COMMISSION 50: IDENTIFICATION AND PROTECTION OF EXISTING AND FUTURE OBSERVATORY SITES

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1. GENERAL

Astronomers are already aware that measurements of the properties of observatory sites are critical, not only to rank sites in order of preference for the particular astronomical tasks to be undertaken, but also to design the most suitable instrumentation. Astronomers are increasingly aware of the deterioration of sites by man-made disturbances, and of the necessity to protect observatories.

The report period saw several publications and conferences devoted to these topics. IAU Colloquium 112 was organised by members of the Commission in 1988 in Washington DC (see *Trans IAU* XXI); the proceedings were published in 1991 (53.012.121; references in this form are to *Astronomy and Astrophysics Abstracts*). Study Group No 189 of the NATO Committee on the Challenges of Modern Society, for the Protection of Observatories, has published its reference report *The Protection of Astronomical and Geophysical Sites* (55.003.038). It contains chapters on light pollution, radio interference, pollution by satellites, space debris, and aircraft, and the legal avenues for the protection of observatories. *Radio astronomical seeing* was the subject of a URSI/IAU Symposium in Beijing in 1989; its proceedings also appeared in the report period (53.012.104, see 53.082.075-092). Problems of optical seeing are addressed by series of SPIE conferences: two published in the report period were on *Propagation Engineering* as part of a Technical Symposium on Optical Engineering and Photonics in Aerospace Sensing, 1990 (53.012.025) and on *Advanced Technology Optical Telescopes*, Tucson 1990 (see 52.082.019 to 025); SPIE conferences on *Adaptive Optics* also contain papers of interest.

2. IAU/UNESCO/ICSU MEETING

The IAU, including Commission 50, co-sponsored a meeting entitled *Adverse Environmental Impacts on Astronomy* at the UNESCO headquarters in Paris in 1992 July. The papers are in press. The Director General of UNESCO, Professor F Mayor, said in his address that UNESCO is sensitive to astronomers' concerns, both because the problems of environmental concern need to be addressed at the government level, both nationally and globally, and because UNESCO is involved in a major way in scientific programmes on the environment and the effects of human activities on the quality and harmony of the terrestrial environment. He said that UNESCO will do what it can to follow up the problems revealed. One possibility is that some observatories could be defined as World Heritage Sites and given protected status. As a result of the meeting, ICSU has set up a Working Group (Chairman Dr D McNally, former IAU Secretary) to take further the meeting's recommendations.

3. PROTECTION OF RADIO ASTRONOMY

Radio Regulations, setting the use to which bands of the radio frequency spectrum can be put, are formulated from decisions of the World Administrative Radio Conference (WARC) whose latest session was held in Spain in 1992 February. A big gain for radio astronomy was the upgrading of the OH allocation at 1610 MHz to primary status, giving added protection from sideband emission from the adjacent satellite transmission band, used for example by the GLONASS navigation satellites. Broadcasting satellites were made an allocation at 1452-1492 MHz, sufficiently far from the 1420

J. Bergeron (ed.), Reports on Astronomy, Vol. XXIIA, 579–582.

MHz 21 cm hydrogen line not to be a nuisance, and additional protection was footnoted for the 150.3-152 MHz band to protect against satellite-to-ground communications in an adjacent band. However High Definition TV was made an allocation at 21.4-22 GHz, near interstellar water, and this could cause problems in the future. WARC requested a study on sideband interference levels so that appropriate protection can be written into future allocations to protect passive (non-broadcasting) services like radio astronomy.

The European Science Foundation Committee on Radio-Astronomy Frequencies (CRAF) is made up of representatives of European radio astronomical observatories and is actively campaigning against the use of the CDMA spread-spectrum technique, which is used to protect privacy in radio transmission by spreading transmissions thinly over a wide band. CDMA is a new technique causing concern to radio astronomy, which is sensitive to interference at a lower level than other services.

4. LIGHT POLLUTION AND OTHER PROBLEMS FOR OPTICAL OBSERVATORIES

Light pollution is an increasing problem in all optical observatories located within, say, 100 km of a town or city (52.013.002). If the light pollution is local, like a lit roadway, then individual arrangements can be made for shielding, or in very favourable cases (as in Turku Observatory in Finland) possessing the right to switch off the lighting. Light pollution over large administrations is controllable only by wider legislation; the Canary Islands' Observatories legislation, which protects the sky to the standards recommended by the IAU, was implemented by Royal Decree in 1992, and the Protection Office of the Instituto dc Astrofisica de Canarias completed a control inventory of lighting on La Palma in 1993.

