



SIDUAQ



Satellite Information Downscaled to Urban Air Quality in Bulgaria - SIDUAQ

Organisations: National Institute of Meteorology and Hydrology - BAS
Space Research and Technology Institute - BAS

Point of Contact: Prof. Ekaterina Batchvarova
Email: Ekaterina.Batchvarova@meteo.bg, Tel: (+359) 887 507 283

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European Space Agency



Contractor: National Institute of Meteorology and Hydrology at Bulgarian Academy of Sciences (NIMH-BAS)			ESA Budget: 164 k€	
Contract No.: 4000124150 / Proposal: BG2-05			Co-funded Budget: 0 k€	
Year of Contract: 2018			TO: Maite Trujillo (IPL-IPS)	
TRL	Initial: 2	Achieved: X		

Background and justification: The SIDUAQ mission is an important step towards wider use of satellite information within science and society in Bulgaria in the area of air quality management. The existing Bulgarian Chemical Weather Forecasting System (BgCWFS) does not use satellite information presently. SIDUAQ will explore the effect of satellite data assimilation in BgCWFS.

Objective(s): The project aims to use the opportunities given by satellite observations for improvement of air quality management at national and local level in Bulgaria for the **city of Plovdiv**. The goal will be achieved by synergetic use of data from ESA satellites (METOP, Sentinel 5P, etc.), in situ air quality monitoring and air pollution dispersion modeling systems. The results will support local authorities in management of air pollution. The technology created for a particular city could be implemented for other Bulgarian cities, so to meet the air quality (AQ) standards on a sustainable basis.

Achievements and status: The work on SIDUAQ project is progressing normally. An inventory of all data for AOD and aerosol columns available so far from different satellites and instruments for Europe, the Balkan region and the territory of Bulgaria was made and criteria for data selection were elaborated. Data organization tables were formed and a data-set of processed satellite data for model input was prepared. The possibilities for satellite data assimilation in the existing BgCWFS were thoroughly investigated. Schemes of the modifications in the BgCWFS and its components that need to be done so to assimilate the satellite retrieved AOD were done. The website of SIDUAQ was established <http://space.bas.bg/SIDUAQ/index.html>.

Benefits: The primary benefits are that the satellite information for air pollution will successfully supplement the irregular in situ monitoring network in Bulgaria. Its use in air quality model systems will permit forecasting AQ violation episodes for Bulgaria and the city of Plovdiv and will aid state and local authorities to take effective measures for improvement of AQ management.

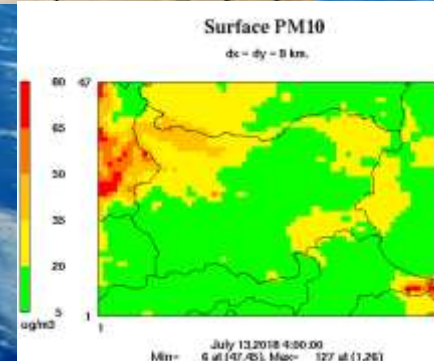
Next steps: Both modelling and observations develop in parallel. The available satellite data are collected and processed in a form suitable for models input. The offline version of BgCWFS is modified so to produce AOD at different model levels to be compared with satellite retrieved AOD. After successful comparison, in the next phase currently available satellite data will be used for air pollution forecasting at different temporal and spatial scales over Bulgaria.

