2022-IP02: IPCC Climate Change 2022: Impacts, Adaptation and Vulnerability

The IPCC has finalized the second part of the Sixth Assessment Report (AR6), 'Climate Change 2022: Impacts, Adaptation and Vulnerability', the Working Group II (WGII) contribution to the Sixth Assessment Report. It was finalized on 27 February 2022 during the 12th Session of WGII and 55th Session of the IPCC. The WGII contribution to AR6 assesses the impacts of climate change, looking at ecosystems, biodiversity, and human communities at global and regional levels. It also reviews vulnerabilities and the capacities and limits of the natural world and human societies to adapt to climate change. The report comprises a very comprehensive 3,675 pages and is structured into 18 chapters and in addition there are 7 cross-chapter papers. Overall, the authors have addressed more than 16k comments on the first order draft (FOD) and more than 40k comments on the second order draft (SOD).

The key messages from the 'Summary for Policymakers (SPM)' are the following:

- **Observed Impacts from Climate Change**. Human-induced climate change, including more frequent and intense extreme events, has caused widespread adverse impacts and related losses and damages to nature and people, beyond natural climate variability. Some development and adaptation efforts have reduced vulnerability. Across sectors and regions the most vulnerable people and systems are observed to be disproportionately affected. The rise in weather and climate extremes has led to some irreversible impacts as natural and human systems are pushed beyond their ability to adapt (*high confidence*).
- **Vulnerability and Exposure of Ecosystems and People**. Vulnerability of ecosystems and people to climate change differs substantially among and within regions (*very high confidence*), driven by patterns of intersecting socio-economic development, unsustainable ocean and land use, inequity, marginalization, historical and ongoing patterns of inequity such as colonialism, and governance (*high confidence*). Approximately 3.3 to 3.6 billion people live in contexts that are highly vulnerable to climate change (*high confidence*). A high proportion of species is vulnerable to climate change (*high confidence*). Human and ecosystem vulnerability are interdependent (*high confidence*). Current unsustainable development patterns are increasing exposure of ecosystems and people to climate hazards (*high confidence*).
- **Risks in the near term (2021-2040)**. Global warming, reaching 1.5°C in the near-term, would cause unavoidable increases in multiple climate hazards and present multiple risks to ecosystems and humans (*very high confidence*). The level of risk will depend on concurrent near-term trends in vulnerability, exposure, level of socioeconomic development and adaptation (*high confidence*). Near-term actions that limit global warming to close to 1.5°C would substantially reduce projected losses and damages related to climate change in human systems and ecosystems, compared to higher warming levels, but cannot eliminate them all (*very high confidence*).
- **Mid to Long-term Risks (2041–2100)**. Beyond 2040 and depending on the level of global warming, climate change will lead to numerous risks to natural and human systems (*high confidence*). For 127 identified key risks, assessed mid- and long-term impacts are up to multiple times higher than currently observed (*high confidence*). The magnitude and rate of climate change and associated risks depend strongly on near-term mitigation and adaptation actions, and projected adverse impacts and related losses and damages escalate with every increment of global warming (*very high confidence*).
- **Complex, Compound and Cascading Risks**. Climate change impacts and risks are becoming increasingly complex and more difficult to manage. Multiple climate hazards will occur

simultaneously, and multiple climatic and non-climatic risks will interact, resulting in compounding overall risk and risks cascading across sectors and regions. Some responses to climate change result in new impacts and risks (*high confidence*).

