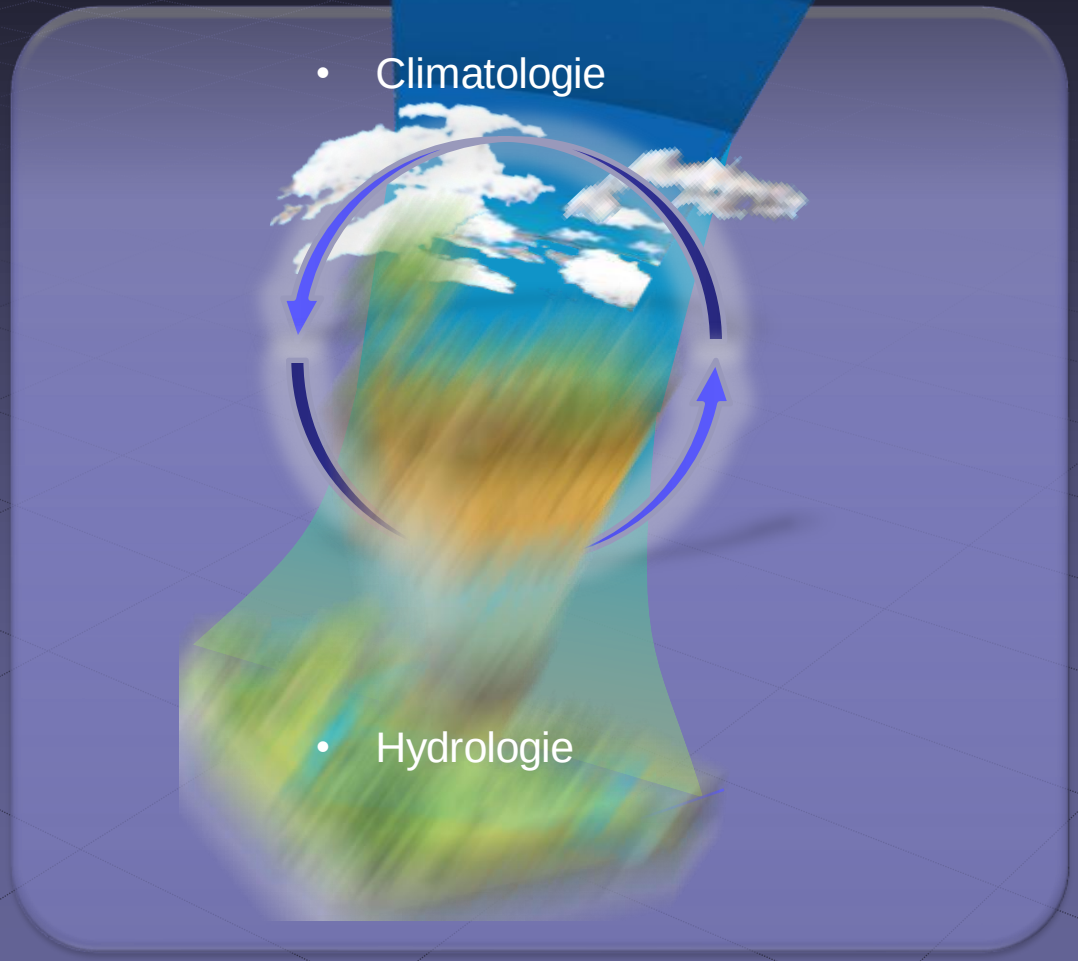
- Hydrologie

Ma légitimité sur le sujet des limites planétaires

Cycle de l'eau
Un objet d'étude
à l'interface
climat-hydrologie

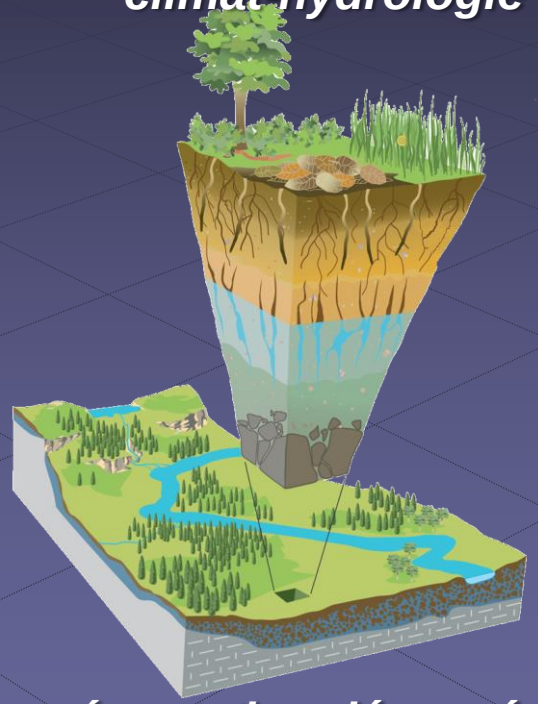


Représentation dépassée
mais encore prégnante de
l'hydrologie



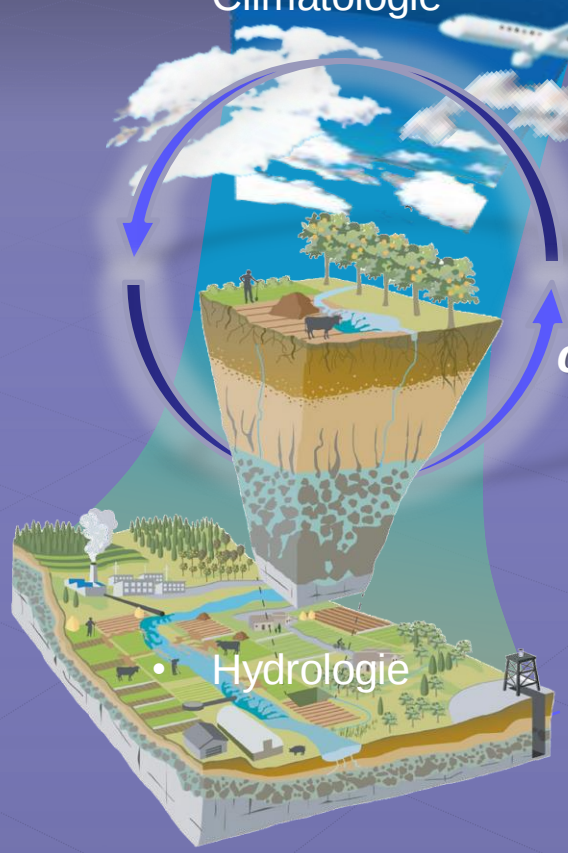
Ma légitimité sur le sujet des limites planétaires

Cycle de l'eau
Un objet d'étude
à l'interface
climat-hydrologie



Représentation dépassée
mais encore prégnante de l'hydrologie

- Climatologie



- Hydrologie

Cycle de l'eau
Un objet d'étude
à l'interface
climat-hydrologie
Société

Ma légitimité sur le sujet des limites planétaires

Cycle de l'eau

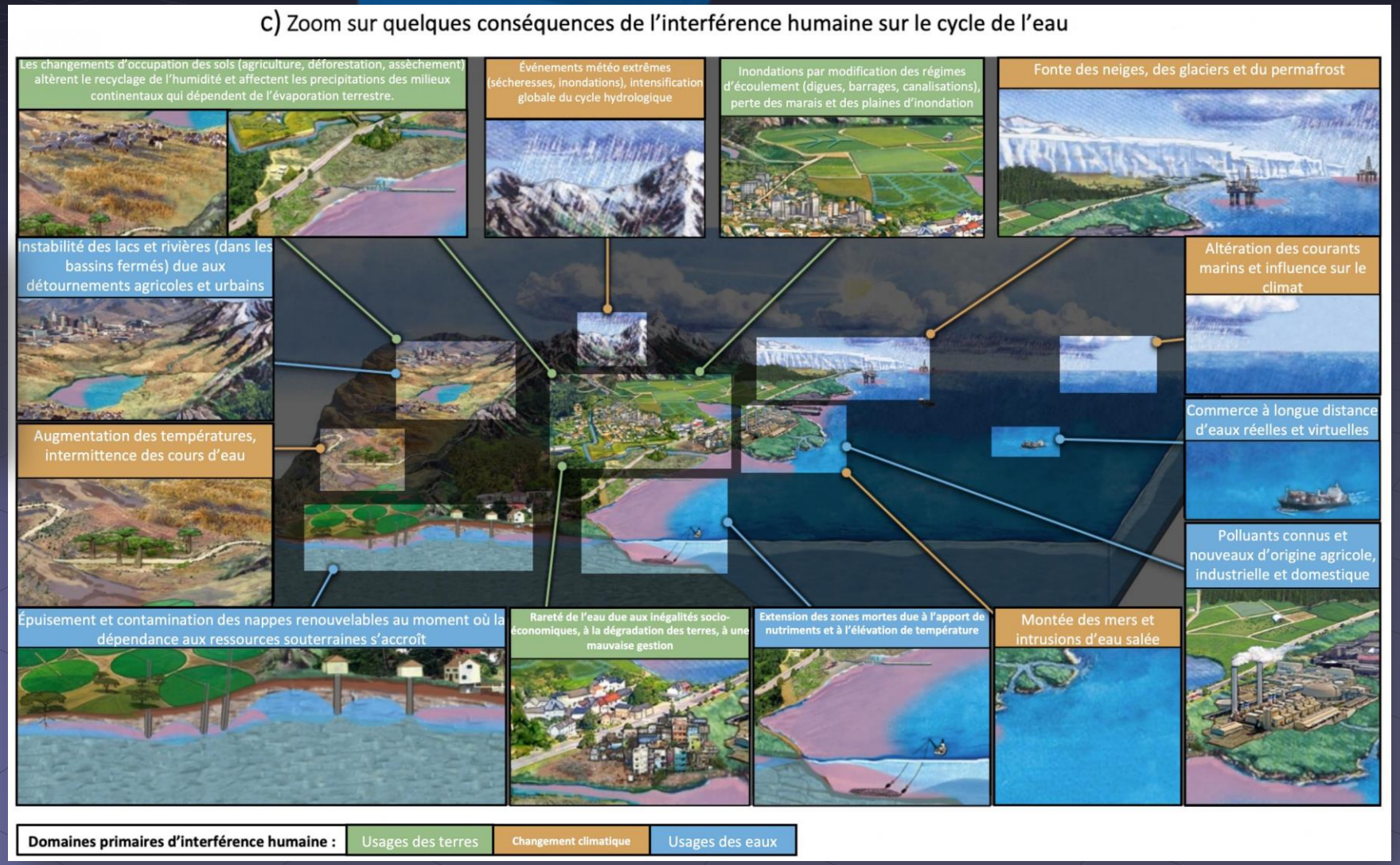
Une science de l'Anthropocène

nature geoscience ARTICLES
https://doi.org/10.1038/s41561-019-0374-y

Human domination of the global water cycle absent from depictions and perceptions

Benjamin W. Abbott[1*], Kevin Bishop[2], Jay P. Zarnetske[3], Camille Minaudo[4,5], F. S. Chapin III[6], Stefan Krause[7], David M. Hannah[7], Lafe Conner[8], David Ellison[9,10], Sarah E. Godsey[11], Stephen Plont[3,12], Jean Marçais[13,14], Tamara Kolbe[2,15], Amanda Huebner[1], Rebecca J. Frei[1], Tyler Hampton[3,16], Sen Gu[14], Madeline Buhman[1], Sayedeh Sara Sayedi[1], Ovidiu Ursache[17], Melissa Chapin[6], Kathryn D. Henderson[18] and Gilles Pinay[19]

Abott et al. 2019



Ma légitimité sur le sujet des limites planétaires

INITIATIVE INDIVIDUELLE

Mieux comprendre les inter-relations entre hydrologie et société

UPPSALA UNIVERSITET
CRCT 2023-24

INITIATIVES COLLECTIVES

Questionner mes pratiques de recherches

IGE Institut des géosciences de l'environnement

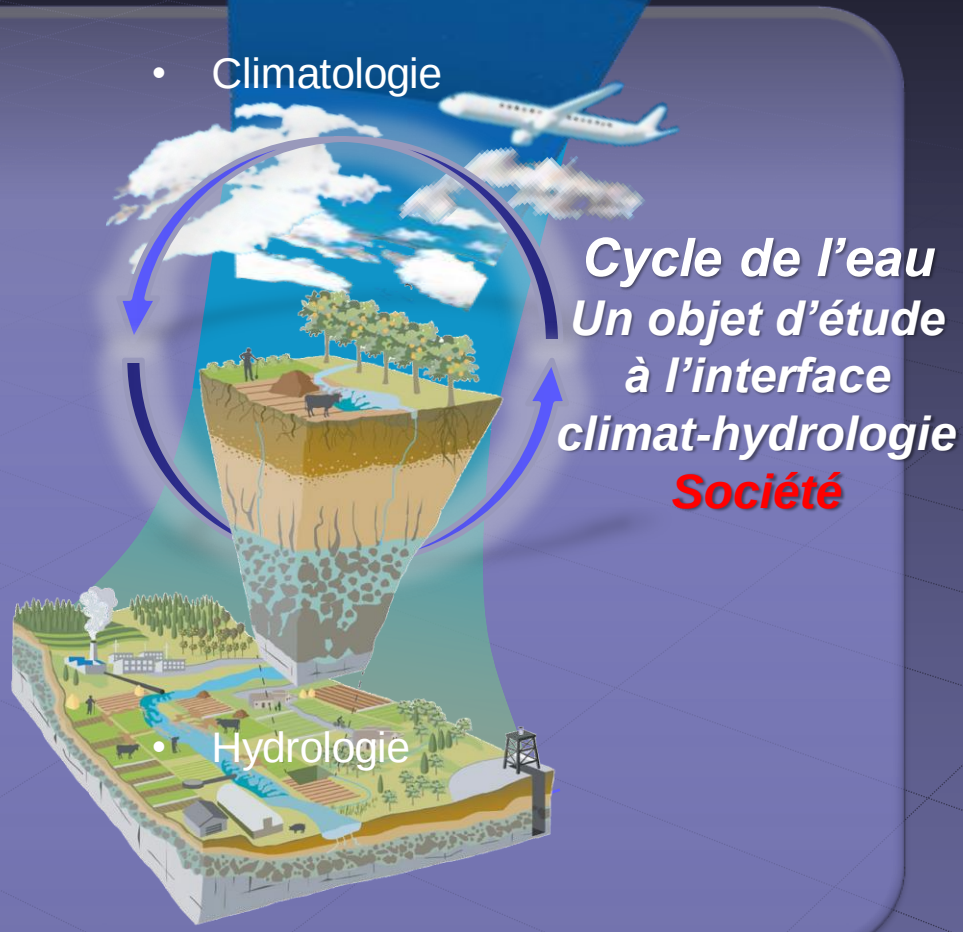
CAMPUS d'après Grenoble
Collectif de l'Anthropocène et de la Mobilisation Participative Universitaire et Sociale

Réorienter une partie de mes enseignements sur les enjeux socio-environnementaux

UGA DESIGN FACTORY

ANTHROPOCÈNE ET LIMITES PLANÉTAIRES

GREEN UNIVERSITY



Cycle de l'eau
Un objet d'étude
à l'interface
climat-hydrologie
Société

Ma légitimité sur le sujet des limites planétaires

INITIATIVE INDIVIDUELLE

Mieux comprendre les inter-relations entre hydrologie et société

UPPSALA UNIVERSITET
CRCT 2023-24

INITIATIVES COLLECTIVES

Questionner mes pratiques de recherches

IGE Institut des géosciences de l'environnement

CAMPUS d'après Grenoble
Collectif de l'Anthropocène et de la Mobilisation Participative Universitaire et Sociale

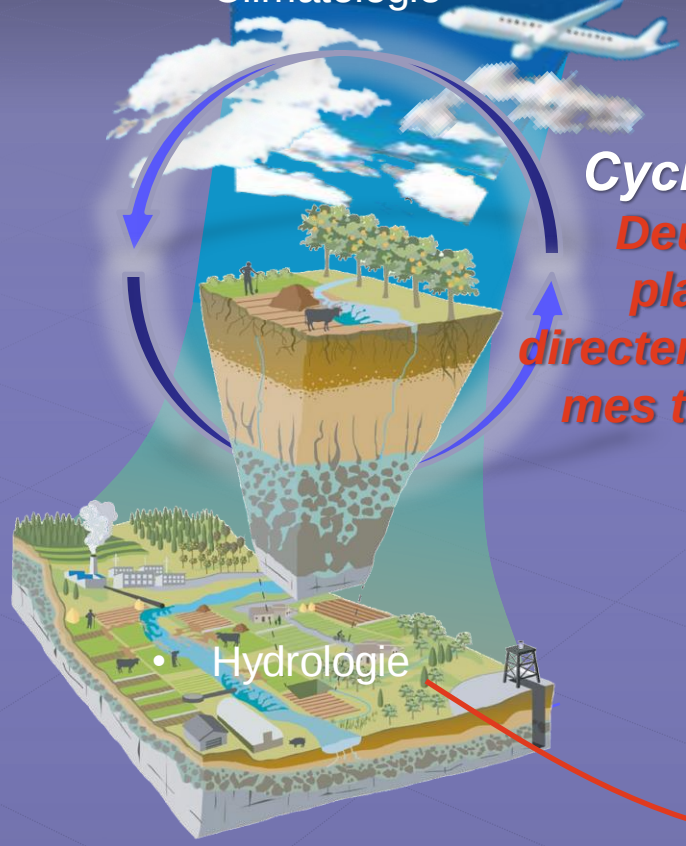
Réorienter une partie de mes enseignements sur les enjeux socio-environnementaux

UGA DESIGN FACTORY

ANTHROPOCÈNE ET LIMITES PLANÉTAIRES

GREEN UNIVERSITY

- Climatologie

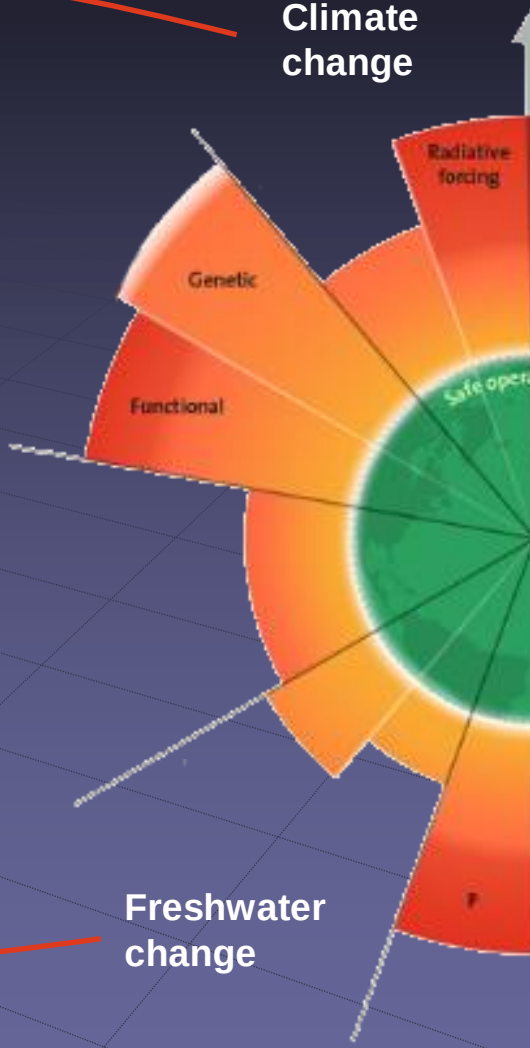


- Hydrologie

Cycle de l'eau

Deux limites planétaires directement reliées à mes thématiques

Climate change



Freshwater change

Mes limites sur les limites

INITIATIVE INDIVIDUELLE

Mieux comprendre les inter-relations entre hydrologie et société

UPPSALA UNIVERSITET
CRCT 2023-24

INITIATIVES COLLECTIVES

Questionner mes pratiques de recherches

IGE Institut des géosciences de l'environnement

CAMPUS d'après Grenoble
Collectif de l'Anthropocène et de la Mobilisation Participative Universitaire et Sociale

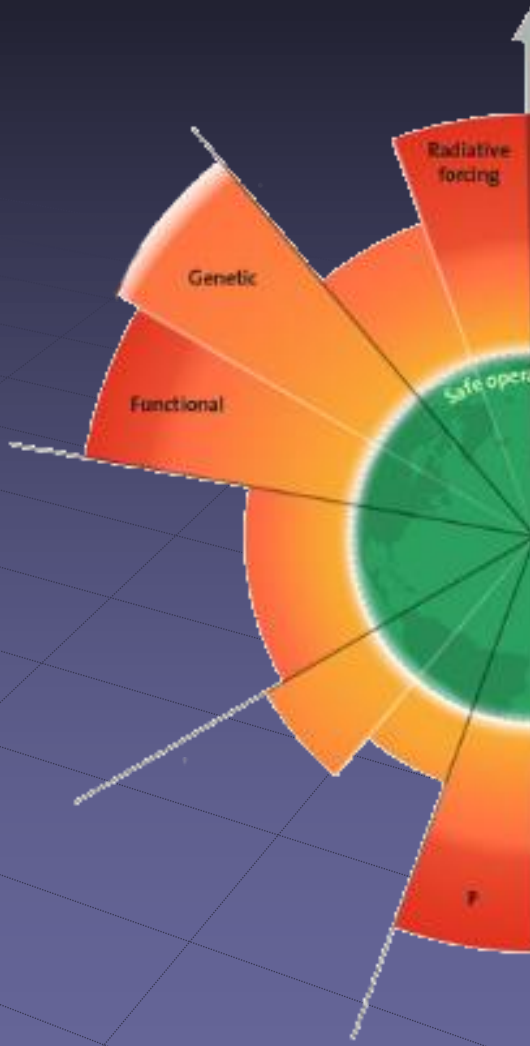
Réorienter une partie de mes enseignements sur les enjeux socio-environnementaux

UGA DESIGN FACTORY

ANTHROPOCÈNE ET LIMITES PLANÉTAIRES

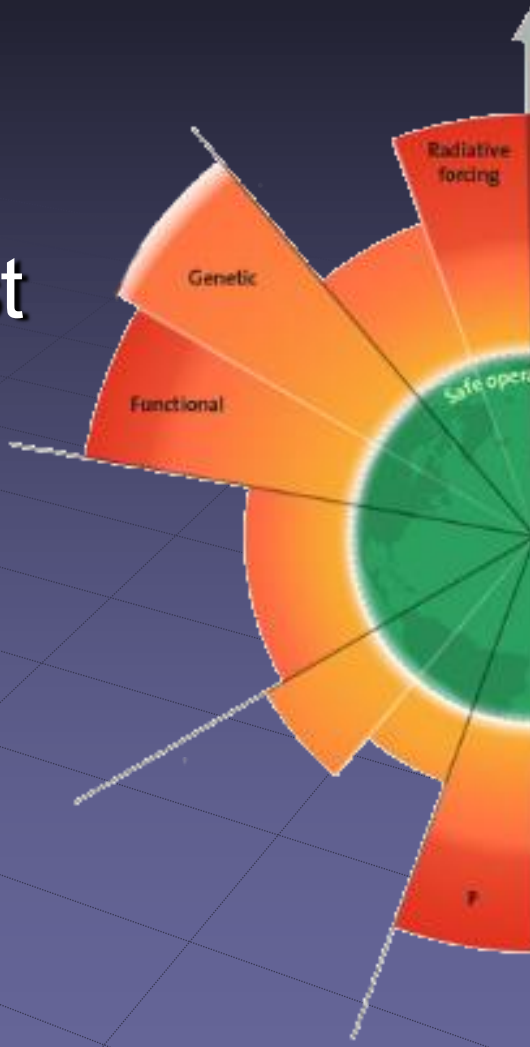
GREEN UNIVERSITY

- Pas de publications personnelles sur le sujet
- Système terre: Objet pluri- inter-disciplinaire
  - Je ne suis pas omniscient
  - Je ne suis pas expert d'une grande partie des concepts mobilisés y compris dans mes thématiques scientifiques
- Lecture sur le sujet
  - Non exhaustive



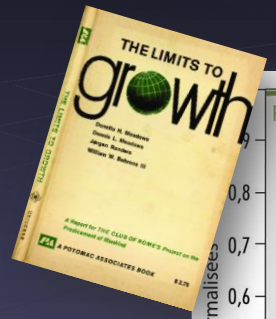
Objectifs de la présentation

- Définir le concept
- Naviguer dans l'étendue littérature et montrer où est la science dans le concept et dans le débat qu'il suscite
- Ouvrir une discussion sur l'intérêt et les limites du concept et son utilisation

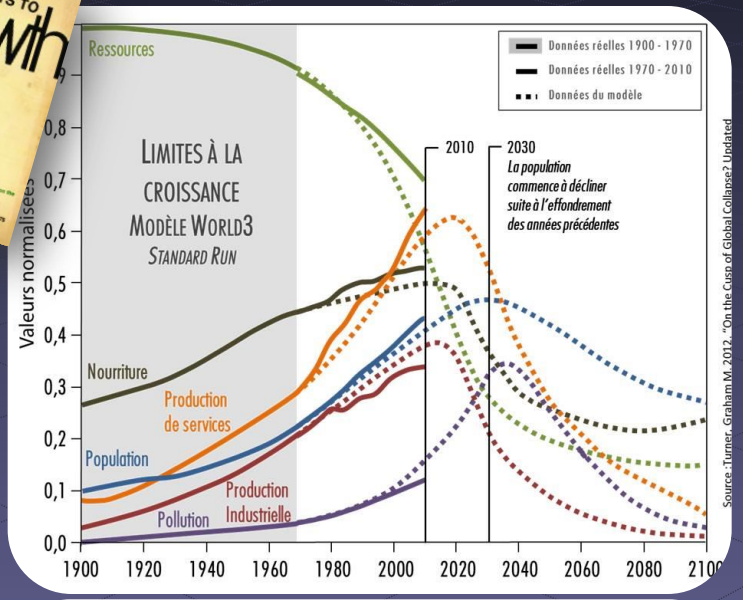


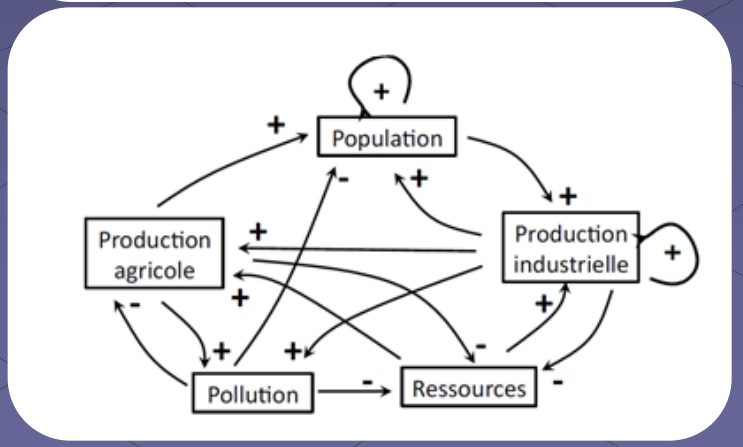
Définition des limites planétaires

Ce qu'elle ne sont pas…



Limites à la croissance



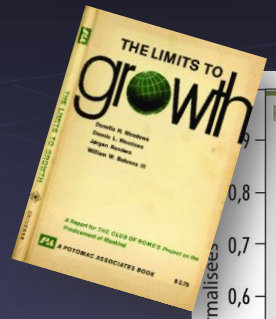


Meadows et al. 1972 (+ update)

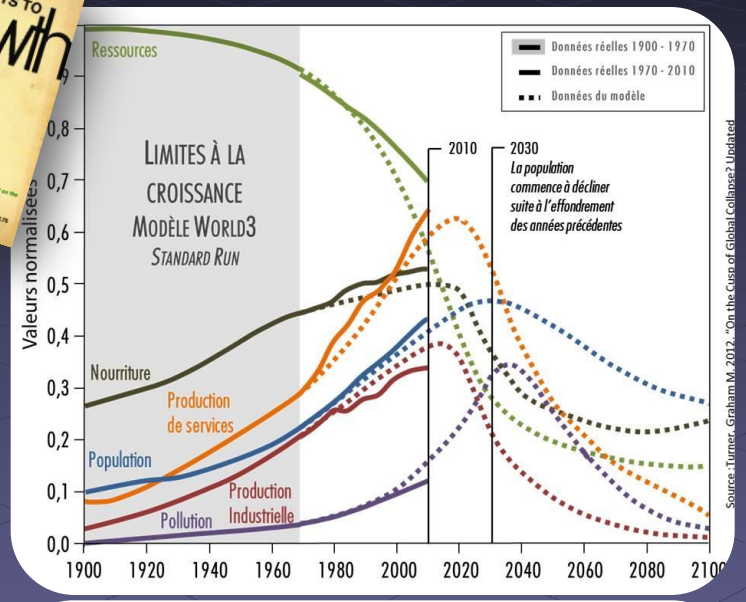
Comment la croissance économique et démographique peuvent conduire à un effondrement systémique sous contrainte des limites physiques des ressources naturelles et des pollutions engendrées.

