EL ROQUE DE LOS MUCHACHOS SITE CHARACTERISTICS

G. Lombardi[1,2], V. Zitelli[2], S. Ortolani[3] and M. Pedani[4]

1. Department of Astronomy, University of Bologna
2. INAF – Bologna Astronomical Observatory
3. Department of Astronomy, University of Padova
4. Fundación Galileo Galilei and Telescopio Nazionale Galileo

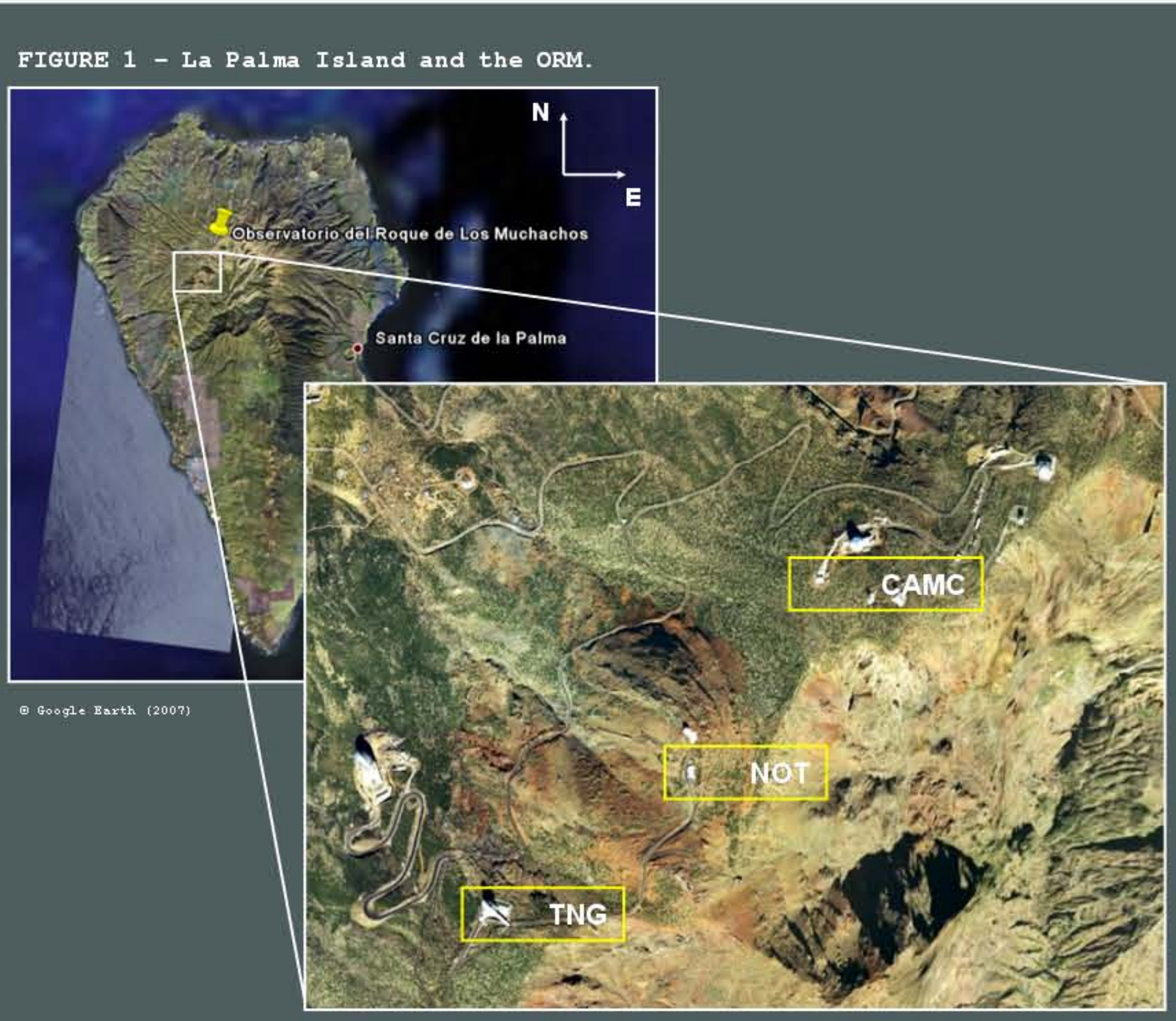
THE OBSERVATORY

The Observatorio del Roque de Los Muchachos (ORM) is located at La Palma Island (Canaries). The very good astronomical conditions of the island are mainly due to a stable subsiding maritime air mass.
All the telescopes are located well above the inversion layer (occourring between 800-1200 m), along the northern edge of the Caldera de Taburiente, at the northwest side of La Palma (Table 1). Figure 1 shows the irregular shapes and the complex orography. As a consequence, the local microclimate differs from site to site, making it difficult to foresee in advance the precise local meteorological parameters.

TABLE 1 - Locations and altitudes of the telescopes.

