

# "SKY ON THE WEB" *your sky with a click*

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The Col Drusciè  
Astronomical Observatory  
in Cortina d'Ampezzo,  
1780 metres above  
sea level.

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*The remote control of telescopes is rapidly becoming a widespread phenomena. Nowadays, anyone, anywhere in the world where an Internet connection is available, can make serious astronomical observations simply by renting an entire observatory at very modest prices. Col Drusciè Observatory, located in the Italian Alps, is an example. Let's see how it all works.*

The astronomical observatory of Col Drusciè is located at the base of the "Tofane" peak, in Cortina d'Ampezzo, in the the Italian Dolomites, at an altitude of 1780 metres.

Here the skies are still transparent and dark, almost completely free of light pollution.

The light from Cortina, "Queen of the Dolomites", doesn't affect the quality of the skies as the observatory is located 600 metres higher, and the lights in the town are mostly shielded against up-illumination.

So from Col Drusciè stars to 6<sup>th</sup> magnitude are easily visible to the naked eye. The weather conditions at Cortina are mostly favourable, characterised by extended

periods of clear skies, especially in autumn and winter, interrupted by unstable periods more common in spring and summer. From a 20 year period of weather statistics it turns out that there are an average of 200 nights per year that are astronomically useful, mostly during the cold seasons, when the air is drier.

The seeing from the site is reasonably good, though not excellent. Although on the best nights values of around 1



The "Helmut Ullrich" telescope, a 20" f/5 Newtonian, the main instrument of the Col Drusciè observatory.

arcsecond are seen, typical values are closer to 2 arcseconds, but this is more than sufficient for deep sky images with instruments of focal lengths around 2 metres.

Col Drusciè Observatory was opened in 1975 and at the time was one of the largest private Italian observatories. The main telescope is a 52 cm diameter Newtonian with a focal length of 251 cm.

After the first semi-professional im-

ages, the members of the Astronomical Association of Cortina, who manage the observatory, spent the '80s and half of the '90s taking deep sky images that were later published in the book "Profondo Cielo" (Deep Sky) published in 1995 by Biroma. In 1998 the observatory was expanded with a second dome and a control room that links the two structures. In the same year the observatory was automated for remote control via desktop computer by the engineer Sergio Pascolini from Perugia. The use of this mode of

Internet interface, thus making it accessible by any computer connected to the web. So the "Astroweb System" was born, which then became "Sky on the Web", a sophisticated and innovative, Internet-based, control system for the two telescopes of the Col Drusciè Observatory, named after "Vittore Maioni" and "Helmut Ullrich", two important figures from the history of the Astronomical Association of Cortina who are unfortunately no longer with us. Users of "Sky on the Web" can auton-

