Review of

Determining stages of cirrus life-cycle evolution:
A cloud classification scheme

by Urbanek et al.

The authors present an attempt to determine the stages of cirrus life-cycle evolution based on in-cloud RHi measurements performed by the airborne Lidar WALES. Though I like the idea and also find the paper well organized and fluently written, I have a major concern with respect to the proposed cirrus life-cycle classification scheme which I explain in the following. To my opinion this point should be cleared before publishing the manuscript in ACP.

Major comment: In the introduction, the authors state:
'*In order to gain more insight into the particular role of different cirrus clouds, great efforts were made to classify cirrus by the meteorological contexts in which they occur (Jackson et al., 2015; Muhlbauer et al., 2014). Categories include "synoptic", "orographic", "lee wave" and "anvil" cirrus. Recently Krämer et al. (2016) introduced a more general classification distinguishing the groups of "liquid origin" and "in situ" clouds that describe whether the cirrus formed from a pre-existing liquid cloud or from cloud-free air. Such a classification of recorded data is a prerequisite for statistically investigating the specific properties and influences of different clouds, and to extract the governing mechanisms and parameters from remote sensing and in situ measurements.*'

However, the cirrus life-cycle classification scheme presented in the paper holds only for 'in situ' formed cirrus clouds. In the so-called 'liquid origin' cirrus, the meaning of 'SUB' will be similar, but what about the interpreation of 'DEP', HETin and HOMin in case of pre-existing ice? It is very likely that in case of further lifting of a liquid origin cirrus cloud the supersaturation rises to values of DEP, HETin or HOMin (then, a new, homogeneous nucleation event can occur on top of the liquid origin cirrus), but they are at different stages of cirrus evolution than the in situ cirrus.

In a recent publication of Wernli et al. (2016), GRL, the frequencies of occurence of in situ and liquid origin cirrus are analyzed from 12 years of ERA-Interim ice clouds in the North Atlantic region. Wernli et al. found that: 'Between 400 and 500 hPa more than 50% are liquid-origin cirrus, whereas this frequency decreases strongly with altitude (<10% at 200 hPa).'

Thus, it seems to be important that first of all these two types of cirrus can be identified by a cirrus classification scheme before going in the detail of stages of cirrus life-cycle evolution. So I would highly encourage the authors to continue their work by including an analysis of the cirrus origin prior to the investigation of the stages of evolution.

It might be an idea to first perform a trajectory analysis as done by Wernli et al. (2016) and also Luebke et al. (2016) using ECMWF wind fields and determine wether the back trajectory of an observed air parcel stemmed from temperatures warmer than -38C and carried ice when entering the cirrus temperature range. Then, the classification scheme can be applied to both types separatly.

I am aware about that this will be a lot of additional work, but am also convinced that it will be worth the effort to make the study scientifically sound and useful for future investigations.

Minor comments:

1) Page 1, line 24 – page 2, line 1:

'*Today many factors are known that determine these properties: the amount and composition of natural and anthropogenic aerosol particles in the troposphere and their ability to nucleate ice crystals (DeMott et al., 2010), ..'*

This statement is much too promising – amount and properties of IN (Ice Nuclei) are not well known until today, in particular in the temeprature range of cirrus clouds. Please correct.

'... the exact freezing condition and mechanism (Cziczo et al., 2013), updraft velocity during cloud formation (Kärcher and Lohmann, 2002), ...'

Same here: it is not clear if the work of Cziczo et al. (2013) is globally valid;
updraft velocities during cloud formation are theoretically known, but measurements are difficult and rare.

2) Page 2, line 13-14:

'...a cloud is expected to show different properties at the time of formation and break up.'

Better 'dissipation' instead of 'break up'

3) Page 3, lines 3-5:

'*Once ice particles are present, remaining supersaturation is depleted by deposition of water vapor onto existing crystals. Depending on the particle number and average radius, it may take a few minutes to a few hours for the equilibrium of 100 % to be reached (Korolev and Mazin, 2003).*'

Korolev and Mazin (2003) show relaxation times to reach the 'dynamical equilibrium' (steady state), which is -in dependence on the updraft- higher than 100%. Saturation in cirrus is quickly reached as soon as the cooling stops, i.e. when the updraft is zero. Please correct.

4) Page 4, line 32:

'It should be noted that ice is forming as soon as conditions for homogeneous freezing get reached, ...'

Please correct:
... ice is forming **latest** as soon as conditions for homogeneous freezing get reached,...
since heterogeneous freezing starts earlier at lower RHi → higher tempeartures.

5) Page 4, line 32 – page 5, line 3:

' *Therefore, a cloud classification should not feature considerable regions of HOMout. This fact should be kept in mind when choosing a BSR threshold value for the cloud border detection, making sure that HOM regions lie inside the cloud. HETout regions, however, may exist in cases with no sufficient amount of aerosol ice nuclei.* '

Have you chosen the threshold BSR? So that no HOMout occured ?

Also, HETout can occur in case RHi is higher than the chosen threshold RHi_HET, not only due to a lack of IN.

6) Page 5, line12:

'*To this end, we use an aerosol classification suggested by Groß et al. (2013). Then we employ simplified onset parameterizations RH^(MD)_i,HET(T) and RH^(CS)i,HET (T) (see Table 1 and Krämer et al. (2016, their Fig. 4)).* '

Please briefly explain the aerosol classifiaction.

In addition, why not define two classes of supersaturation,
HET^(MD)_in/out and HET^(CS)_in/out ? This would provide even more detail!

7) Page 6 line15:

'…; *low clouds are depicted in yellow.'* green *??*

Technical recommendations:

- Fig. 1: BSR < 2 would be better BSR <> 2 in the scheme

general: DEP why not ISSR_in sounds more clear
general: ISSR ISSR_out sounds more clear

- Fig. 2 b: explain also the green color

- Fig. 3 - 7: insert an arrow to show the wind direction

- Fig. 4: insert a panel with the ECMWF temperature !