What have we learnt from global intercomparison programmes and what should we do next?

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Carbon Related Atmospheric Measurement Lab

1) GOLLUM:

Global Oxygen Laboratories Link Ultra-precise Measurements

- first ever O_2 intercomparison programme (of more than 2 labs); since 2004.

2) 'Cucumbers':

- emphasis on **field stations** and **rapid turnaround** to build up time histories.
- funded by EU's CarboEurope and IMECC projects; since 2005 (a); since 2007 (b)

MPI-BGC Jena

CARBO EUROPE IP

IMECC

http://gollum.webapp2.uea.ac.uk/

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GOLLUM

Global Oxygen Laboratories Link Ultra-precise Measurements

Background on Atmospheric oxygen measurement

Atmospheric oxygen (O_2) measurements are used to provide insight and quantitative understanding of the global carbon cycle [*Bender et al.*, 1996; *Bender et al.*, 1998; *Keeling and Shertz*, 1992]. More recently they have been used in other applications such as understanding air-sea gas exchange [*Keeling et al.*, 1998] and critiquing ocean biogeochemical and atmospheric transport models [*Battle et al.*, 2006; *Stephens et al.*, 1998].

Atmospheric O_2 measurements were first established in 1988 by Professor Ralph Keeling at Scripps Institution of Oceanography [*Keeling*, 1988], and are now made at ~12 laboratories around the world, and at ~25 field stations. The

Disclaimer:

1. All results here are preliminary and provisional

2. These data must NOT be used to adjust any laboratory's calibration scales.

3. If you wish to use or present these data for

http://cucumbers.webapp2.uea.ac.uk/

Cucumbers

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CarboEurope-Atmosphere Cucumber Intercomparison

Home | Rotations (PNG / PDF) | Cylinder Certificates | Participants (PDF) | Protocols (PDF) | Logsheets | Results (password required) | 2009 Report

Cucumbers

The Cucumber intercomparison programme is one of several run in the CarboEurope project. This programme has the distinct difference that it compares results from the many atmospheric CO_2 monitoring field stations within Europe, in addition to several laboratories. Presently, 21 field stations and 10 laboratories are engaged in the programme. The aim of all such intercomparison programmes is to assess and quantify possible

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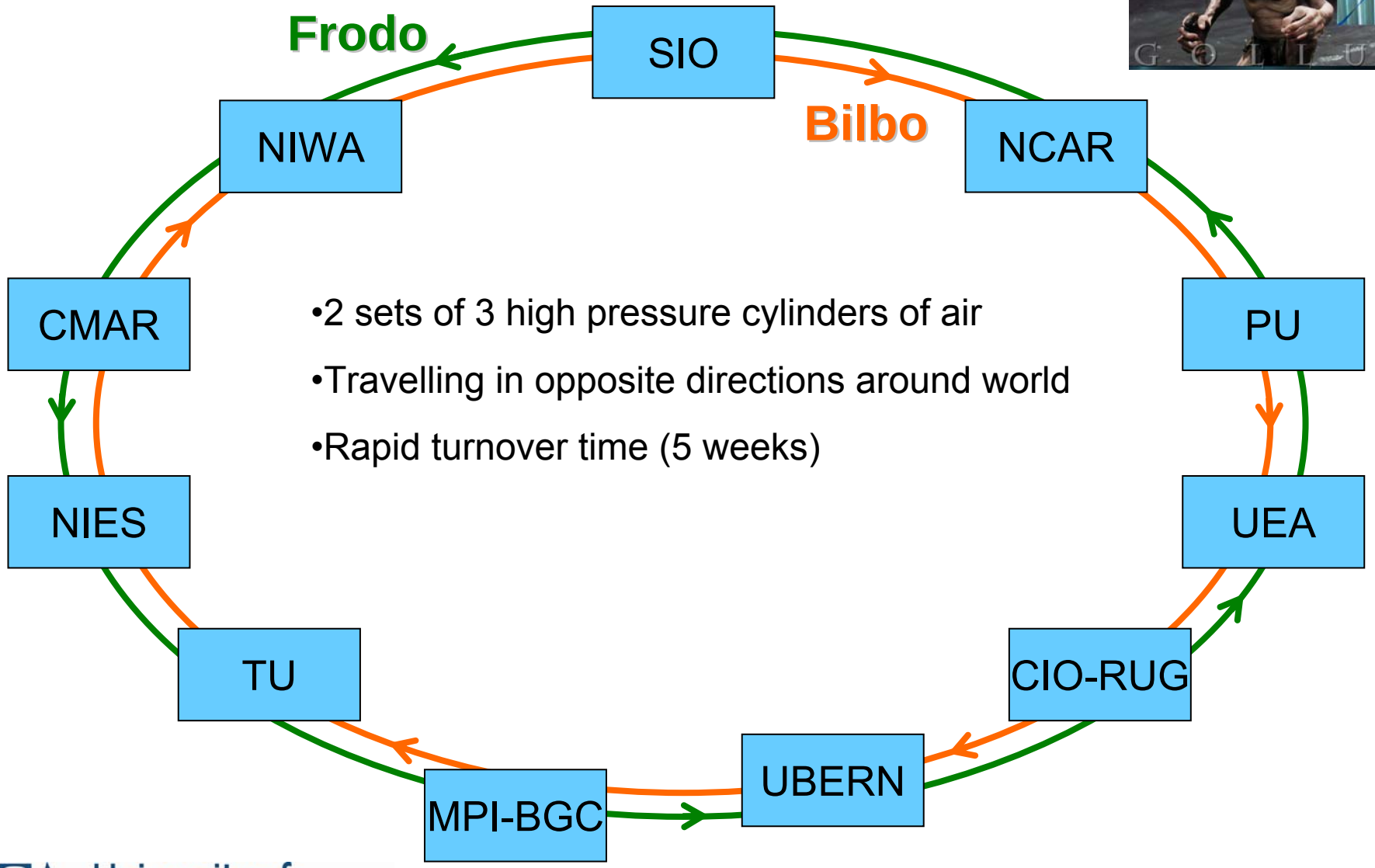
Circulation of GOLLUM Cylinders



- 2 sets of 3 high pressure cylinders of air
- Travelling in opposite directions around world
- Rapid turnover time (5 weeks)

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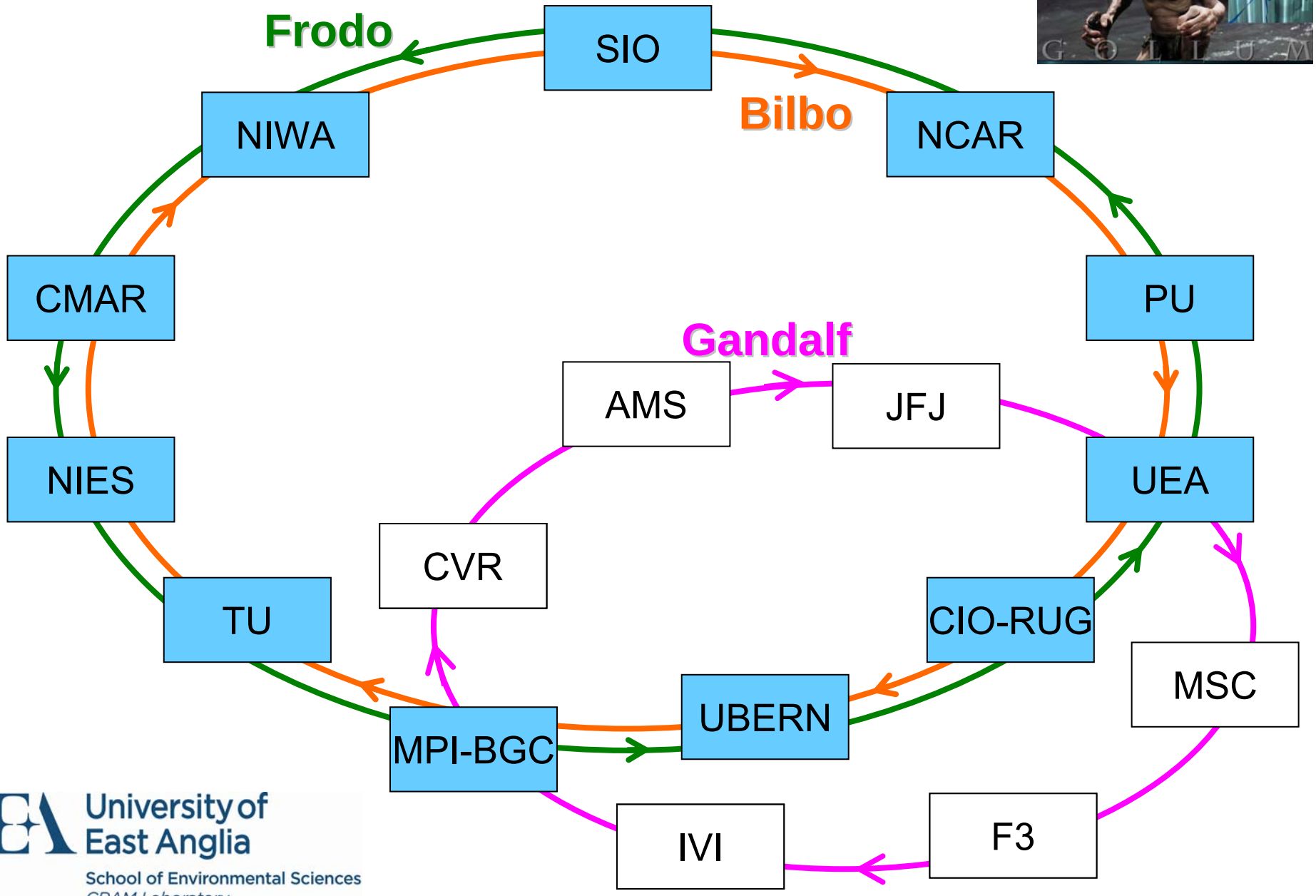
Circulation of GOLLUM Cylinders



