Research to Evaluate Climate Engineering

The German Research Foundation's Priority Program 1689, coordinated at GEOMAR, ran from 2013 – 2020 with the participation of 20 universities and research institutes from German-speaking countries. In SPP 1689, different climate engineering approaches were evaluated in an interdisciplinary way in order to create a basis for a responsible use of climate engineering methods. In addition to the scientific-technical dimension, social, political, legal and ethical aspects have also been investigated.

The work within SPP 1689 has shown that solar radiation management methods would be extremely problematic globally, could also have significant regional effects on neighboring regions, and would not be responsible in principle without an accompanying effort to remove CO2 from the atmosphere (CDR). The focus of further research is therefore on CDR methods.

A major concern of SPP 1689 was also the transparency of the research (see contributions Knowledge Transfer).

The news portal which has been established in SPP 1689 will continue to be operated by the research mission CDRmare at https://www.carbondioxide-removal.eu/news.

Brochure SPP 1689

Climate engineering and our climate targets – a long-overdue debate

This publication was produced in 2019 as part of the public outreach work under the DFG Priority Programme, with only minor changes made for the English-language edition compared with the German

edition. Its aim is to promote open social and political debate that is informed by the best available knowledge about the possibilities and risks of the various climate engineering ideas.

PDF Download English

climateengineering_spp1689_english.pdf (7.0 MiB)

PDF Download Deutsch

climateengineering_spp1689_brosch.pdf (7.7 MiB)

Animation film on youtube: Ambitious climate targets – the role of negative emissions

SPP 1689 Publication 2021

- Burt DJ, Fröb F and Ilyina T (2021) **The Sensitivity of the Marine Carbonate System to**

Regional Ocean Alkalinity Enhancement. *Front. Clim.* 3:624075. doi: 10.3389/fclim.2021.624075 / https://www.frontiersin.org/articles/10.3389/fclim.2021.624075/full

- Stenzel, F., Gerten, D., Hanasaki, N. (2021): **Global scenarios of irrigation water abstractions for bioenergy production: a systematic review.** In Hydrol. Earth Syst. Sci. 25 (4), pp. 1711–1726. DOI: 10.5194/hess-25-1711-2021. https://doi.org/10.5194/hess-25-1711-2021

- Stenzel, F., Greve, P., Lucht, W., Tramberend, S., Wada, Y. and Gerten, D. **Irrigation of biomass plantations may globally increase water stress more than climate change.** Nat Commun 12, 1512 (2021). https://doi.org/10.1038/s41467-021-21640-3
- Klaus, G., Oswald, L., Ernst, A. and Merk, C. (2021) **Effects of opinion statements on laypeople's acceptance of a climate engineering technology. Comparing the source credibility of researchers, politicians and a citizens' jury.** doi:10.22323/2.20010203
- Robrecht, S., Vogel, B., Tilmes, S., Müller, R. **Potential of future stratospheric ozone loss in the midlatitudes under global warming and sulfate geoengineering.** doi:10.5194/acp-21-2427-2021 /https://acp.copernicus.org/articles/21/2427/2021/

Digitale Woche Kiel 2020

Wie können wir das 1,5-Grad-Ziel noch erreichen?

Interaktiver Vortrag von Prof. Dr. Andreas Oschlies, GEOMAR Kiel, 09.09.20

New Publications 2020

- Robrecht, S., Vogel, B., Tilmes, S., Müller, R. (2020) **Potential of future stratospheric ozone loss in the mid-latitudes under climate change and sulfate geoengineering** https://acp.copernicus.org/preprints/acp-2020-747/
- Rickels,W., Quaas, M. F., Ricke, K., Quaas, J., Moreno-Cruz, J., Smulders, S. (2020) **Who turns the global thermostat and by how much?** https://doi.org/10.1016/j.eneco.2020.104852

SPP 1689 in Oxford Research Encyclopedias: Geoengineering

- Barben, Daniel and Matzner, Nils (2020): **Anticipatory Governance of Climate Engineering.** In Oxford Research Encyclopedias: Geoengineering. DOI: 10.1093/acrefore/9780190228620.013.69.
- Ott Konrad and Neuber, Frederike (2020) **The Debate on Climate Engineering in the Context of Climate Change.** In Oxford Research Encyclopedias: Geoengineering. DOI: 10.1093/acrefore/9780190228620.013.815

Publications 2020

- Kreuter, J., Matzner, N., Baatz, C., Keller, D.P., Markus, T., Wittstock, F., Bernitt, U. and Mengis, N. **Unveiling assumptions through interdisciplinary scrutiny: Observations from the German Priority Program on Climate Engineering (SPP 1689).** Climatic Change (2020). https://doi.org/10.1007/s10584-020-02777-4
- Neuber, F. and Ott, K. **The Buying Time Argument within the Solar Radiation Management Discourse.** Appl. Sci. 2020, 10, 4637. https://doi.org/10.3390/app10134637
- Amann, T., Hartmann, J., Struyf, E., de Oliveira Garcia, W., Fischer, E. K., Janssens, I., Meire, P. and Schoelynck, J. (2020) **Enhanced Weathering and related element fluxes – a cropland mesocosm approach.** https://doi.org/10.5194/bg-17-103-2020

- Matzner, N. and Barben, D. (2020): **Climate Engineering as a Communication Challenge: Contested Notions of Responsibility Across Expert Arenas of Science and Policy.** https://doi.org/10.1177/1075547019899408

Das Klima retten - aber wie? // Tagesschau 24 // THEMA

ARD // 22.12.2019

New Publications

- Merk, C., Klaus, G., Pohlers, J., Ernst, A., Ott, K., and Rehdanz, K. (2019): **Public Perceptions of Climate Engineering: Laypersons' Acceptance at Different Levels of Knowledge and Intensities of Deliberation.** https://doi.org/10.14512/gaia.28.4.6

- Klaus, G., A. Ernst, L. Oswald (2019) **Psychological factors influencing laypersons' acceptance of climate engineering, climate change mitigation and business as usual scenarios**. https://doi.org/10.1016/j.techsoc.2019.101222

Unsere Klimaziele – die Rolle negativer Emissionen: SPP 1689 beim Tag der offenen Tür des GEOMARs

Sonntag, 18. August 2019, 11 - 17 Uhr.

GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, Wischhofstr. 1-3, 24148 Kiel.

New Publication

- Rickels, W., C, Merk, F. Reith, D. Keller and A. Oschlies (2019). **(Mis)conceptions about modelling of negative emissions technologies**. Environ. Res. Lett., https://iopscience.iop.org/article/10.1088/1748-9326/ab3ab4
- Stenzel, F., D. Gerten, C. Werner and J. Jägermeyr (2019) **Freshwater requirements of large-scale bioenergy plantations for limiting global warming to 1.5 °C,** Environmental Research Letters 14, https://iopscience.iop.org/article/10.1088/1748-9326/ab2b4b

Unsere Klimaziele – die Rolle negativer Emissionen: Trickfilm auf der Kieler Woche 2019

Zu sehen auf der Kieler Woche im Zelt auf der "Schlaumachwiese" vor dem GEOMAR.

