

# FRAM telescopes and their measurements of aerosol content

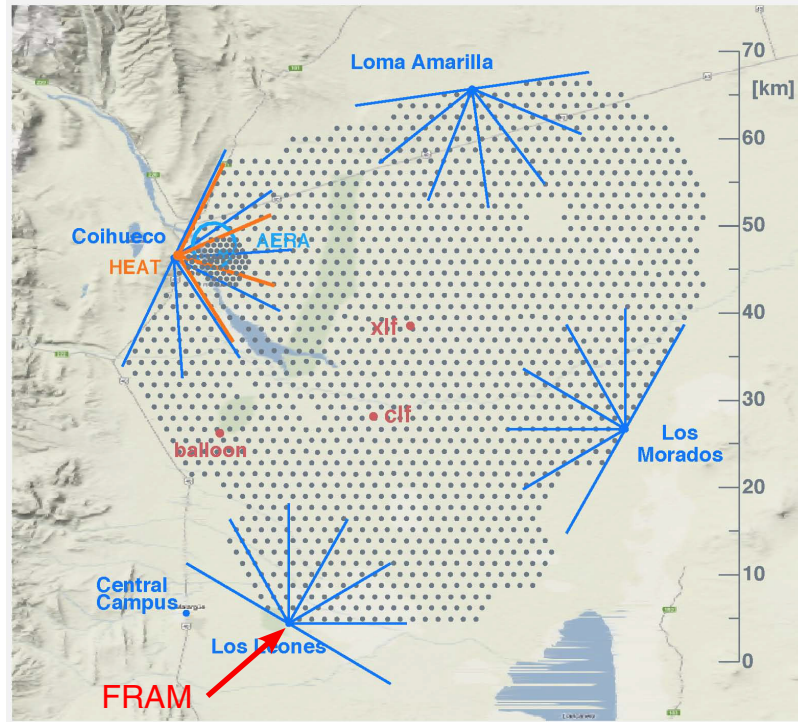


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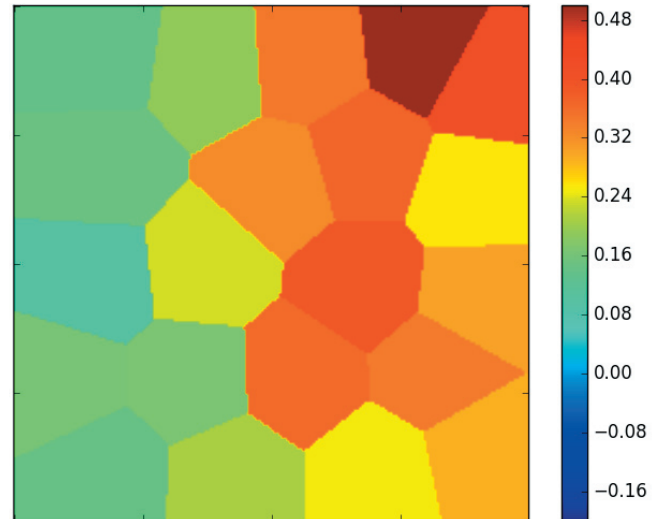
# FRAM: (F/Photometric Robotic Atmospheric Monitor)

- Stellar photometry -> atmospheric extinction
- Pierre Auger Observatory
  - Malargue, Argentina ( $36^\circ$  S)
  - Fluorescence detector -> atmospheric monitoring
  - FRAM telescope since 2005
- Original target: wavelength dependence of aerosols
  - still not adequately solved
  - a tiny effect on data
- Main use: rapid monitoring
  - since 2009
  - follow up "interesting" cosmic ray events -> particle physics
  - are double-bump events physical, or due to clouds?



