PERSPECTIVES ON THE COCONET PROJECT

A CONTRIBUTION FROM STAFF OF THE SEISMIC RESEARCH CENTRE[1], L'OBSERVATOIRE DE LA GUADELOUPE [2], L'OBSERVATOIRE DE LA MARTINIQUE [3] AND MONTSERRAT VOLCANO OBSERVATORY [4]

Abstract

Volcano and Earthquake Observatories in the Eastern Caribbean have been collecting geophysical data for several decades in fulfilment of their mandate to provide expert advice on regional seismicity and volcanic hazards to civil authorities and the public in the English and French West Indies. Due to a combination of cost saving from pooled orders and collaborative projects there has been a significant increase in the number of cGPS stations operated by the Observatories over the past decade. Ground deformation monitoring are routinely conducted by the Observatories using either (1) periodic GPS campaigns targeted towards volcano deformation monitoring or (2) continuous GPS stations targeted mainly to understanding regional tectonics. The GAMIT/GLOBK tool developed by MIT have adopted and implemented the to produce high precision GPS solutions and velocities and the GPS acquisition and processing has been automated with this tool to allow the production of daily reports. This has resulted in a significant increase in precision for volcano GPS networks and greater possibilities for studying plate boundary processes in the Eastern Caribbean.

In response to the request for White Papers in support of the objectives sent out by the COCONet Workshop Organising Committee, staff of Eastern Caribbean Observatories have discussed and drafted this White Paper which provides input to the overall goals of the workshop. It seeks to influence the direction of the collaboration so that it is better suited to the needs of the Eastern Caribbean region. The paper outlines the objectives, current limitations and future plans of Eastern Caribbean Observatories with respect to cGPS and attempts to identify possible synergies that could be realised with COCONet collaboration. It identifies some issues which the Workshop should consider given the responsibilities and research interest of existing Caribbean research and monitoring agencies.

[1] Richard Robertson, Joan Latchman, Lloyd Lynch, Machel Higgins, Roderick Stewart, Robert Watts

[2] Jean-Bernard Chabalier, Steve Tait, A. Anglade, Deroussi

[3] Valérie Clouard

[4] Paul Cole, Henry Odbert

Introduction

The Seismic Research Centre (http://www.uwiseismic.com), L'Observatoire de la Guadeloupe (http://www.ipgp.fr/pages/030304.php), L'Observatoire de la Martinique (http://www.ipgp.fr/pages/030303.php) and the Montserrat Volcano Observatory (http://www.mvo.ms) operate seismic and geodetic networks that span the entire Eastern Caribbean. They are the agencies responsible for providing scientific advice and information on seismic and volcanic hazards in this region to civilian authorities and the public. Most of these institutions have been in operations for over 50 years.

In response to the request for White Papers in support of the objectives sent out by the COCONet Workshop Organising Committee, staff of these institutions have discussed and drafted this White Paper which provides input to the overall goals of the workshop which are listed as:

- Refine the overarching science plan for pan-Caribbean infrastructure.
- Revise the GPS station siting plan in light of science goals and existing open-data GPS infrastructure.
- Develop a mechanism for ongoing science oversight.
- Define capacity building activities and funding mechanisms, including development of the scientific and technical capacity of the international and in-country community conducting research in the Caribbean, and ensuring a climate of free and open access to COCONet geodetic data.

Objectives of White Paper

1. To influence the direction of the collaboration so that it is better suited to the needs and desires of the Eastern Caribbean
2. To outline the objectives, current limitations and future plans of existing Eastern Caribbean observatories with respect to cGPS especially with respect to identifying possible synergies that could be realised with COCONet collaboration – specifically to answer questions such as:
    i. How can COCONet complement existing ECAR cGPS program?
    ii. How can the ECAR cGPS program complement COCONet?
    iii. How can COCONet assist with volcano, earthquake, tsunami monitoring?
3. To recommend some issues which the Workshop should consider given the responsibilities and research interest of existing Caribbean research and monitoring agencies
4. To lobby for the involvement of representatives of the Observatory community in the various workgroups/committee that may be established with respect to the implementation of the COCONet project.

