The TNG Automatic Weather Station

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A preliminary analysis of the archive data

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Contents

1 Presentation

The National Galileo Telescope (TNG) is one of the astronomical facilities located at the Observatorio del Roque de Los Muchachos (ORM), in north side of the La Palma Island. Since the year 1970, La Palma Island appeared a favorable geophysical site from the point of view of the sky conditions, and it was choosen to host the main astronomical telescopes to explore the northern hemisphere of the sky. The very good astronomical conditions are mainly due to the stable subsiding maritime airmass that place most of the time TNG and the other telescopes near the top of the mountain well above the inversion layer (occurring in the range between 800m and 1200 m (McInnes et al. 1974)).

All the telescopes are located along the northern edge of the Caldera de Taburiente. The complex horography, due to the irregular shape of the Caldera, and the crowdness of the top, due to the presence of the other astronomical observatories, suggests a possible modification of the local microclimate making difficult to foresee in advance the local meteorological parameters used to optimize the temperature control inside the domes or for the safety operational limits of the telescopes. Therefore in these last years the ORM has been extensively monitored thanks to the dedication of the several site testing groups affering to the hosted astronomical observatories.

Since the years 1998, TNG site is monitored on a continuous basis by an automatic weather station, which provides measurements of a few local meteorological parameters. All these istantaneous and long term record of the meteorological data are important tools for meteorological and climatological studies, as well as for the calibration of satellite remote sensing of the atmospheric and ground conditions.

Furthermore the proximity of the Sahara desert induces dust events during the years. It is our opinion that a knowledge of the amount and, if possible, of the distribution of this airborne dust is an important tool to have reliable astrophysical measurements in the widest range of wavelenght. Therefore in the beginning of the year 2001 we added to the set of meteorological sensors a multichannel dust monitor. This facility provides the size distribution of atmospheric dust particles close to the TNG and it is able to detect and discriminate among four different particle sizes (0.3, 0.5, 1 and 5 μ): the typical size of Sahara dust.

In this report we present for the first time measurements of the meteorological and environmental conditions made at TNG and a first analysis of such data.

In the first part of this report we present the instruments and the summary of the meteorological data, including the monthly averages since the Year 1998.

The second part contains the plots averaged for each month of the years 2001, 2002, 2003 and 2004.

The meteo data have been also compared to those obtained at the meteorological stations of the Nordic Optical Telescope (NOT) and Carlsberg Automatic Meridian Circle Telescope (CAMC) in order to check local variations or instrumentation biases. The analysis of these

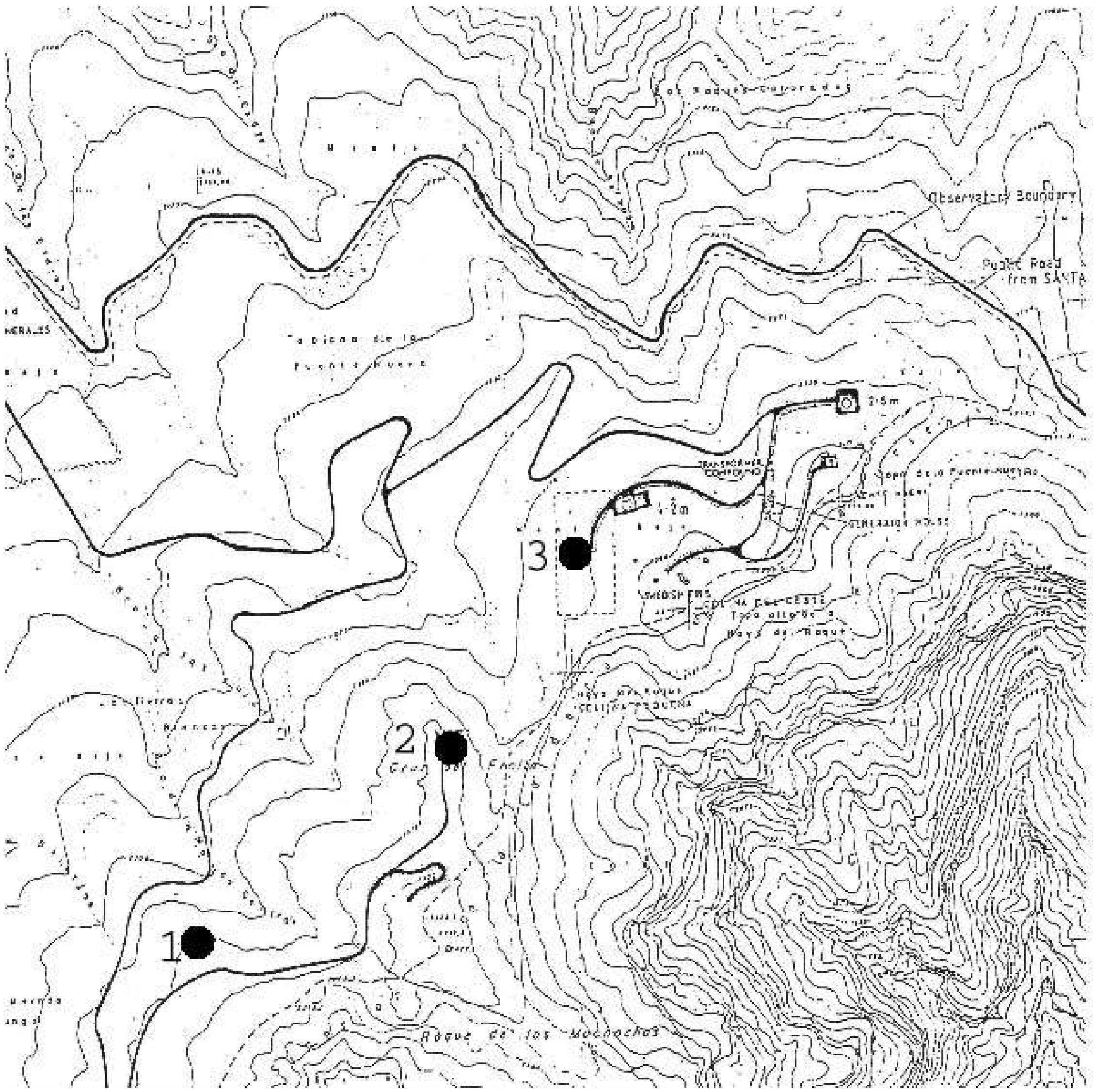

Figure 1: Map of the ORM showing locations of: 1. Galileo Telescope, 2. NOT Telescope, 3. CAMC

Figure 2: The Meteo Tower of TNG. Clear appear the sensors distributed along the tower

differences in terms of image qualities at the telescopes will be discussed in a next paper.

1.1 The Automatic TNG Weather Stations

The TNG meteo tower is a robust steel structure with a total height of 15 meters. The tower is located about 100 m far from TNG building. The sensors are distributed along the tower at five different heights.

The upper part of the tower is designed with a telescopic arm to better maintain the anemometer on top of it. The meteorological sensors are read automatically and stored in a computer. All data acquisition system is hosted at the bottom of the tower and the data are regularly sent from the tower to TNG annex building by means of an optic fiber link. The data sampling rate is 10 sec, while data storage is done every 30 seconds. Both sensor sampling and data logging are driven by a Vaisala QLC50 datalogger. The choice of the sensors and control equipment was determined by the need to survive to the high altitude and to the severe winter conditions.

Most of the adopted instrumentation has been previously tested in similar, or even worst, environmental conditions.

The devices providing the basic meteorological measurements are listed here below:

- Temperature: temperature sampling is available at four different locations (-1, 2, 5 and 10 meters above the ground)
  - Analog device : Pt100, 4 wires
  - Accuracy : 0.2^0Celsius
- Atmospheric Pressure: it is measured at 10 m from the ground, it is given in mbar.
  - Digital device : Vaisala PTB200 class A
  - Accuracy : 0.1 hPa
- Relative Humidity: it is measured at 2 m from the ground
  - Device : Humicap HMP35D Vaisala
  - Accuracy : $\pm$ 1% for RH $<$ 90%; $\pm$ 2% above 90%
- Wind speed and wind direction: it is measured at the top of the tower
  - Device : WMS301 Anemometer Vaisala. The wind speed is measured in m/s.
  - Accuracy : $<$ 2% for wind speed; $\pm 3^0$ for wind direction The wind speed is measured in m/s, the wind direction is measured in degrees, North is represented with 0^0, East with 90^0, South with ^{0} and West with 270^0

A summary of the meteorological data from 1998 to 2004 taken at TNG, can be found from Table 1 to Table 7. Each tabulated value is the monthly mean computed at four hours: 2, 8, 2 p.m, and 8 p.m. as indicated in the tables. The indicated hours are choosen because they are the most representative in this site analysis. In fact at these specific hours typically we have minimum and maximum values.

Table 9 shows the annual statistics of TNG data. Each value is the mean annual value computed taking into account the whole data set.

The tables 10, 11, 12 and 13 report and compare TNG meteo data with those of NOT and CAMC.

We found that CAMC shows a lowest wind speed with respect the other telescopes, while the NOT presents the highest wind speed.

TNG shows a cumulative mean of wind speed of about 4.8 m/s similar to that measured at the 10m segmented Gran Telescopio Canarias (GTC) : 89% of the time lower than 5 m/s as found by Jabiri et al. (2000). NOT is the coolest telescope site with more than 2 deg. difference during the nigth and in the evening, while during the day temperature at TNG and CAMC show differences within 0.1-0.2 deg. The year to year variations appear confirmed, by both the meteo sets, at a level of about 0.5 degrees.

Figure 3: The ABACUS^{TM} particle measuring systems

1.2 The Dust Monitor

The western Canary Islands are under the influence of the Ocean weather with dominant trade winds from north, specially during the summer time. Moreover the eastern side is influenced by the continental weather, in particular La Palma Island suffers the Calima effect: the wind, carries an high concentration of dust on suspension that can reach high altitudes. The amount of the the moved dust is considerable: the wind transfer from Sahara desert about $2 \cdot 10^8$ tonnes of dust every years (Whittet 1987). The knowledge of the effect of this storm of dust is important because presents several implications, in particular may to affect the astronomical observations.

The TNG site group, in order to improve the Galileo astroclimatic station and to study some relationship between the counts of dust particles measured at the TNG and the environmental parameter, put in operation a dust monitor. Up to now no ground based data are available about the size distribution of the dust particles at the ORM, nor their correlation with the extinction data and with the local meteorological measurement.

The knowledge of the distibution of dust particles is interesting and useful in particular

- to understand if local measurements may be taken as good indicators of the upper air conditions

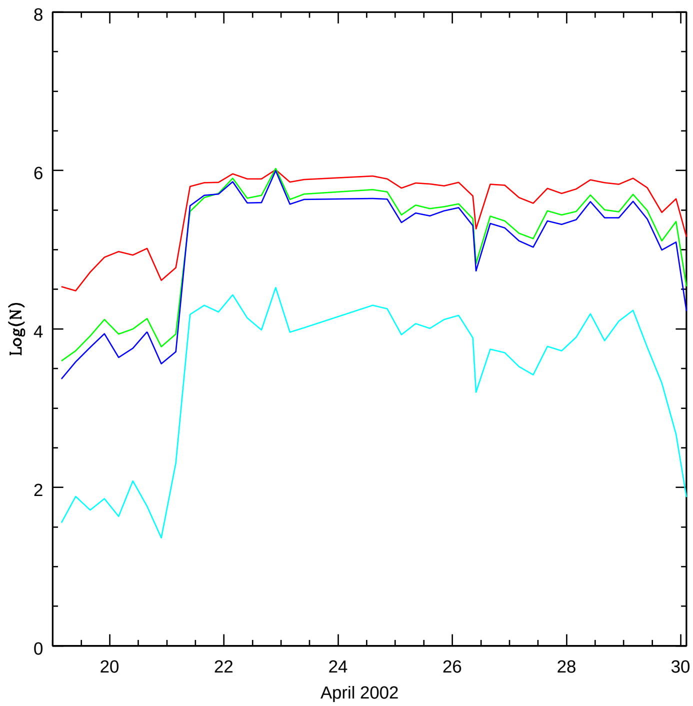

Figure 4: Calima effect in April 2002.

- as a warning for the telescope control system, indicating a potentially dangerous situation for the telescope

Chap.7 of this report shows the distributions of air dust particles collected close to TNG telescope from the Year 2001 to the Year 2004. Data are recorded as counts/m^3. The files of the data produced are discontinous during the time because no data were collected where the relative humidity gave a value above 90% because the humidity may affect dust counts.

Our measurements confirm a seasonal distribution of dust with a maximum of the density in the summer time. However we found strong activity also in “non dusty season”. A first analysis of these data can be found in Ghedina et al. (2004) and in Porceddu et al.(2002 a,b).

We found that the mean values of counts ranging between few undred for coarse particles to 10^6 for fine particles, but during the storm event the number may increase also of about a factor 6. In particular particles having size of 5μ show the highest increased number counts.

An example of the calima effects in the dust counts is given in the Figures 4 and 5 . Different colours are used for the different size of particles: red for 0.3μ, green for 0.5μ, blue for 1μ and cyan for 5μ.

Figure 4 shows the increased dust counts during the month of April 2002. Dust monitor give the maximum value on April 22^{th}. The event is about one week long.

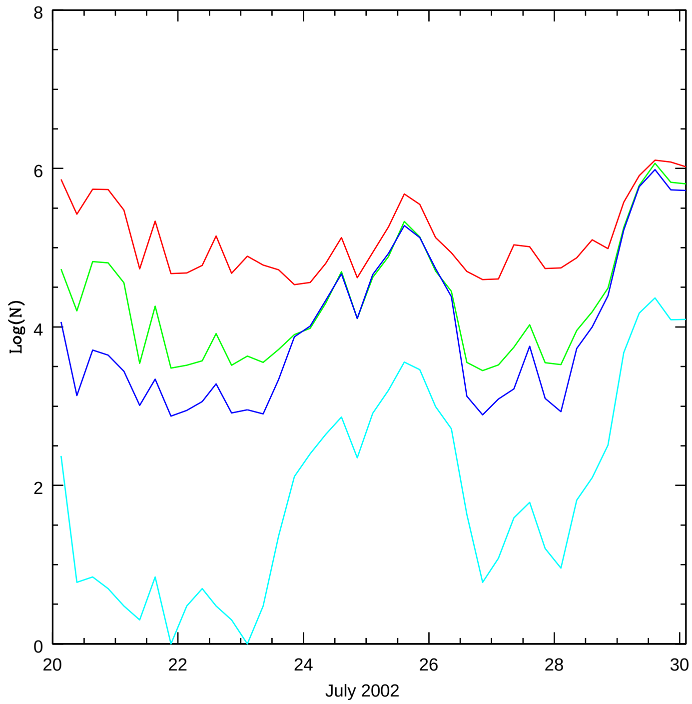

Figure 5: Calima on July 2002.

Guerrero et al. (1998) studied the atmospheric extinction in the V band using a set of measurements from CAMC during the years 1984-1998 taken at La Palma. Guerrero shows that during the dust event value of extinction increase up to 0.6 mag./airmass.

Figure 5 shows an other dust event occurred in the same year. The maximum value is given on July 29^{th}, but several small dust bump are during the whole month.

A preliminary analysis of these events with the meteo parameters shows that there is a very fast changing in the wind direction from ESE to WSW. A more deep analysis of the relationship between dust storm and meteo parameters is in preparation.

Murdin (1986), from a study of dust and atmospheric transmission, found that the transmission shows variation from 90% of nights classified as good and 58% in July, August and September, months affected by calima.

Moreover, dust and poor sky conditions due to clouds are correlated through a southerly wind.

1.3 The TNG Meteorological Data

In the following tables are reported values of the basic meteorological parameters for each month. Each table reports in column 1 the measured parameter at the four indicated hours, and in the columns are reported the months of the year identified with a number.

Table 1: **Year 1998**

Par.	1	2	3	4	5	6	7	8	9	10	11	12
$t2/2^h$			3.14	7.19	5.69	11.63	17.02	16.67	13.89	10.16	7.28	3.63
$t2/8^h$			2.69	7.72	6.52	12.59	18.16	17.32	14.11	10.41	7.74	3.35
$t2/14^h$			6.96	10.86	10.05	15.91	21.79	21.19	17.99	13.92	10.64	6.19
$t2/20^h$			3.68	7.71	6.79	13.16	18.21	17.34	14.73	10.29	7.54	4.20
$t5/2^h$			3.48	7.42	5.97	12.03	17.95	16.97	14.19	10.46	7.60	3.90
$t5/8^h$			2.96	7.87	6.5	12.66	18.29	17.45	14.31	10.70	8.03	3.57
$t5/14^h$			6.34	10.10	9.04	14.98	20.79	20.27	17.15	13.23	10.18	5.88
$t5/20^h$			3.82	7.72	6.67	13.00	18.63	17.27	14.75	10.43	7.71	4.39
$t10/2^h$			3.66	7.58	6.12	12.81	18.17	17.13	14.36	10.63	7.78	4.04
$t10/8^h$			3.15	7.92	6.39	12.48	18.72	17.45	14.32	10.78	8.21	3.69
$t10/14^h$			5.9	6.62	8.38	14.36	20.32	19.73	16.63	12.70	9.76	5.61
$t10/20^h$			3.89	7.72	6.61	12.69	20.02	17.21	14.76	10.50	7.79	4.49
$P/2\ ^h$			766.0	770.1	769.2	773.3	774.4	774.8	773.7	772.9	772.4	771.5
$P/8^h$			766.5	770.4	769.6	773.6	775.2	775.1	773.7	773.5	772.7	771.7
$P/14^h$			766.0	770.6	769.9	773.8	775.6	775.6	773.8	774.0	772.3	771.3
$P/20^h$			765.7	770.5	769.9	773.9	774.2	774.8	774.5	774.9	772.7	772.0
$RH/2^h$			63.5	27.7	43.5	62.7	11.3	21.9	27.7	39.7	30.4	42.9
$RH/8^h$			54.43	25.3	46.5	27.8	12.1	19.9	29.8	40.9	28.6	52.7
$RH/14^h$			62.33	31.2	46.0	32.2	17.4	20.1	35.1	40.9	39.3	62.2
$RH/20^h$			66.44	25.2	38.5	25.6	14.0	19.6	27.0	42.2	38.0	46.4
$WS/2^h$			5.36	4.97	4.80	3.86	4.41	5.33	3.78	4.41	3.61	5.79
$WS/8^h$			4.88	4.92	5.26	3.58	4.11	4.97	3.97	4.31	4.19	4.67
$WS/14^h$			5.4	4.41	5.02	4.31	4.99	5.47	4.50	4.47	3.28	4.40
$WS/20^h$			6.8	5.31	4.89	4.16	4.25	5.17	4.07	4.04	4.42	5.10
$WD/2^h$			231	108.6	142.1	138.6	165.3	180.5	155.8	190.1	152.7	144.9
$WD/8^h$			298	92.2	133.9	129.3	187.3	156.3	141.9	198.5	146.5	157.8
$WD/14^h$			264	149.9	182.1	203.1	241.3	215.4	211.1	207.9	182.4	190.9
$WD/20^h$			260	102.5	102.0	137.6	185.2	160.1	153.6	201.7	154.1	153.0

Table 2: **Year 1999**

Par.	1	2	3	4	5	6	7	8	9	10	11	12
t2/2^h	1.61			6.62	9.43	12.75	15.54	15.28	12.22	7.55	5.95	4.94
t2/8^h	2.6			8.98	10.80	14.39	16.97	16.08	13.14	7.80	6.06	4.93
t2/14^h	3.09			11.37	15.26	17.81	20.67	19.6	16.42	10.90	8.59	7.58
t2/20^h	1.70			7.63	10.93	13.93	16.67	16.11	12.74	7.97	6.50	5.46
t5/2^h	1.72			6.72	9.79	13.16	15.88	15.60	12.56	7.94	6.23	5.21
t5/8^h	2.67			8.96	10.75	14.40	17.02	16.16	13.40	8.10	6.30	5.21
t5/14^h	2.99			10.4	14.09	16.72	19.64	18.71	15.54	10.28	8.15	7.27
t5/20^h	1.71			7.56	10.83	13.79	16.53	16.02	12.77	8.16	6.72	5.67
t10/2^h	1.71			6.76	9.99	13.32	16.05	15.76	12.74	8.15	6.38	5.34
t10/8^h	2.66			8.83	10.62	14.23	16.92	16.14	13.42	8.17	6.41	5.32
t10/14^h	2.82			9.61	13.28	16.01	18.97	18.10	14.90	9.81	7.83	7.05
t10/20^h	1.71			7.51	10.82	13.71	16.43	15.96	12.78	8.24	6.80	5.75
P/2^h	766.6			769.8	771.2	773.9	774.5	773.6	772.5	770.9	771.0	771.7
P/8^h	767.2			771.9	771.6	774.3	775.0	774.0	773.4	771.4	771.4	772.1
P/14^h	765.9			770.7	771.9	774.6	775.1	774.2	773.1	771.2	770.8	771.5
P/20^h	766.6			770.9	771.9	774.6	775.0	774.1	773.3	771.7	771.4	772.3
RH/2^h	83.3			39.8	24.8	18.96	19.5	34.6	34.6	51.4	59.6	40.3
RH/8^h	78.0			38.8	24.1	19.87	18.5	34.2	21.5	46.5	62.5	43.4
RH/14^h	79.8			42.6	24.4	24.45	22.8	35.9	36.6	62.2	62.3	43.9
RH/20^h	84.4			35.6	18.1	19.28	20.0	33.1	34.5	54.7	56.5	40.8
WS/2^h	17.3			7.09	4.63	4.39	4.05	4.40	4.80	4.08	5.48	4.25
WS/8^h	17.6			4.5	4.22	4.58	3.68	4.13	4.94	4.88	5.54	3.95
WS/14^h	14.7			4.8	4.71	5.30	4.22	4.50	5.27	4.66	5.07	3.76
WS/20^h	18.6			5.6	4.12	4.61	4.29	4.25	4.54	4.22	5.85	4.82
WD/2^h	154.4			106.9	226.0	194.1	150.6	198.9	190.0	198.9	155.6	147.8
WD/8^h	164.6			101.9	217.4	193.2	169.5	216.7	163.0	181.1	159.8	138.0
WD/14^h	161.4			181.1	226.6	237.8	227.6	247.3	227.2	215.6	194.2	159.4
WD/20^h	153.4			139.5	219.6	181.7	133.6	190.6	183.6	183.8	150.1	123.2

Table 3: **Year 2000**

Par.	1	2	3	4	5	6	7	8	9	10	11	12
$t2/2^h$	1.12	4.88	5.72	4.31	6.22	14.29	15.92	15.89	12.80	9.15	7.47	5.90
$t2/8^h$	0.72	5.05	5.85	4.90	7.60	15.46	17.45	16.52	13.50	9.26	7.22	6.06
$t2/14^h$	2.69	8.13	9.35	7.78	10.99	18.93	20.82	19.92	17.23	12.71	10.28	8.35
$t2/20^h$	1.25	5.44	6.05	4.82	7.22	14.99	16.93	16.29	13.17	9.53	7.84	5.74
$t5/2^h$	1.26	5.13	6.00	4.70	6.49	14.63	16.25	16.32	13.14	9.43	7.80	6.26
$t5/8^h$	0.89	5.35	6.08	5.02	7.60	15.45	17.53	16.64	13.70	9.55	7.48	6.39
$t5/14^h$	1.47	7.75	8.76	7.07	10.11	17.89	19.80	18.97	16.29	12.12	9.75	7.99
$t5/20^h$	1.25	5.64	6.15	4.85	7.14	14.92	16.86	16.34	13.25	9.62	8.03	5.97
$t10/2^h$	1.34	5.24	6.15	4.82	6.47	14.75	16.23	16.44	13.18	9.43	7.79	6.30
$t10/8^h$	0.97	5.49	6.14	5.12	7.71	15.53	17.71	16.77	13.72	9.52	7.53	6.44
$t10/14^h$	2.17	7.38	8.24	6.90	10.01	17.61	19.60	18.80	16.04	12.15	9.72	8.14
$t10/20^h$	1.23	5.72	6.18	4.82	7.05	14.90	16.80	16.29	13.23	9.58	8.06	6.05
$P/2^h$	768.3	773.9	769.4	767.1	768.7	773.7	773.6	775.2	773.2	772.6	771.4	771.3
$P/8^h$	768.6	774.0	769.6	767.4	769.4	774.1	774.1	775.6	773.7	772.2	771.8	771.5
$P/14^h$	768.2	773.6	769.6	767.8	769.8	774.4	774.4	775.6	773.7	772.8	771.2	771.6
$P/20^h$	768.9	774.1	769.6	767.7	769.5	774.4	774.4	775.6	774.0	773.2	771.9	771.8
$RH/2^h$	64.4	36.7	28.4	37.1	43.1	13.9	15.5	18.8	23.35	35.51	37.0	43.9
$RH/8^h$	70.4	37.4	28.6	41.8	41.2	16.8	15.9	19.5	23.99	35.84	48.7	45.0
$RH/14^h$	82.5	42.9	33.7	46.2	44.3	18.4	16.9	24.7	32.72	39.97	46.0	52.6
$RH/20^h$	75.2	36.1	29.1	40.9	41.7	14.1	15.2	20.4	27.36	43.82	32.2	49.2
$WS/2^h$	3.4	3.33	5.65	4.76	4.71	5.44	4.17	3.80	4.68	4.83	4.54	4.96
$WS/8^h$	3.4	3.26	5.35	4.95	3.99	5.03	4.05	4.09	4.26	4.67	4.48	5.55
$WS/14^h$	2.8	3.18	5.0	5.06	4.23	5.41	5.00	4.57	4.86	4.25	4.46	4.65
$WS/20^h$	3.1	3.27	5.78	5.23	4.58	5.34	4.75	3.90	4.62	5.27	5.38	5.31
$WD/2^h$	177.5	153.3	193.7	239.3	228.2	184.3	163.7	194.7	164.1	124.5	134.0	219.0
$WD/8^h$	170.7	151.1	189.6	229.3	190.1	207.5	181.8	205.7	177.0	116.4	137.3	198.0
$WD/14^h$	181.3	195.8	208.4	242.9	225.4	219.2	200.3	229.3	198.7	151.2	169.5	219.6
$WD/20\ ^h$	150.3	147.2	178.0	222.6	218.6	206.8	149.0	198.7	154.4	90.7	105.2	206.2

