Just how high are we then?

Ed Williams

SMXGig 2000 - Santa Maria Ca

No - we're talking about *altitude*!

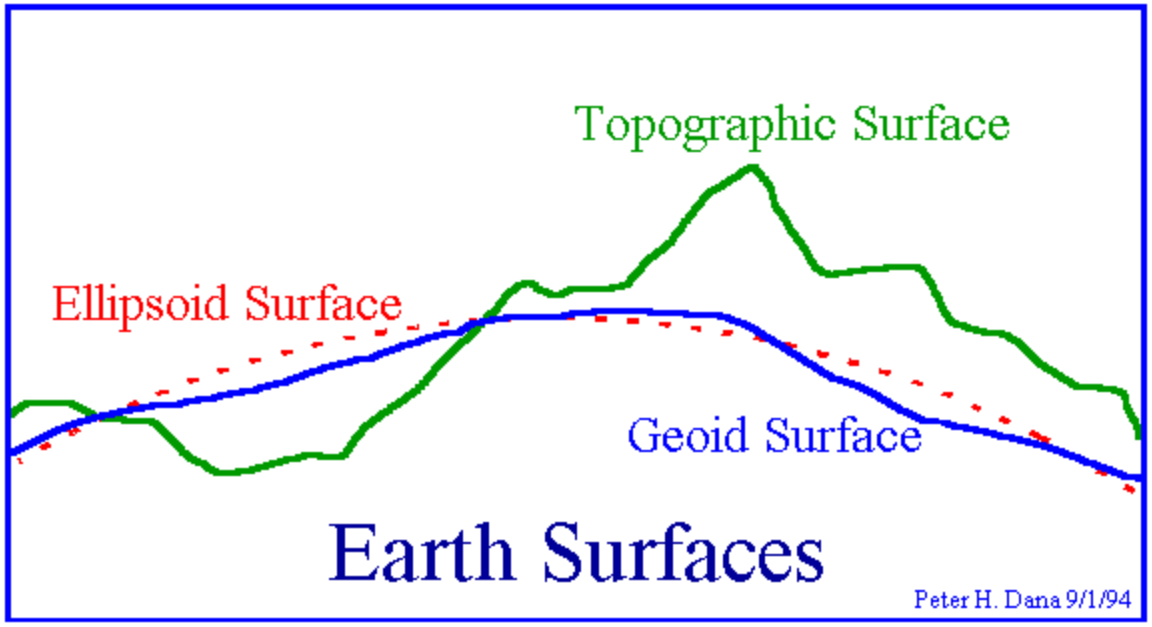
Altitude is very important to aviators

- Terrain clearance - especially IFR
- Traffic separation
- Aircraft Performance

There's many flavors of "altitude"

- Different purposes
- Different methods of measurement
- MSL/true altitude
- AGL/absolute altitude
- Pressure altitude
- Indicated/calibrated altitude
- Density altitude

MSL is height above the “geoid”



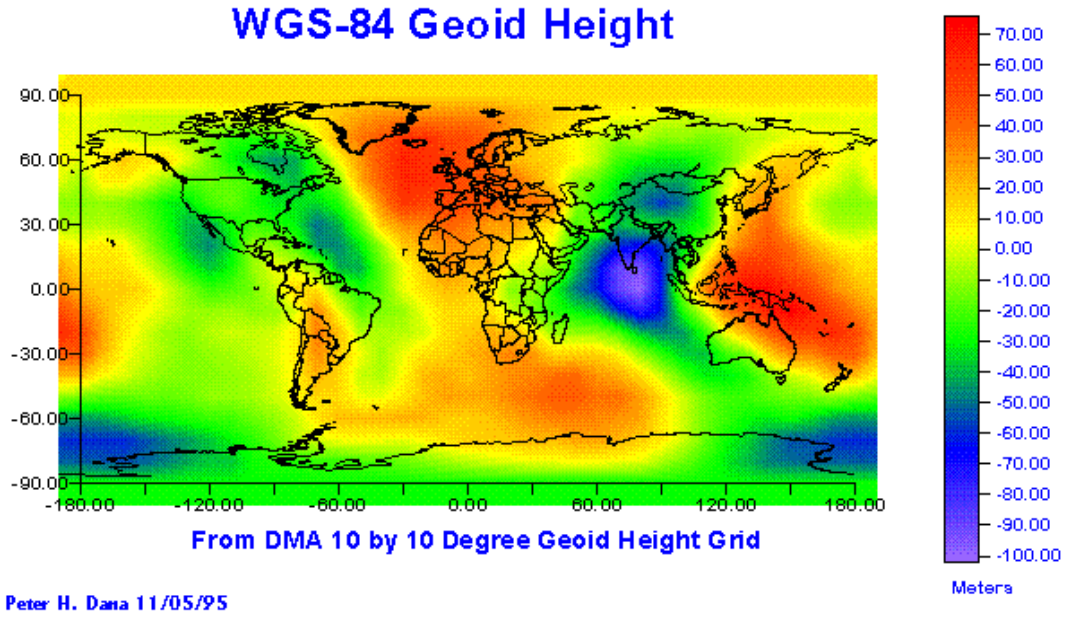
“Mean Sea Level” is the height of the oceans absent tides, winds, waves.

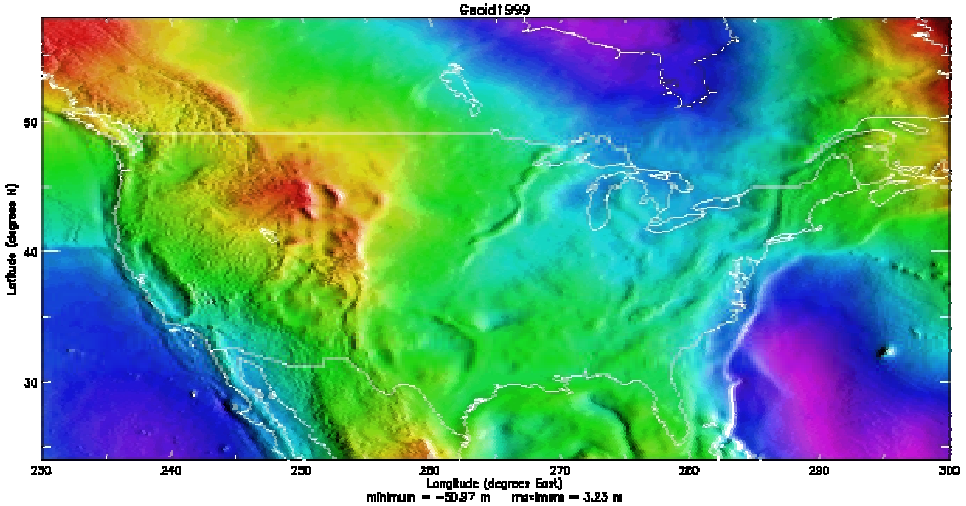
Under the continents, it’s the level to which water would rise if narrow canals were dug

The geoid is close to an ellipsoid in shape.

- A sphere flattened at the poles by 1 part in 297
- Only recently is there a global standard - WGS84- using satellite geodesy.
- Historically, different regions have their own “datums”, determined by massive triangulations. But the maps don’t fit together!

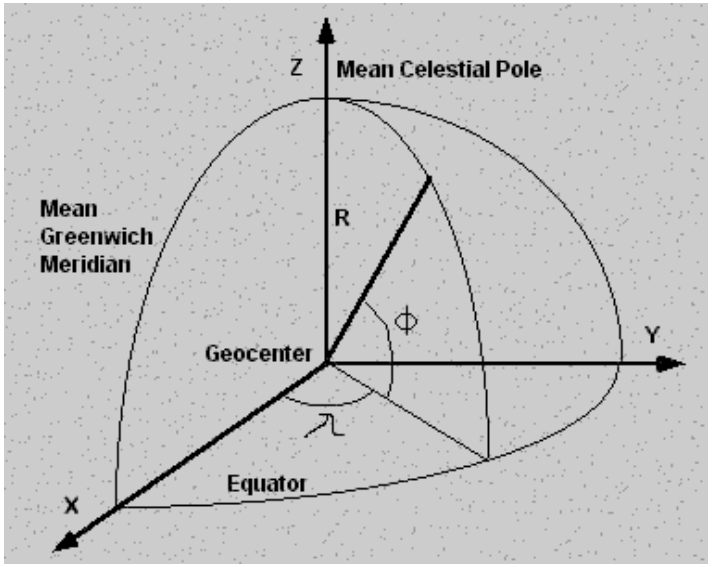
The geoid and ellipsoids differ.



