SHORT-TERM AEROSOL TRENDS: REALITY OR MYTH

Gregory Leptoukh[1] *and Viktor Zubko*[2,1]

[1]NASA Goddard Space Flight Center, Greenbelt, MD 20771
[2]Wyle IS, McLean, VA 22102

1. INTRODUCTION

Assessments of human impact on climate change have been attracting much of attention in recent years. One of the main aspects is assessing change in aerosol emissions for studying direct and indirect effects of aerosols on the Earth atmosphere radiative budget and changes there in [1]. And vice versa, it is important to assess even short-term changes in air pollution strength and patterns to understand climate change effect on humans and their activities.

MODIS sensors onboard Terra and Aqua, the NASA EOS satellites, have been successfully measuring aerosols from space for almost a decade. Despite this short (from the climate change perspective) temporal span, it is tempting to analyze spatial patterns of the short-term variations to identify areas with steady increase or decrease in measured aerosols [2, 3].

2. POSSIBLE CAUSES FOR HIGH TRENDS

The computed maps of monthly anomalies short-term trends exhibit interesting spatial variability with some contiguous areas seemingly showing significant positive or negative trends (Fig 1, upper maps). The corresponding percent change per year values reach 10% and even more in some areas. How can this be? Is it real?

There are various possible causes for observing high monthly aerosol trends in some areas (computed by using individual month anomalies, e.g., all Junes): It can be real, i.e., there are new sources of aerosol loading or increase in old sources: more and stronger dust storms (due to climate change); wider and stronger fires, more pollution from factories and traffic, etc., which is of real interest. Or it is artifact of trend calculation or changes in non-aerosol factors but attributed to aerosol trends.

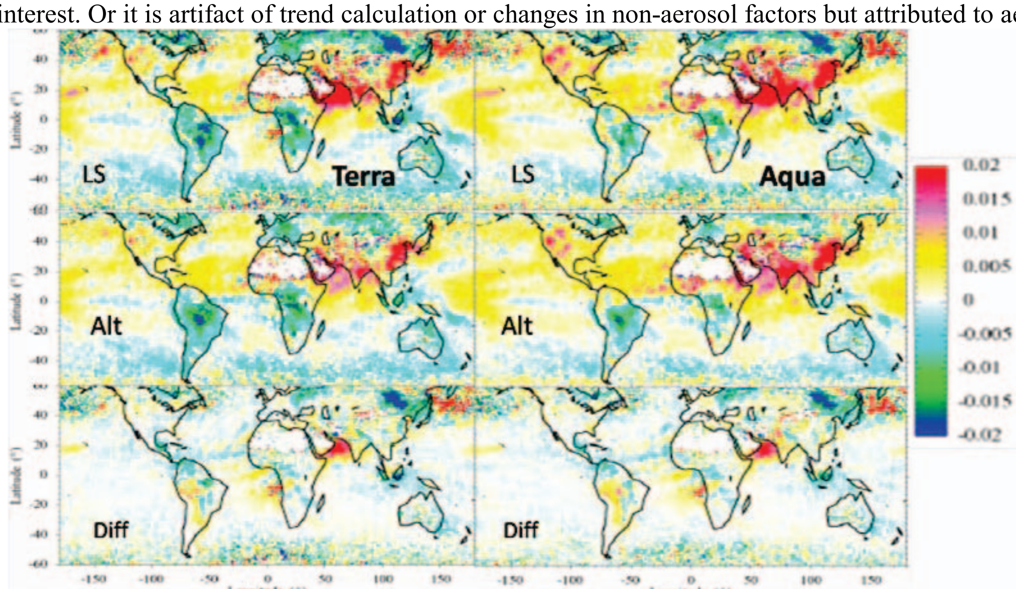

Fig 1. Maps of MODIS AOT anomaly linear trends: left panel is for Terra, right is for Aqua. The upper trend maps calculated using Least Squares (LS) linear fit, the middle maps are trends calculated using alternative (Alt) method for linear fit, and lower maps are difference between LS and Alt.

3. SENSITIVITY TO LINEAR FIT CALCULATION

We analyzed various potential causes, starting with linear fit calculation assessment. In fact, the Linear Squares (LS) linear fit calculation is known to be quite sensitive to outliers. And our analysis shows that there were exceptional aerosol events in some areas (beyond any monotonous yearly change) that led to high trend values.

We used an alternative (ALT) more robust method of linear fit slope calculation based on Kendall nonparametric statistics. The resulting maps (middle portion of Fig 1) show lesser number of high trend areas. The lower maps in Fig 1 show the difference between LS and ALT methods that in most cases can be attributed to exceptional events.

4. TEMPORAL AND SPATIAL SHIFTS IN METEOROLOGY

However, even with alternative calculation, some high trend areas remain (middle maps in Fig 1). Our analysis shows that in some areas, when computing monthly trends, especially without using running means, these spurious trends are related to temporal and/or spatial shift in meteorological factors affecting aerosol transport. For example, a temporal shift of typical seasonal high loading event to the next or the previous month may lead to appearance of a significant monthly anomaly or an outlier. If this forward shift happens early in the period or aerosol time-series, then the corresponding fictitious trend is negative and rather high. This kind of a temporal shift might be sporadic or may be due to a more interesting effect of shrinking or expanding of season duration (for example, earlier spring offset).

If there is a spatial shift in high aerosol event location, i.e., an event still happens the same month every year but at a different location, then a significant temporal trend can be found using LS linear fit. The ITCZ is a good example –with the well-known seasonal shifts in ITCZ latitudinal location, even small interannual variations due to El Nino lead to shifts in wind patterns, and therefore in aerosol locations. If this shift is not taken this into account, a straightforward time-series trend calculation may lead to significant ghost trends due outliers in fixed locations.

There could be other sources for trend misidentification, e.g., more clouds being mistaken for aerosols due to sensor or retrieval artifacts (changes in calibration or algorithm, or cloud fraction).

5. CONCLUSIONS

Studying maps of aerosol trends allows clearly identify regions with different regimes of aerosols changes. Their temporal trends are more pronounced compared to those in predefined regions (like those in [3]) where two opposite regimes may cancel each other.

The usual Least Squares linear trend calculation in some areas leads to misleading trends due to LS trend sensitivity to outliers. An Alternative robust trend computation allows eliminating some areas with spurious events. Using differences between LS and Alt linear trends, it is possible (to a certain extent).identifying anomalous (outlier) events. Using relative vs. absolute anomaly trends allows identifying areas with significant changes. In some areas, the relative change can be up to 10% per year for the LS and Alternative linear trends.

These areas exhibit collective or correlated behavior, i.e., within a certain radius of correlation, all the cells tend to have very close slopes. It can be illustrated by PDF of slopes for three representative cases: positive trend, negative trend, and “random” or undefined. In many cases, these areas are due to temporal and/or spatial shifts in meteorology not in aerosol loading.

The main conclusion is that aerosol trends in some areas are real while might be attributed to other causes elsewhere.

6. REFERENCES

[1] IPCC, “Climate Change: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,” [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp, 2007

[2] Mishchenko, M., I.V. Geogdzhayev, B. Cairns, B.E. Carlson, J. Chowdhary, A.A. Lacis, L. Liu, W.B. Rossow, and L.D. Travis, “Past, present, and future of global aerosol climatologies derived from satellite observations: A perspective,” J. *Quant. Spectroscopy & Radiative Transfer* ***106***, pp. 325-347, 2007

[3] Remer L. A., et al., “Global aerosol climatology from the MODIS satellite sensors,” *J. Geophys. Res.*, **113**, D14S07, 2008