The LaACES Balloon Vehicle and Flight Profile

What can you do with ballooning? Access to "space"

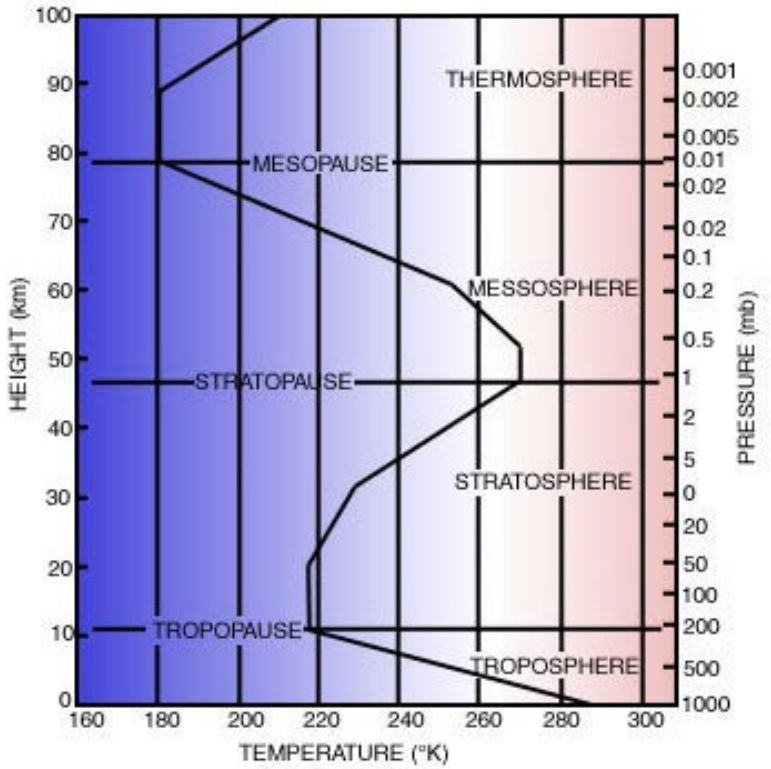

Figure showing the major layers in the Earth's atmosphere, the vertical temperature scale and pressure scale. From the MET Education Office

- Balloon vehicles typically reach altitude of 30 to 35 km
- At these altitudes the vehicle is above 99% of the atmosphere
- Absorption of Infrared, UV, X-rays and Gamma rays is significantly reduced
- Primary energetic particles (cosmic ray) can be observed
- Can test hardware in a "space" environment.

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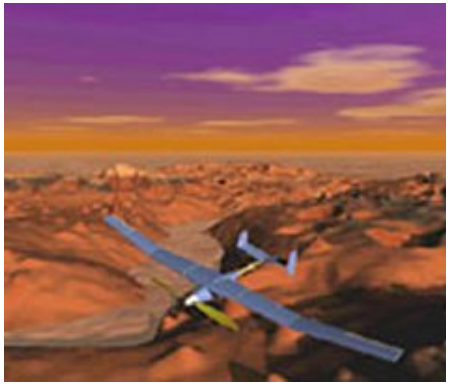
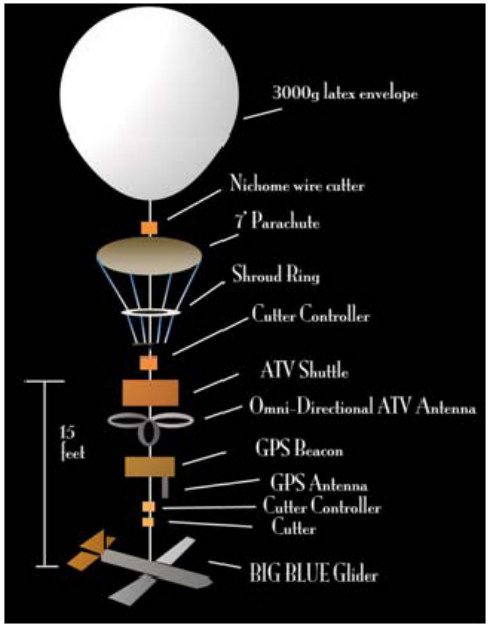
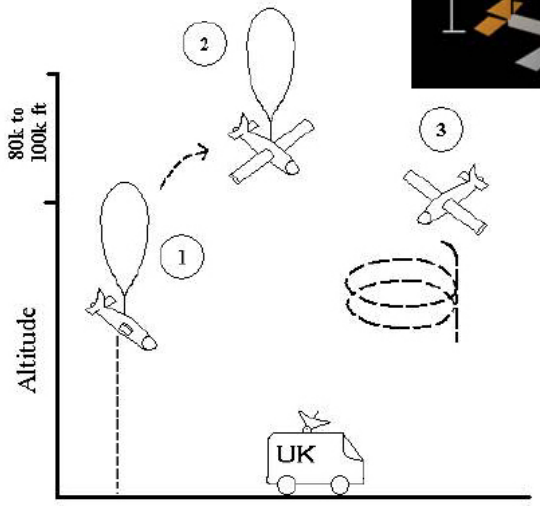
What can you do with ballooning? High Altitude / Low Pressure





