Nighttime Aerosol-oxidant Plume Experiment
NAOPEX Summer 2001

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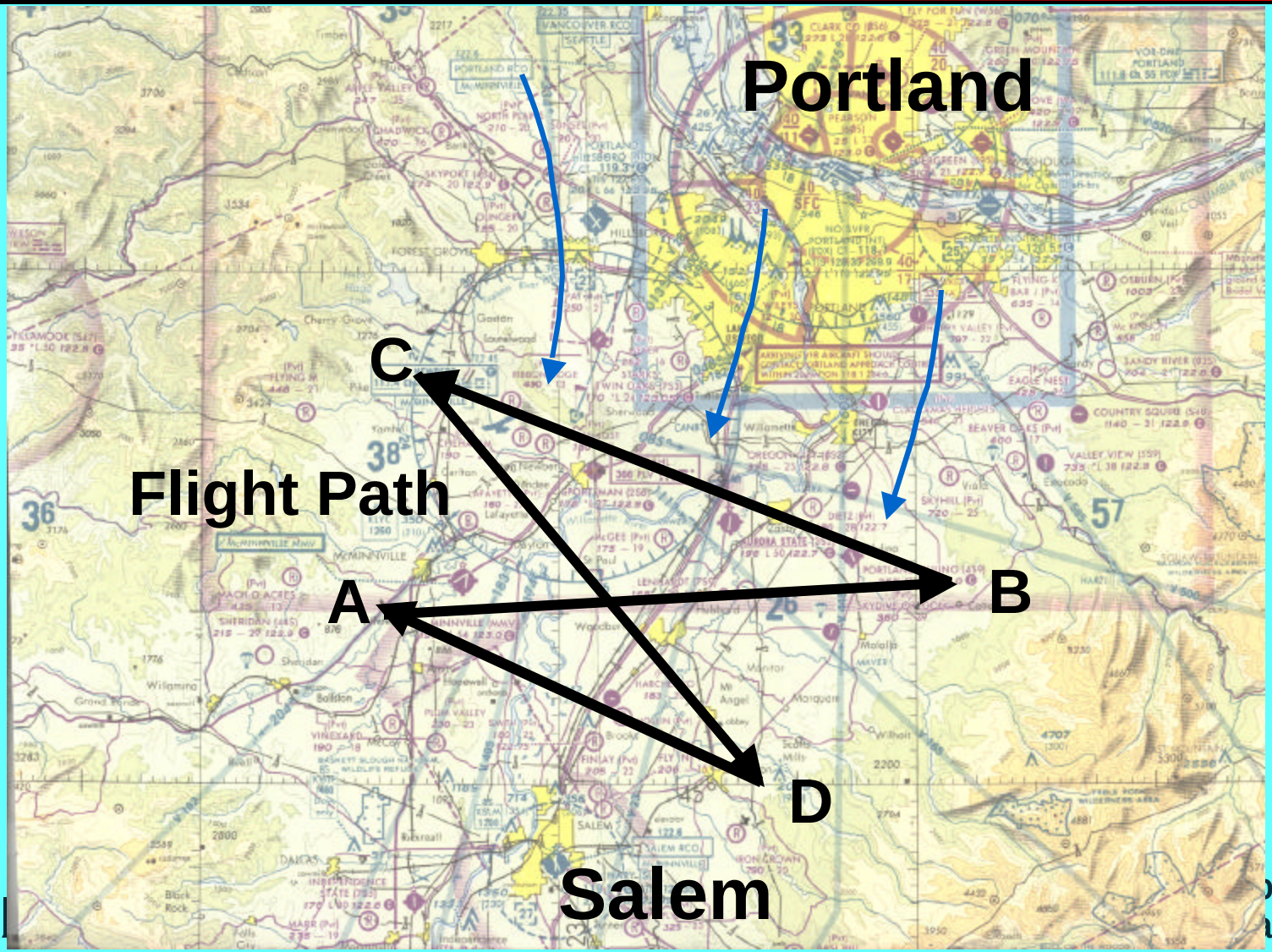
Hypotheses / Unresolved Issues

