Retrieval of CHOCHO using observations from the IUPB and BOKU MAX-DOAS instruments

Second Cabauw Intercomparison of Nitrogen Dioxide Measuring Instruments

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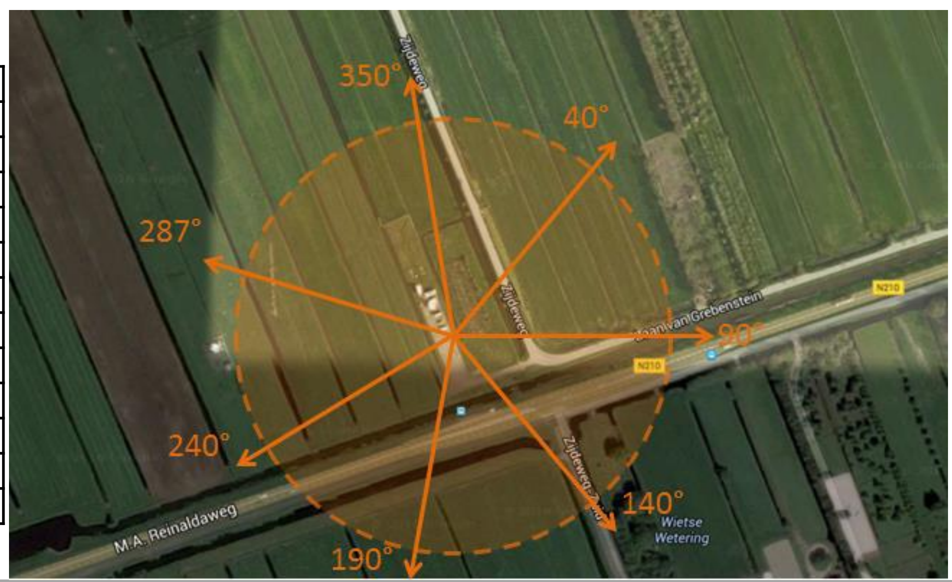
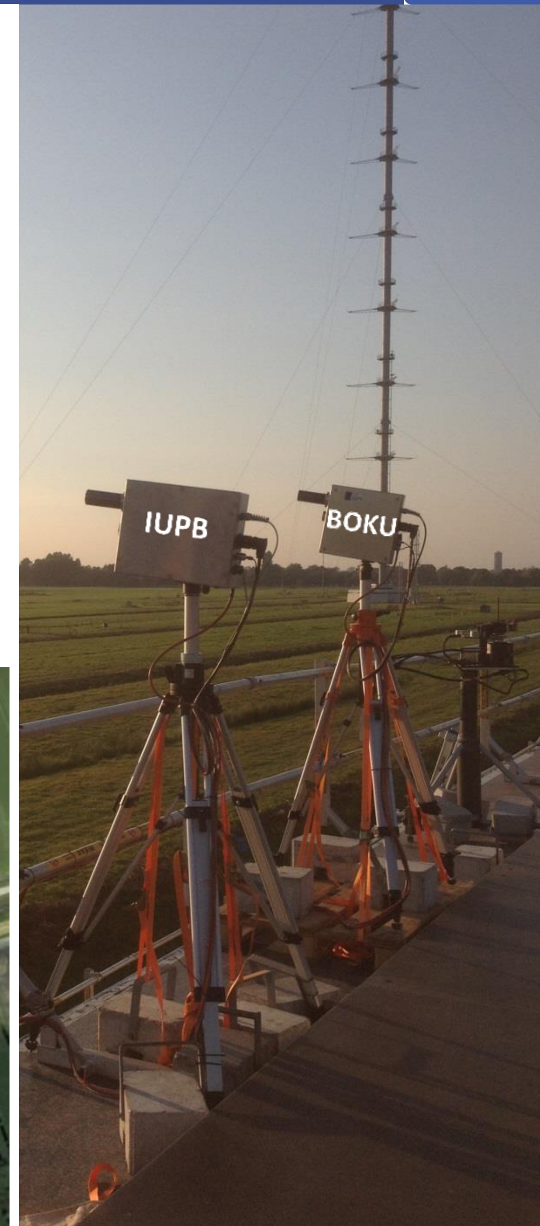
Instrument Characterization

	BOKU (CINDI-2.06)	IUPB (CINDI-2.18)
Measurement period	7 Sep - 28 Sep	8 Sep - 29 Sep
Spectrometer	Acton Standard Series SP-2356	Acton ARC500
Wavelength range	418-553 nm	407-579 nm
FOV	0.8°	0.8°
Spectral resolution	0.75 nm	0.8 nm
Detector	PIX100B-SF-Q-F-A (-60°C)	Princeton NTE/CCD-1340/400-EMB (-30°C)

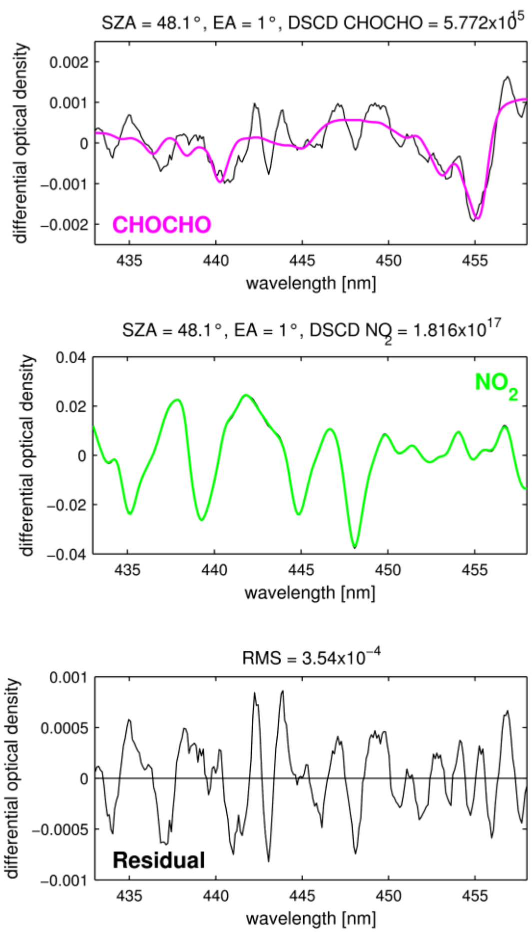
Azimuth	File-character
287 / zenith	_
287	S
355	T
45	U
95	V
145	W
195	X
245	Y
287 / horizon	Z
almucantar	A
30° test	R
dark	N





