IWGGMS-12
7-9 June 2016, Kyoto, Japan

SCIAMACHY and GOSAT XCO_2 and XCH_4 retrievals: The GHG-CCI CRDP3 data set

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University of Leicester

Max-Planck-Institut für Biogeochemie

THE UNIVERSITY OF EDINBURGH

EMPA

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DLR

LMD

KIT Karlsruhe Institute of Technology

European Commission

The Inversion Lab

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B. Dils, E. De Wachter, M. De Mazière, BIRA, Brussels, Belgium, Validation

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T. Kaminski, M. Scholze (Lund Univ.), **The Inversion Lab, Germany,** User requirements CO_2 and CCDAS

J. Marshall, MPI-BGC, Jena, Germany, User requirements and inverse modelling CO_2 and CH_4

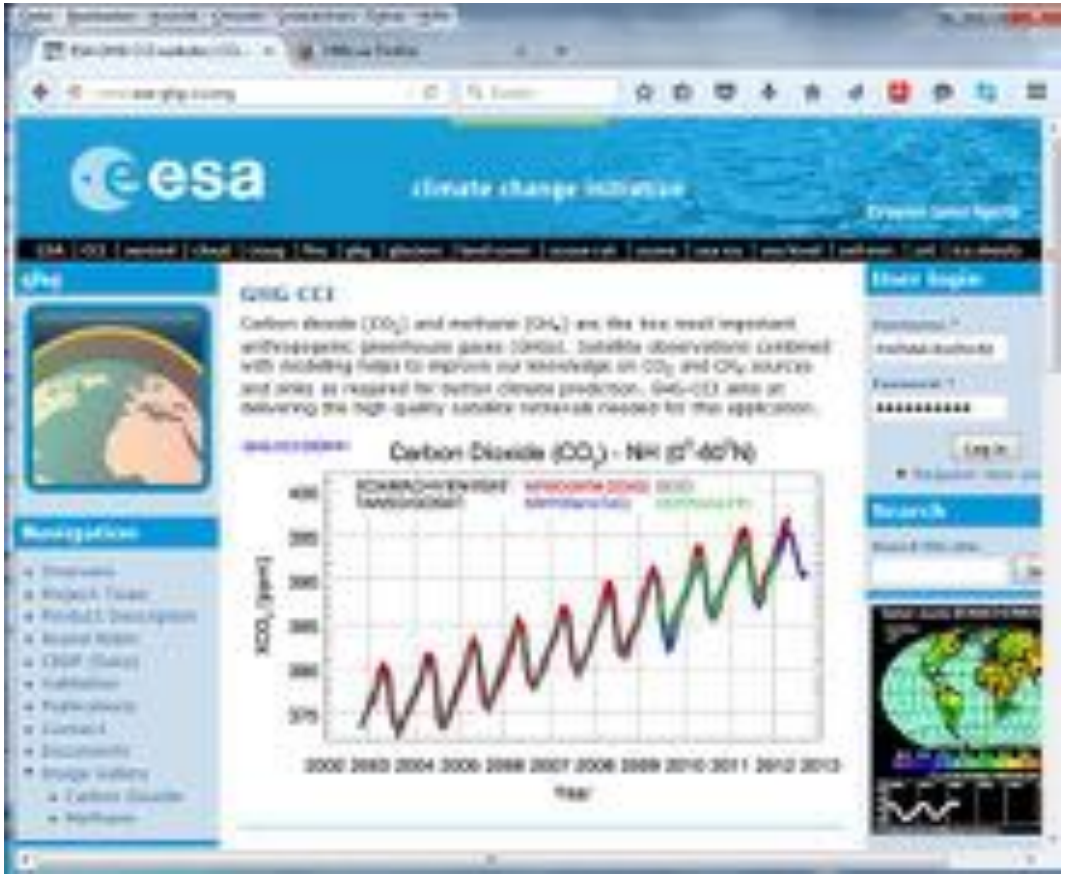
P. Palmer, L. Feng, Univ. Edinburgh (UoE), UK, User requirements and inverse modelling CH_4

D. Brunner, A.-M. Sundström, **EMPA, Switzerland,** User requirements & inter-comparisons focus CO_2

C. Zehner, **ESA/ESRIN, Frascati, Italy,** ESA technical officer

ESA Climate Change Initiative (CCI)

to generate Essential Climate Variables (ECVs)



www.esa-ghg-cci.org/

ESA programme

led by Mark Doherty & Pascal Lecomte, ESA

ECV projects:

- Aerosol-CCI
- Cloud-CCI
- Fire-CCI
- **GHG-CCI - CO_2 & CH_4**
- Glaciers-CCI
- LandCover-CCI
- OceanColour-CCI
- Ozone-CCI
- SeaLevel-CCI
- SST-CCI
- SoilMoisture-CCI
- SeaIce-CCI
- IceSheets-CCI (Greenland, Antarctica)
- plus cross-ECV: Data Portal & ToolBox

+ **CMUG** (Climate Modelling User Group)

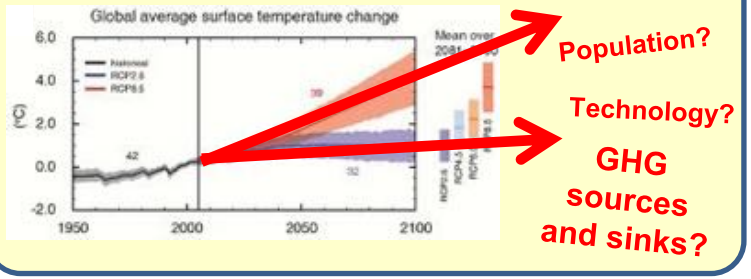
- Lead: Roger Saunders (Met Office Hadley Centre)
- Met Office Hadley Centre, ECMWF, MPI-Meteorology, Météo France, IPSL, SMHI, DLR

ECV GHG ?

Essential Climate Variable Greenhouse Gases ?

CO_2 and CH_4 are the two most important greenhouse gases emitted by humans & increasing atmospheric concentrations result in global warming.

Observed and predicted temperature change (AR5)



Future?

Ecomomie?

Population?

Technology?

GHG sources and sinks?

Reliable climate prediction requires a good understanding of the natural and anthropogenic (surface) **sources and sinks of CO_2 and CH_4**.

Important questions are, for example

- Where are they ?
- How strong are they ?
- How do they respond to a changing climate ?

A better understanding requires appropriate global observations and (inverse) modelling.

ECV GHG (GCOS-154*)):

"Retrievals of greenhouse gases, such as CO_2 and CH_4, of sufficient quality to estimate regional sources and sinks."

*) „SYSTEMATIC OBSERVATION REQUIREMENTS FOR SATELLITE-BASED DATA PRODUCTS FOR CLIMATE"

GHG-CCI project www.esa-ghg-cci.org

Global satellite observations

Global information on near-surface CO_2 & CH_4

Upper layer CO_2 & CH_4

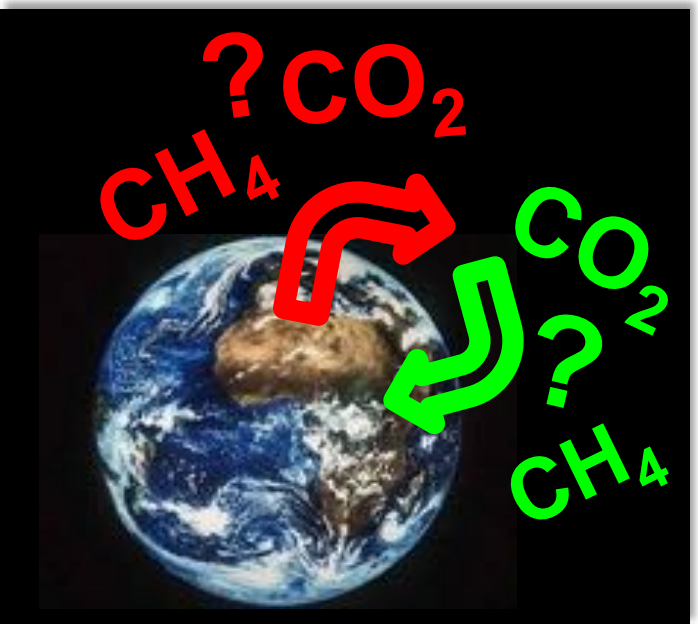
SCIAMACHY/ENVISAT

TANSO/GOSAT

(Other: **OCO-2, S5P, …**)

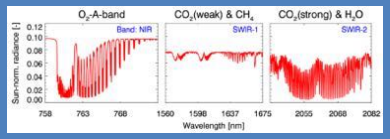
IASI, MIPAS, SCIA/occ, AIRS, ACE-FTS, …

Global observations



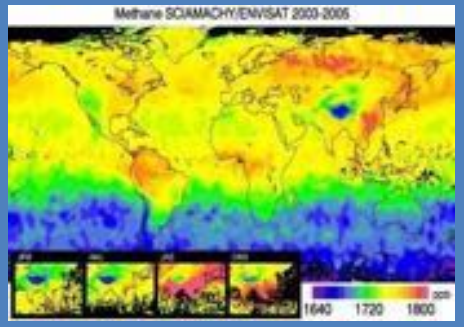
Calibration (L 0-1)

