

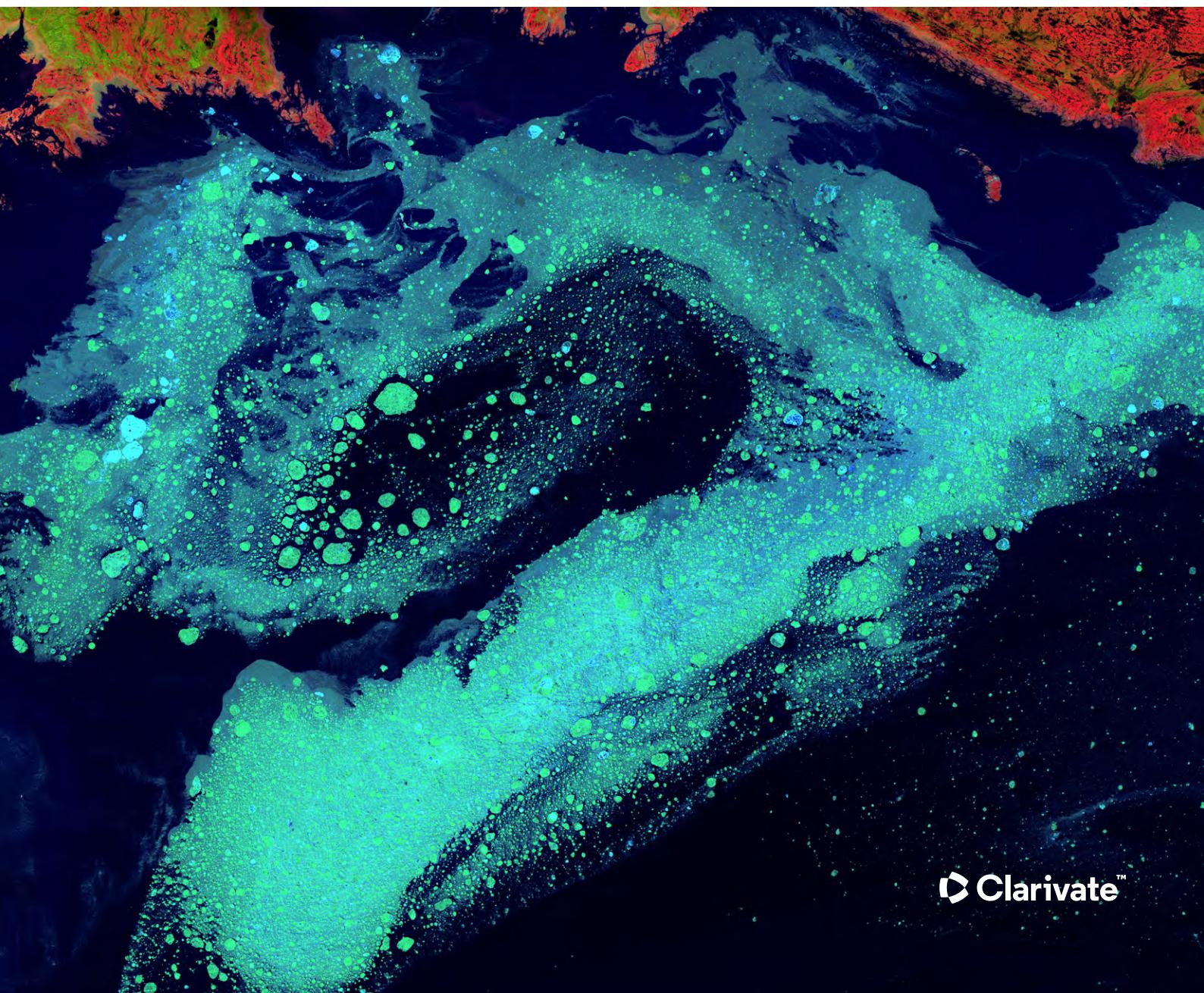


Institute for
Scientific
Information

Insights: Climate change collaboration

Why we need an international approach to research

Ross Potter and Gali Halevi



Author biographies

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The Institute for Scientific Information at Clarivate has pioneered the organization of the world's research information for more than half a century. Today it remains committed to promoting integrity in research while improving the retrieval, interpretation

and utility of scientific information. It maintains the knowledge corpus upon which the Web of ScienceTM index and related information and analytical content and services are built. It disseminates that knowledge externally through events, conferences

and publications while conducting primary research to sustain, extend and improve the knowledge base. For more information, please visit www.clarivate.com/webofsciencegroup/solutions/isi-institute-for-scientific-information/.

About ISI Insights

ISI Insights is a new series of analyses from the Institute for Scientific Information. Each paper offers a concise and informative analysis of topical research trends, using best-in-class citation data and analytics from Clarivate.

Climate change is a global crisis. In this paper, we draw attention to the main climate change research topics within the scientific literature over the past 20 years. Research topic diversity is low and focuses on natural science themes, but recent emphasis on social

and public research demonstrates a greater need to inform and educate the public. While international collaboration has increased, climate change research generally remains a nationally focused issue.

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Cover image: Foxe Basin, Nunavut, Canada

Foxe Basin is a shallow oceanic basin north of Hudson Bay, in Nunavut, Canada, located between Baffin Island and the Melville Peninsula. For most of the year, it is blocked by sea ice (fast ice) and drift ice made up of multiple ice floes. The nutrient-rich cold waters found in the basin are known to be especially favourable to phytoplankton and the numerous islands within it are important bird habitats, including Sabine's gulls and many types of shorebirds. Even though the image is from late July, there was still ice floating in the water this far north.

1

Fifty percent of all climate change research in the last 20 years has focused on just three topics:

- Oceanography, Meteorology and Atmospheric Sciences (OMAS)
- Climate Change (as its own topic)
- Forestry

2

Regional research aligns with these topics, although some local priorities vary slightly.

3

Several research topics focusing on social and public issues related to climate change emerged post-2000, with rapid expansion in the past 10 years. These include Hospitality, Leisure, Sport & Tourism, Agricultural Policy, and Education & Educational Research.

4

Climate change research has remained largely a national focus, although international collaboration has increased from one-quarter (2000 to 2009) to more than one-third (2015 to 2019) of the research base.

5

International collaboration is driven by developed research economies (e.g., the United States and the United Kingdom) and aided by a strong European nexus. Collaboration with other regions can be driven by factors such as language or proximity. Given the global effects of climate change, we recommend greater international collaboration as a necessity.

