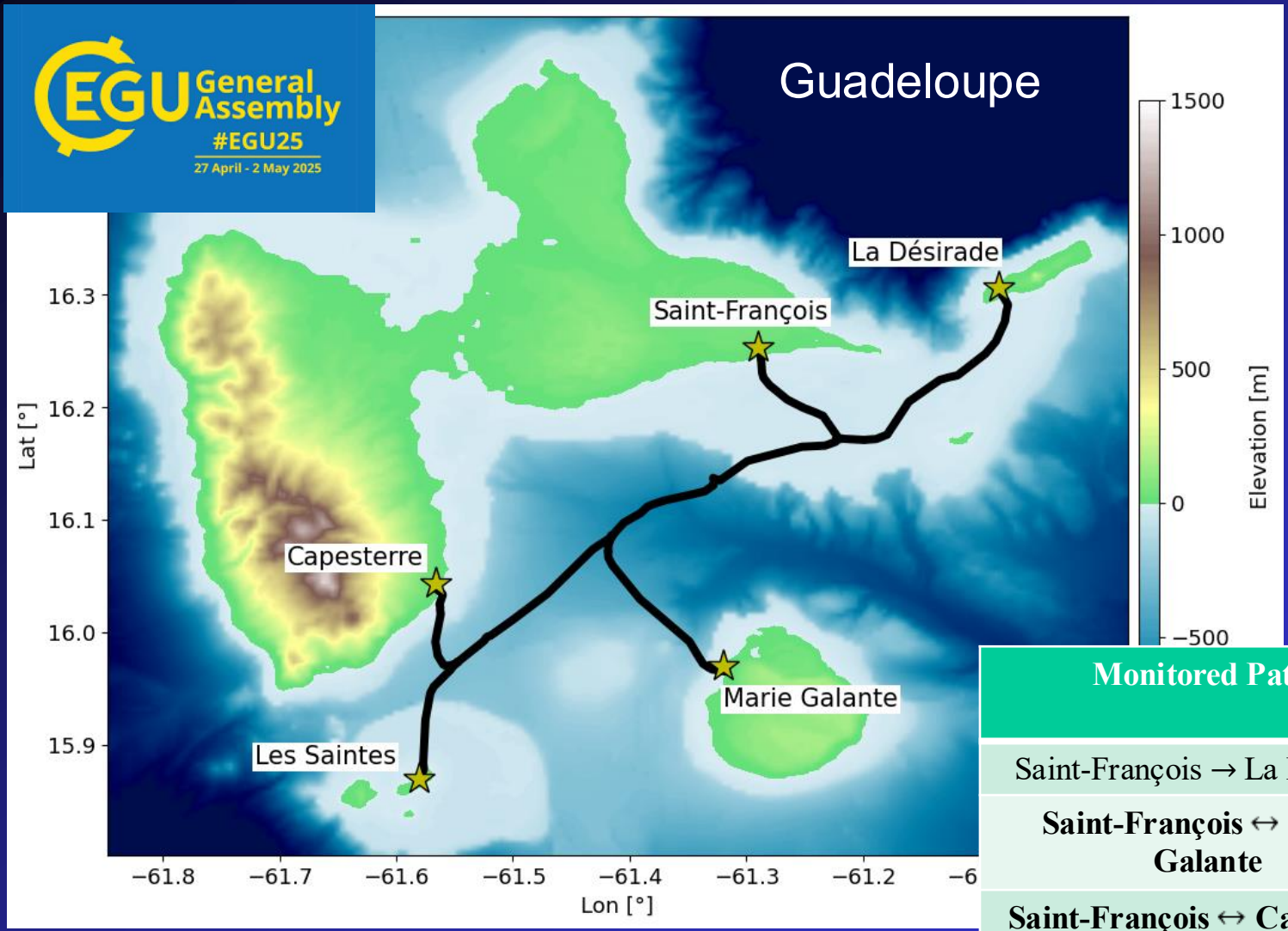
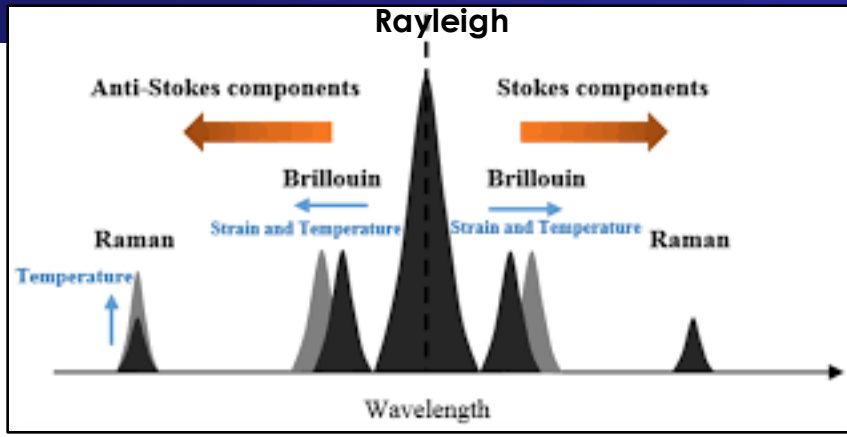
Monitoring long-term bottom water temperature changes using fiber-optic sensing in submarine telecommunication cables



