MEASURING THE LAKE EVOLUTION IN THE QINGHAI-TIBET PLATEAU WITH RADAR ALTIMETERS

- Garcia-Mondéjar, A.; Martínez-Val, B. ; Escorihuela, M. J.; García, P. Nilo; Martin-Puig, C. - Yang, JungangLiao, Jingjuan

Project Context

ESA-MOST Dragon 3 Cooperation Programme

Project Title: Applications of radar altimetry data

Project Goals:

WP1- Study on the sea-level, ocean tide, ocean wave and mesoscale eddy in the Chinese Sea

WP2- **Monitoring elevation changes of lakes** in Qinghai-Tibet Plateau.

Lead investigators:

Prof. Liao Jingjuan; Center for Earth Observation and Digital Earth, Chinese Academy of Science [China]

B. Martinez-Val; isardSAT S.L.

Objectives

OBJECTIVES

- Stablish the state of the art for lake elevation retrieval.
- Understand the benefits of the new altimeter *techniques* (SAR mode, Ka band, new retrackers) for lake level measurements.
- Stablish a methodology to retrieve the lake level from altimeters and performs time series of the Qinghai Tibetan lakes.

Outline

1. Introduction
    1. Altimeter chronology
    2. Platforms characteristics
    3. Lakes description
2. Results
    1. Peakiness
    2. Lake Surface Elevation
3. Conclusions & Future work

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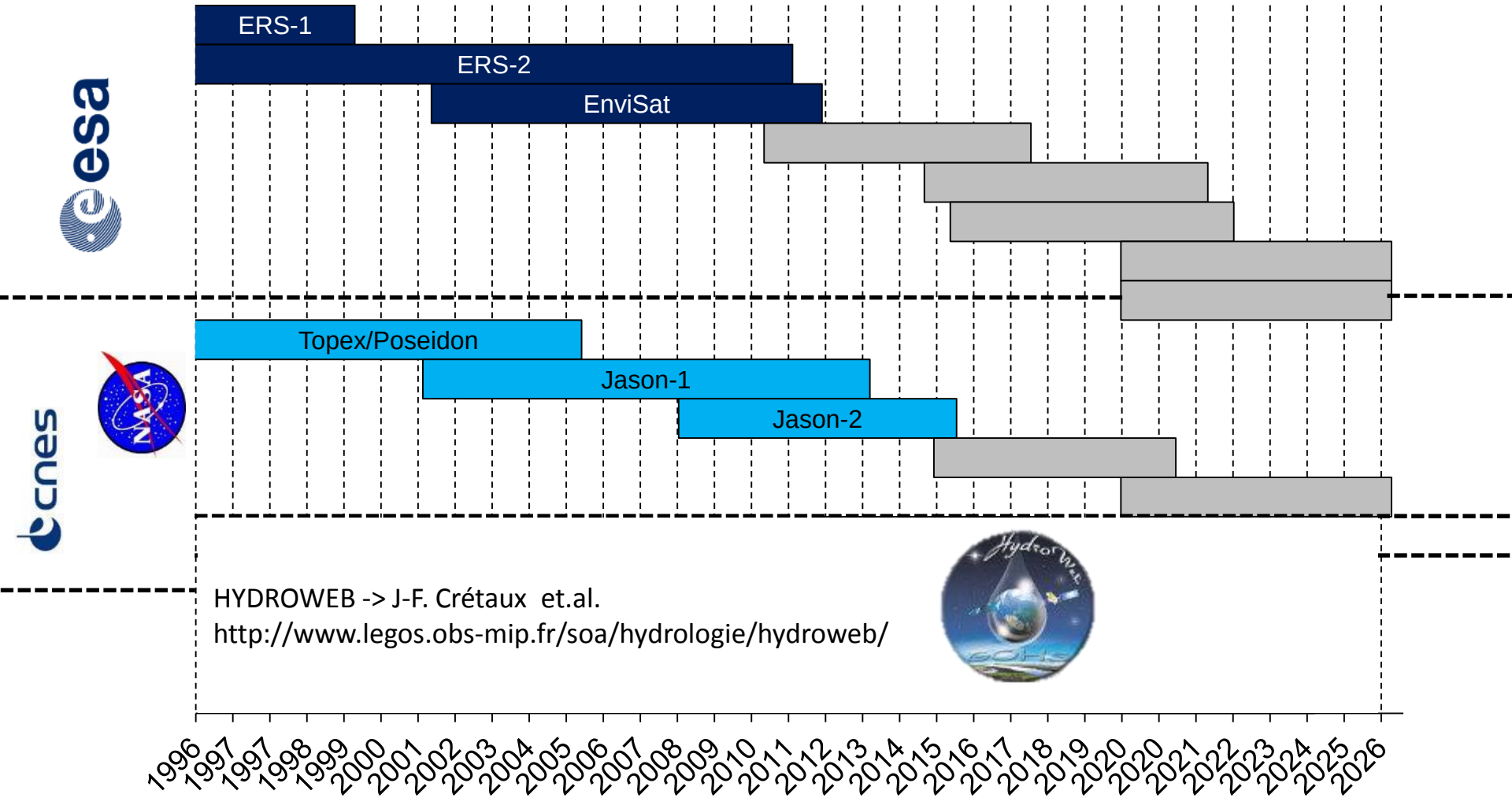
Timeline


ERS-1
ERS-2
EnviSat
Topex/Poseidon
Jason-1
Jason-2
HYDROWEB -> J-F. Crétaux et.al.
http://www.legos.obs-mip.fr/soa/hydrologie/hydroweb/
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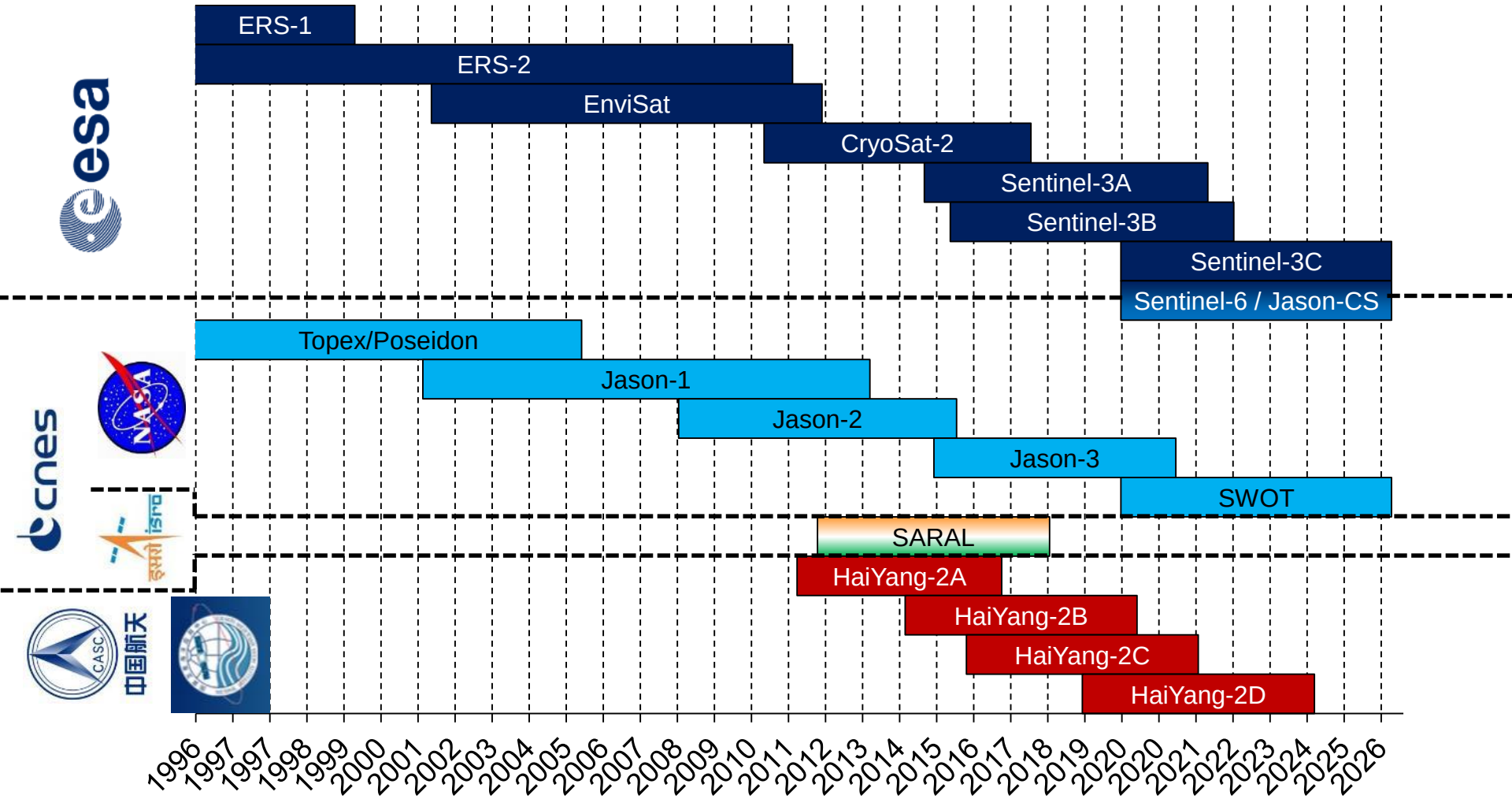
Timeline


ERS-1
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CryoSat-2
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Sentinel-3B
Sentinel-3C
Sentinel-6 / Jason-CS
Topex/Poseidon
Jason-1
Jason-2
Jason-3
SWOT
SARAL
HaiYang-2A
HaiYang-2B
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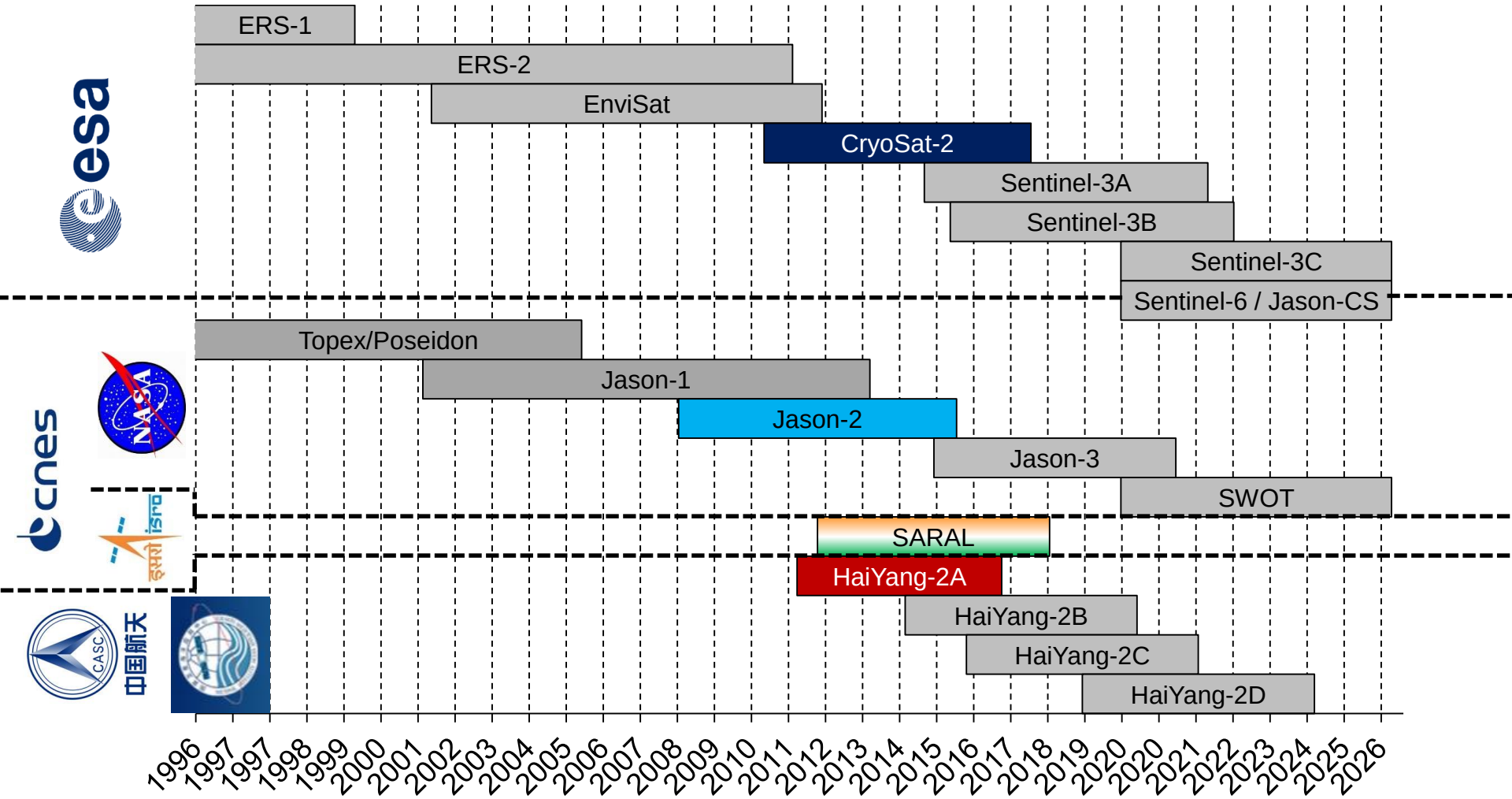
Timeline


ERS-1
ERS-2
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Sentinel-3B
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HaiYang-2A
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HaiYang-2C
HaiYang-2D
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Platform characteristics

	HaiYang 2A	Jason-2	CryoSat-2	SARAL
Instrument	Radar Altimeter	Poseidon-3	SIRAL	AltiKa
Orbit	Sun-sync	Non-Sun-sync	Non-Sun-sync	Sun-sync
Repeat Cycle	**14 days**	**10 days**	**369 days subcycle 30**	**35 days**
Altitude	963 km	1336 km	717 km	799 km
Inclination	99.3 deg.	66 deg.	92 deg.	98.55 deg.
Band	Ku & C	Ku & C	Ku	Ka
PRF	2 kHz	2 kHz	2 kHz & 17.8 kHz	**4 kHz**
Modes	LRM	LRM	LRM, SAR, SARin	LRM

Coverage over the Plateau

	HaiYang 2A	Jason-2	CryoSat-2	SARAL
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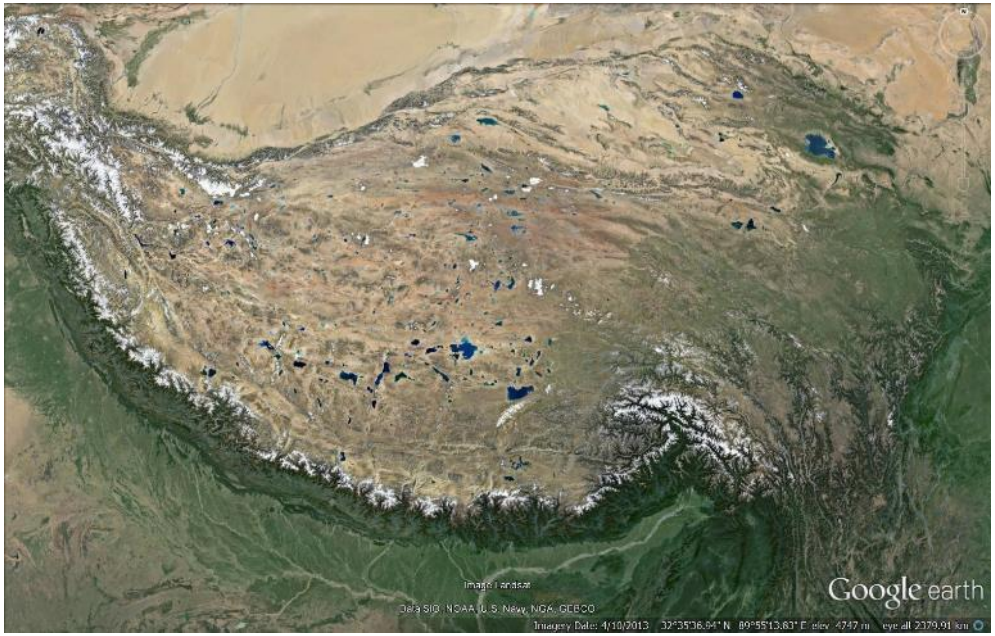