6

Climate change research is highly specific and specialized. Increased global focus by governments and institutions on a more diverse range of topics could encourage additional innovation and insights to tackle it.

7

The emergence and growth of social and public-related research topics, such as science communications and educational research, demonstrate a deeper awareness of the need to educate and inform the public about the effects of climate change, and a move beyond solely natural science-focused research.

Data behind this analysis

The Web of Science from Clarivate organizes the world's research information to enable academia, corporations, publishers and governments to accelerate the pace of research. It is the world's largest publisher-neutral citation index and research intelligence platform.

Learn more:

<https://clarivate.com/webofsciencegroup/solutions/web-of-science/>

A global crisis, tracked through evolving research topics

Extreme weather was one of the defining features of the summer of 2021. With wildfires in Greece, Russia and wide swathes of the United States¹; flooding in Europe and Mainland China²; and prolonged droughts in extensive parts of the Middle East and Africa³, the entire world watched the effects of global warming on the planet. The United Nations published an extensive report⁴ that summer which focused on the dramatic changes in climate, its main causes and major implications. The report featured heavily across the global news media and drew the world's attention to humankind's role in effecting these changes. Evidence presented within the report included greenhouse gas and aerosol increase, stratospheric ozone depletion and ocean acidification.

As a truly global challenge, climate change research must be conducted internationally, assembling scientific expertise, innovation and technologies to address critical issues that have vital implications for all life on Earth.

The United Nations member states also recommended an international approach to climate change collaboration as part of the 2030

Agenda for Sustainable Development. Among the 17 UN Sustainable Development Goals (SDGs) is Climate Action (SDG 13). As part of this goal to combat the climate crisis, member states advise six Climate Positive Actions including “Cooperation—no country can succeed alone.” Many of the studies discussed in this paper also align with other SDGs, including SDG 12: Responsible Production and Consumption, SDG 14: Life Below Water and SDG 15: Life on Land.

In this ISI Insights paper, we provide an overview of climate change research and its evolution over the past 20 years. Additionally, we analyzed how the world collaborates on various climate change subtopics with the purpose of highlighting current trends and future needs.

To pinpoint the most relevant documents, our analysis used the Web of Science™ to focus on articles with ‘climate change’ in their title published from 2000 to 2019. This search provided a dataset of ~37,000 papers. To investigate topics, we utilized the meso-level classification from InCites Benchmarking & Analytics™ Citation Topics — a document-level classification scheme based on citation relations.

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¹<https://www.dw.com/en/global-wildfires-greece-surveys-damage-from-fires-of-exceptional-magnitude/a-58833737>

²<https://www.cnbc.com/2021/07/27/floods-in-europe-and-china-disrupt-global-shipping-supply-chains.html>

³<https://reliefweb.int/sites/reliefweb.int/files/resources/GAR%20Special%20Report%20on%20Drought%202021.pdf>

⁴<https://www.un.org/en/climatechange/reports>

Climate change research is predominantly natural science focused

Climate change research is dominated by three main topics:

- Oceanography, Meteorology, and Atmospheric Sciences (OMAS)
- Climate Change (as an independent research topic)
- Forestry

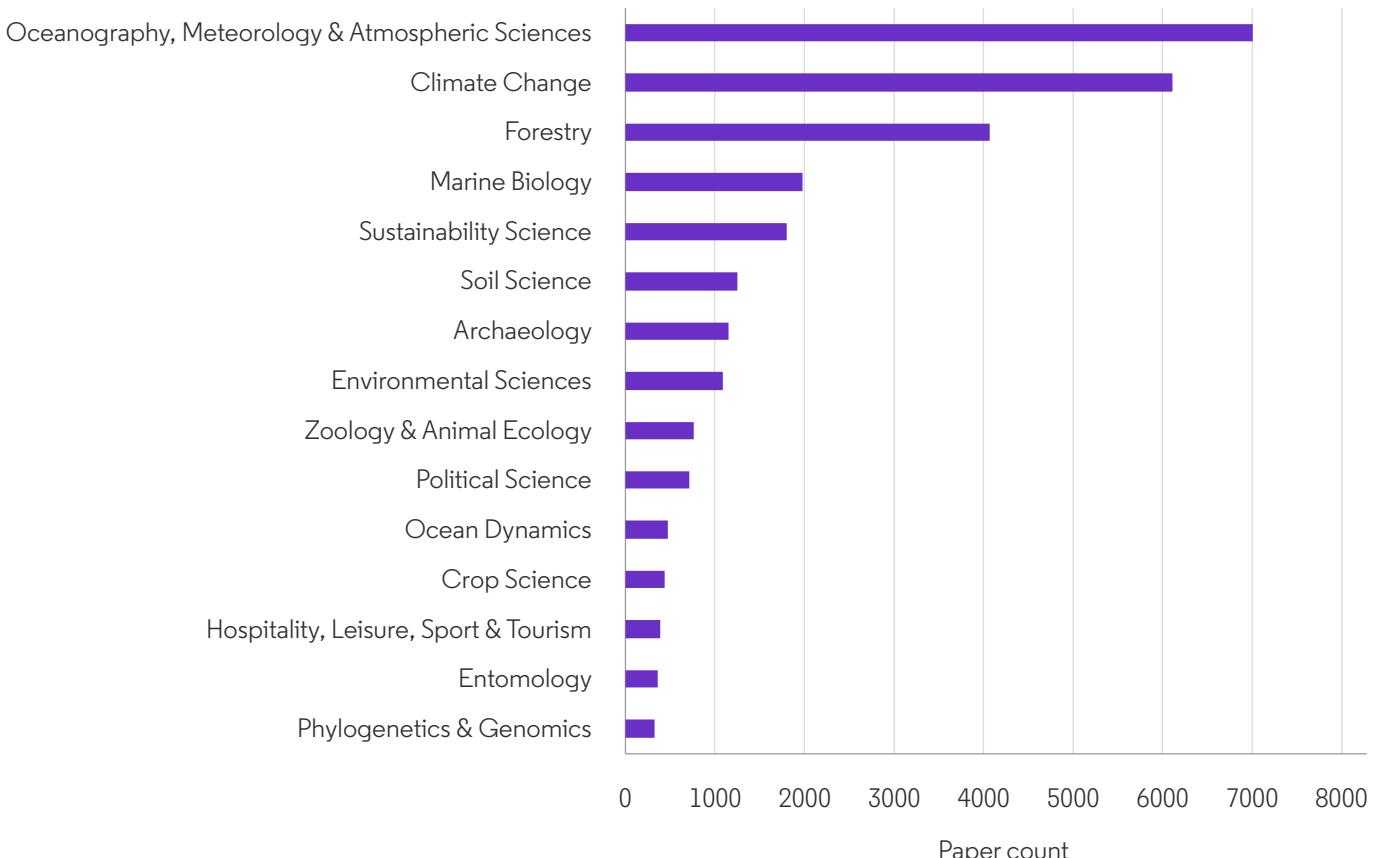
These three topics make up ~50% of output (Figure 1). Marine Biology and Sustainability Sciences are the next most researched topics, each representing ~5% of output.

