Comments from Public Consultation on ECV Requirements 13/01 – 13/03 2020 for:

# Greenhouse Gases

## ECV Product: N2O mole fraction

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | N2O mole fraction | | | | |
| **Definition** | 3D field of amount of N2O (expressed in moles) divided by the total amount of all constituents in dry air (also expressed in moles) | | | | |
| **Unit** | ppb | | | | |
| **Note** | Units  are ppm & ppb since these units are more familiar to the community.   N2O was not an ECV product in the GCOS IP but should be added as it is a strong GHG. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 100 |  |
| B | 500 |  |
| T | 2000 |  |
| **Vertical Resolution** | km |  | G | 0.1 |  |
| B | 1 |  |
| T | 3 |  |
| **Temporal Resolution** | hr |  | G | 1 |  |
| B | 24 | afternoon |
| T | 168 | afternoon |
| **Timeliness** | day |  | G | 1 |  |
| B | 30 |  |
| T | 180 |  |
| **Required Measurement Uncertainty** | ppb |  | G | 0.05 | GAW Rep. No. 242 |
| B | 0.2 | GAW Rep. No. 242 |
| T | 0.6 | GAW Rep. No. 242 |
| **Stability** | ppb/decade |  | G | 0.05 | Within accuracy |
| B | 0.1 | Within accuracy |
| T | 0.3 | Within accuracy |
| **Standards and References** | Blue Report, 2015:  Towards a European Operational Observing System to Monitor Fossil   CO2 emissions  <https://www.copernicus.eu/sites/default/files/2019-09/CO2_Blue_report_2015.pdf>    Red Report, 2017: Baseline Requirements, Model Components and Functional Architecture  <https://www.copernicus.eu/sites/default/files/2019-09/CO2_Red_Report_2017.pdf>    Green Report, 2019: Needs and High Level Requirements for in situ Measurements  <https://www.copernicus.eu/sites/default/files/2019-09/CO2_Green_Report_2019.pdf>    CO2M  <https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Copernicus_High_Priority_Candidates>    MRD, v 2.0:  <https://esamultimedia.esa.int/docs/EarthObservation/CO2M_MRD_v2.0_Issued20190927.pdf>      ESA Climate Change Initiative (CCI)  User Requirements Document Version 2.1 (URDv2.1) for the Essential Climate Variable (ECV) Greenhouse Gases (GHG)  <http://www.esa-ghg-cci.org/?q=node/85>    CEOS documents:  <http://ceos.org/ourwork/virtual-constellations/acc/>    CEOS GHG report/white paper:  <http://ceos.org/document_management/Virtual_Constellations/ACC/Documents/CEOS_AC-VC_GHG_White_Paper_Publication_Draft2_20181111.pdf>    GAW Report, 242. 19th WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases and Related Measurement Techniques (GGMT-2017)  Crotwell Andrew; Steinbacher M.; World Meteorological Organization (WMO) -  WMO, 2018  <https://library.wmo.int/doc_num.php?explnum_id=5456> | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  | Reviewers are invited to suggest answers for these fields | | |
| **Extremes[3]** |  |  | Reviewers are invited to suggest answers for these fields | | |

[1]Goal (G); Breakthrough (B) (not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Martin Steinbacher | Email: martin.stonycreek@gmail.com |
| \* Temporal resolution: B and T: replace "afternoon" by "well-mixed or background" as for example nighttime observations may be more representative at mountain stations | |

### Comment 2

|  |  |
| --- | --- |
| Author: Martin Steinbacher | Email: martin.stonycreek@gmail.com |
| If Required Measurement Uncertainty - Goal and Breakthrough refer to the network compatibility goal and the extended network compatibility goal (see Table 1) in Ref GAW report #242, G is 0.1 ppb, B is 0.3 ppb, T = 0.6 ppb is not mentioned in GAW #242 | |

