2016 AMS Annual Meeting

Influence of the measured snowfall intensity on the assessment of the collection efficiency

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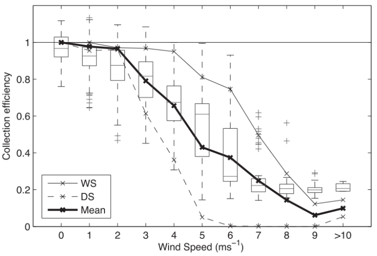
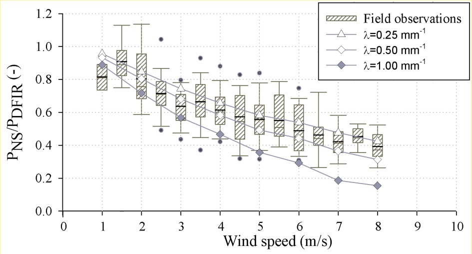
Environmental variables that impact on the Collection Efficiency (CE)

- Horizontal wind speed **U**.
- Type of precipitation (usually assumed according to the environmental temperature **T**).
- Particles size distribution (parametrized by the **PSD** slope factor or mean volume **D**)
- Particles fall velocity (has a certain dependency on the other factors)
- Airflow turbulence (object of future investigation)

Sensitivity to the type of crystal (Thériault et al., 2012)



Sensitivity to **PSD** (Colli et al., 2015)



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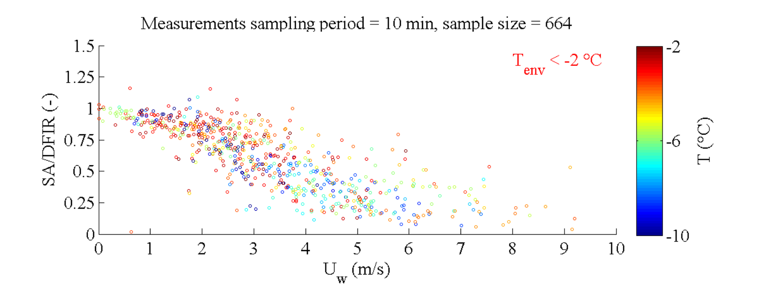
Operational problem #1: At short sampling interval the high variability of the wind/precip. may affect the comparison between different instruments.

Operational problem #2: The identification of the precipitation type, PSD and particle terminal velocity requires additional information that is not always available.

Difficulties in recognizing the types of snowfall relying on the environmental temperature T



Single Alter shield

DFIR shield

Advantages of using the **Snowfall Intensity** (SI)

- **SI includes at least two parameters that impact on CE**:

$$SI = \alpha \int_{D_{min}}^{D_{max}} n_0 \cdot e^{\lambda D} \cdot w_T(D) \cdot D^3 dD \qquad (1)$$

- SI **is easily computed basing on the uncorrected snow accumulation**. On the contrary, λ, w_T or the $mean(D)_{Vol}$ must be assumed or measured by additional sensors.

$$CE(U, \lambda) \text{ or } CE(U, mean(D)_{Vol}) \rightarrow CE(U, SI) \qquad (2)$$

