

# WIND ROSES FOR TeX DOCUMENTS

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# OUTLINE

- Wind and wind data
- Wind roses
- Using TikZ to draw
- Setting the geometry
- Building the charts
- Still to do

# HOW DO WE QUANTIFY WIND

- Wind is a vector quantity
- Magnitude (speed) and Direction (direction wind comes from)
- When speed is zero; there is no direction
- BUT; we also have the case when the speed is non-zero and direction is “Variable”

# SOURCES OF THE DATA

- Sources: WMO; World Meteorological Organization
  - NCDC; National Climate Data Center; Ashville, North Carolina
- Formats
  - METAR; METeorological Aerodrome Report
    - Formal text format (147 columns) for “Hourly” observations
    - Direction 27--29; Speed 31--33; Gusts 35--37

# DESCRIPTIONS

## SURFACE HOURLY ABBREVIATED FORMAT

ONE HEADER RECORD FOLLOWED BY DATA RECORDS:

### COLUMN DATA DESCRIPTION

- 01-06 USAF = AIR FORCE CATALOG STATION NUMBER  
08-12 WBAN = NCDC WBAN NUMBER  
14-25 YR--MODAHRMN = YEAR-MONTH-DAY-HOUR-MINUTE IN GREENWICH MEAN TIME (GMT)  
27-29 DIR = WIND DIRECTION IN COMPASS DEGREES, 990 = VARIABLE, REPORTED AS  
    '\*\*\*' WHEN AIR IS CALM (SPD WILL THEN BE 000)  
31-37 SPD & GUS = WIND SPEED & GUST IN MILES PER HOUR  
39-41 CLG = CLOUD CEILING--LOWEST OPAQUE LAYER  
    WITH 5/8 OR GREATER COVERAGE, IN HUNDREDS OF FEET,  
    722 = UNLIMITED  
43-45 SKC = SKY COVER -- CLR-CLEAR, SCT-SCATTERED-1/8 TO 4/8,  
    BKN-BROKEN-5/8 TO 7/8, OVC-OVERCAST,  
    OBS-OBSCURED, POB-PARTIAL OBSCURATION  
47-47 L = LOW CLOUD TYPE, SEE BELOW  
49-49 M = MIDDLE CLOUD TYPE, SEE BELOW  
51-51 H = HIGH CLOUD TYPE, SEE BELOW  
53-56 VSB = VISIBILITY IN STATUTE MILES TO NEAREST TENTH  
    NOTE: FOR SOME STATIONS, VISIBILITY IS REPORTED ONLY UP TO A  
    MAXIMUM OF 7 OR 10 MILES IN METAR OBSERVATIONS, BUT TO HIGHER  
    VALUES IN SYNOPTIC OBSERVATIONS, WHICH CAUSES THE VALUES TO  
    FLUCTUATE FROM ONE DATA RECORD TO THE NEXT. ALSO, VALUES  
    ORIGINALLY REPORTED AS '10' MAY APPEAR AS '10.1' DUE TO DATA  
    BEING ARCHIVED IN METRIC UNITS AND CONVERTED BACK TO ENGLISH.  
58-68 MW MW MW MW = MANUALLY OBSERVED PRESENT WEATHER--LISTED BELOW IN PRESENT WEATHER TABLE  
70-80 AW AW AW AW = AUTO-OBSERVED PRESENT WEATHER--LISTED BELOW IN PRESENT WEATHER TABLE  
82-82 W = PAST WEATHER INDICATOR, SEE BELOW  
84-92 TEMP & DEWP = TEMPERATURE & DEW POINT IN FAHRENHEIT  
94-99 SLP = SEA LEVEL PRESSURE IN MILLIBARS TO NEAREST TENTH  
101-105 ALT = ALTIMETER SETTING IN INCHES TO NEAREST HUNDREDTH  
107-112 STP = STATION PRESSURE IN MILLIBARS TO NEAREST TENTH  
114-116 MAX = MAXIMUM TEMPERATURE IN FAHRENHEIT (TIME PERIOD VARIES)  
118-120 MIN = MINIMUM TEMPERATURE IN FAHRENHEIT (TIME PERIOD VARIES)  
122-126 PCP01 = 1-HOUR LIQUID PRECIP REPORT IN INCHES AND HUNDREDTHS --  
    THAT IS, THE PRECIP FOR THE PRECEDING 1 HOUR PERIOD

# THE BEGINNING OF EACH RECORD

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990 = VARIABLE, REPORTED AS

'\*\*\*' WHEN AIR IS CALM (SPD WILL THEN BE 000)

31-37 SPD & GUS = WIND SPEED & GUST IN MILES PER HOUR

# SOME SAMPLE DATA

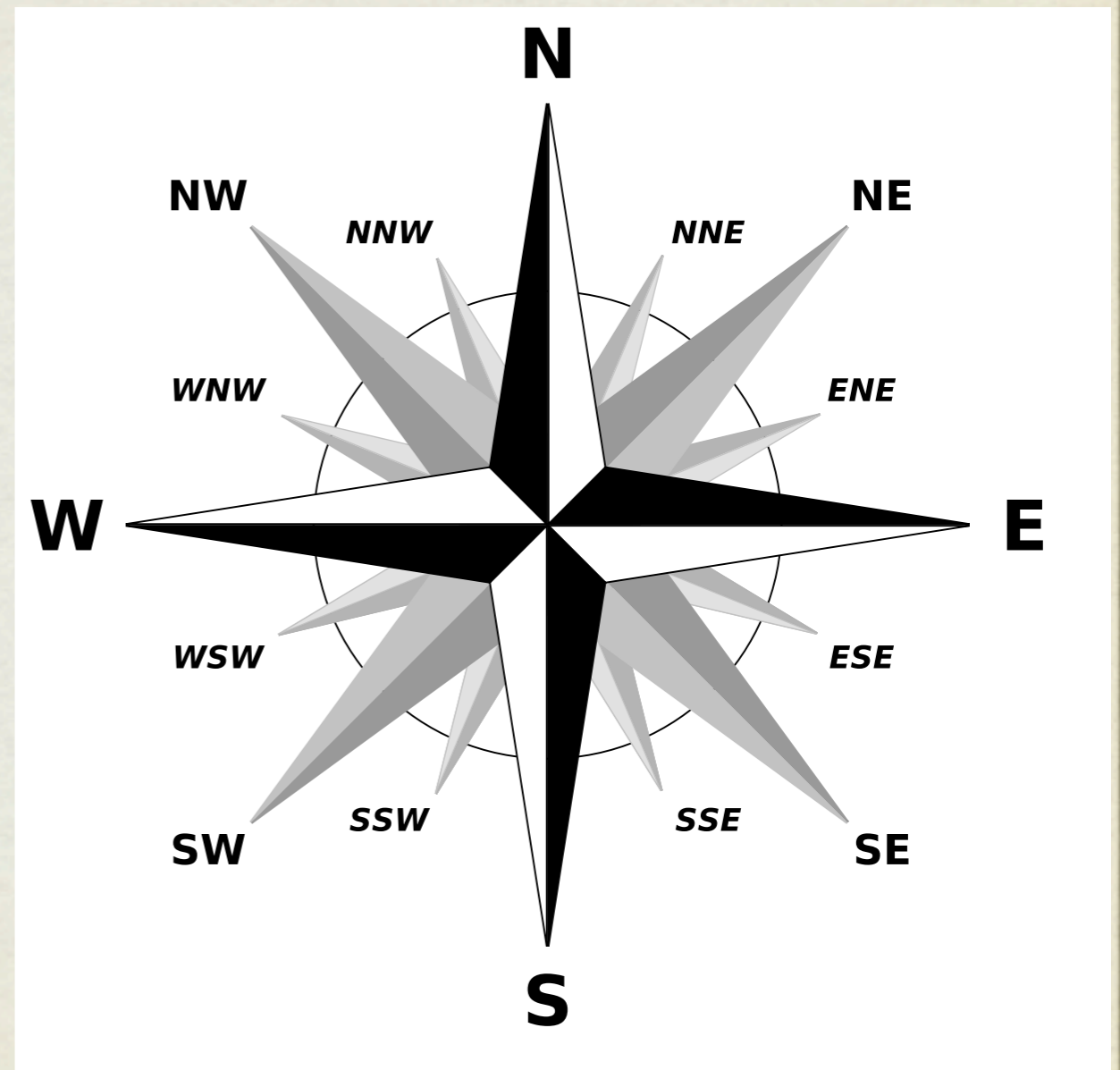
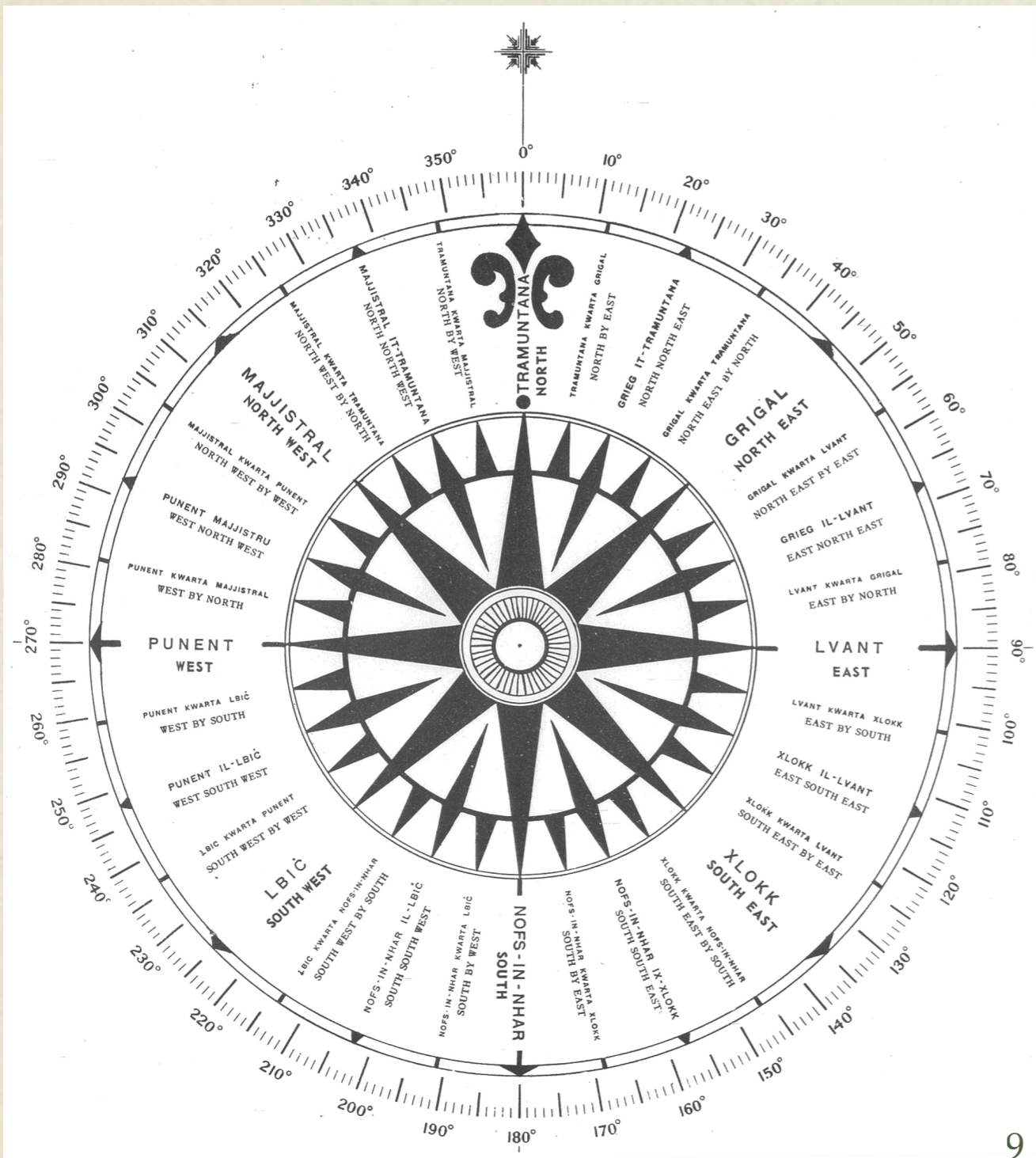
USAF	WBAN	YR--MODAHRMN	DIR	SPD	GUS
725090	14739	201205111200	280	14	***
725090	14739	201205111254	300	14	24
725090	14739	201205111354	300	16	28
725090	14739	201205111454	300	14	23
725090	14739	201205111500	300	14	***
725090	14739	201205111554	320	10	22
725090	14739	201205111654	290	18	24
725090	14739	201205111754	270	17	24
725090	14739	201205111800	270	17	***
725090	14739	201205111854	300	21	33
725090	14739	201205111954	320	10	20
725090	14739	201205112054	***	0	***
725090	14739	201205112100	***	0	***
725090	14739	201205112154	990	6	***
725090	14739	201205112254	100	6	***
725090	14739	201205112354	130	8	***
725090	14739	201205120000	130	8	***

# WIND ROSES: WHAT THEY SHOW

- Which direction the wind blows
- How often from each direction; counting the records
- The wind speeds in each direction; speed correlated with direction
- We will ignore other more sophisticated uses that deal with other correlations for now.



