Improved GEO Derived LW Broadband Fluxes for the Edition5 CERES SYN1Deg Data Product

Moguo Sun[1,2], David Doelling[2], Kyle Itterly[1,2]

1: Analytical Mechanics Associates, Inc, Hampton, VA
2: NASA Langley Research Center, Hampton, VA

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Outline

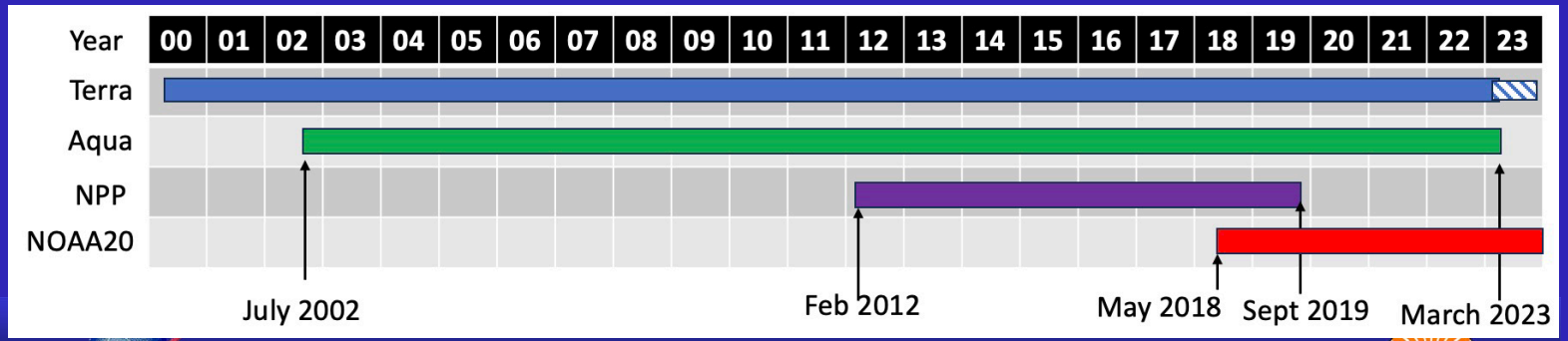
- CERES Data Products Highlights
- SYN1Deg Ed5 Derived GEO LW Fluxes Improvement
  - Based on machine learning technique
- Summary

CERES products

- The NASA CERES project has multiple products depending on user application
- They can be ordered from the CERES ordering and visualization tool (https://ceres.larc.nasa.gov/data/) (Google 'NASA CERES')
  - This site has brief product descriptions, and the products can be sub-setted by parameter, temporal and spatial resolution and range
- CERES SSF L2 product (instantaneous 20-km footprints) is formatted into single satellite hourly files
  - Contains CERES observed radiances and fluxes as well as imager derived cloud properties
  - The CERES instruments are onboard the Terra, Aqua, SNPP and NOAA-20 satellites, where all satellites have a 1:30 PM local equator crossing time (LECT), except for Terra, which has a 10:30AM LECT

