# 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

Here we present 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 centers. The aim of the campaign is 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 circulation system. Evidence of aerosols circulation is also given by using HYSPLIT model for better understanding of pollution sources. Chemical analysis of wet and dry deposition and filters from impactor was performed.

## Experimental set-up and air mass circulation

The meteorological observatory of NIMH at Ahtopol is located in south-eastern part of the Bulgarian black sea coast region (42.084 N and 27.951E ) (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 coastal line stretches out from NNW to SSE with a steep about 10 m high rocks. 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. Previous studies characterising air masses dynamics at Ahtopol are given in Kirova et al, 2016; Lo Feudo et al, 2016a and 2016b.

During the experimental campaign in Ahtopol the following measurements and methods were running:

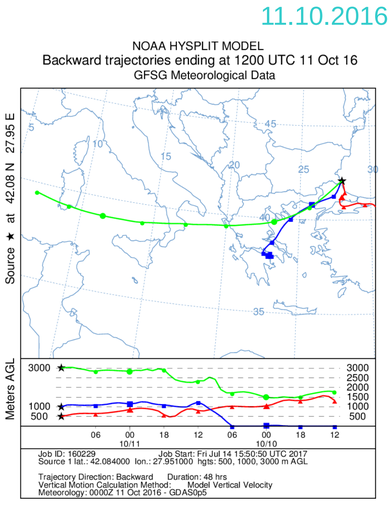
**MFAS SCINTEC SODAR** for wind speed and direction and turbulence profiles in the layer 30-600 m above ground;

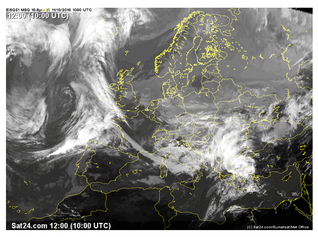
**IMPACTOR** collecting mass concentration on filter samples for PM10; Teflon filters were used to reduce perturbations due to high humidity;

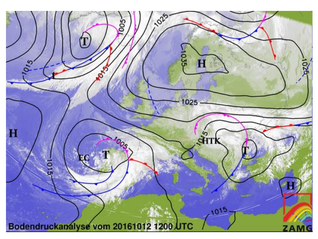
**AEROCET 531** (a laser particles counter) measuring aerosol concentration (number particles/liter) fractions PM5 and PM0.5

**SAMPLES** of wet and total deposition were collected.

11.10.2016




According the synoptic charts and satellite picture, Ahtopol and Lamezia Terme fell in the same circulation system during the first days of the campaign. Back trajectories ran with HYSPLIT for a period of 2 days at heights 500, 100, 3000 m agl confirmed conclusions from synoptic analysis – 11-12.10.2016 (rainy period) flow from SW in altitude and on the first day only SE at 500 m. Back trajectories at 3000 m showed air masses coming from west, crossing Lamezia Terme, and lower from Greece and Turkey during first day of the 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.

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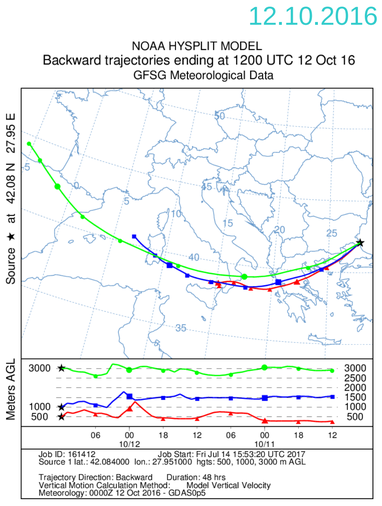
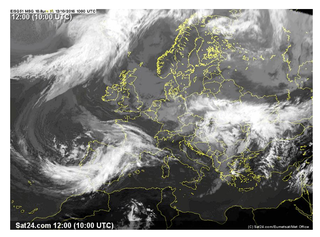
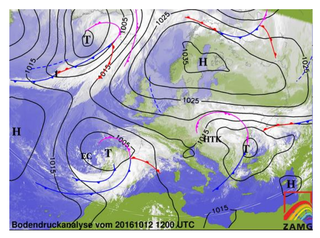
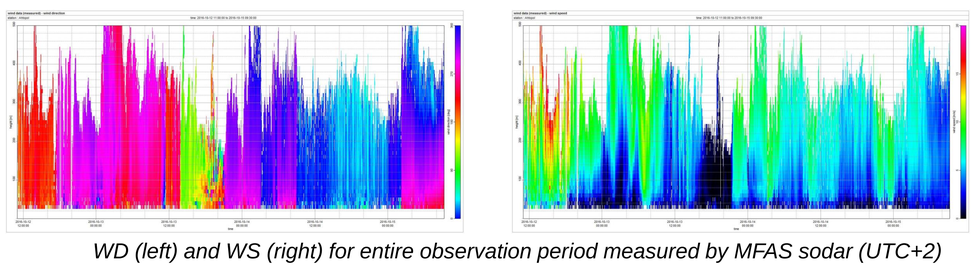


