Detection of Desert Dust Aerosol using S5P DOAS Observations

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Andreas Richter, Kezia Lange, and John P. Burrows
Email: Andreas.Richter@iup.physik.uni-bremen.de
Institute of Environmental Physics/Remote Sensing, University of Bremen, FB 1, P.O. Box 330440, D-28334 Bremen, Germany

sentinel-5p

1 Introduction

What is Desert Dust?
- Wind blown particles from deserts and dry lands
- Europe sometimes affected by dust from Sahara
- Export from Sahara to the Atlantic and towards South America
- Gobi desert as another large source

Relevance of Desert Dust
- Health + visibility, mainly close to sources
- Radiative forcing through absorption and reflection
- Nucleation of ice and droplets
- Surface for heterogeneous chemistry
- Tracer in sediments

Observations from space through
- RGB images
- AOD (aerosol optical depth)
- AAI (absorbing aerosol index)

2 Surface Sand / Soil Signatures

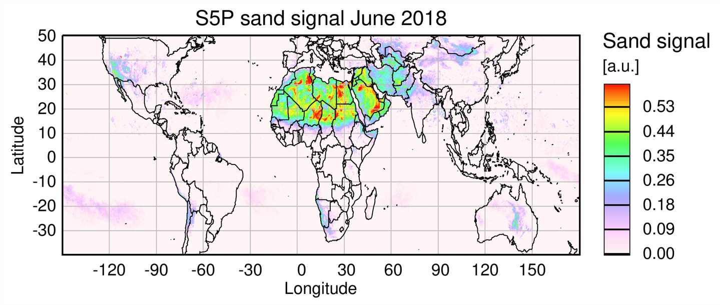

Figure 1: Global map of sand signal in S5P NO_2 fits for June 2018. All desert regions show high values as for other sensors such as GOME-2 and OMI

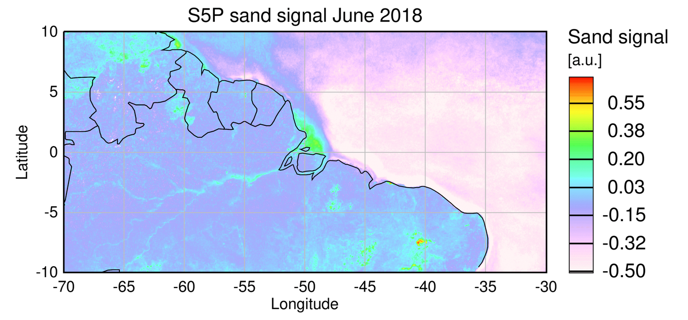

Figure 2: Zoom on the Amazonas region. The river as well as the delta are clearly visible, presumably because of suspended matter transported in the water.

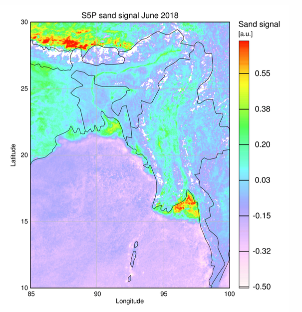

Figure 3: Zoom on Bangladesh, India, Myamar. All river deltas are clearly detected, as well as the Brahmaputra river and water bodies in Myamar. Higher values are also seen over India.

Sand signatures in NO_2 fits
- NO_2 fits using a large fitting window (425 - 497 nm) show larger than expected residuals over deserts
- This can be compensated by using a large order polynomial
- Alternatively, an empirical cross-section derived from GOME-2 observations over deserts can be included in the fit
- The fitting parameter of this "sand" cross-section gives a good representation of deserts in the world

Comparison with other observations
- Similar signatures were found in retrievals of other satellite sensors, aircraft observations over sand and in sand storms
- Direct measurements of light reflected from desert sand show similar spectral structures

Additional signatures
- Zooming into S5P observations provides evidence for "sand"-signals in large (and muddy) rivers as well as over delta regions with large amounts of suspended matter

Acknowledgements

- Funding by the University of Bremen and through DLR Bonn are acknowledged
- Copernicus S5P lv1 data were used for the desert dust retrievals
- Copernicus S5P UV Aerosol Index data were used

