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Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

Spoke 5: Environment & Natural Disasters

"*High-performance photogrammetry for hydro-geomorphological risk monitoring*"

High-Performance computing in UAV photogrammetry

La Salandra, M.*, Nicotri, S., Donvito, G., Colacicco, R., Dellino, P., Capolongo, D.

*Department of Earth and Geoenvironmental Science, University of Bari

marco.lasalandra@uniba.it

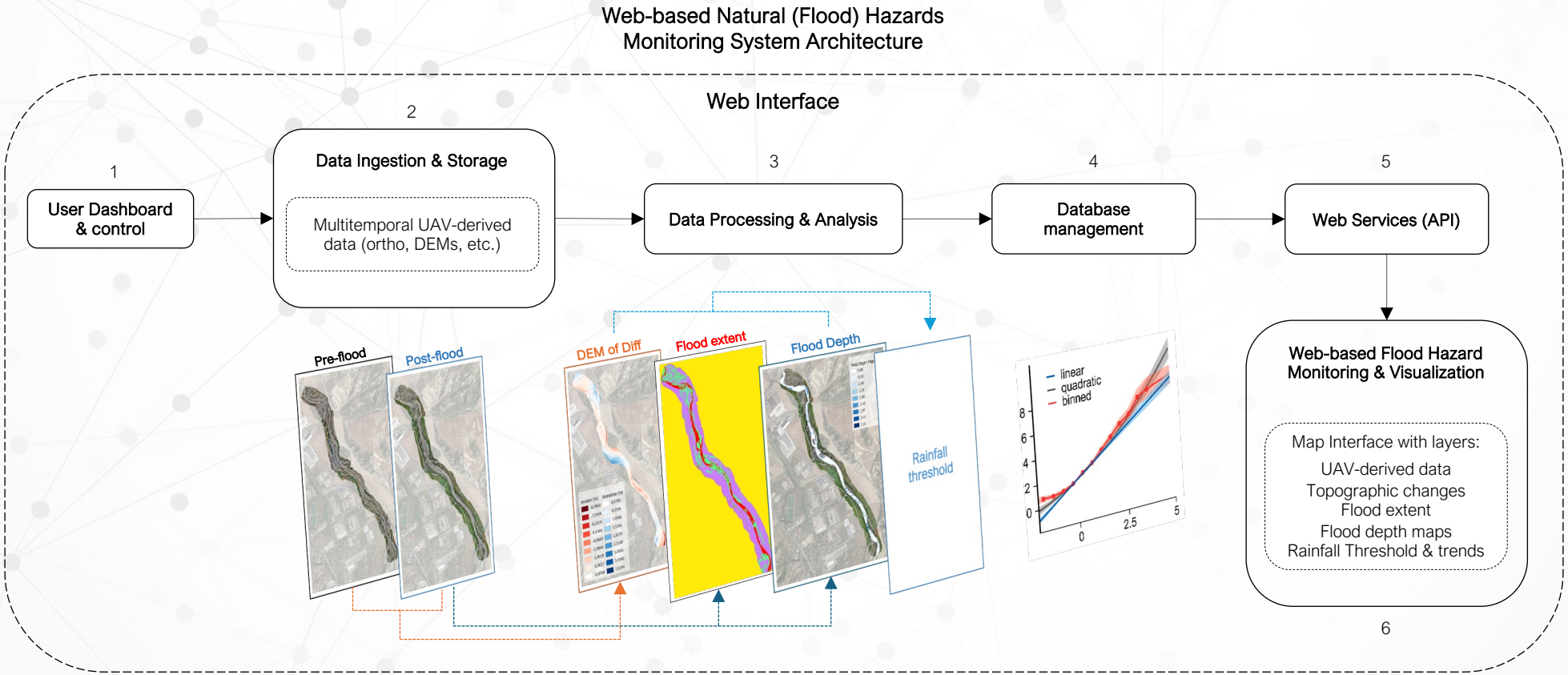
UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO
DIPARTIMENTO DI SCIENZE DELLA TERRA E GEOAMBIENTALI - DISTEGEO
ReCaS
INFN Istituto Nazionale di Fisica Nucleare