Within these topics, we also identified more specific research subtopics (Figure 2). The most researched and dominant subtopic within OMAS is Evapotranspiration (the transfer of water to the atmosphere). El Niño/Southern Oscillation (ENSO), Glacier activities and Urban Heat Island (warmer temperatures in built-up areas) subtopics are the next most researched.

Within the Climate Change topic, research on Adaptation, Science Communication and Water Governance lead. Research in Forestry is led by Maximum Entropy

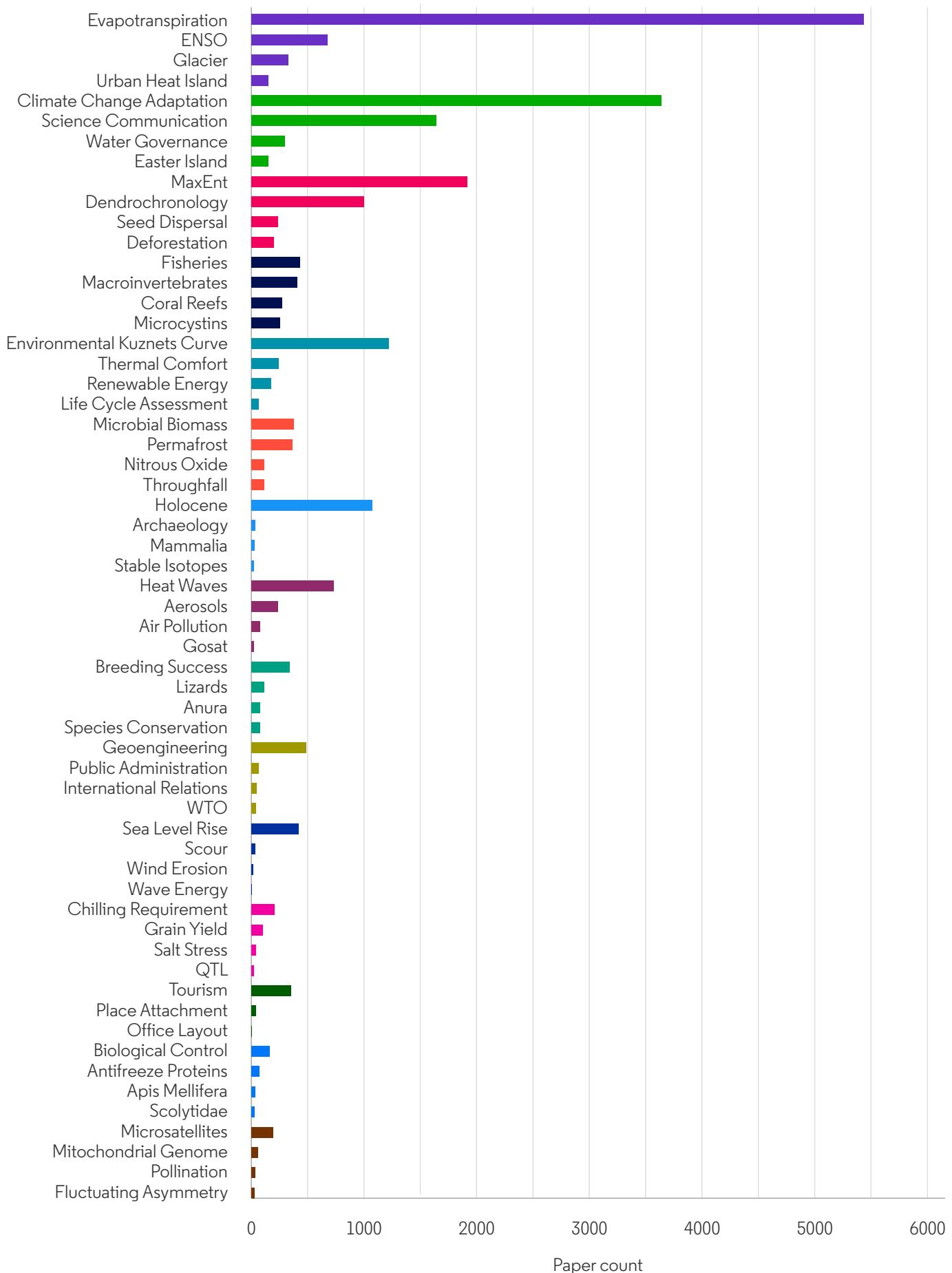
(MaxEnt: species distribution modeling), Dendrochronology (climatic conditions through examination of tree ring growth), Seed Dispersal and Deforestation. In Marine Biology, research focused on Fisheries, Macroinvertebrates (small aquatic animals including crayfish), Coral Reefs and Microcystins (a toxin). Other prominent subtopics include Environmental Kuznets Curve (the relationship between environmental degradation and economic growth) for Sustainability Science and the Holocene period (the last ~12,000 years) for Archaeology.