Calibrated radiances



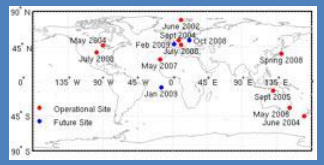
Retrieval (L 1-2)

Atmospheric GHG distributions



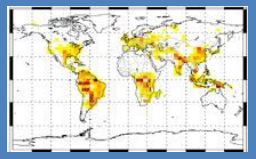
Validation

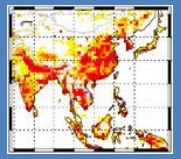
Reference observations



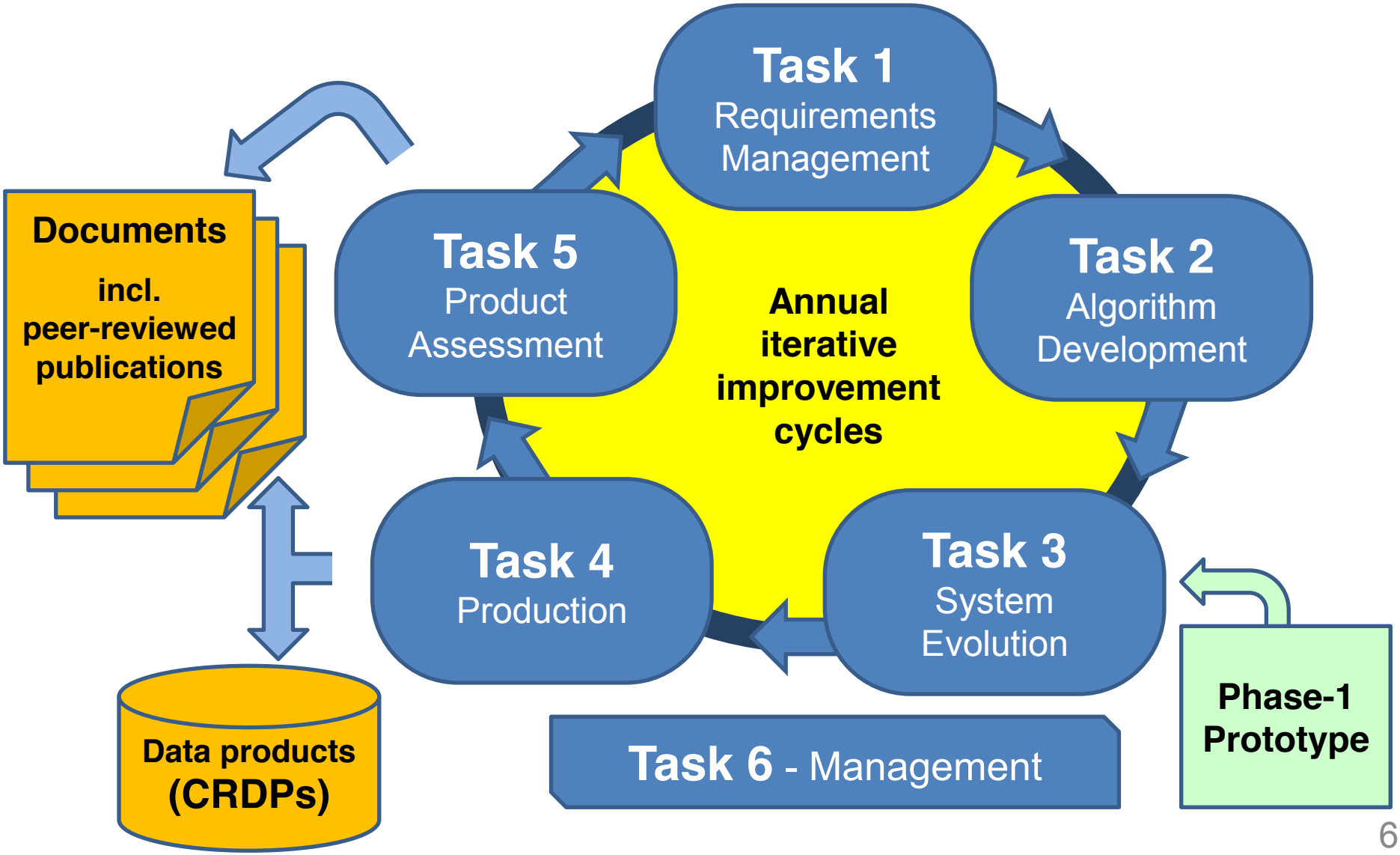
Inverse modelling (L 2-4)

Improved information on GHG sources & sinks





GHG-CCI Tasks



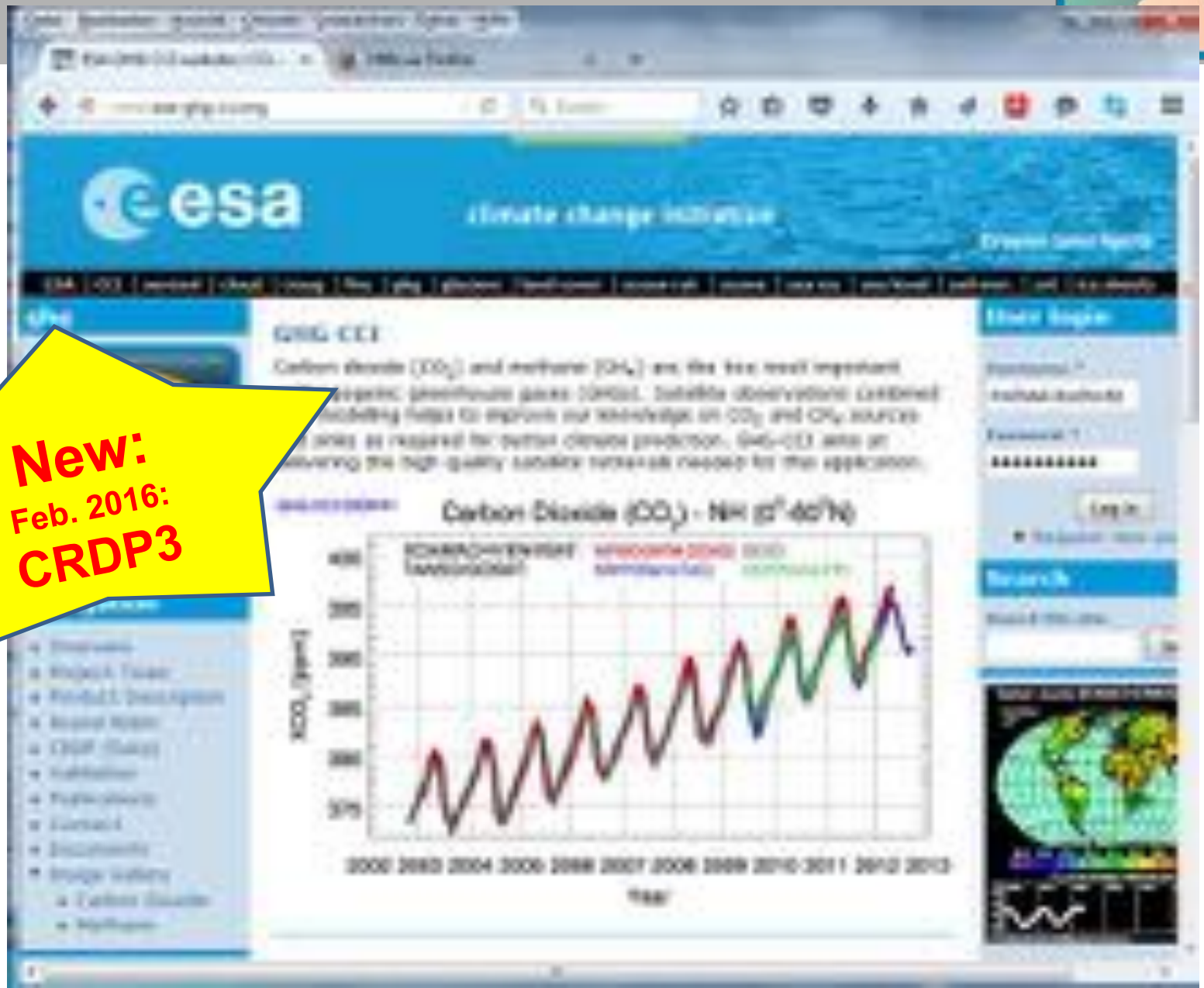
Requirements

GCOS – 154 (2011)

