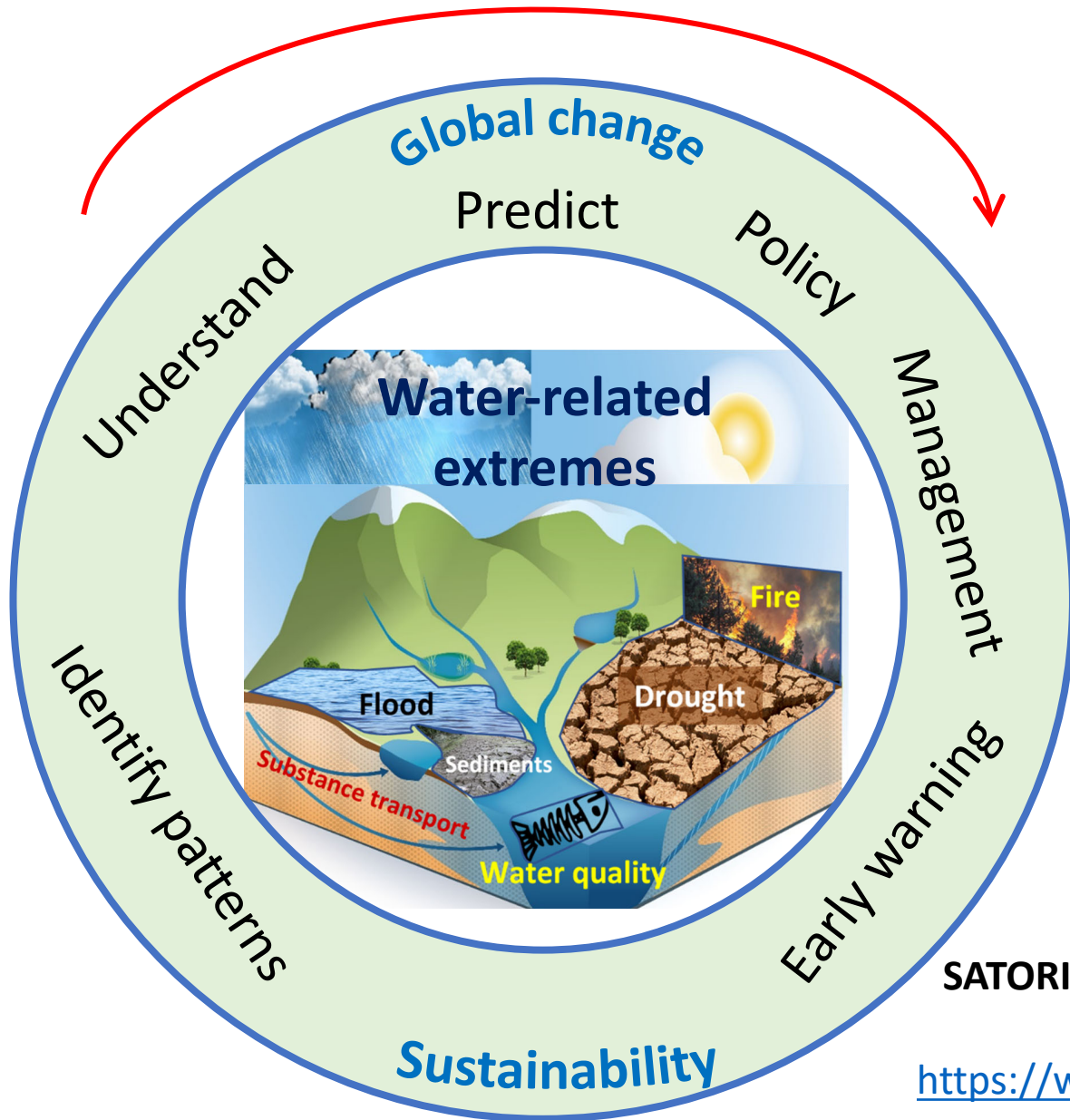


Understanding and managing water extremes: Machine learning-powered data and modeling