## ECV Product: CO2 Total column

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | CO2 Total column | | | | |
| **Definition** | 2D field of total amount of CO2 molecules per unit area in an atmospheric column extending from the Earth’s surface to the upper edge of the atmosphere | | | | |
| **Unit** | ppm | | | | |
| **Note** | Units  are ppm & ppb since these units are more familiar to the community.  A conversion factor from ppm to mol/cm2 will be provided at a later stage.  - For the Total column, we give also 1-sigma values - this are also more familiar to the community. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 1 | imaging |
| B | 5 | ~OCO-2/3 |
| T | 10 | CO2M, CEOS document - LEO, GEO |
| **Vertical Resolution** | N/A |  | G |  |  |
| B |  |  |
| T |  |  |
| **Temporal Resolution** | hr |  | G | 1 | geostationary |
| B | 12 | Blue report |
| T | 72 | CO2M |
| **Timeliness** | day |  | G | 1 |  |
| B | 7 |  |
| T | 14 |  |
| **Required Measurement Uncertainty** | ppm |  | G | 0.6 | 1-sigma: 0.3ppm  TCCON / Green report |
| B | 1 | 1-sigma: 0.5ppm  improved CO2M |
| T | 1.6 | 1-sigma: 0.8ppm  CO2M, WMO Report 242 |
| **Stability** | ppm/decade |  | G | 0.1 | 1% of yr growth (2-sigma) |
| B | 0.15 | 5% of yr growth (2-sigma) |
| T | 0.2 | 10% of yr growth (2-sigma) |
| **Standards and References** | Blue Report, 2015:  Towards a European Operational Observing System to Monitor Fossil   CO2 emissions  <https://www.copernicus.eu/sites/default/files/2019-09/CO2_Blue_report_2015.pdf>    Red Report, 2017: Baseline Requirements, Model Components and Functional Architecture  <https://www.copernicus.eu/sites/default/files/2019-09/CO2_Red_Report_2017.pdf>    Green Report, 2019: Needs and High Level Requirements for in situ Measurements  <https://www.copernicus.eu/sites/default/files/2019-09/CO2_Green_Report_2019.pdf>    CO2M  <https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Copernicus_High_Priority_Candidates>    MRD, v 2.0:  https://esamultimedia.esa.int/docs/EarthObservation/CO2M\_MRD\_v2.0\_Issued20190927.pdf      ESA Climate Change Initiative (CCI)  User Requirements Document Version 2.1 (URDv2.1) for the Essential Climate Variable (ECV) Greenhouse Gases (GHG)  <http://www.esa-ghg-cci.org/?q=node/85>    CEOS documents:  <http://ceos.org/ourwork/virtual-constellations/acc/>    CEOS GHG report/white paper:  <http://ceos.org/document_management/Virtual_Constellations/ACC/Documents/CEOS_AC-VC_GHG_White_Paper_Publication_Draft2_20181111.pdf>    GAW Report, 242. 19th WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases and Related Measurement Techniques (GGMT-2017)  Crotwell Andrew; Steinbacher M.; World Meteorological Organization (WMO) -  WMO, 2018  <https://library.wmo.int/doc_num.php?explnum_id=5456> | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  | Reviewers are invited to suggest answers for these fields | | |
| **Extremes[3]** |  |  | Reviewers are invited to suggest answers for these fields | | |

[1]Goal (G); Breakthrough (B) (not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Michael Buchwitz | Email: michaelbuchwitz@gmail.com |
| Satellites generating CO2 ECV data products (see, e.g., EU Copernicus C3S (https://climate.copernicus.eu/) or ESA CCI (http://cci.esa.int/ghg)) such as GOSAT, OCO-2, etc. do not generate CO2 total columns in molecules/area but column-averaged dry-air mole fractions of CO2, denoted XCO2 (in ppm). The “Definition” is therefore not appropriate and needs to be adjusted. This would also solve the unit problem listed as a note (“A conversion factor from ppm to mol/cm2 will be provided at a later stage.”). Critical requirements (see the detailed information as provided in the cited CCI URDv2.1 document (http://cci.esa.int/sites/default/files/URDv2.1\_GHG-CCI\_Final.pdf)) are random (precision) and systematic errors (biases) separately, not “Required Measurement Uncertainty”. | |

### Comment 2

|  |  |
| --- | --- |
| Author: Frederic Chevallier | Email: frederic.chevallier@lsce.ipsl.fr |
| I agree with Michael Buchwitz. It is difficult to really comment on the table since it refers to a physical quantity which is not relevant (a number of molecules rather than a ratio of molecule numbers; the conversion factor that goes from one to the other depends on (uncertain) dry surface pressure) and to a statistical quantity for uncertainty (1 or 2 sigmas) which is not the critical one for most applications ("systematic error", or "trueness"). Actually, I do not see where the numbers for 1 sigma come from here: apparently not from the quoted documents. For "systematic error" or "trueness" you can refer to ESA's GHG-CCI URD with G/B/T = 0.2/0.3/0.5 ppm. | |

