Some papers with a focus on using information from the past (or present) to improve predictions of future climate change

Chronological by publication date, most recent first:

An assessment of Earth's climate sensitivity using multiple lines of evidence

S. Sherwood M. J. Webb J. D. Annan K. C. Armour P. M. Forster J. C. Hargreaves G. Hegerl S. A. Klein K. D. Marvel E. J. Rohling M. Watanabe T. Andrews P. Braconnot C. S. Bretherton G. L. Foster Z. Hausfather A. S. von der Heydt R. Knutti T. Mauritsen J. R. Norris C. Proistosescu M. Rugenstein G. A. Schmidt K. B. Tokarska M. D. Zelinka
https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2019RG000678 Preprint: https://climateextremes.org.au/wp-content/uploads/2020/07/WCRP_ECS_Final_manuscript_2019RG000678R_FINAL_200720.pdf

(It's still 3 plus or minus a bit. -Ed)

Abstract: `We assess evidence relevant to Earth's equilibrium climate sensitivity per doubling of atmospheric CO2, characterized by an effective sensitivity S . This evidence includes feedback process understanding, the historical climate record, and the paleoclimate record. An S value lower than 2 K is difficult to reconcile with any of the three lines of evidence. The amount of cooling during the Last Glacial Maximum provides strong evidence against values of S greater than 4.5 K. Other lines of evidence in combination also show that this is relatively unlikely. We use a Bayesian approach to produce a probability density (PDF) for S given all the evidence, including tests of robustness to difficult-to-quantify uncertainties and different priors. The 66% range is 2.6-3.9 K for our Baseline calculation, and remains within 2.3-4.5 K under the robustness tests; corresponding 5-95% ranges are 2.3-4.7 K, bounded by 2.0-5.7 K (although such high-confidence ranges should be regarded more cautiously). This indicates a stronger constraint on S than reported in past assessments, by lifting the low end of the range. This narrowing occurs because the three lines of evidence agree and are judged to be largely independent, and because of greater confidence in understanding feedback processes and in combining evidence. We identify promising avenues for further narrowing the range in S , in particular using comprehensive models and process understanding to address limitations in the traditional forcing-feedback paradigm for interpreting past changes.`

Future climate forcing potentially without precedent in the last 420 million years

Foster, G. L., Royer, D. L., & Lunt, D. J., (2017). Future climate forcing potentially without precedent in

the last 420 million years. Nature Communications, 8, 1–8. http://doi.org/10.1038/ncomms14845
https://www.nature.com/articles/ncomms14845

Abstract: The evolution of Earth's climate on geological timescales is largely driven by variations in the magnitude of total solar irradiance (TSI) and changes in the greenhouse gas content of the atmosphere. Here we show that the slow B50 Wm 2 increase in TSI over the last B420 million years (an increase of B9 Wm 2 of radiative forcing) was almost completely negated by a long-term decline in atmospheric CO2. This was likely due to the silicate weathering- negative feedback and the expansion of land plants that together ensured Earth's long-term habitability. Humanity's fossil-fuel use, if unabated, risks taking us, by the middle of the twenty-first century, to values of CO2 not seen since the early Eocene (50 million years ago). If CO2 continues to rise further into the twenty-third century, then the associated large increase in radiative forcing, and how the Earth system would respond, would likely be without geological precedent in the last half a billion years.

The University of Victoria Cloud Feedback Emulator (UVic-CFE): cloud radiative feedbacks in an intermediate complexity model

In review at GMD, doi:10.5194/gmd-2016-220
http://www.geosci-model-dev-discuss.net/gmd-2016-220/ (open access)

from the abstract: Here, we describe and evaluate a method for applying GCM-derived shortwave and longwave cloud feedbacks from 4xCO2 and Last Glacial Maximum experiments to the University of Victoria Earth System Climate Model. The method generally captures the spread in top-of-the-atmosphere radiative feedbacks between the original GCMs, which impacts the magnitude and spatial distribution of surface temperature changes and climate sensitivity. These results suggest that the method is suitable to incorporate multi-model cloud feedback uncertainties in ensemble simulations with a single intermediate complexity model.

