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

Thomas R.H. Holmes
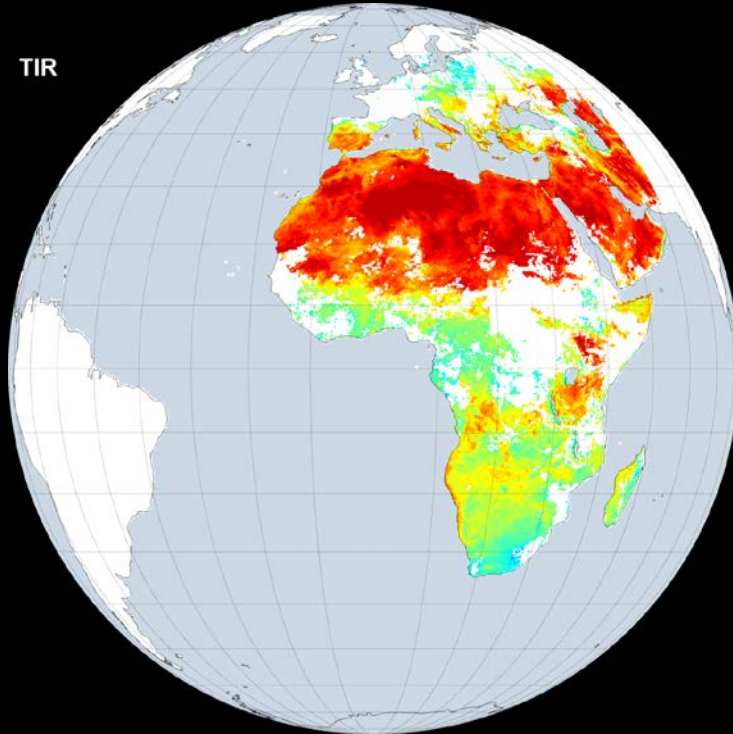**NASA/GSFC, Greenbelt, MD**

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Background

diurnal Land Surface Temperature (LST)

Geostationary view
Thermal Infrared

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LEO Satellite
Microwave
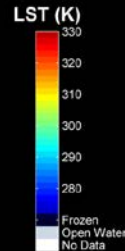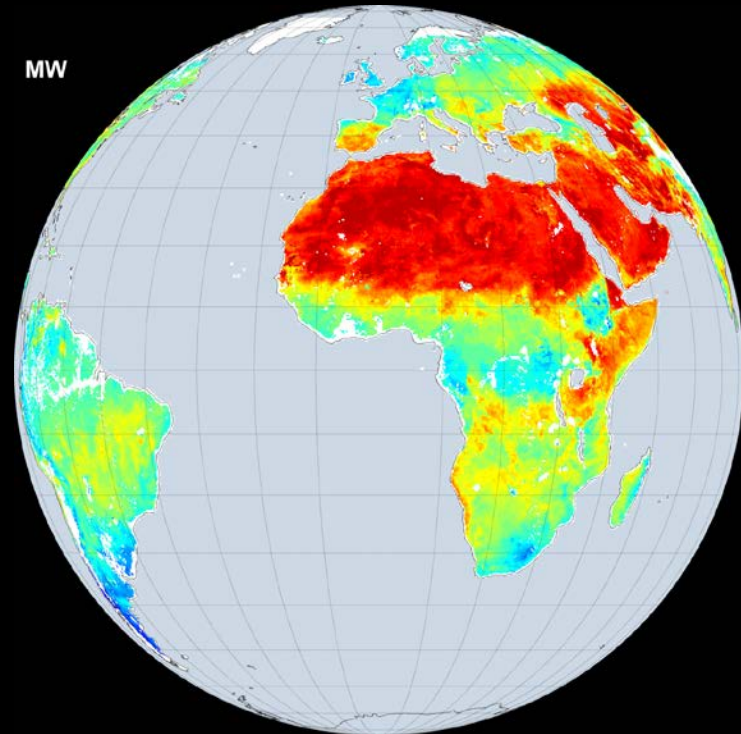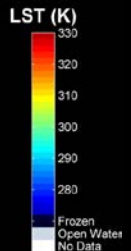
2-day composites of LST estimates at 11.45

