National Aeronautics and Space Administration

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SMAP Radiometer L1 calibration and validation studies

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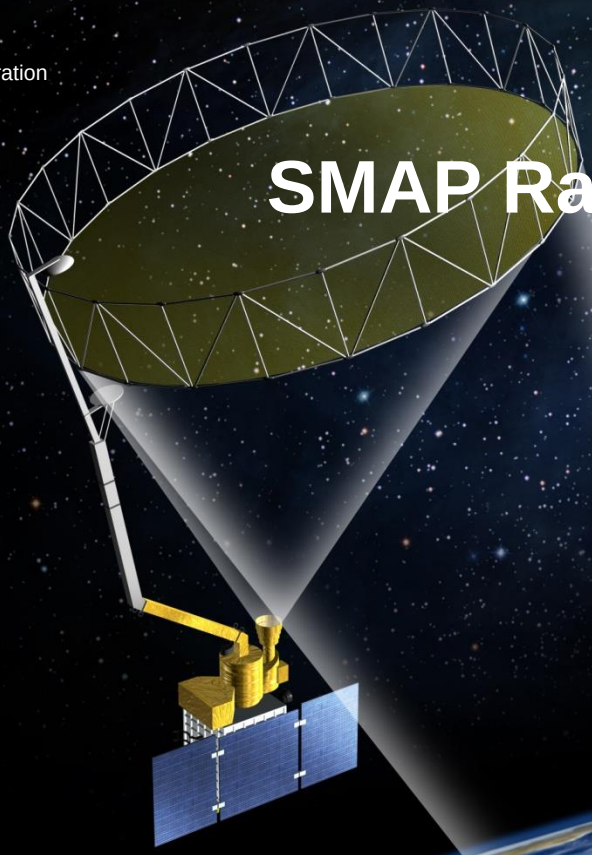
Soil Moisture Active Passive Mission

SMAP



4th Cal/Val Workshop

Pasadena, CA

November 5-7, 2013

Outline

- Introduction
- Synergistic effort – L1 DAART
- L1 Calibration effort
  - *In-orbit calibration effort*
  - *Vicarious calibration targets*
  - *RFI algorithm mitigation validation/optimization*
  - *Sub-channel calibration*
- Summary

Introduction

- In answer to *NASA ROSES NNH12ACDA001N-SMAP*
  - Call to join the SMAP science team, due earlier this year
  - The call asked for -
    - *"The ST role will primarily be to provide expert guidance and contributions to the SMAP project in the areas of preparation for science and applications utilization of SMAP science data products,* ***calibration, and validation (Cal/Val) of the Level 1*** *through Level 4 science data products,* ***assessments of accuracies*** *of the science data* ***products****…"*
  - We chose to concentrate on a radiometer level 1issues -
    - "*Postlaunch calibration of antenna and brightness temperatures*"
    - "*Detection and removal of RFI in radar and radiometer science data*"

Introduction

- The objective is to provide level 1 calibration support under the direction of the Project Scientist as science team members
- We have been actively involved in RFI algorithm development and calibration efforts for many space-borne radiometers (including Aquarius)
- Objectives
  - *Apply various performance analysis tools for the SMAP RFI detection and mitigation algorithms – to allow optimization*
  - *Implement tools to assess on-orbit static/dynamicTb calibration (many developed from Aquarius, Jason etc.)*
  - *Improve external L-band vicarious targets – including Amazon, Antarctic, flat dry desert areas*
  - *Bootstrap a full-band calibration algorithm to sub-bands and develop a spectrogram grid-dependent calibration algorithm*
  - *Inter-calibration techniques between Aquarius/SMOS/SMAP*

Synergy with L1 DAART

- The work we are suggesting will complement the Cal/Val plan laid out by the project team
  - *We will identify alternate targets*
  - *Apply different calibration and RFI optimization schemes*
  - *Apply a separate calibration monitoring*
  - *Apply different cross-calibration and boot-strap calibration techniques*
- Some work might be repetitive, but that should help confirm and validate and in some cases enhance the instrument calibration undertaken by the *DAART Team*

