1.5

Hann's Thermodynamic Foehn Theory and its Presentation in Meteorological Textbooks in the Course of Time

Petra Seibert
Institute of Meteorology, University of Natural Resources Vienna, Vienna, Austria
petra.seibert@boku.ac.at

1. Introduction

Foehn, especially the south foehn of the Alps, is a classical topic in the history of meteorology. In the middle of the 19th century, a famous scholars' dispute finally led to the acceptance of the so-called "thermodynamic foehn theory" which is commonly attributed to Julius (von) Hann[1]. Already in 1885, it became subject of historical considerations. Hann (1885) wrote: *Certainly it is not to the dishonour of our time, that the historical element, too, is finding more and more attention and esteem in the disciplines of science (...) However, also the works themselves of researchers of previous periods are read more assiduously and their results are commemorated more and more again.*[2] This process is not at all concluded, not even for the 150-year-old thermodynamic foehn theory. Renewed interest in the dynamical aspects of Alpine meteorology, culminating in the ALPEX 1982 project, brought to the light that this theory had became distorted mainly around the middle of the 20th century. This distortion took place primarily in textbooks of general meteorology and spread widely into schools and the general public.

2. Development and presentation of the thermodynamic foehn theory in the 19th century

In October 1866, in the first volume of the Zeitschrift der Österreichischen Gesellschaft für Meteorologie (later Meteorologische Zeitschrift), Hann published his first article on the origin of the foehn, where he explained the dryness of the subsiding air as a consequence of its warming by adiabatic compression,

[1] Born in 1839, obtains Dr. phil. degree in Vienna in 1867 and habilitation already one year later. Becomes full professor in Vienna 1877, in Graz 1897 and again 1900 in Vienna. His name is found with and without the "von", as he was raised to nobility on the occasion of his emeritation in 1910. Dies 1921. (Steinhauser, 1989)

[2] Translation from the German original by the author, as for all other quotes from German-language sources.

while, however, still accepting Dove's view of the foehn as an air stream coming from equatorial latitudes (Hann, 1866). In his historical view back 20 years later, Hann commented this: *At that time I still stood almost completely under the domination of Dove'ian theories, which were later slowly stripped off and refuted by means of autonomous thinking* (Hann, 1885). In a discussion that developed by a remark of Bezold to Hann's article, Hann wrote: *When I wrote my first article about the foehn, I was a beginner, a completely unknown young meteorologist, who could not not expect that his views would find special consideration* (Bezold and Hann, 1886). One year after the 1866 paper, in the second volume of the Meteorologische Zeitschrift, he published the article "Der Föhn in den österreichischen Alpen" (The foehn in the Austrian Alps), which is the basic reference for 'Hann's thermodynamic foehn theory' Hann (1867). Hann was eager to point out that Wild in his 1867 inaugural speech as rector of the University of Berne, Switzerland, independently presented the same view. Hann also pointed out that much of the thermodynamic foehn theory had been discovered independently by James Espy in the USA.

In 1901, the first edition of Hann's famous textbook "Lehrbuch der Meteorologie" was published (Hann, 1901). We can safely assume that the section on foehn in this book represents the essence of what Hann had established as the description and explanation of foehn by the end of the 19^{th} century. This section comes in the chapter "Isobarentypen und Witterung" (Types of isobars and weather character) as "II. Besondere Arten der cyklonalen und anitcyklonalen Winde in Gebirgsländern. Föhn (Scirocco) und Bora. A. Föhn." (Special types of cyclonic and anticyclonic winds in mountain countries), and covers 10 pages. It states, inter alia, that the warming experienced in the foehn valleys is an effect of the diabatic warming of the subsiding air and that it is the larger the more stable the air is stratified originally, and that this is the reason why the foehn is felt less in summer than in winter. Hann notes that on the windward side the air is rather stably stratified. Concerning the role of the condensenation heat, he wrote: *Earlier it had been assumed that (...) a strong S- or SW-wind crossing the Alps (or any mountain ridge) would be necessary, which on the southern side condenses its water vapour in heavy precipitations, and then on the northern side, experiencing 1 temperature increase for each 100 m, occurs as a very warm wind, and the high warmth there thus to be attributed to the vapour heat released on the other side. Such cases do occur indeed, and most of the long foehn periods of the autumn and winter (...) have this origin (...). However, this is not at all an absolute condition for the generation of foehn, and just the* *typical foehn cases come into being through the way presented previously (...). The decrease of heat with height is almost always, and especially with the calm weather preceding foehn, so little that a pure subsidence of the air from the height of the alpine crests is sufficient to impart to it the warmth and dryness of foehn* (Hann, 1901).

The "Lehrbuch der Meteorologie" (Textbook of meteorology) of Sprung (1885) extensively quotes Hann to explain the foehn, in the same sense as in Hann's 1901 textbook, and Wrangel about the bora. Wrangel already in 1876 explained the bora as a catabatic wind of cold air masses flowing from the plateau behind the Dinaric coastal mountain range. Bebber (1890) also bases his remarks about the foehn on Hann. Another textbook of the late 19th century (Günther, 1889), presents the "historical" foehn debate and also follows largely Hann.

