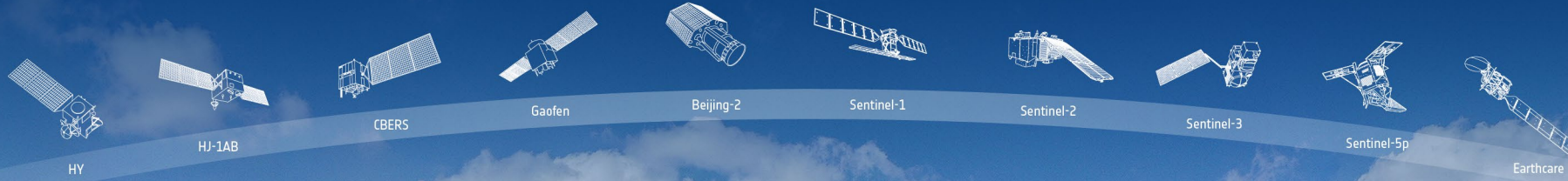




中国科学技术交流中心
China Science and Technology Exchange Center



→ THE EUROPEAN SPACE AGENCY



2025 DRAGON 6 SYMPOSIUM

14-18 JULY 2025

PROJECT ID. 95481

REMOTE SENSING OF ENVIRONMENTAL EFFECTS ON MATERIALS - APPLICATION
TO THE DEGRADATION OF CULTURAL HERITAGE MONUMENTS





BATCH-1, JULY 2024

ID. 95481

PROJECT TITLE: REMOTE SENSING OF ENVIRONMENTAL EFFECTS ON MATERIALS - APPLICATION TO THE DEGRADATION OF CULTURAL HERITAGE MONUMENTS

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PRESENTED BY: XIAO-HU SUN



Project's objectives

Focusing on specific monuments in China and Europe, the project has three main tasks:

- 1) Developing deterioration and soiling indices,
- 2) Creating new SSD-DRFs (Satellite Sensed Data Dose-Response Functions) for the materials copper and stainless steel
- 3) Monitoring seismicity in culturally significant areas using satellite observations.



Project's description

Recently, our team (Kouremadas et al., 2023) proposed an innovative technique for estimating deterioration levels of various materials and the soiling of materials' surfaces using satellite environmental and air pollution data. These tools, named Satellite Sensed Data Dose-Response Functions (SSD-DRFs), provide the capability to estimate materials' deterioration and soiling for almost any point on the planet.

Traditional deterioration modeling tools, such as Dose-Response Functions (DRFs) found in the literature, are designed to utilize ground-based environmental and air-pollution data. This dependence limits their applicability to areas where such data is available from ground-based observing stations, and such areas are often sparse.



This limitation is overcome by SSD-DRFs.

In the following figure (Kouremadas et al., 2023) two of the developed SSD-DRFs are presented

Limestone

$$R = 0.433 \cdot \ln(RH) + 0.18 \cdot \ln(RH \cdot O_3) + 0.095 \cdot \ln(RH \cdot SO_2) - 1.914$$

Modern glass

$$H = 16.511 \cdot \ln(Temp) + 0.824 \cdot \ln(AOD) + 0.018 \cdot \ln(NO_2 \cdot D_{NO_2}) + 0.333 \cdot \ln(O_3 \cdot D_{O_3}) + 0.015 \cdot \ln(SO_2 \cdot D_{SO_2}) - 94.12$$

R = surface recession, μm (absolute values);

H = haze, %;



Team experience and background

PIs, along with members of their teams, have been working in this research field since 2009. One part of the research relates to the development of corrosion/soiling models based on ground-based data, expanding the already available knowledge. Based on these findings, attempts were made to develop corrosion/soiling models using satellite data in the framework of DRAGON 3 and 4 projects. Recently, new Satellite Sensed Data – Dose Response Functions (SSD-DRFs) were published in the literature.

A full reference list presenting the research's timeline and achievements is provided at the end of this presentation. The number of publications and the long-lasting research effort underline the experience of PIs in the field, as well as their commitment to continuing to contribute to this field.



Task 1

The primary goal of the proposed project is to develop two indexes:

- the Limestone Deterioration Index (LDI) and
- the Soiling Index (SI).

