

SENTINELNAMIB : combining Sentinel 1-2-3 missions for the monitoring of the Kuiseb River in Namibia

Cassandra Normandin

University of Bordeaux / Laboratory of Astrophysics

LIVING PLANET FELLOWSHIP

BIOSPHERE

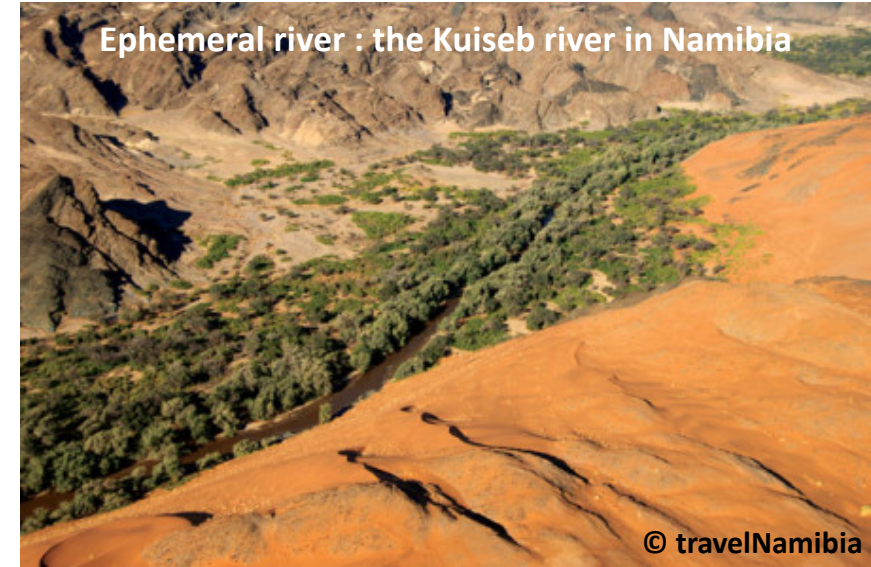
Water in arid environments

➤ **Water resources** : more and more crucial for arid environments (~ 1/3 of Earth surface)

- **Fossil aquifers**, related to past rivers and lakes, which are poorly known or still to be discovered
- **Ephemeral rivers** : measurable discharge occurs <10 % of the year, **well-defined peaks, downstream reductions** = infiltration into channel and floodplain sediments.



The improvement of our knowledge on river dynamics is a global necessity to reduce periods of food insecurity



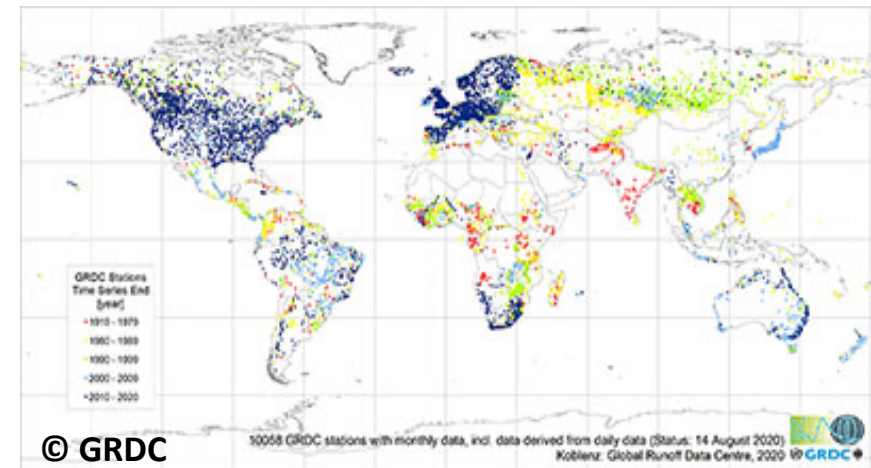
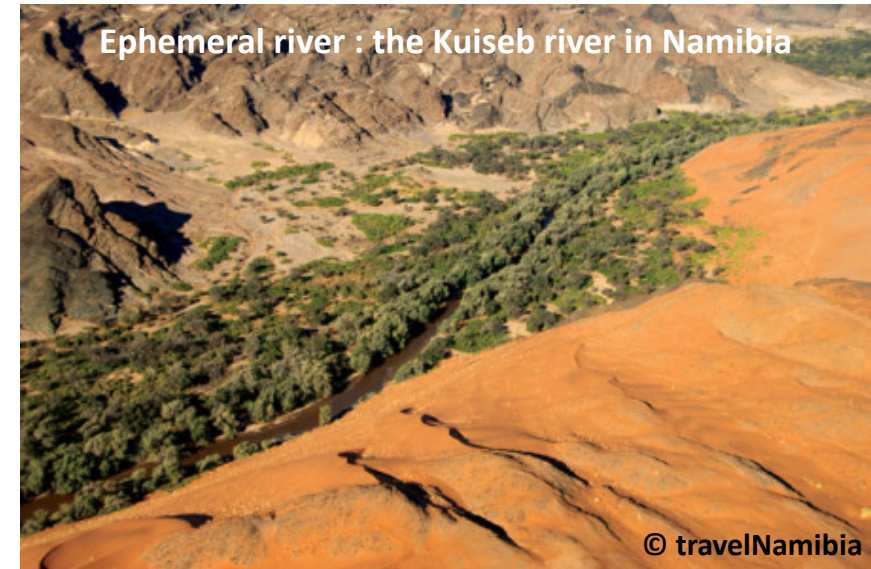
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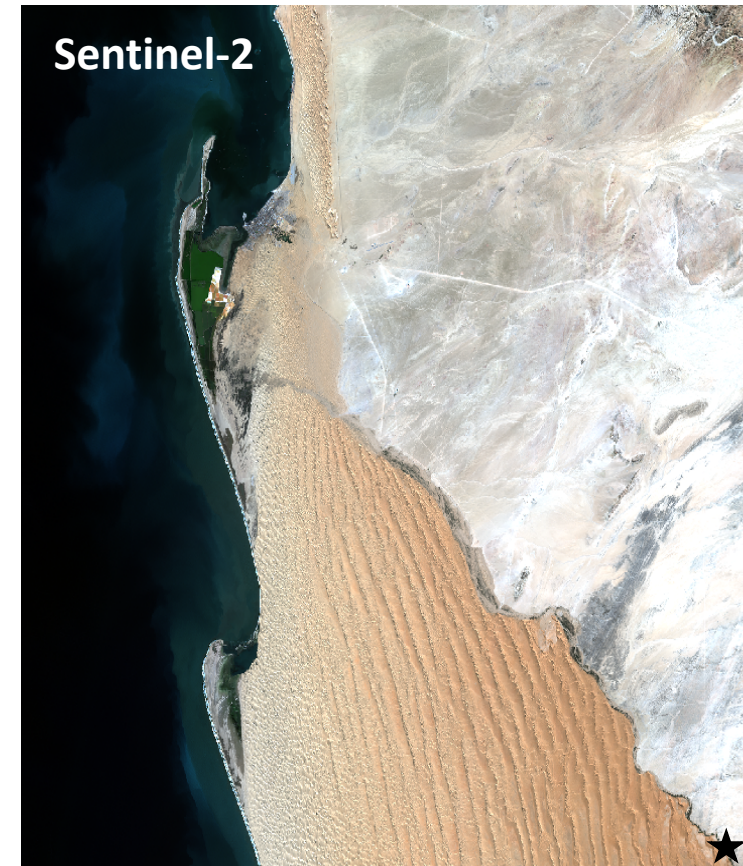
- **Few *in situ* gauges** in arid environments to monitor hydrological parameters (runoff, groundwater level, soil moisture,...)
- **Space remote sensing** : provide a unique contribution to this question