Podiumsdiskussion im Museum für Naturkunde

MITTWOCH 15. MAI 2019 // 19:30 – 22:30
MUSEUM FÜR NATURKUNDE BERLIN

WIRD CLIMATE ENGINEERING SALONFÄHIG?

Das Schwerpunktprogramm der Deutschen Forschungsgemeinschaft zu Climate Engineering und das Museum für Naturkunde luden zur öffentlichen Podiumsdiskussion ein.

Weitere Informationen und Impressionen hier.

SPP 1689 Workshop

Climate Engineering: Opportunities and Challenges for Responsible Research and Anticipatory Governance

May 14-16, 2019 in Berlin

Read more

New Publications

- Boyd, P., C. Vivian, M. Boettcher, F. Chai, J. Cullen, T. Goeschl, R. Lampitt, A. Lenton, A. Oschlies, G. Rau, R. Rickaby, K. Ricke an R. Wanninkhof (2019). **High Level Review of a Wide Range of Proposed Marine Geoengineering Techniques**, Journal Series GESAMP Reports and Studies 98, http://www.gesamp.org/publications/high-level-review-of-a-wide-range-of-proposed-marine-geoengineering-techniques
- Irvine, P., K. Emanuel, J. He, L. W. Horowitz, G. Vecchi and D. Keith (2019). **Halving warming with idealized solar geoengineering moderates key climate hazards,** Nature Climate Changevolume 9, 295–299, https://www.nature.com/articles/s41558-019-0398-8
- Mengis, N., D. P. Keller, W. Rickels, M. Quaas and A. Oschlies (2019). **Climate engineering–induced changes in correlations between Earth system variables—implications for appropriate indicator selection,** Climate Change, https://link.springer.com/article/10.1007/s10584-019-02389-7
- Pfrommer, T., Goeschl, T., Proelss, A. et al. Climatic Change (2019). **Establishing causation in climate litigation: admissibility and reliability.** https://doi.org/10.1007/s10584-018-2362-4
- Reith, F., W. Koeve, D. P. Keller, J. Getzlaff and A. Oschlies (2019). **Meeting climate targets by direct CO2 injections: What price would the ocean have to pay?** Earth System Dynamics, https://www.earth-syst-dynam-discuss.net/esd-2018-87/
- Robrecht, S., B. Vogel, J.-U. Grooß, K. Rosenlof, T. Thornberry, A. Rollins, M. Krämer, L. Christensen and R. Müller (2019) **Mechanism of ozone loss under enhanced water vapour conditions in the mid-latitude lower stratosphere in Summer,** Atmos. Chem. Phys., 10, 5805-5833, https://www.atmos-chem-phys.net/19/5805/2019/
-

Öffentlicher Vortrag in der GEOMAR-Reihe »Wissen Schaffen«: Wie wir das 1.5 Grad Ziel noch erreichen könnten

Prof. Dr. Andreas Oschlies // Mittwoch, 16. Januar 2019

Sehen und hören Sie den Vortag auf youtube: https://youtu.be/APnDQsenbdI

Klar Soweit? No.59 – Dr. Greenhouse

Comic der Helmholtz Gemeinschaft zum Thema Climate Engineering:

https://blogs.helmholtz.de/augenspiegel/2018/12/klar-soweit-no-59/

Workshop Detection and Attribution of Climate Engineering

3 – 5 December 2018, Hamburg, Elsa-Brandström-Haus (www.ebh-hamburg.de)

More information and some impressions here ...

Debatte zu Geoengineering vom 28. November ab 18 Uhr im Spreepalais in Berlin: https://www.die-debatte.org/geoengineering/ **(deutsch)**

Auf dem Podium zu Gast waren die Geographin Lili Fuhr von der Heinrich-Böll-Stiftung, der Ökonom Prof. Jan Christoph Minx, PhD vom Mercator Research Institute on Global Commons and Climate Change und der Physiker Prof. Dr. Andreas Oschlies vom Helmholtz-Zentrum für Ozeanforschung in Kiel und Sprecher des SPP 1689. Christoph Koch (Stern) und Dr. Mai Thi Nguyen-Kim (freie Wissenschaftsjournalistin) moderierten die Veranstaltung.

Online
Die Debatte zu Geoengineering mit Texten, Videos und Grafiken: https://twitter.com/die_debatte
https://www.die-debatte.org

Zusammenfassung der Livedebatte auf youtube: https://www.youtube.com/watch?v=qmqKW5Uim7I

Wissenschaft, natürlich!

Mo / 26.11.2018 / 19:30 bis 21:00
Museum für Naturkunde Berlin · Invalidenstr. 43 · 10115 Berlin

Zum Thema: Climate Engineering – mit gezielten technischen Eingriffen das Klima verändern. Hilft uns das weiter?

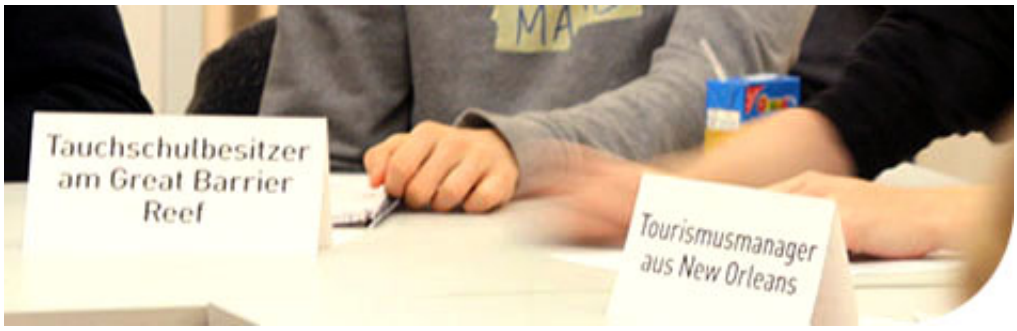
Diskussionsveranstaltung

Prof. Dr. Andreas Oschlies vom GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel und Prof. Dr. Alexander Proelß, Rechtswissenschaftler der Universität Hamburg diskutieren mit dem Publikum.

Eine Veranstaltung des Naturkundemuseums Berlin in Zusammenarbeit mit dem SPP 1689 im Rahmenprogramm zur Sonderausstellung ARTEFAKTE im Naturkundemuseum.

Weitere Informationen und Anmeldung:
https://www.museumfuernaturkunde.berlin/de/museum/veranstaltungen/wissenschaft-natuerlich

„Klimaforschung und Handlungsoptionen im globalen Wandel – Hintergründe, Möglichkeiten und Ideen für den naturwissenschaftlichen Unterricht“



Eine Kooperation des SPP 1689 mit dem Pädagogischen Landesinstitut Rheinland-Pfalz: Lehrerfortbildung am 26.10.2018 in Trier mit einem aktivierenden Vortag von Ulrike Bernitt und dem Climate engineering Rollenspiel „Globaler Krisenstab zum Klimawandel“.

