Seminar on measurement and data processing techniques for hydro-morphological assessment of regulated rivers, lakes and reservoirs

January 9th, 2018, Trondheim

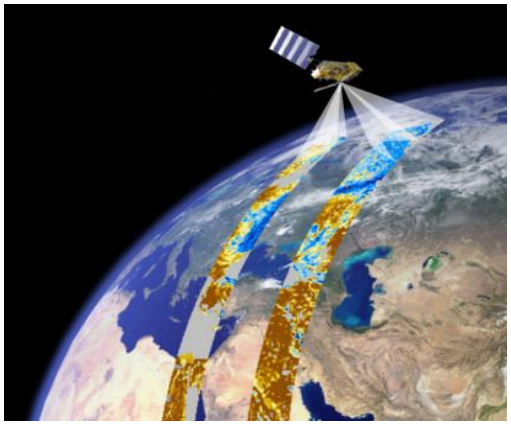
The use of remote sensing to characterize hydromorphological properties of European rivers

Speaker: Simone Bizzi

Co-authors: Francesco Asaro, Barbara Belletti, Andrea Castelletti, Patrice Carbonneau, Luca Demarchi, Matt Kondolf, Giulia Marchetti, Hervé Piegay, Claudio Prati, Rafael Schmitt, Wouter Van de Bund

Big Earth Science Data – Boon or bane?

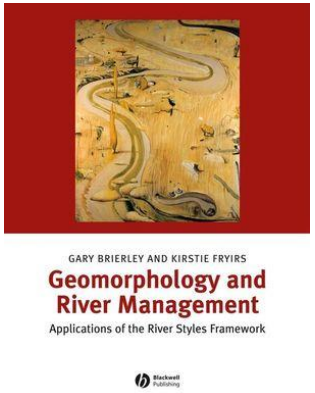
“Currently, a data scientist spends 80% of the time with managing and pre-processing the data and has only 20% for the actual data evaluation. Every stakeholder along the data value chain, from data generator over data provider to data user has to work on innovative approaches to tackle concurrent challenges and to leverage the full potential of Big Earth Science Data. The bane comes into play, if we continue generating and storing massive amounts of data and fail to turn it into value-added content.”



http://blogs.egu.eu/divisions/essi/2016/07/11/big-earth-science-data-boon-or-bane/

Bizzi et al. (2016) The use of remote sensing to characterise hydromorphological properties of European riversfor Aquatic Sciences, doi: 10.1007/s00027-015-0430-7

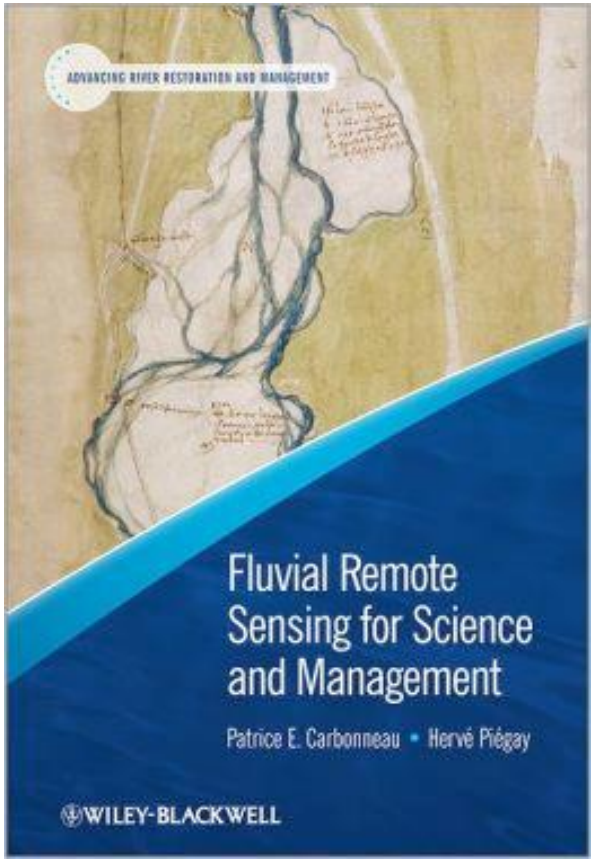
River Survey practices



G. J. Brierley, K. A. Fryirs (2005)

In EU, MQI framework from the REFORM project (2015)

Emerging RS technologies



P. E. Carbonneau, H Piégay (2012)

Uptake urgently needed!

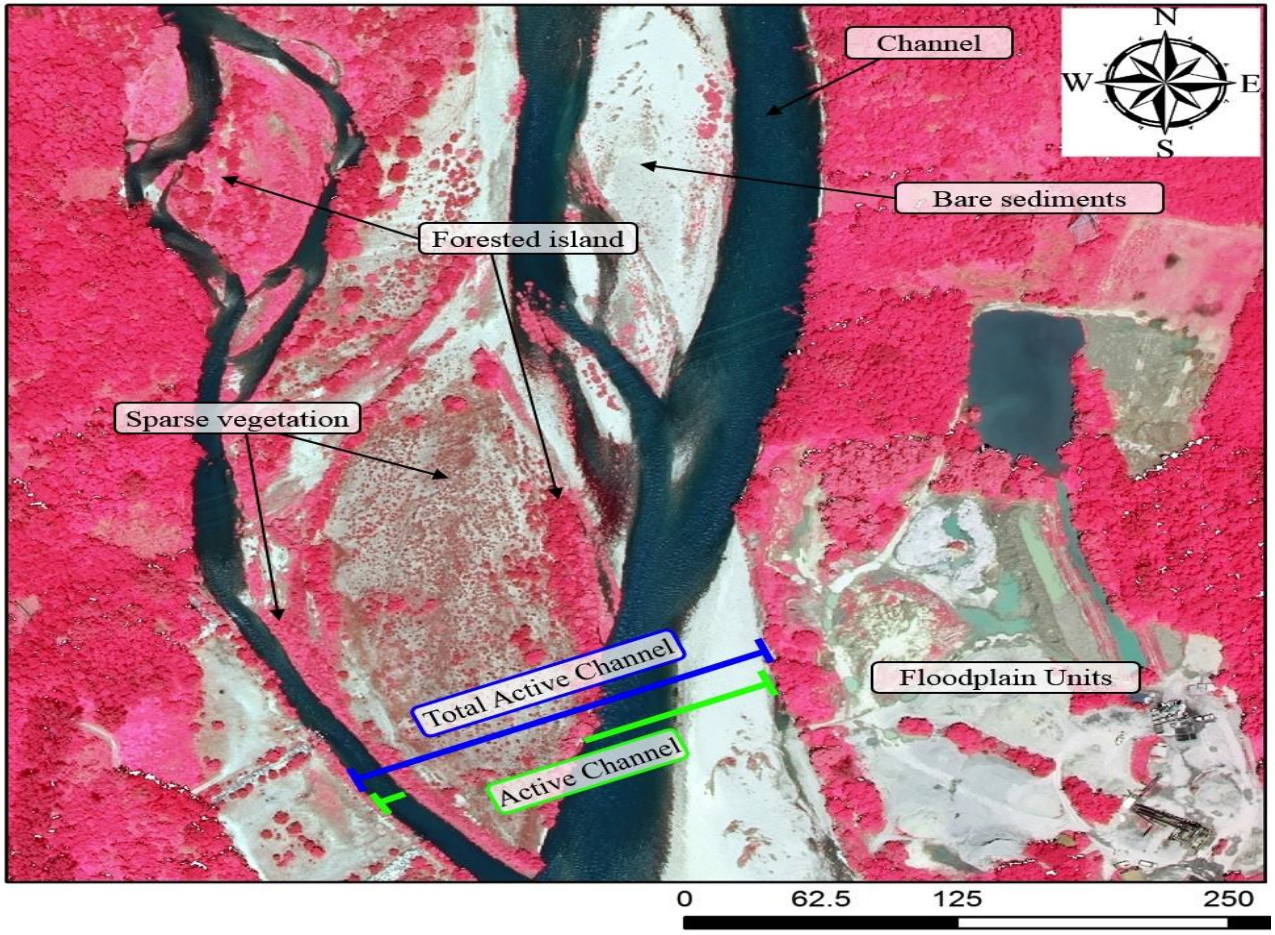
Mapping Hydromorphology at Regional Scale

Regional Analysis in Piemonte (15 major rivers, 1556 km)

Input RS data
(whole region, 25400 km^2 covered in 2009-2010):

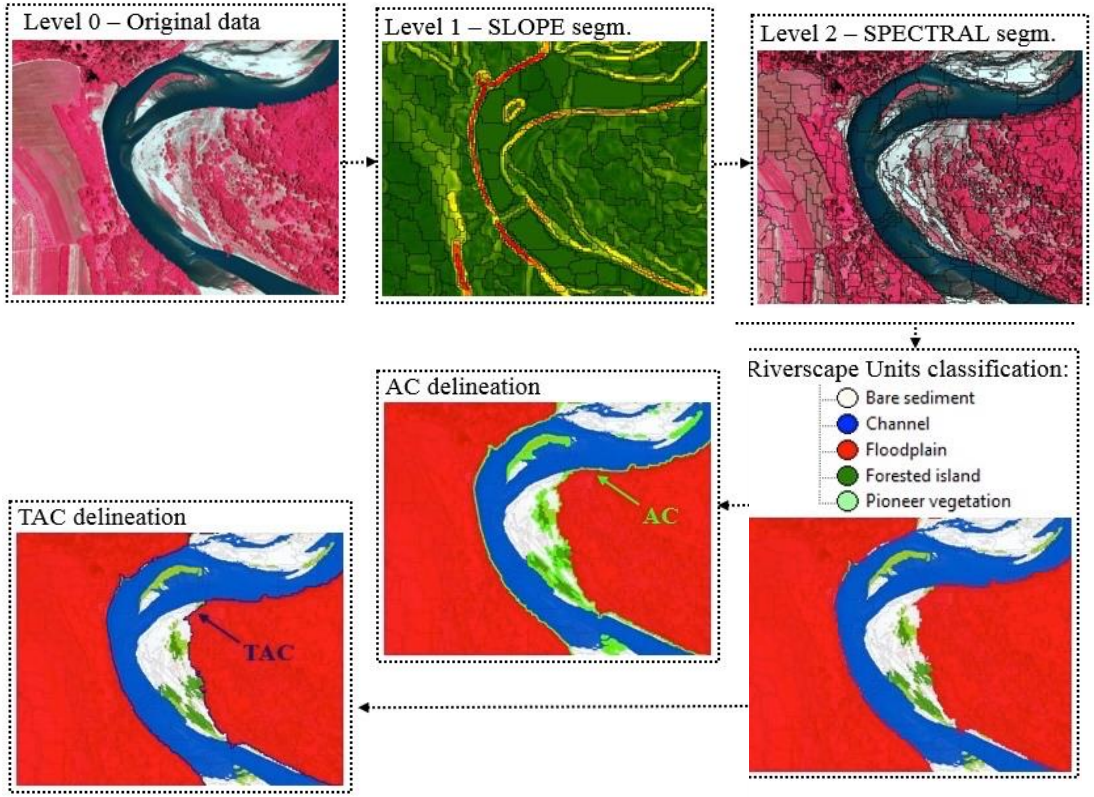
- Near infrared imagery (VHR, 0.4 m)
- LiDAR (0.4 pts/m^2) ➔ (DTM at 5 m)

