



Local Air Quality

NO_x, HAPs, and PM

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Current ICAO certification



➤ Current certification requirements

- Nitrogen Oxides (NO_x) ↙ Speciation and Tradeoffs
- Carbon Monoxide (CO)
- Unburned Hydrocarbons (UHC) ↙ Hazardous Air Pollutants (HAPs): specific HC species
- Smoke Number (SN) ↙ Particulate Matter: mass, number, size; non-volatile and volatile



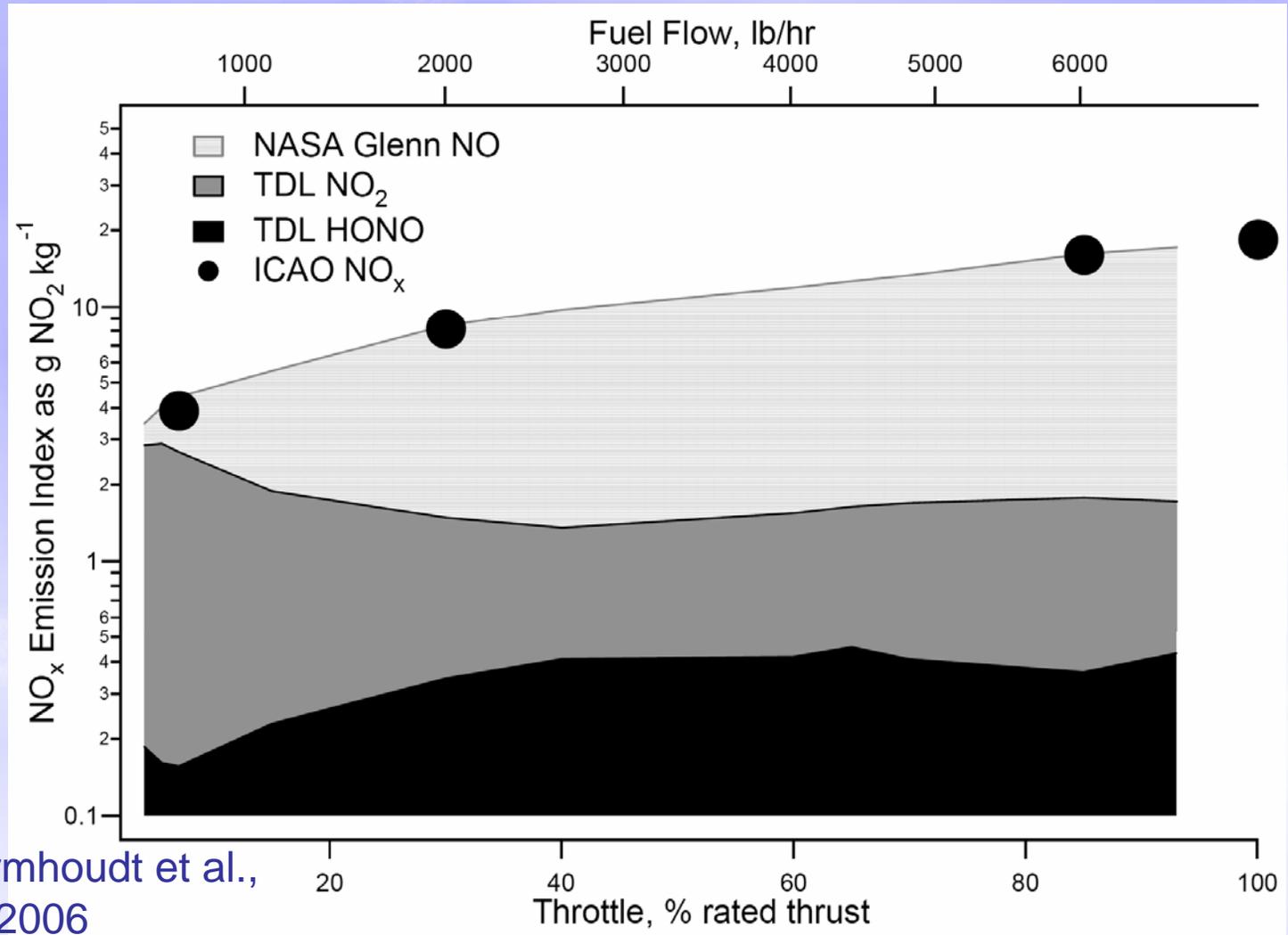
Relevant Emerging Science: Local Air Quality



