Total Column Water Vapour (TCWV) in the Visible „Blue“ Spectral Range: Validation and Comparisons Between GOME-2, OMI, and TROPOMI

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28/11/2018
Motivation

- Water vapour plays a key role in Earth’s radiation budget and many atmospheric processes
  → Knowledge of global spatiotemporal changes of water vapour is essential for NWP and climate modelling
- DOAS TCWV retrievals usually conducted in „red“ spectral range (~640nm)

**Red (640nm):**
- Strong saturation effects
- Low ocean surface albedo
- Abrupt changes of albedo at coasts

**Blue (442nm; Wagner et al., 2013):**
+ Much weaker saturation
+ Higher ocean surface albedo
+ More uniform distribution of surface albedo
+ More satellite sensors cover this range
DOAS H$_2$O retrieval

- Fit window: 430-450nm
- Trace gas absorbers: H$_2$O, NO$_2$(220K), O$_4$, O$_3$
- 2 Ring spectra from daily irradiance
- Pseudo-absorbers for slit function changes and shift & stretch (Beirle et al., 2013; 2017)
- AMF look-up table
  - McArtim simulations of Box-AMF for more than 500,000 scenarios
  - Parameters: viewing geometry, surface albedo, surface height
  - H$_2$O profile shapes: scale heights of 1.5km & 2.0km
  - Clouds as Lambertian reflector assuming an albedo=0.8
Validation study

- Time range: boreal summer (June, July, August)
- TROPOMI, GOME-2A (2018) and OMI (2007 due to row anomaly)
- Clear-sky observations (cloud fraction < 20%)
- Reference data sets:
  - Satellite: SSMIS (only ocean), daily daytime
  - Reanalysis: ERA5, hourly
  - GPS: SuomiNet (North & Central America), 30min

<table>
<thead>
<tr>
<th>Input</th>
<th>TROPOMI</th>
<th>GOME-2A</th>
<th>OMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clouds</td>
<td>NO₂ L2 OFFL</td>
<td>AC-SAF/DLR L2</td>
<td>OMCLDO2</td>
</tr>
</tbody>
</table>
Validation study – SSMIS

**TROPOMI**

0.97x - 0.29  
$R^2 = 0.82$

**GOME2A**

0.97x + 0.17  
$R^2 = 0.67$

**OMI**

1.12x - 0.88  
$R^2 = 0.66$
Validation study – SSMIS

TROPOMI

GOME2A

OMI

SSMIS f16 TCWV [kg/m²]

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TROPOMI H₂O VCD [kg/m²]

GOME2A H₂O VCD [kg/m²]

OMI H₂O VCD [kg/m²]

0.97x - 0.29

R²=0.82

0.97x + 0.17

R²=0.67

1.12x - 0.88

R²=0.66

Relative share of total points [%]
Validation study – ERA5

- TROPOMI - GOME2A - OMI

Ocean

TROPOMI H₂O VCD [kg/m²]
- 1.03x - 2.25
- R²=0.88

GOME2A H₂O VCD [kg/m²]
- 1.03x - 1.46
- R²=0.78

OMI H₂O VCD [kg/m²]
- 1.16x - 3.09
- R²=0.70

Land

TROPOMI H₂O VCD [kg/m²]
- 0.83x - 0.36
- R²=0.79

GOME2A H₂O VCD [kg/m²]
- 0.77x + 1.93
- R²=0.44

OMI H₂O VCD [kg/m²]
- 0.85x - 0.81
- R²=0.47

Relative share of total points [\%]
Validation study – ERA5
Validation study – ERA5

TROPMI

GOME2A

OMI

ocean

land

Relative share of total points [%]
TROPOMI H$_2$O VCD for JJA 2018, CF<20%
Unusually low VCDs over land
→ replace OMI/GOME-2A LER with albedo from MODIS Terra (MOD13C2) and Aqua (MYD13C2)
→ scale MODIS albedo by 0.9 accounting for different spectral windows
TROPOMI H$_2$O VCD for JJA 2018, CF<20%

Unusually low VCDs over land
TROPOMI H$_2$O VCD for JJA 2018, CF<20%

now with scaled MODIS albedo
Validation study – ERA5

Ocean

Land

TROPOMI

GOME2A

OMI

Relative share of total points [%]

- 15 -
Validation study – ERA5

Now with scaled MODIS albedo
Validation study – SuomiNet

- Low clouds cause underestimation, mid and high clouds cause overestimation
Validation study – SuomiNet

- Low clouds cause underestimation, mid and high clouds cause overestimation
Summary and outlook

- For TROPOMI and GOME-2A very good agreement over ocean
- Over land
  - good agreement for TROPOMI
  - suboptimal agreement for GOME-2A and OMI
- Large uncertainties due to uncertainties in land surface albedo & clouds
- Extension of validation to
  - all-sky observations,
  - further reference data sets (E-GVAP, Sentinel-3?),
  - further satellite sensors (SCIAMACHY, GOME)
Acknowledgement

We acknowledge:

- ESA
- DLR & KNMI
- NASA
- EUMETSAT
- ECMWF
- UCAR & SuomiNet

Thank you for your attention
References