	Latitude	Longitude	Altitude [m]
TNG	28°45′28.3″N	17°53′37.9″W	2387 (Elevation axis)
CAMC	28°45′36.0″N	17°52′57.0″W	2326 (Dome floor)
NOT	28°45′26.2″N	17°53′06.3″W	2382 (Dome floor)

FIGURE 1 - La Palma Island and the ORM.



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THE DATA

Meteorological data are obtained from TNG, CAMC, and NOT weather stations located in places not influenced by the presence of the domes. The three telescopes are lies on an imaginary straight line in NE direction: TNG and CAMC are about 1000 m far, while NOT is placed in the middle at about 500 m from TNG.
The database of TNG is 7 yr long (1998-2005), NOT is 8 yr long (1997-2005), while CAMC is 20 yr long (1985-2004). We analyzed temperature (T), wind speed (wsp), relative humidity (RH), and air pressure (P). From each raw data series, we compute the hourly averages, and then from each set of these, we compute the monthly averages and finally the annual averages. Vectorial wind direction is evaluated by calculating the annual percentage of hours in which the wind comes from fixed directions.

MICROCLIMATE DIFFERENCES BETWEEN THE THREE SITES

The CAMC 20 yr annual temperatures baseline (Fig. 2) shows an increasing trend (about 1.0 deg per 10 yr). Is this the first confirmation of global warming above the inversion layer? CAMC and TNG trends are remarkably similar, with average temperatures differing by no more than 0.6 deg (2001; Lombardi et al. 2006). CAMC is the driest site, maintaining a RH < 58% in wintertime (Fig. 3, top) and RH < 44% in summertime (Fig. 3, bottom), while both TNG and NOT have comparable trends and appear to dampen 15% on average in wintertime and 7% in summertime (Lombardi et al. 2007). CAMC has the highest pressures (773-776 hPa). Figure 4 shows an increasing behaviour through 20 yr. Does it drive temperature increasing? NOT shows lower pressures (771-772 hPa). TNG display big differences compared to NOT in 2000 and 2002, but very similar values in 2003, 2004, and 2005. The barometric correction applied to P for the three sites demonstrates that ORM is dominated by high pressure (Lombardi et al. 2007).

FIGURE 2 - Annual temperatures.

