TV White Space and ICT4D

Marco Zennaro and
Ermanno Pietrosemoli
Telecommunication/ICT4D Lab
The Abdus Salam International Centre
for Theoretical Physics

What is the ICTP

The Abdus Salam International Centre for Theoretical Physics was founded in 1964, by the late Nobel Laureate Abdus Salam

ICTP is administered by UNESCO and the International Atomic Energy Agency (IAEA)

The Centre is located in Trieste, Italy

What is the ICTP

ICTP is an institution that is run by scientists for scientists to support the best science possible, with special attention to the needs of scientists from Developing Countries
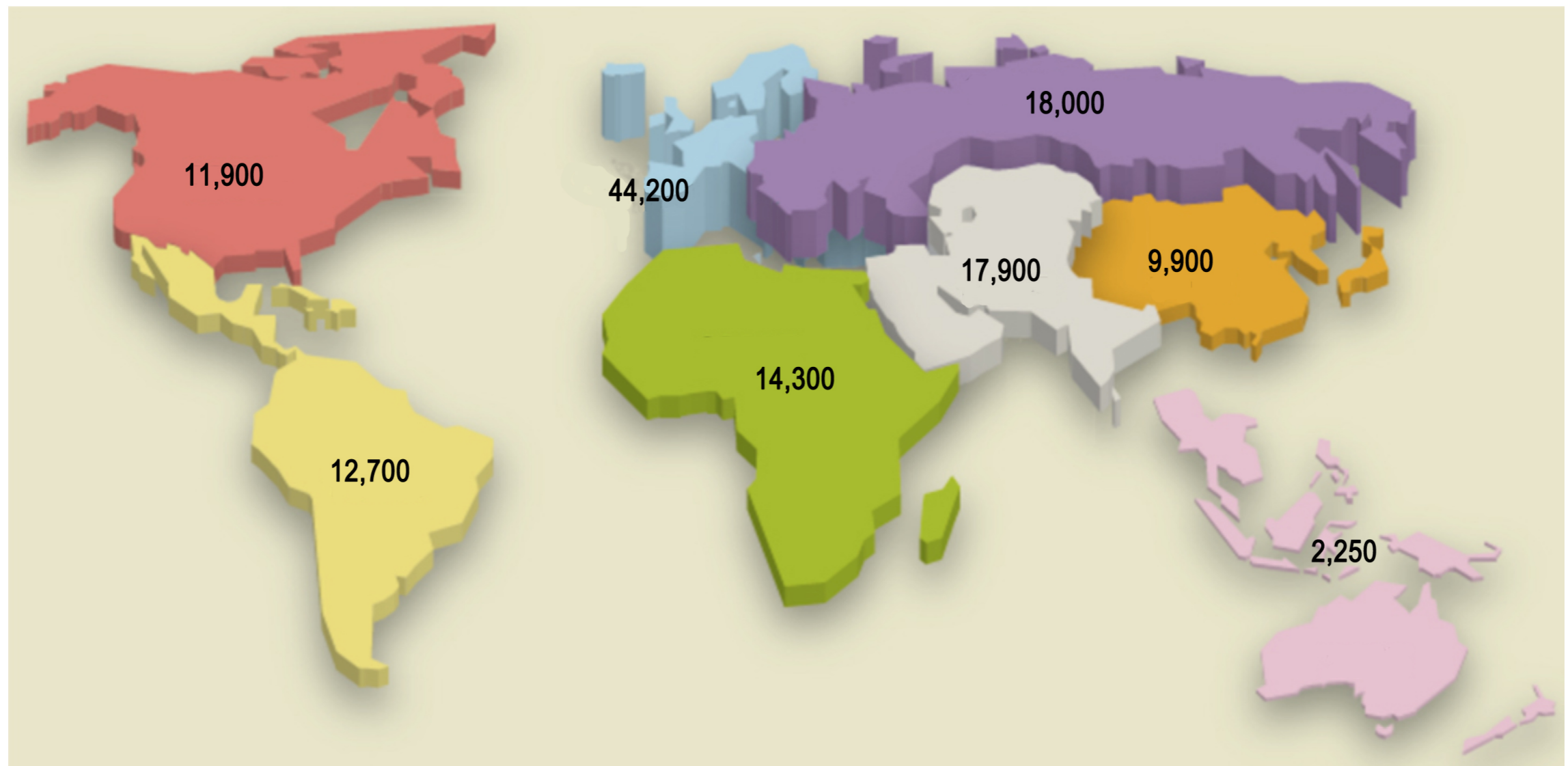
"Scientific thought is the common heritage of mankind"
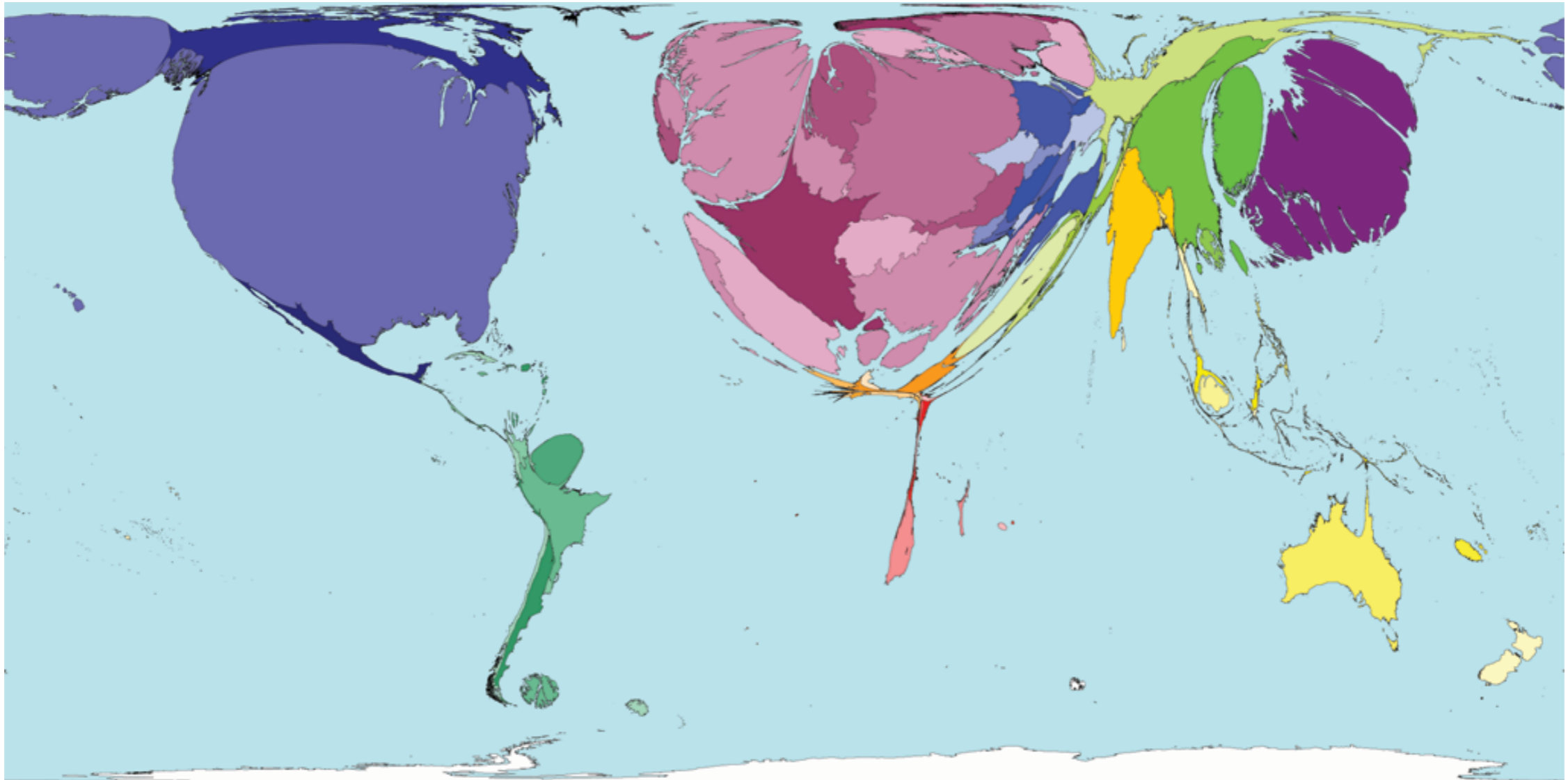
Abdus Salam