Figure 1. Main climate change research topics



Source: Web of Science data and ISI research

Figure 2. Research subtopics within the largest topics



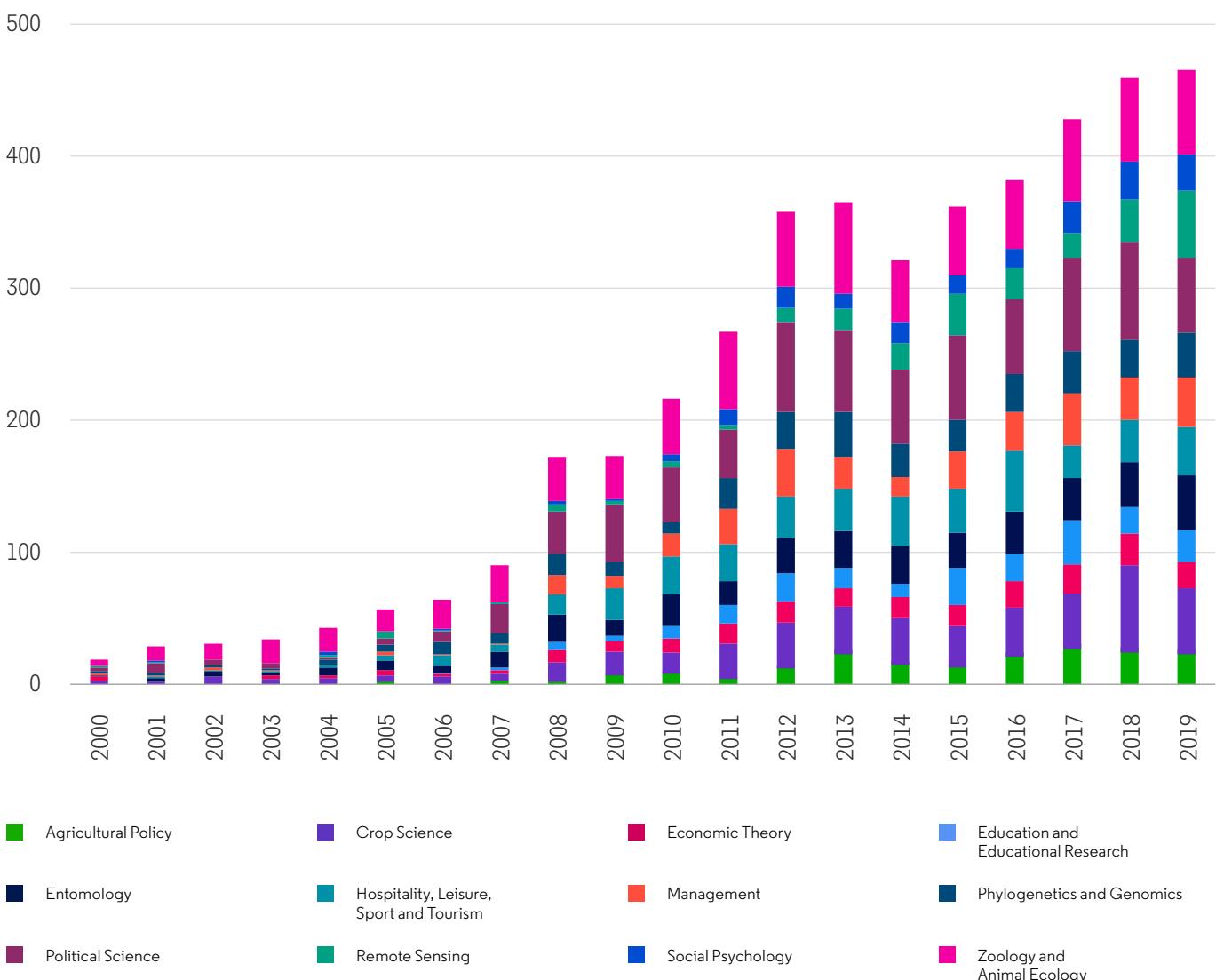
Source: Web of Science data and ISI research

Emerging topics demonstrate growing awareness of social responsibility

Using our data, we identified emerging research topics in the past ~10 years (Figure 3). We found that these new topics show greater social and public service relevance, suggesting growing prioritization of the role people, organizations and governments play in addressing climate change. Data suggest output in these topics will continue to rise. The emerging topics include:

- **Agricultural Policy** (a total of 12 papers from 2000 to 2009; 170 papers from 2010 to 2019) and **Crop Science** (a four-fold increase from 2000 to 2010, with another four-fold increase from 2010 to 2019)
- **Economic Theory** (34 papers from 2000 to 2009; 174 papers from 2010 to 2019)
- **Hospitality, Leisure, Sport & Tourism** (61 papers from 2000 to 2009; 330 papers from 2010 to 2019)
- **Political Science** (129 papers from 2000 to 2009; 587 papers from 2010 to 2019)
- **Education & Educational Research and Human Geography** (where papers began appearing from 2006)

Figure 3. Emerging research topics (≤ 5 papers in 2000 but more than ≥ 20 papers in 2019)⁵



Source: Web of Science data and ISI research

⁵ Human Geography is not plotted as it produced only 11 papers in 2019.