2. Method of investigation

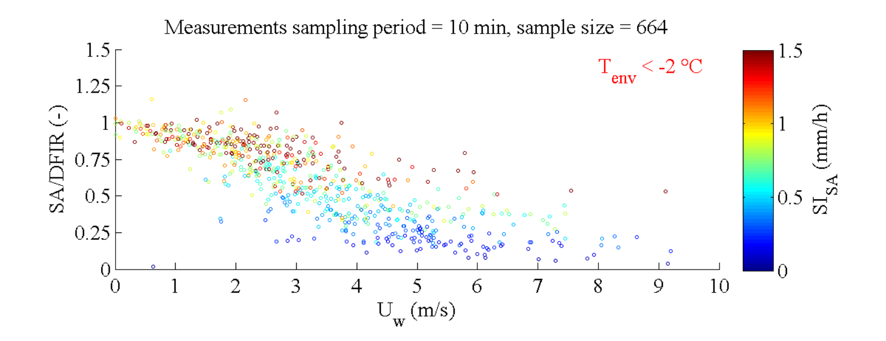
Data processing

- Measurements from the Marshall field site during three years of observation (2012-2014).
- Unshielded (UN), single Alter (SA) and Double Fence International Reference (DFIR) shielded gauges
- We used **1-min QCed (WMO SPICE data processing)** total accumulation measurements.
- We considered **only** $T < -2^oC$ **(mainly dry snow cases)**.
- Different **sampling** intervals have been tested to obtain snow accumulation over 1, 5, 10, 30 and 60 min.

Data classification

