50. IDENTIFICATION AND PROTECTION OF EXISTING AND POTENTIAL OBSERVATORY SITES

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1. Identification of Observatory Sites

While a number of site testing campaigns are in progress throughout the world, the dominant efforts seem to be associated with plans for very large telescopes. These plans, improved telescope technology, and the realization that astronomical observations from space will put increasing demands on ground-based observing facilities have given new impetus to site identification and to the optimum utilization of existing sites. A most excellent review of the factors involved in site identification is now available in the **Proceedings of the ESO Workshop on Site Testing for Future Large Telescopes,** edited by A. Ardeberg and L. Woltjer, 1984. These **Proceedings** and Woolf's review (1982, **Ann. Rev. Astron. Astrophys.** 20, 367) provide a solid background of current site evaluation factors.

In the last triennium, an improved theoretical and experimental knowledge of turbulence, a widespread evaluation of Fried's parameter, r_0 (characteristic scale of wavefront coherence), and a growing awareness of image degradation caused by properties of the facilities themselves have engendered new interest in site evaluation studies.

A few summaries of site identification studies provided for this report follow. Other surveys are noted in the literature summary with **Astronomy and Astrophysics Abstracts** notation at the end of this report.

Professor Eduardo Brieva reports a site testing campaign has been initiated for the establishment of an astrophysical observing station for the Columbian National Observatory. Visual observations at four sites in the Columbian Andes and independent studies based on satellite images indicate that up to 250 useful nights per year may be obtainable at a site named Otún in the central cordillera.

In connection with plans for developing observational astronomy in India, Professor Bhattacharyya writes that several projects for finding new observatory sites are in progress. The Uttar Pradesh Observatory at Nainital is engaged in the task of identifying a suitable site for a projected 4-meter telescope. Following a survey of 40 locations in the Kumaon Hills of the Himalayan range, four locations have been instrumented for recording meteorological data. In western India, a site at 1700-meter elevation on Mount Abu has been selected for an infrared telescope and a site in the Ladhak region of the Himalayas at 3400-meter elevation is being evaluated as a potential good infrared site.

Dr. Elmar Brosterhus writes concerning a major survey in Saudi Arabia that has been organized with assistance from the National Research Council of Canada. Following an extensive preliminary survey, four sites were selected for comprehensive study with photoelectric image monitors and meteorological instruments. Data were gathered from May 1982 through all of 1983, at which time observing was terminated at the two least desirable sites. The remaining two installations are still operating. The image monitors, used on 15-cm aperture reflecting telescopes, accurately record image motion, size, and brightness. Extinction measures are obtained by observations of suitable stars.

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In connection with plans for a very large telescope, Crawford completed a "Dark Sky Survey" (1983, KPNO special report), and Lynds and Goad have made a cartographic exploration of sites in the southwestern United States (1984, **Publ. Astron. Soc. Pacific** 96, 750). Woolf and Merrill have directed attention to Mount Graham in southeastern Arizona as a possible NNTT site (1984, **NOAO Technology Development Program Report** No. 4).

Dr. Zeki Aslan describes a long-term survey being conducted in Turkey. Meteorological records delineate two promising regions south of latitude 38°. A number of candidate sites have been selected by reconnaissance, and a four-year program of evaluation with Walker-type Polaris trail telescopes was started in 1982 following consultation with B. McInnes of the Royal Observatory, Edinburgh.

Special attention is again directed to the proceedings of the ESO Workshop on Site Testing for Future Large Telescopes and particularly to Walker's article on "High Quality Astronomical Sites Around the World" in those proceedings.

2. Extinction

Special reports on atmospheric extinction have been received from Jozef Tremko and G. W. Lockwood. The first of these concerns measures of extinction at the Skalnaté Pleso and Brno Observatories. Papoušek and Vetešník of Brno and Tremko and Juza of the Astronomical Institute of the Slovak Academy of Sciences report analyses of large numbers of UBV extinction measures made at Brno, an urban location, and at Skalnaté Pleso, a "mountain observatory," for the interval 1963-1980. The mean visual extinction at Skalnaté Pleso, altitude 1783 meters, is characteristic of good sites, $\langle k_v \rangle$ being the order of $0^m.15$. The yearly means show a variation with period of about 22 years and an amplitude of about $0^m.02$, seemingly in phase with sunspot activity. The minimum values of extinction in U, B, and V occurred at about 1975 near the time of minimum sunspot numbers. Observations are being continued to see if this relation persists.

