S5P VALIDATION TEAM CALL ACCEPTED PROJECTS *

Prj_id	Title	Principal Investigator	Institution	Country	Summary
28329	Participation in S5PVT to validate SO2 and HCHO Products	Dr. Nickolay Krotkov	NASA GSFC	UNITED STATES	Spatiotemporal distributions of sulfur dioxide (SO2) and formaldehyde (HCHO), two important short-lived (hours to few days) precursors of aerosols and ozone, offer key information on the air quality and interaction between atmospheric chemistry and climate change. Satellite measurements represent the only viable approach for obtaining such information on a global scale. The TROPOspheric Monitoring Instrument (TROPOMI) aboard ESA's Sentinel 5 Precursor (S5P) mission will extend and enhance global trace gas measurements carried out by the Aura Ozone Monitoring Instrument (OMI). TROPOMI boasts ground resolution a factor of ~six greater than OMI, making it an optimal instrument for measuring weak SO2 and formaldehyde (HCHO) pollution signals in the boundary layer. It will fly in a polar orbit in close proximity with NASA's Aura satellite and in loose formation with the NASA/NOAA Suomi National Polar Partnership (SNPP) mission that carries the Ozone Mapping Profiler Suite (OMPS), also capable of measuring SO2 and HCHO, but with much lower spatial resolution. We thus have a unique opportunity to make extensive comparison between the S5P official products and the mature data products from the Aura and SNPP. Such comparisons are essential for cross-validation of these important satellite data sets and help to enhance the data quality of the official TROPOMI products for SO2 and HCHO.Our team is responsible for NASA's operational SO2 product from Aura/OMI that has been widely utilized by both science and application communities. We are currently producing the next generation OMI SO2 product using an innovative principal component analysis (PCA) algorithm. We have also demonstrated promising results for HCHO retrievals from both OMI and OMPS by applying our PCA approach. The PCA algorithm directly derives spectral features from the measured radiances to account for various interferences in SO2 and HCHO retrievals such as ozone absorption and rotational Raman scattering (RRS). This data-driven approach makes the PCA algorithm conceptually very different from the official TROPOMI SO2 and HCHO algorithms based on Differential Optical Absorption Spectroscopy (DOAS), which employs a forward modelling approach to minimize interferences. We propose to participate in ESA's S5P TROPOMI validation team with the following goal: to evaluate and improve the quality of the official TROPOMI SO2 and HCHO products through intercomparison with our independent PCA retrievals and other independent ground and airborne measurements. To this end, we will work with the official TROPOMI SO2 and HCHO product team to 1) compare our OMI/OMPS PCA retrievals with their OMI/OMPS retrievals using the TROPOMI pre-launch algorithms, 2) implement our PCA algorithm on TROPOMI for selected cases and compare our independent PCA TROPOMI retrievals to the official TROPOMI SO2 and HCHO products, 3) compare our independent OMI and OMPS PCA retrievals to the official TROPOMI products, and 4) leverage existing aircraft, sonde, and ground-based measurements to evaluate both PCA and official TROPOMI SO2 and HCHO retrievals.This research will help evaluate and improve the quality of the official TROPOMI SO2 and HCHO products. If two very different algorithms (PCA vs. DOAS) yield very similar results after this investigation, it will lend confidence to both algorithms as well as the TROPOMI standard and value-added products. Our participation in the S5PVT will help to ensure that the official SO2 and HCHO products will meet or exceed the mission requirements.
28505	TEMPO Team Participation in S5P Validation	Dr. Kelly Chance	Harvard-Smithsonian Center for Astrophysics	UNITED STATES	We will validate S5P Level-2 gas products O3, NO2, SO2, HCHO, and CH4 (and CHOCHO, H2O and BrO, as available from S5P). This will include comparisons of slant column measurements when appropriate, air mass factors (AMFs), algorithm approaches, and supporting reference spectra and other aspects of algorithm physics such as wavelength calibration and Ring effect correction.We will use OMI Aura and TEMPO geostationary satellite observations, ground-based ultraviolet, visible, and infrared measurements, and algorithm physics studies to validate Sentinel-5P. Satellite measurements include O3, NO2, SO2, HCHO, CHOCHO, H2O, and BrO. Ground-based measurements include CH4, O3, NO2, SO2, HCHO, H2O, and BrO, with CHOCHO as a possibility.In order to perform this research, we will use tools that have been developed over the years for satellite measurements by SAO and our collaborators. These include the SAO fitting algorithms BOREAS (BOAS Retrieval for Atmospheric Spectra) used operationally on OMI for HCHO, BrO, OClO, and now for CHOCHO and H2O, and the ΓÇ£eXceLΓÇ¥ optimal estimation determination of tropospheric ozone and SO2, now working on the GOME instruments, SCIAMACHY, and OMI. They also include the GEOS-Chem 3-D chemistry and transport model (CTM) developed at Harvard, and the VLIDORT discrete ordinate multiple-scattering radiative transfer code (RTM).Initial studies will include in-flight slit function and wavelength calibration, analysis of fitting residuals and simulation/observation differences to check radiometric calibration, residual stray light. This will include analyzing the spatiotemporal variation of the wavelength scale, the slit function, and the fitting residuals in their determinations. Following, we will evaluate S5P Level 1b radiance and irradiance calibration through radiative transfer modeling comparisons.Level 2 data product comparisons will start with slant column measurements, and will include collaborative comparisons with European colleagues performing fits and with ground-based measurements using SAO Pandora spectrometers and Harvard FTIR spectrometers. AMF differences will also be addressed, beginning with intercomparisons for calculations by different research groups of selected scenarios. Thus, the outcomes will be understanding of the contributions of each aspect of the retrievals to the results and to the error budget and an understanding of the relative values of different approaches to retrievals for different geophysical scenarios. In addition to contributing to S5P, we expect that the validation exercise will present an invaluable opportunity to improve results from OMI and TEMPO measurements.

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28536	Validation of TROPOMI using Environment Canada Ground-Based Remote Sensing Network	Dr. Vitali Fioletov	Environment Canada	CANADA	Ground-based measurements of total columns of NO2, SO2, ozone, HCHO, UV index, AOD, as well as ozonesonde profiles collected by the Environment Canada networks will be used to validate S5P data products during the entire duration of the mission. As several types of Environment Canada ground-based remote sensing network instruments are operated by the same team and share a common infrastructure, it is feasible to combine the validation of S5P data by these network observations into one proposal. During the commissioning phase of S5P, the near-real time ground-based data will be employed to check the behaviour of the S5P spectrometer. After this phase, archived data will be used for the validation of total column values provided by S5P. Near-real time ground based data will also act as an early warning tool for the detection of possible problems during the operation of S5P. Validation of total ozone and ozone profile data has as its primary goal the merging of S5P data sets with the existing, long-term satellite data sets in order to extend the current ΓÇ£trend qualityΓÇ¥ ozone records and use them for ozone recovery monitoring and to study springtime ozone depletion in the Arctic. Validation of S5P NO2, SO2, and HCHO retrievals is aimed at improvement of airmass factors used in the retrieval algorithms over Canada. Once validated, S5P data will be then used for Environment Canada applications related to monitoring of air quality and the ozone layer.The proposed work will be funded internally by Environment Canada
28548	Evaluation of Instrument Performance and Validation of total O3, SO2, and NO2 Products from TROPOMI on S5P	Dr. Kai Yang	University of Maryland College Park	UNITED STATES	The next-gen hyper-spectral instrument, the TROPOMI on S5P, will achieve unprecedented measurement sensitivity to key tropospheric constituents, such as ozone (O3), sulfur dioxide (SO2), and nitrogen dioxide (NO2). The S5P will fly in formation with the SNPP satellite, thus TROPOMI will provide near simultaneous observations co-located with the nadir-viewing SNPP/OMPS instrument, which has provided high-quality O3, SO2, and NO2 data since early 2012. Inter comparison between the corresponding TROPOMI and OMPS products will allow valuable assessment of the performance of both instruments, and identify calibration and algorithm issues for correction and improvement, thus achieving the synergistic benefits for both missions. We therefore propose a membership in the S5PVT to evaluate and validate TROPOMI total O3, SO2, and NO2 products, through inter-comparisons with the corresponding SNPP/OMPS standard products, and with independent retrievals from TROPOMI using the same algorithm developed for the OMPS standard products. We will also assess the radiance and irradiance measurements of TROPOMI using the same analysis technique and approach developed for monitoring the on-orbit performance of OMI and OMPS. Our proposed investigation will enable a better understanding of the various impacts of S5P processing, from instrument calibration to algorithm physics treatments, on the quality of TROPOMI products. The insights gained from the inter-comparison will facilitate the identification of major error sources, and lead to the development of system performance enhancements that reduce the uncertainties in both TROPOMI and OMPS products.Our team consists of Dr. Kai Yang (PI, UMCP), Dr. Simon A. Carn (Co-I, MTU), Dr. Jun Wang (Co-I, UNL), and Dr. Hao He (Co-I, UMCP). We are current members of NASA Aura, SNPP, and DSCOVR science teams, and have extensive experiences in retrievals and validations of trace gases from satellite UV and VIS measurements. This proposal builds on our previous achievements in developing, implementing, and maintaining the operational processing software for the O3, SO2, and NO2 products from hyper-spectral instruments such as OMI and OMPS.Our team is currently funded by NASA to produce the standard SO2 and NO2 products from SNPP/OMPS, and the total O3, SO2, UV reflectivity, and Aerosol Index products from DSCOVR/EPIC. Evaluation and inter-comparison with TROPOMI data fall within our funded activities for validating OMPS and EPIC products

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28568	Validation of total ozone from S5P TROPOMI on the global scale using Brewer, Dobson and UV-visible/SAOZ networks - (VALTOZ)	Dr. Dimitris Balis	Aristotle University of Thessaloniki - Laboratory of Atmospheric Physics	GREECE	The current proposal aims to verify whether SP5 TROPOMI total ozone data meets the requirements for long-term trend monitoring on a global scale, for research on polar process studies and ozone-climate interactions, as these have been established from GCOS. The observations by GOME, SCIAMACHY, GOME-2, TROPOMI and the foreseen Sentinel 4 and 5 payloads will result in global long-term total ozone records and therefore the consistency, intercomparability and stability between the different instruments needs to be checked and verified continuously. As for previous missions and algorithm upgrades this will be carried out through regular comparisons with observations from quality checked Brewer and Dobson ultraviolet spectrometers part of WMO's World Ozone and UV Data Centre (WOUDC) and NCACC qualified UV-visible spectrometers observations. In addition during the commissioning phase, the near-to-real time ground-based data, which are submitted to the WMO Northern Hemisphere Ozone Mapping Centre and to the LATMOS SAOZ NRT webpage within 24 hours after observations, will be employed to check the behavior of the TROPOMI instrument as a function of measuring geometry. After this phase, archived consolidated data will be used for the validation of absolute total ozone column values provided by TROPOMI. Near-to-real time ground-based data will also act as an early warning tool for the detection of possible problems during TROPOMI operation. The proposing team has been involved in the validation of all GOME, TOMS, SCIAMACHY, OMI and GOME-2 operational TOC productss and all their successive algorithm upgrades, and therefore has a long experience and acknowledged know-how for such studies. The expected outcome of the project will be the full characterization (bias, spread, decadal stability, verification of ex-ante uncertainties, dependences on relevant parameters, mutual consistency with other satellite data) of the TROPOMI level-2 total ozone observations with respect to the product specific requirements using the ground-based network data as the reference measurements. The basis of the proposed work will be funded internally by the academic and research institutions involved for which some groups get permanent funding for data acquisition and instruments maintenance. In addition, once the AO proposal will be accepted by ESA, dedicated proposals will be submitted to national agencies and associated bodies (e.g. ProDEx), whenever relevant call will be issued, especially for raising funding for the commissioning phase and for up to 1 to 2 years of the operational phase of the mission, as well as for future validation upgrades and data reprocessing.
28579	Methane and CO validation and verification for S5P (MECOVAL-S5P)	Dr. Michael Buchwitz	Institute of Environmental Physics	GERMANY	This project will address validation and verification aspects related to the operational S5P XCH4 and CO column products. This will be achieved by combining several complementary approaches: * Validation of XCH4 and CO columns by comparison with TCCON ground-based data* Validation of XCH4 by comparison with (validated) GOSAT satellite data* Comparison of S5P XCH4 and CO columns with the corresponding products retrieved independently at IUP using IUP's S5P scientific retrieval algorithm BESD * Comparison of S5P XCH4 with MAMAP XCH4 aircraft dataBy combining these components, the project will deliver a range of results relevant for validation and improvement of the S5P XCH4 and CO products:* The validation results obtained by the comparisons with TCCON and GOSAT will provide detailed information on the quality of the S5P XCH4 and CO products (e.g., mean differences, standard deviation of differences, correlation coefficients). This will also include assessments related to stability and the identification of problem areas.* The comparison with the MAMAP data are expected to provide additional information more local XCH4 pattern (on the order of ~100 km, i.e., city-scale)* The independent retrievals of XCH4 and CO columns from the S5P spectra (Level 1 products) are expected to help in identifying the underlying reason for identified issues (if any) as this requires detailed understanding of the link between Level 1 and Level 2 products. It is expected that this activity will result in important recommendations on how to improve the S5P operational products.The project team is located at IUP Bremen and consists of scientists who have performed similar measurements and assessments for many years. Funding for this activity is not yet available.

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28580	MODELLING AND ASSIMILATION FOR THE VALIDATION OF TROPOMI CHEMICAL OBSERVATIONS (MATRICS)	Dr. Trissevgeni Stavrakou	Belgian Institute for Space Aeronomy	BELGIUM	In order to carefully assess the quality of SP5 data products, and to evaluate their suitability for the predefined mission objectives, comparisons with independent measurements are an essential component. These include data evaluation using experimental campaigns and correlative exercises between remote sensing products and in-situ observations. However, the scope of these analyses is limited by the scarcity of suborbital measurements and by their limited representativeness. In order to draw a comprehensive global picture, the use of atmospheric chemistry-transport models is a powerful and innovative validation tool addressing the priorities of the call. Such models provide the capability not only to contend with the global data coverage, but also to integrate orbital and suborbital data into one analysis. Our main objective is to support the S5P mission with evaluation of TROPOMI products using atmospheric modelling, inverse modelling and data assimilation. To take full advantage of the global coverage and high spatiotemporal resolution of S5P, we will use a combination of a global (BIRA-IASB-IMAGES) and a regional high resolution (TNO-LOTOS-EUROS) chemistry-transport model. The objective will be reached through the following research goals: - Development of an integrated approach to TROPOMI data characterization based on the combination of models, ground-based and suborbital measurement capabilities - Assessment of the quality of the targeted products through direct comparisons between TROPOMI, other space-borne sensors, ground-based observations and model output - Investigation of the possible reasons for model-data biases based on physical and chemical arguments - Assessment of the consistency between OMI, GOME-2 and TROPOMI, given their different overpass times, through modelling and comparisons with ground-based measurements - Use of data assimilation to identify outliers, instrumental and representation error and bias between model and observations, and to assess the consistency between different satellite datasets- Quantification of the added value from the use TROPOMI data for air quality monitoring and emission estimates with respect to previous generation sensors- Evaluation of the stability and suitability of the TROPOMI generated datasets for long-term studies (trend estimates) using forward and inverse model systems - Quality check of TROPOMI data through cross-constituent cross-sensor inversions- Systematic consulting and feedback to developers, if found necessary including updated a priori information for use in the retrieval.The project is aimed at 6 out of 8 mandatory Level 2 products (tropospheric O3, NO2, HCHO, SO2, CO, and aerosol profile). The consortium has drawn together two modelling groups, from BIRA-IASB (Belgium) and TNO (The Netherlands), both with long experience in modelling and integrating capabilities afforded by data assimilation systems. Furthermore, the project will benefit from (i) measurements operated by BIRA-IASB, (ii) links to observational stakeholders through projects responding to the same call (TCCON4S5P, NIDFORVal, CHEOPS-5P), and (iii) freely available data.The expected outcomes are a set of recommendations regarding the validity and suitability of TROPOMI observations, which will ensure an active contribution to the production line of Level 2 data, and therefore support the retrieval teams. The evidence gathered during the project will be summarized in a living document. In particular, the consistency of TROPOMI data with other measurement platforms, potential model-data mismatches, and the overall suitability of the targeted species for the defined mission objectives will be regularly reported. The project will be presented at the Belgian Science Policy Office and at the Netherlands Space Office to negotiate the funding and its sustainability, necessary to provide informed recommendations and meet the observation requirements of the call.

