Air quality observations from EMI

Reporter: C. Liu
China's first hyperspectral satellite
China's first hyperspectral satellite was launched in May 9, 2018. We got operational measurements since Sep, 2018, and responsible for its official product.
Preflight evaluation of the performance of the EMI (Xenon lamp)

Put the known concentration of NO2 into the cell, let light pass through it, then retrieval the observed spectrum, compare the retrieved results with NO2 concentrations in the cell.
The retrieved NO$_2$ results by both UV and visible spectra were $(1.41+0.1) \times 10^{17}$ molec/cm$^2$, the true concentration of the standard gas is $1.40 \times 10^{17}$ molec/cm$^2$. It indicated that both channel can meet the accuracy requirements for NO$_2$ observation.

The results indicate that the variability of the corrected NO2 SCDs for different spatial rows is less than 3% in general.

Cx. Zhang, C.Liu., et al., Transactions on Geoscience and Remote Sensing, 2018
Comparisons of EMI and TROPOMI instrument Performance

<table>
<thead>
<tr>
<th>Instrument Performance</th>
<th>EMI</th>
<th>TROPOMI</th>
<th>Ratio (TROPOMI/EMI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variations of FWHM with row</td>
<td>&gt;0.25nm</td>
<td>&lt; 0.03nm</td>
<td>~8.3</td>
</tr>
<tr>
<td>Variations of FWHM with time</td>
<td>8.09%</td>
<td>0.01%</td>
<td>~80.9</td>
</tr>
<tr>
<td>Wavelength shift</td>
<td>0.1nm</td>
<td>0.003nm</td>
<td>~33.3</td>
</tr>
<tr>
<td>Bias of radiometric calibration</td>
<td>&lt;40%</td>
<td>&lt; 10%</td>
<td>~0.4</td>
</tr>
<tr>
<td>UV SNR</td>
<td>&lt;250</td>
<td>&gt;850</td>
<td>~3.4</td>
</tr>
<tr>
<td>Irradiance</td>
<td>Once six months</td>
<td>daily</td>
<td>~182.5</td>
</tr>
</tbody>
</table>
EMI captures similar spatial patterns and amplitude of NO2 distribution to TROPOMI.

EMI NO2 data shows better performance than OMI in the smoothness and coverage, yet lower spatial resolution than TROPOMI.

Good correlation was found between pixel-to-pixel daily comparisons of EMI and TROPOMI NO2 observations over the North China Plain.

EMI NO2 Retrieval: cross-validations

R=0.89

OMI: 48*13 km  EMI: 24*13 km  S5P: 7*3.5 km

EMI HCHO Retrieval

2019/05/15

HCHO DSCD

SCD error

RMS

EMI HCHO: in preparation
EMI HCHO Retrieval: cross-validations

- EMI HCHO VCDs good correlation with MAX-DOAS HCHO VCDs with the Pearson correlation coefficient of 0.73 and 0.85 at NC and CAMS sites.

- The normalized mean biases (NMB) between EMI and MAX-DOAS HCHO VCDs are 7.65 % 14.50 % at NC and CAMS sites.

EMI HCHO: in preparation
Annual mean HCHO VCDs measured by EMI, OMI and TROPOMI instruments show similar spatial patterns and amplitudes.

Hotspots in Amazon basin, Equatorial Africa and Southeast Asia are detected by EMI instruments successfully.

Wj. Su, C. Liu et al., Tropomi HCHO, AMT, 2020
EMI HCHO: in preparation
Validations with ozonesonde O3 products:
1. Spatial comparisons:
   
   
   [-90S ~ 90N, 180W ~ 180E]

   

   Correlation is 0.879 with the mean bias of 2.7 DU with EMI AKs

   

   USTC: Optimal Estimation (OE) algorithm
   Ref: Liu et al., Atmos. Chem. Phys. 2010;

   Monthly a priori profiles from GEOS-Chem simulations;

   

   F. Zhao, C. Liu et al., Tropomi O3 profile: STOTEN, 2020
   EMI O3: in preparation
GF5 SO2: compared with S5P SO2 over India

**Validations:**

1. **Spatial comparison:**
   With S5P OE SO$_2$ Product
   [18N ~ 26N, 78E ~ 90E]
   Correlation is 0.84 with the mean bias of 0.01 DU

2. **Temporal comparison:**
   With in situ measurements
   Correlation is 0.63 with the relative mean bias of 54%

**EMI SO$_2$ Product**

**S5P OE SO$_2$ Product**

Vindhyachal Power Plant: 24.109°N, 82.646°E

**USTC: Optimal Estimation (OE) algorithm**

Monthly a priori profiles from GEOS-Chem simulations;

CZ. Xia, C. Liu et al., Sci Bull. 2021
TanSat (CarbonSat): 

- the **first** dedicated carbon mission of the Chinese space program
- Launched in **December 2016**, flies in a sun-synchronous, **700 km** altitude orbit with a **3-year lifetime** and a **16-day revisit period**
- Carries two instruments: **ACGS** and **CAPI**
- Can monitor atmospheric O\(_2\) and CO\(_2\) in three bands
- Spatial resolution is **2 km × 2 km** and spectral resolution is **0.044 to 0.16 nm**.

### Technical Characteristics of TanSat-ACGS

<table>
<thead>
<tr>
<th>Band</th>
<th>O(_2)-A</th>
<th>Weak CO(_2)</th>
<th>Strong CO(_2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral coverage (nm)</td>
<td>758–778</td>
<td>1594–1624</td>
<td>2042–2082</td>
</tr>
<tr>
<td>Spectral resolution (nm)</td>
<td>0.044</td>
<td>0.12</td>
<td>0.16</td>
</tr>
<tr>
<td>Pixels number</td>
<td>1242 × 9</td>
<td>500 × 9</td>
<td>500 × 9</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>2 km × 2 km</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data coverage</td>
<td>Feb 2017 to present</td>
<td>Feb 2017 to Oct 2018</td>
<td>Feb 2017 to Oct 2018</td>
</tr>
</tbody>
</table>
Cross-satellite validations of TanSat with GOSAT and OCO-2 showed consistently spatiotemporal trends and a better coverage than GOSAT.

Comparisons between TanSat X_{CO2} retrieval and TCCON indicated a good correlation with the mean bias of -0.78 ppm, the standard deviation at 1.75 ppm.
Thank you for your attention!