Response to Reviewer #2's Comments:

Jiming Li et al. (Author)

We are very grateful for the Review #2's detailed comments and suggestions, which help us improve this paper significantly. Some grammatical errors already were corrected in the revision and the paper also be edited by a native English speaker to make it more readable. Based on two Reviewers' comments, we rewrote the manuscript and paid more attentions to investigate the impacts of meteorological parameters on the supercooled liquid cloud fraction under different aerosol loadings at a global scale. In addition, some superfluous information in each section was deleted and some interpretations in each section were added in order to make the manuscript more clear.

Detailed information:

(1)Due to the modeled T-Phase relation cannot be compared directly to observations like it is done in the paper, Reviewer #1 suggested us to remove the comparison with "model relation" part and focused our study on the observational part (relation of the cloud phase transition with the aerosols). In the revised paper, we followed the suggestion from reviewer #1 to remove the comparison part with "model relation". In addition, duo to some studies have investigated the impact of different aerosol types on cold phase clouds over East Asia (Zhang et al., 2015) or at a global scale (Choi et al., 2010; Tan et al., 2014). However, systematic studies of the statistical relationship between cloud phase changes and meteorological parameters at a global scale have received far less attention. Thus, the revised paper paid more attentions to investigate the impacts of meteorological parameters on the supercooled liquid cloud fraction at a global scale.

(2) We reorganized the introduction section. Some confused sentences and wrong quotations were revised.

(3) In the section 2, we replaced the cloud phase information from the 2B-CLDCLASS-LIDAR product with the GCM-Oriented Cloud-Aerosol Lidar and

Infrared Pathfinder Satellite Observation (CALIPSO) Cloud Product (GOCCP). This product can provide us more longer-time cloud phase information. Thus, all statistical relationship in the revised paper were derived from 8 years (2008–2015) of data from CALIPSO-GOCCP, the ERA-Interim daily product and the CALIPSO level 2, 5 km aerosol layer product. Some introductions about datasets were added in this section. Please see the section 2.

(4) In the section 3 (results part), we did a lot of changes, and mainly investigated the temporal correlations over the 8-year period (96 months) between monthly supercooled water cloud fraction and different meteorological parameters. Some new results were added. For those regions with temporal correlations between SCFs and meteorological parameters at the 95% confidence level were further used to calculate the spatial correlations between SCFs and meteorological parameters.

Specific responses

We appreciated the insightful suggestion and comments made by reviewer #2. In the revised paper, the comparison with "model relation" part was removed. Thus, we only provided the point-by-point responses to the reviewer's comments about the observational part.

1. Title: The study could be separated into two parts, the first part evaluating the temperature ramp schemes used in climate models against observations and the second part examining statistical relationships between dynamical variables and SCF. The title only reflects the latter part. Please change the title to better reflect the content of the manuscript.

Response: We agreed with reviewer. In the revised paper, we focused on the statistical relationship between cloud phase changes and meteorological parameters at a global scale. Thus, the title can reflect the content of the revised manuscript.

2. Introduction: The logical flow can be improved to enhance clarity. Cold cloud schemes in models are discussed in the first paragraph before the existence of supercooled liquid clouds in the second paragraph. Also, on lines 107-109: the Clausius-Clapeyron equation simply relates the saturation vapour pressure and the temperature. If the authors wish to cite theoretical support for the existence of liquid, they should refer to the free energy barrier of pure water droplets and classical nucleation theory.

Response: We appreciated the insightful suggestion from reviewer #2. In the revised paper, we reorganized the introduction section. Some confused sentences and wrong quotations were revised.

3. Datasets and Methods: Lines 177-185: Please include indicate that the ERA-Interim reanalysis dataset was used to obtain the aerosol and cloud-top temperatures.

Response: Some detailed introductions about datasets were added in this section. Please see the section 2.

Line 182: why was a resolution of 2_ _ 6_ chosen? The longitude dimensionis quite wide. Please clarify.

Response: In the revised paper, we performed the temporal correlation between supercooled water cloud fraction and meteorological parameters. However, due to the 16-day orbit of CALIOP, the horizontal resolution of the data set had been reduced to 10 ◦ latitude by 10◦ longitude grid boxes to avoid the issue of a sparse data set when performing the temporal correlations, similar with the study of Tan et al. (2014).

Line 184: It’s not clear to me why only daytime observations were used. Wouldn't it be better to use nighttime observations, especially for the CALIOP observations since sunlight decreases with the signal to noise ratio?

Response: Yes, we very agreed with reviewer. To avoid artifacts due to noise from scattering of sunlight, it is better to conduct the CALIOP retrieval during nighttime. However, in view of the lack of CALIPSO observations at high latitudes of the northern Hemisphere during boreal summer nights, this study utilizes the mean values of SCFs, meteorological parameters and RAFs during daytime and nighttime to perform the temporal and spatial correlations analysis.

4. Results: Why have the global distributions of the vertical velocity at 700 hPa, LTSS and surface temperature have not been plotted? It may help to plot these since Figures 12, 13 and 14 do not contain any information about the distribution of these variables. Also, have pattern correlation coefficients between the variables been calculated?

Response: We very agreed with reviewer. The temporal and spatial correlations between supercooled water cloud fraction and meteorological parameters was performed in the revised paper. In addition, we also provided the global distributions of vertical velocity at 500 hPa, LTSS, skin temperature, and u wind at 100hPa in the Fig. s1 in the supplemental materials.

5. "Probably my biggest concern about the manuscript is that the model cloud thermodynamic phase partitioning schemes in Table 1 may not be directly comparable to the cloud-top observations made by CloudSat and CALIPSO in this study. The CAM3 and CAM5 schemes, at least are not, since the temperatures do not refer to the cloud-top temperatures and these limitations should be discussed in the text.....................Liquid and ice mass and number concentrations for stratiform clouds are computed from prognostic equations in CAM5, which has a very different cloud microphysics scheme from that in previous version (e.g. CAM3/CAM4). This may also be the case for the other models. Please discuss these points".

Response: Yes, **t**he modeled T-Phase relation cannot be compared directly to observations like it is done in the paper. We appreciated the insightful suggestion from reviewer #2. Based on the suggestion from the Reviewer# 1, we removed the comparison part with "model relation" and paid more attentions to investigate the impacts of meteorological parameters on the supercooled liquid cloud fraction under different aerosol loadings at a global scale.

Line 474: Please clearly define the relative aerosol occurrence frequency.

Response: The detailed information was added in section 2.3.