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Abstract

This chapter analyses the international cooperation network of the articles in the 307 mainstream SCI/SSCI-listed geographical journals, the independent research and international cooperation situation of the top 20 countries as reflected in published research articles, and the research fields where China and its major cooperating countries (regions) are active. International cooperation is a general trend in geographical sciences' research. The pattern of international cooperation is characterized by that the USA, the UK, France, Germany, Canada and Australia lead the cooperation network and that the countries such as China and Brazil are taking the central position in the network as a fast pace. In the past 30 years China has cooperated with 141 countries (regions). In the last five years this number is 6.7 times that for 1986–1990. China cooperates most with the USA, taking 46 % of all cooperatively written articles with foreign researchers. Environmental pollution and global change are two major topics attracting cooperation between China and the USA, the UK, and Germany. Geographical information science, human geography and paleoenvironment are research fields especially important for cooperation with the USA, the UK and Germany, respectively.

Keywords

International cooperation network • Independent research • Closeness centrality • Sino-USA cooperation

This chapter analyses the international cooperation network of the articles in the 307 mainstream SCI/SSCI-listed geographical journals, the independent research and international cooperation situation of the top 20 countries as reflected in published research articles, and the research fields where China and its major cooperating countries (regions) are active. Statistics are based on the number of articles where the country name can be identified from the mailing address of the first author or the corresponding author. Cooperation between China and its partners is identified by identifying co-published papers.

2.1 Global Cooperation Network

Since 1986, China has built cooperation networks with 141 countries (regions), increasing from 4 in 1986 to 32 in 2000 and 97 in 2014.

From the figure it can be seen that international cooperation networks have evolved from a single centre in 2000 (Fig. 2.1) to a multi-centre and complex network in 2014 (Fig. 2.2). The USA was the centre in 2000, and the whole network was mainly built by the USA, France, Germany, the UK and Canada. China was at the edge of the network and

its cooperating partners were limited to the USA, and the number of cooperation was even lower than India, Japan, Spain, Australia, Sweden and Switzerland. After 15 years of development, several centres have emerged, including China, the UK, the USA, Canada, Germany, Italy, the Netherlands, Spain and Belgium. China has already built extensive cooperation with the UK, Australia, Germany and Canada besides the USA. There is also an increase in the cooperation network of Asian countries (regions), such as

India, Chinese Taiwan, South Korea, Thailand, Pakistan, Malaysia, Vietnam and Singapore.

Closeness centrality represents the extensiveness of cooperating countries (regions) for the countries (regions) occupying critical nodes. The higher the value of this index, the greater the number of countries (regions) cooperating with this country (region) concerned and the more contribution it makes to the forming of this network and the stability of its structure. Comparing these two figures it can be

