Review of ‘Subvisible cirrus clouds – a dynamical system approach’ by E. J. Spreitzer, M. P. Marschalik and P. Spichtinger

The article introduces a new model to describe the evolution of subvisible cirrus clouds based on first principles, interpreting the results using concepts of dynamical systems theory. While the work is interesting and important for advancing the modelling of clouds in numerical atmospheric models, I feel that some aspects need to be corrected before it can be published in NPG. In particular, I think that the use of the dry adiabatic approximation as an assumption of the air parcel’s vertical motion needs stronger justification. Also, there are several sections comprising detailed descriptions of general dynamical systems theory that do not seem to be used in the investigation. Finally, equation (42) appears to be incorrect. A less crucial, yet important point, is the use of very informal language throughout the in the manuscript. I give more detailed comments in the following lines:

Major comments

L252-256 and L288: Given that the model describes phase changes it is difficult to see that the motion can be described as dry adiabatic. There will be significant latent heat exchange. The motion could be assumed moist adiabatic but not dry adiabatic.

L363-364: How long does it take to reach the limit cycle? And how can we be sure that it is a limit cycle and not a very slow approach to a different kind of attractor? Fig. 2 shows the amplitude of the oscillations slowly decreasing rather than going into tending to a motion with stable amplitude.

L377-380: Please double-check that (42) is correct. I am getting different exponents for r_0 and RH_I so that the factors involving these variables would be:

$$r_0^{\frac{\alpha_i-\delta}{2}}$$

for r_0, and

$$RH_i(RH_i - 100\%)^{\frac{1}{\alpha_i-1-\delta}}$$

for RH_i.

If (42) is correct, please provide more details for its derivation. Also it is not clear how this equation was used to produce any results. Was Fig. 5 produced by solving (42)? If so, please make sure it corresponds to the correct version of the equation. Figure 6 and 7 might also be affected.

L384-406: Dynamical systems theory is invoked for the interpretation of the results from the numerical model. However, I feel that this interpretation is very descriptive and not very quantitative. For example, the eigenvalues are never shown to prove that indeed they are behaving as described by the theory. Please show the eigenvalues and how they change as the parameter space is explored.

L407-413: In this paragraph it is stated that the limit cycle was determined numerically and the construction of a Poincare map is described. But then, without showing any results, in the last sentence it is stated that this is of no further interest! I don’t understand why to determine the limit cycle and why to describe so much about the procedure if no results will be presented and no discussion will be made. Please show this results or else delete the seemingly unnecessary paragraph.

Minor comments

L11: A limit cycle can be an attractor. It might be worth revising the terminology (i.e. attractor v limit cycle) or providing a definition for these two concepts in the main text.

L21: Separate ‘up to’

L24: It is implicitly claimed that the net effect of liquid clouds on the total energy budget is already known. I don't think this is correct, judging by the amount of research into that area. Please provide some references to back up this implicit claim.

L28: The *low temperature regime* is mentioned here for the first time, and no link to the clouds' environment has been made previously. In order to complete the background about the environment in which cirrus clouds exist, please explicitly state the order of temperatures and pressures in which subvisible cirrus clouds can be found. This can be done after the very first sentence of the Introduction.

L41: The sentence starting with 'For these subvisible clouds…' is not clear as written. What would warm, the clouds or the environment?

L42: The sentence starting with 'Our knowledge…' is poorly linked to the rest of the paragraph. Perhaps start a new paragraph.

L50: Why would sedimentation of ice crystals be important and so why should it be included?

L53: Change 'short:' for 'hereafter'.

L63: Change 'systems' for 'system'.

L63: Delete 'respectively'.

L65: What is meant by 'more general'? With respect to what is the new approach 'more general'?

L67: Where is 'here'? Perhaps change to 'In this article'.

L72: Delete 'respectively'.

L79: Define ∇_x.

L83: Clarify what inertial system is being consider. And if it is inertial, why does its velocity depend on time ($\boldsymbol{v} = \boldsymbol{v}(\boldsymbol{x}, t)$)?

L90: What is meant by '(even with this simplification)'? the only assumption that has been introduced is the writing of total velocity as u=v+v', but I cannot see how this simplified equation (3). Please clarify.

L94 and L101: Is it right to define k as a real number? What is the advantage of defining generalized moments?

