CTA-North site at
sierra San Pedro Martir in Baja California

Gagik Tovmassian on behalf of IA UNAM

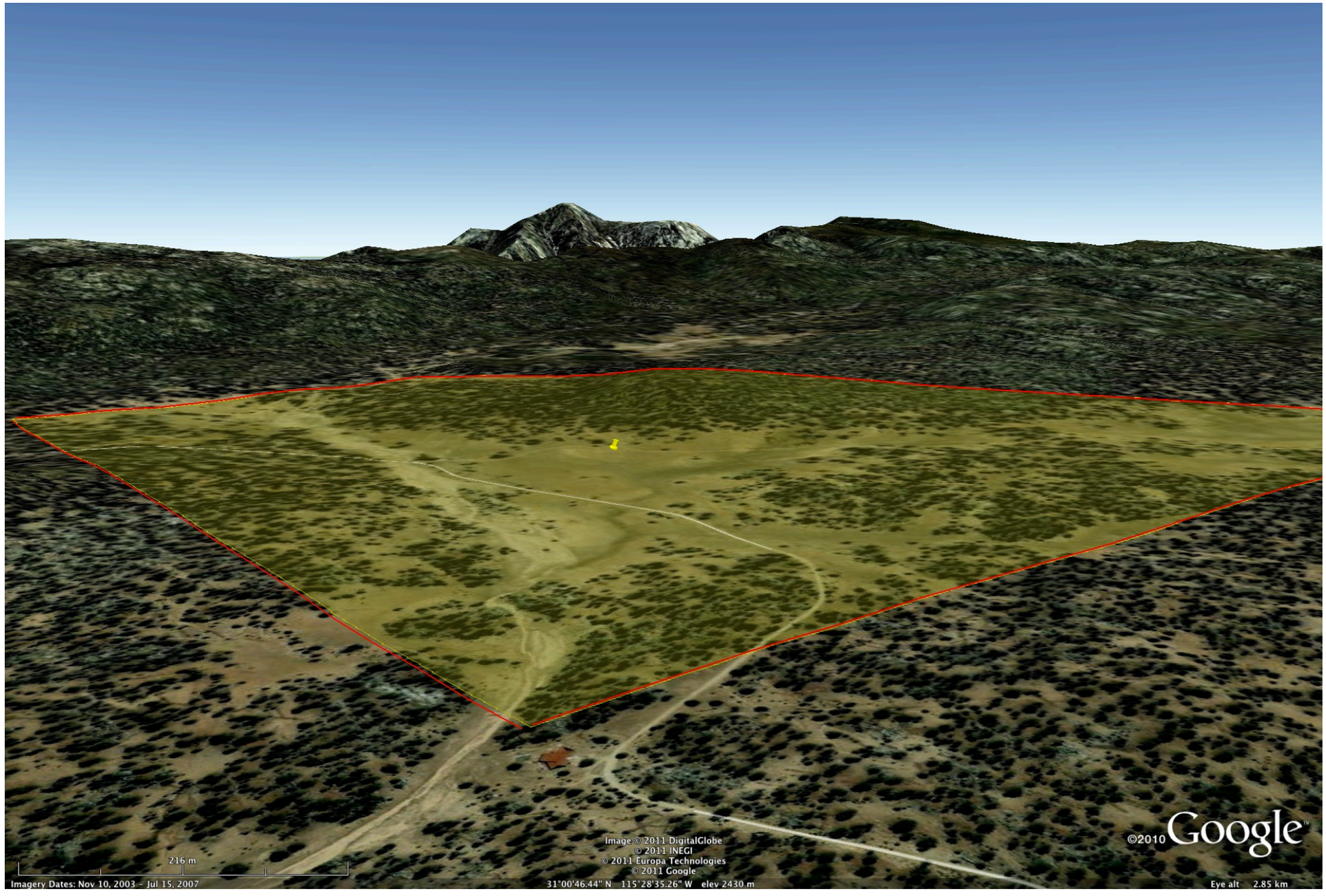
OAN SPM

- Universidad Nacional Autonoma de Mexico (UNAM) operates the Observatorio Astronomico Nacional SPM since 1967.
- At the present the observatory operates three optical telescopes: 2.12 m, 1.5 m & 0.84 m.
- The observatory is located at 31 02'40"N and 115 28'00" W within a National Park. The National Park is 72,900 hectares large. OAN occupies 500 hectares, but slightly more than 3,000 hectares are reserved exclusively for astronomy research.

The Proposed site for CTA-

- is entirely located within limits of the area destined for astronomy.
- UNAM is responsible for all environmental and construction permits in any astronomical project at SPM.
- Environmental permits are given by a federal authority, the Secretaria del Medio Ambiente y Recursos Naturales (SEMARNAT) after the Environment Impact Study & Technical Justification Study are submitted to this governmental body.
- SEMARNAT is obliged to respond to these requests within 60 and 30 working days for EIS and TJS correspondingly. The TJS time-line begins once EIS is approved.

The Proposed site for CTA-NORTH



Characterization of the site

- There are various studies of the SPM: Cruz-Gonzalez et al. (2003, 2004), Michel et al. (2003) Erazmus & van Staedel (2003), Tapia et al. (2007), more recently series of papers commissioned by the 30m telescope site testing Schoeck et al. (2011 and references therein) and the latest is Carrasco et al 2012.

- According to all tests the **SPM is one of the 4 best locations on the planet** for ground based astronomical observations, on par with Hawaii and only slightly inferior to the best Chilean sites.

Characterization of the site

- Sky brightness is the second darkest studied in the Northern Hemisphere, after Mauna Kea and is superior to La Silla, Cerro Tololo and continental USA observatories.

- $21.5 < U < 21.7$; $22.3 < B < 22.4$ $21.4 < V < 21.6$

Tapia et al, 2007

- The IA (Ensenada) is hiring a person in charge publicizing the Baja California's state law on light pollution and to provide a tech assistance to the businesses and government agencies. Meanwhile the state government sets an office to reinforce that law.
- Negotiations with corresponding authorities are underway and near successful completion to declare the area above OAN no fly zone.

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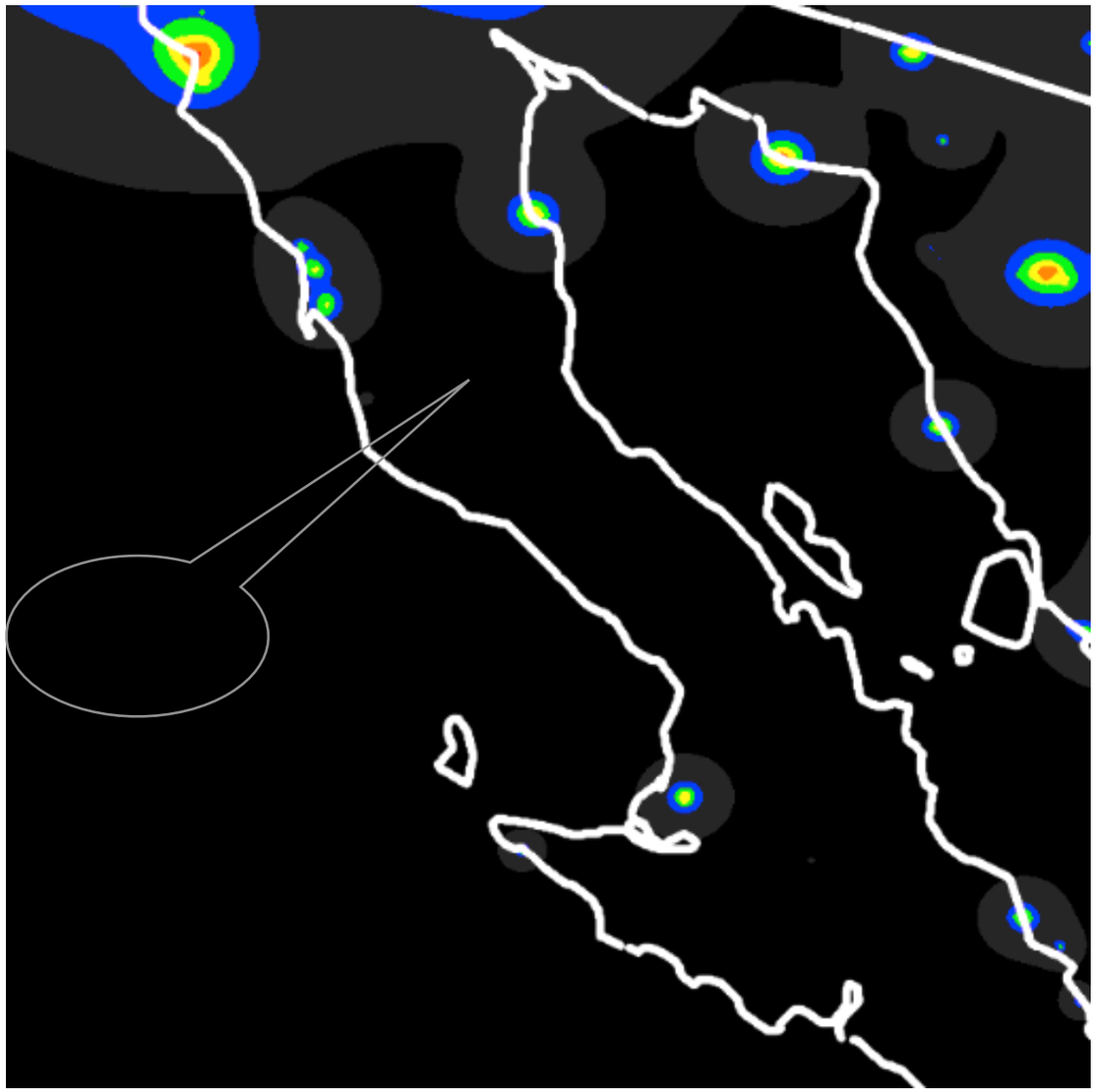
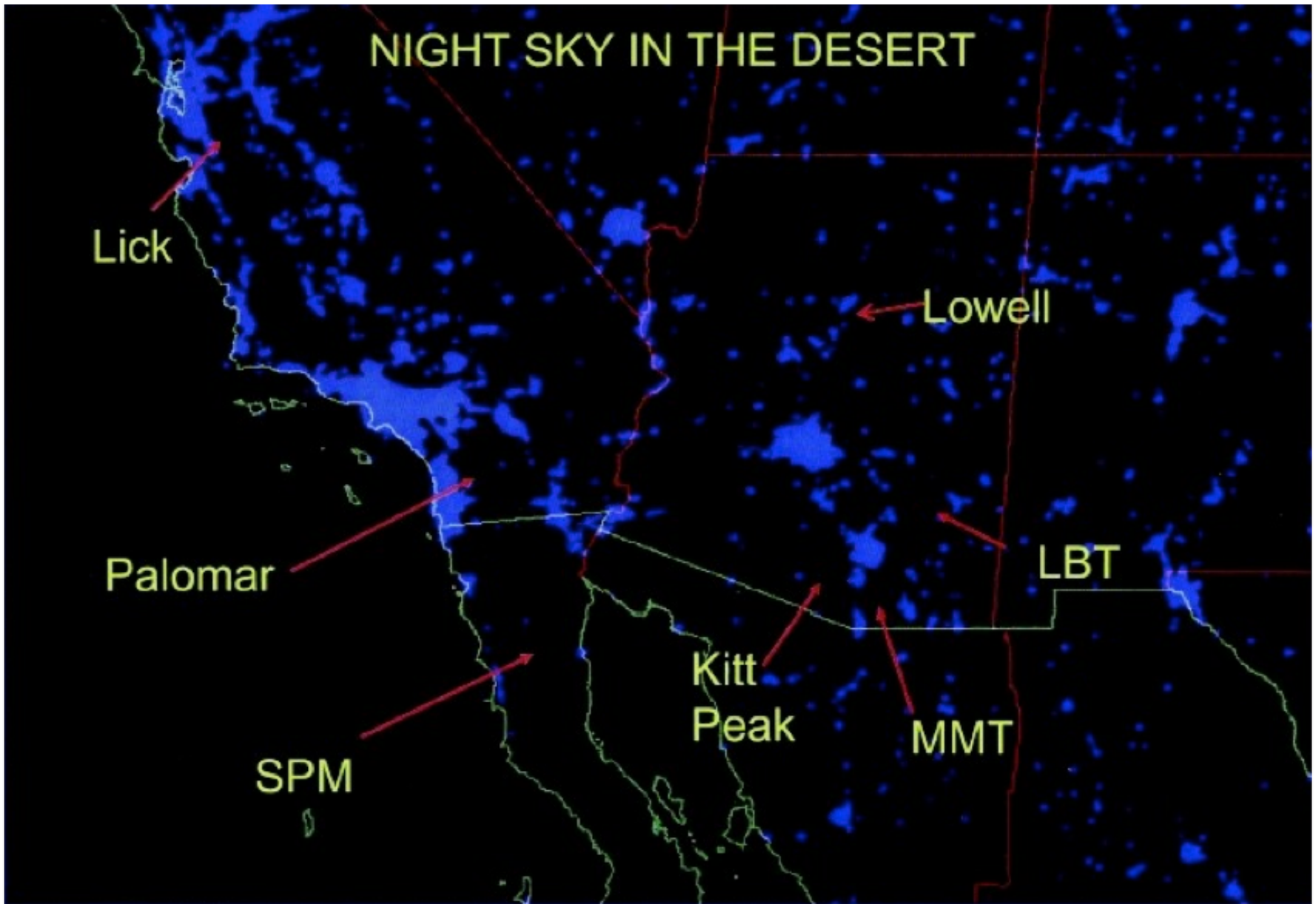


