

Referee comment on “Supercooled liquid water clouds observed over Dome C, Antarctica: temperature sensitivity and surface radiation impact” by Ricaud et al.

In general, the authors revised their manuscript thoroughly, taking into account all reviewers' comments. The manuscript has been significantly improved.

I only have a few minor suggestions that could be considered before the final publication.

### General Comments

The authors introduced the cloud radiative forcing. Starting with the definition of the net irradiance:

$$F_{Net} = (F_{LW}^{Down} - F_{LW}^{Up}) + (F_{SW}^{Down} - F_{SW}^{Up}) \quad (1)$$

the cloud radiative forcing is difference between the net irradiances, in cloudy ( $F_{net, cld}$ ) and cloud-free ( $F_{net, cf}$ ) conditions (e.g., Stapf et al., 2020):

$$\Delta F_{net,cf} = F_{net,cld} - F_{net,cf}$$

The authors also refer to the difference between the individual components as cloud radiative forcing (CRF). As I understand it, radiative forcing only refers to the differences in net irradiance. Below (Specific Comments) I have listed some examples of texts that should therefore be changed.

### Specific Comments

Abstract:

L37/L38: Please use either “solar” or “shortwave” throughout the manuscript.

L40 and others: “net cloud radiative forcing” – remove “net”, as the CRF is related to the net irradiance.

Introduction:

L66: “Bromwich et al. (2012) mention in their review paper that CCN and INPs are of various nature and large uncertainties exist relative to their origin and abundance over Antarctica.” - Do you mean variability or uncertainties?

L104: “the longwave downward” → “downward longwave”, the same for the other quantities

L105: “At a given time, the impact of a cloud on the surface irradiance can be estimated by subtracting what would have been the cloud-free surface irradiance from the measured surface irradiance, to provide the so called “cloud radiative forcing”.” – maybe you could write “At a given time, the impact of a cloud on the surface irradiance is estimated from the difference between the net irradiances, in cloudy ( $F_{net, cld}$ ) and cloud-free ( $F_{net, cf}$ ) conditions to provide the so-called ...”

Why is the equation for the CRF not already given here?

Section 3.1:

L201: “The same method is used for F. BSRN Fs are time interpolated to be coincident with the other parameters.” I would delete the first sentence, since the irradiance is only interpolated in time and not in space (vertical direction like the temperature). “BSRN Fs” → “BSRN irradiances”

Section 3.2:

L223-L226: “The cloud radiative forcing ( $\Delta F$ ) can be defined as: ...”: see general comments

L226: “Several studies have been performed ...” – give references.

L243-L246: Please note that the surface albedo of snow under cloudy conditions may differ from the surface albedo under cloud-less conditions (e.g., Gardner and Sharp, 2010, Stapf et al., 2020). Maybe mention it here since it is another source of uncertainty.

L249: “Note that computationally simple, theoretically based parameterization for the broadband albedo of snow and ice can accurately reproduce the theoretical broadband albedo under a wide range of snow, ice, and atmospheric conditions (Gardner and Sharp, 2010).” – Why is this mentioned here? The albedo is not parameterized in this study.

L256: “Screen-level temperatures are provided by the American automated weather station (AWS) situated at ~500 m from the Concordia base.” – Can be removed. It was already mentioned before.

Section 4.2:

L358-L359: “PDs of the cloud radiative forcing  $\Delta F$  as a function of the LWP, for ...” – CRF is  $\Delta F_{\text{net}}$ , the others are only components that contribute to the CRF (see general comments)

Section 5.1:

The section needs a little more interpretation. What is the critical temperature exactly? What does it tell us for this study?

L406: “SR anomaly” – you mean the CRF here, I guess

Section 5.5:

Figure 10 is not really needed.

L517-L518: “The large diurnal signal present in the observed surface albedo is likely the signature of the sastrugi effect.” – It depends on sastrugi orientation (geometry) and sun geometry that affects the surface albedo. Even with a flat snow surface, one would expect the surface albedo to depend on the SZA (Gardner and Sharp, 2010). You might mention that.

L525: “We can state that the sastrugi effect on the observed cloud-free surface albedo at Concordia is successfully fitted by two sine functions of 24h and 12h periods ...” – Since the orientation of sastrugis could be different, would it be possible that your fit is more related to the SZA effect?

Section 5.6:

L545: Eq. (18) assumes a linear dependence between cloud fraction and CRF. Perhaps it should be mentioned that there are 3D radiation effects in nature that contradict this assumption.

#### Technical comments

L285: “increases to values of +40-90 W m<sup>-2</sup>” – Here and elsewhere better write “+40 to 90 W m<sup>-2</sup>”

L551: “... over Antarctica of about 12, 10 and 7 W m<sup>-2</sup>, respectively.” → 12 W m<sup>-2</sup>, 10 W m<sup>-2</sup>, and 7 W m<sup>-2</sup>

References:

Gardner, A.S. and Sharp, M.J.: A review of snow and ice albedo and the development of a new physically based broadband albedo parameterization. *Journal of Geophysical Research: Earth Surface*, 115(F1), 2010.

Stapf, J., Ehrlich, A., Jäkel, E., Lüpkes, C., and Wendisch, M.: Reassessment of shortwave surface cloud radiative forcing in the Arctic: consideration of surface-albedo–cloud interactions, *Atmos. Chem. Phys.*, 20, 9895–9914, <https://doi.org/10.5194/acp-20-9895-2020>, 2020.