Background

The COCONet project aims to provide free, high-quality, low-latency, open-format data and data products for researchers, educators, students and the private sector. In doing so it provides for the establishment of a network that consists of 50 new and data from 50 existing, continuously operating GPS stations. The stations will be installed by UNAVCO on behalf of the science and other user communities in the United States and abroad. The project proposal states that the core of COCONet is the idea of coordinating and educating existing researchers, Caribbean governments and agencies, and GPS station operators toward the goal of creating a pan-Caribbean reference network that would be used for both scientific and socioeconomic purposes.

The intentions of COCONet are indeed quite noble and despite its ambitious goals could prove quite useful to the region. Notwithstanding our firm belief that the project would have benefited from discussion with the observatory community prior to its submission we welcome the attempts to obtain feedback through the workshop. We believe that the COCONet project provides an opportunity to significantly increase the number of high-quality, real-time cGPS stations in the Caribbean Basin and Adjacent Areas. Observatories in the Eastern Caribbean have made profound contributions to society through their contributions to hazard mitigation. Since the establishment of the first observatories in Martinique in the 1930s less than 30 lives have been lost from volcanic eruptions in this region. Seismic provisions for building codes are regularly made available to the engineering community and through public education and outreach programmes the communist at risk have been made more aware of prevailing hazards. The observatories are also all involved with the current efforts to establish a regional tsunami early warning system. We believe that there are some real benefits that can be derived from collaboration with the COCONet project and will participate through this submission and our participation in the workshop hope to ensure that maximum benefits are derived from the planned installations.

Objectives of the cGPS operated by the Observatories

Our broad objectives with respect to the operations of continuous GPS networks in the Eastern Caribbean are the mitigation of geologic hazard and the execution of research that may assist in better understanding of geologic processes so as to guide such mitigation. We have outlined below some of our specific areas of interest with respect to the use of continuous GPS data.

1. Hazard and Risk Mitigation:
    - Volcano deformation monitoring: detection of ground deformation which may act as a precursor to future volcanic eruptions in the region;
    - Early warning for major earthquakes and tsunamis
2. Research
    - Crustal deformation of the Lesser Antilles plate boundary distribution/localisation of the deformation, partitioning.
    - Segmentation of the lesser Antilles subduction

- Establish strain rate database and construct temporal models of tectonic strain
- Earthquake cycles: loading vs. stress released on fault systems in relation with seismicity/tremor
- Post event modelling of earthquakes and crustal dynamics from co-seismic GPS record
- Improved understanding of volcanoes/faults interactions

Characteristics of the cGPS networks

The technical details of the cGPS networks operated by various agencies in the Lesser Antilles including sites which are planned development by SRC and IPGP in the near future are provided in Tables 1 and Figures 1-3 at the end of this document. Although the cost of equipment continues to be a key challenge, a combination of pooling orders either through UNAVCO or amongst observatories has enabled a significant increase in the number of stations operated by the Observatories in the Eastern Caribbean. The high cost of data transmission continue to pose challenges for real-time transmission and the issue of data archiving and access by external collaborators and regional agencies remain a problem for some observatories.

Two main types of ground deformation monitoring are routinely conducted by the Observatories: (1) periodic GPS campaigns targeted towards volcano deformation monitoring and (2) continuous GPS stations targeted mainly to understanding regional tectonics. The observatories have adopted and implemented the GAMIT/GLOBK tool developed by MIT to produce high precision GPS solutions and velocities. The GPS acquisition and processing with this tool has been automated and allows for the production of daily reports and a significant increase in precision for volcano GPS networks.

Opportunities offered by COCONet Project

The COCONet project offers a number of opportunities for the existing cGPS networks operated by our various observatories in the Eastern Caribbean. These include:

1. Rationalization of existing cGPS networks:
   - Opportunity to learn from UNAVCO expertise with respect to cGPS installation and maintenance and to use this knowledge to improve the quality of our existing sites
   - Assistance with current efforts to establish real-time communications through VSAT and other methods
   - Co-location of cGPS sites with seismic stations and tide gauges to maximise benefit to the monitoring community (infrastructures, transmissions)
2. Capacity building – growing the community of users of cGPS data and so ensuring more support and buy-in for such networks
3. Assist with lobbying/advocating for support at high level – government/utilities/lifelines for support of efforts designed to reduce risk
4. Opportunity to study plate boundary kinematics on a broader scale than would be possible without the collaboration

5. Reduction in the total cost of ownership of the network.

Possible new sites for COCONet stations

Having examined the existing network of cGPS stations in the Eastern Caribbean, we list below a number of sites which we believe could be considered for new installations by the COCONet project. Given our present operations and responsibilities we should be able to assist with the logistics of getting the chosen sites established.

