Further details to

Lens, Switzerland: Long-term forest meteorological data from the Long-term Forest Ecosystem Research Programme (LWF), from 1997-2016

Matthias Haeni[1,*], Arthur Gessler[1], Martine Rebetez[1]
[1] Swiss Federal Institute for Forest, Snow and Landscape Research WSL

November 2016

Summary

High quality meteorological data are needed for long-term forest ecosystem research, particularly in the light of global change. The long-term data series published here comprises almost 20 years of measurements for one meteorological station in Lens in Switzerland which is located within a natural coniferous forest with Scots pine (*Pinus sylvestris*; 150-170 yrs)) as dominant tree species. The meteorological time series are presented in hourly time resolution of air temperature, relative humidity, precipitation, photosynthetically active radiation (PAR) and wind speed. Lens is part of the Long-term Forest Ecosystem Research Programme (LWF) established and maintained by the Swiss Federal Research Institute WSL.

*Correspondence to Matthias Haeni, matthias.haeni@wsl.ch

1 Introduction

High quality meteorological data often found the basis for numerous scientific analyses in the light of global change. The Long-term Forest Ecosystem Research programme (LWF) at the Swiss Federal Research Institute WSL investigates anthropogenic and natural forces on the long-term health and functioning of forests and the potential effects on ecosystem services. For that purpose, a profound understanding of the relationship between processes, causes and effects in forest ecosystem is necessary (Schaub et al., 2011) and weather data usually provide the background information to infer such interrelations.

Within the LWF, measurements have been started in 1995 on 16 forest stations within the level 2 plots of ICP Forests (ICP Forests, 2016; http://icp-forests.net/). This data repository here comprises the most important meteorological time series of one of those stations: Lens, located in the canton of Valais in Switzerland.

2 Materials and Methods

2.1 Site

he measurements were carried out at Lens in the Swiss Canton of Valais on the southern hillside of the Rhone Valley (Fig. **??**). Time series of one plot within the forest have been recorded (Fig. 1). Tab. 1 shows further details on the research station characteristics.

Table 1: Meteorological station setting.

Community / canton	Lens / VS
Commissioning date	15 March 1996
	LEB (forest)
Coordinates (Lat. / Long.)	46.268368 ° / 7.435198 °
Altitude	1083 m a.s.l.
Orientation	SE
Mean slope	72.0 %

Figure 1: LEB: Forest station

Table 2: Forest characteristics.

Woodland association*	Nr. 64; Cytiso-Pinetum silvestris
Main tree species (lat.)	*Pinus sylvestris*
Management system	High forest
Silvicultural system	None / unmanaged
Top-height diameter	31.8 cm
Plot size	2 ha
Number of trees DBH $\geq$ 12 cm (2011)	N = 2304
Maximum tree age	
Pinus sylvestris	150-170 yrs
Geology (German)	Surface: Gehängeschutt
	Underground: Penninikum, Ferret-Zone, Trias; sandiger Kalkstein
Soil types (WSL)	Randzina, Pararendzina, Braunerde

2.2 Sensors

Sensor and measurement specifications

Each station within the LWF acquires data continuously over ten minute periods. Here with this data set, hourly data is provided. All measurements are post-measurement values (e.g., values from 15:10 o'clock compromise data averaged (temperature, humidity, photosynthetic active radiation and wind speed) or summed up (precipitation) over the period of 15:00:01 to 15:10:00). The sensor types are listed in Tab. 3.

Table 3: Sensor specifications.

Parameter	**Unit**	**Height**	**Interval**	**Mode**	**Producer / Model**	**Fig.**
Temperature	°C	2 m	10 min	Mean	Retronic / MP100A	2
Rel. humidity	%	2 m	10 min	Mean	Retronic / MP100A	2
Precipitation	$mm\ m^{-2}$	1.5 m	10 min	Sum	Campbell Sc. / ARG100	3
PAR*	$W\ m^{-2}$	3 m	10 min	Mean	Skye Instr. / Quantum	4
Wind speed	$m\ s^{-1}$	4.6 m	10 min	Mean	Vector Instr. / A100R	5

