NOAA ROSES Semi-Annual Report

Reporting Period: March 2021 – August 2021 (2nd for FY20)

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Project Title: Enhancing Evapotranspiration and Evaporative Stress Index Data Products from GOES-R Advance Baseline Imagers for NOAA NWP, NWM and Drought Monitoring Operations

Executive Summary (1 paragraph max)

In the second half of FY20, we continued to work on the GET-D system upgrades and refinement. With the implementation of machine learning method for all weather LST derivation, the GET-D system can generate ET data product under both clear sky and cloudy conditions. Two experimental runs have been set up with the upgraded GET-D system to produce clear-sky and all-weather ET maps separately for the year of 2018. The quality of these two sets of ET products is evaluated and intercompared. Meanwhile, we have worked intensively with our collaborators to collect in-situ fluxes measurements from the AmeriFlux network. Measurements from more than 80 sites have been collected and preprocessed for the calibration and validation of the GET-D ET products. The validation results will be documented in this semi-annual report. A manuscript for a Frontiers journal is submitted.

Progress toward FY21 Milestones and Relevant Findings

1. GET-D system upgrades and refinement to meet user needs

To better meet users' needs, the upgraded GET-D system is designed to produce ET and ESI products at 2 km spatial resolution over CONUS domain (125W-66.75W, 24.83N-49.83N). Although some subroutines/functions of the GET-D software system remain unchanged in the upgraded GET-D system, several key modules have been heavily revised.

First, the GOES-R Observation Processor has been developed to adopt GOES-16/17 ABI based inputs. This module is responsible for spatial resampling GOES16/17 thermal infrared (TIR) observations to our study domain and temporal resampling GOES land surface temperature at 1.5 hours after sunrise and 1.5 hours before noon. Because of the cloud contamination to the GOES TIR observations, the spatial coverage of the daily GET-D ET product has been severely impacted. Therefore, the second big upgrade is to test and implement a machine learning module to estimate all-weather land surface temperature from TIR and microwave (MW) combined satellite observations. The all-weather LST estimates enable the GET-D system to derive an all-weather ET product.

2. Collect and Process in situ ET Measurements from AmeriFlux Networks

The AmeriFlux, the North, Central and South America part of the FLUXNET, is the most referred network measuring ecosystem CO2, water, and energy fluxes. The standard flux measurement instrument of AmeriFlux is the Eddy Covariance tower. Since the measurement sites are all PI-managed, access to the measurement data, especially the most recent year data, has to be obtained from the specific site PI for each of the sites. With help from our collaborators, more than 80 sites over the CONUS domain have been collected for validation of GET-D ET outputs.

The Eddy Covariance system continuously measures fluxes every 30 minutes. In order to compare with daily estimates from the ALEXI model, the raw in-situ measurements need pre-processing and conversion before calibration and validation effort. The major steps of the processing include,

(1) integrating the observed half-an-hour fluxes into daily estimates using 48 observations throughout the day.

(2) applying the energy budget closure to the integrated daily fluxes using the Bowen Ratio correction algorithm.

(3) ET calculation after the dynamic correction of Lambda.

Our team member has obtained a couple of processed, denoised and quality-controlled daily ET observations from the OpenET group, which can be used as benchmarks to evaluate our proposed processing method. Figure 1 shows the comparison between our daily in-situ ET estimates and the values from OpenET team over two in-situ sites in CA. The comparison illustrated that our processing method is reliable with correlation coefficients higher than 0.96.