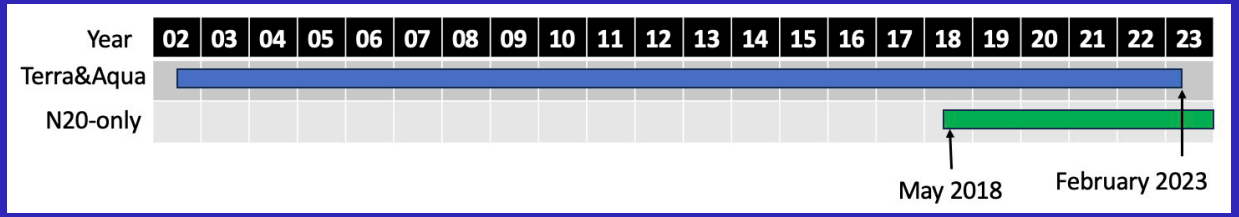
SSF1deg product

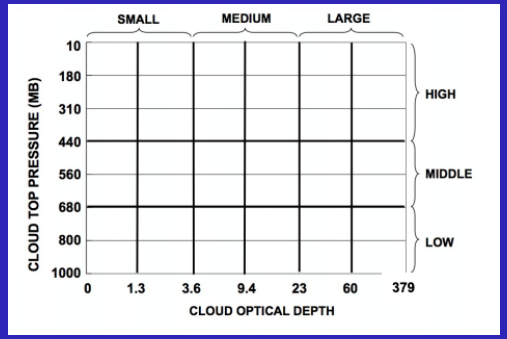
- The SSF1deg provides single satellite regional (1º x 1º) gridded daily and monthly fluxes and clouds
  - For LW fluxes and clouds, utilizes linear temporal interpolation between instantaneous measurements to infer the daily and monthly means
  - For SW fluxes, utilizes constant meteorology albedo diurnal models based on the daytime satellite overpass conditions to compute the daily and monthly means



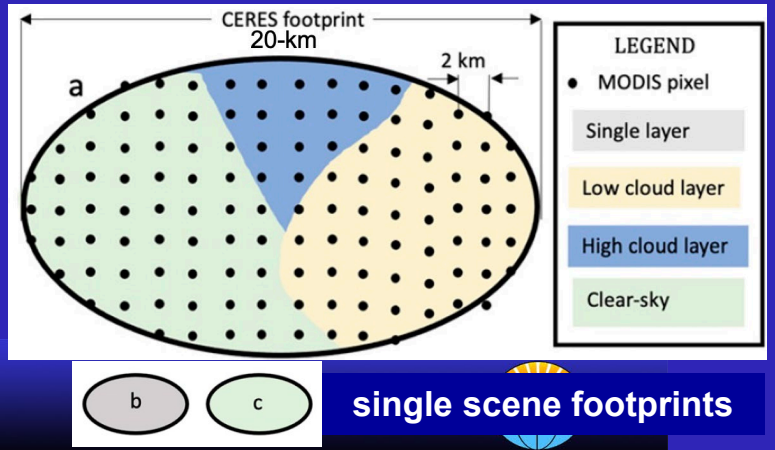
FluxByCldTyp (FBCT) product

- The FBCT product provides observed daytime-only CERES daily and monthly mean fluxes stratified by 7 cloud layer and 6 optical depth bins (similar to ISCCP)



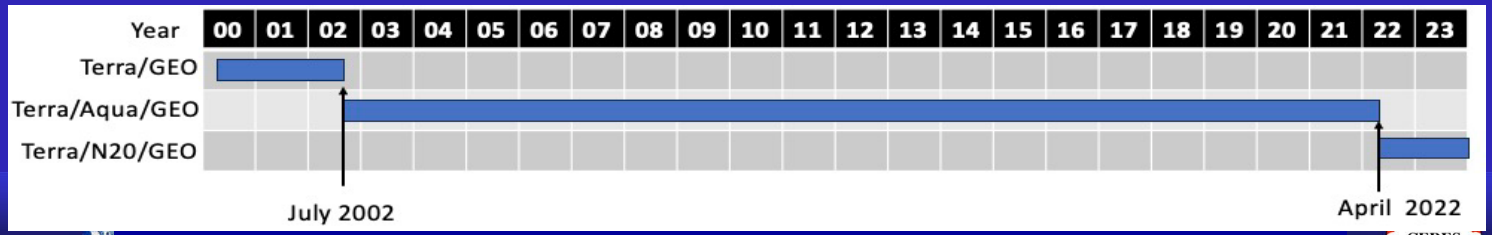


- For single-scene footprints use the CERES observed flux
- For multi-scene footprints, Compute sub-footprint BB fluxes area from empirical NB to BB coefficients based on single scene CERES footprints. Normalize the computed BB flux to the CERES observed flux at the footprint level



