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# METEOROLOGY AND AIR POLLUTION AT A COASTAL SITE - EXPERIMENT AND MODELING

*E. Batchvarova[1], C. Calidonna[2], D. Barantiev[1], H. Kirova[1], E. Georgieva[1], M. Kolarova[1], E. Hristova[1], D. Syrakov[1], M. Prodanova[1], I. Ammoscato[2], E. Avolio[2], D. Gulli[2], T. Lo Feudo[2], C. R. Torcasio[2], E. Chianese[3], A. Riccio[3]*

[1]National Institute of Meteorology and Hydrology - BAS, Sofia, Bulgaria
[2]Institute of Climate and Atmospheric Science- CNR, Lamezia Terme, Italy
[3] Università degli Studi di Napoli Parthenope, Napoli, Italy;

**Abstract**: We present here results of an experimental campaign performed in October 2016 in Ahtopol (Bulgaria) in the context of Exchange program between ISAC-CNR and NIHM-BAS research centres. The aim of the campaign was to collect aerosols in the coastal area, together with physical parameters; to consider air-masses circulation from meteorological output and to demonstrate that for some period Ahtopol and Lamezia Terme sites are in the same system. Evidence of aerosols circulation is also given by using HYSPLIT model for a better understanding of pollution sources also by chemical analysis form wet and dry deposition and filters from impactor.

***Key words:*** *coastal studies, aerosols, air pollution, HYSPLIT, sodar measurements, wet-deposition chemical analysis*

## INTRODUCTION

Coastal dynamics is a challenging topic not only for physical processes capturing but also for phenomena related to aerosols exchanges and transport.

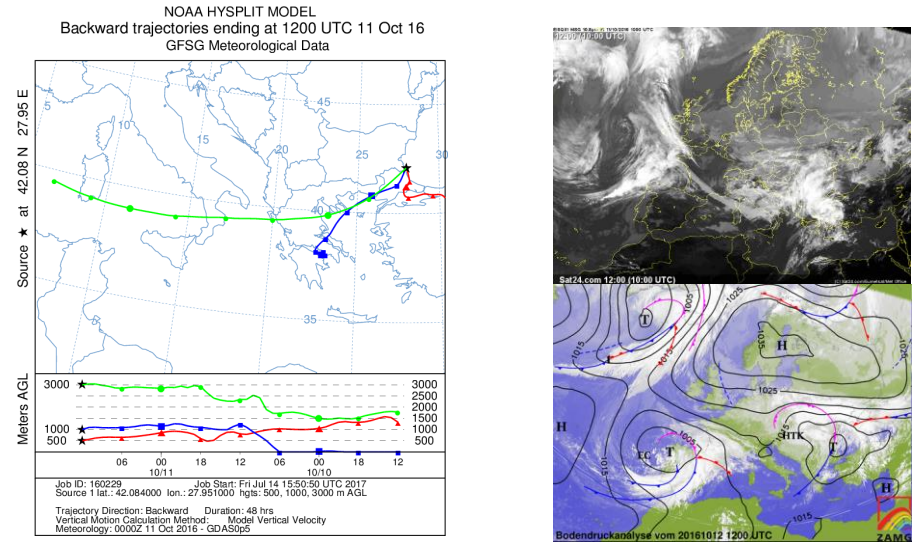
Previous studies characterising air masses dynamics (Kirova et al, 2016; Lo Feudo et al, 2016a and 2016b) were conducted by the two groups in the frame of Project CNR-BAS (2013-2015). As part of a new bilateral cooperation between NIMH-BAS and ISAC-CNR focussed on aerosols, a complex experimental campaign was performed at Ahtopol, Bulgaria during the period 11 - 15 October 2016. The cooperation aims to harmonize the meteorological and air quality studies at marine coastal sites in Bulgaria and Italy using both modelling and measurements. The observation programme of the experiment included in situ and remote sensing equipment to capture both physical and chemical parameters. The investigated period was characterized by fast changing synoptic conditions at Ahtopol, which is an additional difficulty in modelling the complex meteorology in coastal areas. Here we compare data from different instruments and analyse the observed synoptic circulation. Furthermore, results from chemical analysis show air pollution transported by specific wind direction.

