GOES-R/JPSS Proving Ground Demonstration Proposal:
Hazardous Weather Testbed – 2015 Spring Experiment

1. **Project Title:** 2015 Geostationary Operational Environmental Satellite R-series (GOES-R)/Joint Polar Satellite System (JPSS) Proving Ground – Hazardous Weather Testbed (HWT) Experimental Warning Program (EWP) and Experimental Forecast Program (EFP) Product Demonstrations

2. **Organization**: HWT/EWP and EFP, Norman, OK

3. **Products to be Demonstrated as a GOES-R/JPSS Proving Ground activity at the HWT:**
   - **a.** GOES Sounder Total Precipitable Water (TPW), Layer Precipitable Water (LPW), and Derived Atmospheric Stability Indices using GOES-R Legacy Atmospheric Profile (LAP) algorithm (Baseline)
   - **b.** GOES-R Convective Initiation (Future Capability)
   - **c.** ProbSevere Model (Decision Aid)
   - **d.** Total Lightning Detection/PGLM (Baseline)
   - **e.** Lightning Jump Algorithm (Risk Reduction)
   - **f.** GOES-14 Super Rapid Scan Operations for GOES-R (SRSOR) 1-min Imagery (Baseline)
   - **g.** Satellite-based Forecaster Guidance for the HRRR model (Decision Aid)
   - **h.** NOAA Unique CrIS ATMS Processing System (NUCAPS) Temperature and Moisture Profiles (JPSS)

4. **Demonstration Project Summary:**
   - **a. Overview:** The HWT will receive early exposure to GOES-R/JPSS Proving Ground products during the 2015 Spring Experiment through activities led by the SPC/HWT Satellite Liaison, William Line. The Proving Ground portion of the Spring Experiment will take place 04 May – 12 Jun 2015, primarily in the EWP "Spring Warning Project". The EWP provides a conceptual framework and a physical space to foster collaboration between research and operations to test and evaluate emerging technologies and science to advance NWS warning operations. Products will be demonstrated within a simulated warning operations environment using a real-time AWIPS-II (D2D) framework within the HWT. For the second year in a row, broadcast meteorologists will participate alongside National Weather Service (NWS) operational forecasters as the Proving Ground continues to involve the broader meteorological community in its activities. Various project scientists will also be in attendance throughout the experiment to provide further project expertise and to communicate directly with the user community. The exposure to appropriate pre-operational GOES-R and JPSS products and capabilities during the height of the spring severe weather season will provide NWS forecasters, broadcast meteorologists, and scientists an opportunity to help determine operational applicability as well as critique and suggest improvements for algorithms in different stages of their development cycle.

b. Plan, Purpose, and Scope: The HWT provides the GOES-R/JPSS Proving Ground with an opportunity to demonstrate Baseline, Future Capabilities, and Decision Aid products associated with the next generation GOES-R geostationary and JPSS polar satellite systems that have the potential to improve short-range hazardous weather forecasting, nowcasting and warnings. The availability of GOES-R products will demonstrate, pre-launch, a portion of the full observing capability of the GOES-R system, subject to the constraints of existing data sources to emulate the satellite sensors. The structure of the GOES-R/JPSS Proving Ground portion of the Spring Experiment in the EWP will be as follows:

There will be a total of 30 external participants spanning the five weeks, with six (five NWS forecasters and one broadcaster) participants in attendance each week. Forecasters will work in pairs participating in simulated short-term forecast and warning operations in County Warning Areas (CWA's) across the CONUS determined via collaboration with the EFP. Using an EWP blog, participants will document their short-term experimental mesoscale discussions in real-time, highlighting the impact of the demonstration satellite products on those testbed forecasts. Additionally, they will record the reasoning behind experimental warnings when possible, once again focusing on how the satellite products influenced those decisions. Participants will be encouraged to provide updates (verification) on the performance of previous experimental issuances using the blog as well.