Table 4: **Year 2001**

Par.	1	2	3	4	5	6	7	8	9	10	11	12
t2/2^h	7.0	5.62	6.15	7.54	9.02	13.34	15.64	15.29	12.17			4.85
t2/8^h	6.6	5.81	5.94	8.50	10.45	15.14	17.24	16.29	12.45			4.99
t2/14^h	9.9	9.36	9.14	11.89	14.14	18.55	20.57	20.17	16.52			6.62
t2/20^h	6.9	5.85	6.38	8.51	10.46	14.52	16.50	16.06	12.98			4.78
t5/2^h	7.38	6.03	6.51	7.85	9.33	13.68	15.98	15.67	12.52			5.08
t5/8^h	7.06	6.25	6.19	8.59	10.45	15.19	17.29	16.44	12.62			5.23
t5/14^h	9.5	8.73	8.58	11.10	13.09	17.48	19.55	19.16	15.58			6.38
t5/20^h	7.18	6.07	6.55	8.62	10.43	14.46	16.45	16.03	12.97			4.93
t10/2^h	7.33	6.17	6.70	7.95	9.45	13.86	16.17	15.84	12.68			5.17
t10/8^h	7.15	6.38	6.27	8.58	10.33	15.05	17.18	16.44	12.62			5.33
t10/14^h	9.9	8.34	8.19	10.65	12.45	16.82	18.96	18.52	14.97			6.13
t10/20^h	7.22	6.17	6.61	8.63	10.40	14.42	16.43	16.02	12.96			4.94
P/2^h	773.5	771.4	768.9	770.6	770.6	774.1	774.7	775.1	773.3			767.0
P/8^h	773.7	771.6	769.2	771.1	771.2	774.6	775.1	775.4	773.6			766.8
P/14^h	773.3	771.2	769.2	770.6	771.3	774.8	775.3	775.7	773.7			766.4
P/20^h	774.0	771.6	769.4	771.4	771.4	774.8	775.3	775.6	773.8			767.0
RH/2^h	29.7	19.8	38.1	25.7	27.5	17.38	17.9	22.5	46.2			70.5
RH/8^h	23.7	20.2	42.3	28.4	27.3	15.31	17.6	23.1	50.0			68.6
RH/14^h	29.2	25.7	44.6	20.9	30.0	20.03	23.6	25.4	44.3			74.5
RH/20^h	31.1	21.6	37.7	24.7	22.1	18.49	17.4	22.3	46.0			74.1
WS/2^h	4.17	3.96	6.74	3.60	4.65	4.76	4.54	4.48	4.86			6.63
WS/8^h	3.98	3.59	6.93	3.77	4.16	3.80	3.63	4.37	5.12			7.17
WS/14^h	3.73	4.19	6.41	3.02	4.58	4.65	4.21	4.46	5.51			6.75
WS/20^h	4.3	4.51	7.08	4.41	5.02	4.62	4.16	4.95	4.65			6.82
WD/2^h	144.7	205.6	189.8	124.6	168.9	127.4	150.5	145.4	220.8			212.3
WD/8^h	178.0	220.2	178.3	108.8	156.9	153.6	177.1	172.7	234.4			211.7
WD/14^h	221.0	222.6	194.0	205.7	228.8	190.7	213.8	202.8	252.4			214.3
WD/20^h	154.1	202.6	192.5	91.7	168.0	149.7	154.3	156.7	222.2			216.9

Table 5: **Year 2002**

Par.	1	2	3	4	5	6	7	8	9	10	11	12
t2/2^h	4.70	5.16	2.17	4.24	9.08	12.19	15.06	13.27	12.19	10.84	8.27	6.54
t2/8^h	4.54	4.61	2.36	4.00	8.84	11.92	15.08	12.90	11.96	10.91	8.41	6.47
t2/14^h	7.29	7.70	5.14	7.59	13.50	16.53	19.56	16.98	16.33	14.45	10.75	8.81
t2/20^h	5.20	5.40	2.69	5.00	11.02	14.34	17.56	14.93	13.43	11.41	8.41	6.46
t5/2^h	5.00	5.42	2.40	4.51	9.30	12.53	15.41	13.71	12.49	11.18	8.59	6.93
t5/8^h	4.85	4.83	2.62	4.15	9.27	12.22	15.59	13.36	12.28	11.22	8.70	6.78
t5/1^h4	6.99	7.29	4.59	7.02	12.65	15.59	18.61	16.08	15.43	13.89	10.31	8.43
t5/20^h	5.46	5.55	2.84	4.96	10.60	13.79	17.06	14.48	13.28	11.54	8.66	6.70
t10/2^h	5.15	5.49	2.47	4.62	9.41	12.70	15.57	13.89	12.65	11.34	8.72	7.11
t10/8^h	4.97	4.93	2.63	4.22	9.29	12.26	15.65	13.55	12.44	11.35	8.81	6.93
t10/14^h	6.8	6.98	4.12	6.60	12.11	15.01	18.03	15.54	14.83	13.51	10.0	8.12
t10/20^h	5.56	5.59	2.79	4.85	10.34	13.47	16.76	14.22	13.18	11.60	8.77	6.80
P/2 ^{h}	771.5	772.0	767.1	767.7	771.6	774.3	774.8	774.1	773.9	773.0	773.1	770.8
P/8 ^{h}	771.9	772.0	767.3	767.8	771.1	774.1	774.4	773.7	773.6	772.8	773.5	771.3
P/14^h	771.7	771.7	767.2	768.5	772.1	775.0	775.2	774.5	774.3	773.3	773.1	770.5
P/20^h	772.4	772.1	767.5	768.4	771.5	774.5	774.7	774.1	773.8	773.1	773.6	771.1
RH/2^h	36.07	23.3	51.6	43.7	26.7	22.6	16.2	20.8	42.0	38.2	43.8	27.9
RH/8^h	41.9	36.6	54.2	45.8	30.6	26.9	18.3	21.6	40.3	35.1	39.2	33.9
RH/14^h	49.4	41.3	57.6	33.4	31.7	24.2	24.0	32.2	39.1	36.6	43.5	42.5
RH/20^h	32.9	29.0	54.2	35.9	27.9	25.0	18.14	28.0	39.6	35.2	36.2	46.1
WS/2^h	3.92	4.51	3.81	4.42	5.16	4.96	3.93	4.02	5.45	4.81	5.23	5.81
WS/8^h	3.18	4.15	4.42	3.52	5.15	5.42	4.73	4.01	4.95	4.57	5.10	5.93
WS/14^h	3.45	3.40	3.95	4.03	4.00	5.1	4.22	4.39	5.27	4.45	4.46	5.85
WS/20^h	3.88	4.03	3.94	4.83	4.53	4.94	3.87	3.89	4.93	4.39	5.91	6.27
WD/2^h	182.5	150.8	181.7	179.1	86.7	153.2	146.1	193.8	241.9	167.1	183.1	170.2
WD/8^h	174.1	157.0	191.2	175.2	98.5	142.8	126.5	200.3	222.2	162.1	177.6	167.8
WD/14^h	185.2	195.6	196.2	189.9	180.0	170.8	179.1	236.3	247.3	208.2	216.3	208.5
WD/20^h	177.5	167.8	189.6	178.7	137.9	177.3	162.6	201.0	239.5	172.9	192.8	164.2

Table 6: **Year 2003**

Par.	1	2	3	4	5	6	7	8	9	10	11	12
$t2/2^h$	4.22	3.47	5.07	5.16	10.74	12.00	15.79	11.11	14.38	7.29	7.57	5.91
$t2/8^h$	3.59	3.09	5.14	4.87	10.71	12.24	15.58	11.13	14.00	7.19	7.50	5.67
$t2/14^h$	5.96	6.14	9.08	8.96	14.98	17.05		16.38	18.45	10.3	10.18	8.36
$t2/20^h$	3.94	3.58	5.61	6.41	12.70	14.95		13.28	15.06	7.34	7.84	6.22
$t5/2^h$	4.47	3.77	4.13	5.48	11.05	12.41	15.99	11.47	14.78	7.55	7.93	6.22
$t5/8^h$	3.8	3.34	5.45	5.18	11.37	12.73	15.94	11.51	14.38	7.44	7.82	5.96
$t5/14^h$	5.58	5.74	8.34	8.07	14.17	16.00		15.37	17.61	9.74	10.03	8.01
$t5/20^h$	4.13	3.71	5.76	6.14	12.27	14.32		12.98	14.99	7.43	8.08	6.50
$t10/2^h$	4.6	3.88	5.59	5.62	11.18	12.57	16.12	11.65	14.94	7.70	8.18	6.35
$t10/8^h$	3.94	3.43	5.57	5.35	11.38	12.71	16.14	11.68	14.57	7.56	7.96	6.11
$t10/14^h$	5.27	5.35	7.76	7.45	13.71	15.40		14.67	17.04	9.28	9.40	7.69
$t10/20^h$	4.24	3.76	5.83	6.0	12.02	13.96		12.78	14.95	7.44	8.22	6.62
$P/2^h$	773.0	769.4	769.5	768.7	772.1	772.5	775.1	773.6	775.1	770.4	770.5	770.9
$P/8^h$	772.9	769.6	769.6	768.3	771.7	772.2	774.8	773.5	774.7	770.1	770.9	771.4
$P/14^h$	772.5	769.6	769.6	769.2	772.6	773.0		774.5	775.3	770.7	770.4	770.7
$P/20^h$	773.2	770.1	769.7	768.6	772.0	772.6		773.8	774.8	770.4	771.1	771.5
$RH/2^h$	37.3	31.4	26.8	47.2	22.6	25.1	30.9	42.8	27.5	48.6	32.4	40.6
$RH/8^h$	38.9	37.6	32.1	44.2	21.7	26.0	19.8	40.2	28.7	48.5	32.5	43.8
$RH/14^h$	47.1	33.9	37.9	44.9	29.5	33.1		43.5	39.4	59.4	41.1	49.1
$RH/20^h$	38.4	35.0	29.2	43.5	23.9	28.1		33.3	28.5	52.4	29.2	42.8
$WS/2^h$	5.37	4.85	3.93	5.43	3.43	3.07	4.87	4.11	3.96	5.58	4.87	5.51
$WS/8^h$	5.17	5.14	4.25	5.71	3.21	3.62	3.56	4.84	3.91	6.20	4.11	5.42
$WS/14^h$	4.53	4.36	3.95	5.14	3.27	3.77		4.23	3.90	4.87	4.13	5.12
$WS/20^h$	5.87	5.52	4.25	5.54	3.45	3.30		4.93	4.02	5.67	5.05	5.35
$WD/2^h$	159.8	180.4	187.2	204.9	130.7	163.2	224.5	149.1	184.4	190.9	180.7	165.0
$WD/8^h$	147.6	173.6	184.0	193.2	126.5	142.6	244.7	216.1	191.2	182.1	171.9	162.2
$WD/14^h$	164.3	172.9	206.1	236.6	200.5	191.1		203.7	227.1	189.2	173.6	186.8
$WD/20^h$	177.7	164.5	202.5	246.4	129.5	200.7		167.1	211.6	196.2	160.1	164.6

Table 7: **Year 2004**

Par.	1	2	3	4	5	6	7	8	9	10	11	12
t2/2^h	5.39	2.63	5.54	2.87	5.55	12.50	16.21	14.06	12.04	11.02		
t2/8^h	5.41	2.77	5.83	2.79	5.81	13.21	15.94	13.76	11.60	10.39		
t2/14^h	8.15	5.80	8.88	6.93	9.68	17.31	20.25	18.40	15.93	14.45		
t2/20^h	5.43	3.08	5.88	4.55	7.46	15.29	18.24	15.61	12.54	11.83		
t5/2^h	5.6	2.83	5.77	3.14	5.84	12.84	16.21	14.37	12.31	11.17		
t5/8^h	5.6	2.95	6.06	3.05	6.13	13.56	15.94	14.15	11.87	10.56		
t5/14^h	7.7	5.39	8.40	6.18	8.78	16.39	20.25	17.44	15.17	13.93		
t5/20^h	5.6	3.18	6.00	4.31	7.12	14.77	18.24	15.21	12.42	11.78		
t10/2^h	5.78	2.93	5.87	3.25	5.97	13.06	16.48	14.53	12.49	11.22		
t10/8^h	5.78	3.01	6.13	3.14	6.17	13.52	16.30	14.30	12.00	10.62		
t10/14^h	7.30	5.03	7.95	5.60	8.06	15.71	19.44	16.80	14.59	13.51		
t10/20^h	5.69	3.18	6.06	4.13	6.86	14.38	17.83	14.94	12.34	11.73		
P/2^h	771.1	768.1	770.6	767.5	769.7	774.9	775.1	774.8	774.3	772.3		
P/8^h	771.2	768.1	770.7	767.0	769.5	774.6	774.8	774.4	774.0	772.0		
P/14^h	770.7	768.0	770.8	767.9	770.4	775.4	775.6	774.3	774.7	773.2		
P/20^h	771.4	768.3	770.9	767.3	769.9	774.9	775.1	774.7	774.1	772.6		
RH/2^h	37.9	51.3	30.2	60.9	41.4	24.5	21.3	36.9	42.2	49.3		
RH/8^h	36.4	53.7	32.7	61.9	43.4	25.7	20.2	38.8	40.0	53.4		
RH/14^h	47.0	58.8	45.0	68.2	53.4	38.2	24.7	43.1	43.3	56.0		
RH/20^h	40.0	53.9	35.0	65.1	41.4	29.1	23.1	37.9	47.9	51.7		
WS/2^h	4.07	3.98	5.17	4.27	4.91	4.13	4.25	4.07	5.03	3.68		
WS/8^h	4.24	3.64	4.39	3.74	5.08	4.15	4.09	4.14	5.43	3.70		
WS/14^h	3.65	4.31	3.92	3.79	4.55	4.11	3.98	4.36	4.59	3.87		
WS/20^h	4.48	4.56	4.77	4.33	5.10	4.17	3.90	4.62	4.84	2.56		
WD/2^h	121.5	178.1	134.0	194.1	151.3	131.8	137.5	199.7	155.5	143.0		
WD/8^h	117.8	162.4	133.8	195.5	145.2	107.2	160.8	183.1	179.8	212.1		
WD/14^h	150.7	212.1	165.6	201.3	184.7	179.8	198.1	214.0	193.6	226.4		
WD/20^h	117.4	185.3	135.1	194.9	157.0	142.0	173.7	186.4	162.0	179.2		

2 Data Analysis

Table 8. Location of the used telescopes

name	latitude	longitude	height [m]
TNG	28^0:45':28,3" N	17^0:53':37.9" W	2387.2
NOT	28^0:45':26.2" N	17^0:53':6.3" W	2362
CAMC	28^0:45':36" N	17^0:52': 57"W	2326

In this analysis TNG data archive are compared with NOT and CAMC. Table 8 lists positions and heights of the telescopes. In Table 9 there is a summary of the meteo parameters computed as yearly average of the values at TNG. Each reported mean values is computed as the mean of the whole set of data for each meteorological parameter and not for only the choosen 4 hours. The year 2003 presents the minimum temperature registered 10 m above the ground. The driest year is the 2001. Wind direction in Table 9 is given in degrees, 0^0 means wind from North, 90^0 from East.

Table 9. TNG yearly mean values

year	t 10m	RH	P	Wind speed	Wind dir.
1998	10.8	36.0	772.2	4.7	172.7
1999	10.4	39.9	771.9	5.9	179.1
2000	9.7	36.2	771.8	4.7	183.3
2001	10.9	32.1	772.2	4.8	183.4
2002	9.6	35.0	772.1	4.6	179.3
2003	9.2	36.3	771.7	4.6	181.9
2004	9.8	42.6	771.9	4.3	167.6

The tables 10, 11, 12, and 13 give us the yearly mean values at 4 choosen hours. The mean values given in the tables are computed as the mean of all measurements registered at each the indicated hours for each meteo parameters. The same statistics methode are applied for the other two telescopes. Table 13 presents the measurements only for TNG and NOT because the measurements from CAMC not are yet available.

Table 10. Year 2001

	2 h.			8 h.			14 h.			20 h.		
par.	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC
t 10m	10.1	7.5	9.1	10.5	8.0	9.9	12.5	10.1	11.9	10.4	7.7	9.1
RH	31.5	36.7	36.1	31.6	37.3	31.2	33.8	39.5	34.7	31.5	38.4	35.7
P	772.5	771.5	775.9	772.2	771.7	775.8	772.1	771.5	776.1	772.4	771.7	775.9
WS	4.6	6.8	1.9	4.6	6.6	1.8	4.7	5.7	1.8	5.0	7.2	2.0
WD	169	171.0	160.9	179.2	174.0	170.9	214.6	174.2	183.9	170.9	159.7	160.1

Table 11. Year 2002

	2 h.			8 h.			14h.			20 h.		
par.	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC
t 10m	9.1	6.9	7.7	8.9	7.1	8.3	11.0	9.1	10.4	9.5	7.1	7.9
RH	32.7	39.2	32.3	35.4	40.6	31.6	37.2	42.4	37.3	33.8	40.9	34.3
P	772.0	771.6	775.4	771.9	771.8	775.4	772.2	771.7	775.7	772.2	771.8	775.7
WS	4.7	7.7	1.7	4.6	7.2	1.7	4.4	6.2	1.5	4.6	7.6	1.7
WD	169.7	181.9	154.4	166.3	182.7	160.5	201.1	183.5	174.0	180.5	175.7	148.9

Table 12. Year 2003

	2 h.			8 h.			14 h.			. 20 h.		
par.	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC
t 10m	9.0	6.6	8.9	8.9	6.6	9.5	10.3	8.9	11.5	8.7	7.0	8.9
RH	34.4	40.1	34.9	34.5	40.3	30.3	41.7	42.4	36.7	34.9	39.4	33.4
P	771.7	770.7	775.8	771.6	771.5	775.6	771.6	771.1	775.9	771.6	770.8	775.9
WS	4.6	6.9	1.8	4.6	6.3	1.8	4.3	5.5	1.7	4.8	7.3	1.9
WD	176.7	171.4	161.2	178.0	177.1	153.4	195.6	179.6	174.4	183.7	163.1	167.6

Table 13. Year 2004

	2 h.			8 h.			14 h.			20 h.		
param.	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC
t 10m	9.1	6.9		9.3	7.0		11.4	9.3		9.7	7.5	
RH	39.6	34.8		40.6	34.4		47.8	37.4		42.5	36.7	
P	771.8	740.6		772.1	737.9		772.1	738.6		771.9	748.1	
WS	4.3	6.7		4.3	6.6		4.1	5.4		4.3	6.4	
WD	154.6	192.0		159.8	190.6		192.6	197.8		163	181.6	

2.1 Temperature

Table 14. Yearly mean temperatures at 10m

year	TNG	$TNG_{inter.}$	$CAMC_{inter.}$	NOT
1998	10.8	10.00	10.0	
1999	10.4	9.21	9.3	
2000	9.7	9.84	9.6	
2001	10.9	10.4	10.1	8.32
2002	9.6	9.67	9.6	7.77
2003	9.2	9.9	9.8	7.27
2004	9.8	9.53		7.67

In Table 14 the values from TNG are given in two columns (2,3): column 2 reports the mean values from the whole sample, column 3 reports the mean obtained from monthly average values with interpolated data when the corresponding months did not have values, then they may be slightly different. The main reason for this choice is to minimize any effect due to biases due to periods lacking of data (typically in winter time). Column 4 gives CAMCaverages from the interpolated monthly sample, the full set instead was used for the NOT, in column 5. In figure 6 we plotted the yearly averages from Table 14, col.3,4,5.

The temperature data show an almost steady trend over the 7 year period of measurements, with year to year fluctuations of about 1 - 0.5 C, as expected given that the global warming predictions are of the order of 0.15-0.4 deg/10 years.

The year 2001 appears to be the warmest year in our sample, but in the tabulated data the month of October and November are missing. Their contributions decrease the real final mean temperature as shown in columns 2 and 3 of Table 14. A similar mean temperature can be found in the year 1998 but the data start only from the month of March, the beginning of regular data recording of the meteo tower. The data from the CAMC are remarkably similar, with average temperatures differing no more than 0.3 C. The values from NOT are, instead, systematically lower by about 2-3 C, a considerable difference certainly not justified by the limited height difference between TNG and NOT.

NOT is the coolest telescope site with more than 2 deg. difference during the nigth and in the evening, while during the day temperature at TNG and CAMC are, instead, surprising with differences within 0.1-0.2 deg. The year to year variations appear confirmed, by both the meteo sets, at a level of about 0.5 degrees.

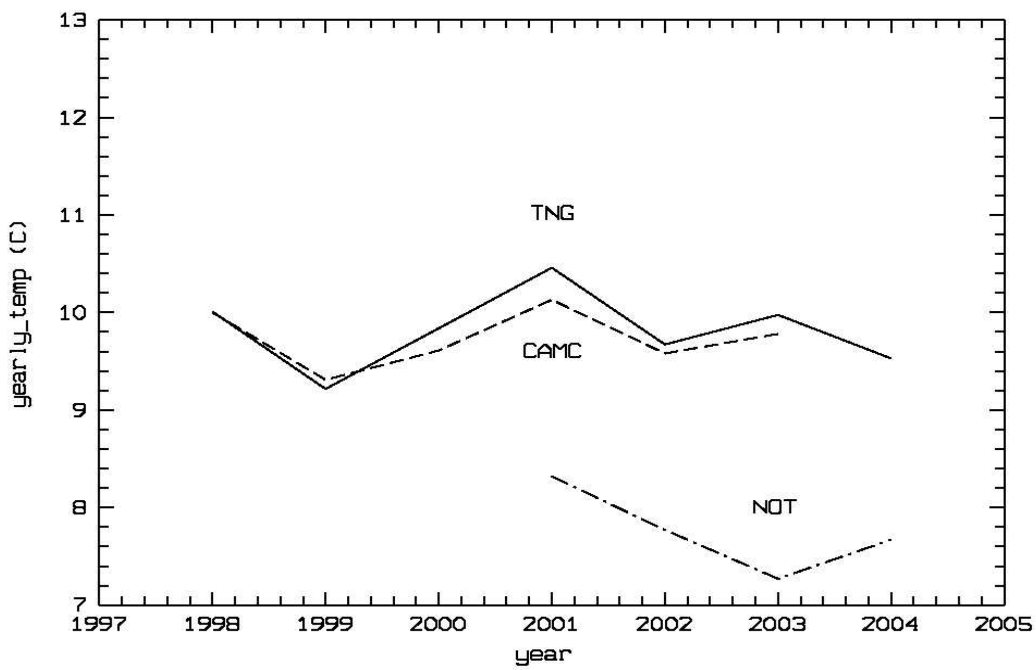

Figure 6: Comparison among yearly mean temperatures taken at TNG and NOT and CAMC telescopes. TNG temperatures are obtained as mean of monthly averaged data, NOT and CAMC temperatures are obtained as yearly mean data.

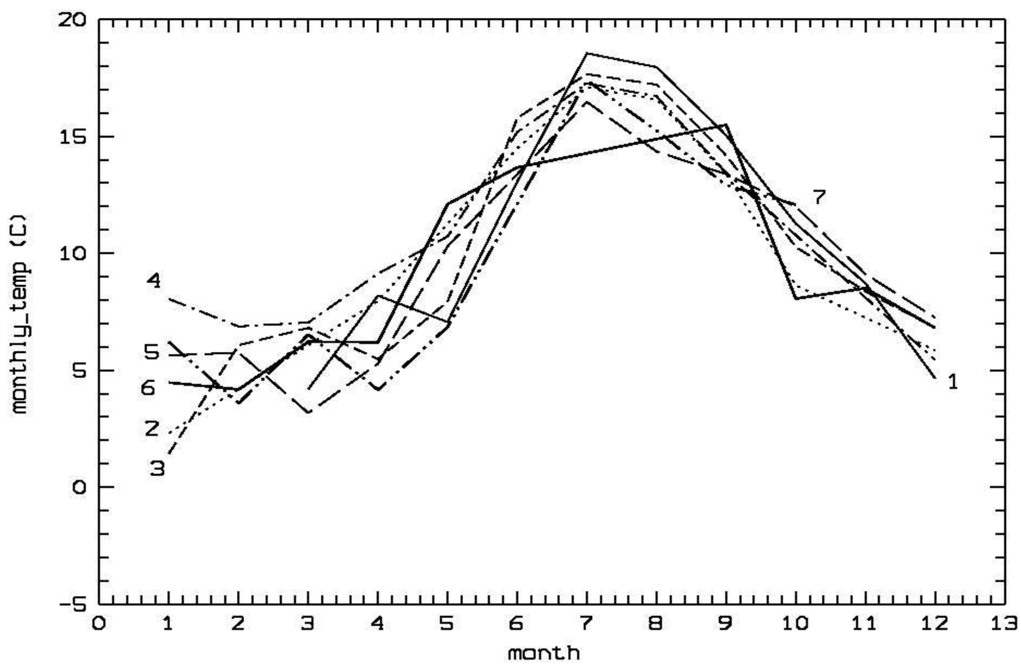

Figure 7: Monthly temperature distributions. Years are indicated as : 1(1998), 2(1999), 3(2000), 4(2001), 5(2003), 6(2003) and 7(2004)

Figure 7 presents the monthly temperatures distribution at TNG computed as the average of each month from 1998 to 2004. The plot shows two different trend: from January to May and after May. Before May there is a wide year to year variation up to about 7^0. After May the variatione is less than half.

