Hydrometeorological Monitoring using Microwave Links from Cellular Communication Networks: Opportunities and Challenges

Remko Uijlenhoet (EGU 25, GI 1.3)

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(identim / Shutterstock)

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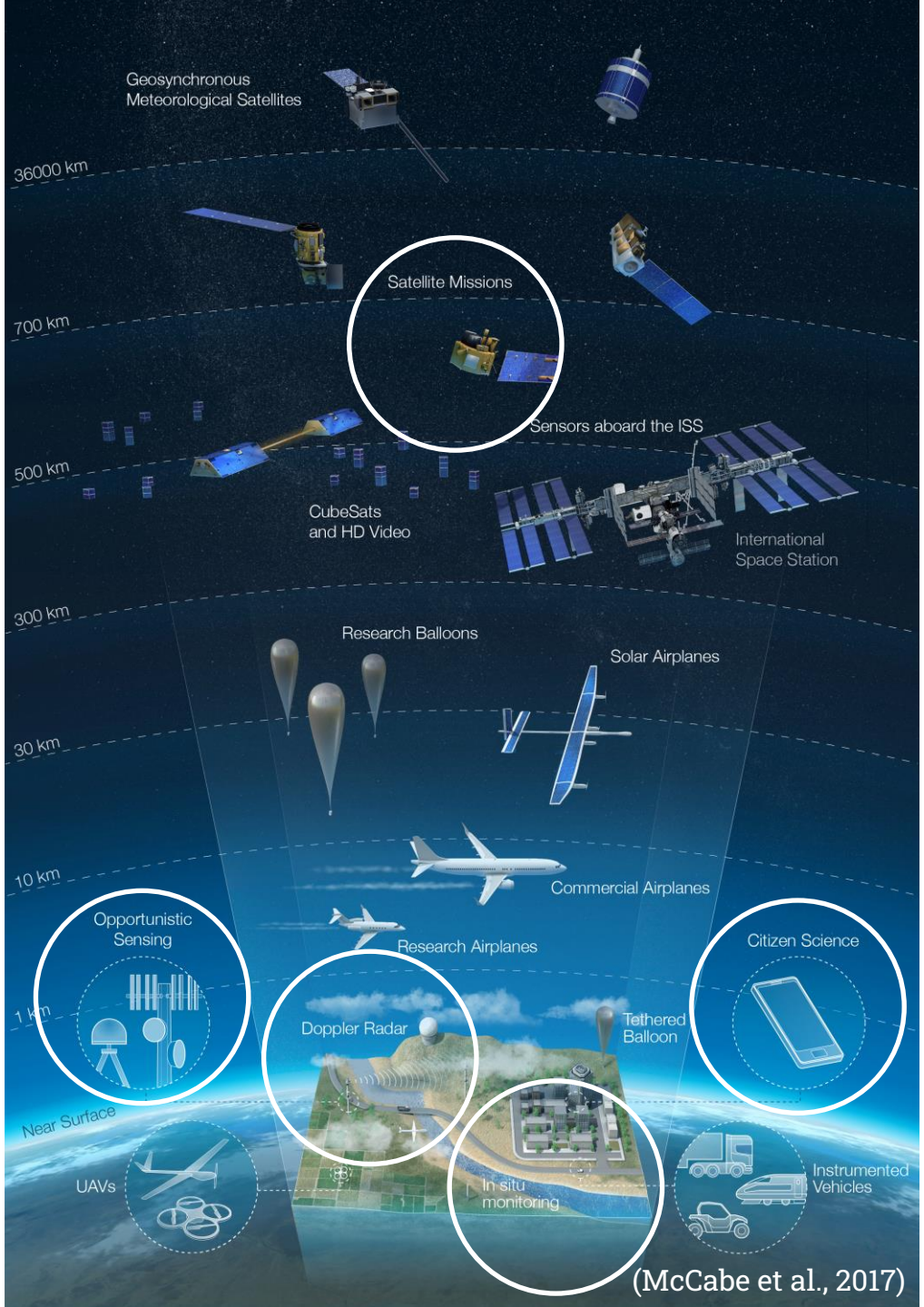
Data revolution

- In situ monitoring
- Ground-based remote sensing
- Spaceborne remote sensing
- Citizen science
- Opportunistic sensing



(McCabe et al., 2017)

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Let’s consider rainfall…

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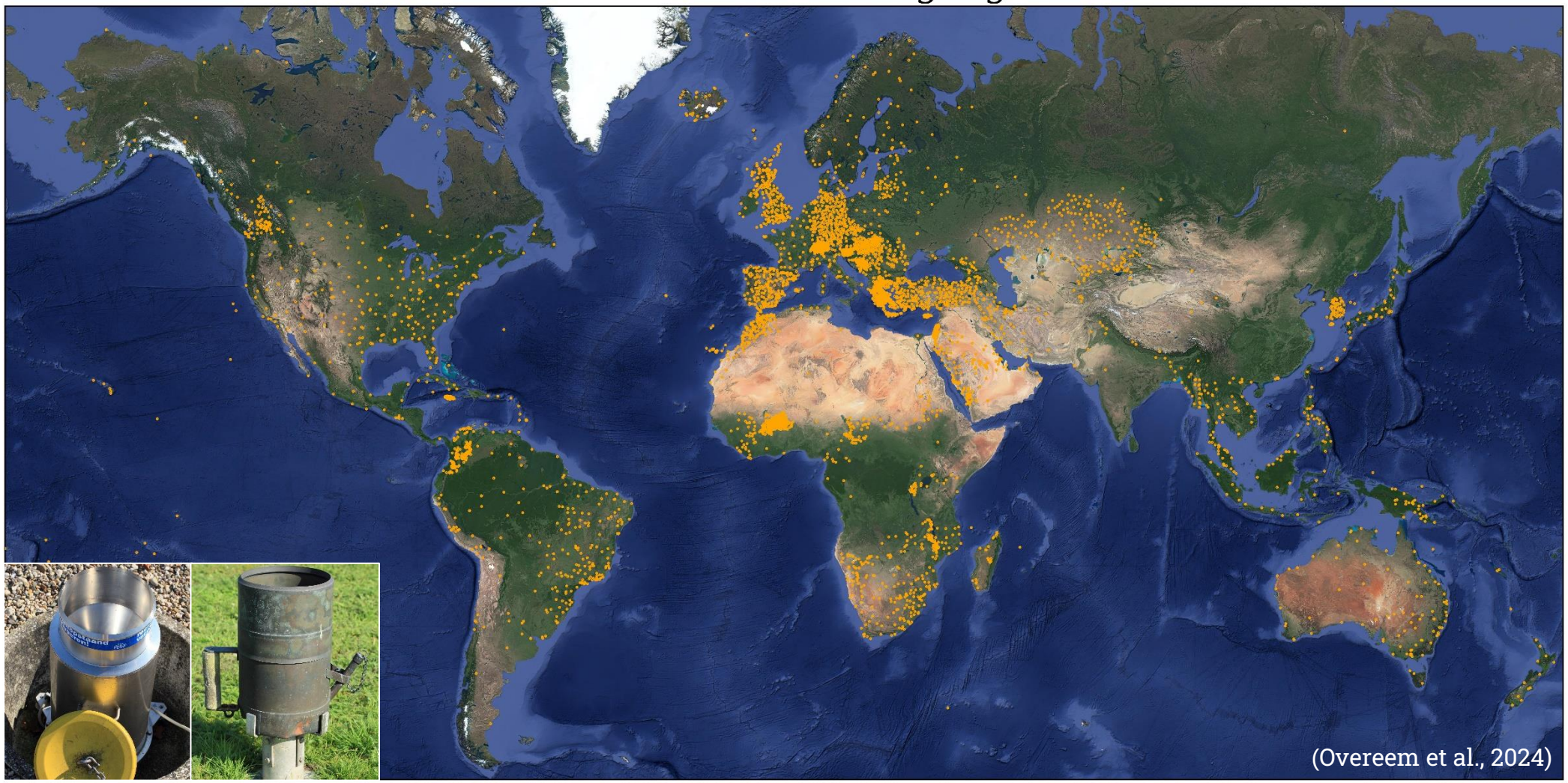
Locations WMO rain gauges



