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Review of Wikipedia [Cloud Feedback](#) article [NB: article may have been edited since review]

*Review collators:* Declan Finney, Xinyi Huang

*Appendices authors:* Declan Finney, Nick Sheppard, Lucy Hinnie

*This review was produced collaboratively by researchers on the UK Natural Environment Research Council programme, [CloudSense](#).*

**CRedit statement:** **Declan Finney:** Conceptualization, Writing - Original Draft, Review collation **Xinyi Huang:** Writing - Original Draft, Review collation, **Nick Sheppard:** Writing - Review & Editing, **Lucy Hinnie:** Writing - Review & Editing

## Summary

Overall, this article is not in a very good state and may be more likely to confuse the reader than illuminate the topic. Particular issues are the incorrect focus on water vapour as the primary means by which clouds influence radiation, not correctly labelling or explaining aerosol *indirect* effects (which are the aerosol effect of most relevance to cloud feedback), and the lack of cloud feedback types and mechanisms which are key for this article. The equations are poorly defined, too complex and broadly unhelpful so we recommend a complete refocus of that content. We have provided a number of structural and targeted content changes. Once these are enacted, it may be possible to have a more nuanced discussion about that article.

## Structure

1. How clouds affect radiation and climate feedback
2. Cloud feedback mechanisms
  - a. Ceppi 2017 recommended as a reference
  - b. Incl. Possible break-up of equatorial stratocumulus clouds
3. Representation in climate models
4. Role of aerosol and aerosol-cloud interaction

## Content to remove and adapt

- Equations to be replaced with clearer/simpler text
- Considering the general readers of this wikipedia article and the complexity of the original equations, we recommend that:
  - Original equations 2 to 5 should be removed
  - Change the first equation ( $\Delta R_{TOA}$ ) to describe the cloud radiative effects ( $CRE$ )

$$CRE = R_{all-sky} - R_{clear-sky}$$

where  $CRE$  is cloud radiative effect ( $W\ m^{-2}$ ),  $R_{all-sky}$  is the radiation flux ( $W\ m^{-2}$ ) under all-sky conditions, and  $R_{clear-sky}$  is the radiation flux ( $W\ m^{-2}$ ) under clear-sky conditions where there are no clouds. (Citation: Ramanathan et al. (1989), Cloud-radiative forcing and climate: Results from the Earth Radiation Budget Experiment, doi/10.1126/science.243.4887.57)

- Add cloud feedback part of Equation 18 from Sherwood et al. (2020) here as well to introduce the feedback term and types:

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$$\lambda_{cloud} = \sum \frac{\partial N}{\partial x_{cloud}} \frac{\partial x_{cloud}}{\partial T}$$

where  $N$  is the net downward radiation ( $\text{W m}^{-2}$ ),  $x_{cloud}$  is the change in cloud characteristic (e.g. cloud cover or height), and  $T$  is the global mean near-surface air temperature (K).

- Maybe add “To summarise the meaning of the equation, the cloud feedback is the combination of the influence of cloud variation on radiation and the response of cloud to global mean temperature change. Cloud feedback is one of a number of [climate feedbacks].”

**Content to move** (if further explanation is needed that structure proposal)

- “Possible breakup of stratocumulus...” will move to “feedback by cloud type” section (or possible “role of aerosol” section”).