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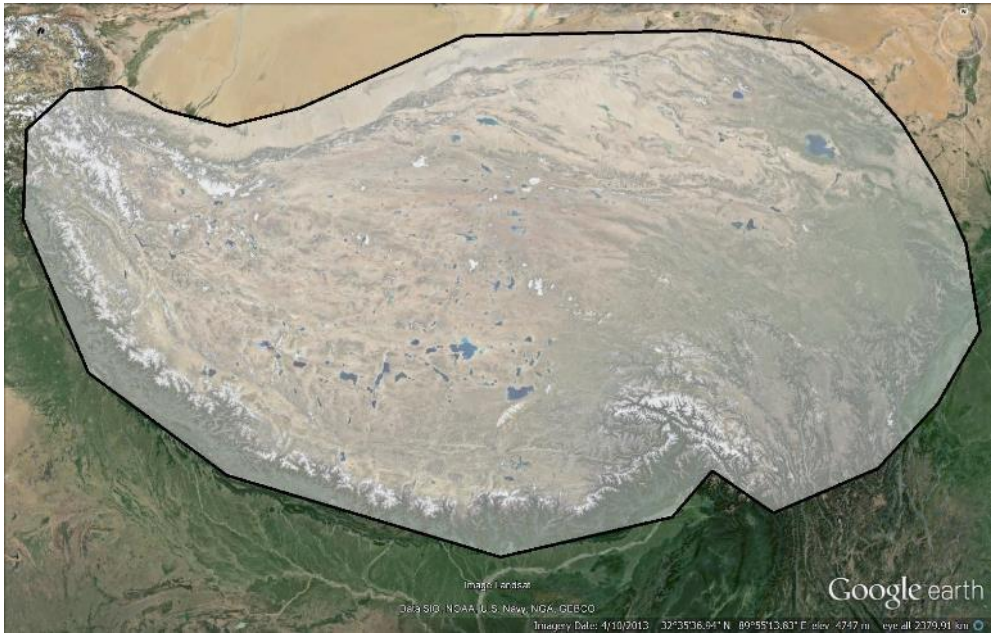
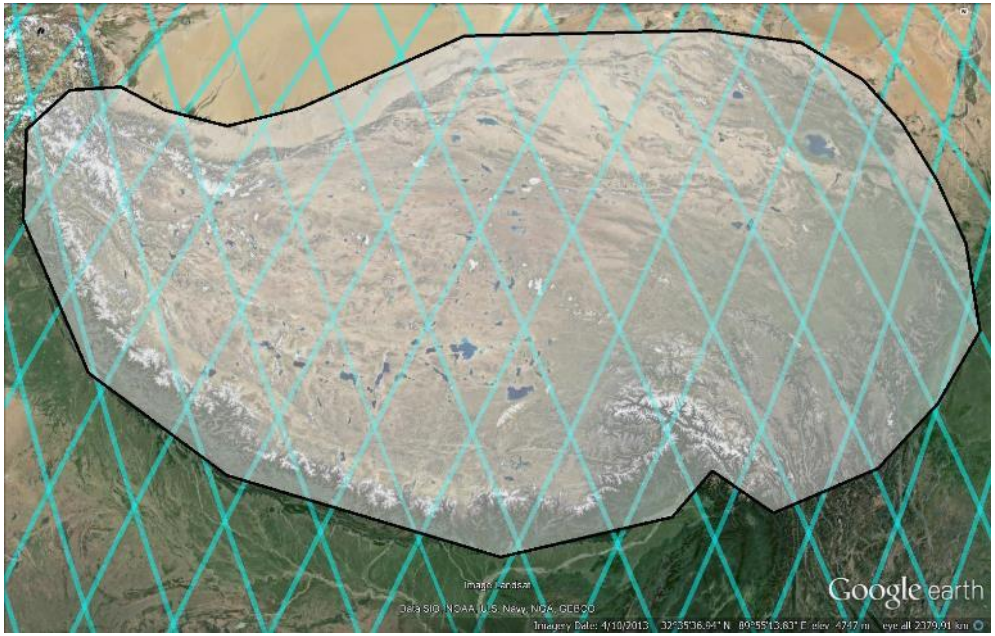


Coverage over the Plateau

	HaiYang 2A	Jason-2	CryoSat-2	SARAL
Repeat Cycle	14 days	10 days	369 days	35 days
Altitude	963 km	1336 km	717 km	799 km
Inclination	99.3 deg	66 deg	92 deg	98.55 deg
Track separation		~240 km		



Coverage over the Plateau

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Repeat Cycle	14 days	10 days	369 days	35 days
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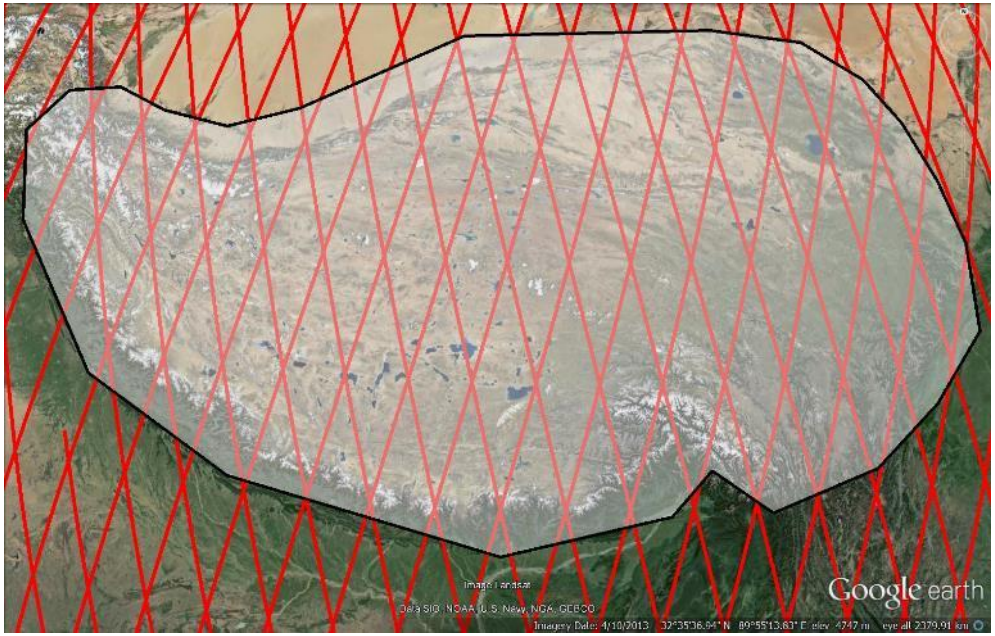
Inclination	99.3 deg	66 deg	92 deg	98.55 deg
Track separation	~170 km	~240 km		



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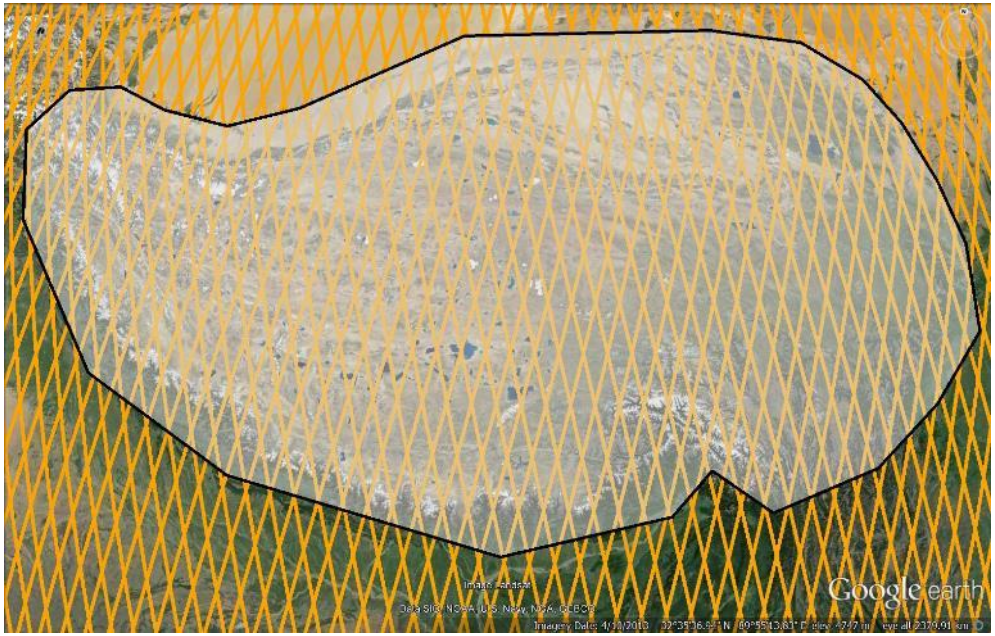

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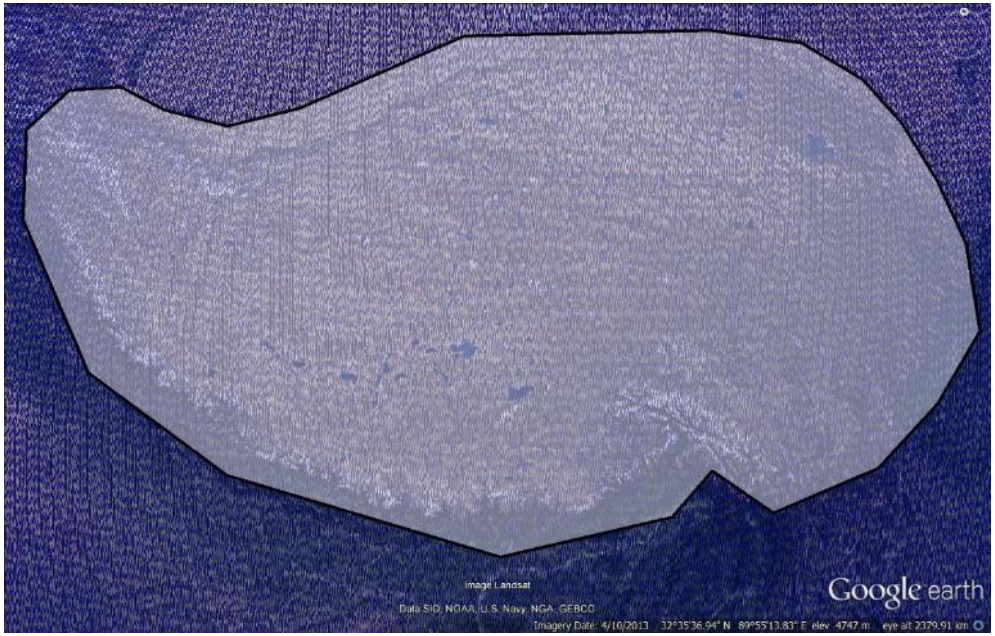
Track separation	~170 km	~240 km	~6 km	~65 km



Lakes analysed

	HaiYang 2A	Jason-2	CryoSat-2	SARAL
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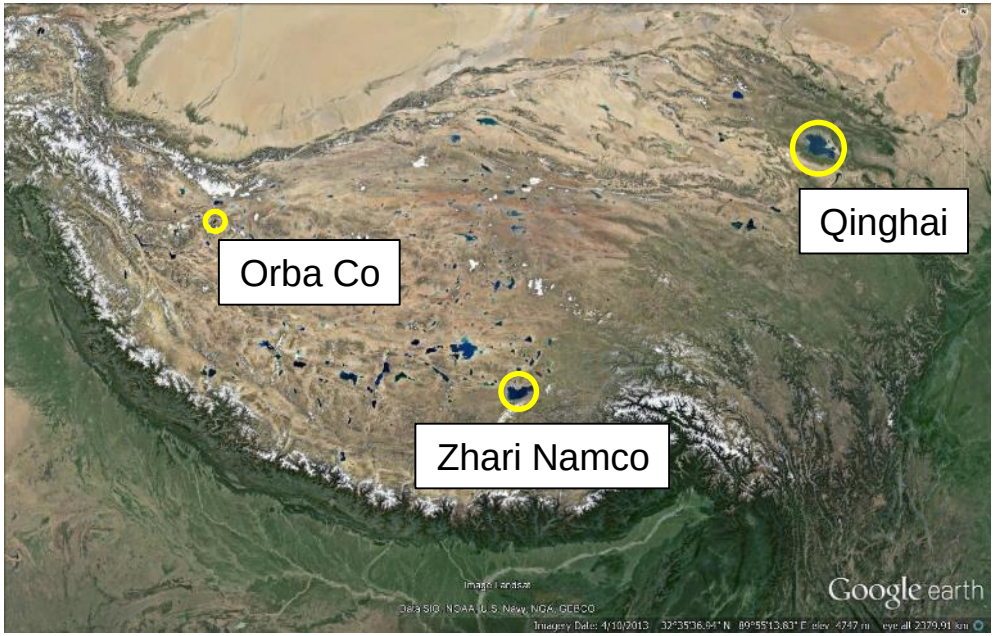

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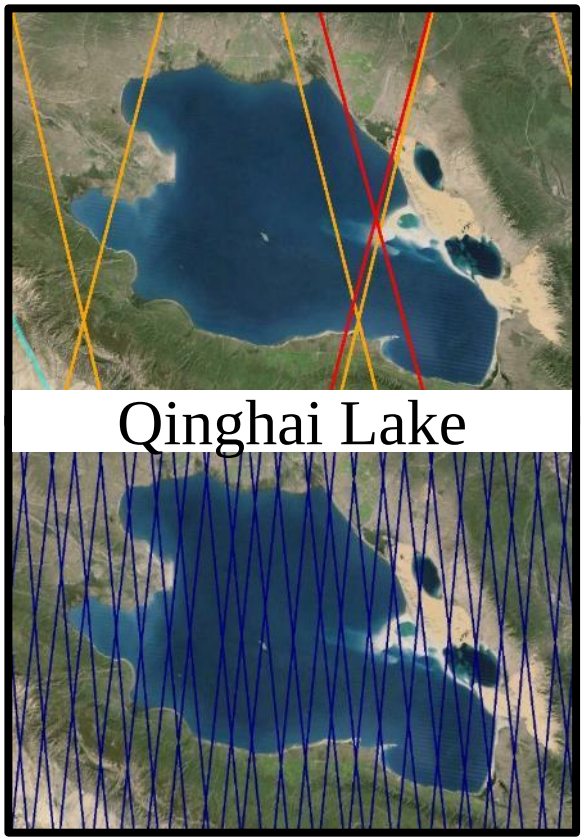
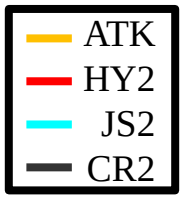
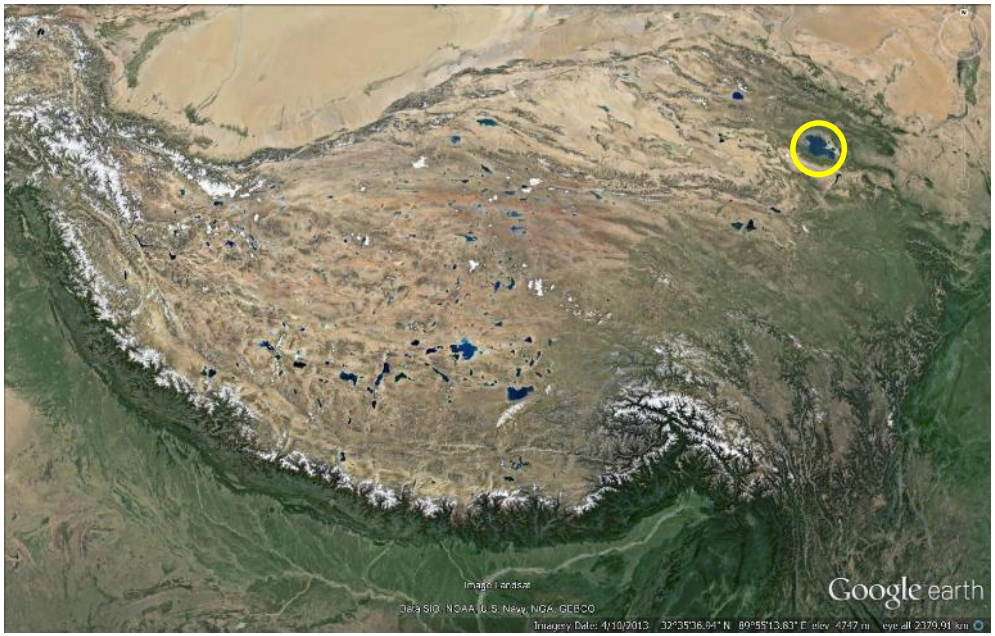
Qinghai Lake

Position	Surface	Elevation
36.9 N, 100.1 E	4,450 km^2	3195 m







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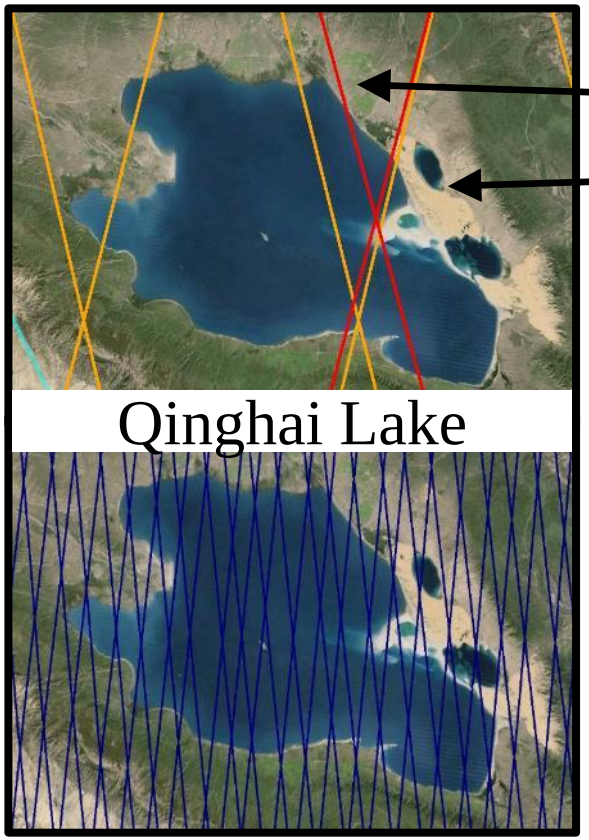
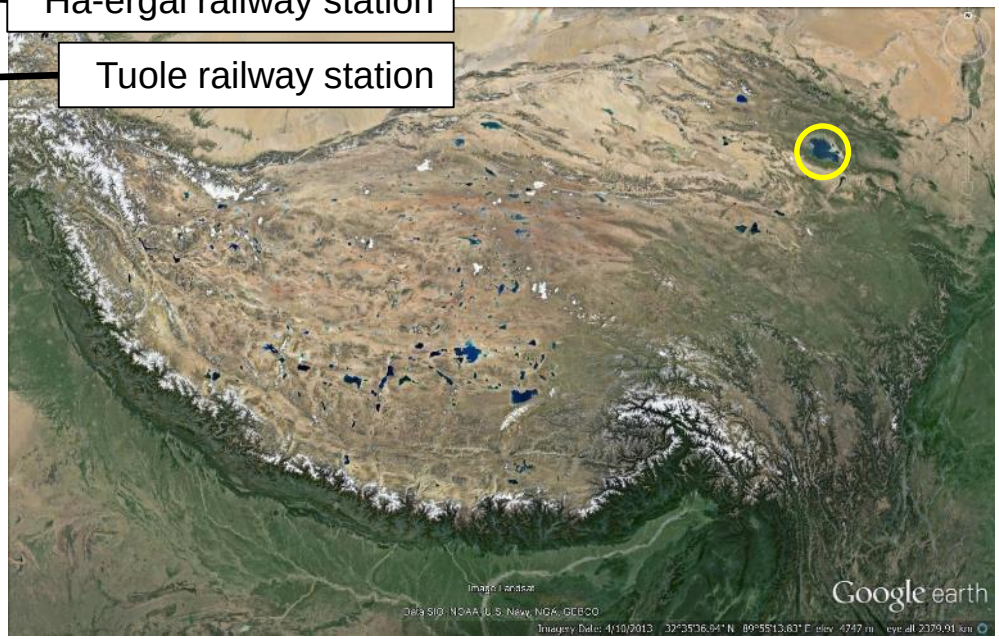


