



SIDUAQ



Annual Review Meeting

Satellite Information Downscaled to Urban Air Quality in Bulgaria - SIDUAQ

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

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PECS Progress Presentation
Annual Review – Sofia, Bulgaria

10.10.2019

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European Space Agency

Satellite information downscaled to urban air quality in BG



SIDUAQ SATELLITE INFORMATION DOWNSCALED TO URBAN AIR QUALITY

Contractor: National Institute of Meteorology and Hydrology (NIMH)				ESA Budget:	164 k€
				Co-funded Budget: 0	0 k€
Contract No.: 4000124150 / Proposal: BG2_05			Year of Contract: 2018		
TRL	Initial: 2	Achieved: X	Target TRL: 3 Date: 2020		
ESA TO: Gertrud Talvik (IPL-IPS)					

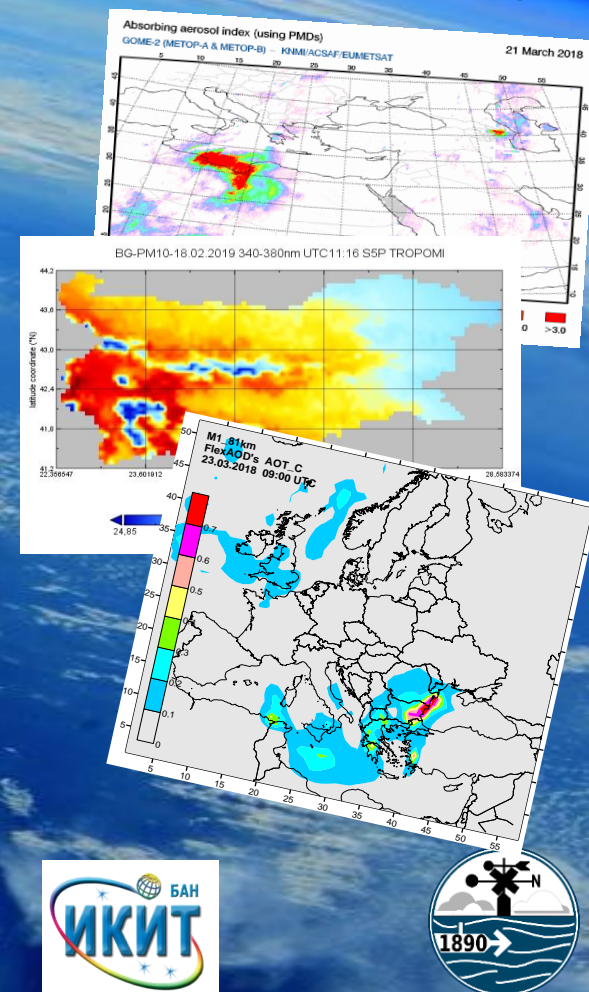
Background and justification: The SIDUAQ mission is an important step towards wider use of satellite information within science and society in Bulgaria in the area of air quality management. SIDUAQ will explore the effect of satellite data assimilation in the existing Bulgarian Chemical Weather Forecasting System BgCWFS, and thus account for emission sources not included in the model (e.g. Dust storms, forest fires) and for related long-range transport processes.

Objective(s): The project aims to use satellite observations for improvement of air quality modeling and management at national (Bulgaria) and local level - **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: (19-th month). Satellite data from MetOp A, B, C and Sentinel 5P are collected, analyzed and processed for input in BgCWFS. Methodologies for assimilation of AOD, NO2 and SO2 are elaborated and model runs are completed for one selected month in two options - base run, and run using satellite data. Downscaling approaches to the local AQ system have been tested and coded, local emission inventories are upgraded. Reference data sets for model validation have been identified, collected and archived in suitable formats. Statistical and deterministic approaches are tested for AAI/AOD to PM conversion over Bulgaria for selected days. Analysis on seasonal air pollution in BG has been performed. The project web site is updated with preliminary results (<http://space.bas.bg/SIDUAQ/index.html>).

Benefits: The primary benefits are for experts in AQ: 1) satellite information for air pollution will successfully supplement the irregular in situ monitoring network in Bulgaria; 2) better forecasting of AQ violation episodes for Bulgaria and the city of Plovdiv that will support local authorities to take effective measures for AQ improvement. Benefits for the scientific team are in enhancing capabilities of current tools and acquiring expertise, filling in gaps in the field in Bulgaria, with possibilities for international cooperation.

Next steps: The following phase will focus on methodologies for evaluation of the performance of BgCWFS with assimilation of satellite data, using ground based data and modeling results from the Copernicus AQ services. In parallel, collection and archiving of satellite data will continue, as well the testing and verification of models for AOD to PM conversion. The local AQ system in Plovdiv will be upgraded and seminars to environmental experts will be organized.



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Summary of Objectives

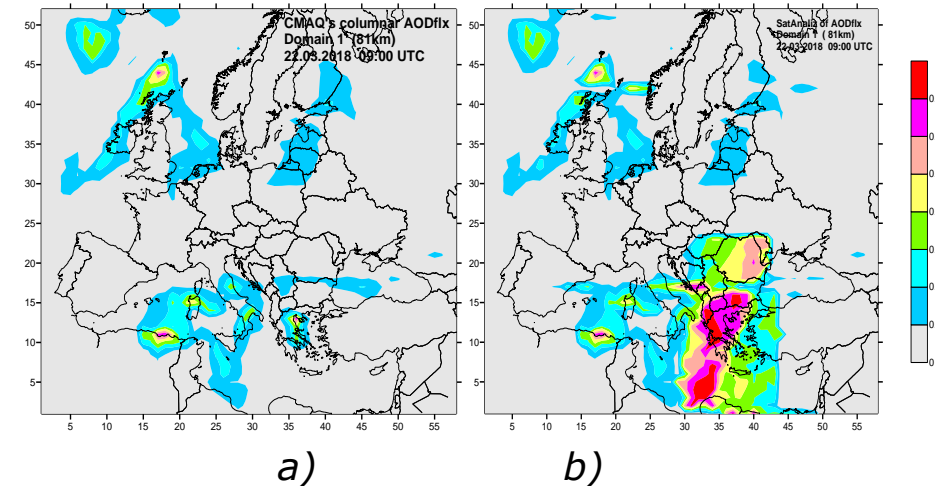
* Usage of satellite information, for the first time in Bulgaria, **for supporting state and local authorities in air quality (AQ) management.**

* **Assimilation of satellite retrieved data** for AOD, NO₂, SO₂ in the Bulgarian Chemical Weather Forecast system (BgCWFS), for providing hourly values of particulate matter (PM) and other key pollutantststs with resolution 9x9 km over the territory of Bulgaria.

