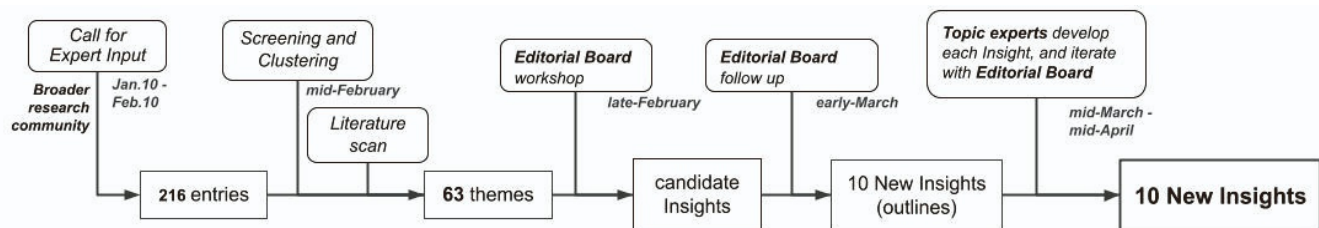


Supplemental information

Ten new insights in climate science 2024

Roberto Schaeffer, E. Lisa F. Schipper, Daniel Ospina, Paula Mirazo, Ane Alencar, Mehrnaz Anvari, Paulo Artaxo, Mehmet Efe Biresselioglu, Tanja Blome, Melanie Boeckmann, Ebba Brink, Wendy Broadgate, Mercedes Bustamante, Wenju Cai, Josep G. Canadell, Roberto Cardinale, Maria Paz Chidichimo, Peter Ditlevsen, Ursula Eicker, Sarah Feron, Mahelet G. Fikru, Sabine Fuss, Amadou T. Gaye, Örjan Gustafsson, Niklas Harring, Cheng He, Sophie Hebden, Adrian Heilemann, Marina Hirota, Nandakumar Janardhanan, Sirkku Juhola, Tae Yong Jung, Jiang Kejun, Şiir Kilkiş, Nilushi Kumarasinghe, David Lapola, June-Yi Lee, Carolina Levis, Adelaide Lusambili, Joannes D. Maasakkers, Claire MacIntosh, Jemilah Mahmood, Justin S. Mankin, Pía Marchegiani, Maria Martin, Aditi Mukherji, Tischa A. Muñoz-Erickson, Zeenat Niazi, Joseph Nyangon, Santosh Pandipati, Amarasinghage T.D. Perera, Geeta Persad, Åsa Persson, Aaron Redman, Ilona Riipinen, Johan Rockström, Sarah Roffe, Joyashree Roy, Boris Sakschewski, Bjørn H. Samset, Peter Schlosser, Ayyoob Sharifi, Wan-Yu Shih, Giles B. Sioen, Youba Sokona, Detlef Stammer, Sunhee Suk, Djiby Thiam, Vikki Thompson, Erin Tullos, René M. van Westen, Ana Maria Vargas Falla, Daniel J. Vecellio, John Worden, Henry C. Wu, Chi Xu, Yang Yang, Mariam Zachariah, Zhen Zhang, and Gina Ziervogel

Note S1 Process from 'Call for input' to '10 New Insights' in 2024



Note S2 Questionnaire (call for expert input)

CALL FOR EXPERT INPUT 2024

The **10 New Insights in Climate Science** series is an annual effort of science synthesis and science communication, aimed at highlighting key recent advances in climate change research, on time for the UNFCCC COP. The ultimate purpose is to equip policymakers and other decision-makers with essential knowledge to make sense of and confront the climate emergency. This is a joint initiative of Future Earth, The Earth League, and The World Climate Research Programme.

This report has been produced every year since 2017, shared with negotiators, and launched at the COP (see press conference at COP28). Underpinning the report, to ensure rigour and credibility, an academic manuscript is prepared and submitted for publication in a peer-reviewed journal. Last year's paper was published in the journal *Global Sustainability* (as was the case in 2020, 2021 and 2022).

We welcome your contribution!