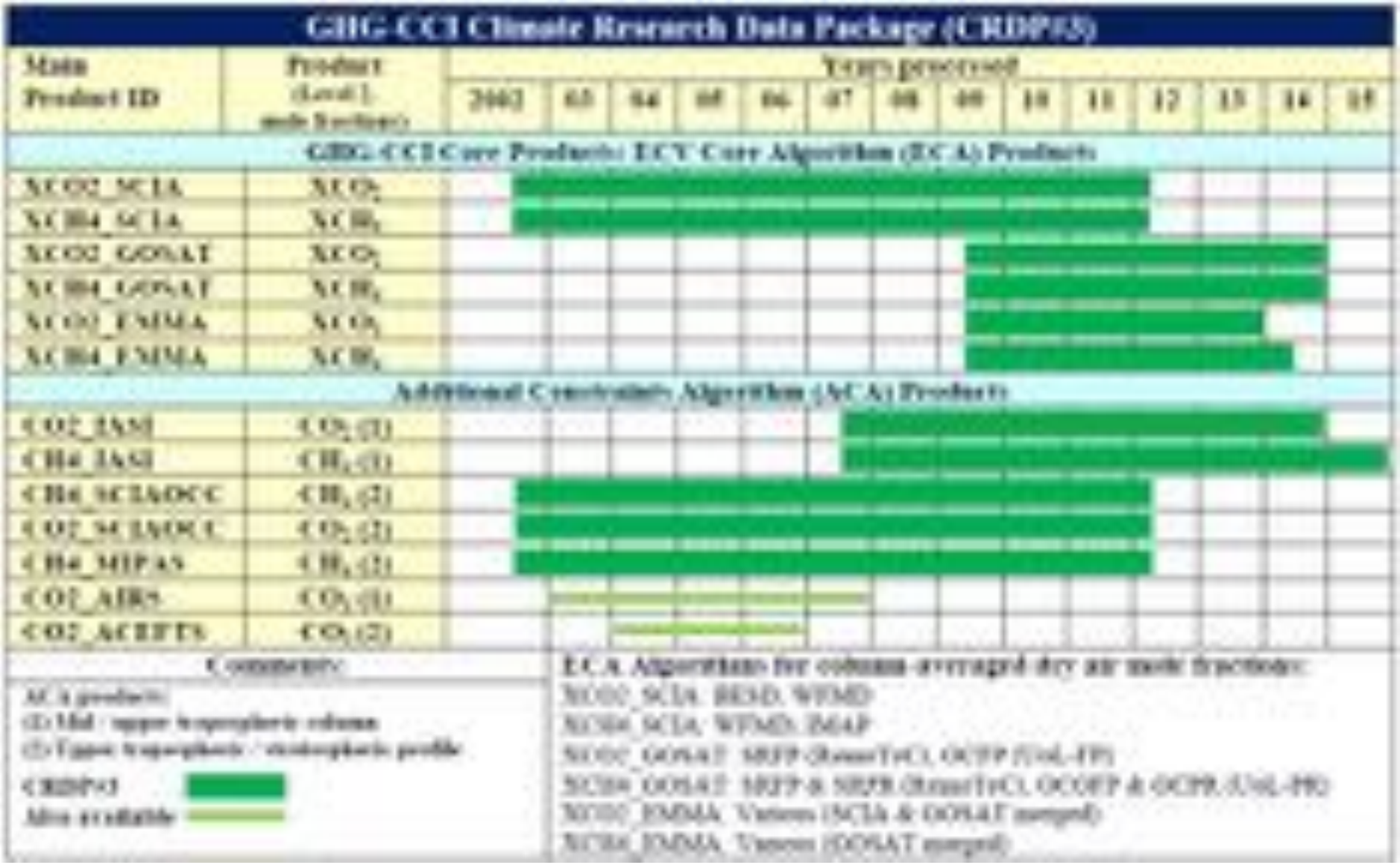
GHG-CCI URD v2.0

http://www.esa-ghg-cci.org/?q=webfm_send/173

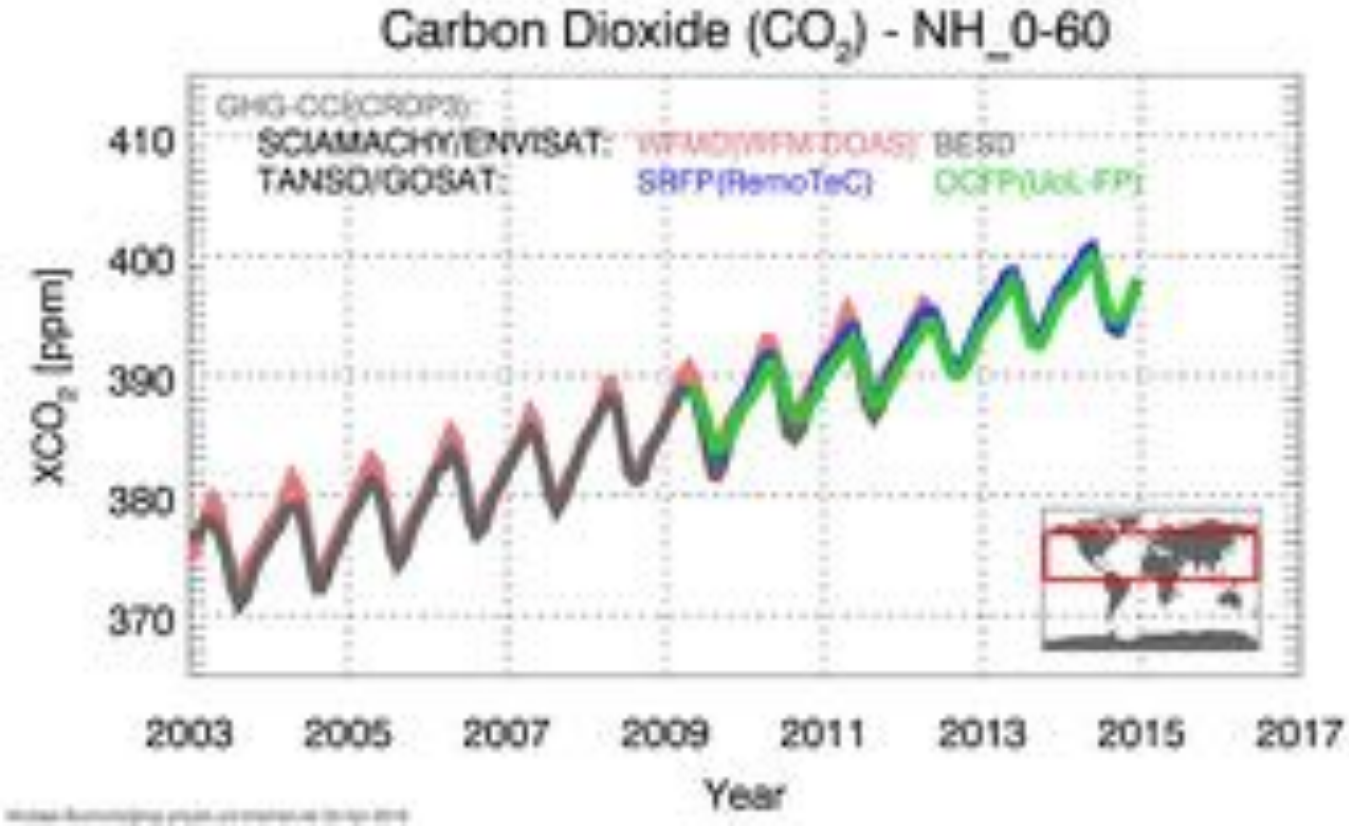
GHG-CCI: Data


esa
climate change initiative
GHG-CCI
Carbon Dioxide (CO_2) - NH
New:
Feb. 2016:
CRDP3