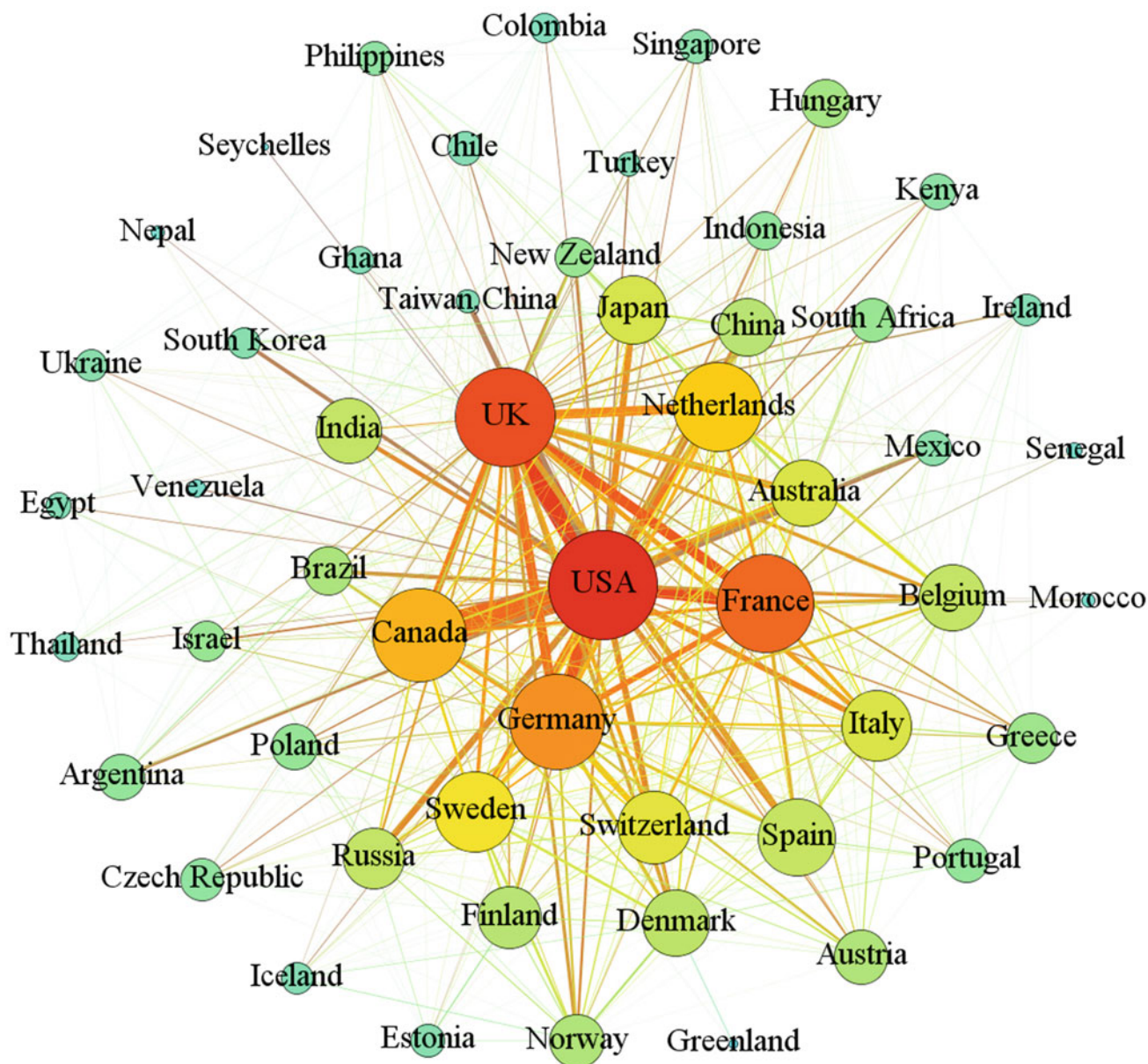


Fig. 2.1 The international cooperation graph in mainstream SCI/SSCI-indexed geographical sciences' journals in 2000. *Note* A threshold frequency for cooperation is 5; each node represents a country or region and the color of nodes represents the number of cooperating

regions for a single node; each line connects two cooperating countries (regions) and the thickness of the line represents the cooperation frequency