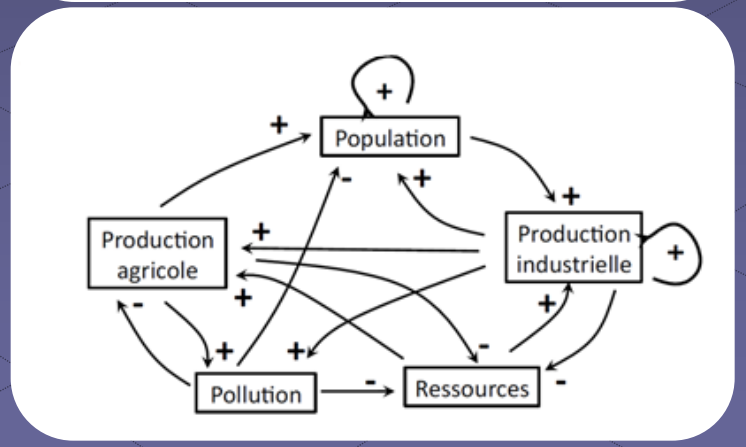
Définition des limites planétaires

Ce qu'elle ne sont pas…



Limites à la croissance



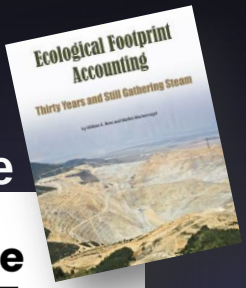


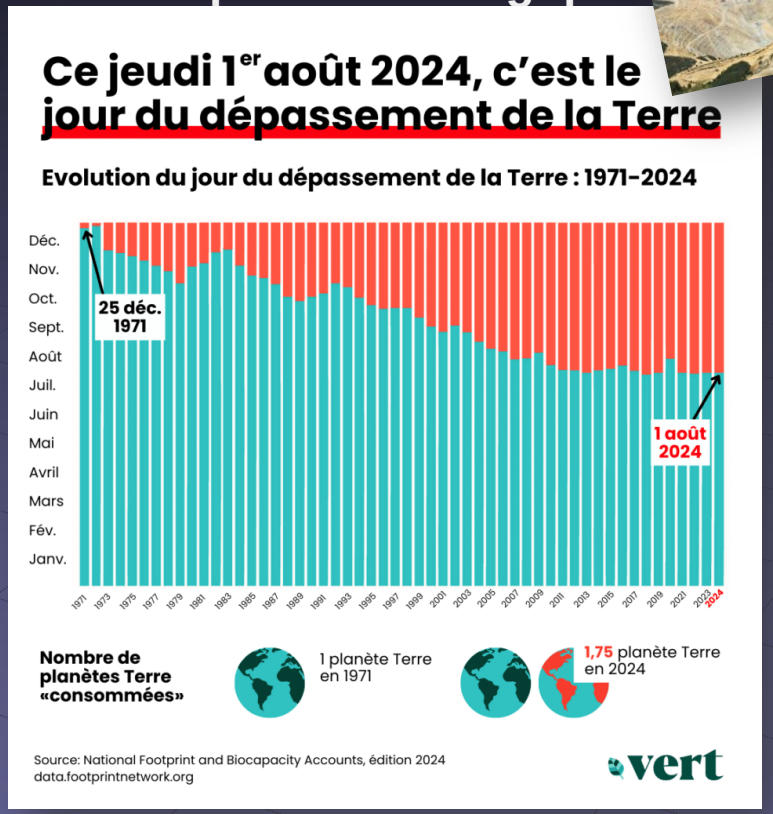
Meadows et al. 1972 (+ update)

Comparaison entre:

- Empreinte: Superficie des terres et des océans pour produire la ressource consommée et absorber les déchets générés
- Biocapacité: la superficie des terres et des océans effectivement disponible pour regénérer les ressources et absorber les pollutions.

Empreinte écologique



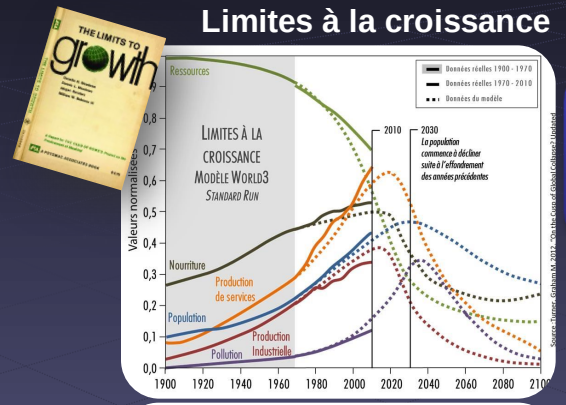


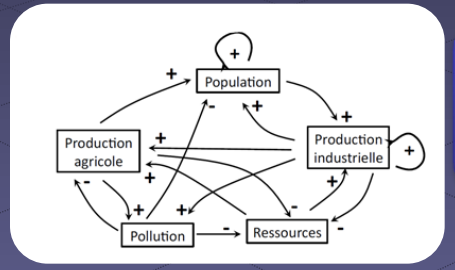
Rees, 1992, Wackernagel and Rees, 1996

Définition des limites planétaires

Ce qu'elle ne sont pas…

Limites à la croissance





Meadows et al. 1972 (+ update)

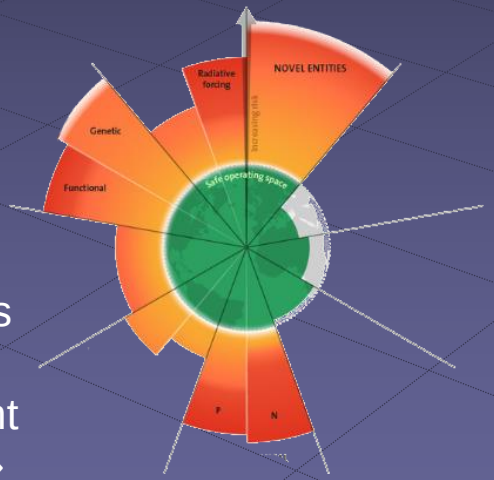
Facteurs socio-économiques

Ressources/Pollutions

Filiation revendiquée
(Rockström et al. 2009a)

Définir des seuils critiques indépendants des choix socio-économiques et dont le caractère « physique » est non-négociable

Limites Planétaires

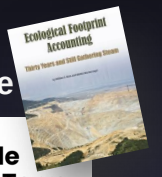


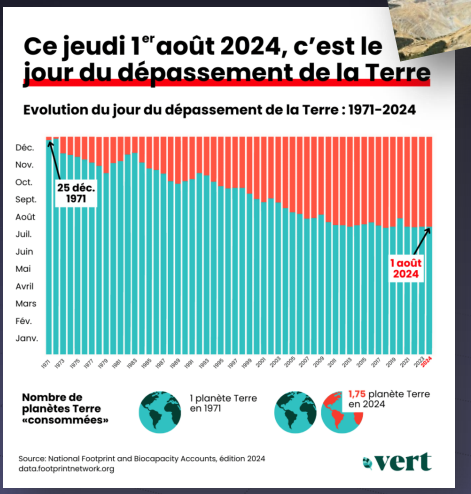
Système Terre

Indicateurs Globaux

Donner une voix à la Terre dans les instances de négociations à partir d'indicateurs globaux

Empreinte écologique





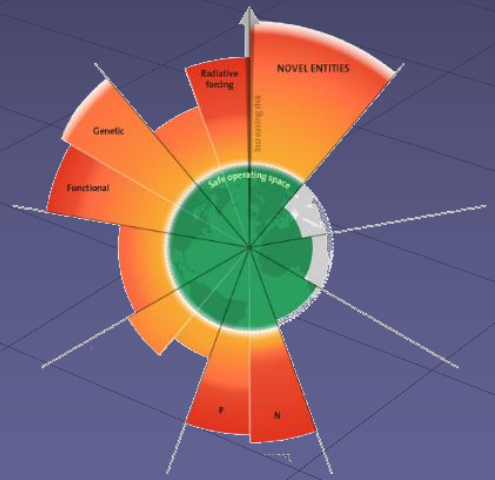
Rees, 1992, Wackernagel and Rees, 1996

Définition des limites planétaires

« The planetary boundaries framework defines a safe operating space for humanity based on the intrinsic biophysical processes that regulate the stability of the Earth system. »
(Rockström et al. 2009a,b; Steffen et al. 2015; Richardson et al. 2023)

Le cadre des limites planétaires définit un espace de fonctionnement sûr pour l'humanité sur la base des processus biophysiques intrinsèques qui régulent la stabilité du système terre.

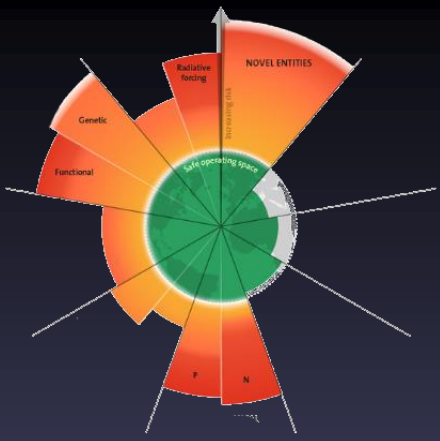
Limites Planétaires

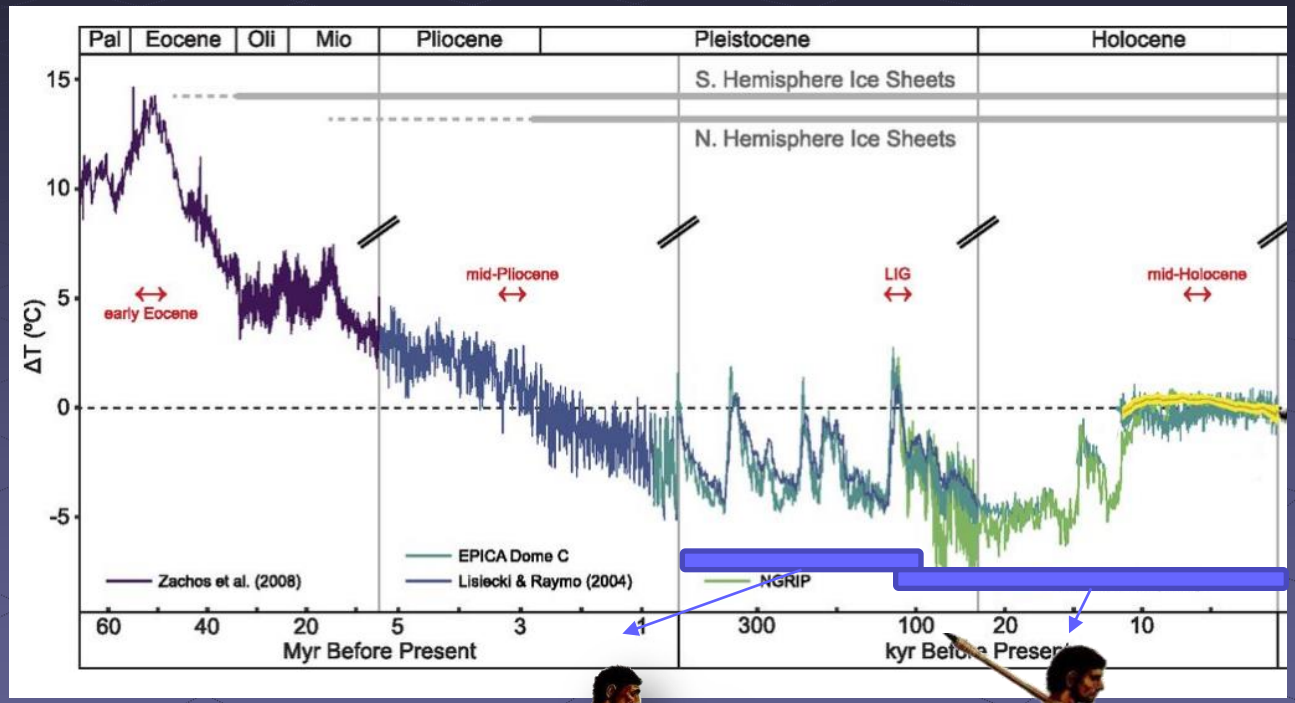


Système Terre

Définition des limites planétaires

« The planetary boundaries framework defines a safe operating space for humanity based on the intrinsic biophysical processes that regulate the **stability of the Earth system**. »
(Rockström et al. 2009a,b; Steffen et al. 2015; Richardson et al. 2023)



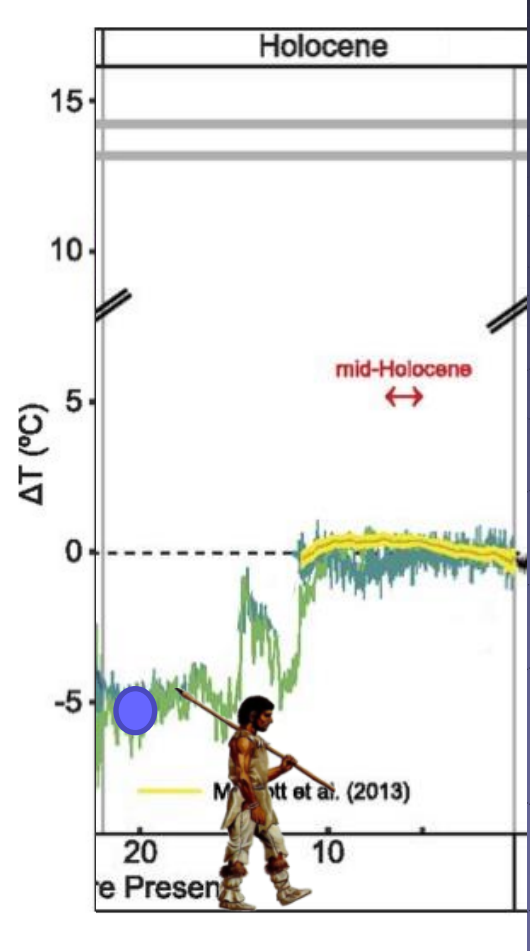


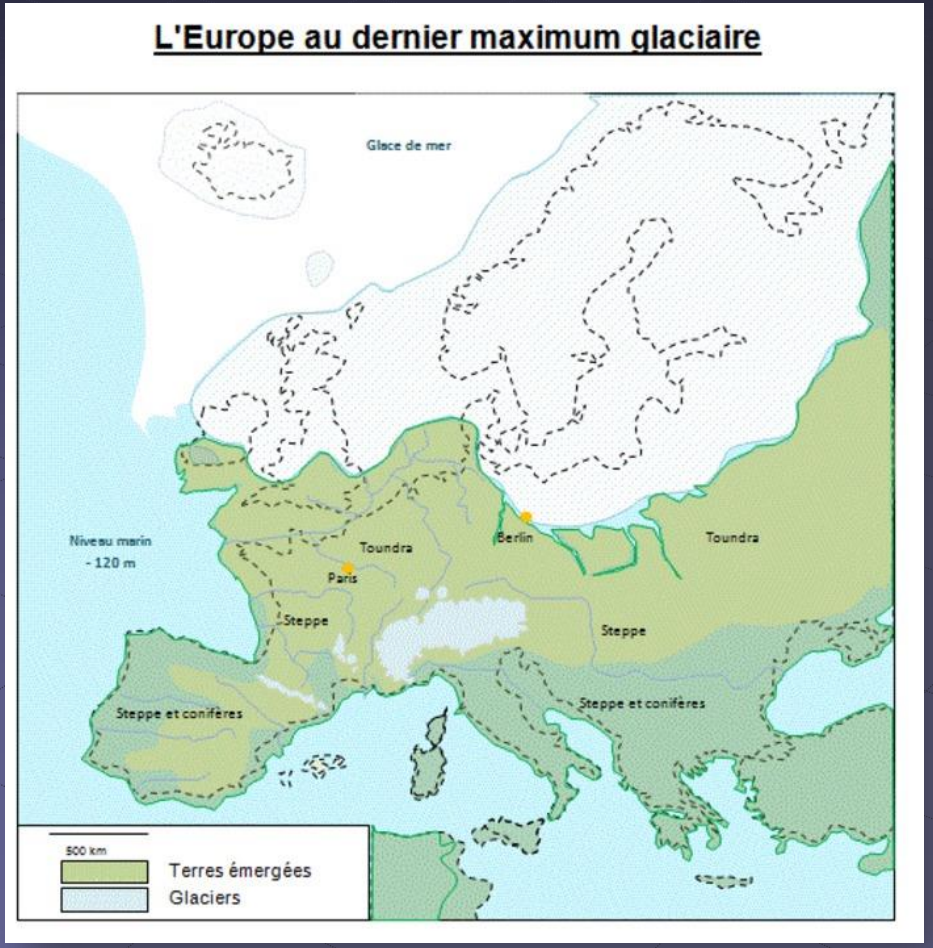
Homo Erectus

Homo Sapiens

Définition des limites planétaires

« The planetary boundaries framework defines a safe operating space for humanity based on the intrinsic biophysical processes that regulate the **stability of the Earth system**. »
(Rockström et al. 2009a,b; Steffen et al. 2015; Richardson et al. 2023)

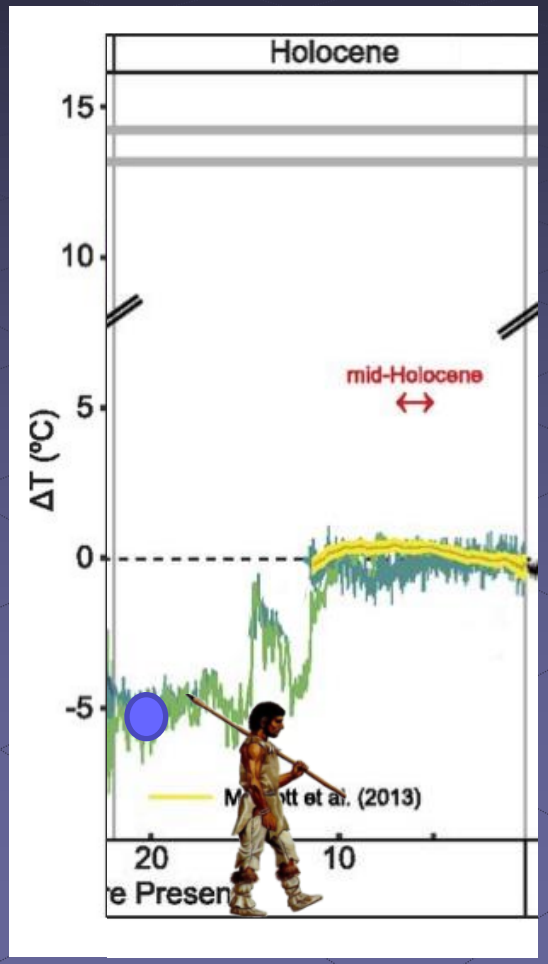


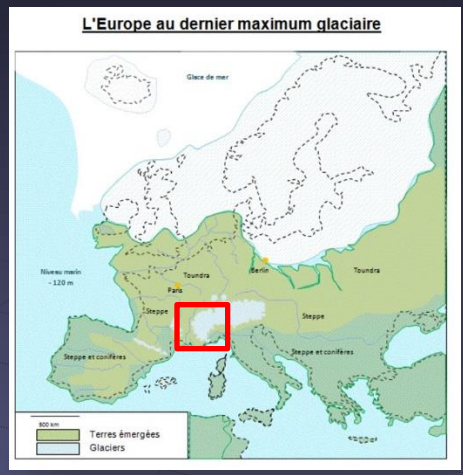


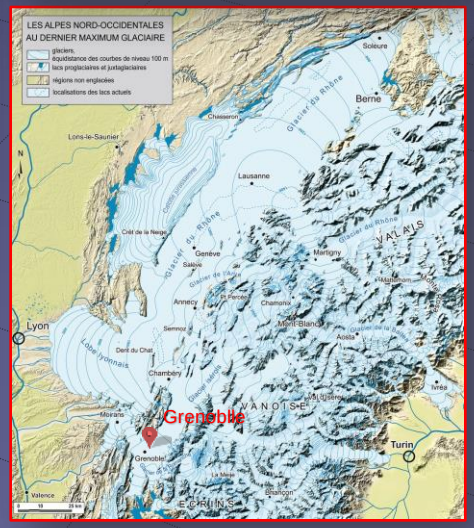
La température de la planète était plus froide qu'aujourd'hui de 5°C

Définition des limites planétaires

« The planetary boundaries framework defines a safe operating space for humanity based on the intrinsic biophysical processes that regulate the **stability of the Earth system**. »
(Rockström et al. 2009a,b; Steffen et al. 2015; Richardson et al. 2023)

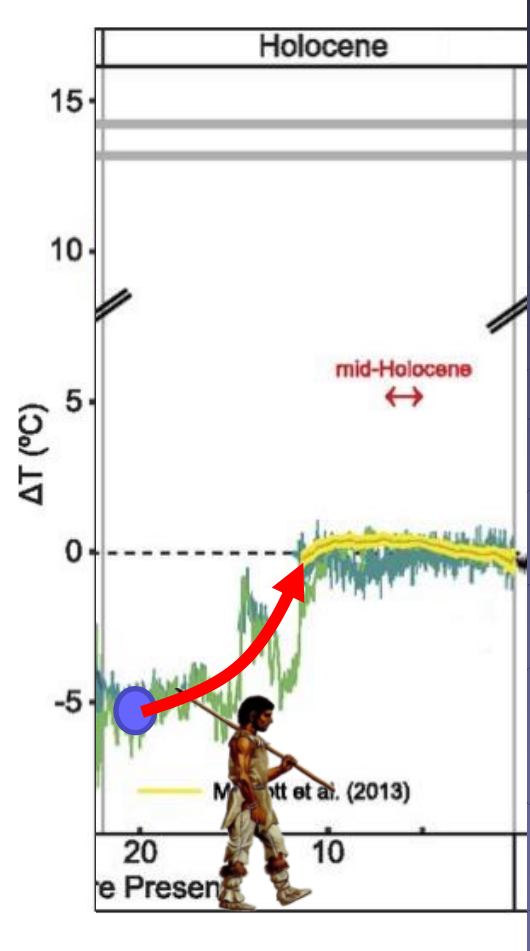


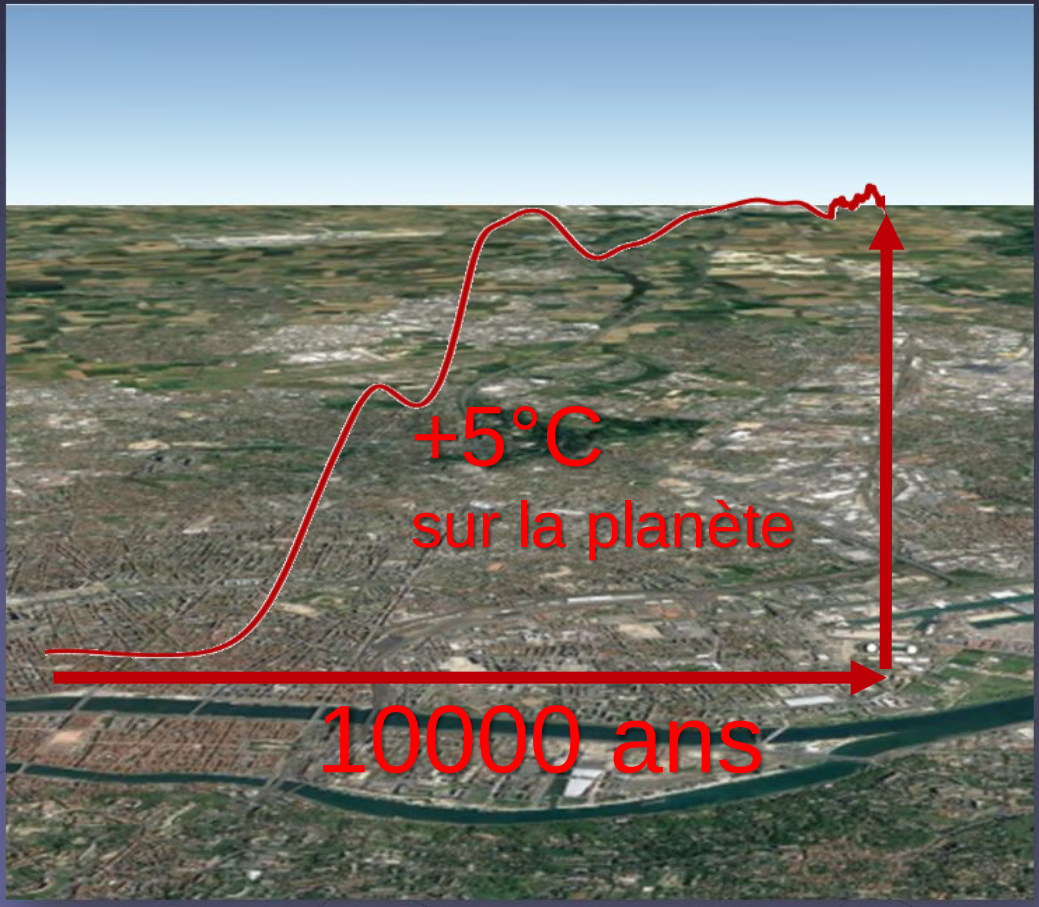




Définition des limites planétaires

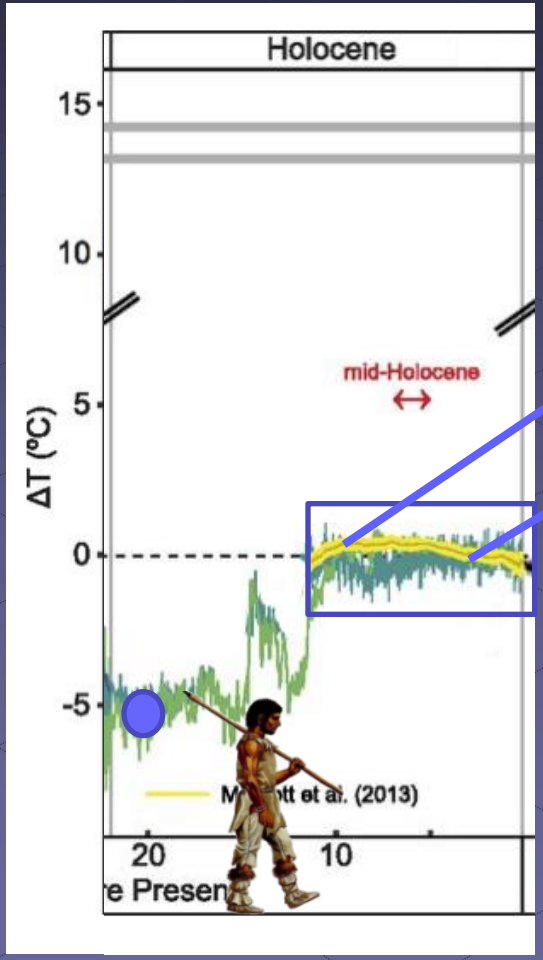
« The planetary boundaries framework defines a safe operating space for humanity based on the intrinsic biophysical processes that regulate the **stability of the Earth system**. »
(Rockström et al. 2009a,b; Steffen et al. 2015; Richardson et al. 2023)





