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PRODEX Programme – Annex 4

Project Reporting

template September 2020

*This file has to be sent **in MS-Word format and by email** to the appointed Technical Officer at ESA (specified in the PEA) and to the responsible thematic administrator at BELSPO (specified in the Guidelines).*

A. Identification of the project.

- *Title and acronym:* **Belgian contribution to the Satellite Application Facility on Climate Monitoring (B-CM SAF).**
- *Identification of the Top-level Project selected/endorsed by ESA: N/A*
- *Possible role of the BPI and of each Bco-I in the Top-level Project (PI, co-I, other): N/A*
- *PEA (contract number, starting and ending date):* ESA Contract 4000140588, 1st March 2022 – 28th February 2027
- *Period covered by this Project Reporting*: 1st January 2024 – 31st December 2024

B. Identification of the BPI and his or her team.

- *Title and full name:* Dr Nicolas Clerbaux
- *List of the team members involved in the project:* Tom Akkermans, William Moutier, Alirio Arboleda, José Miguel Barrios, Françoise Meulenberghs, Nicolas Clerbaux.
- *Institute/University:* Royal Meteorological Institute of Belgium (IRM/KMI)
- *Department/Laboratory:* Join collaboration between Remote Sensing from Space unit of Scientific Service "Observations" (with activities coordinated by N. Clerbaux) and land surface fluxes modelling group of the Scientific Service "Meteorological and Climatological Research" (with activities coordinated by F. Meulenberghs).
- *Address:* Avenue Circulaire 3, 1180 Brussels, Belgium.
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C. Identification of the Bco-I's and their team (if applicable).

N/A

D. Describe the results obtained since the last reporting and compare with the original objectives foreseen at this stage (see section G of the original *Project Proposal).* Identify the contributions from the BPI and those from the Bco-I's. (max. 2 pages)

The following tables correspond to the CM SAF work packages for which activities co-funded by PRODEX (i.e. the "Operational" activities are not covered by PRODEX) are performed during the reporting period (1/1/2024 - 31/12/2024).

The work has focused on three of the CM SAF Climate Data Records (CDRs) under development during CDOP-4:

- the CLARA-A3.5, in WP 5110, WP 5120,
- the CLAAS-4, in WP 5410, WP 5420,
- the GeoRing Land flux, in WP 5610 and WP 5620.

In general, the WP 5*10 correspond to the analysis of the requirements while the WP 5*20 correspond to the product consolidation (i.e. the main development phase).

In 2024, we also started a support activity for the International Satellite Cloud Climatology Program - Next Generation (ISCCP-NG) project:

- Contribution to ISCCP-NG in WP 4100

WP4100	**Contribution to ISCCP-NG**
Description	Contribute to the ISCCP-NG activity and make an FCI demonstration dataset.
Tasks (all)	- improve cloud algorithms exploiting capabilities of modern geostationary sensors (FCI, ABI, AHI, ...) - contribute to ISCCP-NG algorithm inter-comparisons (through ICWG) - produce and evaluate 1-year high-resolution FCI cloud and TOA radiation demonstration dataset - take part in ISCCP-NG meetings
Tasks (RMI)	- Develop TOA radiation products optimized for FCI, and applicable to ISCCP-NG channels - Contribute TOA radiative fluxes to FCI demonstration dataset.
Status	The work has started in 2024. First results and plans have been presented at an ISCCP-NG workshop on 29 Feb. and 1 Mar. 2024 at EUMETSAT HQ (Darmstadt). The work focused on the development of empirical NB-to-BB relations for the different geo-ring imagers. This will continue through 2025 and 2026.

WP 5110	**TCDR global CLARA A3.5 – RR 4.2**
Schedule (WP start – end): 01.03.2022 – 31.12.2022 **Resources RMI (Prodex+EUM):** 2 pm (2022) **Milestones:** requirements review (RR 4.2) **Constraints:** (none) **Deliverables:** • RR document • Updated PRD entries for CM-11013, CM-11023, CM-11033, CM-11043, CM-11053, CM-11063, CM-11203, CM-11226, CM-11227, CM-11228, CM-11263, CM-11273, CM-11313, CM-11343	
Status	• The RR document was finalized and the RR review was successfully organized on 19.03.2024, and its results endorsed by the SG (see minutes in the documents package). • **WP 5110 is finalized and closed**.

