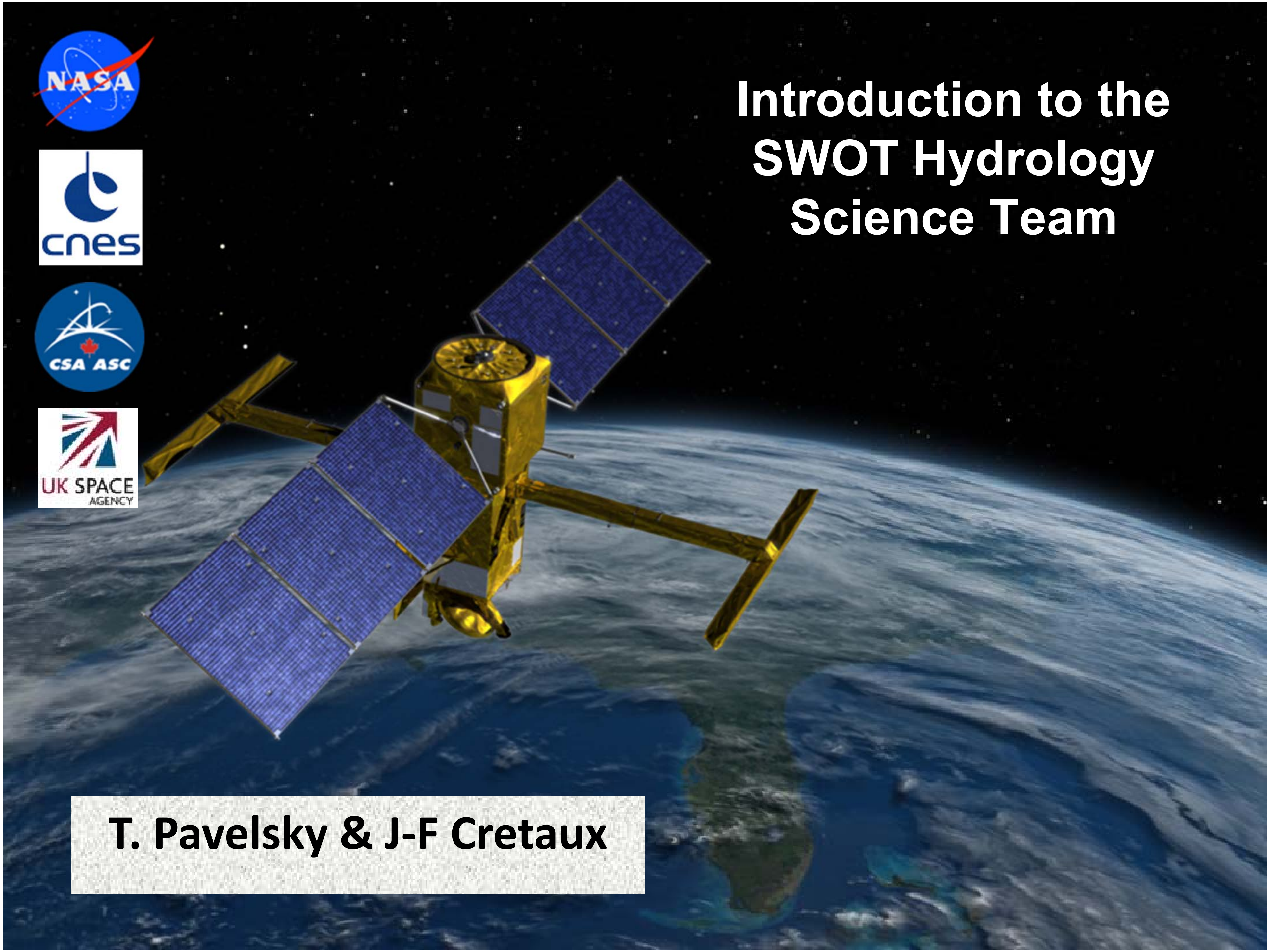
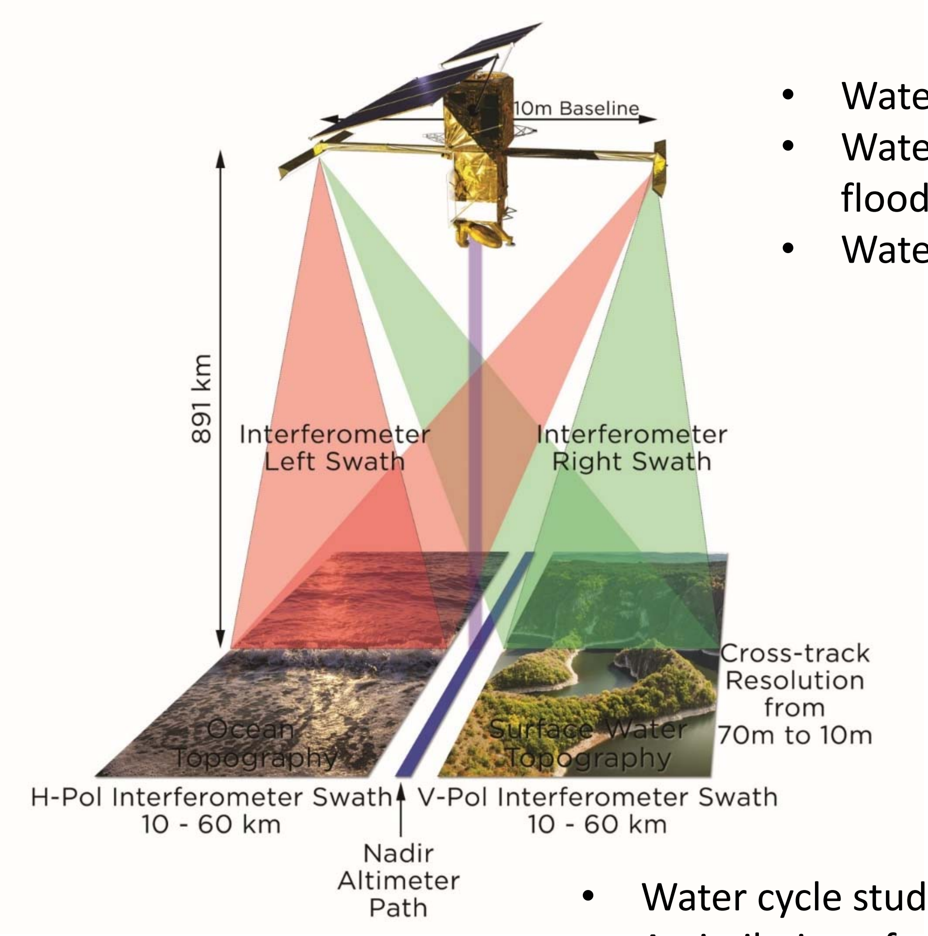
Introduction to the SWOT Hydrology Science Team