CHOCHO retrieval settings / examples

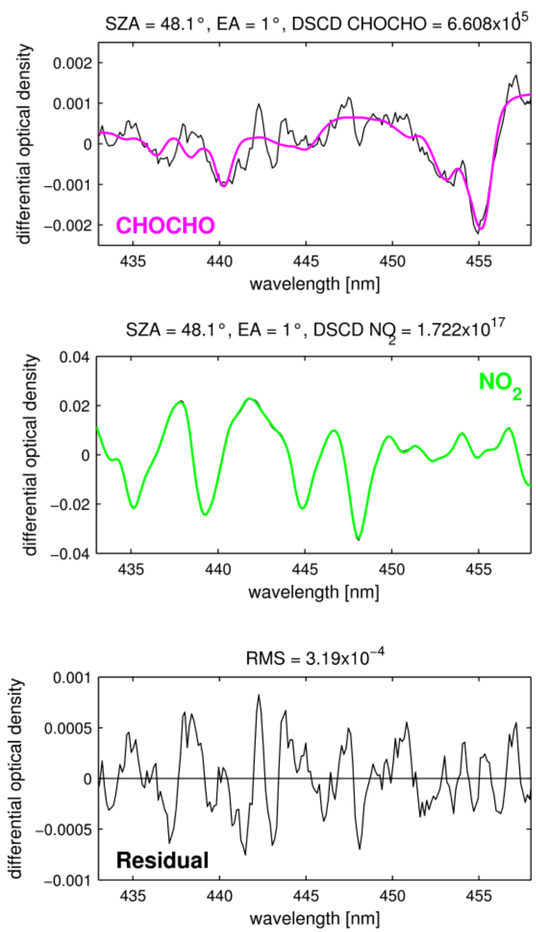
BOKU



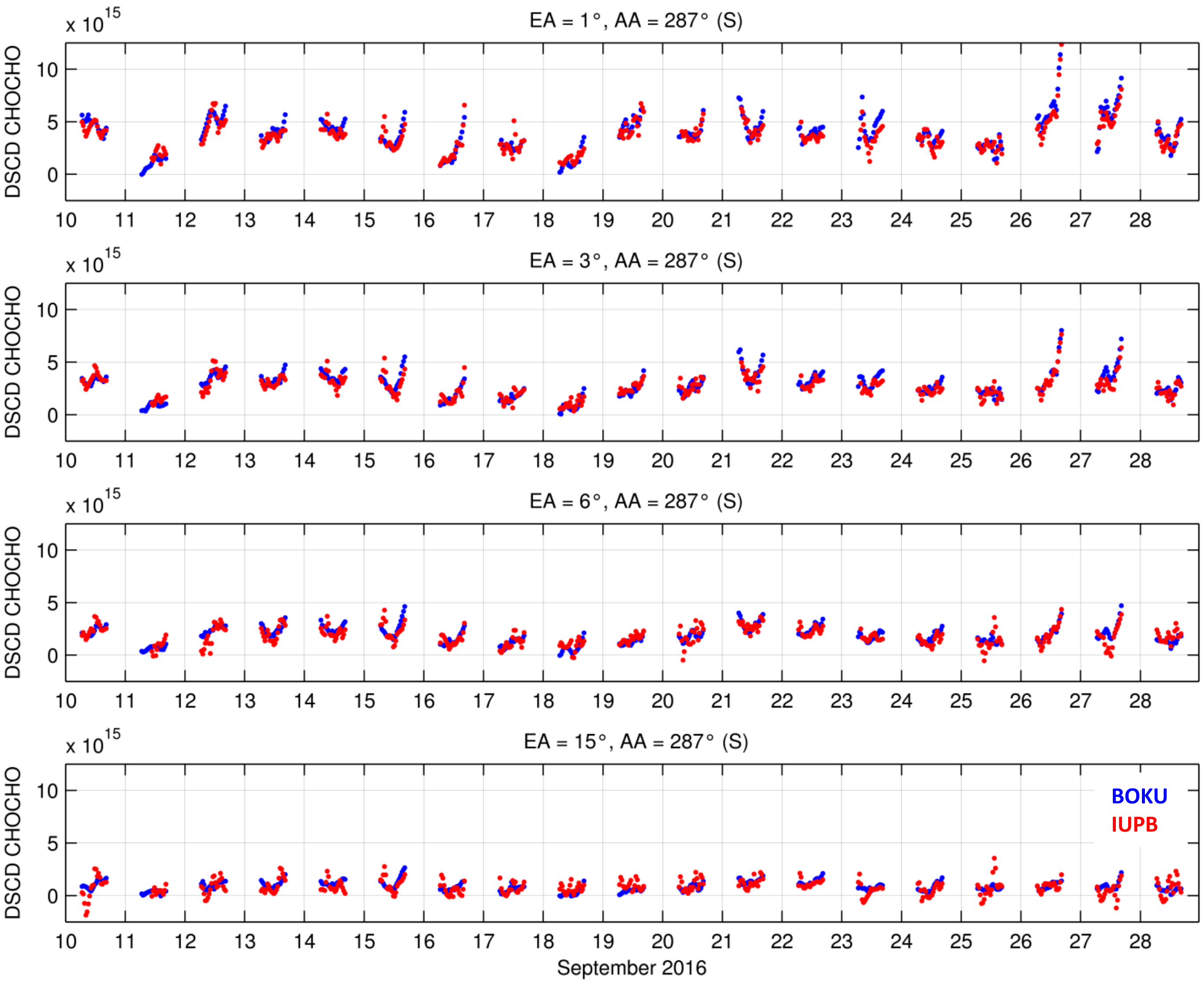
Fit parameter		Selection/Source
Spectral range		433-458 nm
Polynomial		Order 5
Wavelength calibration		Solar atlas (Kurucz et al., 1984)
Reference		Sequential zenith spectrum
Cross section	**Temp.**	**Data source**
O_3	223 K	Serdyuchenko et al. (2014) (I_0 corr.)
NO_2	298 K	Vandaele et al. (1998) (I_0 corr.)
	220 K	Vandaele et al. (1998) (I_0 corr.)
O_4	293 K	Thalman and Volkamer (2013)
CHOCHO	296 K	Volkamer et al. (2005)
H_2O	296 K	Rothmann et al. (2010)
Ring	-	QDOAS

- consistent fit residuals
- overall good agreement for glyoxal
- IUPB CHOCHO is 10-15% higher than BOKU CHOCHO
- for NO_2, only about 5% relative difference