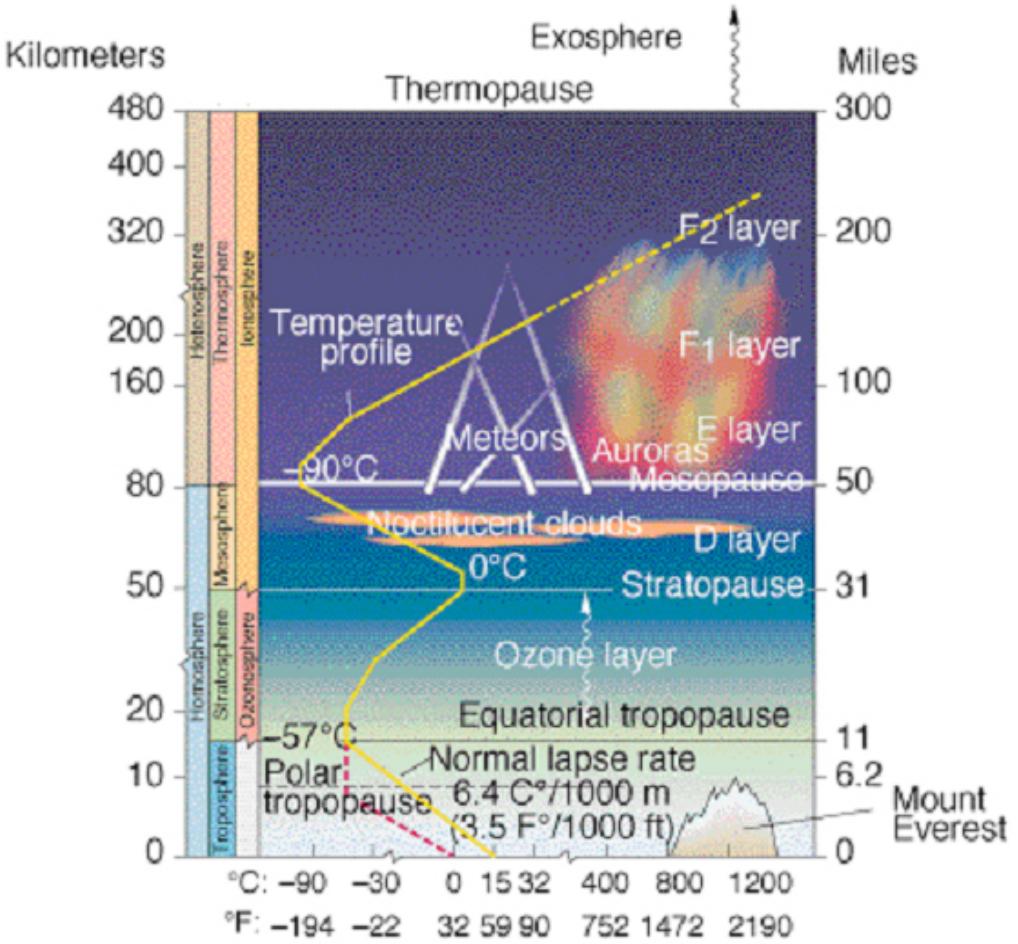


Concept of Mars airplane (above left). Courtesy of NASA. Big Blue test vehicle (above right) and flight profile (left). Courtesy of UK Big Blue

