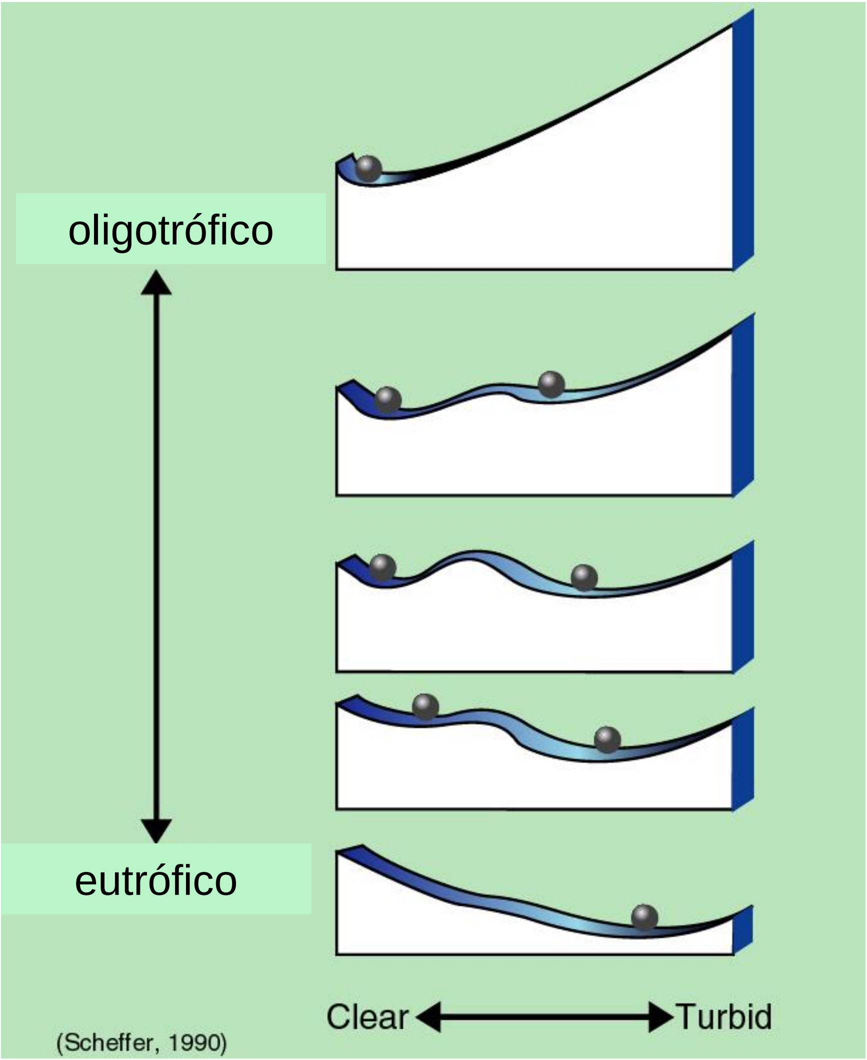
Y qué pasa con la Eutrofización con el Cambio climático?

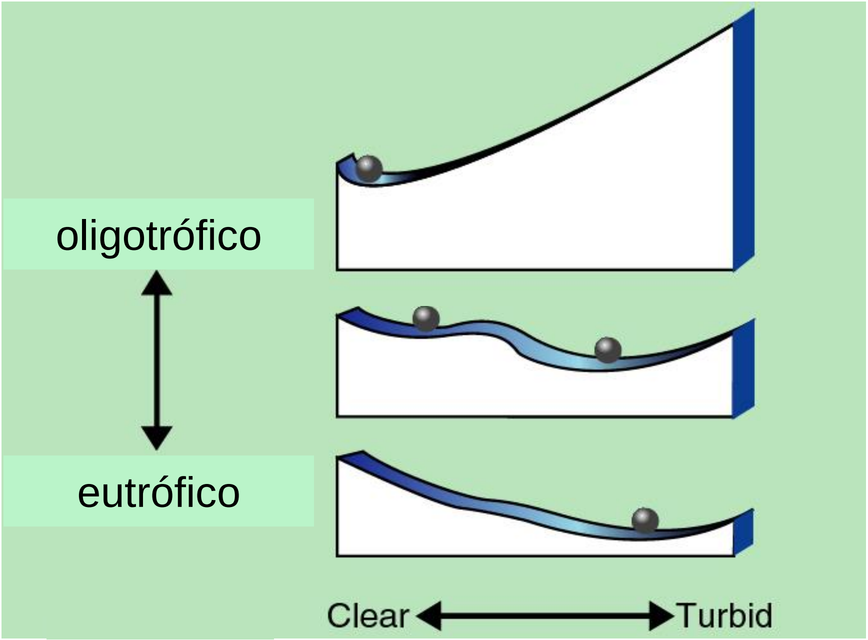
Mariana Meerhoff

Depto Ecología y Gestión Ambiental CURE, UDELAR

Curso: Eutrofización y biogeoquímica ambiental del P (2024)

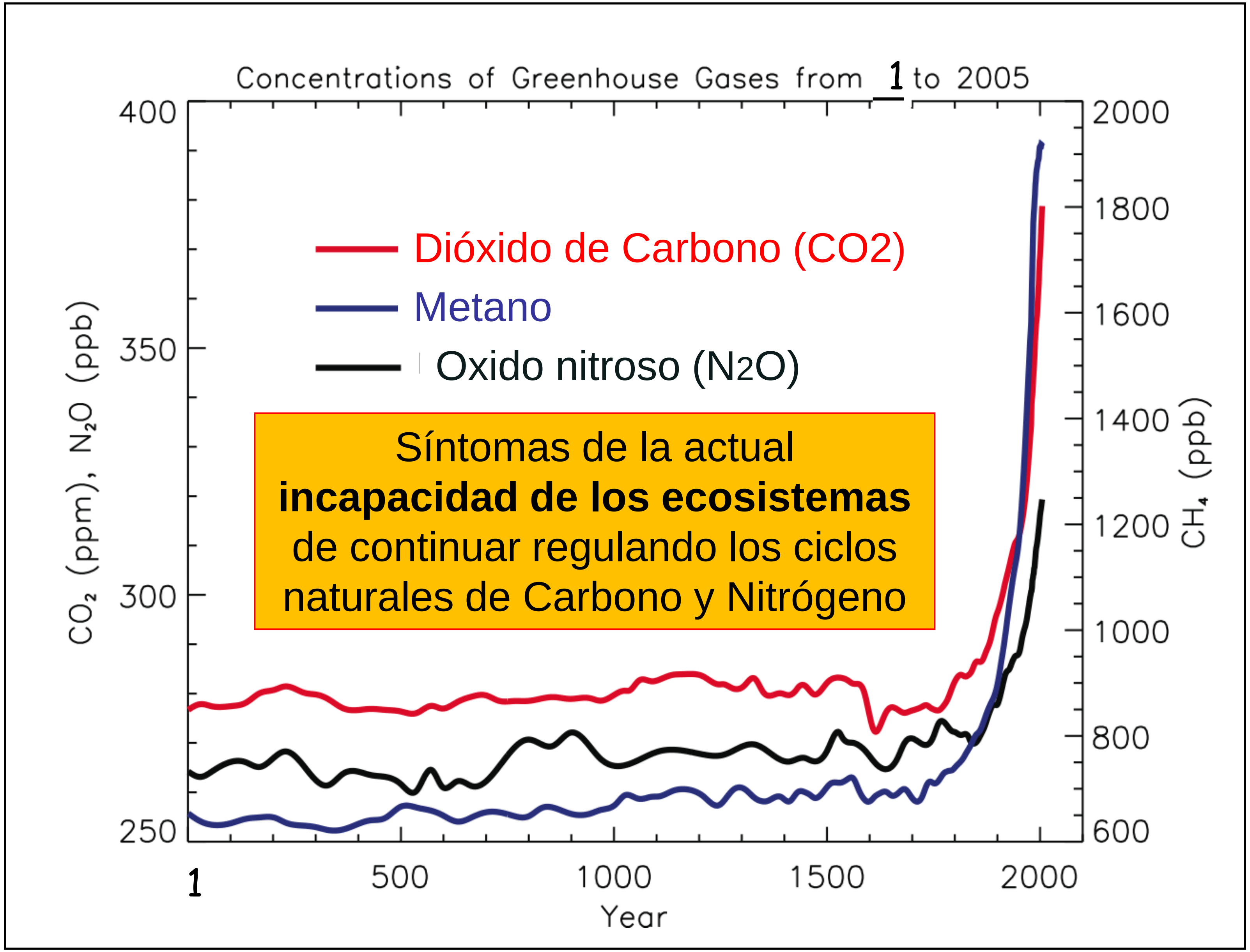
2do Mensaje: La mayor temperatura también disminuye la resiliencia de los ecosistemas





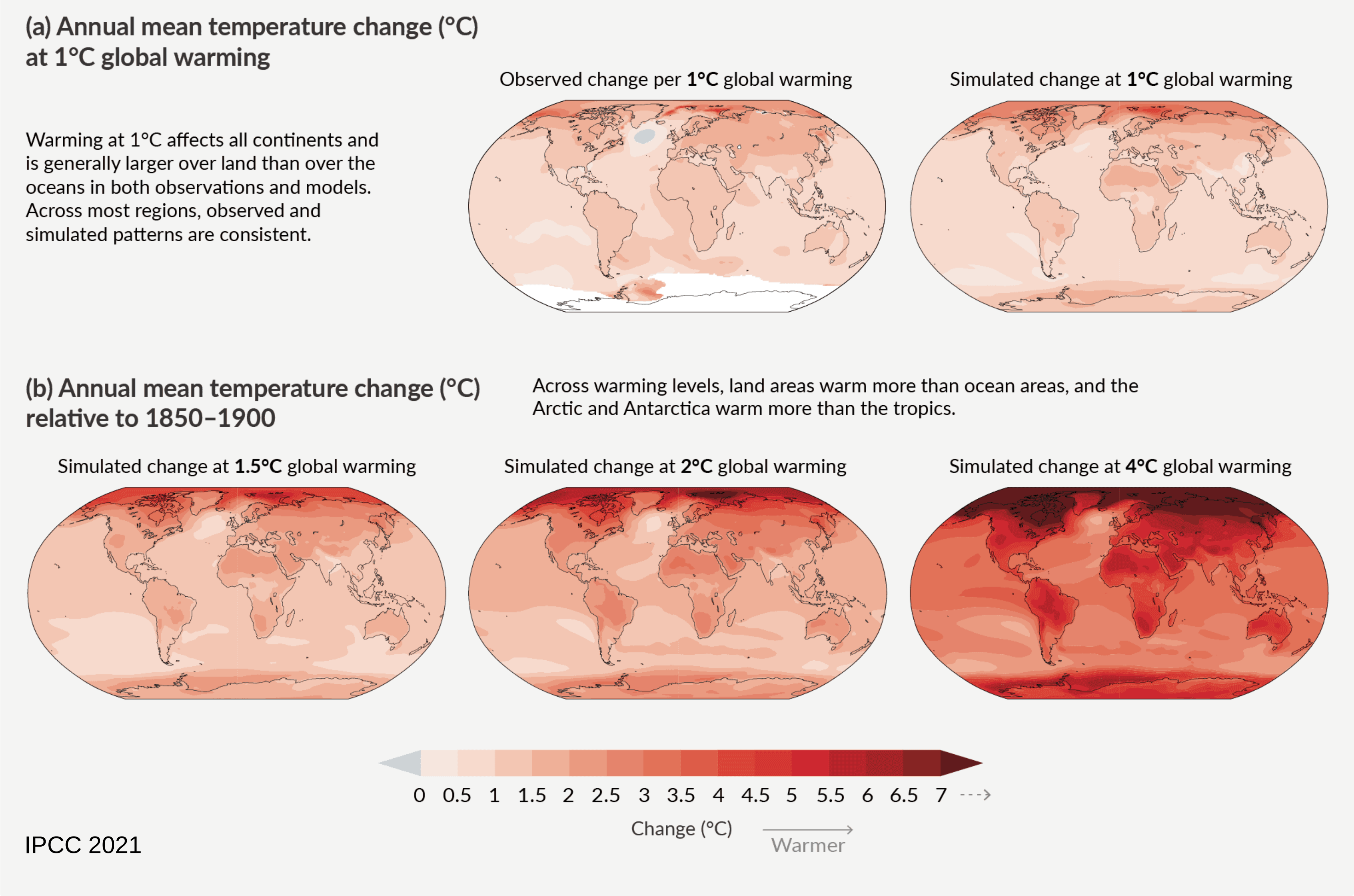
Menor estabilidad del "estado de agua clara" en ecosistemas subtropicales