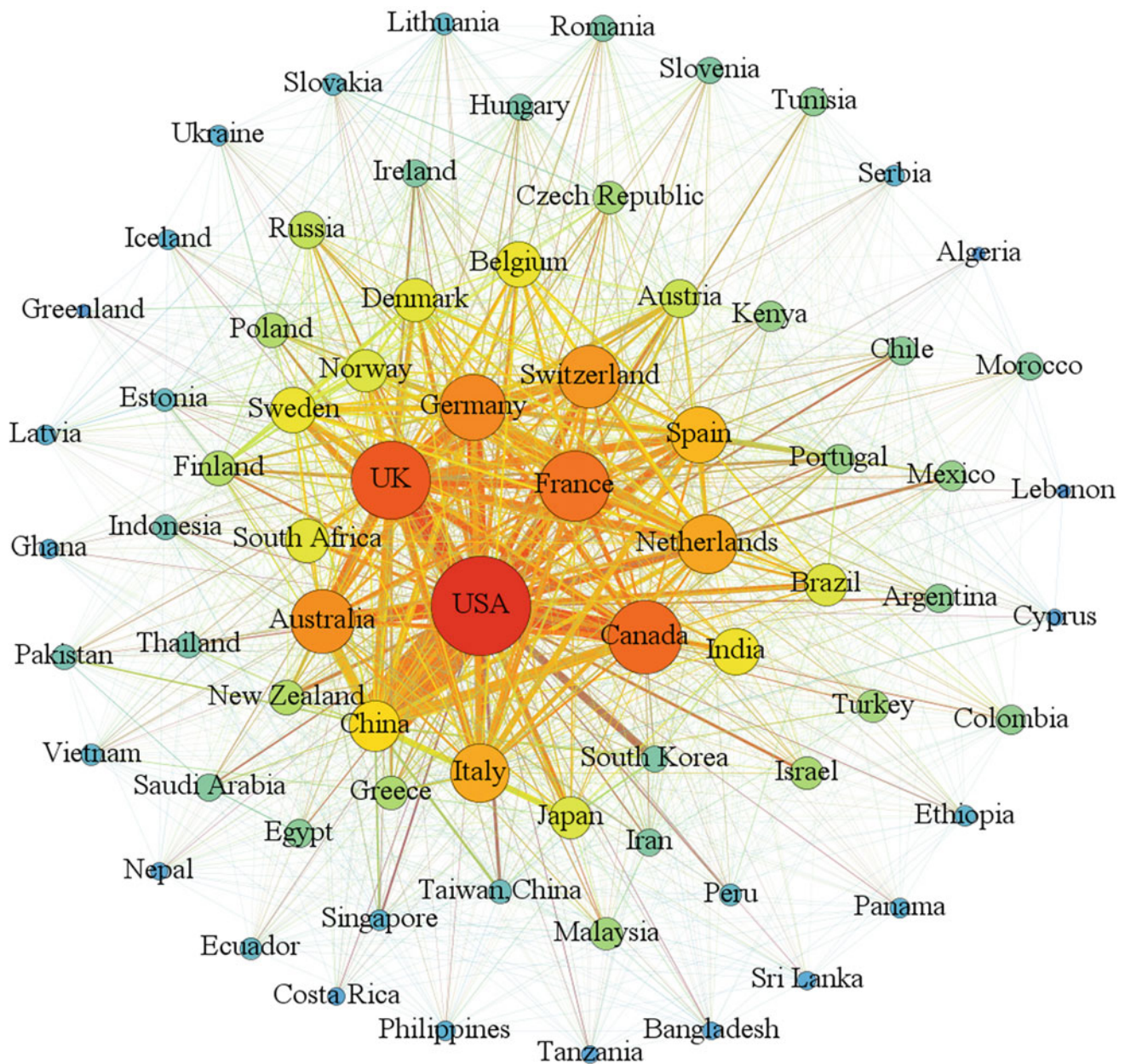


Fig. 2.2 The international cooperation graph in mainstream SCI/SSCI-indexed geographical sciences' journals in 2014. *Note* A threshold frequency for cooperation is 15; each node represents a country or region and the color of nodes represents the number of

cooperating regions for a single node; each line connects two cooperating countries (regions) and the thickness of the line represents the cooperation frequency

seen that the USA, the UK, France, Germany and Canada have always dominated the core, leading the development of international cooperation in the Geographical Sciences. Australia, Spain, China, Belgium, Brazil and South Africa rose fast. For China, enhanced centrality mainly came from strengthening cooperation with core countries (regions). By contrast, Japan and Russia were losing centrality (Table 2.1).

2.2 International Cooperation and Independent Research

Independent research/international cooperation is represented by the number of articles written by author(s) from more than one country (region). The country/region was determined by the address of the first author or corresponding author. International cooperation played a growing role in getting

Table 2.1 Top 20 countries (regions) regarding closeness centrality of international cooperation networks in the geographical sciences in 2000 and 2014

Year	Rank	Countries (Regions)	Closeness centrality	Year	Rank	Countries (Regions)	Closeness centrality
2000	1	USA	0.5608	2014	1	USA	0.8174
2000	2	UK	0.4867	2014	2	UK	0.7424
2000	3	France	0.4627	2014	3	Canada	0.7225
2000	4	Germany	0.4410	2014	4	France	0.7129
2000	5	Canada	0.4277	2014	5	Germany	0.6946
2000	6	Netherlands	0.4192	2014	6	Australia	0.6887
2000	7	Sweden	0.4091	2014	7	Switzerland	0.6829
2000	8	Switzerland	0.3994	2014	8	Netherlands	0.6715
2000	9	Australia	0.3957	2014	9	Italy	0.6688
2000	10	Italy	0.3957	2014	10	Spain	0.6606
2000	11	Japan	0.3938	2014	11	China	0.6397
2000	12	Spain	0.3867	2014	12	India	0.6273
2000	13	India	0.3849	2014	13	Sweden	0.6201
2000	14	Belgium	0.3849	2014	14	Belgium	0.6201
2000	15	Russia	0.3849	2014	15	Denmark	0.6130
2000	16	Denmark	0.3832	2014	16	South Africa	0.6130
2000	17	China	0.3797	2014	17	Brazil	0.6084
2000	18	Finland	0.3797	2014	18	Norway	0.6084
2000	19	Norway	0.3763	2014	19	Japan	0.6061
2000	20	Austria	0.3763	2014	20	Austria	0.5928

research results, as indicated by the top 20 countries (regions) regarding the number of articles in mainstream SCI/SSCI-indexed Geographical Sciences' journals in the period 2000–2004 and 2010–2014 (Table 2.2). Articles from cooperation with the UK, Germany, Spain, France, the Netherlands, Switzerland and Belgium all have increased more than 10 % between these two periods; articles from top 10 countries have increased by 8.9 % on average, and all of these countries except India had high centrality. China ranked second in term of number of articles in 2010–2014, with articles involving international cooperation increasing by 4.9 %. However, the share of independent research was still higher for all of these countries, accounting for 68.2 % for the Top 20 countries in 2010–2014. Countries with a generally balanced share in these two modes were Switzerland and Belgium. Countries with a relatively low share of independent research (the difference was less than 20 %) were the Netherlands, France and Germany.