2.2 Wind velocity and direction

TNG presents a mean wind speed of 4.6 m/s. The yearly mean of wind speed recorded at TNG is lower than the value of 6 m/s reported by Brand & Righini (1985) obtained from meteorological observations at Roque de los Muchachos in the period 1971-1976, mereover the yearly mean wind speed obtained at NOT is 7m/s very similar to those of Brand and Righini.

The prevaling mean wind direction is different among the different telescopes and some differences are evident also during the different hours of the day: at TNG and CAMC, during the night the wind typically blow from North, while at NOT it is coming from WSW. There is a different prevaling direction during the day, coming from W-WSW at all the telescopes. The final result from TNG is similar to that as reported by Brandt and Righini in their Table 1: a prevailing wind from NW and frequently from NE.

CAMC shows a lowest wind speed with respect the other telescopes. The NOT presents the highest wind speed. TNG shows a cumulative mean of wind speed of about 4.8 m/s. Jabiri (2000) have also analysed weather parameters at ORM and found a mean wind velocity of 2.6 m/s, and in 89% of the data the value is lower than 5m/s.

2.3 Relative Humidity

The humidity at TNG range from 32 and 42%. The driest year is 2001. The average is 37% to be compared with 25-30% of table 1 in Brand & Righini. NOT presents the highest umidity with respect the other two telescopes. Before to analyze and to compare the data can be usefull to check the set of each meteo sensors.

2.4 Pressure

Figure 8 shows the yearly average pressure from the 1998 to 2004 computed for both TNG anc CAMC. Figure 7 shows a similar trend between TNG and CAMC. According to the mean height above sea level of the three sites, the TNG one should present the lowest relative pressure, while this is not true when looking at recorded values. TNG, when compared to CAMC and NOT shows, on a regular basis, higher values. Even using an oversimplified equation in order to derive the relationship between differential pressure and related heights,

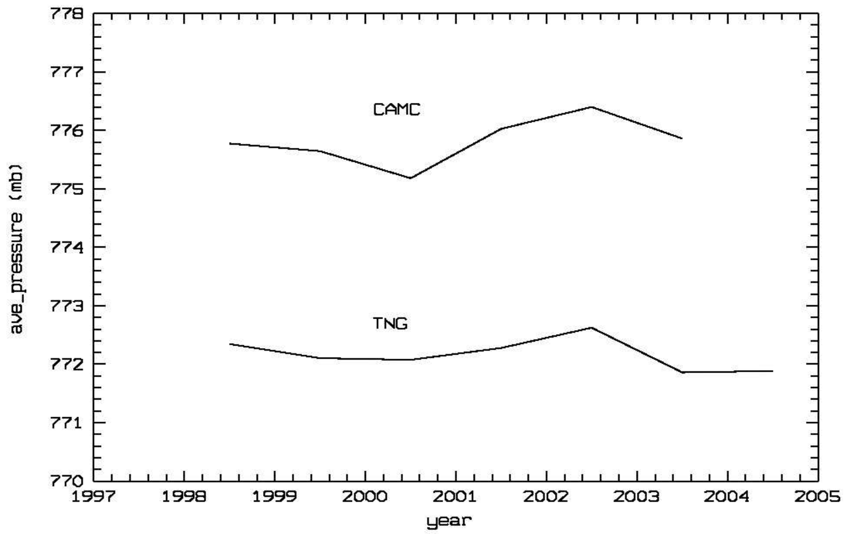

Figure 8: Yearly distributions of the pressure between TNG and CAMC.

TNG pressure values appear to be higher than expected from theory. Notwhitstanding, we can not derive any definite conclusion about this since no cross calibration among the three selected sites has been done. We strongly suggest to perform an accurate calibration campaign of the whole set of barometers, even specifically comparing their reference points. Since then, no actual analyses can be done.

3 Temperature Plots

The plots show yearly distribution for temperature taken at 10 m above the ground for the year 2001 to 2004. Data are computed as hourly average. For each years it is given

- the yearly plot for TNG,NOT and CAMC
- the montly plots for temperature at TNG
- The montly plot of differences of hourly temperatures computed between 2 and 5 meter, 2 and 10 meter and ground and 10 meter

3.1 Year 2001

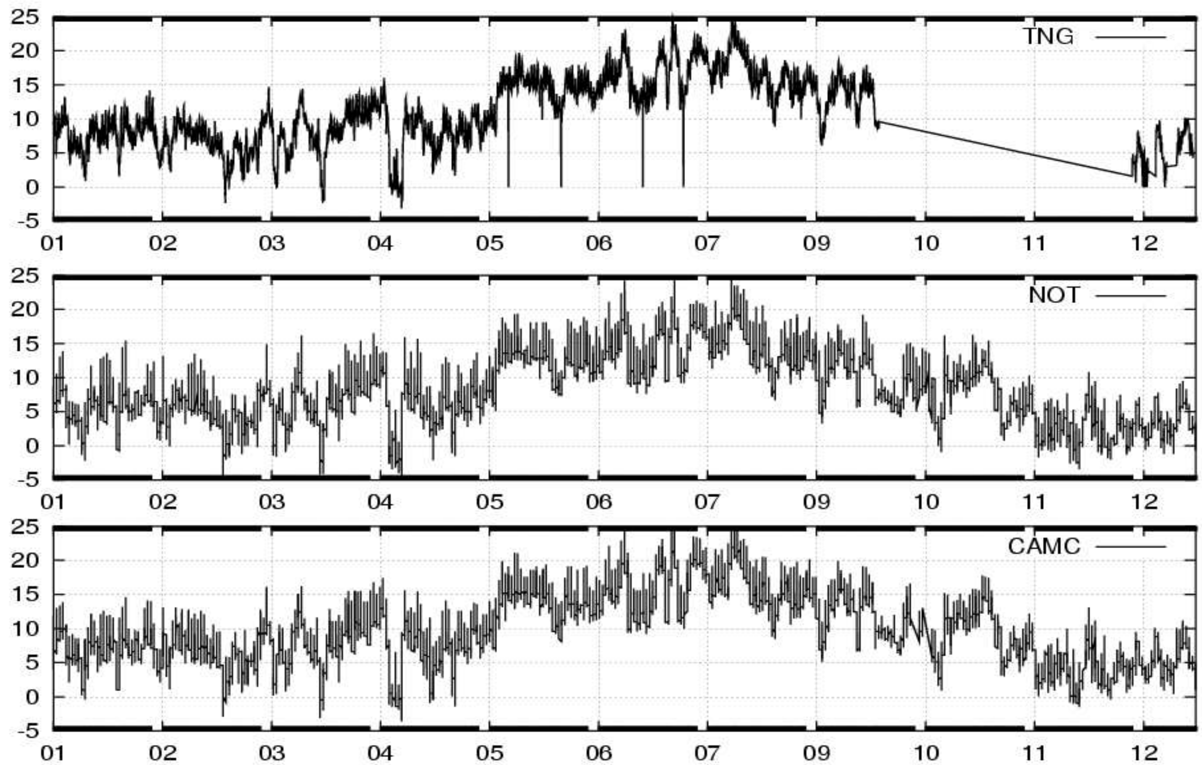

Figure 9: Hourly mean temperaure taken at TNG, NOT and CAMC telescopes for the year 2001. Plots show temperatures taken 10 m above the ground level

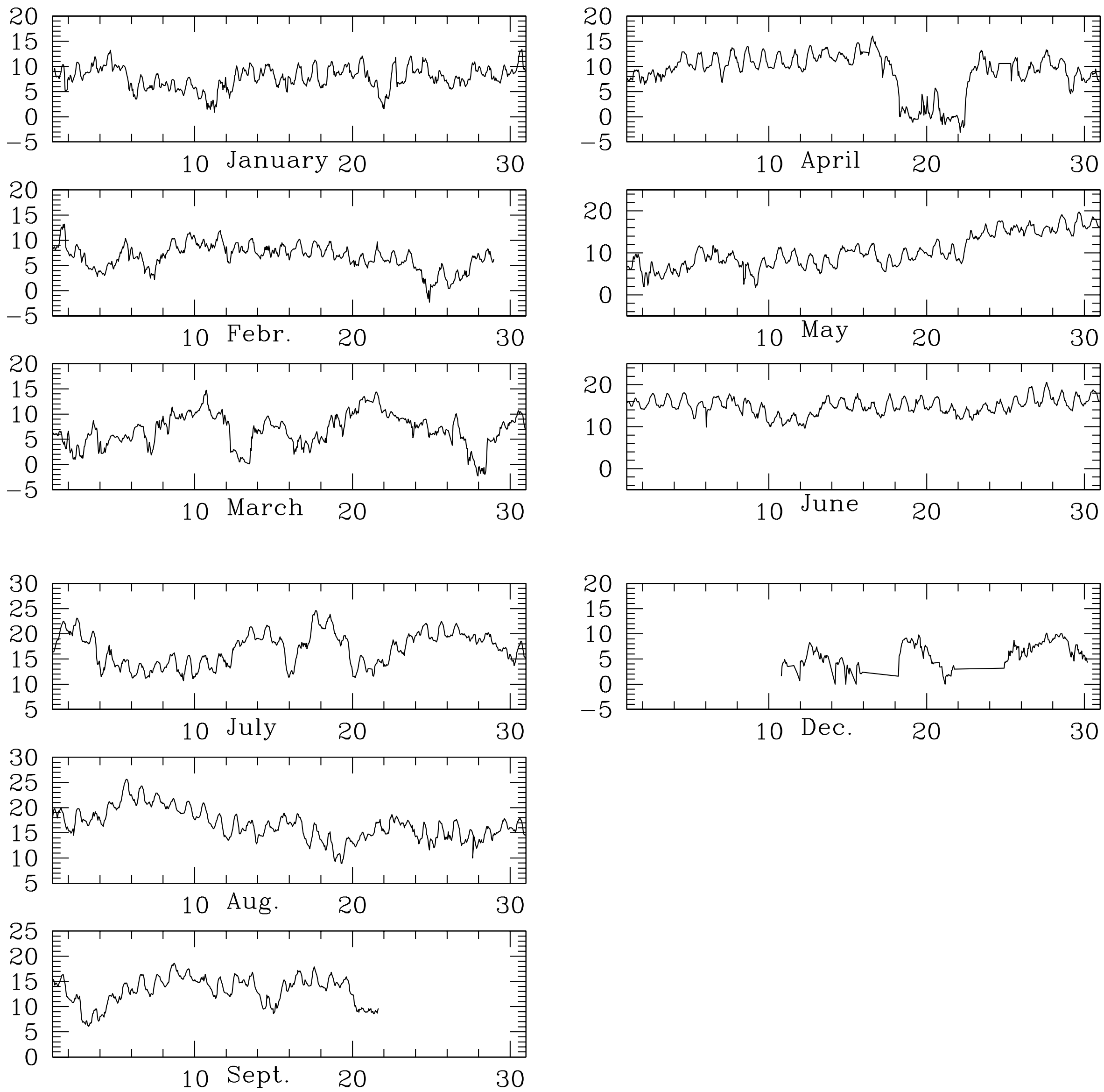

Figure 10: Monthly plots of mean hourly temperature taken at 10 m above the ground at TNG telescope.

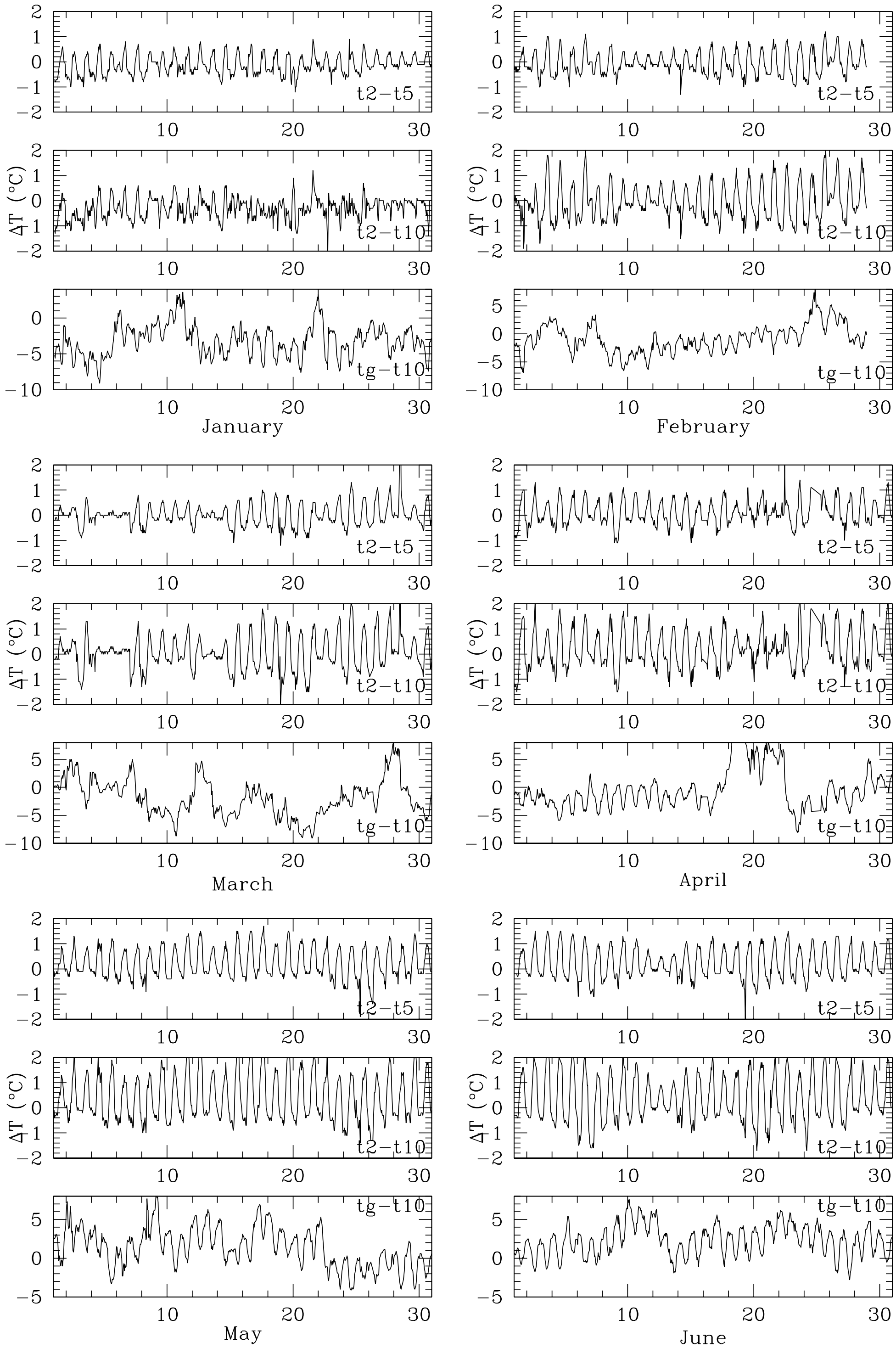

Figure 11: Monthly difference of hourly mean temperature computed between 2-5 m, 2-10 m and ground-10 m sensors. The trend of t2-t5 and t2-t10 seems to be similar. The differences between tg-t10 are very large. Clear appear for all plots the day to night variation.

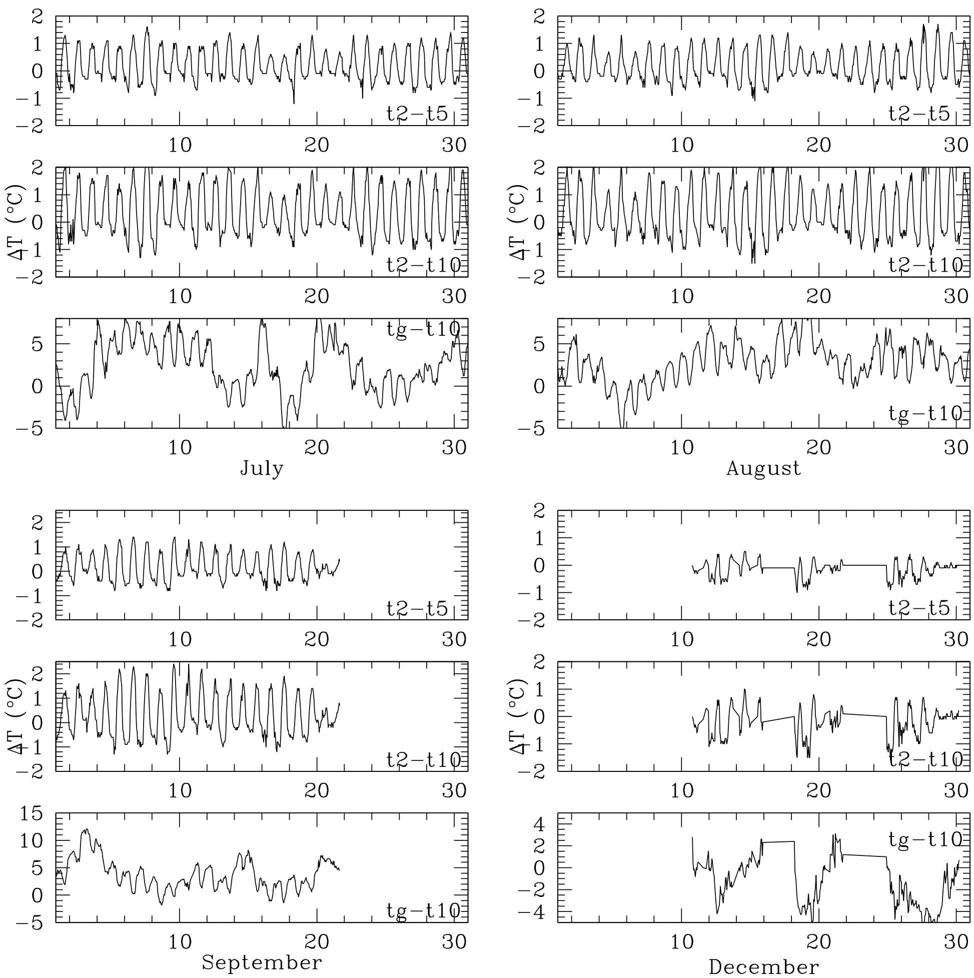

Figure 12: continue

3.2 Year 2002

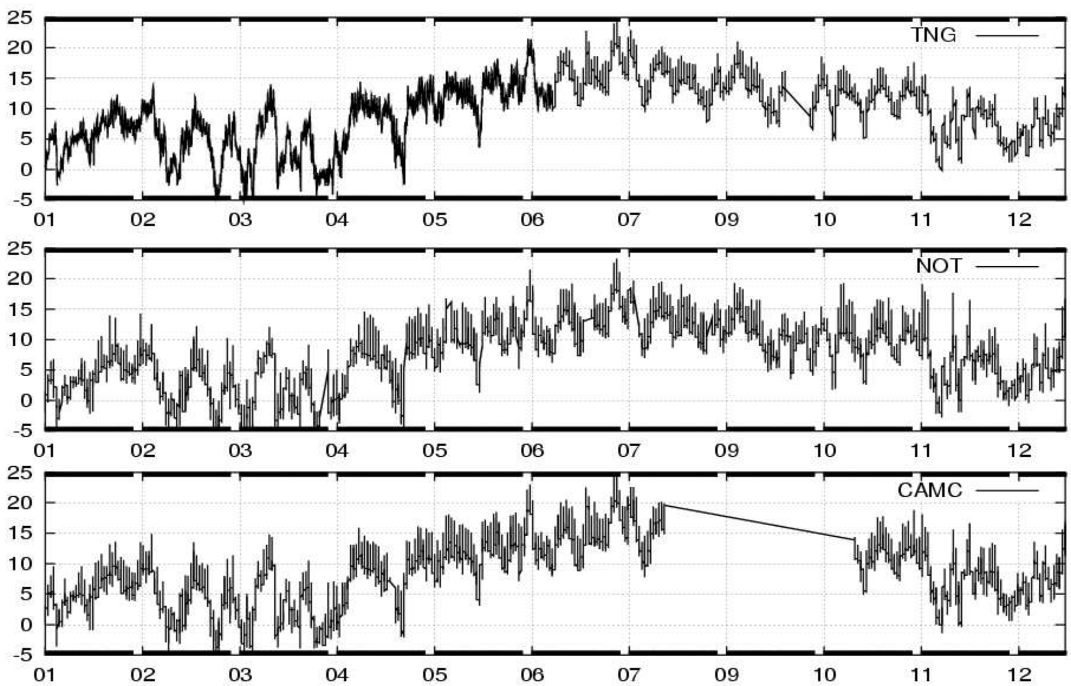

Figure 13: Temperature taken 10 m above the ground at TNG, NOT and CAMC telescopes for the year 2002. The plot shows the hourly mean values.

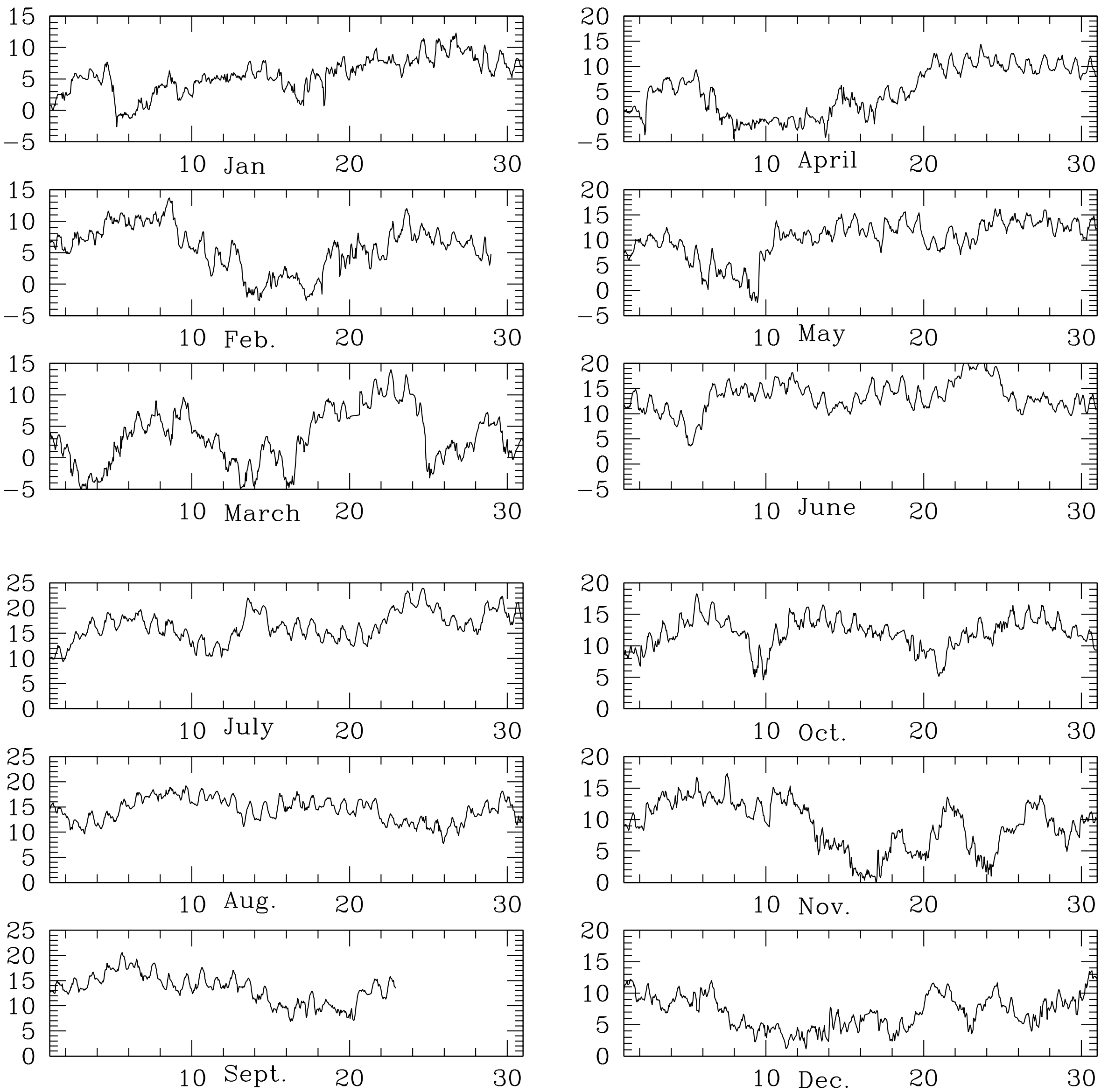

Figure 14: Monthly plots of TNG temperature taken 10 m above the ground. Hourly mean temperature are plotted.

