EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

SHORT TERM SCIENTIFIC MISSION (STSM) – SCIENTIFIC REPORT

The STSM applicant submits this report for approval to the STSM coordinator

Action number: COST Action CA15211 – 42048, Electronet
STSM title: Dust size distribution profiling with balloon-borne optical particle counters
STSM start and end date: 08/09/2018 to 23/09/2018
Grantee name: Maria Kezoudi

PURPOSE OF THE STSM

This STSM has allowed to participate in an intense field campaign at the National Observatory of Athens' (NOA) atmospheric observatory on the Mediterranean island of Antikythera from 8 to 23 September 2018. The STSM was part of the 5-year multi-national measurement campaign D-TECT (Does TriboElectrification affect our ClimaTe) headed by NOA. This campaign aims to study the impact of the electric field associated with atmospheric dust layers via a host of remote and in-situ instrumentation. The campaign began in May 2014 and was based at the Finokalia research station on the island of Crete. It was since decided to relocate the research station to the remote island of Antikythera which benefits from fewer airspace restrictions (for radiosoundings and drone-based research).

The focus of the mission was on dust particle orientation due to the induced electric field, and the possible modification of dust transport due to charging. This STSM added further measurement capabilities allowing an extended study of the origins and broader impacts of the electric field. During the mission, the following instruments have been deployed on Antikythera: (i) a unique, high-sensitivity solar polarimeter (SolPol) -belonging to the University of Hertfordshire (UH)- for quantifying dust alignment due to the electric fields, (ii) novel radiosondes for in-situ measurements of the dust size distribution, and (iii) a second UH field mill to carry out a calibration of the already present field mill. In addition, the UH sounding equipment was used to launch NOA's balloon-borne electrometers for vertically-resolved measurements of the electric field.

This mission provided an excellent opportunity for training early career researchers from both UH and NOA and tightening existing collaborations between both institutions. All the proposed instrumentation has successfully been set up and properly calibrated. First measurements from all the instruments have been taken and analysed. As no dust events occurred during the period of the STSM, measurements focused on quantifying the clear-sky conditions which are crucial in accurately capturing future dust events. Therefore, the measurements discussed here focus solely on clear-sky conditions, although the operation of the station continues on a daily basis and the next significant dust events are expected to occur in early spring.

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DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

Due to the novelty of the station and the rough terrain, the mission started with determining suitable locations for setting up the sounding station, the balloon filling site as well as the receiving station. The first days on the island were focussed on transporting the equipment to the field site, which was located near the top of a hill, as well as setting up the stations for balloon filling, launching and receiving data.

The following days were spent on setting up the in-situ and meteorological station. On September 12, the field station was equipped with a Cloud Droplet Probe (CDP) (figure 1) as well as a meteorological mast (figure 2). The subsequent days were focussed on training the partners from NOA, who were new to the field of balloon-borne launches. I taught them how to prepare a UCASS launch configuration including filling the balloon, attaching all the equipment and initialising the radiosondes. We also went through the software procedure and got the NOA colleagues familiar with the format of transmitted data.

Figure 1: The CDP at the field station on Antikythera.

Figure 2: The meteorological mast at the field site on Antikythera.

On September 14, the SolPol software was updated to meet the measurement requirements at the station and a final alignment of the instrument was carried out. The cloud-free skies on the 15th of September provided ideal conditions for some first clear sky tests for the SolPol, as well as for testing the field mill operation. A data logger malfunction on the field mill was detected and fixed. The following day we performed the first launch (figure 3) of the electrometer sensor, which was attached to a GRAWmet DFM-09 sonde, used for transmitting GPS, altitude, temperature, pressure and humidity data. The wind speed on the 17th of September reached up to 25 knots while low-level clouds were observed over the station. In these circumstances, it was deemed unsafe to conduct launch and the scheduled electrometer launch was moved to Tuesday 18th September.

