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Calculating Average wind speed and direction

👤 HAFEDH78 · 🕐 Nov 6, 2012

Nov 6, 2012	⤹ #1

H

HAFEDH78
New Member

Joined	Messages
Nov 21, 2011	5

Hi Everyone,

I was wondering if someone could check if the following formulas make sense. I am trying to calculate the daily average wind speed and wind direction derived from values taken at 6hr

Forum statistics

Threads:	1,138,303
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Latest member:	EdwardL95

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intervals.

From wind speed and direction </SPAN>	
> (meteorological wind direction (wdir): eg E=90, S=180, W=270) </SPAN>	
> (1) calculate u and v </SPAN>	
> u = -wspd*sin(wdir) </SPAN>	
> v = -wspd*cos(wdir) </SPAN>	
> </SPAN>	
> (2) calculate the daily mean of each wind component: </SPAN>	
> uave, vave </SPAN>	
> </SPAN>	
> (3) transform to wspd and wdir </SPAN>	
> rad = 4.0*atan (1.0)/180.	0.

</SPAN>	
> WSPD = sqrt(uAve^2+vAve^2) </SPAN>	
> WDIR = atan2(uAve,vAve)/rad +180. ; mean wind direction [0,360] </SPAN>	
> </SPAN>	
</SPAN>	
</SPAN>	

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Excel Facts

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1   2   Next ▸

Nov 6, 2012   ⤴   #2

Jeffrey Smith
Well-known Member

Joined   Messages
Feb 11, 2005   795

Can I open a discussion on this. I cannot agree with those formulas based on some tests I ran. I sorted a list of wind speeds and wind directions. I use a weighted average method to calculate average wind direction. I calculate my average speed by taking the weighted average of discounted velocities. Discounted means to me that the velocity is reduced based on the angle to the weighted direction. I will show my formulas and would like to see if anybody has a better idea.

Columns Q and R are given values.

The formula in cell S9 is: =INT(Q9/MAX($Q$9:$Q$28)*1000)
Cell T9 formula: =ABS(COS(RADIANS(R9-WeightedDir))*Q9)
Row 30 are averages for each column

Cell S32 formula: =SUMPRODUCT(S9:S28,R9:R28)/(SUM(S9:S28))
(WeightedDir)
Cell S33 formula: =SUMPRODUCT(S9:S28,T9:T28)/SUM(S9:S28)

Other test
Cell U9 formula: =Q9*SIN(R9)
Cell V9 formula: =Q9*COS(R9)
Cell V32 formula: =SQRT(U30^2+V30^2)
Cell V33 formula: =4*ATAN(1)/180
Cell V34 formula: =ATAN2(U30,V30)/V33+180

	Q</SPAN>	R</SPAN>	S</SPAN>	T</SPAN
	Wind Speed</SPAN>	Wind Direction</SPAN>	Weighted Count</SPAN>	Discounte Speed</S
9</SPAN>	2.62</SPAN>	146.59</SPAN>	173</SPAN>	0.37</SP/
10</SPAN>	3.80</SPAN>	227.76</SPAN>	252</SPAN>	3.80</SP/
11</SPAN>	3.96</SPAN>	207.28</SPAN>	262</SPAN>	3.69</SP/
12</SPAN>	4.27</SPAN>	131.76</SPAN>	283</SPAN>	0.50</SP/
13</SPAN>	4.40</SPAN>	5.65</SPAN>	291</SPAN>	3.23</SP/
14</SPAN>	5.33</SPAN>	247.87</SPAN>	353</SPAN>	5.03</SP/
15</SPAN>	5.42</SPAN>	111.83</SPAN>	359</SPAN>	2.43</SP/
16</SPAN>	6.21</SPAN>	341.56</SPAN>	412</SPAN>	2.44</SP/
17</SPAN>	6.45</SPAN>	241.80</SPAN>	428</SPAN>	6.28</SP/
18</SPAN>	7.80</SPAN>	254.33</SPAN>	517</SPAN>	7.02</SP/
19</SPAN>	8.02</SPAN>	187.06</SPAN>	532</SPAN>	6.02</SP/
20</SPAN>	9.22</SPAN>	329.24</SPAN>	611</SPAN>	1.72</SP/
21</SPAN>	9.87</SPAN>	288.18</SPAN>	654</SPAN>	4.98</SP/

