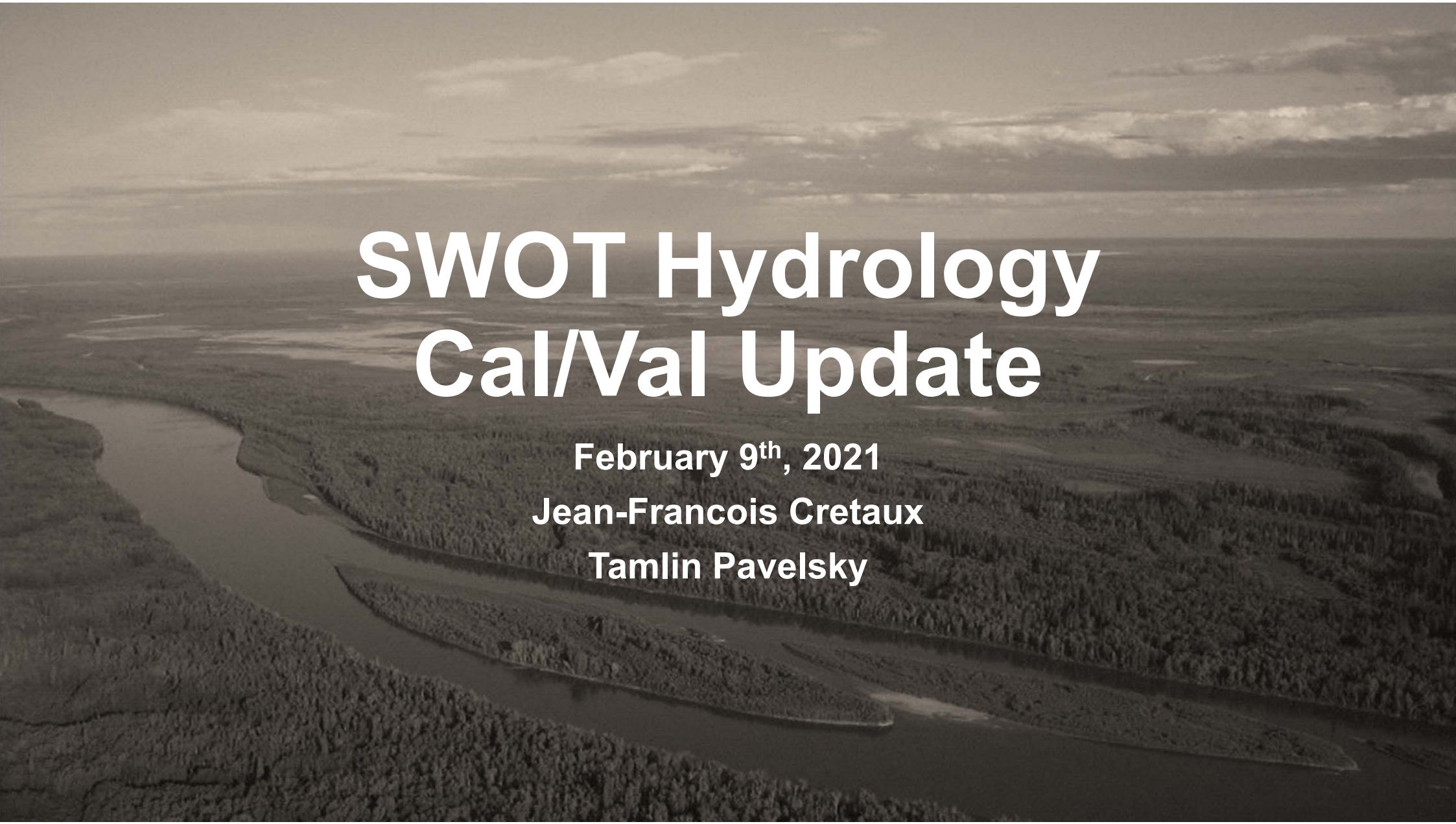


SWOT Hydrology Cal/Val Update

February 9th, 2021

Jean-Francois Cretaux

Tamlin Pavelsky

Overall Hydrology Cal/Val Approach

2 types of approaches will be adopted:

- **Global Cal / Val**
  - Comparison with existing in situ network
  - Comparison with global satellite products
- **On site Cal / Val**

  2 types of sites are proposed
  - "Tier-1" : High level of perennial and operational in situ measurements associated to field works
  - "Tier 2": opportunity site with limited in situ measurements and occasional field works.

2 Phases of cal/val:

- 1D-Orbit during 3 months at the beginning of the mission
- Nominal Orbit at 21 days during the 36 months of lifetime

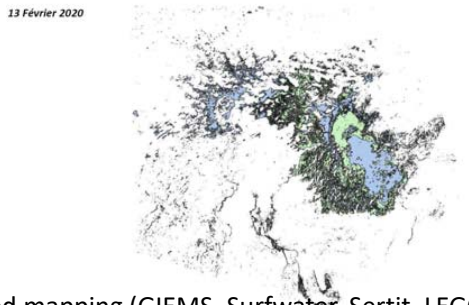
U.S., French, and Canadian teams will work together, leveraging the different strengths of each team

Global validation: comparison to global satellite products

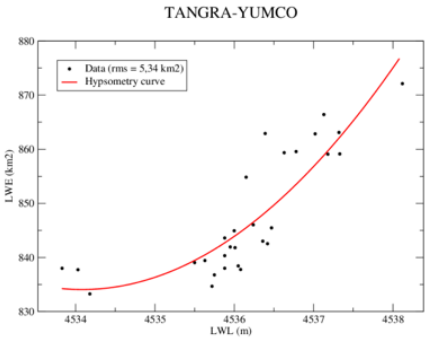
Nadir altimeters: Jason-CS/S6, Sentinel-3, ICESAT-2 → Water level on lakes & rivers

Radar and optical imageries: Landsat-8, Sentinel-1, Sentinel-2 → Water extent on lakes and width on rivers

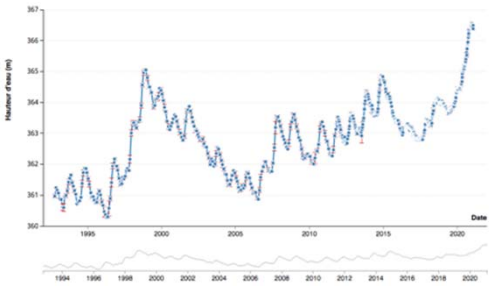
A priori satellite products: rating curves, hypsometry, bathymety → River Discharge, lake storage changes



