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The conversation on the impact of air travel on the environment has been very lively recently in academic settings as individuals have been reflecting on the impact of their own research related travel (see, for example, Malabika Pramanik's article in the *CMS Notes*[1]). This is a touchy subject, as many academic factors such as promotion, funding opportunities, networking, etc, naturally depend on and encourage travelling. Surely the most important issue for mathematicians has to do with collaborations. While there are many communication resources that facilitate remote collaboration, ultimately the best way to exchange ideas remains the face to face conversation, and conferences and other academic trips provide invaluable opportunities to facilitate those encounters. Of course, the optimal outcome in terms of diminishing environmental impact would be to eliminate all academic travel, but this would greatly reduce the number of such opportunities. An important question is then whether we can transform conferences and other events in order to diminish our impact on the environment.

A measure encouraging remote participation in workshops and seminars involves video streaming, which allows remote participants to ask questions during presentations. I have been aware of a number of seminars working in this way. For example, about 10 years ago I was at the University of Alberta and we used to have a shared number theory seminar involving several Western Canadian universities. An ambitious new initiative is the VaNTAGe (a virtual math seminar on open conjectures in number theory and arithmetic geometry[2]), which started last month and allows for 100 simultaneous remote connections.

In 2009, I participated in the "Workshop on Discovery and Experimentation in Number Theory"[3] that took place both at the Fields Institute in Toronto and at the IRMACS in Vancouver. While participants were welcome to go to either site, they were encouraged to attend the site closer to their location. There were around 70 participants in Toronto and about half that number in Vancouver. The core invited lectures were shared and video streamed allowing for attendance and questions from each site. There were also some individual simultaneous sessions at each site with shorter lectures which were also video streamed. I flew from Edmonton to Vancouver. While climate change was not on my radar back then, I was grateful for the short fly, as I had a young baby and was trying to diminish my travel as much as possible.

A more current example of a climate conscious scientific event is the POM (Photonics Online Meetup) conference[4] that took place on January 13th 2020. It was hosted using webcasting. Each speaker gave their presentation from their own location. Several organizations hosted POM-hubs sites, where participants were able to network and watch the presentations together. There were more than 50 hubs around the world that included Helsinki, Mumbai, Melbourne, Buenos Aires, Mankweng, Austin, Ottawa, and Montreal, to name just a few locations. The event also included poster presentations, where the posters were initially posted in Twitter a few days in advance and then presented during the conference.

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Both of the above examples give ideas regarding the adaptation of bigger conferences. How about small specialized workshops of, say, up to 50 participants? Personally, I find that small specialized workshops, often held in research institutes, to be among the most productive academic trips in terms of starting and maintaining collaborations. It is hard to imagine how to replace the dynamics and interactions that take place during coffee breaks and other unstructured times during these workshops. It is now common place for presentations at these workshops to be recorded and made publicly available. In collaborative workshops, I have seen remote group members who connect to work with a specific group. These measures allow for some level of remote participation, even if it is not the same as being present in the workshop.

Last July, I flew over 4,000 km from Montreal to San José to participate in a SQuaRE (a Structured Quartet Research Ensemble) at the American Institute for Mathematics (AIM)[5]. The program SQuaREs allows a small group of mathematicians to spend a week at AIM in order to collaborate. During that week, members are away from their home institutions and can dedicate most of their time to research in excellent and stimulating conditions. The group can meet three times in different years, which encourages the continuation of the collaboration. Several institutes have similar versions of these programs, such as the "Focused Research Groups" at BIRS (Canada), the "Research in Pairs" at MFO (Germany), the "Summer Research in Mathematics" at MSRI (USA), specially directed towards women and gender-expansive individuals, and the "Collaborate@ICERM" at, obviously, ICERM (USA). I find this type of initiatives to be extremely stimulating for research. That said, they also come with the environmental cost of air travel sometimes in absurd ways. For example, back in July, two people from the UK and three people from the east of USA/Canada flew to California to meet at AIM. This is almost 60,000 km in air travel for a small group of people to meet.

Now imagine that several institutes had an agreement allowing each collaborative group to be sent to a location that minimizes the total distance flown by the members of the group. For example, if our group had met at ICERM, in Providence, or at the Fields Institute, in Toronto, the total air travel would have been about 12,000 km. Of course, this estimate does not take into account eventual connections, but there is no doubt that in terms of minimizing the total amount of air travel, these institutes are geographically better situated for this particular group of individuals. Of course, the best possibility (with under 11,000 km of air travel), given that two people are from Montreal, would have been to meet at the Centre de recherches mathématiques (CRM), but this defeats the purpose of getting everybody out of their home institutions. This idea sounds very difficult to implement, as it raises questions about sharing and coordinating funding, administration capabilities, and other resources among diverse institutes in different countries. Still, it would be very interesting to start investigating the feasibility of this idea, or similar ones, to see if the possibly large impact justifies the resources and effort this coordination will require.

At the end of the day, these ideas are simply part of a larger conversation on how to reduce our impact via air travel, which is a significant contribution our community can do in the global effort to address climate change.

## References

- [1] Malabika Pramanik, "Conferences and... climate?", *CMS Notes*, May 2019, p. 1.
- [2] VaNTAGe, a virtual math seminar on open conjectures in number theory and arithmetic geometry. organised by Rachel Pries. <<https://sites.google.com/view/vantageseminar>>
- [3] Workshop on Discovery and Experimentation in Number Theory, organized by Peter Borwein, Michael Coons, Michael Filaseta, Kevin Hare, Michael Mossinghoff, and Chris Smyth. <<http://www.fields.utoronto.ca/programs/scientific/09-10/FoCM/discovery/index.html>>
- [4] Photonics Online Meetup, organized by Andrea Armani, Orad Reshef, Igor Aharonovich, Rachel Grange, Mikhail Kats, and Riccardo Sapienza. <<https://sites.usc.edu/pom>>
- [5] Structured Quartet Research Ensemble, American Institute for Mathematics. <<https://aimath.org/programs/squares>>