(~11,000 GTS gauges; ~32,000 GPCC gauges)

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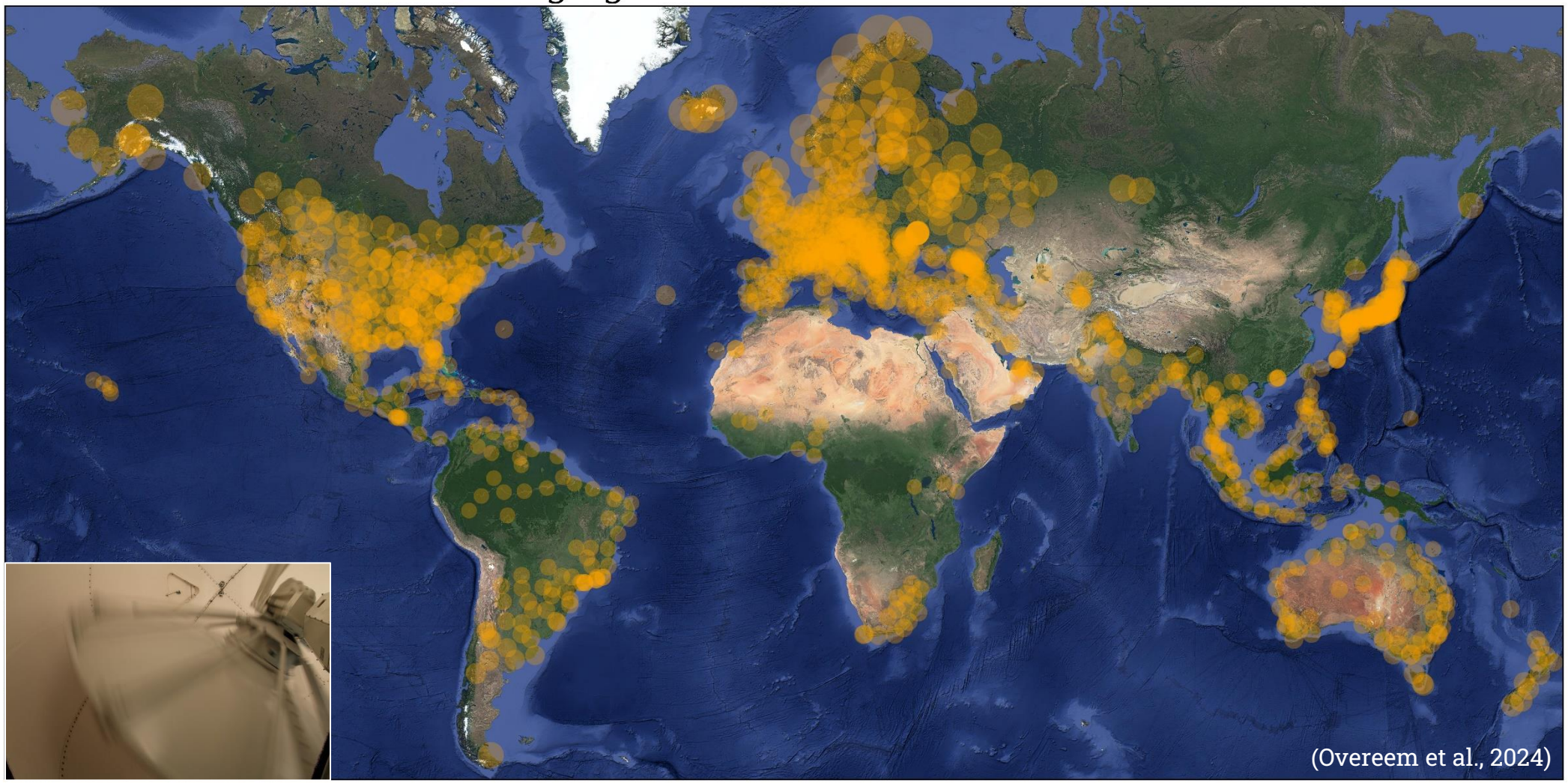
Coverage ground-based weather radars



(~1,300 radars; 200 km range markers)

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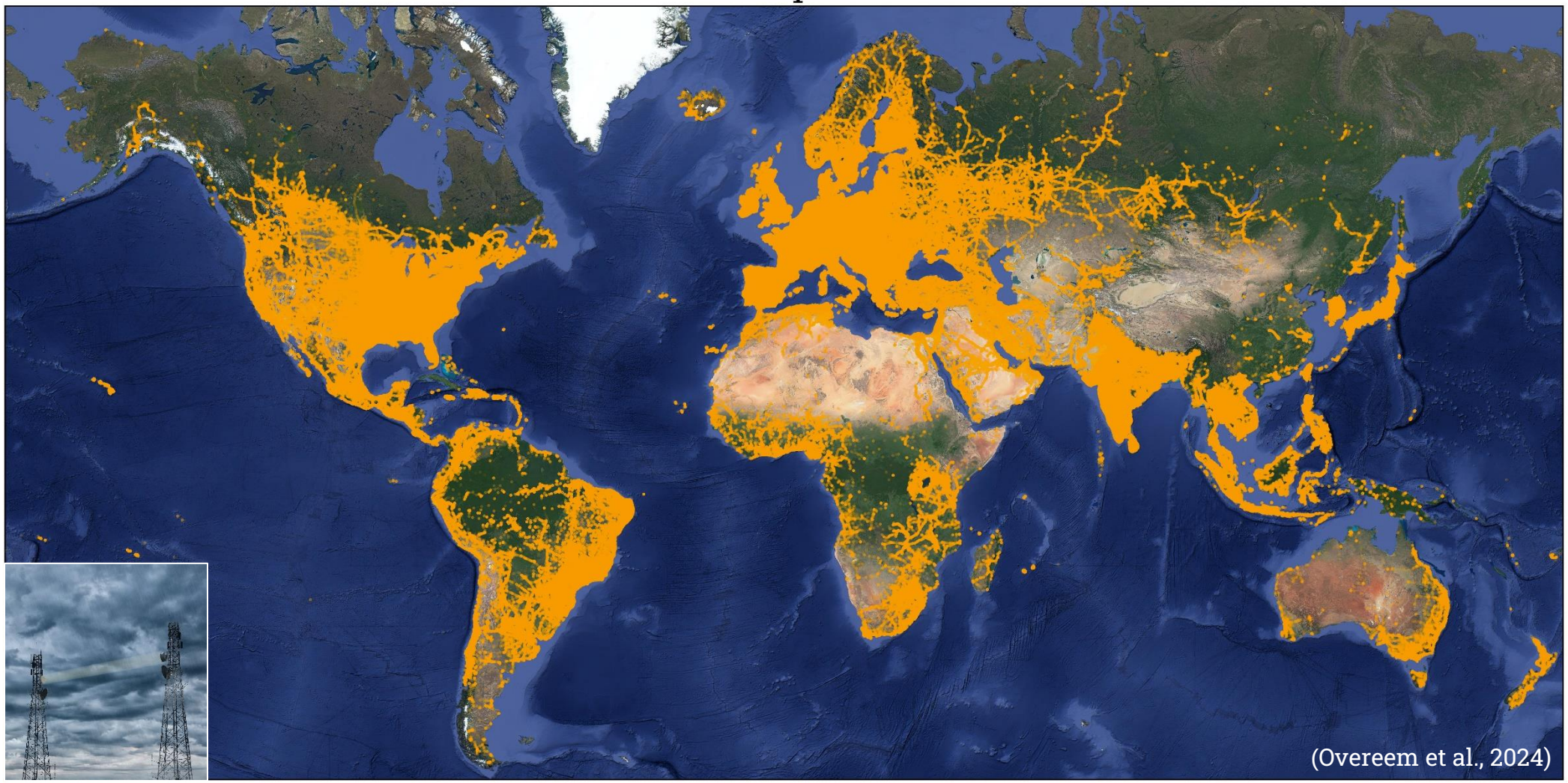
Locations cell phone towers



