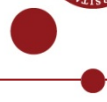




Faculty of Science



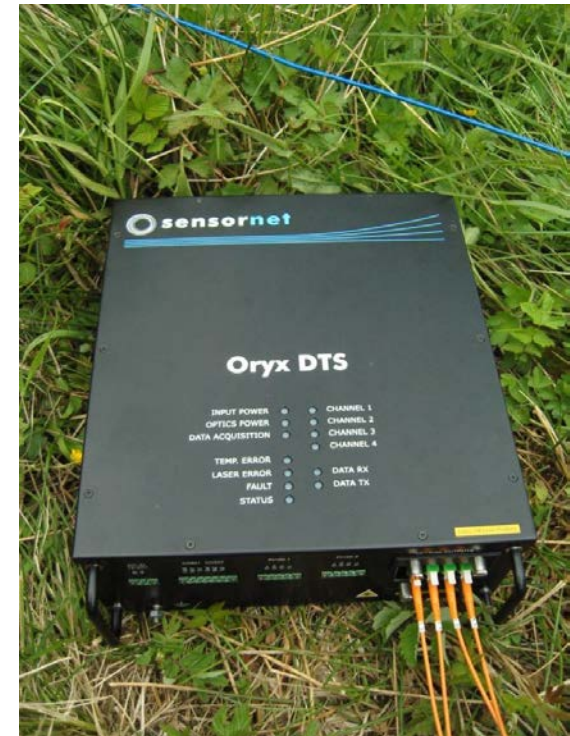
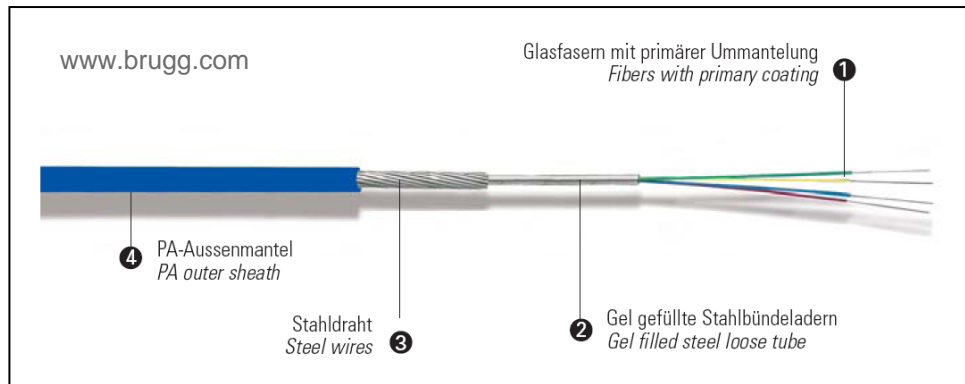
# Hydrological applications of Fiber Optic Distributed Temperature Sensing (DTS)

Eva Sebok



## Introduction

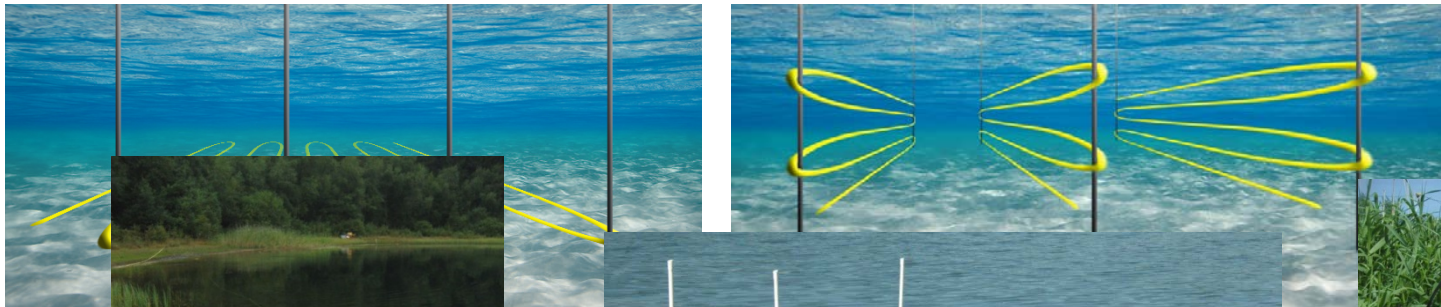
The aim of the Distributed Temperature Sensing (DTS) technique is to monitor temperature continuously both in space and time along a fibre optic cable



