ADVANCES IN NEW EO TECHNOLOGIES AND COMPUTER MODELING COULD SOON ENABLE BETTER FLOOD FORECASTING AT IMPACT-LEVEL SCALE

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#HydrologyWS21

Overview

Motivation for this talk

A bit of History

New Era for Satellite Missions

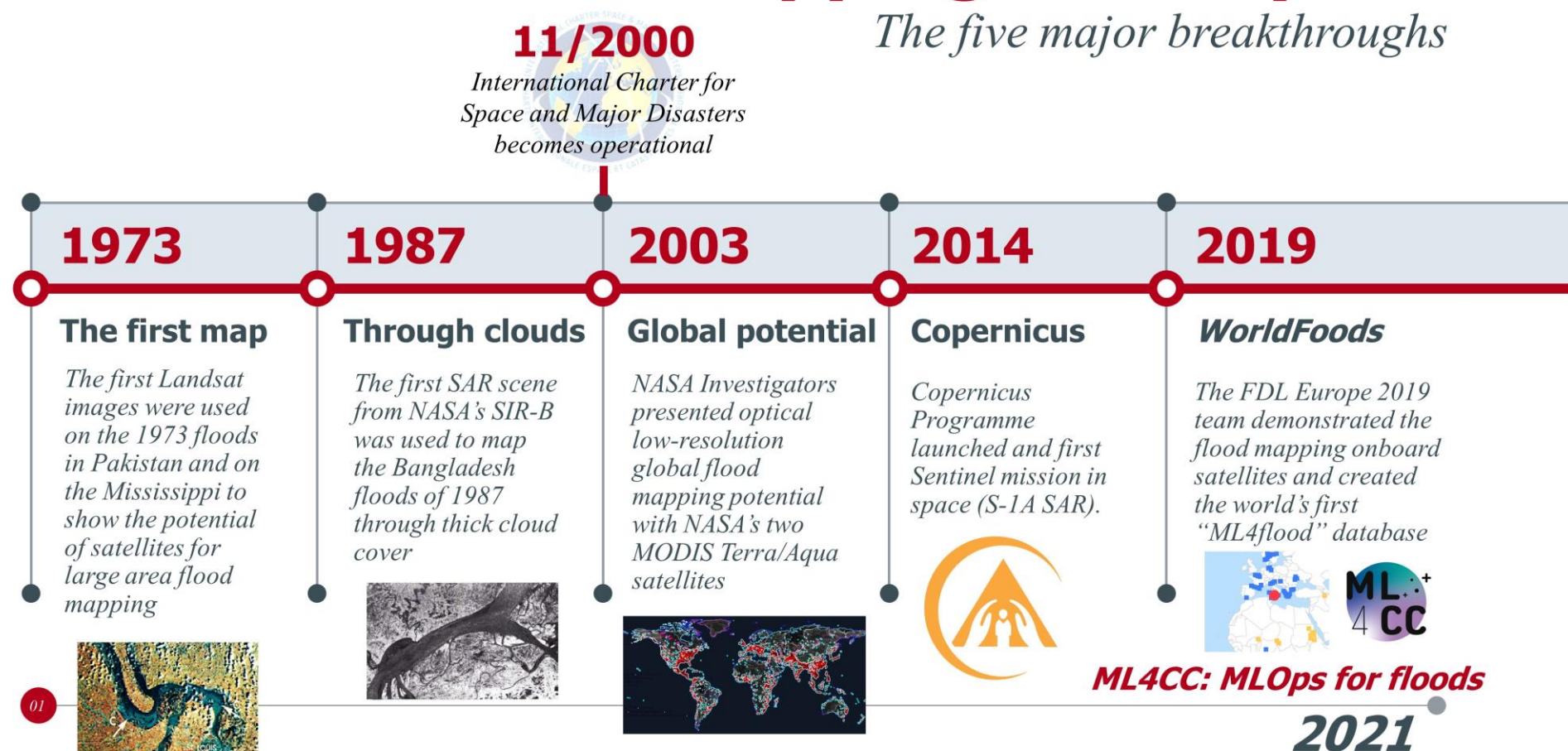ML/AI for Flood Mapping & Forecasting

Conclusions

RSS-Hydro

Motivation

- Floods are a top-ranking disaster in terms of insured and uninsured losses

- Flood frequency and magnitude projected to increase in future

- Clear need for high-quality, reliable flood forecasting

- Problem: floods are happening at the global scale but their impacts and consequences are truly felt at the local community level

- Solution: flood forecasting needs to be at the highest resolution possible and multi-dimensional in space

- Recent advances in Earth-observing technologies, in particular with the opening of the new space economy as well as considerable progress in computing architecture, interoperability and machine learning, have given rise to many opportunities but also many challenges.