(~5 million commercial microwave links)

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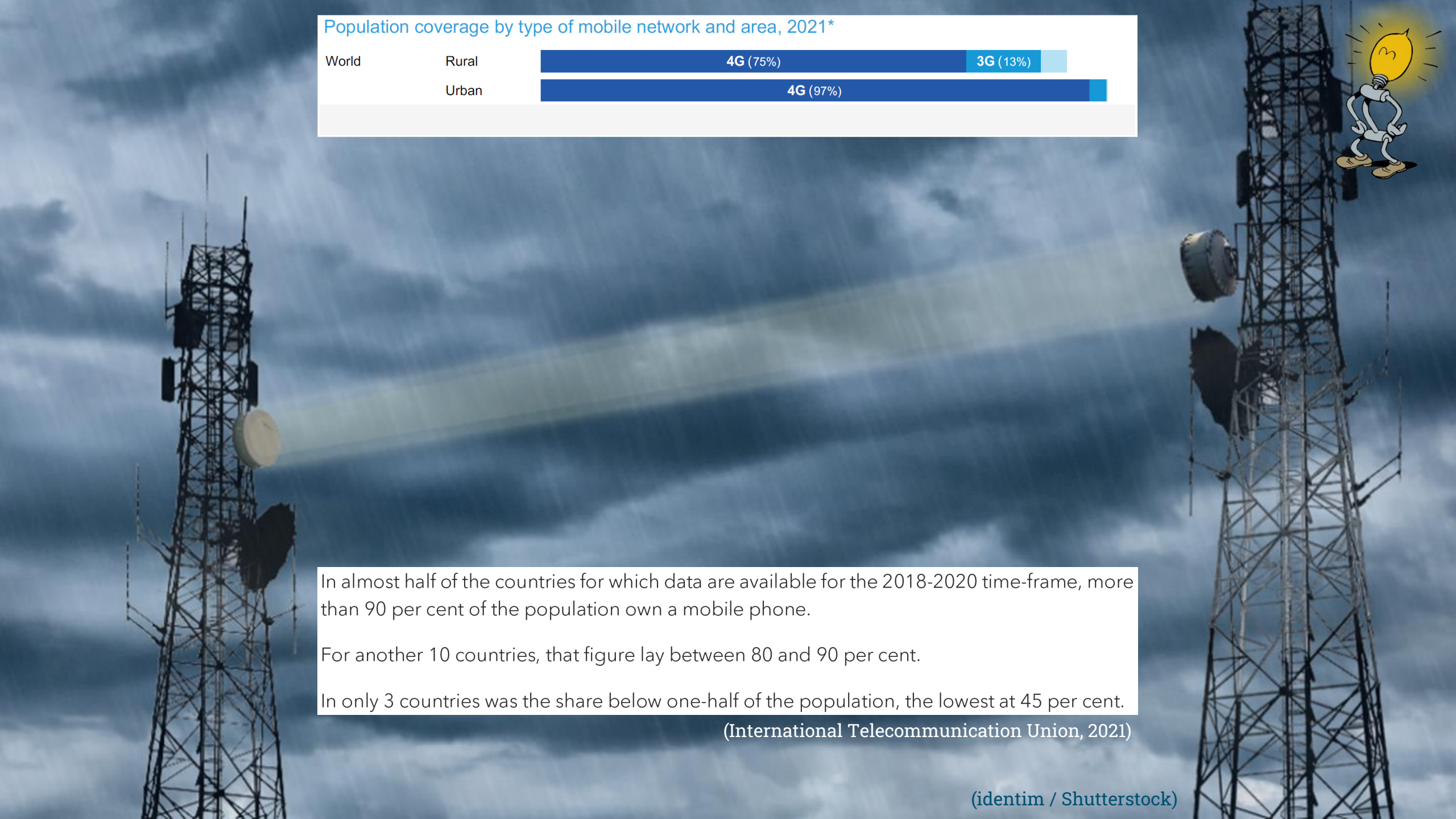

In almost half of the countries for which data are available for the 2018-2020 time-frame, more than 90 per cent of the population own a mobile phone.

For another 10 countries, that figure lay between 80 and 90 per cent.

In only 3 countries was the share below one-half of the population, the lowest at 45 per cent.

(International Telecommunication Union, 2021)

(identim / Shutterstock)

How to reduce Africa's undue exposure to climate risks

Africa is disproportionately exposed to catastrophic climate, hydrological and meteorological risks. Well-funded weather monitoring, nowcasting and early-warning systems must become a priority. (Tzachor et al., 2023, Nature)

(Photo AFP / HO / UN World Food Programme)

People in Africa, South Asia, South, and Central America, and small island states are **15 times more likely** to die from climate disasters. These deaths are preventable.

Early Warnings for All

WMO

Trans-African Hydrometeorological Observatory (TAHMO)

(Van de Giesen et al., 2014)

(~600 stations deployed)

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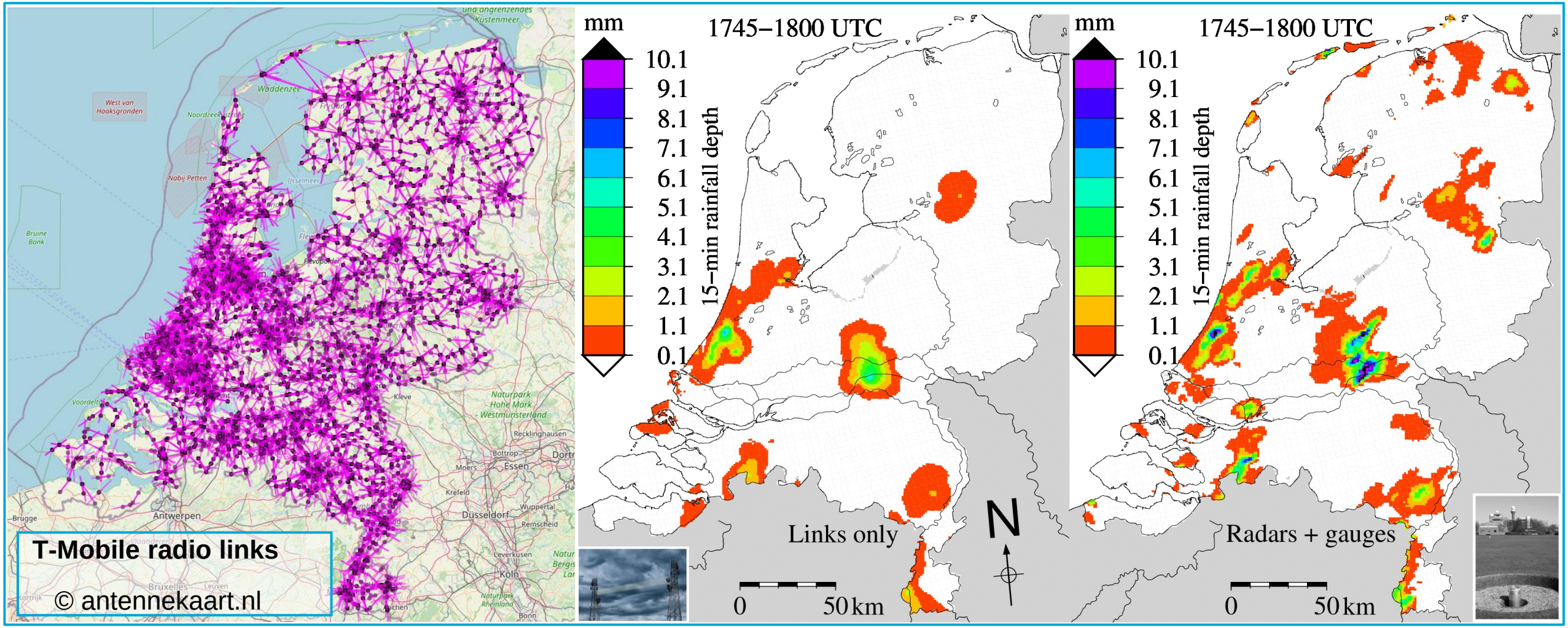
Microwave links as opportunistic rain gauges



(Overeem et al., 2013, in collaboration with T-Mobile NL; currently Odido)

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Comparable results for Israel, Sweden, Germany, Czech Republic, France…

NewScientist

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Health Space Physics Technology Environment Mind Humans Life Mathematics Chemistry Earth Society

Earth

Cellular signals used to make national rainfall map

By Hal Hodson

5 February 2013

The Economist

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Counting raindrops

How to use mobile-phone networks for weather forecasting

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Le Monde

PLANÈTE

Mesurer les précipitations grâce aux réseaux de téléphones mobiles

Des chercheurs ont démontré que les variations de signal entre les antennes relais donnent une image précise de l'intensité et des déplacements des pluies.