Nonlinear climate sensitivity and its implications for future greenhouse warming

Tobias Friedrich, Axel Timmermann, Michelle Tigchelaar, Oliver Elison Timm and Andrey Ganopolski, Science Advances 09 Nov 2016, Vol. 2, no. 11, e1501923, DOI: 10.1126/sciadv.1501923
http://advances.sciencemag.org/content/2/11/e1501923.full

abstract: Global mean surface temperatures are rising in response to anthropogenic greenhouse gas emissions. The magnitude of this warming at equilibrium for a given radiative forcing—referred to as specific equilibrium climate sensitivity (S)—is still subject to uncertainties. We estimate global mean temperature variations and S using a 784,000-year-long field reconstruction of sea surface temperatures and a transient paleoclimate model simulation. Our results reveal that S is strongly dependent on the climate

background state, with significantly larger values attained during warm phases. Using the Representative Concentration Pathway 8.5 for future greenhouse radiative forcing, we find that the range of paleo-based estimates of Earth's future warming by 2100 CE overlaps with the upper range of climate simulations conducted as part of the Coupled Model Intercomparison Project Phase 5 (CMIP5). Furthermore, we find that within the 21st century, global mean temperatures will very likely exceed maximum levels reconstructed for the last 784,000 years. On the basis of temperature data from eight glacial cycles, our results provide an independent validation of the magnitude of current CMIP5 warming projections.

Could the Pliocene constrain the equilibrium climate sensitivity?

J. C. Hargreaves and J. D. Annan, Clim. Past, 12, 1591-1599, 2016 doi:10.5194/cp-12-1591-2016, http://www.clim-past.net/12/1591/2016/ (open access)

Short summary The mid-Pliocene Warm Period, 3 million years ago, was the most recent interval with high greenhouse gases. By modelling the period with the same models used for future projections, we can link the past and future climates. Here we use data from the mid-Pliocene to produce a tentative result for equilibrium climate sensitivity. We show that there are considerable uncertainties that strongly influence the result, but we are optimistic that these may be reduced in the next few years.

How well do simulated last glacial maximum tropical temperatures constrain equilibrium climate sensitivity?

P.O. Hopcroft and P.J. Valdes, Geophys. Res. Lett., 42, 5533–5539, doi:10.1002/2015GL064903. http://onlinelibrary.wiley.com/doi/10.1002/2015GL064903/full

KEY POINTS: New LGM simulations [CMIP5/PMIP3] show no tropical temperature to climate sensitivity relation. This is caused by a model complexity, especially due to Earth System components. It is unclear how inferred ECS will change as more model components are included

Last glacial maximum constraints on the Earth System model HadGEM2-ES

P.O. Hopcroft and P.J. Valdes, Clim Dyn (2015) 45: 1657. doi:10.1007/s00382-014-2421-0, http://link.springer.com/article/10.1007%2Fs00382-014-2421-0

From the abstract: HadGEM2-A simulates extreme cooling over northern continents and nearly complete die back of vegetation in Asia, giving a poor representation of the LGM environment compared with reconstructions of surface temperatures and biome distributions. The model also performs significantly worse for the LGM in comparison with its precursor AR4 model HadCM3M2. Detailed analysis shows that the major factor behind the vegetation die off in HadGEM2-A is a subtle change to the temperature dependence of leaf

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mortality within the phenology model of HadGEM2. This impacts on both snow-
vegetation albedo and vegetation dynamics. A new set of parameters is tested
for both the pre-industrial and LGM, showing much improved coverage of
vegetation in both time periods, including an improved representation of the
needle-leaf forest coverage in Siberia for the pre-industrial. The new
parameters and the resulting changes in global vegetation distribution
strongly impact the simulated loading of mineral dust, an important aerosol
for the LGM. The climate response in an abrupt 4× pre-industrial CO2
simulation is also analysed and shows modest regional impacts on surface
temperatures across the Boreal zone.
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Tropical cyclone genesis potential across palaeoclimates

