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Explicit measurements-based aerosol correction for OMI HCHO retrievals

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Uncertainties in trace gas retrievals

- Although trace gas retrievals have improved over the last decades, there is still a need for a more complete understanding of the uncertainties in retrievals.

AMF uncertainty (%)

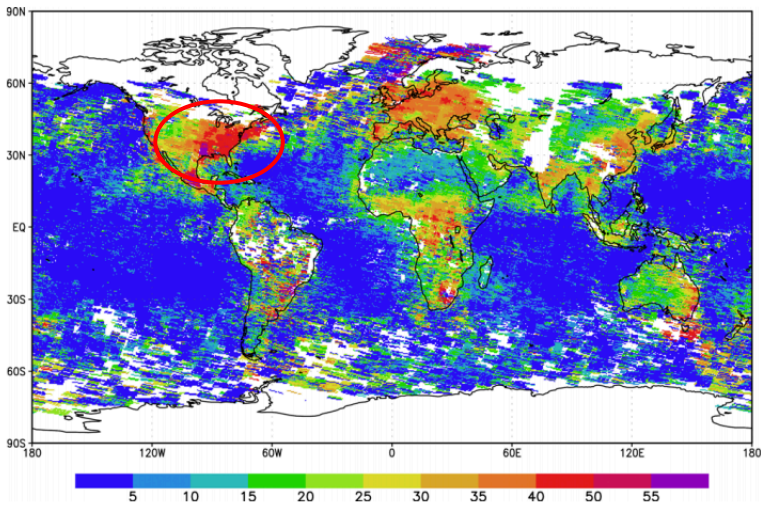


Figure 10. Uncertainty (%) in the tropospheric air mass factor for March 1997 due to uncertainties in the cloud fraction, cloud height, surface albedo and profile shape. Only pixels with a cloud radiance fraction <0.5 were taken.