- **The whole** CE **dataset has been subdivided into smaller bins** according to the value of two variables, SI **and** T.
- The SI and T data binning has been optimized by means of a **derivative-free optimization algorithm** (genetic model implemented in the DAKOTA toolkit by Sandia Labs.)

Classification by SI: There is an evident clustering of 10-min CE data basing on SI!



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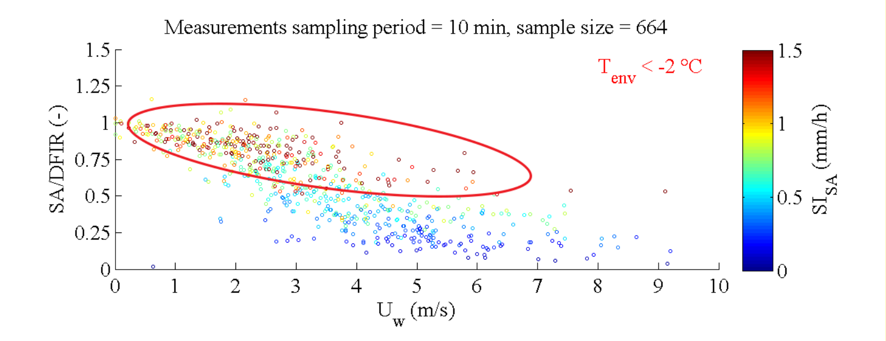

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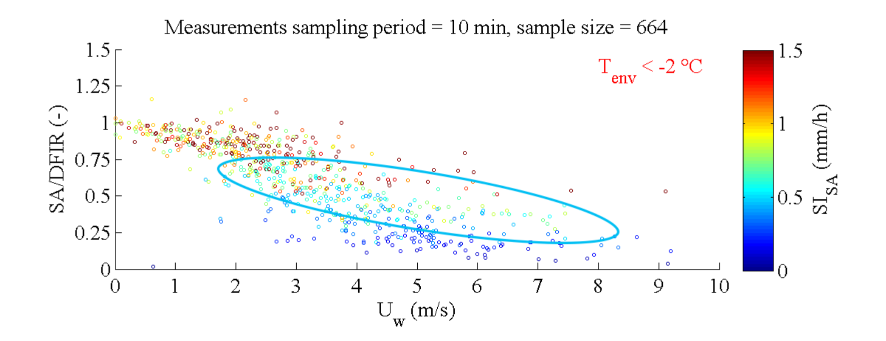
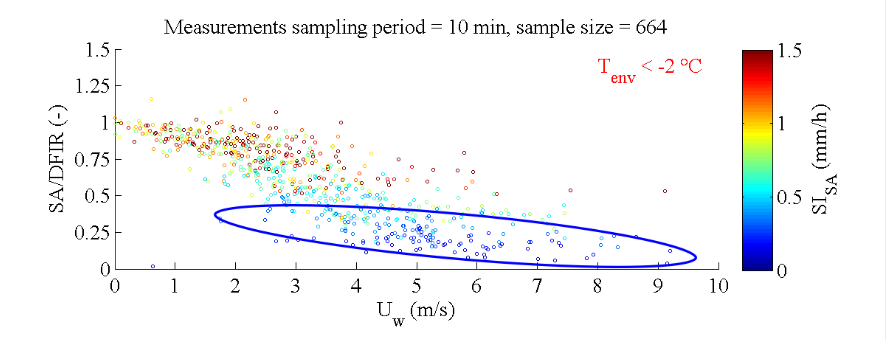
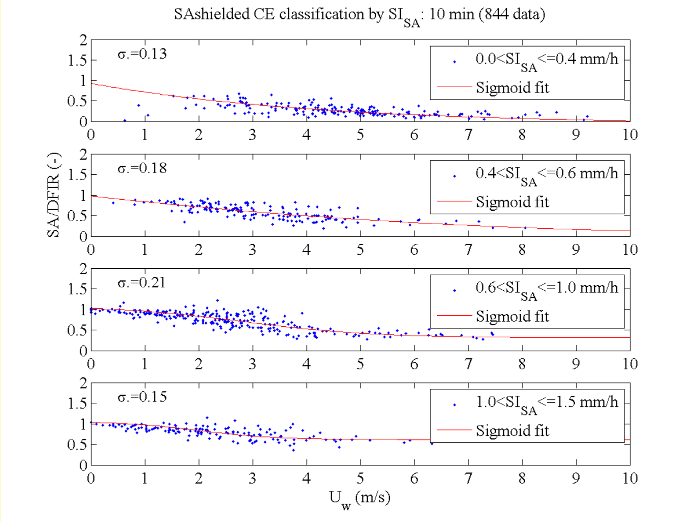