1. Anguilla (site TBD)
2. St Martin/Maarten (site TBD)
3. Barbuda (USGS GSN site)
4. Saba/Statia[5] (site TBD)
5. Redonda (Antigua) or Silver Hills (Montserrat)
6. Grenada (USGS GSN site)
7. Barbados (USGS GSN site)
8. Trinidad (site TBD)

Possible existing and planned stations that can be integrated into COCONet

The following are sites that already exist or are already planned for installation. They would require upgrade to real-time transmission but are currently offered as possible options for integration into the COCONet list of 50 existing sites.

1. St Barthélemy (existing site)
2. All Saints, Antigua (planned site funded by INTERREG Project)
3. Guadeloupe (one of the existing sites TBD)
4. Roseau, Dominica (existing site)
5. Martinique (one of the existing sites TBD)
6. Saint Lucia (planned site funded by INTERREG Project)
7. Kingstown, St. Vincent (existing site)
8. Carriacou, Grenada (planned site funded by INTERREG Project)
9. St. Augustine, Trinidad

Matters for discussion:

There are a number of issues that would require clarification and some discussion at the Workshop and/or by the COCONet project investigators. We have listed some of what we consider the main issues below and will highlight any additional ones during our presentations at the workshop.

[5] This would require collaboration with the Meteorological Service of the Netherlands Antilles and Aruba

1. The issue of long-term funding and provision in the project for maintenance and ownership of COCONet sites beyond the life of the project. This is currently not clear and should be settled prior to actual installation of equipment.
2. The need to agree and maintain some ground rules especially with regards to local and regional responsibilities for volcano and earthquake monitoring in the Eastern Caribbean particularly.
3. The question of the data products to be offered by COCONet – will processed data (i.e. results) be available to the community? This is not clear from the proposal.
4. Are there plans for the development of tools to enable real-time data processing and computation of time series – will these be made available to the Observatories?
5. Provision for the participation of researchers other than the COCONet PIs in the scientific plan for the cGPS infrastructure established is not clear.
6. Provision for capacity building and expansion of the use and application of cGPS to the wider community in the Caribbean region and adjacent areas needs to be discussed.
7. The need to put measures in place to ensure that the role of reginal experts as risk reduction advocates is not diminished or compromised.