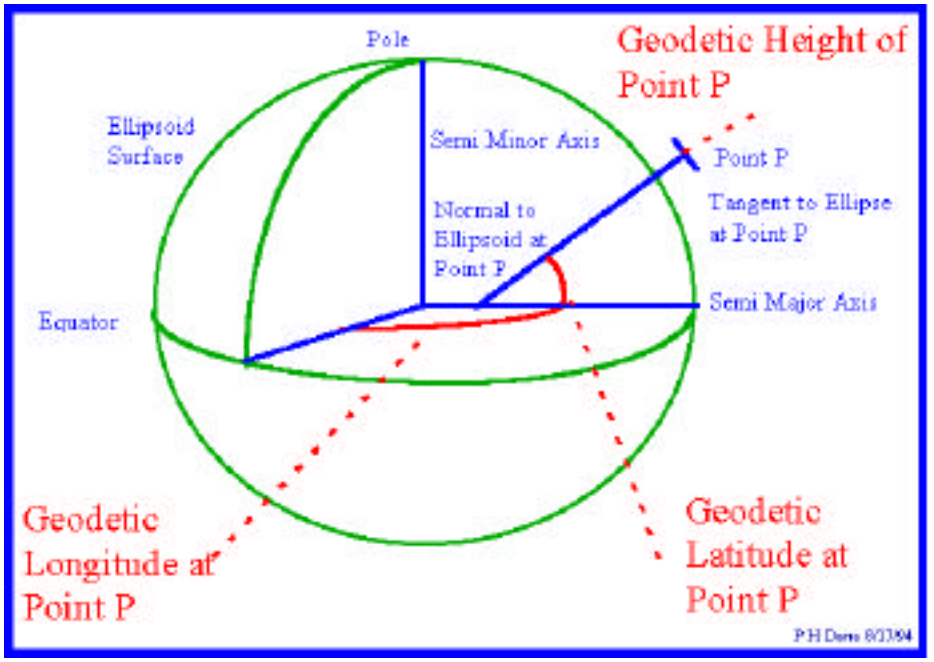


550 feet worldwide
175 feet US

Latitudes and longitudes give a global location reference.



Spherical earth



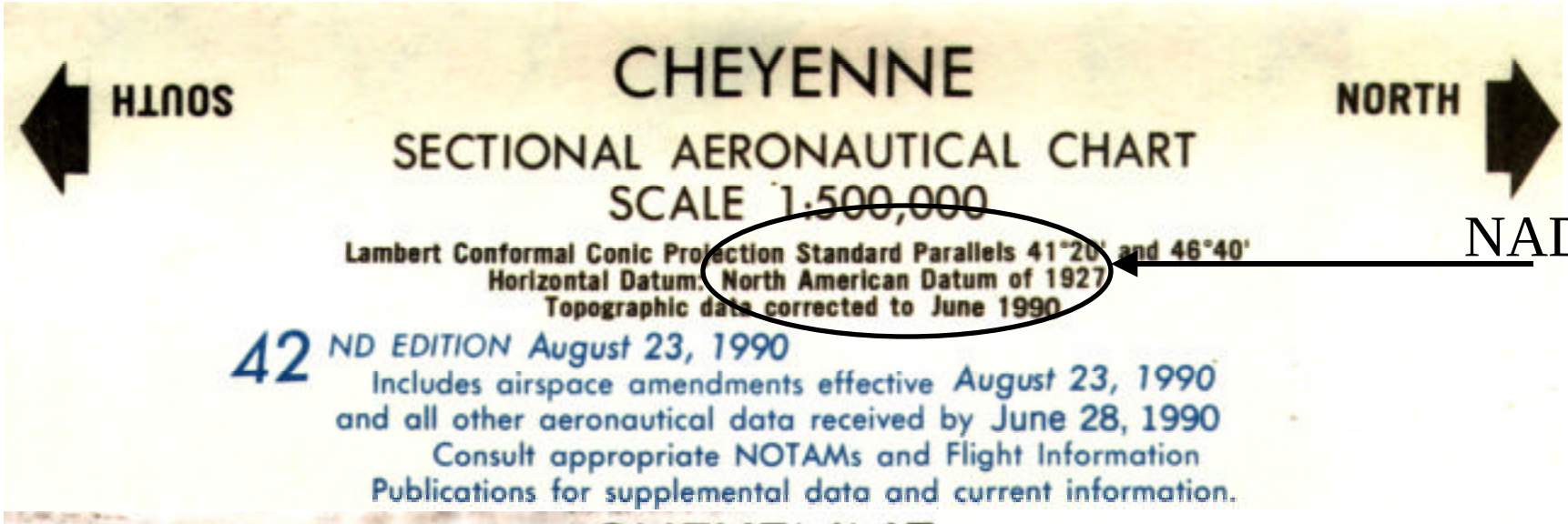
Ellipsoidal earth

Geodetic coordinates depend on the datum!

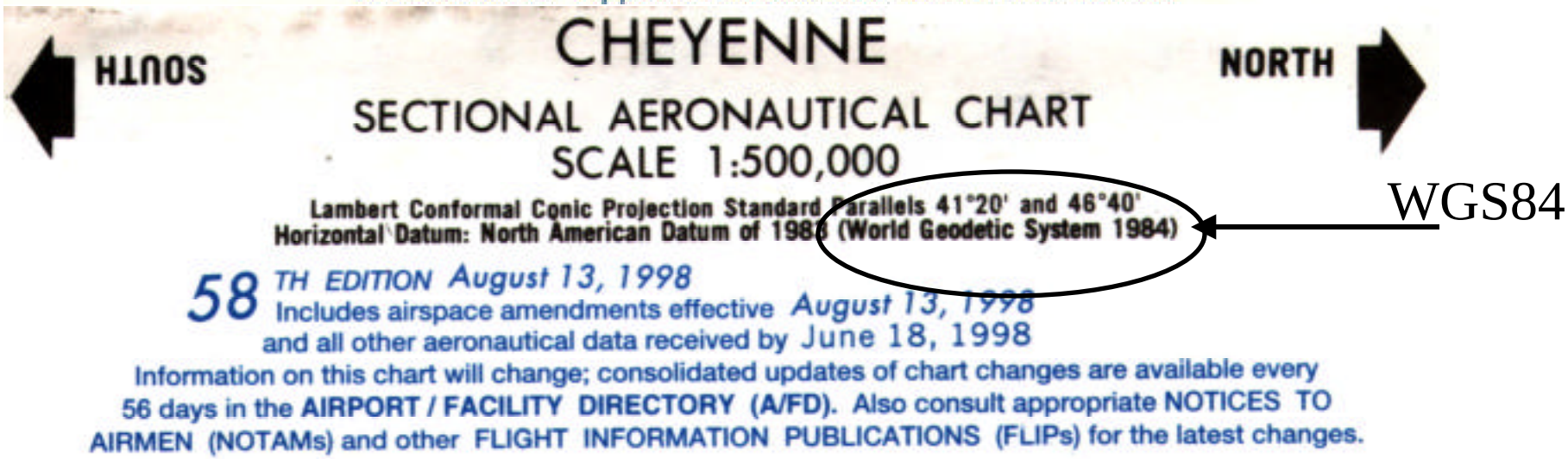
The US datum is now WGS84

- Aero- and other charts were based on NAD27, which used Clarke's 1866 ellipsoid, which was wrong! The datum was fixed at Meade's ranch, Kansas. As one moved away, the errors pile to up to 300 ft.
- After the change, all lat/lon databases had to be updated.
- For high-accuracy navigation (eg DGPS)
- one must use the correct datum (and new
- surveys!