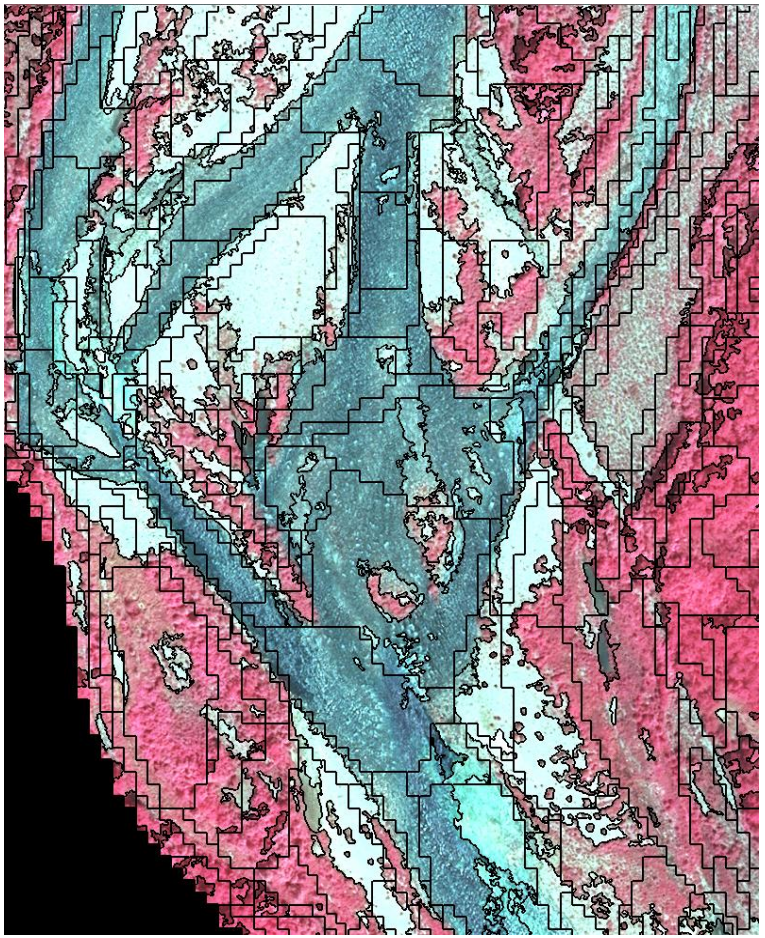
What do we measure by (semi)-automated procedure?



Extent and topographic features of riverscape units for 1556 km of rivers

Method: Multilevel object-based approach



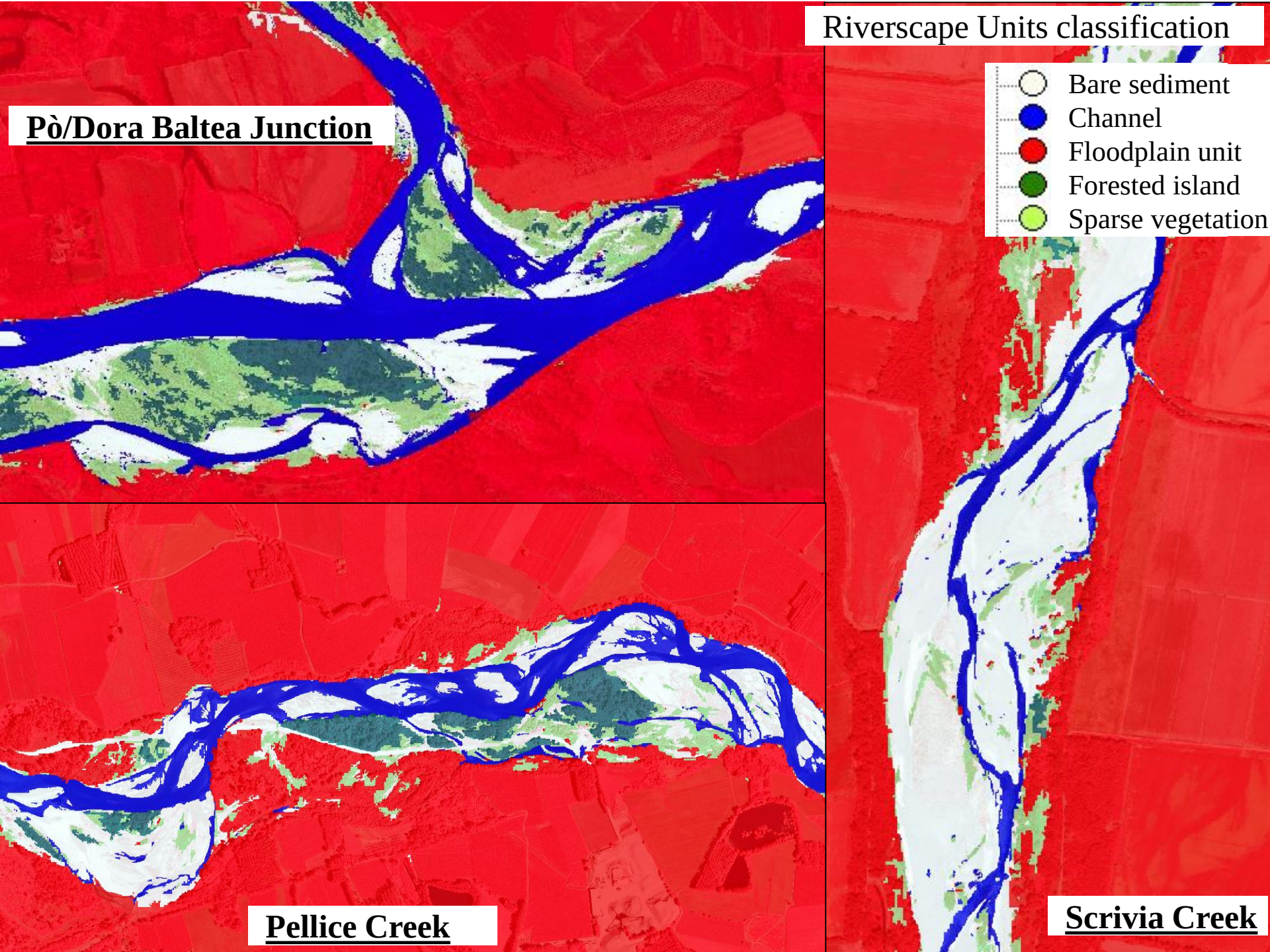


Supervised Machine Learning Classification:

Demarchi et al. (2016) Hierarchical object-based mapping of riverscape units and in-stream mesohabitats using LiDAR and VHR imagery, Remote Sensing doi 10.3390/rs8020097

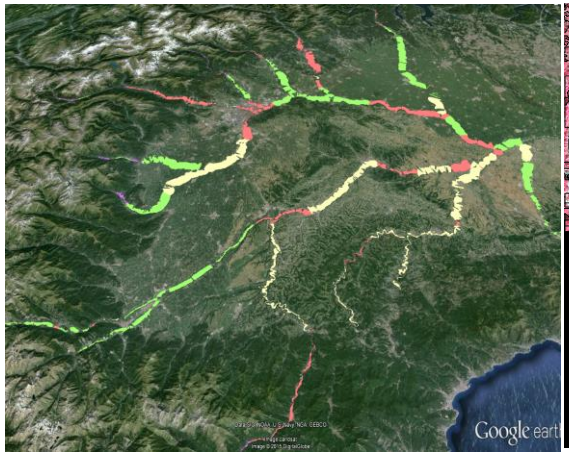
Demarchi et al. (2016) Regional hydromorphological characterization with continuous and automated remote sensing analysis based on VHR imagery and low-resolution LiDAR data ESPL, doi 10.1002/esp.4092

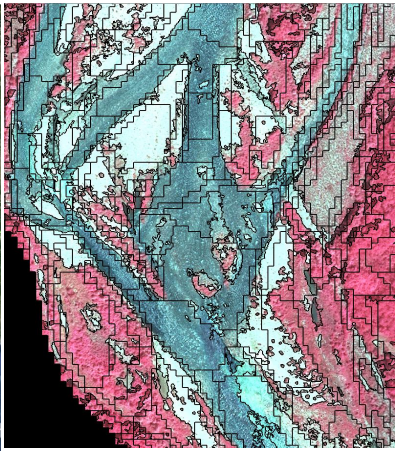
Riverscape Units classification

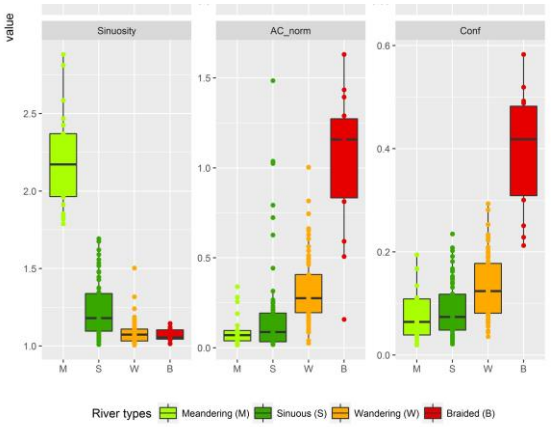

Riverscape Units classification
Bare sediment
Channel
Floodplain unit
Forested island
Sparse vegetation
Pò/Dora Baltea Junction
Pellice Creek
Scrivia Creek