Characterization of the site

- Light pollution: SPM is really a dark spot on the night map of western northern hemisphere



Characterization of the site

Clear Nights

- > 80 % nights are cloudless. Carrasco et al 2012 find that 82.4 per cent of the time the sky is clear of clouds

- Tapia et al, 2007

TABLE 2

PERCENTAGE OF PHOTOMETRIC AND SPECTROSCOPIC NIGHTS: JANUARY 1984 TO DECEMBER 2006

Month	% Over scheduled nights	
	photometric	spectroscopic
January	53.2	72.7
February	44.6	63.7
March	59.1	76.0
April	66.6	84.3
May	72.2	90.2
June	83.8	94.0
July	65.6	79.9
August	63.2	80.3
September	65.9	85.9
October	68.0	80.9
November	60.5	76.4
December	55.3	69.5
Total	64.1	80.3

- Schock et al, 2009

TABLE 2

SUMMARY OF RESULTS FROM THE TMT CANDIDATE SITES (THESE VALUES ARE EXTRACTED FROM THE MORE DETAILED RESULTS IN THE OTHER PAPERS IN THE TST SERIES, AS INDICATED IN COLUMN (3). ALL VALUES ARE MEDIANS, UNLESS NOTED OTHERWISE. THE EXPECTED UNCERTAINTIES OF THE RESULTS ARE GIVEN IN TST-3–TST-11. DATA THAT ARE KNOWN TO HAVE PROBLEMS ARE SHOWN IN PARENTHESES)

Parameter (1)	Instrument (2)	TST (3)	Tolar (4)	Armazones (5)	Tolonchar (6)	SP Mártir (7)	Mauna Kea 13N (8)
Elevation (m)			2290	3064	4480	2830	4050
Total seeing (″)	DIMM	5	0.63	0.64	0.64	0.79	0.75
10% DIMM seeing (″)	DIMM	5	0.42	0.41	0.44	0.50	0.46
Free atmosphere seeing (″)	MASS	5,6	0.44	0.43	0.48	0.37	0.33
10% MASS seeing (″)	MASS	5,6	0.24	0.23	0.25	0.17	0.15
GL seeing 7–500 m (″)	D-M	5,6	0.34	0.35	0.32	0.58	0.54
Isoplanatic angle, θ_0 (″)	MASS	5,6	1.93	2.04	1.83	2.03	2.69
Coherence time, τ_0 (ms)	M+D	7	5.2	4.6	5.6	4.2	5.1
Night temperature 2 m (°C)	AWS	8	14.0	7.5	−0.7	5.4	2.3
Night wind speed 2 m (m/s)	AWS	8	3.2	6.3	2.7	(2.2)	3.7
Night wind speed 7 m (m/s)	Sonic	8	4.8	7.2	4.3	(3.3)	5.7
Night humidity 2 m (%)	AWS	8	19	21	36	38	30
T variation (10–90%) [°C]	AWS	8	5.6	7.5	9.5	16.2	6.8
Clouds: clear fraction	Satellite	9	87%	89%	82%	83%	76%
PWV (mm)	Combination	10	4.0	2.9	1.7	2.6	1.9
Fraction of PWV <2 mm	Combination	10	18%	29%	62%	35%	54%

- In terms of the percentage of clear and usable nights, the Erasmus & van Staedel 2003 report found SPM to be the best in the Northern hemisphere.

Characterization of the site

precipitable water vapor

- The overall median PWV shows that the atmospheric transmissions at San Pedro Mártir and Armazones are comparable in magnitude.

Otarola et al, 2010

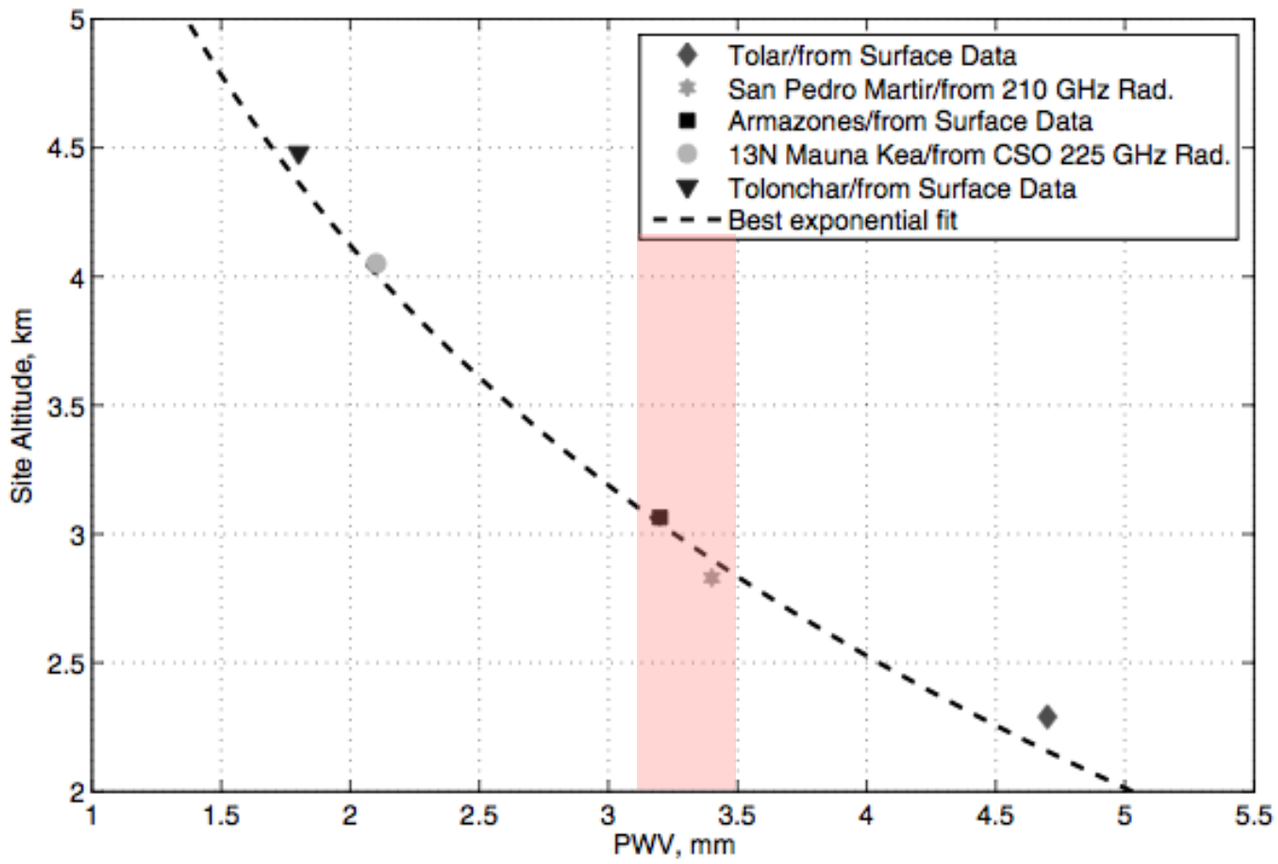


FIG. 8.—Overall median PWV values obtained in this study for the five TMT candidate sites in the period from 2004 until the end of 2007. The dashed line represents the exponential function that best fit the median PWV values and is given by the equation $\mathrm{PWV}(z) = 12 \cdot e^{-\frac{z[\mathrm{km}]}{2.5\,\mathrm{km}}}$ with results in mm. Symbols are defined in Fig. 6.

