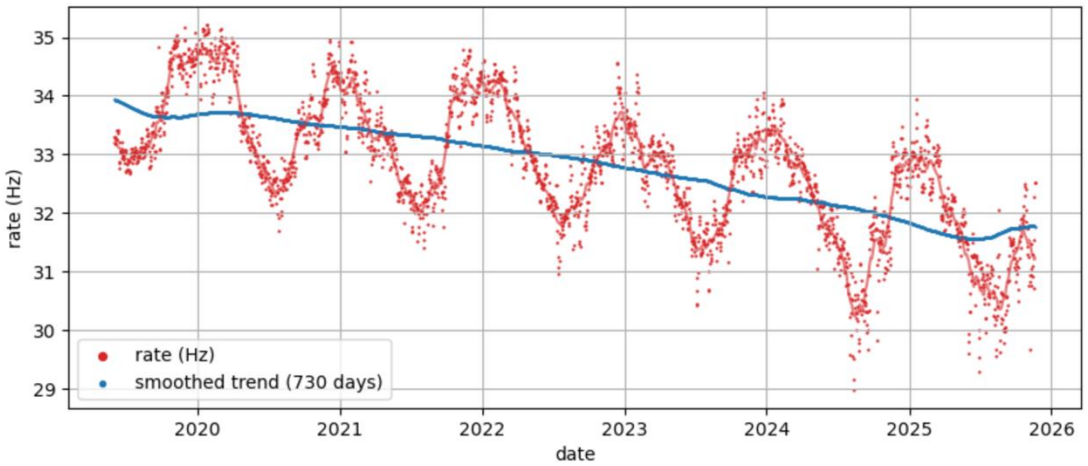
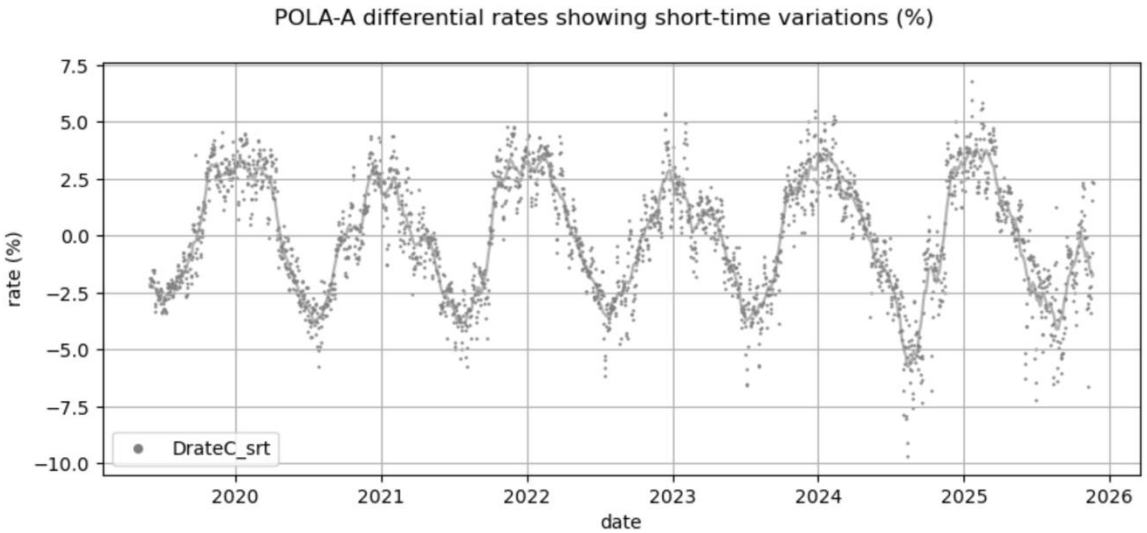
“Atmospheric effects on cosmic-ray muon rate at high latitude (78.9°N)”

Rosario e Ombretta

27 novembre 2025

Modelli che descrivono l'effetto della temperatura atmosferica





- rateC → rateC_srt (togliendo il trend principale)
- DrateC_srt rate differenziale espresso in %

Modelli empirici lineari

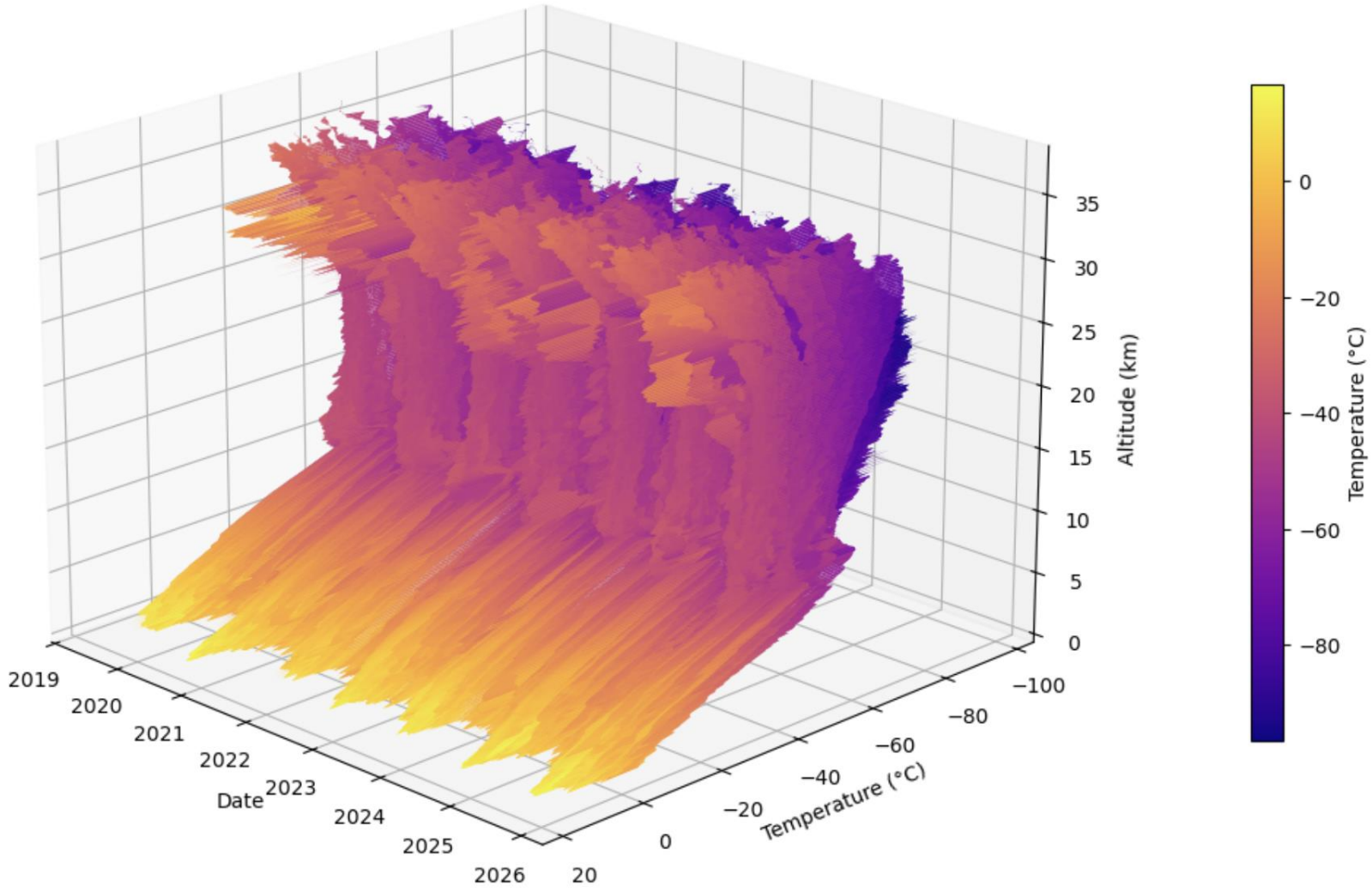
$$\Delta I_{PTC} = \Delta I_{PC} - \Delta I_T$$

$$\Delta I_T = \alpha_T * \Delta T$$

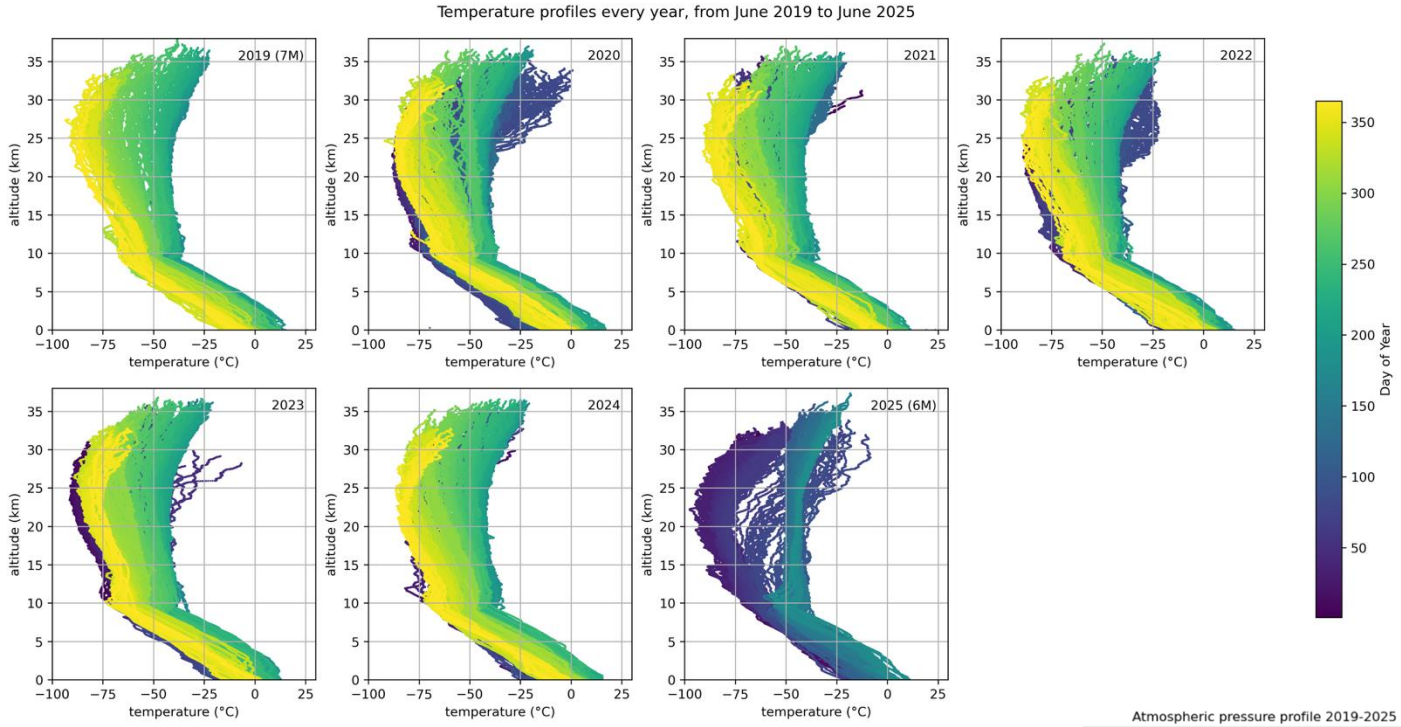
Modelli integrali o discreti

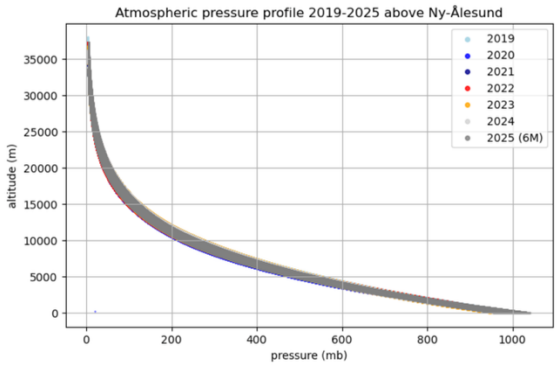
Non si basano su uno specifico parametro atmosferico ma tengono in considerazione tutto il profilo verticale

