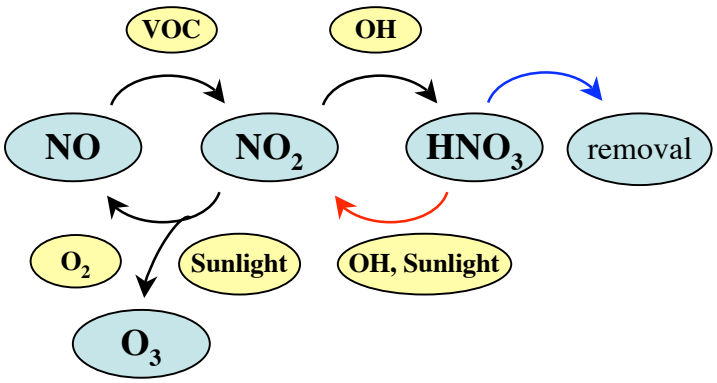
Efficient Pollution Transport Affects Remote Regions

Do urban pollutants affect air quality over the remote oceans?

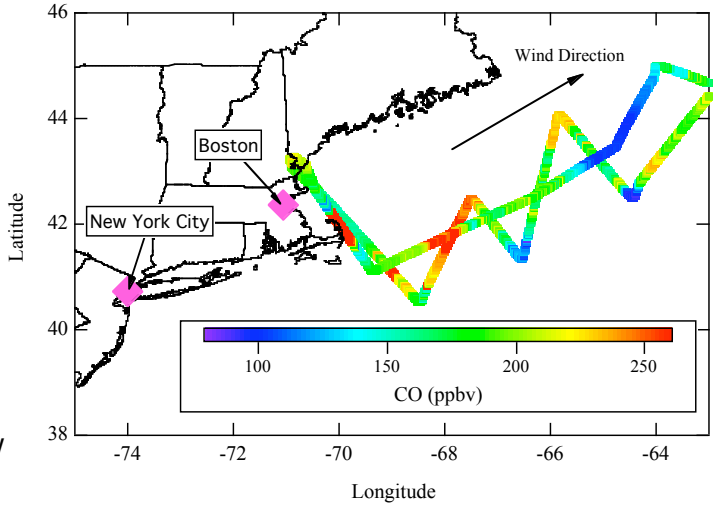
- The effects of pollutants are regionally confined if the pollutants are rapidly removed from the atmosphere.
- Over cold water, the atmosphere can become layered and plumes of pollutants can be transported without surface contact. This decoupling of plumes from the surface extends the lifetime of some compounds in the atmosphere.
- Nitric acid (HNO_3) is usually lost rapidly from the atmosphere when air encounters precipitation or surfaces. But when plumes are decoupled from the surface over the ocean, HNO_3 can build to high levels.
- The slow production of NO_2 from HNO_3 becomes important to ozone photochemistry when HNO_3 is present at high levels for extended periods.



NOx (NO and NO_2) and VOCs react in the presence of sunlight to form ozone (O_3). O_3 formation is terminated if HNO_3 formed from NOx is rapidly removed from the atmosphere by rainout or deposition to the surface (blue arrow). If HNO_3 is preserved, it can slowly reform NO_2 (red arrow) and enhance O_3 production.

What did we do during ICARTT?

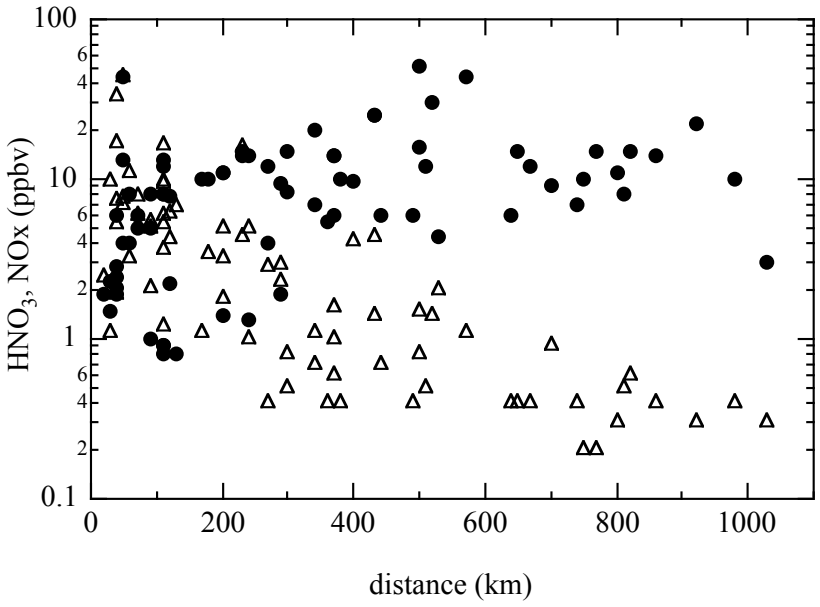
- A NOAA P-3 aircraft sampled plumes of pollutants from urban areas as they were transported over the North Atlantic Ocean.
- Plume chemistry was accurately and precisely characterized using fast-response instruments that measured both emitted trace gases (NO, CO, and others) and secondary products (HNO_3, O_3, and others) formed from chemical reactions that occurred in that atmosphere.



An aircraft flight track that measured urban plumes carried over the North Atlantic Ocean. High amounts of carbon monoxide (CO), shown in yellow and red, indicates urban pollution plumes.

What did we learn?

- Plumes of pollutants were frequently observed between 160 m and 1.5 km altitude in highly stratified layers over the North Atlantic Ocean. Transport in stable layers over the ocean prevented air masses from interacting with the surface.
- In plumes transported many hundreds of kilometers, nearly all nitrogen oxides had been oxidized to HNO_3. The HNO_3 abundance was considerably higher than previously observed over the continent, since the plumes were decoupled from the surface where HNO_3 is rapidly removed.
- Plume transport over the ocean did not rapidly remove HNO_3 and consequently redistributed HNO_3 and NOx far from their urban sources.



Maximum values of HNO_3 (solid circles) and NOx (open triangles) measured in plumes over the North Atlantic Ocean versus distance from the urban source. The HNO_3 abundance was large in many plumes that were observed at lower altitudes and far from their sources on the East Coast of the United States.

What does it mean?

1. Ozone-related pollutants can survive longer in the atmosphere when they are transported in layers above the ocean. Consequently, urban areas can affect air quality far from the source and even over remote regions of the globe.
2. Nitric acid is not always a terminating step in ozone formation. Nitric acid abundance was sufficiently elevated to make a substantial contribution to NOx levels in remote regions. These elevated NOx levels allow for continuing O_3 production.
3. Some pollutants (such as nitric acid) will be eventually removed from the air when storm passage occurs, causing high levels of nitrate to be episodically deposited to the remote oceans. Ocean life in remote regions can be especially sensitive to these large nutrient inputs.

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The multi-agency ICARTT <http://www.al.noaa.gov/ICARTT/> was formed to study the sources, sinks, chemical transformations and transport of ozone, aerosols and their precursors to and over the North Atlantic Ocean. ICARTT Fact Sheets are designed to present important new science results and findings of high societal relevance to technical non-experts in the community and have been reviewed by an internal committee of peers.