- Pressure at balloon altitudes is 5 mb to 10 mb
- Very similar to the pressure at the surface of Mars
- Test vehicles that might one day flight on Mars
- Test Mars prototype dust, biological and atmosphere composition experiments

What can you do with ballooning? In-situ Measurements

- The Earth's atmosphere has a structure & composition that is a function of altitude
- The ozone layer is a famous example
- Also dust, temperature, pressure, humidity, winds and chemical composition will vary with height
- Sampling of biological and nuclear materials for national security



What can you do with ballooning? Look-Down Remote Sensing

Image from a BOREALIS High Altitude Ballooning program student built payload. Picture was take at an altitude close to 100,000 feet and shows the Earth's surface, the atmosphere and the space. Courtesy of the BOREALIS program.

- Provide aerial view of ground from low to high altitude
- Test of sensors for possible satellite missions
- Wide area surveillance for national security

What can you do with ballooning? Many other possibilities

- Cosmic Ray Experiments
- Ozone profile
- UV profile
- CMB observation
- Particulate sampling
- Biological sampling
- Trace gas sampling
- Wind Profiles
- Temperature Profile
- Pressure Profile
- Accelerometer/Gyro
- Weight & Power Reduction Strategies
- Telemetry & Tracking
- Attitude stabilization
- Cutdown systems
- Ground Station Testing

Components of the balloon vehicle

- Latex sounding balloon
- Parachute & cut mechanism
- Primary GPS beacon
- Primary antenna
- HD Video payload
- Student payloads
- Secondary GPS beacon
- Secondary antenna
- APRS tracking beacon
- Iridium tracking beacon

Lift & Recovery Components

Filling the sounding balloon with helium prior to the ACES61 flight

- A Kaymont 2000 gm sounding balloon is used to lift
- Ascent rate is around 1000 fpm
- Total nozzle lift is ~17 pounds
- Burst altitude is about 100,000 feet

- Parachute used for recovery
- Descent rate of about 17 fps to 20 fps with a 12 pound payload

The ACES01 parachute shrouds tangled with balloon remnants

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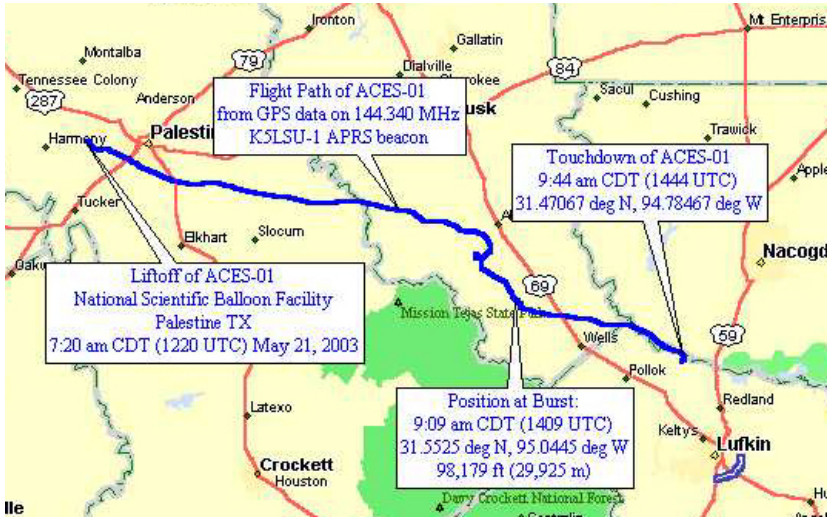
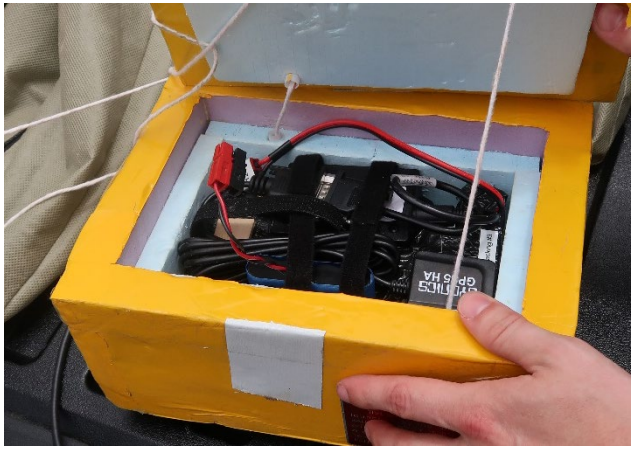
Tracking Components