Engineering: enhancing **quantitative** knowledge and capabilities

to find **actionable solution pathways** for managing the multi-faceted roles of

water as both a key **resource** and a source of major **hazard and risk** for society

Georgia Destouni

Royal Swedish Academy of Engineering Sciences – IVA
Euro-CASE 2024

SATORI Research Lab for coupled natural-human systems

<https://www.satoriresearchlab.org>



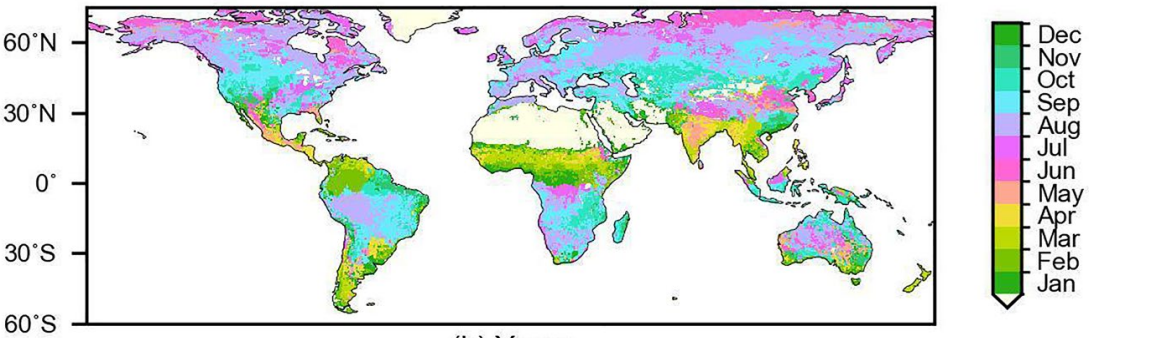
Stockholm University

Examples:

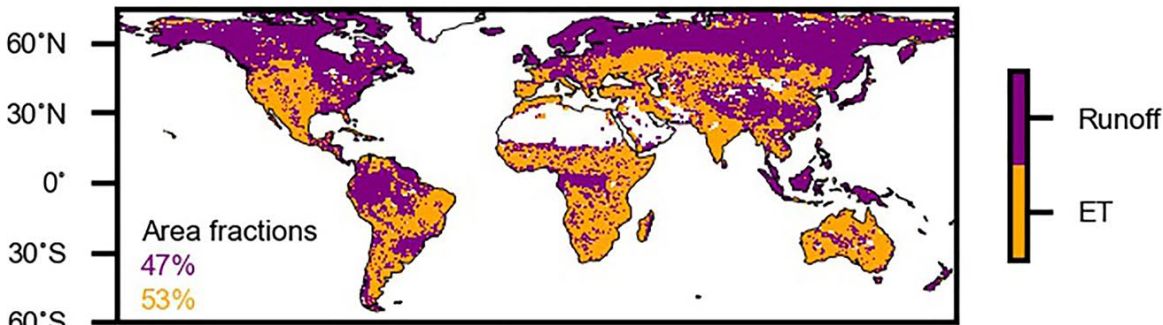
Role of engineering for sustainable development

- **Floods, droughts** and their **compounds** – floods-after-droughts, heatwaves-droughts-wildfires, floods-landslides, floods/droughts-pollution/disease-spreading - can have **devastating consequences** for society, ecosystems & sustainability
- **Complex multi-dimensional cause-effect-impact relationships** - linked atmospheric, hydrological and societal causes & societal and ecosystem impacts
- **Key needs for engineering research and practice** to meet the challenges of **accurately quantifying** and **timely predicting** these relationships, identifying hotspots of risks in space and warning early in time for occurrences & impacts around the world
- Some highlight examples of how **engineering rises to** these quantification-prediction **challenges** with **machine learning-powered data and modeling**

Droughts – global scale: ML-assisted bridging of data gaps & upscaling of satellite and in-situ observations



