A preliminary assessment of the biases between forecasted by ECMWF Numerical Weather Prediction model precipitation and the adjusted observed snowfall precipitation in different SPICE sites

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CIMO TECO 2018
Amsterdamm

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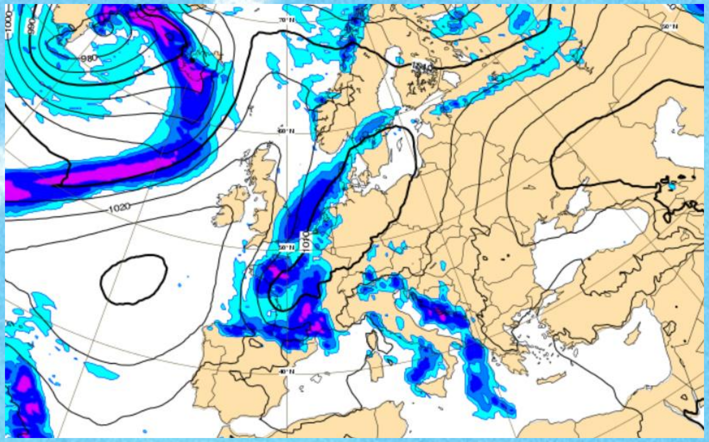
NWP

Forecaster



Forecast: 40 cm of fresh snow and 40 mm of precipitation

→ **Snowfall warning**

(Based on a true story)

Observation

Gauge: 16 mm

Snow depth: 60 cm

What’s happening? Differences between measurements, forecast and reality

	Precip (mm)	Temp (°C)	Wind (km/h)	Catch	Adjusted (mm)
19/01/2017 15:00	0.0	-4.08	28.32	0.17	0.00
19/01/2017 16:00	0.4	-4.22	28.56	0.18	2.27
19/01/2017 17:00	0.4	-4.40	27.18	0.19	2.15
19/01/2017 18:00	0.4	-4.60	23.82	0.22	1.85
19/01/2017 19:00	0.4	-4.18	24.24	0.22	1.83
19/01/2017 20:00	0.4	-3.87	26.10	0.20	1.97
19/01/2017 21:00	0.6	-3.63	26.28	0.21	2.88
19/01/2017 22:00	1.0	-3.62	20.34	0.29	3.48
19/01/2017 23:00	1.4	-3.53	16.50	0.36	3.89
20/01/2017 0:00	0.6	-3.45	14.76	0.37	1.62
20/01/2017 1:00	0.4	-3.37	19.68	0.29	1.39
20/01/2017 2:00	0.2	-3.15	20.34	0.28	0.72
20/01/2017 3:00	0.2	-3.08	18.84	0.30	0.66
20/01/2017 4:00	0.2	-2.97	18.30	0.31	0.64
20/01/2017 5:00	0.2	-2.85	13.08	0.41	0.49
20/01/2017 6:00	0.2	-2.67	14.22	0.39	0.51
20/01/2017 7:00	0.2	-2.63	15.78	0.36	0.55
20/01/2017 8:00	0.2	-2.40	15.48	0.37	0.54
20/01/2017 9:00	0.2	-2.07	18.93	0.32	0.62
20/01/2017 10:00	1.4	-1.33	14.04	0.47	2.96
20/01/2017 11:00	0.4	-1.10	19.74	0.34	1.19
20/01/2017 12:00	1.6	-0.97	17.64	0.41	3.87
20/01/2017 13:00	1.4	-0.90	16.50	0.43	3.24
20/01/2017 14:00	1.2	-1.08	17.82	0.39	3.05
20/01/2017 15:00	0.6	-1.60	17.28	0.37	1.61
20/01/2017 16:00	0.4	-2.02	20.28	0.31	1.30
20/01/2017 17:00	0.4	-2.20	21.48	0.29	1.40
20/01/2017 18:00	0.2	-2.02	26.46	0.22	0.89
20/01/2017 19:00	0.2	-2.00	24.00	0.25	0.79
20/01/2017 20:00	0.0	-1.88	21.24	0.29	0.00
20/01/2017 21:00	0.4	-1.70	22.26	0.29	1.40
20/01/2017 22:00	0.2	-1.80	19.38	0.32	0.62
20/01/2017 23:00	0.0	-1.65	23.67	0.26	0.00

Measured
16 mm

Transfer function

Adjusted
50.4 mm

(Closer to reality)

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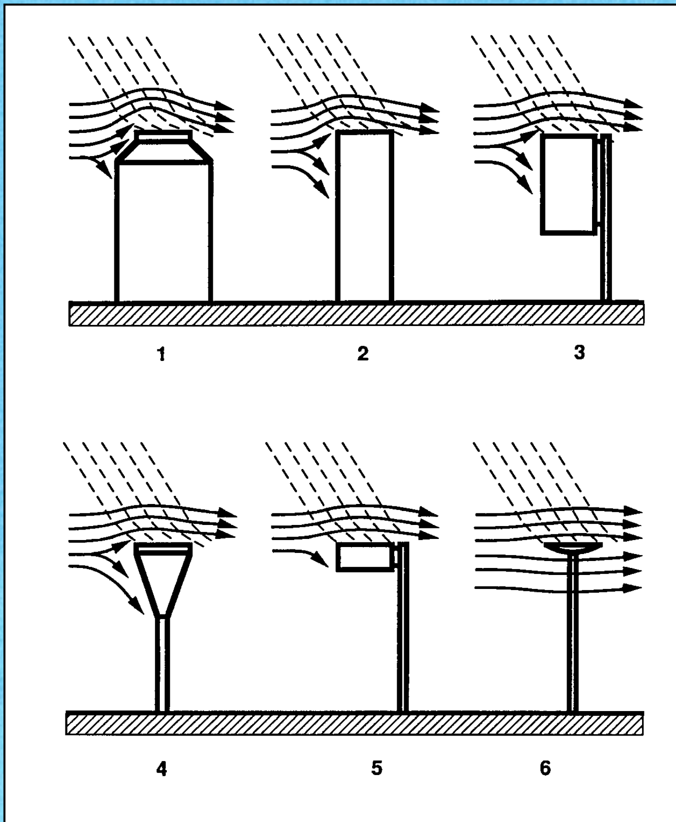
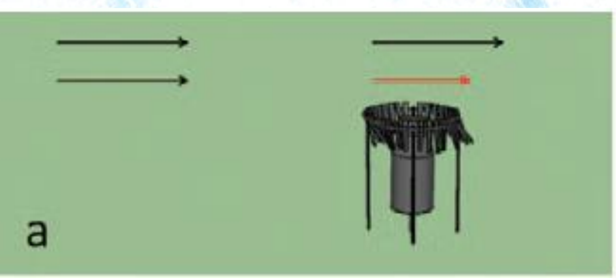


The accurate prediction and verification of snowfall is encumbered by the large potential undercatch of solid precipitation

Solution→ Windshields and Transfer Functions



World Meteorological Organization(WMO)
SPICE (Solid Precipitation Intercomparison Experiment)

SPICE Sites

List of SPICE Sites contact persons

Commissioning protocols of the SPICE Sites
(Some protocols are still in finalization and will be made available below when completed)

Australia - Guthega Dam
Canada - Bratt's Lake
Canada - CARE (Annexe)
Canada - Caribou Creek
Chile - Tapado
Finland - Sodankyla
France - Col de Porte
Italy - Forni Glacier
Japan - Joetsu
Japan - Rikubetu
Rep. of Korea - Gochang Observatory
Nepal (operated by Italy) - Pyramid International Laboratory Observatory
New Zealand - Mueller Hut
Norway - Haukeliseter
Poland - Hala Gasienicowa
Russian Fed. - Valdai (Manual observation part only)
Russian Fed. - Voljskaya
Spain - Aramon-Formigal
Switzerland - Weissfluhjoch
USA - Marshall

Legend

1.	Caribou Creek, Saskatchewan, Canada	11.	Haukeliseter, Norway
2.	Bratt's Lake, Saskatchewan, Canada	12.	FMI/Sodankylä Arctic Research Centre, Finland
3.	Marshall Site, Colorado, USA	13.	Valdai, State Hydrological Institute, Russia
4.	CARE, Ontario, Canada	14.	Voljskaya Observatory, Gorodec, Russia
5.	Tapado AWS, Región de Coquimbo, Chile	15.	Pyramid Observatory, Nepal
6.	Formigal, Spain	16.	Gochang, Korea
7.	Col de Porte, France	17.	Joetsu, Japan
8.	Weissfluhjoch, Davos, Switzerland	18.	Rikubetu, Hokkaido, Japan
9.	Forni Glacier, Italy	19.	Guthega Dam, New South Wales, Australia
10.	Hala Gasienicowa Station, Poland	20.	Mueller Hut Weather Station, New Zealand