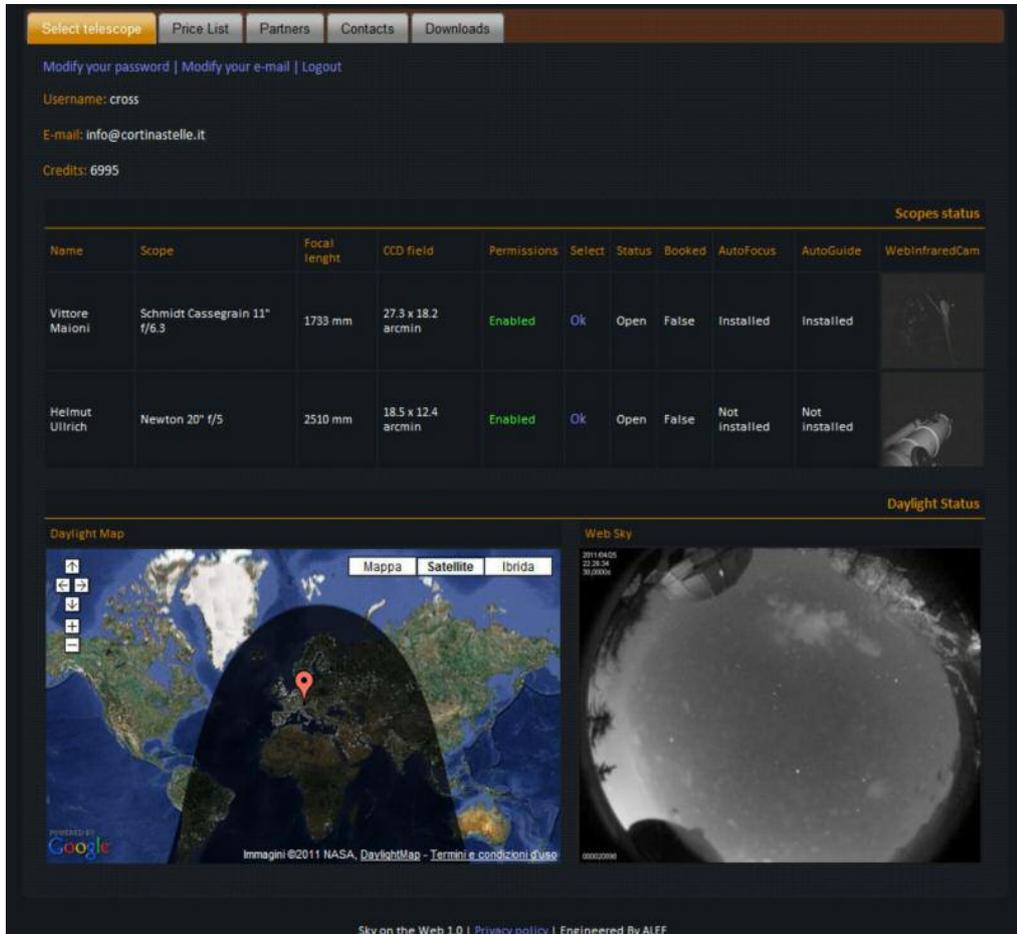
The introductory screen of "Sky on the Web".



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operation has allowed those involved in the CROSS program (Coldrusciè Remote Observatory Supernovae Search) to discover around 30 supernovae in 10 years. In 2009 the remote control system for the observatory was completely overhauled to make it compatible with an

ously take images of the night sky, simply by connecting to the site, [www.skyontheweb.org](http://www.skyontheweb.org), even from a Smart Phone! A real revolution in the way astronomy is done. There is no need to install any software on the user's computer. With "Sky on the Web", the user over-



The telescope selection screen. Google's "day-night" map is shown as well as the images of the night sky above the observatory taken by the all sky web-cam.

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sees the entire observing session, allowing control of both telescopes of Col Drusciè Observatory: a 28 cm diameter f/6.3 Schmidt-Cassegrain, and a 52 cm diameter f/5 Newtonian. The user therefore controls the opening of the dome, the pointing of the telescopes towards the object of interest and the taking of filtered monochromatic or colour images, as well as the archiving and downloading of the images to the user's computer. An advanced system is also in place to cope with the closing of the domes in case of weather emergencies such as rain, or even just when cloudy, so the user need not worry about these factors and can concentrate on imaging the spectacles that the sky has to offer.

In order to use the observatory one just needs to register with "Sky on the Web" at [www.skyontheweb.org](http://www.skyontheweb.org) and buy the number of hours required. The time can then be used as required throughout the year.