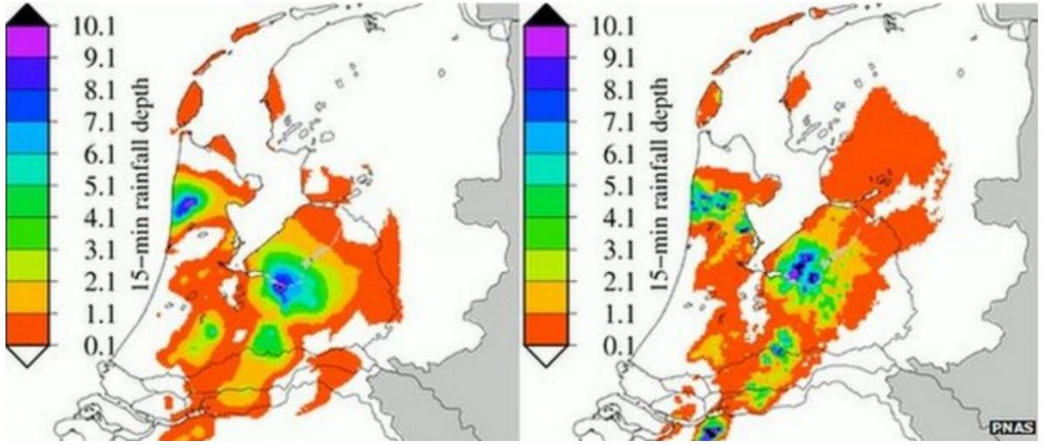
Par Grégoire Allix

Publié le 05 février 2013 à 11h49, modifié le 05 février 2013 à 11h49 · Lecture 2 min.

BBC NEWS

Rain tracked with mobile network

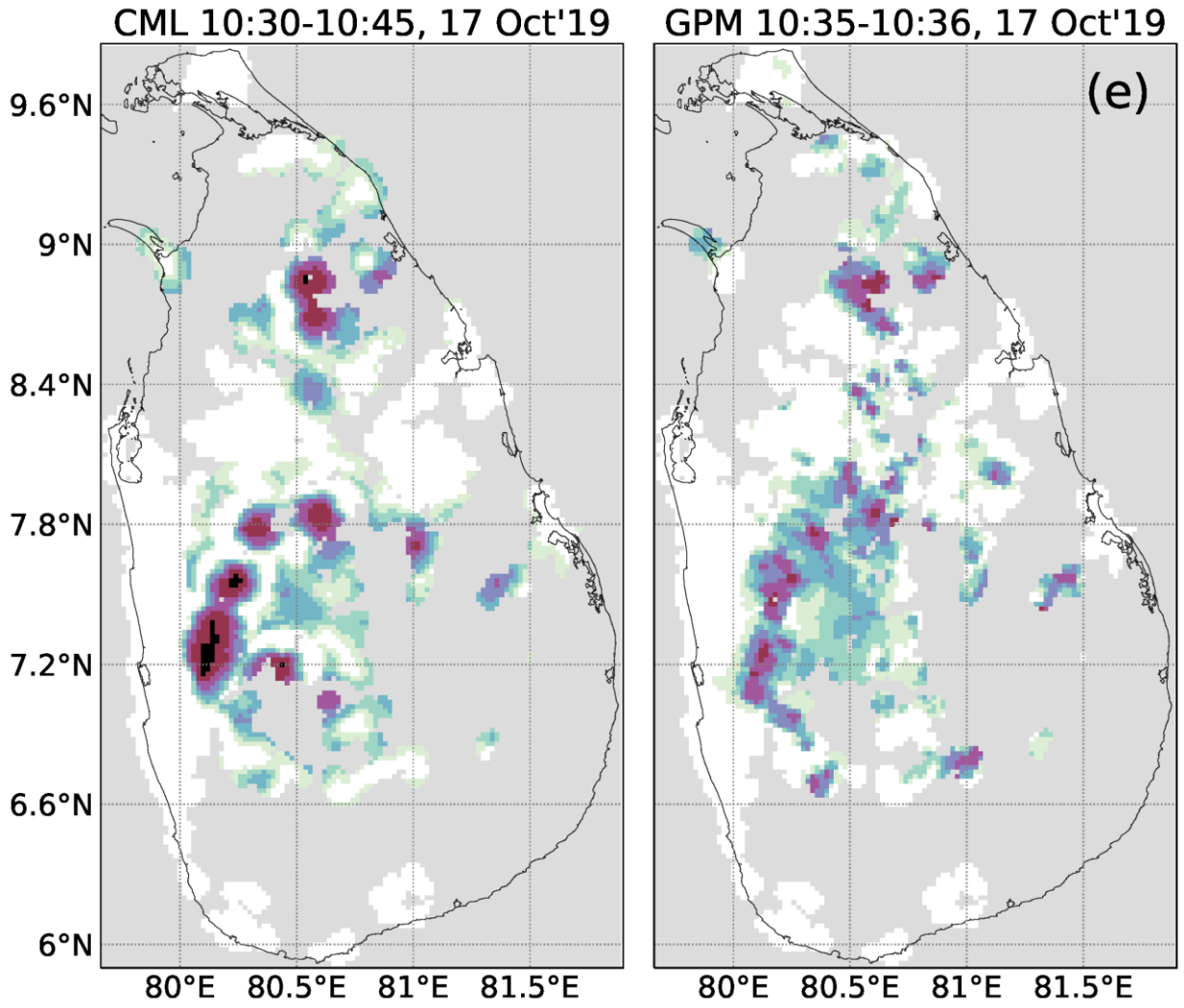
4 February 2013



The mobile network data (left) were shown to be nearly as informative as radar and rain gauges (right)

A way to measure rainfall using mobile phone network signals has been put into practice across a whole country.

Rainfall maps for Sri Lanka from links and satellite



(Overeem et al., 2021, in collaboration with GSMA and Dialog)

