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AIA is All You Need: SDO MEGS A&B virtualization via Convolutional Deep Learning

4th NASA Eddy Symposium 2023
31st October

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William Fawcett[2], Manuel Indaco[3], Richard Galvez[4],
Andrés Muñoz-Jaramillo[5], Paul Wright[6]

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Google Cloud NVIDIA

FDL-X combines integrated AI pipelines, machine learning and domain science across heliophysics challenges. Please join us for presentations from all three teams.

Multiscale Geoeffectiveness Forecasting using SHEATH and DAGGER

Vishal Upendran
Tuesday 2:25 PM

Improving thermospheric drag modeling with EUV images: an FDL-X 2023 project

Tom Berger
Wednesday 1:45 PM

AIA is All You Need: SDO MEGS A&B virtualization via Convolutional Deep Learning

Daniel Gass
Tuesday 2:15 PM

A Scientific Cloud Computing Platform for Ingestion and Processing of SDO Data

Manuel Indaco
Wednesday 2:10 PM

AI Inference products, foundation models and multi-domain approaches to NASA Heliophysics.

FDL-X
James Parr
Wednesday 2:20 PM

Learn more at FDL.AI

Thank you to our partners

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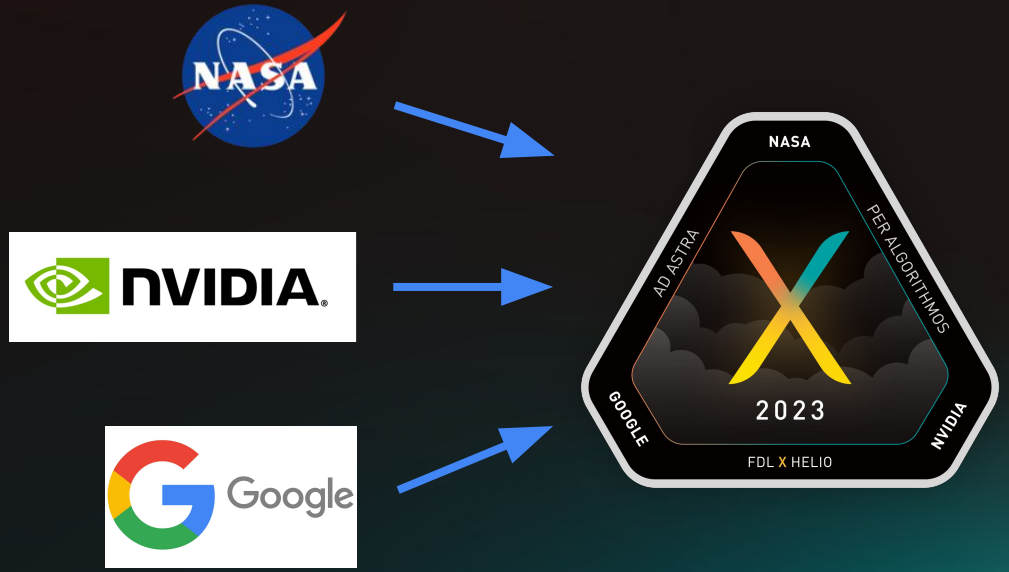
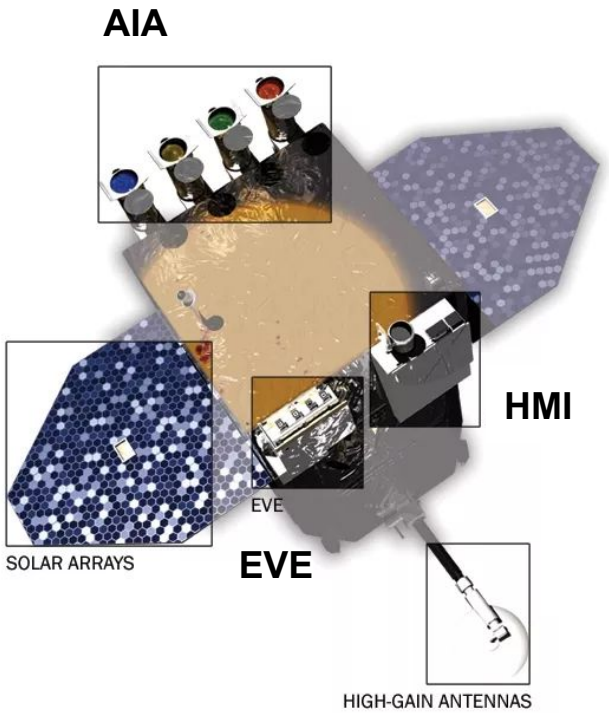
FDL Is a private/public partnership between NASA, Google, and NVIDIA.



Innovative AI solutions of interest to NASA (& everyone else!)