Koh, J. H. and Brierley, C. M., Clim. Past, 11, 1433-1451, doi:10.5194/cp-11-1433-2015, 2015. http://www.clim-past.net/11/1433/2015/ (open access)

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The favourability of the mid-Pliocene, Last Glacial Maximum (LGM) and mid-
Holocene for tropical cyclone formation is investigated in five climate
models. During the mid-Pliocene and LGM, changes in carbon dioxide led to sea
surface temperature changes throughout the tropics, yet the potential
intensity is calculated to be relatively insensitive to these changes.
Changes in tropical cyclone genesis potential during the mid-Holocene are
found to be asymmetric about the Equator: being reduced in the Northern
Hemisphere but enhanced in the Southern Hemisphere. This is clearly driven by
the altered seasonal insolation. Nonetheless, the enhanced seasonality drove
localised changes in genesis potential, by altering the strength of monsoons
and shifting the intertropical convergence zone. Trends in future tropical
cyclone genesis potential are consistent neither between the five models
studied nor with the palaeoclimate results. It is not clear why this should
be the case.
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Evaluation of CMIP5 palaeo-simulations to improve climate projections.

Harrison, S.P., Bartlein, P.J., Izumi, K., Li, G., Annan, J., Hargreaves, J., Braconnot, P.B., and Kageyama, M., 2015. Nature Climate Change 5: 735-743.
http://www.nature.com/nclimate/journal/v5/n8/full/nclimate2649.html

from abstract: `Past climate changes provide a unique opportunity for out-of-sample evaluation of model performance. Palaeo-evaluation has shown that the large-scale changes seen in twenty-first-century projections, including enhanced land–sea temperature contrast, latitudinal amplification, changes in temperature seasonality and scaling of precipitation with temperature, are likely to be realistic. Although models generally simulate changes in large-scale circulation sufficiently well to shift regional climates in the right direction, they often do not predict the correct magnitude of these changes. Differences in performance are only weakly related to modern-day biases or climate sensitivity, and more sophisticated models` [within the CMIP model ensembles] `are not better at simulating climate changes. Although models correctly capture the broad patterns of climate change, improvements are required to` produce reliable regional projections.

Glacial Atlantic overturning increased by wind stress in climate models

Juan Muglia and Andreas Schmittner, 2015, Geophys. Res. Lett., 42, doi:10.1002/2015GL064583, http://people.oregonstate.edu/~schmita2/pdf/M/muglia15grl.pdf

excerpts from conclusions: Since LGM wind stress, closure of Bering Strait [Hu et al., 2010], and increased tidal mixing [Schmittner et al., 2015] all tend to increase the strength and depth of the AMOC, a countering effect has to be invoked to reproduce observations of a weaker and shallower overturning during the LGM." … "It will be an important task for future work to resolve the apparent inconsistency between PMIP models' LGM circulation and reconstructions.This inconsistency casts doubt on future AMOC projections with these models [e.g., Weaver et al., 2012]. One possible explanation may be that not all PMIP3 models were in equilibrium [Zhang et al., 2013].

Interglacial analogues of the Holocene and its natural near future.

Yin Q.Z. and Berger A., 2015. Quaternary Science Reviews, 120, 28-46, http://www.sciencedirect.com/science/article/pii/S027737911500150X

Highlights: •Five warm interglacials are intercompared with both snapshot and transient simulations. •Relationships between astronomical parameters and temperature and precipitation of different latitudes are examined. •Contributions of insolation and CO2 to the intensity and duration of the five interglacials are discussed. •Analogue of the Holocene and its natural future is looked for from the past interglacials.