Context

- The effects of climate changes (natural causes and anthropogenic activities) are increasing the frequency and magnitude of hazardous phenomena
- Development of new mapping techniques from Unmanned Aerial Vehicles (Beyond-Visual-Line-Of-Sight, UAV swarm, some Artificial Intelligence)
- Collecting large datasets that limit the photogrammetric process due to high requirements for computing power, file size, data storage and processing time
- High-performance computing represents the key for running the Structure-from-Motion while keeping pace with the dynamic nature of natural processes

Aims

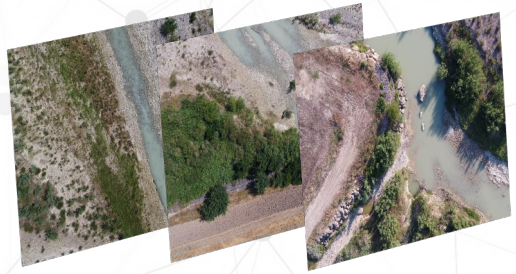
- Development of a system based on a powerful, flexible and scalable architecture capable of processing and analyzing big datasets of UAV images, modeling in near-real time the topographic surface at the scale and extent at which natural processes act



Datasets

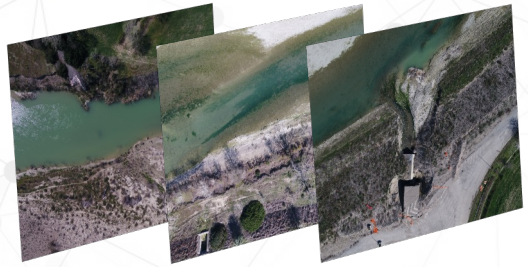
UAV multitemporal RGB images

DATASET 2019
3000 geotagged imgs
JPEG format
GSD 1.09 cm/pix
Area covered 2000 x 320 m
June 2019

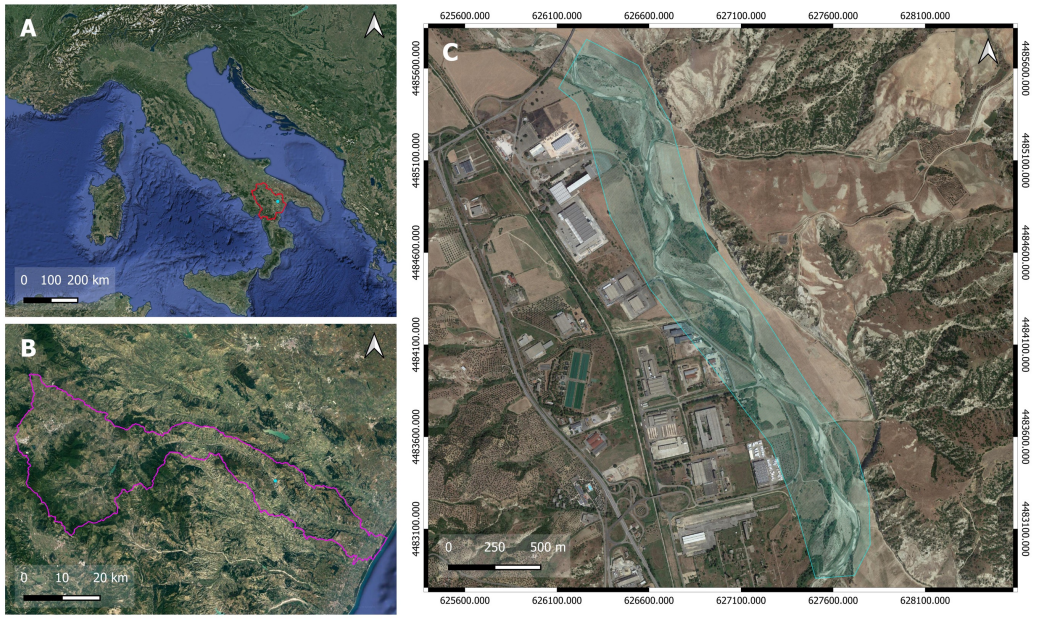


DATASET 2020
3960 geotagged imgs
JPEG format
GSD 1.09 cm/pix
Area covered 3000 x 320 m
July 2020