* **Downscaling** of BgCWFS outputs for the local AQ Management System (AQMS) in Plovdiv with resolution 300x300m, for simulating hourly NO₂, SO₂, PM₁₀ and PM_{2.5} concentrations as analysis and forecast up to 3 days ahead.

* **Elaboration of expert analysis module** (post-processing) suitable for the local AQ authority in Plovdiv - maps of AQ violations and contribution (in %) of different emission sources to the concentrations of air pollutants

* **Evaluation of model performance** based on ground based measurements data and intercomparison to other models from the Copernicus AQ server



AOD in BgCWFS for 22.03.2018
a) Without satellite data usage
b) With satellite data assimilation

Contract Schedule



SATELLITE INFORMATION
DOWNSCALED TO URBAN AIR QUALITY

All activities are progressing as planned, no changes are required

Date mm/yy	07.18	08.18	09.18	10.18	11.18	12.18	01.19	02.19	03.19	04.19	05.19	06.19	07.19	08.19	09.19	10.19	11.19	12.19	01.20	02.20	03.20	04.20	05.20	06.20	09/2020 warranty	12/2020 warranty
Project Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	27	30
Milestones				MS1								MS2						MS3						MS4		MS5
WP1 Scientific coordination and Project management				PR-1			PR-2			PR-3		PR-4			PR-5			PR-6			PR-7			PR-8	PR-9	PR-10
WP2 AOD, SO ₂ and NO ₂ retrieval from satellite data				TN2.1, TN2.2								TN2.3, TN2.4												TN4.5		
WP3 Satellite AOD-to-PM10 and PM2.5 conversion				TN3.1														TN3.2						TN3.3, TN4.5		
WP4 Assimilation of satellite data in BG Chemical Weather Forecast System				TN4.1								TN4.2 TN4.3 TN4.4												TN 4.5		
WP5 Downscaling of satellite AQ products to urban scale																		TN5.1						TN5.2, TN5.3		
WP6 Validation of project products												TN6.1												TN6.4		
WP7 Expert analysis, User interaction and Product Dissemination				TN7.1																				TN1.4, TN7.2 to 7.7		TN7.4_A

Legend:		finalised/delivered	planned
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Main Technical Developments -1



WP 1. Management

- Contract Change Notice CN1 (March 2019) – change of Contractor Name (NIMH is now part of Ministry of Education and Science; change of 1 key personnel)
- Regular Contractor - Subcontractor meetings – up to now 8 meetings (5 in this year)
- Progress Reports submitted: 5 (4 in this year)
- MS1 and MS2 achieved (1 in this year)
- Technical Notes (PRs excluded) submitted and approved: 11 (6 in this year)

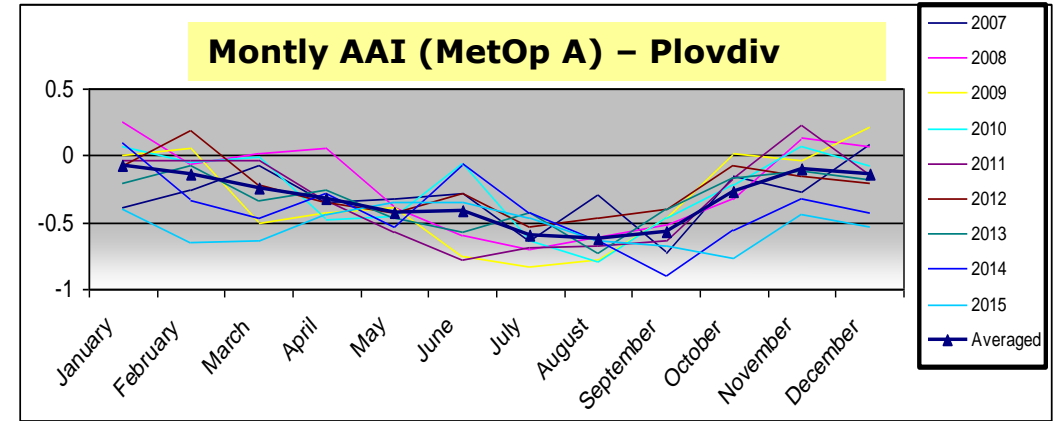
WP 2. Satellite data for AOD, SO2, NO2.

- Core activities finished ; 4 TNs submitted and approved (2 in this year)
- Collecting, archiving and processing of SAT-data for BgCWFS is ongoing

