ACM 2017

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S3B Presentation

S3B-1 (Invited Talk)

Original monitoring of ozone and aerosol in continental air masses transported over sea by quasi-Lagrangian drifting balloons: Results from ChArMEx over the Mediterranean and ideas for a transpacific campaign

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This work focuses on balloon-borne measurements from summer regional field campaigns in the western Mediterranean basin performed in the framework of the project ChArMEx (the Chemistry and Aerosol Mediterranean Experiment; 2010-2020; see special issue https://www.atmos-chem-phys.net/special_issue334.html). Due to long-range transport from surrounding continents with contrasted emissions, the lower troposphere over this regional sea is subject to high levels of both aerosols including desert dust and gaseous pollutants such as ozone (O3), with a maximum during the long dry and sunny Mediterranean summer season. Moreover, strong climate change in the region is expected to develop positive feedbacks on pollution levels (e.g., the net decrease in solar radiation by aerosols has been shown to reduce evaporation and subsequently regional precipitation that scavenge aerosols) and the Mediterranean type of climate is expected to expand over a large part of Europe.

Based on developments of boundary-layer pressurized balloons (BLPBs) and dedicated scientific payloads, we were able to perform original quasi-Lagrangian monitoring of O3 and desert dust aerosols over the sea. The strategy included the combination of classical sounding balloons and drifting BLPBs to document both their vertical distribution and long-range transport. Three test flights of a BLPB with O3 measurements, launched in June 2012 from Martigues on the French Mediterranean coast, and a total of 13 BLPBs with O3 measurements and 10 with dust measurements by the new Light Optical Aerosol Counter/sizer (LOAC), launched between mid-June and early August 2013 from Mediterranean islands, namely Minorca (Spain) or Ile du Levant (France), were successfully performed. Drifting altitudes ranged between 0.25 and 3.2 km above sea level for O3 measurements, and between 2.0 and 3.3 for mineral dust. The longest flight exceeded 1000 km and lasted more than 32 h.

We present the drifting balloon and its basic payload, and the instruments developed for ChArMEx: a modified electrochemical ozone sonde and the new optical particle counter/sizer LOAC with dual scattering angle measurements allowing identification of dust particles. Numerous tests and validations were performed, including comparisons with collocated airborne measurements, sounding balloons, and remote sensing measurements.

Ozone levels encountered during the flights were moderate, rarely exceeding 70 ppbv. Data are analyzed to examine O3 diurnal variations in the marine atmospheric boundary layer and in the free troposphere above. By selecting flight segments with the best probability of pure Lagrangian conditions, we report O3 photochemical production in both the boundary layer and the free troposphere, at rates of 1 2 ppbv h-1, significantly lower than those previously reported over land in the same region.

Dust events were relatively frequent but aerosol optical depths in the balloon vicinity did not exceed about 0.4. LOAC data can generally be fitted by a 3-mode lognormal distribution at roughly 0.2, 4 and 30 µm in modal diameter. Concentrations of dust particles larger than 40 μm up to about 10-4 per cm3 are reported and we did not observe any significant evolution of the size distribution during the flights. The presence of such large particles several days after emissions is unexpected given their theoretical sedimentation velocity. An indirect evidence of the presence of charged particles has been derived from the LOAC measurements and we speculate that electrical forces might counteract gravitational settling of the coarse particles.

Over the Mediterranean, the duration of measurements was limited by the size of the basin. However at least 4-5 days of measurements are in principle possible in the present configuration thanks to a programmable on-off procedure to save energy (and electrolyte in the case of O3), allowing, for instance, transatlantic flights from Africa in the desert dust loaded trade-winds. We finally propose to build a collaborative project including the same type of balloon campaign than during ChArMEx within a multidisciplinary project involving modelling groups to study the long-range transport of dust and pollution across the North Pacific and their impact on the regional climate, with a focus on the spring season when highly dusty and polluted air masses are exported from Asia. A preliminary study is conducted to document expected air mass trajectories and the suited duration of measurements. First results suggest that higher BLPB ceiling altitudes than in the Mediterranean, up to 5 km, and that at least 1-wk measurements should be targeted.

S3B-2

High reduction of ozone and particulate matter during the 2016 G-20 summit in Hangzhou by forced emission controls of industry and traffic studied with the observations and WRF-CMAQ model

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Many regions in China experience air pollution episodes because of the rapid urbanization and industrialization over the past decades. Emission controls were implemented in Hangzhou, China and its surroundings (Zhejiang, Shanghai, Jiangsu, and Anhui) to improve air quality during the G-20 2016 Hangzhou summit. This implementation provides an ideal test-bed to study the extent to which both the emission reduction efforts improved air quality in Hangzhou, and an air quality forecast system consisting of the two-way coupled WRF-CMAQ was able to simulate the air quality. Observed air quality (PM2.5 and O3) in Hangzhou during the G-20 summit was considerably better than that before the G20 summit as a result of these emission reductions. The model simulations corresponding to the implemented emission controls agree well with the observations of O3 (correlation (R)=0.73, Normalized Mean Bias (NMB)=4.6%) and PM2.5 (R=0.67, NMB=-8.7%) in Hangzhou. During the G-20 Summit period, the predicted concentrations of O3 and PM2.5 were reduced by 20.1 μg/m3 (or 25.4%) and 20.5 μg/m3 (or 56.1%) in Hangzhou, respectively. These results provide support for use of the WRF-CMAQ model for assessing the impact of emission controls.

