Atmospheric characterization at TNG

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TELESCOPIO NAZIONALE GALILEO – INAF
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Outline

- Overview of Systems at TNG and usage of data:
  - Particle counter (2001-)
  - Night Sky Background (2004 - )
  - Lightning Detector (2006-)

- Future Development:
  - NSB+Atmospheric Extinction meter
  - All sky camera for Cloud Coverage
Characterization of the TNG/ORM site

Search on ADS for these people:

• Ortolani, S.
• Zitelli, V.
• Lombardi, G.
• Pedani, M.
• Garcia de Gurtubai, A.
• Porceddu, I.
• Ghedina, A.
• … in collaboration with many others
TELESCOPIO NAZIONALE GALILEO (TNG)

- 3.6m alt-az optical telescope (VIS-NIR)
- Operating since 1998
- ORM observatory, 2370m.a.s.l.
- Instruments: HARPS-N, LRS, NICS, GIANO
Roque de los Muchachos Observatory (ORM)

- Island of La Palma → Open to any weather (Storms, winds, calima)
- Annual Averages: \( T = 10 \, \text{C} \); \( P = 772 \, (+9) \, \text{hPa} \); \( WS \sim 5\, \text{m/s} \)
- RH; \( T - T_{\text{Dew Point}} < 5\, \text{C} \) is \(~4\%\) (summer) and \(>10\%\) (winter)
- Atmospheric Extinction: \( r' \sim 0.1 \, \text{mag/airmass} \), but increases (0.2-1.0 mag) during dust outbreaks.
- Median seeing \( \sim 0.7 \, \text{arcsec} \)
- NSB (V) = 21.7 mag arcsec\(^{-2}\) (avg +0.1 mag LPS lamps)
- Complex orography → Microclimates
Galileo Automatic Weather Station (GAWS)

- 15m high tower with several sensors
- Working since 1996; Data collected every 30s
- Temperature sensors at 10m, 5m, 2m, ground
- Anemometer: wind speed, direction (z)
- Pressure
- Relative Humidity
- Solar irradiance
- Solar panel + backup batteries
- Optical fiber link
GAWS... problems

- Occasional extreme conditions in winter; ice+wind
- Tower structure ok but delicate sensors → brake
- Difficult access for substitution (climbing)
- Expensive hi-class components (Vaisala)
- Bad weather (low clouds, Fog) → no charging
- Ice falling on solar panel → no power (plug)
  - and... located downwind in bad weather (means that clouds arrive first at telescope and then at meteo tower)
Dome weather station

- On the roof, radio link
- Temperature, RH, Pressure, ws, wdir
- Single person easy maintenance
- Cheaper components (Davis), reliable

...but:
- too close to the dome (ok for wind, no lead time for rain)
- not good for site characteristics, (turbulence, thermal emission from dome...)
Temperature

Relative Humidity

Pressure

Dust Concentration

Wind Speed

Wind Direction

Solarimeter

DIMM Seeing (airmass=1 and λ=0.5µm)

Meteo

Temperature: 13.8 °C
Temp. GND: 12.0 °C
Relative Humidity: 38%
DewPoint: -0.4 °C
T Air - T Air-24h: N/A
Air Pressure: 771.2 mbar
Wind Speed: 3.13 m/s
Wind Direction: 242°
Dust: 13.284 µg/m³
Solarimeter: 1064.00 W/m²
DIMM Seeing: N/A

Links

- Satellite (EUMETSat AMV)
- Ephemerides
- AEMET Lightning Detector
- SKYCAM (Liverpool)
- SKYCAM (GTC)

Other Weather Stations
AWS data usage

1. Easy, fast and direct feedback for observing conditions in particular telescope safety:
   1. Wind speed+dir → Observe downwind (>10m/s) / close (>15m/s)
   2. P/T/RH → Dew point, water drops, rain... (close RH > 80%)
   3. P risk of approaching perturbations
   4. Also check AWS of others telescopes

2. Data go through an algorithm to set A/C temperature:
   - Minimize T gradients telescope/air
   - Micro-turbulence; dome seeing (T_{in} - T_{out})

3. More time and effort: find correlation with other ground and satellites atmospheric parameters
   → statistics, available nights/hours per year, forecasting, trends, etc.
Differential Image Motion Monitor (DIMM)

- TNG site one of the first site at ORM to host a stationary DIMM
- TNG DIMM-tower with IAC/DA DIMM for seeing measurements campaign during 94-95 (at the same time with the ING group)
- TNG DIMM installed in 1996; seeing measurements for 2-3 years
- Few problems:
  - Not automatic system, need of an operator, no maintenance
  - Major damages due to bad weather
  - Custom made with no spare parts
  - Given Lower priority and never repaired
A New DIMM@TNG
Telescope: Celestron 11”CGE(XLT)
Focal: 2800 mm
f-ratio: f/10
Pupil diameter: 80 mm
Pupil separation: 198 mm
Prism angle wedge: 40 arcsec
CCD detector: Sony ICX098AL/BL
CCD format: 640 × 480 pixel
Pixel size: 5.62 × 5.62 μm
FOV: 4.62 × 3.52 arcmin
Plate scale: 0.432 ± 0.004 arcsec/px
Automatic DIMM