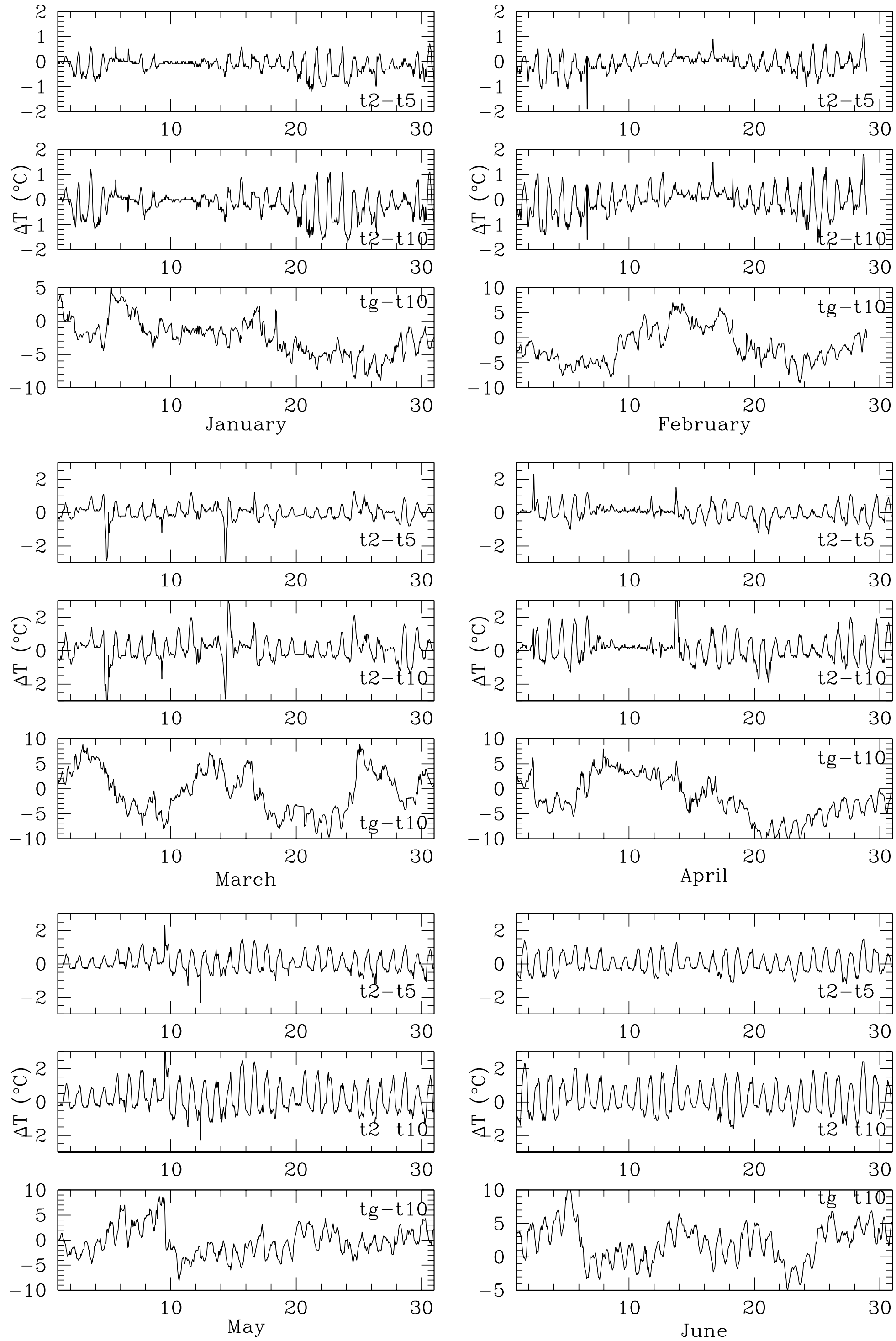

Figure 15: ΔT at TNG. Clear appear the amplitude as a function of the months: smaller in the winter and bigger in the summer months corresponding to day to night variations

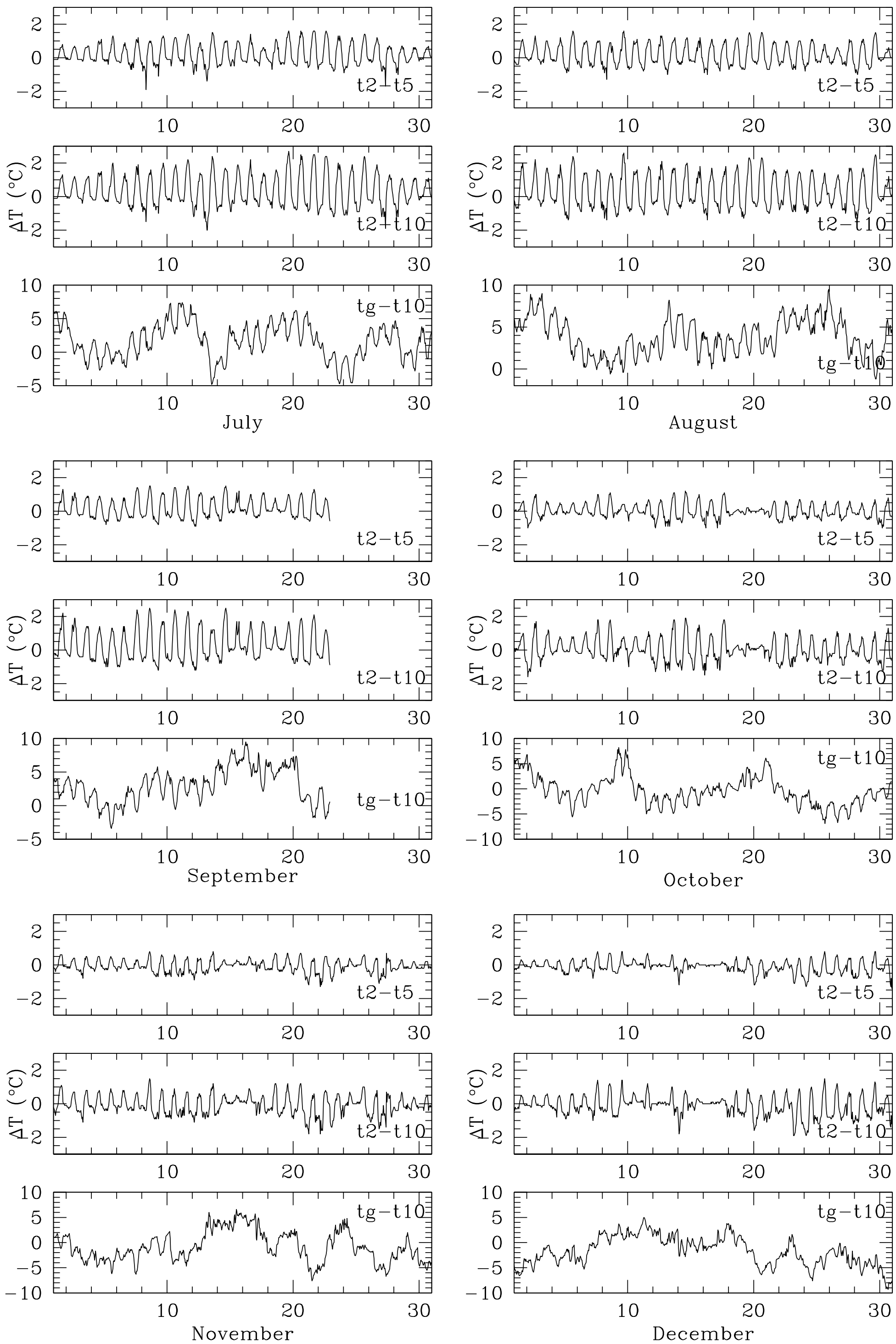

Figure 16: continue

3.3 Year 2003

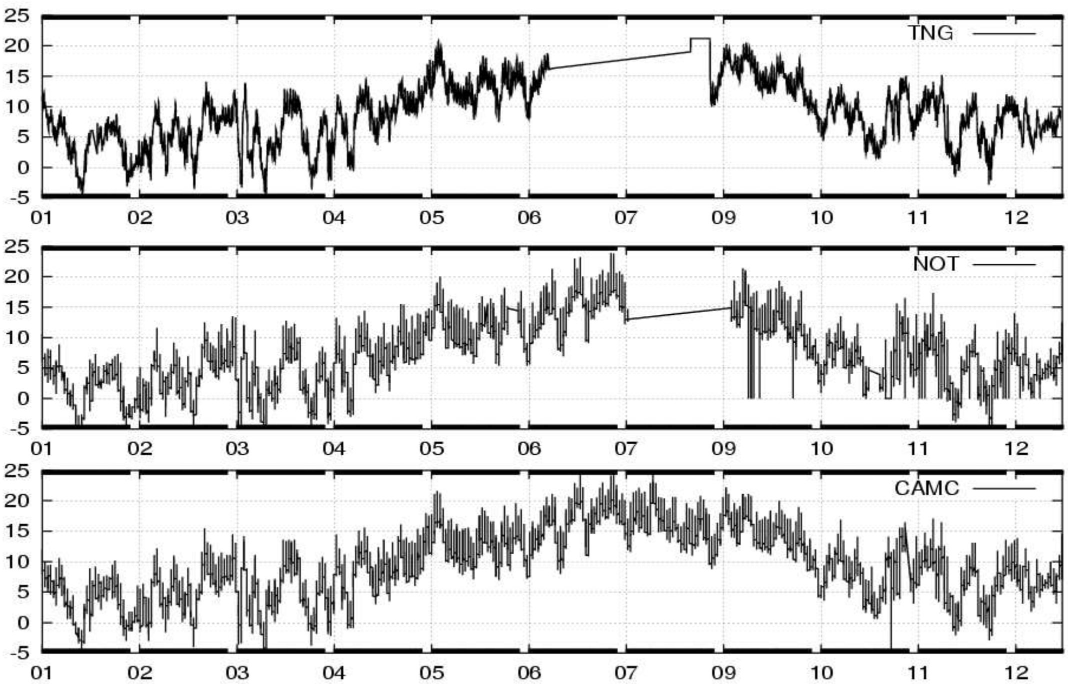

Figure 17: Hourly mean temperaure taken at TNG and NOT and CAMC telescopes for the year 2003. Plots show temperatures 10 m above the ground level

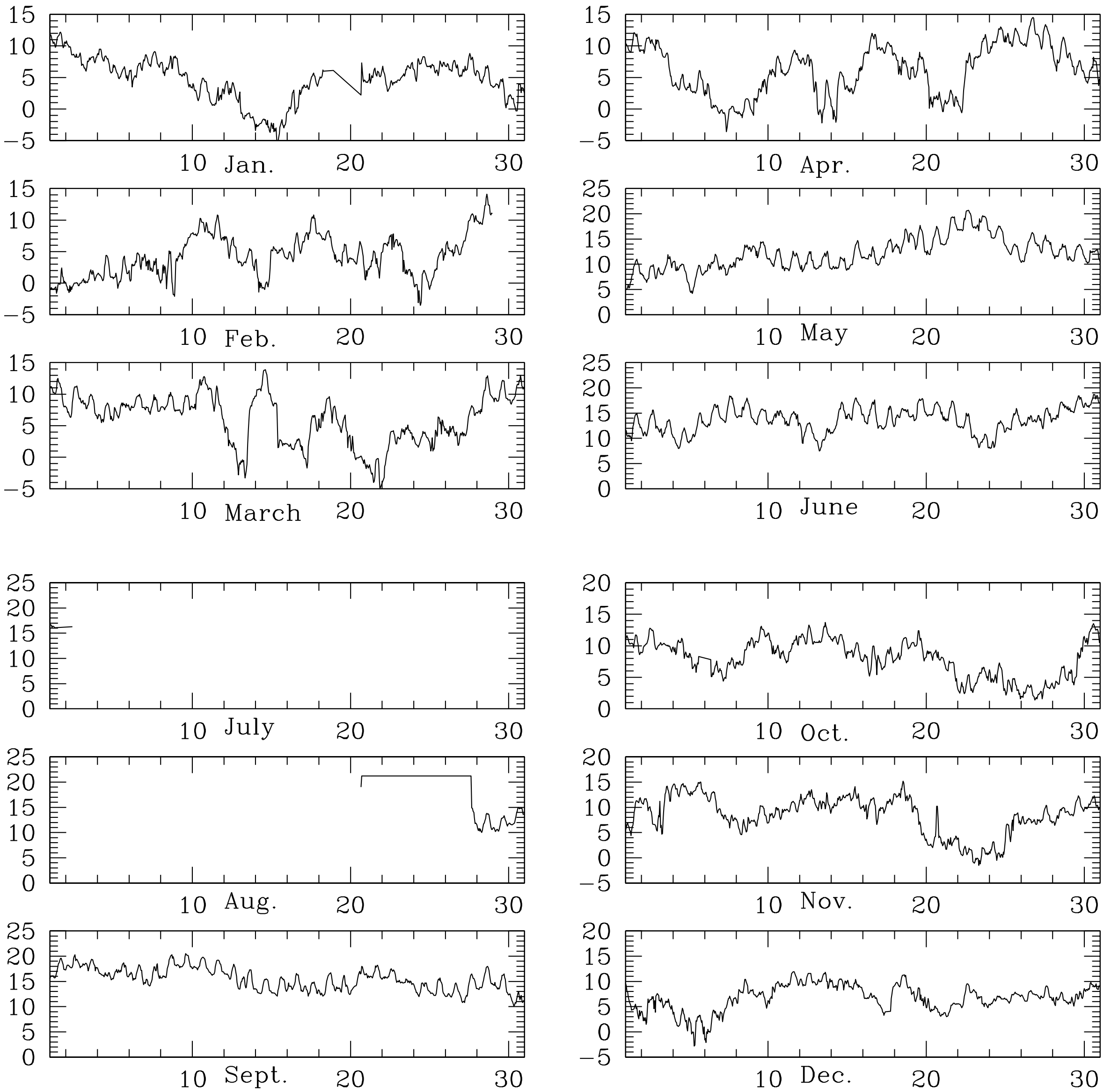

Figure 18: Monthly plots of hourly mean temperature taken at 10 m above the ground at TNG.

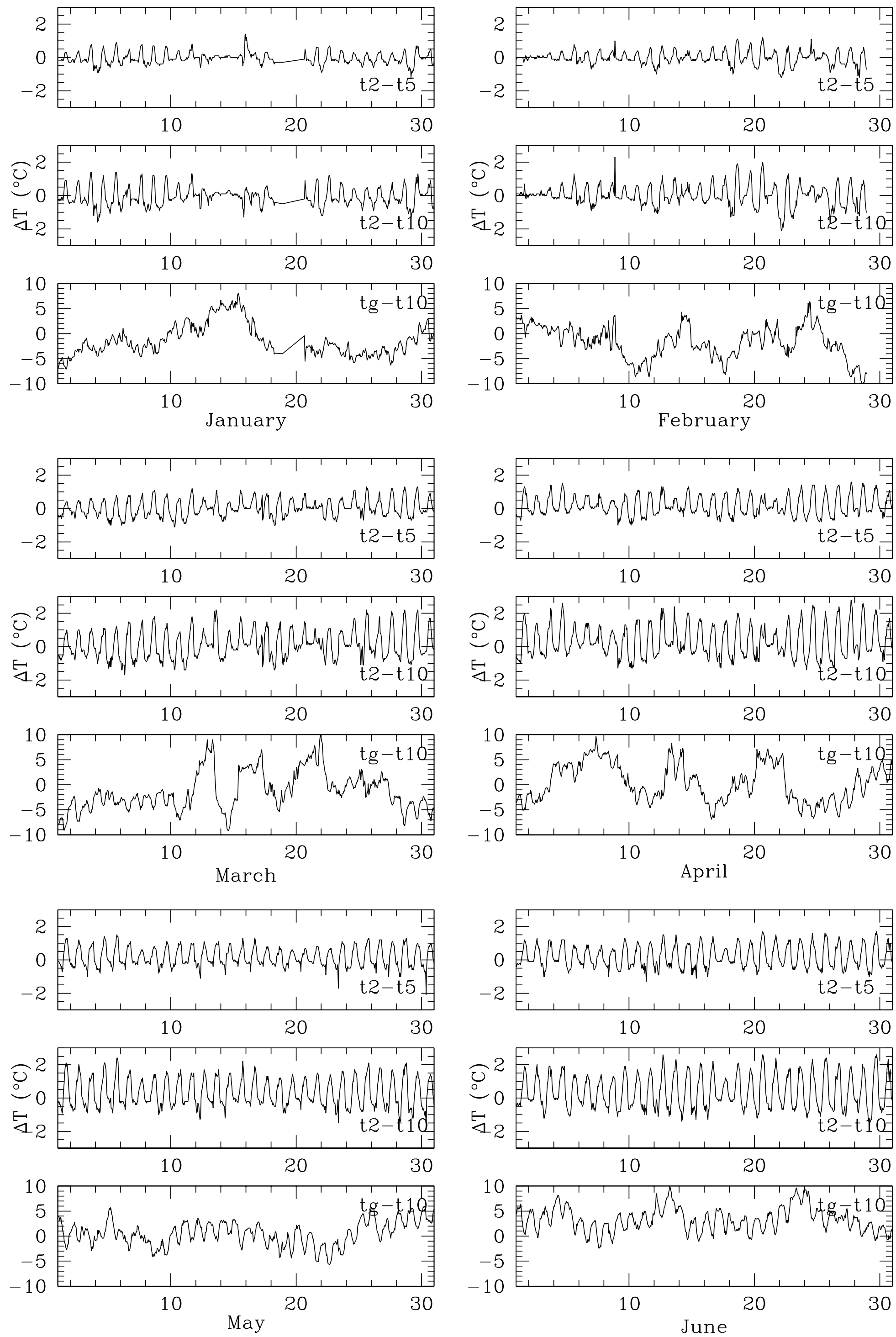

Figure 19: ΔT at TNG for the year 2003. April shows the biggest day to night variation between 2 and 10 m sensors and between gound and 10m sensors.

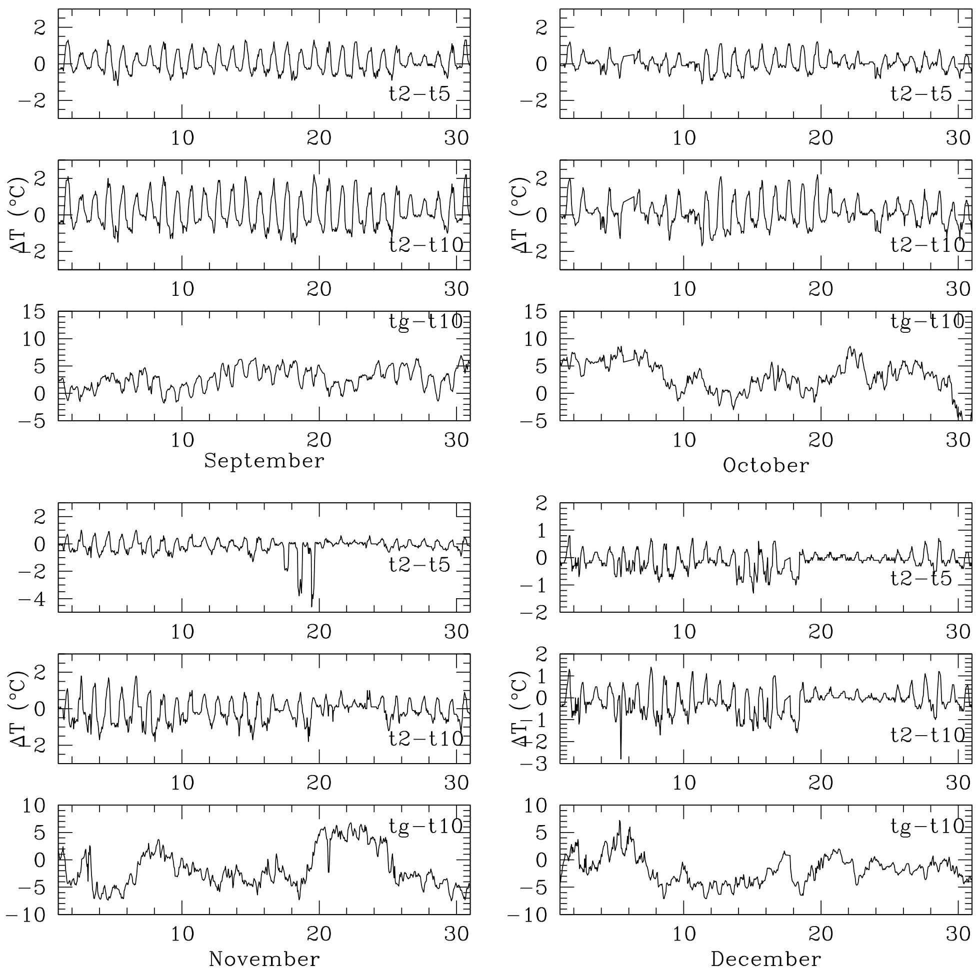

Figure 20: continue

3.4 Year 2004

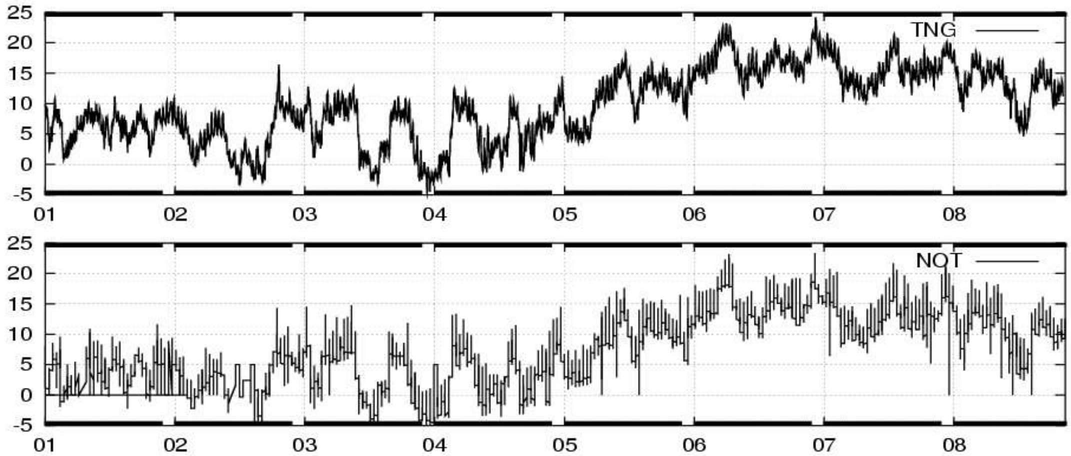

Figure 21: Hourly mean temperaure taken at TNG and NOT telescopes for the year 2004. Plots show temperatures 10 m above the ground level. Data from CAMC are not included being not yet available.

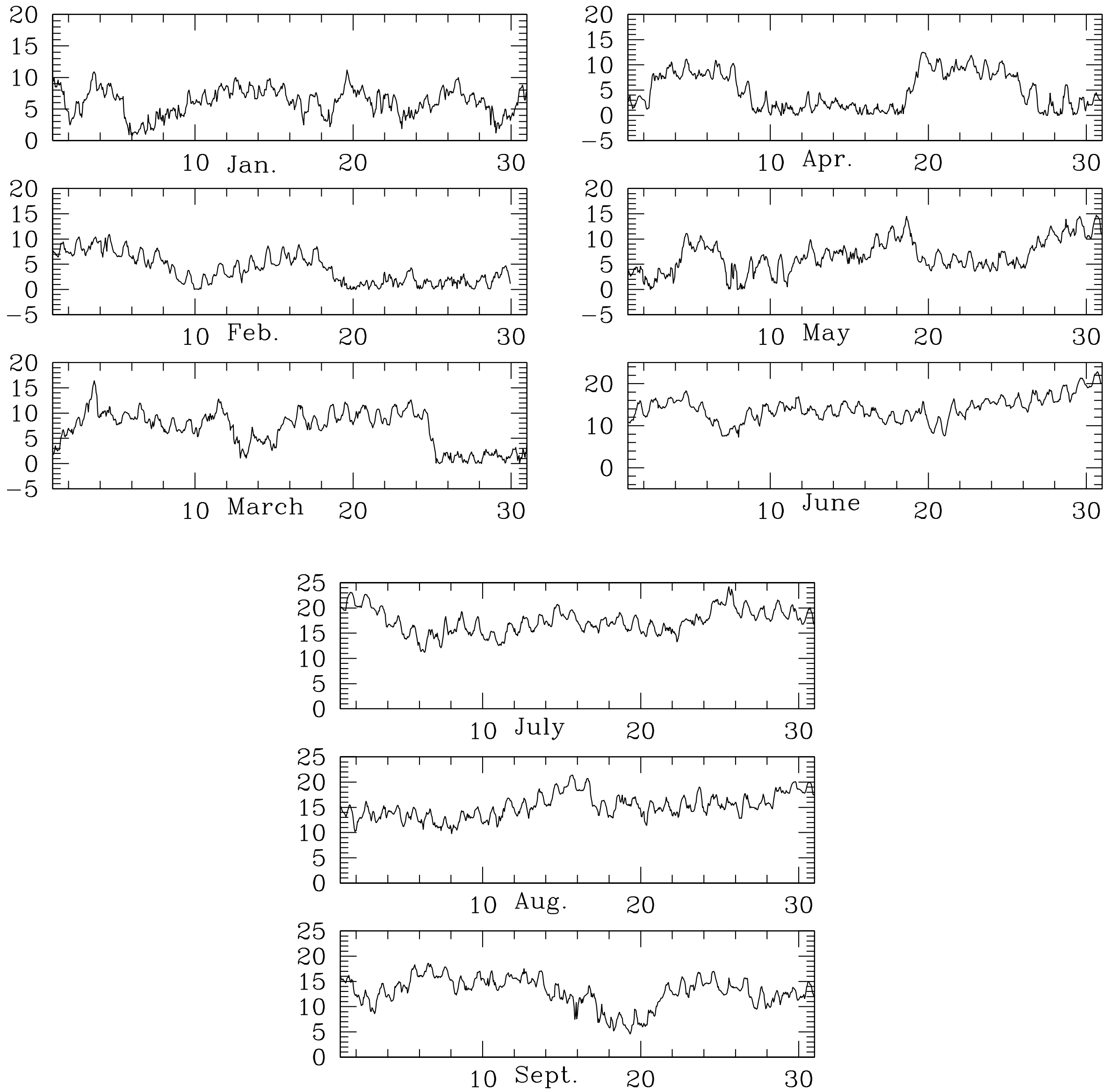

Figure 22: Monthly plots of hourly mean temperature taken at 10 m above the ground at TNG.

