



VOLCANIC ERUPTION IN LA PALMA

The Roque de los Muchachos Observatory experience

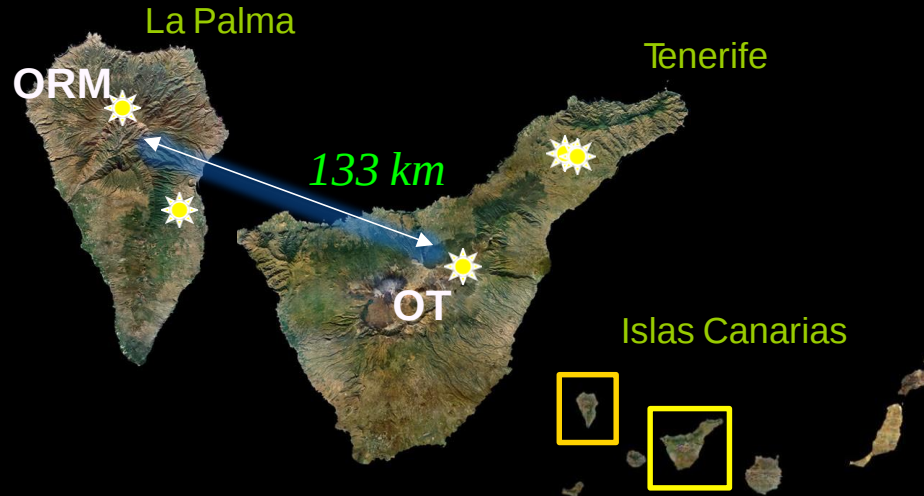


Carlos Martín Galán
Juan Carlos Pérez Arencibia



IAC: Organismo Público de Investigación

1. Science & Innovation Ministry
2. Canarian Government
3. La Laguna University (ULL)
4. Spain's Science Research Council (CSIC).



3 locations & 2 Observatories



OT

- 1979 INTERNATIONAL AGREEMENTS
- 1982 IAC WAS FOUNDED
- 1985 OFFICIAL OPENING OF OOC
- 1988 LAW ON SKY PROTECTION
- 2012 Unique Science and Technology Infrastructures

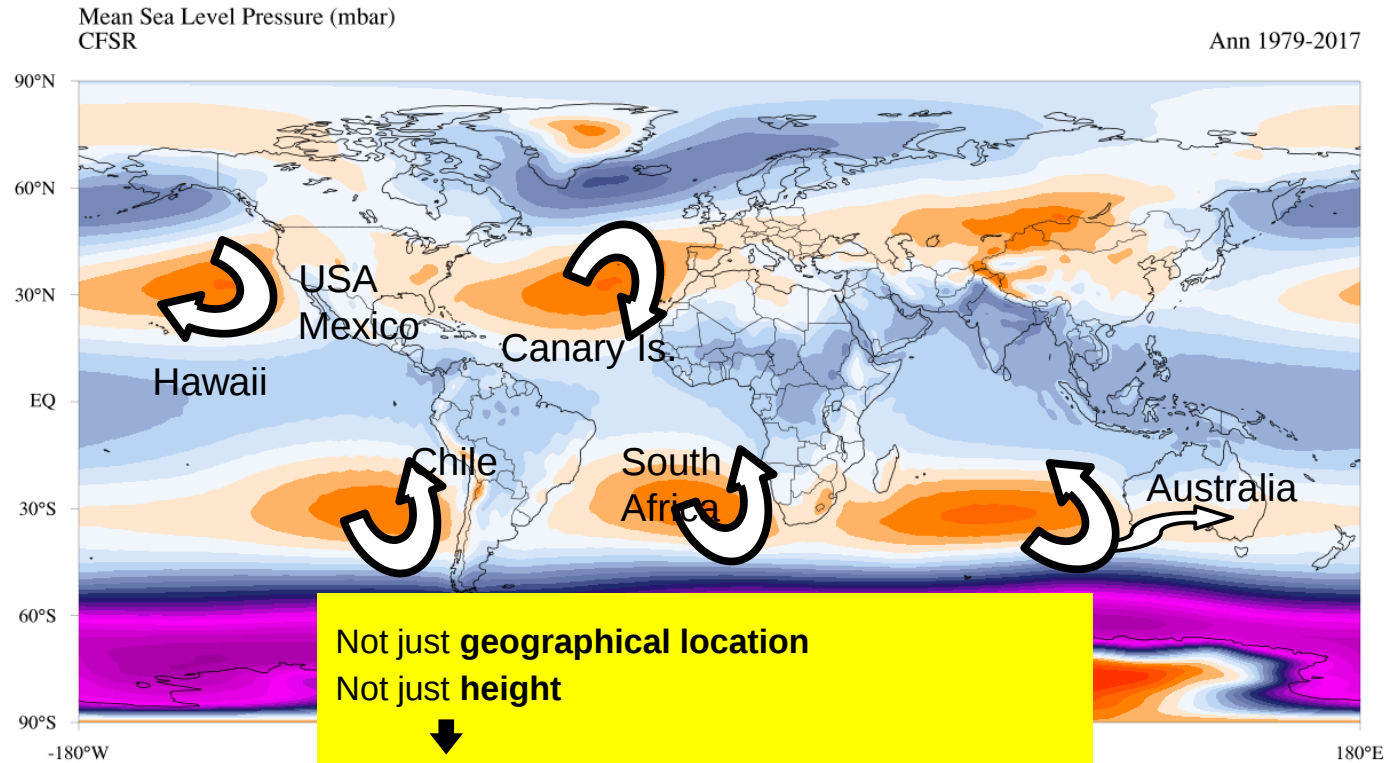
ORM



Canary Sky

- Excellent Sky for Astronomy
- Well characterized and protected
- Internationally accredited

Where we are and why



Not just **geographical location**

Not just **height**



A combination of both defines the handful of privileged sites in the world that are candidates to host the best astronomical observatories