## EXPERIMENTAL SET-UP AND AIR MASSES CIRCULATION

The meteorological observatory of Ahtopol is located in the south-eastern part of the Bulgarian Black Sea coast region (42° NE and 18° ), which is 80 km south-east of Burgas. The site is about 400 m inland and 30 m height above the sea level located primarily in flat grassland. The coast line is stretching out from NNW to SSE with a steep about 10 m high cost. At Athopol the flow regime is characterized by several types of breeze circulation, days with strong synoptic flow and no breeze circulation and combined regional and local forcing situations. During the campaign in Ahtopol for the whole period were running:

- MFAS SCINTEC SODAR for wind speed and direction and turbulence profiles in the layer 30-600 m above ground;
- Impactor collecting mass concentration measurements of filter samples for PM10 on Teflon filters to reduce humidity perturbation;
- AEROCET 531 a laser particles counter measuring aerosol concentration (number particles/litre) fractions PM 5 and PM 0.5.

In addition, samples of wet and total deposition were collected.

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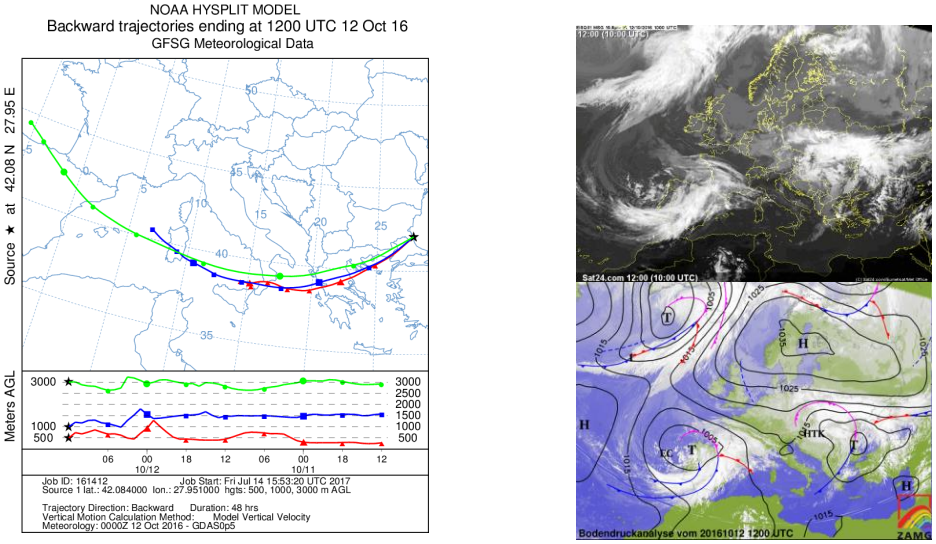


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**Figure 1** Air masses circulation through HYSPLIT (left), Satellite and synoptic charts (right) on 11 (upper panels) and 12 (lower panels) October 2016

According the synoptic charts and satellite pictures in Fig.1, Ahtopol and Lamezia Terme fall in the same circulation system during first days of the campaign. Back trajectories run with HYSPLIT for a period of 2 days at heights 500, 100, 3000 m agl confirm conclusions from synoptic analysis – on October 11and 12 (rainy period) flow was from SW in altitude and on the first day only SE at 500. Back trajectories at 3000 m show air masses coming from west, same crossing Lamezia Terme, and lower from Greece and Turkey during first day campaign (11 October 2016). The situation was in evolution during the following days, and in particular on 12 October 2016, air masses at different heights crossed South Mediterranean regions Italy (Lamezia Terme) and Greece.

## EXPERIMENTAL RESULTS

In this section we discuss experimental results considering physical parameters and aerosols analysis.

**Physical parameters measures and analysis**

Diurnal variability of wind in height (Fig. 2), measured by MFAS sodar, showed that predominant winds were from SW, W for the first 2 days of the experiment, E, SE winds in the afternoon hours on 13 Oct (13-19 EEST) changing to westerly winds in the evening and N and NE winds on 14 Oct (all day long) and in the morning hours on 15 Oct and above 250 m for the rest of the day (below that height winds were from W). On the base of hind cast performed by SWAN (Simulation WAves Near Shore) wave model using the ALADIN operational atmospheric model input data, the sea state (on 12 and 13 October) was with wave force 4 (WMO scale) i.e. 1.25-2.5 m significant wave height. During the rest of the experimental period the sea state was below wave force 4 (Galabov et al. 2015).

