Klima jako nelineární dynamický systém: existuje tendence podhodnocovat skutečnou rychlost a dopady změny klimatu?

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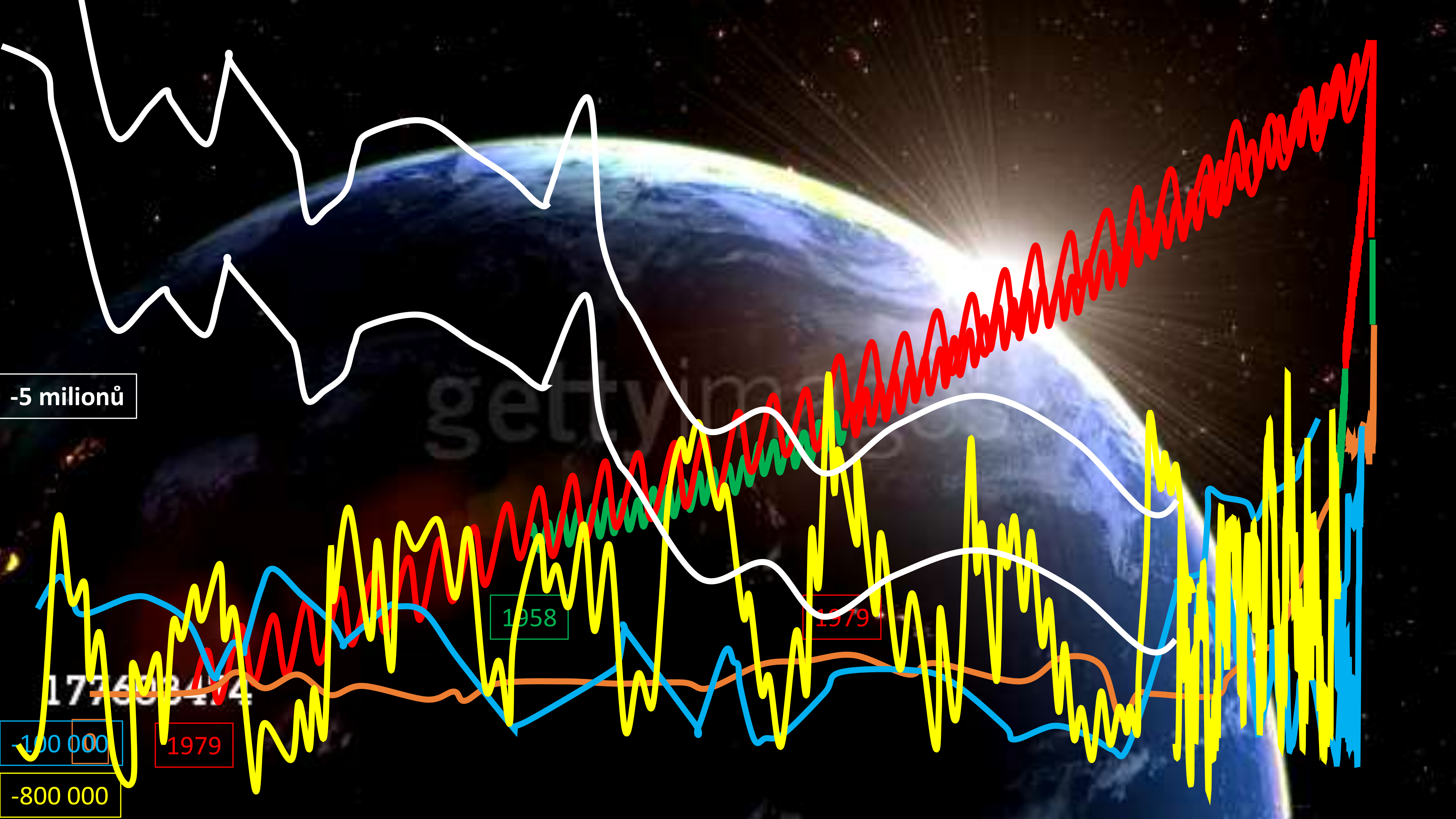
Klimatická změna v ČR: projevy, důsledky, adaptace, výroční seminář České meteorologické společnosti, Uherské Hradiště, 21. - 23. 9. 2016


-5 milionů
1958
1979
-100 000
1979
-800 000

Outline

- Climate and climate sensitivity – more than 3 °C (1,5 – 4,5 °C) for $2xCO_2$?
- Is there „systematic“ underestimation of real and predicted changes in the nature?

“As we learn more, we’re finding that the changes could be **greater and more rapid than we previously thought**”

prof. Michael Mann

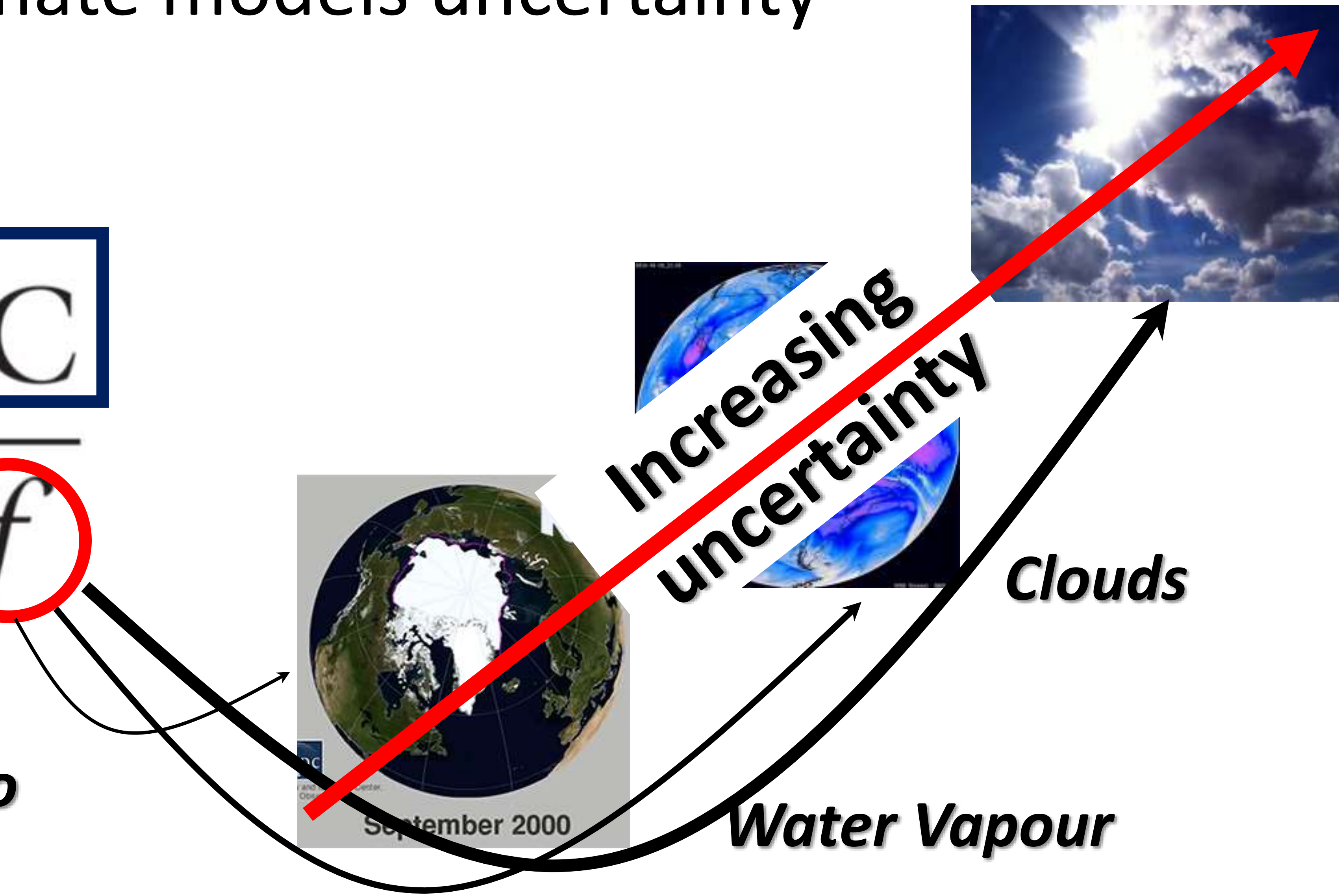
Climate models uncertainty

Black-body emission (2xCO2; 3,7 W/m2)