T. Pavelsky & J-F Cretaux

Science Objectives in Hydrology



SWOT will measure:

- Water mask globally at high resolution
- Water surface elevation and extent in lakes and floodplains
- Water surface elevation, width and slopes in rivers

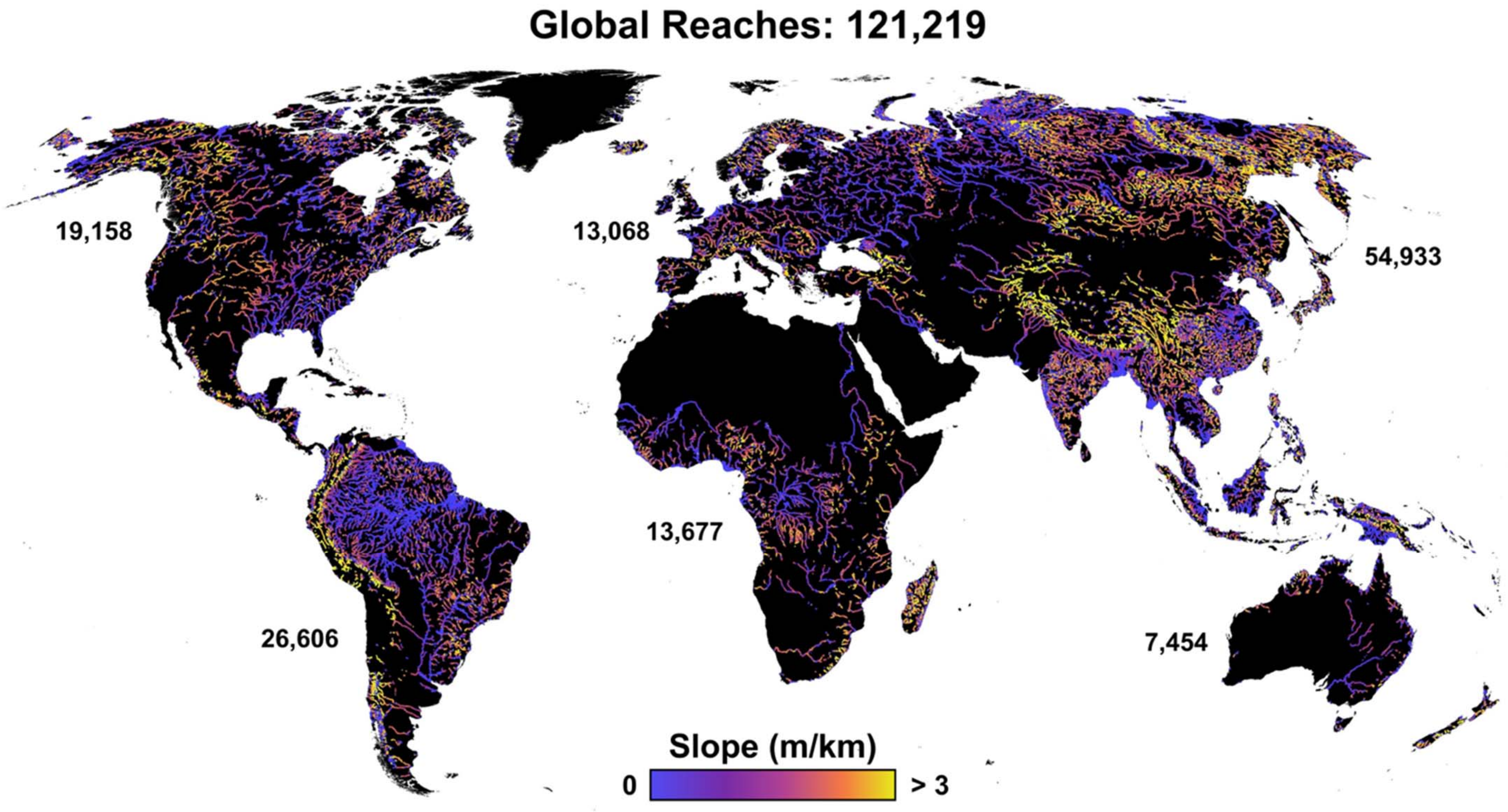
SWOT will provide

- Lake storage changes
- River discharge

SWOT will allow

- Water cycle studies and improved water budget closure
- Assimilation of new data into global hydrological and cimate models
- Study of the connectivity of rivers, lakes, reservoirs, wetlands
- Production of floodplain DEMs

SWOT Rivers Spatial Coverage