WP 5120	**TCDR global CLARA A3.5 – PCR 4.2**
Schedule (WP start – end): 01.01.2023 – 31.03.2024 **Resources RMI (Prodex+EUM):** 10 pm (2023) **Milestones:** product consolidation review (PCR 4.2) **Constraints:** RR 4.2 document + PRD, PPS version 2021 from NWC SAF, Access to VGAC data and AVHRR FDR data beyond 2020 in EWC, readers from WP 3200. **Deliverables:** • ATBDs for entries: CM-11013, CM-11023, CM-11033, CM-11043, CM-11053, CM-11063, CM-11203, CM-11226, CM-11227, CM-11228, CM-11263, CM-11273, CM 11313, CM-11343. • DGCDD	
Status	• All the work in WP 5120 has been realized except the formal Product Consolidation Review (PCR). Our work is summarized in an ATBD that describes the TOA radiation products. • The PCR planned on Q2/2025.

WP 5410	**TCDR regional clouds (CLAAS-4) – RR 4.6**
Schedule (WP start – end): 1.03.2022 - 31.05.2023 **Resources RMI (Prodex+EUM):** 6 pm (2022) **Milestones:** RR 4.6 **Constraints:** CLAAS-3, SEVIRI and FCI data, PRD, Access to SEVIRI data and to FCI (commissioning phase) data. **Deliverables:** • RR document • Updated PRD entries for CM-21016, CM-21024, CM-21034, CM-21044, CM-21054, CM-21064, CM-21302, CM-21332	
Status	• The RR document was finalized and the RR review was successfully organized on 31.03.2024, and its results endorsed by the SG (see minutes in the documents package). • **WP 5410 is finalized and closed**.

WP 5420	TCDR regional clouds (CLAAS-4) – PCR 4.6
Schedule (WP start – end): 1.06.2023 - 31.08.2024 **Resources RMI (Prodex+EUM):** 9 pm (2023), 3 pm (2024) **Milestones:** PCR 4.6 **Constraints:** CLAAS-3, SEVIRI and FCI data, RR 4.6, PRD, Access to SEVIRI data and to FCI (commissioning phase), PPS version 2021 from NWC SAF incl. SEVIRI patch, CPP version. **Deliverables:** • PCR 4.6 documents (ATBD, DGCDD)	
Status	• All the work in WP 5120 has been realized except the formal PCR review. The work is summarized in the ATBD. • The PCR planned on Q2/2025.

WP5610	TCDR GeoRing Land Fluxes – RR 4.7
Schedule (WP start – end): 1.03.2022 - 28.02.2024 **Resources RMI (Prodex+EUM):** 2 pm (2022), 1 pm (2023), 1 pm (2024) **Milestones:** RR 4.7 **Constraints:** BSRN and Fluxnet data; Himawari, GOES and Meteosat data; Land Flux v1.0 algorithms, Himawari and GOES data including historical data to be available, LSA SAF on SOL, SDL, SAL and LE/H; EUMETSAT on SAL, FA with EUMETSAT and LSA SAF on SAL (algorithm comparisons and evaluations)**.** **Deliverables:** • RR 4.6 document • Updated PRD entries for land flux algorithms (CM-25271, CM-25811, CM-25921).	
Status	• All the work has been done and the RR document written. • The requirement review meeting is organized on 05.05.2025

WP5620	TCDR GeoRing Land Fluxes – PCR 4.7
Description	Prepare algorithms for the Land Flux GeoRing TCDR, PCR 4.7
Task (all)	- Prepare PCR 4.7 documents: ATBD, DGCDD - Organize, prepare and perform PCR 4.7 review - Prepare and process GeoRing test data
Task (RMI)	- Adapt the CDOP-3 LE/H processor for GeoRing - Process and evaluate part of the dataset (feedback loop) - Software preparation for processing at ECMWF or EWC
Status	• The processing has been adapted for the GeoRing. • The processing has been evaluated using radiation data (SW and LW) from ERA5 (later this will be replaced by radiation data from MeteoSwiss). • The PCR is to be organized before end of CDOP-4 (28 Feb. 2027).

In general, the work is progressing as expected and the different processors have been developed for all the CDOP-4 processing systems. The team has restructured as far as possible the processors so the share the same "bricks" to estimate TOA radiation fluxes in the CLARA, CLAAS and ISCCP-NG datasets.

The risks associated with these developments can therefore be considered as limited. Still, delays in the organization of the different review meetings are observed (e.g. the RR meetings in WP 5110 and WP 5410, which were originally foreseen for 2023 have been organized only in 2024).