Flood mapping (GIEMS, Surfwater, Sertit, LEGOS)

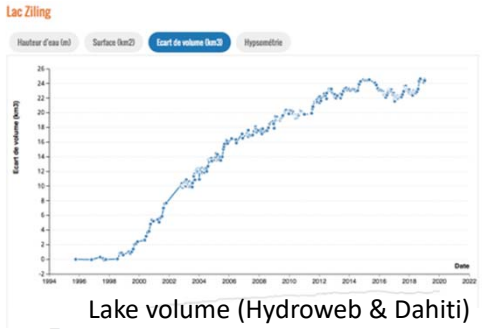


Hypsometry (Hydroweb & Dahiti)

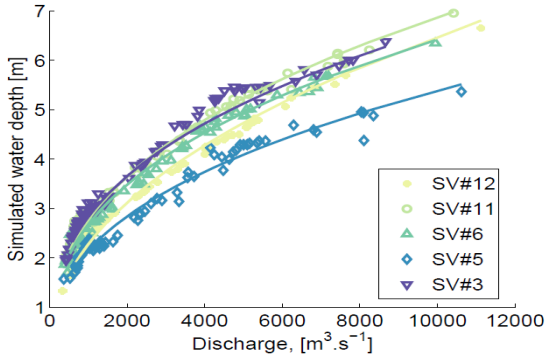


Lake & river level (Hydroweb & Dahiti)

Lake extent (Hydroweb & Dahiti)



Lake volume (Hydroweb & Dahiti)

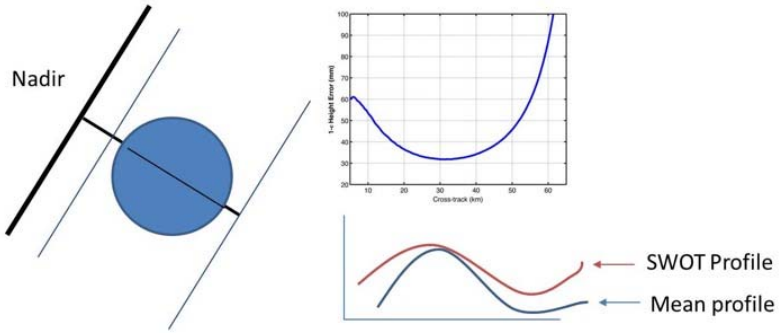


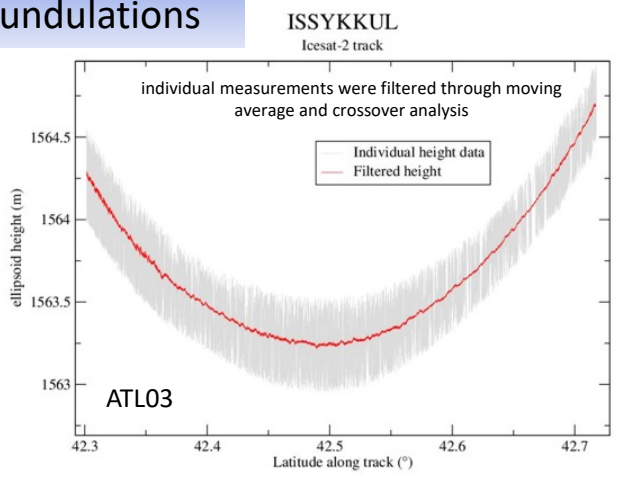
Rating curve (Hydroweb + MGB)

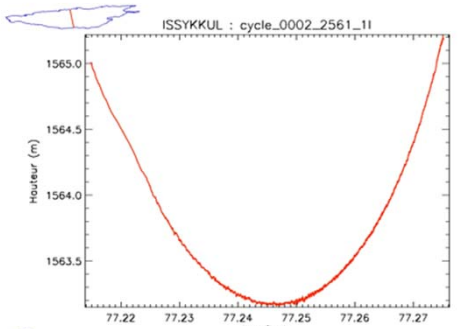
Global calibration: comparison to global satellite products

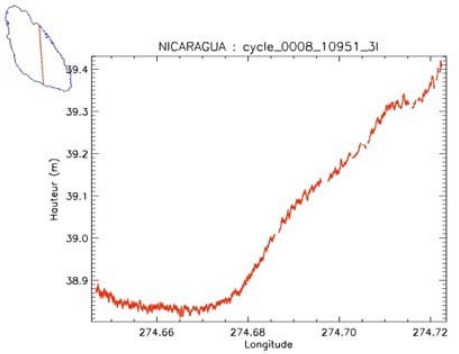
A priori database on lakes: geoid height undulations

- **Control data for:**
  - calibration of the roll errors
  - validation of SWOT heights across the swath