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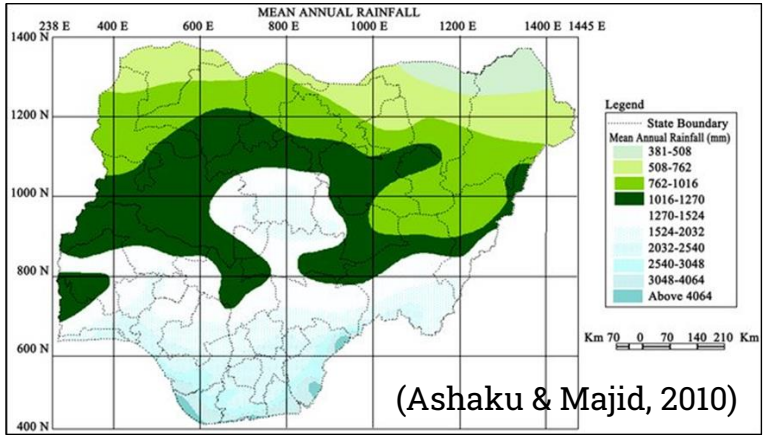
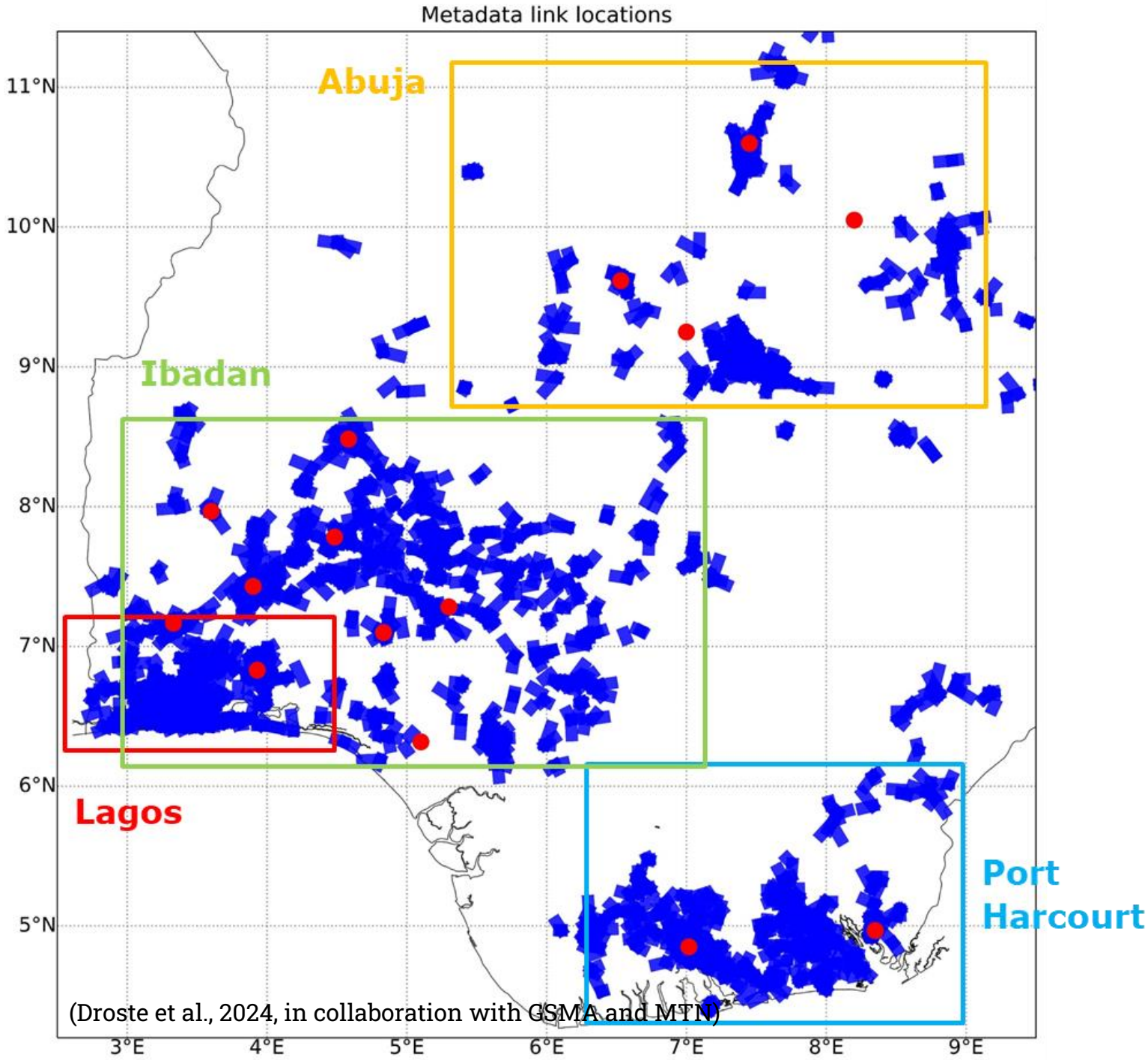
Nigeria link network

- ~12,000 link paths (MTN Nigeria)
- Apr–Oct 2020
- NiMet: 12 gauges, hourly data
- Strong N-S rainfall gradient

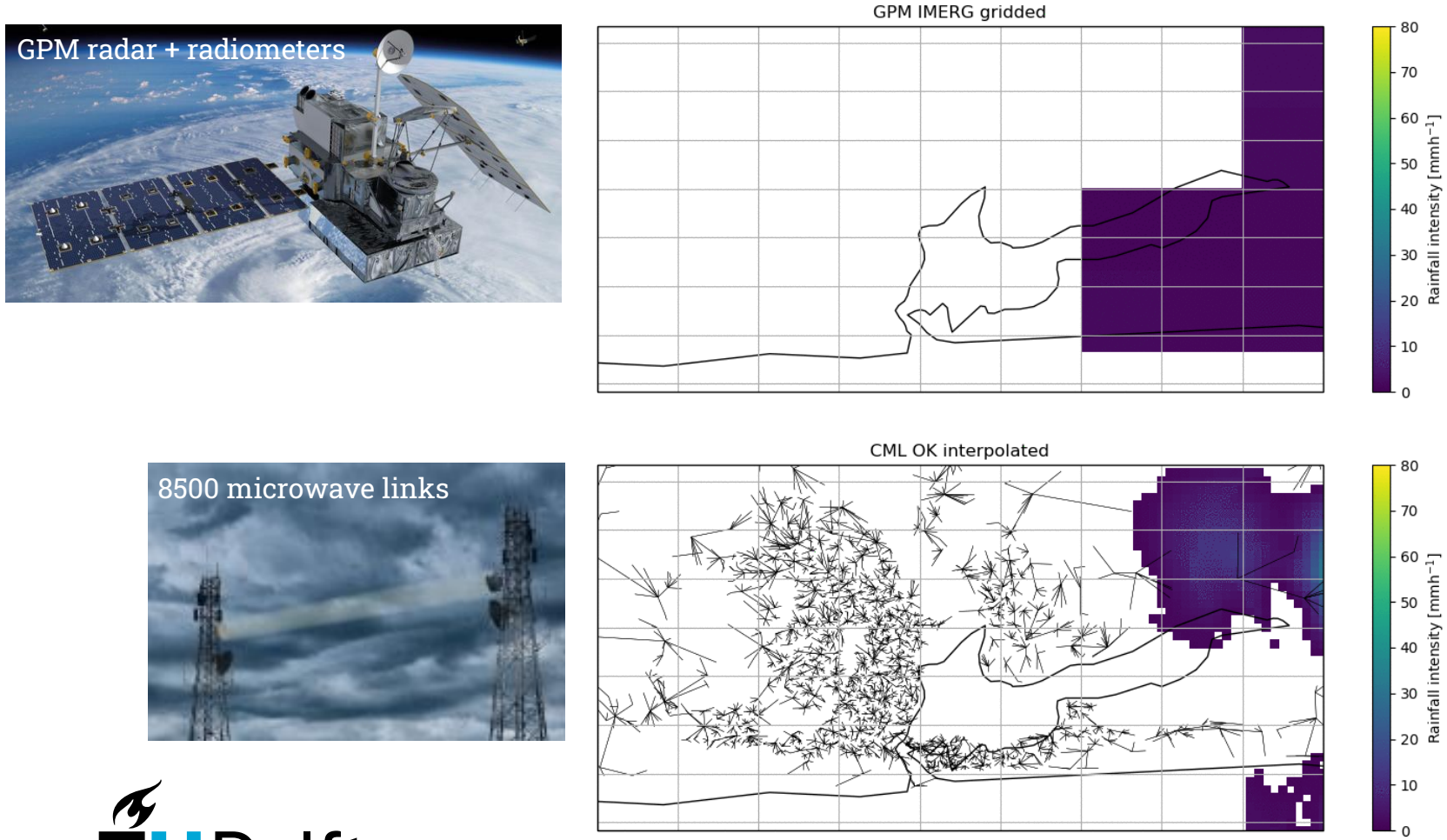


(Ashaku & Majid, 2010)