Monitored Paths	Length (km)
Saint-François → La Désirade	36 km
Saint-François ↔ Marie Galante	54 km
Saint-François ↔ Capesterre	63 km
Saint-François → Les Saintes	63 km
Capesterre → Les Saintes	22 km
Capesterre ↔ Marie Galante	45 km

- 5 landing points
- 3 measuring sites: St. François, Capesterre, Marie Galante
- Several cable paths measured in both directions (bold)

FOCUS = Fiber Optic Cable Use for Seafloor studies of earthquake hazard and deformation (Oct. 2018 - Sep. 2025)



Optical Pulse

Interrogator

Optical Fiber

Acoustic Vibration

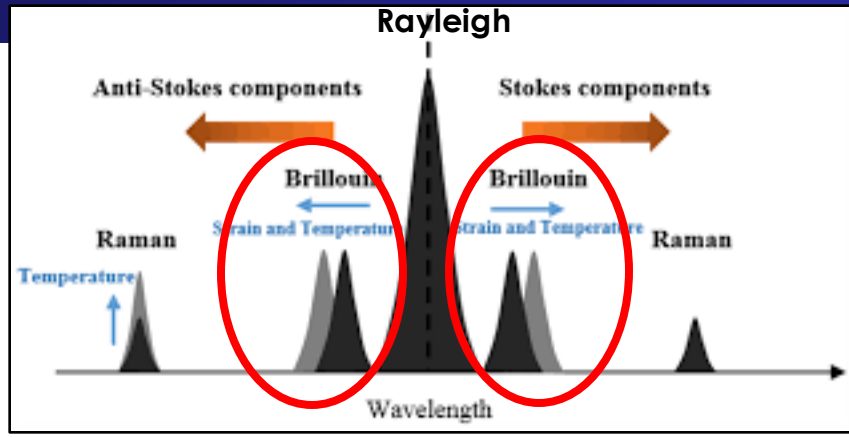
Temperature Change

Intrusion

Scattered Light

Fiber optic sensing: backscattered laser light is sensitive to acoustic (vibrations), mechanical (strain) and thermal disturbances in the fiber

FOCUS = Fiber Optic Cable Use for Seafloor studies of earthquake hazard and deformation (Oct. 2018 - Sep. 2025)