- Primary & secondary GPS radio beacons used to provide real time latitude, longitude and altitude of the balloon
- Tracking required by FAA regulations
- An APRS radio beacon used to track ground location
- Iridium beacon provides tracking over the horizon

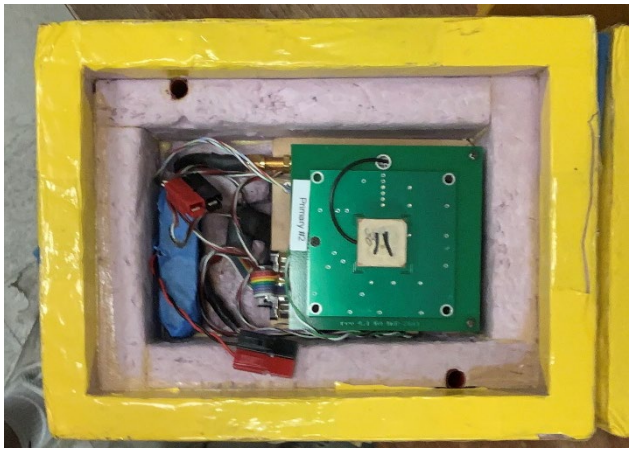


Track of the ACES01 flight during May, 2003

ACES61 Iridium Beacon



ACES61 APRS Beacon



ACES61 Primary Beacon

Vehicle Payload

- Vehicle can carry ~5.4 kg total without a FAA waiver
- Subtracting 2.5 kg for "balloncraft" leaves about 2.5 kg for payloads.
- Support 4 to 5 payloads per flight, so each payload is limited to about 500 grams weight