- Heterogeneous chemistry of N_2O_5, NO_3, HONO, HNO_3, O_3, etc. on ambient aerosol is still poorly understood.
  - Expected to be most significant at night when there is no photochemistry
  - Expected to be most readily observed in the absence of fresh emissions and mixing, e.g. in a nocturnal residual layer
  - Reactivity of these species on different types of ambient aerosols not well characterized
- Not included in air quality models: there are reasons to think this is a significant factor
- Nighttime transport of pollutants not well understood

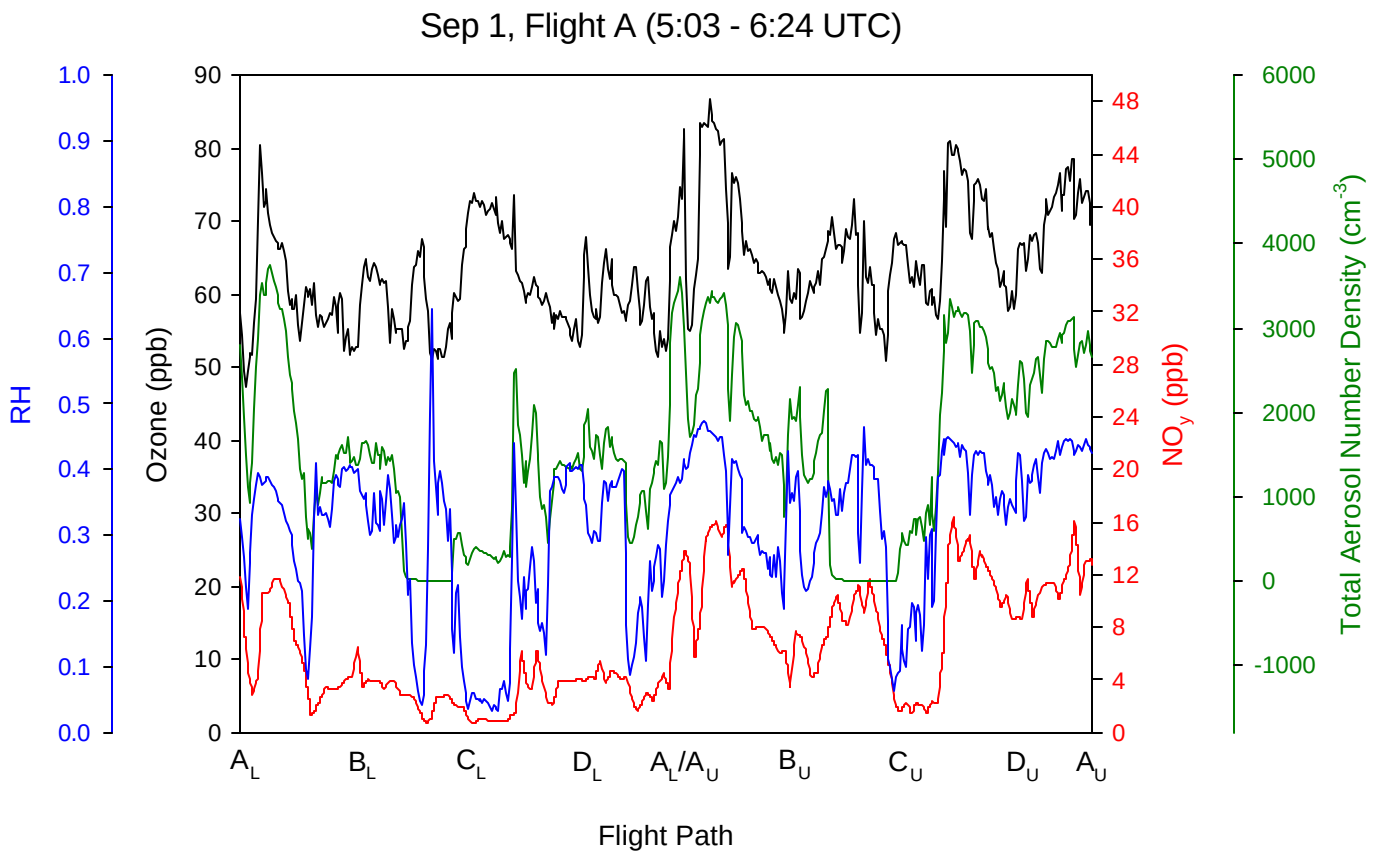
Objectives