### Comment 3

|  |  |
| --- | --- |
| Author: Kazuto Suda | Email: kazuto.suda@gmail.com |
| I support the previous comments to use column-averaged mole fractions and adjust the definition accordingly. | |

### Comment 4

|  |  |
| --- | --- |
| Author: ECMWF | Email: ecresgcosreqs@gmail.com |
| We agree with what has been said already. The table is confusing at the moment with the use of different units. It is good to see that the most relevant recent documents are listed. It is also important to take into account that the playing field is changing rapidly for CO2 measurements. We are shifting from a focus on monitoring and studying the natural carbon cycle to monitoring anthropogenic emissions. This is a very significant step up in requirements. The CEOS white paper and the CO2M MRD can be taken as guidance for these new requirements. | |

## ECV Product: CO2 mole fraction

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | CO2 mole fraction | | | | |
| **Definition** | 3D field of amount of CO2 (Carbon dioxide, expressed in moles) divided by the total amount of all constituents in dry air (also expressed in moles) | | | | |
| **Unit** | ppm | | | | |
| **Note** | Units  are ppm & ppb since these units are more familiar to the community. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 100 |  |
| B | 500 |  |
| T | 2000 |  |
| **Vertical Resolution** | km |  | G | 0.1 |  |
| B | 1 |  |
| T | 3 |  |
| **Temporal Resolution** | hr |  | G | 1 |  |
| B | 24 | afternoon |
| T | 168 | afternoon |
| **Timeliness** | day |  | G | 1 |  |
| B | 30 |  |
| T | 180 |  |
| **Required Measurement Uncertainty** | ppm |  | G | 0.1 | GAW Rep. No. 242 |
| B | 0.5 | GAW Rep. No. 242 |
| T | 1 | GAW Rep. No. 242 |
| **Stability** | ppm/decade |  | G | 0.1 | Within accuracy |
| B | 0.15 | Within accuracy |
| T | 0.2 | Within accuracy |
| **Standards and References** | Blue Report, 2015:  Towards a European Operational Observing System to Monitor Fossil   CO2 emissions  <https://www.copernicus.eu/sites/default/files/2019-09/CO2_Blue_report_2015.pdf>    Red Report, 2017: Baseline Requirements, Model Components and Functional Architecture  <https://www.copernicus.eu/sites/default/files/2019-09/CO2_Red_Report_2017.pdf>    Green Report, 2019: Needs and High Level Requirements for in situ Measurements  <https://www.copernicus.eu/sites/default/files/2019-09/CO2_Green_Report_2019.pdf>    CO2M  <https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Copernicus_High_Priority_Candidates>    MRD, v 2.0:  <https://esamultimedia.esa.int/docs/EarthObservation/CO2M_MRD_v2.0_Issued20190927.pdf>      ESA Climate Change Initiative (CCI)  User Requirements Document Version 2.1 (URDv2.1) for the Essential Climate Variable (ECV) Greenhouse Gases (GHG)  <http://www.esa-ghg-cci.org/?q=node/85>    CEOS documents:  <http://ceos.org/ourwork/virtual-constellations/acc/>    CEOS GHG report/white paper:  <http://ceos.org/document_management/Virtual_Constellations/ACC/Documents/CEOS_AC-VC_GHG_White_Paper_Publication_Draft2_20181111.pdf>    GAW Report, 242. 19th WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases and Related Measurement Techniques (GGMT-2017)  Crotwell Andrew; Steinbacher M.; World Meteorological Organization (WMO) -  WMO, 2018  <https://library.wmo.int/doc_num.php?explnum_id=5456> | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  | Reviewers are invited to suggest answers for these fields | | |
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[1]Goal (G); Breakthrough (B) (not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Martin Steinbacher | Email: martin.stonycreek@gmail.com |
| \* Temporal resolution: B and T: replace "afternoon" by "well-mixed or background" as for example nighttime observations may be more representative at mountain stations | |

### Comment 2

|  |  |
| --- | --- |
| Author: Martin Steinbacher | Email: martin.stonycreek@gmail.com |
| If Required Measurement Uncertainty - Breakthrough refers to the extended network compatibility goal (see Table 1) in Ref GAW report #242, 0.5 must read 0.2 ppm | |