Mean NO_2 column

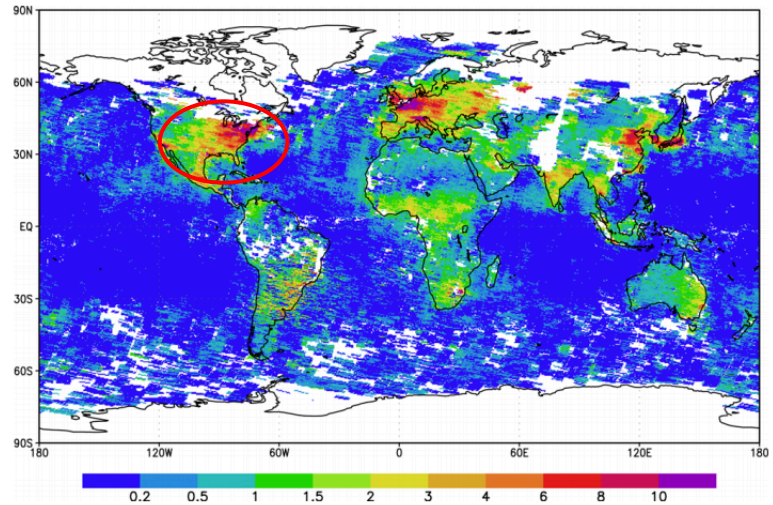


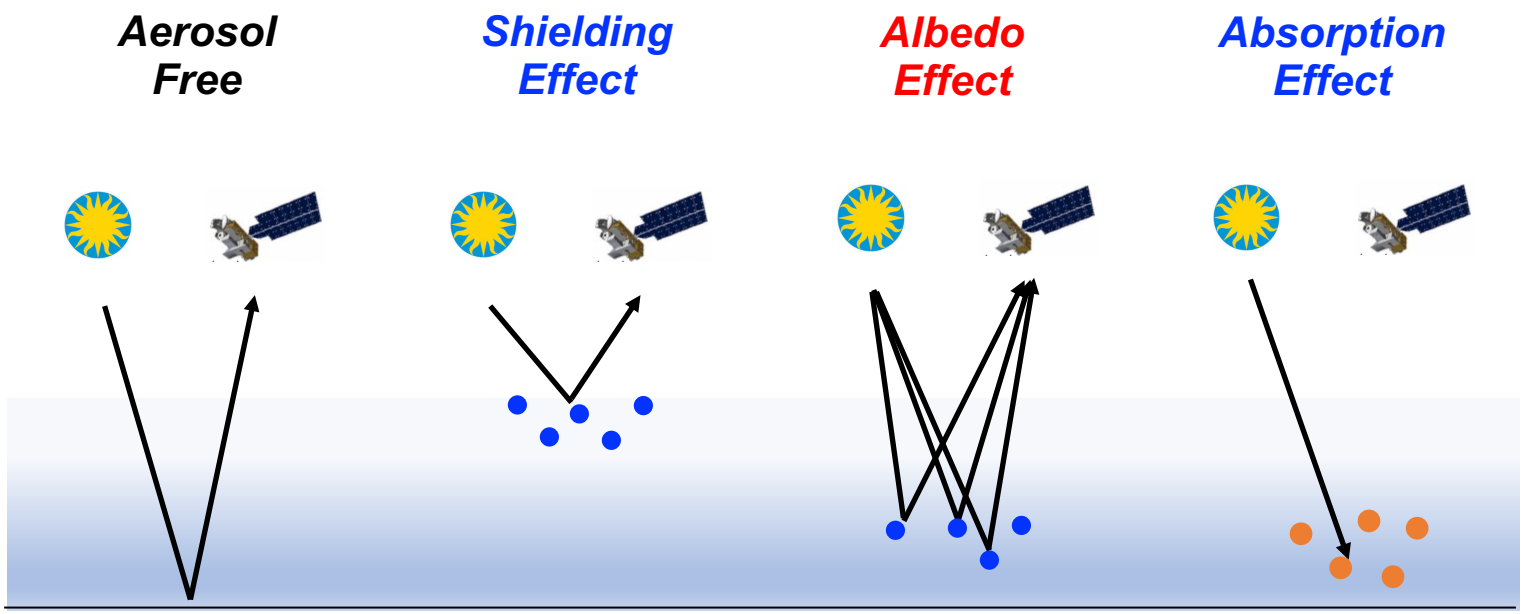
Figure 11. Monthly mean tropospheric columns for March 1997. Only pixels with a cloud radiance fraction <0.5 were taken.

Boersma et al. (2004)

- Aerosols have the biggest impact on AMF calculation among many factors that cause the retrieval uncertainties (Martin et al., 2002).

Aerosol impacts on trace gas retrievals

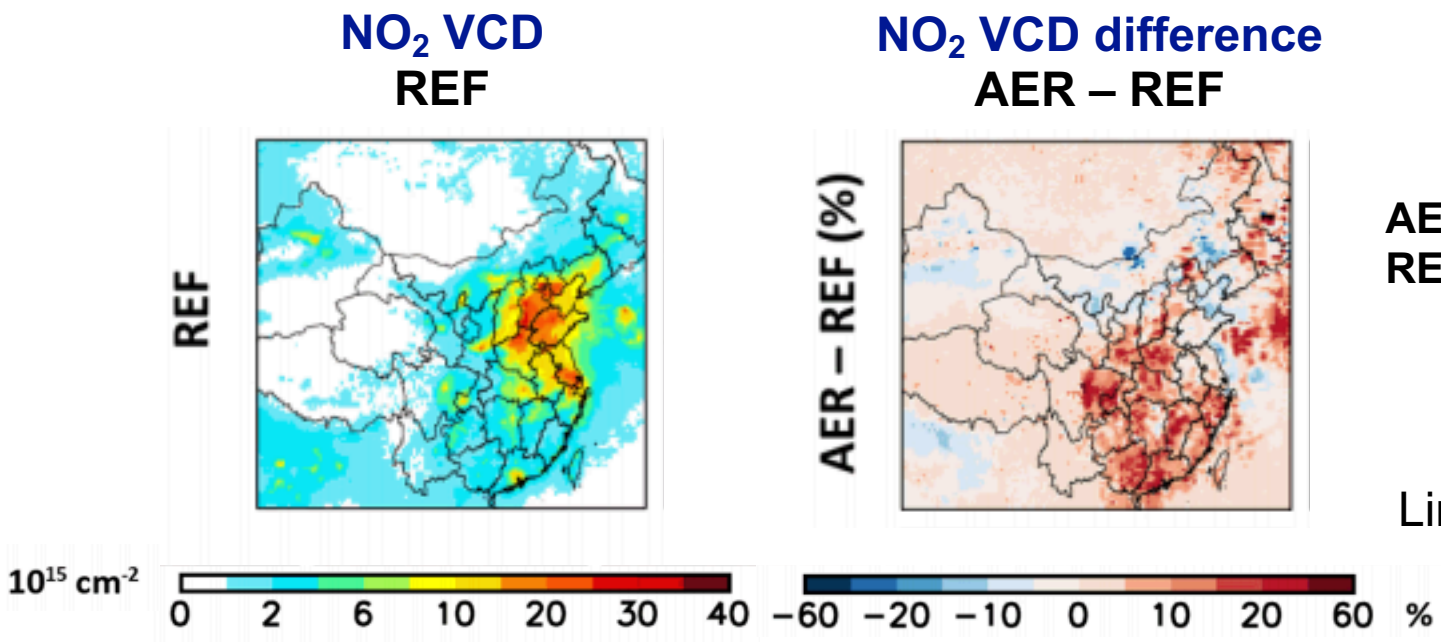
- The presence of aerosols can change the individual light path lengths in three ways (Leitao et al., 2010):



