Future Directions for Global and Hemispheric Cooperation

IGAC & IGBP

Prof. Paul S. Monks - IGAC co-Chair
IGAC: International Global Atmospheric Chemistry project

IGAC’s role in Earth System Science is to:

- **determine global distributions** of chemical species in the atmosphere & **document their changing concentrations** over time;

- provide **understanding of the processes** that control the distributions of atmospheric chemical species and their **impact on global change and air quality**;

- **improve our ability to predict** the chemical composition of the atmosphere over the coming decades by integrating our understanding of atmospheric processes **with the response and feedbacks of the Earth System**.
Pollution: important interactions with biosphere, oceans, stratosphere & impacts on climate

- nano-scale
- macro-scale
- local
- regional
- global

Pollution: important interactions with biosphere, oceans, stratosphere & impacts on climate

- Year 2000
- Year 2070
- Year 2090: IPSL-Climate Model

IPCC: predicted global temperatures

Atmospheric chemistry

Long-range transport

Climate change
Science from IGAC: A look ahead!

Atmospheric Chemistry and Climate Initiative (w/ SPARC)

- Hindcasts of short-lived species
  - compare inter-model differences; test against obs

- Future Scenarios: ACC-MIP
  - coordinated with climate model MIP (AIMES)

- Vertical distributions
  - being re-defined by leads from SPARC’s CCMVal & AMMA-AC

- Bounding the Role of Black Carbon in climate
  - report expected submission for journal publication mid-summer

- Above will allow for a coordinated assessment of the role of short-lived forcers in climate: input to future IPCC Assessments

- Hindcasts & Vertical distributions exercises will contribute to future WMO Ozone Assessments.
“Bounding the Role of Black Carbon in Climate”

- Summarize state of the science of BC as a climate forcing agent and, specifically, the implications for mitigation decisions.
  - goal: facilitate decisions that allow co-benefits for both climate and air quality/human health

- Explain widely varying forcing estimates, esp. context of IPCC values
  - update to AR4, input to AR5

- Present bounded uncertainties for everything
  ~ especially co-emitted species & cloud changes

- Hand over usable numbers for mitigation decisions
  - assured by engaging policymakers from start

- New gold standard: delta-impact per action

- Peer-reviewed journal publication w/ SPM
Science from IGAC: A look ahead!

- **Megacities Assessment**
  - draft of many chapters complete
  - has already produced increased collaboration across national boundaries
  - WMO is co-sponsoring → will publish report as book
    → Will aid in achievement of Millenium Development goals (for air quality)

- **Aerosols, Clouds, Precipitation and Climate (w/ iLEAPS, GEWEX)**
  - Science Plan and Implementation Strategy now published
  - first ACPC activity to be planned for September, Hamburg
    → Contribution to future IPCC Assessments

- **Megacities & Coastal Zones: FTI, SI&E (with SOLAS & LOICZ)**
  - First workshop for FTI: April, Norwich UK

- **Aerosols SI&E + Air Pollution & Climate SI&E (with iLEAPS, SOLAS, AIMES...)**
  → expected to inform future IPCC Assessments as well as air quality policy decisions
Megacities - Asia (IGAC task) - rapidly increasing urban population - high pollution levels

20 µg m⁻³ WHO air quality guideline for PM₁₀ annual mean

Source: The World Bank, Development Economics Research Group Estimates

Beijing
Osaka
Tokyo
Shanghai
Guangzhou

Beijing

NO₂ column - Randal Martin

Parrish and Zhu, 2009
“World faces 'perfect storm' of problems by 2030, chief scientist to warn”

(ToString, 18th March 2009)

Would you enter the storm if you had a good forecast?
Perfect Storm

- Food
- Energy
- Climate

Atmospheric Science and Societal Need
Atmospheric Chemistry in the Earth’s System

Move towards cross-programme coordination:

- Fundamental science *(lab, models, observations)*
- Monitoring and prediction of atmospheric composition change *(for mitigation & adaptation)*
Atmospheric Chemistry in the Earth’s System

Move towards …

❖ Coordinated research programmes addressing societal needs (climate, air quality, food, water, etc.)