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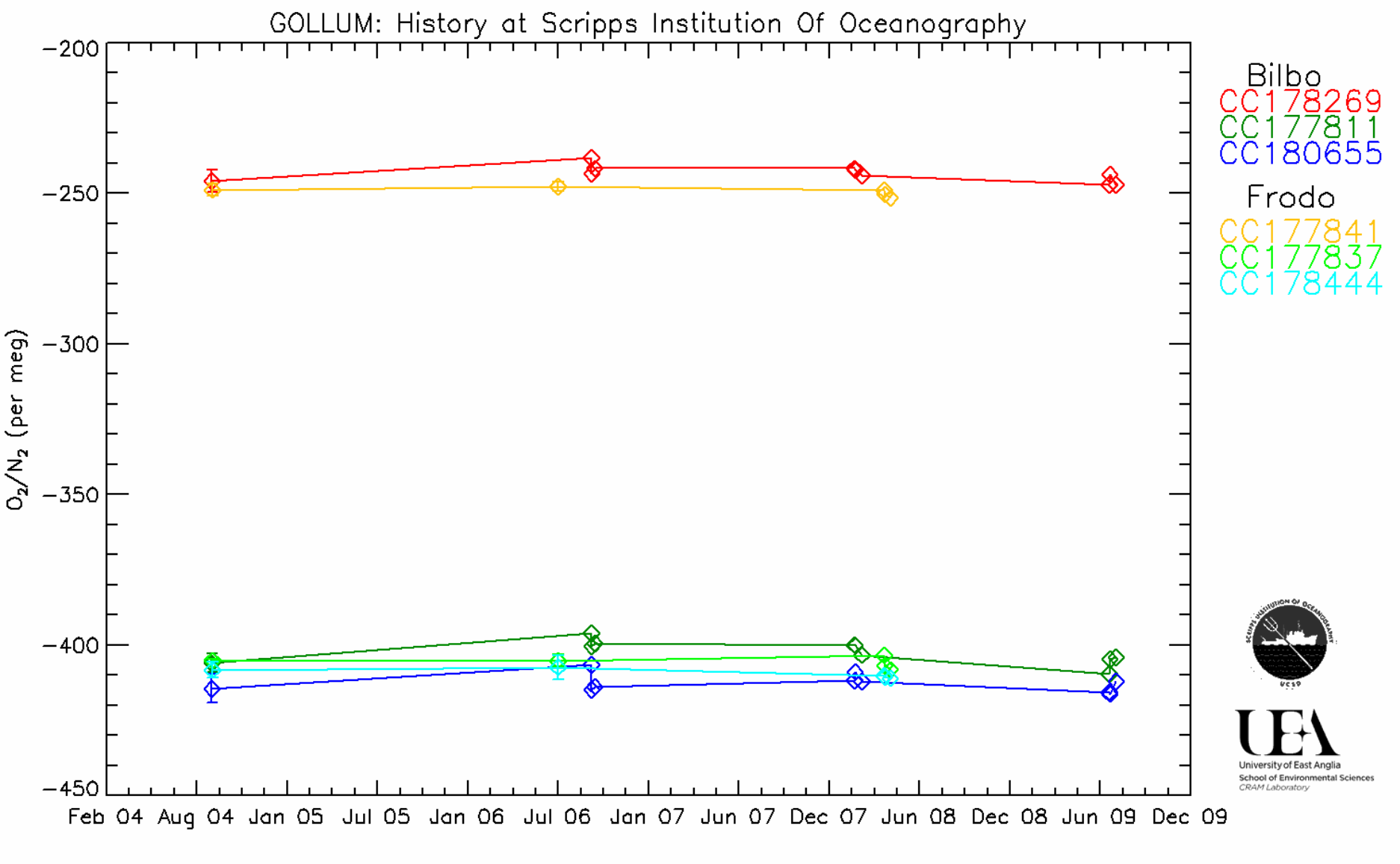
GOLLUM: History at Scripps Institution Of Oceanography
−200
−250
−300
−350
−400
−450
O2/N2 (per meg)
Feb 04
Aug 04
Jan 05
Jul 05
Jan 06
Jul 06
Jan 07
Jun 07
Dec 07
Jun 08
Dec 08
Jun 09
Dec 09
Bilbo
CC178269
CC177811
CC180655
Frodo
CC177841
CC177837
CC178444
University of East Anglia
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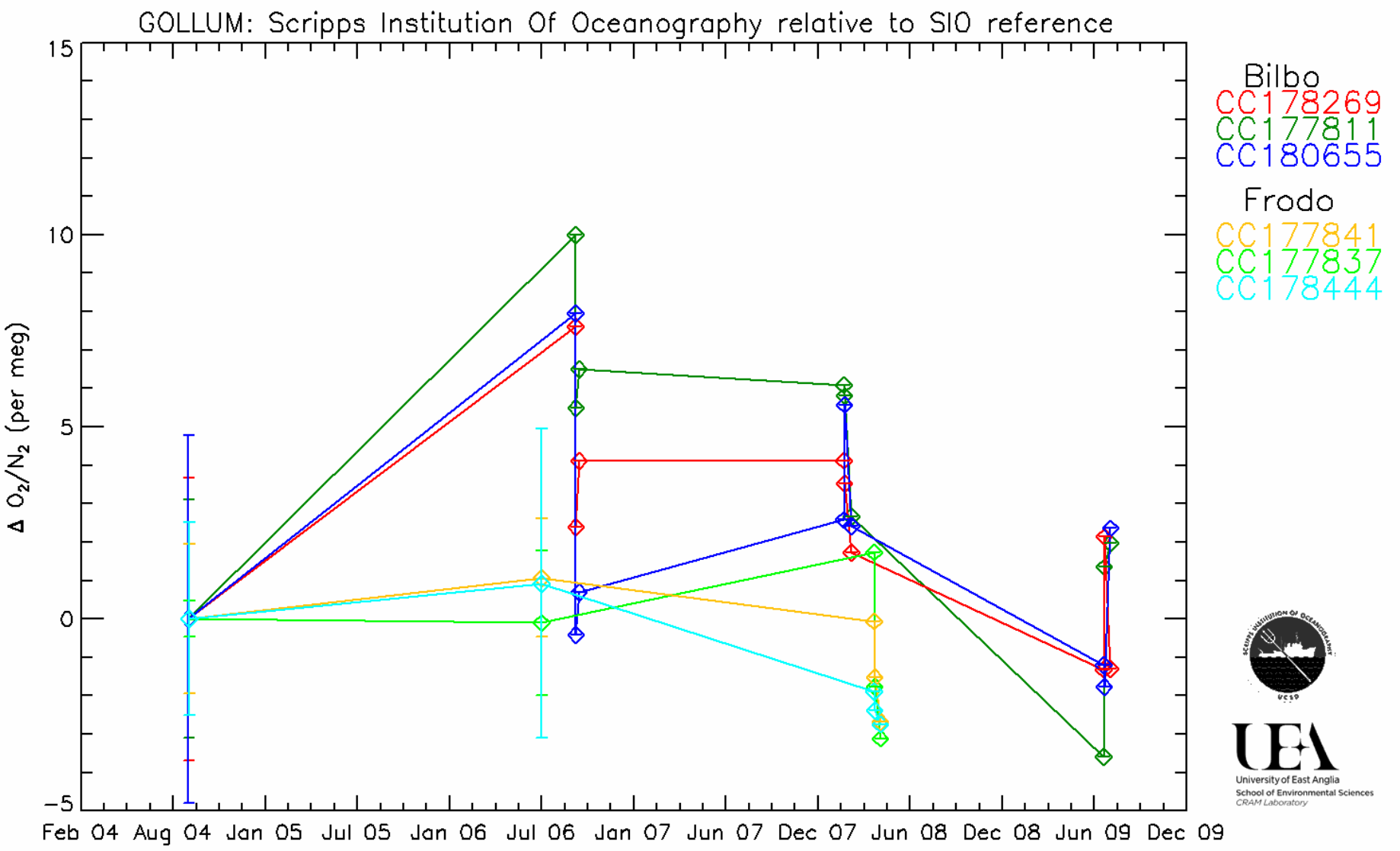
GOLLUM: Scripps Institution Of Oceanography relative to SIO reference
Δ O2/N2 (per meg)
15
10
5
0
−5
Feb 04
Aug 04
Jan 05
Jul 05
Jan 06
Jul 06
Jan 07
Jun 07
Dec 07
Jun 08
Dec 08
Jun 09
Dec 09
Bilbo
CC178269
CC177811
CC180655
Frodo
CC177841
CC177837
CC178444
University of East Anglia
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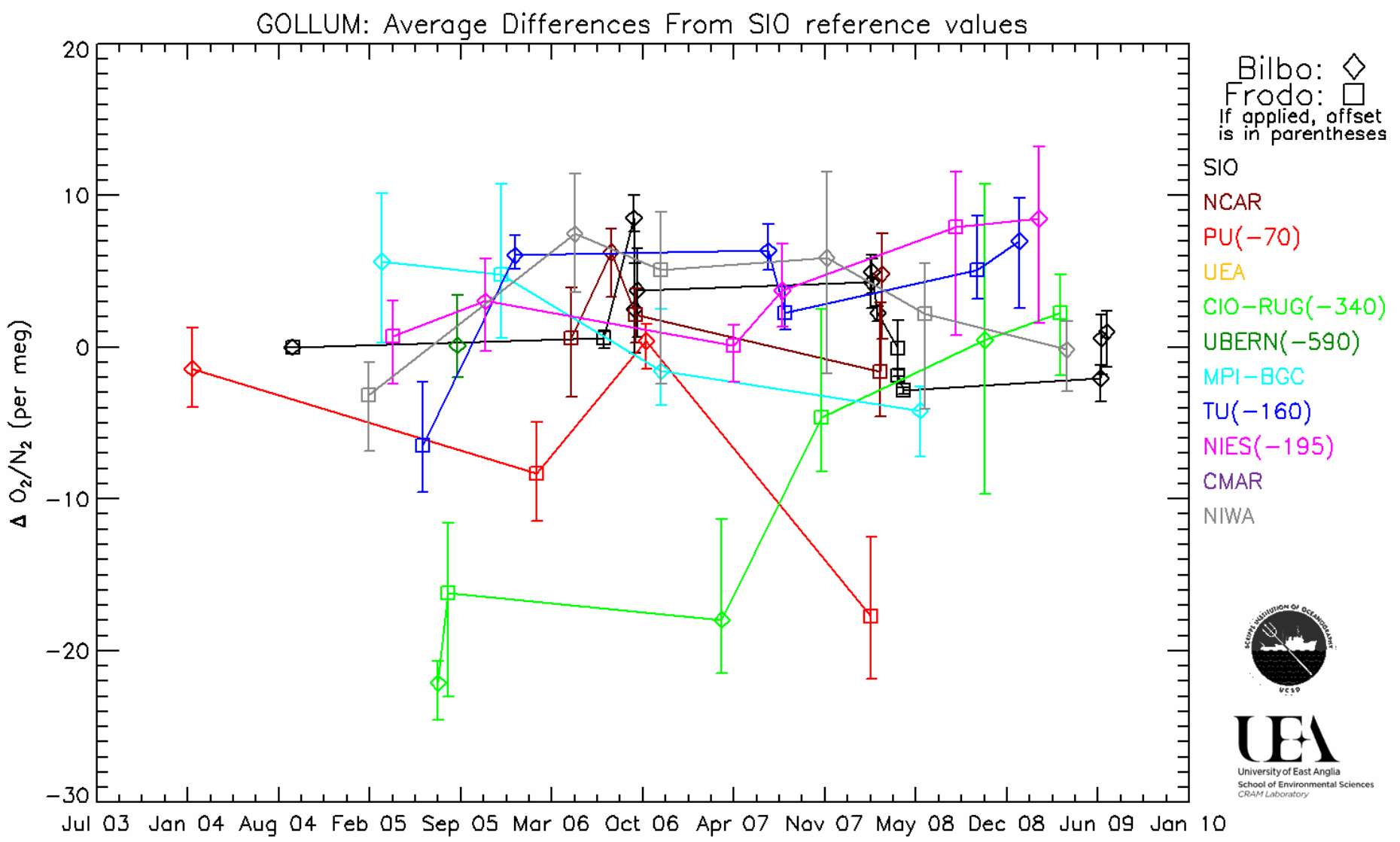
GOLLUM: Average Differences From SIO reference values
Δ O2/N2 (per meg)
20
10
0
−10
−20
−30
Jul 03
Jan 04
Aug 04
Feb 05
Sep 05
Mar 06
Oct 06
Apr 07
Nov 07
May 08
Dec 08
Jun 09
Jan 10
Bilbo: ◇
Frodo: □
If applied, offset is in parentheses
SIO
NCAR
PU(−70)
UEA
CIO−RUG(−340)
UBERN(−590)
MPI−BGC
TU(−160)
NIES(−195)
CMAR
NIWA
University of East Anglia
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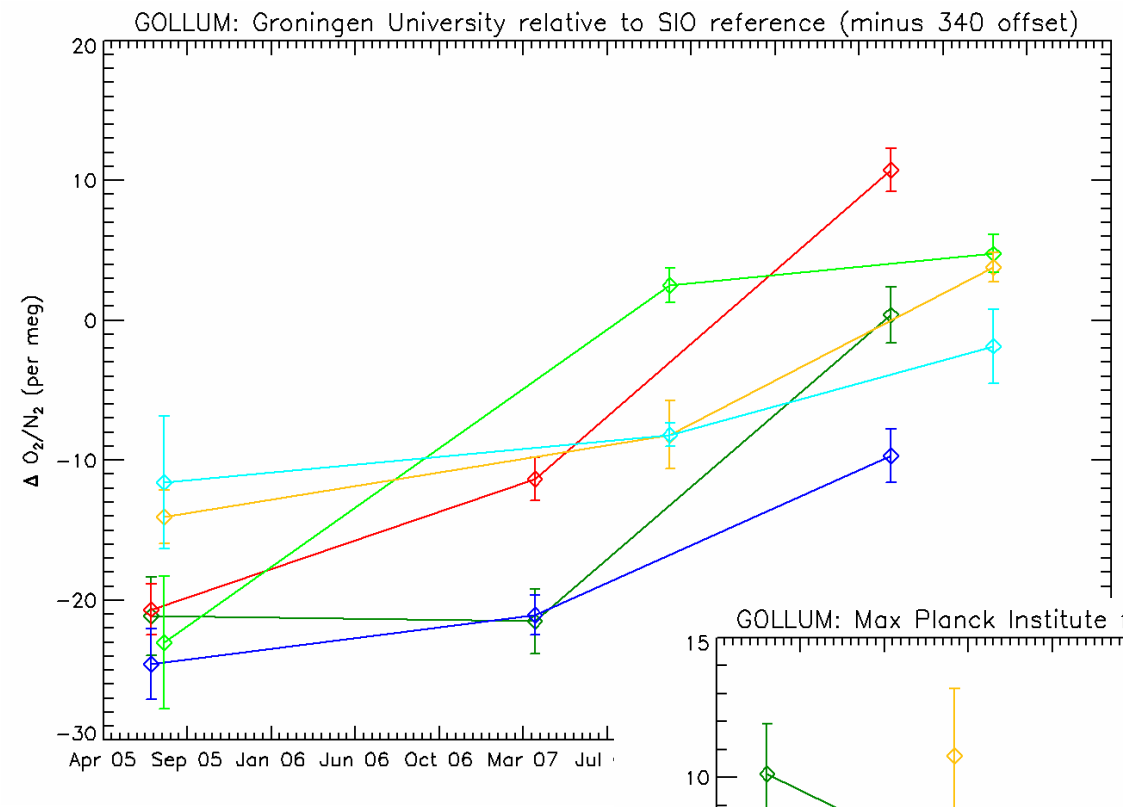
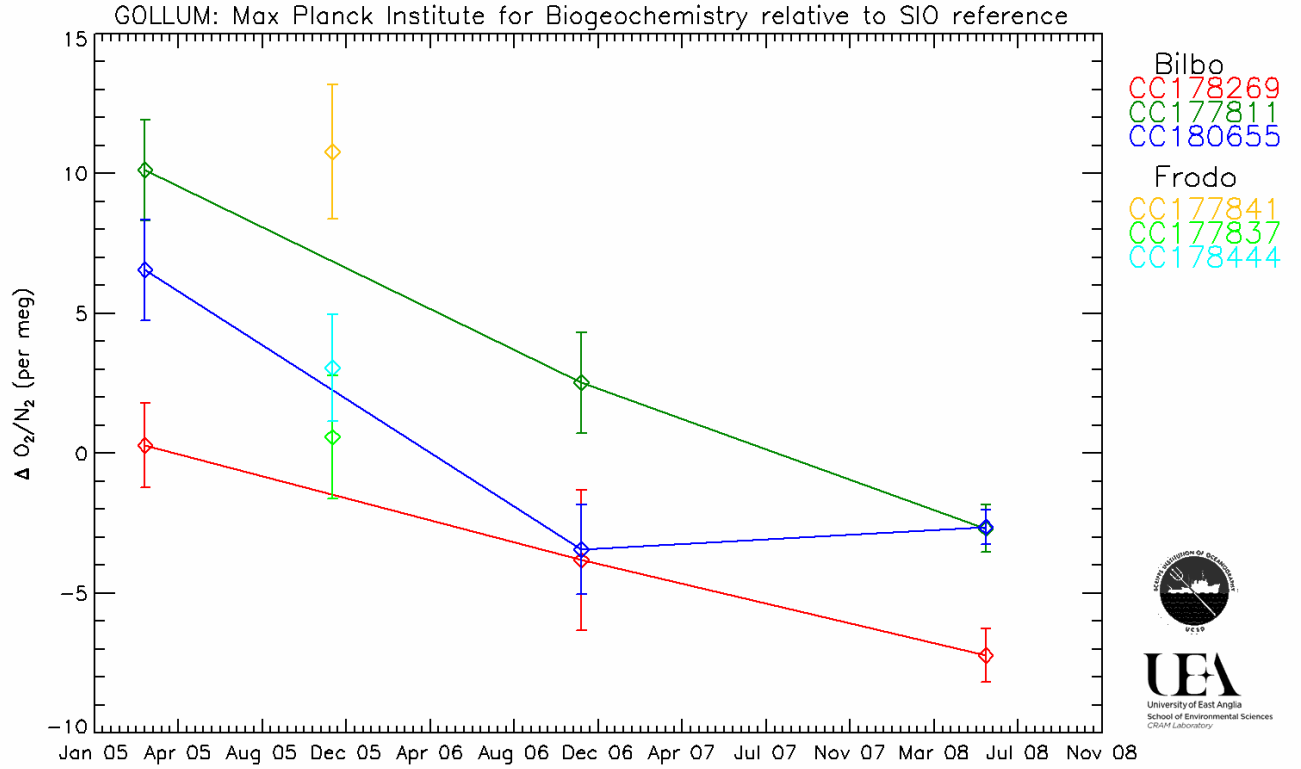