Since 1986, Chinese authors have published 57,912 papers in the Geographical Sciences SCI/SSCI-indexed journals, with those involving cooperation amounting to 21,568 (37.2 %), of which 96.6 % were published after 2000. Compared to 2000, in these cooperatively published

papers, the proportion of papers with Chinese scholars as the first or corresponding authors increased to 76.6 % and 73.9 % in 2015 and 2014, increasing by 18.7 % and 16 %, respectively. The most popular partner of China was from the USA (9932, 46 %), followed by Canada (10.2 %), the UK (9.1 %), Australia (9.0 %), Japan (8.5 %) and Germany (7.5 %). Other countries (regions) within the top 10 partners of China were the Netherlands (3.9 %), France (3.7 %), Taiwan, China (2.3 %) and South Korea (2.3 %).

Table 2.3 shows the Top 20 countries (regions) in terms of the number of highly cited articles in mainstream SCI/SSCI-indexed geographical sciences' journals during the period 2000–2004 and 2010–2014. The USA, Germany, Chinese Taiwan and Brazil rank first, fourth, nineteenth and twentieth. The ranks of other countries have changed. The ranking of China, Spain, Switzerland, Italy, India and South Korea has risen with China advancing six places and India and South Korea advancing five. The other countries went backwards with the Netherlands dropping four places and Sweden and Denmark three. Those highly cited articles were mainly from independent research, and the average proportion in 2010–2014 for the Top 20 countries was 57.4 %. In addition, the proportion of the highly cited articles involving

Table 2.2 Top 20 countries (regions) with the number of articles in mainstream SCI/SSCI-indexed geographical sciences' journals during the period 2000–2004 and 2010–2014

Countries (Regions)	Rank	2000 – 2004				2010 – 2014			
		Independent research		International cooperation		Independent research		International cooperation	
		Articles	Proportion	Articles	Proportion	Articles	Proportion	Articles	Proportion
USA	1	26,781	86.8%	4,068	13.2%	36,293	79.2%	9,511	20.8%
China	2	2,611	76.7%	792	23.3%	21,232	71.8%	8,342	28.2%
UK	3	10,677	83.1%	2,164	16.9%	10,986	69.2%	4,898	30.8%
Canada	4	4,777	79.2%	1,258	20.8%	7,415	72.7%	2,788	27.3%
Germany	5	3,302	72.1%	1,275	27.9%	5,601	59.0%	3,894	41.0%
Spain	6	2,076	78.7%	563	21.3%	5,724	65.8%	2,975	34.2%
Australia	7	2,526	78.4%	697	21.6%	6,013	70.6%	2,498	29.4%
France	8	2,054	68.8%	933	31.2%	4,197	58.7%	2,951	41.3%
Italy	9	1,993	78.3%	553	21.7%	4,885	68.4%	2,261	31.6%
India	10	1,369	87.4%	198	12.6%	5,173	84.4%	953	15.6%
Netherlands	11	1,976	73.8%	700	26.2%	2,968	58.7%	2,084	41.3%
Japan	12	2,071	78.7%	560	21.3%	3,117	69.1%	1,393	30.9%
Brazil	13	685	74.5%	234	25.5%	2,480	72.6%	934	27.4%
Sweden	14	1,512	72.1%	584	27.9%	2,164	63.5%	1,245	36.5%
Switzerland	15	886	64.5%	487	35.5%	1,651	49.5%	1,687	50.5%
South Korea	16	647	75.1%	215	24.9%	2,304	69.8%	996	30.2%
Taiwan, China	17	977	87.4%	141	12.6%	2,109	79.9%	531	20.1%
Turkey	18	827	88.2%	111	11.8%	2,190	86.2%	350	13.8%
Belgium	19	724	67.7%	346	32.3%	1,263	51.4%	1,194	48.6%
Portugal	20	274	68.0%	129	32.0%	1,471	62.2%	893	37.8%

Note Rank according to the number of articles in 2010–2014

international cooperation was higher than that for all of the articles considered in Table 2.2, indicating to some extents that international cooperation was particularly important in producing highly cited articles.

2.3 Major Research Fields Involving International Cooperation of China

Since 2000, the USA, the UK, France and Germany have long occupied the central position of international cooperation networks (Figs. 2.1 and 2.2), and they have carried out research with many countries (regions) including China. Considering trends in the development of international cooperation and the characteristics of China's international cooperation networks, this book uses 307 SCI/SSCI mainstream geographical journals as a research object to analyse articles produced by cooperation between China and the USA, the UK and Germany during 1986–2015. The research fields are environmental pollution, global change, biogeography and ecology, hydrology and water resources, human geography, the humanities and the social sciences,

geographical information science, paleoenvironmental research. CiteSpace was used to analyse the research topics chosen by researchers from China and the other three countries by the clustering of keywords.