3. Development of the presentation in 20th century textbooks

In 1915, the third, revised edition of the "Lehrbuch der Meteorologie" appeared with Reinhard Süring as a co-author. In order to accommodate new research mainly by Ficker, the original text is shortened, but the sense and the key statements are not touched. Ficker, who become famous through his "Innsbrucker Föhnstudien", later studied cyclogenesis. In a study about cyclogenesis in the Mediterranean (Ficker, 1920), he emphasized the asymetric flow patterns on both sides of the Alps during foehn: *The warm air on the northern side thus stems from aloft, without warm air flowing in in the lower layers of the southern side of the Alps. (...) The Alpine range (...) inhibits on the southern side of the Alps the outflow of the air towards the minimum in the northwest of the Alps (...) thus the region north of the Alps is filled with air from aloft with south wind, whose higher potential temperature delivers the foehn warming on the northern side.*

This presentation is contrasted, interestingly enough, by a book of Ficker and De Rudder (1943). The principle of the new view is well characterised by Figure 1 (Ficker and De Rudder, 1943). These figures virtually mark a new "foehn paradigm". It is characterised by the depiction of a flow pattern which is symmetric between north and south and where the streamlines follow the topography, and by declaring the condensation during the ascent to be a crucial element required to explain the temperature difference between north and south. Ample use is made of thermodynamic diagrammes, and the difference between

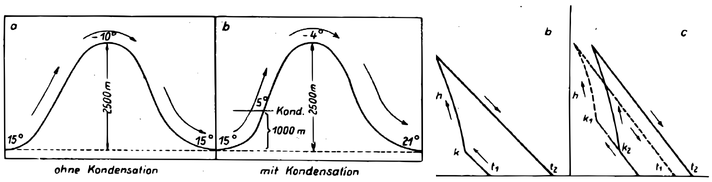

Figure 1: Figures 1 ab and 2bc of Ficker and De Rudder (1943) with flow and temperature schemes for foehn.

north and south is the primary focus, not the one between foehn and foehn-free situations. Börnstein (1906) is one of the earliest examples for this development. Though used heavily to illustrate moist thermodynamics, the role of the different forms of water is not sufficiently well considered in many of these texts. For example, Ficker and De Rudder (1943) wrote: *If the air rises further towards the main divide, just that amount of water vapour is removed that its humidy remains always at 100%; however, now the heat released as a consequence of condensation (cloud formation and precipitation) acts against the cooling and slows it down to such a degree that the cooling per 100 m of ascent is now only about 0.6 /100 m. (...) If now the air sinks down on the other side into the foehn valley, it passes immediately into the unsaturated state because of the warming and warms up by 1 /100 m (...).* This presentation ignores the fact that not all of the condensed humidity is removed by precipitation, and some cloud water is carried over the crest and thus the descend cannot start immediately along the dry adiabate. Furthermore, it is now claimed that foehn would always be accompanied by clouds and precipitation in the south, in direct contradiction to what “grandmaster” Hann had written. The fact that dry foehn cases are observed is explained away on a linguistic level by making a distinction between ‘anticyclonic’ ‘pre-stage’ and the ‘real’, ‘fully developed’ foehn which by definition must be accompanied by precipitation in the south. It is a kind of tragic irony that this view later entered into the very “Hann textbook”. In its “5th, completely revised edition” of 1951 the new editor of this chapter, Fritz Müller, wrote: *The basic event of the foehn process consists of the lifting on one side of the mountain and the subsidence on the other. During the lifting, dynamic cooling occurs and after passing of the condensation level, liquefaction of the water vapour. In this process, condensation heat is released and imparted to the air. If the liquid water falls out completely, the air is warmed purely adiabatically on the lee side of the mountain during the subsidence and thus arrives with an excess temperature which exactly corresponds to the released vapourisation heat* (Hann and Süring, 1951).

This style of presentation spread extremly widely and quickly into many other textbooks. Interestingly, authors with a background in dynamical meteorology did not fall into this pit. Probably they were too much aware of the basic principles of air flow over mountains, which in any stably stratified environment are characterised by an asymetric flow pattern. Luise Lammert (1920), one of the early women in meteorology, constructed three-dimensional streamlines from pilot ballon observations in the Po Basin which also showed that the flow during foehn does not normally follow the relief of the southern Alps.

