expected climate VaR and the distribution tails — it turns out that mitigation will shrink the potential losses of financial asset value; under unabated climate change there is a 1% chance that at least US$24 trillion will be lost, but mitigating part of this climate change reduces the climate VaR to almost half, with a 1% probability that at least 9.2% of US$ 143.3 trillion (US$13 trillion) will be lost. This makes a strong case for mitigation.

The stylized top-down approach employed by Dietz *et al.*[5] cannot answer all questions about how financial assets will be affected. In particular, it does not allow us to draw any conclusions on how different countries and regions will be affected, and we cannot use it to trace the repercussion effects throughout the economy. So far, such detailed analysis of on the ground impacts is inherently constrained by lack of data and a more thorough understanding of climate impacts.

Dietz *et al.*[5] offer first estimates of the magnitudes of climate impacts on the value of financial assets, relying on simple economic relationships. Though using a one-sector model (with a global damage function) falls short of considering heterogeneity of assets and possible reallocation in response to climate change — the impact of which could be large — the authors succeed in demonstrating that climate risks to financial assets could be substantial.

The study demonstrates that investors have multiple causes of concern, either about stranded assets and high abatement costs under ambitious climate policy, or about climate impacts on their assets under unabated climate change. This underlines both the need for full disclosure so that climate risks can be assessed and portfolios adjusted accordingly, and the need for more research to develop comprehensive estimates of the risk of such losses. ❐

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ENERGY ECONOMICS

Cheap oil slows climate mitigation

Oil prices are notoriously tricky to predict. This uncertainty could slow climate mitigation unless policymakers implement stringent climate policy.

Laurent Drouet

The oil industry has a history of booms and busts, and prices have slumped significantly over the past two years. The drop in prices will have a rapid effect on the energy sector and global economy. Low oil prices result in less investment in the exploration for (and extraction of) oil and gas, and could simultaneously see increased demand for related equipment and services, stimulating the world's economy[1].

If cheap oil becomes the new normal, there may be no price constraint to prevent burning of the remaining underground oil and gas resources. In such a world, carbon emissions could continue to grow, and temperatures may rise to significant levels if no action is taken[2].

In *Nature Energy*, David McCollum and colleagues[3] explore the implications of oil price uncertainty on future emissions, and policymakers' ability to limit global warming to 2 °C above pre-industrial levels. They find that long-term oil prices have a significant impact on cumulative emissions: low oil prices hamper climate mitigation action whereas high oil prices boost it. The authors identify some critical uncertainties in the energy system with consequences for possible mitigation emission pathways.

They use the MESSAGE integrated assessment model to explore scenarios with sustained high and low oil prices, about US$110 and US$40 per barrel, corresponding to the levels observed in late 2014 and early 2016, respectively. They include a set of future uncertainties related to the evolution of the energy sector: the coupling of gas and oil prices; the potential of biomass; the availability and costs of technologies related to bio-fuels and synthetic fuels for electric, natural gas and hydrogen vehicles. For each factor, the two opposite scenarios were combined in order to explore the limits of uncertainty. A 'no climate policy' case was compared to a case where policies limit warming to 2 °C by 2100, using a global carbon tax.

The findings confirm that oil prices are an important driver of energy system changes and emissions levels. Climate policy remains the most important lever to mitigate long-term emissions, however, because a sustained high oil price does not have an equivalent effect to a carbon tax.

An important point is the difference in emissions between the wide-ranging oil prices scenarios: the magnitude is less than expected because it relies not only on oil prices but also on many other factors. For example, in terms of fuel substitution, cheaper coal may be consumed when oil prices are high. The main uncertainty in terms of energy system evolution is whether oil and gas prices are coupled, as was historically the case. This may change in the future, with the US looking at decoupling the prices. Uncertainty related to the potential of biomass is also important, as is the cost and capacity of electrification of the energy system.

In a scenario where warming is limited to below 2 °C, oil price uncertainty is less important because climate policy eventually removes a large share of oil from the energy mix anyway. More important in this case are the uncertainties about the other technical developments in the energy system, as they drive decarbonization.