Optical Pulse

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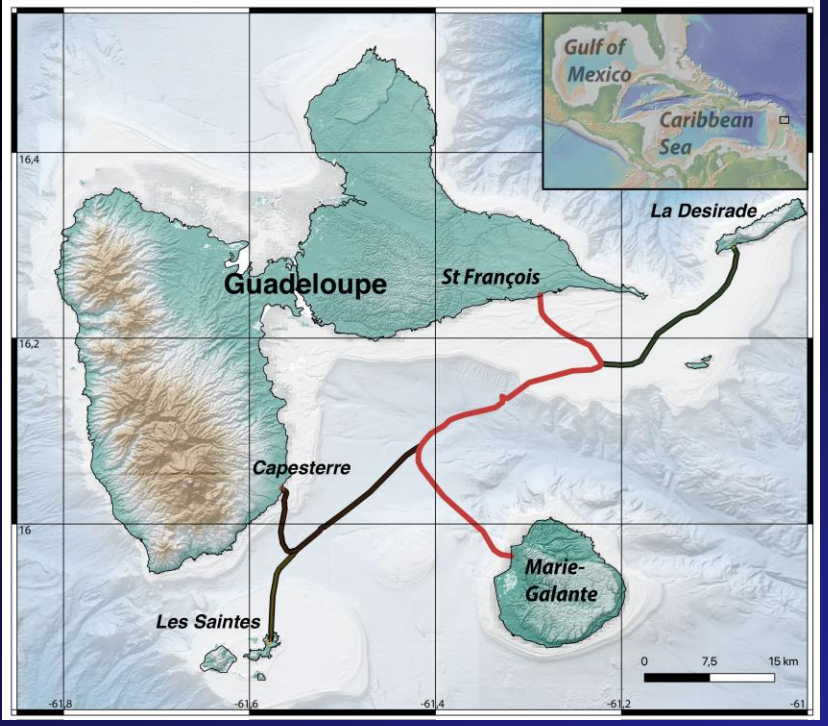
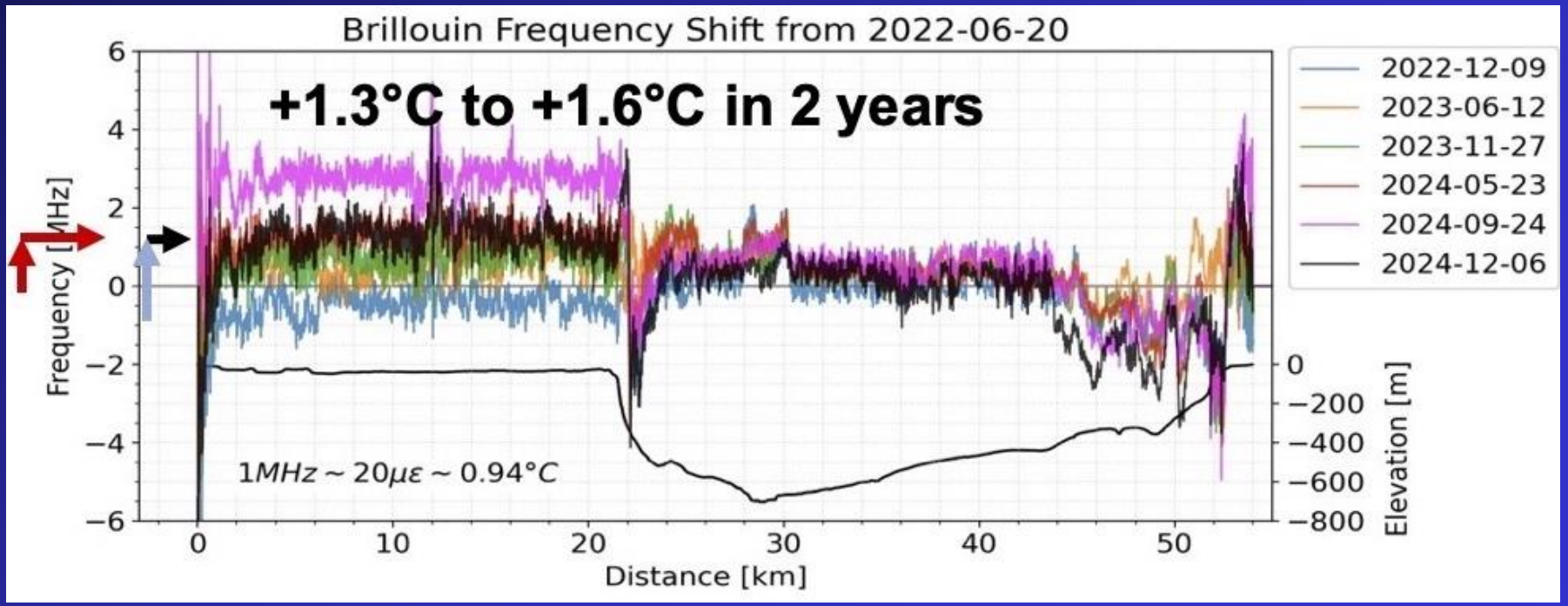
BOTDR = Brillouin Optical Time Domain Reflectometry

BOTDR records mechanical (strain) and thermal disturbances in the fiber

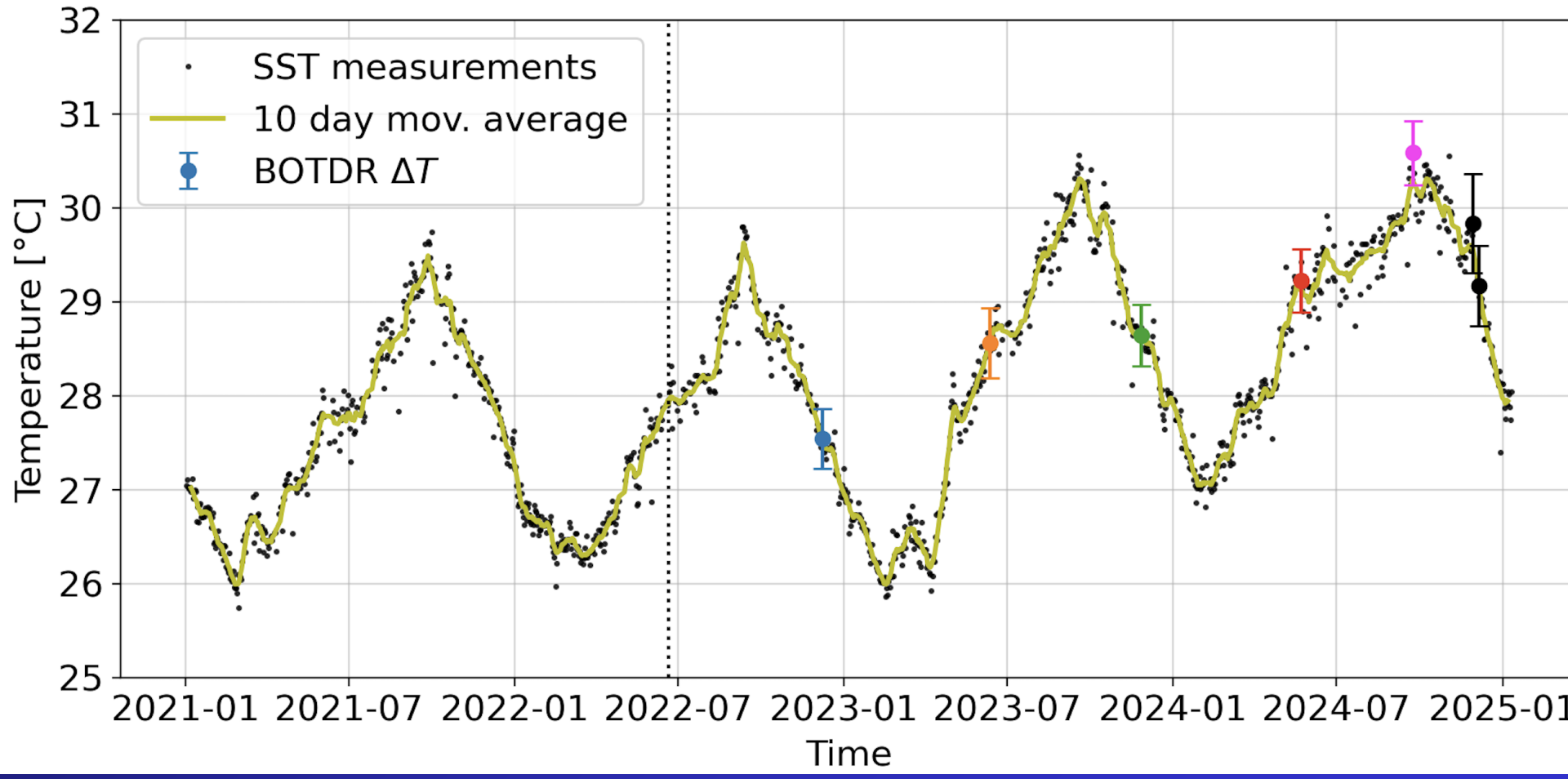
Roadside field measurements in Saint François (1st baseline Jun 2022)