Cooper et al. (2018)

Previous aerosol corrections

- Operational algorithms currently do not include explicit aerosol corrections.
- "Implicit" cloud product correction does not apply for high AOD and strongly absorbing aerosols (Castellanos et al., 2015; Chimot et al., 2016).



AER: implicit
REF : explicit

Lin et al. (2015)

In this study, we focus on HCHO retrievals with an explicit aerosol correction using OMI observations.

Approach

GOME Ozone Profile Climatology

Aerosol Optical Properties
(OMAERUV)

Radiative Transfer Model
(VLIDORT)

OMI Aerosol Products (OMAERUV)
Aerosol Information
(Aerosol Type, AOD, SSA, ALH)

Simulation Conditions
(Geometry, Surface Pressure,
Surface Albedo, Aerosols)

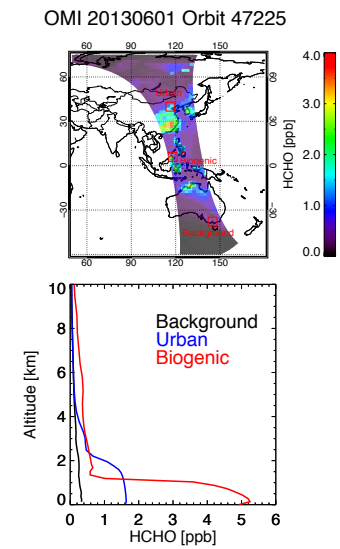
Look-Up-Table of
Aerosol-corrected Scattering Weights
~f (Geometry, Surface pressure and albedo,
Aerosol Type, SSA, AOD, ALH)

Aerosol-corrected
Scattering Weights

OMI HCHO Products (OMHCHO)
(Geometry, Gas profiles, SCDs,
Cloud and Surface properties,
Pressure level grid)

Aerosol-corrected HCHO AMFs
Aerosol-corrected HCHO VCDs

GEOS-Chem HCHO Climatology
at surface level
OMI orbit 47225 (June 1st, 2013)



