

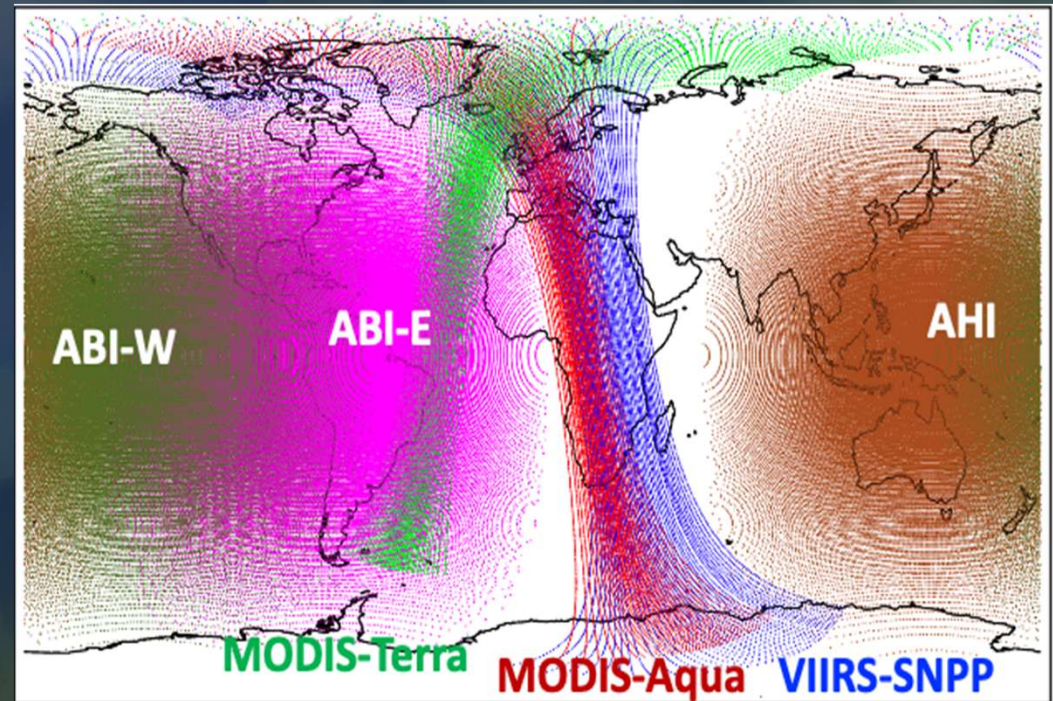
Pyroscopegridding GEO-LEO Aerosol Data Fusion (an Open-Source Package)

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Challenges and Opportunities

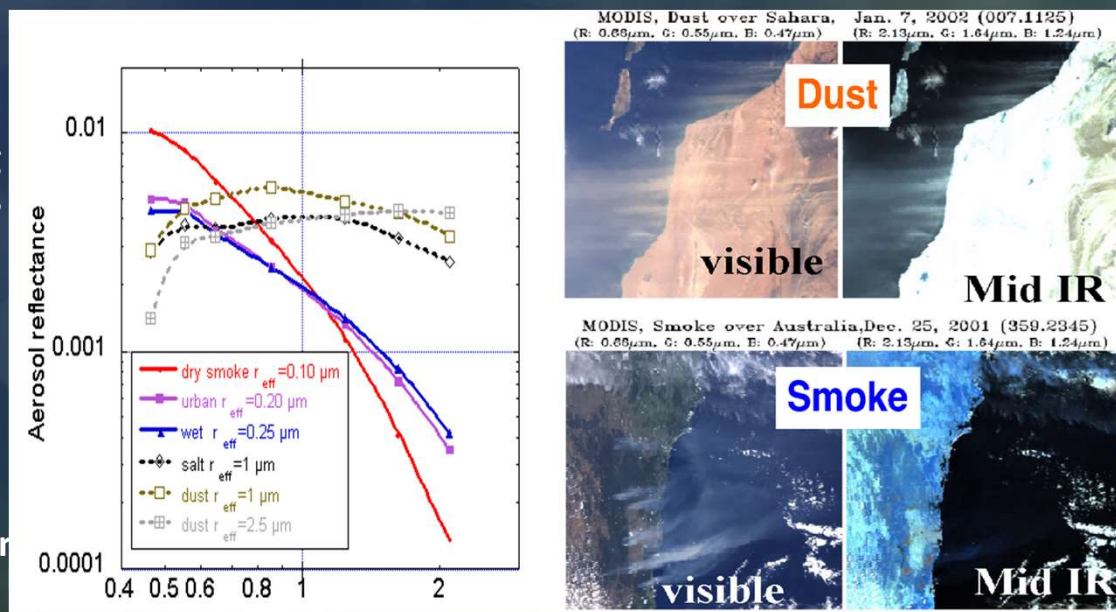
- Aerosol optical depths (AOD) are crucial indicators of particulate matter and atmospheric phenomena but have limited temporal resolution from sun-synchronous polar orbiting satellites, hindering diurnal cycle characterization.
- Sun-synchronous polar orbiting satellites (MODIS, VIIRS, OMI, TROPOMI) provide once-per-day observations, limiting the temporal resolution for aerosol optical depths (AOD) and diurnal cycle characterization.
- Geostationary satellites (e.g., GOES-16/17/18, Himawari-8/9, MTG) revolutionize AOD observations with high temporal resolution (10 minutes) and multiple daylight images per hour, facilitating diurnal variability studies.
- Integrating aerosol observations from geostationary and polar orbiting satellites poses significant "Big Data" challenges in storage, accessibility, and discoverability.
- Our research aims to address these challenges and maximize the potential of GEO-LEO data fusion.



