Applying inter-calibrated Ka-band brightness temperature observations to resolve diurnal temperature cycles

An example application of XCAL Level 1C data for the Global Space-based Inter-Calibration System (GSICS) Microwave Subgroup Meeting
October 25th, 2016

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Background

**diurnal Land Surface Temperature (LST)**

Geostationary view

Thermal Infrared

MW: Global coverage achieved every 2-days, despite of clouds.

2-day composites of LST estimates at 11.45

LEO Satellite

Microwave

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## Background

**Land Surface Temperature: Every 15 minutes, 0.25 degree resolution**

<table>
<thead>
<tr>
<th>2-day composites</th>
<th>6AM</th>
<th>10AM</th>
<th>1PM</th>
<th>6PM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TIR</strong> LSA SAF LST MSG-9 (geostationary)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MW LST</strong> Combination of Low orbiting Satellites</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Example of 8 days of temperature measurements at Fluxnet sites in Germany. 

In situ data: LST (from long wave radiation), weighted average, 
TIR-LST: sampling poor due to clouds. 
MW-LST-Sparse: sampling during clear and cloud-covered periods, 
MW-LST DTC: diurnal fit to sparse data

Published in: 
Cloud tolerance of remote-sensing technologies to measure land surface temperature 
Thomas R. H. Holmes, Christopher R. Hain, Martha C. Anderson, and Wade T. Crow 
www.hydrol-earth-syst-sci.net/20/3263/2016/
Implementation of MW-LST in two-source energy balance method (ALEXI) to estimate Evapotranspiration (ET)

Cumulative (Jul/Aug/Sep 2004) - Clear Sky - Evapotranspiration (mm)

Cloud issues in TIR result in low ET values in tropics (red): MW looks more consistently wet (blue)

TIR-ALEXI underestimates ET over Ethiopian highlands: MW looks more realistic
Methodology (pre-XCAL)

- Ka-band channel available from all multichannel radiometers
- For 2003-2013, we ingest data from 8 satellites:

<table>
<thead>
<tr>
<th>Radiometer Name</th>
<th>Platform</th>
<th>Overpass</th>
<th>Years</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMSR-E</td>
<td>Aqua</td>
<td>1:30 AM/PM</td>
<td>2002-2011</td>
<td></td>
</tr>
<tr>
<td>AMSR2</td>
<td>GCOM- W</td>
<td>1:30 AM/PM</td>
<td>2012-Present</td>
<td>Half year gap</td>
</tr>
<tr>
<td>SSM/I, SSMIS</td>
<td>DMSP F13-F18</td>
<td>7-9 AM/PM</td>
<td>2002-2011</td>
<td></td>
</tr>
<tr>
<td>WindSat</td>
<td>Coriolis</td>
<td>6 AM/PM</td>
<td>2003-Present</td>
<td></td>
</tr>
<tr>
<td>TMI</td>
<td>TRMM</td>
<td>Variable</td>
<td>1997-2015</td>
<td></td>
</tr>
<tr>
<td>MWRI</td>
<td>FenYun-3B</td>
<td>1:40 AM/PM</td>
<td>2011-Present</td>
<td>In research</td>
</tr>
<tr>
<td>GMI</td>
<td>GPM Core</td>
<td>Variable</td>
<td>2014-Present</td>
<td></td>
</tr>
</tbody>
</table>

→ Overall 5-10 observations per day
- Data aggregated in bins of 0.25 degree spatial resolution, and 15 minute temporal resolution.
- Variance of oversampled Ka-band is used as quality control
Methodology (pre-XCAL)

- All satellites inter-calibrated with TMI as transfer reference
  - This is to double check the instrument calibration for the TB range over land

![Graphs showing correlation between different satellite measurements]

- Geostationary Thermal Infrared (TIR) LST for calibration: LSA-SAF LST product 2007-2012, split window method based on MSG-9 SEVIRI TIR window channels, 3 km native resolution upscaled to 0.25 degree for this study
Constructing MW-LST based only on XCAL Level 1C TB’s
Simplified workflow

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Switch from I/O heavy annual timeseries approach to global 2-day windowing

Scale DTC parameters to TIR LST product. (Currently still LSA SAF LST, but will move to MODIS (MOD16))

Combine 37 GHz(V) from all satellites in XCAL database in single 0.25° by 15 minute daily ‘data-cube’.
Application of XCAL TB’s

0.25° Global maps of DTC parameters, example for Europe, April 2014.

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Application of XCAL TB’s

• After scaling to TIR LST, we can construct diurnal LST based only on MW data.
• Main limiting factors are snow and frost (dramatic impact on emissivity), and the need for observation close to daily maximum (in practice reliant on AMSR-E, AMSR2 asc. overpass)

4-day series examples of fitted diurnal to XCAL Level 1C Ka-band

Example of 4 days of XCAL(37 GHz) based temperature estimates at Fluxnet sites in Germany, April 1-4, 2014.

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• XCAL Level 1 data greatly simplifies a ‘constellation approach’ to satellite retrievals.

• Daily production of MW-LST based only on XCAL Level 1C data is now possible. Applications:
  • Evaporation: Application in ALEXI to sample despite of clouds, and/or improve cloud masking of TIR
  • Soil Moisture: Estimate L-band Effective temperature for ascending and descending paths of SMAP and SMOS

• Eagerly anticipating extended XCAL record (back to 2002)

• Can diurnal LST help with effective temperature for all MW channels as part of a consistent radiative transfer model?