Visiting scientists

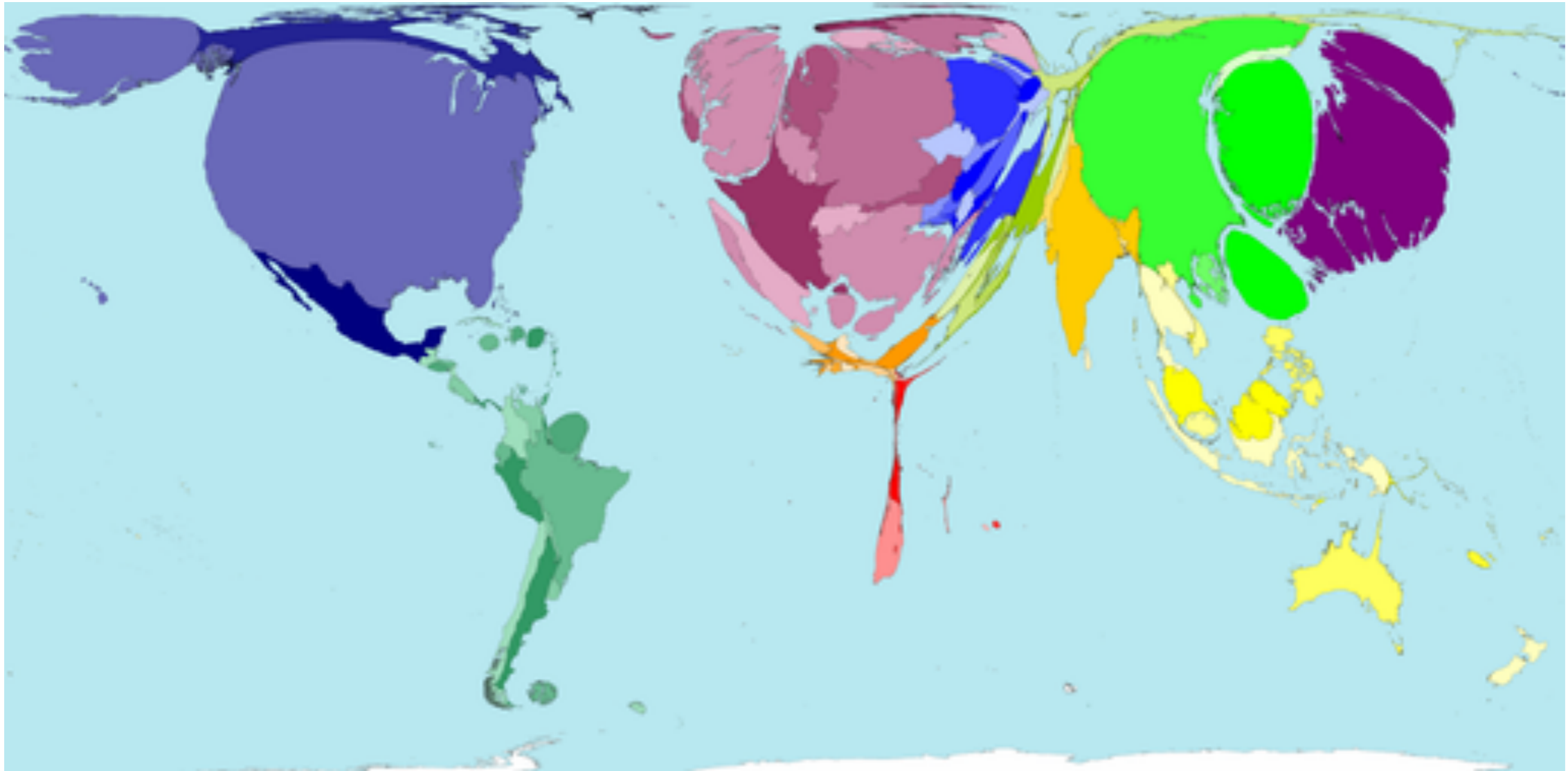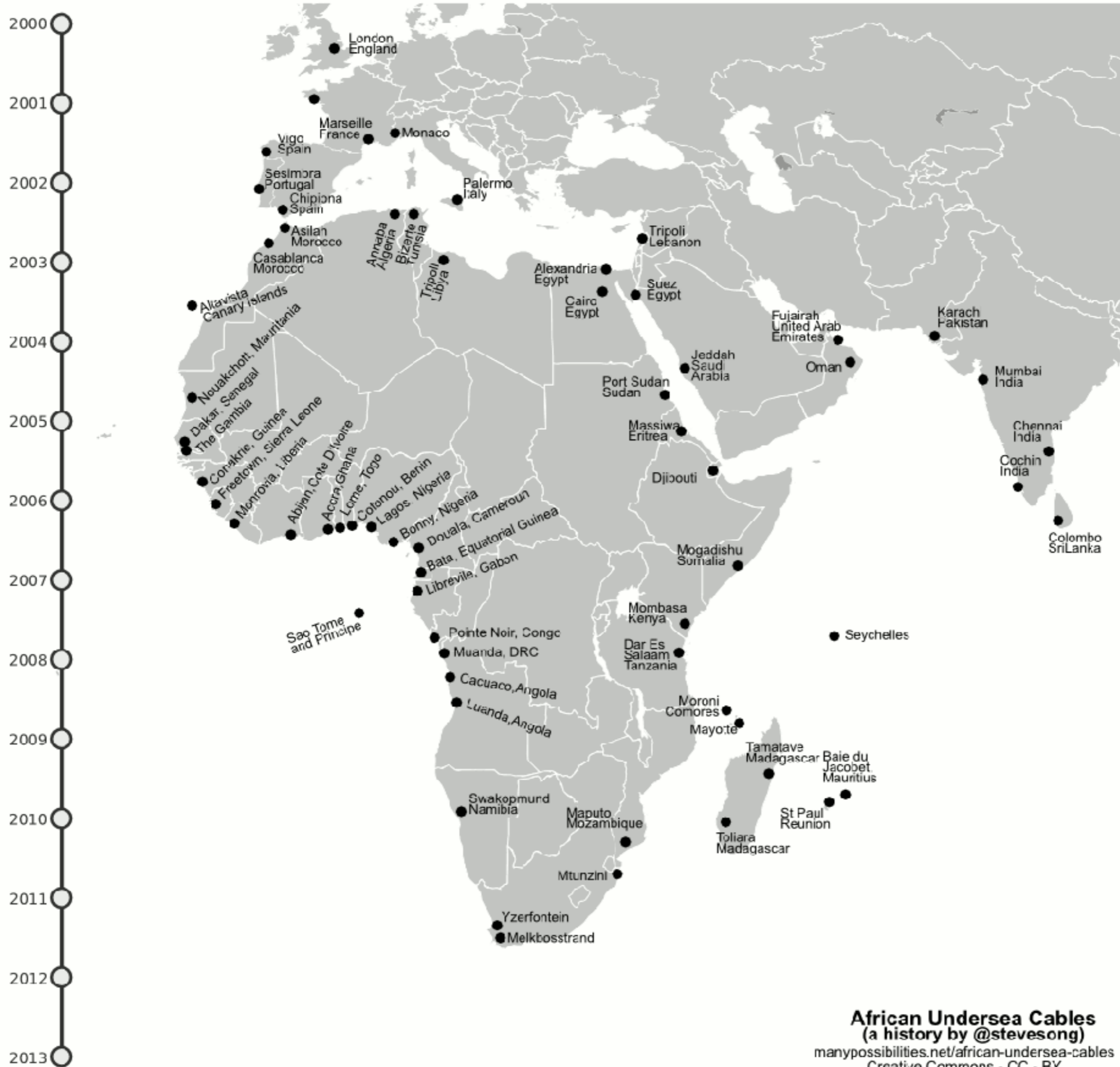More than 120'000 visits from 188 countries, 20% of visitors are women

Why ICT at ICTP

Scientific publications

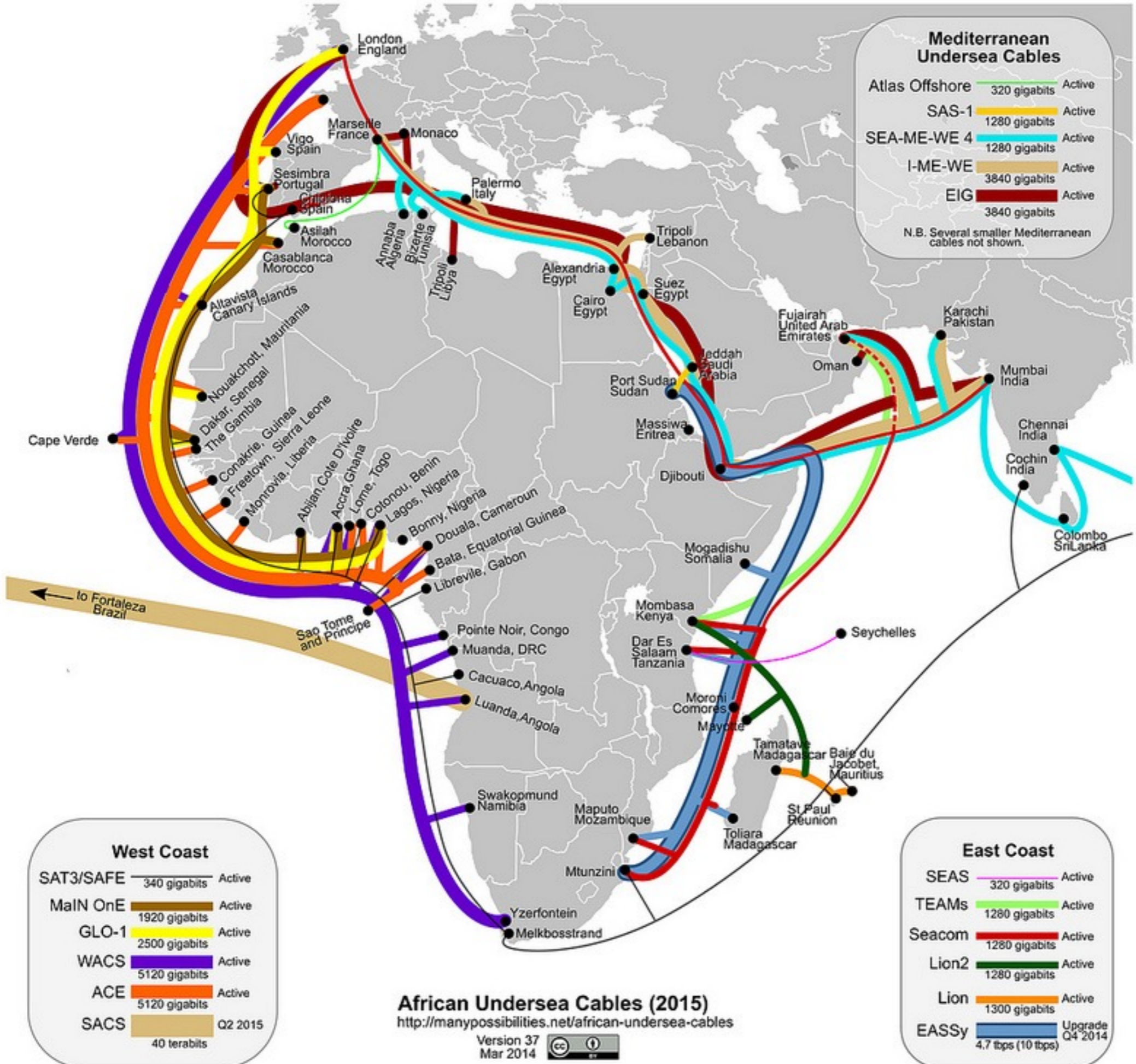# Why ICT at ICTP

Internet connectivity

2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013

London
England

Marseille
France

Monaco

Vigo
Spain

Sesimbra
Portugal

Palermo
Italy

Chipiona
Spain

Asilah
Morocco

Annaba
Algeria

Bizerte
Tunisia

Tripoli
Lebanon

Casablanca
Morocco

Tripoli
Libya

Alexandria
Egypt

Altavista
Canary Islands

Cairo
Egypt

Suez
Egypt

Fujairah
United Arab
Emirates

Karachi
Pakistan

Nouakchott, Mauritania

Port Sudan
Sudan

Jeddah
Saudi
Arabia

Oman

Mumbai
India

Dakar, Senegal

The Gambia

Massiwa
Eritrea

Chennai
India

Conakrie, Guinea

Freetown, Sierra Leone

Djibouti

Cochin
India

Monrovia, Liberia

Abijan, Cote D'ivoire

Accra, Ghana

Lome, Togo

Cotonou, Benin

Lagos, Nigeria

Colombo
SriLanka

Bonny, Nigeria

Douala, Cameroun

Bata, Equatorial Guinea

Mogadishu
Somalia

Libreville, Gabon

Sao Tome
and Principe

Mombasa
Kenya

Seychelles

Pointe Noir, Congo

Muanda, DRC

Dar Es
Salaam
Tanzania

Cacuaco,Angola

Luanda,Angola

Moroni
Comores

Mayotte

Tamatave
Madagascar

Baie du
Jacobet,
Mauritius

Swakopmurd
Namibia

Maputo
Mozambique

St Paul
Reunion

Toliara
Madagascar

Mtunzini

Yzerfontein

Melkbosstrand

African Undersea Cables (2015)

http://manypossibilities.net/african-undersea-cables

Version 37
Mar 2014

Mediterranean Undersea Cables

Cable	Capacity	Status
Atlas Offshore	320 gigabits	Active
SAS-1	1280 gigabits	Active
SEA-ME-WE 4	1280 gigabits	Active
I-ME-WE	3840 gigabits	Active
EIG	3840 gigabits	Active

N.B. Several smaller Mediterranean cables not shown.

West Coast

Cable	Capacity	Status
SAT3/SAFE	340 gigabits	Active
MaIN OnE	1920 gigabits	Active
GLO-1	2500 gigabits	Active
WACS	5120 gigabits	Active
ACE	5120 gigabits	Active
SACS	40 terabits	Q2 2015

East Coast

Cable	Capacity	Status
SEAS	320 gigabits	Active
TEAMs	1280 gigabits	Active
Seacom	1280 gigabits	Active
Lion2	1280 gigabits	Active
Lion	1300 gigabits	Active
EASSy	4.7 tbps (10 tbps)	Upgrade Q4 2014

London England
Marseille France
Monaco
Vigo Spain
Sesimbra Portugal
Crilona Spain
Asilah Morocco
Casablanca Morocco
Altavista Canary Islands
Nouakchott, Mauritania
Dakar, Senegal
The Gambia
Conakrie, Guinea
Freetown, Sierra Leone
Monrovia, Liberia
Abidjan, Cote D'Ivoire
Accra, Ghana
Lome, Togo
Cotonou, Benin
Lagos, Nigeria
Bonny, Nigeria
Douala, Cameroun
Bata, Equatorial Guinea
Librevile, Gabon
Cape Verde
to Fortaleza Brazil
Sao Tome and Principe
Pointe Noir, Congo
Muanda, DRC
Cacuaco, Angola
Luanda, Angola
Swakopmund Namibia
Yzerfontein
Melkbosstrand
Mtunzini
Maputo Mozambique
Toliara Madagascar
Tamatave Madagascar
Baie du Jacobet, Mauritius
St Paul Reunion
Moroni Comores
Mayotte
Dar Es Salaam Tanzania
Mombasa Kenya
Seychelles
Mogadishu Somalia
Djibouti
Massiwa Eritrea
Port Sudan Sudan
Jeddah Saudi Arabia
Suez Egypt
Cairo Egypt
Alexandria Egypt
Tripoli Lebanon
Tripoli Libya
Palermo Italy
Bizerte Tunisia
Annaba Algeria
Fujairah United Arab Emirates
Oman
Karachi Pakistan
Mumbai India
Chennai India
Cochin India
Colombo SriLanka

How big is Africa

TV White Spaces

In telecommunications, white spaces refer to frequencies allocated to a broadcasting service but not used locally.