As expected from the urban location, the extinction coefficients measured at Brno are large and show large disperson. However, a systematic decrease in extinction values has been observed over the interval. For example, $\langle k_v \rangle$ during 1964-1968 was about $0^m.48$, while $\langle k_v \rangle$ during 1977-1981 was about $0^m.35$, the trend being approximately linear.

Information communicated by G. W. Lockwood concerns spectrally resolved measurements of the El Chichon cloud during May 1982-August 1983 at Flagstaff (elevation 2200 meters). Measures by Lockwood, White, and Tüg show that a maximum extinction of $0^m.33$ at λ350 nm by stratospheric aerosols alone occurred on 15 May 1982. At this time, the cloud was essentially gray. Continuing extinction determinations by Lockwood show that observable effects of the El Chichon cloud persisted for more than a year.

Lockwood has analyzed precision **b** and **y** extinction determinations for more than 300 nights during 1972-1982. He finds no secular change, in spite of rapid growth of Flagstaff, and no solar cycle effect. There is a seasonal effect with almost pure Rayleigh scattering in January to an aerosol component of about $0^m.08$ in June.

The accompanying publication list shows that extinction monitoring is being done at a large number of sites.

3. Sky Brightness and Urban Sky Glow

A few special communications have been received, the most complete being by Carlos Torres, who described the situation at the Observatório Astrofísico

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Brasileiro (altitude 1865 meters), which is located near Brasópoles in Minas Gerais State. He details the direction, distance, population, lighting technology, and terrain for 13 municipalities and towns, the largest of which is São Paulo with 10^7 inhabitants at a distance of 160 km. An azimuthal scan at 45° elevation in August 1982 yielded values of B_{sky} ranging from 21.5 to 22.1 mag•arcsec^{-2}, with maximum brightness in the general direction of São Paulo. Zenith sky brightness measured on 14 nights from July 1981 to July 1984 ranged from 22.2 to 23.0 mag•arcsec^{-2} in B and from 21.0 to 21.9 in V on clear moonless nights away from the galactic plane. A zenith sky spectrophotometric recording, also included in his report, shows only very weak mercury and sodium emission lines from urban lighting.

Dr. Yoshihide Kozai, director of the Tokyo Observatory, has sent sky measures for their Kiso Observatory (altitude 1130 meters), where a 105-cm Schmidt camera is operated. Total sky brightness at λ530 nm averaged from 1980 through 1984 is 21.9 mag•arcsec^{-2}, with very little dispersion. The average urban contribution is estimated to be 24.0 mag•arcsec^{-2}. Only a few small towns are visible at a distance of 20 km.

These zenith dark-sky values for V_{sky} of about 21.5 mag•arcsec^{-2} for Brazil and 21.9 mag•arcsec^{-2} for Japan may be compared to Walker's (1970, **Publ. Astron. Soc. Pacific** 82, 672) 1966 value for three California dark-sky sites of 21.6 and the 1964 value of 21.6 cited by Allen (1973, **Astrophysical Quantities**, third edition, Athlone, London). However, Dawson (**I.A.P.P.P Light Pollution Newsletter** No. 2) gives a value of 21.1 for Kitt Peak in 1980; Smyth reports (1982, **Occasional Reports of the Royal Observatory, Edinburgh** No. 8) a value of 21.1 for Siding Springs, and the value for the Lowell, Anderson Mesa dark-sky site was 21.1 in 1981- 1982 (Hoag, unpublished). These interesting differences, and the possibility that these values might be affected by solar activity, indicate the need for more extensive monitoring and reporting.

Dr. Carlo Blanco, director, Osservatorio Astrofisico di Catania (1725 meters) writes that urban lighting from Catania, distant 20 km, has markedly increased during the last decade. Recently, outdoor lights have been installed at hotels only 0.5 km distant; but low-pressure sodium lamps have been used at his request.

