

# The Ephemeral Kuiseb River (Namibia): Past and Present History from SAR Imagery

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# The Kuiseb Ephemeral River

## ➤ Namibia, South-West of Africa

- 12 ephemeral rivers including the Kuiseb river

## ➤ Kuiseb river :

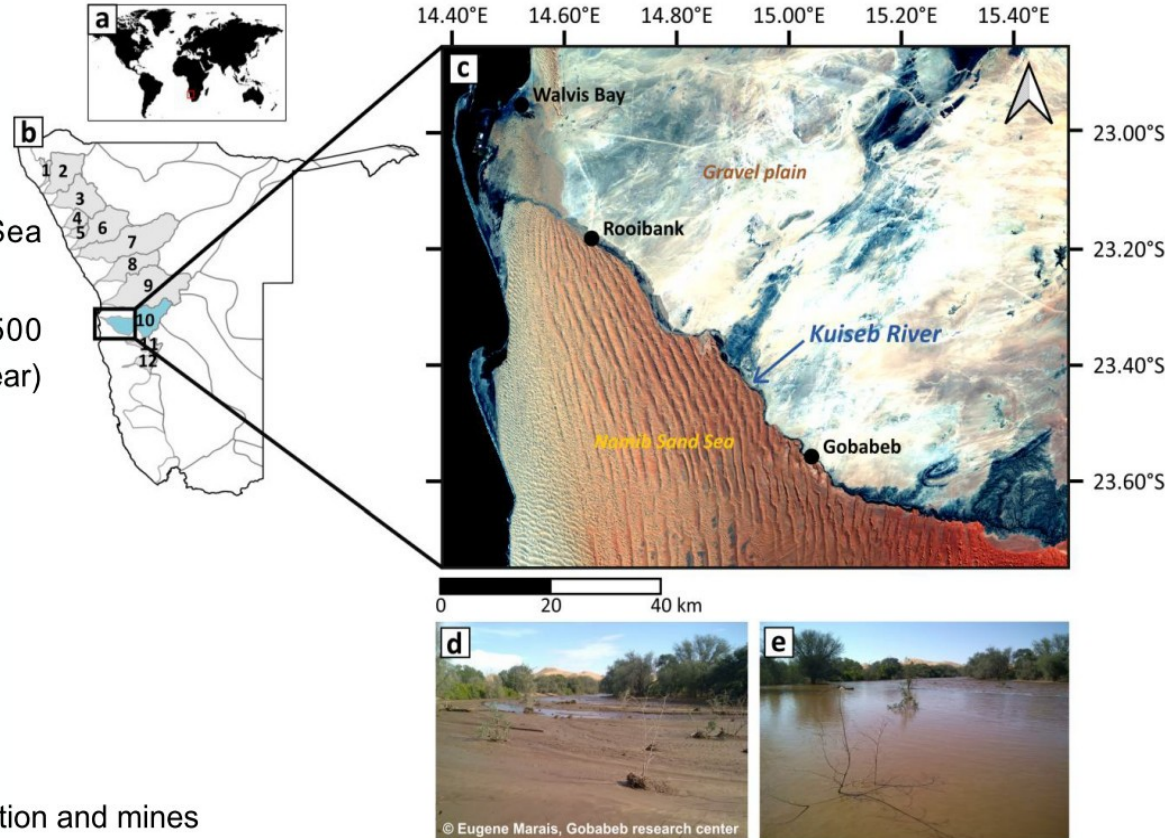
- 560 km (longest of Namibia), 15,500 km<sup>2</sup>
- Border between gravel plain (North) and Namib Sand Sea (South)
- **Climate gradient** : plateau located in the East with 500 mm/year of rainfall to the coast with no rainfall (<50 mm/year)

## ➤ Thunderstorms (January – April)

- Main source of water
- **Floods** : Mean ~ 12 days, a big flood every 25 years
- **Last 20 years : 3 floods (2011, 2021, 2022)**

## ➤ Groundwaters : « hidden treasure »

- 100,000 boreholes in the last century
- Drinking water to man, livestock, irrigation for crop production and mines

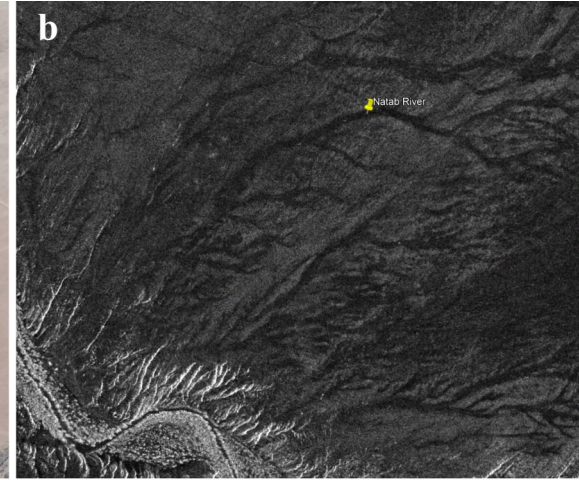




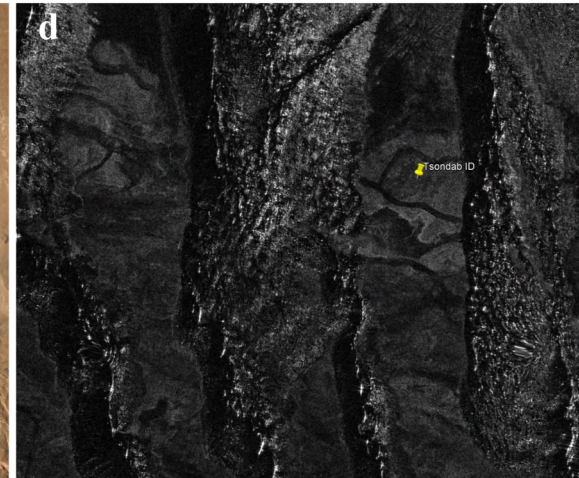
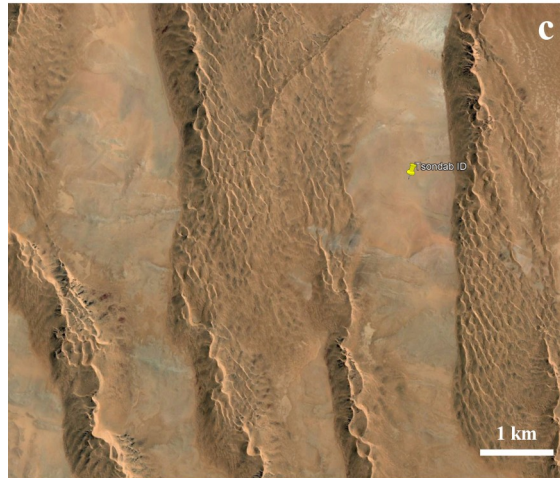
# **Part 1: The Past** *(Paillou et al., Water, 2020)*