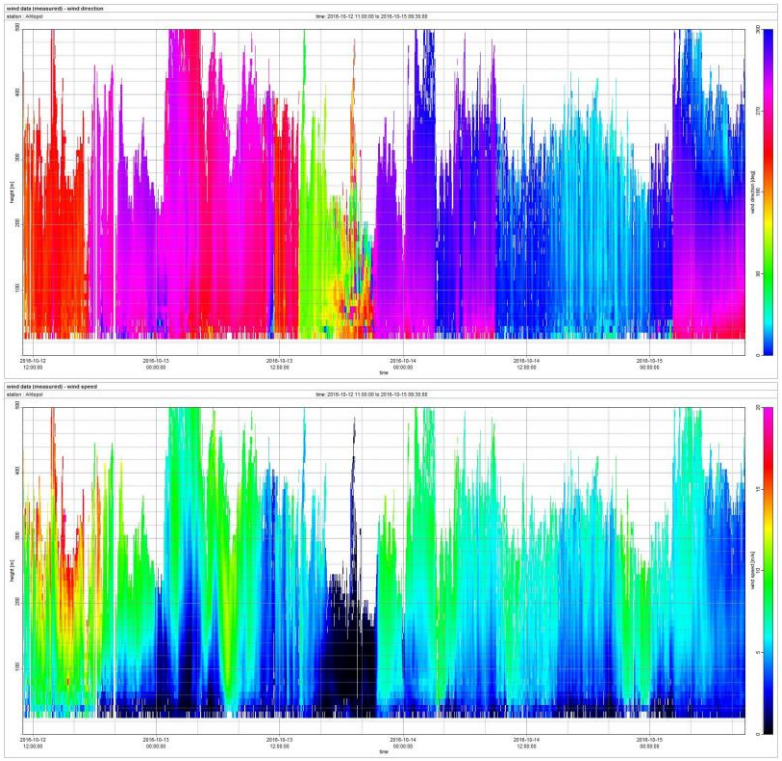

**Figure 2** WD (upper panel) and WS (lower panel) for entire observation period measured by MFAS sodar (UCT+2)

During the campaign, according to deposition measurements we identify Wet Periods (WP1 – 11 October) and WP2 (12 October) and Dry Period (DP – 13 - 15 October), see Fig. 3. During WP1 10-m winds were from SW quadrant. The average WS for WP1 was 3.2 $ms^{-1}$, as the strongest winds were from SW. During WP2 prevailing winds (at 10 m) were from SW quadrant, ESE and ES occurred as well, but the strongest winds were from SE. The average wind speed for entire period was 3 $ms^{-1}$. During dry period winds (at 10 m) were from SW and NE quadrant, and the strongest winds were from N and NNE.

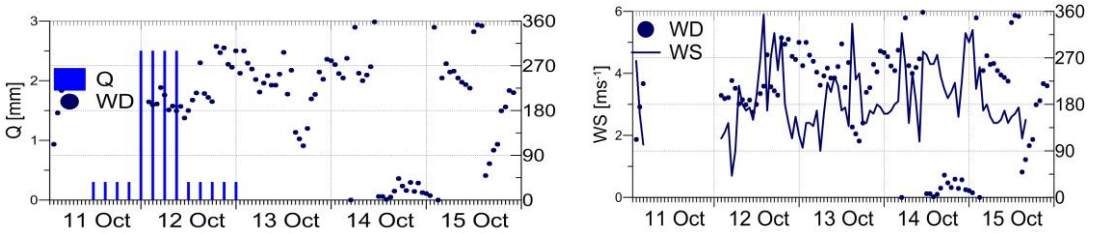


**Figure 3** Three-hour-accumulated precipitation (Q) and WD at 10 m (left); WS and WD at 10 m (right), measured by automatic anemometer MS&E – Wind2 (EEST=UTC+3)

**Aerosols measures and analysis**

Aersols (PM10) were collected with impactor. A Teflon filter was used to avoid humidity influences on the sample. Average of air sampling volume was 15.4 $m^3$ and sampling time 1063 min per day. In Fig. 4 the PM10 concentration in each filter is presented. In average, the weight is 12.72 $\mu g/m^3$.