Classification by SI: There is an evident clustering of 10-min *CE* data basing on *SI*!

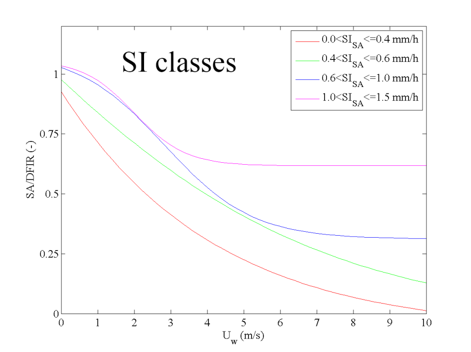


Data separation by SI: regression of 10-min data with a sigmoid fit (Wolff et al., 2015)

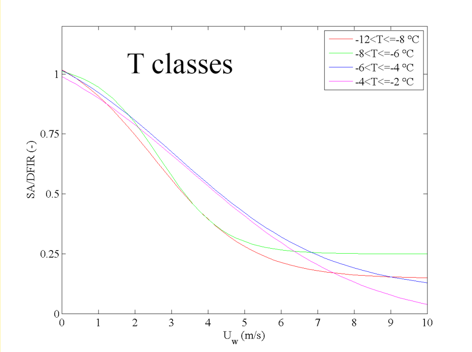


10-min sampling time interval

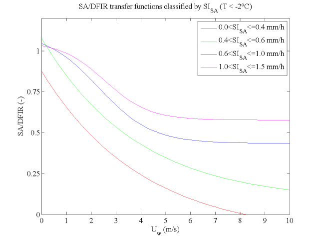
$CE(U, SI)$



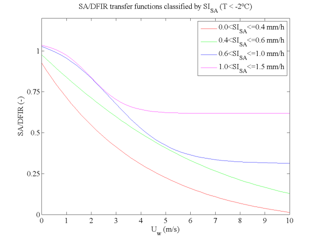
$CE(U, T)$



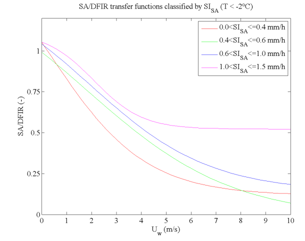
1-min $CE(U, SI)$



10-min $CE(U, SI)$

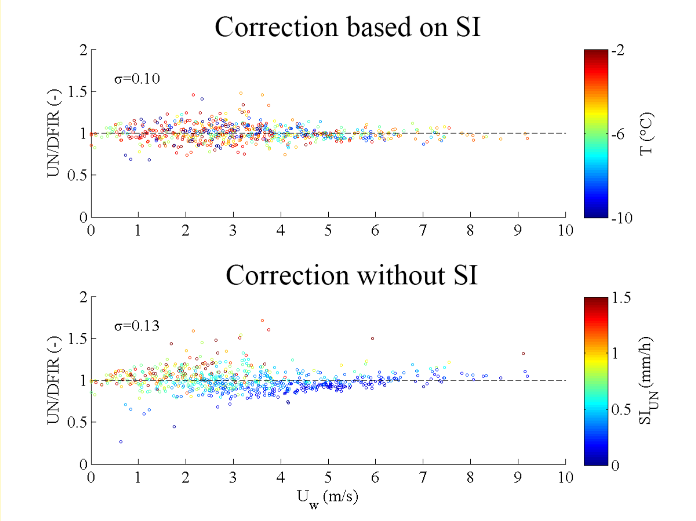


30-min $CE(U, SI)$

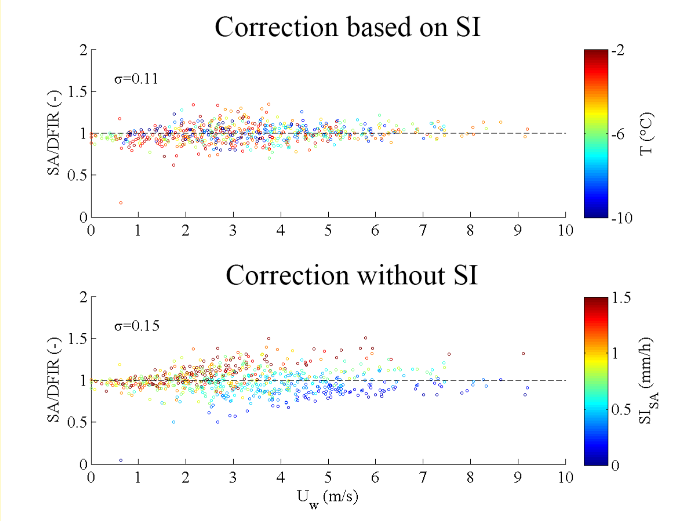


- The separation of the $CE(U, SI)$ curves tends to reduce by increasing the time interval but remains efficient with 10-min data.

Unshielded gauge performance after correction based on 10-min CE curves



SA shielded gauge performance after correction based on 10-min CE curves



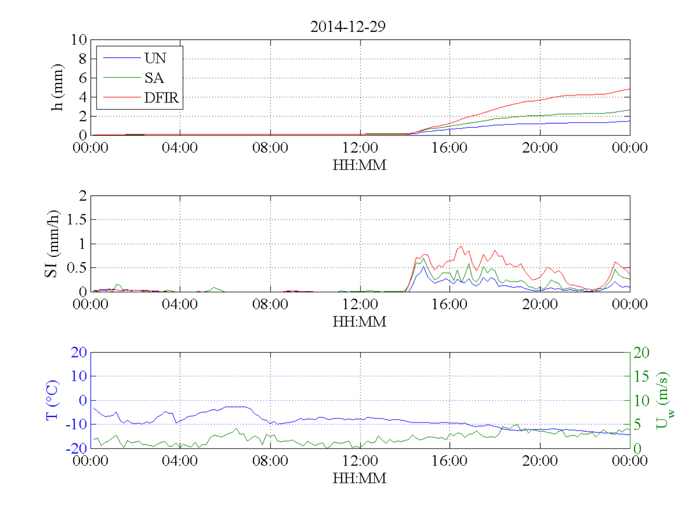
We compare the scattering of the corrected data according to the new and the traditional methods by defining the $\Delta\sigma$ index:

$$\Delta\sigma = \sigma(CE) - \sigma_{SI}(CE)$$

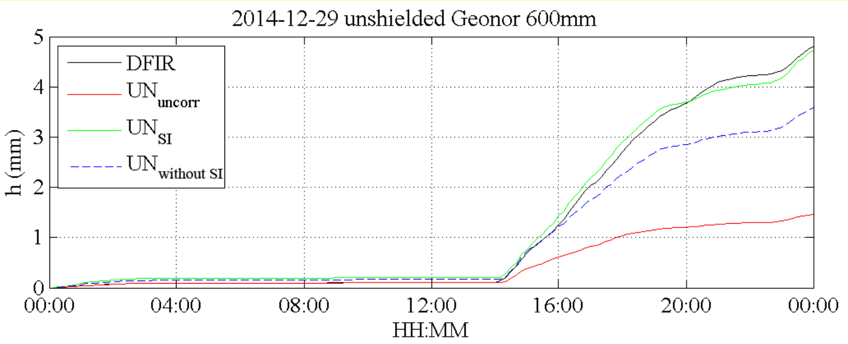
Time resolution *(min)*	UNshielded gauge $\Delta\sigma$ (-)	single Alter gauge $\Delta\sigma$ (-)
1	**0.08**	**0.07**
5	**0.05**	**0.05**
10	**0.03**	**0.04**
30	**0.02**	**0.03**
60	**0.02**	**0.03**

- A shorter sampling time corresponds to better efficiency of the correction based on SI with respect to a general correction.

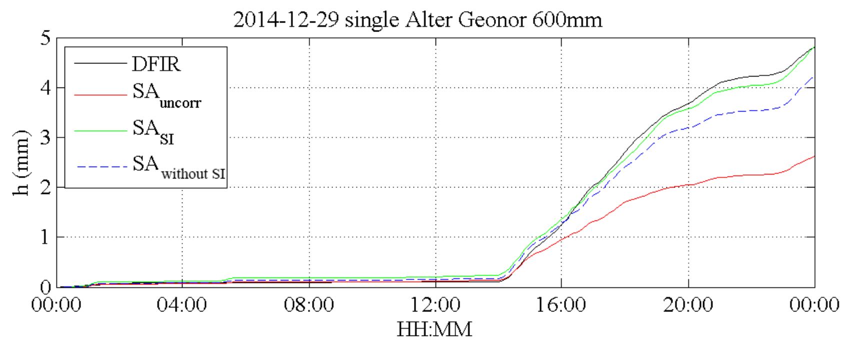
Let's consider the following precipitation event observed in Marshall (CO, USA)



Correction of the UNshielded gauge measurements



Correction of the SA shielded gauge measurements



5. Final comments

- After a preliminary data filtering by temperature ($T < -2^oC$), a gross sensitivity analysis showed that the measured $CE(U)$ **is more dependent on SI than on T**.

- The correlation between $CE(U)$ and the measured SI tends to decrease by increasing the sampling time interval **but remains significant**.

- We are currently analyzing snowflakes trajectories from numerical simulations (Theriault et al., 2012 and Colli et al., 2015) to confirm the dependency of CE to the measured SI and the physical base of such behavior.

Thank you for your attention!

References

- Colli, M., R. Rasmussen, J. M. Theriault, L. G. Lanza, C. B. Baker and J. Kochendorfer, 2015: An Improved Trajectory Model to Evaluate the Collection Performance of Snow Gauges. Journal of Applied Meteorology and Climatology, 54, 1826-1836
- Thériault, J. M., R. Rasmussen, K. Ikeda, and S. Landolt, 2012: Dependence of snow gauge collection efficiency on snowflake characteristics. J. Appl. Meteor. Climatol., 51, 745–762.
- Wolff, M., K. Isaksen, A. Petersen-Øverleir, K. Ødemark, T. Reitan, and R. Bækkan, 2014: Derivation of a new continuous adjustment function for correcting wind-induced loss of solid precipitation: Results of a Norwegian field study. Hydrol. Earth Syst. Sci. Discuss, 11, 10043–10084

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