- Issues related to NO_x impacts
 - NO_x speciation (NO/NO_2) versus engine power
 - Chemical evolution in the aircraft plume
 - Ozone sensitivity depends on location ...
- How NO_x enters into trade-offs
 - Impacts, metrics, costs ... site specific. Weigh aviation contribution
 - Trades versus PM:
 - non-volatile soot *and volatile*:
 - Sulfate: initially sulfuric acid
 - Organics: many different species, several sources (partially burned fuel, lube oil)
 - Trades vs UHCs and HAPs (formaldehyde, acrolein ...)
- Emission measurement issues



Speciation of NO_x : (note logarithmic scale)



APEX results: Wormhoudt et al.,
submitted to JPP 2006

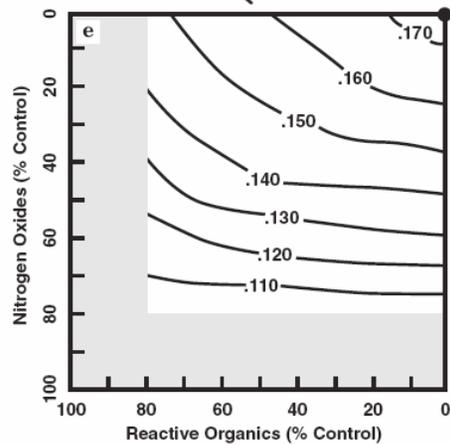
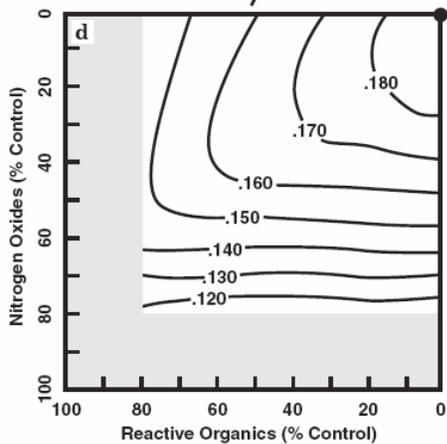
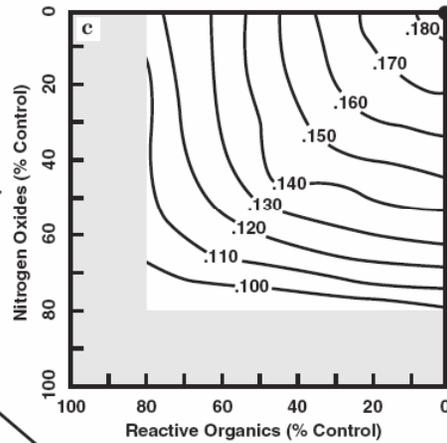
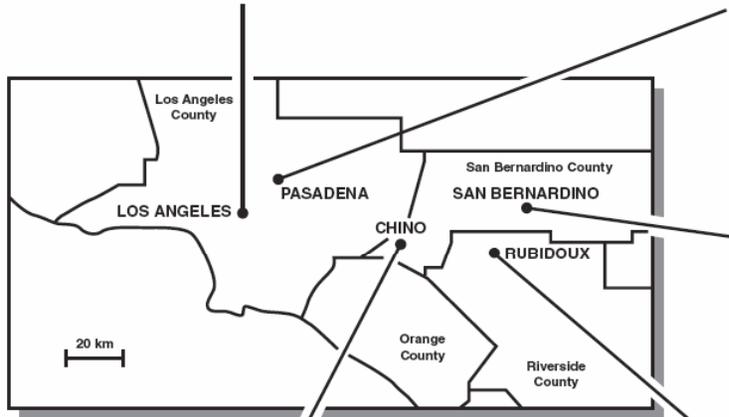
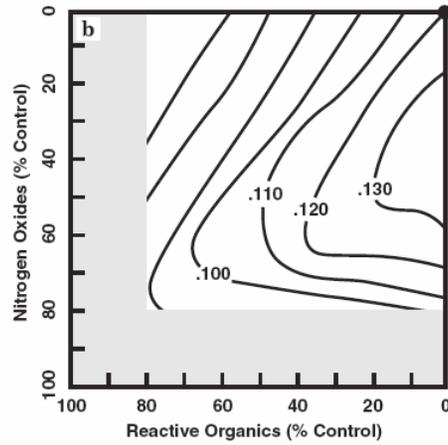
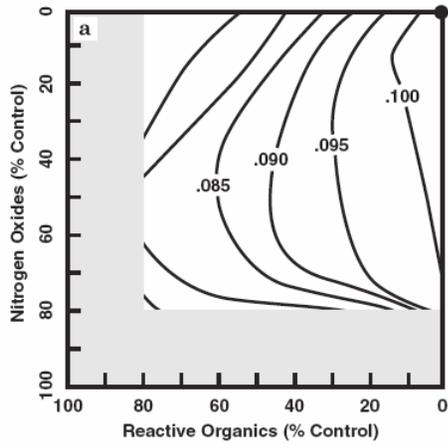