Research focus remains largely consistent by region, with some exceptions

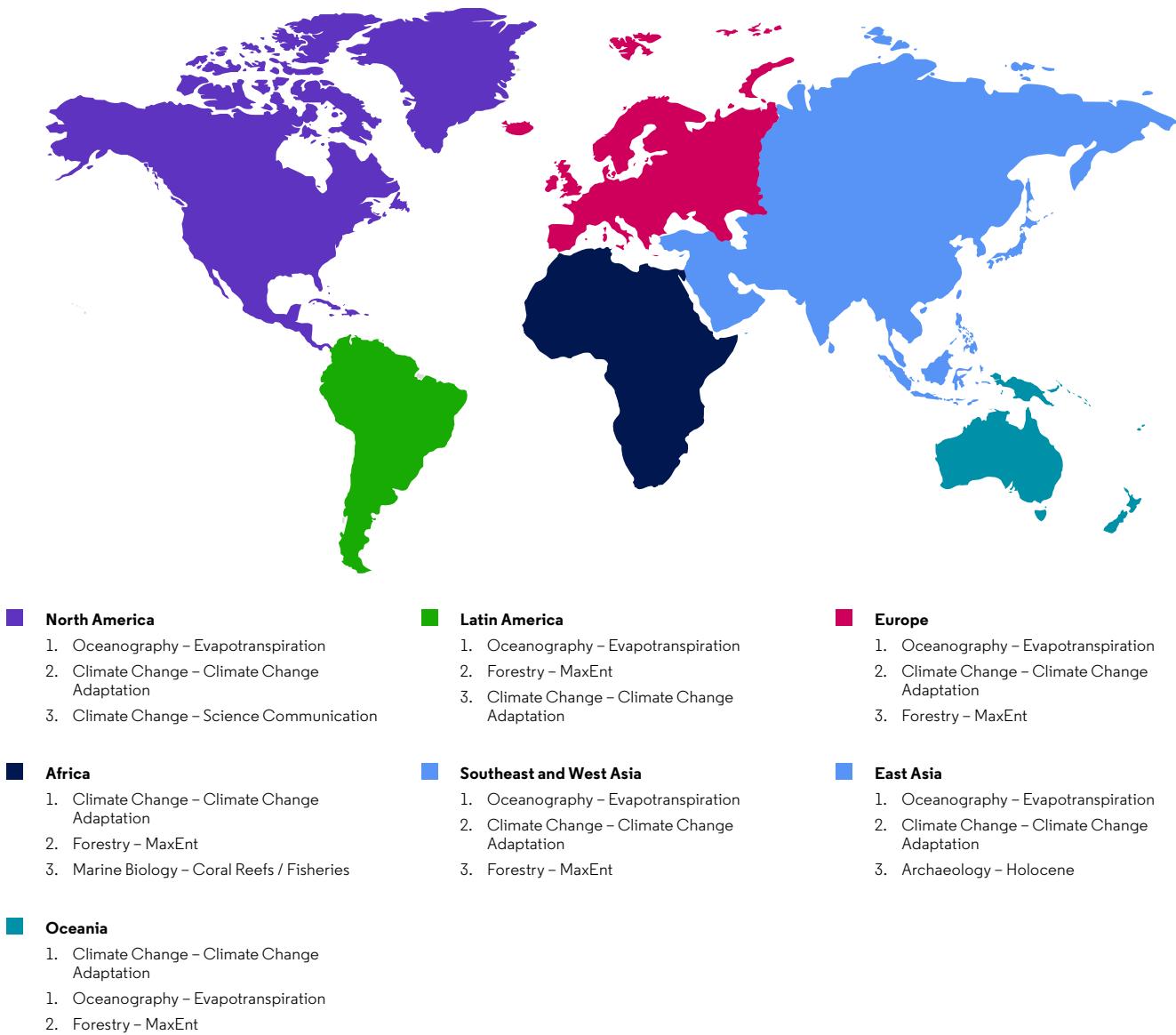
Using author address data, we next analyzed regional output to compare regional research (sub)topics and depicted the top three by output (Figure 4). The major topics, as expected, reflect the same priorities as global output (Figure 1). At the subtopic level, Evapotranspiration and Climate Change Adaption feature prominently in all regions, demonstrating the truly global extent of related crises,

although output varies considerably. For example, the European Union produced 2,028 papers on Evapotranspiration during the period whereas the continent of Africa produced 332.

MaxEnt (species distribution modeling) is also a major subtopic for all regions except North America and East Asia; Science Communication and the Holocene fill these gaps, respectively.

Accompanying growing awareness of the role people play in climate change – both in its occurrence and its solution, science communication can provide an important public service by reliably and responsibly informing and educating the public on scientific topics. Its prevalence demonstrates the increasing social focus of climate change research, as well as its importance as a solution.

Figure 4. Regional focus on climate change research



Source: Web of Science data and ISI research

Climate change research is becoming increasingly international

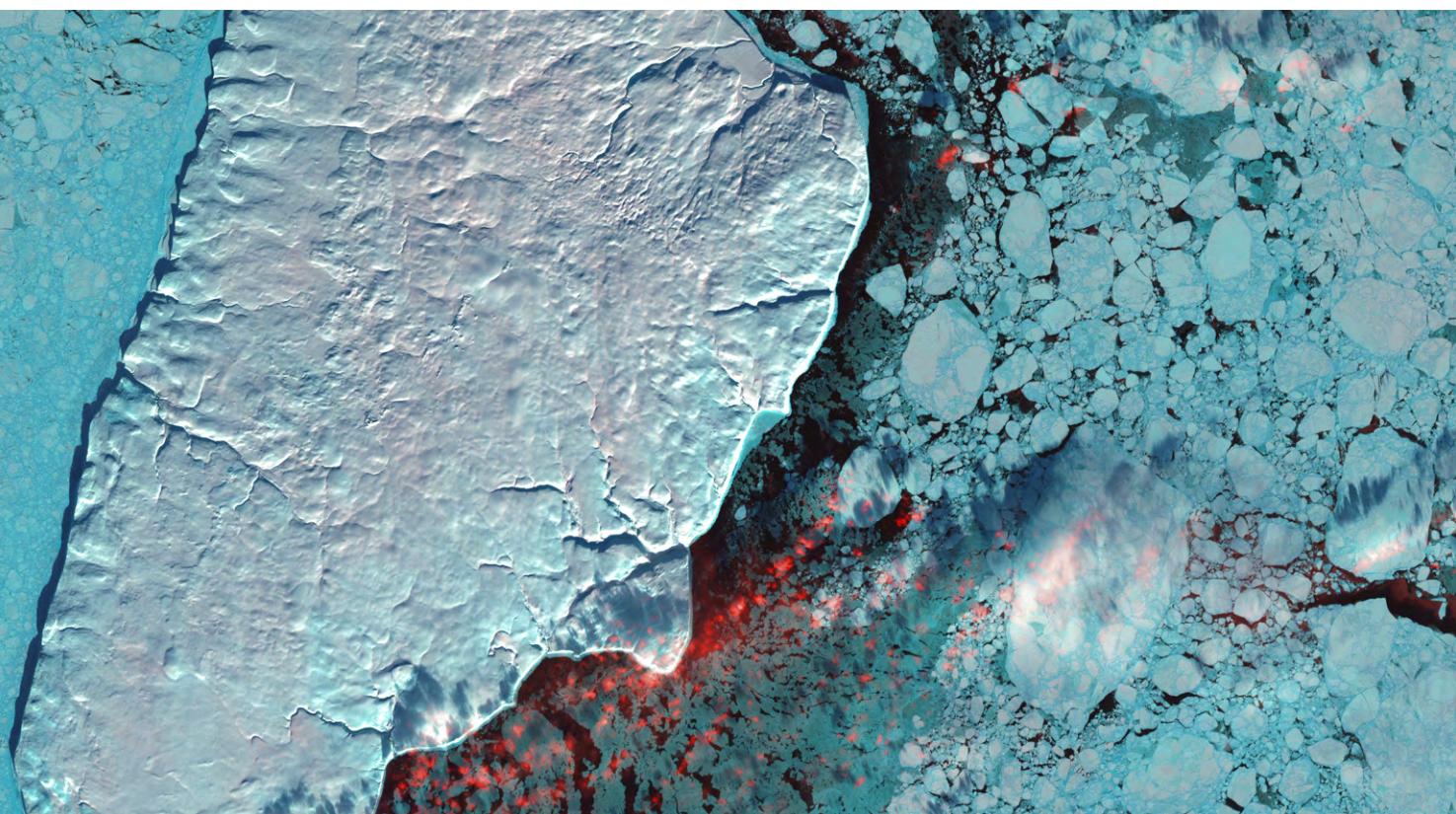
One-quarter of all climate change-related papers published from 2000 to 2009 involved international collaboration (i.e., at least two countries listed in address information). In the most recent five years (2015 to 2019) this has increased to over one-third, showing that climate research is becoming increasingly international, although is still generally conducted nationally.