# FRAM: (F/Photometric Robotic Atmospheric Monitor)

- Cherenkov Telescope Array (CTA)
  - planned sites: near Cerro Paranal, Chile ( $24^{\circ}$  S), Observatorio Roque de los Muchachos, La Palma, Canary Island ( $28^{\circ}$  N)
  - Cherenkov telescopes -> atmospheric monitoring
  - 3 FRAMs planned
- FRAM telescope(s) to cover CTA field of view during operation
  - provide aerosol maps
  - define periods of constant conditions
- Deployed ahead of time to characterise sites
  - Chile 09/2017
  - La Palma 10/2018
  - Chile II 2019



# Auger FRAM

- 2005: Losmandy G11, 20cm Cassegrain, Optec photometer + small pointing camera, wide-field (WF) FLI 1.5 Mpix @ 200/2.8 Pentacon
  - tube flexing
  - mount getting lost



- 2009: Paramount ME, 30cm Meade SCT (on loan from IAA), Photometr + narrow-field (NF) 2nd FLI 1.5 Mpix (WF kept)
  - mount much more reliable, but required maintenance due to heavy load
  - FLI cameras not suitable for heavy use: filter wheels and shutters suffer

# Auger FRAM

- 2011: Photometer abandoned, NF FLI changed for Moravian G2-1600
- usefulness of NF observations for atmospheric monitoring limited
  - small field of view  $23 \times 15$  arcmin -> limited amount of stars with good catalog data (except for special fields)
- 2013: WF changed to Nikkor 300/2.8 + G4-16000, 16Mpix large format camera
  - $7 \times 7$  degrees FoV, 12cm aperture
  - beginning of precise aerosol measurements using altitude scans (see Jan Ebr's talk)
  - NF used mainly for astronomical targets in free time



# Auger FRAM

- 2018: 10micron GM2000 HPS + Orion UK ODK 30cm Dall-Kirkham
  - maintenance-free mount with absolute position sensors
  - NF changed to 2nd G4-16000: 1 sq. degree FoV
  - can NF now be used for atmosphere?
  - improved WF holder (CTA style) to get rid of mechanical issues





# CTA FRAMs

- Based on Auger experience, tailored for CTA
- Paramount MYT, G4-16000, Zeiss 135/2
  - 15×15 degrees FoV
- La Palma FRAM on 10micron GM2000HPS
  - added 25cm Meade SCT (from BART project), temporary, for the pre-CTA phase
- all HW tested in Prague before shipping
  - some interesting observations from city conditions





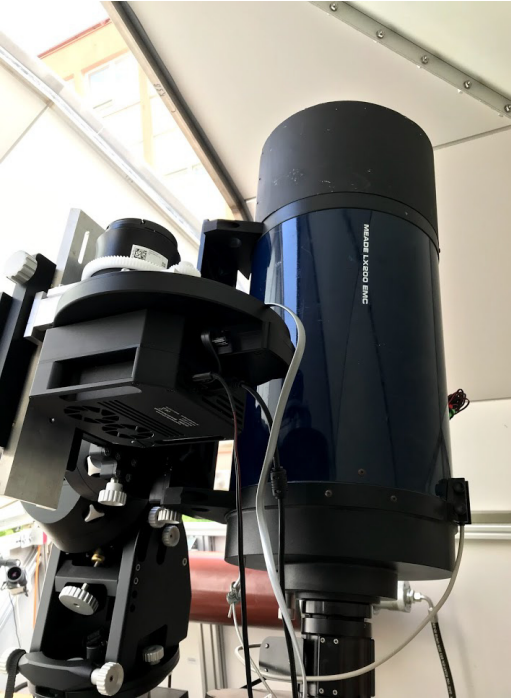
# CTA FRAM in Chile

- Operated since 09/2017, fully autonomous (solar powered)
- Prototype for all CTA FRAMs -> allows to learn lessons
  - bug in PLC code caused dome to get stuck, solved
  - cooling of CCD failed: new standards for dessicant maintenance