- **Impacts of Temporary Overshoot**. If global warming transiently exceeds 1.5°C in the coming decades or later (overshoot), then many human and natural systems will face additional severe risks, compared to remaining below 1.5°C (*high confidence*). Depending on the magnitude and duration of overshoot, some impacts will cause release of additional greenhouse gases (*medium confidence*) and some will be irreversible, even if global warming is reduced (*high confidence*).
- **Current Adaptation and its Benefits**. Progress in adaptation planning and implementation has been observed across all sectors and regions, generating multiple benefits (*very high confidence*). However, adaptation progress is unevenly distributed with observed adaptation gaps (*high confidence*). Many initiatives prioritize immediate and near-term climate risk reduction which reduces the opportunity for transformational adaptation (*high confidence*).
- **Future Adaptation Options and their Feasibility**. There are feasible and effective adaptation options which can reduce risks to people and nature. The feasibility of implementing adaptation options in the near-term differs across sectors and regions (*very high confidence*). The effectiveness of adaptation to reduce climate risk is documented for specific contexts, sectors and regions (*high confidence*) and will decrease with increasing warming (*high confidence*). Integrated, multi-sectoral solutions that address social inequities, differentiate responses based on climate risk and cut across systems, increase the feasibility and effectiveness of adaptation in multiple sectors (*high confidence*).
- **Limits to Adaptation**. Soft limits to some human adaptation have been reached, but can be overcome by addressing a range of constraints, primarily financial, governance, institutional and policy constraints (*high confidence*). Hard limits to adaptation have been reached in some ecosystems (*high confidence*). With increasing global warming, losses and damages will increase and additional human and natural systems will reach adaptation limits (*high confidence*).
- **Avoiding Maladaptation**. There is increased evidence of maladaptation across many sectors and regions since the AR5. Maladaptive responses to climate change can create lock-ins of vulnerability, exposure and risks that are difficult and expensive to change and exacerbate existing inequalities. Maladaptation can be avoided by flexible, multi-sectoral, inclusive and long-term planning and implementation of adaptation actions with benefits to many sectors and systems (*high confidence*).
- **Enabling Conditions**. Enabling conditions are key for implementing, accelerating and sustaining adaptation in human systems and ecosystems. These include political commitment and follow-through, institutional frameworks, policies and instruments with clear goals and priorities, enhanced knowledge on impacts and solutions, mobilization of and access to adequate financial resources, monitoring and evaluation, and inclusive governance processes (*high confidence*).
- **Conditions for Climate Resilient Development**. Evidence of observed impacts, projected risks, levels and trends in vulnerability, and adaptation limits, demonstrate that worldwide climate resilient development action is more urgent than previously assessed in AR5. Comprehensive, effective, and innovative responses can harness synergies and reduce trade-offs between adaptation and mitigation to advance sustainable development (*very high confidence*).
- **Enabling Climate Resilient Development**. Climate resilient development is enabled when governments, civil society and the private sector make inclusive development choices that

prioritise risk reduction, equity and justice, and when decision-making processes, finance and actions are integrated across governance levels, sectors and timeframes (*very high confidence*). Climate resilient development is facilitated by international cooperation and by governments at all levels working with communities, civil society, educational bodies, scientific and other institutions, media, investors and businesses; and by developing partnerships with traditionally marginalised groups, including women, youth, Indigenous Peoples, local communities and ethnic minorities (*high confidence*). These partnerships are most effective when supported by enabling political leadership, institutions, resources, including finance, as well as climate services, information and decision support tools (*high confidence*).

- **Climate Resilient Development for Natural and Human Systems**. Interactions between changing urban form, exposure and vulnerability can create climate change induced risks and losses for cities and settlements. However, the global trend of urbanisation also offers a critical opportunity in the near-term, to advance climate resilient development (*high confidence*). Integrated, inclusive planning and investment in everyday decision-making about urban infrastructure, including social, ecological and grey/physical infrastructures, can significantly increase the adaptive capacity of urban and rural settlements. Equitable outcomes contribute to multiple benefits for health and well-being and ecosystem services, including for Indigenous Peoples, marginalised and vulnerable communities (*high confidence*). Climate resilient development in urban areas also supports adaptive capacity in more rural places through maintaining peri-urban supply chains of goods and services and financial flows (*medium confidence*). Coastal cities and settlements play an especially important role in advancing climate resilient development (*high confidence*). Safeguarding biodiversity and ecosystems is fundamental to climate resilient development, in light of the threats climate change poses to them and their roles in adaptation and mitigation (*very high confidence*). Recent analyses, drawing on a range of lines of evidence, suggest that maintaining the resilience of biodiversity and ecosystem services at a global scale depends on effective and equitable conservation of approximately 30% to 50% of Earth's land, freshwater and ocean areas, including currently near-natural ecosystems (*high confidence*).
- **Achieving Climate Resilient Development**. It is unequivocal that climate change has already disrupted human and natural systems. Past and current development trends (past emissions, development and climate change) have not advanced global climate resilient development (*very high confidence*). Societal choices and actions implemented in the next decade determine the extent to which medium- and long-term pathways will deliver higher or lower climate resilient development (*high confidence*). Importantly climate resilient development prospects are increasingly limited if current greenhouse gas emissions do not rapidly decline, especially if 1.5°C global warming is exceeded in the near term (*high confidence*). These prospects are constrained by past development, emissions and climate change, and enabled by inclusive governance, adequate and appropriate human and technological resources, information, capacities and finance (*high confidence*).