*after Ellenberg and Klötzli (1972)

*Photosynthetically active radiation

Annotations

Temperature / relative humidity	For both temperature and relative humidity a combined sensor is used. The thermometer is a commonly used DIN Class B sensor (accuracy ±0.3 K) whereas the hygrometer has an accuracy of ±1.5 % rH (both at 23 ±5°C).
Precipitation	Precipitation is collected by a raingauge with a funnel width of 254 mm and a tipping bucket registering 0.2 mm of precipitation.
PAR	The PAR sensor measures solar radiation with wavelength between 400 nm and 700 nm.
Wind speed	Wind speed is measured by an anemometer with an accuracy of ±0.1 m s^{-1} at wind speed up to 10 m s^{-1} (±1 % of reading between 10-55 m s^{-1}).

3 Results

3.1 Air temperature (temp)

The recorded data from 10 minute intervals have been averaged to the full hour (minutes 30, 40, 50, 00, 10, 20 averaged). First, minor manual data exclusions have been made where data values were in irrecoverably bad shape. Then an absolute filter (-42°C < x < +47°C) and a relative filter have been applied (0.001 % quantile). A differential filter removed data entries with jumps larger than 6°C from one hour to the other. Then a relative moving window filter has been applied, where data points have been excluded if they exceeded the 0.1 % quantiles on both ends (0.1 %, > 99.9 %) in a fourteen day moving window for every single hour. After filling small gaps linearly (two hours), we compared the data from the individual station with the partner station (i.e. field vs. forest stations). Large differences between the two time series (> 20°C) were removed. Furthermore, in a density plot between field and forest station, data outside of the 99.9 % contour (not including the extreme edges) were removed (for details please contact Matthias Haeni, matthias.haeni@wsl.ch). If the station data correlated in a linear manner with a $R^2 > 0.95$, data gaps were filled with the calculated data from the partner station.

3.2 Relative humidity (rH)

The recorded data from 10 minute intervals have been averaged to the full hour (minutes 30, 40, 50, 00, 10, 20 averaged). First, minor manual data exclusions have been made where data values were in irrecoverably bad shape. Then an absolute filter (0 % < x < 110 %) and a relative filter have been applied (0.001 % quantile). A differential filter removed data entries with larger jumps than 30 % from one hour to the other. The data have then been compared to Meteonorm computed data (Meteonorm, 2016; http://www.meteonorm.com/en/), and the time series have been scaled conservatively for each individual year to counteract large sensor drifts. Then, a relative moving window filter has been applied, where data points have been excluded if they exceeded the 0.1 % quantiles on both ends (< 0.1 %, > 99.9 %) in a fourteen day moving window for every single hour. After filling small gaps linearly (two hours), we compared the data from the individual station with the partner stations (field to forest stations and vice versa). Large differences between the two time series (> 60 %) were removed. Furthermore, in a density plot between field and forest station, data outside of the 99.9 %

contour (not including the extreme edges) were removed (for details please contact Matthias Haeni, matthias.haeni@wsl.ch). If the station data correlated in a linear manner with an $R^2 > 0.95$, data gaps were filled with the calculated data from the partner station.