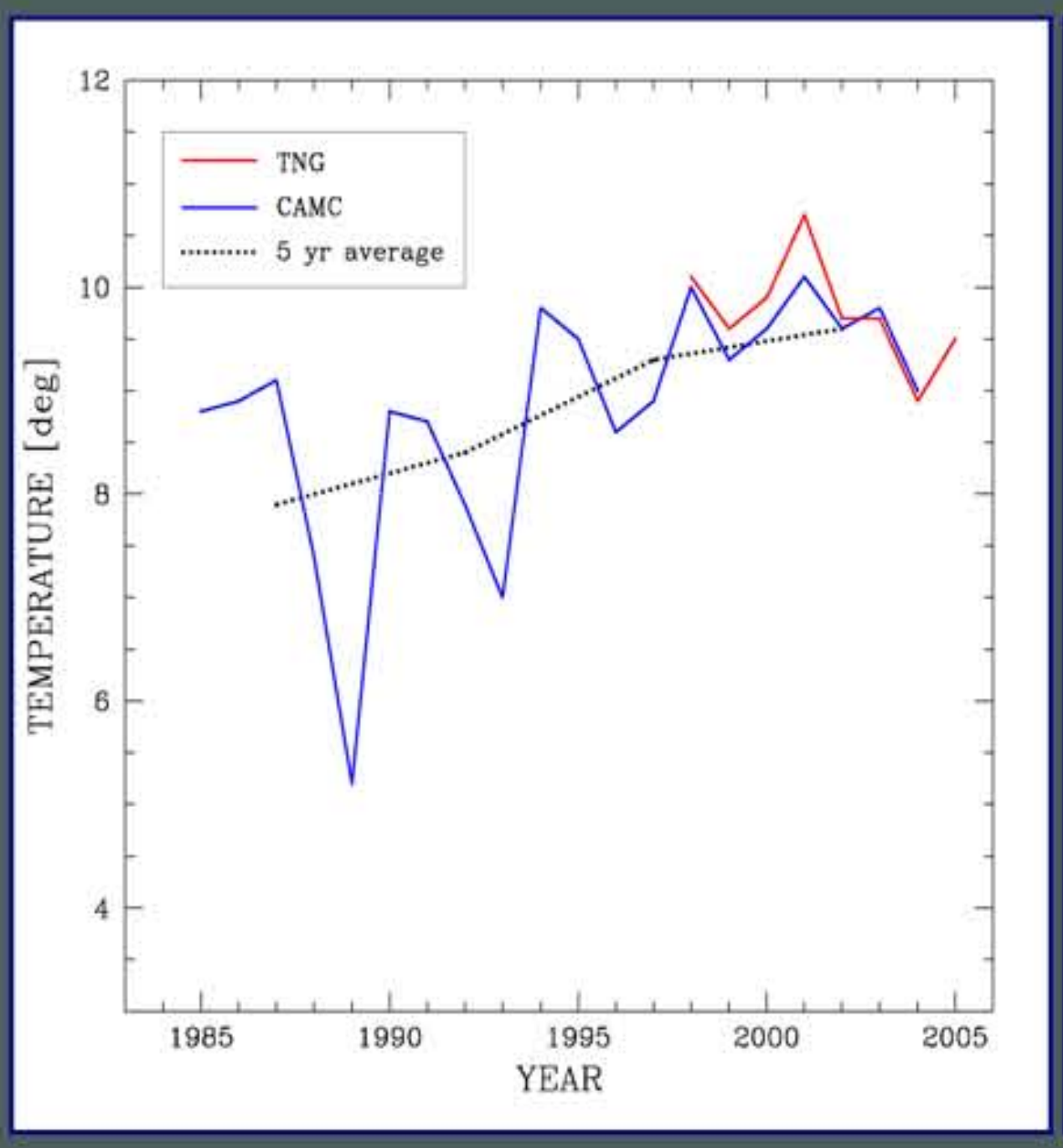


FIGURE 3 - Annual relative humidity.

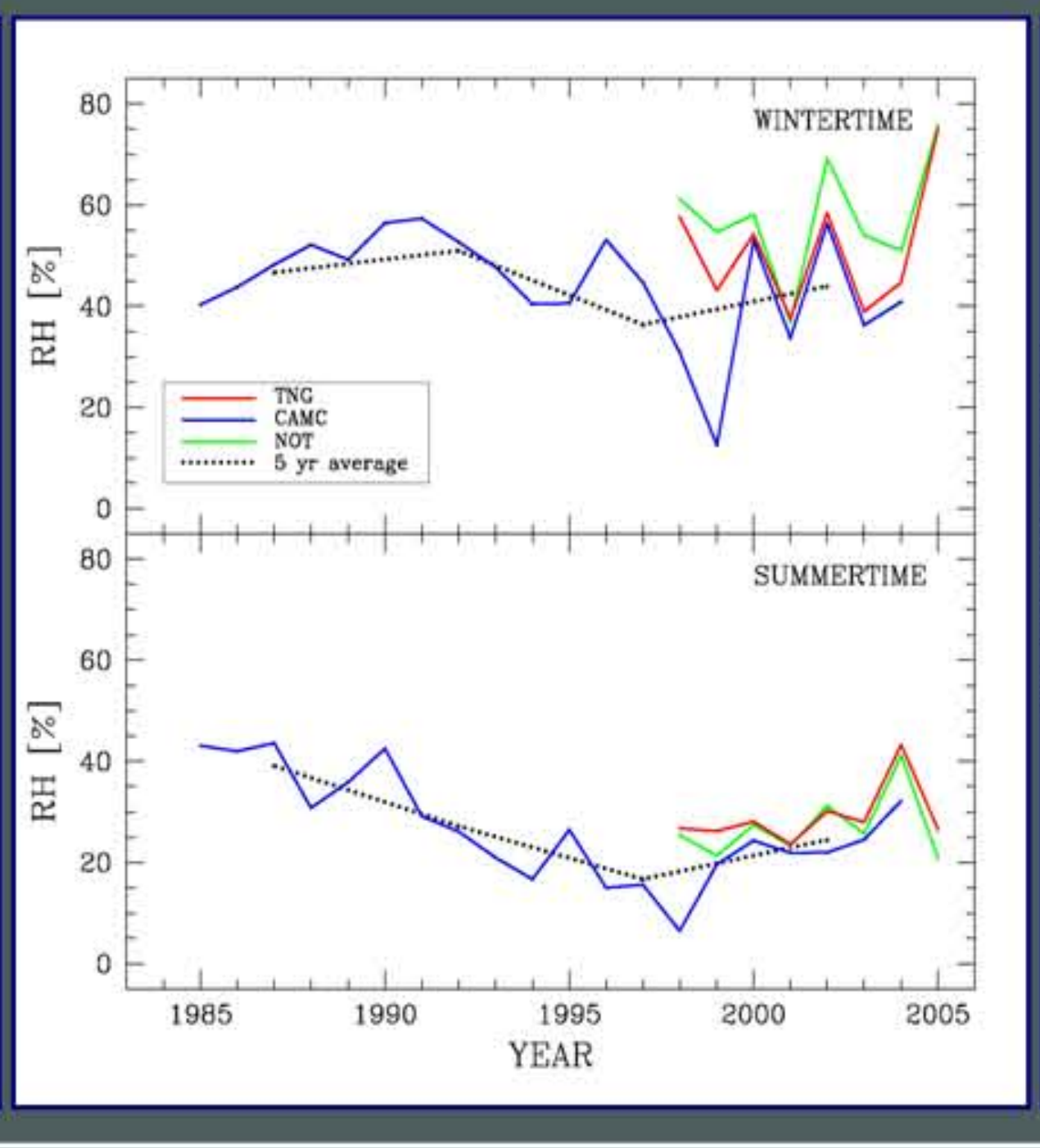


FIGURE 4 - Annual pressures.