GOLLUM: Groningen University relative to SIO reference (minus 340 offset)
Δ O2/N2 (per meg)
20
10
0
−10
−20
−30
Apr 05
Sep 05
Jan 06
Jun 06
Oct 06
Mar 07
Jul
Bilbo
CC178269
CC177811
CC180655
Frodo
CC177841
CC177837
CC178444


GOLLUM: Max Planck Institute for Biogeochemistry relative to SIO reference
Δ O2/N2 (per meg)
15
10
5
0
−5
−10
Jan 05
Apr 05
Aug 05
Dec 05
Apr 06
Aug 06
Dec 06
Apr 07
Jul 07
Nov 07
Mar 08
Jul 08
Nov 08
Bilbo
CC178269
CC177811
CC180655
Frodo
CC177841
CC177837
CC178444
UEA
University of East Anglia
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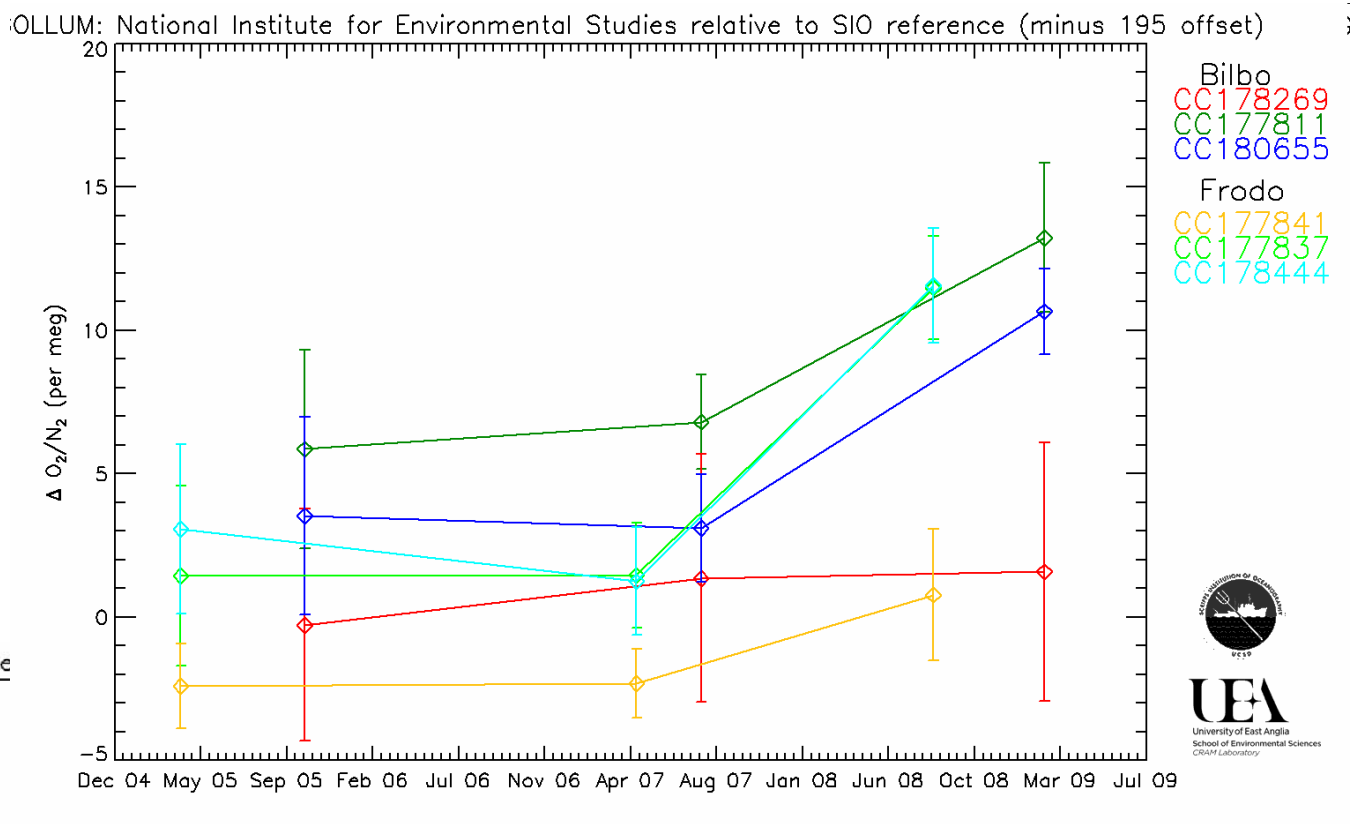
OLLUM: National Institute for Environmental Studies relative to SIO reference (minus 195 offset)
Bilbo
CC178269
CC177811
CC180655
Frodo
CC177841
CC177837
CC178444
Δ O2/N2 (per meg)
20
15
10
5
0
−5
Dec 04
May 05
Sep 05
Feb 06
Jul 06
Nov 06
Apr 07
Aug 07
Jan 08
Jun 08
Oct 08
Mar 09
Jul 09
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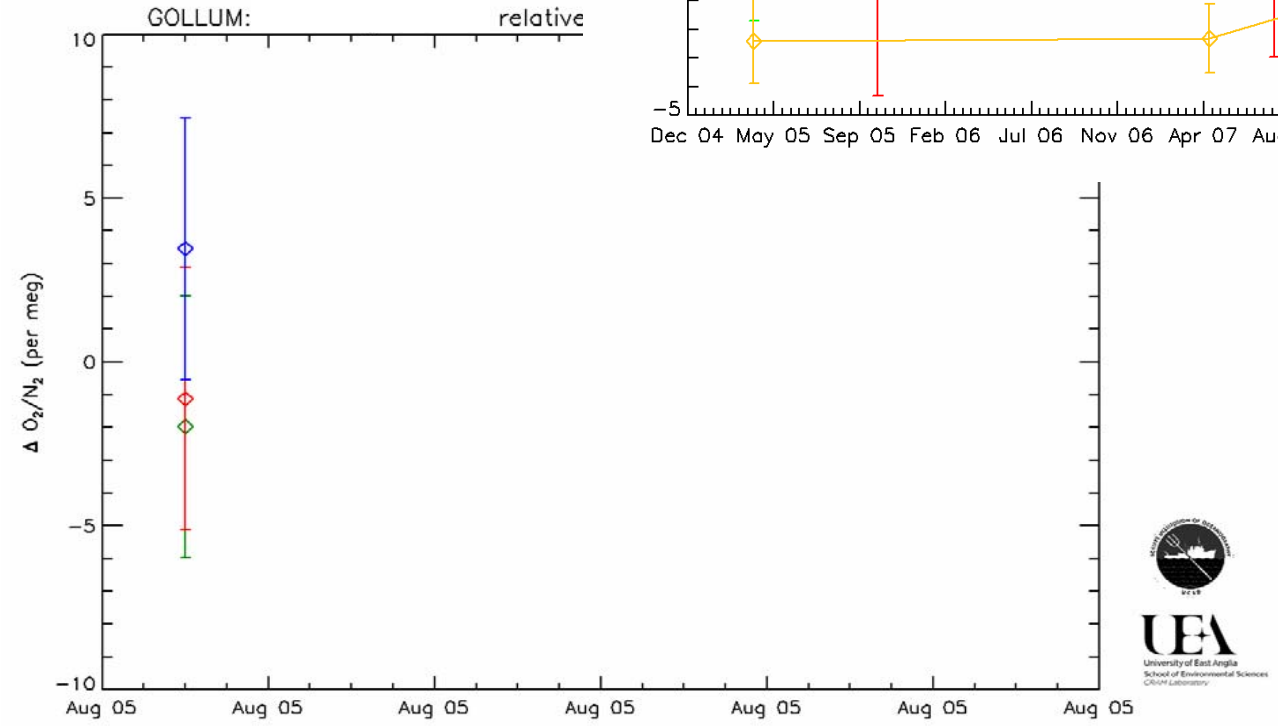
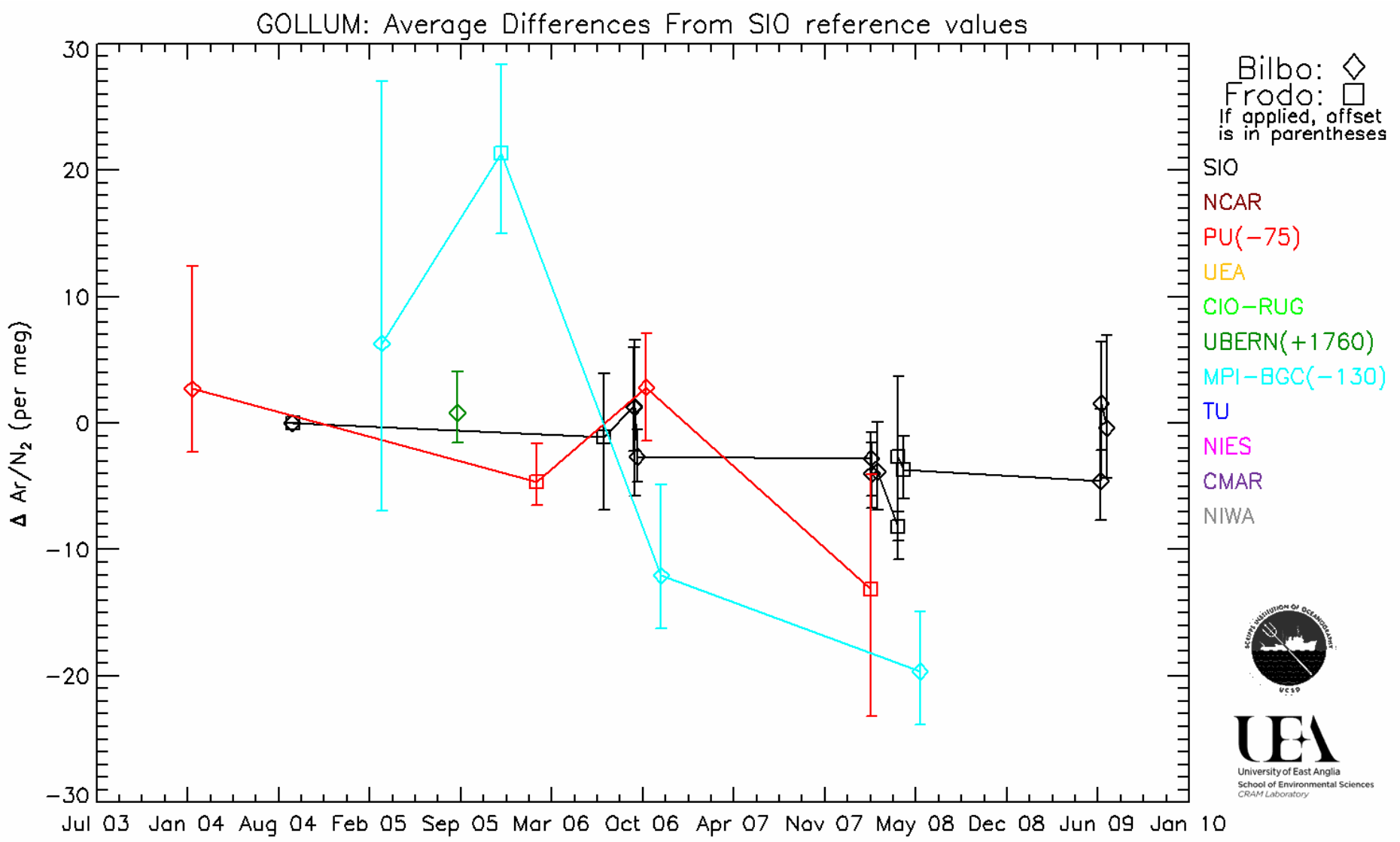