Each above key message is a main key message, which is elaborated and contextualised further by several sub key messages in the SPM. The main body of the report only occasionally mentions carbon capture, utilisation and storage (CCUS) and carbon dioxide removal (CDR) but sometimes concerningly in an unbalanced way (see comments on the messages below).

Messages related to CCS

1. Developing countries are projected to witness the highest increase in future energy demand under 2°C global warming leading to significant increases in water use for energy production (Fricko et al., 2016) (4.5.2). Results from a simulation study on retrofitting coal-fired power plants built after 2000 with carbon capture and storage (CCS) technologies show an increase in global water consumption, currently at 9.66 km^3/year, by 31% to 50% (to 12.66 km^3/year and 14.47 km^3/year, respectively) depending on the cooling and CCS technology deployed, and hence are best deployed in locations which are not water scarce (Rosa et al., 2020c) (*medium confidence*). In Asia, the near-term mitigation scenario with high CCS deployment increases the average regional water withdrawal intensity of coal generation by 50-80% compared to current withdrawals (Wang et al., 2019b). Carbon can be 'scrubbed' from thermo-electric power-plant emissions and injected for storage in deep geological strata (Turner et al., 2018), but this can lead to pollution of deep aquifers (Chen et al., 2021) and have health consequences (*low confidence*).

Comment: The water use of CO_2 capture can be managed to not increase (see references: *Giannaris, S. et al (2020). "Implementing a second generation CCS facility on a coal fired power station", Greenhouse Gases: Science and Technology, 10(3), 506-518; Magneschi et al (2017) "The Impact of CO2 Capture on Water Requirements of Power Plants", GHGT-13, Energy Procedia 114 6333-6347 ; IEAGHG (2020) "Understanding the cost of reducing water usage in coal and gas fired power plants with CCS", IEAGHG 2020-09; IEAGHG (2011) "Evaluation and Analysis of Water Usage of Power Plants with CO2 Capture" IEAGHG 2010/05; IEAGHG (2020) "CCS and the Sustainable Development Goals", IEAGHG 2020-14; Mikunda et al (2020) "CCS and the Sustainable Development Goals", International Journal of Greenhouse Gas Control (submitted 17 Nov 2020); also IPCC (2018) SR1.5 Chap 5 p500 which cites Magneschi*). Some of the papers cited here (Rosa, Lui, Yang) whilst recent (2019, 2020) have been checked and found to have chosen outdated water use assumptions based on papers from 2010 and 2011 (Rosa), 2012 (Lui) and 2011-2013 (Yang).

Messages related to CDR

1. A sudden and sustained termination of solar radiation management (SRM) in a high CO_2 emissions scenario would cause rapid climate change (*high confidence*; WG1 Chapter 4). More scenario analysis is needed on the potential likelihood of sudden termination (Kosugi, 2013; Irvine and Keith, 2020). A gradual phase-out of SRM combined with emission reduction and CDR could avoid these termination effects (*medium confidence*) (MacMartin et al., 2014; Keith and MacMartin, 2015; Tilmes et al., 2016).
2. The assessment includes the interactions between CDR and adaptation outcomes: compared to previous ARs, it is clear that the ambitious temperature targets agreed upon in Paris in 2015 will require at least some CDR, i.e. all 1.5°C pathways feature annual removals at Gigaton level (Rogelj et al., 2018). This necessitates assessing the interactions of CDR with adaptation.
3. Negative-emission technologies, such as direct air capture (DAC) of CO_2, could reduce emissions up to 3GtCO_2/year by 2035, equivalent to 7% of 2019 global emissions. However, they can increase net water consumption by 35 km^3/year in 2050 (Fuhrman et al., 2020) under the low-overshoot emissions scenario. According to other estimates, capturing 10GtCO_2 could translate to water losses between 10-100 km^3, depending on the technology deployed and climatic conditions (temperate vs. tropical) (Chapter 12, WGIII). Some DAC technologies that include solid sorbents also produce water as a by-product, but not in quantities that can offset total water losses (Beuttler et al., 2019; Fasihi et al., 2019)(*medium confidence*).