Assess 50-100 yr human induced channel change

Geomorphic DB





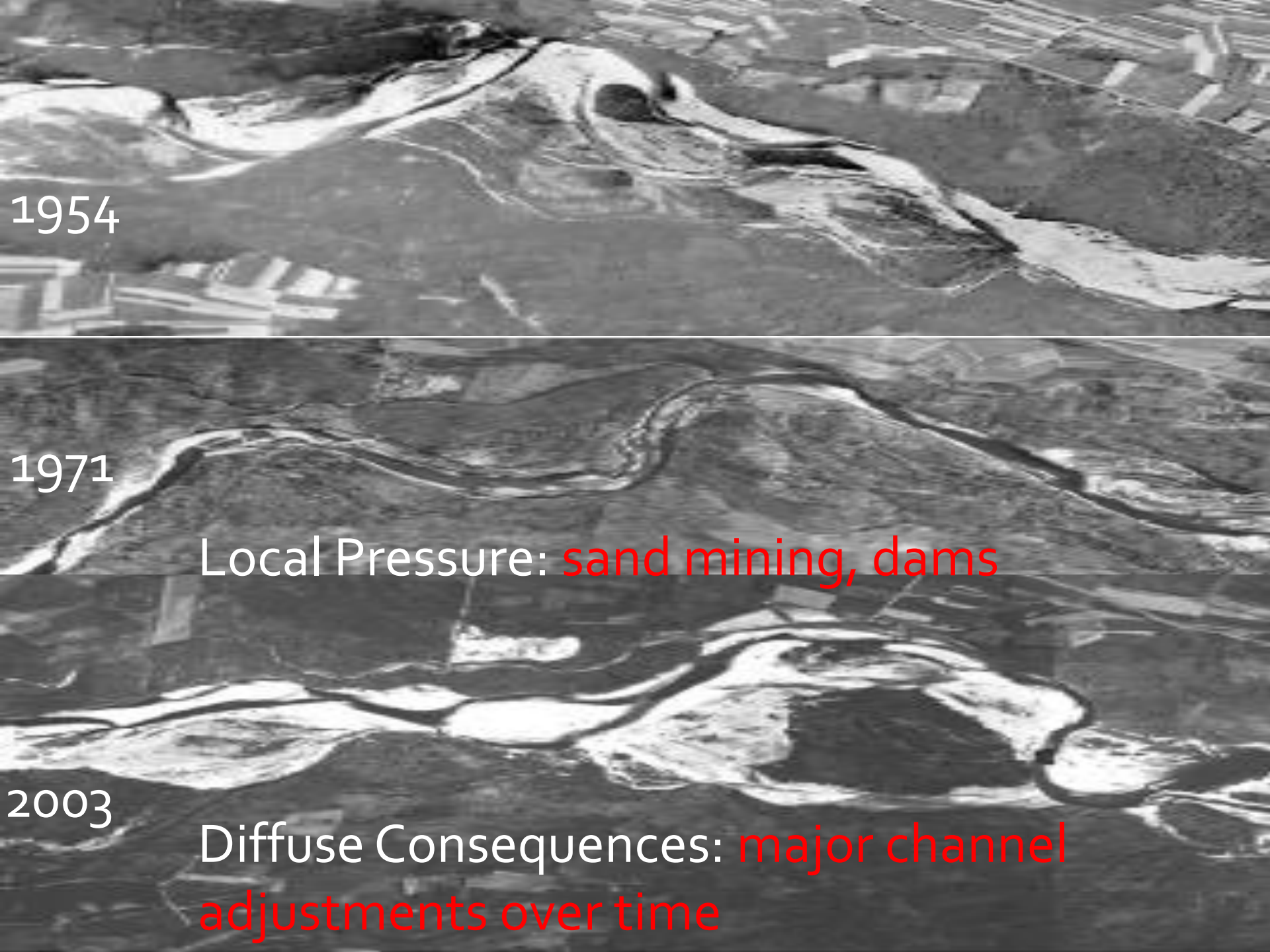


Meandering

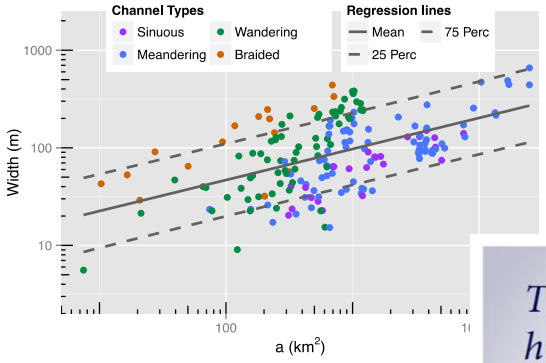
Sinuous

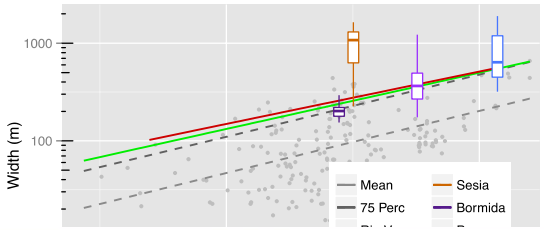
Wandering

Braided

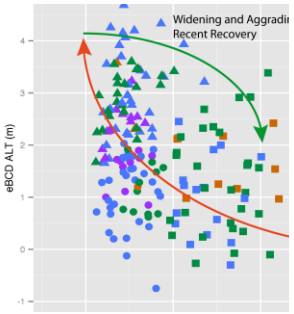

1954
1971
Local Pressure: sand mining, dams
2003
Diffuse Consequences: major channel adjustments over time

Assess 50-100 yr human induced channel change

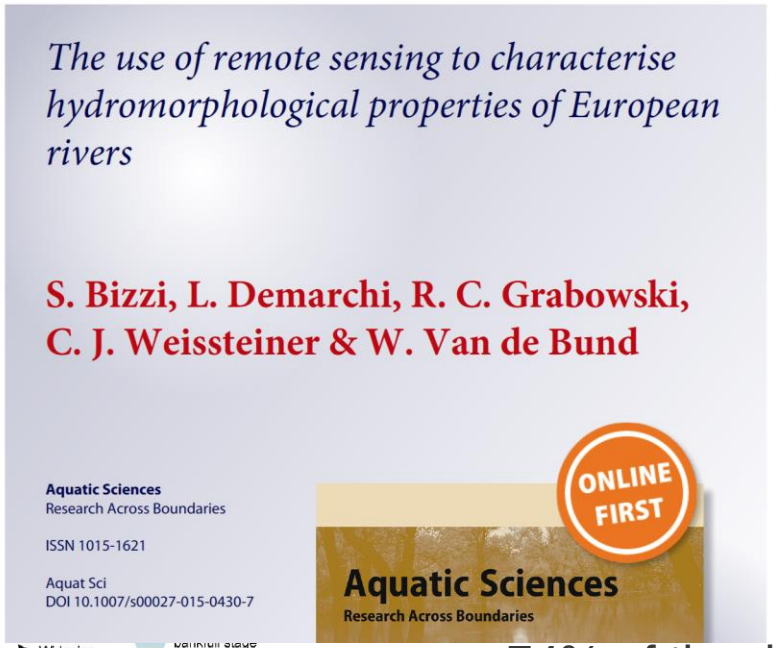


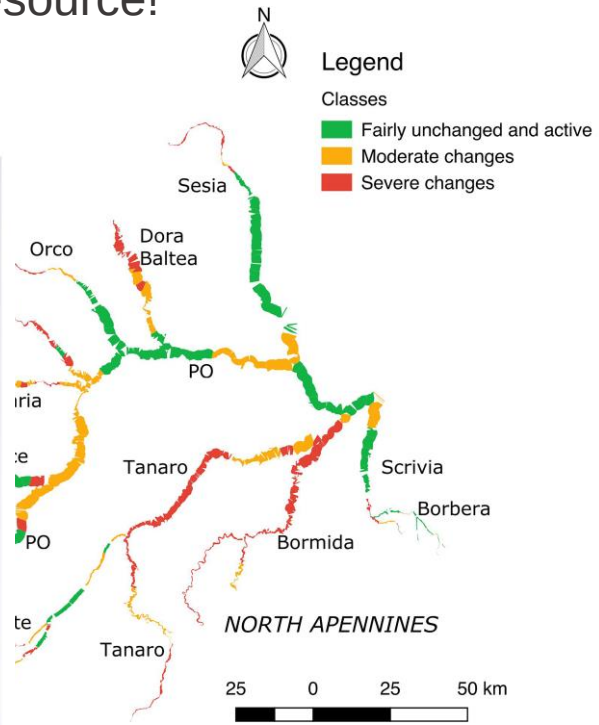


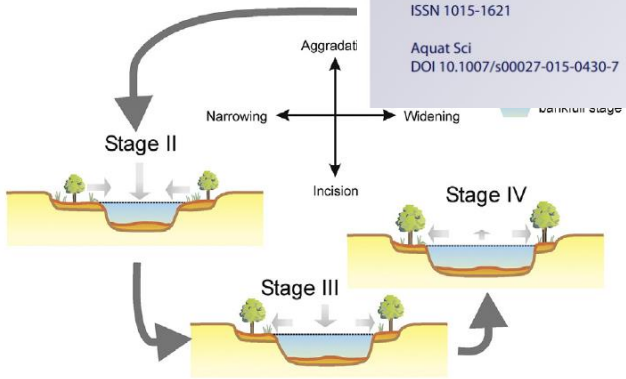
Historical RS information is a resource!



(A)







Bollati et al. 2014 Geomorphology

- 74% of the river network has a riverbed incision greater than a meter
- 66% of channels have halved their historical widths
- in total 617 ha of land have been subtracted to the active channels

Current Projects

AMBER

Adaptive Management of Barriers in European Rivers
Horizon 2020, €6.2 M, 20 partners, 11 countries 2016-2020

Swansea University Prifysgol Abertawe · Durham University · University of the Highlands and Islands Oilthigh na Gàidhealtachd agus nan Eilean · DTU Technical University of Denmark · UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh · Iascach Intíre Éireann Inland Fisheries Ireland · World Fish Migration Foundation · Universidad de Oviedo · AEMS Ríos con vida

UNESCO ERCE United Nations Educational, Scientific and Cultural Organization · European Regional Centre for Ecohydrology Under the auspices of UNESCO · IRS · Politecnico Milano 1863 · Conservatoire National du Saumon Sauvage · WWF · ingenieurbüro kauppert · uniper · University of Southampton · EDF · European Commission · innogy

IRIS

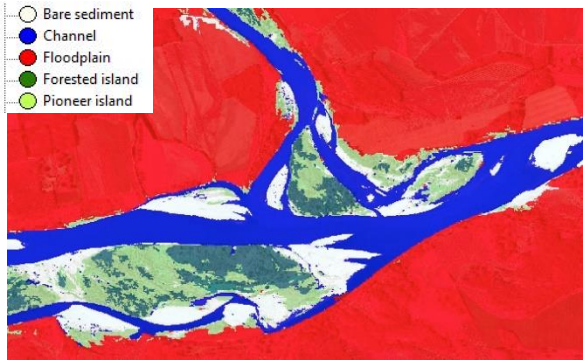
Italian Research and development Initiative for Spaceborne river monitoring

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

POLITECNICO MILANO 1863
DIPARTIMENTO DI ELETTRONICA INFORMAZIONE E BIOINGEGNERIA

2.5 year project, € 178k, 2017-2019

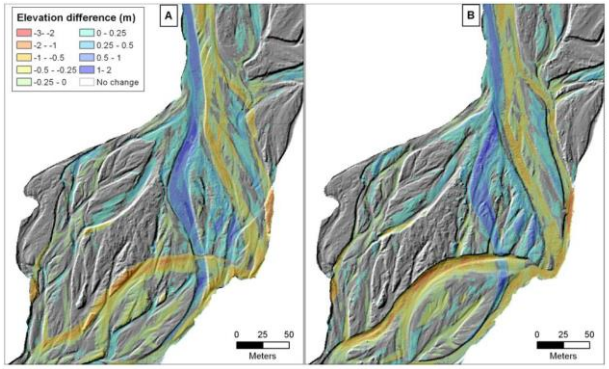
Hydromorphological indicators from drones and satellite remote sensing



