Weekly Report

CIRA
STAR/NESDIS
National Oceanic and Atmospheric Administration (NOAA)

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Products and Applications

Publications (Citation: followed by a short **Summary:** (Why & so what)**, & detailed summary):**

Citation: White, C. H., Noh, Y.-J., Haynes, J. M., & Ebert-Uphoff, I. (2025). Emulating daytime ABI cloud optical properties at night with machine learning. *Journal of Geophysical Research: Atmospheres*, 130, e2024JD042829. **https://doi.org/10.1029/2024JD042829**
Summary: Current NOAA operational products for cloud optical properties have very different behavior between daytime and nighttime scenes. This is due to a relative lack of sensitivity to properties of optically thick clouds in infrared spectra compared to visible and near-infrared spectra. We show that an AI model, specifically a U-Net neural network, can effectively exploit information about local cloud organization and texture to overcome this deficiency in infrared spectra. The resulting model can significantly improve cloud optical property estimates at night compared to current NOAA operational products.
Detailed Summary: We trained several neural networks to emulate the GOES-16 ABI NOAA Daytime Cloud Optical and Microphysical Properties (DCOMP) algorithm using only infrared channels. We show that neural networks that with access to spatial context significantly outperform their counterparts that operate solely on infrared spectra within a given satellite pixel. We then compared the neural networks to the NOAA operational products, and the Nighttime Lunar Cloud Optical and Microphysical Properties (NLCOMP) algorithm utilizing JPSS VIIRS DNB. The primary model we trained, U-NetCOMP, can reasonably match DCOMP during the day and significantly reduces artifacts associated with day/night terminator. U-NetCOMP estimates also align more closely with VIIRS NLCOMP compared to the nighttime operational products for ABI. Lastly, we perform a comparison with ground-based instruments at the Atmospheric Radiation Measurement (ARM SGP) and find that U-NetCOMP improves upon the

nighttime operational product with some exceptions for thin cirrus clouds over cold surfaces. This general approach can serve as a path forward for further improving the characterization of clouds at night using AI/machine learning. (POC: C. White, Y.J. Noh, J. Haynes, I. Ebert-Uphoff, CIRA charles.white@colostate.edu. Funding: GOES-R, JPSS and Office of Naval Research)