### Comment 3

|  |  |
| --- | --- |
| Author: ECMWF | Email: ecresgcosreqs@gmail.com |
| It is not clear what we are exactly referring to here. Is this ECV about surface concentrations? If so, it should be stated. Otherwise the vertical resolution requirements are very demanding. Also, the horizontal resolution requirement is vague. The requirement cannot really be captured by a spatial resolution,but should point to specific sampling needs. Not sure how to do this in this table, though. | |

## ECV Product: CH4 Total column

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | CH4 Total column | | | | |
| **Definition** | 2D field of total amount of CH4 molecules per unit area in an atmospheric column extending from the Earth’s surface to the upper edge of the atmosphere | | | | |
| **Unit** | ppb | | | | |
| **Note** | Units  are ppm & ppb since these units are more familiar to the community.  A conversion factor from ppm to mol/cm2 will be provided at a later stage.  - For the Total column, we give also 1-sigma values - this are also more familiar to the community.  Temporal resolution and timeliness are kept the same/compatible with CO2 | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 0.3 | Imaging, permafrost region |
| B | 1 | Improved TROPOMI |
| T | 10 | TROPOMI/S5P |
| **Vertical Resolution** | N/A |  | G |  |  |
| B |  |  |
| T |  |  |
| **Temporal Resolution** | hr |  | G | 1 | Geo constellation + LEO |
| B | 12 | In the middle between threshold and goal |
| T | 72 | TROPOMI  revisit, single geostationary |
| **Timeliness** | day |  | G | 1 |  |
| B | 7 |  |
| T | 14 |  |
| **Required Measurement Uncertainty** | ppb |  | G | 7 | 1-sigma: 3.5ppb  GeoCARB and MERLIN mission requirements, 0.2% of current CH4 burden |
| B | 10 | 1-sigma:5ppb |
| T | 20 | 1-sigma: 10ppb  TROPOMI/S5P, CEOS doc, advancing from GCOS 2011 |
| **Stability** | ppb/decade |  | G | 1 | 1% of yr growth (2-sigma) |
| B | 2 | 5% of yr growth (2-sigma) |
| T | 5 | 10% of yr growth (2-sigma) |
| **Standards and References** | Blue Report, 2015:  Towards a European Operational Observing System to Monitor Fossil   CO2 emissions  <https://www.copernicus.eu/sites/default/files/2019-09/CO2_Blue_report_2015.pdf>    Red Report, 2017: Baseline Requirements, Model Components and Functional Architecture  <https://www.copernicus.eu/sites/default/files/2019-09/CO2_Red_Report_2017.pdf>    Green Report, 2019: Needs and High Level Requirements for in situ Measurements  <https://www.copernicus.eu/sites/default/files/2019-09/CO2_Green_Report_2019.pdf>    CO2M  <https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Copernicus_High_Priority_Candidates>    MRD, v 2.0:  https://esamultimedia.esa.int/docs/EarthObservation/CO2M\_MRD\_v2.0\_Issued20190927.pdf    ESA Climate Change Initiative (CCI)  User Requirements Document Version 2.1 (URDv2.1) for the Essential Climate Variable (ECV) Greenhouse Gases (GHG)  <http://www.esa-ghg-cci.org/?q=node/85>    CEOS documents:  <http://ceos.org/ourwork/virtual-constellations/acc/>    CEOS GHG report/white paper:  <http://ceos.org/document_management/Virtual_Constellations/ACC/Documents/CEOS_AC-VC_GHG_White_Paper_Publication_Draft2_20181111.pdf>    GAW Report, 242. 19th WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases and Related Measurement Techniques (GGMT-2017)  Crotwell Andrew; Steinbacher M.; World Meteorological Organization (WMO) -  WMO, 2018  <https://library.wmo.int/doc_num.php?explnum_id=5456> | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** |  |  | Reviewers are invited to suggest answers for these fields | | |
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[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Michael Buchwitz | Email: michaelbuchwitz@gmail.com |
| Satellites generating CH4 ECV data products (see, e.g., EU Copernicus C3S (https://climate.copernicus.eu/) or ESA CCI (http://cci.esa.int/ghg)) such as GOSAT, Sentinel-5-Precursor, etc. do not generate CH4 total columns in molecules/area but column-averaged dry-air mole fractions of CH4, denoted XCH4 (in ppb). The “Definition” is therefore not appropriate and needs to be adjusted. This would also solve the unit problem listed as a note (“A conversion factor from ppm to mol/cm2 will be provided at a later stage.”). Critical requirements (see the detailed information as listed in the cited CCI URDv2.1 document (http://cci.esa.int/sites/default/files/URDv2.1\_GHG-CCI\_Final.pdf)) are random (precision) and systematic errors (biases) separately, not “Required Measurement Uncertainty”. | |