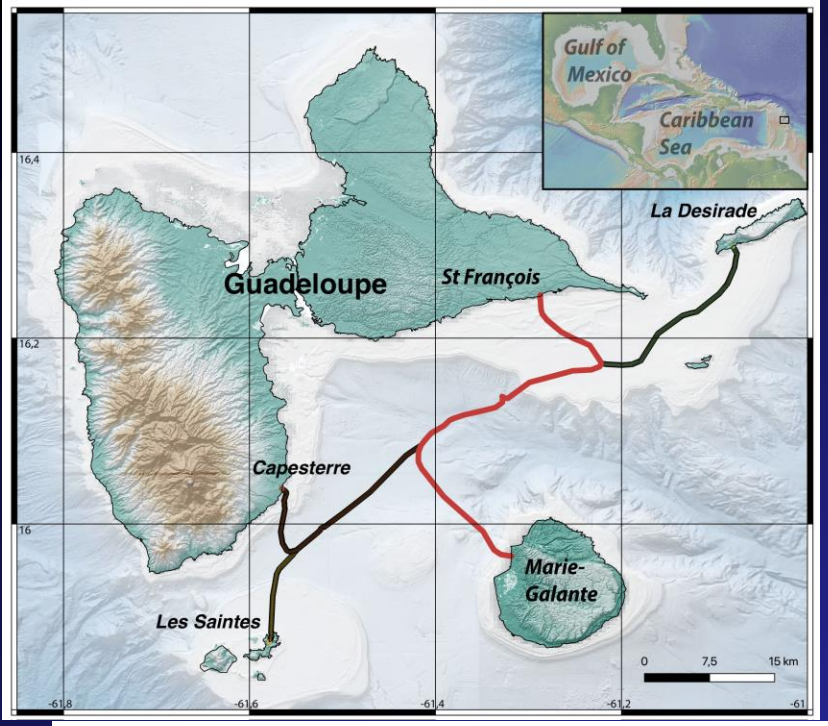
Monitoring every 6 months of the Saint François - Marie Galante telecom cable
→ +1,5° C in 2 years (2022 to 2024)