Study site – Kuiseb River



- **Namib Desert** : calibration/validation site for the Earth Explorer BIOMASS mission with the **DesertSAR airborne campaign** (Coordinator : Pr. Paillou Philippe)
- Cooperation between the **Gobabeb Research and Training Center (GRTC)** in **Namibia** and the **Laboratory of Astrophysics of Bordeaux (LAB)**

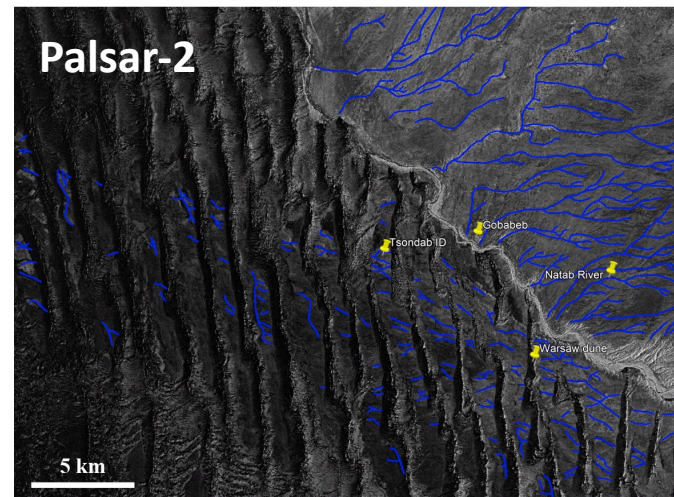
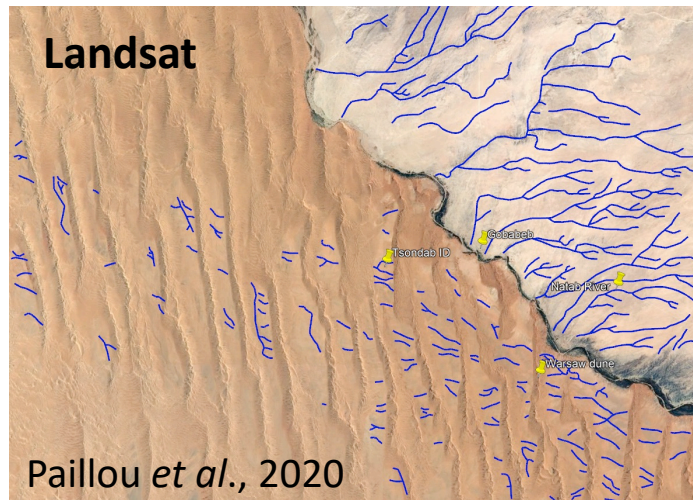
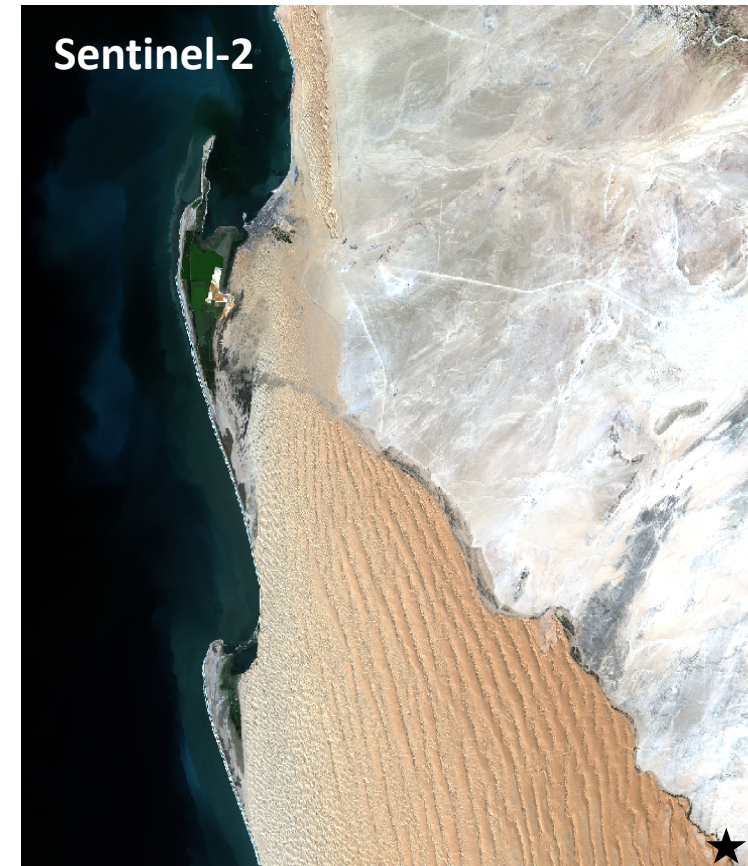


Gobabeb

Study site – Kuiseb River



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Gobabeb ★

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Paleo-Kuiseb:

- relevant marker for the recent paleo-climate in South Africa
- important resources, in terms of fossil water, for Namibia

➔ **What about the actual Kuiseb River ?**

Study site – Kuiseb River

General characteristics

- **Namibia**, South West of Africa
- One of the 12 **ephemeral rivers** in Namibia
- **Length of the river** : ~ 560 km
- **Drainage basin** : ~ 15,500 km²
- Border between **gravel plains in the North** and the **Namib Sand Sea in the South**

Climate

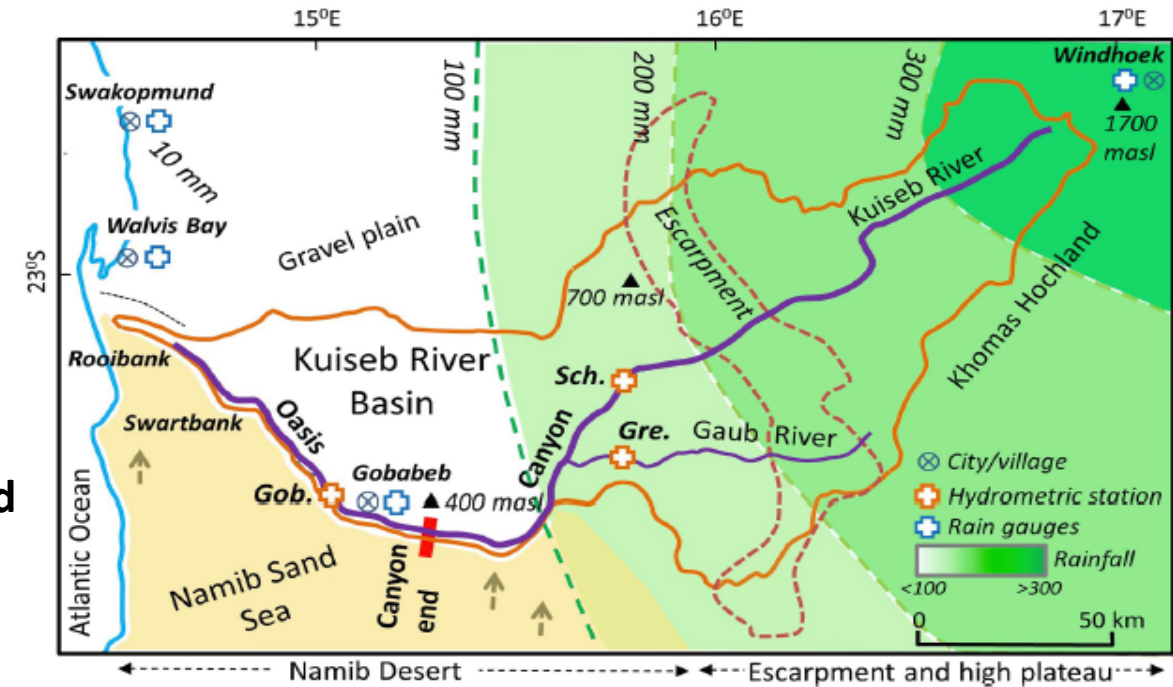
- **Semi-arid/arid** = mean annual temperature ~ 18°C
- **Climatic gradient** from the east to the west :
 - Windhoek (east) = 350 mm/year of rainfall
 - Walvis Bay (west) = <100 mm/year of rainfall



➔ **FLOODS** ➔

Main water resources

Important losses (evaporation, transmission, recharging, human needs)



Grodek et al., 2020

Project objectives :

- **Usefulness of combining multi-sensor** data provided by the **Sentinel** missions
- To develop **new methods** in order to **better understand** and **monitor ephemeral rivers** related to processes at the surface-subsurface interface

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Scientific question :

- **What information can provide the joint use of multi-sensor spatial data to improve our knowledge of the hydrological dynamics of the Kuiseb River?**
- ➡ looking for some **feedback mechanisms** (moisture-runoff, moisture-vegetation, ...)