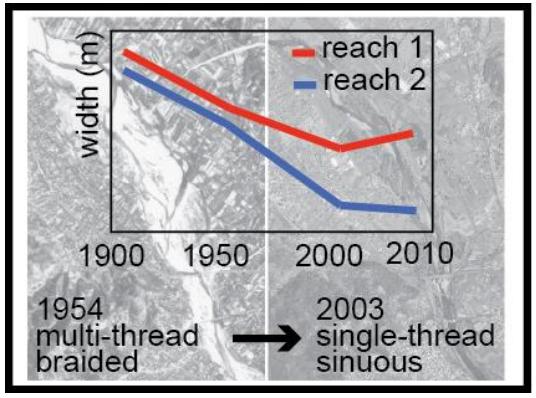
Habitat mapping

Sediment size

Water extraction

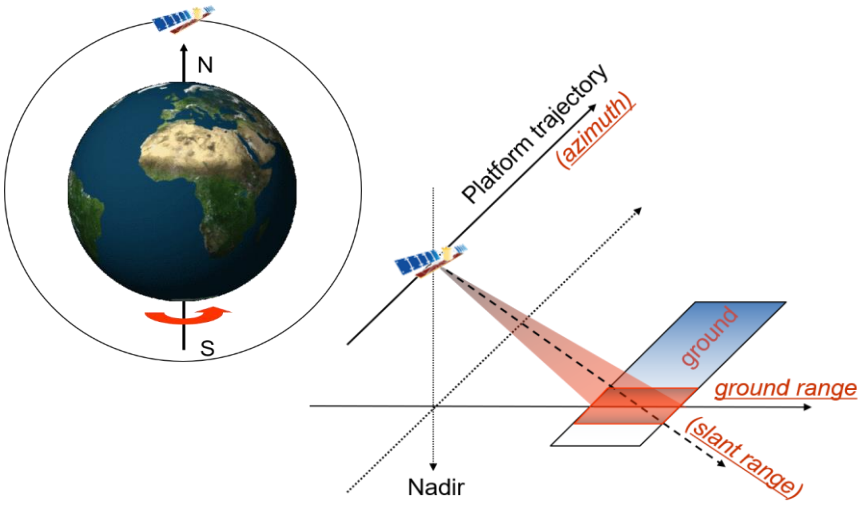


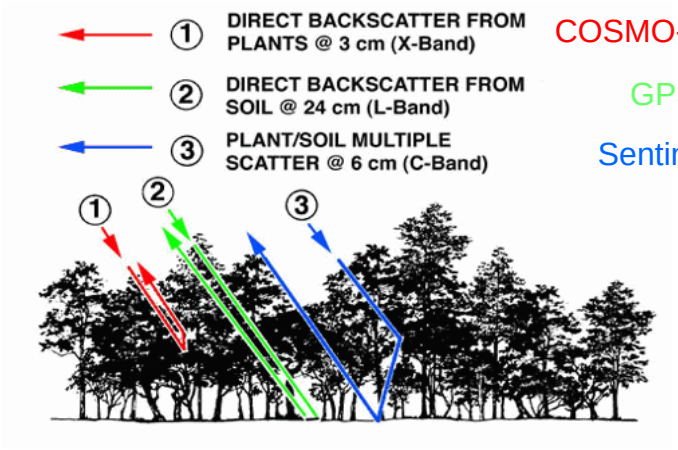
Indicators of processes



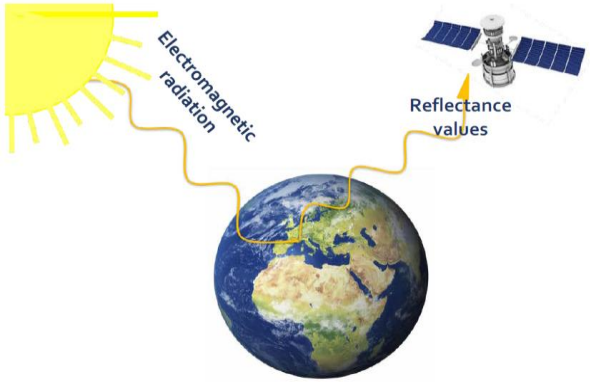
Satellite data – EU Copernicus programme

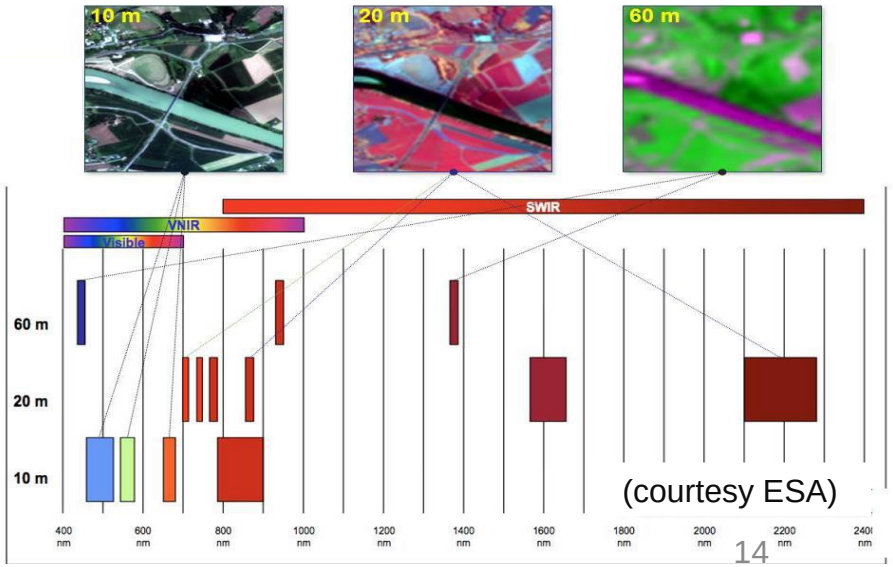
SENTINEL 1: radar (SAR) C-Band
Pixel 20 x 5 m
Frequency of acquisition: 6 days





SENTINEL 2: Multispectral optical
Pixel 10x10 or 20x20 m
Frequency of acquisition: 5 days

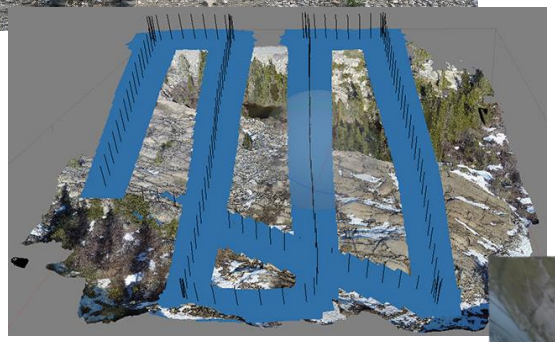


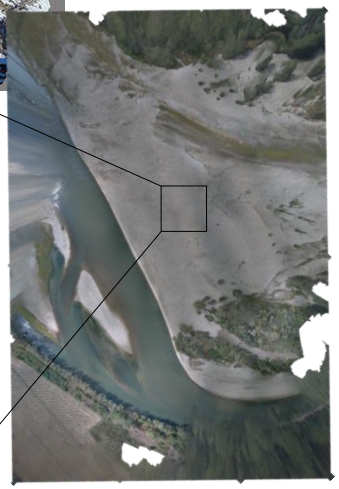


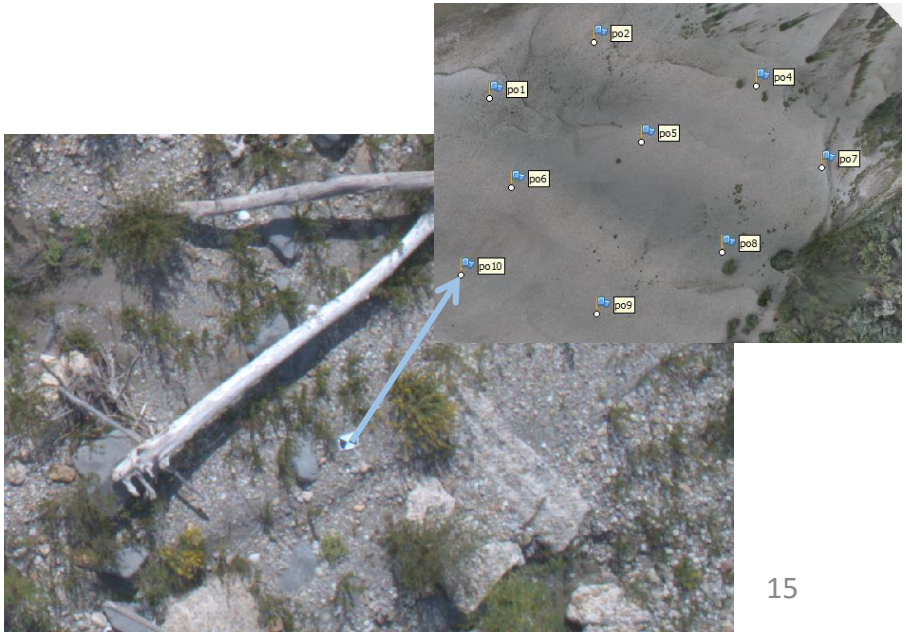
Field data

Very high resolution remote sensing data (UAV)

Very high resolution Topographic data (GPS)



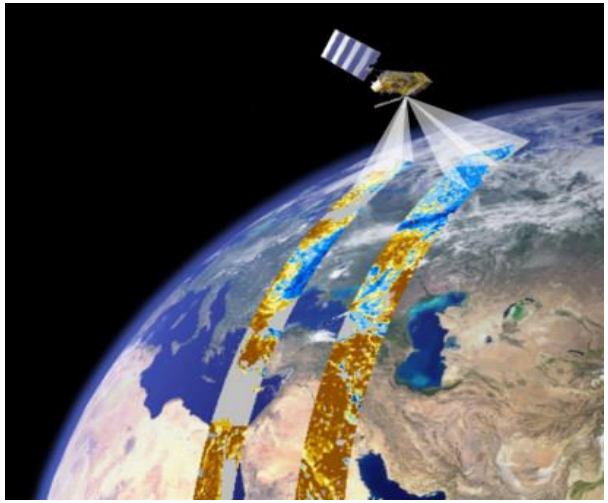




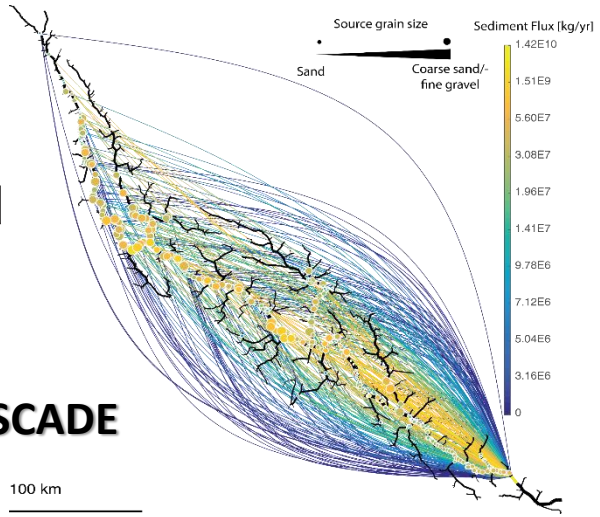
Ground truth to calibrate and validate satellite data