A bit of History

Flood Mapping from Space

The five major breakthroughs

11/2000
International Charter for Space and Major Disasters becomes operational

1973 — **The first map**
The first Landsat images were used on the 1973 floods in Pakistan and on the Mississippi to show the potential of satellites for large area flood mapping

1987 — **Through clouds**
The first SAR scene from NASA's SIR-B was used to map the Bangladesh floods of 1987 through thick cloud cover

2003 — **Global potential**
NASA Investigators presented optical low-resolution global flood mapping potential with NASA's two MODIS Terra/Aqua satellites

2014 — **Copernicus**
Copernicus Programme launched and first Sentinel mission in space (S-1A SAR).

2019 — *WorldFoods*
The FDL Europe 2019 team demonstrated the flood mapping onboard satellites and created the world's first "ML4flood" database

**ML4CC: MLOps for floods**
2021

New EO missions

- More public open-access missions from Copernicus
- We are at the start of the commercial new space era of small sats
- Many companies are sending up rainfall measurement missions (Spire, Tomorrow.io, etc.) with a view to assimilate those data real-time for better weather forecasts
- New innovative concepts/studies for using ML/AI onboard satellites (ESA Phi Lab, FDL)
- Opens up new partnership opportunities for downstream industry (e.g. ICEYE and Swiss Re)
- Need to really democratize availability, access and affordability of commercial EO data: this has been promised but we are far from it