Energy-balance mechanisms underlying consistent large-scale temperature responses in warm and cold climates.

Izumi, K., Bartlein, P.J. and Harrison, S.P., 2015. Climate Dynamics 44: 3111 DOI 10.1007/s00382-014-2189-2, http://link.springer.com/article/10.1007/s00382-014-2189-2 (open access)

Climate simulations show consistent large-scale temperature responses including amplified land–ocean contrast, high-latitude/low-latitude contrast, and changes in seasonality in response to year-round forcing, in both warm and cold climates, and these responses are proportional and nearly linear across multiple climate states. We examine the possibility that a small set of common mechanisms controls these large-scale responses using a simple energy-balance model to decompose the temperature changes shown in multiple lgm and abrupt4 × CO2 simulations from the CMIP5 archive. Changes in the individual components of the energy balance are broadly consistent across the models. Although several components are involved in the overall temperature responses, surface downward clear-sky longwave radiation is the most important component driving land–ocean contrast and high-latitude amplification in both warm and cold climates. Surface albedo also plays a significant role in promoting high-latitude amplification in both climates and in intensifying the land–ocean contrast in the warm climate case. The change in seasonality is a consequence of the changes in land–ocean and high-latitude/low-latitude contrasts rather than an independent temperature response. This is borne out by the fact that no single component stands out as being the major cause of the change in seasonality, and the relative importance of individual components is different in cold and warm climates.

On the state dependency of fast feedback processes in (paleo) climate sensitivity

A. S. von der Heydt, P. Köhler, R. S. W. van de Wal, H. A. Dijkstra GRL, Volume 41, Issue 18, pages 6484–6492, 28 September 2014, DOI: 10.1002/2014GL061121, http://onlinelibrary.wiley.com/doi/10.1002/2014GL061121/abstract

from abstract Here we assess the dependency of the fast feedback processes on the background climate state using data of the last 800 kyr and a box model of the climate system for interpretation. Applying a new method to account for background state dependency, we find Sa=0.61±0.07 K (W m−2)−1(±1σ) using a reconstruction of Last Glacial Maximum (LGM) cooling of −4.0 K and significantly lower climate sensitivity during glacial climates. Due to uncertainties in reconstructing the LGM temperature anomaly, Sa is estimated in the range Sa = 0.54–0.95 K (W m−2)−1.

Consistent large-scale temperature responses in warm and cold climates.

Izumi, K., Bartlein, P.J. and Harrison, S.P., 2013. , Geophysical Research Letters 40: 1817-1823, doi:10.1002/grl.50350, http://onlinelibrary.wiley.com/doi/10.1002/grl.50350/full

Abstract: Climate-model simulations of the large-scale temperature responses to increased radiative forcing include enhanced land-sea contrast, stronger response at higher latitudes than in the tropics, and differential responses in warm and cool season climates to uniform forcing. Here we show that these patterns are also characteristic of model simulations of past climates. The differences in the responses over land as opposed to over the ocean, between high and low latitudes, and between summer and winter are remarkably consistent (proportional and nearly linear) across simulations of both cold and warm climates. Similar patterns also appear in historical observations and paleoclimatic reconstructions, implying that such responses are characteristic features of the climate system and not simple model artifacts, thereby increasing our confidence in the ability of climate models to correctly simulate different climatic states.

Making sense of palaeoclimate sensitivity

PALAEOSENS Project Members Nature 491, 683–691 (29 November 2012) doi:10.1038/nature11574, http://www.nature.com/nature/journal/v491/n7426/abs/nature11574.html

from abstract: …to improve intercomparison of palaeoclimate sensitivity estimates in a manner compatible with equilibrium projections for future climate change. Over the past 65 million years, this reveals a climate sensitivity (in K W−1 m2) of 0.3–1.9 or 0.6–1.3 at 95% or 68% probability, respectively. The latter implies a warming of 2.2–4.8 K per doubling of atmospheric CO2, which agrees with IPCC estimates.

