The Relevance of Winds in Bicycling

It seems obvious: if you ride a bicycle, wind conditions will affect your ride. Ever since bicycle computers became ubiquitous, I have imagined that wind indication would play an important role in the evolution of cycling gear. But oddly enough, it hasn't. Weathervanes have been adorning roofs of farmhouses for more than a century, and electronic wind sensors (digital or analog) for RVs etc., may be available at some roadside convenience stores. But ironically, even in today's sophisticated tech gear market, which is inundated with scores of fitness gadgets from wearable electronics to mobile apps, power meters, data logging bicycle computers, GPS-enabled action cameras, PC software and cloud services capable of analyzing almost every aspect of the sport, measuring wind speed and direction, on a handlebar-mounted device designed for a bicycle, remains in the domain of far-fetched imagination. For the last few months I have been using an iBike Newton power meter, which, in order to estimate air drag, measures the wind speed. But because it doesn't measure the wind direction, I attached a piece of thread to it so that I can monitor my wind speed and wind direction as I ride. The contrivance looks similar to wind indicators used in other sports that are affected by wind, such as windsurfing, hang gliding, sailing, etc. But when fellow cyclists ask about the odd-looking piece of thread hanging on my handlebar and I explain what it is for, they often ask why I want to know about the wind on a bicycle. Evidently, something I had assumed to be obvious is not so obvious. This article is about why I think winds are relevant to cyclists.

A bike ride can mean different things to different people; so, generalizations can be misleading. But judging by the size of the market of fitness and cycling gadgets, and the variety of parameters that are measured and tracked by cycling enthusiasts, it is clear that if a quantity is relevant and measurable, enough people will want to measure it. There is no doubt that air speed is a measurable quantity. So, the question is whether it is relevant for cycling.

Under most typical conditions, and especially when going fast, a cyclist expends a lot of effort just to overcome an opposing force called air drag. In technical literature it is expounded that air drag is proportional to the square of the bike speed. We tend to assume that this 'bike speed' is the familiar quantity that is measured and displayed by any old bicycle computer. But this assumption is wrong. To understand why, we must differentiate between two distinct quantities, *ground speed* and *air speed.* The quantity that all bike computers measure is *ground speed*. The quantity whose squared value is proportional to air drag, is *air speed*. Only when the wind speed is zero (for example, when riding on an indoor track) are ground speed and air speed equal. Under all other conditions, they are different. When riding into a direct headwind, air speed is the *sum* of ground speed and wind speed. When riding with a direct tailwind, it is the *difference* between ground speed and wind speed. With side winds, the formulas become more complex, but nevertheless, air speed is always related to wind speed and wind direction. And it is the air speed that requires aero power, which often represents most of the power that a cyclist is putting out.

Because a cyclist (and spectators) can see the ground but not the air, one might get the false impression that cycling performance is about motion on the ground. Actually it is about motion in two media. In sailing, windsurfing and other similar sports or activities concerning motion in two media, air speed is given a lot of attention. But in bicycling, it is not even included among the dozens of parameters displayed by typical bike computers. So what sets bicycling apart? The short answer is *hills*. On a flat road, cycling performance is dominated by air speed; on an uphill slope it is dominated by ground speed. Thus, the relevance of winds to a cycling activity changes depending on terrain. But it is always relevant to some degree. This is why we need to quantify the wind.