SYN1deg product

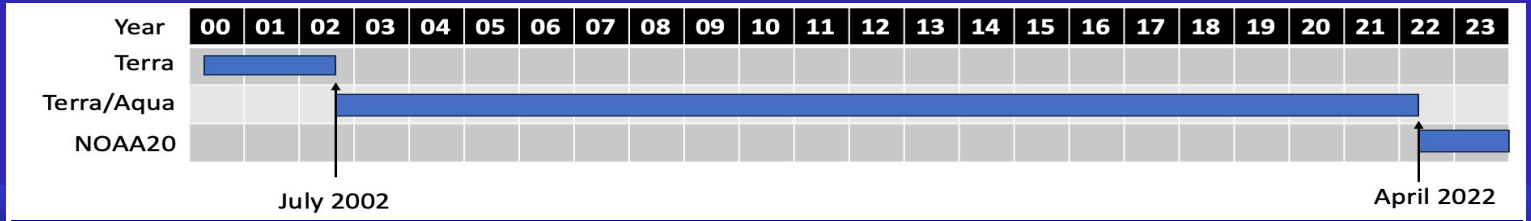
- The SYN1deg Ed4 product utilizes hourly GEO fluxes and clouds to infer the regional diurnal flux in between CERES measurements
  - SYN1deg-hour, SYN1deg-day, SYN1deg-mhour, SYN1deg-month
  - Surface and in-atmosphere fluxes are computed hourly from the imager clouds and GEOS atmosphere
- The derived GEO SW TOA fluxes are based on GEO visible radiance (converted to MODIS-like radiance), empirical MODIS narrow band to broadband radiance relationships, and Ed4 CERES ADM.
- The derived GEO LW TOA fluxes are based on empirical GEO IR and WV channel radiance to broadband flux relationships
- Both the SW and LW GEO derived TOA fluxes are normalized regionally with the coincident CERES observed fluxes, to tie the fluxes to the CERES onboard instrument calibration