Comment on point 3: The claim is made that even DAC technologies that produce water cannot offset their total water losses. Neither the paper by Beuttler nor by Fasihi provide this conclusion, rather the opposite, they both point out the potential for solid DAC processes to produce water. The only paper from which this could have been concluded is the Fuhrman paper. One main conclusion of this paper is that DAC can exacerbate demand for energy and water but the interpretation of this is complex:

- The paper cites other sources that have shown that DAC would substantially reduce water use for negative emissions compared with total evapotranspiration from bioenergy crop and forest cultivation, plus additional water demand for bioelectricity generation.
- The paper used a different water use scaling approach than previous studies.
- The reasons for the increase in total water demand (compared to the reference) in the DAC scenarios are the following:
  - DAC reduces the demand for negative emissions from bioenergy with carbon capture and storage (BECCS), but also allows for increased positive emissions to the atmosphere, which are then offset by DAC. Therefore, even though DAC is still less water intensive than bioenergy crop irrigation, large DAC deployment results in increased total water use for negative emissions—a phenomenon analogous to a rebound effect.
  - Irrigated cropland that would be used for BECCS if DAC were not available is then freed up for other agricultural production, further increasing water demand.
  - The DAC process used in this paper is a liquid DAC process that is a water consumer. The scenarios use a 100% share of this process, potentially water producing or neutral solid DAC processes were not considered.

Recent IEAGHG reports on DACCS and negative emissions technologies (NETs) (*IEAGHG (2021) "Global Assessment of Direct Air Capture Costs", 2021-05; IEAGHG (2021), "Assessing the Techno-Economic Performance, Opportunities and Challenges of Mature and Nearly-mature Negative Emissions Technologies (NETs)", 2021-04*) conclude that overall water demand of DACCS is lower than for BECCS.

Messages related to BECCS

1. There are concerns about large-scale conversion of non-forest land into forest plantations for the sole purpose of increasing carbon sinks through BECCS (Hanssen et al., 2020; Heck et al., 2018; Cross-Chapter Box in Chapter 2), which may actually result in negative carbon sink (Jackson et al., 2002; Mureva et al., 2018) and significant loss of overall biodiversity (Abreu et al., 2017). Such large-scale afforestation may also lead to the dispossession of previous users, such as smallholders and pastoralists. Hence, when nature based solutions (NBS) includes forest plantations or other large-scale conversion of land-use, there is a risk that it results in maladaptation and malmitigation including climate injustice (Cousins, 2021; Seddon et al., 2019).
2. Degrowth proponents question the feasibility of decoupling at a scale and rate sufficient for meeting Paris Agreement goals (Gómez-Baggethun, 2020; Hickel and Kallis, 2020; Kallis, 2017; Parrique et al., 2019). Using precautionary principle-rooted arguments (Latouche, 2001), degrowth aims for the intentional decreases in both GDP and coupled greenhouse gas (GHG) emissions (Kallis, 2011) using policy mechanisms such a "cap and share" framework for distributing emissions permits on an annually declining basis with legislation to prohibit the overshoot of established carbon budgets (Douthwaite, 2012; Kallis et al., 2012). Degrowth thus seeks to minimize reliance on negative emissions technologies, such as the large-scale deployment of BECCS (e.g., illustrative emissions reduction pathway labelled P4 in IPCC SR1.5, 1 also WGIII Chapter 3) and aims to generate progress toward achieving the SDGs by prioritising redistribution rather than GDP growth. Sustainable development goals (SDGs)

potentially addressed by degrowth include universal basic income (SDGs 1 and 10), work sharing to guarantee full employment (SDGs 8 and 10) and shifting taxation burdens from income to resource and energy extraction (SDGs 8 and 12).