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R2

A field reference configuration for the SPICE project

DFAR

(Double Fence Automatic Reference)

Octogonal double fence (DFIR fence)

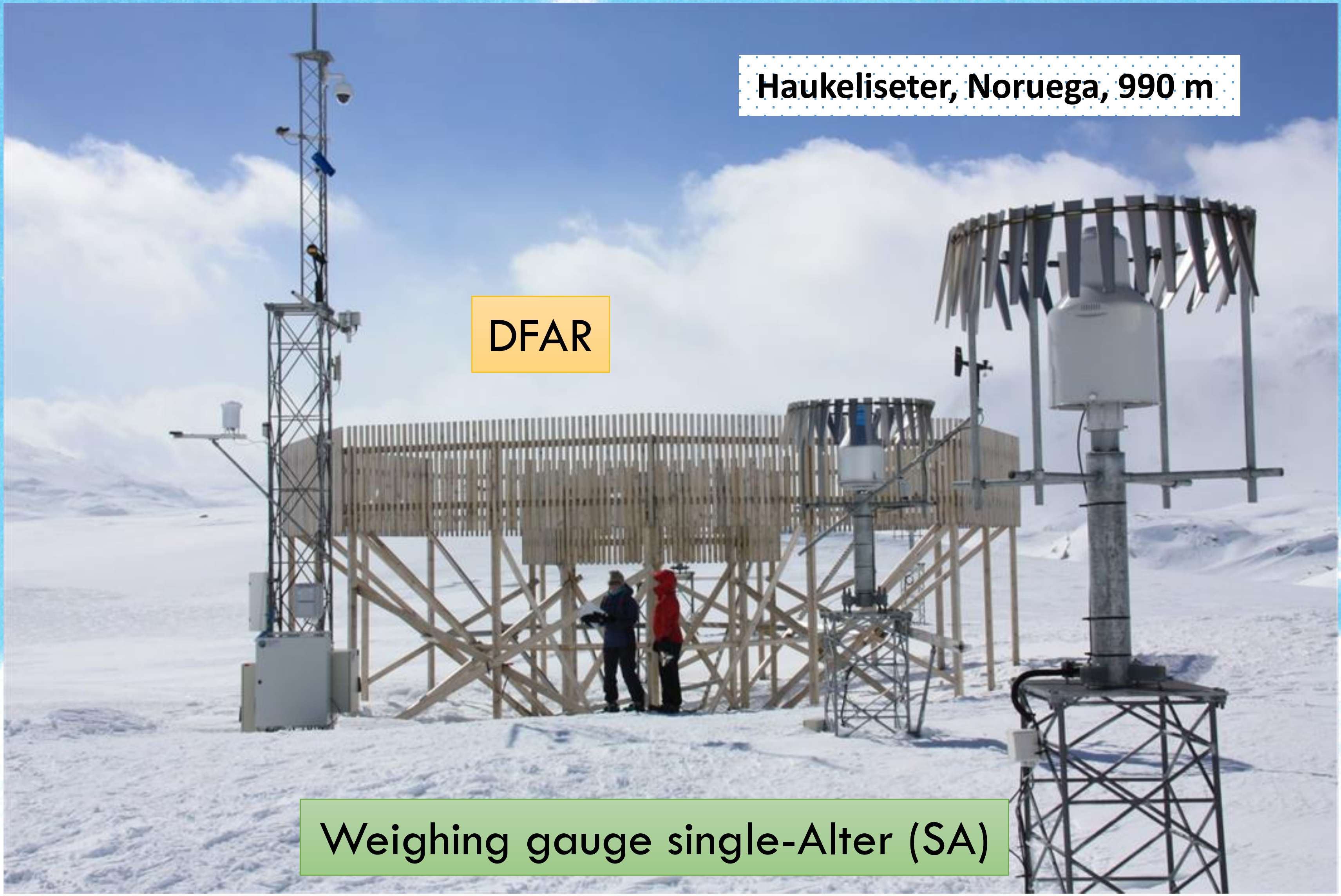
+

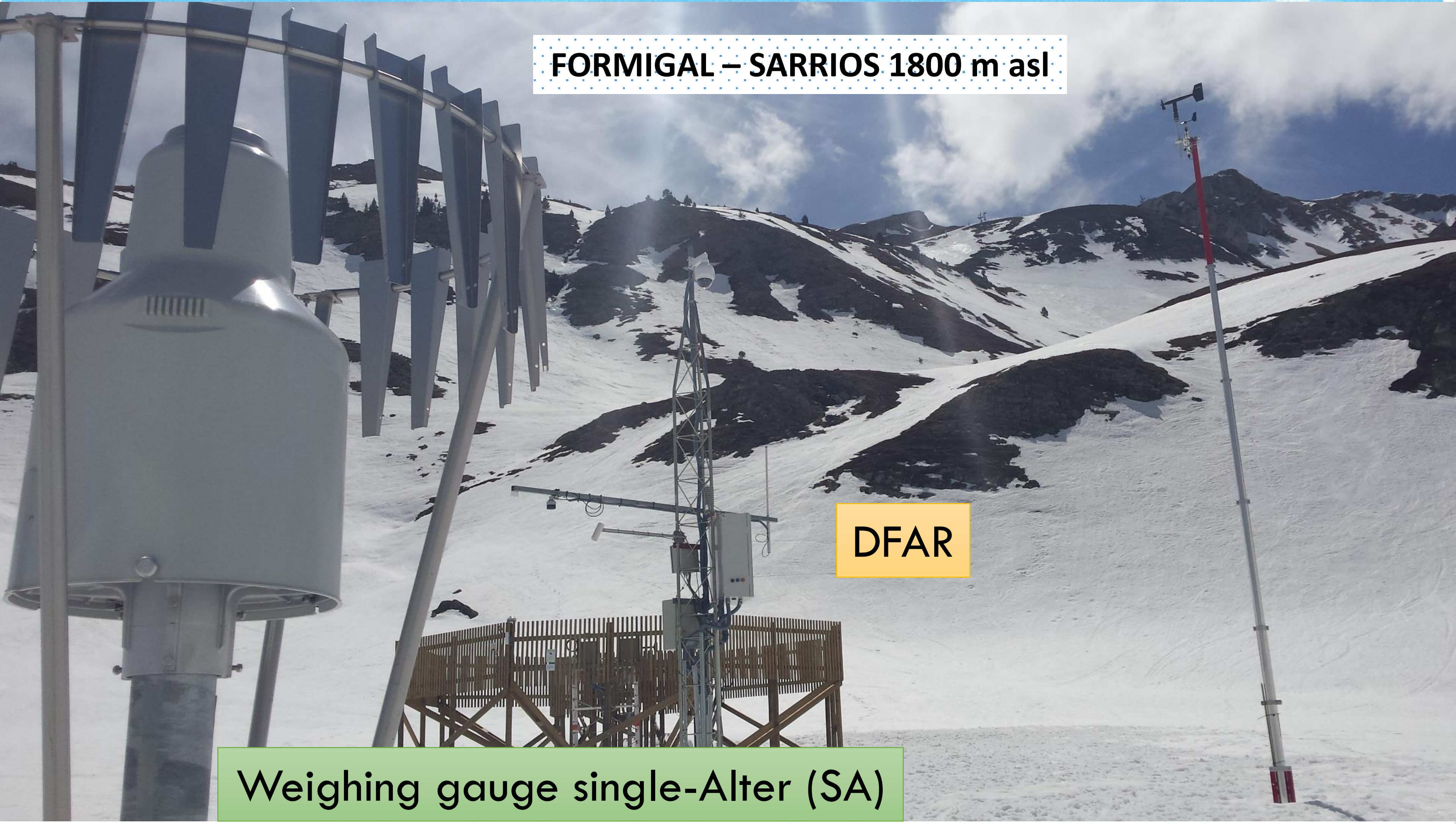
Automatic gauge (model not prescribed) with Alter shield

+

Precipitation Detector or Precipitation Type Sensor

DFAR


Haukeliseter, Noruega, 990 m
DFAR
Weighing gauge single-Alter (SA)


FORMIGAL – SARRIOS 1800 m asl
DFAR
Weighing gauge single-Alter (SA)

Universal transfer functions (and determining how universal they are)

$$CE = e^{-a(U)\left(1 - \left[\tan^{-1}(b(T_{air}))+c\right]\right)} \quad (3)$$

$$CE = (a)e^{-b(U)} + c \quad (4)$$

- U is wind speed, T_{air} is air temperature, and a, b, and c are coefficients
- Eq. 4 is defined separately for liquid, mixed, and solid precipitation

Kochendorfer and other SPICE authors.: **Analysis of single-Alter-shielded and unshielded measurements of mixed and solid precipitation from WMO-SPICE,** Hydrol. Earth Syst. Sci., 21, 3525-3542, https://doi.org/10.5194/hess-21-3525-2017, 2017.