Figure 2.3 shows the major fields of cooperation between China and the USA. The total number of articles was 9932, in which there were 6535 (65.8 %) ones with Chinese scholars as the first or corresponding authors. In 2014 this proportion was 77.1 %, which was 21.7 % more than that in 2000. These articles were published in 269 journals with 25,908 keywords used. The ten most frequently chosen journals included 3033 articles accounting for 30.5 % to all the cooperatively published articles. The most frequently chosen journal was *Environmental Science and Technology* (732). Of the top ten chosen journals six focused on environmental pollution, two on geographical information science, one on global change, and one on hydrology and water resources. There were 776 Chinese institutions involved in cooperation with American peers, and the top ten active institutions included Beijing Normal University, Peking University, Institute of Geographic Sciences and Natural Resources Research of CAS, Nanjing University, Tsinghua University, University of

Table 2.3 Top 20 countries (regions) with the number of highly cited articles in mainstream SCI/SSCI-indexed geographical sciences' journals during the period 2000–2004 and 2010–2014

Countries (Regions)	Rank	2000–2004				2010–2014			
		Independent research		International cooperation		Independent research		International cooperation	
		Articles	Proportion	Articles	Proportion	Articles	Proportion	Articles	Proportion
USA	1	3,060	80.5%	739	19.5%	2,165	70.7%	896	29.3%
China	2	170	70.8%	70	29.2%	986	68.2%	459	31.8%
UK	3	734	70.6%	305	29.4%	481	53.4%	420	46.6%
Germany	4	302	63.0%	177	37.0%	294	48.8%	308	51.2%
Canada	5	357	68.9%	161	31.1%	311	61.5%	195	38.5%
Australia	6	212	72.4%	81	27.6%	267	57.5%	197	42.5%
Spain	7	169	71.0%	69	29.0%	261	56.6%	200	43.4%
France	8	169	63.8%	96	36.2%	181	45.0%	221	55.0%
Switzerland	9	134	60.9%	86	39.1%	146	48.2%	157	51.8%
Netherlands	10	179	66.1%	92	33.9%	154	51.0%	148	49.0%
Italy	11	131	73.2%	48	26.8%	168	56.2%	131	43.8%
India	12	74	90.2%	8	9.8%	127	72.6%	48	27.4%
South Korea	13	51	69.9%	22	30.1%	114	66.3%	58	33.7%
Sweden	14	139	63.5%	80	36.5%	78	47.6%	86	52.4%
Japan	15	108	68.4%	50	31.6%	90	58.1%	65	41.9%
Belgium	16	77	67.0%	38	33.0%	60	42.6%	81	57.4%
Denmark	17	89	68.5%	41	31.5%	75	56.0%	59	44.0%
Norway	18	48	53.3%	42	46.7%	60	49.2%	62	50.8%
Taiwan, China	19	63	87.5%	9	12.5%	79	76.0%	25	24.0%
Brazil	20	32	58.2%	23	41.8%	63	62.4%	38	37.6%

Note Rank according to the number of articles in 2010–2014

Chinese Academy of Sciences, Zhejiang University, The University of Hong Kong, the Research Centre for Eco-Environmental Sciences of CAS, and Wuhan University, with 4291 articles published (43.2 % of the total Sino-USA co-authored articles). Major research fields were environmental pollution (35.9 %), geographical information science (15.5 %), global change (15.1 %), biogeography and ecology (9.7 %), human geography, the humanities and the social sciences (8.7 %), paleoenvironment (7.6 %) and hydrology and water resources (7.5 %). Research areas selected more than 15 times included China, the Tibetan Plateau (Qinghai Tibetan Plateau), the United States, South China, the Loess Plateau (Chinese Loess Plateau), Beijing, Hong Kong, Shanghai, the Yangtze River, the Pearl River Delta, Inner Mongolia, South China Sea, North China, East Asia, North-east China, North America, the North Atlantic, the North Pacific, the East China Sea, the Yellow River, the Gulf of Mexico, Yunnan, the Yangtze River Delta, the Pacific, the Himalayas, California, the Indian Ocean, and Guangzhou.

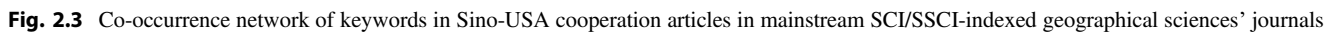
Environmental Pollution Papers arising from Sino-USA cooperative research on environmental pollution were published mainly in the following five journals: *Environmental*

Science & Technology, Atmospheric Environment, Chemosphere, Journal of Hazardous Materials, Science of the Total Environment.