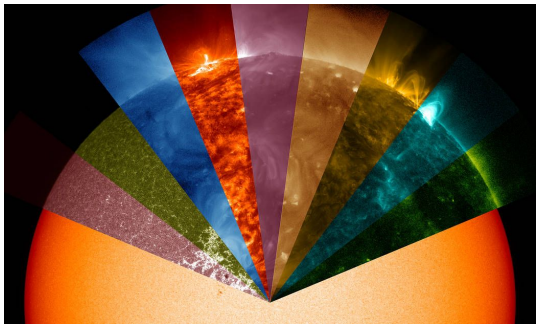
The Solar Dynamics Observatory



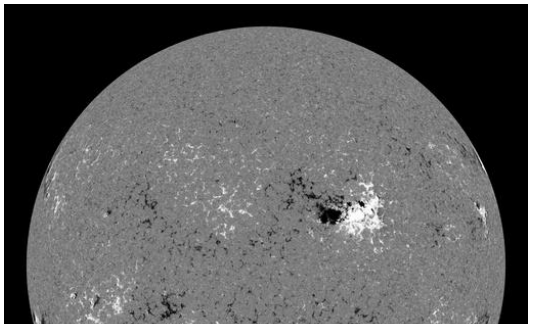
The Atmospheric Imaging Assembly (AIA)
4096 x 4096 full-sun images in 10 channels

The Helioseismic and Magnetic Imager (HMI)
Effectively image sun's magnetic activity

The Extreme ultraviolet Variability Experiment (EVE)
Measures EUV irradiance in select ion ranges

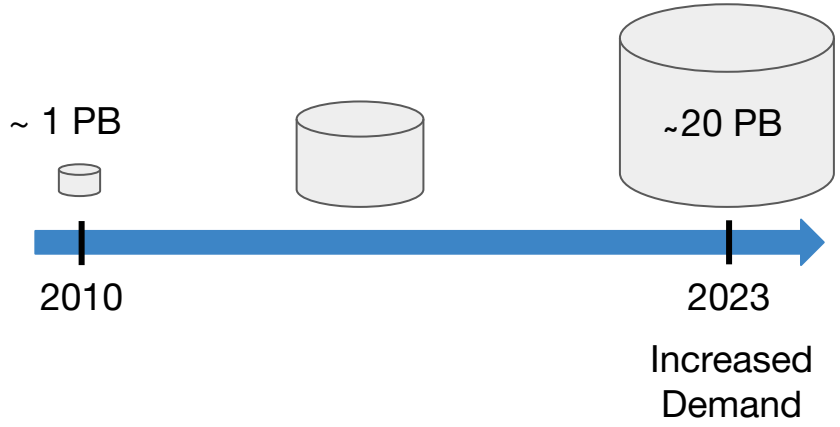


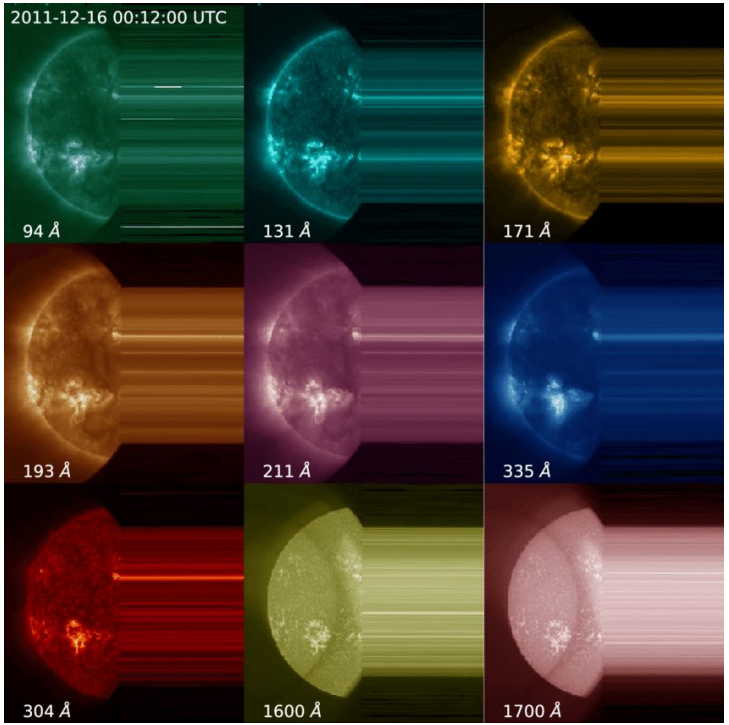
AIA



HMI

SDO Data Infrastructure Issues





- Data infrastructure designed decades ago, SDO now has massive data volumes (~20 PB).
- Scientists need access to curated data and the compute resources to perform large-scale analysis.
- Clear need for an **automated** pipeline to prepare and serve data.