Light pollution has been quantified over the whole of Japan in the Star Watch programme (organised by the Commission Vice Chairman as a joint programme of the National Astronomical Observatory in Tokyo and the Japanese Environmental Agency). The technique uses simple photographic exposures of star trails obtained by thousands of school children and amateurs under standard conditions (54.082.060; see also *Teaching of Astronomy in the Asian-Pacific Region* Bulletin No 6, available from Dr Isobe). Other simple ways of determining night sky background with naked eye measurements (54.082.057) and a visual photometer (55.082.076) have been described by Upgren. The spectral contribution of light pollution has been quantified in Okayama (55.082.077), where the dominant light background below 700 nm is light pollution, but beyond 700 nm it is OH emission; so, optimistically ('looking on the bright side'), the site is competitive in this respect. Studies in Canada (54.013.095,100), in Israel (54.082.001), at Kitt Peak (52.082.053) and at Mauna Kea (52.082.054) show mixed results, with the more remote sites still remaining relatively unaffected. Light pollution can be propagated large distances (54.082.001), with dust being able both to increase and lessen the pollution (54.082.055), and with effects which are different for different types of astronomical observations (54.082.001).

The British Astronomical Association (the UK's amateur astronomers' society), affiliated to the US-originated Campaign for Dark Skies; it organised a European Colloquium on Light Pollution jointly with the UK Institution of Lighting Engineers at Reading in 1993 July. The ILE has published *Guidance for Lighting Engineers* on avoiding light pollution and is working on more detailed standards appropriate for different lighting projects in various environments. The Commission Internationale de l'Eclairage (CIE) has established, under the chairmanship of Dr D Schreuder, consultant to IAU Commission 50, a Technical Committee TC4.21 on the *Interference by Light of Astronomical Observations* and is also producing a design guide for lighting engineers.

French naturalists and astronomers have produced a Charter, part of the Cousteau Foundation's manifesto on the rights of future generations, aiming to preserve the night as a natural and inalienable element of man's environment on this planet. The Charter points to the threat to the natural balance of life as well as to the astronomical environment.

Italian astronomers have called for European Community action on light pollution. The

Societa Astronomia Italiana and the Unione Astrofili Italiani (the professional and amateur bodies in Italy respectively) have coordinated action to create in Italy zones of protection around astronomical observatories of radius up to 25 km. Local action has successfully improved lighting (Milano-Baroni), turned off lighting at a certain time (Oderzo-Perissinotto) and given observatories a say in the control of lighting (Treviso-Romano, Campo Catino-Di Sora, and Perigrine-Dalmeri).

Other intrusions on astronomical observing include aircraft condensation trails; their frequency and effect on solar observing has been studied at Carinthia, Austria (54.082.067). Refraction of the atmosphere affects accurate meridian circle observations; natural variability is large (52.082.048) but the effects of exhaust gases from a large incinerator in Tokyo are much worse (53.082.059).

5. SPACE ADVERTISING AND SOLAR REFLECTORS

FLAG was the name of a 300 square metre solar sail deployed from the Space Station MIR in 1993 February as a feasibility study for reflectors illuminating terrestrial locations for industrial processes and disaster control. The sail was unfurled and partly stabilised by rotation, but in the present experiment its pointing was uncontrolled. The success of the experiment was mixed, with sites in the south of France reporting the appearance of the sail as brief flashes of a bright 'star' in the sky.

Early in 1993, Space Marketing Incorporated, a company of Roswell, Georgia, USA, proposed to launch a Space Billboard 1 kilometer in dimension. The billboard would be attached as a sponsorship mechanism to a so-called ENVIRONMENTAL SPACE PLATFORM for space experiments. It would appear with a brightness and size rivalling the Moon, and would of itself interfere with optical astronomy at the start and the end of the night.

It was proposed that the billboard would be launched by NASA. ESA has undertaken not to launch any advertising satellite unacceptable to astronomers, but NASA does not appear to have taken a public stance on the environmental issue. The American Astronomical Society issued a statement strongly opposing the use of an earth orbiting spacecraft for advertising purposes, saying that the effects of such a spacecraft will interfere with the capabilities of most existing astronomical telescopes and the many ultra-sensitive telescopes under construction around the world.

For both these space activities, mislaunch might produce additional exposure for ground based telescopes. Fragmentation of the sails (10000 impacts daily was the estimate for the Space Billboard) would add to space debris and increase background throughout the night. The precedent for future billboards is a matter of concern. Both proposals were for devices in near-earth orbit. However the advantage of additional exposure would create pressure for high launches which would then be visible longer through the night. This would gravely interfere with astronomical research.

The Executive Committee of the IAU has asked the UN Committee on Peaceful uses of Outer Space, ICSU, the Space Agencies, and UNESCO to oppose satellite-borne solar reflectors which may damage scientific research.