- Erasmus & van Staedel 2003 report a mean precipitable water vapor (PWV) in SPM of 2.63 mm.

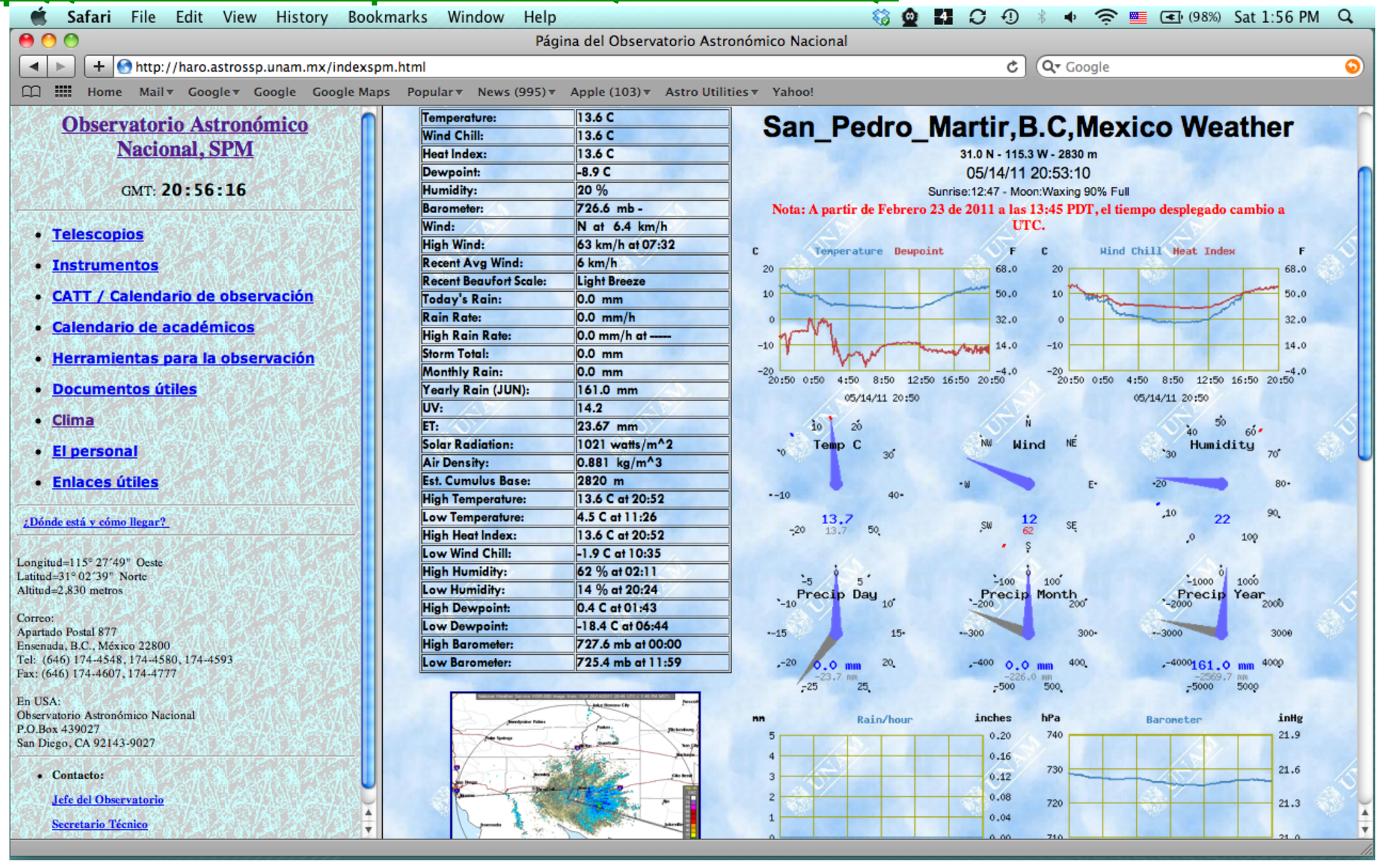
The Precipitable Water Vapor (PWV) is the amount of water vapor in the atmosphere contained in a vertical column of unit cross-sectional area above a site extending between two levels.

The Total Precipitable Water Vapor is that contained in a column of a unit cross-section extended all the way up from the earth's surface to the top of the atmosphere. It is also expressed in terms

Characterization of the site

monitoring

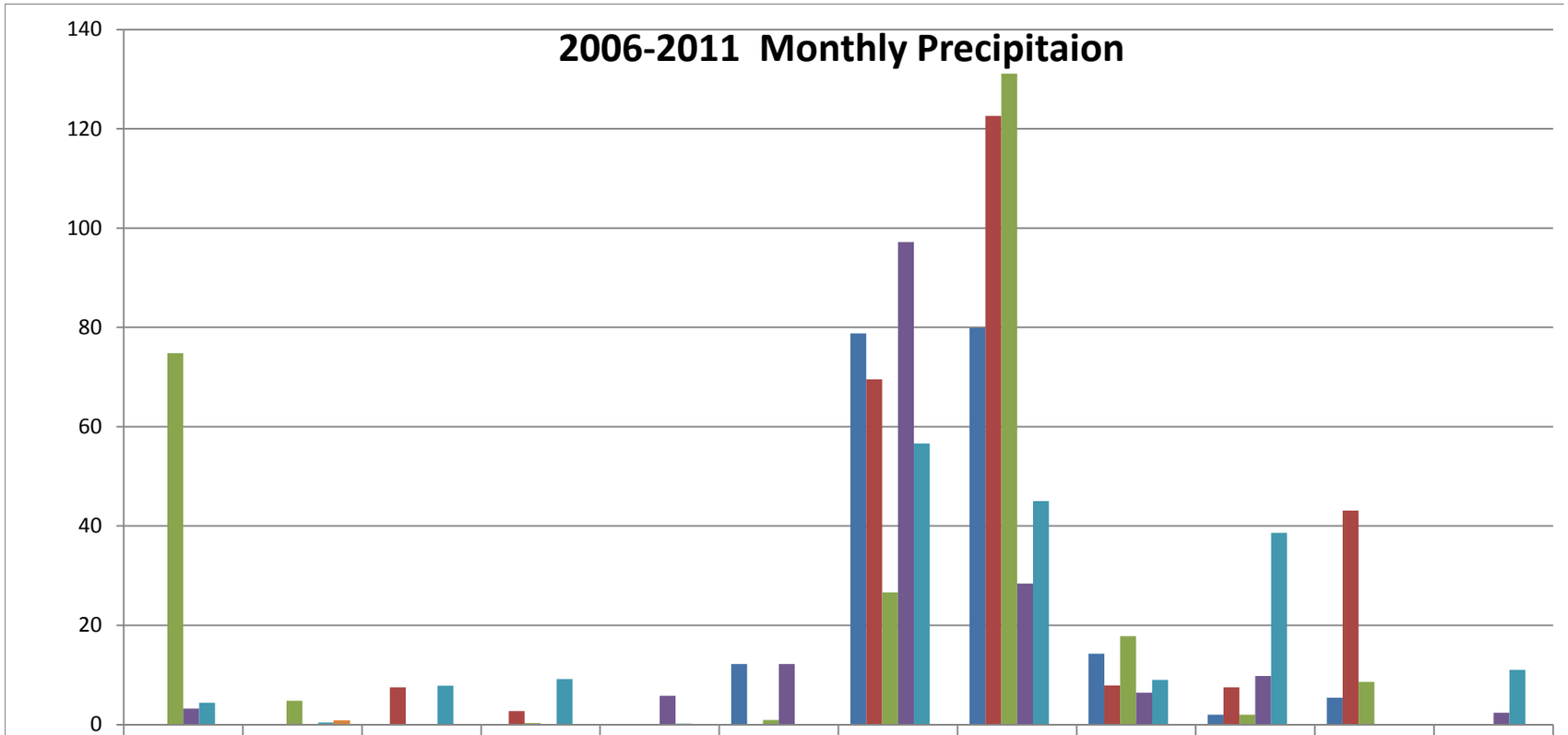
- The observatory has a weather station accessible from the web at http://www.astrossp.unam.mx/weather15/



Characterization of the site

precipitable water vapor

- I downloaded the data taken by the weather station available from mid-2006 to date and made some simple analyzes (terrible number of data taken every 15 min).