In addition to white space assigned for technical reasons, there is also unused radio spectrum which has either never been used, or is becoming free as a result of technical changes.

Spectrum Allocation Enforcement

Uruguay

Indonesia

South Africa

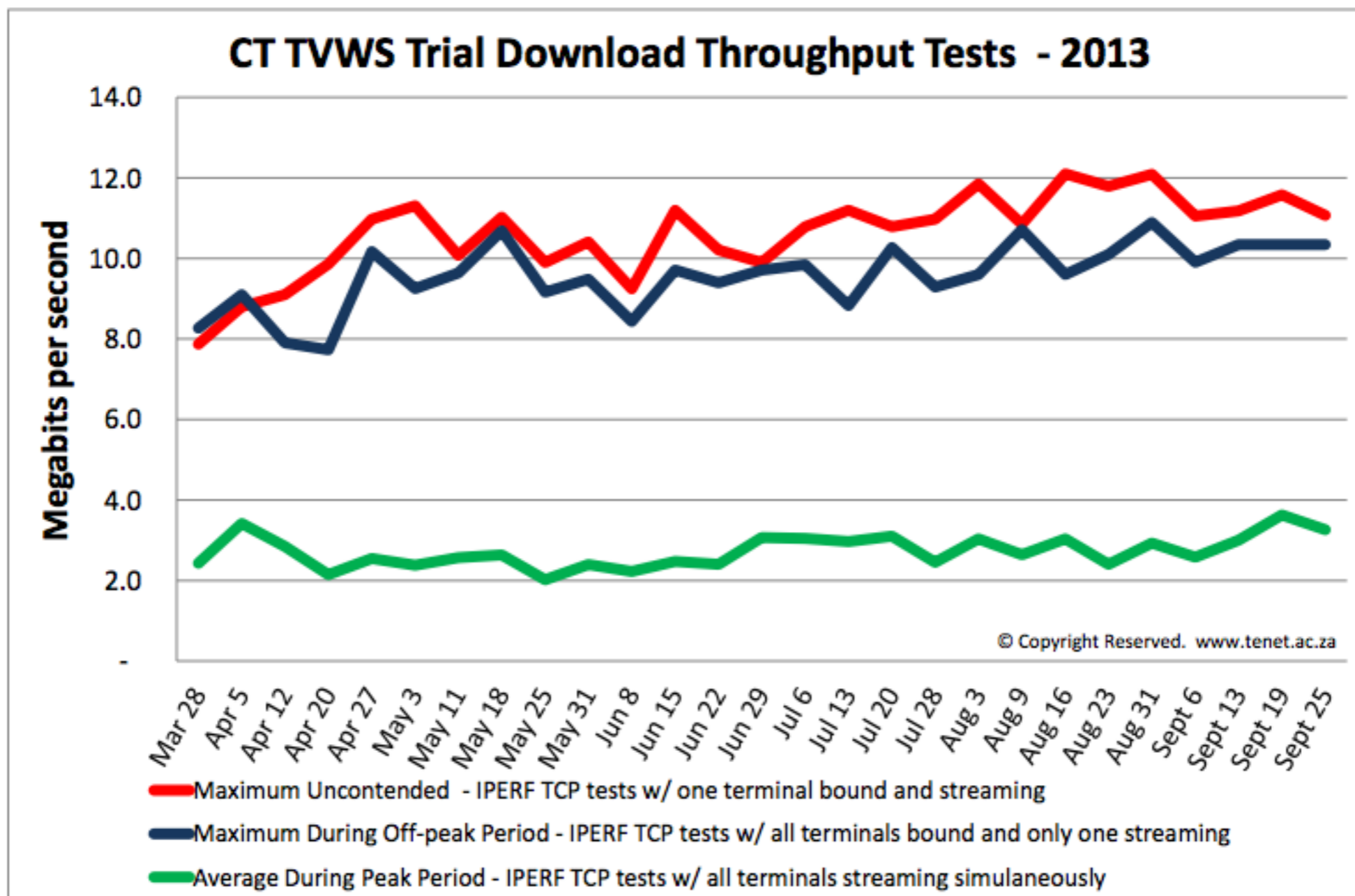**Microsoft beams Internet into Africa -- using TV 'white spaces'**

By **Teo Kermeliotis**, for CNN

September 23, 2013 -- Updated 1018 GMT (1818 HKT) | Filed under: **Innovations**

Microsoft launched its first Africa TV white spaces pilot project in Kenya last February.

South Africa

Kenya

Bringing internet to underserved communities in Kenya

See the technology in action →

Tanzania

Microsoft announces new TV white spaces project to connect students in Tanzania

8 May 2013 12:01 AM | 💬 0

Posted by **Paul Garnett**
Director, Technology Policy Group, Microsoft

Today at the World Economic Forum on Africa in Cape Town, Microsoft **announced** a new pilot project in Dar es Salaam, Tanzania. Microsoft will work in collaboration with the Tanzania Commission for Science and Technology (COSTECH) and local Internet service provider UhuruOne to provide affordable wireless broadband access to university students and faculty. The pilot will target The University of Dar es Salaam, among others, and we expect that tens of thousands of Tanzanian students and faculty members could take advantage of the integrated solutions available through the project.

Information communications technology (ICT) holds enormous potential for many aspects of development, but is particularly key to education. Use of ICT in schools and universities can increase productivity, enable individualized and peer-to-peer learning and more easily adapt to meet the needs of learners with disabilities. It is particularly critical in emerging markets as it can level the playing field, enabling access to resources, such as international research and books, which would otherwise be difficult for either students or teachers to attain. Broadband Internet is therefore becoming an

Publish or Perish

Berry's World
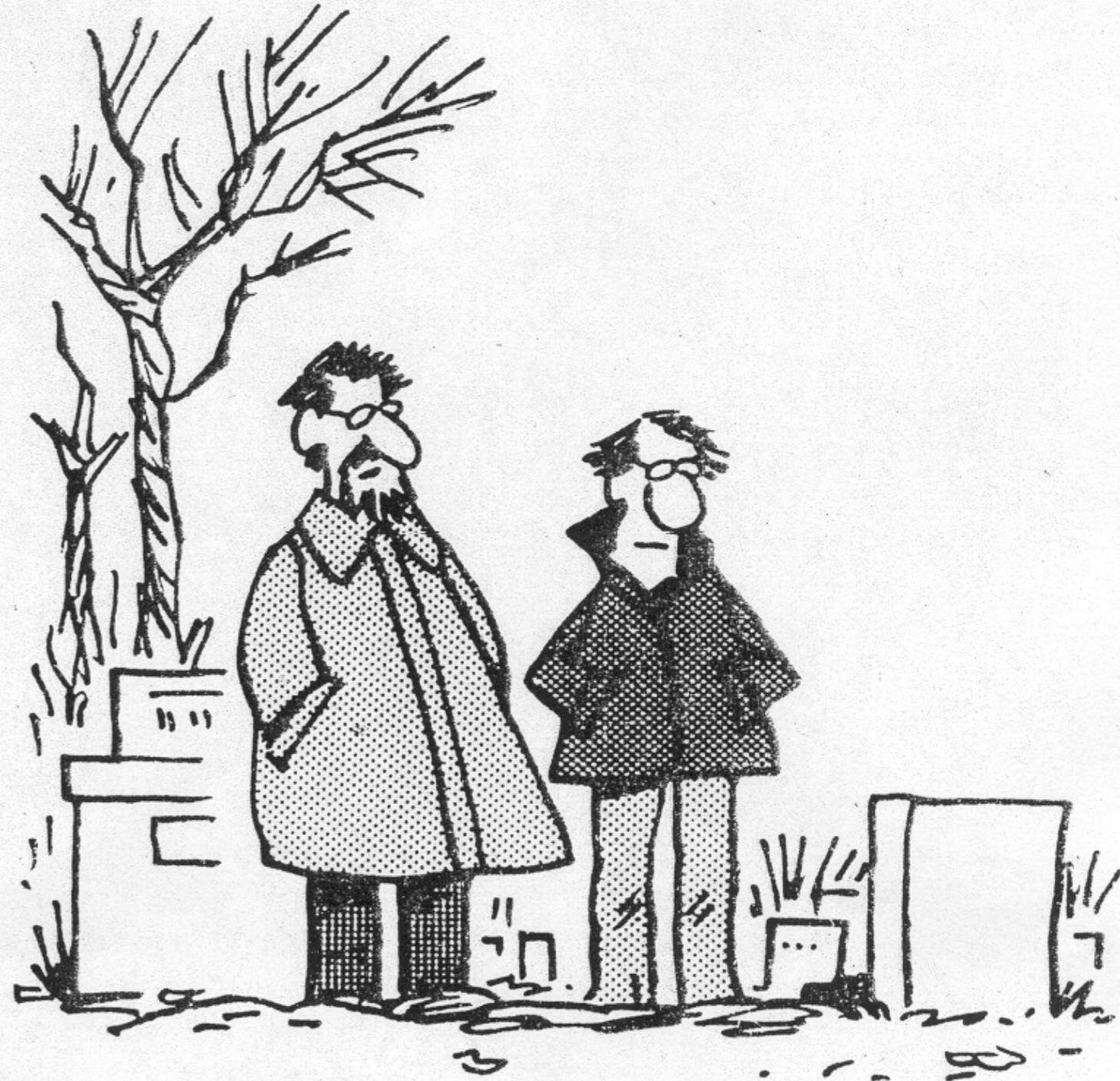
"He didn't publish, so he perished."

© 1992 by NEA, Inc.

QuantifyingTVWS

How many TVWS are there?

In cities? In rural areas?

Do they change in time?