3. Natural ecosystems can provide carbon storage and sequestration at the same time as providing multiple other ecosystem services, including ecosystem based adaptation (EbA) (*high confidence*) but there are risks of maladaptation and environmental damage from some approaches to land-based mitigation (*high confidence*). Plantation forests in areas which would not naturally support forest, including savannas, natural grasslands and temperate peatlands, or replacing native tropical forests on peat soils, have destroyed local biodiversity and created a range of problems, including for water supply, food supply, fire risk and greenhouse gas emissions. Large scale deployment of bioenergy, including BECCS through dedicated herbaceous or woody bioenergy crops and non-native production forests can damage ecosystems directly or through increasing competition for land.
4. Nevertheless, renewable energy is a large and essential element of the climate change mitigation and there are adverse impacts on biodiversity associated with some renewable energy, including wind and solar technologies (Rehbein et al., 2020) However, of the most serious emerging conflicts are between land-based approaches to mitigation and the protection of biodiversity, particularly as a result of afforestation strategies and potentially large areas devoted to bioenergy, including BECCS. It is important to recognise the impacts of climate change mitigation at the same time as assessing the direct impacts of climate change and ensure that adaptation and mitigation are joined up.
5. BECCS is an integral part of all widely accepted pathways to holding global temperature rise to 1.5°C (IPCC, 2018b). This requires large areas of land which can conflict with the need to produce food and protect biodiversity (Smith et al., 2018). One study that examined the combined impacts of climate change and land use change for bioenergy and found severe impacts on species were likely if bioenergy were a major component of climate change mitigation strategies (Hof et al., 2018). A study on the potential impacts of bioenergy production and climate change on European birds found that land conversion for biodiversity to meet a 2°C target would have greater impacts on species range loss than a global temperature increase of 4°C, if bioenergy were the only mitigation option (Meller et al., 2015). To avoid the worst impacts of BECCS, it will need to be carefully targeted, according to context and local conditions (and other mitigation strategies prioritised so its use can be minimised IPCC, 2019, Special Report on Land; Ohashi, 2019, Biodiversity can benefit).
6. Finally, while limiting global warming to 1.5°C would minimize the increase in risks in the various water use sectors and keep adaptation effective, many mitigation measures can potentially impact future water security. For example, BECCS and afforestation and reforestation (A/R) can have a considerable water footprint if done at inappropriate locations (4.7.6, see also Canadell et al. (2021)). Therefore, minimizing the risks to water security from climate change will require a full-systems view that considers the direct impacts of mitigation measures on water resources and their indirect effect via limiting climate change (*high confidence*).
7. BECCS involves CO_2 sequestration as biofuel or forest bioenergy (Creutzig et al., 2015). BECCS has profound implications for water resources (Ai et al., 2020), depending on factors including the scale of deployment, land use, and other local conditions. Evaporative losses from biomass irrigation and thermal bioelectricity generation are projected to peak at 183 km^3/year in 2050 under a low overshoot scenario (Fuhrman et al., 2020). (Senthil Kumar et al., 2020) projected that while BECCS strategies like irrigating biomass plantations can limit global warming by the end of the 21st century to 1.5°C, this will double the global area and population living under

severe water stress compared to the current baseline. Both BECCS (Muratori et al., 2016) and DAC can significantly impact food prices via demand for land and water (Fuhrman et al., 2020). The direction and magnitude of price movement will depend on future carbon prices, while vulnerable people in the Global South will be most severely affected (*medium evidence, high agreement*).

8. Overall, extensive BECCS and A/R deployment can alter the water cycle at regional scales (*high confidence*) (Cross-Chapter Box 5.1 in Chapter 5, WGI, (Canadell et al., 2021)).
9. Concerns about the potential sustainable development implications of some mitigation technologies may be motivation for precluding the use of some mitigation options. For instance, the potential food security and environmental quality implications of bioenergy have received significant attention in the literature (e.g., Smith et al., 2013). However, constraining or precluding the use of bioenergy without or with CCS could have significant implications for the cost of pursuing ambitious climate goals, and potentially the attainability of those goals (e.g., Clarke et al., 2014; Bauer et al., 2018; Rogelj et al., 2018; Muratori et al., 2020). Bioenergy is not unique in this regard. Social and sustainability concerns have also been raised about the large-scale deployment of many low-carbon technologies, e.g., REDD+, wind, solar, nuclear, fossil with CCS, and batteries. See WGIII Chapter 3 for examples of the potential implications of limiting or precluding different low-carbon technologies.
10. Evidence of the interactions between ecosystems and resilience come from a range of sources including both regional and sectoral examples (Box 18.2; Tables 18.7–18.8). For example, regional examples suggest that the use of land to produce biofuels could increase the resilience of production systems and address mitigation needs (Box 2.2). Nevertheless, the potential of BECCS to induce maladaptation needs deeper analysis (Hoegh-Guldberg et al., 2019).