The US datum is now WGS84



NAD27

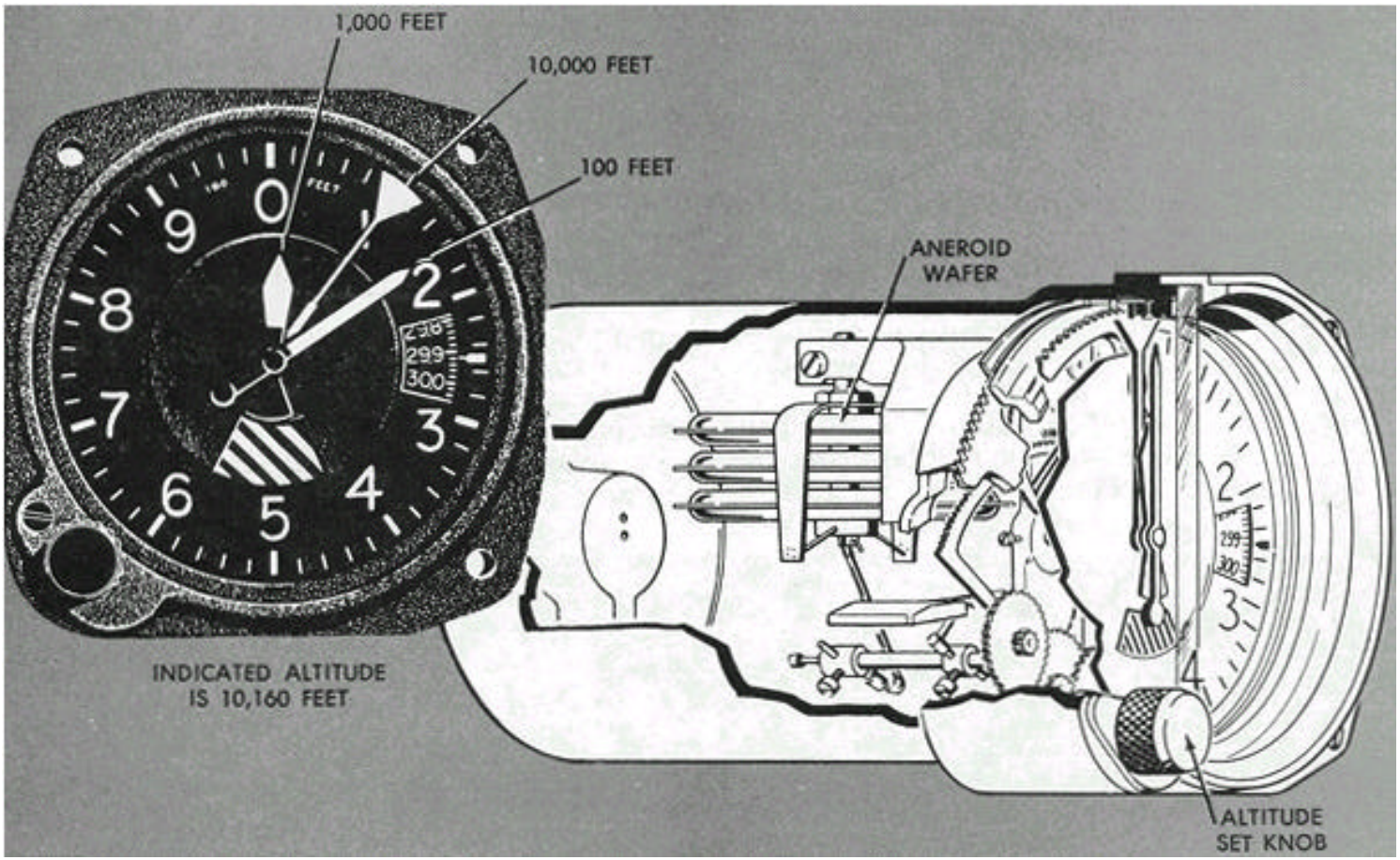


WGS84

GPS altitude ~ True altitude

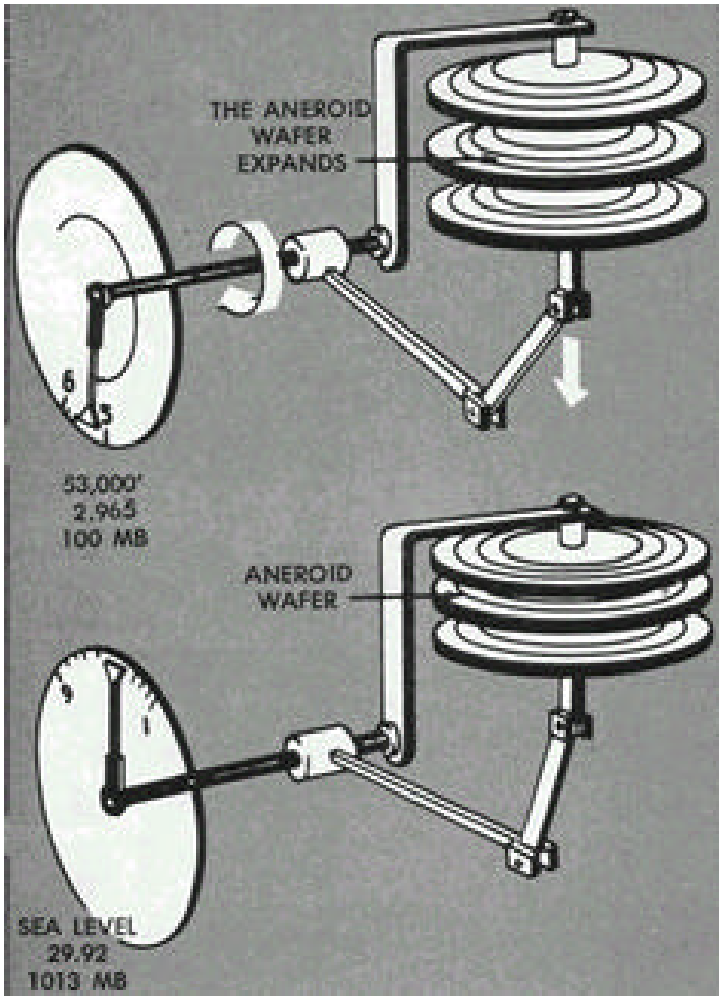
- It differs by:
- (a) The geoid height (< 175’ US, <550’ worldwide) Might be included in the GPS software.
- (b) The GPS error ±90’ PPS, ±485’ (95% probability) with SA.
- Not adequate as a primary altitude reference!

We rely on the pressure altimeter



An aneroid barometer, indicating atmospheric pressure on an altitude scale.

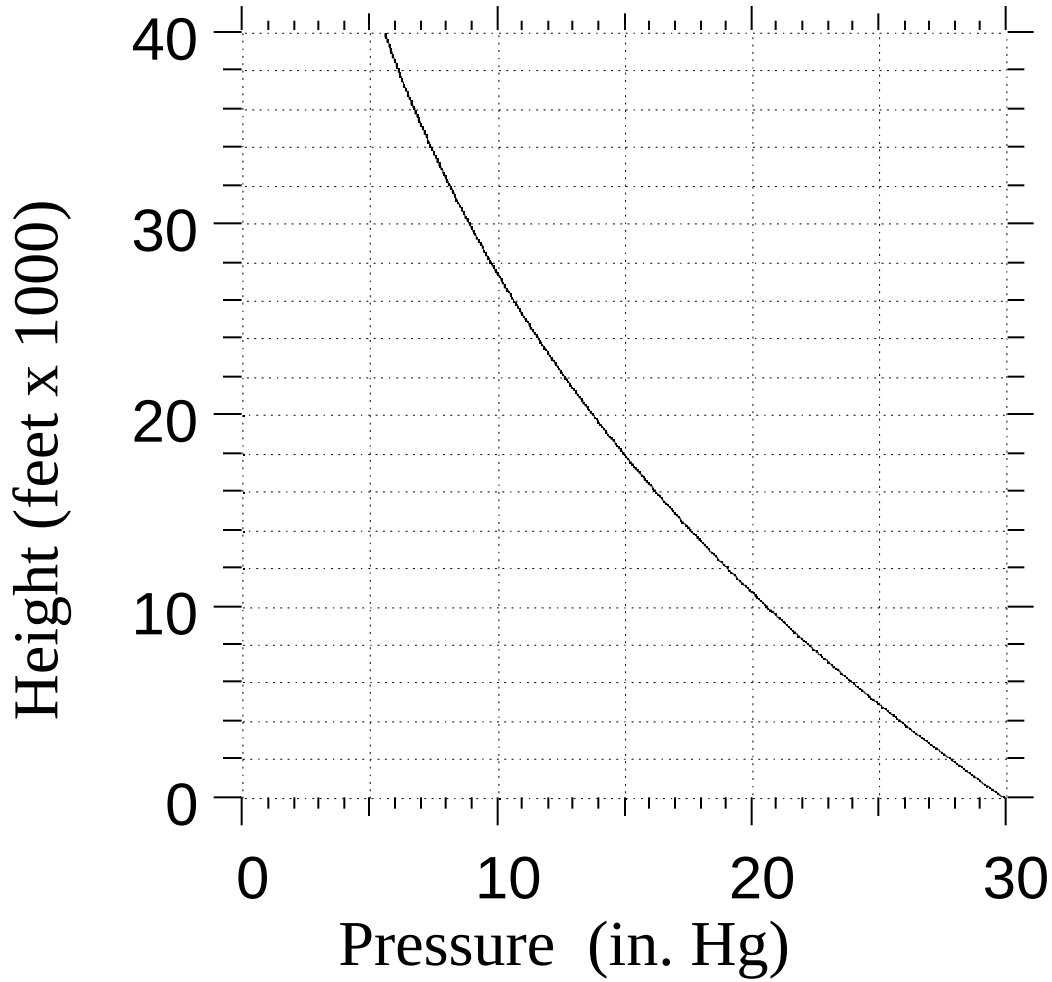
The altimeter is a precision instrument.



The bellows expand and contract with atmospheric pressure.

The “zero” is adjusted with the Kollsman setting knob.

Altimeters are calibrated to the "standard" atmosphere.



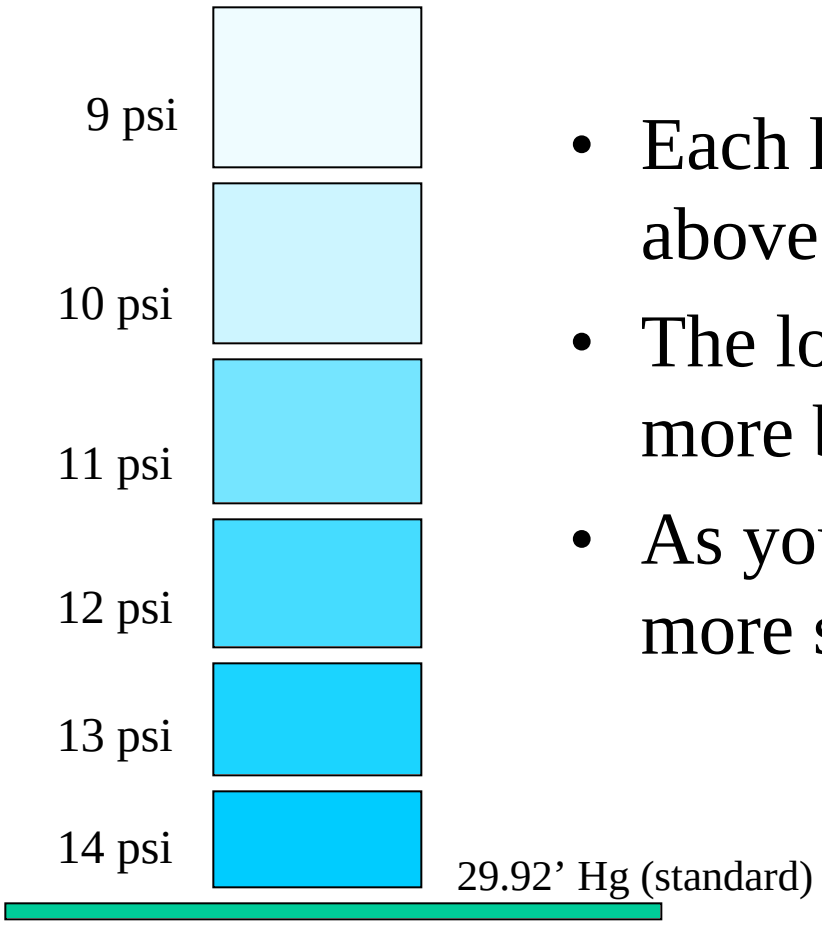
The standard relates air pressure to altitude.