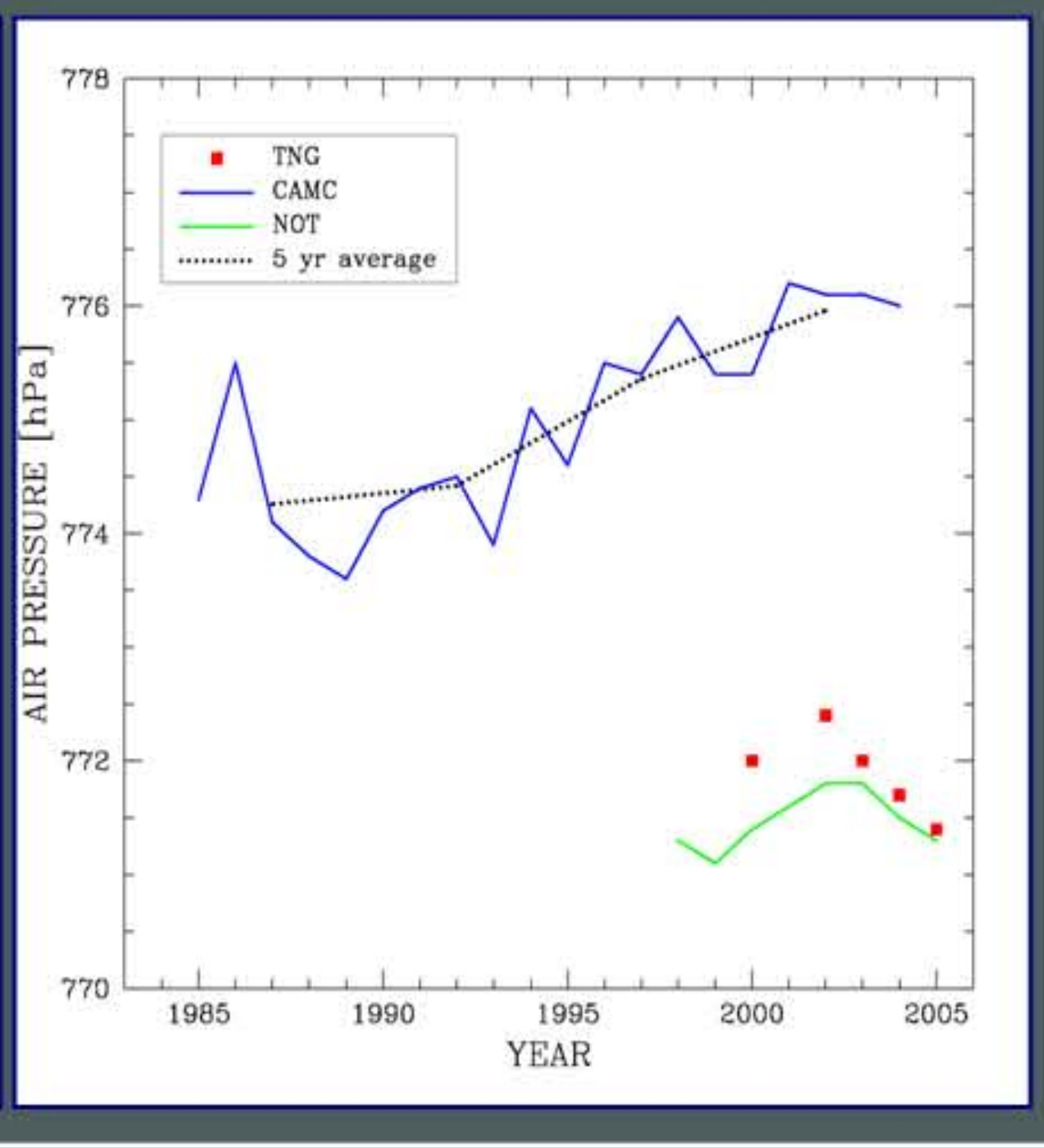


FIGURE 5 - Nighttime windroses for TNG, CAMC and NOT in the common period 1998-2004 (Lombardi et al. 2007). The typical wind direction significantly changes across the site.

