# Spatio-temporal characterization of drought

**Vitali Díaz Mercado**

TU Delft
netherlands eScience center
nD-PointCloud

# Outline

- Vitali Díaz Mercado
- Spatio-temporal characterization of drought
- nD-PointCloud data to represent spatio-temporal phenomena

**Vitali Díaz Mercado**

**PhD Hydroinformatics**

Spatio-temporal characterisation of drought:
data analytics, modelling, tracking, impact and prediction

**Specialist Watershed Management**

Runoff calculation of ungauged basins with distributed hydrological modelling and data of neighbouring basins

**MSc Water Sciences**

Geomatics design and implementation of the distributed hydrological model CEQUEAU for (quasi-) natural basins

**BSc Civil Engineering**

Statistical analysis and probabilistic modelling of variables in the reliability analysis of concrete vehicle bridges

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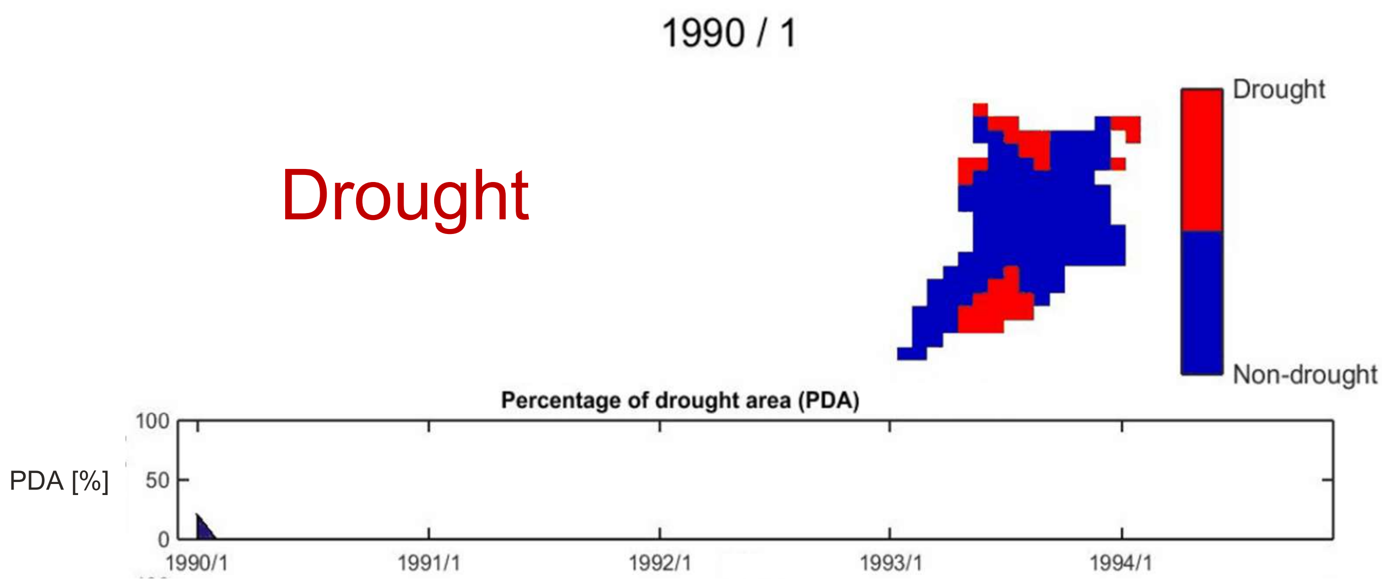
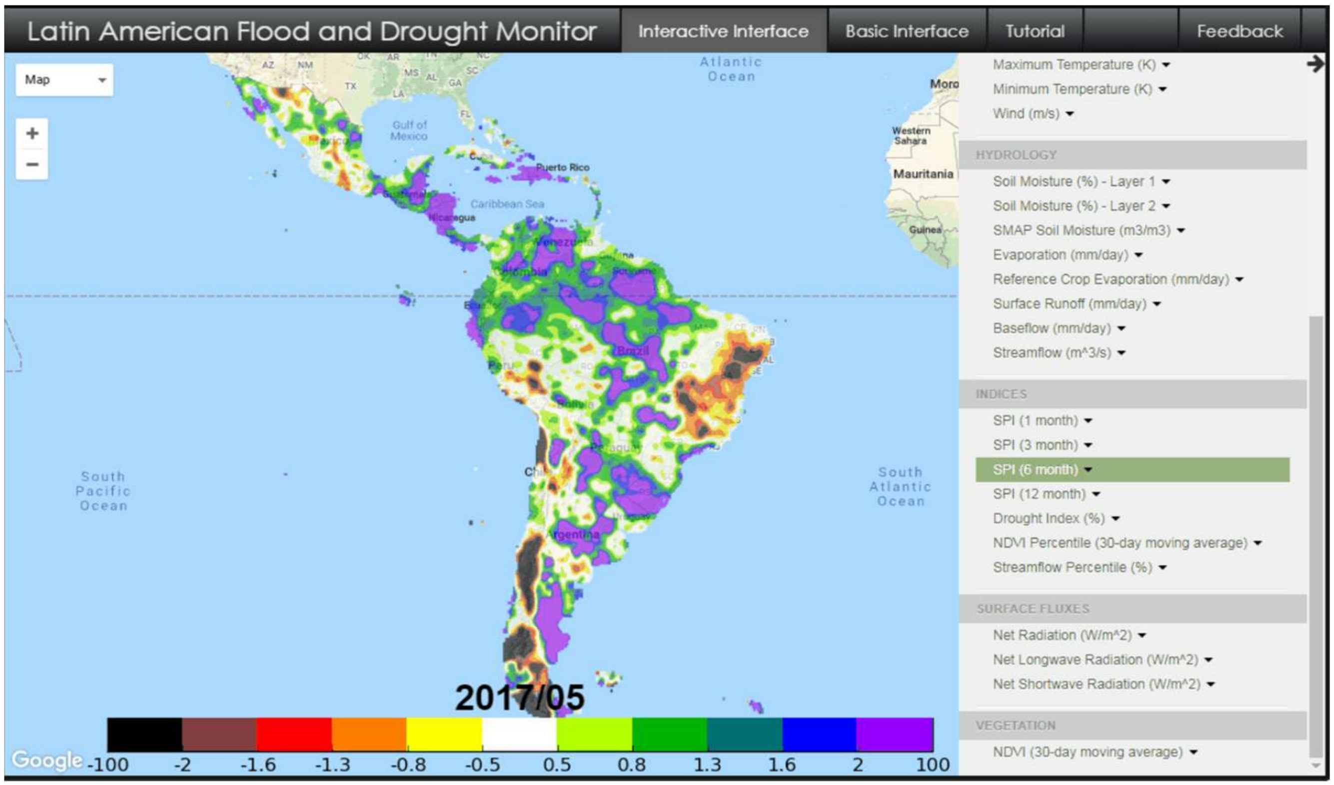
# Spatio-temporal characterization of drought