Monitoring of the hydrological dynamic of the Kuiseb River, in relationship with the neighbouring paleo-channels (2016 – 2020)



Extraction of **hydrological parameters** :
soil moisture, aquifer level, flooded areas, water levels, vegetation

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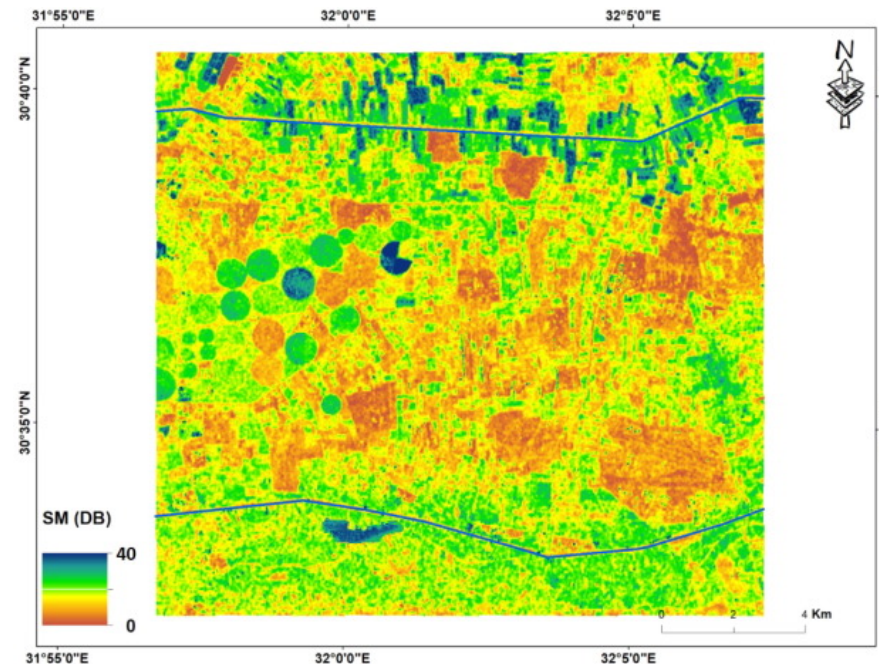


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Sentinel-1
Radar images

Changes in the soil
moisture



Mohamed *et al.*, 2019

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Sentinel-2

Multispectral imagery

Flood extent, vegetation
growth

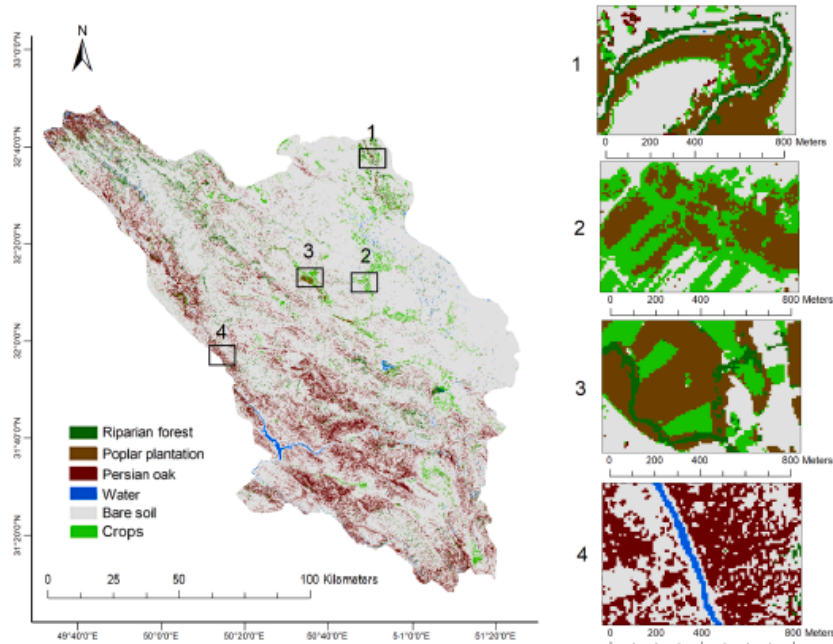


Fig. 5. Final vegetation map for the entire Chaharmahal-va-Bakhtiari province based on combined use of UAV and Sentinel-2 data.

Daryaei *et al.*, 2020

10

Monitoring of the hydrological dynamic of the Kuiseb River, in relationship with the neighbouring paleo-channels (2016 – 2020)

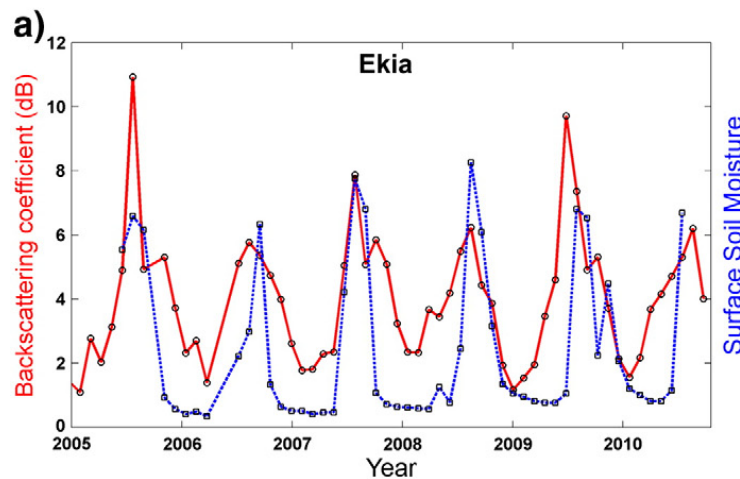


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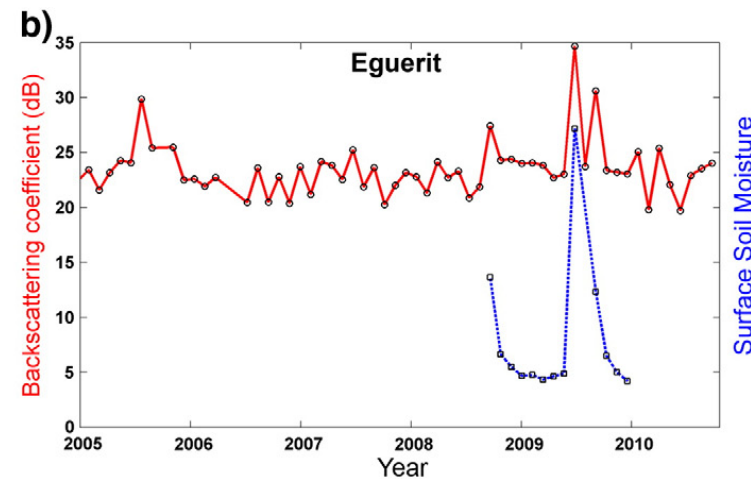