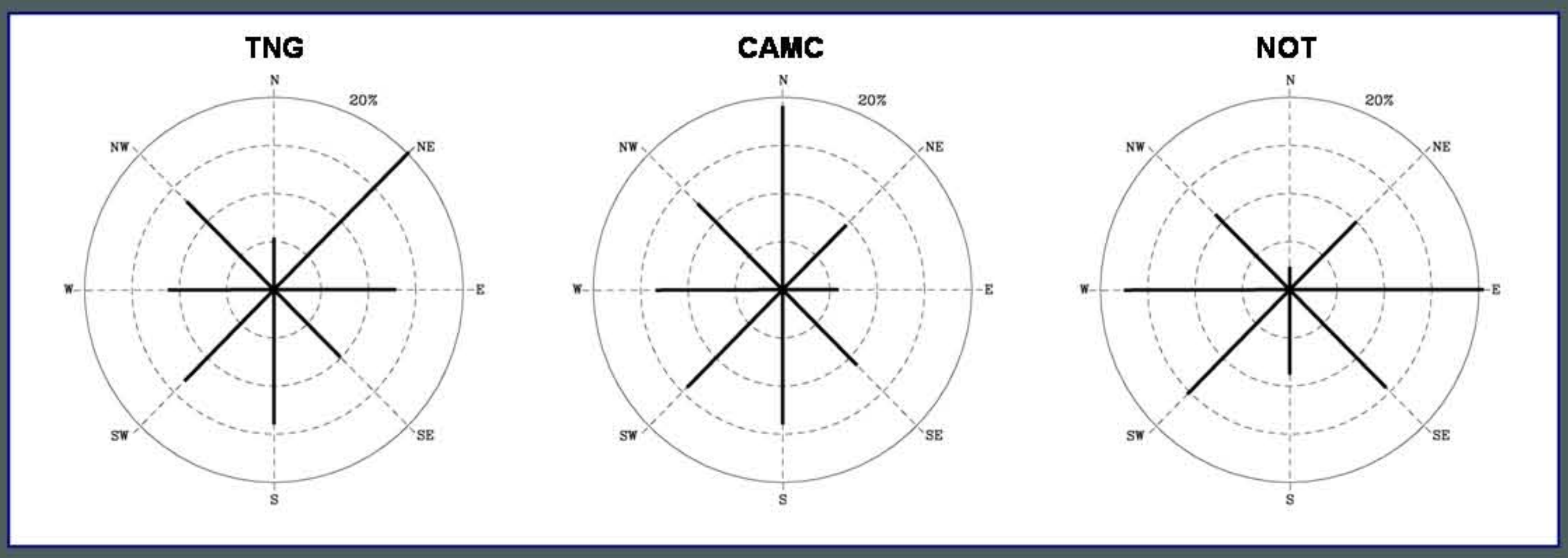


Table 2 shows the percentage of time computed for four wsp (Lombardi et al. 2007). TNG and NOT have optimal observing conditions ($3.3 \le wsp < 12$ m/s, see Figure 7) about 70% of the time, compared to 16.4% at CAMC. The evaluation of time in which $wsp \ge 15$ m/s gives an estimation of the downtime due to high wind velocity. The lost time at TNG is only 0.3% of the total. CAMC never shows $wsp \ge 12$ m/s, and NOT is more affected by high wind speed (4.2%).

TABLE 2 - Nighttime wsp statistics.

Wind speed [m/s]	TNG [%]	CAMC [%]	NOT [%]
$wsp < 3.3$	30.2	83.6	18.5
$3.3 \le wsp < 12.0$	68.4	16.4	70.2
$12.0 \le wsp < 15.0$	1.1	0.0	7.1
$wsp \ge 15.0$	0.3	0.0	4.2

TEMPERATURE, WIND SPEED AND ASTRONOMICAL SEEING

The image quality in terms of FWHM is compared to the difference DT between the ground temperature and the temperature at the level of the TNG primary mirror:

$$DT = T(G) - T(M1)$$

Figure 6 shows that seeing deteriorates when DT > -0.6 deg. This can be explained as a consequence of the higher temperature at the level of the primary mirror that inhibits the thermal convection below (Lombardi et al. 2006).

The FWHM are also compared to the wind speed (Fig. 7). We see that 50% of the points are distributed below a wind speed of 3.3 m/s (red dashed line), with median FWHM of 1.5 arcsec. For $wsp \ge 3.3$ m/s, the distribution of the points has a median value of 1.3 arcsec. This indicates that we have optimal observing conditions when $wsp < 3.3$ m/s (Lombardi et al. 2007).

We use 118 images obtained with the Optical Imager of Galileo at TNG in V-band, pointed near the zenith (and corrected to true zenith by a small amount) from 2000 January 31 to February 4.

FIGURE 6 - Seeing in V-band vs DT.