3.3 Precipitation (precip)

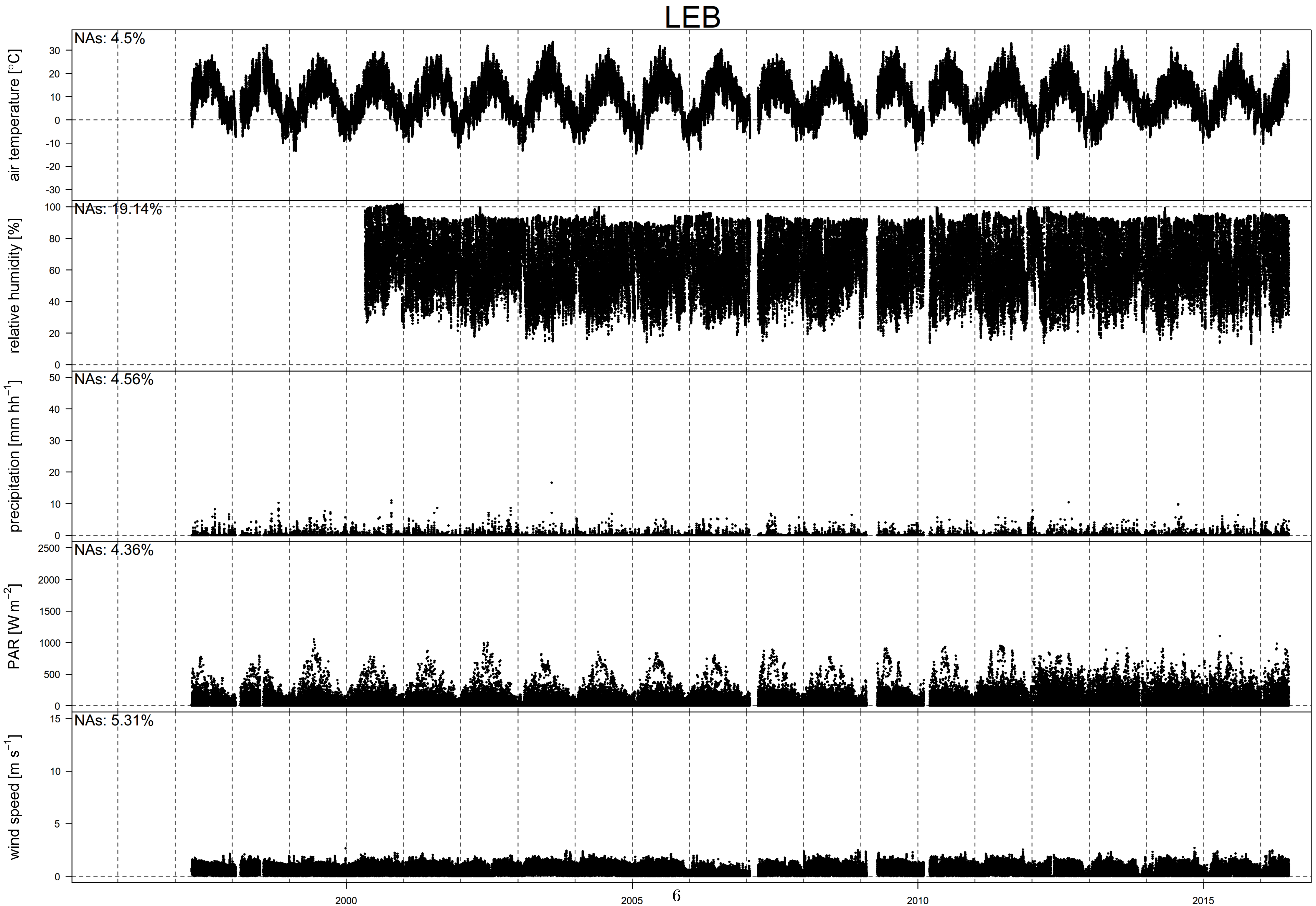
The recorded data from 10 minute intervals have been summed up to the full hour (minutes 10, 20, 30, 40, 50, 00 to the hour). First, minor manual data exclusions have been made where data values were in irrecoverably bad shape. Then an absolute filter (0 mm $<$ x $<$ 100 mm) has been applied. Long periods with no precipitation($>$ 120 days of zero values) have been excluded, because in this case a clogged rain gauge system must be assumed. Then we compared the data from the individual station with the partner station (field to forest stations and vice versa). Large differences between the two time series ($>$ 50 mm) were removed. Furthermore, in a density plot between field and forest station, data outside of the 99.9 % contour not including the extreme edges were removed (for details please contact Matthias Haeni, matthias.haeni@wsl.ch). If the station data correlated in a linear manner with an $R^2 > 0.8$, data gaps were filled with the calculated data from the partner station.