On the 18th and 19th of September, two more electrometer launches were performed, whereby the NOA electrometer was launched in tandem with the commercially available GRAW-DFM09 sonde. The DFM09 provided meteorological data (pressure, temperature, humidity), whilst the novel electrometer sonde provided vertically resolved measurements of the electric field. The NOA electrometer sondes have recently been fitted with meteorological sensors, and therefore the meteorological data from the DFM09 will be used in validating the new sensor package. It was the intention to transmit the electrometer data via the DFM09 using the XDATA protocol however a firmware issue was found which could not be corrected on site. For this reason, the two sondes (the electrometer and the DFM09) transmitted separately to two receiving stations, and the electrometer data is still in the process of being decoded. In addition, further clear-sky tests were performed with the SolPol. These measurements verified that the software issues had been resolved. The mount and dome are now operating synchronously via remote control without any technical problems detected so far. TeamViewer was installed, and it is now running, providing remote access to real-time data. No dust events occurred during the time on the island due to strong northerly winds, and short-term forecasts from DREAM predicted the winds to continue beyond the end of the planned campaign. As the island has a small, rocky harbour, the strong winds had caused several ferry cancellations during my stay. Therefore, due to the absence of dust and the potential difficulties in returning home, the inbound trip was moved forward to 20th September.

Figure 3: The first electrometer and radiosonde launch performed on the 16th of September at the field station on Antikythera.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

1) **Electric Field Mill**

One of the campaign's goals was to determine the ambient electric field strength and to quantify the fair-weather Potential Gradient (PG). For this purpose, an Electrostatic Field Meter belonging to UH was re-located from Finokalia, Crete and installed on Antikythera (figure 4). As a synergistic tool to the novel electrometer sensor launches, the field mill data were used as ground truth and comparison for the launches. Figure 5 shows the raw field mill data for the duration of 3 days, between the 17th and 19th of September. The data interval is within 1sec and can be averaged to 1 minute / 5 minutes in order to reduce the spiking effects. It becomes apparent that no significant layer charging occurred during this duration. This can be verified by the absence of dust layers, as derived from (i) the low aerosol optical depth from the sunphotometric data (figure 6) as well as (ii) the PollyXT lidar profiles (figure 7).

Therefore, as expected we observed a typical fair-weather behaviour of the electric field with a mean PG value of 140 V/m. In order to measure dust charging in the future, the field mill operation continues on a daily basis and monitors the PG on the Antikythera site.

Figure 4: The electric field mill belonging to UH as installed at the field station on Antikythera. For security reasons a low fence comprised totally of plastic material surrounded the instrument.

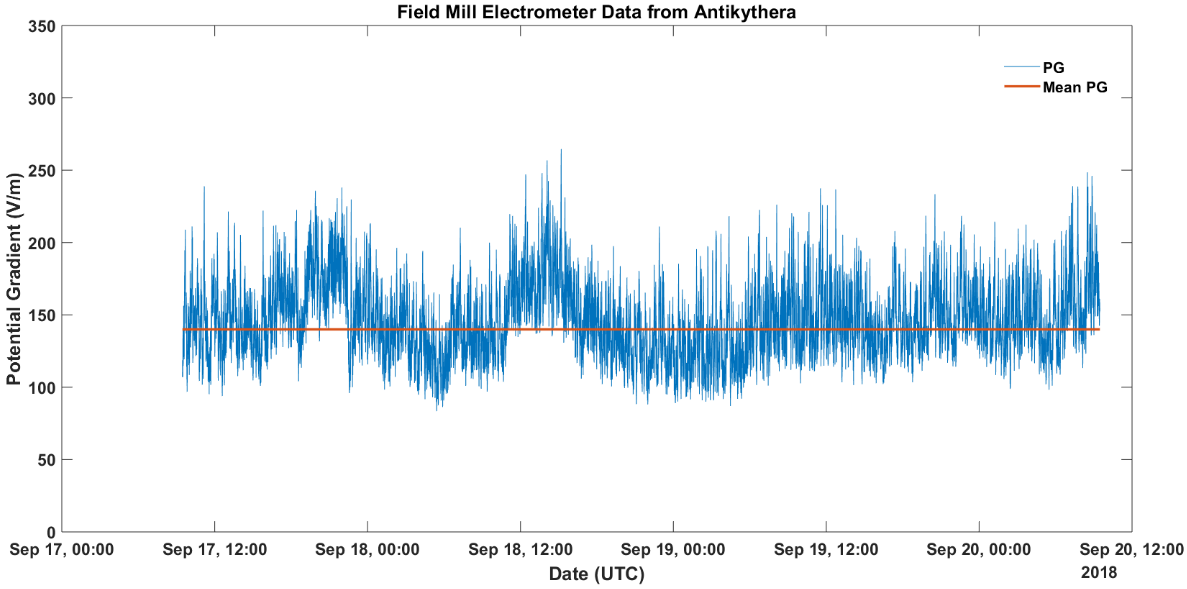

Figure 5: The Potential Gradient (V/m) (blue) and the mean Potential Gradient (brown line) as measured from the electric field mill from 10 UTC on 17 September to 10 UTC on 20th September at the field site on Antikythera. We see some diurnal patterns for the first 3 days, with periodic peaks in the afternoon, followed by troughs overnight. However, to build up a reliable dataset, the field mill will continue to run through the course of the D-TECT project. A dust event would be evidenced by a significant spike in PG corresponding to the edge of a dust layer passing over the field mill. Therefore, remote access to the field mill will allow us to observe the arrival time of dust layers and their spatial and temporal extent as they pass over.