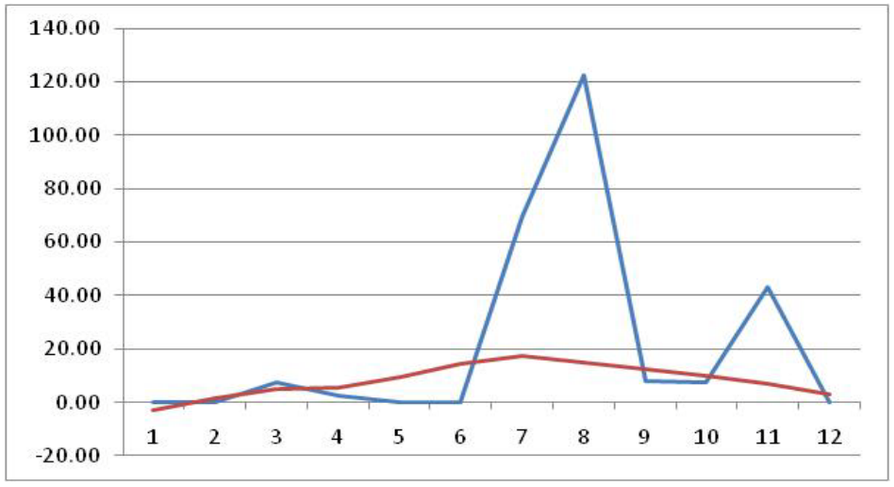
	January	February	March	April	May	June	July	August	September	October	November	December
2006						12.2	78.8	79.9	14.3	2	5.4	0
2007	0	0	7.5	2.7	0	0	69.5	122.6	7.9	7.5	43.1	0
2008	74.8	4.8	0	0.3	0	0.9	26.6	131.1	17.8	2	8.6	0
2009	3.2	0	0	0	5.8	12.2	97.2	28.4	6.4	9.8	0	2.4
2010	4.4	0.4	7.8	9.2	0.2	0	56.6	45	9	38.6	0	11
2011	0	0.8	0	0	0	0	0	0				

Characterization of the site

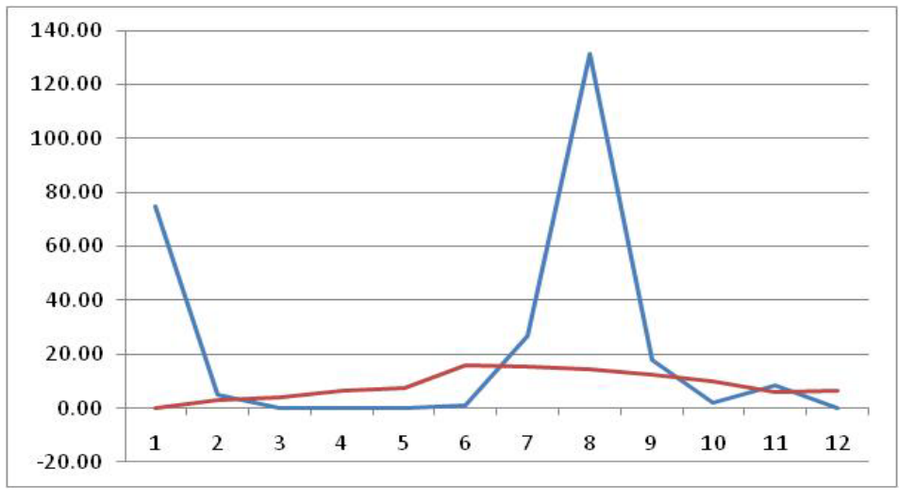
precipitable water vapor

- Binned data (PWV - blue; Temperature red)

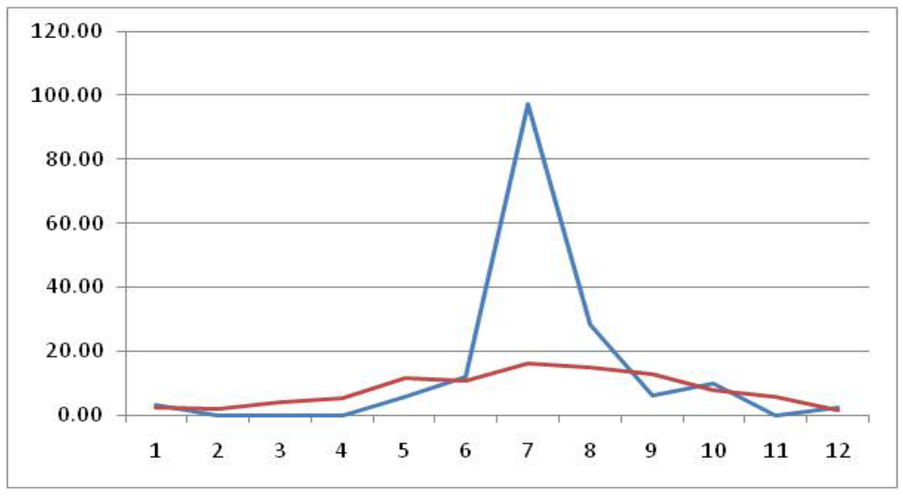
2007



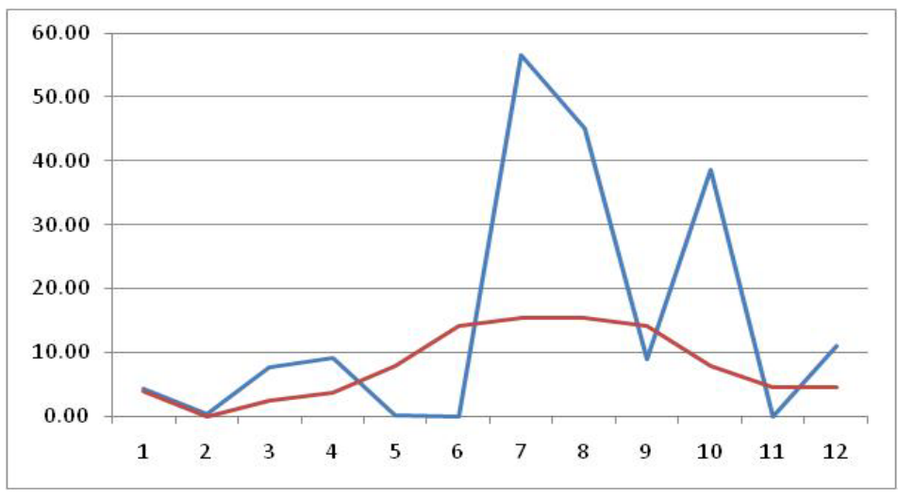
2008



2009



2010



Characterization of the site

orography effects

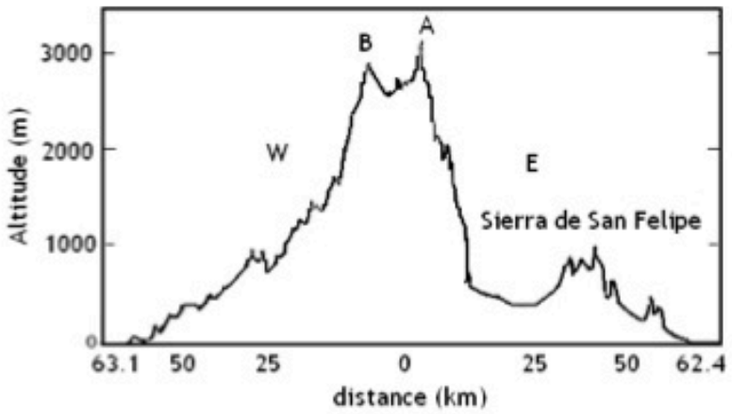


Fig. 3. *"Transversal cut" across the BC Peninsula, showing the steep gradient at both sides of the mountain. The orography of the mountain chain, controls precipitation and helps to keep a stable horizontal layer of the atmosphere on top of the SPM observatory. Horizontal axis in kilometers from the OAN (A) and vertical axis in meters, from sea level.*

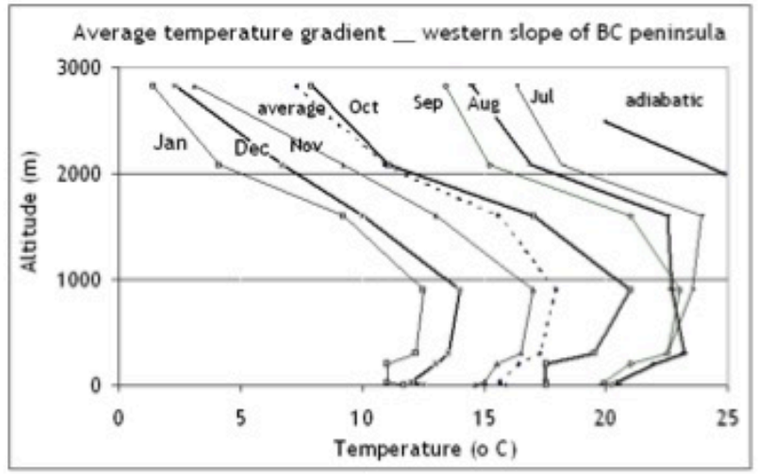


Fig. 4. *Temperature Gradient–SPM mountain. The average temperature of several climatological stations are plotted versus the altitude of the station, showing the stability of the atmosphere. The humidity of the lower layers stays most of the time below 1000 m altitude. Adiabatic gradient of the atmosphere is shown.*

- There are two important effects we want to stress in order to understand the behavior of the climatic considerations on top of a mountain; these are: a) the orography that controls the humidity and pluvial precipitation at the mountain tops and b) the global effect of the cold ocean current that surrounds Baja California peninsula.
- Figure 3 is a "transversal cut" of the BC peninsula through the SPM mountain tops, point A corresponds to the observatory located in the eastern side of the mountain and point B is the peak called La Corona, the highest peak at the western side of SPM. Most of the time the prevalent low velocity winds from the Pacific Ocean come from the West and the steep gradient of the mountain insures homogeneous atmospheric layers on top of the observatory, as can be seen from many astronomical observations made so far.

Characterization of the site

precipitable water vapor

- clear line of sight (CLOS) according to Alvarez and Maisterrena (1977). Summer weather with storm clouds and afternoon rain is clearly present during July and August; where the CLOS is less than 50% of the time during those months.