IUPB

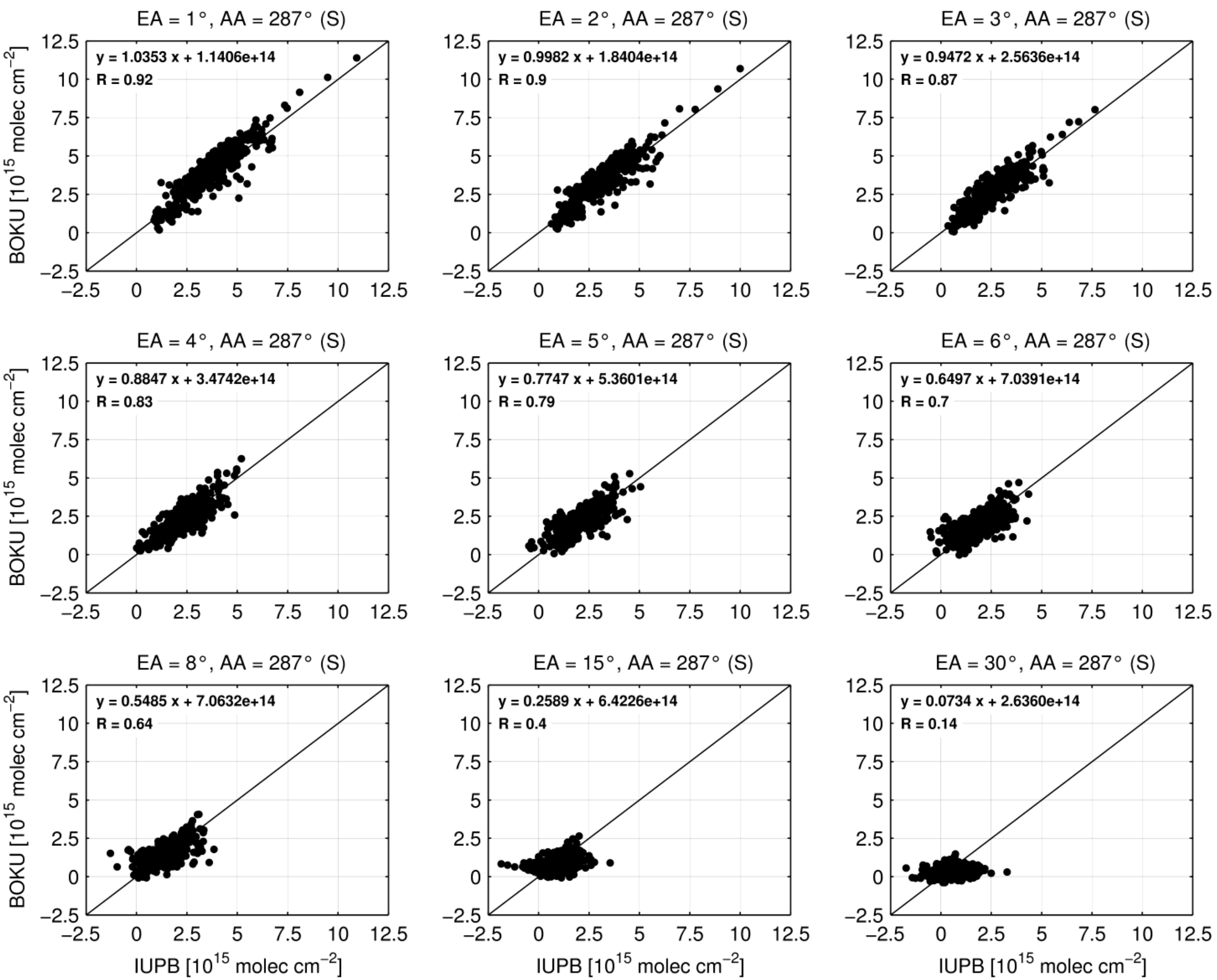


Slant column intercomparison (time series)



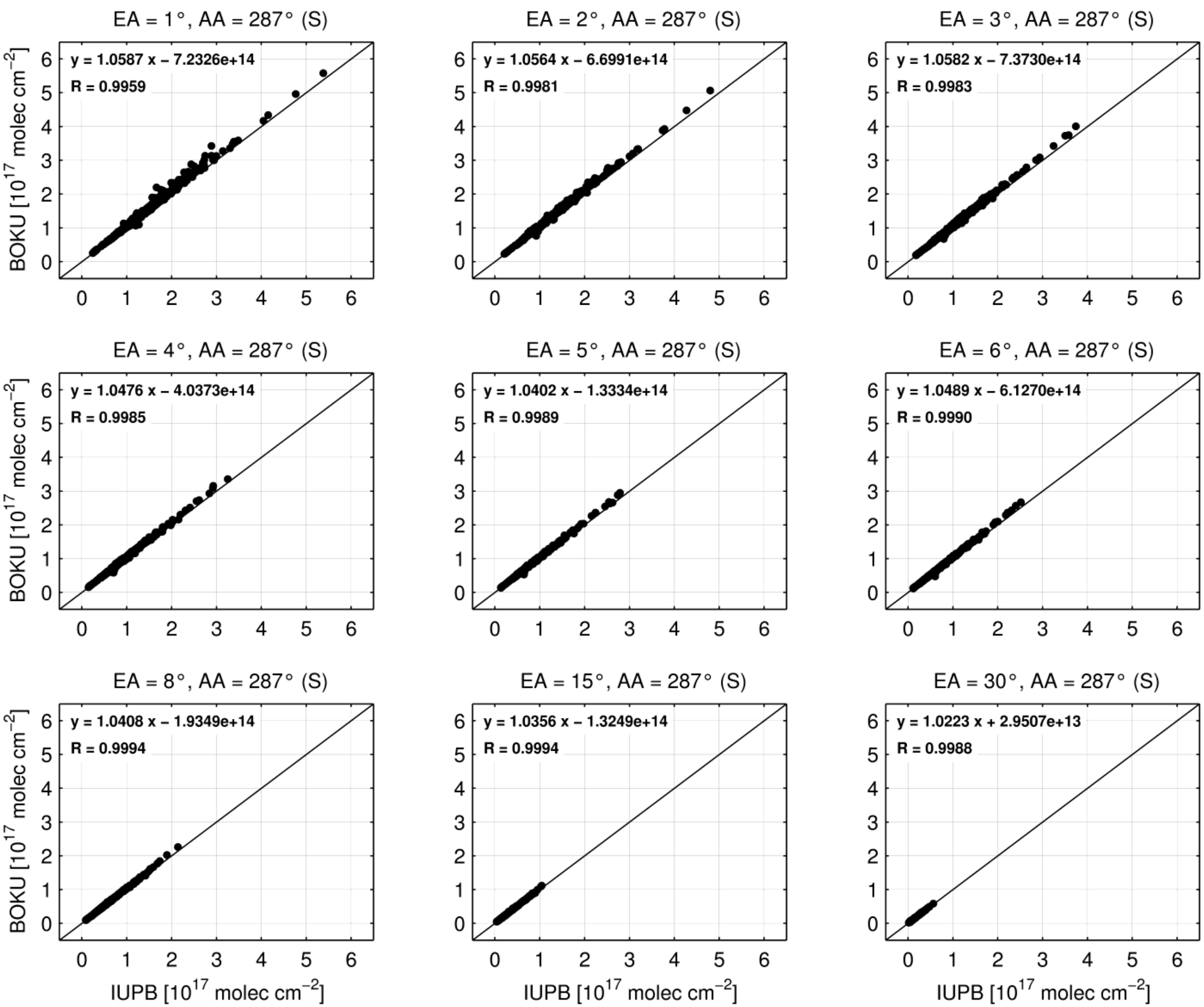
- good agreement for the lowest elevation angles
- BOKU glyoxal is more smooth
- scatter increases with increasing elevation angles, in particular for the IUPB instrument
- IUPB glyoxal shows many negative values for EA = 30°