In addition to the work performed in these work packages, the following ancillary activities are reported for 2024:

- The project team has been working on an "Use Case" to illustrate the capability of the newly released LE/H data record. In this study, the LE/H data are combined with the CM SAF GIRAFE precipitation data and compared with in-situ river run-off data. This use case will be released to the users in Q2/2025.
- The project team has prepared the "CM SAF User Workshop 2025" that took place in Bonn, Germany, during 3 days early 2025 (28-30 January 2025).
- The project team started to brainstorm about the CDOP5 proposal that is due for Autumn 2025 latest.

E. Describe the tangible outputs of the Project; include separately what is still to be expected.

Hardware (+ give an evaluation of its performance)

N/A

Software (+ give an evaluation of its performance)

No official CM SAF software was released as part of this project during the reporting period.

Equipment (+ give an evaluation of its performance)

The file server used in this project has been working smoothly during 2024. It allows storing all the needed input data, including several hourly fields from ERA-5.

Climate Data Records

The following Climate Data Record, with DOI, has been published in June 2024:

- Moutier, William; Bourgeois, Quentin; Tetzlaff, Anke; Clerbaux, Nicolas; Stöckli, Reto; Schröder, Marc; Hollmann, Rainer (2024): CM SAF Surface Radiation and Fluxes from Meteosat First and Second Generation - Edition 1 (LANDFLUX Ed. 1), Satellite Application Facility on Climate Monitoring, , https://doi.org/10.5676/EUM_SAF_CM/SLF_METEOSAT/V001

Corresponding "news" is : https://www.cmsaf.eu/EN/Highlights/Dokumente/News_42.html

Documentation

The following documents have been generated/published through 2024:

- Product User Manual - Meteosat Latent and Sensible Heat Flux: https://www.cmsaf.eu/SharedDocs/Literatur/document/2023/saf_cm_rmib_pum_leh_1_1_pdf.pdf?__blob=publicationFile
- Validation Report - CM SAF Latent and Sensible Heat: https://www.cmsaf.eu/SharedDocs/Literatur/document/2023/saf_cm_rmib_val_leh_1_1_pdf.pdf?__blob=publicationFile
- Algorithm Theoretical Basis Document - Meteosat latent and sensible heat fluxes: https://www.cmsaf.eu/SharedDocs/Literatur/document/2023/saf_cm_rmib_atbd_lehv1_2_pdf.pdf?__blob=publicationFile

- Requirements Review AVHRR GAC Edition 3.5 CDR and ICDR (CLARA-A3.5), not public (see document package).
- Requirements Review CLAAS-4 CDR and ICDR, not public (see document package).

Per Reviewed Publications, since start of CDOP3 (1st March 2017):

Urbain M., N. Clerbaux, A. Ipe, F. Tornow, R. Hollmann, E. Baudrez, A. Velazquez Blazquez, J. Moreels (2017): The CM SAF TOA Radiation Data Record Using MVIRI and SEVIRI, *Remote Sensing, 9, 466, doi: 10.3390/rs9050466*.

Tornow F., N. Clerbaux, A. Ipe, U. Manon (2017): An improved method to estimate reference cloud-free images for the visible band of geostationary satellites, *International Journal of Remote Sensing, 38(23), 7220-7241, doi:10.1080/01431161.2017.1372859.*

Dewitte S. and N. Clerbaux (2017): Measurement of the Earth Radiation Budget at the Top of the Atmosphere — A Review, *Remote Sensing, 9, 1143; doi:10.3390/rs9111143*.

Dewitte S. and N. Clerbaux (2018): Decadal Changes of Earth's Outgoing Longwave Radiation, *Remote Sensing, 10, 1539; doi:10.3390/rs10101539.*

S. Dewitte, N. Clerbaux, J. Cornelis, 2019: Decadal Changes of the Reflected Solar Radiation and the Earth Energy Imbalance, *Remote Sensing, 11, 663; doi:10.3390/rs11060663*.

Akkermans T. and N. Clerbaux (2020): Narrowband-to-Broadband Conversions for Top-of-Atmosphere Reflectance from the Advanced Very High Resolution Radiometer (AVHRR), *Remote Sensing, 12(2), 305; doi:10.3390/rs12020305*.