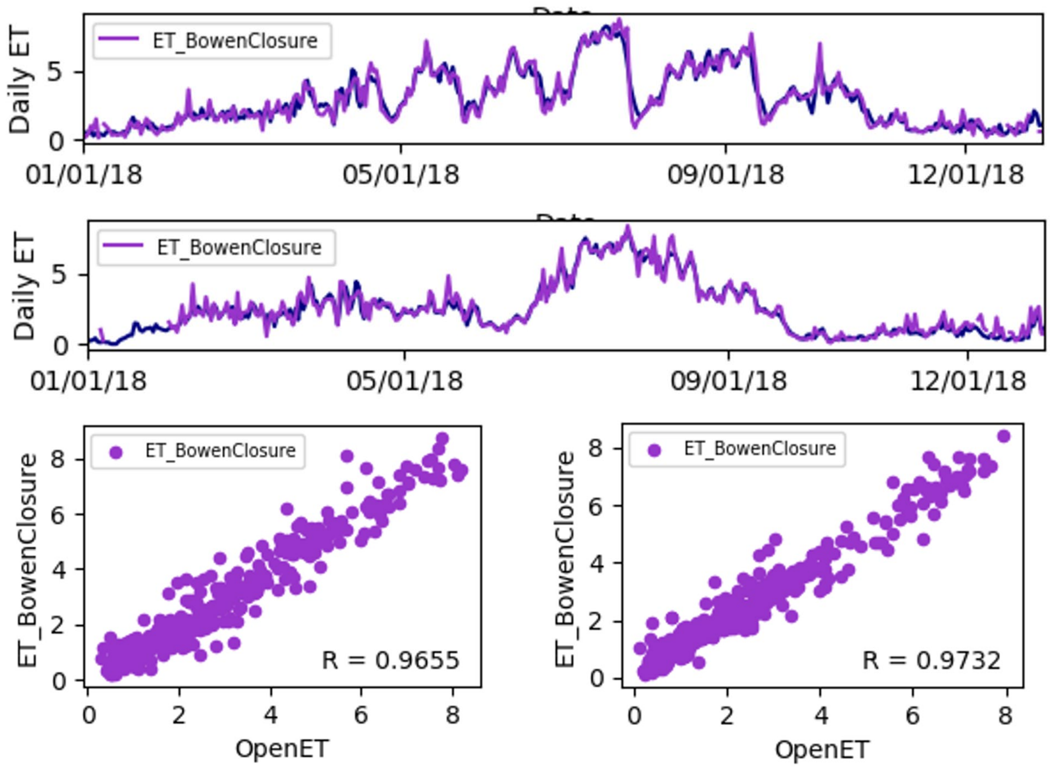

Figure 1 Comparison between the proposed in situ ET processing method and qualified daily ET from the OpenET group over two sites in CA; (a) and (c) are time series comparison and scatter plots over the US-Bi1 station (38.0992N, 121.499W); (b) and (d) over the US-Bi2 station (38.109N, 121.535W)

3. Generate all-weather ET data product based on MW and TIR coupled LST

The TIR and MW coupled LST data is applied to The ALEXI model to derive ET under all weather conditions. The all-weather ET outputs are compared with the clear-sky ET product visually and quantitatively. The two sets of ET retrievals are comprehensively examined against AmeriFlux field measurements over CONUS.

One example of clear-sky ET from GOES-16/17 compared with the all-weather ET over CONUS domain on July 3 2018, is shown in Figure 2. With the introduction of AMSR2 descending and ascending combined observations, the spatial coverage increases by around 260%. Most of the Great Plains and the Northern East Coast regions affected by the cloud have been filled in with reasonable patterns. Particularly, the states of Washington, North Dakota, South Dakota, Nebraska, and Minnesota are among the most contaminated areas by the cloud and yet have been almost fully filled in by the all-weather ET map. The machine-learning predicted ETs present a general decreasing trend from western to eastern of the CONUS domain.

The all-weather ET retrievals are evaluated by comparing with in-situ ET measurements over the validation period from Jan. 1 to Dec. 31, 2018. The example shown in Figure 3 is time series comparison over the North Carolina site from the AmeriFlux network. As shown in the figure, the wine triangles are the clear-sky ET from GOES 16/17 observations only, while green dots are the all-weather ET retrievals covering both clear and cloudy days. It is very impressive to see that the all-weather ET retrievals can capture much better daily dynamics which agree with the in-situ records very well (Figure 3 b). It is also worth noting that there is the scenario (Figure 3 c) when the GOES thermal observations were missing for more than two weeks in Dec. 2018 because of the cloud contamination and yet the all-coupled ET estimates could provide decent predictions.

Further validation effort is ongoing and more comprehensive validation results will be reported in the next funding cycle as planned in the Task Schedule and Milestones.