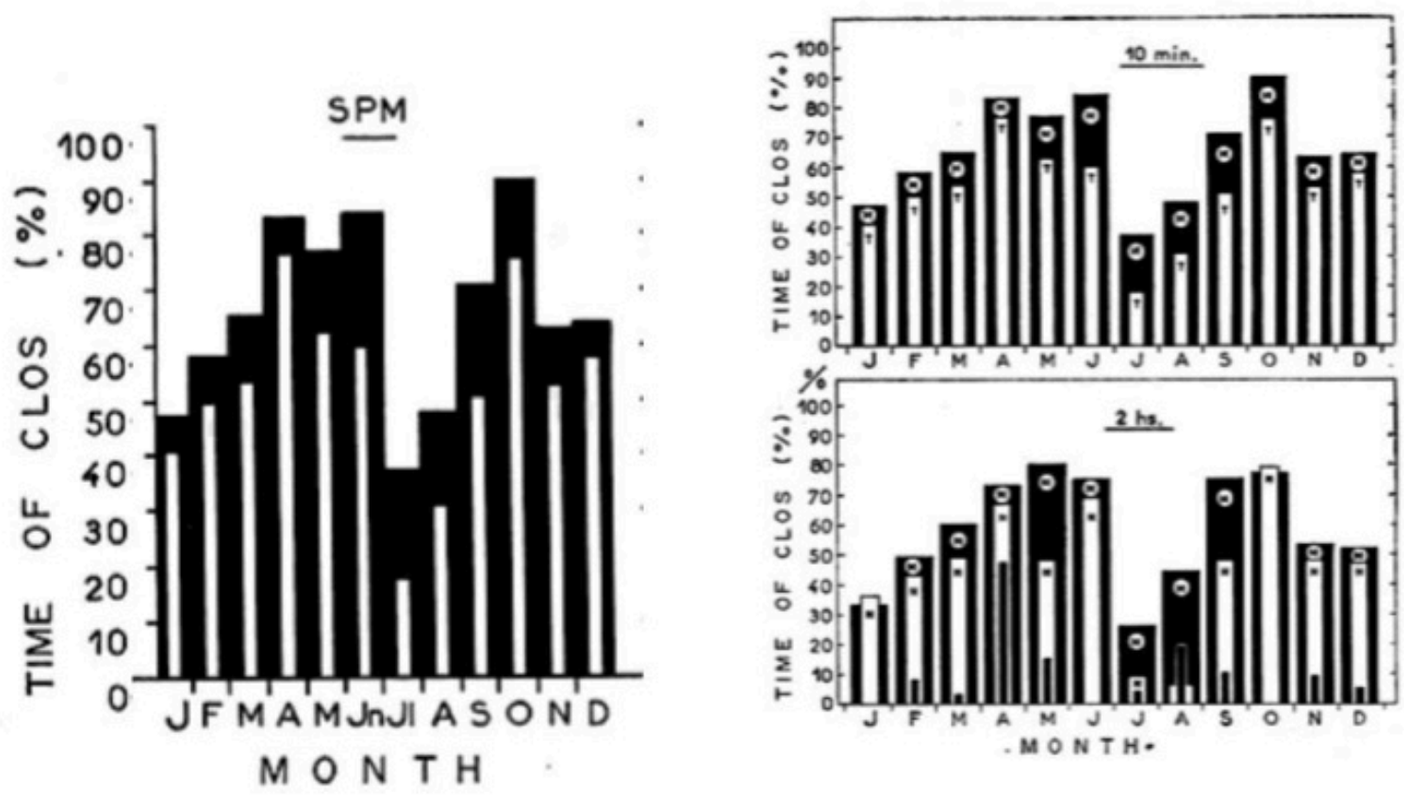


Fig. 1. *Insolación-SPM - left monthly average of Clear Line of Sight (CLOS) (black for morning, white for afternoon Right up 10 min periods of CLOS - right below 2 hr periods of CLOS - black and white as in the left panel*

Characterization of the site

precipitable water vapor

- The raining conditions for Ensenada and consequently for the San Pedro Martir Sierra are reproduced here from Alvarez et al. (2007) paper. Analysis of the data, show that there is a pattern of nearly 30 to 35 years showing periods of heavy rain following strong drought conditions, that extends through the whole interval of more than 115 years.

- The statistics of the 112 studied years give the following results, 62.5% show precipitation smaller or equal than the mean; 27.7% show extreme droughts (annual rain less than 100 mm below average); 37.5%,have rains heavier than the mean; 10.7%, showed strong rains (precipitation larger than 150 mm above the mean).

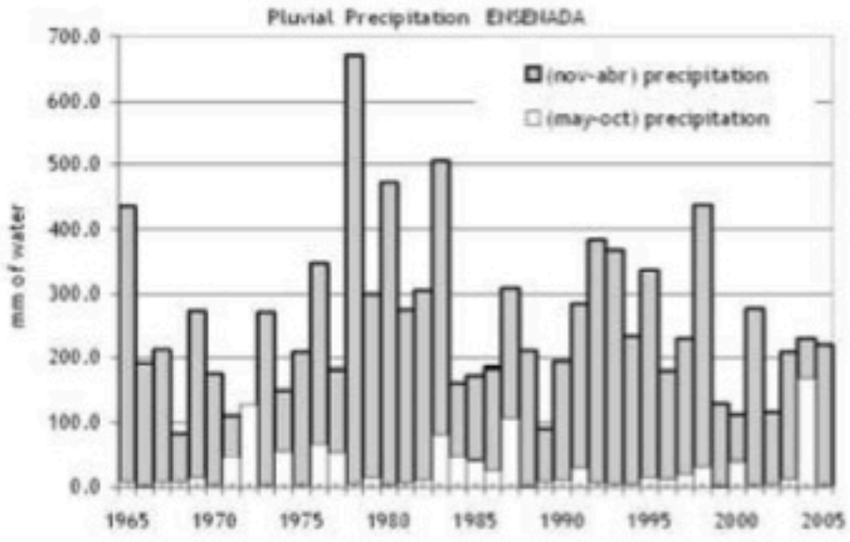


Fig. 6. *Invernal precipitation at ENSENADA from 1965 to 2005. Site testing at SPM mountains started in 1967. During those years, precipitation was below average (286 mm of water), and most of the time, this fact characterizes the region. The heavy rains from 1978 to 1983 are clearly seen. Alvarez et al (2007)*

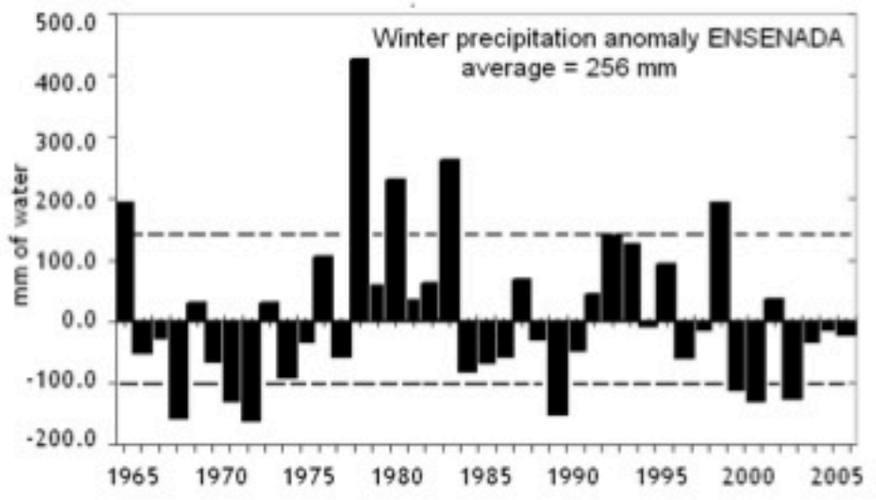


Fig. 7. *Precipitation anomaly of ENSENADA from 1965 to 2005. The years with a rain anomaly below the horizontal line at -100 mm of the average precipitation, corresponds to epochs of severe droughts. For those years with rain anomaly above 150 mm of water, severe rains and floods occurred. Alvarez et al (2007)*

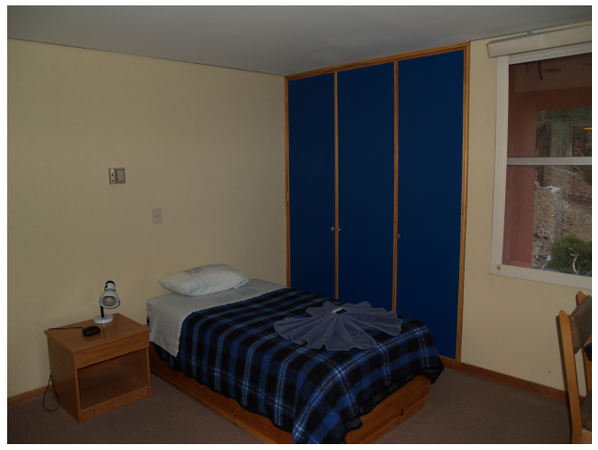
The Astro Climate for Proposed site CTA-NORTH is superb and always been the strongest card in our hand

The infrastructure

- The infrastructure at the summit and at the base in Ensenada is another strong point of our proposal. The cite is well developed with history of running successful operations, highly professional technical staff and services.

- However inn order to satisfy requirements of large project as CTA some upgrades are necessary.