OBJECTIVE

To assess, at a set of selected sites with different climatic conditions, the biases between a Global Numerical Weather Prediction Model and the observed precipitation (adjusted and unadjusted) in order to illustrate the magnitude of the error and its relation with the forecast accuracy of the model for each site.

Note / Disclaimer: This is not a verification work

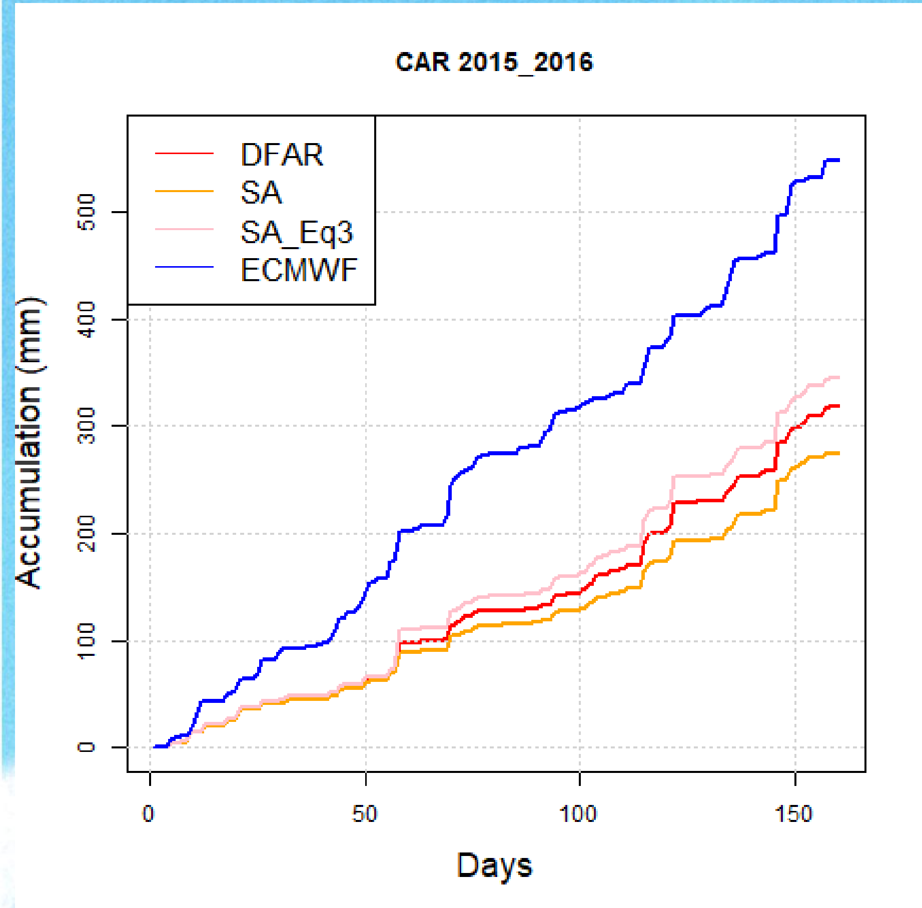
Site	Acronyms	Climate zone	Elevation (m)	Nearest grid point (m)
CARE	CAR	Humid continental subject to lake effect	251	242
Formigal-Sarrios	FOR	Alpine climate with Atlantic influence	1800	2144
Haukeliseter	HKL	Mountains, well above the tree line	991	1071
Marshall	MAR	Continental	1742	1646
Sodankyla	SOD	Northern Boreal	179	204
Bratts Lake	XBK	Continental	585	583.5
Weissfluhjoch	WFJ	Alpine	2537	1941

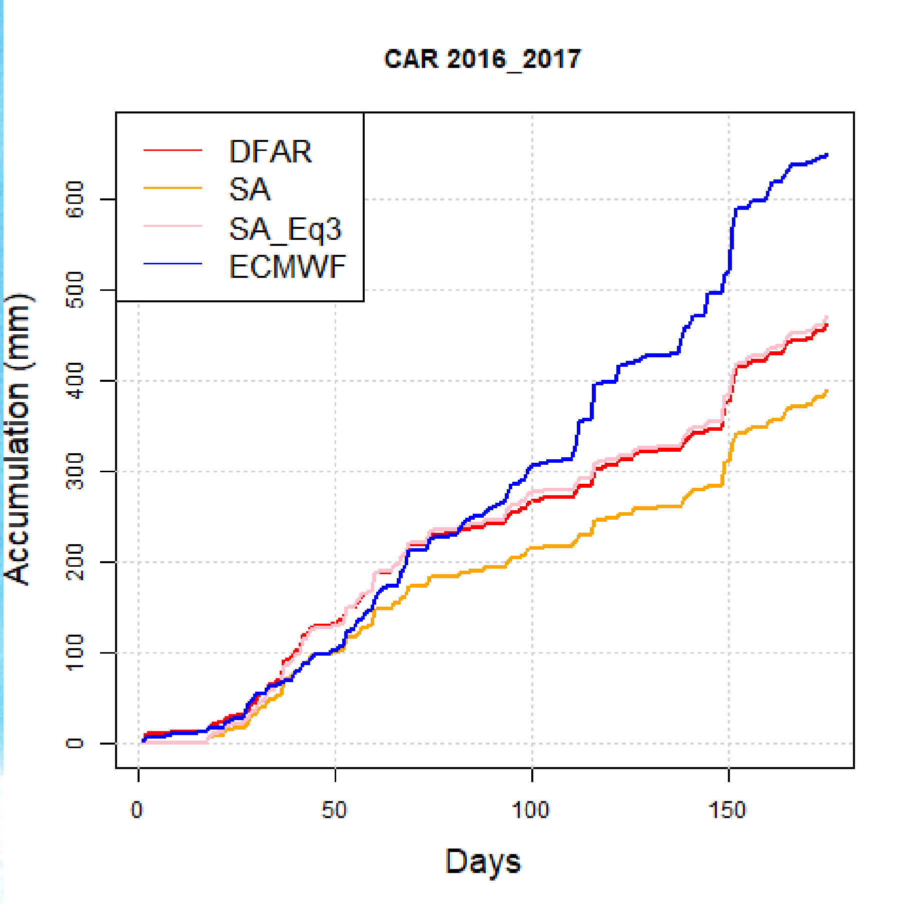
Methodology

- Quality control : remove outliers and noise filtering
- DFAR vs Single-Alter shield (SA)
- 1-min → 30 minute accumulations
- Transfer function equation (3)
- 24h forecasted accumulation at nearest grid point of each SPICE site from the high resolution operational ECMWF model
- Removed days with missing data
- 2015-2016 and 2016-2017 winter season