4. Recent developments

Dynamic meteorology and work on gravity waves and air flow over mountains on one hand and what had become 'the thermodynamic foehn theory' remained two rather separate traditions for many decades. This changed in the late 1970ies and early 1980ies, with the ALPEX programme. Meteorologists at Innsbruck studied dynamic and thermodynamic properties of the air in north-south cross sections during foehn in Innsbruck and found that most of the air masses in the south would be trapped in a cold-air pool (Steinacker, 1983; Seibert, 1990). Beginning with the end of the 1990ies, high-resolution simulations of foehn situations including a realistic treatment of moisture and precipitation became available. One such study (Seibert et al., 2000) indicated, in partial contradiction to the results of the previous two decades, that foehn air can be lifted from the bottom of the Po Basin. Such events tend to be nonstationary, and they are of course connected with enormous amounts of precipitation on the southern side of the Alps. The MAP programme and preparatory work for it recalled the huge precipitation amounts that are quite often observed in the Lago Maggiore area. The present image of foehn is a wide range of events from very shallow and completely dry events to motions across the troposphere and lower stratosphere with heavy precipitation and strongly rising air masses at least in some parts of the Western Alps. Though Ficker (1910) apologised for presenting one more foehn study "though the remarkable features of this fall wind are among the best-explained features of atmospheric physics", enough interesting problems are still there.

References

Bebber, J. W. v. (1890), *Lehrbuch der Meteorologie für Studierende und zum Gebrauche in der Praxis*, pp. 163–167. Verlag von Ferdinand Enke, Stuttgart.

Bezold, W. V. and J. Hann (1886), Noch ein Wort zur Entwicklungsgeschichte der Ansichten über den Ursprung des Föhn. *Meteorologische Zeitschrift* **21**, 85–87.

Börnstein, R. (1906), *Leitfaden der Wetterkunde, gemeinverständlich bearbeitet*, pp. 48–53. Vieweg u. Sohn, Braunschweig.

Ficker, H. (1920), Der Einfluss der Alpen auf Fallgebiete des Luftdruckes und die Entstehung von Depressionen über dem Mittelmeer. *Meteorologische Zeitschrift* **55**, 350–363.

Ficker, H. v. (1910), Innsbrucker Föhnstudien IV. Weitere Beiträge zur Dynamik des F"ohns. *Denkschr. Kaiserl. Akad. d. Wiss., math.-natwiss. Kl.* **85**, 114–173.

Ficker, H. v. and B. De Rudder (1943), *Föhn und Föhnwirkungen. Der gegenwärtige Stand der Frage*. Akademische Verlagsgesellschaft Becker & Erler, Leipzig, 112 pp.

Günther, S. (1889), *Die Meteorologie ihrem neuesten Standpunkte gemass und mit besonderer Berücksichtigung geographischer Fragen*, pp. 93–99. Th. Ackermann, München.

Hann, J. (1866), Zur Frage über den Ursprung des Föhn. *Zeitschrift der österreichischen Gesellschaft für Meteorologie* **1**(1), 257–263.

Hann, J. (1867), Der Föhn in den österreichischen Alpen. *Zeitschrift der österreichischen Gesellschaft für Meteorologie* **2**(19), 433–445.

Hann, J. (1885), Einige Bemerkungen zur Entwickelungs-Geschichte der Ansichten über den Ursprung des Föhn. *Meteorologische Zeitschrift* **20**, 393–399.

Hann, J. (1901), *Lehrbuch der Meteorologie*, chap. Isobarentypen und Witterung. II. Besondere Arten der cyklonalen und anticyklonalen Winde in Gebirgsländern. Föhn (Scirocco) und Bora., pp. 594–605. Chr. Herm. Tauchnitz, Leipzig.

Hann, J. v. and R. Süring (1951), *Lehrbuch der Meteorologie*. Chr. Herm. Tauchnitz, Leipzig, 5. vollst. neu berb. Auflage edn.

Lammert, L. (1920), Der mittlere Zustand der Atmosphäre bei Südföhn. Veröff. des Geophys. Inst. d. Univ. Leipzig, 2. Bd. H. 7, p. 261-332.

Seibert, P. (1990), South foehn tudies since the ALPEX experiment. *Meteorol. Atmos. Physics* **43**, 91–103.

Seibert, P., H. Feldmann, B. Neininger, M. Bäumle, and T. Trickl (2000), South foehn and ozone in the eastern Alps – case study and climatological aspects. *Atmos. Environ.* **34**(9), 1379–1394.

Sprung, A. (1885), *Lehrbuch der Meteorologie im Auftrage der deutschen Seewarte*, chap. III. Die vertikale Komponente der Luftströme, pp. 182–190. Hoffmann und Campe, Hamburg.

Steinacker, R. (1983), Fallstudie eines Süd- und eines Nordföhns. *Aero-Revue* **8**, 141–144.

Steinhauser, P. (1989), Leben und Wirken Julius von Hanns. *ÖGM Bulletin* **2**(2), 1–3.

Petra Seibert, b. 1956, studied meteorology at the University of Innsbruck, Austria. Her dissertation dealt with the south foehn in the Alps and especially in Tyrol. After obtaining the Dr. phil. degree in 1985, she moved to Vienna as a scientist at the Institute of Meteorology and Geophysics at the University of Vienna. Since 1996, she is at her current affiliation at the University of Natural Resources (Universität für Bodenkultur), also in Vienna, where she received the habilitation in meteorology in the year 2000. Her work is dealing with air pollution and mountain meteorology.