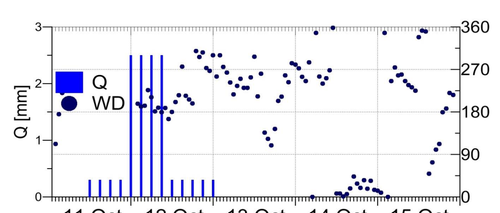



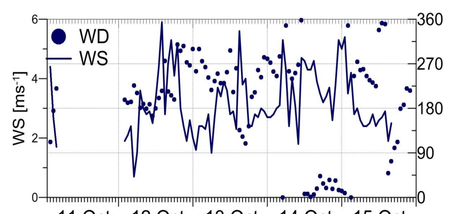




## Analysis of measured physical and chemical parameters



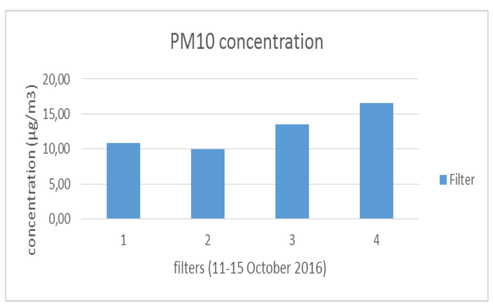
*WD (left) and WS (right) for entire observation period measured by MFAS sodar (UTC+2)*



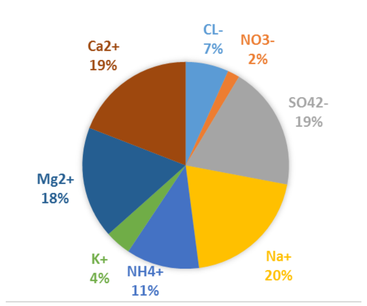




*3-h accumulated precipitation (Q) and WD at 10 m (left); WS and WD at 10 m (right), measured by MS&E – Wind2 (UTC+2)*

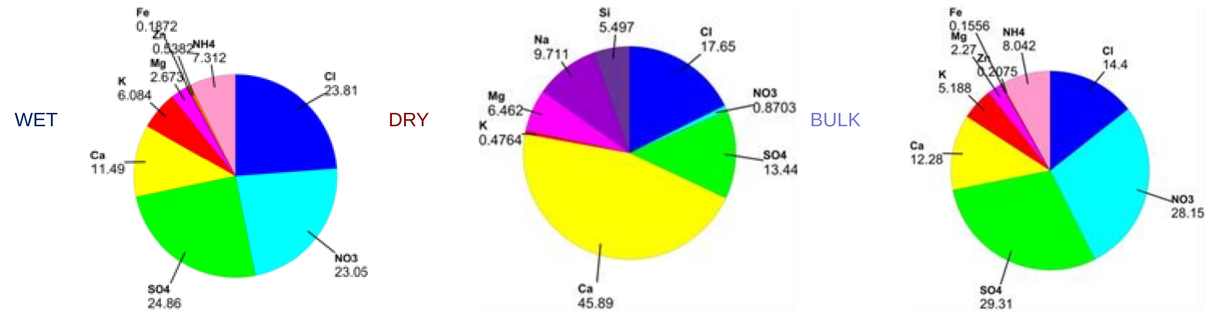
Diurnal variability of wind in height, measured by MFAS sodar showed that predominate winds were from SW, W for the first 2 days of the experiment, E, SE winds in the afternoon hours on 13 October changeing to westerly winds in the evening and N and NE winds on 14 October (all day long) and in the morning hours on 15 October and above 250 m for the rest of the day (below that height winds were from W). On the base of hindcast 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).




