Reprint 2016-23

Splitting the South: China and India's Divergence in International Environmental Negotiations

Leah C. Stokes, Amanda Giang & Noelle E. Selin

Reprinted with permission from *Global Environmental Politics*, 16(4): 12–31.

MIT Joint Program on the Science and Policy of Global Change

Massachusetts Institute of Technology
77 Massachusetts Ave., E19-411
Cambridge MA 02139-4307 (USA)

T (617) 253-7492 F (617) 253-9845
globalchange@mit.edu
http://globalchange.mit.edu

Research Articles

Splitting the South: China and India's Divergence in International Environmental Negotiations

*Leah C. Stokes, Amanda Giang, and Noelle E. Selin**

Abstract

International environmental negotiations often involve conflicts between developed and developing countries. However, considering environmental cooperation in a North-South dichotomy obscures important variation within the Global South, particularly as emerging economies become more important politically, economically, and environmentally. This article examines change in the Southern coalition in environmental negotiations, using the recently concluded Minamata Convention on Mercury as its primary case. Focusing on India and China, we argue that three key factors explain divergence in their positions as the negotiations progressed: domestic resources and regulatory politics, development constraints, and domestic scientific and technological capacity. We conclude that the intersection between scientific and technological development and domestic policy is of increasing importance in shaping emerging economies' engagement in international environmental negotiations. We also discuss how this divergence is affecting international environmental cooperation on other issues, including the ozone and climate negotiations.

Global environmental negotiations scholars have largely analyzed two major negotiating blocs: developed countries or the Global North, and developing countries or the Global South (Joshi 2013). Research has explored differences within the North—for example, contrasting the EU and US's positions in the climate change and ozone negotiations (Downie 2014; Fisher 2004; Hoffmann 2005). However, the global environmental politics literature, largely based in

* We thank Rebecca Silverman for research assistance on this project, and Henrik Selin, Peter Dauvergne, and anonymous peer reviewers for helpful feedback on earlier drafts. We also greatly appreciate the time that interviewees gave to this project. This project was financially supported by the US National Science Foundation (Grant Nos. 1053648 and 131755), the J. H. and E. V. Wade Fund (MIT), the Martin Family Society of Graduate Fellowships in Sustainability (MIT), and an MIT Sociotechnical Systems Research Center Fellowship.

Global Environmental Politics 16:4, November 2016, doi:10.1162/GLEP_a_00378

the North, has paid less attention to differences within the South. Yet, as countries in the South begin to diverge in their development trajectories, their interests and preferences are also changing. This is particularly the case for emerging economies, most notably China and India.

Developing countries and emerging economies have historically cooperated in international negotiations, often through large coalitions such as the Group of 77 (G77) plus China (Najam et al. 2003). At the Rio Earth Summit in 1992, where the UN Framework Convention on Climate Change (UNFCCC) was negotiated, developing countries worked together to successfully argue for several principles, including common but differentiated responsibilities. This pattern of Southern cooperation continued through numerous UNFCCC Conference of the Parties (COP) meetings on topics such as financing, capacity building, and targets and timetables. In the ozone negotiations, developing countries similarly took a common position on many issues. When ozone standards were being strengthened in the mid-1990s, developing countries together argued that tighter controls should be contingent on increased financing (Parson 2003).

However, over time, these developing country alliances have frayed, particularly between two major emerging economies: China and India. In the ozone regime, China has shown greater willingness to act on limiting hydrofluorocarbons (HFCs), but India has resisted (Hwang 2013). On climate change, China has enacted significant domestic policies, including an emissions trading system, and has announced a bilateral climate agreement with the US. By contrast, India has enacted less ambitious domestic climate policies, committing to reductions in intensity rather than absolute reductions, and its cooperation with the US is limited.

Although other scholars have pointed to growing divergence in the South, it is not clear *why* this is happening. Why has cooperation between these emerging economies, with previously similar perspectives on the environment and development, changed over time? In this article, we explain this divergence empirically and explore its implications for future international negotiations. We focus on China and India, who often play a large role within negotiations and whose decisions on global environmental issues can have substantial impacts. We argue that domestic resources and regulatory politics, development constraints, and domestic scientific and technological capacity all help explain the increasing divergence in China's and India's negotiating positions over time.

This article uses the Minamata Convention on Mercury, as the most recent, successful example of international environmental cooperation, to examine underlying interests, preferences, and their temporal evolution. Evidence is drawn from meeting documents, technical reports, scientific assessments, the UN Environment Programme (UNEP), national governments, and the Earth Negotiations Bulletin (ENB). Further information was gathered from participant observation at the Intergovernmental Negotiating Committee (INC) sessions on mercury and interviews with the individuals and delegates involved in the negotiations.

In the next section, we provide a theoretical background, followed by an overview of the mercury negotiations, including how India's and China's positions have changed over time. Next, we explain why this divergence in positions occurred. Although we developed this argument using evidence from the mercury regime, we argue that it may generalize to other regimes, including climate and ozone. We conclude by discussing the implications for theory and practice in international environmental cooperation.

Developing Countries' Positions in Global Negotiations

Developing countries have historically cooperated and crafted common positions, despite differences in interests, to achieve more favorable outcomes. The global environmental politics literature has largely treated developing countries as a collective within international environmental negotiations (Hoffmann 2005; Roberts and Parks 2007). Examining ozone, biodiversity, and the hazardous waste trade, Miller (1998) characterized Third World countries as a negotiating bloc throughout the 1980s and 1990s. Building on her work, Williams (2005) argued that this grouping continued to have relevance within international environmental negotiations in the 2000s. In the climate negotiations, Najam, Huq, and Sokona (2003) argued that developing countries share common interests, including securing an equitable architecture, enhancing capacities, and pursuing sustainable development. The G77 is a key venue for this cooperation, and internal negotiations within the South-South collective push the group toward common positions (Najam 2004).

However, it is increasingly unclear whether this dichotomy continues to accurately capture negotiating dynamics. In the development literature, the North-South model has been critiqued for ignoring heterogeneity among Southern countries (Eckl and Weber 2007; Therien 1999). In environmental negotiations, scholars have documented divergence in the Southern group on climate policy—between OPEC and the G77, and between emerging economies and least developed countries (Barnett 2008; Roberts 2011). Perkins (2013) characterized the developing world as increasingly diverse in terms of development, governance capacities, and power in negotiations. Najam (2005) also hypothesized that developing countries' pursuit of specific national interests might magnify as global environmental politics moves from a declaratory stage toward a more substantive regulatory phase.

The role of China and India as emerging powers in global environmental governance has drawn particular attention (Humphrey and Messner 2006). Research has focused on tensions between emerging economies' negotiating positions and how parties' interests have shaped the Southern coalition's behavior (Hochstetler and Milkoreit 2014). The climate regime, which has not yet resulted in substantive commitments from the developing world, has received significant focus. Examining India's position in the climate negotiations, Joshi (2013) argued that the North and South are "fluid and dynamic categories" and that these groups fluctuate between unity and plurality, depending on geopolitical and development factors. Despite this fluidity, however, she argues that North-South distinctions retain their importance, with the Indian delegation emphasizing historical differences between the developed and developing worlds as a negotiating strategy.