GOLLUM:
relative
Δ O2/N2 (per meg)
10
5
0
−5
−10
Aug 05
Aug 05
Aug 05
Aug 05
Aug 05
Aug 05
Aug 05
University of East Anglia
School of Environmental Sciences
CRAM Laboratory


GOLLUM: Average Differences From SIO reference values
Δ Ar/N2 (per meg)
30
20
10
0
−10
−20
−30
Jul 03
Jan 04
Aug 04
Feb 05
Sep 05
Mar 06
Oct 06
Apr 07
Nov 07
May 08
Dec 08
Jun 09
Jan 10
Bilbo: ◇
Frodo: □
If applied, offset is in parentheses
SIO
NCAR
PU(−75)
UEA
CIO−RUG
UBERN(+1760)
MPI−BGC(−130)
TU
NIES
CMAR
NIWA
University of East Anglia
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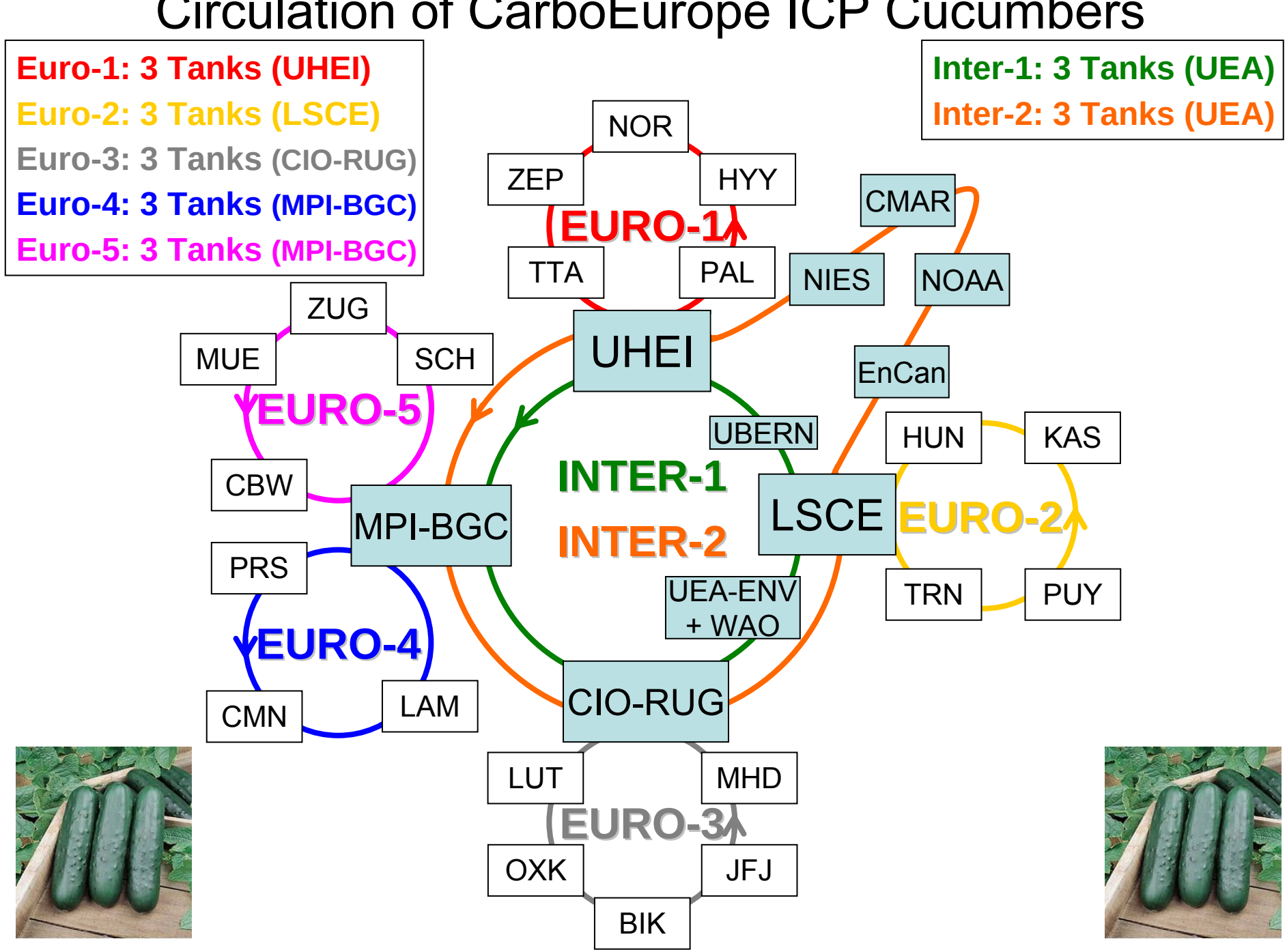
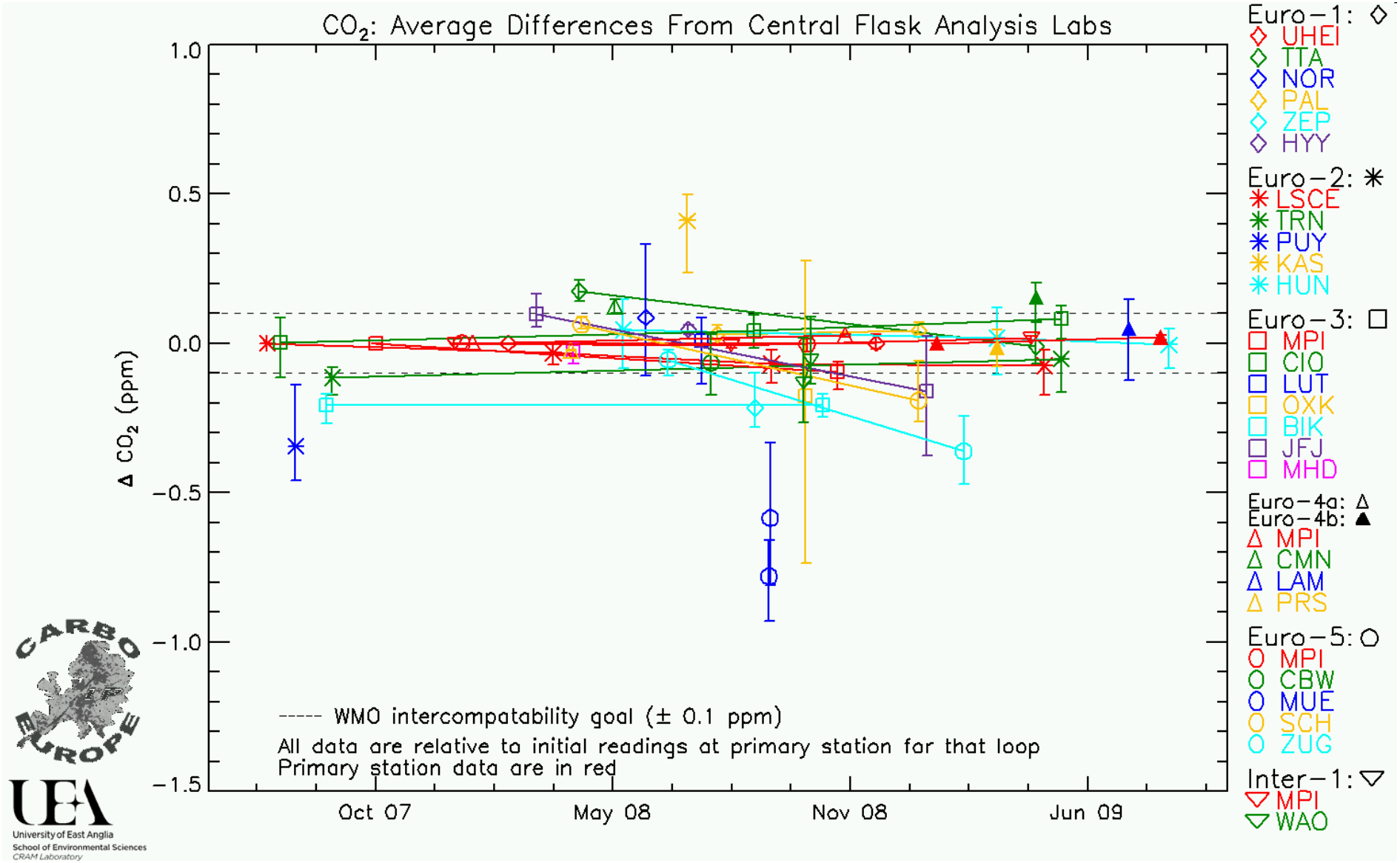
Circulation of CarboEurope ICP Cucumbers

Euro-1: 3 Tanks (UHEI)
Euro-2: 3 Tanks (LSCE)
Euro-3: 3 Tanks (CIO-RUG)
Euro-4: 3 Tanks (MPI-BGC)
Euro-5: 3 Tanks (MPI-BGC)

Inter-1: 3 Tanks (UEA)
Inter-2: 3 Tanks (UEA)




CO2: Average Differences From Central Flask Analysis Labs
Δ CO2 (ppm)
1.0
0.5
0.0
−0.5
−1.0
−1.5
Oct 07
May 08
Nov 08
Jun 09
----- WMO intercompatability goal (± 0.1 ppm)
All data are relative to initial readings at primary station for that loop
Primary station data are in red
Euro−1:
UHEI
TTA
NOR
PAL
ZEP
HYY
Euro−2:
LSCE
TRN
PUY
KAS
HUN
Euro−3:
MPI
CIO
LUT
OXK
BIK
JFJ
MHD
Euro−4a:
Euro−4b:
MPI
CMN
LAM
PRS
Euro−5:
MPI
CBW
MUE
SCH
ZUG
Inter−1:
MPI
WAO
CARBO EUROPE
UEA
University of East Anglia
School of Environmental Sciences
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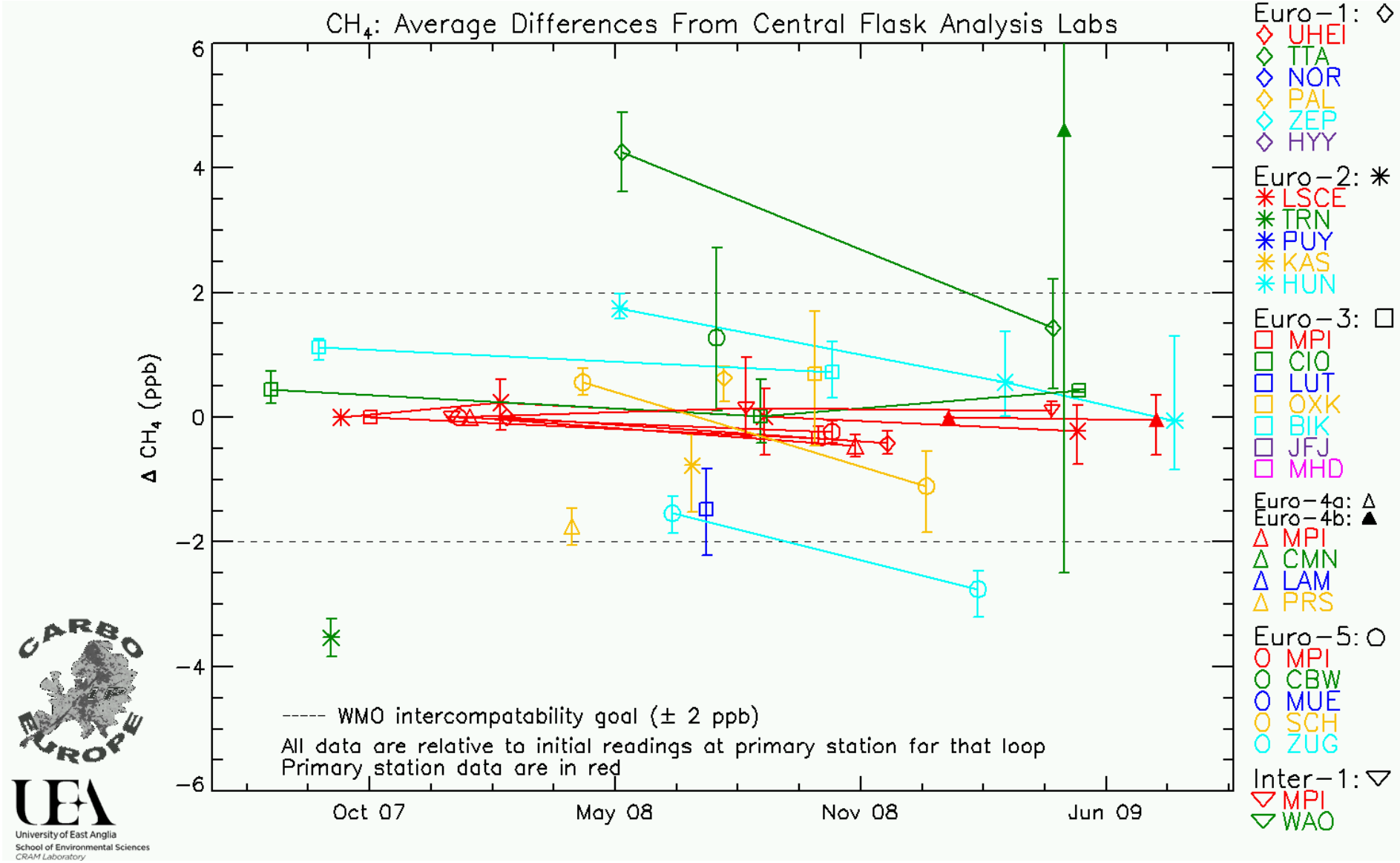