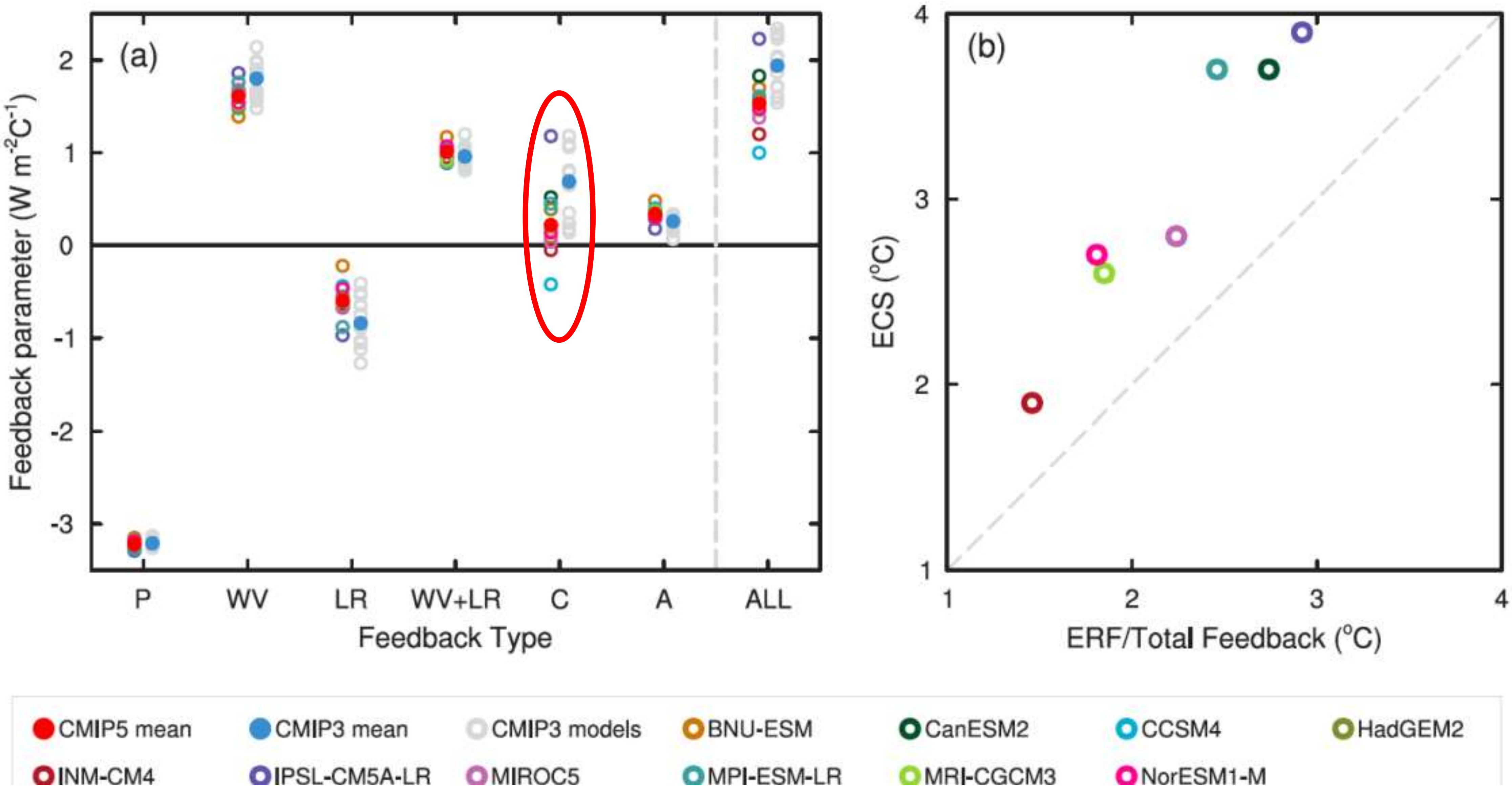
$$CS = \frac{1.2\,°C}{1 - f}$$

Feedbacks

Albedo



CMIP5 lowered /included *negative*/ cloud feedback



LETTER

doi:10.1038/nature18273

Evidence for climate change in the satellite cloud record

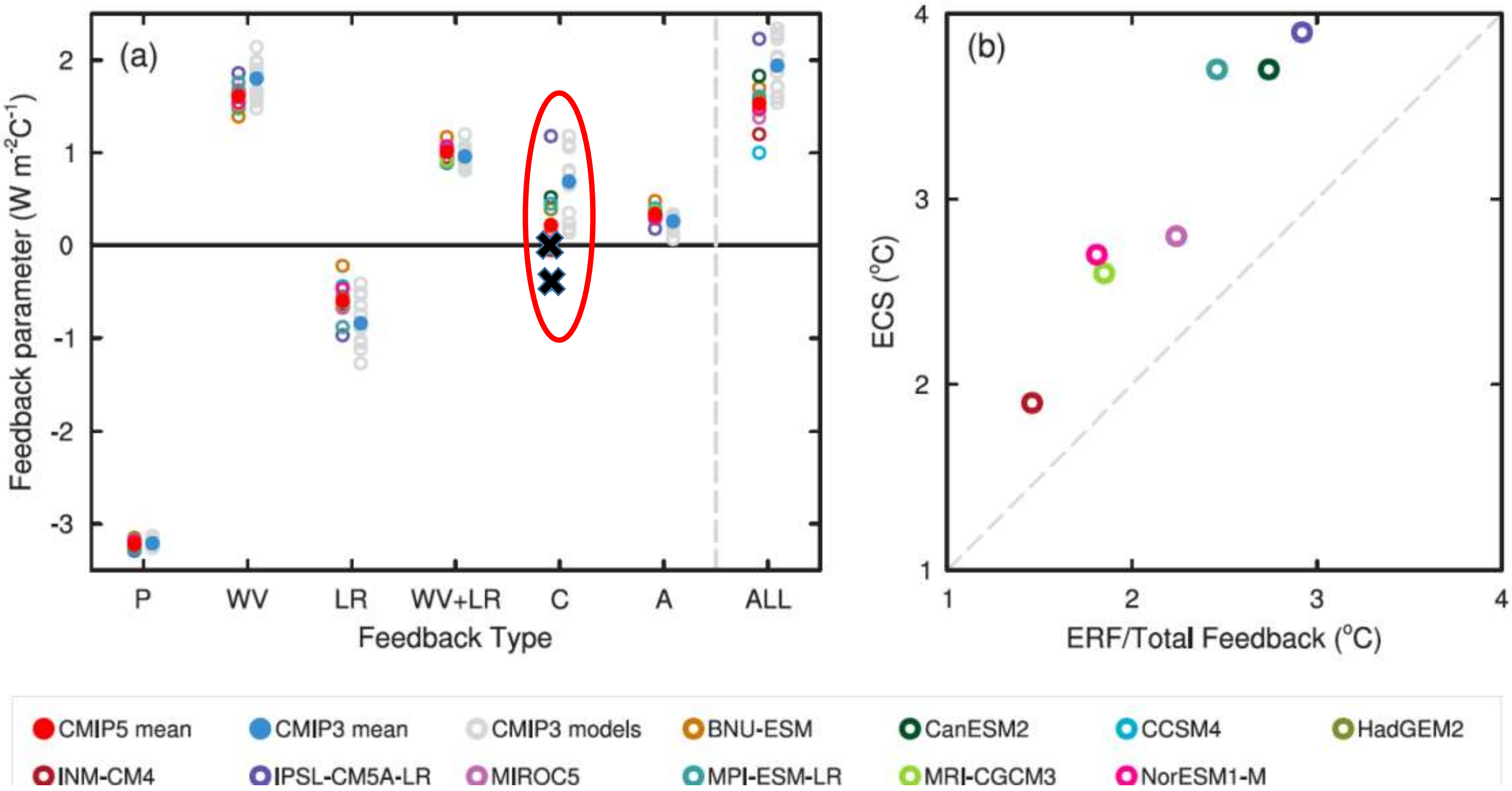
Joel R. Norris[1], Robert J. Allen[2], Amato T. Evan[1], Mark D. Zelinka[3], Christopher W. O'Dell[4] & Stephen A. Klein[3]

Clouds substantially affect Earth's energy budget by reflecting solar radiation back to space and by restricting emission of thermal radiation to space[1]. They are perhaps the largest uncertainty in our understanding of climate change, owing to disagreement among climate models and observational datasets over what cloud changes have occurred during recent decades and will occur in response to global warming[2,3]. This is because observational systems originally designed for monitoring weather have lacked sufficient stability

2002–2014 CERES albedo and the 1985–1989 ERBS albedo. All observational records agree that cloud amount and albedo increased over the northwest Indian Ocean, the northwest and southwest tropical Pacific Ocean, and north of the Equator in the Pacific and Atlantic oceans. Cloud amount and albedo decreased over mid-latitude oceans in both hemispheres (especially over the North Atlantic), over the southeast Indian Ocean, and in a northwest-to-southeast line stretching across the central tropical South Pacific. MAC-LWP exhibits a similar trend

