CMUG Integration-3 Meeting,
3-5 June 2013, MPI-M, Hamburg

The GHG-CCI project of ESA's Climate Change Initiative: Overview and Status




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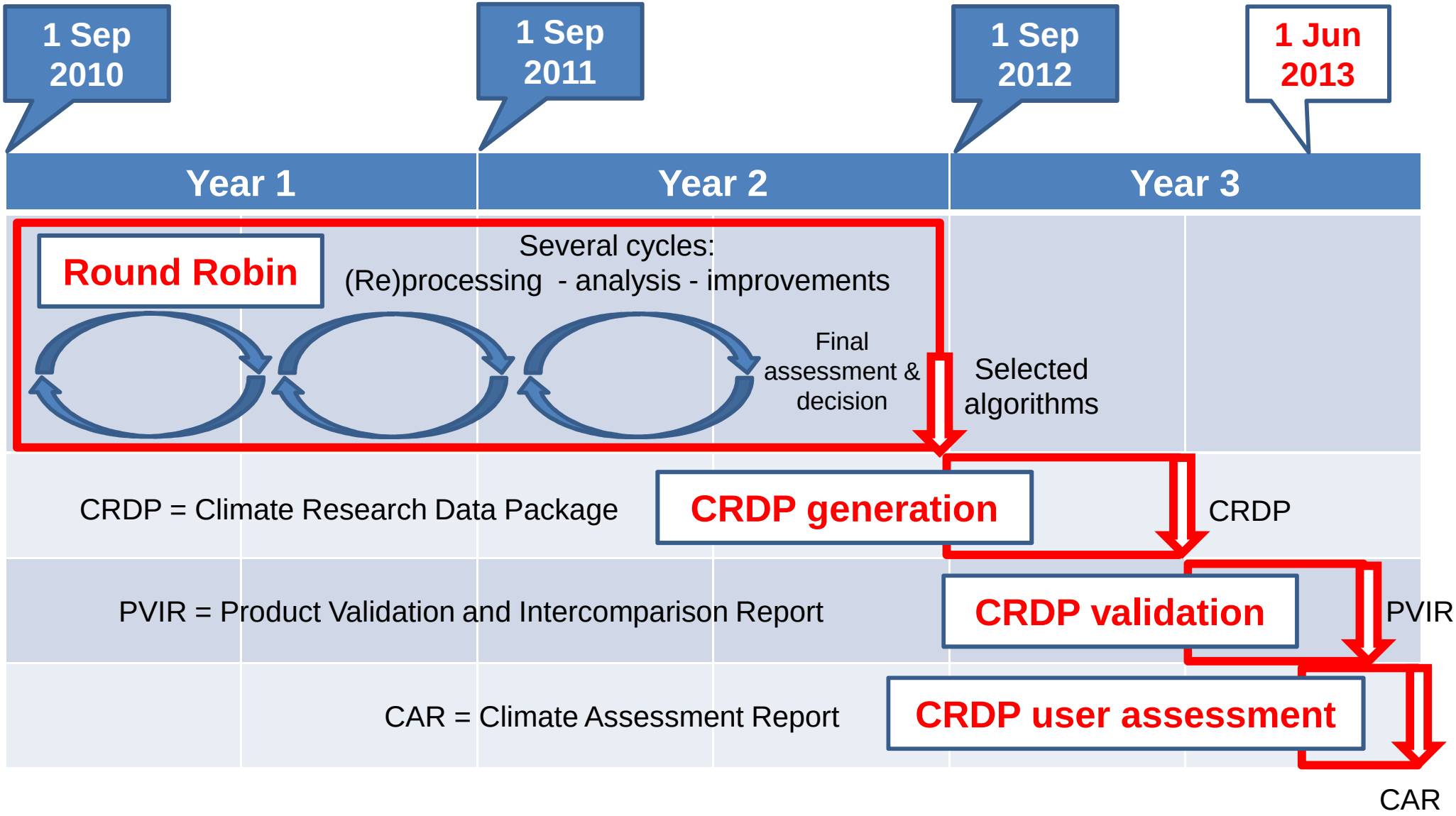
and the GHG-CCI project team

GHG-CCI Phase 1 Schedule



Algorithms & Products compared during Round Robin (RR)

Core Products	GHG-CCI ECV Core Algos. (ECAs)						For comparison	
	IUP		UoL		SRON		NIES	NASA
	BESD	WFMD	OCPR	OCFP	SRPR	SRFP	Official GOSAT & PPDF	ACOS
SCIA XCO_2	ECV?	ECV?						
SCIA XCH_4		ECV?			ECV? (IMAP)			
GOSAT XCO_2				ECV? (OCO)		ECV? (RemoTeC)	cmp	cmp
GOSAT XCH_4			ECV? (OCO)	ECV? (OCO)	ECV? (RemoTeC)	ECV? (RemoTeC)	cmp	

Additional Constraints Algorithms (ACAs) / data products:

LMD: AIRS CO_2, IASI CO_2&CH_4, ACE-FTS CO_2, …,

KIT: MIPAS CH_4, IUP: SCIAMACHY/solar-occultation CH_4 & CO_2, …

FCDR: DLR: SCIA L1 (in coop. with SQWG), JAXA: GOSAT L1, …

GHG-CCI: Performance estimates
(status @ end of Round Robin)

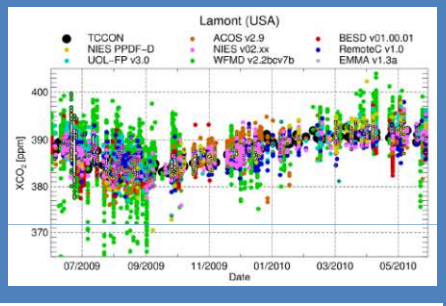
Comparison of GHG-CCI core data products (ECAs) with TCCON				
XCO_2 [ppm]				
Algorithm	**Sensor**	**Estimated precision single observation**	**Estimated relative accuracy**	**Number of satellite obs.**
WFMD v2.2	SCIAMACHY	5.1	1.3	30752
BESD v1 *)	SCIAMACHY	2.3	0.7	9467
OCFP v3.0	TANSO	2.7	0.6	2830
SRFP v1.1	TANSO	2.8	0.9	2558
Required (URD):		< 8(T), 3(B), 1(G)	< 0.5(T), 0.3(B), 0.2(G)	-
XCH_4 [ppb]				
Algorithm	**Sensor**	**Estimated precision single observation**	**Estimated relative accuracy**	**Number of satellite obs.**
WFMD v2.3	SCIAMACHY	82 (~30#))	11 [4-12#)]	37628
IMAP v6.0	SCIAMACHY	50 (~30#))	15 [4-13#)]	39489
OCFP v3.2	TANSO	16	8	3176
SRFP v1.1	TANSO	15	3	2558
OCPR v3.2	TANSO	13	2	7323
SRPR v1.1	TANSO	14	3	4900
Required (URD):		< 34(T), 17(B), 9(G)	< 10(T), 5(B), 3(G)	-

Requirements: T = Threshold, B = Breakthrough, G = Goal
#) SCIAMACHY 2003-2005 (lower quality after 2005 due to detector degradation)

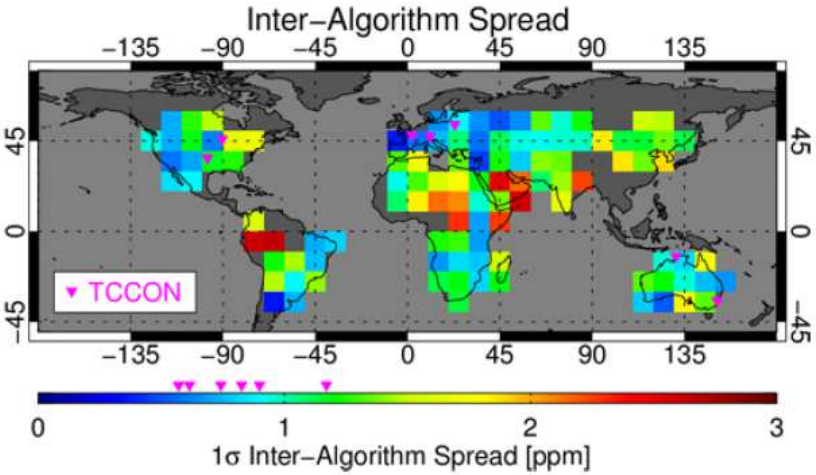
Buchwitz et al., Remote Sensing of Environment (in press)

XCO_2: Comparison with ground-based TCCON & global comparison

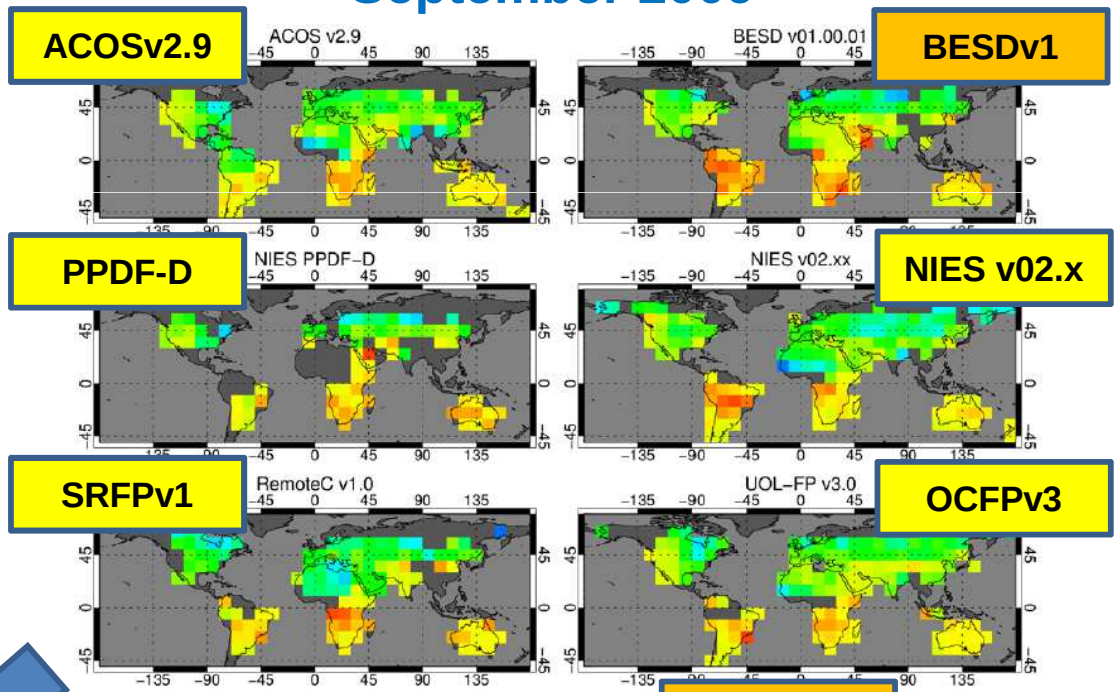
XCO_2: Satellite vs TCCON
(Jun 2009 – May 2010)