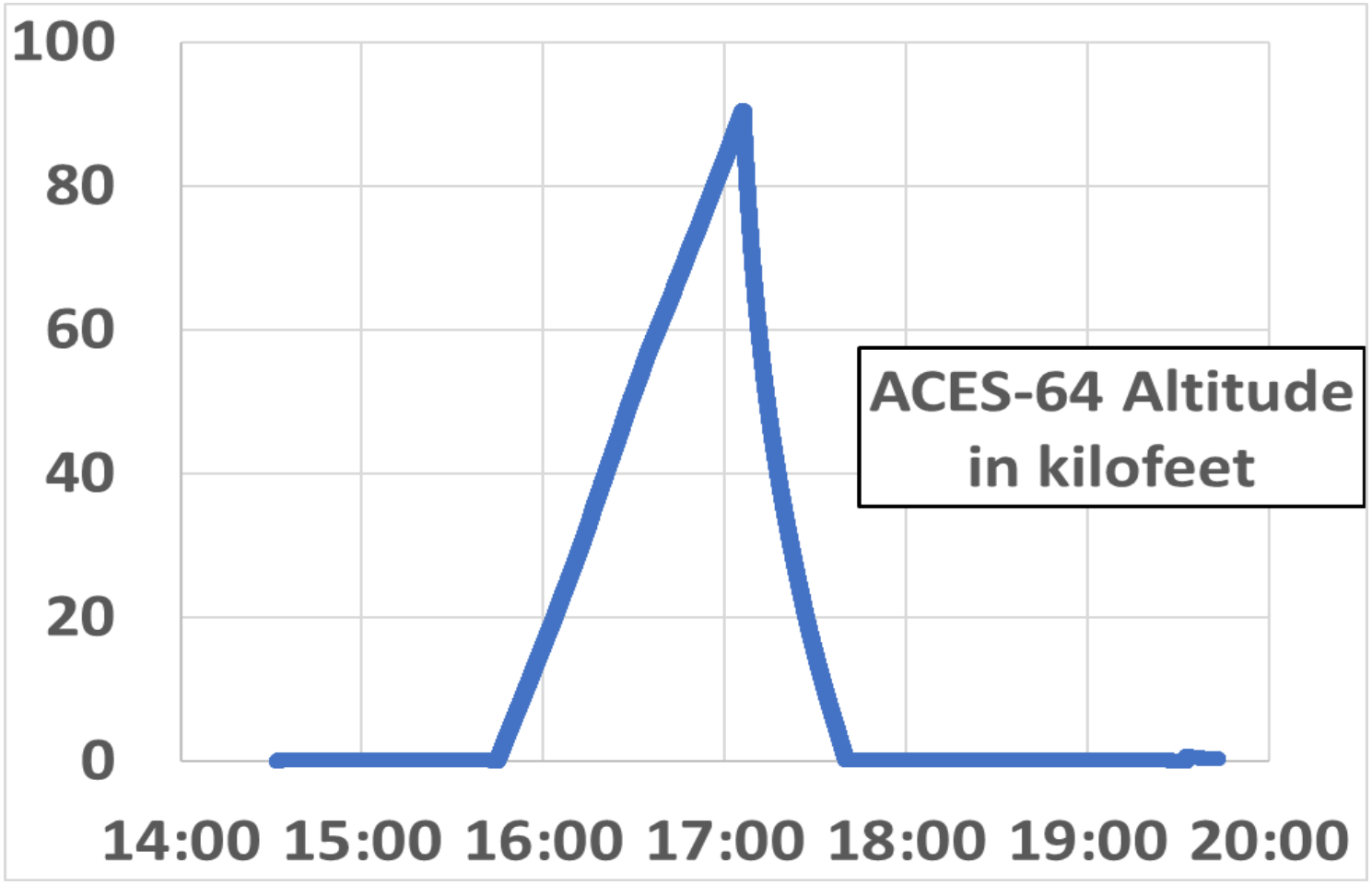
The ACES01 student payloads

- FAA waiver is also needed if payload exceed 3 oz / inch^2 on any surface

Payload mechanical interface

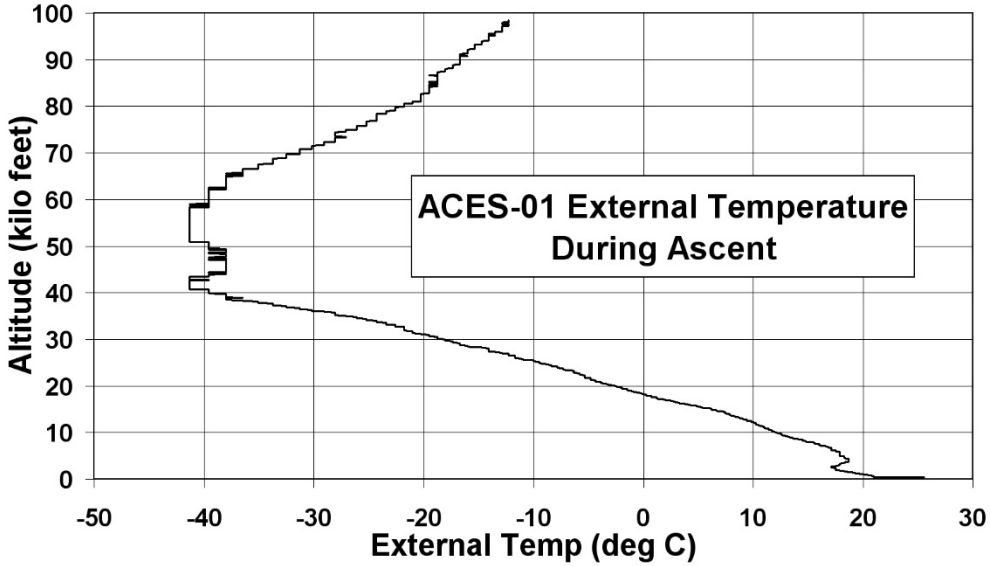
- Mechanical structure is polystyrene foam board, which can be easily cut, shaped, and glued
- Mechanical interface to vehicle is a pair of structural strings, separated by ~17 cm, that pass through the payload unbroken and is secured with spring clips.