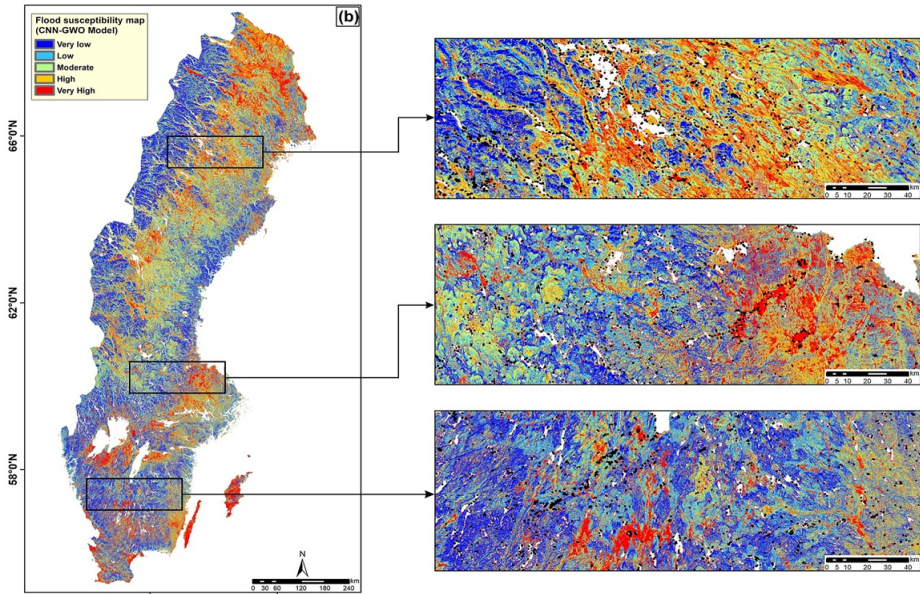
Timing of soil moisture drought - months during 2001–2015



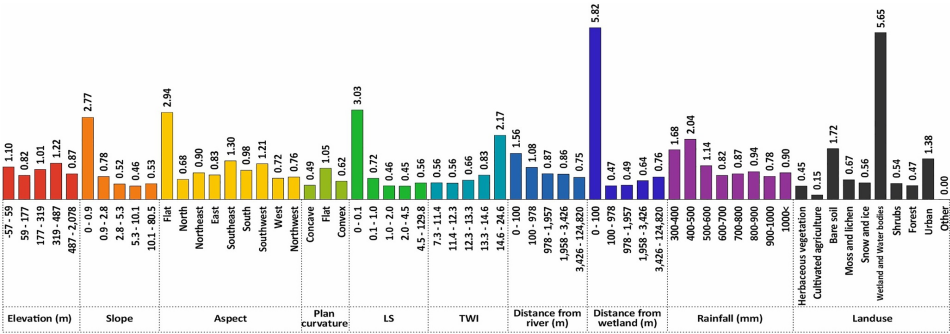
Most reduced Runoff or Evapotranspiration (ET) during drought peaks

Li et al., *Earth’s Future*, 2023
Contrasting Drought Propagation Into the Terrestrial Water Cycle Between Dry and Wet Regions

Floods – national scale, 50m resolution: ML based modelling



Flood susceptibility map over Sweden



Deciphering Importance of different geo-environmental factors for flooding

Panahi et al., *Earth’s Future*, 2023. **A country wide evaluation of Sweden's spatial flood modeling with optimized convolutional neural network algorithms**

General message:

Role of engineering for sustainable development

- **Complex interactions** - synergies and tradeoffs - **inherent** to almost all issues involved in achieving sustainability
- **Measurability** of achievement & **predictability** of evolution - **key needs** for driving progress in achieving the 17 SGDs and their 169 targets
- **Good engineering** is a fundamental prerequisite for handling & achieving these by:

Creatively combining scientific principles from many disciplines to

- develop & implement **solutions to complex problems**
- **quantify** involved **complex systems**
- **forecast** system & solution behaviors under uncertain forthcoming scenario conditions