Menor concentración umbral de nutrientes para evitar cambio de estado



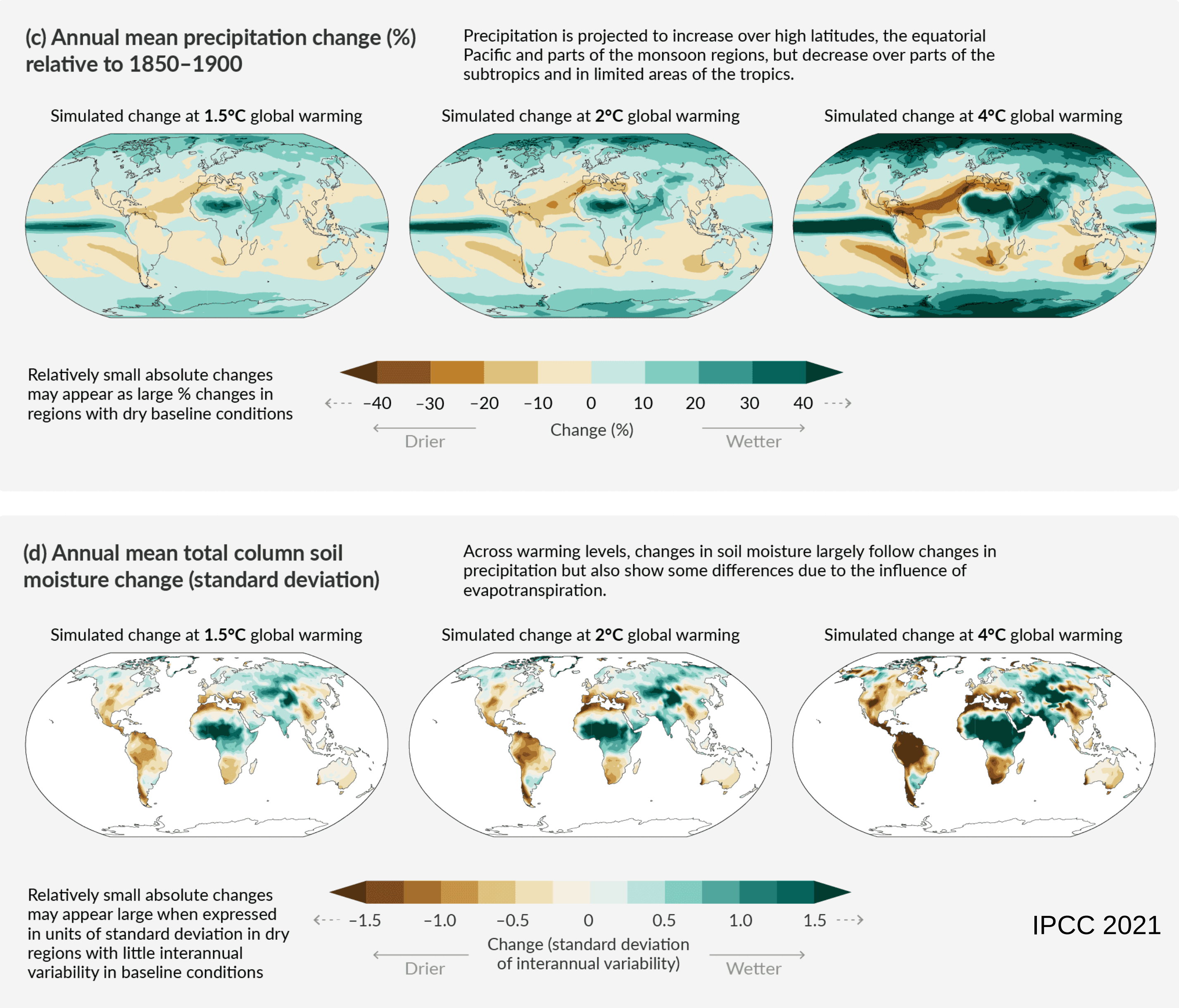
Concentrations of Greenhouse Gases from 1 to 2005
Dióxido de Carbono (CO2)
Metano
Oxido nitroso (N2O)
Síntomas de la actual incapacidad de los ecosistemas de continuar regulando los ciclos naturales de Carbono y Nitrógeno
CO_2 (ppm), N_2O (ppb)
CH_4 (ppb)
Year
400
350
300
250
2000
1800
1600
1400
1200
1000
800
600
1
500
1000
1500
2000

Respuestas regionales a cada incremento de Calentamiento Global: temperatura media



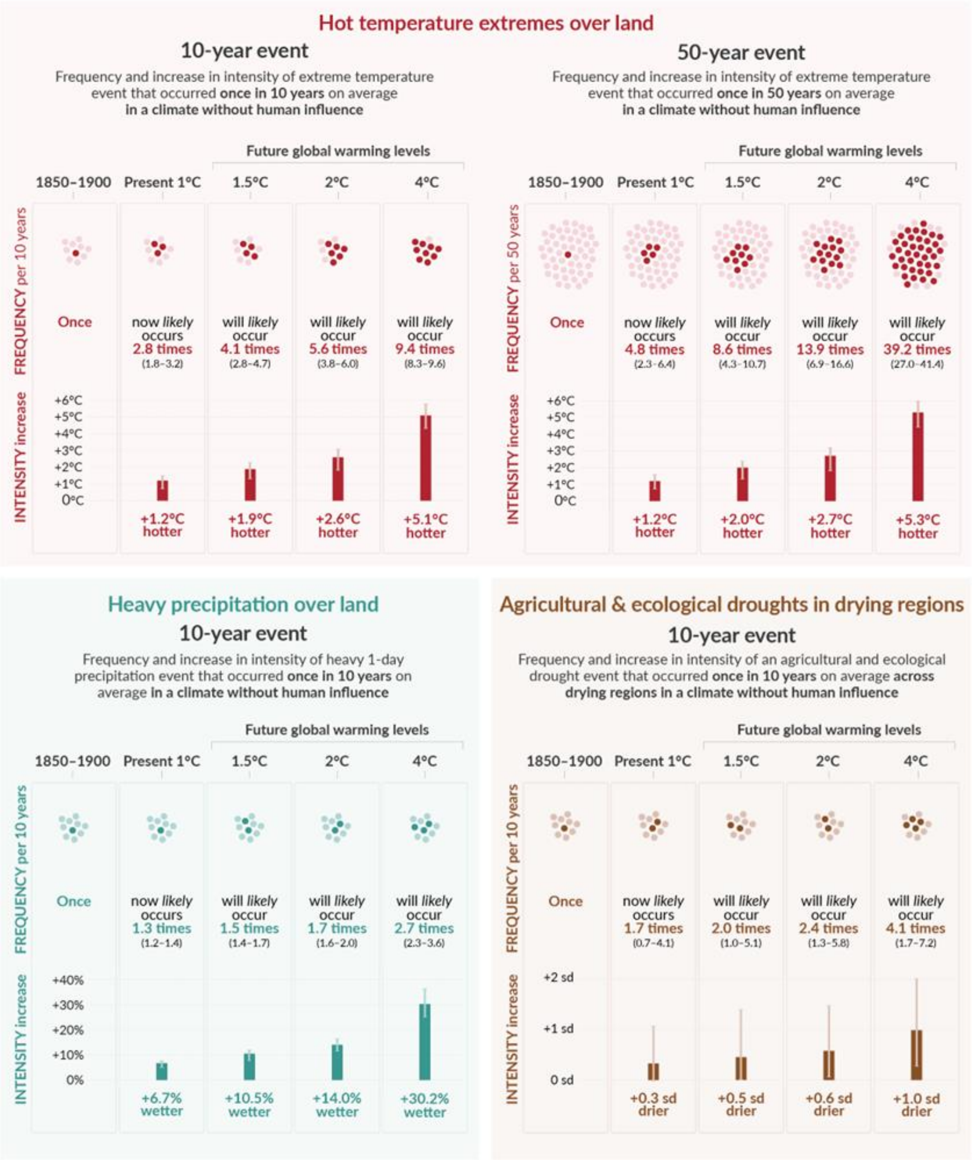
IPCC 2021

Respuestas regionales a cada incremento de Calentamiento Global: precipitación media



IPCC 2021

Respuestas a cada incremento de Calentamiento Global: valores extremos



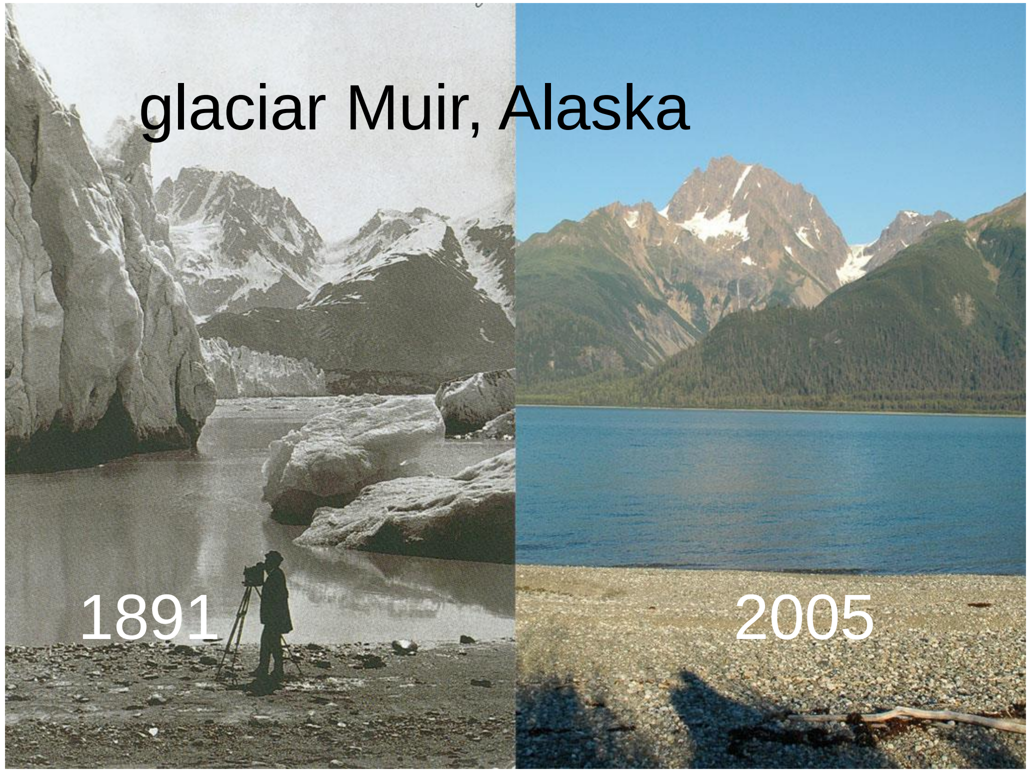
Mayor frecuencia de ocurrencia y magnitude, con variación no lineal por cada incremento de temperatura:

Temperaturas altas extremas terrestres

Precipitaciones Fuertes terrestres

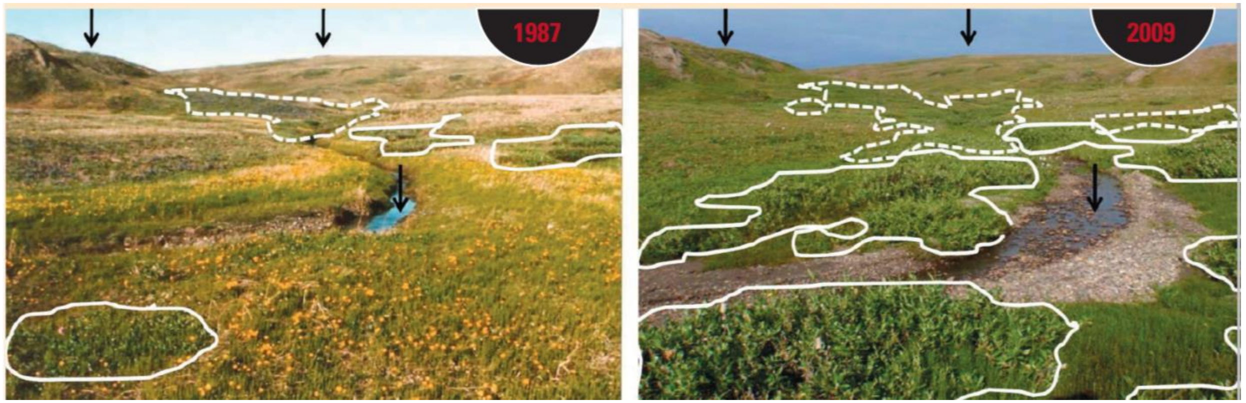
Sequías agrometeorológicas y ecológicas en regiones áridas