DATASET 2021
2691 geotagged imgs
JPEG format
GSD 1.09 cm/pix
Area covered 2300 x 320 m
October 2021



DATASET 2022
1300 geotagged imgs
JPEG format
GSD 1.6 cm/pix
Area covered 3000 x 320 m
March 2022

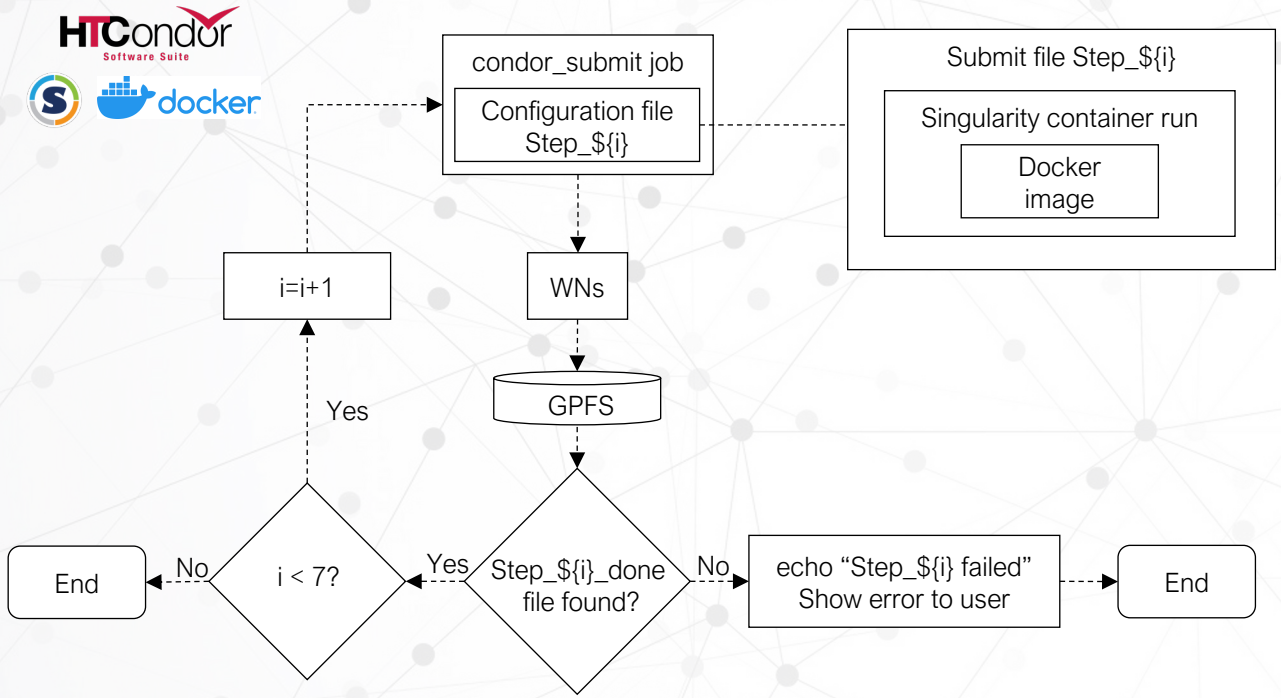


A) Location of study area; B) Basento river catchment area; C) River reach investigated