ATK
HY2
JS2
CR2

Ha-ergai railway station

Tuole railway station



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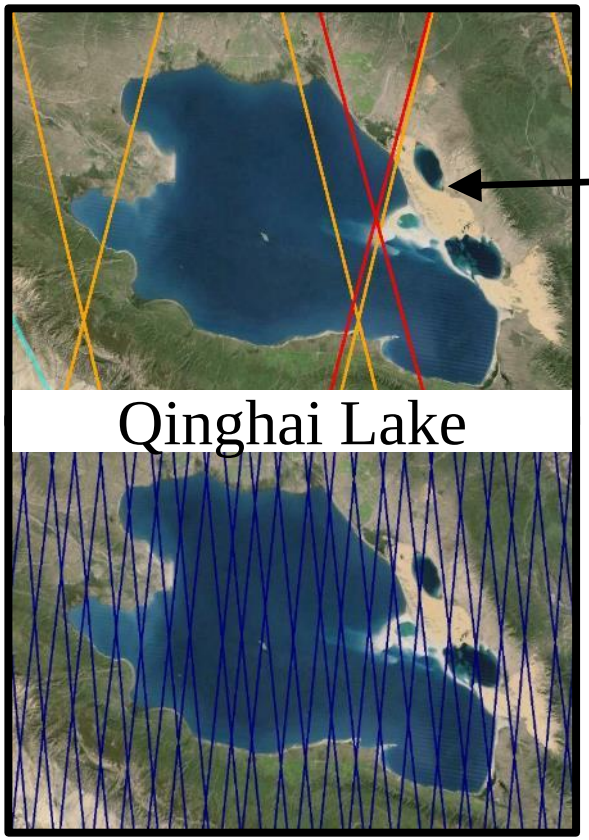

Imagery by DigitalGlobe

Qinghai Lake

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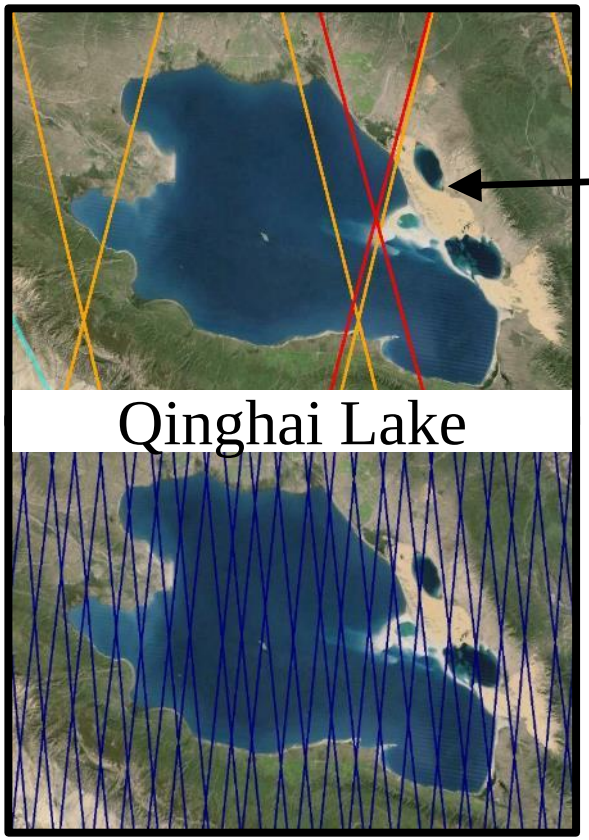

Photo by yuhongspace

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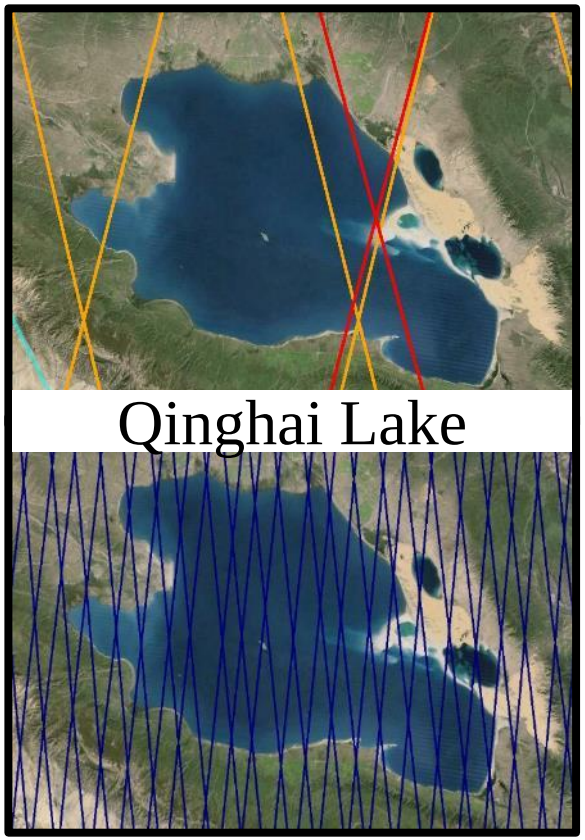
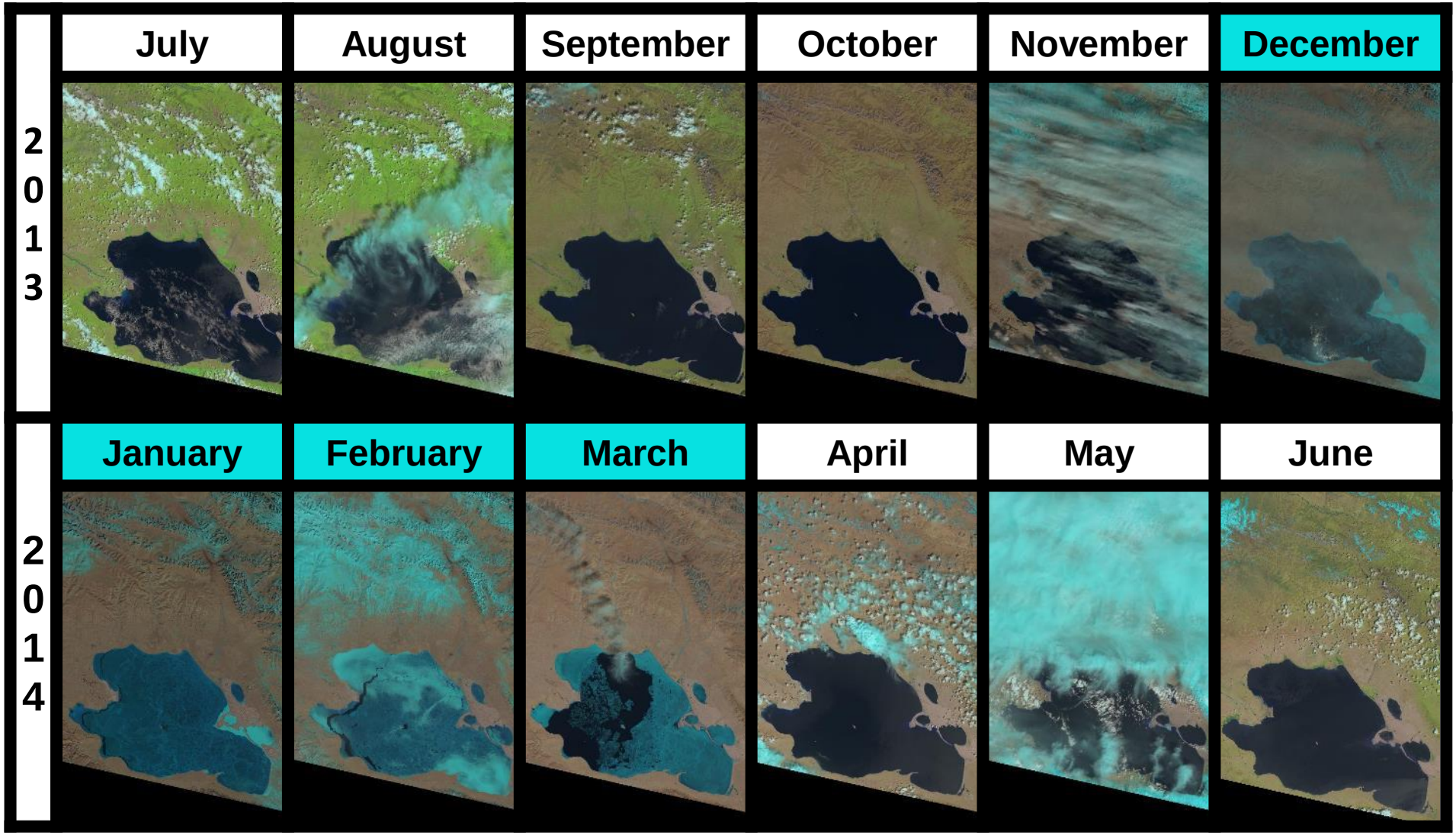


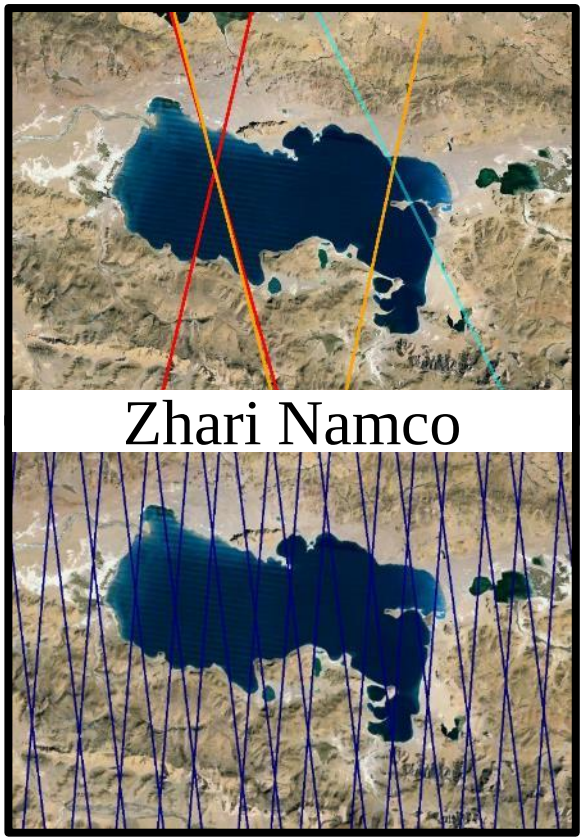
Photo by http://www.thelandofsnows.com/

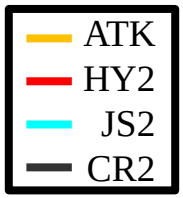
Qinghai Lake: Landsat 8 mosaic

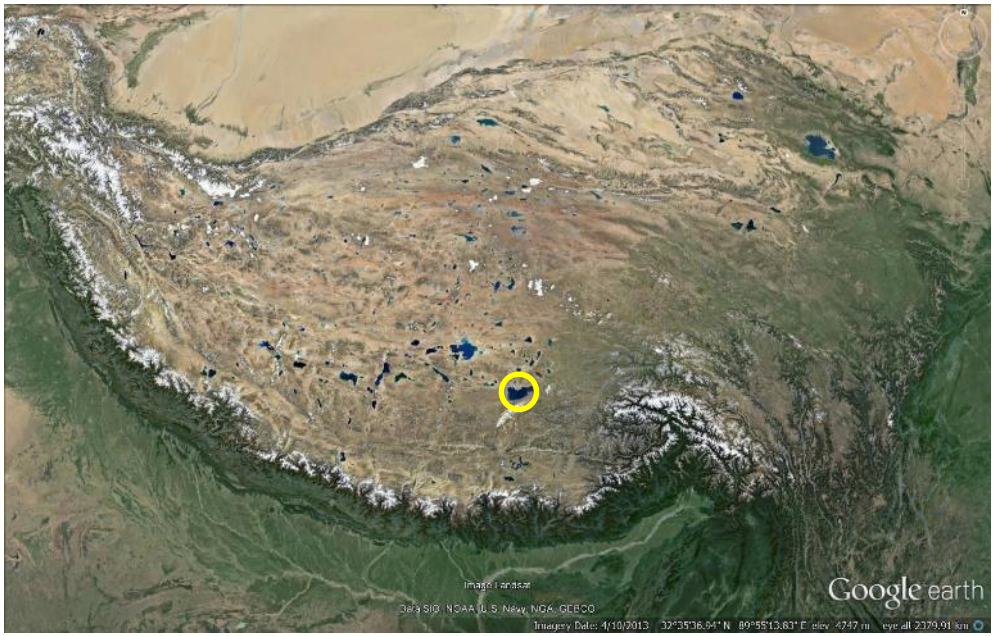


Zhari Namco

Position	Surface	Elevation
30.4 N , 85.5 E	1004 km^2	4612 m







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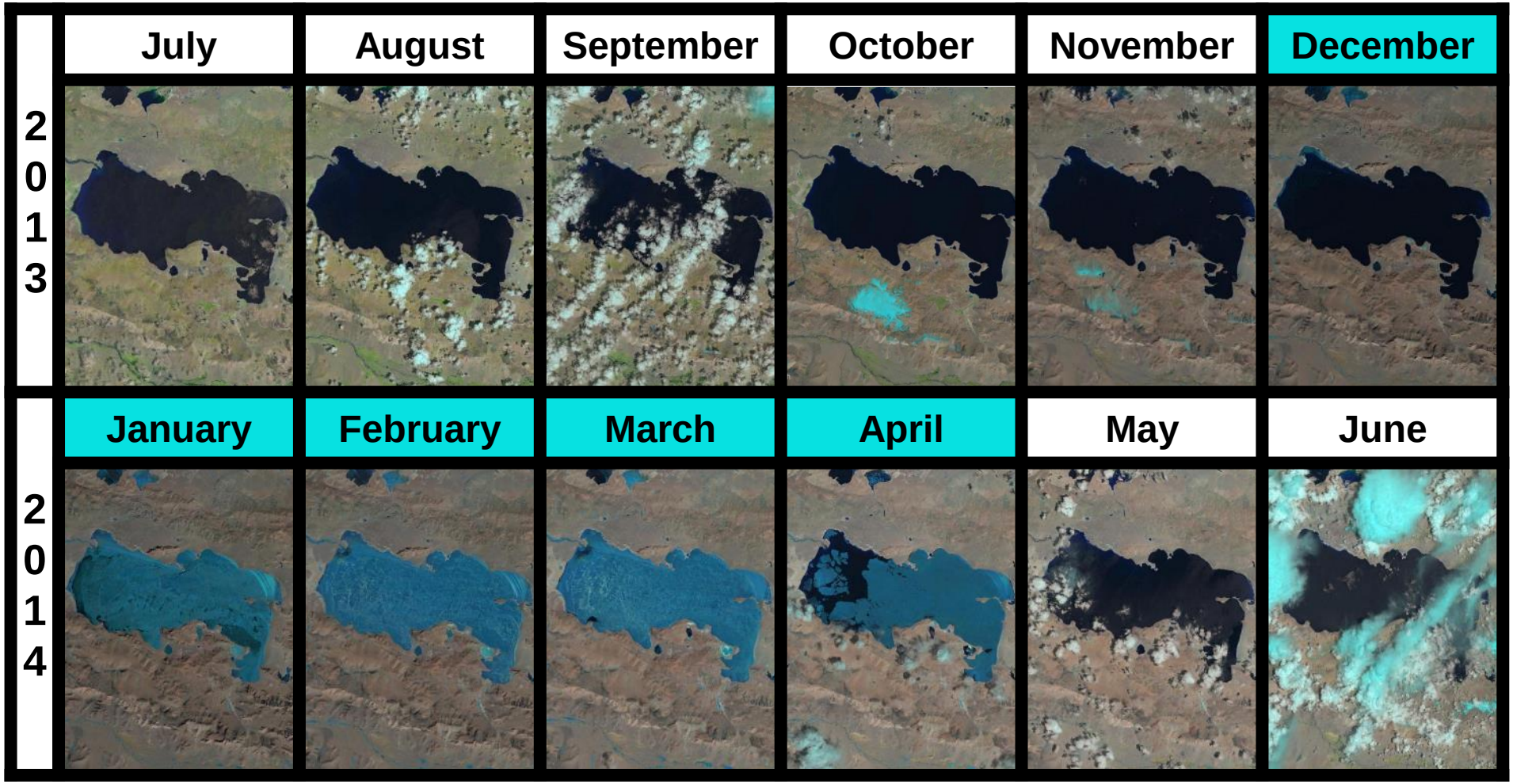
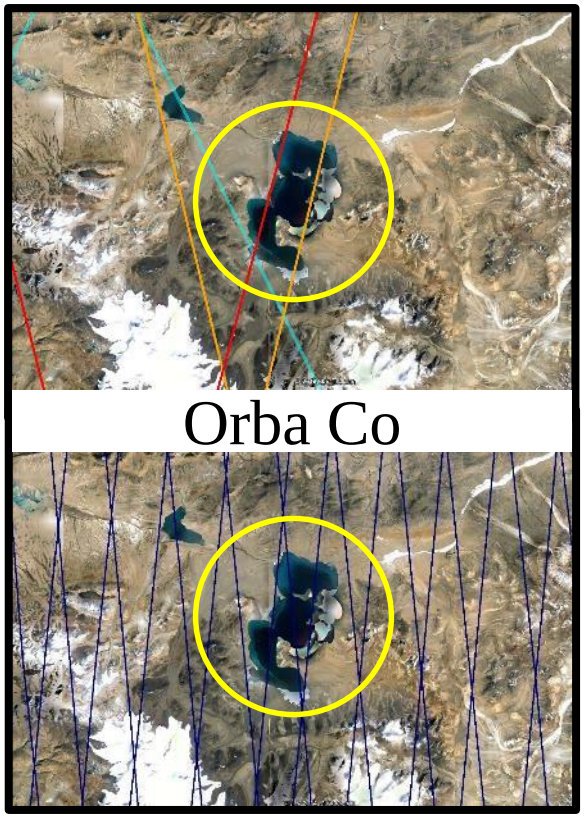
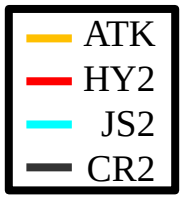
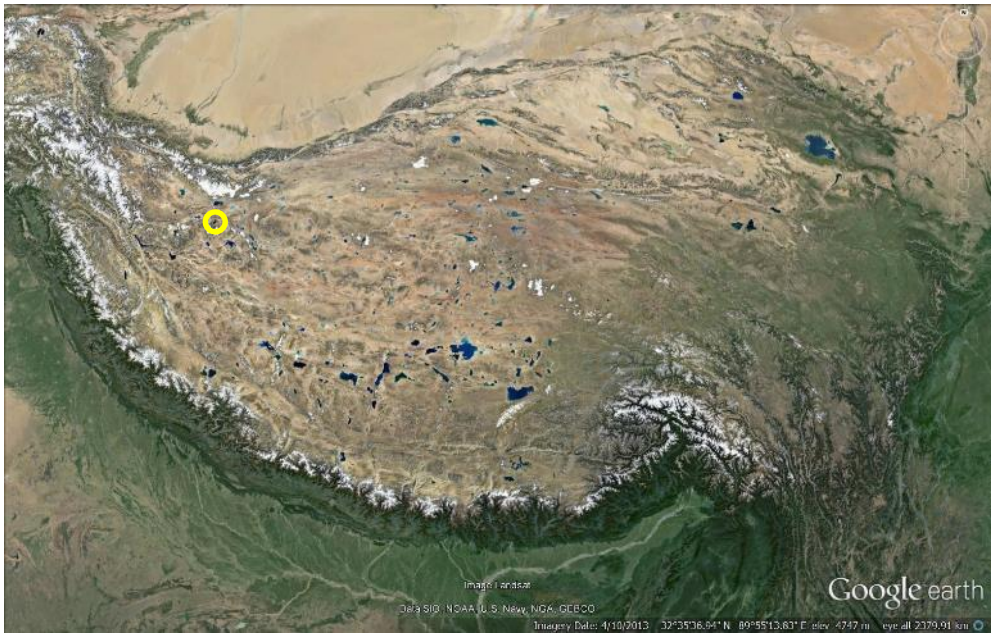