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

Background

Land Surface Temperature: Every 15 minutes, 0.25 degree resolution

2-day composites   6AM   10AM   1PM   6PM

TIR
LSA SAF LST
MSG-9
(geostiationary)
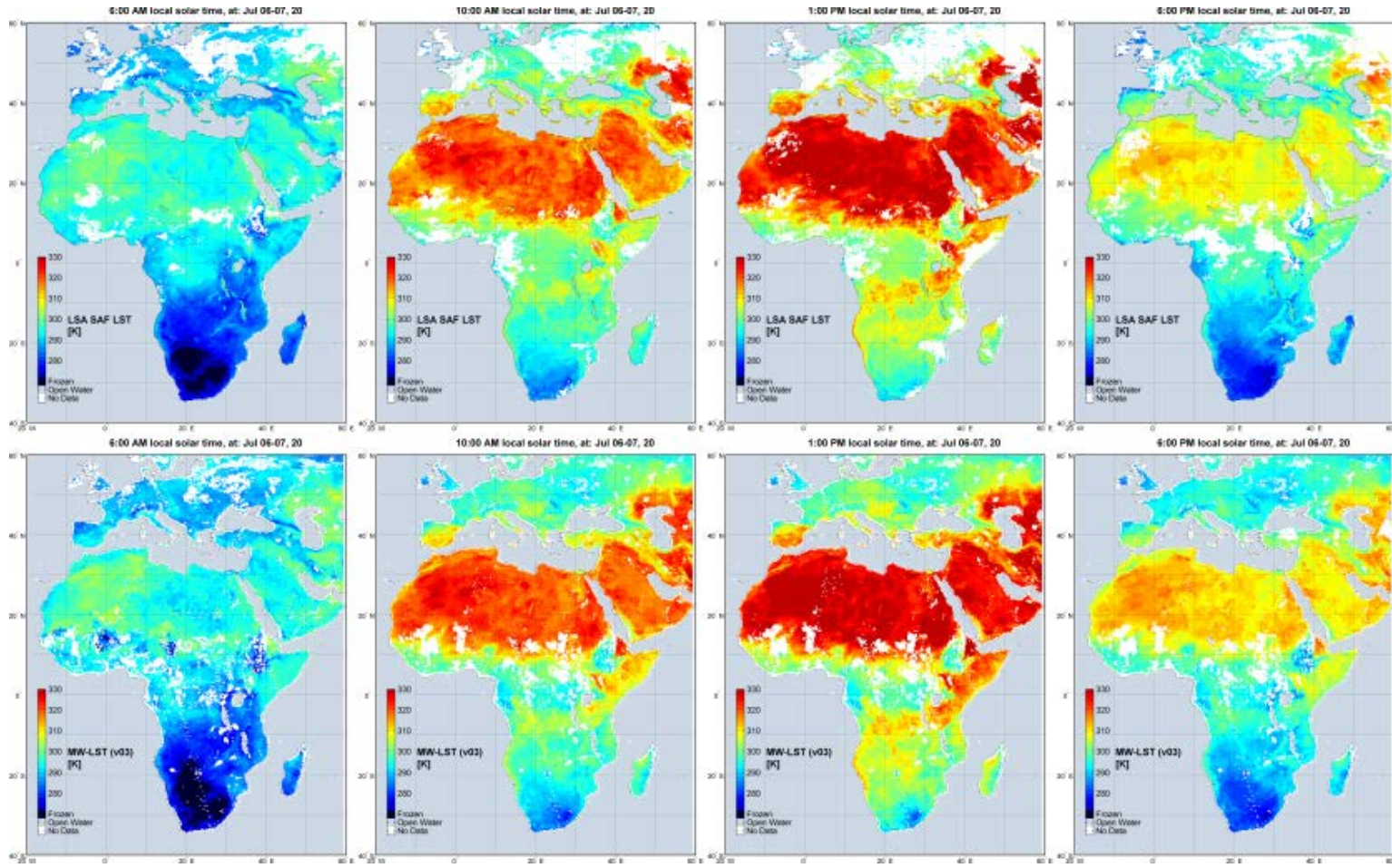
MW LST
Combination of
Low orbiting
Satellites

