Atmospheric aerosols' impact on Cherenkov telescopes' Crab measurements

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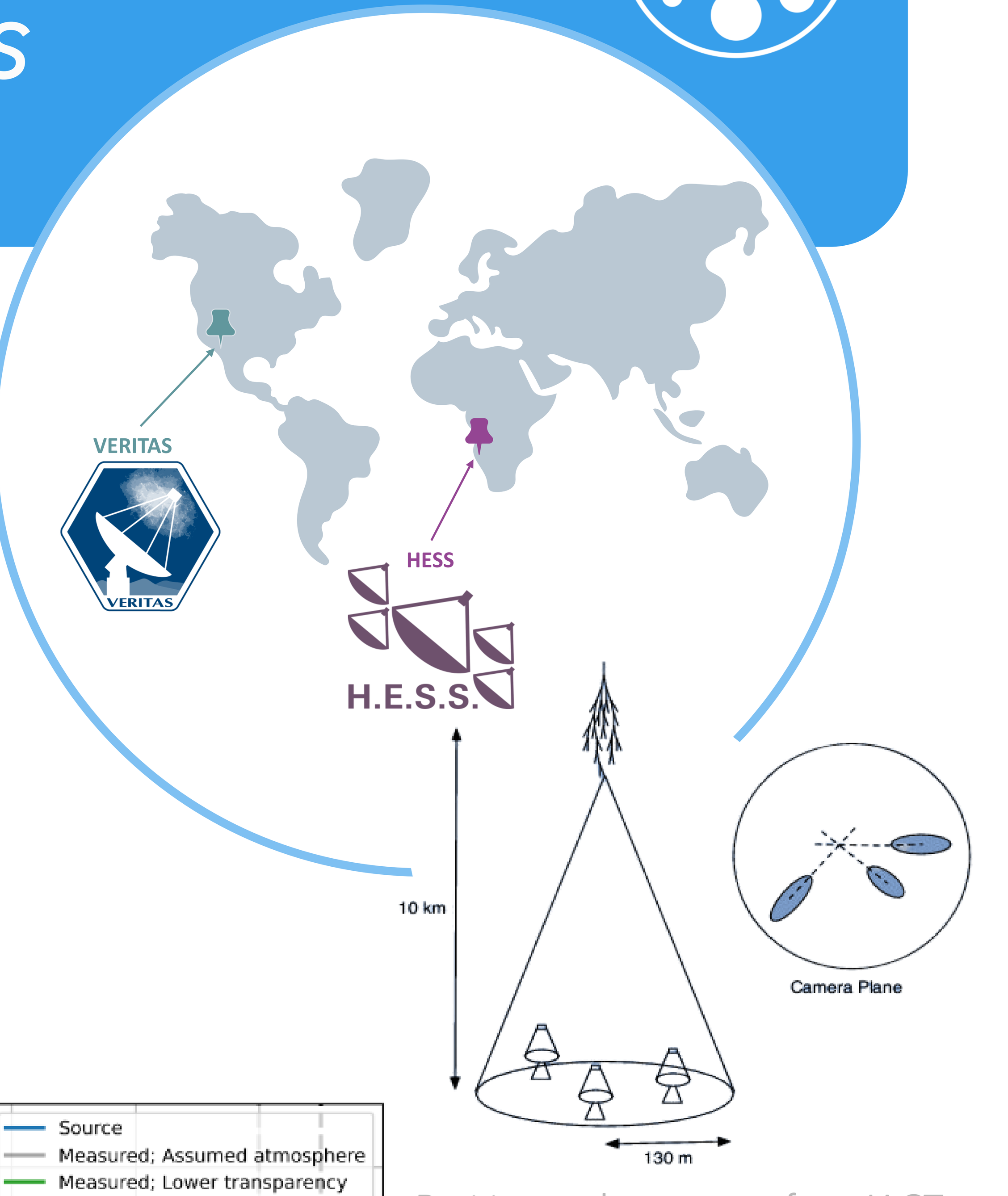
The Crab Nebula has shown unexpected flares in the GeV range detected by space telescopes. Although theoretical models predict that TeV flares should arise via inverse Compton scattering of the GeV electrons, ground-based Cherenkov telescopes have not yet observed these high-energy events. Atmospheric aerosols, which vary by location and season, may affect the accuracy of these ground-based measurements, motivating a study on how aerosol optical depth influences Crab Nebula observations.



