Lake, River, and Wetland Processes & Science

- ☑ Thakur (India)—SWOT cal/val & science in India
- ☑ Leon (Colombia)/Calmant(FR)—SWOT preparation in the Orinoco Basin
- ☑ Tomasella (Brazil)/Papa/Frappart—Development of inundation maps for SWOT cal/val.
- ☑ Al Bitar / Parrens (FR)—SWOT & L band sensors for wetlands
- ☑ Yesou (FR) – Yangtze River Basin science
- ☑ **Sheng**/Lettenmaier (US) – Lake delineation & modeling

Characteristics of Projects

- ☑ International:
  - International group;
  - Study sites across six continents;
  - International contributions to Cal/Val (with in-situ measurements).
- ☑ Addressing lake, river and wetland dynamics;
- ☑ Radar altimeter data being used in common and water surface extents more or less.

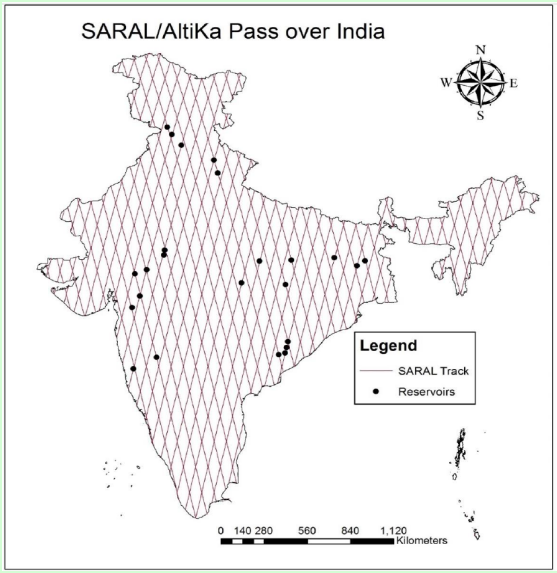
India SWOT Cal/Val and Science Studies

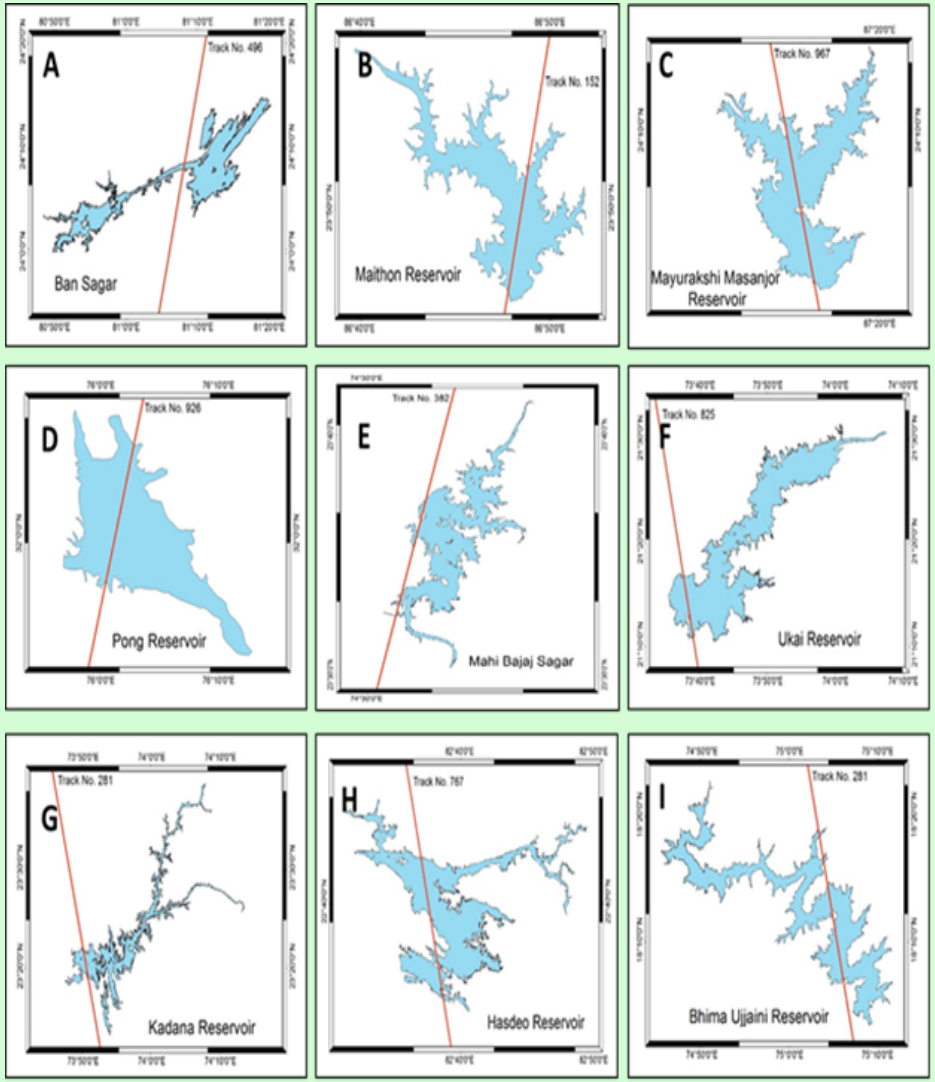
Dr. Praveen K. Thakur
WRD, IIRS (ISRO) Dehradun

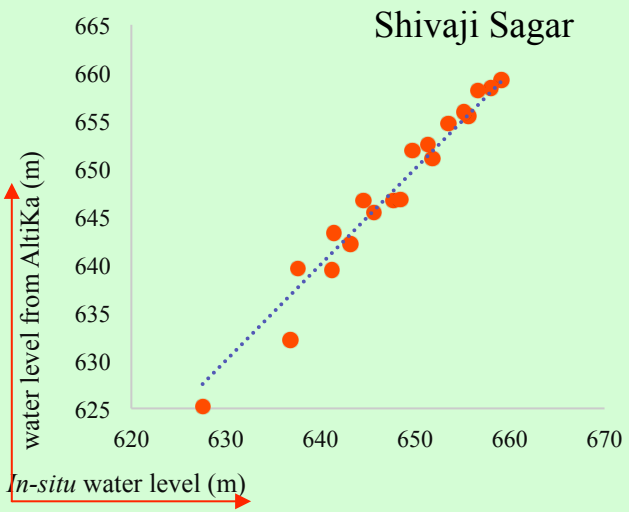
Research objectives:

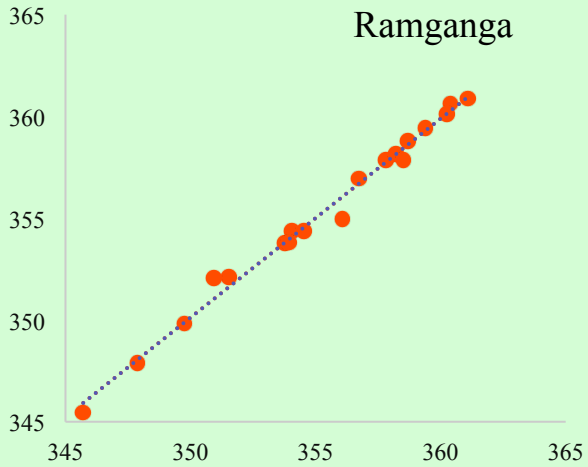
1. Estimating Water Level and Discharge of inland water using SWOT KaRIN altimetry
2. Study of water storage change in the Ganges basin using SWOT, SMAP, GRACE, Global Precipitation Mission, MODIS ET
4. Glacier and Snow/Ice Monitoring using SWOT
5. Calibration and validation of SWOT derived water level and discharge results

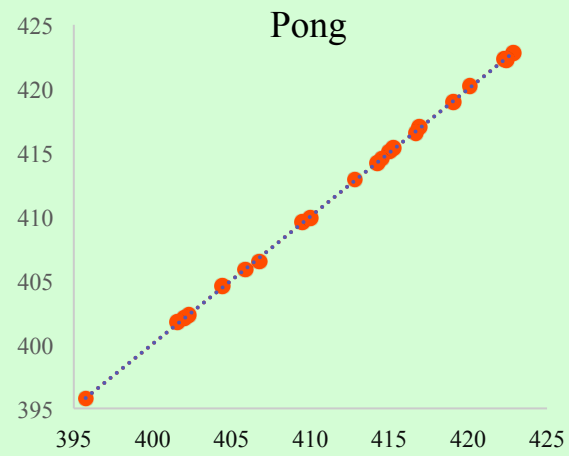
Current results: Water level of reservoirs using Saral-Altika altimeter