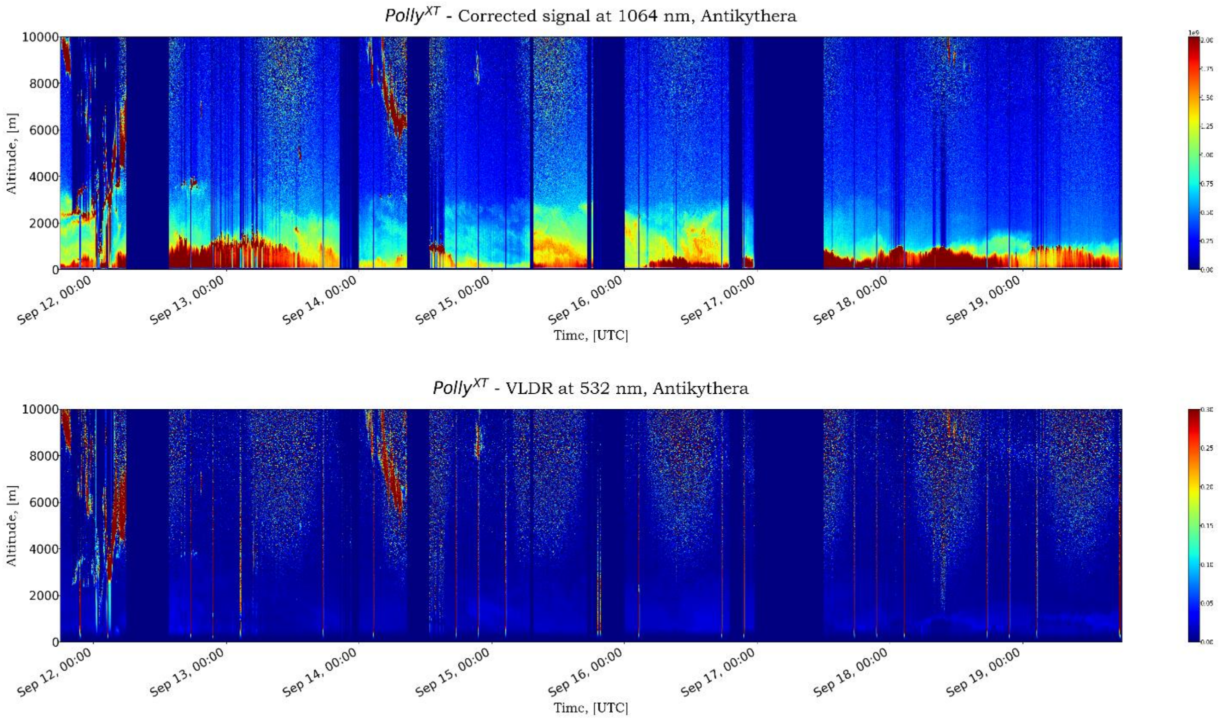

Figure 6: Top: 1064-nm range-corrected signal of PollyXT based at Antikythera from 12 to 20 September 2018, with the blue colours on the colour scale presenting low aerosol concentration while the red colours present high concentration. Bottom: 532-nm volume depolarisation ratio of PollyXT based at Antikythera from 12th to 20th September 2018. The colour scale from blue to red shows the low to high volume depolarisation ratio, respectively. During the course of the campaign, these measurements show the presence of low-level marine aerosol (seen here as low depolarising layers at 1-3 km altitude), and a lack of dust, which would be seen as highly polarising. The figures were kindly provided by Eleni Tetoni (NOA). PollyXT continues to run and quick-looks can be found here http://polly.rsd.tropos.de/?p=lidarzeit&Ort=38.