Forest: 30 %

Fluxnet stations

0.25 degree

Cropland: 70 %
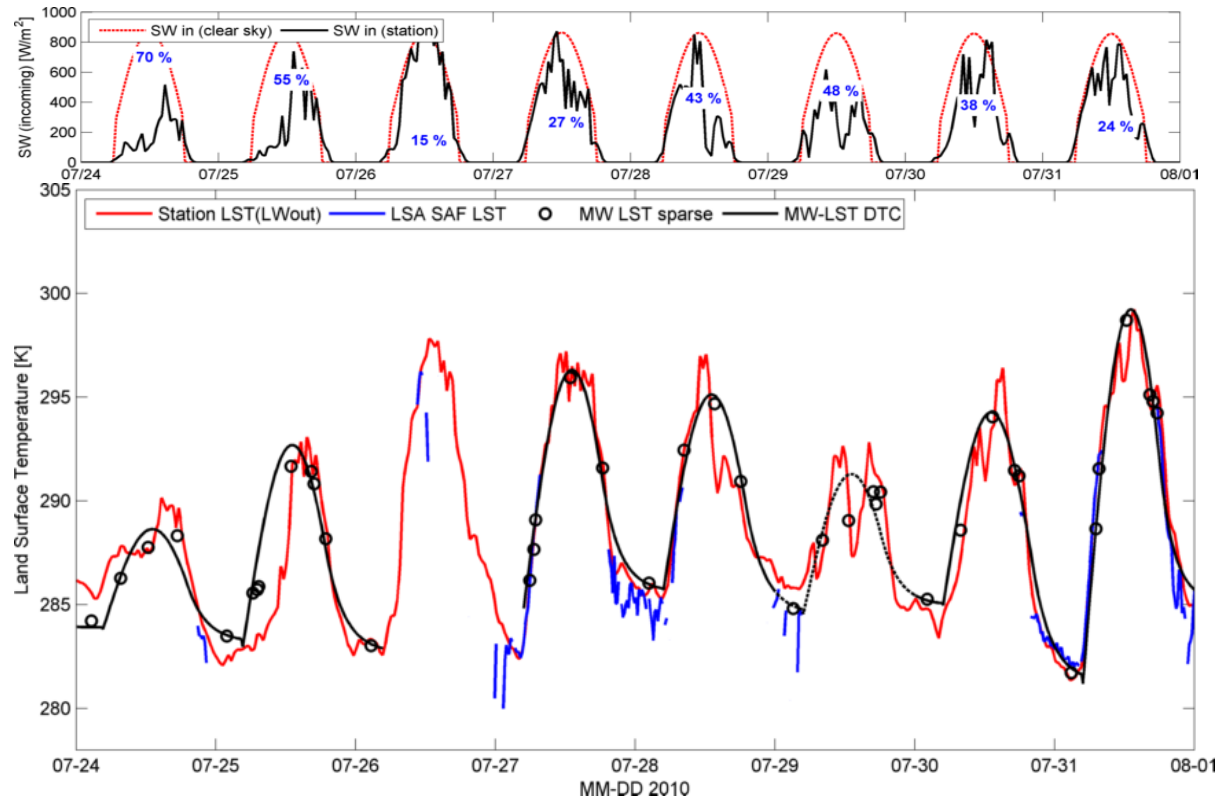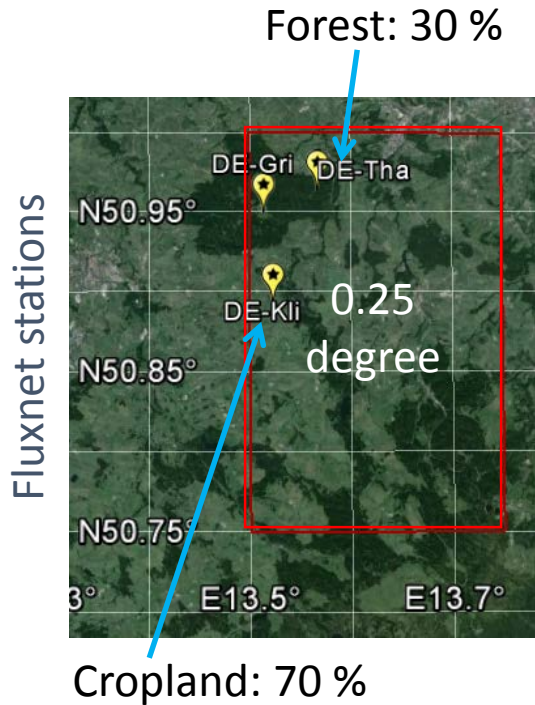
Example of 8 days of temperature measurements at Fluxnet sites in Germany.
In situ data: LST (from long wave radiation), weighted average,
TIR-LST: sampling poor due to clouds.
MW-LST-Sparse: sampling during clear and cloud-covered periods,
MW-LST DTC: diurnal fit to sparse data