- To better understand the nighttime chemistry of aerosols and oxidants in an urban plume
- Look for evidence for heterogeneous reactions/activity
- Evaluate the role of dispersion and mixing within the nocturnal residual boundary layer.
- Use results from the field campaign to evaluate and improve current air quality models and mechanisms
- Provide directions for future laboratory experiments involving aerosol/gas-phase interactions (e.g., what type of aerosol?)

Past Experiment: Portland 1998



After Sunset Flight



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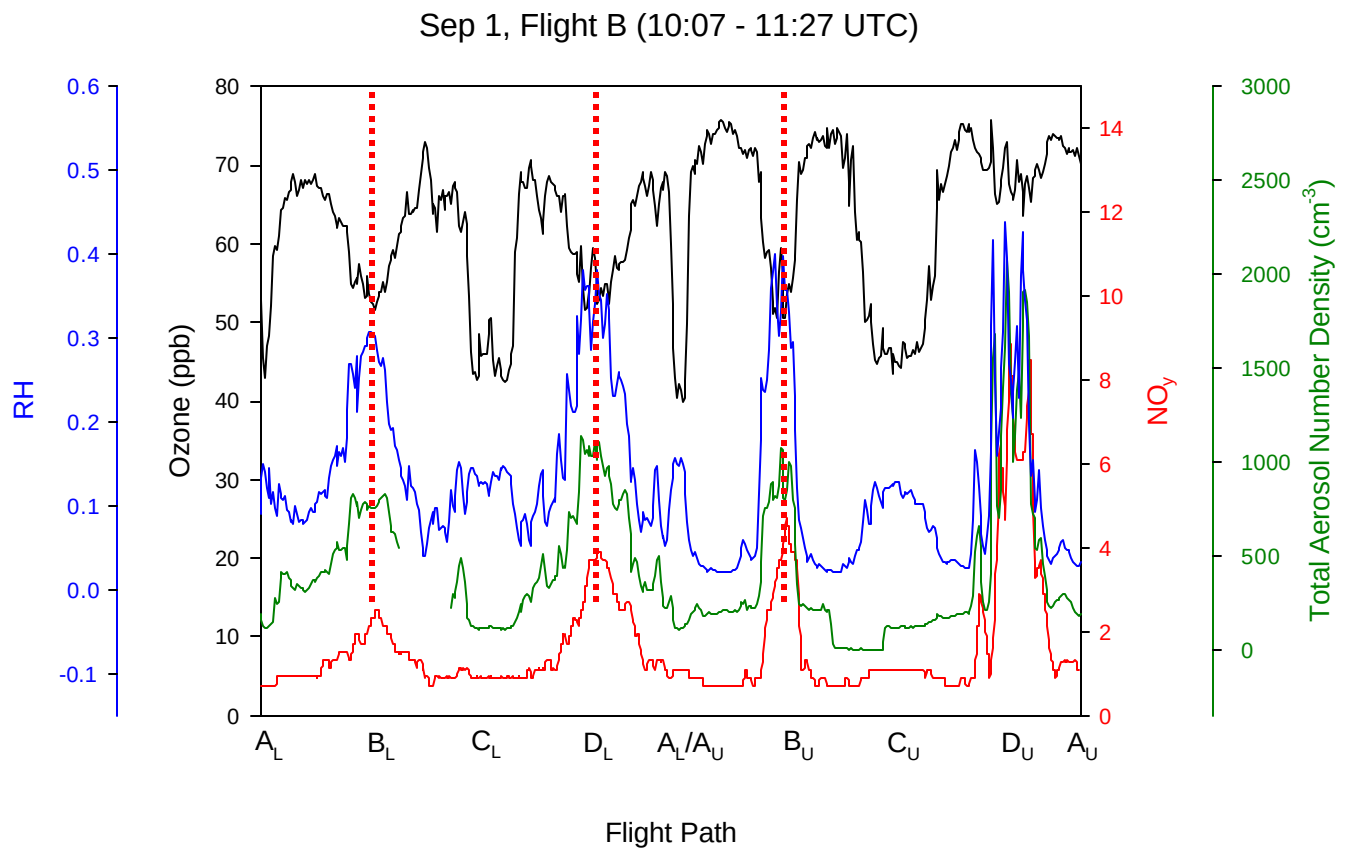
Before Dawn Flight: ozone anticorrelations… suggestive but inconclusive