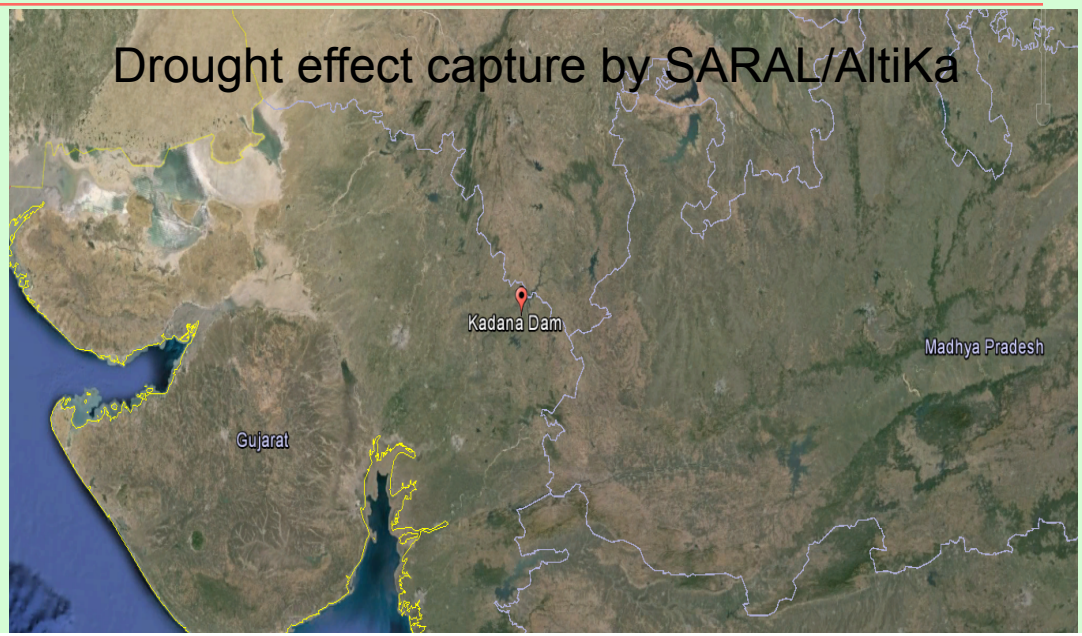


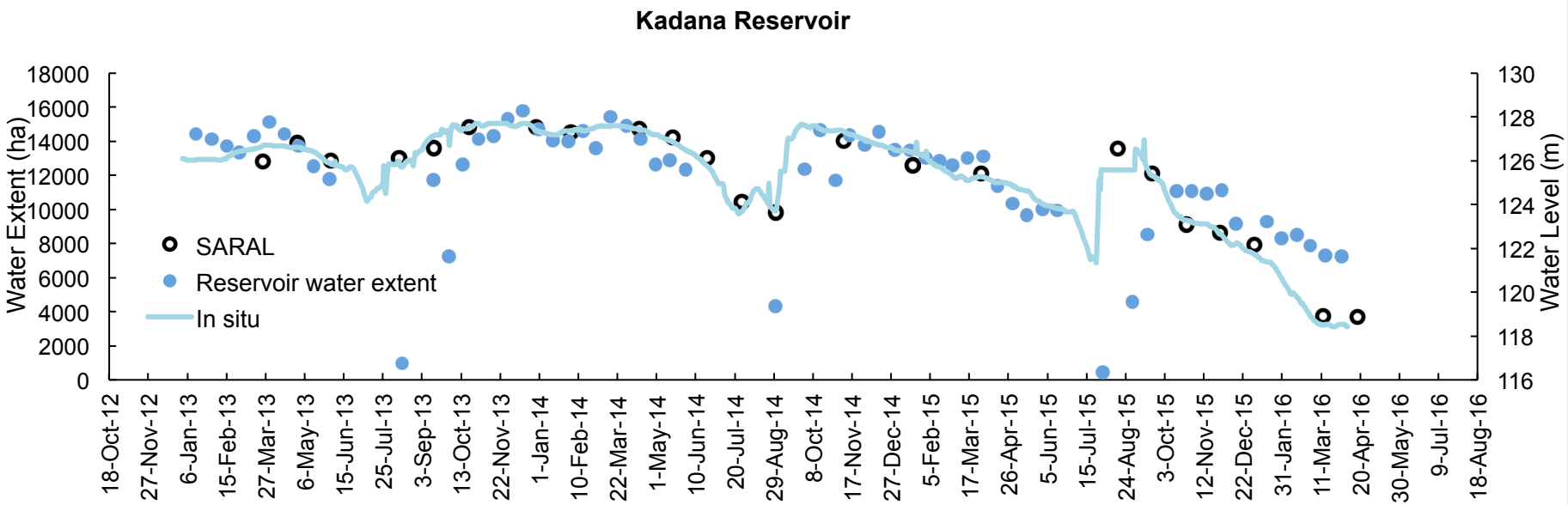
Results

Sl. No.	Reservoir	RMSE (m)	R^2	Correction factor (m)
1	Ban Sagar	0.14	0.996	0.25
2	Gandhi	0.62	0.939	0.47
3	Hasdeo	0.24	0.983	-0.27
4	Indravati	0.27	0.997	1.23
5	Jalatput	0.55	0.984	13.79
6	Kadana	0.32	0.938	0.4
7	Kolab	0.73	0.925	1.34
8	Mahi	0.38	0.995	0.36
9	Maithon	0.49	0.981	0.44
10	Massanjore	0.41	0.991	0.57
11	Pong	0.11	1.000	0.67
12	Ramganga	0.35	0.993	1.33
13	Ranapratap	0.21	0.991	0.36
14	Shivaji	1.64	0.990	-10.53
15	Tilaiya	0.13	0.993	1.41
16	Ujjaini	0.32	0.992	0.68
17	Ukai	0.21	0.998	0.85

Sl. No.	Reservoir Name	State	SARAL Pass no	Minimum WL (m)	Maximum WL (m)	Amplitude (m)
1	Ban Sagar	Madhya Pradesh	496	333.47	341.64	8.17
2	Gandhi Sagar	Madhya Pradesh	840	391.79	399.86	8.07
3	Hasdeo Reservoir	Chatishgarh	767	348.17	359.30	11.13
4	Indrawati Reservoir	Odhisa	309, 324	627.65	642.10	14.45
5	Jalaput Reservoir	Odhisha	324	825.19	838.03	12.84
6	Kadana Reservoir	Gujrat	281	118.42	127.71	9.29
7	Kolab Reservoir	Odisha	324	847.56	856.95	9.39
8	Mahi Bajaj Sagar	Rajasthan	382	267.6	281.50	13.9
9	Maithon Reservoir	Jharkhand	152	136.2	150.81	14.61
10	Massanjor Reservoir	Jharkhand	967	109.42	120.52	11.1
11	Pong Reservoir	Himanchal Pradesh	926	395.7	423.80	28.1
12	Ramganga Reservoir	Uttarakhand	395	330.04	362.43	32.39
13	Ranapratap Sagar	Rajasthan	840,653	345.59	352.82	7.23
14	Shivaji Sagar	Maharashtra	840	620.22	659.51	39.29
15	Tilaiya Reservoir	Jharkhand	238	359.59	371.39	11.8
16	Ujjani Reservoir	Maharashtra	281	486.24	497.73	11.49
17	Ukai Reservoir	Gujrat	825,382	90.01	105.04	15.03

Kadana Dam


Drought effect capture by SARAL/AltiKa
Kadana Dam
Madhya Pradesh
Gujarat


Kadana Reservoir
Water Extent (ha)
Water Level (m)
SARAL
Reservoir water extent
In situ
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
130
128
126
124
122
120
118
116
18-Oct-12
27-Nov-12
6-Jan-13
15-Feb-13
27-Mar-13
6-May-13
15-Jun-13
25-Jul-13
3-Sep-13
13-Oct-13
22-Nov-13
1-Jan-14
10-Feb-14
22-Mar-14
1-May-14
10-Jun-14
20-Jul-14
29-Aug-14
8-Oct-14
17-Nov-14
27-Dec-14
5-Feb-15
17-Mar-15
26-Apr-15
5-Jun-15
15-Jul-15
24-Aug-15
3-Oct-15
12-Nov-15
22-Dec-15
31-Jan-16
11-Mar-16
20-Apr-16
30-May-16
9-Jul-16
18-Aug-16