Pressure altitude is altitude in the standard atmosphere corresponding to the atmospheric pressure.

The standard atmosphere specifies:

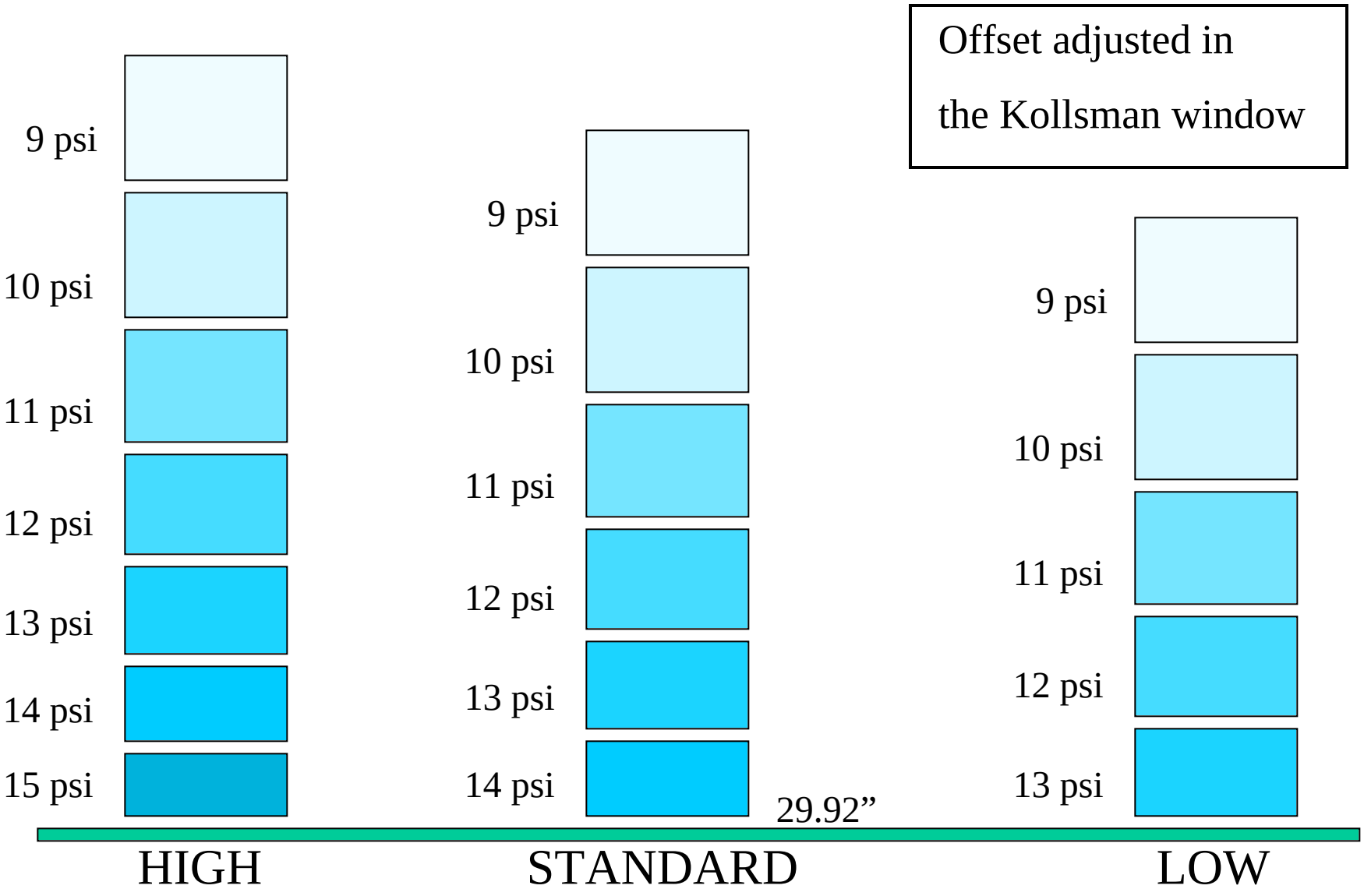
- The atmospheric composition (dry!)
- The sea-level pressure (29.92” Hg)
- The temperature at each altitude (15ºC at sea-level, decreasing 2ºC/1000ft up to the tropopause)
- The real atmosphere is never exactly standard!

Pressure is the weight per unit area of the air above.



- Each layer supports all the layers above.
- The lower layers are compressed more by the greater pressure.
- As you climb, the pressure drops more slowly with altitude.

Air heaps up in the highs



What is the altimeter setting?

- The altimeter setting is the value to which the Kollsman scale of a calibrated pressure altimeter is set, so that it indicates true altitude at field elevation.

- Your altimeter should indicate correctly at touchdown.

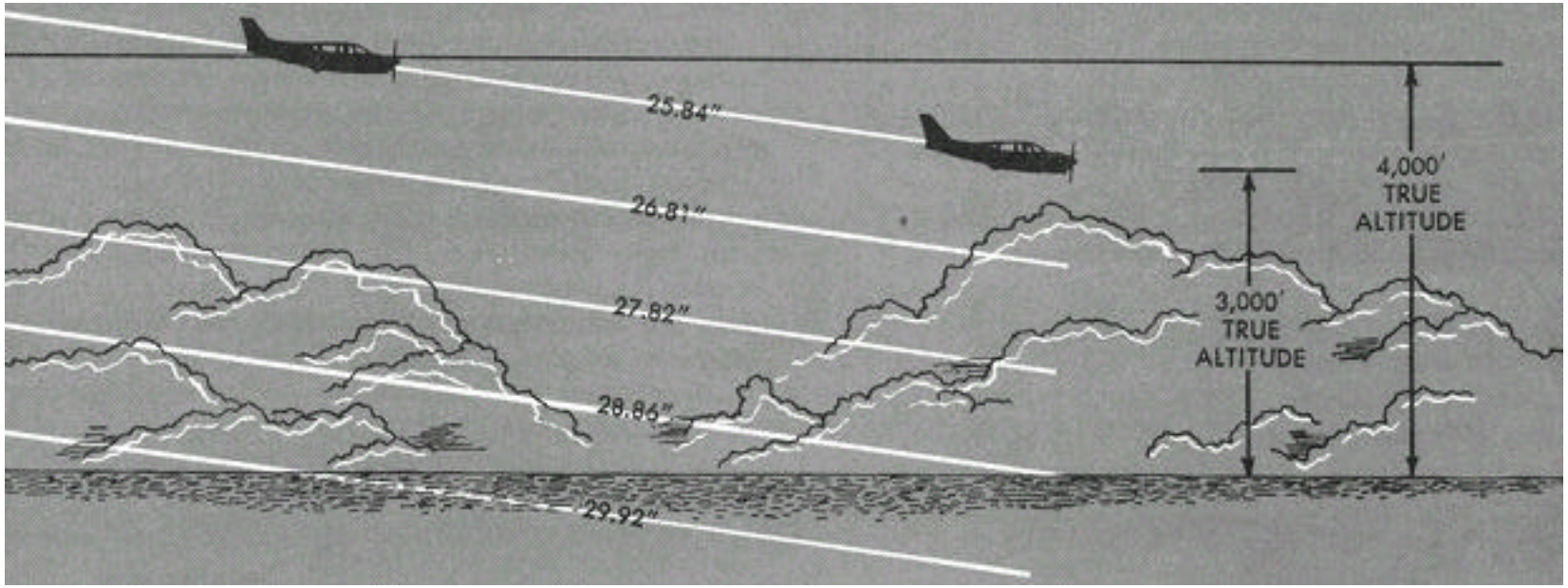
Altimeter setting on departure:

- 1. Set the current reported altimeter setting on the altimeter setting scale.
- 2. Altimeter should now read field elevation if you are located on the same reference level used to establish the altimeter setting.
- 3. Note the variation between the known field elevation and the altimeter indication. If this variation is in the order of plus or minus 75 feet, the accuracy of the altimeter is questionable and the problem should be referred to an appropriately rated repair station for evaluation and possible correction.

Altimeter setting procedures.

- The cruising altitude or flight level of aircraft shall be maintained by reference to an altimeter which shall be set, when operating:
- Below 18,000 feet MSL:
- When the barometric pressure is 31.00 inches Hg. or less: to the current reported altimeter setting of a station along the route and within 100 NM of the aircraft, or if there is no station within this area, the current reported altimeter setting of an appropriate available station. When an aircraft is en route on an instrument flight plan, air traffic controllers will furnish this information to the pilot at least once while the aircraft is in the controllers area of jurisdiction. In the case of an aircraft not equipped with a radio, set to the elevation of the departure airport or use an appropriate altimeter setting available prior to departure.
- Above 18000 feet MSL:
- to 29.92

“High to low-- look out below.”



Maintain a current altimeter setting!

Altimeter setting procedures when > 31.00”’

- When the barometric pressure exceeds 31.00 inches Hg.: the following procedures will be placed in effect by NOTAM defining the geographic area affected:
- (a) For all aircraft: Set 31.00 inches for en route operations below 18,000 feet MSL. Maintain this setting until beyond the affected area or until reaching final approach segment. At the beginning of the final approach segment, the current altimeter setting will be set, if possible. If not possible, 31.00 inches will remain set throughout the approach. Aircraft on departure or missed approach will set 31.00 inches prior to reaching any mandatory/crossing altitude or 1,500 feet AGL, whichever is lower. (Air traffic control will issue actual altimeter settings and advise pilots to set 31.00 inches in their altimeters for en route operations below 18,000 feet MSL in affected areas.)