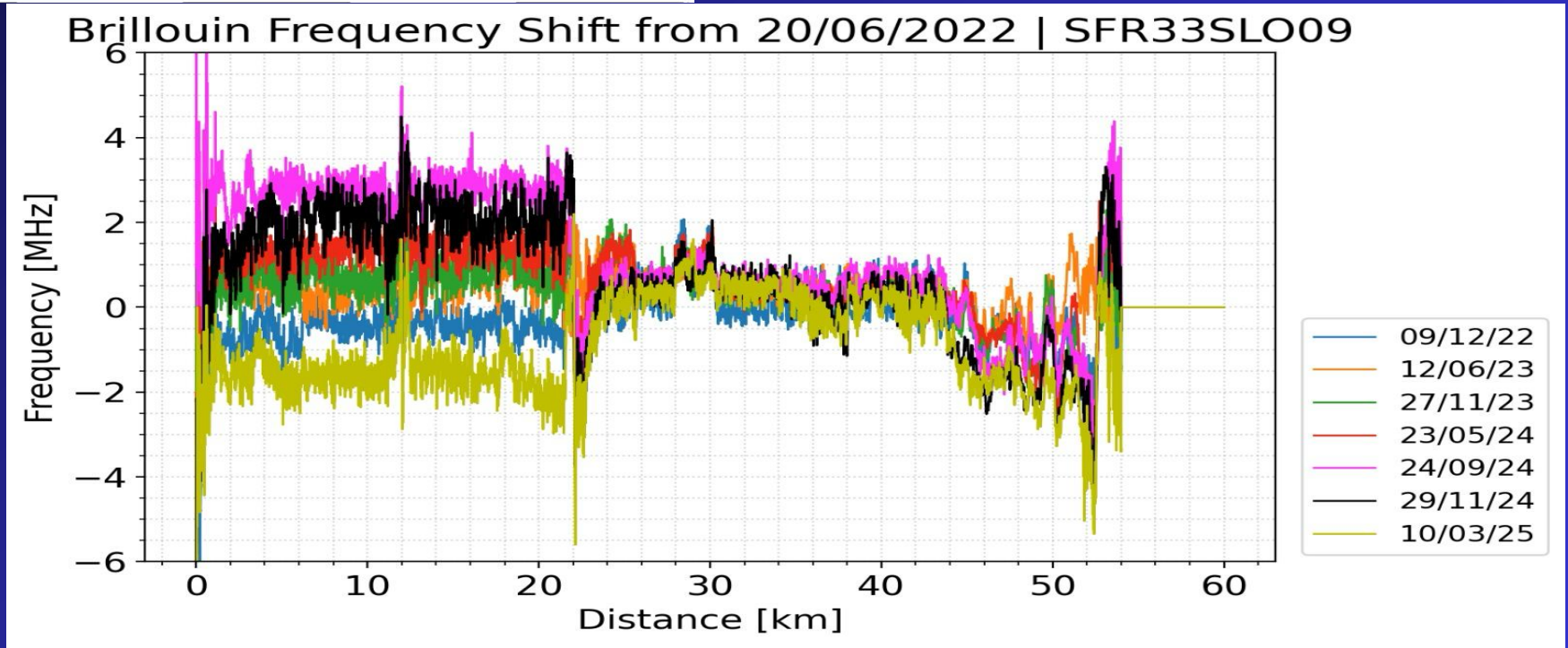
Sea Surface Temperature (SST) shallow carbonate platform south of Saint François → +1.5° C in 2 years !!



Perfect agreement between BOTDR (Δ T) and SST (within 0.1° C)