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28581	**Investigation of the effect of horizontal gradients of trace gases, aerosols and clouds on the validation of tropospheric TROPOMI products (TROPGRAD)**	**Prof. Thomas Wagner**	**Max-Planck-Institute for Chemistry**	**GERMANY**	The proposed activities address an important fundamental problem in the analysis of tropospheric data products from satellite observations: the effect of vertical and horizontal gradients of the trace gases (and aerosols) within the satellite ground pixel. Vertical profiles are important for the calculation of air-mass factors, which are required for quantitative interpretation of satellite measurements. Horizontal gradients complicate the quantitative comparison of ground-based with satellite column measurements (see e.g. Chen et al., 2009, Ma et al., 2013). Here we focus on observations of tropospheric NO2 and HCHO. Especially close to strong emission sources strong spatial gradients exist, which can significantly affect the satellite retrievals. The main aims of the proposed project are to use MAX-DOAS observations with our 4-azimuth instrument in Mainz, Germany, to characterise these spatial gradients and their effects on the satellite retrievals. The effect of horizontal gradients is especially important for S5P, because of the rather small ground pixels of about 7 x 7 km2, whereas for larger ground pixels the effects of spatial gradients partly cancel out. It is expected that close to strong emission sources significant horizontal gradients of NO2 and probably also HCHO exist on similar scales as the dimensions of the S5P ground pixels. Our 4 azimuth MAX-DOAS instrument is well suited to resolve the horizontal gradients on exactly these spatial scales.The following activities are planned:MAX-DOAS retrievals:┬╖ Horizontal gradients of NO2 and HCHO will be determined from simultaneous MAX-DOAS observations at low elevation angles in 4 azimuthal directions (see e.g. Brinksma et al., 2008).┬╖ Vertical profiles of NO2 and HCHO based on full profile inversions using different elevation scans will be performed separately for the 4 azimuth viewing directions (for details see Wagner et al., 2011).┬╖ Tropospheric VCDs of NO2 and HCHO will be determined using the so called geometric approximation (e.g. Brinksma et al., 2008). The geometrical approximation is more robust that the full profile inversion and can e.g. be also performed under cloudy conditions.┬╖ Aerosol extinction profiles will be analysed from the O4 observations (Wagner et al., 2004) in the 4 azimuth directions (the aerosol profile inversion is actually the first stept of the trace gas profile retrieval (e.g. Clemer et al., 2010; Wagner et al., 2011).┬╖ The cloud distribution over the measurement site will be retrieved using MAX-DOAS observations of the colour index and the O4 absorption (Wagner et al., 2014; Gielen et al., 2014).MAX-DOAS ΓÇô satellite comparisons:┬╖ Tropospheric VCDs of NO2 and HCHO derived using the geometric approximation and integrated vertical profiles will be compared to coincident satellite observations.┬╖ The level of agreement will be analysed as function of the spatial gradients (of trace gases, aerosols and clouds), the vertical trace gas and aerosol profiles and the cloud products derived from the satellite.Improvement of the satellite retrievals:┬╖ The satellite retrievals will be modified using the vertical profiles of trace gases and aerosols derived from the MAX-DOAS observations.┬╖ In cases of strong horizontal gradients of the trace species, different trace gas and aerosol profiles will be used in different parts of the satellite ground pixels (corresponding to the 4 azimuth directions of the MAX-DOAS instrument. For this purpose the independent pixel approximation will be applied as a starting point. As an alternative, possibly also full 3-dimensional radiative transfer simulations will be applied.┬╖ In cases of heterogeneous cloud cover, the trace gas and aerosol results in the different parts of the satellite ground pixel will be weighted according to the respective TOA radiances and air mass factors (depending on the cloud shielding), and the weighted average will be compared to the satellite products.

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28587	**CHEOPS-5p ΓÇô Validation of Copernicus HEight-resolved Ozone data Products from Sentinel-5P TROPOMI using global sonde and lidar networks**	**Dr. Jean-Christopher Lambert**	**Belgian Institute for Space Aeronomy**	**BELGIUM**	Part of the space segment of the future Copernicus Atmosphere and Climate Services, the Sentinel-5 Precursor (S5P) mission is dedicated to global and European atmospheric composition measurements of air quality, climate and the stratospheric ozone layer. On board, the imaging spectrometer TROPOMI (TROPOspheric Monitoring Instrument) will measure nadir atmospheric radiance and solar irradiance in the ultraviolet, visible, and near-infrared spectral range, from which ozone profile and tropospheric ozone column data will be retrieved using a variety of retrieval methods: Optimal Estimation, Convective Cloud Differential, Cloud Slicing... The proposed activity will provide the required geophysical validation of these height-resolved ozone data products in the troposphere and stratosphere, and validation support to the evaluation and further evolution of the associated retrieval algorithms. The validation/evaluation methodology relies on analysis of S5P data retrieval diagnostics and on comparisons of S5P data with reference ozone profile measurements acquired by ozonesonde, stratospheric lidar and tropospheric lidar stations performing network operation in the context of WMO's Global Atmosphere Watch, including the NDACC global and SHADOZ tropical networks. After adaptation of in-house versatile satellite validation environments currently operational in the context of ESA's CCI and Multi-TASTE projects, EUMETSAT O3M-SAF, and CEOS and SPARC initiatives, a list of S5P data Quality Indicators (QI) will be derived from complementary investigations: (1) data content and information content studies based on the analysis of the S5P data products, retrieval diagnostics and ancillary parameters; (2) traceable preparation of the S5P data and correlative measurements in view of data comparisons (co-location studies, unit and representation conversions, handling of smoothing and sampling issues, independent estimate of tropopause altitude, (sub-)column integration...), with estimates of the additional uncertainties introduced by the necessary data manipulations; (3) data comparisons leading to statistical estimates of the systematic bias and random difference between S5P and reference network data as a function of latitude, their cycles, their long-term evolution, and their dependences on measurement and atmospheric parameters (e.g., clouds, solar zenith angle, aerosols and slant column density); (4) assessment of compliance with user requirements as formulated, e.g., by Copernicus Atmosphere and Climate services and by GCOS. The proposed activity will be carried out by a team uniting official representatives of the GAW, NDACC and SHADOZ networks of ozonesondes and lidars and their associated technical WGs, satellite validation experts who have experience with nadir ozone profiling and nadir tropospheric column retrievals and their specific issues, and atmospheric scientists involved in the Copernicus programme, GCOS and the Sentinels. Baseline activities, which include semi-automated operation of our in-house validation systems in routine mode, will be partly funded internally by the research and academic institutions involved. After approval of this AO proposal, dedicated proposals will be submitted to national agencies and associated bodies (including ProDEx) in order to obtain funding for more extensive activities during the S5P commissioning phase and for more specific activities contributing to the evolution of S5P data products.

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28595	**Airborne and Lidar Validation of Sentinel-5 Precursor in the Arctic (ALIVO S5P Arctic)**	**Dr. Michael Gausa**	**Andoya Space Center**	**NORWAY**	The present Cal/Val project proposes to validate the Sentinel-5 Precursor Mission with ground based and airborne measurements at our stations: ALOMAR Observatory 69N,16E (ASC) and the FMI Arctic Research Center 67N,26E (FMI). We will collect profiles and columns of ozone, aerosol- and cloud content at high latitude stations and compare our data to the satellite products during the pre-launch, commissioning and the operative phase of S5P. Both locations are distinguished for the validation of polar orbiting satellites due a comprehensive set of instruments and a 2-4 times higher amount of overpasses compared to mid-latitude sites. High solar zenith angle, midnight sun in summer, long twilight periods in winter and arctic weather conditions are challenging for the instrumentation at the stations and for the instrument on-board the satellite. The number of suitable stations for satellite validation at comparable latitude is very limited. Hence a careful validation has to take place here to ensure reliable satellite data throughout the whole mission period. Both sites were involved in previous satellite validation projects (e.g. ENVISAT) and the present ground-based instrumentation and the data processing software is inter-calibrated through different international networks. For the composition of the team, we emphasise extensive knowledge on ozone chemistry, optical atmospheric profiling and column measurements. The TROPOMI instrument aboard S5P is a NADIR pointing spectrometer, which allows both column and profiling measurements of trace gasses, cloud- and aerosol layers. The instrumentation at both sites is suitable to compare TROPOMI data products for selected atmospheric components. Table 1 in Appendix 1 gives an overview over the different profiling and column instruments at ASC and FMI and the appropriate atmospheric parameters measured. Table 2 shows the validation products from the two stations versus the data product from the S5P. FMI has long term experience in ozone profile measurements using the balloon borne ozone sondes. During the project these sondes will be flown at Sodankyl ├ñ, with an option to organize dedicated sounding campaigns. The ASC tropospheric lidar is part of the EARLINET network. The system is certified as an EARLINET station. The system has three elastic and one inelastic channel plus depolarisation capability at 532 nm. Data products that contribute to the validation are the aerosol backscatter, extinction coefficients and vertical extension of clouds and aerosol layers. The Ozone lidar at ALOMAR started operation in December 1994 and underwent several upgrades e.g a daylight detection system with the help of ESA funding and new acquisition system and photon detectors. The wavelength dependent differences of the absorption at the two wavelengths emitted allows the retrieval of the ozone density and ambient temperature in a height range between 9 and maximal 50 km altitude (during daytime about 42km). We envisage airborne aerosol profiling with manned and unmanned platforms. The endurance of both platforms allows reliable operations within a 200 km radius around of the Andoya Island and thus further increases the number of usable overpasses. The airborne instrumentation comprises of a well-proven package of meteorological sensors (PTU) together with 3D wind measurements. Additionally we probe the black carbon content with an Aethalometer and an in-house developed three-colour laser sensor. Both stations use CIMEL Sun Photometers and Brewer Spectrophotometers for column measurements of AOD and ozone respectively. While standard operation is in daytime, the Brewer systems and the ASC CIMEL are also capable to measure around full moon in winter. The activities proposed in this Cal/Val project will be eligible for PRODEX funds and national funds from the Academy of Science in Finland. As a collaborative proposal between Nordic countries, we will also approach the Nordic Science Foundation for funding.
28596	**Sentinel-5p/TROPOMI L2 products validation using the Cabauw Experimental Site for Atmospheric Research CESAR**	**Dr. Arnoud Apituley**	**Royal Netherlands Meteorological Institute**	**NETHERLANDS**	The CESAR site is the Dutch focal point for collaboration on climate monitoring and atmospheric research and is situated on the KNMI meteorological research site near Cabauw. It offers a large suite of observations aimed to fully characterize the atmospheric column in terms of composition and vertical structure. Main themes are clouds and radiation and atmospheric composition that are well-aligned with the TROPOMI products. Many of the observations are running continuously, providing a long-term record. In addition, the observational programme can be augmented by dedicated campaigns, involving additional instrumentation to study specific aspects such as spatial variability. This CAL/VAL proposal exploits the unique capabilities of CESAR to study the characteristics in detail of the L2 products of the S5P mission. The key aspects that will be taken into account are 1) the unprecedented high spatial resolution (7x7 km at nadir) of TROPOMI, 2) validation of new data products (e.g. Aerosol Layer Height) and the 3) unique capabilities of the CESAR site where a comprehensive suite of instruments measures the atmospheric column, as well as the vertical profile. The validation activities offered aim to provide the detailed information about the atmosphere needed to understand and improve the TROPOMI products. In the commissioning phase initial validation will be performed, in close co-operation with the L2 algorithm developers. The work will be based on routine observations and if funding allows, additional dedicated campaigns. The site is also available for collaboration with other initiatives, e.g. airborne campaigns.

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28603	**Validation of S5P Methane and Carbon Monoxide with TCCON Data (TCCON4S5P)**	**Dr. Kumar Sha Mahesh**	**Royal Belgian Institute for Space Aeronomy**	**BELGIUM**	The present proposal represents the answer of the Total Carbon Column Observing Network (TCCON) community to the ESA Sentinel-5 Precursor (S5P) Mission Announcement of Opportunity to engage expertise in the mission validation team. As noted in the ┬ôRequirements for the Geophysical Validation of Sentinel-5 Precursor Products┬ö document, the TCCON provides data that is excellently suited for the validation of S5P methane and carbon monoxide total column measurements.In this proposed activity, entitled ┬ôTCCON4S5P┬ö, we will focus our efforts on the geophysical validation of S5P CO and CH4 total column products using coinciding TCCON and NDACC CO data.The proposed activity will be carried out in two phases. During the first phase, which will last for 12 months, the participating TCCON sites will contribute to a rapid data-delivery effort, where the most recent TCCON data will be delivered every three months (i.e. there will be 4 rapid data deliveries during this one year phase). This phase of the activity will start as soon as S5P is able to carry out a sufficient number of qualitative measurements over participating TCCON sites. If these conditions are met during the commissioning phase (E1), then the one year phase will start at this point, and the partners will contribute a first rapid delivery before the end of phase E1, so that the results of the validation can be used in the update of the S5P operational processor at the end of the commissioning phase. The remaining 3 rapid data deliveries are then spread out to cover the rest of the one year period.After the initial year of rapid data delivery, the second phase of this activity starts, which entails the continuing long-term validation of S5P level 2 CO and CH4 data using coinciding TCCON and NDACC CO data for the operational lifetime of the satellite. This includes re-validation of data as updated versions of the S5P, TCCON, and NDACC data product are released. In addition to this, a global CO2 field model will be further developed and extended to CH4 fields. High resolution fields could be produced for regions of special interest. Furthermore, the possibility of reducing the intercomparison error by using independent profile information will also be investigated as part of this project.The team consists of experts representing 21 different TCCON sites covering Europe, North- and South America, Japan, Australia, New Zealand and Africa. This ensures a detailed knowledge of the regional effects influencing each participating TCCON site, which will help to interpret the results of the validation activity.The proposed work in this proposal is conditional to availability of sufficient funding. All contributing sites commit themselves to deliver TCCON data according to the TCCON requirements (i.e. with a delay of maximum one year). Any additional workload mentioned in this proposal (rapid data delivery, validation and modeling work) is conditional on additional funding being found.