UAV survey using a DJI Inspire 2 equipped with DJI Zenmuse X5S optical sensor

High-Performance photogrammetry

Batch script implementation



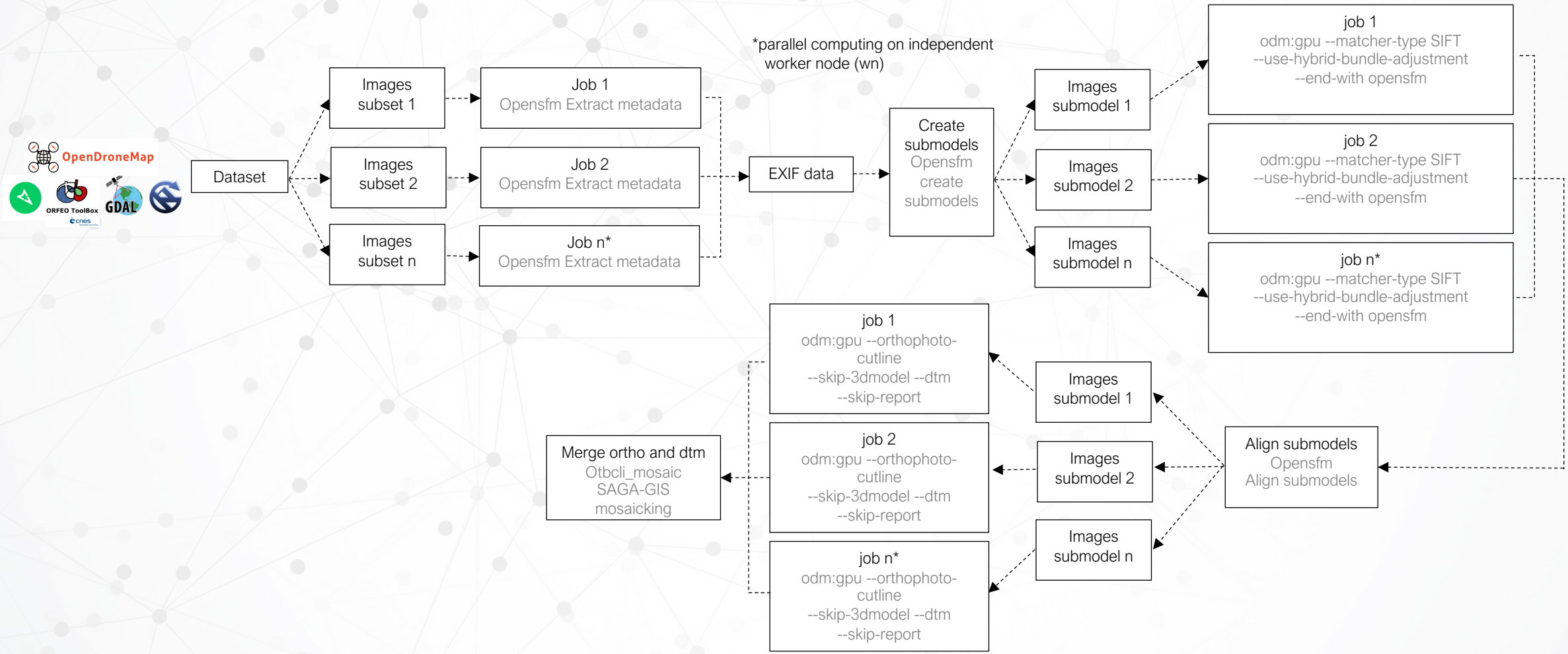
Automatic execution of the photogrammetric workflow on ReCaS cluster through HTCondor batch system

SERVER ROOM ReCaS-Bari
(*https://magnanimo.it/progetti/terziario-ed-industria/infn-–-recas-bari.html*)

La Salandra, M., Nicotri, S., Donvito, G., Italiano, A., Colacicco, R., Miniello, G., Lapietra, I., Roseto, R., Dellino, P., Capolongo, D. (2024). A paradigm shift in processing large UAV image datasets for emergency management of natural hazards. International Journal of Applied Earth Observation and Geoinformation (under review).