L1 Radiometer Calibration Effort

- The calibration effort is primarily focused on four areas
  1. *In-orbit calibration*
     - Derive experience from Aquarius and other space-borne radiometers, and apply those tools to SMAP.
  2. *External calibration target development*
     - L-band calibration is still evolving. Continue work done under Aquarius to SMAP.
  3. *RFI algorithms optimization*
     - SMAP has a unique RFI mitigation architecture, never been deployed on a space-borne mission. We expect to see unique challenges.
  4. *Boot-strapping and Cross-calibration algorithms*
     - Presence of Aquarius and possibly SMOS offer different cross-calibrating opportunities. Similarly, combination of sub-band data for RFI mitigation presents it's own challenges.

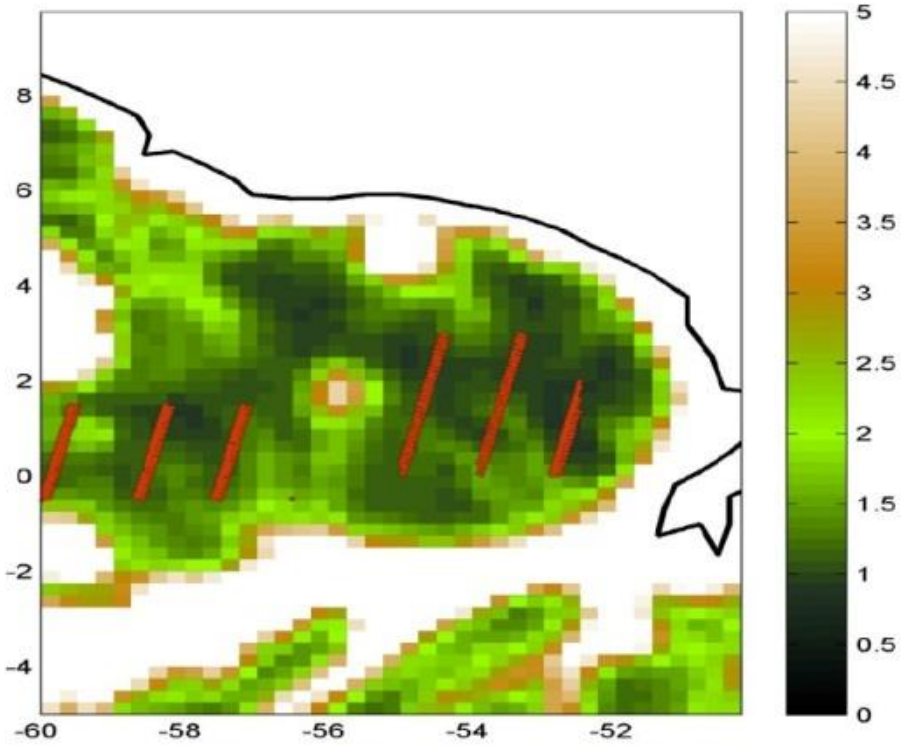
In-orbit calibration: Instrument level monitoring

- We will use tools developed from previous radiometer calibration missions, and new ones developed for SMAP to track various issues such as,
  - *Non-linearity checks*
  - *State dependent errors*
  - *Relative noise diode stability*
  - *Distributions of higher-order moments to assess backend anomalies*
  - *Potential thermal errors from radome and mesh*
  - *Potential scan dependent errors from mesh reflector*
- We will upgrade our automated calibration tools to SMAP to separate out residual geographically or temporally correlated errors (as opposed to a ground-truth bias)
- We expect this work to continue beyond the L+9 month phase

External calibration target development

- Need multiple external targets (in multiple scenarios) to deal with various coupled calibration error sources
  - *Gain drift (Relative)*
  - *Offset drift (Relative)*
  - *APC (Absolute)*
    - Cross-pol coupling
    - Spillover
  - *…*
- In addition to Cold-sky, Ocean and Antarctica used by the project – we will concentrate on Amazon, north-east Antarctica and potentially flat-dry desert regions
- Pre-launch discussions on maneuvers necessary for required decoupling
- Note: These models as of now have not been developed as absolute sources (one of our *major* tasks)
  - *Weighted regression fit*
- Drift analysis is expected to go beyond L+9 months