Some research has focused specifically on the Minamata Convention on Mercury, as an example of a recent international regime. Selin (2014a) showed that linkages with other international environmental regimes affected the mercury negotiation. Templeton and Kohler (2014) argued that developing countries worked together in negotiations to secure a commitment for new financing. These studies demonstrated that the Minamata Convention represents a useful case through which to examine larger issues of coalitions and consensus in international environmental politics. Like other environmental regimes, such as climate and ozone, the developed world has been responsible for the majority of historic mercury emissions, but emerging economies are currently the largest emitters. Minamata also offers a case that has progressed from negotiation to a legally binding agreement, allowing us to examine changes in coalition dynamics as regulatory requirements become more concrete.

India's and China's Positions in the Mercury Negotiations

Although mercury is naturally occurring, human emissions have increased its presence in the environment (Giang and Selin 2016). Exposure to mercury, which often occurs through fish consumption, can lead to adverse health effects. The main motivations for a global mercury treaty were human health impacts and emissions transporting globally (UNEP 2002; UNEP 2008). In its most recent assessment, UNEP estimated that the largest anthropogenic sources of mercury emissions are artisanal and small-scale gold mining (ASGM) (37 percent) and fossil fuel combustion (25 percent); however, emissions data for ASGM remain highly uncertain (UNEP 2013).

In the early 2000s, a large Southern coalition cooperated in the global mercury negotiations through the UNEP Governing Council and Global Ministerial Environment Forum. The G77 and China argued that the existing chemicals regime and voluntary measures were sufficient, and that developing countries knew little about mercury and had insufficient capacity to address the problem (ENB 2003). However, as negotiators considered developing a legally binding agreement, countries organized into regional groups, such as GRULAC (Group of Latin American and Caribbean Countries) and the African Group, with growing disagreements. Increasingly, the African Group supported the EU's interests in negotiating a binding agreement, viewing it as a pathway toward financial and technical support, including reducing mercury use in ASGM. GRULAC, along with the US, was less willing to move forward.

As the two largest country emitters, India and China initially cooperated and formed an influential coalition (ENB 2007b). In both countries, rapid economic development drove emissions growth, through coal combustion, cement, and nonferrous metal production. Projections suggested that they would continue to be the leading emitters. Given the substantial emissions from these two countries alone, cooperation from both China and India was essential to addressing mercury globally (Giang et al. 2015).

However, India and China argued against legally binding action in the mid-2000s (ENB 2007b). Their tactics were to downplay the science and availability of alternatives to mercury and to limit the scope of the negotiations. They both expressed skepticism that action was necessary and that abatement technology was feasible. Several negotiators from developed countries expressed frustration that India, in particular, consistently argued for more baseline data and questioned the science on mercury's impacts on health and the environment (ENB 2005).[1] China argued that a standalone treaty would be long and unnecessarily arduous to negotiate. Both countries stressed the need for flexibility and cited development goals, and the use of fossil fuels to attain these goals, as the priority (Eriksen and Perrez 2014). On the issue of scope, both China and India argued that mercury demand should be regulated rather than reduced, and that trade in mercury-containing products should be excluded (ENB 2007a). They argued that eliminating atmospheric mercury emissions was not economically and technically feasible.

By the mid-2000s, North-South coalitions were already beginning to break down. The EU advocated for action alongside the African Group. The US and other developed countries did not support a binding instrument. Consequently, China, India, and the US, with support from other resistant countries, were able to postpone global regulatory action on mercury for almost a decade. Only when the US changed its position in 2009, after President Obama took office, did the negotiating dynamic alter (Selin 2014a). Still, China and India cooperated to delay action on a legally binding instrument an additional year, moving the start date for the Intergovernmental Negotiating Committee (INC) process from 2009 to 2010.

At the first and second INC meetings, China and India signaled a continuing alliance based on common interests. In one session, China's negotiator referred to his Indian counterpart as his "brother."[2] Substantively, China and India worked together to issue joint proposals and cooperate. On atmospheric emissions, neither China nor India supported mandatory emissions targets or timelines, arguing instead for a voluntary approach (ENB 2010a). China was unwilling to commit to emissions *reductions* that might limit their growing energy sector, arguing that the term *control* should be used. India emphasized the importance of common but differentiated responsibilities and the need for financial and technical assistance for developing countries (ENB 2011a). Indian delegates asserted that technology transfer would be necessary to comply with obligations to control emissions and releases of mercury.

1. Interview with EU member state negotiator, January 30, 2014.
2. Personal observations, INC2.

These common positions continued into the third and fourth INCs, where draft text was formulated. These negotiations centered on voluntary versus mandatory emissions standards, compliance, and financial and technical assistance (ENB 2011b). Both China and India stressed the importance of a financial mechanism. India emphasized that assistance from developed countries should be mandatory. On compliance, India and China also cooperated, arguing that any compliance article was contingent on both assistance and technology transfer commitments. On emissions, India and China, along with Brazil, continued to argue for weaker standards and a single approach for all emitters (ENB 2011a). Since these emerging economies all had significant emissions, requiring all countries to act would likely weaken the standards. By contrast, other developing countries, such as those in the African Group, argued that large emitters should be considered separately. By this point, the African Group and GRULAC tended to side with the EU, Norway, and other developed countries on many issues. Thus, the negotiations were not based on a developed versus developing country cleavage, but rather, a more complex blend of current and historic emitters, and countries' development status.

At INC4, China and India issued a joint submission that emphasized coal electricity expansion for development, arguing against adopting the best available techniques (BAT) for existing facilities and mandatory emissions reductions. The document stated that the agreement should comprise both voluntary and binding measures, specifying products and processes as one area for flexibility. This was particularly in China's interests, given their large use of mercury in manufacturing processes (Selin 2014a). Where requirements would be binding, China and India's joint submission called for financial support. Similarly, in statements at INC4, China stressed a voluntary and flexible approach, as well as consideration of the differing circumstances of developed versus developing countries. India argued that the mercury regime should not "encroach" on a climate regime by imposing stringent technology standards and emphasized coal-based electrification's importance for development (UNEP 2012).

Despite these strongly aligned positions, during the fifth and final INC, Chinese negotiators made a sudden, clear, and unanticipated break with India. The Chinese delegation stated that it was willing to accept more stringent measures on emissions.[3] For new sources, China suddenly accepted mandatory control requirements, provided that parties were allowed to flexibly choose measures based on their own situation. For existing sources, China was also more willing to accept timelines for controls.[4] This willingness to compromise allowed China to play a more active role in shaping the final text. For example, China argued that emissions should only cover major sources. This view was

3. Interviews with senior developed country negotiators, January 17 and February 4, 2014; and with three UK negotiators, January 21, 2014.
4. Personal observations, INC5.

incorporated into the final text, which focused on major point source emissions. It was clear that China had a broader negotiating mandate and was interested in reaching an agreement. By contrast, India was less constructive at INC5, and was reluctant to commit to implementing any emissions control technologies above existing standards. India obstructed contact group attempts to operationalize broad concepts like source thresholds. India also objected to forming a consensus on final negotiating packages regarding the mercury phase-out dates, without China's support.[5]

In the final treaty, the emissions article called for parties to "control, and where feasible, reduce" emissions of mercury, depending on whether the sources were new or existing. For new emissions sources, BAT and best environmental practices (BEP) would apply within five years of the treaty entering into force. For existing sources, within ten years, parties would have to implement one or more of the following options: emission limit values, BAT and BEP, a multi-pollutant control strategy with co-benefits for other air pollutants, or alternative measures to reduce emissions.