# CTA FRAM for La Palma

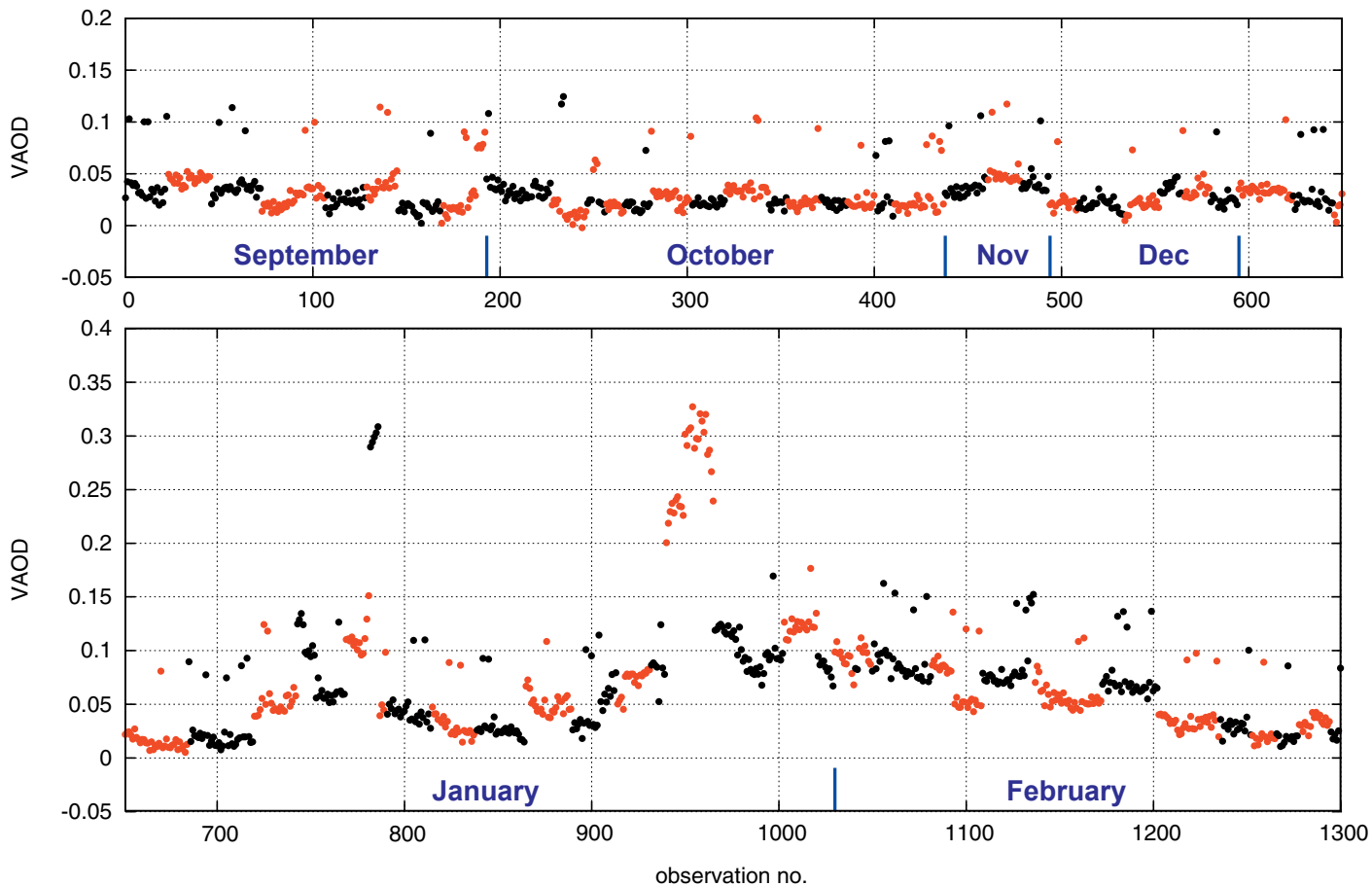
- Temporary site near MAGIC fence tested 07/2016
  - many thanks to MAGIC, especially Martin Will!
- Last AtmoHEAD we estimated installation in 03/2017
  - bureaucracy ... now 10/2018, shipment in transit