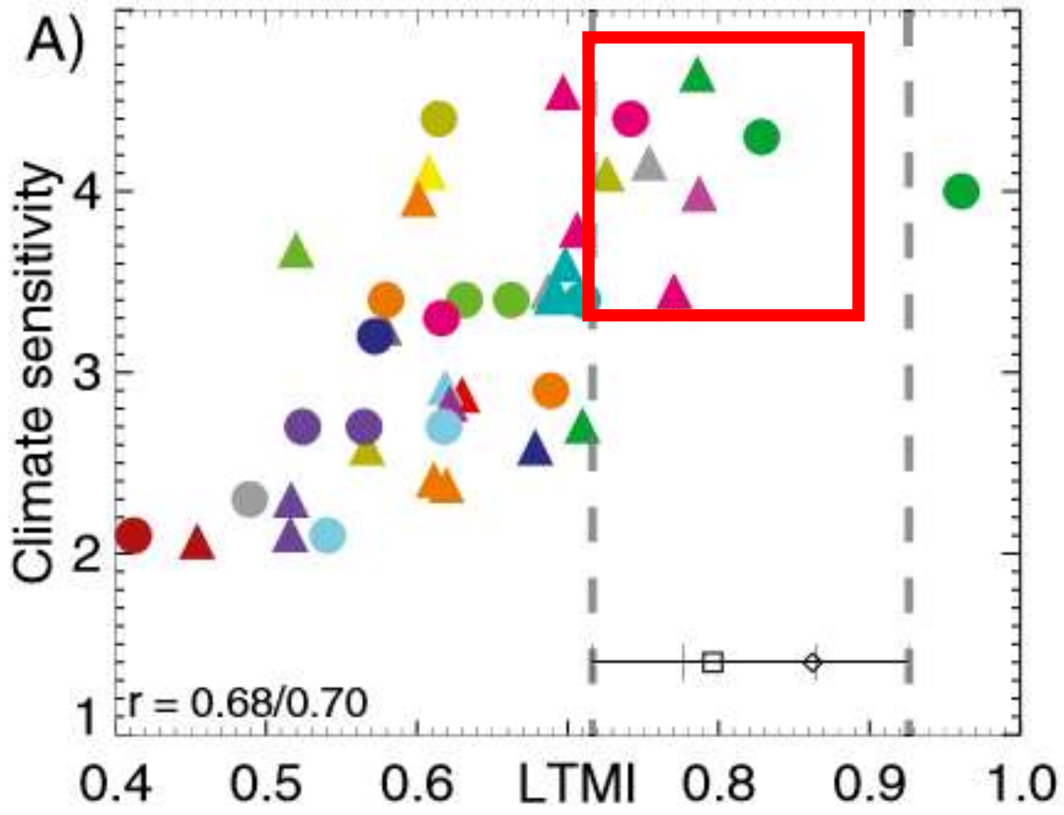
The expansion of subtropical dry zones results in less reflection of solar radiation back to space. As cloud tops rise, their greenhouse effect becomes stronger. Both of these cloud changes have a warming effect on climate. Our results suggest that radiative forcing by a combination of anthropogenic greenhouse gases and volcanic aerosol has produced **observed cloud changes during the past several decades that exert positive feedbacks on the climate system**. We expect that increasing greenhouse gases will cause these cloud trends to continue in the future, unless offset by unpredictable large volcanic eruptions.

CMIP5 lowered /included *negative*/ cloud feedback



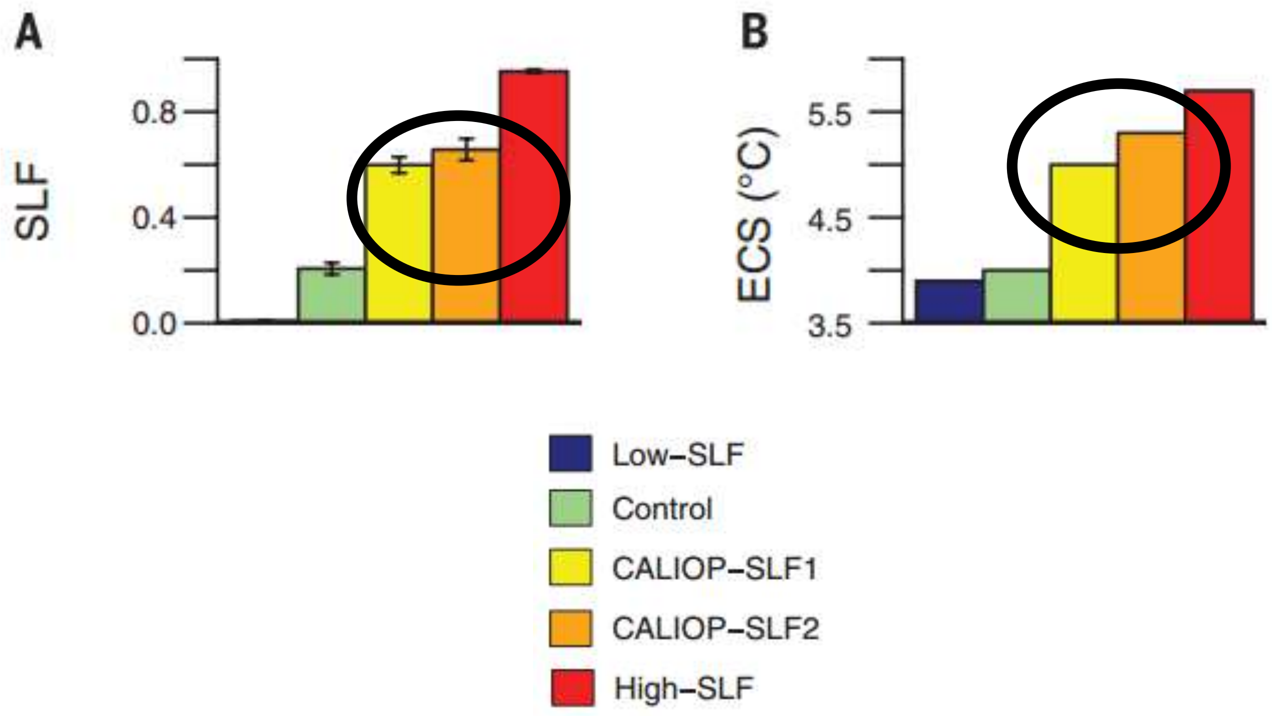
Climate sensitivity – underestimation of cloud feedback

Lower-tropospheric mixing implies higher ECS



Fasullo et al. 2015
See also Marvel et al. 2015, Sherwood et al. 2014
Brient and Schneider 2016, Forster 2016, Tian 2015

Model which includes realistic supercooled liquid fraction, implies climate sensitivity of **5-5,3 °C.**



„unrealistically low SLFs common to a multitude of GCMs lead to a cloud-phase feedback that is too negative.“ (Tian et al. 2016, Science)

Earth System Sensitivity (including slow feedbacks)

Table 1 Published proxy-based estimates of Earth system climate sensitivity (ESS)

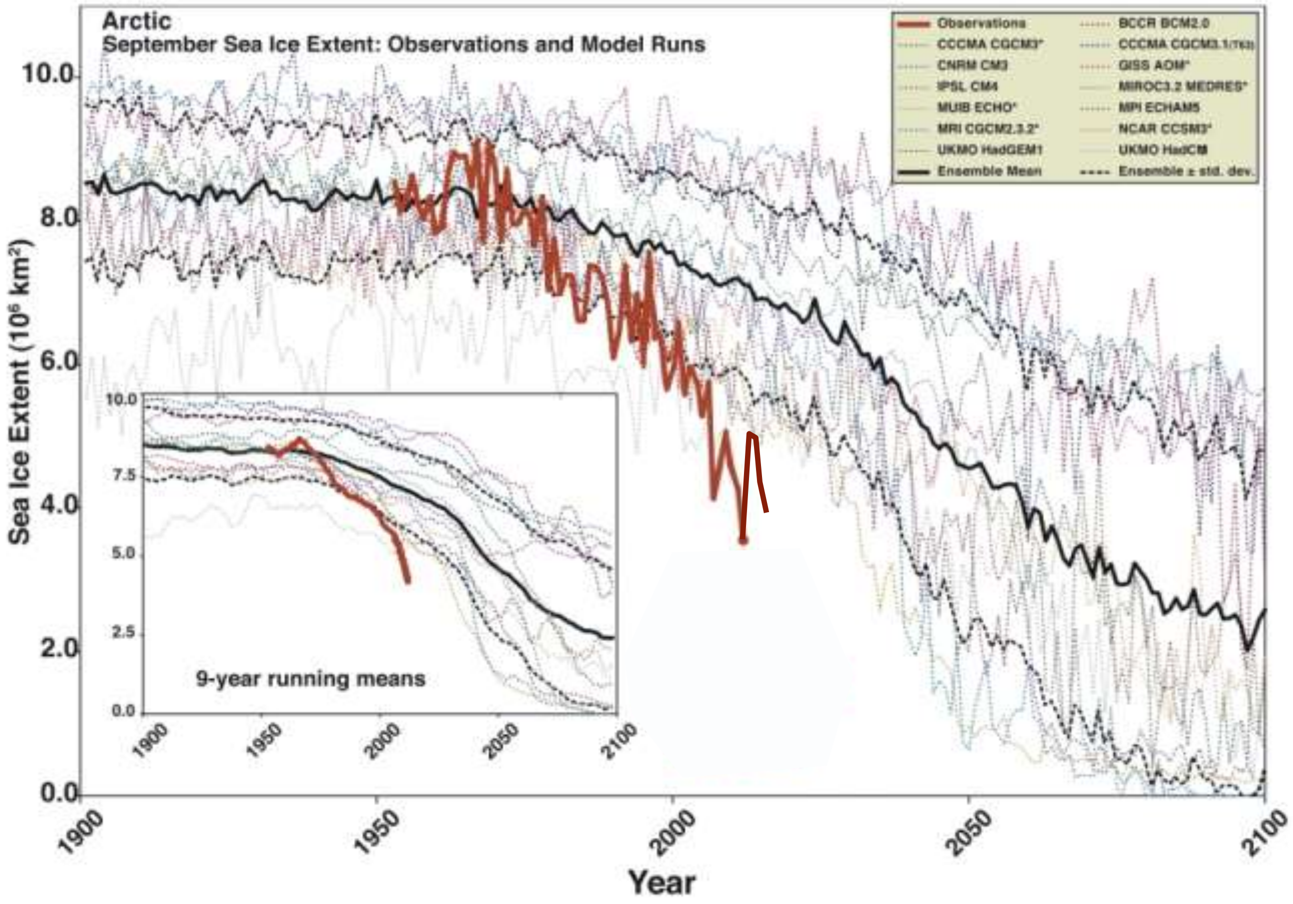
Time period	ESS (°C)	Reference
Large ice sheets present		
Pleistocene (last 400 000 year)	6	Hansen *et al.* (2008)
Pliocene (5-3 Ma)	>7	Pagani *et al.* (2010)
Pliocene (5-3 Ma)	6[*]	Budyko *et al.* (1987) and Borzenkova (2003)
Cenozoic glacial (34-0 Ma)	6	Hansen *et al.* (2008)
Phanerozoic glacial (340-260, 40-0 Ma)	>6	Park & Royer (2011)
Large ice sheets absent		
Late Eocene (35 Ma)	High	Kiehl (2011)
MECO (40 Ma)	2–5	Bijl *et al.* (2010)
Early Eocene (55 Ma)	2.4[*,†]	Covey *et al.* (1996)
PETM (55.5 Ma)	4	Higgins & Schrag (2006)
PETM (55.5 Ma)	High	Pagani *et al.* (2006)
PETM (55.5 Ma)	High	Zeebe *et al.* (2009)
Cretaceous (100 Ma)	3.4[*,†]	Hoffert & Covey (1992)
Cretaceous-early Paleogene (110-45 Ma)	3.7[*]	Budyko *et al.* (1987) and Borzenkova (2003)
Phanerozoic non-glacial (420-340, 260-40 Ma)	>3	Park & Royer (2011)