External calibration target development: Amazon

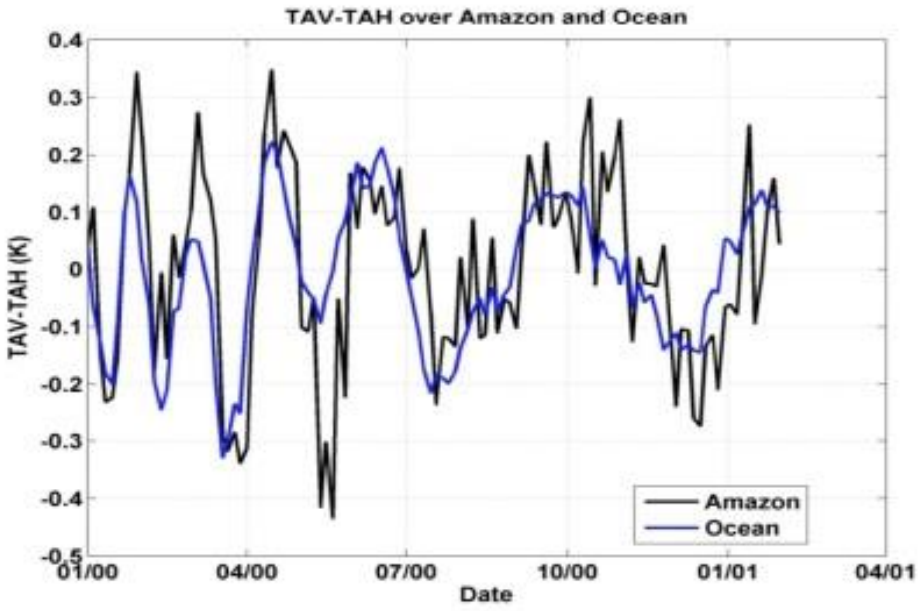


- Require temporally stable on-orbit calibration targets for long-term relative calibration
- We will use highly de-polarized Amazon targets to track relative calibration of the system
- Calibration models will be constrained by higher frequency AMSR-2
- We have used this for Aquarius
- Need additional sources to identify gain and offset component of drifts

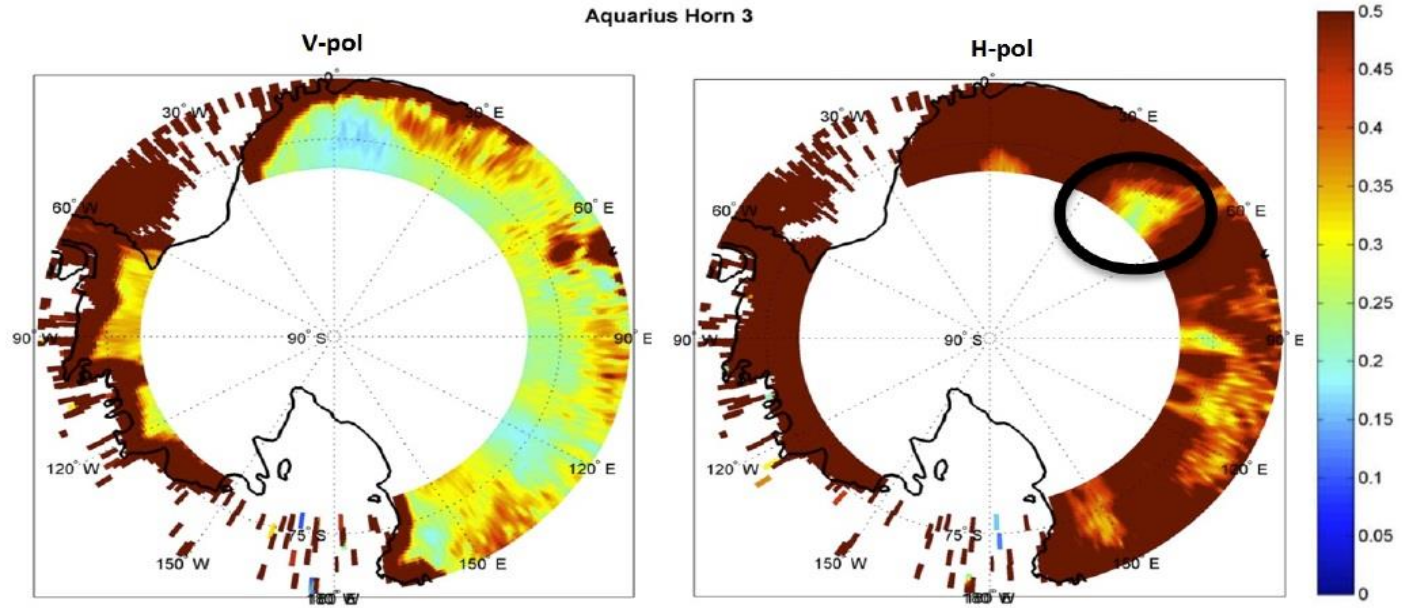
External calibration target development: Amazon