22</SPAN>	9.88</SPAN>	200.27</SPAN>	655</SPAN>	8.71</SP/
23</SPAN>	10.74</SPAN>	320.15</SPAN>	712</SPAN>	0.32</SP/
24</SPAN>	11.00</SPAN>	281.36</SPAN>	729</SPAN>	6.64</SP/
25</SPAN>	12.62</SPAN>	213.19</SPAN>	837</SPAN>	12.17</SI
26</SPAN>	12.66</SPAN>	155.24</SPAN>	840</SPAN>	3.65</SP/
27</SPAN>	13.40</SPAN>	242.27</SPAN>	889</SPAN>	13.01</SI
28</SPAN>	15.07</SPAN>	207.99</SPAN>	1000</SPAN>	14.12</SI
29</SPAN>				
30</SPAN>	8.14</SPAN>	217.1</SPAN>		5.31</SP/
31</SPAN>				
32</SPAN>		Weighted Direction: </SPAN>	228.47</SPAN>	
33</SPAN>		Weighted Speed:</SPAN>	6.51</SPAN>	
34</SPAN>				

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</COLGROUP>

If I look at the highest velocities, they should drive the average wind speed. So the direction that the highest speeds are traveling will dominate the average direction. If I artificially inflate any given wind speed in the list to a value 1000 times higher I expect the average speed to be very near the inflated value. Just as I expect the direction for that inflated value to dominate the average direction. My calculations show that to be true.

	Q</SPAN>	R</SPAN>	S</SPAN>	T</SP/
	Wind Speed</SPAN>	Wind Direction</SPAN>	Weighted Count</SPAN>	Discou Speed
9</SPAN>	2.62</SPAN>	146.59</SPAN>	1</SPAN>	1.16</:
10</SPAN>	3.80</SPAN>	227.76</SPAN>	2</SPAN>	3.62</:
11</SPAN>	3.96</SPAN>	207.28</SPAN>	2</SPAN>	3.95</:
12</SPAN>	4.27</SPAN>	131.76</SPAN>	2</SPAN>	0.86</:
13</SPAN>	4.40</SPAN>	5.65</SPAN>	2</SPAN>	4.00</:
14</SPAN>	5.33</SPAN>	247.87</SPAN>	3</SPAN>	4.22</:
15</SPAN>	5.42</SPAN>	111.83</SPAN>	3</SPAN>	0.79</:
16</SPAN>	6.21</SPAN>	341.56</SPAN>	4</SPAN>	4.10</:
17</SPAN>	6.45</SPAN>	241.80</SPAN>	4</SPAN>	5.49</:
18</SPAN>	7.80</SPAN>	254.33</SPAN>	5</SPAN>	5.60</:
19</SPAN>	8.02</SPAN>	187.06</SPAN>	5</SPAN>	7.37</:
20</SPAN>	9.22</SPAN>	329.24</SPAN>	6</SPAN>	4.48</:
21</SPAN>	9.87</SPAN>	288.18</SPAN>	6</SPAN>	2.05</:
22</SPAN>	9.88</SPAN>	200.27</SPAN>	6</SPAN>	9.73</:
23</SPAN>	10.74</SPAN>	320.15</SPAN>	7</SPAN>	3.67</:
24</SPAN>	11.00</SPAN>	281.36</SPAN>	7</SPAN>	3.55</:
25</SPAN>	12.62</SPAN>	213.19</SPAN>	8</SPAN>	12.60<
26</SPAN>	12.66</SPAN>	155.24</SPAN>	8</SPAN>	7.27</:
27</SPAN>	13.40</SPAN>	242.27</SPAN>	8</SPAN>	11.35<
28</SPAN>	1507.00</SPAN>	207.99</SPAN>	1000</SPAN>	1505.8
29</SPAN>				

30</SPAN>	82.73</SPAN>	**217.1</SPAN>**		**80.09<**
31</SPAN>				
32</SPAN>		**Weighted Direction: </SPAN>**	**210.20</SPAN>**	
33</SPAN>		**Weighted Speed:</SPAN>**	**1383.31</SPAN>**	
34</SPAN>				

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</COLGROUP>

Dec 6, 2012   ⰾ   #3

I guess all that work I
put into solving the
problem was ignored

Jeffrey Smith
Well-known Member

Joined	Messages
Feb 11, 2005	795

H

HAFEDH78

New Member

Joined	Messages
Nov 21, 2011	5

Dec 6, 2012   ⇲   #4

> Jeffrey Smith said: ⬆
>
> I guess all that work I put into solving the problem was ignored

Hi Jeffrey,

Sorry I didn't answer back to your solution, it actually made rethink my maths and then found out that there was some other ways of calculating average wind speed.... And didn't help when i got handed a spreadsheet with several wind directions and speeds taken at diffrent times with 3 min interval between each reading... Oo

So I am still working on it.