Main Technical Developments - 2

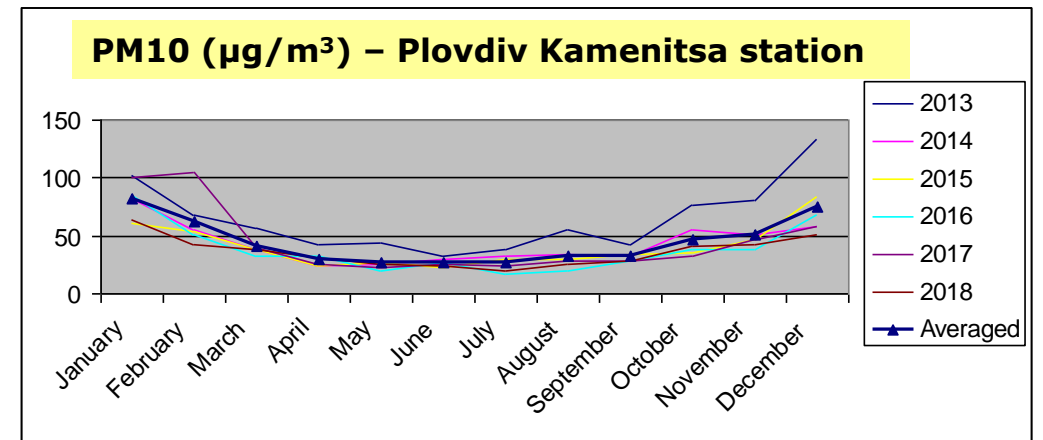
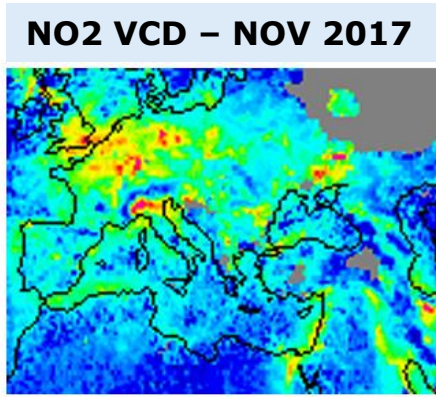
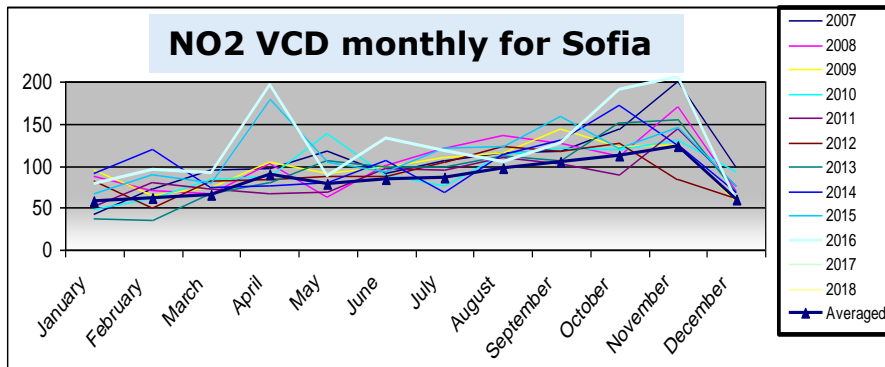
WP 2. a) Analysis of seasonal pollution (AAI, NO₂, SO₂, PM) for Bulgaria and selected cities based on :

- MetOp A, B and C monthly data (2007 – 2019)
- Terra & Aqua images (2004 – 2018)
- Sentinel-5P (01.-03.2019)
- in situ AQ data (2013 -2018)



NO₂ VCD (MetOp A) : BG is not a hot spot for EU ;
 Increase of column NO₂ in autumn-winter over Sofia

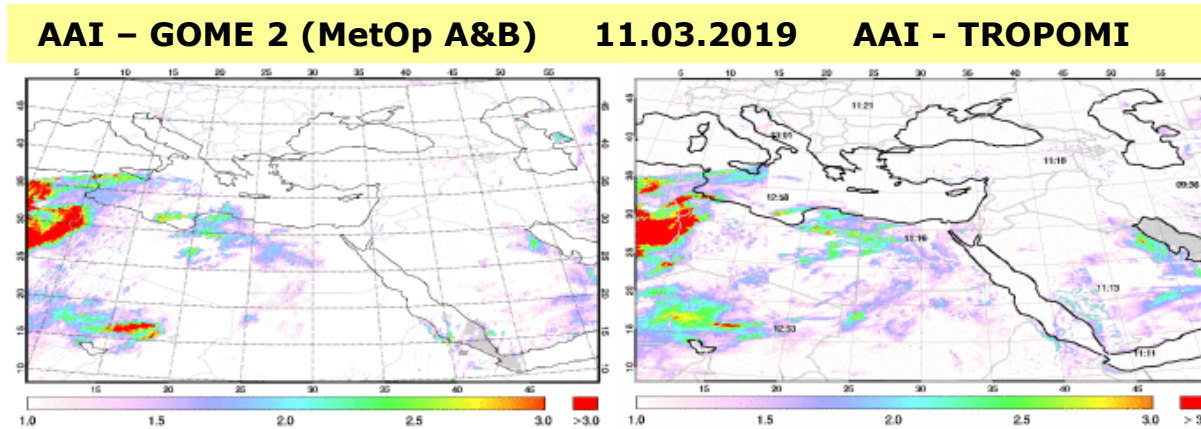
Both satellite & in-situ data indicate higher PM levels in Plovdiv for the winter period



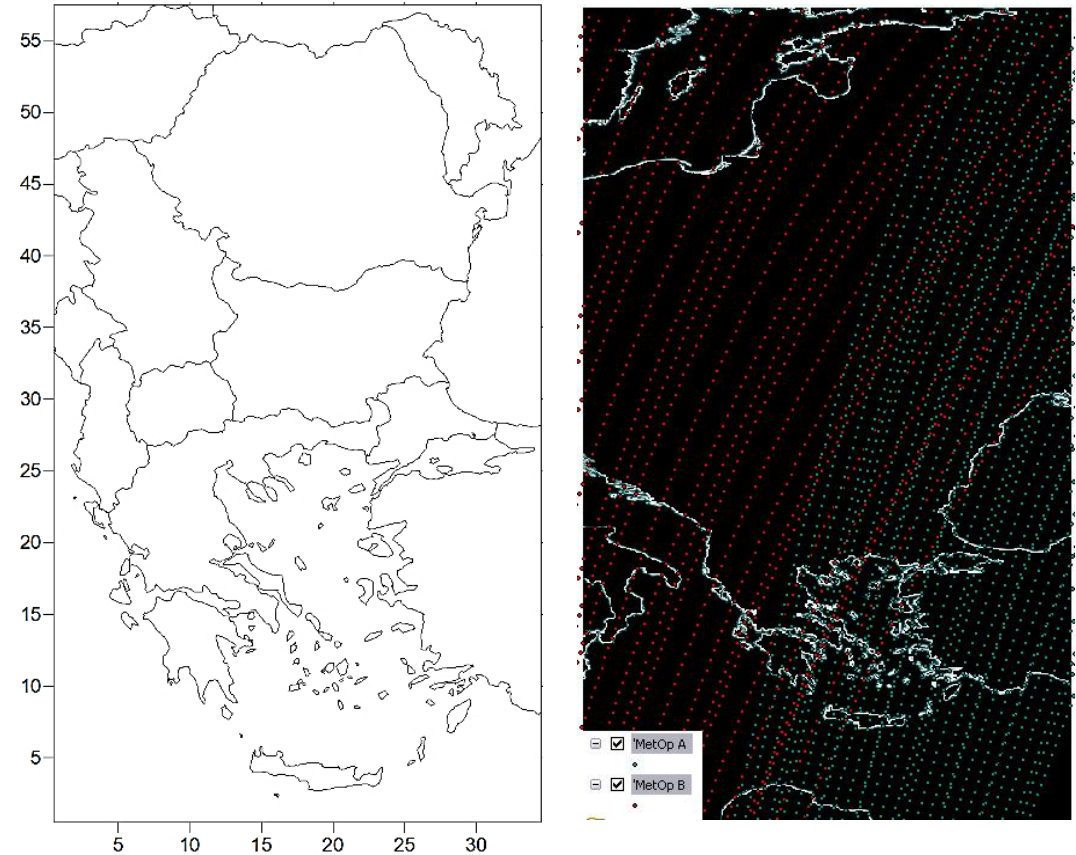
Main Technical Developments – 3

WP 2. b) Selection of optimal satellite data for BgCWFS

- Combination of MetOp A & B & C for the model domains EU, Balkan, Bulgaria
- Sentinel – 5P for domain BG and smaller