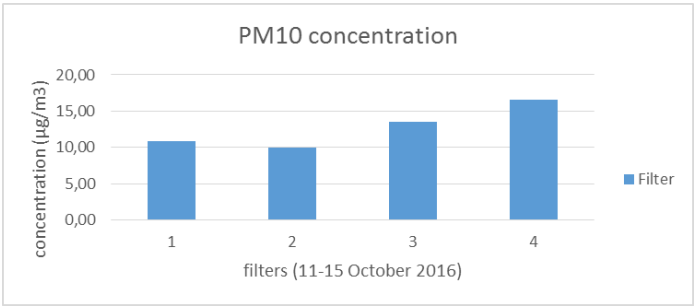


**Figure 4.** Aerosol concentration in samples (filters) from 11 to 15 October 2016

Filter two for PM10 showed smallest concentration of particles, sampled from 18:00 on 12 October until 17:00 on October 13 – aerosol concentration of 9.94 $\mu g/m^3$, while the highest aerosol concentration of 16.55 $\mu g/m^3$ was observed in sample 4, the night 14 to 15 October, associated with northerly flow during the first hours and later in height and then and westerly flows (Fig. 2) – possible plume from Burgas.

**Chemical analysis: deposition and impacted filters**

Chemical analysis of collected wet and dry deposition and impacted filters was performed and the results are shown in Fig.5. Figure 6 shows that the relative contribution of major cations and anions in the PM10 filters. $Na^+$ has the major contribution due to the impact of sea-spray during campaign, as well as $Ca^{2+}$ and $Mg^{2+}$. The presence of ions as ammonium, nitrate and sulphate indicate the influence of secondary processes forming particulate matter.

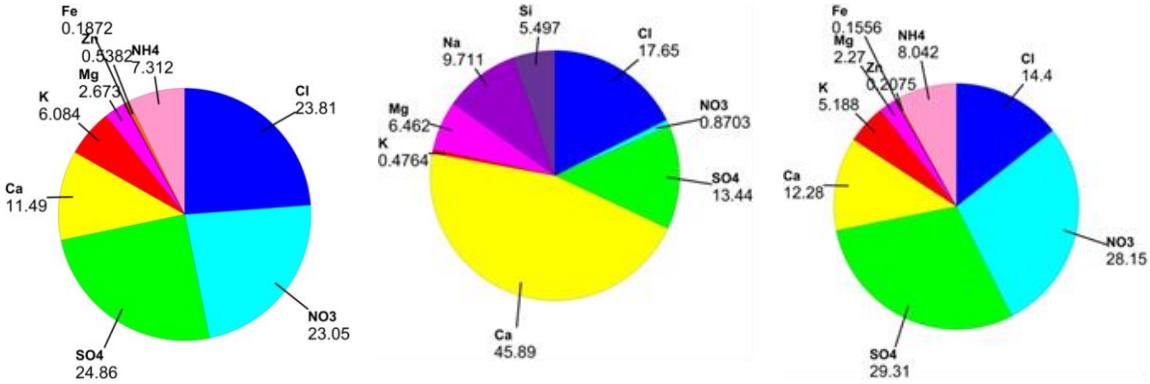


**Figure 5.** Relative contribution [%] of major cations and anions if wet (left panel), dry (middle panel, pH=6.4) and bulk (right panel, pH=4.4) deposition

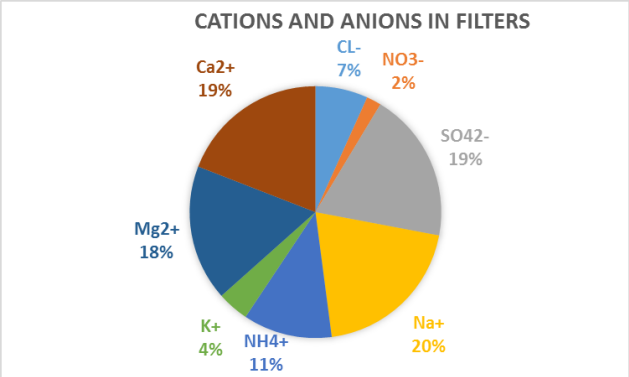


**Figure 6.** Relative contribution of major cations and anions in filters percentages.

## CONCLUSIONS AND FUTURE WORK

Measurements, analysis and HYSPLIT trajectories for the Ahtopol experimental campaign during 11-15 October 2015 are discussed. The period was characterised by highly variable conditions altering wet and dry periods, and different synoptic situations. During the wet periods Lamezia Terme and Ahtopol were in the same low-pressure system.

The measured number of particles followed sharply the wind direction changes, with lower numbers of coarse grain particles for marine air masses, and higher number of particles for flow from the land. The chemical analysis of filters showed a difference in chemical composition of marine and land air flows.

These observations will be used for comparison with the chemical weather forecast of NIMH for the coastal region.

## ACKNOWLEDGEMENTS

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