This annual process starts with a request for input from the wider scientific community: We invite climate change researchers from around the world, and with expertise across the natural and social sciences, to contribute by telling us what are key recent developments in climate change research that should be raised to the attention of policymakers. Relevant topics span a very broad scholarship on the underlying patterns and bio/geophysical processes of the climate system, the impacts of climate change, as well as the means for and barriers to confronting the climate emergency.

Through this questionnaire, we also seek to identify **potential co-authors** for the policy report and the academic manuscript.

Completing this questionnaire takes approximately **15 minutes**.

*Deadline for submitting your input is **February 9, 2024***

If you have any questions or comments, do not hesitate to contact us: clea.edwards@asu.edu and daniel.ospina@futureearth.org

About the information collected through this form

In compliance with the General Data Protection Regulation (GDPR):

- **Legitimate interest:** Personal data allow us to characterise the group of respondents, and ensure that the inputs collected come from trusted sources and a diverse group of experts.
- **Data retention:** Personal data will be stored until the end of 2024, unless explicit consent is given to keep it any longer. At any point you can request that your personal data is deleted from our database.
- Personal data will not be shared with third parties, nor will it be used for any other purpose than the development of the "10 New Insights in Climate Science".
- If you have any questions about the collection and processing of these personal data or if you change your mind after filling this form, please contact clea.edwards@asu.edu and daniel.ospina@futureearth.org.

By filling out this form you accept that we will collect and process some of your **personal data**.

GIVE US YOUR PITCH

What key recent advance in climate change research do you think should be highlighted for policymakers?

By "**recent**" we mean that core supporting references should be published after December 2022. (Older references can be included as background).

By "**key advance**" we mean

1) new evidence or analyses that significantly update our understanding of the patterns or process of climate change, its impacts on societies, and the possible means and barriers to address it; or

2) novel research topics and questions following emerging developments in climate change (whether geophysical, ecological, socioeconomic, political or cultural).

While the former refers to concrete new insights, the latter refers to important issues appearing on the horizon of climate change research.

To be considered for inclusion, any suggested "research advance" has to be supported by at least one peer-reviewed reference.

These inputs will be discussed and prioritised by our Editorial Board, leading to a final list of 10 Insights.

What key recent advance in climate change research do you think should be highlighted for policymakers? *

Please be as succinct as possible. No need to provide context, just explain what is new and why it matters.

0/150

Email *

Please provide at least one peer-reviewed reference that explicitly supports the research advance that you are suggesting.*

These should be peer-reviewed papers, published after Dec. 2022.

0/150

Do you want to suggest another recent key advance in climate change research? *

- YES, I want to suggest another.
- NO, I'm all set for now.

Background references

Background references can be peer-reviewed papers published prior to 2023, as well as institutional reports, working papers, and similar grey literature.

0/150

Any comments?

0/150

Give us your SECOND pitch

What key recent advance in climate change research do you think should be highlighted for policymakers? *

Please be as succinct as possible. No need to provide context, just explain what is new and why it matters.

0/150

Please provide at least one peer-reviewed reference that explicitly supports the research advance that you are suggesting.*

These should be peer-reviewed papers, published after Dec. 2022.

0/150

Background references

Background references can be peer-reviewed papers published prior to 2023, as well as institutional reports, working papers, and similar grey literature.

0/150

Any comments?

0/150

Give us your THIRD pitch

What key recent advance in climate change research do you think should be highlighted for policymakers? *

Please be as succinct as possible. No need to provide context, just explain what is new and why it matters.

0/150

Please provide at least one peer-reviewed reference that explicitly supports the research advance that you are suggesting.*

These should be peer-reviewed papers, published after Dec. 2022.

0/150

Background references

Background references can be peer-reviewed papers published prior to 2023, as well as institutional reports, working papers, and similar grey literature.

0/150

Any comments?

0/150

About you

This information will allow us to characterise the group of respondents, and ensure that the inputs collected come from trusted sources and a diverse group of experts.

Do you want to suggest another key recent advance?*

- YES, I want to suggest another.
- No, I'm all set for now.

Country of your home institution (primary affiliation)*

Gender*

Have you contributed to previous installments of the ‘10 New Insights in Climate Science’ series?*

- YES
- NO

Any comments?

