Advertisement

- As mentioned at end of presentation – we have an activity with high-school or middle-school students, involving:
  - Radiosonde launch
  - Talking about atmospheric structure (density, pressure, temperature)
  - Re-discovering the stratosphere, talking about discovery around 1900
  - Possible to do simple calculations (exponential curves, change in temperature with height ...)
  - Lots of Q&A time (on anything, can easily involve ozone in the stratosphere & ozone hole story)
- Please let me know if you're interested in something like this: thomas 'at' atmos.colostate.edu

Discovery of the Stratosphere

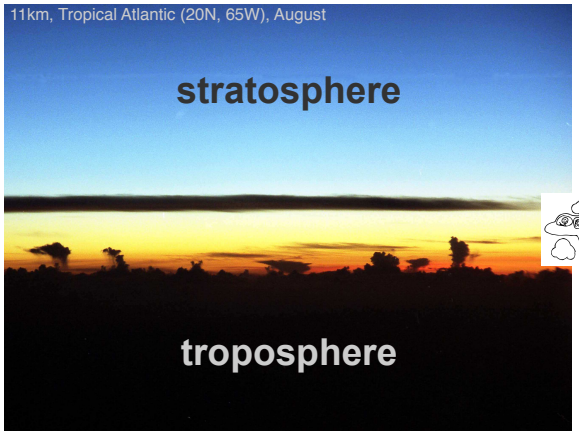


photo courtesy Andrew Gettelman, NCAR

- 200 years ago steady temperature drop with height was known from observations at mountain tops
- this would result in 0 K (absolute zero) somewhere between 30–40 km (~20 mi) altitude
- It was assumed that rate of temperature drop diminishes, but temperature still decreases with height throughout the atmosphere

"*It doesn't matter how beautiful your theory is, it doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong.*"
-- Richard Feynman

Discovering the 3rd Dimension (around 1900)

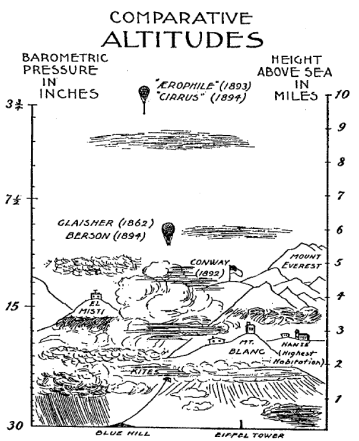


Fig. 3. Upper-air research at the end of the 19th century (taken from ROTCH 1896).

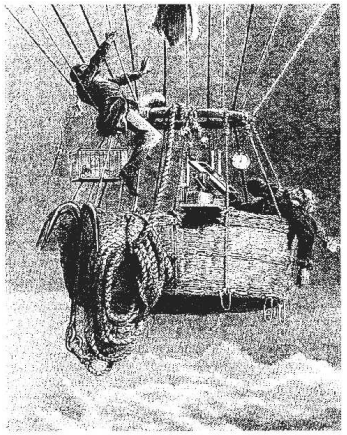
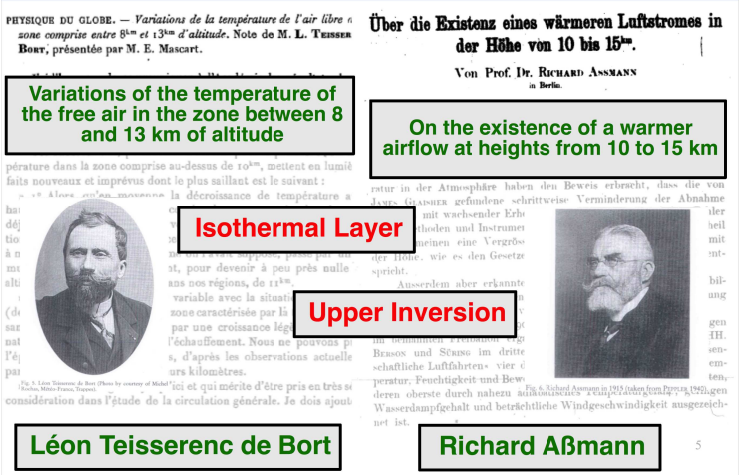


Fig. 1. Contemporary sketch of the dramatic situation when Coxwell and Glaisher became unconscious during their flight in an aerostat in 1862 (taken from FLAMMARION 1885).

from Hoinka (1997)

Discovery of the Stratosphere:1902



PHYSIQUE DU GLOBE. — *Variations de la température de l'air libre à zone comprise entre 8km et 13km d'altitude*. Note de M. L. Teisserenc de Bort, présentée par M. E. Mascart.

Variations of the temperature of the free air in the zone between 8 and 13 km of altitude

Über die Existenz eines wärmeren Luftstromes in der Höhe von 10 bis 15km.

Von Prof. Dr. Richard Assmann in Berlin.

On the existence of a warmer airflow at heights from 10 to 15 km

Isothermal Layer

Upper Inversion

Léon Teisserenc de Bort

Richard Aßmann

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- First balloon soundings during 1890's
- Reached stratospheric altitudes, but warm temperatures above ~12 km were adjusted ("corrected") to match expected temperature drop
- Teisserenc de Bort took over 200 soundings within ~ 10 years, carefully examining possible measurement errors
- Only then did he announce the discovery of the stratosphere to the French Academy of Science (on 28 April 1902, Aßmann announced essentially the same discovery to the German Academy of Science on 1 May 1902)

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- Radiation error (absorption of solar radiation, also related to lack of ventilation)
  - soundings during day vs. during night
  - aspiration psychrometer due to Aßmann (ventilated thermometers enclosed in polished metal tubes)
- Balloon material:
  - paper, treated silk, goldbeater's skin
  - rubber introduced by Aßmann (in collaboration with Continental)
- Balloons were filled with hydrogen

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- Terms troposphere ('tropos' – greek for 'to turn' or 'to mix') and stratosphere ('stratos' – from latin 'stratum' = layered, stratified) were coined by Tesserenc de Bort
- Term tropopause (= interface between troposphere & stratosphere) was popularized later by Sir Napier Shaw around 1920

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M.O. 074.