The LDI will indicate the deterioration potential of the atmospheric environment on the limestone.

The SI will express the soiling potential at the same locations. These indexes will be developed for the following monuments:

<u>Chinese sites:</u>	<u>European sites:</u>
Fujian Tulou	Acropolis, Greece
Historic Centre of Macao	Colosseum, Italy
Ancient Building Complex in the Wudang Mountains	Historic Centre of Vienna, Austria
Dazu Rock Carvings	Historic City of Toledo, Spain
Circular Mound Altar - Temple of Heaven	Palace of Versailles, France





The SSD-DRFs will be utilized for the development of the above-mentioned indexes. The models will be fed with both old and recent satellite data and databases will be created containing degradation and soiling time series values for each monument studied. Based on this data, the proposed indexes will be built. This constitutes Task 1 of the project.

Task 2

Another objective of the project is to develop SSD-DRFs for new materials. While the existing literature covers cases such as carbon steel, zinc, and limestone, we plan to create SSD-DRFs for copper and stainless steel. To achieve this, experimental deterioration data will be used, along with satellite-derived environmental and air pollution data. Artificial Intelligence (AI) and Machine Learning Techniques (MLT) will be applied to the development of new SSD-DRFs. This constitutes Task 2 of the project.



Task 3

Furthermore, the project aims to monitor seismicity in archaeologically interesting areas using satellite observations. The case studies will include the Archaeological site of Delphi as a European candidate site and the Temple and Cemetery of Confucius and the Kong Family Mansion in Qufu as a Chinese candidate place. This research effort is expected to contribute to the development of tools focused on the protection of cultural heritage sites from degradation and natural hazards, employing satellite data. This constitutes Task 3 of the project.



Indicative deliverables

- **Deterioration/Soiling Databases:** Compilation of databases containing degradation and soiling time series values for selected monuments, copper, and stainless steel.
- **SSD-DRFs:** Development of new SSD-DRFs for copper and stainless steel materials using experimental and satellite-derived data.
- **Seismicity Database:** Creation of a prototype seismicity database for archaeological sites, contributing to cultural heritage site protection.
- **Indices (LDI and SI):** Establishment of the Limestone Deterioration Index (LDI) and Soiling Index (SI) for the selected monuments, providing insights into the atmospheric impact on materials.
- **Publications:** The project aims to publish at least 2 or 3 co-authored research papers, presenting results at international conferences and DRAGON Symposia.



Indicative timeline

Schedule Date	Work package
Kick off + 6 months	Establishment of procedures for the collection of the necessary satellite and ground-based data sources. Valid for all Tasks
Kick off + 12 months	Task 1: First deterioration/soiling results of the studied sites based on historical satellite data. Task 2: Development of database containing environmental and air pollution data as well as experimental deterioration data of copper and stainless-steel materials. Task 3: Preparation of seismicity satellite data processing.
Kick off + 24 months	Task 1: Integration of deterioration/soiling database. Task 2: Development of new SSD-DRFs for copper and stainless-steel materials. Task 3: Development of prototype seismicity database for the Archaeological sites of Delphi and the Temple and Cemetery of Confucius.
Kick off + 36 months	Task 1: Development of Limestone Deterioration Index (LDI) and Soiling Index (SI). Task 2: Development of database containing environmental and air pollution data as well as experimental deterioration data of copper and stainless-steel materials. Task 3: Validation of seismicity satellite data using ground-based data.
Kick off + 48 months	Task 1: Finalization of the database. The final form of database will contain data about deterioration/soiling data as well as timeseries of LDI and SI. Analysis of LDI and SI timeseries investigating the deterioration/soiling potential at the studied sites. Task 2: Finalization of the new SSD-DRFs and publication of relevant results. Task 3: Finalization of the database, publication of the obtained results.