Can you recommend a researcher whom we should consider inviting as a co-author (i.e., an expert on precisely the topic you suggested)? If so, in addition to full name, please include contact information and/or current institutional affiliation.

NOTE: 1) If you have more than one recommendation, please add each on a new line. 2) If you suggested more than one research advance, please indicate which expert is suggested for each advance. 3) If you have no expert(s) to recommend, feel free to skip this Question.

What best describes your current focus of research or practice?*

- Natural science
- Social science
- Across natural and social science

Are you affiliated with any of the three organizations that jointly develop the ‘10 New Insights in Climate Science’ series (Future Earth, The Earth League, The World Climate Research Programme)?

- YES
- NO

Which are you affiliated with?

- Future Earth
- The Earth League
- The World Climate Research Programme.

Since you are affiliated to Future Earth, could let us know more specifically how?

e.g. Secretariat (Hubs), Global Research Networks, National or Local Committees. Which?

Potential co-authors (topic experts)

Each co-author will be part of a small team of topic experts responsible for writing one of the insights for the scientific manuscript and the policy report.

Would you be interested in being a co-author for one insight, suited to your area of expertise?*

- Sure!
- No, thank you.

Institutional affiliation*

If you have multiple affiliations, feel free to list them all or just the main one.

Potential reviewers (topic experts)

This could either be as a recommendation for the journal to contact you, or as a “friendly-reviewer” for a section of the report.

Would you be interested in being suggested as a reviewer for the academic manuscript and/or the policy report?*

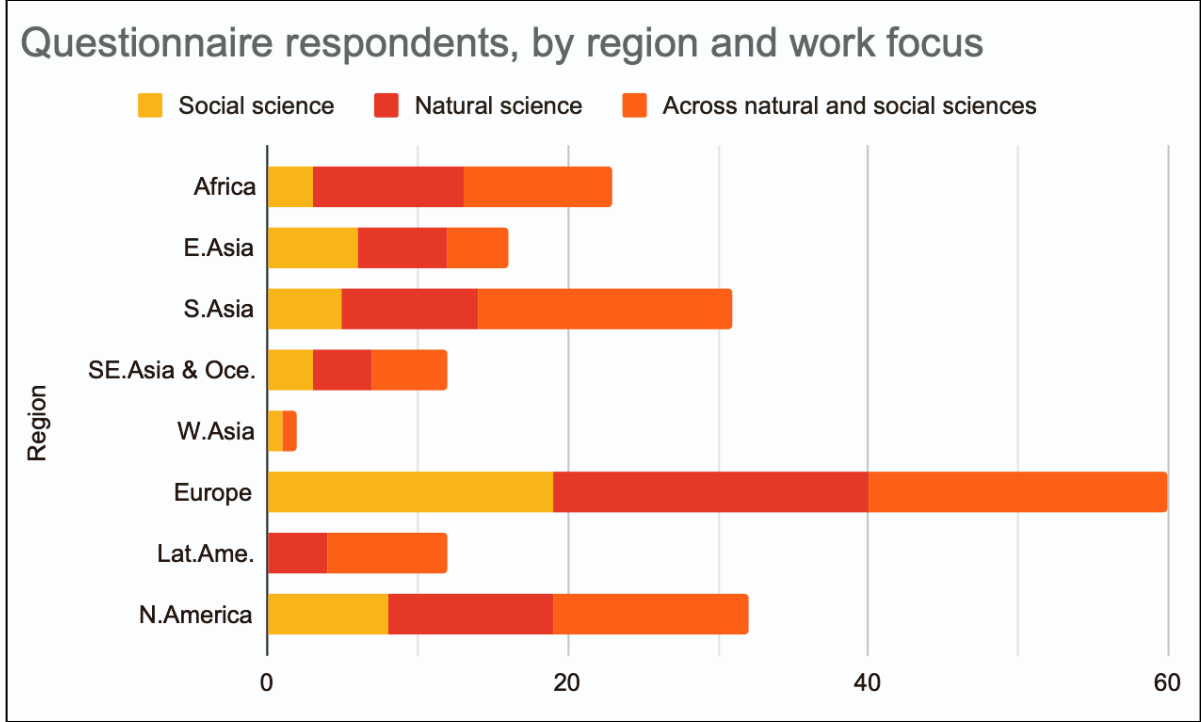
- Sure!
- No, thank you.