Similar AAI spatial distribution by GOME -2 and TROPOMI



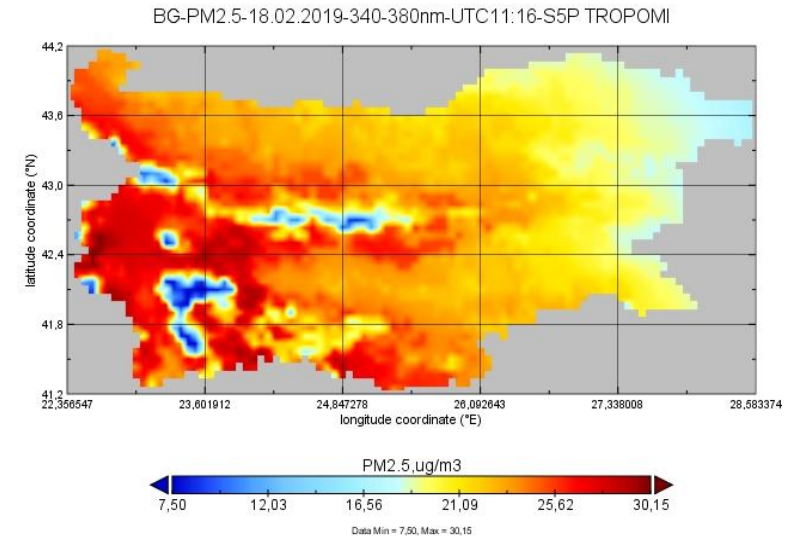
The Balkan domain of BgCWFS (left) and the corresponding area covered by one track of MetOp A (blue dots) and one of MetOp B (red dots) satellites (right). Points indicate centers of measurement grid cells

Main Technical Developments - 4

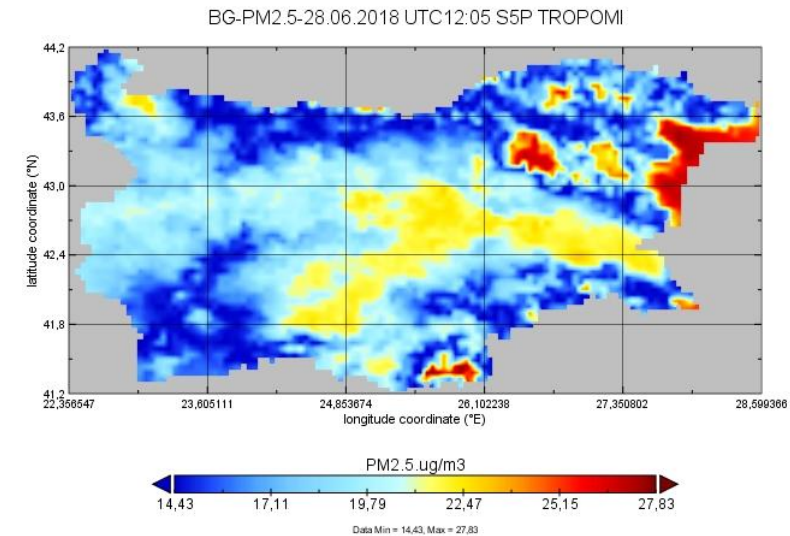
WP 3. Satellite AOD-to-PM10 and PM2.5 conversion

- **Statistical and deterministic models created** based on data from TROPOMI and ground stations in Bulgaria from Jun'18 till Aug'19
- **models tested** for different meteorological conditions
- **Maps of PM10 and PM2.5** over Bulgaria produced for selected days and at hour of satellite overpass
- **Data archived** in .txt and .xls format

Example of elaborated maps for surface concentrations of PM2.5 for winter (18.02.2019) and summer day (28.06.18) 11:16 UTC



PM2.5
Winter day



PM2.5
Summer day

Main Technical Developments - 5

WP 4. Assimilation of satellite data in BgCWFS

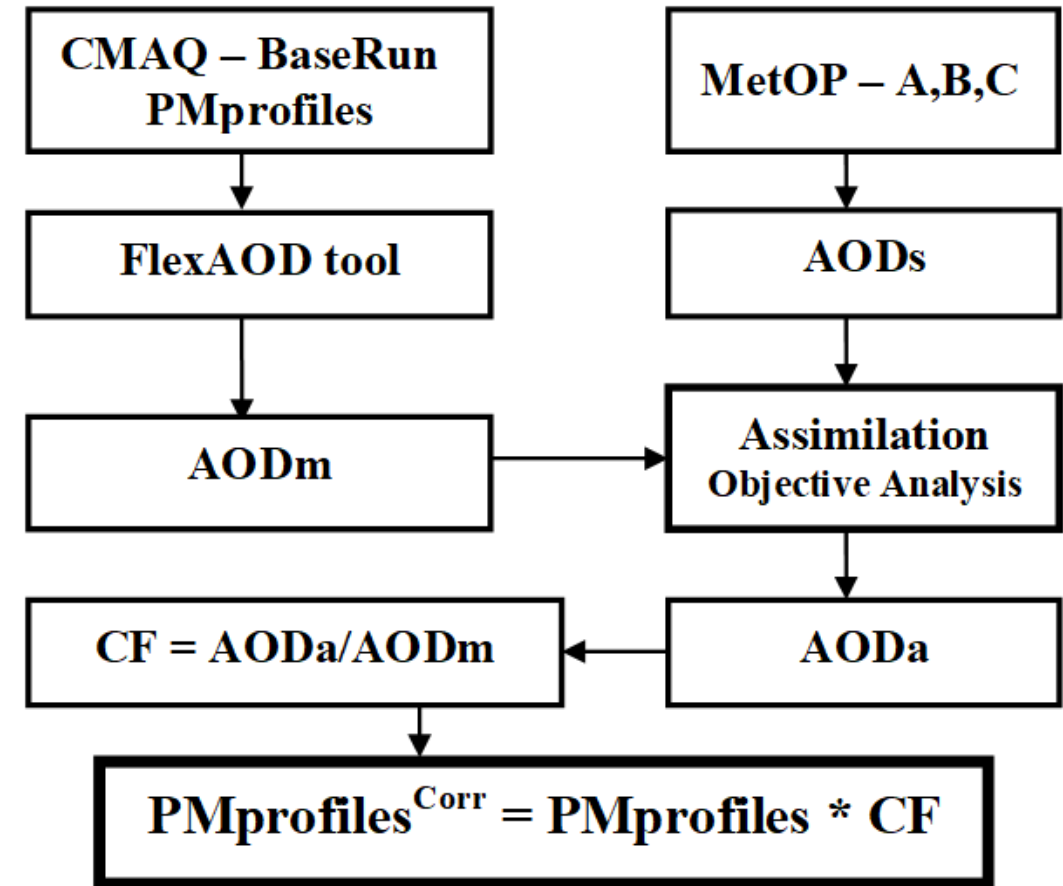
4 TNs submitted and approved (3 in this year)

