

# A user-oriented verification methodology for wind forecast

Maria Stefania Tesini

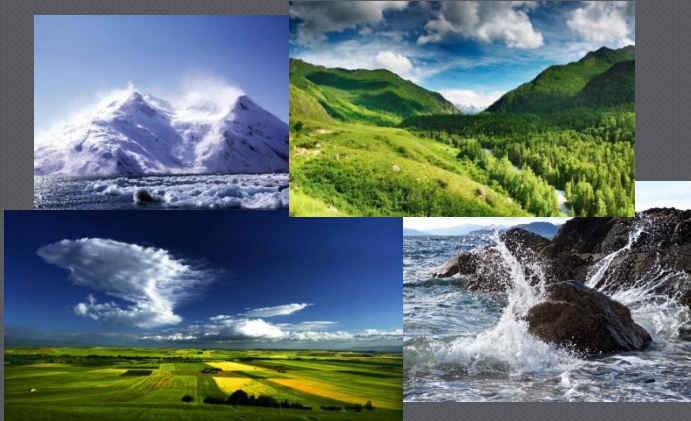
7th International Verification Methods Workshop

11-05-2017 Berlin, Germany

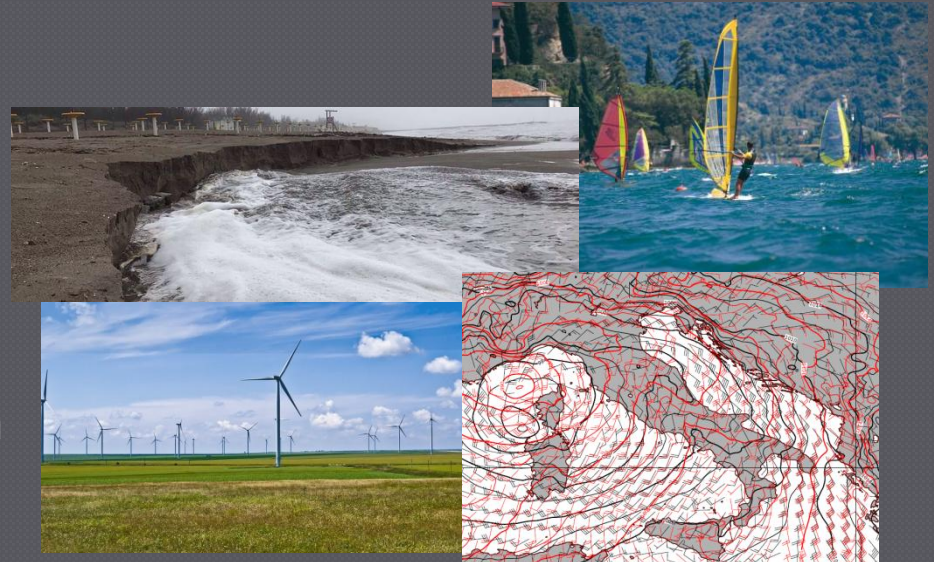


# Motivation

The 10-m wind is a weather parameter characterized by strong dependence on orographic and topographic details and high temporal variability.



Any verification method should be tailored for the specific purpose defined by the user of that forecast, being the developer of the model, the forecaster in the operational room or the stakeholder for a practical application.

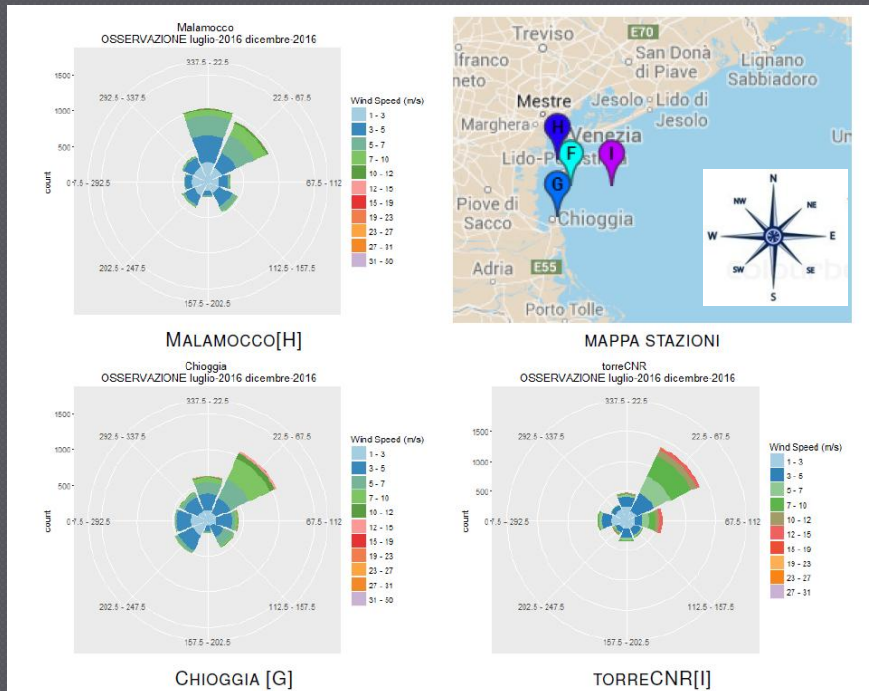


**Hence the need to develop a methodology of verification that is able not only to take into account these aspects but also effective in communicating results to the end user**

# “My” typical end-user



- One of the main uses of wind forecast is to issue warnings when wind speed exceed some threshold



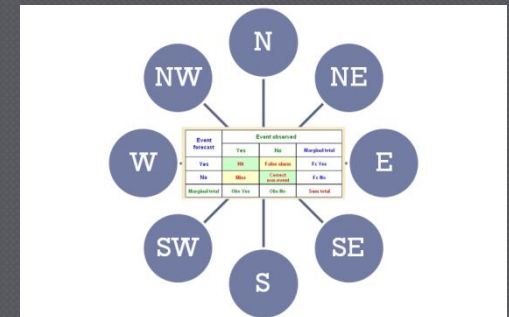
- Since high winds can determine the possible occurrence of sea storms over the Adriatic Sea, also the correct prediction of wind direction plays a key role

Observed wind rose for the period July-December 2016

# What “my” user wants to know

- Is the model able to predict strong wind?
  - How many false alarms or misses?
  - Does it have the same performance in all directions?
- Is the direction correctly forecast?
  - Does it depend on wind speed?
  - Is there a shift/bias?

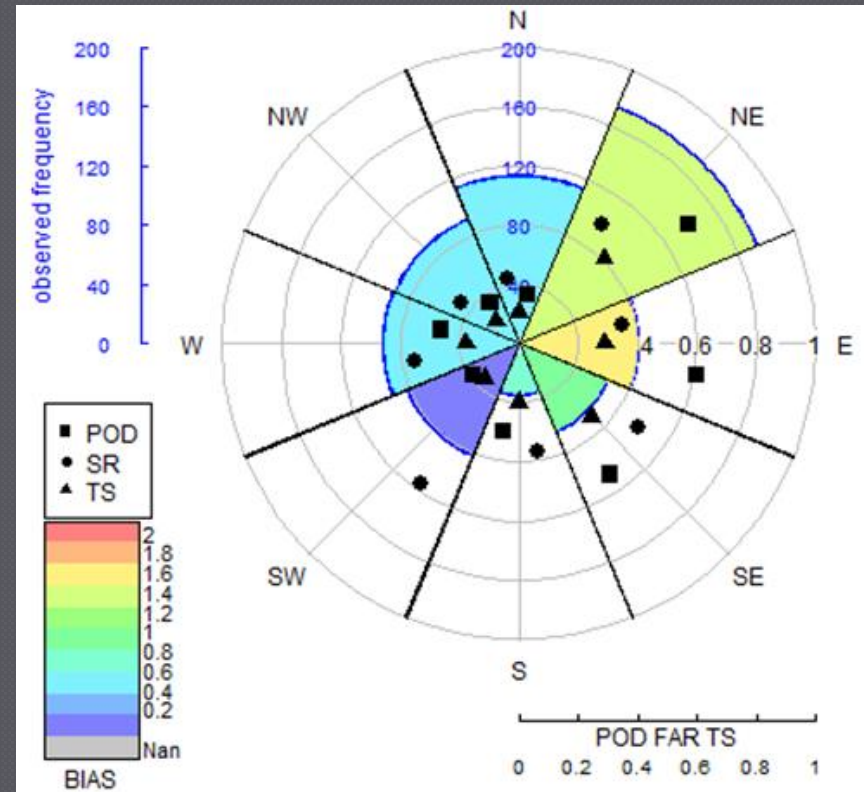
Event forecast	Event observed		Marginal total
	Yes	No	
Yes	Hit	False alarm	Fc Yes
No	Miss	Correct non-event	Fc No
Marginal total	Obs Yes	Obs No	Sum total



How to take into account wind speed and direction and summarize the results in a plot ?