Each week will begin with an 11 am - 7 pm shift on Monday, while the Tuesday through Thursday eight hour shifts will begin between 9 am and 3 pm, depending on when the primary convective activity is likely to start. The goal will be to begin Tuesday through Thursday one to two hours before the onset of severe thunderstorm development as many of the satellite products being demonstrated are designed to have their greatest utility in helping to increase lead time to initial convective development and to the issuance of hazardous weather warnings. Each Mon-Thurs shift will begin with a ~15 minute briefing from the EFP highlighting details regarding the anticipated convective threat (location/timing/mode/severe type) for the day. At the end of the day on Thursday, in collaboration with the NWS Warning Decision Training Branch (WDTB), participants will develop presentations sharing their experiences in the Spring Experiment, highlighting appropriate cases and satellite products. These will be presented virtually Friday morning as part of the "Tales from the Testbed" webinar, in which scientists and NWS entities outside of Norman are encouraged to participate.

Participant training for each satellite product will consist of a narrated PowerPoint Articulate presentation sent to participants for completion before their arrival in Norman. Additionally, "quick-guides" highlighting key points about each product will be available as a reference for participants during daily experimental activities. Feedback will be gathered throughout the experiment in the form of: 1) surveys to be completed at the end of each day, 2) real-time blogging, 3) real-time discussions, 4) daily debriefs during the start of each day, and 5) weekly debriefs Friday morning. Notes from the daily and weekly debriefs will also be posted to the EWP blog. All

satellite-related blog posts will be forwarded to the GOES-R HWT blog (http://goesrhwt.blogspot.com/)

c. **Goals:** The main objective of the GOES-R/JPSS product demonstrations within the HWT is to demonstrate and evaluate Baseline, Future Capability and Decision Aid products that have the potential to improve short-term forecasts, nowcasts and warnings of hazardous weather across the CONUS. Highlights of forecaster feedback will be organized in a final report which will be submitted to the GOES-R/JPSS Proving Ground and eventually provided to product developers so that recommended changes and improvements to products can be addressed. The one-on-one interactions between the SPC/HWT Satellite Liaison, project scientists, NWS forecasters, and broadcast meteorologists allow for valuable discussions during real-time hazardous weather events, maximizing operations-to-research (O2R) feedback, a key goal of the Proving Ground. Additionally, the real-time demonstration ensures the algorithms work properly in AWIPS-II. Finally, exposing NWS forecasters and broadcast meteorologists to GOES-R products and capabilities pre-launch increases day-1 readiness, another goal of the Proving Ground.

5. **Participants Involved:**
   a. **Providers:**
      i. GOES Sounder TPW, LPW, and Derived Atmospheric Stability Indices using GOES-R LAP algorithm (Li – CIMSS)
      ii. GOES-R Convective Initiation (Mecikalski – UAH)
      iii. ProbSevere Model (Pavolonis – CIMSS)
      iv. Total Lightning Detection (PGLM) (Stano – SPoRT)
      v. Lightning Jump Algorithm (Carey/Calhoun – UAH/NSSL)
      vi. GOES-14 SRSOR 1-min Imagery (Schmit/Lindsey/Goodman – NESDIS)
      vii. Satellite-based Forecaster Guidance for the HRRR model (Otkin/Sieglaf – CIMSS)
      viii. NUCAPS Temperature and Moisture Profiles (Neitfeld/Motta/Line – NWS/CIMMS)

   b. **Consumers:**
      i. Hazardous Weather Testbed

6. **Project Schedule/Duration (some dates are preliminary and subject to change):**
   a. Products tested in HWT AWIPS-II system: 20 Apr 2015
   b. Training sent to participants: 13 Apr 2015
   c. Product demonstrations begin: 04 May 2015
   d. Product demonstrations end: 12 Jun 2015
   e. Final evaluation report: 20 Jul 2015

7. **Project Decision Points and Deliverables:**
   a. Proving Ground Operations Plan – First Draft: 25 Mar 2015
   b. Proving Ground Final Report: 20 Jul 2015

8. **Responsibilities and Coordination:**
    - **a.** William Line, OU/CIMMS and NOAA/NWS/SPC – SPC/HWT Satellite Liaison
    - **b.** Gabriel Garfield, OU/CIMMS and NOAA/NWS/WFO OUN – EWP Coordinator
    - **c.** Kathryn Miretzky, AS&D for GOES-R Program Office – PG Coordinator

9. **Budget and Resource Estimate:** Funded through the GOES-R Science Office as part of the Omnibus Proving Ground funding to CIRA, CIMSS, UAH, and NASA/SPoRT.