# Sub-surface Imaging from Orbital Radar



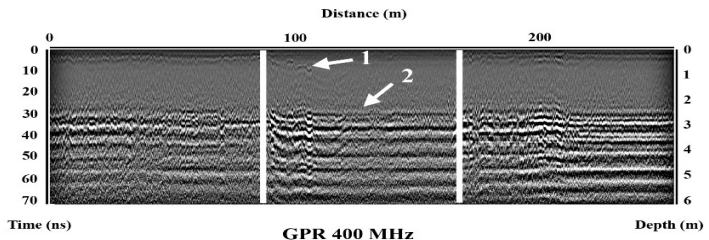
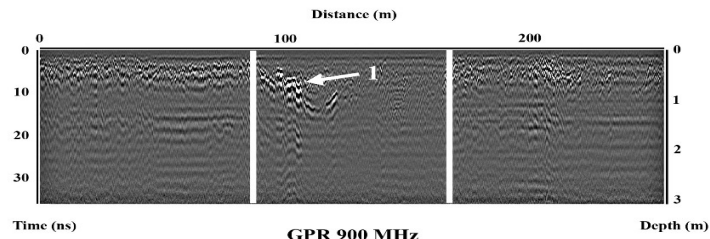
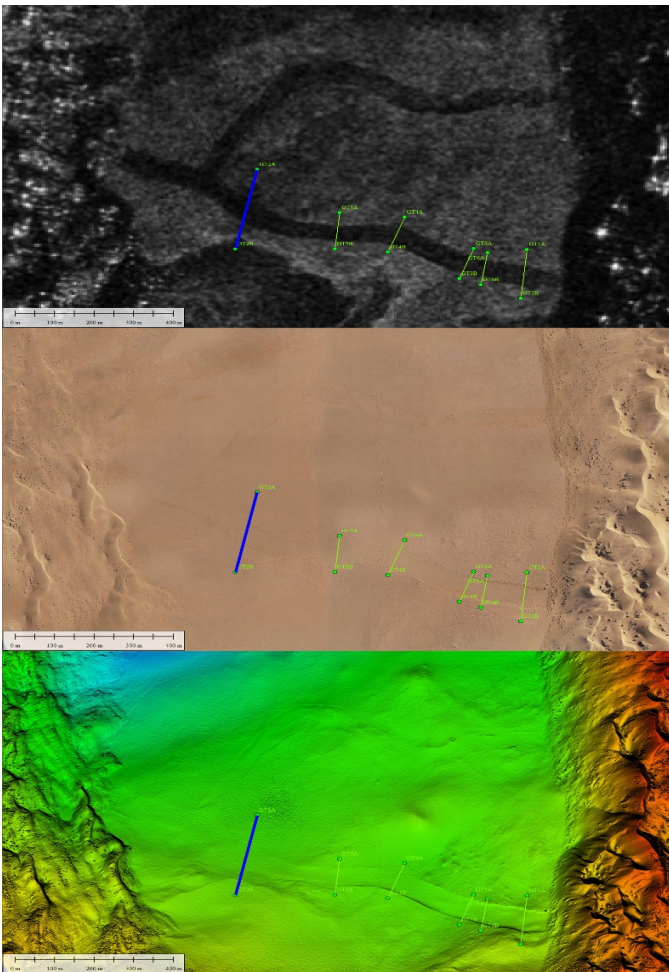
Landsat-7 image (a) and PALSAR-2 radar image (b) of the Northern plains.