Where we are and why

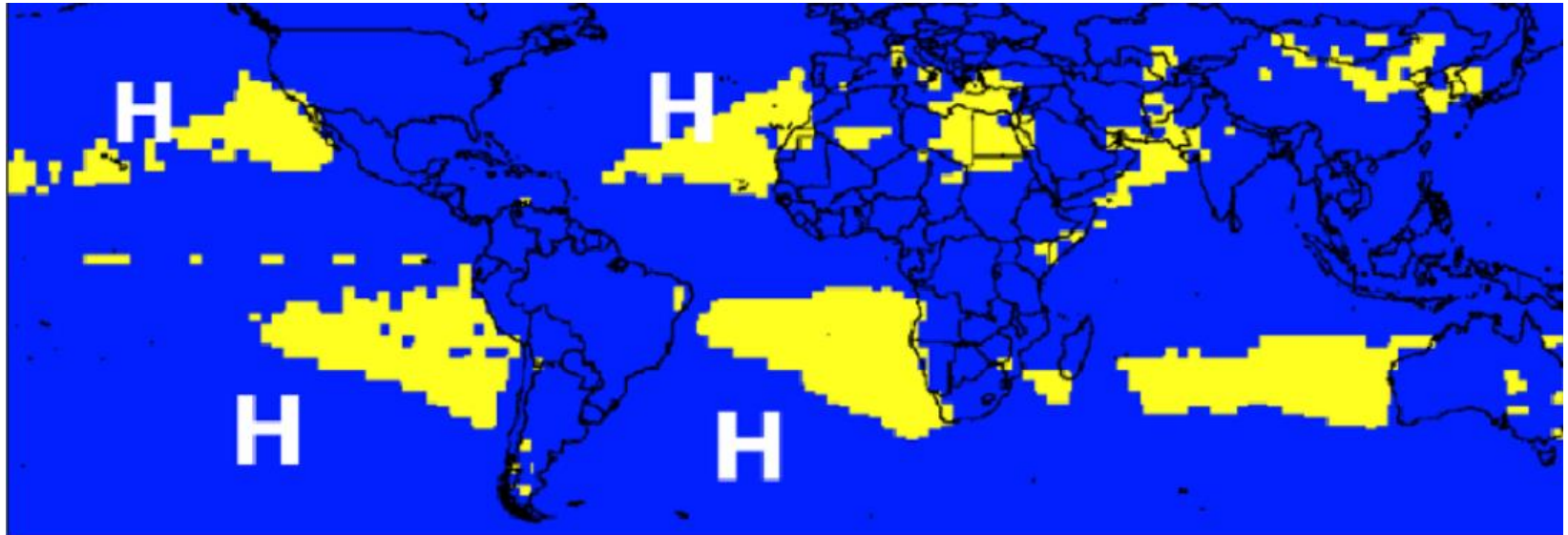
Gentle descent of air from close to the Tropopause (~8-14km)



Adiabatic process: no heat is gained or lost



Stability and low humidity (and *water vapour*)



vertical velocities of 0.025 to 0.045 Pa/sec (yellow)
(equivalent to ~2 to 4 mm/sec)

Graham, 2008





The international dimension of Astrophysics in Canary Islands

The sky is protected by Law.

The Observatories are Astronomical Reserves

- Austria
- Belgium
- Denmark
- Finland
- France
- Germany
- Italy
- Japan
- Mexico
- Norway
- Russia
- Spain
- Sweden
- The Netherlands
- United Kingdom
- USA
- Over the last 40 years more than 75 institutions of 25 countries have installed their telescopes & instruments
- >600 people working for Astrophysics in Canary Island
- Observatories foster international collaborations

TELESCOPES & FACILITIES

Location: Island of La Palma (Canary Islands/Spain)	
Altitude: 2.396 m.	Area: 189 hectares
Longitude: 17°52'34" West	Latitude: 28°45'34" North

Ø cm	INSTRUMENT	OWNER &/or OPERATOR	YEAR
20	Automatic Seeing Monitor (DIMMA)	IAC (ES), UN (FR)	2004
30	Automatic Seeing Monitor (RoboDIMM)	STFC/ING (UK)	2007
<u>Optical & IR Telescopes</u>			
40 x 4	GOTO	Un. Warwick (UK)	2017
45	DOT	DOT Foundation (NL)	1997
60	Optical Telescope	KVA (SE)	1982
97	SST	Un. Stockholm (SE)	2002
100	Warwick 1m	Un. Warwick (UK)	2014
100	JKT	IAC/SARA	2015
120	MERCATOR	KUL (BE) IS (BE)	2002
200	LT	LJMU (UK)	2003
250	INT	IAC/ING (ES)	1984
256	NOT	NOTSA (DK, FI, IL, NO & SE)	1989
350	TNG	INAF (IT)	1998
420	WHT	IAC/ING (ES)	1987
1,050	GTC	GRANTECAN (ES), Un. Florida (US) INAOE & UNAM, (MX)	2008
<u>Cherenkov Telescopes</u>			
	FRAM	Czech Academy of Sciences (CZ)	2017
300	FACT	FACT Collaboration*	2011
1,700x2	MAGIC I & MAGIC II	MAGIC Collaboration**	2005 & 2008
2,300	LST 1	LST Collaboration***	2017
<u>Cameras</u>			
	CILBO	ESA (International)	2011
	AMOS-CI	CU in Bratislava (SK)	2014

Location: Island of Tenerife (Canary Islands/Spain)	
Altitude: 2.390 m.	Area: 50 hectares
Longitude: 16°30'35" West	Latitude: 28°18'00" North

Ø cm	Instrument	Owner	Year Operational
20	Automatic Seeing Monitor (DIMMA)	IAC (ES)	2010
<u>Microwave telescopes</u>			
40	GroundBIRD Experiment	RIKEN (JP)	2018
250x2	QUIJOTE I + II	IAC, IFCA & UnC (ES); UC & UM (UK)	2012 + 2014
<u>Optical & IR telescopes</u>			
8	Earthshine	NJIT (USA)	2009
34	COAST	OU (UK)	2016
40x2	LCOGT-Teide Node	LCOGTN (US)	2015
40x2	MASTER	Sternberg Institute MSU (RU)	2014 & 2015
30x2 & 40x2	Optical Telescope Array	Telescope Society (US)	2015
40	PIRATE	OU (UK)	2017
40x1 + 45x2	MAGEC	OAM (ES)	---
50	Mons Telescope	Un. Mons (BE)	1972
70	Vacuum Tower (VTT)	L-KIS (DE)	1989
80	IAC-80	IAC (ES)	1993
90	THEMIS	CNRS (FR)	1996
100	SONG	Un Aarhus (DK) IAC (ES)	2014
100	OGS	ESA (International)	1996
120 x 2	STELLA	AIP (DE)	2005 & 2008
150	Gregor (GT)	KIS, AIP & MPS (DE)	2014
155	Carlos Sánchez Telescope (TCS)	IAC (ES)	1972
<u>Solar Laboratory Instruments:</u>			
	Integral Spectrophotometer: MARK-I	UB (UK) & IAC (ES)	1977
	GONG	NSO (US)	1996
	High Resolution Photometer EAST	IAC (ES)	2006
<u>Cameras:</u>			
	CILBO	ESA (International)	2011
	AMOS-CI	CU in Bratislava (SK)	2014
	QES	Qatar Research Foundation (QA)	2016

Scientific Impact IAC

PI: Publicaciones en Revistas Internacionales con Árbitro
IR: *Invited Reviews*
CI: Comunicaciones en Congresos Internacionales
CN: Comunicaciones en Congresos Nacionales
T: Tesis Doctorales