Characterization of spatial and temporal variations in surface waters at Orinoco Basin based on SWOT measurements and other satellite radar altimetry sources

Juan Gabriel LEON - UNIVERSIDAD NACIONAL DE COLOMBIA (COL)

Stéphane CALMANT - IRD – LEGOS (FRA)

Rafael REBOLLEDO - INSTITUTO DE INGENIERIA PARA LA INVESTIGACIÓN (VEN)

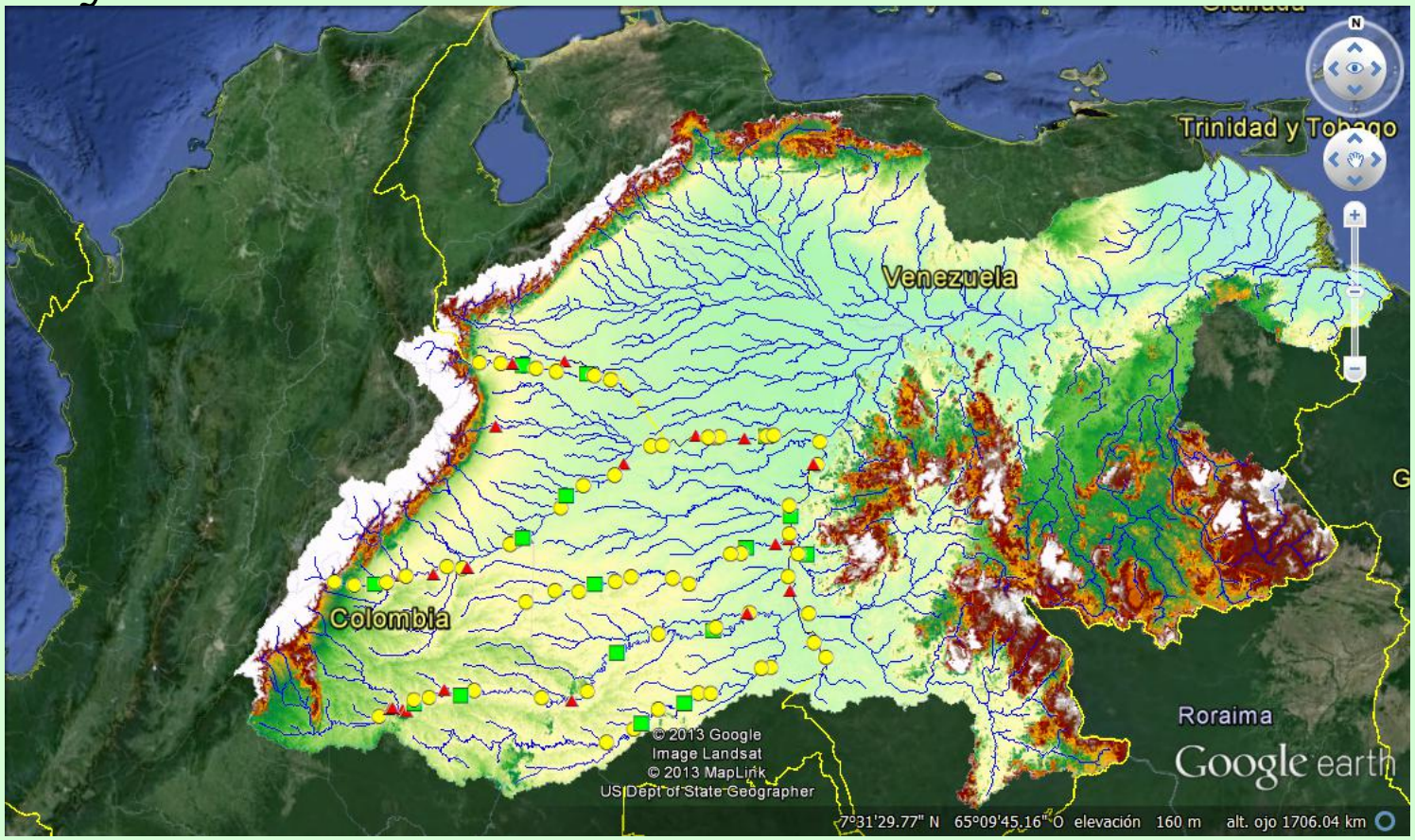
Main objective: to characterize spatial and temporal variations in surface waters at Orinoco Basin based on SWOT measurements and ENVISAT, JASON-2 & 3 and SARAL virtual stations network.

UNIVERSIDAD NACIONAL DE COLOMBIA SEDE PALMIRA

IRD Institut de recherche pour le développement

Fundación Instituto de Ingeniería para Investigación y Desarrollo Tecnológico

Study area



Orinoco basin. Surface: 1,015,000 km2. Main river length: 1,783 km. Main river discharges to the ocean: up to 30,000 m3/s. Yellow and green dots: potential monitoring virtual stations, red dots: in situ hydrological stations. No information available for Venezuelan surface.

Main Activities:

i) Transferring Satellite Radar Altimetry (SRA) techniques and applications in hydrology, from the Colombian and French research teams to the Venezuelan research team.

ii) Completing the actual virtual spatial network, already developed by the Colombian research team at the upper Orinoco Basin, over the total surface of the basin by joint collaboration between the research teams involved.

iii) To explore the alternatives to integrate SWOT measurements into the SAR virtual spatial network regarding the following actions:

   i) To participate into the SWOT calibration and validation.

   ii) To integrate SWOT measurements in hydrological models.

   iii) To evaluate SWOT measurements in lake processes, for river water levels and discharges analysis, and for wetlands surface waters, storage and connectivity analysis.

SELECAO: SurfacE water volume from high resoLution wetland Extent maps Combined with Altimeter Observations

SWOT ST France-South America

PI: Fabrice Papa (IRD- France) and Javier Tomasella (CEMADEN, INPE Brazil),
Co-I: Frédéric Frappart (LEGOS), Joecila Santos Da Silva (Uni. Manaus), Rodrigo C.D. Paiva (IPH-UFRGS), Stéphane Calmant (LEGOS-IRD) and Filipe Aires (Obs. Paris)
fabrice.papa@ird.fr
LEGOS-IRD, Toulouse, France
Presently at IFCWS, IRD-IISc, Bangalore, India

Cemaden
Centro Nacional de Monitoramento e Alertas de Desastres Naturais

LEGOS

IRD
Institut de recherche pour le développement

SELECAO: SWOT NASA-CNES ST 2016-2019

The scientific objectives of SELECAO are:

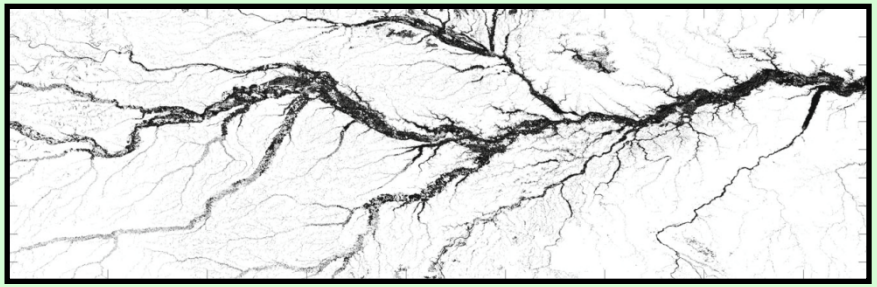
1) Infer the spatial and temporal variability of surface freshwater stored in the Amazon basin at high spatial resolution (500 m)

2) Analyze the seasonal and interannual dynamics of Amazon surface water extent and volume, and the different processes at play at different spatial/temporal scale to better characterize extreme events such as flood and drought for 1993-2007.

3) Study the impact of high spatial resolution estimates of surface water to better characterize sub-surface water storage dynamics in the Amazon basin.

4) Evaluate the ability of current hydrological simulations to estimate the dynamic of high spatial resolution surface water extent to prepare the future SWOT era.

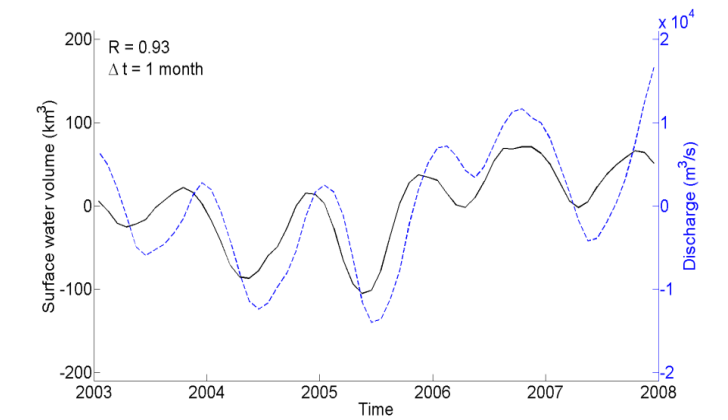
5) Provide the community with important benchmark products to future evaluation of SWOT observations in the Amazon basin.