Evolution in the plume



- Changes in emissions in concentrated exhaust plume prior to dispersion into region
 - Conversion of NO to NO₂ via oxidation by O₃
 - Mixing and transport initially driven by aircraft
 - Other plume chemistry, *e.g. hydrocarbons*
- Making connection (not just NO_x) between:
 - engine exit plane measurements (*certification*)
 - deposited emissions to be used by urban and regional models (*impacts*)
- Measurement approaches, ARPs (E-31)

Ozone Isopleths: Ozone dependence on NO_x and Organics *Variations within Los Angeles Basin*



NARSTO Ozone
Assessment 2000
Chapter 3



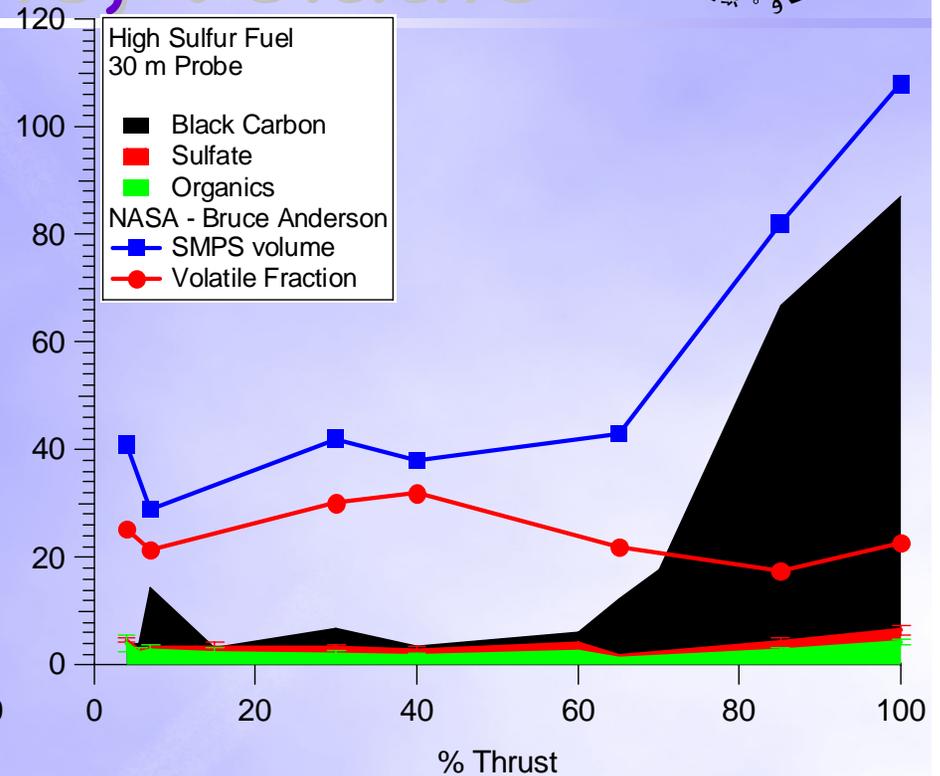
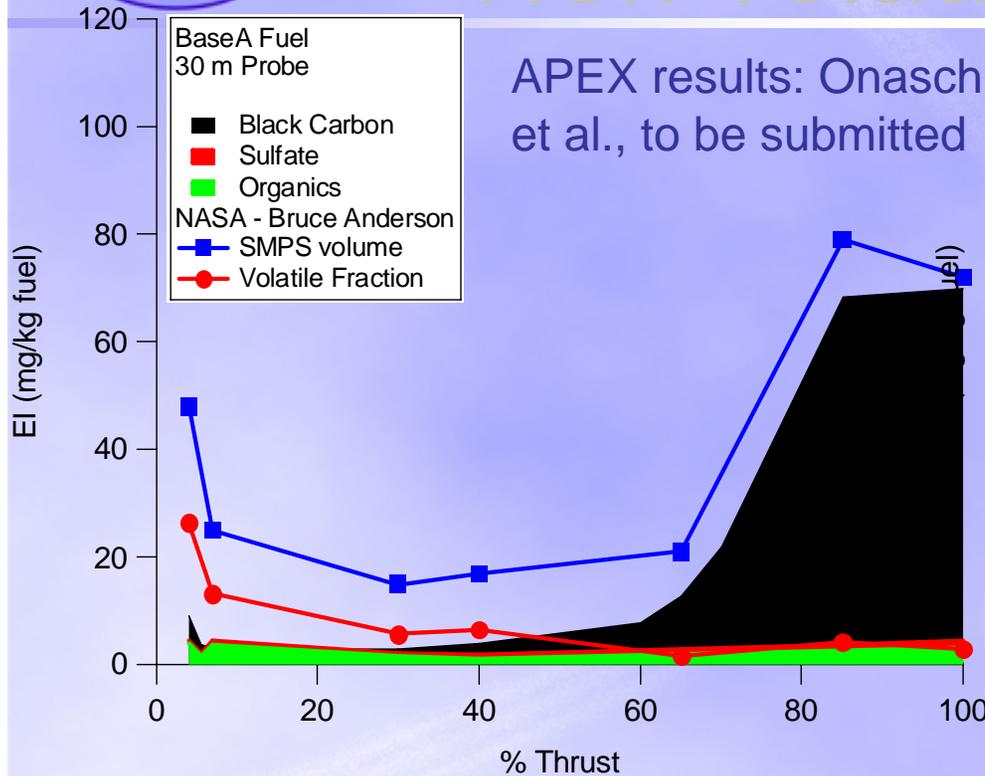
Trade-offs: LAQ NO_x versus ...



- Emissions metrics are in place (need to account for plume effects? ... speciation?)
- Impact metrics need to account for site specificity, to trade versus:
 - Other LAQ emissions impacts (CO, HCs), emerging PM and HAPs (HCHO, acrolein ..)
 - Global impact metrics, *e.g.* CO₂ as long-lived Green House Gas
- Relative contribution from aviation versus other modes of transport and other industries



Particle Emissions: Non-volatile, Volatile



- Emitted mass dominated by non-volatile particles at high power.
- Many small volatile particles form downstream, dominate numbers and mass at low power.
- Evaluation of other engines and environments underway.