The SDO Machine Learning dataset (SDOML)

- The SDOML dataset was introduced in FDL2018 and has had subsequent improvements over the years

- Some key points are:
  - AIA & HMI images, and ion irradiance from EVE
  - Images corrected for instrument degradation
  - Calibration to “level 1.5”
  - Solar disk position & size harmonized across images
  - 512x512 resolution (easy for ML)

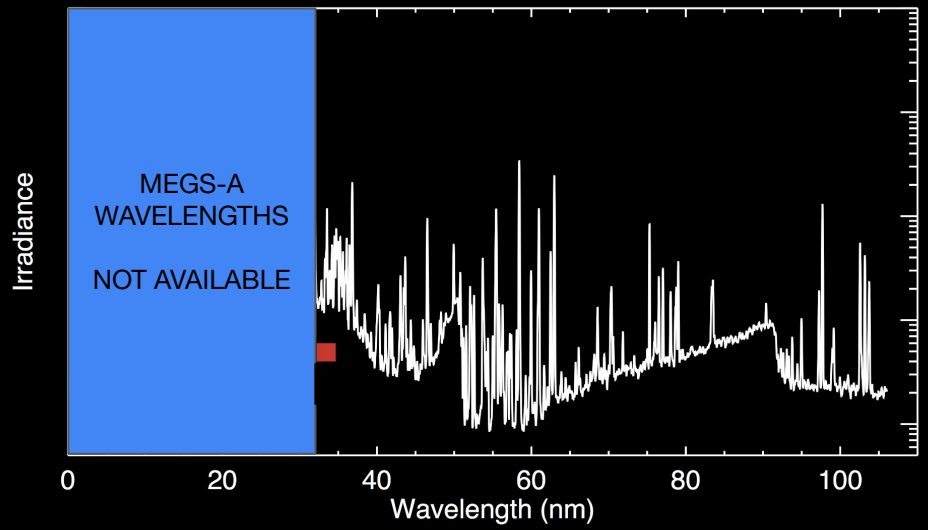
- The dataset is a curated, **machine-learning ready** dataset