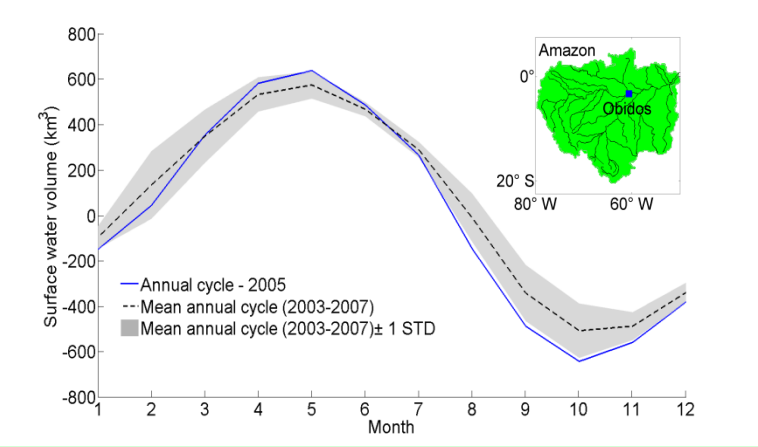


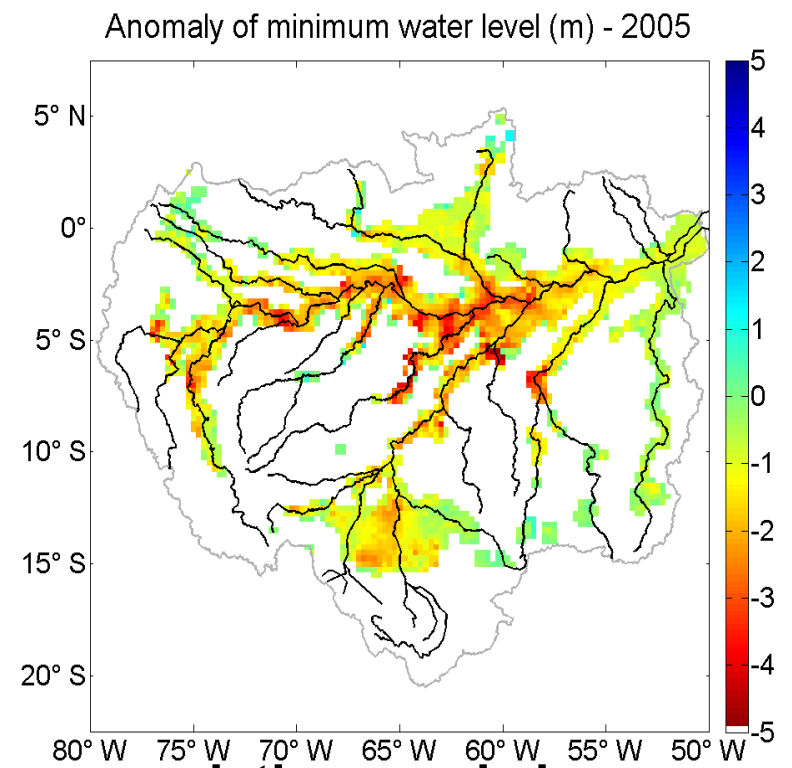
Downscaled GIEMS over the Amazon at ~500 m resolution, available from 1993 to 2007. Here January 1993 (adapted from Prigent et al., 2016)

Variations of surface water storage: 1st Approach

Dynamic surface water storage in the Amazon: the 2005 drought







5-year variations and changes
Water Level Anomaly in 2005

=-- Surface water reservoir varies from 800 to 1,200 km^3 per year
-=- ~50% of the total water storage variations as detected by GRACE
--= During the 2005 drought, surface water were 70% below average

Same approach over the Ganges-Brahmaputra, Orinoco and the Congo

TOSCA-SOLE

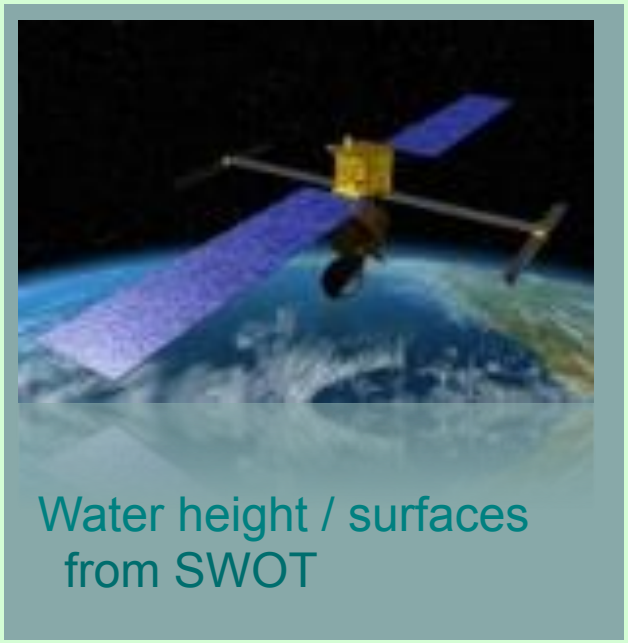
Synergies between SWOT and L-Band sensors for wEtlands

Ahmad Al Bitar (CESBIO/CNRS – PI)
Marie Parens (Post- doc CNES – co-PI)

Partners:

Frederic Frappart (LEGOS)
Fabrice Papa (IRD)
Yann Kerr (CESBIO)
Jean-François Cretaux (LEGOS)
Jean-François Cretaux (LEGOS)
Stephane Calmant (GET)
Rodrgo Paiva (IPH)
Marie Laure Bonnet (IRD, GET)

> Altimetric levels and water surfaces for water volumes



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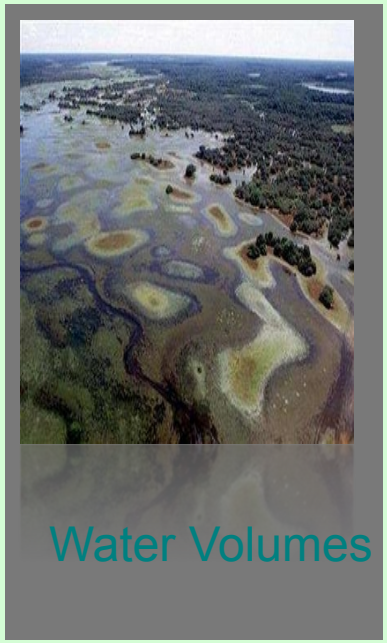
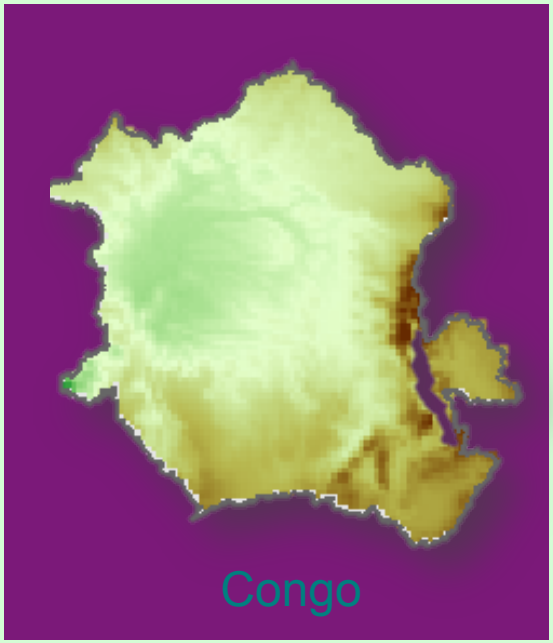


SWOT will provide unprecedented information over wetlands via its « imaging reconstruction «capabilities.

We recently showed the capabilities of L-Band radiometers to monitor water sufaces over large extents at a relatively high temporal resolution in all weather and under vegetation.