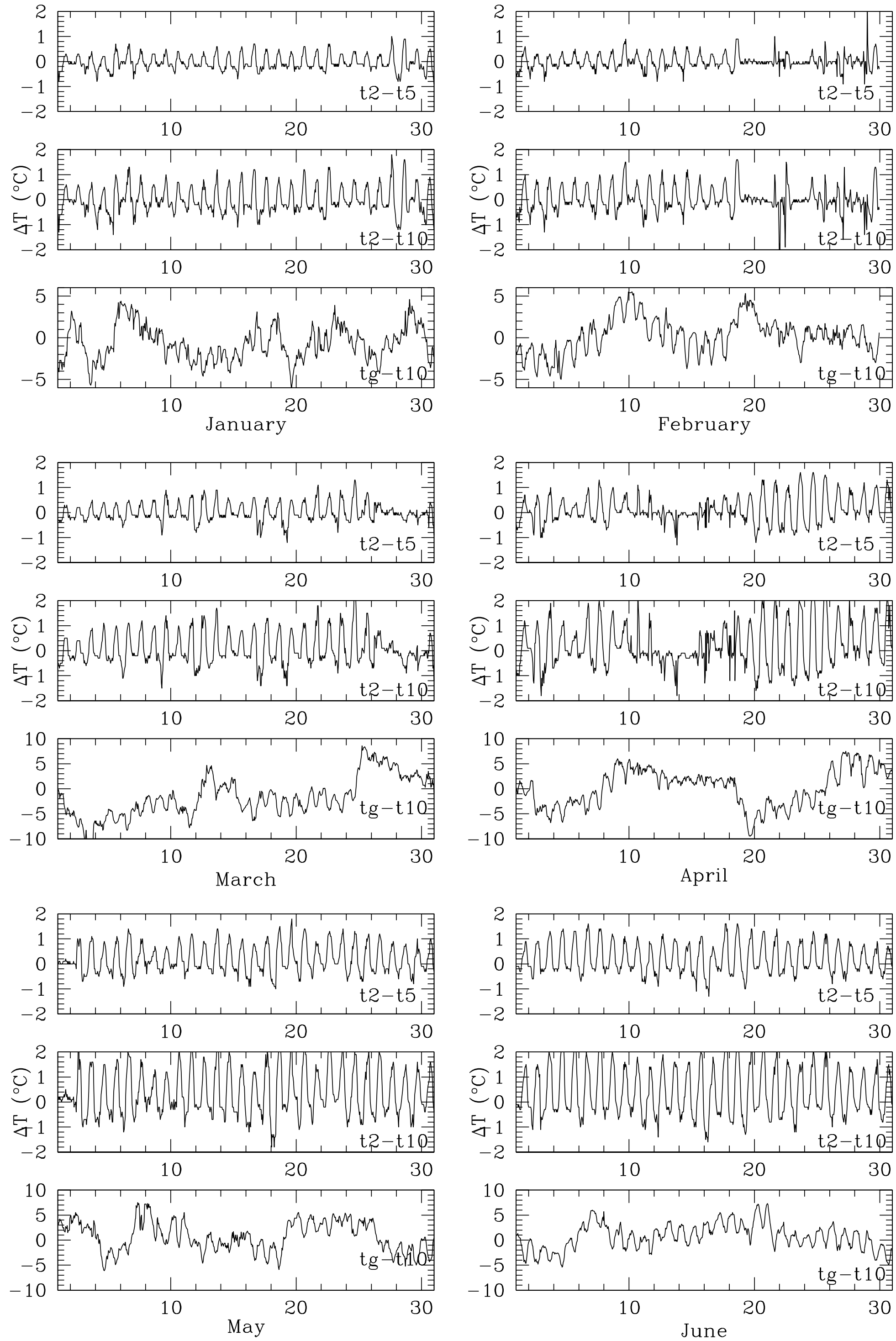

Figure 23: Monthly plots of temperature difference computed as hourly mean. Clearly show the day to night variation and the increased difference in the summer months.

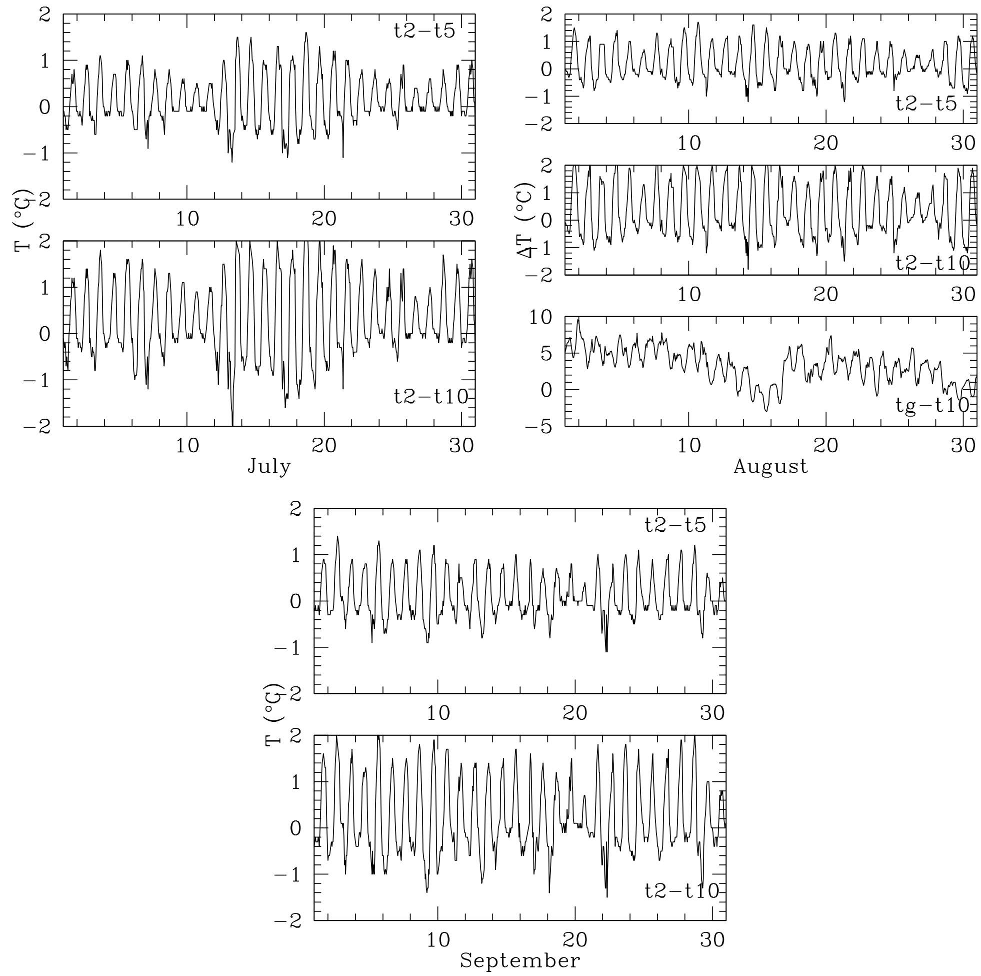

Figure 24: continue

4 Relative Humidity Plots

The plots show yearly distribution for Relative Humidity. Sensor is located 2 m above the ground until June 2003. From July 2003 humidity is reading at 10 m above the ground . Data are computed as hourly average. For each years it is given

- the yearly plot for TNG,NOT and CAMC
- the montly plots at TNG

4.1 Year 2001

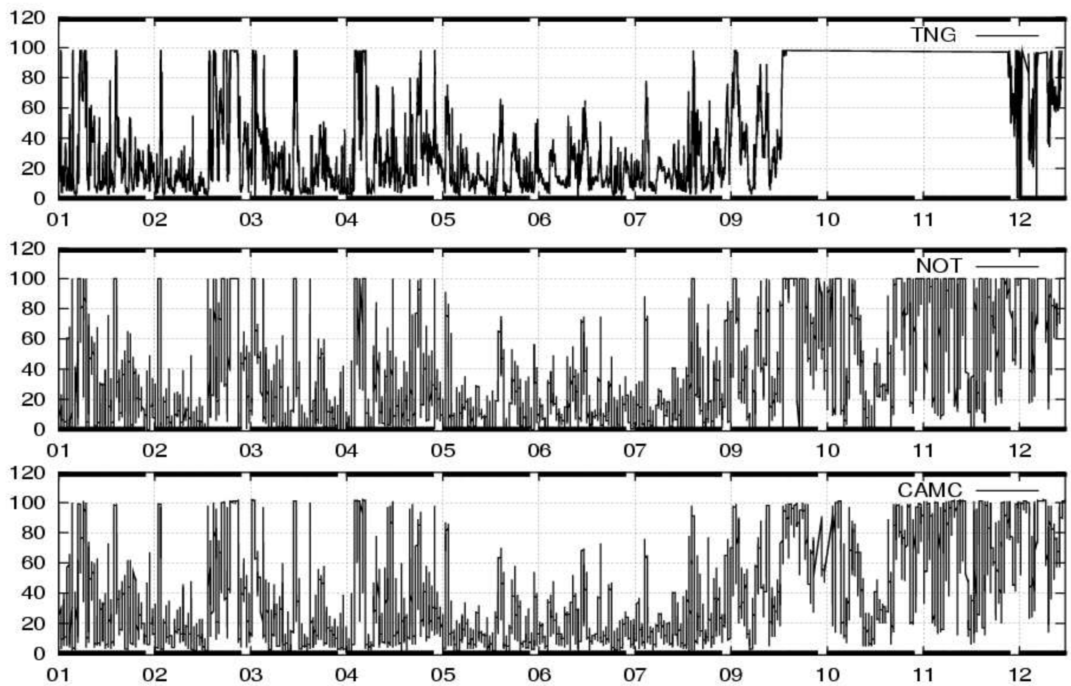

Figure 25: Hourly mean relative humidity taken at TNG, NOT and CAMC telescopes for the year 2001. All the telescopes show a low values of RH from May to the beginning of August.

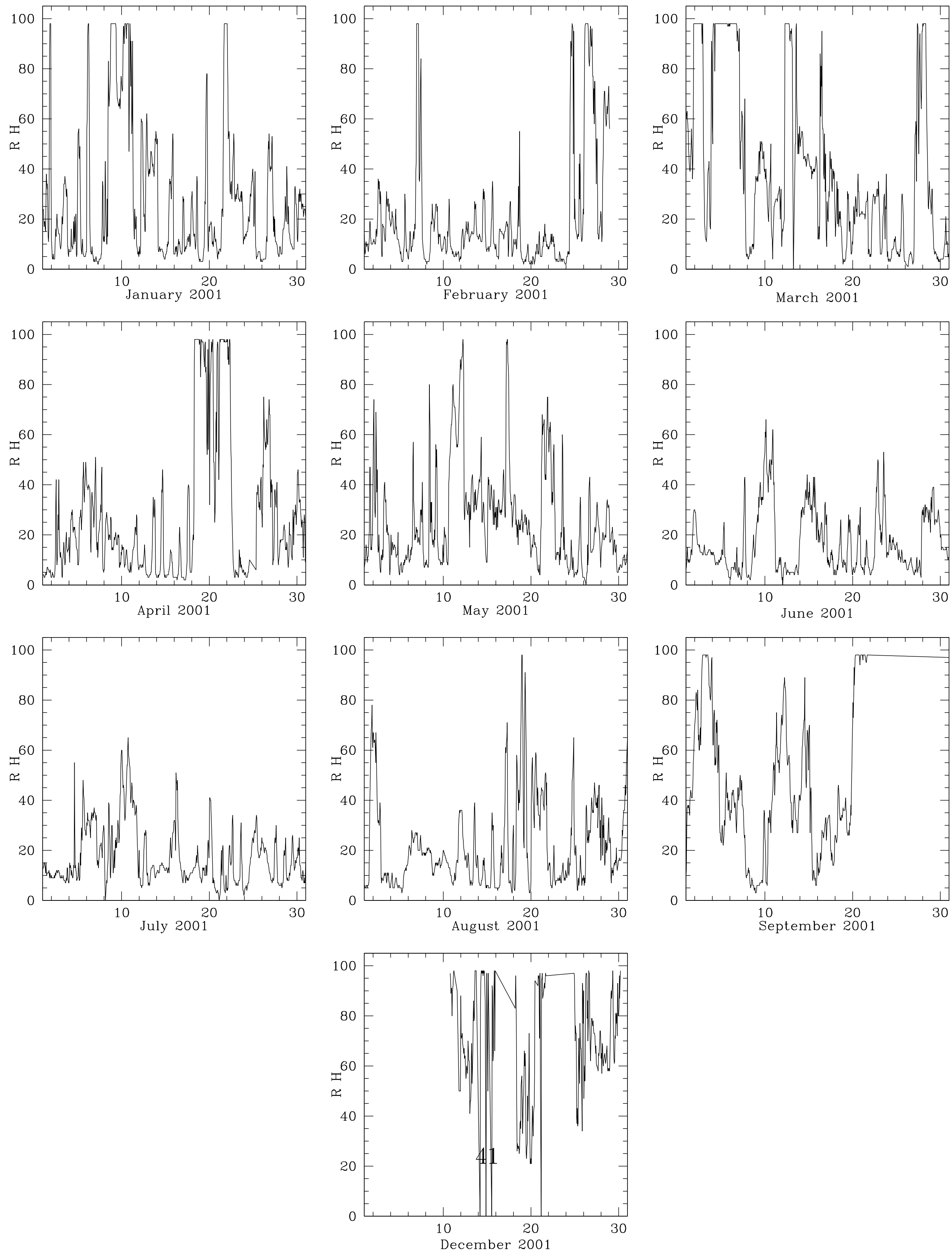

Figure 26: Monthly plots of Hourly mean relative humidity taken at TNG

4.2 Year 2002

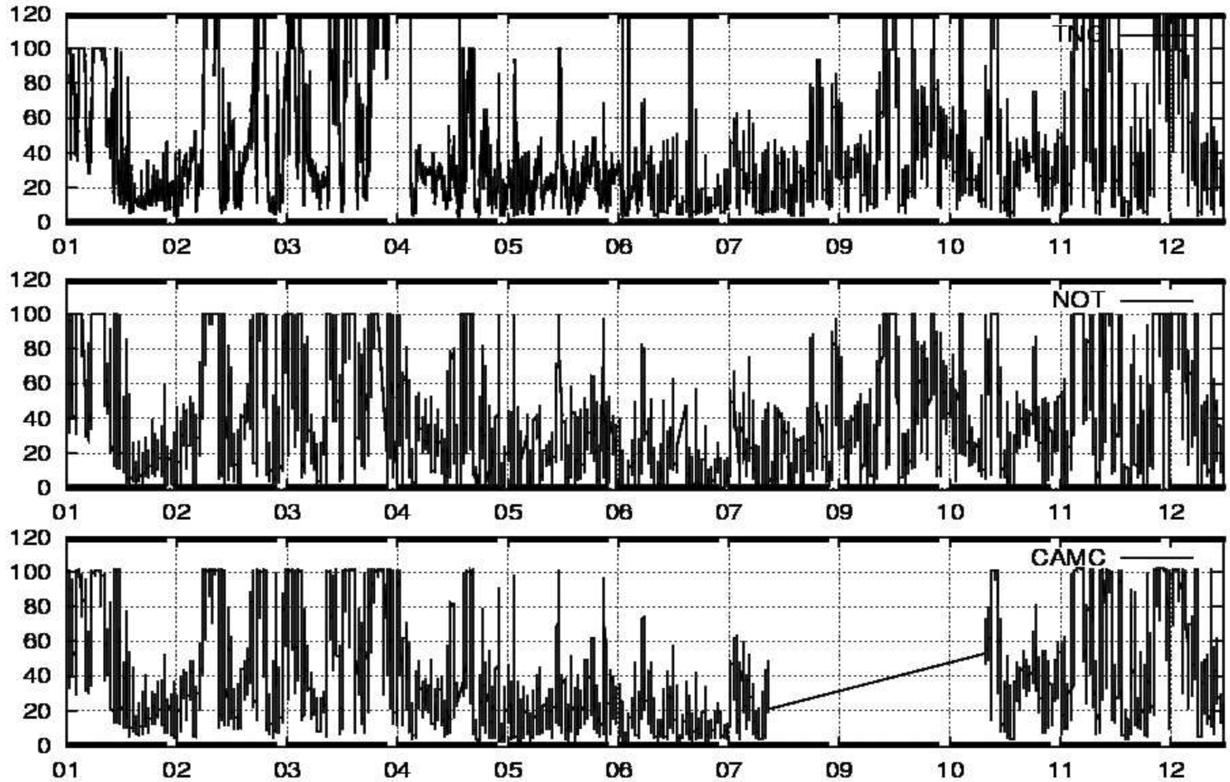

Figure 27: Hourly mean relative humidity for the year 2002 for TNG, NOT and CAMC telescopes

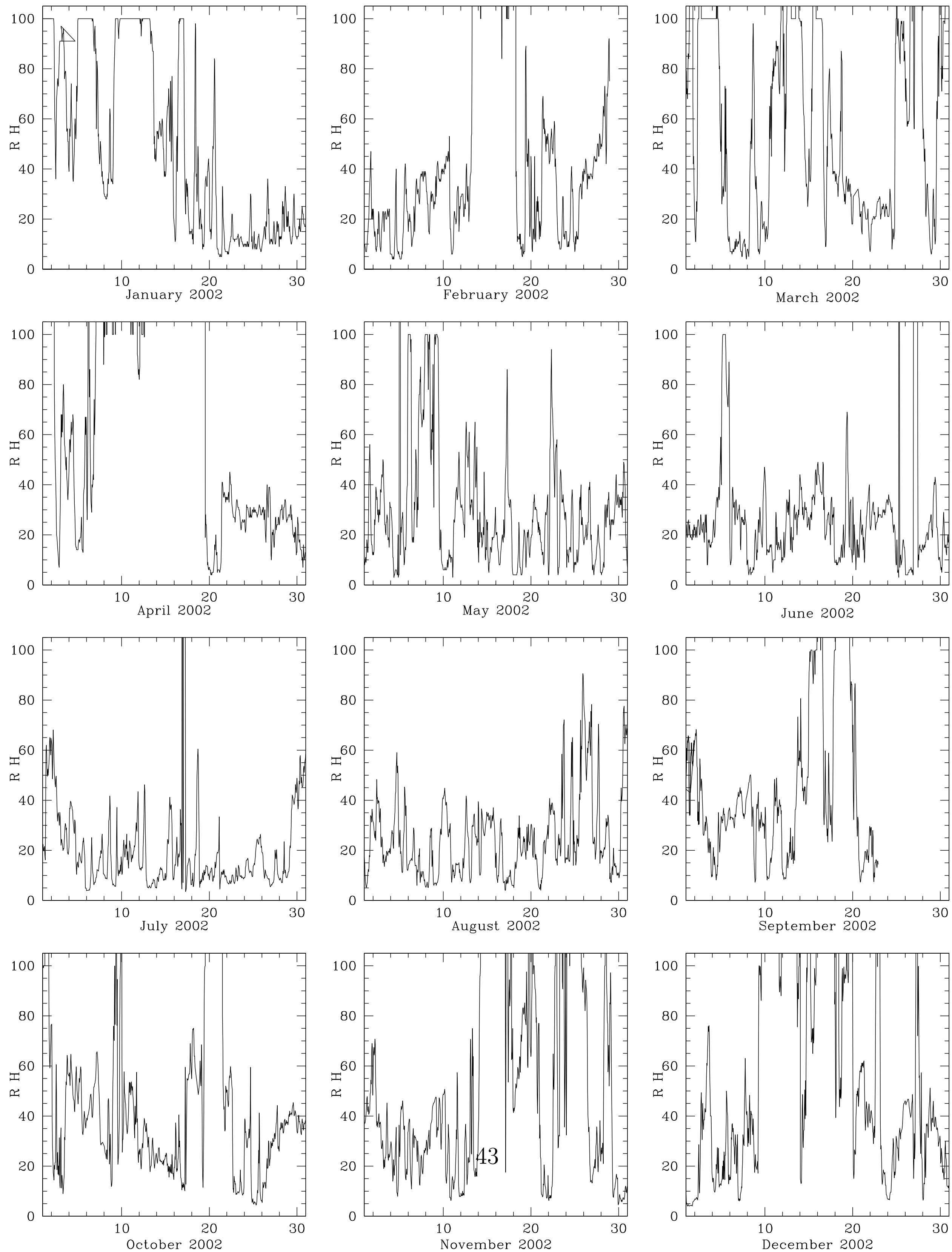

Figure 28: Montly plots of hourly mean relative humidity at TNG

4.3 Year 2003

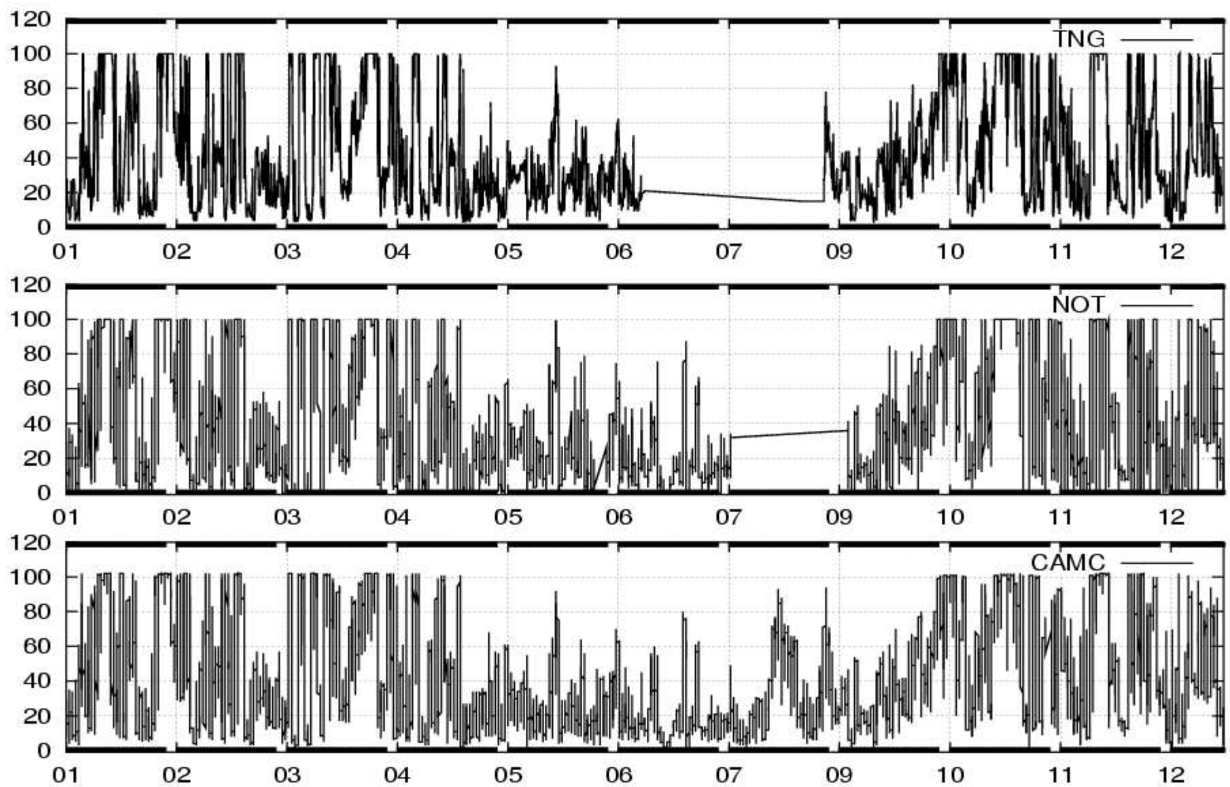

Figure 29: Hourly mean relative humidity for the year 2003 for TNG, NOT and CAMC telescopes

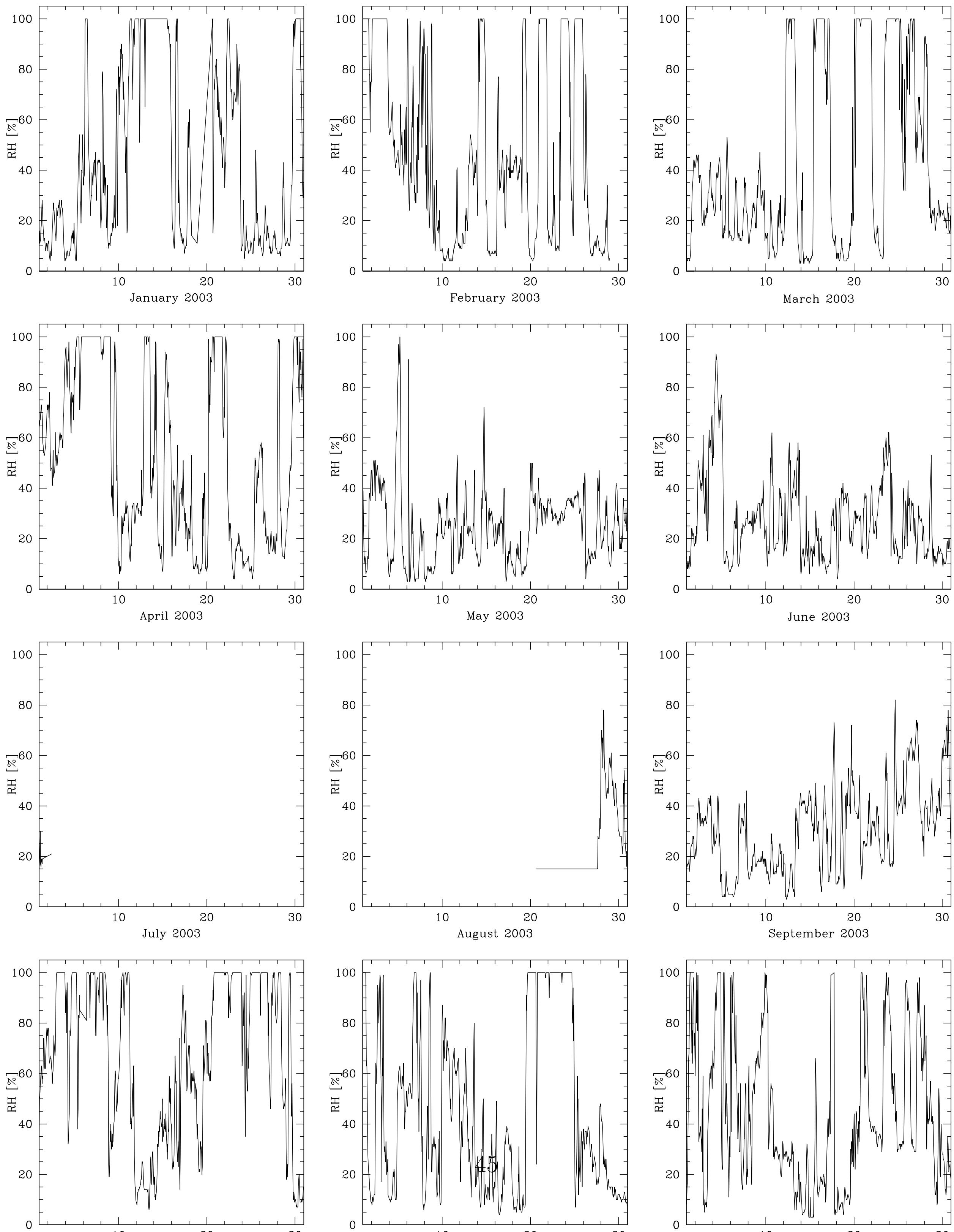

Figure 30: Plots of hourly mean relative humidity at TNG

4.4 Year 2004

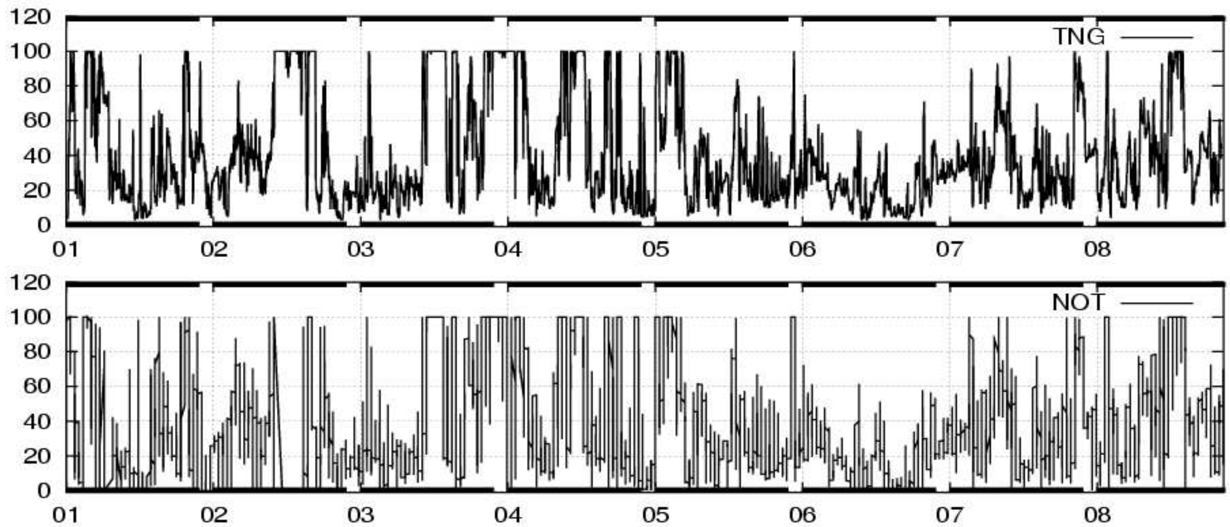

Figure 31: Hourly mean relative humidity for the year 2004 for TNG and NOT telescopes