SWOT will provide unique observations or estimates of river elevation, width, slope, and discharge for the world's rivers wider than 50-100 m, shown above.

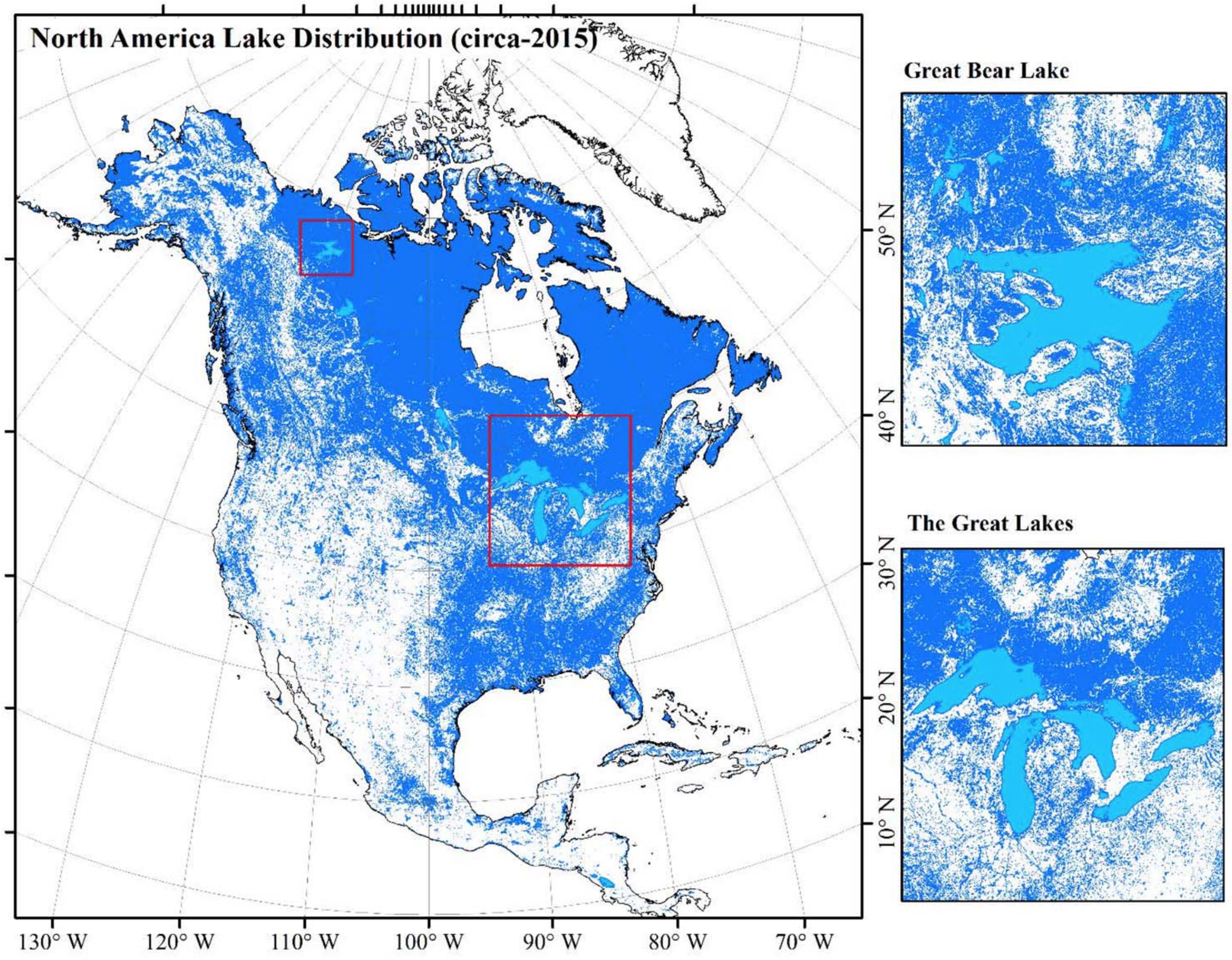
River products by nodes and reaches

- Complete coverage: for rivers > 30 m width
- Generated for each pass of the satellite in .shp form for nodes, and also by cycle for reaches
- Contents:
  - width, height, flooded area… in average around each node
  - averaged height, slope, discharge… over each reach of the river
- Nodes every 200 m along the river central line
- Central line of the river split in ~10-km reaches

