Blimps as Research Platforms

Rahul Zaveri and Tom Jobson

Atmospheric Sciences

Pacific Northwest National Laboratory

DOE Atmospheric Science Program Meeting

Albuquerque, NM, March 21, 2002

Purpose of this Talk

To explore the use of a blimp for atmospheric research

Outline

- General operating parameters for a blimp
- Scientific motivation: A modeler's point of view
- Blimps for process-oriented studies
- Potential applications and a specific example
- Previous studies with blimps
- Blimp options, costs, logistics, etc.
- Aircraft + Blimp synergism
- Other potential benefits

General Operating Parameters

- Weather: Calm and clear. BL clouds, light rain OK.
  Snow and icy conditions, thunderstorm not OK.
- Winds: max 22 mph at take-off. Survive 90 mph while moored.
- Flight Rules: VFR day or night. IFR also possible
- Locations: Urban, rural and remote with FAA permission
- Air Speed: 10 - 50 mph
- Payload: 1000 - 4000 lbs (includes fuel, crew and equipment)
- Altitude: 200 – 8000 ft msl (depends on payload and FAA)
- Endurance: 7 - 12 hrs (depends on speed, payload & altitude)
- Range: 100 – 400 miles (depends on the factors above)

A Blimp flying over the Sydney Harbor in partly cloudy conditions

Scientific Motivation

There is a clear need to:

- Better understand chemical and physical processes at different scales
- Develop, evaluate and improve process models
- Reduce uncertainties of these process modules embedded in 3-D Eulerian models

Modeler's Point of View

There is a clear need for:

- Observing spatial evolution of chemical, physical and meteorological variables at surface and aloft
- Observing temporal evolution of these variables in a Lagrangian sense: Tracking air mass history

Current Approaches

- Surface stations
  - Temporal evolution at fixed points
  - Useful for Eulerian model evaluation

- Fixed-wing aircrafts
  - Large-scale spatial distributions aloft
  - High altitude vertical profiling
  - Data useful for Eulerian model evaluation, but
  - Difficult to interpret for process studies

There is a clear need for a platform for Lagrangian type measurements for process-oriented studies

Blimps for Process-oriented Studies

A blimp would be more suitable for:

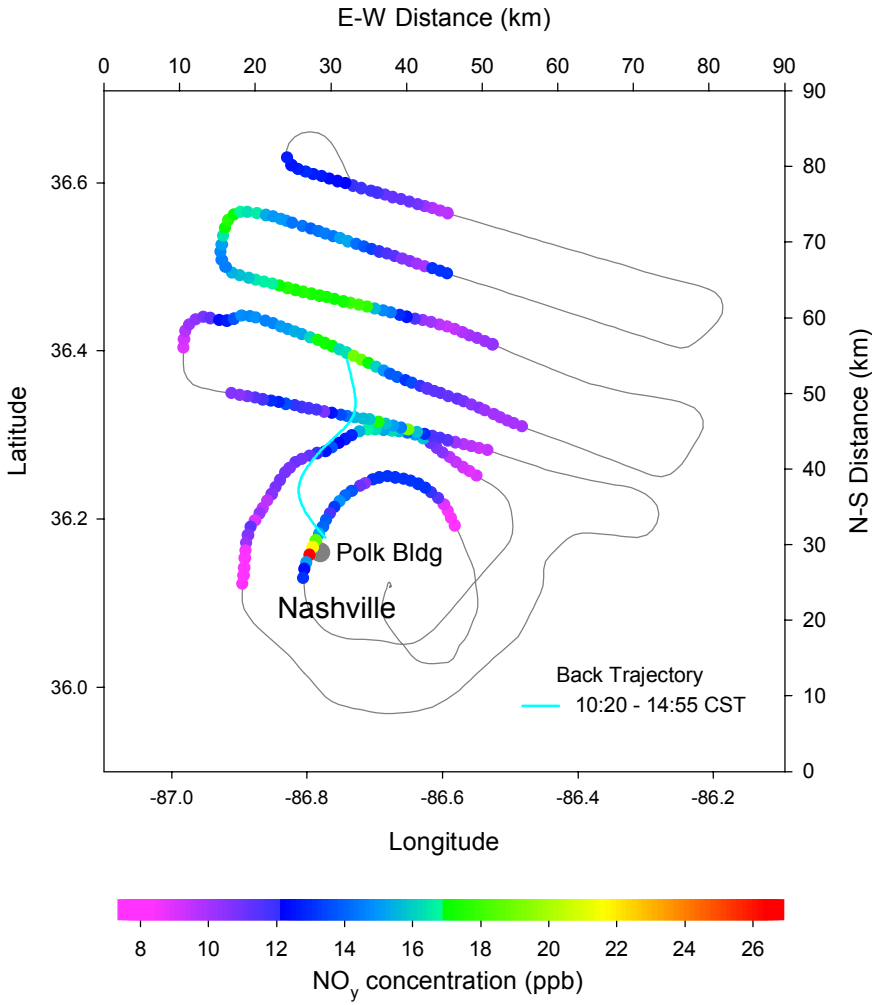
- Time evolution observations in an air mass:
  Lagrangian or semi-Lagrangian measurements
- Stationary measurements aloft for 8-10 hrs:
  "Portable tower"
- Evolution of vertical profiles downwind of localized sources,
  e.g., in urban and power plant plumes
- Measurements where low-speed minimizes sampling errors: better signal/noise ratios