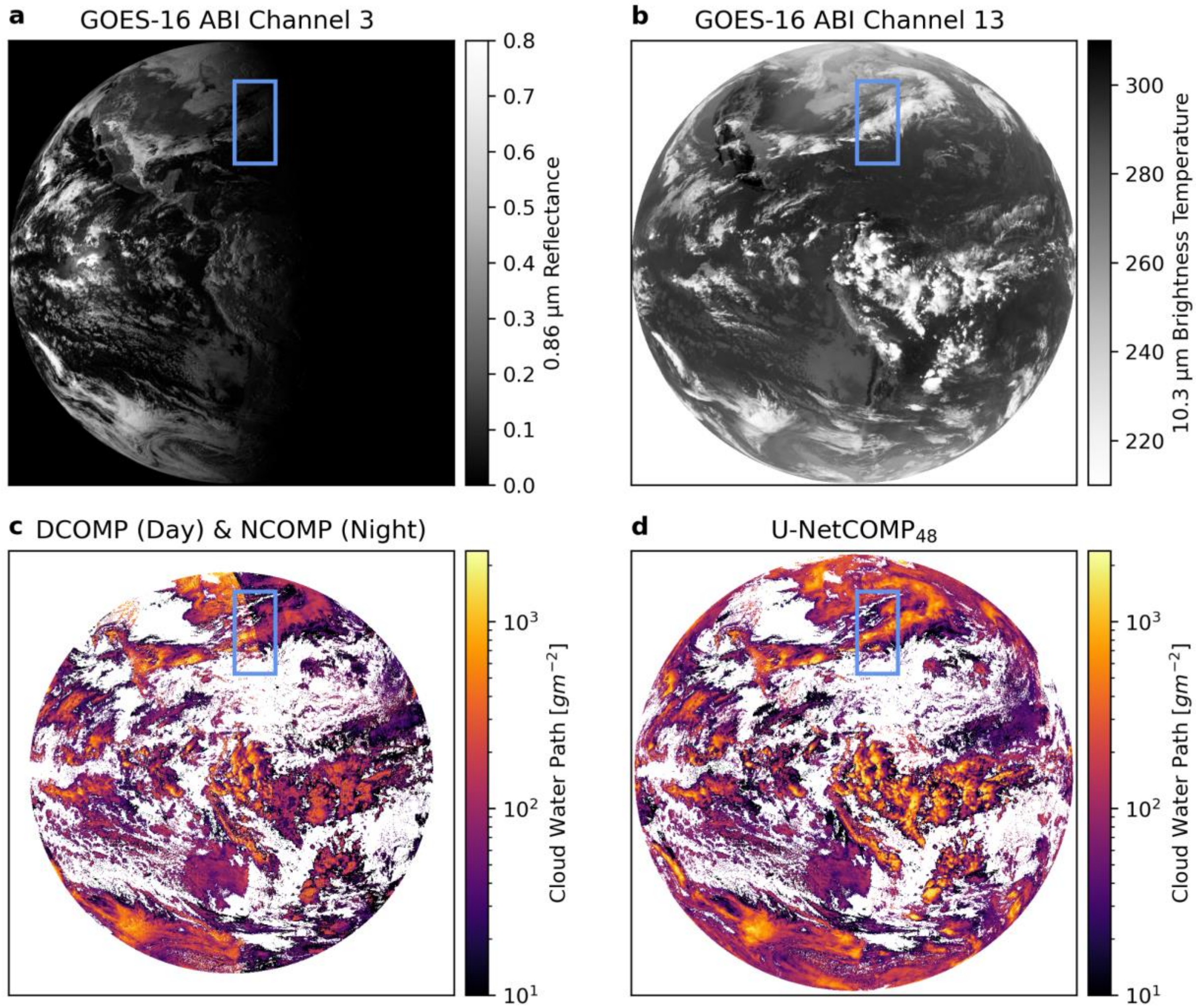

Figure 6 of White et al. (2025): *(a) and (b) are the 0.86 µm and 10.3 µm channels on GOES-16 ABI in a scene where the day/night terminator nearly bisects the full-disk image on 19 March 2024 at 00:50 UTC. (c) is the cloud water path derived from the NOAA operational products (DCOMP during the day and NCOMP at night). (d) is our new AI method, U-NetCOMP, that removes the artifact associated with the terminator and produces more similar values to DCOMP at night. The blue box represents a region we focus on in more detail in the article.*

Citation: DesRosiers, A. J., Bell, M. M., DeHart, J. C., Vigh, J. L., Rozoff, C. M. & Hendricks, E. A.

(2025). Tropical Cyclone Surface Winds From Aircraft With a Neural Network. *Journal of Geophysical Research: Machine Learning and Computation*, 2, e2025JH000584. https://doi.org/10.1029/2025JH000584

Summary: Wind reductions (WRs) are important to translating tropical cyclone (TC) wind observations collected at flight level by TC reconnaissance aircraft down to the surface. WRs are governed by complex physical relationships which hinder the accuracy of the existing operational method. In this study, a neural network (NN) trained with aircraft observations is used to improve the WRs of TC winds from flight level to the surface. The NN, called the Surface Winds from Aircraft with a Neural Network (SWANN) model, benefits from a custom loss function, prioritizing the accurate prediction of strong surface winds with high damage potential. Results indicate SWANN outperforms the current operational method and may prove useful as a real-time tool for forecasters.

Detailed Summary: Reconnaissance aircraft provide useful observations of the wind field within tropical cyclones (TCs). Most of this data is collected at the aircraft flight level, well above the Earth's surface. Wind reductions (WRs) are used to reduce these wind observations from flight level down to the surface to better understand the hazardous conditions there. Many complicating factors modulate the spatial variability of these WRs such as TC motion and intensity. Traditional formulations of WRs are fairly simple, limiting their ability to account for these complicating factors and produce realistic surface wind fields. In this study, these factors are analyzed and the results are used to train a neural network (NN) model with observational data to predict a surface wind field from aircraft observations and other TC information. The NN model, called Surface Winds from Aircraft with a Neural Network (SWANN), benefits from a custom loss function which prioritizes accurate predictions of high-wind values, given their importance to intensity estimation and damage potential. Validation of the model with airborne radar and dropwindsonde data from past flights into TCs shows that SWANN improves on the current operational WR method while producing surface wind fields that can be used to assist forecasters. The work is part of the Hurricane Ocean Testbed (HOT) and real-time testing is ongoing to demonstrate the potential utility of the SWANN model to forecasters. (POC: A. J. DesRosiers, CIRA adesros@rams.colostate.edu. Funding: NOAA and the Office of Naval Research)