Pixel clouds products will also be released as for wetlands

Note: see Data Products presentation tomorrow for more details

SWOT Lake Spatial Coverage



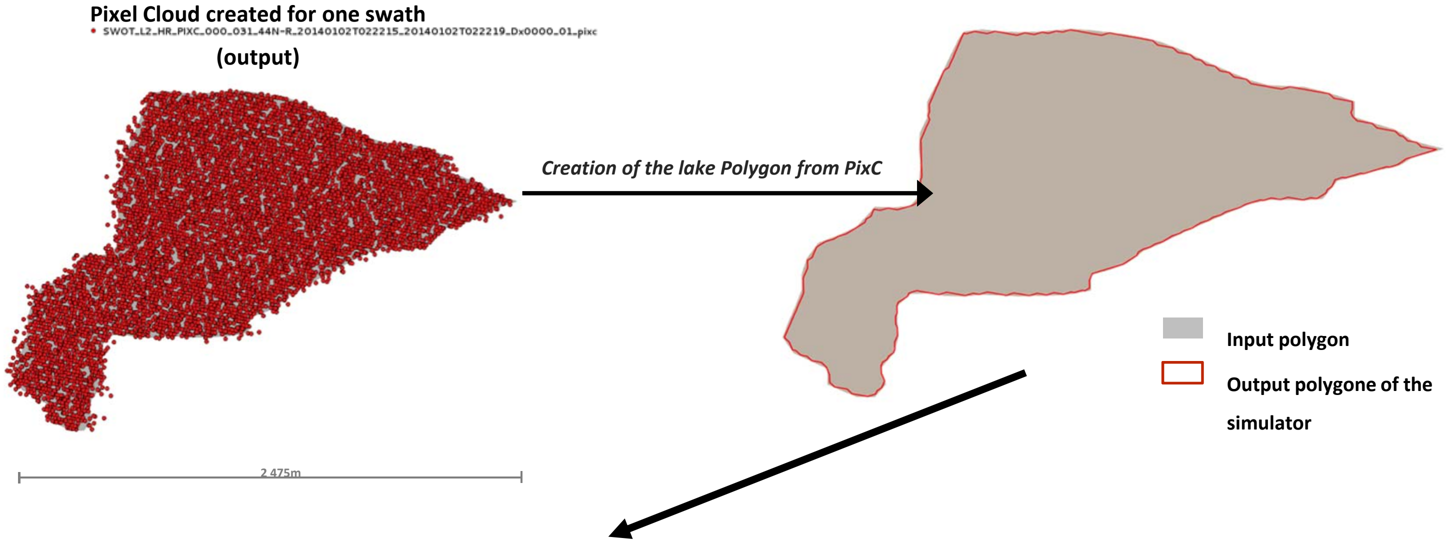
SWOT is required to observe lakes larger than 250 m x 250 m.

Recent work by Yongwei Sheng at UCLA suggests that there are ~1.8 M such lakes worldwide.

Most of these are small lakes, almost none of which are currently observed on the ground or by satellite altimeters.

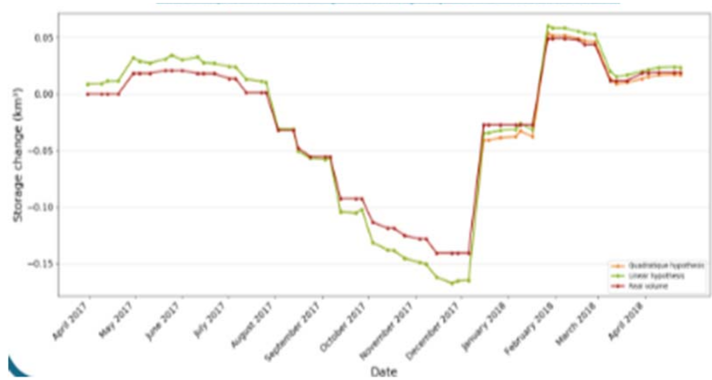
Figure Courtesy Yongwei Sheng, UCLA

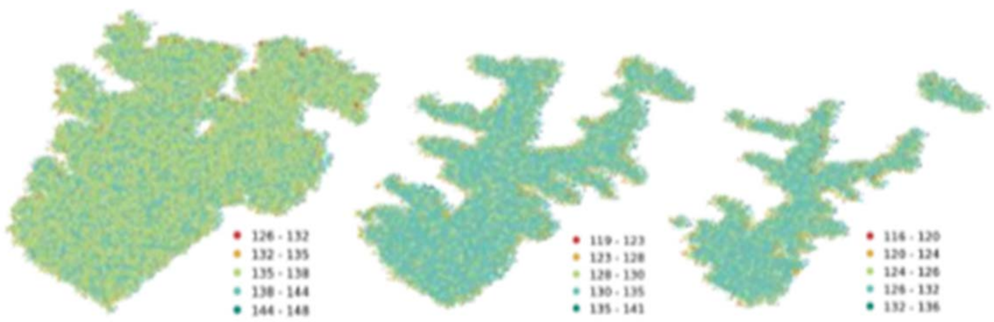
Lakes and wetlands products



- Vector per lake: H, Ex, dV/dt
- Raster images over wetland

Simulation of the volume variation of lac d'Orient in France compared to real values