CRDP3: Overview

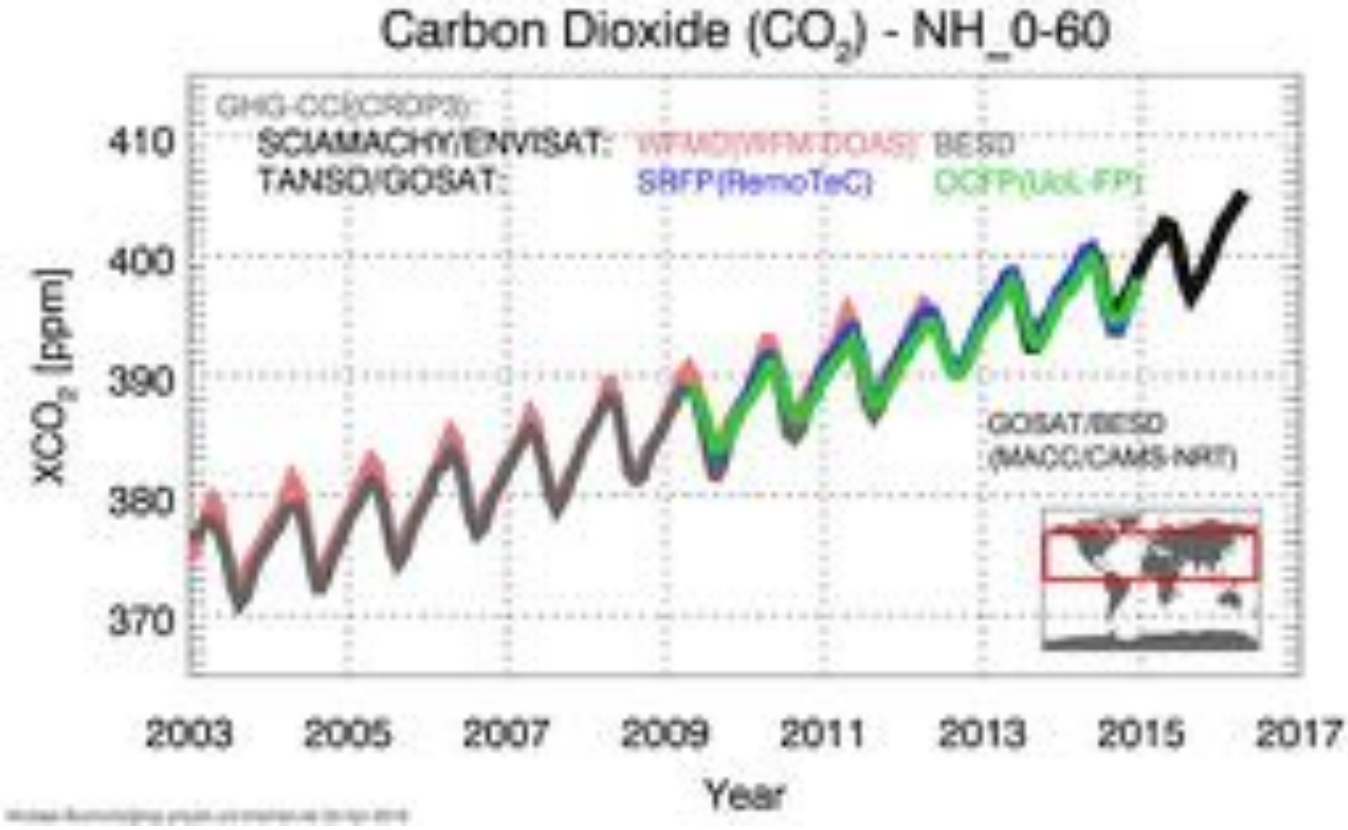


Satellite XCO_2 products



ESA CCI GHG-CCI SCIAMACHY & GOSAT CRDP3

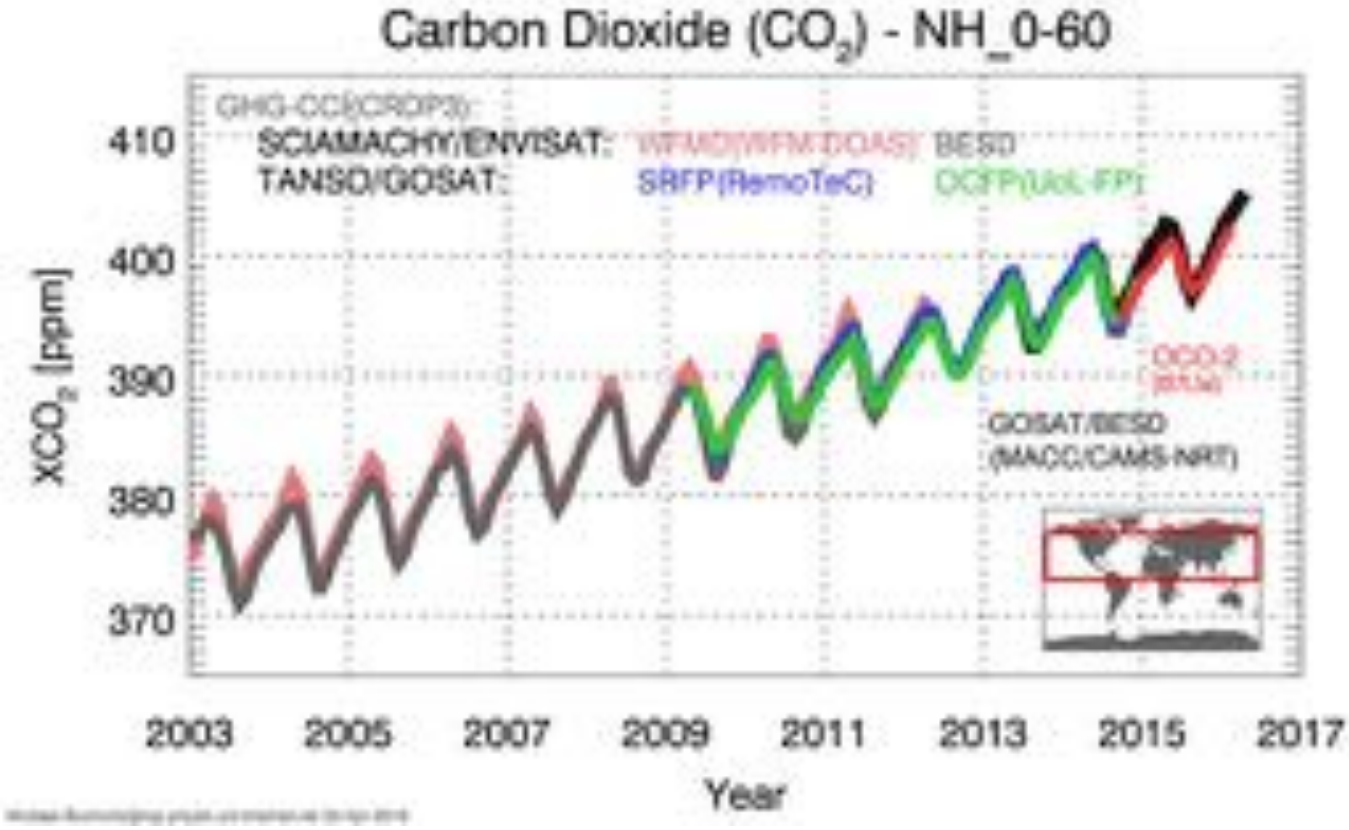
Satellite XCO_2 products



ESA CCI GHG-CCI SCIAMACHY & GOSAT CRDP3

EU MACC/CAMS GOSAT NRT

Satellite XCO_2 products

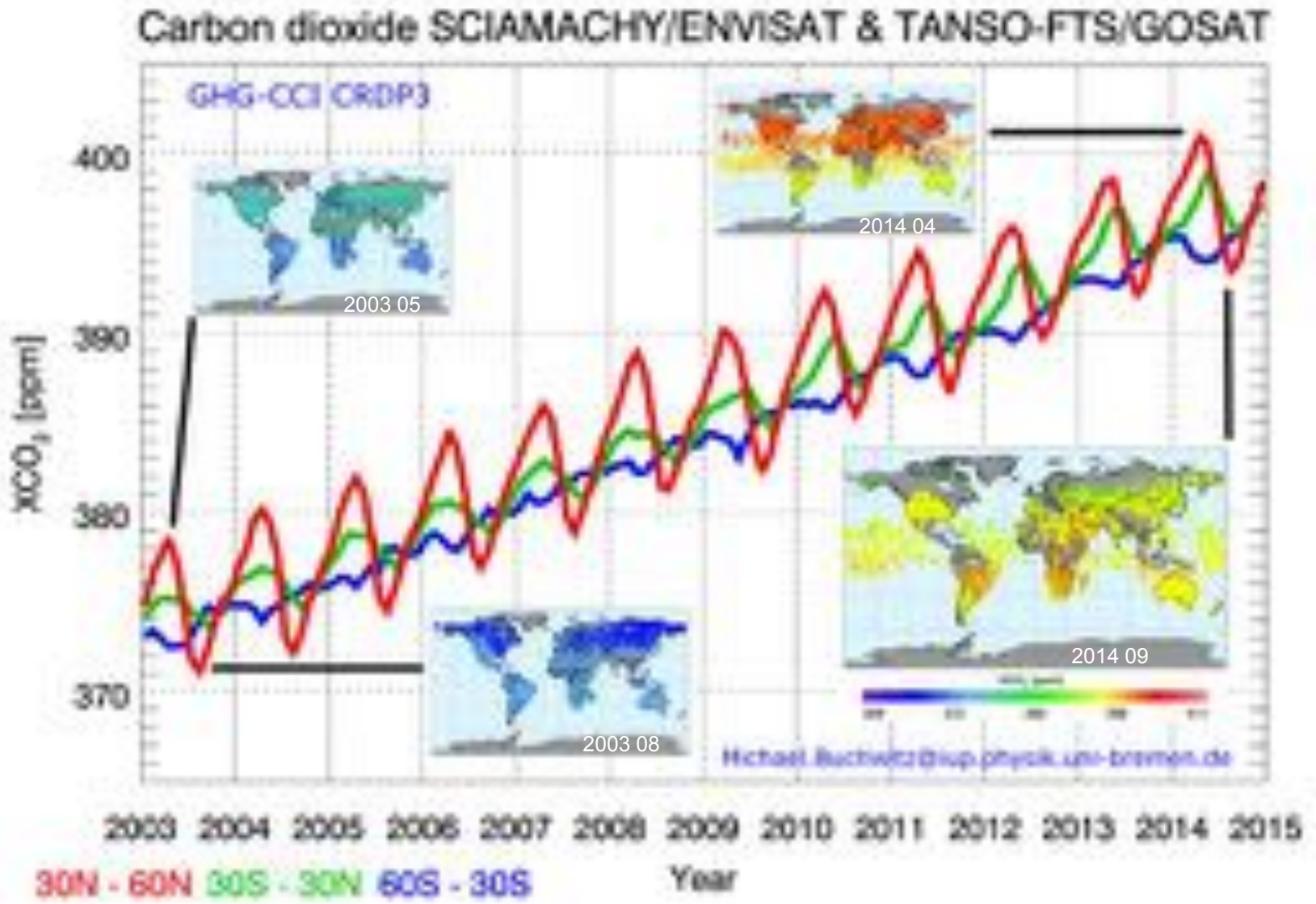


ESA CCI GHG-CCI SCIAMACHY & GOSAT CRDP3