a) Methods for Columnar values of NO₂, SO₂, and AOD calculation in BgCWFS examined and coded

- Focuss on AOD estimation - 5 different algorithms tested and compared, FlexAOD tool selected

b) Assimilation techniques carefully investigated for their suitability. A program based on optimal interpolation was elaborated, using spatial autocorrelation functions

c) Model runs performed for 1 month (AUG'17) in 2 modes: base case (without satellite data) and test run (with assimilation of AOD, NO₂, SO₂)

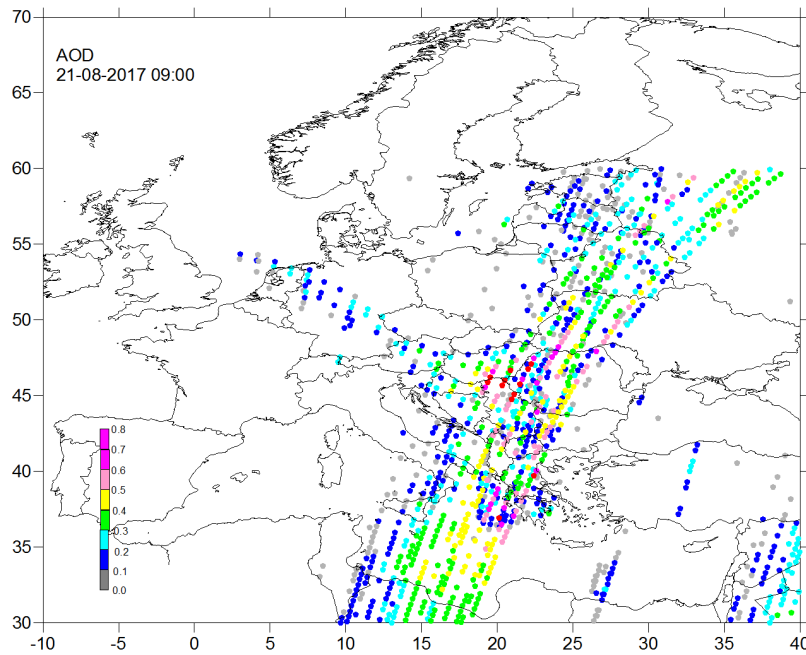


Scheme for assimilation of satellite data in BgCWFS

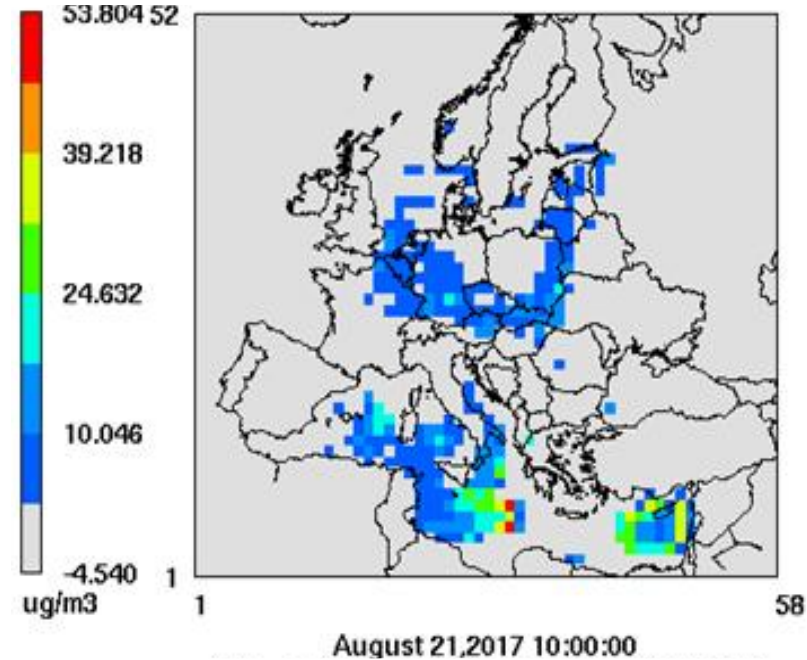
Main Technical Developments - 6

WP 4. Example on **effect of AOD assimilation** in BgCWFS – 21.08.2017

AOD from MetOp A & B & C: input to BgCWFS



Difference in PM10 ("satellite" – "no satellite") - hourly values **animation**

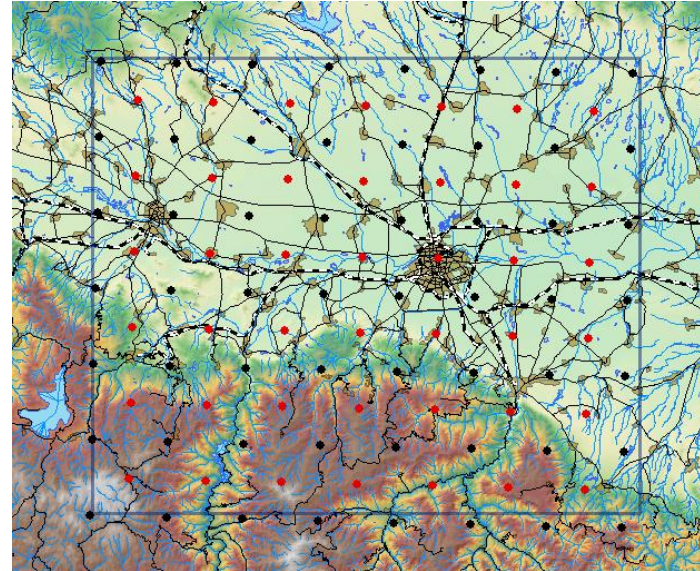


Main Technical Developments - 7

WP 5. Downscaling to urban scale
- Downscaling algorithms and scripts created for transferring BgCFWS (9km) results **to local AQ model system in Plovdiv** for **24** meteorological parameters and **8** chemical species.