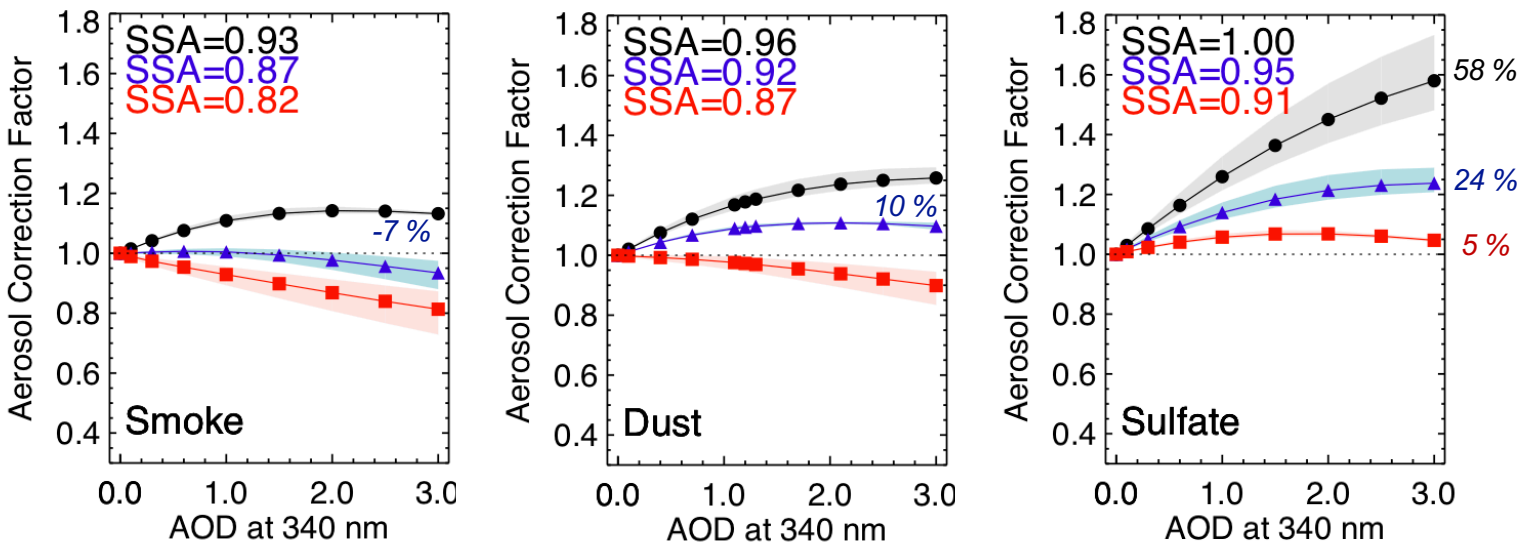
AMF Sensitivity Test

Aerosol Optical Depth (AOD)
Single Scattering Albedo (SSA)
Aerosol Layer Height (ALH)

AMF sensitivity to aerosol information

$$\text{Aerosol Correction Factor (ACF)} = \frac{AMF_{aer}}{AMF}$$

AMF sensitivity depends on their absorptivity



- Sulfate aerosols almost always cause an increase in the AMF while dust and smoke aerosols can either increase or decrease the AMF.

Reference condition

SZA = 30º, VZA = 15º, RAA = 60º
Albedo = 0.05
ALH = 1 km (Smoke/Dust), Surface (Sulfate)
SSA = 0.87(Smoke), 0.92(Dust), 0.91(Sulfate)

Shade region means the ACF range for three representative HCHO profiles

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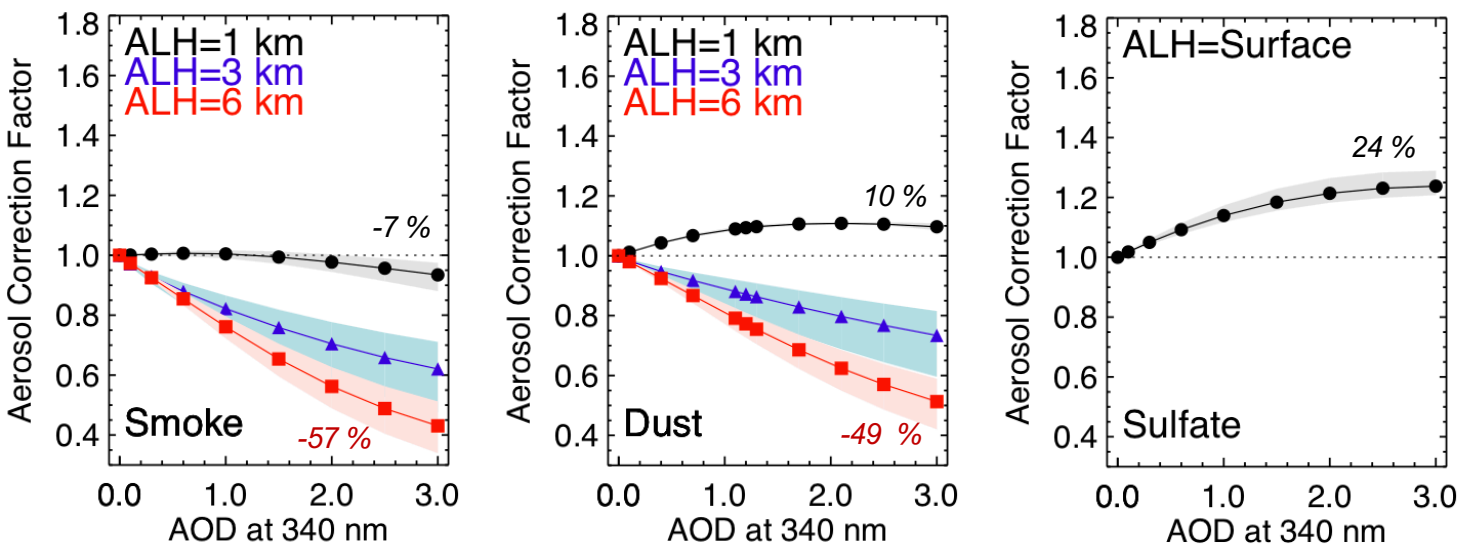
AMF sensitivity to aerosol information