Définition des limites planétaires

« The planetary boundaries framework defines a safe operating space for humanity based on the intrinsic biophysical processes that regulate the **stability of the Earth system**. »
(Rockström et al. 2009a,b; Steffen et al. 2015; Richardson et al. 2023)



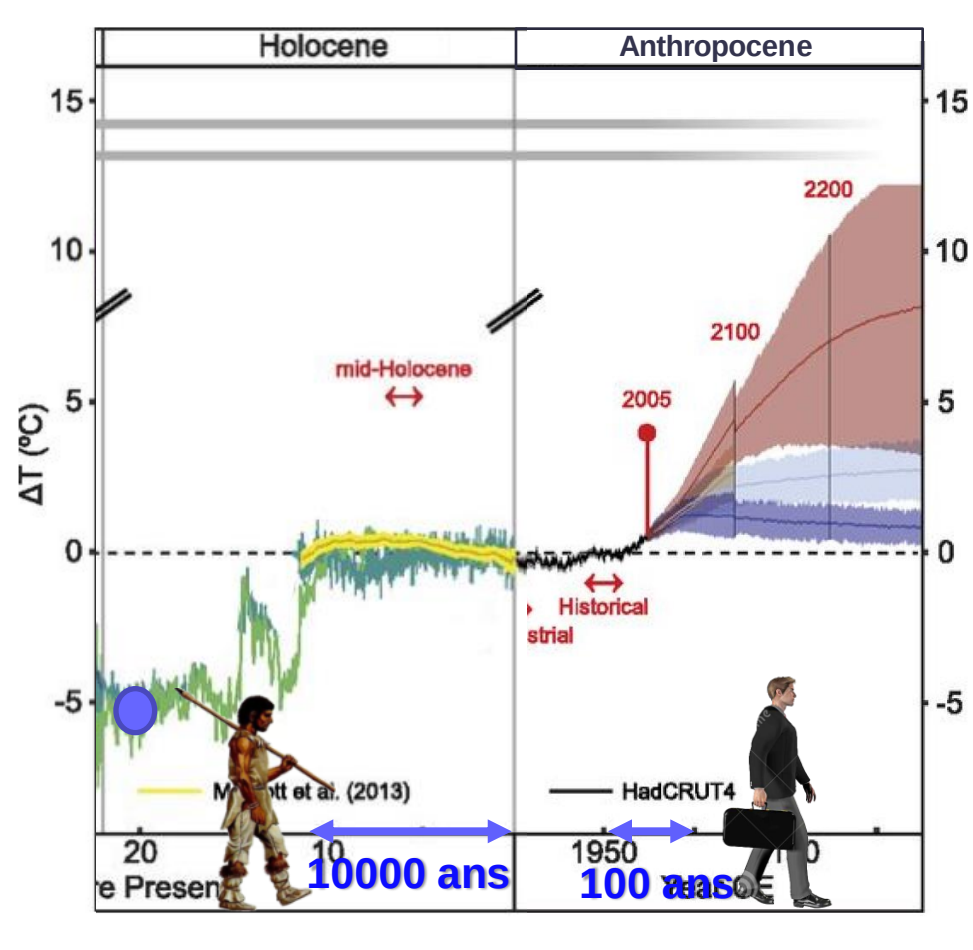
- Début de l'agriculture
- Développement des grandes civilisations sur l'ensemble des continents.
- Des impacts humains connus (modifications d'occupation des sols, des feux, extinction d'espèces) mais rien de global jusqu'ici.

« The relatively stable, 11,700-year-long Holocene epoch, [is] the only state of the planet that we know for certain can support contemporary human societies »

Steffen et al. 2015

Définition des limites planétaires

« The planetary boundaries framework defines a safe operating space for humanity based on the intrinsic biophysical processes that regulate the **stability of the Earth system**. »
(Rockström et al. 2009a,b; Steffen et al. 2015; Richardson et al. 2023)

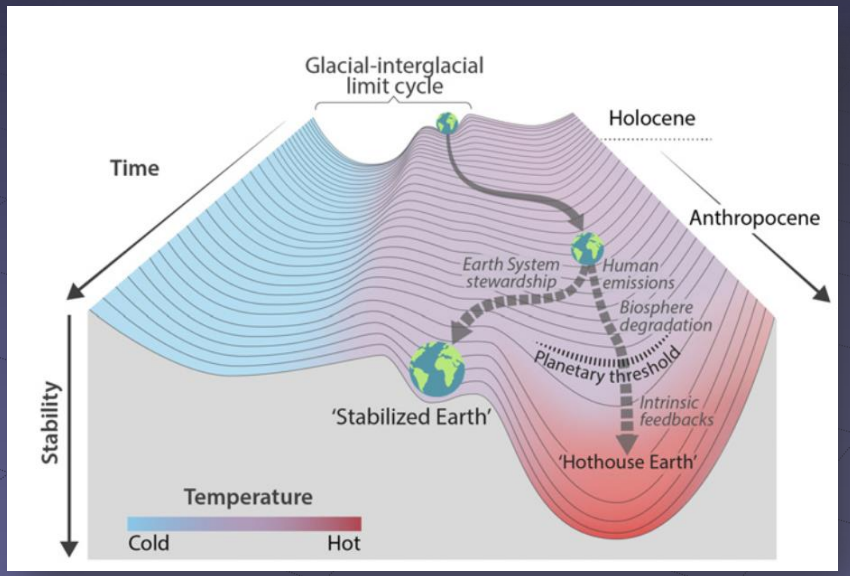


Anthropogenic Climate Change

+1.3°C en 100 ans!

+1.5° +3° +6°C en 200 ans?

Evolution future qui pose la question de la réversibilité des trajectoires

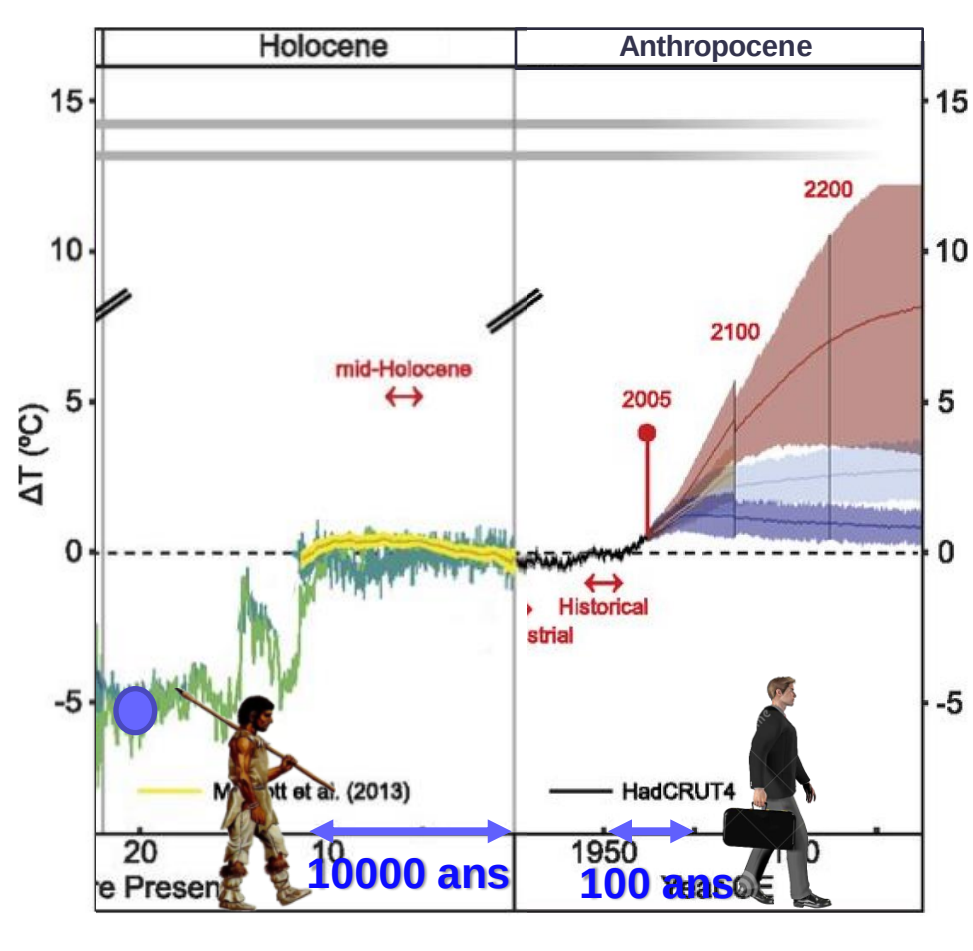


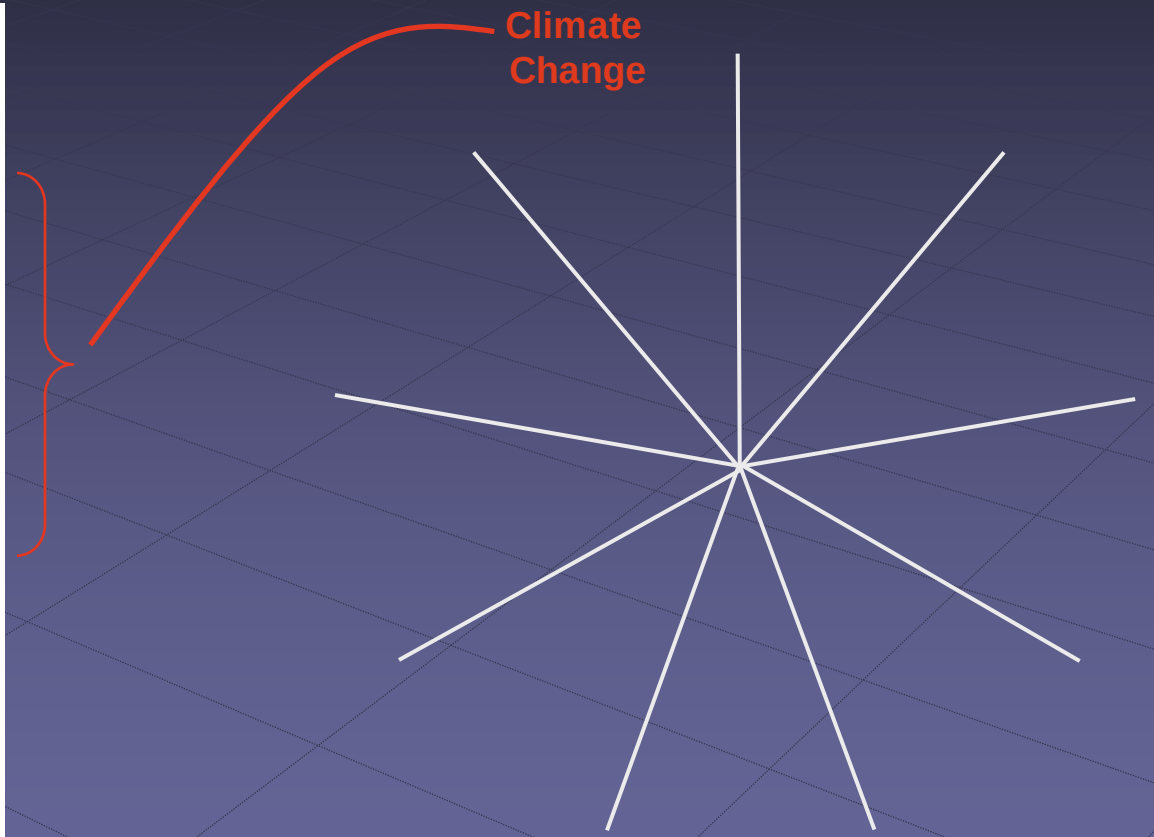
Steffen et al. 2018, PNAS

"Environmental changes that would be deleterious or even catastrophic for human well-being"
Rockström et al. 2009a

Définition des limites planétaires

« The planetary boundaries framework defines a safe operating space for humanity based on the **intrinsic biophysical processes** that regulate the **stability of the Earth system**. »
(Rockström et al. 2009a,b; Steffen et al. 2015; Richardson et al. 2023)



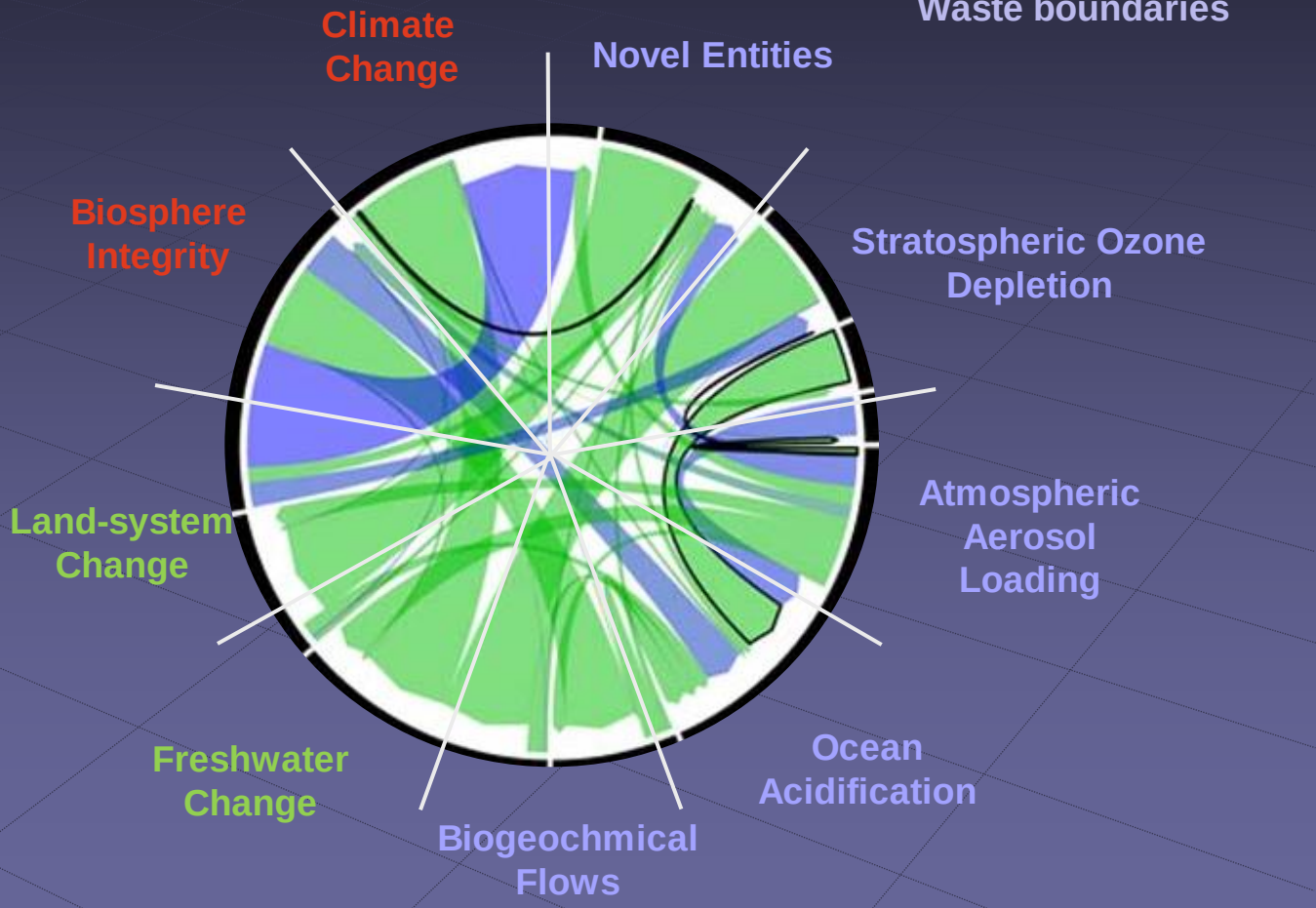


Définition des limites planétaires

« The planetary boundaries framework defines a safe operating space for humanity based on the **intrinsic biophysical processes** that regulate the **stability of the Earth system**. »
(Rockström et al. 2009a,b; Steffen et al. 2015; Richardson et al. 2023)

Cadre d'analyse

- **9 processus biophysiques**
  - Déterminent la capacité d'auto-régulation du système Terre



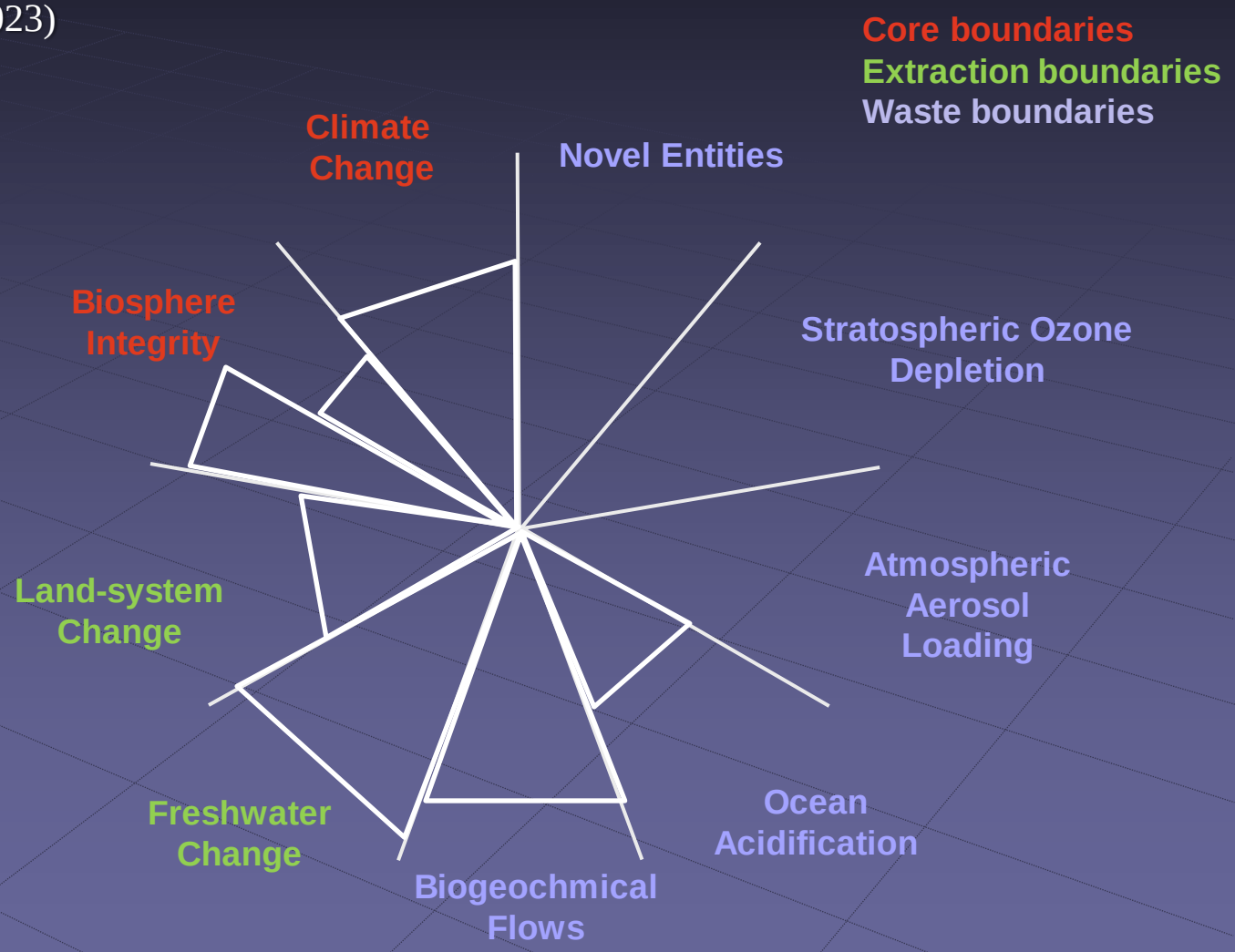
Lade et al. 2020

Définition des limites planétaires

« The planetary boundaries framework defines a safe operating space for humanity based on the **intrinsic biophysical processes** that regulate the **stability of the Earth system**. »
(Rockström et al. 2009a,b; Steffen et al. 2015; Richardson et al. 2023)

Cadre d'analyse

- **9 processus biophysiques**
  - Déterminent la capacité d'auto-régulation du système Terre
- **Variables de contrôle**
  - Descripteurs (1 ou 2) de chaque processus
  - Echelle globale – ou régionale agrégée

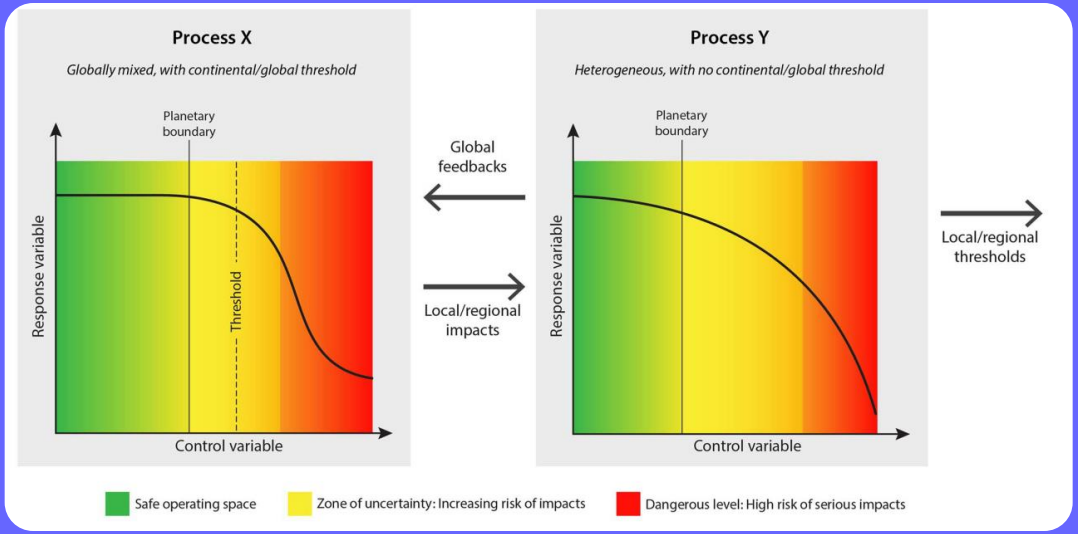


Définition des limites planétaires

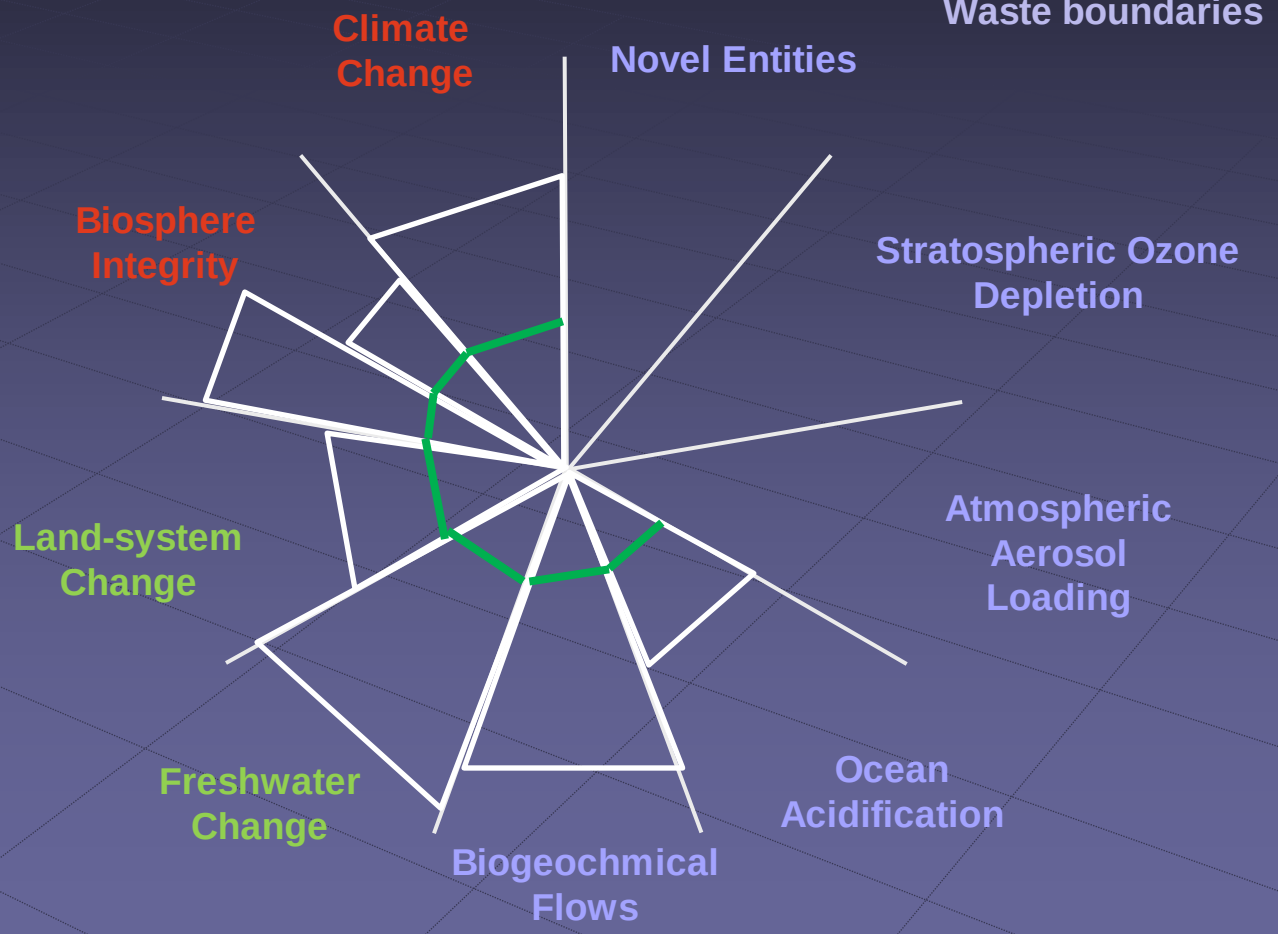
« The planetary boundaries framework defines a **safe operating space for humanity** based on the intrinsic biophysical processes that regulate the **stability of the Earth system**. »
(Rockström et al. 2009a,b; Steffen et al. 2015; Richardson et al. 2023)