The combination of the two previous products will provide unprecedented monitoring at 3 days and kilometric over densly

> Three basins

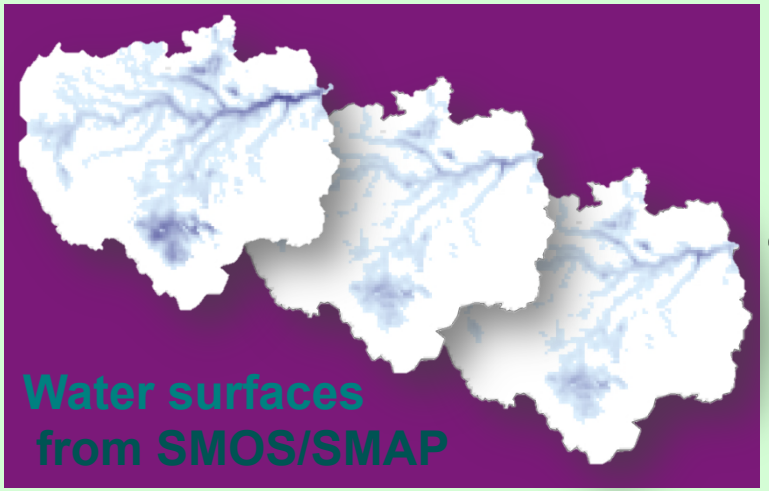


Very well documented site with a fair ammount of validation information.

Not very well documented site with poor ammount of validation information but presents is high stacks.

More challenging for L-Band microwave and SWOT mission

> Altimetric levels and water surfaces for water volumes



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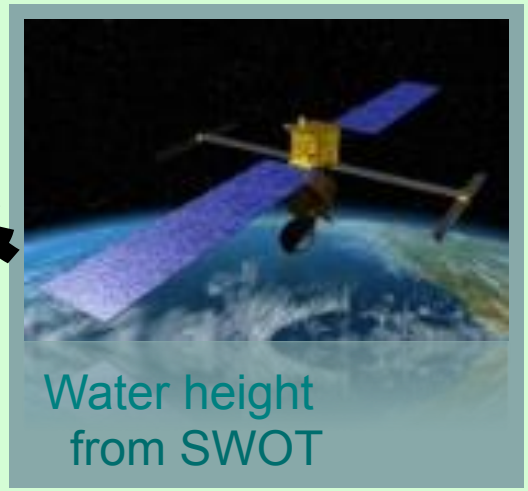
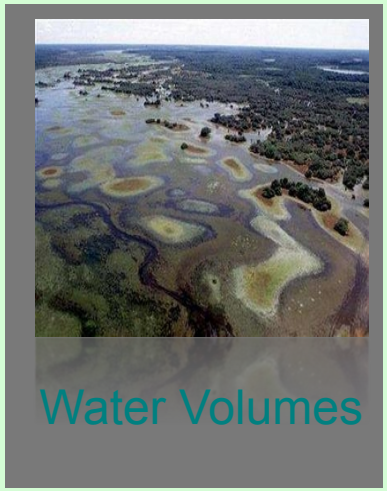
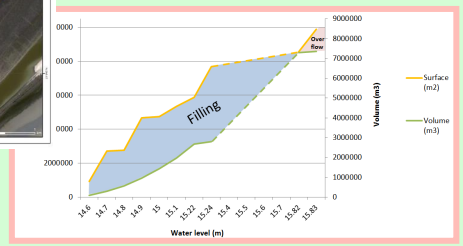


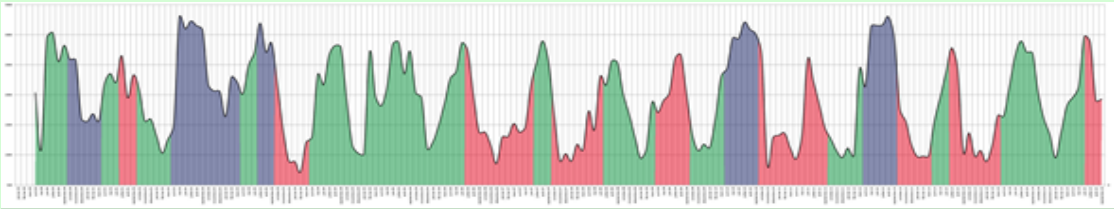


> Improving discharge by assimilation of water height/surfaces/volumes of wetla

> asssimilation using sequential filters into IPH-MGB hydrodynamic model with water storage reservoirs

Yangtze river Basin Science

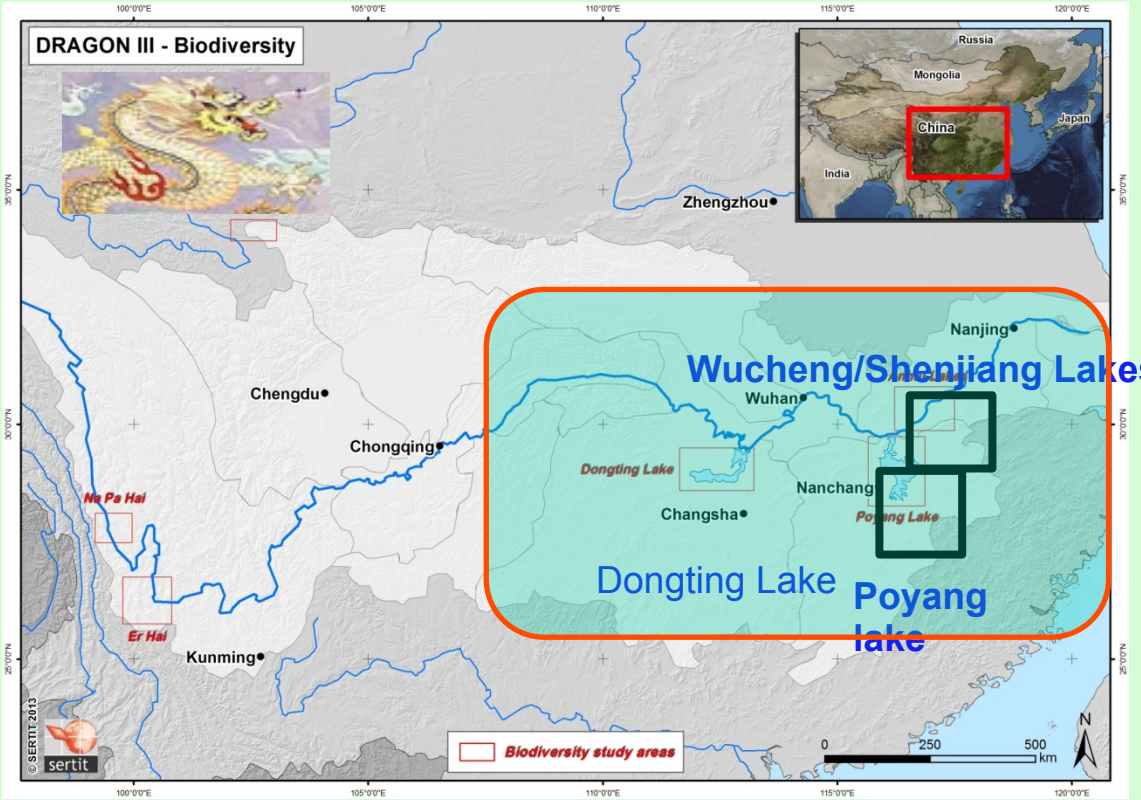




Herve Yesou, Laurence Fruteau, Denis Blumstein, Sadri Haouet, Claire Huber, Henri Giraud, Mathias Studer, Pierre André Garambois Jérome Colin, Benoit Laignel & Jean François Cretaux

ICube- SERTIT / MecaFlu/Trio, Un. of Strasbourg, Strasbourg, France: herve.yesou@unistra.fr
LEGOS-CNES, Toulouse, France: Jean.Francois.Cretaux@legos.obs-mip.fr
M2C, Rouen, France, benoit.laignel@univ-rouen.fr

Yangtze river's monsoons lakes & wetlands



- Downstream 3GD 748 000 km²
- 25% freshwater of SE Asia
- +6000 Lakes, pounds, reservoirs
- 1 ha to 3500 km²
- Large flooded lakes: 30-40 % of area

330 000 000 of inhabitants as a fresh water resource.

- Climate fluctuation (rainfall deficit the ten latest years) and man activities (ie Three Gorges dam) could have significant impact on water resource;

Public Health (Schistosomiasis) & Biodiversity stakes (World importance wintering areas for wildfowl)

General context: SWOT modeling over FloodPlain & Wetland

1 - Large diversity of water bodies along Yangtze reaches=> How SWOT signal would be able to distinguish these ?