Plovdiv had the most Polluted Air in the Last Heating Season



MODIS Aqua channels 143 and AOD combined from Terra and Aqua

Model results from BgCWFS – domain Bulgaria (9x9km)



Summary of Objectives



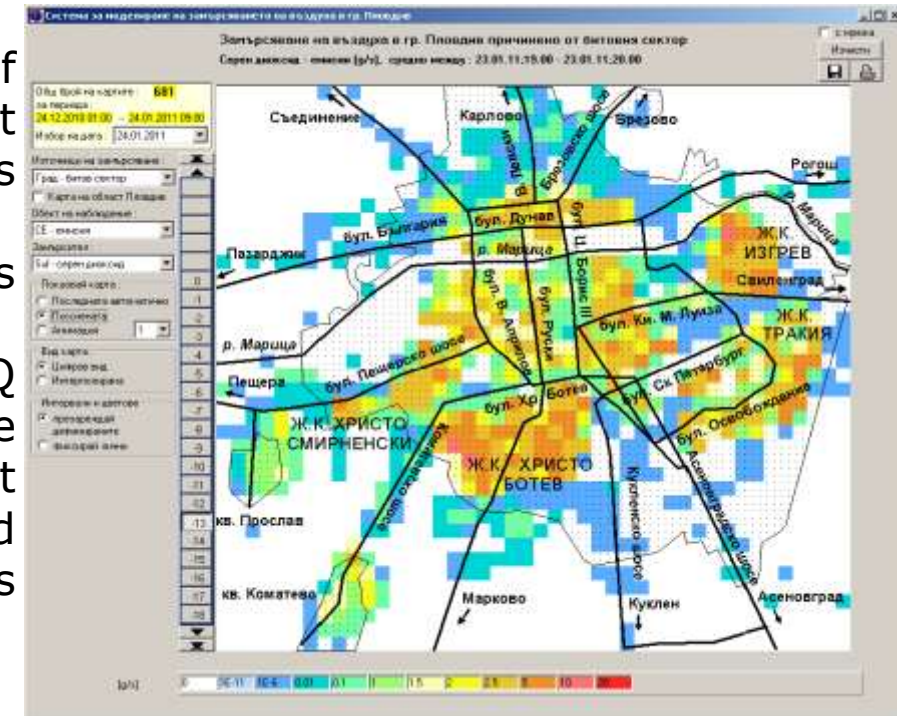
* Satellite information will be used for the first time in Bulgaria for supporting state and local authorities in air quality (AQ) management.

* Analysis and 3 day forecast for air pollution shall be produced by the Bulgarian Chemical Weather Forecast system (BgCWFS), providing hourly AQ maps of AOD and different pollutants (NO₂, SO₂, PM₁₀ and PM_{2.5}) at surface level and profiles over the territory of Bulgaria and Balkan peninsula with resolution 9x9 km.

* The local AQ Management System (AQMS) for the municipality of Plovdiv will be nested into the BgCWFS with resolution 250x250m. It shall produce hourly AQ maps of NO₂, SO₂, PM₁₀ and PM_{2.5} thus giving AQ analysis and forecast up to 3 days ahead.

* The modeled data will be validated on all available measurements from monitoring sites in the city.

* Expert analysis module (post-processing) will produce maps of AQ violations and AQ indexes for Bulgaria, as well as exposure of the population for the city of Plovdiv. The contribution (in %) of different emission sources to the resulting air pollution will be determined and suggestions for proper measures for AQ improvement to local authorities will be proposed.



Contract Schedule



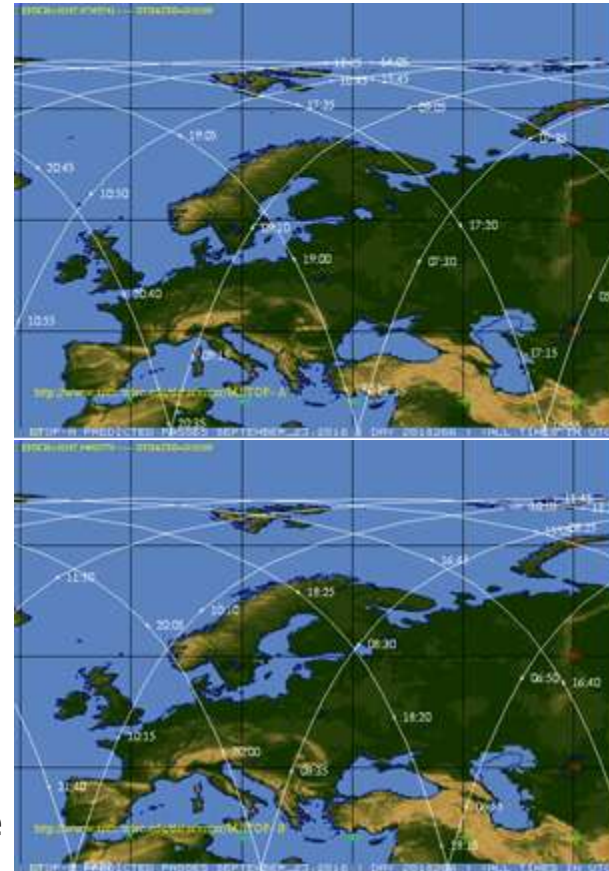
At present, all planned activities are progressing normally and no changes in the GANTT chart are required.