$$\text{Aerosol Correction Factor (ACF)} = \frac{AMF_{aer}}{AMF}$$

AMF sensitivity depends on aerosol layer height



Reference condition

SZA = 30º, VZA = 15º, RAA = 60º

Albedo = 0.05

ALH = 1 km (Smoke/Dust), Surface (Sulfate)

SSA = 0.87(Smoke), 0.92(Dust), 0.91(Sulfate)

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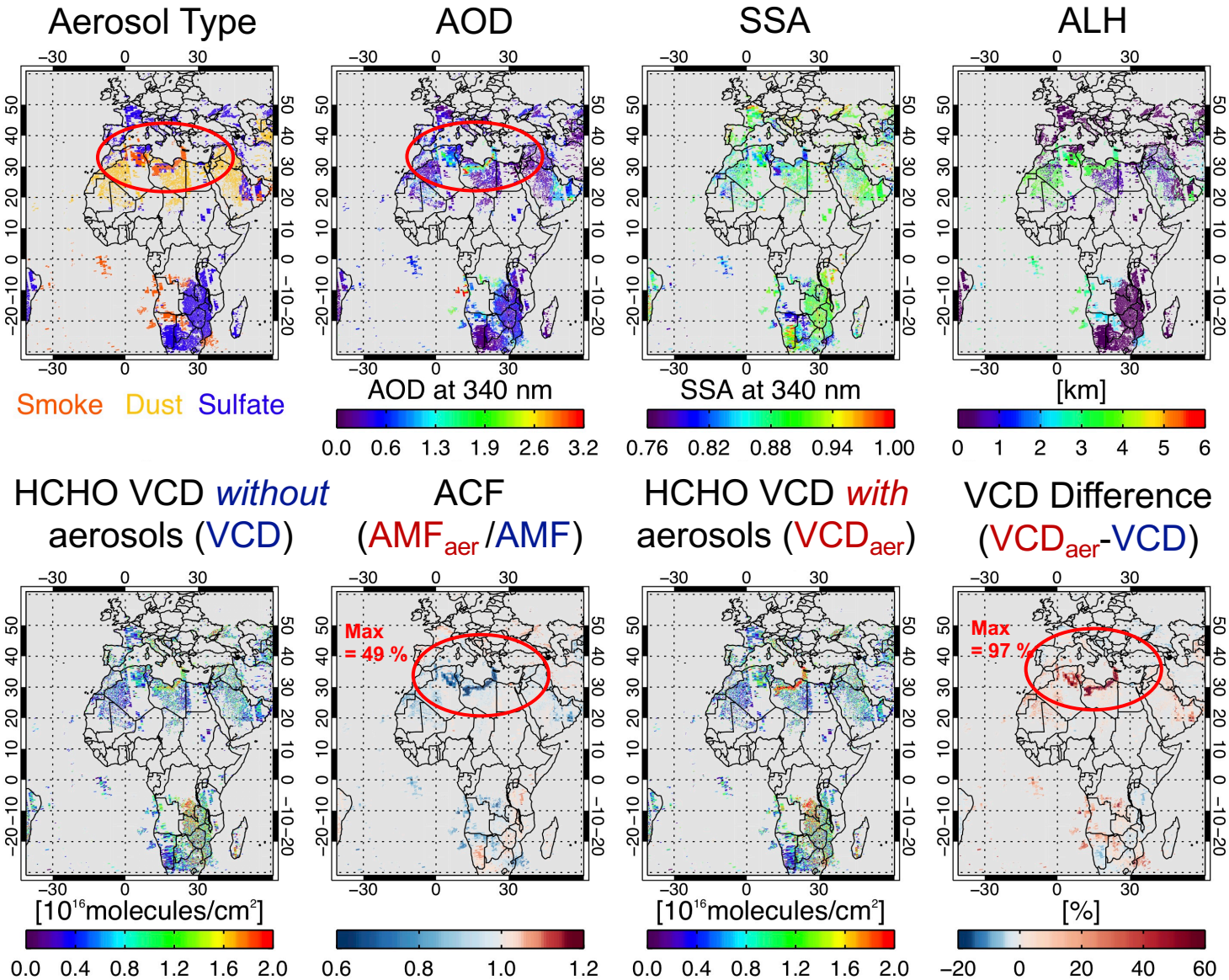
Example Case: Impact of absorbing aerosol over Sahara