# COMPASS ROSES



# WHAT NEXT?

## STRATIFY SPEED

Range of wind speeds for  
Beaufort Scale (miles per hour)

[0,1)	➤	B0
[1,4)	➤	B1
[4,7)	➤	B2
[7,11)	➤	B3
[11,17)	➤	B4
[17,22)	➤	B5
[22,28)	➤	B6
[28,34)	➤	B7
[34,41)	➤	B8
[41,48)	➤	B9
[48,55)	➤	B10
[55,64)	➤	B11
[64,...)	➤	B12

- The Beaufort Scale was designed for sailors who certainly cared about wind more than most.
- It is originally designed measuring speeds in nautical miles per hour (knots) but can be adapted to miles per hours (mph) or meters per second (mps)
- Since my MET data is stored using mph; it makes sense to avoid too many conversions between units.
- As we prepare the statistics of our wind measurements we will group using these bins

# SOME EXAMPLES FROM THE WWW

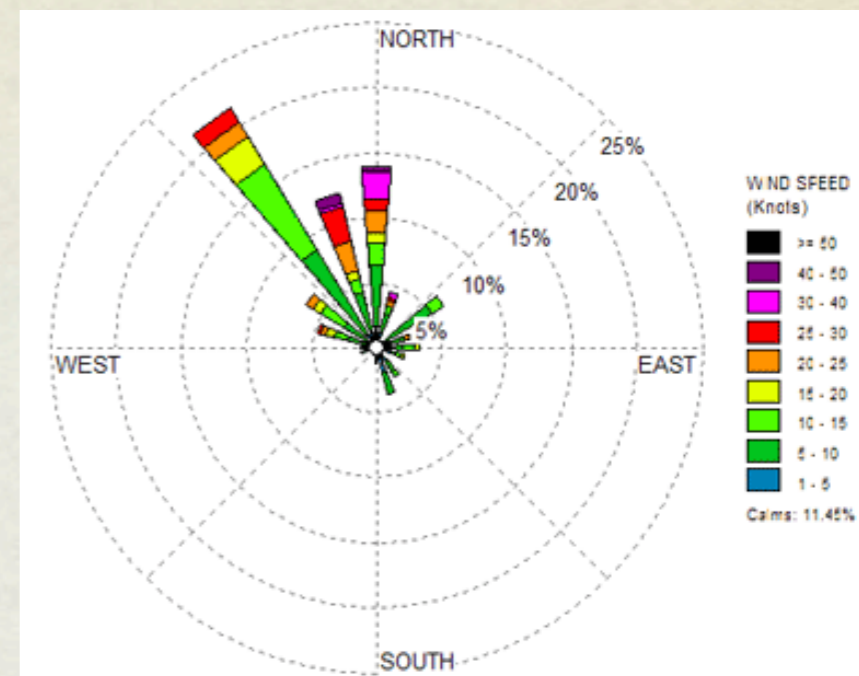
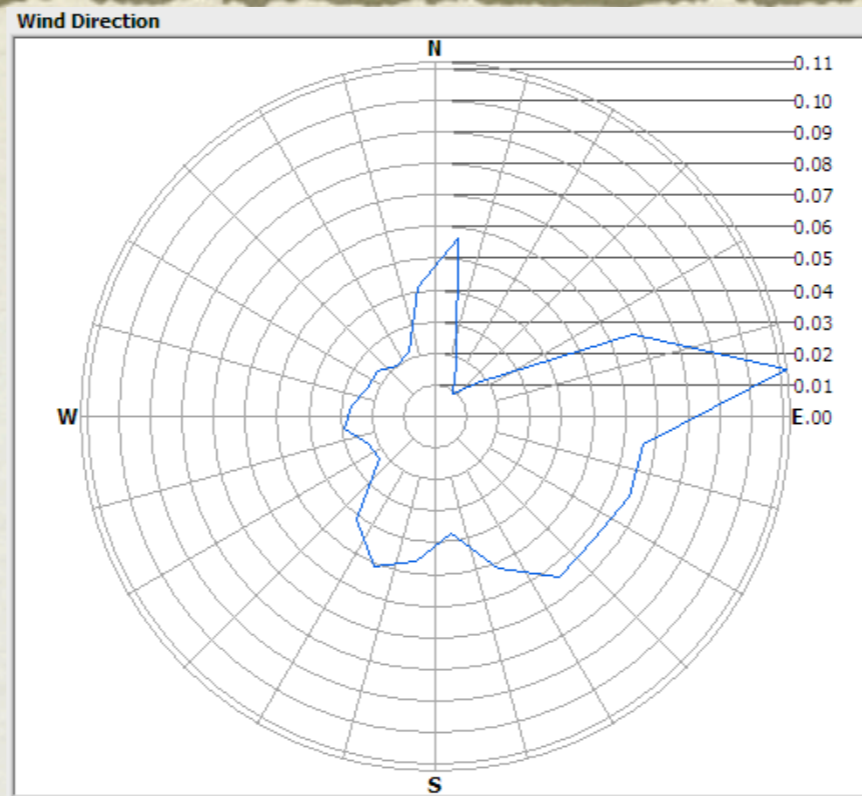
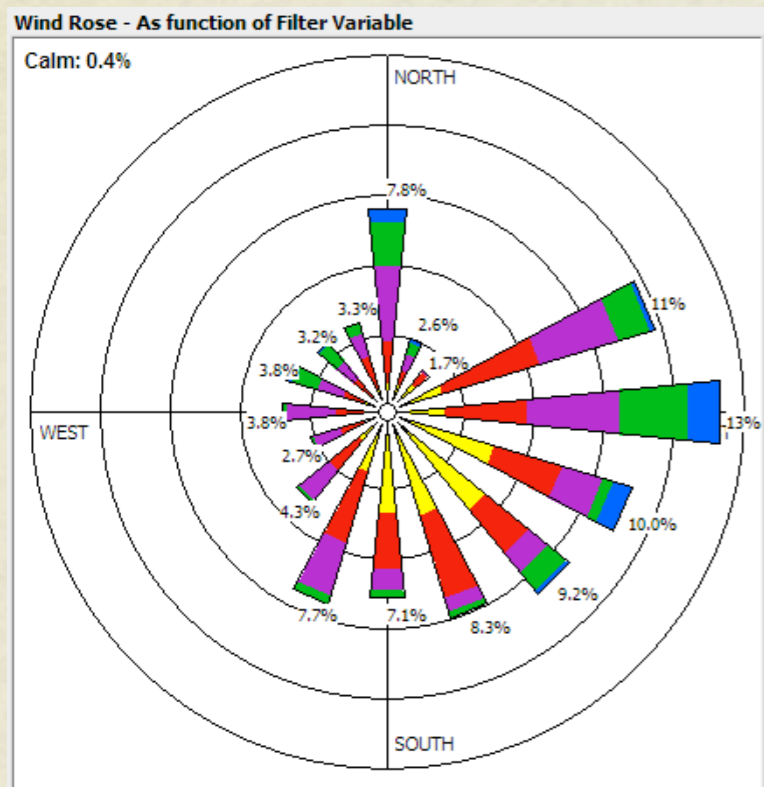
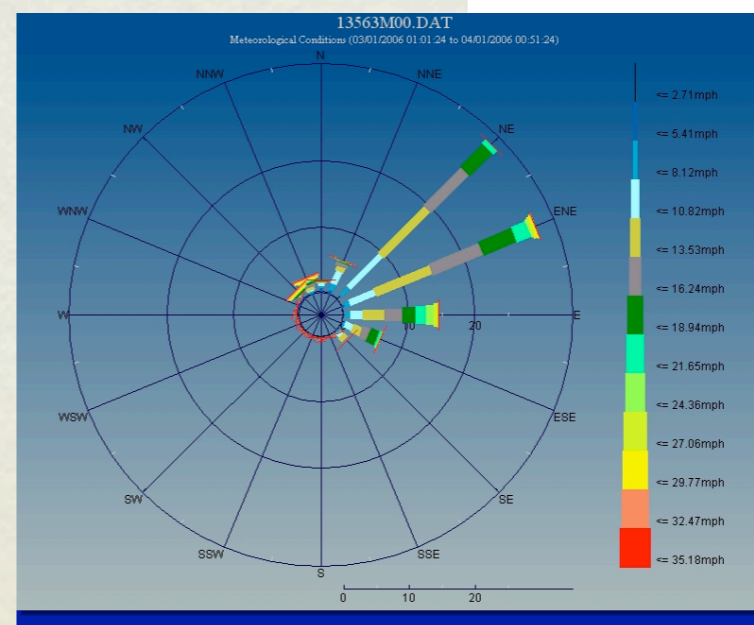
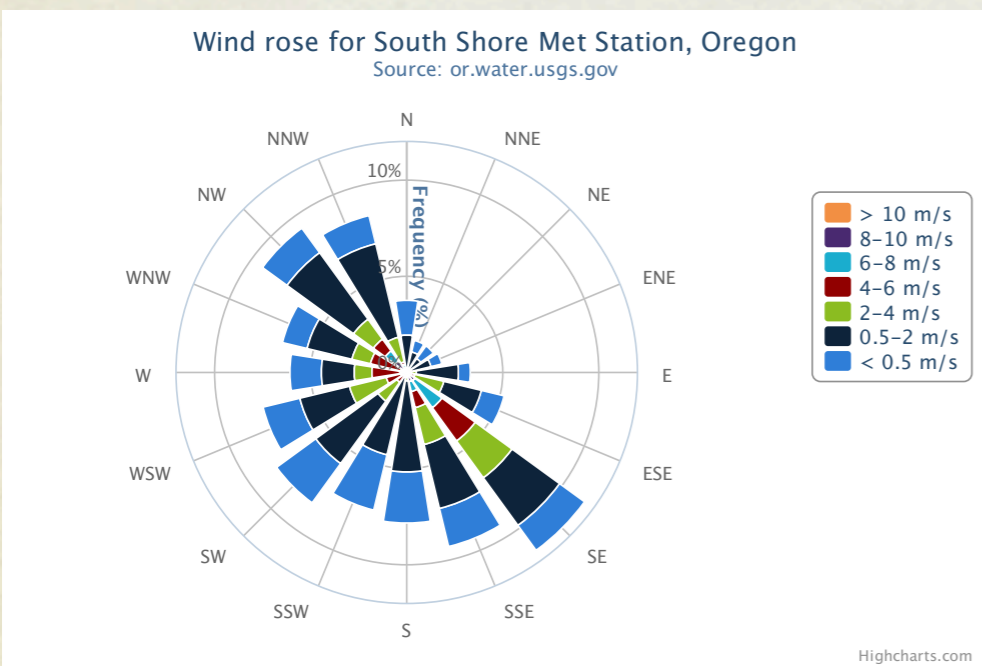
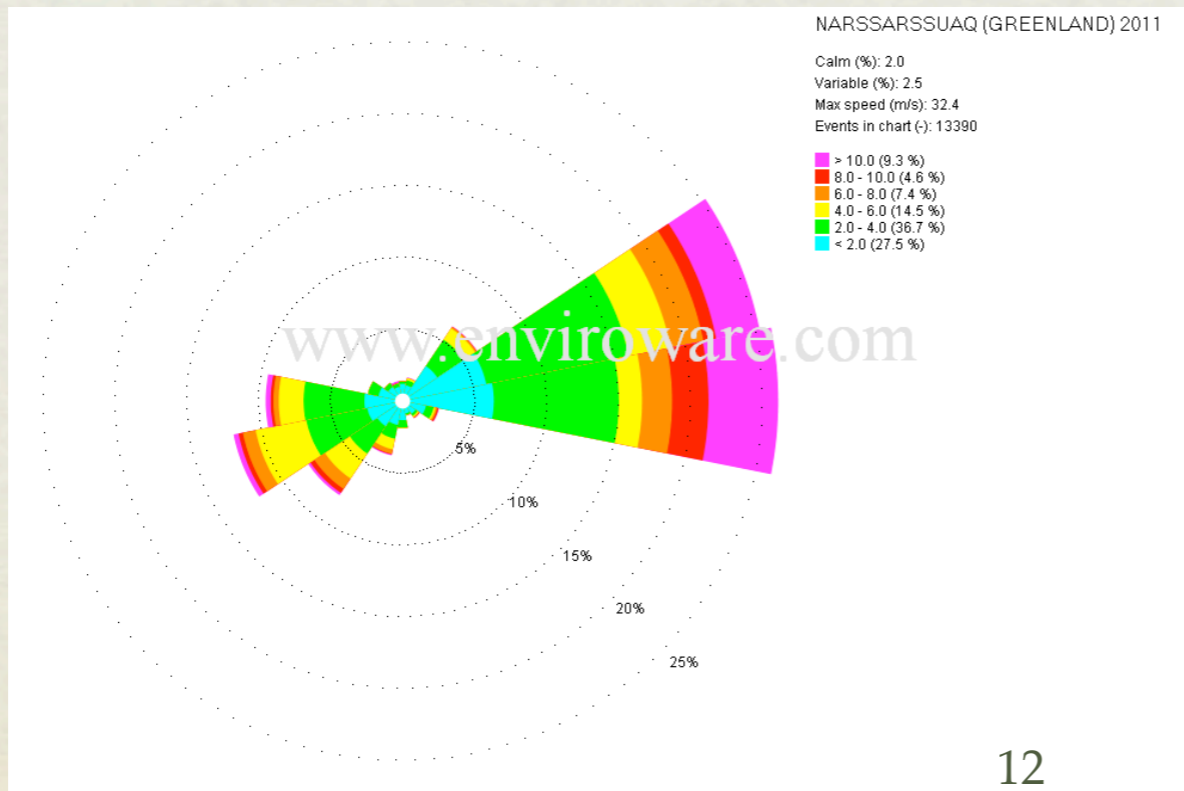
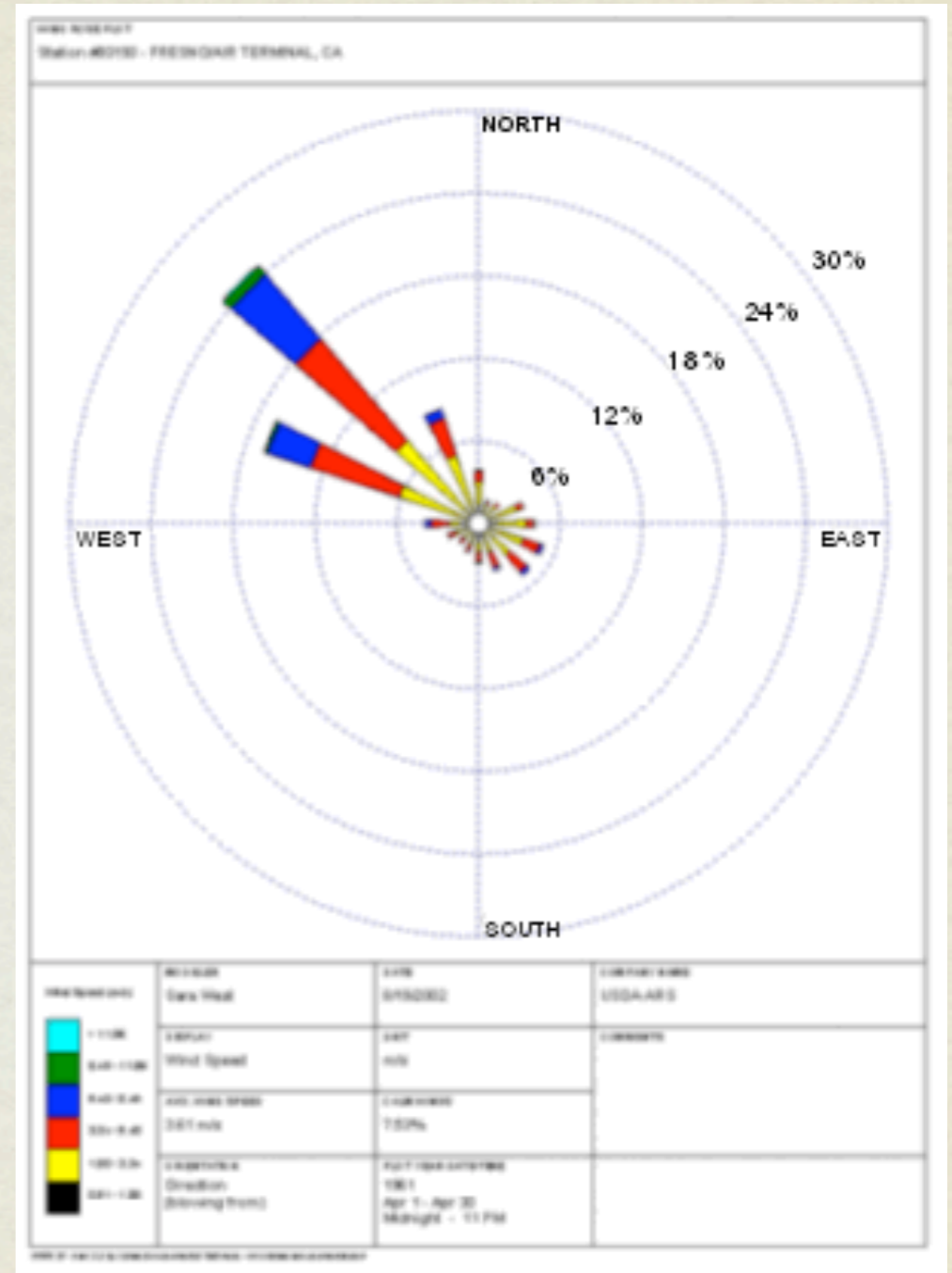
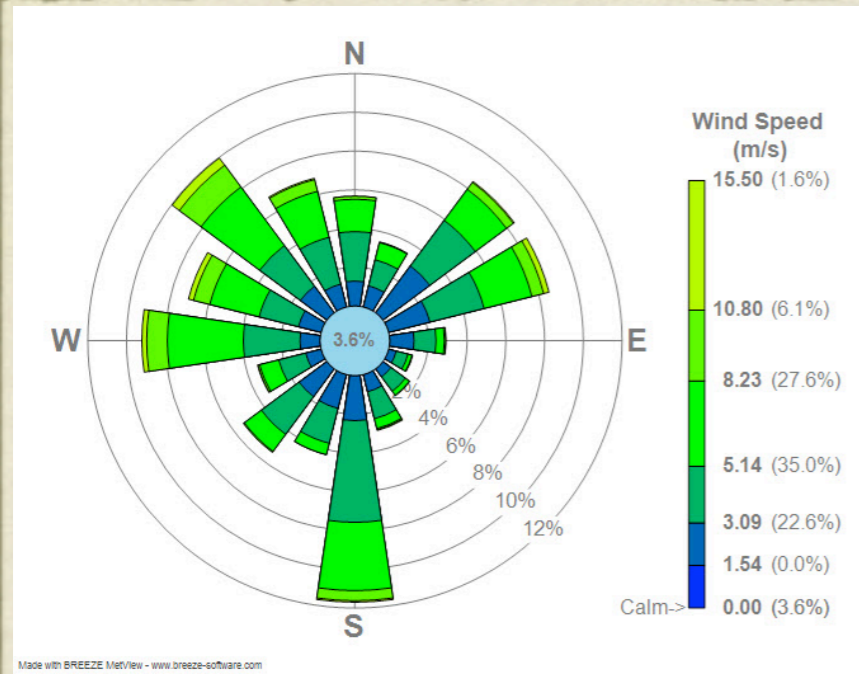