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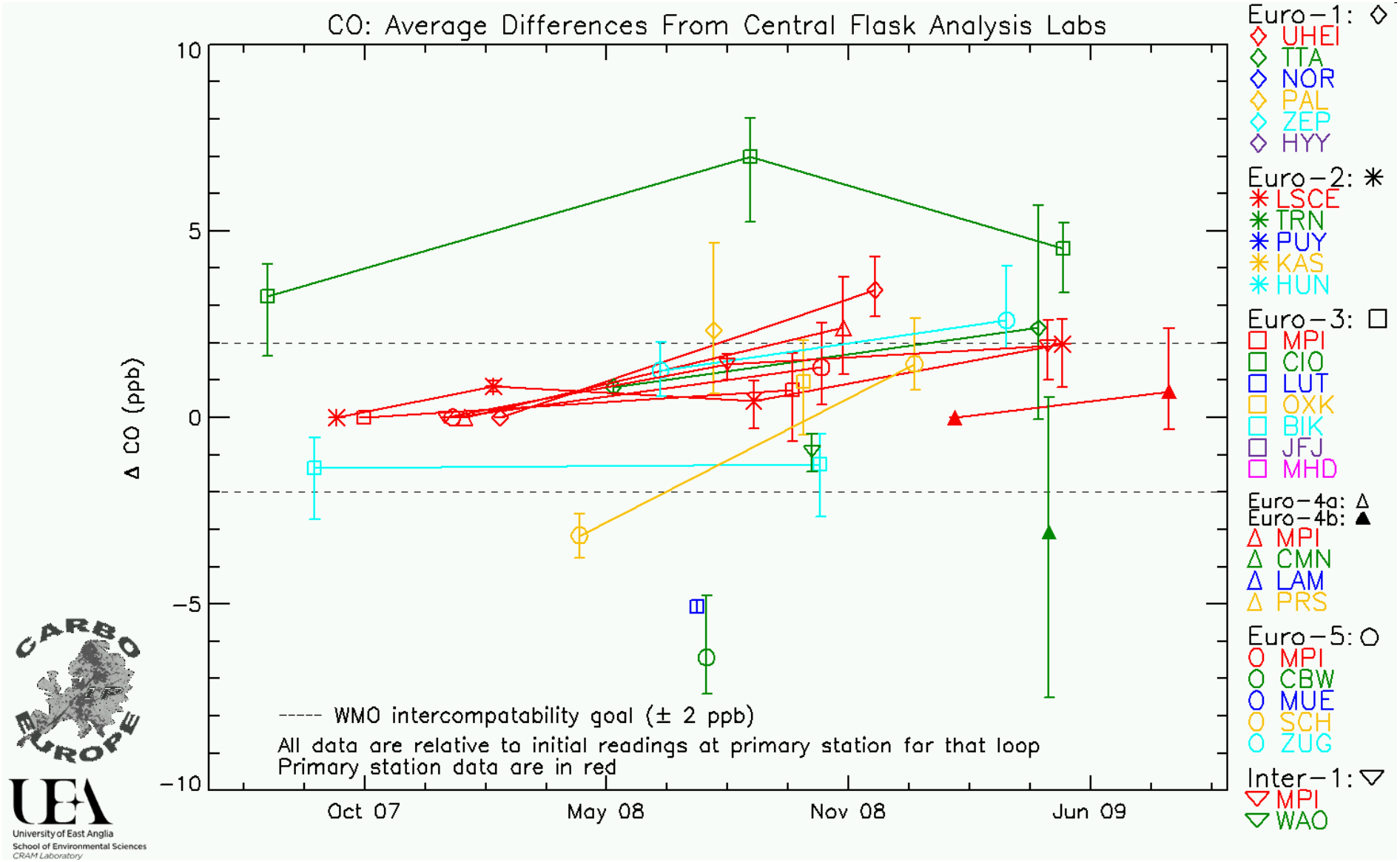

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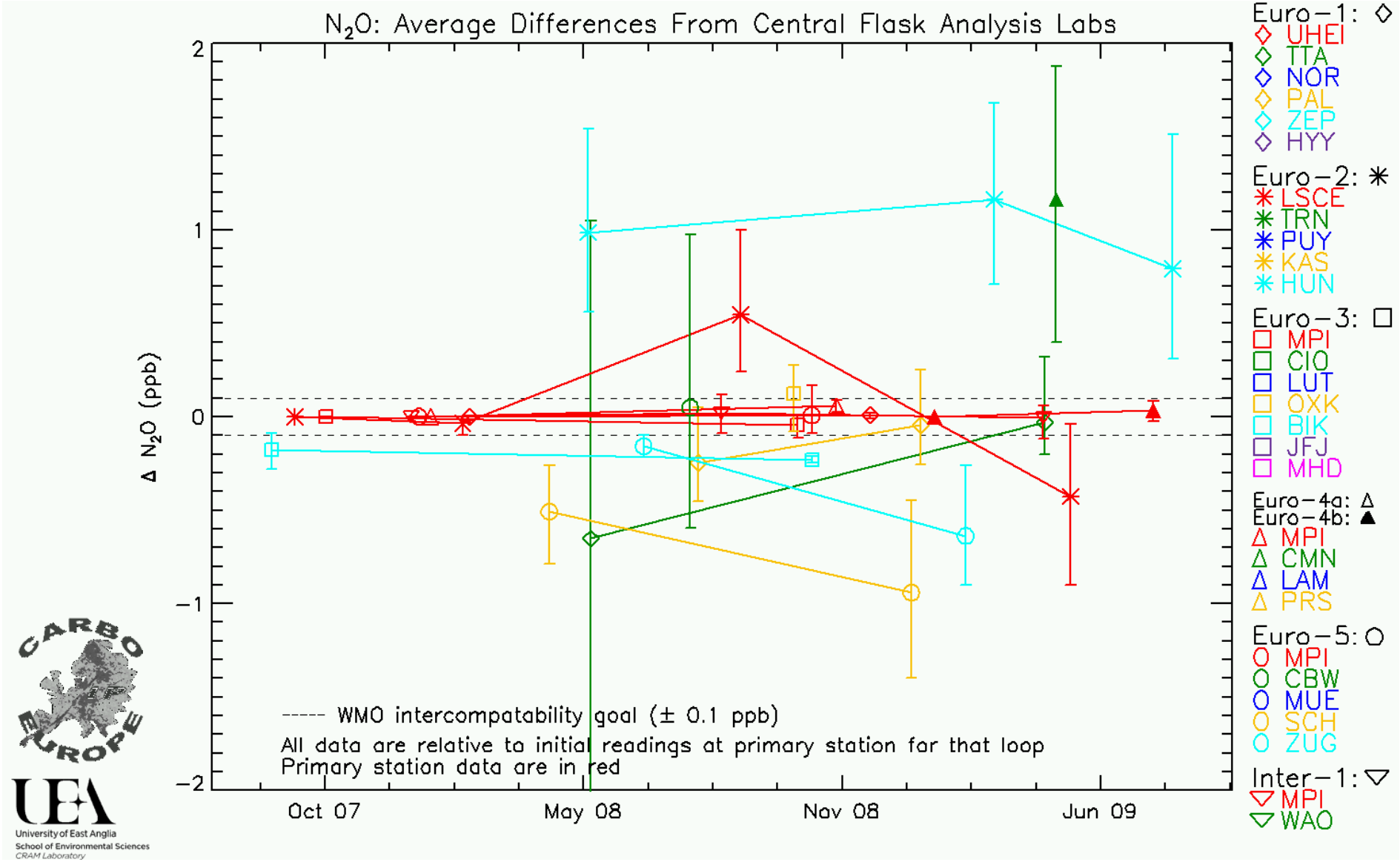

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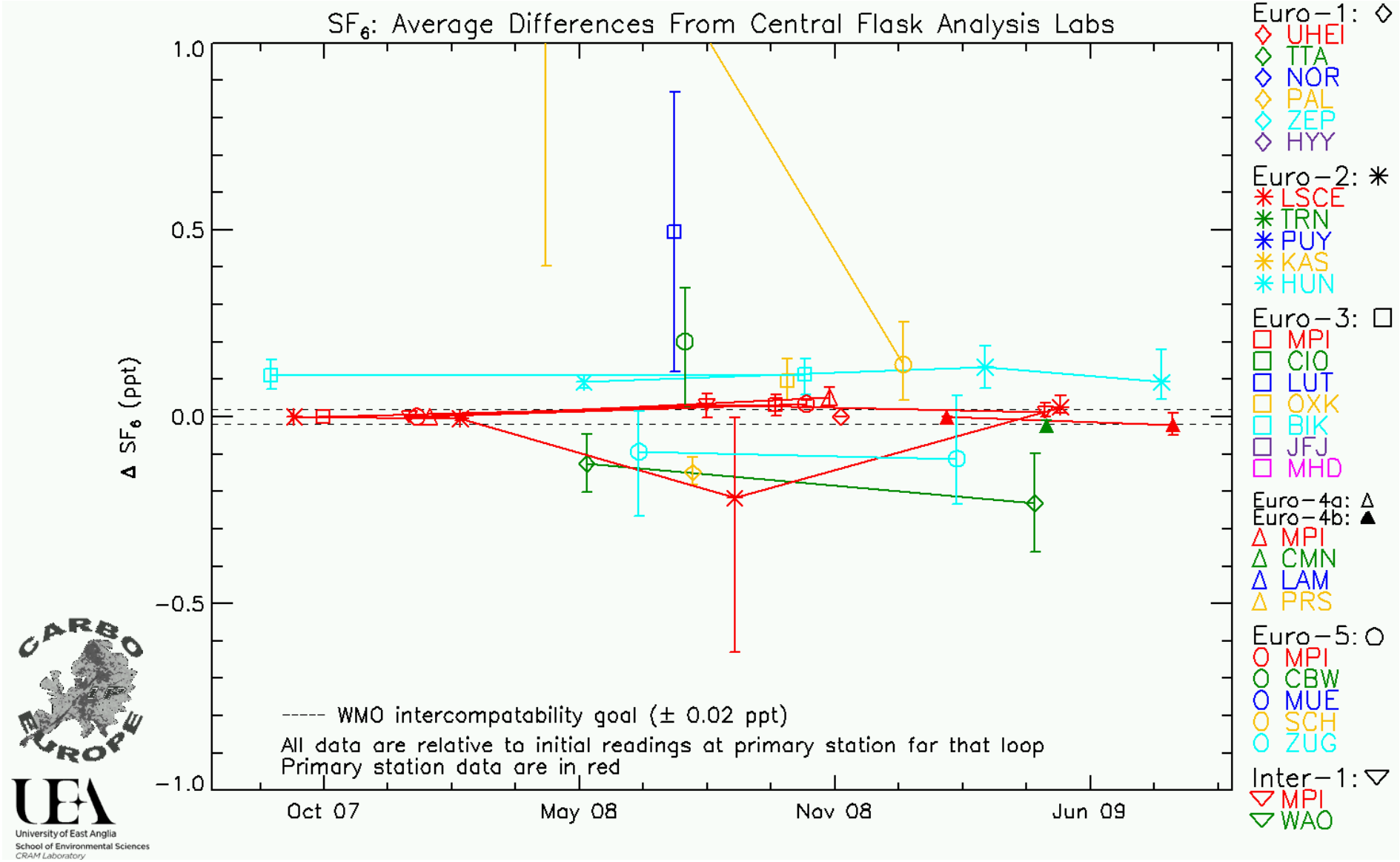
SF6: Average Differences From Central Flask Analysis Labs
Δ SF6 (ppt)
1.0
0.5
0.0
−0.5
−1.0
Oct 07
May 08
Nov 08
Jun 09
----- WMO intercompatability goal (± 0.02 ppt)
All data are relative to initial readings at primary station for that loop
Primary station data are in red
Euro−1:
UHEI
TTA
NOR
PAL
ZEP
HYY
Euro−2:
LSCE
TRN
PUY
KAS
HUN
Euro−3:
MPI
CIO
LUT
OXK
BIK
JFJ
MHD
Euro−4a:
Euro−4b:
MPI
CMN
LAM
PRS
Euro−5:
MPI
CBW
MUE
SCH
ZUG
Inter−1:
MPI
WAO
CARBO EUROPE
UEA
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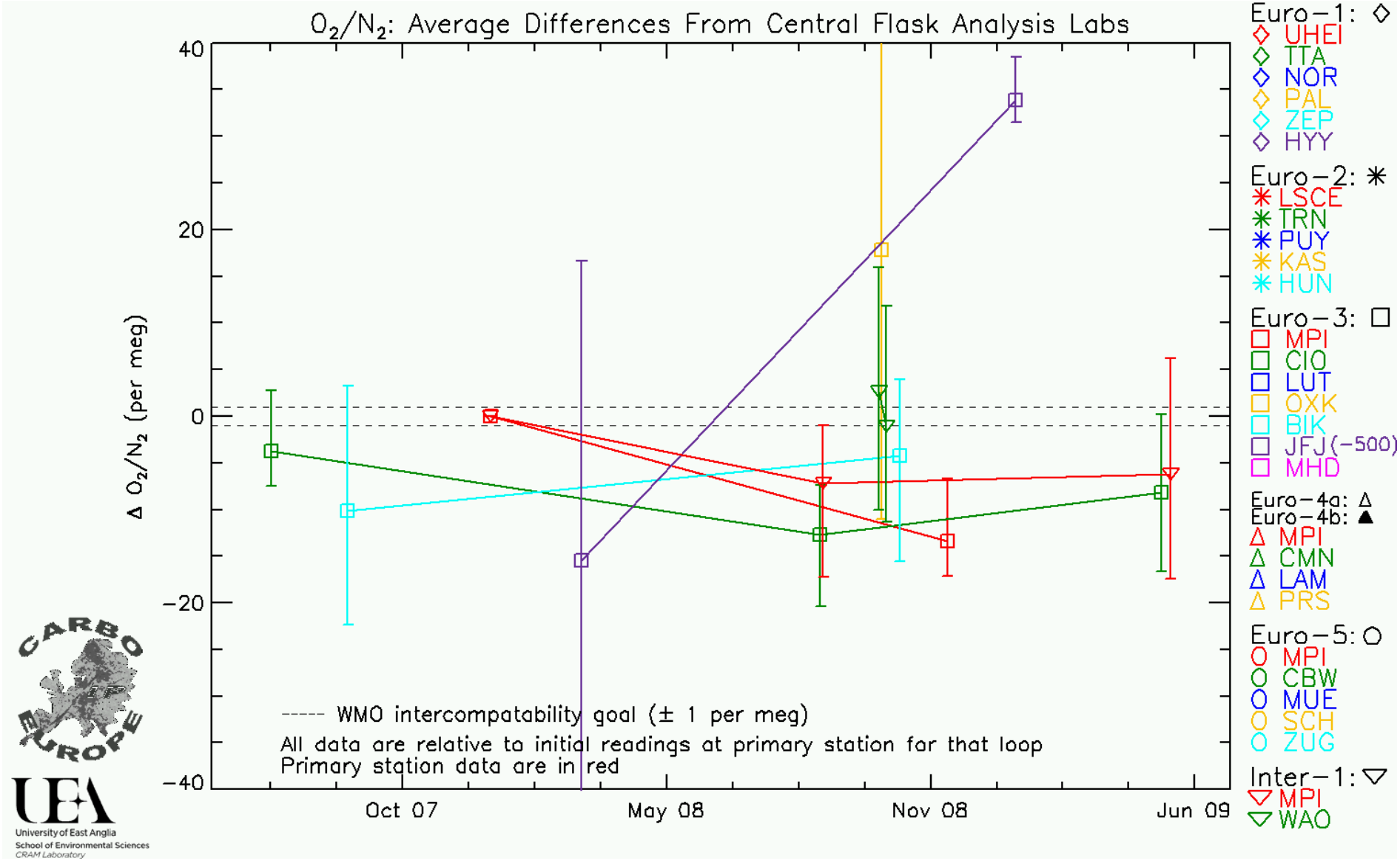