Sentinel-3 :
Radar altimetry

**Changes in soil moisture,
backscattering coefficients**



Fatras *et al.*, 2012



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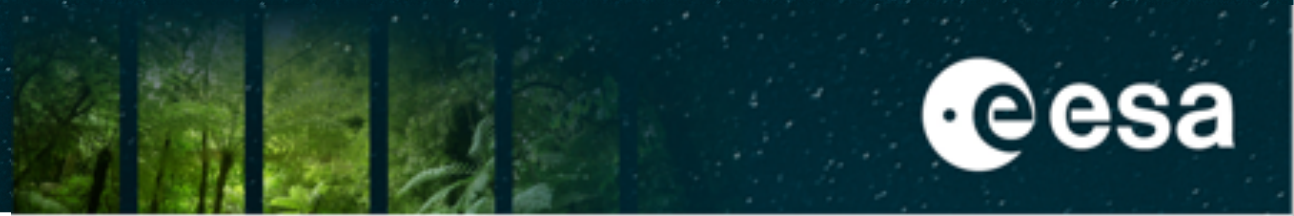
Changes in soil moisture,
backscattering coefficients

Softwares : SNAP, PolSarpro, BRAT, MAPS, ...

Validation and comparison :

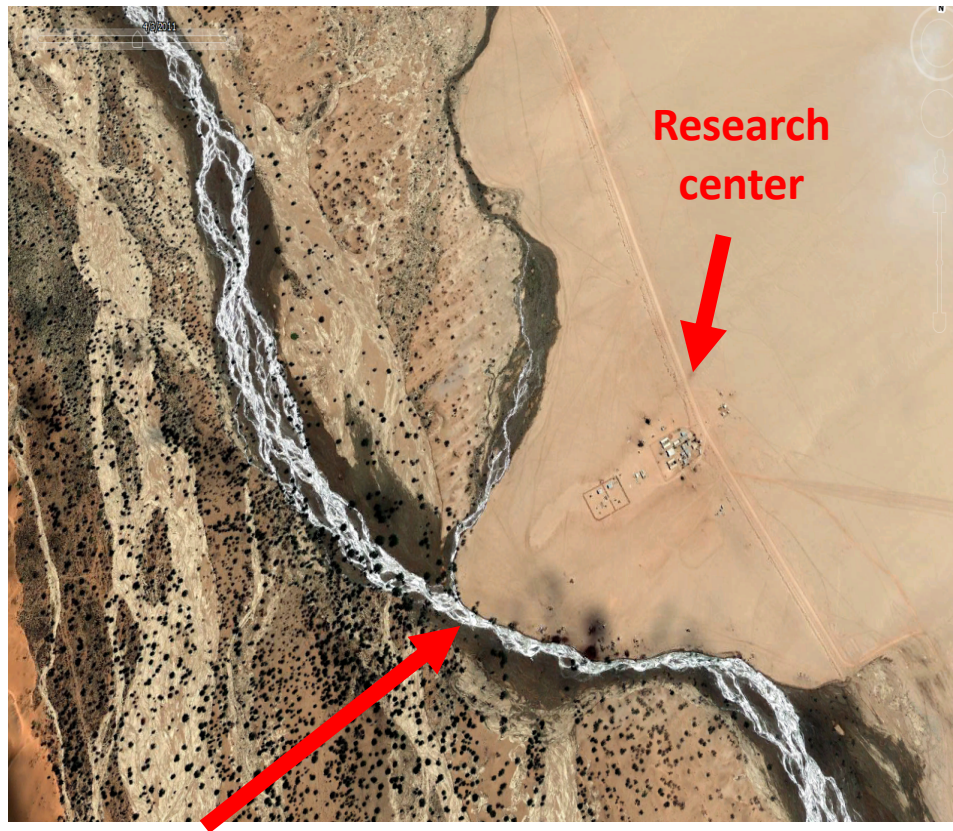
In situ measurements, field work (DesertSAR campaign)

Multispectral imagery



Field work at Gobabeb Research and Training Center (GRTC)