Potential Applications

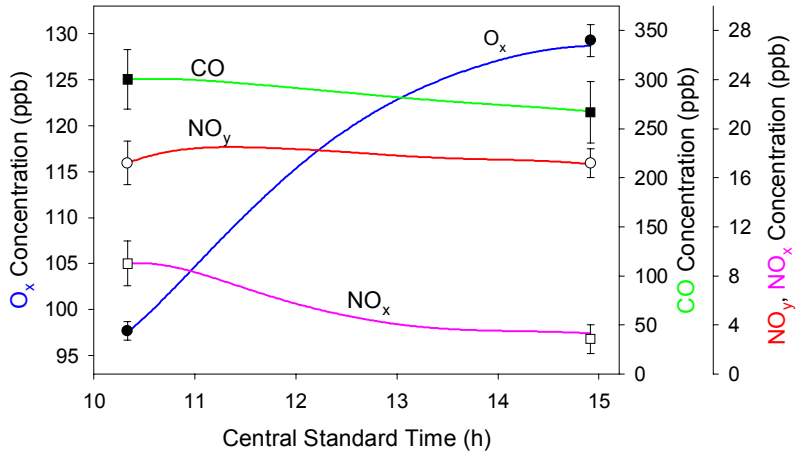
- Chemistry
  - Lagrangian evolution of trace gases and aerosols in an air mass
  - Diel cycles of trace gases and aerosols aloft over fixed locations
  - Lagrangian observation of aerosol nucleation and their precursors
- Meteorology
  - Dispersion studies using PFT tracers
  - Vertical fluxes of momentum, heat and moisture
  - High-res vertical mixing, turbulence and Eddy correlation studies
- Climate
  - Radiation measurements above and below clouds
  - Lagrangian observation of interaction of aerosols and clouds
  - Vertical profiles of aerosols and radiation
- Emissions
  - Development and verification of emission inventories
- Instruments
  - Use measurement techniques that take advantage of slow speed and low turbulence

A Specific Example: Nashville 99

G-1: Spatial Snap-shot



Lagrangian Box Model



Lagrangian measurements along the Trajectory with a blimp can help evaluate the model more effectively

Previous Studies with Blimps

Institute: Naval Research Laboratory
Lead Scientist: Bill Hoppel
Location: MBL, off Oregon coast
Years: 1992 and 1994.

Instrument Suite:

- SO_2, NH_3, O_3, NOx, H_2O_2
- DMA, PMS OPC, TSI CPC
- 3-wavelength nephelometer
- Cloud liquid water
- Aethalometer (BC)
- UV radiometer
- GPS

Key Observations:

- Cloud processing of aerosols
- Effects of ship aerosols on cloud droplet spectra
- Evidence of new particle formation

Institute: Univ. of Washington
Lead Scientist: Bill Plant
Location: MBL, off Oregon coast
Years: 1992 and 1993.

