Planned PLT/PLPT GOES-R Field Campaigns & Report on the GOES-R April Planning Workshop

Frank Padula & Steve Goodman
In coordination with the GOES-R CWG & AWG Teams
Joint MTG LI Mission Advisory Group & GOES-R GLM Science Team Workshop

May 28, 2015
Outline

Overview

Campaign Objectives

Baseline Plan

Summary Items

Image courtesy: Brian Hobbs (NASA ER-2 Program)
The purpose of the GOES-R field campaign is to support post-launch validation of L1b & L2+ products:

- **Advanced Baseline Imager (ABI) & Geostationary Lighting Mapper (GLM):**
  - Planning ~6 week field campaign (~100 flight hours) with the high-altitude NASA ER-2 platform coordinated with ground based and near surface observations over several Earth targets
  - An official flight request has been submitted to the NASA ER-2 Program
  - Tentative plan resulting from the GOES-R Field Campaign Workshop:
    - Split Phase 1 & 2 into potentially 2 campaigns
      - **Phase 1 (2 weeks)**
        - October – November 2016
        - ER-2 Based in Palmdale, CA (U.S. West Coast)
      - **TBD - Phase 2 (4 weeks)**
        - April – May 2017
        - ER-2 Based on the East Coast or Central U.S.
The purpose of the GOES-R field campaign is to support post-launch validation of L1b & L2+ products:

- Advanced Baseline Imager (ABI) & Geostationary Lighting Mapper (GLM):
  - Planning ~6 week field campaign (~100 flight hours) with the high-altitude NASA ER-2 platform coordinated with ground based and near surface observations over several Earth targets

**Investigating a revised strategy:**
- Combine Phase 1 & 2: April – May 2017
  - Phase 1 (2 weeks)
    - ER-2 Based in Palmdale, CA on the West Coast U.S.
  - Phase 2 (4 weeks)
    - ER-2 Based on the East Coast or Central U.S.
- Reduces costs & may provide greater value (currently evaluating potential risks)
- Better aligns the campaign with severe weather opportunities
- Underflights to be collected, when possible, with low Earth orbit environmental satellites which may include S-NPP, Terra/Aqua, METOP, Landsat, ISS & GPM
- We invite international participation in the field campaign
- We plan to have an open data access policy
GOES-R Field Campaign Planning Timeline

- Submitted Official Flight Request with NASA ER-2 Program
- CWG/AWG: Established initial GOES-R Field Campaign L1b/L2+ science requirements and objectives
- Conducted Several focused Trade Studies in support of Risk Mitigation Efforts
- Drafted & Submitted an initial set of near surface UAV science requirements to the NOAA Unmanned Aircraft Systems Program

- GOES-R Field Campaign Workshop: Established a baseline consensus of the GOES-R field campaign validation plan for L1b & L2+ products
- Ground & Near Surface Validation Readiness Review
- Continue Coordination & Preparation Efforts
- GOES-R Field Campaign Mission Planning Rehearsals
- GOES-R Launch
- GOES-R Field Campaign

- January, 2015
- February 5, 2015
- March, 2015
- April 8-9, 2015
- Summer, 2015
- December, 2015
- Summer, 2016
- October - November, 2016
- April – May 2017
GOES-R Field Campaign Workshop

**Milestone:**

Established a baseline consensus of the GOES-R field campaign validation plan for L1b & L2+ products

- Included participants from NOAA, NASA, and Universities
- All of the presentations are available at:
- ~14 actions were submitted
  - All are closed or actively being worked to closure
- Developing a campaign validation matrix
- Enhancing our data management planning and developing a GOES-R field campaign portal
- Strengthening our collaboration efforts to ensure mission success
- Preparing to conduct mission planning rehearsals

**GLM Validation Collection Strategies:**

Collect Main Storms OR Stratiform Regions

**Examples of Flight Patterns to Optimize Collection:**

Graphics courtesy of Douglas Moch
GOES-R Calibration Working Group (CWG) has provided excellent support in the pre-launch calibration data analysis to verify the pre-launch instrument performance on behalf of NOAA over the past several years:

- CWG has established an in-depth knowledge of the GOES-R instruments through extensive pre-launch support
- Established a strong communication line between the CWG and Algorithm Working Group (AWG) as a result of GOES-R pre-launch activities

Understanding both CWG & AWG pre-launch performance concerns & waivers and post-launch validation limitations and challenges fosters a value added opportunity to develop comprehensive field campaign activities
GOES-R ABI & GLM

Key Validation Metrics

ABI Performance Metrics:
- Reflective Solar Bands (RSB)
  - 5% radiometric uncertainty
- Thermal Emissive Bands (TEB)
  - 1 K radiometric uncertainty
- SI traceability established pre-launch

GLM Performance Metrics:
- 70% flash detection efficiency
- 5% false alarm rate
ABI Field Campaign Approach:

**Primary Objective:** provide high-altitude validation of ABI L1b spectral radiance observations to validate SI traceability

**Secondary objective:** provide surface and atmospheric geo-physical measurements to support L1b & L2+ product validation

**Targets of Interest:**
- Desert
- Open Ocean
- Land/Vegetation
- Clouds

Diagram showing:
- GOES-R
- ER-2 Aircraft
- Instruments
- Coincident Collection
- Ground Instruments, Systems & Support Teams

Layers:
- 20 km Stratosphere
- 10 km ~Tropopause
- 2 km Boundary Layer
- 10 m Near Surface
ABI L1b & L2+ Validation Priorities

Set of Priorities:

• Collect coincident & collocated high altitude airborne Hyper-Spectral Imagery (HSI), for all 16 ABI bands, with the same look angle as ABI over “uniform” Earth targets:
  Required Collection Set (no ground based obs.):
  – Desert & Water
  Minimum Collection Set (with ground based & near surface obs.):
  – Desert
  – Open Ocean (≥ 100 km off-shore)
  – Vegetation – over the Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Cloud And Radiation Testbed (CART) site
    ▪ Other sites as available (i.e. SURFRAD sites, Chesapeake Bay, Great Lakes)
• Collect coincident & collocated high altitude airborne Lidar & Doppler Radar observations for validation of cloud and microphysical products:
  Minimum Collection Set for Clouds:
  – Mixed phase, Multi-layer, Clouds in low light conditions (i.e. terminator)
• Collect coastline data when possible for INR validation
• Collect pre-storm environment and convective events
• Collect U.S. East coast (or subset) 50 km on-shore & 50 km off-shore following frontal passage
• Collect clouds over snow (if available)
• Collect active fires (need <100m spatial resolution coincident with VIIRS)
GLM Field Campaign Approach:

**Primary Objective:** provide validation of GLM flash detection efficiency day through night over land at well characterized total lightning super sites: Northern AL, Lubbock TX, Norman OK, KSC FL, and Wallops/DC area

**Secondary Objective:** provide validation of GLM flash detection efficiency day through night at other land locations and over ocean

**Tertiary Objective:** provide validation of GLM flash location & time stamp accuracy, and GLM image navigation and registration (INR) accuracy

**Targets of Interest:**
- Storms
GLM Validation Priorities

1) Validation of GLM flash detection efficiency: collect coincident and collocated high altitude data over thunderstorms with the Fly’s Eye GLM Simulator (FEGS*):
   - **Minimum Collection Set:** Over-flights of thunderstorms over total lightning super sites. Emphasis on large scale convection such as Mesoscale Convective Systems (MCSs) from pre-storm through entire evolution (include all times of day & other storm types)
   - **Secondary Collection Set:** Over-flights of thunderstorms at other locations (day / dawn or dusk/ night; high / low latitudes; land / ocean; various storm types / regimes)

2) Validation of GLM flash location & time-stamp accuracy, and INR

3) Validation of optical energy calibration for the GLM product (lightning, which consists of events, groups, and flashes)

* Also known in some circles as AGS (Airborne GLM Simulator)
Achievement Metrics

Field campaign success improved by complying with the following:

- Sample size on the order of 1000 flashes must be observed for any region and period of interest in order to characterize detection efficiency, and geo-location & time-stamp accuracy.