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28607	S5P NItrogen Dioxide and FORmaldehyde Validation using NDACC and complementary FTIR and UV-Vis DOAS ground-based remote sensing data (NIDFORVal).	Dr. Corinne Vigouroux	Belgian Institute for Space Aeronomy	BELGIUM	The NIDFORVal project aims at providing an assessment of the quality of two key atmospheric constituents that are mandatory products of the Sentinel 5 Precursor (S5P): Nitrogen Dioxide (NO2) and formaldehyde (HCHO). Two different and independent ground-based remote sensing techniques will be used: Fourier Transform Infrared (FTIR) and UV-Visible Differential Optical Absorption Spectroscopy (UV-Vis DOAS). Both techniques can provide accurate NO2 and HCHO data that fulfill the S5P validation requirements:- NO2 total columns from DirectSun DOAS measurements - NO2 stratospheric columns from FTIR and ZenithSky DOAS measurements - NO2 tropospheric columns and profiles from MAXDOAS measurements - HCHO total columns from FTIR and MAXDOAS measurementsBeyond the interest of combining two independent techniques for validating the same species, the project will take benefit from the different vertical sensitivities of FTIR and UV-Vis DOAS measurements to fulfill complementary S5P validation objectives, and to better diagnose the individual validation results. High quality measurements from over 60 ground-based stations will be gathered from NDACC and complementary networks or recent infrastructures, extending the overall data set to a large range of observation conditions sampling high, mid- and low latitudes, as well as background (unpolluted), sub-urban and urban polluted sites. Experienced measurement PIs will commit to regularly deliver data directly to relevant data bases endorsed by ESA or to the team at BIRA-IASB for further format transformation and submission to the data base. The latter team will coordinate validation activities, making use of common tools and data processing strategies derived from the experience developed in precursor projects (CINAMON, FTIRval, Multi-TASTE, O3M-SAF, GEOmon, GECA, NORS).The first task is to provide homogenized and characterized FTIR and UV-Visible time-series of NO2 and HCHO data. Data retrieval homogenization will be based on the experience developed by project partners on NO2 (Hendrick et al., 2012, Vlemmix et al., 2014, Wittrock et al., 2014) and HCHO (Vigouroux et al., 2009, Wagner et al., 2011, Pinardi et al., 2013, Hendrick et al., 2014). To characterize the various data products, averaging kernels will be extensively used as well as comprehensive uncertainty budgets. The second task consists in the validation of the S5P products during the S5P commissioning Phase E1. This will be based on a subset of ground-based FTIR and UV-Vis DOAS stations ready for operational data submission in rapid delivery mode. Following Phase-E1, the S5P project will enter into the routine operation phase (Phase E2). In this phase, approaches and methods will be further developed. The progressive accumulation of large data sets will allow for improved statistics, which in turn will allow for a refinement of the validation and results. This will include: refined categorization of validation sites and search for patterns or specific behaviours in validation results; analysis of seasonal cycle effects and finally verification of long-term consistency throughout the mission. Also efforts will be done to improve collocation criteria, through an in-depth exploration of the representativity of each validation site based on appropriate model data.The main outcomes of the project will be: - The creation of a comprehensive database of archived FTIR and UV-Vis DOAS homogenized time series of NO2 and HCHO columns (2016-2023). Data will be archived in the ESA Cal/Val database or linked to it through the NDACC database at NOAA. Only the stations that will be able to secure national funding for this project can commit to submit data.- An assessment of the quality of the NO2 and HCHO S5P products based on independent high-quality ground-based FTIR and UV-Vis DOAS data sets.- The communication of results in ESA reports, S5PVT and international meetings, as well as peer-reviewed publications
28608	Validation/verification of TROPOMI ozone data products (S5POZVAL)	Dr. Mark Weber	Institute of Environmental Physics University Bremen FB1	GERMANY	We propose the validation of S5P/TROPOMI ozone data products (profiles and total columns) by comparison with collocated Brewer/Dobson/filter (total columns), ozone sondes and lidar (both ozone profiles) from the WOUDC and NDACC data base. In addition comparisons will be made with our scientific retrievals applied to GOME-2 aboard Metop-A and -B (columns and profiles). Detailed comparison will be also carried out by comparing TROPOMI columns with OMPS nadir observations (columns) and TROPOMI profiles with limb observations from MLS, OMPS, OSIRIS, and ACE-FTS (dependent of availability). For the profile comparisons averaging kernel approaches are to be used to account for differences in vertical resolution. Alternatively, subcolumn amounts are compared. Comparisons will be carried out on global scale. From the biases and debiased standard deviations the accuracy and precisions (repeatability) are to be established. Dependencies of the data product quality on geophysical parameters like solar zenith angle, swath angle, cloudiness, albedo etc are to be investigated. In particular, the nadir ozone profiles critically depend on the absolute radiometric calibration of radiances, and our validation activities will also include a verification of the radiance calibration (based upon radiation transfer simulation), that may strongly be affected by changes from pre- to post-launch conditions.
28612	Validation and intercomparison of TropOMI sun-normalized radiances	Dr. Glen Jaross	NASA-GSFC	UNITED STATES	In this proposal we offer the services of the OMPS instrument team in applying calibration validation techniques to TropOMI that we have previously used for SNPP OMPS Nadir sensors and Aura OMI before that. Our proposed effort will identify radiometric errors through evaluation of well-understood stable Earth scenes and through comparison with other satellite instruments, especially those of Aura OMI and SNPP OMPS. Cross-calibration with OMI is clearly important for reasons of data product continuity. And comparisons with OMPS are a natural choice since the viewing conditions of the two will be so similar.In situations where the errors clearly indicate multiplicative calibration errors we will provide adjustment factors as a function of the detector dimensions. In cases where additive errors appear to play a role, we will identify the location and magnitude of the error along with phenomenology that should assist the TropOMI instrument team to track down the source of error. Internally scattered stray light is a prime example of such additive errors.We intend to monitor TropOMI calibration changes over the course of the mission using the techniques proposed here. And we will report our initial and subsequent results to ESA and to the KNMI team in the form of brief reports, presentations, and data sets.

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28613	Initial Validation of the TROPOMI NO2, Ozone Profile and Aerosol Products and Preparation for the Core Validation Phase	Dr. Pepijn Veefkind	Royal Netherlands Meteorological Institute	NETHERLANDS	The validation activities will be focused and the assessment and improvement of the TROPOMI NO2, ozone profile and aerosol products. During the pre-launch period we will prepare semi-automated tools for the comparison of the TROPOMI products with correlative datasets. In the commissioning phase initial validation will be performed, in close co-operation with the L1-2 algorithm developers. At the beginning of the E2 phase, we aim to have semi-automated systems that can routinely produce validation reports. The work will be based on existing databases of observations and models.
28617	SERVE: S5P Earth reflectance validation experiment	Dr. Pieter Stammes	Royal Netherlands Meteorological Institute	NETHERLANDS	In this project we will compare TROPOMI/S5P 's Earth reflectance measurements with radiative transfer model calculations in the UV-VIS range for selected Earth scenes, like clouds, deserts, and clear sky scenes. In this way instrumental calibration errors can be detected and monitoring of calibration can be performed.
28618	High latitudes validation for TROPOMI/S5P (HIGHVAL)	Dr. Iolanda Ialongo	Finnish Meteorological Institute	FINLAND	HIGHVAL-project aims to validate the products from TROPOMI (TROPOspheric Monitoring Instrument) on Sentinel 5 precursor (S5P) with specific focus on high latitude conditions. The validated products include total ozone and ozone profiles, NO2, SO2, surface UV, CO, CH4, aerosol and clouds. Ground-based instruments located at latitudes above 60°N will be used for the comparison. The instrumentation includes: Brewer spectrophotometers, UV radiometer, Pandora spectrometer, ozonesondes, TCCON (Total Carbon Column Observing Network) Fourier Transform spectrometer (FTS) and AirCore system for GHG (Green-House-Gases) measurements, PFR (pulse repetition frequency) and Cimel sun photometers for AOD, LIDAR. These instruments are maintained in several sites at the Finnish Meteorological Institute (FMI) and include a variety of independent atmospheric observations and measuring techniques. The validation team includes a large number of experts on satellite retrieval and validation of several atmospheric key species, e.g., ozone, NO2, aerosols, surface UV and GHGs. Some of the validation team members are directly involved in the ground-based measurements maintenance and their scientific application. The others are experts in satellite retrievals, e.g. PI of OMI and TROPOMI UV product (A. Arola and A. Lindfors, respectively) and OMI (Ozone Monitoring Instrument) co-PI (J. Tamminen).HIGHVAL-project will be carried on as different work packages for different TROPOMI/S5P products. In particular, the effect of surface albedo on the retrieval algorithm performances will be analysed in case of snow/ice cover for different cloud conditions. This work is supported by the numerous snow observations done in Finland as well as snow products based on satellite data. In addition, cloud information of ground based and other satellite instruments will be used in evaluating the algorithm performances in partly cloudy conditions. Also, in general, the quality of the observations, at high solar zenith angles will be evaluated.The outcomes of the HIGHVAL-project include:- A cohesive validation of most of the TROPOMI/S5P products under specific conditions at high latitudes- Validated total ozone and ozone profiles measurements for high latitude conditions.- Improved UV algorithm at high latitudes for high solar zenith angles and snow cover at various cloudiness conditions.- Improved understanding of the performance of TROPOMI UV in relation to clouds. - Validated NO2 and SO2 observations for high latitude conditions. Increased application potential for air quality monitoring at high latitudes.- Improved TCCON retrievals and validated TROPOMI GHGs, in particular under polar vortex conditions.- Validated aerosols and cloud information for high latitude conditions.There is no specific funding exclusively dedicated to the proposed work but some of the existing activities, in which the team members are involved, support this project. The ground-based instruments are maintained using FMI budget. The team members have and will apply for national and international funding to different national agencies.
28621	Validation of TROPOMI UV Measurements Using Polar Mesospheric Cloud Detection	Dr. Matthew DeLand	Science Systems and Applications, Inc.	UNITED STATES	We propose to help validate the radiance measurements made in Band 1 (270-300 nm) of the TROPOMI instrument. This task will be done by implementing an algorithm to detect and characterize polar mesospheric clouds (PMCs). The basic PMC detection algorithm has already been successfully demonstrated with Aura OMI data. The brightness of PMCs detected by TROPOMI can be compared to PMCs measured by other satellites that are in very close orbits and use the same measurement technique. Our team has many years of experience with on-orbit validation of satellite instruments and PMC measurement and analysis. The agreement between different PMC data sets will help to validate the absolute calibration and stray light characterization of TROPOMI. The efforts of the PI are supported by a NASA research grant.

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28622	GLORIA for Sentinel-5P Validation (GASVal)	Dr. Martin Kaufmann	Forschungszentrum Jülich GmbH	GERMANY	This project aims to provide independent measurements of ozone, cloud top height and other constituent data to validate selected level-2 data products in the commissioning and operational phases of S5P. These data are obtained by the Gimballed Limb Observer for Radiance Imaging of the Atmosphere (GLORIA) during two aircraft campaigns conducted in 2016 and 2017. These campaigns are funded in the framework of other projects. The conduction of further aircraft campaigns to validate operational S5P data products after 2017 is envisaged.GLORIA is an infrared remote limb sounder which combines the high horizontal resolution of a nadir sounder (tens of km) with the altitude resolution provided by a limb-sounding instrument. In the so-called dynamics mode, GLORIA can deliver trace gases in the upper troposphere / lower stratosphere with a resolution of up to 20 km x 20 km horizontally and 200 meters vertically. The aircraft campaign in Summer 2016 is conducted in the framework of the EU FP-7 STRATOCLIM project. It utilizes the Russian GEOPHYSICA aircraft (ceiling altitude ~20 km). The campaign base will be in the Indian region, the main scientific objective is the outflow of the Indian Monsoon. Measurements obtained during the transfer flights from Europe to Asia may also be used for S5P validation activities.In Fall 2017, the WISE measurement campaign utilizing the German HALO aircraft (ceiling altitude ~15 km) will be conducted. The campaign base will be in Ireland, the main scientific objectives are planetary wave breaking and troposphere-stratosphere exchange. This campaign is led by Research Centre Juelich and funded by a consortium of German research centers and universities. Both campaigns are supported by modeling activities to predict and analyze the mesoscale meteorological situation. This data can also be provided for S5P validation activities.
28626	TropOMI Validation using the NASA ER-2 high altitude aircraft	Dr. Brian Cairns	NASA Goddard Institute for Space Studies	UNITED STATES	The Tropospheric Monitoring Instrument (TROPOMI) on the Sentinel-5 Precursor Mission (S5P) is currently in Phase D with an expected launch early in 2016 and the European Space Agency (ESA) is in the process of soliciting proposals for membership in the Sentinel-5 Precursor Validation Team (S5PVT) with a closing date of October 1st 2014. S5P is expected to provide measurements of ozone (O3), nitrogen dioxide (NO2), sulphur dioxide (SO2), carbon monoxide (CO), methane (CH4) and formaldehyde (HCHO). In addition to the trace gas products, the TROPOMI retrieval algorithms are expected to provide estimates of an absorbing index (AI) and aerosol layer height for tropospheric aerosols from Ultraviolet (UV) and Visible Near Infrared (VNIR) observations, whereas trace gas retrievals of CO and CH4 that use the VNIR and Shortwave Infrared (SWIR) observations require in addition the accurate determination of Aerosol Optical thickness (AOT) and, in the case of CH4, the power law dependence of the aerosol size distribution. The announcement of opportunity ΓÇ£aims to engage leading expertise for the Calibration and Validation of the S5P in the S5PVT, providing independent experimental data, analysis and recommendations to critically assess the end-to-end performance of the instrument and its products.ΓÇ¥ The primary objective of this proposal is to provide an independent assessment of the radiometric stability and accuracy of the TROPOMI sensor and an evaluation of the aerosol and cloud properties retrieved, or assumed in the trace gas retrieval algorithms. We therefore propose to fly a package of instruments on the NASA Earth Resources 2 (ER-2) aircraft that can be used to assess and validate the radiometric performance of TROPOMI and also the aerosol and cloud retrieval products. This package of instruments will be flown as part of the Hyperspectral Infrared Imager (HySPIRI) airborne campaign prior to the TROPOMI launch to ensure that the experimental design and integrated sensor package function perform as expected. The flights funded by our proposal to NASA will take place in each of the succeeding five years once TROPOMI is acquiring data to track the stability of the sensor and the algorithms. The package of instruments that we will fly on the ER-2 consists of the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS), the Portable Remote Imaging Spectrometer (PRISM), the Research Scanning polarimeter (RSP), and the Spectropolarimeter for Planetary Exploration (SPEX) instruments. The PRISM and AVIRIS sensors provide high spatial resolution, continuous spectral sampling over spectral ranges of interest for TROPOMI and cross-track coverage to allow for direct matching of the airborne sensor observations to the TROPOMI pixel level radiance observations. The RSP and SPEX sensors have lower spatial resolution and less cross-track coverage, but make multi-angle observations over wide spectral ranges of not just the intensity but also the state of linear polarization of the reflected sunlight. These observations have been demonstrated to provide extremely accurate retrievals of aerosol optical thickness (AOT), Single Scattering Albedo (SSA), particle shape and size distributions, layer height and complex refractive index of aerosols. They have also been demonstrated to provide highly accurate information on the (presence and) properties of (sub-visible cirrus) clouds.The airborne observations that we will obtain are directly relevant to the radiometric and accuracy objectives of S5PVT. Furthermore, given the potential value of TROPOMI to improve our knowledge of the global distribution of absorbing aerosols it is particularly important that the optimal aerosol retrievals be implemented in reprocessing the TROPOMI observations. Our validation of the TROPOMI aerosol products are a key means to facilitate this goal as well.