Instrument Suite:

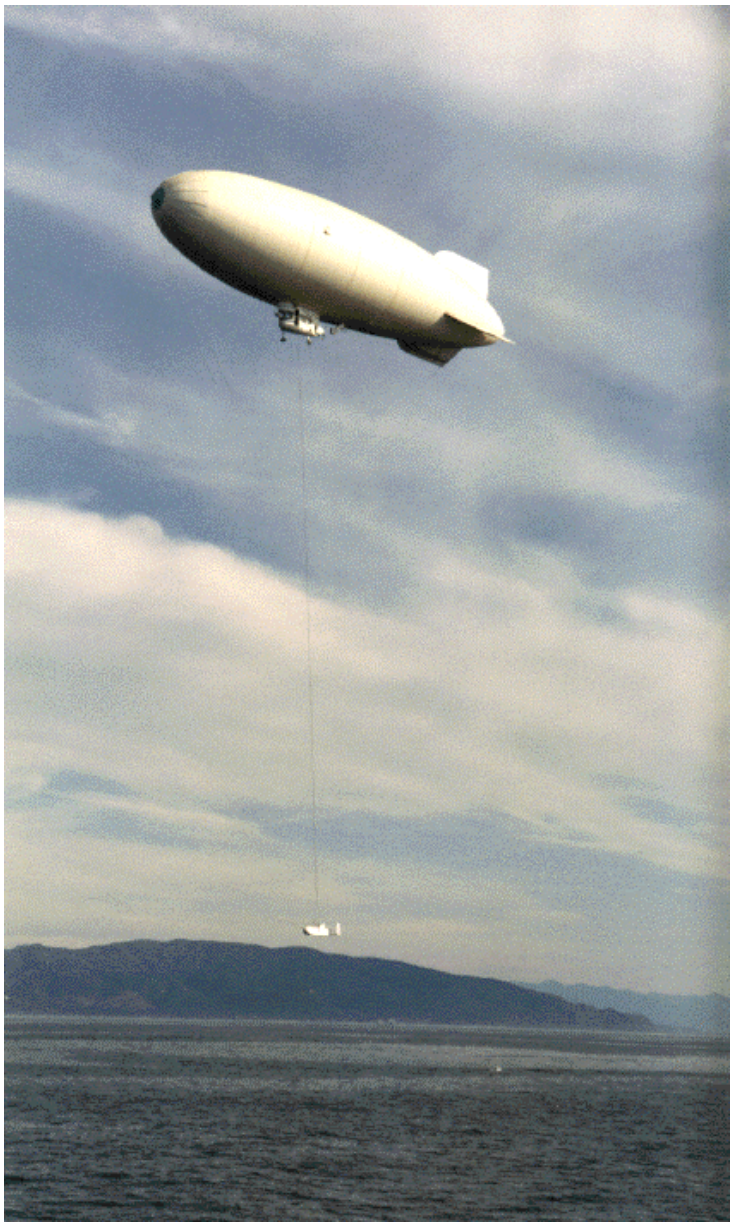
- Sonic anemometer
- Fast humidity sensor
- Laser altimeter
- IR imaging system

Key Observations:

- Atmospheric fluxes
- Microwave cross sections
- Doppler characteristics
- Turbulence
- Air and sea surface temps
- Wave heights

NRL

Univ. of Washington



References

Frick G.M. and W.A. Hoppel, 1993: Airship measurements of aerosol size distributions, cloud droplet spectra, and trace gas concentrations in the marine boundary layer, BAMS, **74**, 2195 – 2202.

Hoppel et al., 1994: Marine boundary layer measurements of new particle formation and the effects non-precipitating clouds have on aerosol size distribution, J. Geophys. Res., **99**, 14,443 – 14,459.

Frick G.M. and W.A. Hoppel, 2000: Airship measurements of ship's exhaust plumes and their effect on marine boundary layer clouds, J. Atmos. Sci., **57**, 2625 – 2648.

Plant et. al., 1998: Measurements of the marine boundary layer from an airship, J. Atmos. Ocean. Tech., **15**, 1433-1458.

Plant et. al., 1999: Air/sea momentum transfer and the microwave cross section of the sea, J. Geophys. Res., **104**, 11,173-11,191.