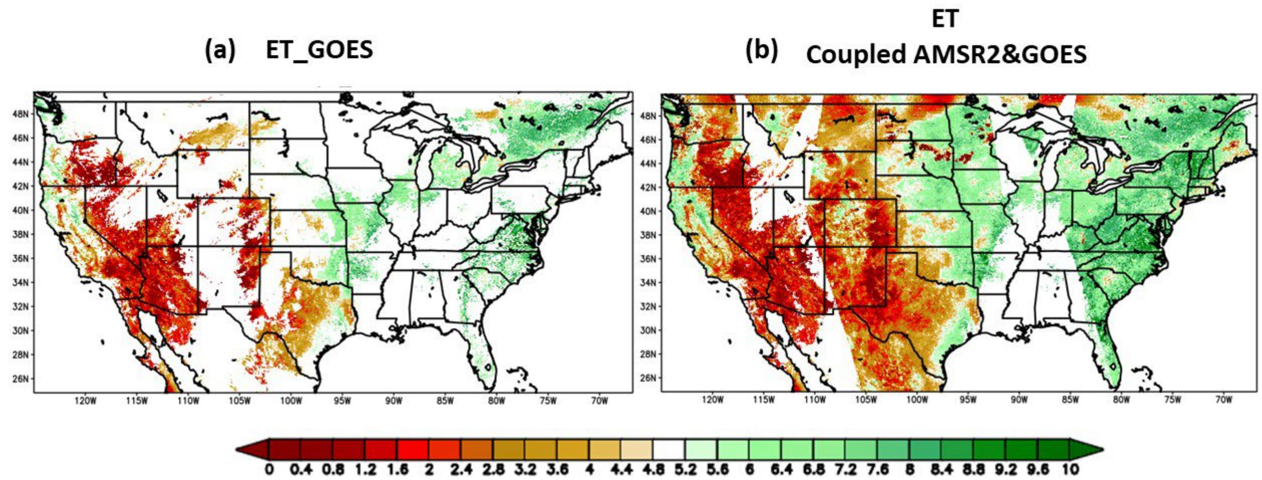

Figure 2 Visual comparison of clear-sky ET derived from GOES16/17 (a) and all-weather ET derived from GOES/AMSR2/CFSR combined LST (b) on May 30, 2018; Unit: mm/day