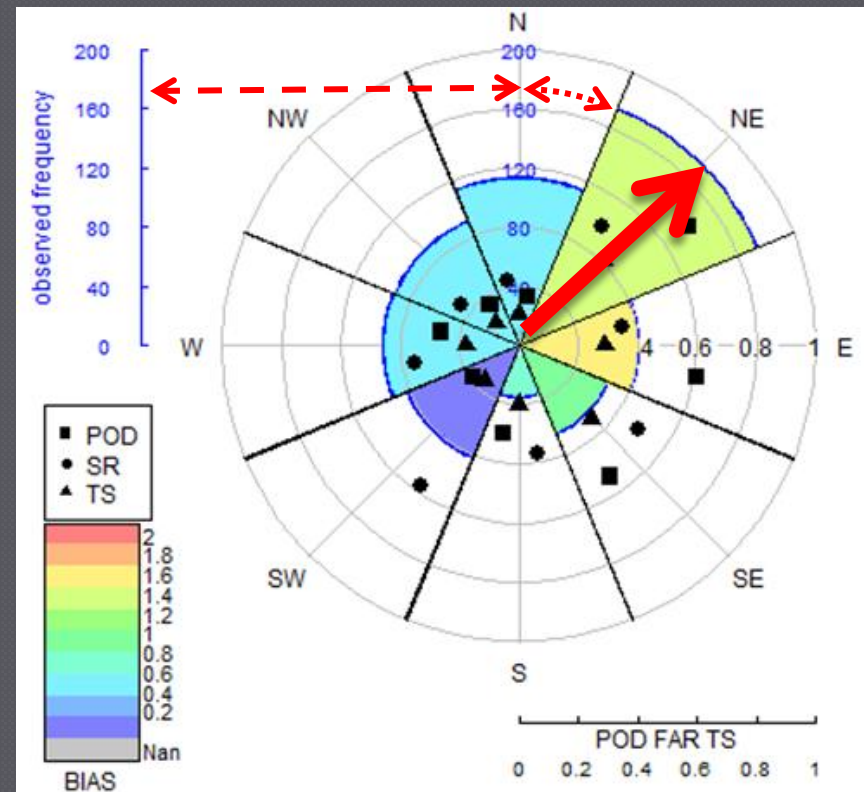
# The “performance-rose” 1<sup>st</sup> version

- The first idea was to summarize in a single diagram the some information (once an event has been defined )
  1. **observed climatology** like a usual wind rose
  2. scores from contingency table as in the “performance diagram”:
    - **BIAS SCORE**
    - **POD, TS, SR (=1-FAR)**



# The “performance-rose” 1<sup>st</sup> version

- the length of the spokes around the circle (arcs in blue) represent how often the event has been observed in each direction
- The values can be read on the blue radial axis



# The “performance-rose” 1<sup>st</sup> version

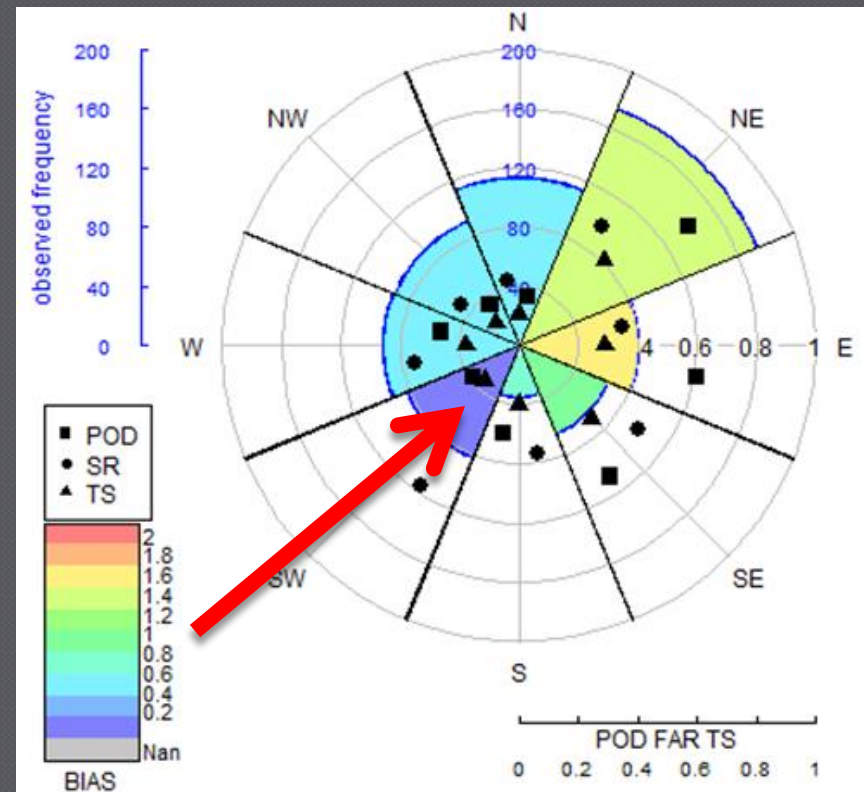
- the colours of the spokes represent the BIAS SCORE

$$BIAS = \frac{\text{forecast frequency of "yes" events}}{\text{observed frequency of "yes" events}}$$

Over-estimation of events

1

Under-estimation of events



# The “performance-rose” 1<sup>st</sup> version

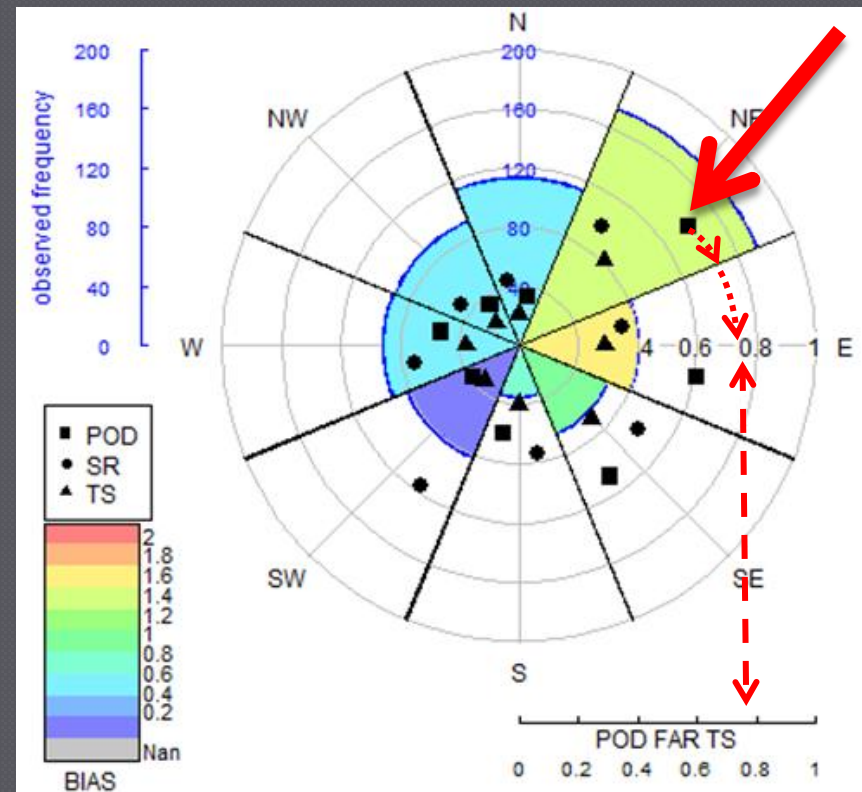
- The symbols represent the following scores:

$$POD = \frac{hits}{hits + misses}$$

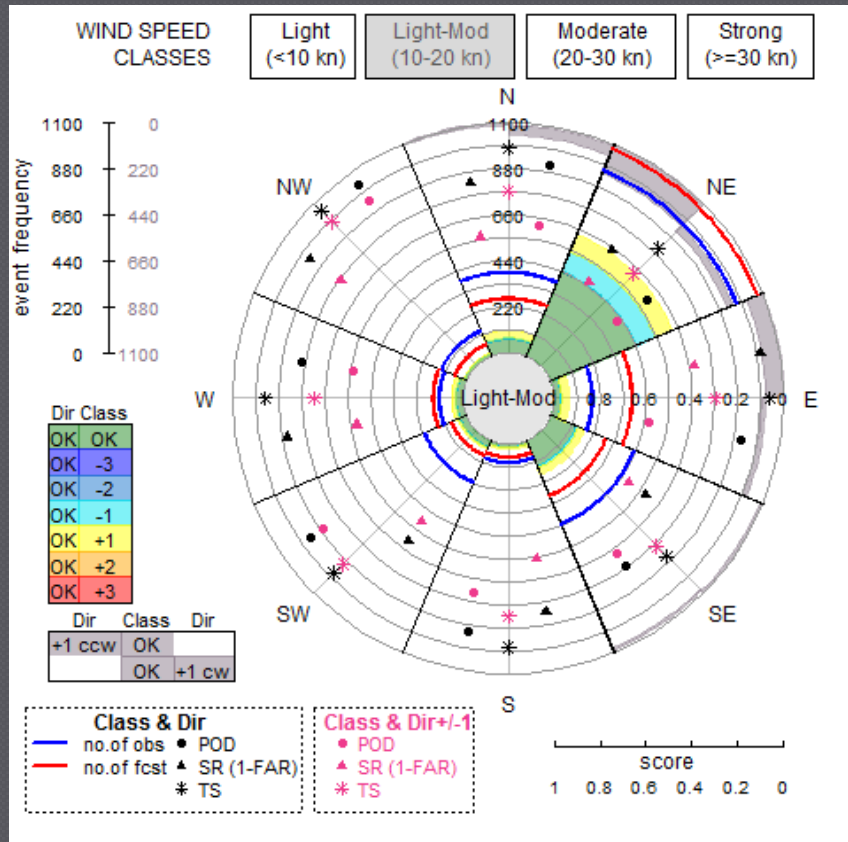
$$SR = \frac{hits}{hits + false\ alarms}$$

$$TS = \frac{hits}{hits + misses + false\ alarms}$$

- The values of the scores can be read on the radial axis using the **black scale**
- Since each score ranges from 0 to 1 (perfect) “the more external is the better”



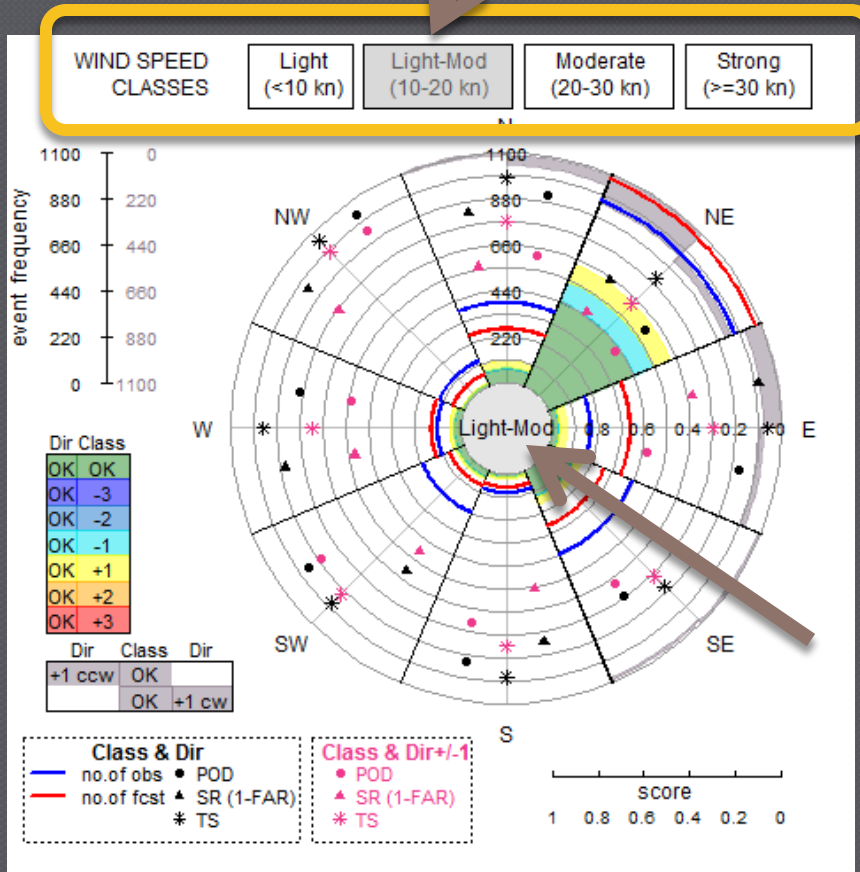
# The “performance-rose” 2nd version



- Taking into account feedback from forecasters (as users of verification)  
the plot has been improved and more information were added

# The “performance-rose”

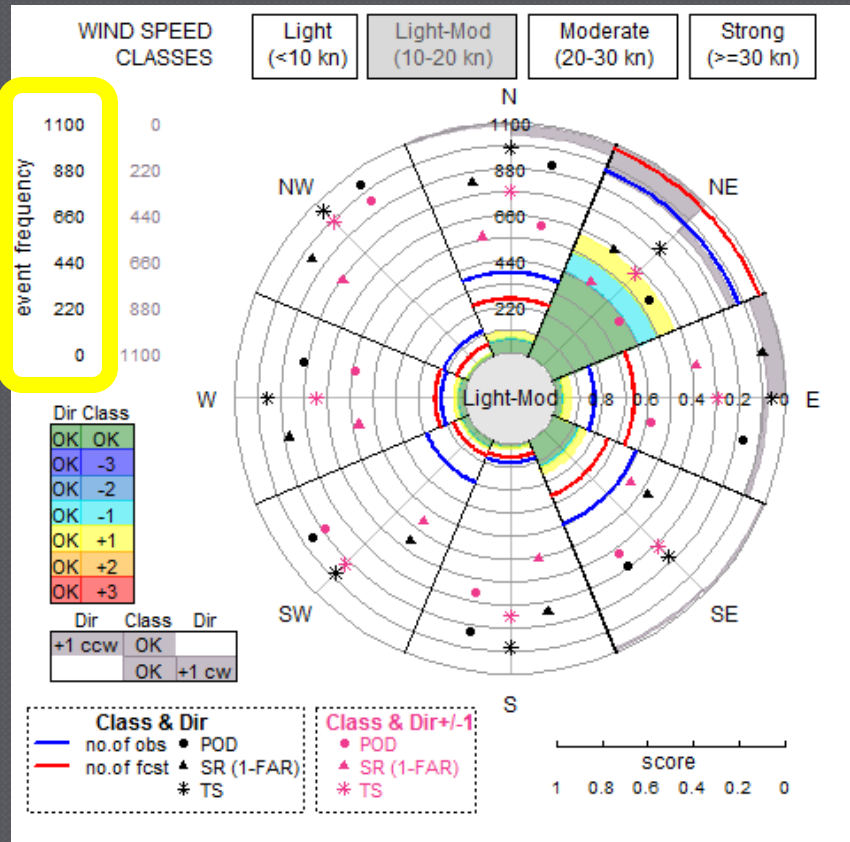
## How it works



- winds (fcst and obs) are categorized in classes according to wind speed
  - Light:**  $ws < 10$  knots
  - Light-Moderate:**  $10 \leq ws < 20$  Knots
  - Moderate:**  $20 \leq ws < 30$  Knots
  - Strong:**  $\geq 30$  Knots
- For each class a separate plot is done