PixC du 2017-03-27 PixC du 2017-10-08 PixC du 2017-11-19

Note: see Data Products presentation tomorrow for more details

Role and Objectives of the Science Team

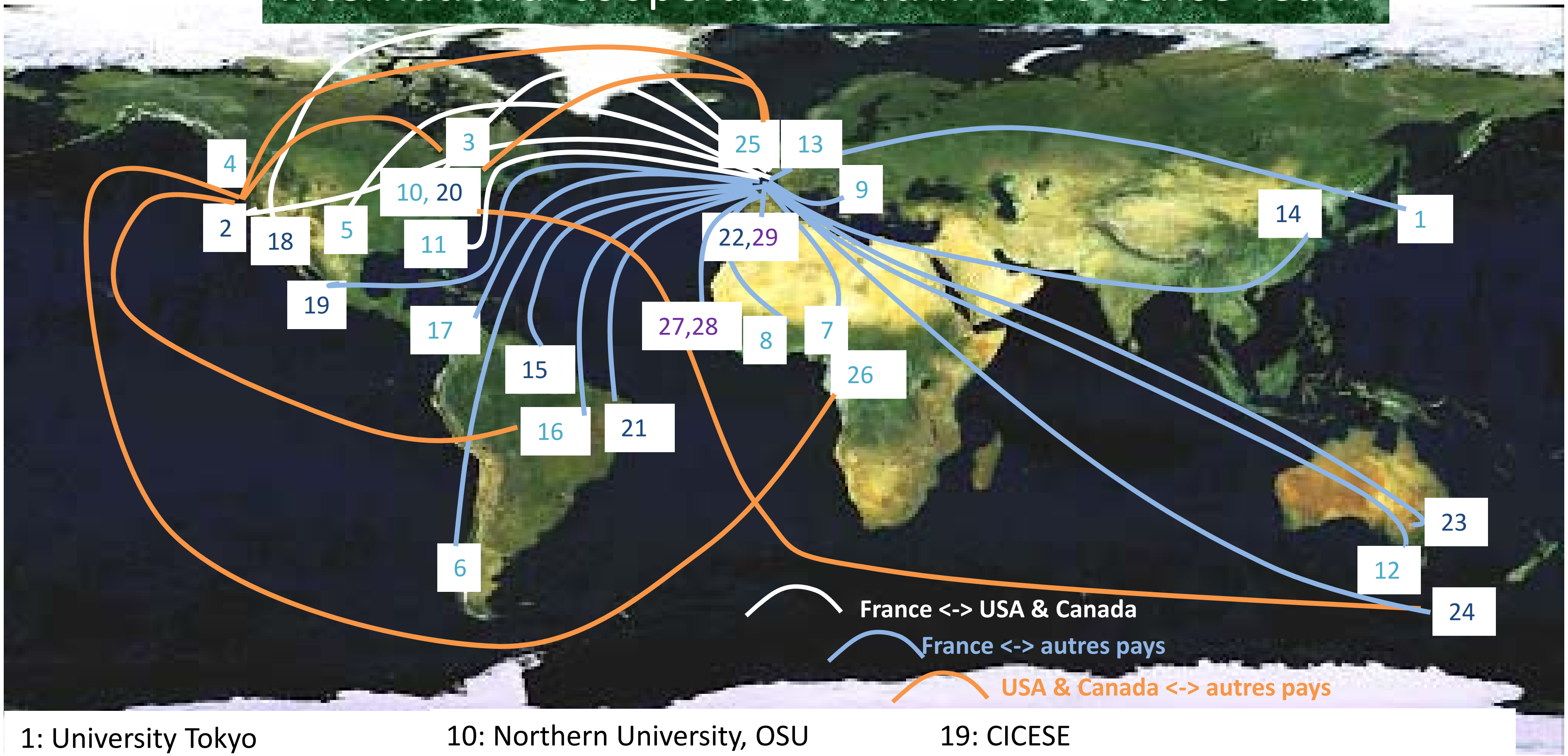
- Research and development on new science applications in hydrology
- Enhancement of international cooperation and promotion of SWOT in the science community
- Participation in the development of algorithms for SWOT data processing and the enhancement of a priori databases within the ADT group
- Participation in the Cal/Val of the mission

A new, extended science team has been selected based on the ROSES/TOSCA calls

- The ST will work closely and interact with the project team
- Thematic working groups will allow regular interaction that isn't possible for the full team

Compared to previous ST the new ST gathers contributions from all continents in a strong international cooperation

International cooperation within the Science Team



1: University Tokyo
2: JPL, UCLA
3: University Sherbrooke, ECCC, McGill University
4: University Victoria
5: University Kansas
6: Univ Concepcion
7: University Niamey
8: University Ouagadougou
9: University Bologna
10: Northern University, OSU
11: UNC
12: Monash University
13: University Stuttgart & Munich
14: Univrsity of Tsinghua
15: Université des Antilles & Guyanne
16: CEMADEN, UFAM, CPRM, UFMG, UFRJ, MAMIRAUA,
17: University of Cali
18: SIO
19: CICESE
20: NOAA, Universiy Michigan & Columbia& Brown& Rhodes Island
21: UFPE
22,29: University Porto, university Cantabria
23, ANU, Canberra
24: University of Tamania & CSIRO
25: Univ Bristol & Leeds
26: Univ Kinshasa
27,28: UMA, UCAD, Dakar, Sénégal