Profilo verticale di temperatura sopra Ny-Ålesund



AWI campagna quotidiana di radiosonde





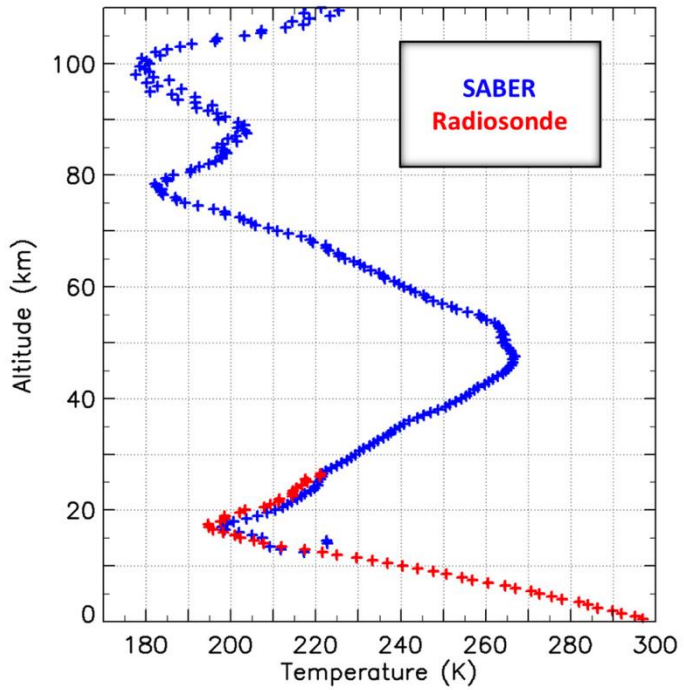
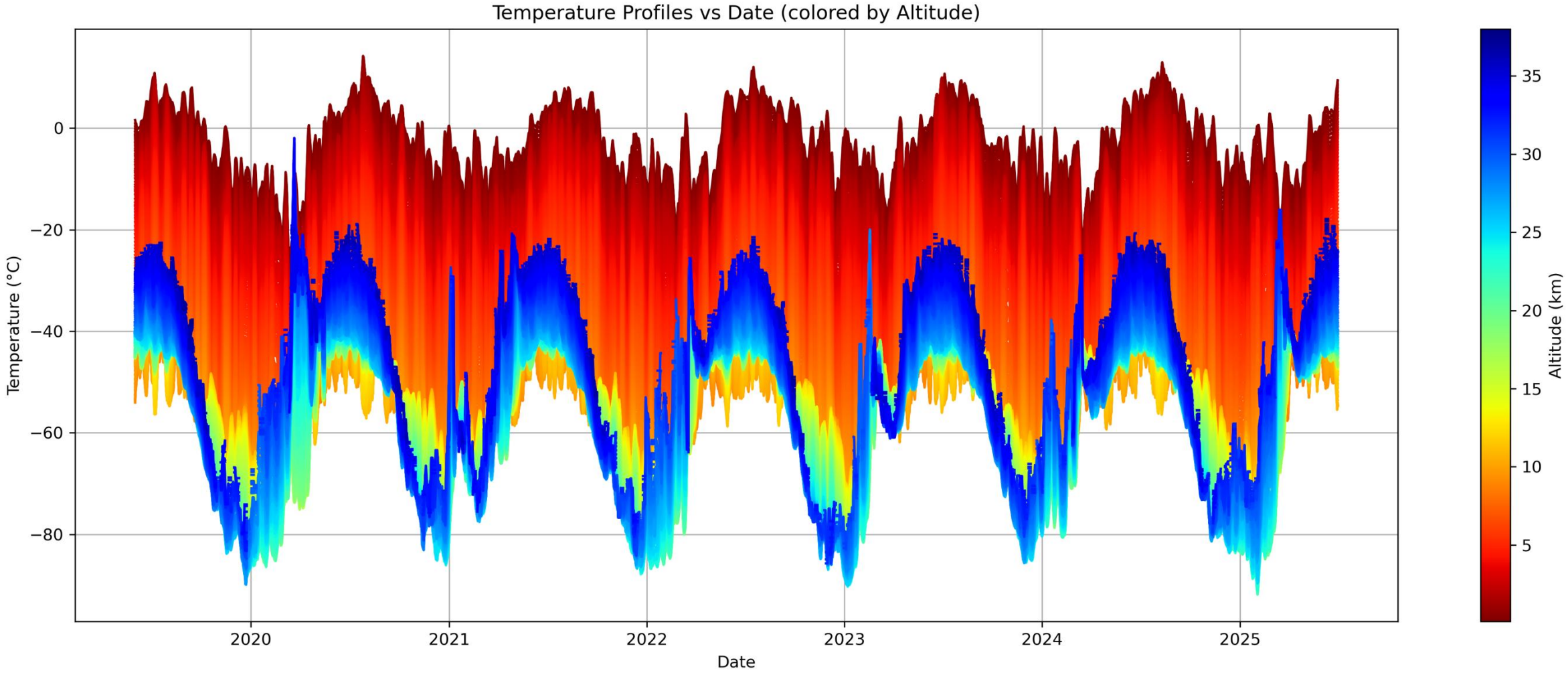


Figure 2. Atmospheric temperature profile composite using SABER (blue) and radiosonde (red) data observed above the SMS detector region on 2009/11/06.

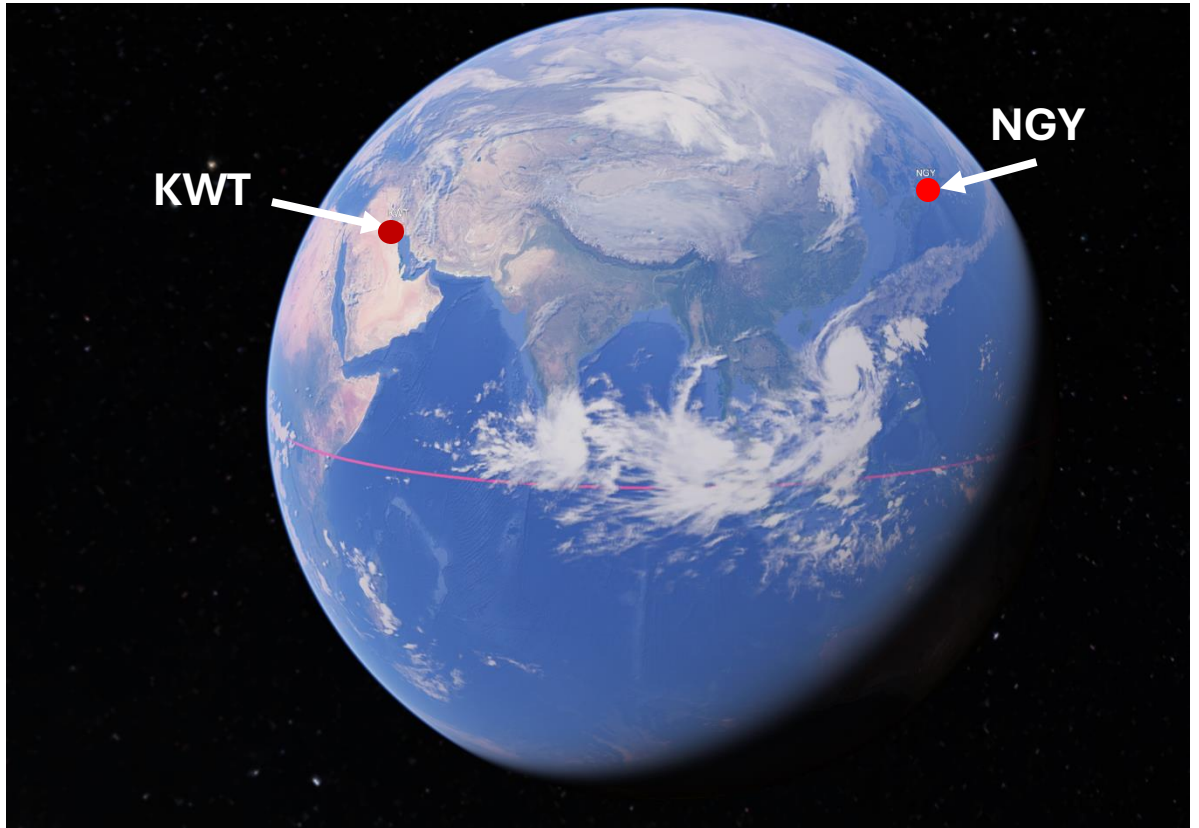
Trend dei profili di temperatura nel tempo



Review di vari metodi con dati GMDN

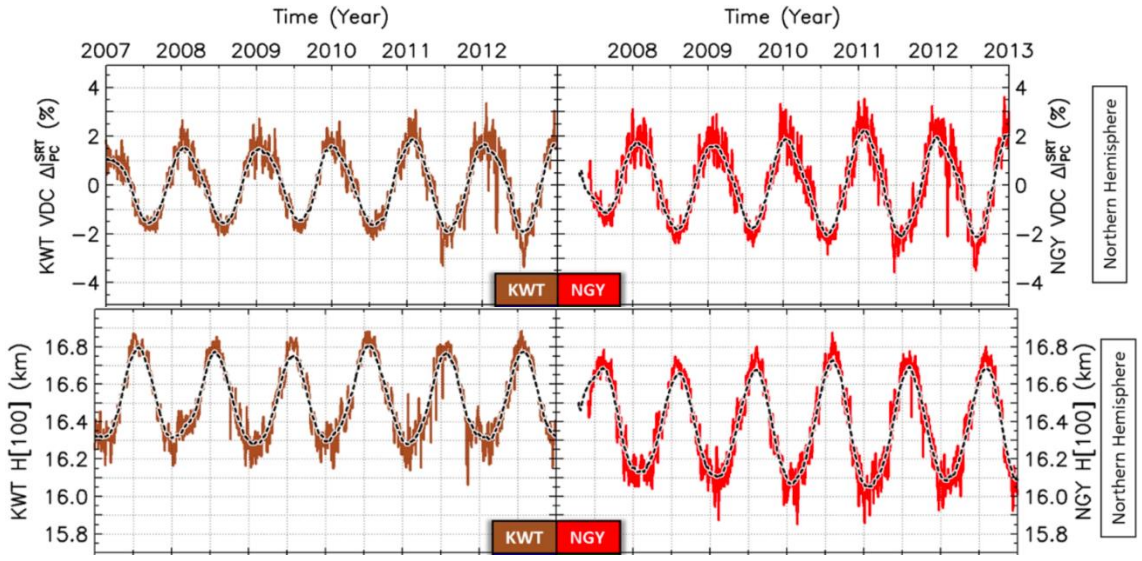
- The temperature effect in secondary cosmic rays (muons) observed at the ground: analysis of the Global Muon Detector Network data. R de Mendonça et al. doi:10.3847/0004-637X/830/2/88