Modeler's Point of View

- Snap-shot observations are difficult to model & interpret
- Need appropriate initial conditions (and boundary conditions for 3-D models)
- Need time-dependent data for model evaluation and validation
- Data must have as little uncertainty as possible
- Independent checks on data and model performance highly desirable

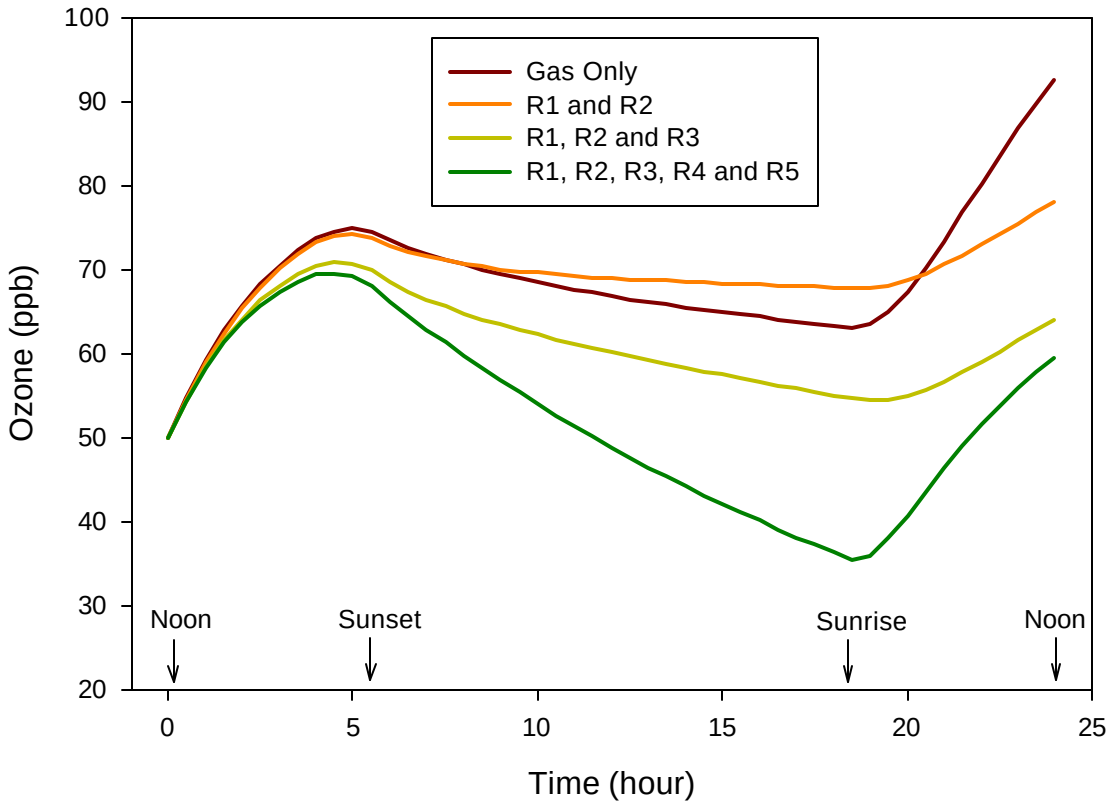
Proposed Heterogeneous Reactions

No.	Reaction	Uptake Coeff.
R1	NO_2 + aerosol sfc → 0.5 HONO + 0.5 HNO_3	$\gamma_1 = 10^{-4}$
R2	N_2O_5 + aerosol sfc → 2 HNO_3	$\gamma_2 = 0.1$