Mehr zum Rollenspiel für Schüler finden Sie hier ...

Mehr zum Thema Climate Engineering als Thema im Schulunterricht hier …

»Date an Expert« im Museum für Naturkunde in Berlin

Treffen Sie Fabian Stenzel aus unserem Projekt CE-LAND+ und weitere Experten am Mittwoch, den 17.10. im Museum für Naturkunde in Berlin:

Mehr zu Date an Expert am 17.10. ...

Eine Veranstaltung im Rahmen der sehenswerten Ausstellung ARTEFAKTE über drängende Umeltthemen.

Video beim Rundfunk Berlin-Brandenburg (rbb) über die Veranstaltung und die Ausstellung mit Fabian Stenzel hier ... (nur bis 25.10.)

Our animation film is now available on youtube: Ambitious climate targets – the role of negative emissions

3rd SPP 1689 Retreat / September 2018

3rd & last annual retreat of the SPP1689/2
26. - 28. September Schloss Buchenau

Some Impressions

SPP 1689 on youtube

Find our films on youtube at the SPP1689 channel:
https://www.youtube.com/channel/UC_jrnTE19gsL2N1xCmhL_Jg

New SPP 1689 Publications

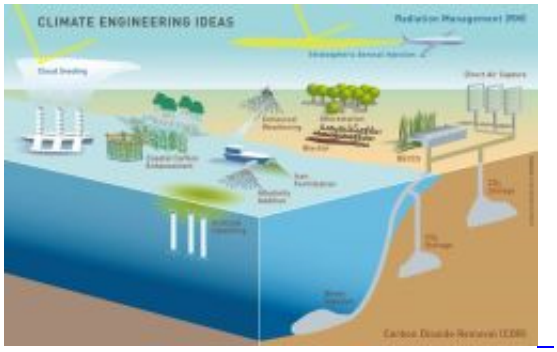
- Beck, Silke; et al. (2018): The politics of anticipation. **The IPCC and the negative emissions technologies experience**, https://doi.org/10.1017/sus.2018.7
- Beck, Silke, M. Mahony (2018): **The IPCC and the new map of science and politics**, WIREs Clim Change, https://doi.org/10.1002/wcc.547
- Held, Hermann (2018): **Der ökonomische Wert von Klimainformation: Zur Neuinterpretation von Klimazielen unter antizipiertem Lernen**, Unsicherheit als Herausforderung für die Wissenschaft, https://www.peterlang.com/view/9783631761533/chapter-003.xhtml#_idParaDest-5
- Janich, Nina and C. Stumpf (2018): **Verantwortung unter der Bedingung von Unsicherheit - und was KlimawissenschaftlerInnen darunter verstehen**, Unsicherheit als Herausforderung für die Wissenschaft, https://www.peterlang.com/view/9783631761533/chapter-009.xhtml#_idParaDest-13
- Lawrence, Mark G., S. Schäfer, H. Muri, V. Scott, A. Oschlies, N. E. Vaughan, O. Bucher, H. Schmidt, J. Haywood and J. Scheffran (2018): **Evaluating climate geoengineering proposals in the context of the Paris Agreement temperature goals**, Nature Communications 9 (3734), https://doi.org/10.1038/s41467-018-05938-3
- Matzner, Nils and D. Barben (2018): **Verantwortungsvoll das Klima manipulieren? Unsicherheit und Verantwortung im Diskurs um Climate Engineering**, Unsicherheit als Herausforderung für die Wissenschaft, https://www.peterlang.com/view/9783631761533/chapter-008.xhtml#_idParaDest-12
- Merk, C., Pönitzsch, G. and Rehdanz, K. (2018) **Do climate engineering experts display moral-hazard behaviour?, Climate Policy,** doi: 10.1080/14693062.2018.1494534
- Neuber, Frederike (2017): **Buying Time with Climate Engineering? An analysis of the buying time framing in favor of climate engineering,** https://publikationen.bibliothek.kit.edu/1000084294
- Oschlies, Andreas (2018): **Bewertung von Modellqualität und Unsicherheiten in der Klimamodellierung**, Unsicherheit als Herausforderung für die Wissenschaft, https://www.peterlang.com/view/9783631761533/chapter-002.xhtml#_idTextAnchor040
- Pfrommer, T. (2018): **Diverging Regional Climate Preferences and the Assessment of Solar Geoengineering**, Discussion Paper Series (654), doi:10.11588/heidok.00025204
- Rickels, W., M. Quaas, K. Ricke, J. Quaas, J. Moreno-Cruz, S. Smulders (2018): **Turning the**

Global Thermostat — Who, When, and How Much?, Kiel Working Paper (2110), https://www.ifw-kiel.de/de/experten/ifw-researcher-internal/wilfried-rickels/turning-the-global-thermostat-who-when-and-how-much/

Video Impression from the SPP 1689 & ISOS Workshop on Science Communication

A video by Zhihong Zho // July 2018 // Travemünde

Updated versions of our information graphics on Climate Engineering ideas



More interesting downloads here under KNOWLEDGE TRANSFER

Contrails vs Chemtrails

More informations (german only)


Young Scientist Retreat & Workshop 2018

The SPP 1689 Young Scientist Retreat & Workshop on Interdisciplinary Exchange took place in

the **Landhaus Lenzener Elbtalaue**, **April 23-25**.

Some impressions

New HYPERAUM.TV-Shows (german)

Report: http://hyperraum.tv/2018/04/01/frei-schwebend/
Talk with Prof. Andreas Oschlies (DFG-Politik) http://hyperraum.tv/2018/04/06/in-schieflage/
Talk with Prof. Andreas Oschlies
(Mesokosmos) http://hyperraum.tv/2018/04/06/waerme-upload-oder-co2-download/
Talk with Prof. Thomas Leisner http://hyperraum.tv/2018/04/01/die-wolke-im-labor/
Teaser: https://www.youtube.com/watch?v=D1SpfQ2-FrY
Video-Blog at SciLogs https://scilogs.spektrum.de/hyperraumtv/von-wolkenmachern-zu-wolkenjaegern/

SPP 1689 citizen's jury

The DFG project TOMACE**,** one of the projects within the SPP 1689 »Climate Engineering«, started in January his citizen's jury. **Participation was only possible by invitation.**

