Comparison of wind speed measurements with sodar, lidars and sonic anemometer at SIRTA

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Context and objective

To produce precise **wind forecasts** we have to compare our **numerical results** with **observations**. In order to define if the **error** is due to the model or to the observations we have to determine the instrumental uncertainty. To do so we used **several instruments of the SIRTA** such as lidars, sodar and anemometer.

Then, the main objective is to determine the **instrumental error** which will be the maximal **precision** our model will be able to reach.

Methodology

To do so we compared **four couples of CEREA's instruments** at SIRTA (cf Table 1) over the past two years (2015/2016). We consider the measurements at **100m** because we are interested in what happens at the hub height.

- High range / low range lidars at 100m
- High range lidar / sodar at 100m
- Low range lidar / sodar at 100m
- Sodar / sonic anemometer at 30m

	Theoretical scope	Spatial resolution	Temporal resolution	Measurement period	Wavelength or frequency
HR lidar	2000m	50m	10min	Since 02/2011	1.54μm
LR lidar	300m	20m	10min	Since 02/2011	1.54μm
Sodar	200m	5m	10min	Since 08/2014	2.5kHz - 4.8kHz
Anemometer	10m and 30m	\	10min	Since 01/2006	\

Table 1: Description of the instruments characteristics

Results

According to the Figure 1 we can say that **the mean bias is always positive**, in other words the instrument with the highest vertical resolution systematically **overestimate** the other.

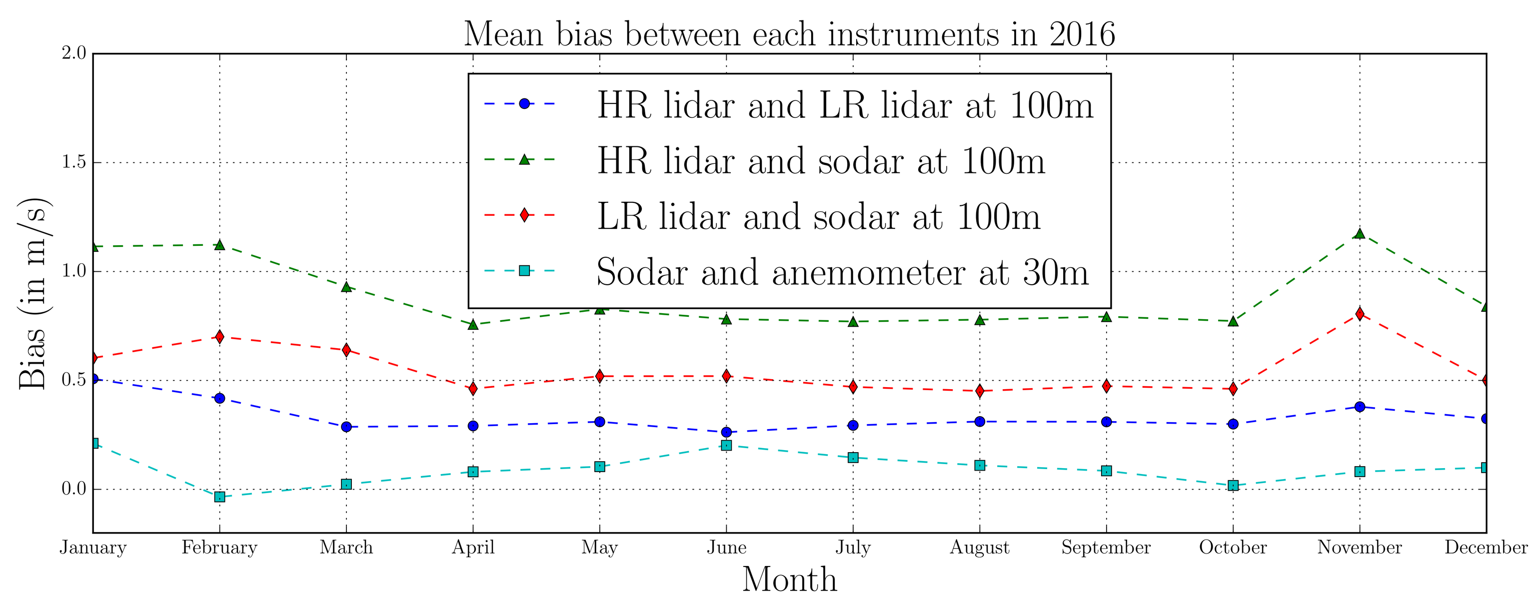

Figure 1: Mean bias in 2016

The main **disadvantage** of the mean bias is that the negative and positive errors may balance out each other, so we decided to look to its **distribution**.