Results

Centre for Atmospheric Research (CARE), Canada

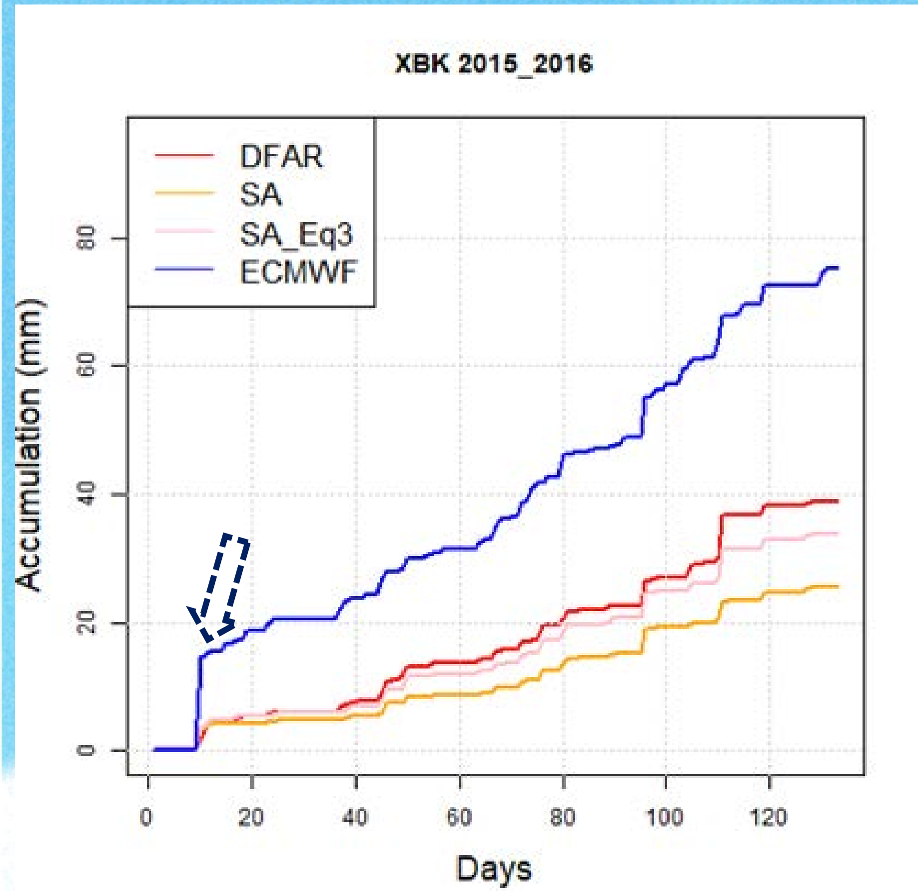


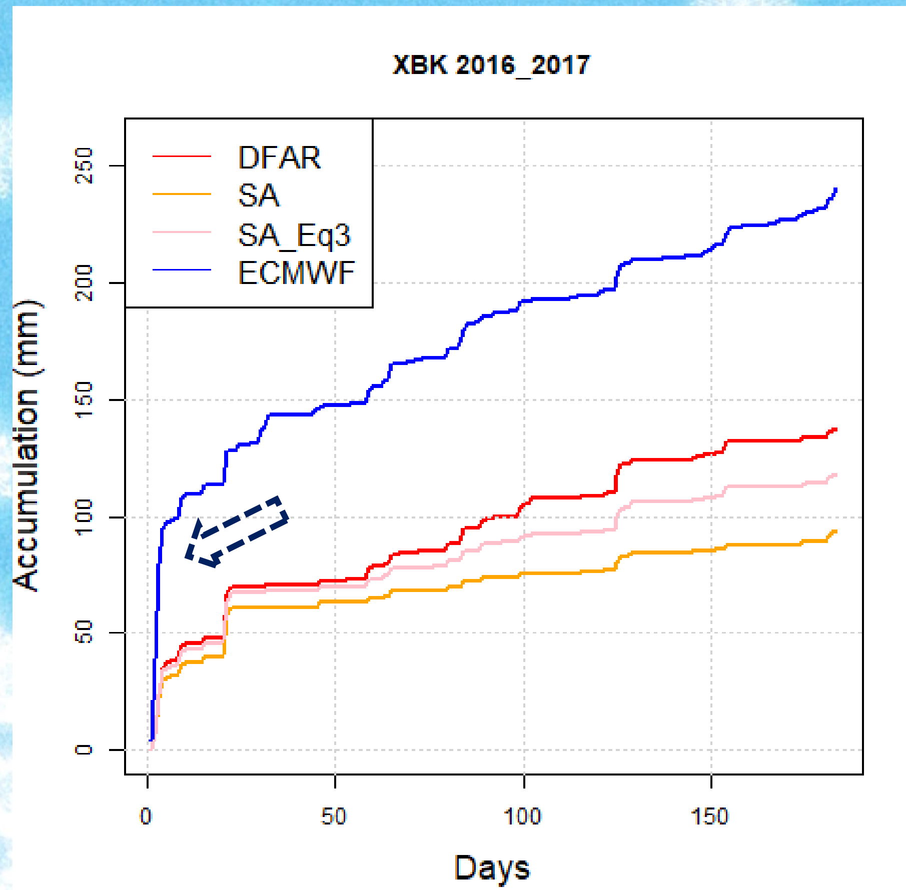


ECMWF > DFAR (Reference)

SA_Eq3 ≈ DFAR (Reference)