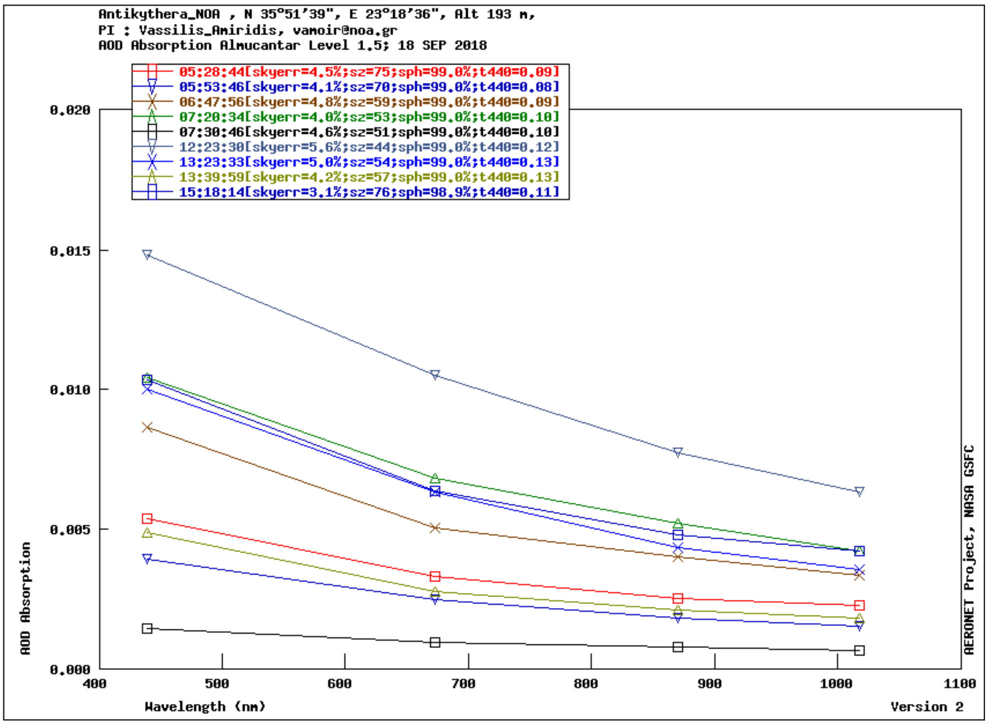

Figure 7: AODs against wavelength (nm) of AERONET sun photometer based at Antikythera as measured from 05:28 to 15:18 UTC (colour scale) on 18 September 2018. Figure taken from https://aeronet.gsfc.nasa.gov. These AODs indicate clean air, as noteworthy dust events typically cause AODs higher than 0.2.

2) **Radiosoundings**

Three electrometer and meteorological sonde launches were conducted during my stay on the island. The data from the GRAW met sensors will be used for validation of the novel temperature and humidity sensors that were attached to the electrometer sensor. The data presented here is solely from the meteorological soundings, as the NOA colleagues are still working on the electrometer data processing.

Figures 8, 9 and 10 show the ascending and descending profiles of temperature and relative humidity (RH) as were retrieved from the GRAWmet soundings. The ascent and descent temperature profiles during the three soundings captured the same variations with respect to height, although some discrepancies in magnitude occur in the humidity sensors. This could be due to spatial non-homogeneity of humidity, or potential sensor issues which will be investigated further. This might be an indication of temperature homogeneity... As can be derived from the temperature measurements, the tropopause over Antikythera is at approximately 12.5 km height (see figure 8 and 9). During the launch on 16th of September, a small temperature inversion was observed at about 3 km height (figure 8). This inversion might be an indication of the top of the humid layer (i.e marine aerosols) as can also be seen in figure 10 and also derived from the humidity data. Above 3 km height, a column of very dry air was detected up to 7 km, with RH from 10% to 25 %. This characteristic layer of dry air between 3 and 7 km height can also be seen in the second and third launches (figure 9 and 10).