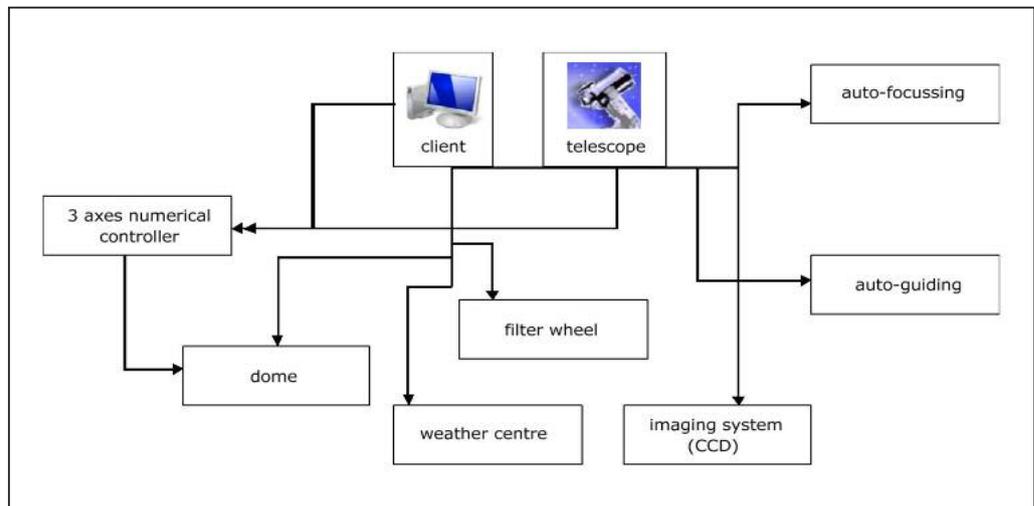
### An outline of the system

"Sky on the Web" is a program which coordinates the Internet-based control of telescopes in various geographical locations, and is made up of a complex combination of interconnected hardware, communication protocols, and data access control. The sequence of events making up an observing session can be summarised as follows:

- 1) Booking of the observing session and telescope.
- 2) Weather check and activation of the observing session, weather permitting, at the pre-established time.
- 3) Pointing of the target object by manually inputting the coordinates or via a list of objects. Once the object is targeted tracking is automatically initiated.
- 4) The dome is rotated in synchronisation with the telescope tracking.
- 5) Automatic focusing if requested by the user.
- 6) Placement of the desired filter.
- 7) Image acquisition of the target object with autoguiding if requested by the user.

tion of the "Sky on the Web" system. The system consists of a front-end server that controls the web site and the central database. This server controls the user permissions and all the operations necessary for the functioning of the system (locating the telescopes connected, IP addresses, permissions, peripheral devices such as the autofocuser) as well as the timing and organisation of the observing sessions. The server also stores all the images that are produced by the various observers. These images can be downloaded directly from the site or via FTP. The database is based on MySQL, while the web site is based on PHP technology.

Schematic representation of the "Sky on the Web" system.



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- 8) Automatic centering of the object in the frame via the "Pin Point" software.
  - 9) Saving of the acquired image in FITS format and in low resolution JPEG.
  - 10) Download of the image if requested by the user.
  - 11) Weather check. If weather permits then points 3 onwards are repeated if required.
  - 12) De-activation of the observing session at the pre-arranged time.
  - 13) Mail sent to the user with a report of the observing session.
- Above we see a schematic representa-

The system coordinates a series of Internet connected clients on which the back-end instruments run. There is also a database for each client that organises locally the access to data and all the devices that are used for the running of the observatory. The client database architecture is also based on MySQL, while the front-end applications are written in various languages, many of which are proprietary to the instrument company (for example the drive system, CCD camera etc.), but often based on the ASCOM platform. Below we look at the main devices

The observing session booking screen. The user has a great deal of flexibility over the choice of integration times and observing modes that can be used during a given night or over many nights. In the inset the details of an observing session.