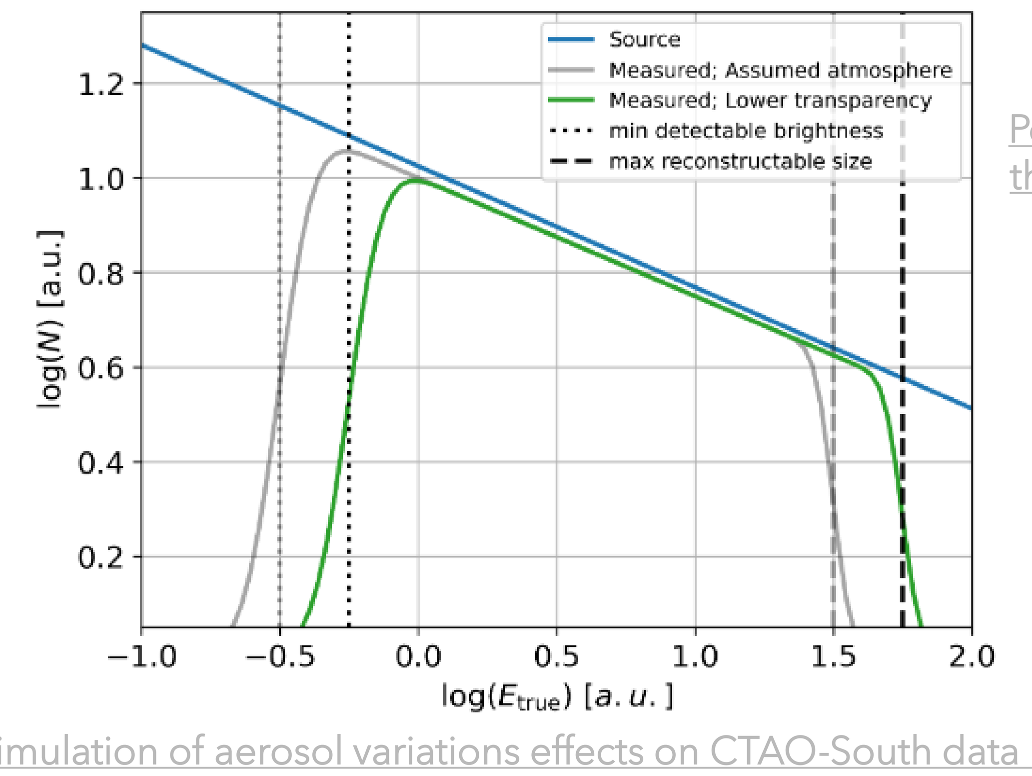
Position and structure of our IACTs that operate under dim moonlight conditions

Aerosol Optical Depth (AOD) measures the concentration of aerosols in a column of air from the Earth's surface to the top of the atmosphere, which may scatter/absorb gamma rays in their path. We will focus on the AODs at 550nm wavelength. Understanding the correlation with varying aerosol levels may make us more sensitive to flares

We analyzed **221** hours of H.E.S.S. data and **721** hours of VERITAS data, correlating gamma-ray flux measurements with aerosol optical depth (AOD) values from the Copernicus atmospheric survey.