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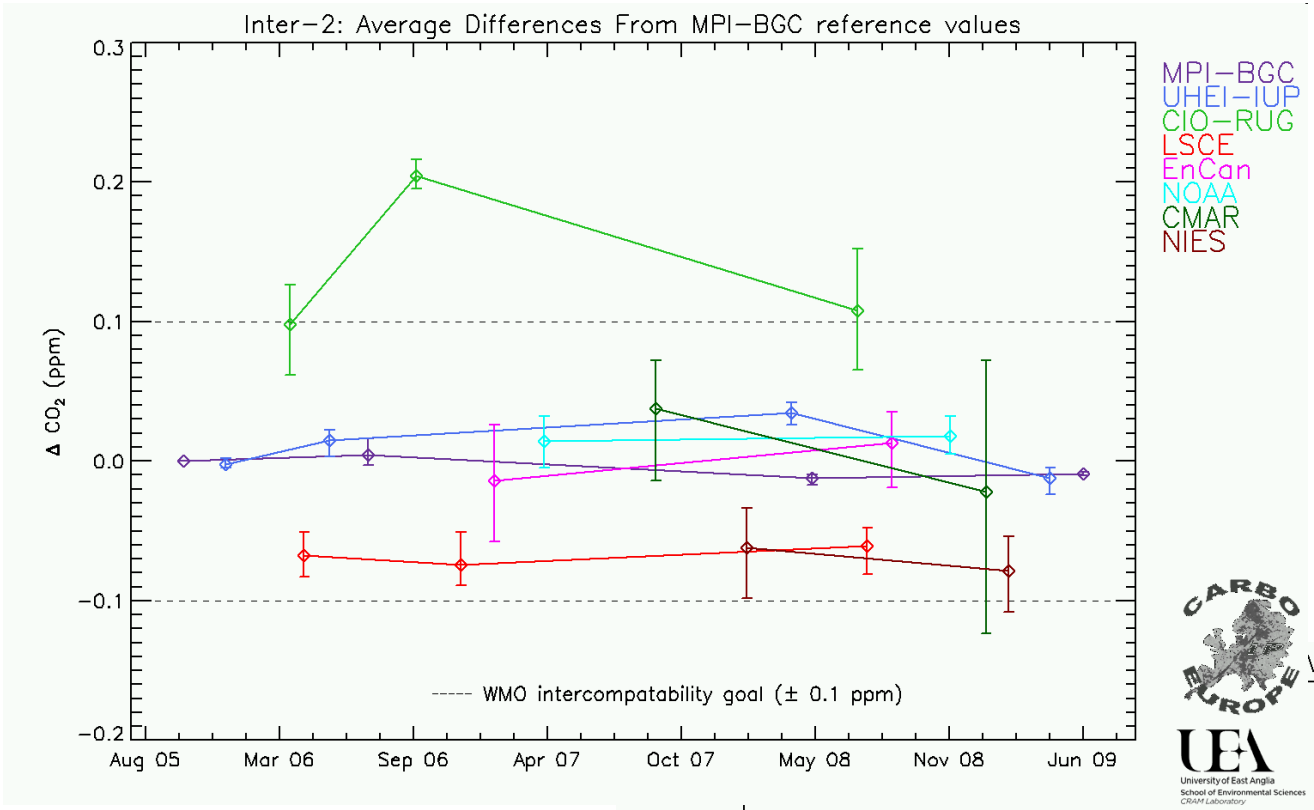
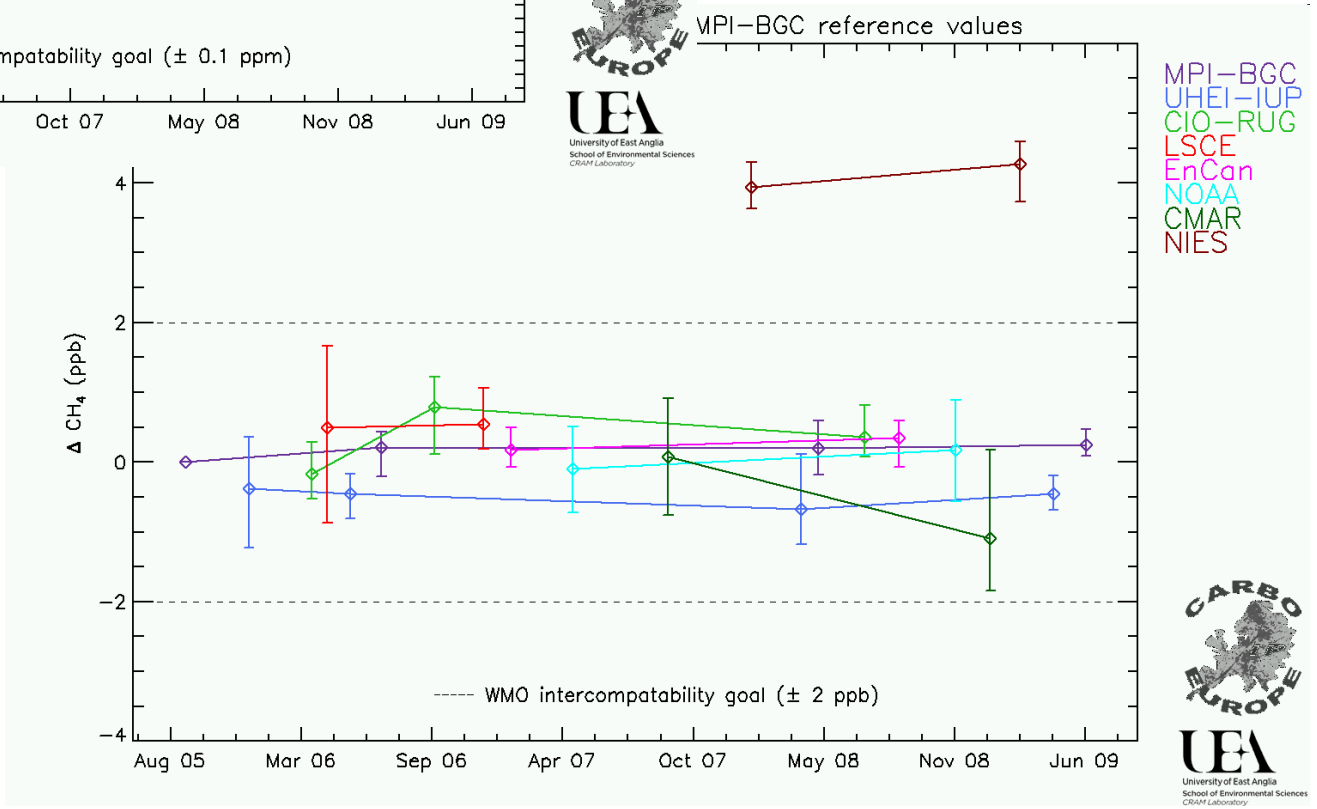
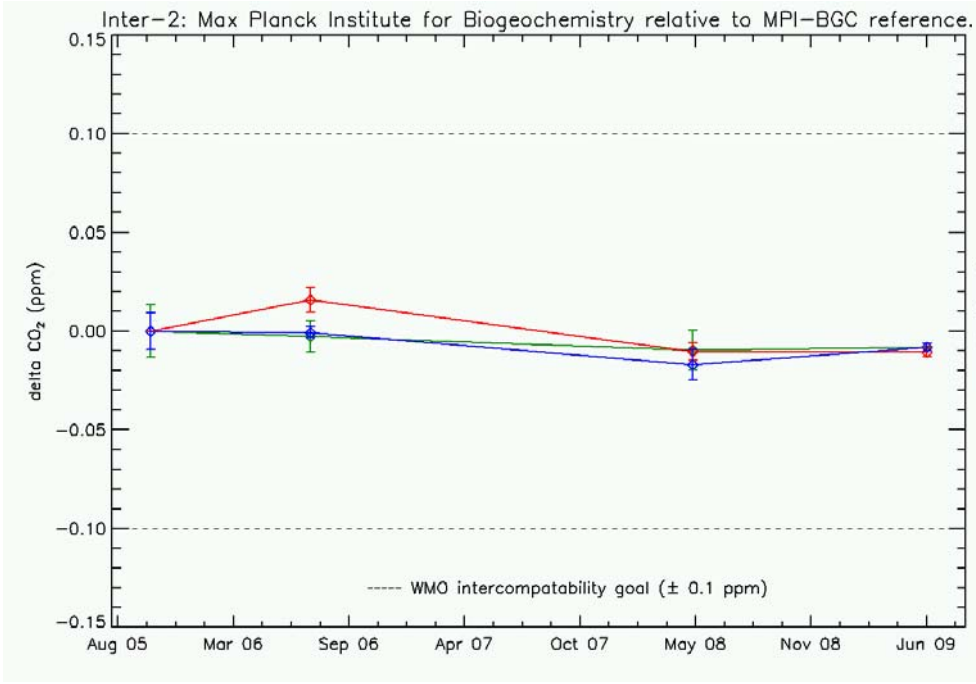
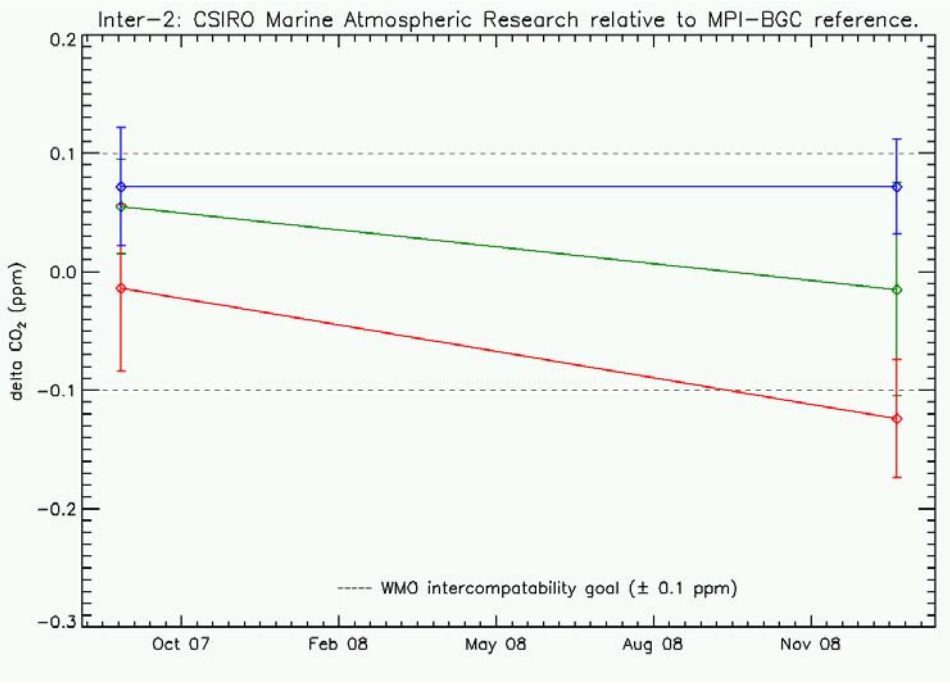
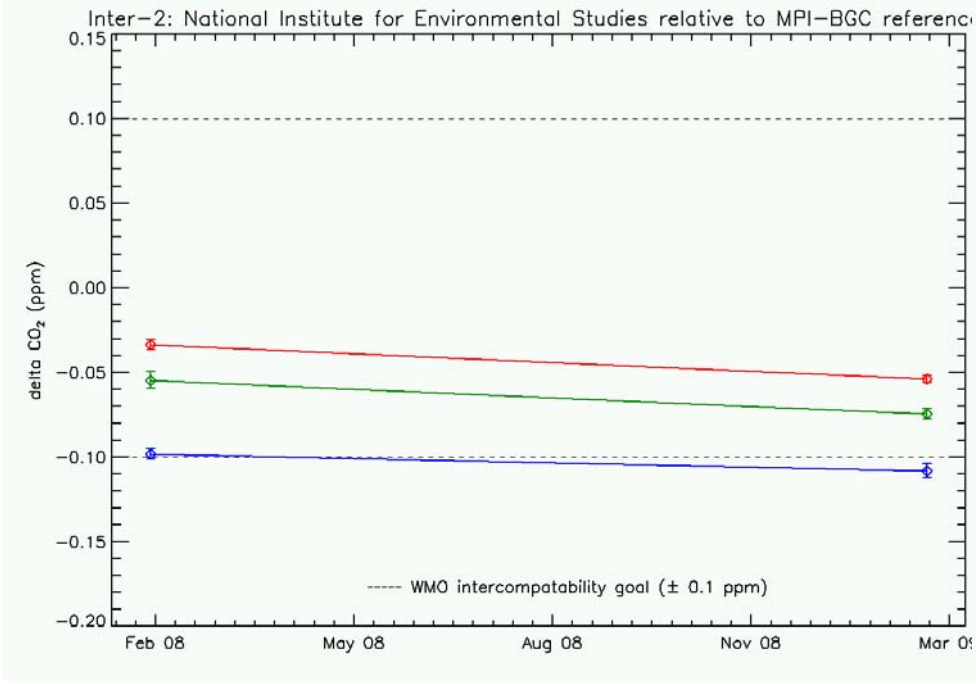
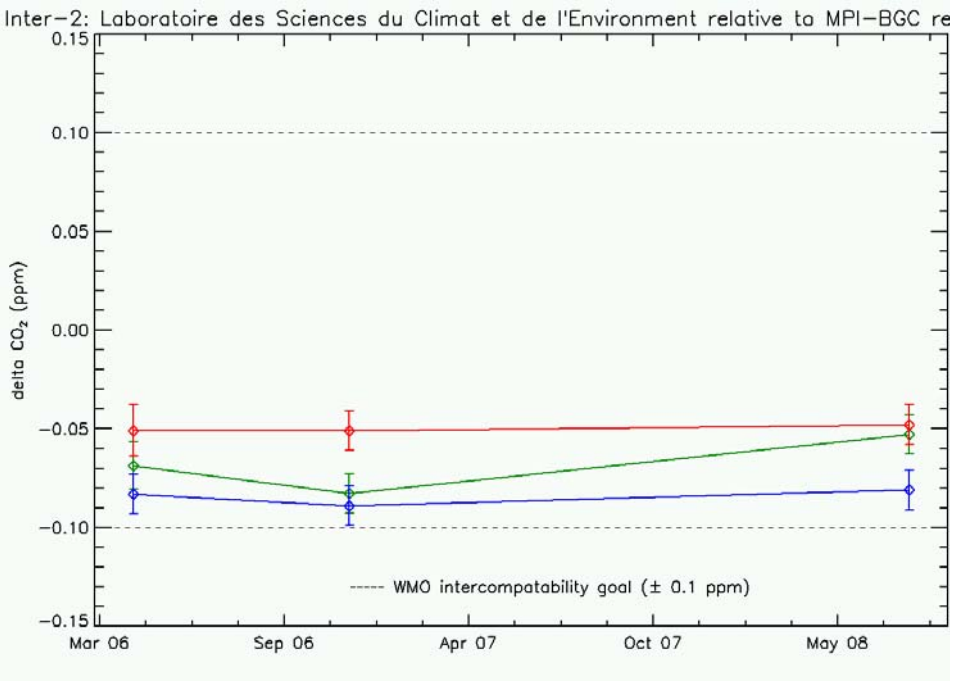

