ZAMBRETTI SCALE DATA
P = Pressure mB
PD Derivative of Pressure
WD = Wind Direction
ZL = Zambretti Key Letter

P	PD	PD	WD	WD	ZL
1030	S	0	N	1	A
1030	S	0	NE	2	A
1030	S	0	NW	3	A
1030	S	0	CALM	4	A
1030	S	0	E	5	B
1030	S	0	W	6	B
1030	S	0	SE	7	B
1030	S	0	SW	8	B
1030	S	0	S	10	B
1030	R	-S 2	N	1	A
1030	R	-S 2	NE	2	A
1030	R	-S 2	NW	3	A
1030	R	-S 2	CALM	4	A
1030	R	-S 2	E	5	A
1030	R	-S 2	W	6	B
1030	R	-S 2	SE	7	B
1030	R	-S 2	SW	8	B
1030	R	-S 2	S	10	B
1030	R	-W 1	N	1	A
1030	R	-W 1	NE	2	A
1030	R	-W 1	NW	3	A
1030	R	-W 1	CALM	4	A
1030	R	-W 1	E	5	B
1030	R	-W 1	W	6	B
1030	R	-W 1	SE	7	B
1030	R	-W 1	SW	8	B
1030	R	-W 1	S	10	B
1030	F	-W -1	N	1	B
1030	F	-W -1	NE	2	B
1030	F	-W -1	NW	3	B
1030	F	-W -1	CALM	4	B
1030	F	-W -1	E	5	B
1030	F	-W -1	W	6	D
1030	F	-W -1	SE	7	D
1030	F	-W -1	SW	8	D
1030	F	-W -1	S	10	H
1030	F	-S -2	N	1	B
1030	F	-S -2	NE	2	B
1030	F	-S -2	NW	3	B
1030	F	-S -2	CALM	4	B
1030	F	-S -2	E	5	D
1030	F	-S -2	W	6	D
1030	F	-S -2	SE	7	D
1030	F	-S -2	SW	8	H
1030	F	-S -2	S	10	H
1020	S	0	N	1	B
1020	S	0	NE	2	B
1020	S	0	NW	3	B
1020	S	0	CALM	4	B
1020	S	0	E	5	B
1020	S	0	W	6	B
1020	S	0	SE	7	E
1020	S	0	SW	8	E
1020	S	0	S	10	K
1020	R	-S 2	N	1	B
1020	R	-S 2	NE	2	B
1020	R	-S 2	NW	3	B
1020	R	-S 2	CALM	4	B
1020	R	-S 2	E	5	B
1020	R	-S 2	W	6	B
1020	R	-S 2	SE	7	B
1020	R	-S 2	SW	8	C
1020	R	-S 2	S	10	C
1020	R	-W 1	N	1	B
1020	R	-W 1	NE	2	B
1020	R	-W 1	NW	3	B
1020	R	-W 1	CALM	4	B
1020	R	-W 1	E	5	B
1020	R	-W 1	W	6	C
1020	R	-W 1	SE	7	C
1020	R	-W 1	SW	8	C
1020	R	-W 1	S	10	F
1020	F	-W -1	N	1	D
1020	F	-W -1	NE	2	D
1020	F	-W -1	NW	3	D
1020	F	-W -1	CALM	4	H
1020	F	-W -1	E	5	H
1020	F	-W -1	W	6	H

Short-Range Local Forecasting with a Digital Barograph using an Algorithm based on the Zambretti Forecaster.

The Meteormetrics Limited Meteor2000D High Precision Intelligent Barograph is equipped with an on-demand forecaster which, in the Northern Hemisphere is over 94% accurate. It will be a valuable tool for sportsmen, environmentalists, farmers, and aviators and indeed all for whom the weather in the next four hours is important. This paper describes the reduction of the forecasting system of the Zambretti Forecaster to a system of algorithms accessible to a Microcontrollers using 8-bit integer arithmetic. It is this algorithm which is used in the Meteor2000D.