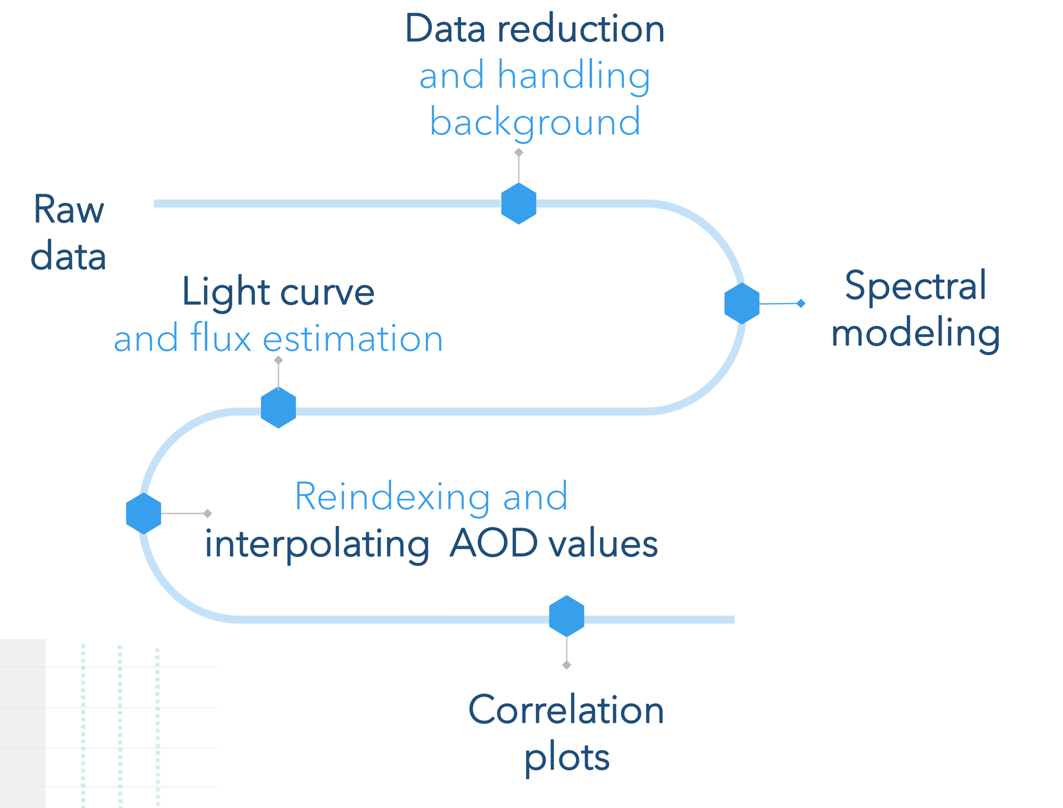
The Copernicus Programme, as the Earth observation component of the European Union's Space Programme, provides high-resolution, time-resolved AOD data. For each observation run, we used the interpolated AOD values corresponding to the exact time of data acquisition.

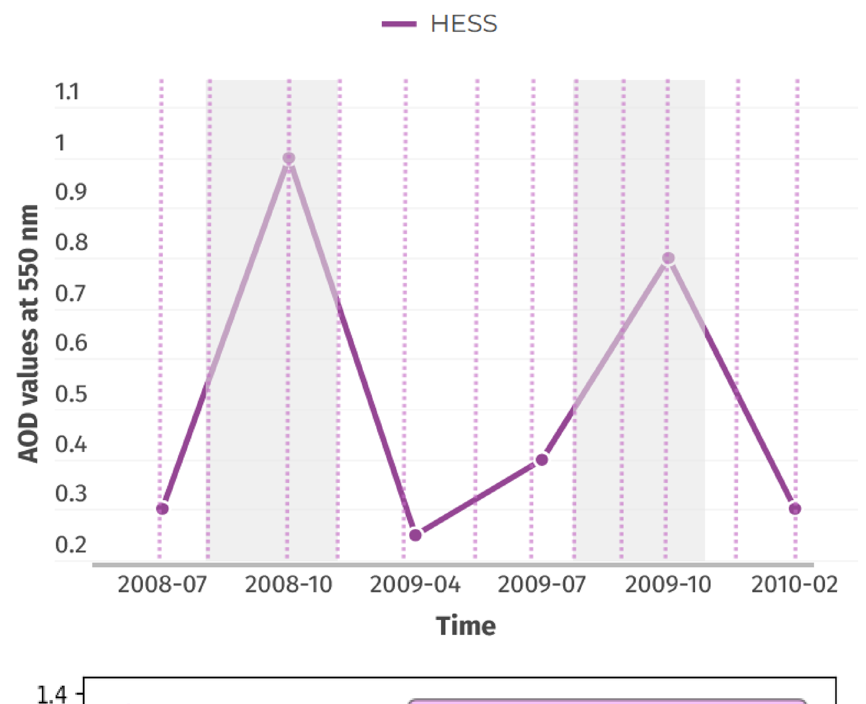
Given that higher AOD values indicate increased atmospheric absorption and scattering, we expect to observe a reduction in flux and a shift towards higher energies under such conditions.



