

## Reply to Reviewer#2:

Overall, the manuscript is well organized and clearly written. The radiative transfer simulations and data analyses are convincing. No major technical errors are found in this manuscript. However, some revisions are suggested for the authors' consideration.

We are grateful to the reviewer's recognition of our work, and we adapted your suggestions sincerely and carefully as shown below in blue.

### Specific comments:

1. Line 6 on page 12: the term "the aspect ratio (AR) factor" defined in this manuscript is not appropriate. Normally, the "aspect ratio" is used to indicate a ratio between two geometric dimensions along two different directions. However, in this manuscript, "the aspect ratio factor" is a quantity to quantify the difference of radiative properties associated with two polarization states. Thus, this factor should be referred to as "the dichroism factor" to indicate the difference due to different polarization states. Please see the following references:

Mishchenko MI. Extinction and polarization of transmitted light by partially aligned non-spherical grains. *Astrophys J* 1991; 367: 561-74.

Mishchenko MI, Travis LD, Lacis AA. *Scattering, Absorption, and Emission of Light by Small Particles*. Cambridge, UK: Cambridge University Press; 2002.

Parker, S. P., *McGraw-Hill Dictionary of Scientific and Technical Terms*, (5th Edition), McGraw-Hill, Inc., New York, 1993.

Yang, P., M. Wendisch, L. Bi, G. Kattawar, M. Mishchenko, and Y. Hu, 2011: Dependence of extinction cross-section on incident polarization state and particle orientation. *J. Quant. Spectrosc. Radiat. Transfer*, 112, 2035-2039.

Thank you very much for bringing our attention to the history of this factor, which we didn't notice before. After reading the aforementioned references, we incline to not change the term and definition of "AR" in this paper. The "dichroism factor", based on my understanding of reading mischenko's series of papers, is associated with the geo-magnetic field which was thought in those papers being responsible for the systematic alignment. In Yang et al. [2011] paper mentioned above, they also thought "this is an optical phenomenon analogous to the dichroism".

In our paper, by assuming homogeneity of other microphysical properties along the line-of-sight, our AR is equivalent to the AR definition in Davis et al. [2005] which has a physical meaning of a ratio between the major and minor axis of a non-spheroid particle projected to the line-of-sight. We have notified this point in the manuscript (last paragraph of Section 4.2). In addition, we now recognize the reviewer's comments on the similarity of "AR" to the "dichroism factor" and included the aforementioned citations in the 2<sup>nd</sup> last paragraph of new Section 4.1.

2. This study suggests "horizontally oriented nonspherical frozen particles are thought to produce the observed PD because of different ice scattering properties in the V and H polarizations." However, previous studies based on observations in the visible channels (Noel and Chepfer 2010, Zhou et 2012, 2013) suggest that the percentage of horizontally oriented ice crystals is quite small. Apparently, further investigations are necessary validate this claim.

We also noticed the related CALIPSO studies as pointed out here. However, CALIPSO is only sensitive to the very top of the ice cloud layer, the conclusion of which are therefore not implacable to be contradictory to our findings here.

Right now using the observations and RTMs provided by our current manuscript, we cannot quantify how much percentage the ice crystals are horizontally aligned. So we fully agree with the reviewer that further investigations using other observations, other channels, more sophisticated models are required to make any stronger claims. As we didn't explicitly claim anywhere in this manuscript that the horizontal alignment dominates, we thought our statement in the abstract is proper to keep in the current form. Also, we mentioned immediately after that sentence that turbulent mixing (i.e., the factor determines how much percent of particles tend to be randomly oriented) likely plays another critical role in the PD-TB relationship.

3. Line 11 on page 1 "It is the first study on global . . .that uses. . .": would it be better to say "It is the first study of frozen particle microphysical properties on a global scale with the use of dual-frequency . . ."

Revised. Thanks.

4. Line 13-14 on page 1: "the scatterings of frozen particles are": would it be better to say "the scattering by frozen particles is"

Revised. Thanks.

5. Line 16 on page 14 (and throughout the manuscript): "particle habitat" should be "particle habit"

Sorry for this typo. We have corrected them.