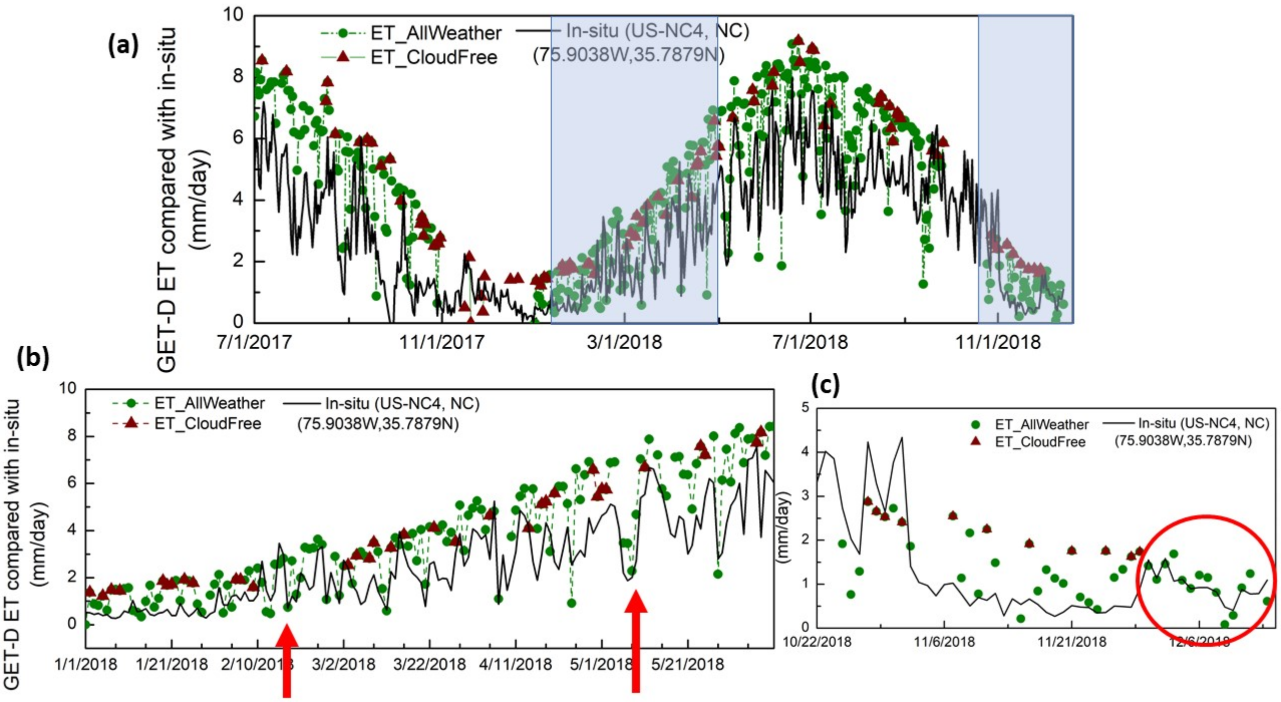

Figure 3 Time series comparison between clear-sky ET and all-weather ET, as well as in-situ ET observations at the AmeriFlux station in North Carolina; (a) over the period from July 1, 2017 to Dec. 31, 2018; (b) Jan.1 – June 10, 2018; (c) Oct. 22 - Dec. 14, 2018

Plans for Next Reporting Period

1. Comprehensive validation of the all-weather ET product using in situ ET observations from AmeriFlux networks

2. Reprocess GET-D with all available GOES-16/17 TIR data retrospectively to 2017 and build long term ET climatology

3. Generate GET-D ESI data based on the long-term climatology

4. Map drought occurrence with GET-D ESI estimates

5. Deliver GET-D ET and ESI Data to NCEP and NWC Users and Collect their Feedbacks

Task Schedule, Milestones and Status

Task and ***milestone (underlined and in italic)***	Y1	Y2	Y3	Progress Status
1. Evaluation of ABI Land Surface Temperature Data Products for GET-D (*LST input for GET-D defined*)	√			Completed
2. Evaluation of ABI-based GSIP Solar Insolation Data Products for GET-D (*Solar insolation input for GET-D defined*)	√			Completed
3. Evaluation of AMSR2 Ka-band LST Retrievals for GET-D Use on Cloudy Days (*Cloudy day LST input for GET-D decided*)	√			Completed
4. Redesign the Spatial Domain and Architecture of GET-D to Meet User Needs (*GET-D domain and architecture meeting user requirements defined*)	√			Completed
5. Code and Assemble All Modules/Functions of the Redesigned GET-D Product System (*GET-D code developed and ready for testing*)	√	√		Completed
6. Collect and Process in situ ET Measurements from AmeriFlux Networks (*GET-D ET validation data collected and processed*)	√	√		Completed
7. Calibrate and Validate ET and ESI Output (*GET-D ET and ESI output calibrated and validated*)		√		On track
8. Deliver GET-D ET and ESI Data to NCEP and NWC Users and Collect their Feedbacks (NCEP and NWC *feedbacks on GET-D ET and ESI output collected and addressed with GET-D refinement*)		√	√	On track
9. Reprocess GET-D with all available GOES TIR Data (*GET-D rerun for all available and collected GOES TIR data)*		√	√	On track
10. Map Drought Occurrence with GET-D ESI (*GET-D drought product generated with the long term GET-D ET climatology*)		√	√	On track
11. Deliver GET-D Drought Maps to USDA and NIDIS and Collect their Feedbacks (*USDA and NIDIS feedbacks collected on GET-D drought products*)			√	On track
12. Identify a plan for implementing the upgraded GET-D in OSPO systems (*Implementation plan of GET-D in NESDIS or Cloud operational environment planned*)			√	On track
13. Submit Semi-Annual and End of Project Reports and Publish Research Results (*Reports, presentations and refereed journal papers submitted or prepared*)	√	√	√	On track