In part because of India's and other hesitant parties' influence during the negotiations, these requirements are relatively weak as compared to what the EU and NGOs advocated. There are no quantified reduction targets, control rather than reduction is required, and the timelines for action are far off, particularly for existing sources (Selin 2014a). However, several negotiators from countries favoring more stringent measures stated in interviews that they felt the final text was a good starting point; compromises were necessary for key emitters, like China and India, to join the treaty.[6] They also highlighted that requirements could be ratcheted up in the Conference of Parties, as had occurred when other chemicals agreements were implemented (Selin 2014b).

At the Diplomatic Conference formally adopting the Minamata Convention in late 2013, China signed the treaty, and even provided financial resources to support other countries' ratification and implementation. In their statement, China emphasized their significant domestic policy measures to address mercury pollution—for example, adopting control standards equivalent to those in Germany. In contrast, India did not attend the conference, and only signed the convention in late 2014, after a change in national government. Although India did not explain its initial reluctance to join, its nonparticipation was criticized by domestic NGOs as illustrating a lack of commitment to addressing the mercury issue (ENB 2013).

Explaining Divergence

How can we explain this divergence between China and India at the end of the mercury negotiations, given that past scholarship would suggest a coalition

5. Interview with senior developed country negotiator, January 17, 2014.
6. Interviews with senior developed country negotiators January 17 and February 4, 2014; and with an EU member state negotiator, January 30, 2014.

would persist between these emerging economies? Since China and India continue to be large emitters, changes in their contributions to the problem are unlikely to explain this change in positions. In fact, China has greater global mercury emissions, suggesting it should bear greater costs and be less willing to cooperate than India. Similarly, differences in the form of government—authoritarian versus democratic—would suggest persistent differences rather than changing coalitions over time. Instead, we argue that the divergence between India's and China's positions was a function of three factors that can explain changes over time: (1) domestic resources and regulatory politics, (2) development constraints, and (3) domestic scientific and technological capacity.

Domestic Resources and Regulatory Politics

China and India have different resource endowments, in terms of both the type and quality of domestic energy sources. As these resources have developed over time, they have resulted in distinct domestic stationary combustion regulations. In other words, there is an interaction between each country's resources and the resulting regulatory politics. In the mercury negotiations, key factors that varied over time across India and China were the salience of air pollution domestically and emissions control measures' feasibility. Air pollution has become an important political issue in China as significant coal resources have been built. Consequently, China has imposed tougher air quality regulations that concurrently remove mercury. In India, fewer coal resources have been built, air quality remains less politically salient, and the domestic coal resource quality creates barriers to installing mercury control technology.

China was responsible for nearly half of global coal consumption in 2010, more than four times India's consumption (Yang and Cui 2012). During the early mercury negotiations, China built more coal than India; in 2012, China alone built 40 percent of new coal generation worldwide (Yang and Cui 2012). However, in 2013, China installed more non-coal than coal sources, signaling the beginning of a shift away from coal-based electricity (CEC 2013). In 2014, China agreed to peak carbon emissions by 2030 through a bilateral pledge with the US. In contrast, India is continuing to invest heavily in new coal, with plans to add 160 GW of additional capacity by 2022, with projected coal consumption growth to 2050 (ICEA 2012; National Institute for Public Health and the Environment Netherlands 2001). Furthermore, China has significant potential shale resources, and India does not (US EIA 2013). In short, China has already built its coal resources, whereas India has lagged behind and is significantly more resource constrained. Given *new* coal capacity, stringent requirements for new sources under the Minamata Convention would have disproportionately impacted India.

Coal resource quality also affected the link between mercury emissions and urban air pollution in each country. Regulation of nitrogen oxides, sulfur dioxide, and particulates—three traditional air pollutants—can lead to co-benefits for mercury reduction, because control technologies capturing these pollutants also capture mercury (Pacyna et al. 2010). However, installing pollution capture technology can result in lower plant efficiency (US EPA 2003). Thus, stringent air quality policies increase the cost of combusting coal. Whether countries are willing to pay for these additional costs is contingent on air quality's political salience, as well as the technical factors that increase costs, including the availability and quality of coal resources.

In recent years, the Chinese public has become concerned about urban air pollution and increasingly dissatisfied with the government's regulation of power plants (Zheng and Kahn 2013). In China, satisfaction with air quality is below the global average, and Hong Kong has the *lowest* satisfaction in the world (Loschky and Ray 2013). Citizens regularly monitor air quality, and the recent pollution documentary *Under the Dome* was watched 200 million times before being banned in March 2015.[7] The Chinese government has signaled that environmental problems are a potential threat to political stability (Economy 2010). As a result, the central government has begun tightening air quality regulations. Over the past ten years, the fraction of coal plants in China with desulfurization systems capturing sulfur dioxide jumped from 14 to 86 percent (Zhang and Schreifels 2011). Further, in 2011, the Chinese Ministry of Environmental Protection adopted a new standard for thermal power plants. One Chinese negotiator described the standard as reflecting a movement toward setting limits comprehensively for multiple pollutants—an approach common in developed countries.[8] Between 2012 and 2014, China adopted some of the most stringent conventional air pollutants emissions limits globally for both new and existing plants (Schreifels et al. 2012). These urban air pollution regulations will lead to substantial mercury reduction co-benefits.

China is also directly targeting mercury emissions, mentioning them as a goal in its most recent five-year plan. The 2011 Emission Standard included a mercury-specific limit. One Chinese expert involved in domestic air policy said the limit was set during the INC negotiations and is based on values used in Germany.[9] Complying with new air quality regulations, described above, will require that almost all plants install several pollution control devices. Since these devices also capture mercury, the coal experts we interviewed were confident that most plants would be below the mercury emission limit without mercury-specific control technologies.[10] For these reasons, meeting the emissions requirements under a mercury treaty was compatible with China's existing actions, particularly under flexible implementation. Consequently, China sought to shape the emissions article to ensure it conformed with domestic standards, did not

7. Daniel K. Gardner, China's "Silent Spring" Moment? *New York Times*, March 18, 2015.
8. Interview with Chinese negotiator, January 24, 2014.
9. Interview with Chinese negotiator, January 24, 2014.
10. Interviews with Chinese negotiator, January 24, 2014; senior developed country negotiator, January 17, 2014; EU member state negotiator, January 30, 2014.

mandate reductions, and did not require mercury-specific control technologies. With these changes, China would be able to comply.

In contrast, air pollution has been a lower public and regulatory priority in India. Satisfaction with air quality in India is higher than in China, and higher than the global average (Loschky and Ray 2013). This is not because air pollution is less of an objective problem in India; rather, it is not seen as a key problem for policy-makers to address (Hsu et al. 2014). Instead, issues such as food insecurity, poverty, and access to basic services are priorities for the population. Consequently, there has only been limited regulation of pollution from coal-fired power plants in India. Instead, improving urban air quality often centers on transportation rather than electricity sources.

