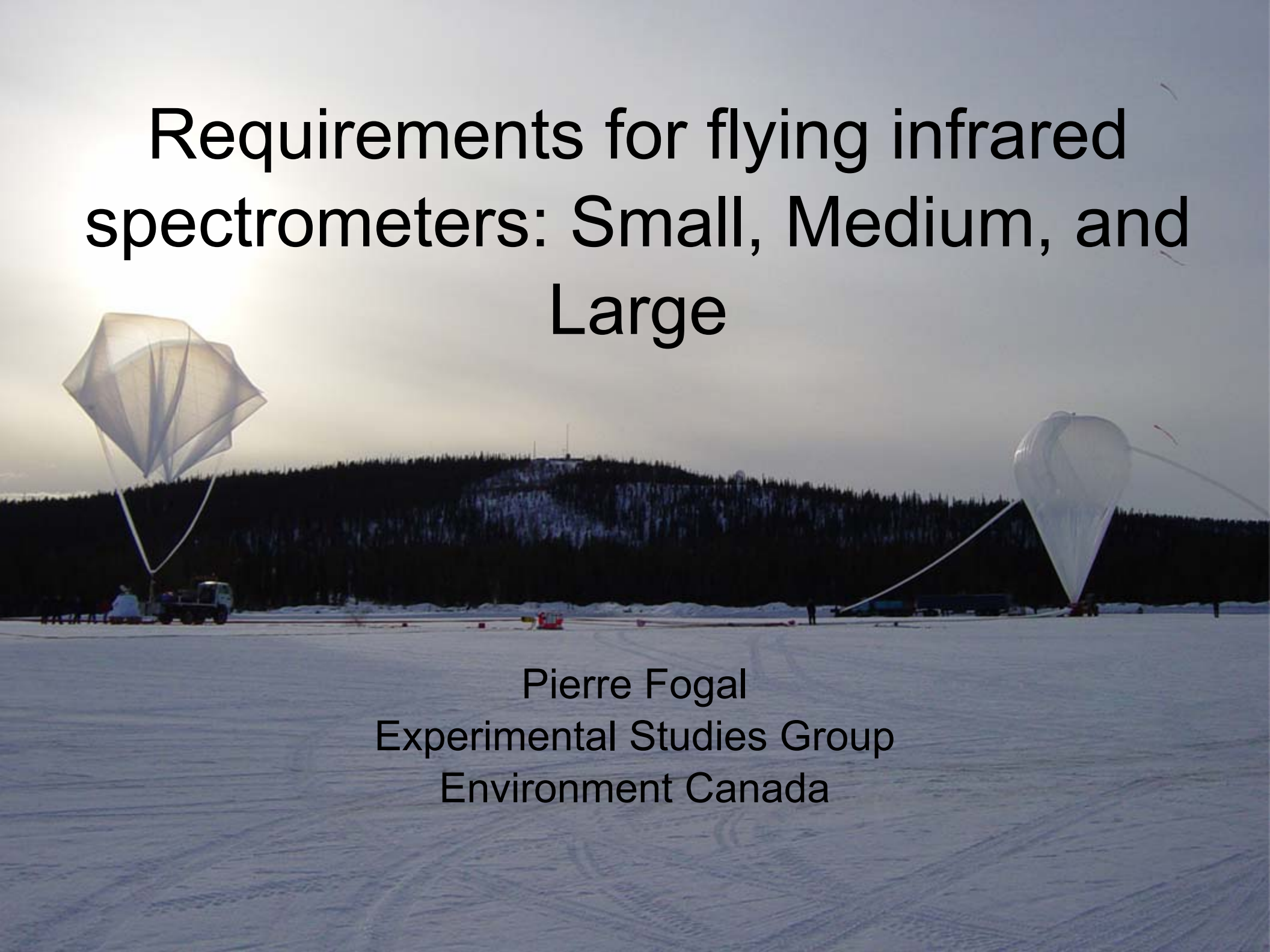
Requirements for flying infrared spectrometers: Small, Medium, and Large



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Science Case for Balloon-borne infrared spectral measurements

- The near to mid infrared spectrum (1- 15μm, 10000-667 cm^{-1}) contains spectral signatures of many, many atmospheric constituents
- One of the few techniques that can be used to study concentrations of isotopologues
- Can operate in a number of viewing geometries to derive vertical profiles:
  - Solar Occulation (solar source)
  - Limb viewing (atmospheric source)
  - Nadir viewing (planet surface or cloud source + atmosphere)
  - Long path (at 90 degrees, atmospheric source)
- Very similar in operation to satellite-based IR spectrometers so very appropriate both for validation and training
- Careful combination of above techniques would sound atmosphere from ground-level to top

A few spectrometer details

- We are talking about interferometers (FTS, FTIR) and grating spectrometers
- Infrared instruments tend to get large and therefore somewhat heavy as you move to more resolution
- They will in general require cryogens
  - Liquid nitrogen
  - Liquid helium
- May require one or more blackbody sources on gondola
- Usually require fairly high data rates (compared to many other instruments)