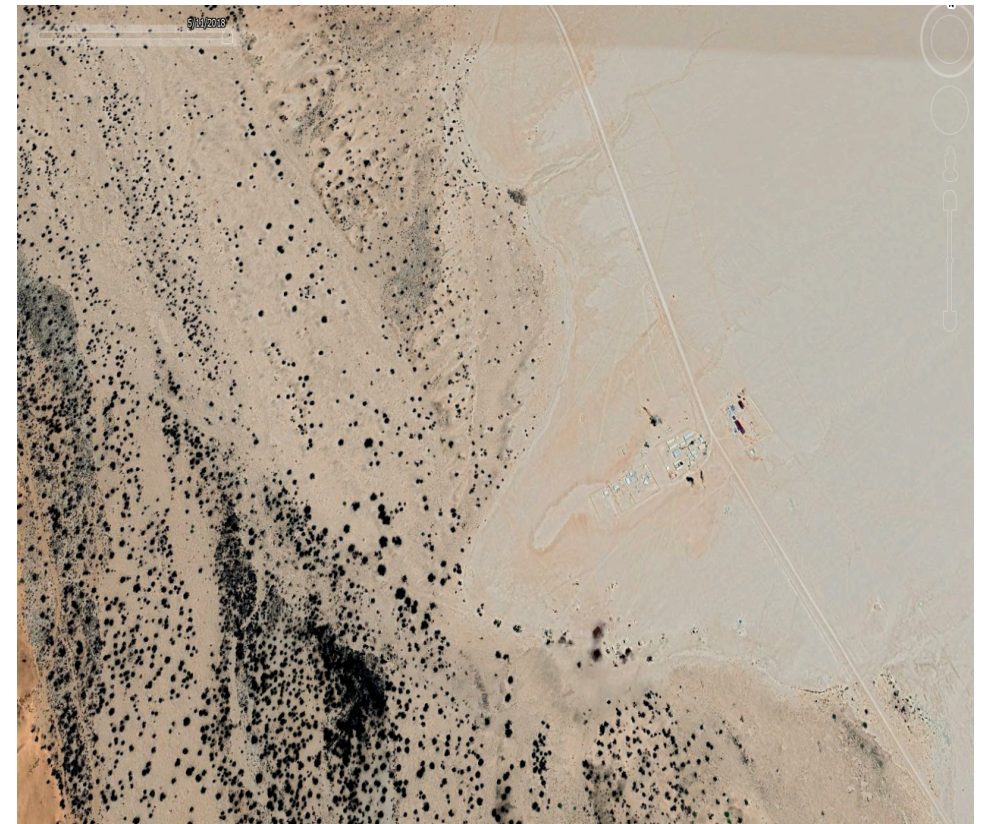
2011



Kuiseb River

© Google Earth

2019



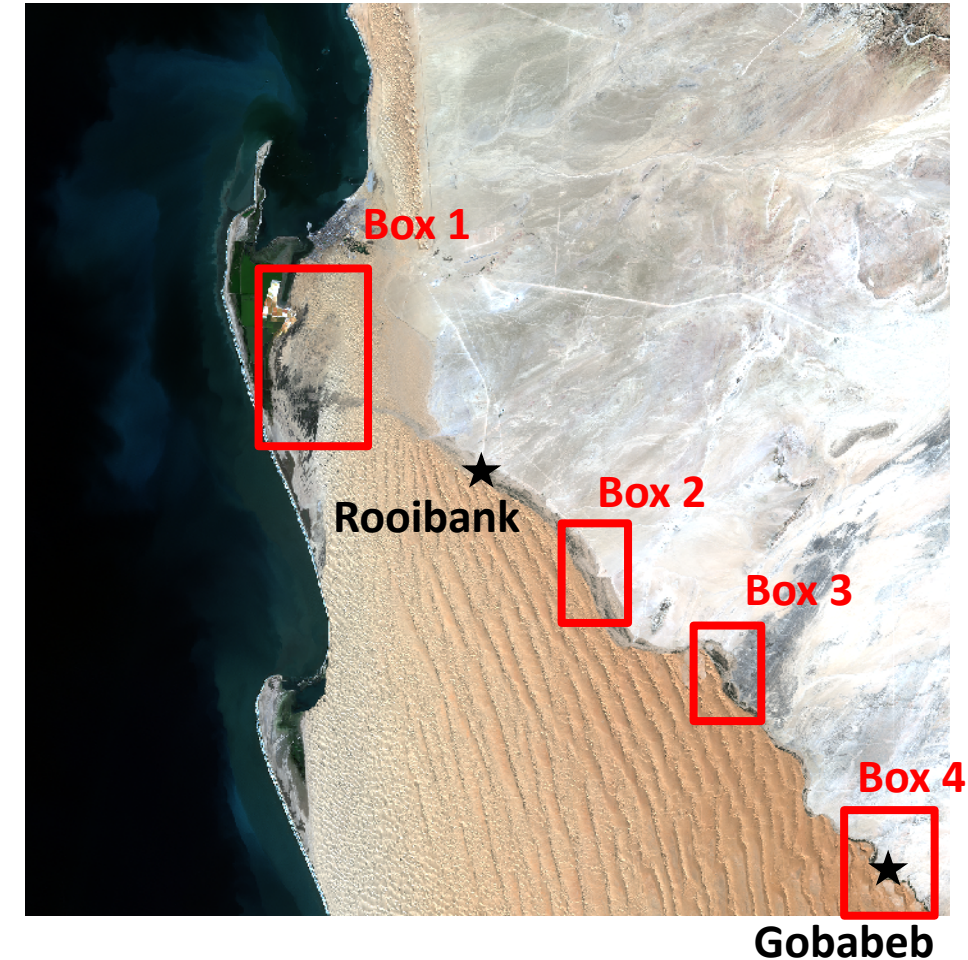
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Vegetation study along the Kuiseb River

- **Sentinel-2A/B** : launched in 2016 and 2018
- **Level L2A** :
 - CNES : PEPS website (<https://peps.cnes.fr/rocket/#/home>)
 - Already corrected : MAJA algorithm
- **Tile 33KVQ**
- 91 images without clouds between 2016 and September 2020
- **Normalised Difference Vegetation Index (NDVI, Tucker, 1979)**

$$NDVI = \frac{NIR - red}{NIR + red}$$

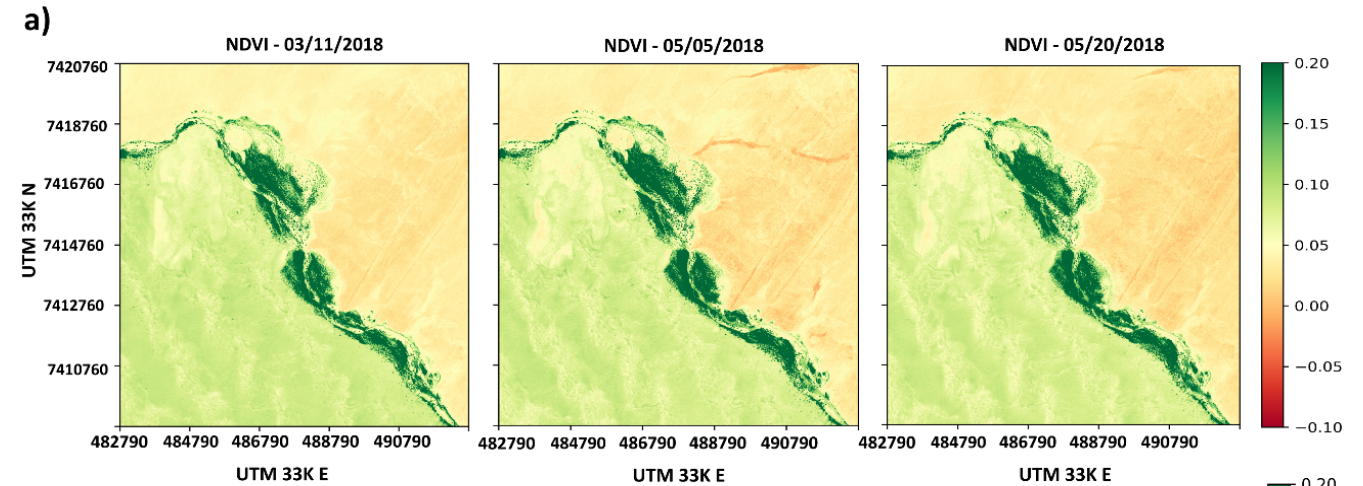
- **4 zooms** (boxes in red)