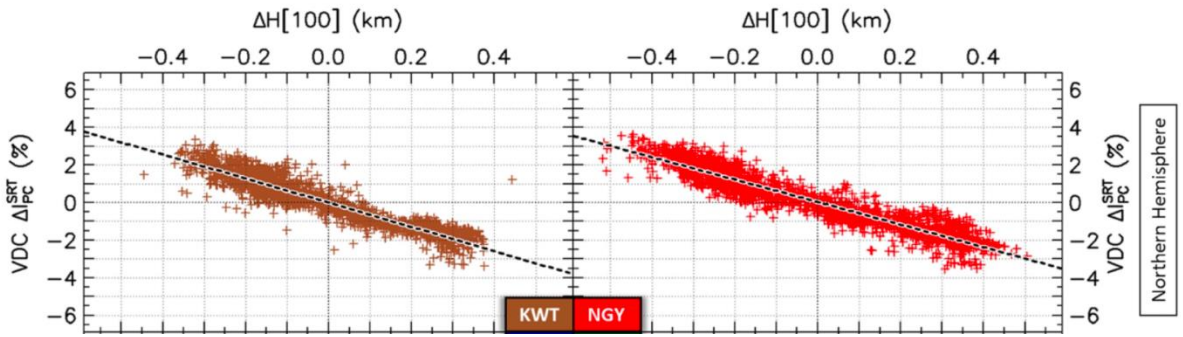
- Kuwait City : lat 29.37°N
- Nagoya : 35.15°N
- Hobart : 42.88°S
- Sao Martinho: 29.94°S



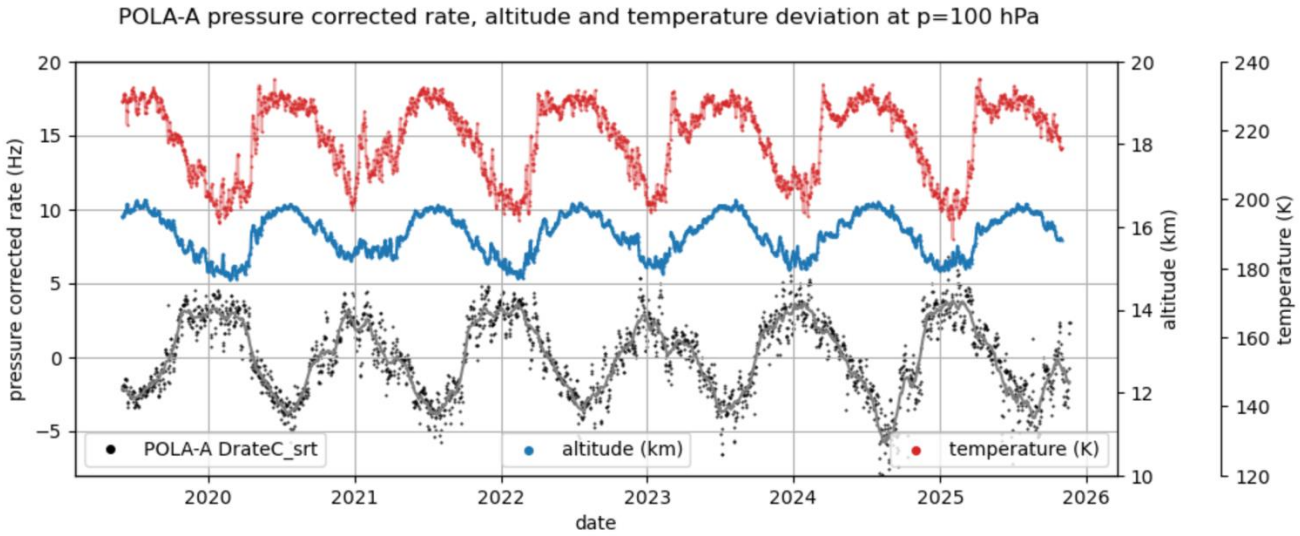
Metodo ATE, si basa sull'isobara a 100 hPa

Paper de Mendonça





nostra analisi




```
Alpha_ATE from best fit:
  alphaA =    −4.486  %/km
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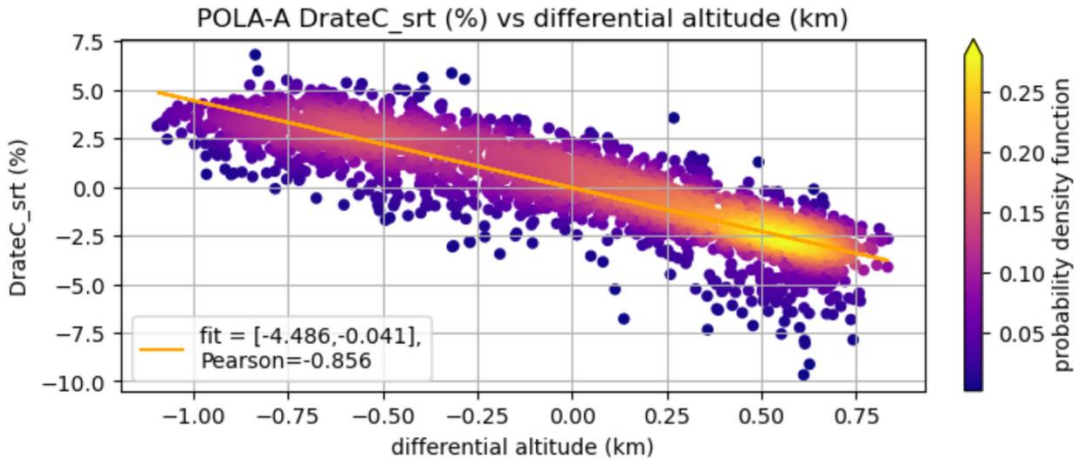
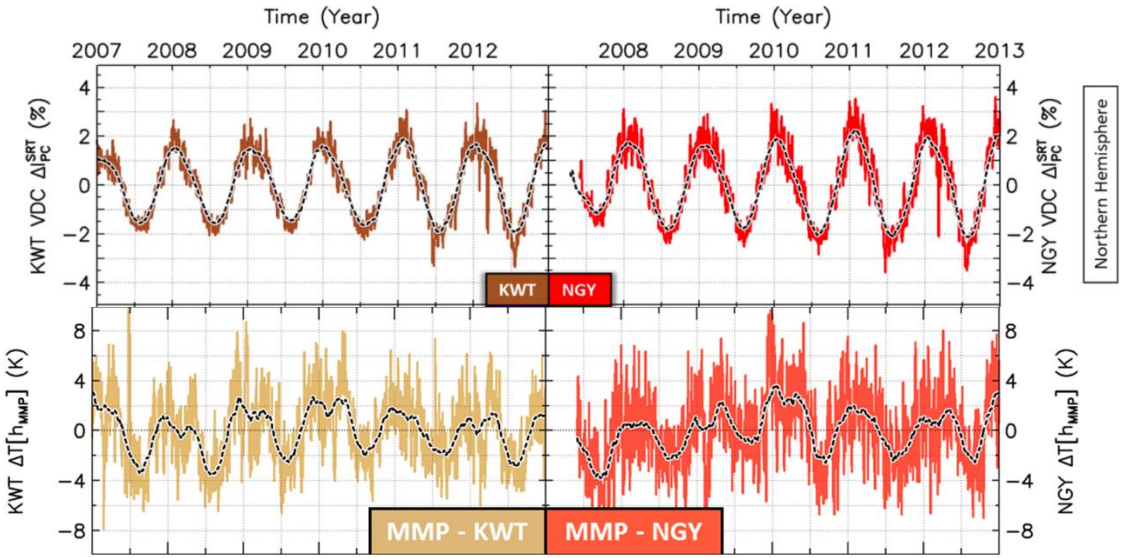
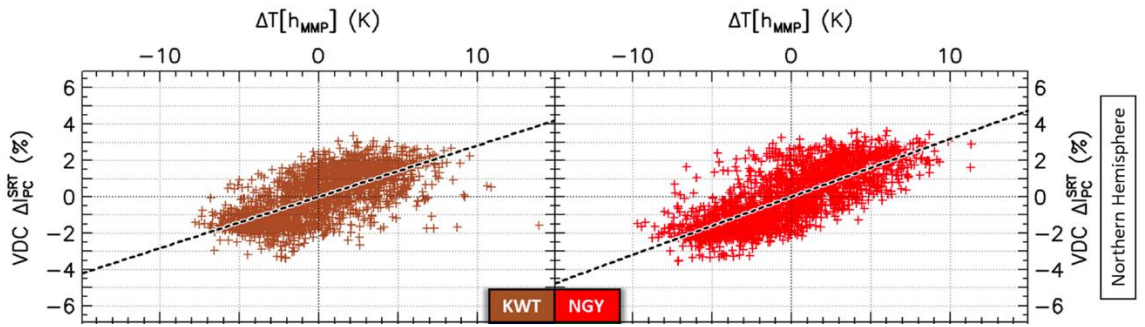


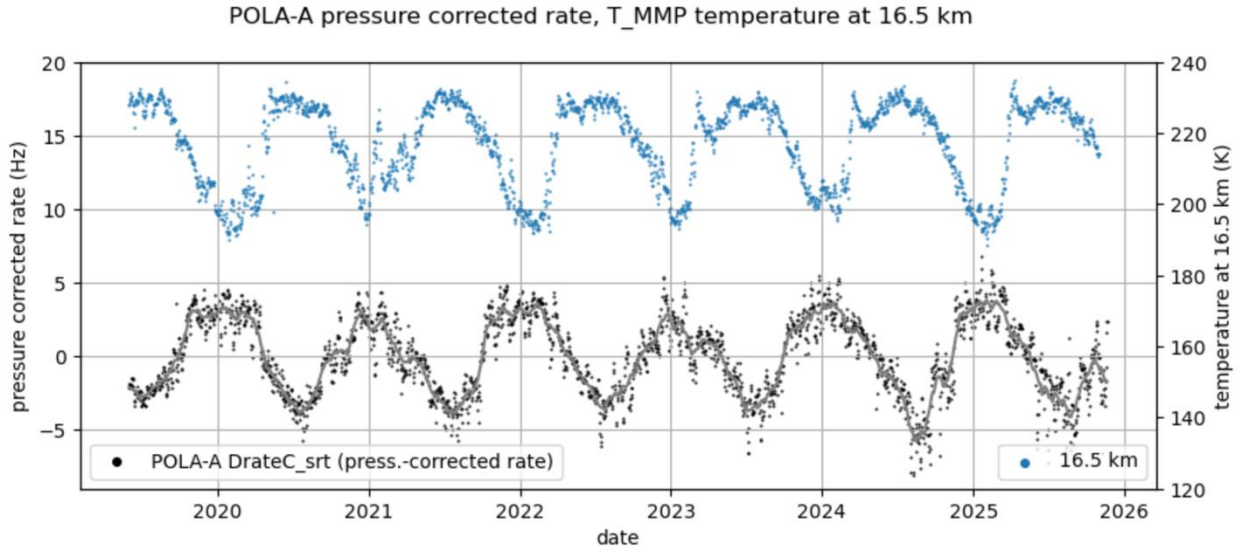
Metodo MMP, temperatura a 16.5 km

Paper de Mendonça

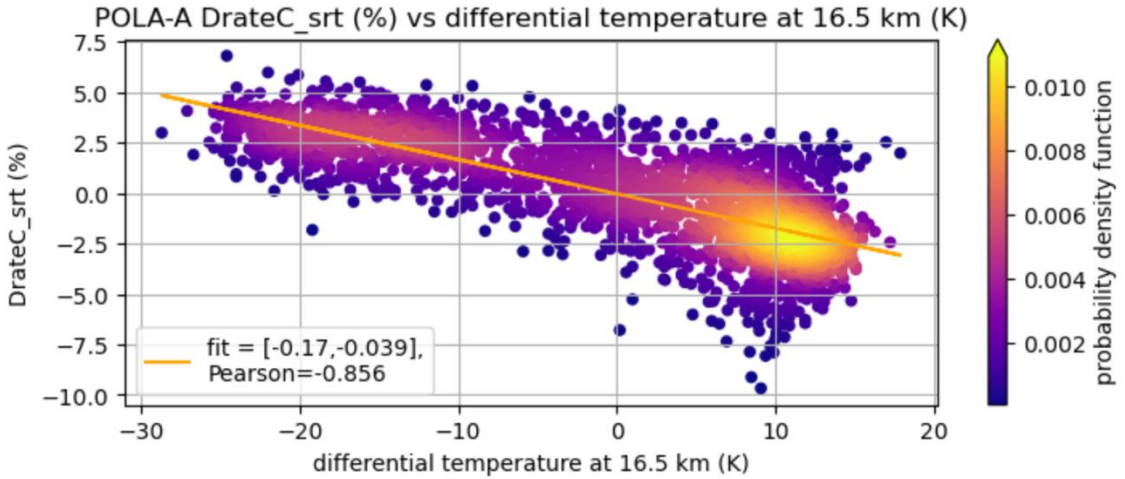




nostra analisi