Full name***Would you like to receive sporadic updates about the ‘10 New Insights in Climate Science’ series (for example, information about the report launch in 2024, or the next call for input in 2025)?***

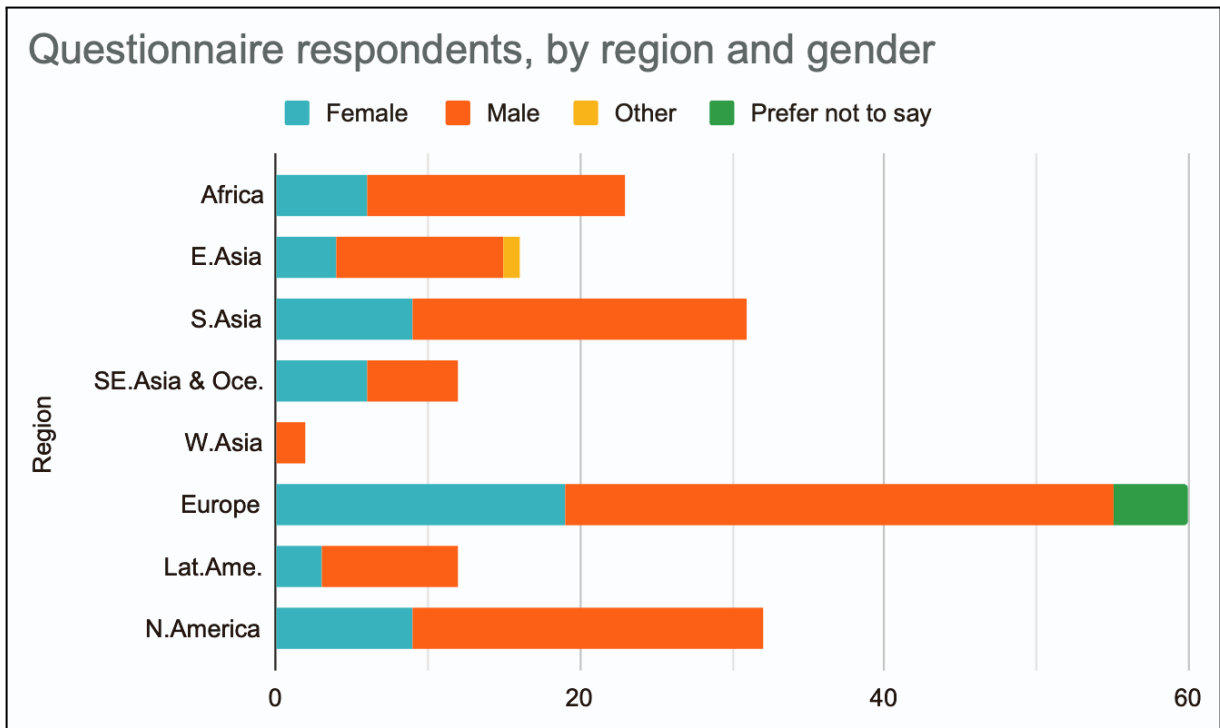
- Approve
- Don’t approve

Any final comments or suggestions?

Note S3 Questionnaire respondents, brief characterisation



Respondents to the call for input (188), regional and work focus distribution



Respondents to the call for input (188), regional and work focus distribution

Note S4 Inclusion/Exclusion criteria for screening for entries from questionnaire

- **Priority/Include** - The entry suggests a concrete message relevant to understanding or addressing climate change, and provides at least one recent (2023-2024) supporting peer-reviewed reference.
- **Not suitable/Exclude** - The entry is not directly relevant to understanding or addressing climate change, or does not provide any credible supporting references).
- **Unclear/Unsure** - This could be used for a number of situations, for example:
 - The entry is too broad (perhaps just a *topic*, rather than a potential Insight)
 - The only supporting reference is a preprint (discussion or working document), and/or grey literature.
 - The only supporting reference is not recent enough (i.e. 2022 or older).