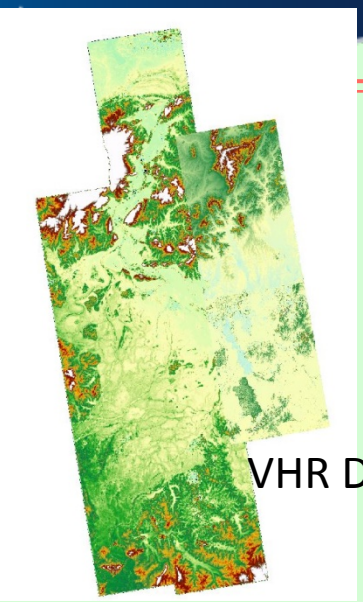
- Water bodies of Yangtze watershed present and important intra and inter annual variability => How to compute water volume and SWOT temporal sampling to reflect such events?

To answer these:
Generation and analysis of SWOT time series of SWOT simulation
Requesting as accurate as possible database: DEM, Flood extent, potential perturbing elements (Aquatic vegetation, etc ..)

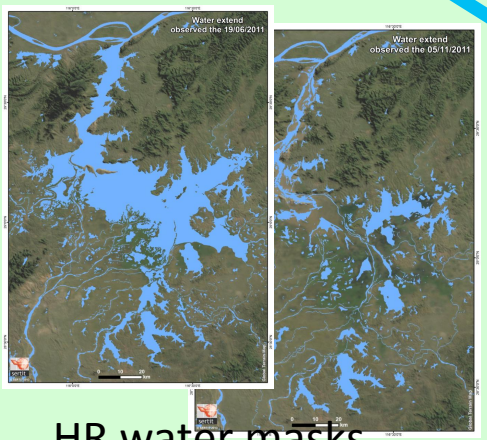
2 – Synergy of SWOT- with others EO missions, such as Sentinel1 and Sentinel2 data, plus Sentinel3 altimeter & Jason mission to increase temporal sampling

3 – Close the water budget (taking into account evaporation + ground water stock)

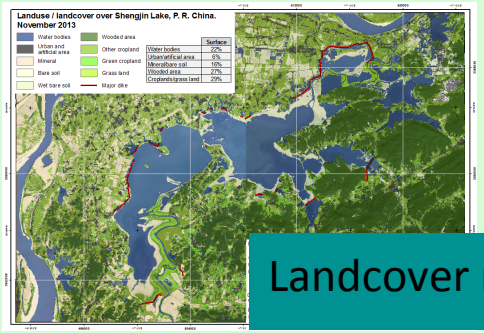
JPL CNES SWOT Simulator



VHR DEM



HR water masks

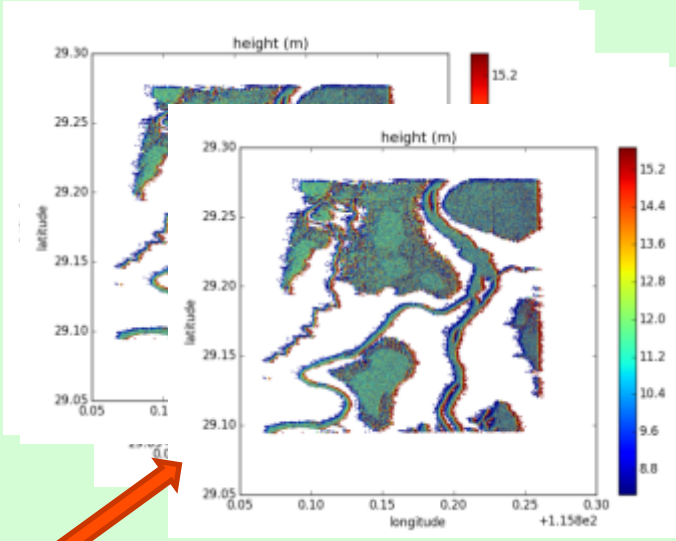


Landcover mask

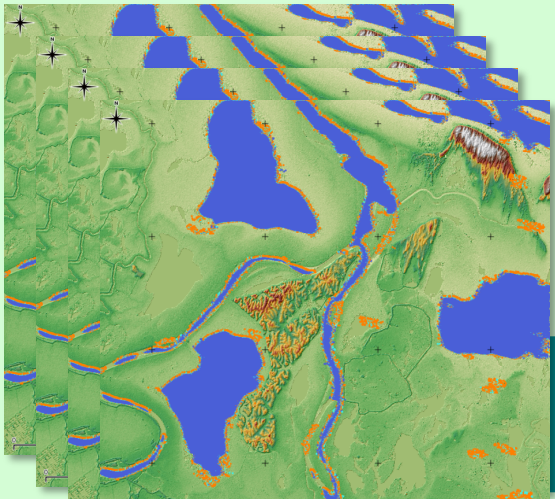
Orbit parameters
Noise

SWOT Scientific Simulator

Water height



Water masks



Model-based Adaptive Lake Mapping and Lake Modeling from SWOT/KaRIn

Yongwei Sheng and **Dennis P. Lettenmaier**
UCLA Department of Geography, ysheng@geog.ucla.edu.

Primary Objectives:

(1) to generate a global mask for lakes > $(250\ m)^2$, which are expected to be observable by SWOT.

(2) to model lake area and storage changes for small lakes that are missed by SWOT.

(3) to develop automated broadly-applicable model-based approaches to address the challenges in KaRIn lake mapping.

Research Questions:

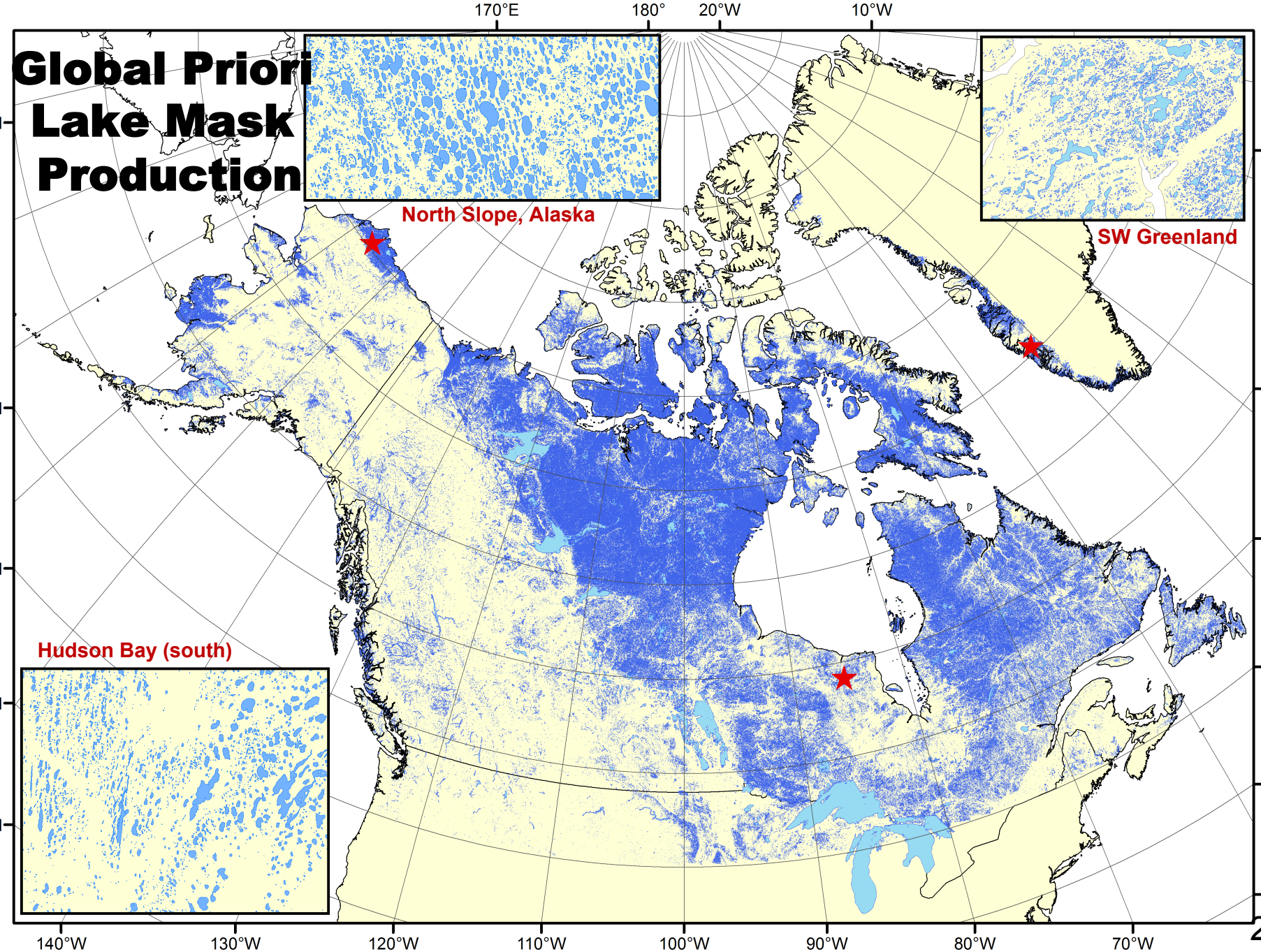
(1) Where and in what quantity are the lakes that are observable by SWOT?