Anyway, I am really greatful for all your help.

Thanks

H

Jeffrey Smith

Well-known Member

Joined	Messages
Feb 11, 2005	795

Dec 6, 2012   ⇲   #5

Thanks for the response H. I'm interested in your findings if you would like to share. Most of my work is analyzing velocity data from acoustic dopplers. I also have installed and

analyzed data from
weather stations,
although not recently. So
my work is right along
your question line.

Mar 1, 2013   ⛊   #6

I stumbled on this thread yesterday when I was looking for ideas on how to
average a range of wind direction/speeds. I came up with bad results
myself.... Any help on squaring the trig on this would be very helpful.... This
is all based on par 1.1 of the following doc -> **http://www.h2ns.com/media
/tech-notes/tn09.pdf**

Chan Weinmeister
New Member

Joined	Messages
Mar 1, 2013	1

DIR	Speed	SIN(DIR)</SPAN>	COS(DIR)</S
360</SPAN>	20</SPAN>	0.958916</SPAN>	-0.28369109<
360</SPAN>	20</SPAN>	0.958916</SPAN>	-0.28369109<
360</SPAN>	25</SPAN>	0.958916</SPAN>	-0.28369109<
360</SPAN>	25</SPAN>	0.958916</SPAN>	-0.28369109<
360</SPAN>	25</SPAN>	0.958916</SPAN>	-0.28369109<
360</SPAN>	25</SPAN>	0.958916</SPAN>	-0.28369109<
10</SPAN>	25</SPAN>	-0.54402</SPAN>	-0.83907153<
10</SPAN>	25</SPAN>	-0.54402</SPAN>	-0.83907153<
10</SPAN>	25</SPAN>	-0.54402</SPAN>	-0.83907153<
	AVERAGE</SPAN>	0.457937</SPAN>	-0.4688179</
15.42353</SPAN>	=(average U^2+ average V^2)^(1/2) </SPAN>		

-0.73851</SPAN>	=ATAN(average U/average V)</SPAN>
-42.3137</SPAN>	=DEGREES(radians above)</SPAN>

<TBODY>
</TBODY>

Mar 4, 2013   ☍   #7

Jeffrey Smith
Well-known Member

Joined   Messages
Feb 11, 2005   795

This is what I came up with by myself. I use a weighted average approach. I would like to have anybody weigh in on this. Tell me how this works for you. I put the average values to show comparison. 6.51 fps is the solution for the table below. I sorted the table by wind speed so I could analyze the results better.

Jeff

Cell U9: =$S9/MAX($S$9:$S$28)
Cell V9: =ABS(COS(RADIANS($T9-WeightedDir))*$S9)

Range Name WeightedDir = Cell U32
Cell U32: =SUMPRODUCT(U9:U28,T9:T28)/(SUM(U9:U28))
Cell V32: =SUMPRODUCT(U9:U28,V9:V28)/SUM(U9:U28)

	R	S	T	U	V
		Wind Speed	Wind Direction	Weighted Count	Discounted Speed
9		2.62	146.59	0.174	0.371
10		3.80	227.76	0.252	3.800
11		3.96	207.28	0.263	3.693
12		4.27	131.76	0.283	0.498
13		4.40	5.65	0.292	3.228
14		5.33	247.87	0.354	5.027
15		5.42	111.83	0.360	2.429
16		6.21	341.56	0.412	2.437
17		6.45	241.80	0.428	6.276
18		7.80	254.33	0.518	7.018
19		8.02	187.06	0.532	6.017
20		9.22	329.24	0.612	1.726
21		9.87	288.18	0.655	4.976
22		9.88	200.27	0.656	8.709
23		10.74	320.15	0.713	0.318
24		11.00	281.36	0.730	6.634
25		12.62	213.19	0.837	12.175
26		12.66	155.24	0.840	3.656
27		13.40	242.27	0.889	13.012

28		15.07	207.99	1.000	14.119
29					
30	Average:	8.14	217.07		5.31
31					
32	Weighted:			228.45	6.51

<colgroup><col><col><col span="2"><col><col></colgroup><tbody>
</tbody>
Mar 7, 2013   ⤢   #8

Jeffrey Smith
Well-known Member

Joined	Messages
Feb 11, 2005	795

Ok, Ignore all previous posts from me on this. Please look at this solution.