Main Technical Developments – 1

WP 1. The project kick-off meeting was held on July 3rd 2018. It coincided with the Expert Council (EC) establishment and the first contractor-subcontractor meeting (CSM). Project management is running smoothly, 2 CSMs and regular meetings of WPs leaders or members from the institutions are a good way to harmonize the work of both teams. First Progress report and MS1 deliverables were submitted on time by October 15th.

WP 2. To achieve the project goals satellite data for assimilation in the Bulgarian Chemical Weather Forecasting System (BgCWFS) with proper space and temporal resolution were collected. At least one dataset per day with spatial resolution similar to that of the model for as much as possible pollution ingredients (AOD, SO₂, NO₂, PM, etc.) has to be prepared. For results comparison it is necessary to have data from one source during the whole calculation period and, when possible, at the same time for the whole region of interest.

Both MetOp A and B satellites pass over Balkan region every day between 10 and 11 am regional time but on different orbits. In order to obtain better spatial resolution, combination of data from both satellites is proposed to be used.



Main Technical Developments – 2



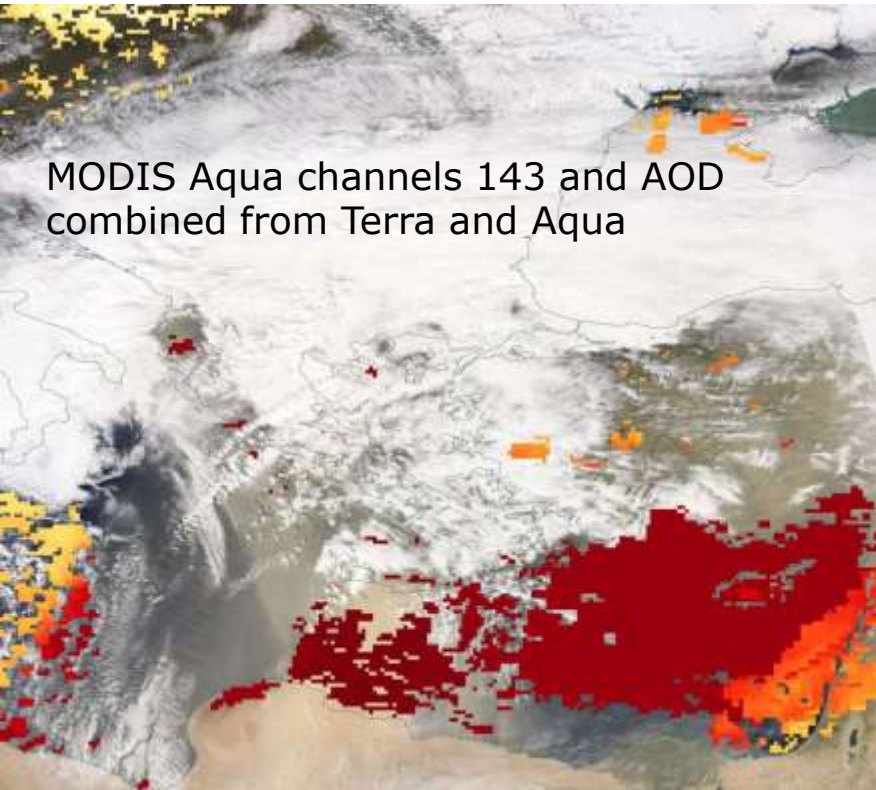
List of instruments and data availability in the first phase of SIDUAQ