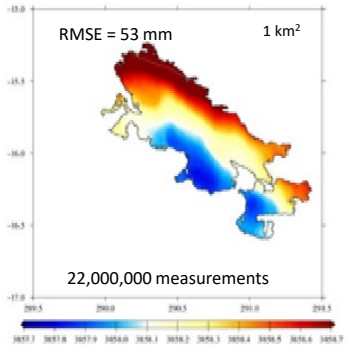




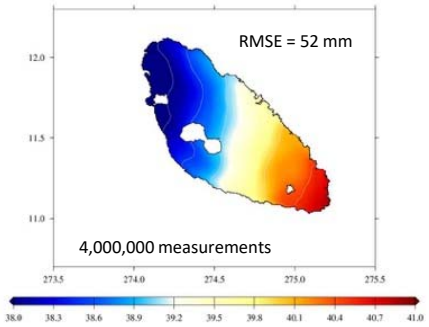




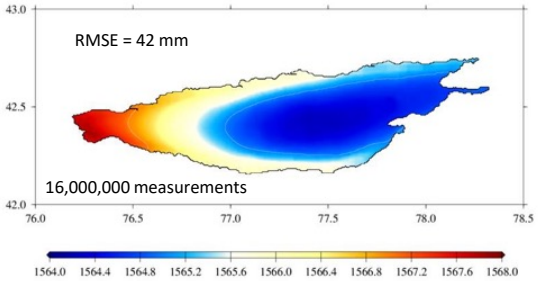
Mean lake surface on Titicaca

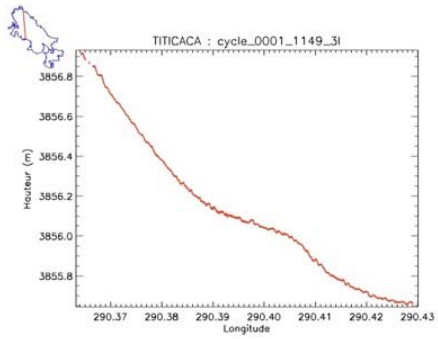


Mean lake surface on Nicaragua



Mean lake surface on Issykkul



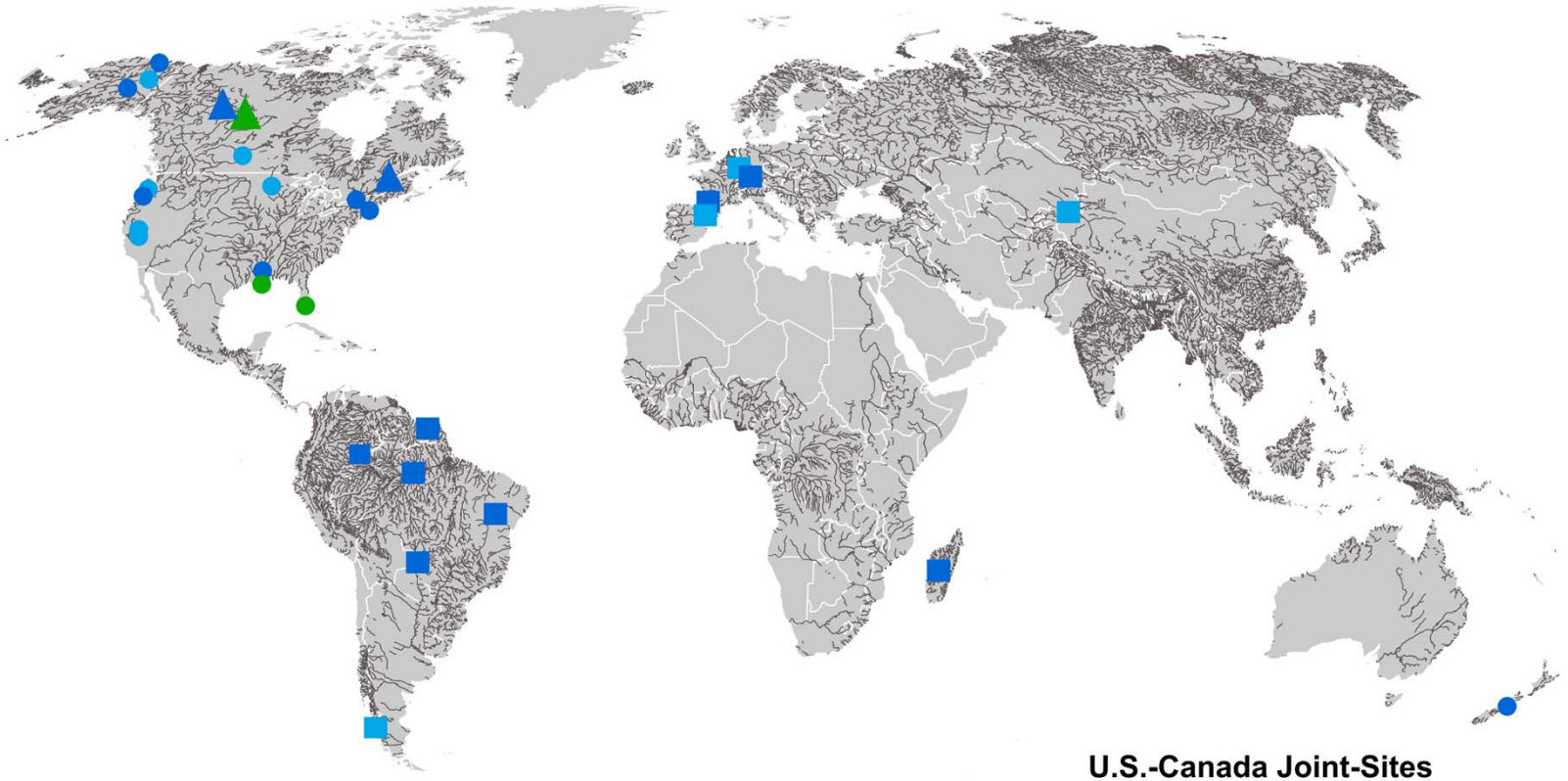


ICESAT-2 filtered ellipsoid height

A set of ~ 3000 to 4000 mean tracks from ICESAT-2 and 40 to 50 mean lakes surface from combination of several altimeters will be used to calibrate SWOT height measurements

Berge-Nguyen et al., 2021

SWOT Hydrology Validation Sites



U.S. Led-Sites

Rivers
- Willamete R. (Oregon)
- Conneticut R.
- Mississippi R.
- Tanana R. (Alaska)
- Sagavanirktok R. (Alaska)
- Waimakariri R. (New Zealand)

Lakes
- Lake Tahoe
- Central U.S. Prairie Lakes
- Sierra Nevada Lakes
- Pacific Northwest Lakes
- Yukon Flats Lakes

Wetlands
- Yukon Flats
- Mississippi Delta
- Everglades

U.S.-Canada Joint-Sites

Rivers
- N. Saskatchewan R. (Canada)
- St. Lawrence R.

