TUR Short Final Report

One of the challenges facing the 10-strong organizational team[1] was the fact that not every aspect of this enormous subject could be covered. Thus, it was decided at an early stage to focus on the more mathematical aspects of the subject even though about a third of the attendees had their institutional roots in Aerospace, Mechanical Engineering and climate-related Departments. The programme was divided into four "quarters": Analysis; Mixing & Transport; Wall-Bounded Flows; and Geophysical & Astrophysical Turbulence, each with its own triad of organizers and workshop.

The global pandemic spanned the whole of the planning period with the Omicron phase developing over the start of the programme in January 2022. All the talks of our opening Workshop (Jan 5th -7th) were held on-line during which senior speakers were asked to present their grand challenges. A gradual transition from virtual to physical was made over the periods covered by Workshops 2 and 3. Various physical, engineering, and climate applications (including machine learning and AI) were discussed during the latter. By the time of Workshop 4 in late March the building was overflowing. This workshop particularly highlighted the sheer range and variety of datasets now available. The tools for making increasing contact with various theoretical models bodes well for the future.

Early in the program, Mike Cullen (Met Office) set the stage in a series of 4 lectures on atmospheric dynamics. Simons Research Fellows Anagha Madhu and Antoine Remond-Tiedrez (both Cambridge and INI) organized the Junior Isaac Newton Crossover Seminar (JINX), jointly with the Kinetic Theory programme. Simon Markfelder (Cambridge) gave a mini-course on Convex Integration, a technique devised in the last decade to analyse very rough solutions of the Euler equations.

Programme highlights were the Kirk Distinguished Lecture on *Mammatus Clouds and Sedimentation Instabilities* (Rama Govindarajan, ICTS Bangalore), and the Rothschild Distinguished Lecture on *How Mathematics Helps Structuring Climate Discussions* (Rupert Klein, Free University of Berlin). A further highlight was the lecture by Joerg Schumacher (TU Ilmenau) on his 3D numerical simulations of extended Rayleigh-Bénard convection layers. An example of continuing cross-cultural interaction among the "quarters" is the collaboration between Rupert Klein (FUB), Leslie Smith and Sam Stechmann (climate scientists, both Wisconsin) and analysts Edriss Titi and Xin Liu (both Cambridge). Moreover, inspired by results from Baylor Fox-Kemper's global ocean model, the three analysts Anna Mazzucato (Penn State), Helena Nussenzveig-Lopes and Milton Lopes (both Rio de Janeiro) have begun a collaboration on the application of 2D Euler vortex methods to the ocean circulation. A further example is the collaboration between Rahul Pandit (IIS Bangalore, Mixing & Transport) and John Gibbon (Imperial, Analysis) on problems in `active' turbulence caused by the swarming of birds, fish or bacteria.

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[1] We record our sadness at the death of one of our organizers Charles Doering (Ann Arbor) in May 2021: https://www.newton.ac.uk/news/ini-news/in-memoriam-charles-doering-1956-2021/. Jean-Luc Thiffeault (Wisconsin) took over Charlie's position and made major contributions to the organization.