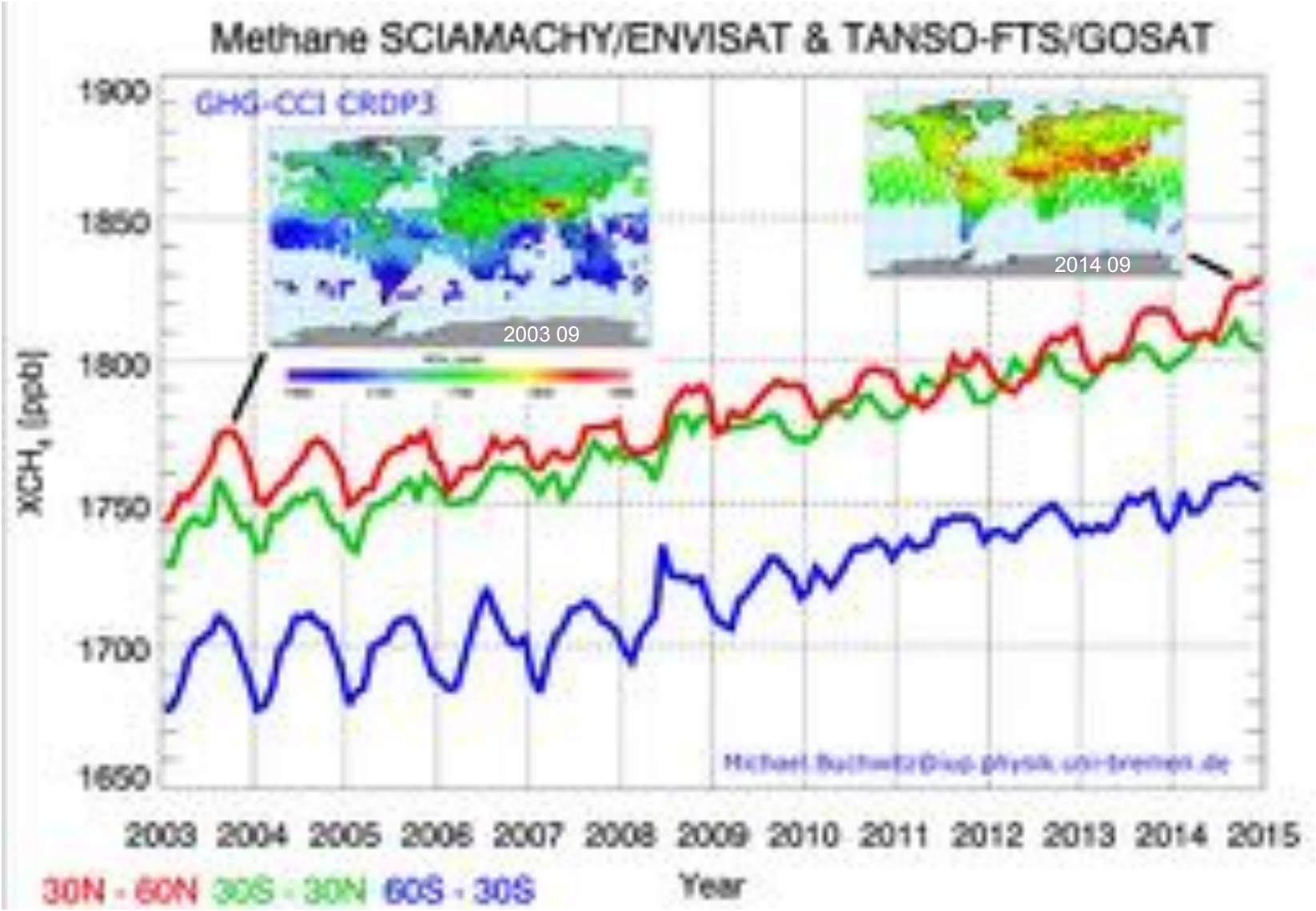
EU MACC/CAMS GOSAT NRT

NASA OCO-2

CRDP3: XCO_2

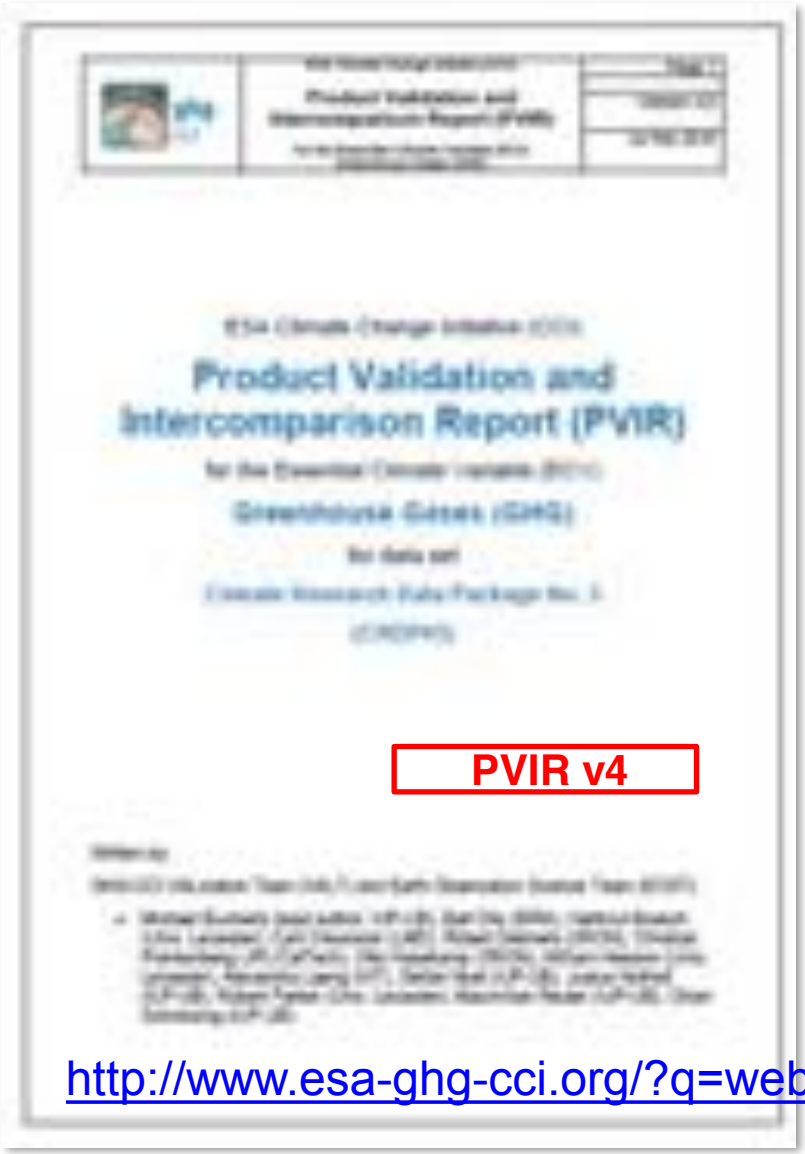

Carbon dioxide SCIAMACHY/ENVISAT & TANSO-FTS/GOSAT
GHG-CCI CRDP3
400
390
380
370
XCO_2 [ppm]
2003 05
2014 04
2003 08
2014 09
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Year
30N - 60N 30S - 30N 60S - 30S