www.iceye.com
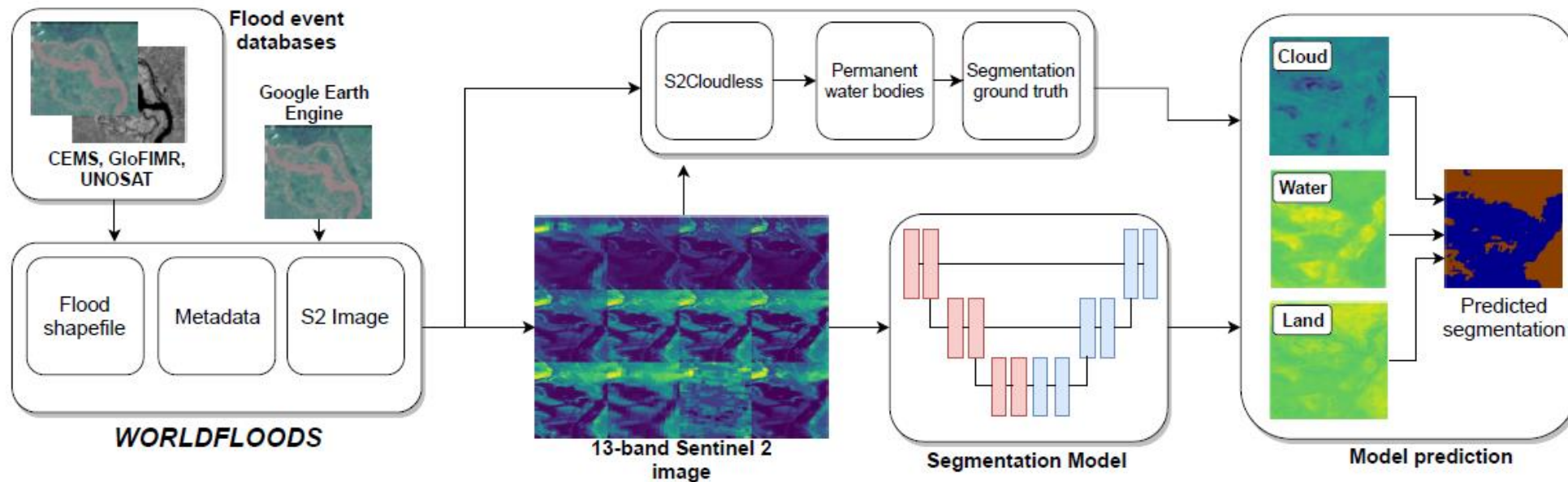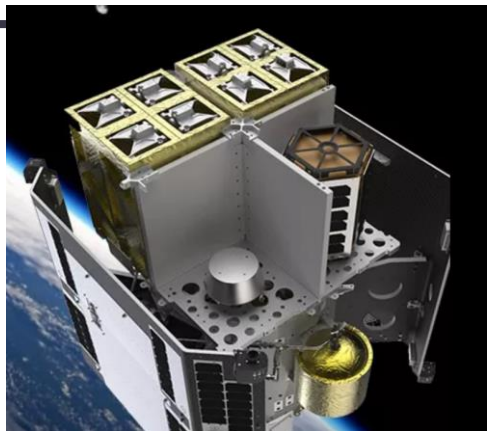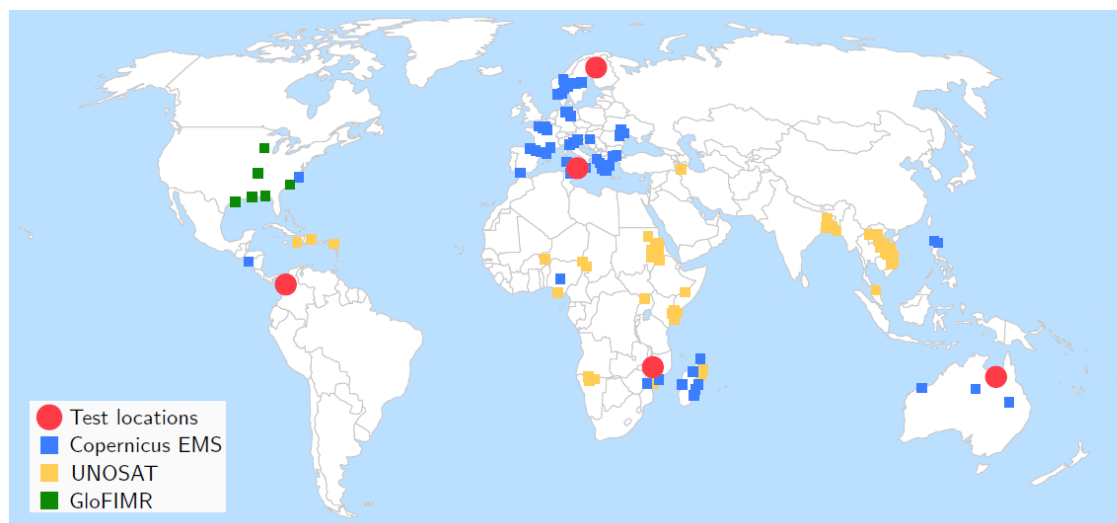
Figure 3. Locations of flood events contained in *WorldFloods*. Blue, orange and green areas denote Copernicus EMS, UNOSAT and GloFIMR data, respectively. Red circles denote test regions. Basemap credit: simplemaps.com

# ML/AI for Flood Mapping & Forecasting

- ML for flood mapping has recently gained popularity (growing scientific literature) but many challenges remain: not enough label data of flood images, ML often not constrained by physical principles, need to improve many in-built drawbacks of ML models (tiling, labeling, etc.)

- Digital Twin Earth : join scientific and industrial excellence to develop a very high precision digital model of the Earth, capitalising on an effective integration of the latest advances and increasing capabilities of EO, Earth system modelling, AI, ICT and HPC capacities with the aim to visualize, monitor and forecast in support of sustainable development and to predict and manage environmental disasters