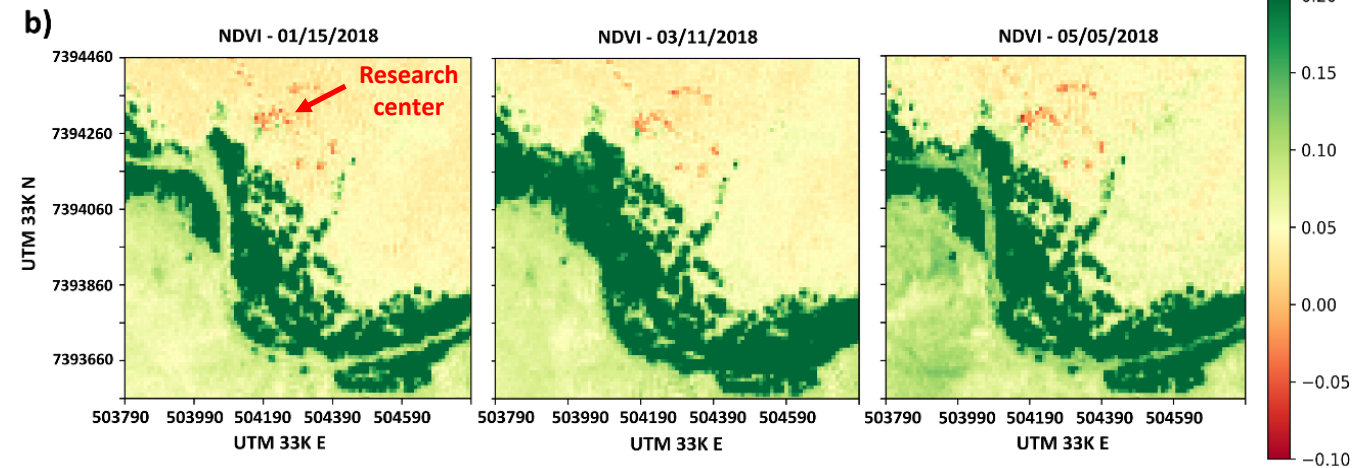
Vegetation study along the Kuiseb River

- NDVI – maps

Box 3

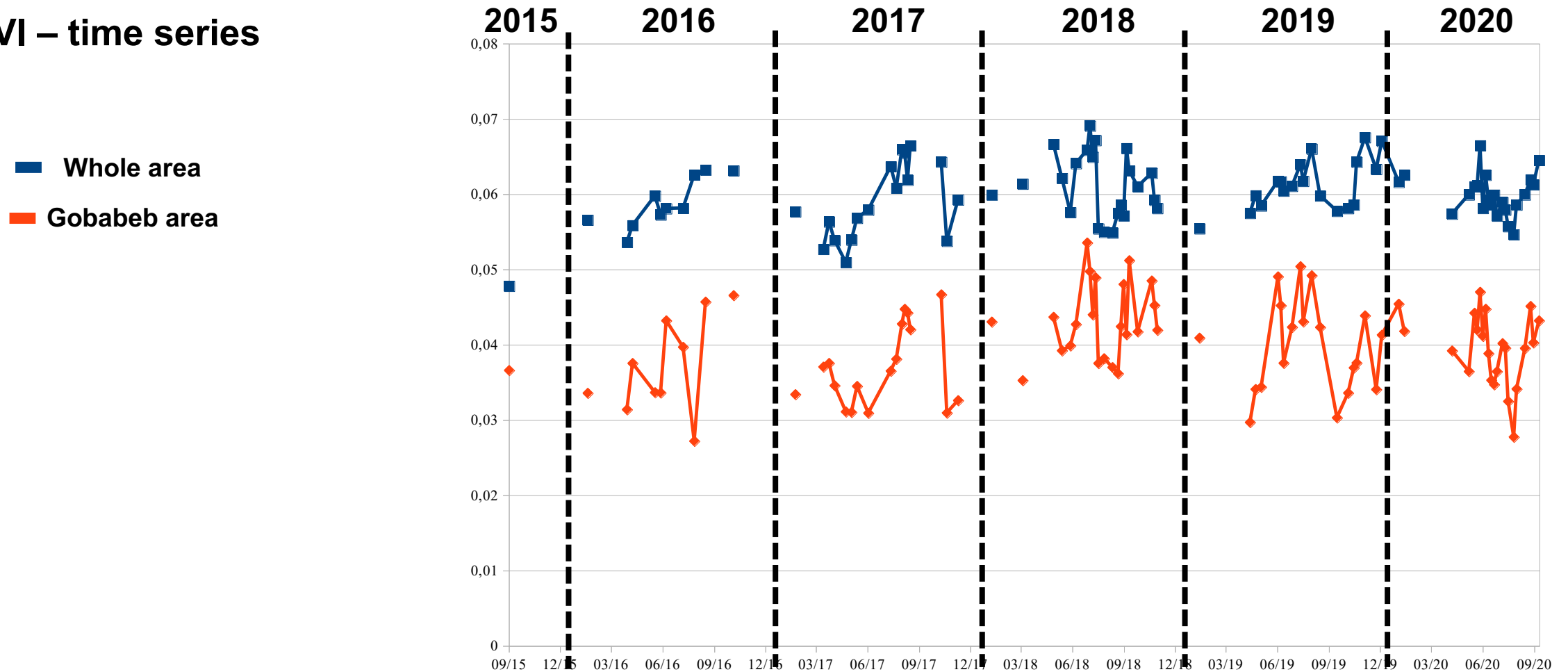


Box 4
(near Gobabeb)