Cadre d'analyse

- **9 processus biophysiques**
  - Déterminent la capacité d'auto-régulation du système Terre
- **Variables de contrôle**
  - Descripteurs (1 ou 2) de chaque processus
  - Echelle globale – ou régionale agrégée
- **Seuils pour chaque processus**



Core boundaries
Extraction boundaries
Waste boundaries



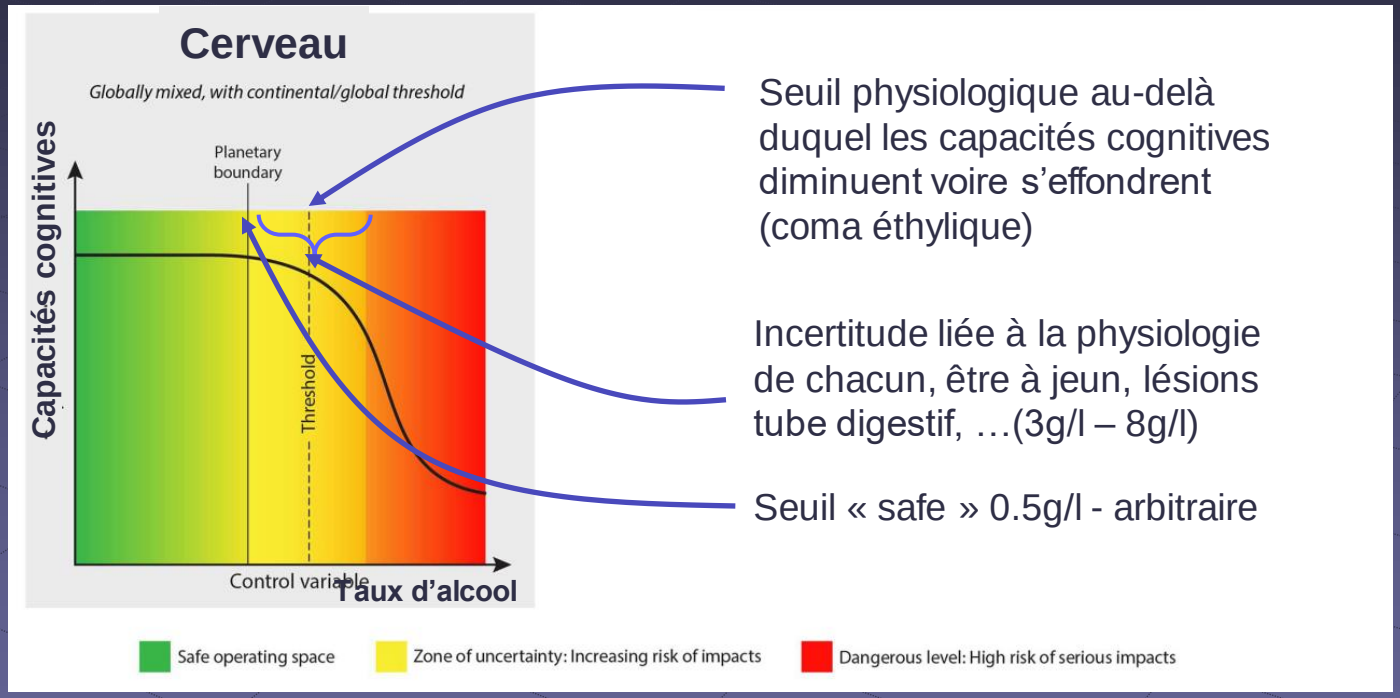
Définition des limites planétaires

« The planetary boundaries framework defines a **safe operating space for humanity** based on the **intrinsic biophysical processes** that regulate the **stability of the Earth system**. »
(Rockström et al. 2009a,b; Steffen et al. 2015; Richardson et al. 2023)

Traduction personnelle

Le cadre des limites planétaire permet d'évaluer si la Terre est en bonne santé:

- les processus sont les organes vitaux de la Terre
- les seuils sont les valeurs critiques
- les limites sur l'organe sont les valeurs à ne pas franchir pour ne pas menacer le fonctionnement d'un organe



Variable à seuil

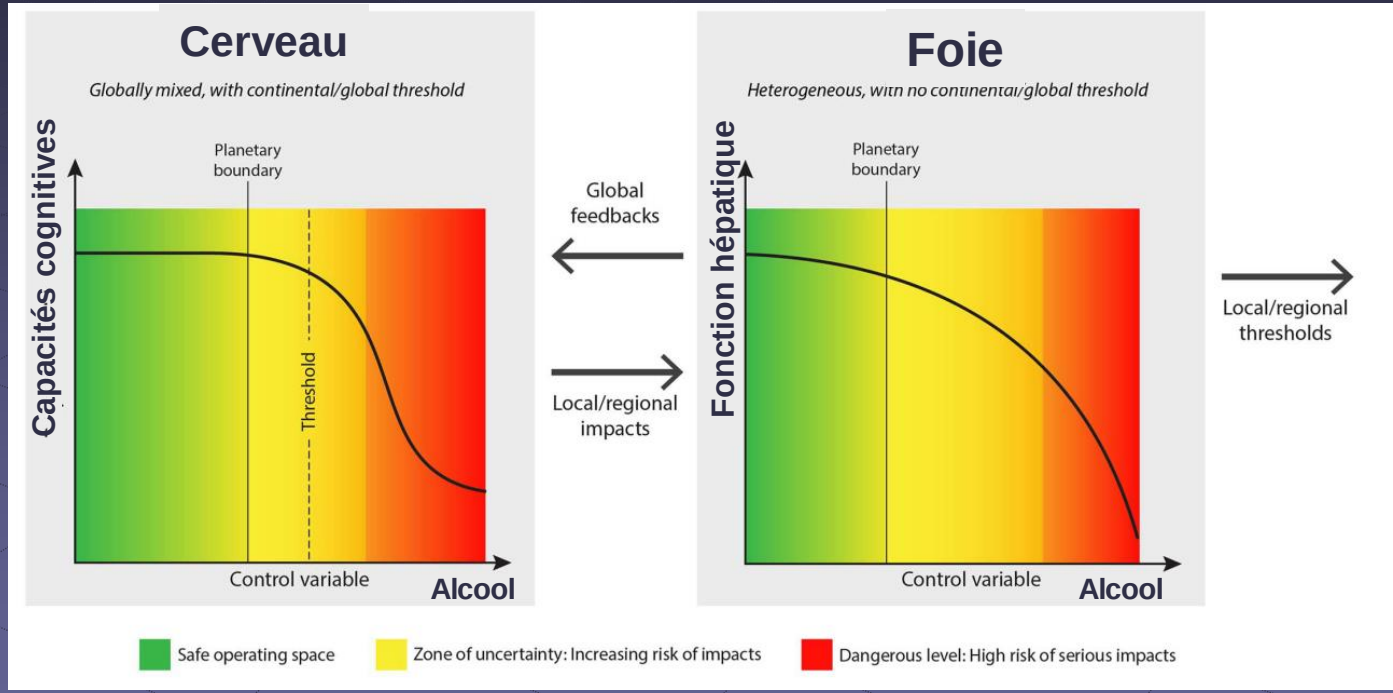
Définition des limites planétaires

« The planetary boundaries framework defines a **safe operating space for humanity** based on the **intrinsic biophysical processes** that regulate the **stability of the Earth system**. »
(Rockström et al. 2009a,b; Steffen et al. 2015; Richardson et al. 2023)

Traduction personnelle

Le cadre des limites planétaire permet d'évaluer si la Terre est en bonne santé:

- les processus sont les organes vitaux de la Terre
- les seuils sont les valeurs critiques
- les limites sur l'organe sont les valeurs à ne pas franchir pour ne pas menacer le fonctionnement d'un organe
- ou avoir un impact important sur un autre organe
- l'Holocène définit l'état de bonne santé de référence.



Variable à seuil

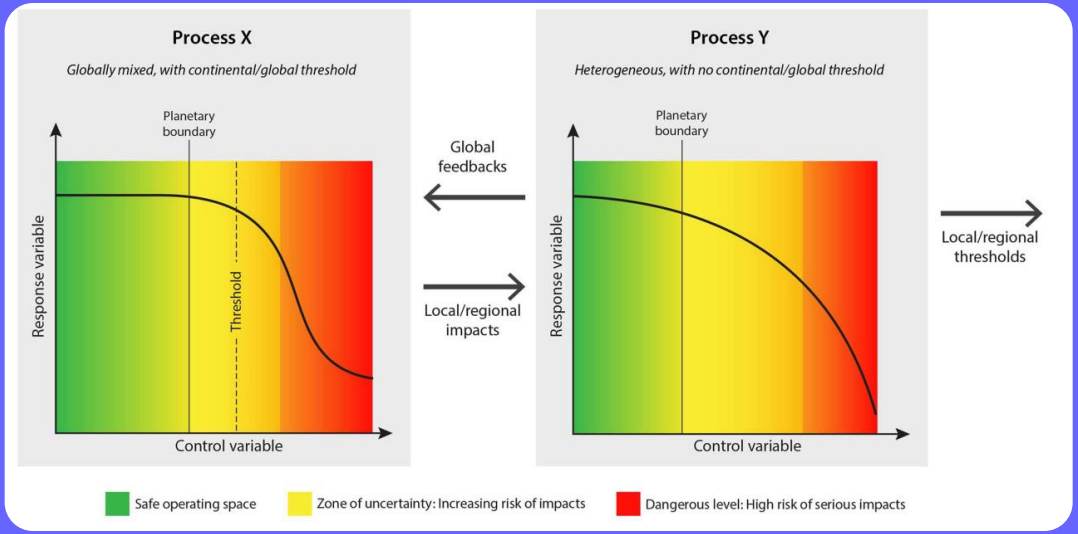
Seuil non défini

Définition des limites planétaires

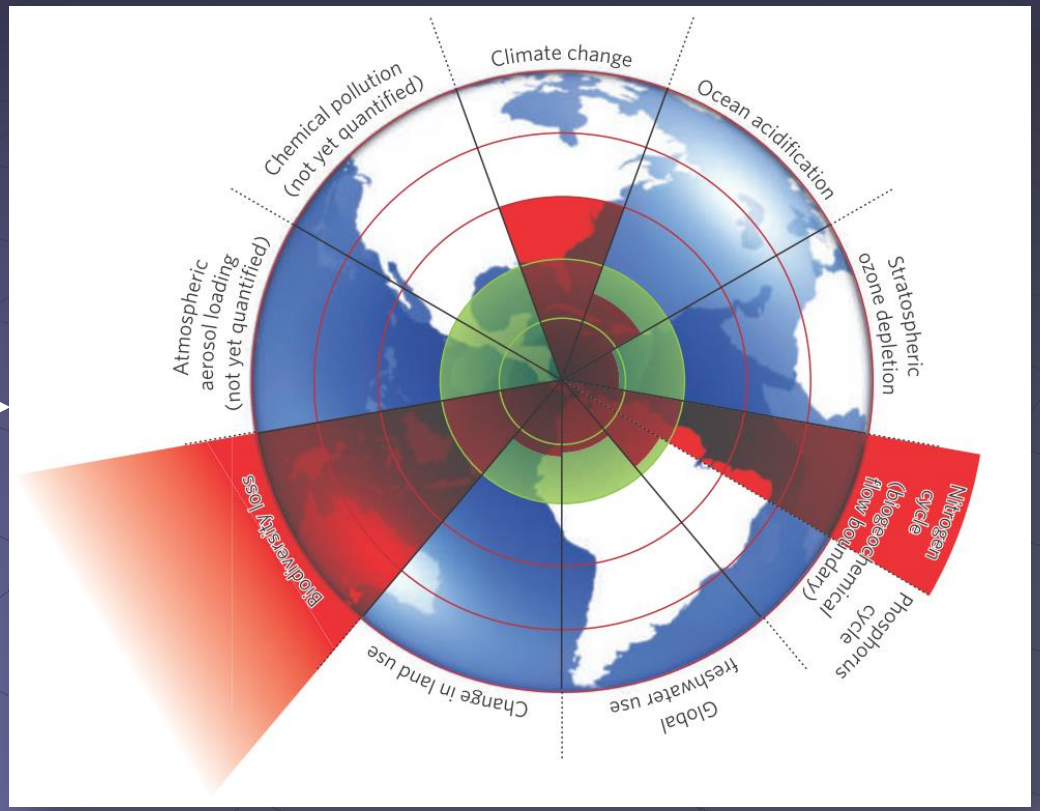
« The planetary boundaries framework defines a **safe operating space for humanity** based on the **intrinsic biophysical processes** that regulate the **stability of the Earth system**. »
(Rockström et al. 2009a,b; Steffen et al. 2015; Richardson et al. 2023)

Cadre d'analyse

- **9 processus biophysiques**
  - Déterminent la capacité d'auto-régulation du système Terre
- **Variables de contrôle**
  - Descripteurs (1 ou 2) de chaque processus
  - Echelle globale – ou régionale agrégée
- **Seuils pour chaque processus**



Quelle science derrière le concept ?



Rockström et al. 2009b, Nature

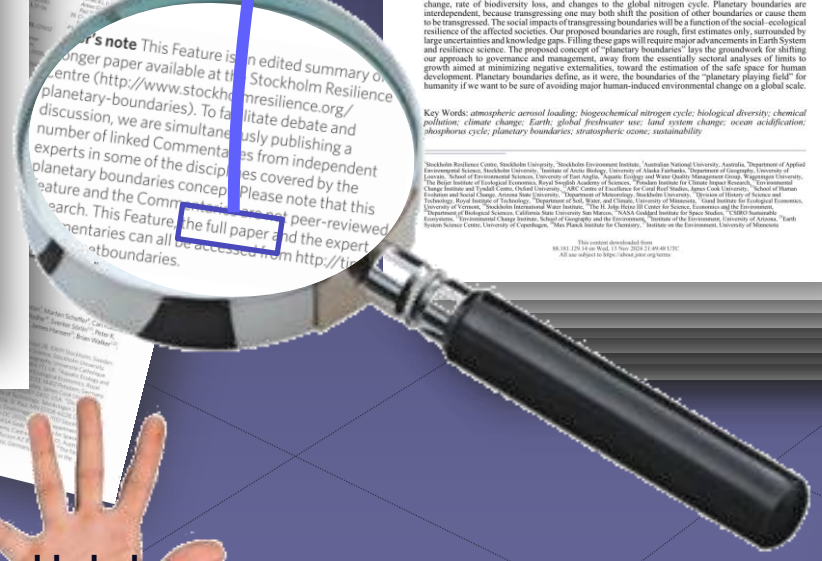
Quelle science derrière le concept ?

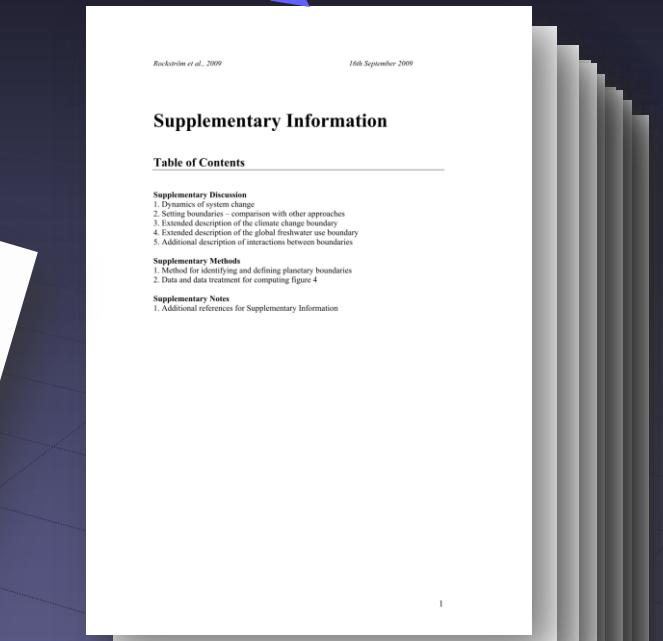
Rockström et al. 2009b, Nature
!! Non peer-reviewed !!

Approndissement

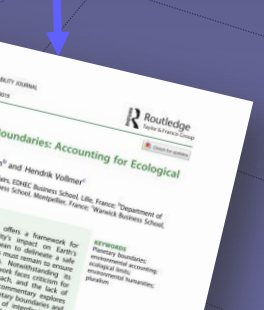
Rockström et al. 2009a,
Ecology & Society

Approfondissement





Fondements scientifiques



Quelle science derrière le concept ?

Dynamique des systèmes

Supplementary Information

Table of Contents

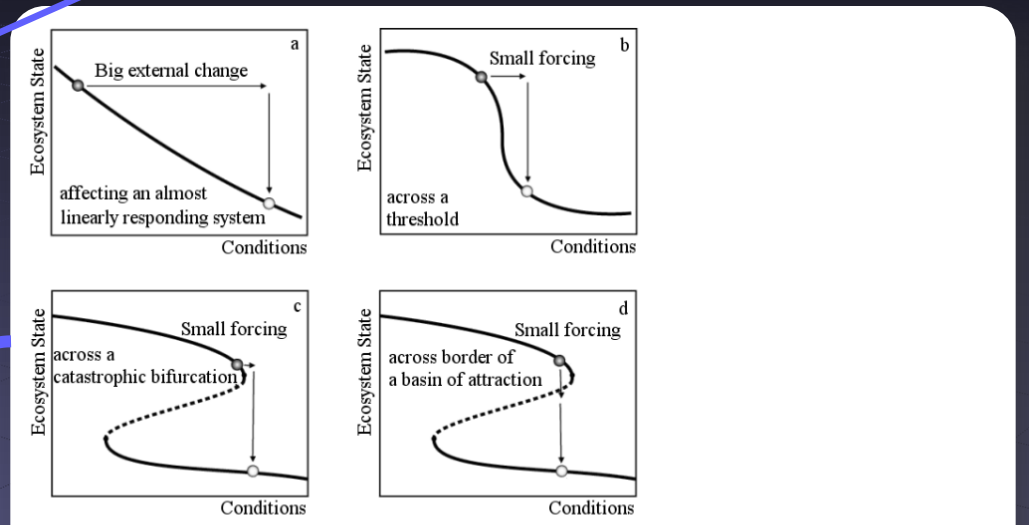
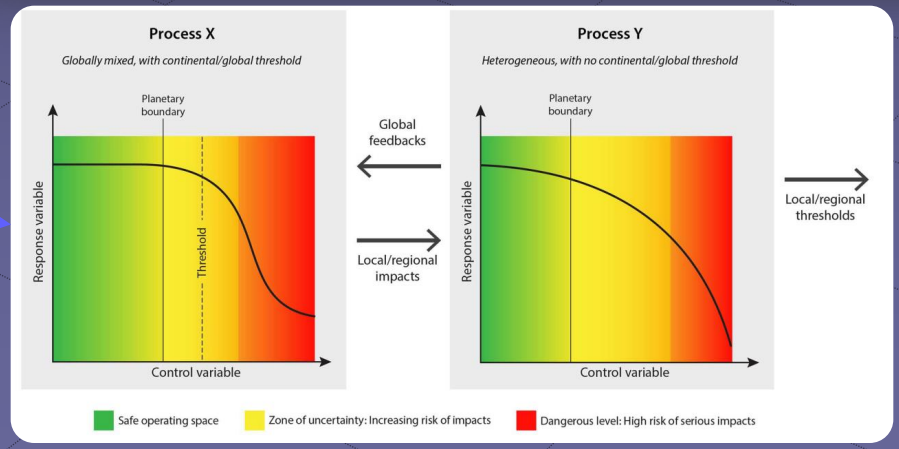


Figure S2. Degree of change in conditions required to generate large impacts in system state. For systems characterized by non-linear threshold dynamics a small forcing can generate large change, while systems responding largely linearly to change, will require big external change to cause large impacts. Source: Scheffer (2009).



Rockström et al. 2009, Ecology & Society

Quelle science derrière le concept ?

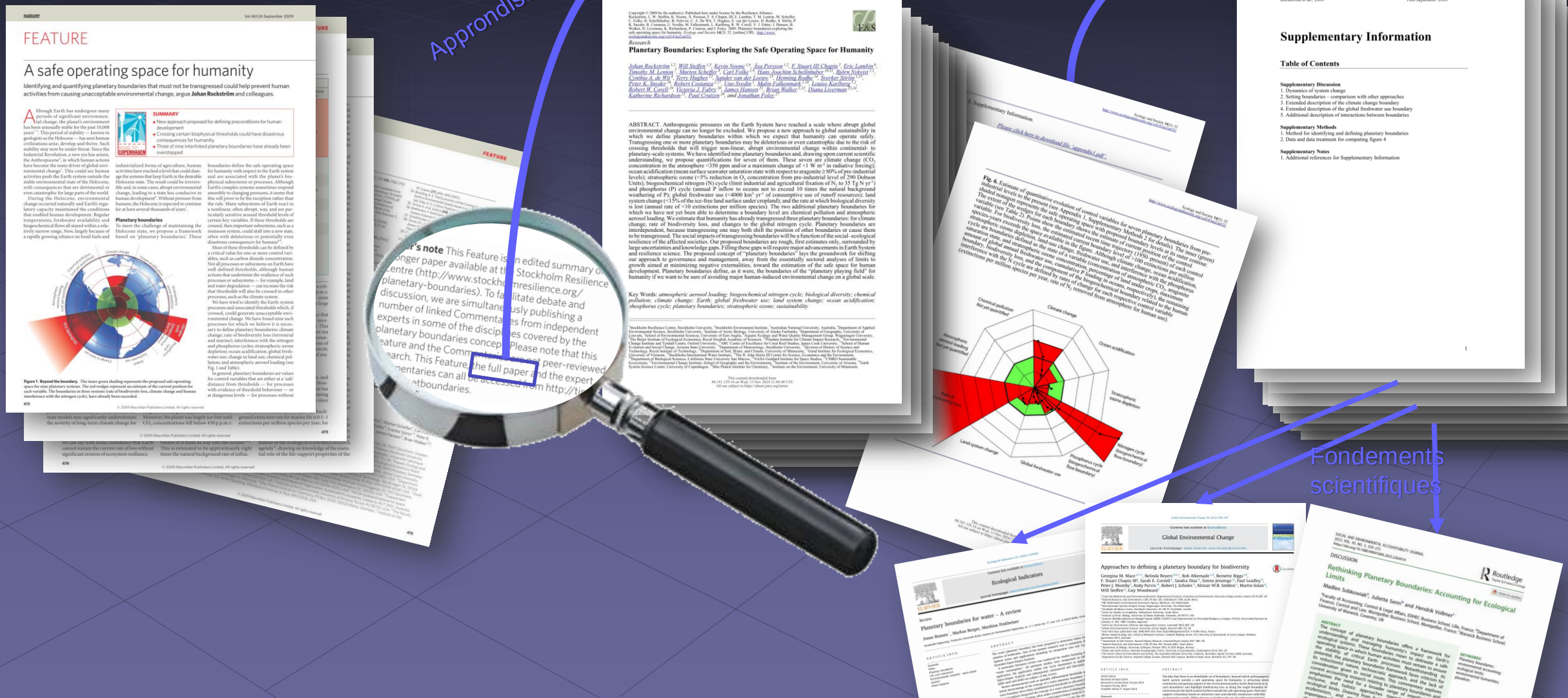
Rockström et al. 2009b, Nature
!! Non peer-reviewed !!

Approndissement

Rockström et al. 2009a, Ecology & Society

Approfondissement

Fondements scientifiques



Quelle science derrière le concept ?

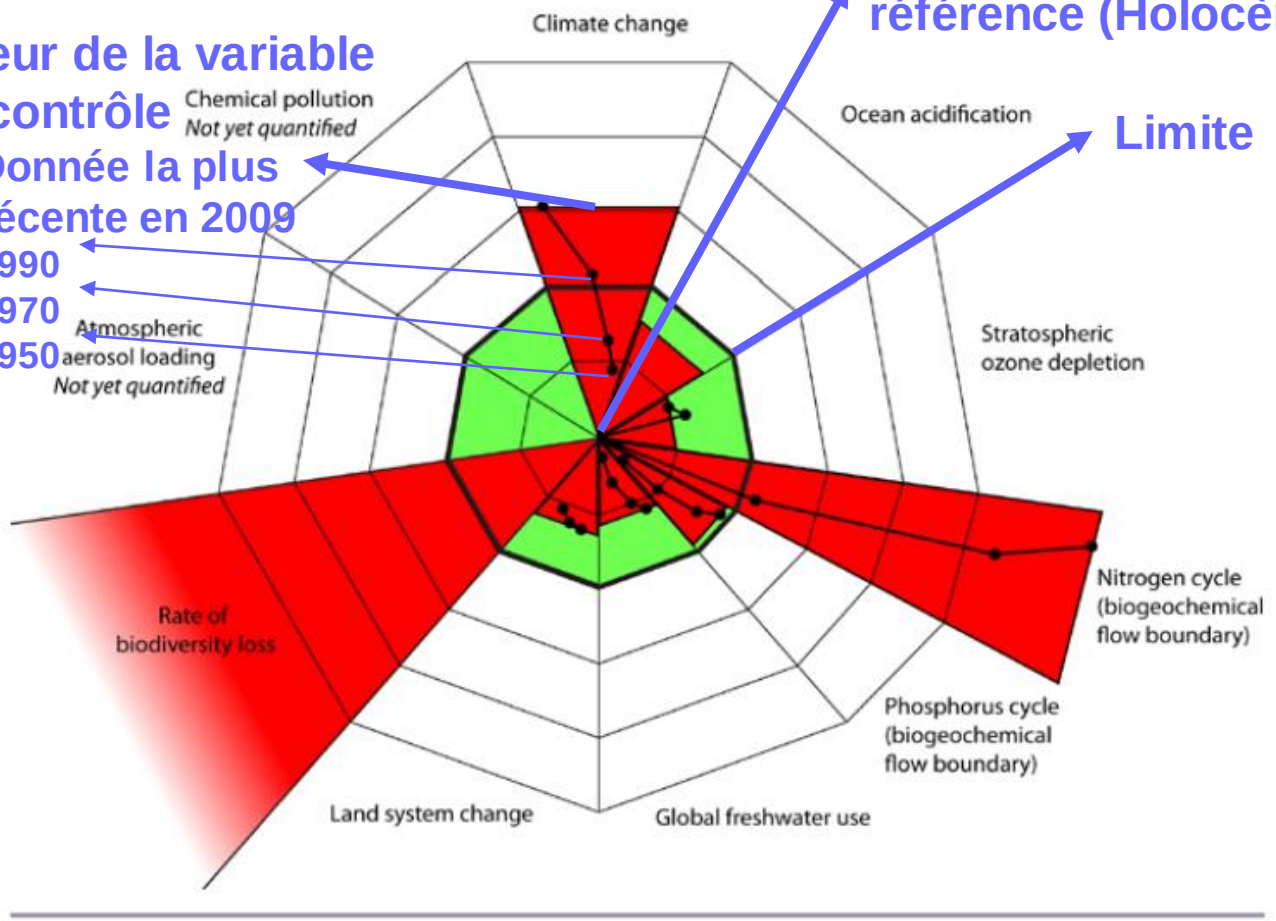
species-years exceeds the space available in the figure. Although climate change, ocean acidification, stratospheric ozone depletion, land-use change, freshwater use, and interference with the phosphorus cycle are [illegible] of change for [illegible] atmospheric CO_2, aragonite saturation, [illegible] stratospheric ozone concentration, [illegible] crops, maximum amount of global annual freshwater use, cumulative P loading in oceans, respectively), the remaining boundary, biodiversity loss, and the component of the biogeochemical boundary related to the human interference with the N cycle are defined by rates of change for each respective control variable (extinctions per million species per year, rate of N_2 removed from atmosphere for human use).