The screenshot shows a web interface for booking observing sessions. At the top left is a calendar for February 2011. To its right is a table of 'Available sessions' with columns for 'Beginning', 'End', and 'Book'. Below this is an inset window titled 'Session details' which contains a table with columns: 'Target', 'Image', 'AR', 'DEC', 'AR Tun.', 'DEC Tun.', 'Manual', 'Dark', 'Autof.', 'Autog.', 'Filtr.', 'Dur.', and 'Bin.'. The table lists four targets: M57, M13, NGC5194, and NGC5194, each with a corresponding image thumbnail and numerical data for coordinates and settings.

controlled by a client.  
 1) The 3-axis numerical controller communicates via the TCP/IP protocol with the client and controls all aspects of movement of the telescope (right ascension and declination) and the dome. The brushless motors used are controlled via cards mounted directly on the controller.

This device also controls the safety system via stops at the track ends which prevent the telescope moving in the case of alarm.

2) The dome is controlled via one of the 3 axes of the controller described above, while opening and closing is achieved via digital outputs from the same controller, activated by the client.

3) The weather station, a Boltwood Cloud Sensor II, is continually queried by the client and its data recorded in the database. Apart from being published on the web site for information, these data are used to suspend or recommence operations in response to changes in the weather.

4) The filter wheel on the telescope is positioned by the client at the start of each exposure. The number of filters available depends on which filter wheel is used.

5) The imaging system, controlled by

MaxIm DL 5.01, deals with all communication with the CCDs installed at the observatory, currently two SBIG ST8 XMEs; that is, activation, exposure, temperature setting, binning etc. The same system is also used for post-processing tasks such as the creation of colour images from the combination of monochromatic RGB and luminance images.

6) The automatic focuser, a 'Robofocus', is invoked as required by the user when object coordinates are entered. This device selects the optimum focus by making small adjustments to the focus position.

7) The autoguiding system is activated as required by the user when object coordinates are entered. This takes images of a bright star, about every 5 seconds, using a second CCD (Orion StarShoot Autoguider) mounted on a secondary refractor with a large field of view. The motion of the guide star

is then used to correct the position of the main telescope so as to track this star, correcting not only guiding errors but also any mechanical give during the exposure.

### How the program works

The program has been realised in such a way as to provide a simple but flexible interface. "Sky on the Web" allows anyone, even with no specific training, to use the telescope control screens to photograph the night sky right from the first session. All that is required is a computer with a broadband Internet connection with any operating system. The following browsers are supported:

Firefox 2.0+, Explorer 6.0+, Google Chrome 1.0+, Safari 3.0+ and Opera 9.0+.

Access to [www.skyontheweb.org](http://www.skyontheweb.org) is via login and password once registered. Even at this stage it is possible to interact with the system, buying credits and requesting instrument activation from the administrator.

Time on the system is expressed in Universal Time, updated constantly over the Internet.

With "Sky on the Web" the night is divided into 15 minute windows, from which the user can choose those that best suit their observational needs. When an observing session is activated, the user will have access to all



Sergio Pascolini, electronic engineer, developed and implemented "Sky on the Web".

the functions of the program, including live imaging of a celestial object.

From the "Observe" menu it is extremely simple to insert the celestial coordinates, exposure times, filters and binning options and to select the autoguiding, autofocus and dark frame options. By choosing the filter "LRGB-Color" it is also possible to automatically acquire colour images even though the sensor of the CCD camera is monochromatic. The system will take a sequence of 5 images in the "Luminance", "Red", "Green" and "Blue" filters, as well as a dark frame that will be automatically subtracted from each of the other frames, so that preview images are shown without thermal and electronic noise. A flat field correction is also applied.

As an example, if the user wanted to image a galaxy or a nebula with an exposure time of 300 seconds it would be necessary to book at least 2 consecutive 15 minute sessions, as the total time required is multiplied by 5. On top of this, some time is also needed for pointing and centering the object, and possible autofocusing, that the

system will estimate. The filters used are the classical dielectric LRGB filters from "Baader Planetarium", to which an H-alpha and an [OIII] filter have been added, also from "Baader". Once the exposures are completed, the user has the option to download the individual LRGB+D frames or the colour FITS file, combined automatically with MaxIm DL 5.01. The downloading of the individual frames is

lem: the utilities included, "Catalogs" and "Skymap", allow you to select, via various selection criteria, the galaxy, nebula or star cluster from a series of catalogues containing tens of thousands of objects.