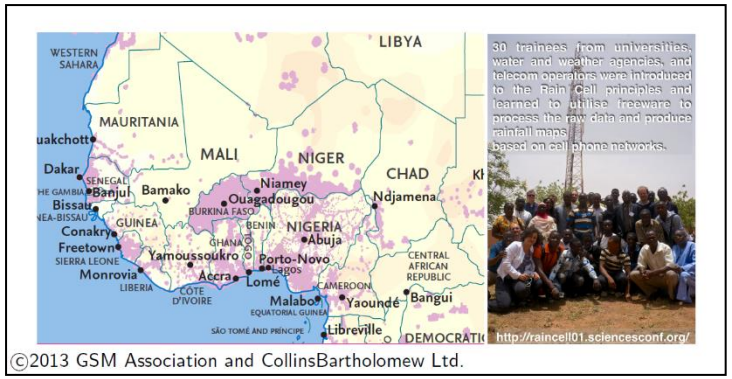
(Droste et al., 2024, in collaboration with GSMA and MTN)

Rainfall maps for Lagos (Nigeria) from links and satellite



(Van Leth et al., 2019, in collaboration with GSMA and MTN)

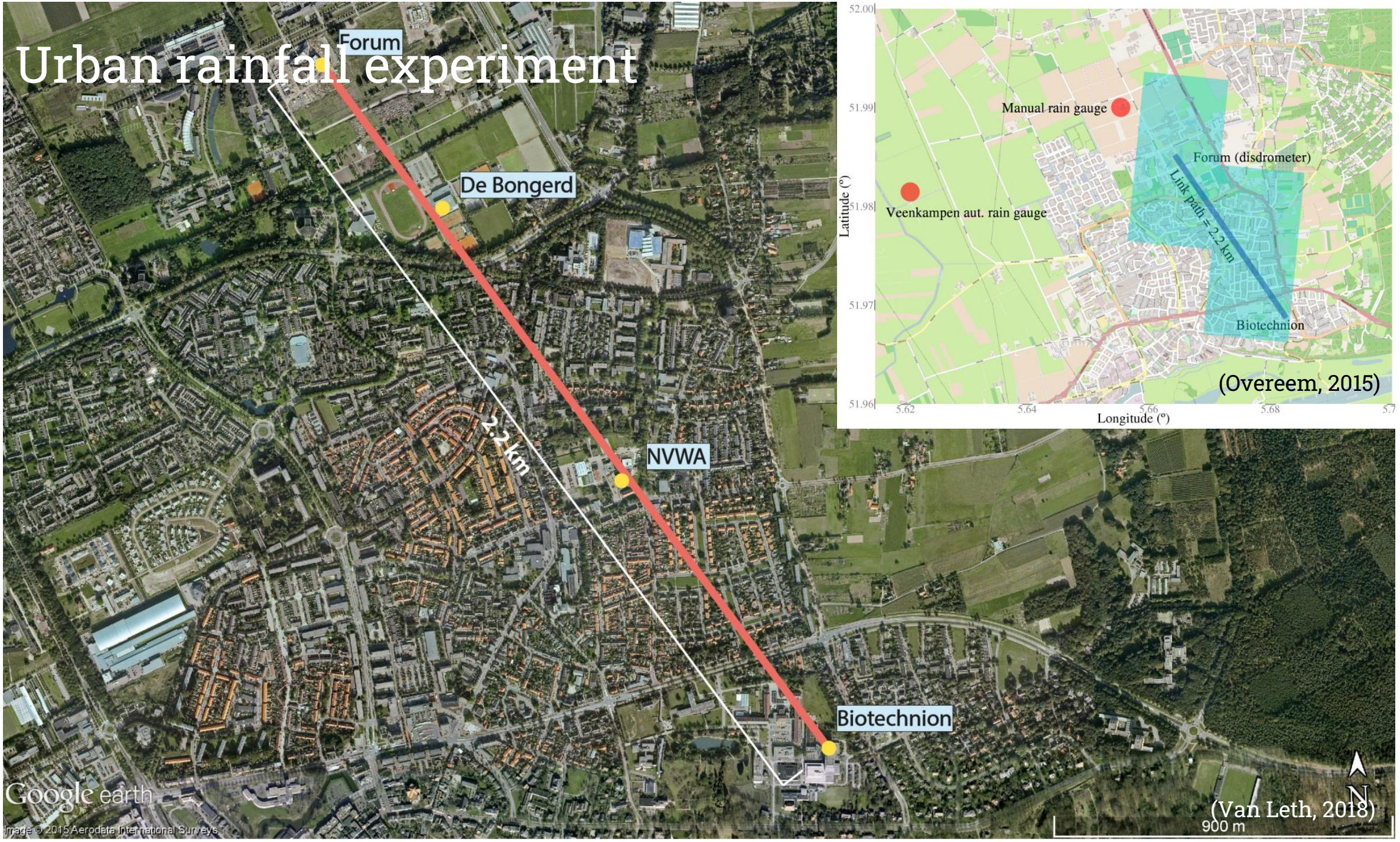
Raincell Africa Training School – Burkina Faso, 2015

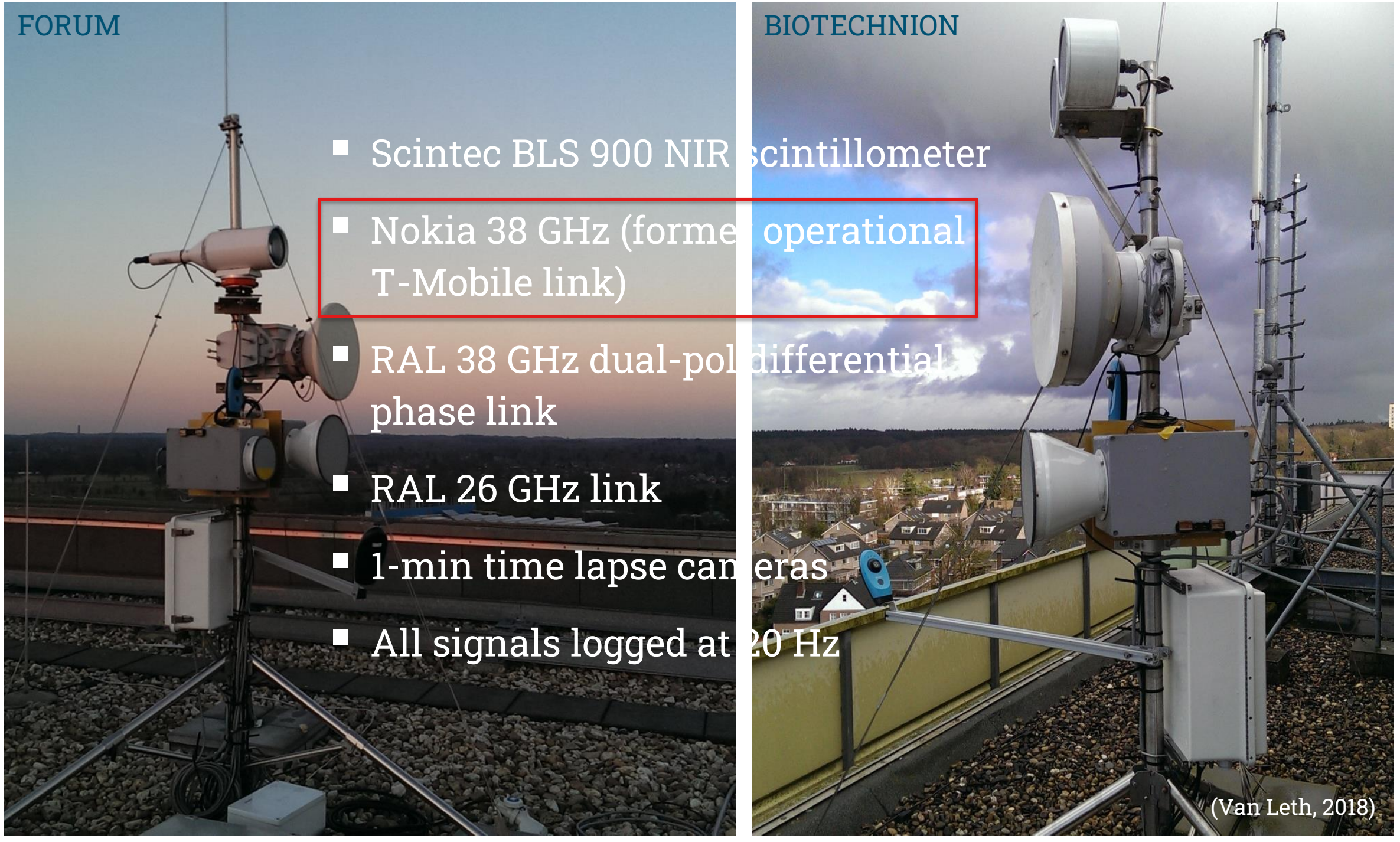


(Gosset et al., 2016)

Comparable results for Cameroon, Kenya, Burkina Faso (, Ghana, Rwanda, ...)