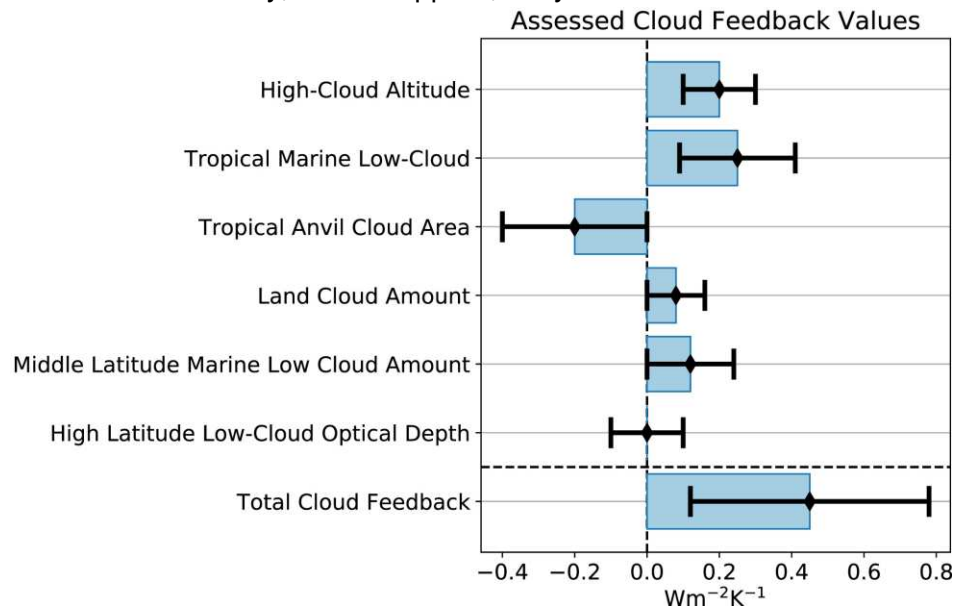
### Targeted edits

- The article incorrectly suggests that clouds affect radiation because they contain water vapour, when it’s actually because they contain liquid and ice particles
  - Intro figure caption - Remove “water vapour in the” and change “absorbs” to “absorb”
  - Intro - change “consist of water vapor” to “consist of liquid droplets and ice particles. Change “which acts as a greenhouse gas and so contributes to warming” to “which absorb infrared radiation and reflect visible solar radiation”. The existing Stephens (2005) source should be fine for the above changes.
  - “Overview” section - change “but the water vapor contained” to “but the cloud droplets and ice particles contained”. Change “but water vapor which is now inside” to “but water which is now condensed inside”.
- Correct the sulphur and aerosol section issue (“Role of aerosols” section)
  - Remove “That is known as a direct aerosol effect”: making clouds brighter is an indirect effect (3rd sentence in paragraph 1).
  - Add “These influences of aerosols on clouds are aerosol *indirect* effects, of which the famous ones are the [[Twomey effect]] and the [[Albrecht effect]] through aerosols acting as cloud condensation nuclei (CCN)” behind the first sentence in the first paragraph.
  - Follow-up with a sentence on INP: “Less well understood indirect effects of aerosols are on the formation of ice, through variation in concentrations and types of [[ice nucleating particles]]”
- Add fig showing cloud feedback by type (uncertainty range) (sherwood2020/zelinka2020 recommended).
  - Caption: Cloud feedback estimated for a selection of cloud types. Quantification of cloud feedback is an active area of research and therefore this plot only provides an example. It is taken from a key review on the topic in 2020.

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- (Intro section-paragraph 1-first sentence, rewrite as...)
 

“A cloud feedback is a [[climate change feedback]], where some aspects of cloud characteristics (e.g. cloud cover, composition or height) are altered due to climate change, and these changes then further affect the Earth’s energy balance.”
- (Intro section-paragraph 1-second sentence) Remove “On their own”
- (Intro section-paragraph 1-third sentence, rewrite the sentence as...)
 

“Whether the presence of a particular cloud cools or warms the atmosphere depends on their characteristics. Broadly speaking, the composition of a cloud determines how reflective they are, while the altitude of a cloud determines their warming effect through the greenhouse effect, with clouds at higher altitude warming the atmosphere more.”
- (Intro section-paragraph 2-first sentence, rewrite the sentence as...) “If climate change causes a change in cloud properties or coverage which increase their cooling effect relative to their warming effect, the overall cloud feedback is negative (i.e. one that reduces the amount warming).”
- (Intro section-paragraph 2-second sentence)
  - Remove “But if clouds become higher and thinner due to climate change”
  - Add “Vice versa, if they change in such a way that their warming effect increases relative to their cooling effect...”
  - The rest of the content is better to be in a new paragraph
  - New paragraph adding “There are many mechanisms by which cloud feedbacks occur. Most substantially, evidence points to climate change causing high clouds to rise in altitude (a positive feedback), the coverage of tropical low clouds to reduce (a positive feedback) and polar low clouds to become more reflective (a negative feedback) (citation: Ceppi et al., 2017). Aside from cloud responses to human-induced warming through greenhouse gases, the interaction of clouds with particles emitted through human activity (known as aerosols) are also known to affect cloud reflectivity {{citation needed}}”