To comply with the recent Paris Agreement, countries have provided climate policy commitments in intended nationally determined contributions (INDCs)[4]. The INDCs represent an intermediate effort at global level between the two studied policy cases. It is not clear if the level of emission reductions and enforced energy policies implied by the pledges will be stringent enough in the case of a low-oil-price world. The implementation of the INDCs implies that an implicit national carbon price could compete with the global oil price, and that this balance will determine the accomplishment of the commitments.

As such, additional mitigation efforts may be necessary to reach the national targets if the oil price remains unexpectedly low. A safer approach may be to consider a low oil price in policy implementation, including a risk of higher policy cost. McCollum and colleagues do not provide any analysis about cost impacts from oil uncertainty, and did not model national emission and energy targets. This point is crucial and requires more investigation.

Following the trend in climate modelling, the joint uncertainty assessment of the energy system conducted by McCollum and colleagues is a practice that should be more systematic, especially when energy modelling embeds a large amount of predictive information on future technologies. This uncertainty analysis could bring a comprehensive overview of the interactions and substitutions within the energy system and help to understand the robustness of the emissions trajectories produced by these models. Going beyond the unique model approach demonstrated by McCollum and colleagues, a multi-model approach should be the standard for this type of assessment. ❐

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OCEANOGRAPHY

Human influence on sea-level rise

Detection and attribution of sea-level rise is hampered by the lack of historical model estimates for the individual components. Now research bridges this gap and uncovers an accelerating anthropogenic contribution over recent decades.

Sönke Dangendorf

Over the past century, tide gauges have shown that the global mean sea level (GMSL) has risen steadily by 14–22 cm (ref. 1) (depending on the reconstruction technique); an increase very likely being unprecedented over any of the previous 27 centuries[2]. Despite having identified ocean thermal expansion and glacier mass loss as the two dominant contributors to GMSL rise over the twentieth century, debate has continued on how much of the observed GMSL change is related to natural or anthropogenic causes. The attribution to natural radiative forcings (such as solar and volcanic), natural internal climate variability and anthropogenic greenhouse gases or aerosols requires, besides observations, fully forced historical climate models containing individual forcings either in tandem or in isolation. Writing in *Nature Climate Change*, Aimée Slangen and colleagues[3] now uncover the anthropogenic contribution from the observed twentieth-century GMSL rise and provide evidence that it accelerated from less than 15% before 1950 to more than 70% in recent decades.

Changes in GMSL are a good climate indicator, as they reflect both thermal expansion/contraction in response to the warming/cooling of the ocean and changing mass input from ice sheets, glaciers or other terrestrial freshwater sources. Such changes occur on a wide range of timescales and it is generally hard to distinguish whether they stem from past or current natural climate variations, or from anthropogenic forcing. Although it has recently been demonstrated that the GMSL rise cannot be explained by natural variability alone[4], formal attribution studies have been limited to the individual components of thermal expansion[5,6] and glacier melting[7]. This is mainly due to a lack of observations spanning the entire century and/or sophisticated models of each individual component.

To address this issue, Slangen and colleagues[3] combined models of thermal expansion, glacier melting and mass change of the Greenland and Antarctic ice sheets, and forced them with results from historical runs of the Coupled Model Intercomparison Project Phase 5 (CMIP5). By summing up the different contributions when forced with both natural and anthropogenic factors, they are able to explain 74 ± 25% ($\pm 2\sigma$) of the observed GMSL change (a mean of four of the most prominent reconstructions; see discussion below) since 1900. To separate natural from anthropogenic factors, the models were then forced with each factor in isolation.

The results suggest that the relative importance of natural and anthropogenic forcing has significantly changed over the twentieth century[3]. Before 1950 the observed increase was dominated by past climate variations and natural radiative forcing (67 ± 23%), but the anthropogenic contribution quickly increased to more than 70% in recent decades. Over the entire century, the authors estimate the anthropogenic contribution to be in an order of 38 ± 12%. The comparatively low value of 38% might be surprising, but it underlines the importance of natural climate variability, which was recently critically discussed with respect to the inertia of the ocean[8,9] and glaciers[7,8], and their combined impact on centennial GMSL variations[4]. In agreement with earlier studies[7], the authors find that much of the GMSL change before 1950 was indeed related to the delayed response to the end of the Little Ice Age, when large parts of the Northern Hemisphere were covered by ice.