```
Alpha_MMP from fit of DrateC_srt (%) vs differential temperature at 16.5 km (K)
  alphaMMPA =  -0.16981622653546777
```

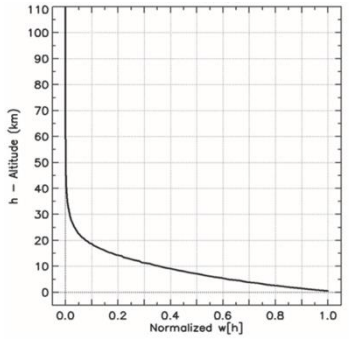


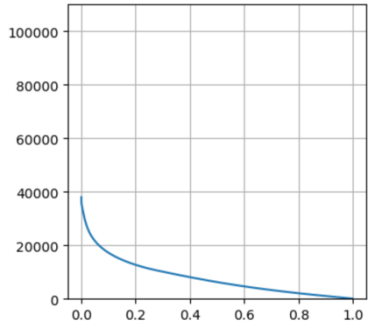
Method MSS

$$T_{MSS} = \sum_{i=0}^{n} w[h_i] * T[h_i]$$

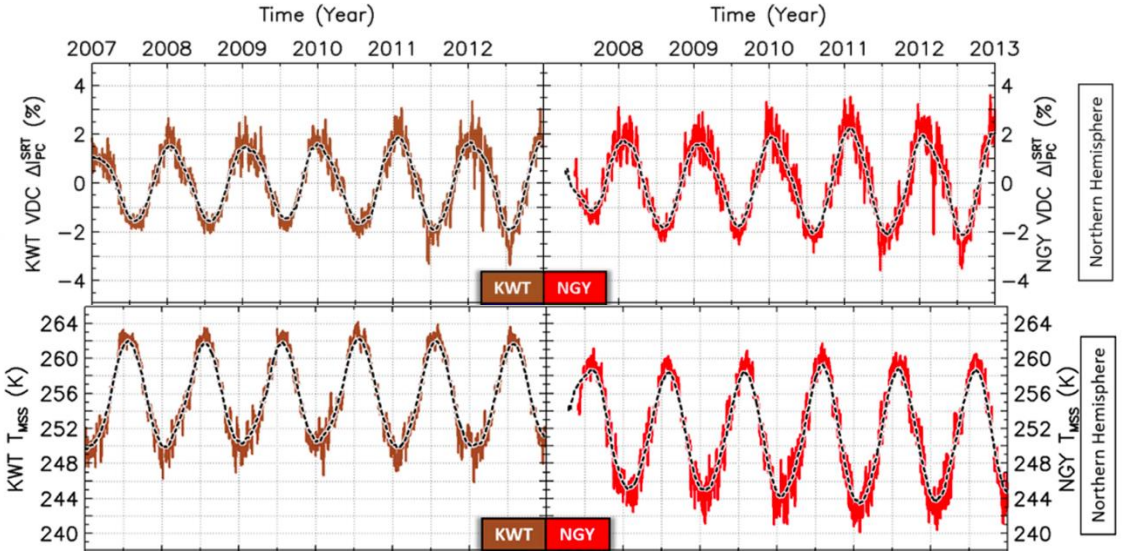
$$w[h_i] = \frac{x[h_i] - x[h_{i+1}]}{x[h_0]}$$

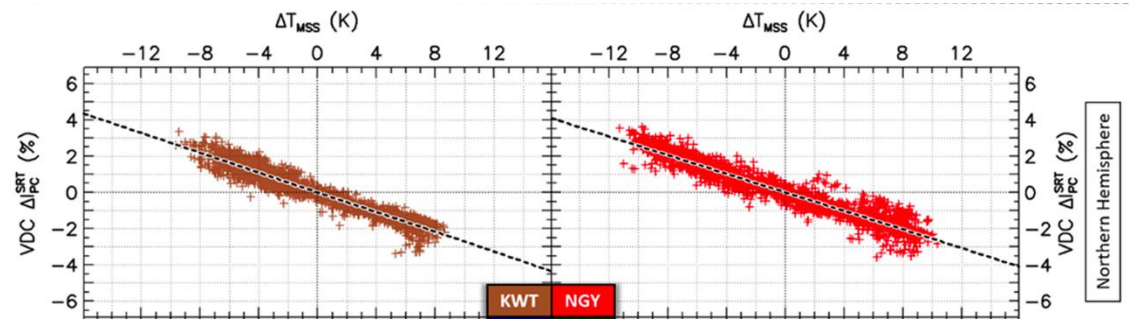
$x[h_i]$ = atmospheric depth



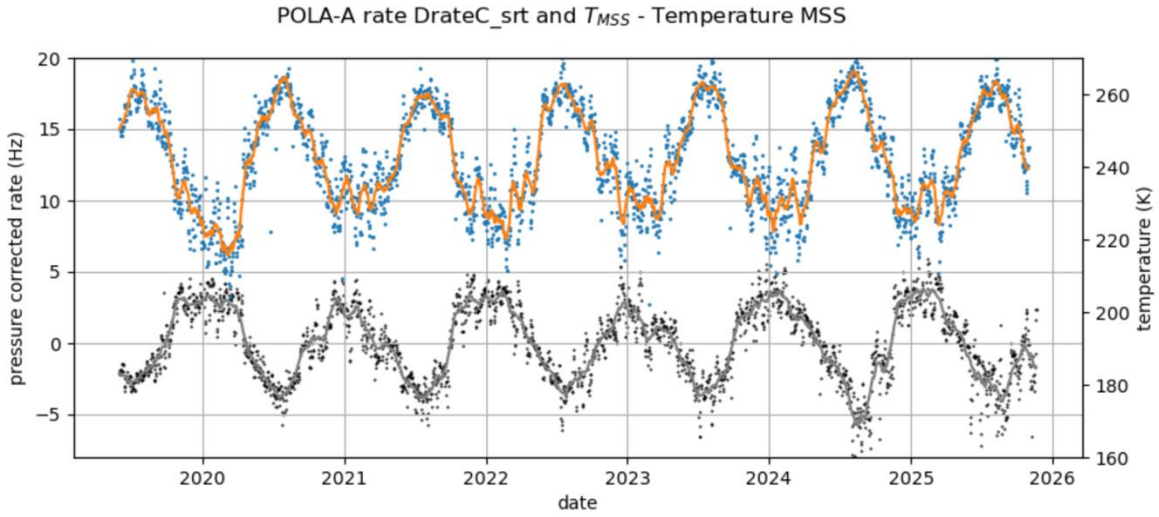


Paper de Mendonça

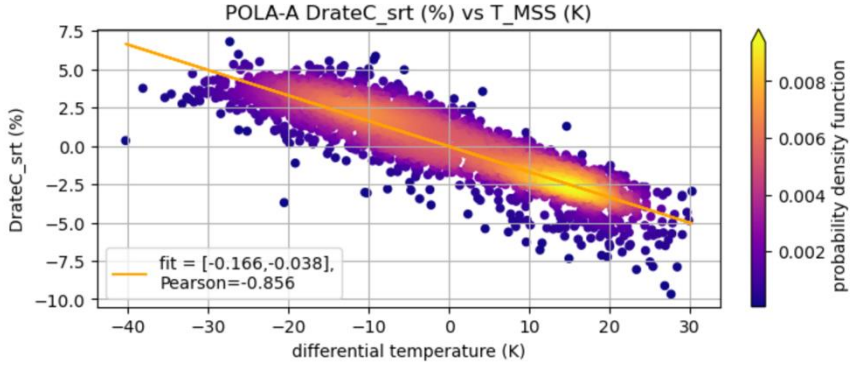




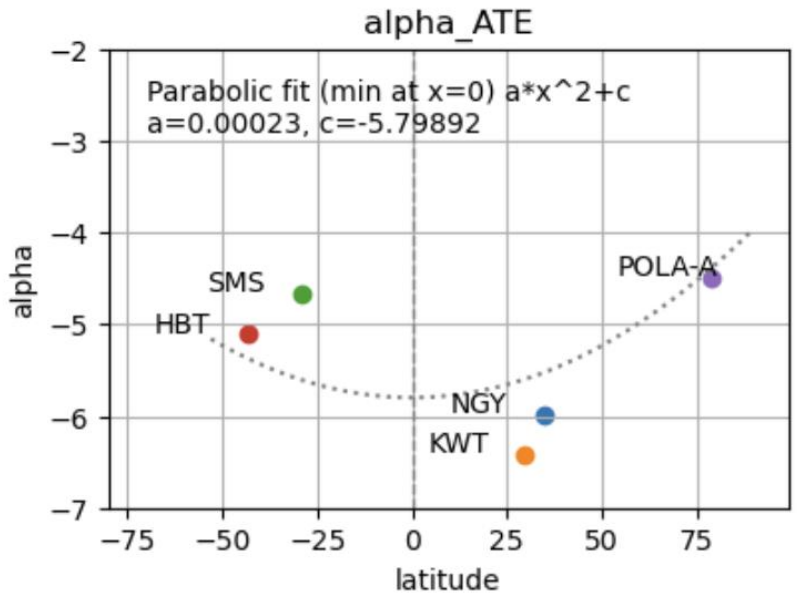
nostra analisi

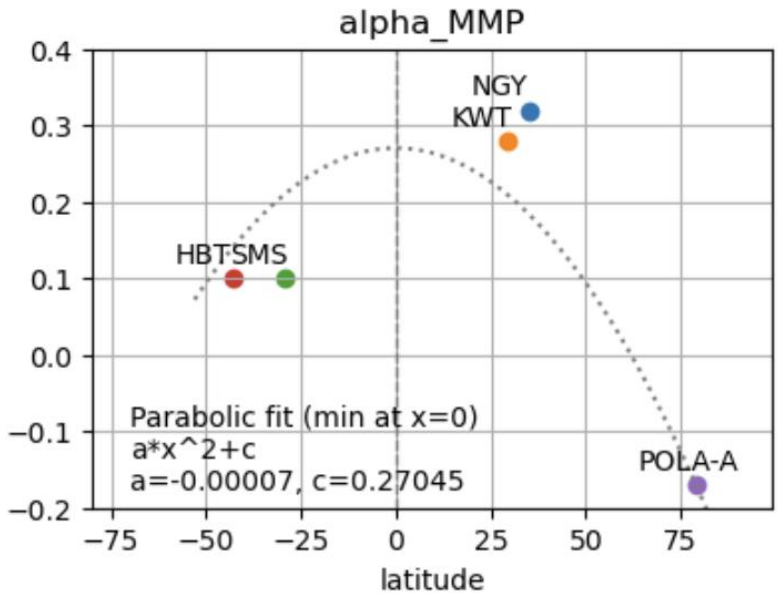


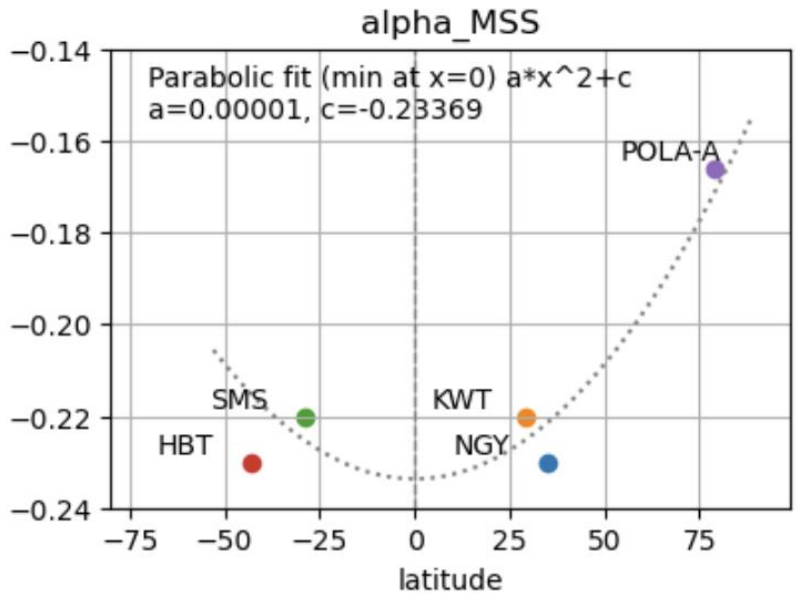