Valeur de la variable de contrôle

- **Donnée la plus récente en 2009**
- **1990**
- **1970**
- **1950**

Niveau moyen de référence (Holocène)

Limite

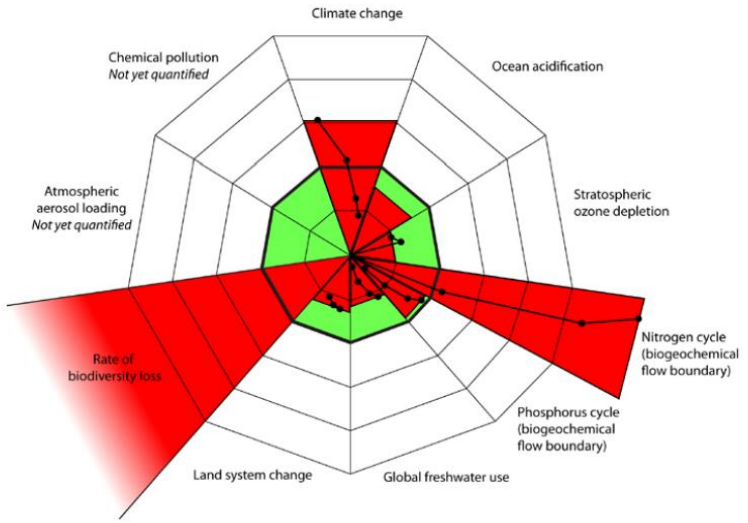


Rockström et al. 2009, Ecology & Society

Quelle science derrière le concept ?

Ecology and Society 14(2): 32
http://www.ecologyandsociety.org/vol14/iss2/art32/

Fig. 6. Estimate of quantitative evolution of control variables for seven planetary boundaries from pre-industrial levels to the present (see Appendix 1, Supplementary Methods 2 for details). The inner (green) shaded nonagon represents the safe operating space with proposed boundary levels at its outer contour. The extent of the wedges for each boundary shows the estimate of current position of the control variable (see Table 2). Points show the estimated recent time trajectory (1950–present) of each control variable. For biodiversity loss, the estimated current boundary level of >100 extinctions per million species-years exceeds the space available in the figure. Although climate change, ocean acidification, stratospheric ozone depletion, land-use change, freshwater use, and interference with the phosphorus cycle are boundaries defined as the state of a variable (concentration of atmospheric CO_2, aragonite saturation state, and stratospheric ozone concentration, percentage of land under crops, maximum amount of global annual freshwater use, cumulative P loading in oceans, respectively), the remaining boundary, biodiversity loss, and the component of the biogeochemical boundary related to the human interference with the N cycle are defined by rates of change for each respective control variable (extinctions per million species per year, rate of N_2 removed from atmosphere for human use).



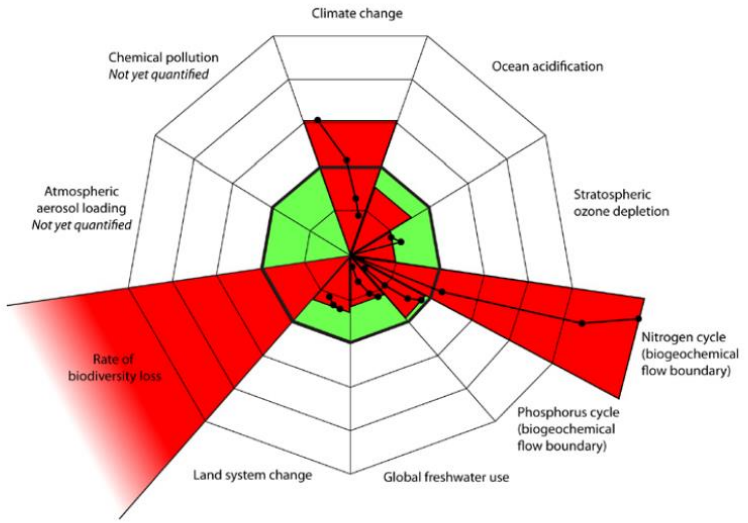
Rockström et al. 2009, Ecology & Society

Earth system process	Control variable	Boundary	Pre-industrial*	1950	1970	1990**	Latest data
Climate change	Atmospheric CO_2 concentration, ppm	350	280	311	326	354	387
Ocean acidification	Global oceanic aragonite saturation ratio	2.75	3.44	n.a.	n.a.	n.a.	2.90
Stratospheric ozone depletion	Stratospheric O_3 concentration, DU	276	290	n.a.	292	282	283
Nitrogen cycle (Part of a single biogeochemical flow boundary)	Amount of N_2 removed from the atmosphere for human use, Mt yr^{-1}	35	0	4	39	98	121
Phosphorus cycle (Part of a single biogeochemical flow boundary)	Quantity of P flowing into the oceans, Mt yr^{-1}	11	1.1	3.4	6.0	8.5	10.3 (9) ****
Global fresh-water use	Consumptive use of withdrawn runoff, km^3 yr^{-1}	4,000	415	887	1,536	2,192	2,600
Land system change	Percentage of global land cover converted to cropland, % (Mha)	15 (1,995)	5 (665)	n.a.	10.71 (1,424)	11.45 (1,522)	11.68 (1,554)
Biodiversity loss	Extinction rate in number of species per million per year, E/MSY	10	1	n.a.	n.a.	n.a.	>100
Atmospheric aerosol loading ***Not yet quantified***	-	-	-	-	-	-	-
Chemical pollution ***Not yet quantified***	-	-	-	-	-	-	-

Quelle science derrière le concept ?

Ecology and Society 14(2): 32
http://www.ecologyandsociety.org/vol14/iss2/art32/

Fig. 6. Estimate of quantitative evolution of control variables for seven planetary boundaries from pre-industrial levels to the present (see Appendix 1, Supplementary Methods 2 for details). The inner (green) shaded nonagon represents the safe operating space with proposed boundary levels at its outer contour. The extent of the wedges for each boundary shows the estimate of current position of the control variable (see Table 2). Points show the estimated recent time trajectory (1950–present) of each control variable. For biodiversity loss, the estimated current boundary level of >100 extinctions per million species-years exceeds the space available in the figure. Although climate change, ocean acidification, stratospheric ozone depletion, land-use change, freshwater use, and interference with the phosphorus cycle are boundaries defined as the state of a variable (concentration of atmospheric CO_2, aragonite saturation state, and stratospheric ozone concentration, percentage of land under crops, maximum amount of global annual freshwater use, cumulative P loading in oceans, respectively), the remaining boundary, biodiversity loss, and the component of the biogeochemical boundary related to the human interference with the N cycle are defined by rates of change for each respective control variable (extinctions per million species per year, rate of N_2 removed from atmosphere for human use).



Rockström et al. 2009, Ecology & Society

Earth system process	Control variable	Boundary	Pre-industrial*	1950	1970	1990**	Latest data
Climate change	Atmospheric CO_2 concentration, ppm	350	280	311	326	354	387
Ocean acidification	Global oceanic aragonite saturation ratio	2.75	3.44	n.a.	n.a.	n.a.	2.90
Stratospheric ozone depletion	Stratospheric O_3 concentration, DU	276	290	n.a.	292	282	283
Nitrogen cycle (Part of a single biogeochemical flow boundary)	Amount of N_2 removed from the atmosphere for human use, Mt yr^{-1}	35	0	4	39	98	121
Phosphorus cycle (Part of a single biogeochemical flow boundary)	Quantity of P flowing into the oceans, Mt yr^{-1}	11	1.1	3.4	6.0	8.5	10.3 (9) ****
Global fresh-water use	Consumptive use of withdrawn runoff, km^3 yr^{-1}	4,000	415	887	1,536	2,192	2,600
Land system change	Percentage of global land cover converted to cropland, % (Mha)	15 (1,995)	5 (665)	n.a.	10.71 (1,424)	11.45 (1,522)	11.68 (1,554)
Biodiversity loss	Extinction rate in number of species per million per year, E/MSY	10	1	n.a.	n.a.	n.a.	>100
Atmospheric aerosol loading ***Not yet quantified***	-	-	-	-	-	-	-
Chemical pollution ***Not yet quantified***	-	-	-	-	-	-	-

Variable de contrôle

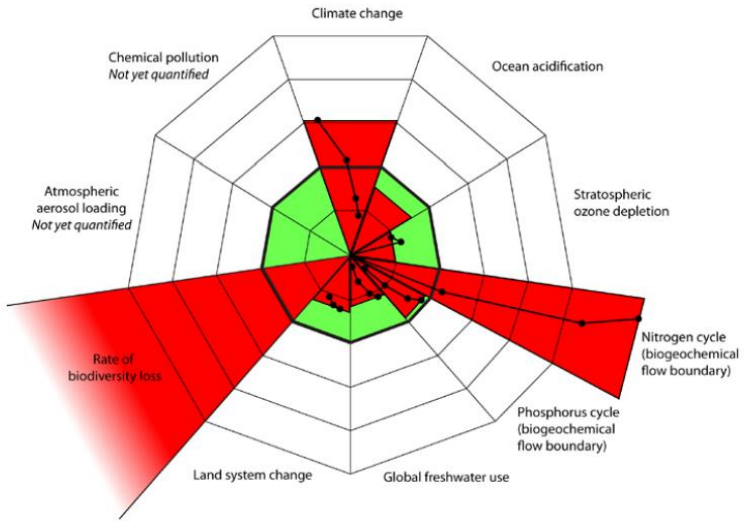
Choisis à dire d'expert

- Au sein du consortium scientifique
- Workshops avec communauté plus large et échange avec décideurs du secteur privé, gouvernementaux et société civile

Quelle science derrière le concept ?

Ecology and Society 14(2): 32
http://www.ecologyandsociety.org/vol14/iss2/art32/

Fig. 6. Estimate of quantitative evolution of control variables for seven planetary boundaries from pre-industrial levels to the present (see Appendix 1, Supplementary Methods 2 for details). The inner (green) shaded nonagon represents the safe operating space with proposed boundary levels at its outer contour. The extent of the wedges for each boundary shows the estimate of current position of the control variable (see Table 2). Points show the estimated recent time trajectory (1950–present) of each control variable. For biodiversity loss, the estimated current boundary level of >100 extinctions per million species-years exceeds the space available in the figure. Although climate change, ocean acidification, stratospheric ozone depletion, land-use change, freshwater use, and interference with the phosphorus cycle are boundaries defined as the state of a variable (concentration of atmospheric CO_2, aragonite saturation state, and stratospheric ozone concentration, percentage of land under crops, maximum amount of global annual freshwater use, cumulative P loading in oceans, respectively), the remaining boundary, biodiversity loss, and the component of the biogeochemical boundary related to the human interference with the N cycle are defined by rates of change for each respective control variable (extinctions per million species per year, rate of N_2 removed from atmosphere for human use).



Rockström et al. 2009, Ecology & Society

Earth system process	Control variable	Boundary	Pre-industrial*	1950	1970	1990**	Latest data
Climate change	Atmospheric CO_2 concentration, ppm	350	280	311	326	354	387
Ocean acidification	Global oceanic aragonite saturation ratio	2.75	3.44	n.a.	n.a.	n.a.	2.90
Stratospheric ozone depletion	Stratospheric O_3 concentration, DU	276	290	n.a.	292	282	283
Nitrogen cycle (Part of a single biogeochemical flow boundary)	Amount of N_2 removed from the atmosphere for human use, Mt yr^{-1}	35	0	4	39	98	121
Phosphorus cycle (Part of a single biogeochemical flow boundary)	Quantity of P flowing into the oceans, Mt yr^{-1}	11	1.1	3.4	6.0	8.5	10.3 (9) ****
Global fresh-water use	Consumptive use of withdrawn runoff, km^3 yr^{-1}	4,000	415	887	1,536	2,192	2,600
Land system change	Percentage of global land cover converted to cropland, % (Mha)	15 (1,995)	5 (665)	n.a.	10.71 (1,424)	11.45 (1,522)	11.68 (1,554)
Biodiversity loss	Extinction rate in number of species per million per year, E/MSY	10	1	n.a.	n.a.	n.a.	>100
Atmospheric aerosol loading ***Not yet quantified***	-	-	-	-	-	-	-
Chemical pollution ***Not yet quantified***	-	-	-	-	-	-	-

Valeurs

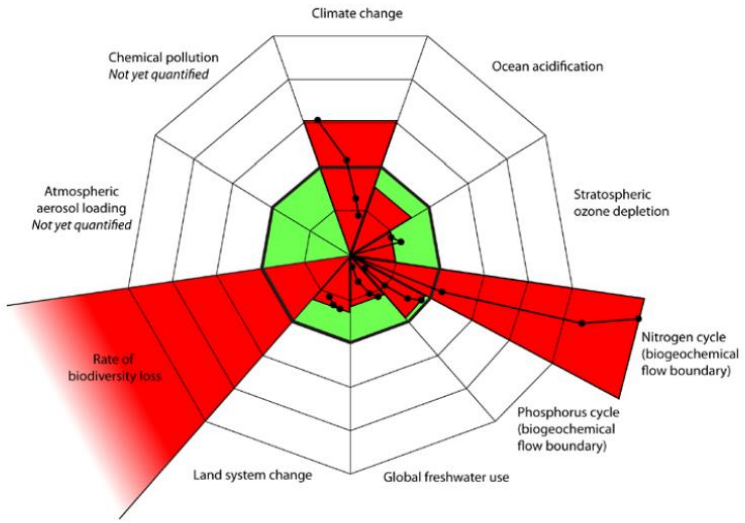
Quantification basée sur

- Littérature scientifique
- Analyses spécifiques conduites au sein du consortium

Quelle science derrière le concept ?

Ecology and Society 14(2): 32
http://www.ecologyandsociety.org/vol14/iss2/art32/

Fig. 6. Estimate of quantitative evolution of control variables for seven planetary boundaries from pre-industrial levels to the present (see Appendix 1, Supplementary Methods 2 for details). The inner (green) shaded nonagon represents the safe operating space with proposed boundary levels at its outer contour. The extent of the wedges for each boundary shows the estimate of current position of the control variable (see Table 2). Points show the estimated recent time trajectory (1950–present) of each control variable. For biodiversity loss, the estimated current boundary level of >100 extinctions per million species-years exceeds the space available in the figure. Although climate change, ocean acidification, stratospheric ozone depletion, land-use change, freshwater use, and interference with the phosphorus cycle are boundaries defined as the state of a variable (concentration of atmospheric CO_2, aragonite saturation state, and stratospheric ozone concentration, percentage of land under crops, maximum amount of global annual freshwater use, cumulative P loading in oceans, respectively), the remaining boundary, biodiversity loss, and the component of the biogeochemical boundary related to the human interference with the N cycle are defined by rates of change for each respective control variable (extinctions per million species per year, rate of N_2 removed from atmosphere for human use).



Rockström et al. 2009, Ecology & Society

Earth system process	Control variable	Boundary	Pre-industrial*	1950	1970	1990**	Latest data
Climate change	Atmospheric CO_2 concentration, ppm	350	280	311	326	354	387
Ocean acidification	Global oceanic aragonite saturation ratio	2.75	3.44	n.a.	n.a.	n.a.	2.90
Stratospheric ozone depletion	Stratospheric O_3 concentration, DU	276	290	n.a.	292	282	283
Nitrogen cycle (Part of a single biogeochemical flow boundary)	Amount of N_2 removed from the atmosphere for human use, Mt yr^{-1}	35	0	4	39	98	121
Phosphorus cycle (Part of a single biogeochemical flow boundary)	Quantity of P flowing into the oceans, Mt yr^{-1}	11	1.1	3.4	6.0	8.5	10.3 (9) ****
Global fresh-water use	Consumptive use of withdrawn runoff, km^3 yr^{-1}	4,000	415	887	1,536	2,192	2,600
Land system change	Percentage of global land cover converted to cropland, % (Mha)	15 (1,995)	5 (665)	n.a.	10.71 (1,424)	11.45 (1,522)	11.68 (1,554)
Biodiversity loss	Extinction rate in number of species per million per year, E/MSY	10	1	n.a.	n.a.	n.a.	>100
Atmospheric aerosol loading ***Not yet quantified***	-	-	-	-	-	-	-
Chemical pollution ***Not yet quantified***	-	-	-	-	-	-	-

Limites

Quantification arbitraires

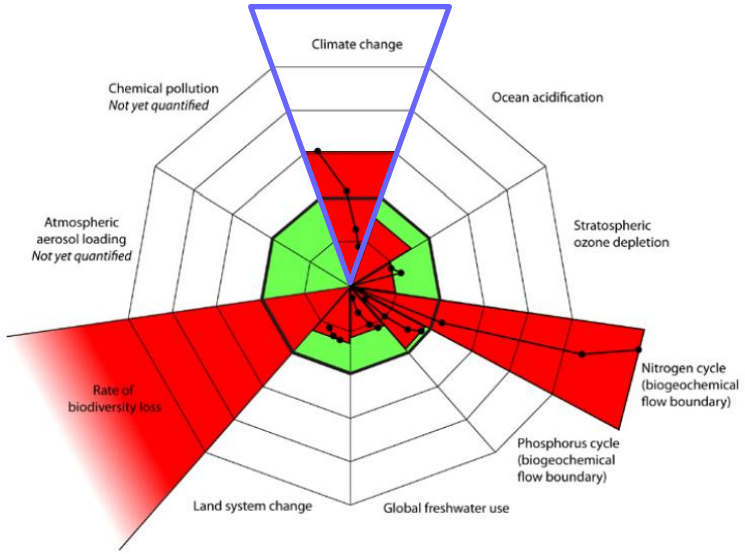
Subjectivité basée sur:

- La capacité des sociétés à gérer le risque et les incertitudes
- L'espace entre le seuil critique et la limite « safe » doit être
  - suffisamment court pour qu'il y ait un intérêt à agir
  - suffisamment éloigné pour avoir une marge de manœuvre

Quelle science derrière le concept ?

Ecology and Society 14(2): 32
http://www.ecologyandsociety.org/vol14/iss2/art32/

Fig. 6. Estimate of quantitative evolution of control variables for seven planetary boundaries from pre-industrial levels to the present (see Appendix 1, Supplementary Methods 2 for details). The inner (green) shaded nonagon represents the safe operating space with proposed boundary levels at its outer contour. The extent of the wedges for each boundary shows the estimate of current position of the control variable (see Table 2). Points show the estimated recent time trajectory (1950–present) of each control variable. For biodiversity loss, the estimated current boundary level of >100 extinctions per million species-years exceeds the space available in the figure. Although climate change, ocean acidification, stratospheric ozone depletion, land-use change, freshwater use, and interference with the phosphorus cycle are boundaries defined as the state of a variable (concentration of atmospheric CO_2, aragonite saturation state, and stratospheric ozone concentration, percentage of land under crops, maximum amount of global annual freshwater use, cumulative P loading in oceans, respectively), the remaining boundary, biodiversity loss, and the component of the biogeochemical boundary related to the human interference with the N cycle are defined by rates of change for each respective control variable (extinctions per million species per year, rate of N_2 removed from atmosphere for human use).



Rockström et al. 2009, Ecology & Society

Climate Change

Variable de contrôle	Seuil critique	Limite (safe)	Valeur (2009)
Concentration atmosphérique CO_2 (ppm)	350-450 ppm	350ppm	387 ppm

Sur la base des travaux paléo-climatiques (Hansen et al. 2008)

- **Variables de réponse**
  - Calottes polaires
  - Température du globe
- **Effet sur la température globale**
  - → **Rétroaction rapides**
  - Modèle de climat IPCC (2007): $[CO_2]x2$ → ΔT ~ + 3°C
  - → **Rétroactions lentes**
  - Entre -20000 ans et -10000 ans: $[CO_2]x2$ → ΔT ~ + 6°C
- **Seuils réversibilité des calottes**
  - Sur les dernières 65 millions d'année oscillations calottes polaires montre une réversibilité possible entre 350-550 ppm
  - Pas de consensus sur risque hystérésis

Sur la base des observations contemporaines (réf. Multiples)

- **Variables de réponse multiples**

→ **Rétroactions rapides**

- Retrait rapide de la banquise
- Retrait des glaciers partout dans le monde et des calottes
- Un décalage vers le nord de la cellule de Hadley avec augmentation de l'aridité de certaines régions (Méditerranée, Sud USA, Est Australie et une partie de l'Afrique)
- Blanchissement et mortalité des coraux
- Accélération du taux d'augmentation du niveau marin
- Augmentation du nombre d'inondation

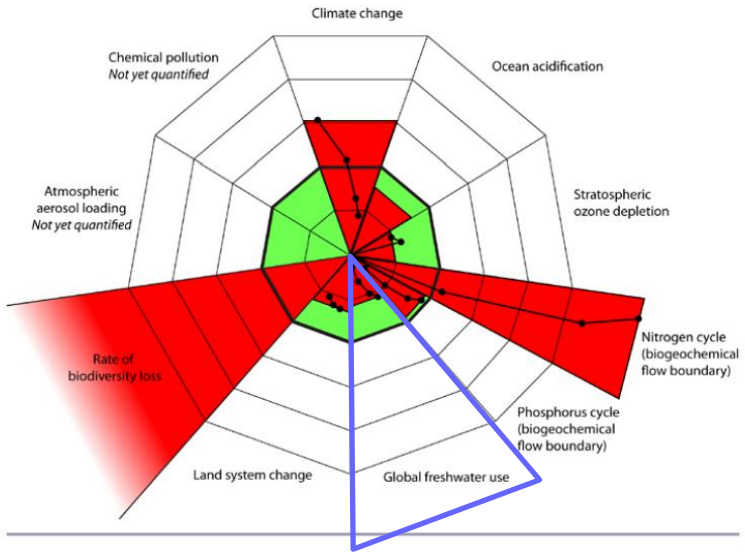
→ **Rétroactions lentes se mettent en place**

- En lien avec le cycle du carbone et le changement d'albedo

Quelle science derrière le concept ?

Ecology and Society 14(2): 32
http://www.ecologyandsociety.org/vol14/iss2/art32/

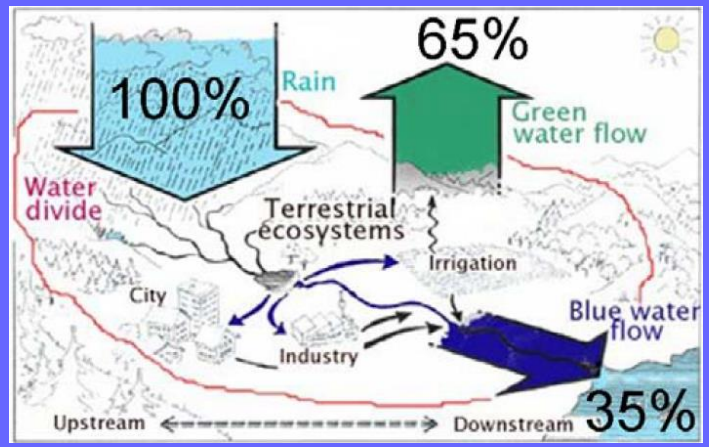
Fig. 6. Estimate of quantitative evolution of control variables for seven planetary boundaries from pre-industrial levels to the present (see Appendix 1, Supplementary Methods 2 for details). The inner (green) shaded nonagon represents the safe operating space with proposed boundary levels at its outer contour. The extent of the wedges for each boundary shows the estimate of current position of the control variable (see Table 2). Points show the estimated recent time trajectory (1950–present) of each control variable. For biodiversity loss, the estimated current boundary level of >100 extinctions per million species-years exceeds the space available in the figure. Although climate change, ocean acidification, stratospheric ozone depletion, land-use change, freshwater use, and interference with the phosphorus cycle are boundaries defined as the state of a variable (concentration of atmospheric CO_2, aragonite saturation state, and stratospheric ozone concentration, percentage of land under crops, maximum amount of global annual freshwater use, cumulative P loading in oceans, respectively), the remaining boundary, biodiversity loss, and the component of the biogeochemical boundary related to the human interference with the N cycle are defined by rates of change for each respective control variable (extinctions per million species per year, rate of N_2 removed from atmosphere for human use).



Rockström et al. 2009, Ecology & Society

Global freshwater use

Variable de contrôle	Seuil critique	Limite (safe)	Valeur (2009)
Prélèvement Eau Bleue	4000 – 6000 km^3/an	4000 km^3/an	2600 km^3/an



- **Deux variables de contrôle identifiées**
  - Eau verte
  - Eau bleue
- **Variables de réponse**

Humidité du sol, production de biomasse, Séquestration de carbone, écosystèmes
Lien directs avec changement climatique, usage des terre et biodiversité

Sur la base de littérature (réf. Multiples)

- Risque de collapse des plusieurs systèmes biologiques régionaux d'ampleur
  - En lien avec l'eau verte:

  e.g. Forêt amazonienne, désertification régionales
  - En lien avec l'eau bleue

  Ecosystème rivières
  Ecosystèmes marins, côtiers, estuaires et lacustres

Sur la base de littérature (réf. Multiples)

- Identification de seuils à risques pour l'eau bleue (uniquement considérée ici)
  - Danger pour les écosystèmes si prélèvement en rivière compris entre 4000 et 6000 km^3

  → **Assèchement de 25% rivières**

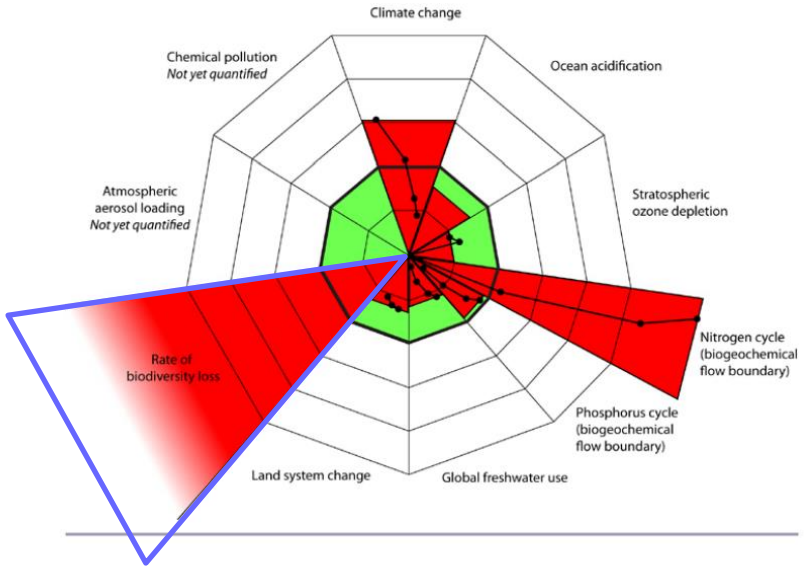
  → **30-35% population risque de manquer d'eau**

Quelle science derrière le concept ?

Rate of biodiversity loss

Ecology and Society 14(2): 32
http://www.ecologyandsociety.org/vol14/iss2/art32/

Fig. 6. Estimate of quantitative evolution of control variables for seven planetary boundaries from pre-industrial levels to the present (see Appendix 1, Supplementary Methods 2 for details). The inner (green) shaded nonagon represents the safe operating space with proposed boundary levels at its outer contour. The extent of the wedges for each boundary shows the estimate of current position of the control variable (see Table 2). Points show the estimated recent time trajectory (1950–present) of each control variable. For biodiversity loss, the estimated current boundary level of >100 extinctions per million species-years exceeds the space available in the figure. Although climate change, ocean acidification, stratospheric ozone depletion, land-use change, freshwater use, and interference with the phosphorus cycle are boundaries defined as the state of a variable (concentration of atmospheric CO_2, aragonite saturation state, and stratospheric ozone concentration, percentage of land under crops, maximum amount of global annual freshwater use, cumulative P loading in oceans, respectively), the remaining boundary, biodiversity loss, and the component of the biogeochemical boundary related to the human interference with the N cycle are defined by rates of change for each respective control variable (extinctions per million species per year, rate of N_2 removed from atmosphere for human use).