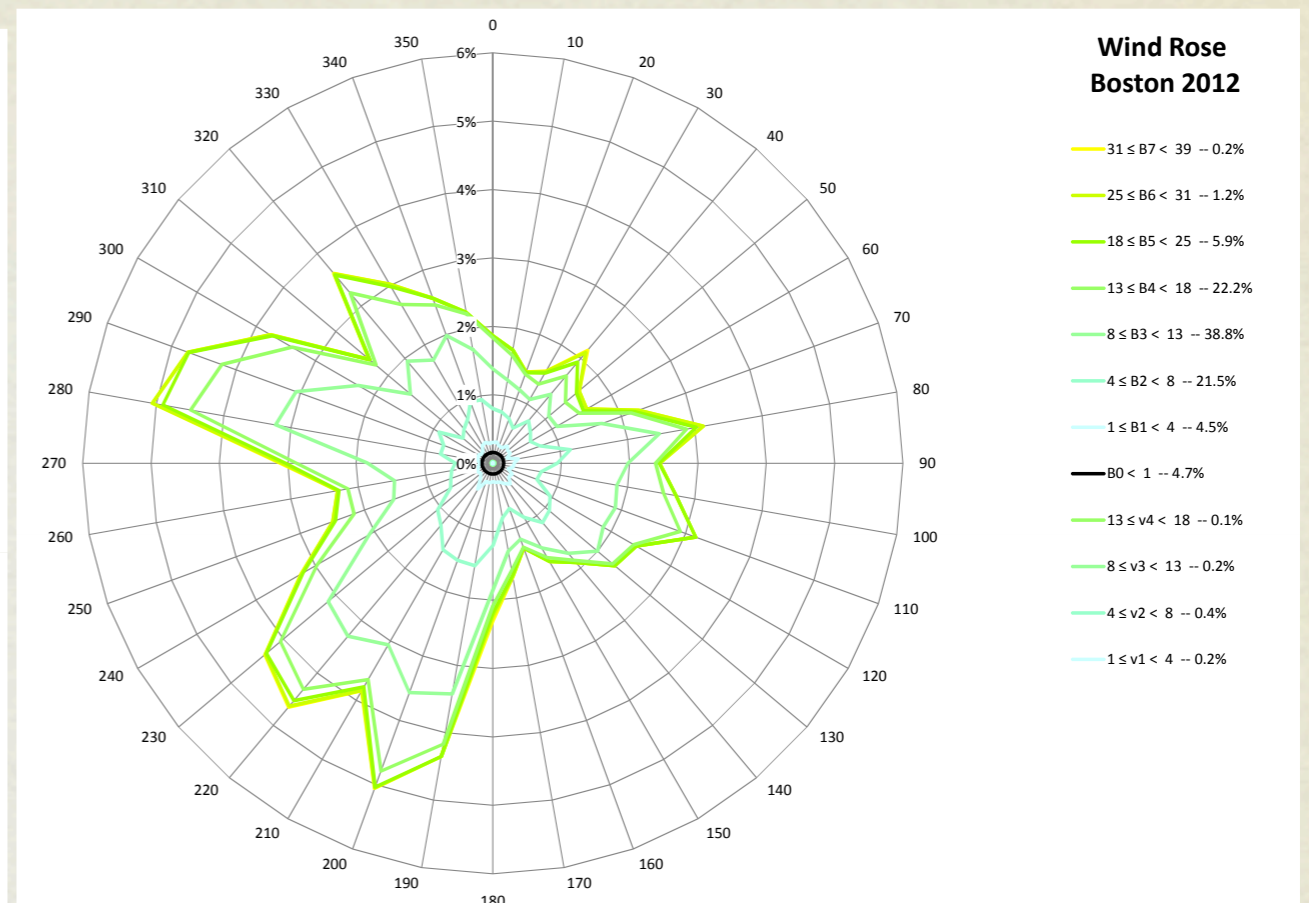
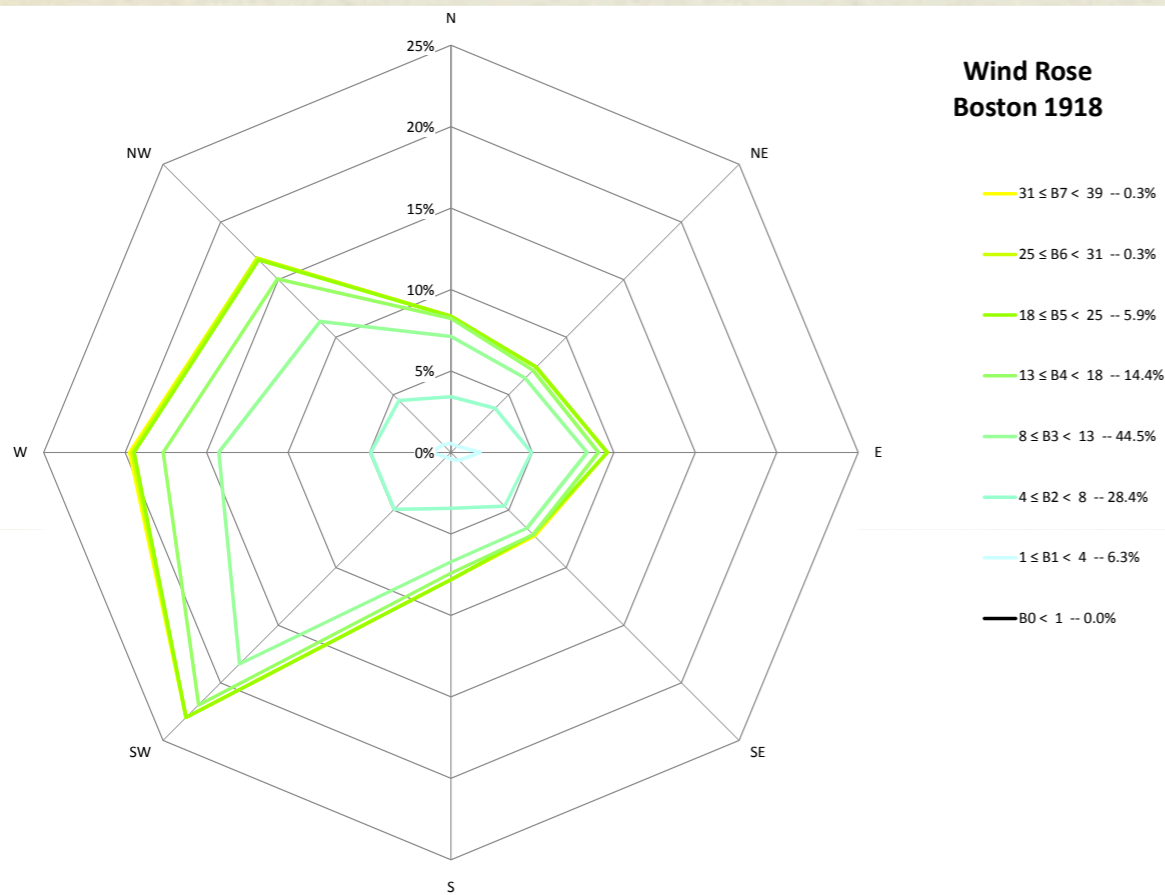
Figure 1. Wind rose plot at 0700 LST from Edgewood/Cedar Grove (CCEN5) at 0700 LST from Sep. 1, 2004 to Aug. 31, 2005.