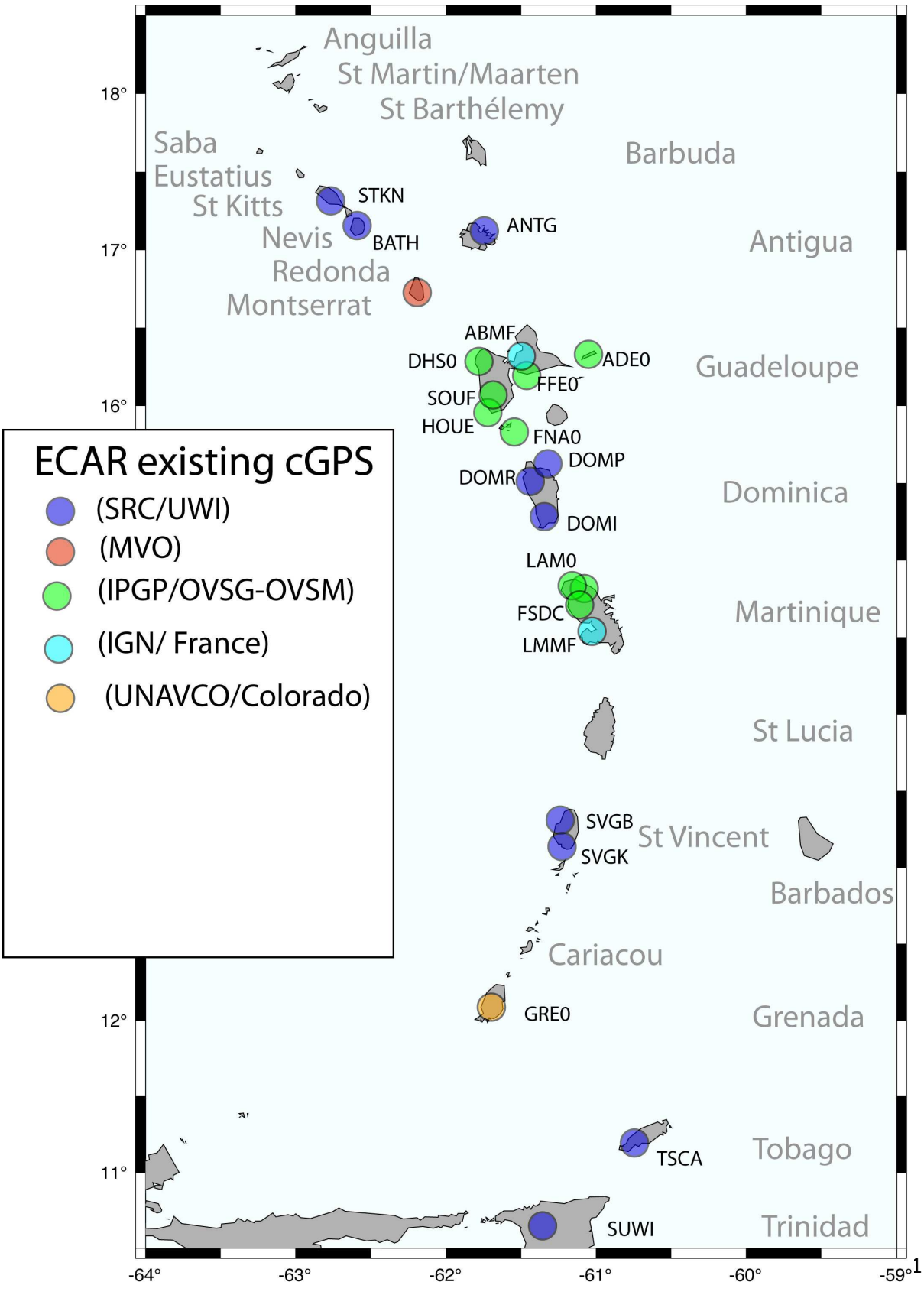
Table 1: Existing and planned cGPS stations operated in the Eastern Caribbean.

SITE	Location	Lat N	Lon W	Operator	Rec	Antenna	Rate	Time delay	Transmission	Infrastructure
HOUE	Guadeloupe, OVSG	15.97961	61.703063	OVSG/IPGP	Ashtech Z12	Choke Ring	30s	24h	Direct	Reinforced concrete pillar on a slab
SOUF	Guadeloupe, Soufrière	16.044981	61.6627189	OVSG/IPGP	Ashtech Zxtreme	Choke Ring	30s	24h	Freewave	Reinforced concrete pillar on rocks
FFE0	Guadeloupe, Gosier	16.217461	61.512362	OVSG/IPGP	Ashtech MicroZ	Choke Ring	30s	24h	Freewave	Reinforced concrete pillar on a old wall
DHS	Guadeloupe, Deshaies	16.27268	61.76509	OVSG-IPGP	Topcon GB1000	Topcon	30s	24h	VSAT	Reinforced concrete pillar on a slab
ADE0	Guadeloupe, Désirade	16.296865	61.146533	OVSG-IPGP	Ashtech MicroZ	Geodetic4	30s	24h	Phone modem	Concrete pillar on a slab in sand
DSD0	Guadeloupe, Désirade	16.31277	61.06605	OVSG/IPGP	Topcon GB100	Topcon	30s	24h	VSAT (underway)	Concrete pillar on limestone
FNA0	Guadeloupe, Les Saintes	15.875325	61.581965	OVSG-IPGP	Ashtech Z12 LP	Choke Ring	30s	24h	No (semi permanent)	Wall on roof of old stone castle (17^{e})
ABMF	Guadeloupe, Abymes	16.262304	61.527531	IGN	Trimble netR5	TRM55971	1s /30s	1h / 24h		Metallic pillar