## Introduction

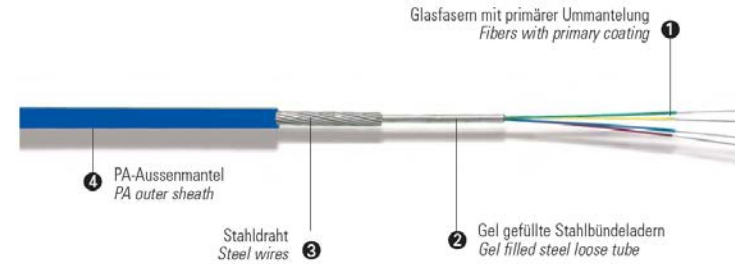
High-resolution and high-frequency temperature data with:

- Spatial resolution down to 25 cm
- Temporal resolution 1 s
- Precision 0.01 °C
- Measurement space depends on the type and layout of the fiber optic cable

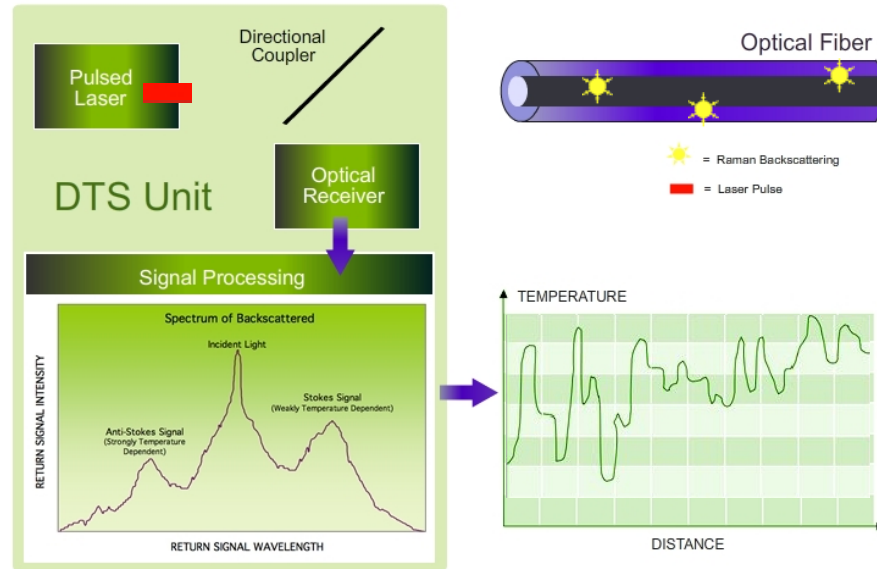




# DTS Basics



## DTS PRINCIPLES



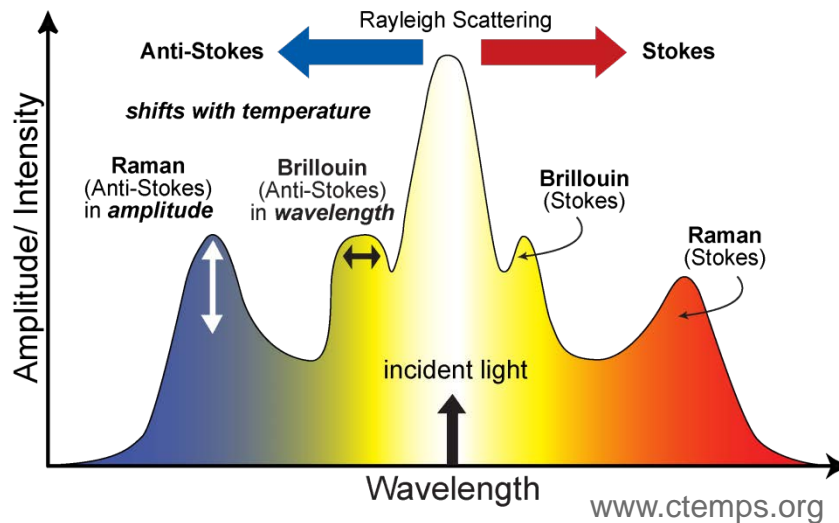
[www.sensortran.com](http://www.sensortran.com)