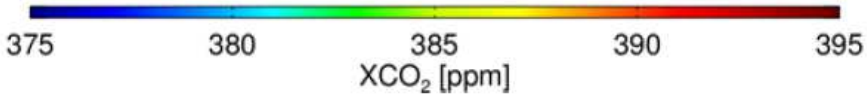
Algorithm	#	σ [ppm]	Δ [ppm]
ACOS v2.9	1530	2.1	0.9
BESD v01.00.01	2789	2.3	0.9
NIES PPDF-D	460	3.1	0.8
NIES v02.xx	1062	1.9	0.7
RemoteC v1.0	1084	2.5	0.9
UOL-FP v3.0	1086	2.3	0.8
WFMD v2.2bcv7b	8884	4.4	1.3



September 2009

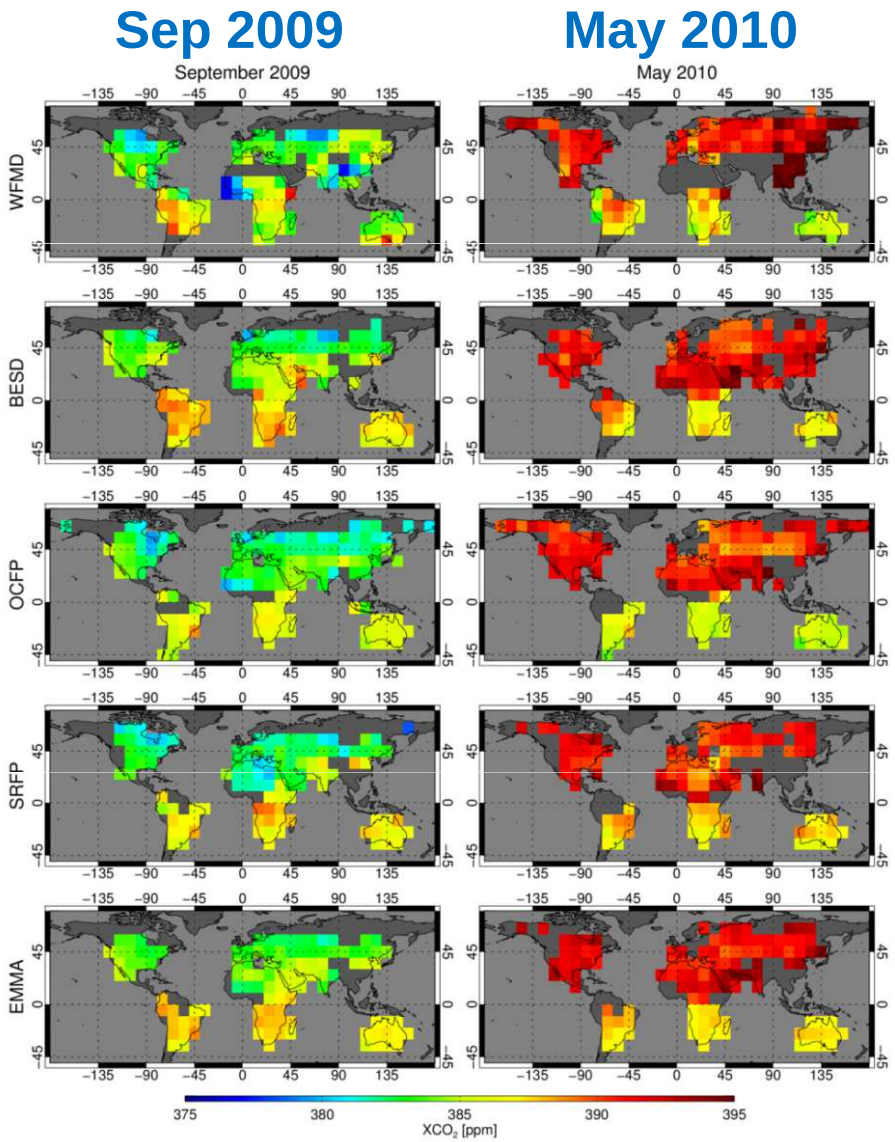


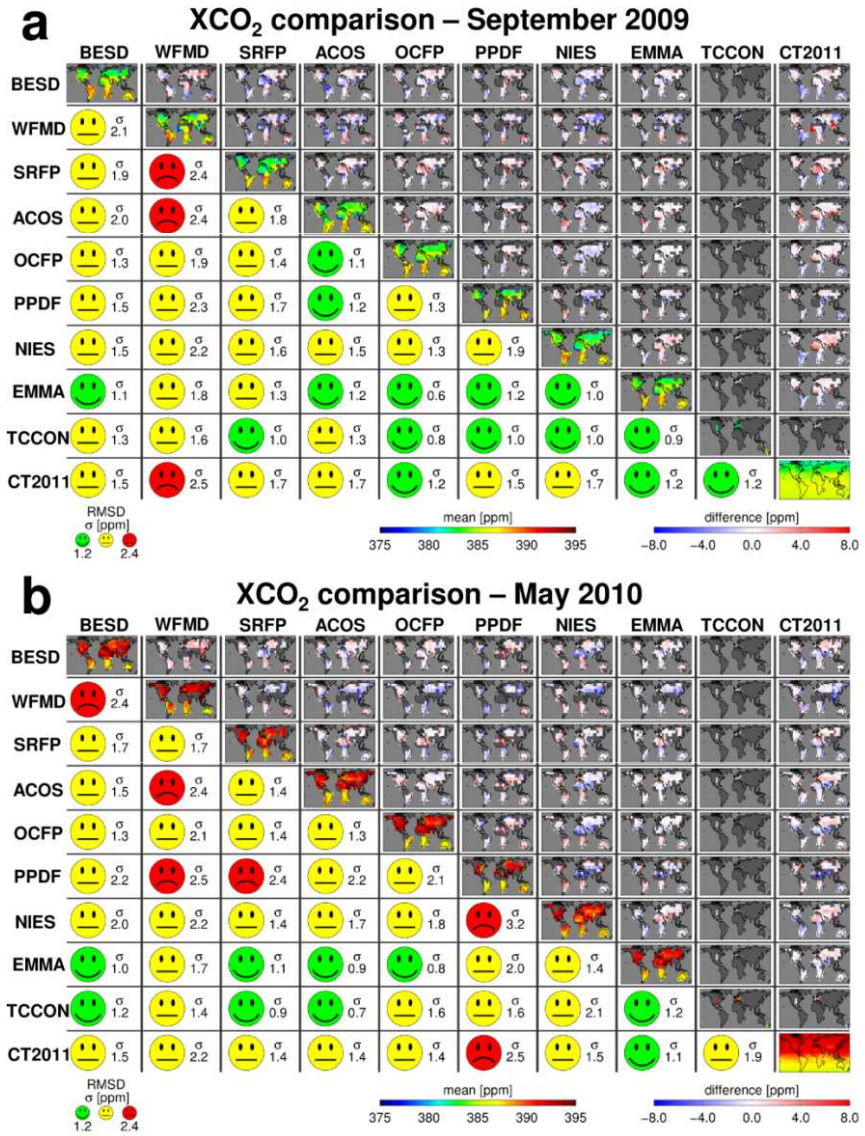
Reuter et al., ACP, 2013



Different algorithms & different sensors: Overall good agreement with TCCON but significant differences remote from TCCON

XCO_2: Global comparisons





Different algorithms & different sensors: Overall reasonable to good agreement (e.g. seasonal variations) but significant differences at smaller scales -> Ensemble product „EMMA“ for comparison & as additional product

Ensemble algorithm ”EMMA”

Atmos. Chem. Phys., 13, 1771–1780, 2013
www.atmos-chem-phys.net/13/1771/2013/
doi:10.5194/acp-13-1771-2013

Atmospheric Chemistry and Physics Open Access

Reuter et al., ACP, 2013

A joint effort to deliver satellite retrieved atmospheric CO_2 concentrations for surface flux inversions: the ensemble median algorithm EMMA

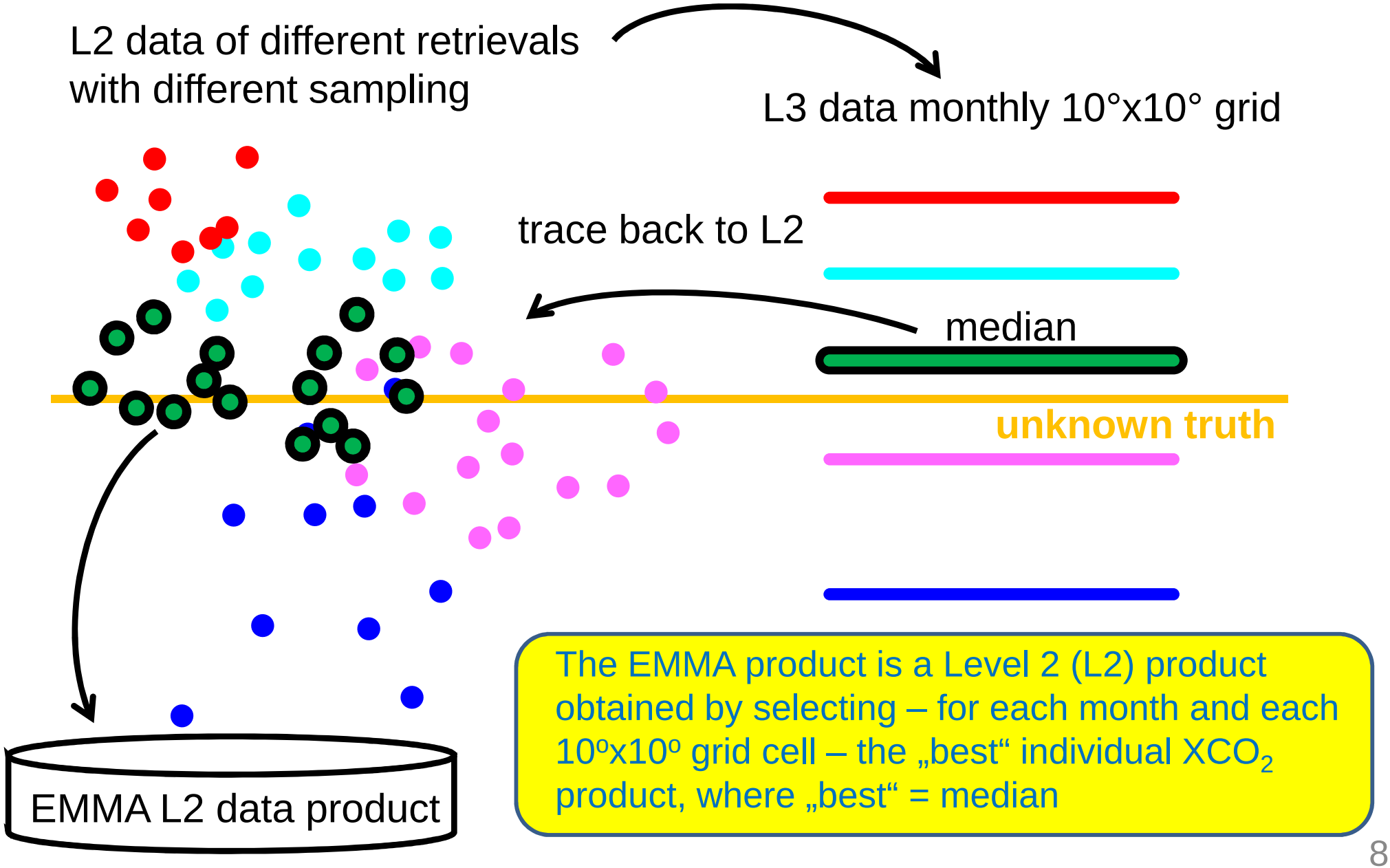
M. Reuter[1], H. Bösch[2], H. Bovensmann[1], A. Bril[3], M. Buchwitz[1], A. Butz[4], J. P. Burrows[1], C. W. O'Dell[5], S. Guerlet[6], O. Hasekamp[6], J. Heymann[1], N. Kikuchi[3], S. Oshchepkov[3], R. Parker[2], S. Pfeifer[7], O. Schneising[1], T. Yokota[3], and Y. Yoshida[3]