SWOT Science Team 2020-2023 :

4 working groups in hydrology

River Science

12 teams US, FR, GM, Am-Sud

<u>*E. Rodriguez, F. Papa*</u>

L. Smith, L Fenoglio, K. Nielsen, C. Schwatke, M. Tourian

Lakes/Wetlands

10 teams US, FR, Am-Sud, CN

<u>*J.Wang, S. Biancamaria*</u>,

M. Grippa, F. Frappart, F. Papa, M. Tourian, C. Schwatke, M. Fenoglio

Discharge algorithms

11 teams US, FR, DK, GM

<u>*M. Durand, C. Gleason, P-O. Malaterre, K.Larnier*</u>

K.Nielsen, M. Tourian, D. Lettenmeir, J. Wang, Oubanas, Ricci

Global modelling

4 teams US, FR, GM

<u>*D. Lettenmeir, A. Boone*</u>

J. Kushe, C. Schwatke, C.Ottle

+

Hydro Cal/Val

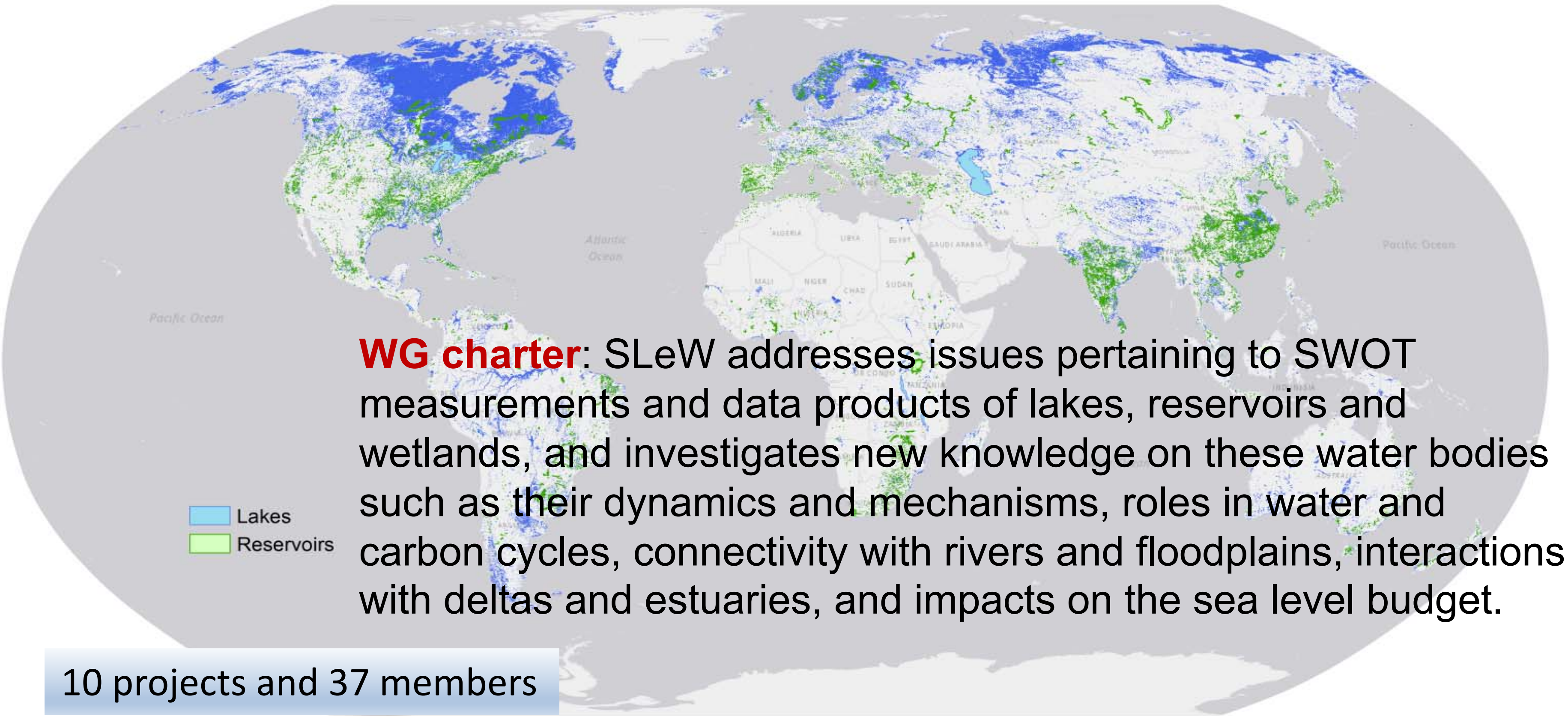
4 teams US, FR, GM, Am-Sud

<u>*P. bonnefond, F. Papa, T. Schöne, D. Moreira*</u>

Lakes and wetlands: SLeW

SWOT will produce water storage change on millions of lakes
SWOT will produce water level and extent over wetlands

⇒ **Which science not done before we can expect?**
⇒ **What can be learned using SWOT combined to other data?**
⇒ **What is the role of the SLeW?**



WG charter: SLeW addresses issues pertaining to SWOT measurements and data products of lakes, reservoirs and wetlands, and investigates new knowledge on these water bodies such as their dynamics and mechanisms, roles in water and carbon cycles, connectivity with rivers and floodplains, interactions with deltas and estuaries, and impacts on the sea level budget.