IPCC 2021

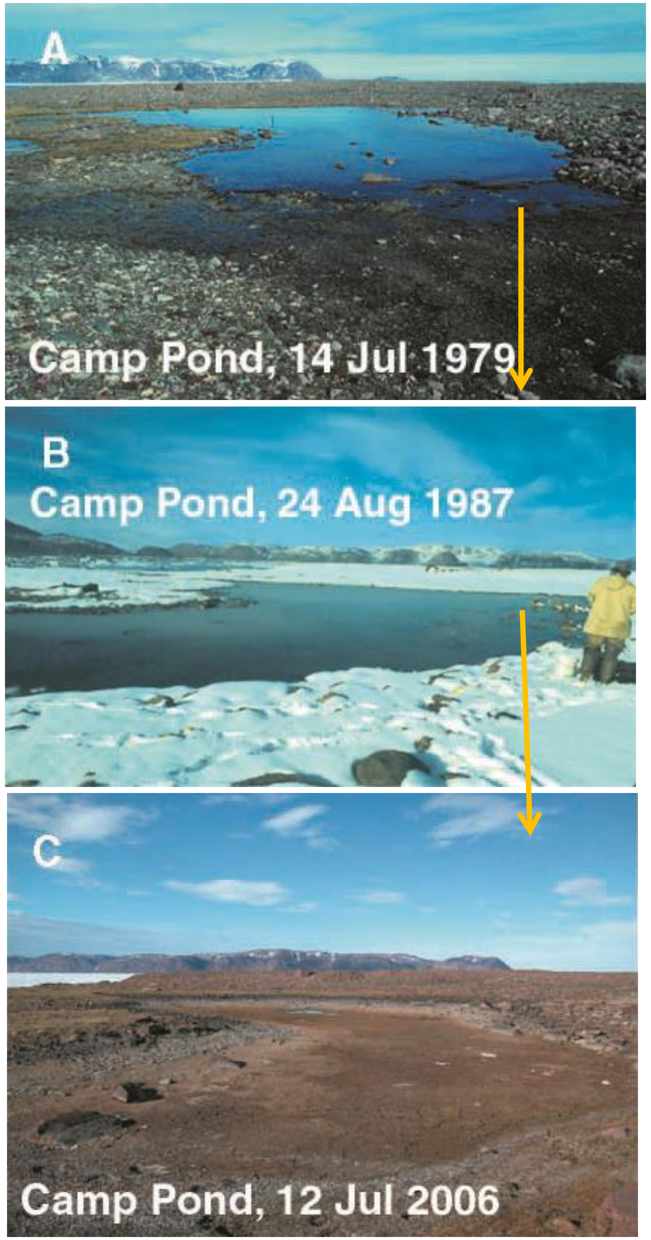


Oerlemans 2005

Tundra



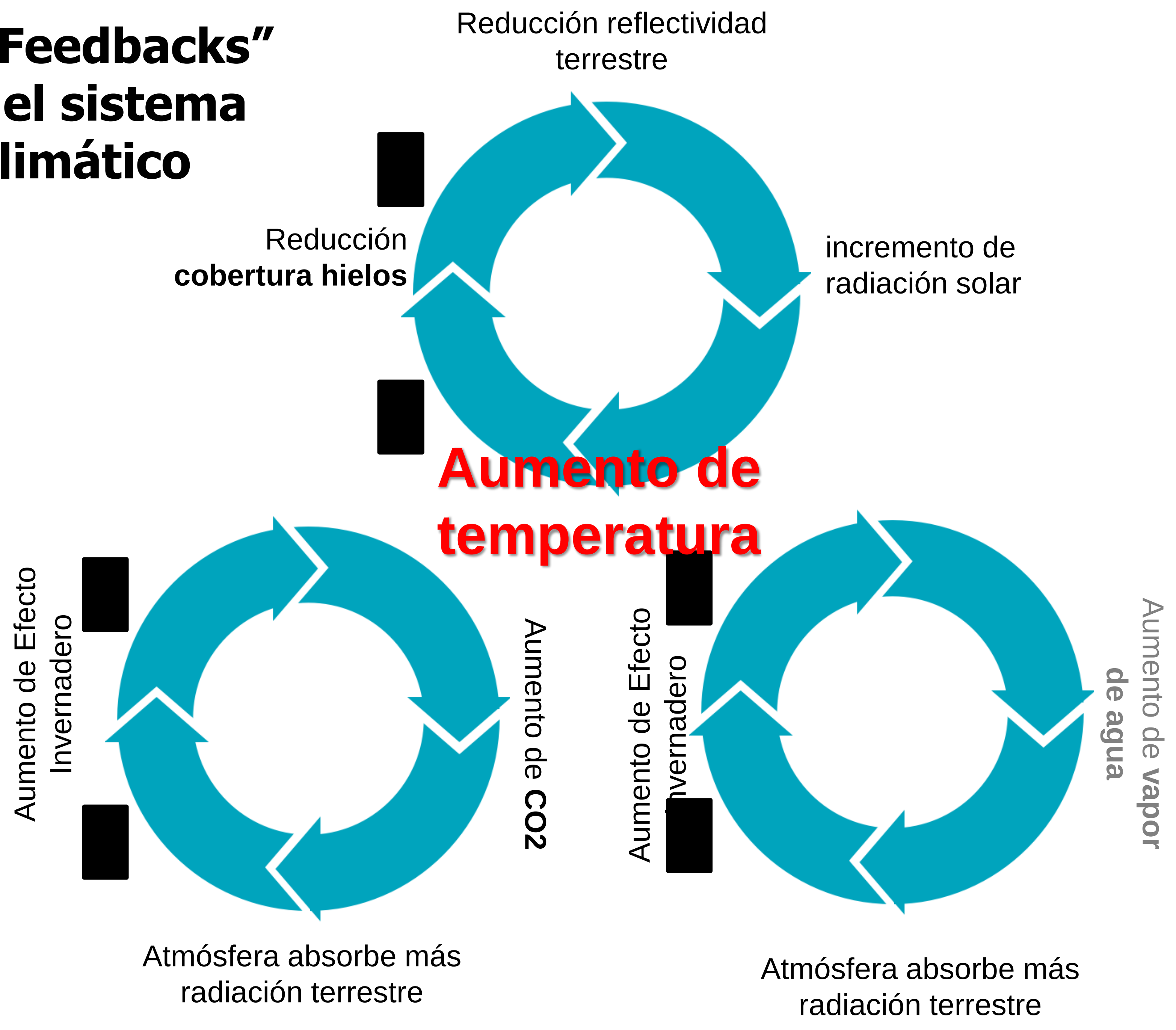
Science 2013



fotos John Smol


www.limnology.metu.edu.tr
20 m
M. Beklioğlu, Turquía

"Feedbacks" del sistema climático



QUÉ PODEMOS ESPERAR PARA LA EUTROFIZACIÓN CON EL CAMBIO CLIMÁTICO?

Menor almacenamiento de agua

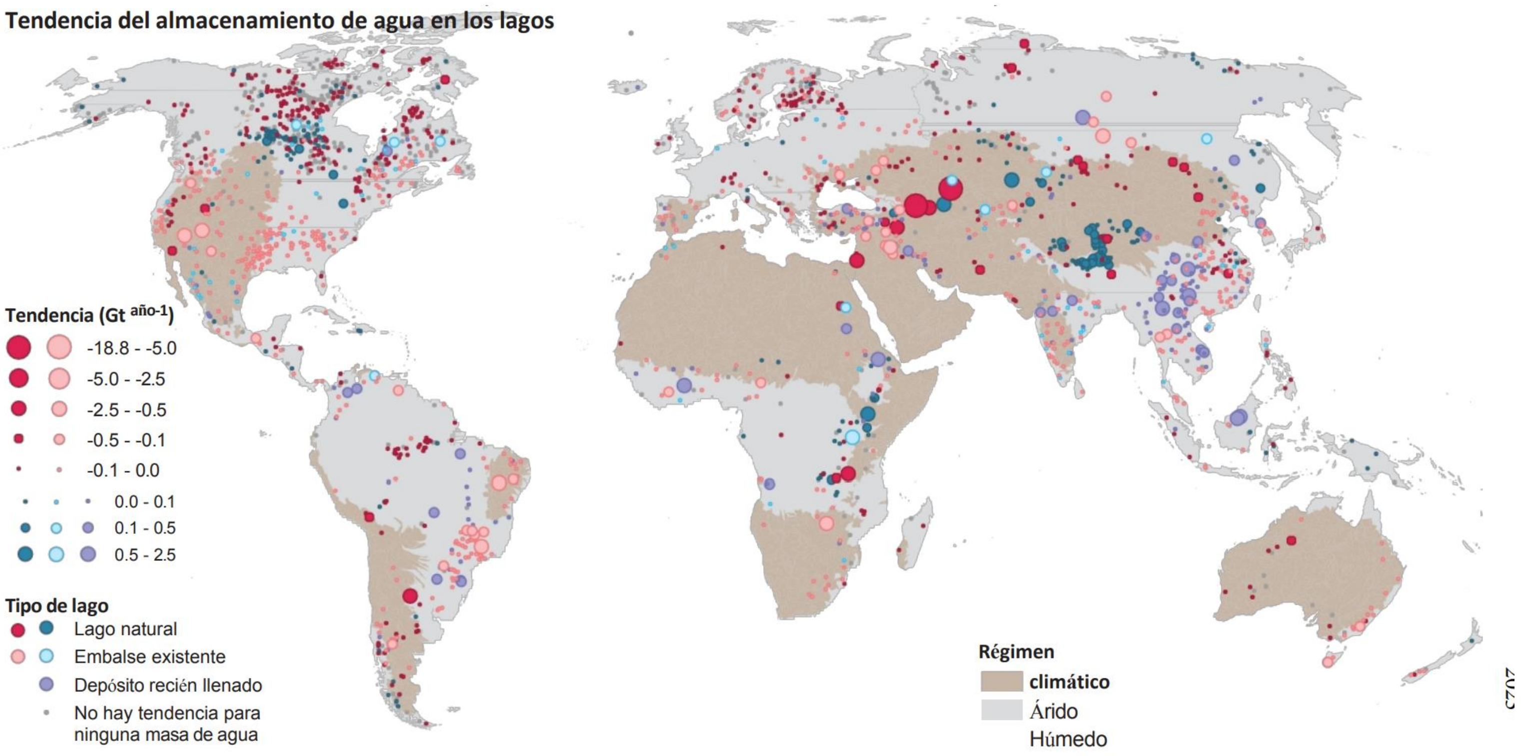
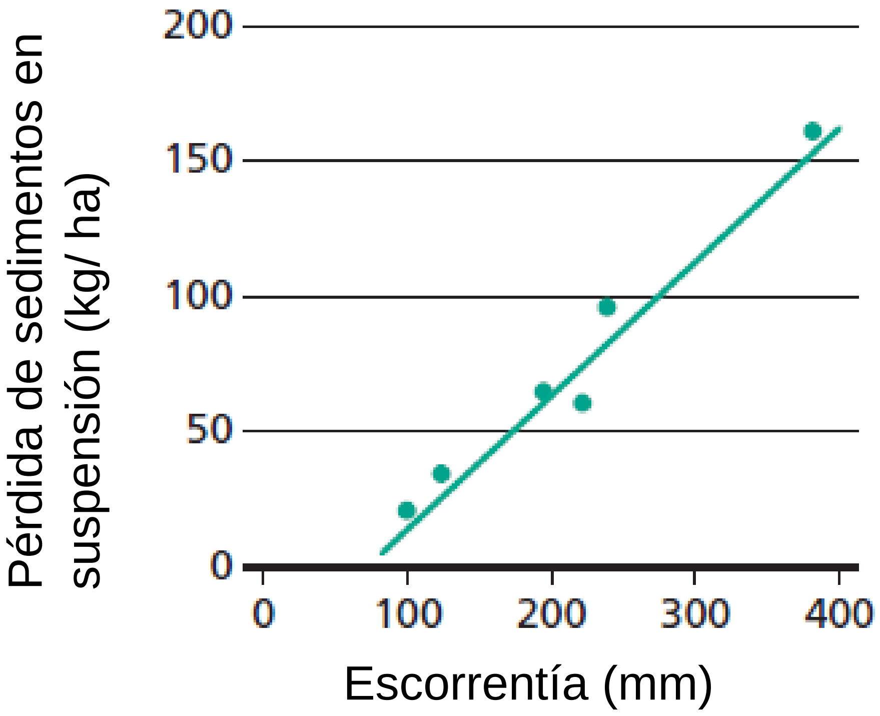


Fig. 1. Disminución generalizada del almacenamiento en los grandes lagos del mundo desde octubre de 1992 hasta septiembre de 2020. Tendencias del almacenamiento de agua en 1058 lagos naturales (puntos rojo oscuro y azul oscuro) y 922 embalses (puntos rojo claro y azul claro). Los embalses llenados recientemente, después de 1992, se indican con puntos morados claros. Todos los colores

Los puntos indican tendencias estadísticamente significativas ($p < 0,1$), mientras que los puntos grises indican tendencias no significativas. Clasificación de los regímenes climáticos entre áridos y regiones húmedas se realizó mediante el índice de aridez [relación entre la precipitación media anual y la evapotranspiración potencial media anual (materiales y métodos)].