```
Alpha_MSS from fit of DrateC_srt (%) vs T_MSS (K)
  alphaMSSA =  -0.16610313547427152
```



Alpha vs latitude



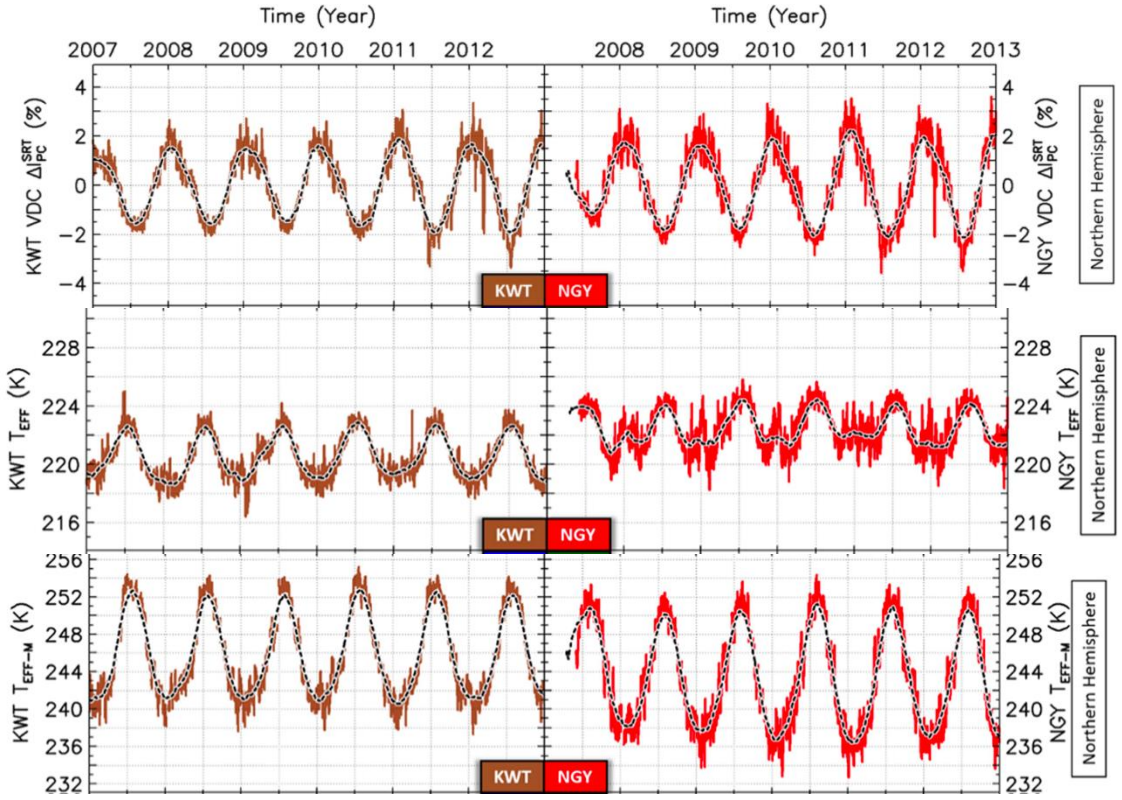


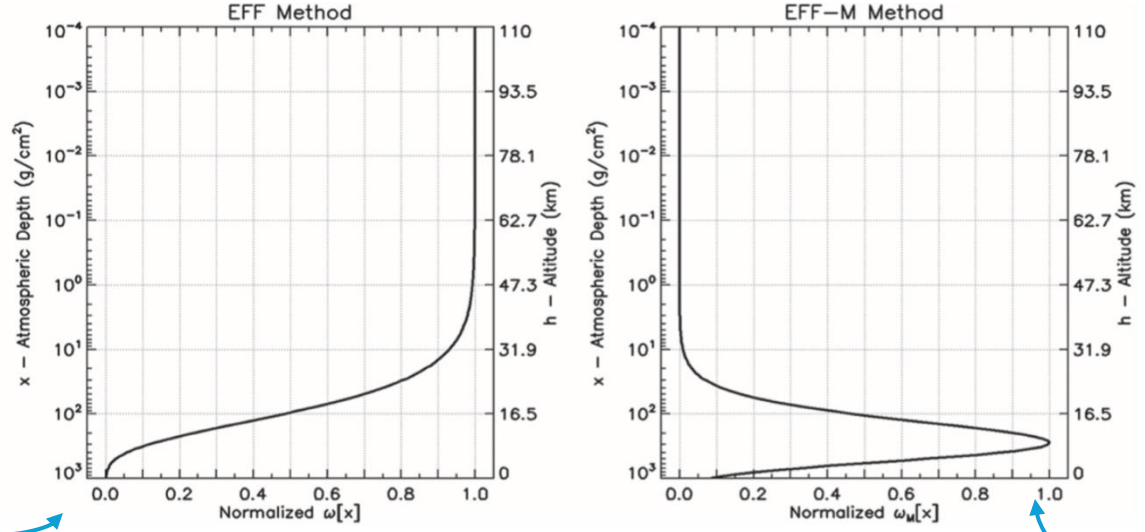


Method EFF (temperatura efficace)

peso utilizzato da tante analisi soprattuto per detector underground

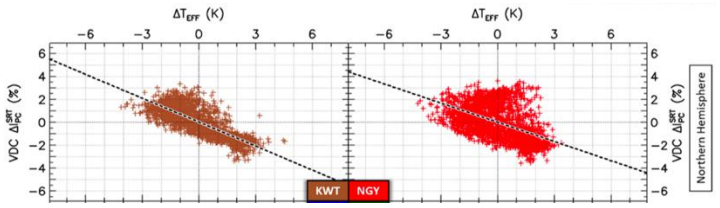
modifica proposta da de Mendonça, senza motivazione scientifica, se non ché si adatta meglio ai dati

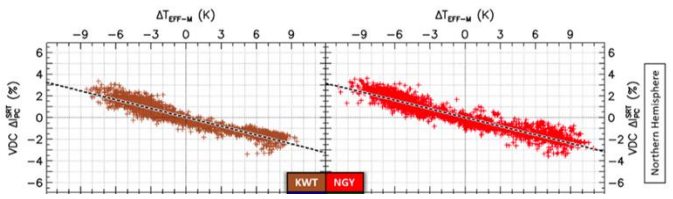




$$T_{EFF} = \frac{\int_0^{x_{GRD}} w[x] * T[x]dx}{\int_0^{x_{GRD}} w[x]dx} \qquad w[x] = \frac{1}{x} * (e^{-\frac{x}{\lambda_\pi}} - e^{-\frac{x}{\lambda_n}})$$