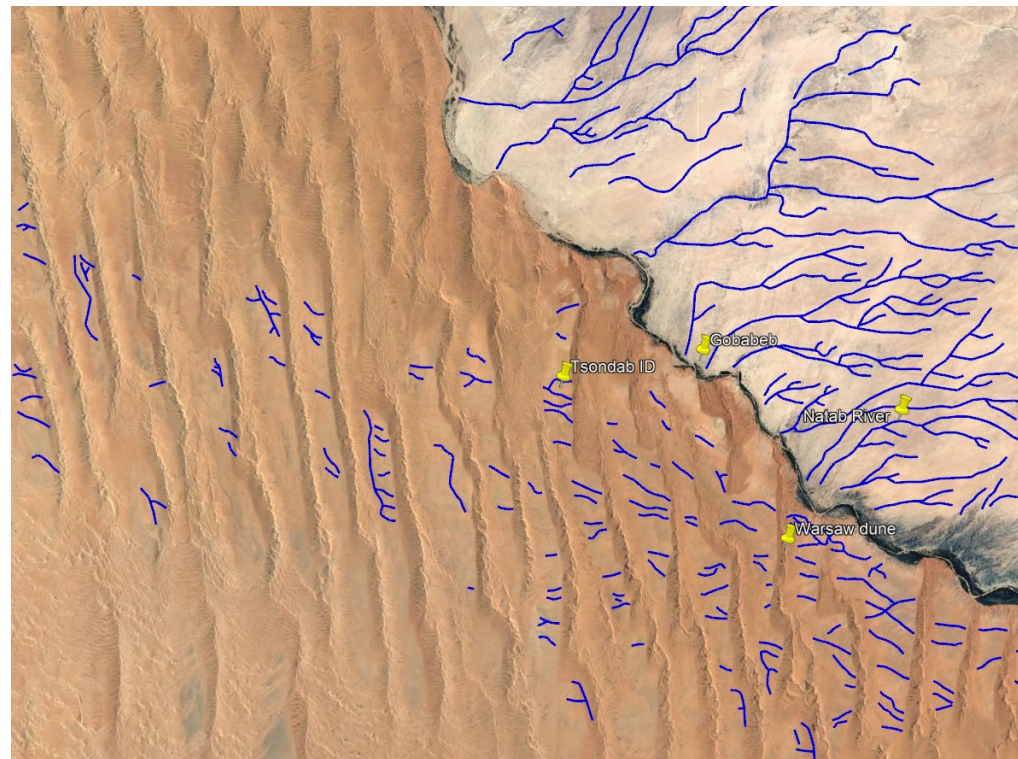
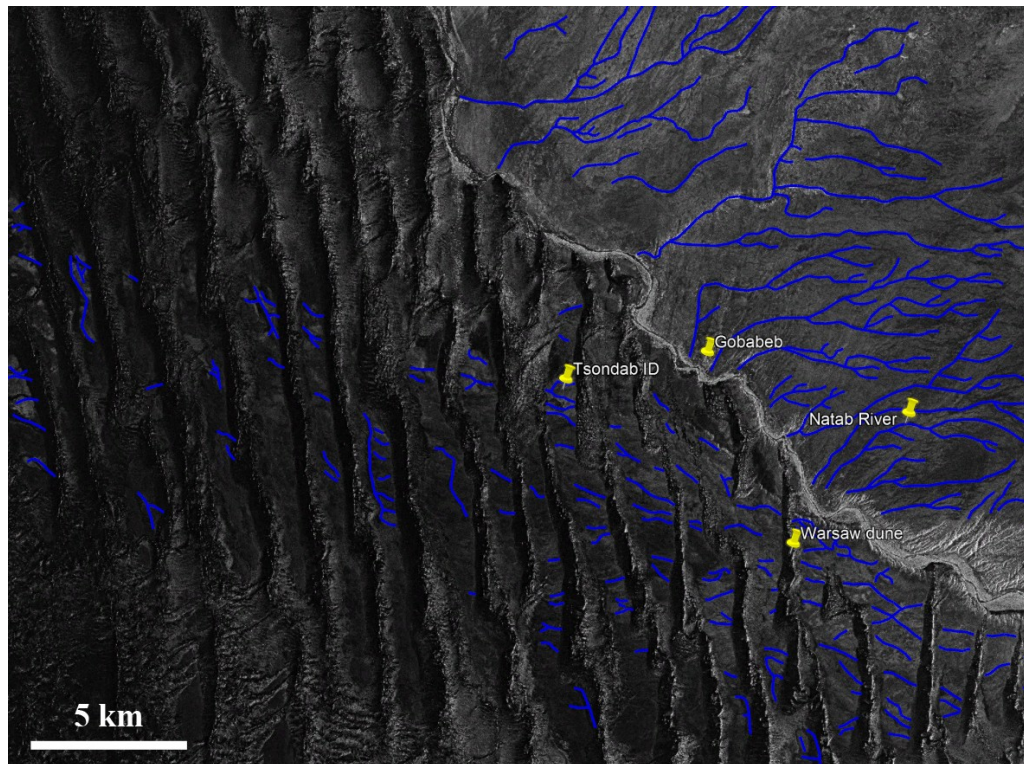
Landsat-7 image (c) and PALSAR-2 radar image (d) of the Southern dunes.