CRDP3: XCH_4


Methane SCIAMACHY/ENVISAT & TANSO-FTS/GOSAT
GHG-CCI CRDP3
2003 09
2014 09
1900
1850
1800
1750
1700
1650
XCH4 (ppb)
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Year
30N - 60N
30S - 30N
60S - 30S

http://www.esa.int/Our_Activities/Observing_the_Earth/Living_Planet_Symposium/Methane_and_carbon_dioxide_on_the_rise

CRDP3: PVIR



PVIR v4

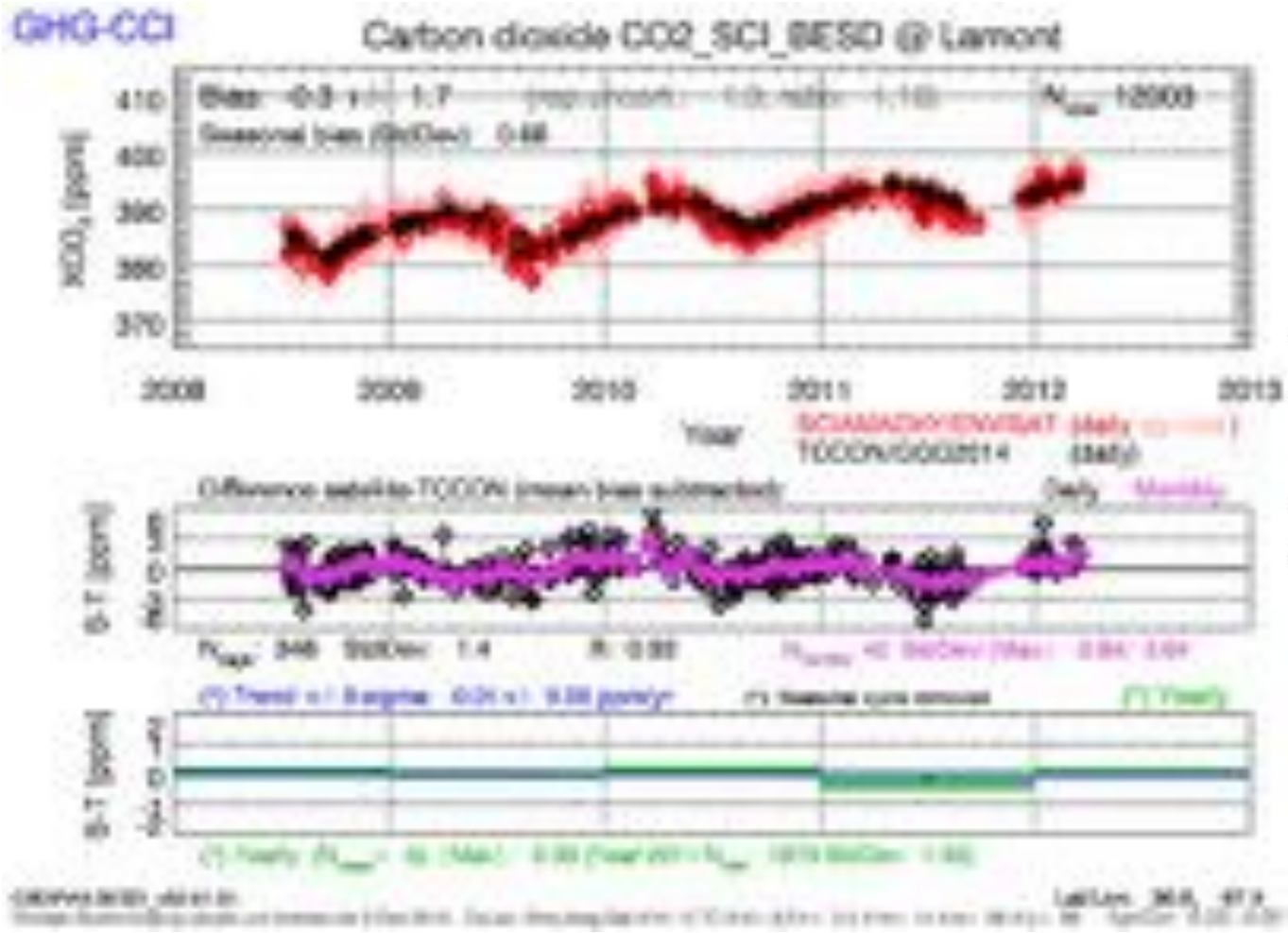
GHG-CCI CRDP#3: Additional Constraints Algorithm (ACA) Products

Algorithm / Product ID	Product	Sensor	Algorithm / Institute	Reference
CO2_IAS_NLIS	Mid/upper tropospheric column	IASI	NLIS / LMD	*Crevoisier et al., 2009*
CO2_ACE_CLRS	Upper trop. / stratospheric profile	ACE-FTS	CLRS / LMD	*Foucher et al., 2009*
CH4_IAS_NLIS	Upper trop. / stratospheric profile	IASI	NLIS / LMD	*Crevoisier et al., 2013*
CH4_MIP_IMK	Upper trop. / stratospheric profile	MIPAS	MIPAS / KIT-IMK	*Laeng et al., 2015*
CH4_SCI_ONPD	Stratospheric profile	SCIAMACHY	ONPD / IUP	*Noël et al., 2011*
CO2_SCI_ONPD	Stratospheric profile	SCIAMACHY	ONPD / IUP	*Noël et al., 2011*
Details (temporal coverage, etc.): http://www.esa-ghg-cci.org -> CRDP (Data)				

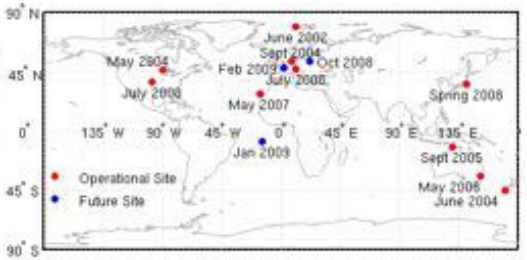
http://www.esa-ghg-cci.org/?q=webfm_send/300 (188 pages)

Validation

Example: SCIAMACHY/BESD XCO_2 @ Lamont, Oklahoma, USA:



TCCON
total carbon column observing network



GHG-CCI: Estimates of achieved data quality (#): CRDP#3 XCO_2

Sensor	Algorithm	Random error [ppm]	Systematic error [ppm]	Stability (§§) [ppm/year]	Details (section)
SCIAMACHY on ENVISAT	BESD v02.01.01	2.1 1.9 2.0 1.9	0.41 - 0.66 0.39 0.42 0.4 – 0.8	-0.03 +/- 0.10 -0.11 +/- 0.28 -0.04 +/- 0.33 -0.01 +/- 0.09	VAL (Sect. 3) DP (6.1.1) EMMA (6.1.5) QC/QA (7.1)
SCIAMACHY on ENVISAT	WFMD v3.9	3.2 3.0 3.1 3.2 3.0	0.63 – 0.99 0.5 0.89 0.64 0.6 – 1.1	0.00 +/- 0.16 [0.01, 0.04] 0.14 +/- 0.29 0.27 +/- 0.46 0.01 +/- 0.10	VAL (3) DP (6.1.2) DP (6.1.1) EMMA (6.1.5) QC/QA (7.1)
TANSO on GOSAT	OCFP v6.0 (UoL-FP)	1.9 1.8 1.8 1.7	0.46 - 0.58 0.42 0.47 0.3 – 0.5	-0.19 +/- 0.19 0.16 -0.19 +/- 0.17 -0.11 +/- 0.14	VAL (3) DP (6.1.3) EMMA (6.1.5) QC/QA (7.1)
TANSO on GOSAT	SRFP v2.3.7 (RemoTeC)	2.0 1.9 1.9 1.9	0.40 - 0.62 0.92 0.53 0.5 – 0.6	0.07 +/- 0.31 -0.015 0.07 +/- 0.28 -0.08 +/- 0.11	VAL (3) DP (6.1.4) EMMA (6.1.5) QC/QA (7.1)
SCIAMACHY & GOSAT	EMMA v2.1a	2.3 2.1	0.51 - 0.61 0.42	-0.04 +/- 0.27 -0.07 +/- 0.33	VAL (3) EMMA (6.1.5)
SCIAMACHY & GOSAT	EMMA v2.1b	1.9 1.7	0.32 - 0.61 0.44	-0.13 +/- 0.45 -0.10 +/- 0.22	VAL (3) EMMA (6.1.5)
TANSO on GOSAT	EMMA v2.1c	1.9 1.8	0.41 - 0.54 0.45	-0.14 +/- 0.33 -0.06 +/- 0.22	VAL (3) EMMA (6.1.5)
Required	G / B / T	< 1 / 3 / 8 -	< 0.2 / 0.3 / 0.5 < 1	< 0.2 / 0.3 / 0.5 < 0.2	**/URD GHG-CCI v2/ /GCOS -154/**

(#) As estimated (mostly) by comparison with ground-based TCCON observations neglecting TCCON accuracy (1-sigma) of 0.4 ppm
Green numbers: at least URDv2 threshold requirement fulfilled; single values random and systematic errors are 1-sigma;
(§§) Long-term drift only