- Generally full storm life-cycle is desired, so do not interrupt life cycle when possible.

- More success is achieved by partially sampling multiple storm types (regime /region/time of day) rather than only fully sampling one or two types.
Value of the GOES-R Field Campaign

GLM:

- Provides independent persistent and flexible validation capability for:
  - Flash detection efficiency
  - Geo-location & time-stamp accuracy characterization
  - Optical energy calibration
- Ability to collect full storm life-cycle
- Greater flexibility to collect over multiple storm types at different times of day and geospatial regions
- No current satellite observations for cross validation as TRMM ended its data collection on April 8, 2015
- The ISS Lightning Imager Sensor (LIS) instrument may be available for comparison (planned launch early 2016), but Airborne GLM Simulator guarantees an optical to optical cross comparison
## GOES-R Field Campaign - Aircraft Candidate Instruments

<table>
<thead>
<tr>
<th>Candidate Instruments</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVIRISng</td>
<td>Next-Generation Airborne Visible/Infrared Imaging Spectrometer</td>
</tr>
<tr>
<td>S-HIS</td>
<td>Scanning High-resolution Interferometer Sounder</td>
</tr>
<tr>
<td>FEGS</td>
<td>Fly’s Eye GLM Simulator</td>
</tr>
<tr>
<td>LIP</td>
<td>Lightning Instrument Package</td>
</tr>
<tr>
<td>CPL</td>
<td>Cloud Physics Lidar</td>
</tr>
<tr>
<td>CRS</td>
<td>94-GHz (W-band) Cloud Radar System (CRS)</td>
</tr>
</tbody>
</table>
# GOES-R Field Campaign Candidate Instruments

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Type</th>
<th>Spectral Range</th>
<th>Spectral Res.</th>
<th>GSD</th>
<th>FOV</th>
<th>Swath Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVIRISng</td>
<td>HSI</td>
<td>380 – 2510 nm</td>
<td>5 nm</td>
<td>0.3 m to 20 m</td>
<td>34 deg</td>
<td>~11 km</td>
</tr>
<tr>
<td>S-HIS</td>
<td>HSI</td>
<td>3.3 - 18 µm</td>
<td>0.5cm⁻¹</td>
<td>2 km</td>
<td>40 deg</td>
<td>40 km</td>
</tr>
<tr>
<td>FEGS</td>
<td>Passive EO</td>
<td>near-infrared (777.4 nm)</td>
<td>10 nm</td>
<td>na</td>
<td>na</td>
<td>~10 km</td>
</tr>
<tr>
<td>LIP</td>
<td>Passive Electrical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPL</td>
<td>Lidar</td>
<td>1064, 532, &amp; 355 nm</td>
<td></td>
<td>30x200 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRS</td>
<td>Doppler Radar</td>
<td>94 GHz (W-band; 3 mm wavelength)</td>
<td></td>
<td>na</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ABI & GLM combined campaign provides an opportunity for data collection with broad suite of instruments.
GLM Field-Of-View centered @ 89.5 W: PLT & PLPT
ABI & GLM Validation

Circles are intended as visual guides for discussion purposes only

Phase 1:
Palmdale, CA
~ 2 weeks

Phase 2:
Central U.S.
~ 4 weeks

Phase 2:
East Coast
~ 4 weeks

List of LMA Sites:

- NALMA – Huntsville, AL
- DCLMA – Washington DC
- OKLMA – Norman, OK
- WTLMA – Lubbock, TX
- KSCLMA – Kennedy Space Center, FL
- NMLMA – Socorro, NM
- HLMA – Houston, TX
- FCLMA – Ft. Collins, CO
- WILMA – Wallops Island, VA
- NGLMA – Atlanta, GA
- TLMA – Toronto, Canada
ER-2 Loiter Time (based on 8 hr mission)

» Operations depart from & return to Palmdale, CA (PMD)