The Dark Target (DT) Aerosol Algorithm

- The "dark-target" (DT) algorithm, initially developed for MODIS, allows quantification of aerosol reflectance over dark land and ocean using Lookup Tables (LUTs).
- This well-validated Dark Target algorithm facilitates seamless fusion of geostationary and polar orbiting AOD observations, harmonizing data across various satellites with its adaptable spatial and temporal resolutions.
- Moreover, DT's portability to other sensors with visible, near-IR, and shortwave-IR observations extends its applicability beyond MODIS, enabling broader aerosol research capabilities.
- DT products (MODIS + VIIRS) meet spatial resolution and accuracy requirements, but their temporal resolution remains limited to daytime retrievals at 10:30 and 13:30 local time.

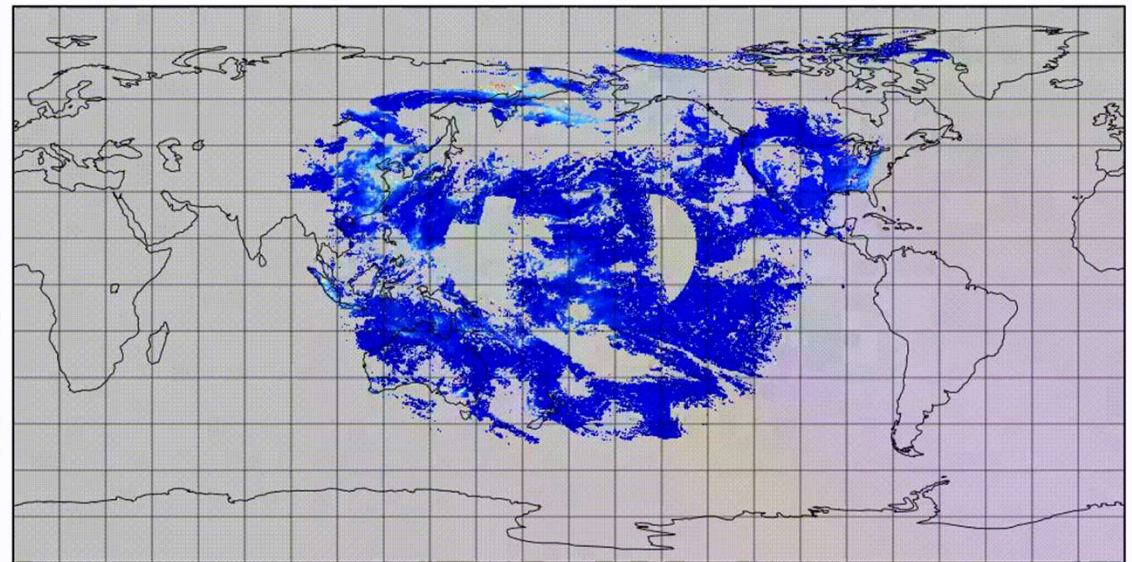
Wavelength dependence of aerosol size/type and contrast over different surface types