Jagniecki et al., 2015
+6 °C

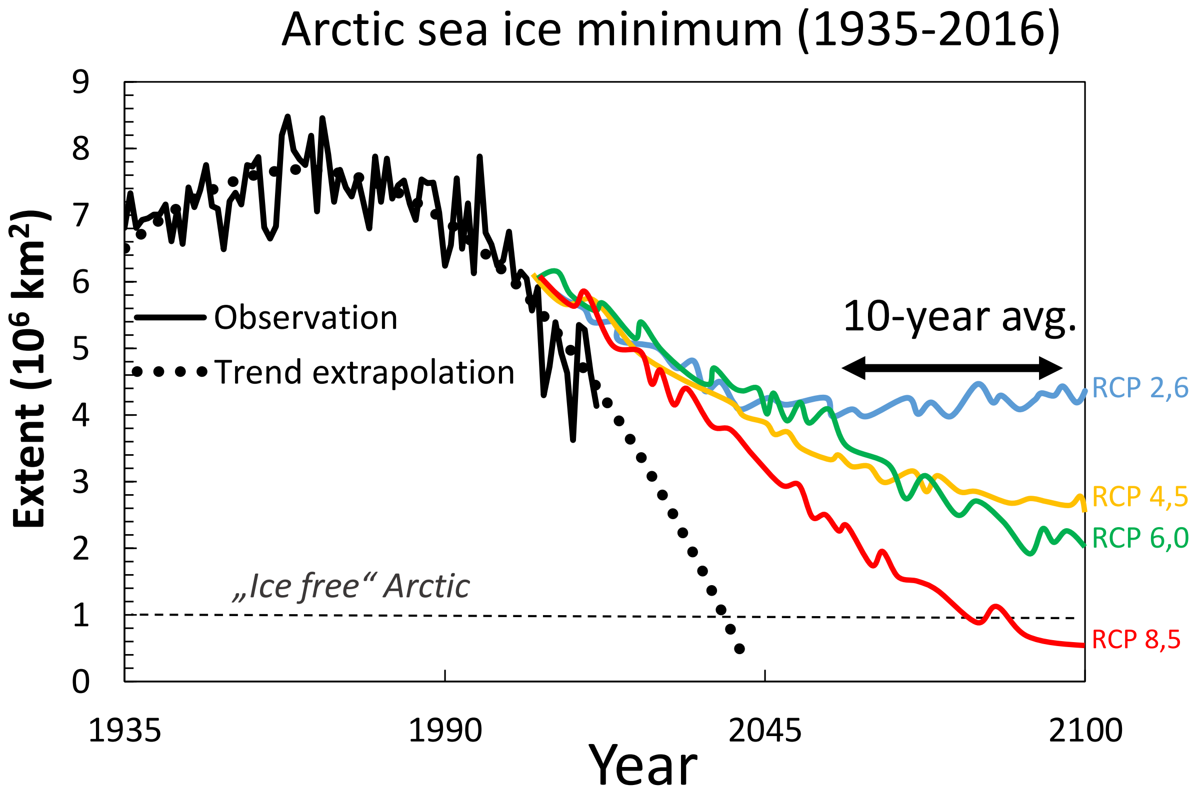
Shaffer et al., 2016
3,7-6,5 °C

Royer et al. 2012, GeoBiology

Arctic sea ice



IPCC AR4 2007 (CMIP3)



IPCC AR5 2013 (CMIP5)

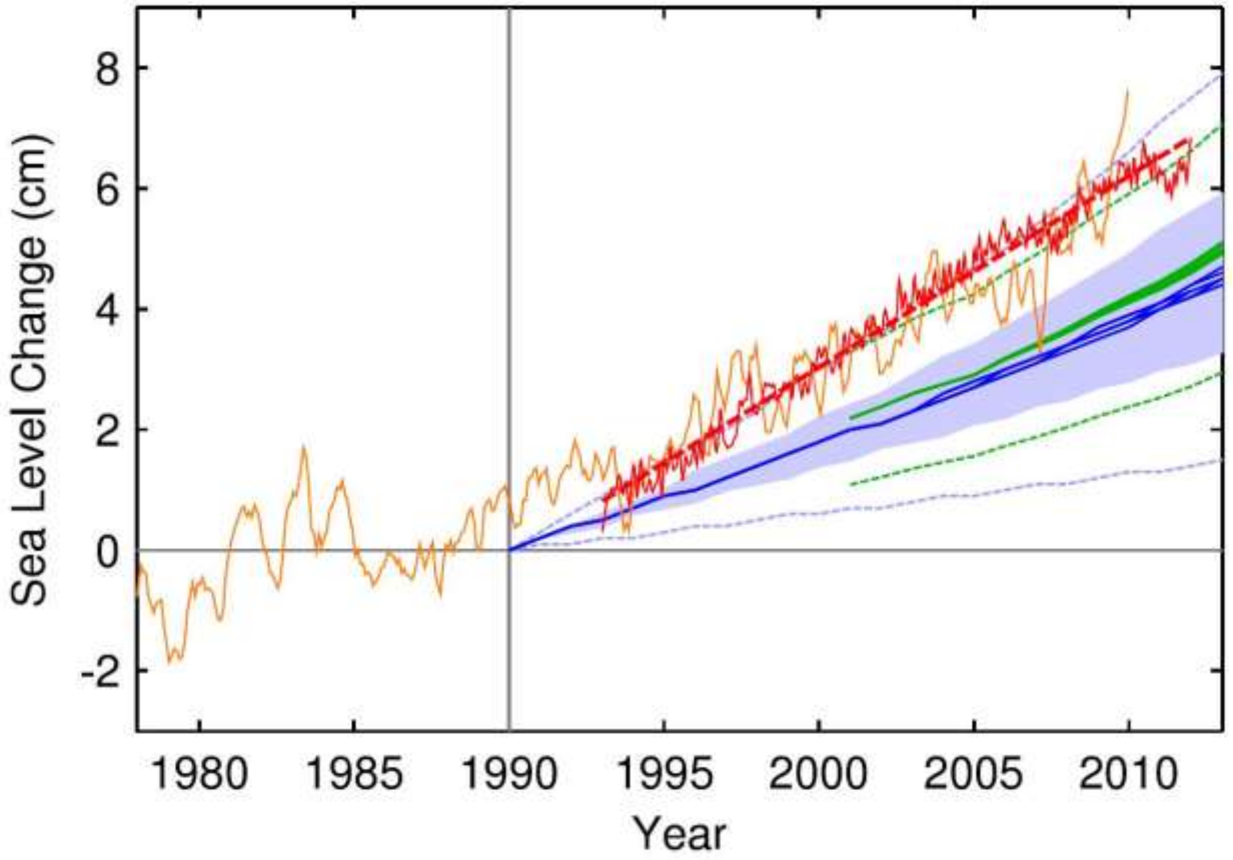
Ocean acidification

Here we present ***observations*** of the chemical and physical characteristics of East Siberian Arctic Shelf waters from 1999, 2000–2005, 2008 and 2011, and find extreme aragonite undersaturation that reflects ***acidity levels in excess of those projected in this region for 2100***.