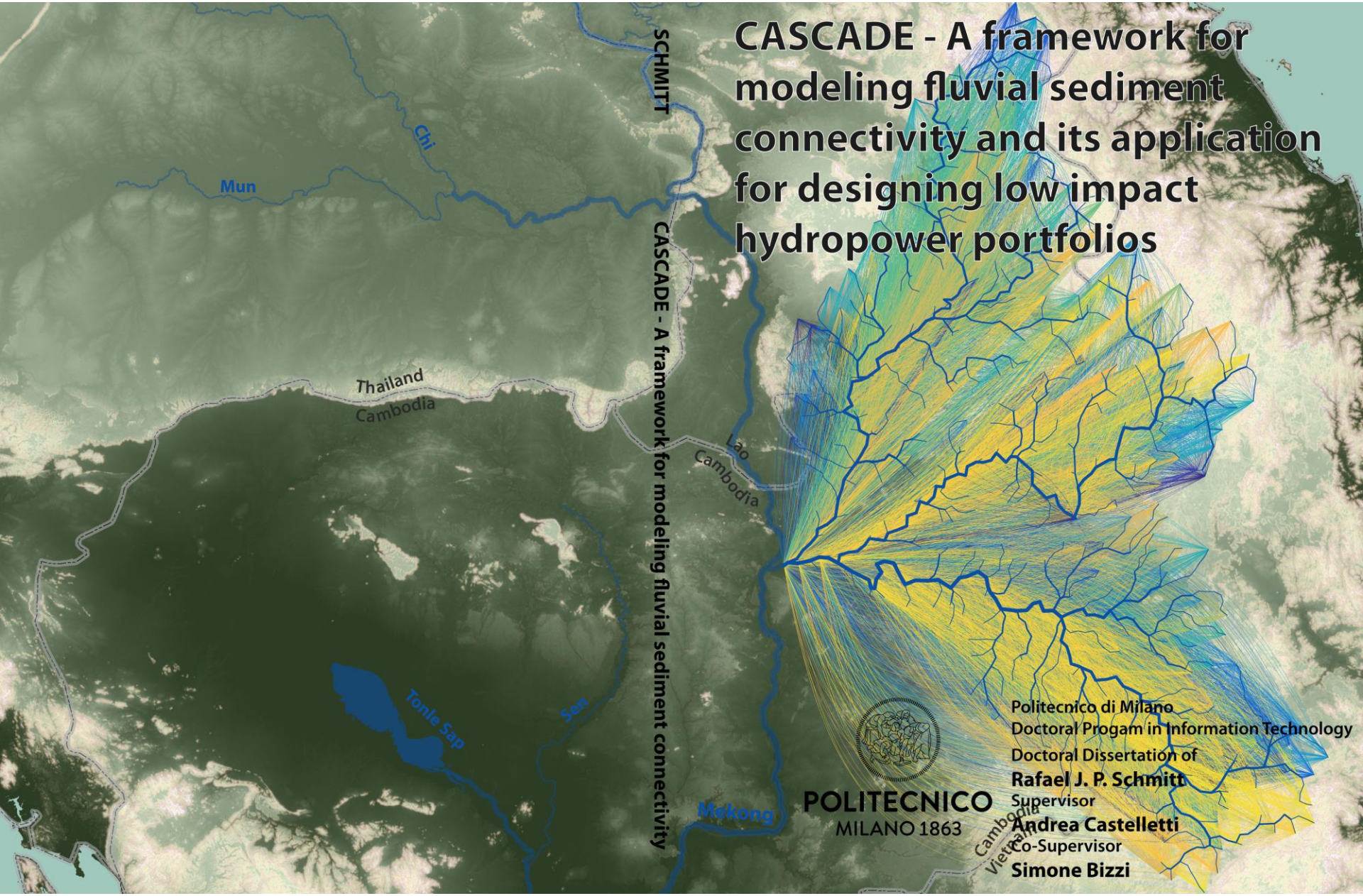
From RS monitoring to modeling at global scale

Low cost global river processes mapping, monitoring and modeling



Multiscale RS for calibration and validation of network-scale models of new generation





CASCADE - A framework for modeling fluvial sediment connectivity and its application for designing low impact hydropower portfolios

Politecnico di Milano
Doctoral Progam in Information Technology
Doctoral Dissertation of
Rafael J. P. Schmitt
Supervisor
Andrea Castelletti
Co-Supervisor
Simone Bizzi

POLITECNICO
MILANO 1863

AIMS TO MODEL SEDIMENT CONNECTIVTY: where CASCADE comes from...

Theory

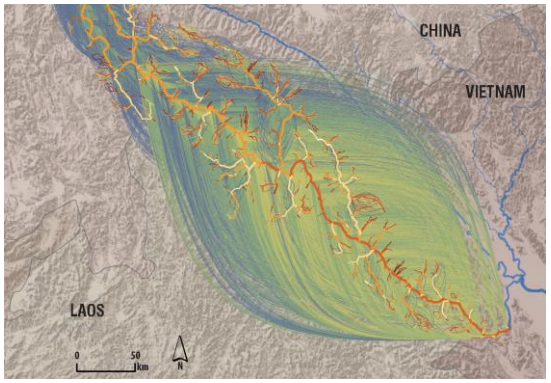
- Quantifying connectivity in river systems (Heckmann & Schwanghart 2013): magnitude, frequency, typology of fluxes
- Reconciling small scale observations with large scale process evidences (Bracken et al. 2013)
- Linking Sources, Sinks and disclosing pathways (Fryirs et al., 2007)

Opportunities

- Flexible to data availability, link to opportunity of Remote Sensing technology (Carbonneau & Piegay 2012, Bizzi et. 2016)

Management urgencies

- Applicable to large river system
- Sensibility to external forces -> support management



Acceptable limitations

- Focus exclusively on fluvial erosion and river sediment transport
- Exploratory tools: aims at map sediment connectivity not a LEM

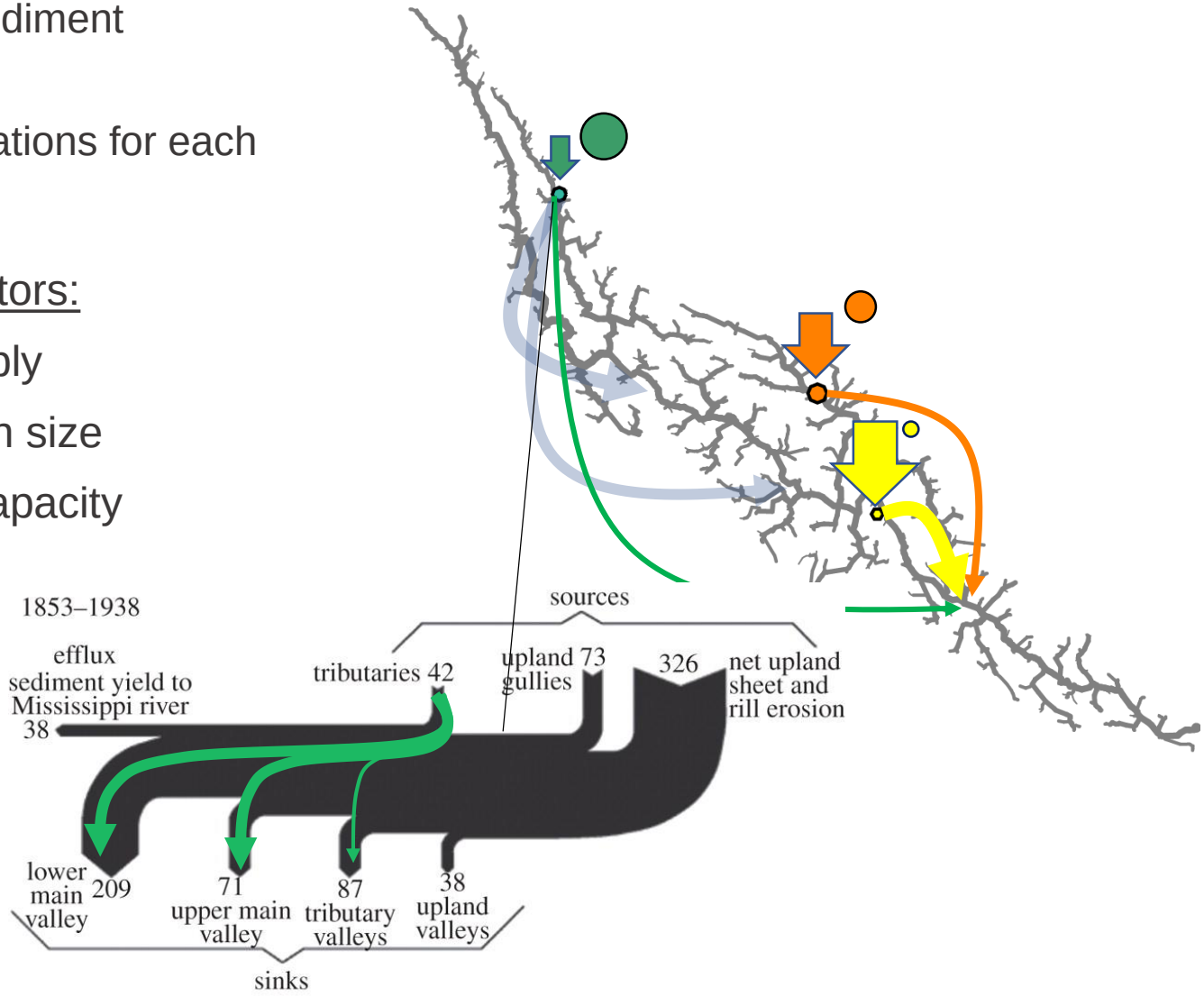
Conceptualizing river network connectivity

Fate of each sediment contribution

Source-sink relations for each reach

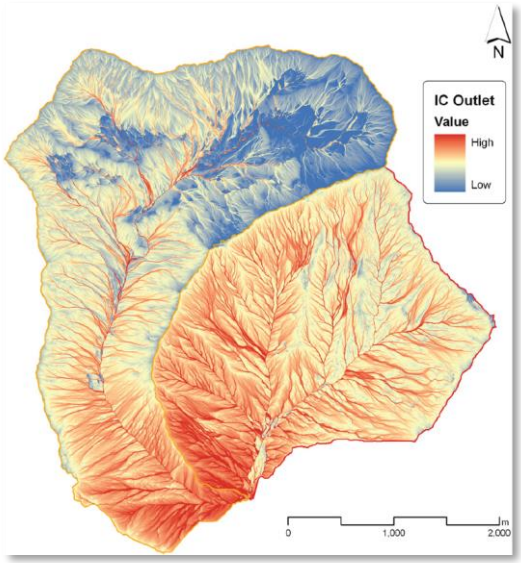
<u>Controlling factors:</u>

- Source supply
- Source grain size
- Transport capacity



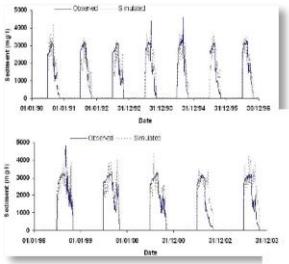
State of art on modelling tools available

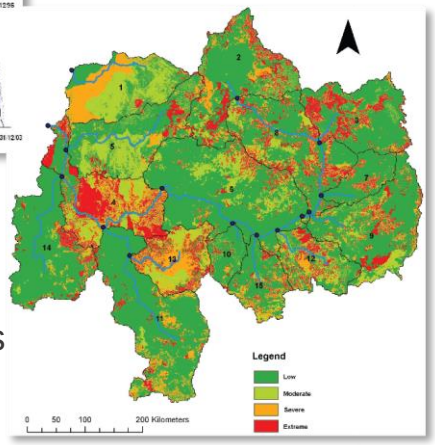
Modelling connectivity

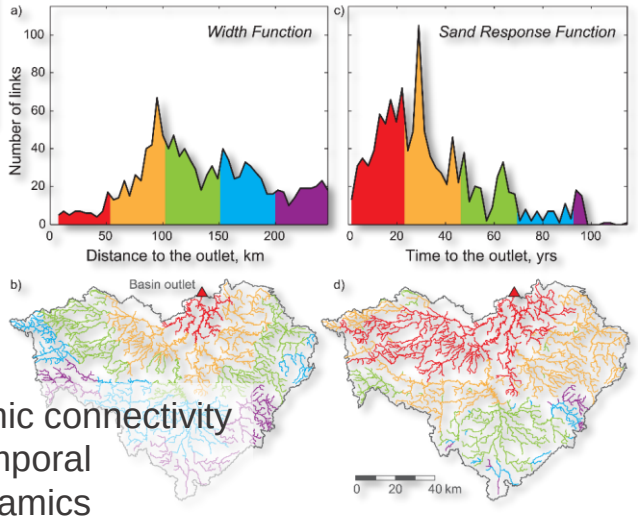


Geomorphic indices
- static / no temporal dynamics
- no process rates

Cavalli et al. 2013, Geomorphology







Hydrologic model add-ons
- some process rates and dynamics (TSS)
- no information on connectivity