Image courtesy: Brian Hobbs (NASA ER-2 Program)
ER-2 Loiter Time (based on 8 hr mission)

Image courtesy: Brian Hobbs (NASA ER-2 Program)
Phase 1 Summary: GOES-R Field Campaign

Duration: ~2 weeks
Flight hours: ~20-30 hrs

Summary:
- Focus is to achieve ABI primary validation objective (L1b)
- Opportunity for ABI Intensive ground campaign at WSMR
- Opportunity for GLM validation targets:
  - GLM LMAs within range:
    - Socorro, NM
    - Ft. Collins, CO
    - Lubbock, TX
    - Norman, OK
- Collections of opportunity for ABI & GLM
Phase 2 Summary: GOES-R Field Campaign

Duration: ~4 weeks
Flight hours: ~70-80 hrs
Summary:

• Focus GLM validation objectives and ABI secondary objectives
• GLM LMAs within range (dependent upon location of GOES-R):
  - Huntsville, AL
  - Washington, DC
  - Kennedy Space Center, FL
  - Houston, TX
  - Wallops Island, VA
  - Atlanta, GA
  - Toronto, Canada
  - Lubbock, TX
  - Norman, OK
• Opportunity for ABI Intensive ground campaigns in the Gulf of Mexico & at the DOE ARM site
• Collections of opportunity for ABI & GLM
Questions?
GOES-R Field Campaign Workshop

Day 1

**Programmatic Overview**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 am</td>
<td>20 min ........ Welcome &amp; Overview – Steve Goodman (NOAA/NESDIS/GPO)</td>
</tr>
<tr>
<td>8:50 am</td>
<td>30 min ........ Overview of Plan – Frank Padula (NASA/GSFC/GPO)</td>
</tr>
<tr>
<td>9:20 am</td>
<td>10 min ........ PLT Coordination &amp; Field Campaign Preparations – Jeff Kronenwetter (NASA/GSFC/Flight)</td>
</tr>
<tr>
<td>9:30 am</td>
<td>15 min ........ ER-2 – Brian Hobbs (NASA/AFRC)</td>
</tr>
<tr>
<td>9:45 am</td>
<td>15 min ........ Discussion Q&amp;A</td>
</tr>
<tr>
<td>10:00 am</td>
<td>30 min break</td>
</tr>
</tbody>
</table>

**ER-2 Instrument Candidates**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30 am</td>
<td>10 min ........ GLM Airborne Simulator, LIP, &amp; High Speed Camera – Richard Blakeslee (NASA/MSFC)</td>
</tr>
<tr>
<td>10:40 am</td>
<td>10 min ........ S-HIS – Dave Tobin/Joe Taylor (UW/SSEC)</td>
</tr>
<tr>
<td>10:50 am</td>
<td>10 min ........ AVIRIS – Rob Green (NASA/JPL)</td>
</tr>
<tr>
<td>11:00 am</td>
<td>10 min ........ CPL – Matthew McGill (NASA/GSFC)</td>
</tr>
<tr>
<td>11:10 am</td>
<td>10 min ........ CRS – Gerry Heymsfield (NASA/GSFC)</td>
</tr>
<tr>
<td>11:20 pm</td>
<td>55 min ........ Discussion Q&amp;A</td>
</tr>
</tbody>
</table>

12:15 pm 1 hr lunch

**Ground Support**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:15 pm</td>
<td>15 min ........ CGW Participation Plans – Fred Wu /Changyong Cao (NOAA/NESDIS/STAR)</td>
</tr>
<tr>
<td>1:30 pm</td>
<td>15 min ........ AWG Participation Plans – J. Daniels (NOAA/NESDIS/STAR)</td>
</tr>
<tr>
<td>1:45 pm</td>
<td>15 min ........ NOAA UAS Capabilities &amp; GOES-R Support – Robbie Hood (NOAA/OAR/UASP)</td>
</tr>
<tr>
<td>2:00 pm</td>
<td>15 min ........ UW/CIMSS Measurement Capabilities – Brad Pierce (NOAA/NESDIS/STAR)/Wayne Feltz (UW/CIMSS)</td>
</tr>
<tr>
<td>2:15 pm</td>
<td>60 min ........ Discussion Q&amp;A</td>
</tr>
<tr>
<td>3:15 pm</td>
<td>15 min break</td>
</tr>
</tbody>
</table>

