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Infrared and millimetric observing sites: a comparison

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Abstract. Infrared and millimetric observations are collecting an increasing interest in the astronomical community. High quality data can be obtained by space platform or from ground-based telescope placed in some peculiar sites. A first-order comparison between already exixting and future observing sites is presented in this paper.

Key words. Site testing – Atmospheric effects

1. Introduction

High quality sites for astronomical observations, from the mid-infrared to the millimetric wavelength range need some peculiar characteristics: low Precipitable Water Vapour (PWV), high atmospheric stability, good weather for most of the year, easy accessibility for instrument mantainance and personnel exchange. Many interesting sites are already operational, such as the Mauna Kea (Hawaii Islands), Tenerife and La Palma (Canary Islands), La Silla, Cerro Paranal (Chile), many high mountain sites in Europe and North America and the Amundsen-Scott station at the South Pole. The high antarctic plateau is collecting interest among astronomers because of the excellent quality for astronomical observations in a wide wavelength range. Projects for large telescope facilities are being developed in the Atacama desert (Chile). This paper will briefly describe the main parameters for site characterization and a first-order comparison between existing and proposed sites.

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2. Site-testing parameters

Some parameters are useful to characterize the quality of a site in the above mentioned wavelength range. PWV, which measures the integrated amount of water vapour in the atmosphere; Wind speed at ground level, which gives indication of how much turbulent is the surface and boundary layer atmosphere; weather stability in terms of *good* observing nigths; accessibility of the site and logistic, which is an important parameter for a proper operation of the instruments. These main indicators will be briefly introduced in this section.

Table 1. Data comparison for the four site under consideration. 50 percentile data only are included. Site testing results for Dome C are available only for the summer period. For the sake of comparison, South Pole data refer to the same season. Atacama and Mauna Kea data refer to the best period during the year.

Site	Transmission			
	225 GHz	492 GHz	PWV(mm)	Wind Speed (m/s)
Mauna Kea	0.96	0.28	1.65	5.0
Atacama	0.94	–	1.00	6.3
South Pole	0.94[a]	0.50	0.47	1.0
Dome C	0.93[a]	0.33	0.52	0.5

[a] Data refer to summer, the worst season for site quality.

Precipitable Water Vapour Water vapour in the Earth atmosphere is the main absorber/emitter for the Mid-Infrared to the millimetric wavelength range. Many high sensitivity experiments are therefore built on stratospheric balloon (de Bernardis et al. 2003) or satellite (i.e. Planck, see (Villa 2003), Herschel (Tofani et al. 2003)) platforms. This is an expensive solution and it is not suitable for large surveys on selected topics or for monitoring specific classes of objects. Ground-based experiments require extremely dry sites. The elevation is not a sufficient condition: geographical location is also important for a site to have a temperature inversion layer that keeps the humid part of the atmosphere below the observer location. This condition is often met on high elevation volcanic islands (i.e. Hawaii, Canary) or on steep mountain ranges close to the ocean (i.e. Andes). The high antarctic plateau is a viable alternative, because of its peculiar geographical position and isolation.

Athospheric stability The optimal site for astronomy should own not only clear but also still atmosphere. Air turbulence is mainly affecting image motion and sky-noise. Moreover the turbulent layers should be confined as close as possible to the ground. The position of the temperature inversion layer plays a crucial role in confining not only wet but also turbulent atmospheric layers below the observatory elevation. In Antarctica the inversion layer is quite close to the ground.

Weather stability The ideal site shoud own exceptional conditions for 100% of the observing time. This is, of course, not possible. It is important to understand if the site quality is stable with time or exceptional conditions are just occasionally met. This is an important parameter to be considered when planning to deploy large experiment at a site.

Accessibility and logistics An observing site should allow easy access for the instrumentation and the personnel. Large experiments always require well organized logistics for optimal operations. It is not only matter of installing the instruments but also to have easy access for mantainance, refurbishments and personnel shift.

3. Site comparison

Some selected Infrared and millimetric sites will be compared in this section: some of them are already operational, some are being developed.

Mauna Kea (4200 m) This is a well-established site in the Hawaii Islands. Some of the largest infrared and submillimetric telescope are operating there (see Mauna Kea web site[1] for details). Logistics is well developed and it is easily reachable by commercial transportation.