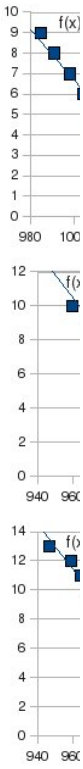


Figure 2.
number a
pressure i
barometer
barometer
rising bar

1020	F	W	-1	SE	7	H
1020	F	W	-1	SW	8	O
1020	F	W	-1	S	10	O
1020	F	S	-2	N	1	D
1020	F	S	-2	NE	2	H
1020	F	S	-2	NW	3	H
1020	F	S	-2	CALM	4	H
1020	F	S	-2	E	5	H
1020	F	S	-2	W	6	O
1020	F	S	-2	SE	7	O
1020	F	S	-2	SW	8	O
1020	F	S	-2	S	10	R
1010	S		0	N	1	E
1010	S		0	NE	2	E
1010	S		0	NW	3	K
1010	S		0	CALM	4	K
1010	S		0	E	5	K
1010	S		0	W	6	K
1010	S		0	SE	7	N
1010	S		0	SW	8	N
1010	S		0	S	10	N
1010	R	S	2	N	1	B
1010	R	S	2	NE	2	C
1010	R	S	2	NW	3	C
1010	R	S	2	CALM	4	C
1010	R	S	2	E	5	C
1010	R	S	2	W	6	F
1010	R	S	2	SE	7	F
1010	R	S	2	SW	8	F
1010	R	S	2	S	10	G
1010	R	W	1	N	1	C
1010	R	W	1	NE	2	C
1010	R	W	1	NW	3	F
1010	R	W	1	CALM	4	F
1010	R	W	1	E	5	F
1010	R	W	1	W	6	F
1010	R	W	1	SE	7	G
1010	R	W	1	SW	8	G
1010	R	W	1	S	10	G
1010	F	W	-1	N	1	H
1010	F	W	-1	NE	2	O
1010	F	W	-1	NW	3	O
1010	F	W	-1	CALM	4	O
1010	F	W	-1	E	5	O
1010	F	W	-1	W	6	R
1010	F	W	-1	SE	7	R
1010	F	W	-1	SW	8	R
1010	F	W	-1	S	10	U
1010	F	S	-2	N	1	O
1010	F	S	-2	NE	2	O
1010	F	S	-2	NW	3	O
1010	F	S	-2	CALM	4	R
1010	F	S	-2	E	5	R
1010	F	S	-2	W	6	R
1010	F	S	-2	SE	7	R
1010	F	S	-2	SW	8	U
1010	F	S	-2	S	10	U
1000	S		0	N	1	N
1000	S		0	NE	2	N
1000	S		0	NW	3	N
1000	S		0	CALM	4	N
1000	S		0	E	5	N
1000	S		0	W	6	P
1000	S		0	SE	7	P
1000	S		0	SW	8	P
1000	S		0	S	10	S
1000	R	S	2	N	1	F
1000	R	S	2	NE	2	F
1000	R	S	2	NW	3	G
1000	R	S	2	CALM	4	G
1000	R	S	2	E	5	G
1000	R	S	2	W	6	G
1000	R	S	2	SE	7	I
1000	R	S	2	SW	8	I
1000	R	S	2	S	10	J
1000	R	W	1	N	1	G
1000	R	W	1	NE	2	G
1000	R	W	1	NW	3	G
1000	R	W	1	CALM	4	G
1000	R	W	1	E	5	G
1000	R	W	1	W	6	I
1000	R	W	1	SE	7	I
1000	R	W	1	SW	8	J
1000	R	W	1	S	10	J
1000	F	W	-1	N	1	R
1000	F	W	-1	NE	2	R
1000	F	W	-1	NW	3	R
1000	F	W	-1	CALM	4	U
1000	F	W	-1	E	5	U
1000	F	W	-1	W	6	U
1000	F	W	-1	SE	7	U
1000	F	W	-1	SW	8	V
1000	F	W	-1	S	10	V
1000	F	S	-2	N	1	R
1000	F	S	-2	NE	2	U
1000	F	S	-2	NW	3	U
1000	F	S	-2	CALM	4	U
1000	F	S	-2	E	5	U
1000	F	S	-2	W	6	V
1000	F	S	-2	SE	7	V