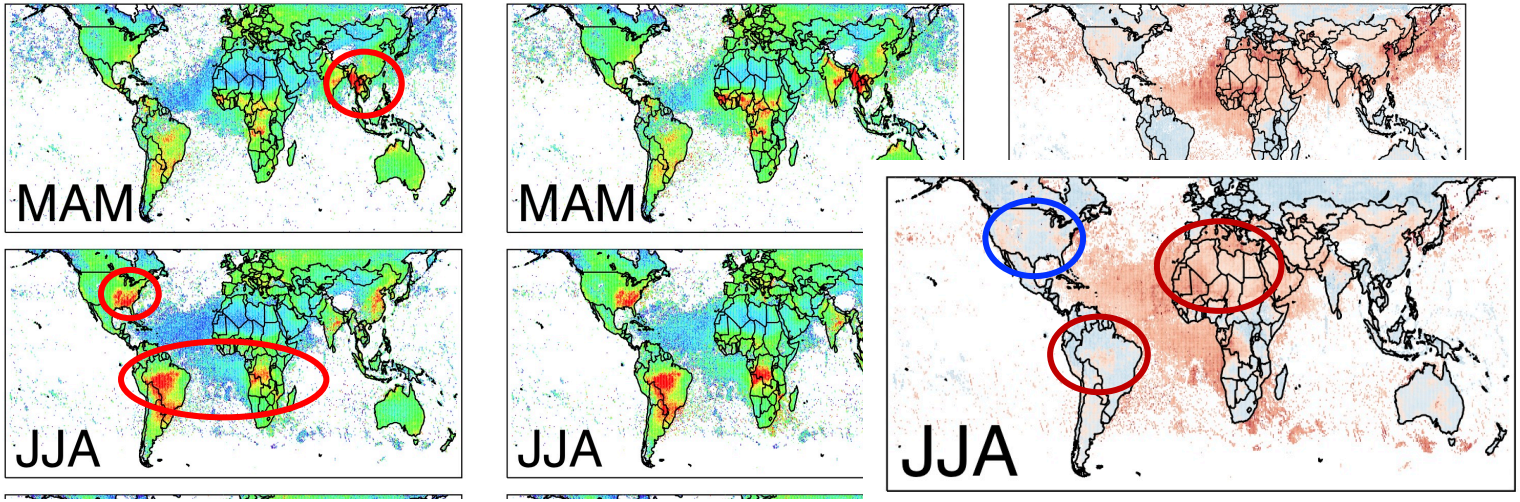
27th August, 2007



Use only OMAERUV with Quality Flag=0 (Most reliable retrievals for AOD and SSA)