Urban rainfall experiment




FORUM
BIOTECHNION
Scintec BLS 900 NIR scintillometer
Nokia 38 GHz (former operational T-Mobile link)
RAL 38 GHz dual-pol differential phase link
RAL 26 GHz link
1-min time lapse cameras
All signals logged at 20 Hz
(Van Leth, 2018)

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(courtesy of A. Berne, EPFL)


GSMA
Enabling climate services through mobile network operator data
Opportunities for CML rainfall data to strengthen rural climate resilience
(GSMA, 2023)

ITUEvents

Second round table on advancing the Global Microwave Link Data Collection Initiative (GMDI)

21 May 2025
Geneva, Switzerland

itu.int/go/GMDI

Co-Organized by:

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ITU

International Conference on Opportunistic Sensing of Precipitation - OpenSense

Jun 25 – 26, 2025
German Weather Service, Offenbach, Germany
Europe/Berlin timezone

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https://opensenseaction.eu/

Related presentations at EGU 25

EGU25-4159 | **ECS** | Orals | HS10.11

Can we estimate evaporation using commercial microwave links?

Luuk van der Valk, Oscar Hartogensis, Miriam Coenders-Gerrits, Rolf Hut, Bas Walraven, and Remko Uijlenhoet

Fri, 02 May, 11:30–11:40 (CEST) Room 2.44

EGU25-10932 | **ECS** | Posters on site | NH1.2

Insights from personal weather stations in the rainfall dynamics preceding and during the 29 October 2024 Valencia floods

Nathalie Rombeek, Markus Hrachowitz, Davide Wüthrich, and **Remko Uijlenhoet**

Thu, 01 May, 08:30–10:15 (CEST) Hall X3 | X3.12

EGU25-21609 | **ECS** | Orals | HS4.5

Opportunities and challenges for Rainfall Nowcasting with Commercial Microwave Links in the Tropics

Bas Walraven, Ruben Imhoff, Aart Overeem, Miriam Coenders, Rolf Hut, Luuk van der Valk, and Remko Uijlenhoet

Wed, 30 Apr, 15:15–15:25 (CEST) Room 2.15

EGU25-19444 | Orals | HS7.6 | **Highlight**

One man's noise is another man's signal - the OpenSense project

Vojtěch Bareš, Christian Chwala, Martin Fencl, Hagit Messer, Jonathan Ostrometzky, Remko Uijlenhoet, Aart Overeem, Remco van de Beek, Jonas Olsson, Maxmilian Graf, Tanja Winterrath, Soeren Thorndahl, Jochen Seidel, Roberto Nebuloni, and Natalia Hanna

Wed, 30 Apr, 10:50–11:10 (CEST) Room 2.15

EGU25-15697 | **ECS** | PICO | HS7.1

Rain scintillation spectra from microwave links: A potential source of information for raindrop size distributions

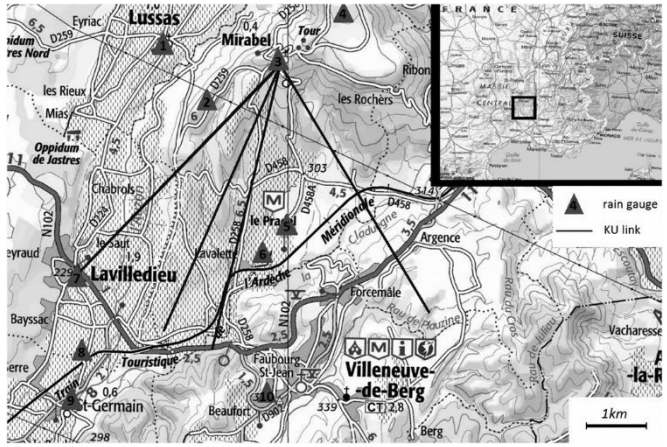
Peiyuan Wang, Arjan Droste, Marc Schleiss, and Remko Uijlenhoet

Tue, 29 Apr, 10:54–10:56 (CEST) PICO spot 4 | PICO4.3

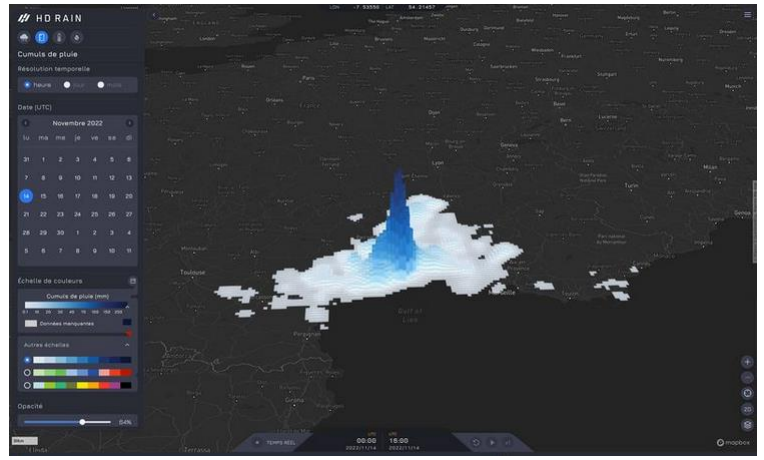
Other environmental variables: fog, smoke, evaporation, …

(Identim / Shutterstock)

Rainfall fields from broadcast TV satellite links



(Mercier et al., 2015)



(hd-rain.com)