Introduction: Warm climates of the past—a lesson for the future?

D. J. Lunt, H. Elderfield, R. Pancost, A. Ridgwell, G. L. Foster, A. Haywood, J. Kiehl, N. Sagoo, C. Shields, E. J. Stone, and P. Valdes, Phil. Trans. R. Soc. A. 2013 371 20130146; doi:10.1098/rsta.2013.0146 (published 16 September 2013) open access

An introduction to a special issue related to the Discussion Meeting 'Warm climates of the past—a lesson for the future?' compiled and edited by Daniel J. Lunt, Harry Elderfield, Richard Pancost and Andy Ridgwell. It is focussed towards emphasising the potential usefulness of the warm climates of the past. Most of the papers seem (I can't read most of them, as only a few are open access and it seems that even mighty JAMSTEC does not subscribe to Phil Trans) focussed towards understanding the past, but there is also one on climate sensitivity by J. Hansen et al, open access

Reducing spread in climate model projections of a September ice-free Arctic

Jiping Liu, Mirong Song, Radley M. Horton, and Yongyun Hu PNAS, 10.1073/pnas.1219716110/-/DCSupplemental, paywall, 2013.

keywords: CMIP, model ensemble, Arctic, Benchmark, past century

In CMIP3, all sea-ice trends were less than observed. In CMIP5 there are models with both greater and lesser trends. Thus the result obtained by Liu et al is less far from the (new) ensemble mean than was the case for Boé et al 2009. From the abstract: "Here we reduce the spread in the timing of an ice-free state using two different approaches for the 30 CMIP5 models: (i) model selection based on the ability to reproduce the observed sea ice climatology and variability since 1979 and (ii) constrained estimation based on the strong and persistent relationship between present and future sea ice conditions. Results from the two approaches show good agreement. Under a high-emission scenario both approaches project that September ice extent will drop to ~1.7 million km2 in the mid 2040s and reach the ice-free state (defined as 1 million km2) in 2054–2058. Under a medium-mitigation scenario, both approaches project a decrease to ~1.7 million km2 in the early 2060s, followed by a leveling off in the ice extent."

Precipitation scaling with temperature in warm and cold climates: an analysis of CMIP5 simulations.

Li, G., Harrison, S. P., Bartlein, P. J., Izumi, K., & Prentice, I. C. Geophysical Research Letters. doi:10.1002/grl.50730, open access, 2013.

keywords: CMIP, PMIP, model ensemble, LGM

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Abstract, “We investigate the scaling between precipitation and temperature
changes in warm and cold climates using six models that have simulated the
response to both increased CO2 and Last Glacial Maximum (LGM) boundary
conditions. Globally, precipitation increases in warm and decreases in cold
climates by between 1.5 to 3%/ ̊C. Precipitation sensitivity to temperature
changes are lower over land than ocean and lower over tropical land compared
to extratropical land, reflecting the constraint of water availability. The
wet tropics get wetter in warm and drier in cold climates, but the changes in
dry areas differ among models. Seasonal changes of tropical precipitation in
a warmer world also reflect this “rich get richer” syndrome. Precipitation
seasonality is decreased in the cold-climate state. The simulated changes in
precipitation per degree temperature change are comparable to the observed
changes in both the historical period and the LGM.”
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Using paleo-climate comparisons to constrain future projections in CMIP5