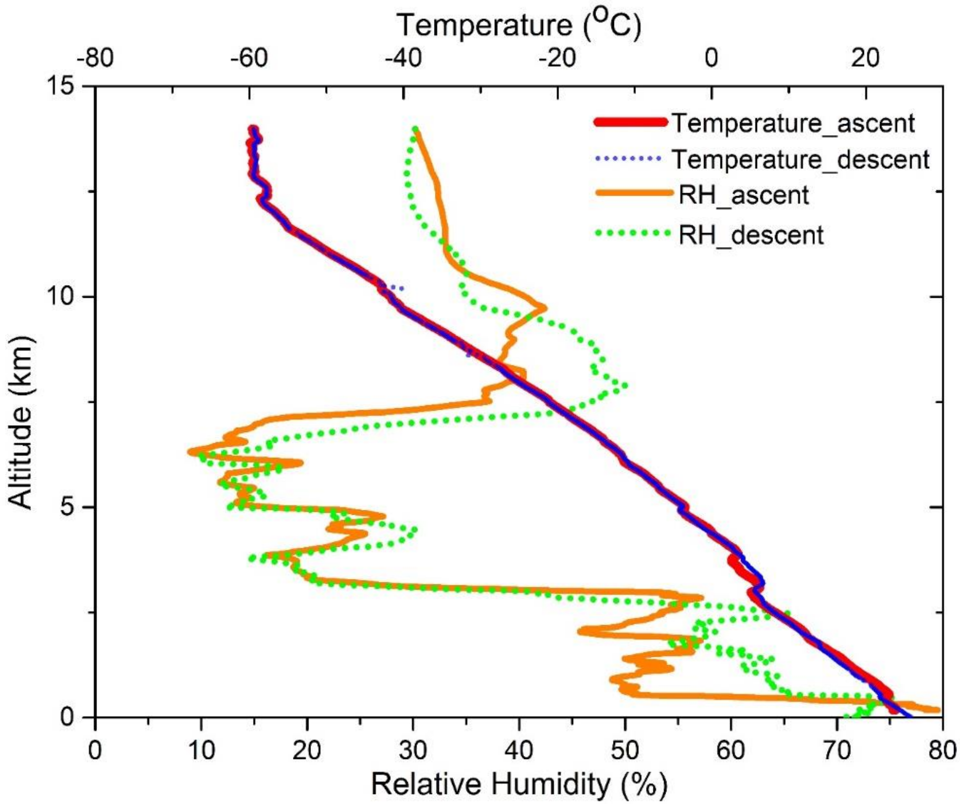

Figure 8: Temperature and RH profiles derived from the sounding at 1700 UTC on 16 September 2018. The ascent and descent profiles capture the same vertical variation in both humidity and temperature. The meteorological data will be used to assess the new sensor package added to the NOA electrometer sonde, however the data is still being decoded.

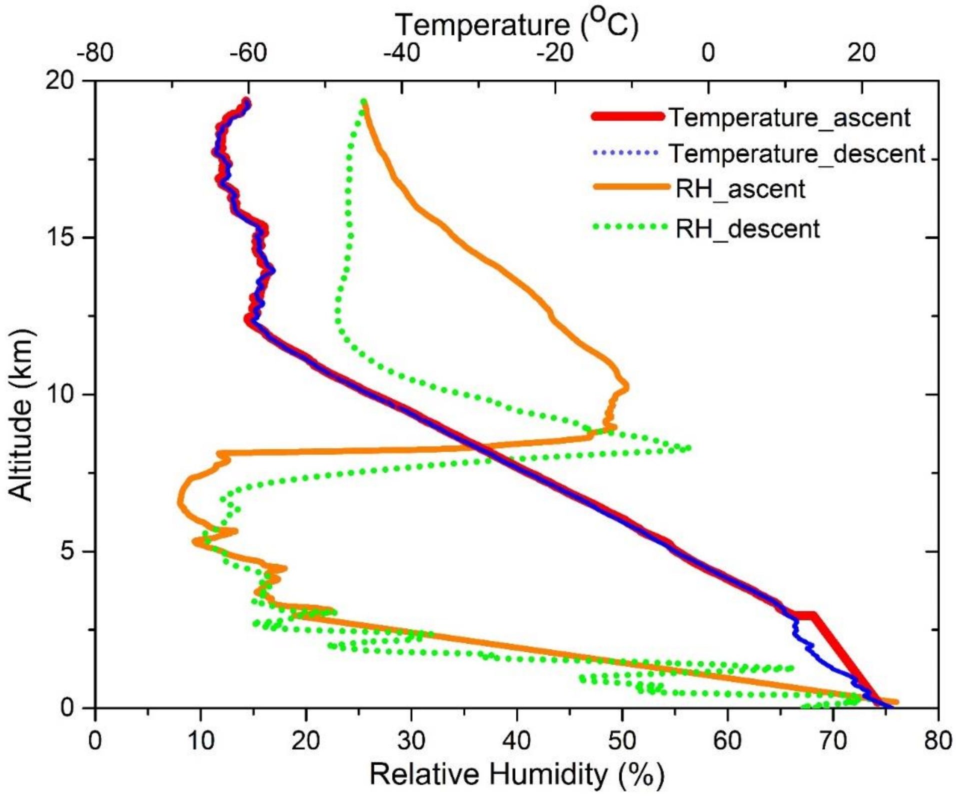

Figure 9: Temperature and RH profiles derived from the sounding at 1700 UTC on 18 September 2018. The ascent and descent profiles capture the same vertical variation in temperature, while RH profiles show some discrepancies above 10 km height.