Yao y colaboradores 2023
Science.

Interacción clima y cobertura suelo



Una **escorrentía superficial** importante provoca un aumento rápido del caudal, generando **gran erosión** del suelo.

Efecto diferencial de las precipitaciones según uso del suelo:

Suelos con **gran capacidad de infiltración** fluctúan menos, y promueven **menor transporte de sedimento y nutrients hacia cuerpos de agua**.

Y viceversa

Cambios predichos en escorrentía superficial + 30-40% a - 30-40% en 2040-60

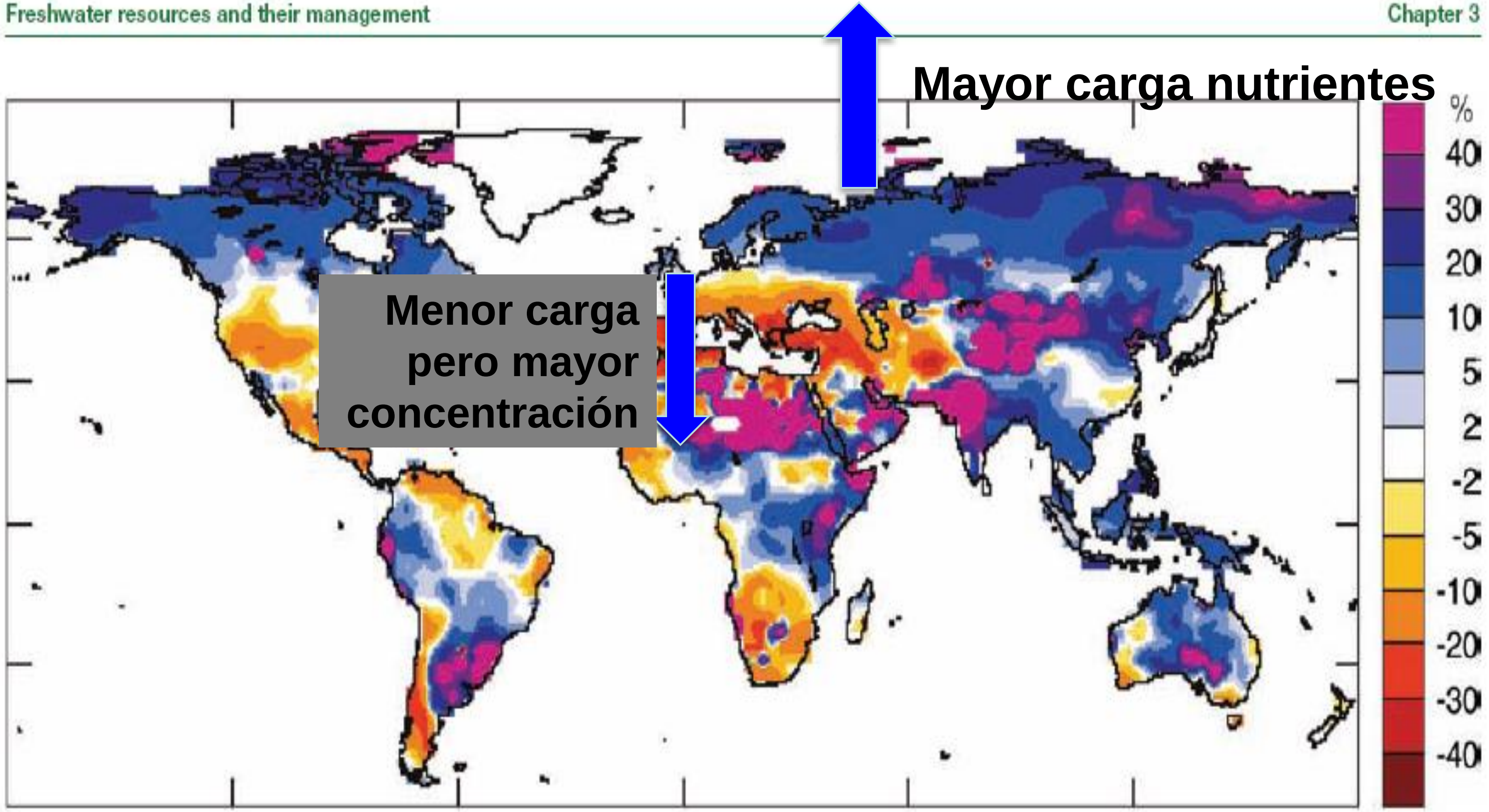
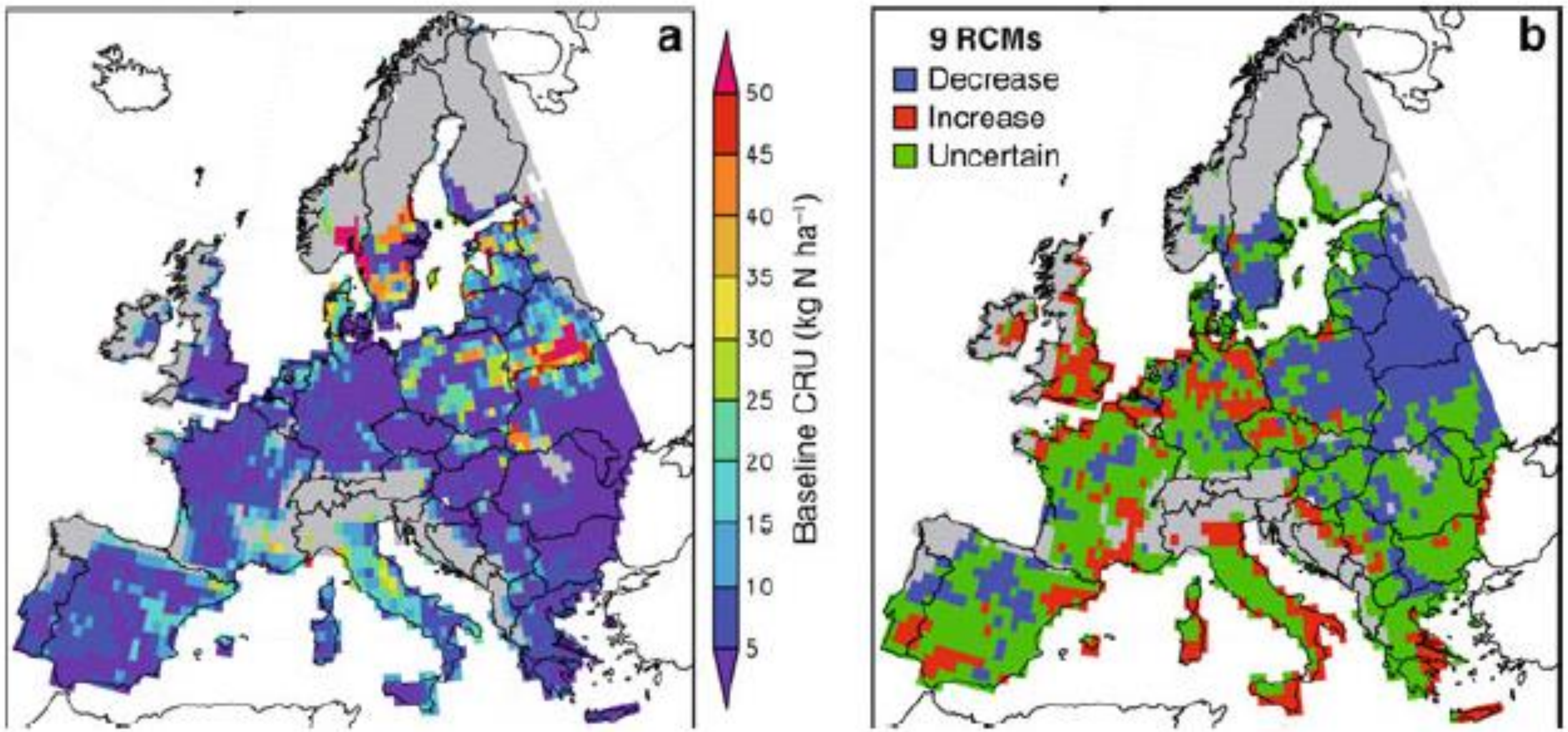


Figure 3.4. *Change in annual runoff by 2041-60 relative to 1900-70, in percent, under the SRES A1B emissions scenario and based on an ensemble of 12 climate models. Reprinted by permission from Macmillan Publishers Ltd. [Nature] (Milly et al., 2005), copyright 2005.*

Predicción: Aumento de liberación de N de cultivos a arroyos y lagos



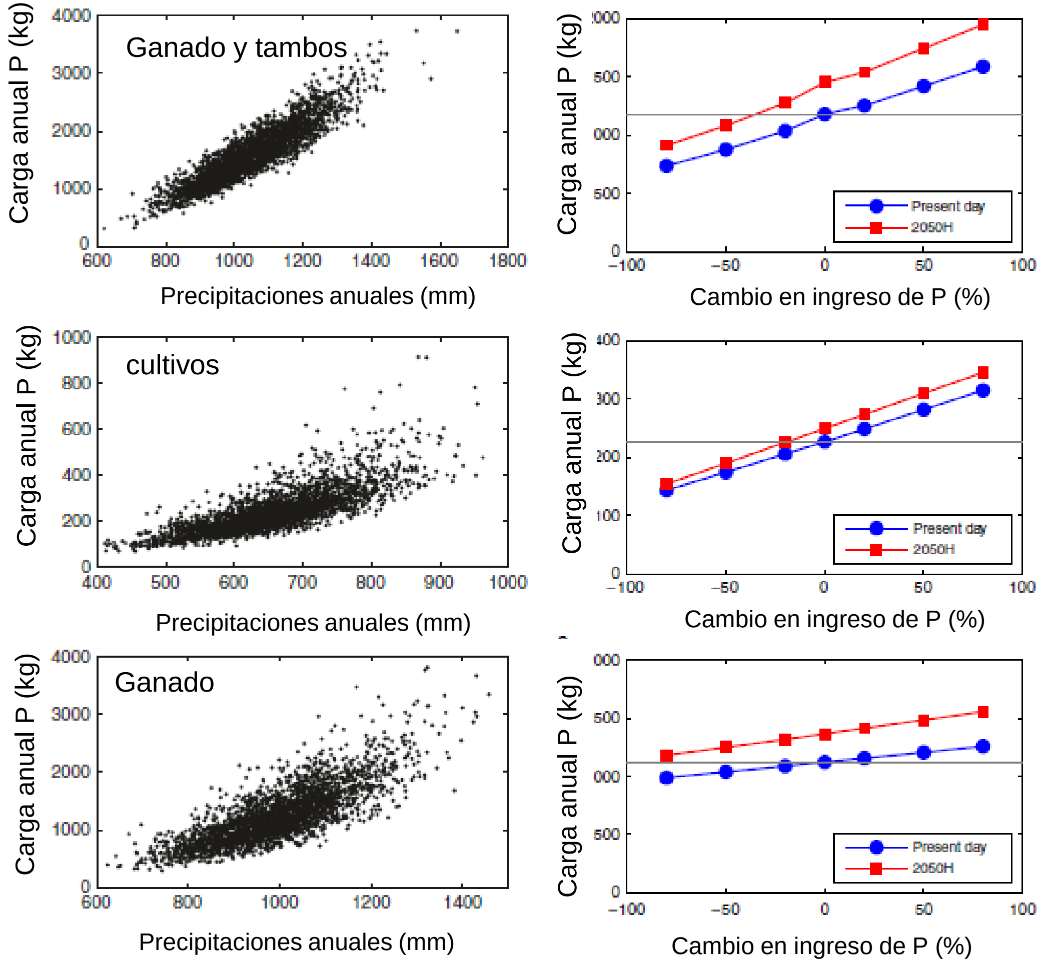
Con fertilización óptima, la liberación dependerá de clima futuro