All entries were assessed by two team members, at least. Discrepancies were further discussed among reviewers to reach a final decision. When necessary project coordinators completed one additional round of screening and made a final decision.

Note S5 Literature scan

The literature scan is intended to complement the expert input gathered through the online questionnaire. The purpose is to reduce the chance of missing highly impactful recent publications. It is not a comprehensive literature review. Literature considered for inclusion was identified via:

1. Web of Science Core Collection, within the period starting from 2023.01, filtering with two 'Highly cited papers' and 'Hot papers' (two of Clarivate's 'Essential Science Indicators'), and with additional query fields:
 - a. Publications:

<i>Bioscience</i> <i>Nature</i> <i>Nature Communications</i> <i>Proceedings of the National Academy of Sciences</i> <i>Science</i> <i>Science Advances</i> <i>The Lancet</i> <i>Climate Policy</i> <i>Climate Risk Management</i> <i>Energy Policy</i> <i>Global Environmental Politics</i> <i>Mitigation and Adaptation Strategies for Global Change</i> <i>Atmospheric Chemistry and Physics</i> <i>Climate Dynamics</i> <i>Climate of the Past</i> <i>Climate Research</i> <i>Communications Earth Environment</i> <i>Climatic Change</i> <i>Earth System Dynamics</i> <i>Earth System Science Data</i> <i>Ecology Letters</i> <i>Global and Planetary Change</i> <i>Global Change Biology</i>	<i>International Journal of Climatology</i> <i>Geophysical Research Letters</i> <i>Journal of Climate</i> <i>Nature Geoscience</i> <i>Quaternary Science Reviews</i> <i>The Cryosphere</i> <i>Theoretical and Applied Climatology</i> <i>Environmental Health Perspectives</i> <i>Environmental Research Letters</i> <i>Environmental Science & Technology</i> <i>Frontiers in Climate</i> <i>Global Environmental Change</i> <i>Nature Climate Change</i> <i>Nature Energy</i> <i>Nature Sustainability</i> <i>Regional Environmental Change</i> <i>Science of the Total Environment</i> <i>The Lancet Planetary Health</i> <i>Wiley Interdisciplinary Reviews-Climate Change</i> <i>Advances in Atmospheric Sciences</i> <i>Frontiers in Environmental Science</i> <i>Joule</i> <i>One Earth</i>
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- b. Topic (which includes Title, Keywords, and Abstract):
Using several generic terms: “climate change”, “global warming” “climate AND mitigation”, “climate AND adaptation” “loss and damage”).

2. Direct recommendations from the Editorial Board and the researchers from the team.

Note S6 Emergent themes from the open call and the literature scan

THE EARTH SYSTEM

Status and trends

1. Earth's climate sensitivity is higher than previously assumed, warranting extraordinary climate action
2. Decline of aerosol emissions since 2010 will increase the global warming rate [“climate penalty” ; “masking effect”]
3. Hotspots of future drier and wetter conditions, including regions already experiencing water scarcity or excess
4. Limited reversal of regional climate signals in overshoot scenario
5. Underestimation of methane emissions and its social cost
6. Global warming impacts El Niño Southern Oscillation (ENSO) variability, increasing its negative economic impacts
7. Underestimation of Greenland Ice sheet mass balance has implications for ocean circulation and global heat distribution
8. Surface albedo darkening over the Tibetan Plateau will exacerbate the current “South Flood-North Drought” pattern over East Asia, and affect water availability locally.