S3B-3

Estimating ground-level particulate matter concentrations using satellite-derived aerosol optical depth

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Many epidemiological studies have shown that adverse human health effects can be caused by exposure to atmospheric aerosols. In particular, Particulate Matter (PM) with diameters that are generally less than 10 micrometers and 2.5 micrometers (i.e. PM10 and PM2.5, respectively) can cause cardiovascular and lung diseases such as asthma and Chronic Obstructive Pulmonary Disease (COPD) that leads to diverse morbidity and premature mortality. Air quality including PM has typically been monitored using station-based in-situ measurements over the world. However, spatial limitation exists if in-situ measurements are only considered to provide information on air quality over large areas. An alternative approach is to use satellite remote sensing as it provides data over vast areas at high spatial resolution. The previous studies have shown that ground-level PM concentrations are related with Aerosol Optical Depth (AOD) that is derived from satellite observations, but it is still hard to identify ground PM concentrations directly from AOD. Some studies used statistical approaches for estimating PM concentrations from AOD while some others combined meteorological variables (i.e. temperature, relative humidity, wind speed, wind direction, etc.) or land use/cover variables and satellite-derived AOD. In this study, a total of seventeen variables from multi satellite sensors (i.e. Geostationary Ocean Color Imager (GOCI), Global Precipitation Measurement (GPM), Shuttle Radar Topography Mission (SRTM), Moderate-resolution imaging spectroradiometer (MODIS)), numerical models (i.e. Regional Date Assimilation and Prediction System (RDAPS)), and in-situ measurements were used to estimate ground PM concentrations for both PM10 and PM2.5 based on random forest machine learning over South Korea during 2015-2016. A simple statistical approach, Ordinary least squares (OLS) was also applied for comparison with the machine learning approach. Relatively low concentrations of both PM10 and PM2.5 were dominant in our study area. Thus, over-sampling was conducted to train the random forest model to learn patterns of high PM concentrations well. Among the entire days of the study period, about 20% of days were separated to validate the proposed approach as a prediction model. Samples from the remaining days were randomly divided into training (80%) and test (20%) sets. The random forest model outperformed OLS for estimation of both PM10 and PM2.5. The root Mean Square Error (RMSE) of the random forest model was 18.90 μg/m3 with R2=0.77 and 9.63 μg/m3 with R2=0.73 for PM10 and PM2.5, respectively. AOD, wind direction (U, V), visibility, wind speed, Planetary Boundary Layer Height (PBLH), Day of Year (DOY), and temperature were identified as contributing variables by random forest to estimate ambient PM concentrations in particular, the wind component (i.e., wind direction and speed) was identified as the most contributing variable, which implies that stable air with very weak wind may aggravate air quality.

S3B-4

Aircraft-Based measurement of the physico-chemical evolution of atmospheric aerosols in the air pollution plume over a megacity and a remote area

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Aerosols influence climate change directly (scattering and absorption) and indirectly (cloud condensation nuclei), also adverse health effects. The Korean peninsula is a great place to study different sources of the aerosols: urban, rural and marine. In addition, Seoul is one of the large metropolitan areas in the world and has a variety of sources because half of the Korean population lives in Seoul, which comprises only 12% of the country's area.

To understand the physico-chemical evolution of atmospheric aerosols in the air pollution plume over a megacity and a remote area, an Aerodyne High Resolution Time of Flight Aerosol Mass Spectrometer (HR-ToF-AMS) was deployed on an airborne platform (NASA DC-8 and Beechcraft King Air) in June, 2015 and May-June, 2016 during MAPS-Seoul and KORUS-AQ campaigns, respectively, in Korea. The HR-ToF-AMS is capable of measuring non-refractory size resolved chemical composition of submicron particle (NR-PM1). NR-PM1 includes mass concentration of organics, nitrate, sulfate, and ammonium with 10 seconds time resolution. Organics was dominated species in aerosol during all of flights. Organics and nitrate were dominant around energy industrial complex near by Taean, South Korea.

The presentation will provide an overview of the composition of NR-PM1 measured in air pollution plumes, and deliver detail information about width, depth and spatial distribution of the pollutant in the air pollution plumes. The results of this study will provide high temporal and spatial resolved details on the air pollution plumes, which are valuable input parameters of aerosol properties for the current air quality models.

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