# Southern Paleo-Channels: GPR+Drone



# Global Map of Paleo-Channels

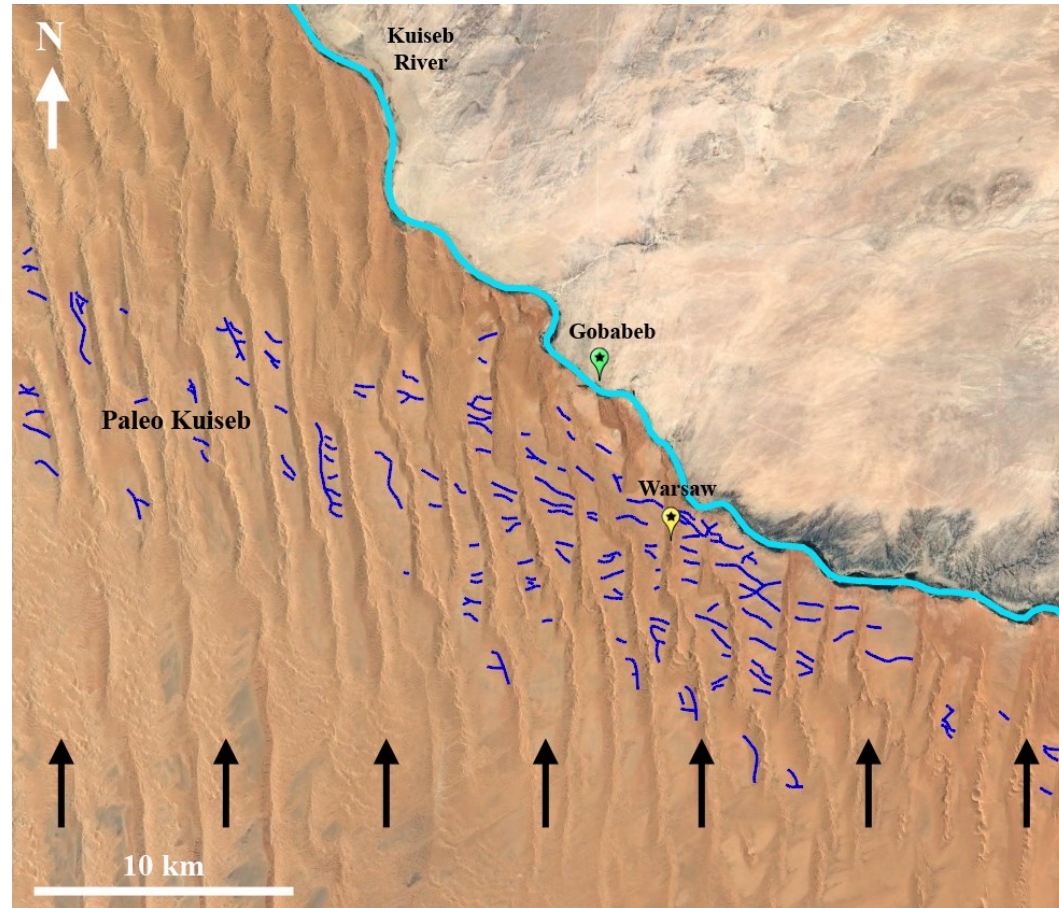




# Kuiseb River is pushed towards North

Location of Warsaw dune (5 ka old), present-day Kuiseb riverbed (cyan) and Paleo-Kuiseb system (dark blue), spreading over 8 km in South–North direction.

Dark arrows indicate the main migration direction of Namib sand dunes: estimated linear migration rate of 1.6 m/y from South to North.





## **Part 2: The Present** *(Normandin et al., Water, 2022)*



# Time series of optical images

## ➤ Sentinel-2

- Sentinel-2A (June 2015) + 2B (March 2017)
- 122 images (June 2015 and December 2021) without clouds
- Downloaded freely on: <https://peps.cnes.fr/rocket/#/home>
- **Level-2A**: atmospherically corrected using MAJA algorithm (processing chain developed by CNES and CESBIO)
- **Multi Spectral Imagery (MSI)** : 13 spectral bands, 10 to 60 m spatial resolution, 5 days
- **Vegetation NDVI and Water NDWI** spectral indexes

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

$$NDWI = \frac{NIR - SWIR}{NIR + SWIR}$$



cnes peps

ACCUEIL EXPLORER PEPS-RSS PLUS SE CONNECTER S'ENREGISTRER



PLATEFORME D'EXPLOITATION DES PRODUITS SENTINEL



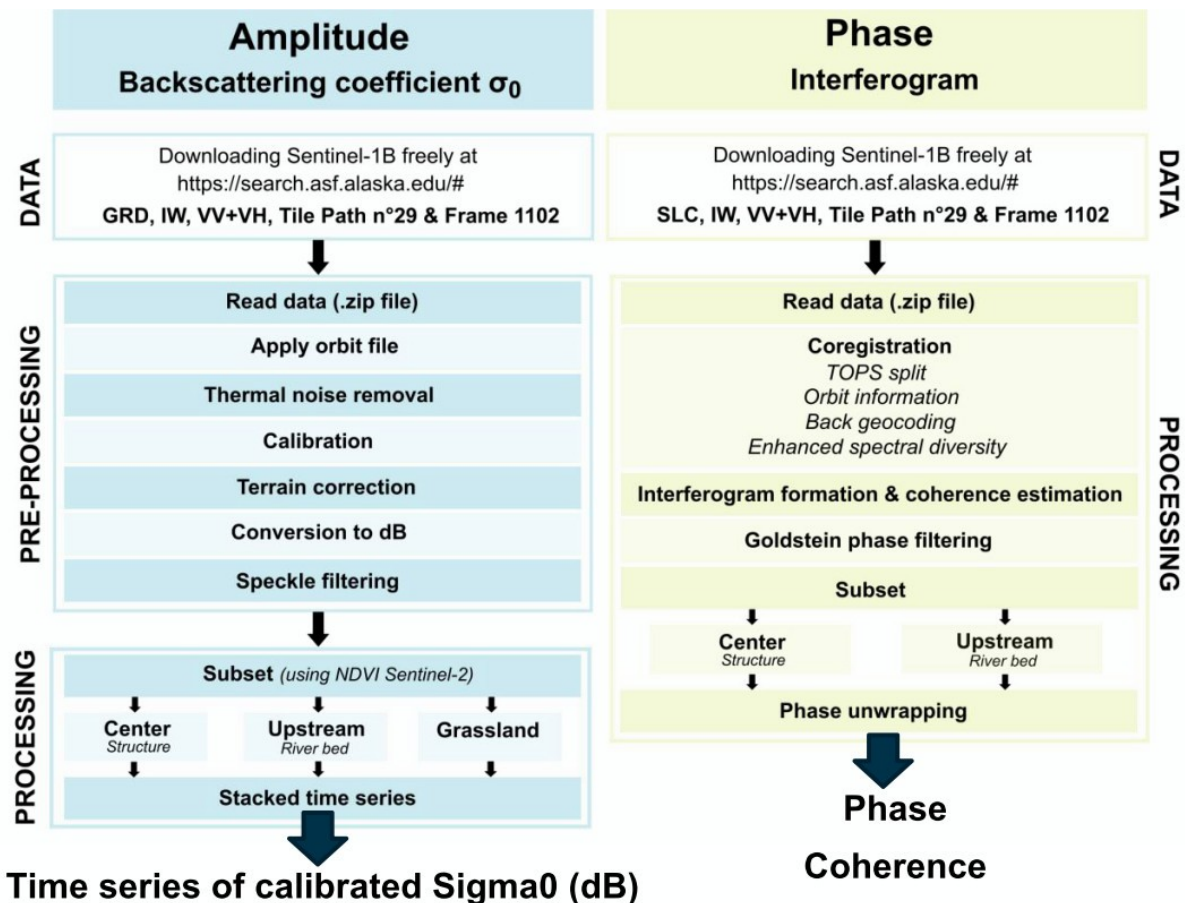
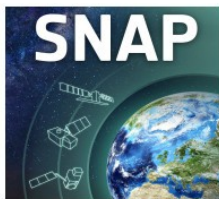