Background

Implementation of MW-LST in two-source energy balance method (ALEXI) to estimate Evapotranspiration (ET)

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

TIR-ALEXI

MW-ALEXI

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

Thomas Holmes, GSICS Microwave subgroup meeting October 2016

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Methodology (pre-XCAL)
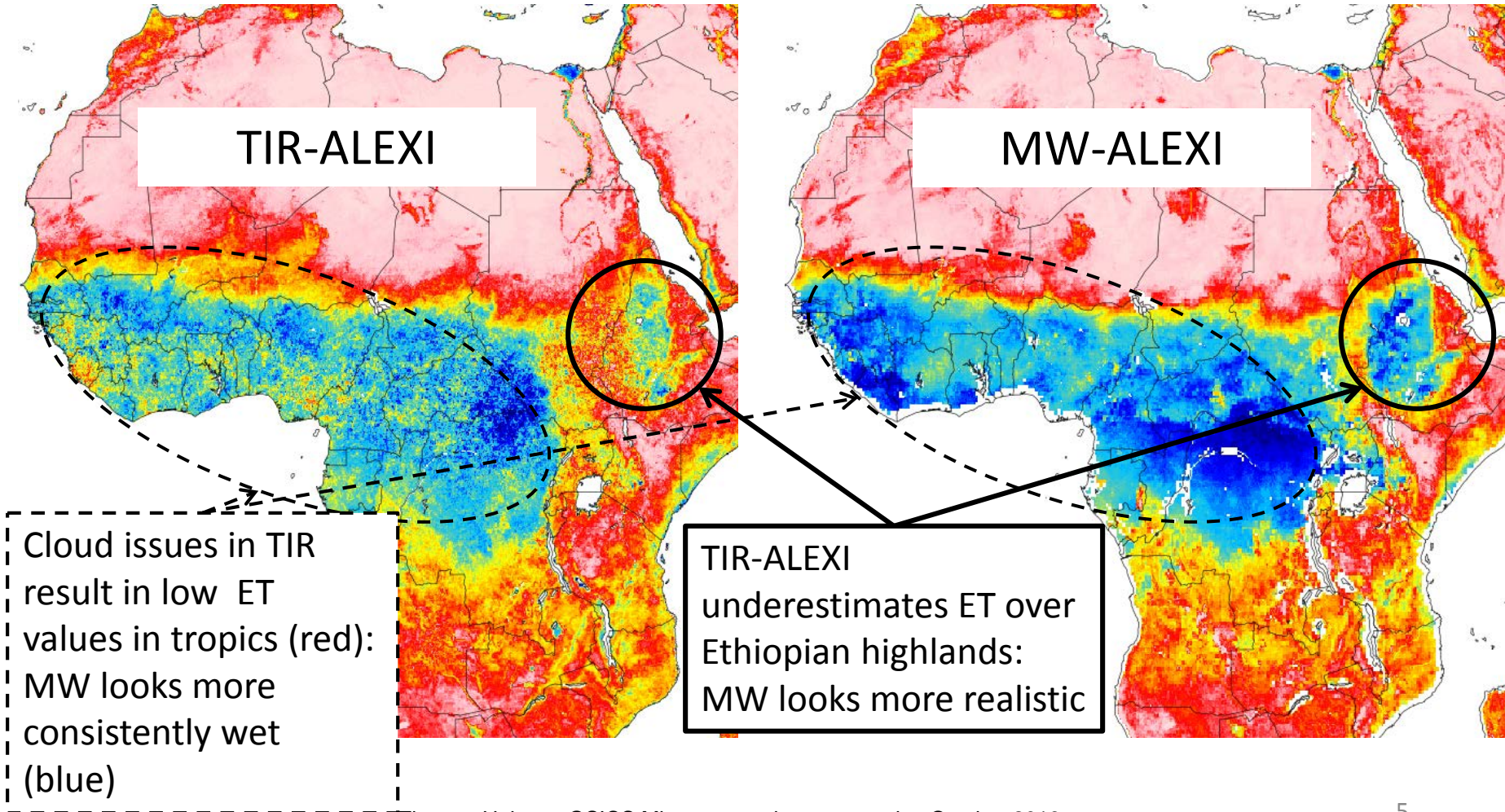
- Ka-band channel available from all multichannel radiometers