## Background

Drought



# Background

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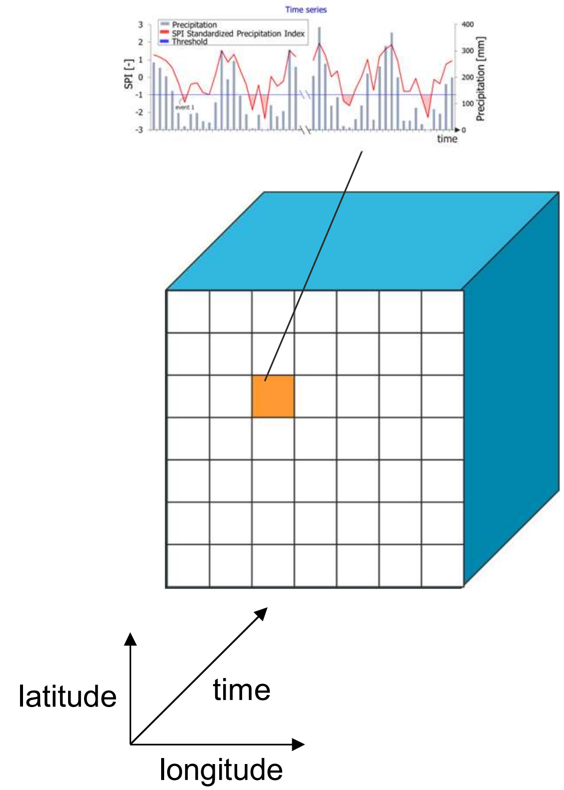
Information of a few databases containing drought indicator data

| Dataset | Source/ Reference | Spatial resolution and coverage | Temporal resolution and coverage | Meteorological data source | Procedure |
|---|---|---|---|---|---|
| SPI-PRECL0p5 | IRI Analyses SPI: Standardized Precipitation Index analyses of multiple global precipitation datasets | 0.5 deg, globe | 1,3,6,9, 12-month, 1948-2016 | P from NOAA's PRECipitation REConstruction over Land (PRECL) | (Guttman, 1999) |
| SPI-TS2p1 | IRI Analyses SPI | 0.5 deg, globe | 1,3,6,9, 12-month, 1901-2012 | P from University of East Anglia (UEA) Climatic Research Unit (CRU), monthly Time Series (TS), Version 2.1 (CRU TS 2.1) | (Guttman, 1999) |
| SPI-UEA | IRI Analyses SPI | 0.5 deg, globe | 1,3,6,9, 12-month, 1901-1998 | P from University of East Anglia (UEA) Climatic Research Unit (CRU), monthly time series, twentieth-century | (Guttman, 1999) |
| SPI-CAMSOPI | IRI Analyses SPI | 2.5 deg, globe | 1,3,6,9, 12-month, 1979-2016 | P from Climate Anomaly Monitoring System (CAMS) and OLR Precipitation Index (OPI) | (Guttman, 1999) |
| SPI-CMAP0407v1 | IRI Analyses SPI | 2.5 deg, globe | 1,3,6,9, 12-month, 1979-2004 | P from NOAA's Climate Prediction Center (CPC) Merged Analysis of Precipitation (CMAP) | (Guttman, 1999) |
| SPI-GPCPv2OPI | IRI Analyses SPI | 2.5 deg, globe | 1,3,6,9, 12-month, 1979-1987 | P from Global Precipitation Climatology Centre, monthly precipitation dataset, Version 2.0 | (Guttman, 1999) |
| African Flood and Drought Monitor (AFDM), SPI dataset | (Sheffield et al., 2014) | 0.25 deg, -19S to 55N, -35W to 37.75E | 1,3,6, 12-month, 1950-present | P from Princeton's Global Meteorological Forcing Dataset | (McKee et al., 1993) |
| Latin American Flood and Drought Monitor (LAFDM), SPI dataset | Latin American Flood and Drought Monitor (LAFDM) | 0.25 deg, -118.5S to -29.25N, -56W to 33.25E | 1,3,6, 12-month, 1950-present | P from Princeton's Global Meteorological Forcing Dataset | (McKee et al., 1993) |
| Standardized Precipitation Evaporation Index (SPEI) v2.3 | (Beguería et al., 2014) | 2.5 deg, globe | 1 to 48-month, 1901-2013 | P from/ET base on CRU TS 3.23 dataset | (Vicente-Serrano 2010; Beguería et al., 2014) |

P precipitation, ET evapotranspiration
IRI Analyses SPI available from http://iridl.ldeo.columbia.edu/SOURCES/.IRI/.Analyses/.SPI/
LAFDM available from http://stream.princeton.edu/LAFDM/WEBPAGE/