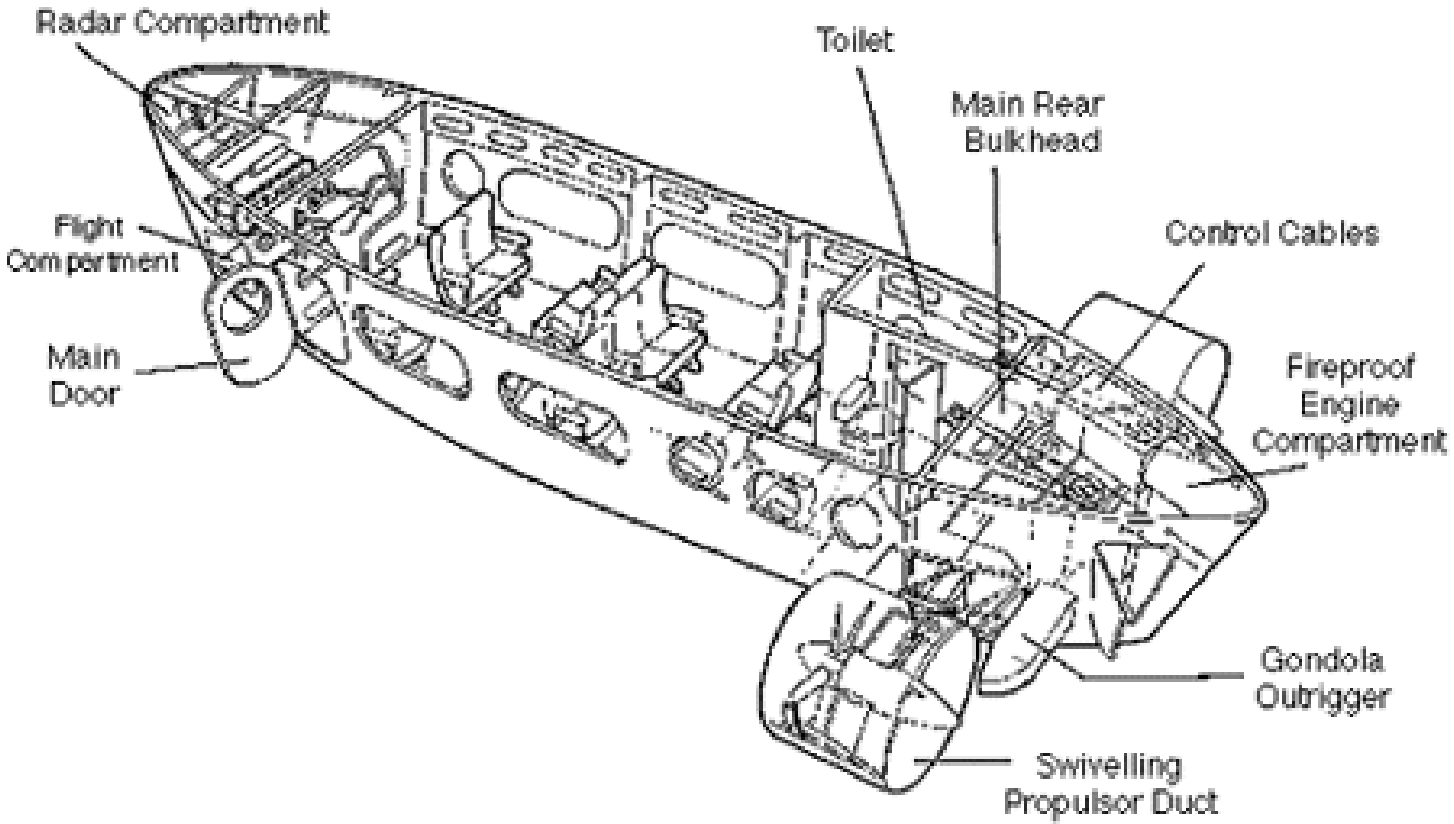
Hesany et al., 2000: The normalized radar cross section of the sea at 10 degrees incidence, IEEE Trans. Geosci. and Rem. Sens., **38**, 64-72.