L104: Change 'components' for 'component'.

L105: It is not the gravitational *acceleration*, but the gravitational *force* that is balanced by *drag*. *Drag* is more appropriate a term then *friction*.

L113: Please do not assume that every reader is familiar with the terminology. Please provide references where the *usual* ansatz is used.

L134: For clarity, state that 'log' is the symbol used for 'natural logarithm' in the paper.

L142: Change 'Similar as' to 'Similar to'.

L151: Change 'assuming' to 'Assuming'.

L155: The sentence 'thus we can treat the integral as a constant' is not clear. Is it that because J is independent of r it can be treated as a constant in the integral?

L159: What are the units of the standard deviationσ_r?

L158-161: Are the modal radius, geometric standard deviation and total number concentration somehow justified by observations? If so, please provide references. Explain otherwise.

L202: Change ‘neglet’ for ‘neglect’.

L205: Change ‘this’ for ‘which’.

L208: The explanation beginning with ‘,which was fitted’ is not clear. Were the coefficients $C_i$and α_i derived from Spichtinger and Gierens (2009) model?

L213: Change ‘we end’ to ‘we end up’. However, consider rewriting as this is not formal language.

L216: Is the definition of saturation ratio correct? Shouldn’t it be $S_i = q_v/q_{v,si}$?

L244: Change ‘Lagranian’ to ‘Lagrangian’ here and in every place in which this word appears.

L246: Please state explicitly the relationship between (31) and $d(\rho\phi)/dt$. Notice that they are not equal.

L260: Rewrite the sentence starting with ‘Hence’. The way it is written is very informal.

L261: Notice that ms^{-1} means ‘per millisecond’ while what is meant is ‘meters per second’.

L262: ‘meaning that after twelve hours’. I am not sure what the point of this argument is. By what process would a weakly air ascent by sustained for twelve hours in this context?

L268: What is the meaning of the comma in the expression for sedimentation flux?

L270-271: In what way would you obtain a hyperbolic term in the equations?

L292-294: The sentence beginning with ‘Note that’ should be moved to the earlier discussion on the assumptions in page 9 and 10.

L296: Do you mean equation (37) or (38)?

L299-300: Why does DEP_{RH} appears in both sides of the equation and how was the last line of (39) derived?

L315-318: I am not sure what is gained with the sentence including (41). Perhaps remove it.

L337: What is meant by ‘further increase’? Relative humidity was already decreasing. Do you mean that it increased again? Please explain and possibly rewrite.

L340: Can you give a quantified range for temperature and vertical velocity rather than saying ‘At rather high temperatures and slow vertical velocities’? Looking at Fig 5 it looks like temperature does not need to be ‘rather high’.

L353: See comment to L340.

L392: What does ‘positive attractor’ mean?

L422: Delete ‘respectively’.

L422: How was the critical point found? Was (42) used? Please explain.

L439-441: The statement beginning with ‘As indicated’ is formally correct but it could be made more precise by indicating that the bifurcation point depend on w.

L455: How are the *mean sizes* calculated?

L462-464: Please provide more details. How is the Spichtinger–Gierens model more complex than the model presented here? In what sense is it more realistic?

L479-480: The sentence is written in informal language. Please rewrite.

L487: Please qualify the assertion that ‘this holds for ALL cases of damped oscillations’. What is its observational, numerical or experimental evidence?

L502 and L516: What is mean by ‘theoretical’ and ‘theoretically determined’? Do these terms refer to the simple model or to the more complex model? Why any of these models can be considered theoretical?

L537: What do the *mean ice crystal sizes* represent? Could they be interpreted as the width, length or perhaps radius of a crystal?

L607: The sentence beginning with ‘we can proceed’ is not clear. Please rewrite.

L609: ‘Last but not least’ is informal language.

L610: It is claimed that the model presented in the article could be a prototype for a new generation of cloud parametrizations. However, for this model to be useful it would need to provide estimates of the effects that subvisible cloud formation have on the environment. This aspect has not been addressed in this paper. It would be worth expanding the discussion on this topic.

Figure 1 and Figure 2: ‘Here,…’ is informal language. Please rewrite.

Figure 7. The caption says that the median is indicated by the dashed line, but there are three dashed lines in each panel.

Figure 9. Is ms^{-1} the correct unit?