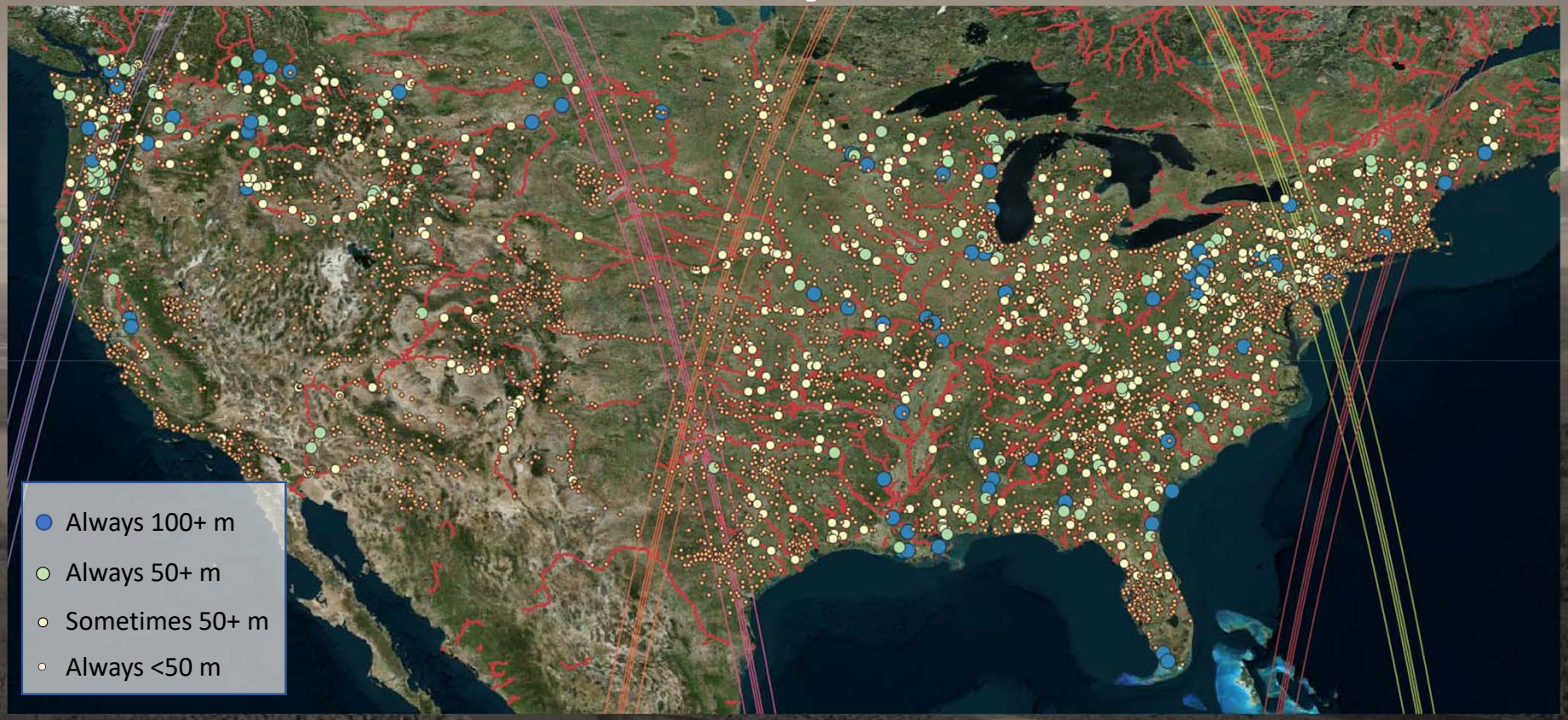
Wetlands
- Peace-Athabasca Delta

French Led-Sites

Rivers
- Rhine R.
- Garonne R.
- South American Rivers
- Madagascar Rivers

Lakes
- Lake Issyk-Kul
- Chilean Glacial Lakes
- Rhine Valley
- Pyrenees

Tier 2 Sites: Example of U.S. Rivers



In addition to Tier 1 sites that we will instrument, we will also make use of existing high quality measurements such as those from USGS stream gauges in the U.S.

On site validation

measurement's and products performances

- **Validation of height, extent on lakes, and height, width and slope on rivers:**
  - GPS ground leveling, drones, installation of limnigraphs
  - Extent by aerial imagery, or GPS mapping (experiment done in lake Chad in April 2019)

- **Validation of storage change & river discharge**

  Some bathymetries exist (Reservoirs in France, lakes in Chile) or generated using satellite imagery and laser altimetry (Lac Poopo, Sobradinho reservoirs).
  Discharge in situ measurements (ADCP) can be performed during field campaigns

On site calibration

Estimate calibration parameters on Large water bodies

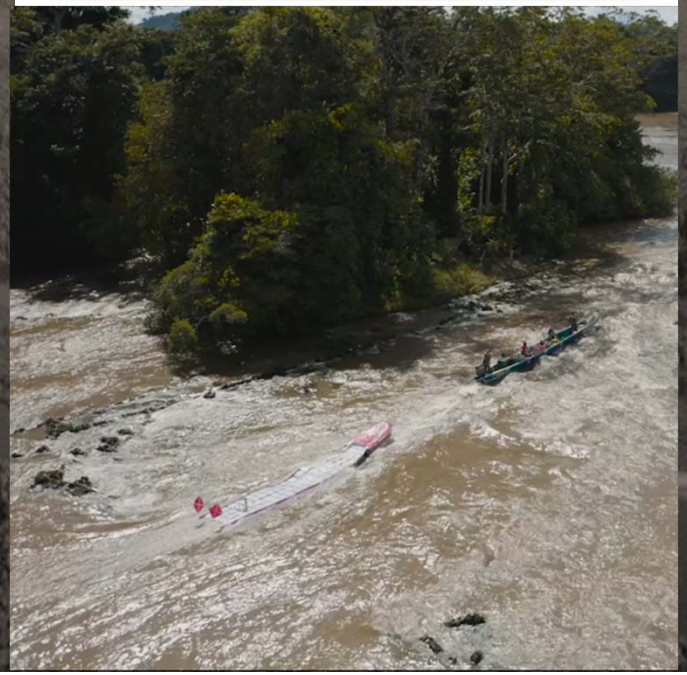
- **Error budget, and calibration of Karin instrument**

  Random cross track error, roll error, phase screen, EM, nadir altimeter bias, processing chain, atmospheric corrections (GPS network, boat campaigns on lakes and rivers, corner reflectors)