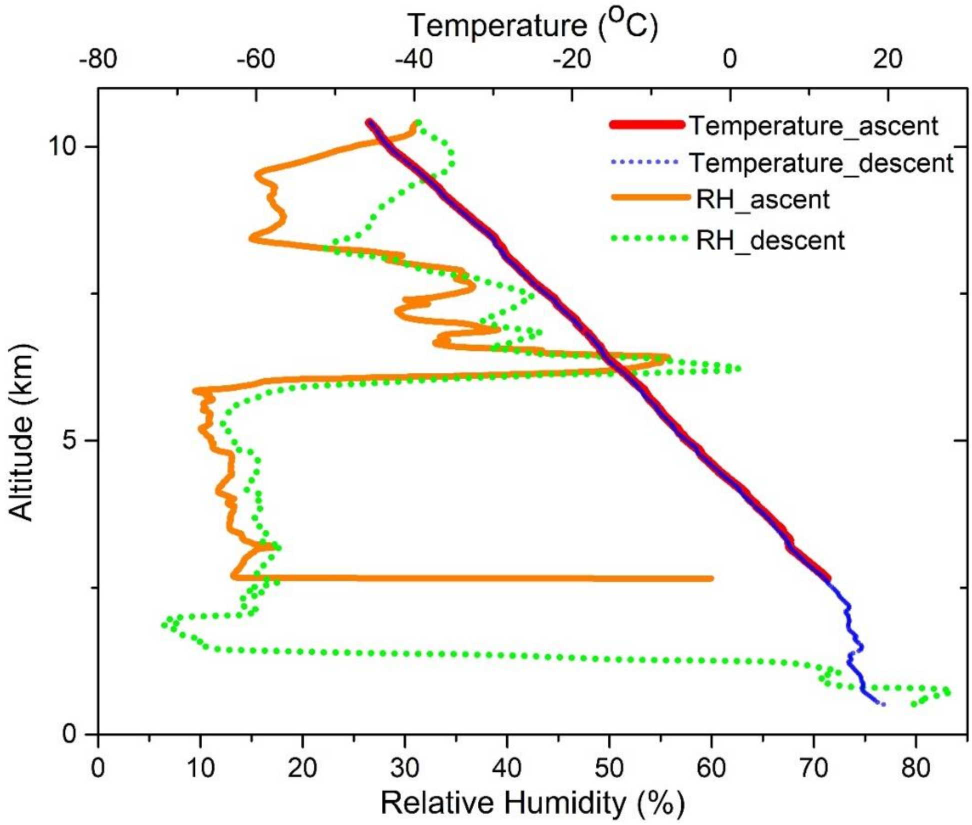

Figure 10: Temperature and RH profiles derived from the sounding at 1630 UTC on 19 September 2018. The ascent and descent profiles capture the same vertical variation in both humidity and temperature.

3) SolPol

The cloud-free skies on the 18th and 19th of September provided ideal conditions for some clear-sky tests for the SolPol, when sixteen-minute sequence was conducted. After the data was deemed reliable, measurements were continued for 1-hour. The most reliable measurement for the SolPol alignment and background was taken on September 18th. This was verified by the signal level on the photodiode matching the anticipated value. The measured signal also agreed with the clear sky background data. Therefore, the large detector signal(>2V) on the 18th suggested the satisfactory operation of the instrument. The periodic variations in the data (figure 11) shows that the tracking was adequate for the purpose of these measurements.

Further measurements were also taken on September 21st (in my absence), when a thin/low concentration layer of fine particles (potentially smoke from Sardinia) was detected over the island. On that day, the SolPol continuously measured for 2 hours. In addition to that, a sixteen-minute measurement was taken at low zenith angles. The interesting feature from these measurements (figure 12) is the increase in polarisation (~1 order of magnitude), compared to the polarisation magnitude measured on the 18th of September (under clear sky conditions) (figure 13).