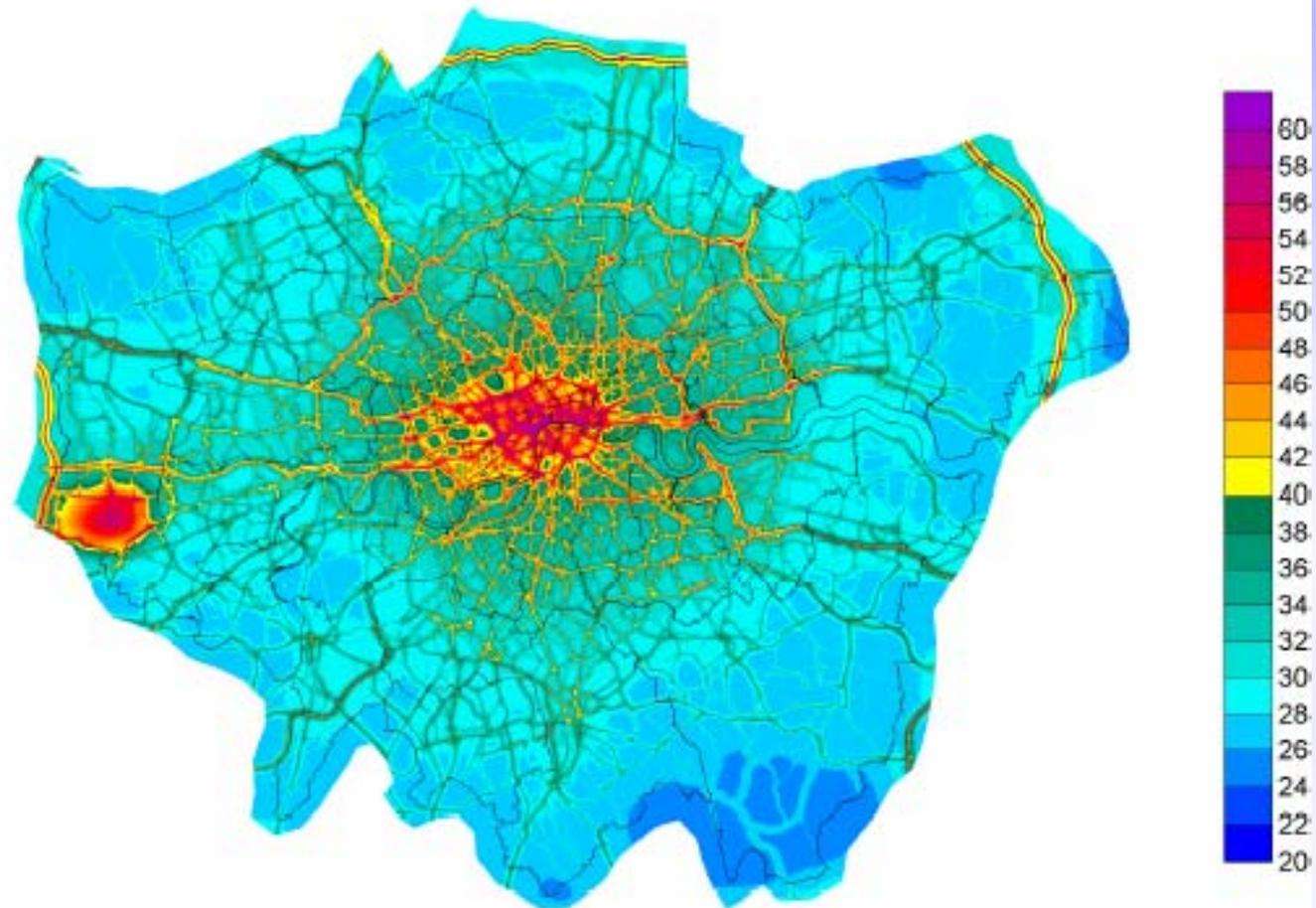
Measurement Issues



- Non-volatile PM Aerospace Information Report (AIR 5892): path to ARP
- Volatile PM:
 - In context of exit plane measurements?
 - Evolution in plume: **What is an aviation particle?**
 - How best to measure volatile particles: **Probes & Sampling!**
- E-31 and research community tackling issues
- HAPs: **What specific organics may be regulated?**
 - What impact on measurement approaches beyond UHCs (total HCs with FID detector)? Probes, instruments ...