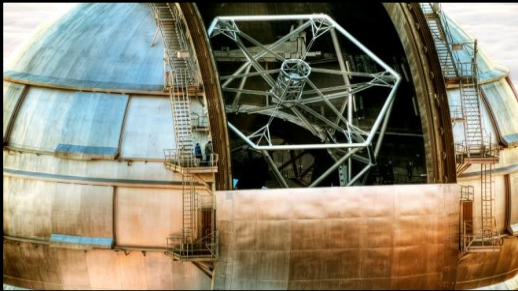
AÑO	PI	IR	CI	CN	T
2010	361	14	292	59	14
2011	367	24	245	30	2
2012	360	38	303	67	11
2013	356	33	250	55	10
2014	414	32	239	47	10
2015	439	17	387	15	16
2016	529	13	241	83	9
2017	596	27	176	20	18
2018	613	14	245	59	17
2019	531	13	196	43	17
2020	464	4	57	25	12

EL gran hito de I+D

GRAN TELESCOPIO CANARIAS

10.4 m

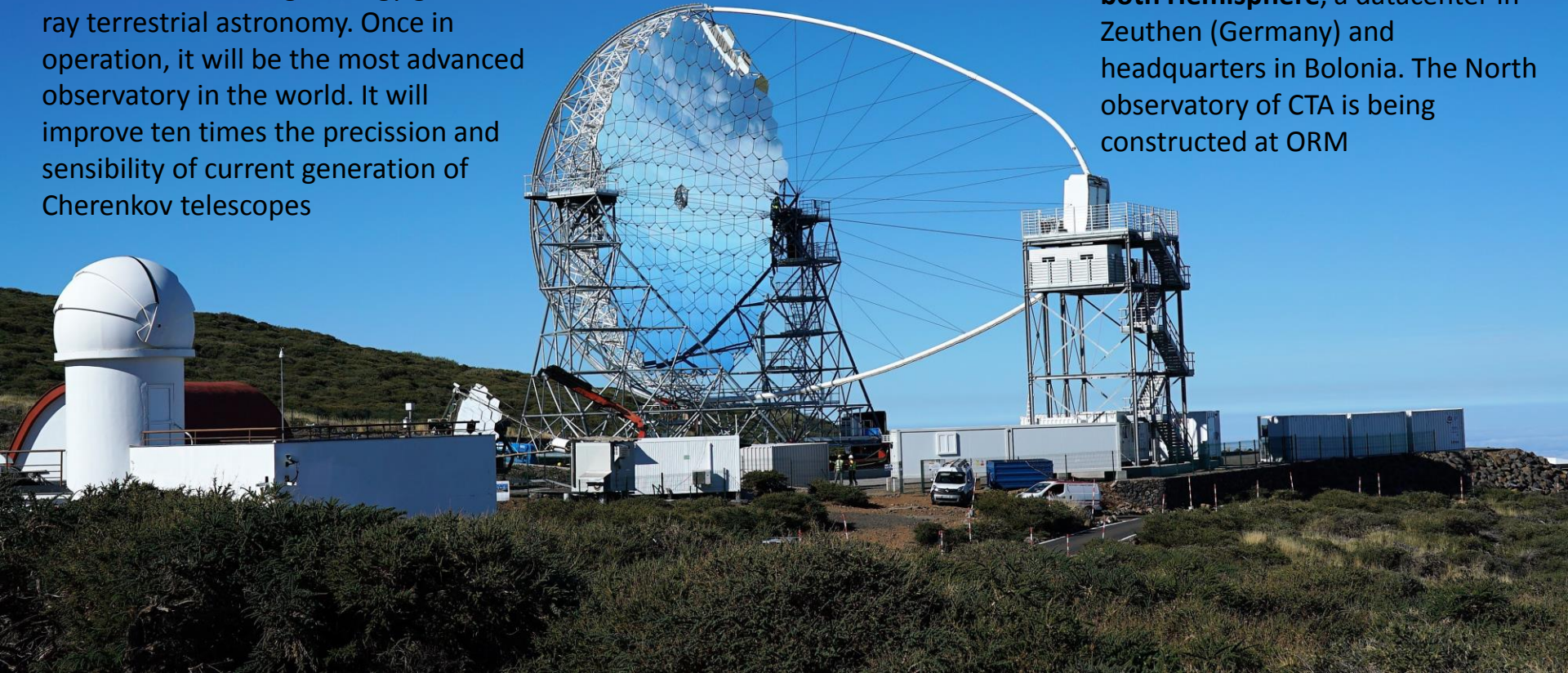
Largest optical/infrared single telescope in the world
>370 refereed publications (7 Nature + 2 Science)



CTA North on deployment

CTA (Cherenkov Telescope Array): large infrastructure for high energy gamma ray terrestrial astronomy. Once in operation, it will be the most advanced observatory in the world. It will improve ten times the precision and sensibility of current generation of Cherenkov telescopes

CTA consists of **two observatories** in **both Hemisphere**, a datacenter in Zeuthen (Germany) and headquarters in Bolonia. The North observatory of CTA is being constructed at ORM

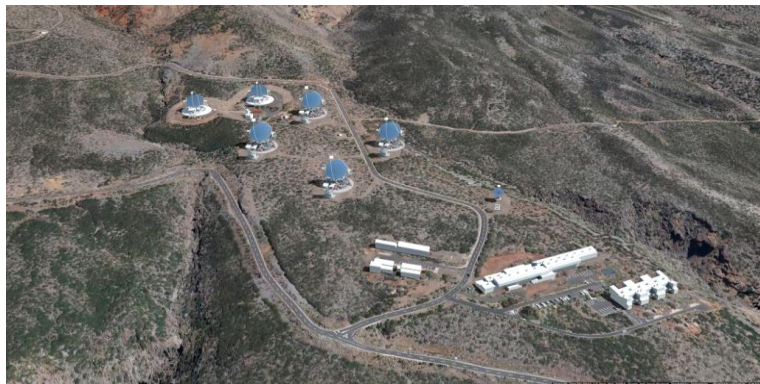




CTA North at the ORM



- This infrastructure **was included in the ESFRI roadmap of 2006** as an emergent project. In the update of 2008 it was updated as one of the 8 large project in Physical sciences and Engineering. After a revision between 2015-2017 **it was granted the category of ESFRI Landmark in 2018**
- In 2014 the legal entity CTA Observatory GmbH was funded. Currently it is the transition phase towards the **final legal form of ERIC**



cherekov
telescope
array



GOBIERNO
DE ESPAÑA

MINISTERIO
DE CIENCIA
E INNOVACIÓN

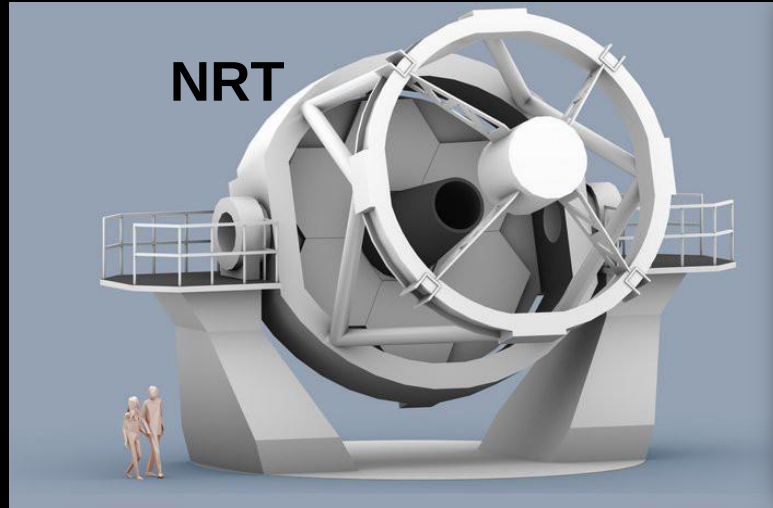


Gobierno de Canarias
Consejería de Economía,
Conocimiento y Empleo



Unión Europea
Fondo Europeo
de desarrollo Regional
"Una manera de hacer Europa"