# The “performance-rose”

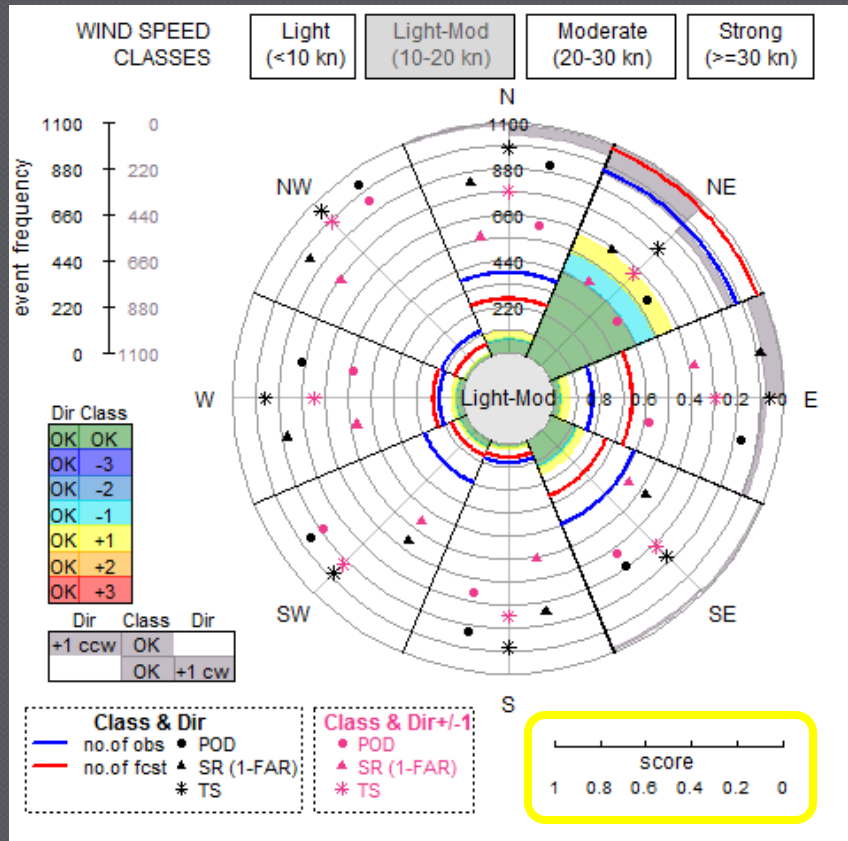
## How it works



- Blue line is the observed frequency of the specific speed-class in each direction
- Red line is the forecast frequency of the specific speed-class in each direction
- The number of events can be read on the radial scale (frequency axis), increasing outward from the center
- The Frequency Bias can be easily deduced by relative position of blue and red line
  - Red outer → overestimation
  - Blue outer → underestimation

# The “performance-rose”

## How it works

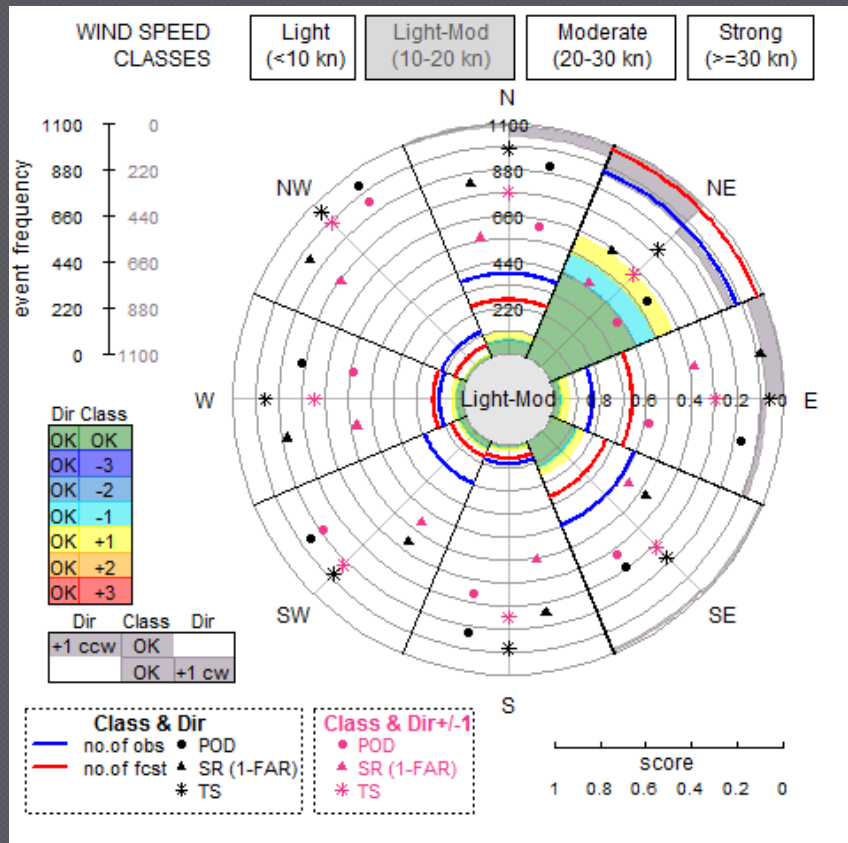


- Other scores from contingency tables (POD, SR, TS) are plotted as symbols
- Their value can be read on the radial scale (score axis)
- Perfect score 1 is in the innermost ring



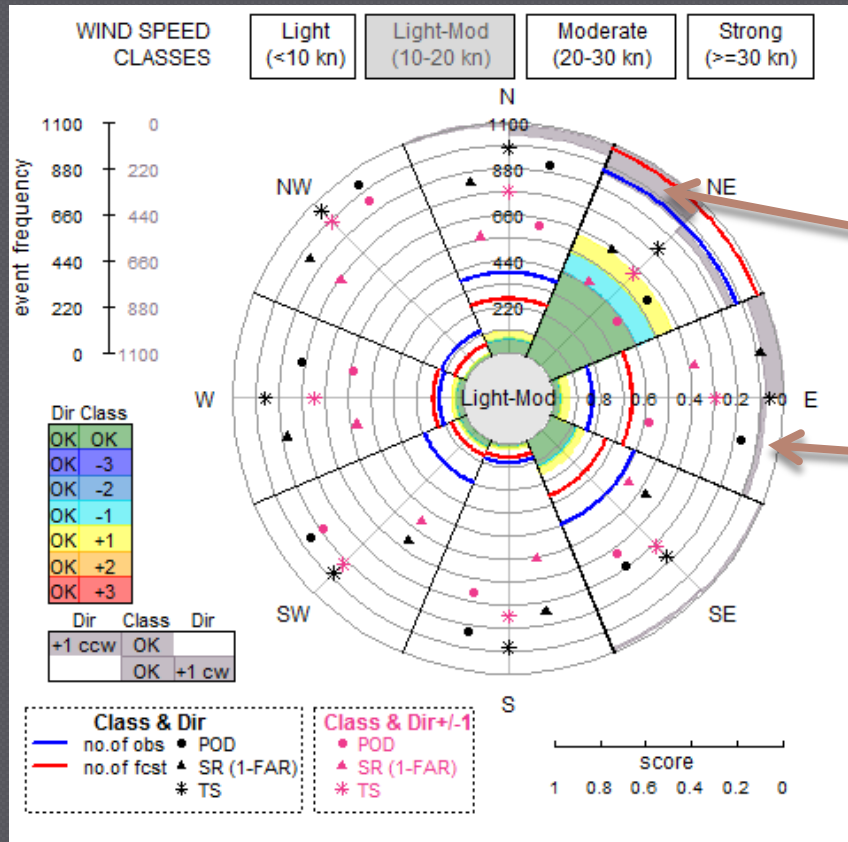
- The colors of the symbols represent 2 type of events:
  - Black:** the yes event is defined by speed class and direction correctly forecast at the same time
  - Pink:** the yes event is defined by speed class correctly forecast, but direction is considered correct even if differs by one octant

# The “performance-rose” 2nd version



- Colored sectors represents how model predicts the reference speed class in each direction, given that the direction is correct
  - Green = Speed class is correctly forecast
  - Cyan: speed is underestimated of 1 class
  - Yellow: speed is overestimated of 1 class
- The number of events of each sector can be deduced using the radial scale of the frequency axis.