More informations
Some impressions

New SPP 1689 Publications

- Ferrer González, Miriam, Tatiana Ilyina, Sebastian Sonntag, Hauke Schmidt (2018): **Enhanced Rates of Regional Warming and Ocean Acidification after Termination of Large-scale Ocean Alkalinization,** Geophysical Research Letters, doi: 10.1029/2018gl077847
- Keller, D.P., Lenton, A., Littleton, E.W. et al. (2018): **The Effects of Carbon Dioxide Removal on the Carbon Cycle**, Curr Clim Change Rep, 1-16, https://doi.org/10.1007/s40641-018-0104-3
- Kriegler, M., G. Luderer, N. Bauer, L. Baumstark, S. Fujimori, A. Popp, J. Rogelj, J. Strefler, . P. van Vuuren (2018): **Pathways limiting warming to 1.5°C: a tale of turning around in no time?,** Phil. Trans. R. Soc. A 2018 376 20160457, https://doi.org/10.1098/rsta.2016.0457
- Oliveira-Garcia, W., T. Amann, J. Hartmann (2018): **Increasing biomass demand enlarges negative forest nutrient budget areas in wood export regions,** Scientific Reports 8 (5280), doi:10.1038/s41598-018-22728-5
- Ott, K. K. (2018): **On the Political Economy of Solar Radiation Management,** Frontiers in Environmental Science 6, 43, https://doi.org/10.3389/fenvs.2018.00043
- Rickels, W., Reith, F., Keller, D., Oschlies, A., & Quaas, M. F. (2018): **Integrated Assessment of Carbon Dioxide Removal**, Earth's Future, 6. doi.org/10.1002/2017EF000724
- Roshan, E., M. M. Khabbazan & H. Held (2018): **Cost-Risk Trade-Off of Mitigation and Solar Geoengineering: Considering Regional Disparities Under Probabilistic Climate Sensitivity,** Environ. Resource Econ., 1-17, https://doi.org/10.1007/s10640-018-0261-9
- Strefler, Jessica; et al. (2018): **Between Scylla and Charybdis: Delayed mitigation narrows the passage between large-scale CDR and high costs,** Environmental Research Letters, 13. 044015. doi.org/10.1088/1748-9326/aab2ba
- Werner, C., H-P. Schmidt, D. Gerten, W. Lucht and C. Kammann (2018): **Biogeochemical potential of biomass pyrolysis systems for limiting global warming to 1.5 °C,** Environmental Research Letters 13 (4), http://doi.org/10.1088/1748-9326/aabb0e

Carbon Dioxide Removal Model Intercomparison Project

CDRMIP

CDRMIP has been endorsed by CMIP6

The Coupled Model Intercomparison Project (CMIP; currently in it's 6th phase) is organized under the auspices of the World Climate Research Programme (WCRP) and designed to better understand past, present, and future climate change through coordinated international multi-model experiments that have become a central element of national and international assessments of climate change, e.g., IPCC reports. The Carbon Dioxide Removal Model Intercomparison Project (CDRMIP), which has just been endorsed

by CMIP6, brings together models of the Earth system in a common framework to explore the potential, impacts, and challenges of Carbon Dioxide Removal (CDR). CDRMIP experiments are designed to address questions concerning CDR-induced climate "reversibility", the response of the Earth system to direct atmospheric CO_2 removal (direct air capture and storage), and the CDR potential of proposed schemes such as afforestation/reforestation and ocean alkalinization.

World Climate Research Program: https://www.wcrp-climate.org/modelling-wgcm-mip-catalogue/cmip6-endorsed-mips-article/1302-modelling-cmip6-cdrrmip

CDRMIP: https://cdrmip.carbondioxide-removal.eu/

New SPP 1689 Publications

- Keller, D. P., Lenton, A., Scott, V., Vaughan, N. E., Bauer, N., Ji, D., Jones, C. D., Kravitz, B., Muri, H., and Zickfeld, K.: **The Carbon Dioxide Removal Model Intercomparison Project (CDR-MIP): Rationale and experimental protocol for CMIP6,** Geosci. Model Dev., https://doi.org/10.5194/gmd-2017-168, 2018
- Kleinschmitt, C., Boucher, O., and Platt, U. (2018): **Sensitivity of the radiative forcing by stratospheric sulfur geoengineering to the amount and strategy of the SO_2injection studied with the LMDZ-S3A model**, Atmos. Chem. Phys., 18, 2769-2786, https://doi.org/10.5194/acp-18-2769-2018
- Oschlies, Andreas (2018): **Solar engineering must take temperature debt into account,** Nature 554, 423**,** https://www.nature.com/articles/d41586-018-02203-x
- Mengis, N., Keller, D. P., and Oschlies, A. (2018): **Systematic Correlation Matrix Evaluation (SCoMaE) – a bottom–up, science-led approach to identifying indicators**, Earth Syst. Dynam., 9, 15-31, https://doi.org/10.5194/esd-9-15-2018

- Keller D.P. (2018) **Marine Climate Engineering**. In: Salomon M., Markus T. (eds) Handbook on Marine Environment Protection. Springer, Cham, doi:10.1007/978-3-319-60156-4_13
- Strefler, Jessica; et al. (2018): **Potential and costs of carbon dioxide removal by enhanced weathering of rocks** https://doi.org/10.1088/1748-9326/aaa9c4

- Sonntag, Sebastian; et al. (2018): **Quantifying and comparing effects of climate engineering methods on the Earth system**, Earth's Future, doi:10.1002/2017EF000620
- Heck, Vera; et al. (2018): **Biomass-based negative emissions difficult to reconcile with planetary boundaries**, Nature Climate Change (2018), doi:10.1038/s41558-017-0064-y

SPP 1689 Workshop Terrestrial CO2 Removal

SPP 1689 WORKSHOP // 22 – 23 Jan 2018 // Potsdam Institute for Climate Impact Research, A56

Terrestrial CO_2 Removal: Potentials and tradeoffs in the SDG context

This workshop will look into a set of pertinent questions related to potentials of tCDR methods and their interaction with SDGs. It will bring together SPP 1689 researchers and external experts to increase our holistic understanding of global and regional potentials and side-effects of tCDR as well as to identify future research priorities.
read more and find the agenda here ...

New Publications

Niemeier, U. and Schmidt, H. (2017): **Changing transport processes in the stratosphere by radiative heating of sulfate aerosols**, Atmos. Chem. Phys., 17, 14871-14886, https://doi.org/10.5194/acp-17-14871-2017

Feng, E. Y.; Koeve, W.; Keller, D. P. and Oschlies, A. (2017): **Model-based Assessment of the CO2 Sequestration Potential of Coastal Ocean Alkalinization**. In Earth's Future. DOI: 10.1002/2017EF000659. http://onlinelibrary.wiley.com/doi/10.1002/2017EF000659/pdf

New Publication

Ferrer-Gonzalez, M. (2017). **Climate engineering by enhancement of ocean alkalinity: impacts on the Earth system and a comparison with solar radiation management.** PhD Thesis, Universität Hamburg, Hamburg. doi:10.17617/2.2472753. http://hdl.handle.net/11858/00-001M-0000-002D-CEB7-1

German Science Hour im Deutschen Pavillion auf der COP 23

https://www.fona.de/de/german-science-hour-22654.html

https://twitter.com/hashtag/GermanScienceHour?src=hash&lang=de

Andreas Oschlies, Mark Lawrence, Oliver Geden and Lilly Fuhr: "**Failing the carbon budget - what's next?"** (Photo)

SPP 1689 Workshop Climate Engineering Regulation and

Liability

16 – 18 October 2017, KIEL

Some photographs, more information and the agenda here (english only) ...