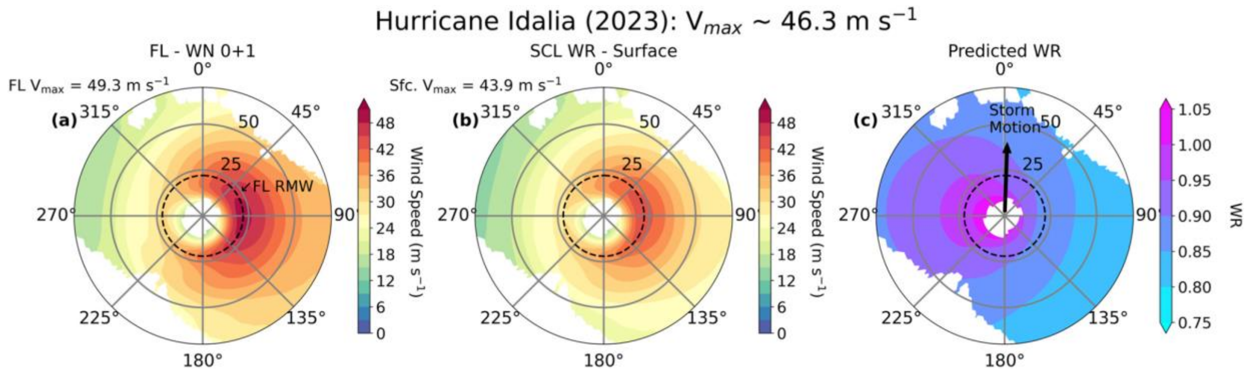

Figure 13 of DesRosiers et al. (2025): *A pseudo-real-time product example of the SWANN model reducing the observed flight-level wind field in Hurricane Idalia near 00 UTC 30 August 2023 at Category 2 intensity. The (a) flight-level wind field at 3-km altitude, (b) predicted surface wind field and its maximum value, and (c) predicted WRs are shown with the flight-level radius of maximum wind (RMW) given as a dashed circle and storm motion direction as an arrow.*

The following paper was already reported in the Weekly Report of 04 April 2025, but at that time no DOI was available. We are repeating the entry here - now with DOI.

Citation: Lagerquist, R., Knaff, J.A., Slocum, C.J., Musgrave, K. and Ebert-Uphoff, I., 2025. Identifying data sources and physical strategies used by neural networks to predict TC rapid intensification. *Weather and Forecasting.* https://doi.org/10.1175/WAF-D-24-0166.1

Summary: TC rapid intensification, which we define as an intensity increase of > 30 kt in 24 hours, is a difficult but important forecasting problem. Operational RI forecasts have considerably improved since the late 2000s, thanks largely to better statistical models including machine learning (ML), which mostly take scalar predictors from the SHIPS developmental dataset. More recent ML applications use convolutional neural networks (CNN), which can ingest full satellite images/videos and freely “decide” which spatiotemporal features are important for RI. However, two questions remain unanswered: (1) Does image convolution significantly improve RI skill? (2) What strategies do CNNs use for RI prediction – and can we gain new insights from these strategies? We use an ablation experiment to answer the first question and explainable artificial intelligence (XAI) to answer the second. Convolution leads to only a small performance gain, likely because, as revealed by XAI, the CNN's main strategy uses image features already well described in scalar predictors used by pre-existing RI models. This work makes three additional contributions to the literature: (1) CNNs with SHIPS data outperform pre-existing models in some aspects; (2) CNNs provide well calibrated uncertainty quantification (UQ), while pre-existing models have no UQ; (3) the CNN without SHIPS data

performs surprisingly well and is fairly independent of pre-existing models, suggesting its potential value in an operational ensemble. Furthermore, we develop an XAI methodology – combining traditional XAI methods with eigenanalysis – that partly overcomes the subjectivity and sensitivity to pixel-level noise inherent in traditional XAI methods. (POC: R. Lagerquist, CIRA, Ryan.Lagerquist@colostate.edu; J.A. Knaff and C.J. Slocum (NOAA); K., Musgrave, K. and I. Ebert-Uphoff (CIRA). Funding: NOAA and NSF)