Orba Co

Position	Surface	Elevation
34.5 N , 81.0 E	89 km^2	5193 m







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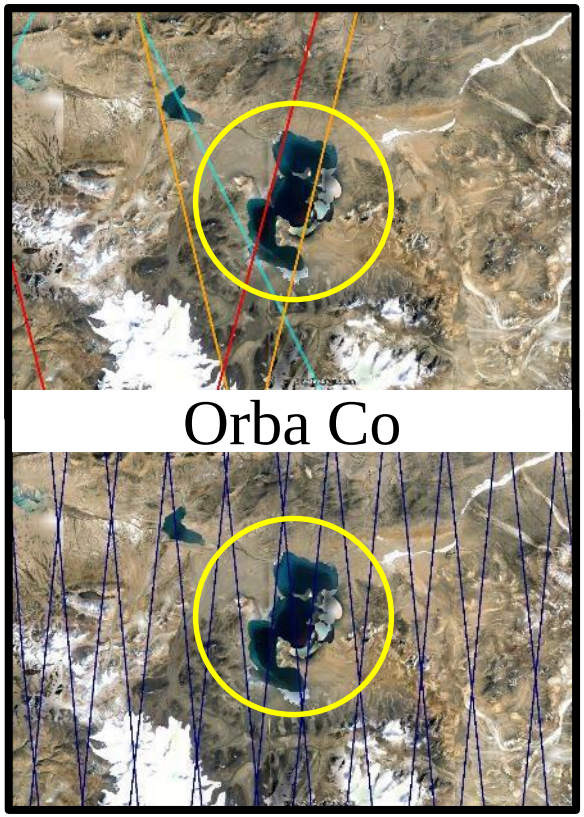
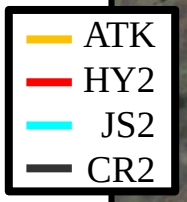
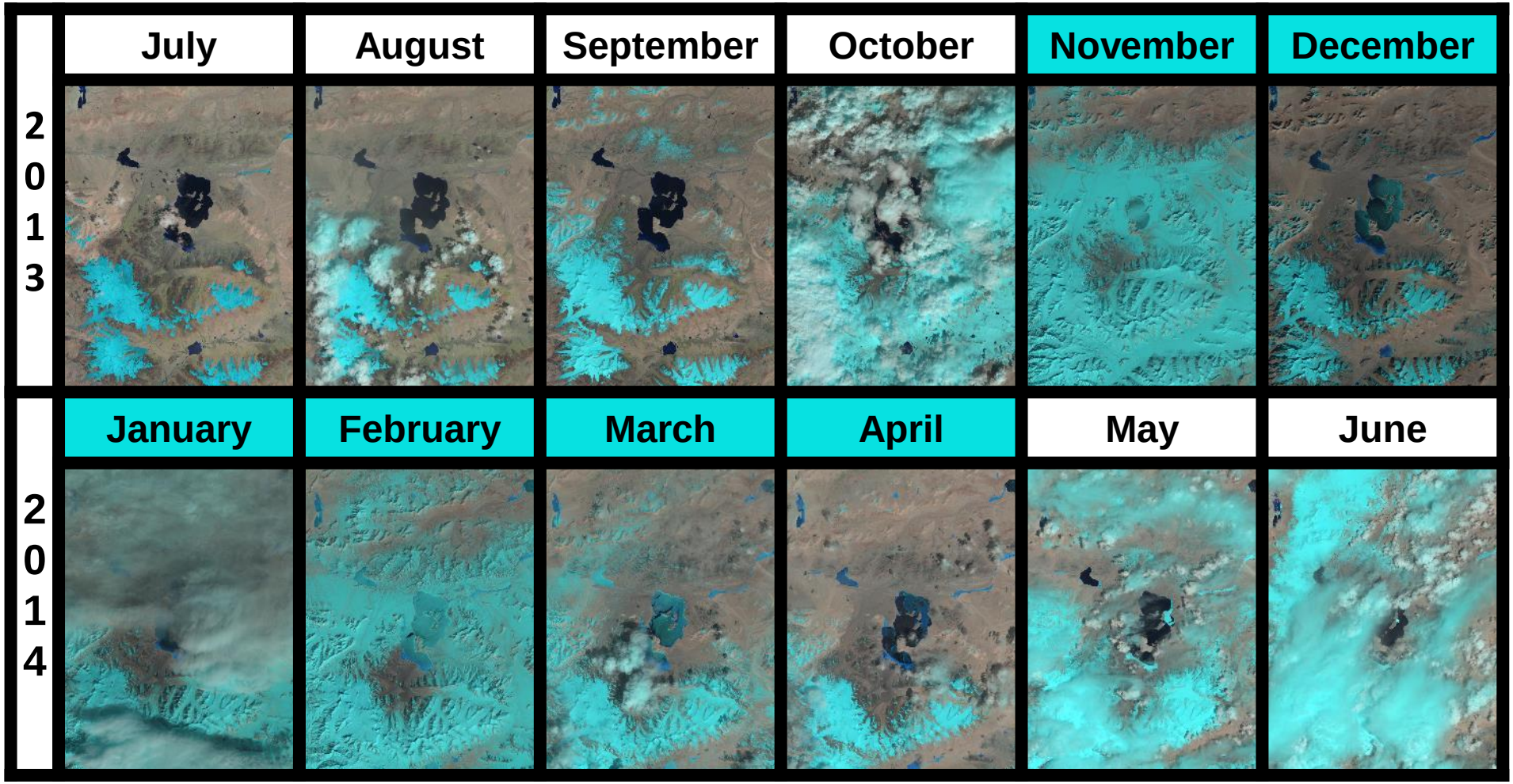




Landsat 8 image, 12th August 2014

Orba Co: Landsat 8 mosaic



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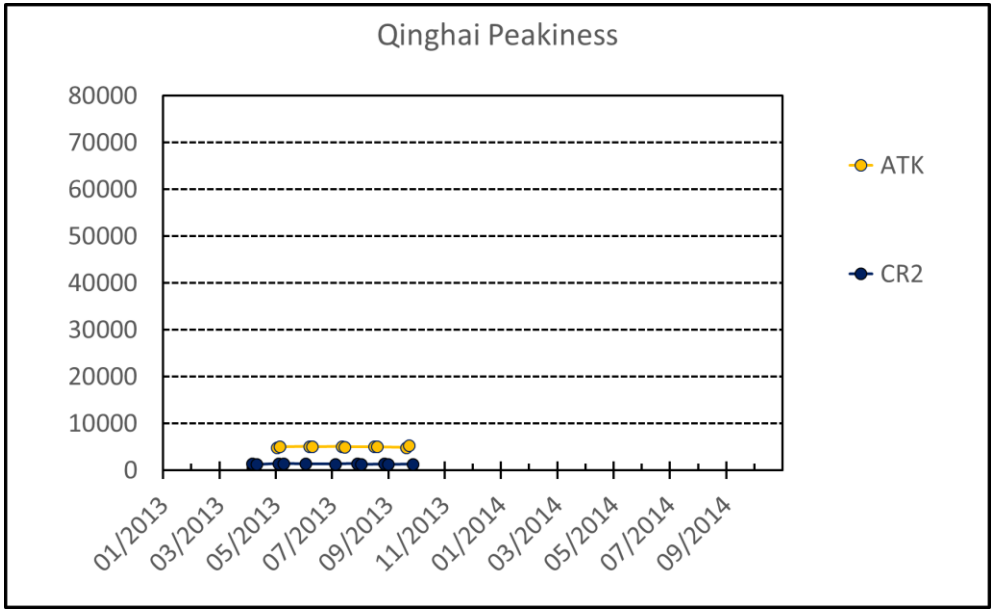
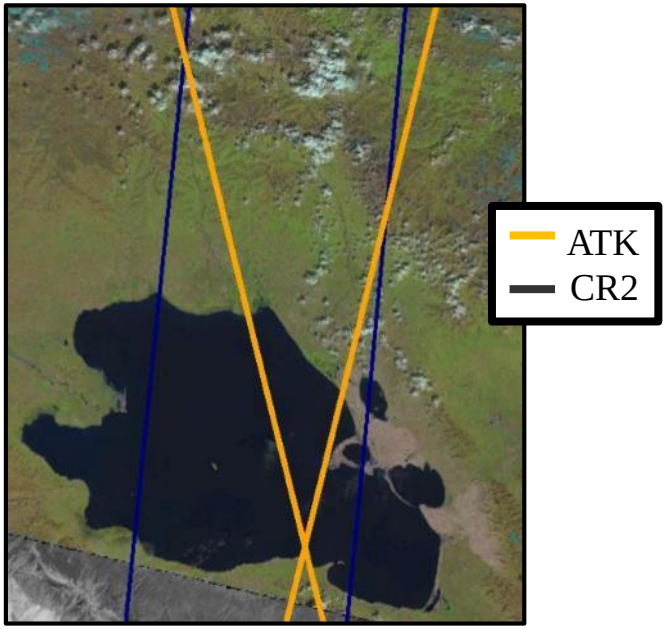
Qinghai Lake: Seasonal variations

L2: Peakiness

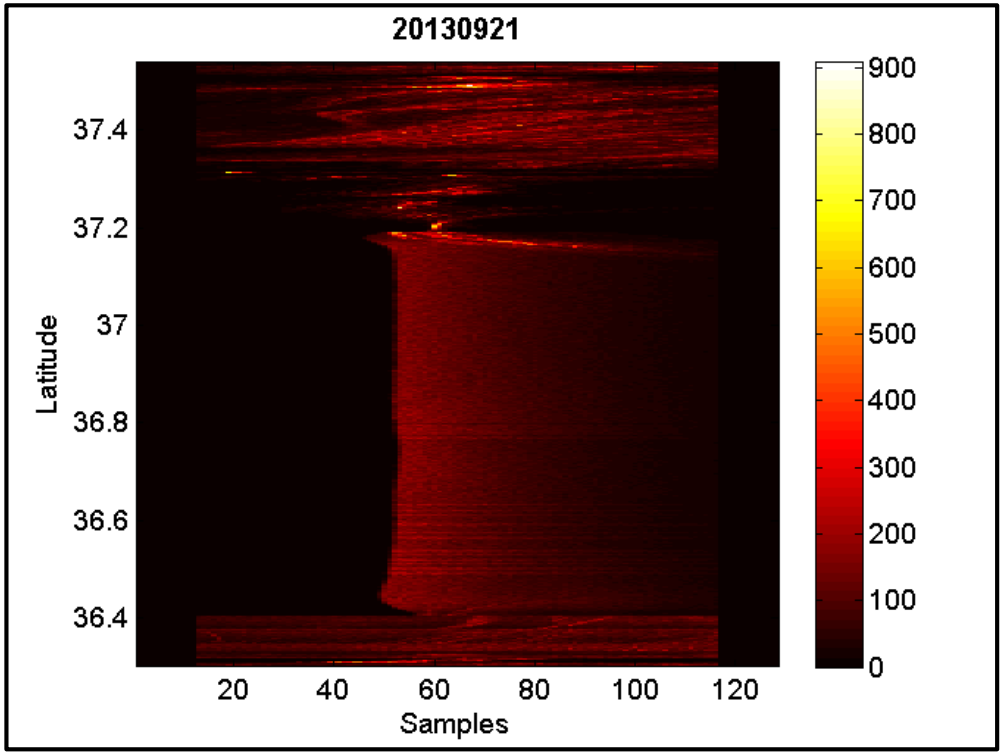


Not frozen lake: Sep 2013



Qinghai Lake: Seasonal variations

L1: waveforms



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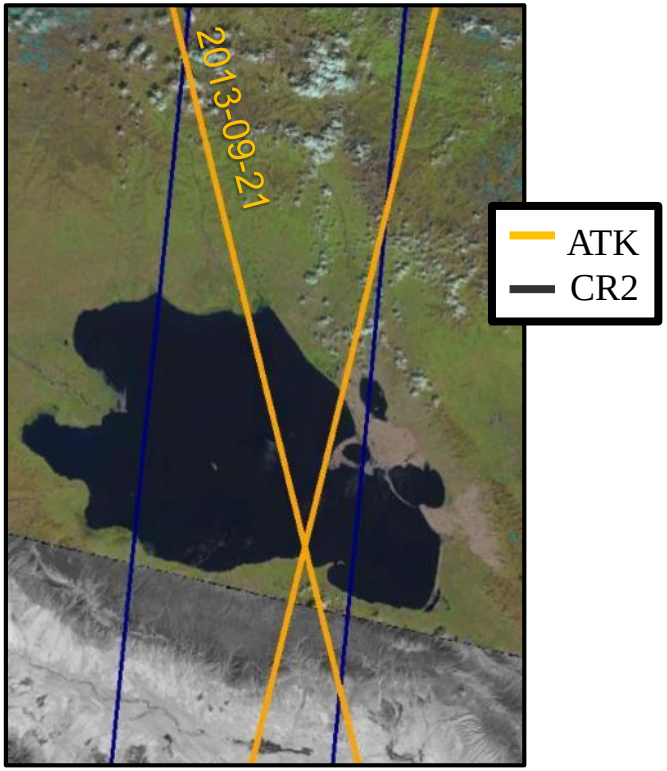

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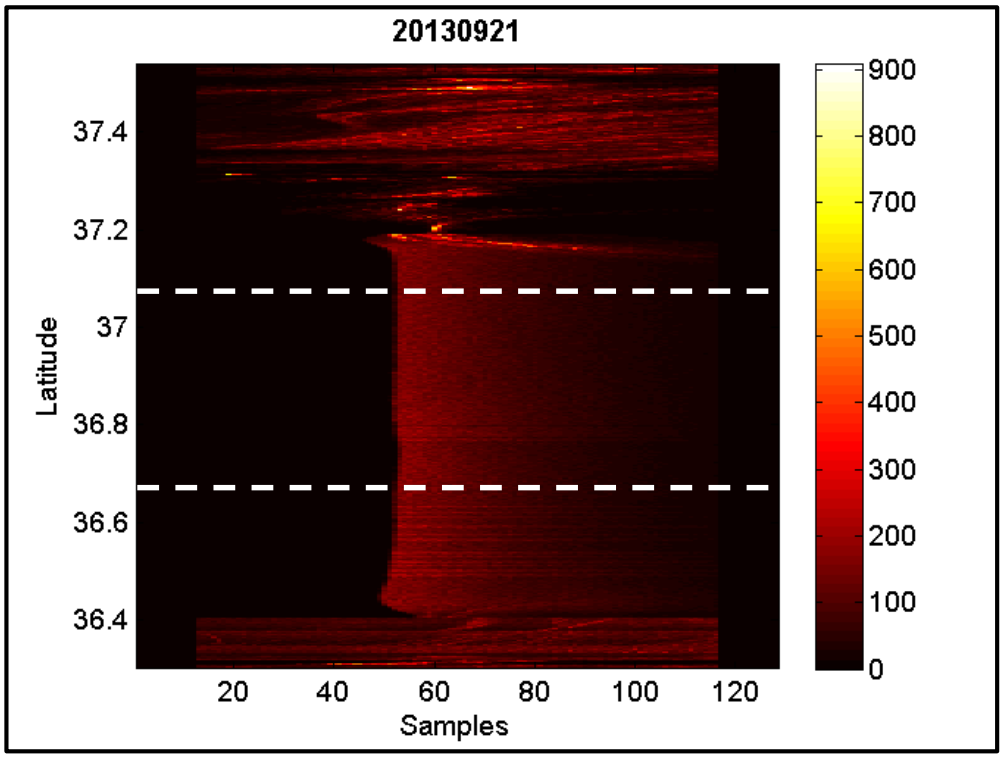