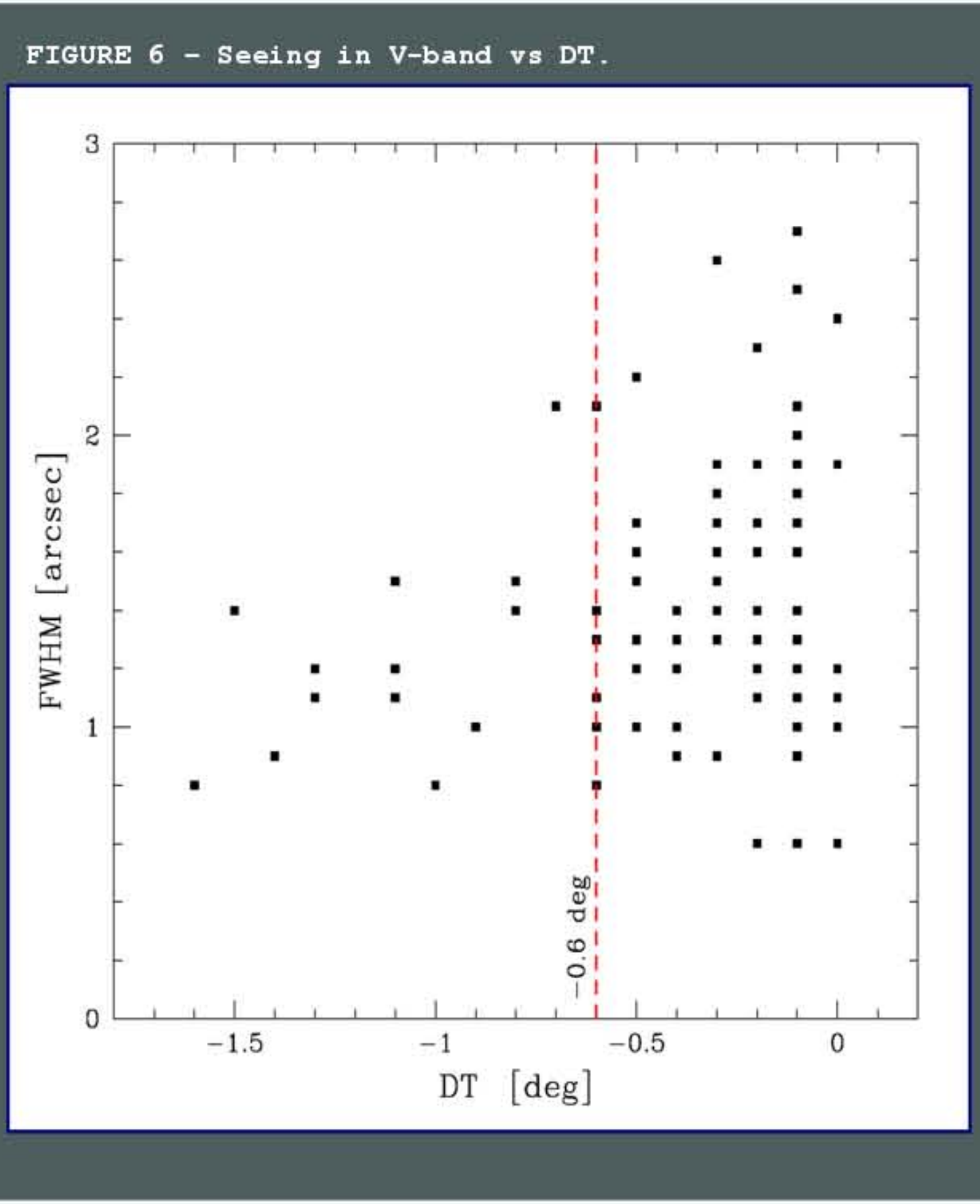


FIGURE 7 - Seeing in V-band vs wind speed.

