

# Assessing vulnerability to vegetation growth on earth dikes using geophysical investigation

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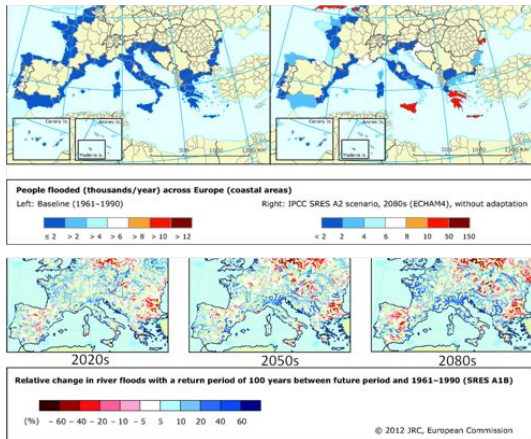
<sup>1</sup>IRSTEA  
<sup>2</sup>CEREGE

OT Med Progress Meeting, 2014



- 1 Some words about the context : a multidisciplinary issue at different scale !
  - At the Mediterranean basin scale
  - At regional scale
  - At the hydraulic structure scale
- 2 Mapping tree root system using EIT : analogie with medical imaging
  - Measurement of natural activity
  - Induced response
  - Monitoring interaction dynamics
- 3 Prospects

# WP1 : Understanding and evaluating Mediterranean climatic changes and natural hazards



## Flood hazards Feedback experience & scenario of impact

- **Mediterranean coastal vulnerability**
- **Continental flood vulnerability**

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**Flood hazards**  
**Feedback**  
**experience &**  
**scenario of impact**

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## Short term adaptation strategy ?

Built protection structure (dikes) (9000 km in our Region)

- Dike : hydraulic structure built to mitigate flood risk on population and assets

### Advantages

- Efficiently solves local problems
- Very socially acceptable

### Drawbacks

- High cost (construction and maintenance)
- Disruption of sedimentological function

### Economic and social issues

- The Mediterranean countries investissement (over the period 1998-2015)  $\approx$  5.8 E billion (coastal flood)
- Much higher amounts are invested in freshwater



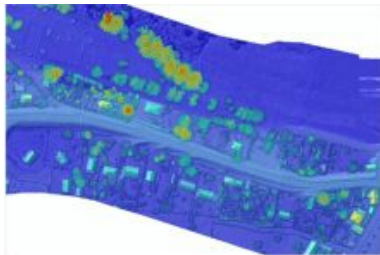
# Woody vegetation is not welcome on hydraulic embankment structures...

## International Research Programs

- FloodProbe ...



Woody vegetation on Rhone river dike



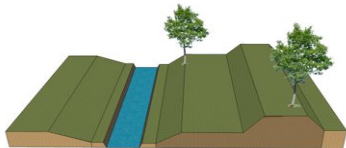
Estimation of density vegetation with LIDAR photography

(LUCIE AURIAU : DIGUES MARITIMES ET FLUVIALES DE PROTECTION CONTRE LES SUBMERSIONS-2E COLLOQUE NATIONAL-DIGUES 2013)

## Main targets of the PhD

- **Diagnosis of the dike**
- Good management of vegetation ecosystems

# What happens during a flood event ?



Typical cross section across a dike-protected valley

## Vegetation specificity -

- Pipe erosion formation due to decomposition of roots
- Tree instability leading to up rooting

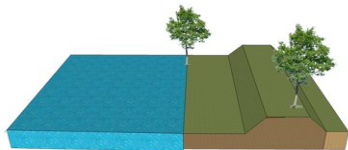
## 2 types of failure mechanisms

- Internal erosion
- External erosion

## Vegetation specificity +

- Reinforcement of mechanical properties

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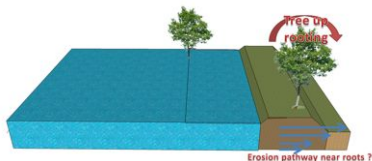
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## Vegetation specificity -

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# How to assess the impact of root systems on the integrity of the structure ?

## Output parameters

- Sizing of the root system
  - mass
  - geometry...
- Characterization of the environment
  - nature of soil
  - water ressource

## Geoelectrical tomography : Sensors mesuring electric field $E$ for deducing the internal characteristics

- Image the medium under study
- Monitor changes and process (4D)

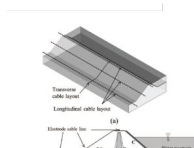
## Localisation of weak self-potential source ?