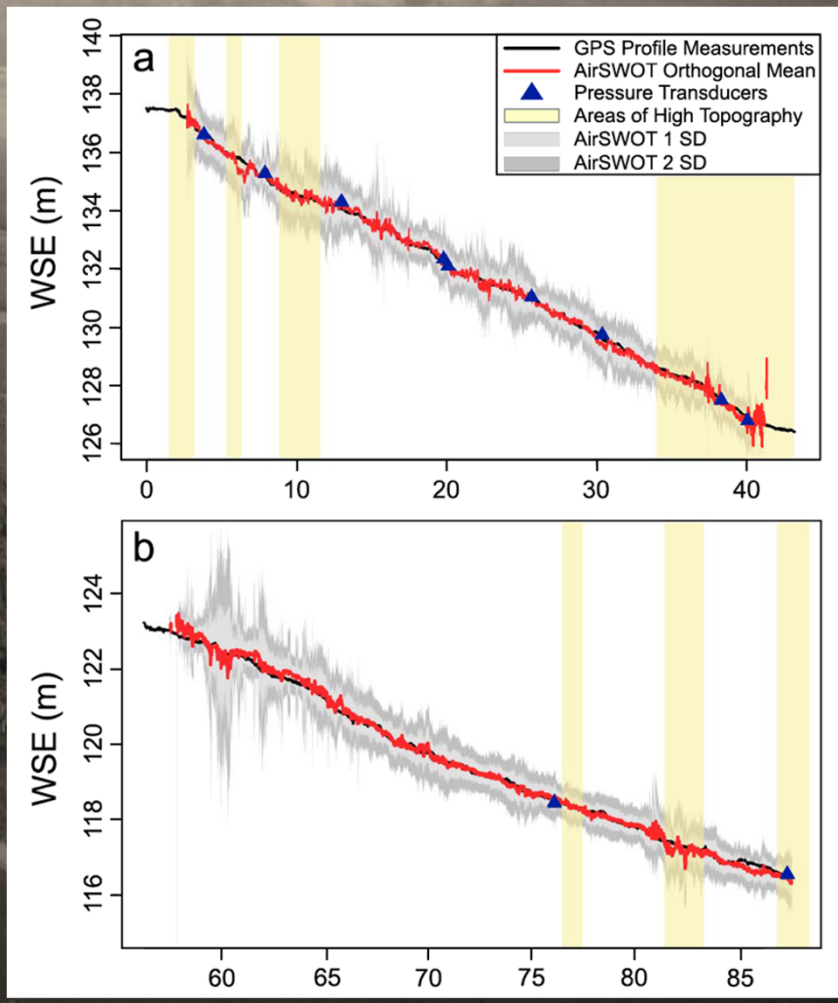
Three Options for Elevation/Slope Measurements

Pressure Transducers

GPS Floats

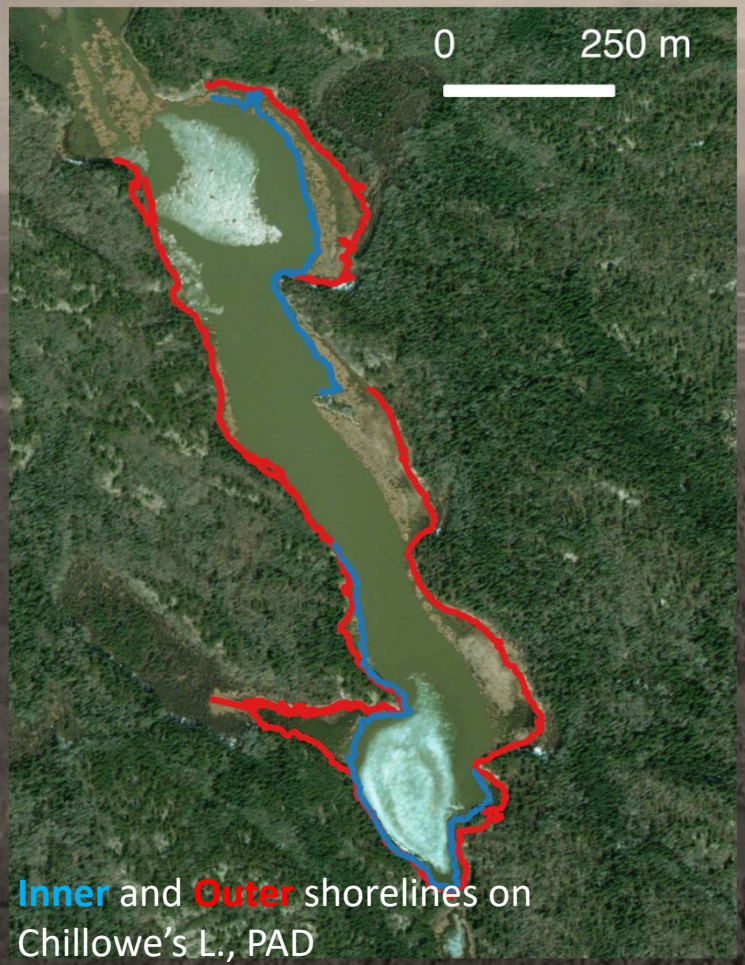


AirSWOT/Lidar



Three Options for Inundation Extent Measurements

Walking Shorelines



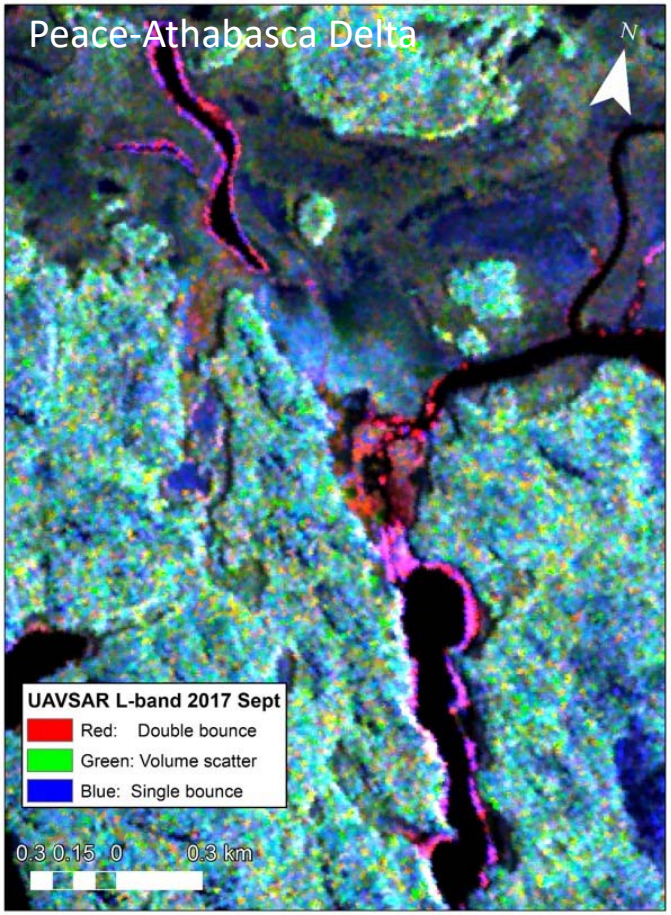
Inner and **Outer** shorelines on Chillowe's L., PAD

Courtesy T. Langhorst, UNC

Airborne Optical Imagery

Tanana River, Alaska

UAVSAR (L band)