6. STUDIES OF EXISTING AND POTENTIAL OBSERVATORY SITES

In the report period, astronomers published studies of the astronomical properties of a large number of existing and potential sites (Table 1). Particularly noteworthy for IAU members were the major survey of India in relation to possible sites for the National Large Telescope, a seeing survey of sites in the former USSR, and discussion of the potential use of the Antarctic area especially for continuous monitoring of solar and stellar oscillation, and infrared astronomy. Optimists will like the analysis of 55.082.062, which concludes that seeing performance in large telescopes and interferometers is likely to be better than expected from the standard Kolmogorov-Taylor theoretical models, especially at infrared wavelengths. Pragmatists should note how building design need not deteriorate local seeing (54.032.022, 52.082.025).

Table 1

USA
Flagstaff (Cloud cover and seeing measurements 55.82.013); Anderson Mesa (as a site for an optical array 52.082.072); Mt Hopkins (seeing 52.082.023); the MMT (seeing 52.082.019); New Mexico (VLA phase stability 53.082.077); Mauna Kea (mirror, dome and natural seeing at the CFHT 54.032.017, seeing properties 52.082.022); NRAO site survey in relation to a millimetre array 53.082.079

Europe
Israel (observational qualities and observing efficiency at Wise observatory 55.82.014); Spain (seeing and IR properties of the Canary Islands 52.082.045, 52.082.047, 54.013.078; a scidar seeing experiment from the Nordic Optical Telescope on La Palma 55.082.035; other NOT results 52.082.025; correlation of point source images at La Palma 52.082.006; interferometric measurements at La Palma 54.082.048; the refraction constant 53.082.037; geotechnical surveys of the LEST site on La Palma 55.082.017; effect of volcanic and Saharan dust 54.082.030; the wind spectrum on La Palma 53.082.074; atmospheric extinction at Calar Alto 53.082.072); Austria (Innsbruck 54.082.068); Italy (Cagliari observatory 52.082.013); France (high resolution solar imaging at the Pic Du Midi 53.013.065)

South America
Chile (studies for the ESO VLT at Cerro Pachon 52.082.038, 55.082.004, 55.09.012; differential image motion used to evaluate seeing 55.082.004; effect of the Pinatubo eruption on La Silla 55.082.06; speckle lifetime and isoplanicity at La Silla 53.082.020); Bolivia (extinction values and water vapour content at the Bolivia-Soviet Observatory 54.082.051, 55.82.072)

Asia
Japan (atmospheric extinction at Yonsei 55.082.081); India (infrared properties of Kavalur 54.082.072; general properties of Leh 52.082.04; surveys in relation to the India National Large Telescope Project for optical/infrared astronomy 54.082.015 to 23); Tibet (Yanbajing at 4300 m for air shower gamma ray detector 52.013.007)

Europe/Asia
Former USSR (seeing measurements at 10 sites, identifying Mt Sanglok in Tadzhikstan as of outstanding seeing 53.082.063, 54.082.014); Ukraine (in relation to SLR telescopes 54.082.052); Mongolia (52.082.034)

Antarctica
South Pole (ice used for detection of muons 53.013.097; prospects generally 53.013.104, 54.013.086; aerosol content (ice crystals) above the Amundsen-Scott Polar Station sites 55.082.037,038; atmospheric characteristics near the Belgrano II station in Argentine Antarctica 54.082.071)

7. SOCIOLOGICAL VULNERABILITY OF OBSERVATORIES

Observatories are affected not only by the natural and the artificial environments in which they lie but also by their environment within society. In Chile, the agreement establishing the European Southern Observatory has been renegotiated in political circumstances; this serious matter was resolved in 1993. The political changes in Europe have had their effect on astronomy as in other areas of life. As a result of the financial challenges associated with the re-unification of Germany, the Sonnenberg Observatory, known for the stellar variability patrol initiated by C Hoffmeister in 1925, has been threatened with closure. After the separation of the USSR into independent republics, Maidanak Observatory was nationalised by Uzbekhistan in 1993 May; at least temporarily the astronomers were sent away from the telescopes. Maidanak, identified as an excellent site by the seeing survey reported in 53.082.063, 54.082.014, contains telescopes built by republics outside Uzbekhistan, including Russia, Ukrainia, and Lithuania. Conditions for astronomers in troubled areas such as Armenia and former Yugoslavia are even more difficult. It is not for astronomers outside the countries concerned to comment on the politics surrounding these events. However all astronomers will join in hoping that troubled colleagues, their talented students (the astronomers of the future), the irreplaceable scientific archives, the exquisite equipment and the noble astronomical activities of the affected institutes, wherever located, will be protected as best as is humanly possible.

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