Blimp Options

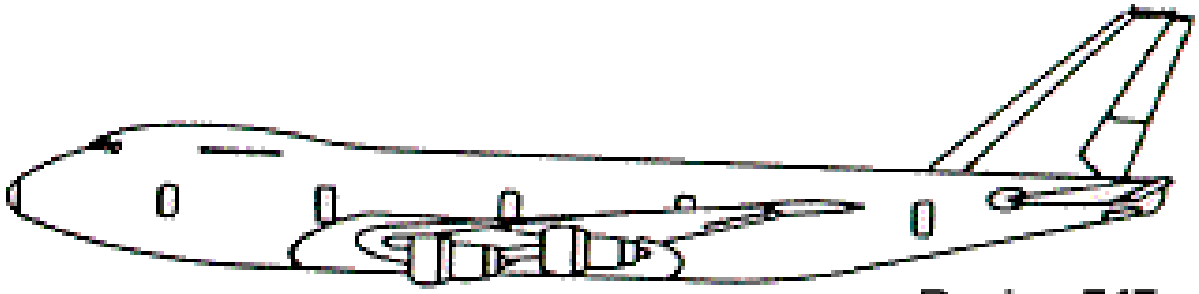
Feature	US-LTA, Oregon	American Blimp, FL	Global Skyships, FL	Fixed-wing Aircraft
Model	138S	A-150	SK-600	G-1
Payload @2K ft (lbs)	3000	3000	4000	4000
Cabin Space (sq ft)	70	70	190	165
Power (Watts)	2000*	2500*	1300*	8000
Cruising Speed (mph)	40	45	40	230
Endurance (hr)	8-10	8-10	8-10	4-5
Approx Month Lease (100 – 120 hrs)	~$250K	~$250K	~$325K	~$500K

*8 KW or more with a gasoline powered generator

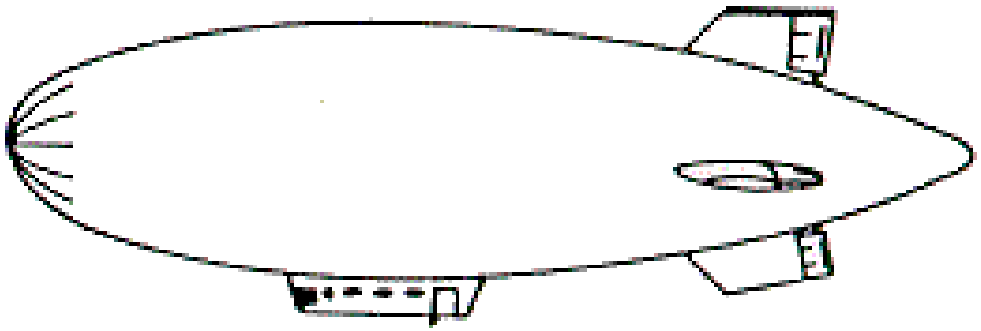
SK600 Gondola



Skyship 600 Size



Boeing 747
231'



Skyship 600
197.1'


StarHub

Blimps and FAA Regulations

- Same as fixed-wing aircraft for cabin modifications (337)
- FAA usually assigns airspace for blimp operation in urban areas
- Fewer FAA restrictions outside urban areas
- Blimp companies have a good relationship with FAA. They can get approval for special missions
- Blimps are increasingly used for
  - Police patrolling (Atlanta PD)
  - Border surveillance
  - Maritime surveillance
  - Wildlife tracking
  - Advertisements

Other Potential Benefits

- High public visibility for ASP research during field campaigns
- DOE could advertise its research on air quality and climate change on the blimp
- Partner with corporations that are willing to subsidize the lease. They can advertise on the blimp and also get more publicity by associating themselves with environmental research

Aircraft + Blimp Synergism

- Aircraft
  - Spatial distribution of pollutants
  - High altitude vertical profiles
  - Short duration, large distances
  - Spatial surveys and long-range transport studies
- Blimp
  - Time evolution of pollutants
  - Low altitude vertical profiles
  - Long duration, short distances
  - Process-oriented studies
- Result: Unique, high-quality datasets
  - Provide deeper insight into spatial and temporal behavior of pollutants
  - Allow more rigorous evaluation of process models
  - Reduce uncertainties in 3-D models

Summary

- A blimp is the platform of choice for process-oriented studies for which geographical coverage and altitude range are not of major concern
- There is a potential for synergism between aircraft and blimp
- Unique spatial and temporal observations would substantially advance the science of air pollution and climate change
- Help DOE carve a niche in process-oriented atmospheric studies
- Economics for a blimp operation appear to be favorable
- Blimps have strong visual presence. An ideal platform for advertising DOE's efforts on air quality and climate research