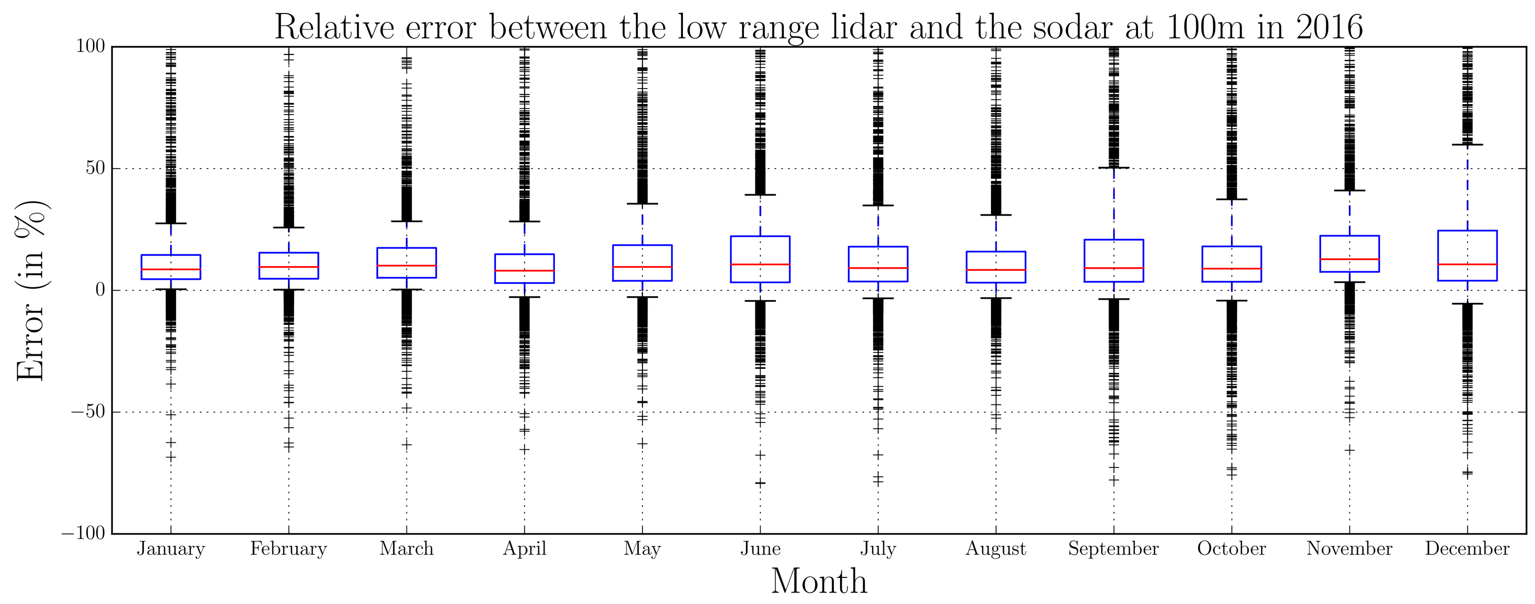

Figure 2: Relative bias distribution in 2016

According to the Figure 2,

- Around **80% of the error** between the low range lidar and the sodar in 2016 are **lower than 25%**
- We also can see some **extreme errors** between 50% and 100%

The first **explanation** might be related to the **principle** of the instruments : the lidar use a laser to measure the wind speed and direction which may be disrupt by **heavy rain**.