Information in each cell

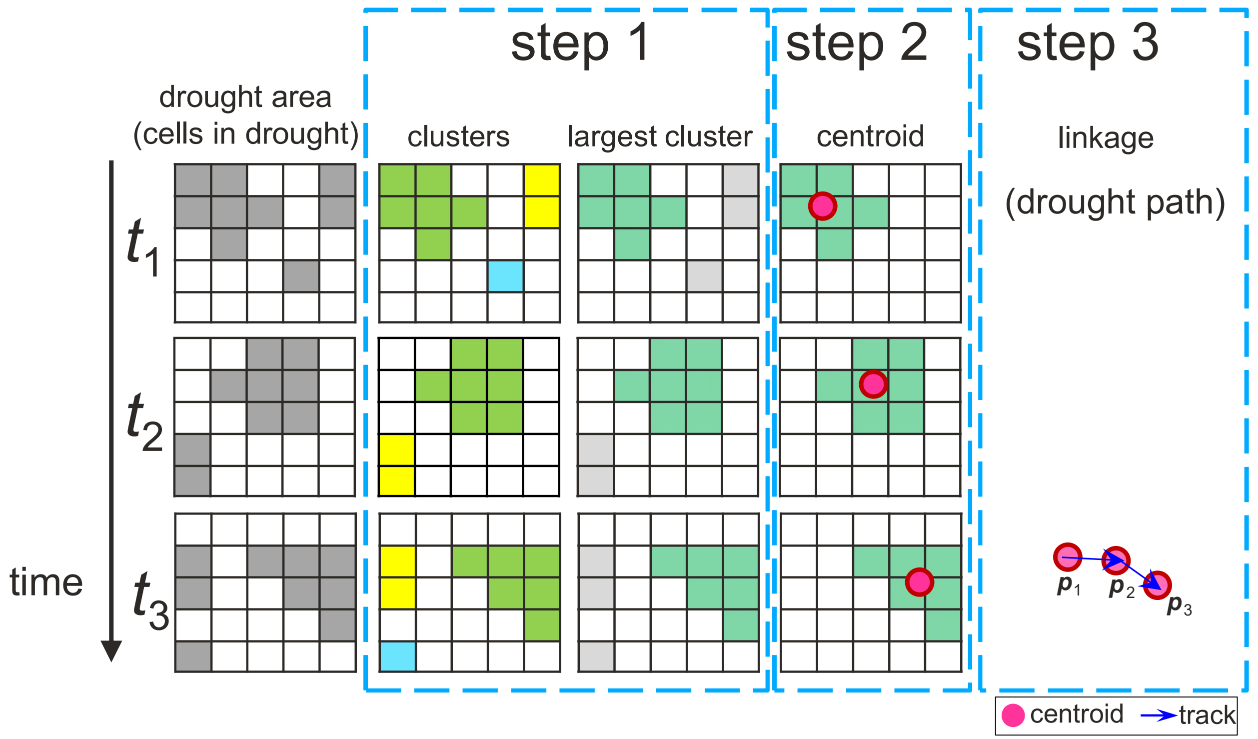


# Gaps in spatio-temporal characterization of drought

- Methods to characterize drought explicitly based on its spatio-temporal features such as spatial extent (area) and pathway

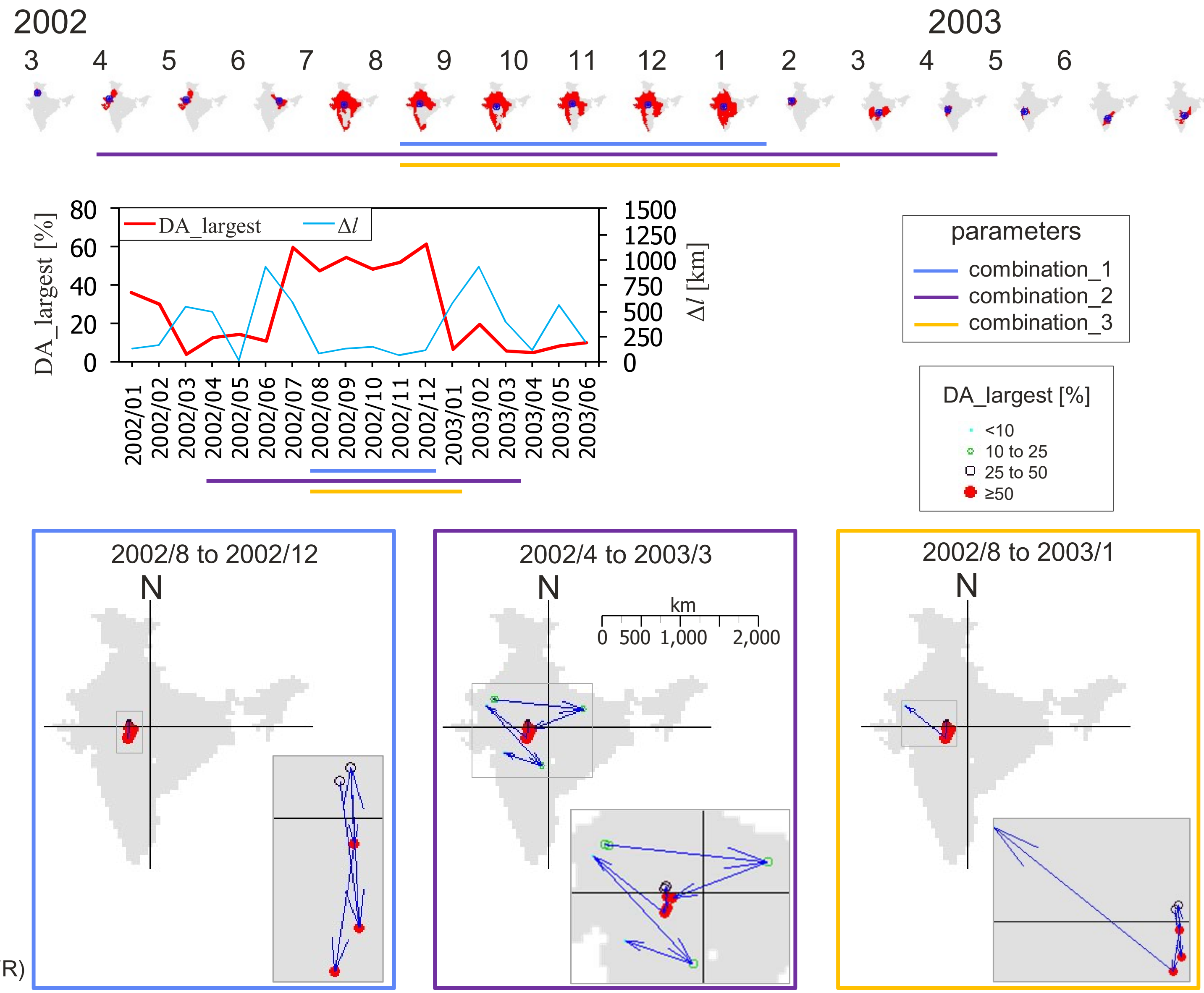
- Methods to monitor and predict drought that consider the spatio-temporal characteristics