[1]Institute of Environmental Physics, University of Bremen, Bremen, Germany
[2]University of Leicester, Department of Physics and Astronomy, Leicester, UK
[3]National Institute for Environmental Studies, Tsukuba, Japan
[4]IMK-ASF, Karlsruhe Institute of Technology, Karlsruhe, Germany
[5]Colorado State University, Fort Collins, CO, USA
[6]Netherlands Institute for Space Research, Utrecht, The Netherlands
[7]Climate Service Center, Helmholtz Zentrum Geesthacht, Hamburg, Germany

- A „**comparison tool**“ for global satellite XCO_2 (truth = unknown !?)
- **A new „robust“ Level 2 product** based on „merging“ individual XCO_2 products
  - removal of outliers
  - realistic error estimates from ensemble spread

Algorithm	Sensor	Bands [µm]				Inversion	CO_2 a Priori	Scattering	Main Cloud Filter	Empirical Bias Correction
		0.76	1.58	1.60	2.05					
ACOS v2.9	GOSAT	•		•	•	OE	model	FP (4EP20)	O_2-A	•
BESD v01.00.01	SCIAMACHY	•	•			OE	static	FP (CWP, CTH, APS_1)	MERIS	•
NIES v02.xx	GOSAT	•		•	•	OE	model	FP (AOD)	CAI	
PPDF-DOAS	GOSAT	•		•	•	OE	static	PPDF (RSL, PLMP)	CAI	
RemoteC v1.0	GOSAT	•		•	•	TP	static	FP (APNC, ASP, AH)	CAI	•
UOL-FP v3.0	GOSAT	•		•	•	OE	model	FP (APS_2, CEPS)	O_2-A	•
WFMD v2.2bcv7b	SCIAMACHY	•	•			LS	static	PR (CO_2/O_2)	PMD	•

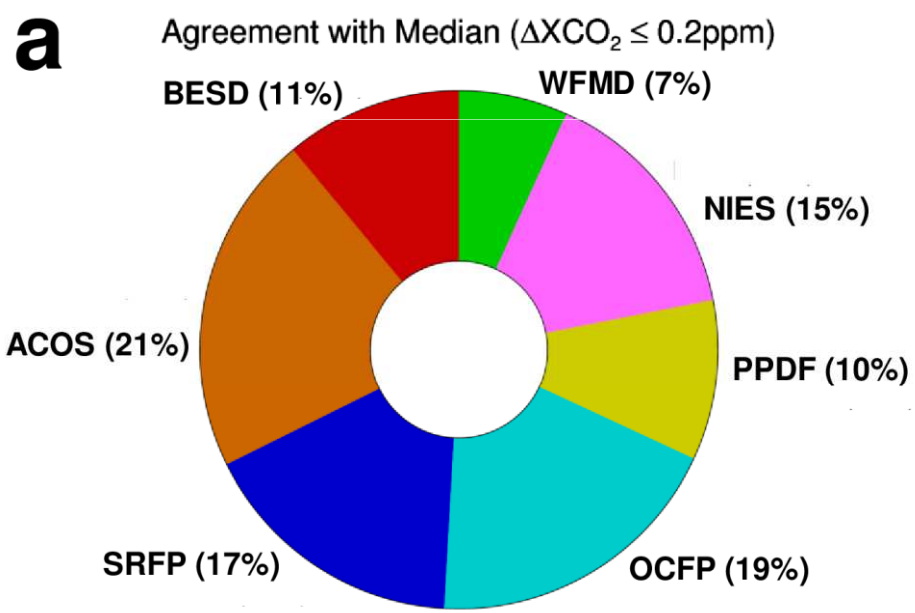
EMMA: Method



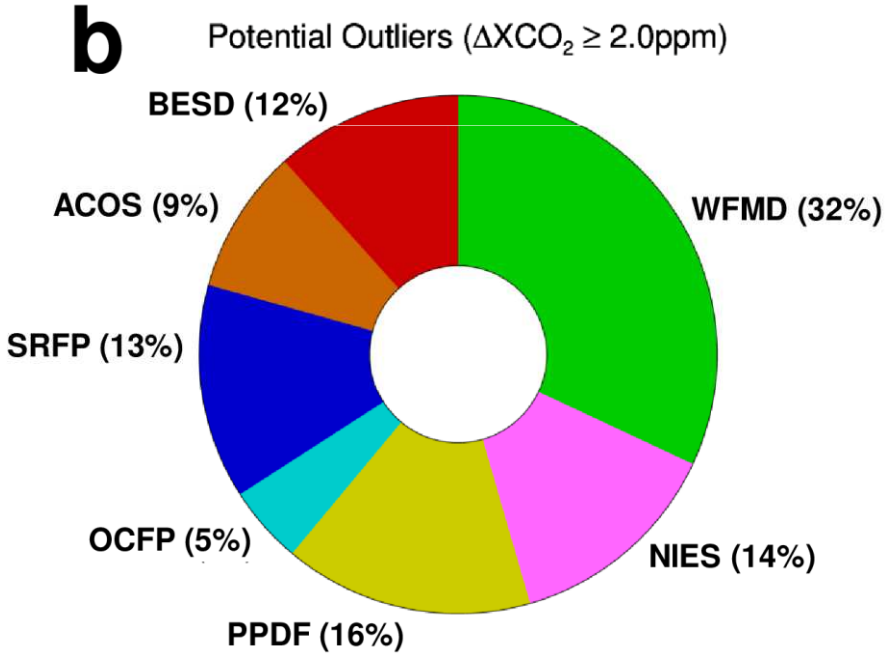
The EMMA product is a Level 2 (L2) product obtained by selecting – for each month and each 10^{o}x10^{o} grid cell – the „best“ individual XCO_2 product, where „best“ = median

Comparison of various XCO_2 data sets using Ensemble Algorithm EMMA

Agreement with Median



Potential outliers



Buchwitz et al., Remote Sensing of Environment (in press)

SCIAMACHY XCO_2:

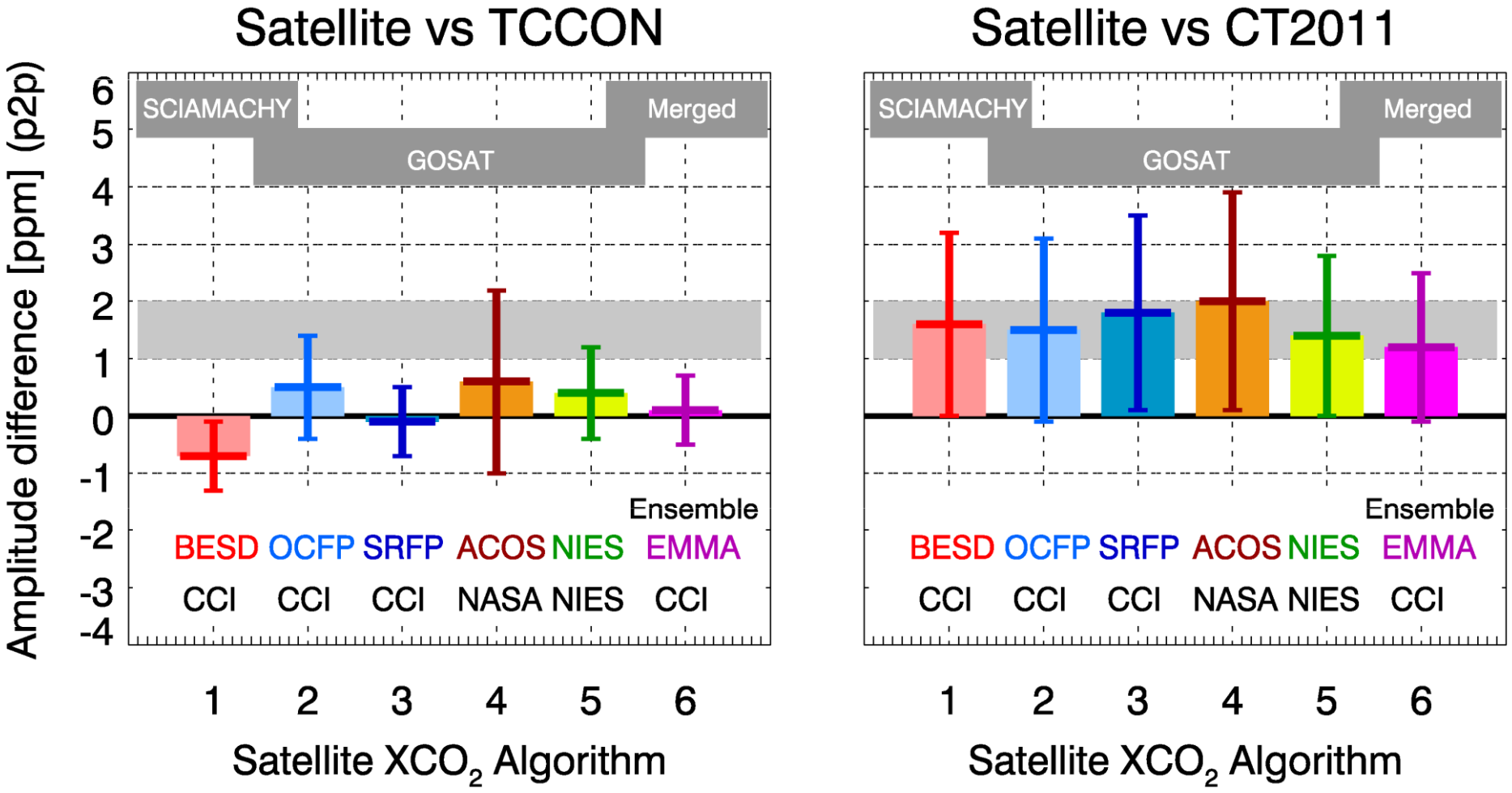
- BESD v01.00.01
- WFMD v2.2

GOSAT XCO_2:

- NIES v02.xx
- PPDF–D
- ACOS 2.9
- RemoteC 1.0 / SRFP
- UoL-FP v3.2 / OCFP

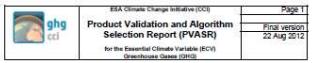
Comparison of various XCO_2 data sets: CO_2 seasonal cycle

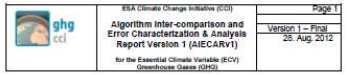
Comparison of CO_2 seasonal cycle amplitudes



Buchwitz et al., RSE (in press)

