Upper-Air Measurements

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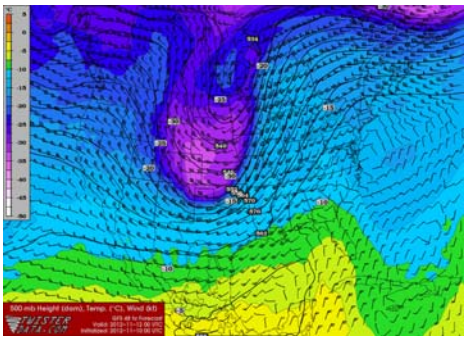
Knowledge of upper-level atmospheric conditions is crucial for numerical weather prediction



Soundings

- Radiosonde
  - A balloon-borne instrument package that measures vertical profiles of atmospheric variables and transmits the data via radio to a ground-receiving system
  - The radio transmitter for NWS soundings uses a frequency of either 403 MHz or 1680 MHz
- Rawinsonde
  - A radiosonde that also includes determination of wind speed and direction via GPS, Loran, radar, or (historically) theodolite

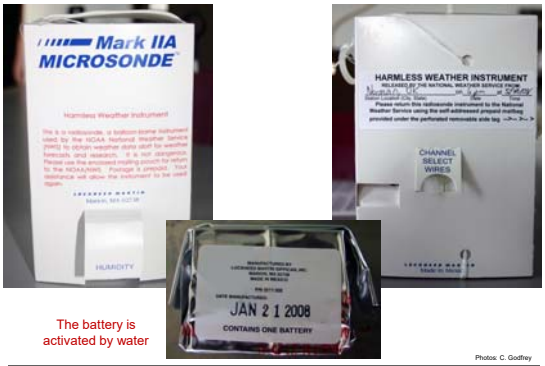
Image source: http://celebrating200years.noaa.gov/theodolites/wurdemann.html

Soundings

U.S. coverage

Africa coverage

NWS radiosonde (front/back/battery)



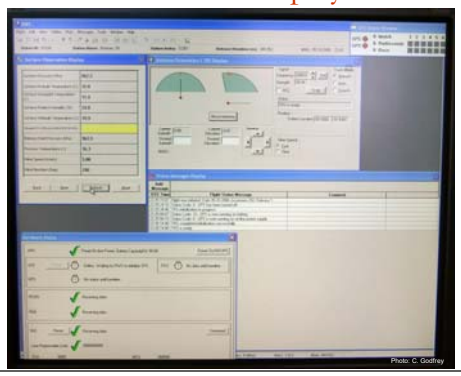
The battery is activated by water

Photos: C. Godfrey

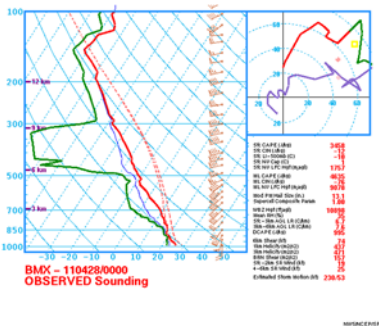
Say goodbye…

Photos: C. Godfrey

Real-time NWS data display



The result



Mark II Radiosonde Sensors

- Temperature
  - Type: Thin rod thermistor
  - Range: -90°C to +60°C
- Humidity
  - Type: Carbon hygristor
  - RH Range: 5% to 100%
  - T Range: -50°C to +40°C
- Pressure
  - Type: Capacitance aneroid
  - Range: 1080 mb to 3 mb

Image source: http://www.erh.noaa.gov/lin/UpperAir/UpperAir2.html

Bottom images: http://usa-satcom.com/sippican-microsonde-iia-teardown/

Remote sensing

- Wind profilers
  - NOAA profilers:
    - Low power
    - Highly-sensitive clear-air radar
    - 404 MHz (74 cm)
    - Vertical T_v profiles from the Radio Acoustic Sounding System (RASS) at 850-900 MHz (corners of image on right)

The NOAA Wind Profiler Network was decommissioned in 2014.

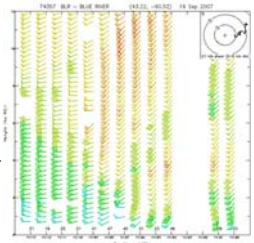


Image source: http://www.profiler.noaa.gov/npn/aboutNpnProfilers.jsp

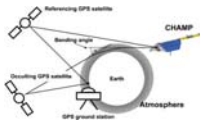
Remote sensing

- Wind profilers
  - NOAA is testing a new phased-array wind profiler

Photos: C. Godfrey

Remote sensing

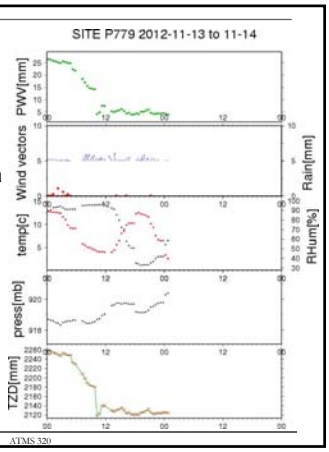
- GPS radio occultation
  - Low-Earth orbit satellite receives signal from GPS satellite while traversing the atmospheric limb
  - Signal refracts
    - Magnitude of refraction depends on vertical temperature and water vapor distribution
  - Can retrieve global soundings!