$$T_{\mathrm{EFF}-M} = \frac{\int_0^{x\mathrm{GRD}} \omega_M[x] * T[x]dx}{\int_0^{x\mathrm{GRD}} \omega_M[x]\,dx}, \quad \omega_M[x] = x * (e^{-\frac{x}{\lambda_\pi}} - e^{-\frac{x}{\lambda_n}})$$

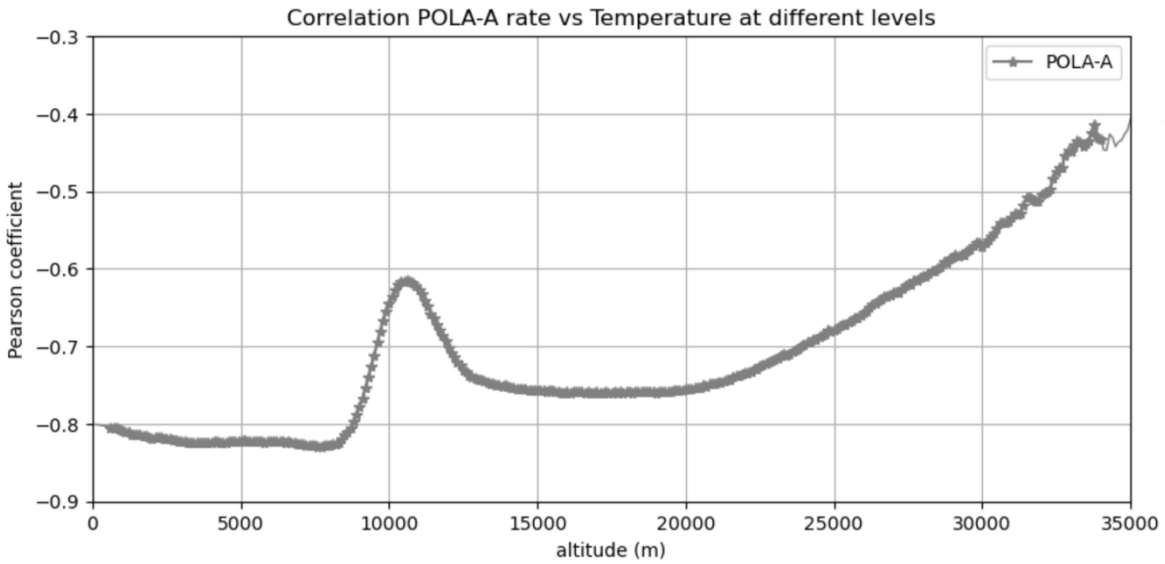


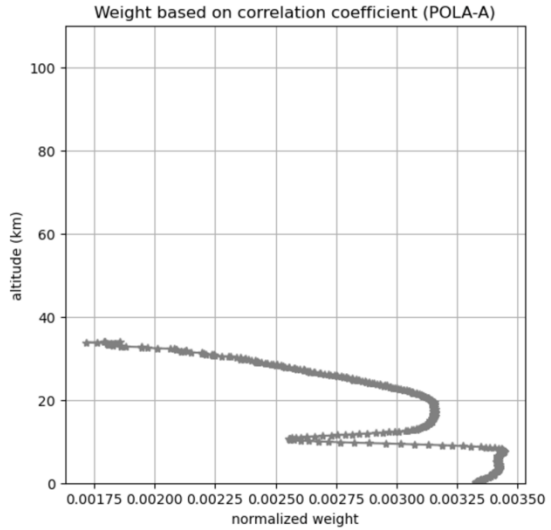


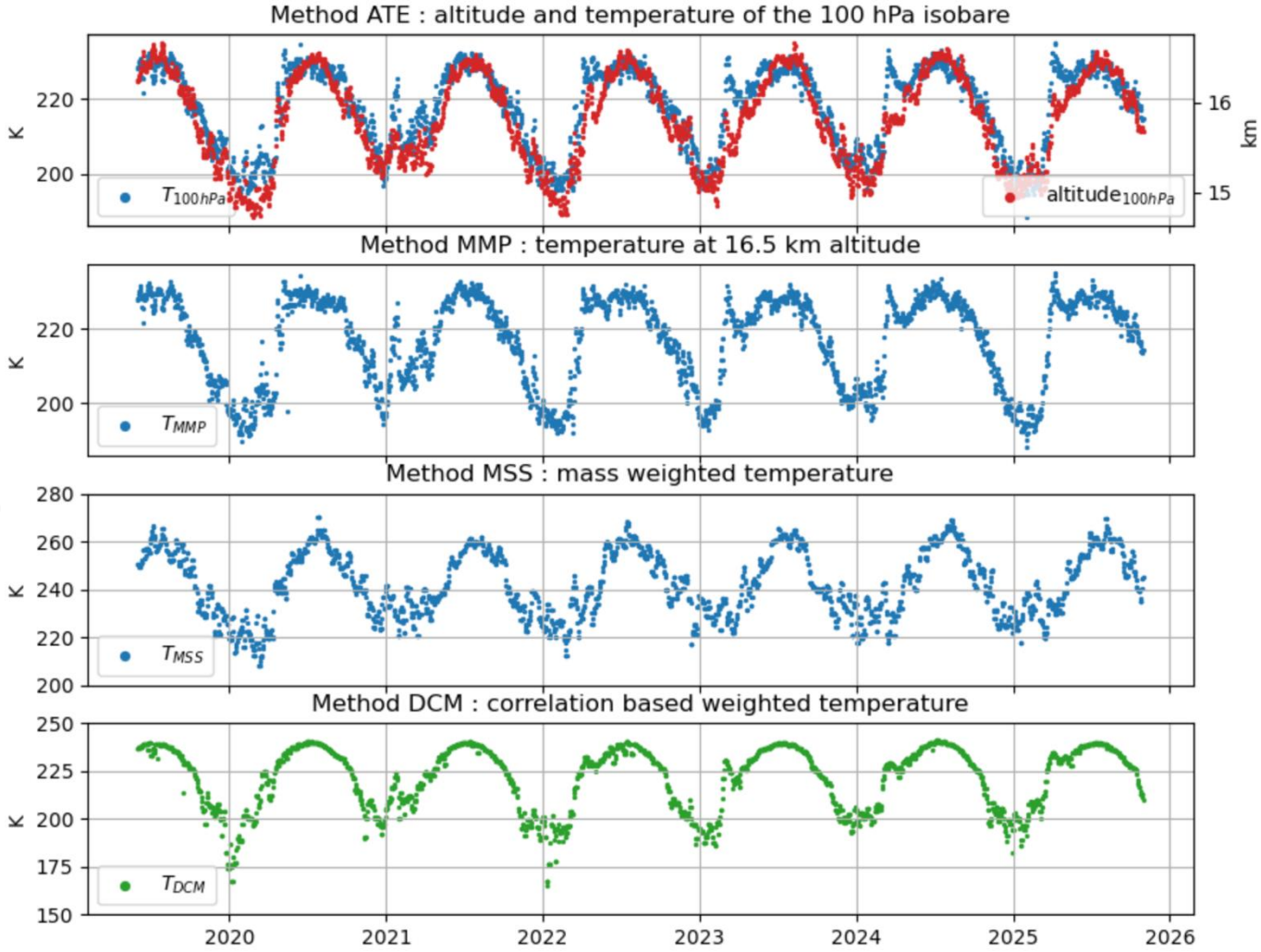
λ_π = 160 g cm^{-2} is the atmospheric attenuation length for *pions*

λ_n = 120 g cm^{-2} is the atmospheric attenuation length for *nucleons*

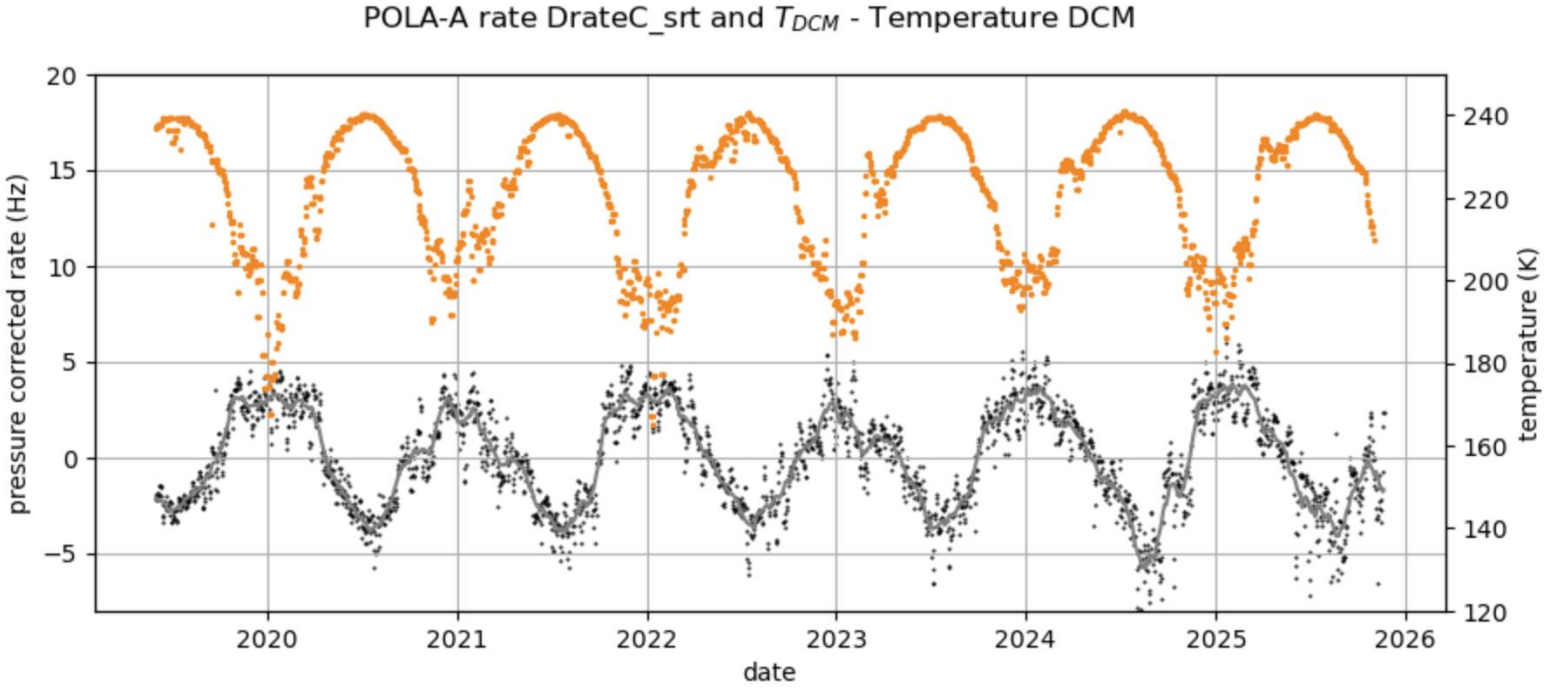
Metodo DCM (Discrete Correlation Method - EEE)







Metodo DCM

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AlphaDCM from fit of DrateC_srt (%) vs T_DCM (km)
  alphaDCM =  -0.1210552467977541