Geographical Information Science Papers arising from Sino-USA cooperative research on geographical information sciences were mainly published in the following five journals: *International Journal of Remote Sensing, IEEE Transactions on Geoscience and Remote Sensing, Remote Sensing of Environment, Remote Sensing, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing.*

Global Change Papers arising from Sino-USA cooperative research on global change were published mainly in the following five journals: *Journal of Climate, Climate Dynamics, Global Change Biology, Biogeosciences, Global and Planetary Change.*

Biogeography and Ecology Papers arising from Sino-USA cooperative research on biogeography and ecology were published mainly in the following five journals: *Ecological Modelling, Ecological Engineering, Chinese Journal of Oceanology and Limnology, Biological Conservation, Landscape Ecology.*



Paleoenvironment The top five journals for publication of Sino-USA cooperatative paleoenvironmental research were *Palaeogeography Palaeoclimatology Palaeoecology*, *Quaternary International*, *Quaternary Science Reviews*, *Quaternary Research*, *Continental Shelf Research*.

Hydrology and Water Resources Sino-USA cooperative research on hydrology and water resource was published mainly in the following five journals: *Journal of Hydrology*,

Water Resources Research, *Hydrological Processes*, *Journal of Hydrologic Engineering*, and *Journal of Hydrometeorology*.

Figure 2.4 shows the major fields of cooperation between China and the UK. The total number of co-authored articles was 1958, in which there were 1170 (59.8 %) ones with Chinese scholars as the first or corresponding authors. In 2014 this proportion was 59.6 %, which was 1.7 % more than in 2000. These articles were published in 234 journals with 7145 keywords used. The ten most frequently chosen journals accounted for 548 articles (28 % to all the cooperatively published articles). The most frequently chosen journal was *Environmental Science and Technology* (105). Of the top ten journals six focused on environmental pollution, two on the paleoenvironment, one on global change, and one on geographical information science.

There were 355 Chinese institutions involved in cooperation with the UK peers, and the top ten active institutions included Peking University, The University of Hong Kong, University of Chinese Academy of Sciences, Beijing Normal University, Hong Kong Polytechnic University, East China Normal University, Lanzhou University, Institute of Botany of CAS, Nanjing Institute of Geography and Limnology of CAS, Institute of Geographic Sciences and Natural Resources Research of CAS, with 797 articles published (40.7 % of all Sino-UK co-authored articles).

Major research fields were environmental pollution (31.1 %), the paleoenvironment (16.2 %), global change (15.3 %), human geography, the humanities and the social sciences (13.2 %), geographical information science (9.4 %), biogeography and ecology (9 %), and hydrology and water resources (5.9 %). Compared to cooperation with