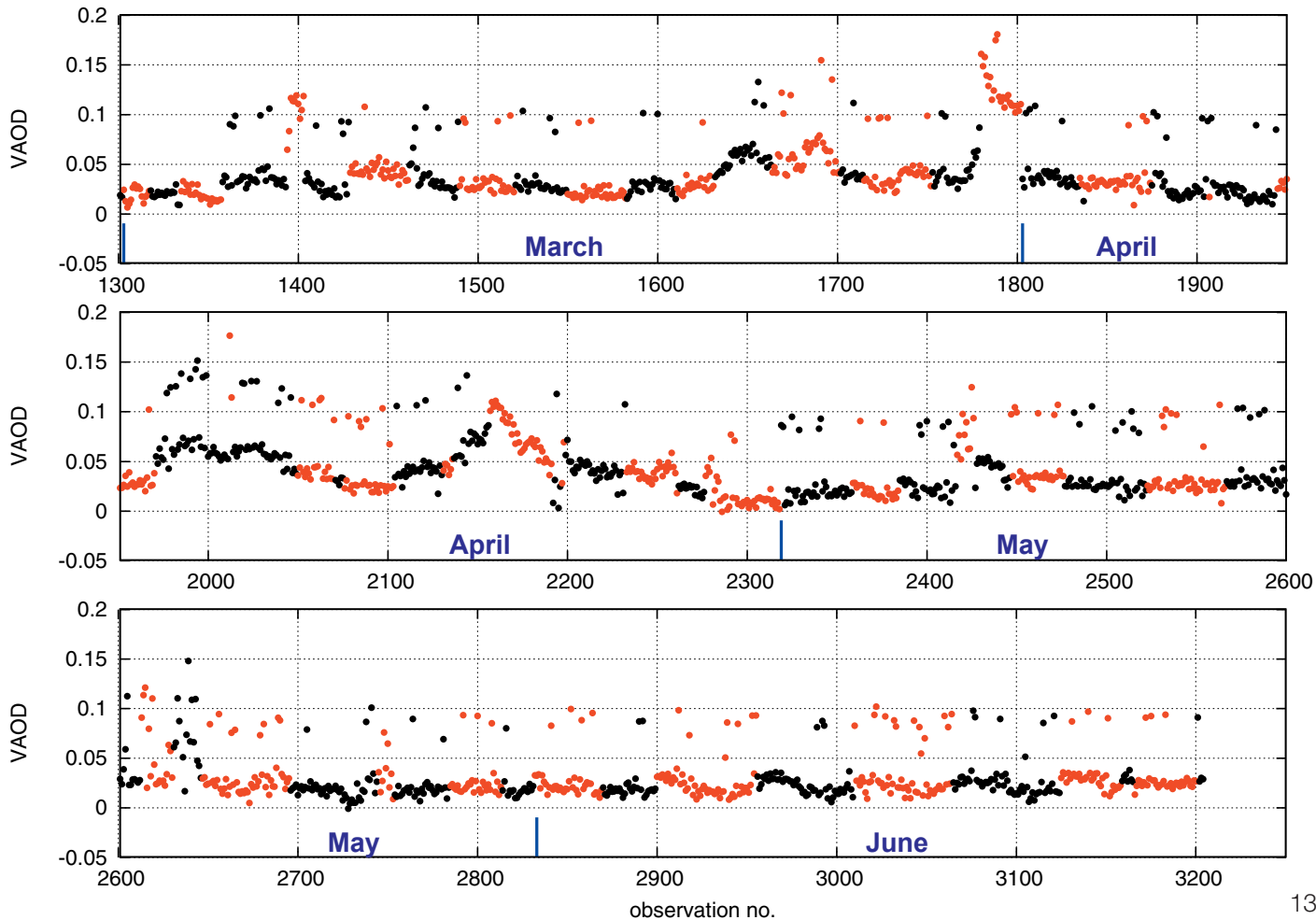
# Aerosol measurements with FRAMs

- Method of altitude scans in development since 2015
  - see Jan Ebr's talk
- Measurements in B filter (closest to Auger/CTA interests)
  - V/R/I measurements done for wavelength-dependence
  - not yet processed, need to deal with molecular absorption
- Auger FRAM (Malargue)
  - scans for anomalous showers used for aerosols since 2013
  - dedicated aerosol scans since 2016 (when no shower triggers)
  - only a part of data processed (HW changes affect calibration)
  - good downlink, good understanding of data
- CTA FRAM (Paranal)
  - 100% of time to aerosol scans when before CTA is built
  - downlink fixed in 07/2018, before then only local processing
  - understanding of data preliminary (outliers to be solved)

