Report from the 18th Annual North German *Mittelgebirge* Lee Wave Meeting

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Over 80 participants from all over Germany attended the 18th Annual *Mittelgebirge* Lee Wave Meeting of the Northern German glider pilots on March 1, 2014. The event was organized by Jörg Dummann of the Luftsportverein Bad Gandersheim and hosted by the German Aerospace Center (DLR) on its premises in Göttingen. Twelve speakers presented new insights and developments regarding practical, technical and theoretical aspects of lee wave soaring in low mountain areas and in general.

The term "Mittelgebirge" refers to regions of hilly terrain whose variations in elevation place them between, on one hand, what English speakers might call "hills," and on the other, more rugged mountainous terrain. A common European feature, the Harz Mountains, the Ardennes, the Eiffel, the Jura, and much of the Appenines are examples.

A new book entitled "Atmospheric Gravity Waves and Soaring Flight — physical principles and practical applications" was presented by its author Dieter Etling. Etling is a professor of theoretical meteorology at the Leibniz University in Hannover, Germany, and while not a pilot himself, he has supported glider pilots' wave flying activities for many years and hosted the meeting several times at his home institute. The book links the physical fundamentals of atmospheric gravity waves with their applications in soaring flight and is primarily aimed at the scientifically interested pilot. Resulting from the scientist's view on wave soaring, the book offers interesting perspectives off the beaten tracks. The text is available in English language as a free download on the web portal of the North German lee wave community, `http://www.schwerewelle.de` (*a review of this book will appear in an upcoming issue of TS — Ed.*)

The majority of the talks concentrated on specific experiences of low mountain wave soaring and their analysis.

Carsten Lindemann demonstrated how thermally triggered gravity waves can be utilized for soaring flight. He presented meteorological and flight data for several examples of isolated thermal waves and of such thermal waves occurring in conjunction with orographically generated mountain lee waves in Europe and overseas.

Lift patterns associated with thermally triggered waves and aligned perpendicular to the direction of the wind offer the glider pilot the possibility of long distance cross country flights in low mountain areas and even in flat areas. Carsten has performed several wave soaring flights in an ASK16 touring motor glider from Lüsse airfield situated in the North German flatlands to the Harz mountains. With the Brocken summit being only slightly higher than 1000 m in altitude, he found it to be very important that low lying inversion layers exits which are prone to oscillatory behavior.

Herbert Horbrügger investigated the issue of frontal passages during a wave situation. Such a scenario frequently occurs for south-westerly winds which are responsible for the majority of wave situations in Northern Germany. Embedded frontal systems can lead to significant perturbations or even the complete disappearance of wave structures. Herbert used flight data and wave forecasts together with weather data, in order to characterize the interaction of frontal and wave systems. He analyzed flights made on four different days when a warm front or a cold front was passing through. He showed that the 850 hPa temperature charts displaying the advection of warm or cold air are suitable additional prognostic indicators for determining whether gravity waves will be usable for soaring flight. In summary, the passage of a warm front only slightly affects the formation of flyable waves, although snow or rain showers might frequently occur in the lee of lenticular clouds. The passage of a cold front, however, drastically reduces the probability for wave formation.

Thomas Seiler analyzed wave flights performed on Oct 3, 2013, at the Acker ridge of the Harz Mountains in a south-easterly flow. While wind speeds were high below 2000 m altitude, a pronounced wind shear above this altitude caused the wind speed to decrease to almost zero at an altitude of 3000 m. This situation had been correctly forecast both by the German Weather Service and by the RASP wave prognosis, and

Fig. 1: Participants gathered at the North German Low Mountain Lee Wave Meeting, March 1, 2014
Photo: Jörg Dummann

consequently soarable wave lift did not extend above altitudes of 2500 m. Surprisingly it was possible to occasionally climb to almost 3000 m of altitude almost without any wind drift by circling in the lift as if it were a thermal. However, these thermal-like lifts were not stationary. Thomas attributes this situation to the occurrence of Kelvin-Helmholtz waves at the shear layer and proved his hypothesis by stability data of the air mass involved and the shear velocity gradient. The existence of Kelvin-Helmholtz waves at the shear layer can be expected, if stability and shear intensity match each other. In favorable cases such Kelvin-Helmholtz waves can be used for gaining additional height in wave flight.