# SOME EXAMPLES FROM THE WWW



# BOSTON EXAMPLES



• 1918: Babe Ruth's last year with the Red Sox; 8 Directions recorded twice a day (731)

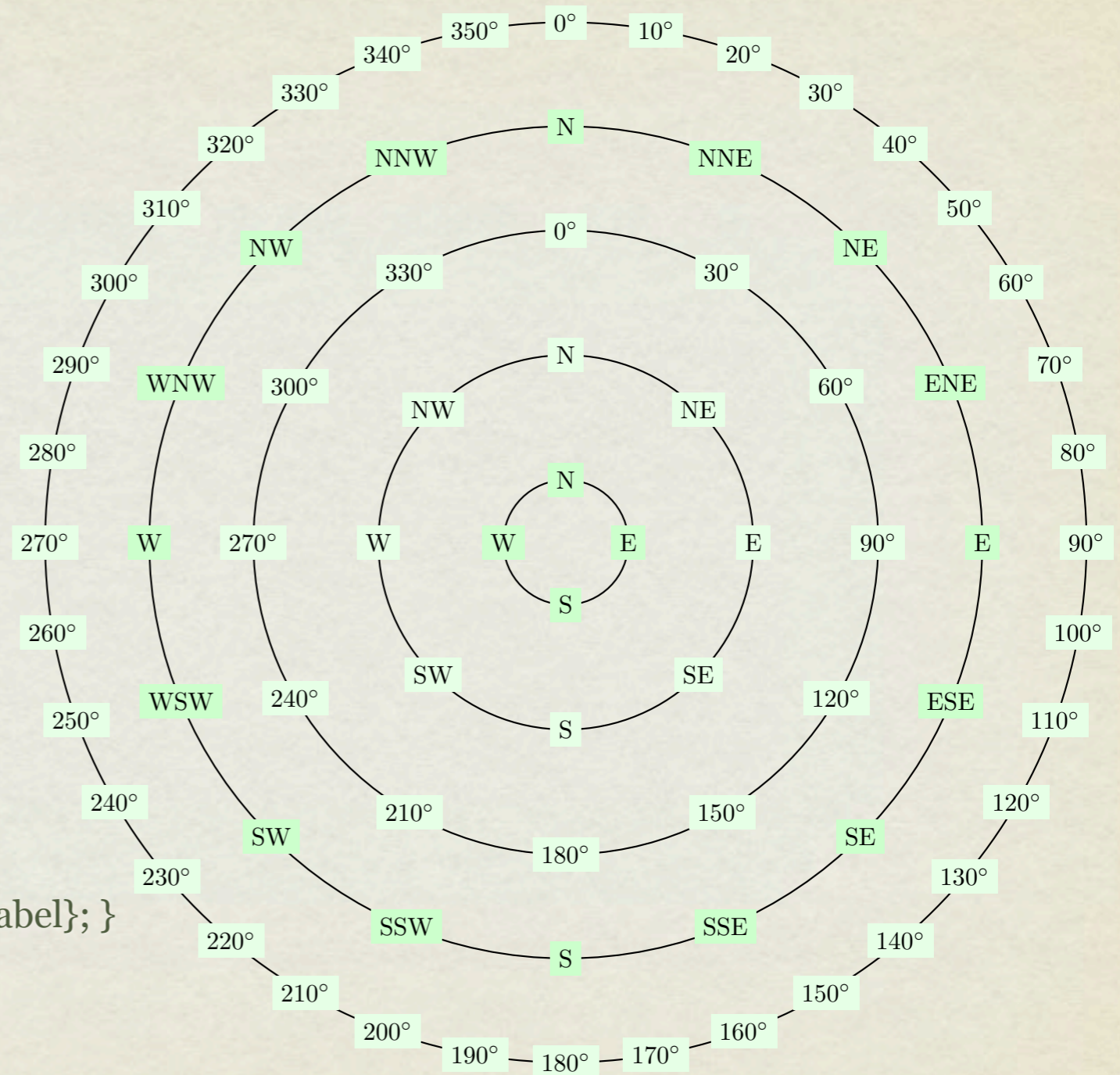
• 2012: Automated Data; 36 directions recorded hourly (8699)

# A WIND ROSE USING: TikZ

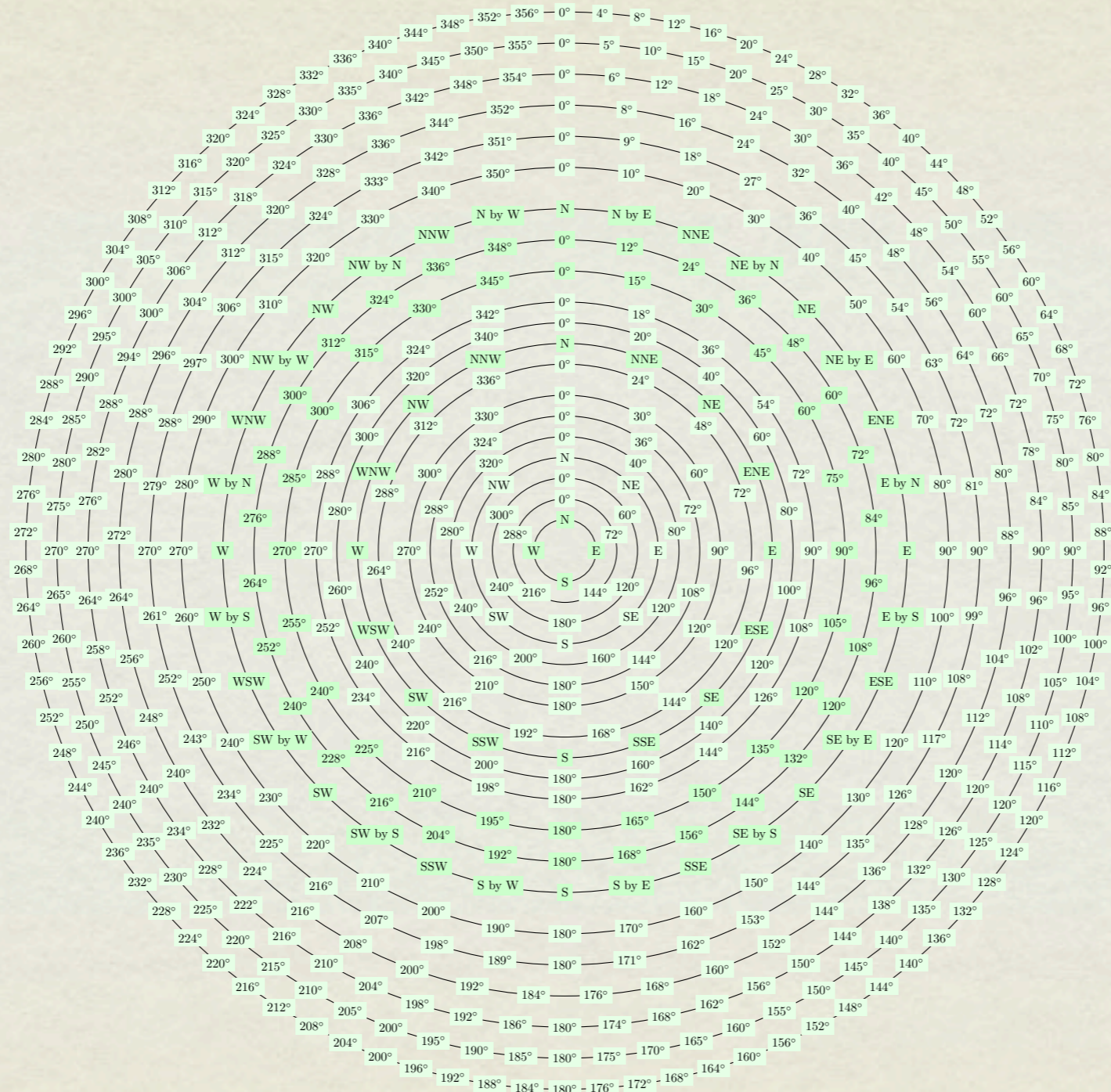
```

\documentclass{standalone}
\usepackage{tikz}
\usetikzlibrary{calc}
\begin{document}
\begin{tikzpicture}[rotate=90, scale=0.35,
    every node/.style={scale=0.6}]
    \coordinate (c1) at (0,0);
    \draw (c1) circle(45 mm);
    \foreach \direction/\label in {%
        0/N, 45/NE, 90/E, 135/SE,
        180/S, 225/SW, 270/W, 315/NW}%
    {\node[fill=green!10] at (-\direction : 45mm) {\label}; }
\end{tikzpicture}
\end{document}

```



# WHAT ANGLES MIGHT WE NEED TO USE?



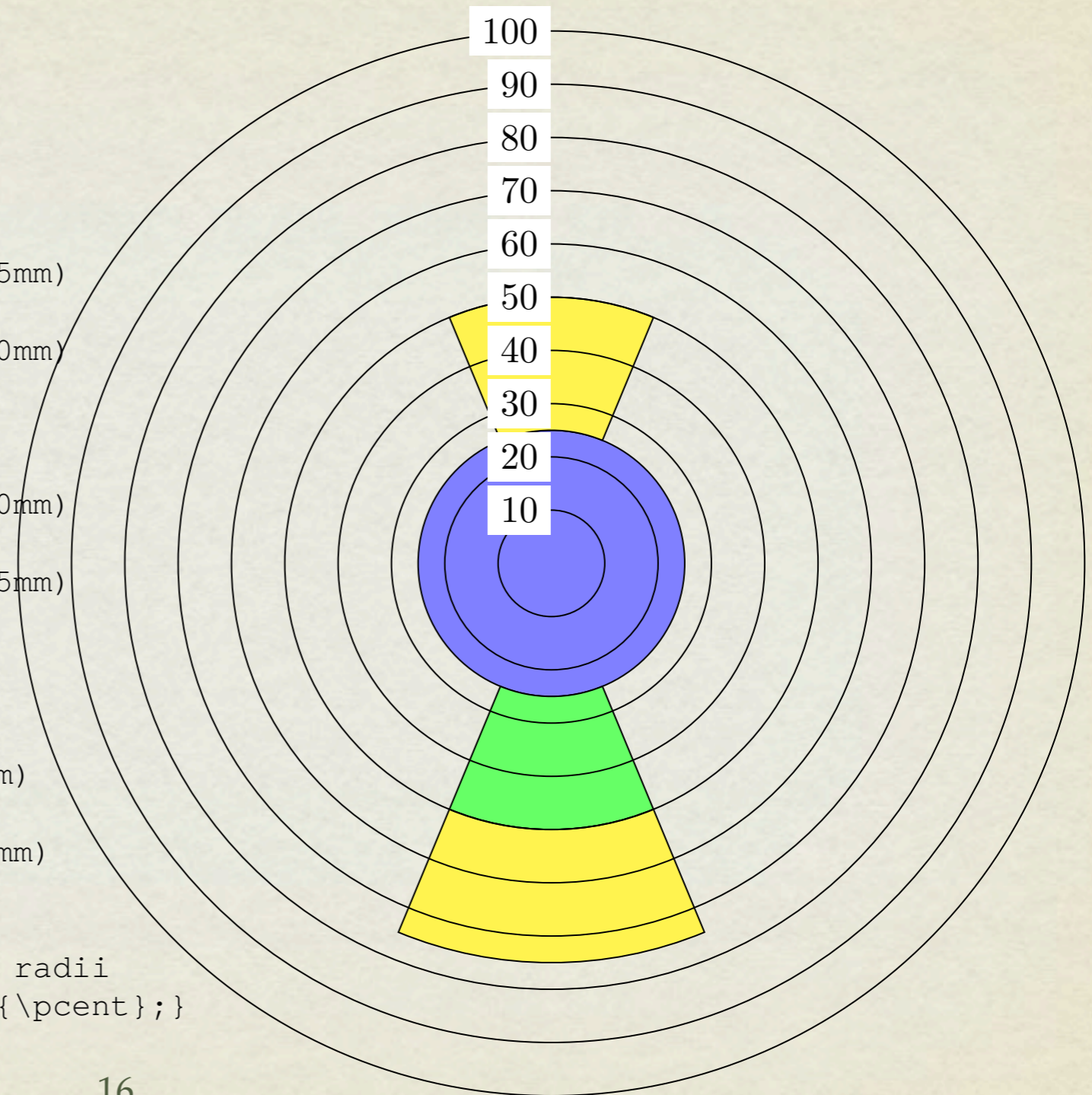
# CONTINUING A WIND ROSE

```
\begin{tikzpicture}[scale=0.5]
\coordinate (c1) at (0,0);
\draw[fill=blue!50] % Calm winds
(c1) + (0:25mm) ) arc (0:360:25mm);

\draw[fill=green!60] % South winds; slow
% initial=247.5, final=292.5
(c1) + (247.5:25mm) ) arc (247.5:292.5:25mm)
-- % reversed
(c1) + (292.5:50mm) ) arc (292.5:247.5:50mm)
-- cycle;

\draw[fill=yellow!80] % South winds faster
(c1) + (247.5:50mm) ) arc (247.5:292.5:50mm)
--
(c1) + (292.5:75mm) ) arc (292.5:247.5:75mm)
-- cycle

\draw[fill=yellow!80] % North winds faster
% initial=22.5, final=112.5
(c1) + (67.5:25mm) ) arc (67.5:112.5:25mm)
--
(c1) + (112.5:50mm) ) arc (112.5:67.5:50mm)
-- cycle;
\foreach \pcent in {10,20,...,100}{
\draw (0,0) circle (\pcent mm); % Label radii
\draw (0,\pcent mm) node[left,fill=white] {\pcent};}
\end{tikzpicture}
```