High-Performance photogrammetry

Structure-from-Motion workflow implementation



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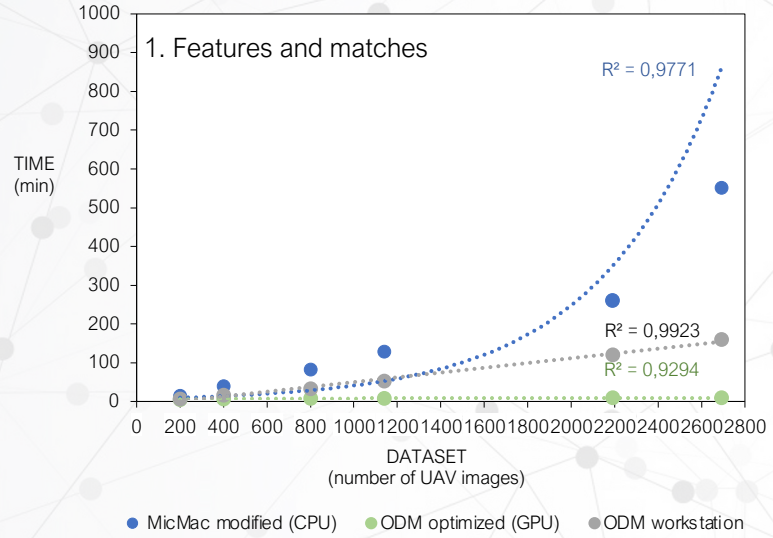
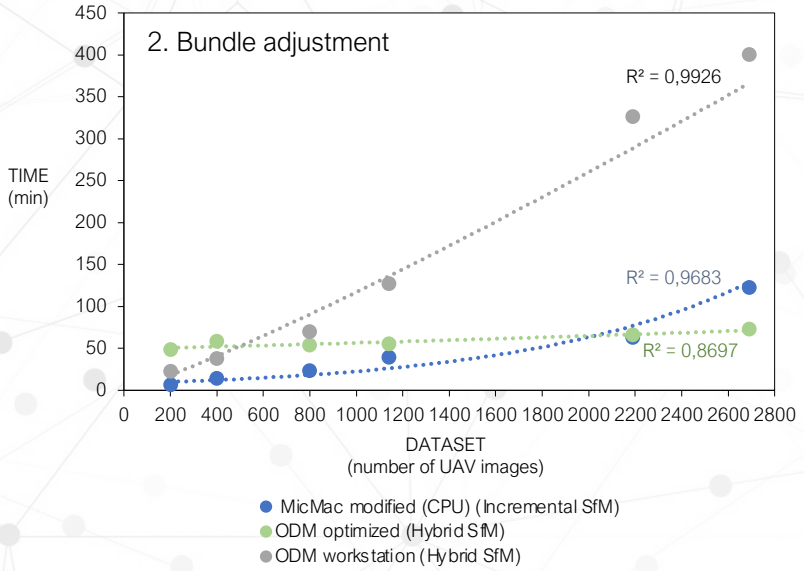
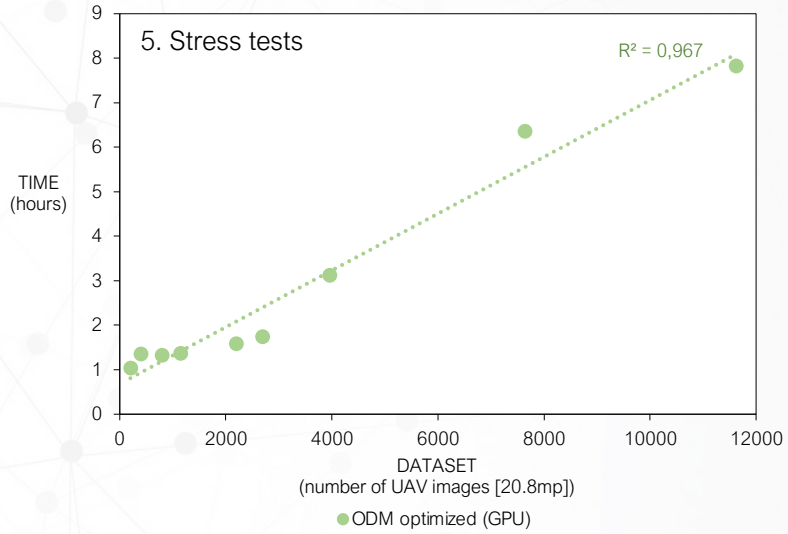
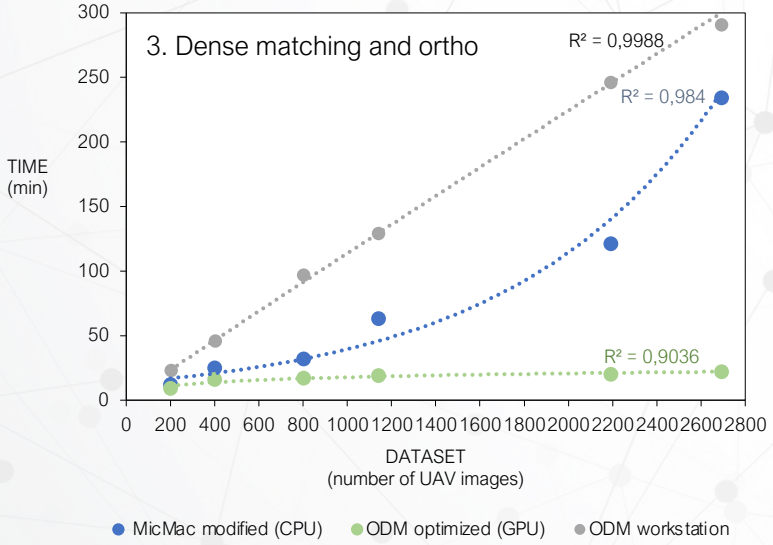
High-Performance photogrammetry