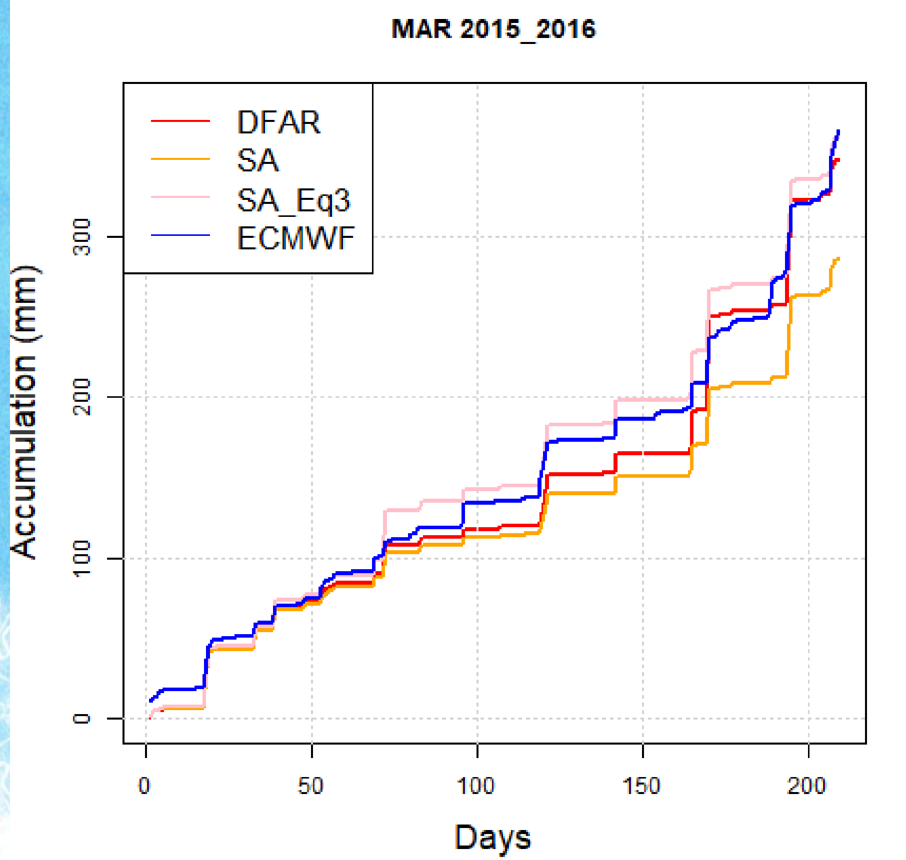
Bratts Lake, Canada





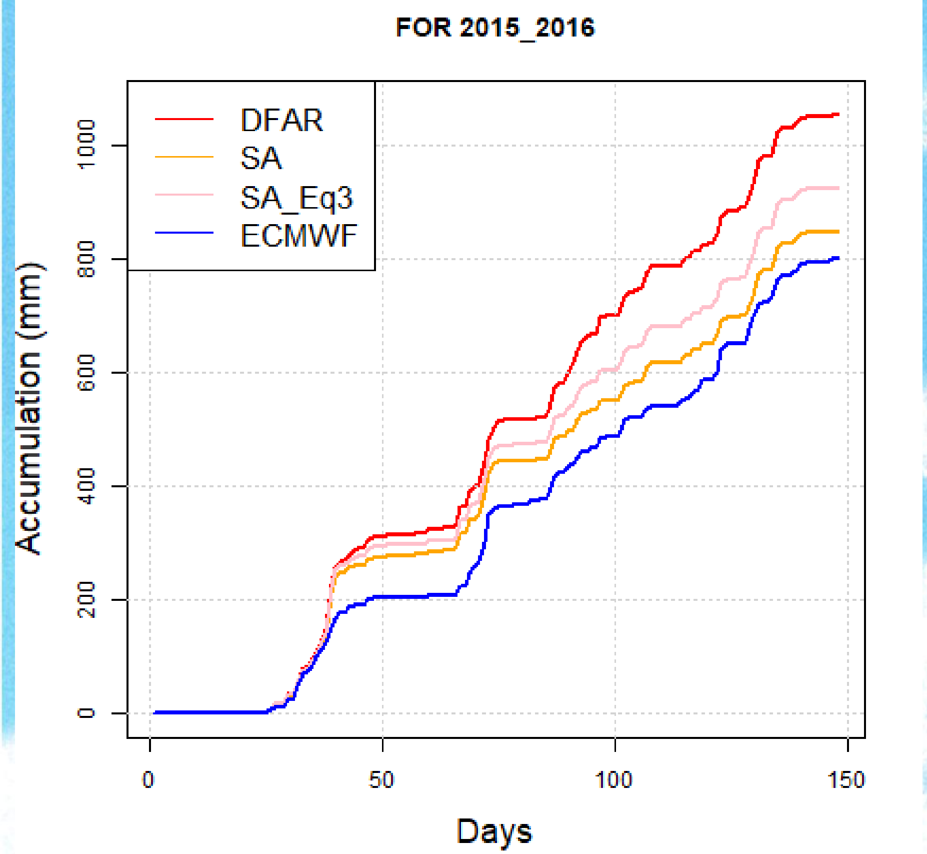
ECMWF > DFAR (Reference)
SA_Eq3 < DFAR (Reference)

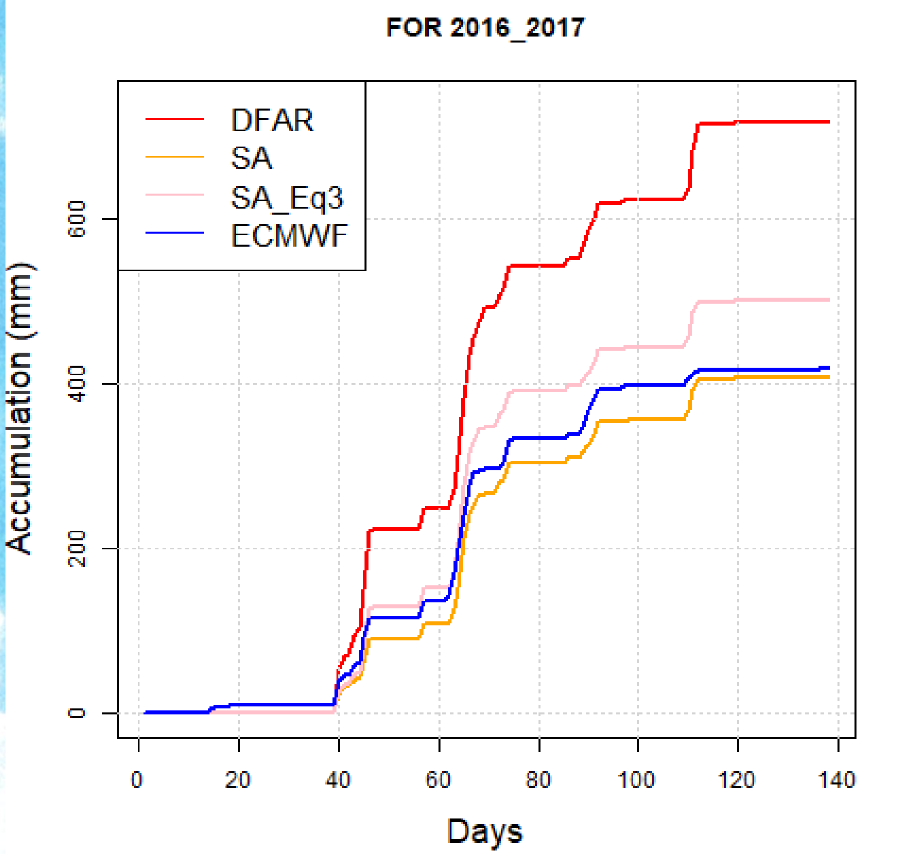
Marshall, USA



ECMWF ≈ DFAR (Reference)
SA_Eq3 ≈ DFAR (Reference)

