THE ANTARCTIC PLATEAU: WHAT IT OFFERS AS A TESTBED FOR SPACE

J.W.V. Storey, M.C.B. Ashley, M.G. Burton, J.S. Lawrence

School of Physics, University of New South Wales, Sydney NSW 2052, Australia, j.storey@unsw.edu.au

ABSTRACT

The Antarctic plateau is unlike anywhere else on earth. It is of course extremely cold and dry. However what is not so well known is that it is also very high and that the atmosphere above the plateau is extremely calm, with very low wind speeds at all altitudes. This makes the plateau an ideal location for testing astronomical instrumentation and for exploring concepts that will later be flown in space. In addition, the plateau provides an ideal location for future telescopes that could carry out some crucial aspects of the science presently being considered for space missions such as Darwin and TPF.

1. INTRODUCTION

Over the past decade the Antarctic plateau has received considerable attention from astronomers. The most established facility is the US NSF's Amundsen Scott Station at the South Pole, although facilities also exist at Vostok (Russia) and at Dome Fuji (Japan). A very important new development is the construction of the French/Italian “Concordia"” station at Dome C. Conditions at South Pole are already known to be exceptionally favorable and, because of its 400-metre advantage in elevation, it is very likely that at Dome C they will be even better.

In this paper we further develop the ideas presented by Storey et al. [1], with a particular emphasis on planet-search programs.

2. EXCEPTIONAL SITE CONDITIONS

2.1 Infrared Sky Brightness

As expected from the extreme cold of the plateau (temperatures can drop below 190K) the infrared sky is extremely dark. In the near infrared, as much as two orders of magnitude reduction in sky brightness can be observed relative to temperate sites [2, 3, 4, 5, 6]. This reduction in sky emission stems not only from the direct effect of having a cold sky, but also from the fact that it is so dry. As a result, water vapour absorption is considerably reduced, the atmospheric windows are wider and more stable, with observations becoming feasible at wavelengths inaccessible to other sites.

In the mid-infrared, a wavelength range of more relevance to the interferometer concepts of Darwin and TPF, the reduction in sky brightness is substantial (10 to 20 times lower than temperate sites). Winter-time data have so far only been acquired at the South Pole [6, 7]. However, preliminary summer-time data from Dome C [8] suggest that it is similar to – and perhaps significantly better than – South Pole.

This reduction in sky brightness translates directly into a sensitivity gain if the detectors are background limited (which is almost always the case). A given magnitude limit can therefore be reached in the same observing time with a significantly smaller telescope. This reduces the cost not only of the telescope but also of the entire instrument complement, as the telescope A is preserved throughout the optical train.

2.2 Atmospheric stability

The first measurements of the seeing from the South Pole (see, for example Loewensteinet al [9]) found that it was relatively poor. However, it is known from microthermal studies [10] that almost all of the seeing degradation comes from the lowest couple of hundred metres of the atmosphere. Most of the high plateau lies within the polar vortex. As a result, the high-altitude jet-stream is expected to be completely absent. This has been confirmed by balloon measurements throughout the year from the South Pole [10] and by summer-time balloon flights from Dome C [11]. Because there are no high altitude winds, turbulence at high altitude is also expected to be dramatically reduced.

The absence of high-altitude turbulence is of profound importance [12]. Although the astronomical “seeing” depends only the integrated turbulence throughout the atmosphere and is independent of the altitude at which it occurs, other image-quality parameters are heavily weighted by the higher altitude layers. These parameters include the isoplanatic angle, amount of scintillation, and the differential astrometric accuracy.

Low wind speed is also a crucial factor in that it determines the coherence time of an interferometer and the bandwidth requirements of an adaptive optics system.

These arguments have led Lloyd et al [13] to propose that an astrometric interferometer constructed on the