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Interactive Comment

Interactive comment on "Improved SAGE II cloud/aerosol categorization and observations of the asian tropopause aerosol layer: 1989–2005" *by* L. W. Thomason and J.-P. Vernier

Anonymous Referee #2

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This paper presents an analysis of SAGE II aerosol measurements, aimed at isolating enhanced aerosols in the Asian summer monsoon tropopause region. An aerosol layer in this region was identified in CALIPSO data by Vernier et al, 2011, and this work seeks to collaborate those findings and study interannual and longer-term variability using SAGE II. The Asian Tropopause Aerosol Layer (ATAL) described by Vernier et al, 2011, is an important new finding, and this follow-on study using SAGE II measurements (with high aerosol sensitivity and high vertical resolution) is a valuable contribution. The author team has strong experience with the SAGE II data, and probably understands these measurements better than anybody else in the world. Overall the subject and objectives of this work are valuable and appropriate for ACP, although I have some

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Interactive Discussion
Discussion Paper

detailed comments on the results that should be addressed in review.

The first part of the paper focuses on a careful analysis of the SAGE II aerosol extinction data, developing a new method to separate aerosols and clouds, based on analyzing the aerosol color ratio vs. extinction (improving upon the so-called Kent separation method). The methodology is clearly explained, and seems reasonable (although the authors acknowledge there is no perfect separation of aerosols vs. cloud-aerosol mixtures). One detail that was unclear to me was the objective of introducing the offset (delta) in Eq. 2. Is this simply intended to provide an enhanced margin for removing aerosol-cloud mixtures? The resulting 9 km climatological aerosol distributions (Fig. 7) show strong seasonally-varying patterns in the high-latitude NH, with maxima during MAM and JJA. The authors attribute these patterns to a combination of human-derived and continental aerosols (Arctic haze), without much further comment. These climatological patterns are interesting and novel (to me), but the seasonality seems curious (for example the lack of aerosols during winter, DJF). Are there previous observations which show this behavior (no other citations are referenced)? Are these patterns somehow related to the SAGE II sampling of polar regions? What do the corresponding climatological cloud patterns derived from SAGE II look like during these seasons; are there clear differences that suggest an effective separation of aerosols and clouds? Overall I suggest substantial more discussions regarding these results.

The climatological aerosol patterns at 16 km (Fig. 8) show strong maxima in the polar regions during all seasons (except for the Arctic during summer), in addition to regional tropical maxima including the ATAL during JJA. The polar maxima are identified as being related to polar stratospheric clouds (PSCs), which seems reasonable except for the precise seasonal variability. Do PSCs occur in the Antarctic during summer (DJF), or in the Arctic during autumn (SON)? These 16 km climatological patterns again make me suspicious regarding the aerosol-cloud separation; are the associated cloud patterns distinct or similar? The climatological tropical maxima seem reasonable, including the ATAL and maxima localized over Africa during the equinox seasons. The

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vertical structure (Fig. 9) identifies enhanced aerosols near the tropopause (16-17 km), very similar to the CALIPSO results. The combination of spatial and vertical structures in Figs. 8-9 are consistent with an identification of an enhanced ATAL in the monsoon region.

The final section of the paper regards examining the year-to-year variability of the ATAL based on SAGE data from volcanically quiet periods. This is a difficult task, as there are relatively few SAGE II measurements each year, especially after 2000. The results in Fig. 10 do not show evidence of an ATAL during individual years; the enhanced layer in 1999 is clearly higher ($\sim$19 km) than the tropopause, and the authors comment that it results from previous volcanic activity (perhaps the confinement in the monsoon region is similar to the Nabro observations in Bourassa et al, 2012, Science). The main year-to-year variability is interpreted from Fig. 11, which shows the aerosol extinction in the Asian tropopause region for MAM and JJA, together with the associated color ratio vs. extinction scatter plots for each year. This analysis does not discriminate the aerosols based on the new separation method used to generate the climatologies, but rather includes all measurements. Identification of an ATAL is based on an enhancement of extinction between MAM and JJA, i.e. a black curve to the right of the red curve in the extinction plots. This occurs for several individual years (with volcanic effects noted for 1999 and 2003), but is less evident for the early part of the record (1989-1990 and 1997). The individual panels in Fig. 11 are very small, and it is difficult for me to clearly see the small differences which are used to identify the presence or absence of an ATAL. Perhaps a complementary diagnostic would be to simply show the extinction curves using only data with color ratios above 2.0, to more clearly focus on aerosols alone (or to otherwise filter the data using the improved aerosol-cloud separation technique). While the results of this section are interesting, the conclusions regarding long-term changes are less easy to interpret because of the large year-to-year variability and influence of volcanic effects (in addition to the lack of observations from the early SAGE II record). This suggests less certainty regarding the (rather strong) conclusion that the ATAL is a relatively recent phenomenon, and hence of human origin. While the paper presents a very strong case for the climatological existence of the ATAL in SAGE II data, this discussion regarding trends might focus more on year-to-year variability and uncertainties, and soften the conclusion regarding long-term trends and human origin.

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