- Working since 02/2011
- Calibrated with IAC software.
- Seeing measured over 300 frames
- A new value every ~minute (at zenith in V band)
- Available on-line →
Seeing on line
Use of seeing data

1. In particular for service/queuing observing → Prioritize programs, increase efficiency, recalculate exp.time, increase image quality (with AO)

2. Correlation with SCI instrument PSF: Remove dome & mirror seeing, Fine tuning dome A/C, SH analysis, aberrations LUT

3. Increase database for statistics and characterize site → results on MRAS
Lrs seeing
2013AB Sci Runs 1253 images
Median = 1.08 arcsec
Mean = 1.16+/- 0.42 arcsec

2013AB Sci Runs 888 images
Median = +0.14 arcsec
Mean = +0.03 arcsec
StdDev = 0.59 arcsec

PSF of LRS
LRS - DIMM
Mirror Temperature vs Air Temperature

Racine (CFHT) $\propto 0.4'' \times \Delta T^{6/5}$
Mirror venting to remove micro-turbulence
### Comparison of Abacus TM301 and LasairII 310B

<table>
<thead>
<tr>
<th>Feature</th>
<th>Abacus TM301</th>
<th>LasairII 310B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input flow rate</td>
<td>0.1 c.f./min</td>
<td>1.0 c.f./min</td>
</tr>
<tr>
<td>Size channels</td>
<td>0.3, 0.5, 1.0, 5.0 μm</td>
<td>0.3, 0.5, 1.0, 3.0, 5.0, 10.0 μm</td>
</tr>
<tr>
<td>Light source</td>
<td>Laser diode ((\lambda=780) nm)</td>
<td></td>
</tr>
<tr>
<td>Sample rate</td>
<td>1 data per min</td>
<td>1 data per 2 h</td>
</tr>
<tr>
<td>Output</td>
<td>RS-232</td>
<td>Ethernet</td>
</tr>
<tr>
<td>Running time</td>
<td>Aug 2001 to Dec 2006</td>
<td>Mar 2007 to today</td>
</tr>
</tbody>
</table>

12m above ground
Data online as \(\mu\)gr/m\(^3\)
Effects of Dust Events

- Increase atmospheric extinction
- Affects the optics, electronics, filters, mechanics...
- No documented damages from calima so far → No defined threshold to close (GTC~100µg/m³)
- Calima can increase NSB with backscattering of street lights (C.Benn 98)
- Seems to improve seeing (stabilizes atmosphere?)
- Breathing problems (asthma / allergies)
Particle Counter vs Extinction

Not so straightforward to derive extinction (K) from local measurement of particles (µgr/m³)
Not always possible to assume a uniform distribution (up to 5km)

Local layer → hi detection but low extinction
High layer of dust → extinction but no local detection
Time lag between extinction and detection → settling

Possible to put a lower limit: >100µgr/m³ → K > 0.4 mag
Night Sky Background measurements

Measurements of light pollution from scientific spectra.

- 2004, New Astronomy, Pedani, M. "Light Pollution at the Roque de Los Muchachos Observatory"
  - Low level of light pollution (Na lamps) up to 0.05-0.1 mag. in the V band,
  - Reduction of about 50% in the Hg polluting lines as an effect of the application of the Canary Sky Law.
  (ref.1998, ING Tech.Note by Benn and Ellison)
- 2006, We buy the Sky Quality Meter (Unihedron)
  - Handheld
  - ~80deg acceptance angle
  - V band; 21.6 - 21.8 mag arcsec\(^{-2}\)
- 2013, we upgrade ...
SQM-LE

- ~20deg acceptance angle
- Ethernet connection
- Remotely operated
Photometer

- Maksutov D=102mm; F/13
- 5 Filters (UBVRI)
- SBIG ST2000XMI
- Mounted on DIMM
- Measure NSB & Extinction
- Data Online
Lightning detector (2006-)

Detect approaching storms
Safety of electronic equipments
Rain sensor
Cloud coverage

- 2πSky (Solaris)
- SBIG 340
**2πSky - cloud monitoring system**

**Product description**
- complete solution including all-sky camera
- available as an add-on module to existing all-sky camera installations
- includes dedicated power and communication hardware modules compatible with the selected all-sky camera
- includes image processing, database and web server software modules
- optional wired Ethernet connection where WiFi is not accessible
- weatherproof enclosure and connectors

![Diagram of 2πSky system](image)

- expandable
- modular
- wireless
- weatherproof
- complete solution

[www.ciliun.pl](http://www.ciliun.pl)
Conclusions

Why do we monitor the Atmosphere at TNG?

- **Telescope safety:** data must be ready available
  (AWS, lightning, dust, clouds)

- **Telescope operation/optimization →** depending on scheduled instruments, imaging/spectroscopy, improve Image Quality
  (DIMM, Atm. Extinction, NSB, but also on wind, clouds)

- **Site characterization**
  (all the data are useful to populate the database for statistical analysis, comparison to other sites and correlation between parameters to search for trends and possibly to forecast)
To Do List:

- Install new gadgets:
  - Photometer
  - Fans for M1
  - SQM
  - 2πSky
- Operate and Maintain the whole lot of instruments
- Find time to analyse the Database
- Clean mirrors...