Review of Wikipedia [Cloud Feedback](#) article [NB: article may have been edited since review]

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- Replace “These processes” with “Cloud feedback processes”.
- (Intro section-paragraph 3-first sentence, rewrite the sentence as...) “Cloud feedbacks are estimated using both observational data and climate models. Uncertainty in both these aspects - for example incomplete observational data or uncertainty in the representation of processes in models- mean that cloud feedback estimates differ substantially between models”
- (Intro section-Paragraph 3)“Those particular models were soon found to contradict both observations and paleoclimate evidence, and the AR6 used a more realistic estimate based on the majority of the models and this real-world evidence instead.” I think that statement is too strong; there’s no consensus here. Several studies advocate against discounting evidence from high-sensitivity models.  
<https://www.nature.com/articles/d41586-022-02241-6>  
<https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2024EF004844>
- (Intro section-Paragraph 4) “One reason why it has been more difficult to find an exact value of cloud feedbacks when compared to the others”. Poor phrasing (what does “the others” refer to?). I think they simply mean “one reason why constraining cloud feedbacks has been difficult...”
- (Intro section-Paragraph 4-third sentence) Add “through aerosol-cloud interactions” after “..., mostly making them more reflective”
- (Overview section-paragraph 1-first sentence) This sentence is long and has some inaccurate information. Edits here:
  - Finish the sentence at “the Earth’s energy budget”
  - Add “Firstly” before “they reflect shortwave...”
  - Add “- a cooling effect for the Earth” after “their high albedo” and finish the sentence here.
  - The rest of the original sentence to be replaced by “Secondly, the condensed and frozen water contained inside them absorbs the longwave radiation emitted by the Earth’s surface”
  - Add “Clouds themselves also emit longwave radiation, both towards the surface and to space. The net effect is that the presence of clouds reduces the longwave radiation emitted to space, i.e. a warming effect” (citation needed)
- (Overview section-paragraph 2-first sentence) Remove “In meteyorology”

### **General comments**

- The introduction and overview sections require substantial changes to make them more logically laid out.
- Types and mechanisms of cloud feedbacks are key to this article but not clearly and sufficiently provided. A review paper from Ceppi et al. (2017) is a good source of information for these. New content would go in the new proposed section called “cloud feedback mechanisms”.
- The last two paragraphs of the overview section are not well laid out with literature bouncing around between different or sometimes conflicting results.
- We note that whilst we have improved the equations content, more work it needed to ensure the best level of clarity. Our proposed change introduces CRE, and then moves on to cloud feedback. This may be confusing, as CRE feedback and cloud

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feedback are related but not the same (see e.g. [https://doi.org/10.1175/1520-0442\(2004\)017<3661:OTUOCF>2.0.CO;2](https://doi.org/10.1175/1520-0442(2004)017<3661:OTUOCF>2.0.CO;2)). Ideally, the text will expanded to explain the link between CRE and cloud feedback, or perhaps the CRE concept should be skipped altogether (although it is easy to understand and frequently used in the literature, so may be best kept in).

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## Appendix A: Recipe for generating a research project / programme review of an existing Wikipedia article

Required: 1 well-integrated, enthusiastic and confident researcher on a research project/programme (called Lead, hereafter)

Ideally: 1-2 experienced Wikipedia editors prepared to assist the Lead in getting useful reviews and then facilitating a workshop on editing Wikipedia, or making the edits themselves.