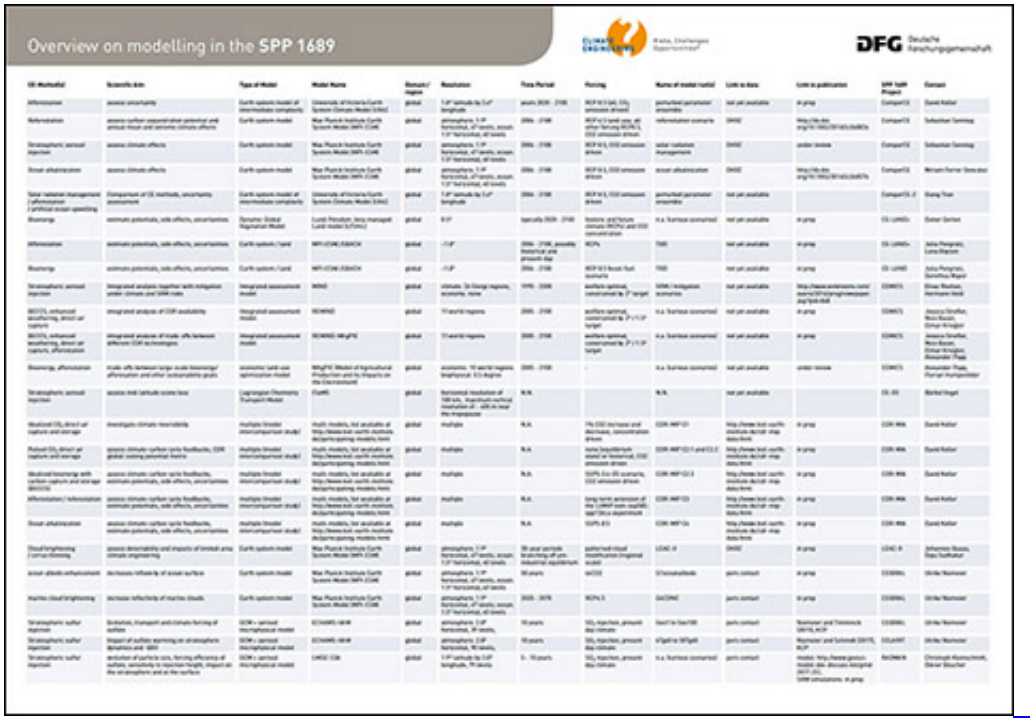
New SPP 1689 Publications

- Tavoni, M., V. Bosetti, S. Shayegh, L. Drouet, J. Emmerling, S. Fuss, T. Goeschl, C. Guivarch, T. S. Lontzek, V. Manoussi, J. Moreno-Cruz, H. Muri, M. Quaas, W. Rickels, (2017), '**Challenges and Opportunities for Integrated Modeling of Climate Engineering**', Nota di Lavoro 38.2017, Milan, Italy: Fondazione Eni Enrico Mattei. http://www.feem.it/en/publications/feem-working-papers-note-di-lavoro-series/challenges-and-opportunities-for-integrated-modeling-of-climate-engineering/

- Kemena,Tronje Peer; Matthes, Katja; Martin, Thomas; Wahl, Sebastian; Oschlies, Andreas: **Atmospheric feedbacks in North Africa from an irrigated, afforested Sahara,** Clim Dyn (2017). https://doi.org/10.1007/s00382-017-3890-8

- Keller, D. P., Lenton, A., Scott, V., Vaughan, N. E., Bauer, N., Ji, D., Jones, C. D., Kravitz, B., Muri, H., and Zickfeld, K.: **The Carbon Dioxide Removal Model Intercomparison Project (CDR-MIP): Rationale and experimental design**, Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2017-168, in review, 2017.