...in developing countries

...with low cost tools

...driven by academia

Quantifying the Availability of TV White Spaces for Cognitive Radio Operation in the UK

Maziar Nekovee
BT Research, Polaris 134, Adastral Park,
Martlesham, Suffolk, IP5 3RE, UK
and
Centre for Computational Science, University College London
20 Gordon Street, London WC1H 0AJ, UK
maziar.nekovee@bt.com

June 18, 2009

Abstract

Cognitive radio is being intensively researched for opportunistic access to the so-called TV White Spaces (TVWS): large portions of the VHF/UHF TV bands which become available on a geographical basis after the digital switchover. Using accurate digital TV (DTV) coverage maps together with a database of DTV transmitters, we develop a methodology for identifying TVWS frequencies at any given
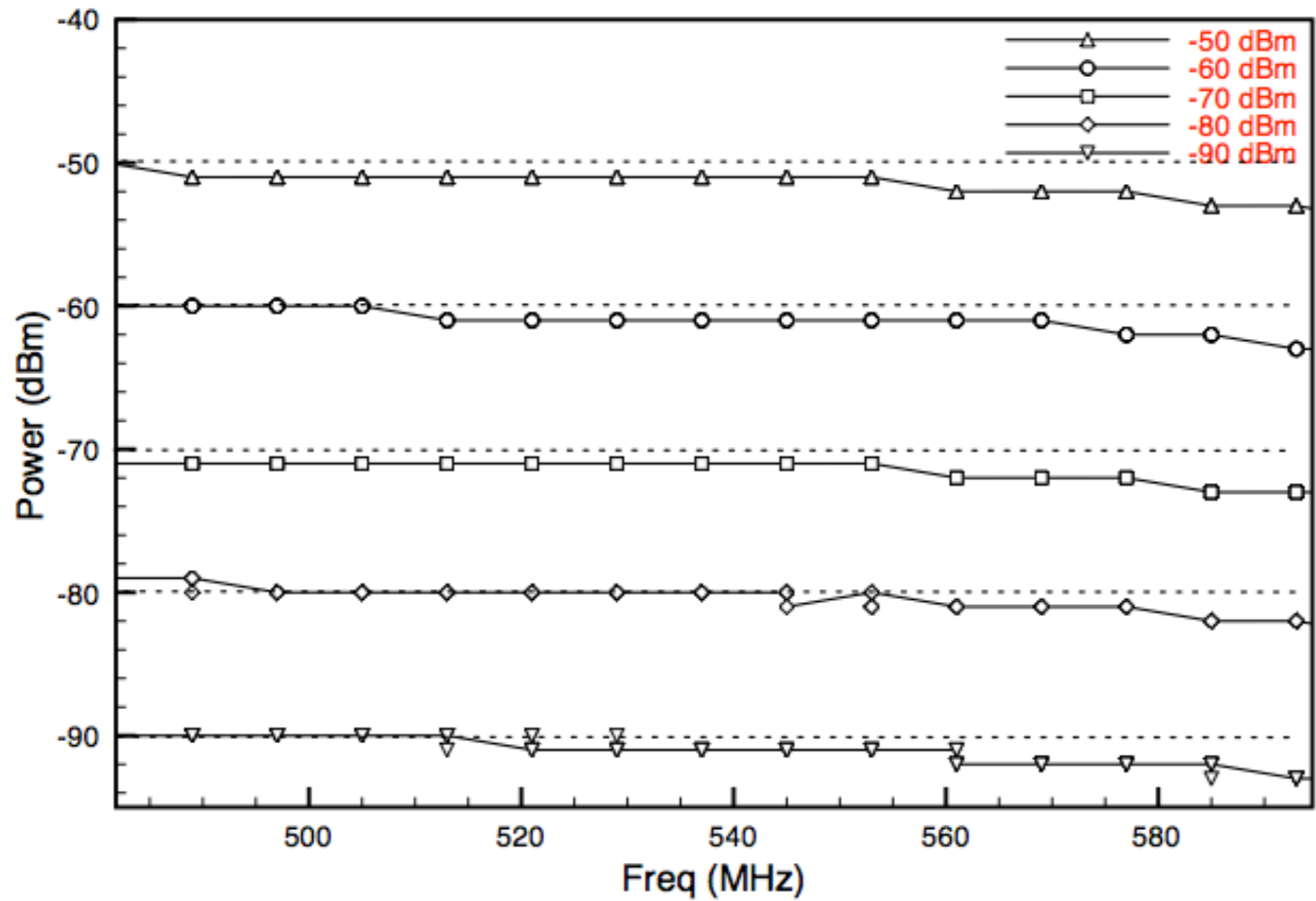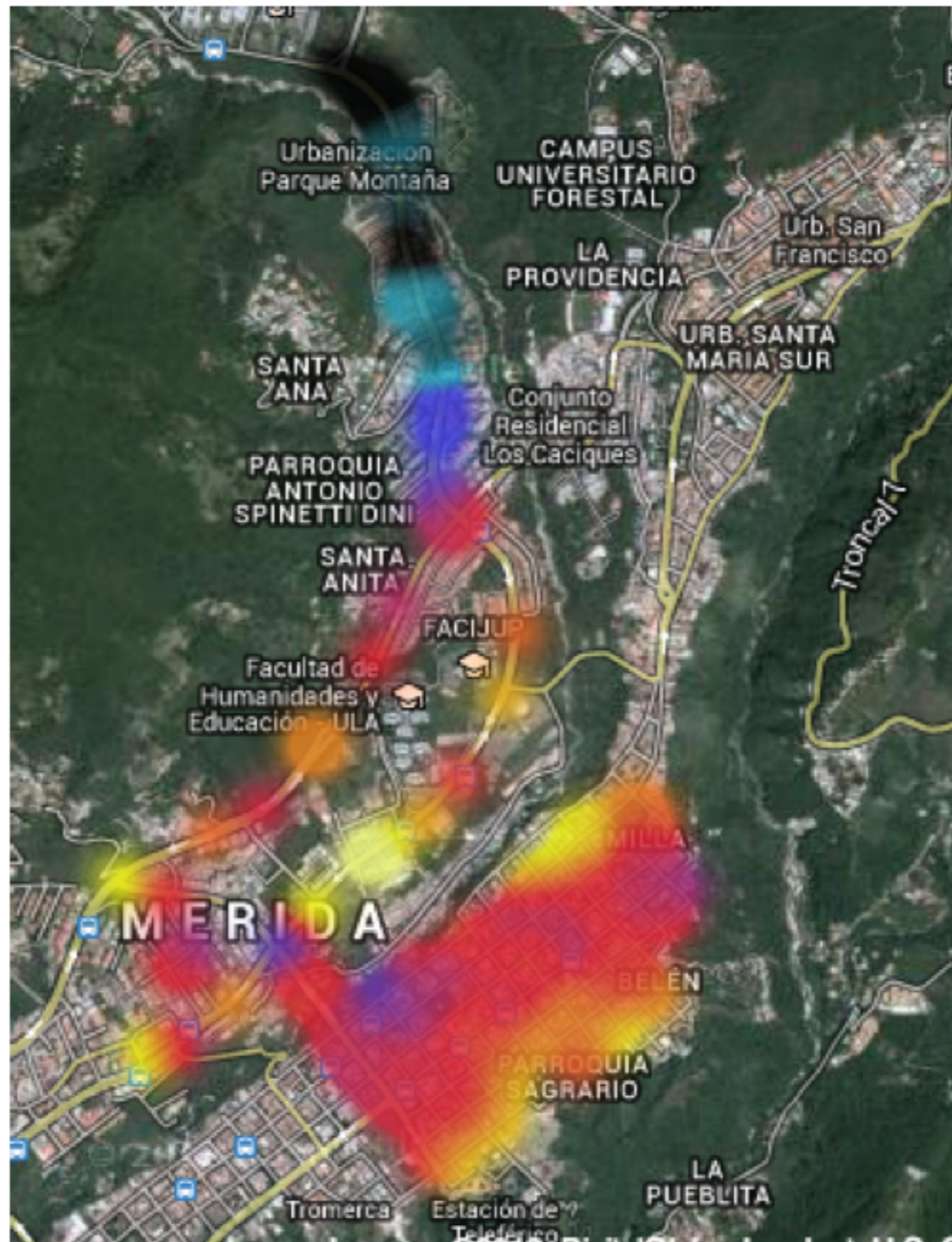
(a) Heatmap of channel 28 (554-560 MHz) in Mérida downtown.
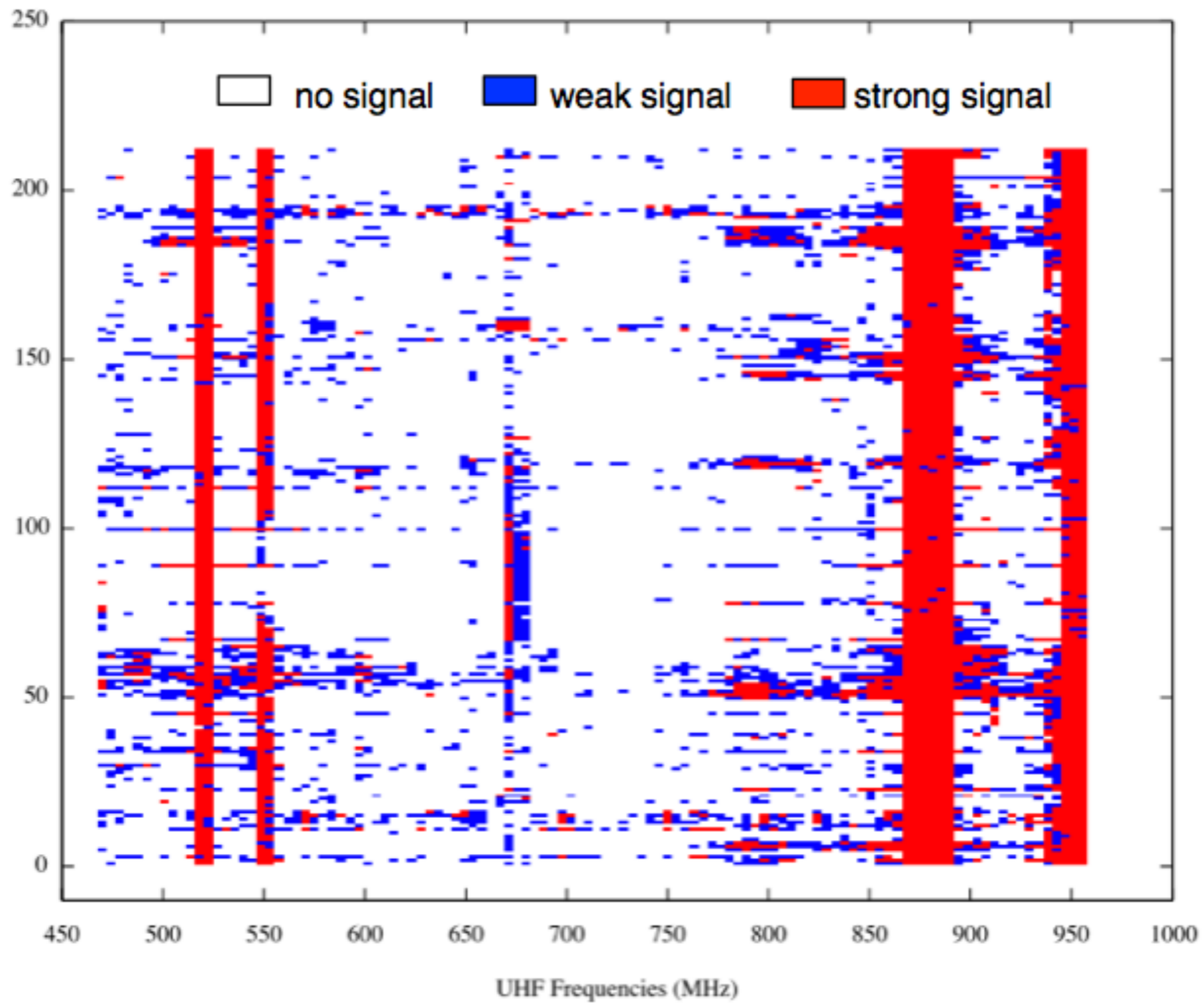
(c) Spectrum from 470 to 960 MHz in Mérida downtown.
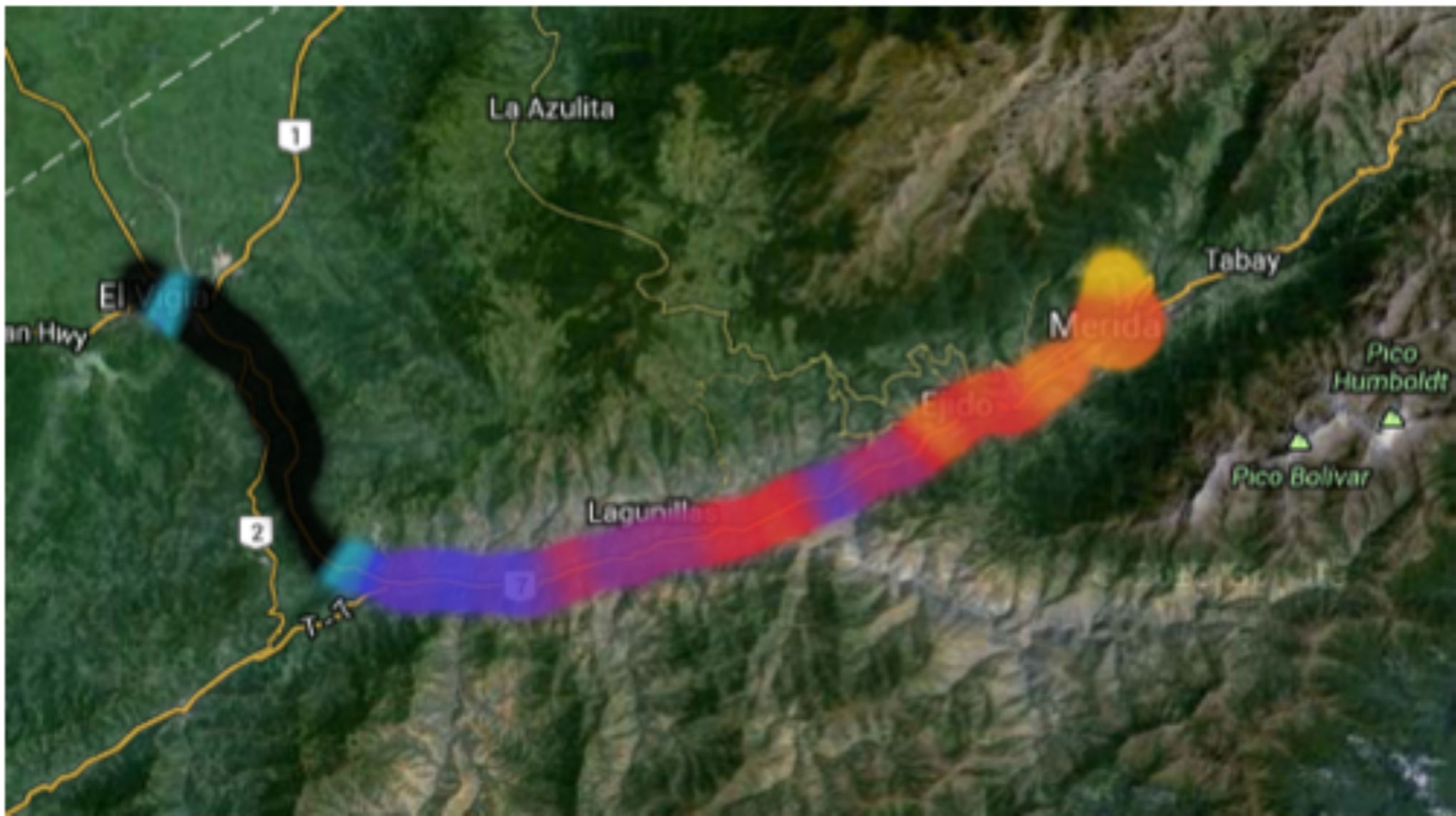
(b) Heatmap of channel 22 (518-524 MHz) in the route from Mérida to El Vigía.
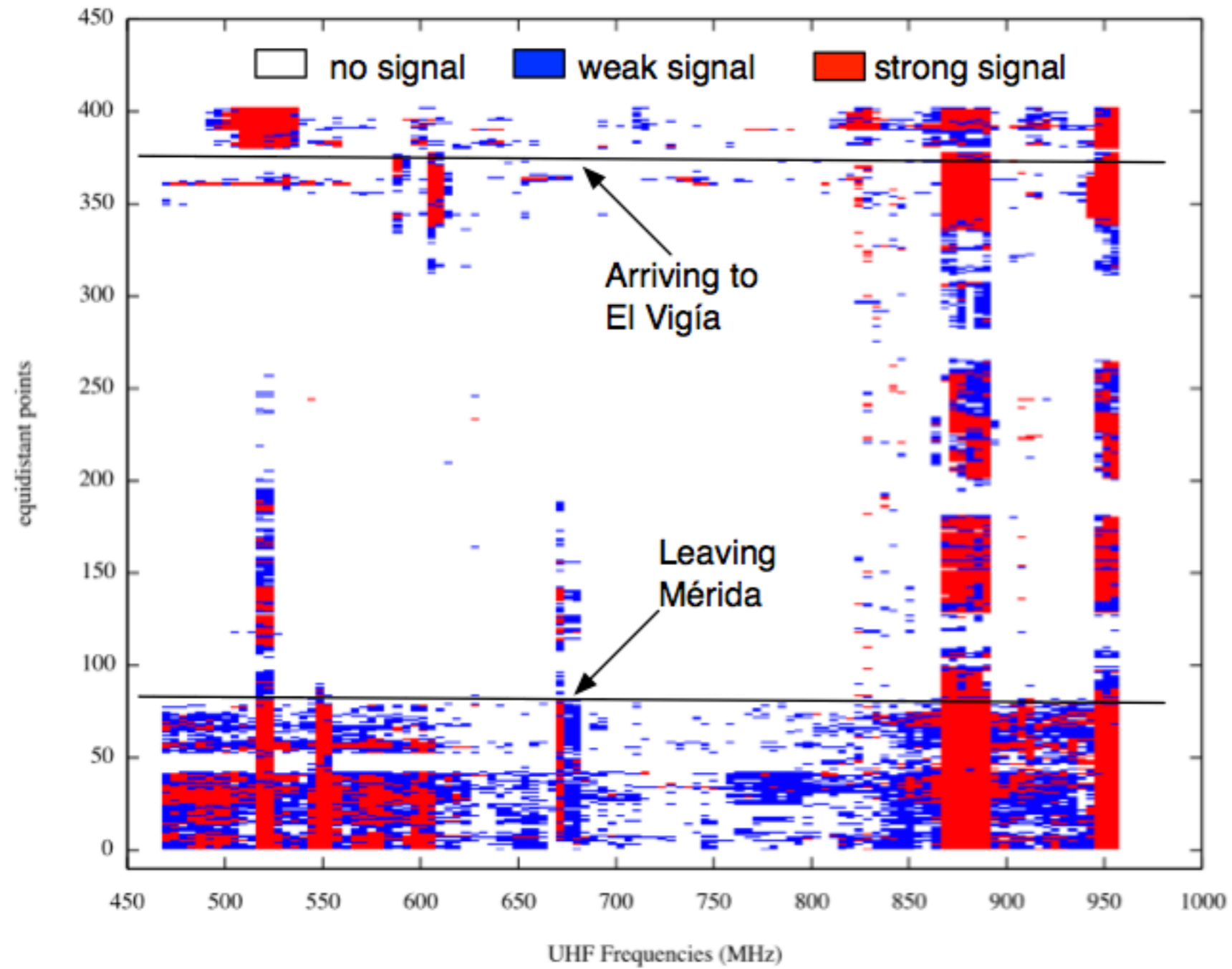
(d) Spectrum distribution from 470 to 960 MHz within the route from Mérida to El Vigía.