Tasks:

- 1) Lead and editors scope a shortlist of potentially relevant existing articles related to the expertise within the research project/programme.
- 2) Pick 1 or more articles to focus on. Things to consider include:
  - Which articles are the project researchers most likely interested/invested in?
  - Which articles require significant work (based on their quality rating and Talk page comments)?
  - Which articles are most visited or considered most important by the Wikipedia community?
- 3) The Lead should formally (through mailing lists) and informally (through contacts on the project), scope interest in Wikipedia activities. In particular they will want to identify at least 1, ideally 2 or more, volunteer(s) for each article they intend to review.
- 4) If (3) is well-received, email the project mailing list to ask for reviews of specific articles. Refer people to the guidance notes (Appendix B or similar). Emphasise that Wikipedia reviews do not need to be complete and that articles are developed incrementally—even a single comment is useful. A 2 week deadline is recommended, and targeted follow-up as required.
- 5) The Lead should keep a document for each article under review to collate suggestions and comments .
- 6) After the deadline, share the documents with the respective volunteers to combine input into a collaborative review (See review from CLOUDSENSE programme for an example approach to this). The lead may need to support the volunteers in producing a useful collaborative review. It does not need to generate all new content proposed

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in the individual review, it is about identifying targeted edits, as much as possible. A soft deadline of 4 weeks is suggested, but this should be chosen in discussion with the collators.

- 7) Once the collaborative reviews are complete, have the editors comment on if the reviews could be phrased or structured differently to make them more useful.
  - 8) Share the final draft round the project mailing list for feedback, ensuring that the project members cannot see any errors, and that everyone is happy for the project name to be put to the review.
  - 9) Publish the review on an open access archive. Then share a link along with summary and general comments to the Wikipedia Talk tab for the articles that have been reviewed. Say that targeted edits can be found at the full published document, and indicate to what extent you expect the project members will be making those edits or if you need the Wikipedia community to support with that.
  - 10) The next stage is making edits but information on that can be found elsewhere and is not academia-specific.
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## Appendix B: Guidance for academics reviewing Wikipedia articles

Any level review is useful, whether it be one comment or a more comprehensive one. Limit yourself to the time you have and the effort you can invest.

You can focus on the whole article or just a portion. Your level of experience doesn't matter: say what you think, and make clear how sure you are. Suggest changes and provide sources as much as possible.

It's a good idea to look at the Talk tab of the article to see if other contributors are discussing areas of improvement.

Aspects to consider and ideas of how to suggest changes are below. You do not have to consider all the points, review based on what is obvious to you and what time/effort you have to invest. Wikipedia [policies and guidelines](#) are available, but you can also just ask me if you are unsure.

**If you suggest a reference of which you are a co-author, please can you note that's the case. It's fine, but it's good practice to declare potential conflicts-of-interest (Col). If you think any other parts of your review might include Col, please let me know.**

### **1) Incorrect content**

- a) Propose outright removal.
- b) Propose minor edit (e.g. slight rephrasing, and suggested rephrasing given)
- c) Propose major edit (e.g. required reading to correctly rephrase sentence, and starting point references provided).

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- 2) **Citation needed** (provide citation if possible).
- 3) **Potentially useful references** (pointing to which bits of text/sections they are relevant to).
- 4) **Unclear text**
  - a) Propose outright removal - justify.
  - b) Propose minor edit (e.g. slight rephrasing, and suggested rephrasing given).
  - c) Propose major edit (e.g. required reading to correctly rephrase sentence, and starting point references provided).
- 5) **Text too verbose** (suggestions of what material is superfluous or ways the text could be made more concise).
- 6) **Missing concepts** (explanation of why additional concepts are important for a general audience, suggest initial references).
- 7) **Structure assessment**
  - a) Do the section headings encompass the subject content?
  - b) Is the ordering of sections sensible? Do they flow?
- 8) **Introduction assessment**
  - a) Is the content of the introduction (i.e. "lead") elaborated on in the main text?
  - b) Does the introduction present a clear description of the topic?
  - c) Does the introduction present a fair overview of the components of the topic that are of wider interest?
- 9) **Are there controversial aspects to this topic that are not acknowledged or not presented neutrally? How can it be improved?**