# Time series of SAR images

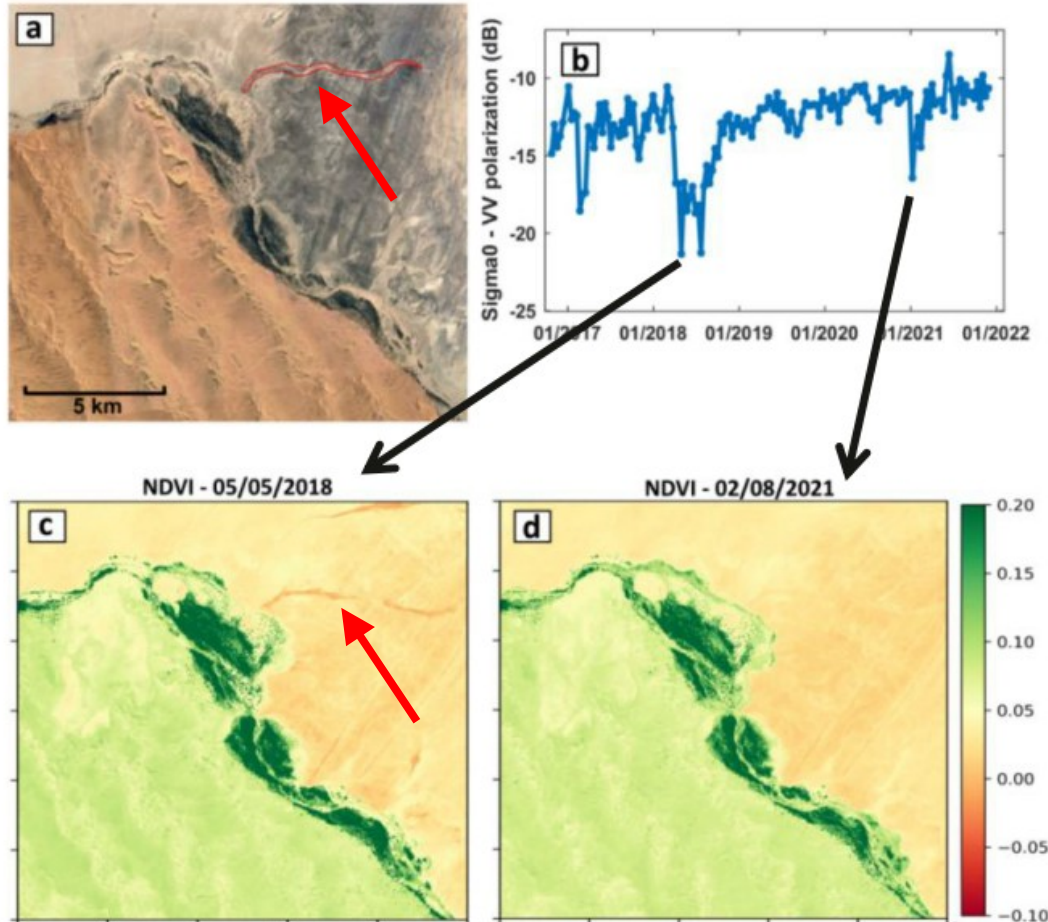
## ➤ Sentinel-1B

- 153 images (April 2016 and December 2021)
- Downloaded freely on : <https://search.asf.alaska.edu/#/>
- C-band (5.4 GHz), 10 days
- Ground Range Detected (GRD) + SLC (Single Look Complex)
- Interferometric Wide Swath (IW)
- VV+VH polarizations

- SNAP software



# An Active Tributary ?



Kuiseb River flooding in 2018 and 2021, with increase of the Kuiseb aquifer level, and local rainfall event in march 2018.

SAR amplitude variations observed in 2018 and 2021 at the tributary location, but NDVI changes only in 2018: two different surface / subsurface effects ?