[1] http://www.ifa.hawaii.edu/mko/

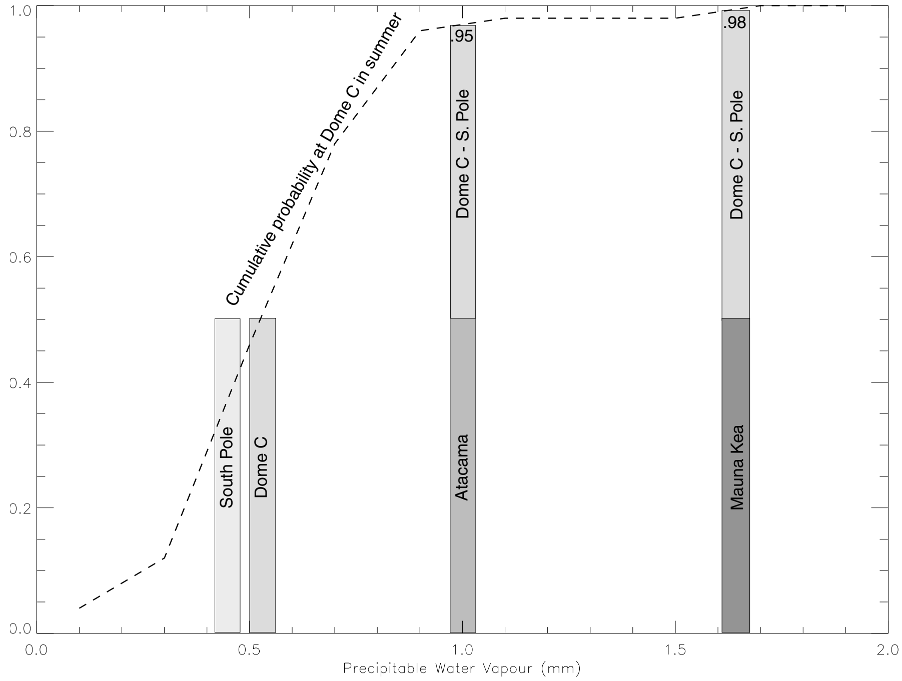

Fig. 1. Comparison of cumulative probability of PWV distribution. It is readily seen that the PWV values reported for at Atacama and Mauna Kea 50 % of the time are always met in Antarctica.

South Pole (2836 m) The Amundsen-Scott base has a permanent all-year-round astronomical facility under the responsibility of the Center for Astrophysical Research in Antarctica (CARA[2]). Many telescope in the Infrared (i.e. SPIREX), Submillimetric (i.e. AST/RO) and millimetric (i.e. Python, VIPER) wavelength range and interferoments (DASI) have been operated there. A site testing observatory has been installed in a collaboration between Australia and USA, the Antarctic Automatic Site Testing Observatory (AASTO[3]), with the purpose of a complete site characterization. The logistics is provided by the US Antarctic Program with frequent dedicated cargo flights.

Atacama-Chajnantor (5000 m) A very promising future observing site is located at a high elevation Atacama desert on the Andes (Chile), Cerro Chajnantor. The Atacama Large Millimeter Array (ALMA, [4]) will be installed there and a huge logistics is being developed (Cesaroni 2003). Commercial flights to Chile and a two-hour trip by car are sufficient to reach the site. The high elevation will require careful attention for operations and trained personnel will operate the instruments.

Dome C - Concordia (3280 m) The Italian (PNRA[5]) and French (IFRTP[6]) antarctic programs are completing the installation of a permanent station

[2] http://astro.uchicago.edu/cara/

[3] http://bat.phys.unsw.edu.au/∼aasto/

[4] ALMA/Chajnantor site testing Web site: http://www.tuc.nrao.edu/mma/sites/sites.html

[5] http://www.pnra.it

[6] http://www.ifremer.fr/ifrtp/wwwenglish/index.html

(Concordia) at Dome C, on the high antarctic plateau. This site offer the best observing characteristic among the accessible ones. However experiments since now have been limited to some *light* instruments operated during the summer (Valenziano et al. 1998; Sironi et al. 2003). A dedicated logistics for astrophysics is not yet established.

A comparison of the four sites, based on the available data reported in Table 1 (see (Valenziano & Dall'Oglio 1999) for more details, (Lane 1998)), shows that the antarctic plateau offer the best conditions for this kind of astronomy. Wintertime results (available for South Pole only) are still better. As far as the infrared is concerned, South Pole opacity is comparable to a stratospheric balloon platform (Mandolesi et al. 1998). The sky-noise in Antarctica is negligible most of the time, both for low wind speed and the small PWV. The temperature inversion layer during the summer is less than 300 m above the ground and it reasonable to assume that wintertime conditions are comparable to those of the stratosphere.

However when accessibility and logistics are taken into account, the two mid-latitude sites are by far superior. Transportation at South Pole is quite frequent for people and materials, while onland sledge trains only (at present) can be used to move large instruments to Dome C. Moreover, the Amundsen-Scott station has part of the buildings dedicated to astrophysics, far from man-made pollution. The Dome C station, presently under construction and not yet operative all-year-round, could be designed to suit the requirement of an astronomical facility.

4. Conclusions

A comparison of some Infrared and millimetric observing sites has been presented.

Not only the absolute quality for observations but also the simplicity of operations has been taken into account. While the high antarctic plateau shows the best observing conditions, the difficoulty of installing and maintaining instruments there is quite high, especially where a logistics dedicated to astrophysics is not fully developed. Mid latitude sites, on the other hand, offer very good conditions and a much easier accessibility. In conclusion, at present, installing large instrumentation in Antarctica is interesting only if unmanned, robotic technology is implemented. Such activity can also be used as test-bench for space instruments.

In conclusion, if strong effort will be made for developing astronomy at Dome C it will be possible to exploit the exceptional quality of that site.

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