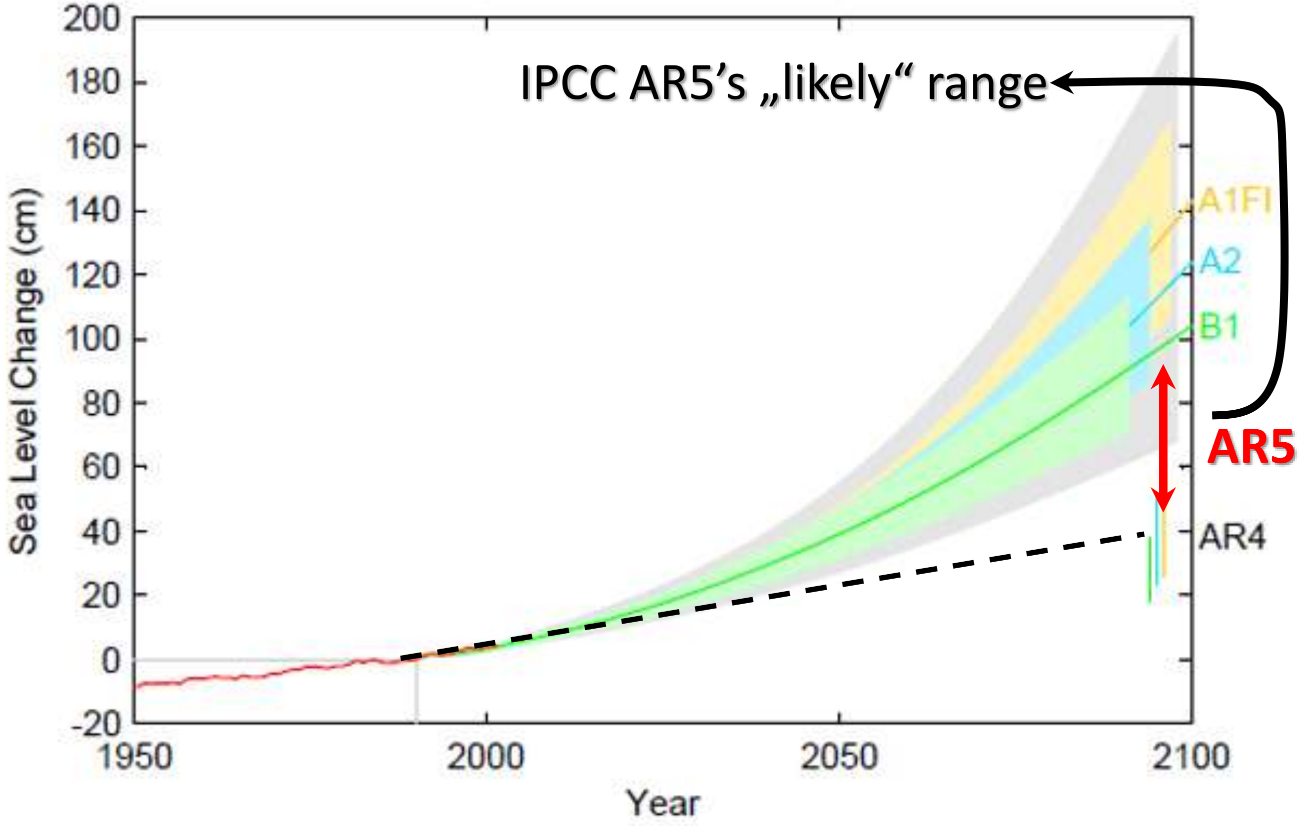
This study also calls into question the capacity of the Arctic Ocean to serve as sink for a growing amount of anthropogenic CO_2.

Sea level rise

IPCC 2001,2007



Process-based vs. **semi-empirical** models

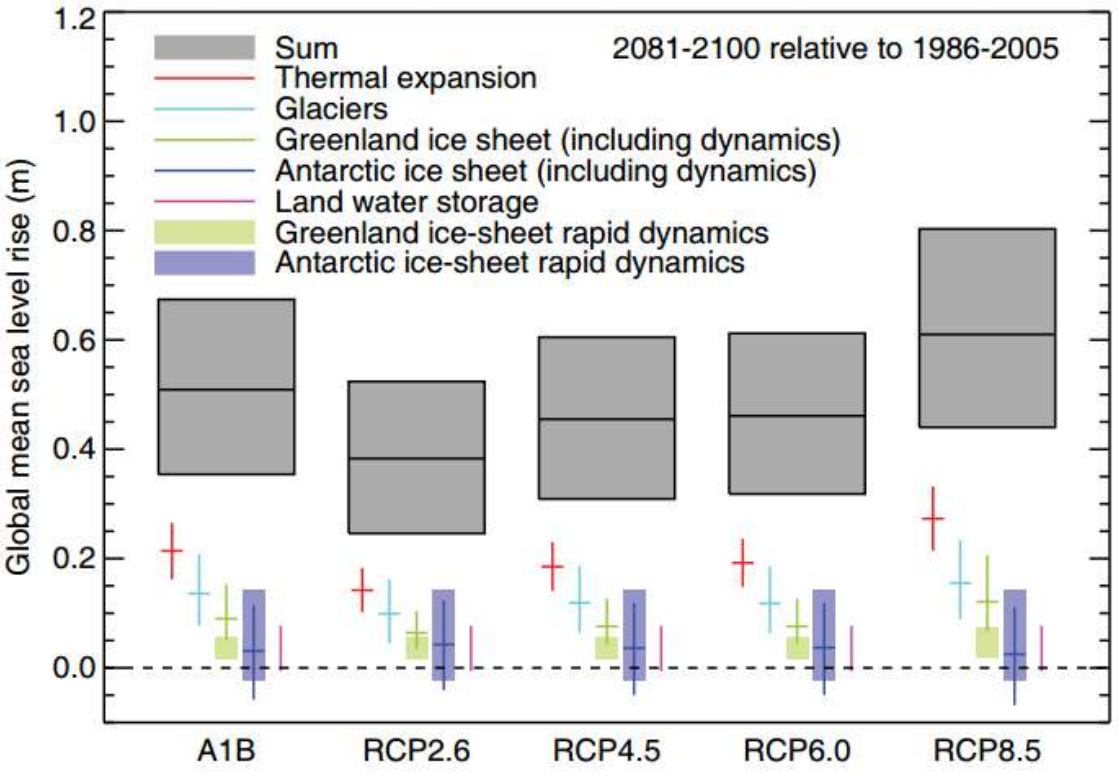


Currently, proces-based models underestimate real SLR and do not project speed-up of SLR (only in the worst-case IPCC 2013).

Rahmstorf 2012, Nature

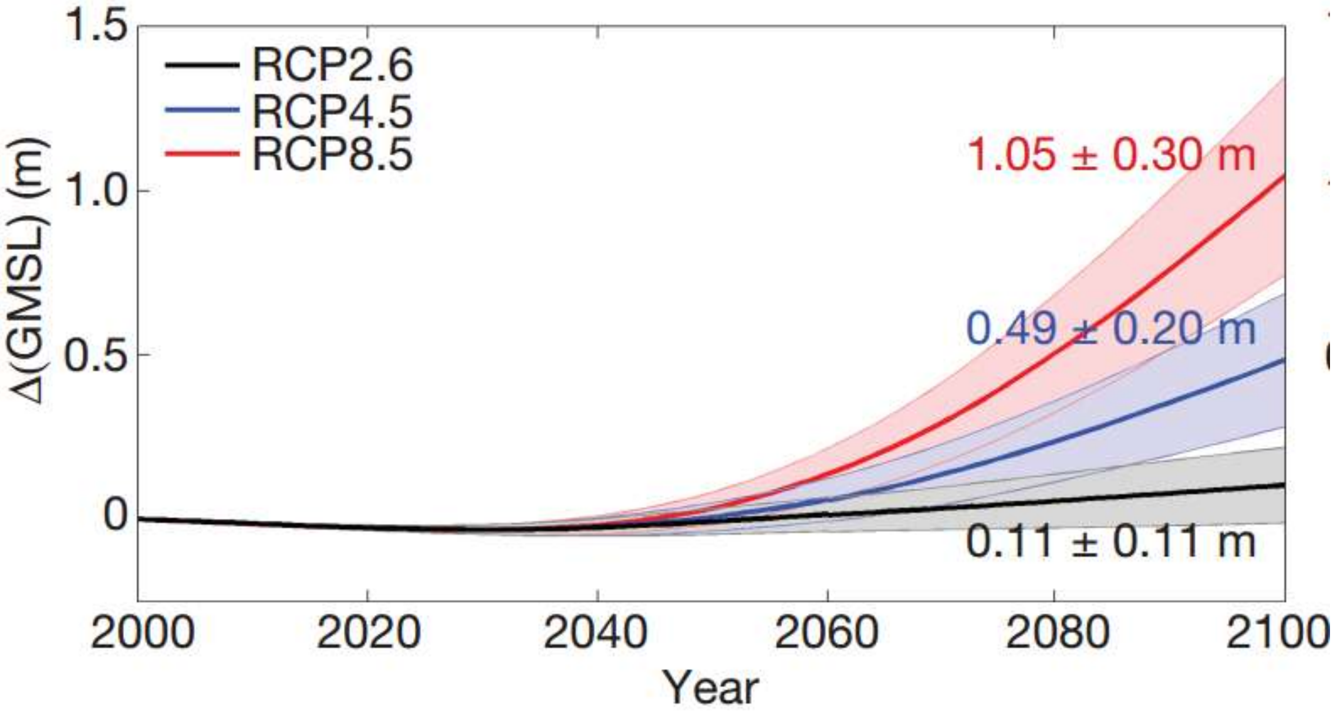
Sea level rise

IPCC 2013



ANTARCTICA

including previously underappreciated processes linking atmospheric warming with hydrofracturing of buttressing ice shelves and structural collapse of marine-terminating ice cliffs