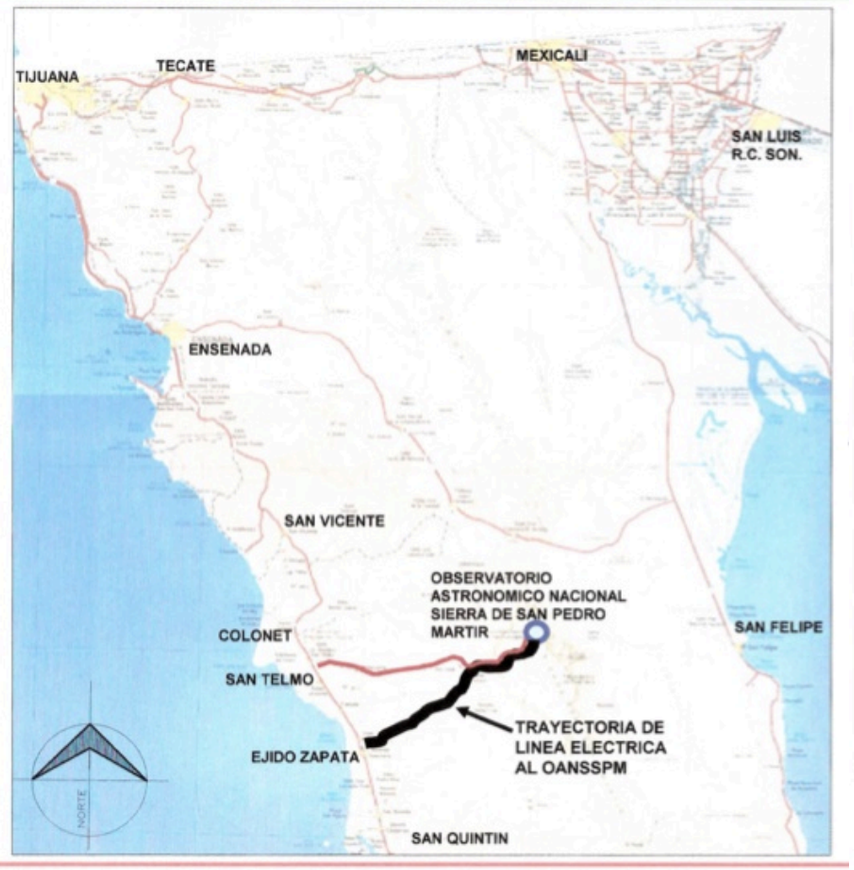
Summit accommodation and resources



The infrastructure

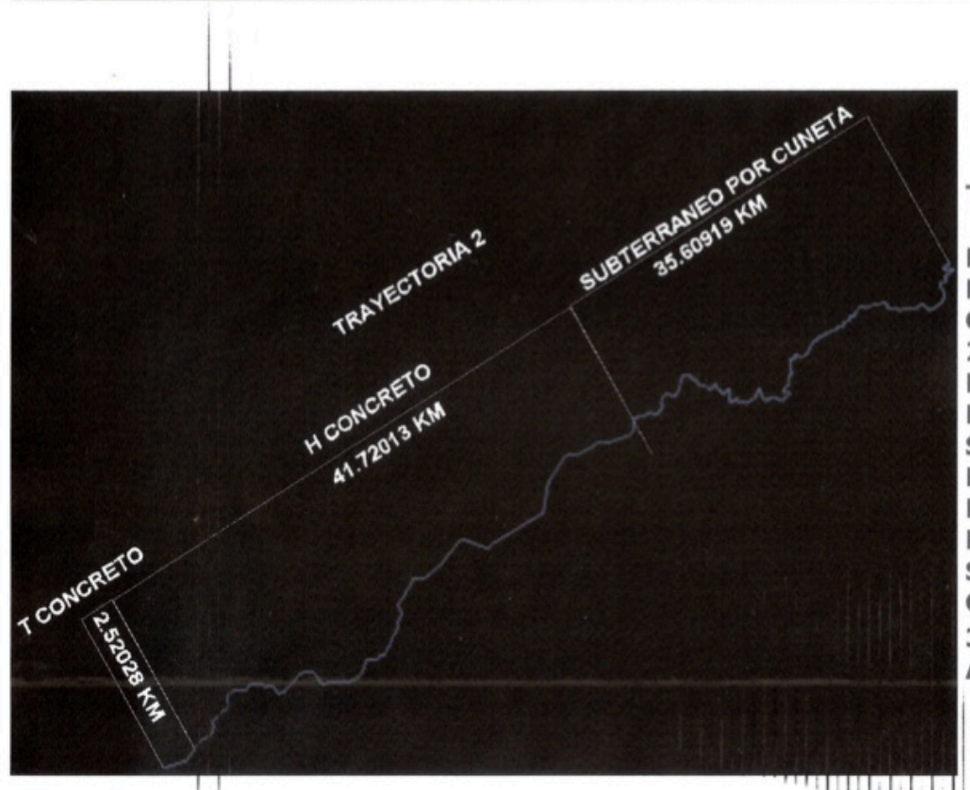
- A power line is being prepared for construction from the coast to the OAN SPM.
- The total length of the line is 80 km. The first 44 km would be built in the air, the remaining 36 km would be underground, including ~20 km crossing the National Park. The electric line will traverse the CTA site.

División de Distribución Baja California
Departamento de Proyectos y Construcción



División de Distribución Baja California
Departamento de Proyectos y Construcción

CFE Una empresa de clase mundial



TRAYECTORIA 2

RUTA AEREA CON ESTRUCTURAS T DE CONCRETO LOS PRIMEROS 2.520 KM, A PARTIR DE ESE PUNTO, ESTRUCTURAS H DE CONCRETO LOS SIGUIENTES 41.720 KM HASTA LLEGAR AL KM 62 DE LA CARRETERA, A PARTIR DE ESE PUNTO RED SUBTERRANEA POR CUNETA DE CARRETERA 35.609 KM HASTA LLEGAR AL OBSERVATORIO.

The infrastructure

- The cost of the project is 76,747,420 Pesos, equivalent to

~7 Million $US

- The cost will be covered by the UNAM, the Energy Department and the Federal Government in equal parts.
- The construction work would last approximately 18 months.

More good news.

- A fiber optics cable would be laid along the electric line. The cost is included above and is covered by a grant IA got from CONACyT to upgrade the internet connection to OAN SPM.

- We are actively conducting negotiations with Secretaria de Energia and CFE and hope to report a signed contract or even start of construction by the end of site selection process.

The infrastructure

The energy tariffs of CFE are:

- kW/h energía de punta: $ 1.9193 M.N.
- kW/h energía intermedia: $ 0.9566 M.N.
- kw/h energía baja: $ 0.7517 M.N.

For comparison, prices of EU are:

- kW/h France € 0.1226 = 2.18 M.N
- kW/h Germany € 0.2433 = 4.32 M.N.
- kW/h Spain € 0.1795 = 3.18 M.N.

- Price of internet connection would depend on the required bandwidth. Maximum 10Gb/s speed would be available.

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After these upgrades Mexico will provide perfect infrastructure for the CTA -North

Human and Technical Resources.

- Although Mexico is not known to be a technically advanced place, but northern Mexico, particularly Baja California, the maquiladora industry is the most dynamic part of regional manufacturing. With growth rates of 10-12% per year up maquiladora-based manufacturing has been one of the engines of regional employment and income growth since at least the mid-1980s.

- A number of plants, for example Sony, Samsung, RCA, and Philips, have their own R&D, particularly in product design, and they manufacture under their own labels and those of other companies. The electronics and auto-parts sectors comprise the two largest and most dynamic manufacturing sectors in the northern border region. The COLEF-FLASCO-UAM survey (ColefCOLEF, 2002) was administered to 180 maquiladora plants in Baja California.

Human and Technical Resources.

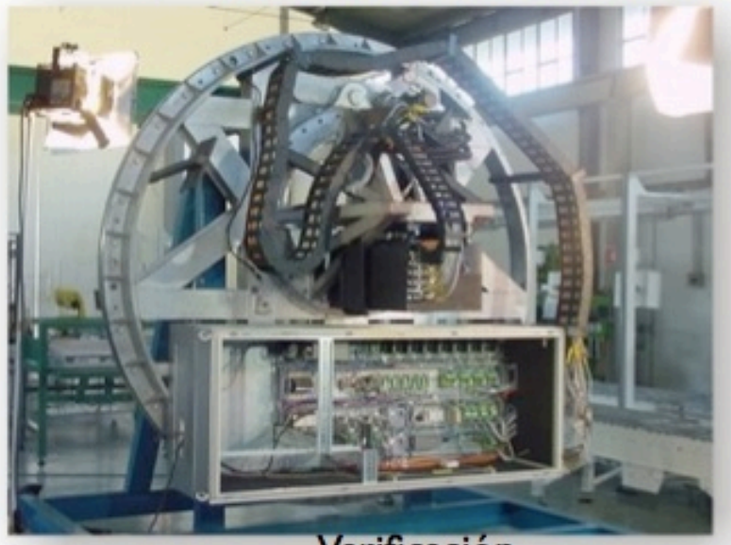
IA UNAM employs large number of highly professional and trained specialists in optics, electronics and high precision mechanics.

IA Ensenada shares a campus with Institute of nano sciences and nanotechnologies of UNAM and number of scientific institutes of CONACyT. Among them departments of applied optics & telecommunications. CICESE itself employs hundreds of skilled technical personnel.

Human and Technical Resources.

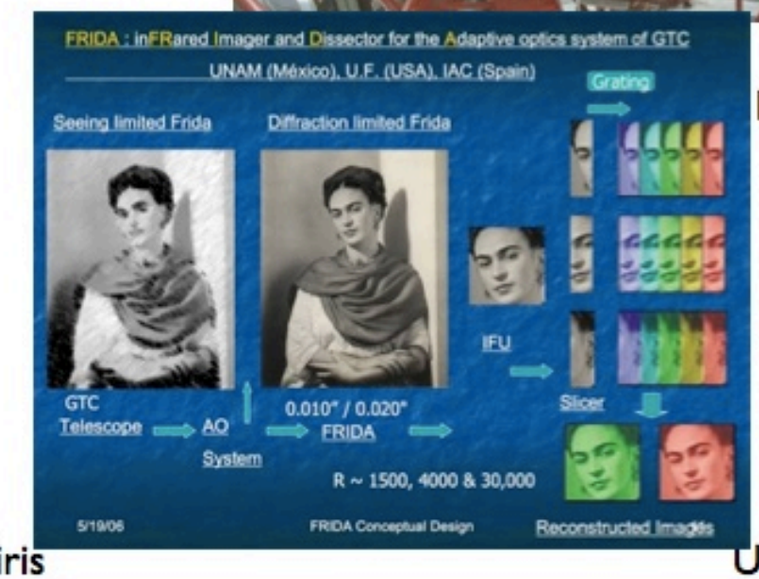
Impacto - 6

Desarrollo de instrumentación-Gran Telescopio Canarias



Verificación

Osiris



FRIDA

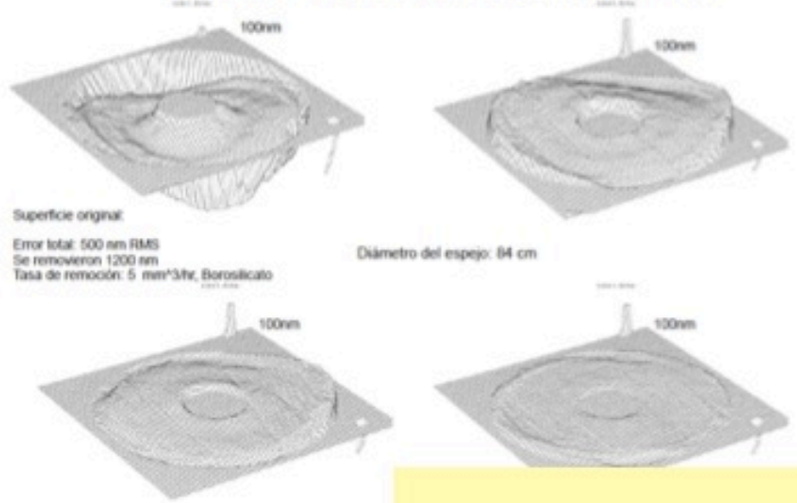
UNAM, CIDESI

Human and Technical Resources.