# The “performance-rose” 2nd version

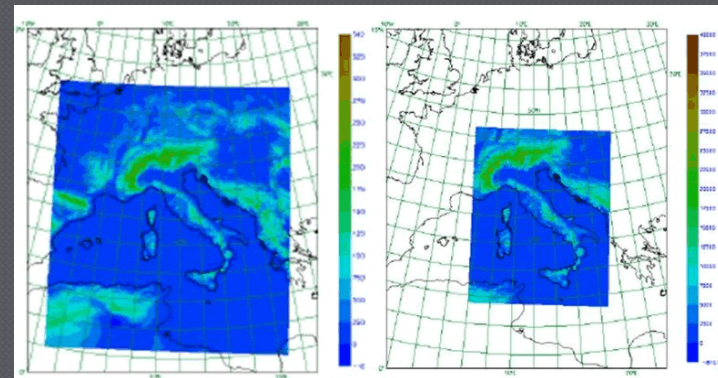


- The gray half-sectors represent the number of forecast in each direction that are “nearly” correct in direction, given that the intensity is correct
  - Half sector on the left means forecast is shifted of 1 octant clock-wise (e.g. if the fcst is NE, the obs in N)
  - Half sector on the right means forecast is shifted counterclock-wise (e.g. if the fcst is NE, obs is E)
- The number of events can be deduced using the reverse radial scale of the frequency axis (starting from the outermost circle)

# Some examples

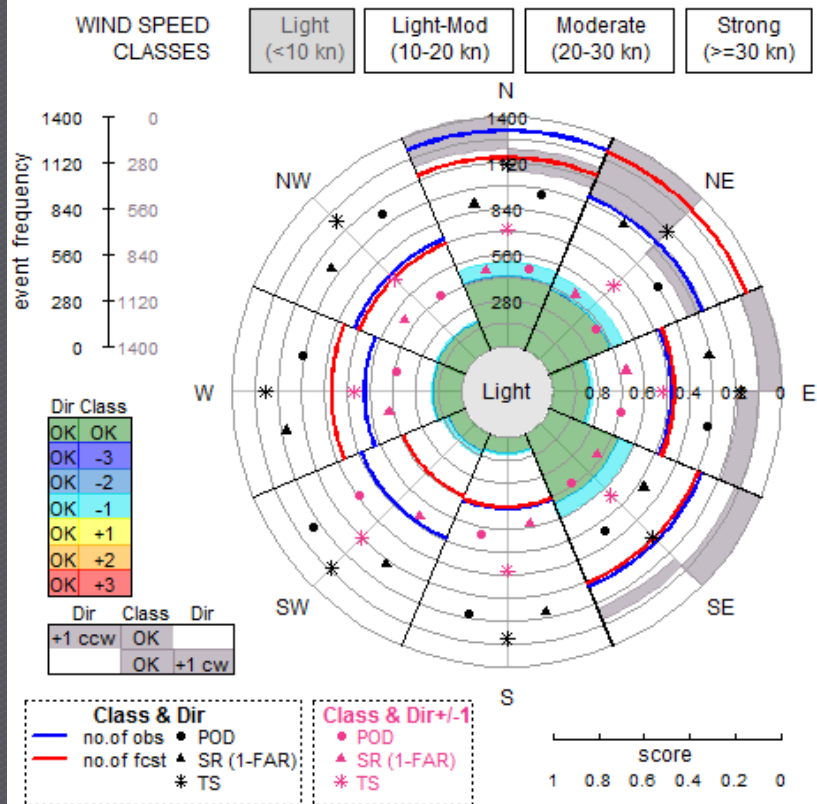
## ○ DATASET:

- OBS:
  - Hourly data for some stations in the North Adriatic sea
- FCST:
  - Hourly nearest grid-point data of
    - COSMO-I7 (7 Km horizontal resolution)
    - COSMO-I2 (2.8 Km horizontal resolution)