3.4 Photosynthetically active radiation (PAR)

The recorded data from 10 minute intervals have been averaged to the full hour (minutes 30, 40, 50, 00, 10, 20 averaged). First, minor manual data exclusions have been made where data values were in irrecoverably bad shape. Then an absolute filter (0 $W\ m^{-2}$ $<$ x $<$ 2500 $W\ m^{-2}$) has been applied. After filling small gaps linearly (two hours), we conducted a so-called night shift correction. Night time hours have been calculated in two ways: 1) From the data, where in the morning average PAR was first above 100 $W\ m^{-2}$ and in the evening first below 100 $W\ m^{-2}$. From the first so-called 'sunrise' time, half an hour was subtracted and to the latter so-called 'sunset' time, half an hour was added. 2) Sunset and sunrise times have been calculated from the google maps API (Google, 2016; https://developers.google.com/maps/). From both calculated methods, the more conservative 'sunrise' and 'sunset' times where chosen, i.e. the earlier one for 'sunrise' and the later one for 'sunset'. For the hours in-between the 'sunset' and 'sunrise' times (i.e. the night time hours) the absence of sunlight should lead to zero $W\ m^{-2}$ PAR. The average deviations of these night time hours from zero were then used to correct each individual day. Data were then scaled from year to year by comparing them to the average 99 % density contour of all years and scaling conservatively to counteract large sensor drift (for details please contact Matthias Haeni, matthias.haeni@wsl.ch).

3.5 Wind speed (ws)

The recorded data from 10 minute intervals have been averaged to the full hour (minutes 30, 40, 50, 00, 10, 20 averaged). First, minor manual data exclusions have been made where data values were in irrecoverably bad shape. Then an absolute filter (0 $m\ s^{-1}$ $<$ x $<$ 100 $m\ s^{-1}$) has been applied. Then, we compared the data from the individual station with the partner station (field to forest stations and vice versa). In a density plot between field and forest station, data outside of the 99.9 % contour (not including the extreme edges) were removed (for details please contact Matthias Haeni, matthias.haeni@wsl.ch). If the station data correlated in a linear manner with an $R^2 > 0.8$, data gaps were filled with the calculated data from the partner station. **See data on the next page.**


LEB
NAs: 4.5%
air temperature [°C]
NAs: 19.14%
relative humidity [%]
NAs: 4.56%
precipitation [mm hh^{-1}]
NAs: 4.36%
PAR [W m^{-2}]
NAs: 5.31%
wind speed [m s^{-1}]
2000
2005
2010
2015

References

Ellenberg, H. and Klötzli, F. (1972). Die Waldgesellschaften der Schweiz, *Mitt. Schweiz. Anst. forstl. Versuchsw* **48**(4): 930.

Google (2016). Google Maps API.
URL: *https://developers.google.com/maps/*, last accessed on November 11, 2016.

ICP Forests (2016). International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests.
URL: *http://icp-forests.net/*, last accessed on November 11, 2016.

Meteonorm (2016). Irradiation data for every place on Earth, easily accessible with Meteonorm.
URL: *http://www.meteonorm.com/en/*, last accessed on November 11, 2016.

Schaub, M., Dobbertin, M., Kräuchi, N. and Dobbertin, M. K. (2011). Preface: long-term ecosystem research: understanding the present to shape the future, *Environmental monitoring and assessment* **174**(1): 1–2.

Appendix

Pictures of sensors

Figure 2: Combined air temperature and humidity sensor

Figure 3: Precipitation sensor

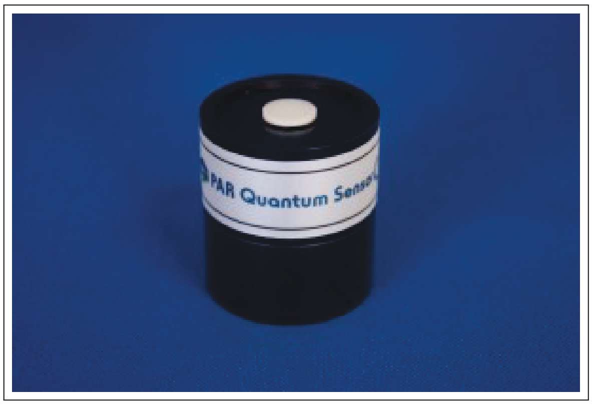


Figure 4: PAR sensor

Figure 5: Wind speed sensor