Vegetation study along the Kuiseb River

• NDVI – time series



Subsurface properties : backscattering coefficients

- Altimetry tracks

Sentinel-3A

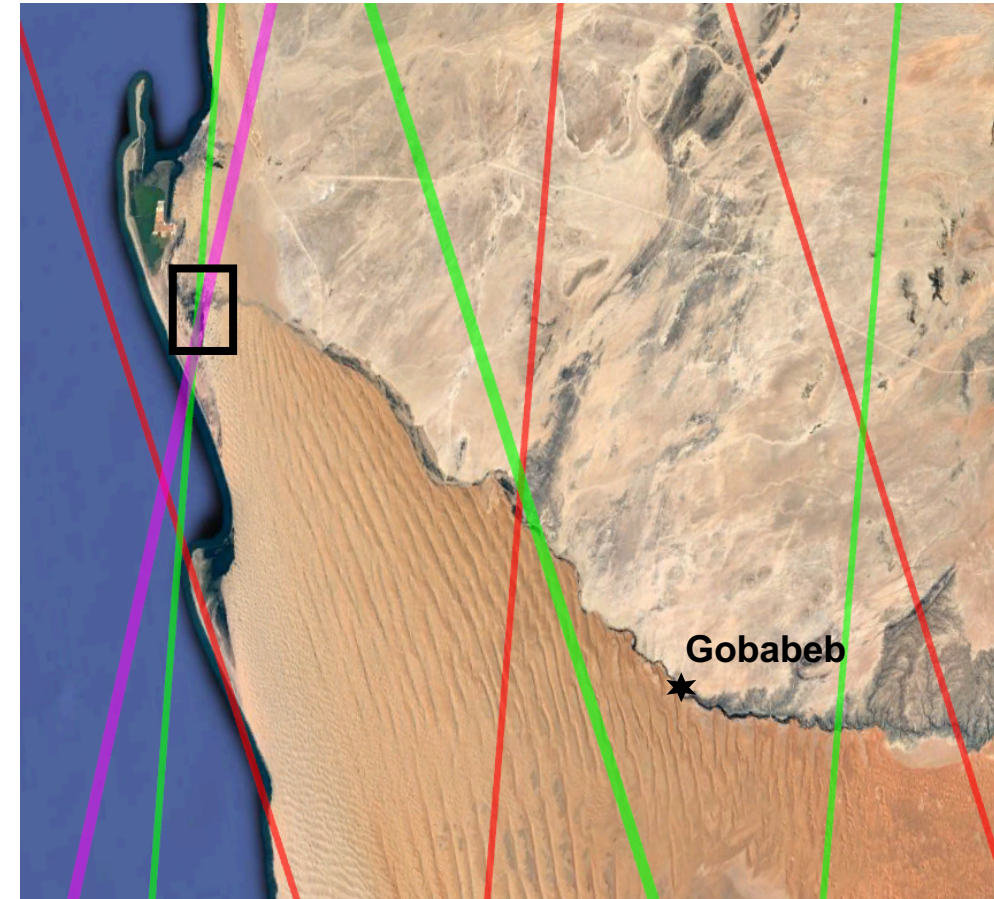
Since February 2016
27 days

Sentinel-3B

Since April 2018
27 days

Jason

Since 2001
10 days



© Google Earth

Radar altimetry



Subsurface properties : backscattering coefficients

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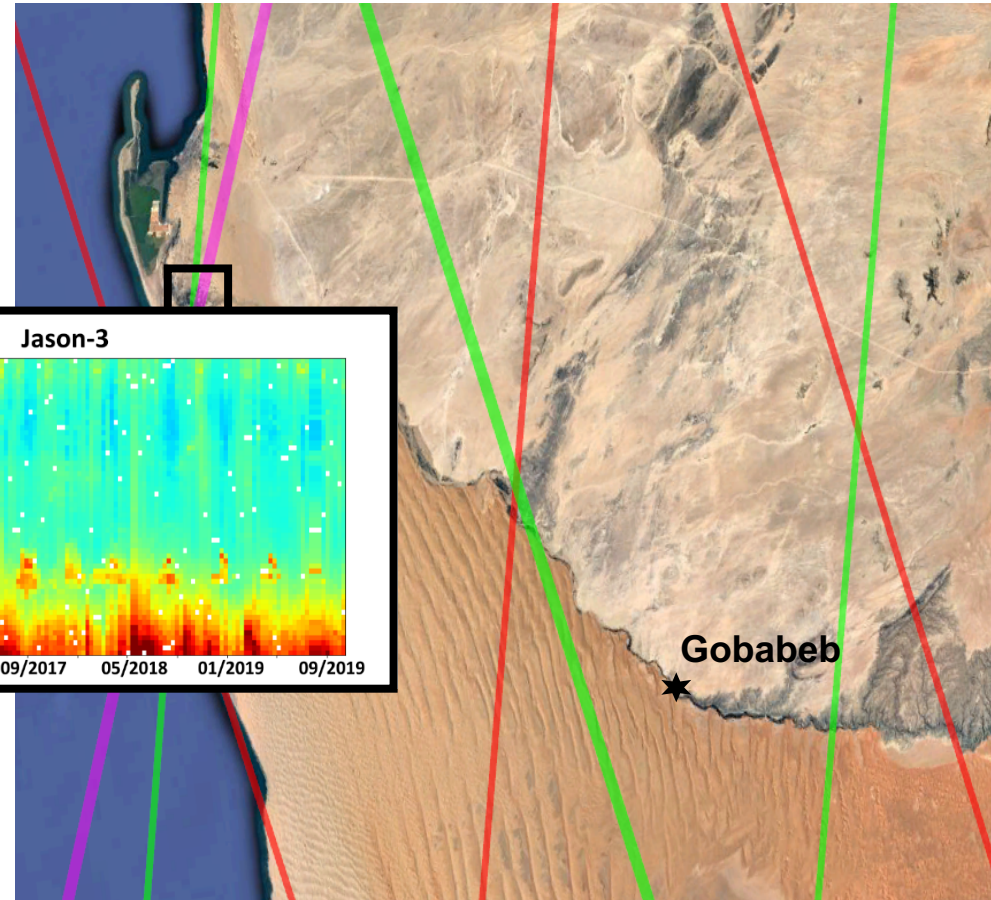
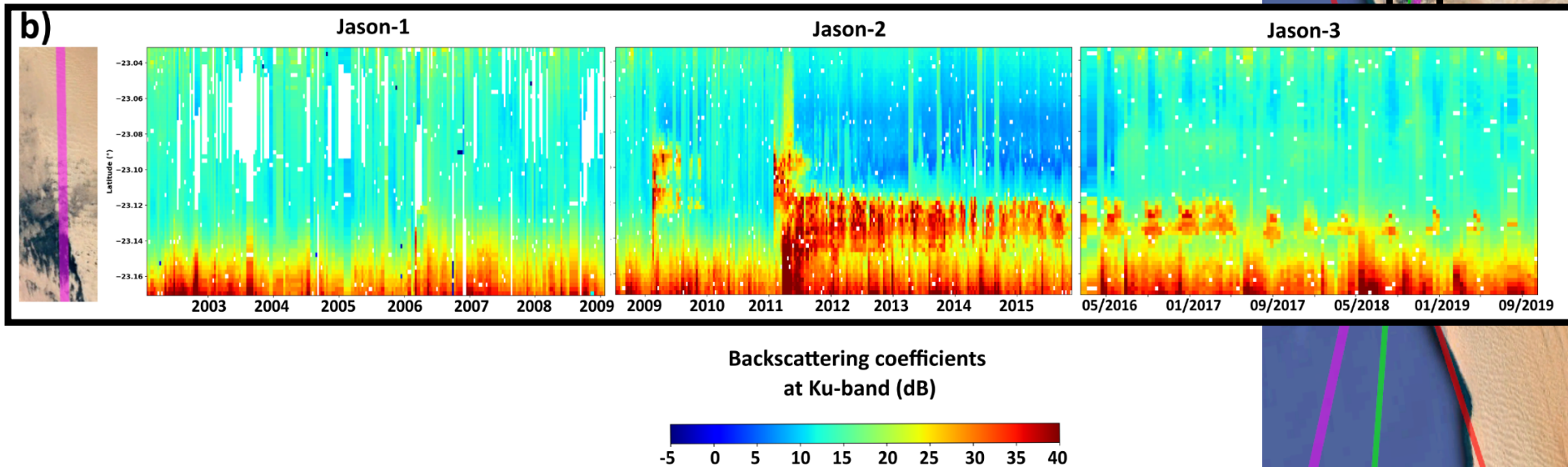
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Radar altimetry