THE FUTURE: NEW TELESCOPES



New 4m Robotic Telescope



European Solar Telescope



EXTREMELY LARGE TELESCOPES



COVID-19 and the Telescopes Operation



GENERAL ASPECTS

- Staff mobility was affected
- Remote access was the main work mode
- We had to improve the capacity access to the network

REACTION

- Remote controlled and Robotic telescopes were not affected
- Other telescopes replicated control rooms in remote location
- Operation in service mode (local astronomers)
- Most of the staff “teleworking”





LA PALMA

Surface **708,32 km²**

Perimeter **155,55 km**

Altitude **2.426 m**

14 municipalities

Population **83.548 inhab.**

Density **117,9 hab./km²**

GDP per cápita (est) **€ 20.402**

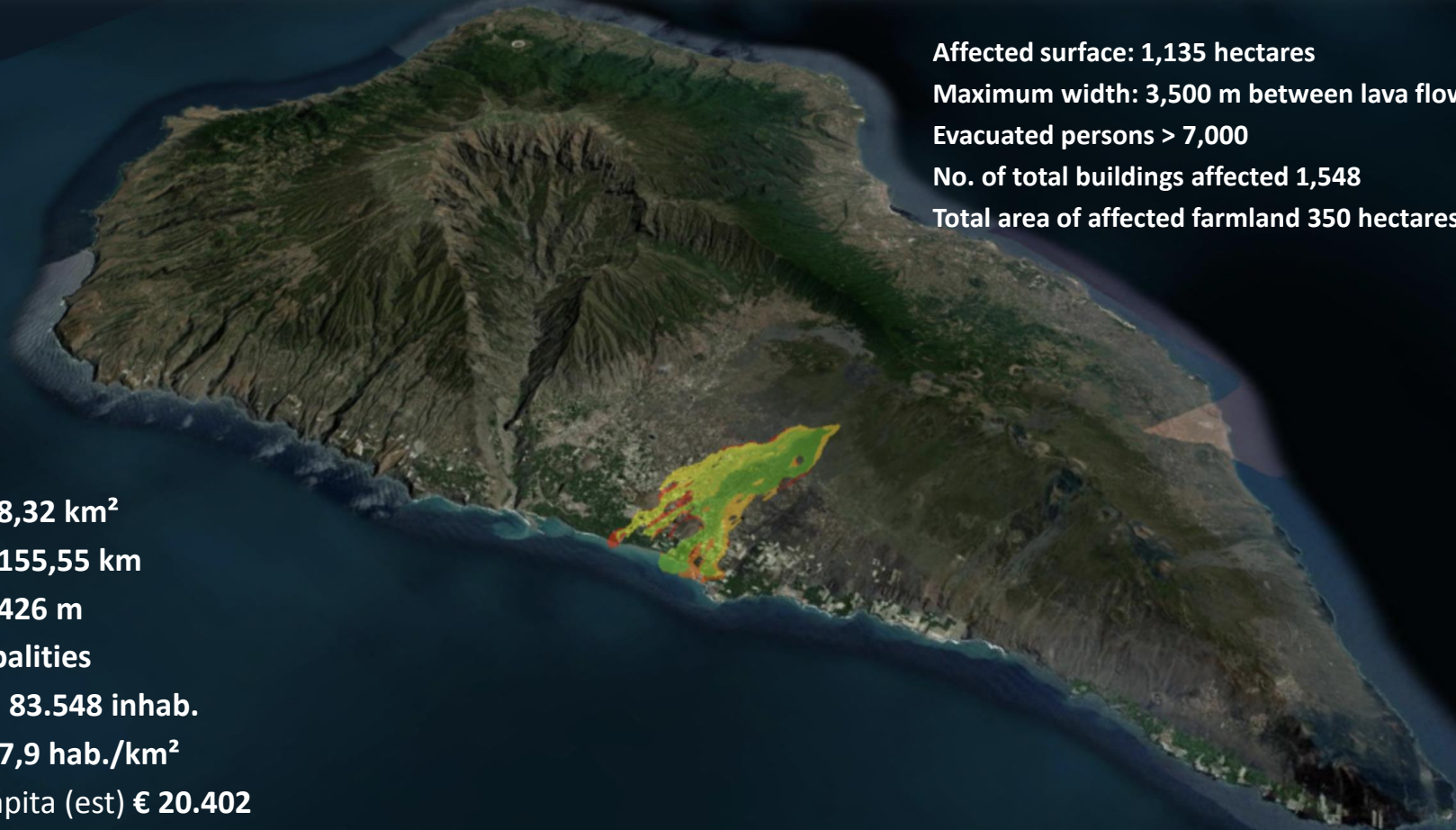
Affected surface: 1,135 hectares

Maximum width: 3,500 m between lava flows

Evacuated persons > 7,000

No. of total buildings affected 1,548

Total area of affected farmland 350 hectares



Support for telescope operations during Cumbre Vieja 2021 eruption

III. Otras Resoluciones

Consejería de Presidencia, Justicia y Seguridad

4147 DECRETO 73/2010, de 1 de julio, por el que se aprueba el Plan Especial de Protección Civil y Atención de Emergencias por riesgo volcánico en la Comunidad Autónoma de Canarias (PEVOLCA).

La Ley 2/1985, de 21 de enero, sobre protección civil, prevé que una Norma Básica de Protección Civil determinará las líneas de actuación en las situaciones de emergencia y contendrá las directrices esenciales para la elaboración de los planes territoriales y de los planes especiales por tipos de emergencia, entre otros.

La Norma Básica de Protección Civil, aprobada por el Real Decreto 407/1992, de 24 de abril, dispone en su artículo 5 que los Planes Especiales se elaborarán para hacer frente a los riesgos específicos cuya naturaleza requiera una metodología técnico-científica adecuada para cada uno de ellos. Entre los riesgos objeto de Planes Especiales, que se detallan en el artículo 6, constan los volcánicos.