Altimeter setting procedures when > 31.00” continued...

- For aircraft operating IFR and unable to set the current altimeter setting, the following restrictions apply:
- To determine the suitability of departure alternate airports, destination airports, and destination alternate airports, increase ceiling requirements by 100 feet and visibility requirements by 1/4 statute mile for each 1/10 of an inch of Hg., or any portion thereof, over 31.00 inches. These adjusted values are then applied in accordance with the requirements of the applicable operating regulations and operations specifications.
- Destination altimeter is 31.28 inches, ILS DH 250 feet (200-1/2). When flight planning, add 300-3/4 to the weather requirements which would become 500-1 1/4.
- On approach, 31.00 inches will remain set. Decision height or minimum descent altitude shall be deemed to have been reached when the published altitude is displayed on the altimeter.

Altimeter setting below 28.00”?

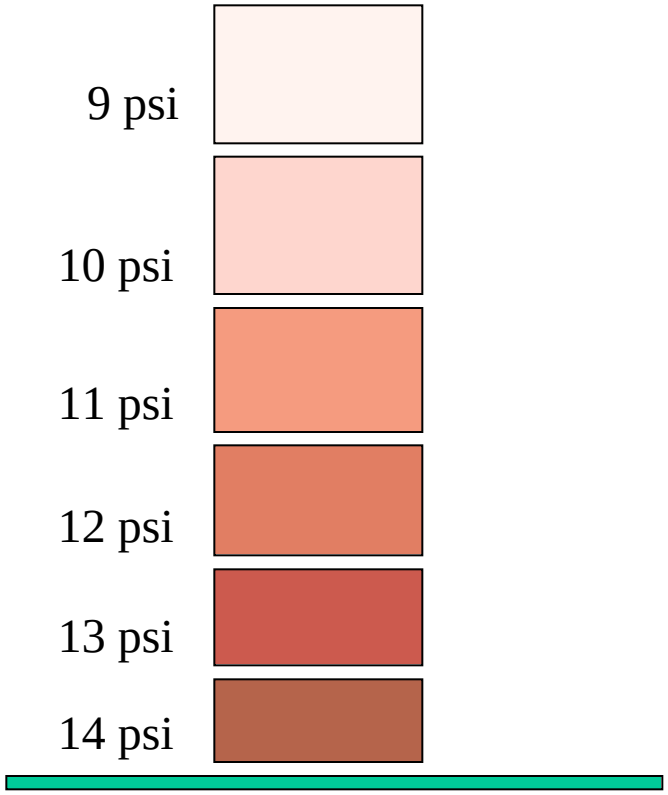
- AIM paragraph 7.2.5:
- When abnormally low barometric pressure conditions occur (below 28.00), flight operations by aircraft unable to set the actual altimeter setting are not recommended.
- The true altitude of the aircraft is lower than the indicated altitude if the pilot is unable to set the actual altimeter setting.
- *You are on your own here!*

When the altimeter setting is below 29.92 some Flight levels become “unusable”

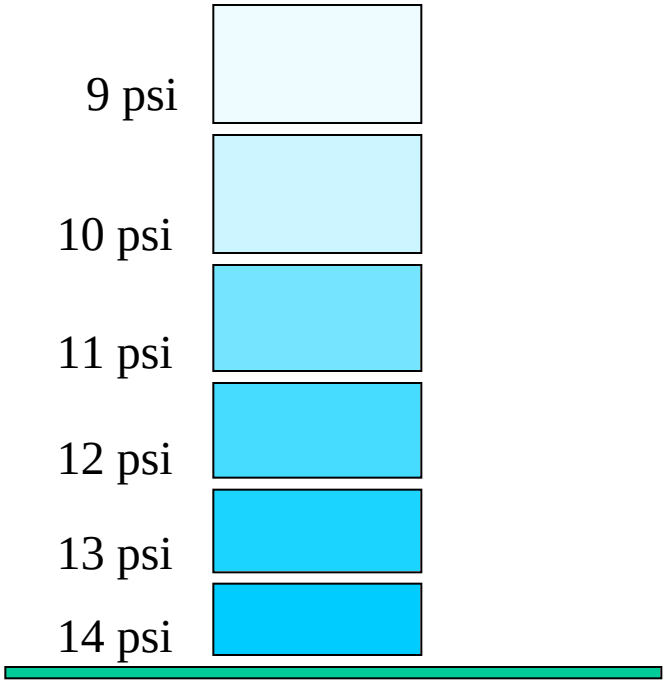
- b. At or above 18,000 feet MSL: to 29.92 inches of mercury (standard setting). The lowest usable flight level is determined by the atmospheric pressure in the area of operation as shown in TBL 7-2-1.

Altimeter Setting (Current Reported)	Lowest Usable Flight Level
29.92 or higher	180
29.91 to 29.42	185
29.41 to 28.92	190
28.91 to 28.42	195
28.41 to 27.92	200

Colder air compresses to a higher density under the same pressure.

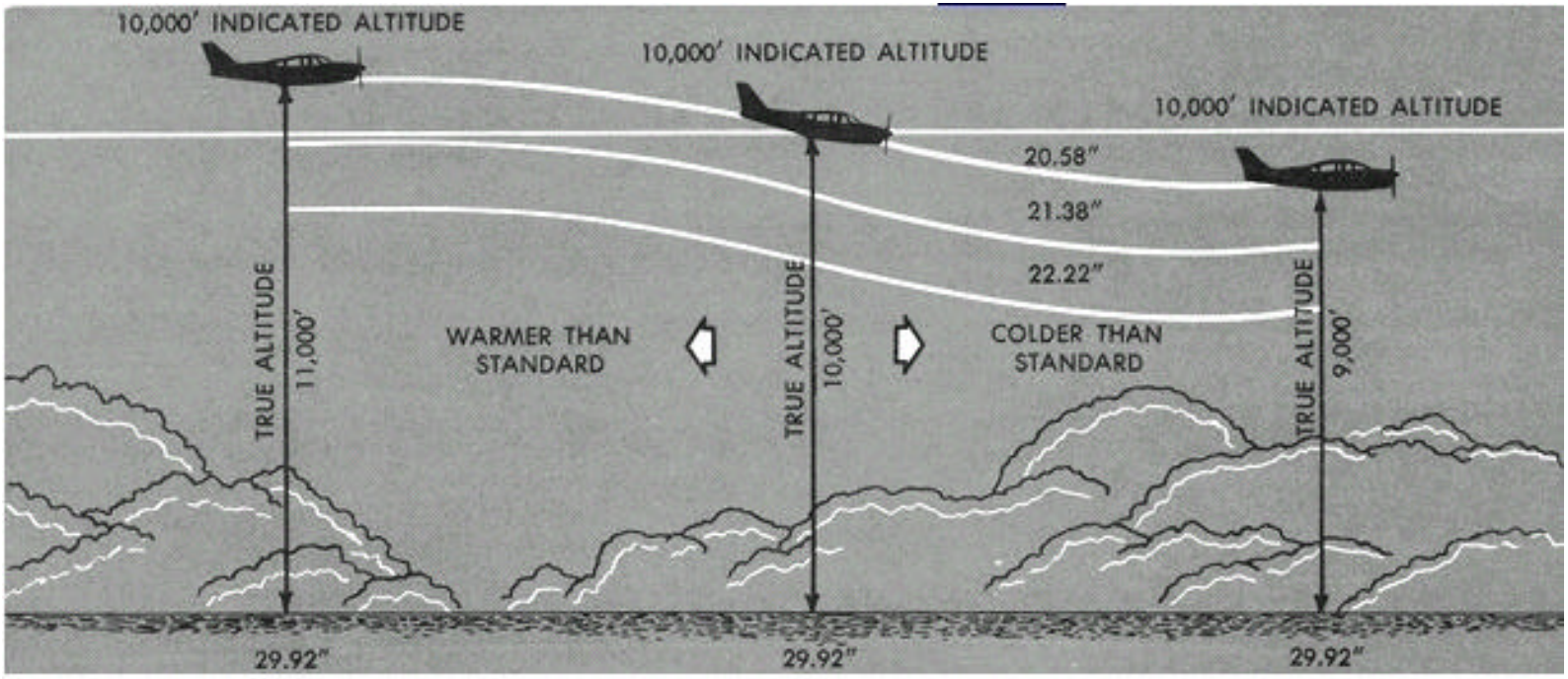


Warm air



Cold air

“High to Low-- look out below”