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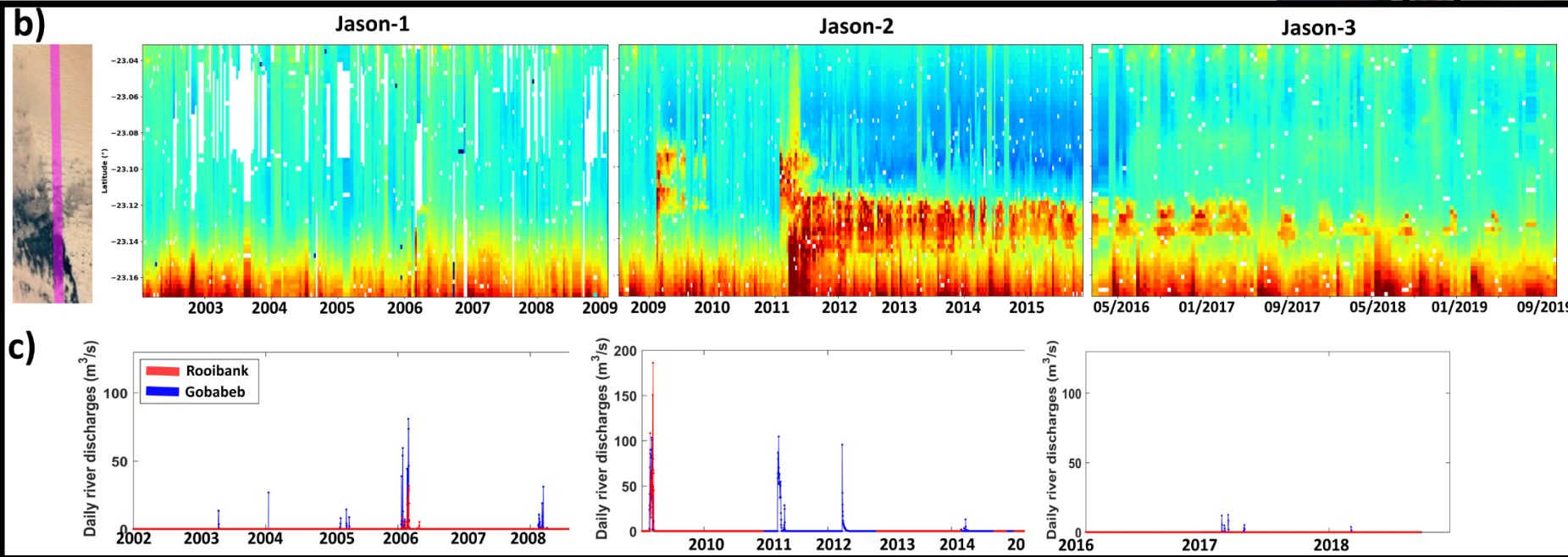
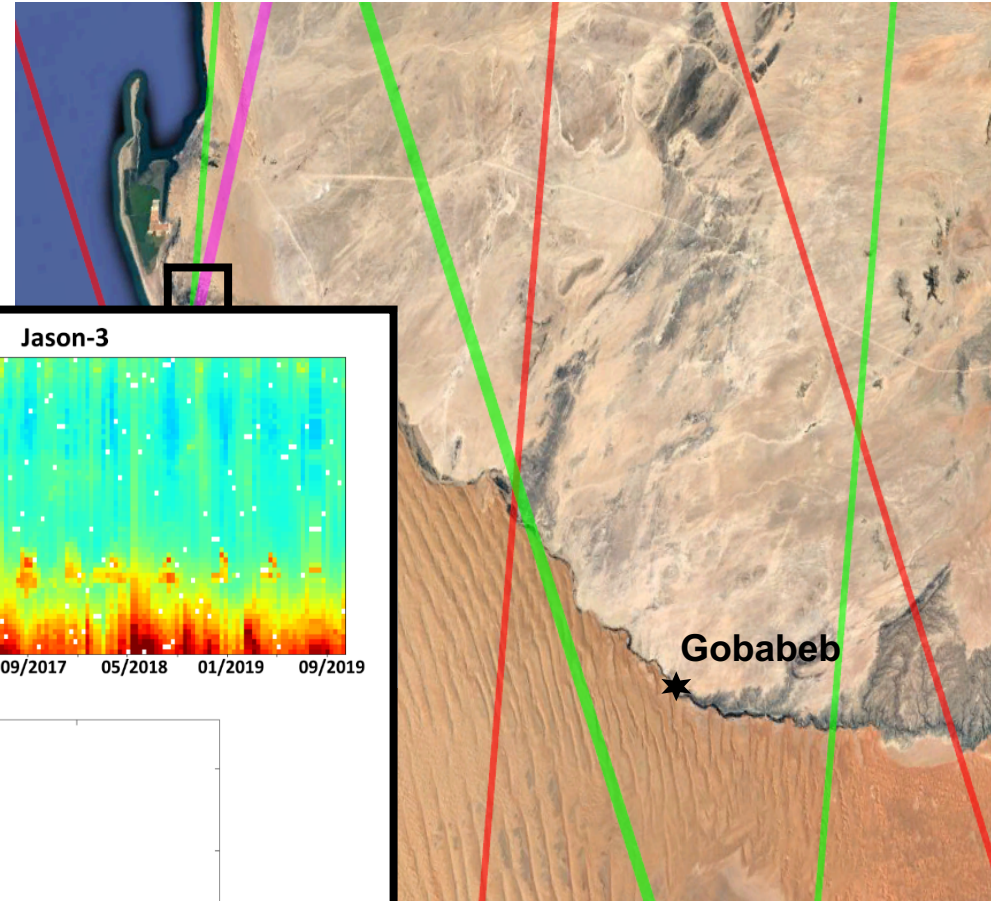
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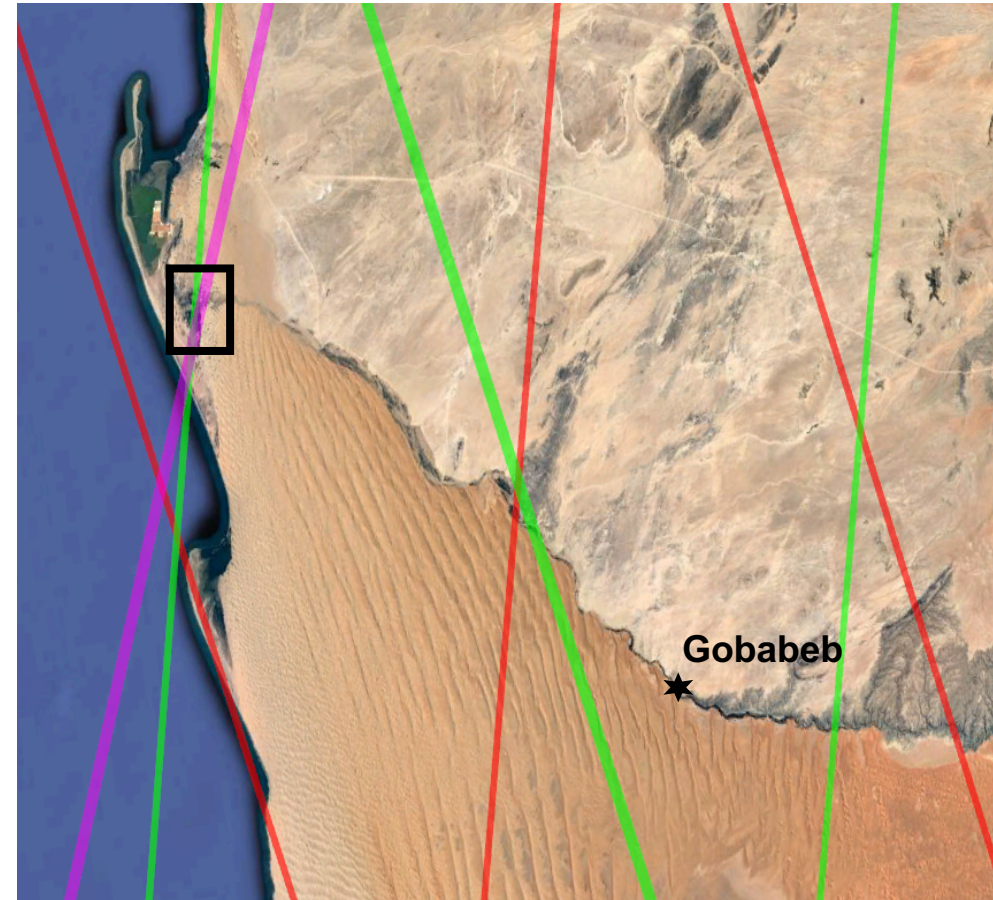
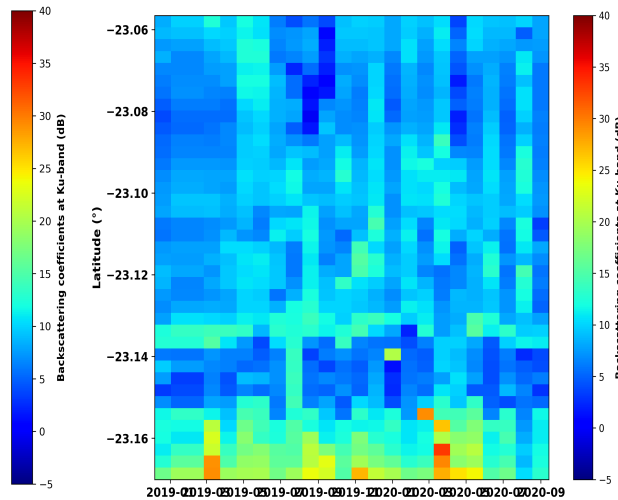
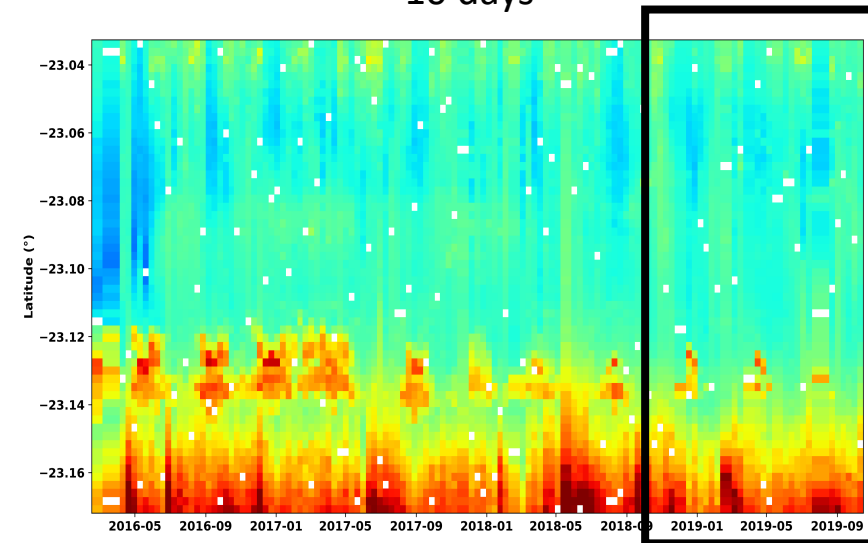
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10 days

Jason-3
10 days

Sentinel-3B
27 days



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➤ **Encouraging first results** for the next months

- Sentinel-2 : variations of vegetation index through time -> moisture? groundwater level?
- Radar altimetry : Sentinel-3 permits to study backscattering coefficients and detect some pattern in the downstream part, high potential for the following years

➤ **Sentinel-1 processing in the next weeks**

- Study of the moisture in surface
- Box 1 : what can explain this pattern observed through time ?

An aerial photograph of a desert landscape. A river flows through the center, surrounded by dense green vegetation. The surrounding desert floor is a mix of light brown sand and darker, rocky terrain. In the background, there are more desert features and distant mountains under a clear blue sky.

**Thank you for your
attention!**