R3	O_3 + aerosol sfc →	$\gamma_3 = 10^{-4}$
R4	HNO_3 + aerosol sfc → NO_2	$\gamma_4 = 2.1 \times 10^{-2}$
R5	HNO_3 + aerosol sfc → NO	$\gamma_5 = 4.2 \times 10^{-3}$

References:

Fendel et al. (1995); Rogaski et al. (1997); Jacob (2000); Jans and Hoigné (2000); Longfellow et al. (2000)

Ozone: large differences between gas-phase and gas/aerosol time series



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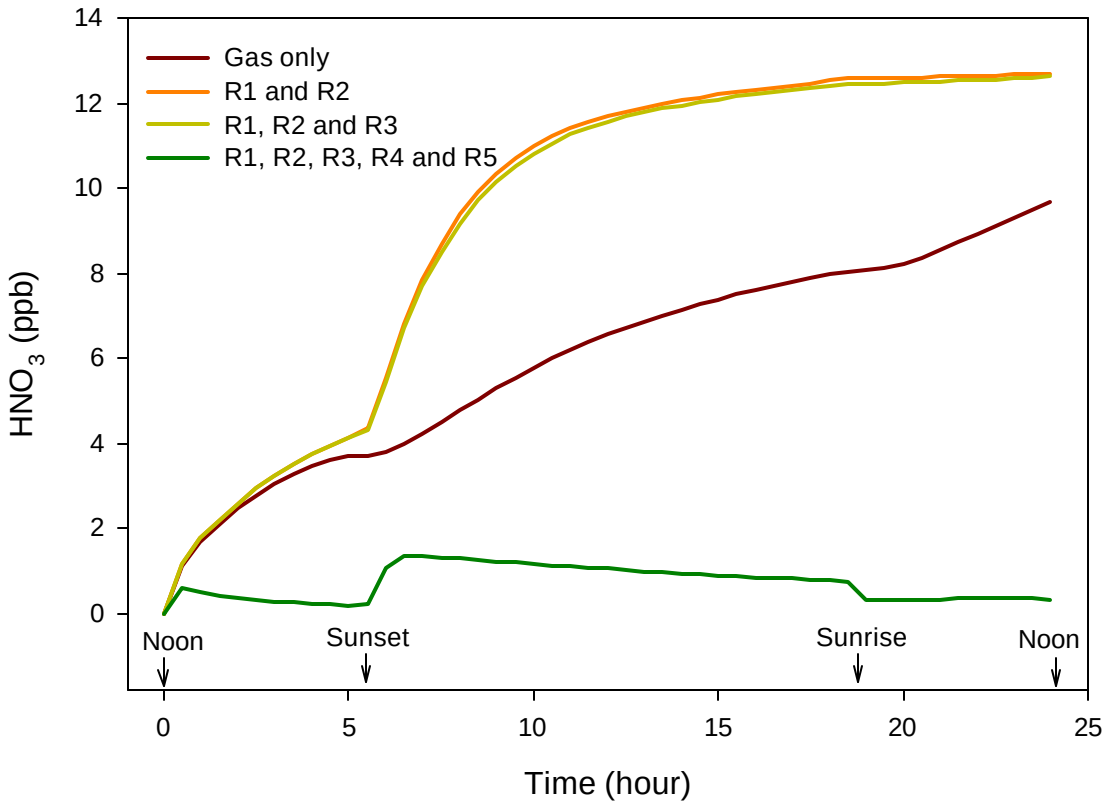
HNO_3 : large differences between gas-phase and gas/aerosol time series