Amongst the catalogues provided are the Messier catalogue, the New General Catalogue (NGC), the Index Catalogue (IC) and the Upsala General Catalogue (UGC) of Galaxies. The non-

The screenshot displays a comprehensive control interface for an astronomical observation session. It is organized into several functional panels:

- Pointing:** Controls for epoch (2000 01 01), target (M 31), right ascension (00 42 42), declination (+ 41 16 00), filter (LRGB-Color), duration (30), binning (2), and autofocus/autoguide/dark frame options.
- Session details:** Shows start and end times for the session (2010-12-26 18:59:00 to 19:14:00).
- Current image:** A live view of the target star cluster M 31.
- Infrared camera:** A live view of the telescope's internal components.
- Scope status:** A table of telescope parameters:
 

Dome status	Dome Open
Cover status	Cover Open
Controller status	Connect
Axis status	Scope On Guiding
Right ascension	02 15 09.00
Declination	+00 00 06.00
Height	43.47
Azimuth	178.20
Air mass	1.45
Dome azimuth	180.31
- Camera CCD:** A table of camera settings:
 

CCD status	CCD Connected
CCD name	SBIG Universal
Pixel x y	765   510
Binning	2
Filter wheel status	FilterWheel Connected
Filter name	Luminance
T* C CCD setting   actual	-20.00   -20.86
CCD Cooler	On
Image Name-Time expo	prova   30s
% Acquired	13
- Meteo:** A table of weather station data:
 

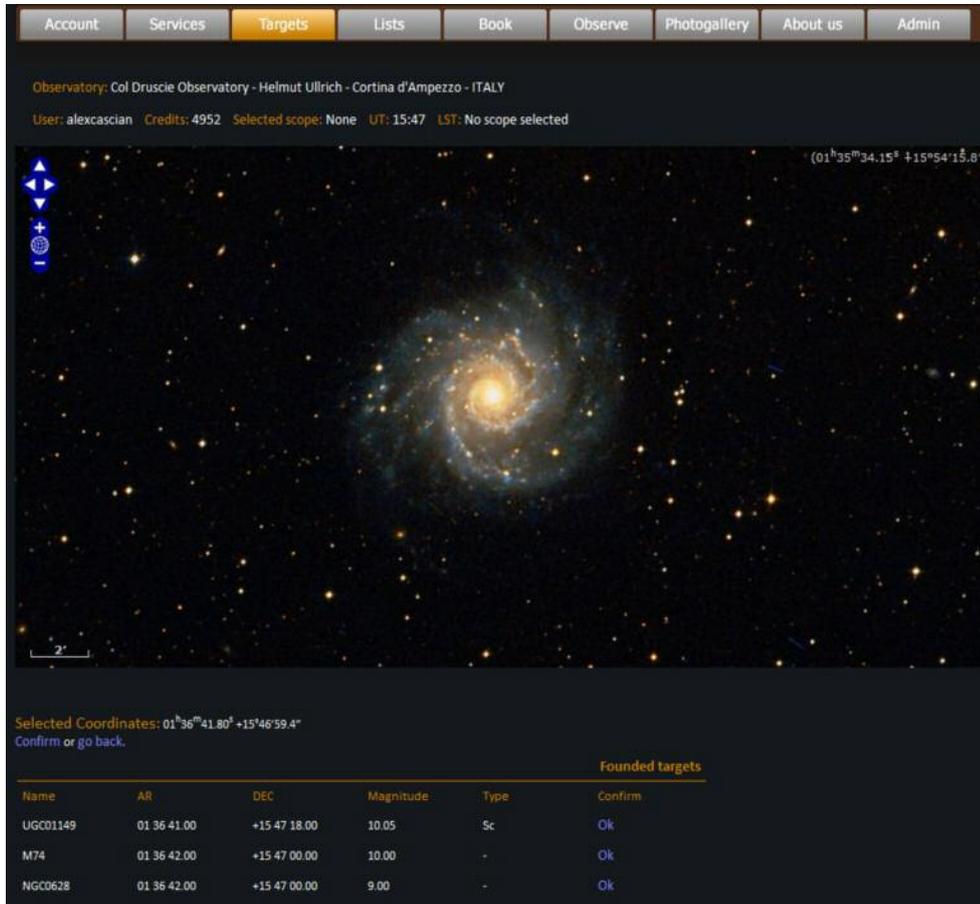
Weather station	Clarity
Temperature* C	-9.10
Humidity %	53.00
Wind	Calm
Wind speed kph	4.80
Cloud	Clear
Light	Dark
Rain	Dry
System	Operating