FSDC	Martinique, OVSM	14.734834	61.1465336	OVSM-IPGP	Ashtech Zxtreme	Geodetic 4	30s	24h	Direct	Roof of OVSM (reinforced concrete)
LAM0	Martinique Mgne Pelée	14.8129587	61.1631079	OVSM-IPGP	Ashtech Zxtreme	Geodetic 4	30s	24h	Free wave	Roof of concrete shelter
LMMF	Martinique Lamentin	14.594817	60.996169	IGN	Trimble netR5	TRM55971	1s /30s	1h /24h		Metallic pillar
STKN	Brumaire, St. Kitts	17.296	297.260	SRC	Trimble NetRS	TRM41249.00	30s	24hr	No telemetry	Roof of reinforced concrete building
TSCA	Scarborough, Tobago	11.177	299.268	SRC	Trimble NetRS	TRM41249.00	30s	24hr	No telemetry	Roof of reinforced concrete building
ANTG	All Saints, Antigua	17.062	298.206	SRC	Trimble NetRS	TRM41249.00	30s	24hr	Broadband Internet	Roof of reinforced concrete building
BELZ	Belize City, Belize	17.483	271.797	SRC	Trimble NetRS	TRM41249.00	30s	24hr	Broadband Internet	Roof of reinforced concrete building
DOMI	Roseau, Dominica	15.306	298.611	SRC	Trimble NetRS	TRM41249.00	30s	24hr	Broadband Internet	Roof of reinforced concrete building
DOMR	Ross University, Dominica	15.557	298.541	SRC	Trimble NetRS	TRM41249.00	1s\30s	24hr	Broadband Internet	Roof of reinforced concrete building

DOMP	Pennville, Dominica	15.627	298.578	SRC	Trimble NetRS	TRM41249.00	1s\30s	24hr	Broadband Internet	Reinforced Concrete monument
SVGB	Belmont, St. Vincent	13.275	298.750	SRC	Trimble NetRS	TRM41249.00	30s	24hr	Broadband Internet	Roof of reinforced concrete building
SVGK	Kingstown, St. Vincent	13.162	298.772	SRC	Trimble NetRS	TRM41249.00	30s	24hr	Broadband Internet	Roof of reinforced concrete building
GRE0	Marli, Grenada	12.222	278.428	SUOMINET\ SRC	Trimble NetRS	TRM41249.00	30s	24hr	Broadband Internet	Roof of reinforced concrete building
BATH	Charlestown, Nevis	17.132	297.374	SRC	Trimble NetRS	TRM41249.00	30s	24hr	No telemetry	Roof of reinforced concrete building
SUWI	St. Augustine, Trinidad	10.640	298.599	SRC	Trimble NetRS	TRM41249.00	30s	24hr	LAN	Roof of reinforced concrete building
HARR	Harris, Montserrat	16.74132	62.16775	MVO	Trimble NetRS	Trimble Zephyr Geodetic	1s\30s	24hr	Freewave	Reinforced concrete monument
HERM	Hermitage, Montserrat	16.72155	62.16977	MVO	Trimble NetRS	Trimble Zephyr Geodetic	1s\30s	24hr	Freewave	Reinforced concrete monument
MVO1	Mongo Hill, Montserrat	16.77669	62.19285	MVO	Trimble NetRS	Trimble Zephyr Geodetic	1s\30s	24hr	Freewave	Roof of reinforced concrete building

SPR1	Spring Estate, Montserrat	16.70134	62.19424	MVO	Trimble NetRS	Trimble Zephyr Geodetic	1s\30s	24hr	Freewave	Reinforced concrete monument
SSOU	South Soufriere Hills, Montserrat	16.68787	62.16139	MVO	Trimble NetRS	Trimble Zephyr Geodetic	1s\30s	24hr	Freewave	Reinforced concrete monument
WTYD	Whites Yard, Montserrat	16.73147	62.16013	CALIPSO	Trimble NetRS	Trimble Zephyr Geodetic	1s\30s	24hr	Freewave	Reinforced concrete monument
AIRS	Air Studios, Montserrat	16.74083	62.21386	CALIPSO	Trimble NetRS	ASH701945 B_M	1s\30s	24hr	Freewave	Reinforced concrete monument
OLVN	Olveston, Montserrat	16.75040	62.23	CALIPSO	Trimble NetRS	ASH701945 B_M	30s	24hr	Freewave/Broadband Internet	Reinforced Concrete Installation
GERD	Geralds, Montserrat	16.79481	62.19430	CALIPSO	Trimble NetRS	ASH701945 B_M	30s	24hr	Freewave/Broadband Internet	Reinforced Concrete Installation
TRNT	Trants, Montserrat	16.76428	62.16	CALIPSO	Trimble NetRS	ASH701945 B_M	30s	24hr	Freewave/Broadband Internet	Reinforced Concrete Installation
RDON	Redonda, Antigua (PLANNED)	16.93427	62.34617	MVO	Trimble NetR8	Trimble Zephyr Geodetic II	1s\30s	24hr	Freewave/VSAT	Reinforce concrete/bedrock
SGH2	St George's Hill, Montserrat (PLANNED)	16.71969	62.20623	MVO	Trimble NetR8	Trimble Zephyr Geodetic II	1s\30s	24hr	Freewave	Roof of reinforced concrete building
FERG	Fergus Ridge, Montserrat (PLANNED)	16.69283	62.17736	MVO	Trimble NetR8	Trimble Zephyr Geodetic II	1s\30s	24hr	Freewave	Reinforce concrete monument