<u>Comment on point 7:</u> This is a huge oversimplification of the Fuhrman paper, especially the second last sentence. The paper investigates several scenarios: (1) reference with no mitigation which will increase food prices 15% compared to 2010; (2) low overshoot without DAC; (3) low overshoot with DAC; and (4) high overshoot with DAC. Scenario 2 without DAC will lead to a 7x increase in food prices compared to the reference, as a high amount of BECCS and A/R is used. Deployment of DAC in Scenario 3 leads to a significant reduction of BECCS and A/R, which are replaced with DAC. Food prices will still increase 3x compared to the reference, as BECCS and A/R are reduced but not eliminated in this scenario. One of the main conclusions from the paper is that DAC can avoid the most severe market-mediated effects of land-use competition from BECCS and A/R. The availability of low-cost DAC can reduce the land requirement by approximately 1 Mkm^2 in 2050, freeing up more land for food production and ameliorating the most severe food price impacts. Realmonte et al. (*An inter-model assessment of the role of direct air capture in deep mitigation pathways. Nat Commun 10, 3277 (2019)*) also conclude rather the opposite: for DAC, land and water use is significantly reduced compared to biological NETs. IEAGHG's recent report on DACCS (*IEAGHG (2021) "Global Assessment of Direct Air Capture Costs", 2021-05*) also concludes that the main advantage of DACCS compared to other NETs, like BECCS, is the smaller land and water footprint. Regarding the water use in particular, the report concludes that this is not likely to be a limitation for the technology in the future, as negative water impacts can be avoided by selection of the DAC process and/or the location (which has a higher degree of freedom than point source CO_2 capture). Recent IEAGHG report on NETs (*IEAGHG (2021), "Assessing the Techno-Economic Performance, Opportunities and Challenges of Mature and Nearly-mature Negative Emissions Technologies (NETs)", 2021-04*) also concluded overall lower land and water footprints for DACCS compared to BECCS.

Conclusions and IEAGHG actions

In conclusion, the WGII contribution to AR6 shows unequivocally that climate change has already caused widespread adverse, and partly irreversible, impacts and related losses and damages to nature and people. It also warns that natural and human systems are being pushed beyond their ability to adapt. The window of opportunity for adaptation and mitigation, which need to go hand-in-hand, is narrowing quickly. The report contains some concerningly unbalanced statements with regards to CCS and DAC, none of which seem to have made it into the SPM, the CCS water issues has made it onto the Technical Summary (TS) though. However, these statements (which concern the negative impacts of mitigation approaches and thus would be expected in the WGIII report rather than in the WGII report) show that there is a potential need for IEAGHG to expand its reviewing activities of IPCC materials. We currently review the WGIII report and the Synthesis Report as a standard but we might need to include the WGI and WGII reports in the future. The WGIII contribution is expected sometime in late March to early April. The review for this has already taken place and IEAGHG provided comments, including on the CCS water use issues that have slipped into the WGII report. We are also currently engaged in the review of the FOD of the Synthesis Report (SYR), which is ongoing and due to finish on 20 March. We will review with great care to check if concerning/unbalanced statements with regards to CCUS and CDR have made it into this report.

Reference list:

Climate Change 2022: Impacts, Adaptation and Vulnerability:

https://www.ipcc.ch/report/ar6/wg2/

IEAGHG (2011) "Evaluation and Analysis of Water Usage of Power Plants with CO_2 Capture", IEAGHG 2010/05

IEAGHG (2020) "Understanding the cost of reducing water usage in coal and gas fired power plants with CCS", IEAGHG 2020-09

IEAGHG (2020) "CCS and the Sustainable Development Goals", IEAGHG 2020-14

IEAGHG (2021), "Assessing the Techno-Economic Performance, Opportunities and Challenges of Mature and Nearly-mature Negative Emissions Technologies (NETs)", 2021-04

IEAGHG (2021) "Global Assessment of Direct Air Capture Costs", 2021-05

Recommended further reading:

CarbonBrief Q&A of the WGII contribution to AR6:

https://www.carbonbrief.org/in-depth-qa-the-ipccs-sixth-assessment-on-how-climate-change-impacts-the-world

IEAGHG (2021) "IPCC Working Group I report on the Physical Science Basis of Climate Change 2021", 2021-IP14

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