Professor S. Marx, Karl-Schwarzschild Observatorium, Tautenburg, sent a 1979 report (**Astron. Nachr.** Bd. 300, 209) describing an experiment we would all like to repeat at will in our localities. A portion of the outdoor lighting in Jena (10-15 km distant, 10^5 inhabitants) was purposely turned off for half an hour while the sky brightness was monitored by a variety of instruments. The sky brightness at λ578 nm decreased by 20%.

Dr. Roy Garstang has recently derived an improved formula for calculations of urban sky light (1984, **Observatory** 104, 196).

4. Radio Frequency Interference

Two kinds of interference were specifically brought to the attention of the Commission in 1984. The first concerns spacecraft transmissions in radio-frequency bands reserved for radio astronomy, and the second relates to interference from transmitters close to observatories.

Because of planned use of a space probe transmitter emitting at 1667.75 MHz, within the 1660-1670 MHz band reserved internationally for observations of spectral lines of the OH molecule, the Committee on Radio Frequencies of the U.S. National Academy of Sciences has sent the following resolution to organizations as URSI, IAU, COSPAR, IUCAF, and the ITU: the Committee "URGES that in the future all parties planning other active radio science or telecommunications experiments

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fully respect the international table of frequency allocations, and most particularly those bands allocated exclusively to passive services."

Professor Osório of the Observatório Astronómico do Porto writes that three nearby transmitters, with a total input power of 30 Kw, have caused severe interference problems with all electronic systems at the 76-cm telescope. Also, we were again reminded of the situation at Mount Wilson, where the 38 transmitters are located less than 1 km distant. In both of these situations the radiated power is orders of magnitude in excess of the acceptable level recommended by the Commission (cf. 1976, **Trans. IAU,** XVIB, 319). Dr. van den Bergh reports that extensive shielding of electronic components of the radial velocity scanner at the Dominion Astrophysical Observatory 48-inch telescope has been required because of a nearby transmitter. This kind of problem has caused technical difficulties at many observatories.

5. Protection of Sites

About 4 kg of U.S. literature on light pollution has been accumulated in the Commission files during the past three years. It would be impossible, as well as parochial, to attempt to treat it in detail. The public information effort has been extensive and greatly aided by amateurs.

Much of the professional effort has been concentrated in Hawaii and the Southwest and has been guided by a Committee on Light Pollution and Radio Interference of the American Astronomical Society chaired by D. L. Crawford. Impetus to the program has also been provided by a growing public and municipal awareness of energy costs for urban lighting. Because urban lighting questions involve aesthetics, economics, politics, and technological questions, the best compromises can be reached only by involving the public, governing bodies, municipal managers, manufacturers, lighting engineers, and utility company representatives.

An extensive report of a working group of the French Academy of Sciences on **La Protection des Observatoires Astronomique et Geophysiques** has been received from J. Kovalevsky. This compendium has the virtue of covering a broad scope of problems, including light pollution, sources of heat, radio-frequency interference, magnetic perturbations, ground vibrations, and chemical pollution.

IAU/CIE Publication No. 1, **Guide Lines for Minimising Urban Sky Glow near Astronomical Observatories**, 1980, continues to be a most significant aid to those concerned with protection of observing sites.

Publication List

SITE STUDIES

McInnes (30.082.014) Hawaii, Madeira, and Canary Islands.
Hartley **et al.** (30.082.015) Roque de los Muchachos microthermals.
Brandt, Wöhl (30.082.037) Solar site, Canary Islands.
discussion (30.082.068) Binchuan, China.
Gur'yanov (30.082.077) Mount Maydanak, surface microthermals, USSR.
Gur'yanov (30.082.078) Mount Maydanak, surface layer and seeing.
Gur'yanov (30.082.079) morning minimum of seeing effects.
Scheglov (30.082.085) r_0 distribution.
Khan (30.082.086) Mount Dushak-Erekdagh PSM seeing data, USSR.
Jarrett (31.082.006) Weather at Boyden Observatory, South Africa.
Sanguin (31.082.042) El Leoncito, Argentina.
Brandt, Wöhl (31.082.045) Solar site, Canary Islands.
Teleki (31.082.078) Astrometric site selection.
Smith (31.082.087) IAU Commission 50 report.