WhispPi:
White Space Monitoring with Raspberry Pi

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Abstract—Recently a lot of attention has been given to the use of TV White Spaces for rural communications. Several monitoring campaigns have been carried out to measure spectrum occupancy worldwide, concluding that most of the spectrum is underutilized. In this paper we present the design and implementation of a low cost system to measure spectrum occupancy and to geo-tag the measurements to allow mobile measurement campaigns. The system is based on the Raspberry Pi system on chip and on an affordable spectrum analyser. After calibrating the system against a professional spectrum analyser, we measured the spectrum occupancy in urban and rural Venezuela, showing that there is plenty of vacant UHF TV spectrum.

I. INTRODUCTION

We believe that TV White Spaces (TVWSs) are ripe to provide badly needed two way communications services in Developing Countries, where protection of the incumbent is

A. White Spaces and Spectum Monitoring

Although there have been many measurements efforts to ascertain the spectrum occupancy in the UHF frequency band allocated to TV broadcasting, most have been carried out in Developed Countries, using highly specialized equipment [1],[2],[3],[4],[8].

A measurement campaign carried out in Bogota is described in [7], using similar equipment, that is, a high cost spectrum analyzer with a steep learning curve and sophisticated signal processing equipment. This is often not affordable in Developing Countries, encumbered with limitations of financial resources and properly trained personnel.