GHG-CCI Round Robin Decisions





ESA Climate Change Initiative (CCI)

Product Validation and Algorithm Selection Report (PVASR)

for the Essential Climate Variable (ECV)

Greenhouse Gases (GHG)

PVASR

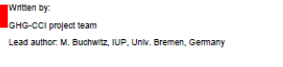
ESA Climate Change Initiative (CCI)

Algorithm Inter-comparison and Error Characterization & Analysis Report (AIECAR)

for the Essential Climate Variable (ECV)

Greenhouse Gases (GHG)

AIECARv1



ASR

ESA Climate Change Initiative (CCI)

Algorithm Selection Report (ASR)

for the Essential Climate Variable (ECV)

Greenhouse Gases (GHG)

Written by:

GHG-CCI project team

Lead author: M. Buchwitz, IUP, Univ. Bremen, Germany

Approved by:

GHG-CCI Climate Research Group (CRG), represented by

- F. Chevallier, LSCE, France
- P. Bergamaschi, EC-JRC-IES, Italy
- T. Kaminski, FastOpt GmbH, Germany

GHG-CCI CRG approved

Purpose of RR decision: Select algos to be used for CRDP

RR decisions:

Product	Competing Algorithms	Selected Algorithm
XCO_2 SCIA	WFMD BESD	BESD Lower biases & higher single observation precision
XCO_2 GOSAT	OCFP SRFP	OCFP & SRFP Sig. sys. differences but not clear which product is more accurate
XCO_2 merged („EMMA“)	N/A	Ensemble algorithm/product -> Add to GHG-CCI portfolio
XCH_4 SCIA	WFMD IMAP	WFMD & IMAP Sig. sys. differences but not clear which product is more accurate
XCH_4 GOSAT	OCFP + PR SRFP + PR	SRFP (slight better than OCFP) OCPR (slight better than SRPR) i.e. 1 FP (GHG-CCI goal) and 1 PR (more data & more mature)
ACA products	N/A	All (RREP criteria fulfilled)

Available on http://www.esa-ghg-cci.org/

Climate Research Data Package (CRDP)

GHG-CCI Climate Research Data Package (CRDP)											
Product ID	Product (Level 2, mixing ratios)	Years processed									
		2003	04	05	06	07	08	09	10	11	12
ECV Core Products (ECAs)											
XCO2_SCIA	XCO_2	■	■	■	■	■	■	■	■	■	■
XCH4_SCIA	XCH_4	■	■	■	■	■	■	■	■	■	■
XCO2_GOSAT	XCO_2							■	■	■	■
XCH4_GOSAT	XCH_4							■	■	■	■
XCO2_EMMA	XCO_2							■	■	■	■
Additional Constraints Products (ACAs)											
CO2_AIRS	CO_2 (1)	■	■	■	■	■					
CO2_IASI	CO_2 (1)					■	■	■	■	■	
CH4_IASI	CH_4 (1)					■	■	■	■	■	
CH4_SCIAOCC	CH_4 (2)	■	■	■	■	■	■	■	■		
CO2_SCIAOCC	CO_2 (2)	■	■	■	■	■	■	■	■		
CH4_MIPAS	CH_4 (2)			■	■	■	■	■	■	■	■
CO2_ACEFTS	CO_2 (2)		■	■	■	■	■	■	■		

Comments:

(1) Mid / upper tropospheric column;
(2) Upper tropospheric / stratospheric profile

Algorithms ECAs:

XCO2_SCIA: BESD (WFMD)
XCH4_SCIA: IMAP, WFMD
XCO2_ GOSAT: SRFP(RemoTeC), OCFP
XCH4_GOSAT: SRFP, OCPR
XCO2_EMMA: Various (merged SCIA & GOSAT)

Climate Research Data Package (CRDP)

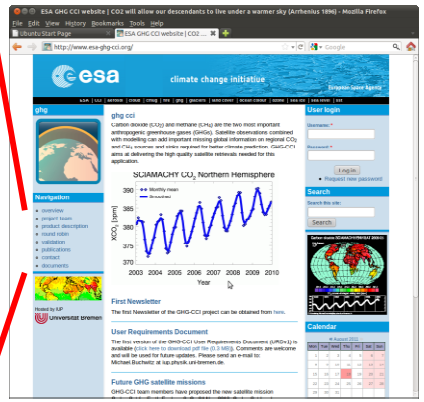
GHG-CCI Phase 1:

- **Round Robin finished** (as planned Aug 2012)
- **CRDP generation finished** (as planned Feb 2013)

- Ongoing:
  - **CRDP validation & user assessment**
  - **If ready, CRDP will be made publicly available** (plan: Sept 2013)
  - Available already now on request

www.esa-ghg-cci.org/

- Overview
- Project Team
- Product Description
- Round Robin
- CRDP **New !**
- Validation
- Data Access
- Publications
- Contact
- Documents



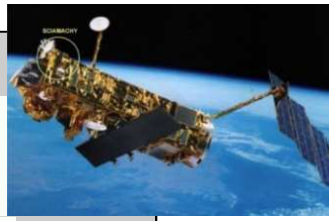
Climate Research Data Package (CRDP)

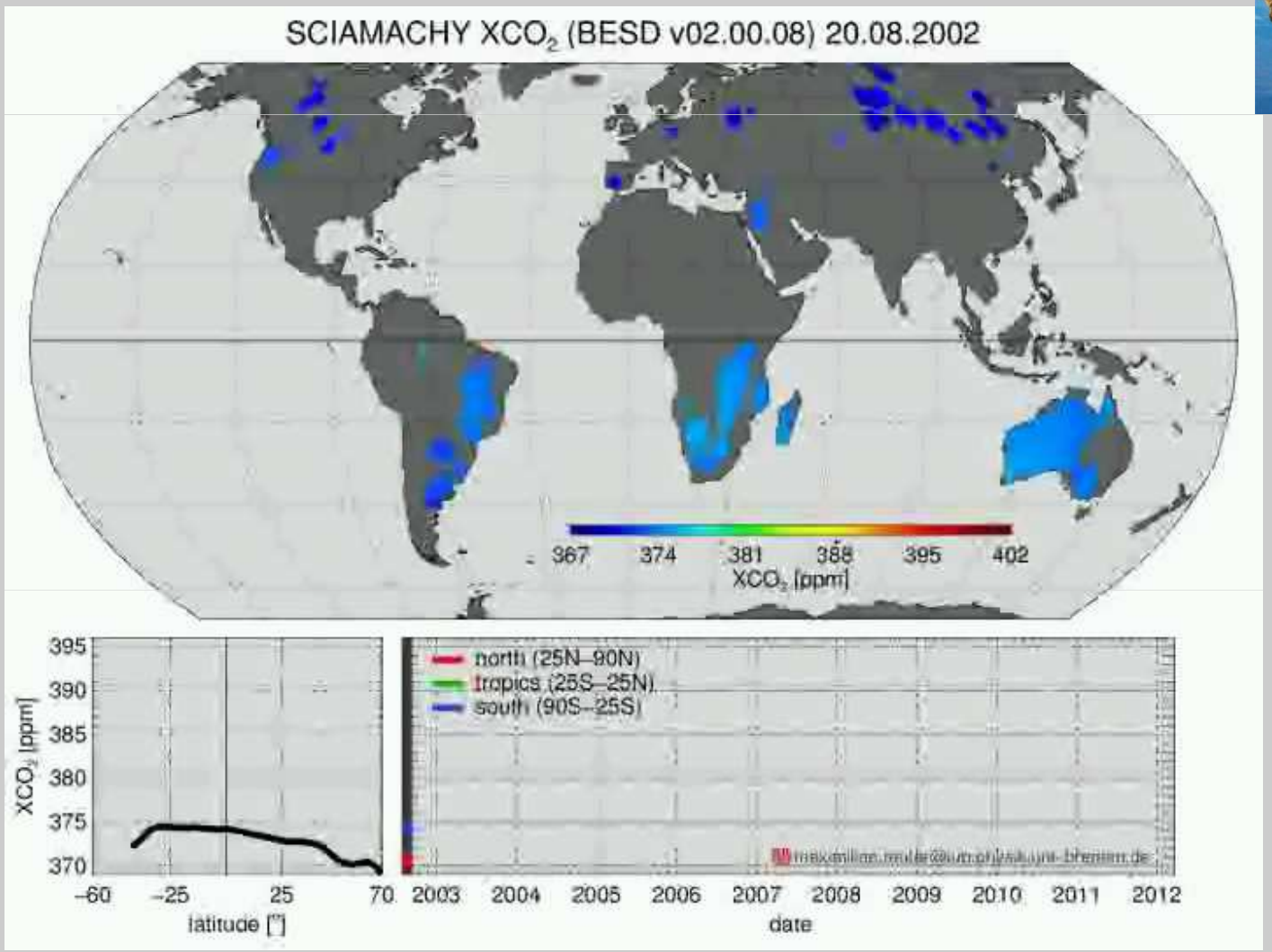
GHG-CCI CRDP available data: Core products (ECAs)

ID	Product	Sensor	Algo	Provider	Coverage	Link to product
CO2_SCI_BESD	XCO2	SCIAMACHY	BESD	IUP	global, 2003-2012	Link
CO2_SCI_WFMD	XCO2	SCIAMACHY	WFMD	IUP	global, 2003-2012	Link
CO2_GOS_OCFP	XCO2	GOSAT	OCFP	Univ.Leicester	TCCON, 2009-2012	Link
CO2_GOS_SRFP	XCO2	GOSAT	SRFP	SRON	TCCON, 2009-2012	Link
CO2_EMMA	XCO2	GOSAT/SCIA	EMMA	Joint	TCCON, 2009-2012	Link
CH4_SCI_IMAP	XCH4	SCIAMACHY	IMAP	SRON	TCCON, 2003-2012	Link
CH4_SCI_WFMD	XCH4	SCIAMACHY	WFMD	IUP	global, 2003-2012	Link
CH4_GOS_OCPR	XCH4	GOSAT	OCFP	Univ.Leicester	global, 2009-2012	Link
CH4_GOS_SRFP	XCH4	GOSAT	SRFP	SRON	global, 2009-2012	Link