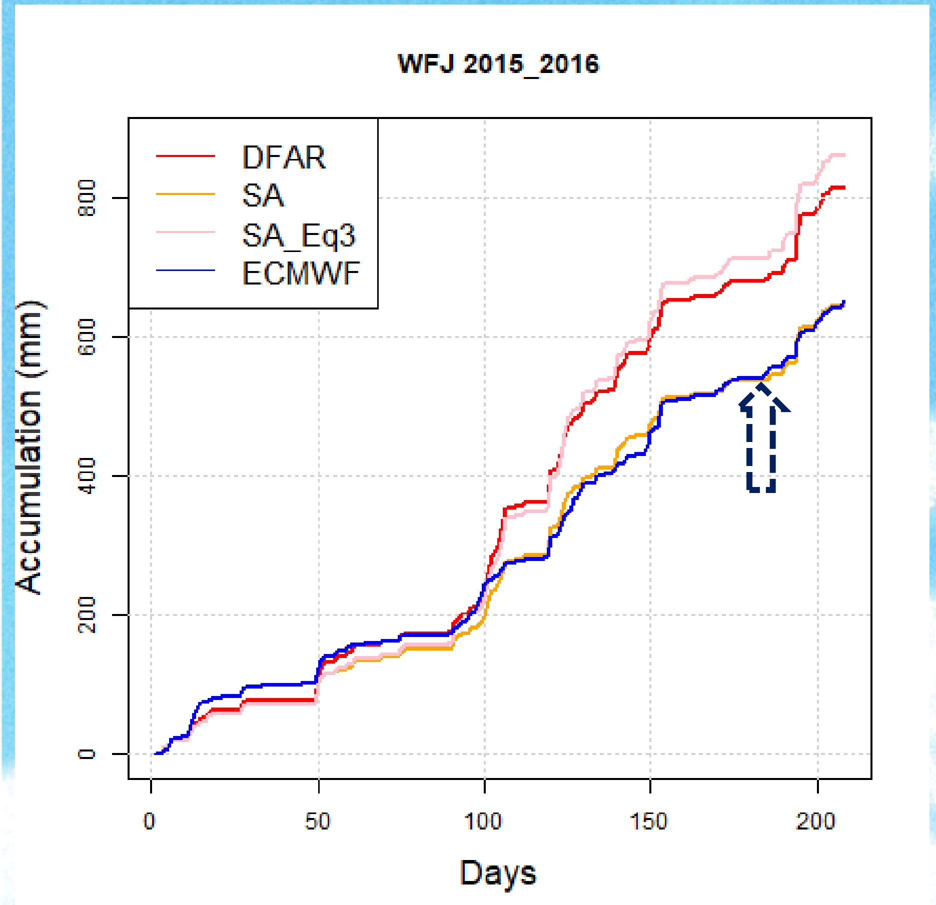
Formigal-Sarrios, Spain

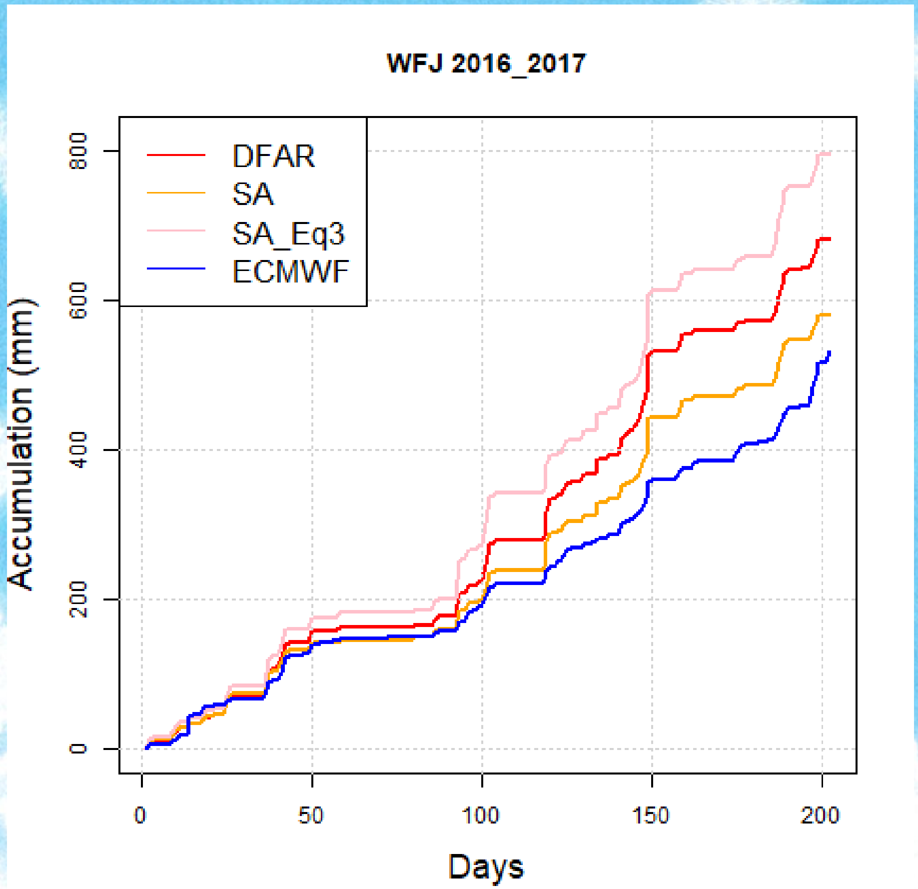




ECMWF < DFAR (Reference)
SA_Eq3 < DFAR (Reference)
SA ≈ ECMWF

Weissfluhjoch, Switzerland



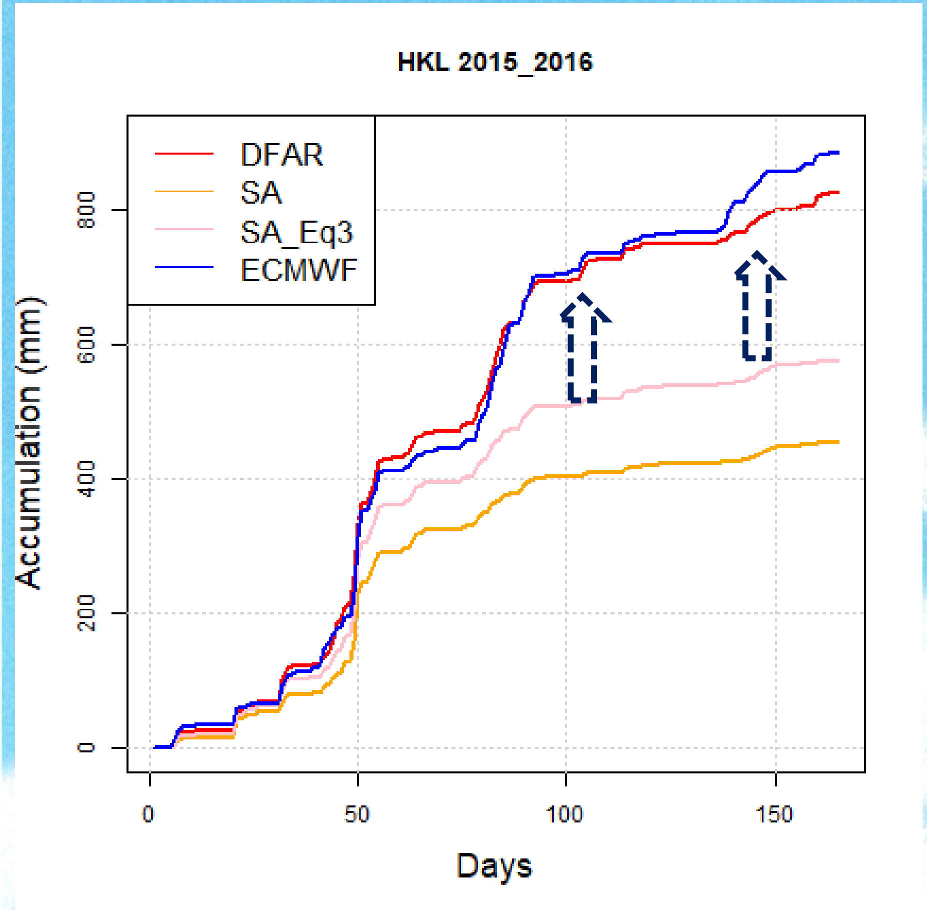


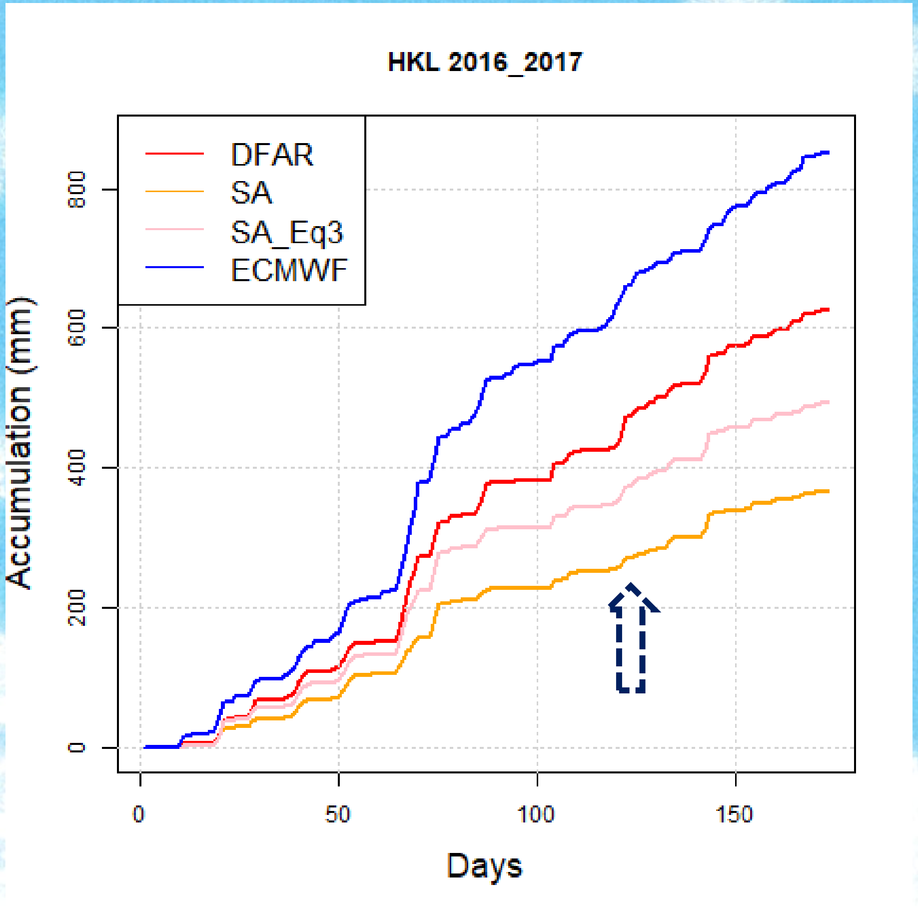
ECMWF < DFAR (Reference)

SA_Eq3 > DFAR (Reference)