The image acquisition screen and display of parameters for the weather, observatory, telescope and CCD.

nonetheless recommended, so that post-processing of the individual frames can be done by the user. The automatically generated colour FITS file sometimes isn't well matched to the chromatic balance of the object or the user's aesthetic tastes. If you can't think of what to photograph, no prob-

expert user can also refer to a selection of bright objects: galaxies, nebulae and star clusters, extracted from the main catalogues, so that the ideal object to image can be selected whatever the time of night or season.

One feature of particular interest is the "Skymap" function, which allows the



Example object selection screen of the "Sky-map" function.

stantly updated graphs from the weather station show the weather trend over the last hours (cloud cover, temperature, humidity, wind speed and light levels) so that the user has a record of the conditions at any point during the night. An SBIG "All sky webcam", in support of the weather data, shows an image of the sky above the observatory every 5 minutes, while two webcams with infrared LEDs show the position and orientation of the instruments. Finally, a preview window shows the last image frame, so that the pointing can be

checked and integration times evaluated by the results, in real time. For the centering of the object, a program automatically adjusts the position of the telescope as a function of the hour angle and declination of the source, while the "Pin Point" program from the American company "DC-3 Dreams" applies final corrections to bring objects to the centre of the field of view in 90% of cases. If the object does not end up perfectly centred, the user can apply corrections manually. At any time, the user can check and download the images taken via the online "Photogallery", easy to consult via thumbnails and medium resolution previews. Here also, a series of filters make it easy to select the images of interest (by observation date, object,

user to navigate a virtual celestial sphere in search of the best or most interesting object observable at any given time. With a simple click on the screen, the name of the object and its coordinates are entered into the system as the next target for observation with the Col Drusciè telescopes. To avoid problems with the image acquisition system, the only object that can't be observed, except for the Sun of course, is the Moon. From the "Observe" menu it is possible keep the state of the observatory under control, as if you were physically in front of the instrument. A set of windows inform the user as to the weather conditions, exposure parameters and on the state and position of the telescope and dome. A series of con-

checked and integration times evaluated by the results, in real time. For the centering of the object, a program automatically adjusts the position of the telescope as a function of the hour angle and declination of the source, while the "Pin Point" program from the American company "DC-3 Dreams" applies final corrections to bring objects to the centre of the field of view in 90% of cases. If the object does not end up perfectly centred, the user can apply corrections manually. At any time, the user can check and download the images taken via the online "Photogallery", easy to consult via thumbnails and medium resolution previews. Here also, a series of filters make it easy to select the images of interest (by observation date, object,

filter, exposure time, telescope etc.), and with a simple click of the mouse the image is downloaded to the users computer. To download an entire observing session or group of images there is a zipped download option. Via "Sky on the Web" the advanced amateur can carry out a serious research program, whether in the field of supernovae, asteroids, variable stars, comets or any of many other possibilities. Thanks to the "List" and "Target" options it is actually possible to pre-load lists or single targets that can be associated with a number of observational parameters. These lists can then

the observations from where they left off. Only the images that should have been taken during the cloudy interval are 'lost'.