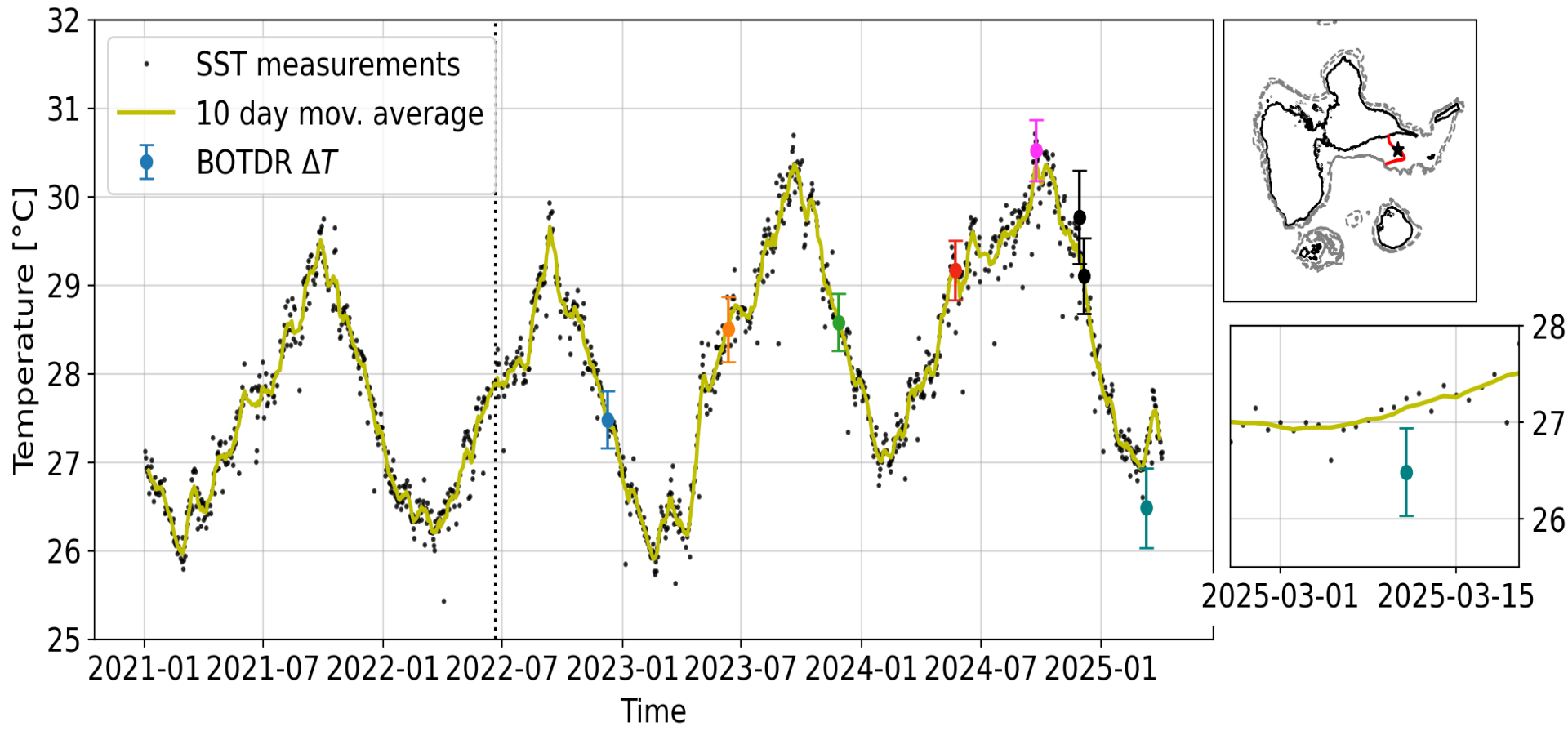


Saint François - Marie Galante cable, late Winter seasonal low (March 2025)

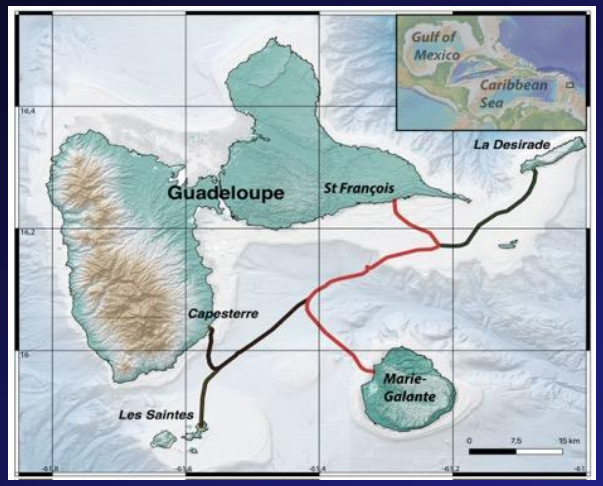


March 2025 late Winter thermal low observations
Discrepancy between BOTDR (Δ T) and SST (offset by 0.7° C)

Stratification of the water column in late Winter / early Spring ?



Future work: begin continuous BOTDR monitoring of telecom cables starting June 2025 (from Orange Caraïbe building - central fiber link station in Saint François)



ERC Proof of Concept project (DeepSCAN) submitted 13 Mar. 2025

Fiber conections to all cables between the islands

Rack where we can install our BOTDR interrogator

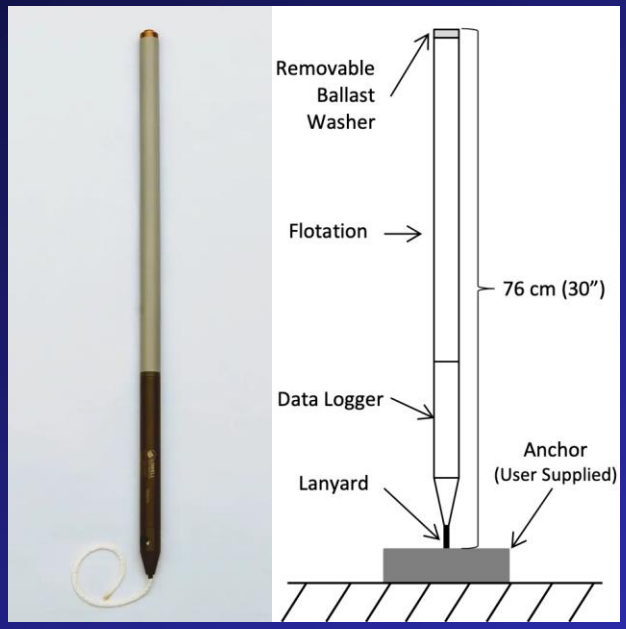
Future work: deploy low-cost instruments on the seafloor next to the cable to measure current and temperature

TCM-1 (shallow water tiltmeter)