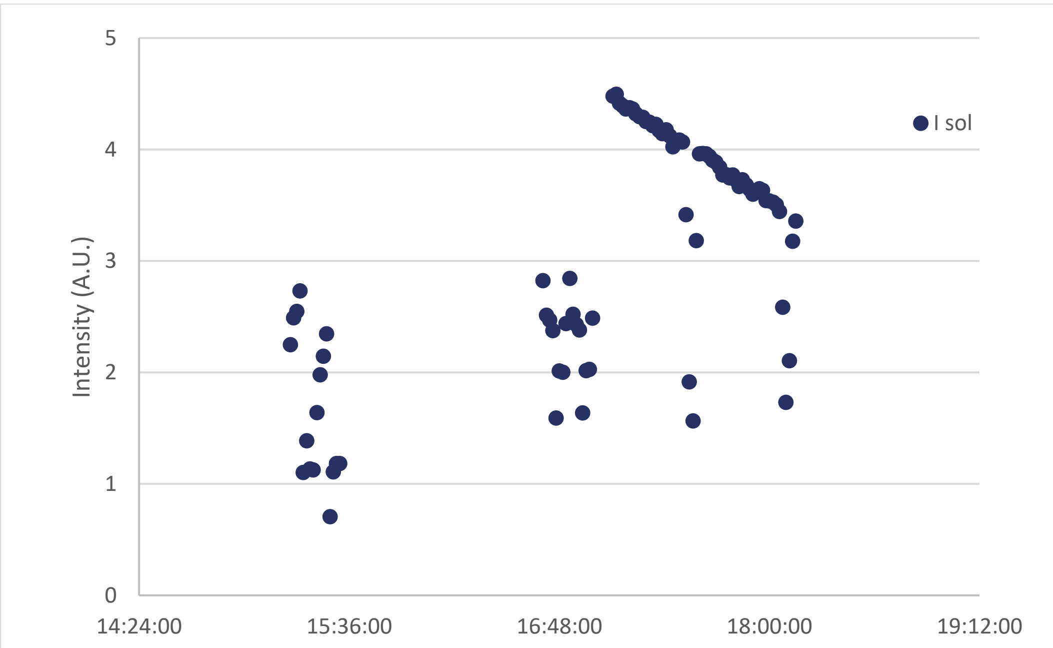

Figure 11: SolPol measured intensity on 18th September 2018. The periodic variations in the I Sol measurements is an indication that that the tracking was adequate for the purpose of these measurements.

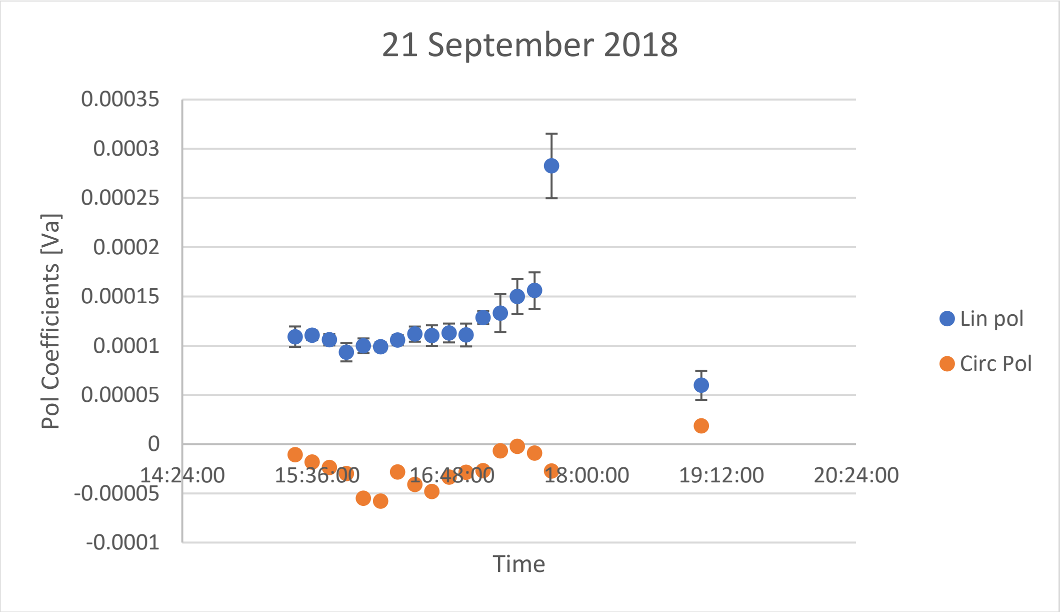

Figure 12: SolPol linear and circular polarisation coefficients, measured on September 21st 2018. The SolPol continues to run and higher polarisation coefficients will be expected in the presence of aligned particles. The collection of clear-sky data is crucial in correctly quantifying the background signal - particularly because the new site will have influence from sea surface reflections. The field mill and PollyXT should notify us of the arrival of dust plumes, and the SolPol should give us quantitative information about the alignment of the particles.