En el supuesto de riesgos volcánicos, la Directriz Básica de Planificación de Protección Civil ante el Riesgo Volcánico fue aprobada por Acuerdo del Consejo de Ministros de 19 de enero de 1996, publicada mediante Resolución de 21 de febrero de 1996, de la Secretaría de Estado de Interior.

De acuerdo con lo dispuesto en los artículos 7 y 8 de la Norma Básica de Protección Civil, los planes especiales cuyo ámbito territorial no exceda del de una Comunidad Autónoma serán aprobados por el Consejo de Gobierno de la Comunidad Autónoma, previo informe de la Comisión de Protección Civil de la Comunidad Autónoma correspondiente y deberán ser homologados por la Comisión Nacional de Protección Civil, homologación consistente en comprobar que los planes se acomodan al contenido y criterios de la norma básica.

Dichos planes podrán integrarse en el Plan Director de la Comunidad Autónoma, y establecerán los mecanismos de coordinación con los planes de ámbito estatal para garantizar su adecuada integración.

En el ámbito de la Comunidad Autónoma de Canarias, tiene el carácter de Plan Director el Plan Territorial de Emergencias de Protección Civil de la Comunidad Autónoma de Canarias (PLATECA), aprobado por el Decreto 1/2005, de 18 de enero, en el que se establece el marco organizativo general para que puedan integrarse los planes especiales cuyo ámbito

sea el de la Comunidad Autónoma, y cuyas directrices sigue el PEVOLCA para establecer las pautas de actuación necesarias para responder ante un posible riesgo volcánico.

La Ley 9/2007, de 13 de abril, del Sistema Canario de Seguridad y Emergencias y de modificación de la Ley 6/1997, de 4 de julio, de Coordinación de las Funciones Locales de Canarias, ordena las competencias de la Comunidad Autónoma de Canarias en materia de seguridad pública mediante la organización del Sistema Canario de Seguridad y Emergencia, y de acuerdo con lo previsto en su artículo 28.c), atribuye al Gobierno la competencia para aprobar los planes especiales.

En virtud de lo expuesto, visto el informe de la Comisión de Protección Civil y Atención de Emergencias de Canarias, de fecha 19 de enero de 2009, previa homologación por la Comisión Nacional de Protección Civil, acordada en la sesión de fecha 3 de diciembre de 2009, a propuesta del Consejero de Presidencia, Justicia y Seguridad y previa deliberación del Gobierno en su reunión del día 1 de julio de 2010,

DISPONGO:

Aprobar el Plan Especial de Protección Civil y Atención de Emergencias por riesgo volcánico en la Comunidad Autónoma de Canarias (PEVOLCA), que figura como anexo.

Contra el presente acto, que pone fin a la vía administrativa, cabe interponer recurso postulatorio de reposición ante el Gobierno, en el plazo de un mes a contar desde el día siguiente al de su publicación, o directamente recurso contencioso-administrativo ante la Sala competente de lo Contencioso-Administrativo, del Tribunal Superior de Justicia de Canarias, en el plazo de dos meses a contar desde el día siguiente al de su publicación; significando que, en el caso de presentar recurso de reposición, no se podrá interponer recurso contencioso-administrativo hasta que se resuelva expresamente el recurso de reposición o se produzca la desestimación presunta del mismo, y todo ello sin perjuicio de cualquier otro que pudiera interponerse.

Dado en Las Palmas de Gran Canaria, a 1 de julio de 2010.

EL PRESIDENTE
DEL GOBIERNO,
Paulino Rivero Baute.

EL CONSEJERO DE PRESIDENCIA,
JUSTICIA Y SEGURIDAD,
José Miguel Ruano León.

Plan Especial de Protección Civil y Atención de Emergencias por Riesgo Volcánico (PEVOLCA)

- **2010** Created
- **2011** First action entry
 - *Tagoro submarine volcano*
 - *Island of El Hierro*
- **2021** Current eruption in Cumbre Vieja

Scientific committee



Civil Protection/ Government committee

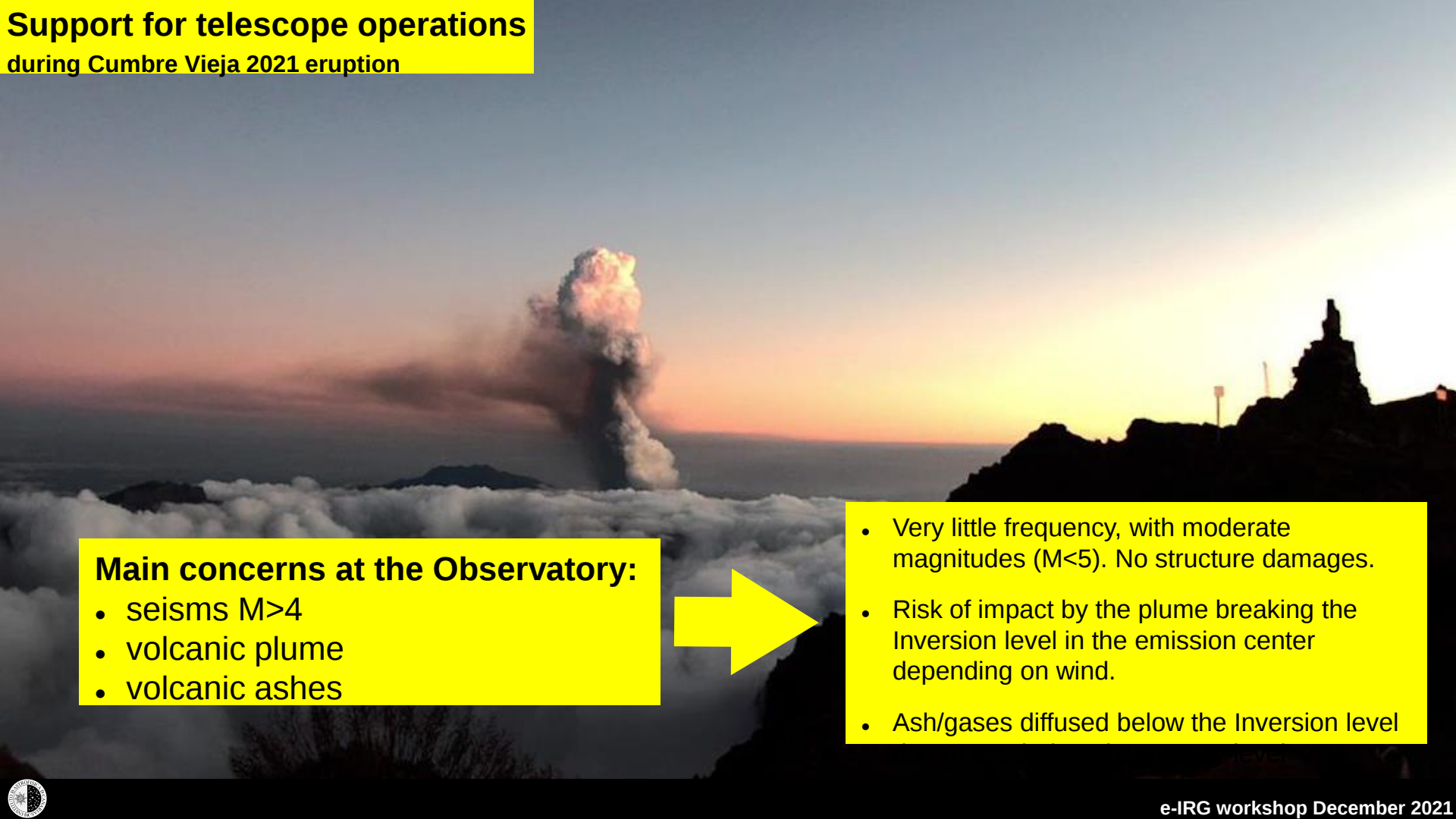


Instructions to the population

10 Scientific Institutions and >200 scientific accreditations

The IAC participates in PEVOLCA as 'invited observer'