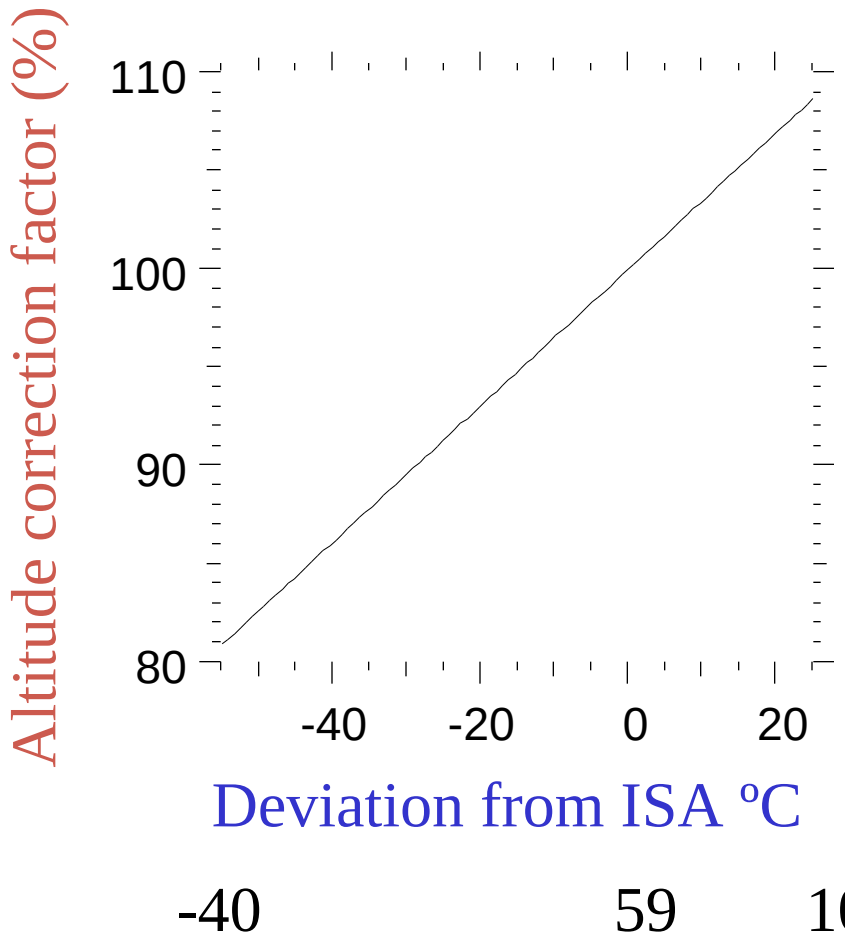


If it is colder than standard- true altitude is less than indicated.

Standard temp- 15C at SL decreasing 2C/1000’

Altimeter reads correctly at the setting station- incorrect aloft.

Your altitude can be ~20% lower than indicated, when it's cold.



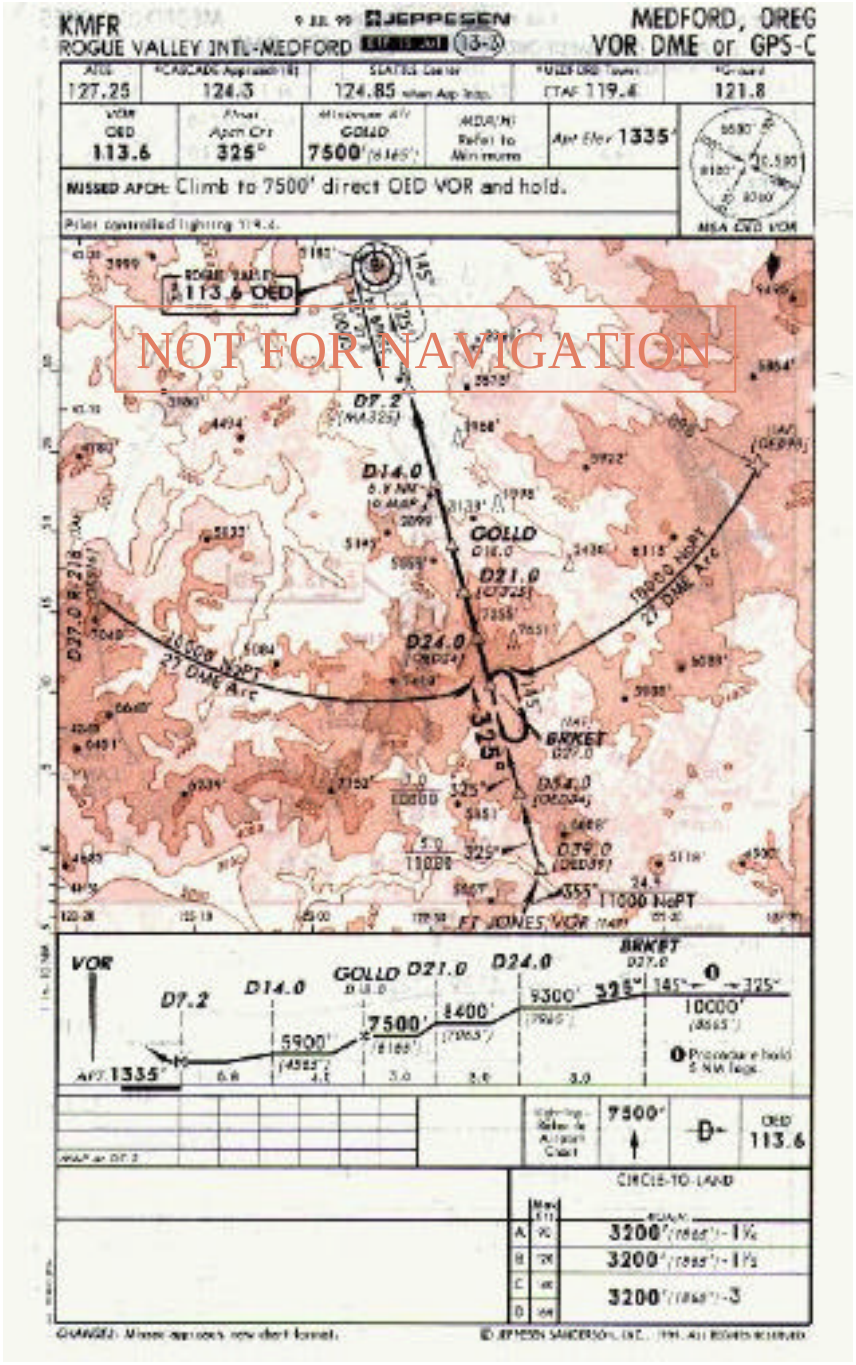
True Altitude
= Indicated Altitude
+ Height above station x
(Temperature deviation /
(OAT +273))

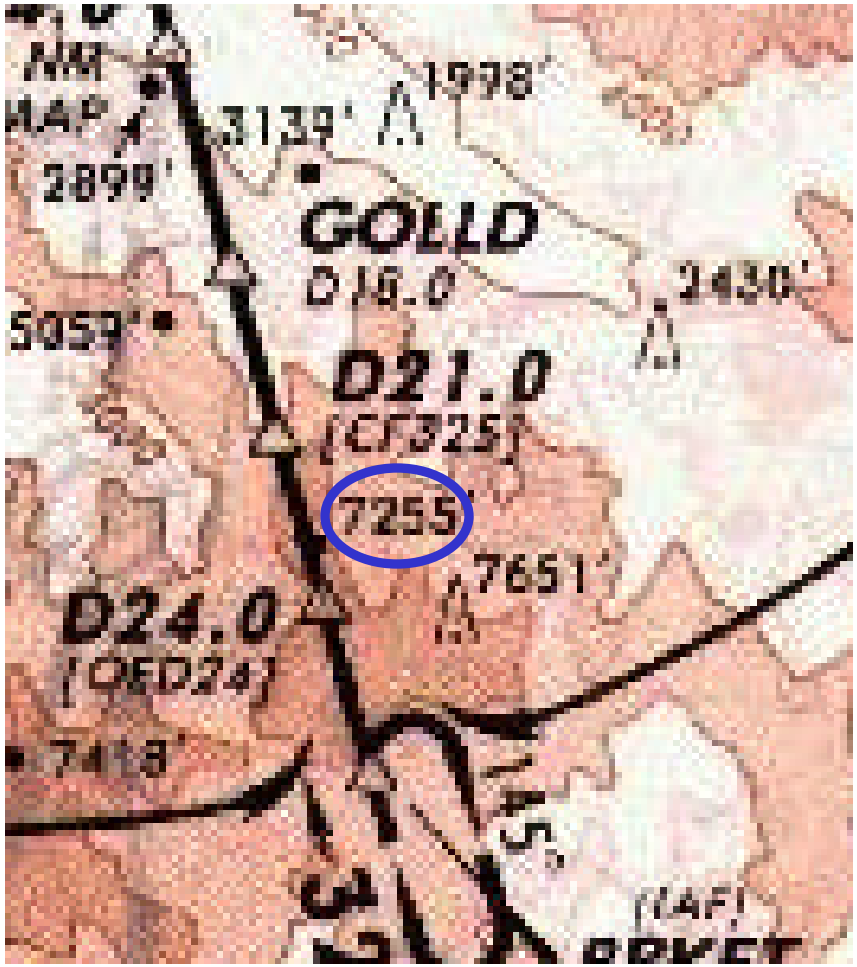
= Station elevation +
Height above station x
Altitude correction factor

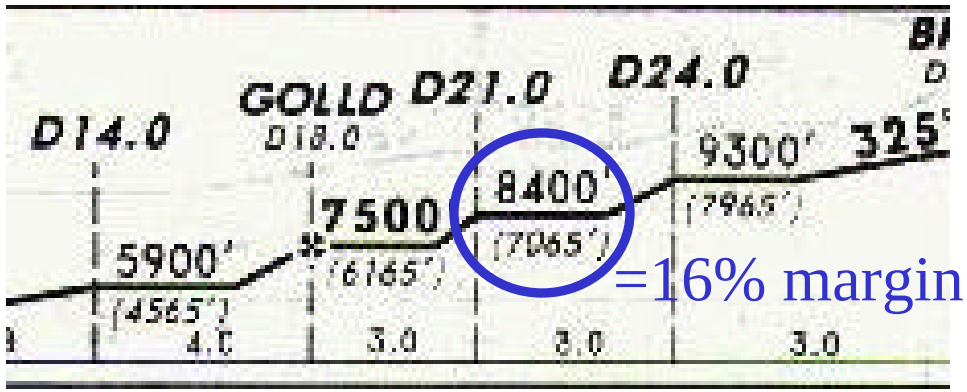
When might the temperature error bite you?