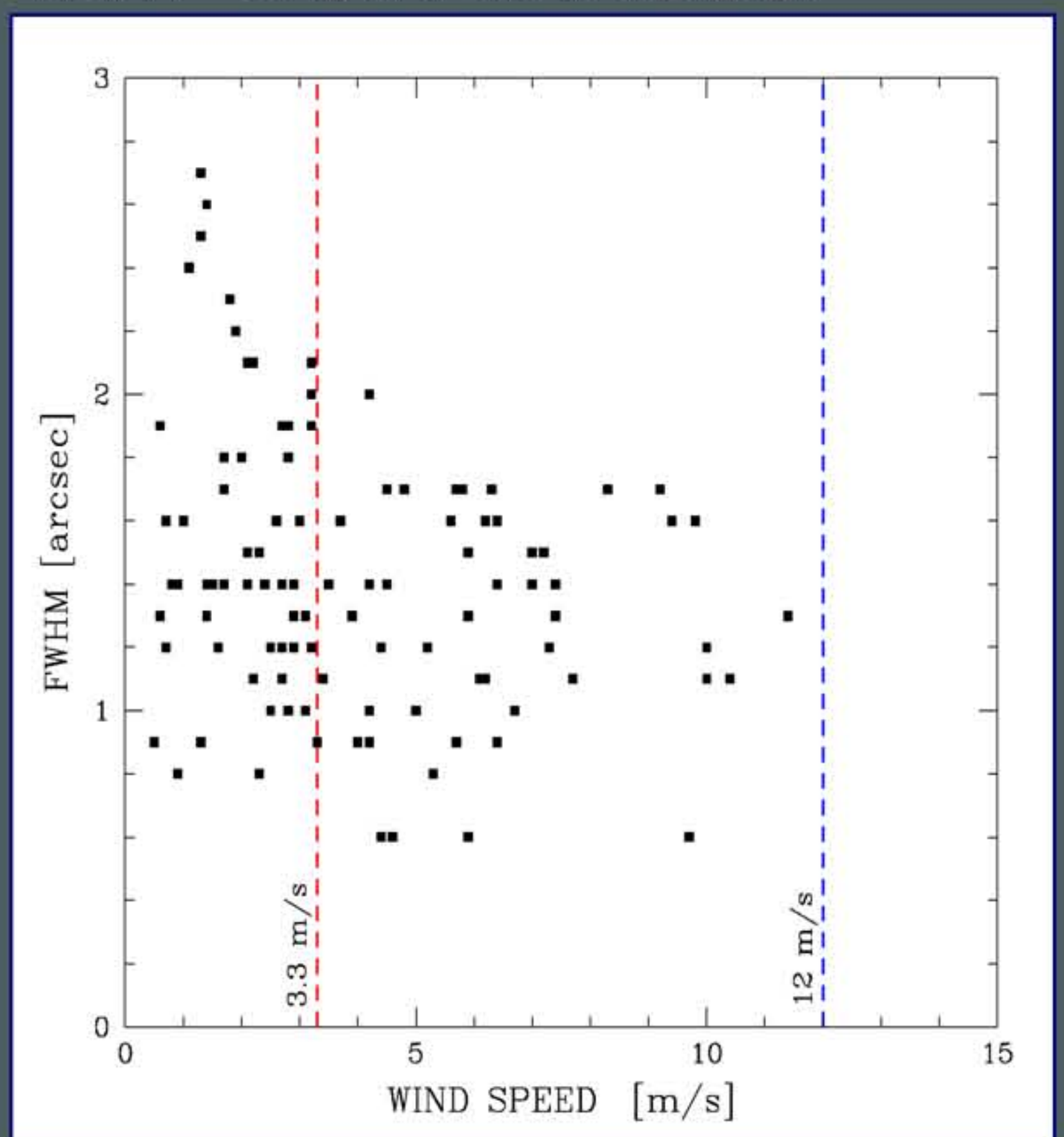


FIGURE 8 - Hour-to-hour pressure (blue) and Temperature (red) trends at CAMC in 1992.