Christof Maul and Torsten Linstädt provided a summary of the "Werra Valley Surf Camps" held in October and December 2013 on the Burgberg gliding field in Witzenhausen. The area between Solling in the Northwest and the Thuringian Forest in the Southeast and between Hoher Meißner and Kaufungen Forest in the Southwest and the Harz mountains in the Northeast was thoroughly examined for the first time by a large number of practical flights in south-westerly flow. More than a dozen pilots performed over 50 flights that are documented on the Skylines platform, `http://www.skylines-project.org`, where they are available for subsequent analysis. Evidence for aligned lift has been found over the whole length of the Werra valley and in higher order wave oscillations towards the north-eastern lee side of the valley all the way up to the Harz Mountains. The Werra valley represents the link between the well-known wave areas of the Thuringian Forest to the South und the Weser mountain ridges to the North. Thus, fall and winter cross country wave flights in the 500 km range appear to be a realistic option in the low mountain area of Northern Germany. In addition, Torsten Linstädt proved that it is possible to ridge soar large portions of the Werra valley, should the wave link fail.

Rickmer Bothe discussed the combination of wave and thermal soaring flight as a possibility for extending soarable time well into the early morning hours to be able to complete large distance cross country flights. He presented two example flights demonstrating the potential, but also the challenges of this approach. In the first flight the pilot had left the Brocken wave at 5000 m altitude for an impressive long distance glide of some 250 km almost to the Polish border in the East, where he could begin thermal flight. However, the long gliding distance requires homogeneous weather conditions in the pre-frontal weather situations prevailing in wave conditions. Moreover the very long flying times of 12 hours and more present a big challenge for mental and physical health of the pilot. As of now, the potential of the combined wave and thermal soaring approach has not fully been exploited in the low mountains of Northern Germany

Technical and meteorological developments for facilitating planning, realizing and analyzing cross country wave flights were in the focus of the contributions of Michael Noll (German Weather Service) and of Hendrik Hoeth (RASP).

Michael Noll showed vertical cross sections that complement the lee wave forecast of the German Weather Service that are available on `http://www.flugwetter.de` since February 2014. In addition to five cross sections in the Alps that have been available for some time already, about 20 additional cross sections have been setup in close collaboration between the German Weather Service and the wave soaring community of Northern Germany. Thus, almost any wave soaring scenario is now covered by one or more of such cross section forecasts.

Hendrik Hoeth demonstrated a fully operable prototype of his Open Glide Computer. The Open Glide Computer hardware is built around the Raspberry Pi, a credit card sized computer running Linux. This choice was made because of the incredible CPU-per-buck ratio, available I/O, size of the board and power consumption. Data collection is performed by pressure sensors for static and pitot, a high resolution GPS, an outside air temperature probe, a magnetic compass, an accelerometer and gyros. With all the sensor hardware in place now for the data logger, the natural next step is to use this infrastructure and make it into a full-fledged open source variometer and glide computer. Open Glide Computer is an Open Source-project which is documented on `http://openglidecomputer.linta.de/wiki`. First devices will be flying at the time when this article is published.

Björn Köhnke delivered a report of the Kebnekaise wave camp in Sweden where each year around Easter time pilots mostly from Sweden and from Finland come together for two weeks in order to fly the wave in the vicinity of Sweden's highest mountain, the 2011 m high Kebnekaise. The airfield is located on a frozen lake with the runway milled into the ice. Björn and his brother Jan Frederick experienced 10 days of wave flying and reached maximum altitudes of 7200 m.

Finally Georg Koppenwallner gave an account of the current status of the "Furbo" fan glider project. The idea is to realize an energy-efficient and fail-safe propulsion concept. Details are published on `http://flugantrieb.ploland.de/`. The meeting was closed by a practical demonstration of the of the Furbo drive.

In summary a balanced mixture of practical and theoretical topics was presented in the low mountain lee wave meeting. The analysis of different wave situations based on meteorological and on flight data has directly resulted in developing perspectives for cross country wave soaring in the low mountains. The analyses are further supported by improved forecasting and development of innovative software and hardware, e.g. by the integration of the RASP wave forecast charts (`http://www.drjack.info/RASP/`) into the XCSoar navigation software, or by the Open Glide Computer project. Perspectives have been brought up, and it will be interesting to see where the low mountain wave flying will go from here and how long it will take to realize a true long distance flight under wave conditions connecting the well-known local wave areas.

The North German *Mittelgebirge* Lee Wave Meeting is open to pilots with or without previous experience in wave soaring. It is held annually in the spring of each year and will be announced on the web portal `http://www.schwerewelle.de`.

Fig. 2: Wave flight over the Harz Mountains, January 3, 2014
Photo: Herbert Hörbrugger