Jeppesen et al. 2011 Hydrobiol., Olesen et al. 2007

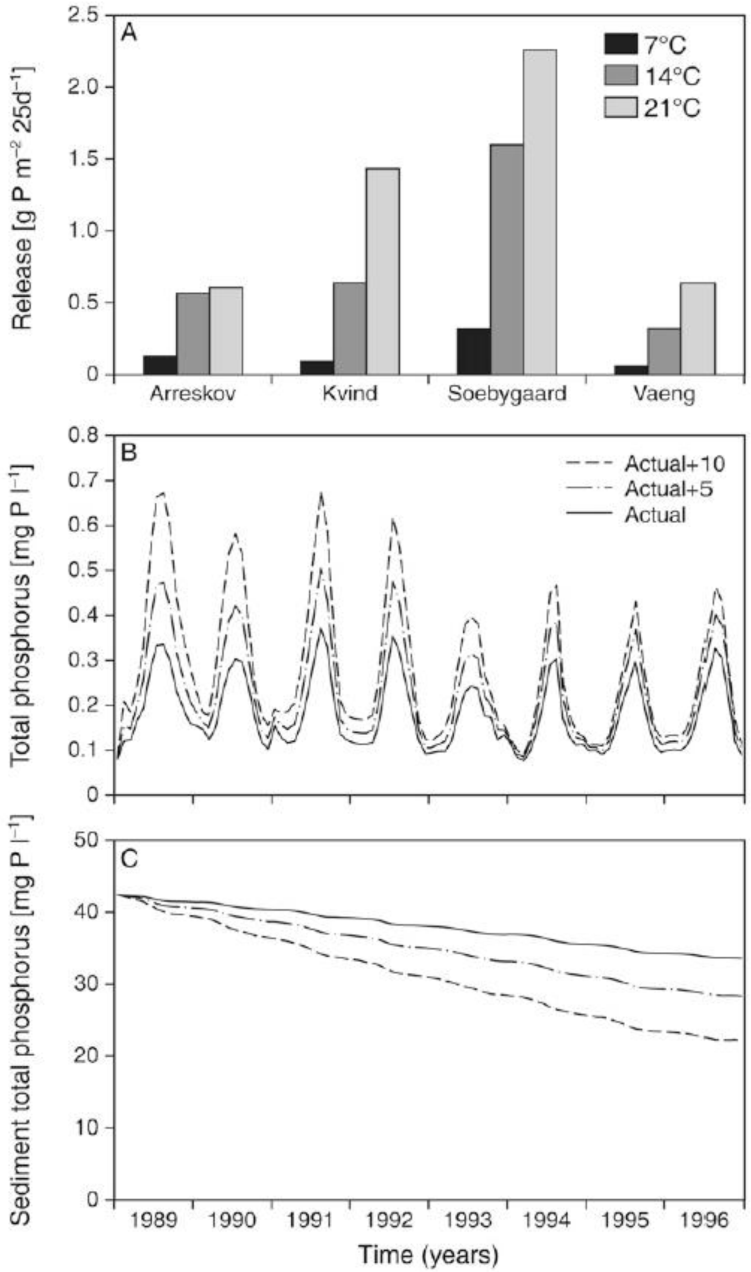
Futuro aumento de precipitaciones:

Mayor transporte de P en cuencas dominadas por agua superficial, en todos los usos del suelo
(2050-rojo versus hoy-azul)

Ockenden et al. 2017 Nature



Predicciones para la carga interna de P



Aumento de temperatura

Aumento liberación de P desde sedimentos y consecuente aumento de concentración de P en agua

(modelos + experimentos)

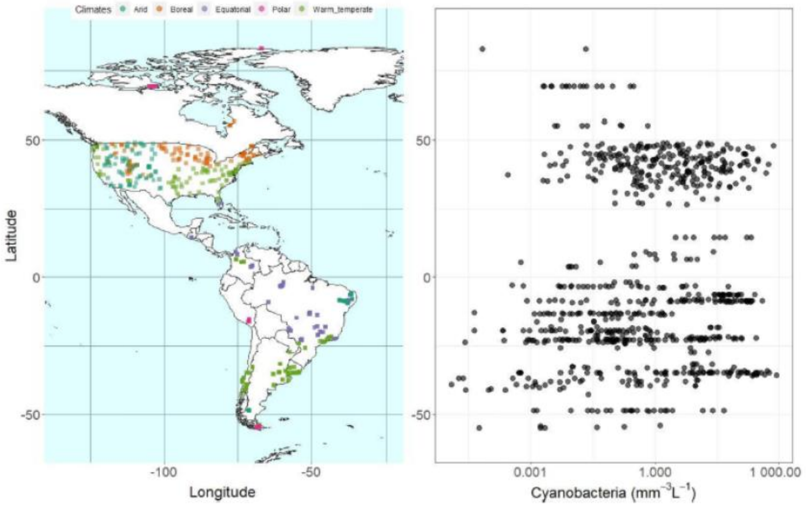
Jeppesen et al. 2009 J.Environ.Qual

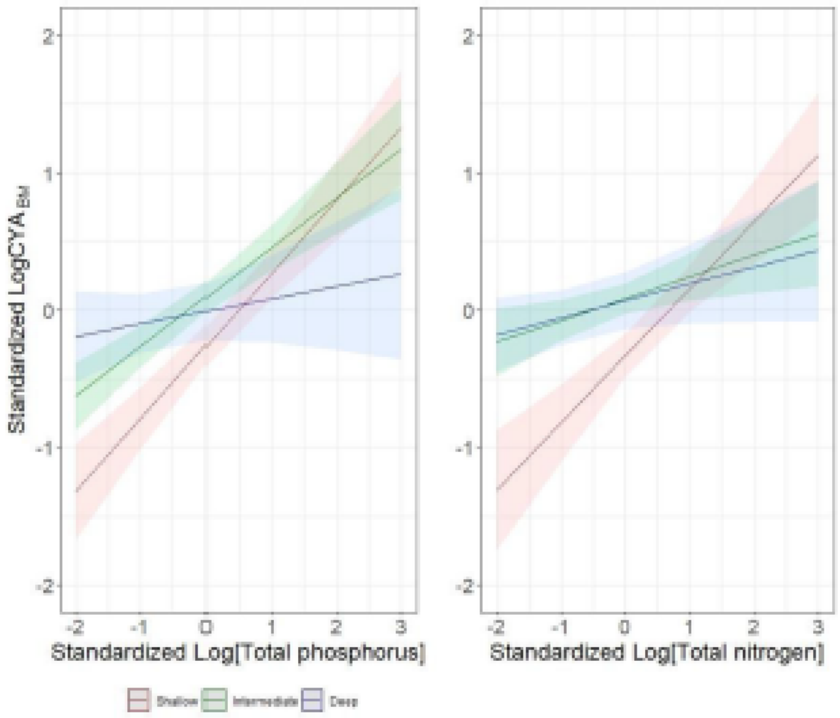
Y QUÉ ESPERAR PARA LAS FLORACIONES DE CIANOBACTERIAS CON EL CAMBIO CLIMÁTICO?

Antes que el calentamiento climático, los nutrientes...

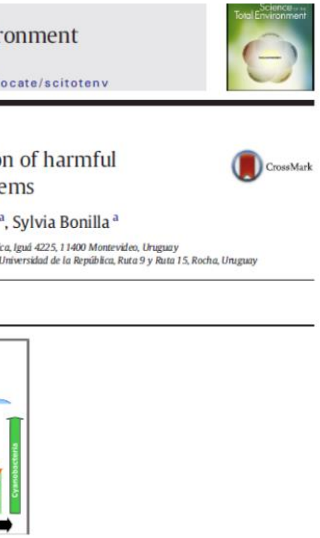
Nutrients and not temperature are the key drivers for cyanobacterial biomass in the Americas

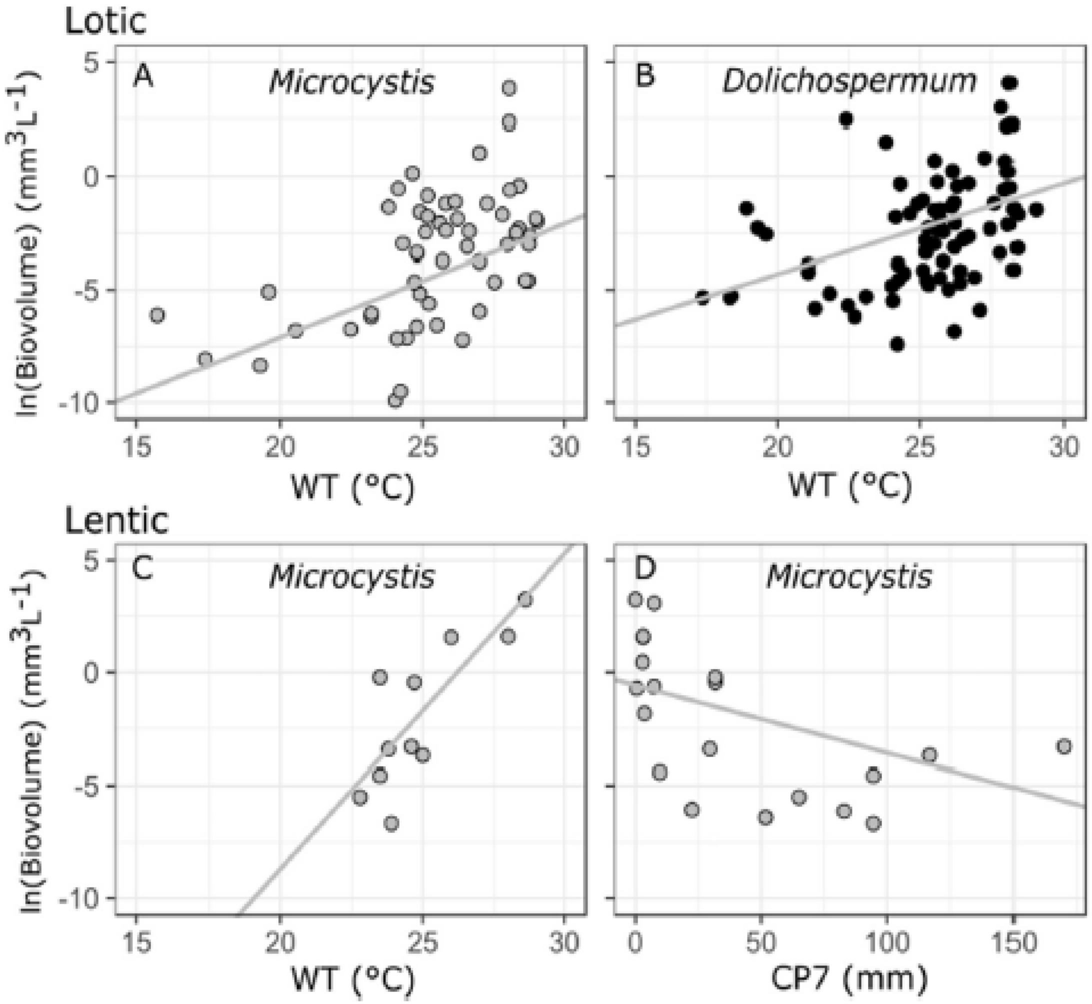
Sylvia Bonilla[a,*], Anabella Aguilera[b], Luis Aubriot[a], Vera Huszar[c], Viviana Almanza[d], Signe Haakonsson[a], Irina Izaguirre[e], Inés O'Farrell[e], Anthony Salazar[f], Vanessa Becker[g], Bruno Cremella[h], Carla Ferragut[i], Esnedy Hernandez[j], Hilda Palacio[k], Luzia Cleide Rodrigues[l], Lúcia Helena Sampaio da Silva[c], Lucineide Maria Santana[i], Juliana Santos[c], Andrea Somma[a], Laura Ortega[l], Dermot Antoniades[m]