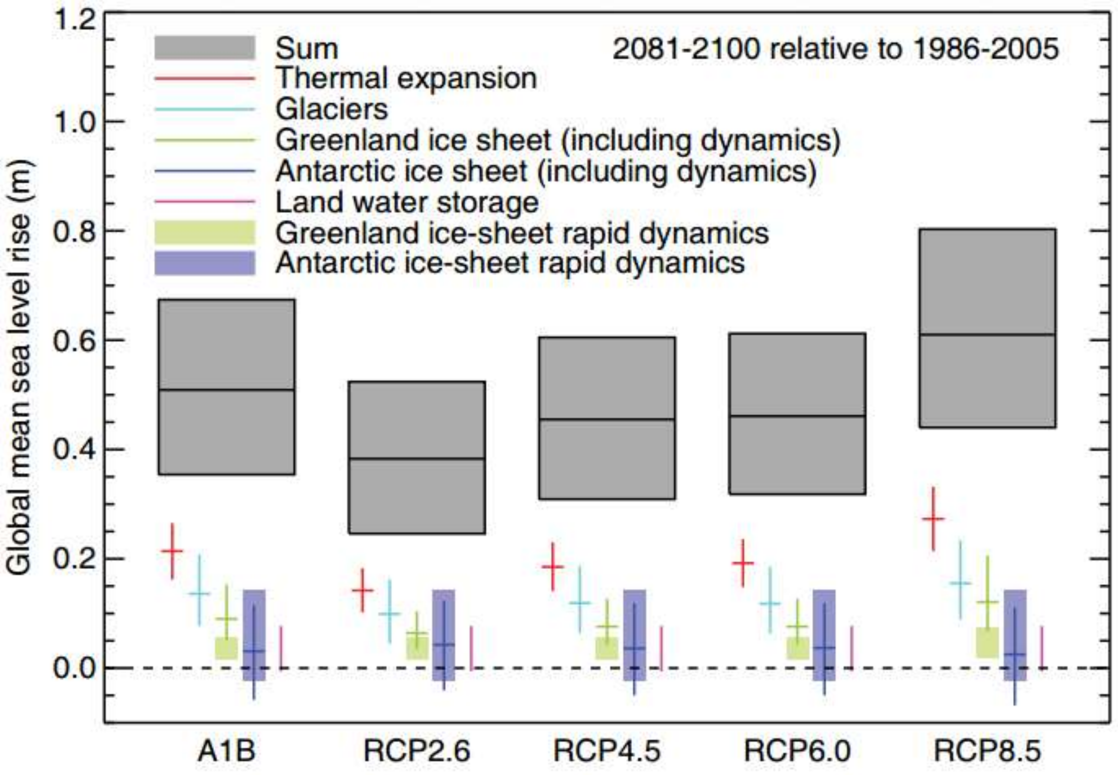


DeConto 2016, Nature

Sea level rise

GREENLAND

IPCC 2013



…the effect of ocean temperature change on the GrIS was not considered in our study, as ***few ice sheet models incorporate an ocean component enabling full ocean–ice interaction***.

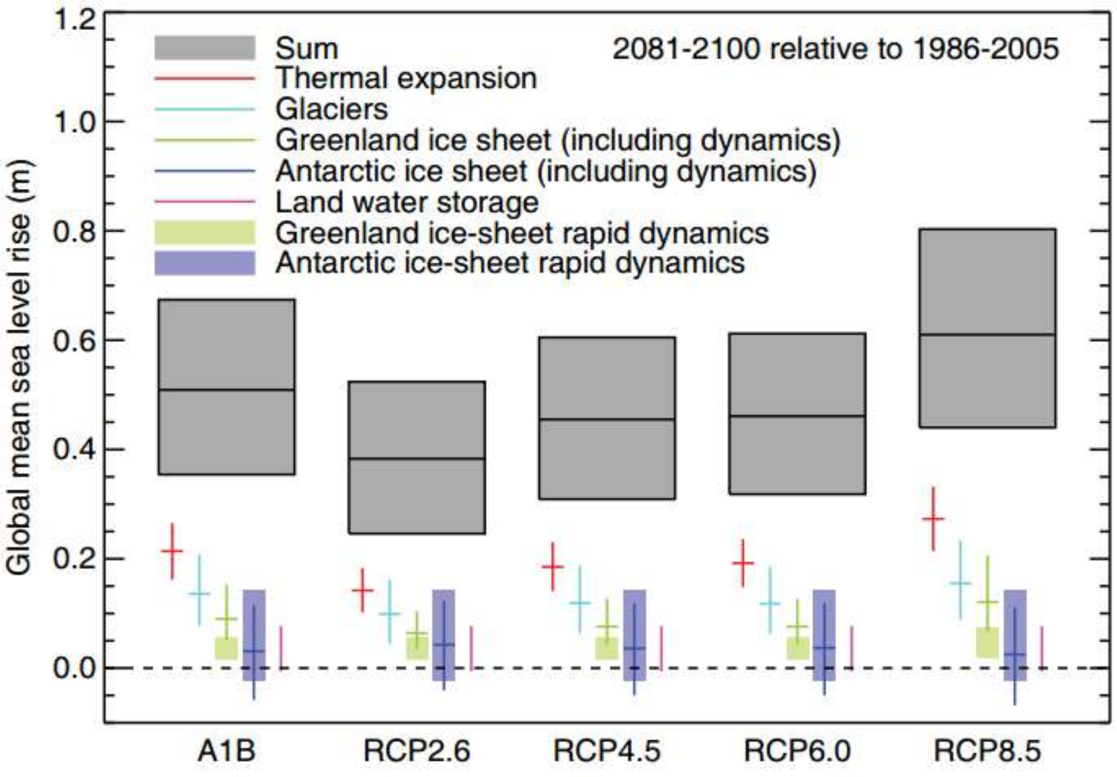
Besides, Winkelmann and Levermann (2012) indicated that by including an annual incursion of warm ocean water, the solid ice discharge of the GrIS by 2100 could be ***up to 42 cm***. Thus, ignoring the effect of ocean temperature change on the GrIS could lead to an underestimation of projected SLR.

Qing et al 2014, Greenland Ice Sheet Contribution to **Future Global Sea Level Rise based on CMIP5 Models**

Sea level rise

GREENLAND

IPCC 2013



"…most notable result of our study is showing that the firn reacts ***faster*** to an atmospheric warming ***than expected***"

nature climate change
LETTERS
PUBLISHED ONLINE: 4 JANUARY 2016 | DOI: 10.1038/NCLIMATE2899

Greenland meltwater storage in firn limited by near-surface ice formation

Horst Machguth[1,2*†], Mike MacFerrin[3], Dirk van As[1], Jason E. Box[1], Charalampos Charalampidis[1,4], William Colgan[1,5], Robert S. Fausto[1], Harro A. J. Meijer[6], Ellen Mosley-Thompson[7] and Roderik S. W. van de Wal[8]

„ *Here we use in situ **observations*** and historical legacy data to demonstrate that surface runoff begins to dominate over meltwater storage well before firn pore space has been completely filled."

Extreme precipitation

Global trends in extreme precipitation: climate models versus observations

B. Asadieh and N. Y. Krakauer

Hydrology and Earth System Sciences

Open Access

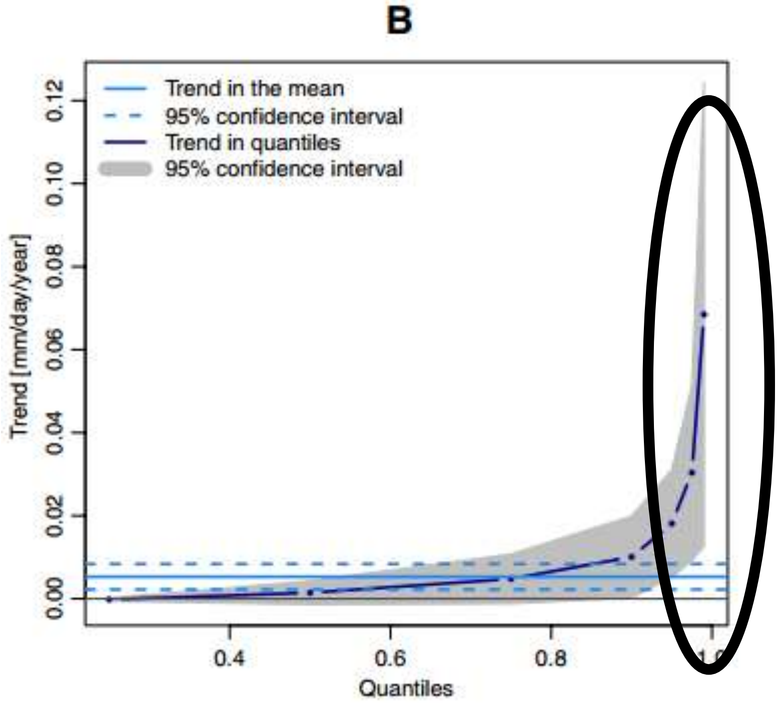
Annual-maximum daily precipitation (Rx1day) has increased ***faster in the observations than in most of the CMIP5 models***. On a global scale, the observational annual-maximum daily precipitation has increased by an average of 5.73 mm over the last 110 years, or 8.5 % in relative terms. This corresponds to an increase of 10 % K^{-1} in global warming since 1901, which is larger than the average of climate models, with 8.3 % K^{-1} .