- Example of Aquarius inter-channel differences over the Amazon and ocean showing similar calibration oscillations despite the ~200K difference in brightness temperature, indicating these are offset oscillations

- Depending on the magnitude and type of drift, surface temperature precision might not be good enough to extract gain/offset information
- Inter-channel differences at monthly time scales might be better suited

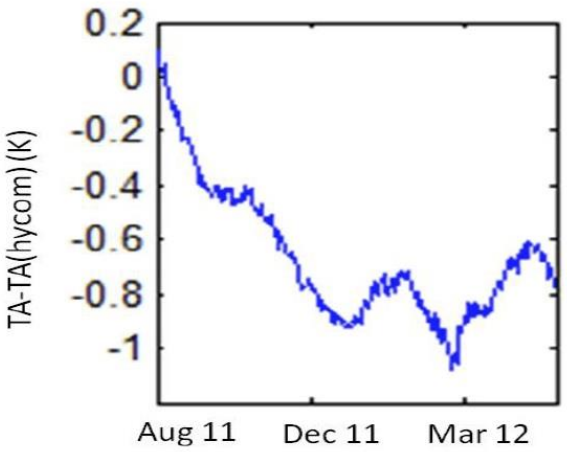


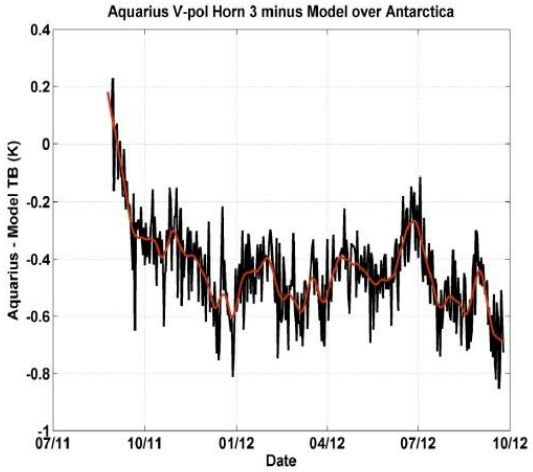
External calibration target development: Antarctic