Product Name: GOES Sounder Total Precipitable Water (TPW), Layer Precipitable Water (LPW), and Derived Atmospheric Stability Indices using GOES-R Legacy Atmospheric Profile (LAP) algorithm

Primary Investigator: Jun Li (CIMSS)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- Provides observation-based details about the recent evolution of moisture and instability in the atmosphere, important factors during pre-storm mesoscale analysis.
- Ability to increase forecaster confidence regarding the state of the past and current thermodynamic environment will be assessed.
- This demonstration will help gauge the operational readiness of GOES-R ABI baseline algorithms.

Product Overview:

- Observation-based fields that indicate where favorable (or not) thermodynamic conditions exist for convective and severe weather development.

Product Methodology:

- GOES Sounder observations are processed through the GOES-R LAP retrieval algorithm.
- GOES-R cloud mask algorithm is implemented for GOES Sounder clear field-of-view (FOV) detection.
- Under development is project to include LAP products under cloudy skies (GOES-R3).
- Total Precipitable Water and various Stability Indices are derived from the GOES Sounder with GOES-R LAP retrieval algorithms.

LAP Products:

- GOES East/West Sounder TPW, LPW, CAPE, LI

Concept for Operational Demonstration:

- GOES Sounder LAP products will be delivered to the HWT via the LDM and formatted for display in AWIPS-II.

Concept for Operations:

- LAP products from GOES-R are expected to be centrally produced at OSPO/ESPC and delivered by SBN or PDA.

Product Name: GOES-R Convective Initiation

Primary Investigator: John Mecikalski (UAH/SPoRT)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- Provides 0-2 h probabilistic forecasts that highlight where convective initiation (35 dBz reflectivity echo at -10C level) is likely.
- Ability to increase forecaster confidence and extend lead time to initial convective development will be part of evaluation.

Product Overview:

- NWP-satellite fused probabilistic product that serves as a strategic aid for determining areas of convective initiation in the next 0-2 h.
- Algorithm incorporates information about the local atmospheric environment in addition to various satellite fields.

Product Methodology:

- Convective initiation probabilistic product is produced using a logistic regression framework.
    - A training database of over 500,000 objects has been developed using an objective validation technique, allowing for a much better representation of convective regimes as compared to earlier versions of the CI product.
- GOES-R proxy cloud products are ingested to diagnose CI under thin cirrus and are also used to substantially enhance the nighttime portion of the algorithm.
- Satellite-based convective cloud properties and NWP model environment fields from the Rapid Refresh model are used to create 0-2 h probabilistic forecasts.
- Development of a Quasi-Discriminant Analysis has reduced some of the noise associated with the lower CI probability values.
- Early verification statistics from the fused NWP-satellite product have much improved skill scores compared to the satellite-only CI product.

GOES-R Convective Initiation Products:

- 0-2 h Probabilistic Forecasts of Convective Initiation

Concept for Operational Demonstration:

- GOES-R Convective Initiation product will be delivered to the HWT via the LDM and formatted for display in AWIPS-II.

Concept for Operations:

- The CONOPs for possible implementation into operations need further development (this assumes approval to proceed/ prioritization from NOAT). To date, possible paths to operations include:
    - Centrally produced at NESDIS/ESPC most likely as part of a “convective toolbox” suite of satellite products.

- Discuss with NCEP/NCO possibility of running at NCO most likely as part of a convective toolbox and deliver to NCO users via NCO-backbone and to non-NCEP users via future AWIPS DDS capability
- Run as AWIPS-II application and/or procedure.

