Response to comments by Referee #2

We thank the reviewer for taking the time to evaluate our manuscript and for providing constructive criticism. We have responded to each comment down below (referee comments in italic, line numbers refer to the revised manuscript):

For more than a decade, digital cameras have been widely used in Europe, North America, and Japan to monitor vegetation phenology and long-term change, but observational sites in the high Arctic have, to date, been sparse. This paper describes a relatively small network of monitoring sites in the high Arctic valley of Adventdalen on the Svalbard archipelago, which thus helps to fill that gap, although the representativeness of the Svalbard relative to the vast (global) Arctic region is unclear. The monitoring sites described feature a range of sensors including soil temperature and moisture, spectral measurements for NDVI, and visible-wavelength digital cameras. These data are potentially useful and valuable for Arctic researchers worldwide, and may spur further efforts to expand Arctic monitoring across North America and Eurasia.

We are glad to see that the importance of this work is being acknowledged.

Details of the installations are somewhat lacking. For example, the camera settings (Auto white balance? Contrast adjustment? Sharpening? JPEG compression) need to be described in greater detail.

Since we aimed for a low-cost setup, these cameras have a relatively basic function set that don't allow for much adjustment. The cameras were used with their default settings at the highest image quality setting, and no white balancing. This is now indicated in the text. See also our answer to comment #4 by referee 1.

Btw, the documentation of the cameras does not indicate whether JPEG compression was applied but from the quality of the photos we suspect this to be minimal. Contrast adjustment and sharpening are not part of the feature set of these cameras.

Unlike other PhenoCam-type networks, which have generally adopted a standard camera and configuration, the data set described here includes cameras of a variety of makes and models. Since the make and model of camera undoubtedly has an effect on the image quality, RGB sensitivity, and GCC (both in absolute terms and in its variance) (see Sonnentag et al AFM 2012), it would be helpful to have some assessment of how camera choice impacts the underlying data and data quality (this is mentioned in passing on L302). I suspect that some of the inconsistency in relationships between NDVI and GCC (L260+) could be attributed to differences in cameras and/or camera settings.

We have expanded on this text (line 329 onwards), also in response to comments by referee 1. We acknowledge that differences may arise, but we found these to be small for GCC when we ran two camera models in parallel in 2017 (GardenWatchCam and Wingscapes). The main purpose of this setup is to get a more precise estimate of the timing of phenological stages, rather than the absolute magnitude of GCC. This timing should not be very different between camera models, as others have also found (Sonnentag et al., 2012).

The image alignment routine sounds very clever and effective, but there are many other aspects of the processing which appear to require human intervention and assessment. The authors might think about how to automate some of these other quality control steps, so that as the data volumes expand over time, the requirement for human intervention doesn't become burdensome.

A more automated setup would be welcome but there is always an additional check necessary afterwards to verify that everything went ok. The current algorithm is a trade-off between the amount of time it takes to verify the image alignment and the amount of time it takes to develop a perfect algorithm with little need for supervision. For just these ten rigs, the photos can be processed in one or two days by an experienced person, which is sufficient for our purposes.

(And somewhat related to this, given that we are now in 2021, it is surprising that that data set extends only to 2018—are there plans to keep this up-to-date in the future?)

The monitoring is still ongoing, but due to equipment failure there was no data collected in 2019. The data from 2020 and onwards will be quality checked and stored in the same data repository. See also line 87.

The authors allude (L290+) to the potential to use the camera data to compare with/evaluate satellite data products – it seems that some analysis of this type could have been done here, as a concrete example, demonstrating proof-of-concept. (Note that in more temperate regions, but in some cases including Arctic sites, many previous papers have conducted this sort of analysis already: Hufkens et al RSE 2012, Klosterman et al Biogeosci 2014, Zhang et al AFM 2018, Richardson et al Sci Reports 2018, and others).

This is indeed one of the possible use cases of this setup, and a direction for future research. We have cited Hufkens et al. (2012) and Richardson et al. (2018) where relevant.

The first sentence of the conclusion – "This paper shows that ordinary RGB cameras are a promising tool to identify temporal and spatial patterns in vegetation productivity and composition at a landscape scale" — is misleading. First, one might think that this paper represents the first time that this kind of monitoring has been attempted and proven successful, which is incorrect. Second, there was no quantitative analysis of differences in productivity in relation to differences in camera-derived indices presented here; Figure 6 is entirely anecdotal. I would therefore encourage re-framing the conclusion in a way that accurately represents the novel contributions of this work.

We have changed the first paragraph of the conclusion to:

> This paper shows how ordinary RGB cameras can be used to identify temporal and spatial patterns in vegetation phenology, through both detailed information at the plot level as well as a broad overview at the landscape scale, and beyond the capabilities of current satellite products. Similar setups with Phenocams remain scarce in the Arctic, where logistical challenges due to the absence of a reliable power supply and the remoteness of field sites makes the continuous operation of field equipment challenging. Our setup resolves this issue by not only being low-cost but also low maintenance. We further show how unwanted movement by cameras can automatically be compensated for with a stabilization algorithm to achieve consistent imagery and high precision.

More generally, it seems that the seminal literature on using digital imaging to track vegetation on ≈ seasonal time scales could (should?) have been cited in various places throughout the manuscript. For example, Eric Graham's classic "Moss Cam" (Int J Plant Sci 2006) paper would seem highly relevant, even though that analysis was conducted in a more temperate setting. Likewise, with the exception of the paper by Brown et al 2016, the numerous papers that really established the viability of camera-based monitoring of vegetation (and the relation of GCC and other indices to e.g. ecosystem-scale fluxes of carbon and water and satellite-based products) by Nagai, Wingate, Richardson, Morellato and colleagues have been strangely ignored.

We thank the referee for reminding us about these papers. We have cited Graham, Nagai, Wingate, Richardson and Sonnentag throughout the manuscript when relevant (see also References).

In terms of the data set itself, I was unable to figure out how to access it (this may be my own incompetence). The landing page (https://adc.met.no/datasets/10.21343/kbpq-xb91) is informative enough, but then the catalog resource *(https://thredds.met.no/thredds/catalog/arcticdata/infranor/SnoEco/catalog.html) is cryptic. The data sets are stored as NetCDF files, which is a commonly used format, but not one I regularly use. The Java viewer that can be downloaded won't run under the current Mac OS because Java support has been discontinued. In the end, I wasn't actually able to download a file and see what was in it. While I understand the attraction of the netCDF format, it also seems that it might be easier for many data end-users if the basic arrays could also be included as flat ASCII or .csv files.*

It is unfortunate that the referee was unable to access the data. We are restricted here by limitations of the online catalog, which only allows for the storage of data in the netCDF format (it actually took quite some effort on their part to include JPEG images as well). We do hope that the website will be updated so the online viewer will also work in internet browsers without the need for Java.

Finally, we want to inform that during a final check of the database we learned that plot 2 and 4 had been switched around for the year 2018 by accident. This will be fixed in the online database. The figures in the paper have been updated accordingly.