Furthermore, the characteristics of India's power sector and domestic coal quality present technical barriers to mercury regulations. Most coal used in India is domestic, with higher ash and lower sulfur content than coal from other countries (Kumari 2011; Sloss 2012b). The high ash content makes it less efficient, meaning India requires more coal for the same energy output, resulting in higher mercury emissions. The low sulfur rates mean that sulfur dioxide controls that also capture mercury have not been a regulatory priority (Sloss 2012a). Desulfurization controls are not common or required, and there are no specific emissions limits for nitrogen oxides in India. Still, since 1981, emissions limits for particulates have been in effect, leading to the use of electrostatic precipitator technology at most plants. However, Indian coal's high ash content may reduce these systems' ability to capture mercury (Sloss 2012b). Consequently, in contrast to China, there are few opportunities for mercury co-benefits in India. Furthermore, India's coal may be very high in mercury, higher than the coal in China; however, with few measurements, this remains highly uncertain (UNEP 2011; UNEP 2014). But even the perception of high mercury content may have presented barriers to India agreeing to emissions regulations in the negotiations.[11]

Unsurprisingly, recent power regulations have focused on improvements to plant efficiency. In 2002, the Indian Central Pollution Control Board capped the ash content of coals used in power generation at 34 percent, leading to increased coal cleaning and blending. Coal cleaning also reduces mercury content. Recent generation capacity expansion plans include the adoption of supercritical boilers in new installations—a technology with substantial efficiency gains (ICEA 2012). Efficiency improvements will have benefits for mercury, traditional air pollutants, and carbon dioxide. However, these changes are likely to take time, as they require modifications to fuels and both new and existing power plants. Furthermore, during the negotiations, it was not clear whether efficiency improvements would be seen as acceptable actions to control mercury under the treaty, making India more hesitant to agree to the convention. If stricter

11. Interviews with coal expert, January 20, 2014; UNEP Chemicals Branch Programme Officer, April 1, 2014.

standards were placed on new sources, this would further compound India's challenges with complying, given the planned coal expansion.

These domestic differences between India and China in their coal quality and power sector attributes interacted with differences in air pollution politics. In India, mandatory emissions obligations were a larger obstacle, requiring end-of-pipe controls that would, in effect, be mercury-specific, rather than offering co-benefits. These differences may also help explain the increased emphasis that Indian delegates put on the availability of financial and technical assistance over their Chinese counterparts, because complying with treaty obligations would likely require larger additional costs in India.

Development Constraints

As emerging economies, China and India have prioritized development through expanding energy capacity. Both countries have similar electricity mixes using substantial amounts of coal. Thus, their mercury emissions trajectories depend not only on mercury control technologies, but also on energy demand and capacity expansion. As is also the case with climate actions, placing significant constraints on mercury emissions could hinder electricity expansion. These shared interests could facilitate a coalition between China and India.

However, there are significant differences in energy access between China and India. One report projected that all of China will be electrified in 2015, as compared to 2030 in India (IEA 2010). Electrification is one of the government's major priorities because a quarter of the Indian population has no access to electricity, with ongoing electricity shortages (Ahn and Graczyk 2012). India brought up electrification needs in the INC process when mandatory emissions limits were raised. As an Indian delegate stated during INC2, the country plans to double its power capacity within the next ten years, largely through new coal capacity, providing electricity for 100 million homes without power (ENB 2011b). The difference in energy access between China and India suggests that India will continue to build significant coal generation capacity into the future, making mercury controls more costly.

In addition to the electrification differentials between India and China, these countries have diverged considerably in terms of their development trajectories over the past ten years. China's growth rate has surpassed India's, with per capita GDP now twice as high in China than in India. Similarly, poverty is more severe in India, with 33 percent living on less than $1.25 per day, as compared to China's 12 percent (World Bank 2009). China's greater economic development may be linked to a higher willingness to regulate air pollution, discussed below. Further, China has shown a strong ability to profit from manufacturing new environmental technology (Lewis 2013). Thus, global environmental regulations may present greater economic opportunities for China than for India. In contrast, several interviewees indicated that for both regulators and citizens in India, other challenges like poverty reduction, electrification, and drinking water are greater priorities. In India, the mercury problem is typically viewed as one for developed countries to address.[12]

Domestic Scientific and Technical Capacity

Although significant research has focused on scientists' roles in international negotiations through linked, global networks (Haas 1992; Kohler et al. 2012), and on the importance of state capacity for environmental policy implementation (Harrison and Kostka 2014), less attention has been paid to how variation in domestic scientific capacity affects countries' negotiating positions (Stokes and Selin 2016). Countries can vary in their domestic knowledge on environmental issues and in the degree to which that knowledge is integrated into policy-making. Efforts within chemicals negotiations have focused on making scientific assessments available to developing countries through regional workshops, which can raise the salience of technical information to facilitate regime participation (Selin 2006). Despite these global-scale efforts, however, dramatic differences still exist in countries' access to scientific and technical knowledge in environmental regimes (Tijssen 2007).

Direct input from academics is an increasingly common part of China's policy-making process (Lewis and Gallagher 2014). Mercury control technologies and their scientific and technical implications became increasingly well-known to the Chinese delegation over the INC process. Four out of 18 members of the Chinese delegation at INC5 were air pollution and mercury scientists from academia. As in North America and Europe, China benefits from a large group of domestic scientific researchers that focus on China-specific mercury issues, such as its domestic coal characteristics, emissions inventories, fate and transport, and human exposure.[13] Furthermore, China hosted the 2009 International Conference on Mercury as a Global Pollutant (ICMGP), and a large number of the presentations focused on China, no doubt deepening scientific knowledge of the mercury problem domestically. Research highlighted the extent of China's local mercury challenges, including contaminated sites and mercury exposure through rice (Feng and Qiu 2008; Jiang and Shi 2006). Research has also demonstrated that, whereas Chinese emissions contribute significantly to deposition in other countries, China is the largest anthropogenic source of mercury deposition within its *own* borders, making mercury emissions control foremost a domestic issue (AMAP and UNEP 2013). This active scientific community participated in developing the new emission standard domestically, as well as the Chinese position in international negotiations.

In contrast, in India the scientific community around mercury is far less developed. According to one scientist, only three research groups in India are

12. Interviews with senior developed country negotiator, January 17, 2014; Indian power sector expert, February 25, 2014.
13. Interviews with senior developed country negotiators, February 4, 2014.

studying mercury emissions.[14] At ICMGP 2013, only two presentations focused on India and were from Indian institutions, whereas 38 addressed China, with 34 from Chinese institutions. Domestically, there have been relatively few studies of mercury impacts in India, though some NGOs have conducted studies of the Singrauli region where mercury acutely affects some communities (Kumari 2011; Sahu et al. 2012). These same groups have brought attention to the lack of India-specific information about mercury emissions and mercury impacts. They have suggested that the government is politically reluctant to develop or release mercury information—for example, on domestic coals' mercury content—because identifying the scope of the problem could commit the government to responding.[15] These gaps are partially being addressed through the UNEP Global Mercury Partnerships rather than domestically. Furthermore, in India, scientists and technical experts on mercury seem to have less influence over government policy. For example, none of the Indian delegates at INC5 were academic scientists. Instead, the representatives came from the environmental and health ministries, the central electricity authority, and diplomatic ministries. Consequently, the Indian delegation did not have the same connection to scientific data when negotiating.