Inter−2: Average Differences From MPI−BGC reference values
MPI−BGC
UHEI−IUP
CIO−RUG
LSCE
EnCan
NOAA
CMAR
NIES
Δ CO2 (ppm)
0.3
0.2
0.1
0.0
−0.1
−0.2
Aug 05
Mar 06
Sep 06
Apr 07
Oct 07
May 08
Nov 08
Jun 09
----- WMO intercompatability goal (± 0.1 ppm)

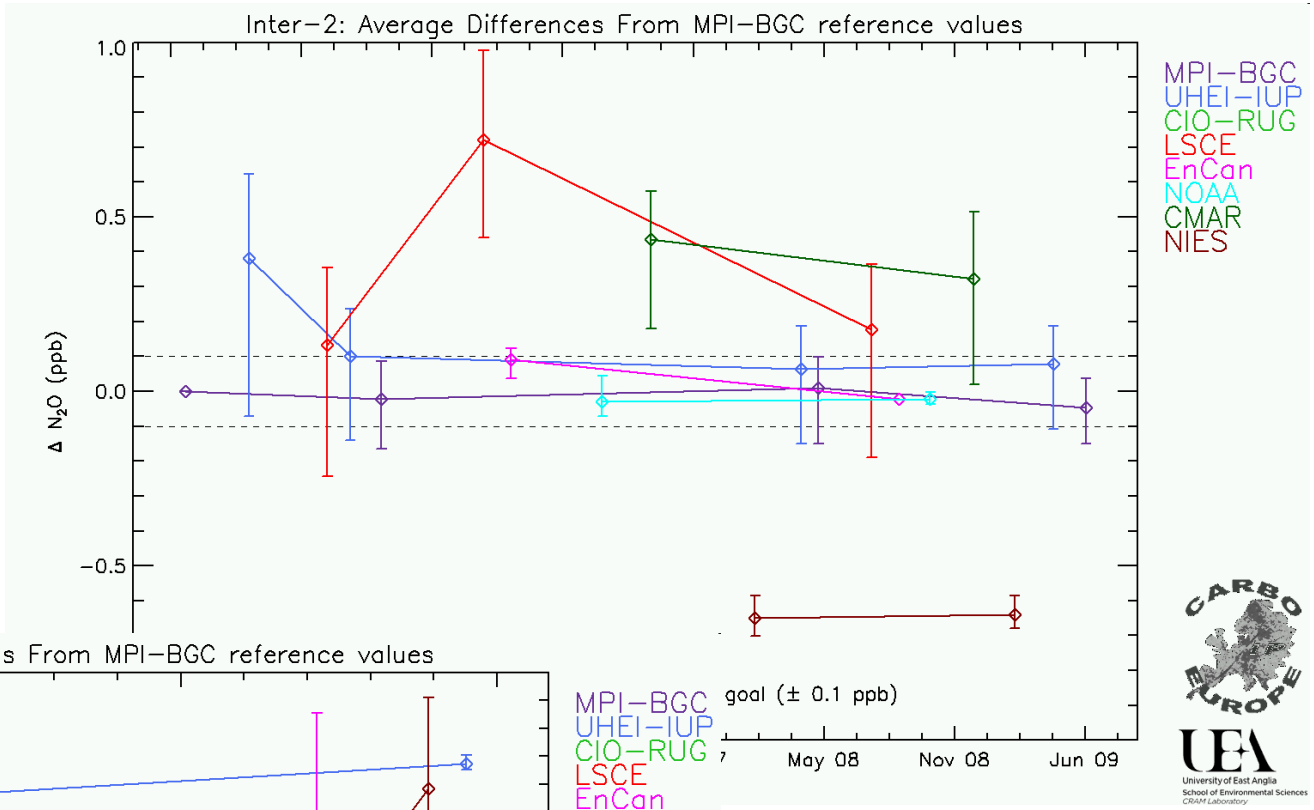

MPI−BGC reference values
MPI−BGC
UHEI−IUP
CIO−RUG
LSCE
EnCan
NOAA
CMAR
NIES
Δ CH4 (ppb)
4
2
0
−2
−4
Aug 05
Mar 06
Sep 06
Apr 07
Oct 07
May 08
Nov 08
Jun 09
----- WMO intercompatability goal (± 2 ppb)

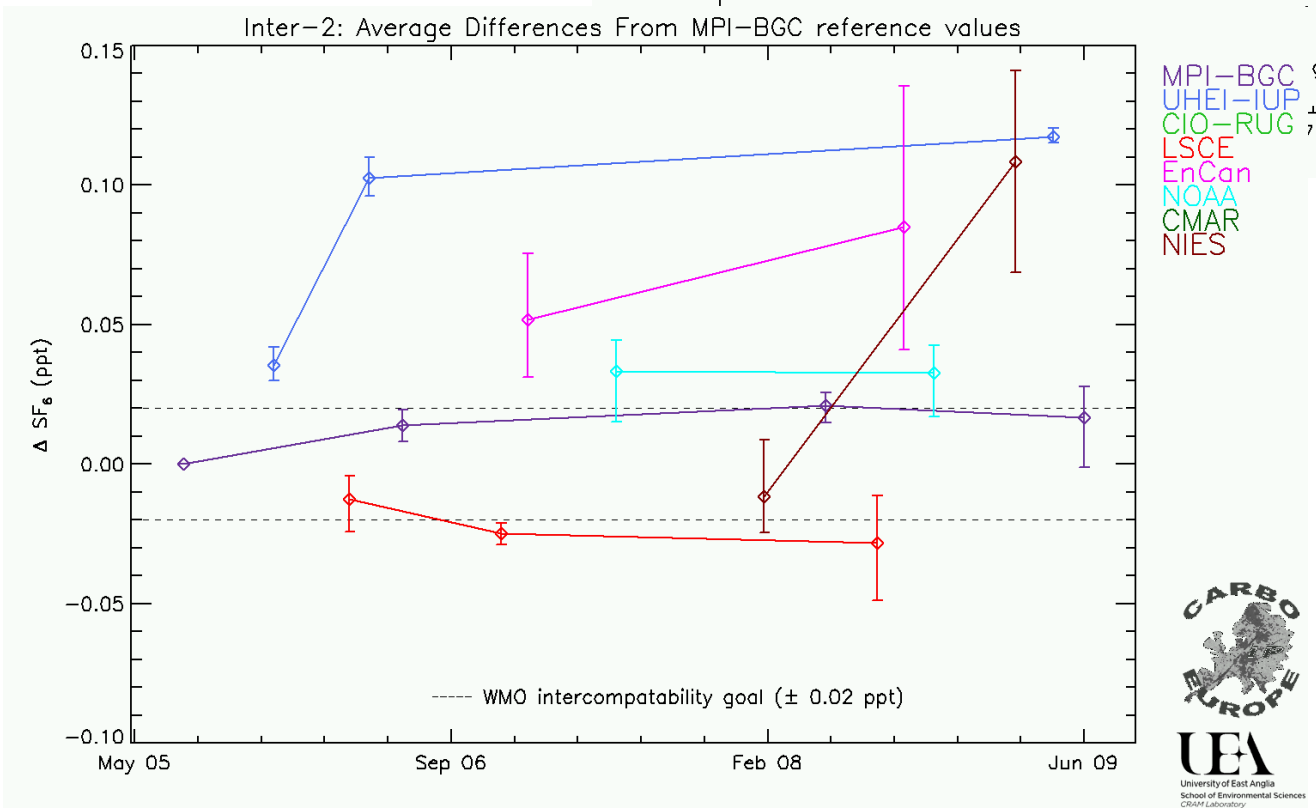

Inter−2: Max Planck Institute for Biogeochemistry relative to MPI−BGC reference.
delta CO_2 (ppm)
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
----- WMO intercompatability goal (± 0.1 ppm)
Aug 05
Mar 06
Sep 06
Apr 07
Oct 07
May 08
Nov 08
Jun 09