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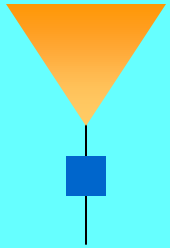
A “Perfect” Experiment

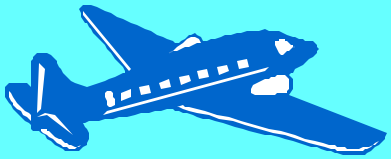
- A “perfect” experiment would consist of both:
  - Lagrangian measurements: temporal evolution of pollutants within a moving air-mass
  - Eulerian measurements: spatial distribution of pollutants within and outside an urban plume

Tetroon- and Aircraft-based Measurements

- Use constant-volume tetroons equipped with GPS as Lagrangian markers



- Use aircraft to make a series of Lagrangian and Eulerian measurements of aerosols and trace gases within a polluted nighttime residual layer that is decoupled from the surface

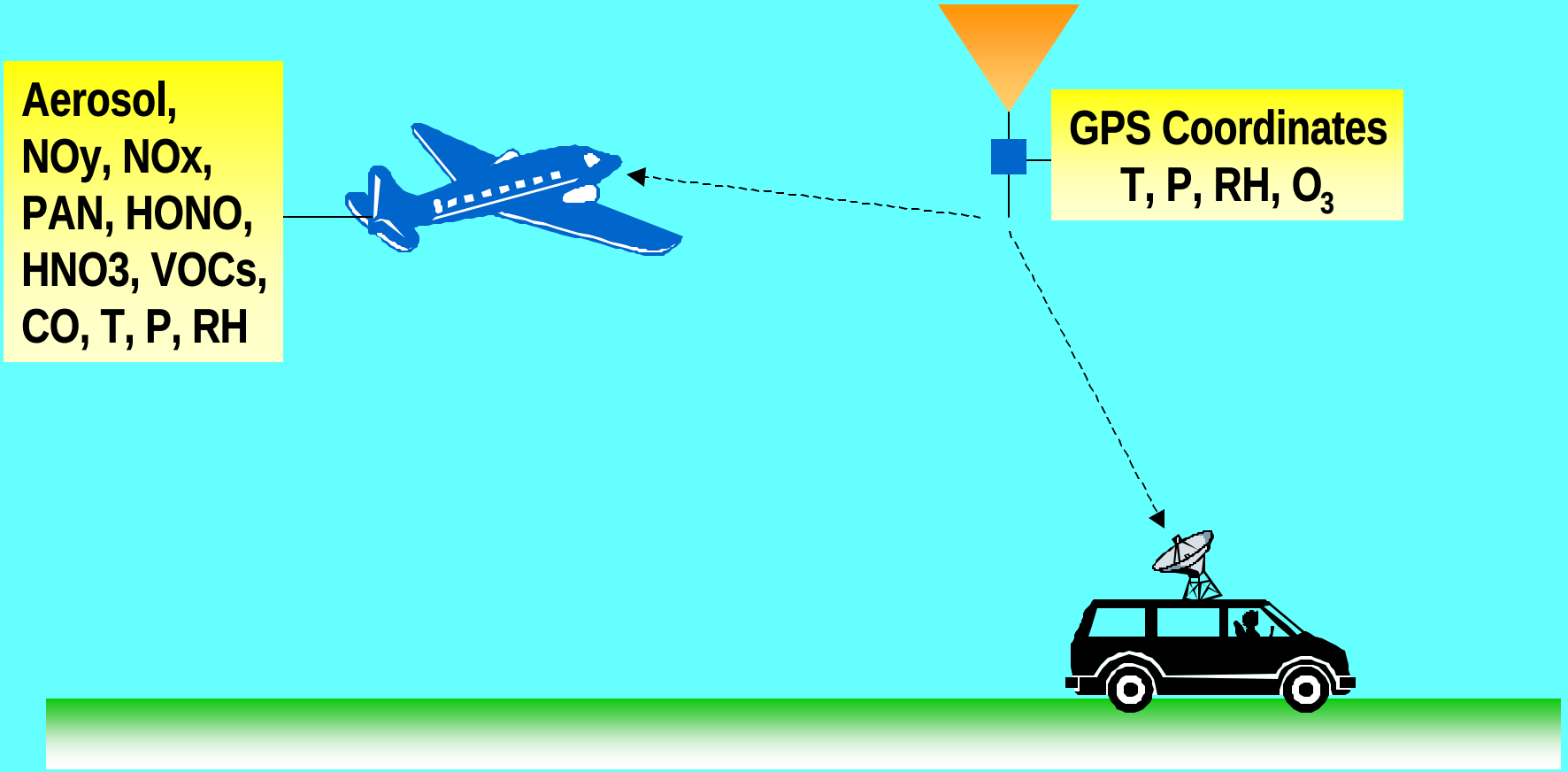


Past Success With Tetroons

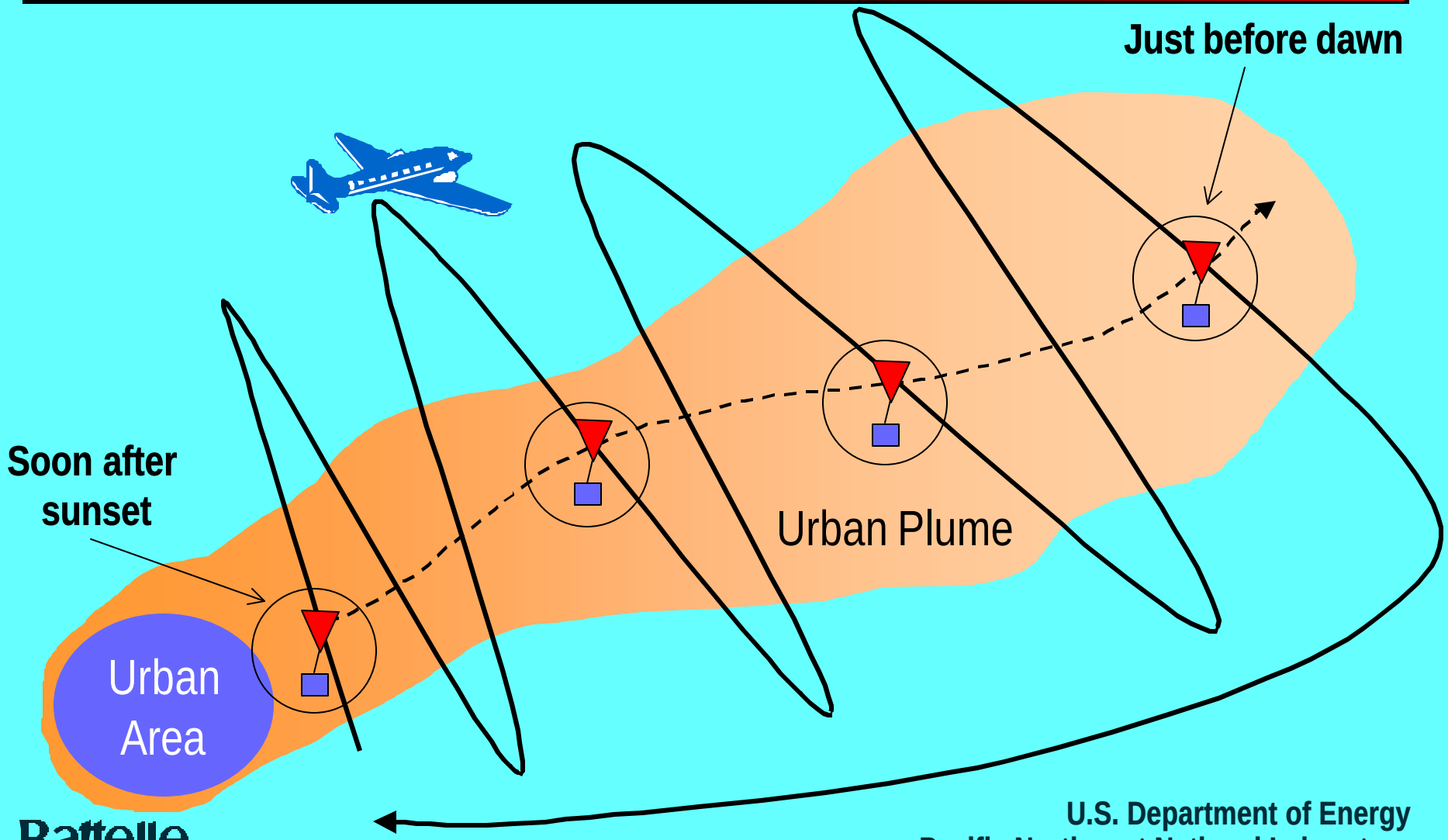
Agricultural Research Service in Texas has used tetroons in the past to track insect movement at night

