NRL Satellite Support for DYNAMO Field Program

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LONG-TERM GOALS

To provide the ONR-sponsored DYNAMO field program with a robust suite of satellite meteorology products capable of tracking mesoscale convective clusters associated with the Madden Julian Oscillation (MJO) in the Indian Ocean.

OBJECTIVES

Develop a NRL-MRY near real-time web page that enables DYNAMO field program participants to view the evolving organization of convective clusters with a suite of geostationary (GEO) and low earth orbiting (LEO) satellite sensors.

APPROACH

GEO visible, infrared (IR), and water vapor (WV) imagery can provide the synoptic and mesoscale views required to monitor the general convective organization and its temporal changes. The Meteosat-7 satellite provides this data set for the DYNAMO project and these products were available every 30 minutes. The web page provided animation or looping capabilities that are needed to view multi-day convection changes and determine if organization is increasing in specific areas that may lead to MJO genesis.

However, the inability to view through expansive upper-level clouds is detrimental to tracking clouds that are actually producing rain, thus LEO microwave imagers were used to create rainrate products. In addition, we used the NRL-MRY "blended" rainrate product that incorporates both GEO and LEO data sets. The more accurate microwave imager data is used to "train" the GEO IR cloud tops as to what rainrate value should be associated with a given cold cloud top temperature. Thus a dynamic histogram look-up table is created for small geographical domains and the look-up table is updated every time a microwave imager overflies. This blending method is used by NOAA and others for a variety of global and regional rainrate products.

Additional microwave imagery products were produced that included ocean surface wind vectors from ASCAT and WindSat, horizontal and vertical polarization 85-91 GHz imagery from SSMI, SSMIS, and AMSR-E/TMI sensors and sea surface temperatures from AMSR-E. The microwave product suite

also included total precipitable water (TPW) and polarization corrected temperatures (PCT) that help the user located rain clouds.

WORK COMPLETED

1. Created NRL-MRY web page with a suite of multi-spectral satellite meteorology products geared toward real-time support of the ONR DYNAMO field program in the Indian Ocean from October 2011 to March 2012.
2. NRL-MRY web page product suite included the following satellite products:
   - Met-7 visible, infrared, and water vapor imagery focused on field program domain,
   - Rainrate products created by blending GEO IR and microwave imager data,
   - Horizontal and vertical polarization ice scattering channel microwave imager data,
   - Polarization corrected microwave imager data sets,
   - Ocean surface wind vectors from ASCAT and WindSat
   - Sea surface temperature (SST) products using AMSR-E
   - Low cloud at night products using multi-channel IR data
3. NRL-MRY web products are available on-line for the entire multi-month project for use by the DYNAMO scientific community.