# LABELS AND RINGS AND RADII

```

\begin{tikzpicture}[rotate=90, scale=0.55]
% center c1
\coordinate (c1) at (0,0);

\draw[fill=blue!50]
% radius=25mm, initial=0, final=360
%([shift={(0:3mm)}]c1) arc (0:90:3mm)
($c1) + (0:25mm)$ arc (0:360:25mm);

\draw[fill=green!60]
% initial=247.5, final=292.5 ! That's West!
($c1) + (247.5:25mm)$ arc (247.5:292.5:25mm)
-- % reversed
($c1) + (292.5:50mm)$ arc (292.5:247.5:50mm)
-- cycle;

\draw[fill=yellow!80]Notice that the angles are centered on 270
($c1) + (247.5:50mm)$ arc (247.5:292.5:50mm)
-- % , reversed
($c1) + (292.5:75mm)$ arc (292.5:247.5:75mm)
-- cycle;

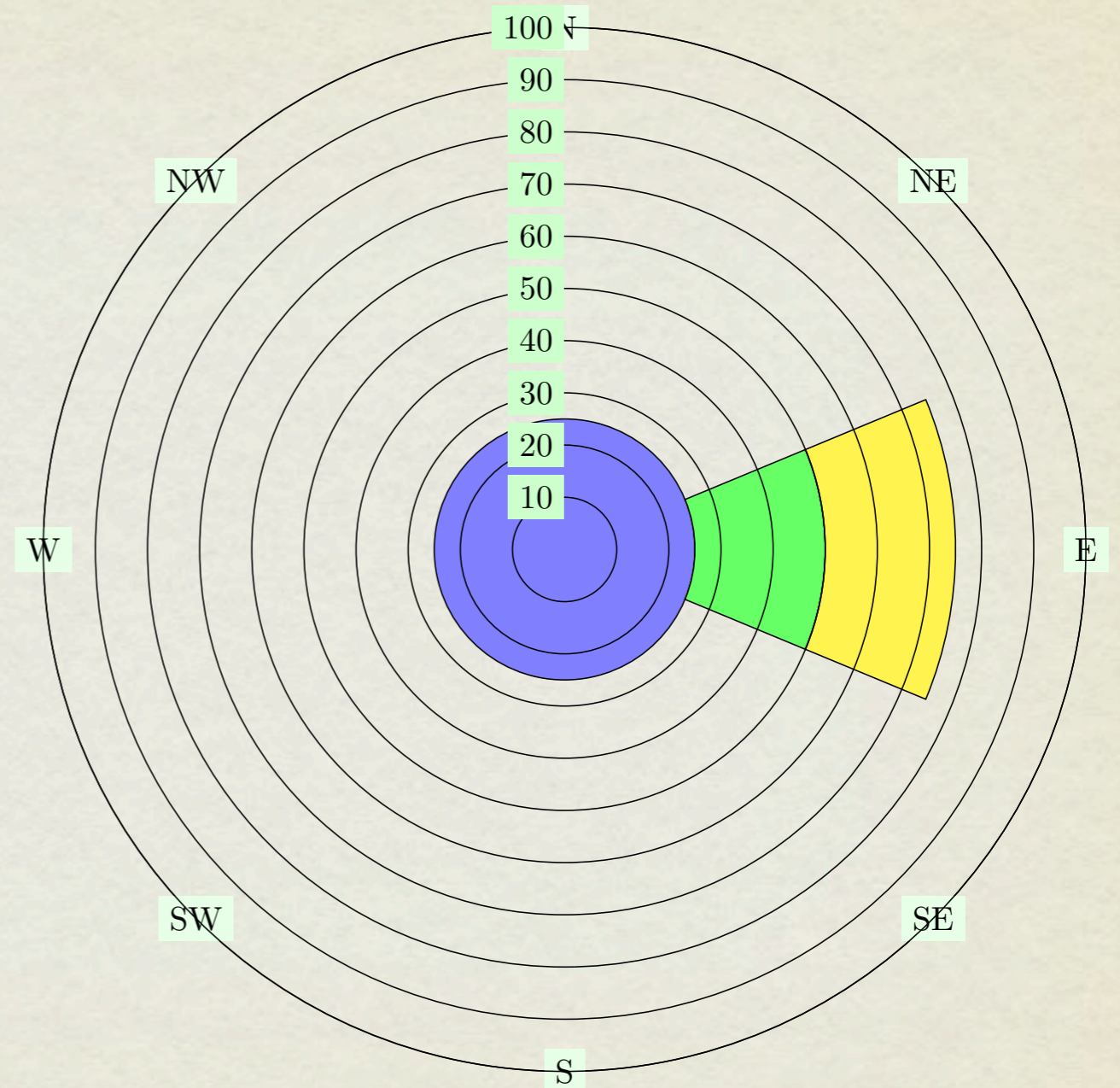
\foreach \pcent in {10,20,...,100}{
%\draw (c1) arc[radius = \pcent mm, start angle= 0, end angle= 0]

\draw (c1) circle (\pcent mm);
\draw (\pcent mm, 0) node[left,fill=green!20] {\pcent};}

\draw (c1) circle(100 mm);
\foreach \direction/\label in {%
0/N, 45/NE, 90/E, 135/SE, 180/S, 225/SW, 270/W, 315/NW}%
{node[fill=green!10] at ( -\direction : 100mm) {\label};
}

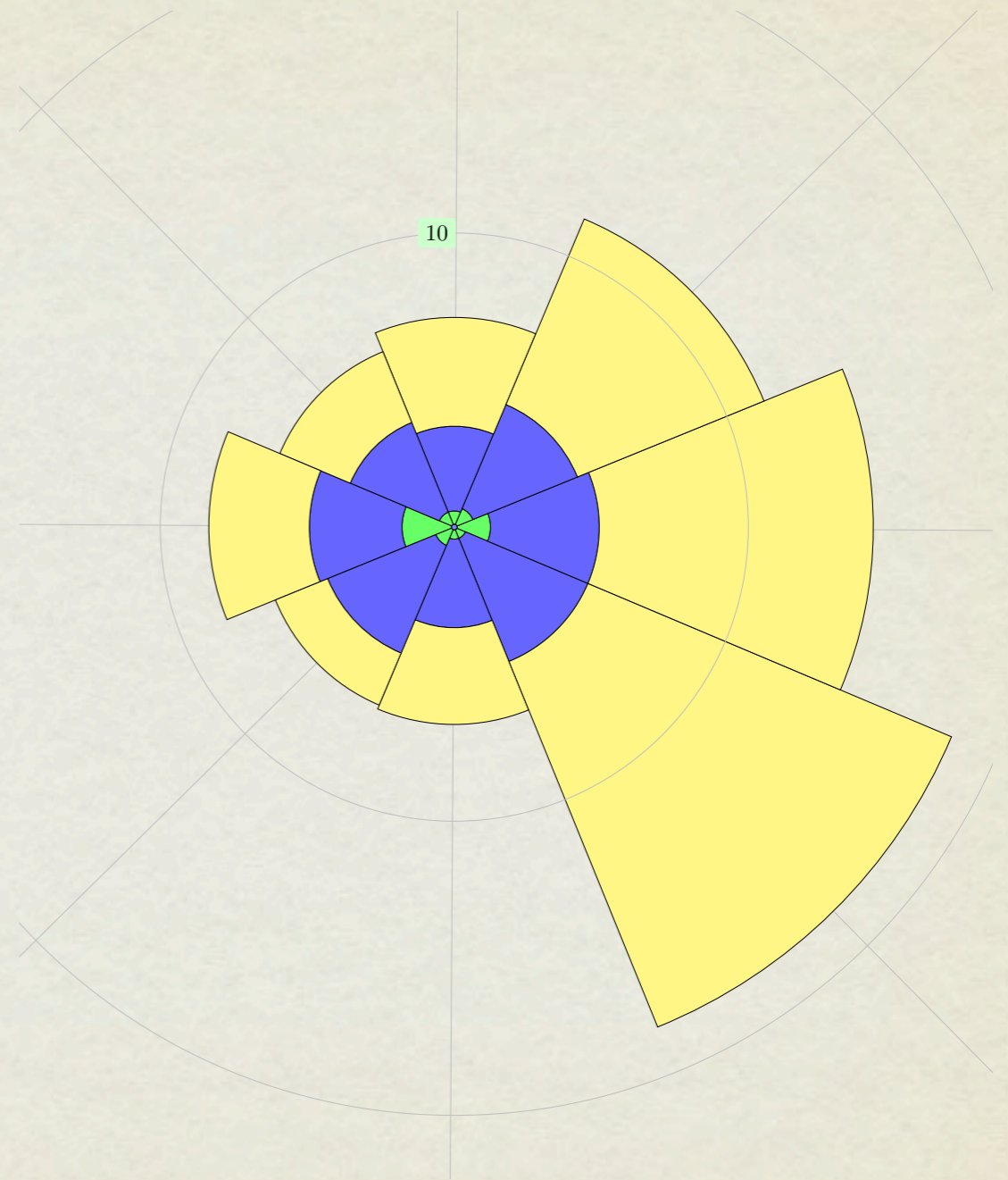
\end{tikzpicture}