For the construction of target lists one can use the online catalogues and "Skymap". The user can also create lists on their own PC using Excel and later upload the list to "Sky on the Web" using a purpose-built function.

### Costs and prospects

The cost of time on the telescopes is proportional to the number of hours requested. For example, 5 hours on



The galaxy M51 and supernova SN2011dh (indicated by the tick marks), taken with the Ul-Irich telescope (tri-colour LRGB - 60 second exposure).

be linked to booked observing sessions, even several days ahead of time, and the system will carry out the observations when weather conditions permit.

If the weather conditions change during an observing session, "Sky on the Web" behaves 'intelligently', remembering the objects in the target list, and, when the weather is once again favourable, automatically restarting

the 28 cm "Vittore Maioni" telescope costs 10 euro per hour. For a more advanced user, intending to use the telescope more often, and who buys a package of 30 hours, the price reduces to 5 euro/hour.

There is also a "researcher" profile, whereby a user can book 250 hours on the telescope, providing the possibility to follow a serious research program, at a price of only 2 euro/hour.



The Trifid Nebula (M20) taken in tri-colour LRGB with the Maioni telescope (60 second exposure).

amateur astronomers to image the night sky and carry out astronomical research at very affordable prices.

### Contacts:

Astronomical Association of Cortina: [www.skyontheweb.org](http://www.skyontheweb.org) and [www.cortinastelle.it](http://www.cortinastelle.it). Engineer Sergio Pascolini: [www.skyontheweb.com](http://www.skyontheweb.com) e [www.alefpg.com](http://www.alefpg.com).

The prices for the 52 cm "Helmut Ulrich" telescope, are exactly double, for a given number of hours.

"Sky on the Web" is the ideal Internet application for the integrated control of an advanced amateur observatory, with medium to large instruments, in, say, the 40-80 cm range, up to 1 metre in diameter. Nowadays there are many programs that come with astronomical mounts that permit the automation of astronomical observations. However, to an astronomical association that manages a traditional observatory, with a classical dome and equatorial mount, such programs are of little use. For such observatories "Sky on the Web" can offer an integrated solution for managing the observatory, with the obvious advantage of allowing all its members, and possibly the whole world, to use its instruments. This obviously expands the research potential of the observatory. "Sky on the Web" is a new experience, that, we hope, will go far. Our dream is to create a network of inter-connected instruments, not only in Italy but all over the world, that will allow

**Alessandro Dimai** is the director of the Col Drusciè Astronomical Observatory. He has worked for over 10 years in the field of extragalactic supernovae with the CROSS programme, organised by the Astronomical Association of Cortina, which has led to the discovery of around 30 supernovae. He has personally discovered 13 supernovae and a minor planet (50240 Cortina). He is author of two books: "Profondo Cielo" ("Deep Sky", Biroma, 1995), and "Hale-Bopp, la Cometa del Secolo" ("Hale-Bopp, Comet of the Century", La Cooperativa, 1997). He coordinated, on behalf of the Astronomical Association of Cortina, the entire construction of the "Sky on the Web" system.

**Sergio Pascolini** graduated in 1992 with a degree in electronic engineering at the University of Perugia, with a final year thesis entitled, "Development of a drive system for the 40 cm telescope of the Astronomical Observatory of Perugia". Research activities: development of a telescope network for automated telescopes, promoted by Digital Equipment spa. Consultancy for: ENEA - University of Perugia - the region of Umbria, for the design and construction of an 80 cm robotic telescope to be installed in the Antarctic; University of Perugia for the development of numerical controllers. He also developed and installed the "Sky on the Web" system for Col Drusciè Astronomical Observatory in Cortina D'Ampezzo, Italy, and is a partner of ALEF srl in Perugia, a management and computing consultancy firm.