Slant column intercomparison (scatter plots)



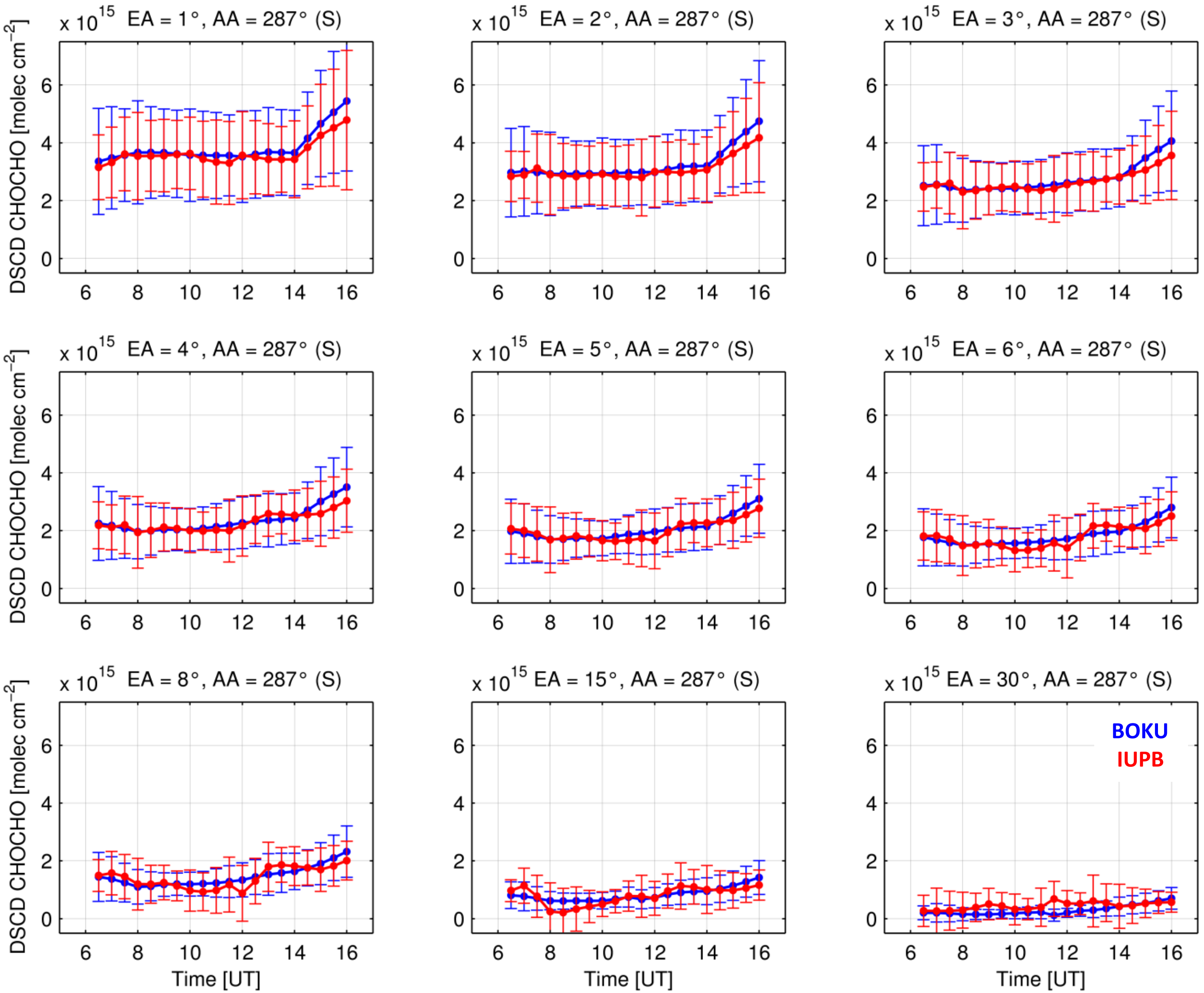
- high correlation coefficients for the lowest elevation angles
- IUPB glyoxal always higher than BOKU glyoxal
- for EA = 15° and 30°, agreement is not good anymore

Slant column intercomparison (scatter plots)



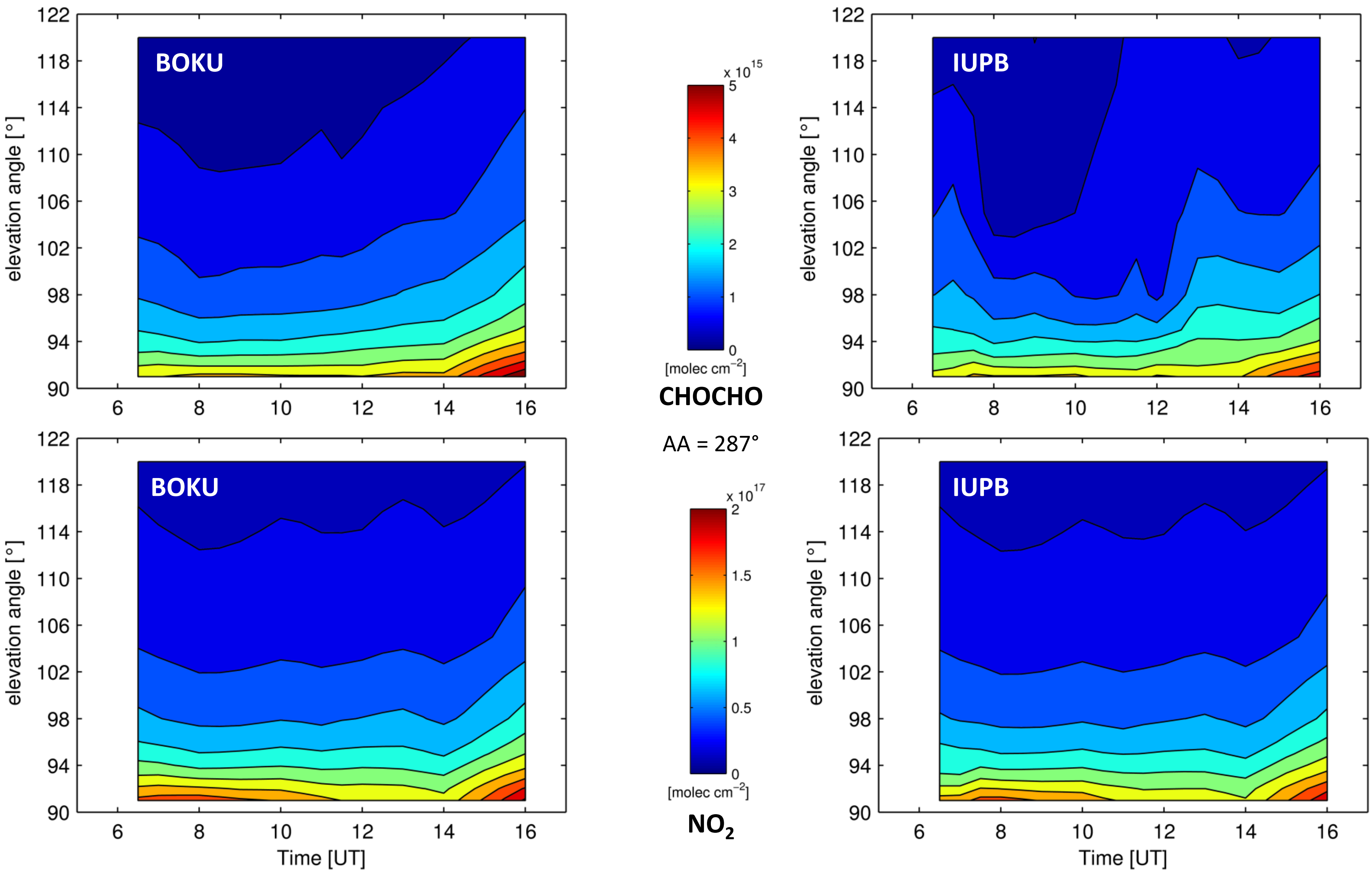
- much better agreement for NO_2 in the same fitting window (no surprise)
- however, higher NO_2 values are observed by the BOKU instrument, excpet for EA = 30°
- highest correlation is found for the larger elevation angles (in contrast to glyoxal)