SA ≈ ECMWF

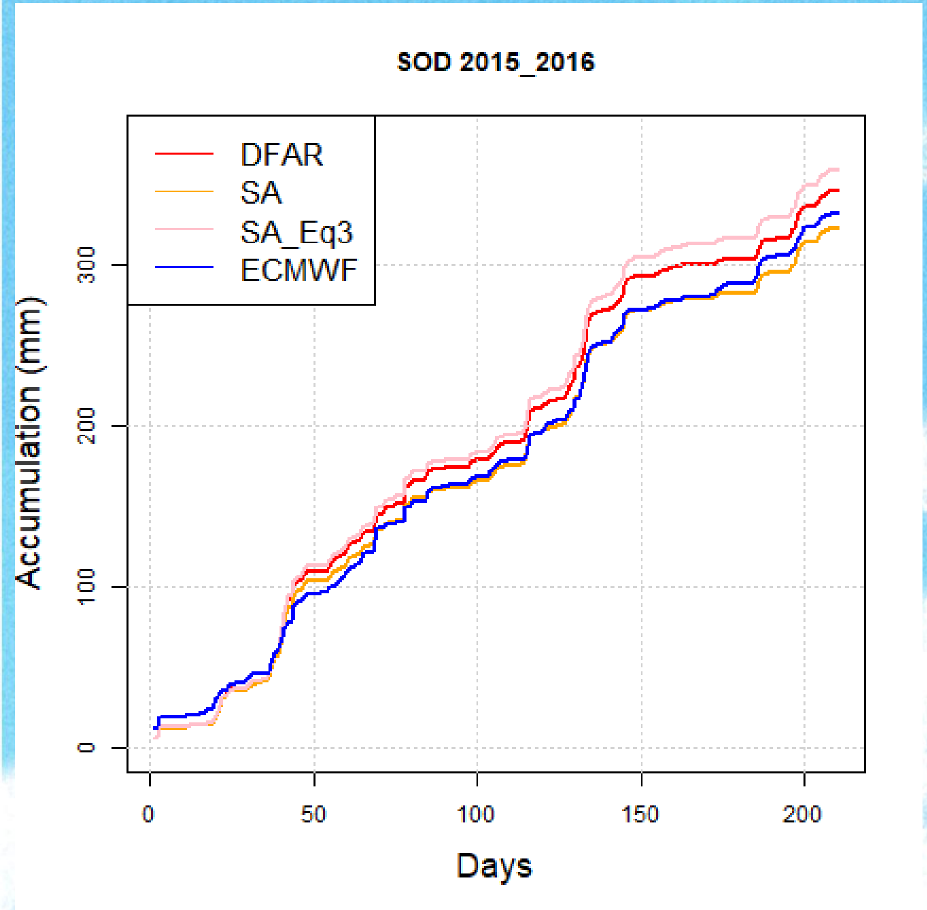
Haukeliseter, Norway

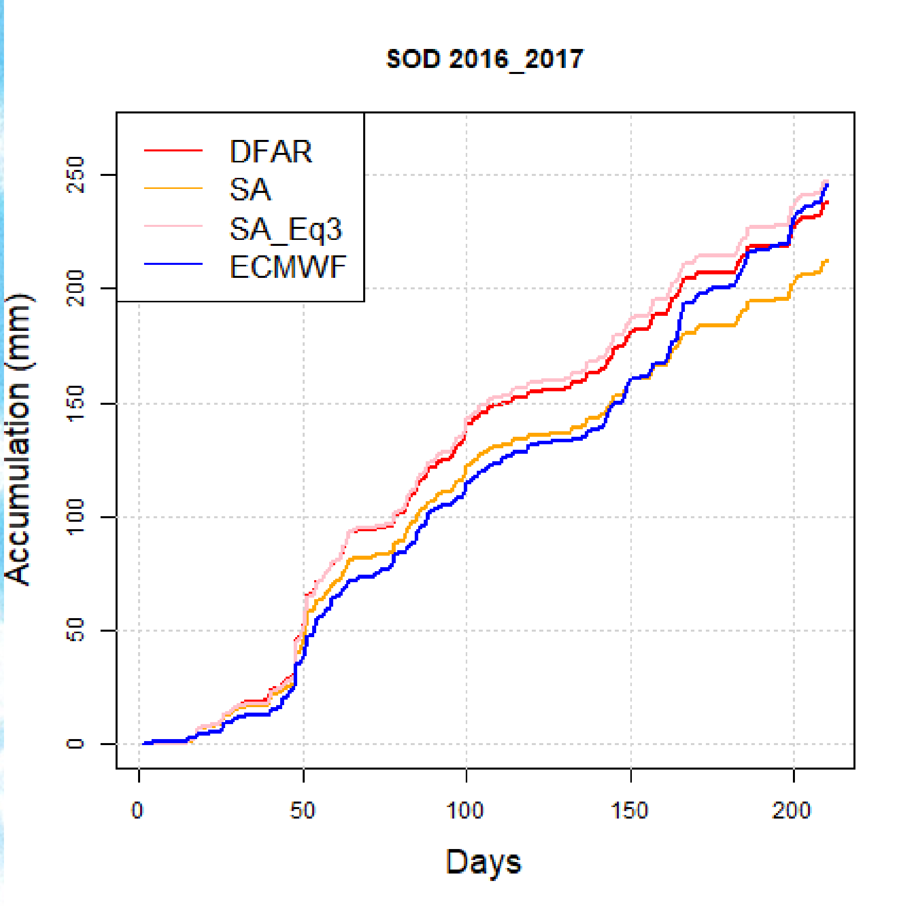




ECMWF > DFAR (Reference) (2016-2017)
SA_Eq3 < DFAR (Reference)

Sodankyla, Finland





ECMWF ≈ DFAR (Reference)

SA_Eq3 ≈ DFAR (Reference)