Scientific information can create shared narratives, forming a basis for cooperation. Importantly, science may play different roles at different scales. Domestic science—in this case, studies of the environmental and health effects within a country's borders—may have a strong influence on domestic regulation, and therefore on countries' positions. This was the case for China, which began to converge more closely with the EU and US as Chinese officials became more knowledgeable about emissions inventories, the available technologies, and their feasibility.[16] International assessments, like those UNEP convenes, may weave a global narrative upon which negotiations can be built, but this information may be insufficient to allow countries to understand their domestic impacts. Instead, there is a need to foster domestic scientific communities that can contribute to negotiators' understanding of global environmental issues.

Conclusions

The North-South dichotomy in international environmental negotiations is breaking down. In this article, we have explored the roots of South-South divergence through a case study of China and India's positions in the mercury negotiations. We find that attention to three main factors can help explain this divergence: domestic resources and regulatory politics, development constraints, and domestic scientific and technological capacity. The splitting of India's and China's positions during the final mercury negotiating session illustrates that

14. Interview with Indian environmental scientist, September 18, 2014.
15. Interview with Indian power sector expert, February 25, 2014.
16. Interviews with senior developed country negotiator, February 4, 2014; coal expert, January 20, 2014.

countries' positions can be highly dependent on socio-technical interactions. Geopolitical considerations—for example, a domestic coal reserve's attributes—interact with technical considerations, such as pollutant control technologies, to constrain domestic policy options and, thus, international cooperation. Furthermore, the extent to which domestic science has framed the problem as important to address can shape countries' positions. Countries' diverging development statuses can further constrain cooperation.

In the past, developing countries gained additional power in negotiations by coming to a common position, even if their underlying interests were not perfectly aligned. However, as emerging economies gain greater negotiating power and as variation in their development statuses increases, they are less willing to work in large, negotiating blocs. These developments, occurring across several international environmental negotiations, suggest a shift away from multilateralism with large Northern and Southern coalitions, toward greater bilateral cooperation. Although we used the mercury case to present our argument, similar dynamics influence other negotiations, including those related to ozone and climate.

In climate negotiations, the South has fragmented over time (Hurrell and Sengupta 2012). At the 1992 Rio Earth Summit, the G77 cooperated to successfully argue for the principle of common but differentiated responsibilities. However, by Kyoto in 1997, tensions within the South had developed. On the Clean Development Mechanism (CDM), Brazil split with China and India to support the US proposal. Here, developing countries would be paid to reduce emissions, with the resulting credits counting toward developed countries' reduction requirements. Although China and India eventually became large beneficiaries under the CDM, they were initially skeptical. Once the CDM was implemented, developing countries diverged further in their views on the mechanism's effectiveness. By 2007, the vast majority of CDM projects were located in China, India, Mexico, and Brazil (Griffith-Jones, Hedger, and Stokes 2009). Consequently, smaller African and Latin American countries clashed with emerging economies over whether to prioritize smaller-scale projects, as their interests were not aligned. By Copenhagen in 2009, progress in the climate negotiations had largely stalled. Since Copenhagen, while developing countries have maintained a common rhetoric on capacity building and financial assistance, their domestic actions have diverged. Roberts (2011) documented over thirteen distinct subgroups, with divergent interests and positions.

China and the US have had bilateral negotiations since 2009 through an annual Strategic and Economic Dialogue, which includes a climate change working group. China is considering a cap on coal use as early as 2016, and a cap on carbon with a peak emissions year as early as 2030. Further, since 2011, China has developed pilot emissions trading programs (Zhang et al. 2014). In part, China may be more willing to act on climate change because of co-benefits with air pollution, as happened with its mercury policy interests. In addition, due to China's development as a manufacturing economy, China stands to benefit as an exporter of renewables and other low-carbon technology (Lewis 2014).

In contrast, India has made fewer domestic climate commitments. Although it has small energy efficiency and solar goals, India lacks a comprehensive climate policy framework (Trancik et al. 2014). Also, while the US attempted to negotiate a bilateral agreement with India, it failed to do so in early 2015. India's plan for the Paris negotiations targeted emissions intensity reductions rather than absolute carbon cuts. Given India's development status and extensive need for electrification, India also stated that more coal power would be built. As in the mercury negotiations, China's and India's interests have diverged in the climate regime due to differences in development and domestic regulatory politics.

Within the ozone negotiations, developing countries cooperated during the 1980s. Once the Montreal Protocol was finalized, it was unclear whether China or India, both significant chlorofluorocarbon consumers, would ratify the agreement. China had been a productive negotiator, signaling a willingness to sign the treaty, whereas India showed little interest in acting, and Indian "officials in private conversations had characterized the issue as a 'rich man's problem—rich man's solution'" (Benedick 1998, 100–101). Although cooperation was sometimes fractious, the two countries largely shared positions on ozone, both signing the Montreal Protocol. Still, the timing of each country's actions has been different: China first ratified the Vienna Convention in 1989, whereas India did not join until 1991. Similarly, China acted a year before India on the Montreal Protocol and London amendments. On the Beijing amendments, China significantly lagged India, by seven years.

More recently, differences between China and India in the ozone negotiations have become substantive, due to disagreements on HFCs, chemicals with significant global warming potential but lower ozone-depleting potential. Due to HFCs' climate effects, several countries, most notably the US, Canada, and Mexico, proposed an amendment in 2010 to create an HFC phase-out (ENB 2010b). Initially, both China and India disagreed with phasing out HFCs in either the ozone or climate negotiations. The issue was moved to the ozone proceedings, with both countries continuing to resist a phase-out, arguing that these were not ozone-depleting substances and that the alternatives had significant problems.

However, the emerging economies began to fracture from this common position. China and Brazil, although not yet committing to a phase-out, signaled a willingness to discuss HFCs in the ozone negotiations. In September 2013, at a G20 meeting, the US and China came to a bilateral understanding that a contact group would be established in the ozone negotiations to discuss costs, alternatives, and a potential HFC amendment to the Montreal Protocol. China may see market opportunities in the switch away from HFCs, since it can manufacture new alternatives (Hwang 2013). In contrast, India continued to oppose action on HFCs under the ozone negotiations, given its large domestic HFC industry. India was concerned that switching away from these chemicals could be a tactic for developed countries to profit from HFC substitutes (ENB 2012). Eventually, in mid-2015, under pressure from the US, India agreed to a compromise phase-down beginning in 2031—hardly an ambitious timeline. Here again, differences in development and domestic industries played a role in Southern countries' diverging positions in the ozone regime.

Across international environmental negotiations, developing countries have begun to hold diverging interests, and thereby, different positions. The mercury, climate, and ozone negotiations suggest that underlying South-South divisions have become apparent in the move from conceptual framing into specific regulatory regimes. As global environmental cooperation moves toward implementation, underlying differences between Southern countries have become clearer. Divergence can be partially attributed to interactions between politics, technology, and resources. In the future, we predict that where technological constraints divide emerging economies' preferences, where scientific knowledge is unequal, and where domestic resources and politics differ, we are more likely to see disruptions to South-South coalitions. Normatively, our findings suggest that building scientific capacity in developing countries and aligning global requirements with domestic constraints can both be potential levers to increase international cooperation. However, whether fracturing in the Southern coalition will lead to better environmental outcomes remains to be seen.