Bertrie et al., 2011, HESS

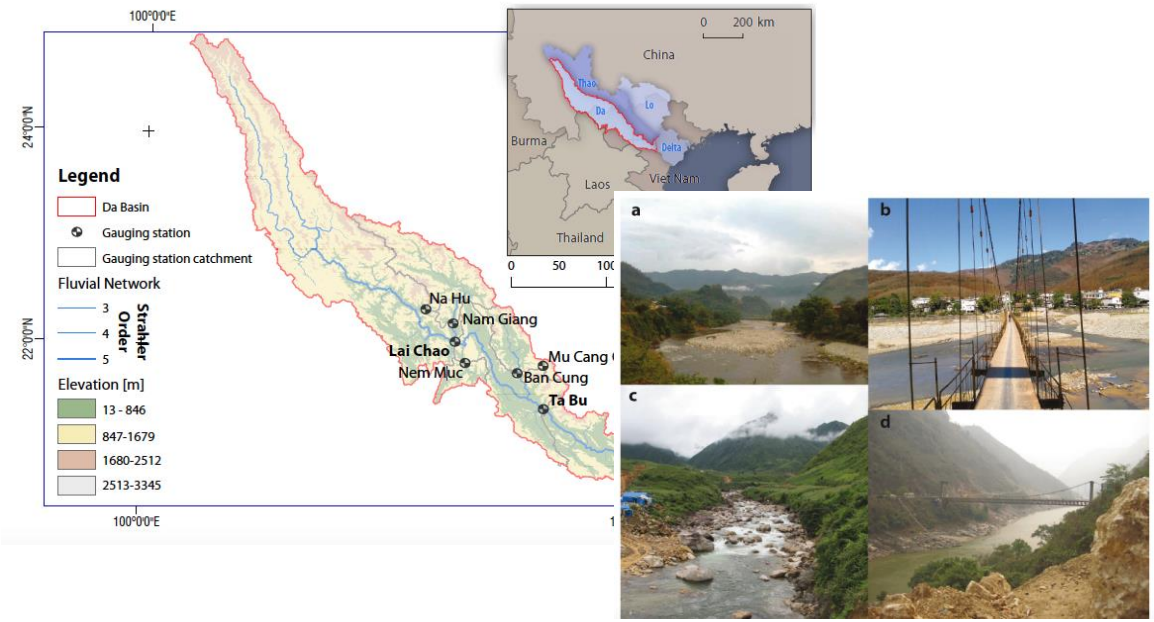
Dynamic connectivity
- temporal dynamics
- no process rates

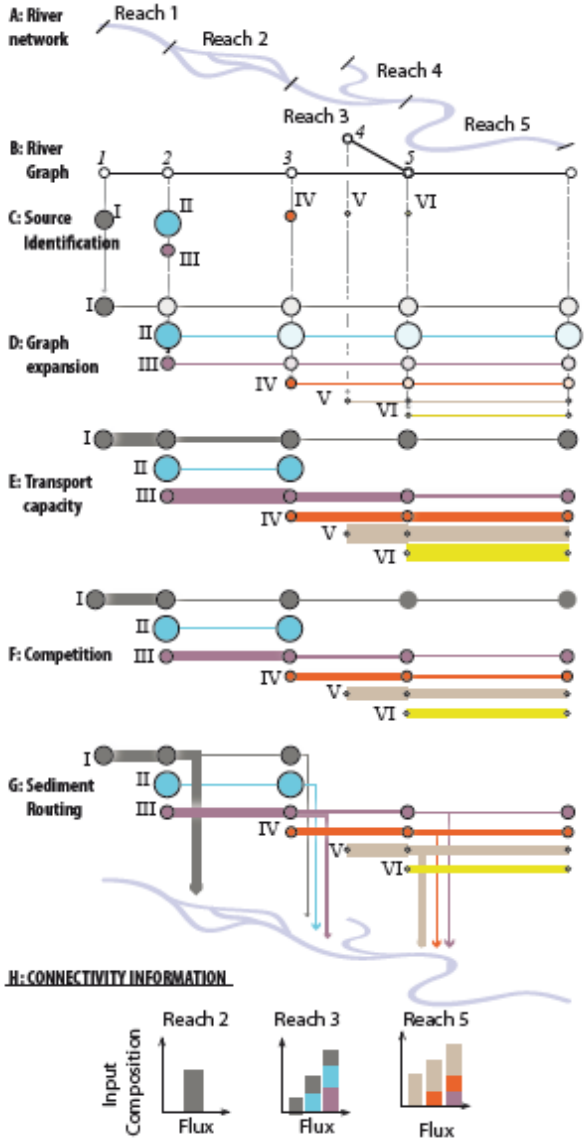
Czuba & Foufoula-Georgiou, 2015, WRR

CASCADE (CAtchment SEdiment Connectivity And DElivery)

Inputs

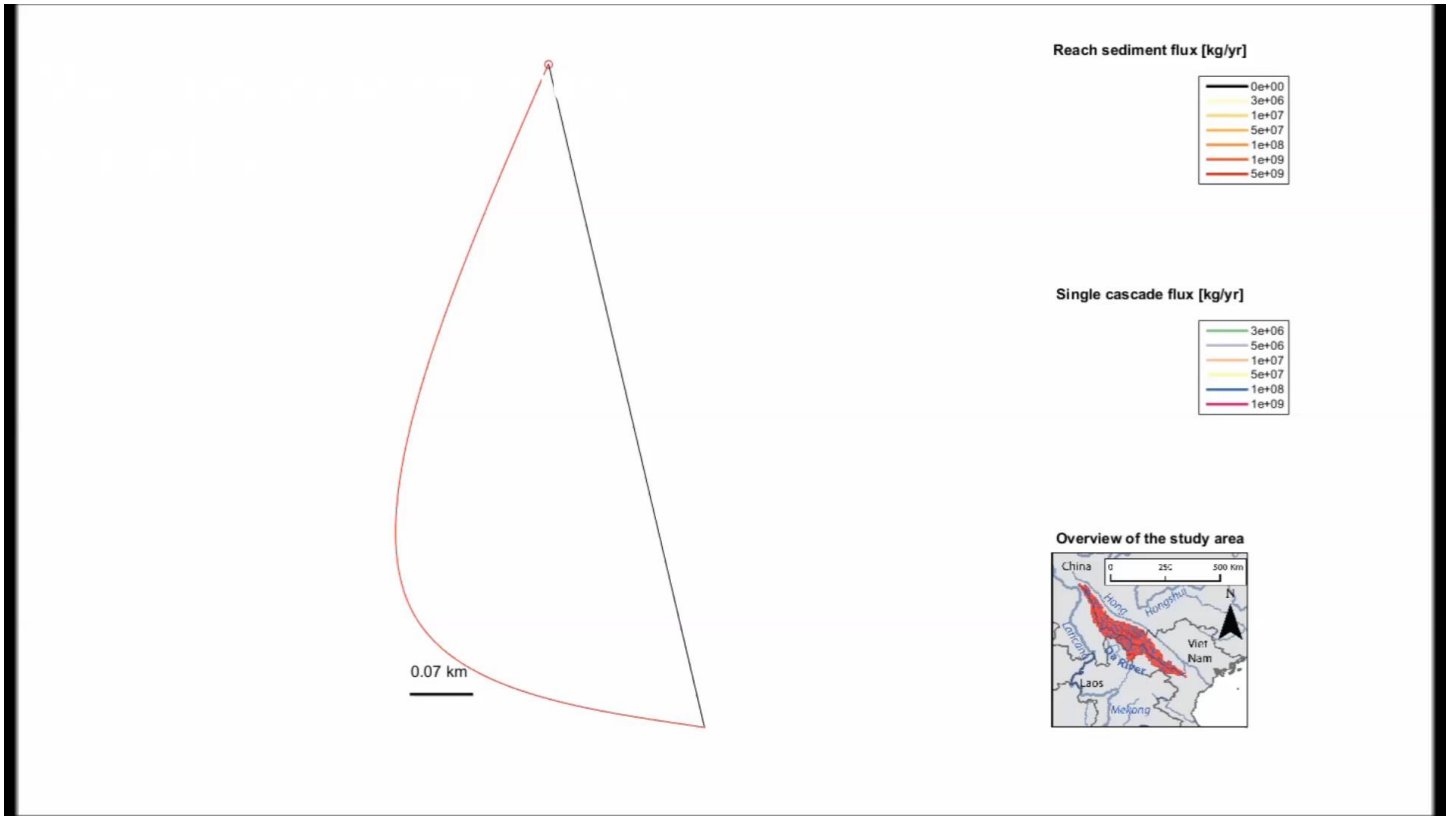
- DEM
- Orthophotos
- Hydrological data
- Sediment Transport observations
- Geomorphological maps