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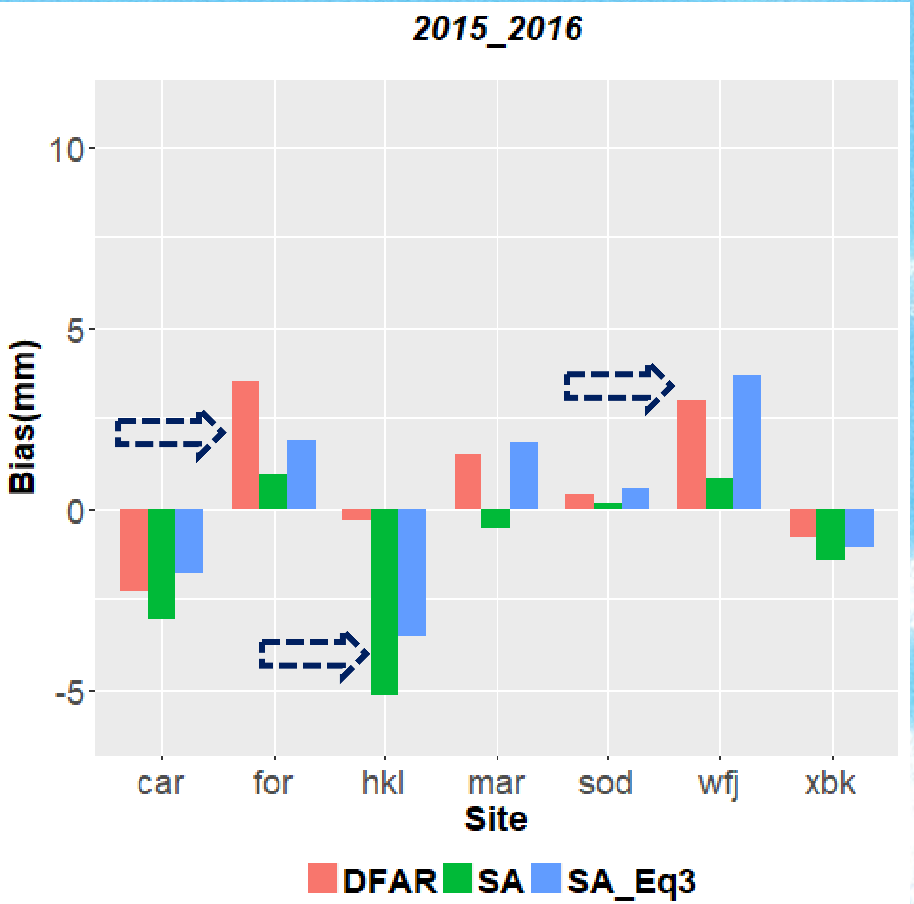
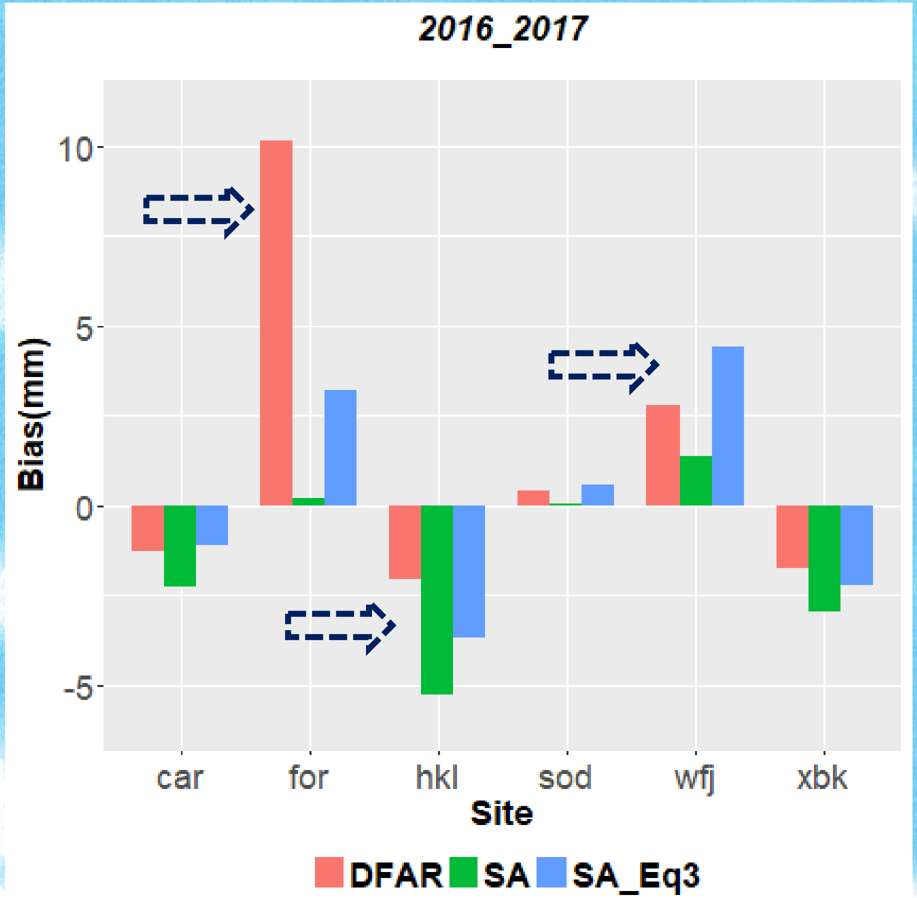
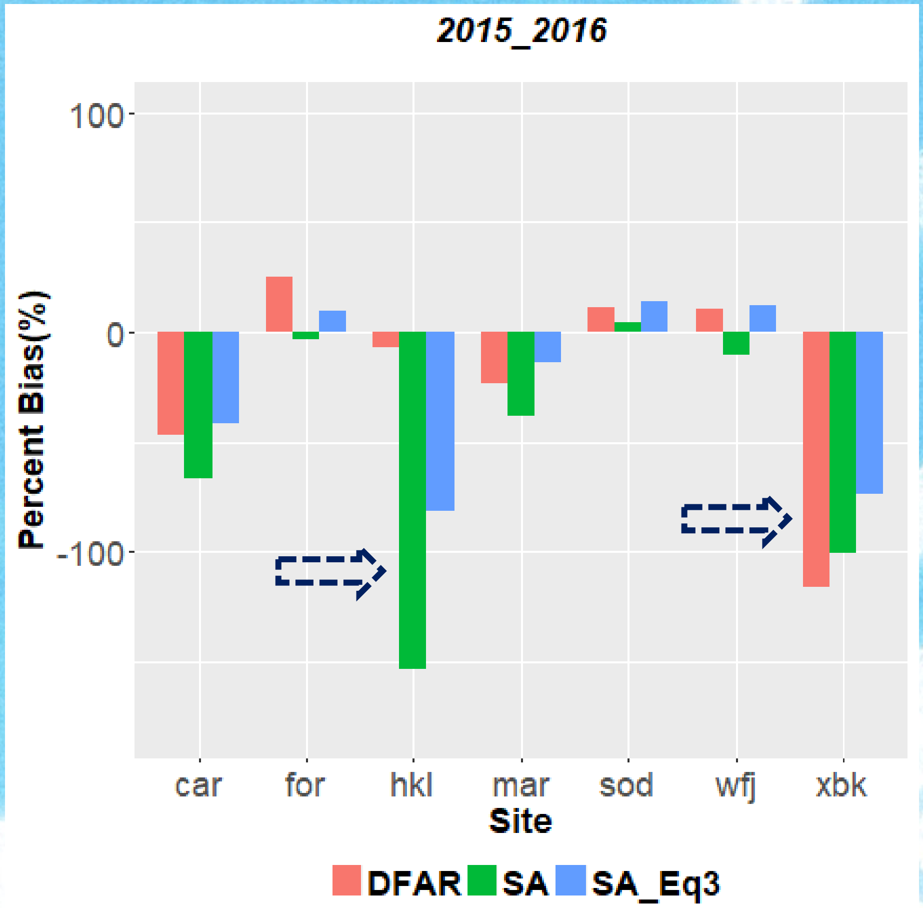
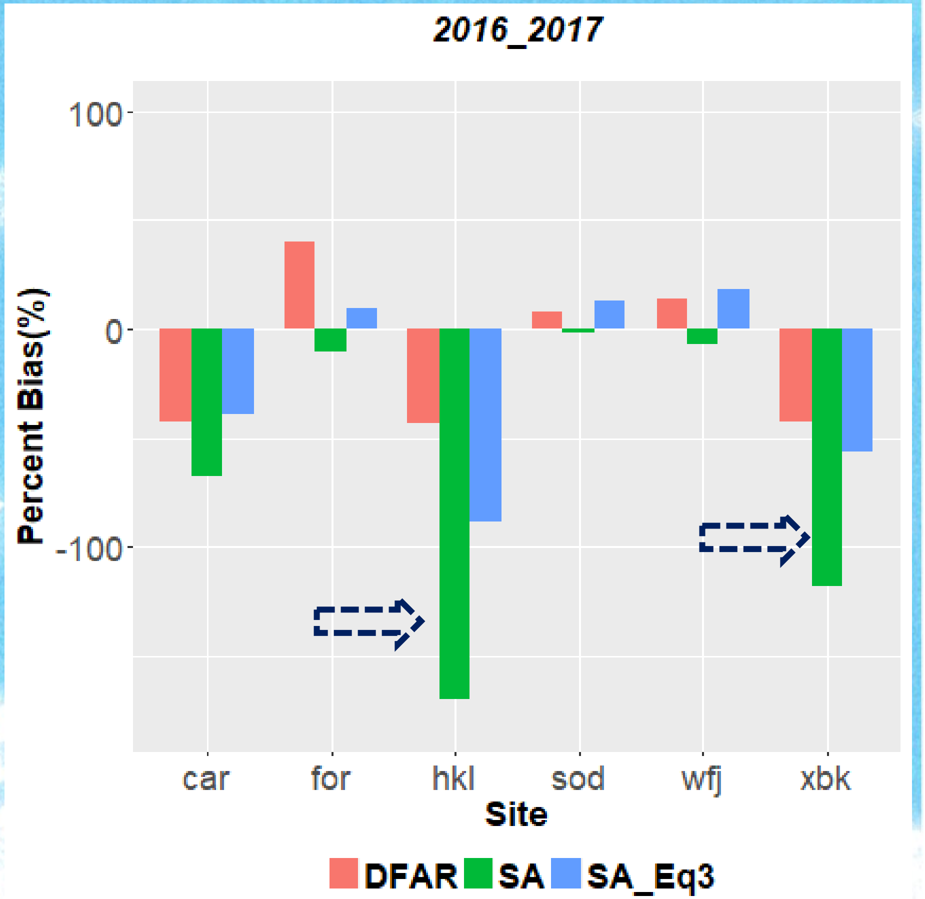




Daily bias (mm) between the DFAR precipitation, SA precipitation, the adjusted precipitation SA_Eq3 as compared to the ECMWF forecasted precipitation for days when the DFAR measured at least 1mm of precipitation.





Daily relative_bias (%) between the DFAR precipitation, SA precipitation, the adjusted precipitation SA_Eq3 as compared to the ECMWF forecasted precipitation for days where the DFAR measured at least 1mm of precipitation.

CONCLUSIONS

This work aimed to illustrate the complexity of verification of the ECMWF model forecast precipitation for winter precipitation. The main conclusions were:

i. At areas where the **model** tends to **overestimate** the precipitation, the adjusted precipitation **reduces** the **bias** and the magnitude of the error.

ii. At areas where the **model** tends to **underestimate** the precipitation, the adjusted precipitation **increases** the **bias** and the magnitude of the error.

iii. **DFAR observations provide ground-truthing for current versions of forecast models,** in the absence of a DFAR, adjusting gauge measurements of winter precipitation is critical (understanding that there are limitations) for an assessment of modelled precipitation bias.

THANK YOU FOR YOUR ATTENTION

GRACIAS POR SU ATENCION

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