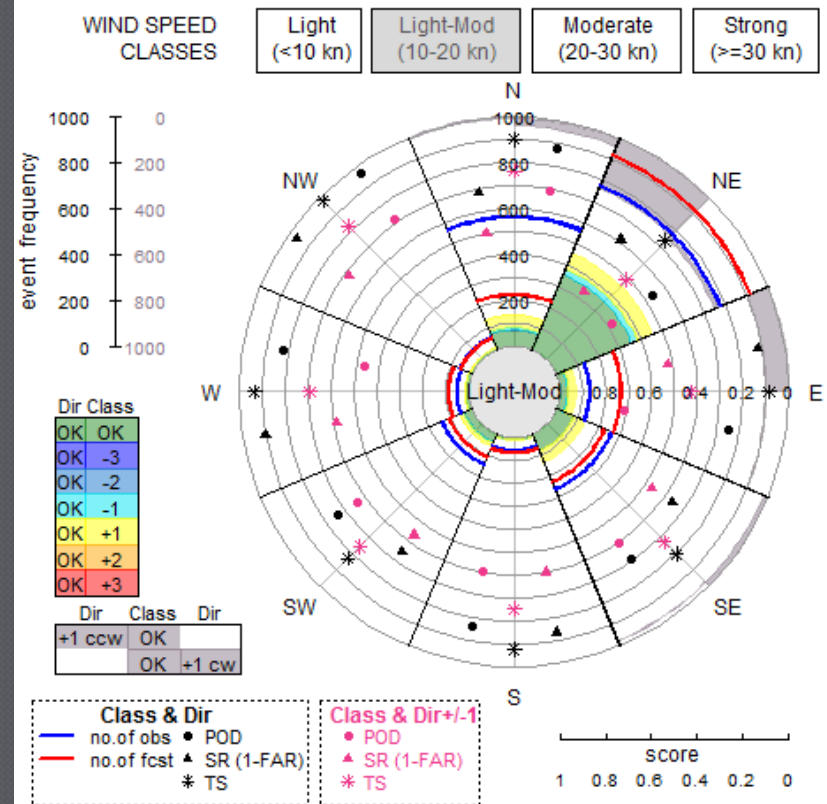


# Example 1

COSMO-I7 run 0 - Day 1 - MALAMOCCO JAN-DEC 2016

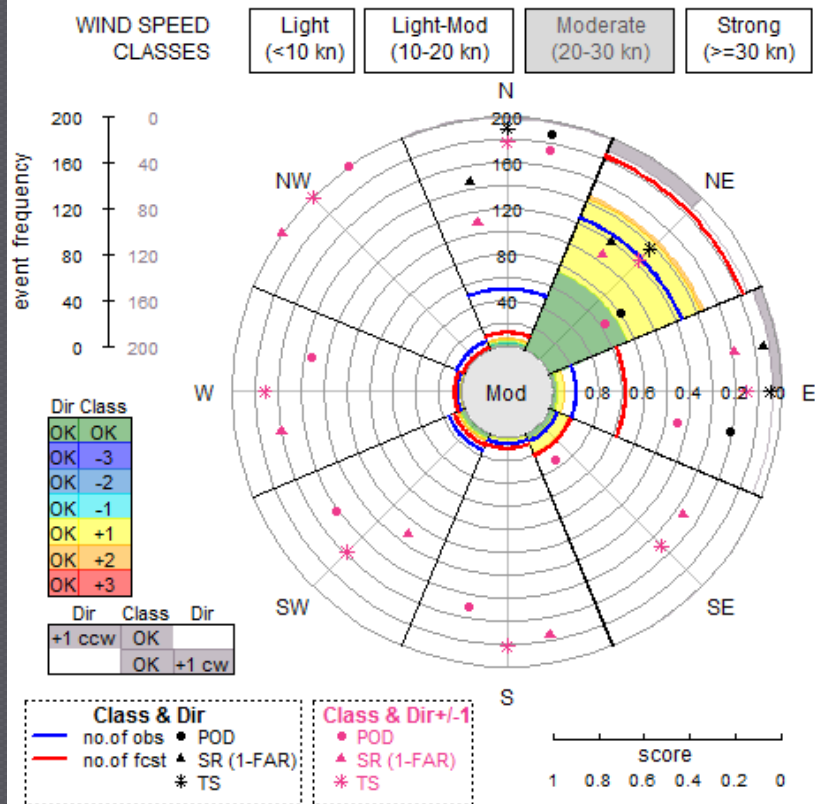


COSMO-I7 run 0 - Day 1 - MALAMOCCO JAN-DEC 2016

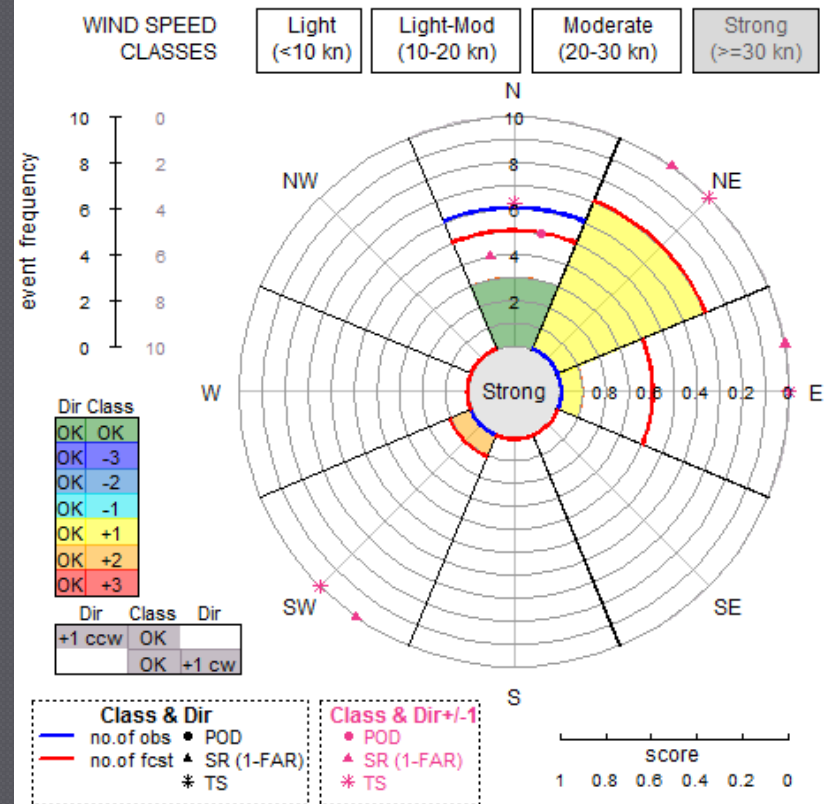


# Example 1(cont.)

COSMO-I7 run 0 - Day 1 - MALAMOCCO JAN-DEC 2016

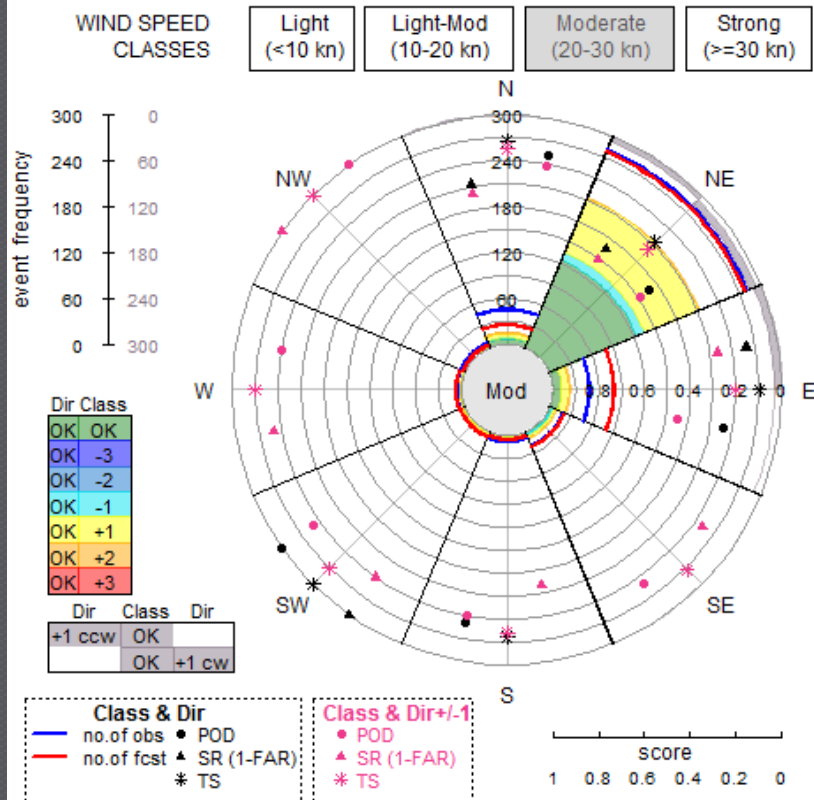


COSMO-I7 run 0 - Day 1 - MALAMOCCO JAN-DEC 2016

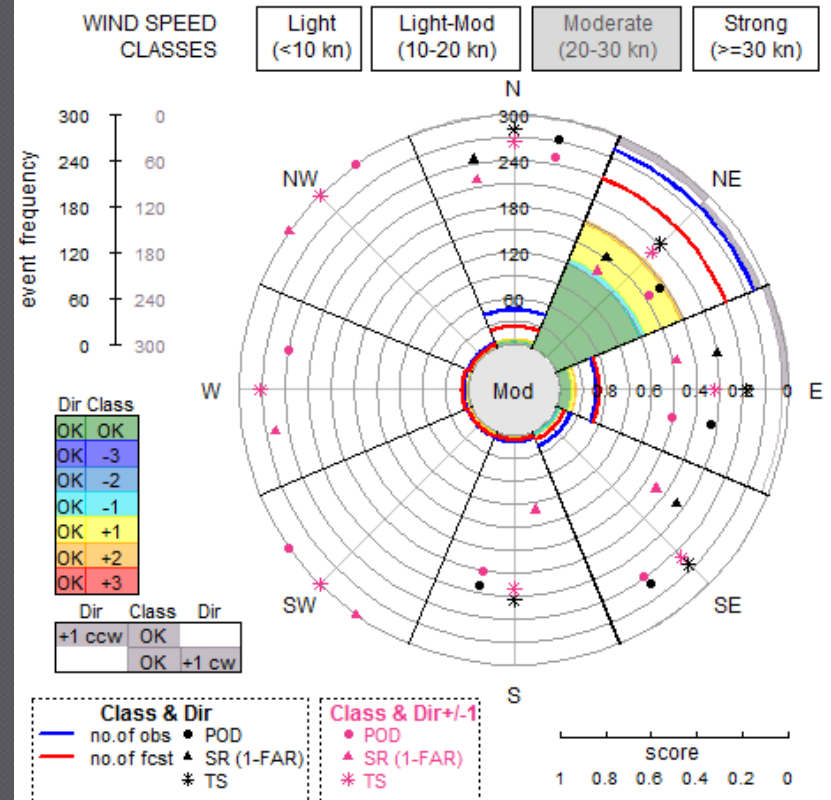


# Example 2

COSMO-I2 run 0 - Day 1 - CHIOGGIA JAN-DEC 2016



COSMO-I2 run 0 - Day 2 - CHIOGGIA JAN-DEC 2016



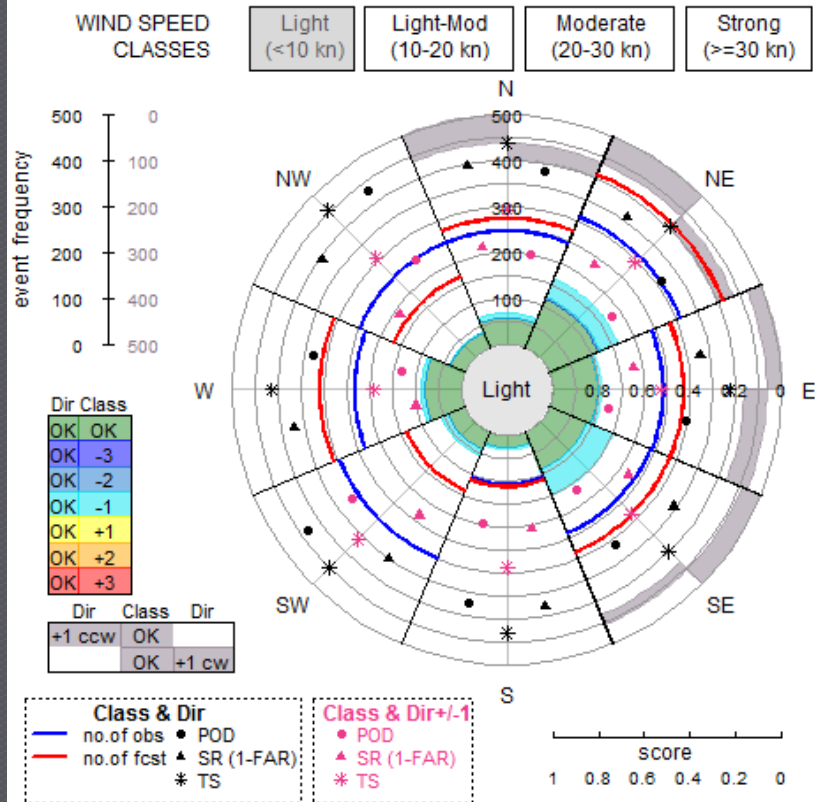
# Aggregation in time (initial approach)

- Both forecast and observed data were aggregated in time intervals
  - for step of 3 hours, 2 hours before and 2 hours after were considered (5 hours overall)
- The comparison of forecast and observation has been done considering the median of wind speed and the prevailing direction in each time interval
  - The prevailing direction is the octant with the higher number of obs/fcst  
If more octants have the same number of obs/fcst, the prevailing direction is the one with the higher median of obs/fcst wind speed