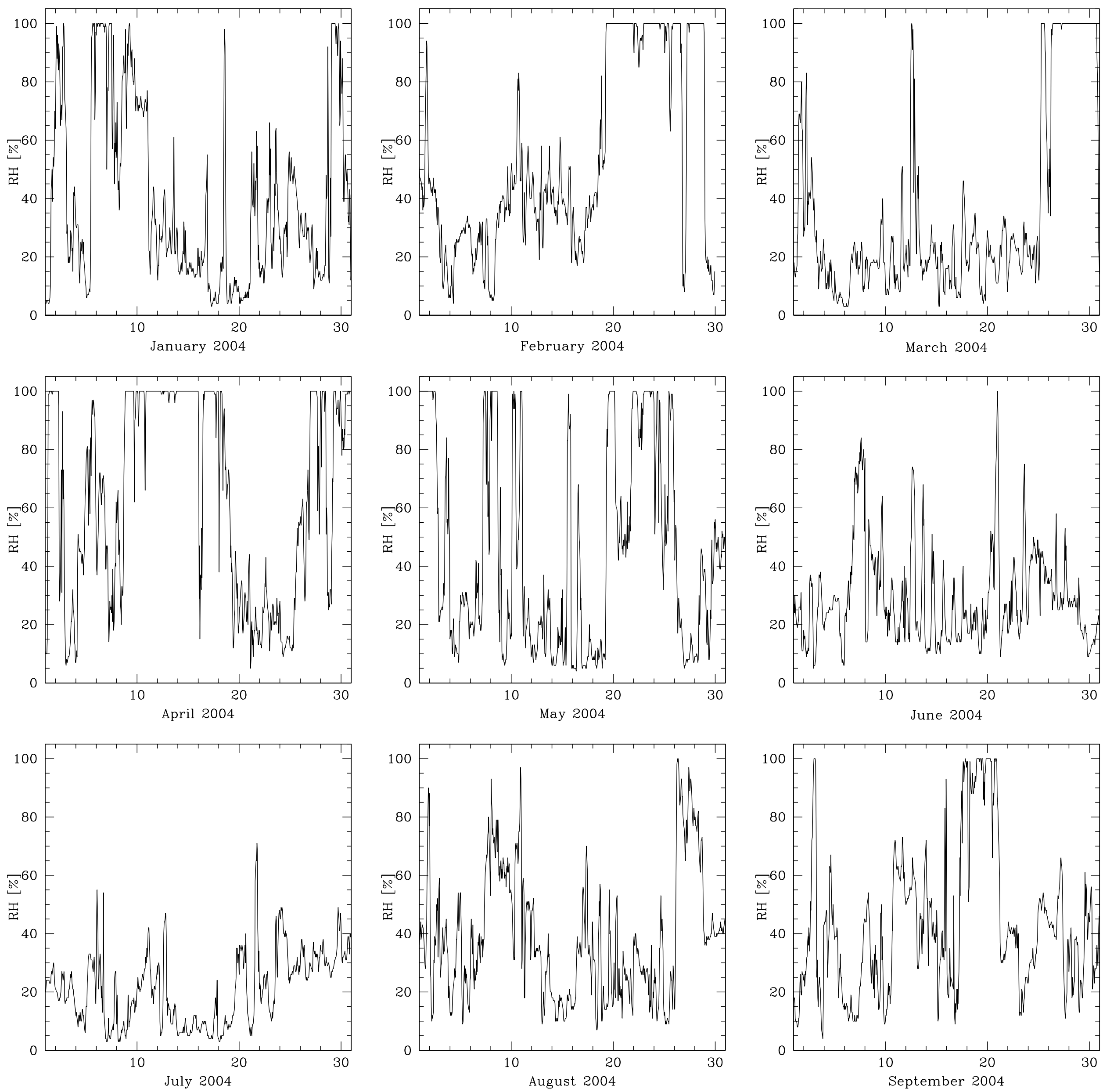

Figure 32: Plots of hourly mean relative humidity at TNG

5 Pressure Plots

The plots show yearly distribution for pressure located 2 meter above the ground for the year 2001 to 2004. Data are computed as hourly average. For each years it is given

- the yearly plot for TNG,NOT and CAMC
- the montly plots for pressure at TNG

5.1 Year 2001

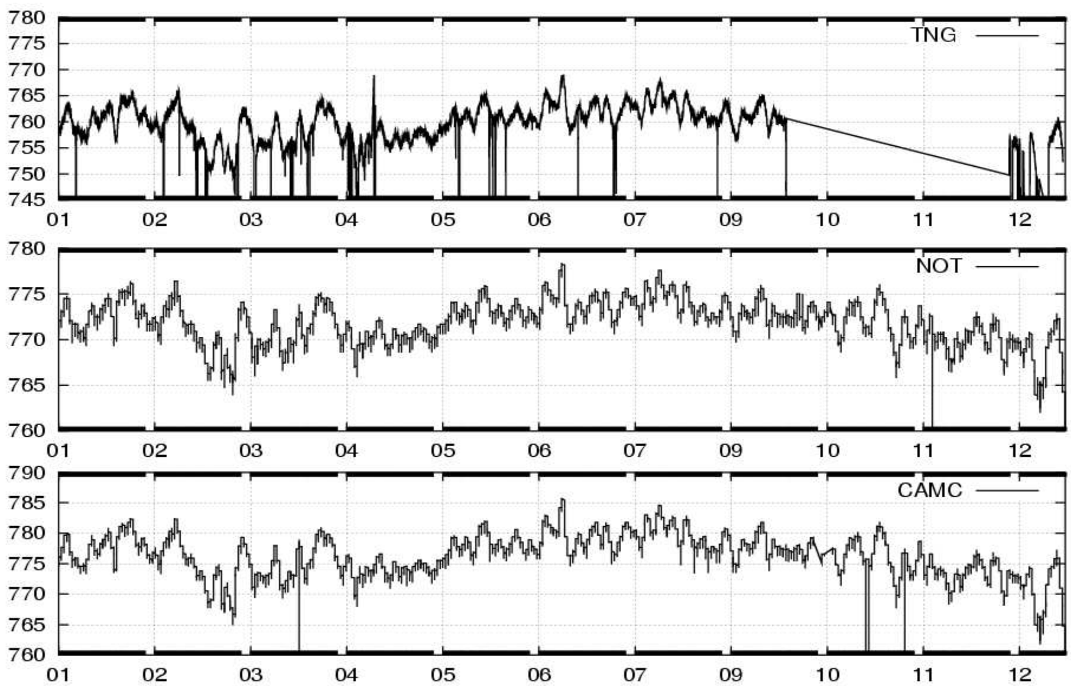

Figure 33: Hourly mean pressure taken at TNG and NOT and CAMC telescopes. TNG shows the minimum value of pressure with respect NOT and CAMC.

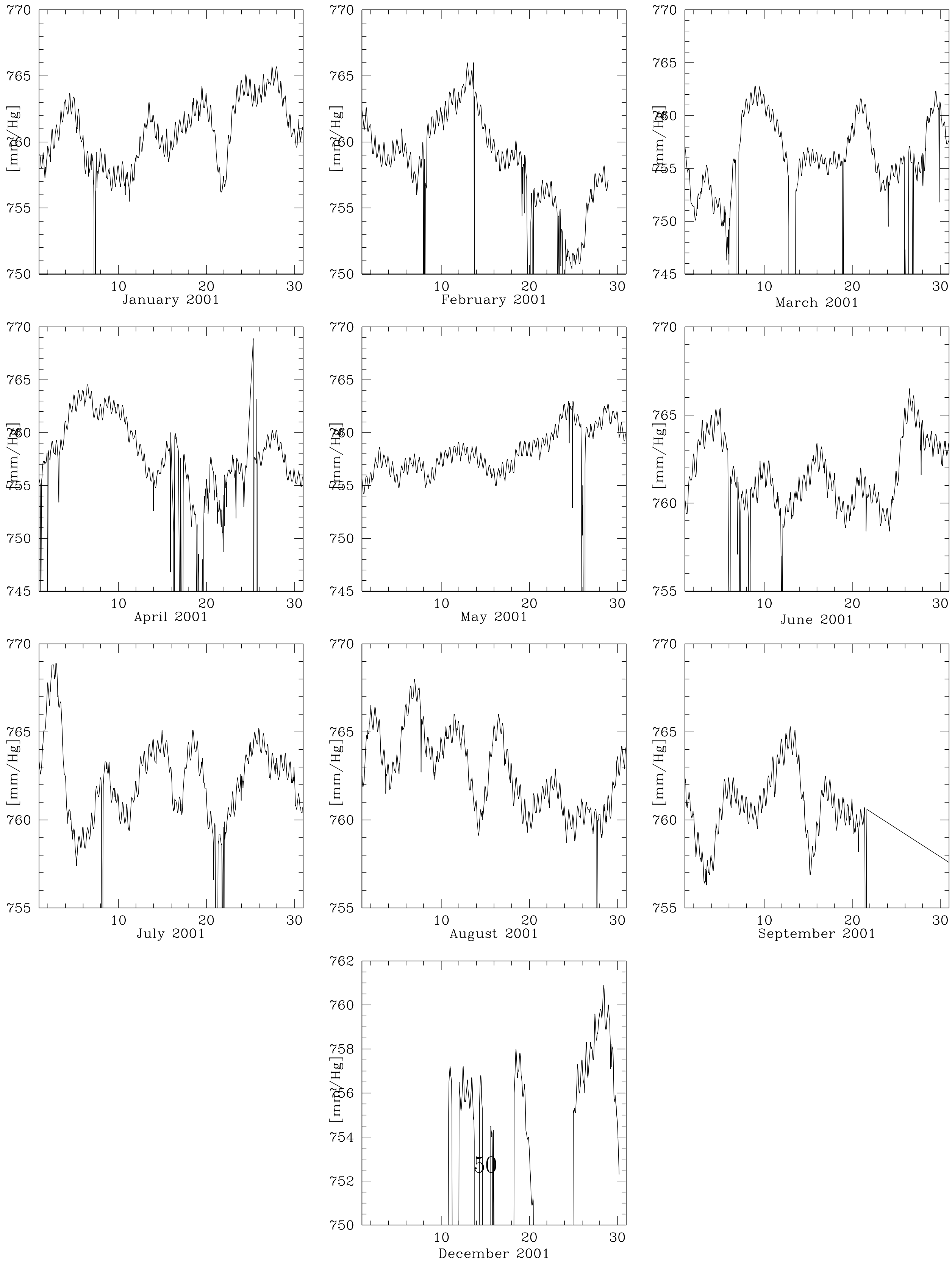

Figure 34: Hourly mean pressure at TNG

5.2 Year 2002

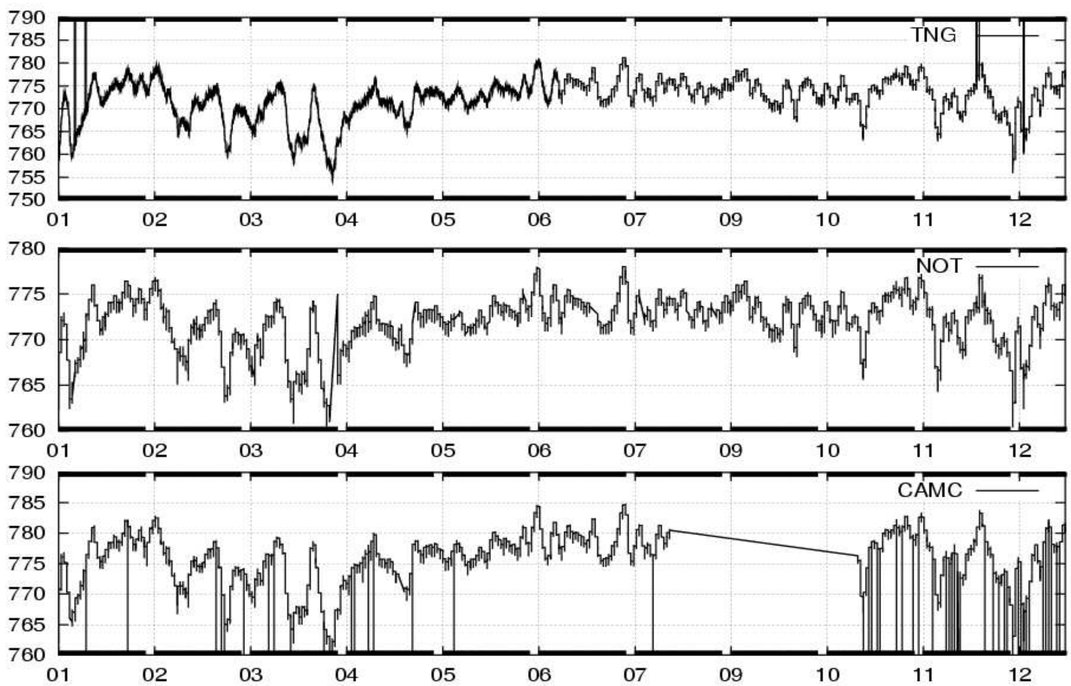

Figure 35: Monthly mean pressure taken at TNG and NOT and CAMC telescopes for the year 2002.

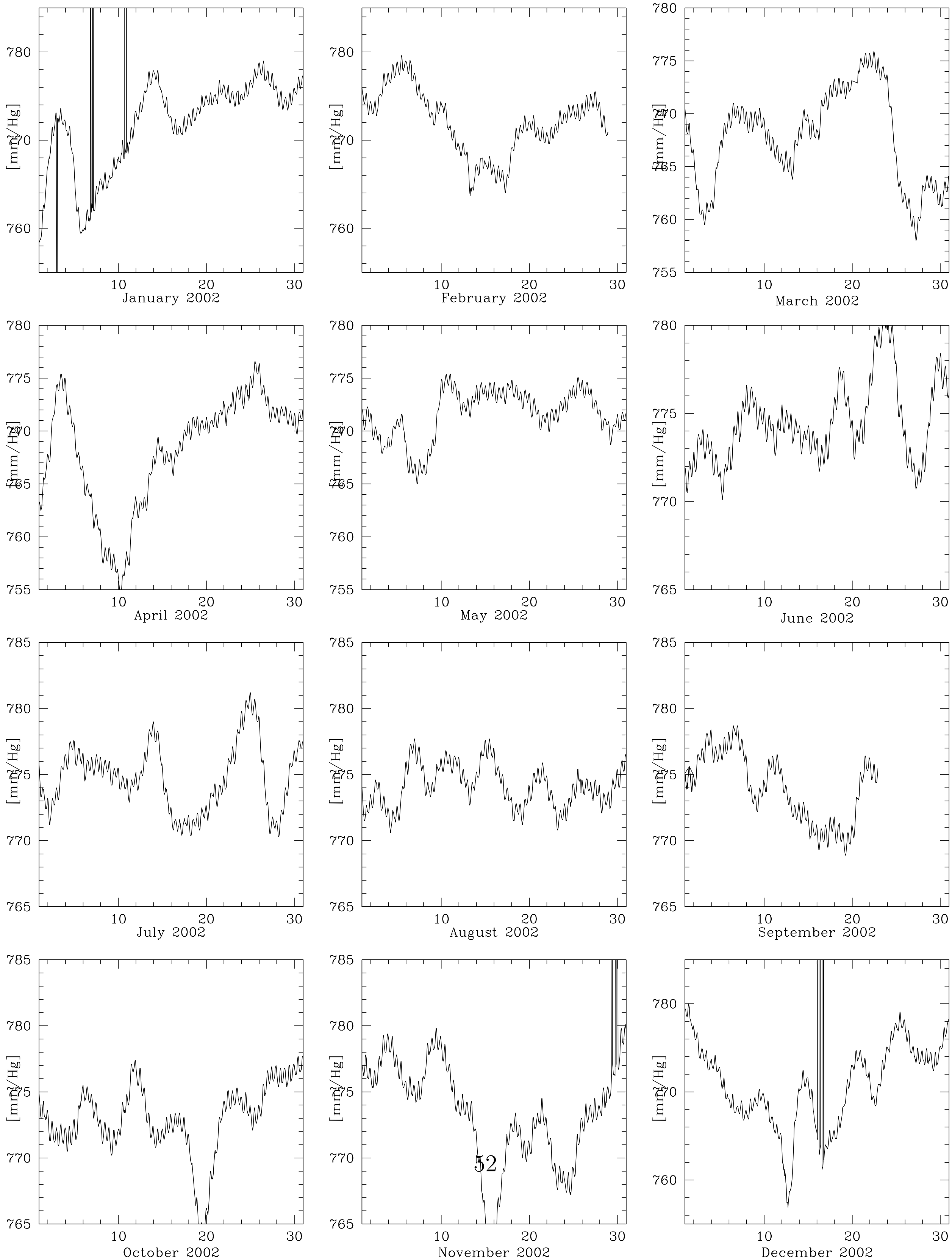

Figure 36: Monthly pressure plots at TNG

5.3 Year 2003

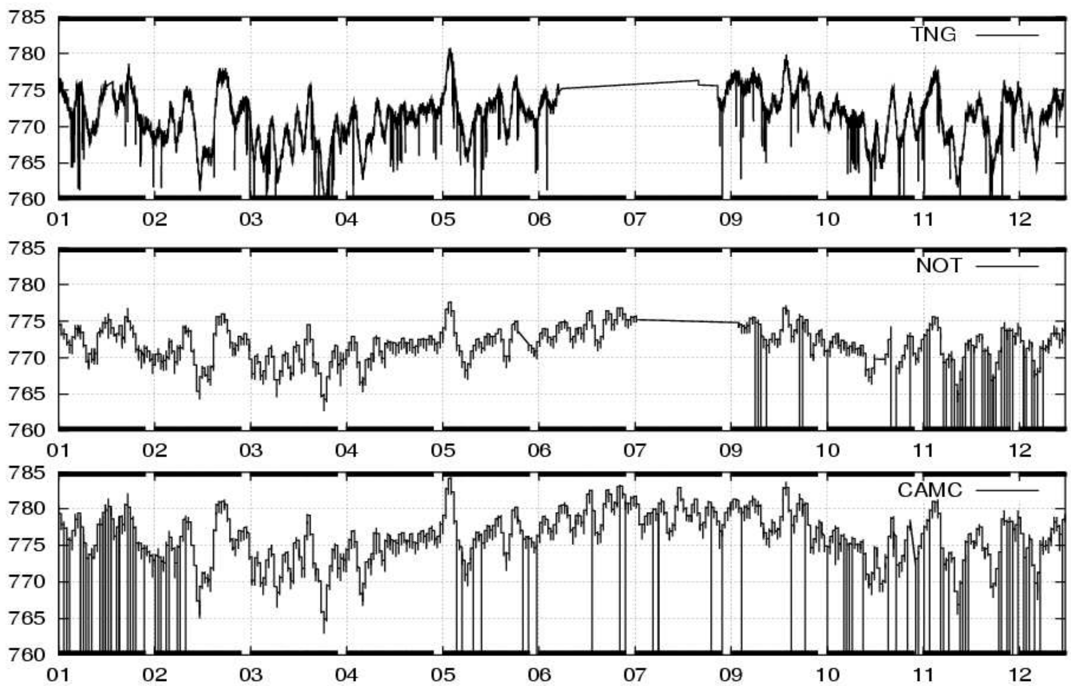

Figure 37: Hourly mean pressure taken at TNG and NOT and CAMC telescopes for the year 2003. Clear appear that each telescope show a different mean value: 772 mbar TNG, 771mbar NOT and more than 775 mbar CAMC. Is this a real difference? The NOT telescope shows the minimum pressure value with respect TNG and CAMC.

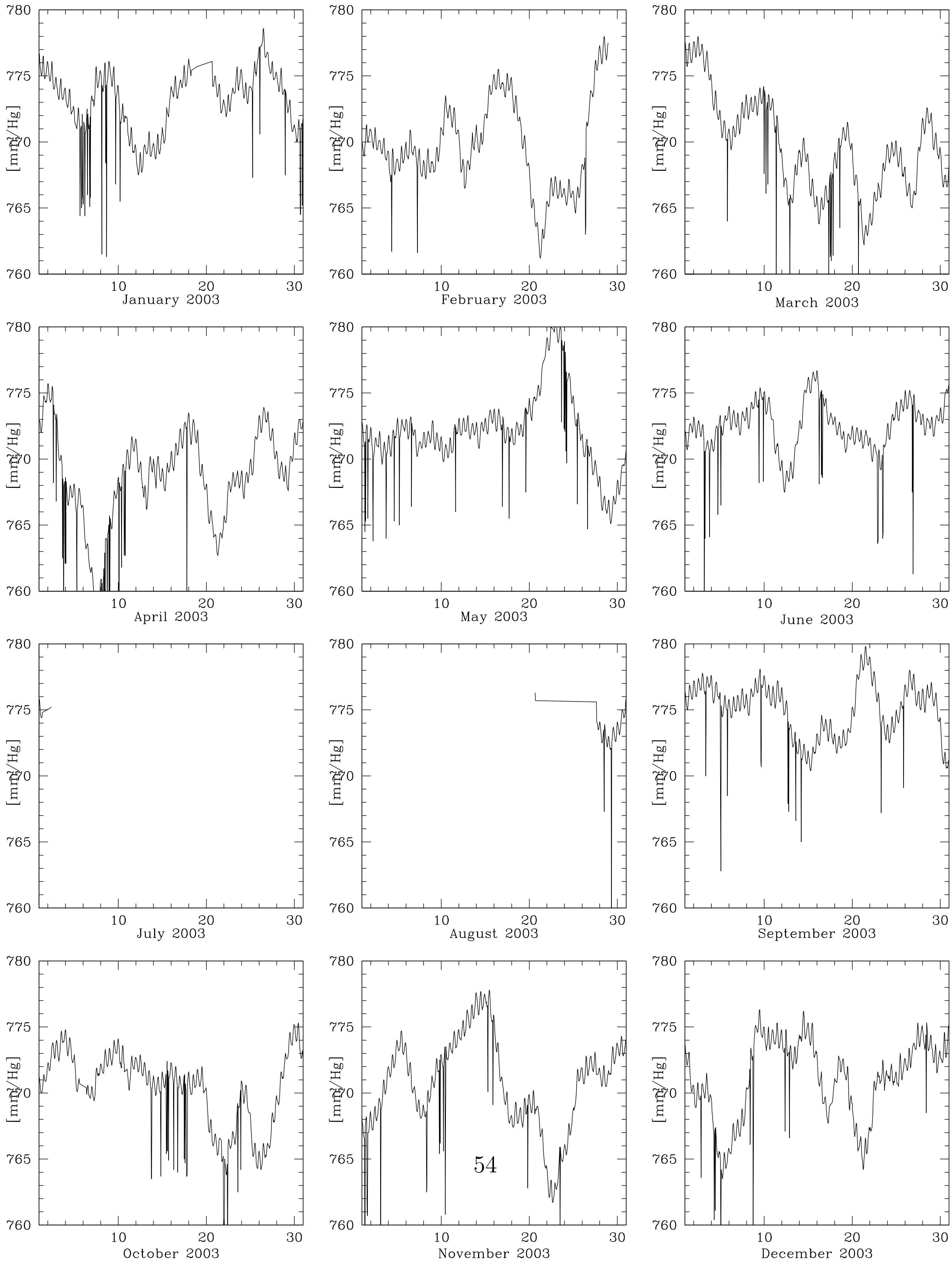

Figure 38: Montly plots of hourly mean pressure at TNG

5.4 Year 2004

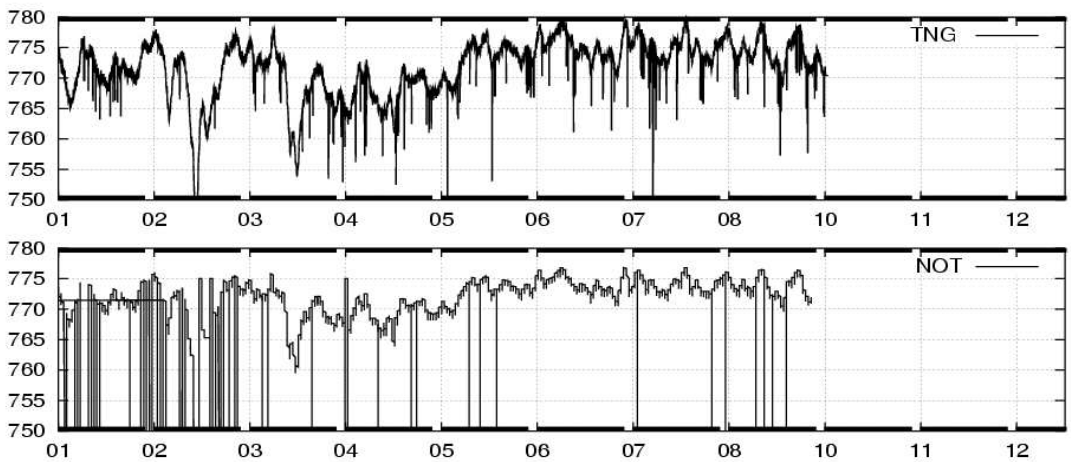

Figure 39: Hourly mean pressure taken at TNG and NOT telescopes. Data from CAMC are not yet available. TNG shows a pressure higher than NOT in the most part of the year.

