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The international global atmospheric chemistry (IGAC) project: Facilitating atmospheric chemistry research for 25 years

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ABSTRACT

This paper outlines the scientific achievements and insights gained from the International Global Atmospheric Chemistry (IGAC) project, which has been jointly sponsored by the international Commission on Atmospheric Chemistry and Global Pollution (iCACGP) and the International Geosphere-Biosphere Programme (IGBP) since 1990. A short history of IGAC is followed by representative key scientific achievements. Over 25 years, IGAC has facilitated international scientific collaborations that have deepened the understanding of how atmospheric composition impacts air quality, climate change, and ecosystems from local to global scales. Activities fostered by IGAC show how the field of atmospheric chemistry has evolved from a focus on the atmosphere as a single natural compartment of the Earth system to an emphasis on its interactions with other Earth components, such as oceans, the cryosphere, the biosphere, and the impact of humans on atmospheric composition. Finally, one of IGAC's significant accomplishments has been building scientific capacity and cooperation in the field of atmospheric chemistry around the globe, especially through its biennial science conferences. As part of IGBP, IGAC has contributed to improving the current state of knowledge of the Earth system and providing the scientific basis to suggest that we have entered the Anthropocene. IGAC will continue to play this role and expand its connections to the larger global change and sustainability research communities, capitalizing on the transition to Future Earth.

Abbreviations: ACPC, aerosols, clouds, precipitation and climate; AICI, air–ice chemical interactions; ASGAMAGE, air–sea gas exchange; ACE-Asia, Asian aerosol characterization experiment; ASTEX, Atlantic stratocumulus transition experiment; ACCMIP, atmospheric chemistry and climate model intercomparison project; BIBEX, biomass burning experiment: impact on the atmosphere and biosphere; BATREX, biosphere–atmosphere trace gas exchange; BATGE, biosphere–atmosphere trace gas exchange in the tropics: influence of land use change; CARBICE, carbon dioxide intercalibration experiment; CCMI, chemistry–climate model initiative; CACR, Commission on Atmospheric Chemistry and Radiation; DEBITS, deposition of biogeochemically important trace species; APARE, East Asia–North Pacific regional experiment; EXPRESSO, experiment for regional sources and sinks of oxidants; FOS/DECAFE, fire of Savannas/dynamics and atmospheric chemistry in the equatorial forest; ACE-1, first aerosol characterization experiment; FAA, focus on atmospheric aerosols; GLOCHEM, global atmospheric chemistry survey; GEIA, global emissions initiative; GHOST, global HO systematic tests; GIM, global integration and modeling; GLOCARB, global tropospheric carbon dioxide network; GLONET, global tropospheric ozone network; HESS, high-latitude ecosystems as sources and sinks of trace gases; IDAF, IGAC/DEBITS/Africa; ITCT-2k2, intercontinental transport and chemical transformations 2002; IAPSO, International Association for the Physical Sciences of the Oceans; IAMAS, International Association of Meteorology and Atmospheric Sciences; iCACGP, international Commission on Atmospheric Chemistry and Global Pollution; IGBP, International Geosphere-Biosphere Programme; IGAC, International Global Atmospheric Chemistry Project; ITOY, International Tropospheric Ozone Years; IUGG, International Union of Geodesy and Geophysics; JOSIE, Jülich ozone intercomparison experiment; MAGE, Marine aerosol and gas exchange; MLOPEX, Mauna Loa observatory photochemistry experiment; MOZAIC, measurements of ozone in airbus in-service aircraft; MAC, multiphase atmospheric chemistry; NASA, National Aeronautics Space Administration; NOAA, National Oceanic and Atmospheric Administration; ITCT 2004, New England air quality study 2004; NOMHICE, nonmethane hydrocarbon intercomparison experiment; ACE-2, North Atlantic regional aerosol characterization experiment; NARE, North Atlantic regional experiment; PEACE, Pacific exploration of Asian continental emissions; PEM-West A, Pacific exploratory mission-west A; PEM-West B, Pacific exploratory mission-west B; PASC, polar atmospheric and snow chemistry; POLARCAT, polar study using aircraft, remote sensing, surface measurements and models of climate, chemistry, aerosols and transport; RCEI, reactive chlorine emissions inventory; RICE, rice cultivation and trace gas exchange; TROPOZ-II, second tropospheric ozone campaign; STARE, south tropical Atlantic regional experiment; SAFARI, Southern African fire/atmospheric research initiative; TRAGEX, trace gas exchange: mid-latitude terrestrial ecosystems and the atmosphere; TRACE-A, transport & atmospheric chemistry near the equator-Atlantic; TARFOX, tropospheric aerosol radiative forcing observational experiment; TRAGNET, U. S. trace gas network; NSF, US National Science Foundation; WMO, World Meteorological Organization.