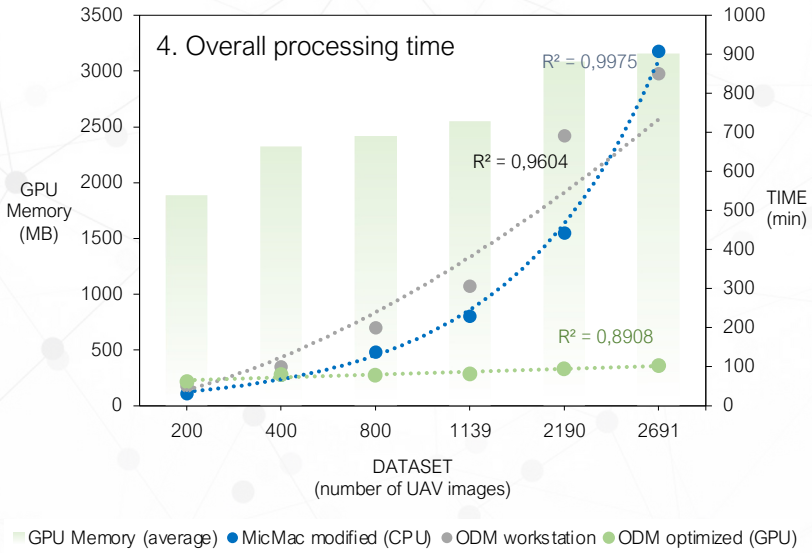
Test results and performance evaluation











Workflow	Servers (WN)	CPU (per WN)	RAM (per WN)	GPU (per WN)
ODM workstation[1]	1	14	256 GB	48 GB
MicMac modified[2]	25	20	30 GB	/
ODM optimized[3]	25	20	30 GB	40 GB

[1] DELL single workstation
[2] ReCaS-Bari HTC cluster
[3] ReCaS-Bari HPC cluster