Rockström et al. 2009, Ecology & Society

Variable de contrôle	Seuil critique	Limite (safe)	Valeur (2009)
Taux d'extinction en extinctions par million d'espèces par an (E/MSy)	Non défini	10 E/MSy	>100 E/MSy

Sur la base de la littérature (réf. Multiples)

- **Variables de réponse**

Multiples

- **Effets**

- Variable lente affecte fonctionnement des écosystèmes à l'échelle du continent et des océans
- Impact sur de nombreuses autres processus – stockage Carbone, eau douce, cycles de l'azote et du phosphore, systèmes terrestres.
- Perte massive de biodiversité, inacceptable pour des raisons éthiques.

- **Seuils non définis**

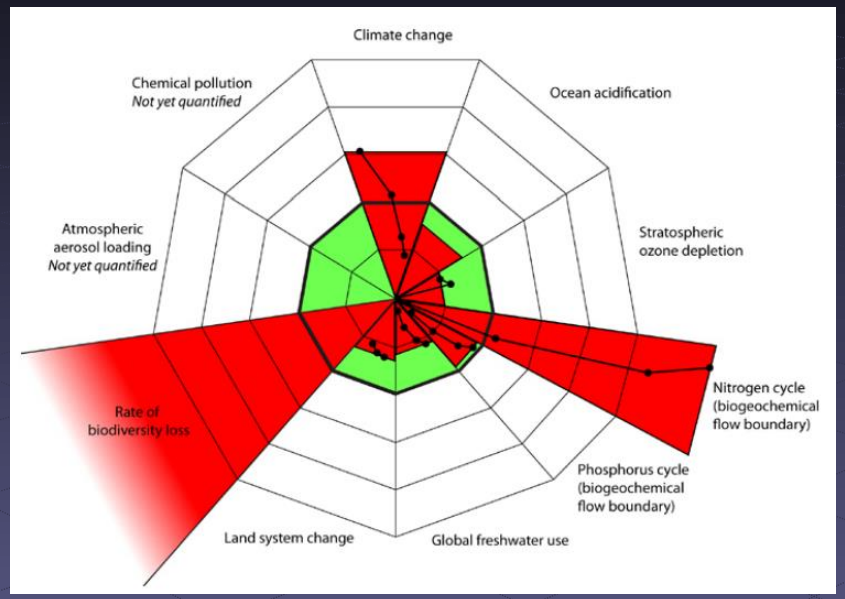
- Existent à l'échelle locale
- Manque de connaissances pour être défini à l'échelle globale

- **Choix de la limite**

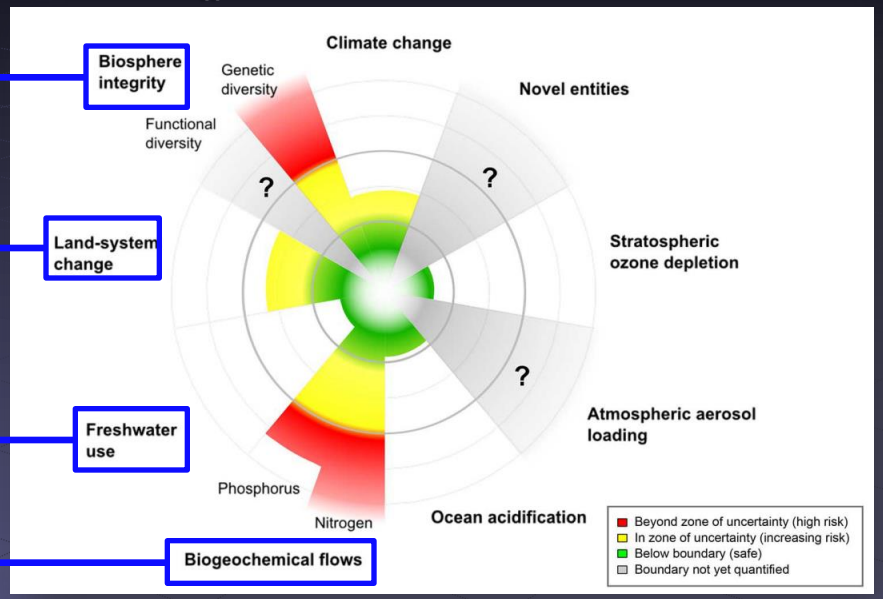
- 10 E/Msy estimation incertaine d'un seuil moyen global Holocène
- Dépassé quoi qu'il en soit

Evolution des limites planétaires

Rockström et al. 2009, Ecology & Society



Steffen et al. 2015, Science



Proposition de seuils régionaux

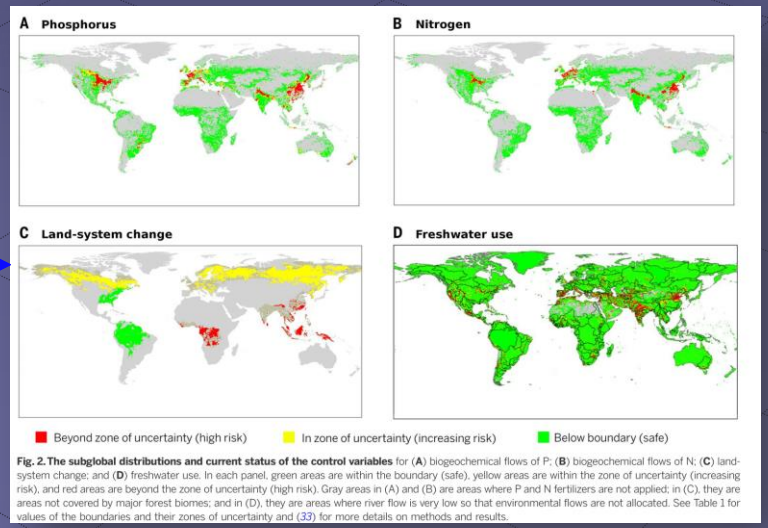


Fig. 2. The subglobal distributions and current status of the control variables for (**A**) biogeochemical flows of P; (**B**) biogeochemical flows of N; (**C**) land-system change; and (**D**) freshwater use. In each panel, green areas are within the boundary (safe), yellow areas are within the zone of uncertainty (increasing risk), and red areas are beyond the zone of uncertainty (high risk). Gray areas in (A) and (B) are areas where P and N fertilizers are not applied; in (C), they are areas not covered by major forest biomes; and in (D), they are areas where river flow is very low so that environmental flows are not allocated. See Table 1 for values of the boundaries and their zones of uncertainty and (*33*) for more details on methods and results.

Inchangé (sauf valeur récente)
- Climate Change
- Stratospheric Ozone depletion
- Ocean acidification

Chgt noms de processus
- Biosphere integrity
- Biogeochmical flows

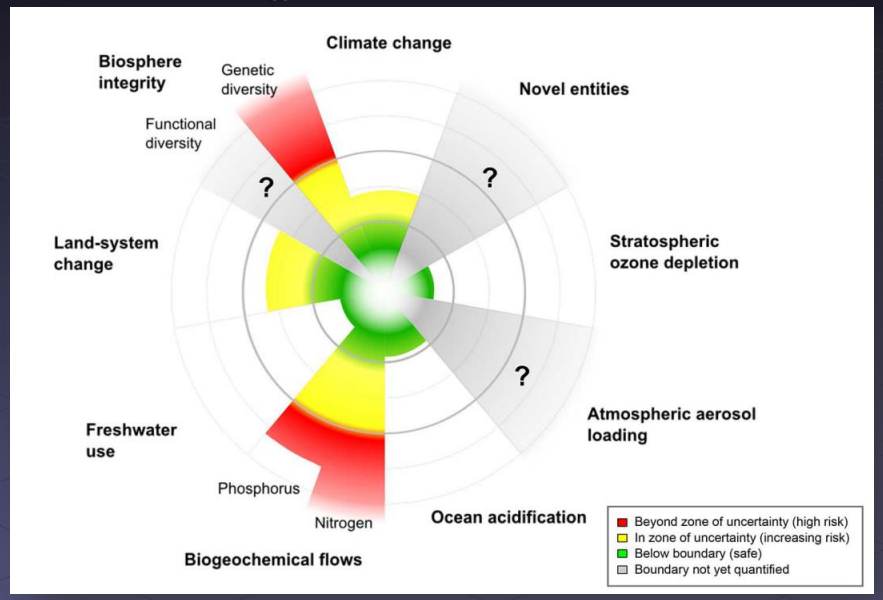
Chgt variables de contrôle
- Genetic diversity
- Function diversity

Chgt estimation des seuils
- Phosphore/Nitrogen
- Land system change

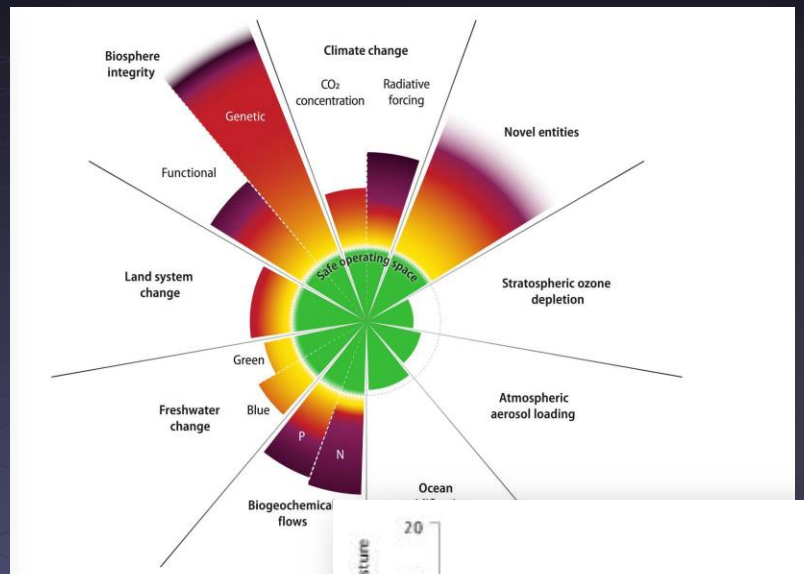
Mise en garde
- Hiérarchisation
- Pas prévu pour usage à échelle nationale ou locale
- « Planetary Boundary thinking » reste à élaborer à ces échelles

Evolution des limites planétaires

Steffen et al. 2015, Science



Richardson et al. 2023, Science Advances



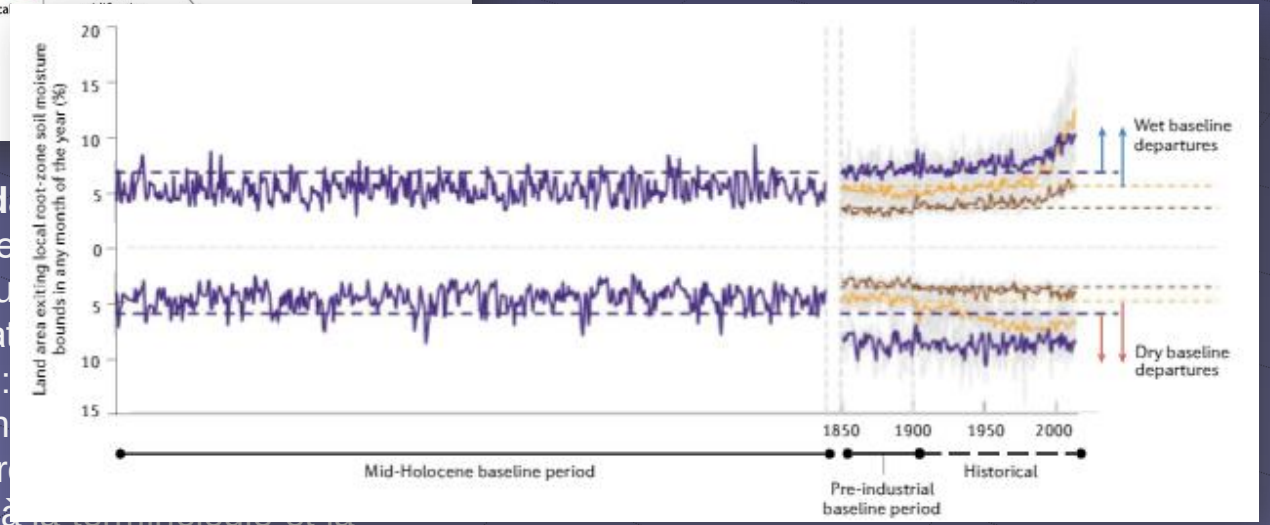
Tous les processus et variables sont documentés

Fresh water défini de façon plus lisible.

- **Variables de contrôle**
  - proxys séparés de blue et green water
  - Évaluation de la déviation temporelle de la variabilité par rapport à l'Holocène
- **Seuil**
  - Le seuil est défini au 95th percentile de la variabilité naturelle et la variabilité sort de cette zone pour près de 20% de la zone continentale et ce depuis le début du XXème siècle.

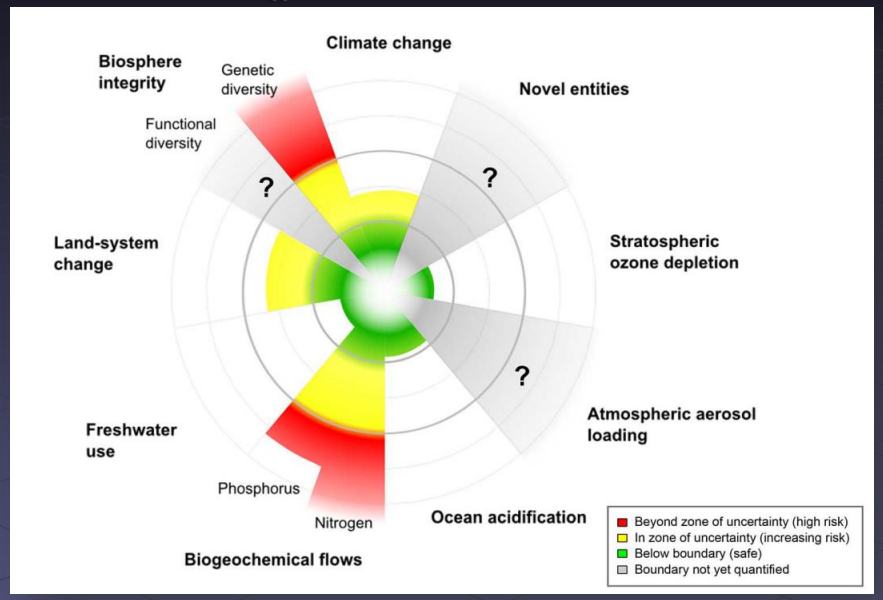
Changement d

- La notion de
  remplacée u
  d'augmentat
  Par exple:
  correspon
  impacts tr
  → Coller à
  sémiologie du GIEC
- Mais le passage à haut risque reste extrêmement difficile à définir….

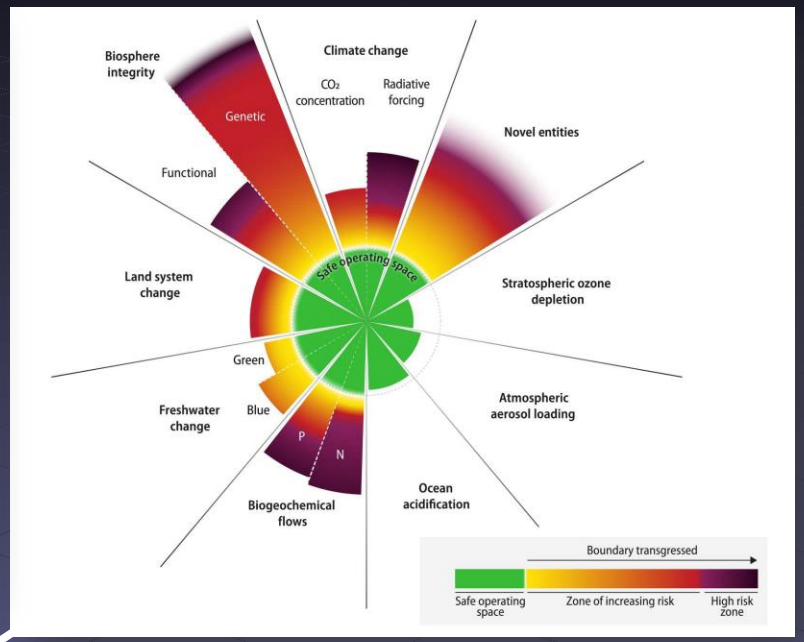


Evolution des limites planétaires

Steffen et al. 2015, Science



Richardson et al. 2023, Science Advances



Tous les processus et variables sont documentés

Changement dans la représentation

- La notion de zone d'incertitude est remplacée une zone d'augmentation des risques.
  Par exple: 350-450ppm correspond à 1°-2° avec des impacts très différents.
  → Coller à la terminologie et la sémiologie du GIEC
- Mais le passage à haut risque reste extrêmement difficile à définir….

Fresh water défini de façon plus lisible.

- **Variables de contrôle**
  - proxys séparés de blue et green water
  - Évaluation de la déviation temporelle de la variabilité par rapport à l'Holocène
- **Seuil**
  - Le seuil est défini au 95th percentile de la variabilité naturelle et la variabilité sort de cette zone pour près de 20% de la zone continentale et ce depuis le début du XXème siècle.

Functional Biodiversity

- **Variable de Contrôle**
  - Human Appropriation of Net Primary Production (appropriation de l'énergie qui ne peut pas être utilisée par la biosphère pour la photosynthèse) lié à agriculture, sylviculture, pâturage. Part augmente 15.7% en 1950 23.5% en 2020.
- **Seuil**
  - comme pour beaucoup de limites sans seuil, il est considéré par accumulation de preuves (ici la diminution de la végétation naturelle) Limite fixée à 10% ce qui a débuté au 19eme siècle

Critiques du concept dans le milieu académique

Littérature scientifique

Critiques constructives

- Choix de processus
- Choix des variables considérées non représentative du processus souvent trop réducteur de la complexité
- Mauvaise estimation des variables.
- Mauvaise prise en compte des interactions entre processus
- Choix des seuils qui cachent des sous-seuils régionaux non représentés.
- Incompatibilité du concept aux problématiques locales et régionales
- Subjectivité des limites basées sur des critères influencés par le contexte socio-économique (capacité à appréhender le risque)
- L'espace « safe » ne garantit par le bien-être
- …

Le concept est accepté
→ Proposition pour améliorer/ajuster/modifier

Environmental Research Letters

CrossMark

OPEN ACCESS

RECEIVED
27 November 2018

REVISED
10 May 2019

ACCEPTED FOR PUBLICATION
20 May 2019

PUBLISHED
9 July 2019

TOPICAL REVIEW

Matching scope, purpose and uses of planetary boundaries science

Andrea S Downing[1,2], Avit Bhowmik[1], David Collste[1,3], Sarah E Cornell[1], Jonathan Donges[1,4], Ingo Fetzer[1,2], Tiina Häyhä[1,5], Jennifer Hinton[1,3], Steven Lade[1,2,6] and Wolf M Mooij[7,8]

1 Stockholm Resilience Centre, Stockholm University, SE-10691 Stockholm, Sweden
2 Bolin Centre for Climate Research, Stockholm University, Stockholm, Sweden
3 Centre d'Études et de Recherches sur le Développement International, CERDI, Université Clermont Auvergne, Clermont-Ferrand, France
4 Potsdam Institute for Climate Impact Research, PO Box 60 12 03, D-14412 Potsdam Germany
5 International Institute for Applied Systems Analysis (IIASA), Schlossplatz 1—A-2361, Laxenburg, Austria
6 Fenner School of Environment and Society, The Australian National University, Australian Capital Territory, Canberra, Australia
7 Department of Aquatic Ecology, Netherlands Institute of Ecology (NIOO-KNAW), PO Box 50, 6700 AB Wageningen, The Netherlands
8 Department of Aquatic Ecology and Water Quality Management, Wageningen University, PO Box 47, 6700 AA Wageningen, The Netherlands

E-mail: andrea.downing@su.se

Keywords: planetary boundaries, resilience, global sustainability science, human dimensions, footprints approach, life cycle analysis, safe operating space

Supplementary material for this article is available online

Downing al. 2019, ERL

120 commentaires autour du concept

Critiques du concept dans le milieu académique

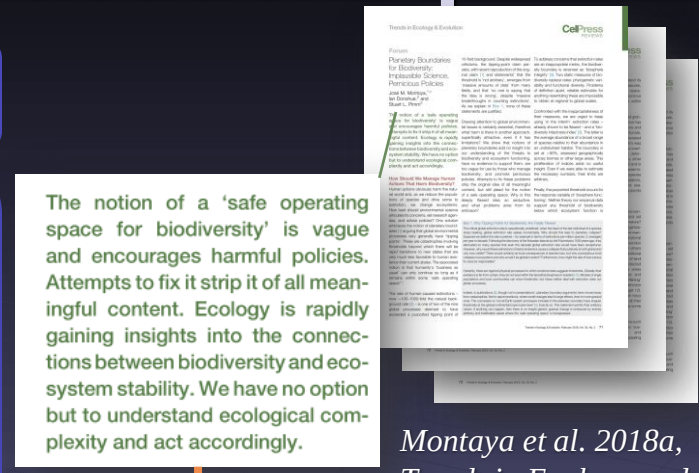
Littérature scientifique

Critiques constructives

- Choix de processus
- Choix des variables considérées non représentative du processus souvent trop réducteur de la complexité
- Mauvaise estimation des variables.
- Mauvaise prise en compte des interactions entre processus
- Choix des seuils qui cachent des sous-seuils régionaux non représentés.
- Incompatibilité du concept aux problématiques locales et régionales
- Subjectivité des limites basées sur des critères influencés par le contexte socio-économique (capacité à appréhender le risque)
- L'espace « safe » ne garantit par le bien-être
- …

Critiques anti-PB

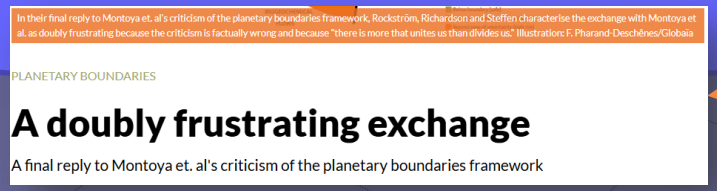
- Il n'y a que de l'arbitraire
- Les indicateurs ne sont pas pertinents
- Les limites reposent sur la définition de tipping point dont l'existence n'est pas scientifiquement avérée
- Les processus sont des boites noires dont la complexité est ignorée
- Les concepts sont flous non objectivés
- Le choix du vocabulaire repose souvent sur l'émotionnel
- Risque de décrédibiliser les scientifiques auprès des décideurs
- Ignore les initiatives communautaires dans lequel il y a une vraie construction de consensus scientifique et une interaction avec les acteurs (IPBES)
- …



Montaya et al. 2018a, Trends in Ecology and Evolution

Rockström et al. 2018a

Montaya et al. 2018b, Trends in Ecology and Evolution



Rockström et al. 2018b

Critiques du concept dans le milieu académique

Littérature scientifique

Critiques constructives

- Choix de processus
- Choix des variables considérées non représentative du processus souvent trop réducteur de la complexité
- Mauvaise estimation des variables.
- Mauvaise prise en compte des interactions entre processus
- Choix des seuils qui cachent des sous-seuils régionaux non représentés.
- Incompatibilité du concept aux problématiques locales et régionales
- Subjectivité des limites basées sur des critères influencés par le contexte socio-économique (capacité à appréhender le risque)
- L'espace « safe » ne garantit par le bien-être
- …

Critiques anti-PB

- Il n'y a que de l'arbitraire
- Les indicateurs ne sont pas pertinents
- Les limites reposent sur la définition de tipping point dont l'existence n'est pas scientifiquement avérée
- Les processus sont des boites noires dont la complexité est ignorée
- Les concepts sont flous non objectivés
- Le choix du vocabulaire repose souvent sur l'émotionnel
- Risque de décrédibiliser les scientifiques auprès des décideurs
- Ignore les initiatives communautaires dans lequel il y a une vraie construction de consensus scientifique et une interaction avec les acteurs (IPBES)
- …

Réseaux sociaux/couloirs

Ressentis/Commentaires

- Il n'y a que de l'arbitraire
- Les indicateurs ne sont pas pertinents
- Les limites reposent sur la définition de tipping point dont l'existence n'est pas scientifiquement avérée
- Les processus sont des boites noires dont la complexité est ignorée
- Les concepts sont flous non objectivés
- Le choix du vocabulaire repose souvent sur l'émotionnel
- Risque de décrédibiliser les scientifiques auprès des décideurs
- Ignore les initiatives communautaires dans lequel il y a une vraie construction de consensus scientifique et une interaction avec les acteurs (IPBES)
- …

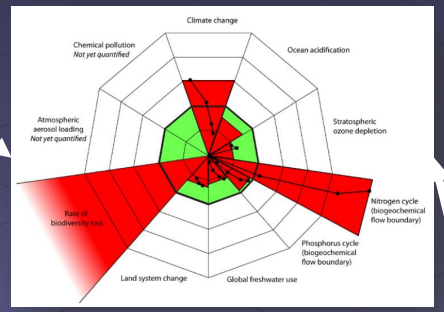
+

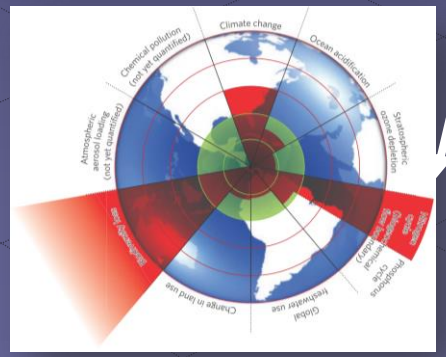
- Consortium fermé – auto-citation
- Principalement un outil de comm'

Un concept au succès planétaire sans limites…

"In 2007 Bo Ekman [*Tällberg Foundation*] made the point that Earth is always the missing 'stakeholder' around any negotiation table — be it climate, trade, or finance," explains Rockström. "So, his idea was to create a big (like ten metres in diameter) round table, have Earth depicted visually as the "cloth" and run a negotiation with actors from business, culture, science, politics, etc., over how to govern humanity's future on Earth.