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Shevchenko (32.082.015) Mount Maydanak, USSR.
Woolf (32.082.046) High-resolution imaging from the ground.
Shcheglov (32.082.074) PSM seeing comparisons for several mountains, USSR.
Khan (32.082.078) Seeing and scintillation, Mount Dushak-Erekdagh, USSR.
Popov **et al.** (32.082.079) Daytime star visibility, Mount Maydanak, USSR.
Banin **et al.** (33.082.001) Astroclimate, Bajkal Observatory, USSR.
Fourikis **et al.** (33.082.028) mm-wave sites, Australia.
Troyan (33.082.030) Day astroclimate, Terskol peak, USSR.
Klepikov, Khodzhadurdyev (33.082.034) Microthermals, Mount Dushak-Erekdagh.
Khan, Khodzhadurdyev (33.082.040) PSM seeing, Mount Dushak-Erekdagh.
Kahn (33.082.048) PSM results, Mount Dushak-Erekdagh.
Liu, Wu (33.082.068) Site testing for observing solar eclipses.
Omarev **et al.** (33.003.091) Astroclimate, Assy-Turgen plateau, USSR.
Ataev **et al.** (34.082.020) Seeing, Mount Sanglok, USSR.
Darchiya, Stajkov (34.082.021) Mount Elbrus, USSR.
Gubkin **et al.** (34.082.023) Astroclimate, Mount Elbrus, USSR.
Troyan, Osipov (34.082.029) Seeing for solar observations, Terskol peak, USSR.
Garcia, Yasukawa (34.082.036) Mauna Loa sky conditions, USA.
Ardeberg (34.082.048) Site selection for very large telescope, Chile.
Weigett (34.082.050) Speckle site testing.
Erokhin, Plyaskin (34.082.063) Sky and image quality at 6-m telescope, USSR.
Shcheglov, Boboev (34.082.097) PSM image motion, Kulab region, Tadzhik SSR.
Dyck, Howell (34.082.100) Infrared speckle seeing, Mauna Kea, USA.
Walker (34.082.103) Comparison of sites on Mauna Kea, USA.
Ferraz-Mello (34.082.113) *Observatório Astrofísico Brasileiro.*

ATMOSPHERIC PARAMETERS AND MEASURING TECHNIQUES

Azouit, Vernin (30.031.535) Vertical profile of turbulence.
Lund **et al.** (30.031.538) Evolution time of turbulence.
Allen, Barton (30.031.540) Infrared sky noise.
Kallistratova (30.031.627) SODAR in site testing.
Sabet-Peyman (30.031.633) Entropy estimation of image spread function.
Hubbard, Reitsema (30.082.096) Scintillation at two wavelengths.
Najbauer, Fedorishina (30.082.110) Scintillation.
Borgnino **et al.** (31.082.011) r_0 and radiosond, solar seeing.
Roddier (31.082.046) Effects of turbulence.
Dainty **et al.** (31.082.068) Scintillation, Mauna Kea.
Tarrius **et al.** (31.031.644) Sky noise.
Kutyrev **et al.** (32.082.075) Interferometric r_0 measures.
Kutyrev (32.082.076) r_0 and image diameter.
Gur'yanov, Khan (32.082.077) Seeing, ground layer, whole atmosphere.
Tugzhsuren **et al.** (32.082.083) Frequency spectra of scintillation.
Brunner (32.082.084) Effects of turbulence.
Alekseeva, Kamionko (32.082.087) Scintillation and spectrophotometry.
Vithal, Vats (32.062.115) Generation of turbulence by solar radiation.
Vernin, Azouit (34.082.008) Speckle formation.
Druesne **et al.** (34.082.009) Point-spread function from solar limb observations.
Ovezgel'dyev **et al.** (34.082.033) Forecasting astroclimate.
Roddier (34.082.049) Testing seeing quality.
Weigelt (34.082.050) Speckle site testing.
Vernin, Azouit (34.082.053) Remote sounding of turbulence.
Mariotti (34.082.058) Infrared speckle turbulence study.
Woolf, Ulich (34.082.089) Seeing and wind effects.
Lazorenko **et al.** (34.082.104) Image motion.

