MINI-DOAS UPDATE

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Observation of path-integrated trace gas absorptions using DOAS:

Slant Column Densities:

\[ SCD = \int_0^S c(s) \, ds \]

\[ SCD_i = \frac{\ln(D')}{\sigma'_i(\lambda)} \]

Removal of solar Fraunhofer lines:

\[ DSCD = SCD_{Elev.Angle} - SCD_{solar} \]
Mini-DOAS Setup

Telescopes for UV, VIS, near-IR

Scanner

Electronics

PC

Quartz

Fibers

Optics

Vacuum Vessel

Spectrometers Ice-Water Insulation

Spectrometer Assembly

<table>
<thead>
<tr>
<th>Type</th>
<th>g/mm</th>
<th>Start WL (nm)</th>
<th>Stop WL (nm)</th>
<th>Spect Res (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV</td>
<td>Ocean Optics QE</td>
<td>2400</td>
<td>300</td>
<td>380</td>
</tr>
<tr>
<td>Vis</td>
<td>Ocean Optics QE</td>
<td>1800</td>
<td>410</td>
<td>513</td>
</tr>
<tr>
<td>NIR</td>
<td>OO NIRQuest512</td>
<td>150</td>
<td>900</td>
<td>1700</td>
</tr>
</tbody>
</table>
... we are here:

- Spectrometers
- Telescopes
- Quartz fibers
2013 Telescope Characterization

- Three high accuracy elevation scanner.
- Aligned relative to aircraft pitch to within ±0.1°
- Active, in-flight, pitch correction at 1Hz with an accuracy of ±0.1° (checked using in-flight data)

- Opening angle in limb
  - UV = 0.265° ± 0.005°
  - VIS = 0.288° ± 0.006°
  - IR = 0.254° ± 0.004°
UV Analysis

BrO fit range: 345 – 360nm

O₄ fit range: 338-347nm 352-360nm

References:

- Solar, O₄, NO₂, O₃, BrO, Ring
- BrO DL: 4 x 10^{13} molec/cm²
- O₄ DL: 2 x 10^{43} molec.²/cm⁵
- BrO: Fleischmann et al. 2000
- O₄: Hermans et al. (2003) (dSCD corrected for temp effect)
- O₃: 203 K and 223 K (Bogumil et al., 2002)
- NO₂ 223 K (Bogumil et al., 2002)
Vis $\text{NO}_2$ Analysis

- $\text{O}_4$: 459.89 - 488.82 nm
- $\text{NO}_2$: 425.29 - 446.82 nm
- $\text{O}_3$: 437.22 - 485.54 nm
- $\text{H}_2\text{O}$: 438.29 - 476.85 nm

- Low temperature, vacuum trace gas references:
  - $\text{O}_4$: Hermans et al. (2003) (dSCD corrected for temp effect)
  - $\text{O}_3$: 203 K and 223 K (Bogumil et al., 2002)
  - $\text{NO}_2$: 223 K (Bogumil et al., 2002)
  - $\text{H}_2\text{O}$ HITRAN 203 K and 100 mbar (Rothman et al., 2003)
  - Ring calculated by DOASIS (Busemer et al.).

- DL:
  - $\text{O}_4$: $1.5 \times 10^{42}$ molec.$^2$ cm$^{-5}$
  - $\text{O}_3$: $1.1 \times 10^{18}$ molec. cm$^{-2}$
  - $\text{NO}_2$: $4.2 \times 10^{14}$ molec. cm$^{-2}$
  - $\text{H}_2\text{O}$: $1.5 \times 10^{22}$ molec. cm$^{-2}$
Vis $O_3$ and $H_2O$ Analysis
Data Collected in 2013

<table>
<thead>
<tr>
<th></th>
<th>UV spectra</th>
<th>Visible spectra</th>
<th>IR spectra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Flight #1</td>
<td>2,471</td>
<td>2,461</td>
<td>1,398</td>
</tr>
<tr>
<td>Science Flight #2</td>
<td>2,614</td>
<td>2,620</td>
<td>1,607</td>
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<tr>
<td>Science Flight #3</td>
<td>2,729</td>
<td>2,772</td>
<td>1,588</td>
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<td>Science Flight #4</td>
<td>2,453</td>
<td>2,494</td>
<td>1,437</td>
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<td>Science Flight #5</td>
<td>2,497</td>
<td>2,520</td>
<td>1,401</td>
</tr>
<tr>
<td>Science Flight #6</td>
<td>2,195</td>
<td>2,214</td>
<td>1,330</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14,959</strong></td>
<td><strong>15,081</strong></td>
<td><strong>8,761</strong></td>
</tr>
</tbody>
</table>

- UV and vis spectra have been analyzed to determine trace gas SCDs.
- Working on interpretation of IR spectra
In-flight instrument performance

GH mini-DOAS Visible Spectrometer: results DOAS-retrieval SF3 02/14/2013 - 02/15/2013

SZA [°]
Altitude [km]
Radiance @450nm [a.u.]
O₃ dSCD [10¹⁴ molec²/cm²]
NO₂ dSCD [10¹⁰ molec/cm²]
O₃ dSCD [10¹⁰ molec/cm²]
H₂O dSCD [10¹⁰ molec/cm²]

Telescope Elevation: 1 0 -0.5 -1 -1.5 2 2.5 3 -1 -3 -7 16
Science Flight 2, 2013

- **Takeoff:**
  02/09/2013 14:45 UT

- **Sunset:**
  02/09/2013 04:17 UT
Science Flight 2

GH mini-DOAS Visible Spectrometer: results DOAS-retrieval SF2 02/09/2013 - 02/10/2013

- OZA [°]
- Altitude [km]
- Radiance @450nm [a u]
- \( \text{O}_3 \) dSCD [\(10^{12}\) molec\(\cdot\)cm\(^{-2}\)]
- \( \text{NO}_2 \) dSCD [\(10^{16}\) molec\(\cdot\)cm\(^{-2}\)]
- \( \text{O}_3 \) dSCD [\(10^{18}\) molec\(\cdot\)cm\(^{-2}\)]
- \( \text{H}_2\text{O} \) dSCD [\(10^{23}\) molec\(\cdot\)cm\(^{-2}\)]

Telescope Elevation:

- A
- B
- C
- D
- E
- F
- GH
- I
- KL
- M

- 1
- 0
- -0.5
- -1
- -1.5
- -2
- -2.5
- -3
- -4
- -7
- -15
Science Flight 2
Conclusion and Status

- All UV & VIS 2013 spectra have been analyzed.
- Software for fast retrieval has been set finalized
- Radiative transfer calculations to determine mixing ratios in progress:
  - First results during Friday’s talk
  - Method for fast conversion of “flight-altitude” NO$_2$ and BrO mixing ratios has been developed (testing still under way) Goal: Have preliminary M.R. while in field.
- Instrument was tested under Guam-like conditions (high R.H., rain, bugs, etc.) over Summer in Nashville.
- No major changes to instrument
- Instrument currently under maintenance (update cables, heaters, and plugs).
- Should be ready by Nov 12.