Satellite	Sensor	Product	Spatial resolution	Time frequency	Time period
MetOp A	GOME-2	AAI, SO ₂ , NO ₂ , BrO, CHO ₂	40 x 40 km	Every day	2007 - 2013
MetOp B	GOME-2	AAI, SO ₂ , NO ₂ , BrO, CHO ₂	40 x 80 km	Every day	2012 till now
NOAA	OMPS	AAI, SO ₂	50 x 50 km	Every day	2012 till now
Aura	OMI	AAI, AOD	40 x 40 km	Every day	2004 - 2013
Terra	MODIS	Visual image (channels 143)	250 x 250 m	Every day	2004 till now
Aqua	MODIS	Visual image (channels 143)	250 x 250 m	Every day	2004 till now

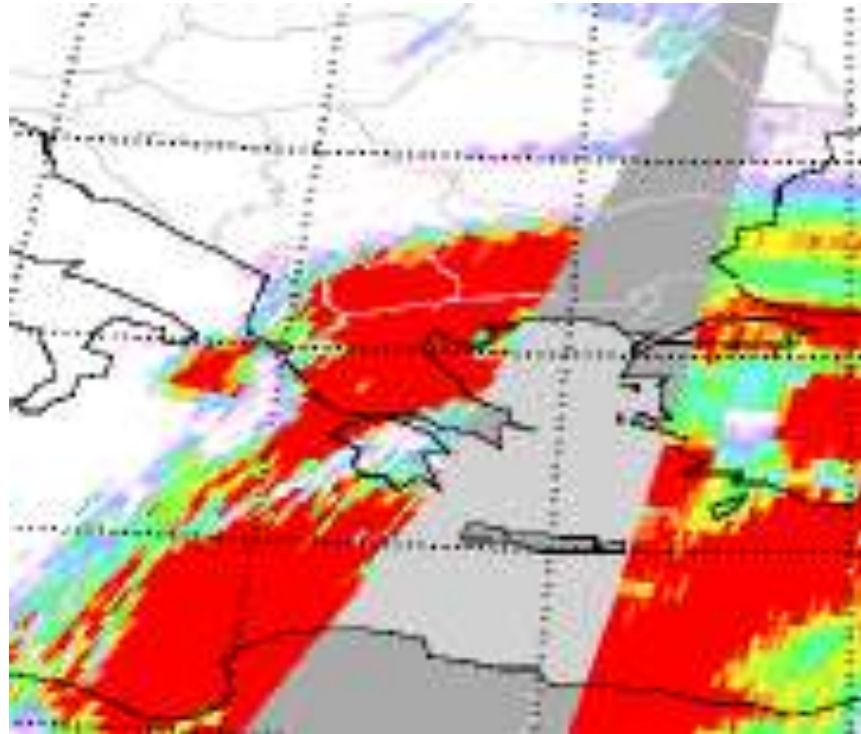
For the first half of 2012 we have data for AAI from OMI, OMPS MetOp A and MetOp B, so it is possible to make comparison between them. Data from MODIS instrument are very good for optical recognizing, comparison and visualization.