❖ Cross-cutting across boundaries (strat-trop, chem-bio-dynamics)

⇒ “One Atmosphere” approach
Global Environmental Change and Societal Need

- Societal Needs
  - Food Security
  - Energy
  - Climate
  - Natural Resource Security - Water
  - Health
  - Environmental Security → Ecosystem Services
  - Land-use Change
2003 summer heatwave

- In the UK, 2000 excess deaths during heatwave
- 700 may have been attributable to high levels of ozone and PM10
- 20-40% of all excess U.K. deaths

Over Europe estimates are between 22,000 and 44,000 excess deaths
The connections between AQ and Climate

- Significant climate forcing by “chemically active” species
- They are most amenable to short-term relief
- Climate Change Impact felt through Chemistry!  (e.g. change in air pollution).

IPCC AR-4 Exec. Summary
Aerosols and other AQ agents on climate

Air Quality “regulated?” aerosols are the largest factors offsetting greenhouse gas forcing!
Could climate goals be achieved, at least partially, by non-climate treaties?

Factors other than climate are also of major concerns regarding these forcing agents.

AQ and climate policies & their impacts need to be examined together and based on sound scientific knowledge.
Synergies and trade-offs between policies to improve air quality and to reduce greenhouse gas emissions

Monks et al, AENV, 2009
Planetary Boundaries


<table>
<thead>
<tr>
<th>PLANETARY BOUNDARIES</th>
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<td>Earth-system process</td>
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<td>Climate change</td>
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<td>Rate of biodiversity loss</td>
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<td>Nitrogen cycle (part of the phosphorus cycle)</td>
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<td>Phosphorus cycle (part of a boundary with the nitrogen cycle)</td>
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<td>Stratospheric ozone depletion</td>
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<td>Atmospheric aerosol loading</td>
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<td>Chemical pollution</td>
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Boundaries for processes in red have been crossed. Data sources: ref. 10 and supplementary information.
Atmospheric N₂ fixed to reactive nitrogen (N₉)

Nutrient Oxide (N₂O)

Nitrogen oxides (NOₓ)

Ammonium nitrate in rain (NH₄NO₃)

Further emission of NOₓ & N₂O carrying on the cascade

The Nitrogen Cascade

Livestock farming

Natural ecosystems

Fertilizer manufacture

Crops for food & animal feeds

Leached Nitrate (NO₃⁻)

Nitrate in streamwaters

Abatement may swap one pollutant for another in the nitrogen cascade
Ecosystems/Food – N/C coupling

Erisman et al, 2010
End to End Assessment

Earth Observation

Eg., NDVI

Crop yield

Eg., FPAR

Risk in food production

Food supply and access

Eg., Precipitation

Meteorological & hydrological data

Eg., Temperature

Risk in food security

Government Policy / Trade

Regional Financial Impact

Socio-Economic Factors

Global Food Security / Financial Impact

Agro-Ecological Factors
“The UK population is growing older. Over the last 25 years the population aged 65 and over has increased by 1.5 million (an increase from 15 per cent in 1983 to 16 per cent of the population by 2008).” ONS
Summary

• Are we ready to meet the challenges of the “perfect storm”?
  • Integrated science
  • Integrated policy
• Linkage of our science to societal benefit
  • Climate-AQ v.v. (Health)
  • AQ-Food-Ecosystems
  • Water-(Aerosol/Cloud/Precip.)-Climate
  • Energy (Future Energy, H₂, Biofuels)
• Transference of these idea into the global context (IGBP/IGAC)
• One Atmosphere - One Planet Living?
Outcomes

- Energy Independence
- Preserve Rainforests
- Sustainability
- Green Jobs
- Livable Cities
- Renewables
- Clean Water, Air
- Healthy Children
- Etc., etc.