Therefore, the deployment of a low cost and easy to use spectrum analysis system specifically geared to identify white spaces in UHF could be a valuable proposition. The use of such system in both rural and urban areas in Venezuela is presented to emphasize the differences in spectrum occupancy
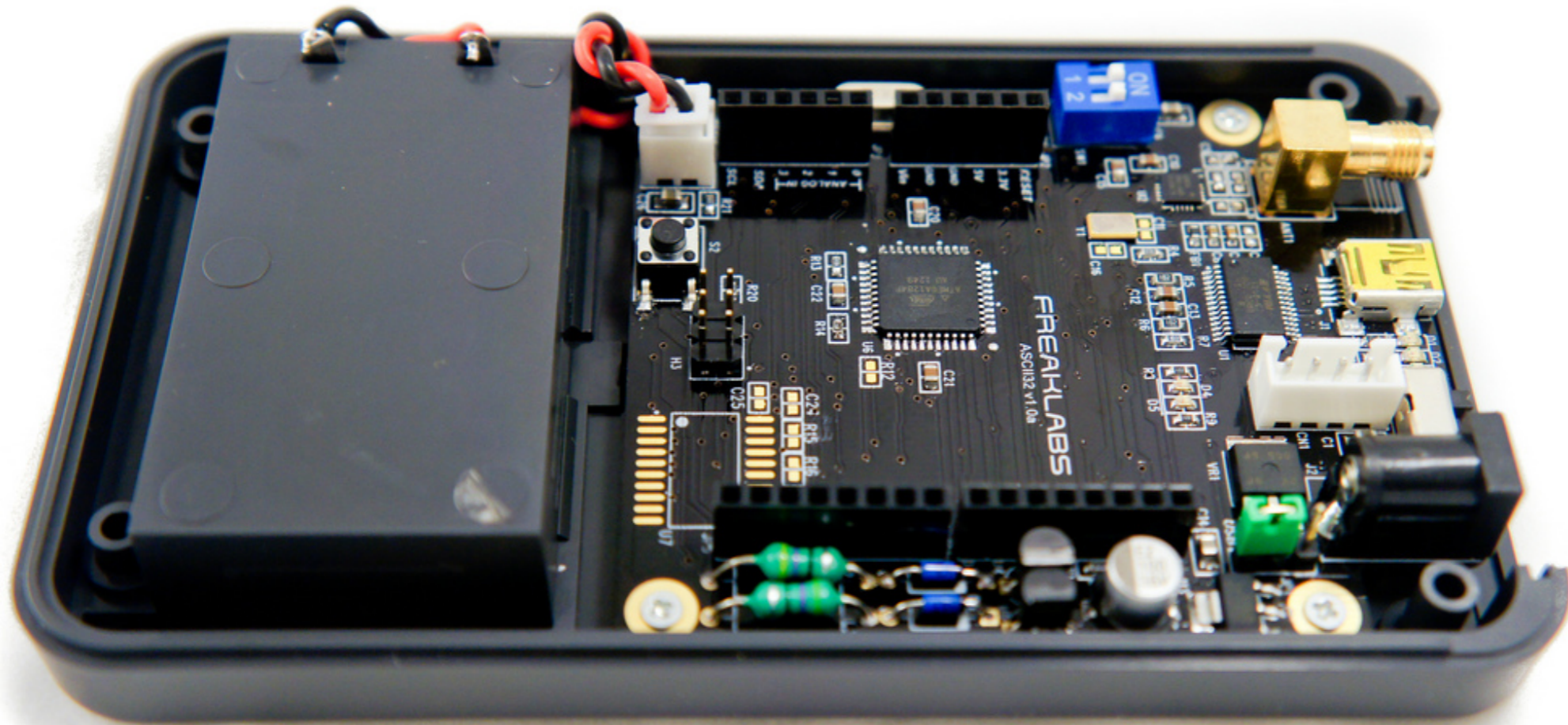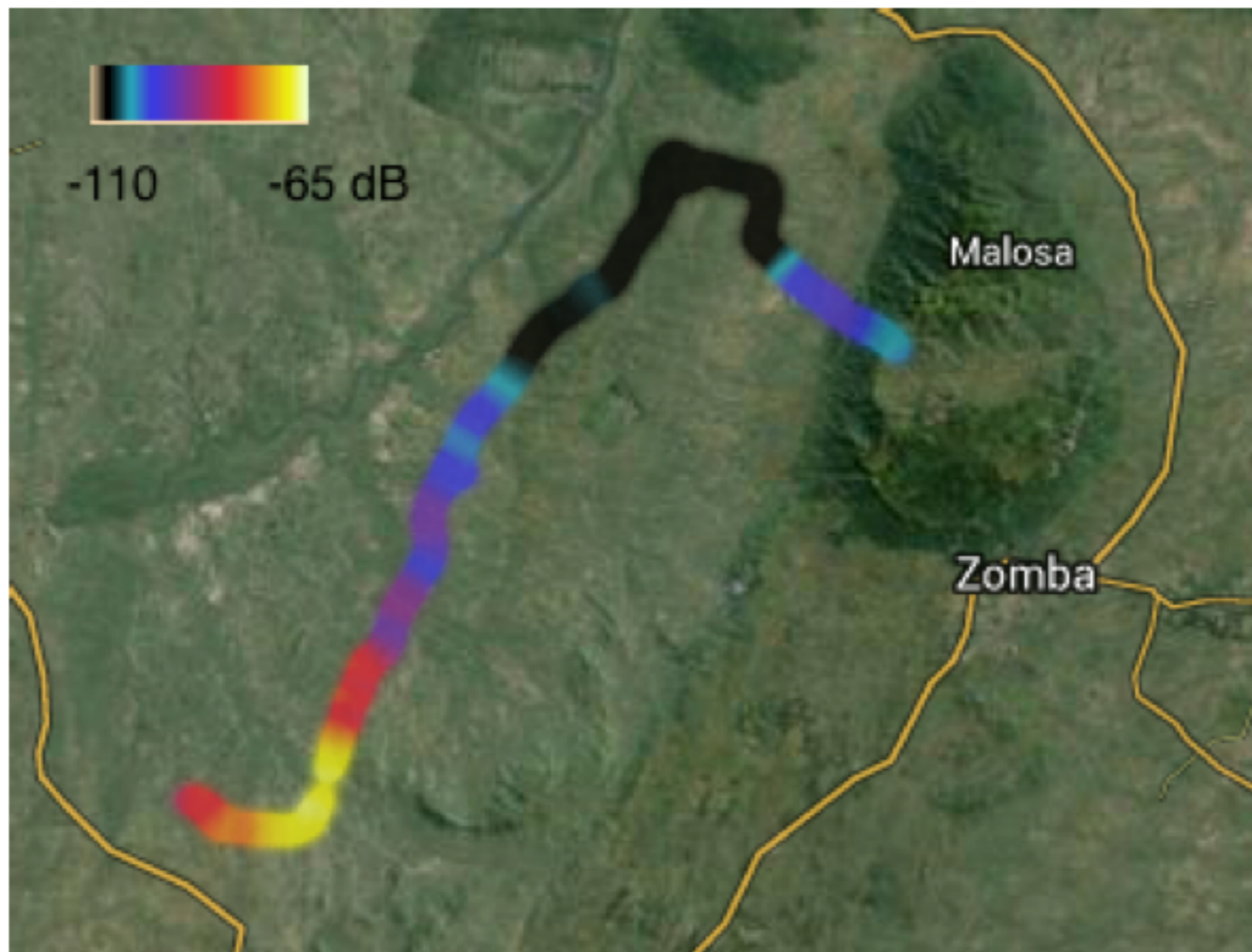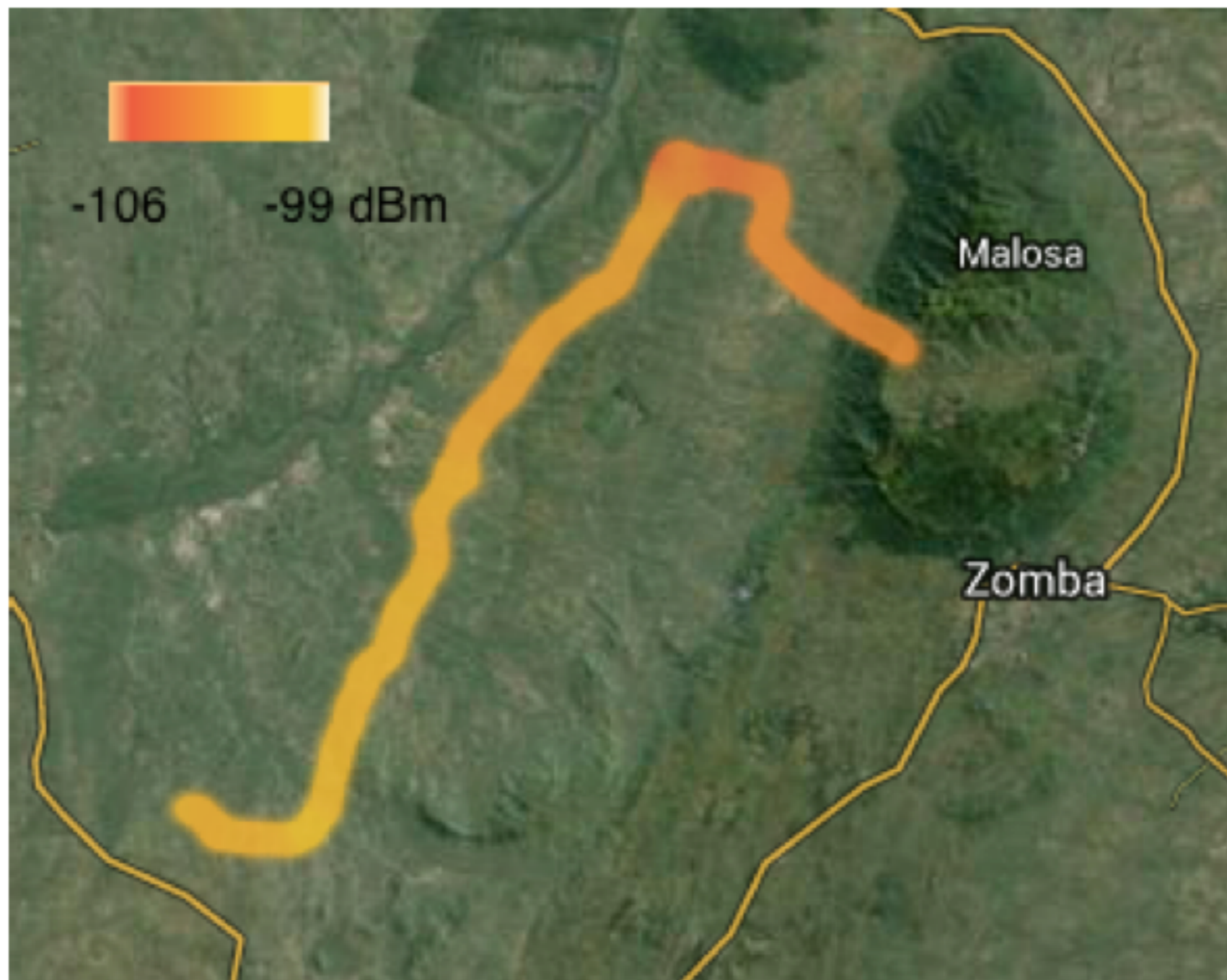
ASCII-32
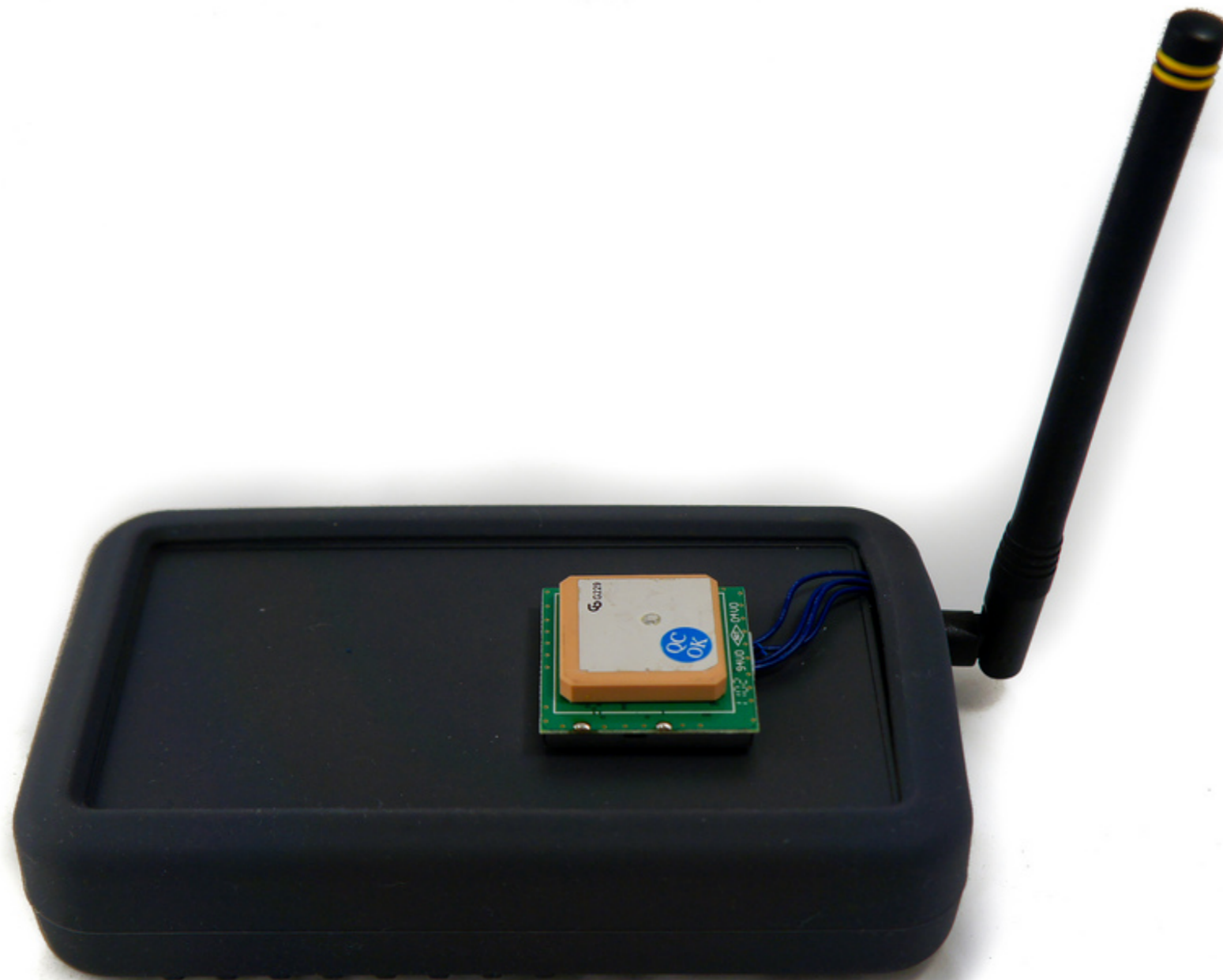
Figure 3: Heatmap for 546 MHz in Malawi.

