The SPEXone polarimeter for the NASA PACE mission

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Multi-angle spectropolarimetry between 385 – 770 nm

5 instantaneous footprints; Simultaneous pushbroom measurement of radiance and polarization

Flight direction
5 instantaneous footprints; Simultaneous pushbroom measurement of radiance and polarization.

### Multi-angle spectropolarimetry between 385 – 770 nm

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial resolution / sampling</td>
<td>5X5 km² (2.5X2.5 km²)</td>
</tr>
<tr>
<td>Spectral resolution radance</td>
<td>400 bands, 2nm FWHM</td>
</tr>
<tr>
<td>Spectral resolution polarization</td>
<td>50 bands λ/FWHM = 35 O2 a band at 2 nm FWHM (TBC)</td>
</tr>
<tr>
<td>Radiometric uncertainty</td>
<td>&lt; 2%</td>
</tr>
<tr>
<td>Polarimetric uncertainty</td>
<td>&lt; 0.003</td>
</tr>
</tbody>
</table>
$S_+ (\lambda) = 0.5 I (1+m_q (\lambda) q(\lambda) + m_u (\lambda) u(\lambda))$

$S_- (\lambda) 0.5 I (1- m_q (\lambda) q(\lambda) - m_u (\lambda) u(\lambda))$

$S_{\text{mod}} (\lambda) = (S_+ - S_-) / (S_+ + S_-) = m_q (\lambda) q(\lambda) + m_u (\lambda) u(\lambda)$
Past Weeks:
• April 24: Spectrometer and telescope integrated
• May 13: DEM integrated
• May 15: DEM Pre-aligned: results promising
• May 28: OSF delivered to SRON

• June 2: OSF integrated with DEM assembly
  • Note: assumption is that inclusion of OSF has no significant effect on alignment
• June 19: Instrument fully integrated and aligned
• July / August: Testing (EMC, vibration, shock, thermal)
• October-December: On-ground calibration

Milestone planning:
- PDR: November 2018
- EPR-2: December 17th 2018
- CDR: February 7th 2019
- SIR: October 21st 2019
- PER: May 26th 2020
- DRB: Q1- 2021
Telescope functional test

Telescope integration with spectrometer

First spectrum

Spectrometer and DEM integrated
Performance Modeling

SNR for dark ocean at SZA = 70°

For most challenging case factor 10 correction is needed. For the vast majority a factor 5 is sufficient.
Level-1 Processing: Test with instrument model

Steps:
- Detector calibration.
- Stray light correction.
- Field of view calibration.
- Spectral calibration.
- Radiometric Calibration.
- Polarimetric Calibration.
**SPEXone level-2 Processing (SRON)**

### Aerosol

<table>
<thead>
<tr>
<th>Heritage</th>
<th>POLDER-3 (global) processing and forcing quantification, airborne data of SPEX airborne, RSP, airMSPI, groundSPEX. TROPOMI operational L2 processor (CH4).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics</td>
<td>Online RT, 1st guess from LUT retrieval, retrieves size, spectral dependent refractive index (base functions), shape, ALH. Flexible state vector definition. Land: fit BDRF parameters (Ross-Li or RPV + Fresnel), ocean: Fresnel reflection on waves (wind-speed+direction), ocean body based on X_chla. Pixel level uncertainty calculation. Aerosol-above-cloud. Multi-instrument retrievals.</td>
</tr>
<tr>
<td>Computational aspects</td>
<td>3-4 seconds (35 wavelengths) /pixel/thread. Parallel processing (openMPI).</td>
</tr>
<tr>
<td>Synthetic test data</td>
<td>ECHAM-HAM +POLDER aerosol data, MODIS+GOME-2+POLDER BRDF, SPEXone orbit simulator</td>
</tr>
<tr>
<td>Developments</td>
<td>Test advanced ocean body models, effect of cirrus, use of O2-a band. Collaborate with PACE SAT PIs to include findings in SPEXone processor, e.g. cirrus (Stamnes), UV ocean model and Brown Carbon (Chowdhary). Harmonize with MAP-CO2M developments.</td>
</tr>
<tr>
<td>Documentation</td>
<td>ATBD (issue 1 July 2020)</td>
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</tbody>
</table>

### Clouds

Collaborate with van Diedenhoven (PACE SAT PI)

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**SPEXone synthetic retrievals (SSA)**

**SPEX airborne AOD**

**Team:** Guangliang Fu, Lianghai Wu, Sha Lu, Jochen Landgraf, Otto Hasekamp
Synthetic orbits (71360 pixels/each orbit, ~1 Million per day)

- Aerosol size distribution, height, and composition from ECHAM-HAM.
- AOD and surface polarization from POLDER-3.
- Cloud mask, BDRF and Chl$_a$ from MODIS
- Geometries from orbit simulator.
In-Flight Calibration/monitoring Approach

Radiometric:
- Comparison to OCI at +/- 20° and 0°
- Deep Convective Clouds (DCC) to translate to +/- 50° viewports

Polarimetric
- Polarimetric zero-point using thick clouds at scattering angles 160-180°
- Polarimetric scaling factor using sun-glint.
(Note that instrument is designed to stay well within polarimetric requirements for expected pollution levels and vibration/shock)