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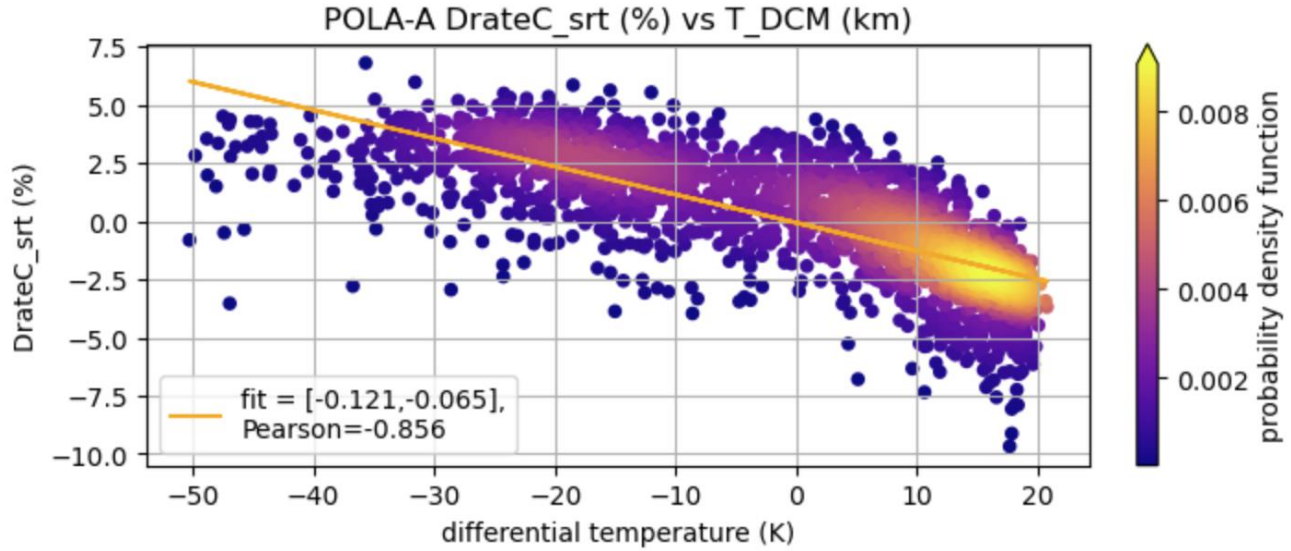
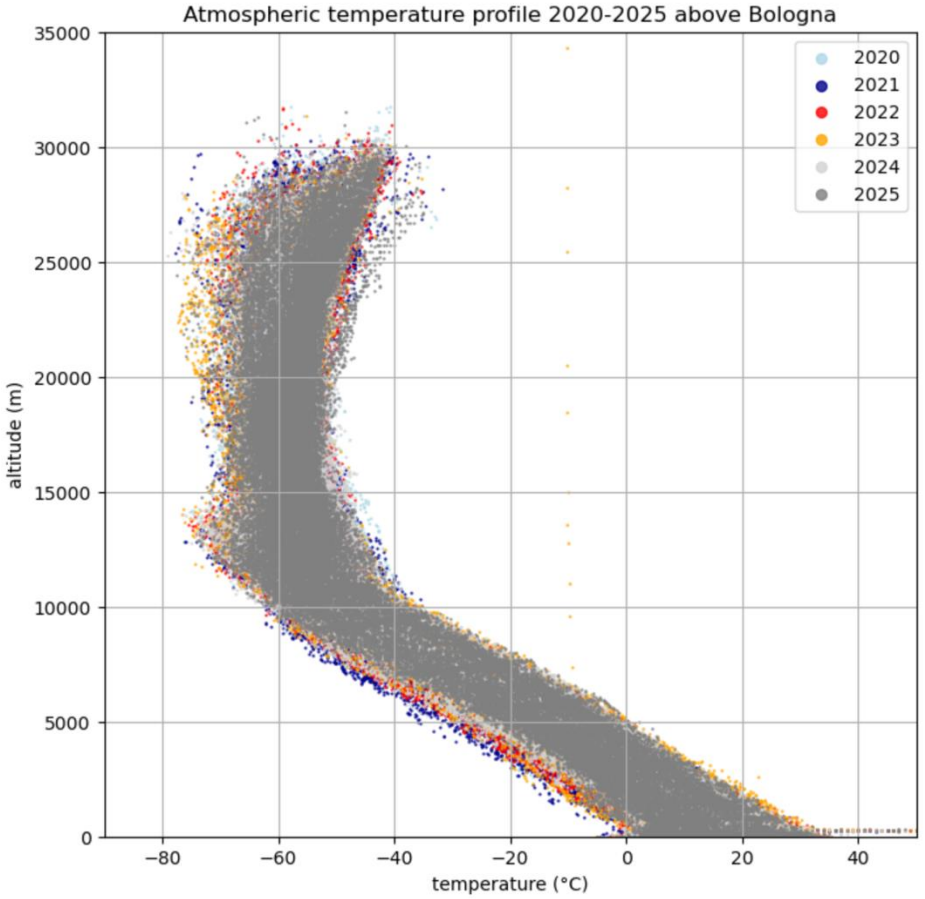
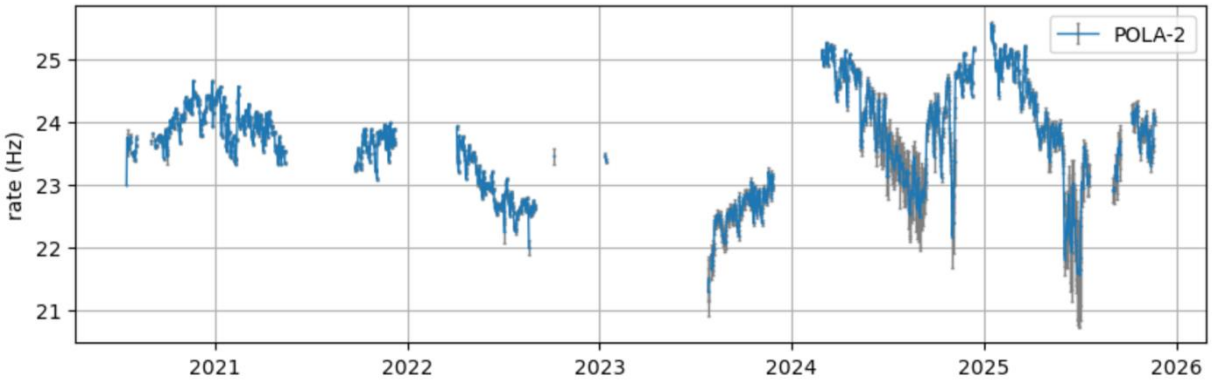
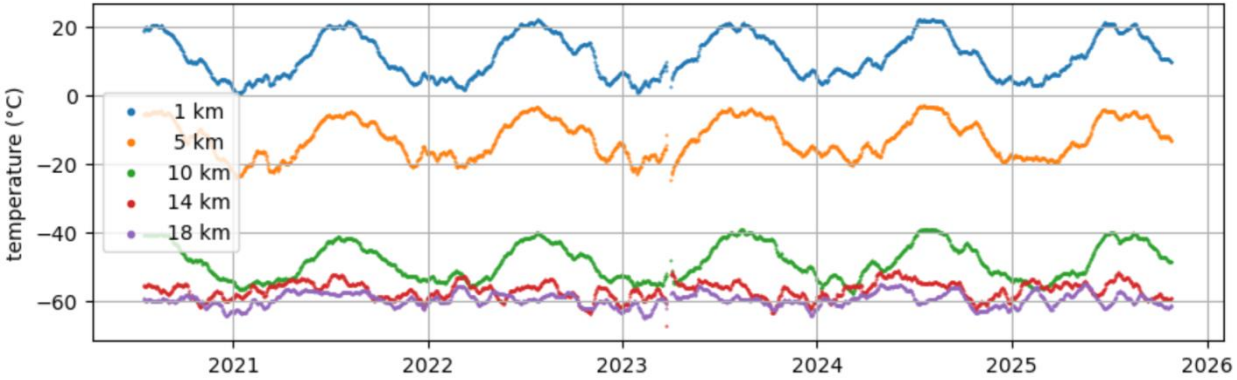


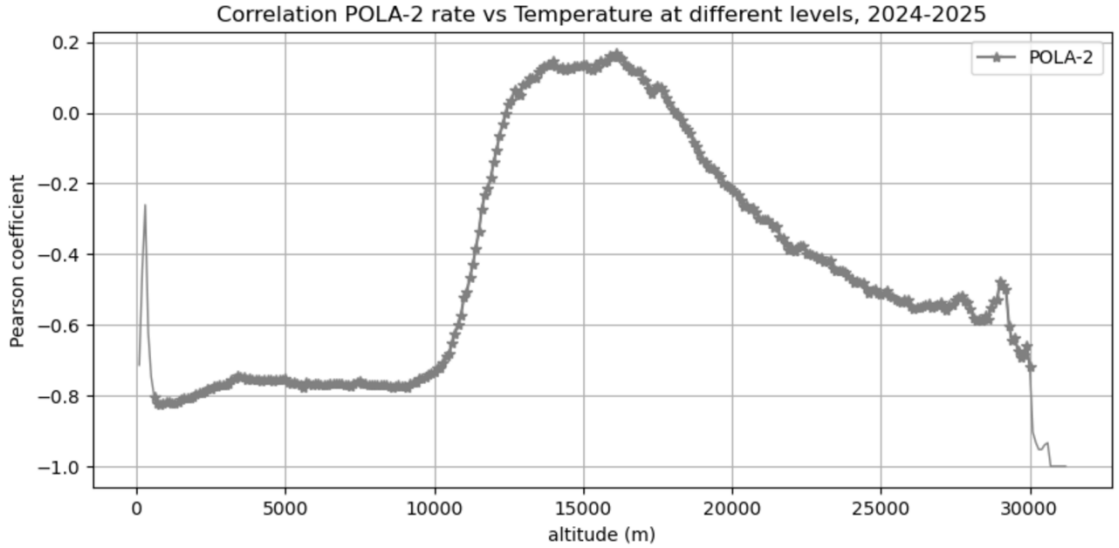
POLA-2 a Bologna

molto preliminary

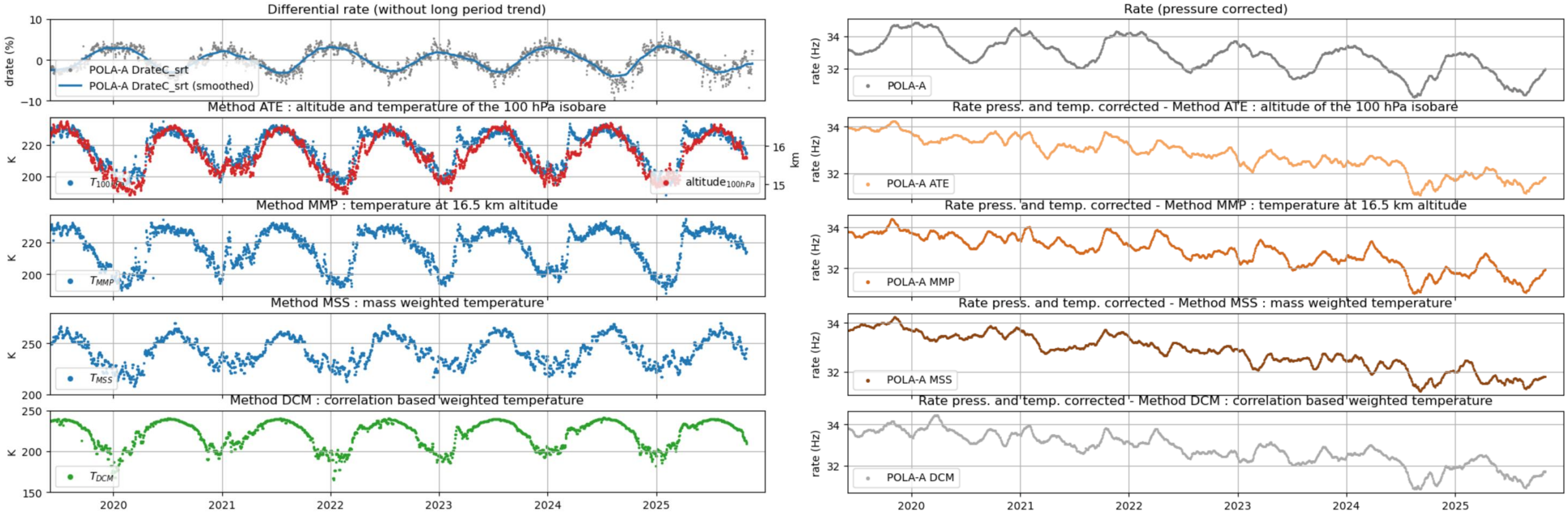




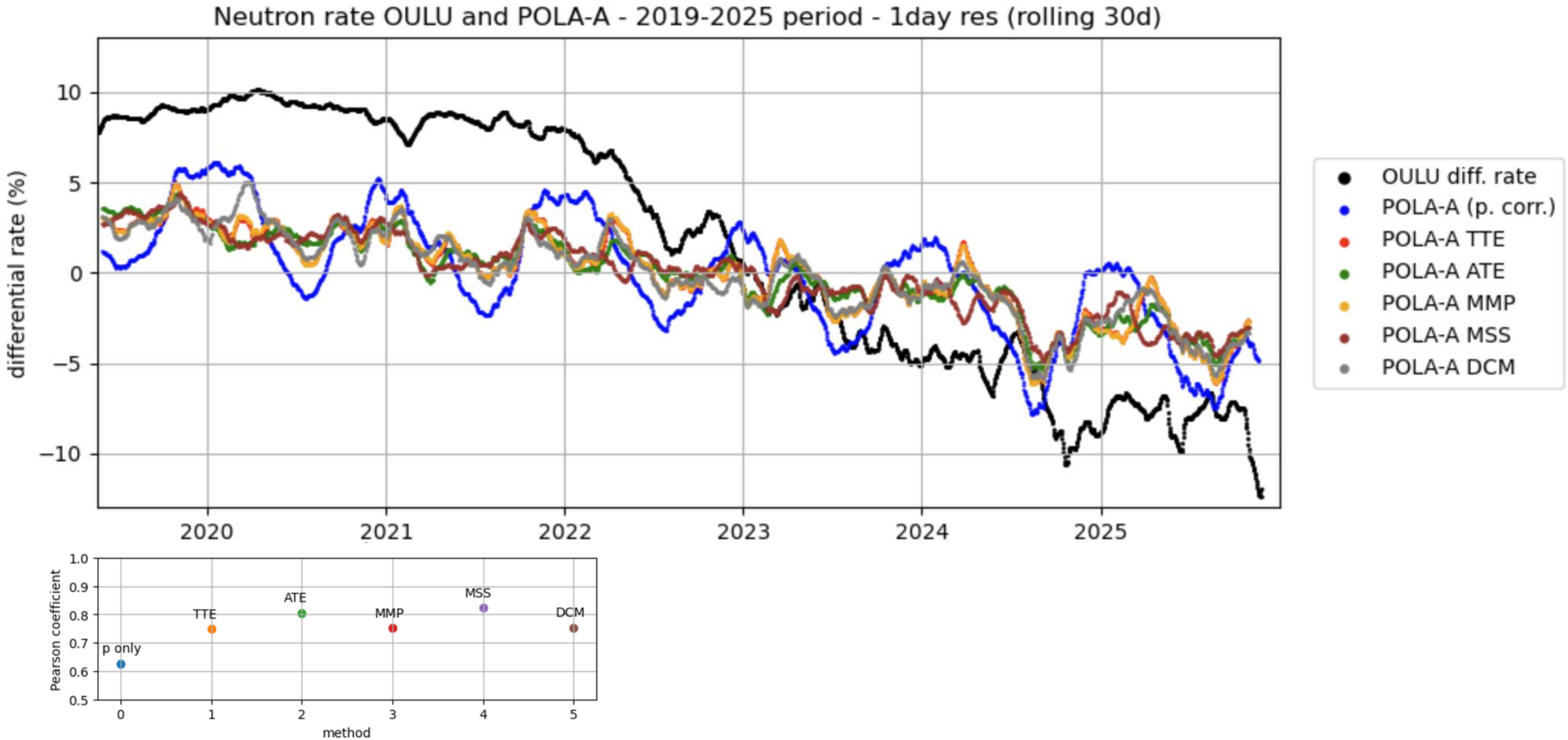




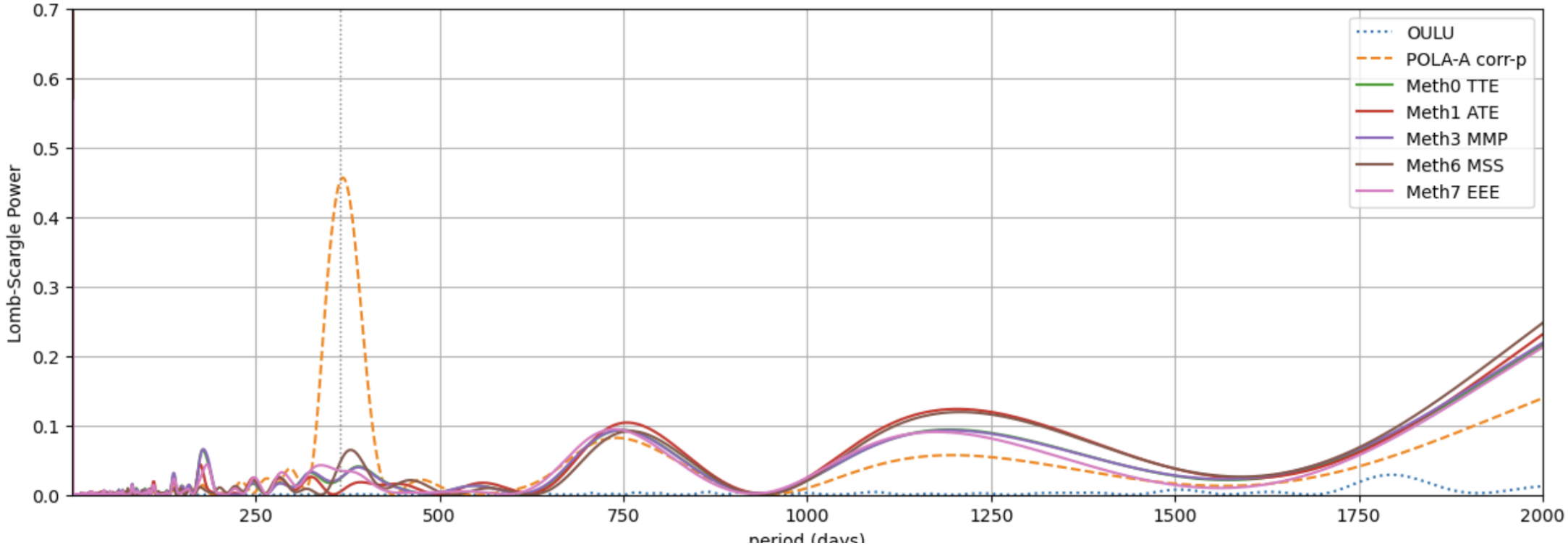
Plot riassuntivi

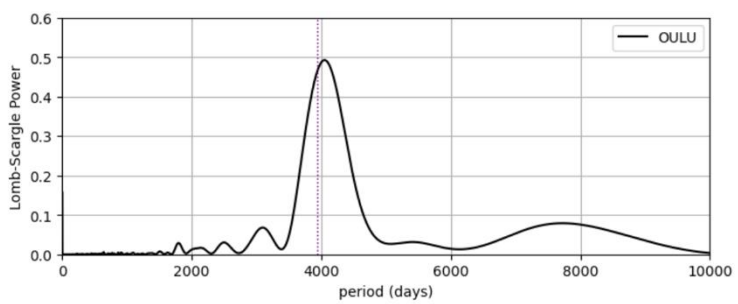


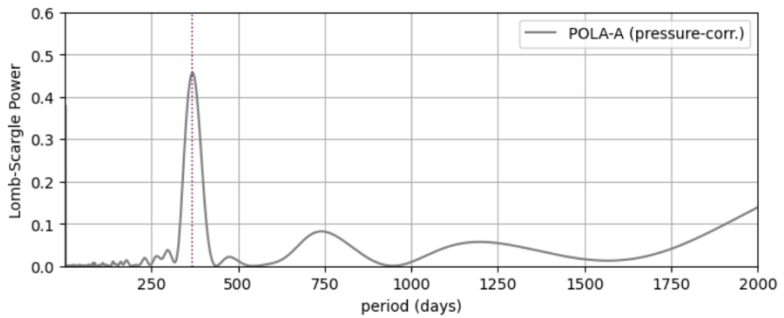
Confronto OULU e POLA differential rates

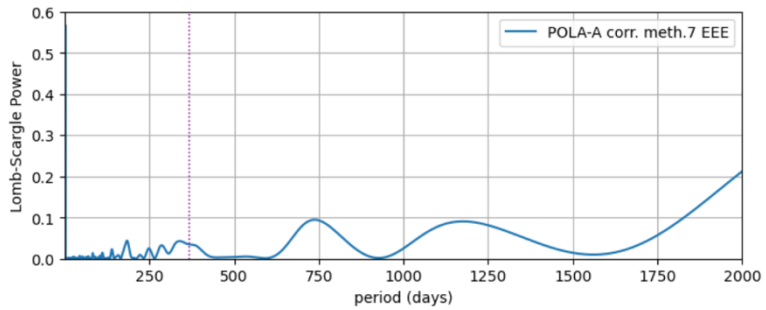


Periodogrammi



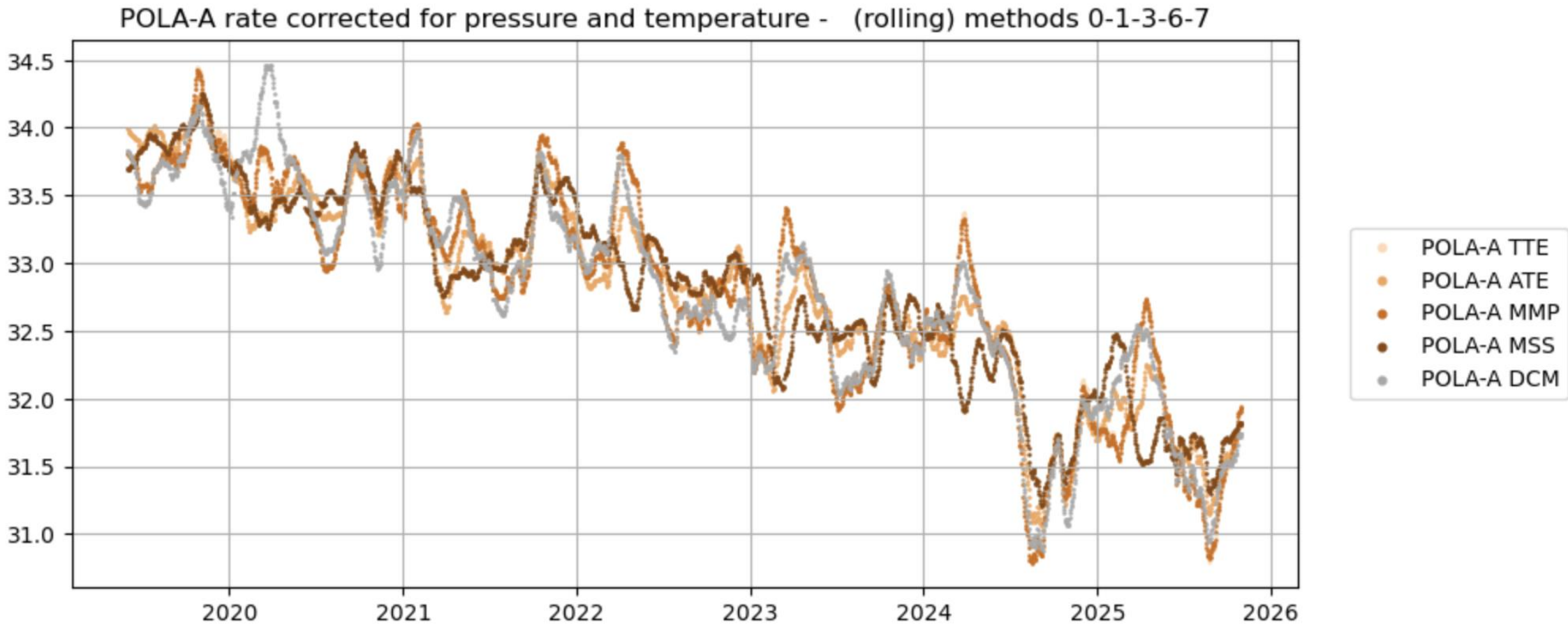






Summary

- Abbiamo applicato metodi empirici e discreti per calcolare l'effetto della temperatura atmosferica sul rate di muoni
- Alcuni metodi utilizzano la struttura verticale dell'atmosfera pesando i diversi strati, ma questi 'pesi' non si adattano alle alte latitudini
- Proponiamo un metodo mirato al profilo verticale locale, basato sul coefficiente di correlazione
- Confrontiamo i rate corretti in pressione e temperatura applicando i vari metodi, fra loro e con OULU
- Verifichiamo la periodicità del rate corretto in pressione e temperatura


POLA-A rate corrected for pressure and temperature - (rolling) methods 0-1-3-6-7
34.5
34.0
33.5
33.0
32.5
32.0
31.5
31.0
2020
2021
2022
2023
2024
2025
2026
POLA-A TTE
POLA-A ATE
POLA-A MMP
POLA-A MSS
POLA-A DCM