Earth system stability / Tipping elements

- 9. Amazon tipping update
- 10. AMOC is on "tipping course" + climate models have systematically overestimated the AMOC stability
- 11. Tipping cascades cannot be ruled out [multiple/strong link to the Amazon]
- 12. Antarctic ice shelves: growing overall since 2009, but the WAIS loss is now locked-in

Climate-Biosphere interactions

- 13. Tropical deforestation causes large reductions in observed precipitation

IMPACTS

Health

- 14. Excess mortality attributed to heat and cold (10-100s of thousands [in Europe alone])
- 15. Increased pregnancy loss associated with flood

Socioeconomic vulnerability and loss

- 16. One third of global population could be outside the "human climate niche" by the end of the century
- 17. Reinforcing inequalities on income, wealth and vulnerability to climate change
- 18. Climate-sensitive and migrant-inclusive health care is a growing need in a warming planet

Extreme weather

- 19. Flash droughts have become more common across the world
- 20. Extreme weather increases pressure on infrastructure [and ecosystems]
- 21. The Pakistan 2022 floods cannot be attributed to human-induced climate change, given natural variability

Sea-level rise

- 22. Widespread retreat of coastal habitat is likely at warming levels above 1.5°C

Oceans

- 23. Marine heatwaves are increasing in frequency and intensity

ACTION NEEDED AND BARRIERS

Trends and projections: needed action

- 24. (Un)Fairness conundrum posed by the moral claim to emissions from Developing countries and the remaining carbon budget
- 25. Paris targets within reach by aligning, broadening and strengthening net-zero pledges

Corporate action and Private Finance

- 26. The catalysing factor of green finance in the energy transition

Cities

- 27. Urban heat island - impact and management
- 28. Challenges toward just transitions cities and sustainable urban futures
- 29. Cities and regions tackle climate change mitigation but often focus on less effective solutions

Nature-based solutions and wet/land management

- 30. EU off track to meet climate mitigation goals for the land sector - social and ecological reasons
- 31. Carbon storage, even if temporary, can have important impacts in lowering the global temperature peaks
- 32. Promoting tree functional diversity can also strengthen global mitigation strategies

Carbon management (CDR and CCS)

- 33. Ongoing implementation of nature-based CDR despite scientific advice risks affecting mitigation and adaptation goals and local resilience
- 34. Emission reduction goals need unambiguous pathways, including on the realistic role of CDR

Other policy measures

- 35. Assessment and decision-making on the water-energy-food nexus for needed systemic solutions
- 36. Methane mitigation actions in NDCs could achieve the Global Pledge goal. But currently very few CH₄ emissions are covered by mitigation policies

Co-Benefits

- 37. Climate mitigation strategies result in health co-benefits across society
- 38. Global food consumption alone could add nearly 1°C to warming by 2100 (mostly methane)

Adaptation/Resilience-building

- 39. Soft limits adaptation persist over decades
- 40. Lessons on reducing the risk of maladaptation
- 41. Planned relocation as part of the solution space to climate migration
- 42. Efficacy beliefs are the underlying drivers of household adaptation behavior
- 43. Disaster risk management needs to factor in the risk of compound events

Transformations

- 44. Barriers to individual behaviour on climate action

Justice / Inequality

- 45. Critical minerals for the energy transition: socio-environmental trade-offs/costs
- 46. What climate change and a “post-carbon” transition means for the future of labour and energy access
- 47. Energy systems modelling for just transitions
- 48. Gender equality can enhance climate resilience and drive social justice

Political feasibility and social movements

- 49. The rise of (right-wing) populism threatens climate action

International governance and multilateral finance

- 50. Problems of multilateral climate finance (and what to do about them)
- 51. Deep political/governance challenges for the operationalising the L&D fund
- 52. Climate finance is not leading to significant mitigation action in developing countries
- 53. Alignment of investments with NDCs is needed
- 54. Countries' geopolitical risk directly increases GHG emissions

New techniques to inform policy decisions

- 55. Emerging digital technologies in climate change research and action - risks and

opportunities

- 56. Extreme weather event attribution to anthropogenic climate change (its role for L&D)
- 57. Earth observations for GHG emissions monitoring [methane focus]
- 58. Industry 4.0 technologies can improve quality of ESG assurance and avoid greenwashing
- 59. Advances in weather and climate services - limitations and potential
- 60. Physical climate storylines for climate risk assessment to explore complex impact transmission pathways and alternative unfoldings

Climate engineering (geoengineering)

- 61. Taking climate engineering seriously: trade-offs and governance for SRM/SAI"

Alternative energy sources

- 62. The possibilities and challenges of hydrogen energy systems
- 63. Underused potential of geothermal energy