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Does The Valley of Assam-Burma Hills Effect on An Asymptotic Solution For 3-D Lee Waves?

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Abstract
In the north-east region of India, the Assam-Burma Hills (ABH) is broadly north-south oriented. ABH has been considered by two three dimensional elliptical barriers and they are separated by a valley of some finite distance. Here, what effect does this valley have on an asymptotic solution for 3-D Lee waves? has been studied. The basic flow is assume to have only one component U normal to major ridges of the ABH and perturbation technique is applied to the governing equations. The perturbation vertical velocity (w') and streamline displacement (η') are expressed as double integrals, which have been attempted to approximate as an asymptotic expansion.

Key word: Assam Burma hills, Asymptotic solution, Valley effect.

1. INTRODUCTION

The weather and climate of any place are depend on the orographic behaviour of that place. In the past, many aircraft accidents recorded in mountainous areas are often attributed to the vertical velocities of large magnitude associated with the lee waves. So, it is very important that studies on the lee waves across the orographic barrier associated with airflow be conducted for the safety of aviation.
The theoretical studies on the 3-D mountain wave problem was first addressed by Scorer and Wilkinson (1956) and thereafter Crapper (1959), Dutta *et al.*(2002), Dutta (2005) Das *et al*. (2013, 2016) etc. In India, the problem on the Lee waves across ABH was first address by De (1970) and thereafter Farooqui and De (1974), Dutta and Kumar (2005), Das *et al*. (2013) etc. Das *et al*. (2013) developed a 3-D lee waves model across ABH, they showed that their solution was crescent shaped updraft regions. But, they are not studied any effect of the valley of ABH associated with lee waves.
In this study, the main goal is to develop a 3-D meso-scale lee wave model for the ABH and to observe the effect of the valley on analytical solution for the updraft and vertical displacement associated with 3-D meso-scale lee waves across ABH.

2. DATA

The nearest only weather station on the upstream side is **Guahati** (26.19^{0}N, 91.73^{0}E). **Hence the RS/RW data of Guahati for those dates, which corresponds to the observed lee waves across ABH, as reported by De (1970)** Farooqui and De (1974) and Das *et al*. (2013), has been obtained from Archive of India Meteorological Department, Pune.

3. METHODOLOGY

In the present study, similar to Das *et al*. (2013), an adiabatic, non-rotating, steady state and laminar flow of a vertically unbounded stratified and Bossiness fluid across a 3-D meso-scale orographic barrier, has been considered and also similar to the study of Das *et al*. (2013) in most of the aspects, except the lower boundary condition. Similar to Das *et al*. (2013) we obtain the following vertical structure equations for perturbation vertical velocity (w') and for perturbation vertical streamline displacement (η') :

$$\frac{\partial^2 \hat{w}_1}{\partial z^2}+\left(m^2-\frac{1}{2\rho_0}\frac{d^2\rho_0}{dz^2}+\frac{1}{4\rho_0{}^2}\left(\frac{d\rho_0}{dz}\right)^2\right)\hat{w}_1=0 \qquad (1)$$

$$\frac{\partial^2 \hat{\eta}_1}{\partial z^2}+\left(m^2-\frac{1}{2\rho_0}\frac{d^2\rho_0}{dz^2}+\frac{1}{4\rho_0{}^2}\left(\frac{d\rho_0}{dz}\right)^2\right)\hat{\eta}_1=0 \qquad (2)$$

All symbols have the same meaning as of Das *et al*. (2013). Now the mathematical expression of the ABH is given by [Das *et al*. (2013)]

$$h(x,y)=\frac{h_1}{1+\frac{x^2}{a^2}+\frac{y^2}{b^2}}+\frac{h_2}{1+\frac{(x-d)^2}{a^2}+\frac{y^2}{b^2}} \qquad (3)$$

Using the same techniques and the same boundary conditions of Das *et al*. (2013) the asymptotic solution of vertical streamline displacement (η') and perturbation vertical velocity (w') are given by:

$$\eta'(x,y,z)=c(z)\eta_1'(x,y,z)=\exp\left(\frac{g-R^\bullet\gamma}{2R^\bullet\overline{T}}z\right)\eta_1'(x,y,z) \qquad (4)$$

where

$$\eta_1'(x,y,z)=\frac{abN^2}{2U^2}\frac{XZ\sqrt{\rho^4+X^2Y^2}\left[h_1\cos\left(\frac{RZ}{\rho}\right)+h_2\cos\left(\frac{RZ}{\rho}-\frac{NXZd}{UR\rho}\right)\right]K_0\left(\frac{XZN\sqrt{a^2\rho^4+b^2X^2Y^2}}{RU\rho^3}\right)}{R^2\rho^3\sqrt{\left\{1+4\left(\frac{XYZR}{\rho^4+X^2Y^2}\right)^2\right\}}}$$

and

$$w'(x,y,z)=\exp\left(\frac{g-R^\bullet\gamma}{2R^\bullet\overline{T}}z\right)w_1'(x,y,z) \qquad (5)$$

where

$$w_1'(x,y,z)=-\frac{abN^3}{U^2}\frac{X^2Z^2\sqrt{(\rho^4+X^2Y^2)}\left[h_1\sin\left(\frac{RZ}{\rho}\right)+h_2\sin\left(\frac{RZ}{\rho}-\frac{NXZd}{UR\rho}\right)\right]K_0\left(\frac{XZN\sqrt{a^2\rho^4+b^2X^2Y^2}}{RU\rho^3}\right)}{2R^3\rho^4\sqrt{\left\{1+4\left(\frac{XYZR}{\rho^4+X^2Y^2}\right)^2\right\}}}$$

All symbols have their same usual meaning as of Das *et al*. (2013).