Clerbaux N., T. Akkermans, E. Baudrez, A. Velazquez Blazquez, W. Moutier, J. Moreels and C. Aebi (2020): The Climate Monitoring SAF Outgoing Longwave Radiation from AVHRR, *Remote Sensing, 12(2), 929; doi:10.3390/rs12060929*.

Akkermans T. and N. Clerbaux (2021): Retrieval of Daily Mean Top-of-Atmosphere Reflected Solar Flux Using the Advanced Very High Resolution Radiometer (AVHRR) Instruments, Remote Sensing, 13(18), 3695; doi:10.3390/rs13183695

Karlsson K-G, M. Stengel , J. F. Meirink , A. Riihelä , J. Trentmann, T. Akkermans , D. Stein, A. Devasthale, S. Eliasson, E. Johansson, N. Håkansson, I. Solodovnik, N. Benas, N. Clerbaux, N. Selbach, M. Schröder and R. Hollmann, 2023 : CLARA-A3: The third edition of

the AVHRR-based CM SAF climate data record on clouds, radiation and surface albedo covering the period 1979 to 2023. *Earth System Science Data Discussions*, https://doi.org/10.5194/essd-15-4901-2023 .

Akkermans T. and N. Clerbaux, 2023: Validation of the CLARA-A3 top-of-atmosphere radiative fluxes climate data record, *Journal of Atmospheric and Oceanic Technology*, 40(11), https://doi.org/10.1175/JTECH-D-23-0065.1

Moutier W., N. Clerbaux, A.Arboleda, J.-M. Barrios, F. Gellens-Meulenberghs, J. Moreels, Q. Bourgeois, A. Tetzlaff, M. Schröder, I. Trigo (2023) : Water and energy fluxes within the EUMETSAT Climate Monitoring SAF: Evapotranspiration and Latent and Sensible Heat Fluxes, *Under CM SAF internal review before submission.*

Moutier W. et al: Surface Soil Moisture: toward a new combined dataset to maximize the use of satellite data, *In preparation.*

Barrios, J. M., Arboleda, A., Dutra, E., Trigo, I., & Gellens-Meulenberghs, F. (2024): Evapotranspiration and surface energy fluxes across Europe, Africa and Eastern South America throughout the operational life of the Meteosat second generation satellite. *Geoscience Data Journal*, 11(4), 589-607.

Participation to congresses: distinguish between as invited speaker, with oral presentation, with poster presentation and without contribution

- Clerbaux, N., Akkermans, T., Moutier, W., 2024: TOA fluxes on ISCCP-NG L1g grid, *GEO-Ring and ISCCP-NG Workshop*, EUMETSAT HQ (Darmstadt, Germany), Feb 29 - Mar 1, 2024. (verbal presentation)

Membership of relevant committees related to the Project and participation to major Project reviews

Participations to:

- CM SAF International Board Meetings (IBM) took place:
    - 3-5 June 2024 (IBM5 in person meeting in Nörrköping, Sweden),
    - 18,19,21 November 2024 (IBM6 virtual meeting).

- CM SAF Steering Group (SG) Meetings took place: 17-19 September 2024 (SG5, Helsinki, Finland).

- Requirement Review Meeting RR 4.2 (CLARA-A3.5) on 19.03.2024 (tele conference)

- Requirement Review Meeting RR 4.6 5CLAAS-4) on 31.03.2024 (tele conference)

Other

F. List your Belgian and international scientific and industrial partners within this reporting period, and summarize their contribution to the Project.

N/A

G. Describe possible problems encountered, their origin and the solutions adopted or proposed. (max. 1 page)

– *Scientific, technical, administrative, personnel, ...;*
– *Budget management (e.g. cost overruns);*
– *Cooperation within the consortium (scientific and industrial partners);*
– *Resulting time delays;*
– *Remaining risks.*

No specific problems have been encountered for out CM SAF works during 2024. The staff situation was stable. The delays in the different reviews and data releases can be somewhat frustrating for the team but this is something we cannot mitigate (the delays are mostly due to programmatic aspects and dependencies on work of partners).

H. Identify problems anticipated for the next reporting period

The following particular problems could affect the CM SAF work in 2025:

- The new U.S. Administration could make the collaboration with U.S. colleagues more difficult, in particular with NOAA. This could impact the CM SAF project in 2 ways:
  - Risk on the availability of VGAC software and data to be used in CLARA-A3.5 and CLARA-A4.
  - Risk concerning the resource that NOAA will dedicate to ISCCP-NG.

Date of this Project Reporting: **15 April 2025.**