```



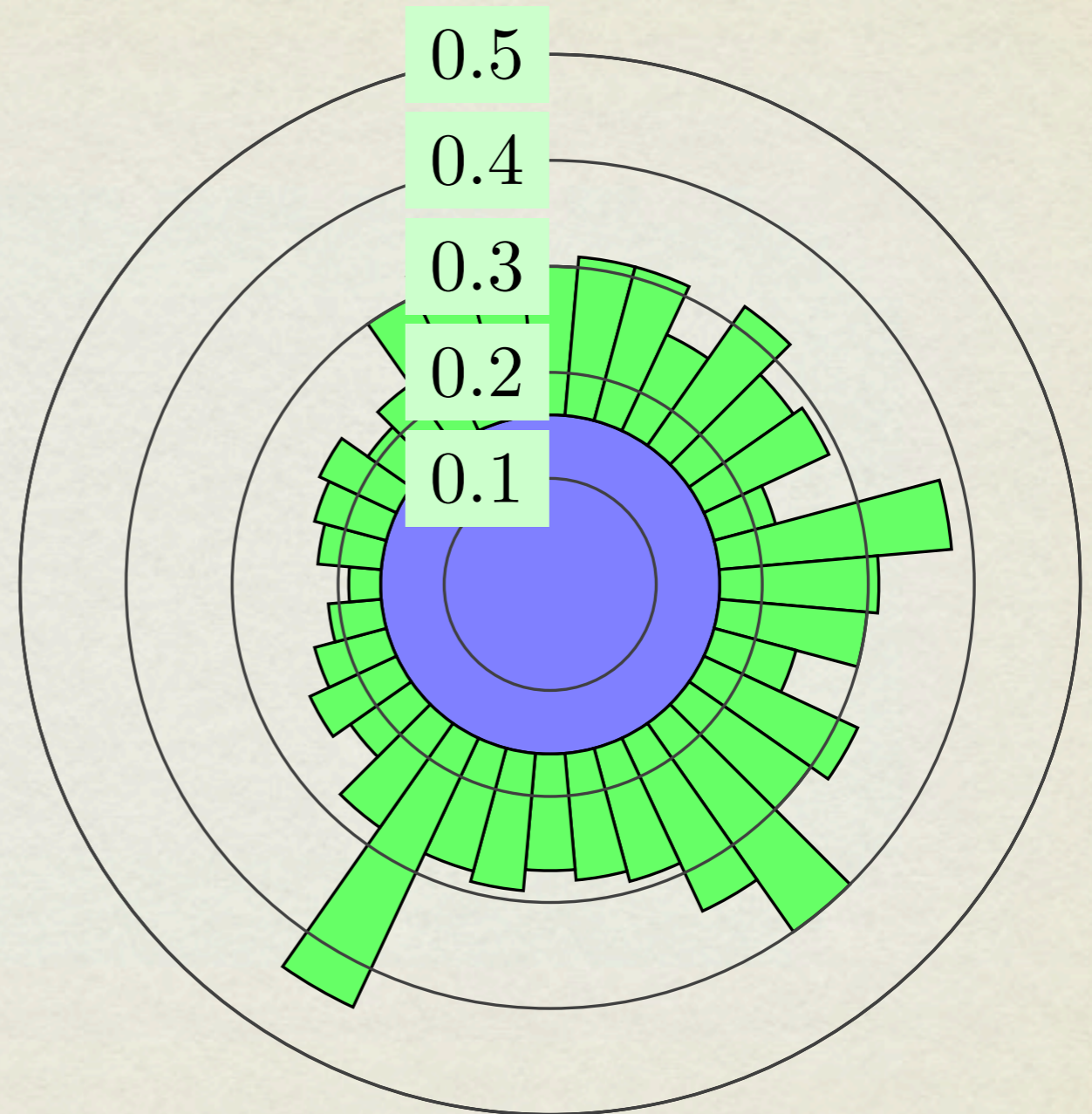
# LABELS AND RINGS AND RADII

- 8 Directions
- Three wind speed bins



# THE CNETER

- Rings ( % )
- Central Beaufort Zero
- 36 Wind Directions
- Beaufort One



# EXAMPLE: BEGINNING

```
\pgfmathsetmacro{\MaxRad}{0.5}
\pgfmathsetmacro{\HalfAngle}{5}

\begin{tikzpicture}[rotate=90, scale=50.5]
  \coordinate (c1) at (0,0); % center c1
  \def\Bzero_N{0.16}
  \draw[fill=blue!50] % Beaufort Zero
    ($(c1) + (0:\Bzero_N mm)$) arc (0:360:\Bzero_N mm);

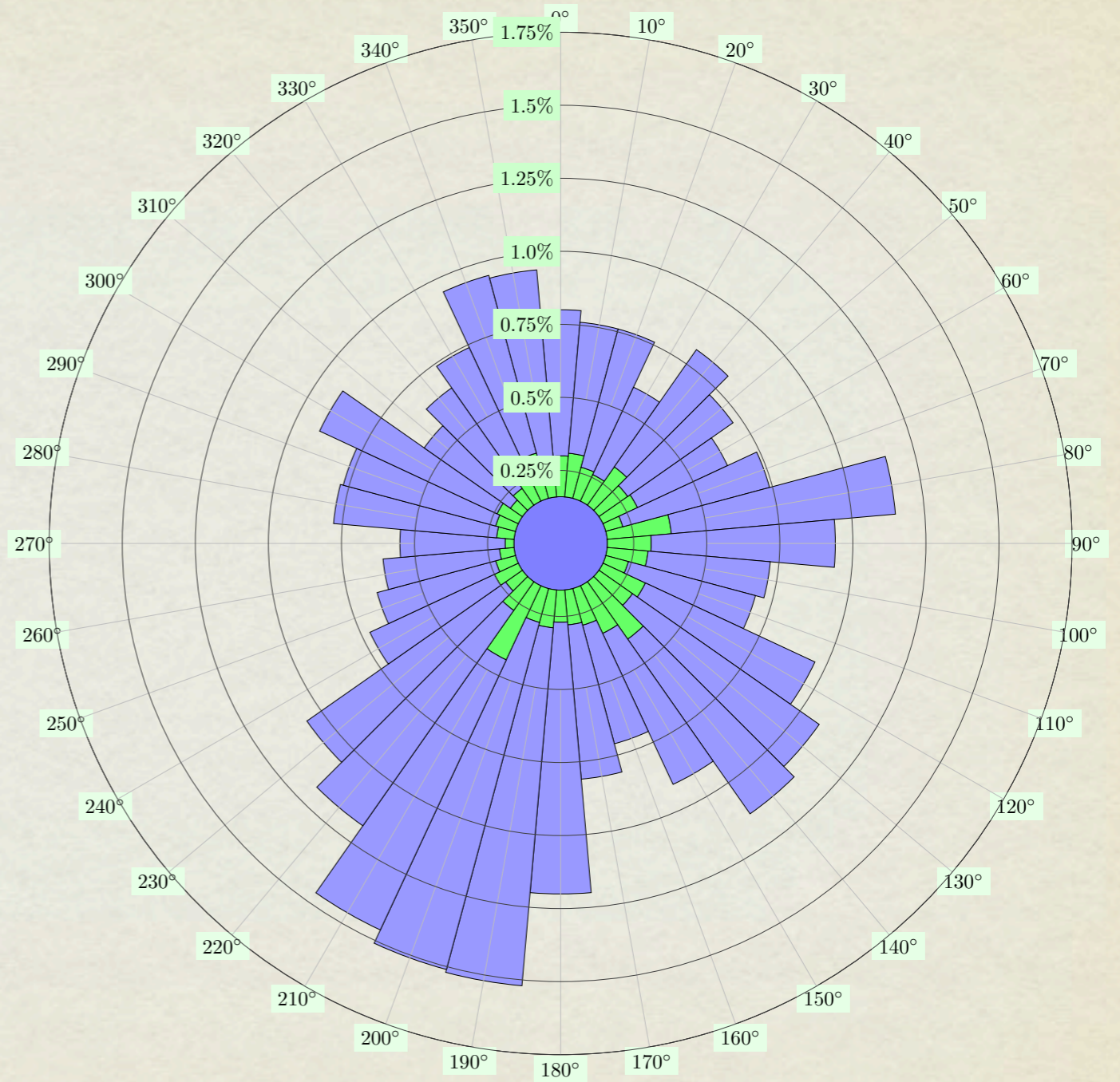
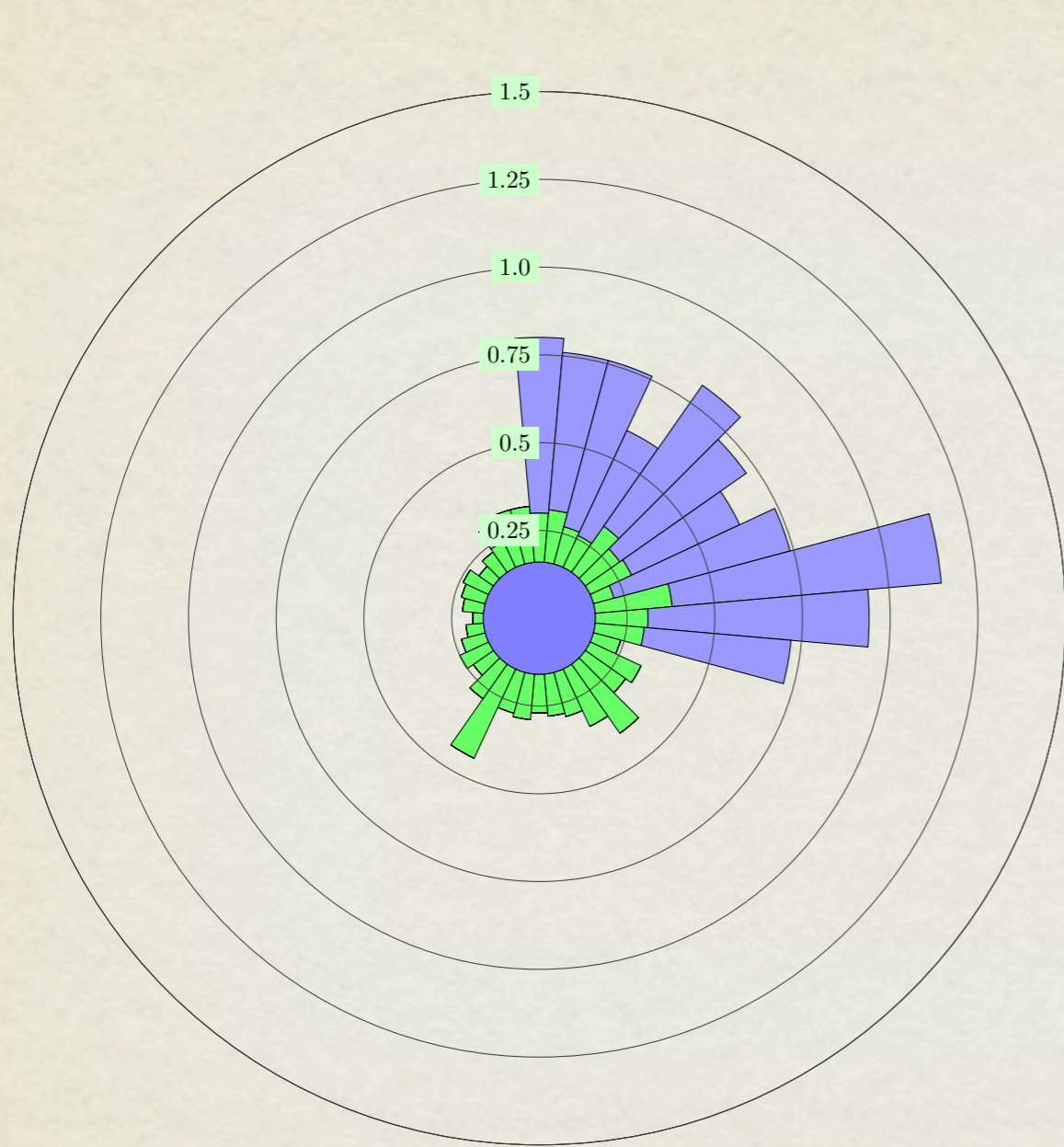
  \draw (c1) circle(\MaxRad mm);
  \pgfmathsetmacro{\lastradius}{\Bzero_N}
  % Beaufort 1
  \def\BiN{0.30} \def\BiNi{0.31} \def\BiNii{0.27}
  \def\BiNiii{0.26} \def\BiNiv{0.32} \def\BiNv{0.28}
  \def\BiNvi{0.29} \def\BiNvii{0.22} \def\BiNviii{0.38}
  \def\BiNix{0.31} \def\BiNx{0.30} \def\BiNxi{0.24}
  \def\BiNxii{0.32} \def\BiNxiii{0.30} \def\BiNxiv{0.40}
  \def\BiNxv{0.34} \def\BiNxvi{0.29} \def\BiNxvii{0.28}
  \def\BiNxviii{0.27} \def\BiNxix{0.29} \def\BiNxx{0.28}
  \def\BiNxxi{0.44} \def\BiNxxii{0.28} \def\BiNxxiii{0.23}
  \def\BiNxxiv{0.25} \def\BiNxxv{0.23} \def\BiNxxvi{0.21}
  \def\BiNxxvii{0.19} \def\BiNxxviii{0.22} \def\BiNxxix{0.23}
  \def\BiNxxx{0.24} \def\BiNxxxi{0.21} \def\BiNxxxii{0.23}
  \def\BiNxxxiii{0.30} \def\BiNxxxiv{0.32} \def\BiNxxxv{0.32}
  \def\BiNxxxvi{0.29}
```

```
\foreach \direction\thisradius in { 0\BiN, 10\BiNi, 20\BiNii,
30\BiNiii, 40\BiNiv, 50\BiNv, 60\BiNvi, 70\BiNvii, 80\BiNviii,
90\BiNix, 100\BiNx, 110\BiNxi, 120\BiNxii, 130\BiNxiii,
140\BiNxiv, 150\BiNxv, 160\BiNxvi, 170\BiNxvii, 180\BiNxviii,
190\BiNxix, 200\BiNxx, 210\BiNxxi, 220\BiNxxii, 230\BiNxxiii,
240\BiNxxiv, 250\BiNxxv, 260\BiNxxvi, 270\BiNxxvii, 280\BiNxxviii,
290\BiNxxix, 300\BiNxxx, 310\BiNxxxi, 320\BiNxxxii,
330\BiNxxxiii, 340\BiNxxxiv, 350\BiNxxxv}{ %
  \draw[fill=green!60]
    $(c1) + (-\direction-\HalfAngle:\lastradius mm)$)
    arc (-\direction -\HalfAngle: -\direction +\HalfAngle:\lastradius mm)
    -- % reversed
    $(c1) + (-\direction +\HalfAngle:\thisradius mm)$)
    arc (-\direction +\HalfAngle:-\direction -\HalfAngle:\thisradius mm)
    -- cycle;}

\foreach \pcent in {0.1,0.2,0.3,0.4,0.5}{ % Draw the percent rings, labels
  \draw [color=darkgray] (c1) circle (\pcent mm);
  \draw (\pcent mm, 0) node[left,fill=green!20] {\pcent};
} %end foreach

\end{tikzpicture}
```