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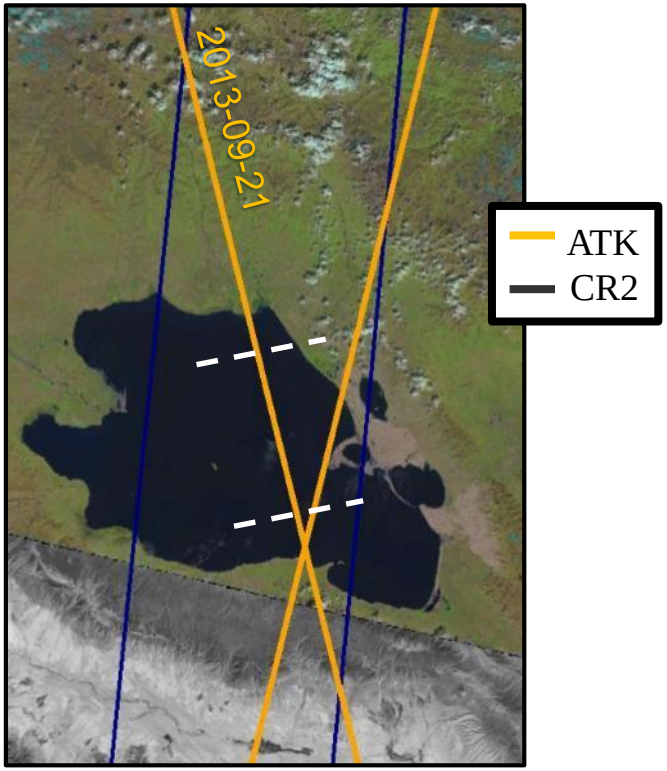
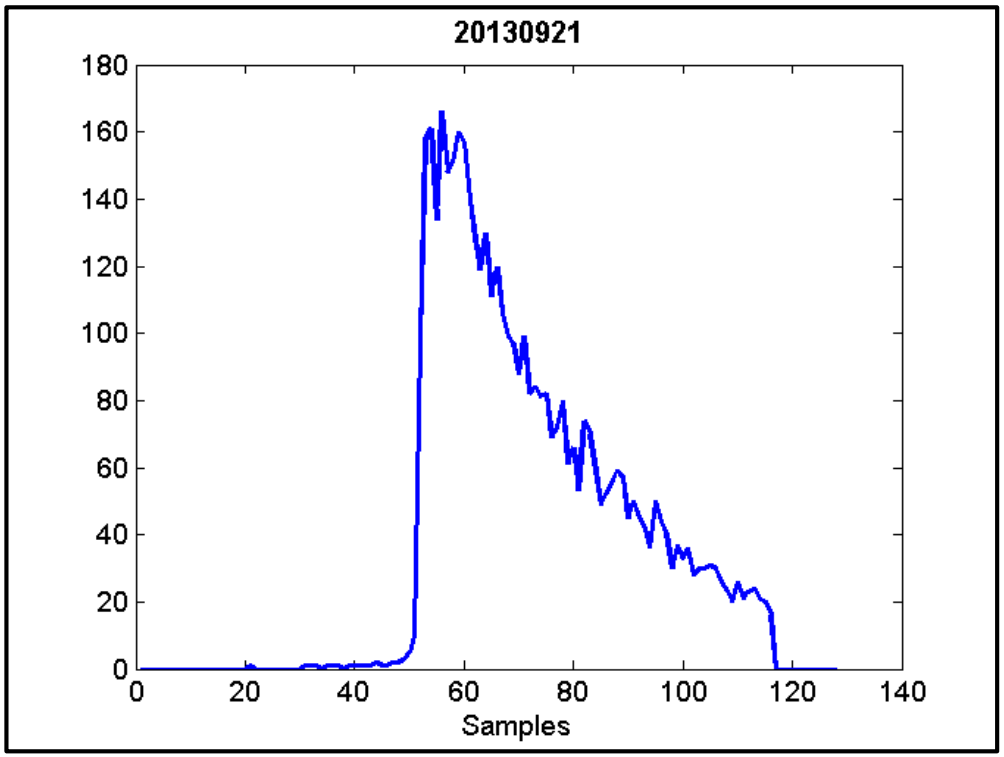


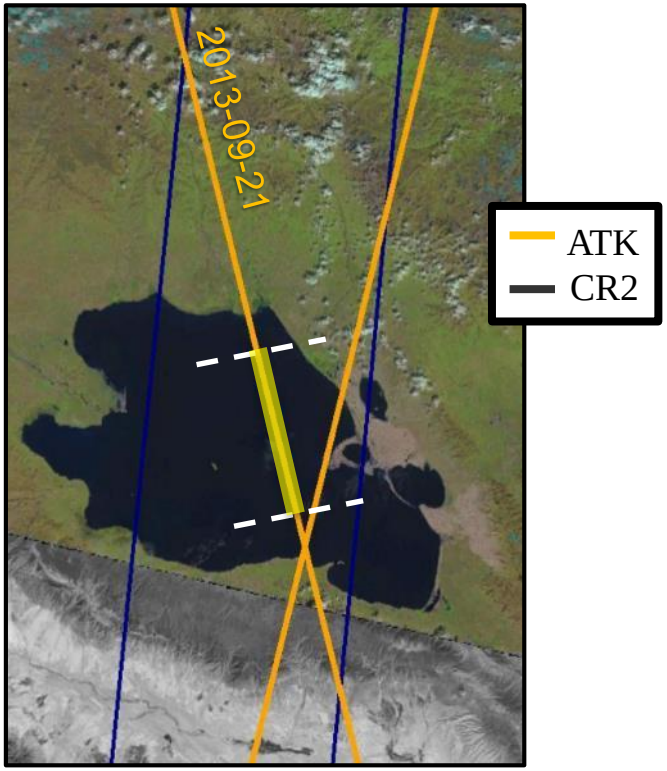
- Brown echoes in the centre of the lake

Qinghai Lake: Seasonal variations

L1: waveforms



Not frozen lake: Sep 2013



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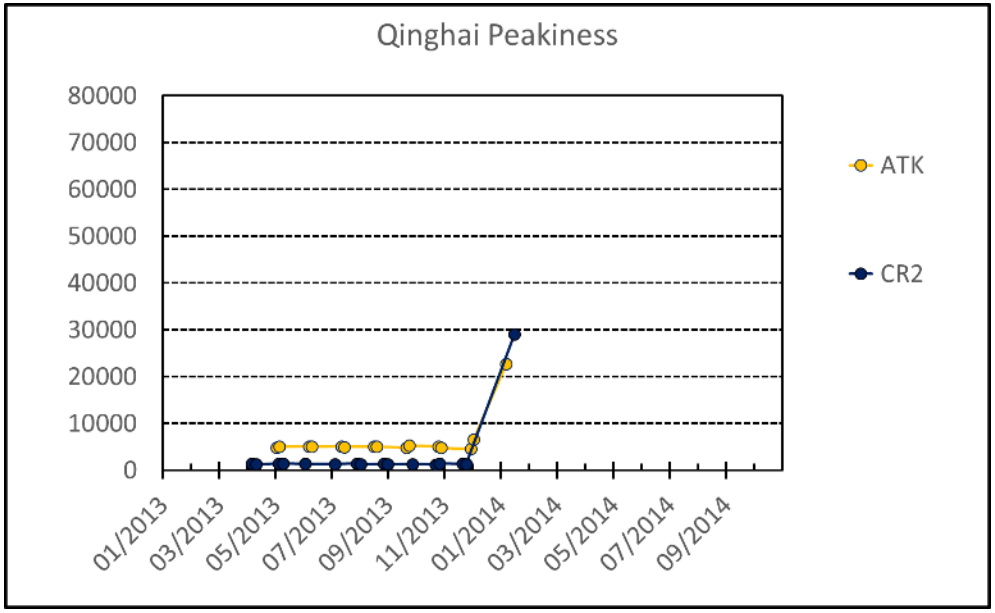
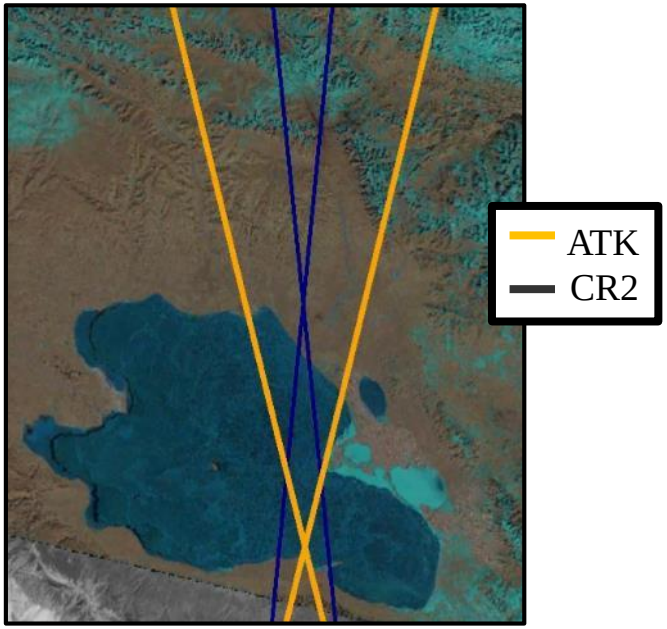
Qinghai Lake: Seasonal variations