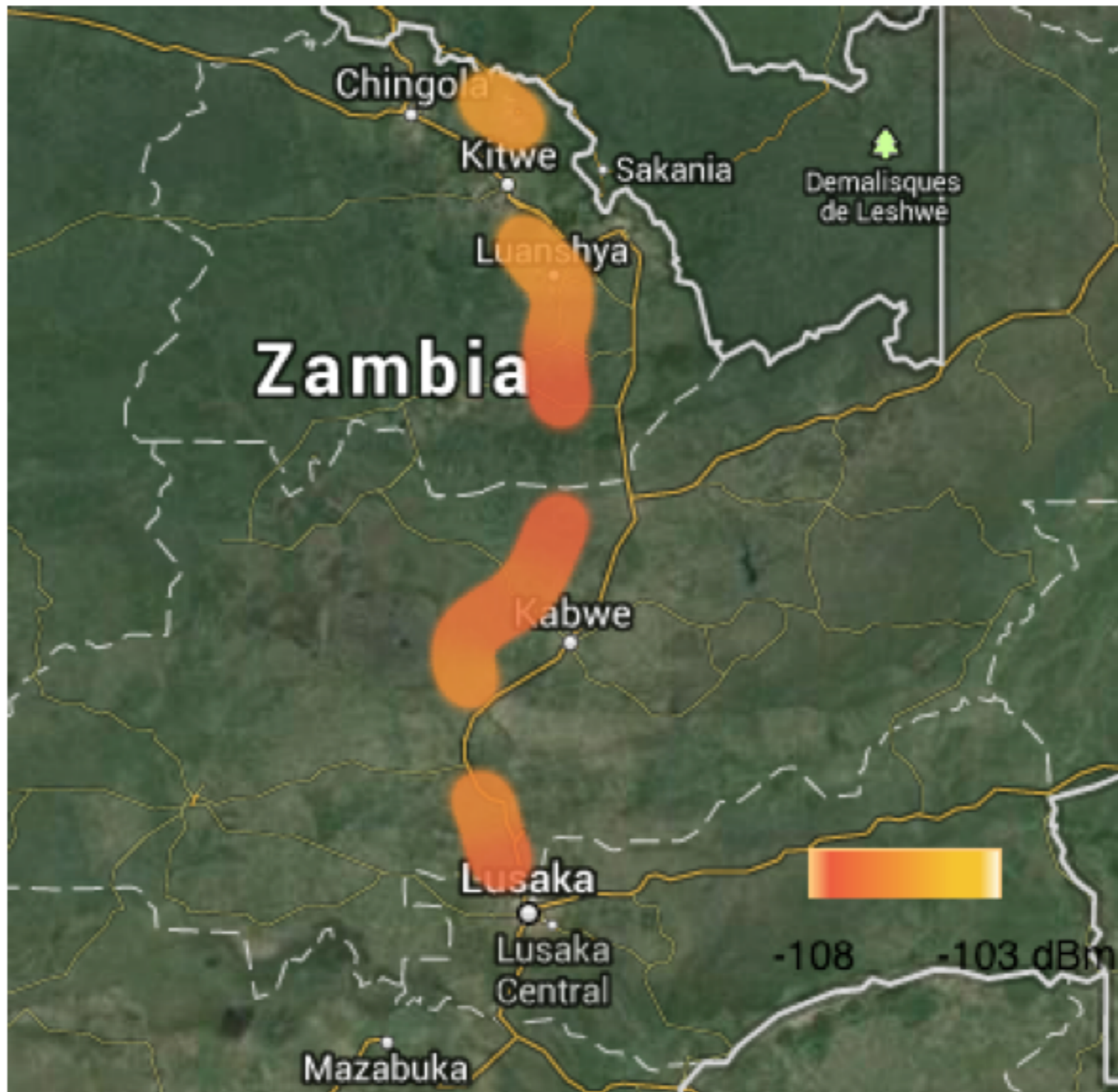**Figure 4: Heatmap for 498 MHz in Malawi.**

Figure 6: Heatmap for 546 MHz in Zambia.

TV White Spaces, I presume?

The quest for TVWS in Malawi and Zambia

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Chancellor College
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Jonathan Pinifolo
MACRA
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Regulatory Authority
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Chris Wang
FreakLabs
and Keio University
Tokyo, Japan

Steve Song
Network Startup Resource
Center
University of Oregon
Eugene, USA

ABSTRACT

The use of TV White Spaces can help mitigate the lack of connectivity that still affects many rural areas in Africa. The general consensus is that the migration from analog to digital TV will free parts of the spectrum. This technology is particularly well suited to connect remote communities for its good propagation characteristics. Following our measurements in Malawi and Zambia, we claim that most UHF spectrum is already available both in urban as well as in rural areas and can be used to provide Internet connectivity. In this paper we present the findings of a first TV White Spaces measurement campaign in Malawi and Zambia. We introduce an open hardware device that geo-tags spectrum measurements and saves the results on a micro SD card. The device can also be used to record the use of spectrum over long periods of time.

Categories and Subject Descriptors

C.2 [**COMPUTER-COMMUNICATION NETWORKS**]: ,Network Architecture and DesignWireless communication

divide. Mobile phones have become more or less synonymous with access in the South. However, much has changed since mobile networks began rolling out in the early-to-mid nineties. When the first generation of mobile operators were granted licenses to use wireless spectrum to build their networks, they were simply given the spectrum at no charge. The availability of spectrum exceeded demand. Today, popular frequency bands are auctioned for large amounts of money, often running into the billions of dollars [1].

Because so much money is now at stake concerning spectrum, the process of making new spectrum available has become complex. It is increasingly hard to ensure that spectrum is made available in a timely manner and to the entities that are most likely to serve a country's strategic interest. As ICTs become increasingly valuable to government, industries and citizens alike, demand for spectrum has steadily increased. Yet the process of making spectrum available and managing it as a resource still fails to feature in ICT4D initiatives and strategies.

Thailand

Nicaragua

490 MHz - 900 MHz at UNI over 19 hours.
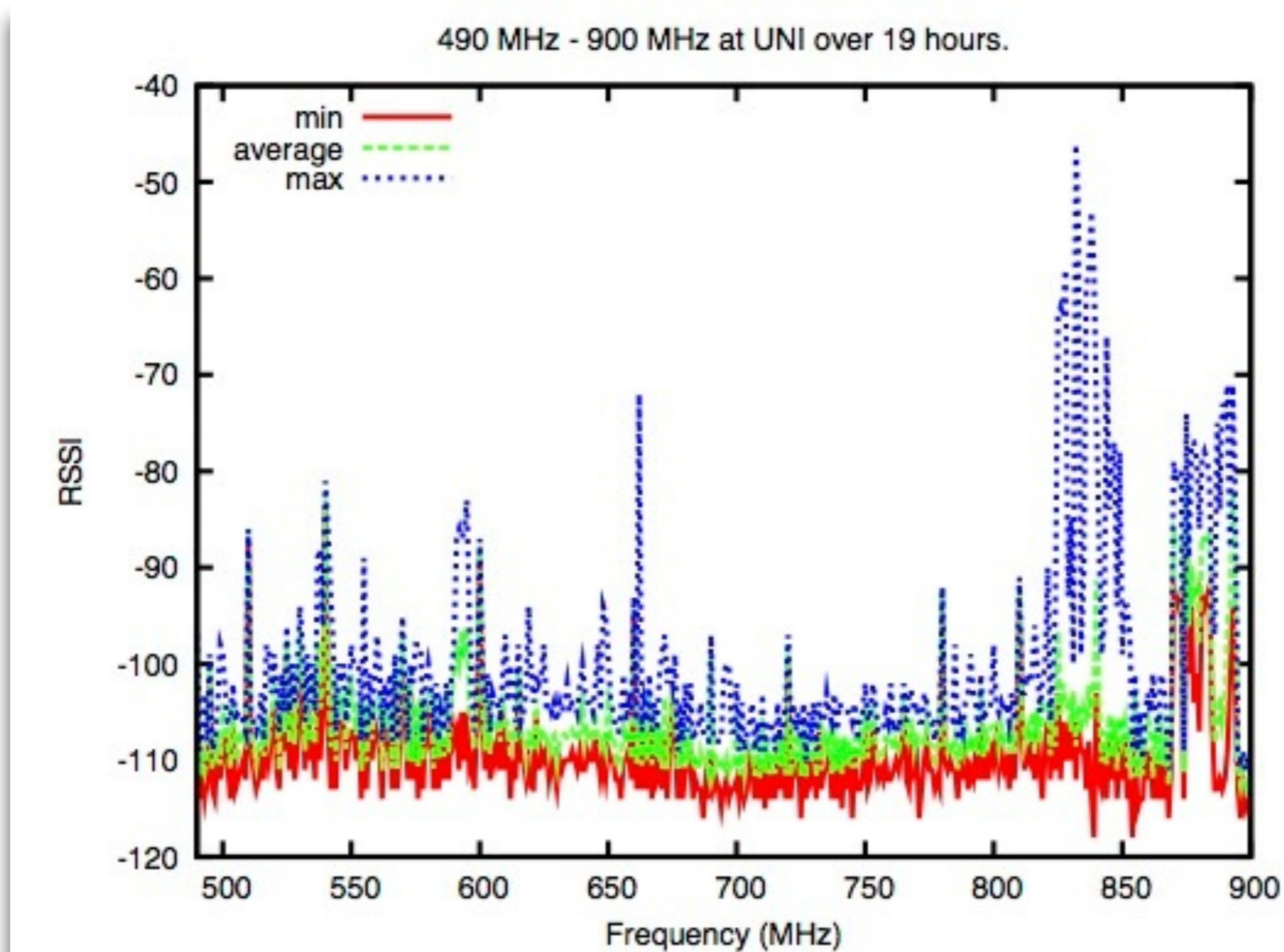
Deploy or Die

Malawi

MALAWI COMMUNICATIONS
MACRA House, Salmin Amour Road
Private Bag 261, Blantyre, Malawi

MACRA

REGULATORY AUTHORITY
Tel: (265) (0)1 883 611 Fax: (265) (0)1 883 890
e-mail: dg-macra@macra.org.mw

Our Ref: MACRA/DOT/50/lm

15th July, 2013

T/ICT4D Lab, The International Center for Theoretical Physics
Trieste
ITALY.

Dear Sir,

MACRA PARTICIPATION IN THE TELEVISION (TV) WHITE SPACE PROJECT

The Malawi Communications Regulatory Authority (MACRA) would hereby like to confirm its commitment to participate and support the implementation of the Television (TV) White Spaces Project in Malawi.