Rockström et al. 2009a



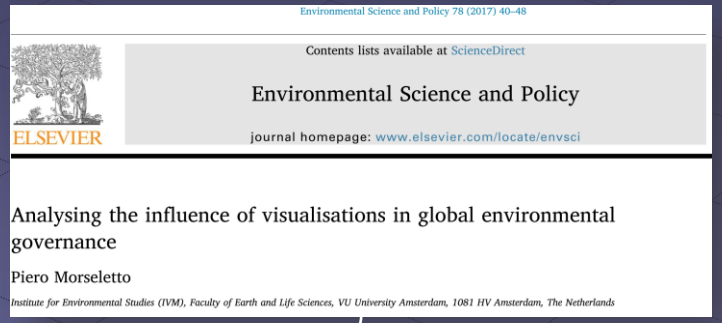


Rockström et al. 2009b

nature

Offre une vitrine pour un résumé **non-reviewé** + Retravaille le diagrammme

Understandable
Meaningful
Engaging



Environmental Science and Policy 78 (2017) 40–48

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

ELSEVIER

Analysing the influence of visualisations in global environmental governance

Piero Morseletto

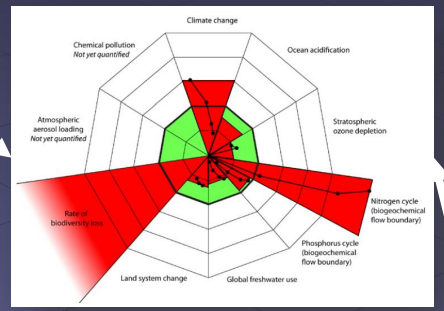
Institute for Environmental Studies (IVM), Faculty of Earth and Life Sciences, VU University Amsterdam, 1081 HV Amsterdam, The Netherlands

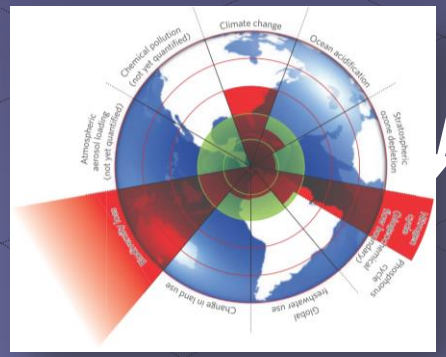
https://blog.duncangeere.com/a-dashboard-for-planet-earth-2/

Un concept au succès planétaire sans limites…

"In 2007 Bo Ekman [*Tällberg Foundation*] made the point that Earth is always the missing 'stakeholder' around any negotiation table — be it climate, trade, or finance," explains Rockström. "So, his idea was to create a big (like ten metres in diameter) round table, have Earth depicted visually as the "cloth" and run a negotiation with actors from business, culture, science, politics, etc., over how to govern humanity's future on Earth.

Rockström et al. 2009a





Rockström et al. 2009b

nature

Impact immédiat

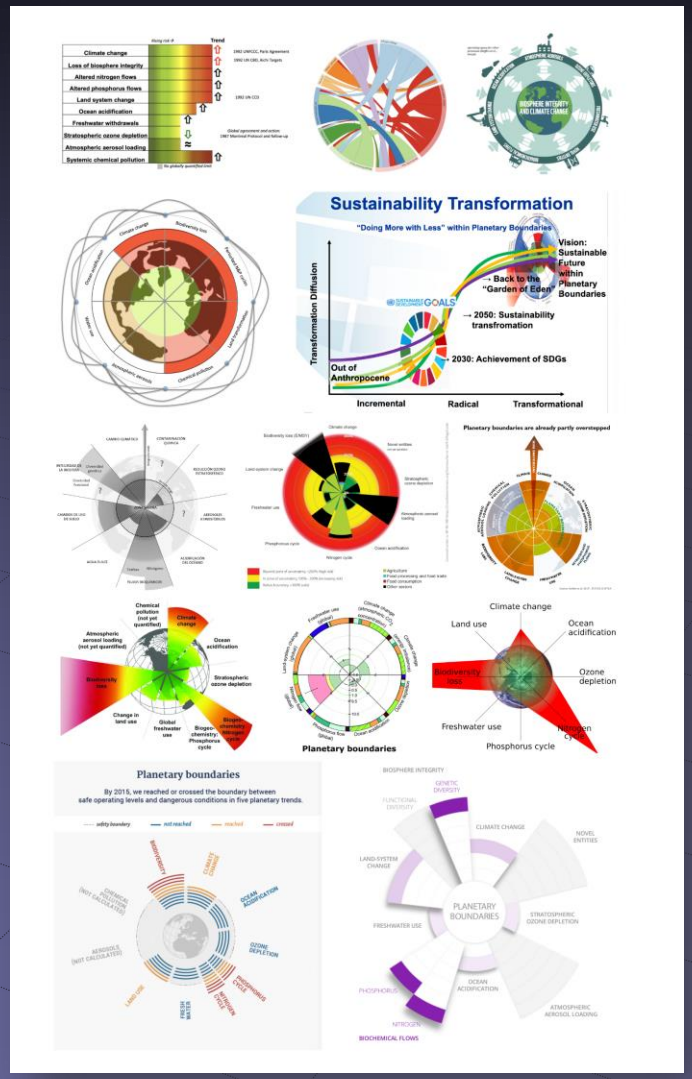
Médiatique
- ONG
- Journaux
- Médias en ligne

Académique
- Commentaires (>120 publications)
- Citations (>8800 citations)

Offre une vitrine pour un résumé non-reviewé
+
Retravaille le diagrammme

Understandable
Meaningful
Engaging

Google Image
« Planetary boundaries »



https://blog.duncangeere.com/a-dashboard-for-planet-earth-2/

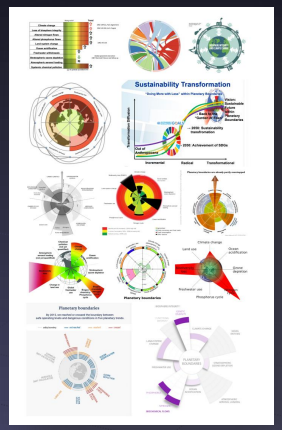
Un concept au succès planétaire sans limites…

"In 2007 Bo Ekman [*Tällberg Foundation*] made the point that Earth is always the missing 'stakeholder' around any negotiation table — be it climate, trade, or finance," explains Rockström. "So, his idea was to create a big (like ten metres in diameter) round table, have Earth depicted visually as the "cloth" and run a negotiation with actors from business, culture, science, politics, etc., over how to govern humanity's future on Earth.

Impact immédiat

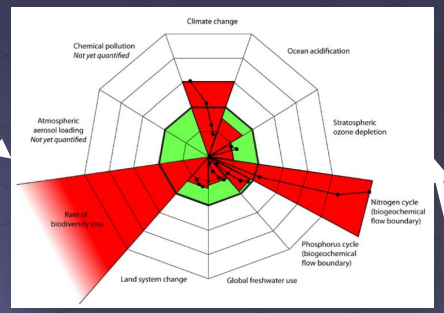
Médiatique
- ONG
- Journaux
- Médias en ligne

Google Image
« Planetary boundaries »



Académique
- Commentaires (>120 publications)
- Citations (>8800 citations)

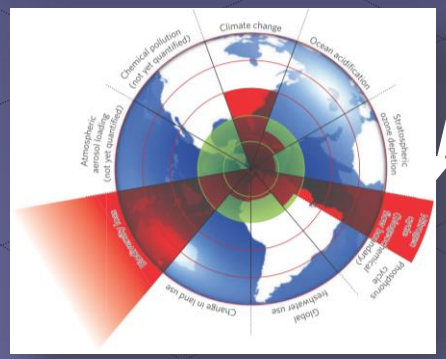
Rockström et al. 2009a



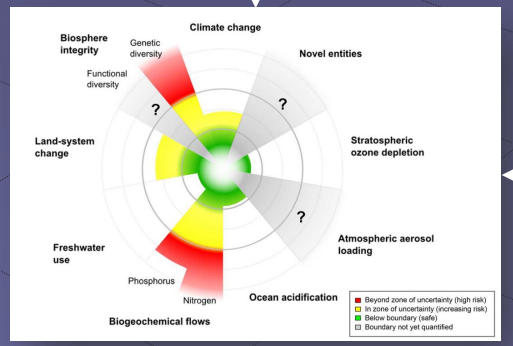
nature

Offre une vitrine pour un résumé non-reviewé
+
Retravaille le diagrammme

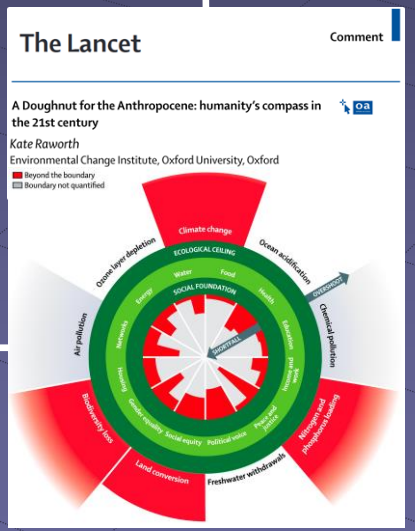
Understandable
Meaningful
Engaging



Rockström et al. 2009b



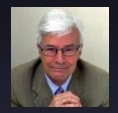
Steffen et al. 2015



Raworth 2017

https://blog.duncangeere.com/a-dashboard-for-planet-earth-2/

Un concept au succès planétaire sans limites…

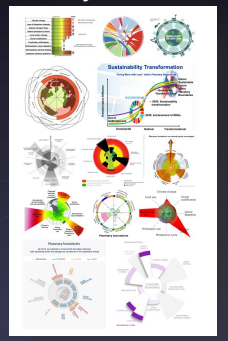


"In 2007 Bo Ekman [*Tällberg Foundation*] made the point that Earth is always the missing 'stakeholder' around any negotiation table — be it climate, trade, or finance," explains Rockström. "So, his idea was to create a big (like ten metres in diameter) round table, have Earth depicted visually as the "cloth" and run a negotiation with actors from business, culture, science, politics, etc., over how to govern humanity's future on Earth.

Impact immédiat

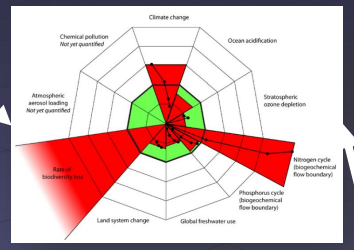
Médiatique
- ONG
- Journaux
- Médias en ligne

Google Image
« Planetary boundaries »



Académique
- Commentaires (>120 publications)
- Citations (>8800 citations)

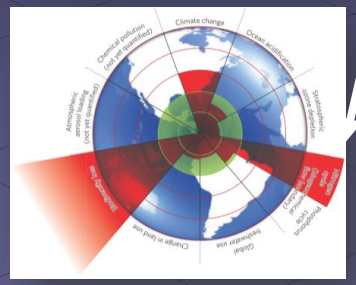
Rockström et al. 2009a



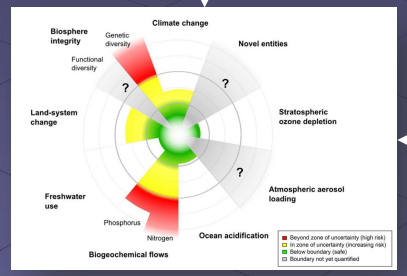
nature

Offre une vitrine pour un résumé non-reviewé
+
Retravaille le diagrammme

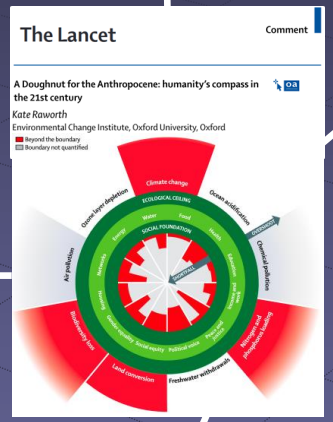
Understandable
Meaningful
Engaging



Rockström et al. 2009b

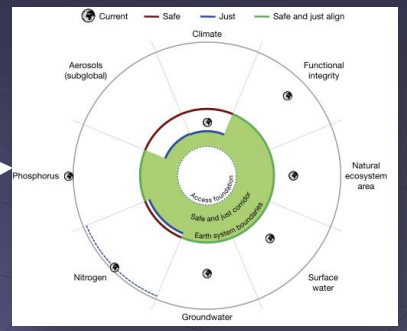


Steffen et al. 2015

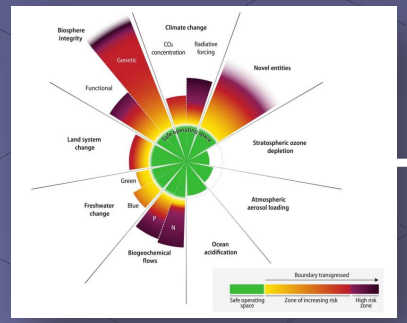


Raworth 2017

Intégration socio-économique
Safe and just space



Rockström et al. 2023, Nature
Gupta et al. 2024, The Lancet Planetary



Richardson et al. 2023

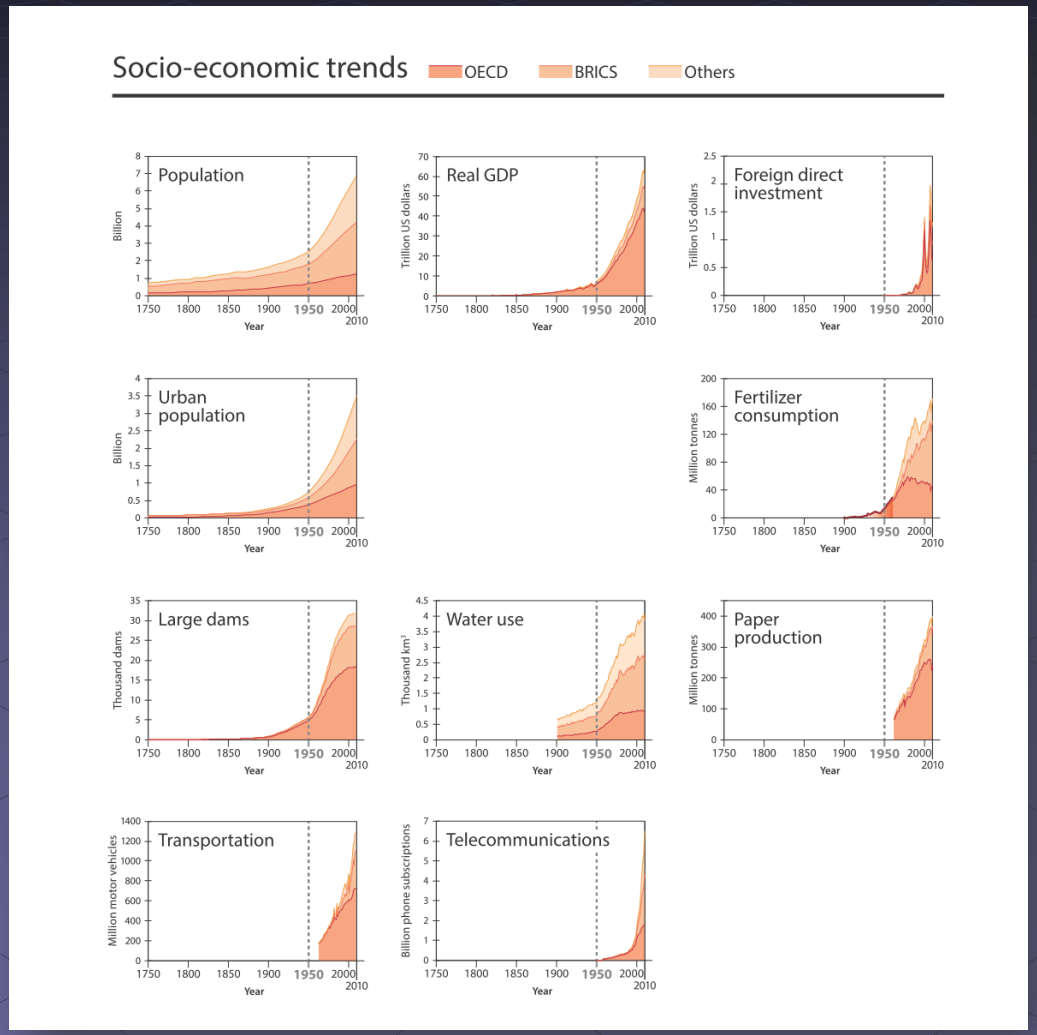
Applications Régionales

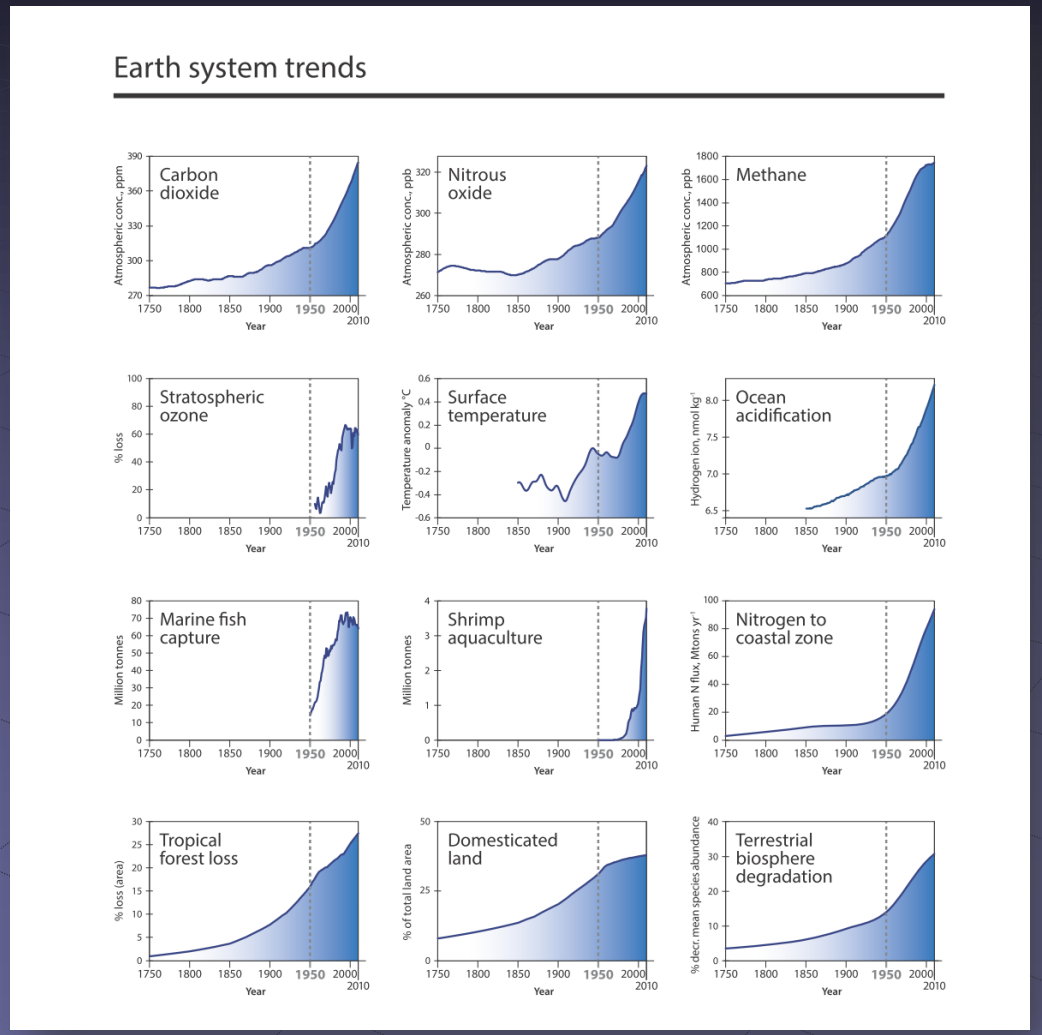
https://blog.duncangeere.com/a-dashboard-for-planet-earth-2/

Au-delà du débat?

The trajectory of the Anthropocene: The Great Acceleration

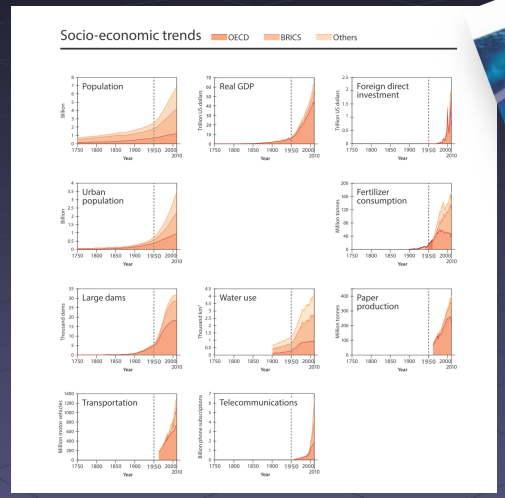
Steffen et al. 2015, The Anthropocene review

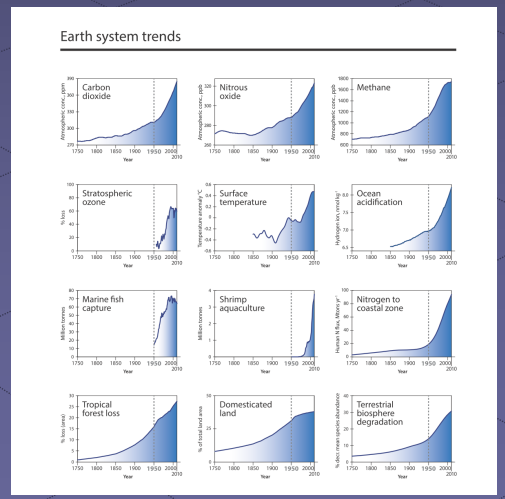


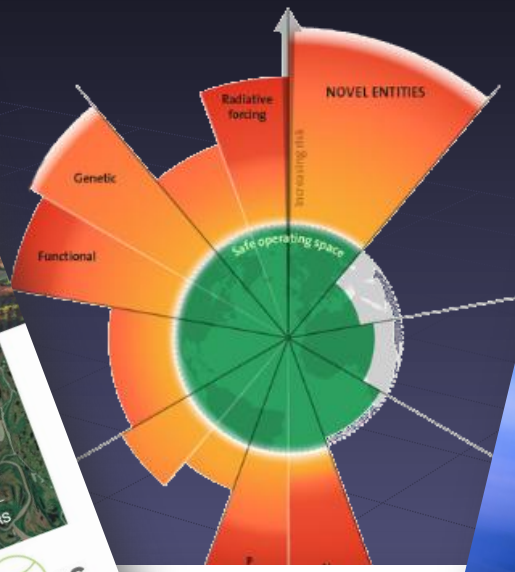


Au-delà du débat?

- Lien thématique
- Approche systémique








Comment

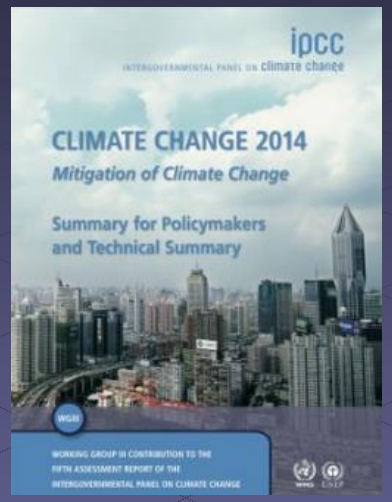
Climate tipping points — too risky to bet against

The growing threat of abrupt and irreversible climate changes must compel political and economic action on emissions.

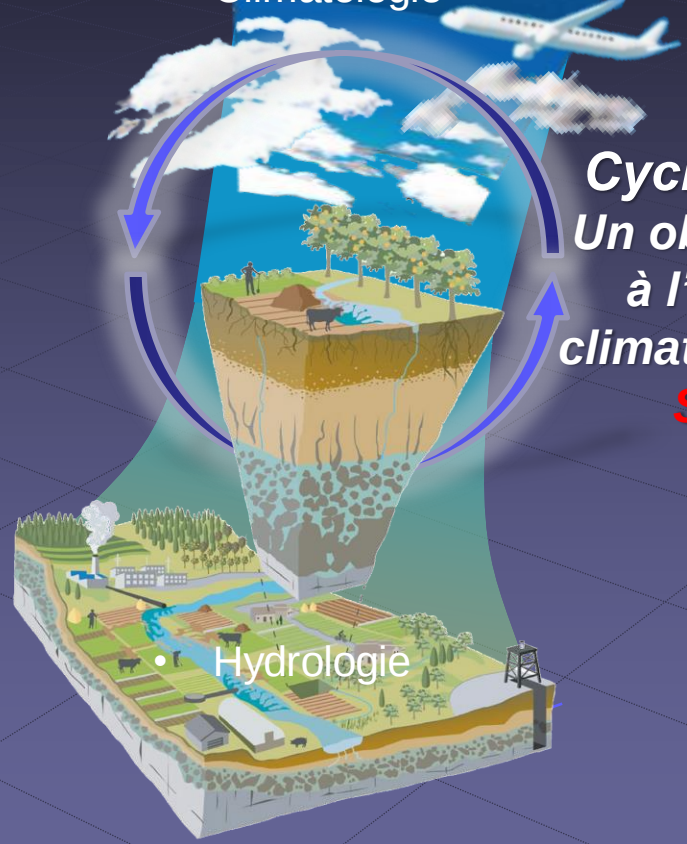
Lenton et al. 2018

Au-delà du débat?

Atténuation



- Climatologie



- Hydrologie

Cycle de l'eau
Un objet d'étude
à l'interface
climat-hydrologie
Société

Adaptation

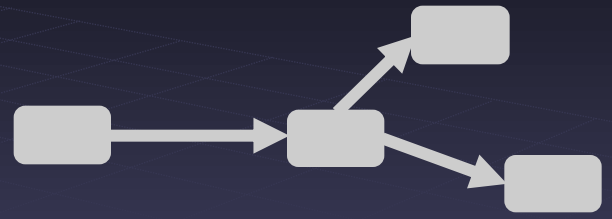
Malatténuation

Maladaptation

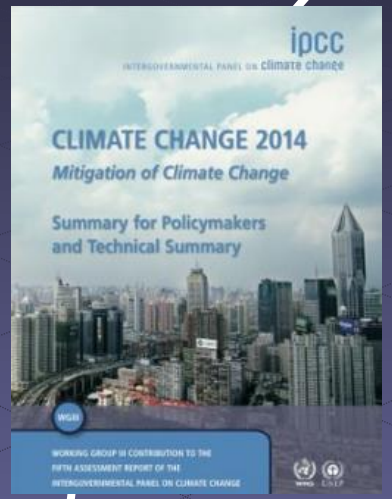
- Lien thématique
- Approche systémique

Au-delà du débat?