Schmitt et al., 2017, WRR, DOI 10.1002/2015WR018097

Building the CASCADE model



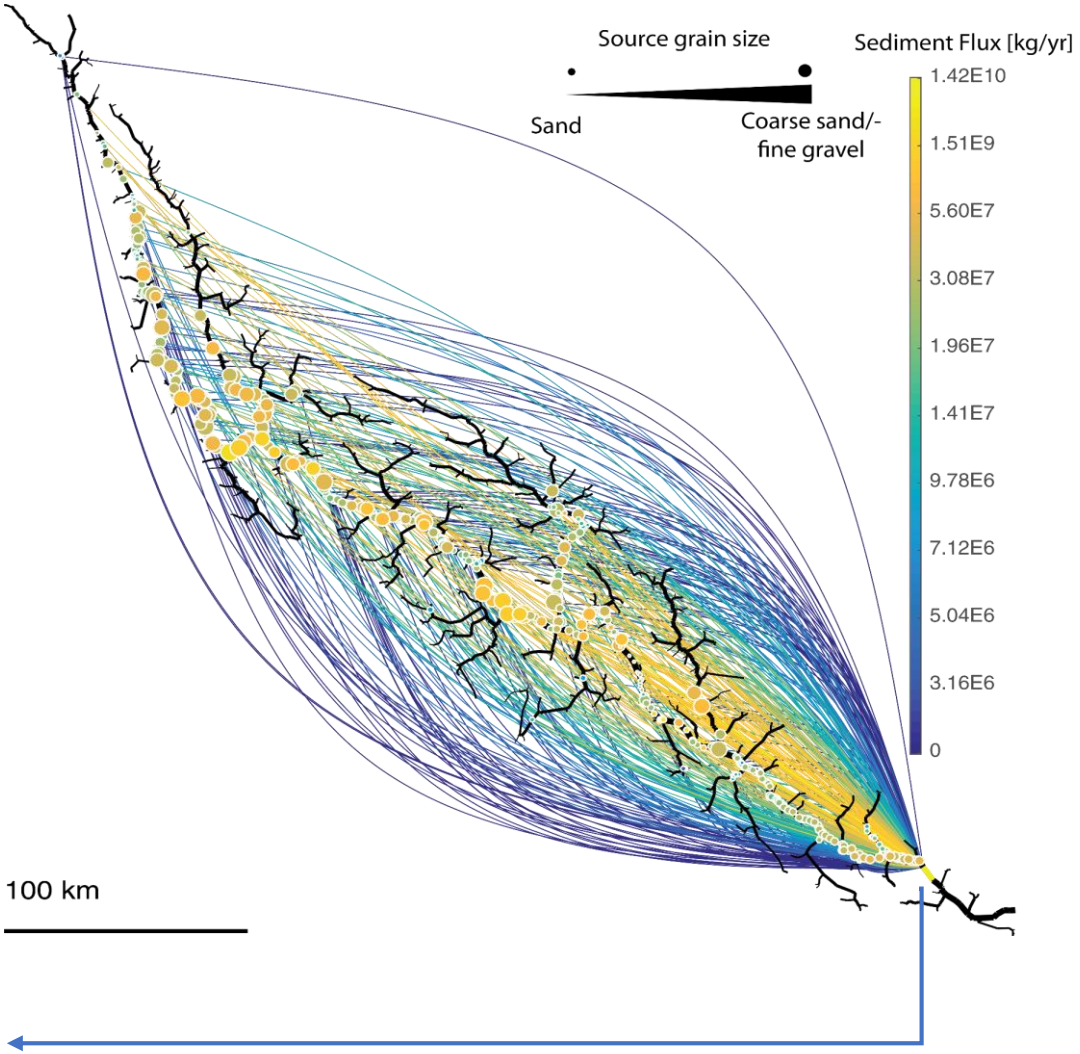
CASCADE outputs

Analyzing reach connectivity

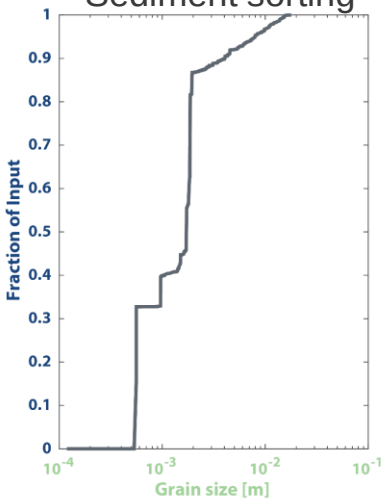
Where are sources located

Source-sink deliveries

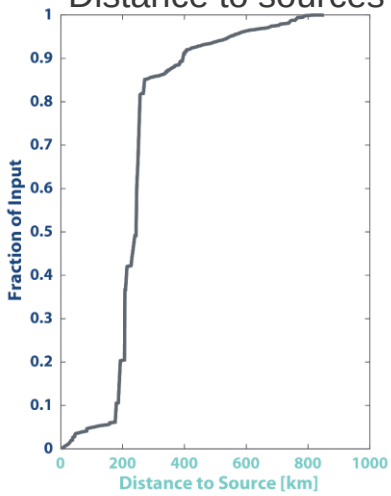
This information is available for all reaches