NO₂ Emissions at Heathrow



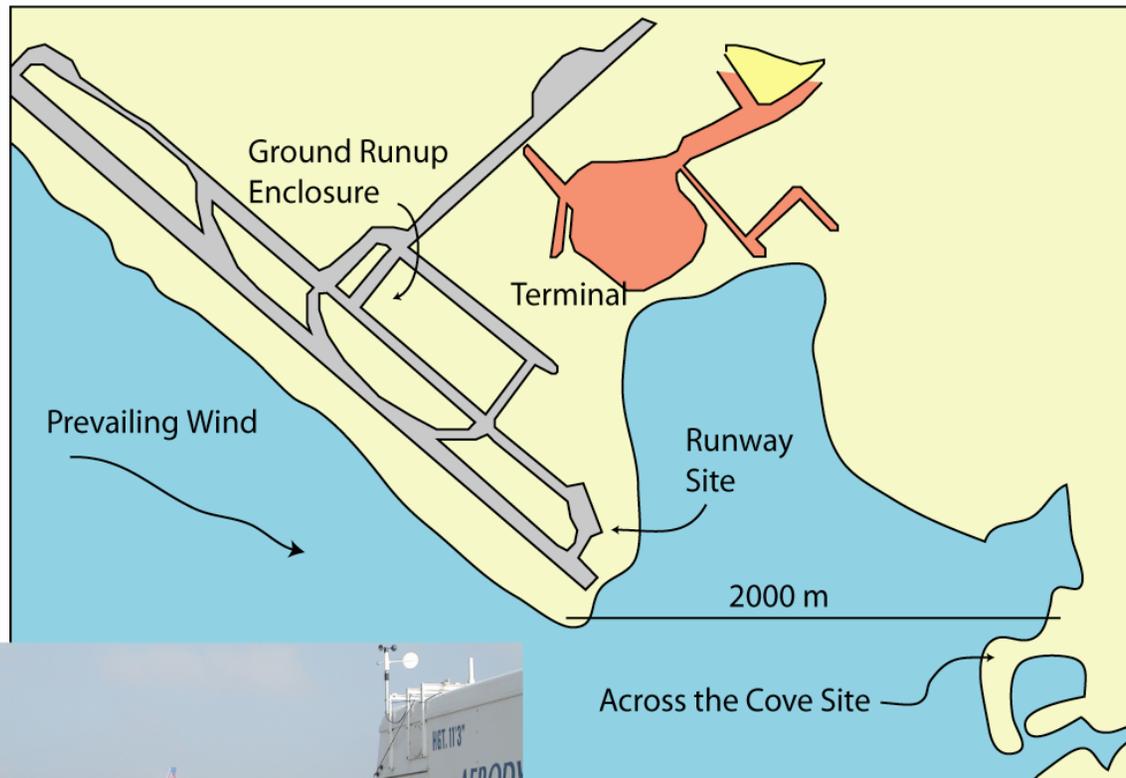
Source: Heathrow study



Measurement during routine operations



Oakland International Airport 8/2005 Measurements JETS/APEX-2



At JETS/APEX-2, GRE measurements similar to Approach II were performed. Advected plumes were sampled at the runway and across-the-cove sites.



Relevant Emerging Science: Local Air Quality



- LAQ NO_x impact metric? [Knowing emissions, plume effects] Exploring Ozone Impact Metric :
[O₃-NO_x sensitivity] X [Total NO_x reduction] X [Aviation Fraction]
- Trade-offs
 - Site specificity. What is aviation aviation contribution?
 - Trades versus PM: non-volatile (soot) and volatile
 - Trades versus HCs & HAPs (formaldehyde, acrolein ...)
 - Trades with Global Impacts: CO₂
- Measurements issues: plume effects, volatile particles, ... specific HAPs?