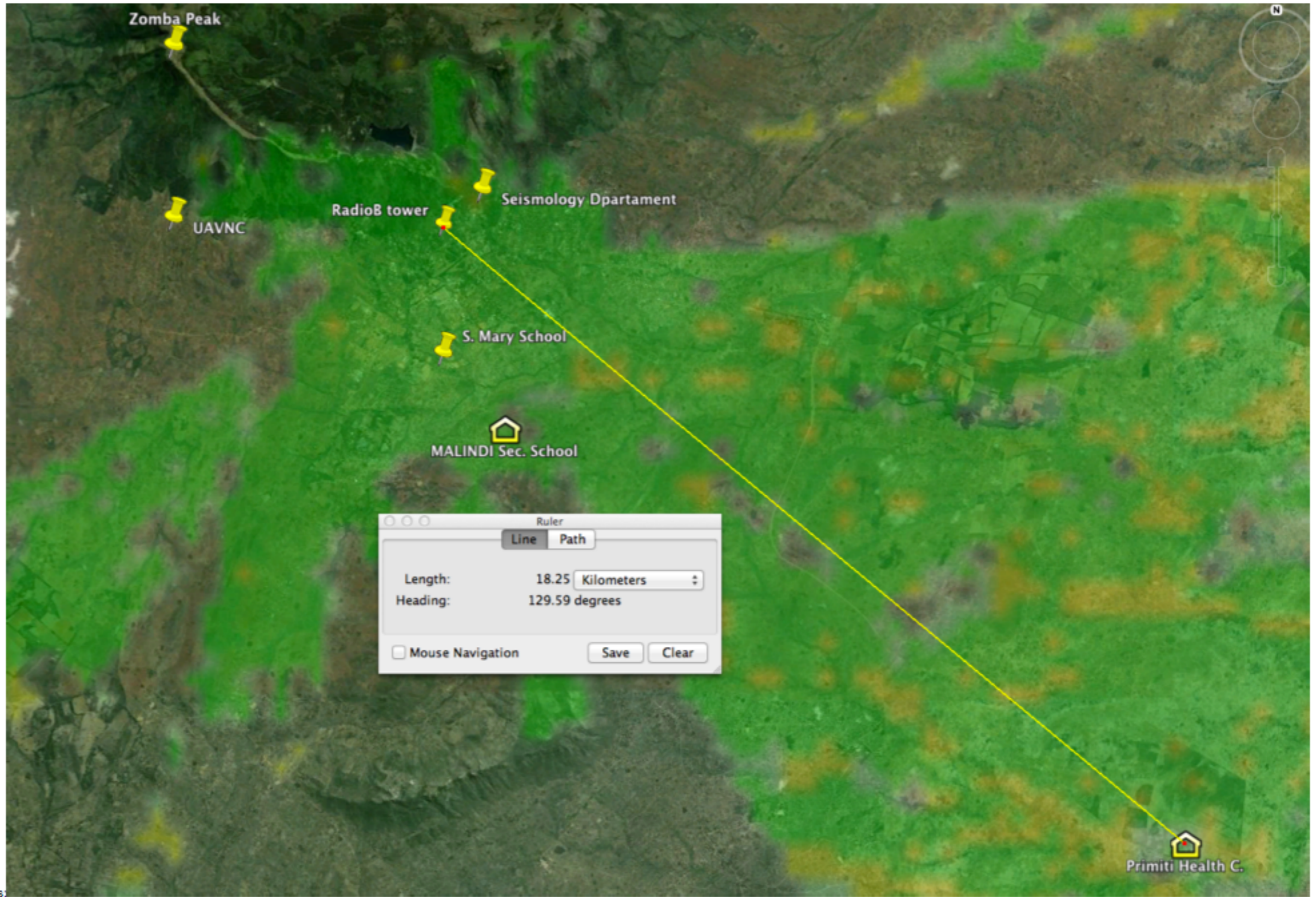The support from the Authority will among others include:

1. The release of officers to work with the Physics Department of Chancellor College;

2. The allocation of TV channels to be used in the pilot phase of the project (deployment starting 2nd September, 2013);, and

3. The partial funding of the operational costs for the project.

MACRA appreciates the donation of equipment from ICTP for the pilot phase in Malawi and will do the needful to facilitate shipment and delivery of the equipment from Italy to Malawi.

In line with its mandate, MACRA is always committed to continue working towards promoting and supporting the ICT industry in Malawi in order to promote universal ICT access in the country.

Yours faithfully,

Charles Nsaliwa
DIRECTOR GENERAL

Deployment

FM tower

SEISMICITY OF SUB-SAHARAN AFRICA

(1071 - 1996)

Council for Geoscience

Pretoria

South Africa

Scale 1:10 000 000

Projection: Mercator
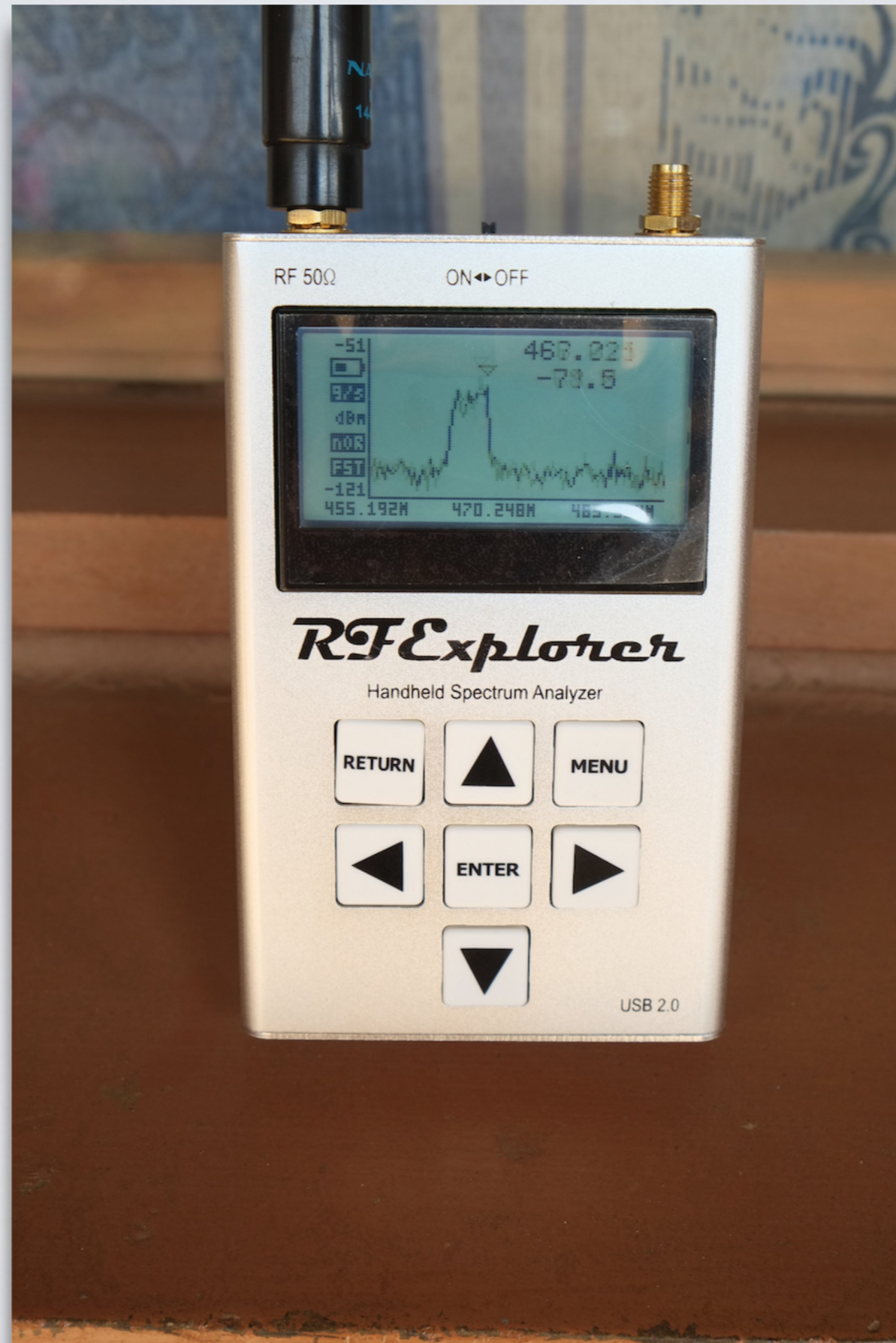
Activities in Malawi

White Space technology improves education in Malawi

FEBRUARY 28, 2014   THERESA CHAPULAPULA   NO COMMENTS

ST MARY'S STUDENTS—Said to be benefitting from Television white space.

St Mary's Secondary School head teacher Mary Chimalizeni says Television White Spaces (TVWS) Pilot project being implemented at the school has helped to improve the quality of education at the institution.
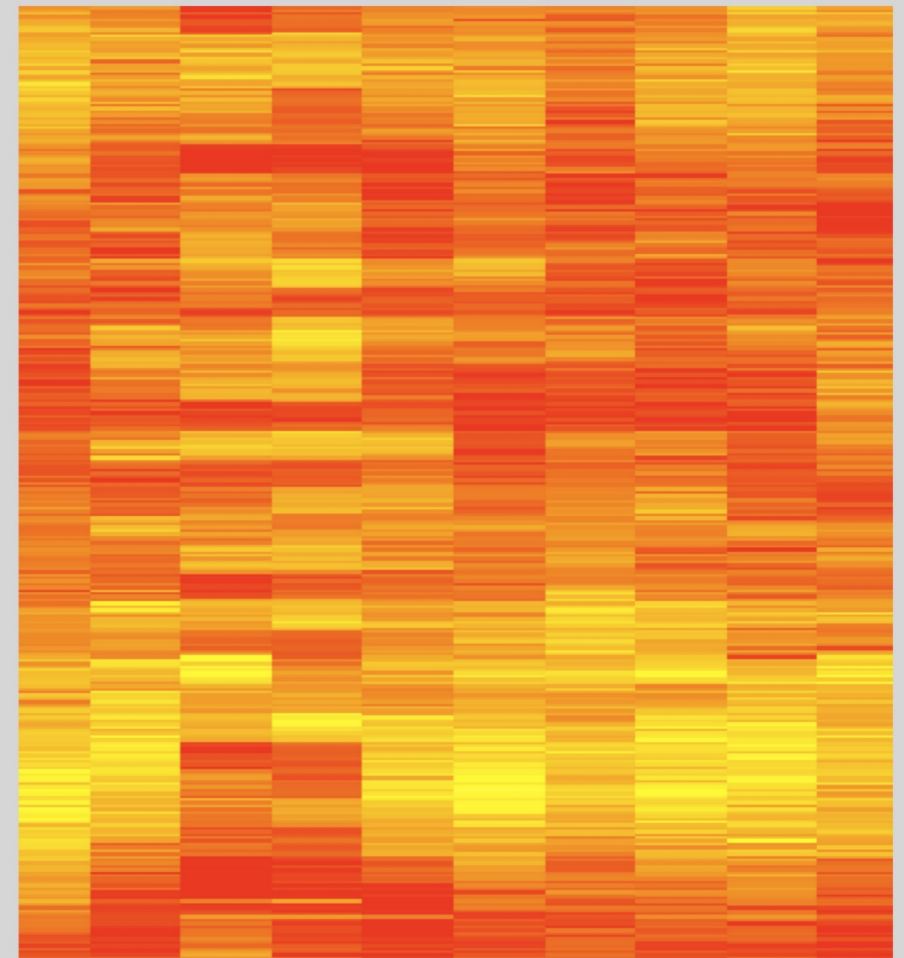
TVWS book

TV White Spaces,
a pragmatic approach

E.Pietrosemoli
M.Zennaro

http://wireless.ictp.it/tvws/book/

TV White Spaces

A pragmatic approach

Editors
Ermanno Pietrosemoli and Marco Zennaro

Thank you!