### Sensors measuring Electric field $E$

Localisation of tree pathology : Erosion pathway

#### Sources of $E$ field

- Natural activity of roots = Sap flow (= qq mV)
  - Unfortunatly **too weak to localise** roots in soil !



Localisation of brain pathology : Epileptic zone

#### Source $E$ field

- Natural activity of the brain = Neurone's communication (= qq mV)



## How to induced a higher response ?

By applying external stimuli

### Sources

- Injected electrical current trough electrodes



Experimental Set-up

### Sources

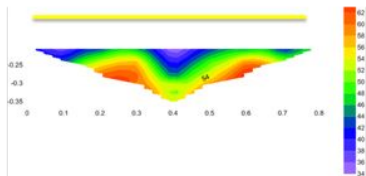
- Audio-visual entrainment
  - Flashes of lights
  - Pusles of tones

### Brain observation

- Activation of area specific to brain activity

## How to induced a higher response ?

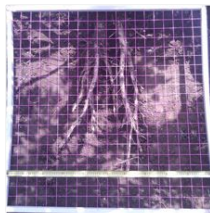
By applying external stimuli



Initial state : 35 % of water content

Resistivity ( $\Omega \cdot m$ ) & Chargeability (ms)

## Comparison with excavation result



Photographie + virtual mesh

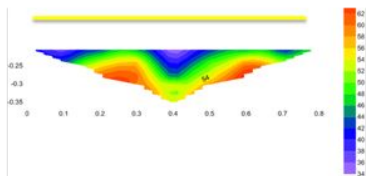
## Tree observations

- Roots appears as an **anomaly of resistivity** in the surrounding soil
- Roots **store and reconstitute electric field** specifically



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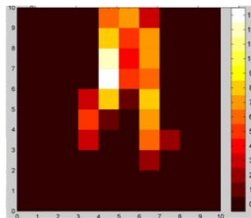
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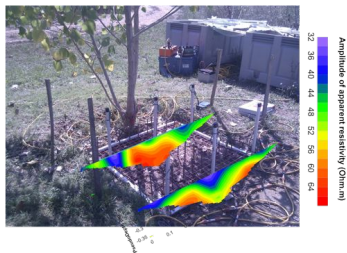
Density probability of presence

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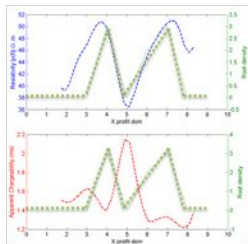
## How to induced a higher response ?

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Correlation roots presence / resistivity & Chargeability term

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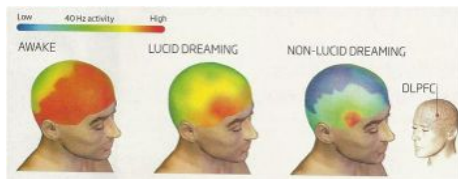
By studying internal variations in interaction with environment :  
Exemple of water content absorption

### Tree observation

- Daily and weekly variations
- Preferential water absorption near roots density zone

### Brain observations

- Activity of differents area during dream period



Time lapses image of a dream period

(NEW SCIENTIST 12 JUNE 2010 AND SLEEP VOL 32 P1191)

## Interaction with environment : exemple of water content absorption

- 1 Evapotranspiration due to heat !
- 2 Water absorption near roots density zone

Global trend of water content

% Evolution of volumetric water content

Is it an effective tool for detection ?

Good correlation roots/ water dynamic but low resolution

# What my Phd and on going project will provide ?

- 1 **New technics for assessing underground properties**
  - Define dangerous tree roots comportement
  - Improve dike management models
- 2 **Better understanding the risk vegetation on dikes**
  - Rational management of vegetation !
- 3 **Meet the solicitation of public actors (decision makers)**
  - Protection of socio-economic issues !

## Articles in progress

- *Mapping tree root system using induced polarization : Focus on the influence of the water content of the soil*
- *Highlighting the frequency dependency of roots sample during laboratory experiment*

# Merci de votre attention ! Questions ?

## Partnerships & Acknowledgement

- SISYPHE UPMC (Paris 6)
- LMA Marseille
- INRA Avignon



## Interaction with environment : exemple of water content absorption



Global trend of water content

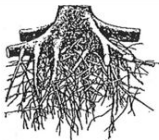
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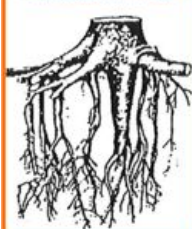
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Structure Mixte



*Mixte root system*

Structure Pivotante



*Pivotante root system*

Structure Traçante



*Running root system*