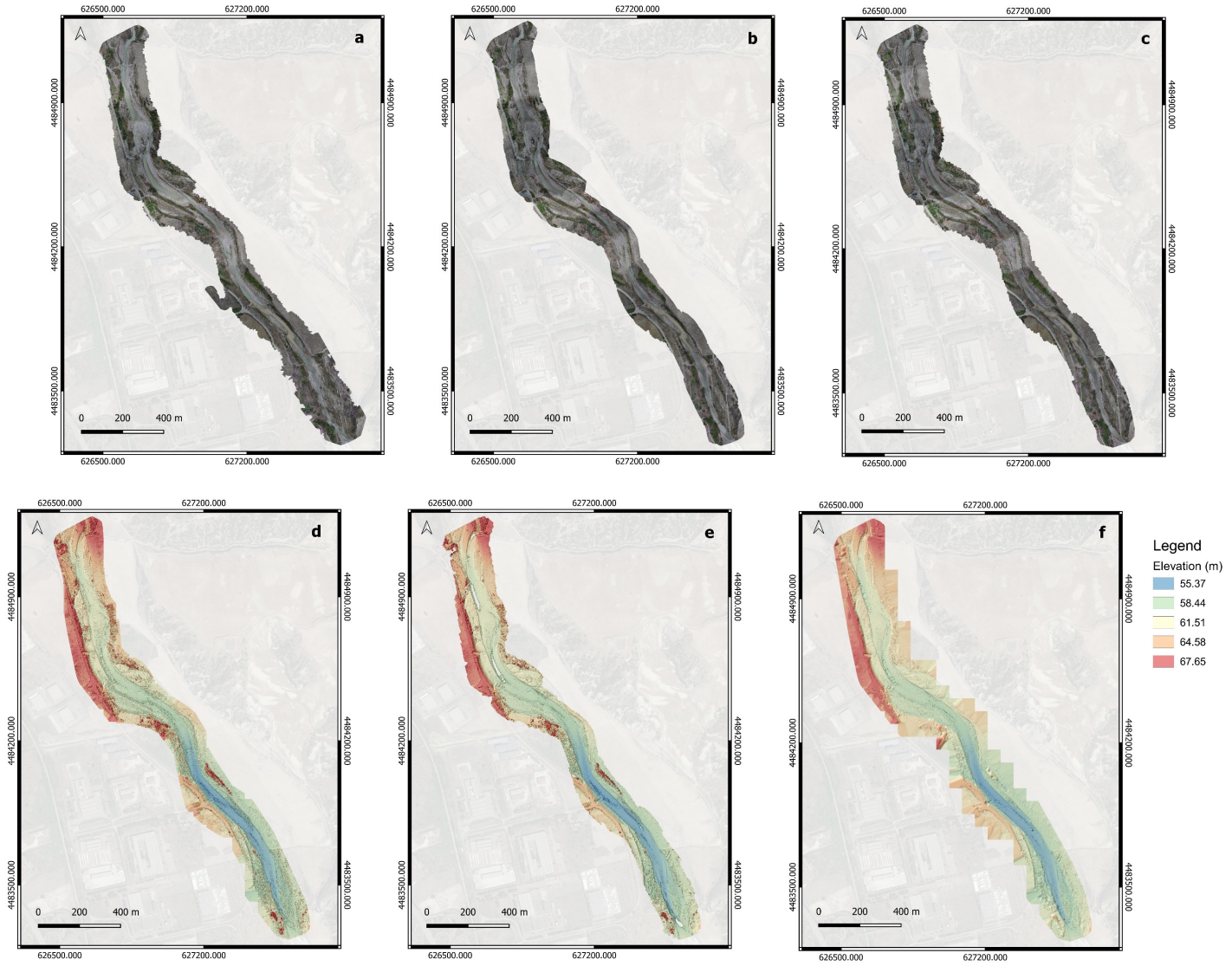
La Salandra et al., 2024 (under review).

Output quality assessment

Pixel Intensity, Roughness and Positional accuracy

Workflow	Pixel Intensity (PI_{std})	Roughness (R_{std})	RMSE [m]		
			X	Y	Z
ODM workstation	53.20	0.43	0.078	0.106	0.806
MicMac modified	55.53	0.05	0.052	0.092	0.813
ODM optimized	53.42	0.22	0.031	0.023	0.767

Standard deviation values of pixel intensity (PI_{std}), Roughness standard deviation (R_{std}), and Root Mean Square Errors (RMSE) of the observed and ground truth values of Checkpoints, of the outputs derived by the dataset of 2,691 images.



Orthomosaics with 5 cm/pix resolution derived by a) ODM workstation, b) ODM optimized and c) MicMac modified workflow. DTMs with 10 cm/pix resolution derived by d) ODM workstation, e) ODM optimized and f) MicMac modified workflow.

La Salandra et al., 2024 (under review).

Take-home Message

- Improving the exploitation of GPU resources and the parallel distribution, it may be possible to push further toward a future real-time processing approach

- Stress test results demonstrate the overcoming of the complexity in processing large UAV image datasets, now the challenge translates into the ability to collect such large datasets

- The implemented high-performance workflow has the potential to serve as a pivotal tool to address critical challenges identified in the field of natural hazards management

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DRONSE

mapping the future with drone intelligence

Drone **Se**nsing is a Laboratory as part of GeoSciencesIR

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https://dronselab.com/