Overview on modelling in the SPP 1689



Overview on modelling in the SPP 1689

CE Method/s	Scientific aim	Type of Model	Model Name	Domain / region	Resolution	Time Period	Forcing	Name of model run/s	Link to data	Link to publication	SPP 1689 Project	Contact
Afforestation	assess uncertainty	Earth system model of intermediate complexity	University of Victoria Earth System Climate Model (UVic)	global	1.8° latitude by 3.6° longitude	years 2020 - 2100	RCP 6.0 GHG, CO_2 emission driven	perturbed parameter ensemble	not yet available	in prep	CompCO	David Keller
Reforestation	assess carbon sequestration potential and annual mean and extreme climate effects	Earth system model	Max Planck Institute Earth System Model (MPI-ESM)	global	atmosphere, 1.8° horizontal, 47 levels, ocean, 1.5° horizontal, 40 levels	2006 - 2100	RCP 4.5 land use, all other forcing RCP6.0, CO_2 emission driven	reforestation scenario	DKRZ	http://dx.doi.org/10.1002/2016JD025836	CompCO	Sebastian Sonning
Stratospheric aerosol injection	assess climate effects	Earth system model	Max Planck Institute Earth System Model (MPI-ESM)	global	atmosphere, 1.8° horizontal, 47 levels, ocean, 1.5° horizontal, 40 levels	2006 - 2100	RCP 8.5, CO_2 emission driven	solar radiation management	DKRZ	under review	CompCO	Sebastian Sonning
Ocean alkalinization	assess climate effects	Earth system model	Max Planck Institute Earth System Model (MPI-ESM)	global	atmosphere, 1.8° horizontal, 47 levels, ocean, 1.5° horizontal, 40 levels	2006 - 2100	RCP 8.5, CO_2 emission driven	ocean alkalinization	DKRZ	http://dx.doi.org/10.1002/2016JD025836	CompCO	Miriam Forster Sonnabend
Solar radiation management / afforestation / artificial ocean upwelling	Comparison of CE methods, uncertainty assessment	Earth system model of intermediate complexity	University of Victoria Earth System Climate Model (UVic)	global	1.8° latitude by 3.6° longitude	2006 - 2100	RCP 8.5, CO_2 emission driven	perturbed parameter ensemble	not yet available		CompCO_2	Giang Tran
Biochar	estimate potentials, side effects, uncertainties	Dynamic Global Vegetation Model	Lund Potsdam Jena managed Land model (LPJmL)	global	0.5°	typically 2020 - 2100	historic and future climate (RCPs) and CO_2 concentration	n.a. Various scenarios	not yet available	in prep	CE LANDs	Dieter Gerten
Afforestation	estimate potentials, side effects, uncertainties	Earth system / land	MPI-ESM/JSBACH	global	~1.8°	2006 - 2100, possibly historical and present day	RCPs	TBD	not yet available	in prep	CE LANDs	Julia Pongratz, Lena Hansen
Biochar	estimate potentials, side effects, uncertainties	Earth system / land	MPI-ESM/JSBACH	global	~1.8°	2006 - 2100	RCP 6.0 fossil fuel scenario	TBD	not yet available	in prep	CE LANDs	Julia Pongratz, Dorothea Wagner
Stratospheric aerosol injection	integrated analysis together with mitigation under climate and SDM risks	Integrated assessment model	MIND	global	climate: 26 Energy regions, economy: none	1990 - 2300	welfare optimal, constrained by 2° target	SDM / mitigation scenarios	not yet available	http://www.sciencedirect.com/science/article/pii/S1750583614000468	CEMICS	Elmar Kriegler, Hermann Held
BECCS, enhanced weathering, direct air capture	integrated analysis of CDR availability	Integrated assessment model	REMIND	global	11 world regions	2005 - 2100	welfare optimal, constrained by 2°/1.5° target	n.a. Various scenarios	not yet available	in prep	CEMICS	Jessica Strefler, Nico Bauer, Elmar Kriegler
BECCS, enhanced weathering, direct air capture, afforestation	integrated analysis of trade offs between different CDR technologies	Integrated assessment model	REMIND MAgPIE	global	11 world regions	2005 - 2100	welfare optimal, constrained by 2°/1.5° target	n.a. Various scenarios	not yet available	in prep	CEMICS	Jessica Strefler, Nico Bauer, Elmar Kriegler, Alexander Popp
Bioenergy, afforestation	trade offs between large scale bioenergy/ afforestation and other sustainability goals	economic land use optimization model	MAgPIE (Model of Agricultural Production and its Impacts on the Environment)	global	economic, 10 world regions, biophysical: 0.5 degree	2005 - 2100	-	n.a. Various scenarios	not yet available	under review	CEMICS	Alexander Popp, Florian Humpenöder
Stratospheric aerosol injection	assess mid latitude scenarios	Lagrangian Chemistry Transport Model	CLaMS	global	horizontal resolution of 100 km, vertical resolution of 400 m near the tropopause	N.A.		N.A.	not yet available		CE 03	Markus Vogel
Idealized CO_2 direct air capture and storage	investigate climate reversibility	multiple limited intercomparison study	multi models, list available at http://www.ecac-earth.mpifdda.de/participating-models.html	global	multiple	N.A.	1% CO_2 increase and decrease, concentration driven	CDR-MIP C1	http://www.ecac-earth.mpifdda.de/cdr-mip-data.html	in prep	CDR-MIP	David Keller
Physical CO_2 direct air capture and storage	assess climate-carbon cycle feedbacks, CDR global cooling potential, inertia	multiple limited intercomparison study	multi models, list available at http://www.ecac-earth.mpifdda.de/participating-models.html	global	multiple	N.A.	none (equilibrium stated or historical, CO_2 emission driven	CDR-MIP C2.1 and C2.2	http://www.ecac-earth.mpifdda.de/cdr-mip-data.html	in prep	CDR-MIP	David Keller
Idealized bioenergy with carbon capture and storage (BECCS)	assess climate-carbon cycle feedbacks, estimate potentials, side effects, uncertainties	multiple limited intercomparison study	multi models, list available at http://www.ecac-earth.mpifdda.de/participating-models.html	global	multiple	N.A.	SSP5, Exc 20 scenario, CO_2 emission driven	CDR-MIP C2.3	http://www.ecac-earth.mpifdda.de/cdr-mip-data.html	in prep	CDR-MIP	David Keller
Afforestation / reforestation	assess climate-carbon cycle feedbacks, estimate potentials, side effects, uncertainties	multiple limited intercomparison study	multi models, list available at http://www.ecac-earth.mpifdda.de/participating-models.html	global	multiple	N.A.	long term extension of the LUMIP non-equilibrium 10^{14} C or equivalent	CDR-MIP C3	http://www.ecac-earth.mpifdda.de/cdr-mip-data.html	in prep	CDR-MIP	David Keller
Ocean alkalinization	assess climate-carbon cycle feedbacks, estimate potentials, side effects, uncertainties	multiple limited intercomparison study	multi models, list available at http://www.ecac-earth.mpifdda.de/participating-models.html	global	multiple	N.A.	SSP5-8.5	CDR-MIP C4	http://www.ecac-earth.mpifdda.de/cdr-mip-data.html	in prep	CDR-MIP	David Keller
Cloud brightening / cirrus thinning	assess detectability and impacts of limited area climate engineering	Earth system model	Max Planck Institute Earth System Model (MPI-ESM)	global	atmosphere, 1.8° horizontal, 47 levels, ocean, 1.5° horizontal, 40 levels	30 year periods starting off pre-industrial equilibrium	pattered cloud modification (regional scale)	LCAC-A	DKRZ	in prep	LCAC-A	Johannes Quaas, Daja Sudhakar
ocean albedo enhancement	increase reflectivity of ocean surface	Earth system model	Max Planck Institute Earth System Model (MPI-ESM)	global	atmosphere, 1.8° horizontal, 47 levels, ocean, 1.5° horizontal, 40 levels	10 years	SnO_2	O'Connor/Bellouin	parts contact	in prep	CEOBNL	Ulrike Neumann
marine cloud brightening	increase reflectivity of marine clouds	Earth system model	Max Planck Institute Earth System Model (MPI-ESM)	global	atmosphere, 1.8° horizontal, 47 levels, ocean, 1.5° horizontal, 40 levels	2020 - 2070	RCPs 3	GeOMIP	parts contact	in prep	CEOBNL	Ulrike Neumann
Stratospheric sulfur injection	Evolution, transport and climate forcing of sulfate	GCM + aerosol microphysical model	ECHAM5-HAM	global	atmosphere, 2.8° horizontal, 31 levels,	10 years	SO_2 injection, present day climate	Sea/Ice Sea/100	parts contact	Neumann and Timmreck (2014), in prep	CEOBNL	Ulrike Neumann
Stratospheric sulfur injection	impact of sulfate warming on stratospheric dynamics and QBO	GCM + aerosol microphysical model	ECHAM5-HAM	global	atmosphere, 2.8° horizontal, 31 levels,	10 years	SO_2 injection, present day climate	4Tg/yr to 50Tg/yr	parts contact	Neumann and Schmidt (2017), ACP	CEOLAST	Ulrike Neumann
Stratospheric sulfur injection	evolution of particle size, forcing efficiency of sulfate, sensitivity to injection height, impact on the stratosphere and at the surface	GCM + aerosol microphysical model	LMDZ-CIM	global	1.9° latitude by 3.75° longitude, 79 levels	5 - 10 years	SO_2 injection, present day climate	n.a. Various scenarios	parts contact	model: http://www.geosci-model-dev.discuss.net/special_issue/GMD_LMDz_aerosols_in_prep	NoOMICS	Christoph Kleinschmitt, Olivier Boucher

