

# Astronomy from the Antarctic Plateau: a global personal vision

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**Abstract.** The Antarctic Plateau (Dome C, also Dome A) is emerging as an especially good site for astronomical observations (high, dry, cold, no wind, good free seeing above a certain-boundary layer). Over the last few years, several meetings and conferences took place to discuss potential astrophysical science cases for such exceptional atmospheric conditions. I summarise my personal conclusions from these discussions and present a global vision (roadmap) for Antarctic Astronomy for future optical, near-IR, thermal-IR, and far-IR/sub-mm observations. The need for international collaboration between Europe, Australia and China is stressed.

**Keywords.** Antarctica, Telescopes, Site Testing, Instrumentation.

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## 1. Introduction

The main advantages of the Antarctic Plateau ( $\sim 3,200$  m) for astronomy are the weather conditions. At Dome C it is cold, high, dry and the sky quite stable. There are few clouds, hardly any wind and there are few aurorae. There is excellent night-time seeing in the Antarctic winter (May–August) above a ground layer of some 30 m, with a median of about  $\sim 0.3$  arcsec in the visible. There are also 4 hours of excellent seeing on the ground during day-time afternoon in the Antarctic summer (Nov–Feb), especially in the thermal infrared (remember the FWHM of the seeing scales with the inverse  $1/5$  power of the wavelength) which allows us to make infrared astronomical observations in Antarctica in the summer-time, i.e. when the conditions are much less harsh than in the winter time and without building towers (cf. Zinnecker (2007)). The Italian 80 cm IRAIT telescope will be the first to prove the concept. Of course, optical observations require winter-time which in turn require telescopes on towers (except long-time series optical photometric observations, where the seeing is not critical).

Although Dome A and Dome F may be slightly better astronomical sites (see the contributions by X. Cui from China and T. Ichikawa from Japan, respectively, in this Special Session and Proceedings), as a matter of fact Dome C and its infrastructure, i.e. the French-Italian Concordia station, exist today and could be used (or even expanded) for optical/infrared/sub-mm astronomy, political problems notwithstanding.

## 2. How best to exploit the Antarctica Plateau for astronomy now

Astronomy in Antarctica is already going on at the Amundsen-Scott South Pole station. The South Pole 10 m radio/sub-mm telescope is installed and taking data and the BICEP 25 cm aperture is studying CMB polarisation anisotropy (J. Carlstrom; Y.D. Takahashi, these Proc.). This raises the question whether Dome C should also have a big radio antenna, to carry out sub-mm observations at 450 and 350 microns, and pushing for THz observations in the 200 microns window. This would be a very good idea considering the

very low precipitable water vapour (PWV) values, often less than 0.25 mm. However, to be competitive a 25 m dish is needed (see the science case described by Minier (2008)) which would be very expensive and would stretch the current logistics at the Dome C Concordia station. In my view, this discourages going for such a Antarctic Submillimetre Telescope (AST) telescope at the present time; furthermore, there is a major push for Dome A which is claimed to be an even better sub-mm site than Dome C and where our Chinese colleagues plan to build a 15 m-class sub-mm-telescope. Finally, we should probably wait to see whether the 25 m CCAT (Cornell-Caltech Atacama Telescope, now under consideration) will be realised on a very high site (5,600 m) near Cerro Chajnantor or not.

Leaving aside sub-mm telescopes, what should we do in optical and infrared astronomy? We have mentioned the advantages of the much reduced sky background in the thermal infrared regime (3–5 microns) compared to more temperate sites (factor  $\sim 30$ ) due to the very cold atmosphere. There are several science cases for this part of the spectrum using a 2–3 m-class telescope (Burton (2005)), including molecular hydrogen surveys of the inner Galaxy, cool protostar and evolved star searches in the LMC/SMC and also Galactic star forming regions in the southern hemisphere (e.g. Carina, Vela, etc.). These would all benefit greatly from the increased spatial resolution with an Antarctic 2.5 m telescope, compared to Spitzer data obtained with a 85 cm telescope (factor 3 gain in angular resolution at 4 microns). Follow-up studies for NASA's soon-to-be-launched WISE (40 cm) near-to-thermal infrared all-sky survey telescope will also be an issue. It has been questioned whether all this would represent 'killer' science as opposed to fairly unique science. Perhaps the best use of a 2.5 m telescope (small enough to be affordable now but large enough to be a pathfinder for future large structures) may be to exploit the  $K_{dark}$  window (2.4 microns, Casali (2007)) where the reduced sky background allows us to really go deep (much below UKIDSS and VISTA) and carry out extra-galactic near-infrared surveys down to  $K_{dark} = 25$  mag. to study distant galaxy populations at high redshifts. JWST will provide competition, but only in principle and not in practice, as the FOV of JWST/NIRCAM is  $3.4 \times 3.4$  arcmin. while an Antarctic survey telescope would have  $20 \times 20$  arcmin. or more, depending on the cost of IR-detectors.

### 3. Roadmap for a Dome C Astronomical Observatory

I consider a roadmap to be a temporal sequence of major milestones, with a beginning and an end. It should give realistic timescales to implement telescopes or instruments of increasing complexity. The beginning and first milestone would be to operate and obtain data with IRAIT as soon as possible (2010). The CAMISTIC bolometer camera on IRAIT will probe the quality of the site for sub-mm/THz (particularly for 200 microns) imaging observations. The second milestone should be an IR-optimised PLT-like telescope, if necessary with ground layer adaptive optics (first light in 5–10 years, 2015–2020). This should take advantage of the good Antarctic summer seeing and start operating in the daytime, doing 0.3 arcsec 2.5–5 microns imaging. At the same time, robotic optical telescopes like ICE-T could operate in the Antarctic winter, without towers (as the seeing is not critical for long-time series photometry). I would leave the lead for 2–4 m class optical telescope to our Chinese friends. The third milestone (in 10–15 years time) would be ALADDIN, the two-telescope thermal-IR interferometer; it would then still be in time to act as an exo-zodiac precursor for DARWIN (the latter won't happen before 2025). The 4th major milestone (around 2030) could be a THz interferometer array (of the order of a dozen telescopes) complementing ALMA and SOFIA and being a pathfinder for a far-IR interferometer in space (ESA's future FIRI mission). The ultimate and 5th milestone

that I see on the horizon (in the 2030-2040 timeframe) would be an optical/IR kilometric array of 2 m class telescopes.

#### 4. The need for international collaboration

Astronomy in Antarctica is expensive for any country trying to establish and maintain a permanent base on this remote continent. For example, the total operating costs of the Concordia station are 8 million Euro per year. Still, astronomy in Antarctica is much cheaper than ESA missions from space. Space projects are usually done in co-operation between several nations. Similarly, it would be too costly if every nation would want to build their own suite of telescopes in Antarctica. We have to share our resources. This means France and Italy will *invite* other European partners to participate in astronomy from Dome C. It also means that Dome C and Dome A should each concentrate and specialise on the best possible science doable from their respective sites. While Dome C might be best suited for near-infrared and thermal-infrared observations, Dome A (at 4,200 m) might be best for sub-mm and THz astronomy. Collaboration would reduce cost and help to exchange scientific, technical, and logistic experience. These and other issues could be discussed at an IAU symposium on Antarctic Astronomy during the next IAU General Assembly in 2012 in Beijing/China. By then, Chinese plans for Dome A will have firmed up, while Europe and Australia may have teamed up again at Dome C pursuing their common interests for a PLT-like telescope. The first IRAIT measurements and results at around that time would hopefully show that Dome C lives up to its expectation as the premier astronomical observing site on the planet.

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