ECAR existing cGPS
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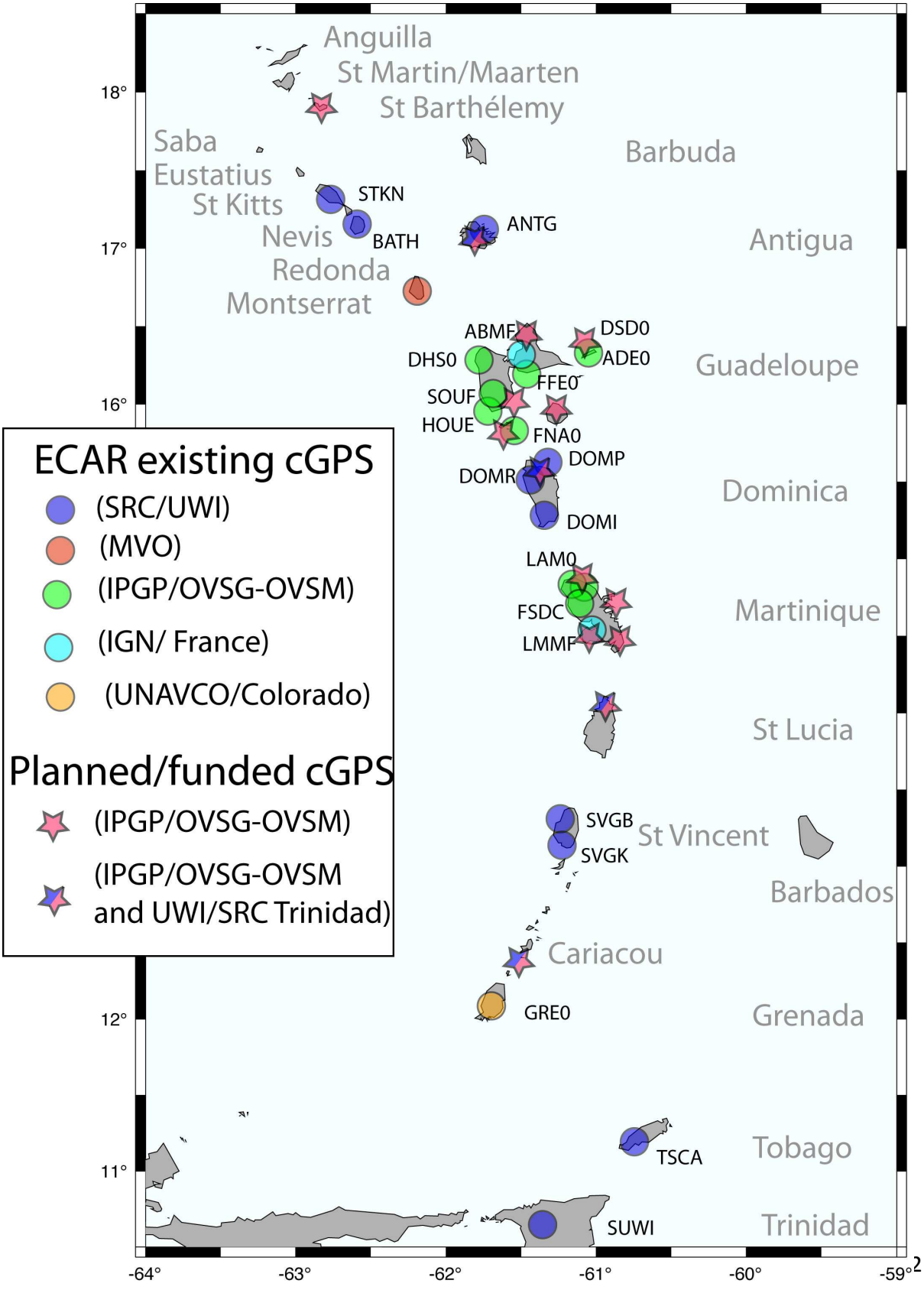
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ECAR existing cGPS
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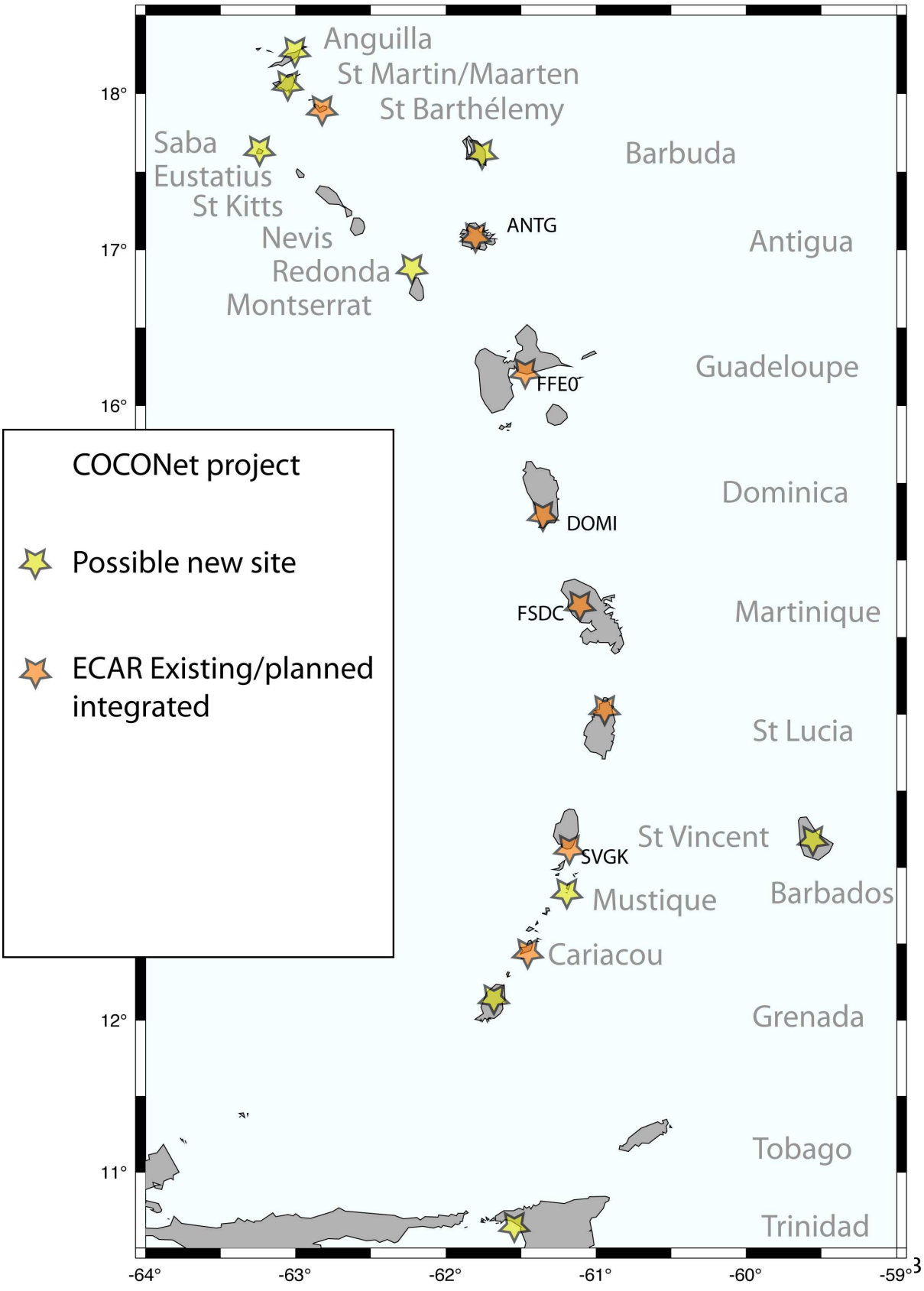
Planned/funded cGPS
(IPGP/OVSG-OVSM)
(IPGP/OVSG-OVSM and UWI/SRC Trinidad)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COCONet project
Possible new site
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