## DTS Basics

Anti-Stokes: linear function of the intensity of illumination and exponential of the temperature of the fiber

Stokes: linear function of the intensity of illumination

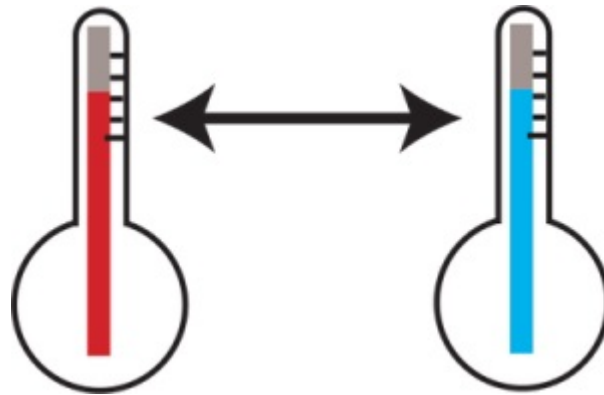


Ratio of Anti-Stokes/Stokes is only temperature dependent



## Potential applications

- Temperature difference
- Abrupt temperature changes
- Temperature survey over large areas



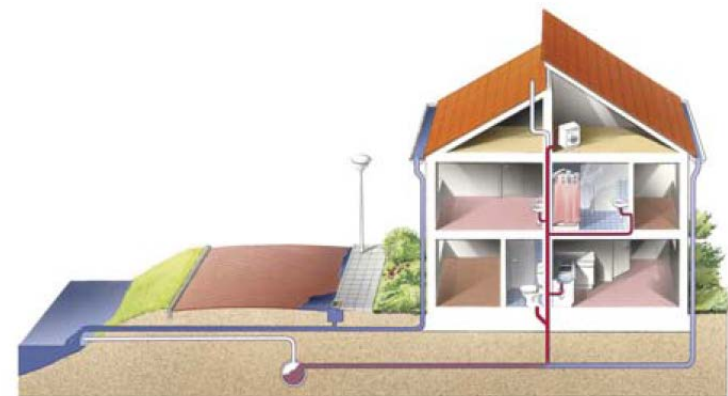
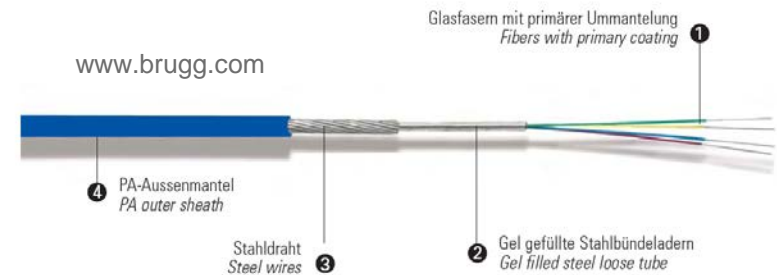
## Potential applications

### Environmental science:

- Air and water thermal stratification/circulation
- Snow melt in glaciers, ice shelves
- Estimation of soil thermal conductivity with heated cables
- Monitoring stream temperature, vegetation cover
- **Tracing groundwater discharge**