Support for telescope operations during Cumbre Vieja 2021 eruption



Main concerns at the Observatory:

- seisms $M > 4$
- volcanic plume
- volcanic ashes



- Very little frequency, with moderate magnitudes ($M < 5$). No structure damages.
- Risk of impact by the plume breaking the Inversion level in the emission center depending on wind.
- Ash/gases diffused below the Inversion level

Support for telescope operations during Cumbre Vieja 2021 eruption

<http://research.iac.es/volcano2021>

VOLCANIC PLUME FROM CUMBRE VIEJA ERUPTION RISK OF IMPACT AT ROQUE DE LOS MUCHACHOS OBSERVATORY

DAILY REPORT

04 OCT - 18H UTC

UTC hours

MEASUREMENTS	OCT 02	AOD (AERONET)		High AOD values (0.3-0.4) in the afternoon.
		PWV (IAC & AERONET)		High PWV (natural process).
		DUST (TNG, GTC & Mercator)		Dust peaks (~150 µg/m³ 03h-06h). High values (~40 µg/m³ 06h-24h), coinciding with OT ('calima' event underway). High concentration of ultrafine particles (18h-00h).
	OCT 03	AOD (AERONET)		Moderate AOD values (0.2), descending in the afternoon.
		PWV (IAC & AERONET)		Moderate PWV (natural process).
		DUST (TNG, GTC & Mercator)		Dust levels slowly descending to ~10 µg/m³ (all stations and OT). Natural 'calima' event is easing.
FORECAST	OCT 04	00H-18H	PWV DUST	Dust values dropping to background (07h-...). Values at OT have also returned to background. Still moderate natural PWV values. Low AOD values (08h-...).
		06H-12H	-	
	OCT 04	12H-18H	-	
		18H-24H	0	
		00H-06H	0	
	OCT 05	06H-12H	0	
		12H-18H	1	
		18H-24H	1	
	OCT 06	00H-06H	1	
		06H-12H	2	

Legend:

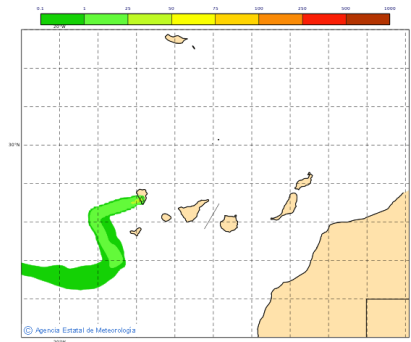
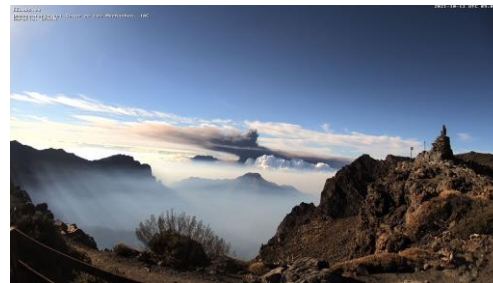
- No data

0 Low risk

1 Minor risk of ash fall

2 Medium risk of ash fall

3 High risk of ash fall - outdoor work not recommended



- **Daily reports updated every 12 hours**
- **Dust and Aerosol Optical Depth** can be indicators of the presence of ash.
- **Precipitable Water Vapour** may be used as a proxy of the presence of other **volcanic gases** (SO₂, e.g.)
- **MOCAGE chemical transport forecast model**
 - (Modèle de Chimie Atmosphérique de Grande Echelle)
 - 500hPa (~5500m)
 - 700hPa (~3000m)
 - 850hPa (~1500m)
 - 950hPa (~500m)
- **Other resources:**
 - CTA and MAGIC LIDARs.
 - CHEMICAL COMPOSITION AND PETROLOGY OF ASH. (IGME-CSIC).



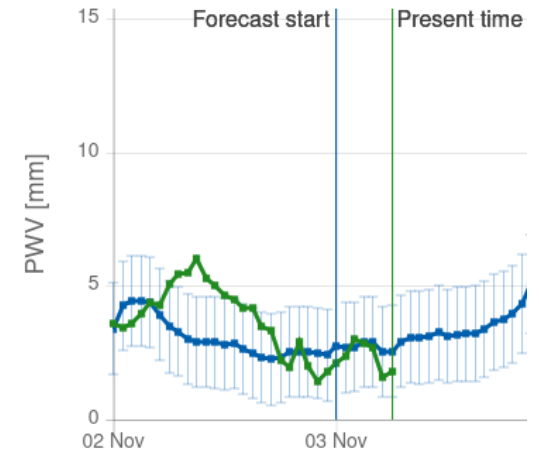
Support for telescope operations during Cumbre Vieja 2021 eruption

Affected by the plume

72-hour PWV forecast

ORM

(GNSS monitor  altitude: 2155 masl)



IAC PWV forecasting (ForO)



Support for telescope operations during Cumbre Vieja 2021 eruption



The
Liverpool Telescope
Observing robotically since 2004





Reproducible
Research
Telescope
Observations
Data
Access
Cumbre Vieja

LIVE STATUS
07 Nov 21:00 UT
Enclosure CLOSED
RCW HOLD RCS Idle

LATEST
Operations suspended due to
ash risk from nearby volcano.