G. A. Schmidt, J. D. Annan, P. J. Bartlein, B. I. Cook, E. Guilyardi, J. C. Hargreaves, S. P. Harrison, M. Kageyama, A. N. LeGrande, B. Konecky, S. Lovejoy, M. E. Mann, V. Masson-Delmotte, C. Risi, D. Thompson13, A. Timmermann, L.-B. Tremblay, and P. Yiou, Clim. Past, 10, 221– 250, open access, doi:10.5194/cp-10-221-2014, 2014

keywords: review/prospective, evaluation, PMIP, CMIP

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A 2013 discussion of recent progress in the field. Overview of general
methods, and some examples, which include direct constraint of the multi-
model ensemble as well slightly more qualitative examples, for example,
looking at common patterns of precipitation changes in the models for past
and future. Recommendations for ways to tackle the problem are also included,
“These examples illustrate some general points that should be required in any
attempts to use the paleo-climate simulations to constrain future
projections:
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- The chosen metrics should be robust to uncertainties in external forcing,
- They should not be overly sensitive to the model representation of key phenomena, and are within the scope of the modelled system.
- A spatially diverse and, preferably multi-proxy, paleo-data synthesis is available for comparison.
- The relationship between metrics and targets in the past and future must be examined, and not simply assumed.”

Quantifying future climate change

Collins, M., Chandler, R. E., Cox, P. M., Huthnance, J. M., Rougier, J., & Stephenson, D. B. Nature Climate Change, 2(6), 403–409. doi:10.1038/nclimate1414, paywall, 2012.

keywords: prospective/review, Bayesian, evaluation

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Some background with links to other papers on probabilistic prediction,
single model ensembles, metrics and the like.
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Can the Last Glacial Maximum constrain climate sensitivity?

J. C. Hargreaves, J. D. Annan, M. Yoshimori, and A. Abe-Ouchi, GEOPHYSICAL RESEARCH LETTERS, VOL. 39, L24702, doi:10.1029/2012GL053872, open access, 2012.

keywords: PMIP, climate sensitiivity, model ensemble

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Using the PMIP2 models and a reconstruction of LGM temperatures (Annan and
Hargreaves 2013), to provide a constraint on climate sensitivity. Two
different methods for constraining the ensemble were compared, which relied
on an apparent correlation between tropical LGM temperature anomaly, and
equilibrium climate sensitivity.
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Sensitivity of tropical precipitation extremes to climate change

O'Gorman, P. A., Nature Geosci, 5(10), 697–700, paywall, doi:doi:10.1038/ngeo1568, 2012.

keywords: model ensemble, CMIP3, modern, precipitation

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Finds a relationship between interannual variability and change in extremes
of tropical precipitation under global warming in models. Uses satellite
observations to estimate the response of the tropical extremes to global
warming.
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Climate Sensitivity Estimated from Temperature Reconstructions of the Last Glacial Maximum

Schmittner, A., Urban N. M., Shakun, J. D., Mahowald, N. M., Clark, P. U., Bartlein, P. J., Mix, A. C., and Rosell-Mele, A., Science, 334, 1385-1388, paywall, doi: 10.1126/science.1203513, 2011

keywords: single-model ensemble, LGM, Climate Sensitivity

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Abstract:Assessing the impact of future anthropogenic carbon emissions is
currently impeded by uncertainties in our knowledge of equilibrium climate
sensitivity to atmospheric carbon dioxide doubling. Previous studies suggest
3 kelvin (K) as the best estimate, 2 to 4.5 K as the 66% probability range,
and nonzero probabilities for much higher values, the latter implying a small
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chance of high-impact climate changes that would be difficult to avoid. Here, combining extensive sea and land surface temperature reconstructions from the Last Glacial Maximum with climate model simulations, we estimate a lower median (2.3 K) and reduced uncertainty (1.7 to 2.6 K as the 66% probability range, which can be widened using alternate assumptions or data subsets). Assuming that paleoclimatic constraints apply to the future, as predicted by our model, these results imply a lower probability of imminent extreme climatic change than previously thought. The data, but not the paper may be downlaoded for free from Andreas' website.

A probabilistic calibration of climate sensitivity and terrestrial carbon change in GENIE-1

Philip B. Holden, N. R. Edwards, K. I. C. Oliver, T. M. Lenton & R. D. Wilkinson Clim Dyn free PDF at Open University repository or journal website, DOI 10.1007/s00382-009-0630-8, 2010.

keywords: Bayesian, emulator, terrestrial carbon, LGM

Using an emulator of multiple varied parameters in the GENIE model. The emulated LGM ensemble is constrained with tropical SST data to produce a probabilistic estimate of climate sensitivity.