Our data show that the most productive collaboration was between the United States and United Kingdom (904 papers), although a set of these papers

also include collaborations with other nations. International collaboration accounts for ~9% of the total output for the United States and ~18% of the total output for the United Kingdom.

We also examined collaborations in three of the four largest research topics (OMAS, Marine Biology and Forestry) to highlight international co-authorship within and between topics. Selecting the top international collaborations in terms of output (at least 10 collaborative papers) over the past 20 years, we produced network diagrams (Figures 5, 6 and 7).

Our data show that the most productive collaboration was between the United States and United Kingdom with 904 papers

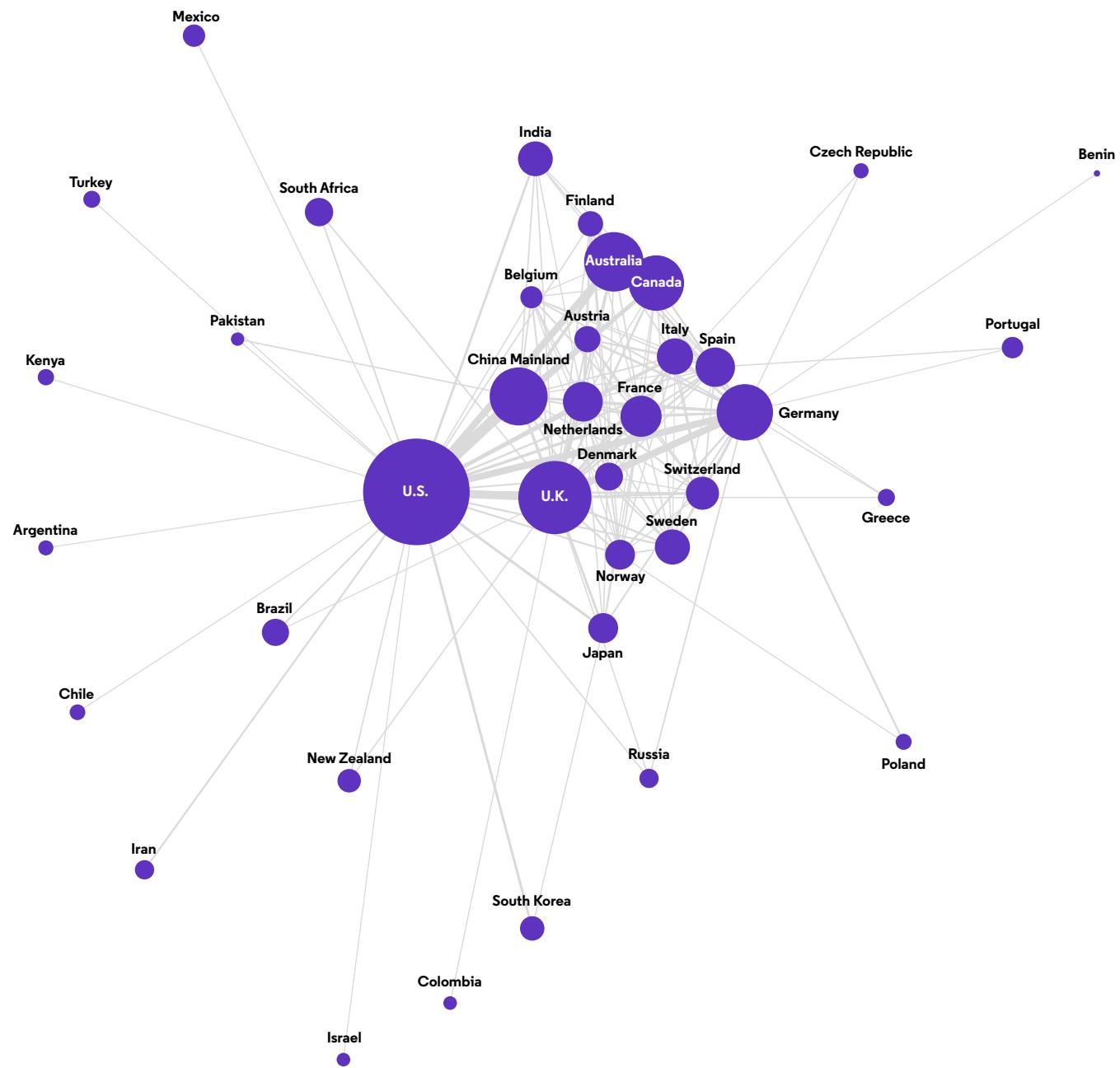


Oceanography, Meteorology and Atmospheric Sciences

The main research hubs for OMAS are the United States, the United Kingdom and Germany. However, the largest collaboration was between the United States and Mainland China (256 papers). There is also a significant European presence driving the collaborations, particularly western and Nordic Europe. Mainland China and Australia are also somewhat well

connected in the main collaboration group, and India and Japan collaborate with several of the main countries. The United States has strong global collaboration reach, linking not only to primary research contributors but also to South and Central America, as well as Africa and the Middle East (Figure 5).

Figure 5. International collaboration network (≥ 10 collaborative papers) for Oceanography, Meteorology and Atmospheric Sciences. Node size is relative to the total number of papers; line thickness is relative to the number of collaborative papers.