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28627	Validation of nitrogen dioxide and Arctic methane from Sentinel-5P	Dr. Ann Mari Fjaeraa	Norwegian Institute for Air Research	NORWAY	The main goal of the proposed activity is to validate methane and nitrogen dioxide products from TROPOMI onboard Sentinel-5P. For methane, there will be a specific focus on the polar regions, and validation will be carried out using observations from multiple ground based instruments as well as inter-comparisons with existing satellite products of proven quality. For NO2 the validation will be on the global scale and will consist of an inter-comparison with other satellite-based NO2 products of proven quality.NILU will validate the TROPOMI products using a wide variety of validation techniques. The work will be organized and carried out in two distinct work packages (WPs).WP1 will validate the TROPOMI methane product in the polar regions by using two separate validation approaches: First, absolute validation of methane total column will be carried out against the well-characterised long-term in situ and NRT (near-real-time) observations from the Zeppelin Observatory (period 2001-present), and against observations acquired at the Birkenes observatory in Southern Norway at 58oN (period 2009-present). Observations from other Arctic sites, e.g. Ny-Alesund, available from the EVDC (ESA Validation Data Centre; http://evdc.nilu.no) database hosted at NILU may also be used in this work. Second, a relative validation will be carried out by inter-comparing the methane total column product against GOSAT, and possibly AURA-TES and IASI CH4 products. The relative validation will cover both Arctic areas and other parts of the globe, e.g. mid-latitudes, where global and regional difference maps between TROPOMI CH4 and other EO products will be generated for studies of the spatial patterns in inter-sensor biases. The planned CH4 validation will involve inter-comparisons with other CH4 products from satellite instruments operational at the time of the Sentinel-5P launch. WP2 will validate the tropospheric and total column NO2 products retrieved from TROPOMI spectra by carrying out a comprehensive inter-comparison with independently validated NO2 products from other satellite instruments. An inter-comparison with independent Earth Observations products is a widely used technique for the validation of satellite products. It tends to be global in scale and has a strong focus on spatial patterns in the quality of the products. This WP complements parallel efforts focusing on validation of NO2 with ground-based remote sensing instruments. While NILU will be providing SAOZ-based NO2 data observed at Ny-Alesund to the NIDFORVal proposal submitted by BIRA, we focus here solely on the inter-sensor comparison to provide a complementary continuous spatial perspective to an otherwise spatially limited distribution of ground-based remote sensing sites. A strong focus on the NO2 validation effort will lie on TROPOMI's ability to seamlessly continue the existing long time series from the heritage instruments such as GOME, SCIAMACHY, and GOME-2A/B and to allow for the computation of unbiased trends from the data.The primary expected outcome of the proposed project is to improve our understanding of the quality and accuracy of the Sentinel-5P methane product in high-latitude areas, and to provide a complementary global-scale and spatially continuous perspective to validation with ground-based remote sensing instruments by inter-comparing the TROPOMI NO2 product against NO2 products from other satellite instruments with quantified uncertainty.The project is dependent on an approval of funding from the ESA PRODEX programme.
28630	Validation of the S5P CO and CH4 total column product	Dr. Jochen Landgraf	SRON Netherlands Institute for Space Research	NETHERLANDS	The primary objective of the Sentinel 5 Precursor (S5P) mission is to monitor air quality and climate change as part of the Copernicus Space Segment. S5P aims at providing high quality and robust datasets of several atmospheric trace gases including the CO and CH4 level-2 product. To assure data quality of these geophysical data products, on-going validation with independent measurements is required during the entire mission lifetime. For S5P purposes, the vertically integrated amount of CO has to be retrieved with an uncertainty of
28631	Early Validation Opportunity in Conjunction with a NASA Spring 2016 Coastal Northwest Pacific Airborne Field Campaign	Dr. Jay Al-Saadi	NASA	UNITED STATES	As expressed in document S5P-RS-ESA-SY-164 `Requirements for the Geophysical Validation of Sentinel-5 Precursor Products,` airborne measurements provide invaluable independent correlative data for validation of Level 2 atmospheric species data products. The airborne measurements have well quantified precision and high spatial resolution but due to their relatively high cost are typically only obtained during infrequent intensive field campaign periods. NASA is considering deployment of a large instrumented aircraft, such as the DC-8, to South Korea during spring 2016 to participate in a joint Korea/US field campaign focused on air quality. The instrument suite would prioritize in-situ and remotely-sensed measurements of several species that are S-5P primary Level 2 products: O3, NO2, HCHO, aerosols, CO, and CH4. NASA will decide no later than summer 2015 whether to proceed with this campaign in spring 2016. If the campaign is conducted in 2016, it will provide an outstanding S-5P early validation opportunity. This proposal team would coordinate activities between NASA and ESA to maximize the value of (1) the airborne observations to S-5P validation and (2) S-5P observations to improved understanding of air quality in East Asia. During the campaign, desired S-5P viewing conditions would be considered in routine flight planning to accomplish as many satellite/aircraft co-incidences as feasible. NASA would invite S-5P mission team members to be team collaborators and participate in the campaign so that the S-5P project would have immediate access to the airborne data during the deployment phase for use in early validation activities. Funding source is NASA.

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28632	SNITCH (SeNtInel 5P validaTion by Comet Halo)	Dr. Andreas Fix	German Aerospace Center Institute of Atmospheric Physics	GERMANY	The goal of the proposed activity is the validation of the methane column of S5P using aircraft measurements. The airborne platform foreseen is the German research aircraft HALO. A dedicated HALO science mission that is focused on the measurement of methane (and carbon dioxide), dubbed CoMet, has been evaluated by the scientific steering committee of HALO and is now scheduled for the 1st half of 2017. In order to maximize gain, the team proposes to make use of the gathered data from this campaign. For CoMet the aircraft will be equipped with a unique payload consisting of a suite of the most sophisticated instruments currently available to measure atmospheric carbon dioxide and methane. Remote sensing instruments, both active and passive, will be complemented by in-situ sensors to obtain maximum synergy. Therefore, this approach can to a significant extent make use of resources already planned to answer the long-term validation needs (phase E2) of S5P.Concerning active remote sensing, the Integrated Path Differential Absorption (IPDA) lidar technique using hard target reflection from the Earth's surface in the near IR (1.64 ┬ m) has been identified in the last few years to measure the column averaged dry air mixing ratio of CH4 (and CO2) and high accuracy and low bias. As a passive remote sensing instrument, the MAMAP2D airborne spectrometer system capable of direct and quantitative remote column-averaged measurements of atmospheric CH4 (and CO2) complements the payload. This instrument measures reflected and scattered solar radiation in the short wave infrared (SWIR) and near-infrared (NIR) parts of the electro-magnetic spectrum. In order to validate the remote sensing instruments and provide the best possible greenhouse gas profile information, the most sophisticated in-situ instruments to measure CH4 (and CO2) currently available based on cavity-ringdown spectrometry (CRDS) will complement the core payload. Also part of this in-situ package is a flask sampler which will collect air samples for subsequent laboratory analysis and thus provide supplemental information on isotopic composition and other tracers correlated with the emission of GHGs. The above listed instruments are complemented by mini-DOAS which is capable of providing another independent method to measure the greenhouse gases and the aircraft's basis measurements system. The latter will provide precise and quality-assured data of temperature, pressure, and humidity as well as aircraft position and attitude which are required to retrieve the dry-air columnar information.The CoMet mission will take place in the European air space. Due to HALO's long range capability, gradients can be precisely captured up to sub-continental scales. It is planned to fly over TCCON sites to validate the TCCON CH4 column against the columns retrieved from aircraft. The flight strategy also foresees flights along forecasted CH4 gradients and over methane hotspots like hard coal mining areas. For S5P validation there is much prospect to synchronize the scientific flights with overflight from S5P. Currently a total of 40-60 flight hours are planned. There is hope that additional funding for flight hours specially dedicated to underfly the satellite can be allocated on the basis of this proposal. It should be mentioned that one of the overarching goals of CoMet is to answer the question whether this payload is an adequate tool to validate future greenhouse gas satellites (e.g. MERLIN, CarbonSat) that will provide even a better accuracy than S5P. One of the CoMet components is to provide important remote sensing and in-situ data information for the inverse modelling approach for regional budgeting of methane fluxes. The S5P validation effort will equally benefit from this activity. For further information on CoMet, a White Paper is available on request.
28633	Heidelberg Sentine5 precursor validation with a ground-based and airborne DOAS Network (HeiSent-Network)	Dr. Klaus PFEILSTICKER	Institut fur Umweltphysik, University of Heidelber	GERMANY	S5P level II products will be validated by means of DOAS observations- regularly performed at ground stations - occasionally performed from research aircrafts (light weight, DLR-HALO, ...)- high flying balloonsOur group was involved in several satellite validation activities. They were partly sponsored by national as well international sources (EU, ESA, NASTA, NASA..). We operating a network of permanent groundbased DOAS stations around the globe which could be used for this purpose. These stations include polar sites at Neumayer Station, Arrival Heights (Antarctica), Kiruna (Sweden), and Alert (Canada) as well as the tropical region (Paramaibo, Suriname) and several mid latitudes sites (Cape Verdie Islands, Hohenpeissenberg, Zugspitze and Heidelberg). SCIAMACHY level 1 and 2 products were also validated by DOAS observations from ships (e.g., RV Polarstern and RV Sonne), manned and unmanned aircrafts (DLR-Falcon and DLR HALO, NASA Global Hawk, Russian Geophysica) and high-flying balloons (LPMA/DOAS, LPMA/IASI/DOAS, MIPAS-B) DOAS-instrumentation. Validation products included the spectral solar irradiance, the skylight radiance field, column amounts and profiles of ozone, NO2, BrO, OClO, IO, HONO, CH2O, CHOCHO, and O4 the latter being often used as a proxy for the radiative transfer. Within the present call, the IUP-Heidelberg will contribute through the analysis of ground-based, and airborne (aircraft and balloon) measurements to the long-term validation of the Sentinel5-precursor atmospheric instrument. Further within a cooperation University of Heidelberg and FH D ├ sseldorf small propelled aircrafts equipped with an imaging DOAS instrument are used to monitor the 2D distributions of trace gas at high spatial resolution since the recent past. Such measurements are in particular useful for footprint mapping of pollutants and as such are key for the validation of the Sentinel-5 sensor.

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28636	Calibration and Validation of Aerosol and Gas S5P products (CaliValAG)	Dr. Svetlana Tsyro	Norwegian Meteorological Institute	NORWAY	The purpose of the planned activity is to contribute to calibration and validation of the experimental data from TROPOMI spectrometer on board of Sentinel-5P by provision and analysis of relevant gas columns and aerosol optical depth (AOD) fields from regional and global calculations with the EMEP chemical transport model and from the Norwegian Earth System Model (NorESM). Within the AeroCom tool, the TROPOMI measurements will be integrated through the models with AOD data from other satellites and the AERONET sun-photometer network. The correspondence between these data sources and the TROPOMI measurements will be investigated. Calibration and validation using model data allows interpolation to get an exact collocation in space and time of model data with the satellite observations. The EMEP chemical transport model (Simpson et al., 2012), will be set up to calculate 3-dimensional aerosol concentrations, chemical composition, aerosol extinction profiles and integrated AOD on both regional and global scales, using resolution down to 7 km over Europe, and down to 0.5ox0.5o on the global scale. The performance of the EMEP model for has been extensively evaluated (Aas et al., 2012; Tsyro, 2008). Model calculated AOD and aerosol extinction profiles have been compared to multi-year data from MODIS, AATSR and CALIPSO satellites, as well as from ground-based AERONET sun-photometers and EARLINET LIDARs (Tsyro et al., 2007; Tsyro, 2009) . Main activities to calibrate and validate S5P/TROPOMI measurements will be based on gridded daily AOD, the column data for SO2, NO3, O3, CO and CH4, as well as O3 vertical profiles. The present CMIP5 version of NorESM (NorESM1-M) is to a large extent based on the Community Climate System Model NCAR CCSM4.0. The atmosphere module CAM4-Oslo was constructed by coupling the CAM4 general circulation model to a detailed module for aerosol life-cycling (Kirkevag et al., 2013). NorESM has contributed with extensive model data to the climate model inter-pomparison project (CMIP5) and to AeroCom Phase 2. Currently, the model is run at 1.9o (latitude) x 2.5o (longitude). In the new model version, NorESM2 (work in progress), the horizontal resolution will be 0.9o x1.25o. In NorESM2 (with CAM5-Oslo), nudging towards reanalyzed meteorology will allow model calculations for a specific year or period. This, together with coupling to MOZART chemistry (also on-going project) will facilitate calculations for comparisons with S5P measurements, based on monthly (or finer) averaged fields.The AEROCOM initiative (http://aerocom.met.no/) is the key community integrating global modelling of aerosols for climate science. AEROCOM has for ten years engaged in comparing different global aerosol models as well as in qualifying and using integrated satellite datasets to initialize and validate these models. Through the EMEP and NorESM1-M models, S5P/TROPOMI measurements will within the AeroCom system be integrated with AOD data from MODIS, AATSR, CALIOP and other satellites, and from AERONET sun-photometers. This, facilitated by additional model information on aerosol chemical composition and size distribution, will make a good basis for analyzing biases, including their regional differences, and systematic errors, and could also help to identify error sources. In addition, the spatial and temporal consistency of S5P data will be evaluated through comparison with global maps from the models and satellite sensors. In order to perform along-track comparison of modelled and Aeolus aerosol data, further development of the model observational operator and post-processing routines is needed. Work will be initiated to prepare the EMEP model for calculating the AOD and gas columns collocated with S5P.Funding for the project will be sought from the ESA PRODEX programme and national research funding from the Norwegian Space Agency.
28651	Validation and Verification of S5P NO2 using ground-based, airborne and satellite data (VVS5P)	Dr. Andreas Richter	Institute of Environmental Physics, University of Bremen	GERMANY	This project will address validation of S5P tropospheric NO2 columns. This will be achieved by combining four complementary approaches: * verification with IUP NO2 retrievals on S5P data* verification / validation with IUP NO2 retrievals on GOME-2 data* validation with ground-based MAX-DOAS NO2 retrievals at three (possibly 4) BREDOM stations* validation and characterisation using AirMap airborne imaging DOAS measurementsBy combining these components, the project will deliver a range of results relevant for validation and improvement of the S5P tropospheric NO2 product:* The satellite data provide global data on the consistency of the tropospheric NO2 product and early and systematic information on possible problem areas. By using both retrievals on S5P data and on GOME-2 spectra, instrumental and retrieval issues can be separated. This type of information will be very useful for the operational S5P team.* The ground-based observations provide classical long-term validation results at a small number of locations in Europe and Africa. These data will be analysed on their own but will also contribute to coordinated activities using data from many instruments.* The airborne measurements provide a unique opportunity for full validation and characterisation of individual S5P pixels and the spatial inhomogeneities within them. To take full advantage of these measurements, they will partly be combined with other validation activities. This information will be very valuable for S5P algorithm developers and for an assessment of possible problems with inhomogeneity in ground-based validation activities.In combination, many important aspects of S5P NO2 retrievals will be addressed and a sound validation will be possible.The project team is located at IUP Bremen and consists of scientists who have performed similar measurements and validation analysis for many years. For all instruments and algorithms, the original developers are part of the team, ensuring smooth operation and successful measurements. Experience of the team with earlier validation activities for GOME, SCIAMACHY, and OMI measurements will be useful for the project and facilitate proper set-up and data analysis leading to the expected validation results.