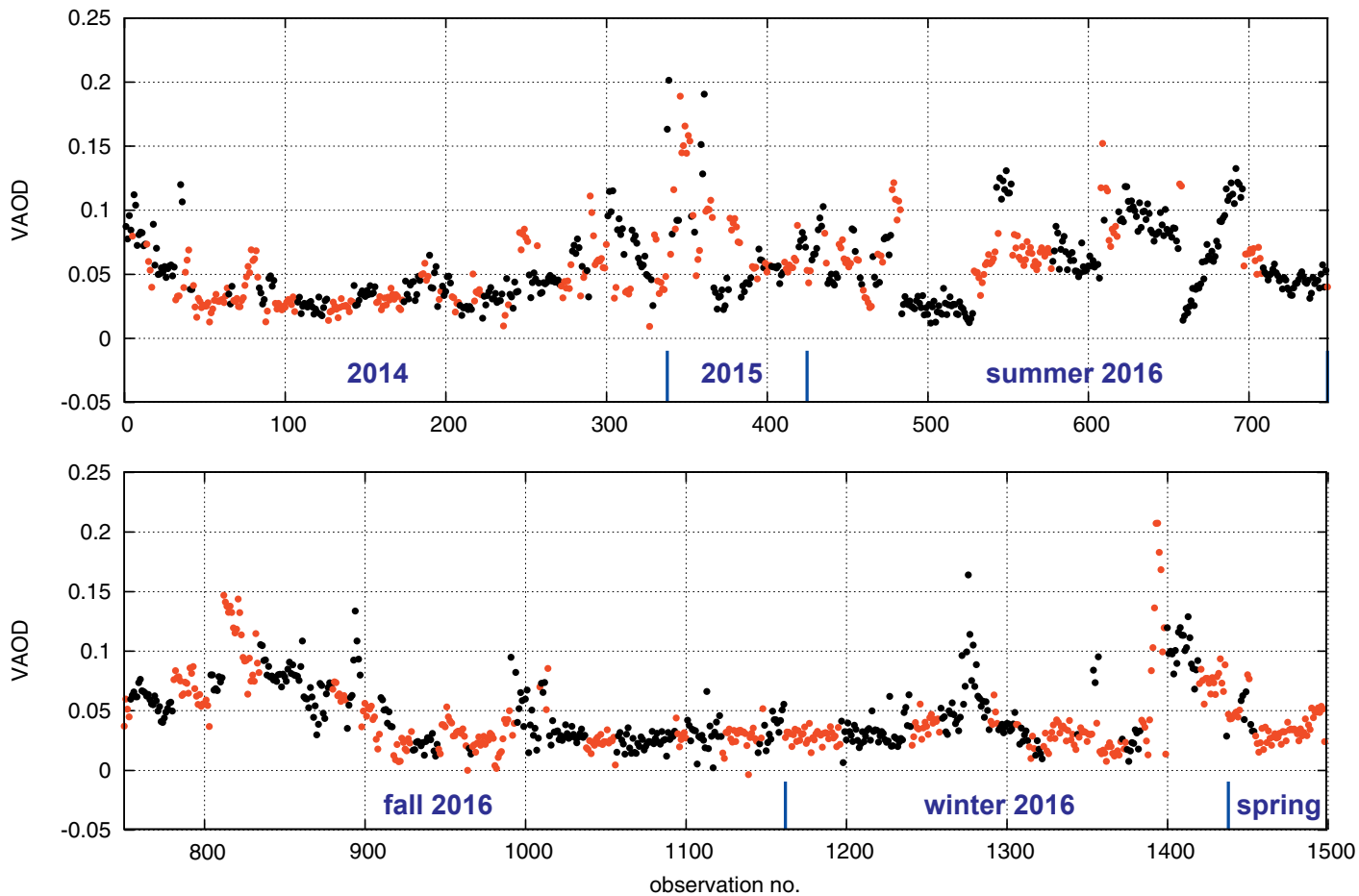
# Aerosol data: CTA FRAM (Paranal)



# Aerosol data: CTA FRAM (Paranal) continued



# Aerosol data: Auger FRAM (Malargue)



# Azimuthal or temporal effect? First look @ Auger

- 1 measurement takes 5-10 minutes
  - a lot of scans hit clouds -> can't be processed
  - dedicated "homogeneity" scans with external cloud information?