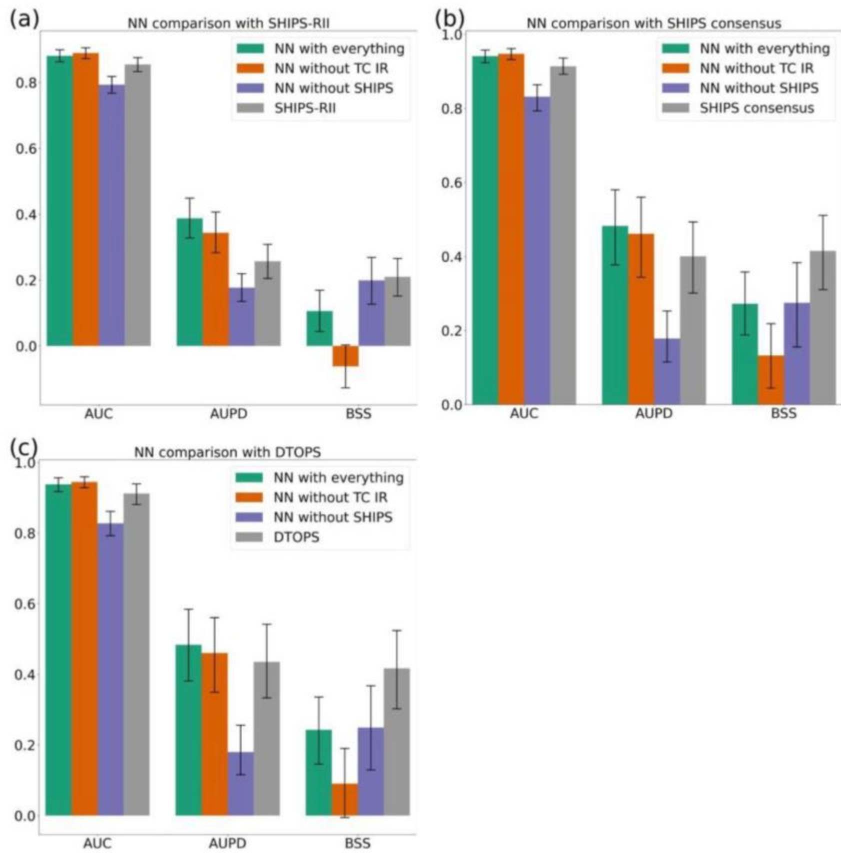

Figure 13: Comparison of our neural networks – one trained with only the TC IR satellite data, one trained with only SHIPS scalars, one trained with both – to pre-existing RI models. Evaluation metrics (area under the ROC curve, area under the performance diagram, and Brier skill score) are positively oriented, meaning that higher is better. Error bars indicate 95% confidence intervals.

Awards and Recognition

Media Interactions and Request

Blog Posts and Social Media

Travel, Workshops, Conferences, and Meeting Reports

LEO Science Seminar on Tropical Cyclone Analysis and Forecasting. Galina Chirokova, Zhixing Ruan, and Mark DeMaria presented a virtual LEO Science Seminar on "Improving Tropical Cyclone Intensity Forecasts and Intensity and Structure Estimates Using Microwave Sounder Data". The presentation discussed the history of estimating tropical cyclone parameters from microwave sounder data, the CIRA Operational Hurricane Intensity and Structure Algorithm (HISA), and application of HISA to new SmallSats data including TROPICS and Tomorow.IO microwave sounder data. In addition, several new experimental applications for forecasting tropical cyclone intensity and diagnosing storm type from JPSS data using artificial intelligence (JETClass model) were introduced. We also discussed a new Experimental LEO Tropical Cyclone web page that will be launched later this year. About 90 people were in attendance. (POC: Galina.Chirokova, Galina.Chirokova@colostate.edu, Zhixing Ruan, Zhixing.Ruan@colostate.edu, Mark DeMaria, Mark.DeMaria@colostate.edu; Funding: JPSS, TROPICS, DACS)