# Spatio-temporal drought tracking

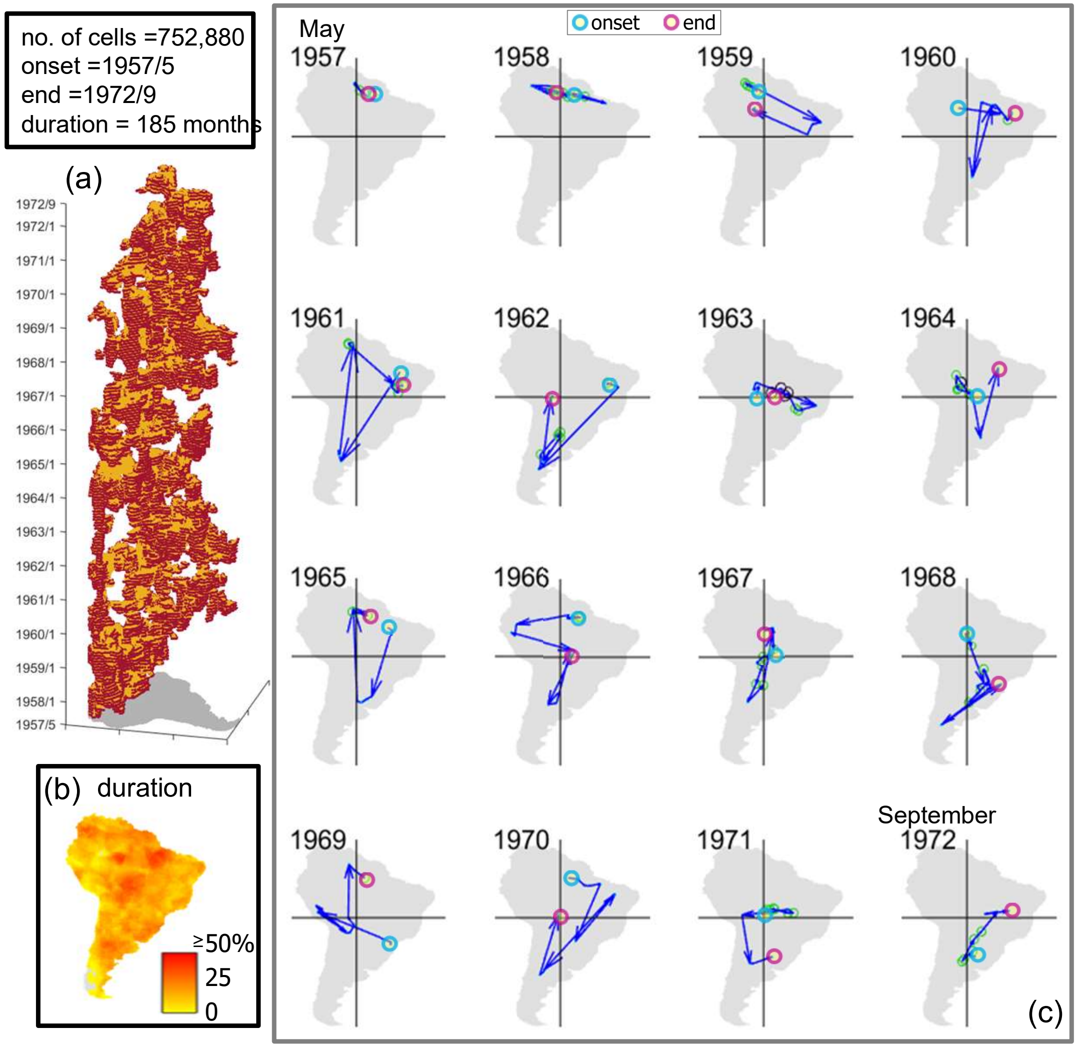



Diaz et al. 2020 (STOTEN), 2020 (ADWR)

$DA$ drought area
$\Delta l$ distance between centroids




Diaz et al. 2020 (STOTEN), 2020 (ADWR)

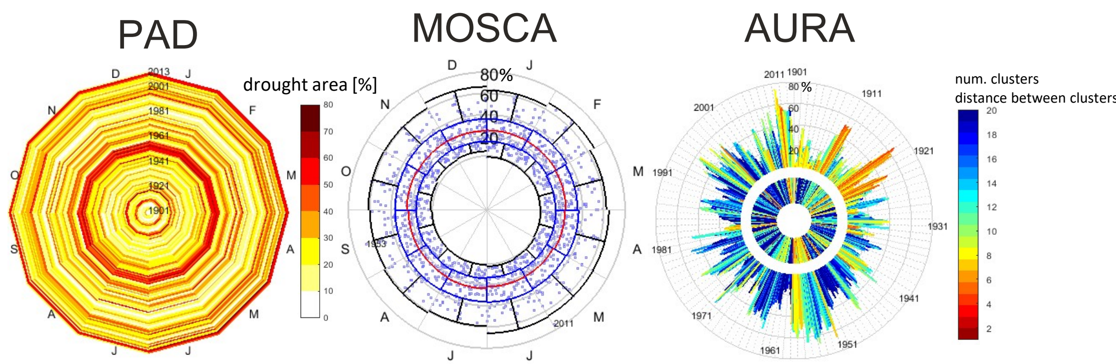



Diaz et al. 2021

# Spatial drought patterns analysis through visual approaches

Radial diagrams

- Polar Area Diagram (PAD)
- MOnthly Spider ChArt (MOSCA)
- AnnUal RAdar chart (AURA)