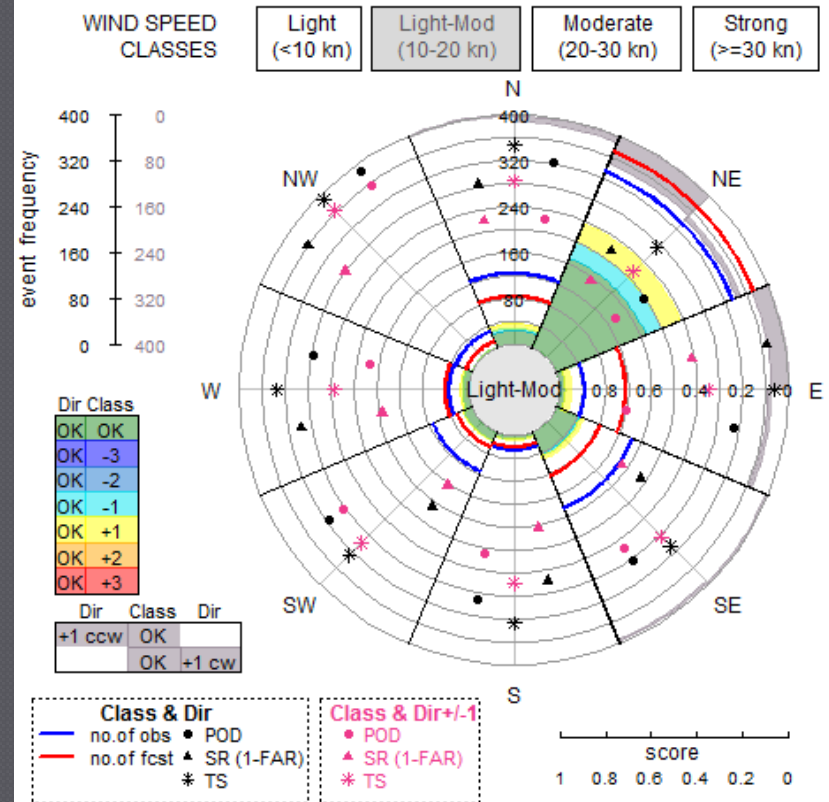
input	aggregation				output
1					
2					
3	3				
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