Impacto - 7

Desarrollo de instrumentación, HYDRA, pulido hidrodinámico

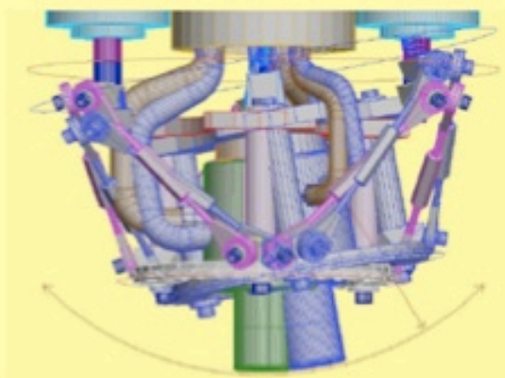
Resultados de pulido para un espejo de 84 cm

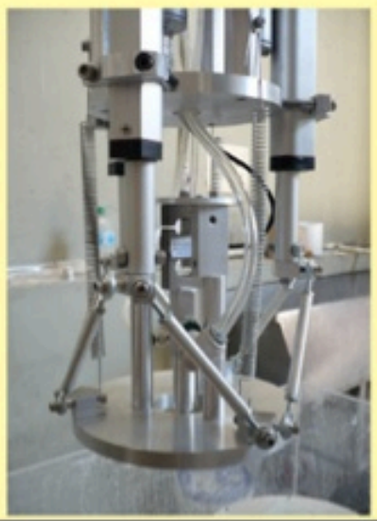


s de ser pulido con HyDRa

Hexápodo pasivo

Hexápodo que agrega tres grados de libertad a la máquina CNC de pulido (tip, tilt, pistón). Incluye una celda de carga y un laser para alinear la herramienta.





Thursday, August 18, 2011

Human and Technical Resources.

Our Partner in hosting CTA in Mexico is INAOE, Puebla based scientific conglomerate of CONACyT. Its another leading astronomical research institute in Mexico with electronics and optics departments.

Synergy with other VHE projects.

- On the top of Cierra Negra there is a Large Millimeter Telescope (LMT)

- In the shadows of mountain top, at 4100 m the High Altitude Water Cherenkov Experiment (HAWC) is being built 100 GeV - 100 TeV

Synergy with other VHE projects.

The Volcano Sierra Negra in Puebla, Mexico, was selected to host HAWC (High Altitude Water Cherenkov), a unique observatory of wide field of view (2π sr) capable of observing the sky continuously at energies from 0.5 TeV to 100 TeV. HAWC is an array of 300 large water Cherenkov detectors (7.3 m diameter × 4.3 m depth) at an altitude of 4100 m. a. s. l. Each detector is instrumented with four upward-looking photomultiplier tubes. HAWC will
1.- discover a large sample of localized gamma-ray sources and measure their spectra and variability to characterize TeV scale acceleration mechanisms;
2.- measure the spectrum and spatially characterize the diffuse TeV emission from Milky Way galaxy to probe the cosmic ray flux in other regions of the galaxy;
3.- observe extragalactic transient sources and notify promptly for multi-wavelength observations and;
4.- perform a deep, unbiased survey of the TeV gamma-ray and cosmic-ray sky to understand TeV astrophysical sources sufficiently to search for new fundamental physics effects.

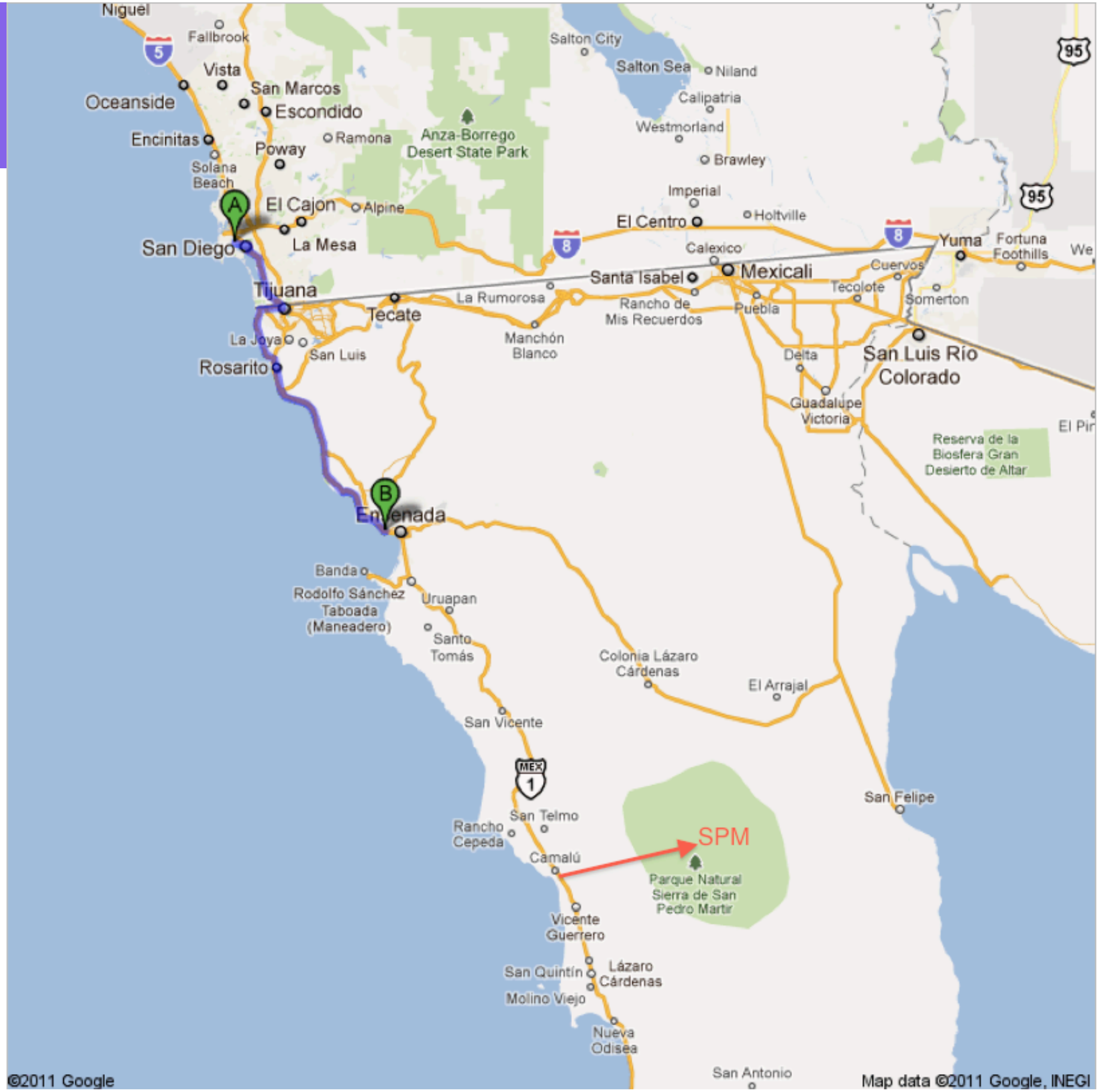
HAWC is a bi-national project between Mexico and U. S. A. where eleven of the twenty-seven institutions that form the collaboration are Mexicans. Instituto Nacional de Astrofísica Óptica y Electrónica (INAOE) and Universidad Nacional Autónoma de México (UNAM, the largest research Mexican institution), lead the Mexican efforts. The Mexican collaboration is formed of high-energy physicists and astrophysicists who have participated in other projects such as the Auger Observatory, the Alice- LHC experiment at CERN, the National Astronomical Observatories and the Milagro Observatory. Therefore, there is synergy between astronomical and high-energy physics instrumentation. The main scientific interests of the Mexican collaboration are solar activity, transient sources, AGNs, cosmic rays and exotic particles. Also, there are about thirty Mexican technicians in the collaboration who are working on the site development, DAQ acquisition system, design front-end electronics, development of the water quality system, design of alternative tank construction techniques, development of a robotic-arm for photo-tubes calibration, site integration and tank instrumentation, database warehouse development and maintenance, etc. Scientists and technicians are supported by Mexican institutions therefore their salaries are not coming from the project budget.
Besides the scientific and technical contributions, the Mexican collaboration has played a key role to keep the project on time (as recognized by NSF-DOE in the review of November 2011) by accelerating the importation process, decreasing the cost of the project, acquiring site permits and developing the site. It has open strong communication with governmental institutions such as U. S. A. embassy and CONACyT. CONACyT has promoted the formation of thematic networks to increase the synergy between groups. One of the most successful networks is the High Energy network (RedFAE) that has strongly supported the HAWC project. Also, the Mexican collaboration has been very active in educational and outreach activities.
The first construction stage of seven Cherenkov detectors is finished and running. The second stage of 30 water Cherenkov detectors is being developed. The construction phase is planned to finish in 2014. At this point, the two main institutions interested in CTA that are also leading HAWC, will be free to continue with a new challenge.

The CTA consortium will have no difficulty in selecting and hiring or employing high tech personnel or companies to deliver, assemble or run the project in northern Mexico.