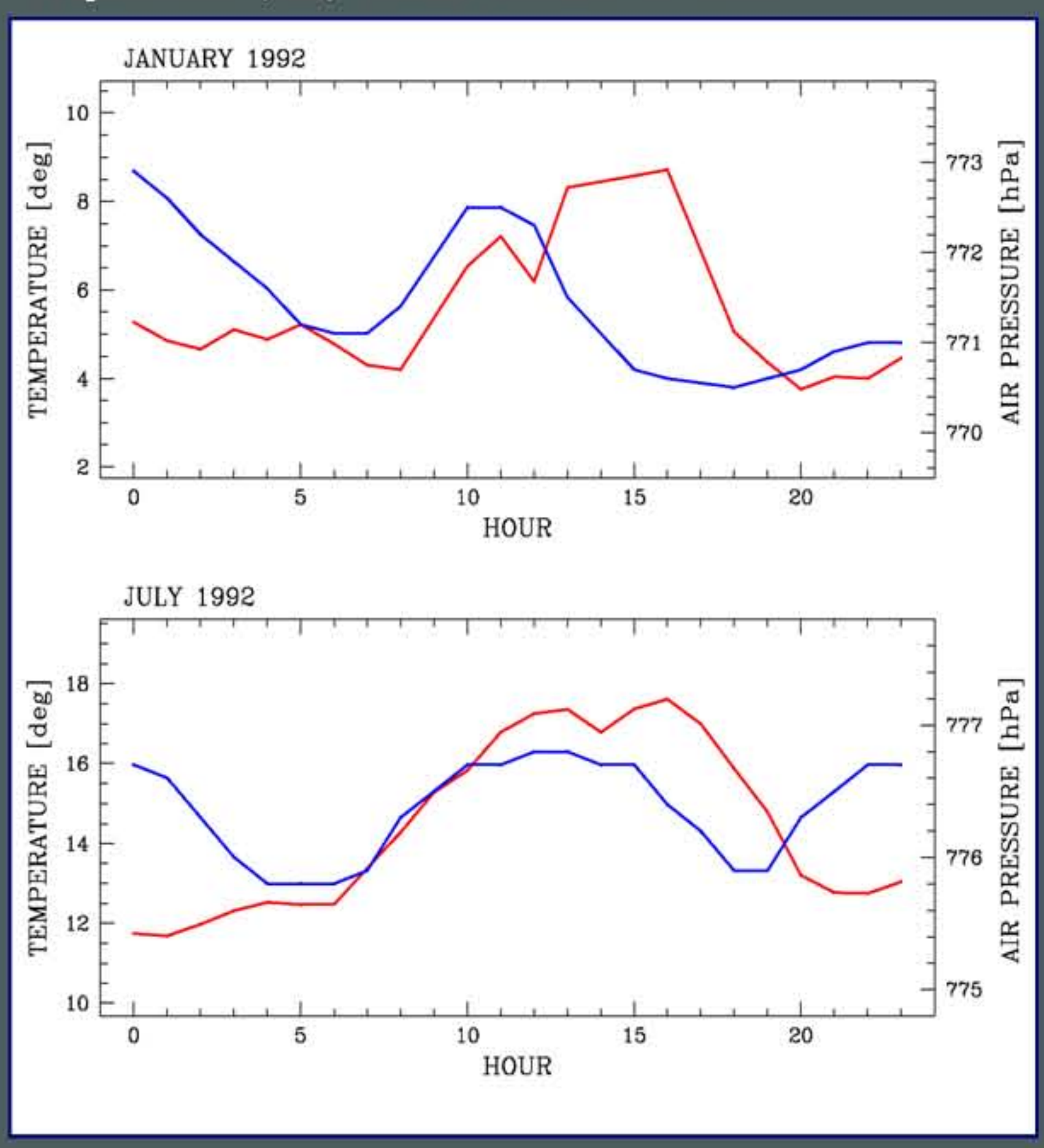
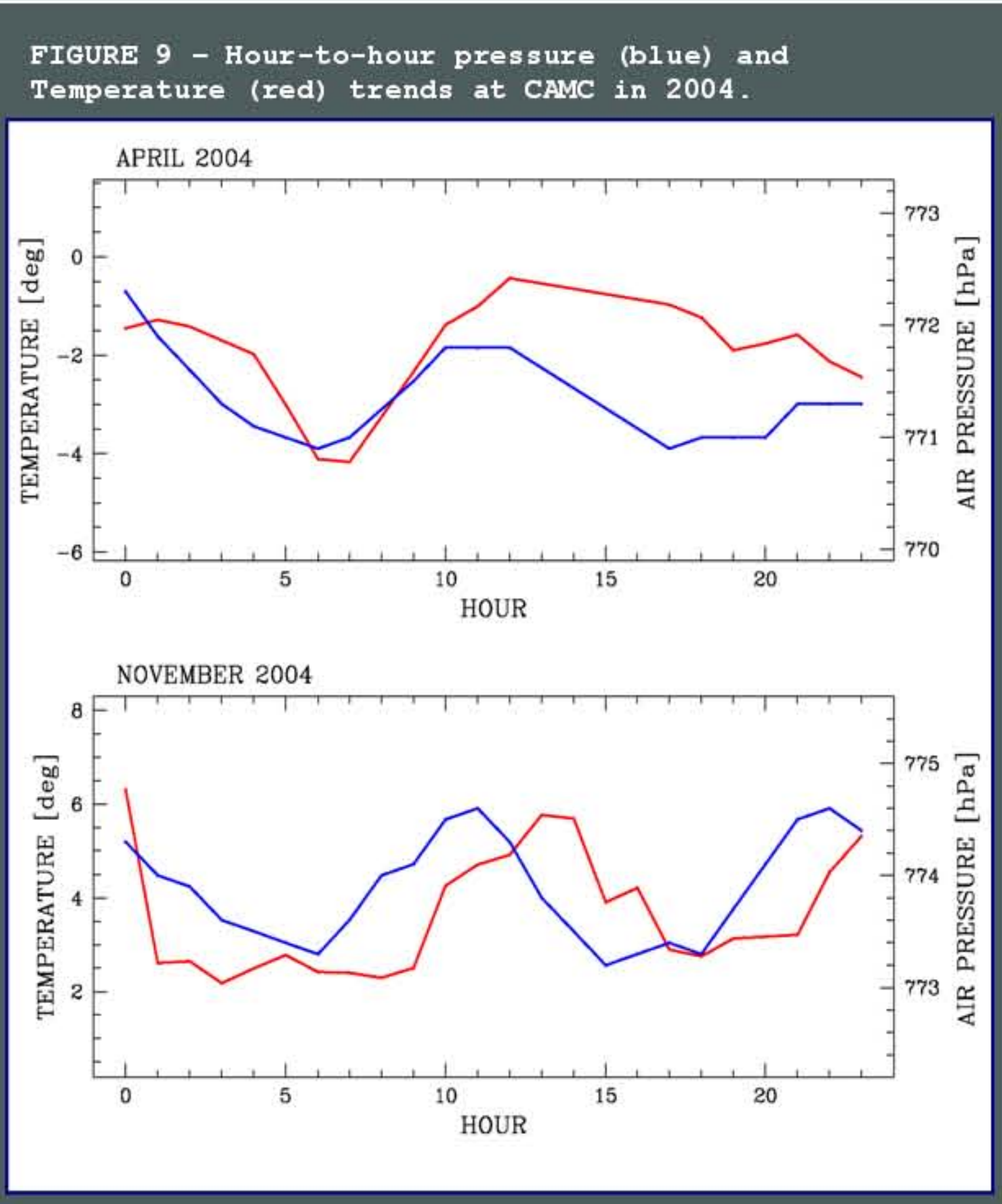


FIGURE 9 - Hour-to-hour pressure (blue) and Temperature (red) trends at CAMC in 2004.



SHORT-TIME SCALE THERMALIZATION FORECASTING

Figure 8 and Figure 9 show that pressure changes anticipate changes in temperature, typically by 2–3 hr, in both the wintertime and summertime (years 1992 and 2004 are taken as examples).

The relationship between P and T suggests the following question: is it possible to foresee the changes in temperature a few hours in advance, on the basis of the changes in air pressure?

If YES, it could be possible to optimize the thermalization of the telescope and the instruments, reducing the instrumental seeing.

The correlation between air pressure and the temperature measured 2 hr later has a confidence level 98%. This correlation typically decreases if temperatures are measured 1 hr (c.l. 84%) or 3 hr (c.l. 95%) later. The ability to make predictions based on hour-to-hour analyses vanishes on timescales higher than a few hours (Lombardi et al. 2007).

REFERENCES

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