CEC17 BERLIN

Critical Global Discussions

Climate Engineering Conference 2017

October 9 -12, 2017, Berlin

plus.faz.net

Klimaschutz braucht mehr Forscher und Erfinder
// Weniger Emissionen allein reichen nicht: Der Atmosphäre muss CO2 entzogen werden / Von Andreas Mihm

Wilfried Rickels u.a. im Artikel auf plus.faz.net (german):

http://plus.faz.net/wirtschaft/2017-08-15/b7d10e4889e5578561092afc696526cd/

New SPP 1689 Publications

- Niemeier, Ulrike, Tilmes, Simone: **Sulfur injections for a cooler planet,** Science 21 Jul 2017, Vol. 357, Issue 6348, pp. 246-248, DOI: 10.1126/science.aan3317, http://science.sciencemag.org/content/357/6348/246

- Lohmann, Ulrike, Gasparini, Blaž: **A cirrus cloud climate dial?,** Science 21 Jul 2017, Vol. 357, Issue 6348, pp. 248-249, DOI: 10.1126/science.aan3325, http://science.sciencemag.org/content/357/6348/248

- Kleinschmitt, C., Boucher, O., and Platt, U.: **Sensitivity of the radiative forcing by stratospheric sulfur geoengineering to the amount and strategy of the SO_2 injection studied with the LMDZ-S3A model,** Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2017-722, in review, 2017. https://www.atmos-chem-phys-discuss.net/acp-2017-722/

- Stelzer, Harald (2017): **Justifying Climate Engineering?**. In: Jahrbuch für Wissenschaft und Ethik. Band 21 (2016). Berlin: De Gruyter, 147–169.

SPP 1689 on youtube

Find our films on youtube at the SPP1689 channel:
https://www.youtube.com/channel/UC_jrnTE19gsL2N1xCmhL_Jg

2nd SPP 1689 Retreat / Summer 2017

July 5-7, 2017 at the Schloss Buchenau **near Fulda/Bad Hersfeld.**

Impressions of the Retreat here.

Agenda (104.1 KiB)

New SPP 1689 Publications

- Braun, Carola; Merk, Christine; Pönitzsch, Gert; Rehdanz, Katrin; Schmidt, Ulrich (2017): **Public perception of climate engineering and carbon capture and storage in Germany. Survey evidence.** In: Climate Policy 5 (1), S. 1–14. DOI: 10.1080/14693062.2017.1304888 http://www.tandfonline.com/doi/abs/10.1080/14693062.2017.1304888?tokenDomain=eprints&tokenAccess=vqDyV6Wab5KBByafy5fX&forwardService=showFullText&doi=10.1080%2F14693062.2017.1304888&doi=10.1080%2F14693062.2017.1304888&journalCode=tcpo2

Radio Ecoshock

Lena Boysen about »green« climate engineering with trees:

http://www.ecoshock.org/2017/05/trees-we-love-but-cannot-save.html

New SPP 1689 Publications

- Boysen, Lena R.; et al. (2017): **The limits to global-warming mitigation by terrestrial carbon removal.** In: Earth's Future. DOI:10.1002/2016EF000469 http://onlinelibrary.wiley.com/doi/10.1002/2016EF000469/full

- Muraca, Barbara; Neuber, Frederike (2017): **Viable and convivial technologies: Considerations on Climate Engineering from a degrowth perspective**. In: Journal of Cleaner Production. DOI: 10.1016/j.jclepro.2017.04.159 http://www.sciencedirect.com/science/article/pii/S0959652617308983

- Beck, Silke; Mahony, Martin (2017): **The IPCC and the politics of anticipation**. In: Nature Climate Change, Vol. 7, p. 311-333, DOI: 10.1038/nclimate3264 http://www.nature.com/nclimate/journal/v7/n5/full/nclimate3264.html?WT.ec_id=NCLIMATE-201705&spMailingID=53950284&spUserID=ODkwMTM2NjQyMAS2&spJobID=1144733188&spReportId=MTE0NDczMzE4OAS2

First Young Scientist Retreat of the 2nd Phase

SPP 1689 Young Scientist Retreat in Malente

Impressions here …

New SPP 1689 Publications

- Boysen, Lena; et. al (2017): **Trade-offs for food production, nature conservation and climate limit the terrestrial carbon dioxide removal potential.** In: Global Change Biology, Accepted Articles, DOI: 10.1111/gcb.13745 http://onlinelibrary.wiley.com/doi/10.1111/gcb.13745/abstract
- Boysen, Lena; et. al (2016): I**mpacts devalue the potential of large-scale terrestrial CO2 removal through biomass plantations.** In: Environmental Research Letters, Vol. 11, Letter 9, DOI: 10.1088/1748-9326/11/9/095010 http://iopscience.iop.org/article/10.1088/1748-9326/11/9/095010/meta;jsessionid=325AACE0FC1BCA551F5ABFF7BC15679E.ip-10-40-2-108
- Montserrat, Francesc; et al. (2017): **Olivine Dissolution in Seawater: Implications for CO2 Sequestration through Enhanced Weathering in Coastal Environments.** In: Environmental Science & Technology, 51, 3960-3970. DOI: 10.1021/acs.est.6b05942 http://pubs.acs.org/doi/abs/10.1021/acs.est.6b05942

Veröffentlichung der Deutschen Meteorologischen Gesellschaft

Die Deutsche Meteorologischen Gesellschaft (DMG) hat eine Stellungnahme und einen kurzen Erläuterungstext zu Climate Engineering in ihren »Mitteilungen« veröffentlicht:

Stellungnahme DMG CE (415.4 KiB)

DFG Klimataucher: Überzeugungssache Klima

Beitrag mit Video angeregt vom SPP 1689 Projekt C-E-THICS.

Mit Prof. Dr. Gregor Betz und Frederike Neuber.

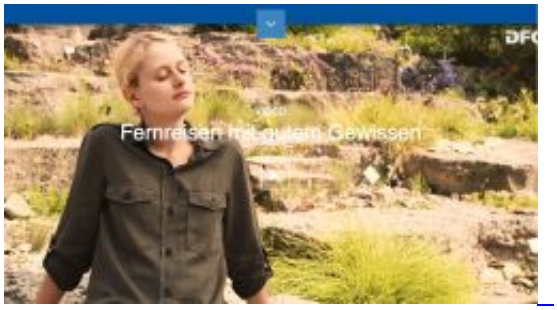
Erschienen im Rahmen der DFG Webapp Klimataucher.

DFG Klimataucher: Klimaeingriffe mit Recht und Ordnung

Beitrag angeregt vom SPP 1689 Projekt CEIBRAL.