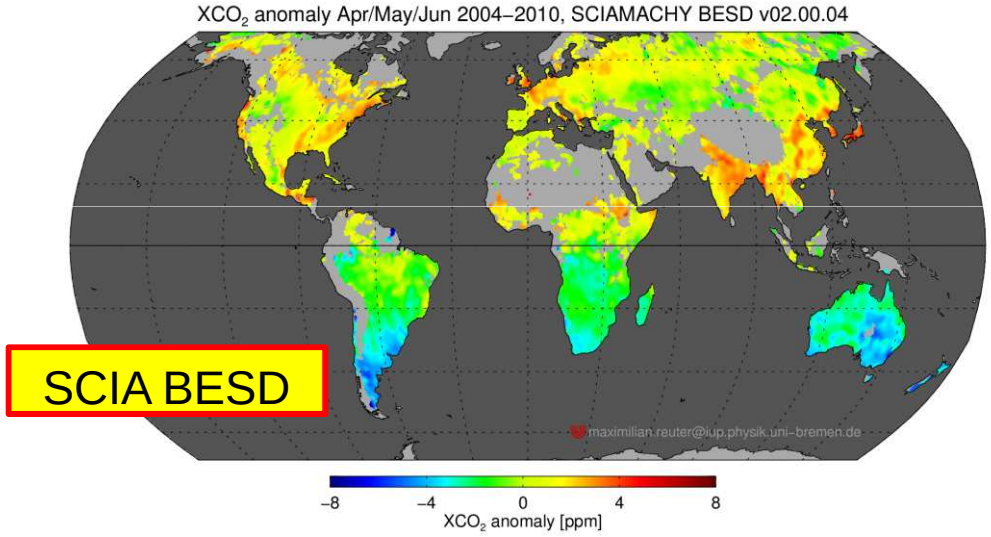
SCIAMACHY/BESD XCO_2 2002-2012

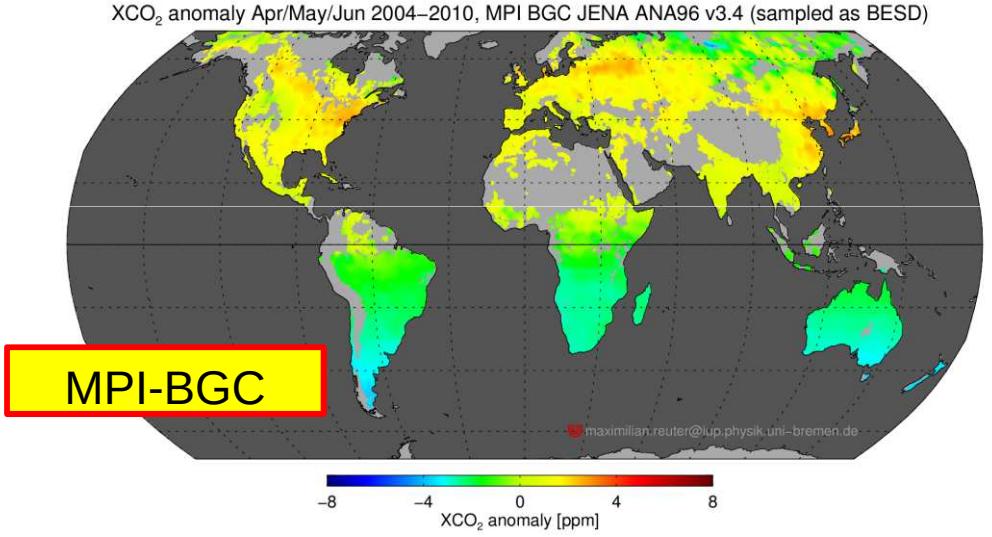
First animation covering entire ENVISAT period