- IFR!
- Enroute, the 1000/2000’ terrain clearance cushion at the MEA should normally be sufficient.
- High circling mins could be compromised.
- Final approach step-downs could be a problem.

Medford VOR-DME-C

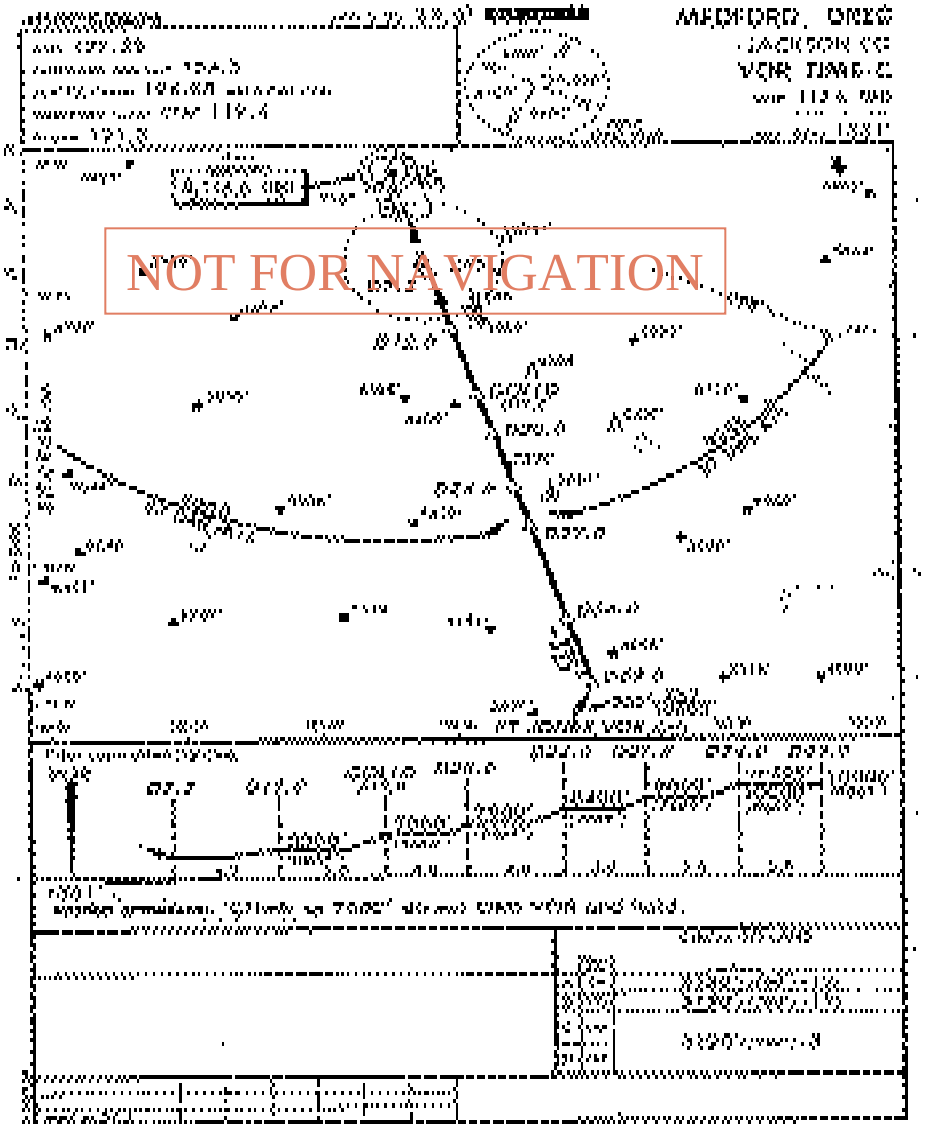


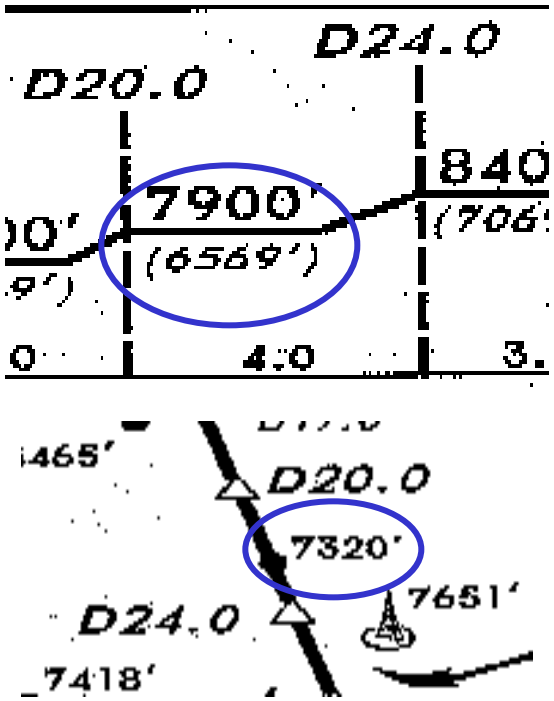




=16% margin

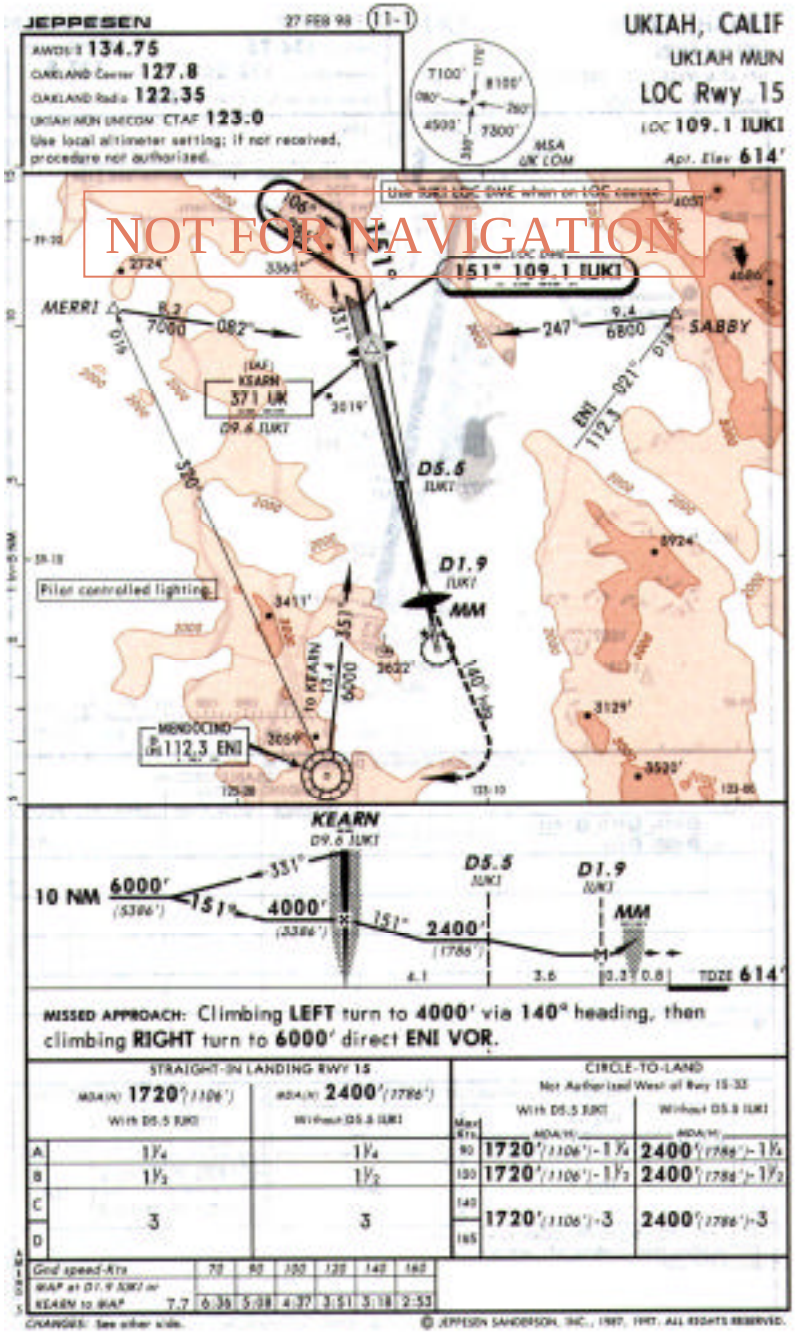
VOR-DME-C MFR before Wally!



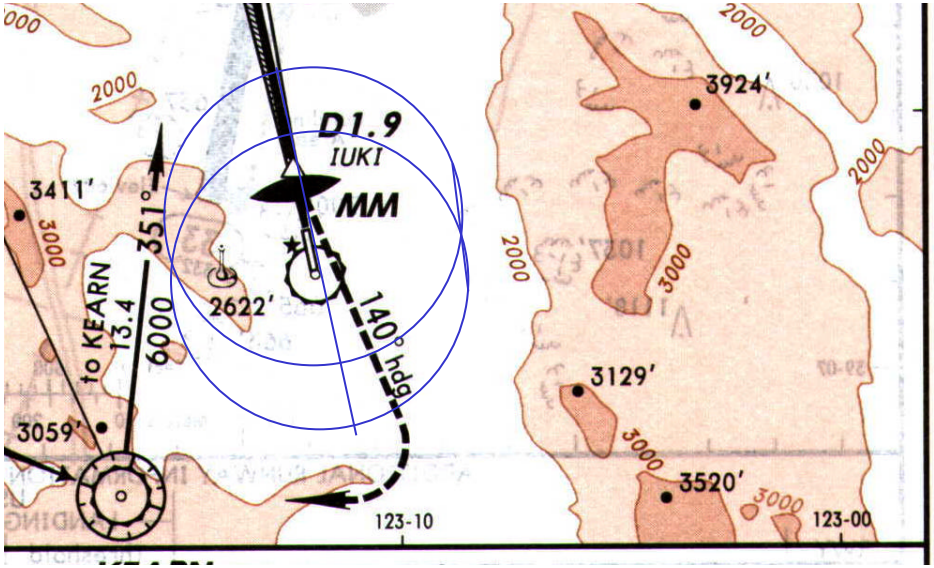


580’ terrain clearance
6569’ above airport =
8.8% margin at ISA
None at ISA -25C !