PVIR v4

GHG-CCI CRDP#3: Comparison with GCOS Requirements

Variable[1]	Resolution	Accuracy	Stability [SS]
XCO_2	Temporal: GCOS: 4 hours Achieved: Days No existing nor any planned mission meets the [GCOS] temporal resolution requirement	GCOS: < 1 ppm URD[R]: < 0.5 ppm Achieved[R]: 0.3-0.9 ppm[5] (5) Depending on sensor, time period and assessment method	GCOS: < 0.2 ppm/yr URD: < 0.5 ppm/yr Achieved: < 0.2 ppm/yr[5] (+) Derived trends not significant
XCH_4	Spatial: GCOS: 5-10 km Achieved[5]: 10 km [6] for GOSAT, SCIAMACHY, Sentinel-5P URD, SCIAMACHY and GOSAT are useful to generate the ECV/GHG	GCOS: < 10 ppb URD[R]: < 10 ppb Achieved[R]: 3-7 ppb[5] (5) for GOSAT, for SCIAMACHY 7-17 ppb depending on time period (degradation after Oct. 2005)	GCOS: < 2 ppb/yr URD: < 10 ppb/yr Achieved: < 1-4 ppb/yr[1] [SS] (1) Depending on sensor (GOSAT < 1 ppb). Derived trends mostly not significant but note [SS]
	Note: GCOS requirements are target (maximum) requirements, but URD requirements noted here are threshold (minimum) requirements	(R) Relative accuracy (i.e., excluding a possible constant global offset) [SS] Stability quantifies only long-term drift and therefore does not capture certain features due to detector issues as observed when analysing SCIAMACHY data (e.g., around mid 2010) **Estimated by comparison with TCCON ground-based observations. TCCON accuracy (1-sigma): 0.4 ppm for XCO_2 and 3.5 ppb for XCH_4**	

[*] Requirements for column-averaged mole fractions (= air-column normalized vertical GHG columns) as required by URD. It is assumed here that this corresponds to GCOS variables „Tropospheric CO_2 column" and „Tropospheric CH_4 column"

References: Requirements for ECV Constituent Class (GHG)
- GCOS-154: „SYSTEMATIC OBSERVATION REQUIREMENTS FOR SATELLITE-BASED DATA PRODUCTS FOR CLIMATE"
- URD: "GHG-CCI User Requirements Document", v3.2

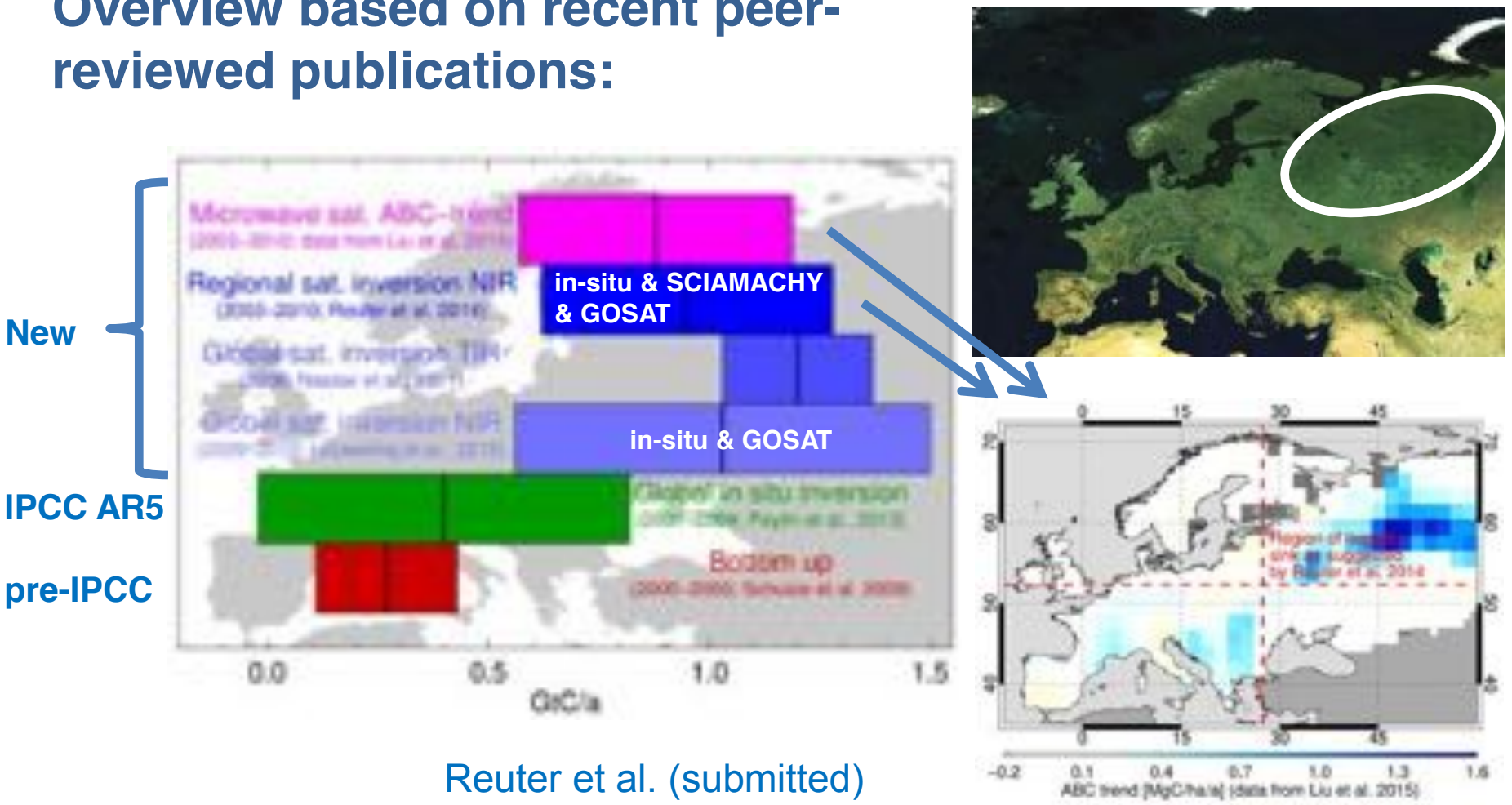
Definition ECV GHG (GCOS-154):
- Product A.8.1 (Retrievals of CO_2 and CH_4 of sufficient quality to estimate regional sources and sinks

PVIR v4

How large is the European(*) C sink ?

(*) Continental / TransCom Europe

Overview based on recent peer-reviewed publications:

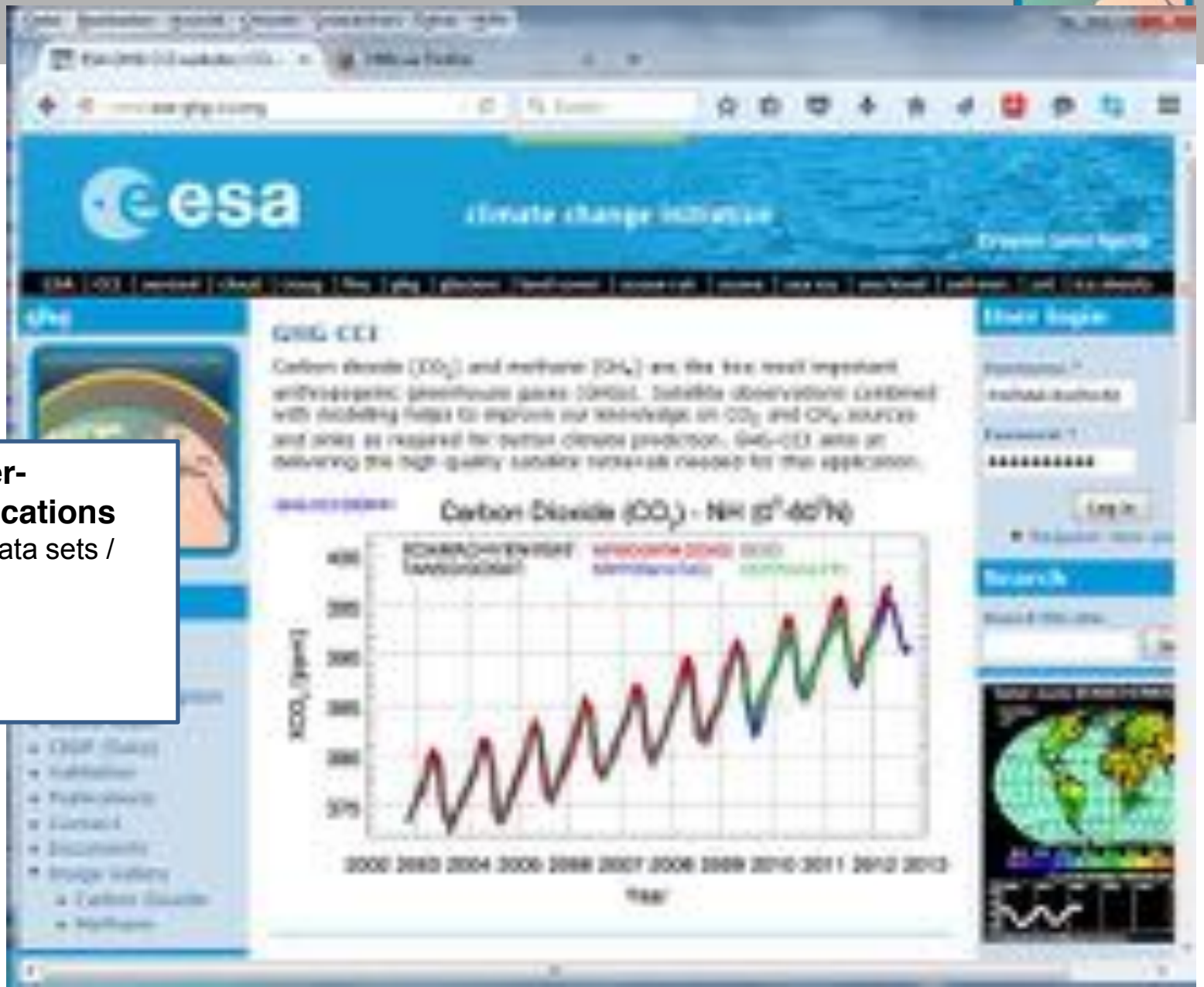


Reuter et al. (submitted)

GHG-CCI: Publications

Number of peer-reviewed publications using GHG-CCI data sets / GHG-CCI funding acknowledged:

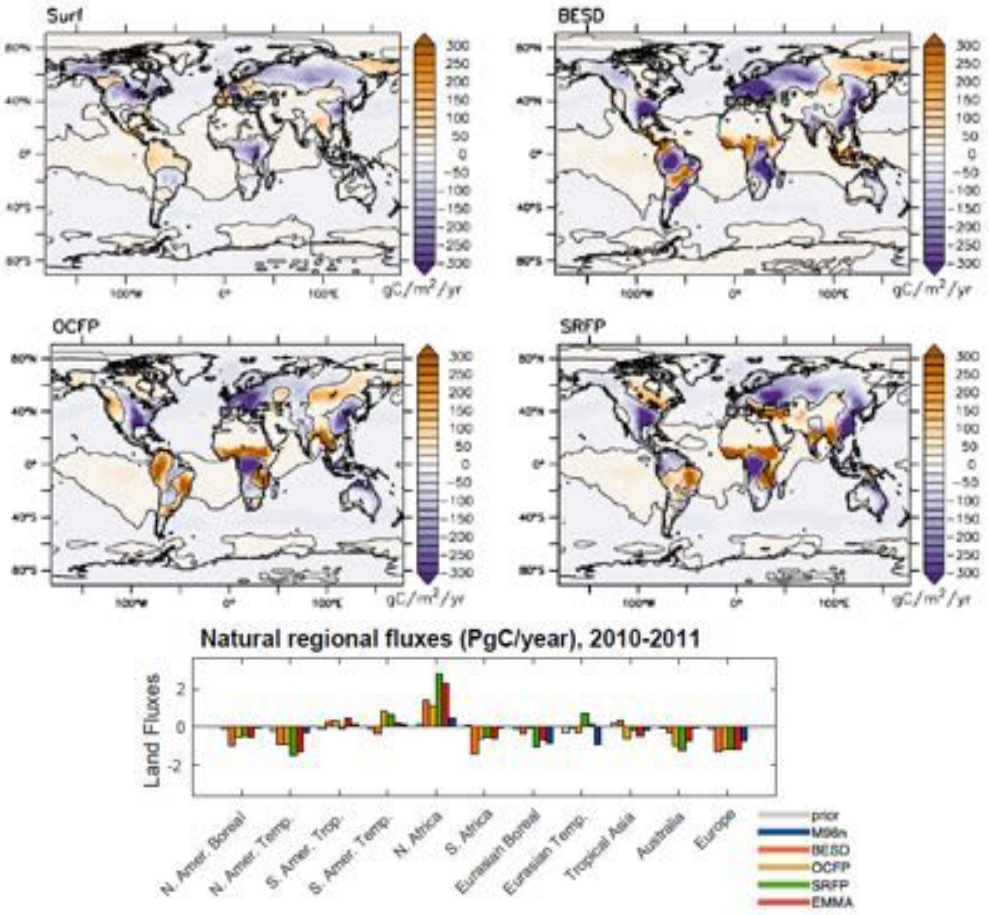
53



CRDP3: CAR

Climate Assessment Report (CAR)

User assessments: Model comparisons, flux inversion results, …:



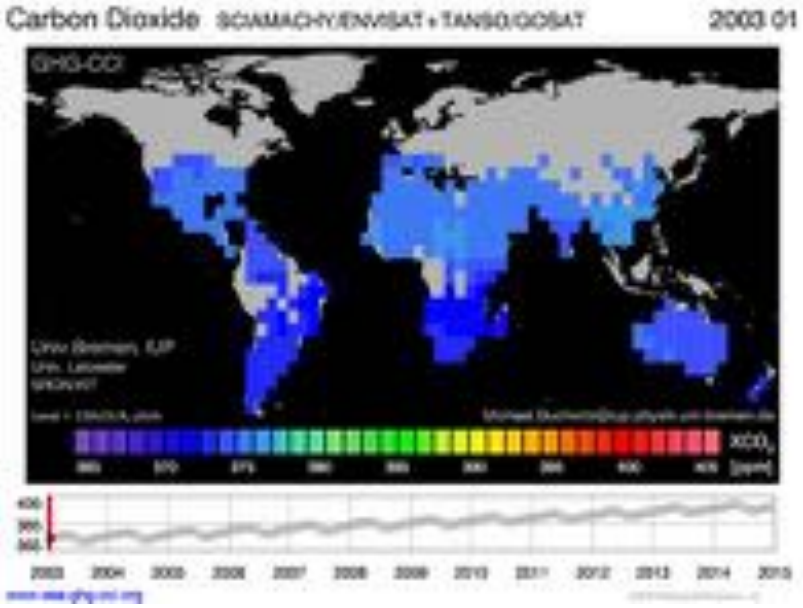
http://www.esa-ghg-cci.org/?q=webfm_send/318 (94 pages)

CRDP3: More ...

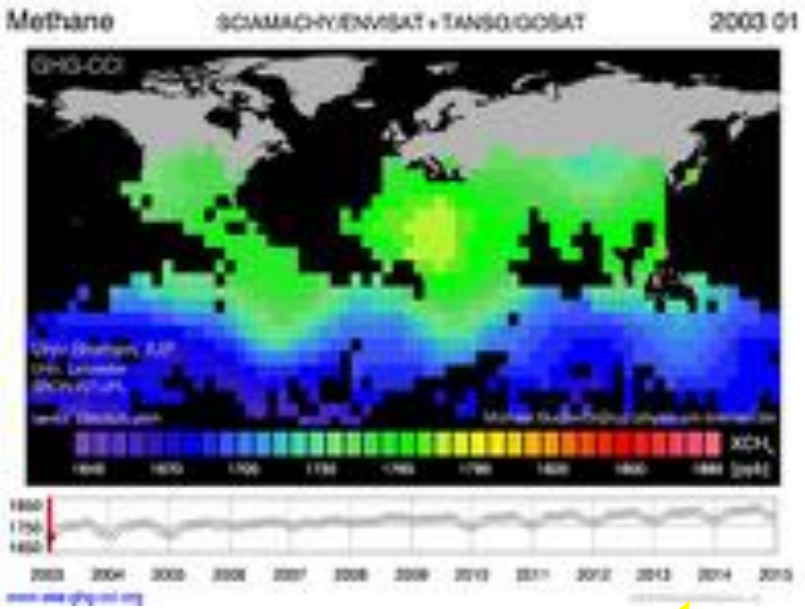
… data, documents, figures, animations, …

Animations CRDP3: http://www.esa-ghg-cci.org/

-> Image Gallery Carbon Dioxide



-> Image Gallery Methane



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- **GOSAT 3 Parties (JAXA, NIES, MOE):**
  - GOSAT Level 1 products, very good cooperation, organizing IWGGMS-12, …
  - **Research conducted as part of GOSAT RA1 PI project CONSCIGO**
- **ESA** for funding the GHG-CCI project and for GOSAT data via ESA Third Party Mission (TPM) ftp access
- **ESA / DLR** for SCIAMACHY Level 1 data products
- **EU** for funding the MACC(H2020) / CAMS(Copernicus) projects
- **TCCON** for TCCON products
- **NASA / JPL / Colorado State Univ**. for OCO-2 Level 2 products

Many thanks for your attention !