Slant column intercomparison (average diurnal cycle)

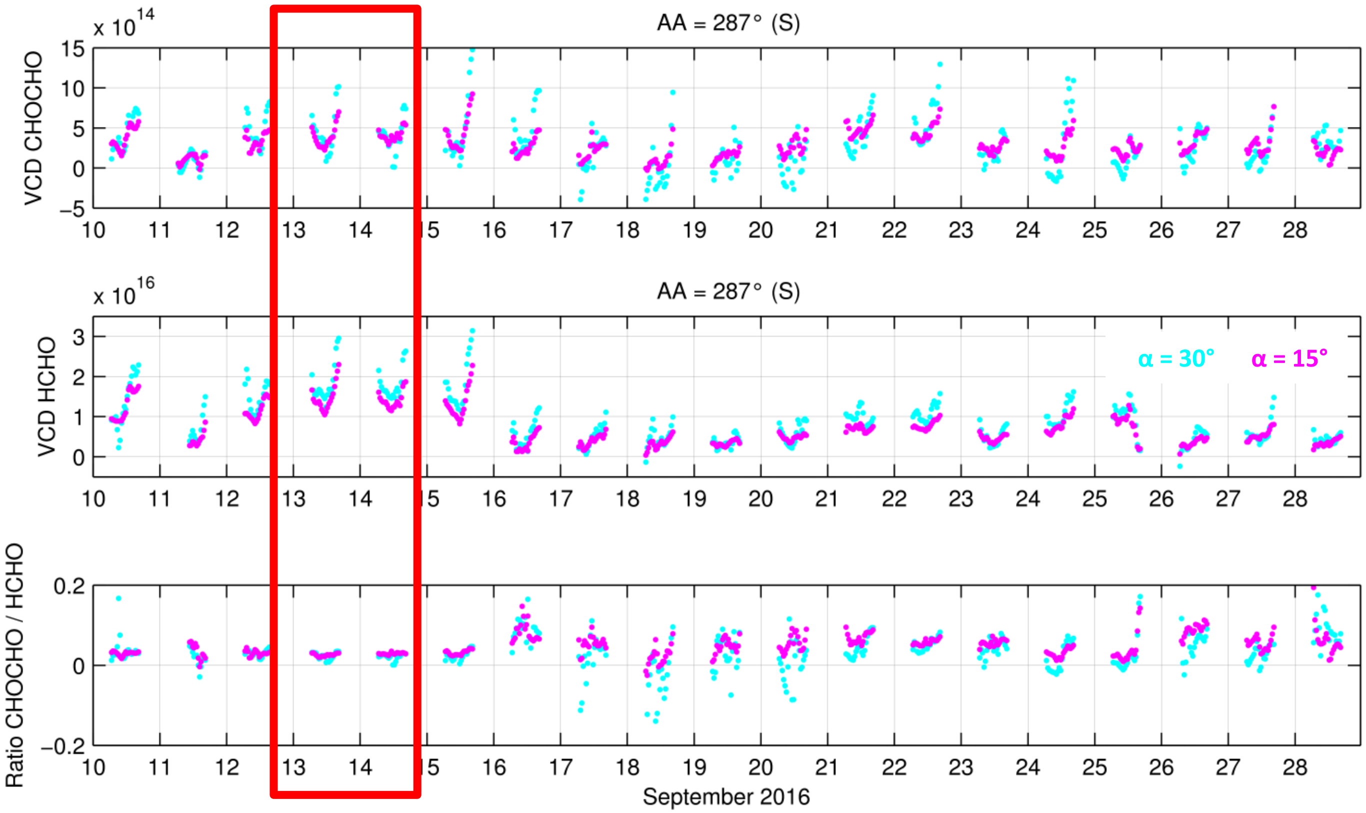


- very stable CHOCHO levels throughout the day
- CHOCHO amounts rise in the afternoon and reach a maximum before sun rise
- BOKU CHOCHO measurements show larger (smaller) values for the standard deviation for the lower (higher) directions

Slant column intercomparison (average diurnal cycle)



Vertical column intercomparison (time series)