Pero cianobacterias sí responden a temperatura y precipitaciones





Hakonsson et al. 2018 STOTEN

Efectos calentamiento climático sobre condiciones físicas lagos

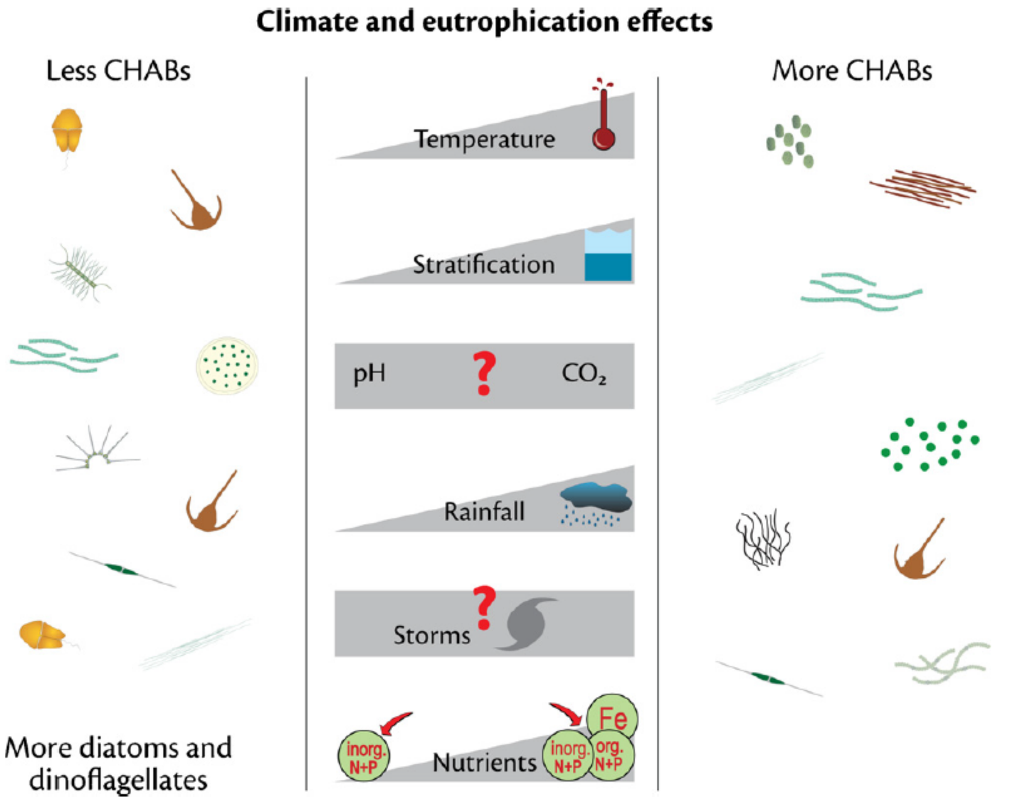


Fig. 2. Eutrophication and potenital effects of climate change on Cyanobacterial Harmful Algal bloom (CHAB) abundance.

Global Change Biology

Global Change Biology (2012) **18**, 118–126, doi: 10.1111/j.1365-2486.2011.02488.x

Warmer climates boost cyanobacterial dominance in shallow lakes

SARIAN KOSTEN*‡‡‡, VERA L. M. HUSZAR†, ELOY BÉCARES‡, LUCIANA S. COSTA†, ELLEN VAN DONK§, LARS-ANDERS HANSSON¶, ERIK JEPPESEN‖***†††, CARLA KRUK**, GISSELL LACEROT**, NÉSTOR MAZZEO††, LUC DE MEESTER‡‡, BRIAN MOSS§§, MIQUEL LÜRLING*, TIINA NÕGES¶¶§§§, SUSANA ROMO‖‖ and MARTEN SCHEFFER*

CLIMATE

Blooms Like It Hot

Hans W. Paerl[1] and Jef Huisman[2]

A link exists between global warming and the worldwide proliferation of harmful cyanobacterial blooms.

Nutrient overenrichment of waters by urban, agricultural, and industrial development has promoted the growth of cyanobacteria as harmful algal blooms (see the figure) (*1*, *2*). These blooms increase the turbidity of aquatic ecosystems, smothering aquatic plants and thereby suppressing important invertebrate and fish habitats. Die-off of blooms may deplete oxygen, lakes to stratify earlier in spring and destratify later in autumn, which lengthens optimal growth periods. Many cyanobacteria exploit these stratified conditions by forming intracellular gas vesicles, which make the cells buoyant. Buoyant cyanobacteria float upward when mixing is weak and accumulate in dense surface blooms (*1*, *2*, *7*) (see the figure). These surface blooms shade underlying nonbuoyant

Harmful Algae 14 (2012) 313–334

Contents lists available at SciVerse ScienceDirect

Harmful Algae

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

The rise of harmful cyanobacteria blooms: The potential roles of eutrophication and climate change

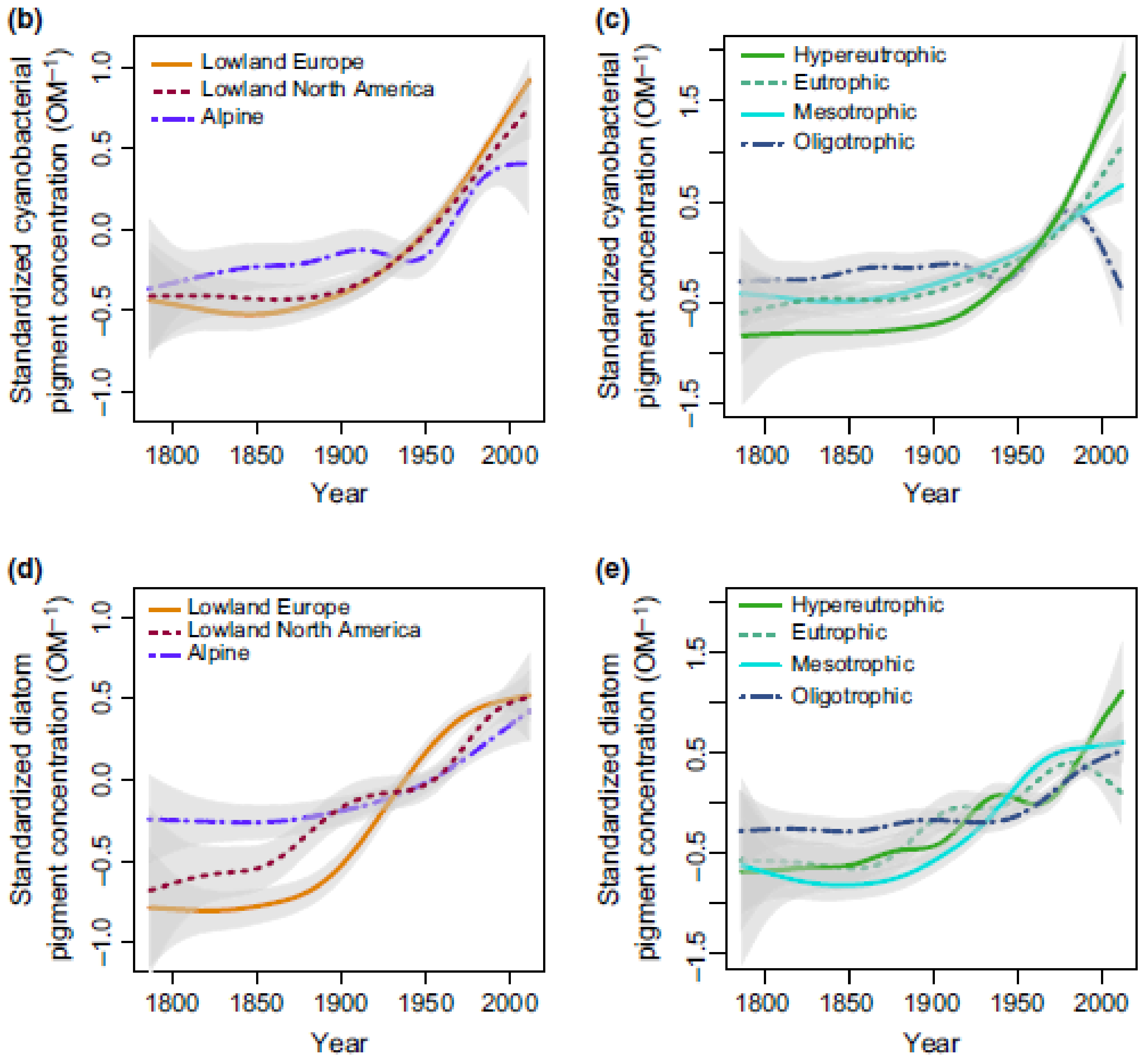
J.M. O'Neil[a,*], T.W. Davis[b], M.A. Burford[b], C.J. Gobler[c]

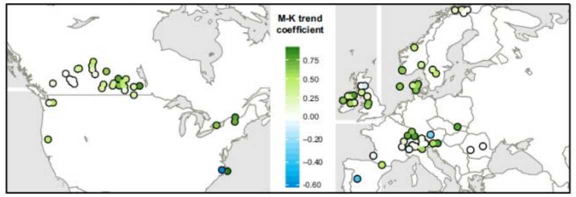
Expectativas y evidencia sobre efectos del calentamiento sobre comunidades clave y sobre interacciones, según distintas aproximaciones

	Theoretical expectations	Palaeo	SFTS	Time series	Heating expectations	Models
Sediment resuspension	Increased if more precipitation and changes in fish community					Deeper thermocline and changes in mixing (4,34)
Internal loading	Increased due to higher decomposition rate and sediment release with temp.				Increased phosphorus (25,27)	Increased phosphorus (4,26,36,44)
Competition	Enhanced due to higher metabolism					Faster nutrient limitation for nutrients to phytoplankton (13,34)
Competition for light	Enhanced due to increased turbidity (more runoff, mixing regime, change in trophic structure)	Enhanced (54)		Enhanced (3)		Enhanced (deep lakes, 34)
Submerged plant biomass	Depends on theory and on balance between direct and indirect effects		Reduced biomass in cold lakes and higher sensitivity to nutrients (30)	Reduced in cold lakes (due to lower fish kills with warming) (22)	No effect (15, 38)	Decreased due to increasing turbidity (44,50)
Free-floating plant biomass	Increased due to higher air temp.				Increased (15, 48)	
Phytoplankton biomass	Depends on theory and outcome of direct and indirect factors	Increased (54,55)	No clear latitudinal effect (42)	Increased (9)	Increased (28); no effect (15,47); decrease (32,60); effect depending on trophic length (21)	Increased (36,44,59); no annual change but increase in spring (13)
Cyanobacteria	Enhanced biomass		Increased (27,31,42)	Increased (9,27)	Increased (11,21); no effects (47); no competitive advantage (35)	Increased (1,11,13,50,59)
Allelopathy	Likely enhanced due to enhanced metabolism				Increased (filamentous algae on phytoplankton) (57)	
Fish assemblage	Smaller fish; enhanced omnivoroy		Smaller size (7,28,40,56); increased omnivory (18,40,46,55)	Reduced size (10,28); changes in community composition (29)	Decreased biomass (45); decreased fitness (24)	Increased predation capacity (23,43); changes in distribution (52)
Grazing macro-invertebrates	Smaller invertebrates, reduced densities		Reduced densities (6, 40)	Unclear effects (2); changes in community composition (8)	Unclear effects (2); no effects on densities (14, 39); differential seasonal effects on size (12); advanced phenology (19)	
Zooplankton	Smaller size, reduced biomass and lower grazing capacity	Increased pelagic taxa (54); smaller taxa (49)	Reduced size and grazing capacity (5, 17, 20, 33,41)		No clear effect (37, 51); enhanced grazing (32, 53)	Decreased abundance (44)
Refuge by plants to zooplankton	No prediction		Decreased (5, 41)			
Benthic/pelagic balance	Enhanced pelagic production	Increased pelagic (54, 57)			Increased pelagic production (53)	

Jeppesen et al. 2014 J.Limnol.