TECHNICAL RESULTS

Section 1: DYNAMO Field Program

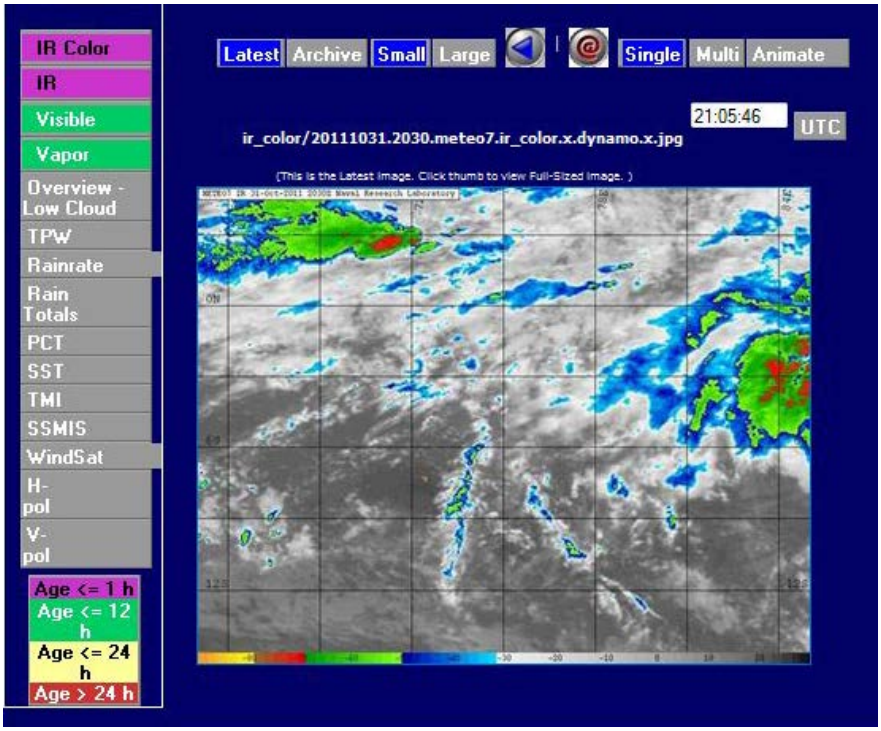

Figure 1. NRL-MRY DYNAMO satellite meteorology product web page available to field program participants in near real-time for the specific Indian Ocean domain.

The DYNAMO field program needed a multi-satellite suite of products in order to ascertain the mesoscale and synoptic scale convection associated with the Madden Julian Oscillation (MJO) cycle. The project was interested in capturing MJO onset and in order to accomplish this task needed to view a large domain with visible (vis), infrared (IR), and water vapor (WV) sensors as well as microwave imagers that permit accurate rain retrievals. A sample set of vis, IR, WV and rainrate imagery is highlighted in Fig. 2 below for November 28, 2011 for the DYNAMO field program domain.