Typical Flight Profile



ACES-64 altitude as a function of UTC time

Expected Flight Environment



- Gets cold at the tropopause (~ -60^{o} C)
- Any water vapor will condense out and cause frost
- Good vacuum (< 0.02 atmosphere)
- Landing can be rough (shock, trees, rocks, dragging)
- High velocity during initial descent (~500 mph)

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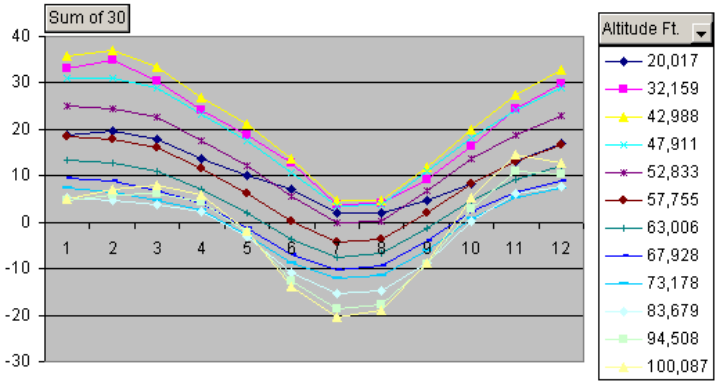
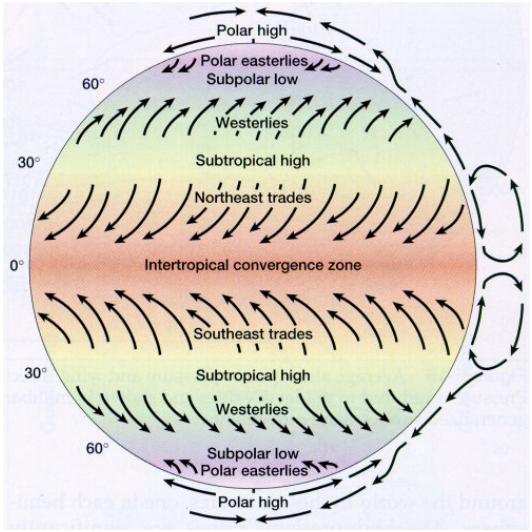
High Altitude Winds

- Vehicle will carry payloads to ~100,000 feet
- Winds at these altitudes show marked seasonal variations
- Summer winds are from the east and from the west during winter



Mean wind flow as function of altitude (coded curves) and month of year (x axis) for 30 degrees latitude. Positive values are for winds from the west and negative value are for winds from the east. From EOSS turn around page.