As a bonus.

- The salaries in northern Mexico for tech staff in privileged institutes as UNAM are approximately 0.7 compared to average in EU, so the operational costs would be significantly lower compared to other perspective northern sites.

Logistics


Niguel
Fallbrook
Vista
San Marcos
Escondido
Oceanside
Encinitas
Solana Beach
Poway
Ramona
Anza-Borrego Desert State Park
Salton City
Salton Sea
Niland
Calipatria
Westmorland
Brawley
Imperial
El Centro
Holtville
Calexico
Yuma
Fortuna Foothills
Mexicali
Santa Isabel
Cuervos
Tecolote
Somerton
Puebla
Rancho de Mis Recuerdos
La Rumorosa
Manchón Blanco
Tecate
Tijuana
La Joya
San Luis
Rosarito
San Diego
El Cajon
Alpine
La Mesa
A
B
Ensenada
Delta
San Luis Río Colorado
Guadalupe Victoria
Reserva de la Biosfera Gran Desierto de Altar
Banda
Rodolfo Sánchez Taboada (Maneadero)
Uruapan
Santo Tomás
Colonia Lázaro Cárdenas
El Arrajal
San Vicente
MEX 1
San Telmo
Rancho Cepeda
Camalú
SPM
Parque Natural Sierra de San Pedro Mártir
Vicente Guerrero
San Quintín
Lázaro Cárdenas
Molino Viejo
Nueva Odisea
San Felipe
San Antonio
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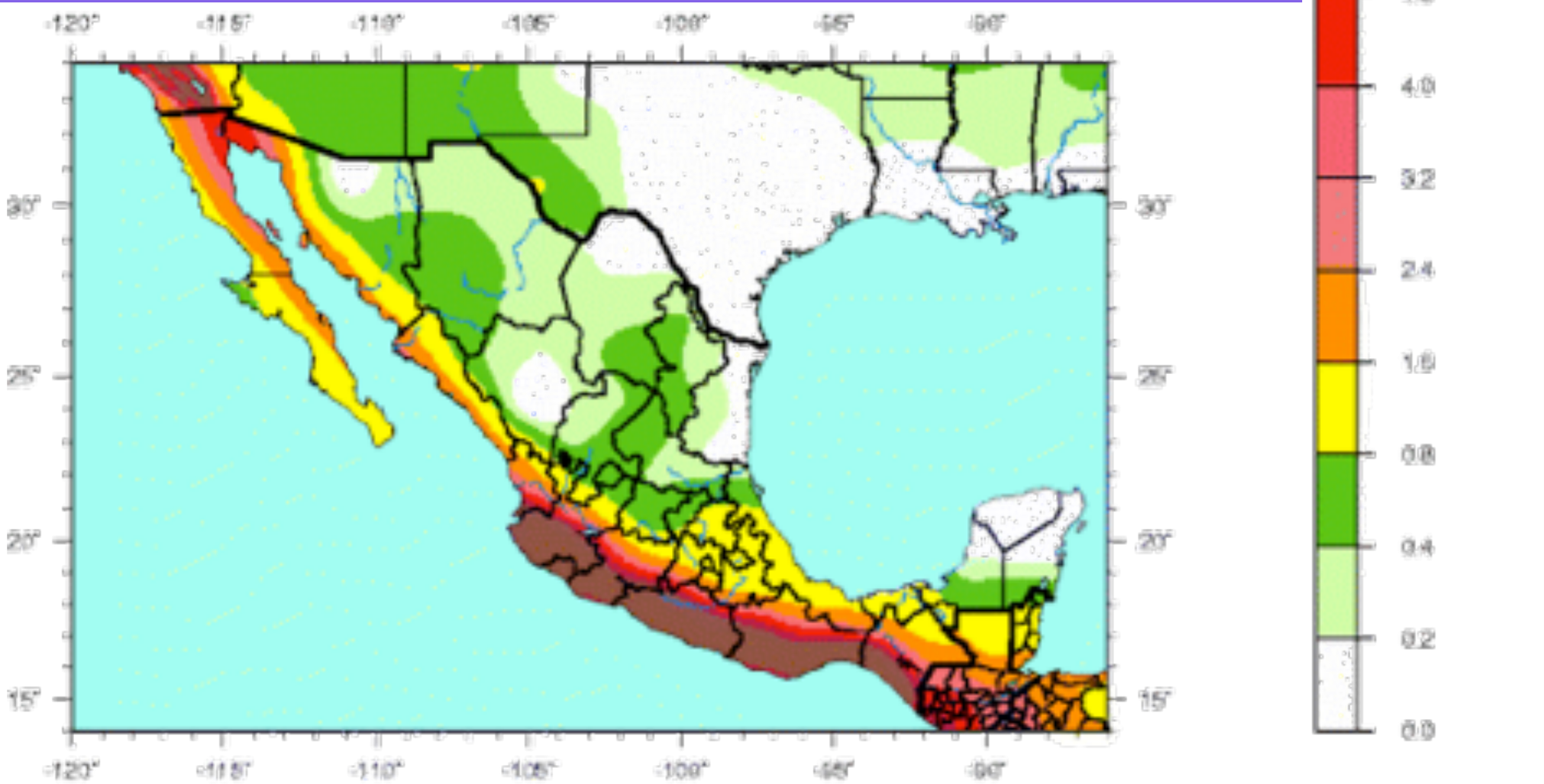
Logistics and base

- Ensenada is a lovely touristic town and port on the Pacific. Has plenty of hotels, reach in seafood, surrounded by vineyards and scenic natural wonders.

- It is also quiet and safe not only compared to other border cities but in general.

- Ensenada is a major commercial port, well connected to the whole world. Delivering large pieces of equipment are not problem.

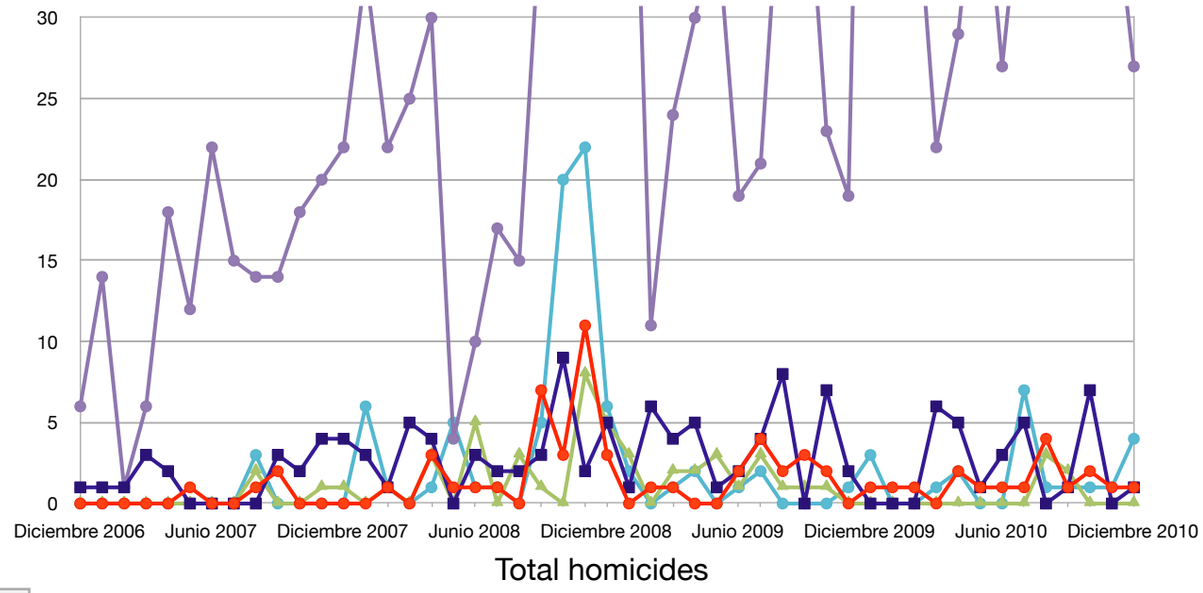
Safety



Peak Ground Acceleration (m/s^2) with 10% Probability of Exceedance in 50 Years

The observatory itself and the site proposed for CTA are located at the sideline of the earthquake activity, where the amplitude of displacement is estimated by the U.S. Geological Survey to be no more than 2.5 m/s2, which is only half of CTA requirements. Actually, one of the largest earthquakes in the region happened a little more than a year ago, on April 04, 2010 reaching magnitude 7.2 at the epicenter (32.259°N, 115.287°W) 50 km (30 miles) SSE of Mexicali, Baja California, Mexico, but it had no significant effect on the observatory and its facilities (no damage was sustained).

Safety



Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Most recent
South Africa	50	48	48	43	40	40	41	39	37	34	34
Bahamas	21	16	16	16	14	17	19	24	22	25	25
Brazil	30	31	32	33	31	29	31	29	30	23	23
Mexico	14	14	13	10	11	11	11	10	12	15	15
Russia	28	30	31	29	27	25	20	18	17	15	15
Argentina	7.2	8.2	9.2	7.6	5.9	5.5	5.3	5.3	5.8	5.5	5.5
United States	5.5	5.6	5.6	5.7	5.5	5.6	5.7	5.6	5.4	5.0	5.0

Table 1: San Pedro Martir Site Characterization.			
Sky transparency			
Usable nights[a;b]	80.1%		
Clear nights[a;b]	73.2%		
Water vapor content			
Mean PWV satellite[a]	2.63 mm		
Mean PWV radiometer[d]	2.40 mm (Oct-June)	3.4 (July-Sept)	4.5 extreme Aug
Sky brightness[f]	Dark	Bright	
U	21.5	19.3	
B	22.3	19.8	
V	21.2	19.7	
R	20.7	19.6	
I	19.2	18.4	
Mean wind velocity[i]	27 ± 3.6 m/s	26.5 ± 1.7 m/s	
Integrated anual seeing[c]	0.61 arcsec		
Spring, Summer	0.58 arcsec		
Autumn, Winter	0.68 arcsec		
Mean k_y[e]	0.14 @ 549 nm	0.055 @ 800 nm	