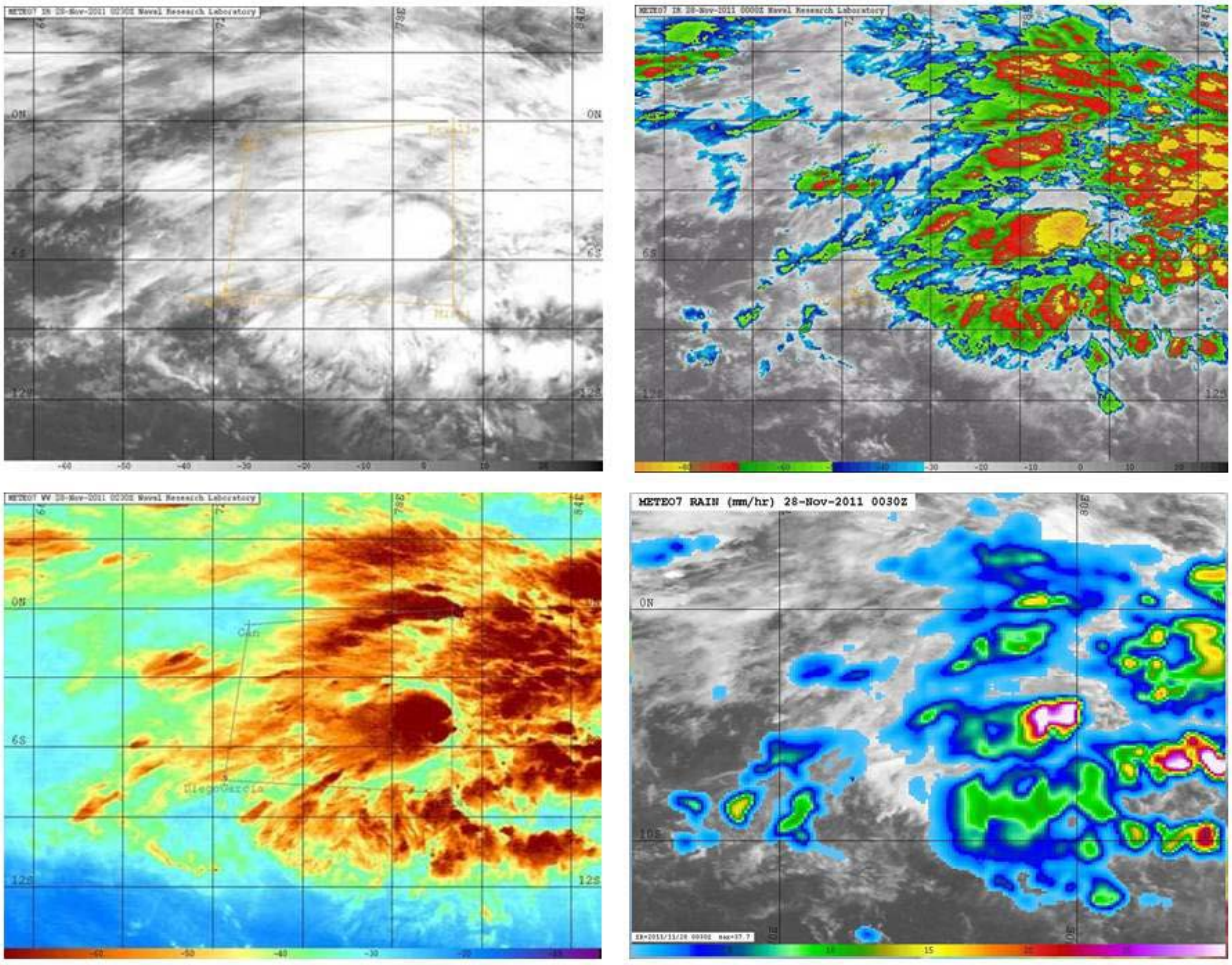

Figure 2. NRL-MRY DYNAMO satellite meteorology products on Nov. 28, 2011 including a) upper-left, regular IR enhancement, b) upper-right, false color IR to highlight cold cloud tops, c) lower-left, water vapor imagery showing upper-level moisture patterns, and d) NRL-MRY blended rainrates for the same timeframe (lat/lon lines are different, but the scale are nearly identical).

Note that the user is able to correlate the coldest cloud tops with the higher rainrates that are verified in part by the microwave imager data sets. Also, thin cirrus clouds do not produce rain and this is in agreement with the rainrate product in the lower right of Fig. 2. The blended rainrate product updates with the 30 minute frequency of the Meteosat-7 GEO data, thus users are afforded with rapid temporal sampling while leaning on the microwave data, since there is not a one to one correlation between cloud top temperatures and rainrate. The blended rainrates could be animated to visualize the organization of mesoscale convective rain events.

Understanding the 3-D moisture environment is crucial to the DYNAMO team members, thus total precipitable water (TPW) was calculated using microwave imager near real-time data sets. Figure 3 is an example for Nov. 28, 2011 at 0000Z. As expected, the majorities of the domain is moisture laden, but note the sharp boundary near the southern edge of the field program domain. The moisture pattern changed significantly along this edge during the course of the multi-month field mission.