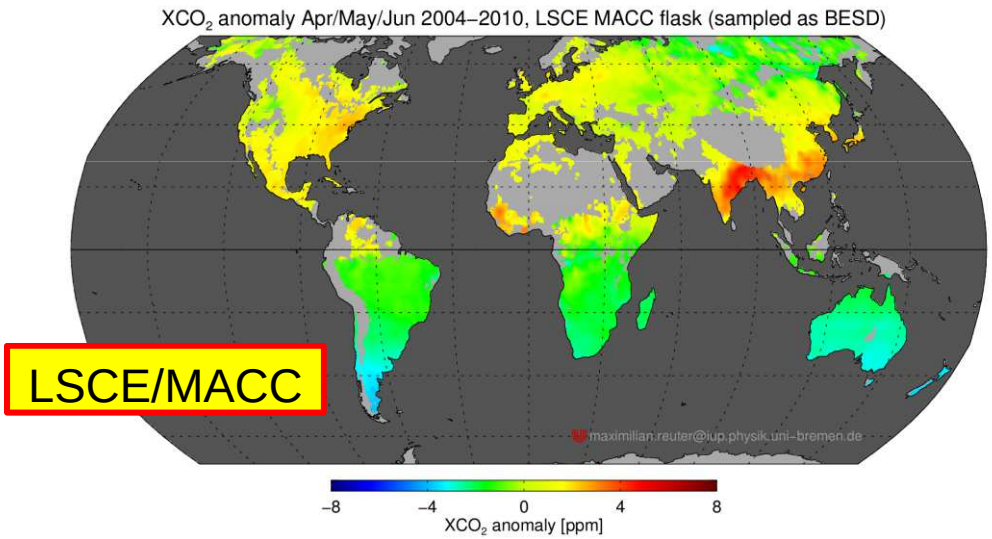


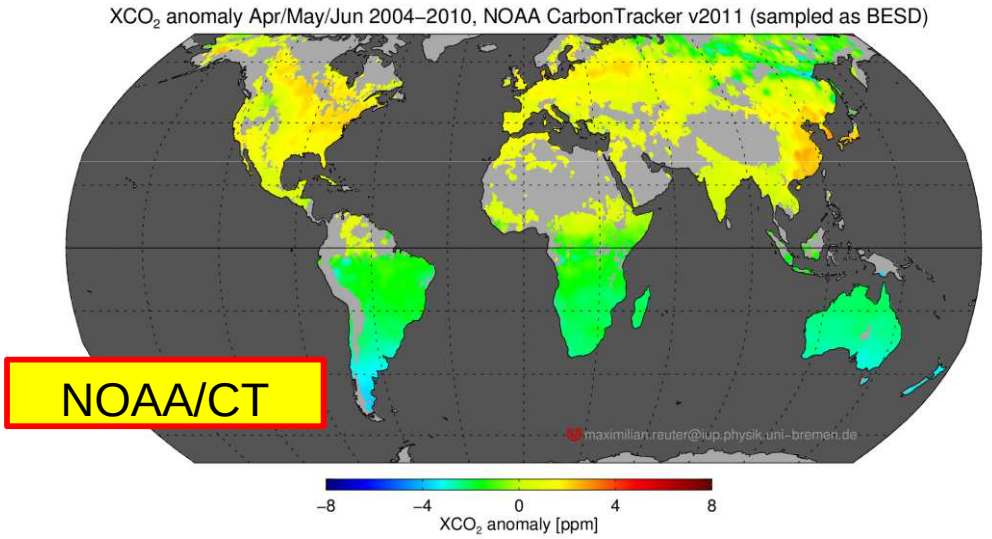


CRDP: SCIAMACHY/BESD XCO_2: Comparison with models: Apr - Jun



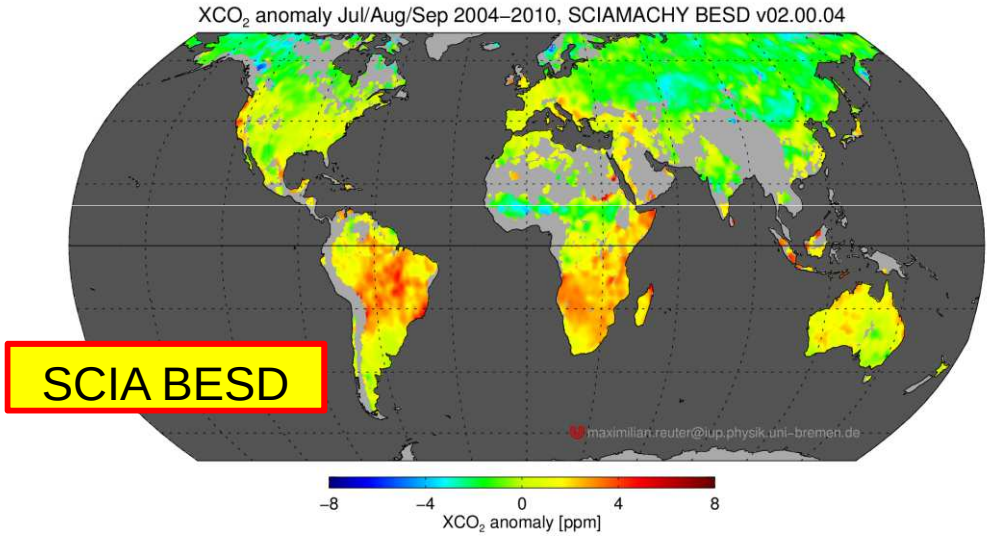


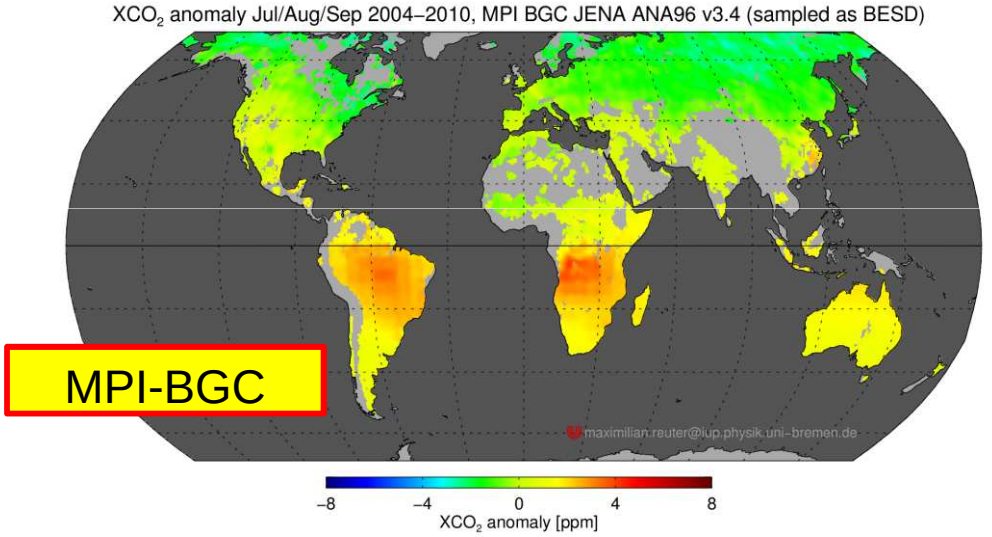


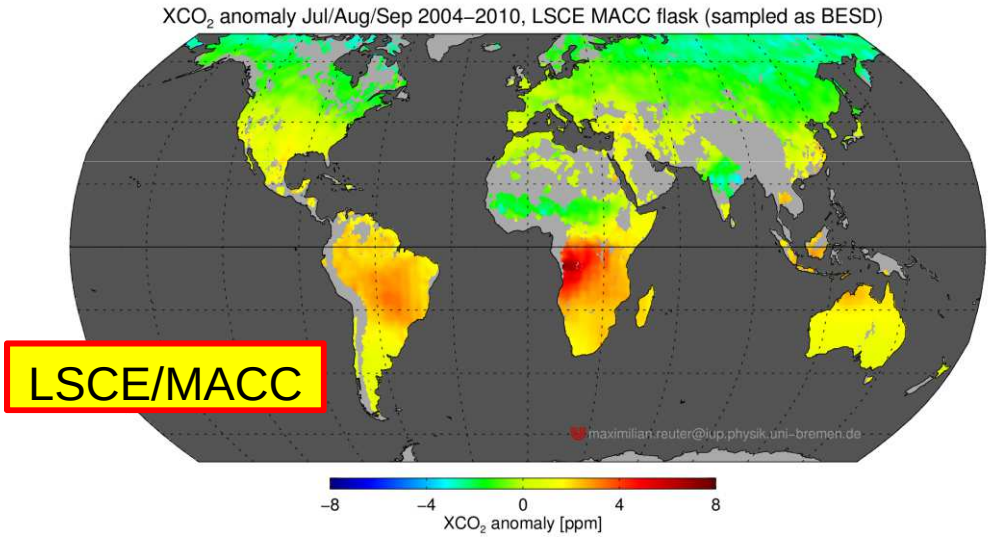


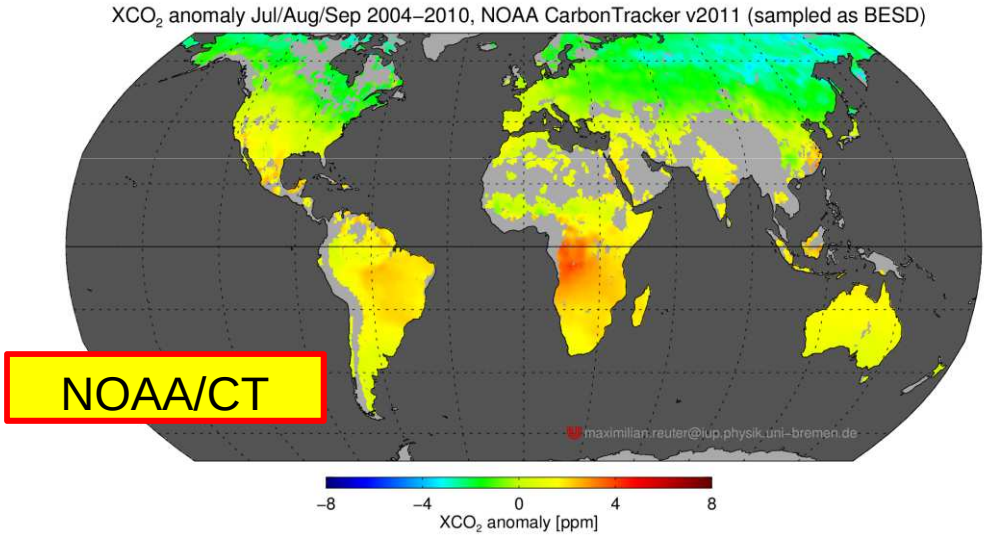
Model data: F. Chevallier, LSCE; C. Rödenbeck, MPI-BGC; NOAA

CRDP: SCIAMACHY/BESD XCO_2: Comparison with models: Jul - Sep







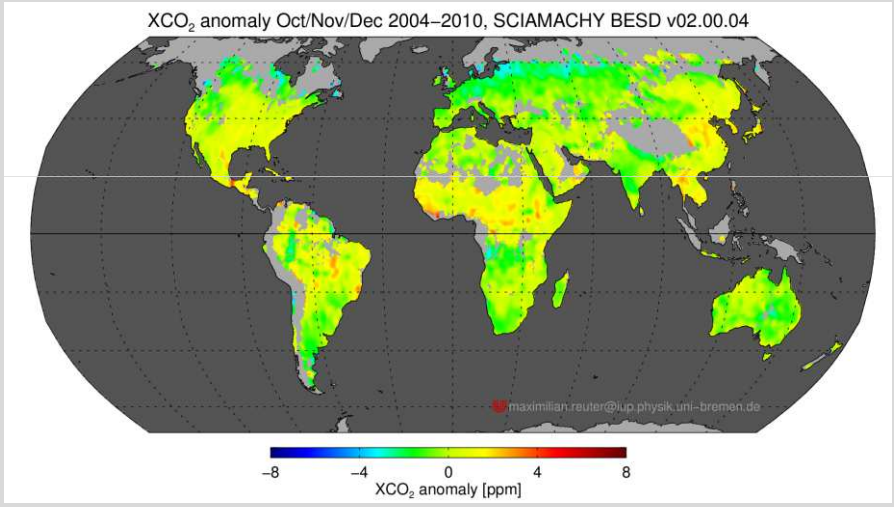


Model data: F. Chevallier, LSCE; C. Rödenbeck, MPI-BGC; NOAA

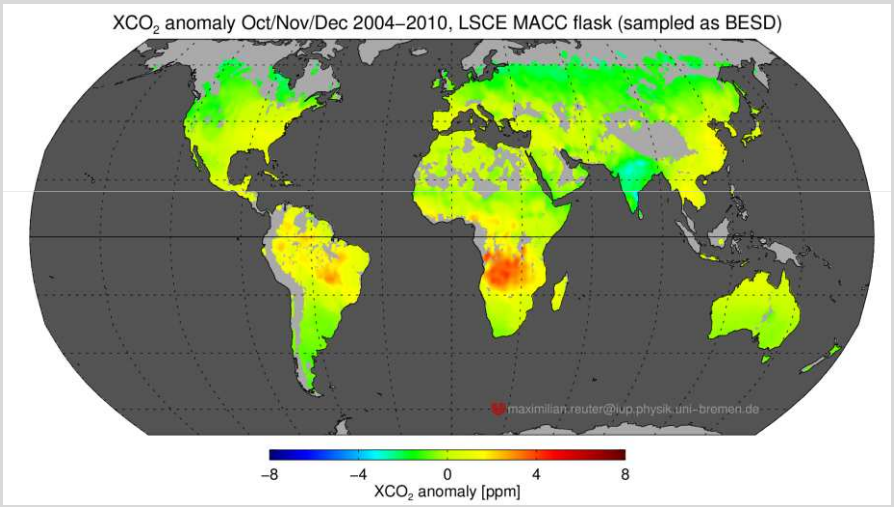
SCIAMACHY/BESD XCO_2: Initial CO_2 flux inversion

SCIA BESD

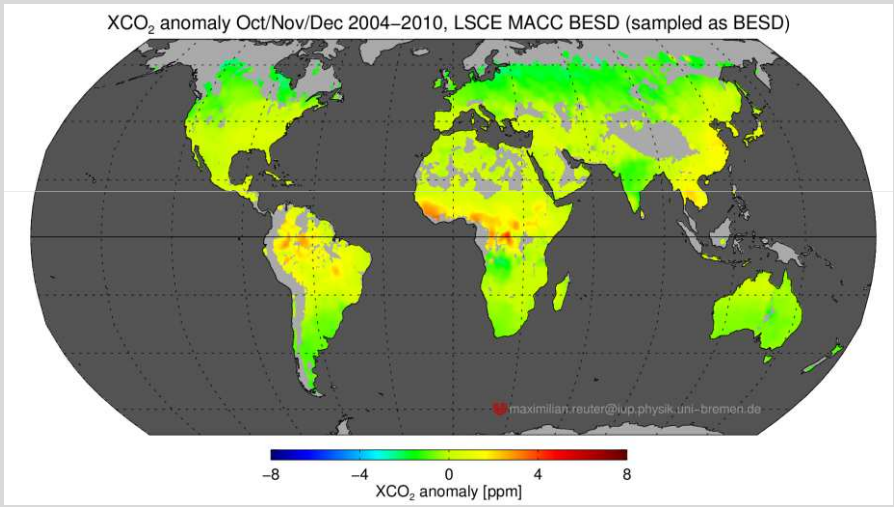
Satellite →



Model (flasks assimilated) ↓



Model (satellite assimilated) ↓

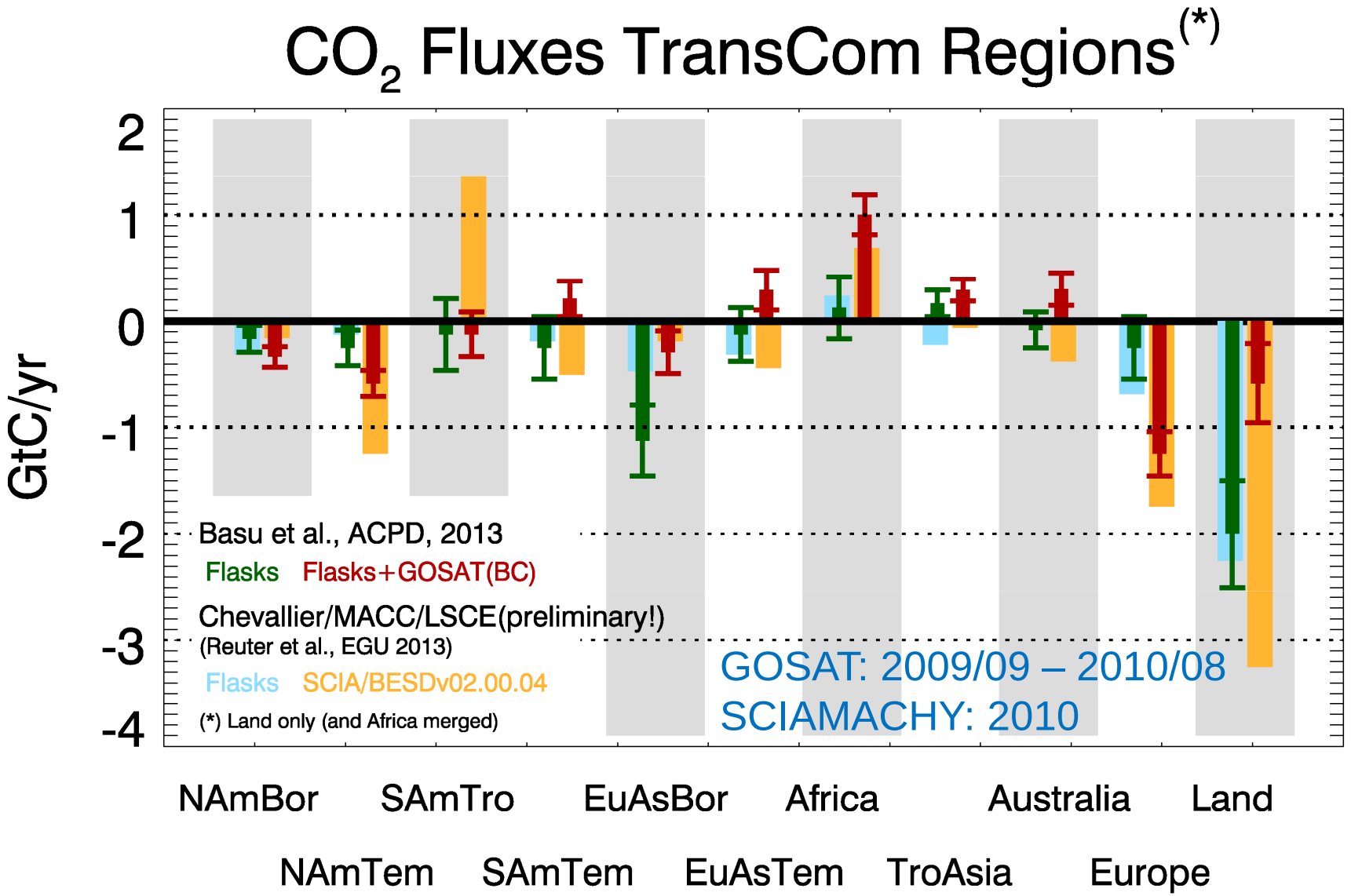


LSCE/MACC

Courtesy: F. Chevallier, LSCE

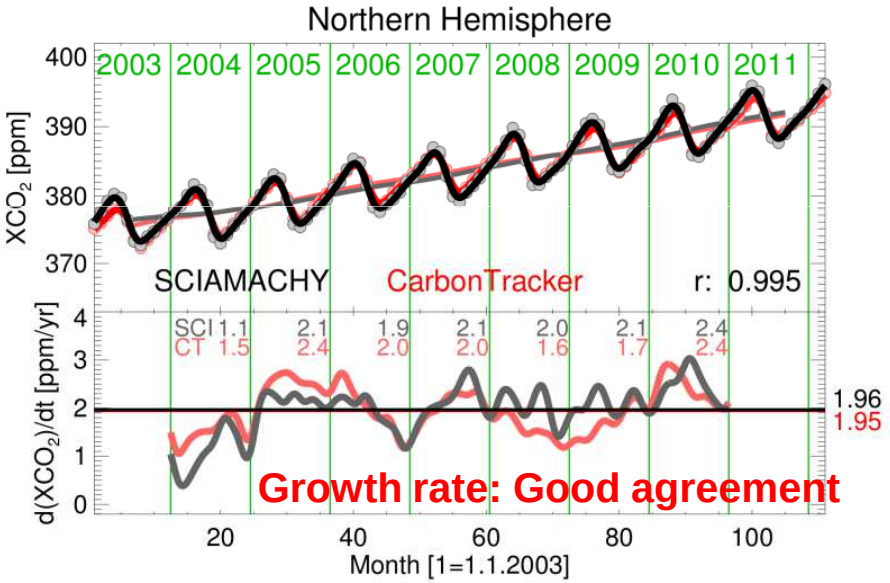
SCIAMACHY/BESD XCO_2:

Initial preliminary surface fluxes & comparision with Basu et al. CO_2 fluxes derived from GOSAT

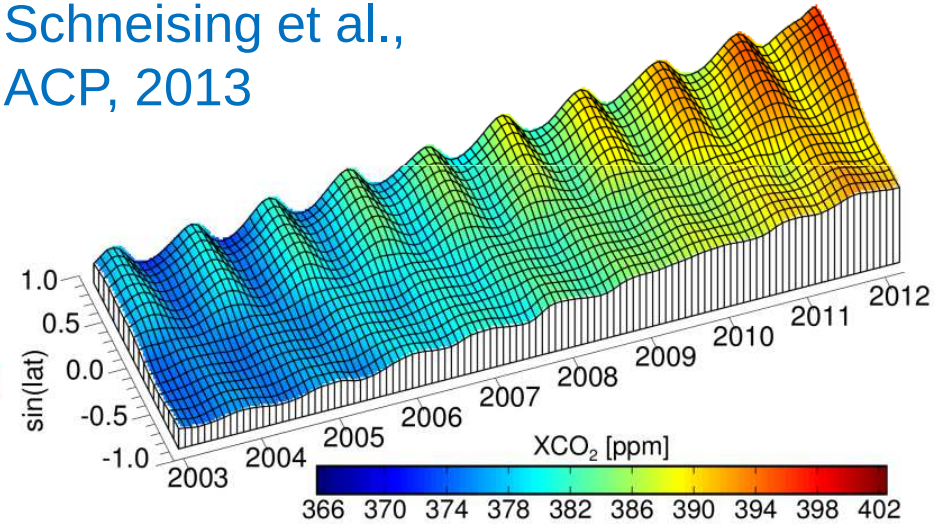


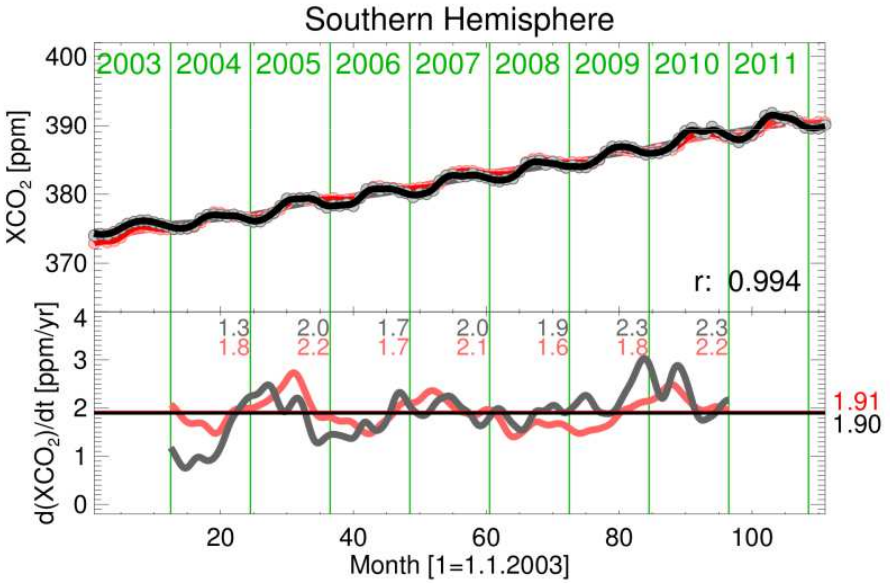
Preliminary SCIAMACHY inversion results courtesy: F. Chevallier, LSCE

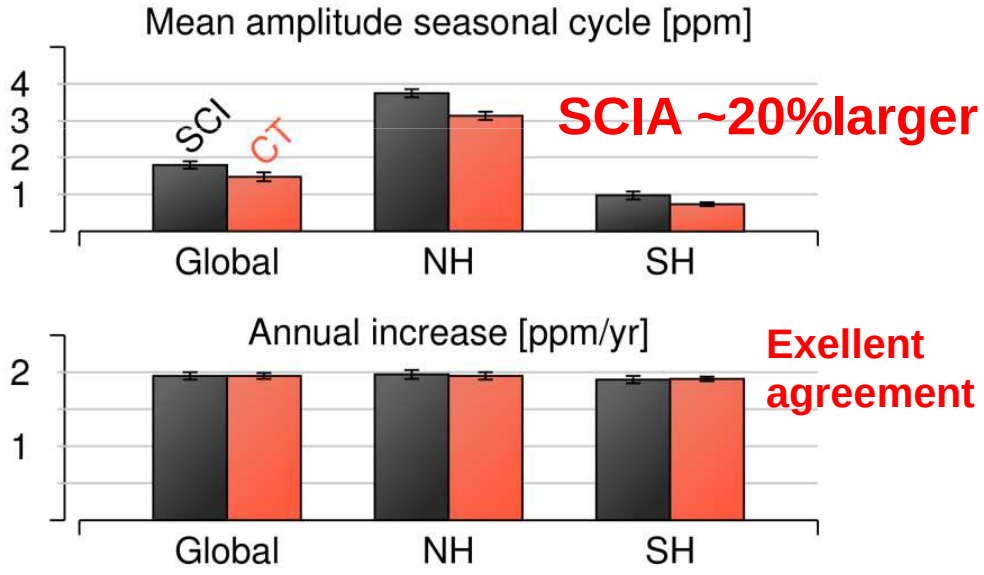
Model comparison: SCIAMACHY/WFMD XCO_2 versus NOAA's CarbonTracker



Schneising et al., ACP, 2013







SCIAMACHY/WFMD: CO_2 over major anthropogenic source regions

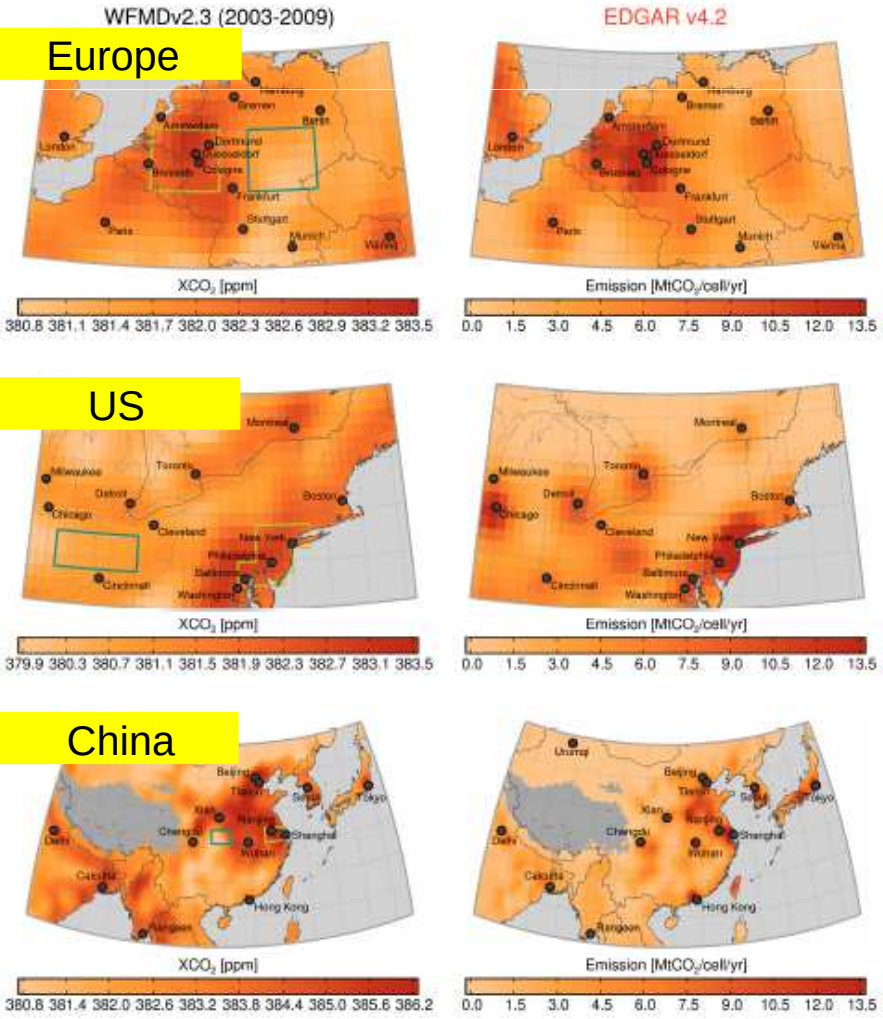
SCIAMACHY XCO_2

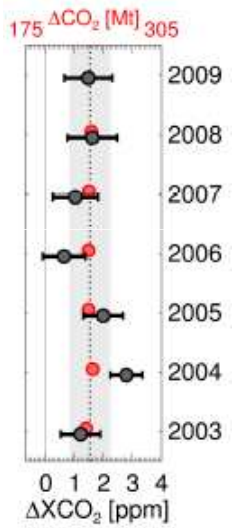
EDGAR CO_2 emissions

Europe

US

China

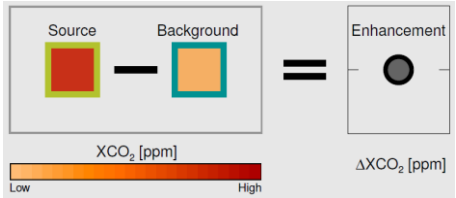


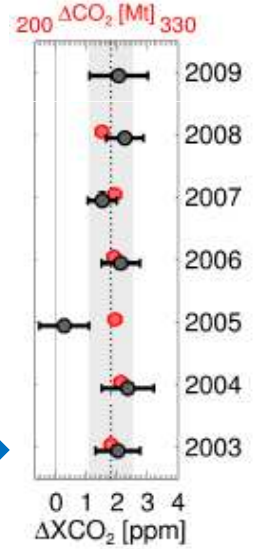


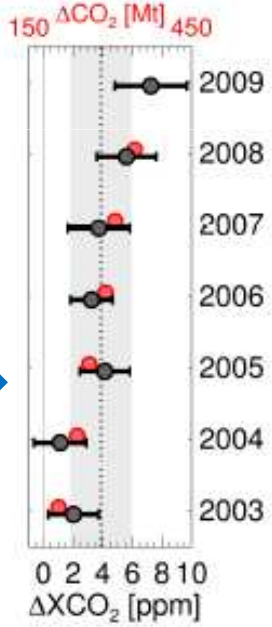
Schneising et al., 2013

SCIAMACHY
EDGAR

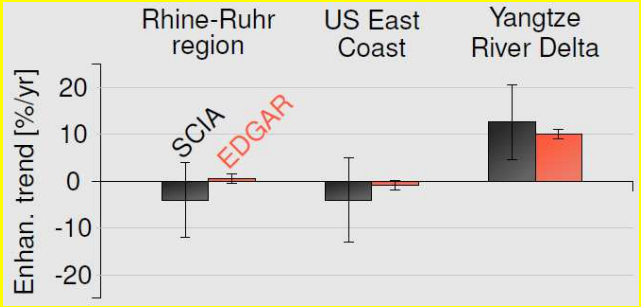
Regional enhancement =
Source - Background