Pensée en silo

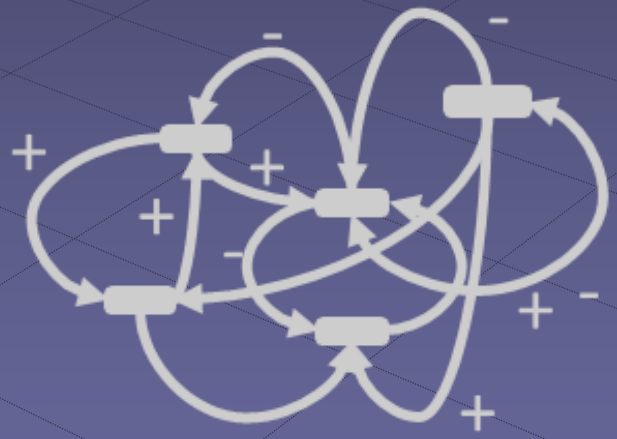


Atténuation



Malatténuation

Pensée systémique



Adaptation

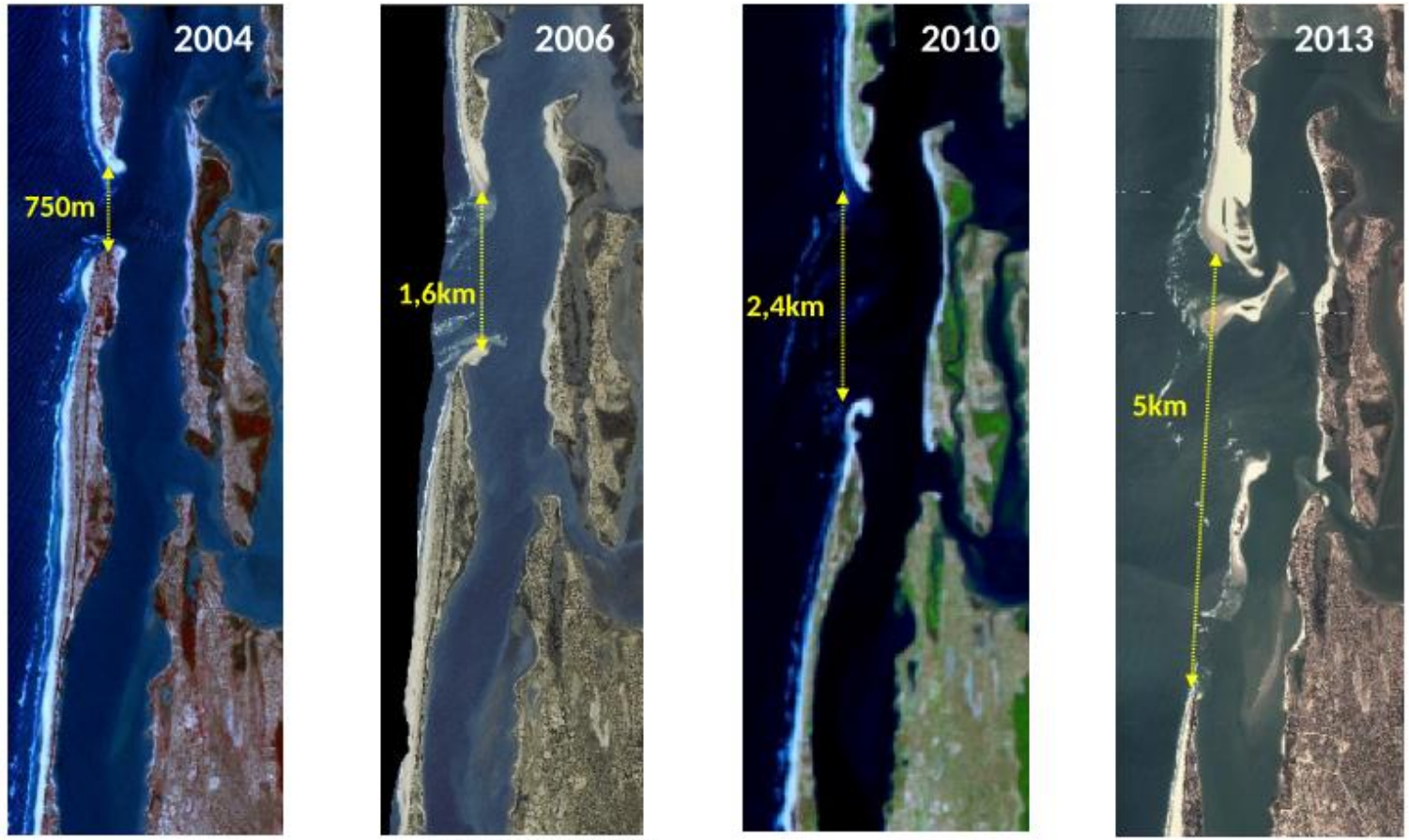
Maladaptation

- Lien thématique
- Approche systémique

Approche en silo

Fleuve Sénégal
La brèche de Saint Louis

Approche en silo



Source: DIENG (2013)

Fleuve Sénégal
La brèche de Saint Louis

Remède pire que le mal: salinisation des terres par incursion d'eau de mer.

Approche en silo

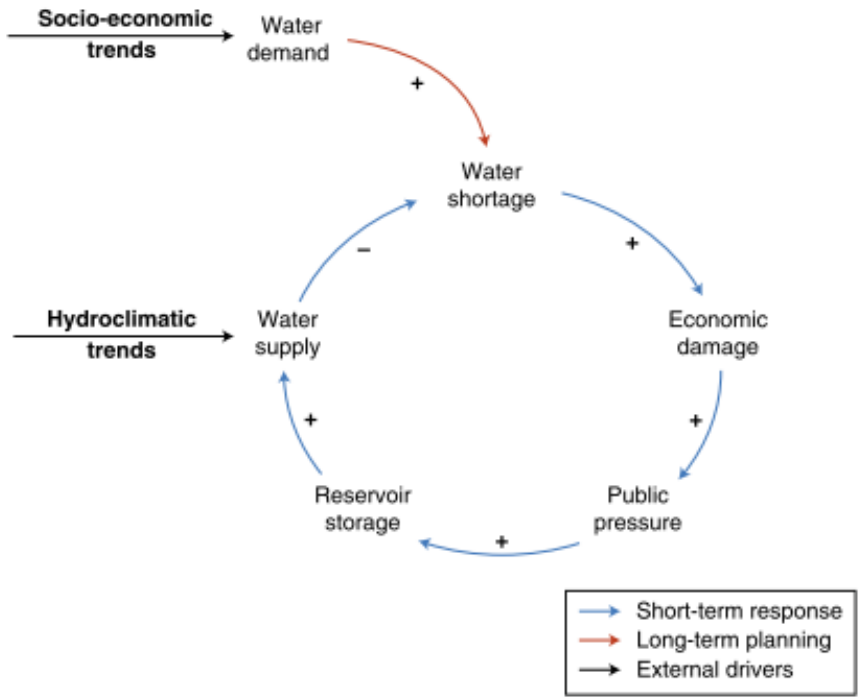


Fig. 1 | Water supply to cope with water shortage. The causal loop diagram shows the positive (+) and negative (−) feedbacks between physical, technical and social processes. This diagram is based on traditional approaches in water management and long-term planning that emphasize the role of external drivers of change (black arrows): socioeconomic trends influencing water demand and hydroclimatic trends influencing water supply.

Approche systémique

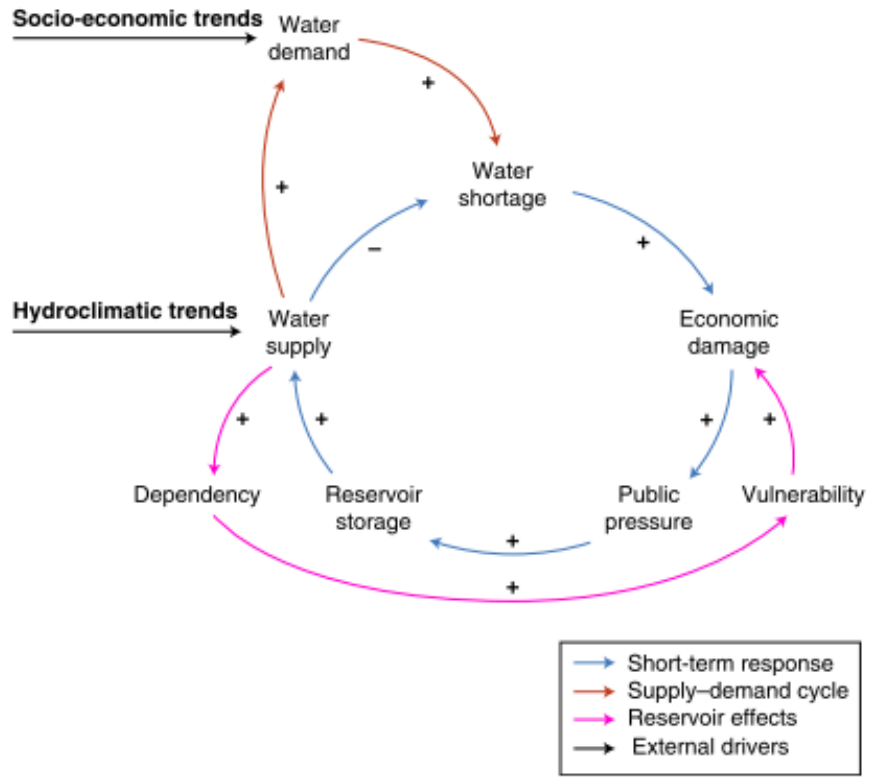
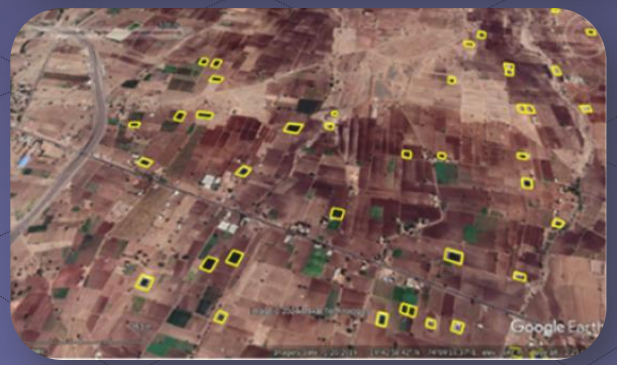
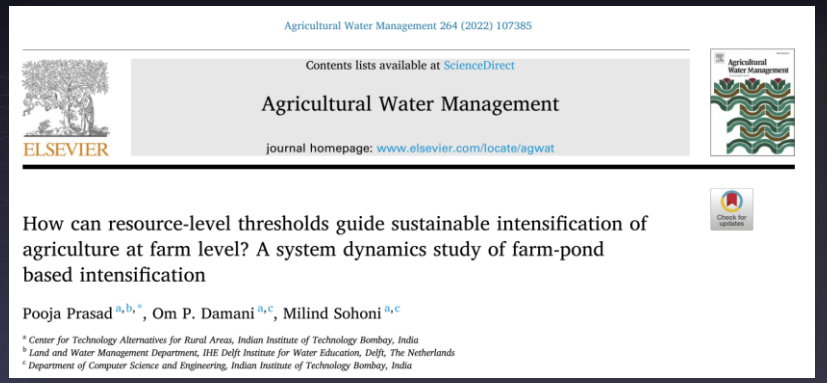


Fig. 2 | Water supply can worsen water shortage. The causal loop diagram shows the positive (+) and negative (−) feedbacks between physical, technical and social processes. Our hypothesis emphasizes the role of internal feedback mechanisms, and the potential emergence of long-term dynamics: supply–demand cycle (red loop) and reservoir effects (pink loop).

Di Baldassarre et al. 2018, Nature Sustainability

Petit exemple de maladaptation



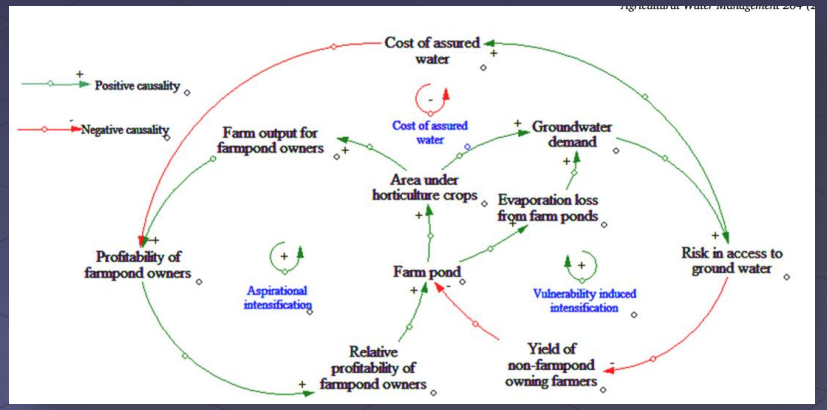

Agricultural Water Management 264 (2022) 107385
Contents lists available at ScienceDirect
Agricultural Water Management
journal homepage: www.elsevier.com/locate/agwat
ELSEVIER

How can resource-level thresholds guide sustainable intensification of agriculture at farm level? A system dynamics study of farm-pond based intensification

Pooja Prasad [a,b,*], Om P. Damani [a,c], Milind Sohoni [a,c]

[a] Center for Technology Alternatives for Rural Areas, Indian Institute of Technology Bombay, India
[b] Land and Water Management Department, IHE Delft Institute for Water Education, Delft, The Netherlands
[c] Department of Computer Science and Engineering, Indian Institute of Technology Bombay, India

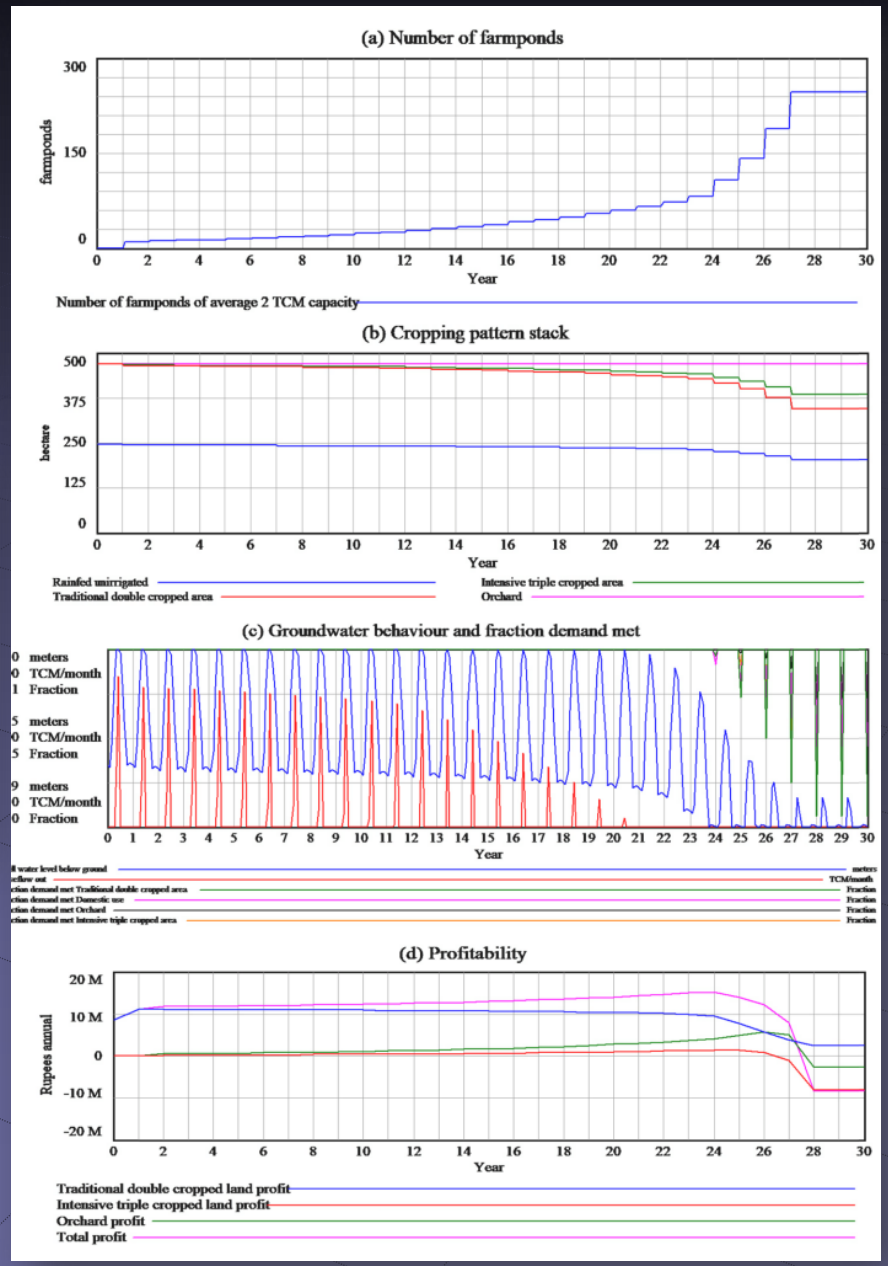
Prasad et al. 2022, Agriculture & Water management



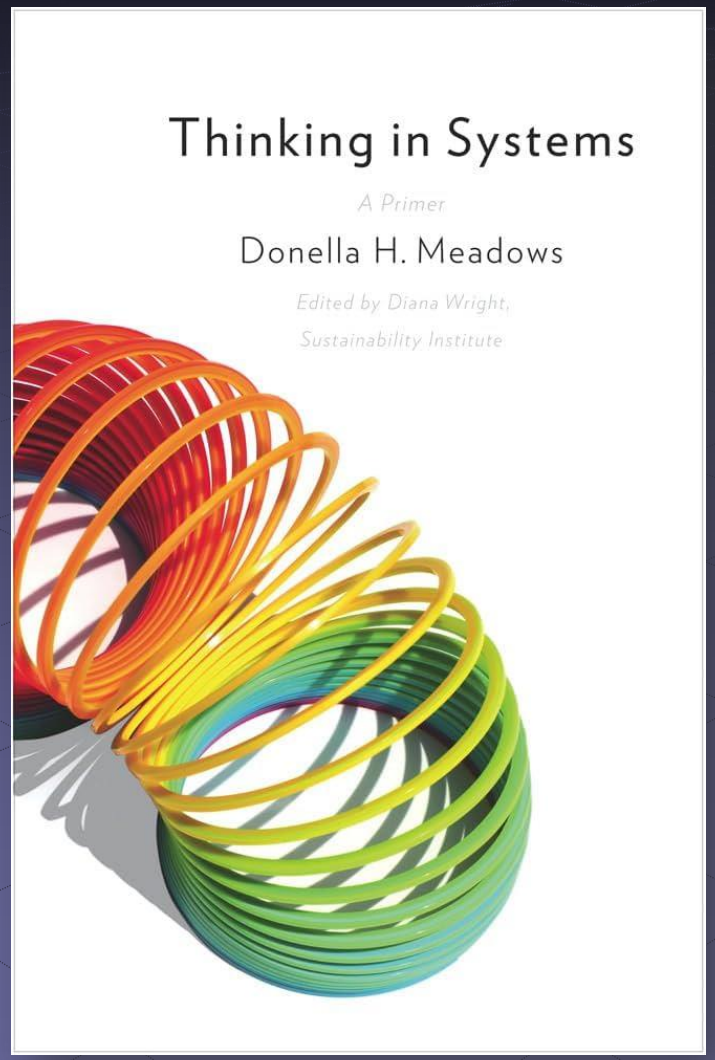
Scénario sans changement climatique

Archétype systémique

« Tragédie des communs »



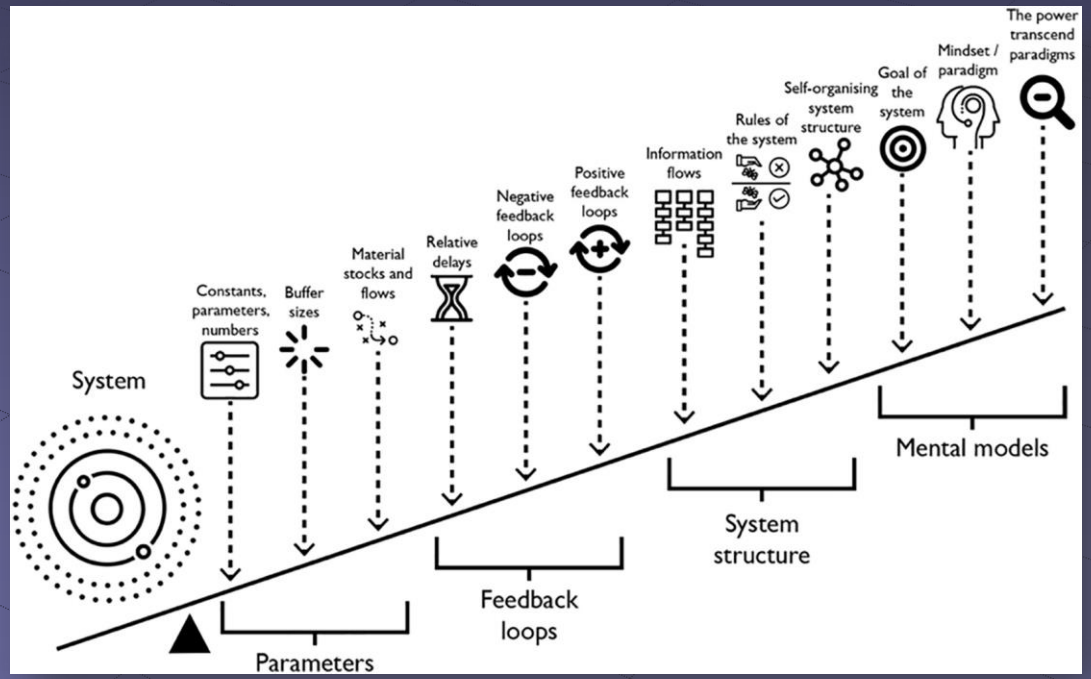
Recommandation de lecture



→ Archétype systémique

→ Leviers systémiques

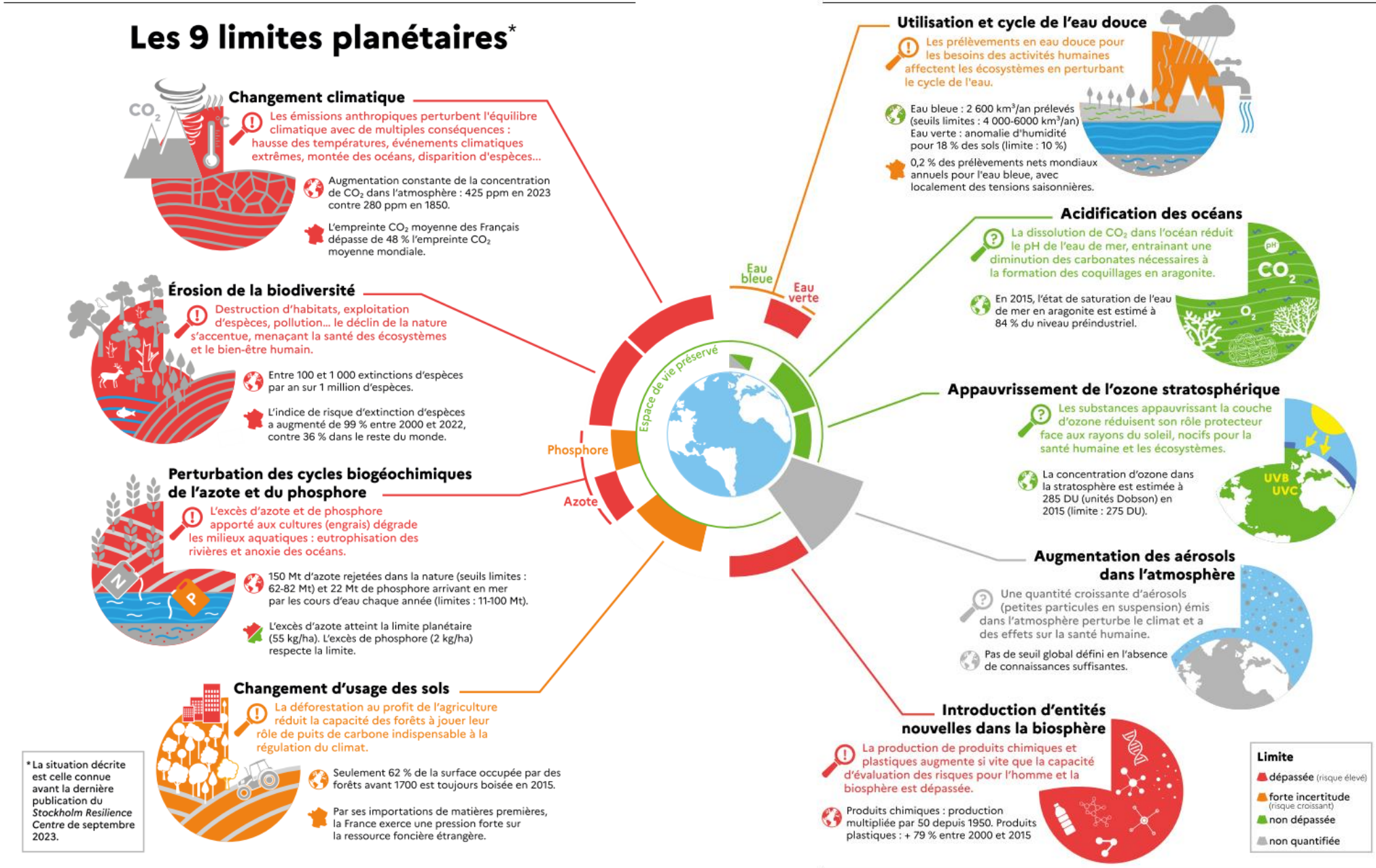
Comprendre pour bien agir



Recommandation de lecture

- Bunsen, J., M. Berger, and M. Finkbeiner, 2021: Planetary boundaries for water – A review. *Ecological Indicators*, **121**, 107022, https://doi.org/10.1016/j.ecolind.2020.107022.
- Gupta, J., and Coauthors, 2024: A just world on a safe planet: a Lancet Planetary Health–Earth Commission report on Earth-system boundaries, translations, and transformations. *The Lancet Planetary Health*, S2542519624000421, https://doi.org/10.1016/S2542-5196(24)00042-1.
- Lade, S. J., and Coauthors, 2019: Human impacts on planetary boundaries amplified by Earth system interactions. *Nat Sustain*, **3**, 119–128, https://doi.org/10.1038/s41893-019-0454-4.
- Lenton, T. M., J. Rockström, O. Gaffney, S. Rahmstorf, K. Richardson, W. Steffen, and H. J. Schellnhuber, 2019: Climate tipping points — too risky to bet against. *Nature*, **575**, 592–595, https://doi.org/10.1038/d41586-019-03595-0.
- Mace, G. M., and Coauthors, 2014: Approaches to defining a planetary boundary for biodiversity. *Global Environmental Change*, **28**, 289–297, https://doi.org/10.1016/j.gloenvcha.2014.07.009.
- Montoya, J. M., I. Donohue, and S. L. Pimm, 2018: Planetary Boundaries for Biodiversity: Implausible Science, Pernicious Policies. *Trends in Ecology & Evolution*, **33**, 71–73, https://doi.org/10.1016/j.tree.2017.10.004.
- Porkka, M., and Coauthors, 2022: Global water cycle shifts far beyond pre-industrial conditions – planetary boundary for freshwater change transgressed.
- Richardson, K., and Coauthors, 2023: Earth beyond six of nine planetary boundaries. *Science Advances*, **9**, eadh2458, https://doi.org/10.1126/sciadv.adh2458.
- Rockström, J., and Coauthors, 2009a: Planetary Boundaries: Exploring the Safe Operating Space for Humanity. *E&S*, **14**, art32, https://doi.org/10.5751/ES-03180-140232.
- ——, and Coauthors, 2009b: A safe operating space for humanity. *Nature*, **461**, 472–475, https://doi.org/10.1038/461472a.
- ——, and Coauthors, 2023: Safe and just Earth system boundaries. *Nature*, **619**, 102–111, https://doi.org/10.1038/s41586-023-06083-8.
- Steffen, W., and Coauthors, 2015a: Planetary boundaries: Guiding human development on a changing planet. *Science*, **347**, https://doi.org/10.1126/science.1259855.
- ——, W. Broadgate, L. Deutsch, O. Gaffney, and C. Ludwig, 2015b: The trajectory of the Anthropocene: The Great Acceleration. *The Anthropocene Review*, **2**, 81–98, https://doi.org/10.1177/2053019614564785.
- ——, and Coauthors, 2018: Trajectories of the Earth System in the Anthropocene. *PNAS*, **115**, 8252–8259, https://doi.org/10.1073/pnas.1810141115.
- Wang-Erlandsson, L., and Coauthors, 2022: A planetary boundary for green water. *Nat Rev Earth Environ*, **3**, 380–392, https://doi.org/10.1038/s43017-022-00287-8.

Les 9 limites planétaires*



https://www.statistiques.developpement-durable.gouv.fr/edition-numerique/la-france-face-aux-neuf-limites-planetaires/

Sélection BD grand public