

A dry high altitude observatory in continental Europe



Enrique Pérez
Research Professor CSIC
Instituto de Astrofísica de Andalucía (Granada)
eperez@iaa.es



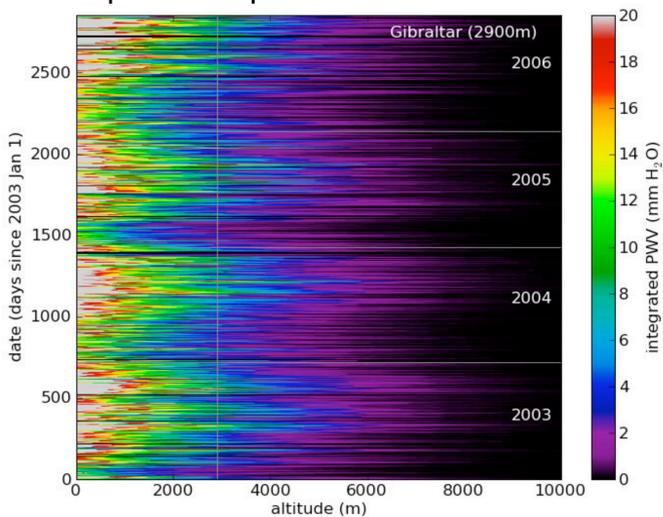
37°N 3°W
2900m a.s.l.

A. Gardini (1), E. Pérez (1), J. A. Quesada, M. Moles (3), D. John (2), J. L. Ortiz (1), J. Peñalver (2), S. Leon (2)

1. Instituto de Astrofísica de Andalucía (CSIC)
2. IRAM, Granada
3. Centro de Estudios de Física del Cosmos de Aragón

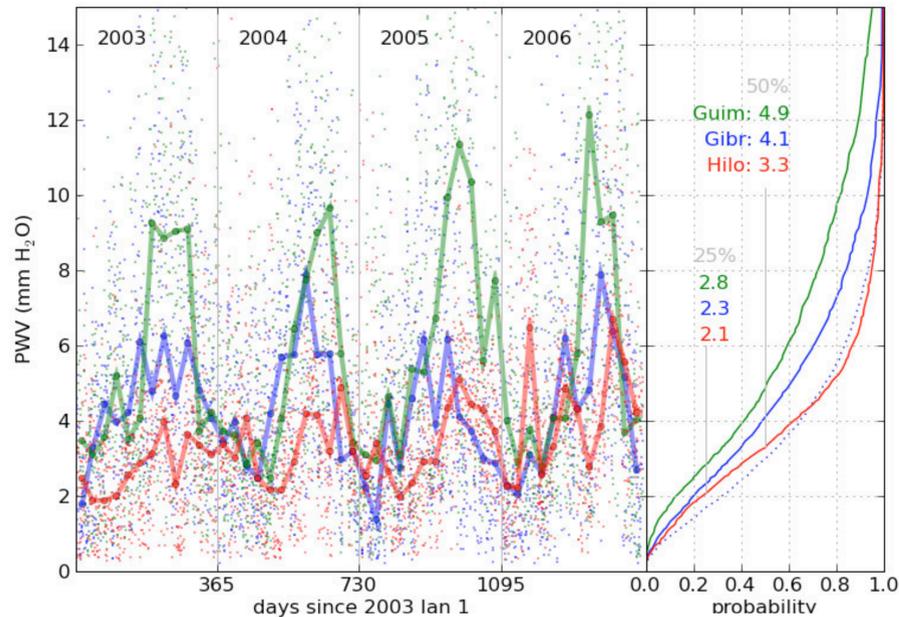
Summary. A study of the precipitable water vapour (PWV) above the observatories in Sierra Nevada, the southernmost high altitude location in continental Europe with a dry climate, indicates that Sierra Nevada is a very competitive location for MIR-submm, with $PWV < 0.2 \text{ mmH}_2\text{O}$, and a 25% quartile of $PWV = 2.3 \text{ mm(H}_2\text{O)}$ as compared with 2.1 for Mauna Kea.

Method. We use four independent methods to measure PWV: (i) radiometer opacity at 225 GHz located at the 30m IRAM observatory; (ii) on- off- narrow band photometry at 940 nm; (iii) dedicated spectroscopic monitoring in the band 800-1000 nm; and (iv) bi-daily balloon-borne atmospheric soundings at nearby proxy locations. The balloon soundings are retrieved from the database maintained by the Department of Atmospheric Science (University of Wyoming), from the sounding stations corresponding to the observatories as indicated in the table, together with the reference altitude for each observatory above where the PWV column is integrated. We analyse all the data sets for the period 2003-2006. We use the radiative transfer code SCIATRAN to model the local atmosphere and calibrate the on-site spectroscopic data which measure with high precision the very dry epochs.



(left) Bi-daily balloon sounding profiles of PWV integrated above the given altitude. The data set for Gibraltar (proxy for Sierra Nevada) is shown. The vertical line at 2900m marks the height of IRAM and OSN.