Erschienen im Rahmen der DFG Webapp Klimataucher.

DFG Klimataucher: Der Traum von der Steuerung des Klimas



Beitrag mit Video angeregt vom SPP 1689 Projekt ComparCE.

Mit Prof. Dr. Andreas Oschlies und Dr. Nadine Mengis.

Erschienen im Rahmen der DFG Webapp Klimataucher.

New SPP 1689 Publications

- Quaas, Martin F.; Quaas, Johannes; Rickels, Wilfried; Boucher, Olivier (2017): **Are there reasons against open-ended research into solar radiation management? A model of intergenerational decision-making under uncertainty.** In Journal of Environmental Economics and Management. DOI: 10.1016/j.jeem.2017.02.002. http://www.sciencedirect.com/science/article/pii/S0095069617300608

New SPP 1689 Publications

- Oschlies, A.; Klepper, G. (2016): **Research for assessment, not deployment of Climate Engineering: The German Research Foundation's Priority Program SPP 1689.** In Earth´s Future. http://onlinelibrary.wiley.com/doi/10.1002/2016EF000446/abstract
- Oschlies, A.; Held, H.; Keller, D.; Keller, K.; Mengis, N.; Quaas, M. et al. (2016): **Indicators and Metrics for the Assessment of Climate Engineering.** In Earth's Future. DOI 10.1002/2016EF000449 http://onlinelibrary.wiley.com/doi/10.1002/2016EF000449/full
- Quaas, J.; Quaas, M. F.; Boucher, O. & Rickels, W. (2016): **Regional climate engineering by radiation management: Prerequisites and prospects.** In: Earth's future, http://onlinelibrary.wiley.com/doi/10.1002/2016EF000440/full
- Baatz, Christian; Ott, Konrad (2016): **Why Aggressive Mitigation Must Be Part of Any Pathway to Climate Justice.** In: Christopher J. Preston (Ed.): Climate Justice and Geoengineering: Rowman & Littlefield International.

http://www.rowmaninternational.com/books/climate-justice-and-geoengineering

- Boysen, Lena; et. al (2016): I**mpacts devalue the potential of large-scale terrestrial CO2 removal through biomass plantations.** In: Environmental Research Letters, Vol. 11, Letter 9, DOI: 10.1088/1748-9326/11/9/095010 http://iopscience.iop.org/article/10.1088/1748-9326/11/9/095010/meta;jsessionid=325AACE0FC1BCA551F5ABFF7BC15679E.ip-10-40-2-108

SPP 1689 Workshop on the 1.5°C Target and Climate Engineering

24–25 November 2016 // Kiel // Germany

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Faltblatt Naturwissenschaftler antworten Journalisten

Einige Naturwissenschaftler aus dem Schwerpunktprogramm SPP 1689 antworten hier professionellen WissenschaftsjournalistInnen vom „Nationalen Institut für Wissenschaftskommunikation“ (Karlsruhe) auf konkrete Fragen zu ihrer Wissenschaft.

Faltblatt Naturwissenschaftler antworten Journalisten (download) (600.4 KiB)

New SPP 1689 Publications

- Kreidenweis, Ulrich; Humpenöder, Florian; Stevanović, Miodrag; Bodirsky, Benjamin Leon; Kriegler, Elmar; Lotze-Campen, Hermann; Popp, Alexander (2016): **Afforestation to mitigate climate change. Impacts on food prices under consideration of albedo effects**. In Environ. Res. Lett. 11 (8), p. 85001–85001. http://iopscience.iop.org/article/10.1088/1748-9326/11/8/085001

- Gasparini, Blaž; Lohmann, Ulrike (2016): **Why cirrus cloud seeding cannot substantially cool the planet**. In J. Geophys. Res. Atmos. 121 (9), pp. 4877–4893. http://onlinelibrary.wiley.com/doi/10.1002/2015JD024666/abstract

- Heck, Vera; Donges, Jonathan F.; Lucht, Wolfgang (2016): **Collateral transgression of planetary boundaries due to climate engineering by terrestrial carbon dioxide removal**. In Earth Syst. Dynam. Discuss., pp. 1–24. http://www.earth-syst-dynam-discuss.net/esd-2016-22/

KlimaTaucher - Fernreisen mit gutem Gewissen? Wie wir das Klima beeinflussen können

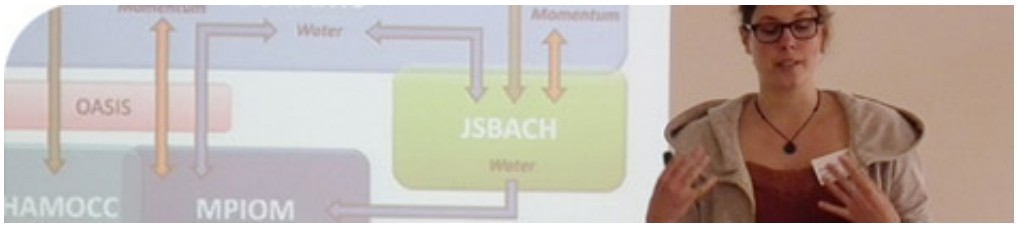
DFG-Filmproduktion zu Climate Engineering mit Andreas Oschlies und Nadine Mengis

http://www.dfg.de/webapps/klimataucher/#/de/vier_fragen_zum_klima/klimamanipulation_klimasteuerung

New SPP 1689 Publications

Ellias Y Feng (□□□), David P Keller, Wolfgang Koeve and Andreas Oschlies (2016): Could artificial ocean alkalinization protect tropical coral ecosystems from ocean acidification? In: Environmental Research Letters, vol. 11, no. 7, http://iopscience.iop.org/article/10.1088/1748-9326/11/7/074008/meta

SPP 1689 Retreat Impressions



First SPP 1689 retreat of the 2nd phase.

See more impressions here ...

First SPP 1689 Retreat of the 2nd Phase

14-16 June 2016, Kloster Haydau **/ Morschen**

(project presentations, discussion of action items for the 2nd phase, setting of cross-project topics)

Download Agenda

Agenda SPP 1689 Retreat June `16.pdf (72.7 KiB)

New SPP 1689 Publications

Mengis, Nadine; et al. (2016): **Assessing climate impacts and risks of ocean albedo modification in the Arctic.** In Journal of Geophysical Research: Oceans, vol. 121, 3
http://onlinelibrary.wiley.com/wol1/doi/10.1002/2015JC011433/abstract

Merk, Christine; Pönitzsch, Gert; Rehdanz, Katrin (2016): **Knowledge about aerosol injection does not reduce individual mitigration efforts.** In: Environmental Research Letters, vol. 11, no. 5
http://iopscience.iop.org/article/10.1088/1748-9326/11/5/054009/meta

Start of 2nd phase

Start of 2nd phase of SPP 1689, May 2016.

Project composition here