Latest TSI as obtained from NORSAT/CLARA

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Overview

- Overview of CLARA
- Issues with one reaction wheel started early 2018
  - Operation stopped March 2018
- Solution found for operation with 2 reaction wheels
- 2nd First Light: Nov 8, 2019
- Fine pointing variable (only two reaction wheels)
- Pointing filter
- Some positive outlook
Absolute-Radiometer: Electrical substitution principle

Solar irradiance \[ \text{W/m}^2 \]

- Shutter
- Cavity
- Electrical heating \( P_{el}[\text{W}] \)
- \( \Delta T \approx 1^\circ \text{C} \)
- Thermal link
- Reference block
- Aperture area \( \text{m}^2 \)

[Logos: pmod wrc, LASP, UTIAS, SFL, Norsk Romsenter]
CLARA optical geometry

Walter et al., 2017
CLARA Radiometer

Mass: 3kg

Walter et al., 2017
NORSAT-1 Platform

* Payloads:  
  - AIS ship tracker  
  - CLARA TSI radiometer  
  - Langmuir probes

* Launch: 14th of July 2017

* Polar low earth orbit (~600 km)

* 3-year nominal mission duration

UTIAS  
SFL  
Space Flight Laboratory

Norsk Romsenter  
NORWEGIAN SPACE CENTRE

pmod  
wrc  
LASP  
SFL  
Norsk Romsenter  
NORWEGIAN SPACE CENTRE
**Preflight Calibration**

### Absolute Uncertainty

- **Cavity A**: 576 ppm
- **Cavity B**: 567 ppm
- **Cavity C**: 912 ppm

### Table

<table>
<thead>
<tr>
<th>Characterization item</th>
<th>TRF Ground (532 nm laser, vacuum)</th>
<th>Space (solar spectrum, vacuum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Channel A</td>
<td>Channel B</td>
</tr>
<tr>
<td>Value</td>
<td>Value</td>
<td>Value</td>
</tr>
<tr>
<td>σ</td>
<td>σ</td>
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<tr>
<td>Aperture area (I/C_{aper}) (mm²)</td>
<td>19.6299</td>
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<td>Aperture temperature</td>
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<td>39</td>
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<tr>
<td>Absorptivity (C_{abs})</td>
<td>1.002056</td>
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<tr>
<td>Pointing (absorptivity)</td>
<td>-</td>
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<td>Diffraction (C_{diff})</td>
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<td>Non-Equivalence (C_{ne})</td>
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<td>Native Scale</td>
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<tr>
<td>Dark correction (C_{dark})</td>
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<td>Heater voltage (C_{H})</td>
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<tr>
<td>Shunt voltage (C_{sh})</td>
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<td>Shunt resistance</td>
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<td>Lead heating (C_{lh})</td>
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<td>Shutter delay issue</td>
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<td>Calibration factor</td>
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<tr>
<td>Native Scale</td>
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<td>Repeatability</td>
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<tr>
<td>Scattered light</td>
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<td>Aperture placement</td>
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<td>TRF calibration uncertainty</td>
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<td>CLARA/TRF ratio</td>
<td>1.001693</td>
<td>512</td>
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</tbody>
</table>

### Notes

Walter et al., 2017

Sun Climate Symposium, Tucson  Margit Haberreiter  28.-31.01.2020
<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
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</thead>
<tbody>
<tr>
<td>July 14, 2017</td>
<td>NORSAT1 Launch</td>
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<tr>
<td>August 22, 2017</td>
<td>First Light</td>
</tr>
<tr>
<td>April 2018</td>
<td>Issues with started</td>
</tr>
<tr>
<td>May 2018</td>
<td>CLARA was shutdown</td>
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<tr>
<td>Nov 8, 2019</td>
<td>“2nd First Light”</td>
</tr>
</tbody>
</table>

- NORSAT1 operates with two reaction wheels
- Limited pointing stability
First Light Measurements

**Channel A:** \[ u = \pm 0.77 \text{ W m}^{-2} \]

- **Mean:** 1358.37 W m\(^{-2}\)
- 1360.15 W m\(^{-2}\)

**Channel C:** \[ u = \pm 1.24 \text{ W m}^{-2} \]

- **Mean:** 1364.09 W m\(^{-2}\)
- 1360.14 W m\(^{-2}\)

Daily averages of new VIRGO scale

- Lower TSI reading
- Pointing instability affecting measurements
- Higher TSI reading
- Stronger scatter
- Worse calibration

Courtesy Benjamin Walter
Sun Climate Symposium, Tucson  Margit Haberreiter  28.-31.01.2020
CLARA measurements since 2\textsuperscript{nd} “First Light”
Fine pointing Nov 28, 2019

Pointing (unit vector)

Time (2019-11-28; hh)

PSS_x interp.
PSS_y interp.

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Fine pointing on Nov 27, 2019

2019-11-27  0.250000 deg

PSS_x interp.
PSS_y interp.

Pointing (unit vector)

00 02 04 06 08 10 12 14 16 18 20 22 00
Time (2019-11-27; hh)

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Pointing filter necessary

- **Pointing Criterion:**
  - Account for cavity alignment versus PSS sensor
  - FOV within +/- 2° from cavity central pointing axis
    - very conservative
- 5 subsequent measurement points need to comply with the pointing criterion
- Only the central data point is taken into account
Filtered data points

Sun Climate Symposium, Tucson  Margit Haberreiter  28.-31.01.2020
Irradiance data with pointing filter

Sun Climate Symposium, Tucson   Margit Haberreiter  28.-31.01.2020
Pointing Criterion applied Nov 28, 2019
Filtered Irradiance Nov 28, 2019

all data points
filtered data points

Irradiance (W m\(^{-2}\))

00 02 04 06 08 10 12 14 16 18 20 22 00

Time (2019-11-28; hh)
Filtered Irradiance Nov 29, 2019

Irradiance (W m⁻²)

Time (2019-11-29; hh)

all data points
filtered data points
TSI = 1359.87 +/- 0.52 W/m²

Not yet degradation corrected!
Summary and Outlook

• First preliminary CLARA TSI data
• Degradation correction still needs to be applied
• Sensitivity study with the filter algorithm
• Look into known issues before the CLARA shutdown
• Study the effect of shutdown
• CLARA TSI values will be made available
CLARA

+X face = connector face
-Y face = CLARA boresight
Right-hand coordinate system

Sun Sensor

+X face = connector face
+Z face = Sun Sensor boresight
Right-hand coordinate system
Shutdown of CLARA in May 2018 lead to critically low temperatures (close to -30 °C)

Courtesy Benjamin Walter