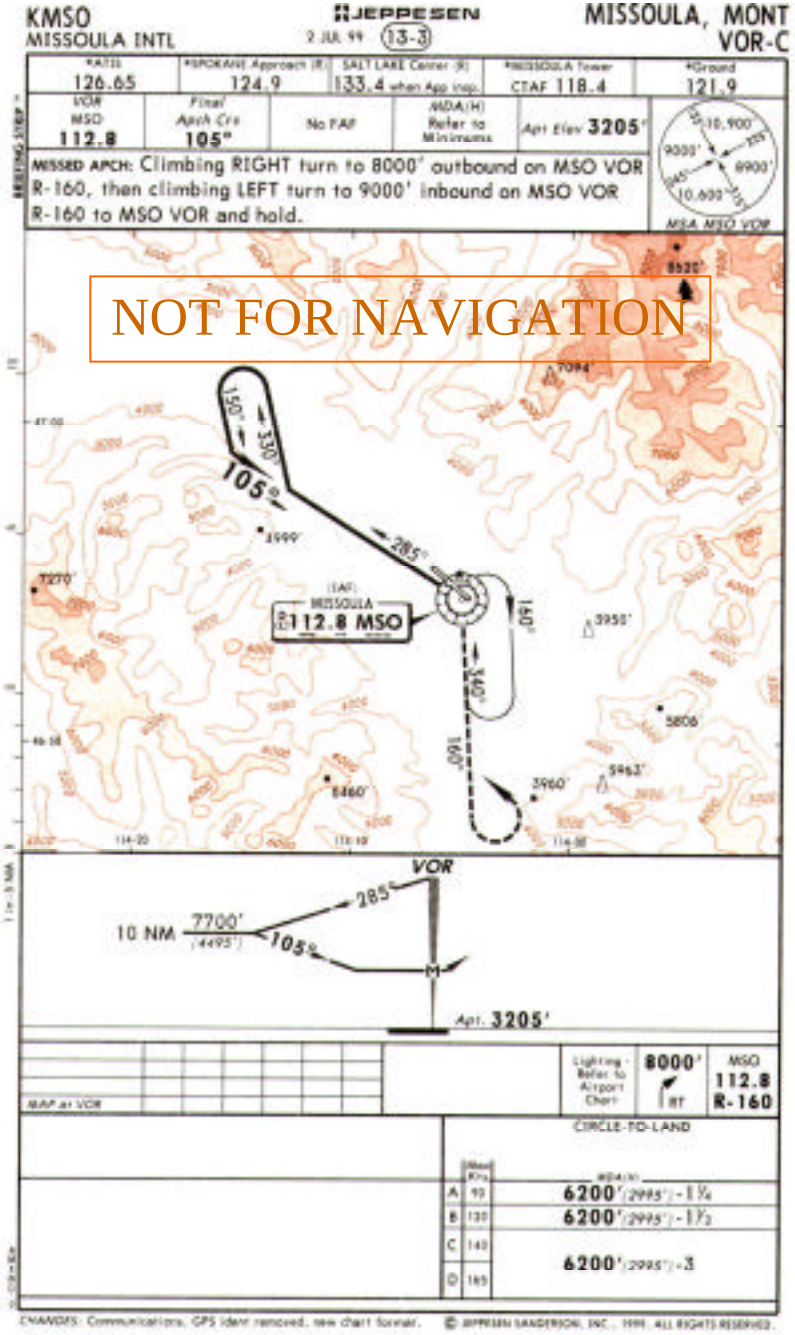
Circling at Ukiah, CA



CIRCLE-TO-LAND Not Authorized West of Rwy 15-33		
Max Kts	With D5.5 IUKI MDA(H)	Without D5.5 IUKI MDA(H)
90	1720'(1106')-1¼	2400'(1786')-1¼
120	1720'(1106')-1½	2400'(1786')-1½
140	1720'(1106')-3	2400'(1786')-3
165		



300’ clearance in circling area =27% margin



MSO has even higher circling minimums!

	Max Kts	CIRCLE-TO-LAND MDA(H)
A	90	6200'(2995')-1¼
B	120	6200'(2995')-1½
C	140	6200'(2995')-3
D	165	

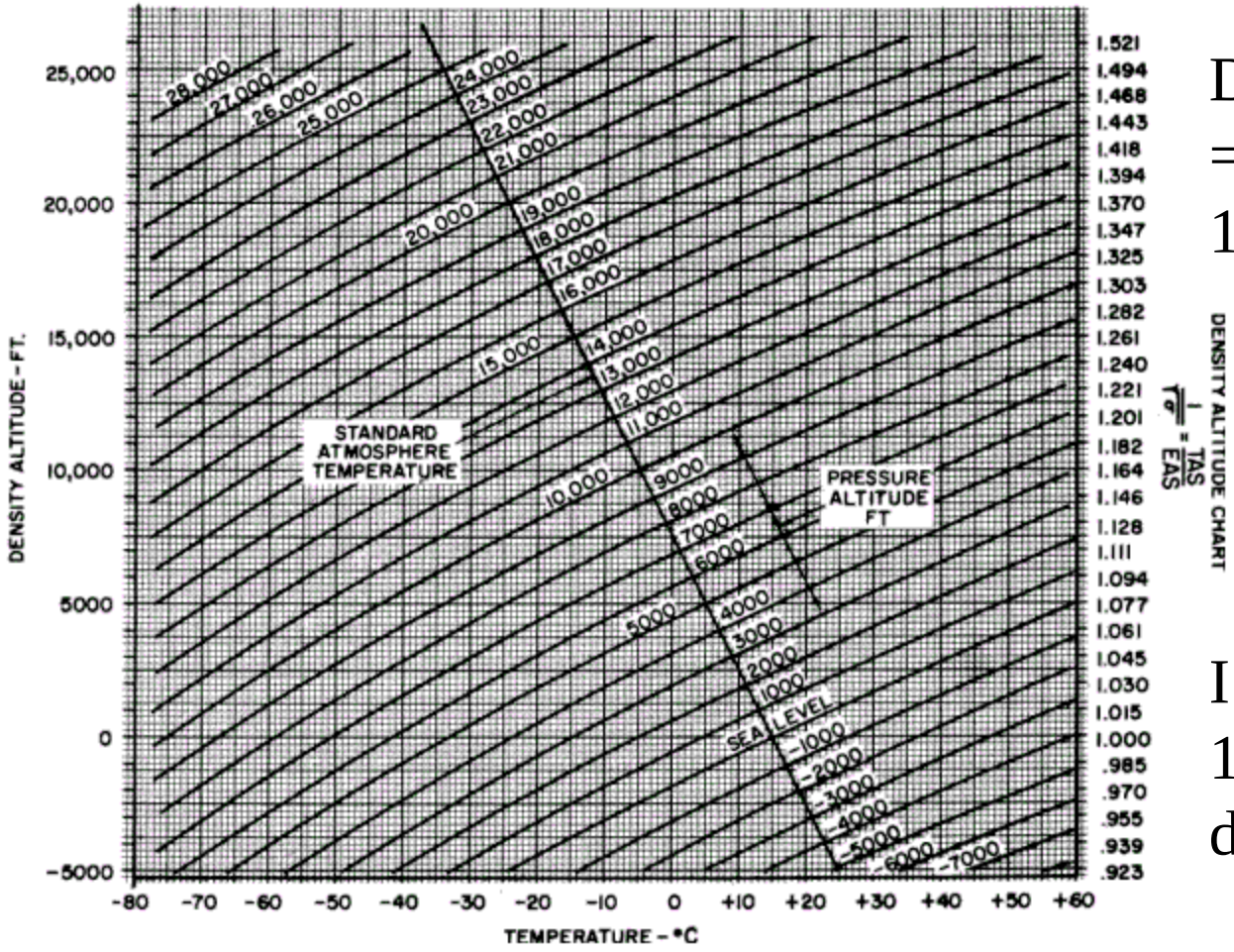
Why not more accidents?

- Requires extreme cold wx.
- Relatively few approaches descend over high terrain at TERPS limits.
- Some cold wx operators adjust minimums?

Air density matters for aircraft performance

- Lift and drag ρ, the air density.
- Max power from a normally aspirated engine available O_2 ρ
- *Density altitude* is the altitude in the standard atmosphere at which the density equals the current density.
- On hot days density altitude is higher and vice versa.

Density altitude derives from pressure altitude and temperature.



Density Altitude
= Pressure Altitude +
120 feet/ºC over ISA

ISA:
15ºC at SL
decreasing 2ºC/1000ft

Final exam

- Name reasons why your GPS doesn’t read true altitude above sea level.
- Under what circumstances could your pressure altimeter read too high, and possibly lead to CFIT?
- *Density altitude* is altitude above what?