L2: Peakiness

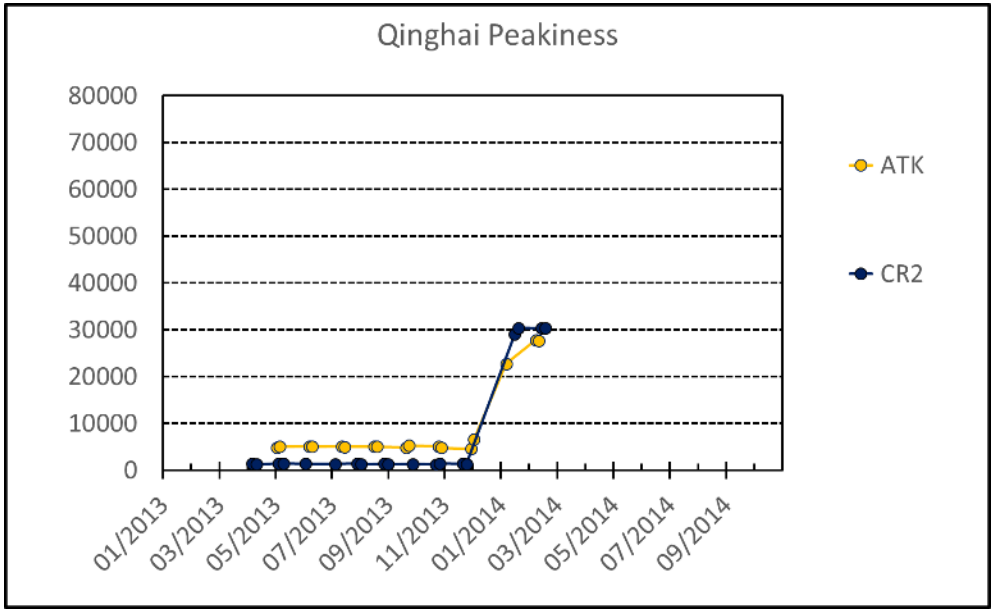


Frozen lake: January 2014

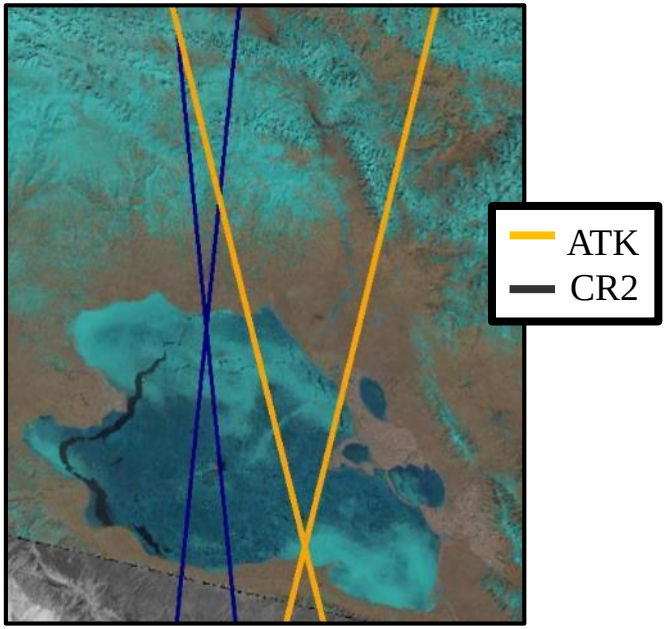


Qinghai Lake: Seasonal variations

L2: Peakiness

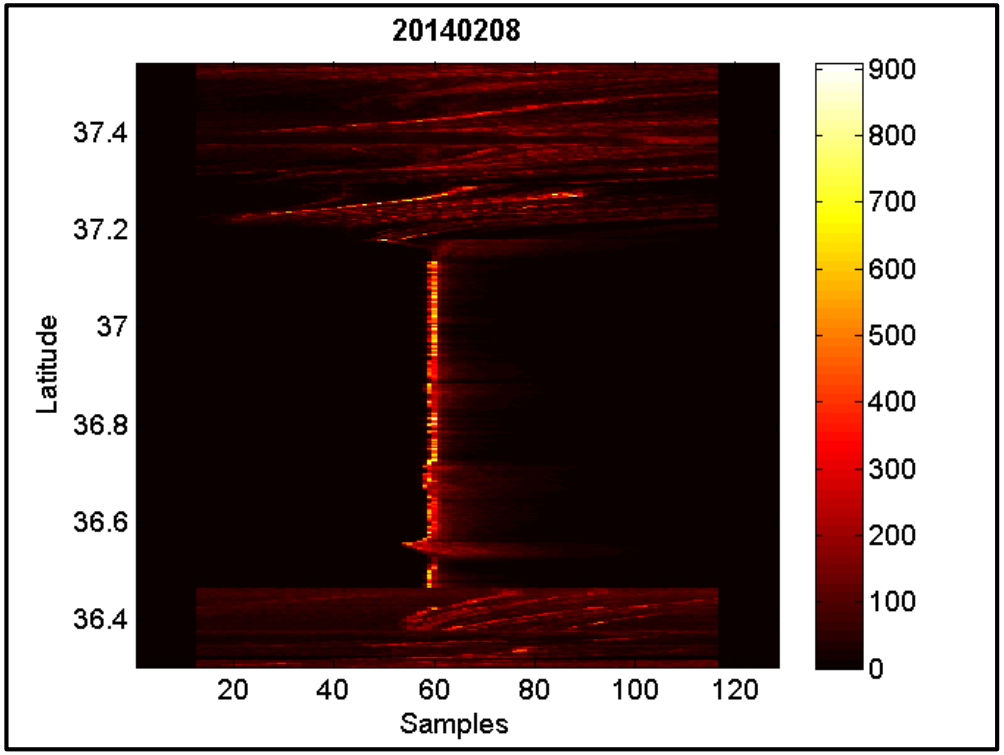


Frozen lake: February 2014

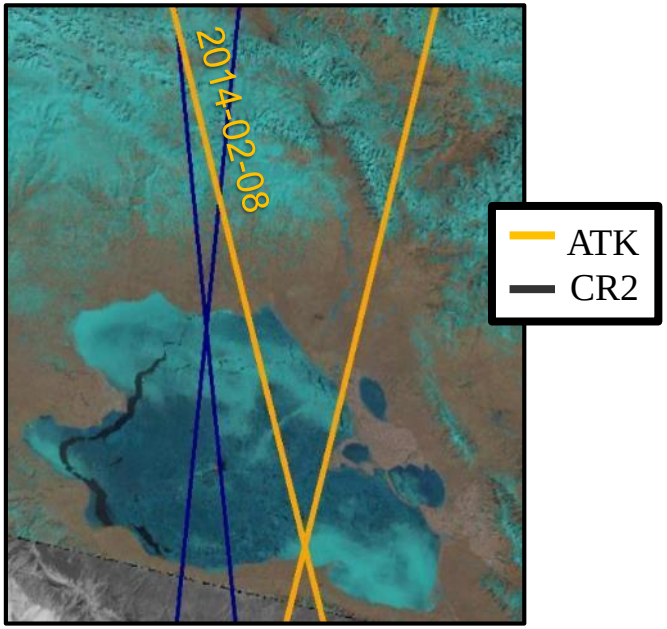


Qinghai Lake: Seasonal variations

L1: waveforms

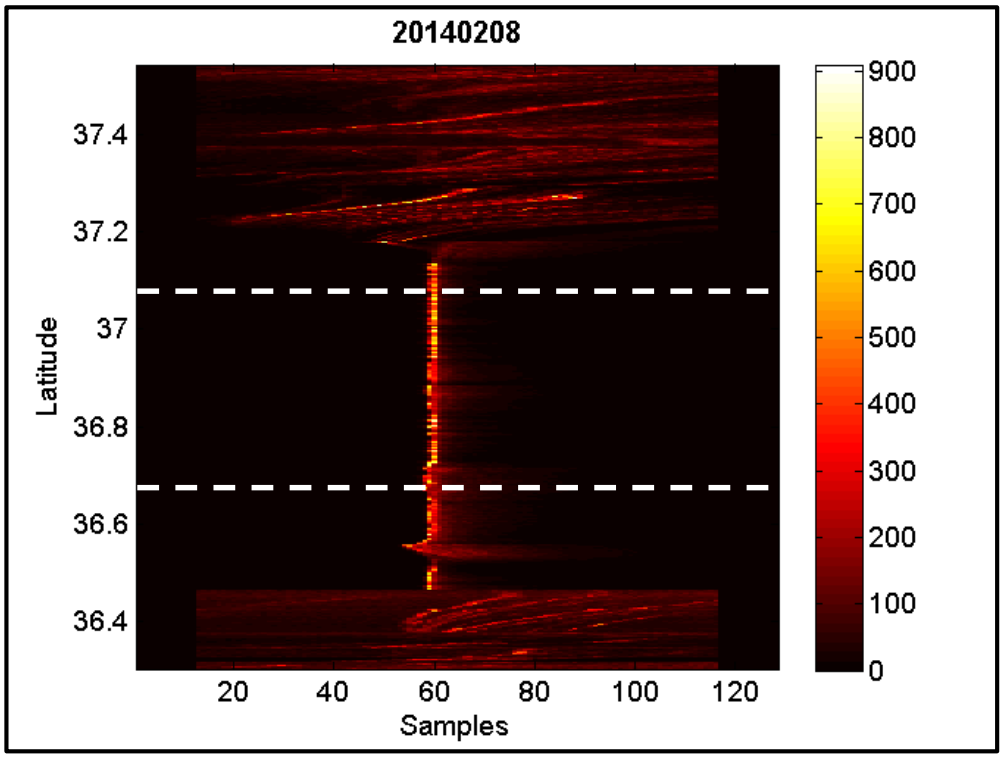


Frozen lake: February 2014

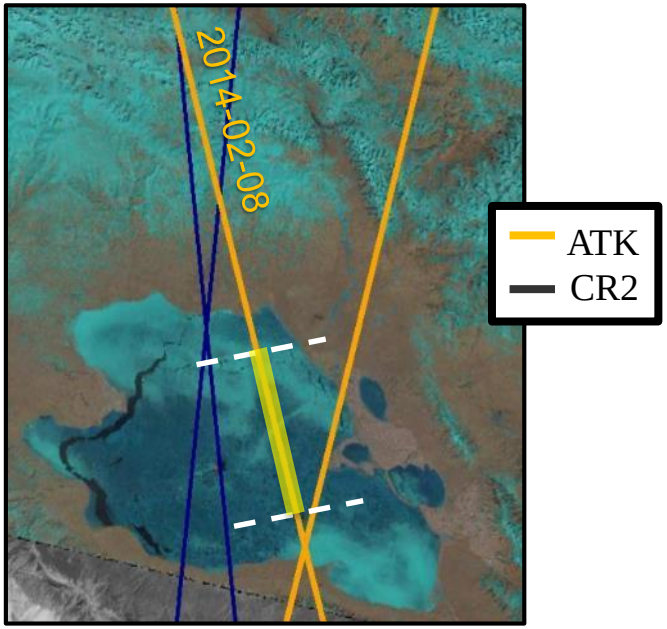


Qinghai Lake: Seasonal variations

L1: waveforms



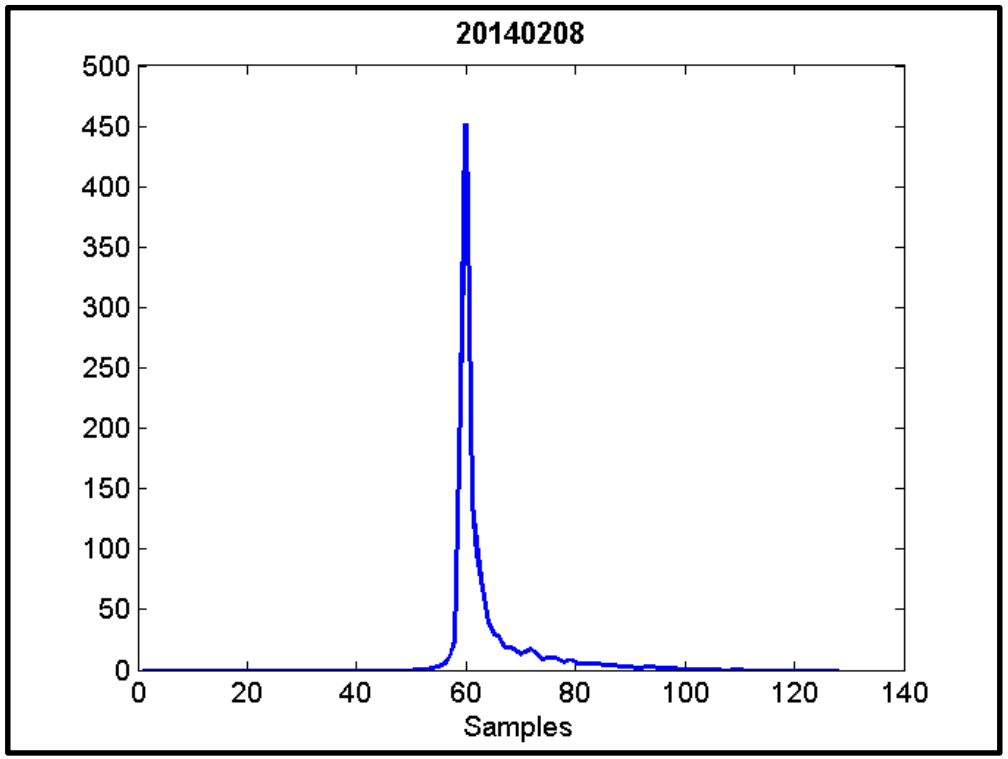
Frozen lake: February 2014



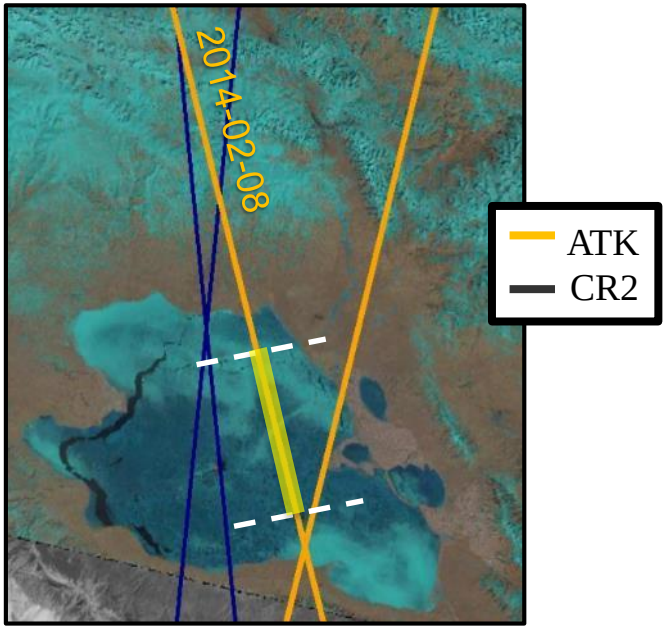
- Peaky echoes because of the frozen lake

Qinghai Lake: Seasonal variations

L1: waveforms



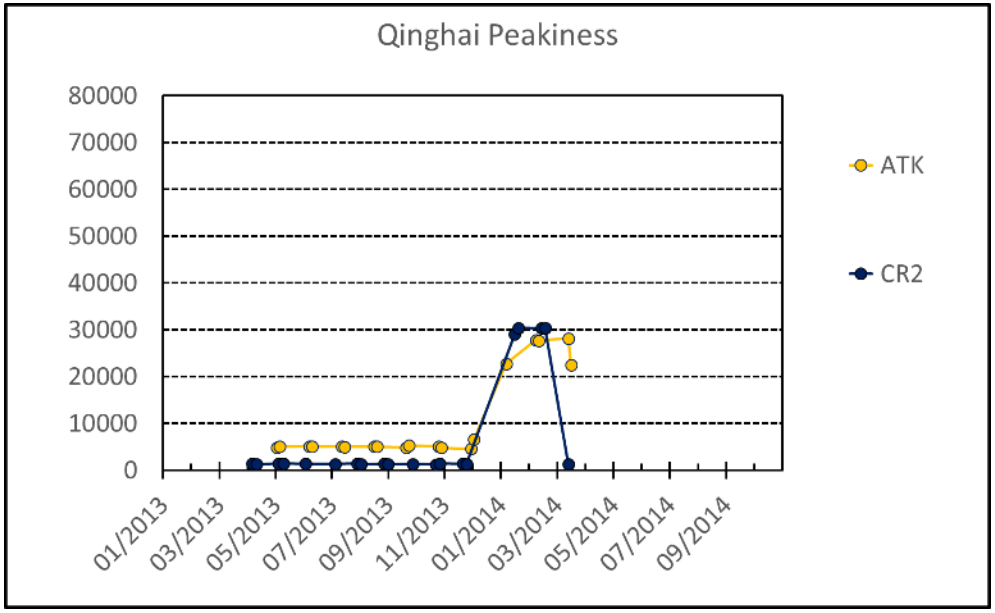
Frozen lake: February 2014



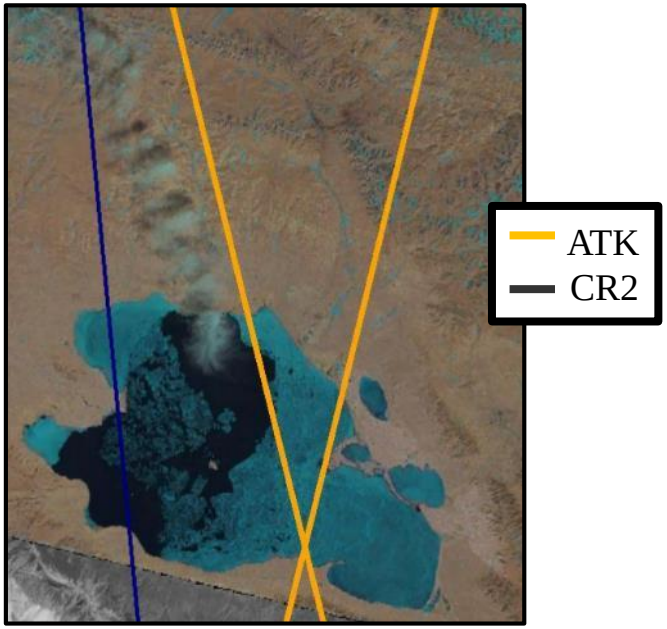
- Peaky echoes because of the frozen lake