Cianobacterias: aumento en registro fósil





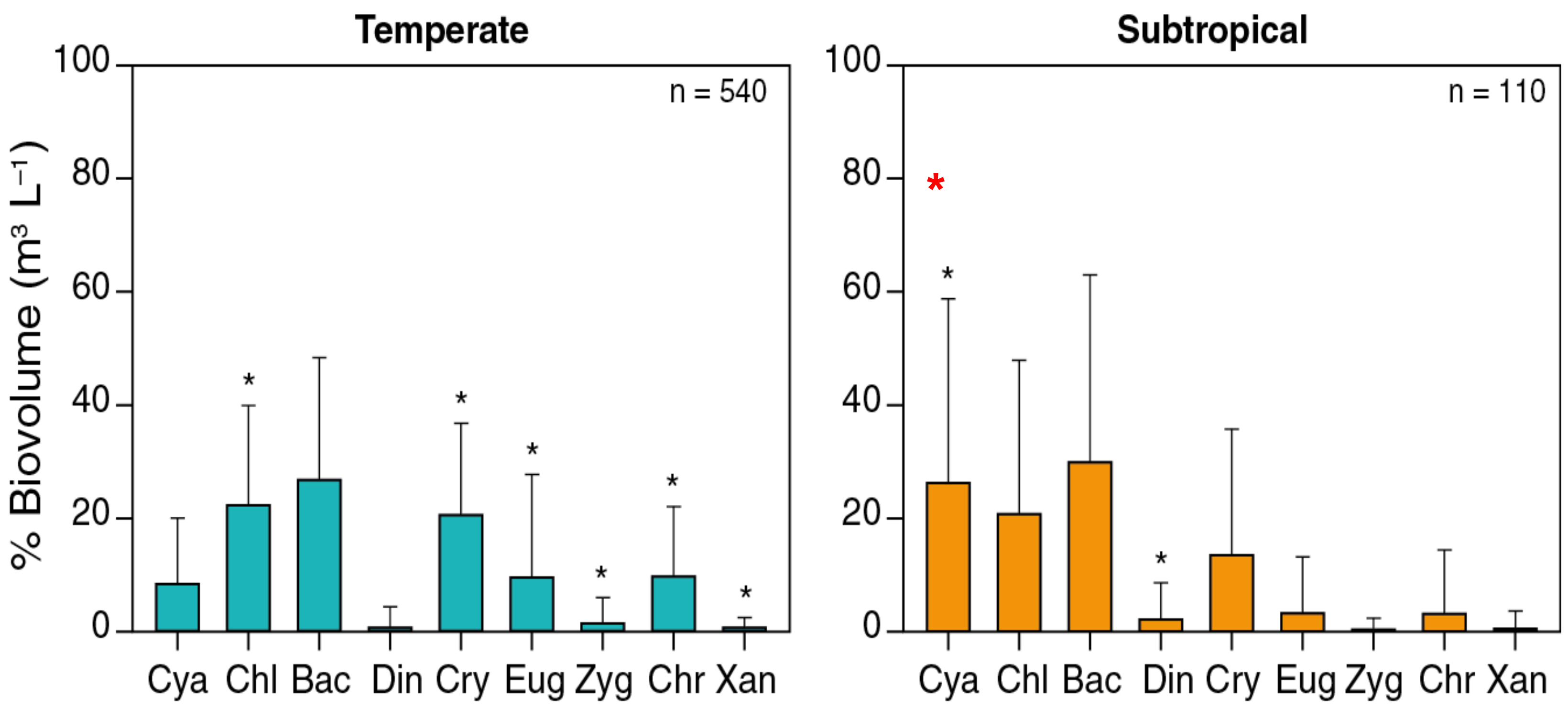
Ecology Letters, (2015) **18**: 375–384 doi: 10.1111/ele.12420

LETTER

Acceleration of cyanobacterial dominance in north temperate-subarctic lakes during the Anthropocene

Taranu et al. 2015

Cianobacterias: son más abundantes en lagos naturalmente cálidos



Meerhoff et al. 2012 (Adv. Ecol. Res.)

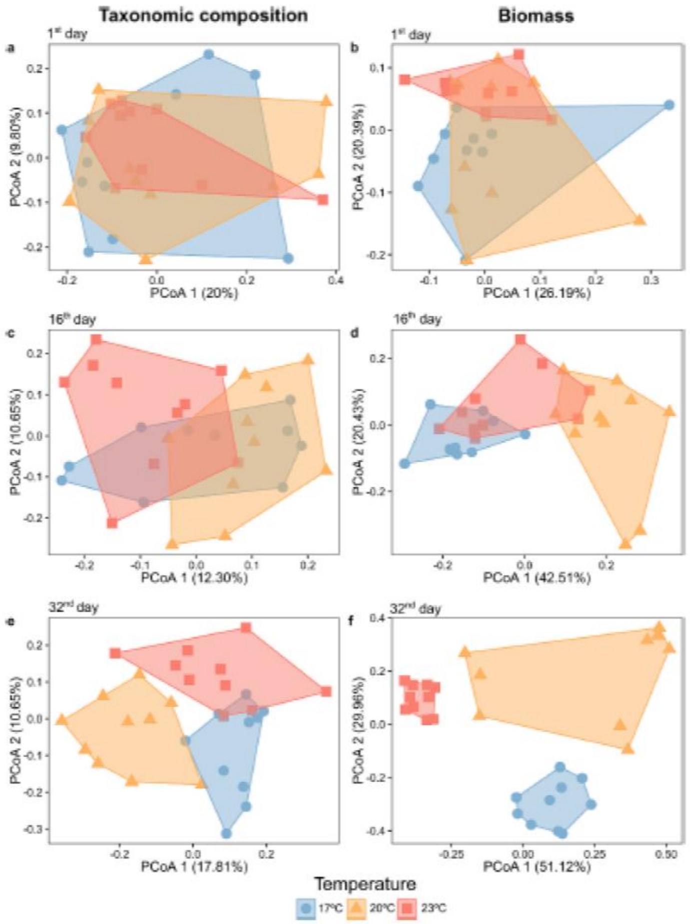
Kosten et al. 2012 Gl. Ch. Biol.

Cianobacterias: aumentan en experimentos


Contents lists available at ScienceDirect
Science of the Total Environment
journal homepage: www.elsevier.com/locate/scitotenv

Experimental warming promotes phytoplankton species sorting towards cyanobacterial blooms and leads to potential changes in ecosystem functioning

Geovani Arnhold Moresco [a], Juliana Déo Dias [b], Lucía Cabrera-Lamanna [c,d], Claudia Baladán [c], Mina Bizic [e,b], Luzia Cleide Rodrigues [a,f], Mariana Meerhoff [c,e,g,*]



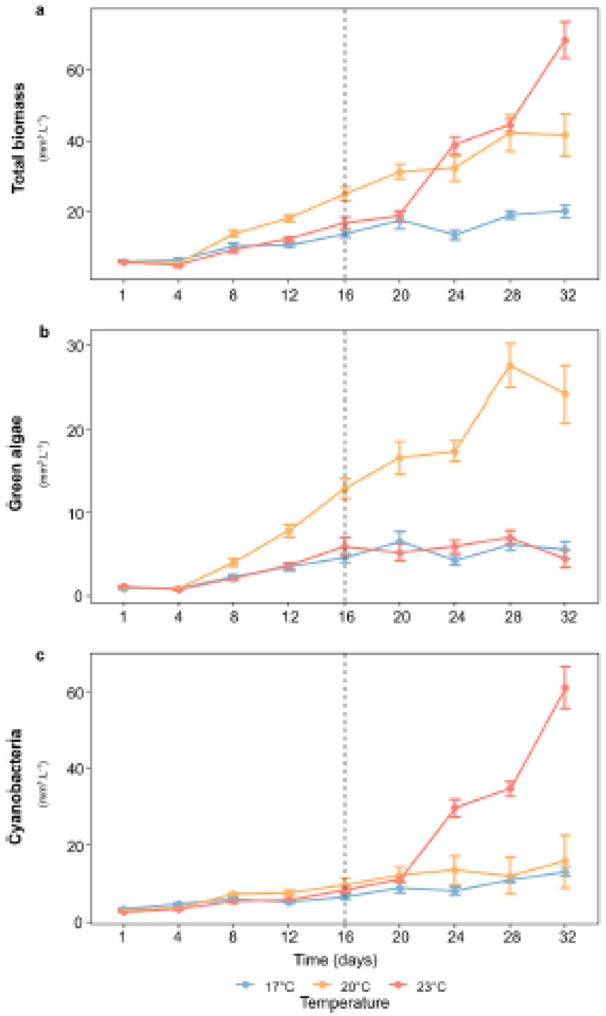


Fig. 3. Variation of phytoplankton biomass (as biovolume in $mm^3 L^{-1}$) with temperature through the 32 days of the experiment: total (a), green algae (b), cyanobacteria (c). The dotted line indicates when final temperatures were achieved (as from the 16th day). The central point denotes the mean value and whiskers represent standard error in each experimental day.

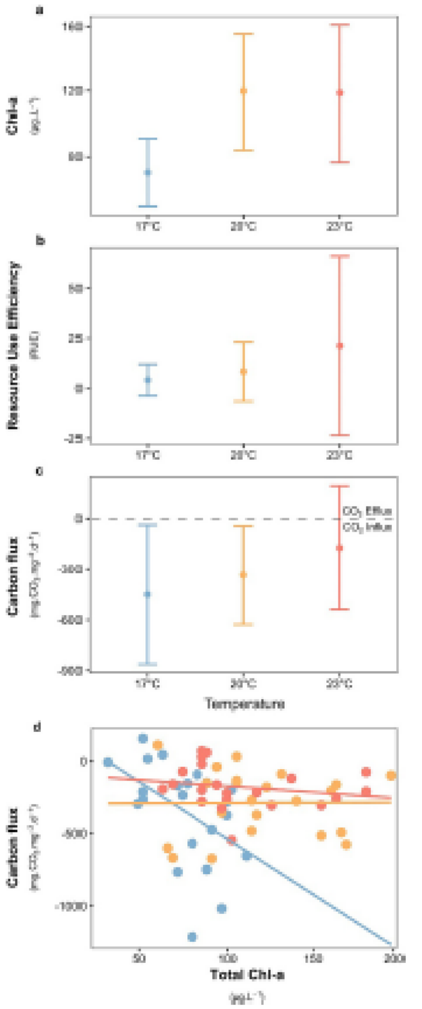
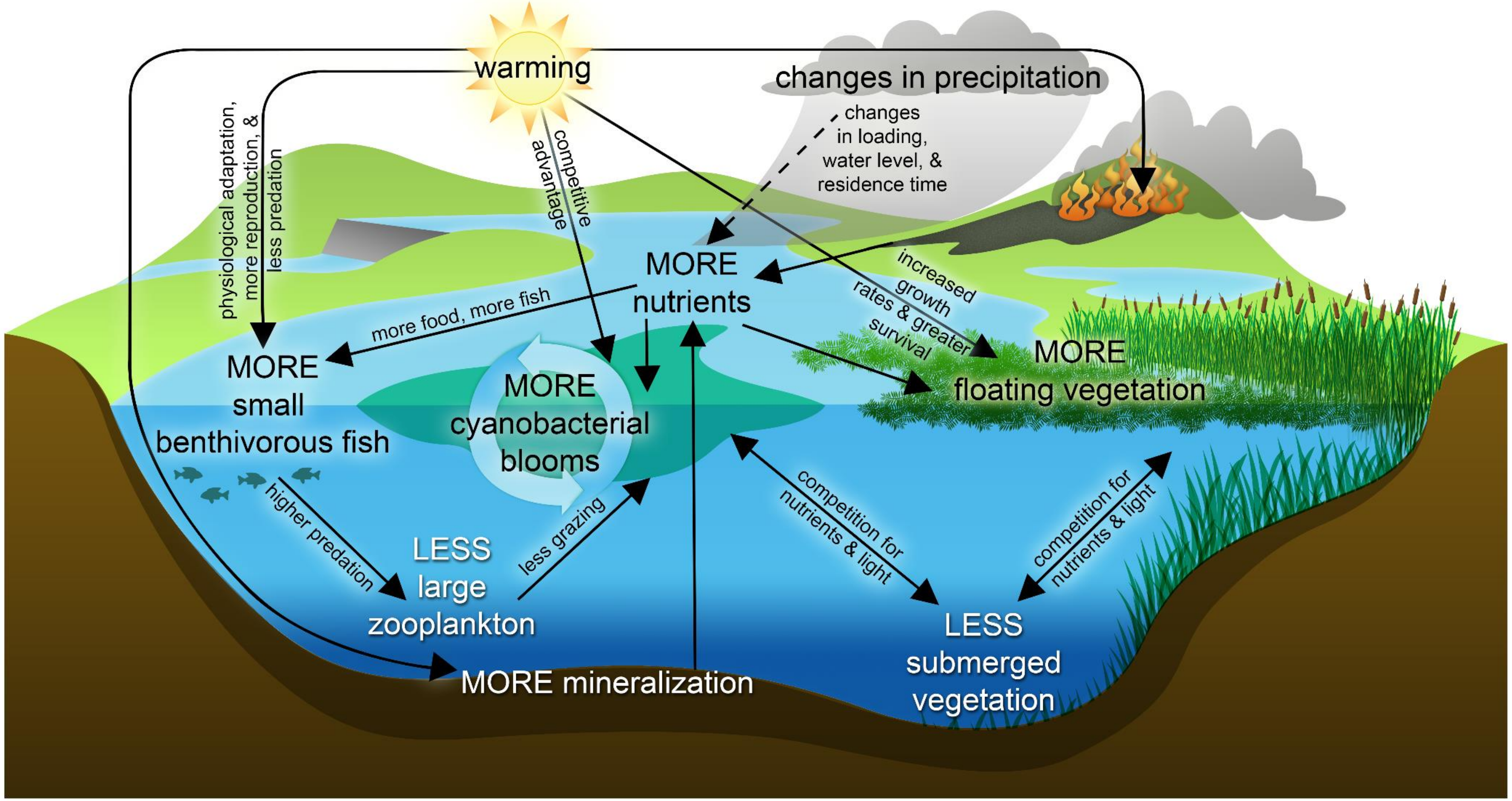


Fig. 5. Different responses to experimental warming: variation of chlorophyll-a concentration (Chl-a) (a), resource use efficiency (b), CO_2 flux (c), and relationship between CO_2 flux and phytoplankton biomass (d). In a, b, and c the central point denotes the mean value, and the whiskers represent standard errors. In d, positive values of carbon flux indicate net CO_2 emissions while negative values indicate net CO_2 sequestration by the phytoplankton communities. Regression lines are shown for all temperatures for comparative purposes, but the relationship was significant only at 17 °C.

