

## ***Interactive comment on “Aerosol optical depth trend over the Middle East” by K. Klingmüller et al.***

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This is a short comment, not a full review of this paper. I am quite interested in the topic of the study and it is good to see the MODIS Collection 6 data products used in this way.

Although I know the main topic of the paper is AOD trends in the Middle East, there is some discussion, and a map (Figure 1), of trends globally. In this Figure the authors note very large positive trends (a factor of 3 or so larger than trends elsewhere) around the edge of the Aral Sea. If this trend is real, then it would certainly be an important result. Because it is such a strong result, I think it warrants some further examination, even though not the main focus of the study. I have a worry that it may be spurious and the casual reader of the paper may see it and read more in to it than is warranted.

The Aral Sea (and indeed much of that part of central Asia) is quite a difficult region

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for space-borne AOD retrievals. The terrain can be quite complicated spatially and temporally, and there is an absence of validation data sources (e.g. AERONET) over much of the region, which means that the performance of the retrievals in this area is really not well-known (and has not to my knowledge been characterised directly before).

For the Aral Sea and surroundings in particular, there is a lot of seasonal and interannual variability in the surface cover: the shorelines have changed a lot over the past decades (even over the past 15 years), there can be temporary flooding/vegetation growth, and dry salty lake beds can get very bright (strong BRDF hotspot effect). In short, characterisation of the surface reflectance in this region is quite complicated, and errors in this can lead to artefacts in retrieved AOD, often over very localised areas and for short periods of time (e.g. a dry lake bed, or surface covered by a very thin layer of water, which happens to be viewed at a geometry close to that of specular reflection). These artefacts will most likely be apparent values of high AOD (as often they mean the surface is brighter than it is assumed to be). As another complication, sharp boundaries in surface cover in low-AOD conditions can sometimes lead to false positive cloud identification (i.e. data being thrown away as cloudy when it is really not cloudy) because some cloud mask tests are based on spatial variability of observed top-of-atmosphere reflectance. This poses risks to trend analyses because, in this area, there may be step changes or trends in surface cover which are not being accounted for well and manifesting as apparent trends in AOD.

A further complication arises from the MODIS Level 3 gridding strategy. As the Level 3 data are a simple mean of Level 2 data (within a single day, then averaged), a small number of very high-biased retrievals can throw off the daily or monthly average for a grid cell, particularly if the total number of retrievals is low.

I therefore advise caution in presentation of trends around the Aral Sea. I would suggest that the authors take a look at some of the time series for the individual grid cells where they see these trends, to check whether the trends are plausible. For example a

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gradual consistent increase in AOD would be physically reasonable, while if the trend is coming from a single year or few years with AOD much higher than all earlier ones, it may be more likely the result of something like a change in surface type leading to a change in the error characteristics of the retrievals. The types of statistical tests used in these trend analyses may not always be able to identify when situations like this occur. Manual inspection of the time series may reveal individual months which stick out, at which point one can go back to daily data (either Level 2 or daily Level 3, in combination with true-colour images) to examine exactly what is going on and whether the retrievals seem realistic.

This is of course potentially an issue everywhere in the world, but our experience with the data suggests that regions of central Asia are among those where it is known to be a concern. One other thing the authors could consider doing here is to apply some threshold on the data volume within a month, to exclude poorly-sampled grid cells, since the MODIS monthly mean AOD product in such cases may not be a good representation of the true monthly mean. It would likely be a bit of trial and error to balance completeness of spatiotemporal sampling with the data volume remaining available for analysis, and I don't know whether it would help in this particular region, but it seems to me like it would be worth exploring.

The authors can feel free to contact me (Andrew Sayer, [andrew.sayer@nasa.gov](mailto:andrew.sayer@nasa.gov)) if they have questions about the MODIS aerosol products.

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