Qinghai Lake: Seasonal variations

L2: Peakiness

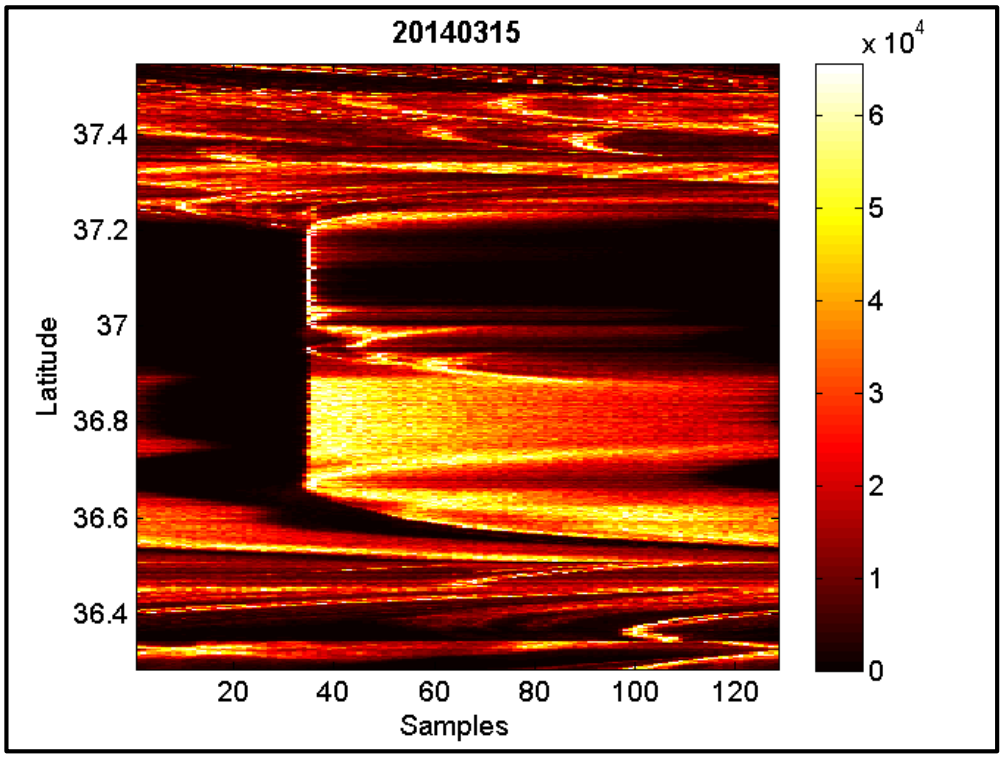


Half frozen lake: March 2014

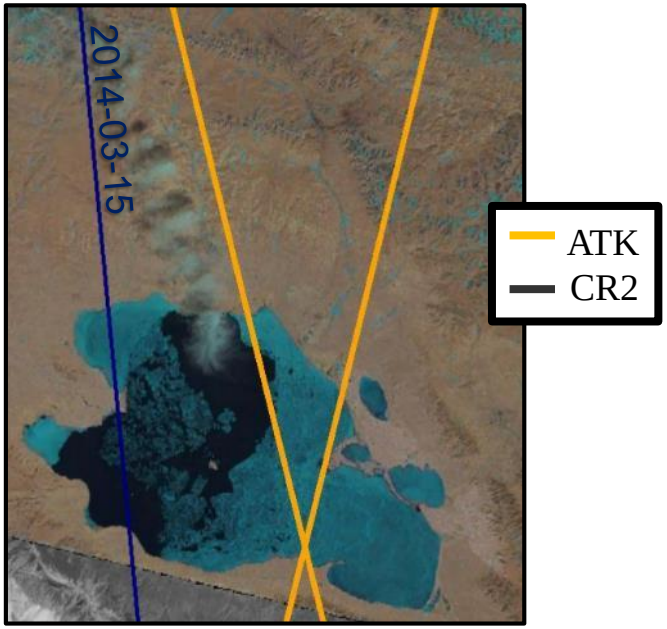


Qinghai Lake: Seasonal variations

L1: CR2 waveforms

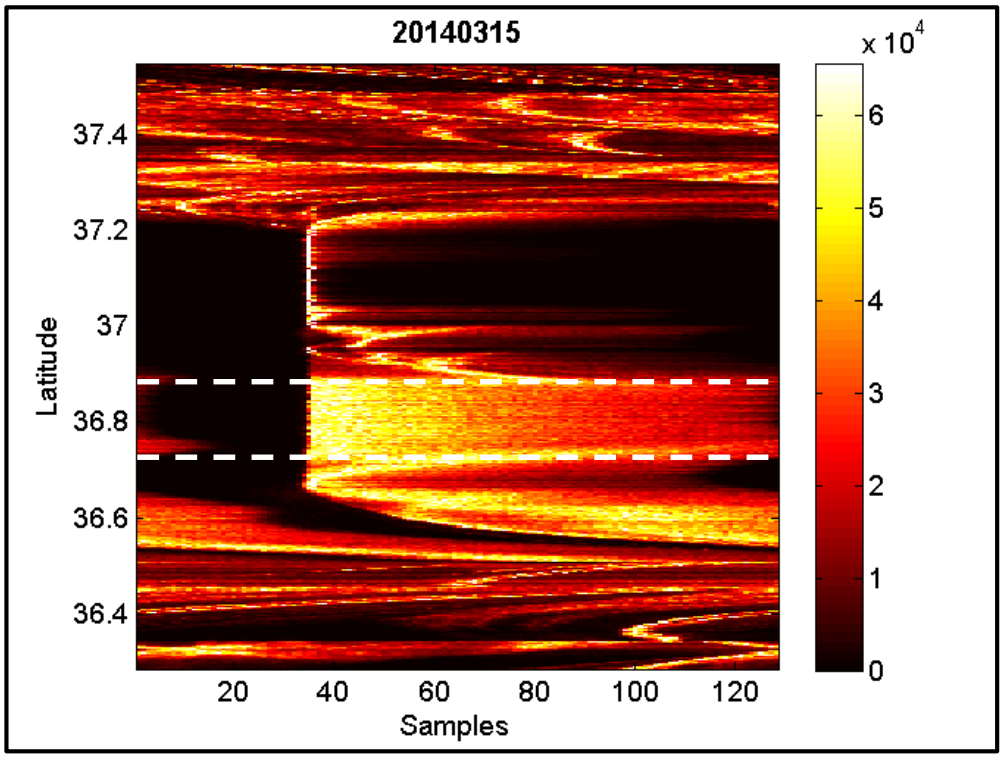


Frozen lake: March 2014

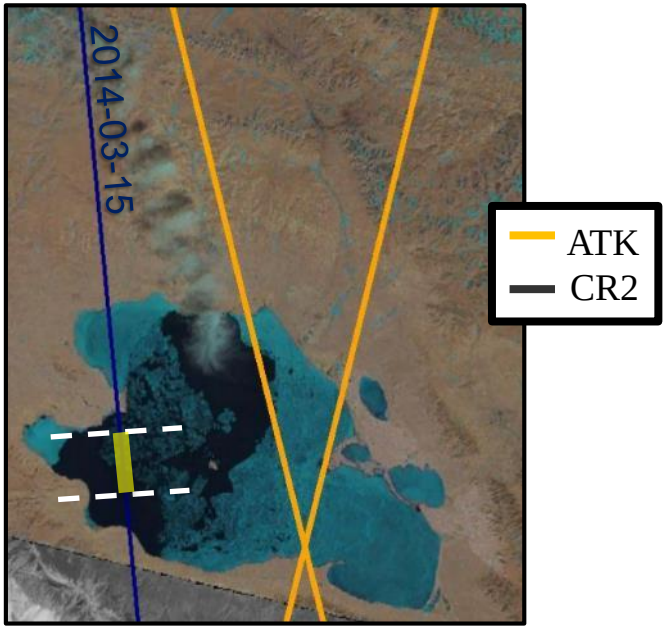


Qinghai Lake: Seasonal variations

L1: CR2 waveforms

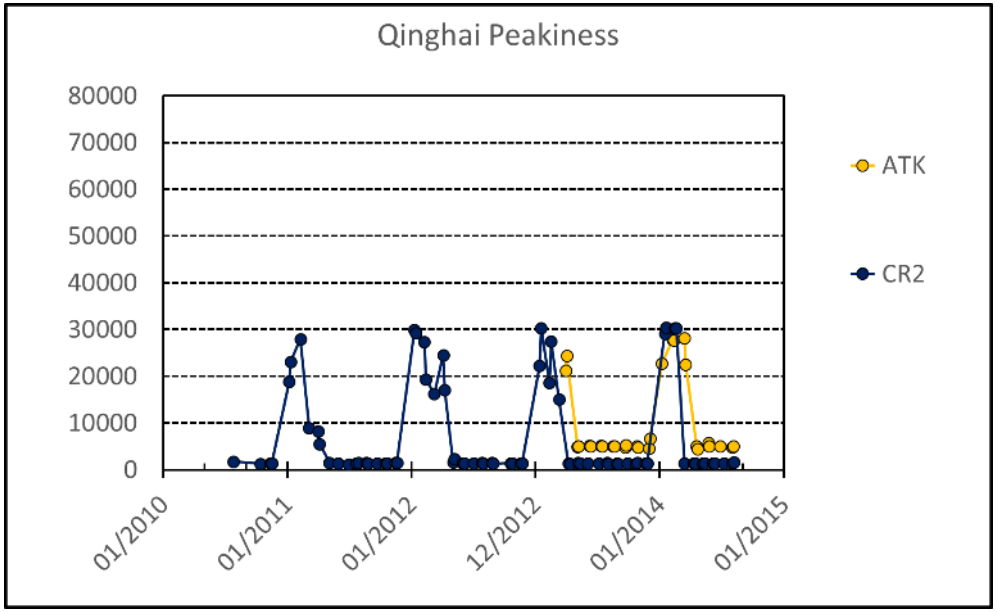


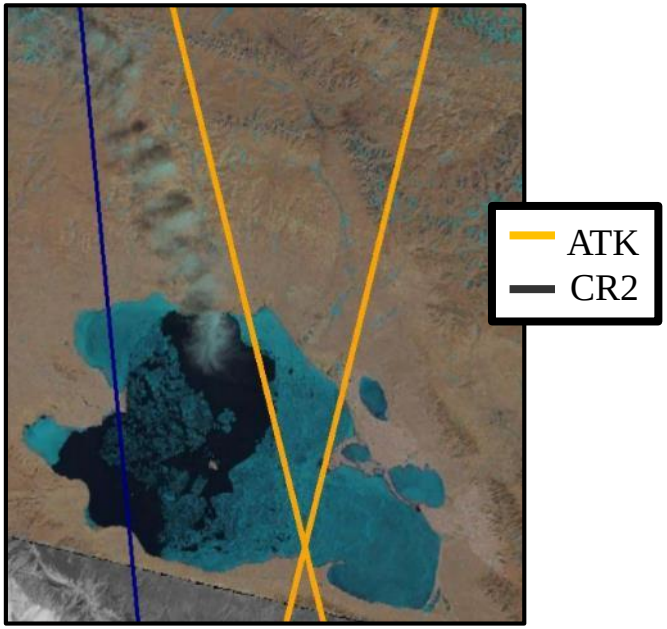
Frozen lake: March 2014



Qinghai Lake: Seasonal variations

L2: Peakiness

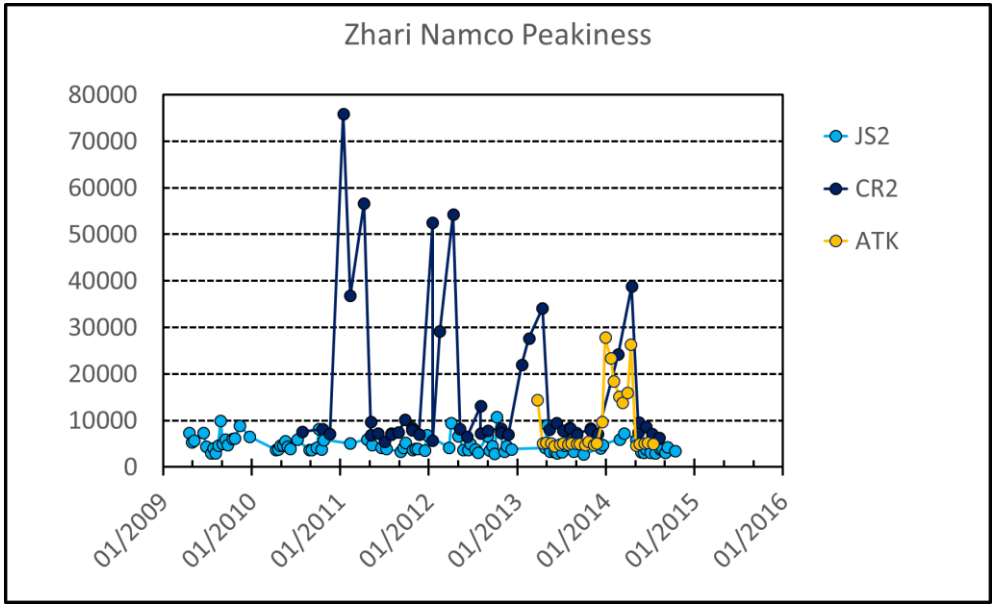


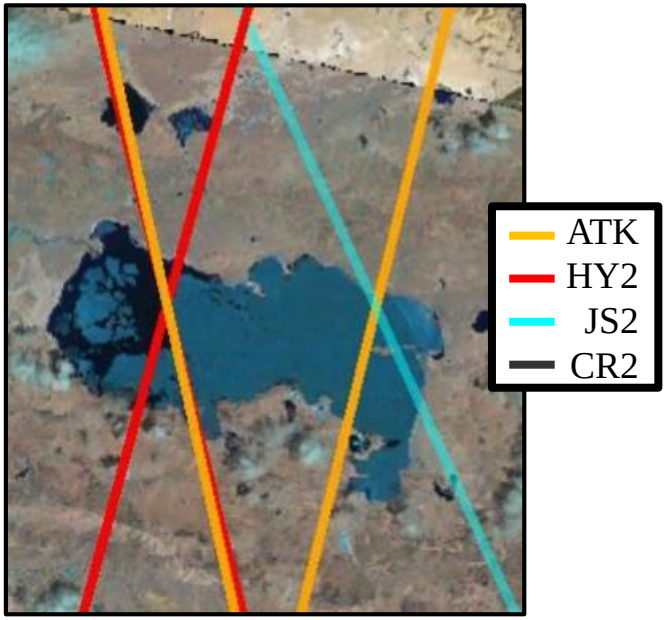


Looking at the peakiness, it can be appreciated the period when the lake starts to freeze (the peakiness increases) and and when the lake starts to melt (the peakiness increases).

Zhari Namco: Seasonal variations

L2: Peakiness

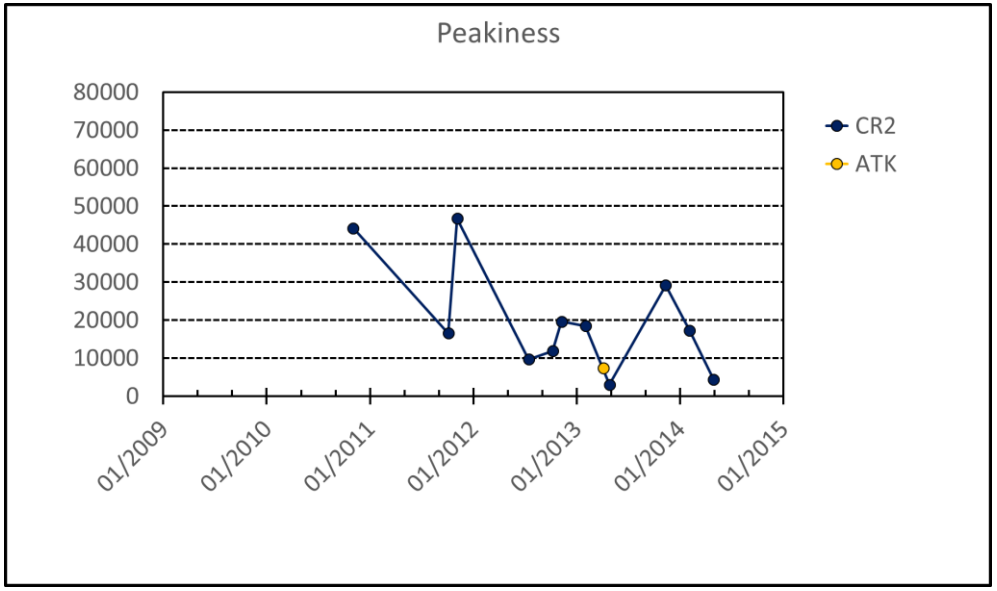


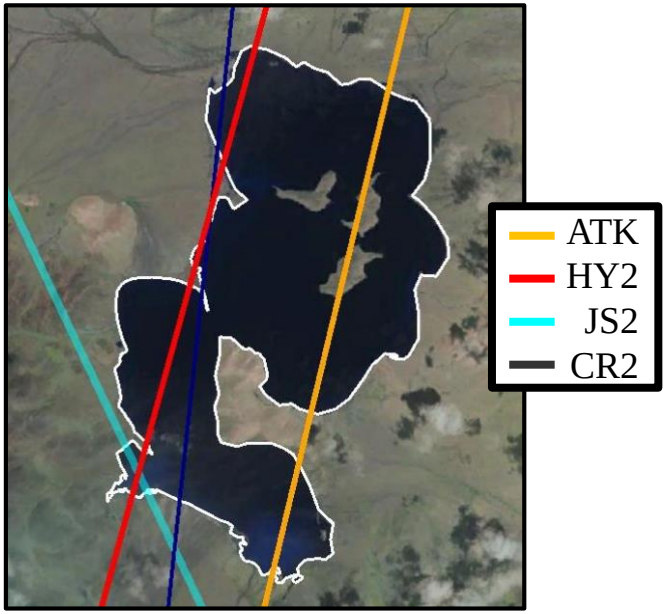


The periodicity of the Zhari Namco peakiness is very similar to the Qinghai lake. Is frozen around 4 months, increasing in the beginning of January and decreasing in mid April.

Orba Co: Seasonal variations

L2: Peakiness





For small lakes as the Orba Co (89 km^2), the freezing and melting periods are difficult to be stablished with the peakiness. The size of the lake does not allow to have good temporal sampling.

Outline

1. Introduction
    1. Altimeter chronology
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    2. Lake Surface Elevation
3. Conclusions & Future work

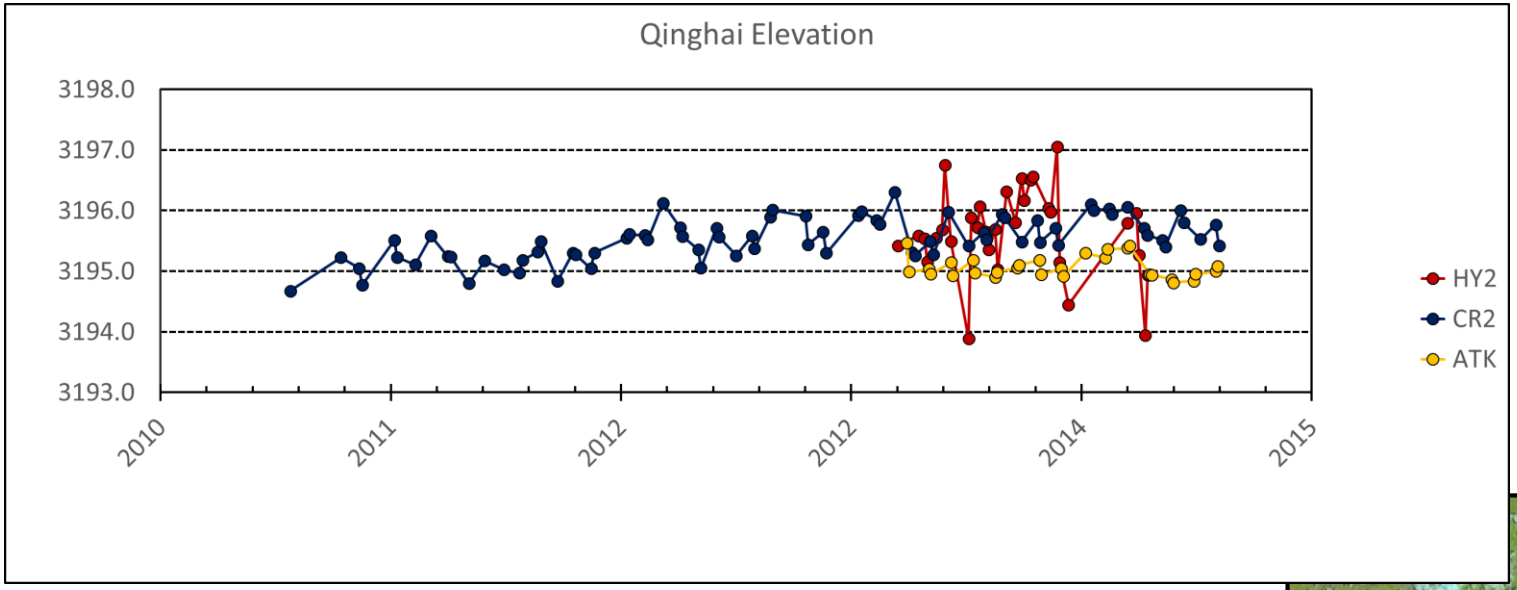
L2: Lake Surface Elevation

- LSE = Sat. Altitude - Range - Atmospheric Corr. - Geoid - Tides - Abs biases.

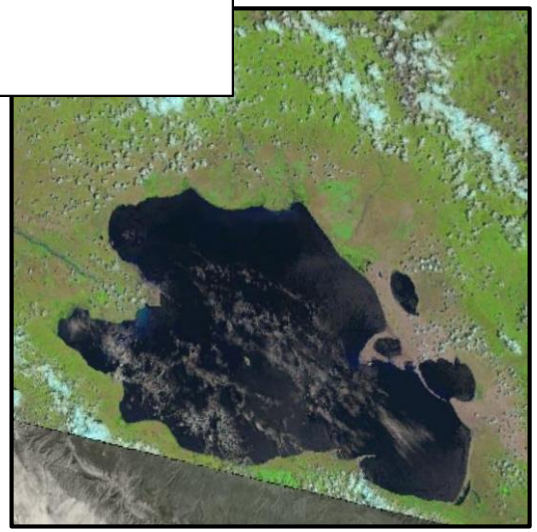
	HY2	JS2	CR2	ATK
Retracked Range	Ocean retr.	**Ice** retracker	**Ice** retracker	**Ice** retracker
Wet troposphere	ECMWF	Radiometer	ECMWF	Radiometer
Dry troposphere	ECMWF	ECMWF	ECMWF	ECMWF
Ionosphere	GIM	GIM	GIM	GIM
Geoid	EGM96	EGM96	EGM96	EGM96
Solid Earth Tide	Cartwright / Tayler	Cartwright / Tayler	Cartwright / Tayler	Cartwright / Tayler
Pole Tide	Wahr	Wahr	-	Wahr
Absolute biases	-	-	- 0.7 m	-

Qinghai Lake: Lake level 2010-2014

L2: Lake Surface Elevation

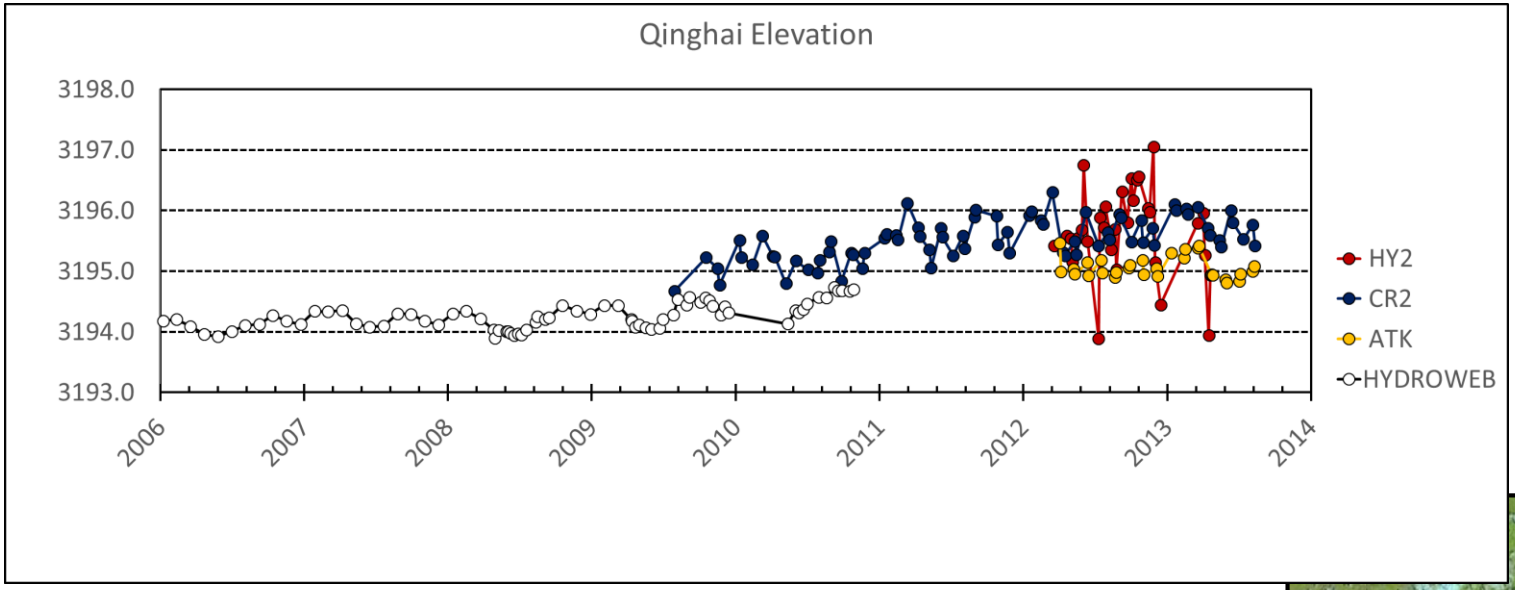


- Lake level increasing 240 mm/year.
- HY2 elevations are very noisy.
- There is a bias between missions that has to be corrected.