4. RESULTS AND DISCUSSION

The perturbation vertical velocity (w') and vertical streamline displacement (η') are computed by using the equations [4] and [5] for different values of valley length (d) and others parameters have taken $a=20km, b=50km, h_1=0.9km, h_2=0.7km, U=10m/\sec, N=0.01s^{-1}$ at $z=1.5km$ above mean sea level, which approximately reassemble to 850hPa. The computed values of w' and η' for different values of valley length(d) are given by in the Table 1.

Table 1: Vertical velocity (w') and streamline displacement (η') for different values of length (d) of the valley.

Experiment No.	U (m/sec)	N (/Sec)	d=Length of the Valley (km)	$\eta'(mtr)$	$w'(m/\sec)$
1	10	0.01	5	2578.37	855.01
2	10	0.01	10	3438.96	953.85
3	10	0.01	15	5348.98	1130.47
4	10	0.01	20	5440.17	1207.12
5	10	0.01	25	5517.14	1398.15
6	10	0.01	30	3759.41	1692.97
7	10	0.01	35	2727.60	1142.67
8	10	0.01	40	4110.28	864.55
9	10	0.01	45	6006.78	839.69
10	10	0.01	50	3122.32	1254.38
11	10	0.01	55	2080.63	350.68

The profile of perturbation vertical velocity (w') and valley length (d) is plotted in Figure-1 and perturbation vertical streamline displacement (η') is shown in Figure-2.

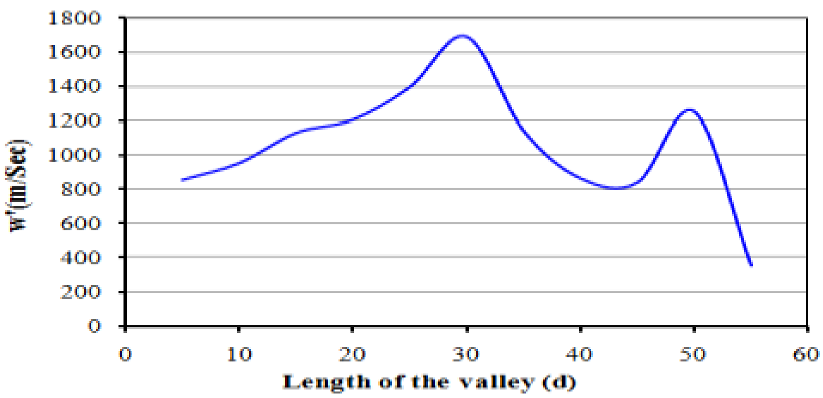

Figure 1: Profile of perturbation vertical velocity (w') and valley length (d)

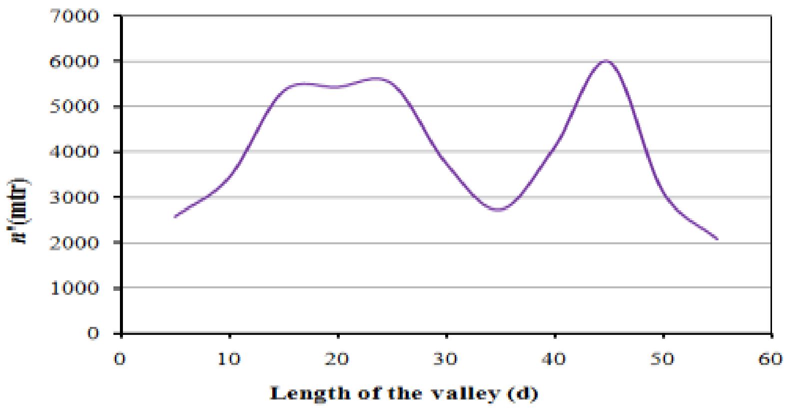

Figure 2: Profile of streamline displacement (η') and valley length (d)

From Table 1 and Figure 1, it is clear that the perturbation vertical velocity (w') is increasing when length of the valley is increasing from d=5km to 30km. But, when length of the valley is increasing after d=30km the perturbation vertical velocity (w') increasing and decreasing. When length of the valley d=30km the maximum perturbation vertical velocity (w') is found in the Table 1.

Again from Table 1 and Figure 2, it is found that the vertical streamline displacement (η') is also increasing when the valley length of ABH is increasing from d=5km to 25km whereas when valley length is increasing after d=25km the streamline displacement (η') is increasing/decreasing. The maximum streamline displacement (η') is found when length of the valley d=45km(see Table 1).

5. CONCLUSION

In this experiment, the effect of the valley length (d) on the asymptotic solution of perturbation vertical velocity (w') and streamline displacement (η') across ABH is very significant. This experiment remarks that the length of the valley plays a crucial role to increase/decrease the values of perturbation vertical velocity (w') and streamline displacement (η').

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