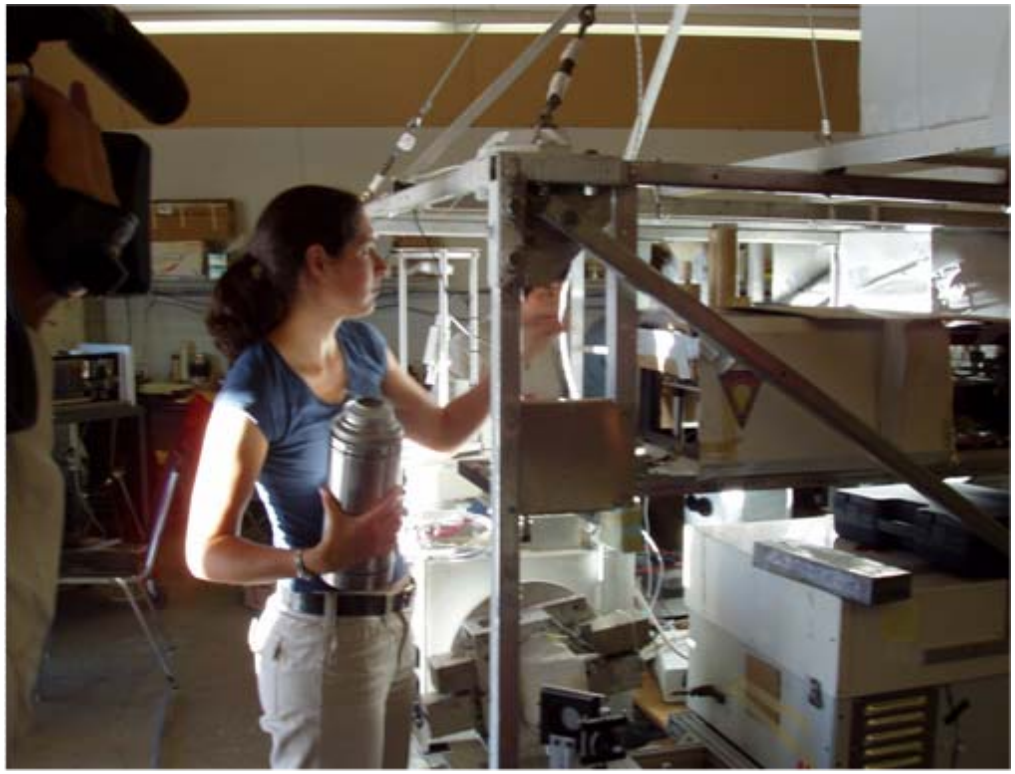
- Will require active pointing of gondola and fine pointing towards target
  - Limb
  - Sun
  - Nadir

The “Small” Case

- Exemplar is the Cold Atmospheric Emission Spectral Radiometer (CAESR) developed by the University of Denver (c. 1990)
- Grating spectrometer resolution varies from 2 to 4 cm^{-1}
- Liquid nitrogen outer jacket
- Liquid helium cooling of instrument and detector
- Size permits many flights of opportunity on other gondolas
- Approximate dimensions of 40x30x50 (cm)
- Data rate of 30 kbaud

The “Medium” Case

- Moderate resolution FTS: Bomem 0.02 cm^{-1}
- Can be major instrument on gondola, or one of two or three similar sized instruments
  - Example is MANTRA 2004 flight in which there were three FTSs + several other instruments
- Works best with its own dedicated fine pointing but input is small enough (typically ~50mm) that it can use part of a central input (if its looking at the right target)
- Approximate power requirement: 80 AH for two transition flight



- Approximate size 141x32x111 cm
- Mass: 85 kg as flown on MANTRA
- Data bandwidth required: 57 kbaud

The “Large” Case

- Bomem DA3, 0.002 cm^{-1} resolution
- Requires a dedicated gondola
  - Can host other small instruments
- Usually operates with dedicated fine pointing and in solar occultation mode
- Dimensions ~75x42x200 cm
- Gondola mass: typically 500 kg all up flight ready
- Approximate power requirement: ~100 AH
- Data bandwidth required: 115.2 Kbaud

Student Opportunities

- These are moderately complex instruments, but quite accessible with supervision
- Hardware learning opportunities:
  - Electronics (all)
  - Optics (all)
  - Thermal design (all)
  - Electro-mechanical design (all)
  - Control software including telecommand, telemetry, and autonomous operation (all)
- Balloon campaigns in and of themselves tend to be highly educational

Student Opportunities

- Spectral Analyses:
  - Can contribute to the improvement of fundamental line parameters (large)
  - Further development of retrieval techniques (all)
  - Continued scientific investigation of atmospheric reactions and reaction cycles especially through a transition (large, medium)
  - Satellite validation efforts (all)
  - Radiation balance throughout the atmosphere(small, medium)
  - Infrared signatures of aerosols(small, medium)

Schedules, Costs, etc.

- Time lines
  - Instrument preparation: Anticipated to be on the order of 2-3 people for 6-12 months
  - On-site flight preparedness: 2-3 people for 2-3 weeks
  - Student support for 1-3 students
  - Technical support
    - Lack of technical support personnel
  - On-site support costs
  - Launch costs
  - Hardware for equipment refurbishement: $15,000.00

Some opinions on Needed balloon flight capabilities

- Preferred flight profiles:
  - Target “turnaround”
  - Float at or near 36 kms or above
  - Launch times and duration of flight( ):
    - Afternoon for sunset occultation for solar measurements(6 hours one occultation, 19 hours for two)
    - Anytime for emission measurements(5-6 hours, measurements on ascent and approximately 2 hour at float to include transition)
    - Late afternoon for limb scanning measurements(16 hours, 12 hours at float)
- A Canadian launch capability that would take small to medium class instruments to 36 km for 2 transitions
- A mechanism to launch large class instruments either in Canada or elsewhere.
- Nice to have: “Mobile” launch capability, long duration capability