LT site search

Home > Night Reports

Use phase2UI

Night Reports 2021

Home

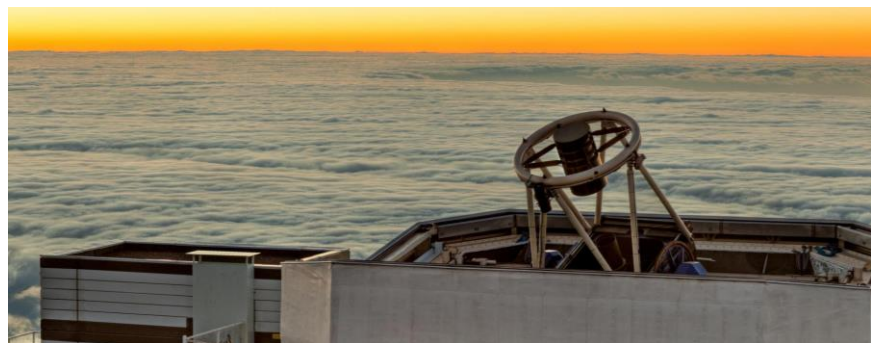
About

News

Night Reports

In the tables below, **Observing**, **Weather** and **Technical** refer to time spent observing, time lost to bad weather, and time lost because of technical problems. Note that Observing includes time spent on calibration observations and, occasionally, scheduled on-sky test observations; Technical does not include scheduled downtime (e.g. for planned engineering work).

Report Archive
2020
2019 - 2018 - 2017 - 2016
2015 - 2014 - 2013 - 2012
2011 - 2010 - 2009 - 2008
2007 - 2006 - 2005 - 2004



October 2021

Date	Hours Used			Comment	SkyCam	
	Observing	Weather	Technical		Zip Plot	Movie
31 Oct	0.0	10.2	0.0	Volcanic ash risk.	-	---
30 Oct	0.0	10.2	0.0	Volcanic ash risk.	-	---
29 Oct	0.0	10.2	0.0	Volcanic ash risk.	-	---
28 Oct	9.3	0.0	0.9	Photometric, average seeing. Cassegrain and azimuth node errors just before morning.	T	AT-
27 Oct	10.2	0.0	0.0	Photometric, average seeing.	T	AT-
26 Oct	0.0	10.2	0.0	Volcanic ash risk.	-	---
25 Oct	10.1	0.0	0.0	Photometric, average to poor seeing.	T	AT-
24 Oct	0.0	10.1	0.0	Volcanic ash risk.	-	---
23 Oct	0.0	10.1	0.0	Volcanic ash risk.	-	---
22 Oct	0.0	10.0	0.0	Volcanic ash risk.	-	---
21 Oct	0.0	10.0	0.0	Volcanic ash risk.	-	---
20 Oct	0.0	10.0	0.0	Volcanic ash risk.	-	---
19 Oct	0.0	10.0	0.0	Volcanic ash risk. RISE repair.	-	---
18 Oct	0.0	10.0	0.0	Volcanic ash risk.	-	---
17 Oct	0.0	9.9	0.0	Volcanic ash risk.	-	---
16 Oct	0.0	9.9	0.0	Volcanic ash risk.	-	---
15 Oct	0.0	9.9	0.0	Volcanic ash risk.	-	---
14 Oct	0.0	9.9	0.0	Volcanic ash risk.	-	---
13 Oct	0.0	9.8	0.0	Volcanic ash risk.	-	---
12 Oct	0.0	9.8	0.0	Volcanic ash risk.	-	---
11 Oct	9.5	0.0	0.3	Non-photometric with good seeing. Cass node reeboot, Negative Torque limit.	T	AT-
10 Oct	9.7	0.0	0.0	Photometric with good/average seeing.	T	AT-
9 Oct	9.7	0.0	0.0	Photometric with good/average seeing.	T	AT-
8 Oct	8.3	0.0	1.4	Non-photometric with good/average seeing. Secondary mirror focus failure.	T	AT-
7 Oct	9.7	0.0	0.0	Non-photometric with average seeing, plenty of high cloud.	T	AT-
6 Oct	0.0	9.7	0.0	Volcanic ash risk	-	---
5 Oct	0.0	9.7	0.0	Volcanic ash risk	-	---
4 Oct	9.6	0.0	0.0	Photometric with good/average seeing.	T	AT-
3 Oct	9.6	0.0	0.0	Photometric with average seeing.	T	AT-
2 Oct	9.6	0.0	0.0	Photometric with average seeing.	T	AT-
1 Oct	0.0	9.5	0.0	Volcanic ash risk	-	---

Géant



RedIRIS



IAC Network



Headquarters

- IAC general headquarter in La Laguna, Tenerife.
- Teide Observatory, Tenerife
- IACTEC Technology, Tenerife
- CALP Sea level office, La Palma
- Roque de Los Muchachos Observatory, La Palma



Network features

- Wide Area Network, two islands, five sites.
- High capacity bandwidth 10G – 100G
- Dark fiber to all sites.
- Private optical links to other international research institutions.

- MAGIC Telescope - Institut de Física d'Altes Energies (IFAE).
- SST Telescope - The Royal Swedish Academy of Science
- GTC Gran Telescopio de Canarias - GTC office
- SWASP, GOTO, W1M robotic telescopes - Warwick University

Coming soon...

- Cherenkov Telescope Array CTA - Port of scientific information (PIC Barcelona)
- Vacuum Tower Telescope VTT - University of Freiburg