References

Ahn, Sun-Joo, and Dagmar Graczyk. 2012. *Understsanding Energy Challenges in India: Policies, Players and Issues*. Paris: International Energy Agency.

AMAP and UNEP. 2013. *Technical Background Report to the Global Mercury Assessment 2013*. Oslo: AMAP Secretariat. Available at bit.ly/2c86FqU, accessed September 13, 2016.

Barnett, Jon. 2008. The Worst of Friends: OPEC and G-77 in the Climate Regime. *Global Environmental Politics* 8 (4): 1–8.

Benedick, Richard Elliot. 1998. *Ozone Diplomacy: New Directions in Safeguarding the Planet*. 2nd ed. Cambridge, MA: Harvard University Press.

China Electricity Council (CEC). 2013. CEC Publishes the Demand/Supply Analysis and Forecast of China Power Industry 2014. Beijing: China Electricity Council.

Downie, Christian. 2014. *The Politics of Climate Change Negotiations: Strategies and Variables in Prolonged International Negotiations*. Northampton, MA: Edward Elgar.

ENB. 2003. Summary of the 22nd Session of the UNEP Governing Council and 4th Global Ministerial Environment Forum. New York: International Institute for Sustainable Development (IISD).

ENB. 2005. Summary of the 23rd Session of the UNEP Governing Council/Global Ministerial Environment Forum. New York: IISD.

ENB. 2007a. 1st Meeting of the Ad Hoc Open-Ended Working Group to Review and Assess Measures to Address the Global Issue of Mercury. New York: IISD.

ENB. 2007b. Summary of the 24th Session of the UNEP Governing Council/Global Ministerial Environment Forum. New York: IISD.

ENB. 2010a. Summary of the 1st Meeting of the INC to Prepare a Global Legally Binding Instrument on Mercury. New York: IISD.

ENB. 2010b. Summary of the 22nd Meeting of the Parties to the Montreal Protocol on Substances That Deplete the Ozone Layer. New York: IISD.
ENB. 2011a. Summary of the 2nd Meeting of the INC to Prepare a Global Legally Binding Instrument on Mercury. New York: IISD.
ENB. 2011b. Summary of the 3rd Meeting of the INC to Prepare Global Legally Binding Instrument on Mercury. New York: IISD.
ENB. 2012. 24th Meeting of the Parties to the Montreal Protocol on Substances That Deplete the Ozone Layer. New York: IISD.
ENB. 2013. Summary of the Diplomatic Conference of Plenipotentiaries on The Minamata Convention on Mercury and Preceding Preparatory Meeting. New York: IISD.
Eckl, Julian, and Ralph Weber. 2007. North-South? Pitfalls of Dividing the World by Words. *Third World Quarterly* 28 (1): 3–23.
Economy, Elizabeth C. 2010. *The River Runs Black: The Environmental Challenge to China's Future*. 2nd ed. Ithaca, NY: Cornell University Press.
Eriksen, Henrik Hallgrim, and Franz Xaver Perrez. 2014. The Minamata Convention: A Comprehensive Response to a Global Problem. *Review of European, Comparative & International Environmental Law* 23 (2): 195–210.
Feng, Xinbin, and Guangle Qiu. 2008. Mercury Pollution in Guizhou, Southwestern China—An Overview. *Science of the Total Environment* 400 (1–3): 227–237.
Fisher, Dana. 2004. *National Governance and the Global Climate Change Regime*. Oxford: Rowman & Littlefield.
Giang, Amanda, and Noelle E. Selin. 2016. Benefits of mercury controls for the United States. *Proceedings of the National Academy of Sciences of the United States of America*, 113 (2), 286–291.
Giang, Amanda, Leah C. Stokes, David G. Streets, Elizabeth S. Corbitt, and Noelle E. Selin. 2015. Impacts of the Minamata Convention on Mercury Emissions and Global Deposition from Coal-Fired Power Generation in Asia. *Environmental Science & Technology* 49: 5326–5335.
Griffith-Jones, Stephany, Merylyn Hedger, and Leah Stokes. 2009. The Role of Private Investment in Increasing Climate Friendly Technologies in Developing Countries. UN World Economic & Social Survey 2009 Research Paper, Columbia University and Institute of Development Studies, Brighton.
Haas, Peter M. 1992. Introduction: Epistemic Communities and International Policy Coordination. *International Organization* 46 (1): 1–35.
Harrison, Tom, and Genia Kostka. 2014. Balancing Priorities, Aligning Interests: Developing Mitigation Capacity in China and India. *Comparative Political Studies*, 47 (3), 450–480.
Hochstetler, K., and M. Milkoreit. 2014. Emerging Powers in the Climate Negotiations: Shifting Identity Conceptions. *Political Research Quarterly* 67 (1): 224–235.
Hoffmann, M. J. 2005. *Ozone Depletion and Climate Change: Constructing a Global Response*. Albany, NY: SUNY Press.
Hsu, Angel, Jay Emerson, Marc A. Levy, Alex de Sherbinin, Laura Johnson, Omar Malik, Jason D. Schwartz, and Malanding Jaiteh. 2014. *The 2014 Environmental Performance Index* (Vol. 1). New Haven, CT: Yale Center for Environmental Law & Policy.
Humphrey, John, and Dirk Messner. 2006. China and India as Emerging Global Governance Actors : Challenges for Developing and Developed Countries. *IDS Bulletin* 37 (1): 107–114.
Hurrell, Andrew, and Sandeep Sengupta. 2012. Emerging Powers, North-South Relations and Global Climate Politics. *International Affairs* 3 (88): 463–484.

Hwang, Cindy. 2013. *Hydrofluorocarbons: Finally, Something the U.S. and China Can Agree On*. Blog Post, Foreign Policy in Focus, June 24. Available at bit.ly/2cBpYZ7, accessed September 13, 2016.

India Central Electricity Authority (ICEA). 2012. *National Electricity Plan: Volume 1. Generation*. New Delhi: ICEA.

International Energy Agency (IEA). 2010. *World Energy Outlook 2010*. Paris: IEA.

Jiang, Gui-Bin, and Jian-Bo Shi. 2006. Mercury Pollution in China: An Overview of the Past and Current Sources of the Toxic Metal. *Environmental Science and Technology* 40 (12): 3672–3678.

Joshi, Shangrila. 2013. Understanding India's Representation of North-South Climate Politics. *Global Environmental Politics* 13 (2): 128–148.

Kohler, Pia M., Alexandra Conliffe, Stefan Jungcurt, Maria Gutierrez, and Yulia Yamineva. 2012. Informing Policy: Science and Knowledge in Global Environmental Agreements. In *The Roads from Rio: Lessons Learned from Twenty Years of Multilateral Environmental Negotiations*, edited by Pamela S. Chasek and Lynn M. Wagner, 59–81. New York: Routledge.