Drought patterns

- Periodicity: PAD, AURA
- Seasonality: PAD
- Persistence: PAD, MOSCA

- Hotspots: PAD, MOSCA, AURA
- Cohesion: AURA
- Fragmentation: AURA

- Similarity: PAD, MOSCA, AURA
- Dispersion (variability): MOSCA
- Trend: PAD, AURA

Diaz et al. (to be submitted)

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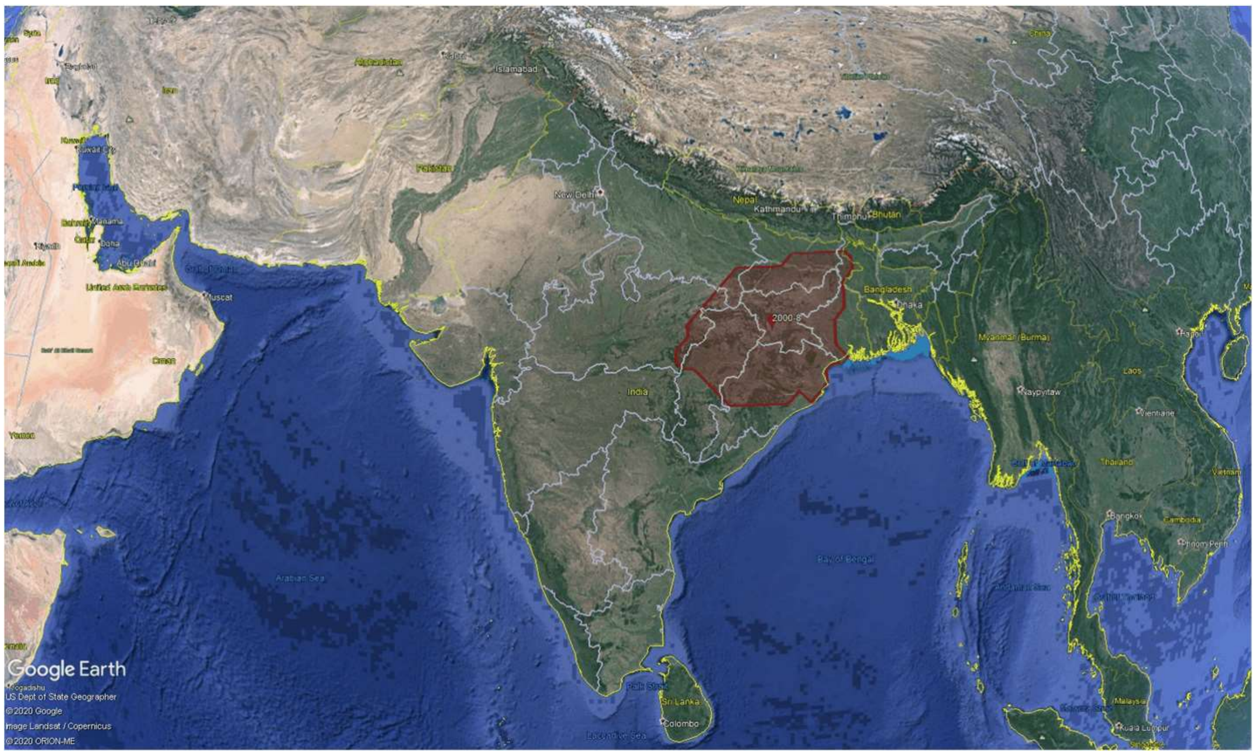
# The proposed scope opens a new area of potential for drought prediction




$(dL_{t+1}, theta_{t+1}, da_{t+1})$=f$(dL_t, theta_t, da_t, L^*, dd^*)$

$da_t$ drought area at time $t$
$da_{t+1}$ drought area at time $t+1$
$dL_{t+1}$ distance between $da_t$ and $da_{t+1}$
$thetha_{t+1}$ angle (deg) of line btw centroids of $da_t$ and $da_{t+1}$
$dL_t$ distance between $da_{t-1}$ and $da_t$
$thetha_t$ angle (deg) of line btw centroids of $da_{t-1}$ and $da_t$
$L^*$ average length of trajectories
$dd^*$ average duration

# nD-PointCloud data to represent spatio-temporal phenomena

The connection with my previous work

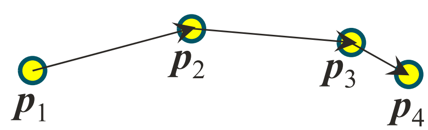
# nD-PointCloud data to represent spatio-temporal phenomena

## 1. Drought paths calculation

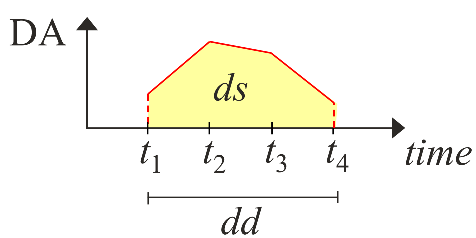
| | |
|---|---|
| Step 1 | • Drought areas calculation<br>• Clusters computation |
| Step 2 | • Centroids extraction |
| Step 3 | • Centroids linkage<br>• Paths construction |

Example of output:

**spatial drought path**




**time series of drought areas**



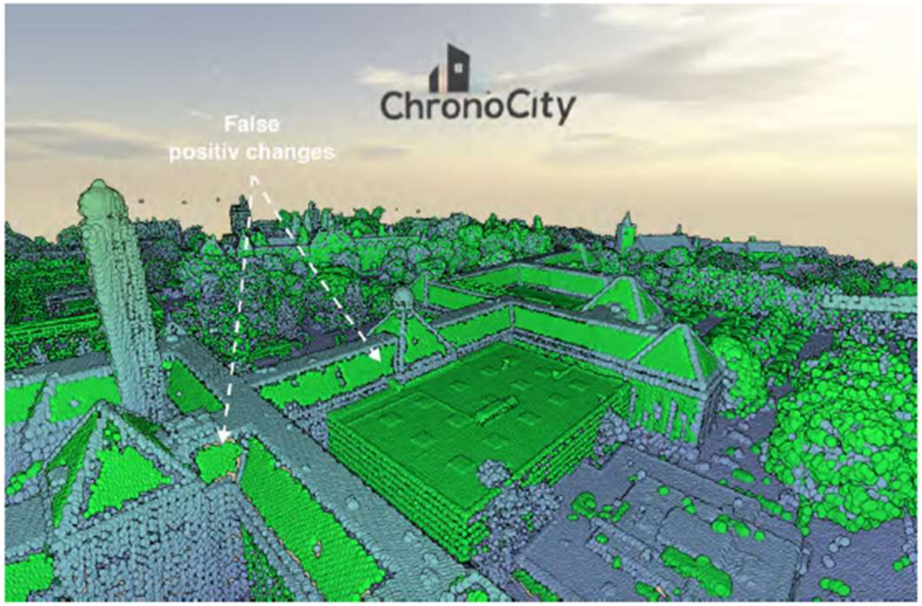

DA drought area
*ds* drought severity
*dd* drought duration
$p_i$ *i*-th centroid coordinates

## 2. Drought characteristics calculation

- Characteristics calculated with time series of **drought areas**
  - onset and end
  - duration
  - severity
  - intensity
- Characteristics calculated with coordinates of **centroids**
  - onset and end location
  - direction
  - rotation
  - path length

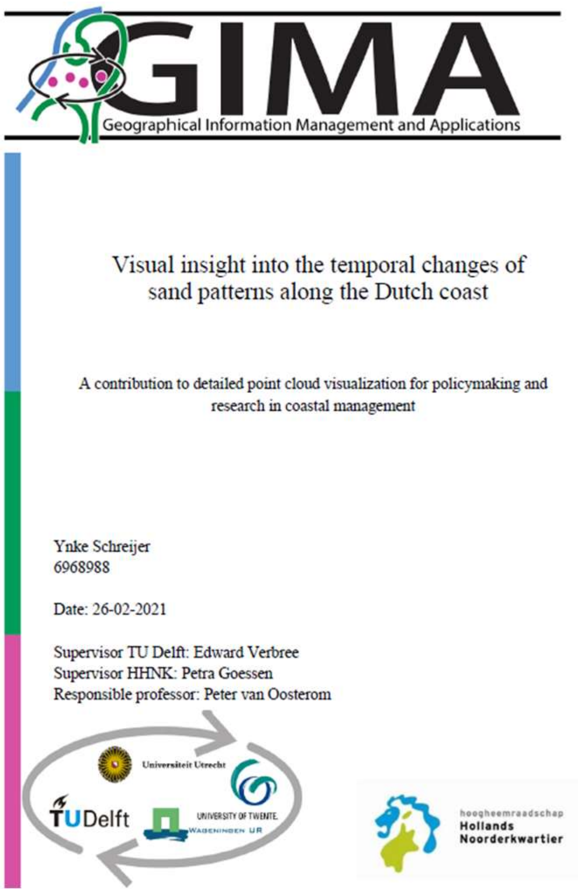
# nD-PointCloud data to represent spatio-temporal phenomena

**Spatio-temporal change detection**

# nD-PointCloud data to represent spatio-temporal phenomena

## Spatio-temporal change detection


GIMA
Geographical Information Management and Applications

Visual insight into the temporal changes of sand patterns along the Dutch coast

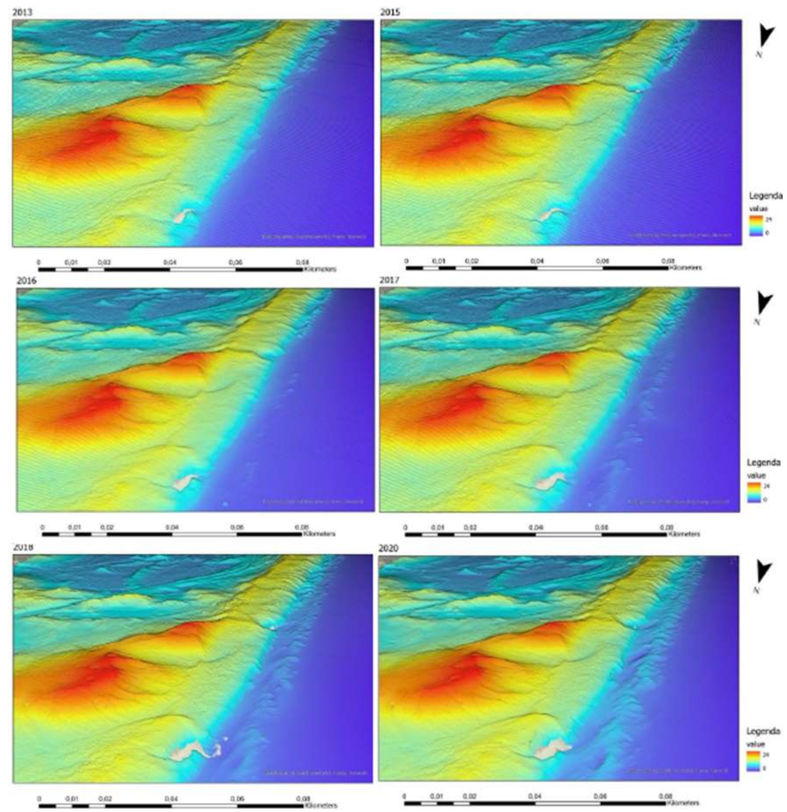
A contribution to detailed point cloud visualization for policymaking and research in coastal management