Main Technical Developments – 3

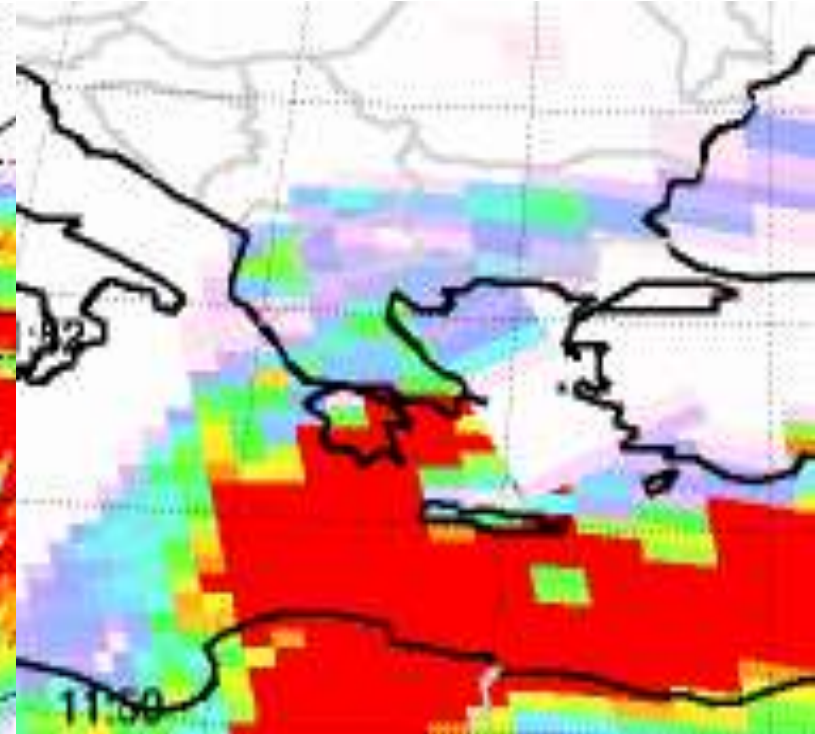
Working on satellite data selection, we have concluded that Aerosol Optical Depth (AOD) product is not very good for the project purposes, mainly because of long cloudy periods over the Bulgarian region. On the other hand, the Absorbing Aerosol Index (AAI) may be used to detect absorbing aerosols over both land and sea surfaces, even in the presence of clouds. The AAI product is derived from the reflectances measured by GOME-2 at 340 and 380 nm.



MODIS Aqua channels 143 and AOD combined from Terra and Aqua



Gome-2 AAI



OMPS AAI.

Data processing:

Data processing consists of the following steps:

1. Collecting data
2. Georeference
3. Extracting data for the area of interest
4. Removing of incorrect data
5. Converting data to needed units and format.

Many events with increased AAI caused by sands blown from Africa are observed even in cases with dense clouds, over the Balkans/ Bulgaria. Such cases could not be registered using only AOD without AAI data.

A	B	C	D	E	F	G
date	18.3.2017					
time	8:01 UT					
Lat [deg]	Lon [deg]	AOD [0÷1]	BrO [µg/cm2]	HCHO [µg/cm2]	NO2 [µg/cm2]	SO2 [µg/cm2]
54.79906	51.43745	0.094924416	0.007554879	0	0.160289204	0
55.129448	50.38017	0.044834754	0.009765197	0	0.173757875	0
55.4584	49.279377	0.074442702	0.008679728	0	0.157587475	0
55.780254	48.14917	0.045811091	0.009744555	0	0.166770862	0.090758312
56.092697	46.9965	0.047518899	0.008249195	0	0.150939959	0.02343055
56.392193	45.831947	0.038433453	0.007679478	0	0.154690551	0.607168418
56.67885	44.656857	0.017597478	0.00775884	0	0.164861013	0