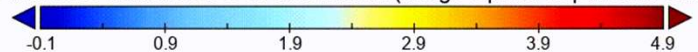
Methodology: Pyroscopegridding

- Our study utilizes Level 2 aerosol data from six satellites: three geostationary (GOES-16/17, Himawari-8) and three polar orbiting (TERRA/MODIS, AQUA/MODIS, SNPP-VIIRS).
- We meticulously fuse the data using the Dark Target algorithm, overcoming the challenges of spatial and temporal disparities, and creating a unified dataset with high temporal resolution.
- By leveraging GEO-LEO data fusion, we unlock the diurnal cycle of global AOD, a significant advancement in aerosol research.

Mean of gridded LEO and GEO sensors AOD at 0.55 micron (Image Optical Depth Land And Ocean) for ...
Time: NAN



Mean of gridded LEO and GEO sensors AOD at 0.55 micron (Image Optical Depth Land And Ocean) for both oc...



Data Min = -0.1, Max = 4.9, Mean = 0.2

Pyroscopegridding:

Python-based Remote-sensing and Observation System for Comprehensive Aerosol Data Fusion in GEO-LEO

Targeted User Personas

- **Atmospheric and environmental scientists** - These individuals require the package to capture the diurnal cycle of global AOD at different scales and understand the characteristics of aerosol particles in the atmosphere and their impacts on air quality, climate, and human health.
- **Data scientists and GIS professionals** - These individuals require the package to handle big data challenges and provide advanced visualization capabilities to analyze satellite data and create maps and visualizations of aerosol particle data.
- **Cloud computing professionals** - These individuals require the package to provide on-demand capability for fusing remote sensing products onto desired temporal and spatial domains in a cloud computing environment.
- **Novice users** - These individuals require the package to be user-friendly and easy to learn, with clear documentation and tutorials that can guide them through the analysis process of satellite data and remote sensing products.

Pyroscopegridding:

Python-based Remote-sensing and Observation System for Comprehensive Aerosol Data Fusion in GEO-LEO (an Open-Source Package)

We developed an open-source package for GEO-LEO aerosol data fusion, promoting collaboration and innovation.

- This user-friendly package ensures seamless data integration, empowering scientists with efficient access to aerosol data processing resources.
- Our aim is to drive advancements in aerosol research and contribute to a sustainable future.

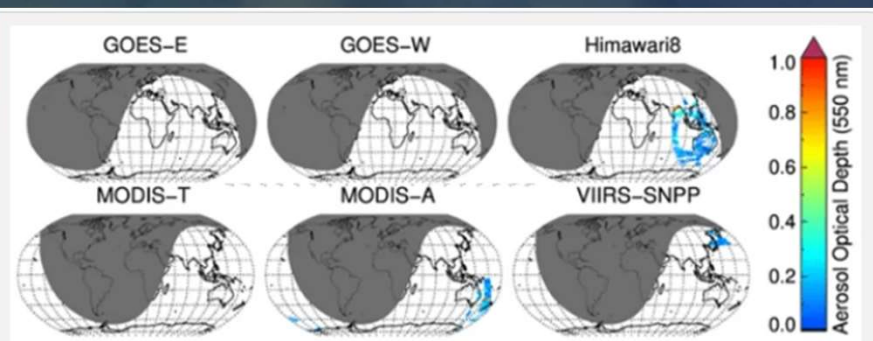
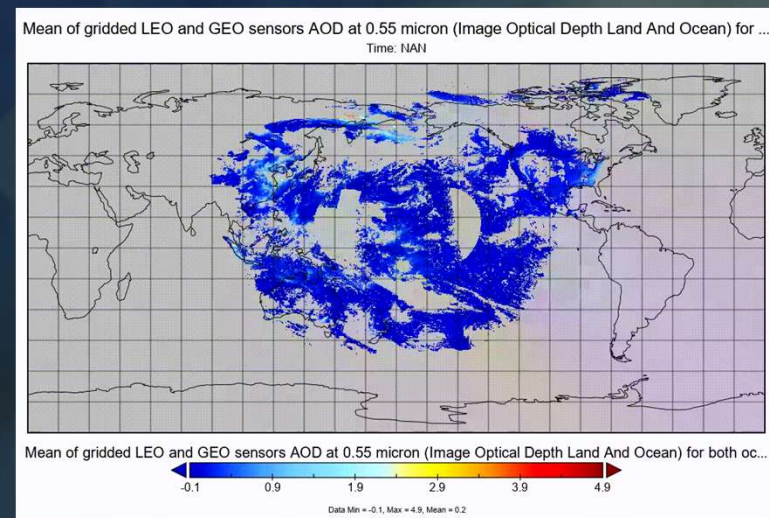