the product combines these satellite records into a single product

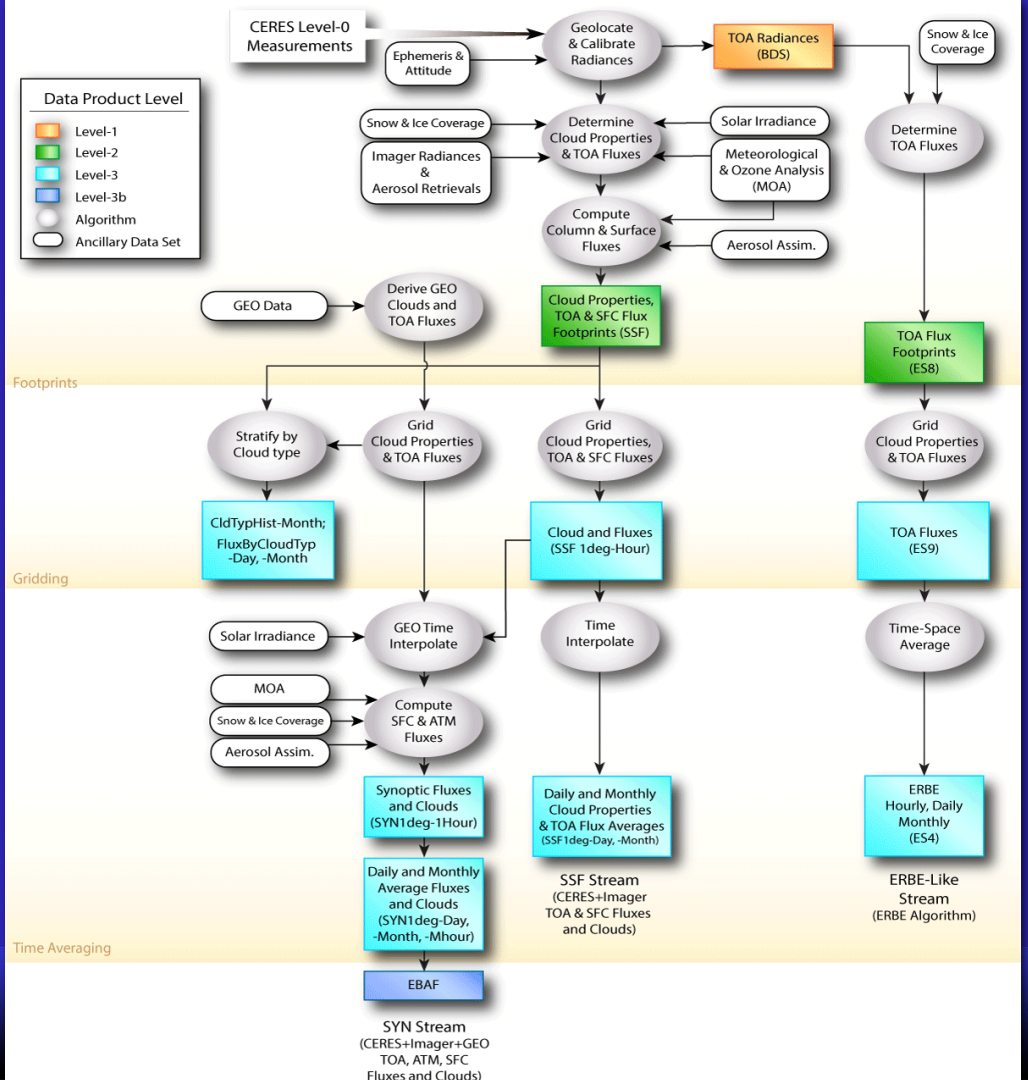
EBAF product

- The EBAF product provides climate quality regional monthly mean observed TOA, computed surface and cloud radiative effect (CRE) fluxes
  - Combines the stability of the SSF1deg products while accounting for the regional diurnal flux, which is free of GEO artifacts
- Utilizes imager derived BB fluxes for spatially complete clear-sky fluxes for regions with no CERES clear-sky measurements
- The TOA net flux is energy balanced and constrained to the ocean heat storage
  - To mitigate any CERES instrument calibration bias
  - For climate model validation
  - Suitable for analysis of variability at the intra-seasonal, inter-annual, and longer time scales



the product combines these satellite records into a single product

CERES Products Chart

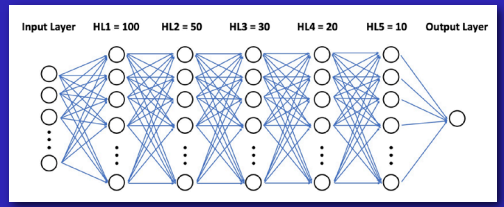


SYN1Deg Ed4 Derived GEO LW Flux

- SYN1Deg Ed4 derived GEO LW TOA fluxes are based on empirical GEO IR and WV channel radiance to broadband flux relationships (*Doelling et al., 2016*)
  - Bin data according to VZA(35 bins), 10.8um radiance(6), total precipitable water(3), surface types(6)
  - Obtain coefficients for each bin from multi-variate linear regression based on MODIS IR and WV bands and observed BB fluxes in SSF Ed4
  - Calibrate GEO imager IR (10.8um) and WV (6.7um) radiances to MODIS radiances
  - Derive GEO BB Flux by applying SSF-based coefficients $LW_{flux} = a_0 + a_1 WIN_{rad} + a_2 WV_{rad}$
  - Normalize GEO fluxes to CERES fluxes

Ed5 GEO LW Flux Improvement based on DNN

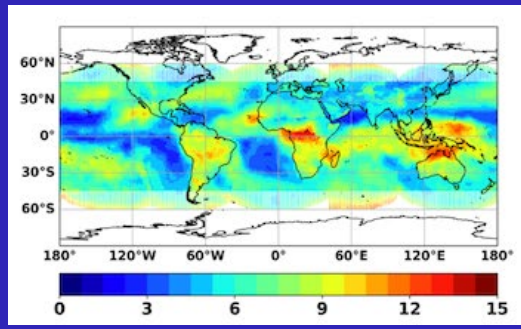
- Deep Neural Network (DNN)
  - 5 hidden layers with varying neurons: [200,50,30,20,10]
- Training Data
  - Ed4 SYN1Deg January 2007-2011 time matched GEO and CERES data
- Input Variables
  - Daytime (12): 10.8um, 6.7um, 0.65um, goe_id, geo_frac, surface type, total precipitable water, longitude, latitude, SZA, VZA, RAA
  - Nighttime (9): 10.8um, 6.7um, goe_id, geo_frac, surface type, total precipitable water, longitude, latitude, VZA
- Target Variable: matched CERES LW fluxes
- Validation Month: January 2012