Dataset prepared for model input

Main Technical Developments – 5

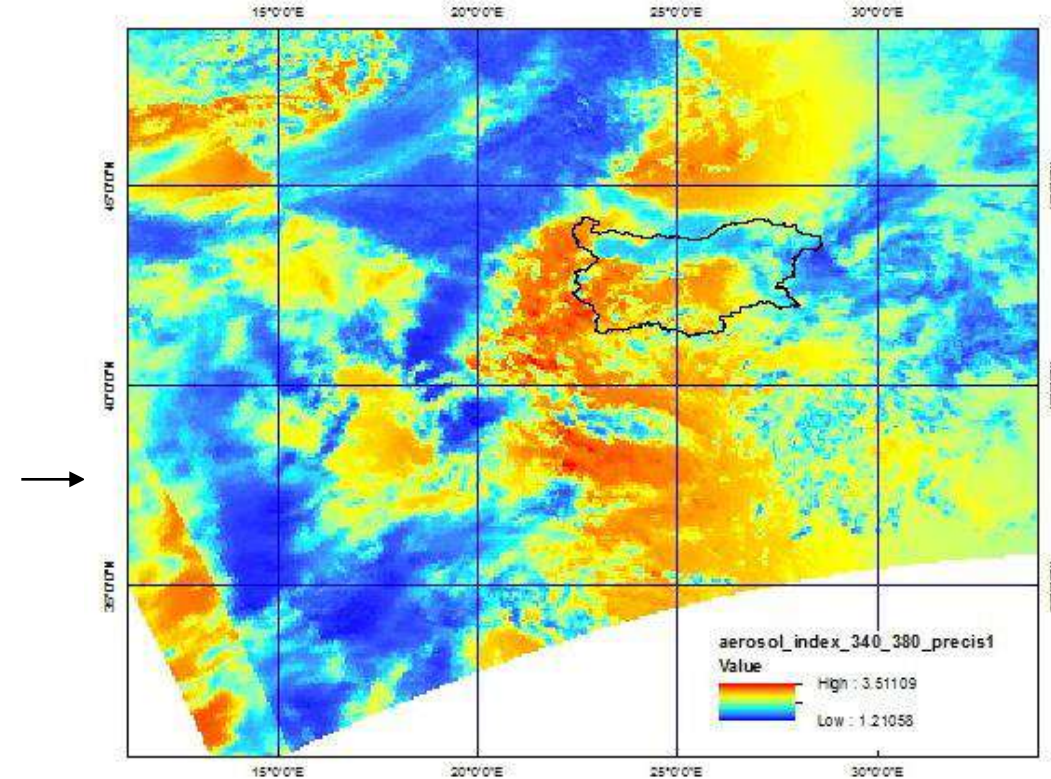
WP 3. Sentinel 5P data set was prepared for input in the BgCWFS.

For the purposes of the project SIDUAQ BG2-05, the **TROPOMI** sensor has a good spatial resolution (for most products 3.5x7km). The list of its characteristics are given on the Table.

Satellite	Sensor	Product	Spatial resolution
Sentinel 5P	TROPOMI	Cloud O ₃ , Total Column O ₃ , Tropospheric Column Aerosol layer height Ultra violet aerosol SO ₂ , NO ₂ , CO, HCHO, CH ₄	Spatial resolution at nadir. For most products this is 3.5x7km, except for "L2__O3__PR", which uses 28x21km and L2_CO and L2_CH4, which both use 7x7km

Aerosol Index 340-380 nm on 02/10/2018 from 11:18:03 to 11:23:03 UTC. Data from TROPOMI sensor on Sentinel 5P satellite (Bulgaria and Balkans)