Photo by Jack Dykinga, Agricultural Research Service

Lagrangian Experiment



Envisioned Flight Plan



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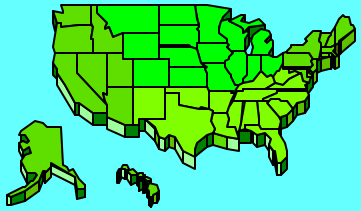
Ideal Location

- Large, isolated urban – unique plume, fewer FAA rules
- Flat terrain – easier to fly an aircraft and track tetroons
- Light winds – less turbulence and shorter tetroon tracks
- No clouds – less complications
- Low humidity – to avoid condensation on tetroons

Potential Locations



Location	Pros	Cons
Boston/ Atlantic Ocean	■ Good wind directions ■ Good logistics	■ High humidity ■ Complex flow patterns ■ Not isolated
Cleveland/ Lake Erie	■ Very good logistics (close to BCO)	■ High humidity ■ Complex flow patterns ■ Not isolated
Puerto Rico/ Atlantic Ocean	■ Isolated urban area	■ High humidity ■ Complex flow patterns
Dallas - Fort Worth/ surrounding countryside	■ Isolated urban area ■ Flat terrain ■ Low humidity ■ Good logistics	■ Low level jet (?)

Measurement Wish List

Aircraft and/or Ground

1. Aerosol
   - Size distributed number concentration (easy)
   - Size distributed composition (elemental, ionic, organic, etc.) (hard!)

2. Trace Gases
   - Ozone, CO, NH_3
   - NO, NO_2, NO_y
   - HONO, HNO_3, NO_3
   - VOCs – alkenes, alkanes, aldehydes
   - Peroxides, SO_2 (?)

3. Meteorological Variables
   - T, P, RH vertical profiles
   - Wind vectors

NAOPEX Timeline

2000

- March: Visit the tetroon manufacturing facility in Tillamook, Oregon.
- May-July: Test communications equipment in the Columbia Basin, WA.
- October-Dec: Tetroon tests in the Columbia Basin

2001

- February: Science and Review Teams meet (next ASP meeting?)
- March: Test tetroon releases (no aircraft) at the chosen site
- July-August: NAOPEX Field Campaign
- Next ASP Meeting: Data workshop/review

Administrative Issues

- Review Panel:
  - Non-participants with scientific input
- Science Team
  - UCLA: Jochen Stutz/DOAS (NO3, HONO, ….)
  - Battelle Columbus: Chet Spicer (HNO3, HONO,….)
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Summary

NAOPEX

- Lagrangian-Eulerian Experiment
- Dallas/Ft.Worth, Texas (?)
- Mid-July to mid-August, 2001
- 4 week period (plus preparation time)
- Test flights over Columbia basin