3 Desert Dust Detection

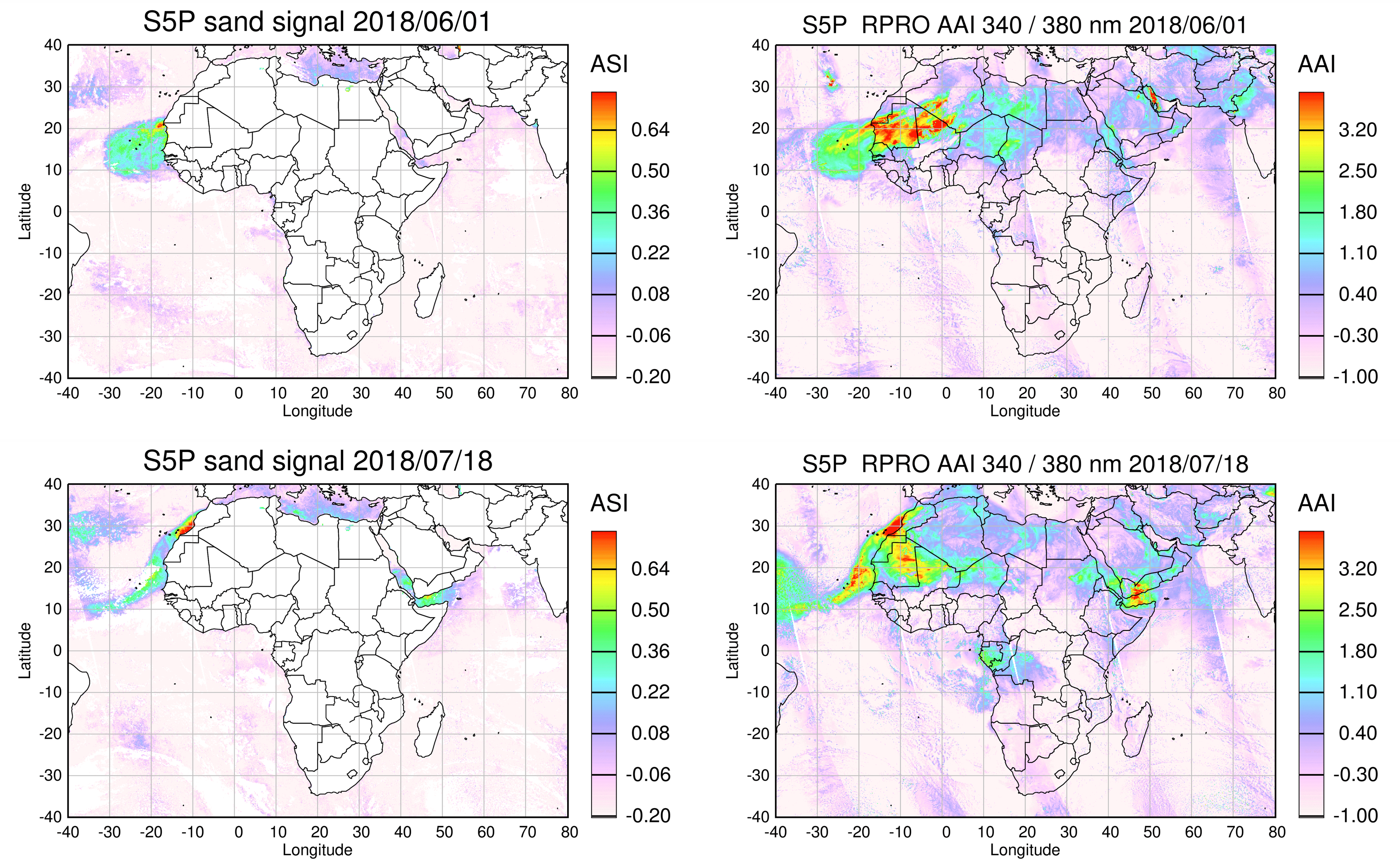

Figure 4: Examples of desert dust detection over the ocean. Left: sand signature in S5P NO_2 fits, right: operational S5P UVAI. No screening for clouds or sun glint has been performed on the UVAI while a weak cloud screening was applied to the sand signal.

Desert Dust signal over ocean
- over ocean, desert dust outbreaks are clearly detected in S5P sand signal
- there are very little "wrong positives" from sun glint or clouds
- artefacts appear over certain oceanic regions for some geometries
- patterns agree well with UVAI signal

watch animation

Desert Dust signal over land
- over land, the signal is dominated by surface features
- if a minimum sand signal background map is created over a time window of +/- 15 days and subtracted from daily data, some large desert dust outbreaks can also be seen over land
- the background map also removes most of the artefacts over the ocean
- however, the minimum sand signal depends on viewing angle (BRDF effect of desert surface)
- more elaborated correction schemes might be needed to improve detection
- the reason why only some events are detected and why the relative intensities do not always agree with UVAI data are still unclear