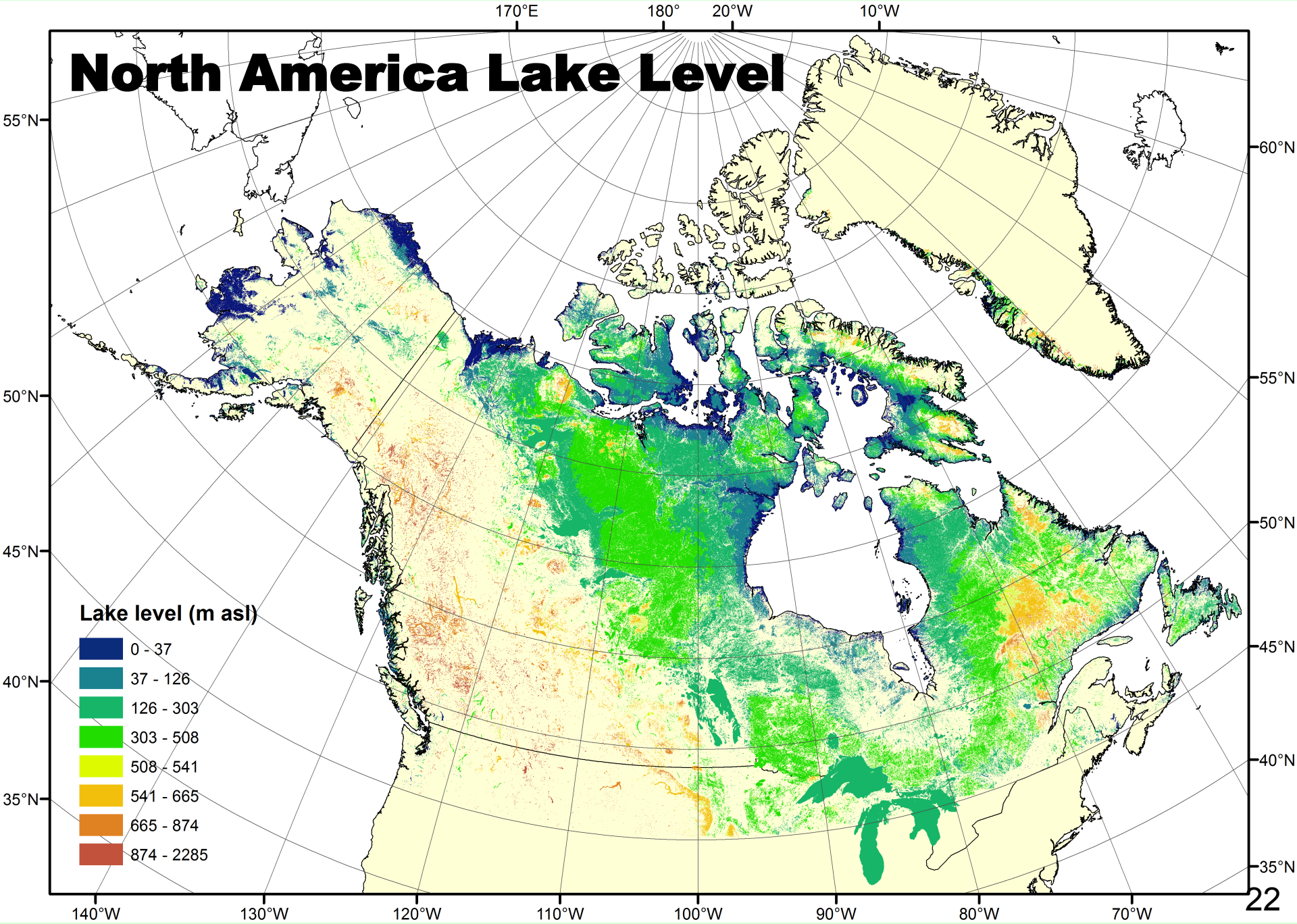
(2) How much lake area and volume change is missed by SWOT if the targeted minimum mapping size is $(250\ m)^2$?

(3) How much can a model-based adaptive mapping method improve KaRIn lake mapping?

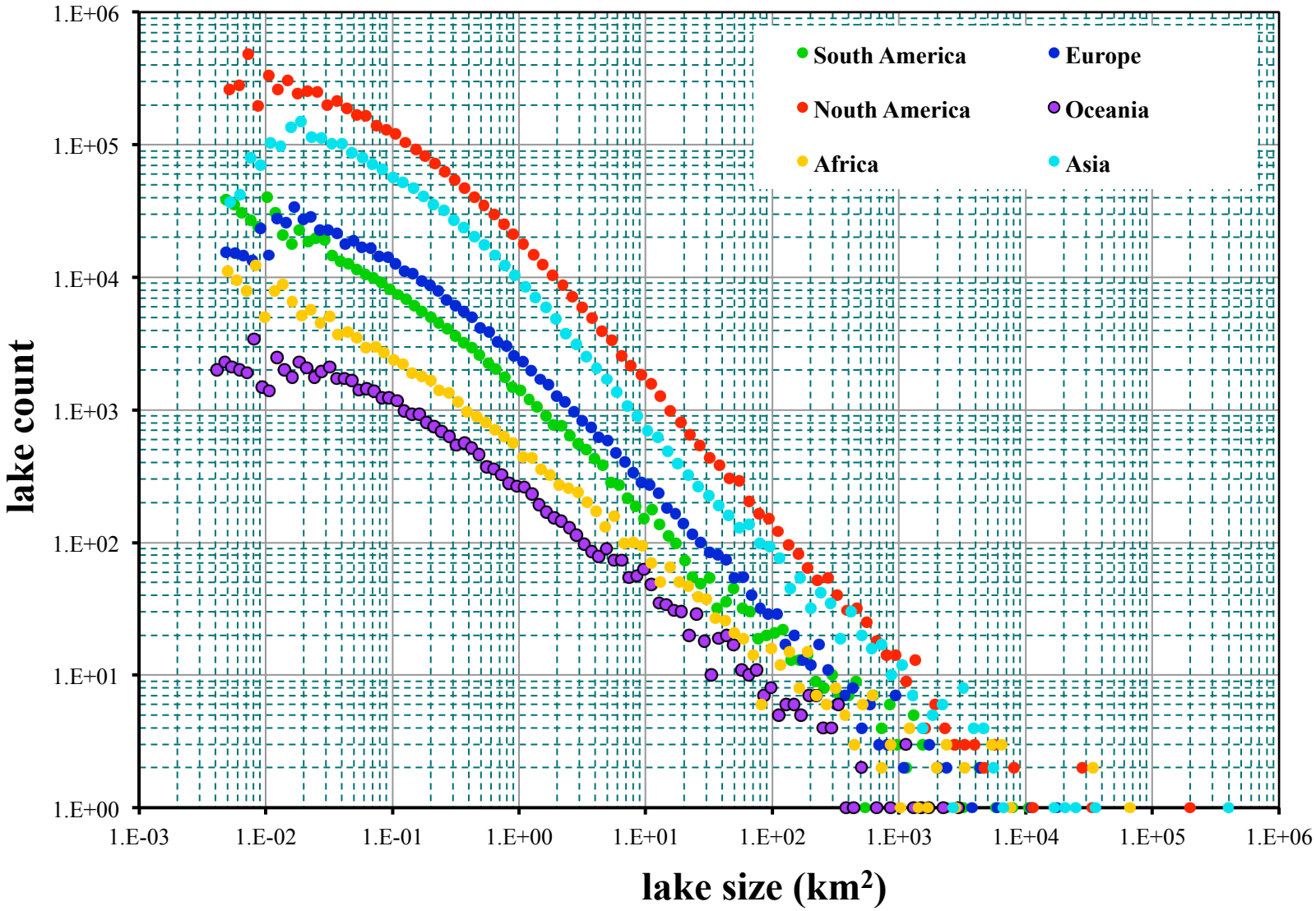
(4) Can the proposed method be used to routinely generate water mask products for the SWOT mission?