Product Name: NOAA/CIMSS ProbSevere Model (ProbSevere)

Primary Investigator: Mike Pavolonis (NESDIS)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- Assists forecasters in severe weather situations by highlighting storms that are more or less likely to become severe in the near future.
- Product will be evaluated on its ability to increase forecaster confidence and skillfully extend lead time to severe hazards for NWS warnings during potential severe weather situations.

Product Overview:

- Model provides probabilistic guidance to forecasters on the likelihood of severe weather occurrence for developing convection in the next hour.
- Algorithm incorporates multiple datasets (data fusion) from satellite, radar, and NWP into one easy-to-interpret product, helping to consolidate/reduce the "fire hose" of data during busy weather situations.
- Model output can be displayed referenced to storms on radar reflectivity images.
- Model output is available over the eastern three-quarters of the CONUS (predominantly east of the Rocky Mountains) and is day/night independent.

Product Methodology:

- A statistical model is employed to compute the probability that a storm will produce severe weather in the near-term, using GOES-derived, NEXRAD-derived, and Rapid Refresh (RAP) model-derived data.
- The model leverages an object-centric approach, whereby satellite-object tracking and radar-object tracking operate simultaneously.
- Satellite growth rates, radar intensity, and RAP-derived environment metrics are extracted from identified storm objects and the trends from satellite storm objects are shared with spatially overlapping radar storm objects.
- Object-centric approach helps keep a history of a storm's development observed by GOES.
- ProbSevere updates approximately every 2 minutes.

ProbSevere Products

- Product is displayed as color contours of severe probabilities around storms on radar.
- Data readout is available by sampling the probability contour. This provides the exact probability of severe and the detailed model predictor values.

Concept for Operational Demonstration:

- An ASCII file (on the order of kilobytes) will be delivered to the HWT via the LDM and converted on-the-fly into a shapefile using AWIPS-II.

Concept for Operations:

- The CONOPs for possible implementation of ProbSevere needs further development and is pending Proving Ground evaluations, as well as formal approval by the NOAT.

Product Name: Total Lightning Detection, Pseudo-Geostationary Lightning Mapper (PGLM)

Primary Investigator: Geoffrey Stano (NASA/SPoRT)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- Identify developing deep convection, initial electrification by observing both cloud-to-ground and intra-cloud lightning, and relationship to storm intensity.
- Prepare forecasters to receive data from the Geostationary Lightning Mapper (GLM), baseline GOES-R instrumentation designed to measure total lightning.
- Trends in total lightning and relationship to storm evolution, severe weather, and flooding potential will be evaluated along with relationships to other fields available at HWT.
- Identify product types, visualization techniques, and tools for future GLM observations.

Product Overview:

- Gridded observations derived from ground-based Lightning Mapping Arrays (LMA).
    - Flash extent density at 8 km horizontal resolution.
        - This will be available every 2 minutes (North Alabama and D.C.) or as a running 2 minute summation every minute.
    - Flash extent density summation at 8 km.
        - All lightning activity will be summed for the previous 6 minutes and update every 1 or 2 minutes based on the particular LMA's native resolution.
        - Six minutes was chosen for easy integration of 1 and 2 minute LMAs.
    - Several color curves will be provided as per previous feedback.
- Designed to give forecasters the opportunity to use and critique a demonstration of GLM type data to help improve future visualizations of these data and its trends.

Product Methodology:

- Takes the raw total lightning observations, or sources, from available ground-based LMA data and recombines them into a flash extent gridded field.
- These data are then re-mapped to a GLM resolution of 8 km and are available at a 1 to 2 minute refresh rate, depending on the ground-based network being used.
- When a flash enters a grid box, the flash count will be increased by one and no flash is counted more than once for a given grid box.

GOES-R PGLM Products:

- Available LMA networks: Colorado (COLMA), Houston (HGLMA), Langmuir Lab, NM (LLLMA), North Alabama (NALMA), Oklahoma (OKLMA), Washington D.C. (DCLMA), and West Texas (WTLMA)
- Possible LMA networks: North Georgia (NGLMA), Southern Ontario (SOLMA), and Wallops Island (WILMA)

Concept for Operational Demonstration:

- The PGLM will be delivered via the LDM and formatted for display in AWIPS-II at HWT.