**Ground Support Cont.**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>3:30 pm</td>
<td>15 min ........ SURFRAD Capabilities &amp; Status Update – Kathy Lantz (UC/CIRES)</td>
</tr>
<tr>
<td>3:45 pm</td>
<td>15 min ........ NOAA Ocean Measurement Capabilities – tentative [Michael Ondruszek/Veronica Lance (NOAA/NESDIS/STAR)]</td>
</tr>
<tr>
<td>4:00 pm</td>
<td>30 min ........ Discussion Q&amp;A</td>
</tr>
<tr>
<td>4:30 pm</td>
<td>60 min ........ Poster Session</td>
</tr>
<tr>
<td>5:30 pm</td>
<td>Day 1 Meeting Adjourned</td>
</tr>
</tbody>
</table>

Day 2

**Field Campaign Experience**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 am</td>
<td>10 min ........ Day 1 Re-Cap – Steve Goodman (NOAA/NESDIS/GPO)</td>
</tr>
<tr>
<td>8:40 am</td>
<td>10 min ........ Suomi NPP Field Campaign Experience – Allen Larar (NASA/LRC)</td>
</tr>
<tr>
<td>8:50 am</td>
<td>10 min ........ GPM Field Campaign Experience – Walt Petersen (NASA/GSFC)</td>
</tr>
<tr>
<td>9:00 am</td>
<td>10 min ........ EOS Field Campaign Experience – Steve Platnick (NASA/GSFC)</td>
</tr>
<tr>
<td>9:10 am</td>
<td>30 min ........ Discussion Q&amp;A</td>
</tr>
<tr>
<td>9:40 am</td>
<td>20 min break</td>
</tr>
</tbody>
</table>

**Focused Discussions**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:00 am</td>
<td>40 min ........ Discussion: Deployment (personnel, instrument integration planning, &amp; operations)</td>
</tr>
<tr>
<td>10:40 am</td>
<td>40 min ........ Discussion: Ground Measurement Coordination</td>
</tr>
<tr>
<td>11:20 am</td>
<td>40 min ........ Discussion: Analysis</td>
</tr>
<tr>
<td>12:00 am</td>
<td>30 min ........ Summary Discussion &amp; Next Steps</td>
</tr>
<tr>
<td>12:30 pm</td>
<td>Meeting Adjourned</td>
</tr>
</tbody>
</table>

When: April 8th - 9th, 2015

(***Day 1**: 8:30 am to 5:30 pm, **Day 2**: 8:30 am to 12:30 pm)

Where: ESSIC-4th floor Conference Room, Univ. of Maryland (M-Square)

Purpose: Achieve a baseline consensus of the initial GOES-R Field Campaign plan: refine validation planning efforts, identify required resources (i.e. budget and support teams), establish and refine coordination efforts, refine time-frames and identify and develop risk mitigation plans.
Intensive Ground Campaign Timelines:

**Collection Day 1 (minimum set):**
- **7:30 am:** Metop, Terra, Landsat, S-NPP
- **10:30 am:** Metop, Terra, Landsat, S-NPP
- **1:30 pm:** Aqua & S-NPP
- **4:30 pm:** Aqua & S-NPP
- **7:30 pm:** ER-2 Collection of Cal/Site (30 min)

**Collection Day 2:**
- **6:30 am:** Metop, Terra, Landsat, S-NPP
- **9:30 am:** Metop, Terra, Landsat, S-NPP
- **12:30 pm:** Aqua & S-NPP
- **3:30 pm:** Aqua & S-NPP
- **6:30 pm:** ER-2

- **15 min Continuous N-S Swath (1.25 hrs/day)**
- **15 min Continuous Ground Obs.**

Legend:
- **ABI**
- **G**
- **ER-2**