*Aerosol concentration in samples (filters) from 11-15.10.2016*




*Relative contribution of major cations and anions in the PM10 filters*




*Relative contribution [%] of major cations and anions of wet, dry (pH=6.4) and bulk (pH=4.4) deposition*

Aerosols (PM10) were collected with impactor on teflon filters. Average of air sampling volume was 15.4 $m^3$ and sampling time 1063 min per day. The average mass concentration was 12.72 $\mu g/m^3$. **Sample 2** for PM10 showed the smallest concentration of particles, sampled from 18:00 on 12 October until 17:00 on October 13 – aerosol concentration of 9.4 $\mu g/m^3$. 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 westerly flows– possible plume from city of Burgas (80 km away from Ahtopol). 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 sulfate indicate the influence of secondary process forming particulate matter.

The concentrations of analysed elements in wet samples followed the next order: $SO_4^{2-}>Cl^->NO_3^->Ca>NH_4^+>K>Mg>Zn>Fe$. In the dry sample the measured concentrations followed the order: $Ca>Cl^->SO_4^{2-}>Na>Mg>Si>NO_3^->K$. The influence of the soil resuspension is obvious (46 % contributions of Ca). The impact of sea-salt aerosol (27 % relative contribution $Cl^-$ and Na) is associated with prevailing wind direction during dry sampling period. The relative contribution of elements in bulk sample followed the order: $SO_4^{2-}>NO_3^->Cl^->Ca>NH_4^+>K>Mg>Zn>Fe$.

## Conclusions and future work

Measurements, analysis and HYSPLIT trajectories for the Ahtopol experimental campaign during 11-15 October 2015 are discussed. The period was caracterised by highly variable conditions alterning wet and dry periods, and different synoptic condition. 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

The study is performed within a bilateral cooperation between NIMH-BAS and ISAC-CNR and the NIMH-BAS project “Study of Atmospheric Boundary Layer (ABL) in coastal areas”. The NOAA Air Resources Laboratory (ARL) is acknowledged for the provision of the HYSPLIT model and READY website (http://www.ready.noaa.gov).

## References

1. Lo Feudo Teresa, Damyan Barantiev, Daniel Gullì, Rosamaria Calaudi, Elenio Avolio, Hristina Kirova, Claudia Roberta Calidonna, Ekaterina Batchvarova, and Anna Maria Sempreviva, A parallel study of costal wind profiles at Ahopol (Bulgaria) and Lamezia Terme (Italy) for wind energy applications using remote sensing data - (ISARS2016) – presentationJournal Article, *Name of Journal*
2. Kirova Hristina, Elenio Avolio, Damyan Barantiev, Ekaterina Batchvarova, Claudia Roberta Calidonna, Teresa Lo Feudo, Daniel Gullì, Rosamaria Calaudi, Valeri Nikolov, Wind field in closed breeze circulation cells: modelling and observations, (ISARS2016) – poster
3. Lo Feudo T. , D. Barantiev , R. Calaudi, E. Avolio, D. Gullì, H. Kirova, A.M. Sempreviva, C. R. Calidonna and E. Batchvarova,, A parallel wind analysis at two coastal sites (tyrrhenian and Black sea) using remote sensing sensors and ground based stations, (6th EnvImeko - IMEKO TC19 – Second Edition Workshop on Environmental Instrumentation and Measurements October 28, 2016, Reggio Calabria, Italy)
4. Galabov, V., Kortcheva, A., Bogatchev, A., Tsenova, B. (2015). Investigation of the hydro-meteorological hazards along the Bulgarian coast of the Black Sea by reconstructions of historical storms. Journal of Environmental Protection and Ecology, vol. 16(3), pp. 1005-1015.