10 projects and 37 members

River Science WG

SWOT will produce water level and discharge every 10 km along with hundreds of thousands of reaches

⇒ **Which science not done before we can expect?**
⇒ **What can be learned using SWOT combined to other data?**
⇒ **What is the role of the SLeW**

Group charter : Rather than focusing on discharge algorithm, this group will investigate new knowledge that we plan and hope to get from SWOT on the hydrology, hydraulics and morphology of rivers; their role in water cycle, the connectivity of rivers with wetland and lakes; the role of rivers in climate changes.

12 projects & 36 researchers in the ST have significant overlap with the SWOT river science goals

It also has overlap / cross-polination with the following groups:

Discharge algorithn WG (DAWGG)
Global modeling and remote sensing
Lake and wetland science
Coastal / Estuarine group

Global Hydrology Modeling and Remote Sensing Working Group

Co-Chairs: Aaron Boone and Dennis Lettenmaier

Mission: Work together to incorporate SWOT observations of rivers, lakes and wetlands into global hydrologic models in order to improve understanding of the global water cycle.

Projects:

Aaron Boone et al: Towards a better understanding of the global hydrological cycle with SWOT

Petra Döll and Jürgen Kusche: GlobalCDA: Understanding the global freshwater system by combining geodetic and remote sensing information with modelling using a calibration/data assimilation approach

Dennis Lettenmaier et al: Development of spatiotemporally continuous runoff using SWOT discharge data products

Christian Schwatke and Denise Dettmering: SWOT for Monitoring Terrestrial Water Storage Changes: Quality Assessment and Combination with other Remote Sensing Data

Jida Wang et al: Integrating reservoirs into SWOT’s global surface water storage and discharge monitoring

The Discharge Algorithm Working Group

Team, Organization, Work Priorities from now until launch

Leads: Mike Durand (Ohio State), Colin Gleason (University of Massachusetts) , Kevin Larnier (CS Group), and Pierre Olivier Malaterre (Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement)

SWOT Science Team Meeting, February 8-9, 2021. Virtual.

The Discharge Algorithm Working Group (DAWG)

- SWOT discharge paradigm:
  - Discharge will be produced by the project using simple flow laws
  - Parameters needed to drive those flow laws will be estimated by the DAWG
- DAWG Mission:
  - Developing methods to estimate discharge from SWOT
  - Partner with the SWOT Project by creating flow law parameters
  - Evaluate SWOT discharge accuracy
  - Support science team discharge products
- DAWG status
  - The DAWG has met ~biweekly for nearly a decade, and has contributed to dozens of publications
  - Currently preparing for launch by implementing algorithms, and making decisions on how to implement and evaluate discharge (see Timeline)

DAWG-Related Science Team Projects

Jida Wang (KSU), George Allen (TAMU) & Yongwei Sheng (UCLA):
- Integrating reservoirs into SWOT's global surface water storage and discharge monitoring

Colin Gleason & Jay Taneja (U Mass):
- Confluence: a cloud-based open-source system to produce a global SWOT discharge product

Michael Durand (OSU) & Renato Frasson (JPL):
- Evaluation of the SWOT discharge data product

Ernesto Rodríguez & Renato Frasson (JPL):
- SWOT Discharge Estimation for Multichannel Rivers

Tamlin Pavelsky & Elizabeth Altenau (UNC):
- Creating the SWORD database*

H. Oubanas (INRAE), S. Ricci (CERFACS), PO Malaterre (INRAE):
- Estimation of River Discharges from SWOT Observations using Data Assimilation

Karina Nielsen (DTU):
- Enhanced Levels and Discharge estimates for Arctic Rivers

Jürgen Kusche (Bonn):
- GlobalCDA

MJ Tourian (Stuttgart):
- Estimation of River Discharge using SWOT: full catchment coverage with optimal space and time resolution (ERDSWOT)

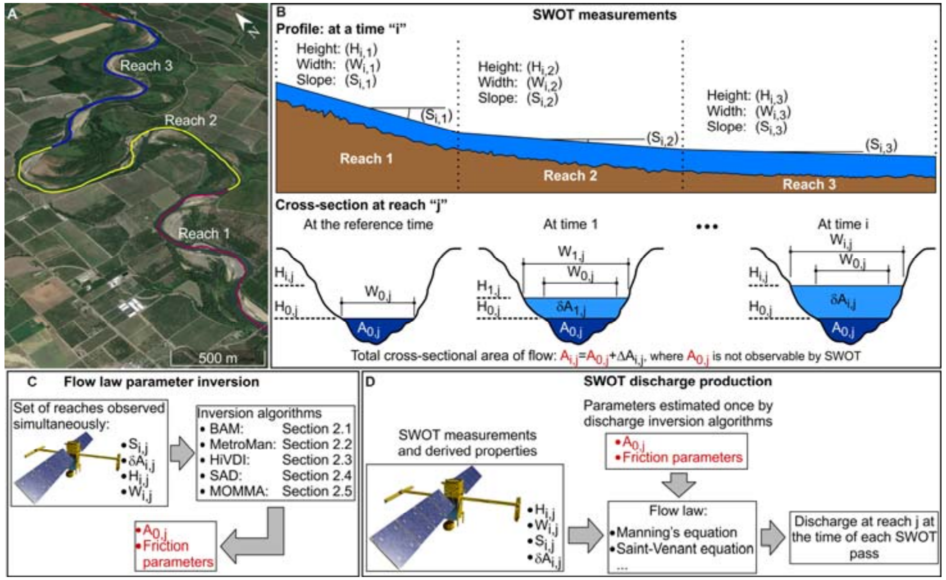
Luciana Fenoglio (Bonn):
- CONtinuum of Water from ESTuaries to coastal Dynamics (CONWEST-DYCO)