Because iBike power meters are the only bicycle accessories currently available that can measure air speed, I will describe their operating principle. They estimate power by measuring hill slope, air speed and ground speed; but their air speed measurement is incomplete. To explain what I mean by that, I must clarify the specific definition of "air speed" in this context. Absolute wind is the wind relative to the ground; apparent wind is the wind relative to the moving cyclist. Air speed is the speed of the apparent wind. Absolute and apparent winds have different speeds and directions. The iBike power meter does not measure the direction or the speed of the apparent wind (or those of the absolute wind, for that matter). Instead, it makes certain assumptions and proprietary approximations to estimate the air drag (a force in the direction of the ground's apparent movement relative to the bicycle), using data from a "wind sensor" that measures the dynamic air pressure acting on its forward-facing wind port. From this dynamic pressure (also called stagnation pressure) and ground speed, the iBike calculates aero power. The rest of the power (namely climbing power, acceleration power and tire rolling power) it calculates from ground speed and hill slope. It also displays and records a quantity that might be called a 'virtual headwind' (negative values mean tailwind), which it calls "wind speed". With direct headwind or direct tailwind (or when there is no wind at all), the virtual headwind is equal to the air speed. With side winds it is an approximation. The iBike power meter records this data, along with calculated power, in its internal memory every second. After the ride, the data file is uploaded to a PC or Mac for performance analysis. The iBike power meter also streams real time power data to a compatible GPS-enabled fitness device (e.g., a Garmin bike computer), where it is merged with other data including location coordinates, and from where it can be uploaded to Strava, an online service that helps cyclists and runners track and analyze their activities and share performance data, route information, comments and photos with other people on the Strava network. I mention particularly Strava because if a power meter is not present, then Strava estimates instantaneous and average power from the available ride data. Ridewithgps, for example, estimates only average power from heart rate.

With relatively small modifications and / or by using peripheral accessories, a device that is similar to the iBike power meter could measure the speed and direction of the apparent wind. When both of these values are known, power calculations and performance analysis may be more accurate whenever significant side winds are encountered. But perhaps even more importantly, the absolute wind velocity (wind speed and wind direction relative to the ground) could be computed, mapped, shared with others and used for simulations. This would represent a major advancement in the technology of quantifying bike rides. It would be as significant a milestone as the introduction of altimeters, heart rate monitors and GPS tracking.

We are witnessing the formation and evolution of an "ecosystem" centered on cycling data. In this system, various interoperable devices, PC software, mobile apps and online services share data and do things together that are much greater than the capabilities of each one alone. For example a modern heart rate monitor supports standard wireless communication protocols so that its output can be viewed, among other things, on a sports watch that also measures temperature and pollution index, or on the "head unit" of a cycling power meter made by a different manufacturer for an entirely different market segment, and at the same time, recorded by a GPS-enabled bike computer or smartphone, which may be also receiving wireless signals from a third-party speed / cadence sensor and the aforementioned power meter. After the ride, this consolidated data will be uploaded from the GPS unit to a laptop PC or cloud service for performance analysis and data sharing, including links from Twitter and Facebook posts. So, for example my "friends" in a faraway country can examine how my 'power-to-heart-rate-ratio versus elevation' plot is changing due to my high-altitude training. Alternately, a pro may protect such data (or analysis tool) as a competitive secret. This scenario is not from a science-fiction novel. It is an example of what is actually happening every day around the world.

This ecosystem is still in the early stages of its evolution with enormous growth potential. At the moment, iBike products are the only wind-aware bike computers, and they enter the ecosystem only if paired to GPS-tracking devices that can export ride data in the FIT file format (namely, bike computers made by Garmin); and then only as power meters. This means that essentially, wind data is currently absent from the system (I should mention, though, that iBike's own cloud service, in combination with a smart-phone running iBike's free Android / iPhone app called iBike Newton Tracker, allows iBike users to view their course and wind data on Google Earth. So, basically the iBike world lives in its own small ecosystem where the wind is acknowledged). It stands to reason that sooner or later, wind-aware bike computers, with or without the ability to measure cycling effort (power), will be integrated into the larger, more inclusive ecosystem. The primary building blocks of this ecosystem are the standardization of wireless data transfer protocols such as ANT+ and Bluetooth, data-logging devices such as smart-phones and GPS-enabled fitness products by Garmin and others, cycling performance analysis software such as Training Peaks, Golden Cheetah and others, and most importantly, data-sharing platforms and cloud-computing services such as Cycling Analytics, Garmin Connect, RidewithGPS and Strava. As soon as a sufficiently large number of Strava users begin to use devices that record air speed, Strava, its competitors, and its natural allies, are all likely to update their products to make use of this additional data. As well, for unconnected devices, and for real-time feedback while riding, wind indication is as useful a feature on a bike computer as heading, temperature, magnetic compass, elevation, grade and other secondary features that the market currently demands. In my opinion, it is now only a matter of time before wind indication becomes a prevalent feature of bicycle computers.