Response to community comment of Andrew Heidinger

This paper is a very thorough sensitivity analysis of SEVIRI IR brightness temperature differences. It will serve as a reference for future studies. Excellent text and high quality figures. I urge its publication and my comments should be considered optional.

Thank you for your positive feedback on our study and for taking the time to write this comment. Your insights are greatly appreciated and we value your thoughtful comments and questions.

Line 30. Many algorithms use these brightness temperature differences along with other measurements (brightness temperature of other channels, reflectances …) to retrieve phase simultaneously with other cloud properties (temperature, reff, tau). Are you saying this is necessary?

Good point, our wording was too strong. We rewrote the sentence to
"Additionally, determining cloud phase is often a prerequisite in the remote sensing retrieval of cloud properties, including τ , Reff and water path (Marchant et al., 2016)."

Figure 2. SEVIRI offers channels at 9.7 and 13.3um but they occur in absorption bands. These seem to offer different single scattering properties that add to the phase story. Do you see any benefit of their inclusion or is the atmospheric absorption too much in your opinion?

As you correctly point out, the SEVIRI 9.7um channel occurs in an ozone absorption band. Ozone variations, e.g. due to its annual cycle, the ozone hole or planetary waves, can be significant and lead to large errors in cloud remote sensing (Ewald et al., 2013). Temperature variations in the stratosphere also add to the complexity. Overall, we believe that these factors make it difficult to use the 9.7um channel for cloud remote sensing.

The 13.4um channel is easier to use in this sense than 9.7, since CO_2 is well mixed in the troposphere and its annual cycle is less pronounced (Ewald et al., 2013). As the 13.4um channel is well suited to retrieve cloud top height (e.g. using CO_2 slicing), it could be helpful to determine a CTT and to get an estimate of the amount of absorbing atmosphere above the cloud (which is important for the interpretation of the 8.7um channel). We therefore believe that the inclusion of the 13.4um channel could be beneficial.

Line 40.0 You mention Parol (1991). One of the main tools of his analysis was to convert BTDs in beta ratios which are directly linked to the single scattering properties and remove many of the temperature, optical depth dependences. Do you have a position on the use of beta ratios in cloud phase determination?

We believe that beta ratios are a very powerful tool that goes beyond BTDs as they can be directly related to microphysical quantities (phase, habit, Reff). Since more information is used to compute beta ratios (RT to compute clear sky radiances, cloud temperature...), we expect that they will be able to discriminate cloud composition better than just using BTDs without any additional information.
However, we have not worked with beta ratios and have not investigated the sensitivities and capabilities/limitations of beta ratios. Nevertheless, we believe that some of our findings could also be applied to beta ratios, in particular the physical understanding of the effects of different cloud

properties on the radiative transfer through the cloud.

Line 355, I am confused by the two statements "the single scattering properties are not CTT dependent" and "cloud emissivity is not CTT dependent (as it is a function of the absorption coefficient)". Is not the absorption coefficient a single scatter property? Emissivity is solely a function of reff and tau unless you mean the "effective emissivity" observed through brightness temperatures.

Sorry for the confusion, our wording was a bit misleading. We wanted to say that the single scattering properties do not depend on CTT and that the effects of the CTT on BTDs can therefore not be traced back directly to spectral differences of the single scattering properties. We changed the sentence in the manuscript to the following:

"Since the single scattering properties are not CTT dependent (see Sect. 2), this CTT effect on the BTDs is also not (directly) due to spectral differences in the single scattering properties - in contrast to the effects of the other cloud parameters discussed above."

Line 490. One of the big issues in satellite imager cloud phase determination is the discrepancy in cloud phase from IR and VIS/NIR approaches for mid-level clouds. Is this something you see in your analysis?

We have not looked more closely at VIS/NIR retrievals and so cannot say much about them. However, one finding of our study is that the primary link between phase and BTDs is their sensitivity to CTT, which is associated with phase. As a consequence, it is easy to distinguish high ice clouds from low liquid clouds, but difficult to distinguish mid-level ice clouds from mid-level liquid clouds. Therefore, mid-level clouds are one of the most challenging cloud types for phase discrimination using BTDs.

Line 550: Is this study only to show these dependencies or is targeted for improving or understanding a current or future cloud phase product?

This study originated from calculations made for a new phase retrieval (Mayer et al., 2024). We wanted to better understand the role of the BTDs used in the retrieval and to optimize the information content gained from them. We hope that other existing or future phase retrieval methods will also benefit from this analysis.

Overall, excellent. It might add to the story to show a compelling SEVIRI scene or two.

Thank you very much. We like the suggestion to add a SEVIRI scene to give an example of how the BTD channel combinations look like. We have added an RGB composite and the two BTDs of the same scene to the introduction.

References

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Mayer, J., Bugliaro, L., Mayer, B., Piontek, D., and Voigt, C.: Bayesian Cloud Top Phase Determination for Meteosat Second Generation, EGUsphere, 2024, 1–32, https://doi.org/10.5194/egusphere-2023-2345, 2024.