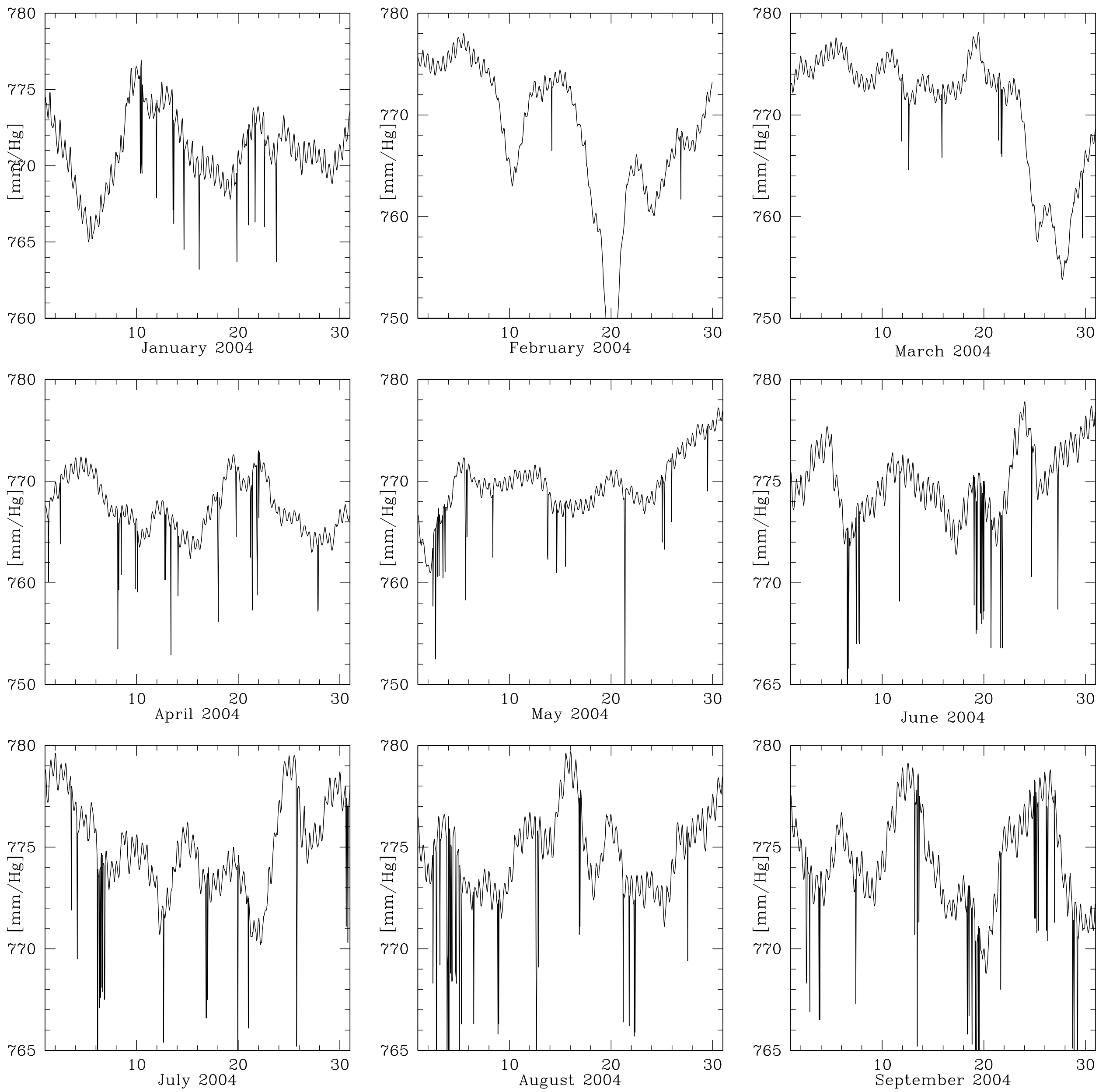

Figure 40: Montly plots of hourly mean pressure at TNG

6 Wind Direction

The statistics of wind direction is given in the following tables. Each sector shows the percentage of the wind direction for each telescope. Data are computed as averages of each indicated hour.

Table 15. Year 2001

	2 h.			8 h.			14 h.			20 h.		
dir.	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC
N	12.7	4.9	17.5	11.2	4.2	16.2	7.6	4.3	15.6	13.9	4.1	20.6
NNE	9.4	3.9	9.1	7.8	4.7	7.5	7.1	6.1	11.0	11.5	6.1	10.7
NE	5.4	8.9	4.4	5.4	8.5	4.4	3.0	5.4	2.1	5.7	9.5	5.5
ENE	6.7	5.4	3.3	5.8	5.2	2.5	3.0	4.5	0.5	6.0	6.0	2.2
E	3.8	8.9	4.8	3.2	13.9	4.4	1.4	14.7	1.5	3.6	8.0	4.9
ESE	3.2	8.4	2.1	3.1	8.0	2.1	1.2	7.7	1.5	1.9	4.1	1.8
SE	3.8	3.2	5.5	3.6	2.8	5.2	2.1	2.8	2.0	2.1	1.8	2.5
SSE	5.0	2.5	6.4	5.3	1.0	8.8	3.9	1.3	6.6	2.9	1.3	3.5
S	6.3	3.4	5.9	6.1	3.5	5.9	4.7	1.8	8.7	5.7	3.0	4.0
SSW	6.2	4.2	9.3	8.2	3.1	8.2	5.5	2.3	7.3	6.1	4.5	8.5
SW	6.1	8.0	4.3	8.3	8.4	3.8	9.1	6.5	4.2	6.1	6.3	3.8
WSW	6.9	12.0	5.5	5.9	11.4	7.8	15.5	13.7	8.6	5.7	12.4	6.0
W	6.6	8.8	5.3	4.8	8.6	4.4	11.5	11.9	10.1	7.4	12.5	5.2
WNW	5.1	8.8	5.2	5.0	9.7	4.1	9.1	9.8	5.9	5.8	11.0	6.4
NW	6.7	4.5	4.9	9.0	3.8	5.1	7.9	3.7	6.3	7.0	5.1	7.2
NNW	6.0	4.2	6.5	7.3	3.2	9.6	7.4	3.5	8.1	8.6	4.3	7.2

Table 16. Year 2002

	2 h.			8 h.			14 h.			20 h.		
dir.	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC
N	10.6	3.5	17.8	10.0	4.4	15.3	8.9	4.7	17.8	10.8	2.8	21.9
NNE	8.6	4.7	9.2	9.8	5.0	9.8	8.0	5.1	9.6	9.8	4.4	9.3
NE	6.2	9.7	6.1	6.2	7.7	5.2	3.5	5.6	1.8	5.9	8.8	3.9
ENE	7.6	5.2	2.7	8.1	6.1	2.0	3.7	4.7	0.6	6.8	6.5	2.8
E	5.9	13.8	4.5	5.3	16.6	4.3	2.9	19.8	2.1	3.8	11.6	7.1
ESE	4.3	9.1	5.5	4.7	8.6	3.7	2.8	9.0	3.2	3.5	9.2	3.5
SE	5.2	3.3	7.1	5.1	3.0	10.0	3.7	1.9	3.9	4.6	2.5	5.1
SSE	5.8	2.0	6.3	5.3	1.5	8.9	4.4	0.9	10.4	4.6	0.8	6.5
S	5.4	2.5	4.7	5.1	2.7	4.6	4.9	1.7	9.0	3.5	1.5	4.7
SSW	5.0	2.7	6.4	6.1	2.8	4.7	5.4	2.1	5.1	4.4	2.2	5.3
SW	5.7	7.5	4.7	6.3	7.4	4.0	8.0	5.1	3.3	6.6	5.2	3.0
WSW	6.0	12.1	3.9	6.3	12.7	5.3	9.6	12.5	5.9	6.7	15.3	4.8
W	5.6	8.1	3.9	5.1	8.0	4.5	9.4	11.1	5.9	6.6	10.1	4.2
WNW	5.7	8.8	4.7	5.7	6.0	5.5	9.9	9.3	6.4	6.5	12.4	6.5
NW	5.1	4.5	4.7	5.2	4.5	5.0	7.4	3.7	6.4	5.6	4.5	5.0
NNW	7.3	2.5	7.8	5.7	2.9	7.2	7.5	2.8	8.6	10.3	2.2	6.4

Table 17. Year 2003

	2 h.			8 h.			14 h.			20 h.		
dir.	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC
N	11.1	4.5	17.1	11.9	6.0	19.3	8.9	4.8	17.6	10.1	5.0	18.4
NNE	8.2	4.6	9.4	9.1	5.3	10.0	8.5	7.1	11.5	10.1	6.6	11.5
NE	5.3	9.1	6.3	5.5	7.2	5.4	4.4	7.0	2.6	4.8	8.7	5.7
ENE	5.9	5.9	2.1	5.6	5.2	2.5	3.7	5.2	1.2	5.0	6.4	2.3
E	4.9	9.8	5.4	4.6	11.4	3.8	2.7	16.7	2.6	3.3	9.0	4.9
ESE	4.1	7.1	3.1	4.1	6.6	2.3	2.5	7.4	2.2	2.7	4.7	2.1
SE	5.9	3.3	5.7	5.9	2.4	7.5	3.5	2.0	2.1	3.9	1.5	3.1
SSE	4.2	1.7	5.9	6.2	1.3	8.3	4.2	1.2	7.3	4.7	1.0	3.8
S	5.6	2.5	5.3	6.2	3.5	5.5	5.9	2.9	7.3	5.6	2.3	4.1
SSW	6.6	2.9	5.8	6.1	4.2	5.1	5.3	2.8	5.2	4.8	2.3	4.0
SW	7.8	7.7	4.6	6.7	6.7	2.9	7.8	5.4	2.7	6.2	4.7	2.7
WSW	5.4	12.7	6.2	5.4	12.3	7.4	10.3	11.6	8.1	7.6	13.7	6.6
W	5.4	10.8	3.6	5.4	8.7	4.4	11.1	10.1	8.8	8.4	16.4	6.4
WNW	6.0	9.5	5.2	5.0	8.4	4.5	7.5	8.9	6.3	9.0	11.5	6.1
NW	6.8	4.4	6.6	5.6	6.5	4.7	7.2	3.9	6.8	6.6	3.6	8.3
NNW	6.4	3.5	7.7	6.6	4.3	6.4	6.3	3.0	7.7	7.1	2.6	10.0

Table 18. Year 2004

	2 h.			8 h.			14 h.			20 h.		
dir.	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC	TNG	NOT	CAMC
N	10.6	4.2		11.0	5.3		9.8	4.9		13.4	4.9	
NNE	12.4	6.6		10.8	5.6		9.1	8.2		12.0	6.7	
NE	6.8	10.5		6.7	9.8		3.9	6.1		6.2	7.7	
ENE	9.0	7.2		8.9	7.2		4.4	5.8		7.0	5.6	
E	5.4	14.5		6.3	16.6		3.2	25.1		4.5	11.9	
ESE	4.5	10.6		5.8	10.4		3.2	8.4		4.1	11.1	
SE	6.2	3.0		6.7	2.3		4.3	2.1		5.3	2.3	
SSE	6.1	1.4		5.6	1.0		4.5	1.1		4.1	1.0	
S	4.2	3.9		4.2	4.3		5.5	3.6		3.5	3.8	
SSW	4.8	2.0		4.0	2.5		5.1	1.6		3.9	2.0	
SW	4.6	4.7		4.2	4.1		6.3	3.0		4.4	4.2	
WSW	3.1	6.7		4.2	8.3		8.9	8.7		5.3	8.5	
W	3.9	9.2		5.1	8.0		10.5	8.7		6.2	12.0	
WNW	5.3	8.7		5.1	8.5		8.2	8.1		6.8	9.2	
NW	7.2	4.3		5.8	3.6		6.8	2.3		6.2	5.6	
NNW	5.9	2.5		5.6	2.5		6.3	2.3		7.0	3.5	

7 Dust Counts Plots

Selection of the dust monitor is triggered by the size of particles to be monitored, and the estimated amount. Among the several parameters we have taken into account: range of sizes (number of available channels), sensitivity, flow-rate and background noise counts.

- The sensitivity is the smallest size of a particle that the sensor can detect.
- The flow-rate of a particle counter is the amount of the flux that a sensor can receive through the sample volume
- the background noise is the instruments dark current value.

We have addressed our choice to an Abacus^{TM} TM301 (made by Particle Measuring Systems Inc.). Abacus TM301 is an instrument easy to use, hand-held, reliable and with high sensitivity. TM301 is a particle counter based on the optical detection technique, and it is able to count particles above a diameter of 1 μ. The reason of such sensitivity is that we have extimated that the number of atmospheric particles occurs mostly in the micron fraction with a typically concentration range of few tens per cubic centimeter in particular during Sahara storms. Abacus TM301 stores in memory about 500 set of data and via RS232 send the data to a PC. The sensor is located outside the TNG dome at the same level of the primary mirror. The data are sampled not instantaneously but are the mean values computed after an integration time of 10 minutes. Before each measurement a reset of 10 minute clean the sensor. The data are collected using different baselines ranging from 1 hours to 6 hours.

Monthly plots of the distributions of the dust counts are reported in the following figures. The counts of particles are plotted in a logarithmic scale. Different symbols are used for the different size of particles.

7.1 Year 2001

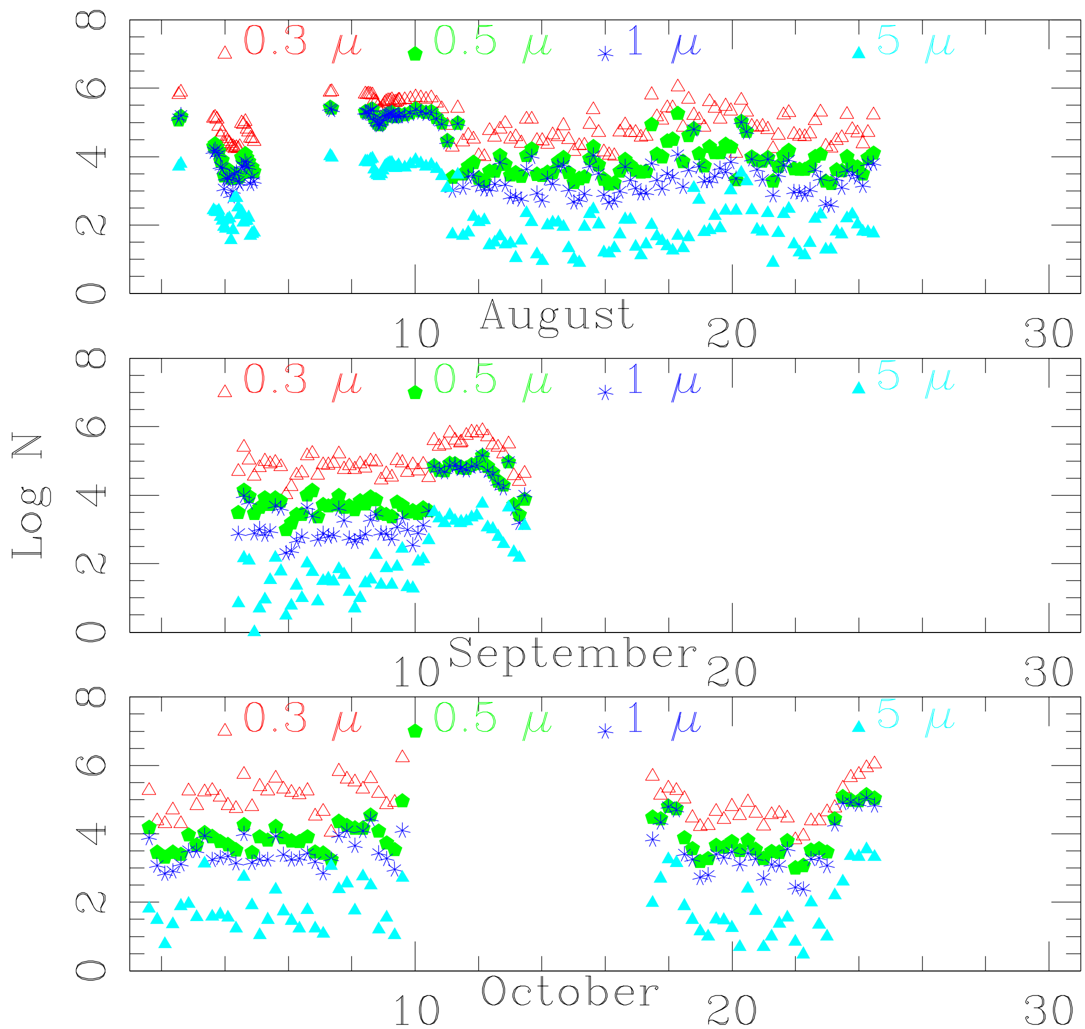

Figure 41: Distribution of the dust for the Years 2001. Counts are plotted Log scale. It is plotted the different size of dust using different colours, dust counter is located at the level of the main mirror.