I created some user defined functions that help with the flow. Otherwise the if statements in the cells would get quite cumbersome. This converts Magnitude and Direction into Velocity components X (East+-) and Y (North+-). Then you average those values for the set. Use PolarCoord to convert the X/Y components into direction again. Using this method allows for the magnitude to be considered into the direction. Given that some wind readings have more magnitude, so they should be weighted more than readings with less magnitude. The Weighted Velocity is using discounted velocities. Meaning, when a reading is angled to the mean direction, it doesn't flow directly toward the mean point.

Jeff

Excel 2010<table cellpadding="2.5px" rules="all" style=";
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<th>E</th><th>F</th></tr></thead><tbody><tr ><td style="color:

#161120;text-align: center;">3</td><td style="text-align: right;;"></td><td style="text-align: center;text-decoration: underline;;">Magnitude</td><td style="text-align: center;text-decoration: underline;;">Direction</td><td style="text-align: center;text-decoration: underline;;">Vel X</td><td style="text-align: center;text-decoration: underline;;">Vel Y</td><td style="text-align: center;text-decoration: underline;;">Double Check Coordinate</td></tr><tr ><td style="color: #161120;text-align: center;">4</td><td style="font-weight: bold;text-align: center;;"></td><td style="text-align: right;;">5.00</td><td style="text-align: right;;">100.00</td><td style="text-align: right;;">4.92</td><td style="text-align: right;;">-0.87</td><td style="text-align: right;;">100.00</td></tr><tr ><td style="color: #161120;text-align: center;">5</td><td style="font-weight: bold;text-align: center;;"></td><td style="text-align: right;;">5.00</td><td style="text-align: right;;">14.00</td><td style="text-align: right;;">1.21</td><td style="text-align: right;;">4.85</td><td style="text-align: right;;">14.00</td></tr><tr ><td style="color: #161120;text-align: center;">6</td><td style="font-weight: bold;text-align: center;;"></td><td style="text-align: right;;">5.00</td><td style="text-align: right;;">13.00</td><td style="text-align: right;;">1.12</td><td style="text-align: right;;">4.87</td><td style="text-align: right;;">13.00</td></tr><tr ><td style="color: #161120;text-align: center;">7</td><td style="font-weight: bold;text-align: center;;"></td><td style="text-align: right;;">5.00</td><td style="text-align: right;;">12.00</td><td style="text-align: right;;">1.04</td><td style="text-align: right;;">4.89</td><td style="text-align: right;;">12.00</td></tr><tr ><td style="color: #161120;text-align: center;">8</td><td style="font-weight: bold;text-align: center;;"></td><td style="text-align: right;;">5.00</td><td style="text-align: right;;">11.00</td><td style="text-align: right;;">0.95</td><td style="text-align: right;;">4.91</td><td style="text-align: right;;">11.00</td></tr><tr ><td style="color: #161120;text-align: center;">9</td><td style="font-weight: bold;text-align: center;;"></td><td style="text-align: right;;">5.00</td><td style="text-align: right;;">10.00</td><td style="text-align: right;;">0.87</td><td style="text-align: right;;">4.92</td><td style="text-align:

right;;">10.00</td></tr><tr ><td style="color: #161120;text-align: center;">10</td><td style="font-weight: bold;text-align: center;;"></td><td style="text-align: right;;">5.00</td><td style="text-align: right;;">9.00</td><td style="text-align: right;;">0.78</td><td style="text-align: right;;">4.94</td><td style="text-align: right;;">9.00</td></tr><tr ><td style="color: #161120;text-align: center;">11</td><td style="font-weight: bold;text-align: center;;"></td><td style="text-align: right;;">5.00</td><td style="text-align: right;;">8.00</td><td style="text-align: right;;">0.70</td><td style="text-align: right;;">4.95</td><td style="text-align: right;;">8.00</td></tr><tr ><td style="color: #161120;text-align: center;">12</td><td style="font-weight: bold;text-align: center;;"></td><td style="text-align: right;;">5.00</td><td style="text-align: right;;">7.00</td><td style="text-align: right;;">0.61</td><td style="text-align: right;;">4.96</td><td style="text-align: right;;">7.00</td></tr><tr ><td style="color: #161120;text-align: center;">13</td><td style="font-weight: bold;text-align: center;;"></td><td style="text-align: right;;">5.00</td><td style="text-align: right;;">6.00</td><td style="text-align: right;;">0.52</td><td style="text-align: right;;">4.97</td><td style="text-align: right;;">6.00</td></tr><tr ><td style="color: #161120;text-align: center;">14</td><td style="font-weight: bold;text-align: center;;"></td><td style="text-align: right;;">5.00</td><td style="text-align: right;;">5.00</td><td style="text-align: right;;">0.44</td><td style="text-align: right;;">4.98</td><td style="text-align: right;;">5.00</td></tr><tr ><td style="color: #161120;text-align: center;">15</td><td style="font-weight: bold;text-align: center;;"></td><td style="text-align: right;;">5.00</td><td style="text-align: right;;">4.00</td><td style="text-align: right;;">0.35</td><td style="text-align: right;;">4.99</td><td style="text-align: right;;">4.00</td></tr><tr ><td style="color: #161120;text-align: center;">16</td><td style="font-weight: bold;text-align: center;;"></td><td style="text-align: right;;">5.00</td><td style="text-align: right;;">3.00</td><td style="text-align: right;;">0.26</td><td style="text-align: right;;">4.99</td><td style="text-align: right;;">3.00</td></tr><tr ><td style="color: #161120;text-align: center;">17</td><td style="font-weight: bold;text-align: center;;"></td><td style="text-align: right;;">5.00</td><td style="text-align: right;;">2.00</td><td style="text-align:

					0.17	5.00	2.00
18		5.00	1.00	0.09	5.00	1.00
19		5.00	0.00	0.00	5.00	360.00
20		5.00	359.00	-0.09	5.00	359.00
21		5.00	353.00	-0.61	4.96	353.00
22		5.00	352.00	-0.70	4.95	352.00
23		5.00	351.00	-0.78	4.94	351.00
24		10.00	350.00	-1.74	9.85	350.00
25						

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weight: bold;text-align: center;;"></td><td style="text-align: right;;"></td><td
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style="text-align: right;;"></td><td style="text-align: right;;"></td></tr><tr
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underline;;">Weighted Dir</td><td style="text-align: right;;"></td><td
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style="text-align: right;;"></td></tr></tbody></table><p style="width:7.2em;
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color: #BBB"><thead><tr style=" background-color: #DAE7F5;color:
#161120"><th width="10px">Cell</th><th style="text-align:left;padding-
left:5px;">Formula</th></tr></thead><tbody><tr><th width="10px" style="
```

background-color: #DAE7F5;color: #161120">D4</th><td style="text-align:left">=VelX(B4,C4)</td></tr><tr><th width="10px" style=" background-color: #DAE7F5;color: #161120">E4</th><td style="text-align:left">=VelY(B4,C4)</td></tr><tr><th width="10px" style=" background-color: #DAE7F5;color: #161120">F4</th><td style="text-align:left">=PolarCoord(D4,E4)</td></tr><tr><th width="10px" style=" background-color: #DAE7F5;color: #161120">B26</th><td style="text-align:left">=AVERAGE(B4:B24)</td></tr><tr><th width="10px" style=" background-color: #DAE7F5;color: #161120">C26</th><td style="text-align:left">=AVERAGE(C4:C24)</td></tr><tr><th width="10px" style=" background-color: #DAE7F5;color: #161120">D26</th><td style="text-align:left">=AVERAGE(D4:D24)</td></tr><tr><th width="10px" style=" background-color: #DAE7F5;color: #161120">E26</th><td style="text-align:left">=AVERAGE(E4:E24)</td></tr><tr><th width="10px" style=" background-color: #DAE7F5;color: #161120">B29</th><td style="text-align:left">=SQRT(D26^2+E26^2)</td></tr><tr><th width="10px" style=" background-color: #DAE7F5;color: #161120">C29</th><td style="text-align:left">=PolarCoord(D26,E26)</td></tr> </tbody></table></td></tr></table>

This is for calculating the Velocity X from the magnitude and Direction

Code:

```
Function VelX(M As Range, D As Range) As Single


    Dim pi As Double
    Dim Mag As Double
    Dim Dir As Double
```

```
  Mag = M.Value
  Dir = D.Value
  pi = Atn(1) * 4


  VelX = Mag * Cos(2 * pi * (90 – Dir) / 360)



End Function
```

This is for calculating the Velocity Y from the Magnitude and Direction

Code: 📋

```
Function VelY(M As Range, D As Range) As Single


  Dim pi As Double
  Dim Mag As Double
  Dim Dir As Double

  Mag = M.Value
  Dir = D.Value
  pi = Atn(1) * 4


  VelY = Mag * Sin(2 * pi * (90 – Dir) / 360)



End Function
```

This is for calculating the degrees from Velocity X and Velocity Y values

Code: 📋

```
Function PolarCoord(Xrng As Range, Yrng As Range) As Single


  Dim rAlpha As Single
  Dim x As Double
  Dim y As Double
  Dim pi As Double

  x = Xrng.Value
  y = Yrng.Value
  pi = Atn(1) * 4

  If x = 0 Then
    If y = 0 Then
      rAlpha = 90
    Else
      rAlpha = 90 - ((y / y) * 90)
    End If
  Else
    rAlpha = 360 + (180 / pi * ATAN2(y, x))
  End If

  If rAlpha < 0 Then
      rAlpha = rAlpha + 360
  ElseIf rAlpha > 360 Then
    rAlpha = rAlpha - 360
  End If
```

I just like using a ATAN2 built in function instead of using worksheetfunction

Code: 📋

```
Function ATAN2(ByVal y As Double, ByVal x As Double) As Double
  Dim Rad As Double

  If x = 0 Then
    Rad = 2 * Atn((Sqr(x * x + y * y) - y))
```

```
      Else
         Rad = 2 * Atn((Sqr(x * x + y * y) - y) / x)
      End If
      If Rad < 0 Then Rad = Rad + pi * 2


      ATAN2 = Rad
   End Function
```

Please use the PolarCoord function below. One minor fix.

Jeffrey Smith
Well-known Member

Joined	Messages
Feb 11, 2005	795

Code:

```
Function PolarCoord(Xrng As Range, Yrng As Range) As Single

   Dim rAlpha As Single
   Dim x As Double
   Dim y As Double
   Dim pi As Double

   x = Xrng.Value
   y = Yrng.Value
   pi = Atn(1) * 4

   If x = 0 Then
      If y = 0 Then
         rAlpha = 0
      Else
         rAlpha = 90 - ((y / y) * 90)
      End If
   Else
      rAlpha = 360 + (180 / pi * ATAN2(y, x))
   End If

   If rAlpha < 0 Then
       rAlpha = rAlpha + 360
   ElseIf rAlpha > 360 Then
      rAlpha = rAlpha - 360
```

```
   End If
```

Jeffrey Smith
Well-known Member

Joined	Messages
Feb 11, 2005	795

Mar 21, 2013   ⤚ #10

The fix above corrected a problem when all wind speeds canceled each other out (both X and Y were zero).

In my opinion, and several other opinions I have seen on line, summing all the wind speed data and dividing by the number of points is NOT an accurate way to calculate average wind speed. This does not allow for wind direction. If all the wind recordings were going in the same direction, that method would work.

If you have two recordings with equal magnitude, but going in the opposite direction, what would your answer be. Based on the average of the two points it would be wrong. The two magnitudes would cancel themselves out. For Example:

Mag	Dir
5	90
5	270

<tbody>
</tbody>

Sum = 10
10 divided by 2 is 5 < wrong
The mean wind speed should be zero
5 - 5 = 0
0 / 2 = 0

A wind speed magnitude higher than others should be given more weight.
For example:

Mag	Dir
5	90
10	270

<tbody>
</tbody>

Sum = 15
15 divided by 2 is 7.5 < wrong
The mean wind speed should be 2.5
10 - 5 = 5
5 / 2 = 2.5

Of course this simple math only works with two wind speeds going in
opposite directions.

Jeff

Last edited: Mar 21, 2013

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