Prj_id	Title	Principal Investigator	Institution	Country	Summary
28659	EC-ACTS: Earlinet and Cloudnet - Aerosol and Cloud Team for Sentinel-5 Precursor Validation	Dr. LUCIA MONA	Istituto di Metodologie per l'Analisi Ambientale - Consiglio Nazionale delle Ricerche	ITALY	Sentinel 5 Precursor will open the Copernicus era providing operational products for global atmospheric studies. Providing information and services in the context of air quality and climate are among the objectives of the S5P mission with a strong focus on the troposphere. Aerosol and clouds are important players in this context, because they and their interactions are responsible for the largest uncertainties on our current knowledge. The new instruments and algorithms, which will be applied in the retrieval of S5P products, call for an accurate validation. Europe can be nowadays regarded as a leader in ground-based vertical profiling observations. ACTRIS (Aerosols, Clouds, and Trace gases Research InfraStructure Network) is an EC funded infrastructure integrating European ground-based stations equipped with advanced atmospheric equipment. Among these, EARLINET (European Aerosol Research Lidar NETwork) and Cloudnet are well-established networks providing vertical profiles of aerosol and clouds with high vertical and temporal resolution. A network of ground-based stations has the ability to provide the spatio-temporal development of aerosol and cloud fields and offers a unique opportunity for the validation of observations from space. In this project, state-of-the-art instrumentations for observing aerosol and clouds will be used for validation purposes: multi-wavelength lidar (EARLINET) and Doppler cloud radar (Cloudnet). A complete characterization of aerosol and cloud fields over the station will be provided by the combined use of EARLINET and Cloudnet data. Additional information will be provided by AERONET data where available. Cloudnet instruments run automatically and unmanned with measurements available 24h/7d in near-real-time. EARLINET instruments are more complex. A specific correlative measurement plan will be designed and realized for the purposes of the project. Dedicated measurements will be performed at selected stations in addition to the routine measurements performed throughout the network.The problem of the variability of the aerosol and cloud fields will be addressed both in the measurement plans and analysis on the basis of our previous experience in satellite data validation and model evaluation [Pappalardo et al., 2010, Wandinger et al., ESA report, 2011]. In addition, collocated satellite lidar data will be used for quantitative evaluation of aerosol and cloud field variability when available.Measurements will be analyzed and archived following the protocols established within their respective networks. Differences will be investigated in terms of aerosol load, aerosol and cloud height, aerosol type, cloud type and underneath surface. A relational database storing all relevant information about correlative measurements datasets will be realized for this aim. As a result, EC-ACTS will provide a quantitative evaluation of the accuracy of S5P aerosol and cloud products. Moreover, the characterization of the observed deviations in different factors will be the basis for proposing improvements to processing algorithms and for evaluating the representativeness of the measurements. The influence of the cloud properties on the S5P/TROPOMI retrieval performance will be investigated through the use of the active remote sensing measurements provided by the EC-ACTS team. Finally, the validity and the stability throughout the instruments operation will be assessed thanks to the long-term validation activities built on the ground-based measurements to be performed for the whole Phase E2.The routine Cloudnet and EARLINET measurement programme runs on National/Institutional funding obtained by the individual partners and secured by individual stations. Additional/correlative measurements and validations studies will be carried on also with the support of National/international agencies.
28673	Impact of Molecular Absorption Spectroscopy Data on S5P Infrared Carbon Gas Concentration Retrievals	Dr. Franz Schreier	German Aerospace Center - Remote Sensing Technology Institute	GERMANY	The objective of this study is a critical assessment of the performance of the Sentinel-5 Precursor's shortwave infrared level 1-2 processing in the view of the used molecular spectrscopic databases. We will investigate the impact of various line parameter databases on the total column of carbon monoxide and methane retrieved from S5P SWIR nadir observations. In particular we will examine the quality of the retrieval products in view of the accuracy requirements defined in the mission preparation phase (15\% and 2\% for CO and CH4, respectively). The retrievals will be performed using two independent codes developed for operational L1-2 processing at the participating partner institutes: The Beer Infrared Retrieval Algorithm (BIRRA) will be used for CO retrievals and RemoTeC will be used for CH4 retrievals. Special emphasis will be put on the exploitation of a new dedicated spectroscopic database currently under development in the context of an ESA study ``SEOM - Improved Atmospheric Spectroscopy Databases (IAS)''. Retrievals using this database will be compared to retrievals based on `standard` databases such as HITRAN or GEISA. Furthermore retrievals will be conducted using different line shapes, i.e. with more advanced models `beyond Voigt' to account for line mixing or speed dependence. For diagnostic analysis we will consider the residual norms, residual spectra, the distribution of errors of the state vector elements, and comparisons with other data products. We will try to evaluate the improvement of the dedicated SEOM-IAS spectroscopic database over existing databases and to give clear recommendations for the shortcomings of existing databases and for further laboratory spectroscopic investigations.

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28675	AirCore vertical profile measurements for validation of the S5P CO and CH4 products (AirCoreS5P)	Dr. Huilin Chen	University of Groningen	NETHERLANDS	The TCCON observations, an essential network to validate the S5P CO and CH4 products, need to be tightly linked to the WMO reference scale. The calibration of the TCCON total column measurements is based on a limited number of vertical profiles made during aircraft campaigns, in which a major uncertainty exists due to the gap-fill above the altitude ceiling of aircraft. AirCore, a balloon-borne sampling tool for trace gas measurements, extends the vertical coverage of the profile measurements up to the altitude ceiling of a balloon, ~30 km or ~99% of the atmosphere, and has thus a great potential to reduce the uncertainty of the TCCON calibration. Furthermore, both the TCCON and the S5P total column products will benefit from the vertical profile measurements in several aspects: 1) improvement of the TCCON priors, especially for the stratospheric part; 2) characterization of spectroscopic errors in the TCCON retrievals 3) detailed validation of the S5P CO and CH4 products, taking into account of the averaging kernels. We propose to take AirCore vertical profiles to make measurements of CO and CH4 at four TCCON stations, Sodankyl ├ñ (67.3668N, 26.6310E, 188m), Bremen (53.10N, 8.85E, 27m), R ├╌union (20.901S, 55.485E, 87m), and Garmisch (47.476 N, 11.063 E). These four stations provide coverage of the Arctic, the mid-latitude, and the tropics, as well as urban and remote sites, allowing for the calibration and validation of the TCCON products under different conditions. The proposed work will not only improve the accuracy of the AirCore measurements but also will resolve two logistical hurdles. Specifically, this proposal seeks to design an AirCore package that will allow flights in the heavily restricted Bremen regional airspace and the challenging landing environment of Reunion Island. The proposed work will also lead to an improved accuracy of the S5P CO and CH4 products through the validation TCCON retrievals, and facilitate routine vertical profile measurements using AirCore for obtaining vertical profile measurements during satellite overpasses.
28691	United Kingdom Collaborative S5P Validation Team (UKCVTS5P)	Prof. Hartmut Boesch	University of Leicester, Department of Physics and Astronomy	UNITED KINGDOM	The proposed activity within UKCVTS5P is centred around six key objectives in relation to early data from S5P:1. Analysis against comparable satellite data (e.g. from GOSAT, GOME-2, OMI). (Boesch, Leigh, Siddans)2. The comparison against model data with appropriate instrument operators applied. (Palmer)3. The ground-truthing of tropospheric products (with a focus on NO2) in areas of the UK with high-density networks. (Leigh)4. The use of airborne data as a satellite validation tool. (Palmer, Leigh)5. Analysis of L1b radiances, comparison with sondes and models, and investigation of geolocation errors. (Siddans)6. Analysis of VIIRS cloud fraction data, including comparisons between S5P and S5P/NPP products, and investigations of scene inhomogeneity. (Siddans)
28695	TROPOMI L2 Validation in the U.S. mid-Atlantic Region	Dr. James Szykman	U.S. Environmetal Protection Agency	UNITED STATES	This proposal is focused on providing a validation resource over the mid-Atlantic region of the United States for select SP5 Level 2 products in both Phase E1 and E2. As discussed within `Requirements for Geophysical Validation of Sentinel-5 Precursor (S5P) Products`, Section 4.1 The Validation Challenge, there are multiple issues which contribute to the ability to validate tropospheric trace gas products. In support of S5P validation activities, we are proposing use of existing resources currently being used in the U.S. to study the linkages between column and surface trace gas measurements. Use of this resource, and the team's experience, will provide the S5P Validation Team (VT) with a set of ground based correlative measurements to help accelerate validation of S5P products along the East Coast of the United States.Starting in mid-2009, EPA researchers teamed with researchers at NASA to develop a prototype ground based air quality research site, Chemistry and Physics Atmospheric Boundary Layer Experiment (CAPABLE - lat. 37┬░6'13.36`N, lon.-76┬░23'13.03`W), focused on the collection of collocated ambient and column reactive trace gases (O3, NO2, and SO2) and aerosols (AOT and PM2.5/PM10) using surface-based trace-gas analyzers and spectrometers/radiometers (PANDORA and CIMEL) (Knepp et al., 2013). The main research objective of the CAPABLE site is to develop a long-term data set of measurements for the study of an improved understanding of how air quality measured at the surface is related to column level observations, and ultimately satellite measurements. Since 2009, the research group established a similar research site located on the EPA research campus in Durham, NC, Ambient air Innovative Research Site (AIRS - lat. 35┬░53'15.27`N, lon. 78┬°52'26.28`W), with a similar set of measurements. These two research sites will serve as ground-based validation sites for the future NASA mission TEMPO. We propose to use these two ground research sites to provide relevant surface and column based geophysical parameters for validation of TROPOMI Level 2 geophysical parameters for both Phase E1 and E2.The approach will be to use appropriate time averaged measurements from both in-situ and ground based spectrometers as independent observations to assess TROPOMI observations over both the CAPABLE and AIRS site. These site are located in moderately polluted areas and are approximately 250 km apart on a SW-to-NE transect, with the CAPABLE site being a coastal site at the south edge of the Chesapeake Bay. The expected outcome is to assess TROPOMI L2 geophysical parameters and provide the results back to the S5PVT.Existing funding sources for EPA and NASA will be used to support this effort.

Prj_id	Title	Principal Investigator	Institution	Country	Summary
28701	Algorithm verification using Bayesian tools ALGOBAT	M.Sc. Johanna TAMMINEN	Finnish Meteorological Institute	FINLAND	This project aims at utilizing modern statistical algorithm verification and validation tools that rely on full characterization of uncertainties related to retrieval process and data as probability distributions. We will concentrate on TROPOMI (TROPOspheric Monitoring Instrument) on Sentinel 5 precursor (S5P) and especially to TROPOMI aerosol algorithm and ozone profile retrieval. The methodolgies will also be applied to CH4 and CO retrievals. Before availability of real data, the algorithms will be validated against simulated data. A simulator prototype will be used and developed during this project, also.Existing operational algorithms are verified by performing the inversion using both the oper- ational algorithm and with more advanced (and computationally demanding) Bayesian algorithm that uses less approximative assumptions. With Bayesian MCMC approach we are able to compute the full posterior distribution, not just its Gaussian approximation by covariance matrices. This contributes to the general error budget analysis by providing information on uncertainties originating from model and retrieval method approximations.There is no specific funding exclusively dedicated to the proposed work but many of the existing activities involving the team members support this project. The team members will apply for funding from different national and international agencies.
35343	Assessment and Applications of S5P TROPOMI Atmospheric Composition Products at NOAA	Dr. Shobha Kondragunta	NOAA	UNITED STATES	The successful introduction of a new sensor into the global observing system involves three broad areas of work. The first is characterization of the measurements and instrument performance. The second is the development and application of algorithms to create estimates of useful products. The third is validation of those products and comparison of their performance to existing records. NOAA team will assist in all three areas by using comparisons with measurements, algorithms and products from the SNPP and JPSS-01 instruments as they overlap with those from S5P TROPOMI. The measurement and instrument performance evaluation will make use of satellite instrument comparison and trending techniques as developed by the GSICS research working group including those for overpasses (LEO/LEO and LEO/GEO), Earth targets, measurement residuals with respect to forward models, and solar irradiance comparisons. Level 2 product evaluation will make use of comparisons of TROPOMI retrievals with correlative products from instruments on SNPP and JPSS-01 to understand product performance globally and seasonally and determine applicability to NOAA user applications. NOAA team will engage its Climate Program Office (CPO), Office of Atmosphere Research (OAR) Air Resource Laboratory (ARL), operational air quality forecasters, and partner Naval Research Laboratory (NRL) in the assessment of S5P TROPOMI products for applications in science studies to understand atmospheric processes and air quality forecasting.
35593	Characterization of TROPOMI level 1B and 2 data set using GEMS algorithm	Prof. MH AHN	Ewha Womans University	SOUTH KOREA	Team compositionTo characterize of TROPOMI level 1B and 2 data set, our team composition is consist of 3 part, first one is focused on wavelength calibration, second is analysis of ozone product, and final one is for nitrogen dioxide, aerosol retrievals and its validation. Each part and its team member are as follows.*Wavelength Calibration Myoung Hwan Ahn and Mina Kang *Ozone ValidationJae Hwan Kim and Juseon Bak *Aerosol and Nitrogen Dioxide ValidationJhoon Kim and YSU team Team strengthWe are the members of GEMS (Geostationary Environment Monitoring Spectrometer) program for GEO-KOMPSAT2B (GEOstationary KOrea Multi Purpose SATellite 2B) of KOREA. Since we have worked together more than 3 years as a team of GEMS algorithm development research group, our team is very good at cooperating and interacting with each other also good at focusing our efforts on the success of the project. Each of us has a different skill relating S5PVT project such as ozone retrieval, aerosol retrieval, and calibration/validation (Cal/Val) which make the synergy effect of the project. So it is possible to validate performance not only level 1B but also level 2B data through our collaborative work. Myoung Hwan Ahn was a PI of COMS-MI (Communication, Ocean and Meteorological Satellite-Meteorological Imager) which is a heritage program of GEO-KOMPSAT 2A of KOREA. Jhoon Kim was one of the PI for the DRAGON-NE Asia with NASA GSFC team in 2012, and is a currently PI of GEMS program. Also he is a team leader for GOCI aerosol products. Jae Hwan Kim and Myoung Hwan Ahn are Co-I of both COMS-MI and GEMS. In COMS-MI program they are responsible for GSICS (Global Space-based Inter-Calibration System), derivations of AMV (Atmospheric Motion Vector), Tropopause Folding and Turbulence Product, and Sulfur dioxide detection. Therefore, these activities and relevant experiences would contribute to perform S5P validation team project successfully.