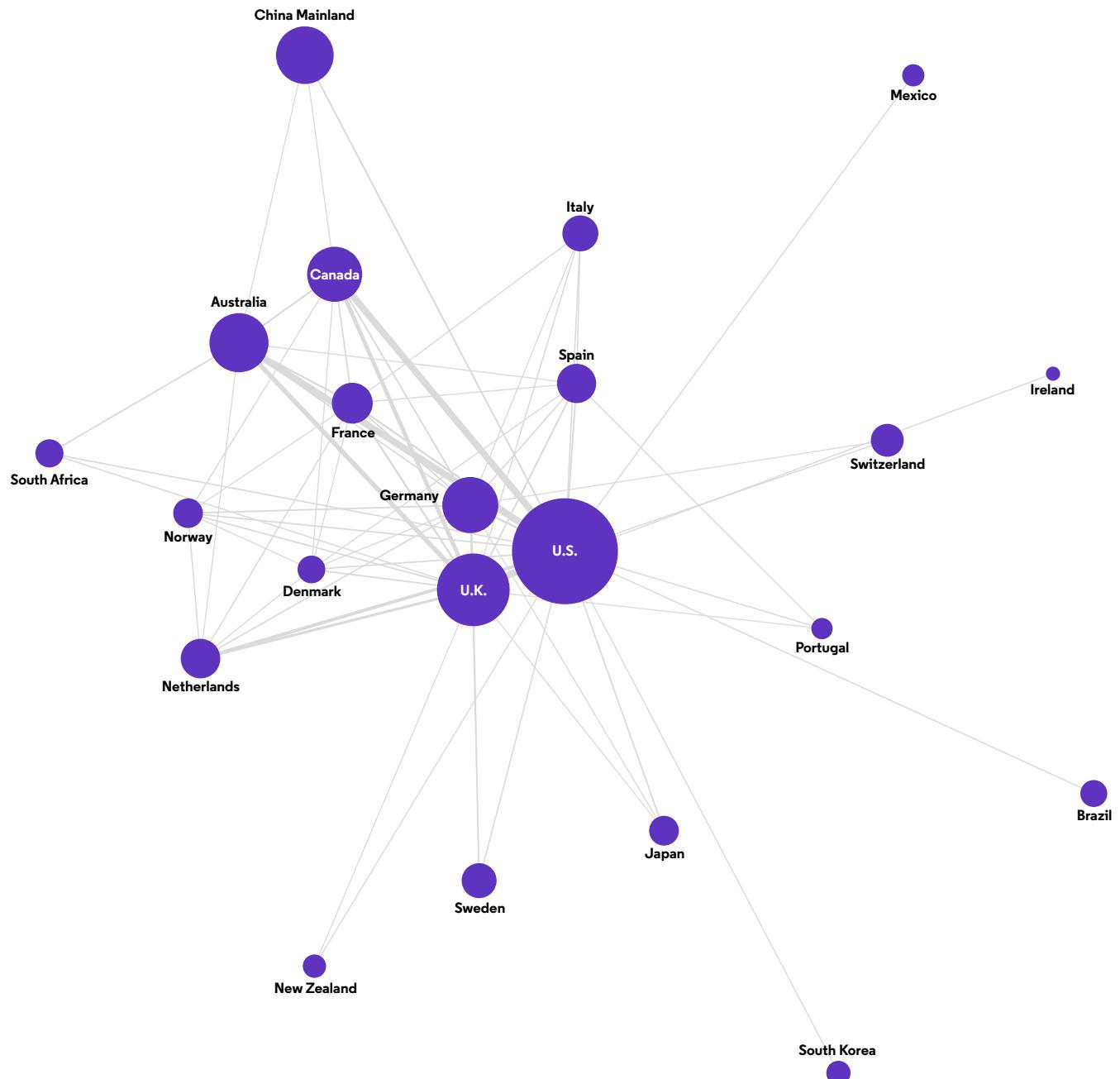
Source: Web of Science data and ISI research

Marine Biology

Marine Biology has a smaller network than OMAS, though almost all countries are connected to the main hubs of the United States, the United Kingdom and Germany. The largest collaborations are between the United States and the nations of Canada (95 papers), Australia (94 papers) and the United Kingdom (83 papers).

Mainland China has a peripheral presence with its largest collaboration producing only 24 papers—largely with the United States. Despite being landlocked, Switzerland has notable collaborations with the United States and Germany. Research is mainly driven by collaborations between European countries (Figure 6).

Figure 6. International collaboration network (≥ 10 collaborative papers) for Marine Biology.



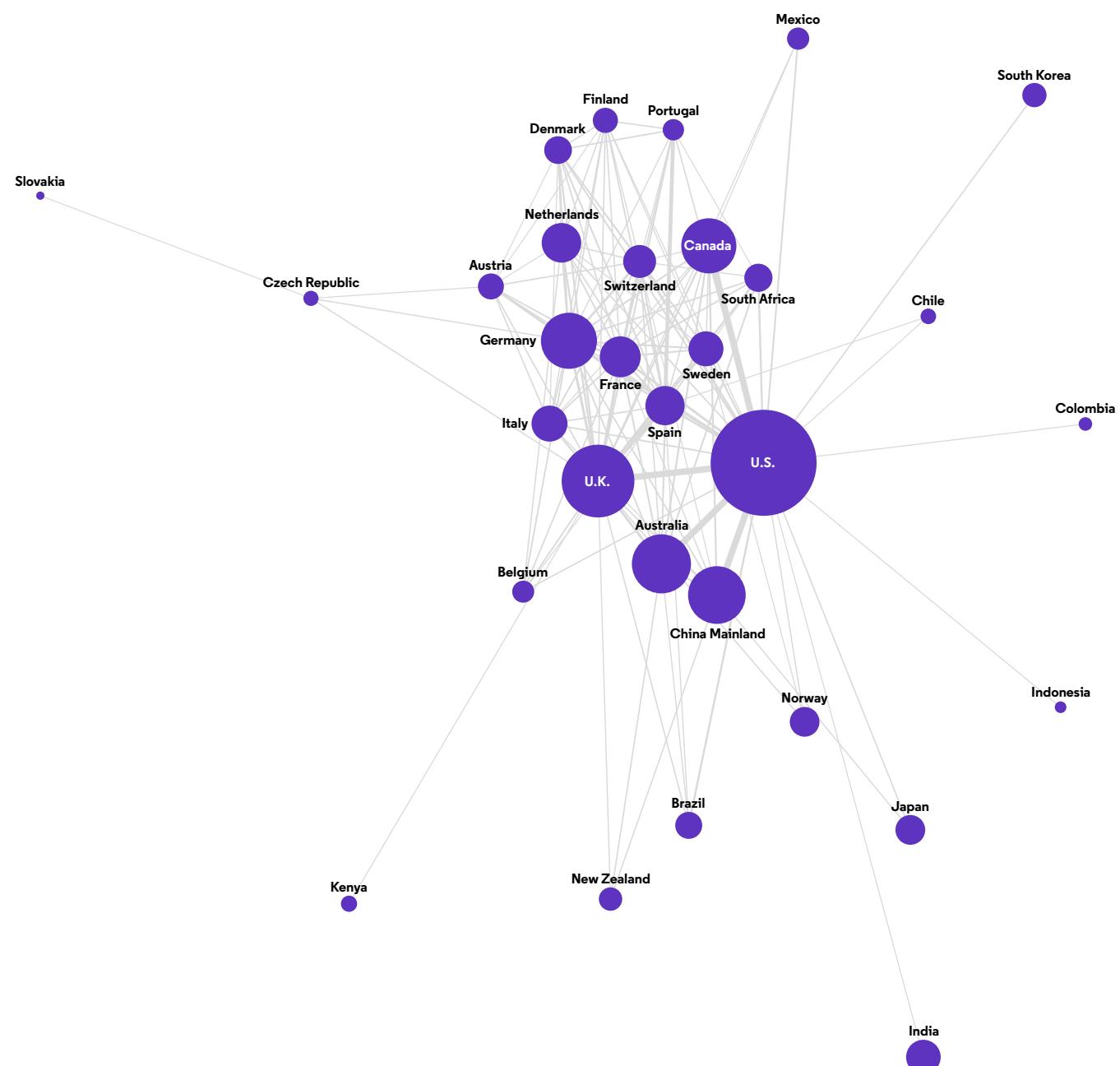
Source: Web of Science data and ISI research