# Example 3.1

COSMO-I2 run 0 - Day 1 +2h - CHIOGGIA JAN-DEC 2016

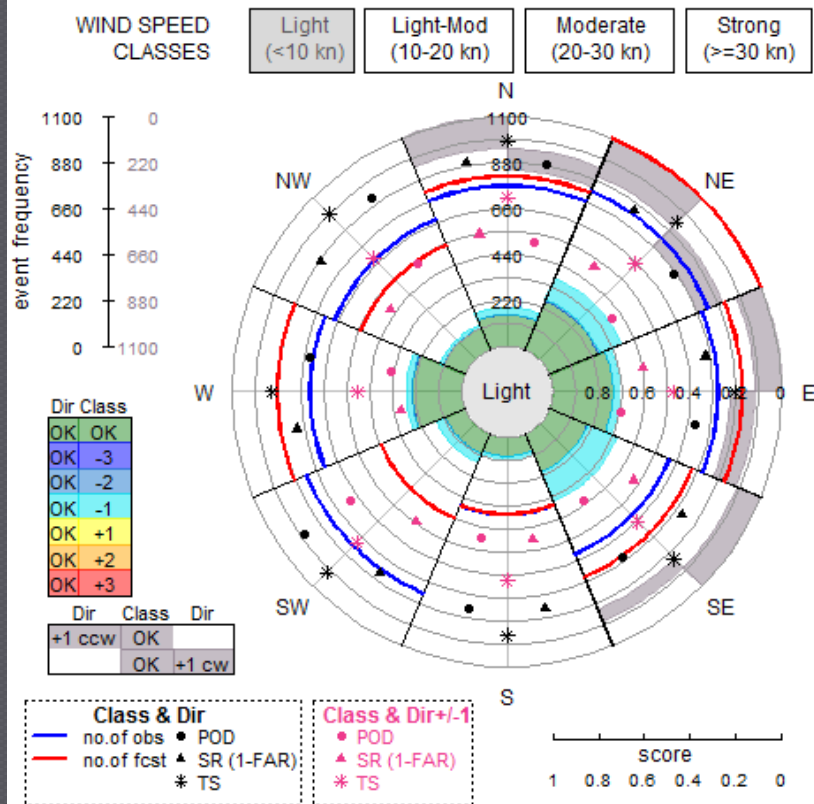


COSMO-I2 run 0 - Day 1 +2h - CHIOGGIA JAN-DEC 2016

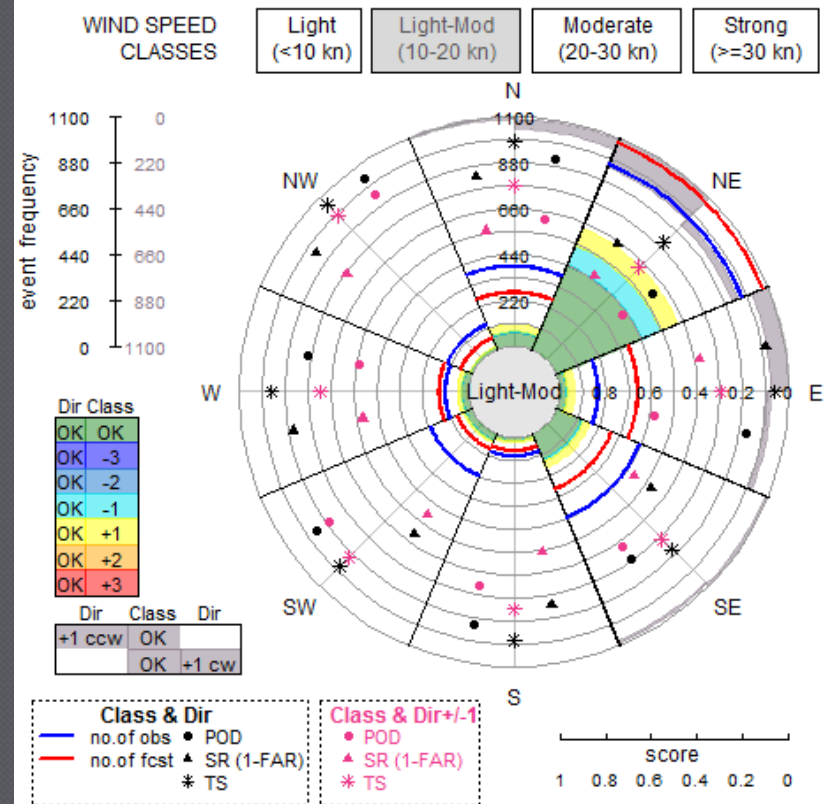


# Example 3.1 (cont)

COSMO-I2 run 0 - Day 1 - CHIOGGIA JAN-DEC 2016

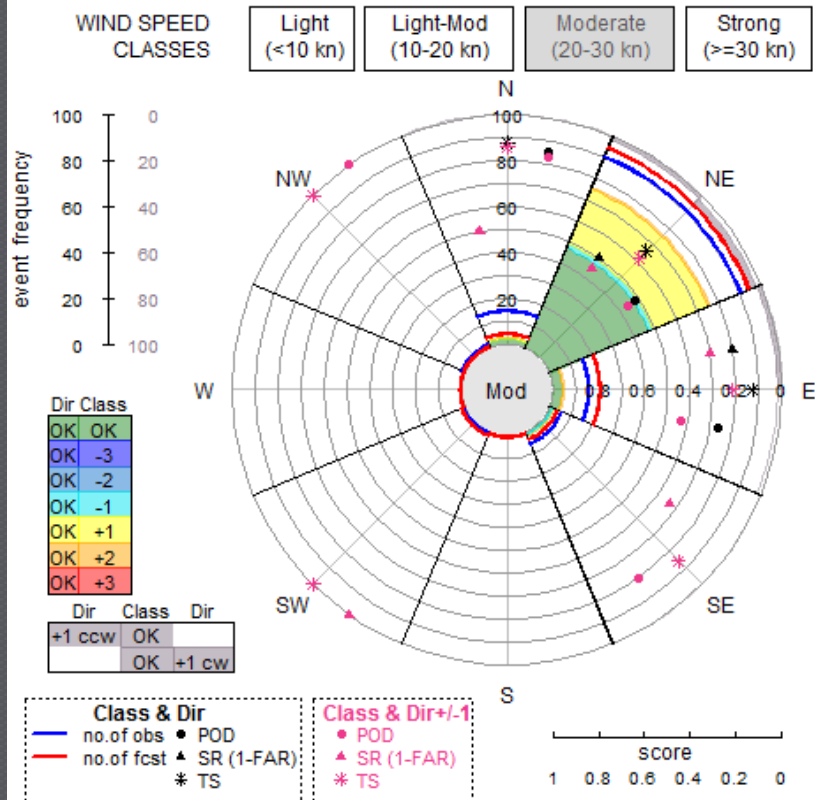


COSMO-I2 run 0 - Day 1 - CHIOGGIA JAN-DEC 2016

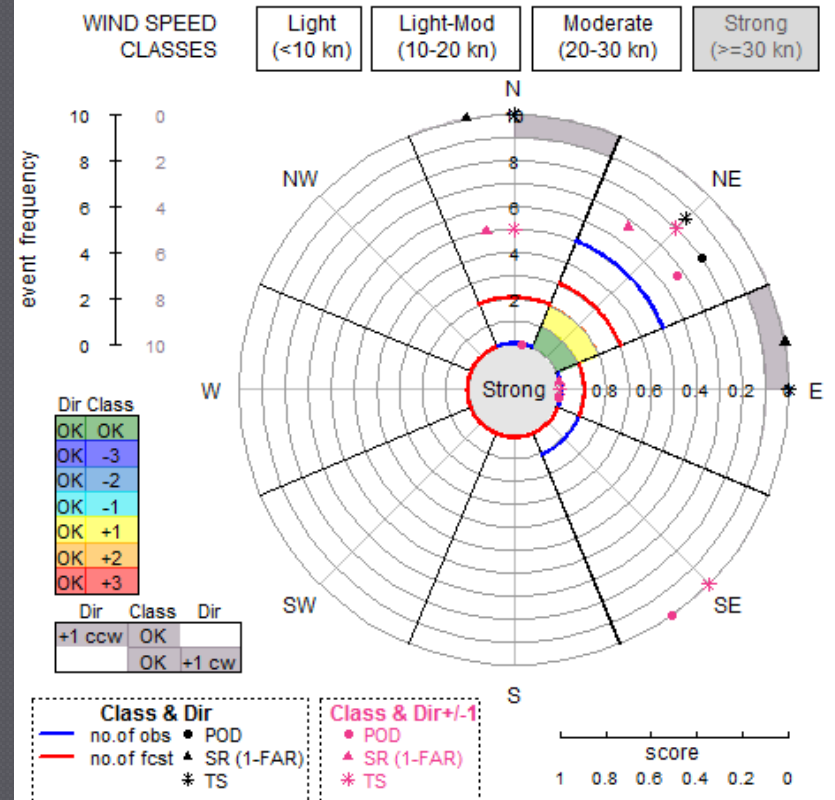


# Example 3.2

COSMO-I2 run 0 - Day 1 +2h - CHIOGGIA JAN-DEC 2016

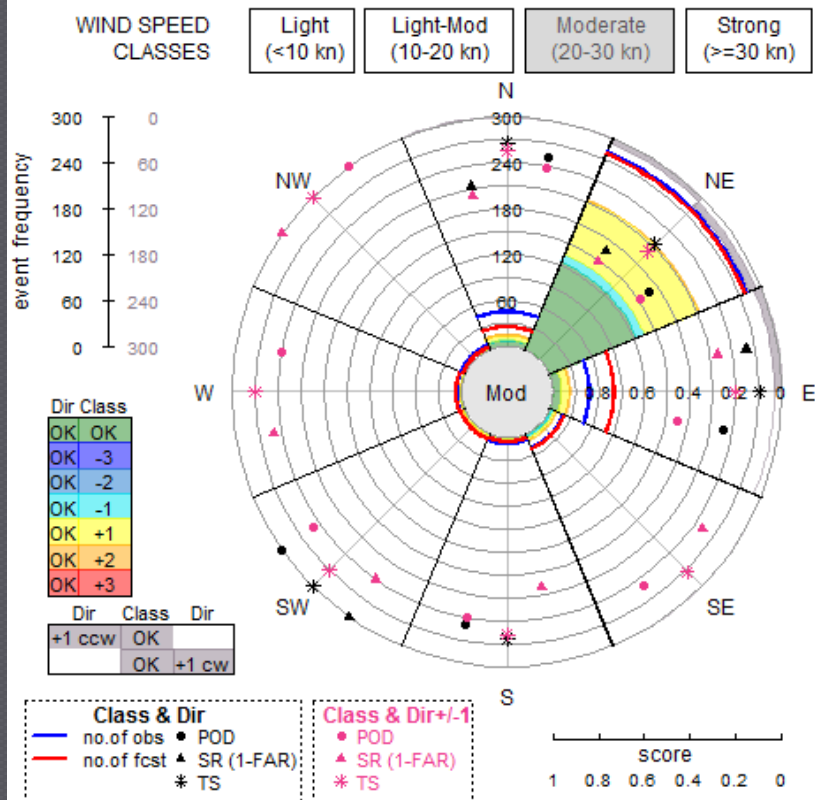


COSMO-I2 run 0 - Day 1 +2h - CHIOGGIA JAN-DEC 2016

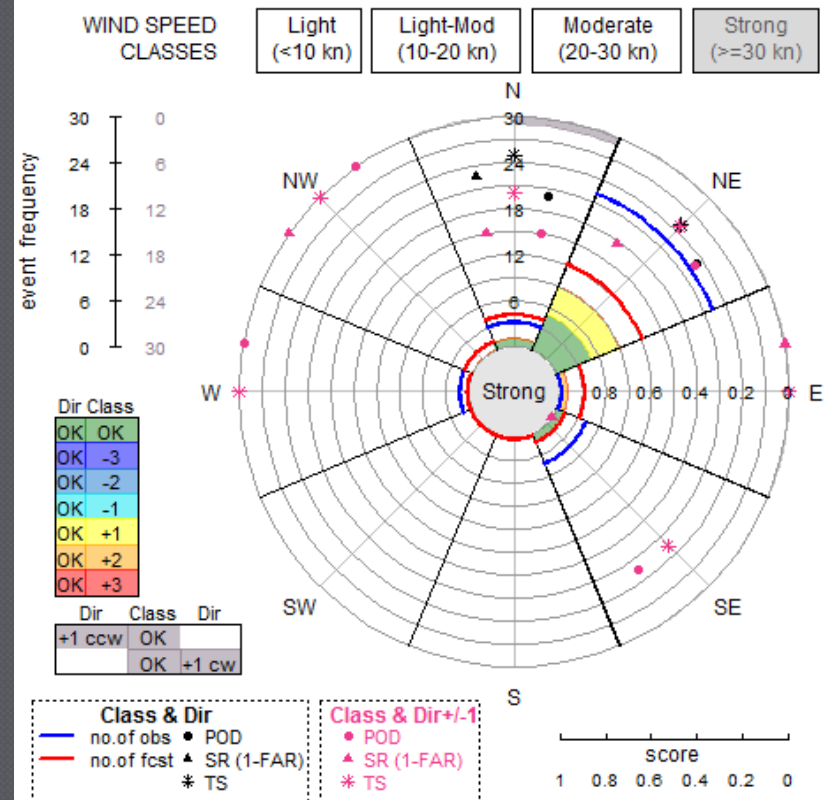


# Example 3.2 (cont)

COSMO-I2 run 0 - Day 1 - CHIOGGIA JAN-DEC 2016



COSMO-I2 run 0 - Day 1 - CHIOGGIA JAN-DEC 2016



# Conclusion

- One of the most tricky aspects of verification is giving to end-users effective feedback on model forecast, both in terms of contents and communication
- The idea of the “Performance Rose” originates precisely for this purpose, as an attempt to answer the questions of a specific users
  - It contains many information and user have to get used to it
  - Scores are evaluates in each direction, even if not all the direction are needed. The advantage of this approach is that the methodology can be applied automatically to many stations and potentially used as a preliminary study of the local climatology of both forecast and observation
  - The definition of the event to verify is peculiar for “my” user (e.g. overestimation/underestimation of wind speed class) but the plot can be adapted to other definition of event or only scores can be plotted as in “version 1” of the “Performance Rose”
- We have just starting using it at ARPAE, most likely visual improvements and changes in the definition of the event will be needed as it will became a common verification tool



**THANKS!**