Dragon 6 EO Data Delivery



Data access (list all missions and issues if any). NB. in the tables please insert cumulative figures (since June 2024) for no. of scenes of high bit rate data (e.g. S1 100 scenes). If data delivery is low bit rate by ftp, insert “ftp”

ESA /Copernicus Missions	No. Scenes	ESA Third Party Missions	No. Scenes	Chinese EO data	No. Scenes
1. ENVISAT	ftp	1.		1. FY-3A	ftp
2. Sentinel-5P	ftp	2.		2. FY-3B	ftp
3. Sentinel-4	ftp	3.		3. FY-3C	ftp
4.		4.		4. FY-3D	ftp
5.		5.		5. FY-3E	ftp
6.		6.		6. CSES-1(01)	ftp
Total:		Total:		Total:	
Issues:		Issues:		Issues:	

Overview of European & Chinese YSs research



In the following are described the contribution and training of the Young Scientists participating in the project, specified for each task and activity planned.

Innovative Technique Development

Contribution: Young scientists will actively participate in the development and refinement of the innovative technique proposed by the team, specifically in the implementation of Satellite Sensed Data Dose-Response Functions (SSD-DRFs).

Training: This phase offers young scientists exposure to cutting-edge methodologies in material deterioration estimation using satellite data, fostering a deeper understanding of environmental impact assessment.



Index Development for Cultural Monuments

Contribution: Young scientists will play a crucial role in the development of the Limestone Deterioration Index (LDI) and Soiling Index (SI) for selected Chinese and European monuments, contributing to the preservation of cultural heritage.

Training: This task provides hands-on experience in index development, satellite data analysis, and cross-cultural application, enriching the young scientists' skill set.

New Material SSD-DRFs Development

Contribution: Young scientists will actively contribute to the creation of SSD-DRFs for copper and stainless steel, expanding the applicability of the innovative technique to new materials.

Training: Involvement in this task exposes young scientists to the integration of experimental data, satellite-derived information, and advanced AI and Machine Learning Techniques in material deterioration modeling.



Seismicity Monitoring using Satellite Observations

Contribution: Young scientists will be integral in the monitoring of seismicity in archaeological areas, contributing to the development of tools for protecting cultural heritage sites from natural hazards.

Training: Participation in Task 3 enhances young scientists' skills in satellite-based monitoring, particularly in assessing geological phenomena, and strengthens their ability to apply research findings to real-world challenges.

Scientific Exchange and Publication

Contribution: Young scientists will actively engage in the Sino-European scientific exchange, contributing fresh perspectives and collaborative efforts towards achieving project objectives.

Training: Participation in international conferences and DRAGON Symposia provides young scientists with exposure to the global scientific community, fostering networking and communication skills.

Overview of European & Chinese YSs research



Exploitation of Satellite Data

Contribution: Young scientists will be involved in harnessing Copernicus Sentinels, ESA, ESA TPM, and Chinese EO data, actively contributing to the project's success.

Training: This aspect exposes young scientists to state-of-the-art satellite technologies, enriching their knowledge in data utilization and interpretation.

Publication of Research Papers

Contribution: Young scientists will actively contribute to the publication of at least 2 or 3 co-authored research papers, showcasing their research findings and collaborative efforts.

Training: The process of publication enhances the young scientists' scientific writing skills and provides a platform to disseminate their research on an international stage.

Overall, the project provides a holistic training experience for young scientists, combining hands-on research, interdisciplinary collaboration, and exposure to advanced technologies in the field of environmental science and cultural heritage preservation.



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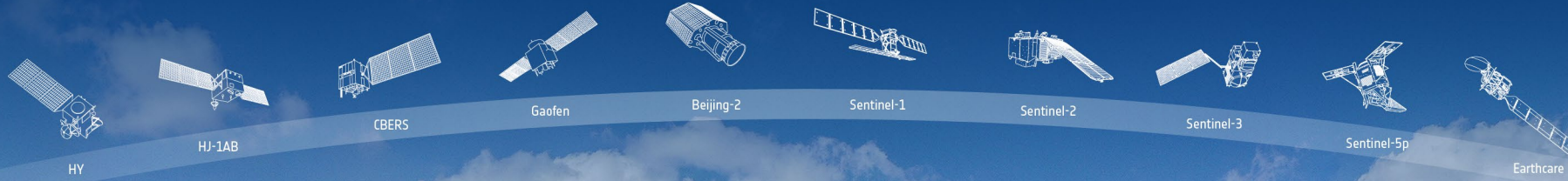
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