September sea-ice cover in the Arctic Ocean projected to vanish by 2100

Julien Boé, Alex Hall and Xin Qu, Nature Geoscience 2, 341, free PDF at author's homepage or paywall, doi:10.1038/ngeo467, 2009.

keywords : model ensemble, past century, sea-ice, Arctic

From the abstract: “Here we analyse the simulated trends in past sea-ice cover in 18 state-of-art-climate models and find a direct relationship between the simulated evolution of September sea-ice cover over the twenty-first century and the magnitude of past trends in sea-ice cover. Using this relationship together with observed trends, we project the evolution of September sea-ice cover over the twenty-first century.”

Correlation between Inter-Model Similarities in Spatial Pattern for Present and Projected Future Mean Climate

Manabu Abe, Hideo Shiogama, Julia C. Hargreaves, James D. Annan, Toru Nozawa, and Seita Emori, SOLA, Vol. 5, 133–136, open access, doi:10.2151/sola.2009–034 133 1, 3, 2009.

keywords: evaluation, past century, CMIP3, model ensemble

One of several papers from around 2007-2009, looking for “metrics” that relate to future performance. The idea was that if a relationship may be found in the multi-model ensemble between a measurable quantity in the present and a feature of the climate in the future projections, then this may in principle be use to constrain the ensemble. In this study the globe was split into broad latitude bands. The metric used is a measure of model similarity. Significant correlations for this metric between present and future were found mostly for precipitation, some also for temperature and none for sea level pressure.

Information on the early Holocene climate constrains the summer sea ice projections for the 21st century

H. Goosse, E. Driesschaert, T. Fichefet, and M.-F. Loutre, Clim. Past, 3, 683-692, open access, doi:10.5194/cp-3-683-2007, 2007

keywords: parameter ensemble, Holocene, sea-ice

Abstract. The summer sea ice extent strongly decreased in the Arctic over the last decades. This decline is very likely to continue in the future but uncertainty of projections is very large. An ensemble of experiments with the climate model LOVECLIM using 5 different parameter sets has been performed to show that summer sea ice changes during the early Holocene (8 kyr BP) and the 21st century are strongly linked, allowing for the reduction of this uncertainty. Using the limited number of records presently available for the early Holocene, simulations presenting very large changes over the 21st century could reasonably be rejected. On the other hand, simulations displaying low to moderate changes during the second half of the 20th century (and also over the 21st century) are not consistent with recent observations. Using this very complementary information based on observations during both the early Holocene and the last decades, the most realistic projection with LOVECLIM indicates a nearly disappearance of the sea ice in summer at the end of the 21st century for a moderate increase in atmospheric greenhouse gas concentrations. Our results thus strongly indicate that additional proxy records of the early Holocene sea ice changes, in particular in the central Arctic Basin, would help to improve our projections of summer sea ice evolution and that the simulation at 8 kyr BP should be considered as a standard test for models aiming at simulating those future summer sea ice changes in the Arctic.

Assessment of the use of current climate patterns to evaluate regional enhanced greenhouse response patterns of climate models

Penny Whetton, Ian Macadam, Janice Bathols, and Julian O'Grady GRL, VOL. 34, L14701, paywall, doi:10.1029/2007GL030025, 2007

keywords: evaluation, CMIP3, regional climate

One of several papers from around 2007-2009, looking for “metrics”. The idea was that if a relationship may be found in the multi-model ensemble between a measurable quantity in the present and a feature of the climate in the future projections, then this may in principle be use to constrain the ensemble. In this study the globe was split into the land-based “Giorgi regions”. The metric is a measure of model similarity. Combining temperature, precipitation and sea level pressure seems to provide the best correlations for future performance both regionally and globally.