Trend [%CO_2/yr]

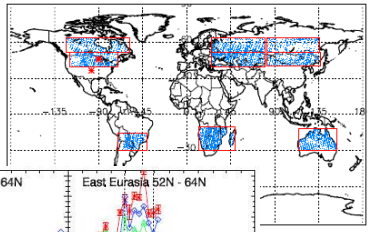


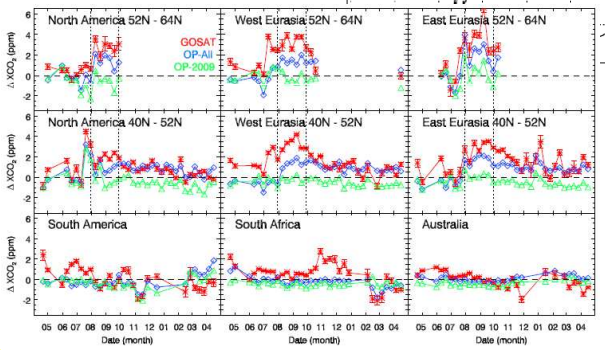
EDGAR emissions consistent with SCIAMACHY

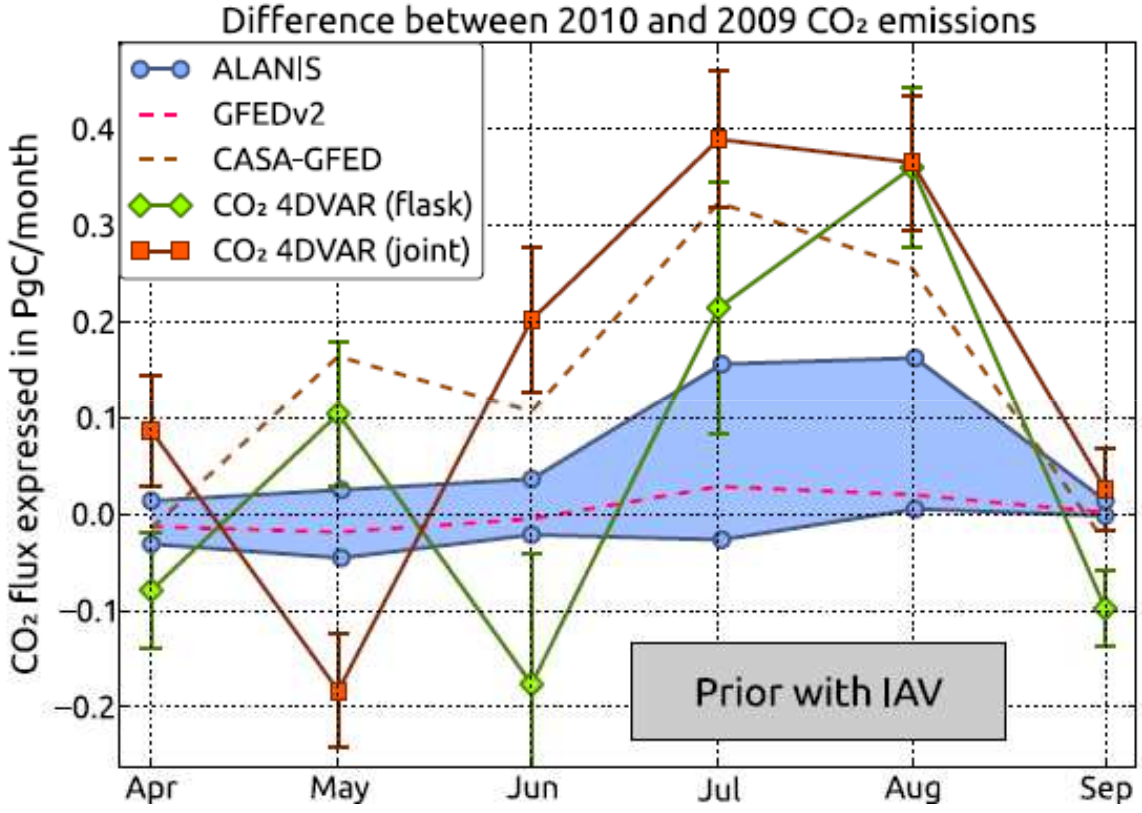
Inter-annual variability of carbon uptake: Guerlet et al., GRL (in press), 2013

Reduced carbon uptake during the 2010 Northern Hemisphere summer from GOSAT

S. Guerlet[1,2], S. Basu[1,3], A. Butz[4], M. Krol[1,3,5], P. Hahne[4], S. Houweling[1,3], O. P. Hasekamp[1], and I. Aben[1]







Reduced carbon uptake in the summer of 2010 is most likely due to the heat wave in Eurasia driving biospheric fluxes and fire emissions.

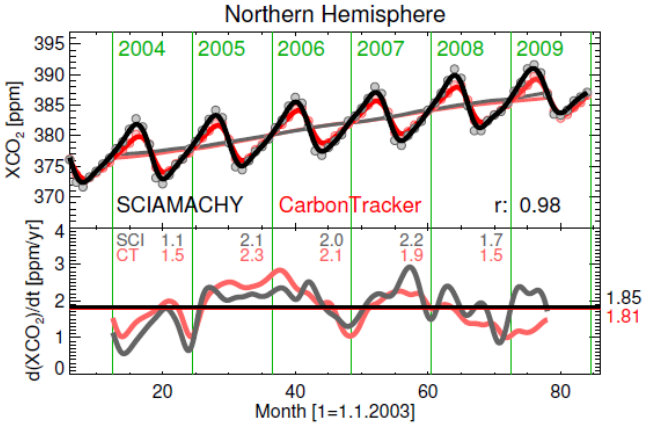
A joint inversion of GOSAT and surface data estimates an integrated biospheric and fire emission anomaly in April–September of 0.89±0.20 PgC over Eurasia.

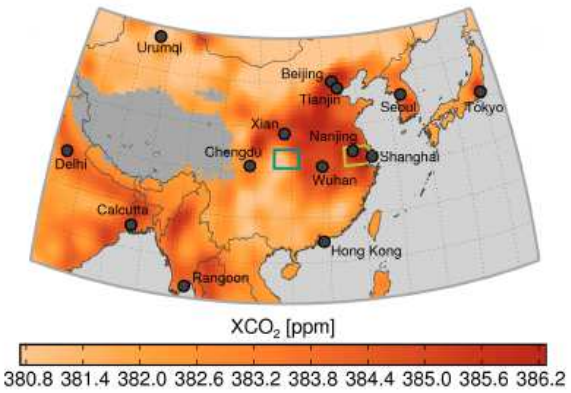
This shows the value of GOSAT XCO_2 in constraining the response of land-atmosphere exchange of CO_2 to climate events.

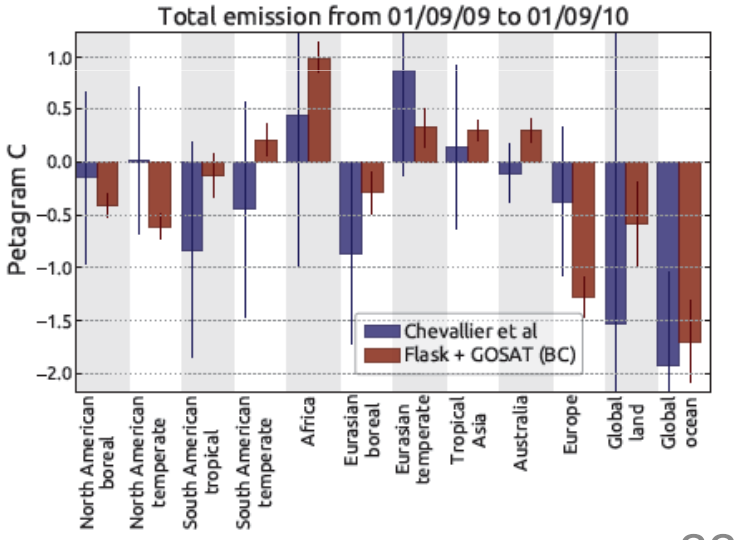
GHG-CCI: Scientific progress

as documented via peer-reviewed publications:

- **SCIAMACHY/ENVISAT XCH_4:** Longer time series with improved quality:
  Schneising et al., 2011, 2012, Frankenberg et al., 2011
- **SCIAMACHY/ENVISAT XCO_2:** Longer time series with improved quality:
  Heymann et al., 2012a/2012b, Schneising et al., 2011, 2012, Reuter et al., 2011, 2013
- **TANSO/GOSAT XCH_4 & XCO_2:** 1st published global data sets incl. inverse modeling results:
  Guerlet et al., 2013, Basu et al., (ACPD), 2013, Cogan et al., 2012, Schepers et al., 2012, Parker et al., 2011, Butz et al., 2011
- **SCIA/GOSAT XCO_2 merged:** New innovative ensemble product („EMMA“):
  Reuter et al., 2013
- & more (e.g, GHG-CCI Round Robin approach & results
  Buchwitz et al., RSE (in press), 2013), …







GHG-CCI: Summary & conclusions

- Project within schedule
- Many interesting scientific results, e.g., first CO_2 flux inversions
- Round Robin finished
  - Details see: Buchwitz et al., RSE (in press), CCI Special Issue
- CRDP ready but analysis ongoing:
  - Validation ongoing (-> PVIR)
  - Initial user assessment ongoing (-> CAR)
  - Will be made publicly available including documentation once initial validation and user assessment ready (plan: Sep 2013)
  - (Unvalidated CRDP) Data available on request (see GHG-CCI website)
- Phase 1 cost neutrally extended until end of 2013 to avoid a likely contractual gap between Phase 1 and 2