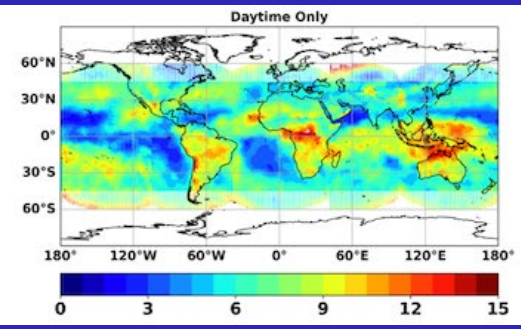
GEO LW fluxes: DNN Baseline vs Ed4

RMSE (W/m^2) before Normalization (January 2012)

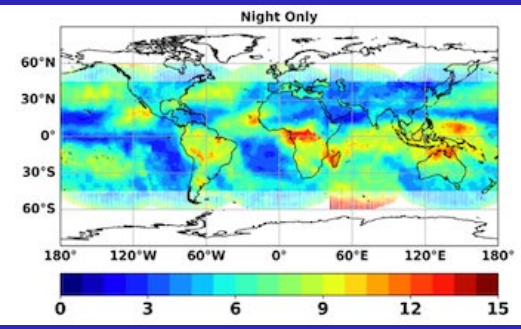
Ed4



Global Mean: 5.89 SD: 1.96

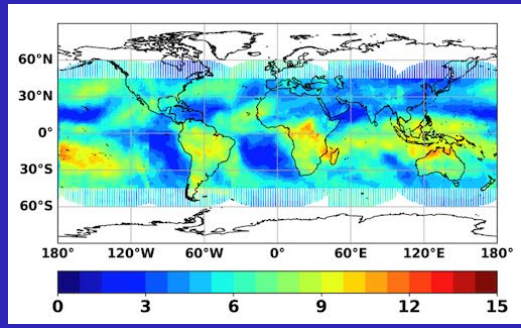


Global Mean: 6.10 SD: 2.08

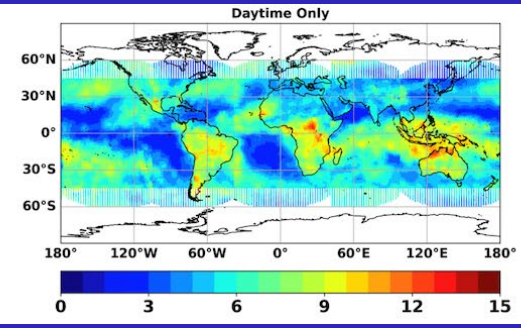


Global Mean: 5.67 SD: 1.98

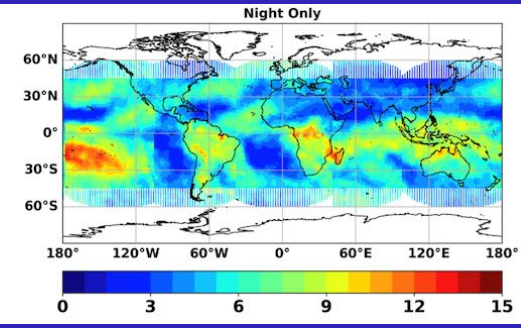
DNN
Baseline



Global Mean: 5.31 SD: 1.98



Global Mean: 5.24 SD: 1.93

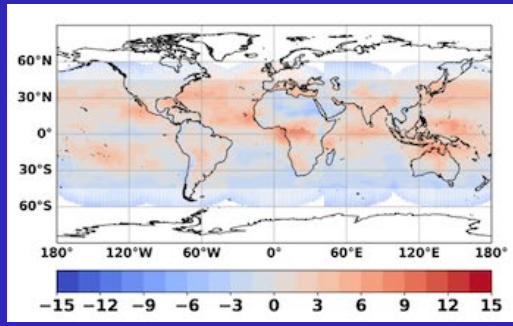


Global Mean: 5.37 SD: 2.17

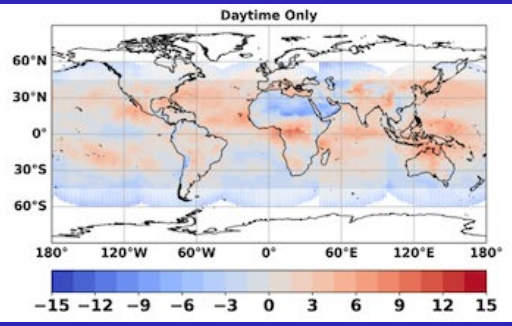
GEO LW fluxes: DNN Baseline vs Ed4

Bias (W/m^2) before Normalization (January 2012)