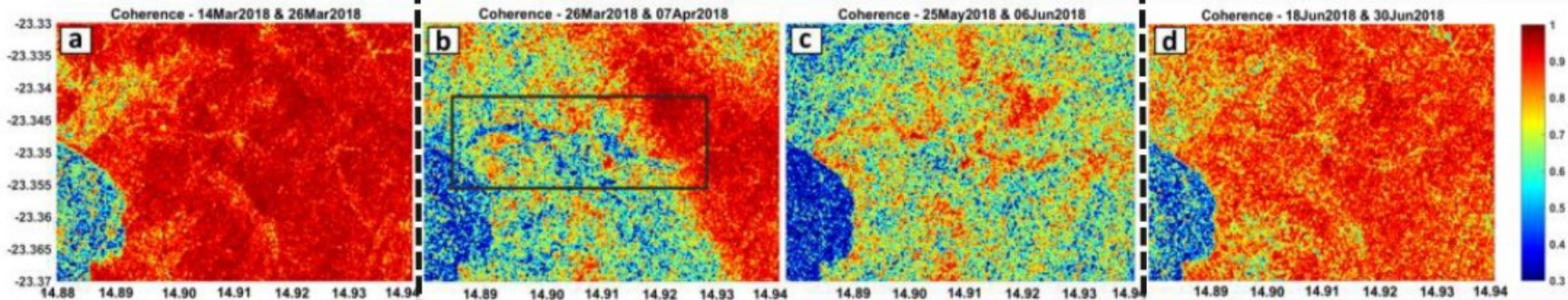
➤ Interferograms and coherence

Before the disturbance

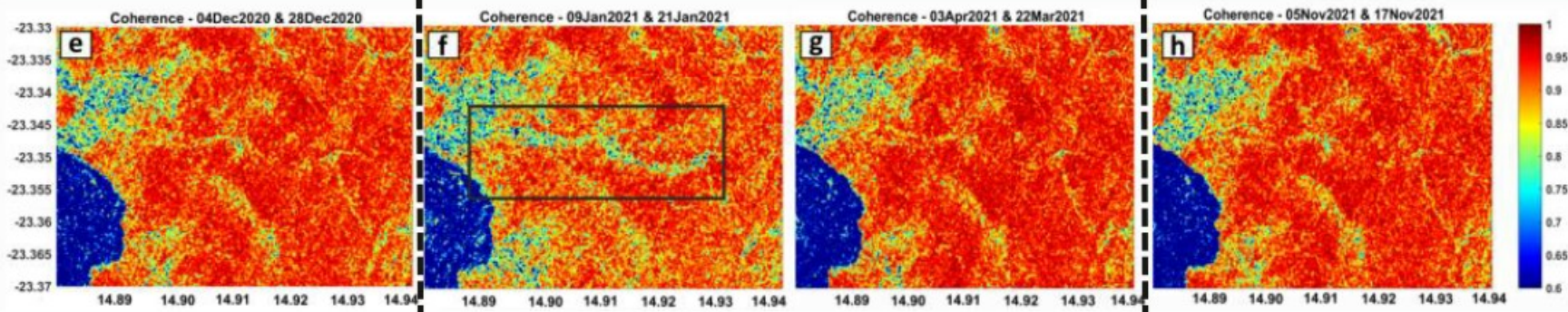
During the disturbance

After the disturbance

**2018**  
Local rainfall event

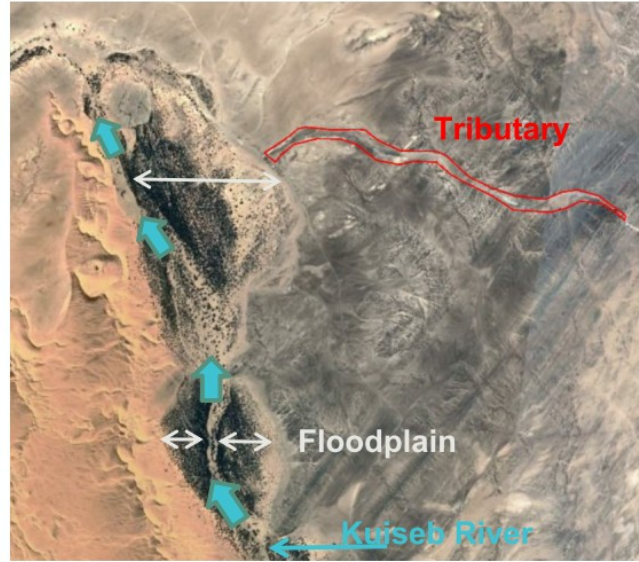


**2021**  
No local rainfall event