Kumari, Ragini. 2011. *Emission Estimate of Passport-Free Heavy Metal Mercury from Indian Thermal Power Plants and Non-Ferrous Smelters*. New Delhi: Toxics Link. Available at bit.ly/2ckWScR, accessed September 13, 2016

Lewis, Joanna I. 2014. The Rise of Renewable Energy Protectionism: Emerging Trade Conflicts and Implications for Low Carbon Development. *Global Environmental Politics* 14 (4): 10–35.

Lewis, Joanna I. 2013. *Green Innovation in China: China's Wind Power Industry and the Global Transition to a Low-Carbon Economy*. New York: Columbia University Press.

Lewis, Joanna I., and Kelly Sims Gallagher. 2014. Energy and Environment in China: National and Global Challenges. In *The Global Environment: Institutions, Law, and Policy*, edited by Regina S. Axelrod and Stacy D. VanDeveer, 4th ed., 187–212. Washington DC: CQ Press.

Loschky, Jay, and Julie Ray. 2013. Nearly Four in Five Satisfied with Quality of Air Worldwide. Gallup. Available at bit.ly/2cowqBq, accessed September 13, 2016.

Miller, Marian A. L. 1998. Sovereignty Reconfigured: Environmental Regimes and Third World States. In *The Greening of Sovereignty in World Politics*, edited by Karen T. Litfin, 173–192. Cambridge, MA: MIT Press.

Najam, Adil. 2004. Dynamics of the southern Collective: Developing Countries in Desertification Negotiations. *Global Environmental Politics* 4 (3): 128–155.

Najam, Adil. 2005. Developing Countries and Global Environmental Governance: From Contestation to Participation to Engagement. *International Environmental Agreements: Politics, Law and Economics* 5 (3): 303–321.

Najam, Adil, Saleemul Huq, and Youba Sokona. 2003. Climate Negotiations beyond Kyoto: Developing Countries Concerns and Interests. *Climate Policy* 3 (3): 221–231.

National Institute for Public Health and the Environment Netherlands (RIVM). 2001. *IMAGE 2.2 Implementation of the SRES Scenarios: A Comprehensive Analysis of Emissions, Climate Change and Impacts in the 21st Century*. Bilthoven, The Netherlands: RIVM.

Parson, Edward A. 2003. Protecting the ozone layer: science and strategy. Oxford: Oxford University Press.

Pacyna, E.G., J.M. Pacyna, K. Sundseth, J. Munthe, K. Kindbom, S. Wilson, F. Steenhuisen, and P. Maxson. 2010. Global Emission of Mercury to the Atmosphere from

Anthropogenic Sources in 2005 and Projections to 2020. *Atmospheric Environment* 44 (20): 2487–2499.

Perkins, Richard. 2013. Sustainable Development and the Making and Unmaking of a Developing World. *Environment and Planning C: Government and Policy* 31 (6): 1003–1022.

Roberts, J. Timmons. 2011. Multipolarity and the New World (Dis)order: US Hegemonic Decline and the Fragmentation of the Global Climate Regime. *Global Environmental Change* 21 (3): 776–784.

Roberts, J. Timmons, and Bradley C. Parks. 2007. *A Climate of Injustice: Global Inequality, North-South Politics, and Climate Policy*. Cambridge, MA: MIT Press.

Sahu, Ramakant, Poornima Saxena, Sapna Johnson, Soundaram Ramanathan, Sugandh Juneja, H. B. Mathur, and H. C. Agarwal. 2012. *Mercury Pollution in Sonbhadra District of Uttar Pradesh and Its Health Impacts*. New Delhi: Centre for Science and Environment.

Schreifels, Jeremy J., Yale Fu, and Elizabeth J. Wilson. 2012. Sulfur Dioxide Control in China: Policy Evolution during the 10th and 11th Five-Year Plans and Lessons for the Future. *Energy Policy* 48: 779–789.

Selin, Henrik. 2014a. Global Environmental Law and Treaty-Making on Hazardous Substances: The Minamata Convention and Mercury Abatement. *Global Environmental Politics* 14 (1): 1–19.

Selin, Henrik. 2014b. Global Politics and Policy of Hazardous Chemicals. In *The Global Environment: Institutions, Law, and Policy*, edited by Regina S. Axelrod and Stacy D. VanDeveer, 4th ed., 259–282. Washington, DC: CQ Press.

Selin, Noelle E. 2006. From Regional to Global Information: Assessment of Persistent Organic Pollutants (POPs). In *Global Environmental Assessments: Information, Institutions, and Influence*, edited by Ronald B. Mitchell, William C. Clark, David W. Cash, and Frank Alcock, 175–199. Cambridge, MA: MIT Press.

Sloss, Lesley. 2012a. *Legislation, Standards and Methods for Mercury Emissions Control*. IEA Clean Coal Centre.

Sloss, Lesley. 2012b. *Mercury Emissions from India and South East Asia*. IEA Clean Coal Centre.

Stokes, Leah C., and Noelle E. Selin. 2016. The mercury game: evaluating a negotiation simulation that teaches students about science-policy interactions. *Journal of Environmental Studies and Sciences*, 6 (3), 597–605.

Templeton, Jessica, and Pia Kohler. 2014. Implementation and Compliance under the Minamata Convention on Mercury. *Review of European, Comparative and International Environmental Law* 23 (2): 211–220.

The World Bank. 2009. *World Development Report 2009: Reshaping Economic Geography*. Washington, DC: World Bank.

Therien, Jean-Philippe. 1999. Beyond the North-South Divide: The Two Tales of World Poverty. *Third World Quarterly* 20 (4): 723–742.

Tijssen, Robert J. W. 2007. Best of Both Worlds? Domestic Relevance vs. International Visibility of Local Science Journals in Developing Countries. Working Paper, Centre for Science and Technology Studies, Leiden University.

Trancik, Jessika E., Michael T. Chang, Christina Karapataki, and Leah C. Stokes. 2014. Effectiveness of a Segmental Approach to Climate Policy. *Environmental Science & Technology* 48 (1): 27–35.

UNEP. 2002. *Global Mercury Assessment*. Geneva: UNEP.

UNEP. 2008. *The Global Atmospheric Mercury Assessment: Sources, Emissions and Transport*. Geneva: UNEP.

UNEP. 2011. *Reducing Mercury Emissions from Coal Combustion in the Energy Sector*. Beijing: UNEP.

UNEP. 2012. *Submission by China and India on Article 10 on Atmospheric Emissions of Mercury (UNEP(DTIE)/Hg/INC.4/CRP.11)*. Punta del Este, Uruguay: UNEP.

UNEP. 2013. *Global Mercury Assessment 2013: Sources, Emissions, Releases and Environmental Transport*. Geneva: UNEP.

UNEP. 2014. *Assessment of the Mercury Content in Coal Fed to Power Plants and Study of Mercury Emissions from the Sector in India*. Geneva: UNEP.

US EIA. 2013. *Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States*. Washington, DC: US Department of Energy.

US EPA. 2003. *Air Pollution Control Technology Fact Sheet: Flue Gas Desulfurization*. Available at www3.epa.gov/ttncatc1/dir1/ffdg.pdf, accessed September 13, 2016.

Williams, Marc. 2005. The Third World and Global Environmental Negotiations: Interests, Institutions and Ideas. *Global Environmental Politics* 5 (3): 48–69.

Yang, Ailun, and Yiyun Cui. 2012. *Global Coal Risk Assessment: Data Analysis and Market Research*. Washington, DC: World Resources Institute.