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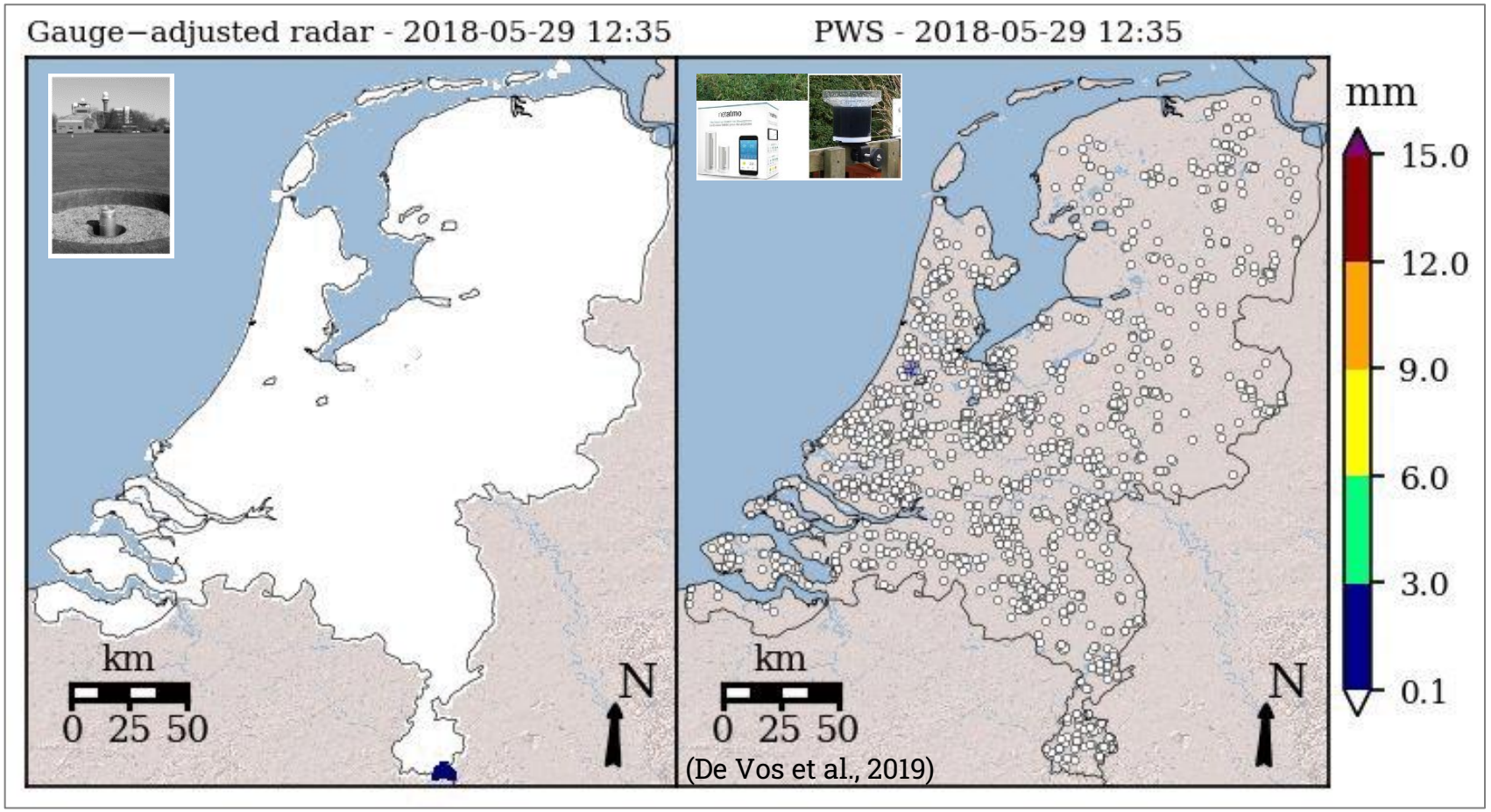
Citizen science: personal weather stations



(several 100,000 globally)

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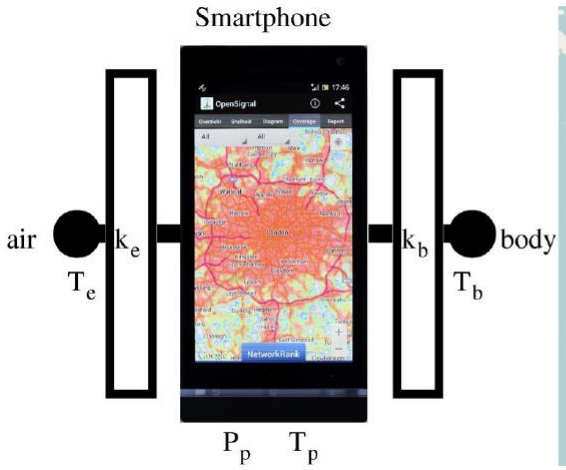
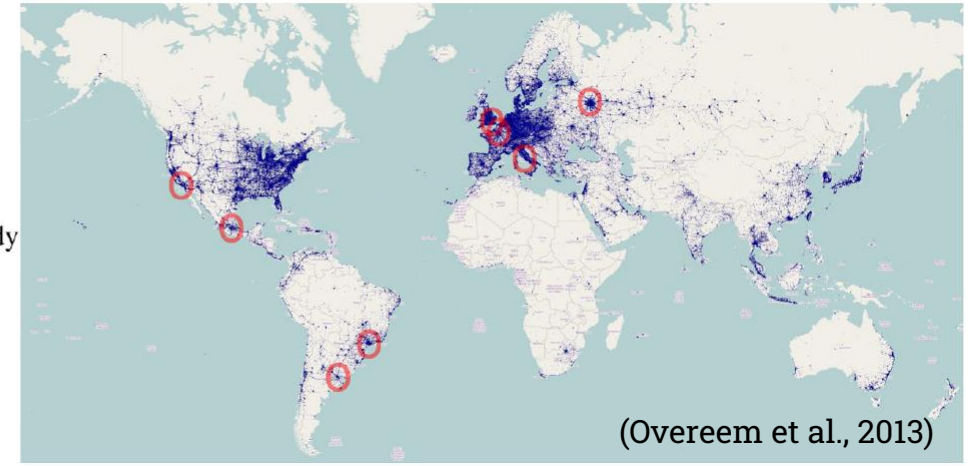
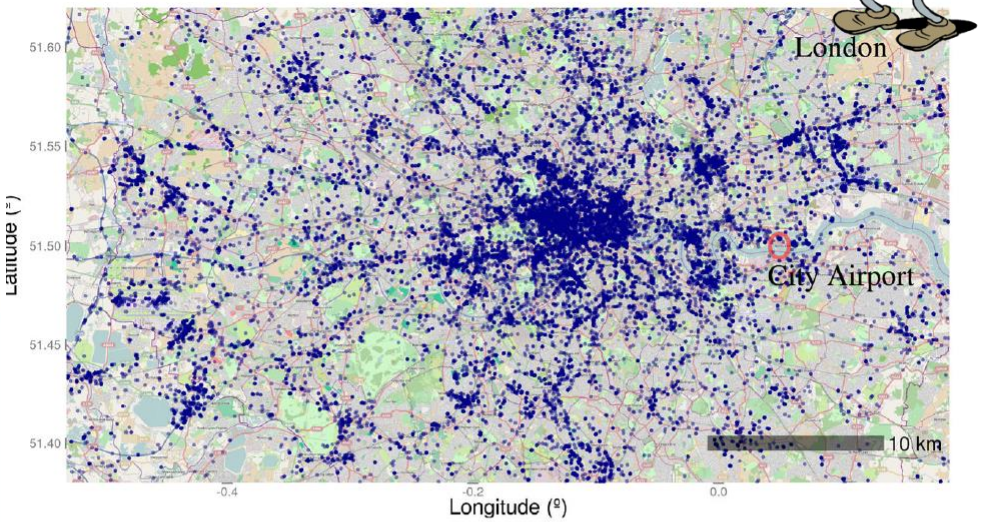
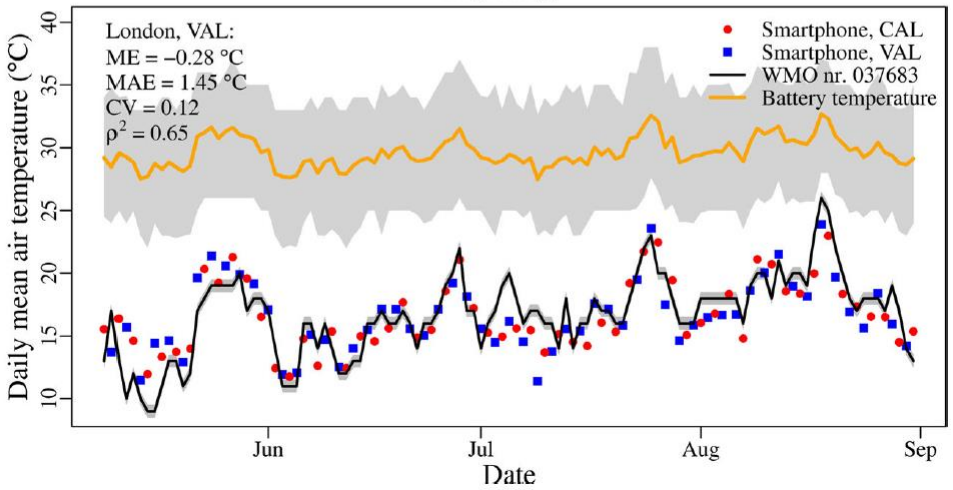
Smartphones as opportunistic downtown thermometers









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(+ Mobile Network Operators and their staff on the ground)

Hydrometeorological Monitoring using Microwave Links from Cellular Communication Networks: Opportunities and Challenges

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