O. H. M. S.

INTERNATIONAL INVESTIGATION OF THE UPPER AIR.

5 SHILLINGS REWARD.

DELICATE METEOROLOGICAL APPARATUS.

This instrument is the property of the Meteorological Office, London. The above reward will be paid for the instrument if it is not tampered with. The finder is requested to pull out the piece of red string (with the match end attached), to put the instrument away in a safe place and to write to the Director, Meteorological Office, London, S.W., when instructions, and if desired, information, will be sent.

The balloon need not be returned.

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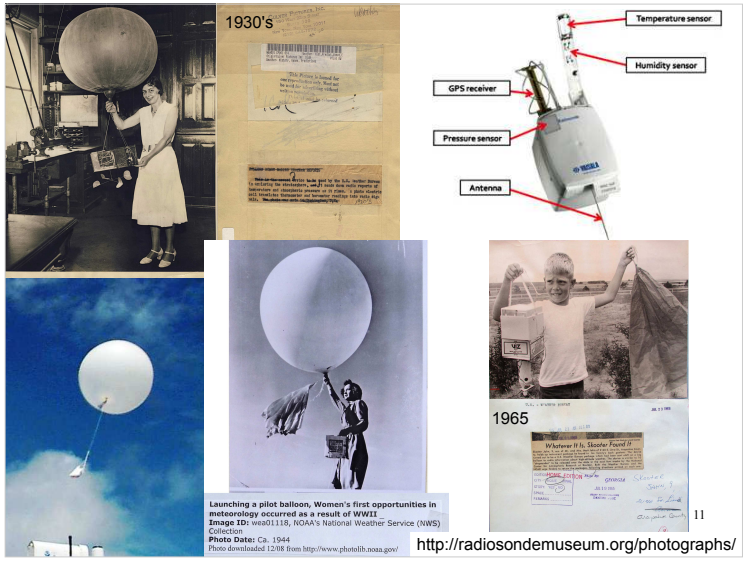
from Hoinka (1997)

Atmospheric Soundings

- Helium-filled weather balloon are released from about 1000 locations around the globe ~ every 12 hours (some places more often)
- Sensor documents temperature, pressure, humidity
- (horizontal) winds can be deduced by tracking the balloon
- Balloons reach maximum altitudes of 30–35 km



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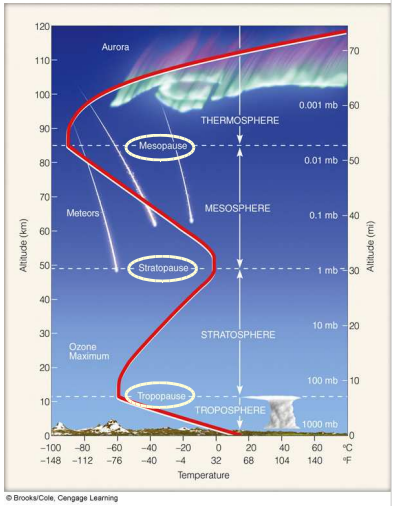
http://radiosondemuseum.org/photographs/

Temperature Structure

- The atmosphere is layered according to its temperature structure
- In some layers temperature increases with height
- In others it decreases with height or is roughly constant

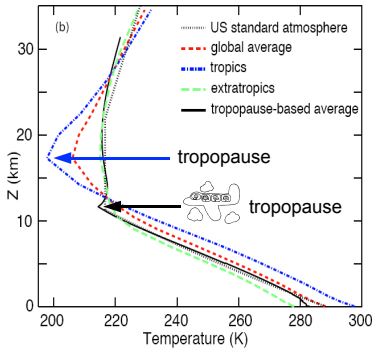
  ..."pause" is a level

  ..."sphere" is a layer



Troposphere

- the "weather sphere", contains between 70–90% of atmosphere by mass
- Temperature decreases with height due to radiative heating of the surface
- Top of troposphere is called tropopause (11 km in mid-latitudes, 18 km in tropics)
- Lapse rate: rate of temperature decrease with height = $-\Delta T/\Delta z$
  (~ 6.5 K/km or 12 F/mi)



from Vallis (2006)

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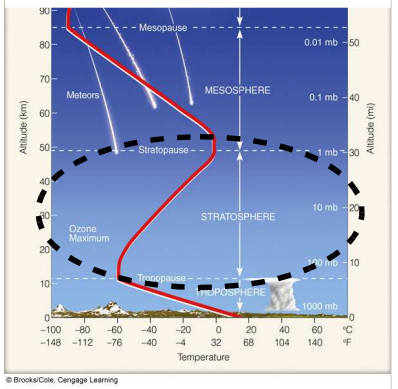
Stratosphere

- Between tropopause and about 50 km (30 mi)
- Temperature increases with height due to absorption of ultraviolet solar radiation and formation of ozone
- Ozone-cycle: $O_3 + uv \rightarrow O_2 + O$; $O_2 + O \rightarrow O_3 + heat$
- O_3 absorbs most energetic and harmful uv-radiation
- Top of stratosphere is called stratopause (50 km)



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