Concept for Operations:

- The PGLM will be displayed via NASA SPoRT's total lightning plug-in for AWIPS-II.

Product Name: Lightning Jump Algorithm (LJA)

Primary Investigators: Larry Carey (UAH) and Kristin Calhoun (CIMMS/NSSL)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- This product can indicate when an updraft is strengthening or weakening on shorter timescales than current radar and satellite.
- LJA can identify when potential for severe or hazardous weather has increased.
- LJA can help forecasters decide on whether or not to issue a warning.

Product Overview:

- The gridded LJA provides a degree of a lighting jump for multiple tracked storm objects on the same display.
- Storm tracking and jumps are completed in the background.
- The LJA is available across CONUS and can use total lightning data from either Earth Networks Total Lightning Network (ENTLN) or Lightning Mapping Arrays (LMA).
- Unique advantage of total lightning data is its high temporal resolution; lightning flash rates can currently be evaluated every 1-2 min in real-time. The LJA will be updated every minute for the HWT evaluation.

Product Methodology:

- Algorithm uses total lightning data from the ENTLN for CONUS coverage. It is also run over multiple LMA regions in Oklahoma, Texas, Northern Colorado, Northern Alabama, and Washington DC which produces a separate product.
- Using the 1-min storm flash rate, the standard deviation over the previous 10-min period of activity (not including the period of interest) is computed. If the degree of jump (or sigma-level) is more than one standard deviation of the previous 10-min period, it is flagged as a "lightning jump."
- Individual storm clusters and objects are defined by the KMeans/SegMotion storm tracking algorithm.
- The LJA grid contains the identified storm objects, colorized by the degree of "jump" (1-sigma, 2-sigma, etc) for that time period.

Concept for Operational Demonstration:

- The LJA grid is produced at NSSL and has been formatted for display in AWIPS-II.
- Forecasters will be asked to determine:
    - If the LJA grid (in current state) was useful in their storm interrogation and/or warning decision.
    - What could be enhanced in either the display or content to increase the products utility in operations.

Concept for Operations:

- Ultimately, an LJA grid can be produced using GOES-R Geostationary Lightning Mapper (GLM) data or any other total lightning product.
- Final AWIPS-II display and product integration (with radar/satellite) will depend on feedback from HWT operations.

Product Name: GOES-14 Super Rapid Scan Operations for GOES-R (SRSOR) 1-min Imagery

Primary Investigators: Tim Schmit, Dan Lindsey, and Steve Goodman (NESDIS)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- The 1-min satellite imagery allows forecasters to observe atmospheric features and processes - such as subtle boundary location and movement - not seen as easily or at all in current routine imagery
- The increased temporal frequency and timeliness of the 1-min satellite imagery increases lead time to various convective processes including convective initiation, intensification, and decay, resulting in more timely forecast product issuance
- The Overshooting Top Detection Algorithm (CIMSS) will be generated from and displayed with the 1-min satellite imagery
- This evaluation continues to explore the value added by 1-min imagery to the severe weather nowcast and warning process. Additionally, forecasters are prepared for a baseline capability of the GOES-R ABI when operating in Scan Mode 3

Product Overview:

- GOES-14 SRSOR provides forecasters with 1-min satellite imagery over a roughly 1500x2000 km daily-changing sector.
- GOES-14 SRSOR is expected to be available from May 18 to June 11.

GOES-14 SRSOR Products:

- 1-min visible (1 km) and infrared (4 km) satellite imagery
- Overshooting Top Detection Algorithm

Concept for Operational Demonstration:

- GOES-14 SRSOR 1-min imagery will be delivered to the HWT via the LDM and formatted for display in EWP AWIPS-II and EFP N-AWIPS.

