Soil Moisture
Active Passive
Mission
SMAP

ComRAD Active / Passive L Band Instrument System

Peggy O’Neill
NASA Goddard Space Flight Center

3rd Cal/Val Workshop
Nov. 14-16, 2012

ComRAD Active / Passive L Band Instrument System

**Frequency:** 1.403-1.424 GHz L radiometers; 1.25-1.3 L band radar

**Polarization:** dual pol radiometers (LH and LV) quad pol L radar (HH, VV, VH, HV)

**Antenna:** 1.22 m parabolic dish w/broadband feed

**Incidence Angle Range:** 0° - 175°

**Azimuth Angle Range:** 0° - 300° autonomous 0° - 360° manual

**Platform:** 19-m hydraulic boom truck

**Power:** standard AC line power

**TIR sensor installed for scene temperature**

**Can accommodate CropScan VISIR sensor**

*Deployed Over Corn Stubble During SMAPVEX08 (Oct. 2008)*
Anechoic Chamber Tests

Performance check of new antenna reflector and feed system in GSFC’s anechoic chamber on February 24, 2012

-- new system is very low loss

-- additional pattern measurements made in March 2012
ComRAD Crop Active / Passive Experiment  [APEX12]

• **Objective** – to obtain a continuous active/passive L band data set over an entire growing season for use in refining SMAP algorithms

• **Location** – USDA OPE3 test site a few miles from GSFC

• **Crop Cover**
  -- measure two crops simultaneously  (corn to north of truck staging area, soybeans to the south)

• **Autonomous data collection to maximize efficiency**
  -- manual external radiometer calibration once per week (sky, absorber)
  -- truck boom stowed & measurement series temporarily interrupted whenever rain/thunderstorms were forecast  -- frequently, though overall field conditions were very warm and dry all summer;  corn canopy stunted due to drought

• **Use of new very low loss antenna system and thermal control to maintain system calibration and to resolve small signals**
USDA OPE3 Test Site
Subwatershed C

-- site is a few miles down the road from GSFC

-- N-S rows

-- corn to north of truck, soybeans to south

-- AC power installed at site

-- corn planted ~ May 16, sprayed May 24, harvested October 17-18

-- soybeans planted June 14, harvested October 26

-- SCAN station to SW; flux tower to NE

November, 2012    SMAP Cal/Val Workshop
ComRAD L-band Active/Passive Measurements
Summer 2012

- **Vegetation Types**: Corn and Soybeans planted
- **Duration**: June 1 to mid-October, 2012 (planting to harvest)
- **L-band Active/Passive** data were acquired at a look angle of 40\(^\circ\) from nadir at both horizontal & vertical polarization
- **Radar** - 120\(^\circ\) azimuthal scan in 4 min. (60 independent measurements)
- **Radiometer** measurements every 15\(^\circ\) in azimuth in a span of 120\(^\circ\) in 20 min. (7 independent measurements)
- **Plant** architectural measurements of stalk and leaf sizes, orientations and densities on each field (weekly)
- **In situ** soil moisture, soil temperature & leaf wetness measurements made (also TIR measurement from ComRAD)
Corn harvested on Oct. 17-18; soybeans on Oct. 26  
Additional ComRAD measurements on Oct. 19, 20, 21, 24
**APEX12 Cover Crops**

<table>
<thead>
<tr>
<th>Corn</th>
<th>Soybeans</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Corn Picture" /> 060112</td>
<td><img src="image2" alt="Soybeans Picture" /> 060112</td>
</tr>
<tr>
<td><img src="image3" alt="Corn Picture" /> 070312</td>
<td><img src="image4" alt="Soybeans Picture" /> 070312</td>
</tr>
<tr>
<td><img src="image5" alt="Corn Picture" /> 071012</td>
<td><img src="image6" alt="Soybeans Picture" /> 071012</td>
</tr>
<tr>
<td><img src="image7" alt="Corn Picture" /> 081112</td>
<td><img src="image8" alt="Soybeans Picture" /> 081112</td>
</tr>
<tr>
<td><img src="image9" alt="Corn Picture" /> 091712</td>
<td><img src="image10" alt="Soybeans Picture" /> 091712</td>
</tr>
<tr>
<td><img src="image11" alt="Corn Picture" /> 101812</td>
<td><img src="image12" alt="Soybeans Picture" /> 101812</td>
</tr>
</tbody>
</table>
Example of ComRAD Time Series Data
August 27 – September 1, 2012

Radiometer

Soybeans

Incidence Angle = 40°

220 240 260 280 300 320
Temperature [K]

220 240 260 280 300 320
Temperature [K]

Incidence Angle = 40°

Radar

Soybeans

Incidence Angle = 40°

Corn

Incidence Angle = 40°
Summary

- Corn planted 5/16, sprayed 5/24, and harvested 10/17-18; soybeans planted 6/14 and harvested 10/26

- ComRAD measurements June 1 – Sept. 26, plus additional measurements in mid-October with corn harvested & soybeans at full senescence

- Final external radar calibration has been completed and instruments removed for the winter [we just beat Hurricane Sandy!]

- Three months of preliminary ComRAD and ground truth data have been delivered to JPL so far

- Complete final data set will be delivered when all data files have been checked (~ end of November)

- Mike Cosh / USDA will do quality check and calibration of all ground truth data before delivery to JPL
New Communication/Control Set-up

Instruments Mounted on The Boom

VNA-Based Radar

Radiometer

Boom Controller & Measurement Scheduler

Router

Instruments on Ground

USP to CAN

Cat 5

Cat 5

GPIB & Extender

Cat 5

VB 2008

VB 2005

October 3-5, 2012  SDT #9
A Controller Area Network (CAN) computer controls boom motion.

CAN computer is connected to hydraulic actuators and position sensors via the CAN network.

CAN computer is controlled remotely from a laptop computer via a serial port.

The motion program resides on the laptop computer.

Boom motion is fully automated for area sweeps and stationary look angles.

Automation is fully functional.
Boom Controller & Measurement Scheduler

Screen shots of new autonomous control program
**Schedule [APEX12]**

- **February / March:**
  - first test of new antenna and feed in anechoic chamber on 2/24/12
  - finish matched network
  - additional tests as needed in chamber to fully characterize performance of new antenna system
  - standard linearity test of radiometer components in GSFC lab (done every year)

- **April:**
  - reinstall all equipment on truck instrument platform
  - build instrument sun & rain shades as needed and install on truck platform
  - do final balancing of autonomous movement and calibration of program parameters
  - perform external calibration of radar & radiometer at GSFC

- **Beginning of May**
  - farm manager at USDA plants corn at OPE3 test site (depends on weather & other factors)
  - deploy ComRAD to OPE3 just after corn planting
  - might have to temporarily remove truck from field during atrazine spraying

- **Beginning of June**
  - farm manager at USDA plants soybeans at OPE3 test site (depends on weather & other factors)
  - might have to temporarily remove truck from field during soybean planting

- **Nominal science measurements May - October**
  - from planting at beginning of May to harvest in mid-October
  - manual calibration once per week (more often if needed)
  - truck boom will be stowed & measurement series temporarily interrupted if heavy rain/thunderstorms are forecast

- **Already completed:**
  - autonomous boom movement program & measurement control program & interfaces written
  - power installed at USDA OPE3 site
Impassible field conditions at OPE3 Subwatershed C in Fall 2011 prevented planting of winter wheat