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1. Introduction

Human emissions of pollutants into the atmosphere have caused dramatic transformations of the Earth system, altering air quality, climate and nutrient flows in every ecosystem. These alterations suggest that we have entered a new geological epoch, the Anthropocene. The effects of human emissions are manifold:

- Air quality has a major impact on public health and ecosystems (UNEP/WMO, 2011; OECD, 2012; WHO, 2014):
- Changing atmospheric composition is driving climate change (IPCC, 2013):
- The atmospheric transport and deposition of Saharan dust to the Amazon determines the amount of phosphorus in this vital ecosystem (Artaxo et al., 1990; Koren et al., 2006; Ansmann et al., 2009; Bristow et al., 2010; Yu et al., 2015 and references therein).

The atmosphere is the integrator of the Earth system. Understanding the global atmosphere requires an organization to create an international network of scientists to provide the intellectual leadership in areas of atmospheric chemistry that must be addressed, promoted, and that would benefit from research across disciplines and geographical boundaries. Acknowledgement of this need led to the formation of the International Global Atmospheric Chemistry (IGAC) Project.

The origins of the International Global Atmospheric Chemistry (IGAC) project date back to the 1950s, when the International Association of Meteorology and Atmospheric Sciences (IAMAS) of the International Union of Geodesy and Geophysics (IUGG) initiated the Commission on Atmospheric Chemistry and Radiation (CACR), which was later renamed the international Commission on Atmospheric Chemistry and Global Pollution (iCACGP). At the fifth iCACGP Symposium in 1983, a committee was appointed to explore the sponsorship of an international research program on atmospheric chemistry. A parallel effort began in 1981 when a number of atmospheric chemists and meteorologists wrote a letter to the US National Science Foundation, urging the government to support the development of a coordinated study on global tropospheric chemistry. This effort resulted in a 1984 report of the U.S. National Research Council, entitled *Global Tropospheric Chemistry: A Plan for Action* (National Research Council (NRC), 1984). The report recommended that, "The US undertake a cooperative research effort with other countries in investigating the chemistry of the global troposphere."

As a result of these two simultaneous efforts, a meeting was held in 1988 in Dookie, Australia, on the formation of the International Global Atmospheric Chemistry (IGAC) Project (Fig. 1). Participants defined the initial six foci that would serve as the foundation of the first phase of IGAC. The six foci were: (1) Natural variability and anthropogenic perturbations of the marine atmosphere; (2) Natural variation and anthropogenic perturbation of tropical atmospheric chemistry; (3) The role of polar regions in the changing atmospheric composition; (4) The role of boreal regions in changing atmospheric composition; (5) Global distribution, transformations, trends and modeling; and (6) International support activities. In 1990, IGAC officially became a core project of the International Geosphere-Biosphere Programme (IGBP) and iCACGP (Galbally, 1989), with its International Project Office (IPO) located in and funded by the US National Science Foundation (NSF), National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration (NASA).

Throughout IGAC's rich 25-year history, the scientific foci have evolved in ways that reflect how the field of atmospheric chemistry has matured. The first phase of IGAC, 1990–1999, focused on understanding the chemistry of the natural atmosphere. In its second phase, 2000–2010, IGAC fostered scientific collaborations that built upon our understanding of the natural atmosphere and began to examine how human emissions were impacting atmospheric chemistry and composition from local to global scales. In its third and current phase, IGAC's mission is to "facilitate

Fig. 1. Participants of the 1988 meeting in Dookie, Australia that was the formative IGAC meeting.

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