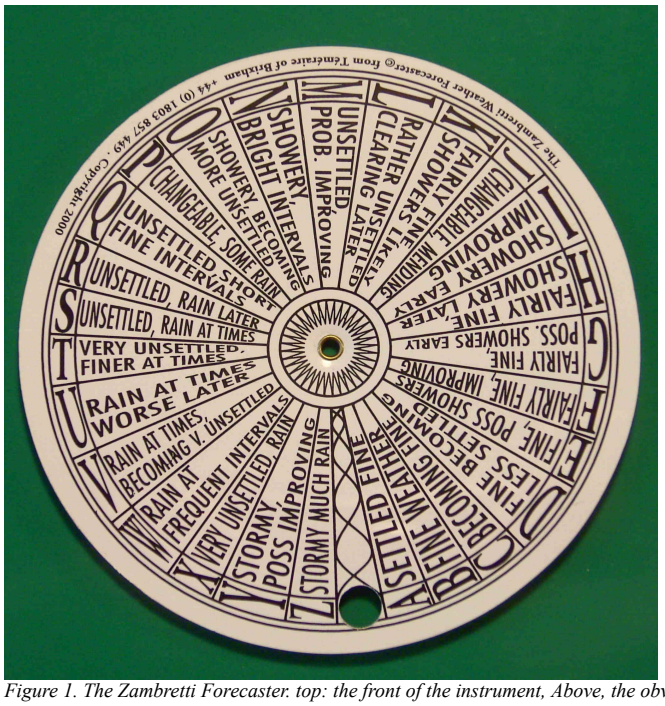


Figure 1. The Zambretti Forecaster. top: the front of the instrument, Above, the obverse showing the key.

The Instrument

The Zambretti Forecaster is shown in figure 1. It consists of 3 plastic discs of descending radius, arranged concentrically and secured together by means of a rivet. The large outside disc A, has a short scale calibrated in wind direction, the middle disc B, has an index to be aligned appropriately with the wind direction scale on A and itself carries a scale calibrated in units of barometric pressure (inches of mercury or millibars.) The inner disc C has an index settable to the atmospheric pressure on B and three windows which allow the selection of a reading based upon of the rising or falling of the barometer in Winter or Summer. Through the appropriate window an alphabetic letter is visible (printed on the disc A) and this letter is the key to the forecast which can be read off on the obverse side of the instrument.
A preliminary investigation of the instrument shows that it is based on practical weather observations and the derivation therefrom of rules which are empirical in two senses:
(a) no theoretical basis is used to derive the rules, and
(b) there appears to be no single mathematical function (even of an empirical kind) which is used to construct the rules.

THE FORECAST LETTER SCALE

The Forecast shown on the reverse of the instrument is a table of descriptions of short term weather changes against the letters of the alphabet. Fine weather has letters early in the alphabet and poor weather, late. The descriptions against each letter are as follows:
A Settled Fine
B Fine Weather
C Becoming Fine
D Fine Becoming Less Settled
E Fine, Possibly showers
F Fairly Fine, Improving
G Fairly Fine, Possibly showers, early
H Fairly Fine Showery Later
I Showery Early, Improving
J Changeable Mending
K Fairly Fine , Showers likely
L Rather Unsettled Clearing Later
M Unsettled, Probably Improving
N Showery Bright Intervals
O Showery Becoming more unsettled
P Changeable some rain
Q Unsettled, short fine Intervals
R Unsettled, Rain later
S Unsettled, rain at times
T Very Unsettled, Finer at times
U Rain at times, worse later.
V Rain at times, becoming very unsettled
W Rain at Frequent Intervals
X Very Unsettled, Rain
Y Stormy, possibly improving
Z Stormy, much rain