LOWELL INSTRUMENTS LLC

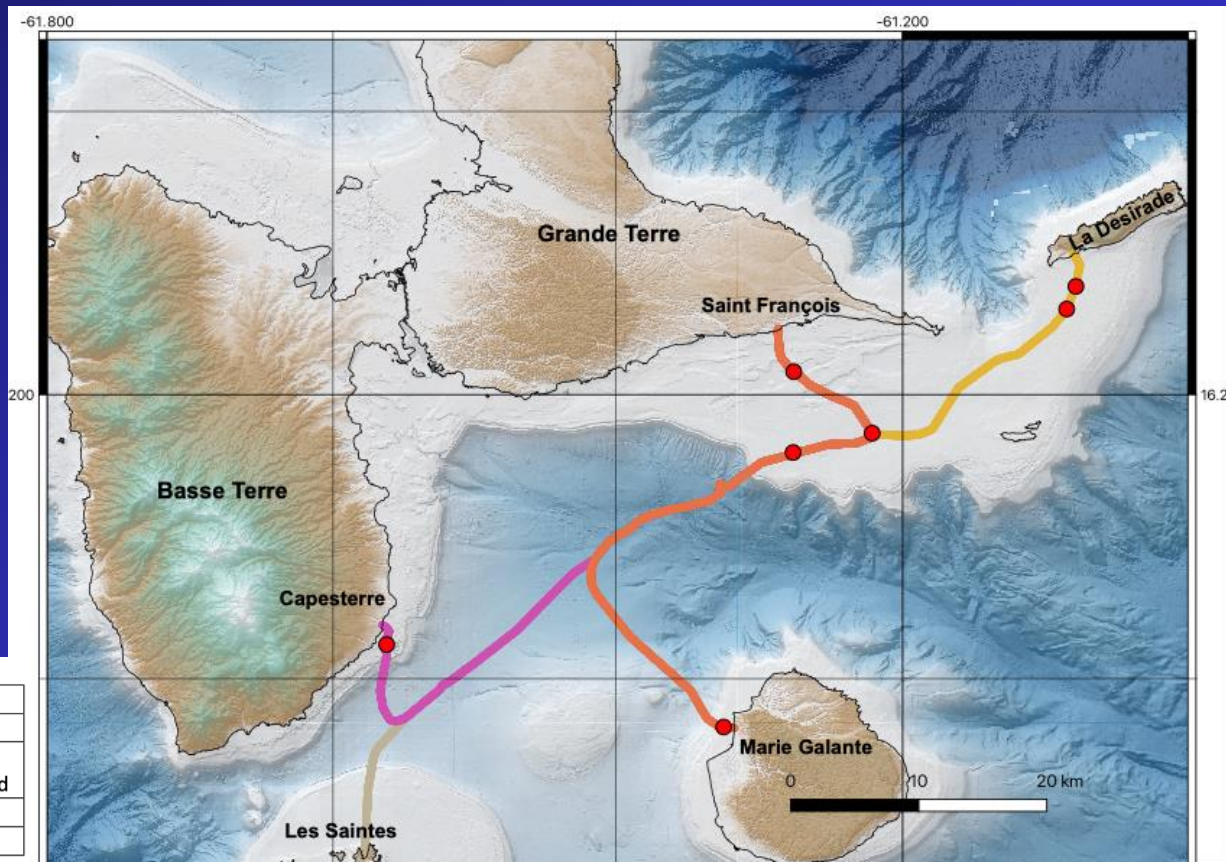
Specifications

	Range	Accuracy	Resolution
Speed (Low Range w/ Ballast Washer)	0-40 cm/s	2 cm/s + 3% of reading	0.1 cm/s
Speed (High Range w/o Ballast Washer)	0-80 cm/s	3 cm/s + 3% of reading	0.1 cm/s
Direction	0-360°	5° (for speed >5 cm/s)	0.1°
Temperature	-5 to 30 °C	0.1 °C	<0.005 °C
	-20 to -5, 30 to 50°C	0.2 °C	<0.01 °C



Mechanical

Minimum Depth	76 cm (30 in)
Depth Rating	300 m (1000 ft)
Dimensions	Diameter: 2.7 cm (1.05 in) Length: 73 cm (28.75 in) not including lanyard
Weight	340 g (12 oz)
Construction	Gray PVC housing with EPDM O-ring