Forestry

For Forestry, the United States is the main hub, showing significant collaboration with the United Kingdom (127 papers – the largest value), Canada, Australia and Mainland China. A tight-knit European collaboration zone is again present, with South and Central America, Asia and Africa on the periphery. Most of these countries have ties with the United

States, although some are language-related, for example, Chile and Spain (Figure 7). These examples further demonstrate the primarily national focus of climate change-related research, as relatively few country-country pairs collaborated and produced at least 10 papers over the 20-year timespan.

Figure 7. International collaboration network (≥ 10 collaborative papers) for Forestry.



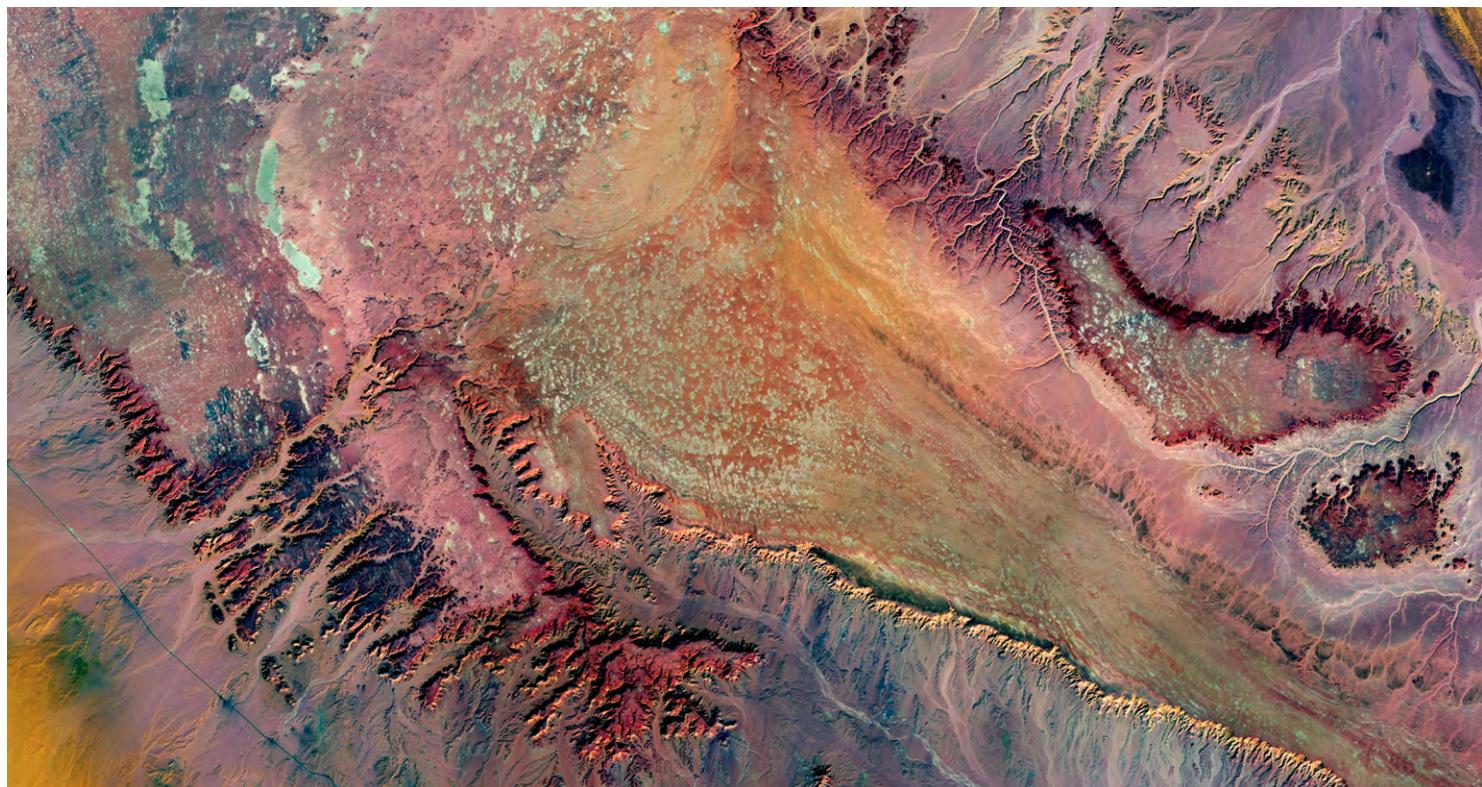
Source: Web of Science data and ISI research

Global challenges need global collaborative solutions

Our analysis shows that climate change research is still primarily produced nationally. However, as a global crisis, international collaboration is imperative to combat the climate crisis, as stated in the UN Sustainable Development Goals. Although manifestations may vary regionally, climate change is an urgent concern that impacts all lives on our planet, as well as our shared future. Partnership between governments, nations and academia may help to drive the innovation and understanding needed to support meaningful change.

Our data also indicate that special attention should continue to be given to emerging, socially focused topics such as science communication and educational research. By helping to inform greater public knowledge and awareness, these focus areas may drive research implementation and our ability to tackle climate change.

Partnership between governments, nations and academia may help to drive the innovation and understanding needed to support meaningful change.



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