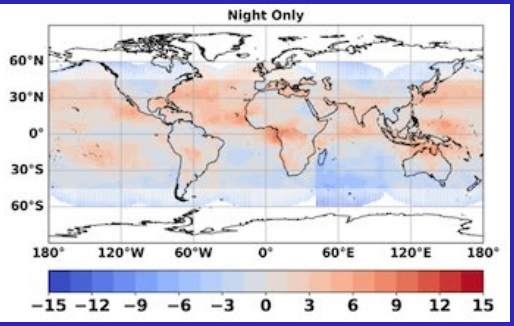
Ed4



Global Mean: 0.41 SD: 2.07

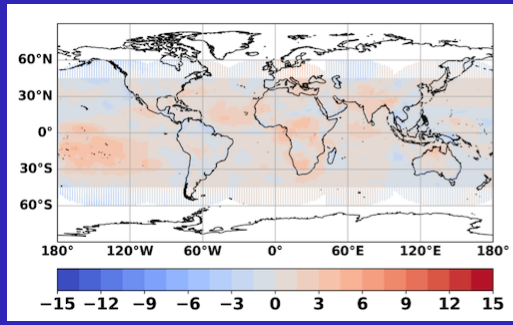


Global Mean: 0.43 SD: 2.26

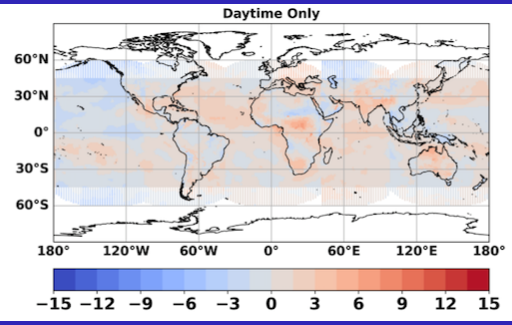


Global Mean: 0.39 SD: 2.20

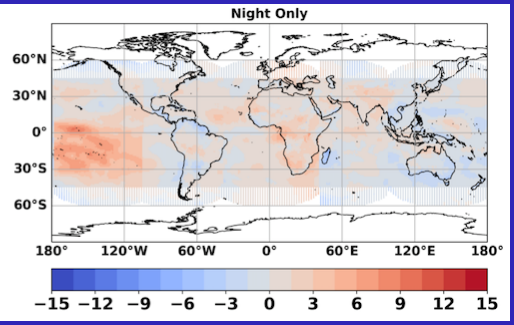
DNN
Baseline



Global Mean: 0.43 SD: 1.10



Global Mean: 0.32 SD: 1.17

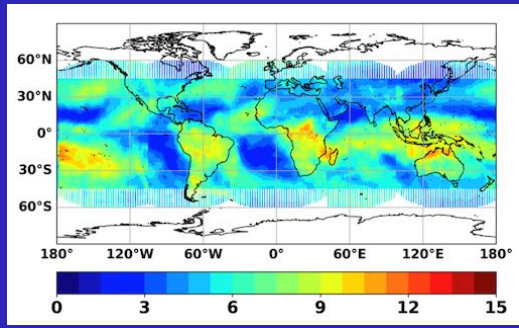


Global Mean: 0.54 SD: 1.63

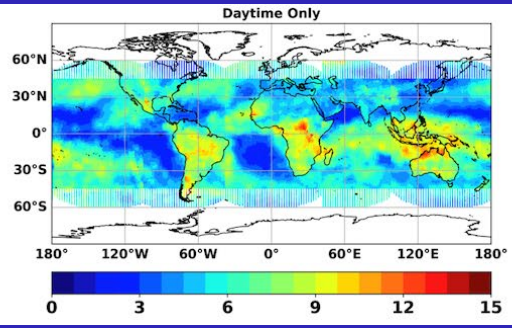
GEO Ed5 DNN fluxes: Sensitivity Study #1

RMSE (W/m^2) before Normalization (January 2012)