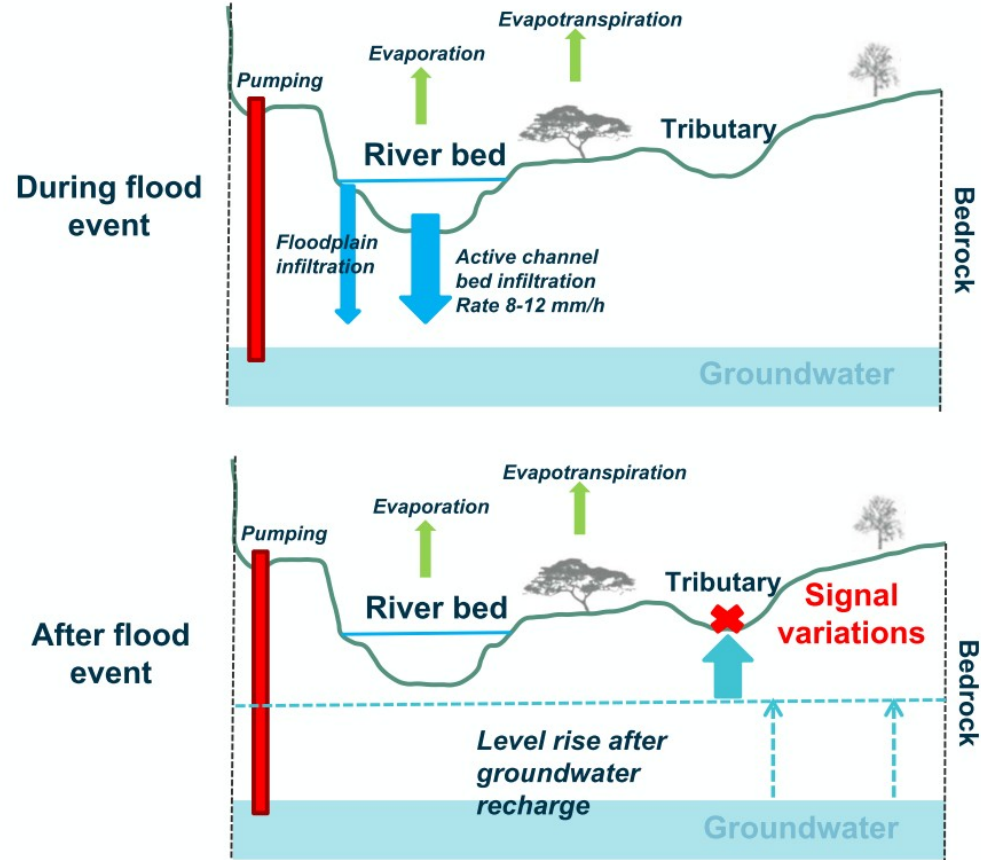


## ➤ Reactivation of the Kuiseb tributary

- Flood 2021
- ~ 1 week duration



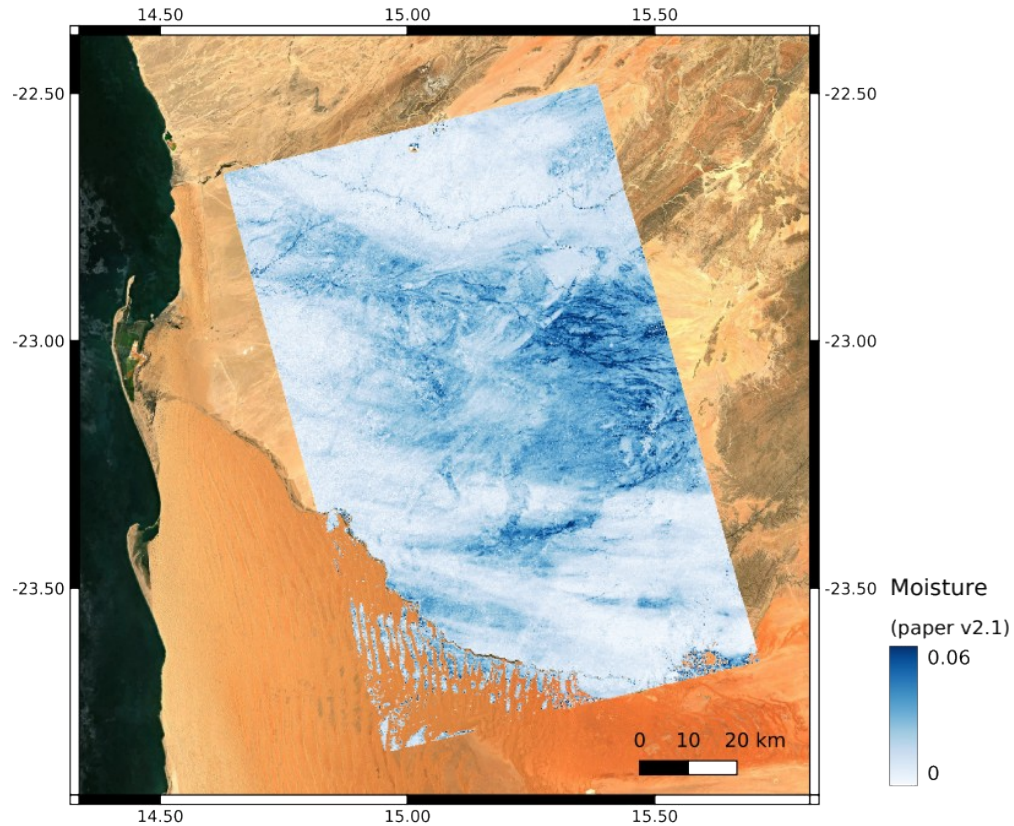
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Modified, after Grodek et al., 2020

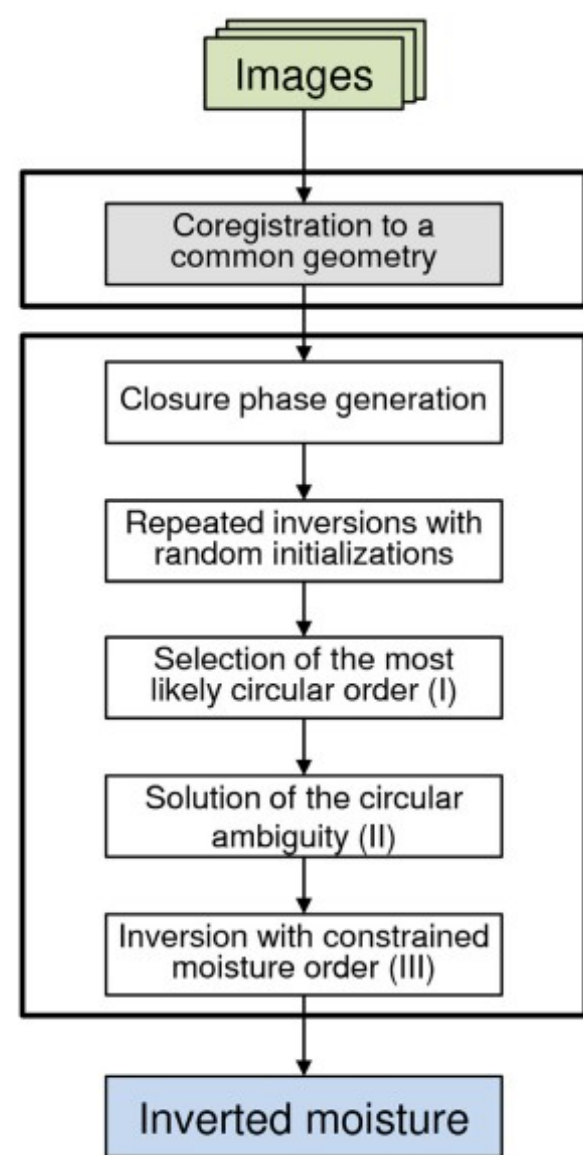
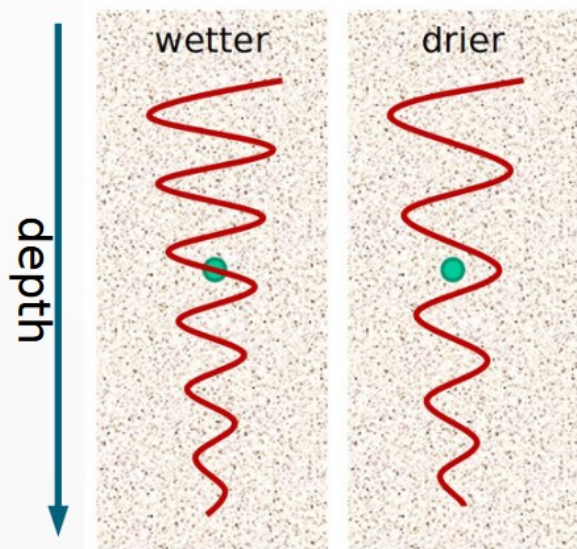