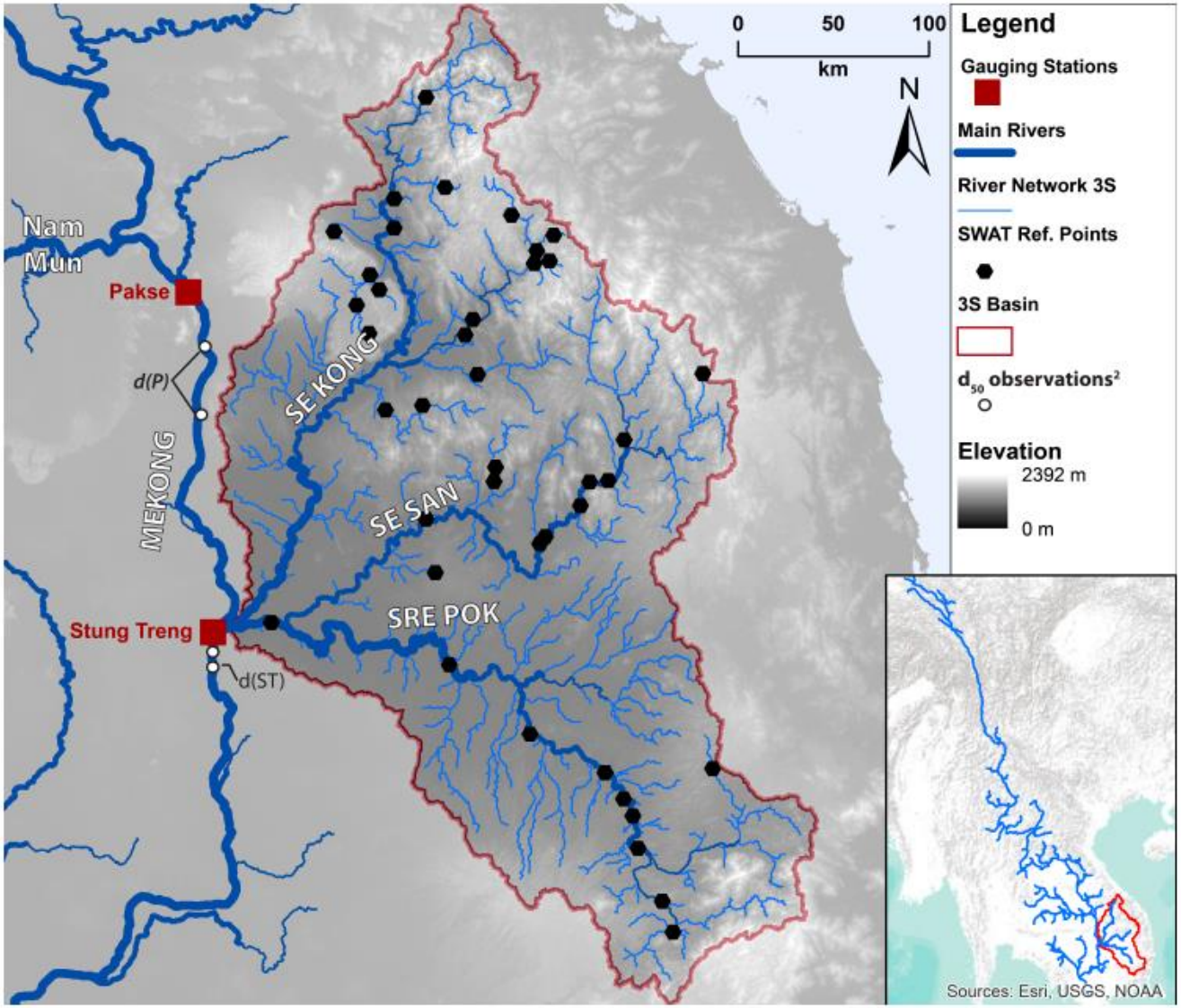
Sediment sorting



Distance to sources

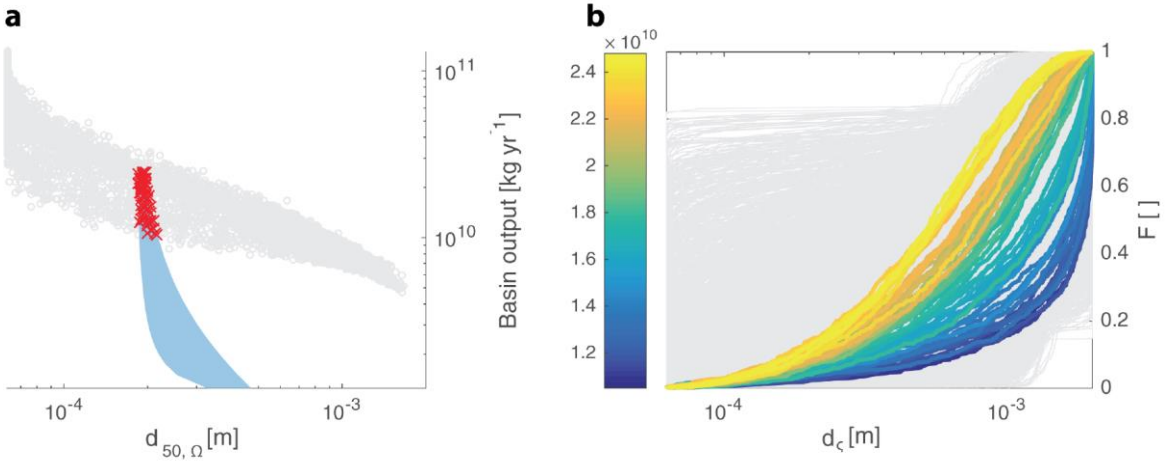


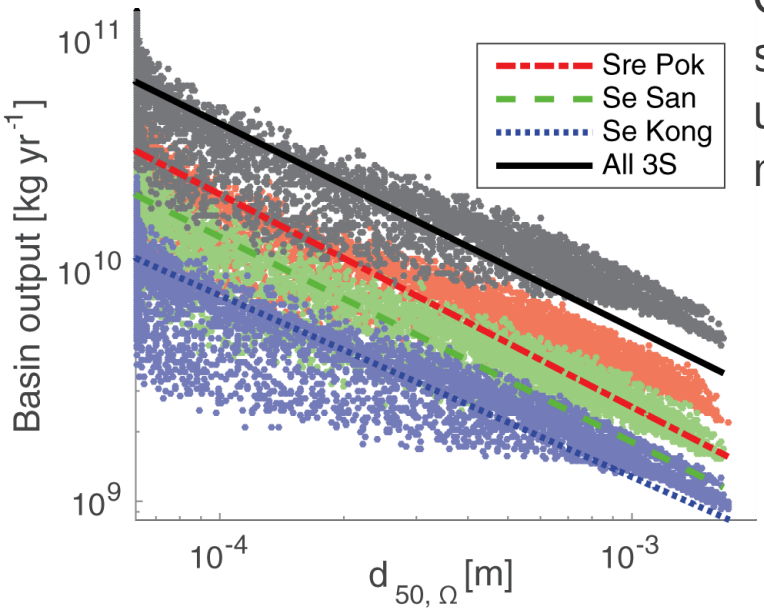
3S case study



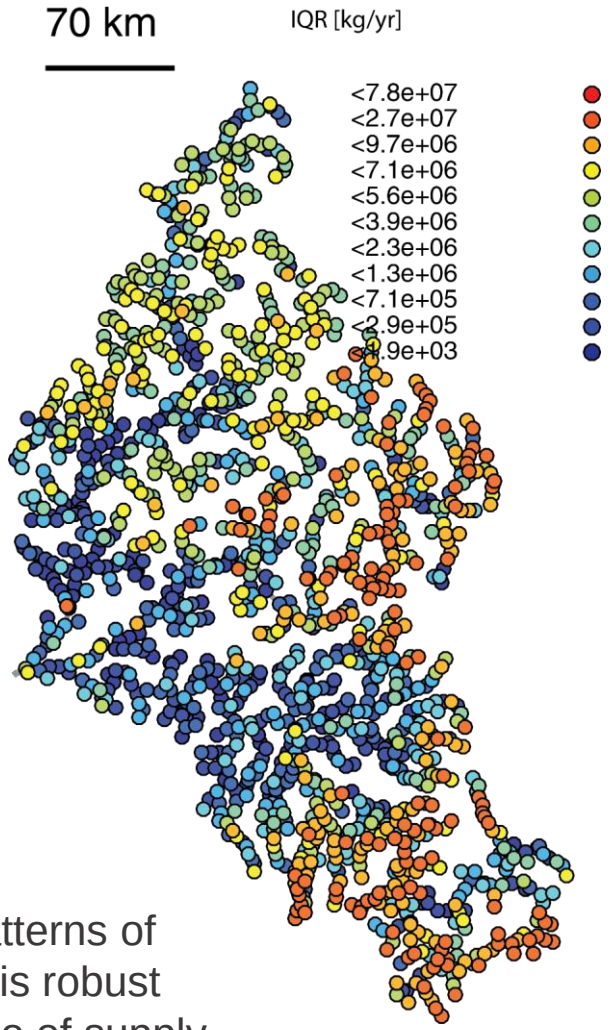
3S case study

Stochastic modeling of sediment transfers





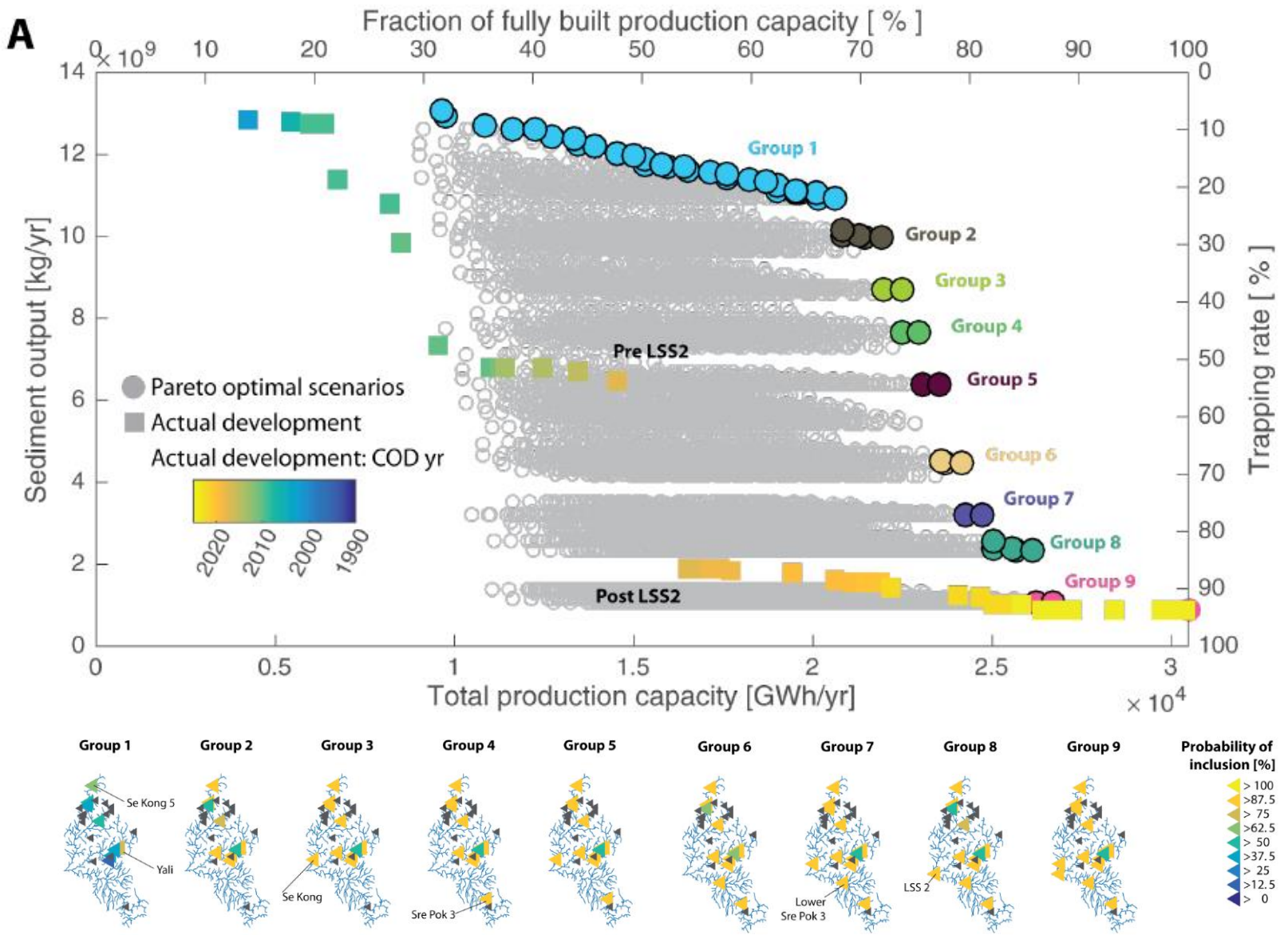
Characterization of sediment transfers and uncertainty in poorly monitored basins



The relative spatial patterns of sediment connectivity is robust under alternative scenario of supply

Schmitt et al., 2017, JGR, DOI 10.1002/2016JF004105

3S case study

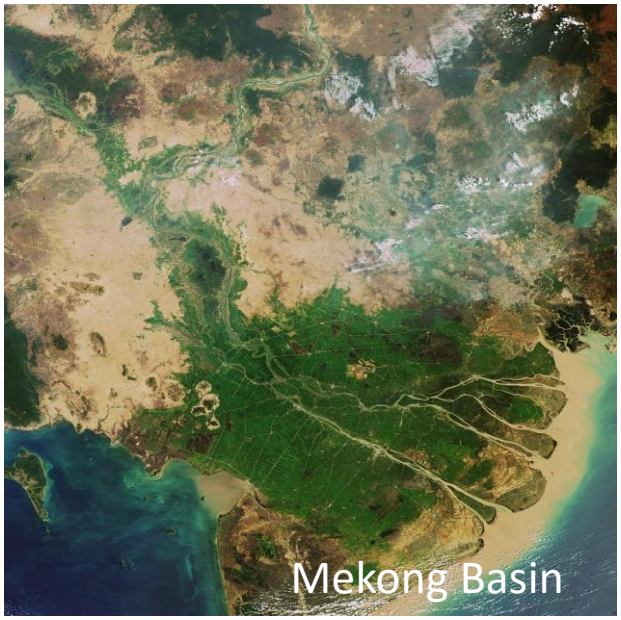


Schmitt et al., 2017, Nat Sust. (in review)

On-going applications of CASCADE to support siting of dams at basin scale

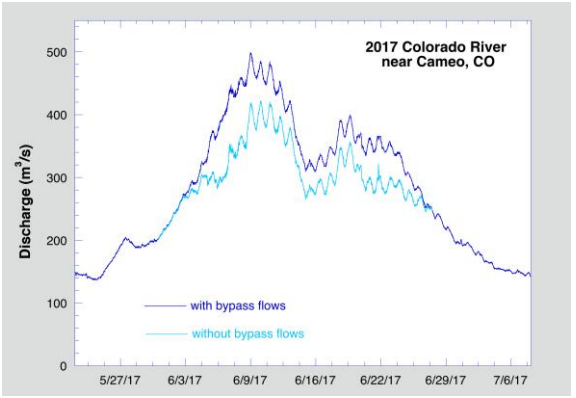
3700 major dam sites that await development world-wide!

Zarfl,et al.. A global boom in hydropower dam construction. Aquat Sci 77, 161–170 (2014)

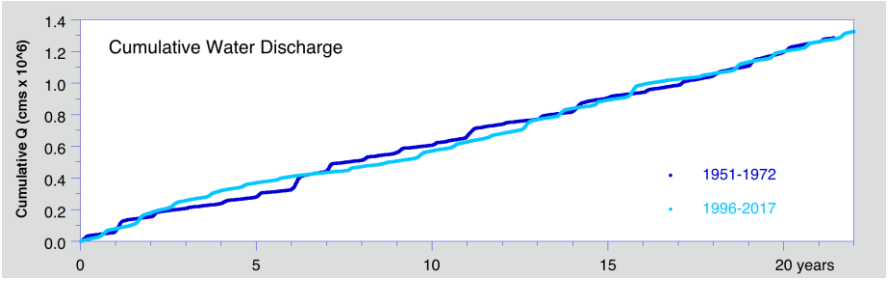


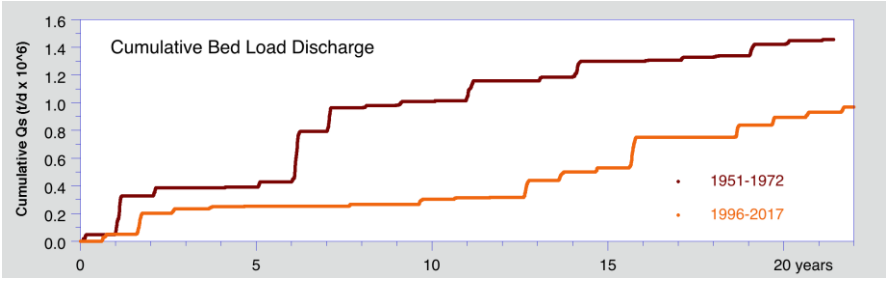
On-going applications of CASCADE to support sediment management

UPPER COLORADO RIVER
ENDANGERED FISH
RECOVERY PROGRAM

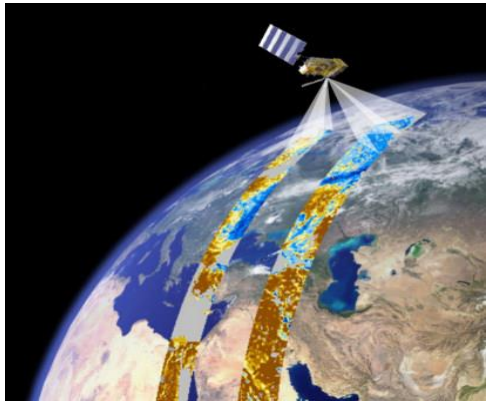


habitats are formed and maintained
by sediment transport
(Pitilick, Bizzi et Schmitt AGU 2017)





We are on a cusp of something in river science and management

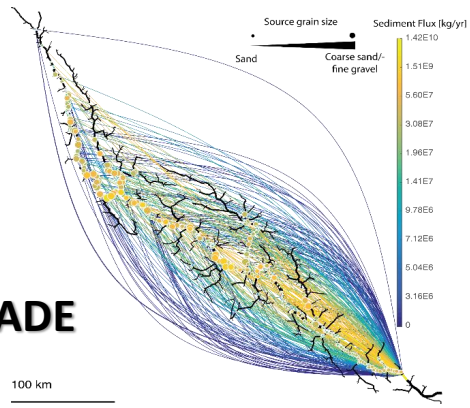


Science

- reframing perspectives from the past (testing conventional theories)
  - Network and Basin perspective
  - linking Local and Global
  - Integrating RS sources from multiple technologies (multi-scales information)
  - Quantifying Connectivity
  - From observing forms to monitoring processes
  - Including ecological processes

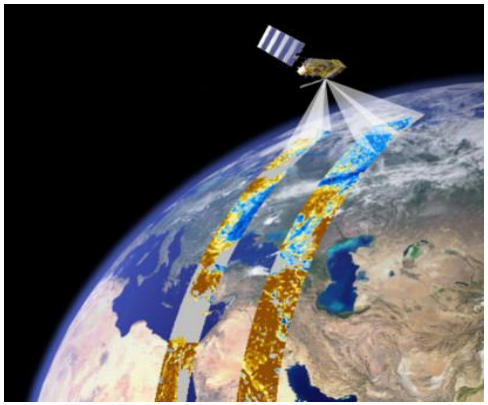
Management

- critical need for an information management framework to help structure our understandings and knowledge
- renew river monitoring: integrating operational and more research oriented applications (payoff can be significant!)



CASCADE

Thanks for your attention!



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