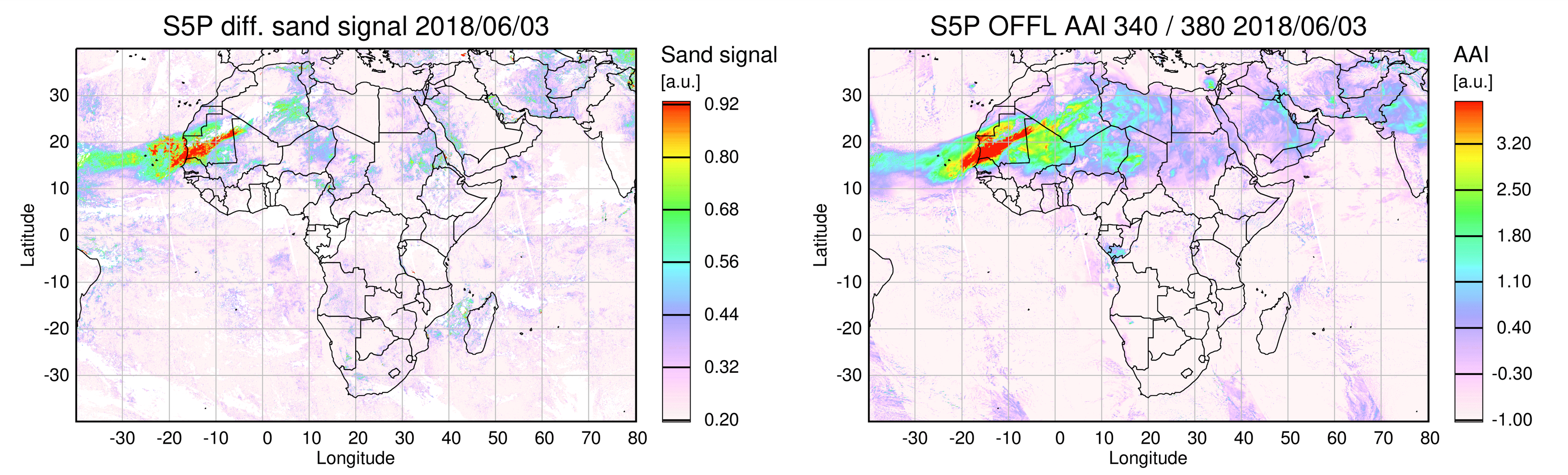

Figure 5: Comparison of background corrected sand signal from S5P NO_2 fits (left) with S5P operational UVAI data.

4 Synergestic use with UVAI

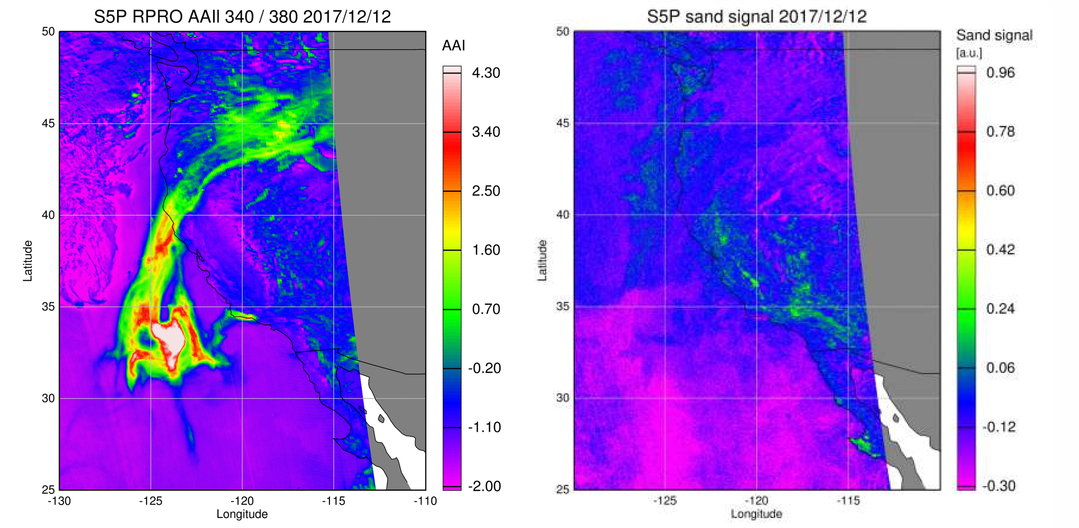

Figure 6: UV absorbing index signal (left) and sand signal (right) in S5P data on December 12, 2017. On that day, a large plume of biomass burning was detected over the ocean by the UVAI but no signal was found in the sand fit.

Separation of desert dust and biomass burning aerosol
- both desert dust and biomass burning aerosol are strongly absorbing in the UV
- for the UVAI, they both look similar
- in the desert dust signal, aerosol from biomass burning does not create any signature
- synergistic use of UVAI and sand signal could provide information on aerosol composition

5 Summary & Conclusions

- Sand / soil signatures found im NO_2 fits from other sensors are also visible in S5P data
- The largest fit coefficients are found over salt lakes
- The surface signal can also be seen over
  - Large and muddy rivers
  - River deltas
  - Other bare soil regions
- Desert dust storms can be detected well over water showing good consistency with UVAI
- As detection is sand specific, there is potential for synergy with UVAI
- Detection over land is also possible for large dust storms by subtracting the background signal, but larger uncertainties remain
- Background signal depends on viewing angle (surface BRDF effect)
- So far, this is not a quantitative but rather a flag-like product

Selected references

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