



Radiosonde observations of 3 March 1995, 00 UTC at 4 different stations including station code, latitude(°N), longitude (°E). (at 500 and 400 hPa)

PRES	HGHT	TEMP	DWPT	RELH	MIXR	DRCT	SKNT	THTA	THTE	THTV
hPa	m	C	C	%	g/kg	deg	knot	K	K	K
Station 0: 10548 Meiningen										
Station latitude (ϕ_0)= 50.56 Station longitude (λ_0)= 10.38										
500.0	5370	-29.1	-34.0	63	0.43	260	59	297.5	299.0	297.6
400.0	6930	-41.9	-47.9	52	0.13	260	71	300.4	300.9	300.5
Station 1: 10739 Stuttgart										
Station latitude (ϕ_1)= 48.83 Station longitude (λ_1)= 9.19										
500.0	5440	-27.1	-32.1	62	0.52			299.9	301.7	300.0
400.0	7000	-40.9	-49.9	37	0.10			301.8	302.1	301.8
Station 2: 10393 Lindenberg										
Station latitude (ϕ_2)= 52.2 Station longitude (λ_2)= 14.1										
500.0	5330	-31.1	-41.1	37	0.21	265	70	295.1	295.8	295.1
400.0	6880	-41.5	-54.5	23	0.06	260	71	301.0	301.2	301.0
Station 3: 10410 Essen (EDZE)										
Station latitude (ϕ_3)= 51.4 Station longitude (λ_3)= 6.96										
500.0	5300	-29.7	-33.3	71	0.46	245	52	296.8	298.4	296.9
400.0	6850	-42.5	-47.4	59	0.13	240	75	299.7	300.2	299.7

Summary of the procedure and specific questions

The desired value of the height at the gridpoint (x_0, y_0) or (λ_0, ϕ_0) is z_0 . Applying this formula to the three measuring points yields three equations with three unknowns: z_0 , $\partial z/\partial \lambda$ and $\partial z/\partial \phi$. These three equations can be written concisely as

$$\begin{pmatrix} z_1 \\ z_2 \\ z_3 \end{pmatrix} = \begin{pmatrix} 1 & (\lambda_1 - \lambda_0) & (\phi_1 - \phi_0) \\ 1 & (\lambda_2 - \lambda_0) & (\phi_2 - \phi_0) \\ 1 & (\lambda_3 - \lambda_0) & (\phi_3 - \phi_0) \end{pmatrix} \begin{pmatrix} z_0 \\ \partial z/\partial \lambda \\ \partial z/\partial \phi \end{pmatrix}$$

which can be written shortly as

$$\begin{pmatrix} z_1 \\ z_2 \\ z_3 \end{pmatrix} = M \begin{pmatrix} z_0 \\ \partial z/\partial \lambda \\ \partial z/\partial \phi \end{pmatrix} \quad \text{or} \quad \begin{pmatrix} z_0 \\ \partial z/\partial \lambda \\ \partial z/\partial \phi \end{pmatrix} = M^{-1} \begin{pmatrix} z_1 \\ z_2 \\ z_3 \end{pmatrix}$$

We need to invert M (<http://matrixcalc.org/en/>) in order to calculate z_0 , $\partial z/\partial \lambda$ and $\partial z/\partial \phi$.

From $\partial z/\partial \lambda$ and $\partial z/\partial \phi$ we can obtain an **estimate of the geostrophic wind** for Meiningen from the geostrophic wind equation (a is the radius of the earth):

$$v_g = \frac{g}{f} \left(\frac{\partial z}{\partial x} \right)_p = \frac{g}{fa \cos \phi} \left(\frac{\partial z}{\partial \lambda} \right)_p; u_g = -\frac{g}{f} \left(\frac{\partial z}{\partial y} \right)_p = -\frac{g}{fa} \left(\frac{\partial z}{\partial \phi} \right)_p$$

If we apply this procedure to the 500 hPa and the 400 hPa pressure surfaces we can find the **thermal wind** between 500 and 400 hPa, Δu_g and Δv_g

According to the thermal wind equation,

$$\Delta v_g = -\frac{R}{f} \frac{\partial T}{\partial x} \Delta \ln p; \Delta u_g = \frac{R}{f} \frac{\partial T}{\partial y} \Delta \ln p.$$

Next we apply the interpolation to the the average temperature in the layer between 500 and 400 hPa, which yields an estimate of the average temperature gradient. Use the thermal wind equations to obtain a new estimate of Δu_g and Δv_g .

Compare these estimates with the measured values of Δu and Δv .

Please be careful with the units and note that $R=287 \text{ J K}^{-1} \text{ kg}^{-1}$ and $f=2\Omega \sin \phi$, with $\Omega=0.00007292 \text{ s}^{-1}$ and ϕ the latitude. The radius of the earth $a=6370000 \text{ m}$ (at the latitude of Meiningen $g/(fa)=0.0137$).

Explain the differences between your theoretical result and the observations

