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Welcome to The World of Saint P

An Eagle Eye on the turn of
Notes and commentary o
Great Britain and the
from 1995 to 20

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PRACTICAL TECHNIQUES & KNOW-HOW FOR MAKING & MEASURING IN THE LABORATORY & WORKSHOP

THE REDUCTION OF A LOCAL BAROMETRIC PRESSURE TO A MEAN SEA LEVEL VALUE.

In order that atmospheric pressures measured at different locations with different heights above sea level be comparable for meteorological purposes, they are commonly reduced to values corresponding to a single height datum. This datum is normally the mean sea level. For all locations situated above sea level, this sea level value is theoretical: it refers to the atmospheric pressure which would be exerted if that location was at sea level, i.e at a subterranean depth in practice. Despite this, the use of mean sea level pressure is a very useful standardisation.

There are internationally agreed methods of carrying out this standardisation. The World Meteorological Organisation publishes its International Meteorological Tables in which is used the method described in WMO Technical Note 91, "Methods in use for the reduction of atmospheric pressure". In the USA, the Smithsonian Meteorological Tables are used. Although there are slight variations between methods used by different countries, they all are based on the same equation and, in practice, yield comparable values.

The fundamental equation which relates the atmospheric pressure to altitude is that due to Laplace.

$$Z = K.\left(1 + a.\ \vartheta_m\right).\left(\frac{1}{1 - 0.378.\frac{e}{b}}\right).\left(\frac{1}{1 - k.\cos 2\phi}\right).\left(1 + \frac{Z_p}{R}\right).\log\frac{p_0}{p}$$

correction for atmospheric temperature

correction for humidity

correction for asphericity of the earth

where:			
h	height of the upper station	metres	
h_0	height of the lower station	metres	
Z	$h - h_0$	metres	
p	atmospheric pressure at the upper station	hPa	
p_0	atmospheric pressure at the lower station	hPa	
R	mean radius of the earth	metres	6367324.0000
θ_m	mean temperature of the air column	C	
e	mean pressure of aqueous vapour in the air column	hPa	
b	mean barometric pressure of the air column	hPa	
φ	lattitude of the stations	degrees	
K	Barometric constant (hypsometric constant) $K = \lfloor \Delta.b/\delta.M \rfloor$	metres	18400.0000
α	coefficient of thermal expansion of the air		0.0037
k	constant depending on the figure of the earth		0.0026
Δ	density of mercury at 0C		13.6
δ	density of dry air at 0C		0.001293
M	Modulus of common logarithms		0.43

The first term, which is a correction for the temperature of the atmosphere is handled in different ways. In the UK, the average temperature of the air column θ_m is taken to be the station temperature. In France, θ_m is calculated assuming a temperature gradient of 0.5 deg C/100 metres. In Italy, 0.6 deg C/100m is used. Other countries use other variants, but in all cases the values are comparable to 0.1 mB.

The second term is a correction for humidity. In the UK it is neglected. In other countries a fixed value is used. In Spain this is a water vapour pressure of 11 mm Mercury. Again these options affect only very slightly the nortmalised pressure.

The third term, the correction for the asphericity of the earth is normally neglected or a fixed value of the lattitude chosen. The fourth term for the variation of gravitational acceleration with height is neglected in the UK and in most other countries.

The effects of temperature, humidity, geo-asphericity, & variation of gravity with height

LAPLACE
CALCUL

Station altitud
=

100
metres
=

feet
Local pressure
=

990
mB
=

mm Hg
=

inches Hg
Station Tempe
=

20
deg C
=

deg K
Station water pressure
=

11
mB
=

mm Hg
Station Latitu
=

51
degrees
Sea level pressure corrected for air compression
=

mB
then corrected temperature
=

mB
then corrected humidity
=

mB
then corrected latitude

Pressure at Mean Sea Level mb	1013.0000
Pressure at 100 metres mb	1000.4023
Corrected for Temperature	1001.2652
Corrected for Humidity	1001.3181
Corrected for geo-asphericity	1001.3388
Corrected for gavitational variation	1001.3390

= [ ]
mB
then corrected
variation of
gravitational
acceleration
= [ ]
mB
Compare valu
obtained from
Babinet's forn
[ ]
mB
[calculate]

The table above shows the relative contributions of the factors for which correction is applied. To correct for temperature is evidently important for 1 mB, and correction for humidity important if 0.1mB precision is needed. Other factors are less significant. The author has noted that in high precision barometry, short-term variations or fine structure is observable on the barometric trace, some of which may be due to short term humidity variations. Constructors of sensitive air-barometers in the eighteenth century noted variations of the readings of their instruments when clouds passed overhead.

The equation used in the Meteormetrics Laplace Calculator

$$\log p_0 = \log p + \frac{Z}{K \cdot (1+\alpha \cdot \vartheta_m) \cdot \left(\dfrac{1}{1-0.378 \cdot \dfrac{e}{b}}\right) \cdot \left(\dfrac{1}{1-k \cdot \cos 2\phi}\right) \cdot \left(1+\dfrac{Z_p}{R}\right)}$$

The above equation is a rearrangement of the Laplace Equation for computational purposes. Using the calculator on the left of this page, the reader will be able to verify the magnitudes of the effects of the correcting factors upon the calculated pressure.

BABINET'S FORMULA

A close approximation to the corrections obtained from the Laplace equation is afforded by the formula of Babinet. This gives close correspondence up to 1000 metres and results within 1% to considerably greater heights. The main advantage of it is that it provides a correction for altitude in processors where maths functions are not available or cannot be accommodated.

Babinet's formula can be expressed as:

$$Z_{METRES} = 16000 \left(1 + \frac{4\theta_m}{1000}\right)\left(\frac{P_0 - P}{P_0 + P}\right)$$

$$\alpha = 16000 \left(1 + \frac{4\theta_m}{1000}\right) = 16000 + 64\theta_m$$

$$P = P_0 \frac{(\alpha - Z)}{(\alpha + Z)}$$

The result of using Babinet's formula rather than that of Laplace can be observed by using the calculator.