Does the Last Glacial Maximum constrain climate sensitivity?

M Crucifix, GRL, doi:10.1029/2006GL027137, paywall, 2006.

keywords: PMIP, climate sensitivity, (small) model ensemble

Finds no clear relationship past and future in the (then) small PMIP2 ensemble, and argues as a result that the LGM can only weakly constrain climate sensitivity, with the caveat, though, that the range of sensitivities covered by PMIP2 was at the time fairly narrow.

Using the past to constrain the future: how the palaeorecord can improve estimates of global warming

Tamsin L. Edwards, Michel Crucifix and Sandy P. Harrison Progress in Physical Geography; 31; 481 free PDF at Uni of St Andrews or paywall, DOI: 10.1177/0309133307083295. 2007.

keywords: review/prospective, climate sensitivity, Bayesian

A 2007 overview of efforts to use models to constrain climate sensitivity. Figure 4 is the most enduring result from this paper. It shows that model ensembles derived from different single models do not always overlap. If the multi-model ensemble is a good representation of uncertainty, then the single model ensemble members may be considered to be lacking in diversity.

Using the current seasonal cycle to constrain snow albedo feedback in future climate change

Hall, A., & Qu, X. Geophysical Research Letters, 33(3), L03502, free PDF at author's website or paywall, doi:10.1029/2005GL025127, 2006

keywords: Northern hemisphere, PMIP, modern, model ensemble

From the abstract: “Large intermodel variations in feedback strength in climate change are nearly perfectly correlated with comparably large intermodel variations in feedback strength in the context of the seasonal cycle. Moreover, the feedback strength in the real seasonal cycle can be measured and compared to simulated values. These mostly fall outside the range of the observed estimate, suggesting many models have an unrealistic snow albedo feedback in the seasonal cycle context. Because of the tight correlation between simulated feedback strength in the seasonal cycle and climate change, eliminating the model errors in the seasonal cycle will lead directly to a reduction in the spread of feedback strength in climate change.

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Though this comparison to observations may put the models in an unduly harsh
light because of uncertainties in the observed estimate that are difficult to
quantify, our results map out a clear strategy for targeted observation of
the seasonal cycle to reduce divergence in simulations of climate
sensitivity.”
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Climate sensitivity estimated from ensemble simulations of glacial climate

Thomas Schneider von Deimling, Hermann Held, Andrey Ganopolski & Stefan Rahmstorf, Climate Dynamics, free PDF at author's website or paywall, DOI 10.1007/s00382-006-0126-8, 2006

keywords: parameter ensemble, climate sensitivity, LGM, dust

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Possibly the first attempt to use information derived from data for the LGM
to directly constrain a model ensemble and provide a constrained prediction
of a variable related to future climate (climate sensitivity in this case). A
single model ensemble of the EMIC, CLIMBER was used, with the ensemble
constrained with estimates of Tropical Atlantic SST for the LGM (GLAMAP). The
influence of dust forcing, not included in most model configurations for the
LGM climate, was shown to potentially cause a significant bias in the
results.
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Efficiently Constraining Climate Sensitivity with Ensembles of Paleoclimate Simulations

J. D. Annan, J. C. Hargreaves, R. Ohgaito, A. Abe-Ouchi and S. Emori, SOLA, Vol. 1, 181–184, open access, doi: 10.2151/sola. 2005–047 181, 2005.

keywords: parameter ensemble, climate sensitivity, LGM, Bayesian

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In this case, estimates of tropical SST taken from the literature were used
to constrain a since model ensemble with varied parameters of the MIROC GCM.
This MIROC ensemble has now been shown to be of much lower dispersion than
the multi-model ensemble (Hargreaves et al above, and Yokohata et al 2010).
Indeed it was found impossible to produce a run with this model climate
sensitivity less than 4C, while the data constraint for the LGM data
suggested a lower value was entirely plausible.
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