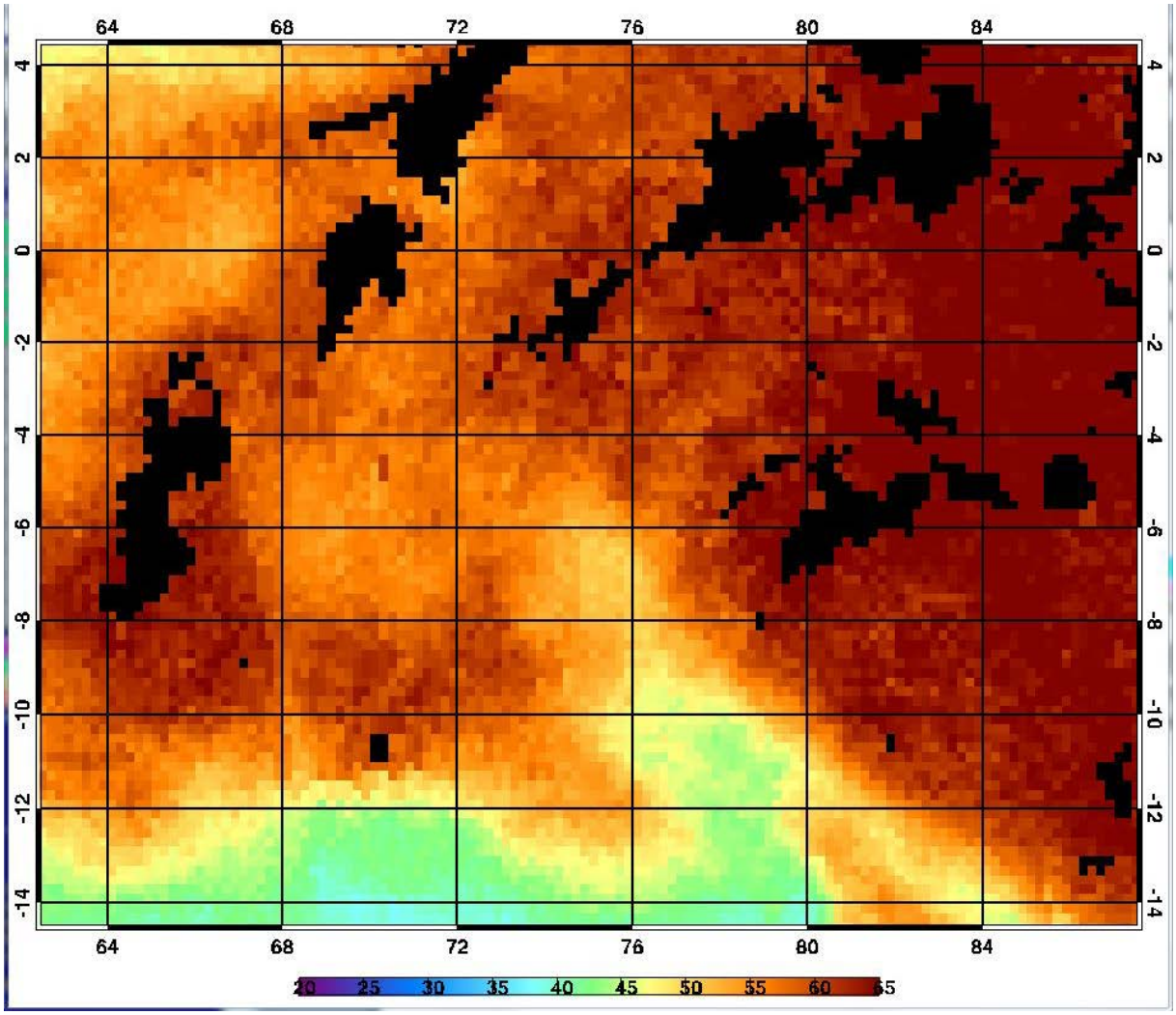

Figure 3. NRL-MRY DYNAMO total precipitable water (TPW) product for Nov. 28, 2011 using microwave imager digital data sets.

Field program scientists used the products by overlaying potential NOAA P-3 flight tracks as they attempted to map the relevant mesoscale rain feature development with airborne radar to supplement the island-based radar data sets. The digital data for the NRL-MRY DYNAMO web page have been retained at NRL and are available for the scientific community to delve into deeper during post analysis.

IMPACT/APPLICATIONS

The suite of GEO/LEO multi-spectral satellite meteorological products will enable the DYNAMO science team to better comprehend the 3-D environment that evolved over the multi-month field program by offering both high temporal resolution (GEO) and all-weather (microwave imager) products geared toward monitoring mesoscale convection at spatial resolutions that match Madden-Julian oscillation scales.

TRANSITIONS

The NRL-MRY Dynamo satellite products created in near real-time have been archived and are available for all users for retrospective scientific studies.

RELATED PROJECTS

This project is closely related to a 6.4 effort sponsored by the Program Executive Office for C4I&Space/PMW-120 entitled "Satellite METOC" funded under PE 0603207N. The 6.4 project serves as the transition vehicle, works closely with the Fleet Numerical Meteorology and Oceanography Center (FNMOC, Monterey, CA). The project also benefits from the NOAA/JPSS funded NexSat project (www.nrlmry.navy.mil/NEXSAT.html) that provides a suite of satellite meteorology products in near real-time to Internet users worldwide.

REFERENCES

Hawkins, J. D. and C. Velden, 2011, Supporting meteorological field experiment missions and post-mission analysis with satellite digital data and products, *Bull. Amer. Meteor. Soc.*, 92, 1009-1022.

PUBLICATIONS/Presentations

Hawkins, J., K. Richardson, and J. Kent, 2012, NRL Remote Sensing DYNAMO Overview, DYNAMO Science Team Meeting.