Concept for Operations:

- Cloud and moisture data from GOES-R are expected to be centrally produced at OSPO/ESPC and delivered by SBN or PDA.

Product Name: Satellite-based Forecaster Guidance for the HRRR model

Primary Investigators: Jason Otkin and Justin Sieglaff (CIMSS)

Hazardous Weather Testbed, Experimental Forecast Program Relevance:

- Provide forecasters with satellite-based tools that can be used to quickly determine the accuracy of current and prior HRRR model forecasts
- Product will be evaluated on its ability to provide useful guidance that promotes the more efficient analysis of rapidly-updating high-resolution model forecast performance

Product Overview:

- Simulated GOES infrared brightness temperatures generated using HRRR model output are used to provide an objective measure of the accuracy of overlapping model forecast cycles in near real-time
- Comparison of observed and simulated GOES imagery at the current time can be used to assess the accuracy of the model forecast cloud and water vapor fields along with other features important to severe weather forecasting
- Forecasters can more easily identify which forecast cycle is the most accurate at the current time (which may not be the most recent cycle) and then consider using that forecast cycle to update or create new short-term forecasts

Product Methodology:

- Simulated 6.2 and 10.7 μm brightness temperatures will be generated for GOES-East and GOES-West projections using the Community Radiative Transfer Model (CRTM) for each 15-hour experimental HRRR model forecast cycle run at ESRL
- Traditional grid-point statistical measures (root mean square error, mean absolute error, and bias) are computed in near-real time through comparison of observed and simulated GOES brightness temperatures
- Observed and simulated GOES imagery and accuracy measures for each forecast cycle are posted to a UW-CIMSS webpage (http://cimss.ssec.wisc.edu/hrrrval/)

HRRR Satellite Verification Products:

- Observed and simulated images and forecast scores computed for each GOES band are posted on the UW-CIMSS webpage
- Statistics and imagery are provided for subsets of the HRRR model domain similar to that done on the Storm Prediction Center's mesoscale analysis page
- Sortable list of forecast accuracy scores used to choose which cycle to evaluate more closely

Concept for Operational Demonstration:

- Statistics and imagery will be displayed on the UW-CIMSS webpage that will be made available to all participants of the HWT

Concept for Operations:

- The CONOPs for possible implementation into operations needs further development (this assumes approval to proceed/prioritization from NOAT)

Product Name: NOAA Unique CrIS ATMS Processing System (NUCAPS) Temperature and Moisture Profiles

Primary Investigator: Dan Nietfeld (NWS), Brian Motta (NWS), and Bill Line (CIMMS)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- This product provides forecasters with JPSS observation-based temperature and moisture profiles to aid in severe weather mesoscale analysis.
- Helps to fill the spatial/temporal gap that exists in observed vertical temperature moisture information.
- This evaluation seeks to capture the value added by NUCAPS soundings to the severe weather nowcast and warning process.

Product Overview:

- Utilization of satellite-derived temperature and moisture profiles in AWIPS2/NSHARP.
- During experimental operations, NUCAPS will augment existing data/observations.

Product Methodology:

- Product uses a regression-based physical retrieval algorithm to combine CrIS and ATMS soundings to produce unique temperature and moisture profiles.
- Profiles are displayed in NSHARP Severe Weather Sounding Analysis tool in AWIPS-II.
- Satellite-observed vertical temperature and moisture data profiles are presented in clear and cloudy Fields of Regard (FOR).

NUCAPS Products:

- NUCAPS Profile Availability (Time/Location)
- NUCAPS Vertical Temperature and Moisture Profiles

Concept for Operational Demonstration:

- NUCAPS is produced at NESDIS/NDE, delivered over the AWIPS Satellite Broadcast Network (SBN) and has been formatted for display in AWIPS-II.

Concept for Operations:

- Ultimately, NUCAPS soundings would be displayed in NSHARP with Quality Control Flags that provide information from the microwave and IR instruments.
- Final AWIPS-II display and product integration (with radar/satellite/RAOBs/Surface Observations) will depend on feedback from various demonstrations.