Prj_id	Title	Principal Investigator	Institution	Country	Summary
38300	**Validation of Trace Gas and Aerosol Products of TROPOMI/S5P over Eastern China**	**Prof. kai qin**	**China University of Mining and Technology**	**CHINA**	The TROPOMI/S5P mission will measure key atmospheric trace gas concentrations and aerosol/cloud properties to provide information on air quality and climate change. Validations are needed under polluted atmospheric conditions to better understand the measurements of species involved in anthropogenic emissions. For this purpose, this project aims to validate the TROPOMI/S5P data with independent ground-based measurements at multiple fixed sites and a moving platform in Eastern China, a densely populated and highly polluted region. The project includes that (i) validation of TROPOMI/S5P tropospheric NO2 and O3 columns with ground-based MAX-DOAS NO2 and O3 retrievals at six MAX-DOAS sites in eastern China, i.e., Xuzhou, Nanjing, Hangzhou, Shenzhen, Fuzhou and Shanghai; (ii) validation of TROPOMI/S5P aerosol layer heights with ground-based LIDAR aerosol backscatter profiles retrievals at six LIDAR sites, i.e., Xuzhou, Zhengzhou, Wuxi, Wuhan, Fuzhou, and Shanghai. In addition, four sun-photometer sites in Xuzhou, Beijing, Wuxi, and Shanghai will be included for providing aerosol optical properties, e.g., aerosol optical thickness, phase function, single scattering albedo. We will collect long-term ground-based measurements at these sites and compare our data to the satellite products during the commissioning and the operative phase of TROPOMI/S5P.In order to improve the coverage of spatial gradients and horizontal inhomogeneity in individual satellite pixels, mobile measurements using a vehicle equipped with a MAX-DOAS and a LIDAR will be carried out in autumn and winter 2018. The vehicle will travel at a constant speed around 100 km/h along the TROPOMI/S5P orbits during 12:00-14:00 under various air quality conditions, i.e., clean, light pollution, and heavy pollution days. The mobile measurements will cover clean regions, polluted regions and pollution hot-spots (e.g., coal-fired power plant). The special route will be planned referring to the possible pollutants transport path under winter monsoon. Our team members come from four institutions including CUMT (China University of Mining and Technology), DLR (German Aerospace Centre), Wuxi CAS Photonics CO., Ltd, and Fudan University. The CUMT members are operating an Atmospheric Observatory at Xuzhou, eastern China, which was built in 2013 equipped with a MAX-DOAS, a LP-DOAS, a sun photometer, an aerosol particle analyser, an aethalometer, a nephelometer, and a visibility sensor. The team PI (Kai Qin) previously worked at DLR as a visiting scholar during 2016-2017. The DLR's scientists have large experience and knowledge in satellite retrieval including the lead of TROPOMI/S5P L2 Expert Support Laboratory (Diego Loyola), as well as Dr. Adrian Doicu and Dr. Jian Xu who are excellent scholars in the fields of atmospheric inverse and radiative transfer. In addition, the DLR's PhD candidate Zhuoru Wang as one of the team members was involved in the ground-based measurements campaign of CINDI-2. The Wuxi CAS Photonics CO., Ltd is operating multiple MAX-DOAS and LIDAR sites in China. Their well-experienced engineer Jie Wang can ensure smooth operation and successful measurements. The Fudan University's scientist Prof Cheng Tiantao has extensive knowledge in aerosol and atmospheric physics and he is operating a LIDAR site in Shanghai. The funding provided by the CUMT will cover the cost for instruments maintenance and car rental etc.The scientific objectives of this project are, (i) to investigate the effect of the presence of aerosols on the NO2 retrieval; (ii) to understand the impact of a-priori information on the aerosol layer height retrieval; (iii) to assess the ability of TROPOMI with high spatial resolution in detecting point source emission as compared to OMI. The primary expected outcome of the proposed project is to improve our understanding of the quality of the TROPOMI/S5P NO2, O3 and aerosol product in highly-polluted areas.
39959	**S5P validation from Chinese multiply observation platform network: MAX-DOAS, LIDAR, FTIR and satellite**	**Prof. Liu Cheng**	**University of Science and Technology of China**	**CHINA**	Objectives:1. Validation using ground-based networkValidation of aerosol, NO2, SO2, HCHO, CHOCHO etc. from satellite using observation from MAX-DOAS, LIDAR and FTIR on several locations at selected sites. 2. Cross-compare S5P UV measurements with Chinese UV satellite (EMI) measurements.Methods:In our proposed activity, we plan to validate the satellite data (e.g., NO2 VCD, SO2 VCD, HCHO, CHOCHO VCD, and aerosol etc.) using ground based MAX-DOAS, LIDAR and FTIR observations in China. And cross-compare S5P UV measurements with Chinese UV satellite (EMI) measurements.The proposed methodology performed in the work include three steps:1. The retrieval of trace gases SCD Satellite and MAX-DOAS SCD retrievals are based on the same algorithm (DOAS) 2. The retrieval of trace gases VCD Satellite and MAX-DOAS are based on the same radiative transfer model (RTM), including:- the same aerosol profile information, - the same trace gas profile information,- the same surface albedo,- the same cloud set,By performing the similar retrieval process, the performances of S5P instruments and the data quality can be assessed. Also, the difference of the both observation can be founded.3. Conducted intensity field campaign The intensity field campaign is performed at some various types of sites to evaluate the sensitivity of satellite observations to near surface.- big cities site, represents high polluted area,- rural site, represents clear area,- counties site, represents medium area.The comparison from three types of site also can evaluate the detection abilities of S5P from high to low level of air pollution comprehensively.The expected outcomes are:- Validation report on trace gas (e.g., NO2, SO2, HCHO, CHOHCO, AOD etc.) with MAX-DOAS, LIDAR and FTS- Validation report on S5P and EMI measurements comparisonFunding: Funding from the NSFC, MOST and CAS of China

Prj_id	Title	Principal Investigator	Institution	Country	Summary
40030	NASA 2018-2019 Airborne Tropospheric Composition Campaigns Contributing to S5P Validation	Dr. Jay Al-Saadi	NASA	UNITED STATES	As expressed in document S5P-RS-ESA-SY-164 `Requirements for the Geophysical Validation of Sentinel-5 Precursor Products,` airborne measurements provide invaluable independent correlative data for validation of Level 2 atmospheric species data products. The airborne measurements have well quantified precision and high spatial resolution but due to their relatively high cost are typically only obtained during infrequent intensive field campaign periods. NASA is planning to deploy a small aircraft operating an airborne UV-Visible mapping spectrometer (GeoTASO or GCAS) during summer 2018 to participate in a multi-institution campaign focused on urban air quality and transport of pollutants in the New York City area. The product suite includes high-spatial-resolution column NO2 and HCHO, and may also include aerosol lidar measurements. Several ground sites will be making companion ground-truth measurements. NASA is also planning deployment of a large instrumented aircraft, the NASA DC-8, for the summer 2019 FIREChem campaign focused on fire emissions and chemistry. The instrument suite prioritizes in-situ and remotely-sensed measurements of several species that are S5P primary Level 2 products: O3, NO2, HCHO, aerosols, CO, and CH4. NASA is also planning regular flights of the Alpha Jet in the San Francisco Bay Area to provide in-situ vertical profiles of O3, HCHO, NO2, CH4, and H2O from the surface to 28,000 feet. These various data sets will provide multiple S5P validation opportunities. This proposal team would coordinate activities between NASA and ESA to maximize the value of (1) the airborne observations to S5P validation and (2) S5P observations to improved understanding of regional air quality in the study regions. During the campaigns, desired S5P viewing conditions would be considered in routine flight planning to accomplish as many satellite/aircraft co-incidences as feasible. NASA would invite S5P mission team members to be team collaborators and participate in the campaigns so that the S5P project would have immediate access to the airborne data during the deployment phase for use in validation activities. NASA is the funding source for these activities.
40202	Participation in S5PVT to assess TROPOMI NO2 products using NASA data	Dr. Lok Lamsal	NASA/USRA	UNITED STATES	Nitrogen dioxide (NO2), produced during combustion processes, is designated as a criteria pollutant owing to its negative effects on public health and the environment. It is regulated as nitrogen oxides (NOx=NO2+NO), which are precursors of ozone and particular matter, both of which are also criteria pollutants that have important implications for human health, crop yields, and climate. Satellite NO2 records, with their global coverage, are instrumental in, for example, inferring long-term trends in global pollution and energy consumption, demonstrating the efficacy of air pollution controls, and assessing the long-term effects of NO2, particulates and ozone on climate, ecosystems (e.g., crop yields), and human health. The power of an NO2 data record for research and applications only increases as the record lengthens and data consistency maintains. Therefore, there is a critical need for developing intra- and inter-mission unbiased NO2 data records as they will lay a foundation for upcoming geostationary missions.The TROPOspheric Monitoring Instrument (TROPOMI) aboard ESA's Sentinel 5 Precursor (S5P) mission will extend and enhance global trace gas measurements carried out by the Aura Ozone Monitoring Instrument (OMI). TROPOMI boasts ground resolution a factor of ~six greater than OMI, making it an optimal instrument for measuring NO2 pollution. Since the instrument flies in a polar orbit in close proximity with NASA's Aura satellite and in loose formation with the NASA/NOAA Suomi National Polar Partnership (SNPP) mission that carries the Ozone Mapping Profiler Suite (OMPS), also capable of measuring NO2, despite with lower spatial resolution. These will provide a unique opportunity to make extensive comparison between the S5P official products and the mature NASA data products not only from the Aura and SNPP, but also from several sub-orbital (NASA operated airborne spectrometers) and ground (NASA Pandora, EPA surface monitors) observations. Such comparisons are essential for cross-validation of these important satellite data sets and help to enhance the data quality of the official TROPOMI NO2 products.Our NASA GSFC team develops, maintains, and extensively evaluates the standard OMI NO2 algorithm and product (OMNO2). These data are publicly available at the GES DISC and the Aura Validation Data Center (AVDC). The proposed work builds directly on our previous NASA-funded investigations and will leverage our NASA funded NASA investigations. The NASA products based on independent retrieval approaches should provide independent testing of TROPOMI NO2 data quality and may help identify avenues for official TROPOMI NO2 algorithm. We propose to participate in ESA's S5P TROPOMI validation team with the following goal: to evaluate and improve the quality of the official TROPOMI NO2 products through intercomparison with our independent NO2 retrievals and other independent ground (e.g., Pandora, surface monitors) and airborne (ACAM/GCAS/Geo-TASO) measurements archived and maintained by our team. To this end, we will work with the official TROPOMI NO2 product team to 1) compare our OMI/OMPS NO2 retrievals with TROPOMI NO2 retrievals, 2) implement our algorithm for TROPOMI Level 1 data for selected cases and compare our independent TROPOMI retrievals with the official TROPOMI NO2 products, and 3) leverage existing aircraft, sonde, and ground-based measurements to evaluate both NASA and official TROPOMI NO2 retrievals.Eventually, our proposed research activities will help evaluate and improve the quality of the official TROPOMI NO2 products. Our end-to-end validation activities will lend confidence to the operational algorithms and associated standard and value-added products, establishing that the official NO2 products will meet or exceed the mission requirements.
40745	CH4, CO and L1B-NIR validation for S5P	Dr. Hiroshi Suto	Japan Aerospace Exploration Agency	JAPAN	Our team will perform the validation of S5P XCH4 and XCO by following activities:1. Analysis of L1B-NIR radiance between S5P and GOSAT-TANSO-FTS over the match-up location.2. Validation campaign for coincident observation between S5P and GOSAT over the Railroad Valley.3. XCH4 and XCO validation by comparing the products which derived by our ground based instrument both of EM27/SUN and TCCON-Saga. 4. The comparison against our airborne based remote-sensing observation over the emission source such as power plant and rice field.

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41074	Comparisons of S5P/TROPOMI column CO measurements with Terra/MOPITT CO columns and profiles	Dr. Helen Worden	NCAR	UNITED STATES	At present, MOPITT and TROPOMI are the only satellite instruments that measure column CO with the 2.3 micron (SWIR) overtone band. MOPITT also uses the 4.6 micron (TIR) fundamental band of CO for retrieving CO vertical profiles and combines TIR and SWIR observations in a multispectral profile retrieval. Here we propose two types of MOPITT/TROPOMI intercomparisons:1: Comparisons of spatial variability in SWIR total columns for cloud free land scenes. 2: Comparisons of ocean scenes with TROPOMI partial CO columns over clouds using the vertical profiles of MOPITT, along with aircraft in situ CO profiles from the spring 2018 ATom campaign.The proposal team includes the NASA U.S. MOPITT P.I. and CO-Is with (collectively) decades of experience using and validating MOPITT data. The expected outcome of MOPITT comparisons with TROPOMI is a global characterization of bias in SWIR total column CO that will enable the use of TROPOMI data to extend the 18 year (and still counting) MOPITT data record. This activity will be funded by existing NASA grants that support data comparisons and bias quantification to extend the MOPITT data record.
41727	Validation of S5P TROPOMI volcanic SO2 products by ground-based NOVAC	Dr. Santiago Arellano	Chalmers University of Technology	SWEDEN	We propose to perform long-term validation of volcanic SO2 observations of the ESA S5P TROPOMI sensor by using measurements of the Network for Observation of Volcanic and Atmospheric Change (NOVAC).NOVAC is a network of standardized ground-based scanning-DOAS instruments implemented since 2005 on more than 40 degassing volcanoes. These instruments measure SO2 flux and plume location with a typical resolution of 5 minutes during daylight. This is the only global network dedicated to volcanic SO2 emission monitoring and will fulfill several validation requirements for the TROPOMI mission:- use of an independent, standardized technique;- high probability of coincident measurement;- long-term validation during entire lifetime of TROPOMI;- possibility to resolve intra-pixel heterogeneities in SO2 distribution due to higher spatial and temporal resolution;- provision of auxiliary information to improve TROPOMI retrievals, such as plume altitude or scattering conditions;- validation under a wide range of geographical, meteorological and geophysical conditions;- possibility to provide accurate results in short time.Our team is composed by four experts in ground- and space-based remote sensing by optical spectroscopy in different stages of their careers:Santiago Arellano (PI) is a researcher in the Division of Microwave and Optical Remote Sensing at Chalmers with 15 yearsΓÇÖ experience in ground-based remote sensing of volcanic gases. He has worked with NOVAC since 2006 and is presently in charge of data analysis, instrument assembly and database management for the network. He serves as co-leader of the IAVCEI-Commission on the Chemistry of Volcanic Gases. Nicolas Theys is a researcher in the UV/Vis Group at BIRA and an expert in SO2 retrievals from satellite observations. He is responsible for the development of the TROPOMI L2 SO2 operational algorithm. He is PI of the RESIST project and responsible of algorithms for the EVOSS and SACS services.Bo Galle is Head of the Optical Remote Sensing group at Chalmers, the main developer of the scanning-DOAS instrument and coordinator of NOVAC. He has more than 40 yearsΓÇÖ experience in application of optical remote sensing to a wide range of environmental problems and coordination of the EU DORSIVA and NOVAC projects. Michel Van Roozendael is Head of the Atmospheric Reactive Gases Division and Leader of the UV/Vis Group at BIRA, with about 30 yearsΓÇÖ experience in atmospheric remote sensing from ground and space. He is co-chair of the UV-VIS Working Group of NDACC and coordinator of the ESA FRM4DOAS, CINDI-2 and Ozone_cci projects, as well as the Copernicus Ozone Climate Data Record Service. He is a member of the Sentinel-5 Precursor Mission Advisory Group.Our approach will consist in comparing time series of SO2 flux (at daily or sub-daily resolution), derived from NOVAC and TROPOMI observations. Ground-based measurements will provide plume altitude, velocity and scattering conditions that can be used for TROPOMI retrievals of SO2 flux. Plume altitude and scattering information will help to constrain the AMF for TROPOMI retrievals and plume velocity will be used for framing the time-span of the satellite SO2 mass observation. Preliminary comparisons conducted by our team during the commissioning phase of the mission showed the feasibility of this approach.The outcomes of this comparison will be:- validation of L2 SO2 operational algorithm on volcanic environments;- comparison of SO2 total emission estimates from TROPOMI and NOVAC;- elucidation of intra-pixel heterogeneities in TROPOMI retrievals;- elucidation of different latitude, altitude and meteorological conditions as well as different states of volcanic activity in SO2 retrievals from TROPOMI.Funding for these activities at Chalmers will be sought through applications to the Swedish Space Board during 2018. The activities at BIRA are presently funded.