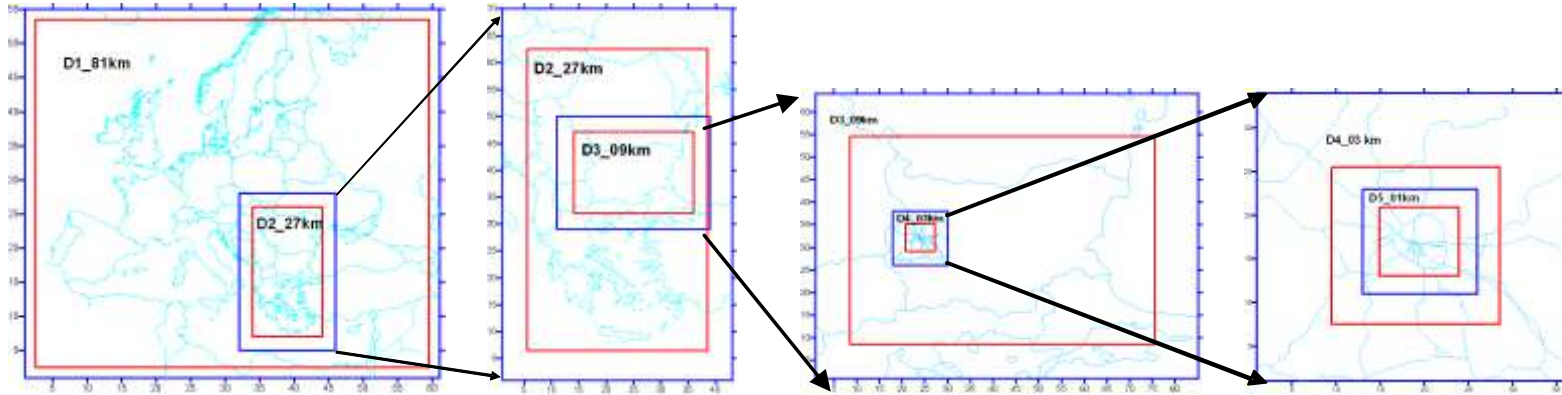
Lat, dd	Long, dd	AI,340-380 nm
44.152	22.631	2.81
44.152	22.698	2.78
44.152	22.764	2.93
44.085	22.631	3.01



Example of file structure for AAI.

Main Technical Developments – 6

WP 4. New configuration of BgCWFS with new data flow

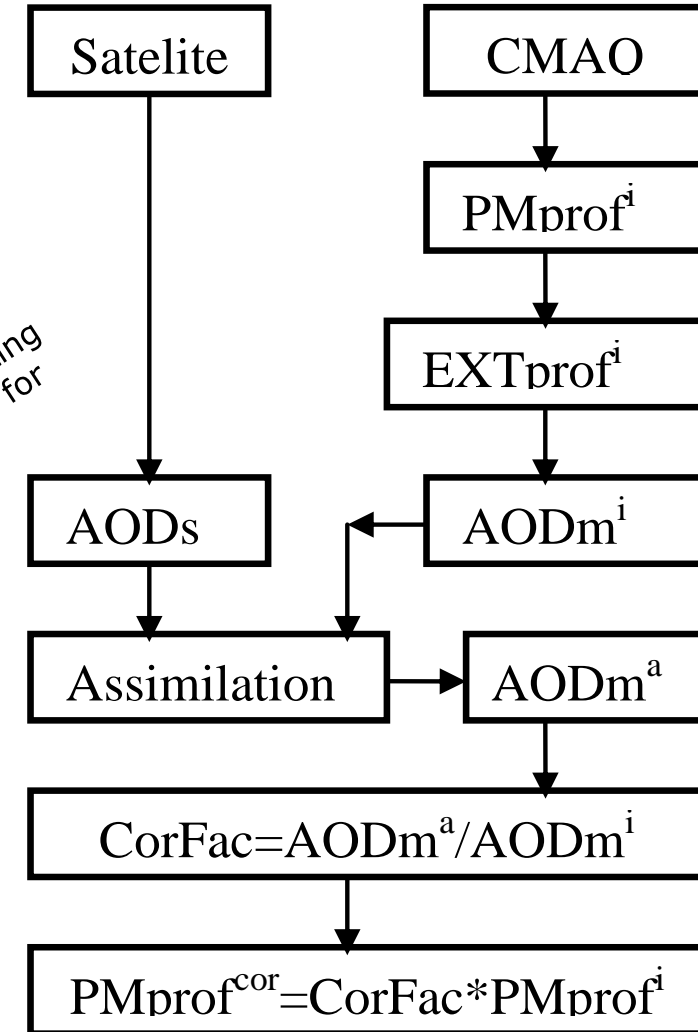


CWF_1_off model domains. Blue lines – WRF domains. Red lines – CMAQ domains.