EXTINCTION

Spencer Jones (30.082.016) at Sutherland SAAO, South Africa.

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discussion (30.082.017) at Binchuan, China.
Terez, Terez (31.021.007) Calculating extinction.
Smolyaninova **et al.** (31.082.007) Components of.
Naku, Chernobaj (31.082.008) at Kishinev, USSR.
Fajnberg **et al.** (31.082.044) at Byurakan, USSR.
Sholomitskij **et al.** (31.082.051) Submillimeter transmission, Shorbulak, USSR.
Conference (32.012.096) Atmospheric transmission.
Brand (32.082.014) at La Silla, Chile.
Gutiérrez-Moreno **et al.** (32.082.057) at Cerro Tololo, Chile.
Alekseeva, Novikov (32.082.073) at Pulkova, USSR.
Kopeika (32.082.088) Effects of aerosols.
Gutman **et al.** (32.082.097) Slant path extinction, White Sands, USA.
(1983, **Geophys. Res. Lett.** 10, 233. Turbidity over Africa - El Chichon eruption?)
Edwards (33.082.045) Measures of turbidity.
Lockwood **et al.** (33.082.046) Effects of El Chichon ash cloud.
Zambakos **et al.** (33.082.060) Smoke at Athens Observatory, Greece.
Sloane (33.082.062) Properties of aerosols.
Jiang **et al.** (33.082.070) at Luanpin and Xinglong, China.
Cardelli, Ackerman (34.082.024) St. Helen's ash cloud.
Garcia, Yasukawa (34.082.36) at Mauna Loa, USA.
Anderson (34.082.052) Asymmetries.
Wang (34.082.055) Atmospheric transparency over China.
Tomasi, Vitale (34.082.057) Extinction models for sun photometer measures.
Randall (34.082.059) Atmospheric transmittance from radiance measures.
Schmidtke (34.082.084) Calculation of extinction.
Miles (34.082.085) Transparency and the El Chichon eruption.
Lahulla (34.082.086) at Calar Alto, Spain.
Keen (34.082.093) Volcanic aerosols and lunar eclipses.
Hasan, Dzubay (34.082.109) Aerosol composition and extinction.
Chobanov (34.082.112) Mean transparency function.
Neizvestnyj (34.082.114) at SAO Academy of Sciences, USSR.

INFRARED

Humphries, Purkins (30.082.108) UKIRT, seeing in infrared.
Chou, Arking (31.082.013) Computing absorption by water vapor.
Barton (31.082.014) Water vapor absorption, Nimbus.
Melik-Alaverdyan **et al.** (31.082.043) Precipitable water, Byurakan and Selim, USSR.
Borghesi **et al.** (31.082.060) Water vapor survey, Italy.
Petri **et al.** (31.082.069) LIDAR remote water vapor measures.
Maiya, Dierich (31.082.088) Water vapor at two sites, India.
Sherwood, Greve (32.082.082) Water vapor at La Silla, Chile.
Han **et al.** (33.034.136) Water vapor at Purple Mountain, China.
Greve (33.082.053) Correlation of surface humidity and precipitable water.
Chandrasekhar **et al.** (34.082.010) Water vapor at Ladakh, India.
(Wallace **et al.** 1984, **Publ. Astron. Soc. Pacific** 96, 836. Water vapor at Kitt Peak.)

SKY BRIGHTNESS

Cayrel **et al.** (30.082.125) IAU guidelines for minimizing urban sky glow.
Lyutyj,Sharov (31.082.005) Night sky in the Crimea, USSR.
Upgren **et al.** (31.082.052) Measures of light pollution.
Tanabe (31.082.086) IAU Commission 21 report, Light of night sky.
Neizvestnyj (33.082.002) Night sky at SAO Academy of Sciences, USSR.
Berry (34.082.083) Techniques for measuring.
(Garstang, 1984 **Observatory** 104, 196. Improved scattering formula.)