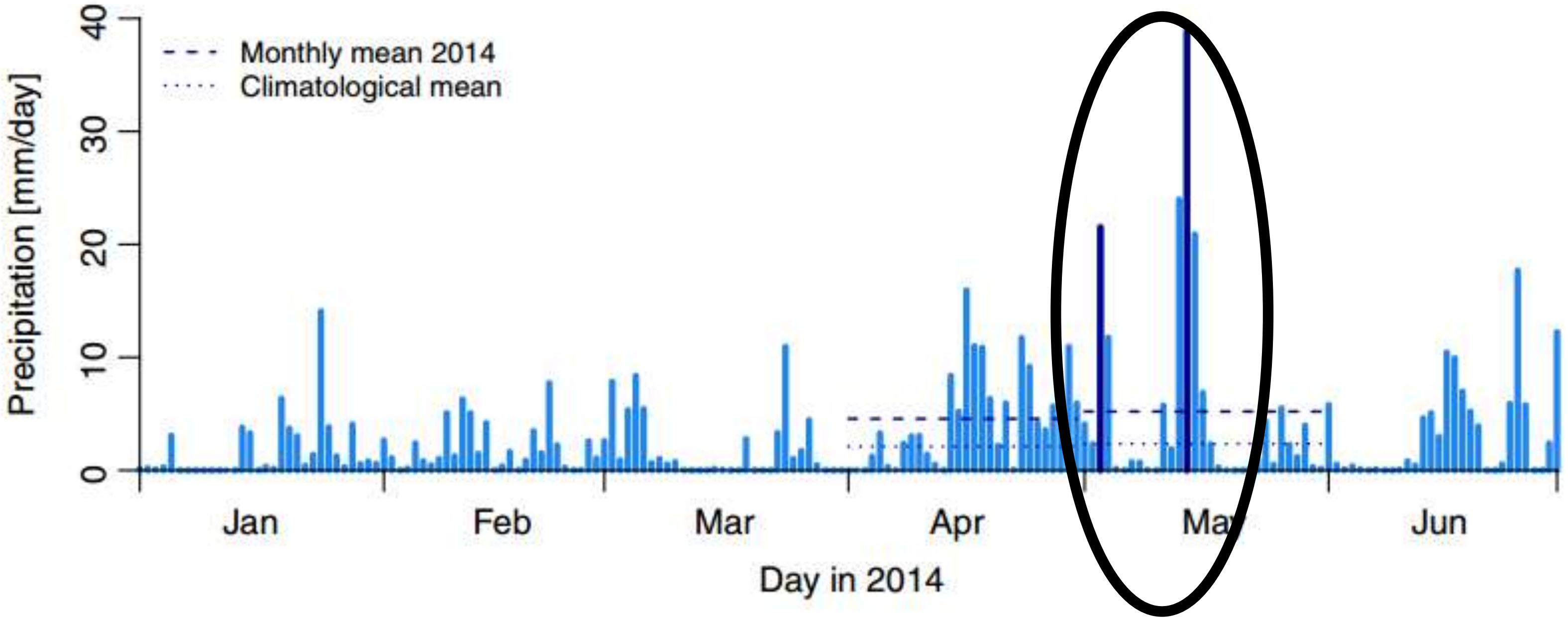
CLIMATE CHANGE

Record Balkan floods of 2014 linked to planetary wave resonance

10.1126/sciadv.1501428

Lisa Stadtherr,[1,2] Dim Coumou,[1]* Vladimir Petoukhov,[1] Stefan Petri,[1] Stefan Rahmstorf[1,3]





Generally, ***climate models struggle*** in capturing summertime Rossby waves and blockings, and likewise, there is large uncertainty in future projections of circulation-related fields. An improved understanding of the underlying ***dynamical mechanisms is thus critical***.

Permafrost melt

Our results indicate that the ***soil C is highly vulnerable*** to climate warming and this vulnerability is determined by a set of ***complex microbial feedbacks*** to the temperature increase.

nature climate change

LETTERS

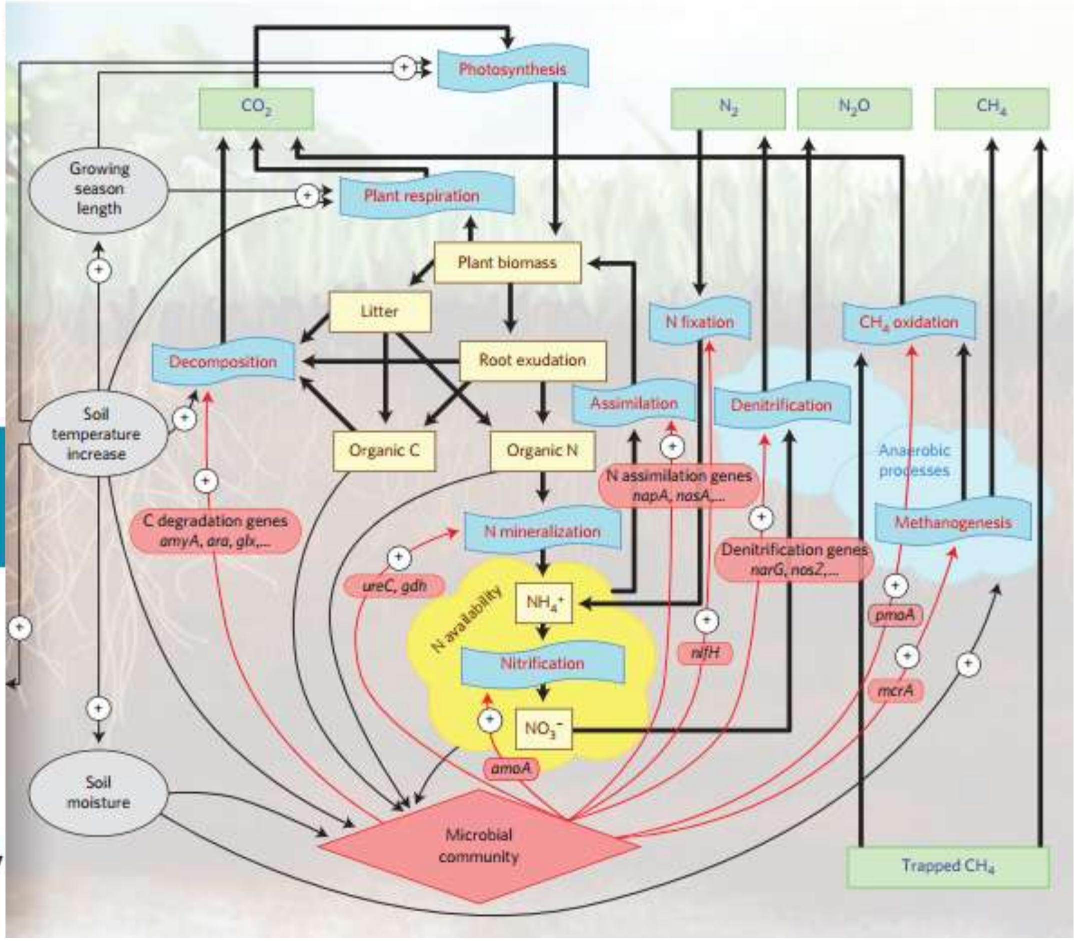
PUBLISHED ONLINE: 22 FEBRUARY 2016 | DOI: 10.1038/NCLIMATE2940

Tundra soil carbon is vulnerable to rapid microbial decomposition under climate warming

Kai Xue[1,2,3†], Mengting M. Yuan[2,3†], Zhou J. Shi[2,3], Yujia Qin[2,3], Ye Deng[2,3,4], Lei Cheng[2,3,5], Liyou Wu[2,3], Zhili He[2,3], Joy D. Van Nostrand[2,3], Rosvel Bracho[6], Susan Natali[7], Edward. A. G. Schuur[6,8], Chengwei Luo[9], Konstantinos T. Konstantinidis[9], Qiong Wang[10], James R. Cole[10], James M. Tiedje[10], Yiqi Luo[3] and Jizhong Zhou[1,2,3,11★]