- SDOMLv2 **only had SDO data up to 2020**

- **Addition of new data not automated**

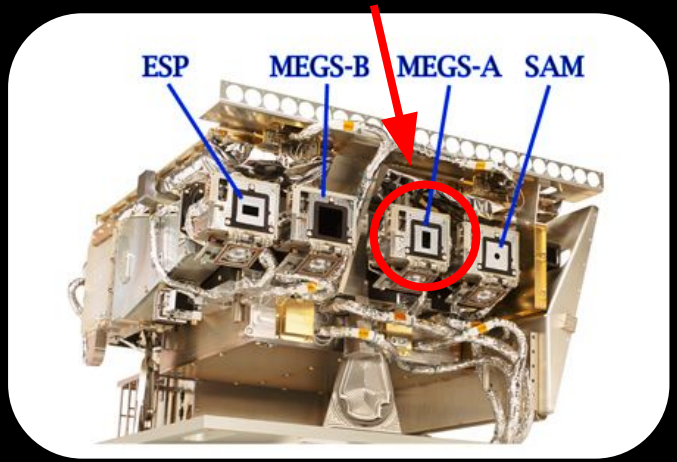
EVE Instrument Virtualization

EVE: How it's going

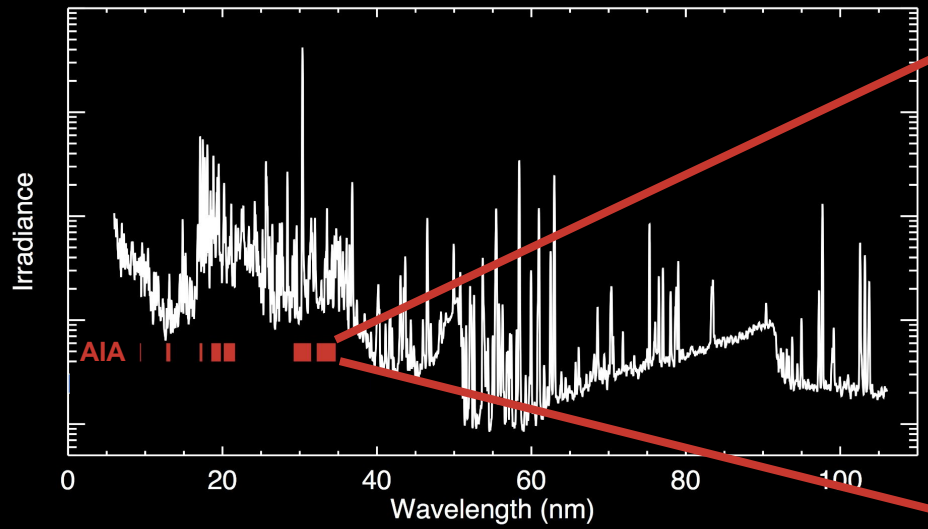


EVE Instrument

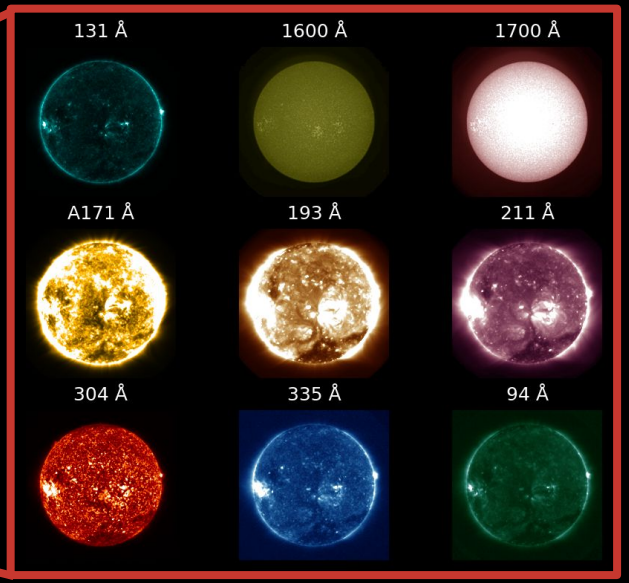
Partly broken since 2014
(Capacitor short in MEGS-A)



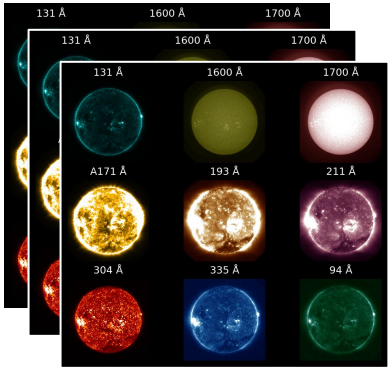
EVE: AIA to the Rescue



Our dataset



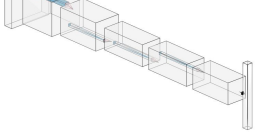
Virtual EVE: Hybrid Model



LINEAR MODEL

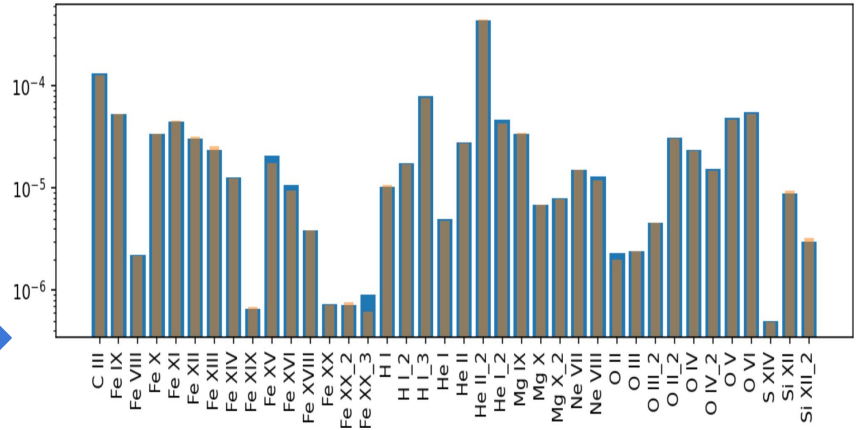
+

CNN MODEL



(EfficientNet backbone)