BOKU instrument

IUPB instrument

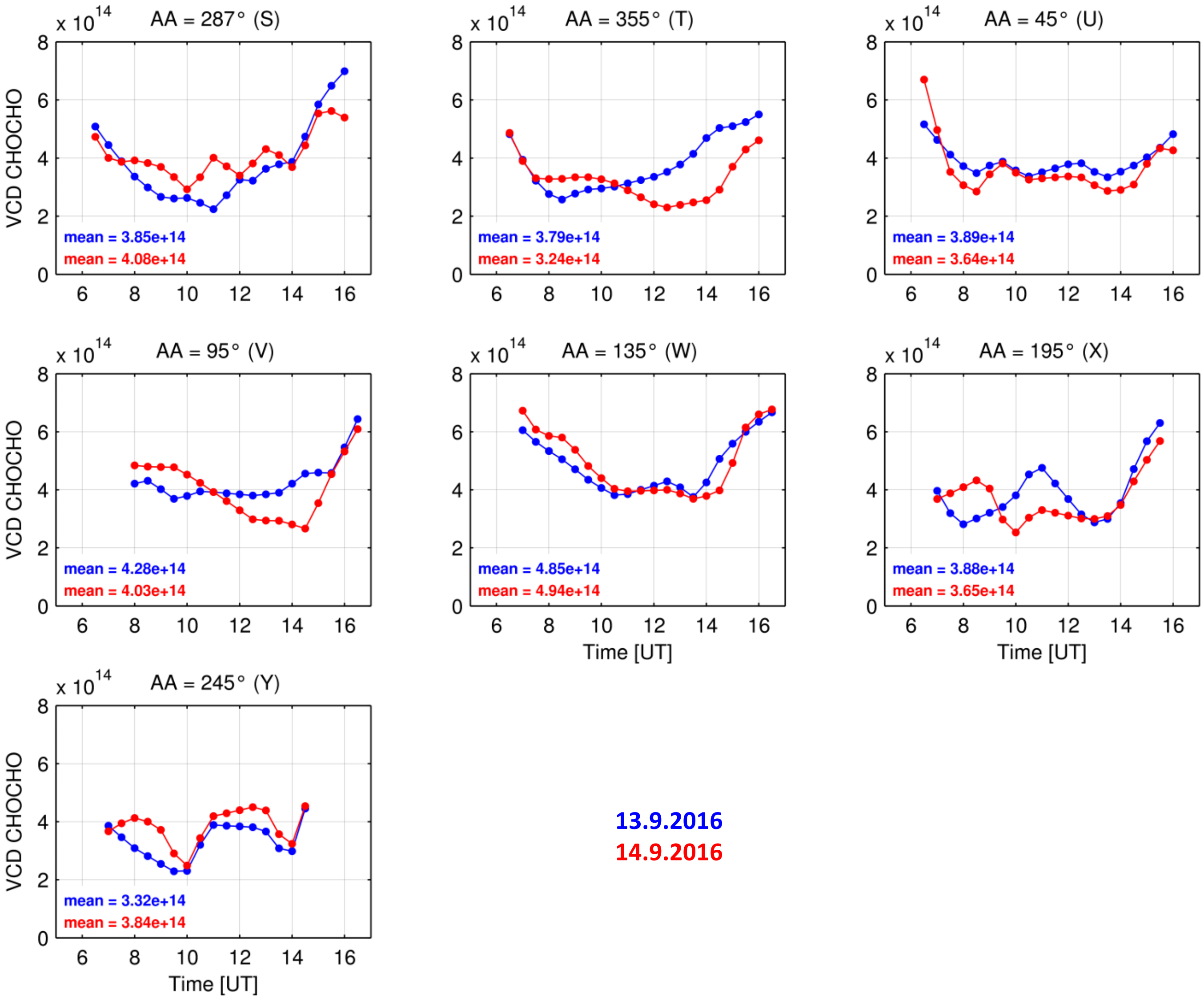
R_{GF}

Geomteric approach:

$$\boldsymbol{VCD\ (CHOCHO, HCHO)} = \frac{\boldsymbol{DSCD\ (CHOCHO, HCHO)}_{(\alpha)}}{\left(\frac{\mathbf{1}}{\boldsymbol{sin}\ (\alpha)}\right) - \mathbf{1}}$$