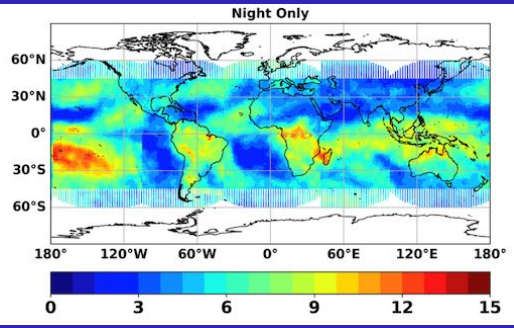
DNN
Baseline



Global Mean: 5.31 SD: 1.98

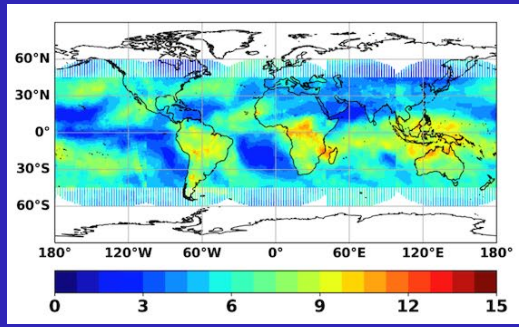


Global Mean: 5.24 SD: 1.93

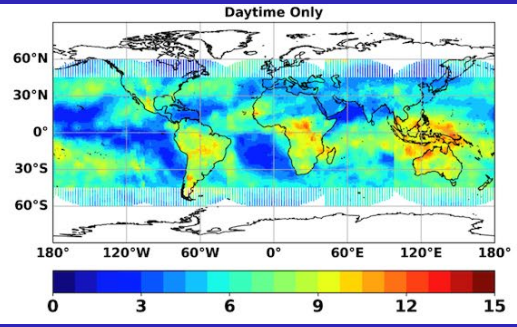


Global Mean: 5.37 SD: 2.17

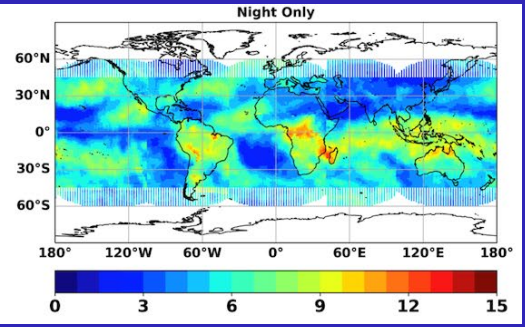
No cloud fraction, GEO ID



Global Mean: 5.25 SD: 1.89



Global Mean: 5.41 SD: 1.97

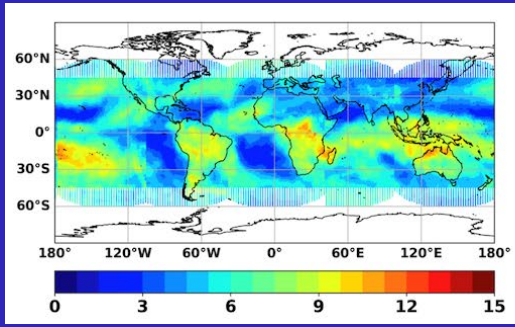


Global Mean: 5.08 SD: 1.93

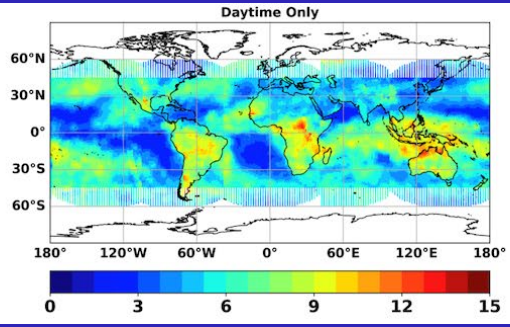
GEO Ed5 DNN fluxes: Sensitivity Study #2

RMSE (W/m^2) before Normalization (January 2012)

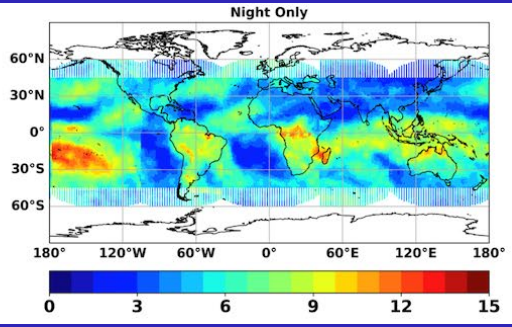
DNN
Baseline



Global Mean: 5.31 SD: 1.98

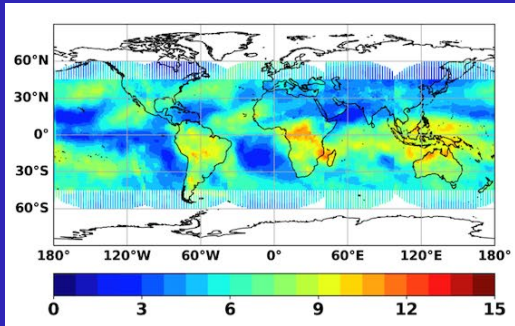


Global Mean: 5.24 SD: 1.93

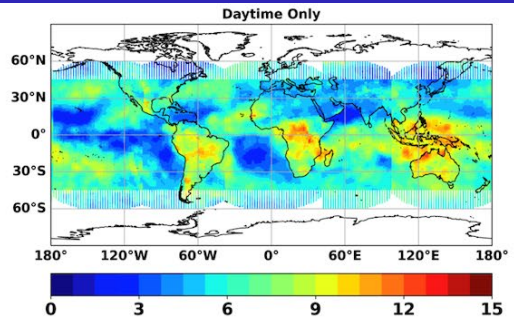