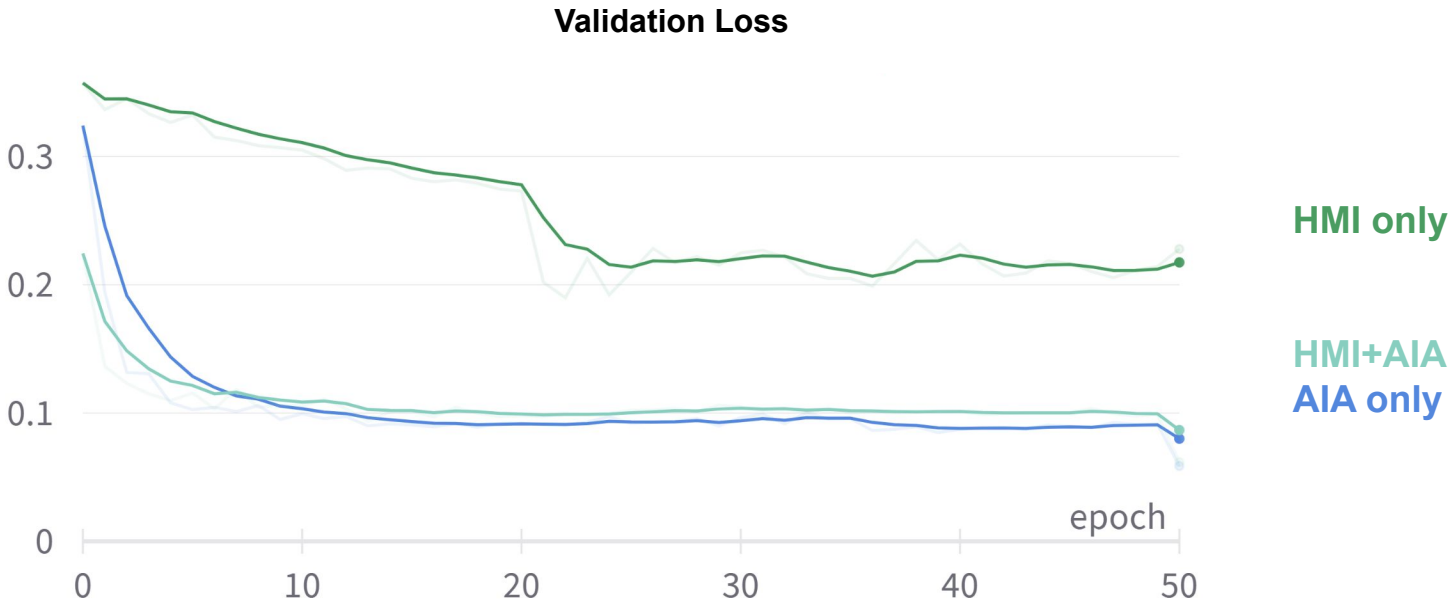
Irradiance Prediction



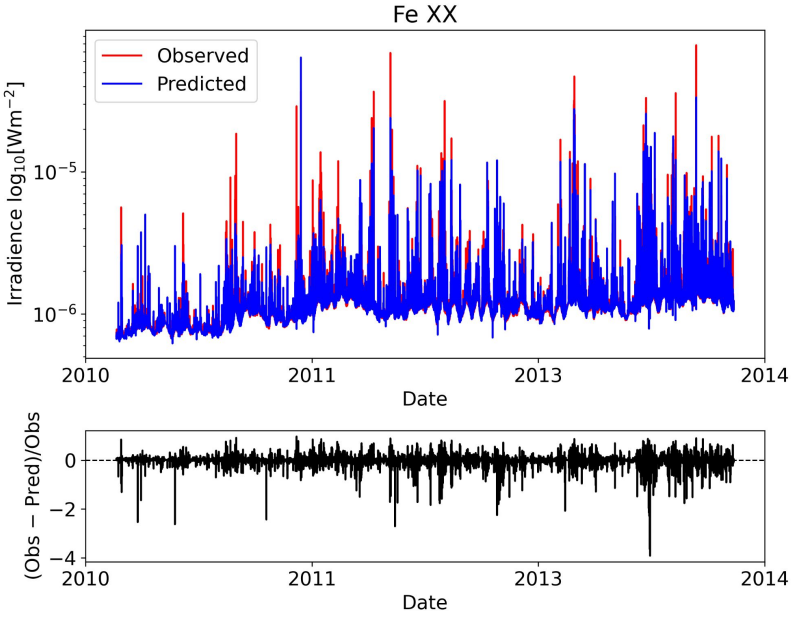
	Previous work (FDL 2018-2022)	This work (FDL 2023)
# ions	14	**38**
# wavelength	8	**9**
prediction	historical	**live inference**

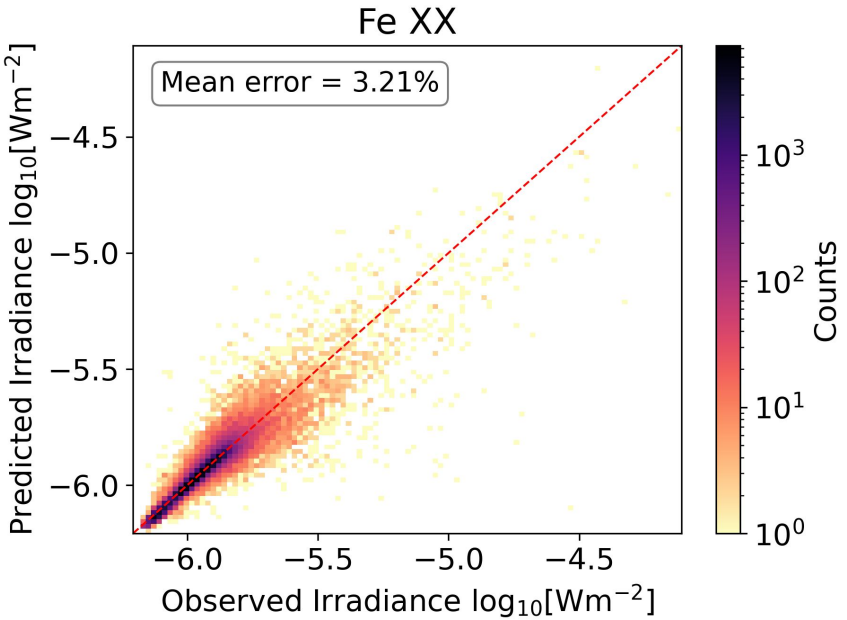
Virtual EVE Results: AIA is All You Need