IAC Fiber Network



Observatory ORM

Roque de los
Muchachos

La Palma

El Paso

CALP

IAC Headquarters

La Laguna

Santa Cruz
de Tenerife

Puerto de
la Cruz

Garachico

Teide Observatory

Tenerife

Adeje

Costa Adeje

Vallehermoso

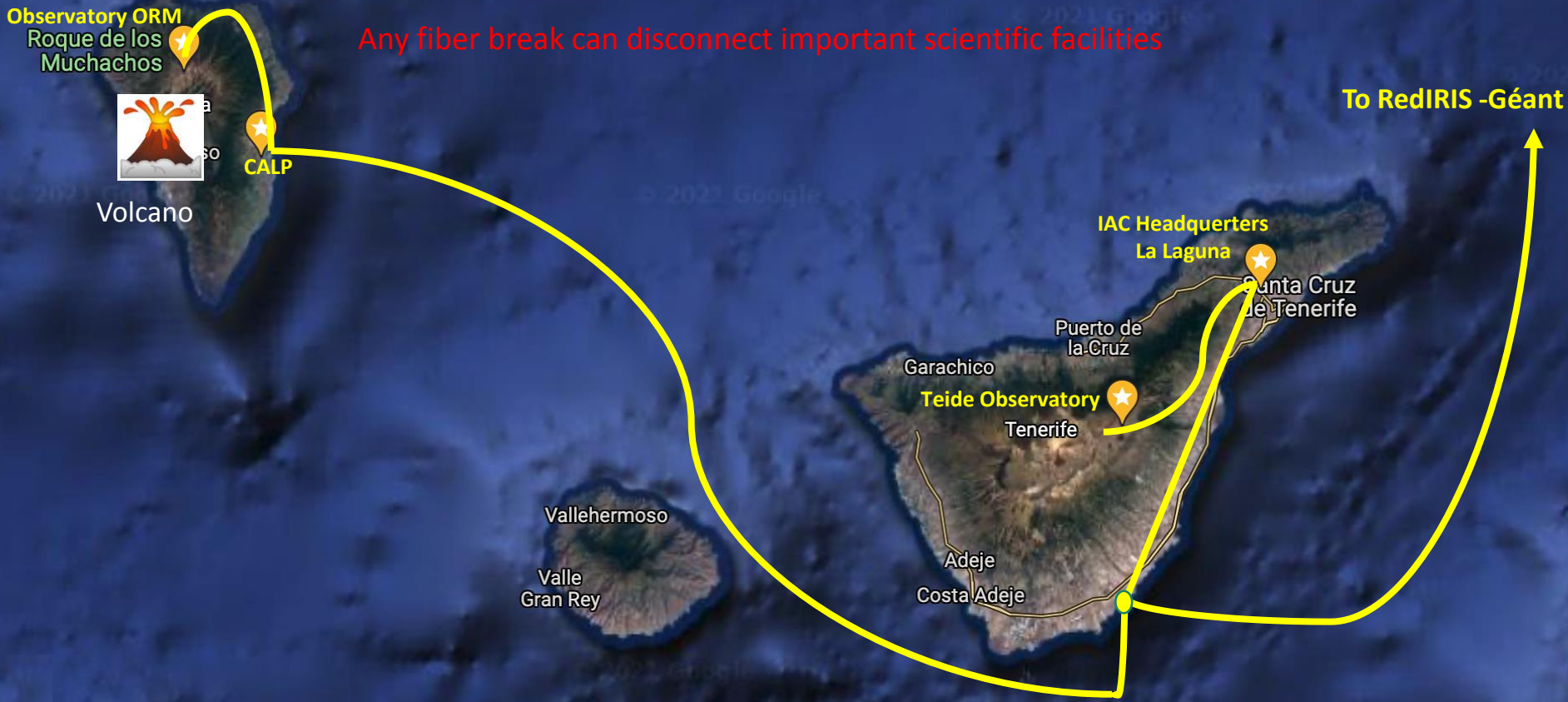
Valle
Gran Rey

To RedIRIS -Géant





Important Weakness. Fiber paths are not redundant.

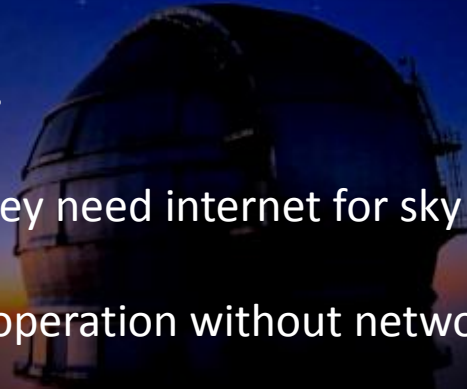




How long can operate our telescopes without connectivity?

Some examples:

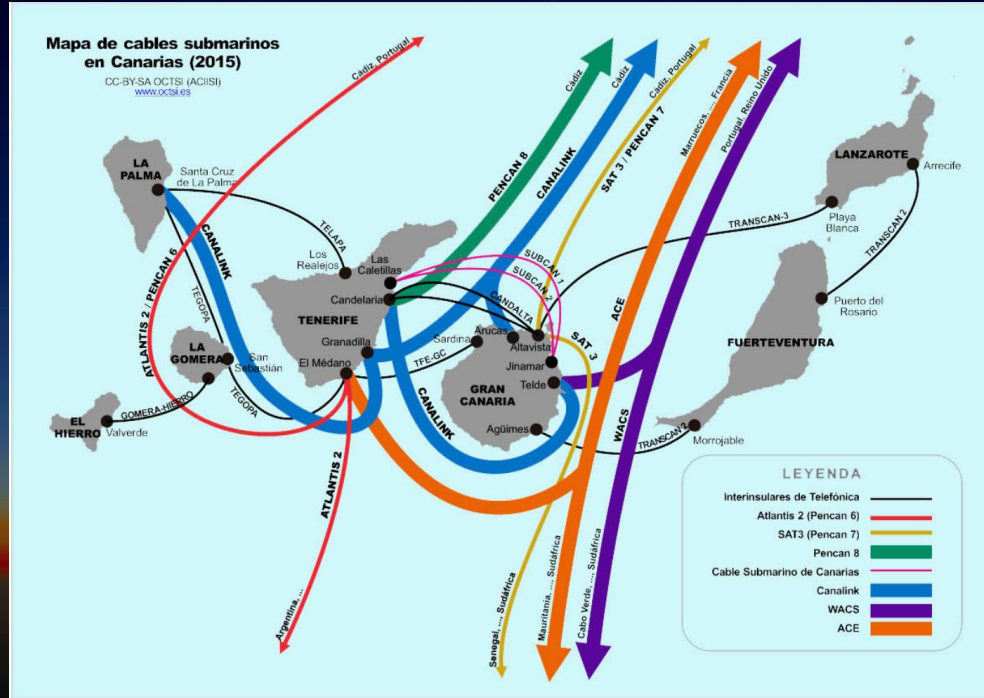
- GTC. 1-6 months saving data in local storage.
- Liverpool Telescope. (Robotic). 3-4 months in some instrument.
- SST. 2-4 weeks saving data in local storage.
- MAGIC. 4 days using local storage.
- TNG. Can use local storage, but they need internet for sky catalogues.
- GOTO-SUPERWASP. (Robotic) no operation without network for security reasons.
- JKT. (Remote controlled) do not operate without network.



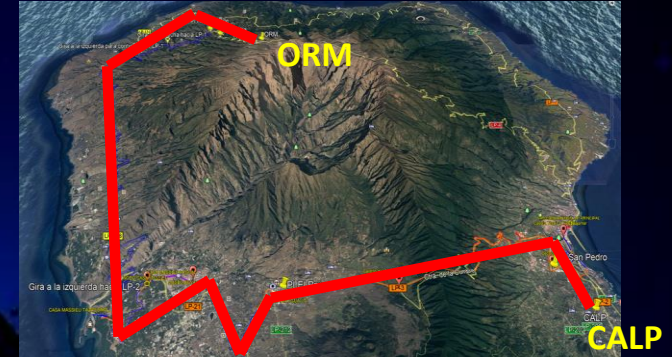
High availability network projects



Redundant submarine fiber



Redundant land links



CONCLUSIONS

- COVID 19 CHANGED OBSERVATIONAL MODE CULTURE: Remote control, Service mode
- VOLCANIC ERUPTION:
 - Instrument protection to prevent volcanic plume damage
 - Strict Telescope operation according to Safety and Security conditions
 - Mobility also affected (some flights canceled by volcanic ashes)

“CONNECTIVITY IS A FUNDAMENTAL ASSET TO ENSURE THE OBSERVATORIES SCIENTIFIC OPERATION”

“TO GUARANTEE SCIENTIFIC FACILITIES RESILIENCE, WE ARE PLANNING HIGH AVAILABILITY NETWORK PROJECTS”

RESILIENCE

Carlos Martín Galán (carlos.martin.galan@iac.es)

Juan Carlos Pérez Arencibia (jcperez@iac.es)