# ***Part 3: Regional View*** (after De Zan et al., RSE, 2018)



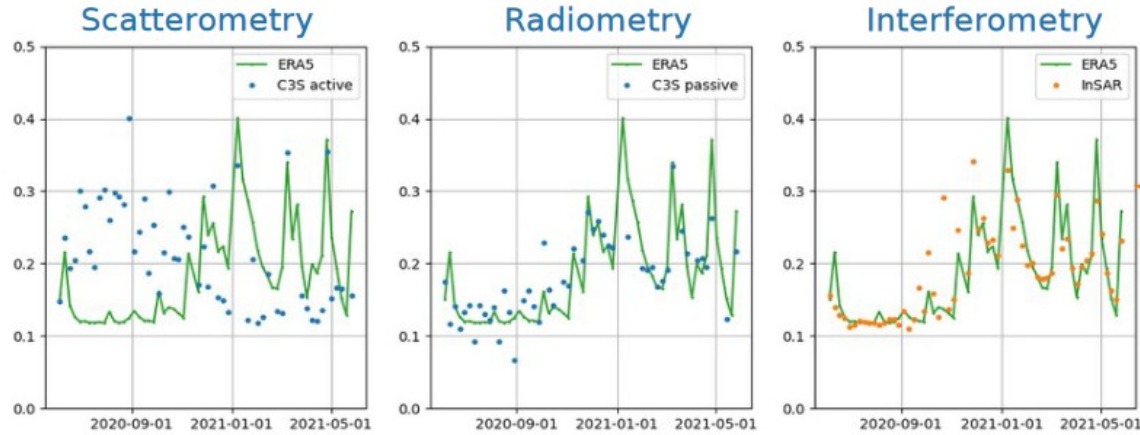
## Physical principle

- In the soil we have **phase propagation** and amplitude attenuation
- Different moisture conditions yield different propagation phases at all depths





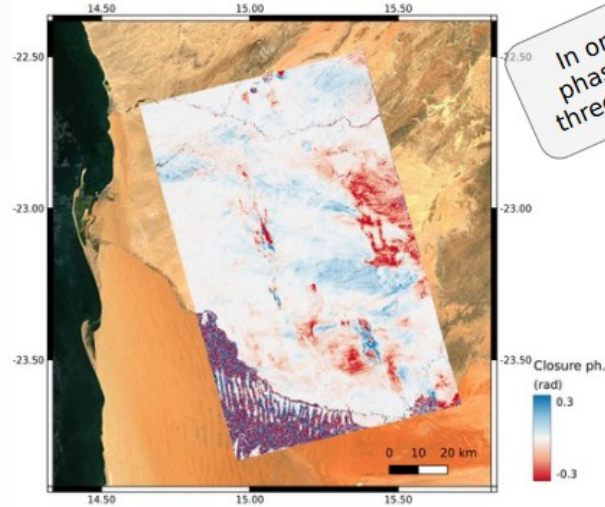
- Spain (Murcia, Alicante)
- Time: 2020-06-06 → 2021-05-26 (58 dates, 1 year with Sentinel-1)



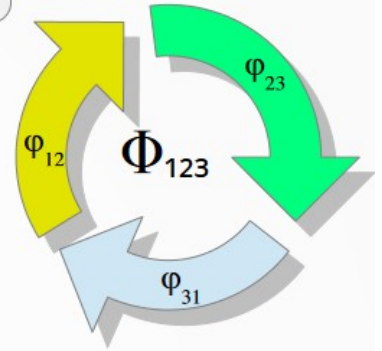
- Comparison with C3S products ( $0.25^\circ \times 0.25^\circ$ ) and ERA5
- The difference std between ERA5 and InSAR product is **less than 3%** (Mv)

2021-01-21 / 2021-02-14 / 2021-03-22

The inversion is based on closure phases from SAR interferometry

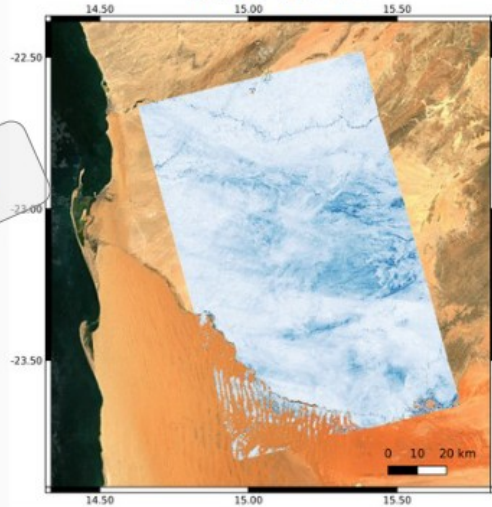


In one closure phase there are three dates mixed

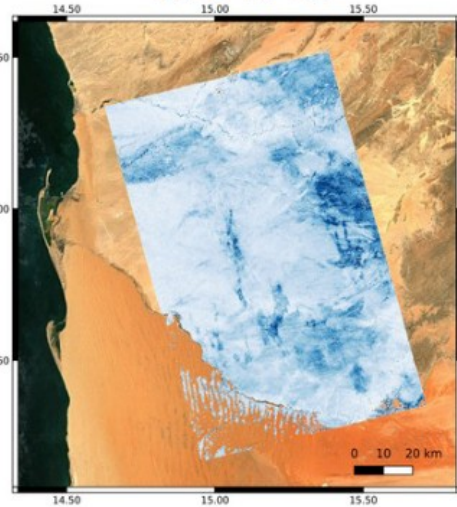


Soil moisture

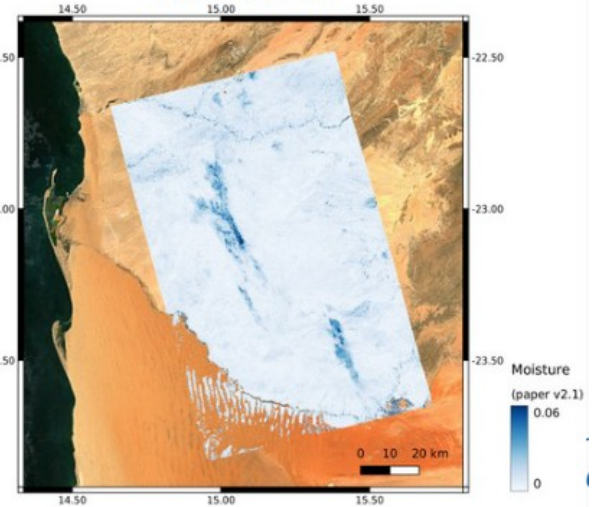
2021-01-21



2021-02-14



2021-03-22





*Thank you !*