Ynke Schreijer
6968988

Date: 26-02-2021

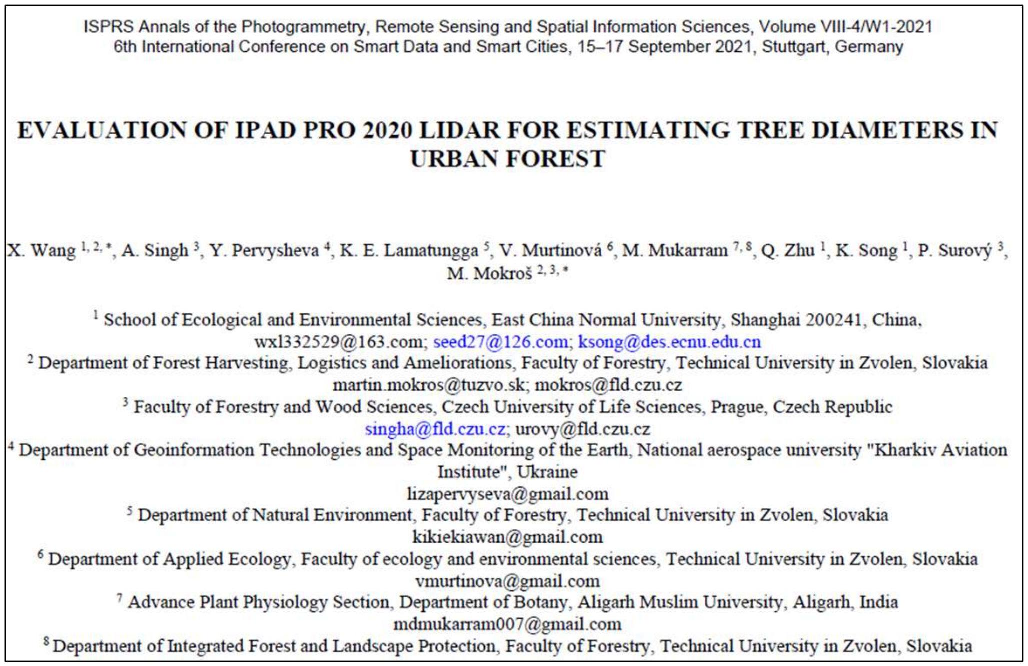
Supervisor TU Delft: Edward Verbree
Supervisor HHNK: Petra Goessen
Responsible professor: Peter van Oosterom





# nD-PointCloud data to represent spatio-temporal phenomena

## Estimation of features for environment monitoring


ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume VIII-4/W1-2021
6th International Conference on Smart Data and Smart Cities, 15–17 September 2021, Stuttgart, Germany

**EVALUATION OF IPAD PRO 2020 LIDAR FOR ESTIMATING TREE DIAMETERS IN URBAN FOREST**

X. Wang [1, 2, *], A. Singh [3], Y. Pervysheva [4], K. E. Lamatungga [5], V. Murtinová [6], M. Mukarram [7, 8], Q. Zhu [1], K. Song [1], P. Surový [3], M. Mokroš [2, 3, *]

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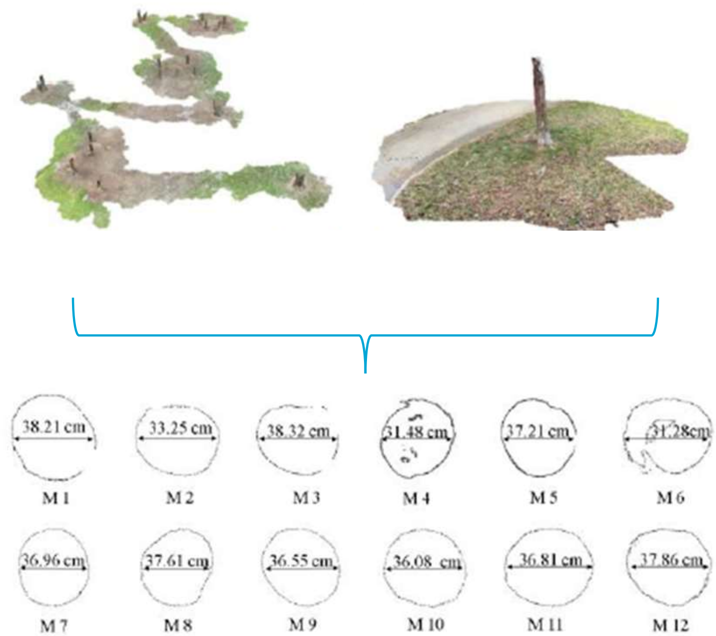
[8] Department of Integrated Forest and Landscape Protection, Faculty of Forestry, Technical University in Zvolen, Slovakia



# nD-PointCloud data to represent spatio-temporal phenomena

## Querying for water-related problems

The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLIII-B4-2021
XXIV ISPRS Congress (2021 edition)