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41968	**Validation of UV-VIS data from Sentinel-5P with ground-based spectral and broadband measurements**	**Dr. Margit Aun**	**Tartu Observatory, University of Tartu**	**ESTONIA**	Problem to be addressed: validation of Sentinel-5P UV-VIS-NIR data with ground-based measurements. As shown during the recent years, validation, quality assessment, fiducial calibration and uncertainty analysis are essential if one wants to use the dedicated space-born instruments to derive the physical quantities useful for the general public and decision-makers. A number of projects to aim these tasks are started in the framework of the Copernicus programme already. Because atmospheric correction is such a vital part for the remote sensing applications, experience gathered during the Sentinel-5 mission can be transferred to the Sentinel-2 and Sentinel-3 data processing as well.Team description: team consists 8 scientists (7 PhD. degree, 1 MSc. degree), including experts of atmospheric sciences, instrument design, metrology, software engineers, water optics, biology and remote sensing. The team members are affiliated with the departments of remote sensing and space technology of Tartu Observatory, University of Tartu (UTTO), targeting the problems of remote sensing data validation and uncertainty analysis on everyday basis.Approach taken: radiometric data measured by the satellite sensors will be compared to the data derived from the in situ measurements. Both the primary (e.g. radiance) and derived quantities can be compared. The proposed in situ instruments are independently calibrated i.e. traceable to the SI units. Variety of instruments are available (spectral, narrow-band, broad-band), including both the continuously logging systems and radiometers used explicitly during pre-selected match-up events. Radiometers belonging to the Estonian Environmental Agency (EEA) are maintained on daily basis. Radiometric calibration of the proposed instruments is conducted in optical laboratory of UTTO. UTTO and EEA have long-term experience in measuring the actinometric data, the collected dataseries are amongst the longest in the world. During last decades, the availability of instruments is updated regularly, including the radiometers developed in UTTO . On the other hand, the team is looking for higher confidence in the atmospheric correction algorithms. Presence of the satellite sensor, dedicated on the measurement of atmospheric parameters, will help to establish the necessary link between these topics. Availability of Sentinel 5 data will, in conjunction with our databases, make available of semi-automatic comparison of satellite and in situ data, revealing long-term drifts, exceptional conditions and machine errors - situations, for which human intervention would be too time-consuming.Our motivation: Spatial variability of UV radiation High quality UV instruments for measurements on ground are expensive and need a constant supervision, therefor ground-based measurements are sparse - in Estonia, spectral measurements are carried out only in UTTO. Broadband instruments are more prevalent due to their lower price, simpler structure and easier maintenance - 5 UV-S-E-T instruments operated by EEA across Estonia and there are few more EEA UV instruments in T ⊢ ravere for comparison. Well-validated satellite measurements would give a large input to the question of spatial variability of UV radiation. Outcomes:1. Evaluation of satellite data2. Database for field and satellite data. Database will be created for data collected with ground-based instruments and satellite instruments and processed satellite data (including uncertainty estimates) will be made available for end-users. 3. If the results of comparison of field and satellite data are satisfactory, spatial changes in Estonia for various data product will be shown.No extra funds are available at the moment for the validation. It will be done alongside with other projects as many of them would benefit from the data.

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42807	An Italian coordinated contribution to the Validation of Sentinel-5p Level-2 products from four atmospheric observatories in the Central Mediterranean Sea	Dr. Stefano Casadio	SERCO	ITALY	The objective of this proposal is to take full advantage of available instrumentation and knowhow from 4 Italian atmospheric observatories in Central Mediterranean to provide high quality correlative data for Sentinel-5p L2 products validation. The observatories are located in the Island of Lampedusa (35.5┬ÿN, 12.6┬ÿE), in the Rome city center (BAQUNIN 80 aslm 41.90┬ÿN,12.50┬ÿE), in a semi-rural (CNR-ISAC CIRAS 110 asl, 41.84┬ÿN,12.65┬ÿE) and (CNR-IIA 48 asl, 42.11┬ÿN,12.64┬ÿE) sites allowing the sampling of different regimes/processes of interest for TROPOMI validation.Lampedusa observatory (www.lampedusa.enea.it), located south of Sicily at more than 100 km from mainland, is composed by atmospheric and oceanographic sections, the latter represented by an instrumented buoy in open ocean, about 15 km SW of the atmospheric observatory. At this site, data are collected since 1997, and are mainly representative of clean maritime regime. The geographical position of the island allows to investigate several specific processes, relevant for aerosol-radiation, and aerosol-cloud-radiation interactions (e.g. Saharan dust transport, ship emissions, long range transport of anthropogenic aerosols). The sites in Rome and surroundings are equipped with twin active (Lidars) and passive (Pandora, POM-Prede, CIMEL) instrumentation. They are representative of typical near-coastal Mediterranean conditions. Their relative position can provide useful information on the impact of the urban environment on satellite products.All sites are characterized by high probability of clear sky during summer season. The different longitude of observatories will increase the probability of a match-up with satellite observations. They share similar instrumentation and homogeneous processing will be carried out thanks to a well-established collaboration with exchange of knowhow, personnel and instruments.The proponent team has a documented experience on atmospheric measurements including instrument development, processing algorithm, participating to experimental campaigns and atmospheric monitoring networks (NDACC, Skynet, AERONET, Pandonia, ACTRIS/EARLINET, LINET etc.). The team has been involved in several activities in the development of satellite missions at different levels from feasibility studies, SAG and MAG participation, algorithm development and implementation, operational processing (e.g. H-SAF, CMEMS). In particular, the team is involved in the validation of satellite missions (e.g. ERS-1, ERS-2, ENVISAT, GPM, S3, EarthCare).The team will provide, in the required format, routine measurements and ad-hoc periodic lidar measurements based on overpass schedule and meteorological conditions.In addition to the currently adopted methodology for match-up, alternative approaches to compare statistical properties of the variables will be explored based on the analysis of acquired long term datasets.Rigorous estimation of ground based observation uncertainties, including product/site dependent estimation of spatio-temporal representativity, will be applied, documented and exploited in the validation exercises.In the framework of this activity, synergistic processing algorithms could be developed to take full advantage of the information carried by the different instruments.The impact of urban environment on the Sentinel-5p products will be investigated.In terms of deliverables the project will produce: + Instruments and algorithms description, including the estimation of uncertainties. + Statistical description of the geophysical variables of interest for a statistical comparison. + Data sets of paired ground based and satellite observations. + Validation results.Personnel and operational costs from the proponents will be partly covered by the institutions.
42901	Validation of TROPOMI CO and O3 Using Chemical Data Assimilation	Prof. Dylan Jones	University of Toronto	CANADA	Over the past two decades space agencies around the world have made considerable investments in new satellite instruments to measure the changing composition of the atmosphere. In this context, observations of carbon monoxide (CO) and tropospheric ozone (O3) are particularly important as O3 is a harmful pollutant and a powerful greenhouse gas and CO is a precursor of tropospheric O3. CO and O3 also play critical roles in controlling the oxidizing capacity of the troposphere through their influence on the hydroxyl radical (OH). The recently launched TROPOspheric Monitoring Instrument (TROPOMI) on the Copernicus Sentinel-5 Precursor satellite provides measurements of CO and O3 with high spatial resolution and significant observational coverage. We propose to perform an indirect validation of TROPOMI CO and O3 data using the GEOS-Chem data assimilation system. The work will be conducted as part of a project entitled ┬ôImproved estimates of NOx and CO emissions through multi-species and multi-sensor chemical data assimilation┬ö that is funded by the Canadian Space Agency.Comparing remote sensing observations with other observations can be challenging because of differences in vertical resolution and spatial and temporal sampling of the observations. One way of addressing these challenges is through data assimilation, which uses an atmospheric model as a transfer function to compare the information provided by different observations. We will use the GEOS-Chem four-dimensional variational (4D-Var) data assimilation system to indirectly validate TROPOMI CO and O3 data. We will assimilate MOPITT and TROPOMI CO columns separately to optimize the distribution of CO and compare the optimized fields with in situ (surface and aircraft) CO data. We will also assimilate OMI and TROPOMI O3 columns separately and compare the assimilated O3 fields with in situ surface data over North America (from the United States Air Quality System (AQS) and the Canadian National Air Pollution Surveillance Program (NAPS)) and with ozonesondes globally. This will enable us to indirectly validate the TROPOMI data with the independent in situ observations and to compare the information provided by TROPOMI CO and O3 data to that obtained from MOPITT and OMI data, respectively.

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42914	Analysis of remotely sensed, aerosol-cloud interaction over the Arctic	Dr. Norm O'Neill	Universite de Sherbrooke	CANADA	Our research objectives are to better understand aerosol-cloud (AC) interactions during the Polar winter and spring. This will involve two thematic foci; AC interactions in the UTLS during the polar winter and AC interactions in the mid to lower troposphere during the polar spring when certain types of aerosols tend to achieve a maximum or at least an important influence. These two foci are part of a CSA (Canadian Space Agency) financed project called SACIA (Signatures of AC Interaction over the Arctic). The goals of SACIA will be accomplished using satellite-based remote sensing (RS) lidar / radar and optical imagery, active and passive ground-based RS measurements, ground-based microphysical and chemistry measurements as well as event-level and climatological-scale models. The key satellite RS activity incorporates one primary and two secondary RS instruments: the CloudSat CPR along with the ESA ALADIN Doppler (wind velocity) lidar and the TROPOMI imager on the Sentinel 5 Precursor satellite) along with important auxiliary RS instruments (the CALIOP lidar and the VIIRS imager on the NPP satellite). The ground-based data will come primarily from our Eureka, Nunavut (PEARL) high-Arctic observatory. The analytical methodology consists of analyzing the AC dynamics and the inter-data coherence of the satellite data, the ground-based data and the simulations at the event and seasonal level (at the process and climatological level).In the process of our analysis we will necessarily be validating TROPOMI layer height estimates using CALIOP profiles along with lidar profiles. The AI is an empirical parameter sensitive to high altitude absorbing aerosols: our approach to validating the TROPOMI AI product will be in terms of comparisons with the OMI-AI product and investigations of physical correlations relative to CALIOP- and ALADIN-derived AODs and lidar / AERONET ground-based AODs. We will employ our ground-based lidar / AERONET tandem to help validate estimated ALADIN aerosol / cloud classifications, lidar ratios, and optical depths. We have no means of directly verifying the ALADIN wind profile products although the CloudSat / CALIOP profiles along with ground-based lidar / radar retrievals will assist in terms of the interpretation of ALADIN backscatter profiles and achieving a better physical understanding of the Doppler wind profiles.
43028	Large scale validation of environmental measurements and Sentinel-5 's TROPOMI	Dr. Nikola Jajcay	SpaceKnow Inc.	UNITED STATES	The team proposes to validate the Sentinel-5P Level-2 gas products, including but not limited to O3, NO2, SO2, CO, CH4, HCHO and cloud information, as well as the aerosol information. The validation procedure will include comparisons of previously validated integrated vertical column measurements of gases. The validation process will exploit data gathered from the OMI/Aura mission (in particular O3 total column and profiles, NO2 columns, SO2 column, HCHO column, and aerosol data), GOME-2 instrument (providing O3 data, NO2 columns, SO2 column, HCHO column, and aerosol data), Suomi NPP / OMPS data (with O3 columns and aerosol data available), GOSAT instrument for CH4 validation, and possibly NASA's MODIS on board of Terra and Aqua satellites for aerosol, clouds and O3 data validation.. The validation team will make use of its strengths: large-scale computing capability, long experience of analysing satellite data, and know-how of writing effective and parallel code. Although the ECMWF-led CAMS service analyses of the chemical state of the atmosphere do not meet several criteria to be given a status of Fiducial Reference Measurements [FRM], they shall be used as a first order monitoring of the TROPOMI data quality. The validation itself will focus on spatial and temporal variability patterns, biases and random errors, and correlation statistics. Moreover, the company will tentatively provide comparison of seasonality and trends between TROPOMI products and independent data gathered from other satellite sources.