Simulation of aerosol variations effects on CTAO-South data [1]

All data processing and correlation analyses were performed using GammaPy, ensuring consistent treatment across the full dataset. This approach enables a robust investigation of the impact of atmospheric conditions on gamma-ray flux measurements.

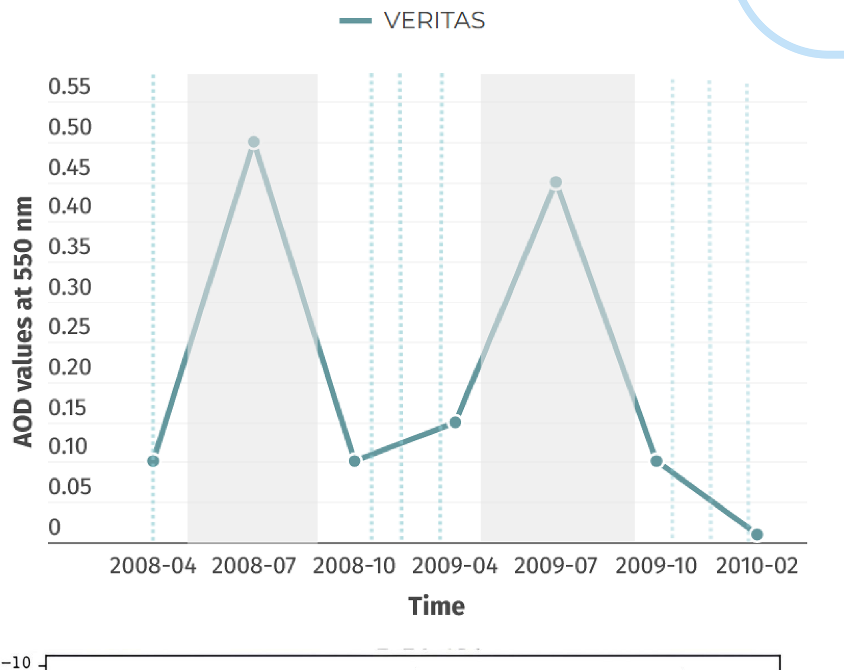


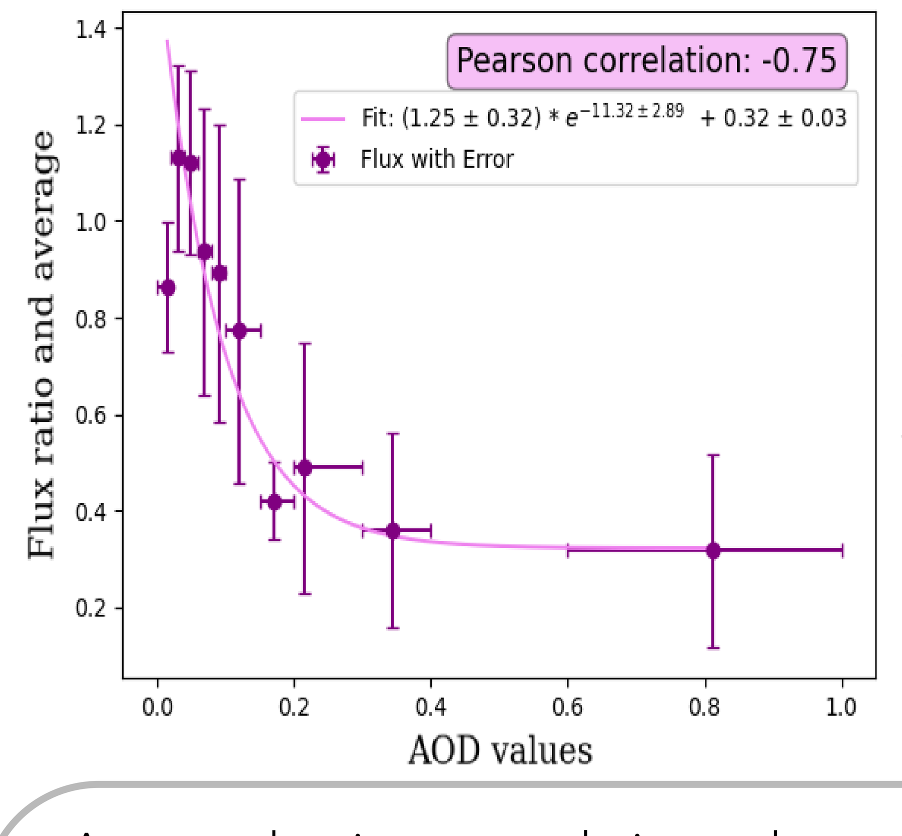


These graphs show aerosol concentrations over time. The vertical lines are run observations scheduled for these IACTs.