7.2 Year 2002

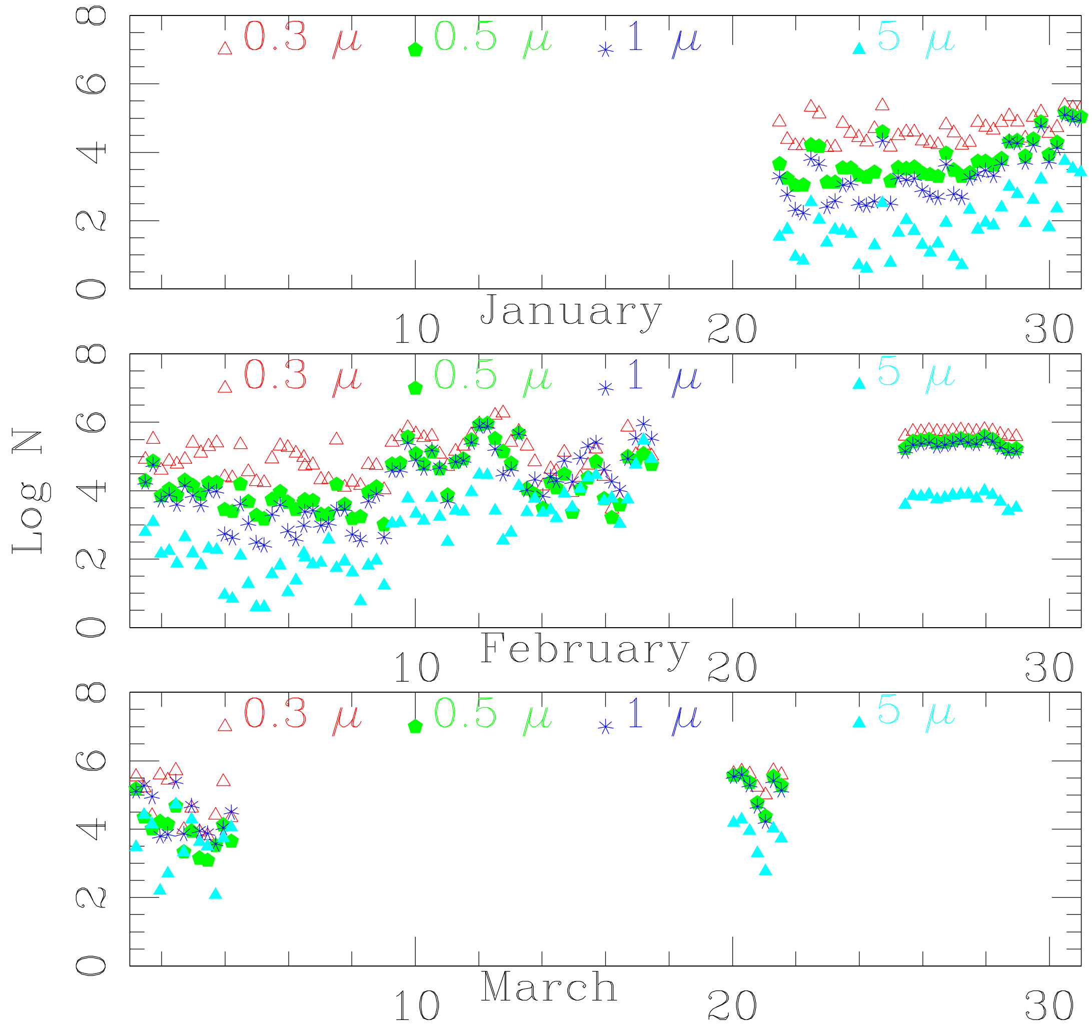

Figure 42: continue

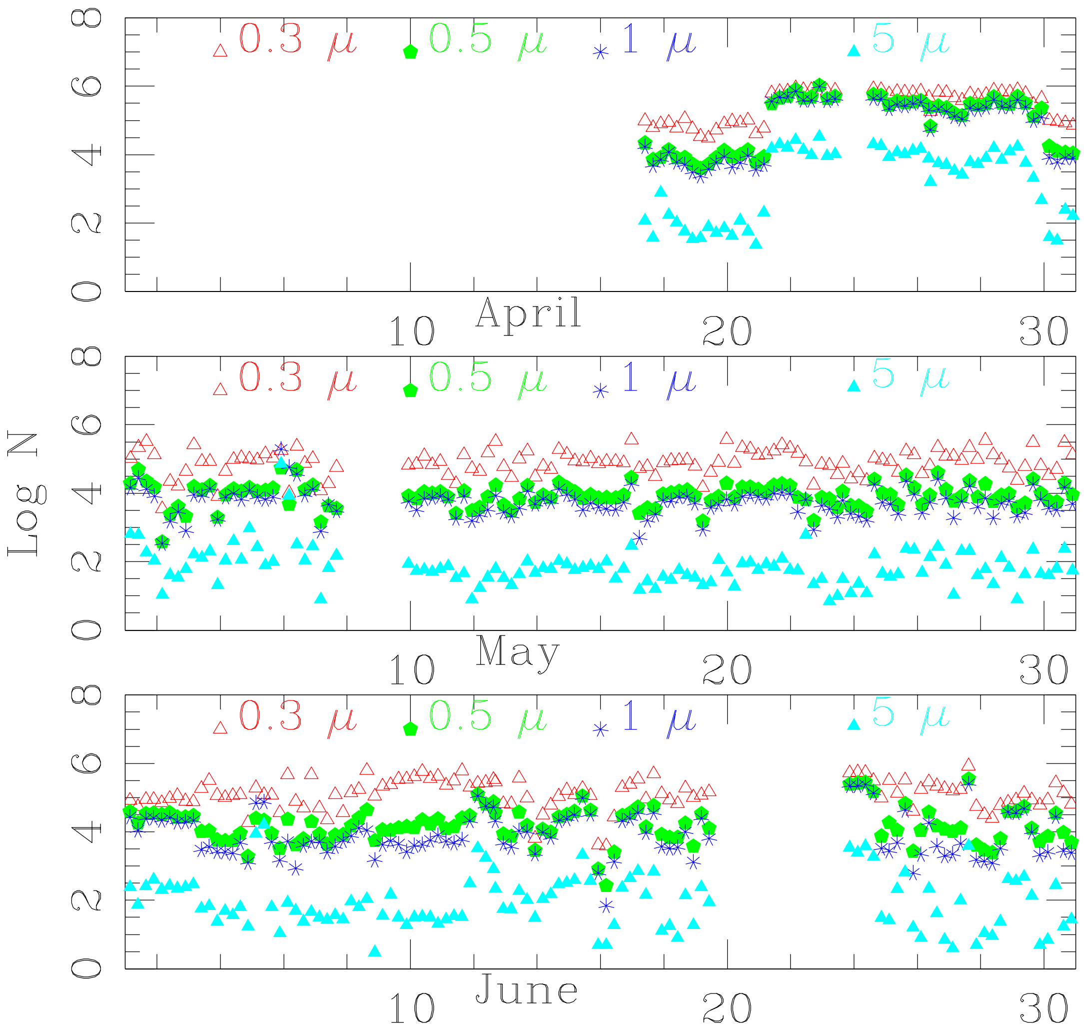

Figure 43: continue

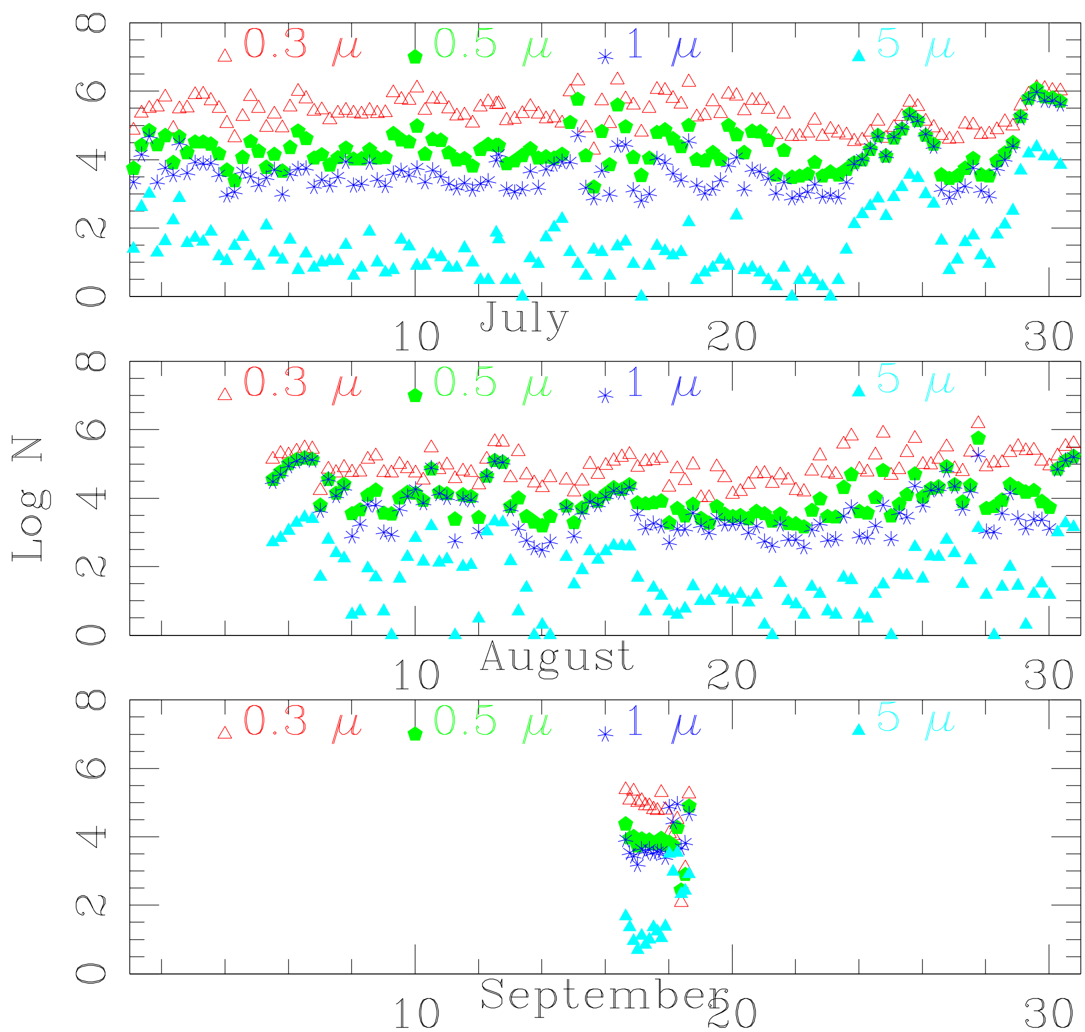

Figure 44: continue

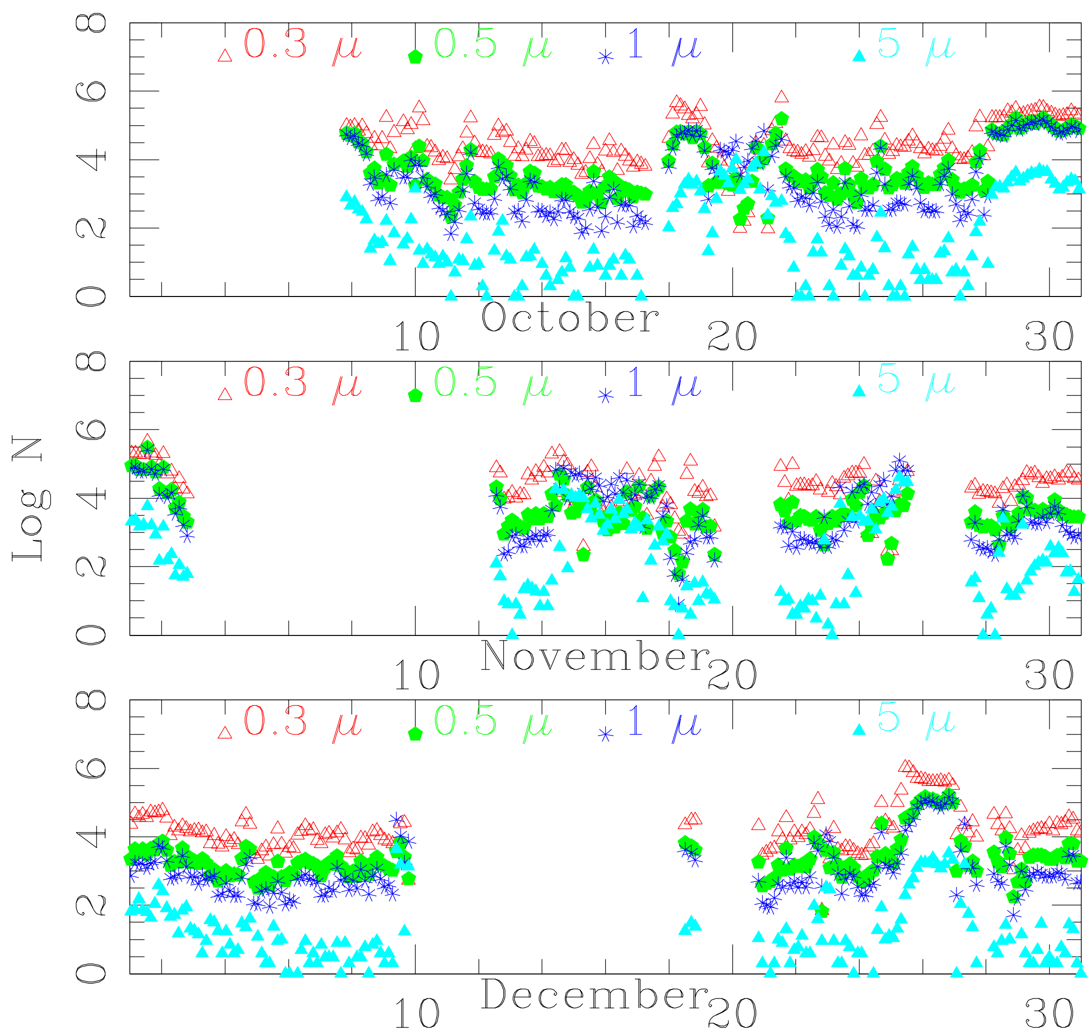

Figure 45: continue

7.3 Year 2003

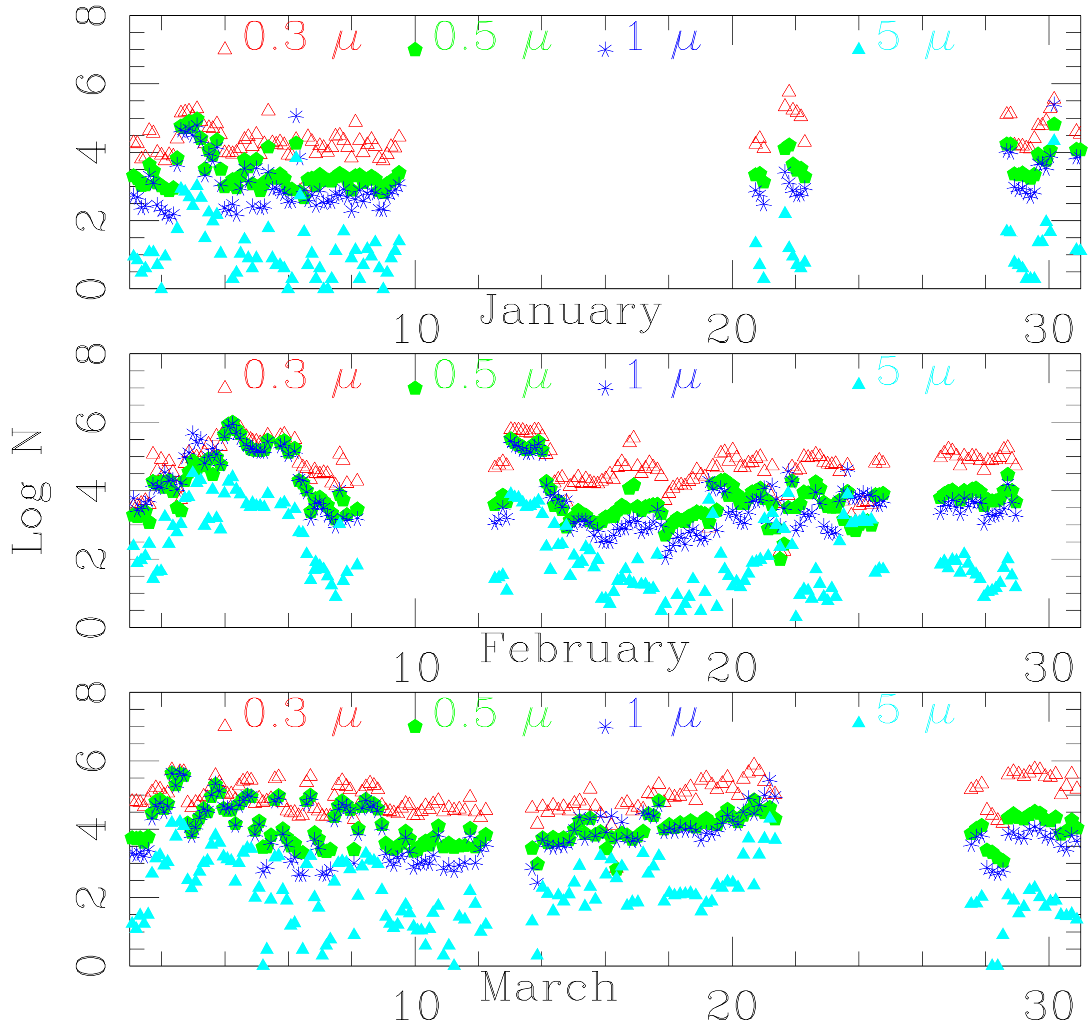

Figure 46: continue

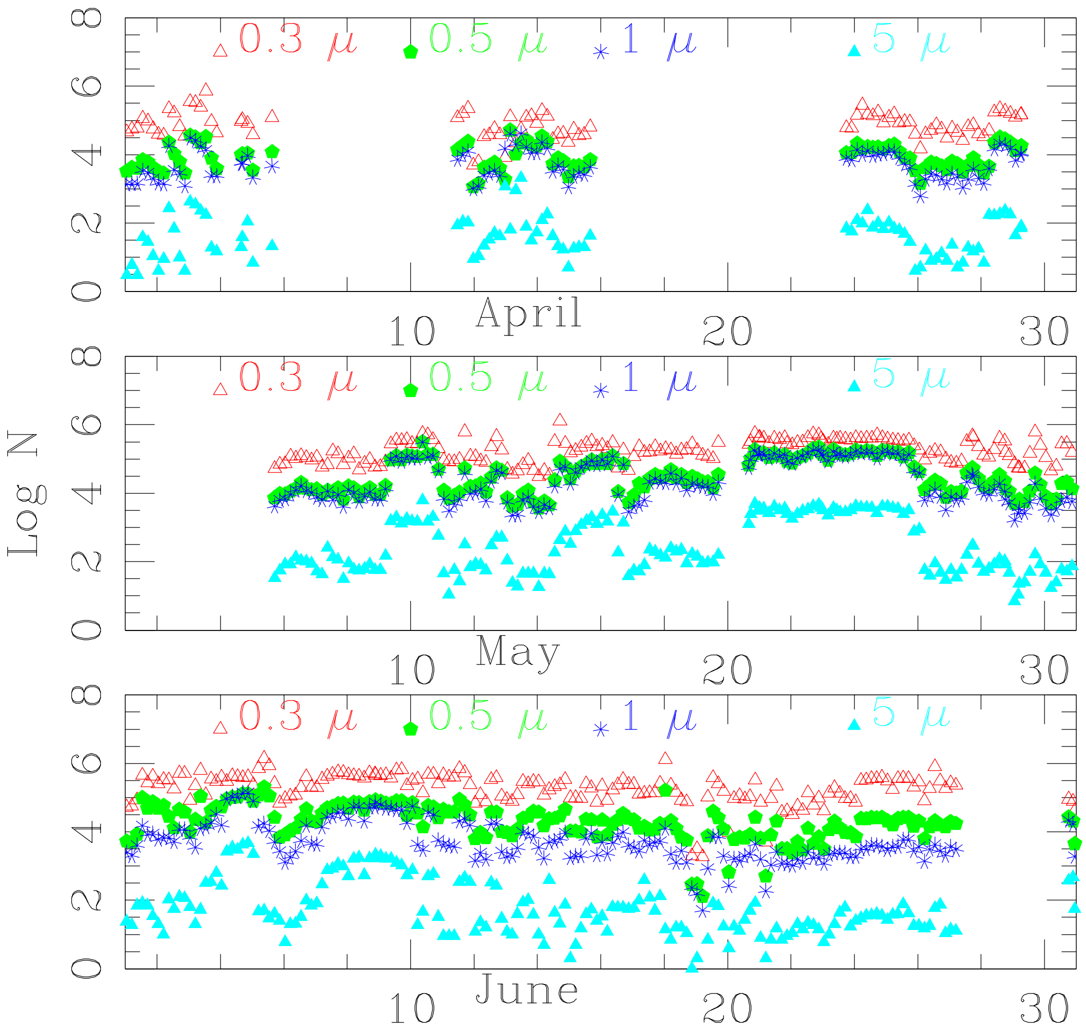

Figure 47: continue

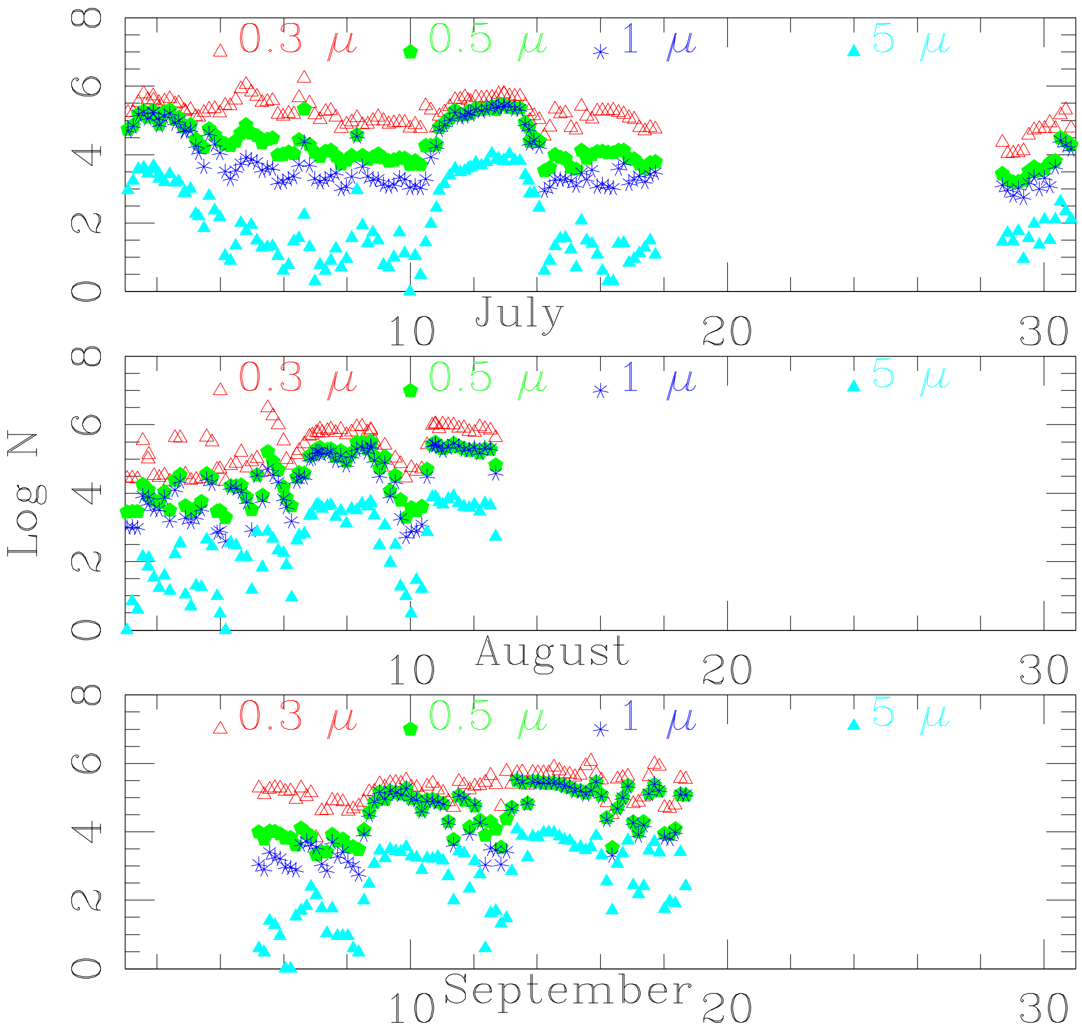

Figure 48: continue

7.4 Year 2004

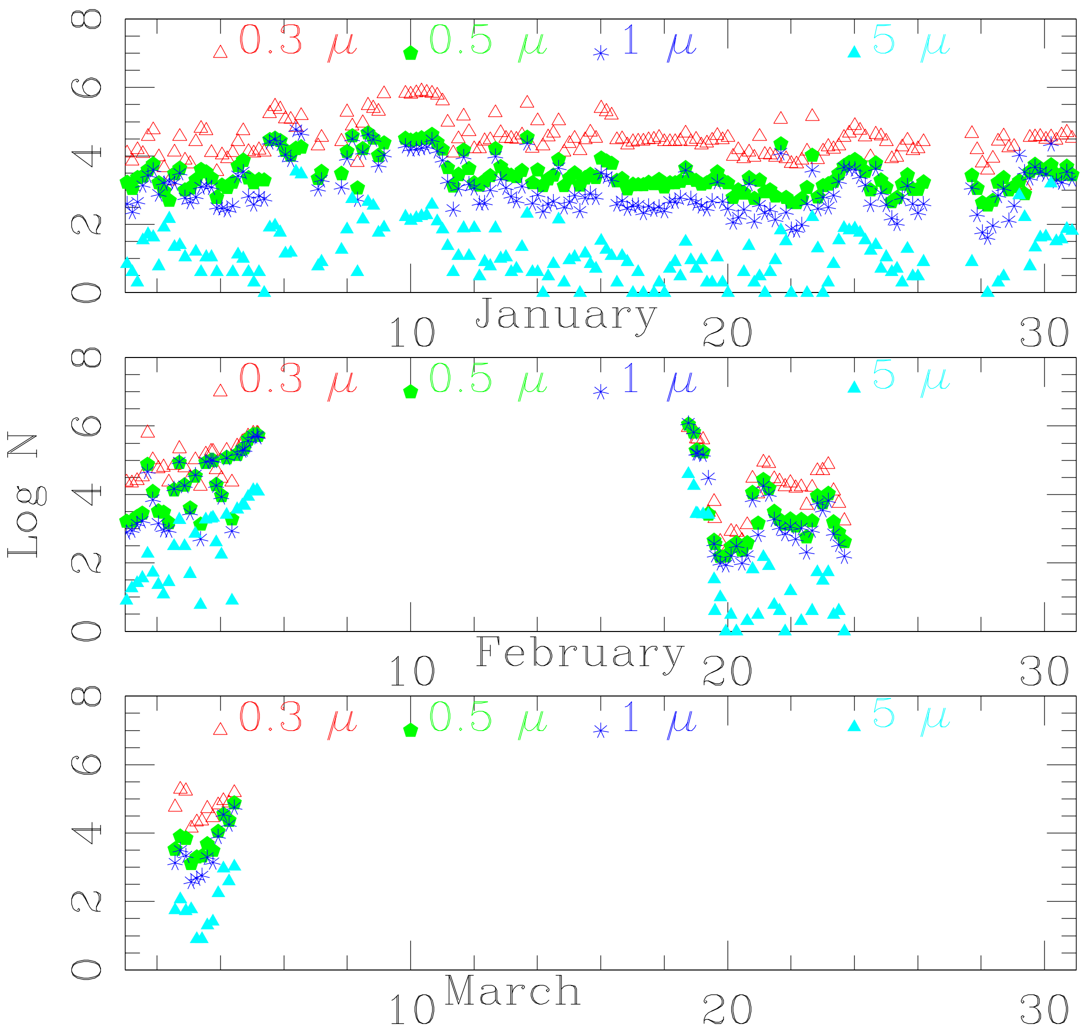

Figure 49: continue

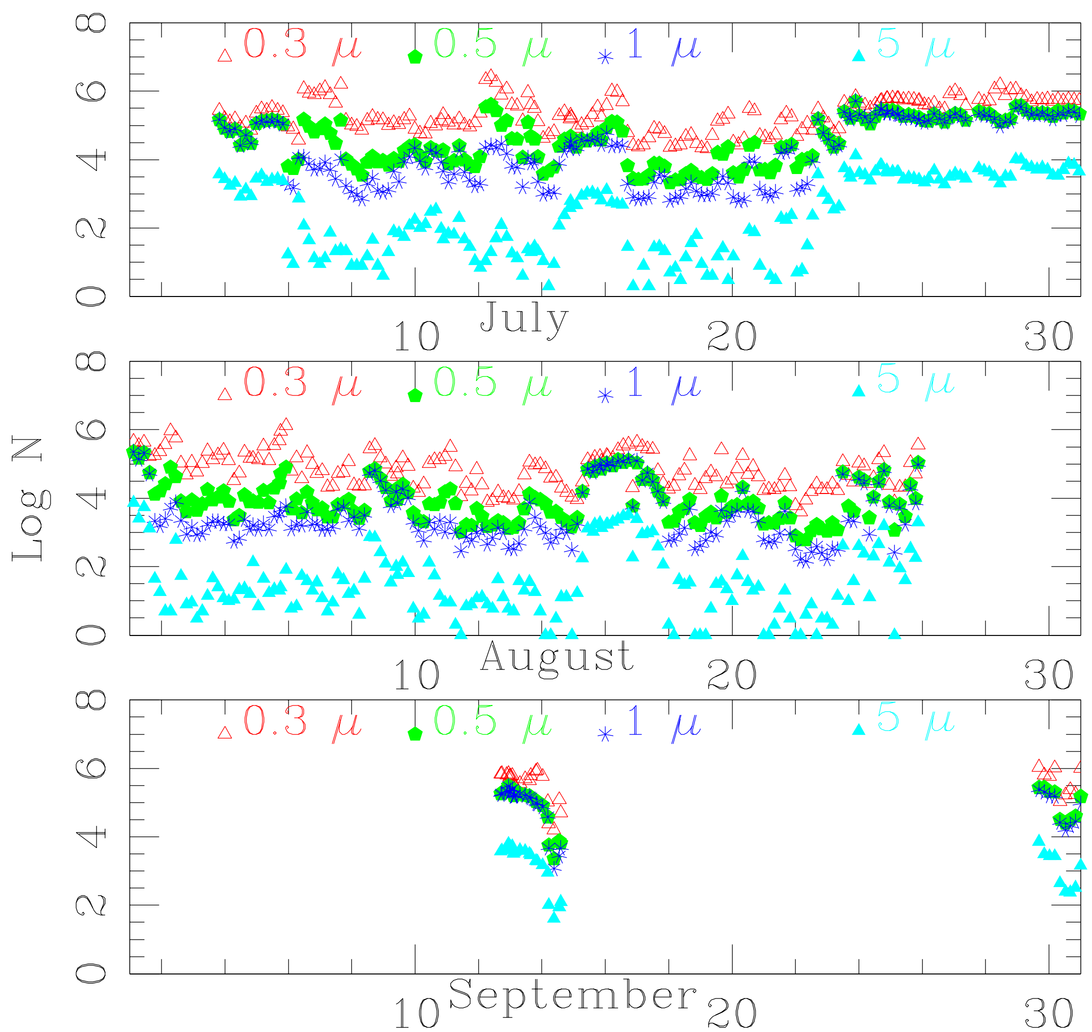

Figure 50: continue

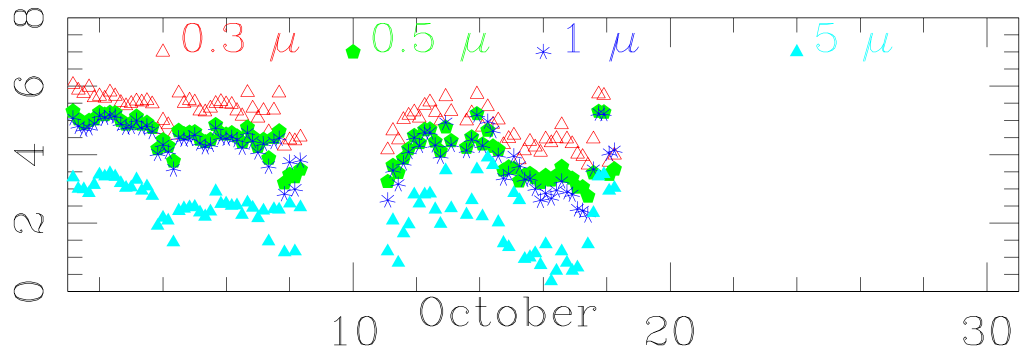

Figure 51: continue

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