- Google's HydroNets — a specialized deep neural network architecture built specifically for water levels forecasting (Google AI blog) able to distinguish between generalizable processes (rainfall-runoff) and more location-specific processes such as rating curves
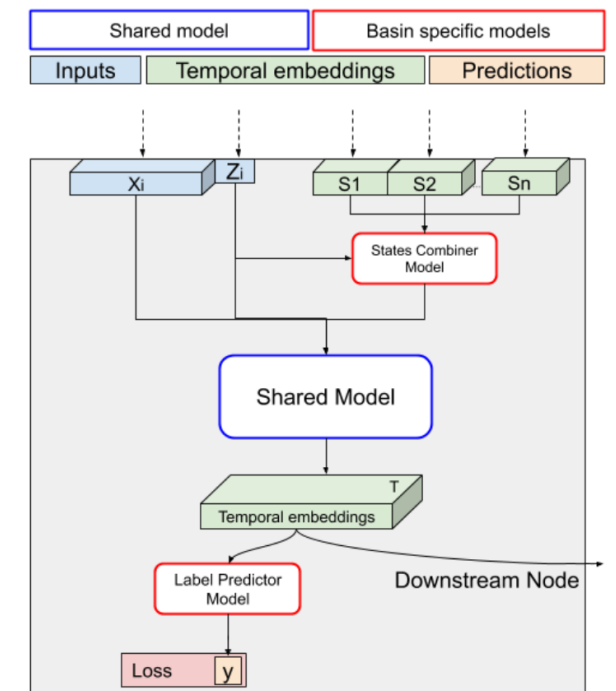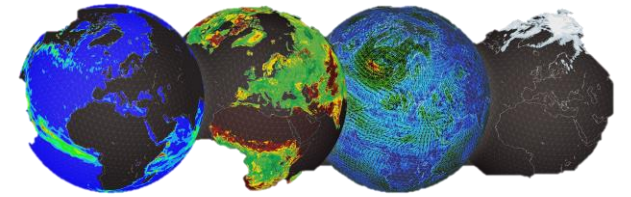
Earth Intelligence Engine
FLOOD GENERATOR
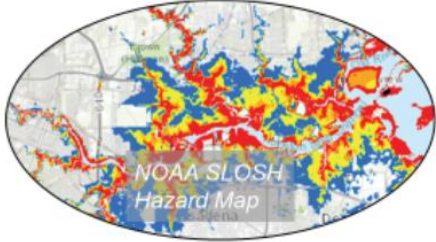
NOAA's SLOSH model visualizes flood extent, but outputs are not high resolution

Unconditioned GAN adds flooding to an image, but w/o physical inputs, it adds water randomly

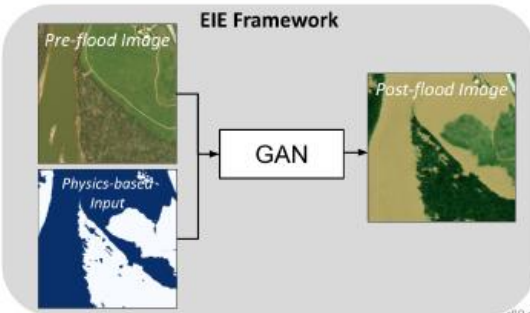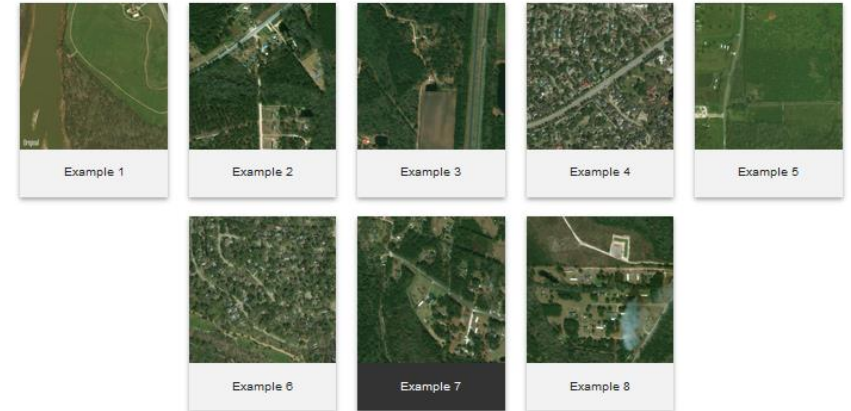Generated and evaluated the **first physically-constrained**, **photorealistic** visualization of future flooding events

EIE Framework

Pre-flood Image

Physics-based Input

GAN

Post-flood Image

Post-flood

Generated Post-flood

Image sources: xBD data: Gupta, et al. 2019

Conclusions

- New era of big data proliferation, advanced online computing architecture, coupled with IoT and much better resolution of global process models

- ML/DL increasingly popular

- Many challenges remain at all fronts

- Call for Action: routinely evaluate flood forecasts, diagnose forecast problems, and allow the forecasting community to develop novel initialization, calibration, and post-processing procedures to deliver more skillful and reliable forecasts at longer lead times globally

- Proper communication, outreach, education and capacity building should always remain at the top of the list

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A vision for improving global flood forecasting

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Published 6 December 2019 • © 2019 The Author(s). Published by IOP Publishing Ltd

Environmental Research Letters, Volume 14, Number 12

Citation David A Lavers et al 2019 Environ. Res. Lett. 14 121002

Thank you!

- For questions, thoughts or comments, please email me at:

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