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43055	**A detailed validation of TROPOMI measurements using ground-based instruments in a polluted and an outflow boundary layer.**	**Dr. Ian Ashpole**	**Saint Mary's University**	**CANADA**	A detailed validation of TROPOMI measurements using ground-based instruments in a polluted and an outflow boundary layer.Aldona Wiacek and Ian AshpoleSaint Mary┬Æs University, Department of Environmental Science, Halifax, Canada(aldona.wiacek@smu.ca, ian.ashpole@smu.ca) We will examine in detail a case of pollution export from Southern Ontario (ON) to Nova Scotia (NS) using multiple satellite data sets and ground-based instruments. This provides us with a unique opportunity to validate TROPOMI measurements in a polluted (ON) and an outflow (NS) boundary layer, in particular vertical profiles for HCHO thanks to the increased boundary layer information offered by the ground-based instruments. The project will make significant use of Total Column and lower-mid tropospheric CO observations from MOPITT (Worden et al. 2014; Deeter et al., 2011) and multi-species mid-upper tropospheric and stratospheric observations from ACE-FTS (Bernath et al. 2005), while additionally utilizing and validating the higher spatiotemporal coverage (7 km2 vs. 22 km2 for MOPITT, daily global coverage) and multi-species measurements (CO plus CH4, SO2, HCHO) made by the TROPOMI instrument. Combined near-surface (active source open-path) and total column (solar) Fourier Transform InfraRed (FTIR) measurements from Canadian ground-based instruments in Halifax (NS) and Toronto (ON) (Wiacek et al., 2006, 2007, 2008) will give increased boundary layer information and thus permit a detailed validation of TROPOMI measurements of CO, CH4, SO2, but also HCHO, which is confined to the bottom three kilometers of the atmosphere (SP5/TROPOMI HCHO ATBD). The validation of vertical profiles for HCHO was identified as a key requirement for the for HCHO validation and is currently not optimally covered by the observation capacities proposed in the frame of the S5PVT. Validation of TROPOMI measurements in a polluted (Toronto) and outflow (Halifax) boundary layer is an explicit objective of TROPOMI validation, which our independent ground-based measurements in Toronto and Halifax will achieve, together with auxiliary in situ data from the National Air Pollution Surveillance (NAPS) network. Comparisons of ground-based and satellite measurements from TROPOMI will be made by considering the averaging kernels of all observation platforms, in so far as this is possible / available.This work is part of the broader CSA-funded project ┬ôModes of pollution transport to Nova Scotia and beyond┬ö and will help to achieve its objectives of: 1) quantifying the long-term variability in the relative contribution of different pollution sources (local vs. regional and long-range Canadian, as well as U.S. and other air pollution) to air quality in Nova Scotia; 2) isolating the specific synoptic scale meteorological conditions leading to different modes (local, regional and long-range) of pollution events in Nova Scotia and export from North America; and 3) developing a framework for the interpretation of near-surface atmospheric composition measurements regularly made by the PI in Nova Scotia. Objectives 1) and 2) will additionally inform policy regarding jurisdictional (provincial, federal, trans-boundary) precursor pollutant reductions, with associated benefits to Canada.
43229	**Validation of TROPOMI with Canadian Satellite and Ground-based Measurements**	**Prof. Kaley Walker**	**University of Toronto**	**CANADA**	This project will validate measurements of total column carbon monoxide (CO), formaldehyde (HCHO) and methane (CH4) from TROPOMI using Fourier transform infrared (FTIR) spectrometers based in Toronto and Eureka, supplemented by satellite measurements from ACE-FTS for CH4. A team based at the University of Toronto (Canada) will be undertaking this project, led by Profs. Kimberly Strong and Kaley A. Walker. Both have extensive experience and expertise in the areas of satellite and ground-based remote sensing and validation of satellite datasets. Measurements that are coincident in space and time will be identified for these comparisons in addition to examining temporal and spatially averaged results. Accurate monitoring of these species is necessary as CH4 is one of the most important anthropogenically influenced greenhouse gases and CO and HCHO are key in understanding the chemistry and transport of air pollutants. The results from this project will supply useful feedback to the TROPOMI team for the development of future data versions and will support and augment the validation comparisons undertaken in the current S5PVT projects, TCCON4S5P (Validation of S5P Methane and Carbon Monoxide with TCCON Data) and NIDFORVal (S5P NItrogen Dioxide and FORmaldehyde Validation using NDACC and complementary FTIR and UV-Vis DOAS ground-based remote sensing data).
43855	**Validation of TROPOMI Aerosol Type Product over North America**	**Dr. Daniel Tong**	**George Mason University**	**UNITED STATES**	Our Team, funded by NASA Earth Science Program, has developed a comprehensive dataset of dust storm observations over North America (http://air.csiss.gmu.edu/nca/). Groud level detection of dust storm is based on the method developed in Tong et al., ACP, 2012. This dataset has been recently extended by Tong et al., GRL, 2017. We have utilized this dataset to validate dust retrievals from US satellite missions, including JPSS and GOES-R (e.g., Kondragunta, EM, 2018). We plan to use the ground dataset, and other ground or in-situ observations, to validate the aerosol type product from TROPOMI, with a focus on dust aerosols over North America.Deliverables: We will present validation results. The ground observations can be made available if there is a need.Funding source: There is no funding for this activity. The ground data was produced from an onging project funded by NASA.

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44365	Validation of TROPOMI using ground-based FTS measurements and aircore sondings over China	Dr. Zhaonan Cai	Institute of Atmospheric Physics, Chinese Academy of Sciences	CHINA	Due to the anthropogenic greenhouse gas emissions our climate is changing. Climate forecasts are needed so that we can prepare, mitigate and adapt to the changing climate. The forecasts require accurate information about the sources and sinks of natural and anthropogenic greenhouse gases (GHG), in particular, carbon dioxide (CO2) and methane (CH4). Remote sensing methods from satellites are needed to obtain global and regional coverage, which are important for climate research. The accuracy requirements of satellite remote sensing of atmospheric composition and, in particular, greenhouse gases are challenging. The validation of the measurements is highly important in the development of satellite remote sensing systems. In addition to ground-based validation also algorithm validation including proper quantification of retrieval uncertainties forms the basis for reliable satellite observations. In this proposal, the ground-based measurements of methane (XCH4) over China will be used to validate satellite products of Sentinel 5 Precursor and GOSAT. In addition, XCO2 observations of TanSat, OCO-2 and GOSAT will be validated to support forming the overall picture of monitoring carbon cycle from space. The experience obtained after launching GOSAT and OCO-2, has emphasized the importance to conduct ground-based measurement to validate the satellite products, especially to improve the accuracy of satellite retrievals to reduce the interference by many other factors, such as aerosols, clouds, ground surface properties, and instrument noise. Therefore, it is crucial to compare space-based column observations with the ground-based Fourier transform spectrometer (FTS) column observations. The overall goal of this proposal is to characterize and improve the TROPOMI XCH4 observations and their uncertainty quantification. We will use Chinese ground-based measurements to validate Sentinel 5 Precursor XCH4 and CO observations. AirCore profile observations in China will be used to support the validation. This project is leading by Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS). No extra funding for this project is presently available. Work by IAP teams will be part of the normal scientific research. Chinese team is funded by CAS, from which a limited amount of funding could be used to support international cooperation research. PI of this proposal is Dr. Zhaonan Cai and and CIs are Prof. Yi Liu and Prof. Pucai Wang. The Chinese team has experiences in tracegases retrieval algorithm, satellite data calibration/validation, radiative transfer modeling, etc., they have applied the remote sensing products on CO2 monitoring, air pollution study and aerosol physical and optical in situ measurements.
45080	Validation of S5P trace gas products using methane emission estimates from agricultural and wetlands sources in Eastern Canada's agricultural landscape	Dr. Jiangui Liu	AAFC	CANADA	Our research objective is to better understand the environmental and management controls of greenhouse gas emissions from agricultural land, in order to reduce uncertainties in estimating regional emissions and evaluating methane (CH4) mitigation strategies. From an agricultural perspective, CH4 is an important greenhouse gas. It accounts for about 26% of the anthropogenic CH4 emissions in Canada. In Eastern Canada CH4 emissions from livestock and wetlands make it very difficult to separate these two sources at the agricultural landscape scale. Estimates from bottom-up techniques have been used for improving regional and national CH4 emission estimates from agricultural sources. Aircraft-based flux techniques have also been successfully used to verify agricultural CH4 inventory at a regional scale. A big unknown is the magnitude of the CH4 emissions from wetlands within the agricultural landscape. We used aircraft-based flux measurements of CH4 to determine the link between CH4 emissions from wetlands and air and surface temperature. We are ready to generate daily CH4 emission estimates at a wide range of spatial and temporal scales. On-farm CH4 emissions as well as our temperature dependent CH4 emission model for wetlands based on our aircraft flux measurements already collected in eastern Ontario, Canada should be very useful to validate and evaluate TROPOMI CH4 column ratio products using . Absolute levels, spatial variability and temporal variations of CH4 emissions will be assessed. We will also assess the CH4 product using TCCON ground based data, and cross compare with GOSAT products.
45290	Vertical profile measurements for validation of the S5P aerosol, NO2 and O3 products (NUIST-S5P)	Prof. Bin Zhu	Nanjing University of Information Science and Technology	CHINA	This project proposes to provide vertical profiles of nitrogen dioxide (NO2), ozone (O3) and aerosol (PM2.5) for the validation of TROPOMI products. The vertical profiles of aerosol and gases will be measured by instruments that carried by Unmanned Aerial Vehicle (UAV)/tethered balloon as well as the MAX-DOAS. We have already carried out a series of air sounding experiments in Yangtze River Delta in 2016, 2017, and 2018. Vertical profiles of NO2, O3, PM2.5, black carbon (BC) as well as meteorological factors are collected, data in 2018 can be used to improve the accuracy of TROPOMI products. In this project we prepare to carry out more profile observations in China and Europe to support the validation. Besides, NO2 profile from MAX-DOAS will be compared with that from UAV and then use to validate TROPOMI NO2. This project is leading by Nanjing University of Information Science and Technology (NUIST). Prof. Bin Zhu and his group from NUIST will carry out vertical observation and use these observations to validate TROPOMI products and improve model simulation. Prof. Ronald van der A will use the vertical observations and model simulations to validate the accuracy of TROPOMI NO2 and he will provide NO2 emissions for the model simulation.

Prj_id	Title	Principal Investigator	Institution	Country	Summary
48535	TROPOMI total, profile and tropospheric O3 VALidation using ground based and ozonesonde data from Athens, Greece - TRO3VALAG	Prof. Costas Varotsos	University of Athens	GREECE	In the framework of this proposal, we intend to contribute to the validation efforts of the ESA satellite instrument TROPOMI (TROPOspheric Monitoring Instrument), onboard Sentinel-5P. Our main objectives in this project are to validate the observations of total, profile and tropospheric ozone, which are going to be conducted by the TROPOMI. Our team consists of researchers specialized in total and profile O3 measurements as well as experienced in satellite data processing. In particular, since 1988, the Dobson spectrophotometer, No. 118, has been installed at the Ozone Layer Monitoring station of National and Kapodistrian University of Athens, Greece, contributing both to WOUDC network (as station ID: 293) and to the GAW stations network (as GAW ID: ATH), since 1989. Our station also has the required equipment array to carry out ozonesonde ascents, being one of the 35 stations participating in the Match experiment. Part of these data has already been used in the validation of SCIAMACHY (SCanning Imaging Absorption SpectroMeter for Atmospheric CHartographY) and MIPAS (Michelson Interferometer for Passive Atmospheric Sounding) instruments onboard ENVISAT (ENVIronmental SATellite). In addition, our team has produced a lot of literature on the satellite data processing not only on ozone issues, but also on the aerosol optical depth and more.Regarding the total ozone validation we shall develop a schedule for ground based observations, using Dobson spectrophotometer No. 118, according to TROPOMI overpass times over the greater area around Athens, Greece. Our target is to implement a number of total ozone observations in the same time window as TROPOMI's observations, so that they can be considered as ΓÇ£simultaneousΓÇ¥. Based on these data, validation reports will be regularly produced and forwarded to satellite instruments operators to contribute to the improvement of the quality of the released total ozone observations.As far as the ozone profile and tropospheric ozone validation is concerned, we shall use ozonesonde data which will be collected during the ozonesoundings that we shall perform. Our plan will be to perform at least one ozonesonde ascent every month. In an attempt to achieve an innovative approach, the ozonesoundings will be carried out at Athens, Greece, according to TROPOMI's profile and the timing of tropospheric observations, so that they can be regarded as ΓÇ£simultaneousΓÇ¥. Using this technique, we shall thoroughly investigate the results obtained in order to produce analytical validation reports together with a detailed description of the procedures followed during this study. In addition, our team is going to evaluate the performance of the innovative approach to validating the TROPOMI ozone profile.All the above results will be presented in international symposia and will be published in leading scientific journals as co-authored papers of the teams involved.

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49714	**Validation of TROPOMI ozone profile retrievals using observations from the Tropospheric Ozone Lidar Network (TOLNet)**	**Dr. Matthew Johnson**	**NASA Ames Research Center**	**UNITED STATES**	The proposed work is designed to provide the required geophysical validation (i.e., characterize accuracy (systematic and random bias) and precision) of the Level-2 (L2) ozone profile products ('full' and 'tropospheric') from S5P TROPOMI retrievals. The validation effort will be centered around the novel validation/evaluation dataset provided from the NASA/NOAA ground-based ozone lidar network, TOLNet (https://www-air.larc.nasa.gov/missions/TOLNet/). The operational validation statistics will be error/accuracy (difference between TROPOMI retrieved ozone and TOLNet observations) and absolute accuracy (e.g., root mean square (RMS) difference between TROPOMI retrieved ozone and TOLNet observations) which will include both systematic and random bias. Precision (standard deviation (1╧â) of the difference between individual TROPOMI-TOLNet comparisons and the average over all measurements) will also be quantified in order to determine whether TROPOMI ozone profile retrievals meet the required accuracy (10-30%) and precision (10%) thresholds as defined in the L2 Validation Requirements document. Additional statistics (e.g., correlation, bias/precision trends, etc.) will also be quantified to further define the performance of the TROPOMI ozone profile product. These statistics will be calculated over the entire lifetime of the TROPOMI ozone profile product in order to determine if the accuracy/precision of the data is stable. Statistical analysis will be conducted at each of the six TOLNet stations both daily (for each day a S5P-TOLNet correlative data point is available) and seasonally to provide validation of the spatio-temporal accuracy/precision in varying regions of North America. Particular focus will be paid to the validation at different vertical layers of the troposphere (e.g., PBL, FT, and the UT) in order to provide information to the TROPOMI Validation Team about sensor performance throughout the troposphere.TOLNet measurements are provided from six different locations of North America which cover regions with different: topography, surface reflectance, pollution levels, meteorological conditions, latitudes, and seasonal cycles. A TROPOMI validation dataset has already been compiled and encompasses well-defined and accurate lidar observations (hundreds of hours of correlative observations made during S5P overpass times (+/- 30 minutes of overpass)) to quantify accuracy/precision and stability of the ozone products. From a TROPOMI ozone profile validation perspective, the TOLNet product is a desirable validation dataset as the observations: 1) have much higher vertical resolution compared to TROPOMI retrievals in the troposphere, 2) are high accuracy observations, and 3) have minimal dependence on a priori information. In order to compare the TOLNet observations with TROPOMI retrievals, TROPOMI averaging kernels (AK) will be applied to interpolated TOLNet vertical profiles (matching the vertical resolution of TROPOMI data) in order to have consistent datasets. Detailed methods will also be applied in order to accurately co-locate TOLNet observations with TROPOMI data. Filters based on time, distance, and wind direction will be applied in order to remove any TOLNet observations which are not representative of the atmosphere being retrieved by TROPOMI. The TOLNet Team sees this proposed validation study as being mutually beneficial. One of TOLNet's main objectives is to validate ozone products from the future NASA satellite mission TEMPO. Validating TROPOMI using TOLNet observations will allow for the development of improved validation methods to be used for TEMPO. Therefore, no funding is required from the ESA for this proposed work. The proposal team will provide general reports, and presentations as needed, of the geophysical validation statistics determined during this work.
52893	**Machine learning shortwave infrared retrievals from TROPOMI, using open-source tools.**	**Dr. Edward Malina**	**ESA**	**NETHERLANDS**	Methane is one of the key targets of S5P/TROPOMI and the future S5/UVNS instruments, due to its significant impact on climate change. Methane products from TROPOMI are currently hosted on the Copernicus Open Access Hub. These products are based on ΓÇÿoptimal estimation methodsΓÇÖ, which although well proven, require large processing resources, especially when considering complex atmospheric effects such as multiple scattering. Machine learning methods do not require these overheads while in operational use, only whilst training prior to active use. This provides an opportunity for using more advanced physics for trace gas retrievals, without the overhead penalty on operational retrievals. Machine learning has not yet been applied to the SWIR band of TROPOMI, this study therefore provides an excellent opportunity to study the benefits of machine learning in this waveband. In this study we aim to develop physics aware machine learning retrieval algorithms, in order to retrieve methane concentrations from TROPOMI spectra. In this case a fully trained Neural Network will replace the forward model element of a traditional retrieval algorithm. This gives the retrieval algorithm the speed of machine learning, without compromising the physical and mathematical aspects of the traditional retrieval algorithms.

** Information related to the Principal Investigators (PIs) and to the accepted projects are made public in accordance with what is reported in the S5PVT Call guidelines (https://earth.esa.int/files/S5PVT_guidelines) accepted by each PIs at the time of submission of the project proposal.*