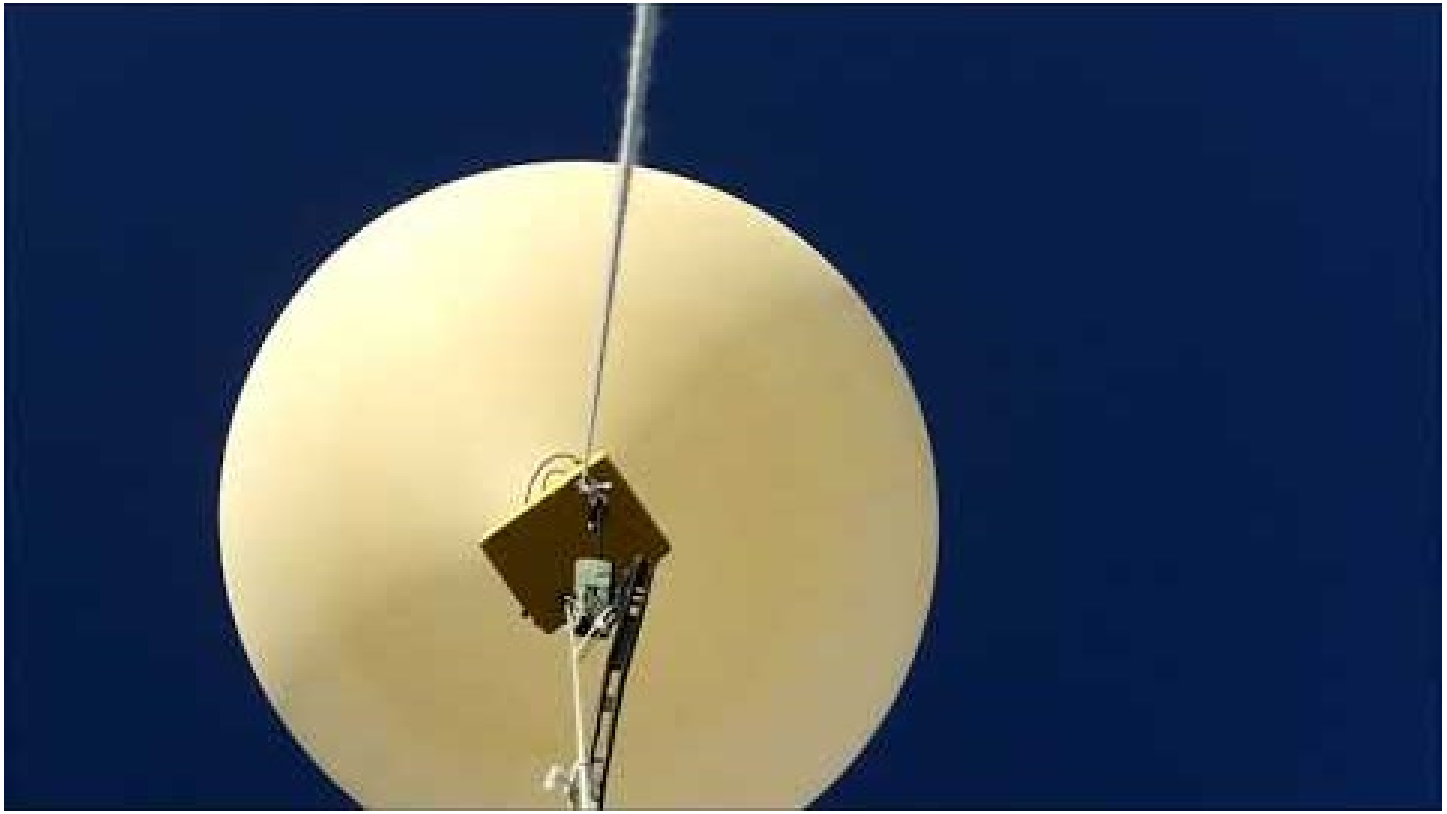


Global circulation. From Naumov lecture on Pressure Systems, Winds and Global Circulation

- Seasonal variation is caused by a latitude shift in the global circulation pattern and by changes in the positions of the continental highs and lows
- Twice a year (May, September) the high altitude winds are at the slowest speed
- It is during this "turn-around" period that we schedule ACES launches

Balloon Vehicle Launch

Balloon cut at ~100,000 feet



Payload Return & Landing

References

- http://www.met-office.gov.uk/education/training/atmosphere.html – The MET Education Office in the UK
- http://www.engr.uky.edu/bigblue/ - University of Kentucky Big Blue student payload
- http://spacegrant.montana.edu/borealis/index.asp – BOREALIS High Altitude Balloon Program
- http://www.eoss.org/ - Edge of Space Sciences amateur ballooning group
- http://www.geog.buffalo.edu/~naumov/TA/GEO101/ - Physical Environment Geography course lecture notes by Aleksey Naumov, SUNY-Buffalo
- https://www.youtube.com/louisianaspacegrant - Louisiana Space Grant Youtube Channel