……. ……


Global Prior Lake Mask Production
North Slope, Alaska
SW Greenland
Hudson Bay (south)
170°E
180°
20°W
10°W
55°N
50°N
45°N
40°N
35°N
60°N
140°W
130°W
120°W
110°W
100°W
90°W
80°W
70°W


North America Lake Level
170°E
180°
20°W
10°W
55°N
50°N
45°N
40°N
35°N
60°N
55°N
50°N
45°N
40°N
35°N
140°W
130°W
120°W
110°W
100°W
90°W
80°W
70°W
Lake level (m asl)
0 - 37
37 - 126
126 - 303
303 - 508
508 - 541
541 - 665
665 - 874
874 - 2285

Global Lake Size Distribution by Continent



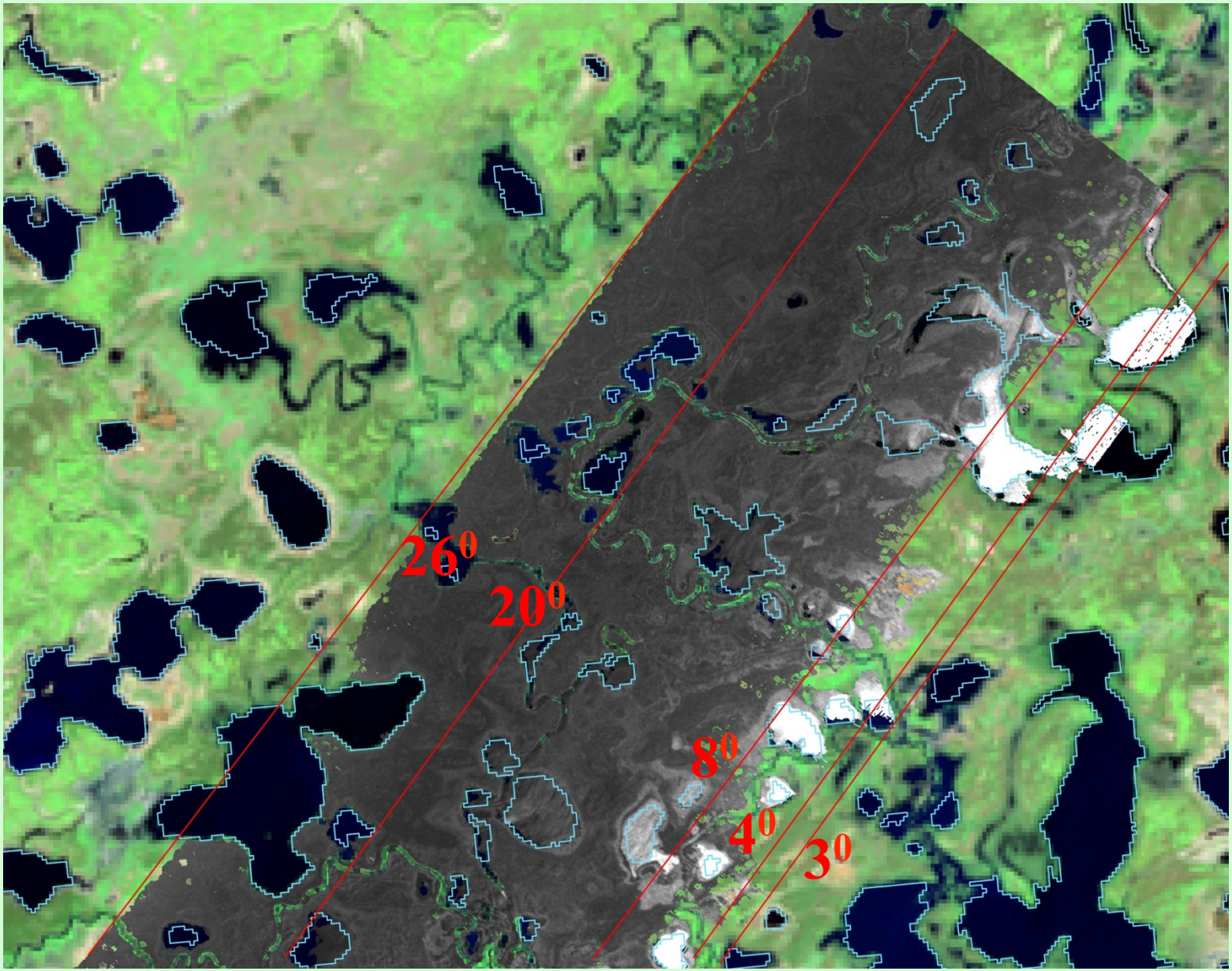
How many lakes are going to be captured by SWOT?

Continent	All Lakes		SWOT-Captured	
	Abundance	Area (km^2)	Abundance (%)	Area (%)
North America	4,954,067	1,238,883	1,339,888 (27%)	1,133,695 (92%)
Asia	1,885,239	1,020,987	554,571 (29%)	972,273 (95%)
Europe	524,154	213,727	178,005 (34%)	200,917 (94%)
Africa	131,869	249,232	34,835 (26%)	246,684 (99%)
South America	506,077	171,358	115,644 (23%)	161,041 (94%)
Oceania	53,992	44,528	20599 (38%)	43,363 (97%)
Total	8,055,378	2,938,691	2,243,542 (**28%**)	2,757,973 (**94%**)

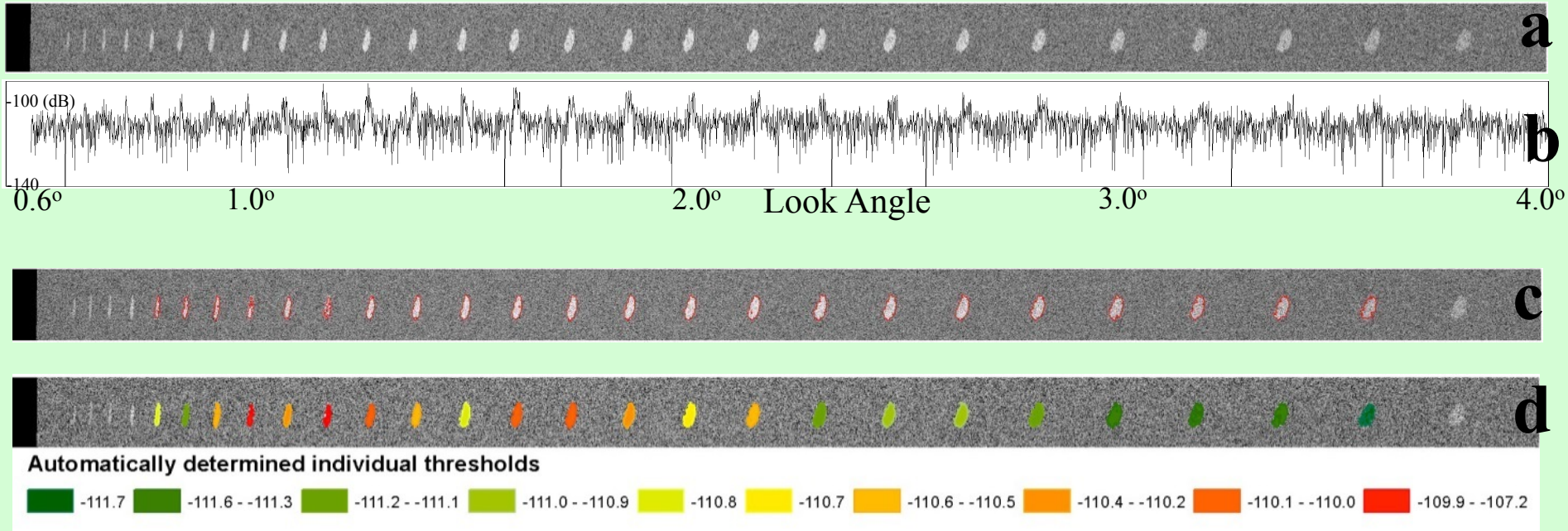
☑ SWOT orbit and layover effects are being addressed:

- Multiple complete coverage;
- Single complete coverage;
- Multiple partial coverage (possibly forming complete coverage);
- None.

Reference Lake Mask even for AirSWOT



KaRIn Geometry and Lake Mapping



More Images Wanted!!!