Global Mean: 5.37 SD: 2.17

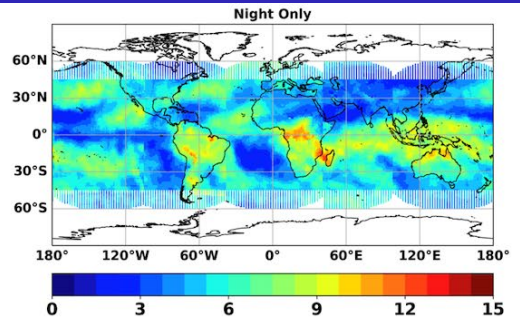
No cloud fraction, GEO ID, 0.65um



Global Mean: 5.33 SD: 1.90



Global Mean: 5.57 SD: 1.97



Global Mean: 5.08 SD: 1.93

Summary

- CERES project offers a variety of products with diverse temporal and spatial resolutions for different user applications. The primary Level-3 data include SSF1Deg, FluxByCldTyp, SYN1Deg and EBAF.
- Preliminary results indicate an improvement in SYN1Deg GEO LW fluxes through the implementation of a DNN algorithm compared to Ed4 GEO LW fluxes.
- Following a comprehensive future study including sensitivity of input parameters, the DNN-based GEO LW algorithm will be integrated into SYN1Deg Ed5.

Thank you!

Fore more information:
https://ceres.larc.nasa.gov/