1000	F	-S	-2	SW	8	V
1000	F	-S	-2	S	10	X
990	S		0	N	1	P
990	S		0	NE	2	P
990	S		0	NW	3	P
990	S		0	CALM	4	S
990	S		0	E	5	S
990	S		0	W	6	S
990	S		0	SE	7	W
990	S		0	SW	8	W
990	S		0	S	10	W
990	R	-S	2	N	1	I
990	R	-S	2	NE	2	F
990	R	-S	2	NW	3	I
990	R	-S	2	CALM	4	I
990	R	-S	2	E	5	I
990	R	-S	2	W	6	J
990	R	-S	2	SE	7	J
990	R	-S	2	SW	8	L
990	R	-S	2	S	10	L
990	R	-W	1	N	1	I
990	R	-W	1	NE	2	I
990	R	-W	1	NW	3	J
990	R	-W	1	CALM	4	J
990	R	-W	1	E	5	J
990	R	-W	1	W	6	J
990	R	-W	1	SE	7	L
990	R	-W	1	SW	8	L
990	R	-W	1	S	10	M
990	F	-W	-1	N	1	V
990	F	-W	-1	NE	2	R
990	F	-W	-1	NW	3	V
990	F	-W	-1	CALM	4	V
990	F	-W	-1	E	5	V
990	F	-W	-1	W	6	X
990	F	-W	-1	SE	7	X
990	F	-W	-1	SW	8	X
990	F	-W	-1	S	10	X
990	F	-S	-2	N	1	V
990	F	-S	-2	NE	2	U
990	F	-S	-2	NW	3	X
990	F	-S	-2	CALM	4	X
990	F	-S	-2	E	5	X
990	F	-S	-2	W	6	X
990	F	-S	-2	SE	7	X
990	F	-S	-2	SW	8	X
990	F	-S	-2	S	10	Z
980	S		0	N	1	S
980	S		0	NE	2	W
980	S		0	NW	3	W
980	S		0	CALM	4	W
980	S		0	E	5	W
980	S		0	W	6	W
980	S		0	SE	7	X
980	S		0	SW	8	X
980	S		0	S	10	X
980	R	-S	2	N	1	J
980	R	-S	2	NE	2	L
980	R	-S	2	NW	3	L
980	R	-S	2	CALM	4	L
980	R	-S	2	E	5	L
980	R	-S	2	W	6	M
980	R	-S	2	SE	7	M
980	R	-S	2	SW	8	M
980	R	-S	2	S	10	M
980	R	-W	1	N	1	L
980	R	-W	1	NE	2	L
980	R	-W	1	NW	3	M
980	R	-W	1	CALM	4	M
980	R	-W	1	E	5	M
980	R	-W	1	W	6	M
980	R	-W	1	SE	7	M
980	R	-W	1	SW	8	M
980	R	-W	1	S	10	Q
980	F	-W	-1	N	1	X
980	F	-W	-1	NE	2	X
980	F	-W	-1	NW	3	X
980	F	-W	-1	CALM	4	X
980	F	-W	-1	E	5	X
980	F	-W	-1	W	6	X
980	F	-W	-1	SE	7	Z
980	F	-W	-1	SW	8	Z
980	F	-W	-1	S	10	Z
980	F	-S	-2	N	1	X
980	F	-S	-2	NE	2	X
980	F	-S	-2	NW	3	X
980	F	-S	-2	CALM	4	X
980	F	-S	-2	E	5	X
980	F	-S	-2	W	6	Z
980	F	-S	-2	SE	7	Z
980	F	-S	-2	SW	8	Z
980	F	-S	-2	S	10	Z
970	S		0	N	1	X
970	S		0	NE	2	X
970	S		0	NW	3	X
970	S		0	CALM	4	X
970	S		0	E	5	X
970	S		0	W	6	X
970	S		0	SE	7	X
970	S		0	SW	8	Z
970	S		0	S	10	Z

THE SCALE DATA

Some general observations are as follows:
1) The Wind Direction has only a modest effect on the forecast letter (except, perhaps for a southerly wind)
2) Above 1020 mB Winter or Summer differences of the pressure results in a change of only 2 Forecast letters
3) below 1020 mb the rate of change of the pressure has a large effect of about 12 -14 Forecast letters in going from +ve to -ve, and only very moderate changes of about 2 Forecast letters in going from Summer to Winter estimates.
4) The Forecast Letter is N when the pressure is 1000mB and steady with no wind.
5) When the pressure is steady the slope of the plot of Forecast Letter (A=1, Z=26) is -0.4letter/mB
6) A rising or falling pressure results in a forecast letter lower or higher than that expected at a steady pressure by about 7.5 letters.