# ADDING BEAUFORT 2 DATA



# LABELS AND RADII AND RINGS, OH MY!

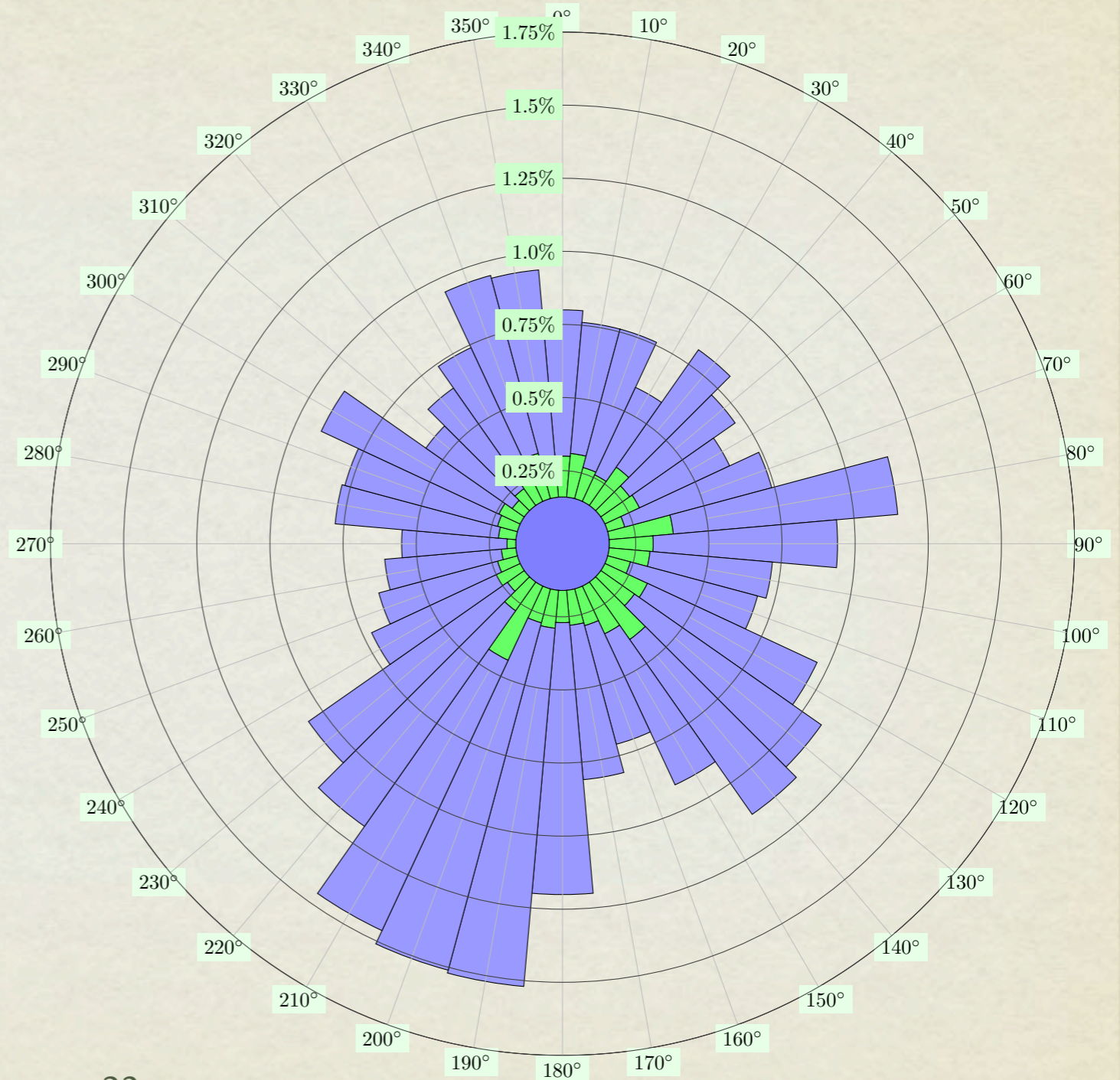
```
\foreach \direction in {%
%\foreach \direction/\label in {%
    0,10,...,350}{%
    %    0/N, 45/NE, 90/E, 135/SE, 180/S, 225/SW, 270/W, 315/NW}{%
\draw[rotate=-\direction,color=lightgray] (0,0.5mm) -- (0,\MaxRad mm);
\draw[fill=green!10] at ( -\direction : \MaxRad mm) {\direction ${{}^\circ$};
% \draw[fill=green!10] at ( -\direction : \MaxRad mm) {\label};

}

%Draw the percent rings and label

\foreach \pcent in {0.25,0.5,0.75,1.0,1.25,1.5,1.75}{
\draw [color=darkgray] (c1) circle (\pcent mm);
\draw (\pcent mm, 0) node[left,fill=green!20] {\pcent \%};}
\end{tikzpicture}
```

- Degree labels
- Second Ring of winds
- Radial Direction lines



```

% Beaufort 2
\def\BiiN{0.80} \def\BiiNi{0.76} \def\BiiNii{0.70} \def\BiiNiii{0.59} \def\BiiNiv{0.81} \def\BiiNv{0.72}
\def\BiiNvi{0.63} \def\BiiNvii{0.74} \def\BiiNviii{1.15} \def\BiiNix{0.94} \def\BiiNx{0.72}
\def\BiiNxi{0.69} \def\BiiNxii{0.96} \def\BiiNxiii{1.08} \def\BiiNxiv{1.13} \def\BiiNxv{0.91}
\def\BiiNxvi{0.71} \def\BiiNxvii{0.81} \def\BiiNxviii{1.20} \def\BiiNxix{1.52} \def\BiiNxx{1.51}
\def\BiiNxxi{1.46} \def\BiiNxxii{1.18} \def\BiiNxxiii{1.06} \def\BiiNxxiv{0.72} \def\BiiNxxv{0.65}
\def\BiiNxxvi{0.61} \def\BiiNxxvii{0.55} \def\BiiNxxviii{0.78} \def\BiiNxxix{0.77} \def\BiiNxxx{0.91}
\def\BiiNxxxi{0.57} \def\BiiNxxxii{0.65} \def\BiiNxxxiii{0.74} \def\BiiNxxxiv{0.95} \def\BiiNxxxv{0.94}

\foreach \direction\thisradius\lastradius in {%
0\BiiN\BiN, 10\BiiNi\BiNi, 20\BiiNii\BiNii, 30\BiiNiii\BiNiii, 40\BiiNiv\BiNiv, 50\BiiNv\BiNv,
60\BiiNvi\BiNvi, 70\BiiNvii\BiNvii, 80\BiiNviii\BiNviii, 90\BiiNix\BiNix, 100\BiiNx\BiNx,
110\BiiNxi\BiNxi, 120\BiiNxii\BiNxii, 130\BiiNxiii\BiNxiii, 140\BiiNxiv\BiNxiv, 150\BiiNxv\BiNxv,
160\BiiNxvi\BiNxvi, 170\BiiNxvii\BiNxvii, 180\BiiNxviii\BiNxviii, 190\BiiNxix\BiNxix, 200\BiiNxx\BiNxx,
210\BiiNxxi\BiNxxi, 220\BiiNxxii\BiNxxii, 230\BiiNxxiii\BiNxxiii, 240\BiiNxxiv\BiNxxiv, 250\BiiNxxv\BiNxxv,
260\BiiNxxvi\BiNxxvi, 270\BiiNxxvii\BiNxxvii, 280\BiiNxxviii\BiNxxviii, 290\BiiNxxix\BiNxxix, 300\BiiNxxx\BiNxxx,
310\BiiNxxxi\BiNxxxi, 320\BiiNxxxii\BiNxxxii, 330\BiiNxxxiii\BiNxxx, 340\BiiNxxxiv\BiNxxxiv,
350\BiiNxxxv\BiNxxxv}{%

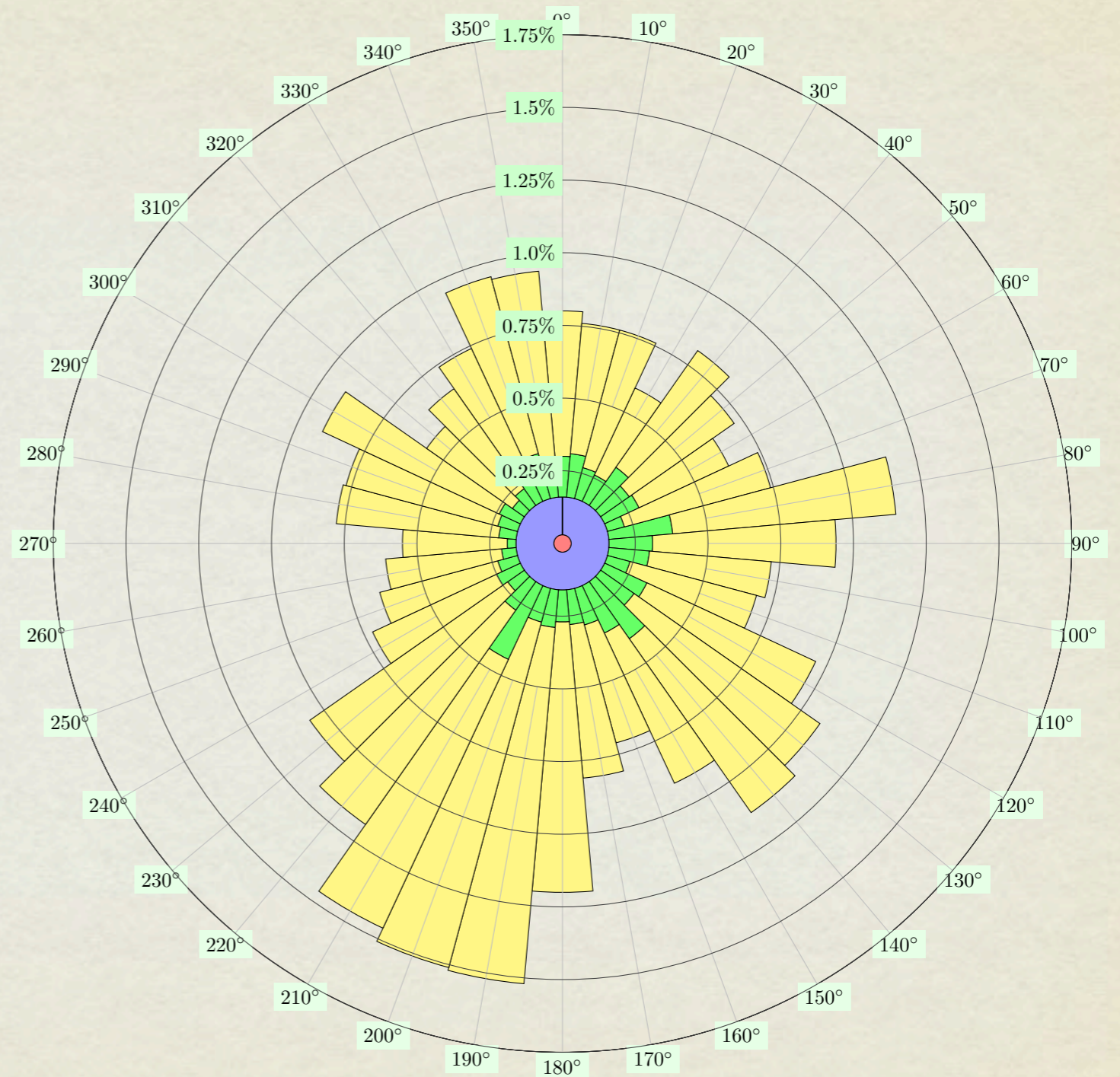
\draw[fill=blue!40]
$(c1) + (-\direction-\HalfAngle:\lastradius mm)$) arc (-\direction -\HalfAngle: -\direction +\HalfAngle:\lastradius mm)
-- % reversed
$(c1) + (-\direction +\HalfAngle:\thisradius mm)$) arc (-\direction +\HalfAngle:-\direction -\HalfAngle:\thisradius mm)
-- cycle;
}

```



# BEAUFORT 3; VARIABLE WINDS

- Adding Beaufort 3, 4, 5, and 6 will be just like adding Beaufort 2
- We added the variable winds that were coded as 990 (the red dot in the center)



# DRAWING THE VARIABLE WINDS THE BEAUFORT ZERO WINDS

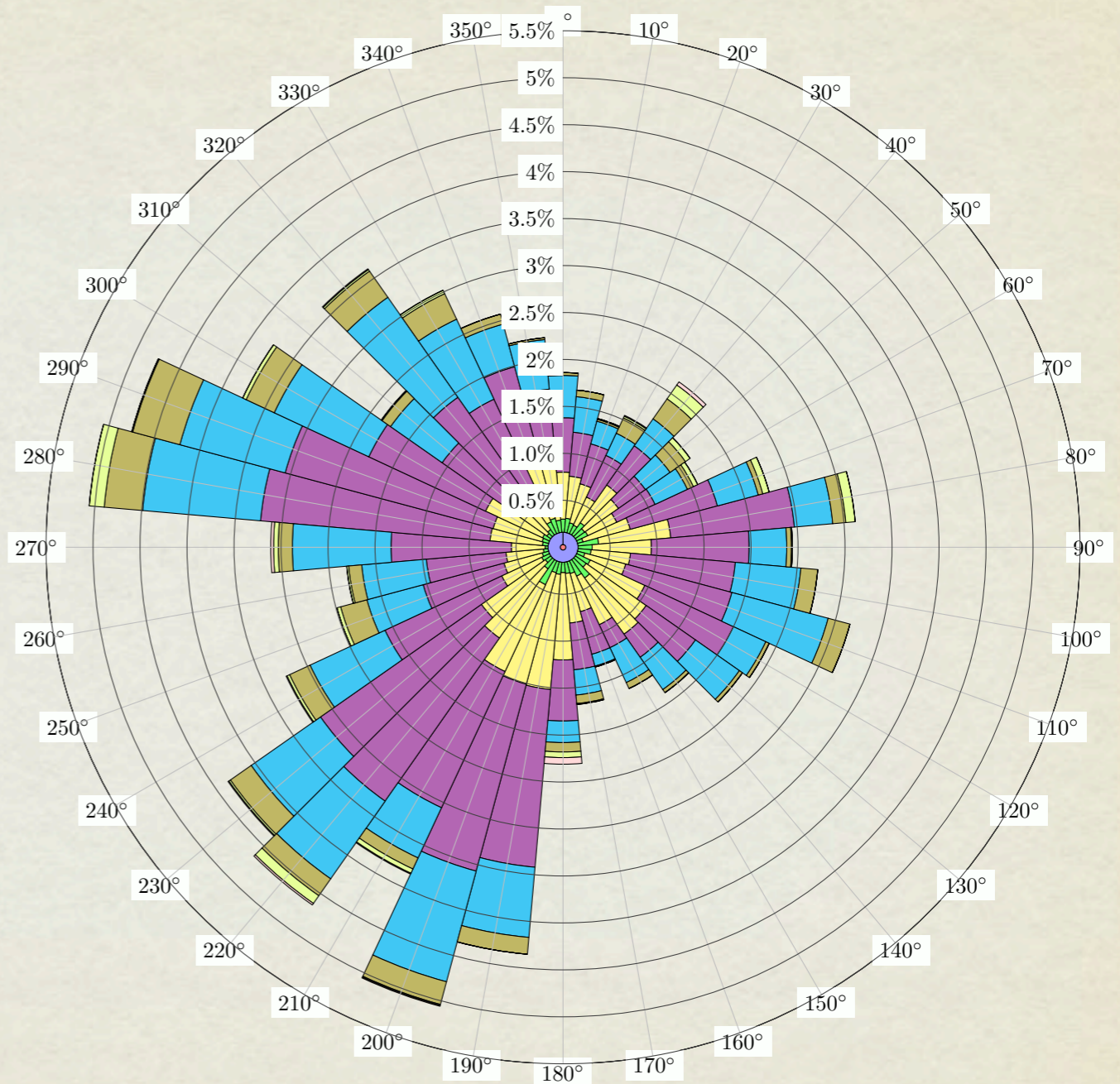
```
\def\Bzero_N{0.03}
  \draw[fill=red!50]   % Variable winds 990
  ($ (c1) + (0:\Bzero_N mm)$) arc (0:360:\Bzero_N mm);

\pgfmathsetmacro{\minlastradius}{\Bzero_N}
\def\Bzero_N{0.16}

\draw[fill=blue!40]
  ($ (c1) + (0:\minlastradius mm)$) arc (0:360:\minlastradius mm)
  -- % reversed
  ($ (c1) + (360:\Bzero_N mm)$) arc (360:0:\Bzero_N mm)
  -- cycle;
```

