The SCO-FLOODDAM project: towards a digital twin for flood detection, prediction and flood risk assessments
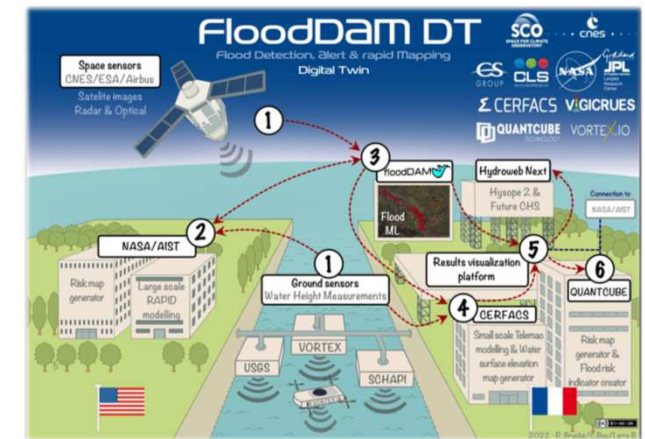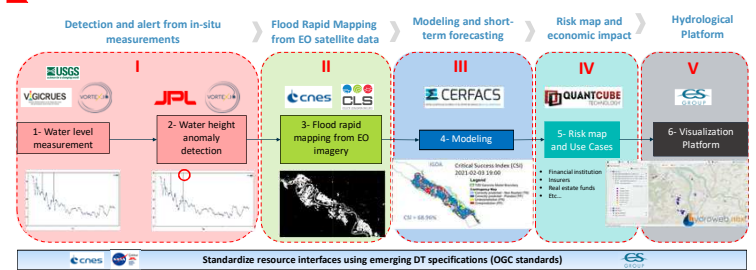
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Federated Earth System Digital Twin solution between NASA IDEAS and SCO **FloodDAM (Flood Detection Alert and Maping)** for alert systems and flood risk maps on local and global scales using space technologies focused on flooding.

PIPELINE AND SELECTED AREAS

Standardize resource interfaces using emerging DT specifications (OGC standards)

France Catchment : **Garonne river**

USA Catchment : **Ohio River**

FlooDAM PRODUCTS

I) Flooding detection and alert service

Micro-station
- LiDAR technology with cm-level accuracy
- 8 Mpx camera
- Fully autonomous (power supply)
- Compact : 10 cm – 800g
- Fully connected (4G & Space IoT)

Drone Flight
- LIDAR
  - cm level accuracy
  - from 50 to 90 m range
- 8 Mpx Camera
  - water mask and orthophotos
- 900 g
- Autonomy : 3h

**Real Time Measurements
API Interface**

II) Flood extent rapid mapping from EO data

Flood rapid mapping from SAR and optical data **over the world**

FloodML flood extent map from Sentinel-2 data, ESA World Cover and GSWO over the Ohio river flood event on the 27th February 2018

FloodML algorithm based on Random Forest flood extent detection from EO satellite data (Sentinel 2, Sentinel-1 VV-VH images, Landsat 8&9, Terrasar-X), MERIT DEM and ESA World Cover. FloodML is trained on Copernicus EMSR samples having >90% water occurrence.

Systematic report generation on each flood event

III) Short-term flood surface forecasting and modeling

Assimilation of SAR-derived flood extent

Simulated vs. observed water level (Feb. 2021)

Simulated vs. observed flood extent maps

FR : Free run simulation
IGDA : FR simulation with Data assimilation of in-situ and remote sensing observations

Improvement of simulated flood extent maps using Data Assimilation of in-situ and RS data

Assimilation of S6-derived WSE
FFSAR processing developped by CNES (Boy et al.)

Simulated vs. observed WSE in the river bed
2021-12-31T21:49:39 - high flow

Improvement of simulated WSE using Data Assimilation S6 nadir altimetry

Hydrology-Hydrodynamic coupling with data assimilation

RMSE (m)	Tonneins	Marmande	La Réole
FR^V	0.106	0.392	0.536
IGDA^V	**0.073**	**0.074**	**0.09**
FR^C	1.209	1.405	1.598
IGDA^C	**0.166**	**0.160**	**0.141**

Improvement of CTRIP simulated forcing and local model WSE using DA of in-situ and S1-derived water extent

Case study: Ohio River 2D hydrodynamics model

2018 flood event on Ohio river between 06/02/2018 and 30/04/2018 (Flood peak around 29/02/2018) :
- preliminary results of T2D modeling with in-situ DA
- Two in-situ stations (Cannelton and Newburgh)

IV) Risk assessment and economic impact

a) damage map computing in Marmande

b) Cost assessment for Cropland Aggregation in Marmande during flood event

Total cost = 1 283 000 €

- Environmental Intelligence Platform and API
- **Real time product on financial risk estimation and risk map generation** of flooding for different type of assets

V) Hydroweb.next platform

✓ An open distribution and visualization portal of hydrological products
✓ FloodDAM-DT processing chain will be **integrated in 2024**

https://hydroweb-pp.next.theia-land.fr/

References

1. R. Rodriguez Suquet et al., 2023: The SCO-FLOODDAM project: towards a digital twin for flood detection, prediction and flood risk assessment, IGARSS 2023 - 2023 IEEE International Geoscience and Remote Sensing Symposium, Pasadena, CA, 2023.
2. S. Ricci et al., 2023: Comparisons and Water Level Analyses using Sentinel-6MF satellite altimetry data, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, doi.org/10.5194/egusphere-egu23-6513.
3. Thanh Huy Nguyen et al., 2022: "Improvement of Flood Extent Representation with Remote Sensing Data and Data Assimilation", IEEE Transactions on Geoscience and Remote Sensing, vol. 60, pp. 1–22, 2022.
4. Thomas Huang et al., 2022, "An Earth System Digital Twin for Flood Prediction and Analysis", IGARSS 2022 - 2022 IEEE International Geoscience and Remote Sensing Symposium, July 17-22 2022, Kuala Lumpur, Malaysia
5. Kettig et al., 2021: "The SCO-FloodDAM Project:New Observing Strategies for Flood Detection, Alert and Rapid Mapping", In IGARSS 2021 IEEE International Geoscience and Remote Sensing Symposium, July 11-16, 2021, Brussels, Belgium.