### Industry, water management:

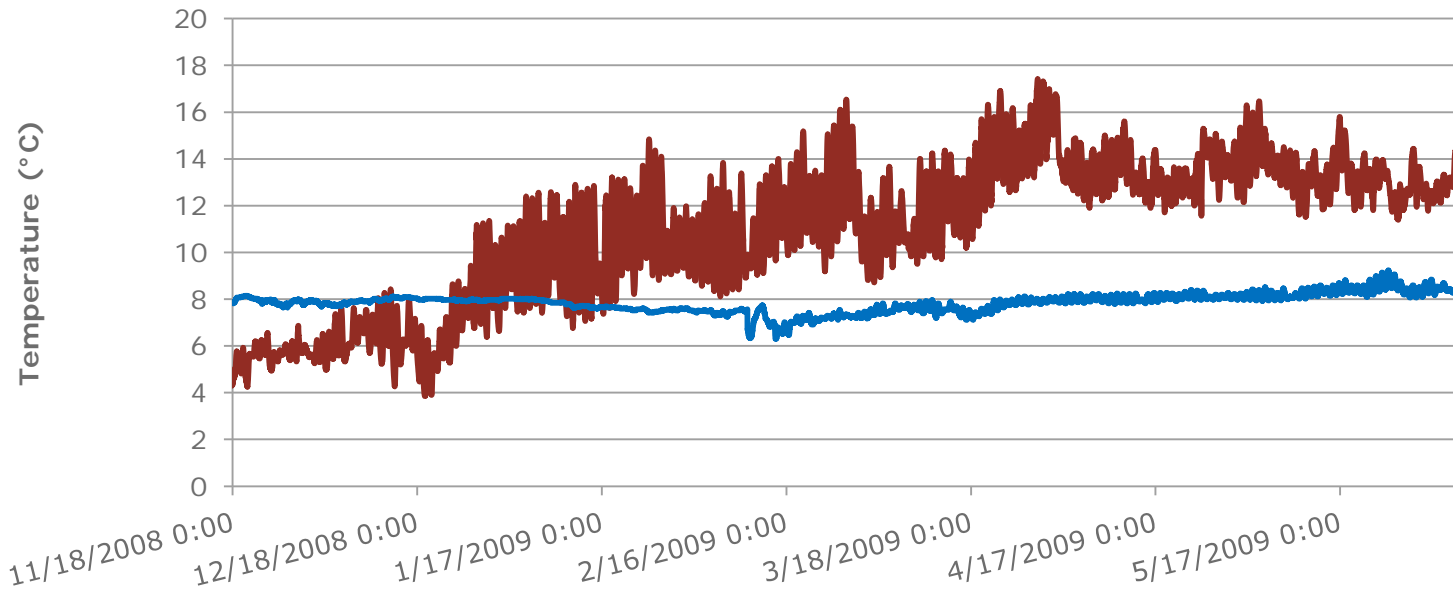
- Leak detection in storage tanks, pipelines, oil wells, geothermic wells
- Liquid level detection in oil production wells
- **Detecting illicit connections to sewer systems**



# Temperature as a tracer of groundwater discharge

Groundwater in Denmark  $\sim 8^{\circ}\text{C}$

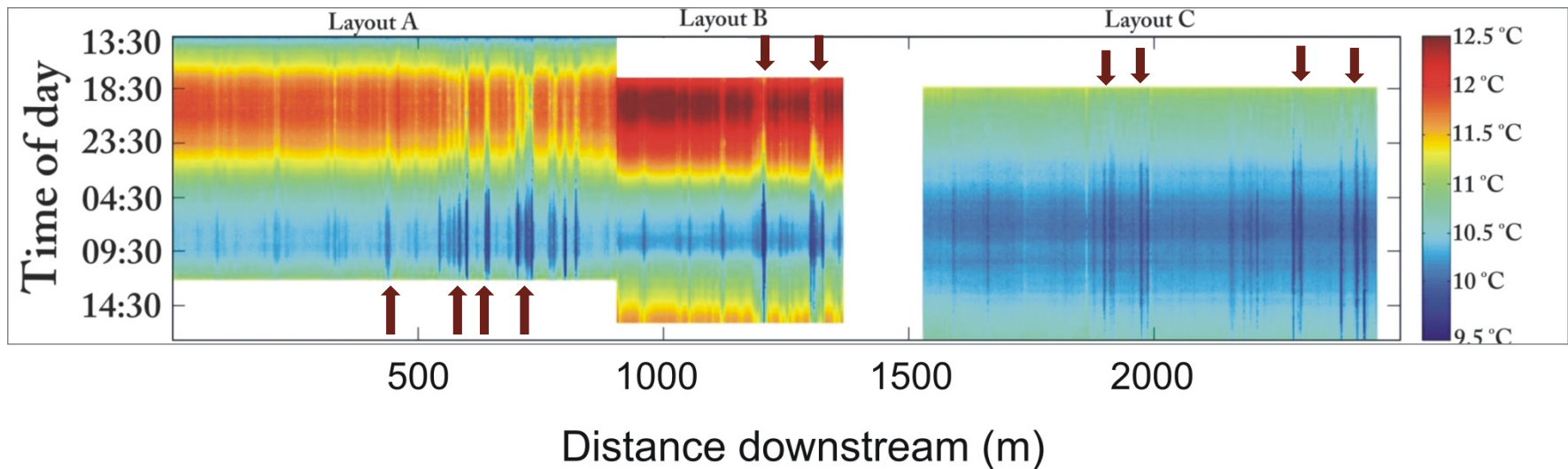
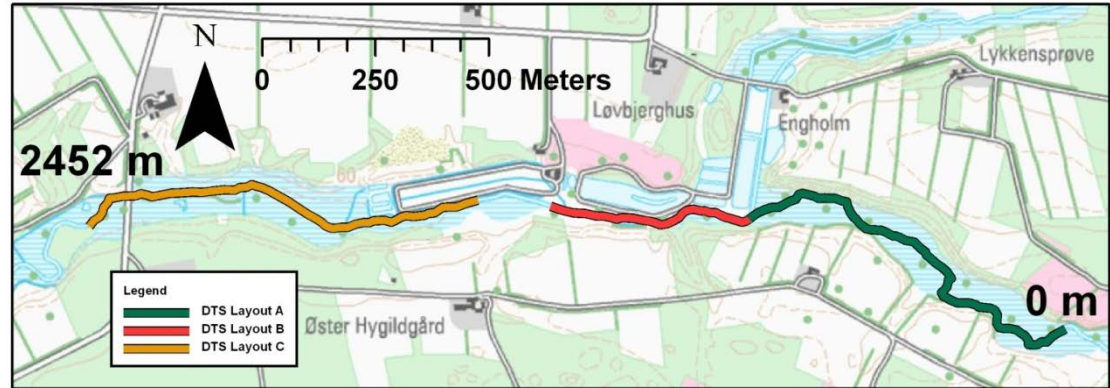
- Warming the surface waters in winter
- Cooling effect in summer