HMI line-of-sight data ***does not*** improve irradiance prediction quality



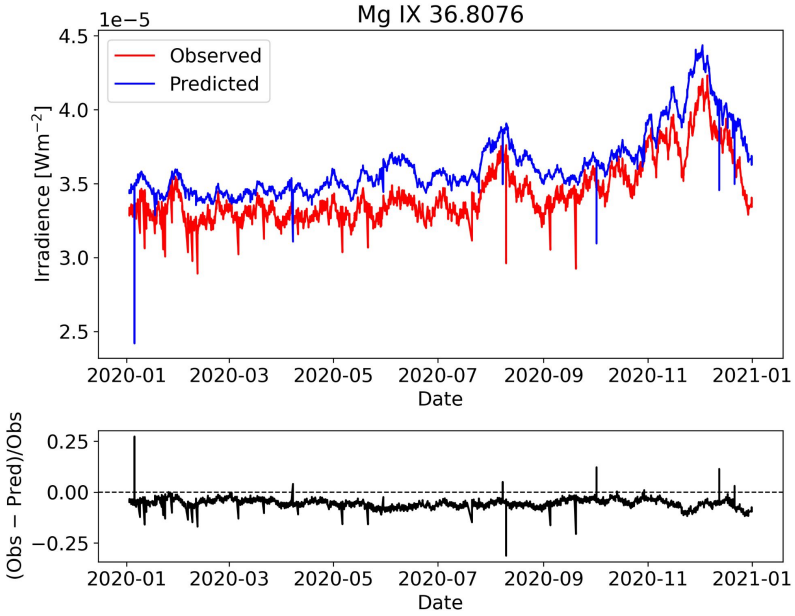
Virtual EVE Results: Irradiance predictions