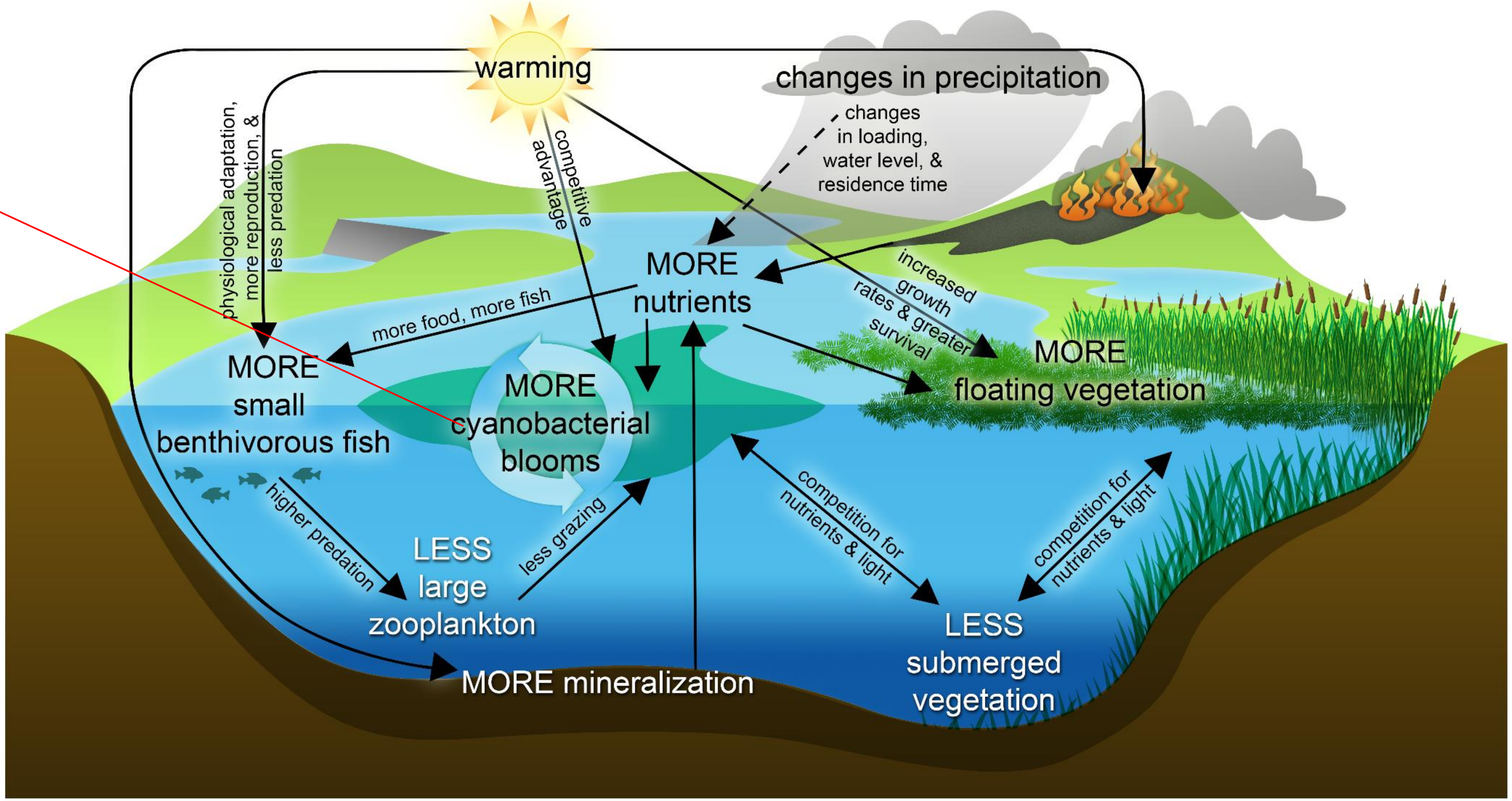
Cambio climático aumenta eutrofización y sus síntomas



Meerhoff y colaboradores 2022 Inland Waters

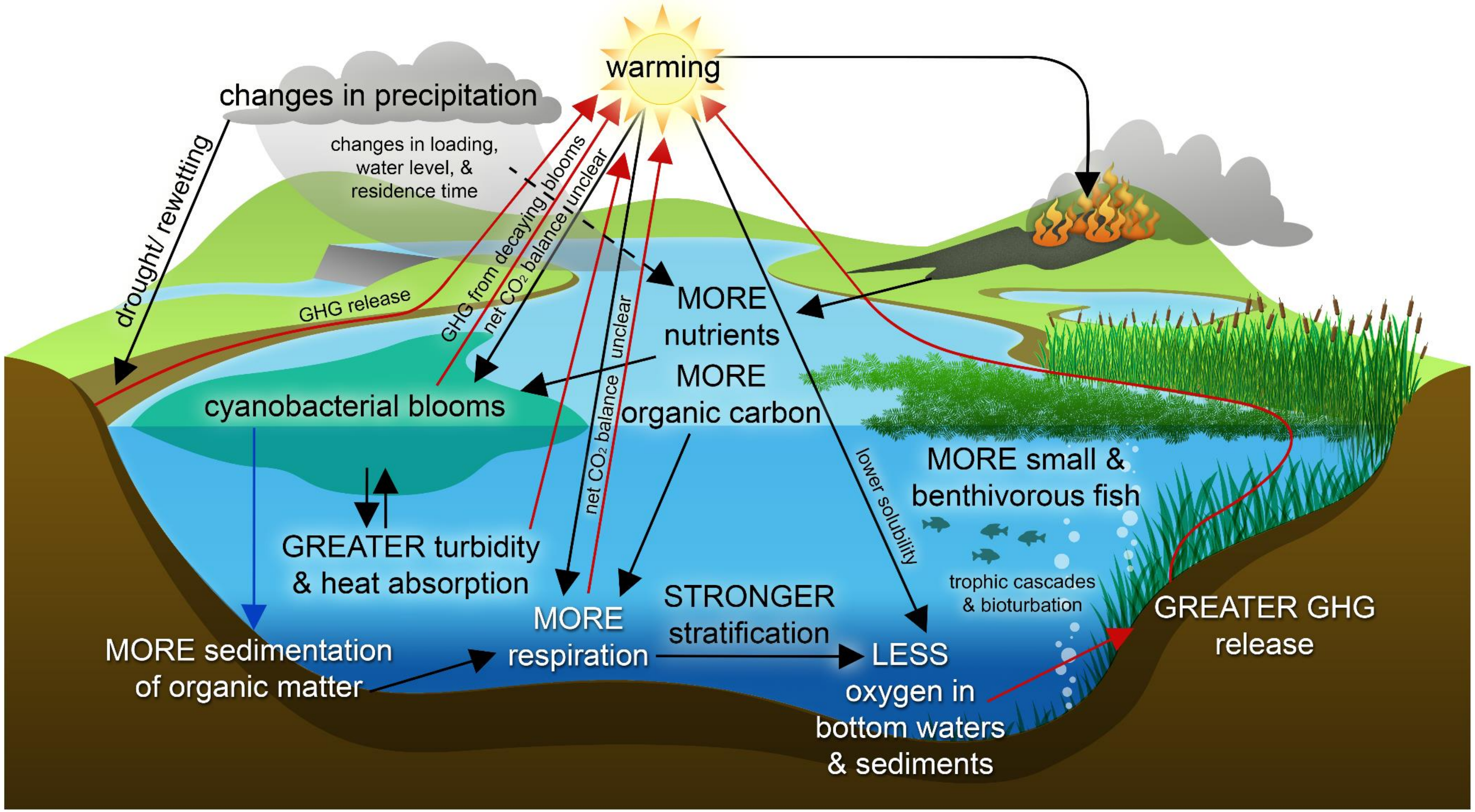
Cambio climático aumenta eutrofización y sus síntomas

Ver mecanismos de automantenimiento asociados a las cianos en clase de Sylvia Bonilla



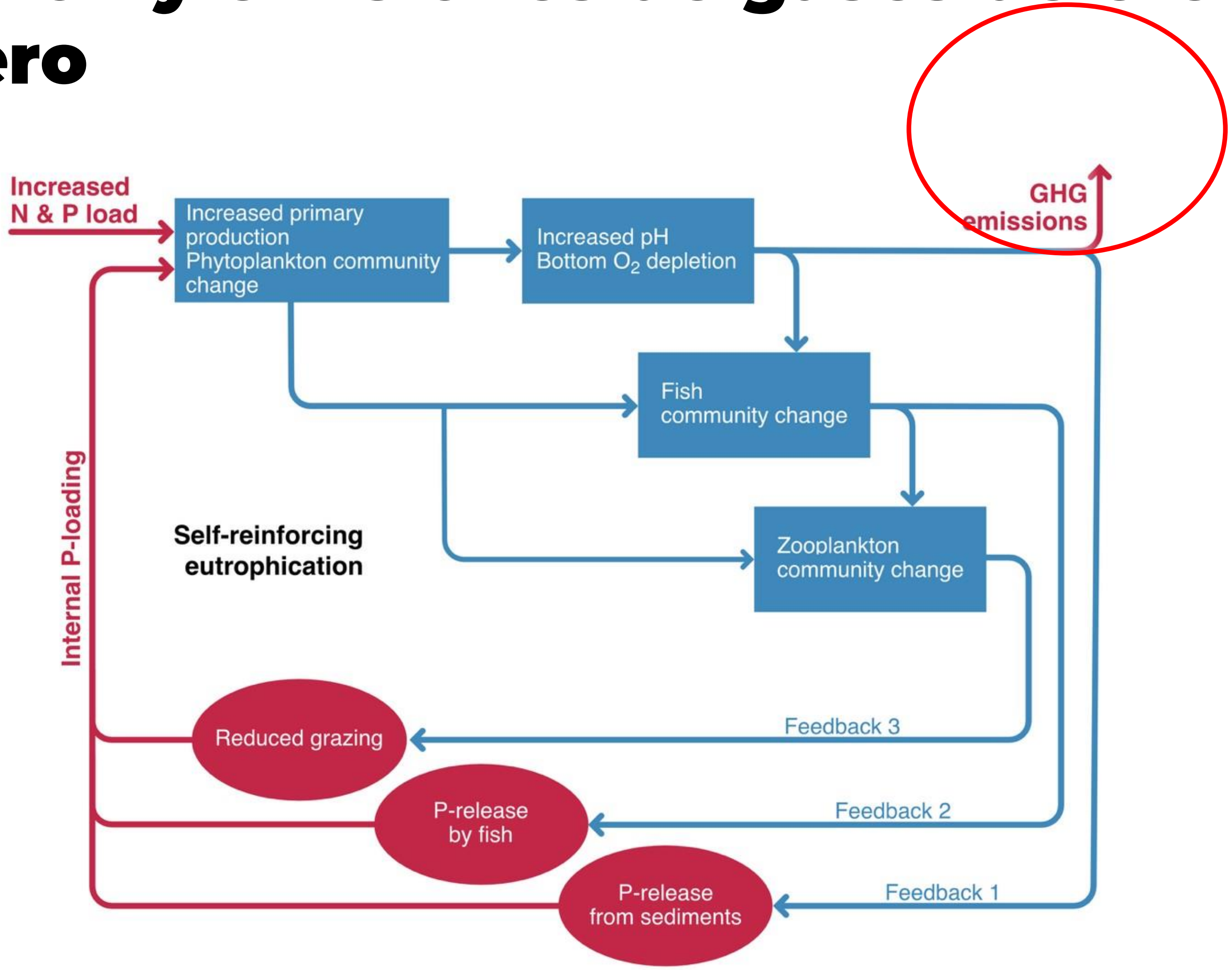
Meerhoff y colaboradores 2022 Inland Waters

Eutrofización y sus síntomas promueven el cambio climático



Meerhoff y colaboradores 2022 Inland Waters

”Tipping-points” y retroalimentación entre Eutrofización y emisiones de gases de efecto invernadero



Hessen et al. under review

Gracias

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