OBTAINING A MATHEMATICAL FUNCTION DESCRIBING THE ZAMBRETTI FORECASTER

Observation of the Zambretti Forecaster shows that the forecasts are derived from three separate series, one for each of the conditions: barometer rising, barometer steady, barometer falling. These are shown in tables 1a,1b & 1c

Table 1a Barometer Falling

Forecast number ;	Forecast Letter ;	Forecast Text ;	Pressure
1;	A;	Settled Fine;	1050
2;	B;	Fine Weather;	1040
3;	D;	Fine Becoming Less Settled;	1024
4;	H;	Fairly Fine Showery Later;	1018
5;	O;	Showery Becoming more unsettled;	1010
6;	R;	Unsettled, Rain later;	1004
7;	U;	Rain at times, worse later. ;	998
8;	V;	Rain at times, becoming very unsettled;	991
9;	X;	Very Unsettled, Rain;	985

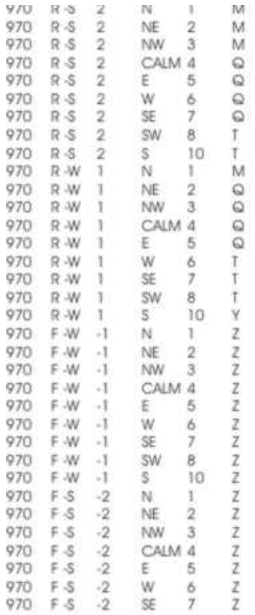
Table 1b Barometer Steady

Forecast number ;	Forecast letter ;	Forecast Text ;	Pressure
1;	A;	Settled Fine;	1033
2;	B;	Fine Weather;	1023
3;	E;	Fine, Possibly showers;	1014
4;	K;	Fairly Fine , Showers likely;	1008
5;	N;	Showery Bright Intervals;	1000
6;	P;	Changeable some rain;	994
7;	S;	Unsettled, rain at times;	989
8;	W;	Rain at Frequent Intervals;	981
9;	X;	Very Unsettled, Rain;	974
10;	Z;	Stormy, much rain;	960

Table 1c Barometer Rising

Forecast Number ;	Forecast Letter ;	Forecast Text ;	Pressure
1;	A;	Settled Fine;	1030
2;	B;	Fine Weather;	1022
3;	C;	Becoming Fine;	1012
4;	F;	Fairly Fine, Improving;	1007
5;	G;	Fairly Fine, Possibly showers, early;	1000
6;	I;	Showery Early, Improving;	995
7;	J;	Changeable Mending;	990
8;	L;	Rather Unsettled Clearing Later;	984
9;	M;	Unsettled, Probably Improving;	978
10;	Q;	Unsettled, short fine Intervals;	970
11;	T;	Very Unsettled, Finer at times;	965
12;	Y;	Stormy, possibly improving;	959
13;	Z;	Stormy, much rain;	947

Figure 2, shows plots of the data in table 1 and the linear regression line for each set of data. In consequence, the equations, with integer intercepts, which summarise the results are as follows:
For a falling barometer Zf = 130-0.12P.....(1)



970	R	S	2	N	1	M
970	R	S	2	NE	2	M
970	R	S	2	NW	3	M
970	R	S	2	CALM	4	Q
970	R	S	2	E	5	Q
970	R	S	2	W	6	Q
970	R	S	2	SE	7	Q
970	R	S	2	SW	8	T
970	R	S	2	S	10	T
970	R	W	1	N	1	M
970	R	W	1	NE	2	Q
970	R	W	1	NW	3	Q
970	R	W	1	CALM	4	Q
970	R	W	1	E	5	Q
970	R	W	1	W	6	T
970	R	W	1	SE	7	T
970	R	W	1	SW	8	T
970	R	W	1	S	10	Y
970	F	W	-1	N	1	Z
970	F	W	-1	NE	2	Z
970	F	W	-1	NW	3	Z
970	F	W	-1	CALM	4	Z
970	F	W	-1	E	5	Z
970	F	W	-1	W	6	Z
970	F	W	-1	SE	7	Z
970	F	W	-1	SW	8	Z
970	F	W	-1	S	10	Z
970	F	S	-2	N	1	Z
970	F	S	-2	NE	2	Z
970	F	S	-2	NW	3	Z
970	F	S	-2	CALM	4	Z
970	F	S	-2	E	5	Z
970	F	S	-2	W	6	Z
970	F	S	-2	SE	7	Z

For a steady barometer Zs = 138 -0.13P.....(2)
For a rising barometer Zr = 160-0.16P.....(3)
The range of the values of Zf, has a maximum value of 9, so if we add 9 to Zs and, similarly as Zs has a maximum value of 10, we add 19 to Zr so that, now Zs = 147 - 0.13P and Zr = 179 - 0.16P, we can write a new forecast table as follows:
Table 2.