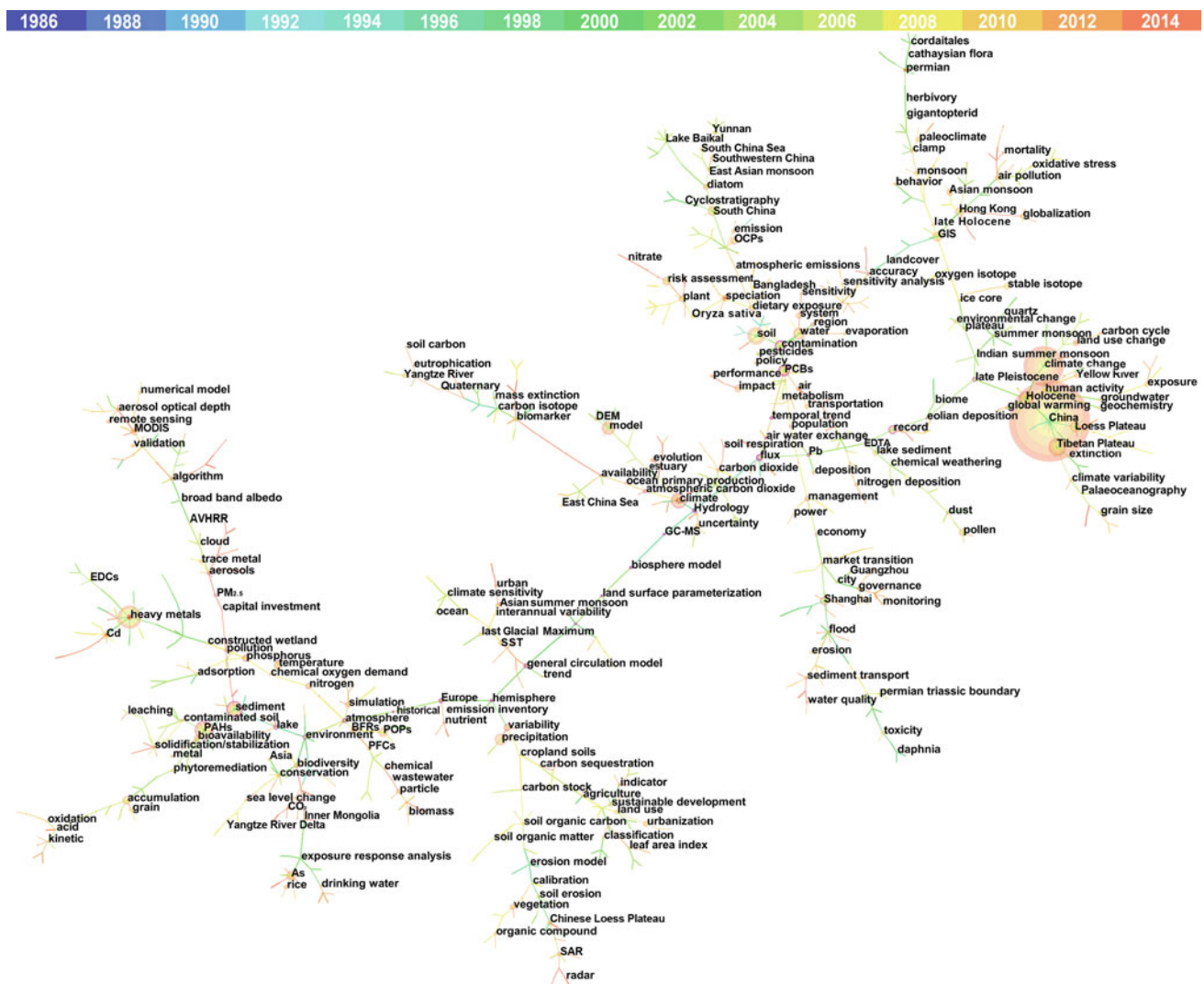


Fig. 2.4 Co-occurrence network of keywords in Sino-UK cooperation articles in mainstream SCI/SSCI-indexed geographical sciences' journals

the USA, cooperation with the UK involved a higher proportion of research in human geography (+4 %) but a lower proportion in environmental pollution (−5 %), indicating an advantage of cooperation in human geography with the UK. Research areas selected more than 15 times were China, Tibetan Plateau (Qinghai Tibetan Plateau), Loess Plateau (Chinese Loess Plateau), South China, Hong Kong and Shanghai.

Environmental Pollution Papers arising from Sino-UK cooperative research on environmental pollution were mainly published in the following five journals: *Environmental Science and Technology*, *Environmental Pollution*, *Chemosphere*, *Journal of Hazardous Materials*, *Science of the Total Environment*.

Paleoenvironment The top five journals for publication of paleoenvironment research involving Sino-UK cooperation were: *Palaeogeography Palaeoclimatology Palaeoecology*, *Quaternary Science Reviews*, *Review of Palaeobotany and Palynology*, *Quaternary International*, *Holocene*.

Global Change Papers arising from Sino-UK cooperative research on global change were published mainly in the following five journals: *Global and Planetary Change*, *Global Change Biology*, *Biogeosciences*, *Climate Dynamics*, *Natural Hazards*.

Human Geography, the Humanities and the Social Sciences Papers arising from Sino-UK cooperative research in human geography, the humanities and the social sciences were published mainly in the following five journals: *Journal of Environmental Management*, *Annals of Tourism Research*, *Habitat International*, *Urban Studies*, *World Development*.

Geographical Information Science Papers arising from Sino-UK cooperative research in the geographical information science were published mainly in the following five journals: *International Journal of Remote Sensing*, *IEEE Transactions on Geoscience and Remote Sensing*, *IEEE Geoscience and Remote Sensing Letters*, *ISPRS Journal of Photogrammetry and Remote Sensing*, *Journal of Environmental Monitoring*.

Biogeography and Ecology Papers arising from Sino-UK cooperative research in biogeography and ecology were published mainly in the following five journals: *Journal of Biogeography*, *Agriculture Ecosystems and Environment*, *Biological Conservation*, *Ecological Modelling*, *Catena*.

Hydrology and Water Resources Sino-UK cooperative research in hydrology and water resource was published mainly in the following five journals: *Journal of Hydrology*, *Hydrology and Earth System Sciences*, *Hydrological Processes*, *Water Resources Research*, *Water Resources Management*.

Figure 2.5 shows the major fields of cooperation between China and Germany. The total number of co-authored

articles was 1623, in which there were 859 (52.9 %) ones with Chinese scholars as the first or corresponding authors. In 2014 this proportion was 50.4 %, which was 22.4 % less than that in 2000. These articles were published in 189 journals with 6064 keywords used. The ten most frequently chosen journals accounted for 562 articles published (34.6 % of all cooperatively written articles). The most frequently chosen journal was *Chemosphere* (99). Of the top ten chosen journals six focused on environmental pollution, three on paleoenvironment, and one on global change.