**AN EFFICIENT ND-POINT DATA STRUCTURE FOR QUERYING FLOOD RISK**

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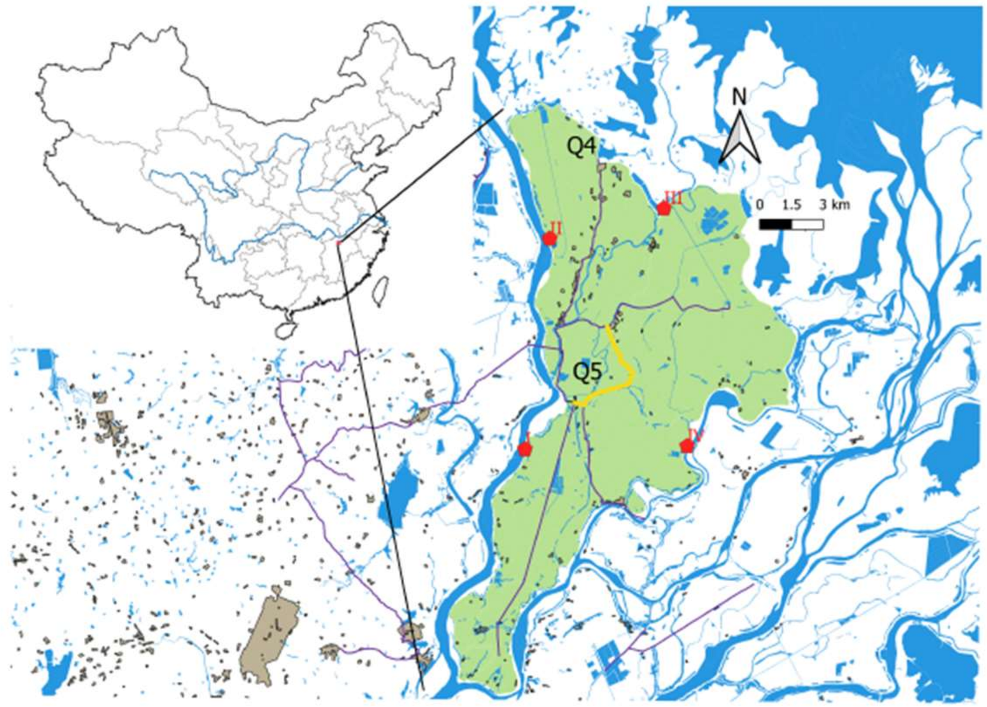
rodnmaria@gmail.com

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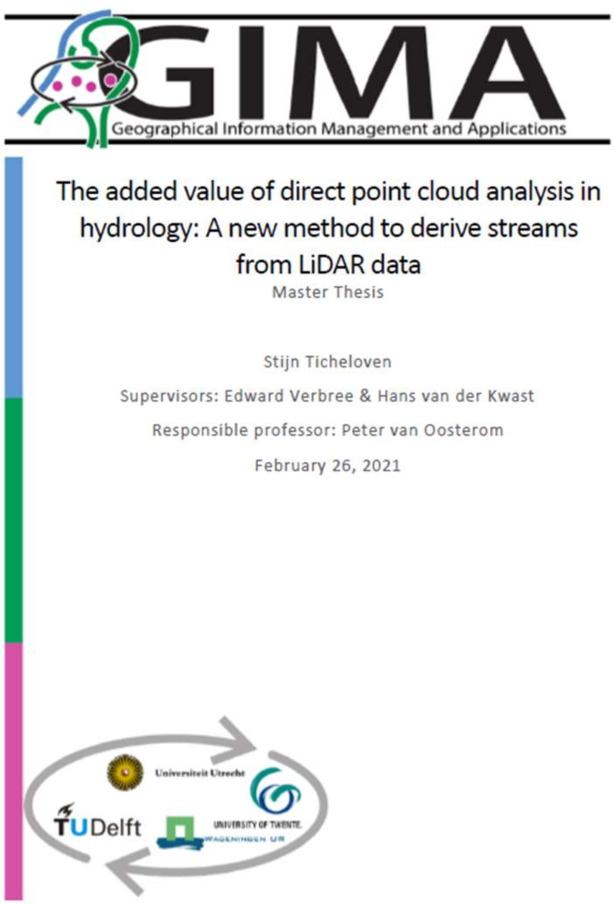
# nD-PointCloud data to represent spatio-temporal phenomena

## Hydrological applications


GIMA
Geographical Information Management and Applications

The added value of direct point cloud analysis in hydrology: A new method to derive streams from LiDAR data

Master Thesis

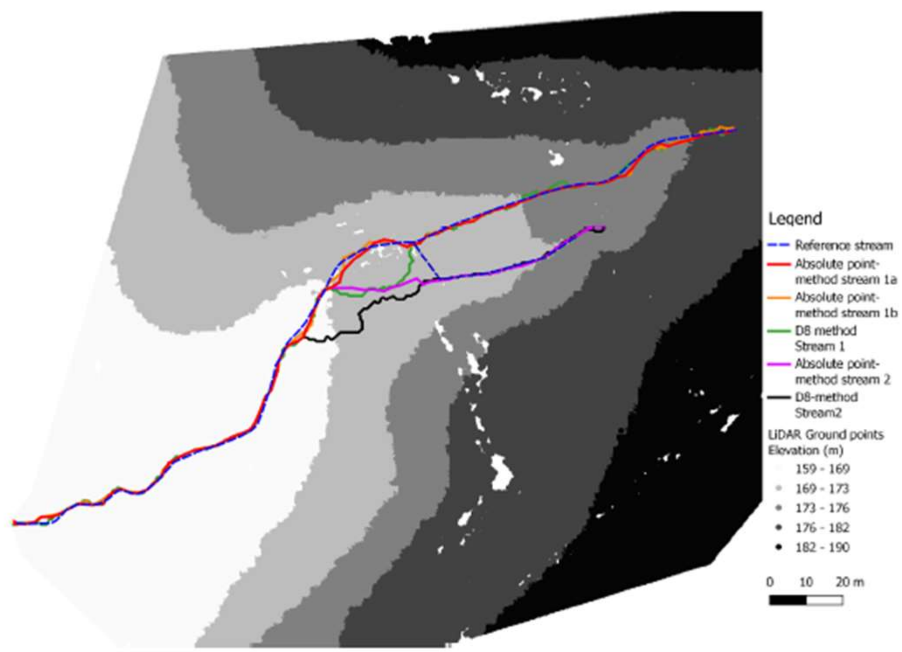
Stijn Ticheloven

Supervisors: Edward Verbree & Hans van der Kwast

Responsible professor: Peter van Oosterom

February 26, 2021

Universiteit Utrecht
TU Delft
University of Twente
Wageningen UR



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