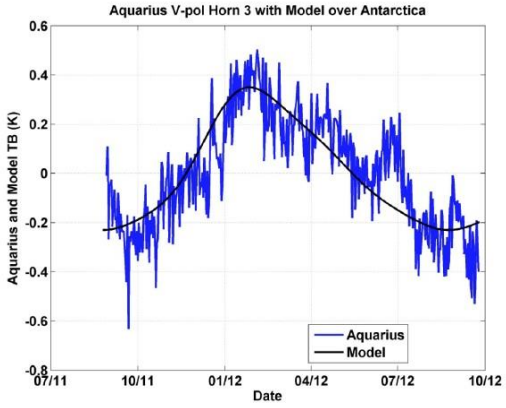


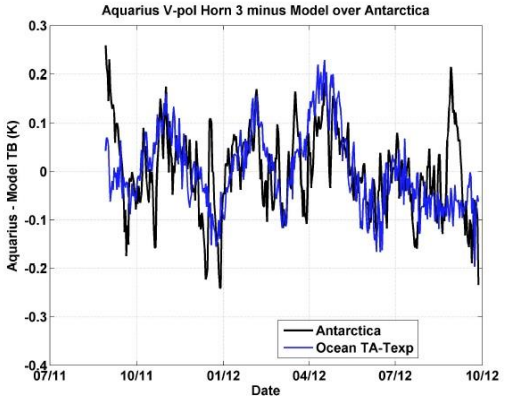
- Antarctic will provide an additional (warm) relative calibration point at 200K
- We've identified stable regions based on Aquarius observations
- Different than Dome-C used by the instrument team
- We have developed an TB model for ice emissions that can accurately predict relative drifts
- Model is still not developed enough for absolute calibration

External calibration target development: Antarctic



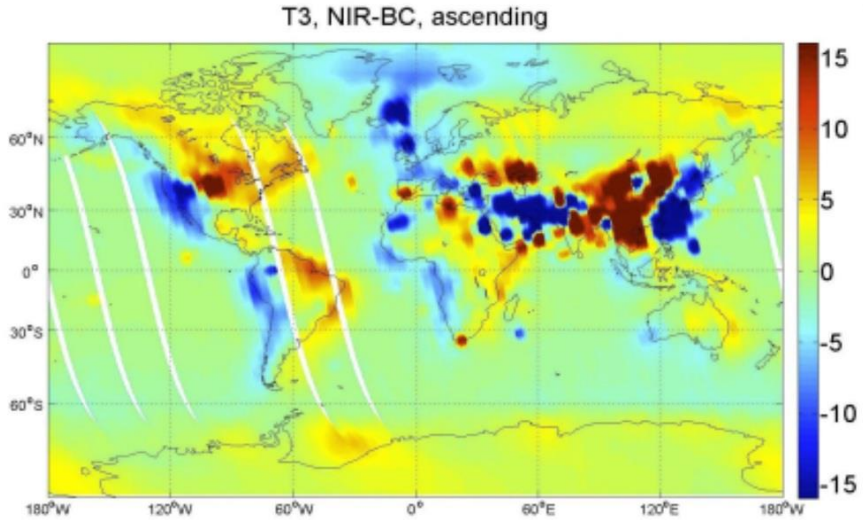


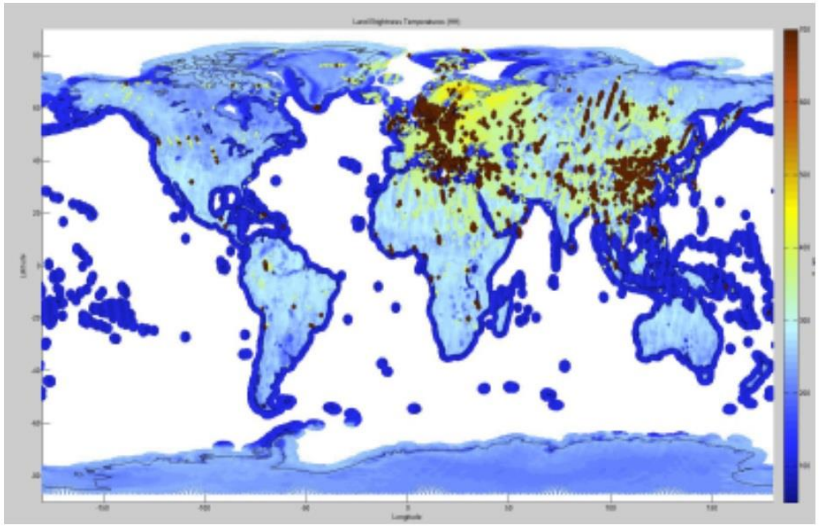




- Model simulates ice-layer emissions with a “randomizer” for the top layer parameters as well as wind-crust inclusions
- Constrained using AMSR-2
- Model very useful in Aquarius for identifying magnitude of drifts and partitioning them into gain/offset components