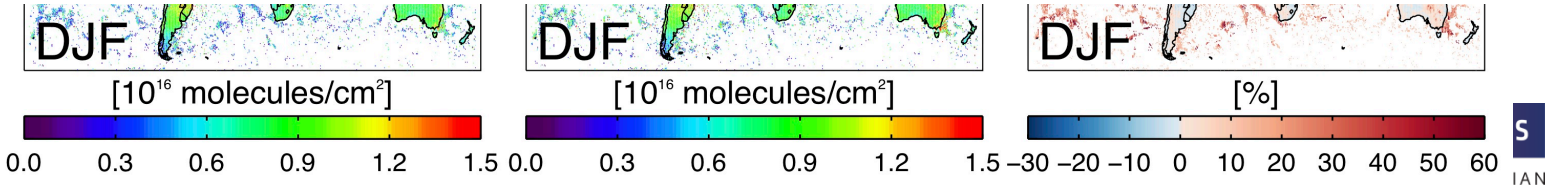
Seasonal aerosol-induced HCHO VCD Difference

without aerosols (VCD) | *with* aerosols (VCD_{aer}) | VCD Difference (VCD_{aer}-VCD)

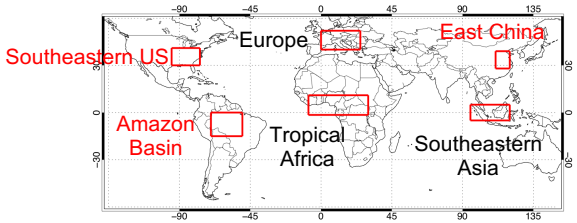


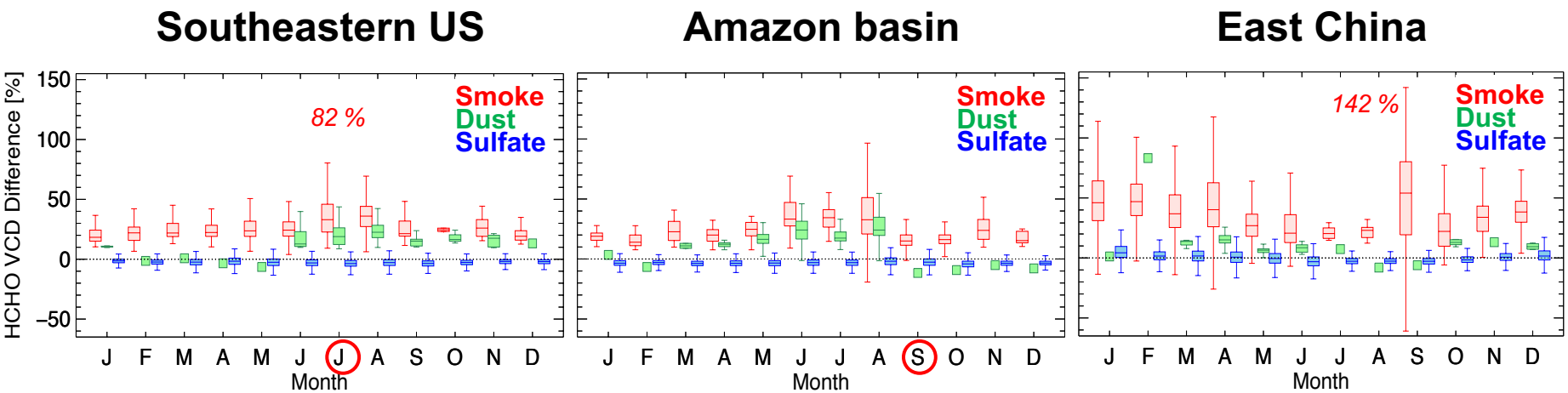
- Over Amazon and Africa, the VCD difference shows a high variability and increase by absorbing aerosols.

- Over the southeastern US, sulfate aerosols contributes very weakly to increasing or decreasing AMF so that the VCD difference does not show much change.



Regional aerosol-induced HCHO VCD difference





- Excluding the aerosol effect underestimates HCHO VCDs by an average of 27 % by smoke aerosols and 6 % by dust aerosols.
- Sulfate aerosols generally have the smallest effect, decreasing HCHO VCDs by 0.3 % on average globally.

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Summary

- We implemented an explicit aerosol correction for AMF calculations in the OMI HCHO retrievals with OMI aerosol information.

- Aerosol correction results applied on OMI products show that for absorbing aerosols the aerosol-induced VCD difference shows 27 % and 6 % for smoke and dust, respectively, while sulfate aerosols shows -0.3 % on global average.

- In the future, this explicit aerosol correction will be implemented in the OMI HCHO operational products to provide error budget.

- The detailed information of this study can be seen in Jung et al. (2019), *in revision*.

Thank you for your attention !