HESS observations are made uniformly during the year, including the Biomass Burning Season

VERITAS observations can only be made outside of the Monsoon season.

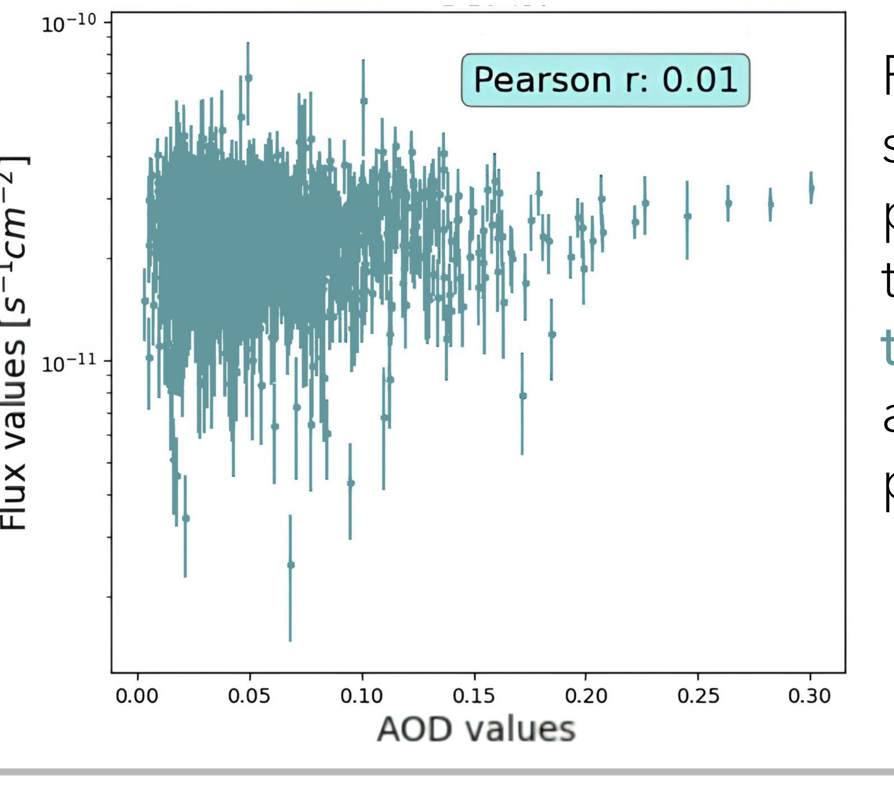




For HESS, a clear correlation exists between higher AOD values-primarily and reduced observed gamma-ray flux.

This correlation could be due to the fact that we are observing at high zenith angles.

p value=0.05



For VERITAS, observations show no strong correlation, possibly because aerosols there tend to remain closer to the ground and less affect the Cherenkov light path.

p value=0.7

Atmospheric aerosols introduce systematic uncertainties that can reduce the sensitivity of ground-based gamma-ray telescopes to transient events like Crab Nebula flares. Incorporating real-time atmospheric corrections into the MC simulations for the instrument response functions (IRF) of our telescopes can enhance measurement accuracy.

By combining data from different telescopes-across various time zones and weather conditions-we can better evaluate systematic uncertainties over time and significantly improve our statistics.

Looking ahead, the upcoming Cherenkov Telescope Array (CTA), with enhanced sensitivity and full-sky coverage, together with advanced atmospheric correction methods, promises better detection prospects for transient very-high-energy emissions.

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References

[1] Holch T. L., *Correcting for atmospheric variations in IACT data analyses*, Pos(ICRC2023): doi: 10.22323/1.444.0779.

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