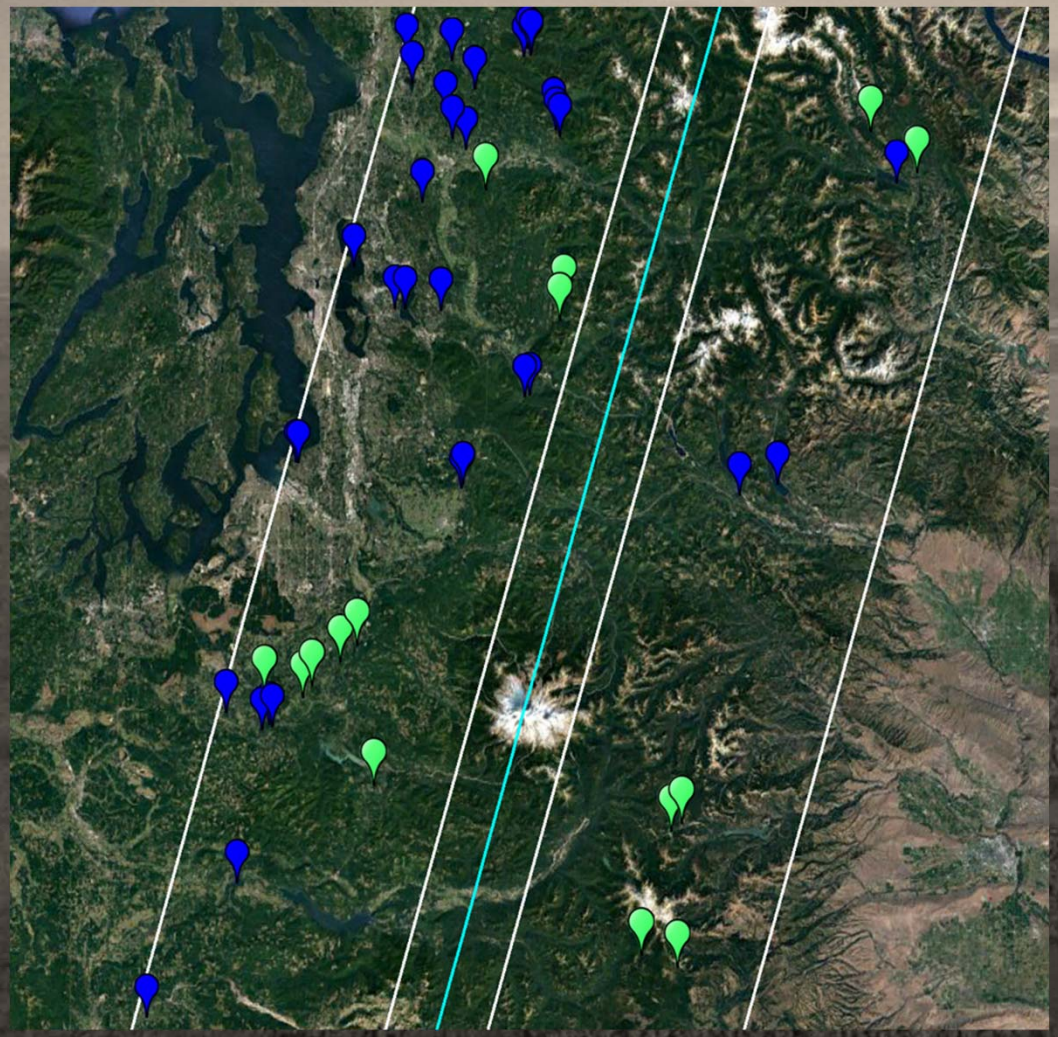


New Cal/Val Site: Waimakariri River, New Zealand

Reasons for Addition:

- Provides increased coverage of braided rivers
- Location in the Southern Hemisphere adds geographic diversity and reduced sensitivity to seasonality (e.g. ice)
- Presence of highly capable local collaborator (James Brasington, U. Canterbury) makes it an attractive target.

New Cal/Val Site: Pacific Northwest Lakes, US



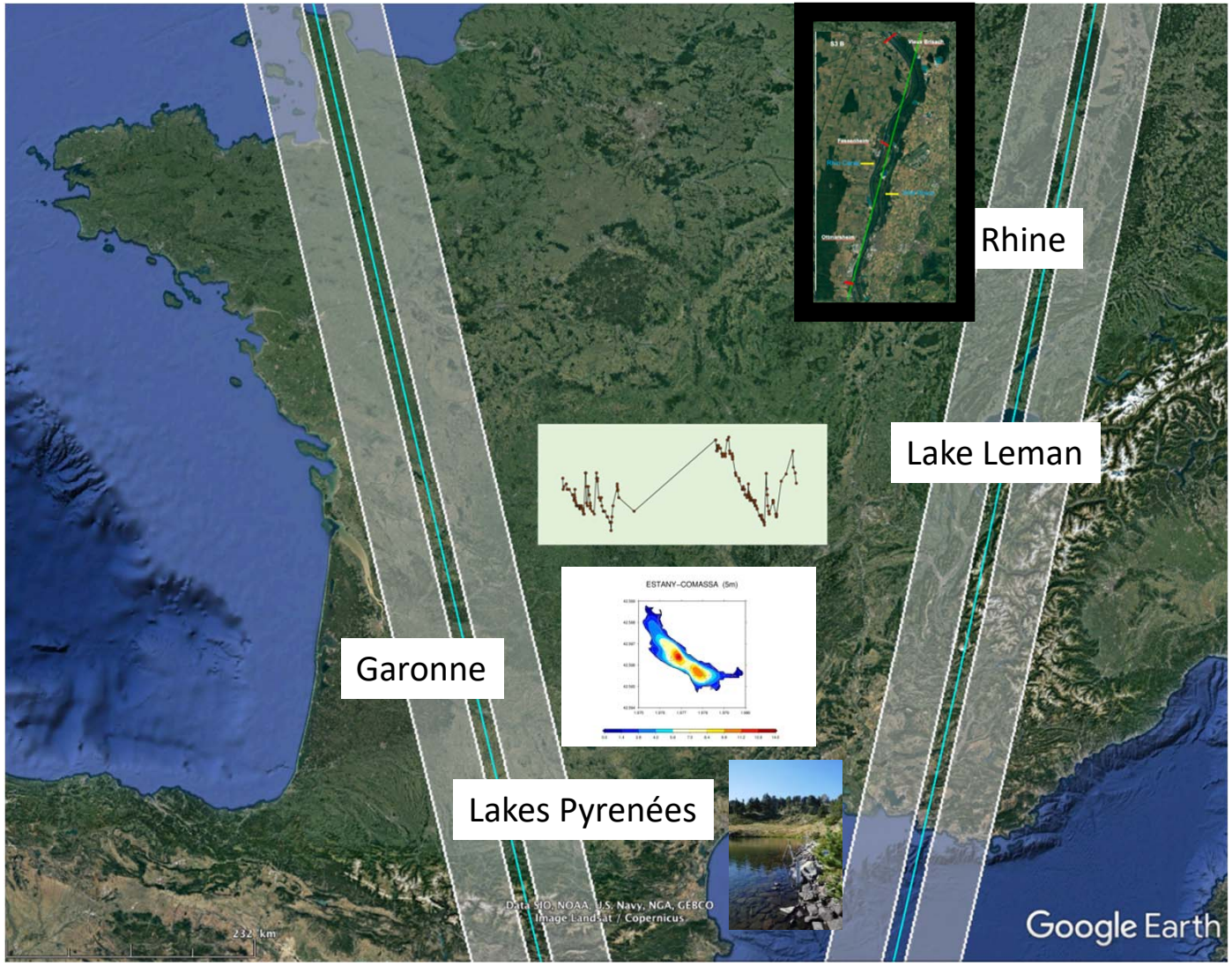
Reasons for Addition:

- Includes largely ice-free small lakes in the conterminous U.S.
- Existing measurement experience as part of the LOCSS project
- Easy access from Seattle

Green lakes are currently have staff gauges as part of the LOCSS citizen science project

Blue lakes are potential additional small lakes

On site Cal / Val: French lakes and rivers



Deployment of drones with GPS leveling

Installation of level gauges

On small lakes

along the rivers

} Citizen Sc Project & TOSCA prog

Bathymetry of lakes using echosounding

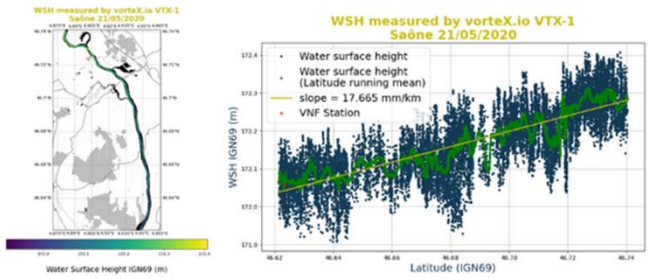
OECS & LOCSS projects

Validation of:

water level (lakes & rivers)

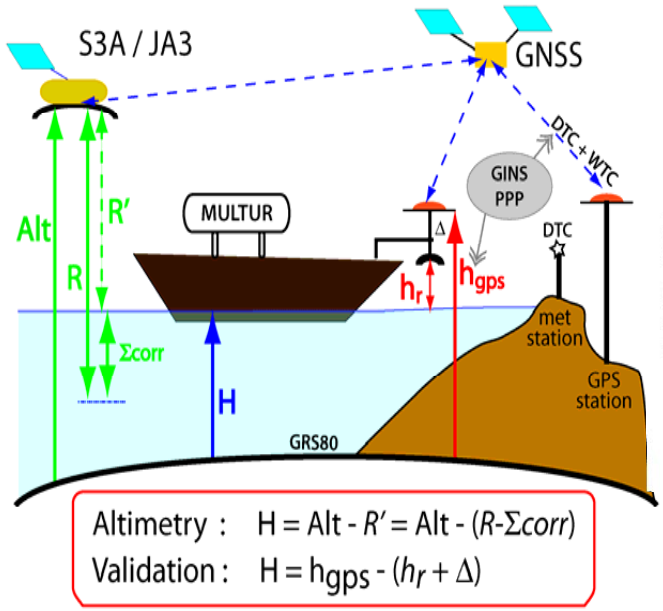
river slope

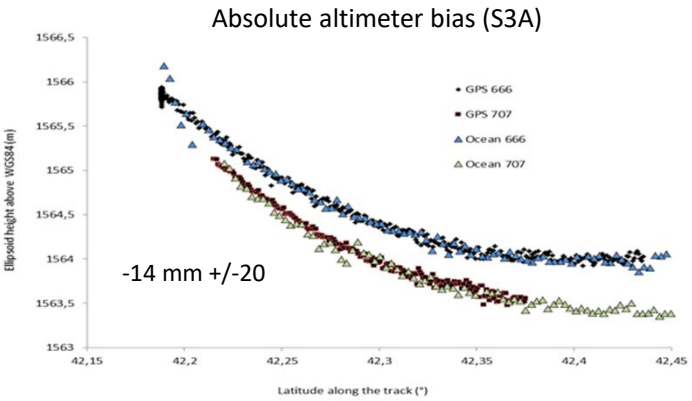
Lake volume changes



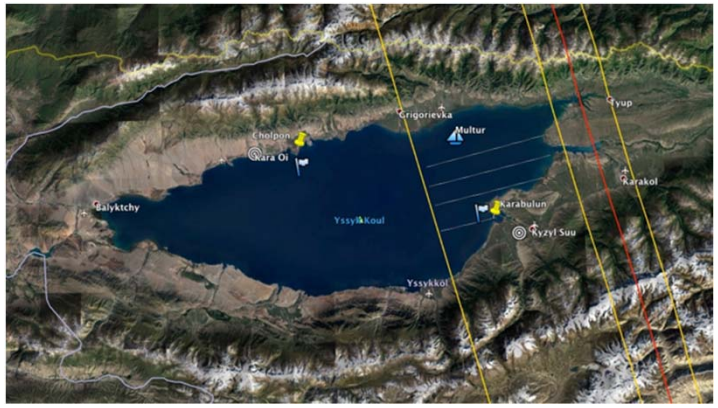
Courtesy Vortex

On site Cal / Val (Tier 1): Lake Issykkul





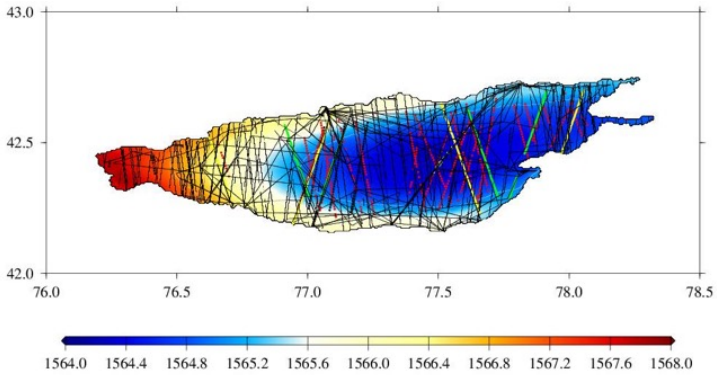
1-day orbit : Cal/Val phase



A 2 months field work will be setup during the C/V phase

- Calibration of absolute Height
- Phase Screen Calibration (small dynamic & geoid known very precisely)
- Atmospheric corrections using GPS ground network
- Validation of ocean and land processing simultaneously
- EM bias (possibly dependent on incidence angle) estimation would be possible
- Potential validation of Karin SWH and Wind estimation