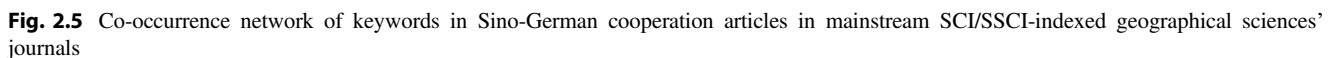
There were 295 Chinese institutions involved in cooperation with German peers, and the top ten active institutions were Nanjing Institute of Geography and Limnology of CAS, Peking University, Institute of Tibetan Plateau Research of CAS, Nanjing University, Lanzhou University, Institute of Botany of CAS, China Agricultural University, Cold and Arid Regions Environmental and Engineering Research Institute of CAS, University of Chinese Academy of Sciences, Institute of Geographic Sciences and Natural Resources Research of CAS, with 776 articles published (47.8 % of the total Sino-German co-authored articles).

Major research fields were environmental pollution (30.6 %), global change (19.5 %), paleoenvironment (19.4 %), biogeography and ecology (11.3 %), geographical information science (10.5 %), human geography, the humanities and the social sciences (4.3 %), and hydrology and water resources (4.3 %). Environmental pollution accounted for a proportion that was similar to that for the UK. In both cases the share was lower than for the USA. But in paleoenvironmental research there was a great advantage in cooperation with Germany. Research areas selected more than 15 times were China, Tibetan Plateau (Qinghai Tibetan Plateau), Inner Mongolia, Yangtze River and South China Sea.

Environmental Pollution The top five journals for publication of environmental research involving Sino-German cooperation were: *Chemosphere*, *Atmospheric Environment*, *Environmental Science and Technology*, *Science of the Total Environment*, *Environmental Science and Pollution Research*.

Global Change The top five journals for publication of global change research involving Sino-German cooperation were: *Biogeosciences*, *Global and Planetary Change*, *International Journal of Earth Sciences*, *Global Change Biology*, *Climate Dynamics*.

Paleoenvironment “Pollen”, “tree ring”, “Dendroecology”, “Dendrochronology”, “Dendroclimatology” and “diatom” are the keywords for biological proxies in the research on paleoenvironment, which is also a prominent research field for Sino-Germany cooperation. The re-occurrence of “pollen” as a cooperative keyword was 27, which was the top number of Sino-USA, Sino-UK and Sino-German cooperation. For Sino-USA cooperation, “glacier”, “ice



Biogeography and Ecology The top five journals for publication of biogeography and ecology involving Sino-German cooperation were: *Agriculture Ecosystems and Environment*, *Catena*, *Journal of Biogeography*, *Ecological Modelling*, *Ecological Research*.

Human Geography, the Humanities and the Social Sciences The top three journals for publication of human geography, the humanities and the social sciences involving Sino-German cooperation were: *Journal of Environmental Management*, *Land Use Policy*, *International Journal of Environmental Research and Public Health*. The other six journals have all ranked the fourth, including *Environmental Health*, *Environmental Management*, *Environmental Science and Policy*, *Land Degradation and Development*,

Population and Development Review, Waste Management and Research.

Hydrology and Water Resources The top five journals for publication of hydrology and water resource research involving Sino-German cooperation were: *Hydrology and Earth System Sciences, Journal of Hydrology, Hydrological Processes, Water Resources Research, Ecohydrology.*

2.4 Summary

International cooperation is a general trend in Geographical Sciences research. The pattern of international cooperation is characterized by that the USA, the UK, France, Germany, Canada and Australia led the cooperation network and that the countries such as China and Brazil were taking the central position in the network at a fast pace. Statistical analysis indicates that although independent research

accounted for at least 60 % of all the articles examined, international cooperation made a significant contribution to the publication of the highly cited papers. In the past 30 years China has cooperated with 141 countries (regions). In the last five years this number was 6.7 times that in 1986–1990. Co-authored articles have accounted for 37.2 % of Chinese authored articles, and 65.9 % of these articles had Chinese first or corresponding authors. China cooperated most with the USA, and their cooperation covered 46 % of all cooperatively written articles. At the same time, China also carried out extensive cooperation with Canada, Japan, the UK, Australia and Germany. With regard to research fields, environmental pollution and global change were two major topics attracting cooperation between China and the USA, the UK, and Germany. Geographical information science, human geography and paleoenvironment were research fields especially important for China's cooperation with the USA, the UK and Germany, respectively.

The Geographical Sciences During 1986—2015

From the Classics To the Frontiers

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He, C.; He, D.; Li, X.; Lin, C.; Liu, H.; Liu, W.; Lü, Y.; Piao,

S.; Tang, Q.; Tao, F.; Tian, L.; Tong, X.; Xiao, C.; Xue, D.;

Yang, L.; Yu, Z.; Zheng, Y.; Zhu, H.; Zhu, L.

2017, LII, 596 p. 211 illus., 209 illus. in color., Hardcover

ISBN: 978-981-10-1883-1