K Larnier (CS Group), J Monnier (IMT-INSA), C Emery (CS Group):
- SWOT Discharge Estimation using HiVDI*

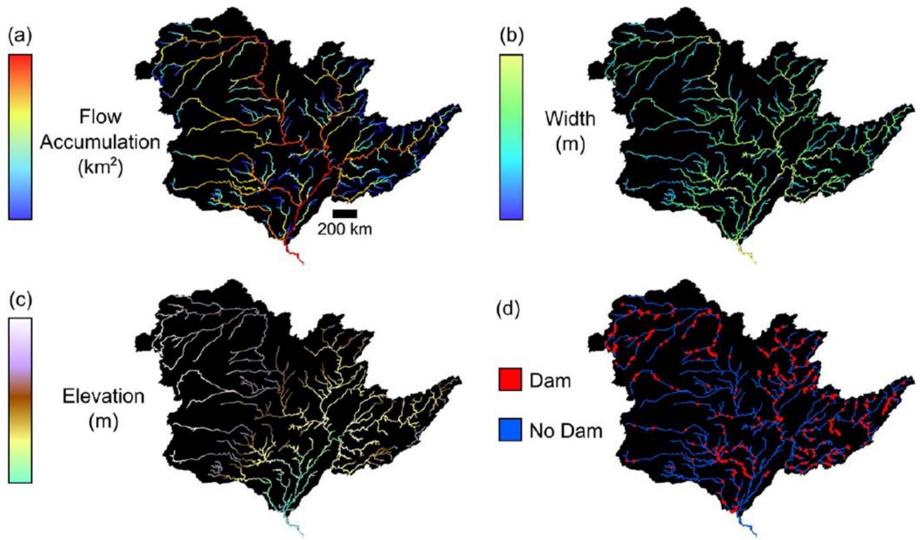
USA, France, Germany & Denmark

*Funded outside the SWOT ST

DAWG investigators have published dozens of papers on SWOT discharge algorithms, including AirSWOT, instrument simulator, synthetic datasets, real datasets using Landsat, at a range of spatial scales.



Pepsi Challenge v2 (developed during the previous ST projects), paper led by Renato Frasson (currently in revision at WRR)



The global SWOT a priori river database (SWORD) will support estimation of flow law parameters, as well as creating river data products for height, width, slope. Created at UNC by Elizabeth Altenau. Manuscript in preparation.

Timeline

- Preparation: 2021-Launch
  - Definition: Make decisions on data product details
  - Data: Assemble databases (SWORD, SWORD of Science, gages, models et al.)
  - Software: Implementation of algorithms to estimate flow law parameters, and auxiliary tools
- Launch: mid-2022
- Evaluation of discharge accuracy (joint with cal/val team): mid-2023
- Discharge products go live: late 2023

If you are interested in joining the DAWG email Mike Durand at durand.8@osu.edu. Everyone is welcome!

Discussion and Actions from Working Groups (1)

- What can be done to help communication within the groups?
- What information from the project is needed in order to enable researchers be ready before launch (documentation, simulations, error budget)?
- Issue on facilitating common database access to all researchers with the groups in order to reduce duplication of efforts? Need to share synthetic data from the simulator to facilitate the dev of algorithms (crucial for wetlands)
- Is there any benefit in sharing algorithm or other software tools (and which) to avoid duplication of effort prior to launch? What is the best way to share these tools?
- How could these two groups coordinate with other efforts (and which) not funded under the SWOT project?

Groups discussion and actions (2)

Which technical issues still need to be addressed before launch?

Do we need:

- Prior Lake Database to be improved before launch?
- to setup a priori DB for reservoirs?
- To develop drainage topology among individual lakes and reservoirs?
- To harmonize connectivity and drainage continuity between water storage and river databases?

How can we make sure that each community will be ready to evaluate the first SWOT data?

- In particular this is less developed for wetlands due to lack of a priori data and uncertainty of SWOT's capability in observing wetlands.
- What are the needs for generation of simulated SWOT HR data
- Identify tools that are still missing for analysis of level-2 data

Work before launch on accuracy analysis

- Participation in the Cal/val groups on lakes & rivers
- Do we need a priori lake &r eservoir inundation probability and bathymetry supporting accuracy assessment and reduces the impact of dark water and layover?
- Intercompare evaluation process and establish a common minimum comparison methodology for after launch data anaysis?