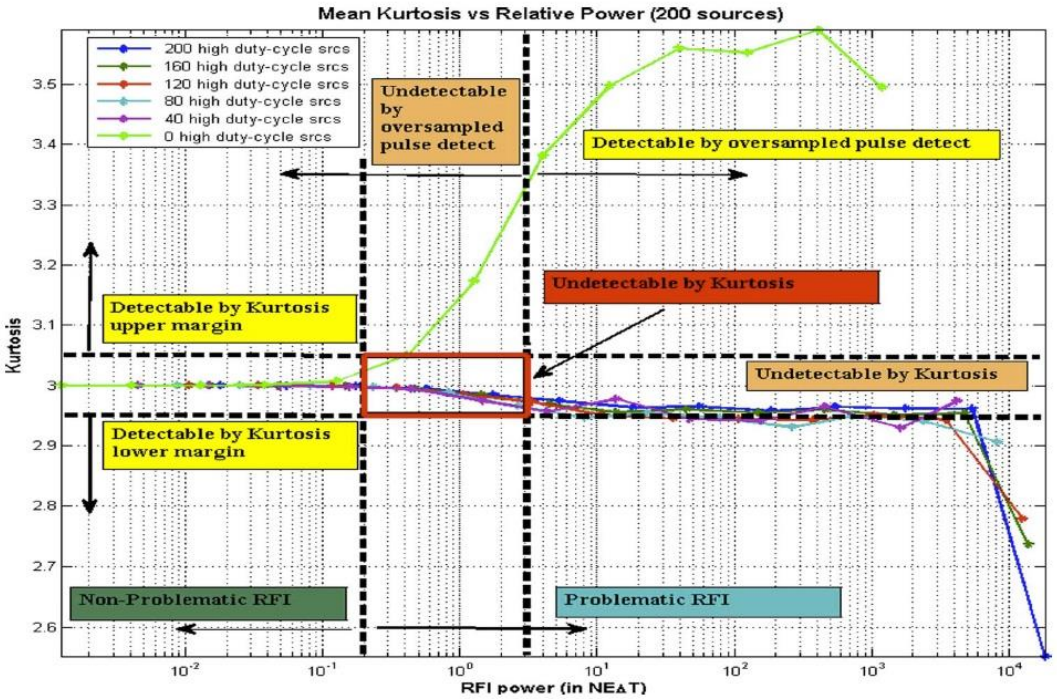
RFI algorithm calibration/validation





- Proposal team involved in the initial conception of the RFI mitigation technique
- Many optimization techniques derived from SMAPVEX data analysis
- False-alarm analysis to determine between clean regions and load to determine backend issues or RFI optimization
- Missed-detect analysis based on,
  - Inter-comparison with Aquarius/SMOS
  - RFI cumulative functions
- Internal algorithm comparison

RFI algorithm optimization



- Central-limit issues might impact SMAP RFI mitigation capabilities
- Based on analysis done on SMAPVEX data we have algorithm techniques to minimize central-limit issues such as temporal grid combination
- We will develop algorithms to use the fore and aft looks of the same scene to detect directional RFI and localize RFI sources
- We will also take advantage of scanning techniques to aid the project in tuning the thresholds based on grid location, expected RFI, expected number of sources, availability of high/slow data, expected side-lobe contamination etc.

Bootstrap calibration and Cross-calibration

- Bootstrap calibration
  - *Utilize full-band calibration to calibrate sub-bands over high contrast scenes*
  - *Analyze requirement of spectrogram grid based calibration given the RFI mitigation scheme*
- Cross-calibration
  - *We've been involved in Aquarius/SMOS calibration*
  - *We will apply similar techniques to cross-calibrate the three L-band missions and come with a long-period L-band data set*

Summary

- The radiometer L1 calibration work is meant to complement, verify and enhance the Tb calibration undertaken by the L1 DAART under the project science's direction
- We will over the mission period
  - *Continue to monitor the instrument calibration,*
  - *Develop external calibration sources moving towards an absolute calibration,*
  - *Analyze the RFI performance and aid in steps towards its optimization,*
  - *Work towards cross-calibration,*
  - *Deal with unexpected calibration issues.*