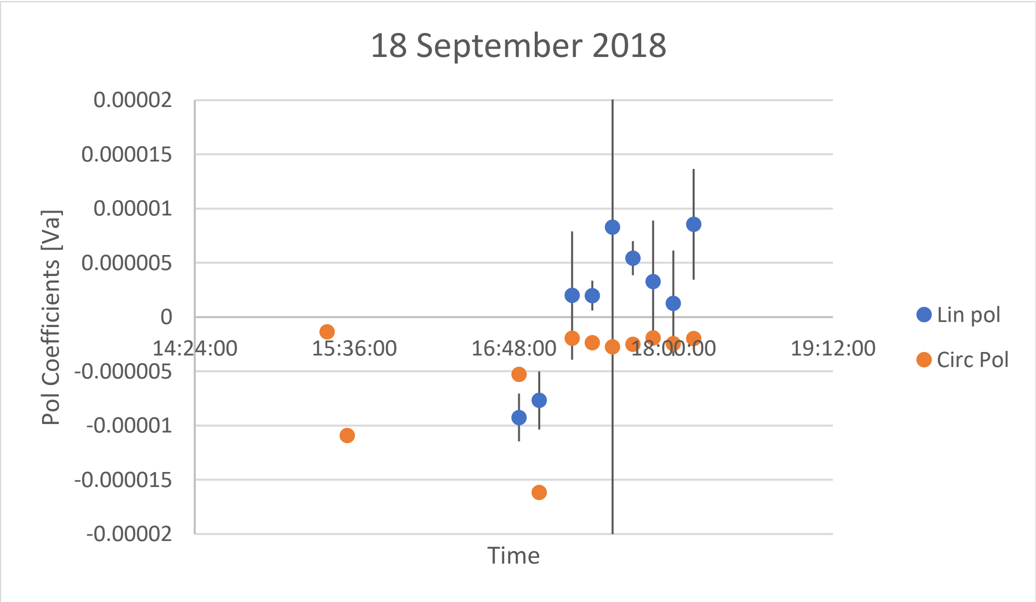

Figure 13: SolPol linear and circular polarisation coefficients, measured on September 18th 2018. It can be seen that during clear sky conditions, the polarisation coefficients can vary and the background can be quite noisy. Therefore, the SolPol will be run frequently to build up a reliable background dataset, ensuring that when dust arrives, the signal to noise ratios are low enough to retrieve meaningful data.

FUTURE COLLABORATIONS (if applicable)

The mission was an excellent opportunity for me as well as the NOA team to familiarize ourselves with the diverse range of instruments and techniques and transfer knowledge between early career researchers. The collaboration between UH and NOA will continue with exchanging data and working together on the analysis of the measurements retrieved from the instrumentation (SolPol, electric field mill, electric sensors, UCASS, CIMEL sun-photometer, CDP and in situ filter samples) on Antikythera for at least the duration of the D-TECT campaign (scheduled to run until 2021).

I also provided the NOA colleagues with a couple of UH UCASS units, meteorological radiosondes and the UH sounding equipment so that future dust events could be covered in my absence. A combination of model results and local observations allow us to anticipate forthcoming dust plumes; in this case we will have video calls/meetings to arrange a launch in coordination with NOA colleagues. The UH team will also participate in the upcoming intensive field campaigns on Antikythera in the framework of D-TECT, organised by NOA. For that purpose, during this STSM mission, a site survey was carried out to select suitable locations for operating UH's UAVs (fixed-wing and multicopter airframes).

Acknowledgment

1) **STSM Committee**

2) **NOA collaborators - Dr Vassilis Amiridis, Dr Alexandra Tsekeri, Dr Nikos Kalivitis (University of Crete), Ms Vassiliki Daskalopoulou, Ms Anna Gialitaki, Ms Eleni Tetoni, Mr Thanasis Georgiou.**