Zhang, Da, Valerie J. Karplus, Cyril Cassisa, and Xiliang Zhang. 2014. Emissions Trading in China: Progress and Prospects. *Energy Policy* 75: 9–16.

Zhang, Xuehua, and Jeremy Schreifels. 2011. Continuous Emission Monitoring Systems at Power Plants in China: Improving SO2 Emission Measurement. *Energy Policy* 39 (11): 7432–7438.

Zheng, Siqi, and Matthew E. Kahn. 2013. Understanding China's Urban Pollution Dynamics. *Journal of Economic Literature* 51 (3): 731–772.

Joint Program Reprint Series - Recent Articles

For limited quantities, Joint Program publications are available free of charge. Contact the Joint Program office to order.
Complete list: http://globalchange.mit.edu/publications

2016-23 Splitting the South: China and India's Divergence in International Environmental Negotiations. Stokes, L.C., A. Giang and N.E. Selin, *Global Environmental Politics*, 16(4): 12–31 (2016)

2016-22 Teaching and Learning from Environmental Summits: COP 21 and Beyond. Selin, N.E., *Global Environmental Politics*, 16(3): 31–40 (2016)

2016-21 Southern Ocean warming delayed by circumpolar upwelling and equatorward transport. Armour, K.C., J. Marshall, J.R. Scott, A. Donohoe and E.R. Newsom, *Nature Geoscience* 9: 549–554 (2016)

2016-20 Hydrofluorocarbon (HFC) Emissions in China: An Inventory for 2005–2013 and Projections to 2050. Fang, X., G.J.M. Velders, A.R. Ravishankara, M.J. Molina, J. Hu and R.G. Prinn, *Environmental Science & Technology*, 50(4): 2027–2034 (2016)

2016-19 The Future of Natural Gas in China: Effects of Pricing Reform and Climate Policy. Zhang, D. and S. Paltsev, *Climate Change Economics*, 7(4): 1650012 (2016)

2016-18 Assessing the Impact of Typhoons on Rice Production in the Philippines. Blanc, É. and E. Strobl, *Journal of Applied Meteorology and Climatology,* 55: 993–1007 (2016)

2016-17 Uncertainties in Atmospheric Mercury Modeling for Policy Evaluation. Kwon, S.Y. and N.E. Selin, *Current Pollution Reports,* 2(2): 103–114 (2016)

2016-16 Limited Trading of Emissions Permits as a Climate Cooperation Mechanism? US-China and EU-China Examples. Gavard, C., N. Winchester and S. Paltsev, *Energy Economics,* 58(2016): 95–104 (2016)

2016-15 Interprovincial migration and the stringency of energy policy in China. Luo, X., J. Caron, V.J. Karplus, D. Zhang and X. Zhang, *Energy Economics,* 58(August 2016): 164–173 (2016)

2016-14 Modelling the potential for wind energy integration on China's coal-heavy electricity grid. Davidson, M.R., D. Zhang, W. Xiong, X. Zhang and V.J. Karplus, *Nature Energy,* 1: 16086 (2016)

2016-13 Pathways to Mexico's climate change mitigation targets: A multi-model analysis. Veysey, J., C. Octaviano, K. Calvin, S. Herreras Martinez, A. Kitous, J. McFarland and B. van der Zwaan, *Energy Economics,* 56(May): 587–599 (2016)

2016-12 Uncertainty in future agro-climate projections in the United States and benefits of greenhouse gas mitigation. Monier, E., L. Xu and R. Snyder, *Environmental Research Letters*, 11(2016): 055001 (2016)

2016-11 Impact of Aviation on Climate: FAA's Aviation Climate Change Research Initiative (ACCRI) Phase II. Brasseur, G., M. Gupta, B. Anderson, S. Balasubramanian, S. Barrett, D. Duda, G. Fleming, P. Forster, J. Fuglestvedt, A. Gettelman, R. Halthore, S. Jacob, M. Jacobson, A. Khodayari, K. Liou, M. Lund, R. Miake-Lye, P. Minnis, S. Olsen, J. Penner, R. Prinn, U. Schumann, H. Selkirk, A. Sokolov, N. Unger, P. Wolfe, H. Wong, D. Wuebbles, B. Yi, P. Yang and C. Zhou, *Bull. Amer. Meteor. Soc.*, 97(4): 561–583 (2016)

2016-10 Energy caps: Alternative climate policy instruments for China? Karplus, V.J., S. Rausch and D. Zhang, *Energy Economics*, 56(May 2016): 422–431 (2016)

2016-9 Cross-country electricity trade, renewable energy and European transmission infrastructure policy. Abrell, J. and S. Rausch, *Journal of Environmental Economics and Management*, 79(Sep 2016): 87–113 (2016)

2016-8 Transient Climate Impacts for Scenarios of Aerosol Emissions from Asia: A Story of Coal versus Gas. Grandey, B.S., H. Cheng and C. Wang, *Journal of Climate*, 29(8): 2849–2867 (2016)

2016-7 Climate and Land: Tradeoffs and Opportunities. Reilly, J.M. and J.M. Melillo, *Geoinformatics & Geostatistics: An Overview*, 4(1): 1000135 (2016)

2016-6 Projections of Water Stress Based on an Ensemble of Socioeconomic Growth and Climate Change Scenarios: A Case Study in Asia. Fant, C., C.A. Schlosser, X. Gao, K. Strzepek and J. Reilly, *PLoS ONE,* 11(3): e0150633 (2016)

2016-5 Determinants of Crop Yield and Profit of Family Farms: Evidence from the Senegal River Valley. Blanc, É., A. Lépine and E. Strobl, *Experimental Agriculture*, 52(1): 110–136 (2016)

2016-4 Metamodeling of Droplet Activation for Global Climate Models. Rothenberg, D. and C. Wang, *Journal of the Atmospheric Sciences*, 73, 1255–1272 (2016)

2016-3 Climate extremes and ozone pollution: a growing threat to China's food security. Tian, H., W. Ren, B. Tao, G. Sun, A. Chappelka, X. Wang, S. Pan, J. Yang, J. Liu, B.S. Felzer, J.M. Melillo and J. Reilly, *Ecosystem Health and Sustainability*, 2(1): 2332–8878 (2016)

2016-2 Carbon emissions in China: How far can new efforts bend the curve? Zhang, X., V.J. Karplus, T. Qi, D. Zhang and J. He, *Energy Economics*, 54 (Feb 2016): 388–395 (2016)

2016-1 Long-term economic modeling for climate change assessment. Y.-H.H. Chen, S. Paltsev, J.M. Reilly, J.F. Morris and M.H. Babiker, *Economic Modelling*, 52(Part B): 867–883 (2016)

2015-35 The impact of advanced biofuels on aviation emissions and operations in the U.S. Winchester, N., R. Malina, M.D. Staples and S.R.H. Barrett, *Energy Economics*, 49: 482–491 (2015)

MIT Joint Program on the Science and Policy of Global Change

Massachusetts Institute of Technology
77 Massachusetts Ave., E19-411
Cambridge MA 02139-4307 (USA)

T (617) 253-7492 **F** (617) 253-9845
globalchange@mit.edu
http://globalchange.mit.edu