Source: http://dx.doi.org/10.1016/j.pce.2004.01.015

Remote sensing

- GPS precipitable water vapor
  - Refraction causes a delay in GPS signals that is a function of the integrated water vapor content

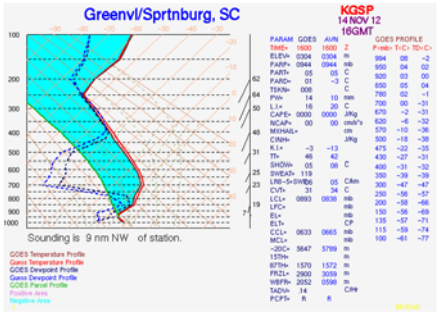


For real-time data, see http://www.suominet.ucar.edu

Remote sensing

- Satellite-derived soundings produce temperature and moisture profiles based on radiance measurements
- Satellites include:
  - GOES
  - Polar orbiters (NASA POES/European Metop series)
    - Advanced TIROS Operational Vertical Sounder (ATOVS)
    - Microwave Integrated Retrieval System (MIRS)
    - Global coverage twice a day
    - Many more:
      - http://www.ospo.noaa.gov/Products/atmosphere/soundings

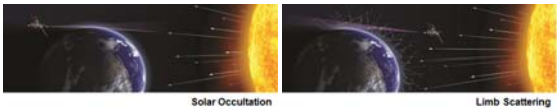
Remote sensing



An example of a GOES sounding for GSP

Remote sensing–SAGE III

- Stratospheric Aerosol and Gas Experiment III-ISS (SAGE III-ISS)
- Locks onto the Sun or Moon and scans the limb to measure the thin profile of the atmosphere from the unique vantage point of the International Space Station (ISS)

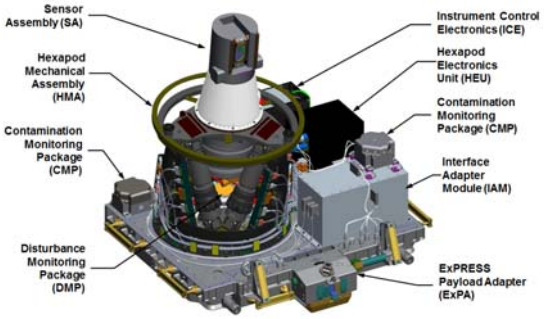


Remote sensing–SAGE III

- Measures aerosols, clouds, water vapor, pressure, temperature, nitrogen dioxide, nitrogen trioxide, and chlorine dioxide

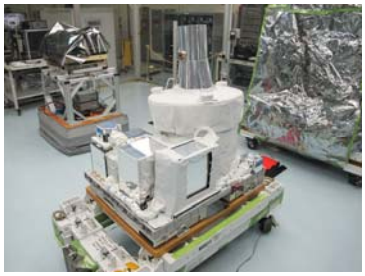
SAGE III is externally mounted on the International Space Station.

Remote sensing–SAGE III



SAGE III instrument payload

Remote sensing–SAGE III



SAGE III Instrument Payload Integrated on EXPRESS Pallet Adapter

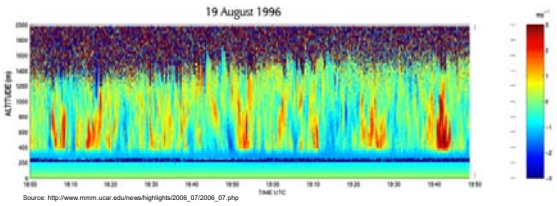
SAGE Instrument Assembly during testing

For a short video from NASA, see https://www.youtube.com/watch?v=j8RWEBmkwMY

Remote sensing

- Doppler LIDAR
  - Light Detection and Ranging
  - Principle is similar to radar, but with a laser

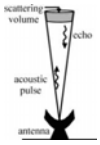
Source: http://www.arm.gov/instruments/id



Source: http://www.mmm.ucar.edu/news/highlights/2006_07/2006_07.php

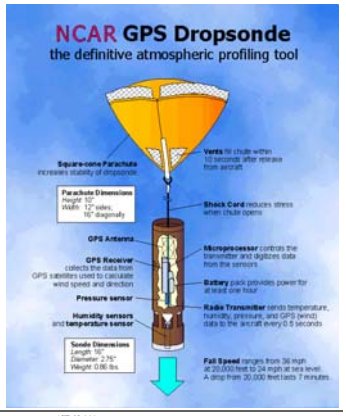
Remote sensing

- SODAR
  - Sonic Detection and Ranging
  - Like radar, but with sound waves
  - Measures vertical wind profile
  - Measures thermodynamic structure of boundary layer



Dropsondes

Delivery system on a NOAA P-3 Hurricane Hunter



Dropsondes

Ceilometer

ASOS Laser Ceilometer

- Laser ceilometer
  - Detects backscatter from laser pulse
  - Measures:
    - Cloud height
    - Cloud thickness
    - Vertical visibility
- Optical ceilometer
  - Uses triangulation with a distant detector to determine height of an intense spot of light on the base of a cloud