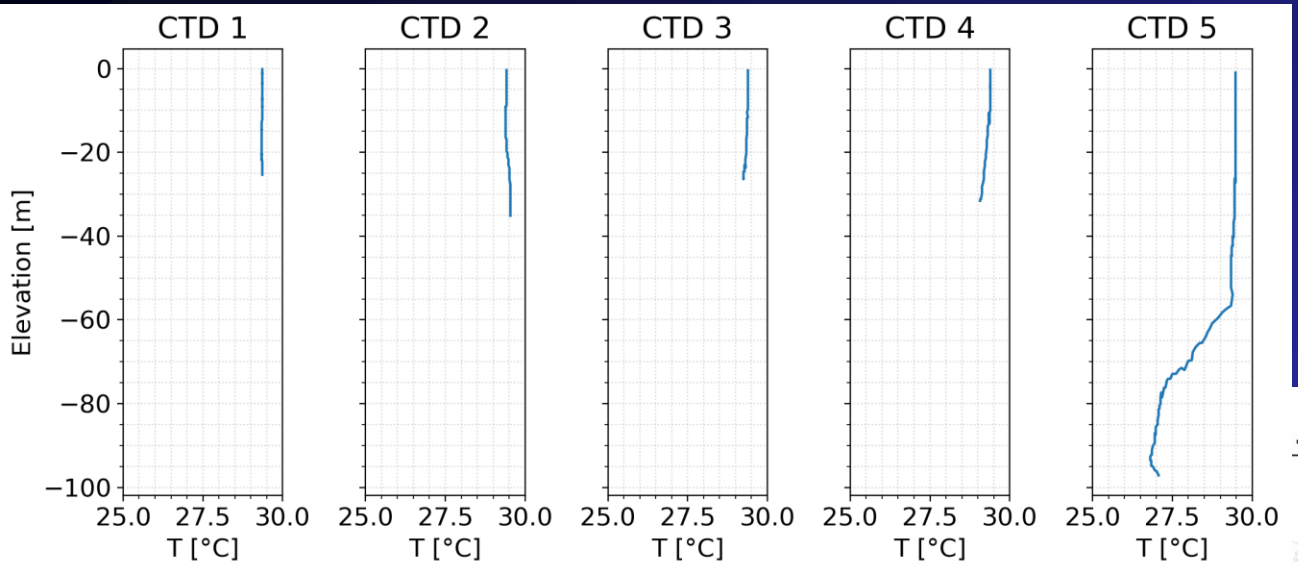


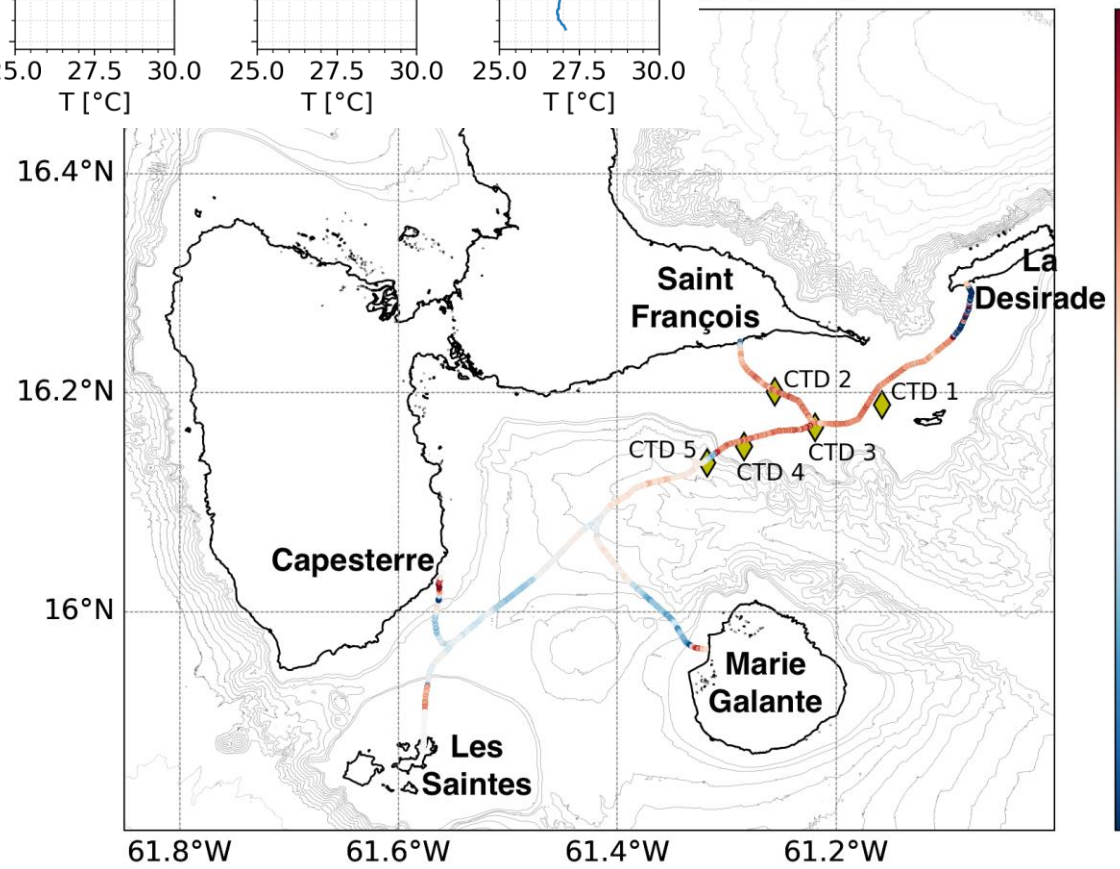
Conclusions

- BOTDR monitoring every 6 months (Jun 2022 - 2024) on Guadeloupe telecom cables (every 3 months from Jun 2024 - Mar 2025) reveals seasonal and long-term temperature variations
- Submarine telecom cables can be used as strain / thermal sensors! Strain/temperature fluctuations can be spatially located and targeted for further studies
- BOTDR indicates a +1.5° C seasonally adjusted temperature increase (from 2022 to 2024) at the seafloor on the shallow shelf (20 - 40 m depth) south of Saint François, (and offshore Marie Galante, and Capesterre)
- SST (Sea Surface Temperature) from satellite observations south of Saint François confirms +1.5° C (from 2022 to 2024)
- Future work: continuous BOTDR monitoring (from Saint François) and deployment of in-situ seafloor temperature and current meters to confirm and calibrate BOTDR observations

Thanks for your attention!

CTD (Conductivity, Temperature, Depth) profiles Dec. 2024





BOTDR statistical analysis of Brillouin frequency shift (expressed as a temperature shift) on the shallow shelf 20 km south of Saint François)
(1 MHz = 0.94 ° C)