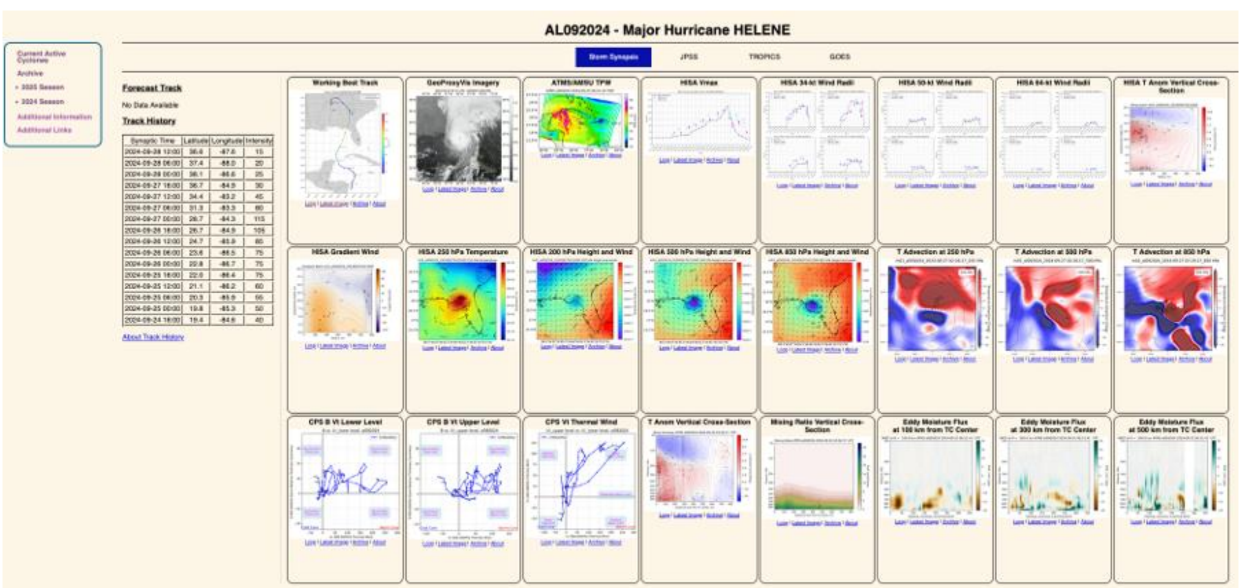

Figure. Snapshot from a new JPSS/TROPICS/LEO tropical cyclone web page that will be made public later in 2025. A snapshot shows multiple examples of updated and experimental JPSS applications for 2024 Hurricane Helene.

Training and Education activities

WMO-CGMS VLab/NOAA Regional Focus Group: The WMO-CGMS VLab/NOAA Regional Focus Group (RFG) of the Americas and the Caribbean meets virtually for monthly weather briefings. These are coordinated by CIRA, the WPC International Desks, and the WMO Centers of Excellence in Barbados, Costa Rica, Brazil, and Argentina. The sixth session of the year was held on 25 June 2025. Topics included a synoptic analysis of the Americas and the Caribbean using satellite products, heavy rain producing systems in Central America, ENSO Neutral conditions and a disorganized MJO, and the key role of tropospheric Kelvin waves in enhancing tropical convection during the next few weeks. The Barbados Center of Excellence provided a short briefing on the conditions in the Caribbean. The session hosted 84 participants representing 35 organizations and 20 countries. RFG sessions are recorded and can be viewed here: https://rammb2.cira.colostate.edu/training/rmtc/focusgroup/ (POC: B. Connell, E. Sanders, and J. Gálvez, CIRA; Bernie.Connell@colostate.edu, Erin.Sanders@colostate.edu, Jose.Galvez@colostate.edu). Funding: GOES, JPSS.