### Comment 2

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| Author: Kazuto Suda | Email: kazuto.suda@gmail.com |
| I support the previous comment to use column-averaged mole fractions and adjust the definition accordingly. | |

## ECV Product: CH4 mole fraction

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | CH4 mole fraction | | | | |
| **Definition** | 3D field of amount of CH4 (Methane, expressed in moles) divided by the total amount of all constituents in dry air (also expressed in moles) | | | | |
| **Unit** | ppb | | | | |
| **Note** | Units  are ppm & ppb since these units are more familiar to the community. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | km |  | G | 100 |  |
| B | 500 |  |
| T | 2000 |  |
| **Vertical Resolution** | km |  | G | 0.1 |  |
| B | 1 |  |
| T | 3 |  |
| **Temporal Resolution** | hr |  | G | 1 |  |
| B | 24 | afternoon |
| T | 168 | afternoon |
| **Timeliness** | day |  | G | 1 |  |
| B | 30 |  |
| T | 180 |  |
| **Required Measurement Uncertainty** | ppb |  | G | 1 | GAW Rep. No. 242 |
| B | 3 | GAW Rep. No. 242 |
| T | 8 | GAW Rep. No. 242 |
| **Stability** | ppb/decade |  | G | 1 | Within accuracy |
| B | 2 | Within accuracy |
| T | 5 | Within accuracy |
| **Standards and References** | Blue Report, 2015:  Towards a European Operational Observing System to Monitor Fossil   CO2 emissions  <https://www.copernicus.eu/sites/default/files/2019-09/CO2_Blue_report_2015.pdf>    Red Report, 2017: Baseline Requirements, Model Components and Functional Architecture  <https://www.copernicus.eu/sites/default/files/2019-09/CO2_Red_Report_2017.pdf>    Green Report, 2019: Needs and High Level Requirements for in situ Measurements  <https://www.copernicus.eu/sites/default/files/2019-09/CO2_Green_Report_2019.pdf>    CO2M  <https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Copernicus_High_Priority_Candidates>    MRD, v 2.0:  <https://esamultimedia.esa.int/docs/EarthObservation/CO2M_MRD_v2.0_Issued20190927.pdf>    ESA Climate Change Initiative (CCI)  User Requirements Document Version 2.1 (URDv2.1) for the Essential Climate Variable (ECV) Greenhouse Gases (GHG)  <http://www.esa-ghg-cci.org/?q=node/85>    CEOS documents:  <http://ceos.org/ourwork/virtual-constellations/acc/>    CEOS GHG report/white paper:  <http://ceos.org/document_management/Virtual_Constellations/ACC/Documents/CEOS_AC-VC_GHG_White_Paper_Publication_Draft2_20181111.pdf>     GAW Report, 242. 19th WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases and Related Measurement Techniques (GGMT-2017)  Crotwell Andrew; Steinbacher M.; World Meteorological Organization (WMO) -  WMO, 2018  <https://library.wmo.int/doc_num.php?explnum_id=5456> | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
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[1]Goal (G); Breakthrough (B) (not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Martin Steinbacher | Email: martin.stonycreek@gmail.com |
| \* Temporal resolution: B and T: replace "afternoon" by "well-mixed or background" as for example nighttime observations may be more representative at mountain stations | |

### Comment 2

|  |  |
| --- | --- |
| Author: Martin Steinbacher | Email: martin.stonycreek@gmail.com |
| If Required Measurement Uncertainty - Goal and Breakthrough refer to the network compatibility goal and the extended network compatibility goal (see Table 1) in Ref GAW report #242, G is 2 ppb, B is 5 ppb, T = 8 ppb is not mentioned in GAW #242 | |

### Comment 3

|  |  |
| --- | --- |
| Author: ECMWF | Email: ecresgcosreqs@gmail.com |
| Same comments as for CO2 mole fraction. | |