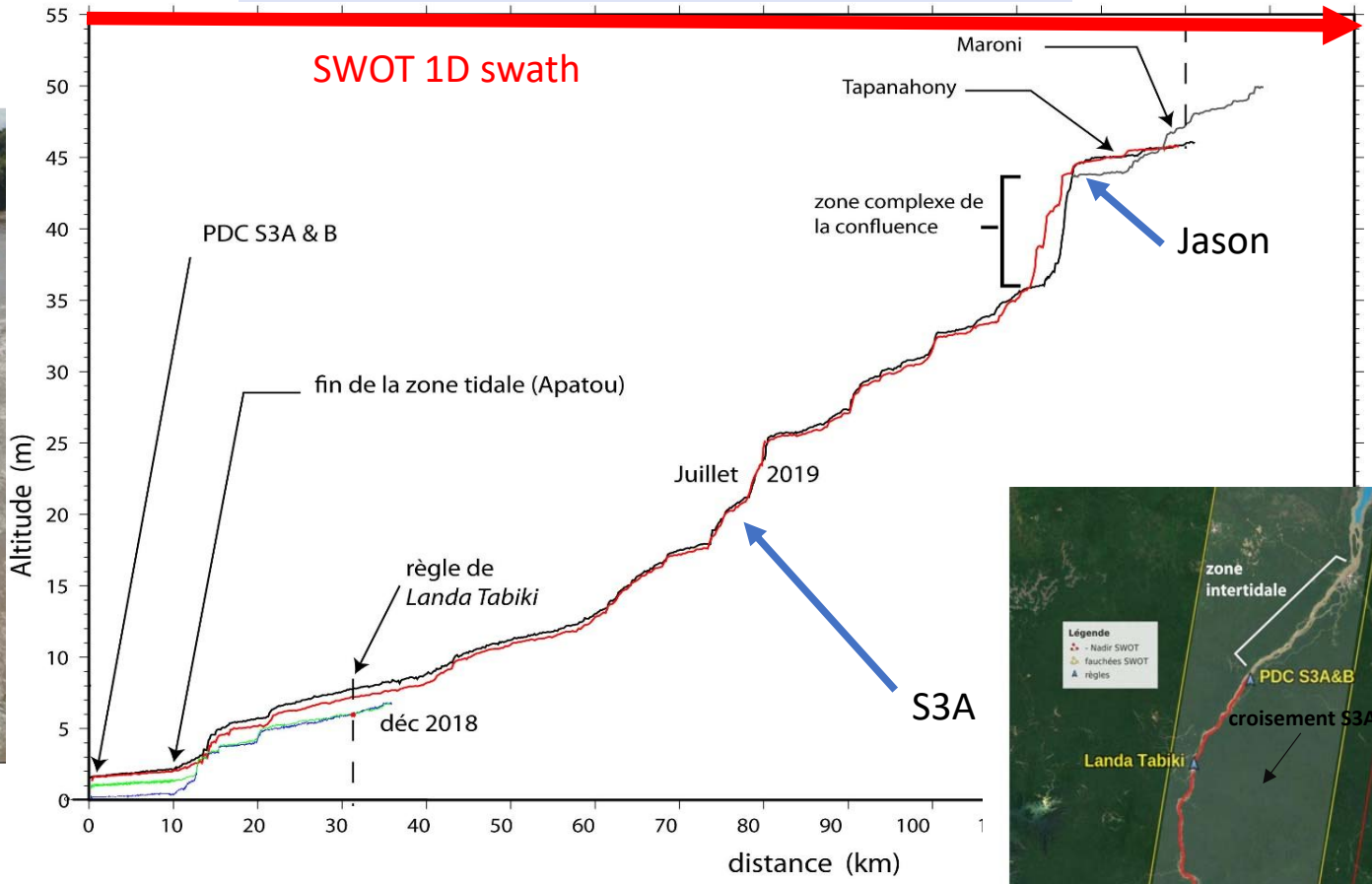
Mean lake surface on Issykkul calculated from 16 years of GNSS & radar + lidar altimeters



On site Cal / Val: South American Rivers

Very high stability of the CalNaGéo system: Even in high streamflow the antenna remain horizontal and stable

Tier 1 Cal/Val site: Maroni river, French Guyana



In Red the 2019 campaign

- A new campaign is planed in 2021 in order to measure the slope from upstream to the estuary
- The river is within the one-day orbit over a long distance

Cal/Val Plans Through Fast Sampling Phase

Team Leadership

USA: Colin Gleason, UMass; Toby Minear, Colorado; Larry Smith, Brown U.; Tamlin Pavelsky, UNC
Europe: N. Picot, (CNES), S. Calmant (IRD), J-F Cretaux (CNES/LEGOS), P. Bonnefond (Obs Paris), F. Papa (IRD/LEGOS)
South America: D. Moreira (CPRM/RIO)
Canada: A. Pietroniro (ECCC)

Prelaunch

- Hire hydrologic technicians (in USA & in France) to lead field measurements and data processing
- Conduct US prelaunch experiment on Connecticut River, the Tsiribinha, Rhine and Garonne in 2021
- Conduct prelaunch experiments on Issykkul and Chilean lakes in 2021
- Conduct joined prelaunch experiment on Willamette River and Issykkul alke in Summer 2022
- Plan logistics for fast sampling phase and early science orbit (US&French coordination)
- Prepare Tier 2 Sites in USA, Canada, France, South America
- In situ data collection: water level, bathymetry on tier 2 sites in Europe, Africa and South America
- Produce the a priori database on lake geoid undulations over a set of 50 large lakes and along Icesat-2 tracks

Fast Sampling Phase

- Conduct extensive measurements in Tier 1 sites that are under the fast sampling orbit
- Process data to meet requirements for comparison with SWOT
- Work with colleagues at JPL, CNES, and in the Science Team to begin evaluating SWOT data