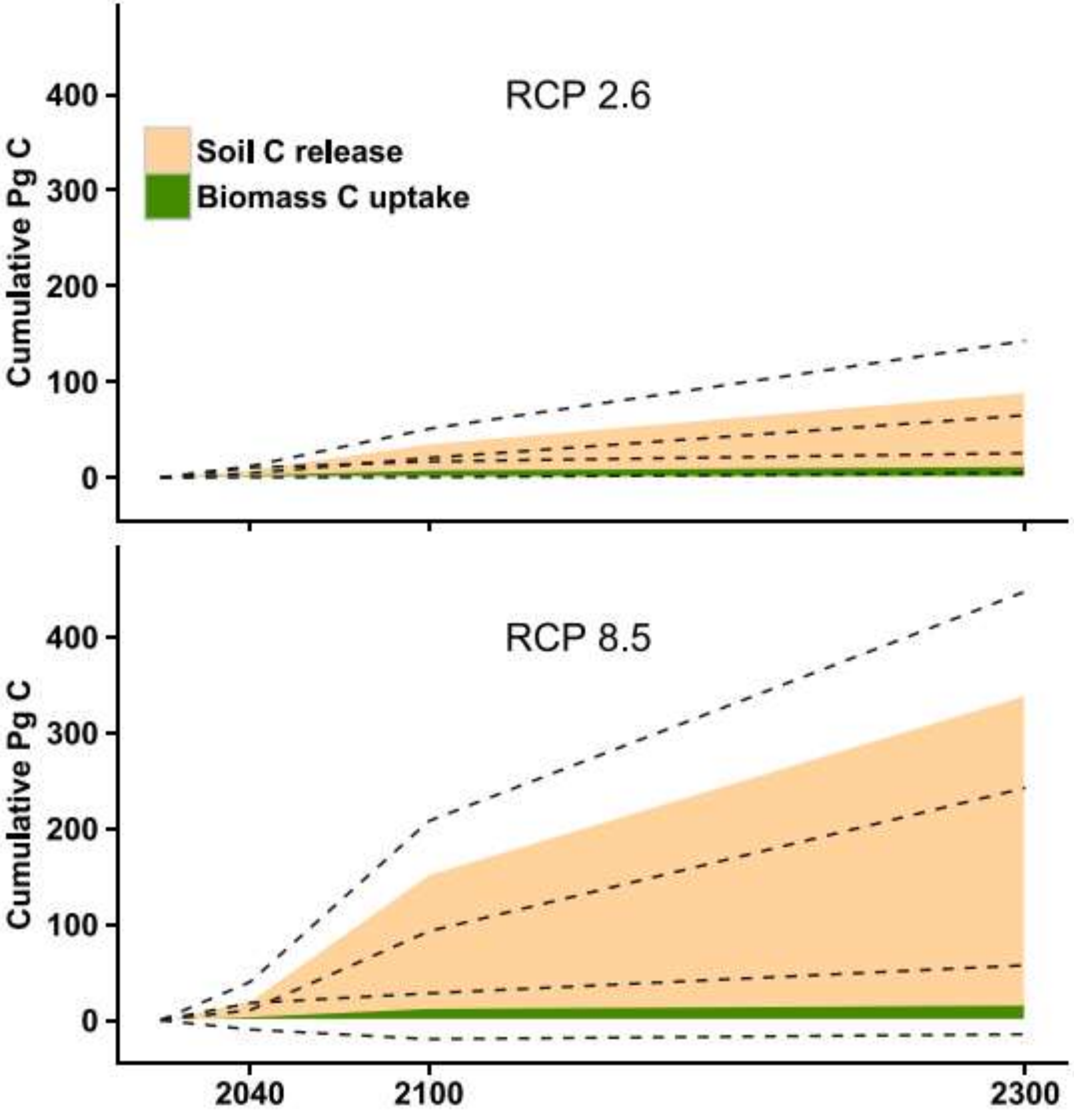
Microbial decomposition of soil carbon in high-latitude tundra underlain with permafrost is one of the most important, but poorly understood, potential positive feedbacks of greenhouse gas emissions from terrestrial ecosystems into the

with microbial decomposition resulting in massive ecosystem C loss, which is likely to dominate the overall net C exchange in permafrost regions[1]. Although plant responses to climate warming in the active layer of the tundra soil have been intensively studied[12–14], microbial



Permafrost melt

„None (of the models) include zero or negative change in biomass as predicted by over a third of participants in our expert assessment. Two potential reasons for this disagreement are an overestimation of the effect of CO_2 fertilization or an underestimation of the role of disturbance in some models.“



Environmental Research Letters, 2016

Vulnerability of forest ecosystems

+350 citations

esa ECOSPHERE

ESA CENTENNIAL PAPER

On underestimation of global vulnerability to tree mortality and forest die-off from hotter drought in the Anthropocene

Craig D. Allen,[1,†] David D. Breshears,[2] and Nate G. McDowell[3]

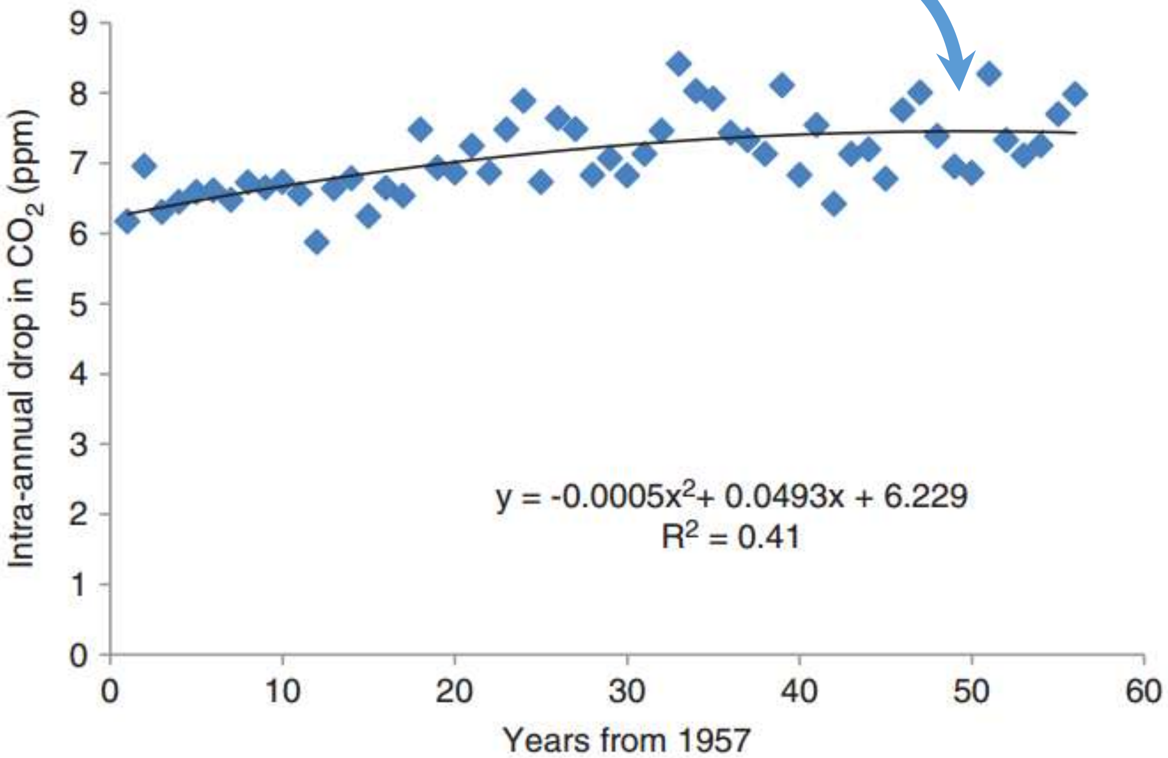
[1]*U.S. Geological Survey, Fort Collins Science Center, Jemez Mountains Field Station, Los Alamos, New Mexico 87544 USA*
[2]*School of Natural Resources and the Environment, joint with the Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, Arizona 85745 USA*
[3]*Earth and Environmental Science Division, MS-J495, Los Alamos National Laboratory, Los Alamos, New Mexico 85745 USA*

Citation: Allen, C. D., D. D. Breshears, and N. G. McDowell. 2015. On underestimation of global vulnerability to tree mortality and forest die-off from hotter drought in the Anthropocene. Ecosphere 6(8):129. http://dx.doi.org/10.1890/ES15-00203.1

Reduction of terrestrial carbon sink capacity (?)

- Current IPCC models predict maximum CO2 sink around **2030** and a switch of terrestrial ecosystems as a net source around 2100 (worst case).

Peak of CO2 absorption in 2006



Earth has reached 'peak carbon', warns Scots climate expert

Curran and Curran 2016, *The Weather:* Indications of positive feedback in climate change due to a reduction in Northern Hemisphere biomass uptake of atmospheric carbon dioxide

Climate models and economics

Floods brought parts of Britain to a standstill earlier this year.

Improve economic models of climate change

Costs of carbon emissions are being underestimated, but current estimates are still valuable for setting mitigation policy, say **Richard L. Revesz** and colleagues.

„The models omit social unrest and disruptions to economig growth.“

Sathkira District, Bangladesh, still flooded a year after 2009's Cyclone Aila.

Current climate models are grossly misleading

Nicholas Stern calls on scientists, engineers and economists to help policymakers by better modelling the immense risks to future generations, and the potential for action.

a profoundly misleading message to policymakers that there is an alternative option in which fossil fuels are consumed in ever greater quantities without any negative consequences to growth itself

CONCLUSIONS

- Climate models have general tendency to underestimate some impacts of climate change.
- Some impacts are neglected (e.g. permafrost).
- Reasons are objective (insufficient knowledge), but also subjective („optimism bias“, ”bad news” filtering)
- Underestimation is more pronounced in situations/areas, where stronger feedback mechanisms come into play (e.g. Arctic)
- It is easier to model linear than non-linear processes

Děkuji za pozornost