- **Geospatial information** from different sources (emissions, population etc.) for Plovdiv region transformed into GIS shapes and imported in ArcGIS.

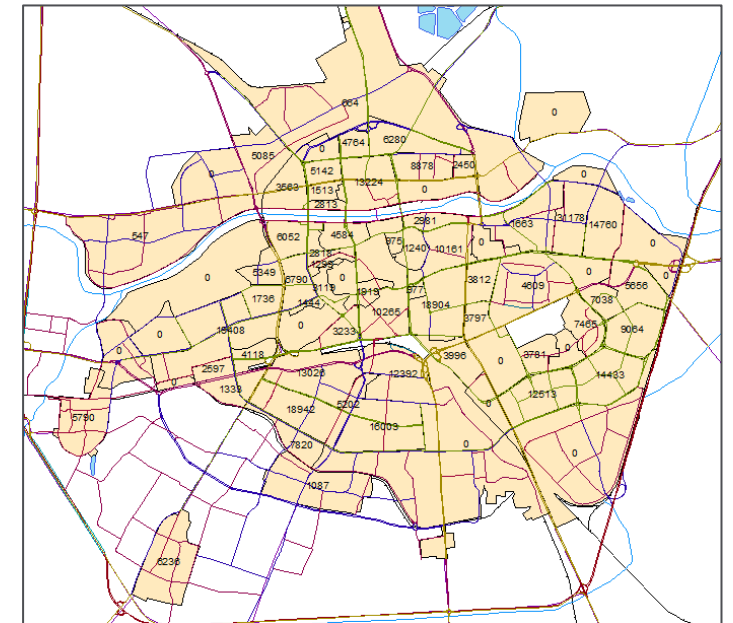
- **Bottom-up emission inventory** for the region of Plovdiv is in progress using 450 questionnaires for household heating and traffic data from 22 street segments.



Model domain Plovdiv and some of the “geographical objects”:

- wind data from BgCWFS;
- pollution data from BgCWFS

Streets categories (bold lines in different colors) and inhabitants in the sub districts of the city of Plovdiv

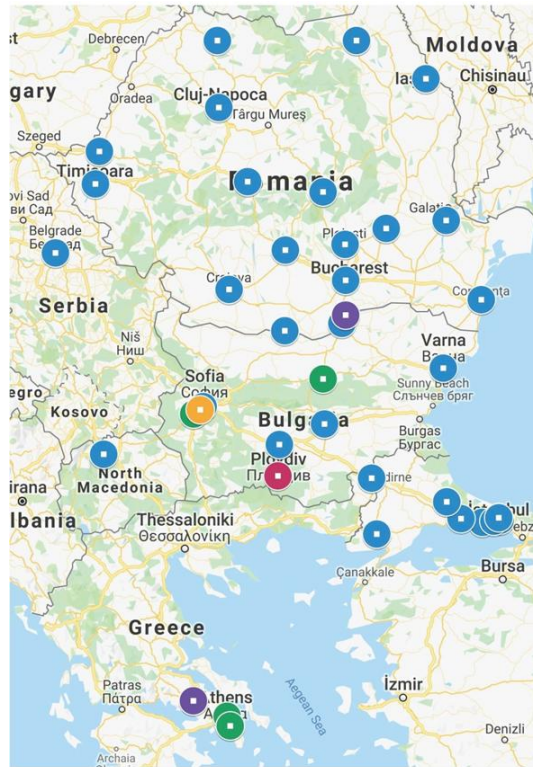


Main Technical Developments - 8

WP 6. Validation of project products – 1 TN submitted and approved

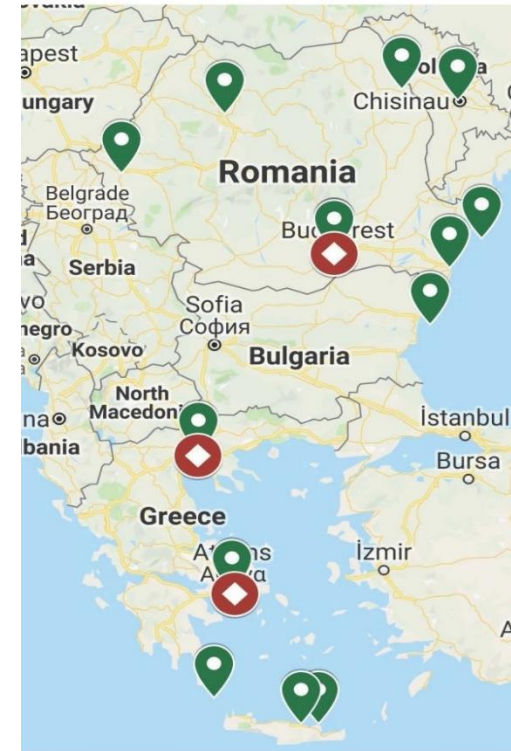
Useful reference data analyzed and collected:

a) in-situ ground measurements for 2016-2019 from 3 networks: AIRBASE (>100 stations in the Balkan countries), AERONET (14) and EARLINET (3)



PM2.5 background stations

- PM2.5 Rural
- PM2.5 Rural-Near_city
- PM2.5 Rural-Remote
- PM2.5 Suburban
- PM2.5 Urban



AERONET+EARLINET stations

- AERONET
- EARLINET

Main Technical Developments - 9

WP 6. Validation of project products

b) 3 modelling systems identified for checking model performance:

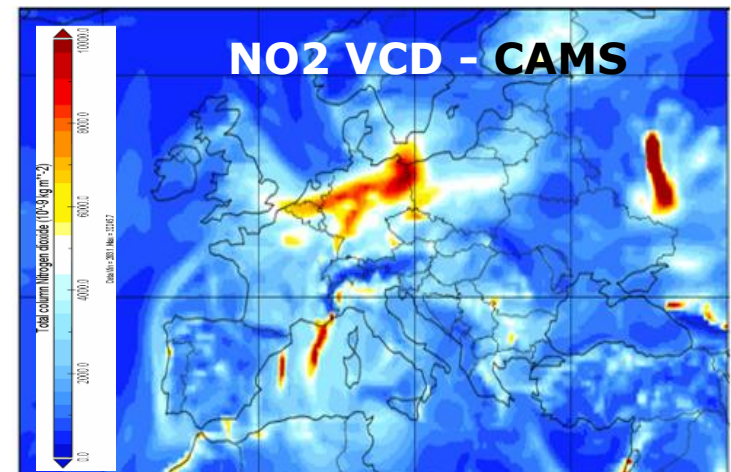
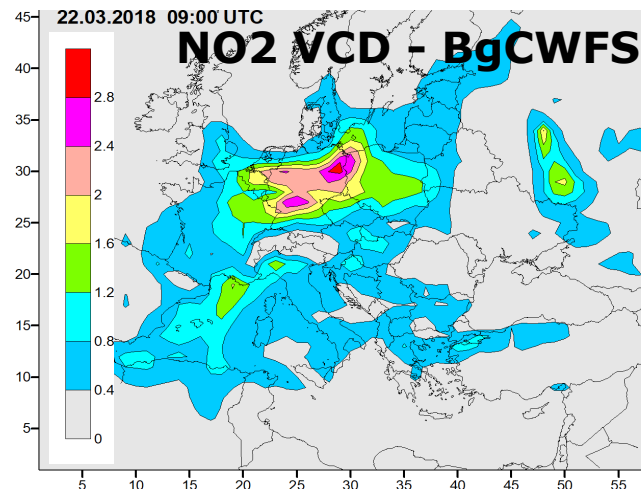
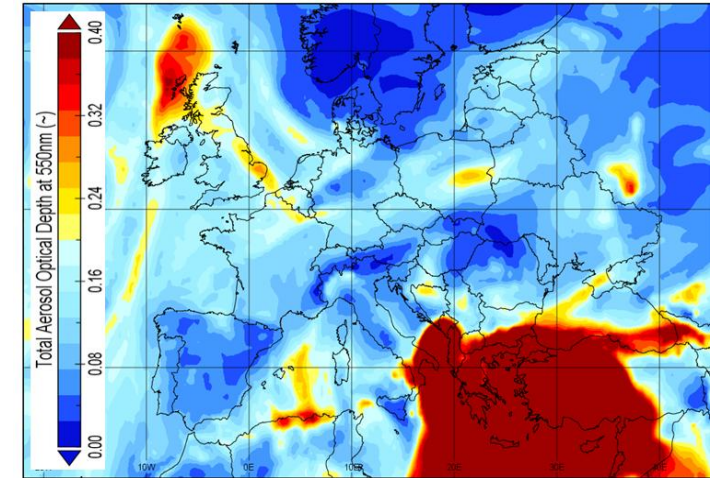
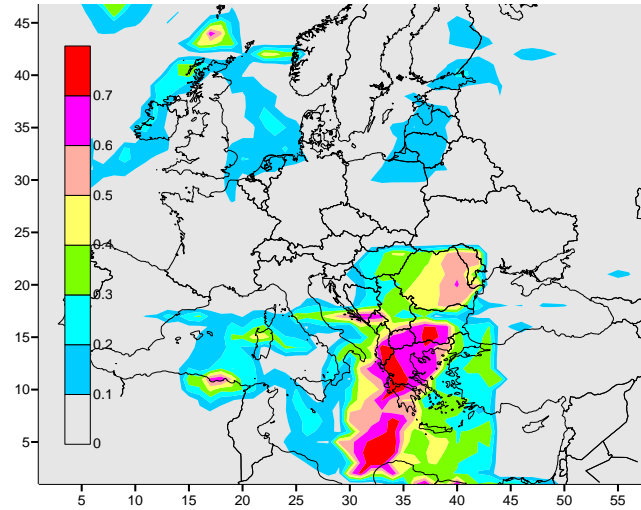
2 are at Copernicus Atmosphere Monitoring Service:

- CAMS regional AQ ensemble
- CAMS-ECMWF global (AOD)
- **EMEP-MSC-W** used by EEA for annual AQ reporting

AOD₅₅₀ - BgCWFS

22.03.18 09:00

AOD₅₅₀ - CAMS



Main Technical Developments - 10



WP 7. Expert analysis, user intereaction, **dissemination**

- **web page** created and updated

- Project details registered in the National Centre for Information and Documentation (**NACID**)

<https://nacid.bg/en/>

- Project outlined at **SOFAIR 2019** - international high-level conference on air pollution, initiated by the Mayor of Sofia



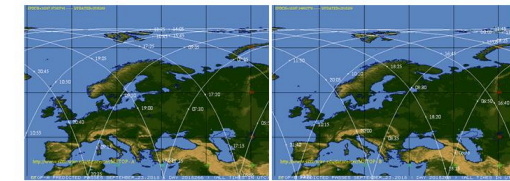
About SIDUAQ

Participants
Structure
Results

The ESA-funded project BG2-05 "Satellite Information Downscaled to Urban Air Quality in Bulgaria" (SIDUAQ) started on 15th June 2019. The overall objective of this project is 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 project results will support local authorities in air quality management, so to meet the air quality (AQ) standards on a medium and long term sustainable basis.

E-mail: siduaq@space.bas.bg

The National Institute of Meteorology and Hydrology, as coordinator, and the Space Research and Technology Institute at the Bulgarian Academy of Sciences, as sub-contractor, cooperate to achieve the ambitious tasks planned in the project.