Assimilation of satellite retrieved AOD. Data from Gome-3 instrument were first tested. Its resolution is 40 km, so assimilation for only BP1 domain (27 km resolution) is performed.

Normal and corrected calculations will be performed sequentially. The results will be compared in WP6.

Data flow diagram in assimilating satellite retrieved AOD, used for correction of PM profiles



Status of Technical Notes - Submission



Deliverable Identifier	Title/ Description	Original Delivery Date	Planned Delivery Date	Associated Milestone	Status
TN1.1.	Progress report (PR) 1	15/10/2018	15/10/2018	MS 1	Delivered to ESA
TN1.2. – TN1.7	PR2 to PR4 with delivery dates in the period 15/06/2019 – 15.06.2020 associated with MS2 to MS4.				Planned
TN2.1.	Methodology for satellite data selection and processing	15/10/2018	15/10/2018	MS 1	Delivered to ESA
TN2.2.	Regional and Temporal aerosol pollution over Bulgaria and Balkans	15/10/2018	15/10/2018	MS 1	Delivered to ESA
TN2.3 -TN2.4	Reports with delivery date 15/06/2019 associated with MS2				Planned
TN3.1.	Sentinel 5P data set prepared for input in BgCWFS	15/10/2018	15/10/2018	MS 1	Delivered to ESA
TN3.2 - TN3.3	Reports with delivery dates 15/10/2019 and 15/06/2020 associated with MS3 and MS4 respectively				Planned
TN4.1.	Report on the new configuration of the systems with new data flow	15/10/2018	15/10/2018	MS 1	Delivered to ESA
TN4.2 – TN4.5	Reports with delivery dates 15/06/2019 and 15/06/2020 associated with MS2 and MS4				Planned
TN5.1 – TN5.3	Reports with delivery dates 15/06/2019 and 15/06/2020 associated with MS2 and MS4				Planned
TN6.1 – TN6.4	Reports with delivery dates in the period 15/06/2019 - 15/06/2020 associated with MS2, MS3 and MS4 respectively				Planned
TN7.1.	Establishment of website of the project	15/10/2018	15/10/2018	MS 1	Delivered to ESA
TN7.2 – TN7.7	Reports with delivery dates in the period 15/06/2019 - 15/06/2020 associated with MS2, MS3 and MS4 respectively 15/12/2020				Planned
TDP	Technical Data Package (containing all approved technical notes)	15/06/2020	15/06/2020	Final Review	Planned

Summary of Main Achievements



The work on SIDUAQ project started on 15 Jun 2018 and is progressing normally.

1. An inventory of all data for AOD and aerosol columns available so far from different satellites and instruments for Europe, the Balkan region and the territory of Bulgaria was made and criteria for data selection were elaborated in TN 2.1.
2. Data organization tables were formed and described in details in TN 2.2.
3. A data-set of processed satellite data for model input was prepared and delivered by subcontractor to Contractor – TN 3.1.
4. The possibilities for satellite data assimilation in the existing BgCWFS were thoroughly investigated. Schemes of the modifications in the BgCWFS and its components that need to be done so to assimilate the satellite retrieved AOD were done – TN 4.1.
5. The website of SIDUAQ was established – TN 7.1.
6. There is an active dialogue and correspondence with the authorities of Plovdiv municipality to specify the information they have to provide for inclusion in the local air quality system (number of households, traffic and GIS information, etc.)

Publications: There are no publications for the moment.

Next Steps / Conclusions / Remarks



SIDUAQ is an ambitious interdisciplinary project performed by two different institutions.

A collaboration with local authorities of local authorities of the city of Plovdiv is established to ensure wider popularization of ESA activities and products in Bulgaria.

We are at the beginning and will work for exact implementation of the project as planned.