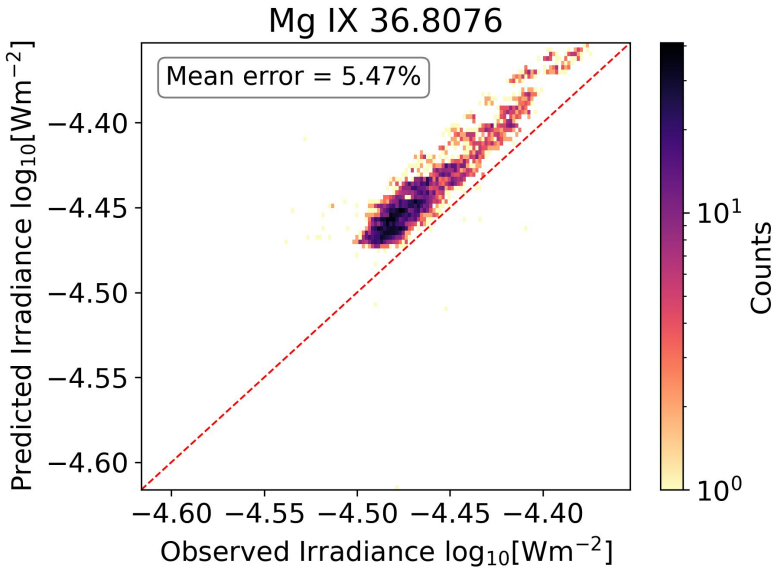


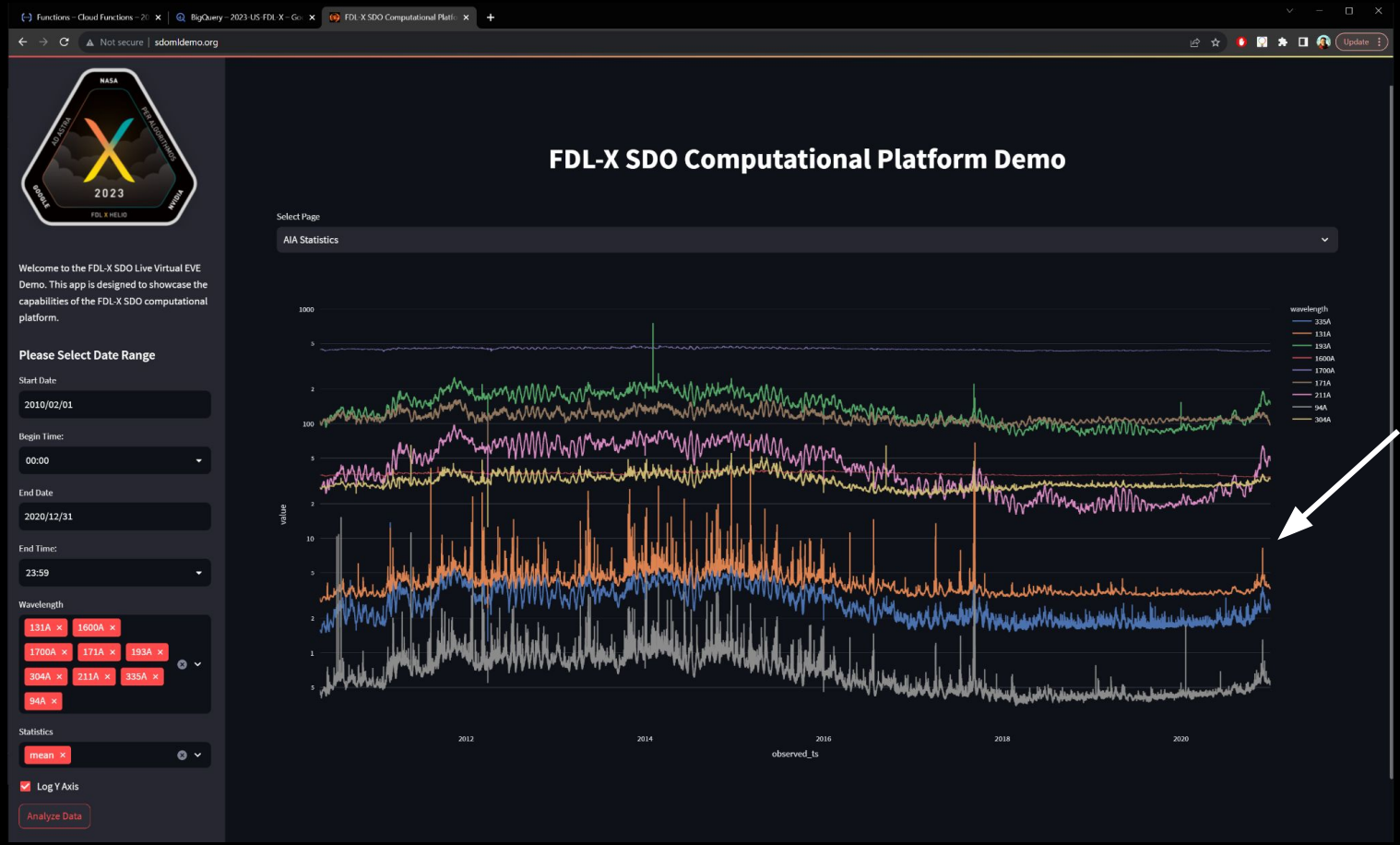


Virtual EVE Results: Irradiance predictions 2020

- Results show irradiance prediction vs observation (MEGS-B), 6 years after training data ends
- Shape and trend looking good, but there's a systematic offset
- Degradation corrections have been applied, but perhaps the degradation correction is slightly off?







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AIA summary statistics

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Virtual Eve

NASA

AD ASTRA

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2023

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Welcome to the FDL-X SDO Live Virtual EVE Demo. This app is designed to showcase the capabilities of the FDL-X SDO computational platform.

Please Select Date Range

Start Date

2017/09/26

Begin Time:

00:00

End Date

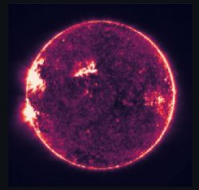
2017/09/27

End Time:

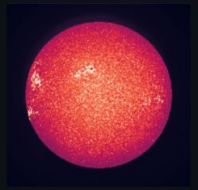
23:59

AIA Data

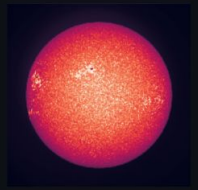
131A



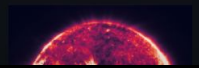
1600A



1700A



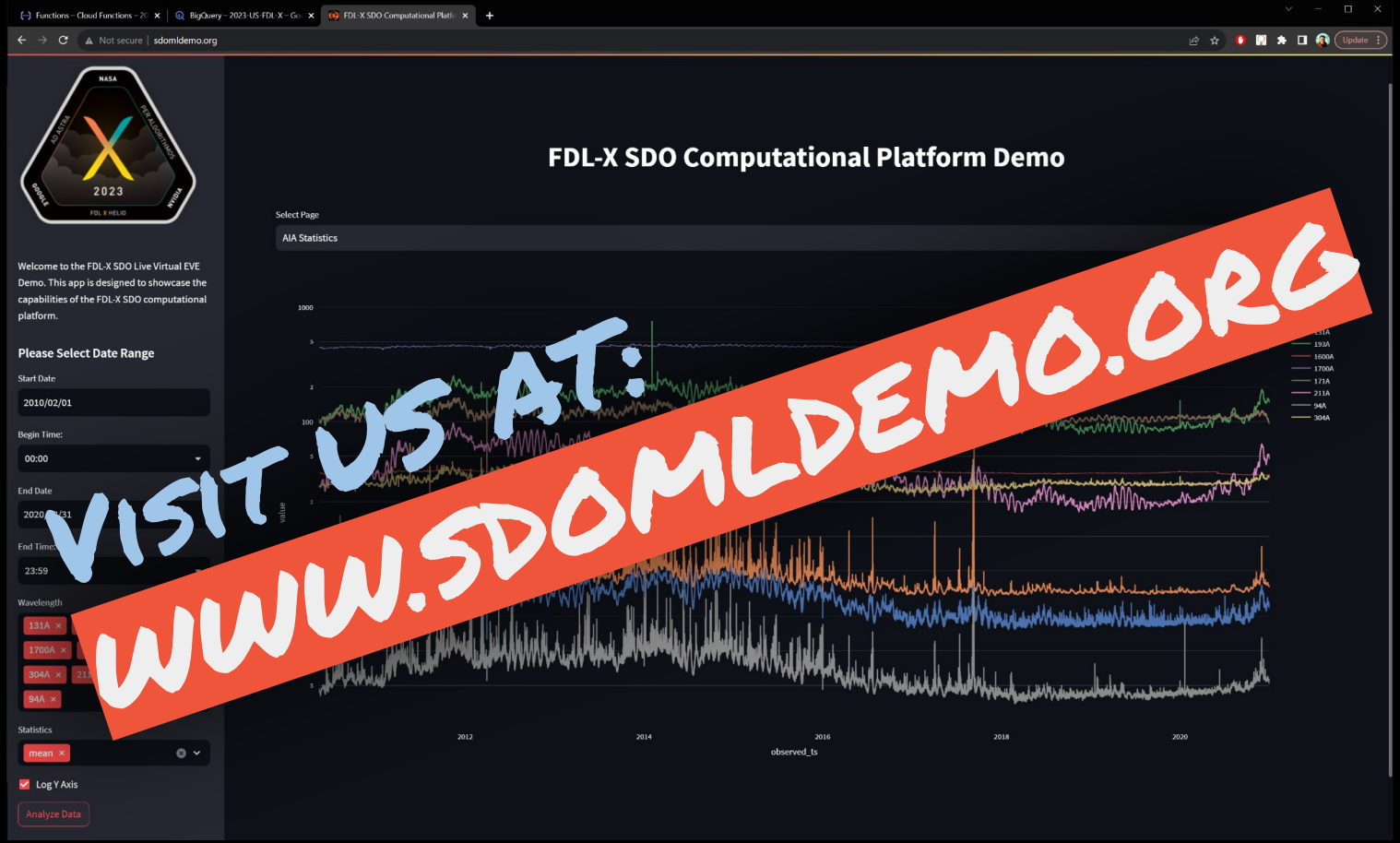
171A



193A

211A

Virtual EVE Irradiance


Functions - Cloud Functions - 20
BigQuery - 2023-US-FDL-X - Go
FDL-X SDO Computational Platfo
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2023
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FDL-X SDO Computational Platform Demo
Welcome to the FDL-X SDO Live Virtual EVE Demo. This app is designed to showcase the capabilities of the FDL-X SDO computational platform.
Please Select Date Range
Start Date
2010/02/01
Begin Time:
00:00
End Date
End Time:
23:59
Wavelength
131A
1700A
304A
94A
Statistics
mean
Log Y Axis
Analyze Data
Select Page
AIA Statistics
1000
100
value
2012
2014
2016
2018
2020
observed_ts
193A
1600A
1700A
171A
211A
94A
304A
VISIT US AT:
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Results

Virtual EVE
A deep learning model based on AIA input data providing live proxy EVE solar irradiance measurements to the community; a blueprint for future virtual instruments like it.

Results available for inspection/download at sdomldemo.org

Paper forthcoming.

Open Science Questions

Does HMI become useful for solar irradiance prediction at higher resolutions? At 512x512, we found that it does not.

What other parameters/input can be provided to improve the model predictive performance, especially for the ions the current model struggles to predict?

Which EUV AIA channels are most useful for the prediction of EVE irradiance?

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Thank you

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