## Temperature as a tracer of groundwater discharge

- Can measure the temperature distribution over km scale
- Relatively fast mapping of large areas



## Detecting illicit connections to storm sewer systems

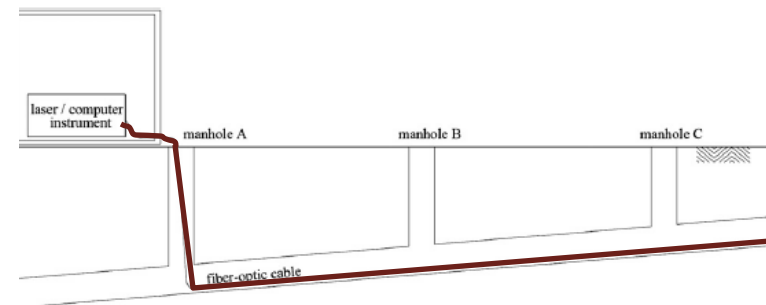
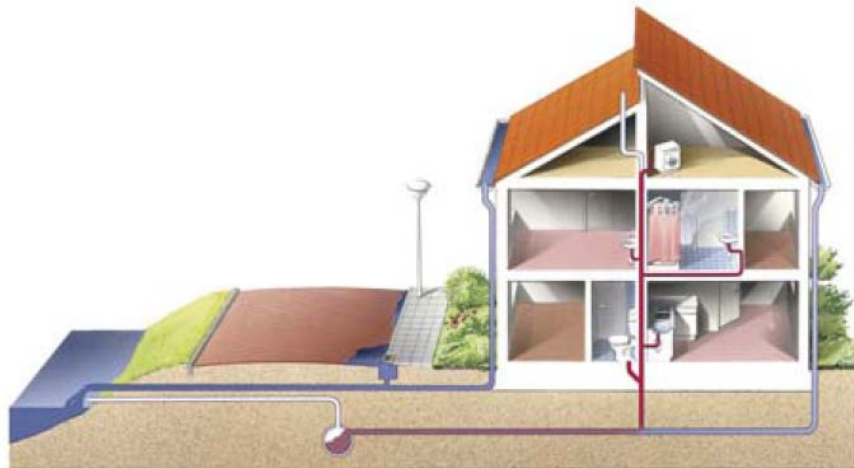
Case study from the Netherlands (Hoes et al., 2009)

Separate sewer system:

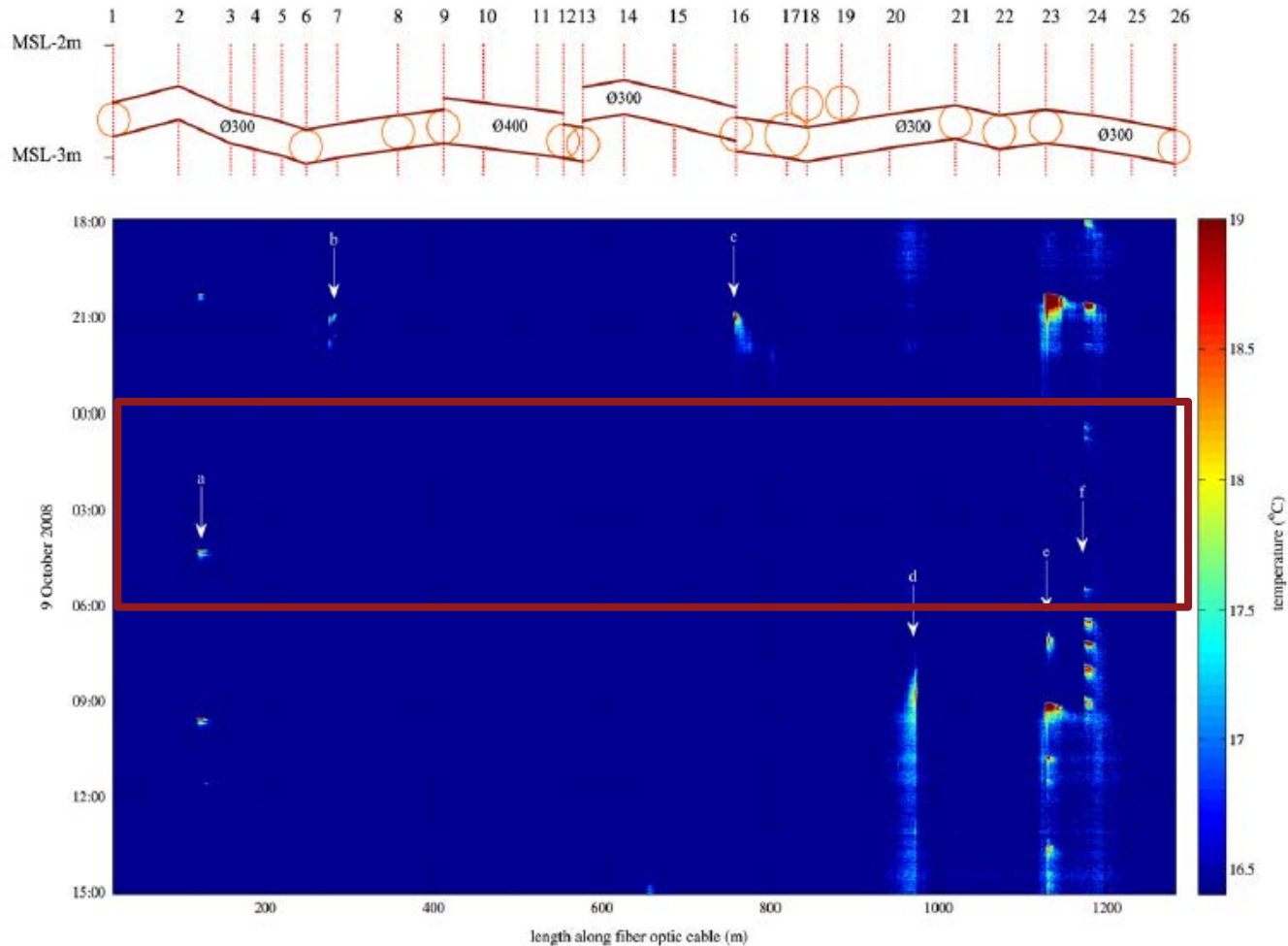
- sanitary sewer system (water to sewage treatment plant)
- storm sewer system (delivering untreated water to the surface water system)

How to detect illicit connections when household water is routed untreated to surface waters?

Temperature as a tracer of household and industrial wastewater



# Detecting illicit connections to storm sewer systems



## Assessment of DTS

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- High frequency and spatial resolution temperature data
- Long-term monitoring possible
- Flexibility of layouts
- Temperatures readily calculated
- In some cases can replace complicated, time consuming measurements
- Once the instrument is purchased, easy to expand from telecommunication instrumentation

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- Problems if the temperature contrasts are small
- Not always plug-and-paly
- Relatively expensive equipment
- Cables, connections break occasionally
- Deployment of cable can be labour-intensive



Thank you for your attention!