Orbit track over Europe for MetOp A and B satellites respectively



Home > Register > Projects



National Institute of Meteorology and Hydrology



Space Research and Technology Institute
Bulgarian Academy of Sciences

Scientific research projects

Satellite Information Downscaled to Urban Air Quality in Bulgaria - SIDUAQ Expand all Collapse all

Main

Number in CRIS: 2409522

Organisation: National Institute of Meteorology and Hydrology

Organisational subdivision responsible for execution: [Empty field]

Project name: Satellite Information Downscaled to Urban Air Quality in Bulgaria - SIDUAQ

Short description of project: The overall objective of the SIDUAQ project (BG2-05 2019-2020) is to use the opportunities given by satellite observations of atmospheric composition (AOD, O3, SO2, NO2) for improvement of air quality (AQ) management at national level in Bulgaria and at local level for the city of Plovdiv. The goal will be achieved by synergetic use of ESA satellite's data (METOP, Sentinel 5P, etc.) and air pollution dispersion modelling systems. The satellite information will be assimilated in the existing chemical weather forecasting system (CWFS). The upgraded with satellite data CWFS will be used to feed local AQ modelling systems.

Keywords: satellite information, air quality, urban environment, atmospheric pollution modelling

Short description of results: Satellite data for NO2, SO2, and AOD, from all ESA satellites covering the Balkan Peninsula territory will be collected and archived in a suitable format. The upgraded chemical weather forecast system CWFS will include satellite data information. The CWFS output products shall provide the background information for local air quality management systems for the territory of the city of Plovdiv.

Project type: [Empty field]

Scientific field: [Empty field]

Status of Technical Notes - Submission

Deliverable Identifier	Title	Submission Date	Status
TN1.1 , TN1.1_A , TN1.1_B, TN1.2, TN1.2_A	Progress reports 1, 2, 3, 4, 5	15/10-2018 – 15/09/2019	Delivered to ESA
TN2.1 TN2.2	Methodology for satellite data selection and processing; Regional and Temporal aerosol pollution over Bulgaria and Balkans	15/10/2018	Delivered to ESA
TN2.3 , TN 2.4	Seasonal changes of aerosol pollution over Bulgaria and Balkans; Identification of optimal satellite data for use in BgCWFS	15/06/2019	Delivered to ESA
TN3.1	Satellite data set prepared for input in BgCWFS	15/10/2018	Delivered to ESA
TN4.1	New configuration of the system with new data flow	15/10/2018	Delivered to ESA
TN4.2, TN 4.3, TN4.4	Downscaling; Columnar Profiles of NO2, SO2 and aerosols; Assimilation techniques	15/06/2019	Delivered to ESA
TN6.1	Useful reference data and periods for test cases	15/06/2019	Delivered to ESA
TN7.1	Establishment of website of the project	15/10/2018	Delivered to ESA
TN3.2, TN3.3	Results from different models for AOD to PM10 and PM2.5 conversion; Comparison of satellite retrieved PM to ground based measurements data	15/12/2019, 15/06/2020	Planned, on schedule
TN 4.5	Model results for test cases	15/12/2019	Planned, on schedule
TN5.1 , TN 5.2, TN5.3	Emission inventory; Modules of the local AQMS operating in NRT; Modification of expert modules of the local AQMS	15/12/2019, 15/06/2020	Planned, on schedule
TN6.2 , TN 6.3, TN6.4	Validation Methodology; Co-location of observational and model data; Models performance evaluation	15/12/2019, 15/06/2020	Planned, on schedule
TN7.2, TN 7.3, TN7.4, 7.4_A, TN7.5, TN7.5_A, TN7.6, TN7.6_A, TN7.7	AQ maps with different space and time resolution; Expert analysis of the outputs from BgCWFS and LAQMS; Elaborated web sites for the systems and maintenance during the warranty period; Publications; seminars with users, User's manual	15/12/2019, 15/06/2020, 15/12/2020	Planned, on schedule
TN1.3, TN1.3_A , TN1.4, 1.4_A, 1.4_B, TN1.5, TN1.6, TN1.7	PR6 to PR10 with delivery dates in the period 15/12/2019 – 15.06.2020 associated with MS3 to MS4 , and the warranty period 15/09/2020; Exe. Summary; Technical Data Package, Contract Closure Documentation		Planned, on schedule

**11 TNs submitted
 + 5 Progress Reports
 23 TNs planned
 No delays are
 foreseen**

Summary of Main Achievements

1. Seasonal pollution (AAI, NO₂, SO₂, PM) over Bulgaria and selected cities is analysed based on data from MetOp A, B and C for the period (2007 – 2019).
2. Satellite data for AOD, NO₂, SO₂ are assimilated in the Bulgarian Chemical Weather Forecast System (BgCWFS) and test runs for 1 month finalised.
3. Deterministic and statistical models using data from TROPOMI and ground observations are elaborated and tested for the conversion AAI /AOD to PM₁₀ and PM_{2.5} over Bulgaria.
4. A downscaling approach for linking BgCWFS outputs to local AQMS in Plovdiv is created.
5. Bottom up emission inventory for household heating and transport in Plovdiv region is in process of compilation

Publications:

1. Syrakov et al. "Aerosol optical depth calculations using the Bulgarian Chemical Weather Forecast System"

submitted to Bulg J. of Meteorology and Hydrology (BJMH) , expected online in Dec 2019

2. Georgieva et al." Satellite Information Downscaled to Urban Air Quality in Bulgaria - Project activities"

submitted to BJMH, expected online in Dec 2019

3. Dimitrova et al. "Identification of optimal satellite data for use in the air quality modeling system BgCWFS"

4. Dimitrova et al. "Seasonal changes of aerosol pollutants over Bulgaria"

3.&4. submitted for Booklet of Proceedings of SES2019 International Conference

Vision of the future



- Next steps : focus will be on **upgrade of the local AQMS**, on **evaluating model performance** for a selected test period, on **further analysis of TROPOMI data** and on **interactions with users**
- The original proposal prediction of the **TRL advancement** is realistic
- The activity is completely in line with the strategic objectives (SO) of NIMH on **using satellite data in weather forecasting, extreme events (e.g. flooding) now casting, and modelling of atmospheric composition for end users**. It is in line also with SO of SRTI-BAS on development of methods and technologies for **remote sensing linked to security and environmental problems**
- SRTI-BAS is the leading scientific institution in BG on **Remote sensing of the Earth** and on **Aerospace systems and Technologies**, with expertise on **design, development and transfer of methods, instrumentation and technologies for regional and global monitoring**

Any Other Business



If any.

Thank you for the attention

Благодаря за вниманието