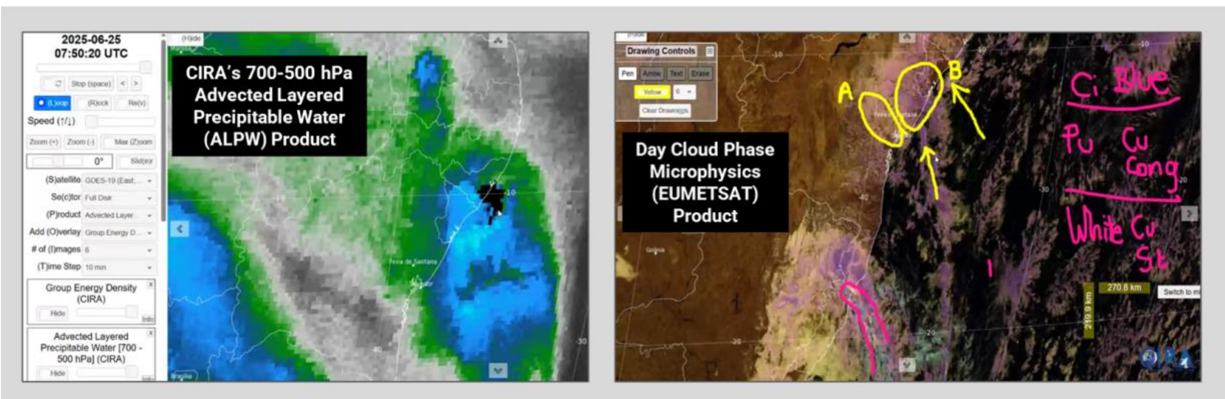

Figure. *One of the many topics discussed during the 25 June 2025 RFG session was a front and a shear line impacting the east coast of Brazil. The discussion focused on the combined application of Advected Layered Precipitable Water Products (left), Day Cloud Phase Products (right) and others for boundary and cloud type detection, and to assess the potential for heavy precipitation.*

Special Training Sessions on the Gálvez-Davison Index (GDI): CIRA's training team organized and hosted two Special Training sessions on the Gálvez-Davison Index (GDI) and application of satellite products for verification and enhancing nowcasting capabilities. This included applying the GDI, its subcomponents and an analysis of atmospheric dynamics to real time weather conditions in North America. The sessions were conducted on June 17th 2025 for English speakers, and on June 18th 2025 for Spanish speakers. The English session hosted 25 participants representing 17 organizations and 14 countries. The Spanish session hosted 172 participants representing 74 organizations and 23 countries. The special sessions are recorded and can be viewed here: https://rammb2.cira.colostate.edu/training/rmtc/focusgroup/ (POC: B. Connell, E. Sanders, and J. Gálvez, CIRA; Bernie.Connell@colostate.edu, Erin.Sanders@colostate.edu, Jose.Galvez@colostate.edu) Funding: GOES, JPSS.

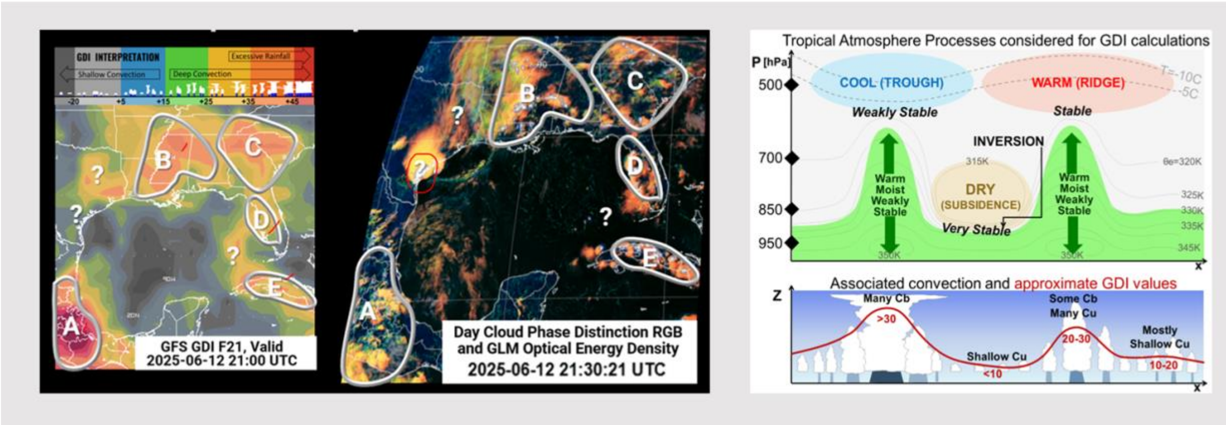

Figure. *Example of a GFS GDI forecast and verification using the Day Cloud Phase Distinction (JMA) RGB (left panels), presented during the GDI training sessions. The right panels summarize the processes considered for GDI calculations (top) and associated GDI values and convection types (bottom).*

<u>Future Meetings and Events (dates, meeting/event, location, staff involved)</u>

<u>Other</u>

Taiga Tsukada reviewed two manuscripts for the Geophysical Research Letters (GRL) and Scientific
Online Letters on the Atmosphere (SOLA). (POC: T. Tsukada, CIRA, taiga.tsukada@colostate.edu)