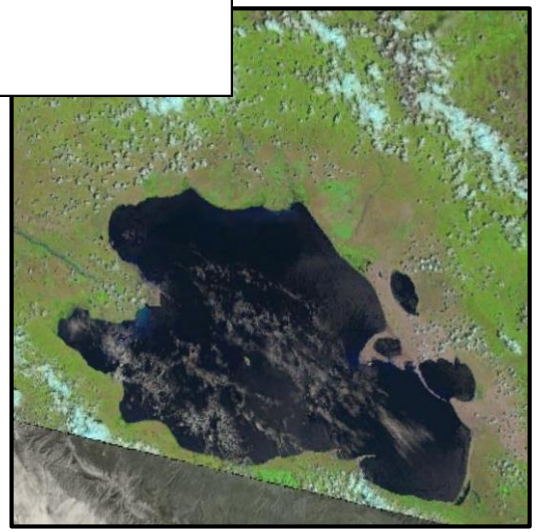


Qinghai Lake: Lake level 2010-2014

L2: Lake Surface Elevation

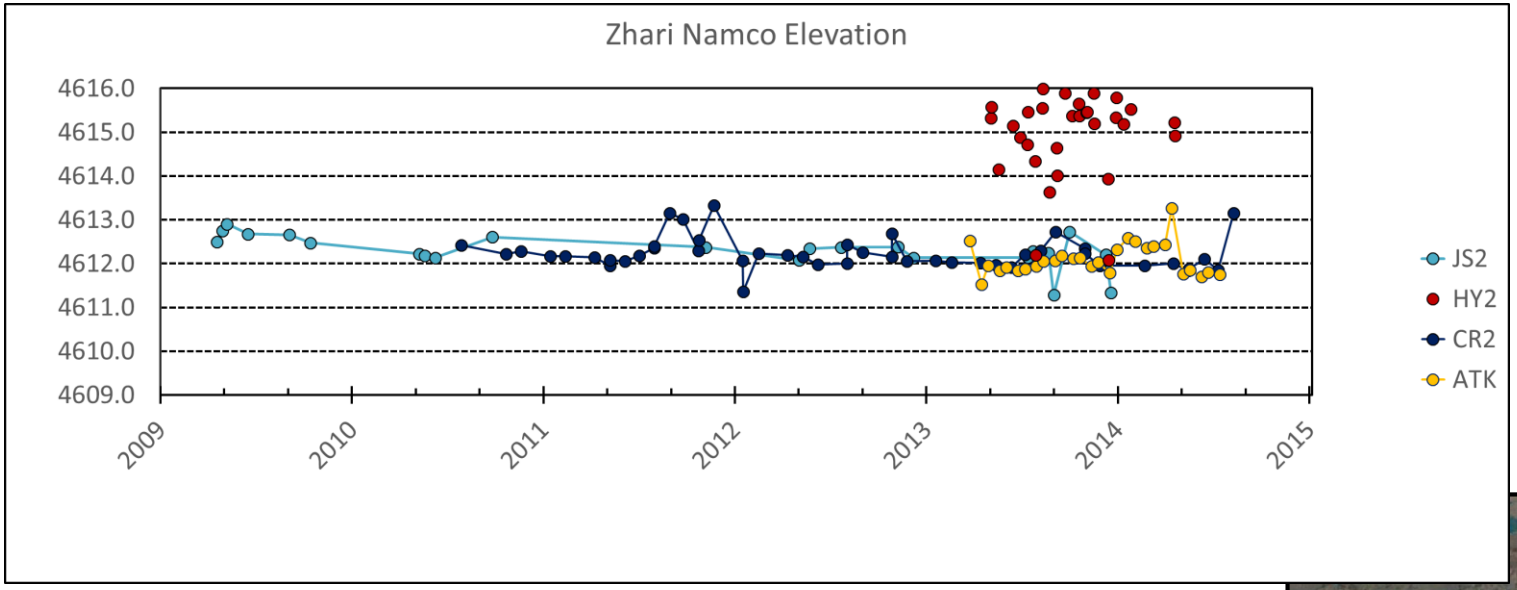


- Hydroweb time series are closed to the computed elevations.

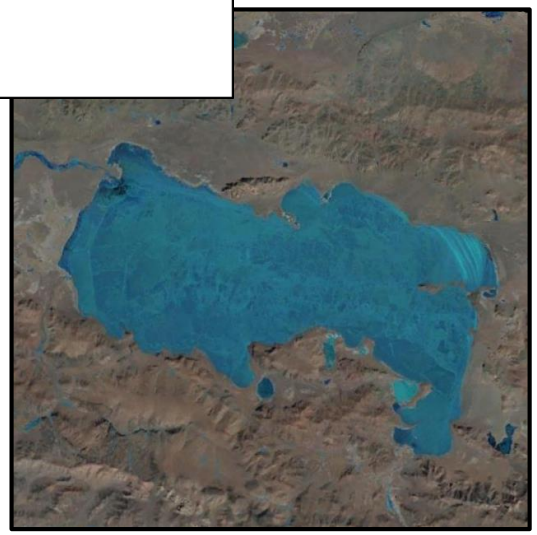


Zhari Namco: Lake level 2010-2014

L2: Lake Surface Elevation

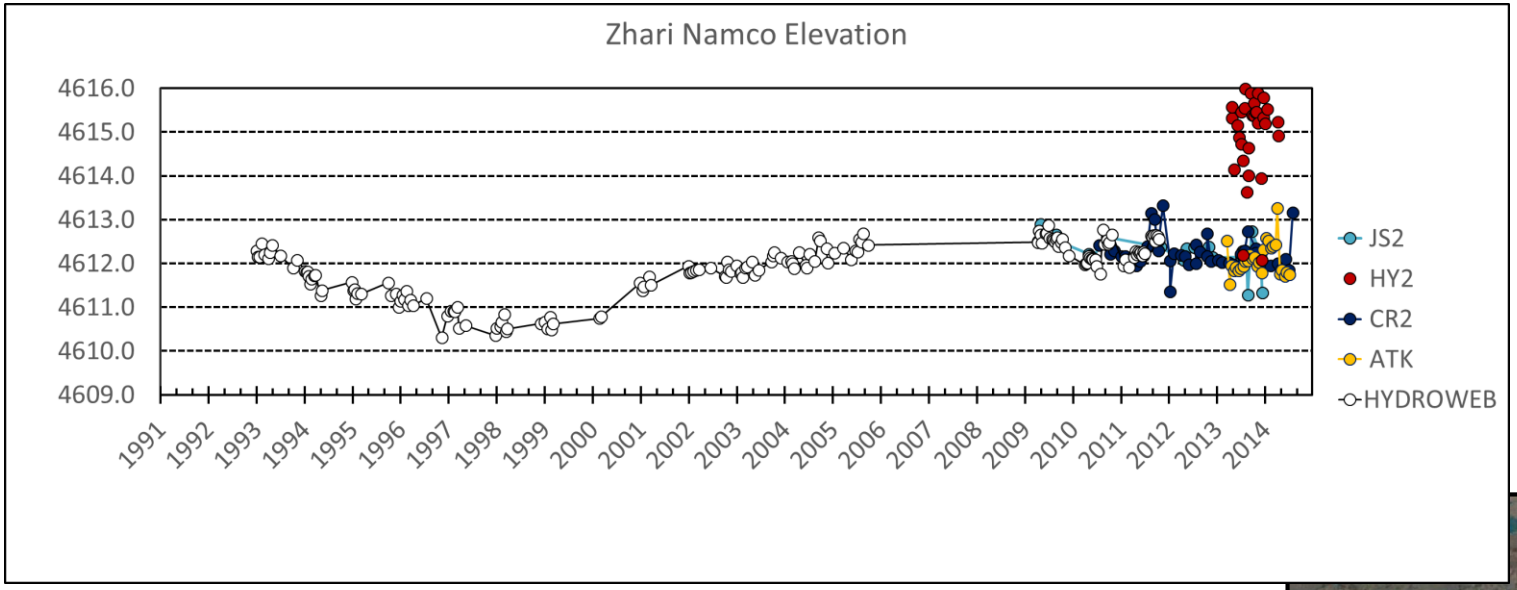


- Lake level almost constant, decreasing ~20 mm/year in the last 4 years.
- HY2 elevations are very noisy.

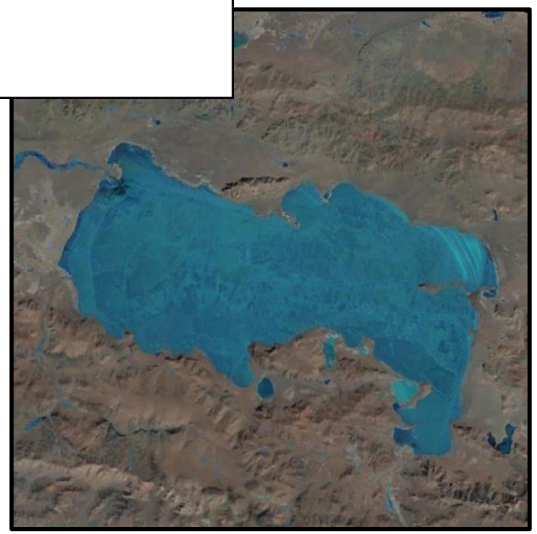


Zhari Namco: Lake level 2010-2014

L2: Lake Surface Elevation

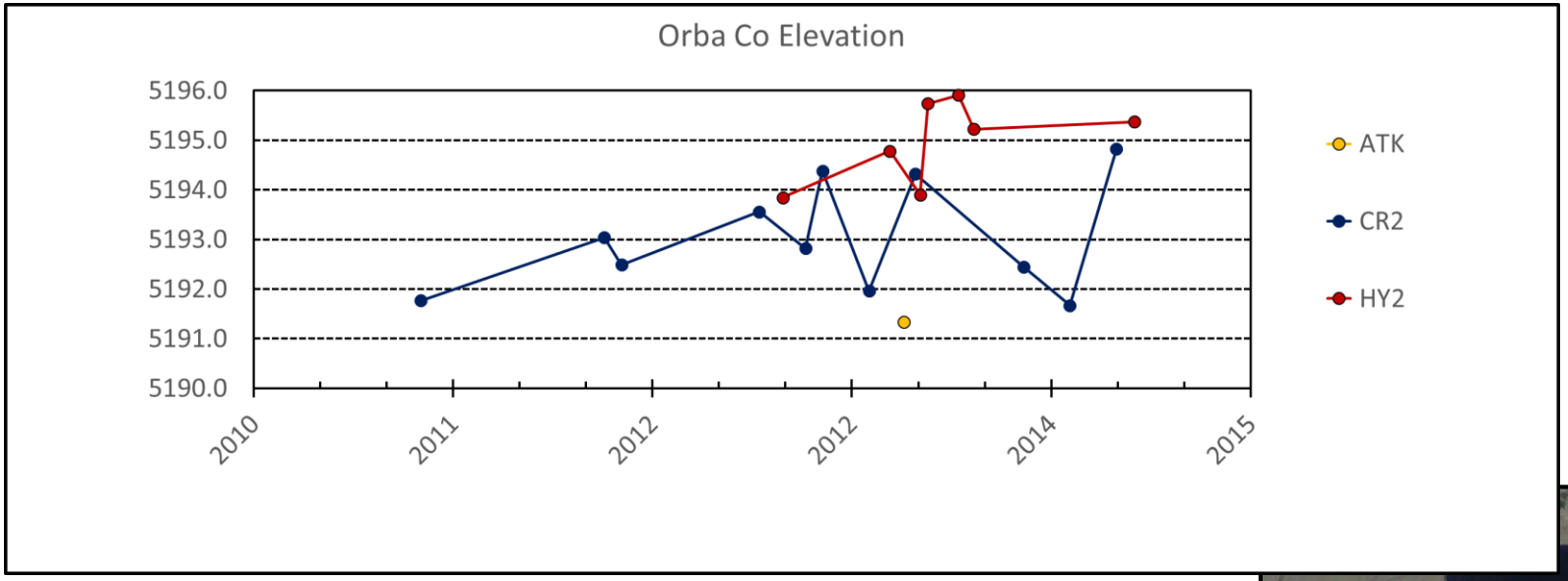


- Hydroweb database is in good agreement with the computed elevations



Orba Co: Lake level 2010-2014

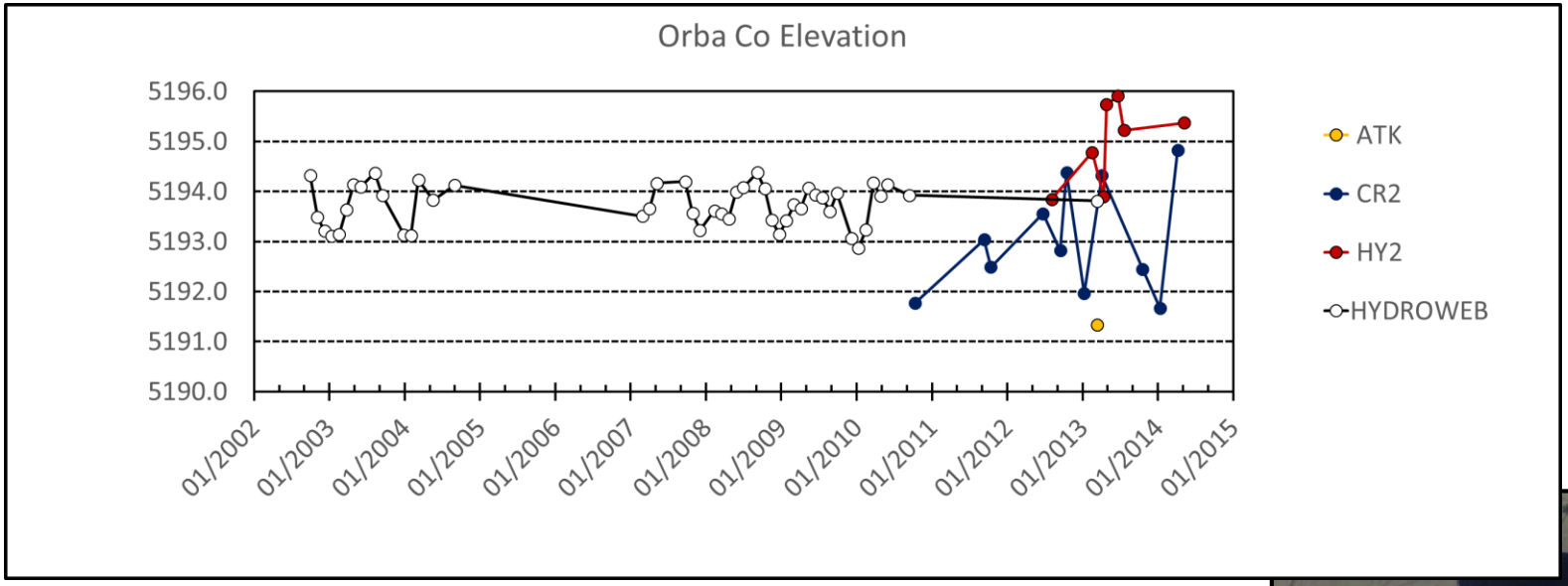
L2: Lake Surface Elevation



- Only one good measurement with AltiKa, and another with JS-2.
- Measurements are noisier due to land contamination.

Orba Co: Lake level 2010-2014

L2: Lake Surface Elevation



- Hydroweb incorporates good previous series with data of the RA-2 of EnviSat.

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Conclusions

- The **methodology** to retrieve the lake level has been **preliminary validated** with data over Qinghai and the Zhari Namco lakes from 2010 to 2014.
- Seasonal variations can be appreciated when the big lakes are frozen in winter or melted in summer.
- Comparing different missions,
  - **CryoSat-2 and SARAL provide better results** because of their orbit configuration and the higher spatial resolution.
  - Jason-2 is not useful during winter as it losses track.
  - The performances with HY2A are noisier than others.
- Qinghai Lake shows an increase of 240 mm/year from 2010 to 2014.
- Zhari Namco shows a decrease of 20 mm/year from 2010 to 2014.
- For the Orba Co, the method has to be improve to reduce land contamination.

Future work

- In situ data would be used to calibrate the biases between the different instruments.
- This study will continue with the development of a **specialised processor from L1b data** in order to classify the waveforms and select the best retracker for each echo type including the data from PISTACH and PEACHI processors.
- The method will be finally validated against 60 lakes of the Tibet Plateau.


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Thanks for your attention!