Forecast number ;	Forecast Letter ;	Forecast Text ;	Pressure
1;	A;	Settled Fine;	1050
2;	B;	Fine Weather;	1040
3;	D;	Fine Becoming Less Settled;	1024
4;	H;	Fairly Fine Showery Later;	1018
5;	O;	Showery Becoming more unsettled;	1010
6;	R;	Unsettled, Rain later;	1004
7;	U;	Rain at times, worse later. ;	998
8;	V;	Rain at times, becoming very unsettled;	991
9;	X;	Very Unsettled, Rain;	985

10;	A;	Settled Fine;	1033
11;	B;	Fine Weather;	1023
12;	E;	Fine, Possibly showers;	1014
13;	K;	Fairly Fine , Showers likely;	1008
14;	N;	Showery Bright Intervals;	1000
15;	P;	Changeable some rain;	994
16;	S;	Unsettled, rain at times;	989
17;	W;	Rain at Frequent Intervals;	981
18;	X;	Very Unsettled, Rain;	974
19;	Z;	Stormy, much rain;	960

20;	A;	Settled Fine;	1030
21;	B;	Fine Weather;	1022
22;	C;	Becoming Fine;	1012
23;	F;	Fairly Fine, Improving;	1007
24;	G;	Fairly Fine, Possibly showers, early;	1000
25;	I;	Showery Early, Improving;	995
26;	J;	Changeable Mending;	990
27;	L;	Rather Unsettled Clearing Later;	984
28;	M;	Unsettled, Probably Improving;	978
29;	Q;	Unsettled, short fine Intervals;	970
30;	T;	Very Unsettled, Finer at times;	965
31;	Y;	Stormy, possibly improving;	959
32;	Z;	Stormy, much rain;	947

and the revised equations, using integers to provide the equivalent of 3 decimal place precision, are:
For a falling barometer Z = 130-P/81.....(4)

For a steady barometer Z = 147 -5P/376.....(5)

For a rising barometer Z = 179-2P/129.....(6)
As long as the correct equation is used for calculating Z according to whether the pressure is rising, falling or steady, and as long as the pressure does not lie outside the ranges of Table 2, a value of Z will be obtained which when used to look up the forecast in Table 2 will yield a correct result. It will be noted that some forecasts are repeated in this table and in this respect it is slightly wasteful of EEPROM space if the table is stored using such a device. This disadvantage may be offset by convenience.

Adjustments for Wind Direction & Seasons

At this stage we have not taken into account wind direction nor the Season in which the measurements are made. The Zambretti Forecaster does make some adjustment for these. Northerly winds are generally estimated by the Forecaster to improve the weather prospects by one up to 1 forecast unit and a subtraction from the value of Z in table 2 would be necessary to account for Northerly winds.
Similarly, Southerly winds are estimated to worsen the weather prospects by up to 2 Z units, and a similar adjustment to the forecast from table 2 could easily be made.
The Forecaster makes an adjustment for Winter or Summer measurements. A Winter falling generally results in a Z value lower by 1 unit compared with a Summer falling pressure. Similarly a Summer rising, improves the prospects by 1 unit over a Winter rising. The modification of the Z value accordingly would be relatively simple, in a post-processing step following the main calculation provided a correctly set real time clock was available.

Conclusions

To obtain an on-demand weather forecast from an electronic barometer based upon the Zambretti Forecaster, the following steps must be built into the embedded firmware:
A) The determination of the time-derivative of the pressure.
B) On the basis of A), select the appropriate equation (4), (5) or (6)
C) Measure the current pressure
D) Apply the appropriate equation from B) to obtain a value of Z
E) Modify Z according to wind direction data if available,
F) Modify Z according to the Season,
G) Use the modified Z to look up forecast in EEPROM storage and send to printer or display.
The proof of the pudding, of course, is in the eating. The Meteor2000D and the Meteor2000WX High Precision Forecasting Intelligent Barographs both use an algorithm based on the method described in this paper. It is expected that this instrument will be a vital tool for all who need a reliable local short-term weather forecast.