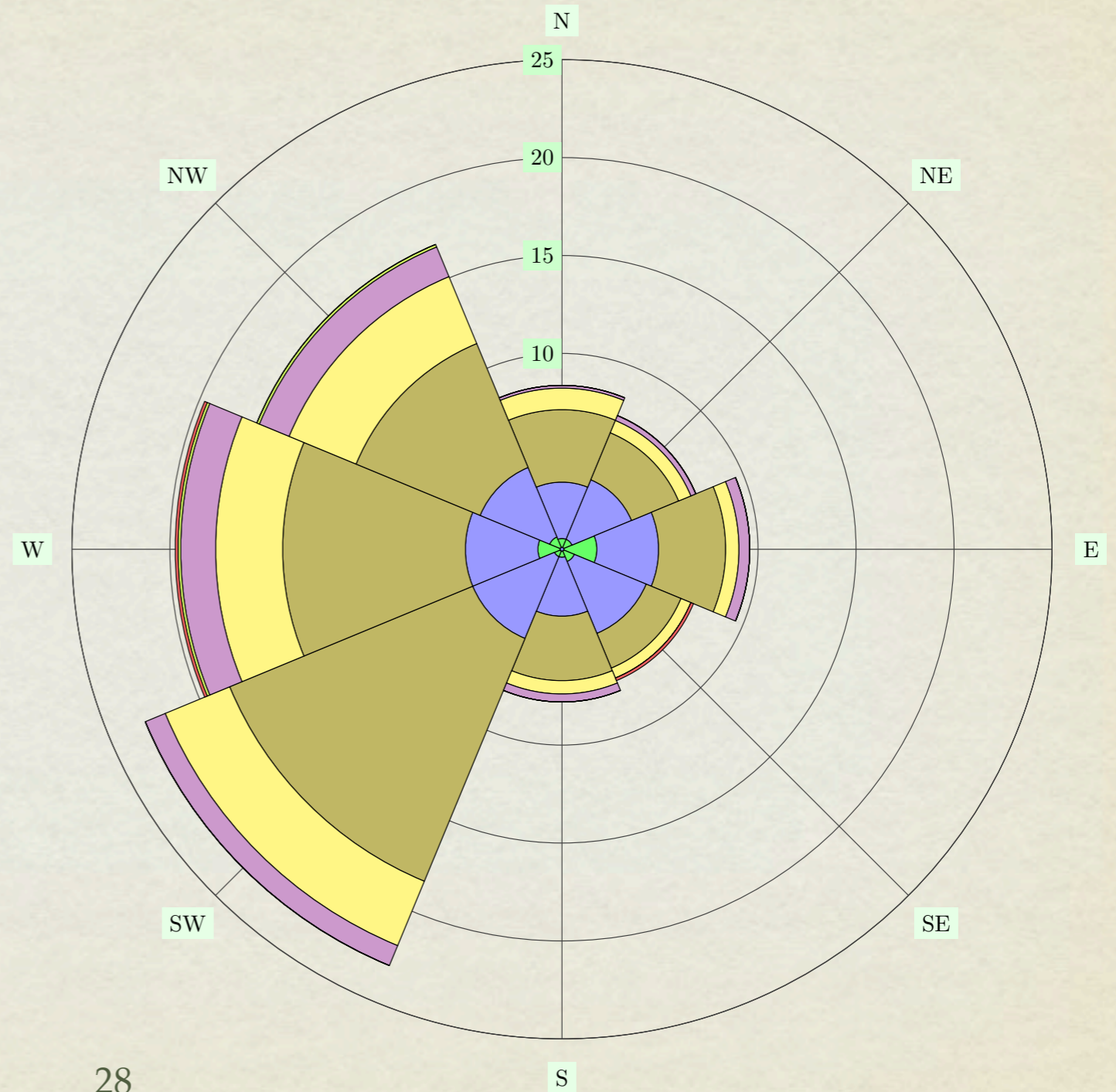
# BOSTON 2012

- Here is the data from 2012 in Boston
- Need some better colors
- Still need a legend or key

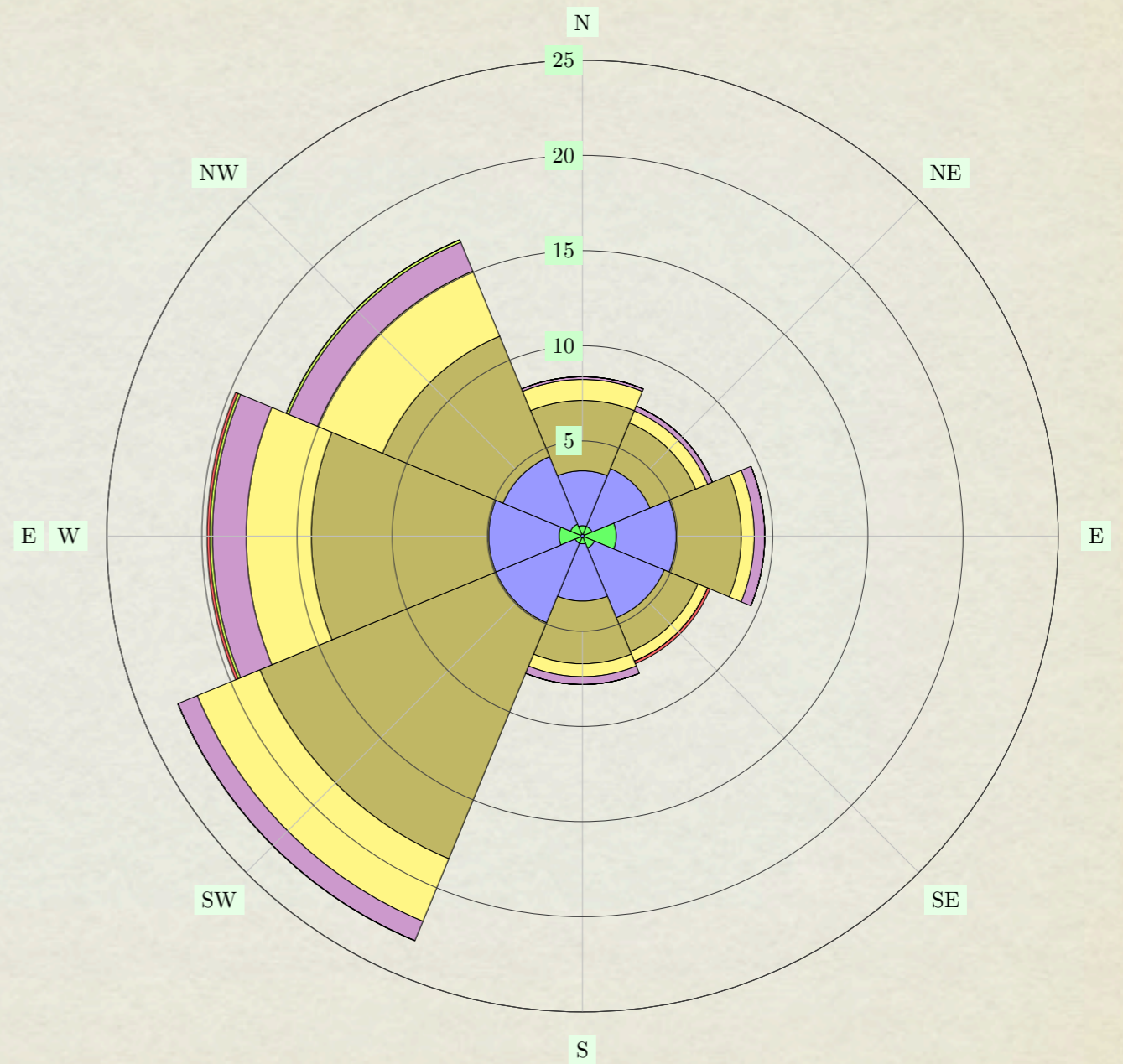
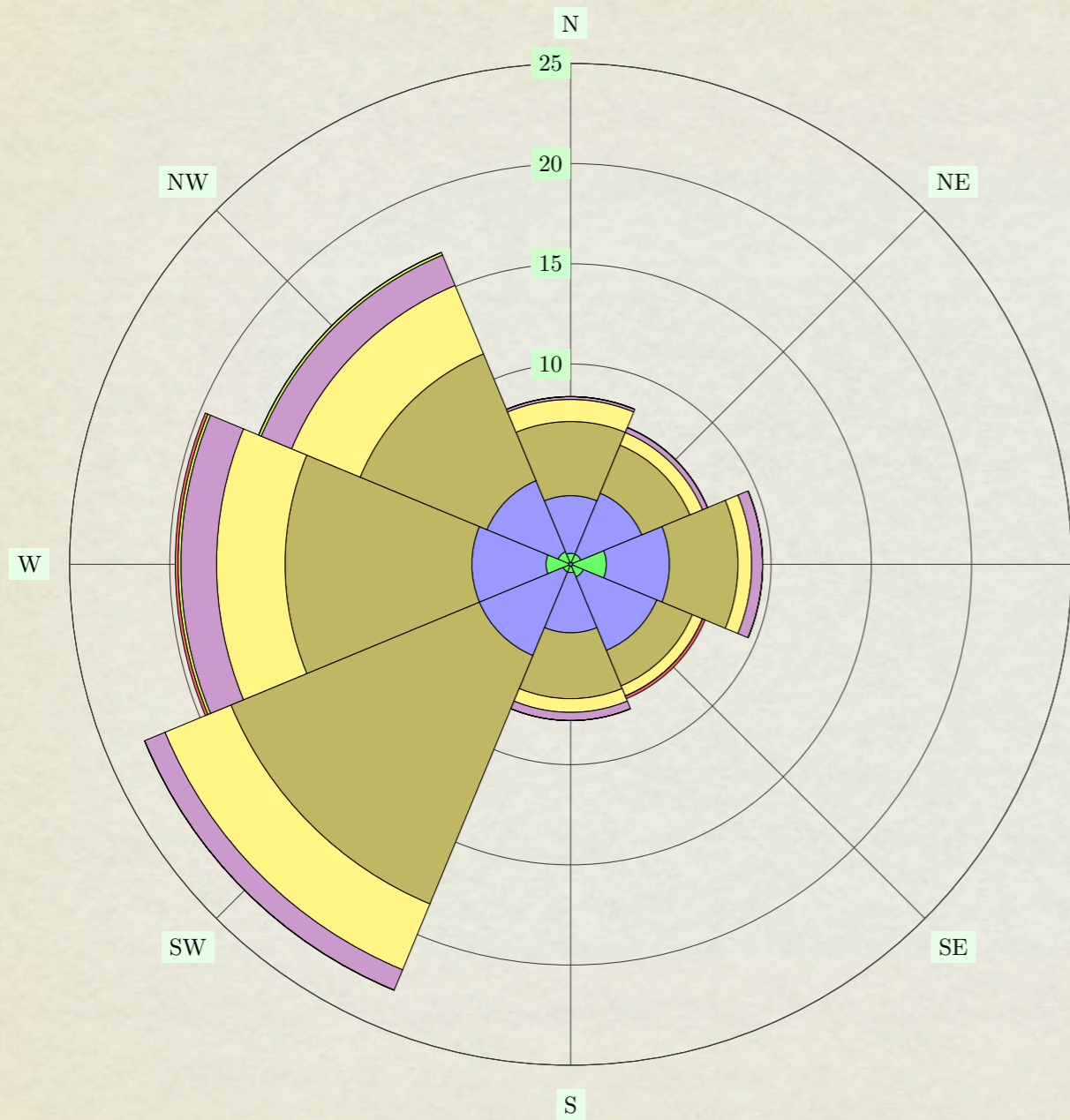


# GETTING CLOSE

- We are almost complete.
- We have our wind statistics reasonably displayed on a polar plot; everything is in the “right” order
- But; the scale; rings, and arcs are obscured; let’s draw them last!



# PUTTING THE LINES ON THE "TOP"



# CLOSER YET?

- Still to do
  - We need a legend
  - Generalize a bit more; reusable macros
  - Is it robust? How can we break it?
  - Automate data ingest
  - csvsimple ?