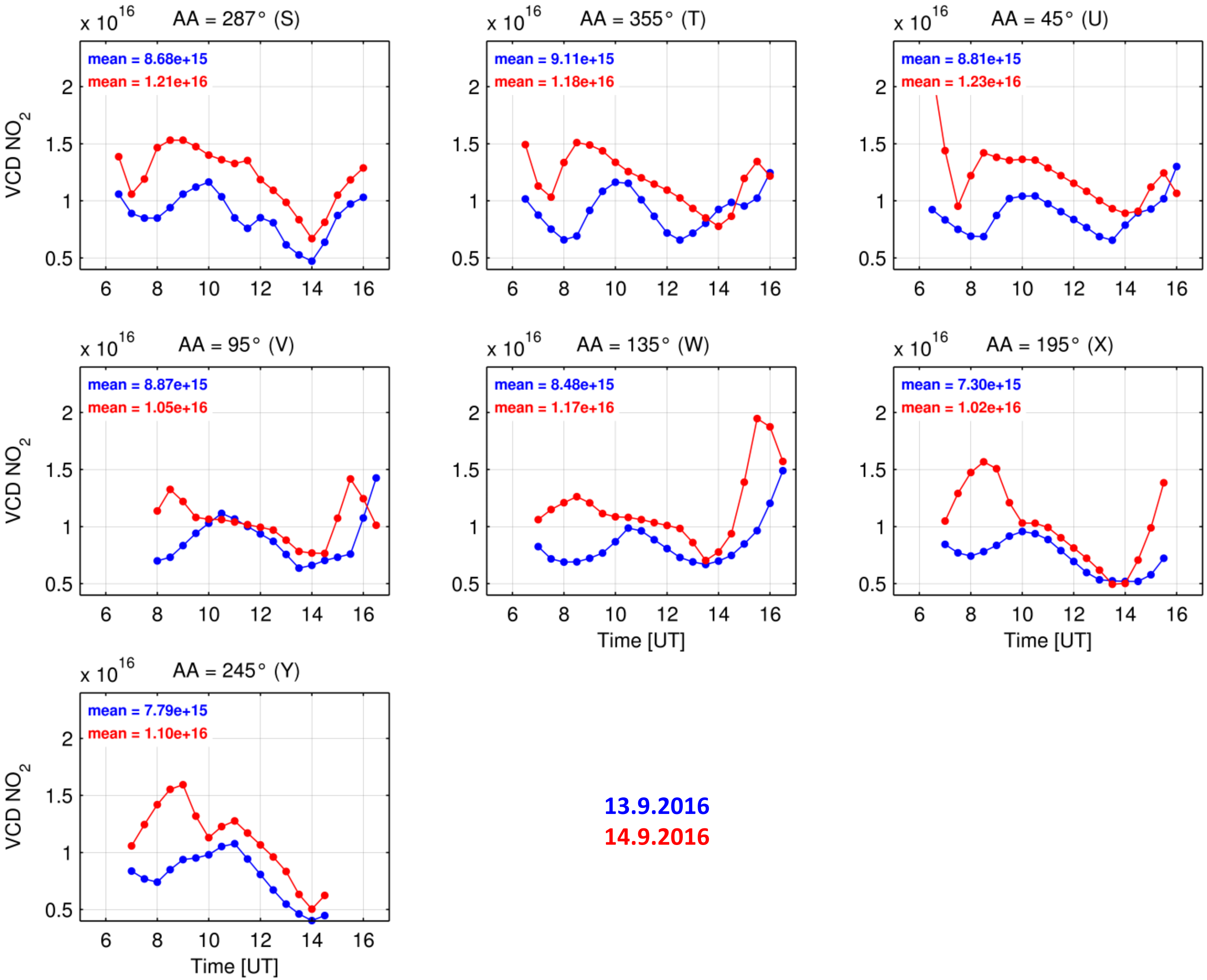
$$R_{GF} = \frac{CHOCHO}{HCHO}$$

Diurnal cycles of VCD CHOCHO



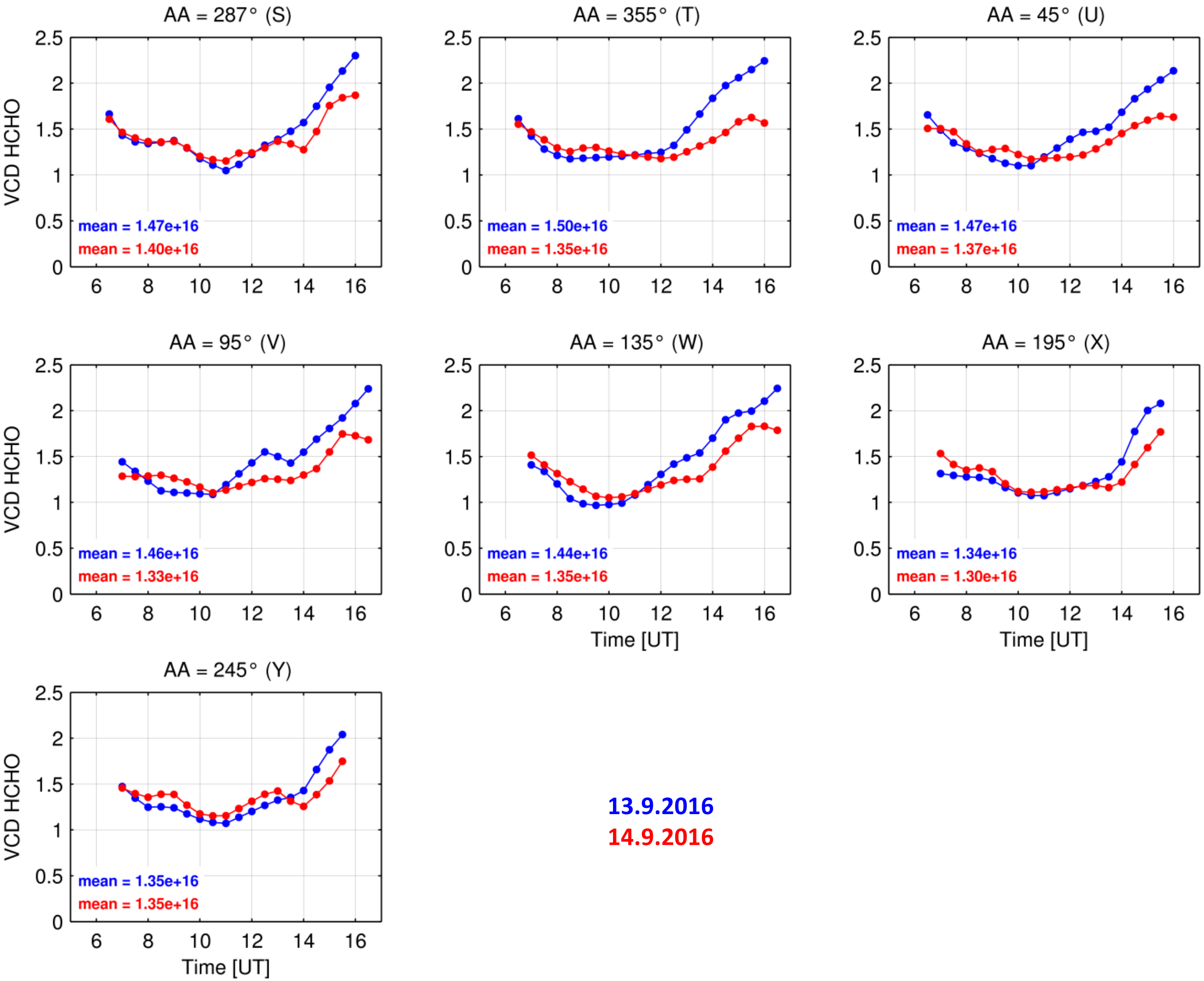
- distinct diurnal variation of CHOCHO for all azimuth angles
- overall, low day-to-day variability for most directions, except for directions T (355°) and X (195°)
- highest daily CHOCHO averages are found at direction W (135°) --> up to factor 1.5 larger than at other directions

Diurnal cycles of VCD NO_2



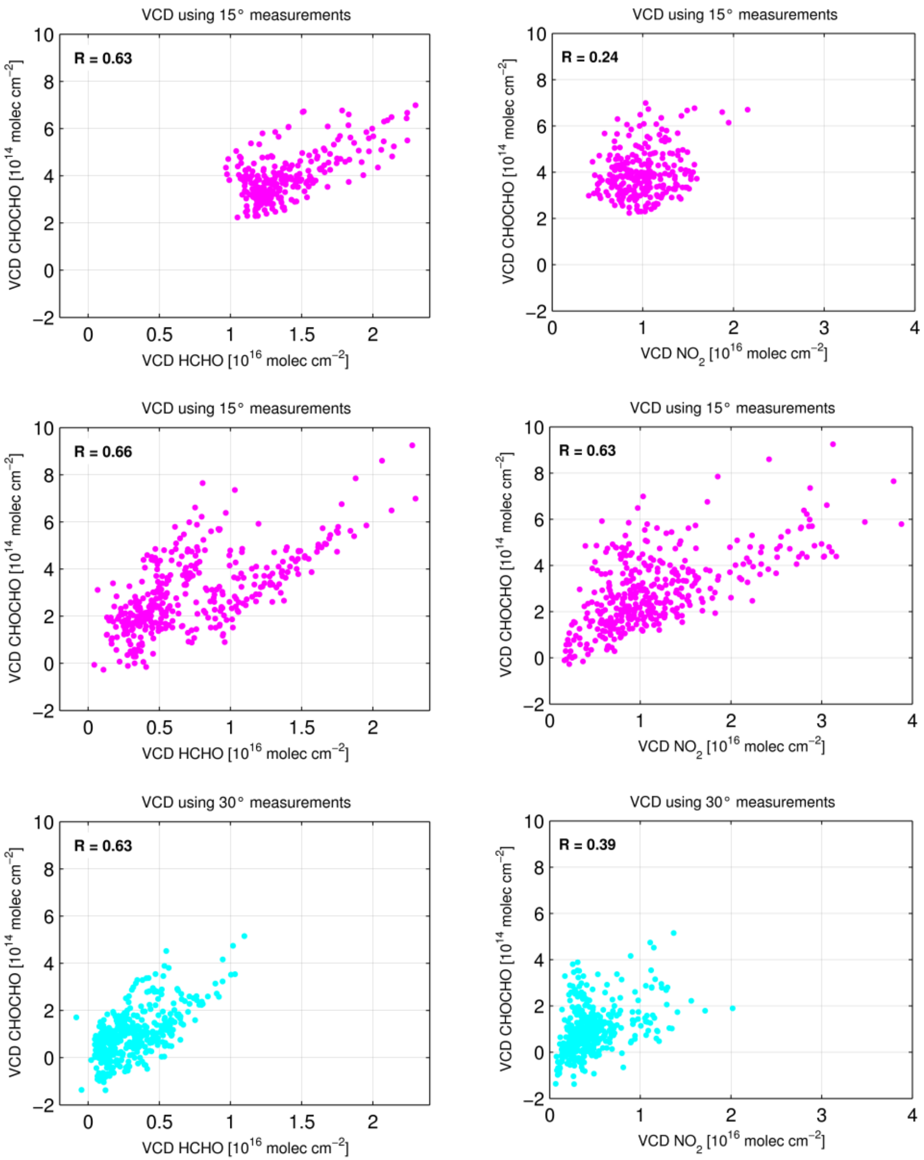
- distinct diurnal variation also observed for NO_2
- larger day-to-day variability (anthropogenic emissions?)
- higher horizontal variability of NO_2 amounts on 14.9.