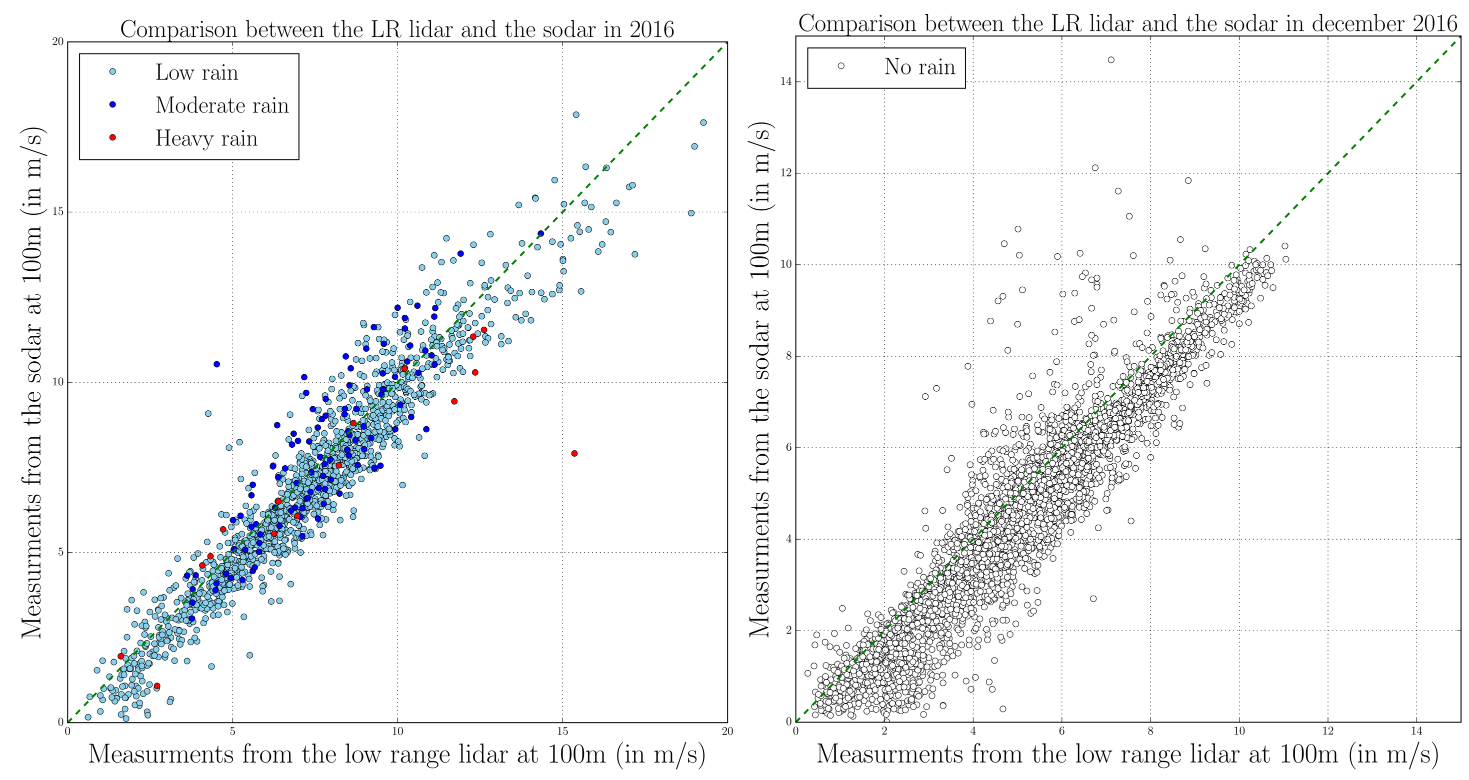

Figure 3: Direct comparisons between the measurements of the LR lidar and the sodar

Surprisingly, the **highest errors did not occur during rain time** (cf Figure 3).

To sum up, we compiled the results in the Table 2:

	LR and HR	HR and S	LR and S	S and A
Mean bias (m/s)	0.24	0.79	0.52	**0.11**
Mean relative bias (%)	**4.42**	26.20	20.13	5.85
Mean square error (m^2/s^2)	**0.34**	1.27	0.68	0.39
Pearson correlation coefficient	**0.98**	0.96	0.94	0.91

Table 2: Comparison of the errors over the past two years (2015/2016)

Conclusion

- In most case the **measurements** from two different instruments are **consistent**.
- The **uncertainty** is due to **several causes**. One of them may be the rain even if we have seen that it can not explain everything.
- Finally, we will consider an **instrumental uncertainty between** $0.5m \cdot s^{-1}$ **and** $1m \cdot s^{-1}$ which can be significant in term of production.

For the moment we only have considered the measurement at 100m. However the wind vary a lot depending on the altitude. In a future work, it might be interesting to consider the wind **from 50m to 150m** (approximately the diameter of the rotor).

Acknowledgements

This work was conducted in the frame of the TREND-X research program of Ecole Polytechnique, supported by Fondation de l'Ecole Polytechnique.

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