Figure 1: Six Geosynchronous Equatorial Orbit (GEO) and Low Earth Orbit (LEO) satellites' independent view of Earth (2020/01/04, 0415 UTC)



Python Performance Optimization

Performance Issues in Python:

- Python is a popular language for functional and convenient programming but can suffer from performance issues.
- When compared to lower-level languages like C, Python can be slower for computationally complex tasks.
- Optimization of data and calculations is crucial to minimize run time for computationally complex packages in Python.

Optimization Solutions: Multi-threading Parallelization

- GPU-based:
 - Custom CUDA kernels used for parallelization on NVIDIA GPUs.
 - Achieved 72x speedup on local hardware with GPU-based parallelization.
- CPU-based:
 - CPU-based parallelization implemented for users without GPUs.

Deployment & Repository



Containerization Deployment:

- Consistent deployment environment
- Improved portability across different environments
- Faster deployment and updates
- Scalability to handle varying levels of traffic
- Efficient use of resources
- Increased security with isolation from underlying infrastructure

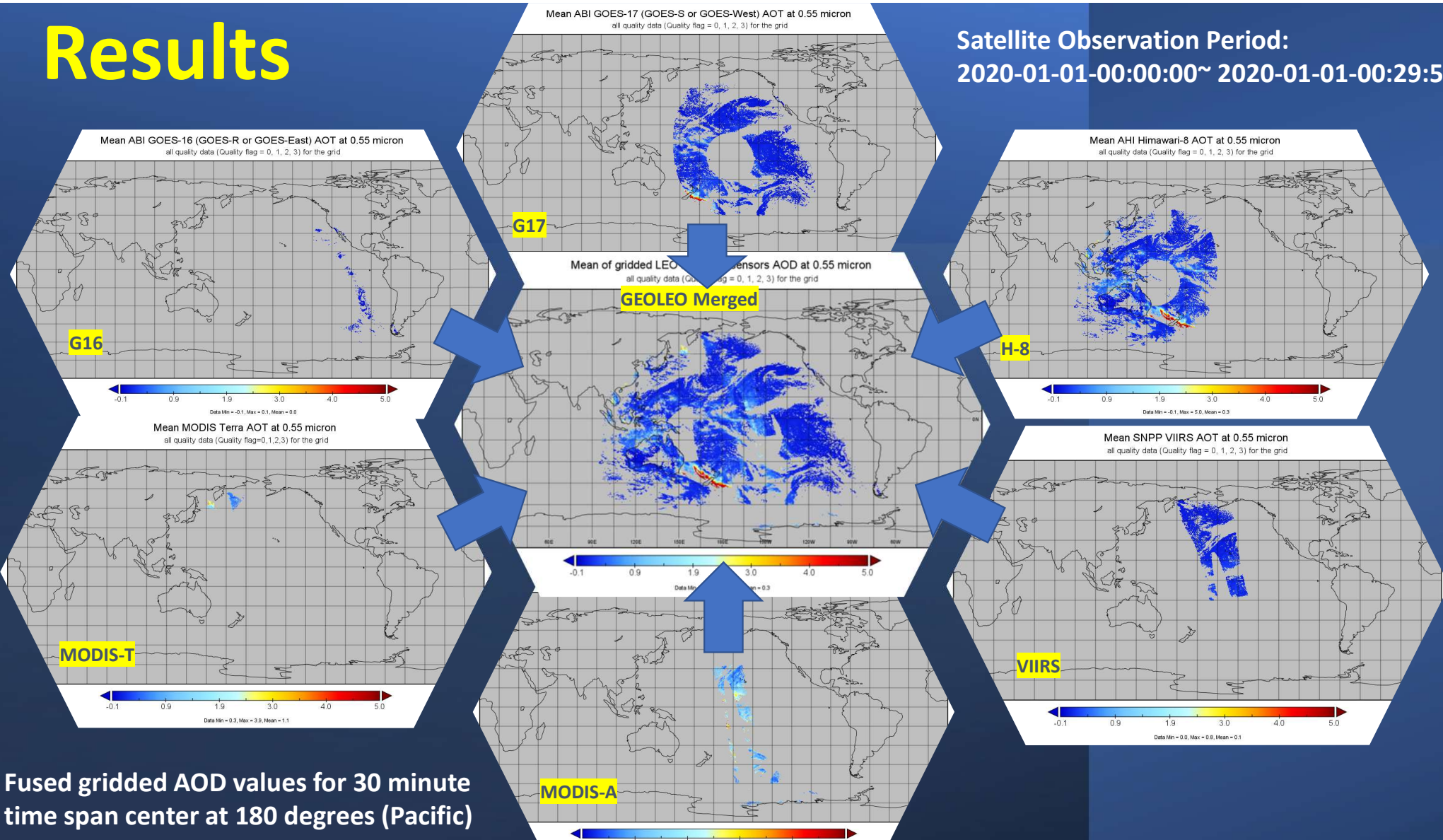


Online Repository:

- Github
- Docker Hub
- PyPI

Results

Satellite Observation Period:
2020-01-01-00:00:00~ 2020-01-01-00:29:59



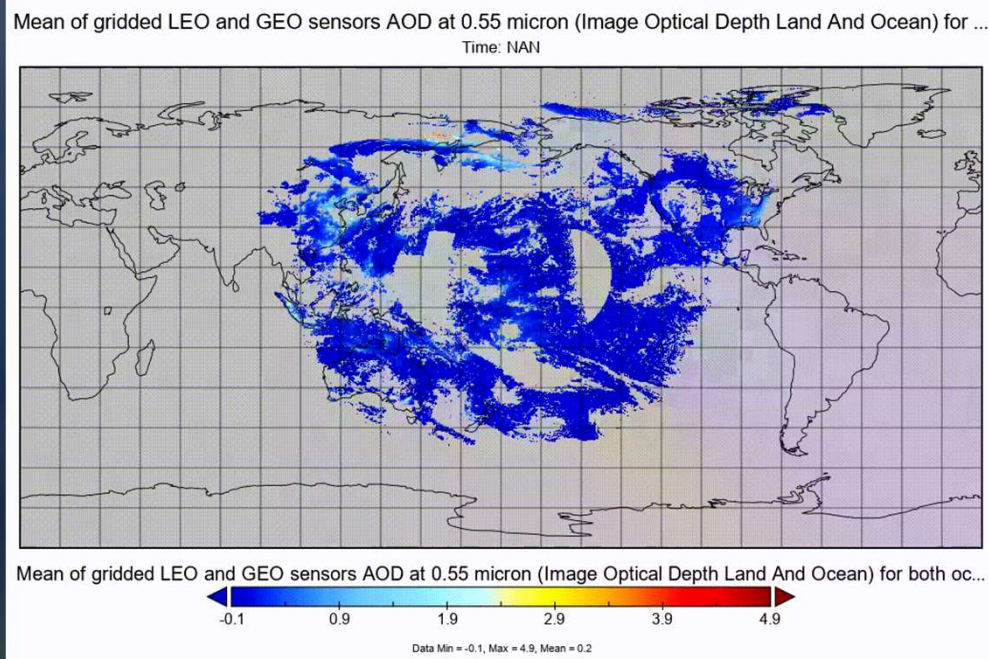
Pyroscopegridding:

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- **Current Status:**
 - Open Source Software Package Approval in the final stage.
 - Data and Metadata verification ongoing.
 - Repository hosted on Git, PyPI, and Docker platforms.
 - Targeted personas: atmospheric scientists, application practitioners.
- L2 and L3 data for period 2019-2022 soon available via NASA LAADS
<https://ladsweb.modaps.eosdis.nasa.gov/>
- Pyroscopegridding software: ask me!

References:

- Levy, R. C., S. Mattoo, L. A. Munchak, et al. 2013. The Collection 6 MODIS Aerosol Products over Land and Ocean. Atmos Meas Tech 6 2989-3034
- Gupta, P.; Remer, L.A.; Patadia, F.; Levy, R.C.; Christopher, S.A. High-Resolution Gridded Level 3 Aerosol Optical Depth Data from MODIS. Remote Sensing. 2020, 12, 2847. <https://doi.org/10.3390/rs12172847>



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