Diurnal cycles of VCD HCHO



- distinct diurnal variation also observed for HCHO
- lower day-to-day variability and also lower horizontal variability
- overall, smoothest curves, when compared with the other two trace gases
- least affected by anthropogenic emissions?

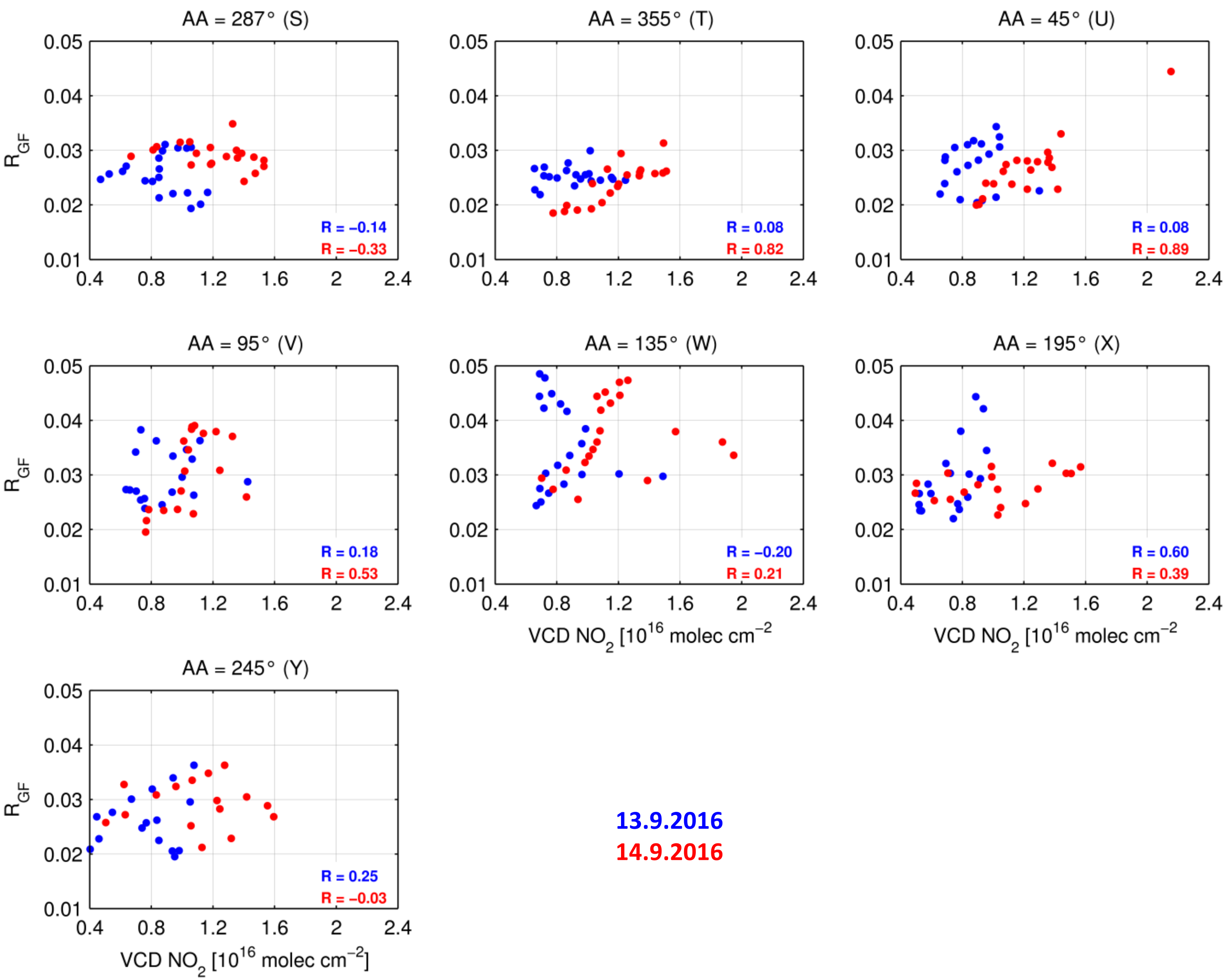
VCD CHOCHO vs. VCD HCHO and VCD NO_2



- data from all azimuth directions
- only 13.9. and 14.9. are included

- data only from direction S (287°)
- but for all days

R_{GF} vs. VCD NO_2



- positive correlation between R_{GF} and VCD NO_2, which is in agreement with ground-based studies and in disagreement with satellite-based studies

- overall better correlation between R_{GF} and VCD NO_2 on 14.9. (because of higher NO_2 amounts?)

Summary

- Overall, the two instruments compare well with each other and the agreement for CHOCHO is good
- Better agreement is found for the lower elevation angles (decreasing signal-to-noise ratio, in particular for the IUPB instrument)
- The IUPB instrument observes higher CHOCHO values than the BOKU instrument, while the opposite is found for NO_2
- Conversion of DSCDs into VCDs works better for 15° than for 30° measurements (better signal-to-noise ratio for 15°)
- For CHOCHO, but also for HCHO and NO_2, distinct diurnal cycles are found on 13.9. and 14.9. (cloud-free and unusually hot days)
- While the day-to-day variability is highest for NO_2, the horizontal variability is highest for CHOCHO
- Low correlation between CHOCHO and NO_2 on those two days suggests that glyoxal amounts are not dominated by anthropogenic emission sources