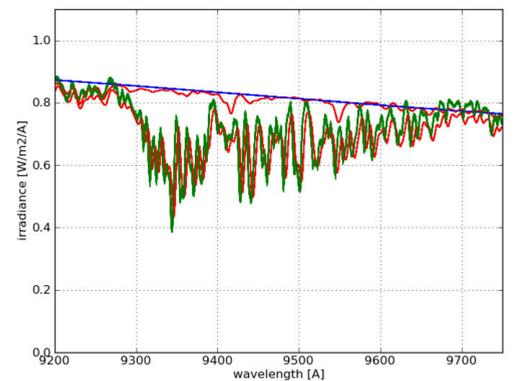
Location	code	Observatory	altitude (m)	
Gibraltar	8495	LXGB	OSN, IRAM	2900
Hilo	91285	PHTO	Mauna Kea	4160
Güímar	60018	Guimar-Tenerife	La Palma, Izaña	2350



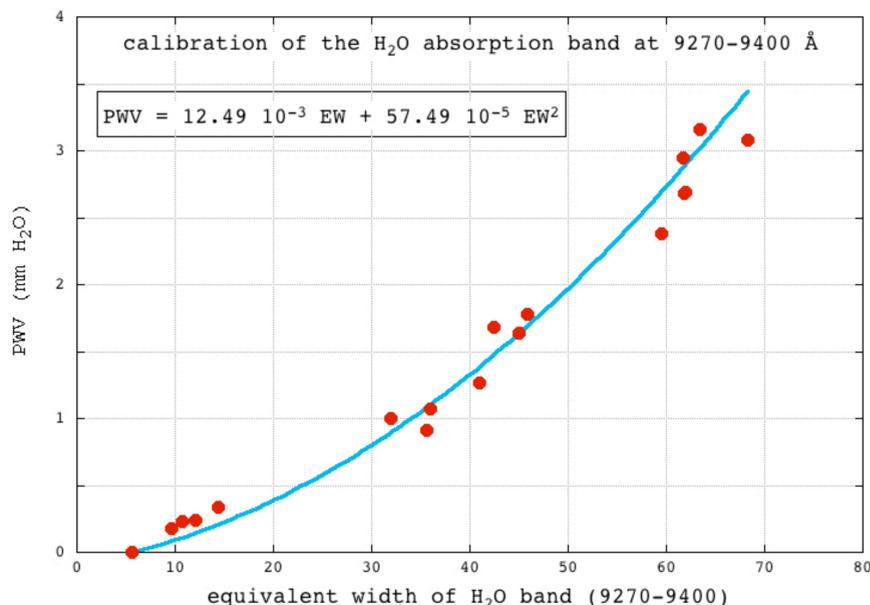
Results. Balloon-borne atmospheric soundings. The statistical calibration of the results between the IRAM taumeter, the narrow band photometry and the balloon soundings for Gibraltar all agree extremely well, which indicates that the Gibraltar soundings are a reliable proxy (although they are not located on site). Thus we can use balloon soundings to compare different observatories: at Sierra Nevada, Canary Is., and Hawaii. The outcome is shown in the figure on the right. We can see that Sierra Nevada compares very favourably with Hawaii, even though its altitude is 1260m less. The dotted probability line gives the values for an altitude of 3400m, the highest available in Sierra Nevada, where **the statistics is similar to or better than Hawaii** at 4160m.

We are now starting to characterize more reliably the statistics of very low PWV epochs.

Results. Radiative transfer model atmosphere and spectroscopic data. We obtain direct solar irradiance spectra with an array spectrometer (BWspec) operating in the 700-1020 nm range (0.25 nm spectral resolution), during the 2007 March-May campaign, for a total of 24 days (the much extensive 2008-2009 data sets are being analysed). The Wyoming University bi-daily radiosounding data is used to provide profiles of Temperature (T), Pressure (P) and H₂O mixing ratio (mr) as a function of the geopotential height. The Radiative Transfer Model (RTM) incorporated in the SCIATRAN 2.2 package developed at the Institute of Remote Sensing/Institute of Environmental Physics of Bremen University (Germany), allows to simulate radiance/irradiance spectra in the 240-2400 nm range. The RTM was used to simulate the direct solar irradiance spectra at OSN and to compare them with those measured with the spectrometer. After testing the RTM we fixed the parameters: aerosols, spectral albedo, profiles of line-absorbers and continuum-absorbers gases. The equivalent width (EW) of measured spectra in the same water vapor absorption bands were also computed.



green: observed spectrum
red: atmospheric model spectrum
pink: PWV=0 model spectrum
blue: continuum fit



We use the spectra observed ± 1 hour from the Gibraltar noon radiosounding (12:00 Zulu time). For each day, the profiles of P, T and H₂Omr provided by the radiosounding were used to define the model atmosphere in the RTM. For each simulated spectrum the EW in the 927-970 nm water vapor absorption band is computed, and the corresponding PWV above OSN were associated. This provides the calibration (for the 2007 campaign) shown in the figure on the left, where red dots are the individual models for March-May 2007, and the cyan line is a 2nd order polynomial fit that goes through the 'origin' EW. The 'origin' EW is measured for an atmosphere of zero H₂O column and contributed by the other residual gases (see the low EW pink line in the spectrum above). Notice that we have measured **very dry** epochs with $PWV < 0.2 \text{ mmH}_2\text{O}$. We are carrying out an observing campaign to quantify in more detail the statistics of very dry epochs, $PWV < 1 \text{ mmH}_2\text{O}$, that are certainly not uncommon in Sierra Nevada.