- For 2003-2013, we ingest data from 8 satellites:

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

  →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

- All satellites inter-calibrated with TMI as transfer reference
  - This is to double check the instrument calibration for the TB range over land
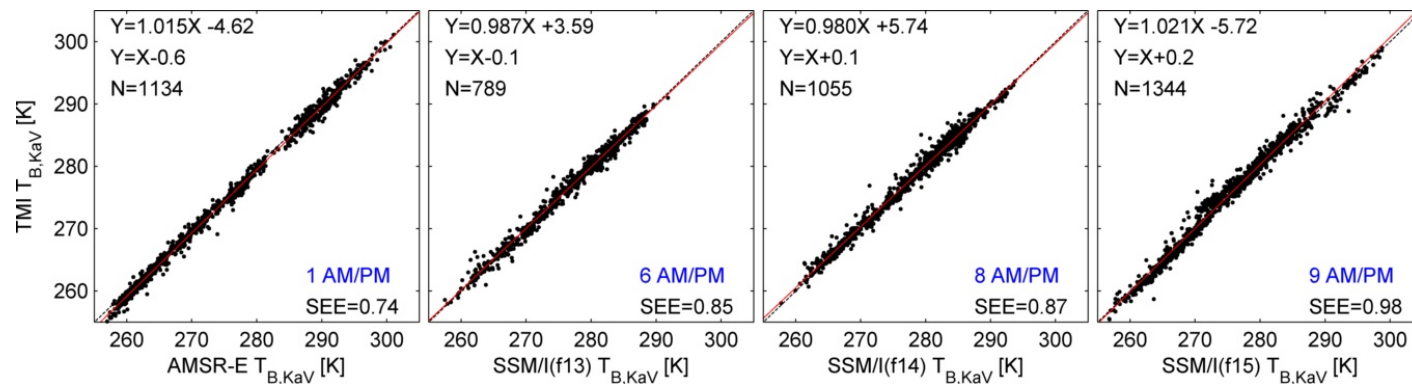
- geostationary Thermal Infrared (TIR) LST for calibration: LSA-SAF LST product 2007-2012, split window method based on based on MSG-9 SEVIRI TIR window channels, 3 km native resolution upscaled to 0.25 degree for this study

Constructing MW-LST
based only on XCAL Level 1C TB's

Simplified workflow

Existing Methodology

XCAL application

Input:
Brightness temperature observations

1. Inter-calibration and quality control

XCAL Replaces inter-calibration and quality control

Combine 37 GHz(V) from all satellites in XCAL database in single 0.25° by 15 minute daily 'data-cube'.

Inter-calibrated, quality controlled, Brightness temperature observations

2. Fit DTC to sparse observations

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

- Daily record of DTC parameters
- RMSE of fit

3. Scaling DTC parameters to TIR LST target

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

- time-constant scaling parameters

4. Constructing MW LST

Output:
MW LST + Quality Flag

Workflow

Application of XCAL TB's

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

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.

Conclusion

- 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?