Föhn fallacies
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Excerpt from

Chapter 11  Clouds and fallout
Section 11.6  The dynamics of fallout
Subsection 11.6 (2)  Föhn fallacies (pages 419 to 422) plus figure 5.15.iii (page 205)

The paragraph layout is identical to the one in the book, figures, however, are not in their original positions.

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(2) Föhn fallacies

It is almost always stated that when the air on the lee side of a mountain is found to be warmer than on the windward side, it is because of the latent heat of the rain which falls out on the mountain. This explanation is usually incorrect. We imagine a mountain range reaching to 700 mb (about 3000 m) above sea level, with a cloud base at 900 mb (about 1000 m) on the windward side at A', and suppose that the cloud base on the lee side is at 700 mb. This is as high as it can possibly be in this situation (Fig. 11.6.iii). From the T-ϕ gram (Fig. 11.6.iv) we deduce that if the temperature at A' at 900 mb on the upwind side is 10 °C, using the wet adiabatic to F at 700 mb and a dry adiabatic to return to B' at 900 mb the air will be at 18.5 °C at B' on the lee side. Thus a warming of the order of 8.5 °C is explained. Such an increase is more easily explained by the blocking mechanism in Section 5.18(7) and Fig. 5.18.xi, and this is more likely because the warming is often observed when there is no cloud at the mountain top. The mixing caused by turbulence may also be effective as described in Section 9.8(6), where the effect of stirring a stably stratified layer is to warm the lower half of it and make the lapse rate dry adiabatic throughout its depth.

One must also be wary of explanations in terms of rain because before the air ascends through the cloud base on the upwind side it may have rain falling through it between A and A' which cools it and lowers the cloud base to A₁'. The suffix 1 is used to indicate that rain has been evaporated into the air at some time. Unless there is a corresponding increase in the rain falling from the air close to the mountain surface on the upwind side, the cloud base on the lee side will be lower and the parcel will return via B₁'' and B₁'. In that case the warming above the temperature at A is roughly half that previously calculated. Likewise rain falling through the air on the lee side would have the effect of bringing the air down the wet adiabatic from F, with the same consequence. Furthermore, when the cloud does engulf the top of the mountain and the air flows up the front face, it is usually observed that the cloud base on the lee side is lower close to the mountain, at B'' for example, than at D. This indicates that on the lowest streamline the air does not have as much water rained out as on higher streamlines which reached a greater altitude in the cloud.
The column of air AC is not unstable, and will normally be slightly stably stratified. In that case C lies on a warmer isentrope than A and is above AA' on the T-ϕgram (Fig. 11.6.iv). The air moving along the track CD'DE is represented on the T-ϕgram, where it is seen that unless D lies above the line BF, E will be on a colder isentrope than B, and the column of air BE will be unstably stratified. This is not observed, which means that in its passage over the mountain the cloud base must be raised on the streamline CE by more than it is raised.
on the streamline AB, unless the column AC is very stably stratified. If it is observed that the cloud base does satisfy this condition, it is more probable that this is because the air below the mountain top does not pass over it. Moreover, because of blocking the air above the top descends on the lee side and evaporates any cloud that may be in it. This evaporation has nothing to do with rain on the mountain. Furthermore, wave theory shows that the clouds do not necessarily disappear on the lee side of a hill (see Fig. 5.16.iii), and Föhn and Chinook warm winds are common with no rain on the mountains. Chinooks in their early stages take-off from the ground not far from the lee of the mountain. It seems probable that, since they descend from a high level because of blocking of the lower layers, the lee wave is of large amplitude and a rotor is present which is filled with cold air not yet displaced from near the foot of the mountain. On such occasions the ground may still be snow covered at the end of the winter on the lee side.

![Fig. 5.16.iii](image)

Whether there is a lee wave visible in cloud at a low level or not there is sometimes a higher layer at which the air ascends above its condensation level when the air at ground level descends. A ‘window’ to the sky then appears over the lee slope, and is often referred to in the literature as a ‘fohn lucke’.

Thus the commonly employed explanation is a facile one which depends on the cloud engulfing the mountain top with rain on the upwind side only. It may occasionally be correct, but blocking is the more common cause of the warming. Perhaps the most spectacular case of warming is provided by the Berg winds of Natal: on arrival at Durban the air sometimes has a potential temperature indicating that it has descended from higher than the mountain tops (3600 m, 150 miles away) with no cloud present. Mechanical mixing of a stably stratified layer probably contributes to the high surface temperature in this case.

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