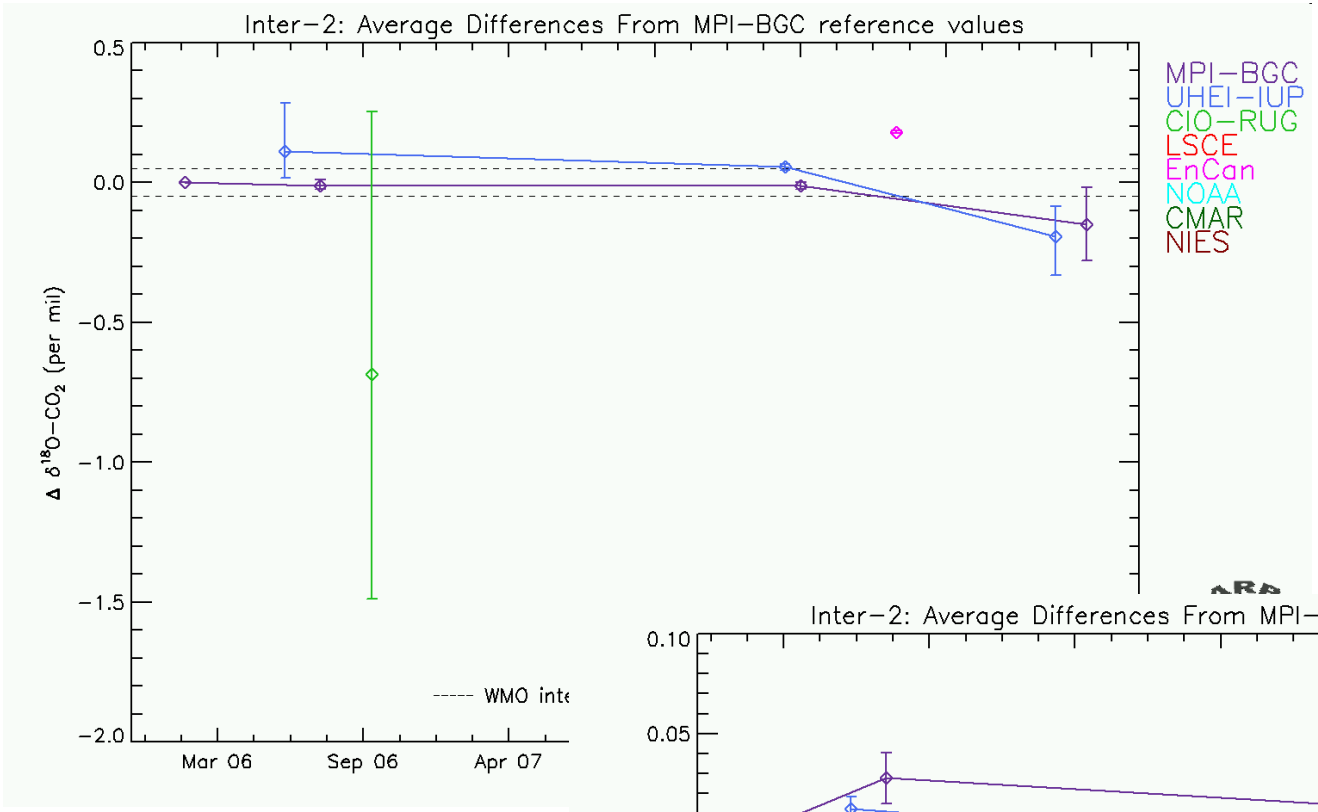

Inter−2: CSIRO Marine Atmospheric Research relative to MPI−BGC reference.
delta CO_2 (ppm)
0.2
0.1
0.0
−0.1
−0.2
−0.3
----- WMO intercompatability goal (± 0.1 ppm)
Oct 07
Feb 08
May 08
Aug 08
Nov 08

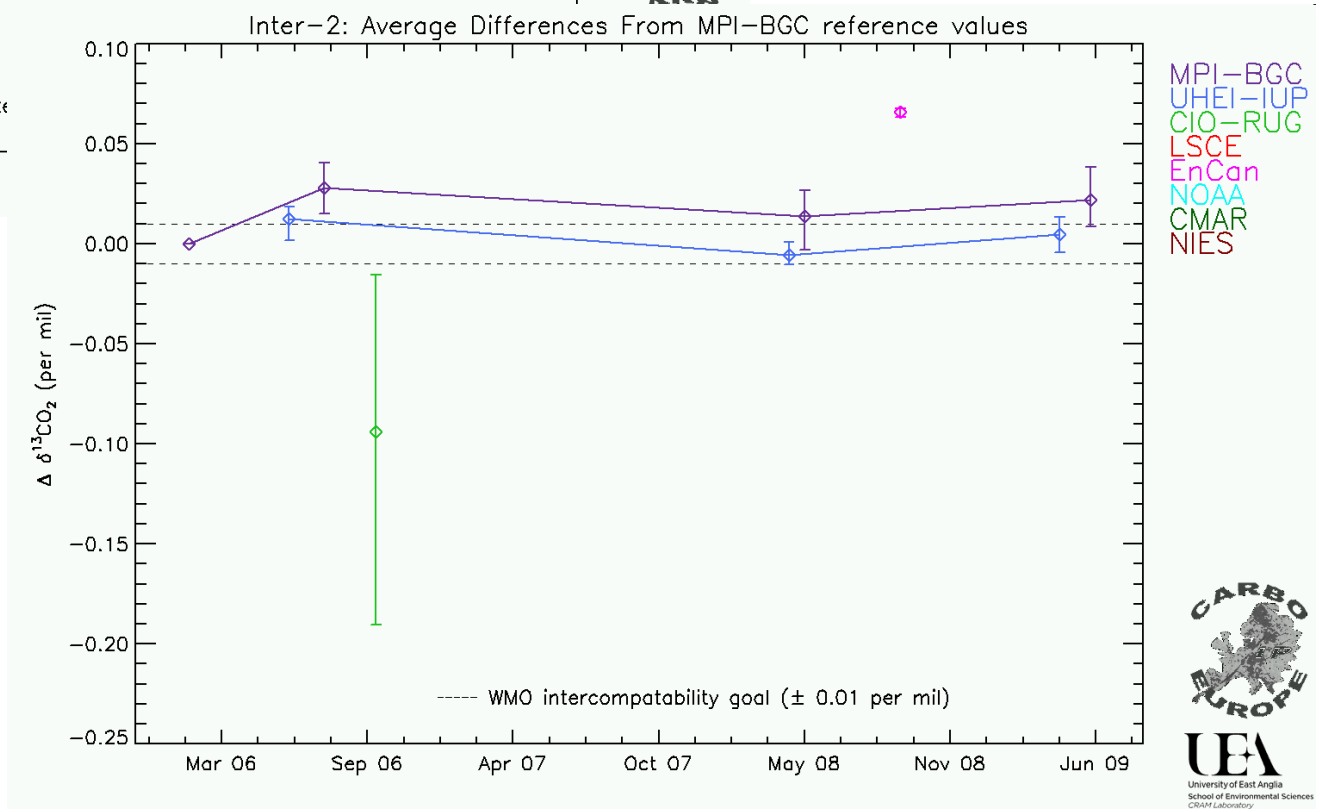

Inter−2: National Institute for Environmental Studies relative to MPI−BGC referenc
delta CO_2 (ppm)
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
−0.20
----- WMO intercompatability goal (± 0.1 ppm)
Feb 08
May 08
Aug 08
Nov 08


Inter−2: Laboratoire des Sciences du Climat et de l'Environment relative to MPI−BGC re
delta CO_2 (ppm)
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
----- WMO intercompatability goal (± 0.1 ppm)
Mar 06
Sep 06
Apr 07
Oct 07
May 08


Inter−2: Average Differences From MPI−BGC reference values
Δ N2O (ppb)
1.0
0.5
0.0
−0.5
MPI−BGC
UHEI−IUP
CIO−RUG
LSCE
EnCan
NOAA
CMAR
NIES
goal (± 0.1 ppb)
May 08
Nov 08
Jun 09


Inter−2: Average Differences From MPI−BGC reference values
Δ SF6 (ppt)
0.15
0.10
0.05
0.00
−0.05
−0.10
MPI−BGC
UHEI−IUP
CIO−RUG
LSCE
EnCan
NOAA
CMAR
NIES
----- WMO intercompatability goal (± 0.02 ppt)
May 05
Sep 06
Feb 08
Jun 09





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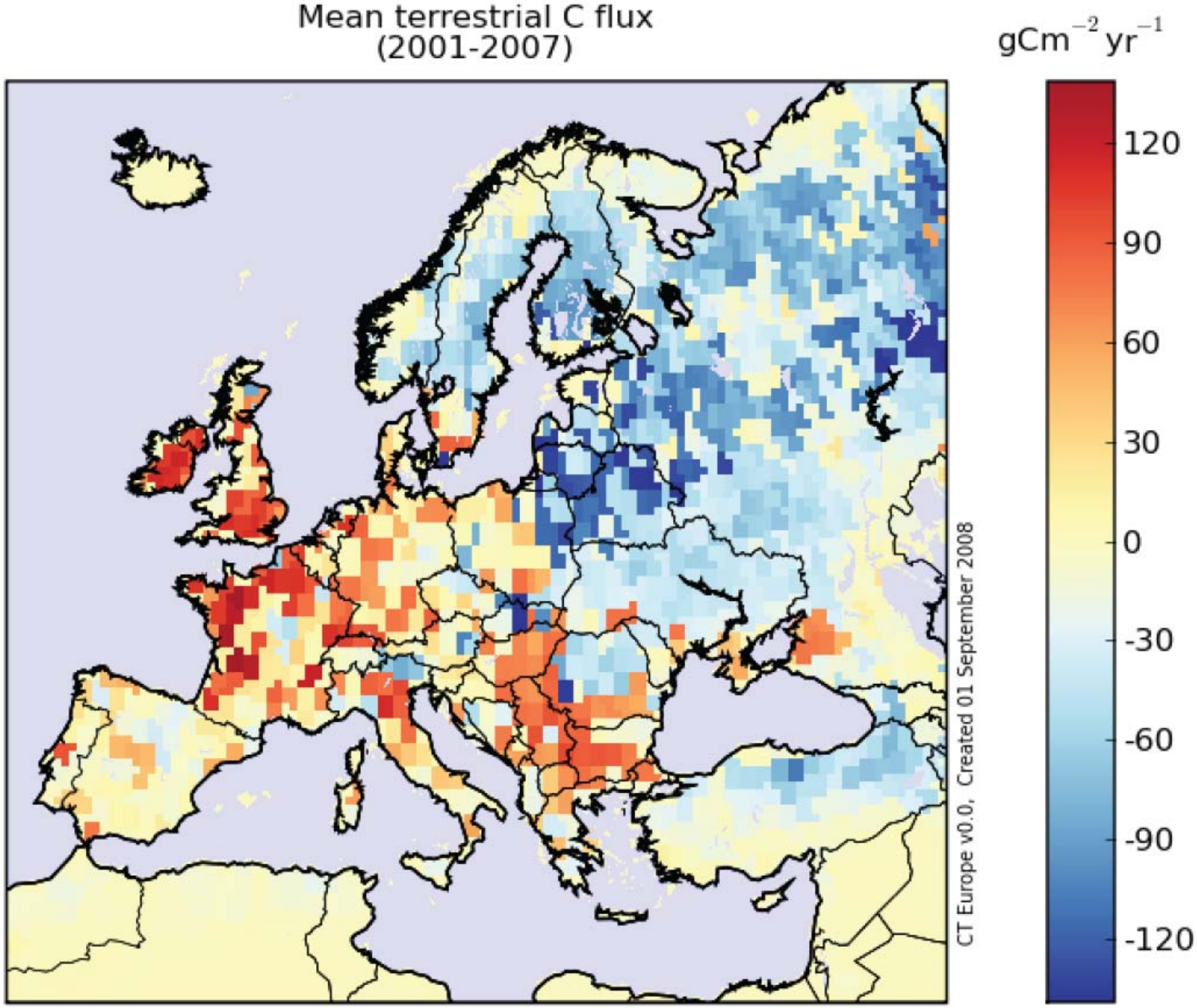
What should we do next?

1) Improve and standardise analytical procedures amongst participants.
2) Identify and assist field stations showing large offsets.
3) Define laboratory offsets for those species without international scales.
4) “Correct” station data based on Cucumber/GOLLUM offsets…….
5) Model sensitivity studies with concentration offsets.

CarbonTracker-Europe; Peters et al., GCB, accepted, 2009.

Code	Name	Lat, Lon, Elev	Lab
		Semi-Continuous continental	
BIK0300_45C9	Bialystok, Poland	53 13'N, 23 1'E, 180.0m	MPI-BGC
CBW0200_52C3	Cabauw, Netherlands	51 58'N, 4 55'E, 200.0m	ECN
HUN0115_35C3	Hegyhatsal, Hungary	46 57'N, 16 39'E, 248.0m	HMS
KAS_53C0	Kasprowy Wierch, Poland	49 13'N, 19 59'E, 1987.0m	AGH
LMP_28C9	Lampedusa, Italy	35 30'N, 12 38'E, 70.0m	ENEA
LMU0079_47C3	La Muela, Spain	41 35'N, 1 50'E, 611.0m	IC3
LUT0060_44C3	Lutjewad, Netherlands	53 21'N, 6 20'E, 60.0m	CIO-RUG
SCH_23C0	Schauinsland, Germany	47 55'N, 7 55'E, 1205.0m	UBA/UHEI-
WES_23C0	Westerland, Germany	54 56'N, 8 0'E, 12.0m	UBA/UHEI-
		Semi-Continuous mountain	
CMN_17C0	Mt. Cimone Station, Italy	44 11'N, 10 42'E, 2165.0m	IMS
PRS_21C0	Plateau Rosa, Italy	45 56'N, 7 42'E, 3480.0m	CESI
PUY_11C0	Puy de Dome, France	45 45'N, 3 0'E, 1465.0m	LSCE
		Semi-Continuous background	
MHD_11C0	Mace Head, Ireland	53 19'N, 9 53'W, 25.0m	LSCE
PAL_30C0	Pallas, Finland	67 58'N, 24 7'E, 560.0m	FMI
ZEP_31C0	Ny-Alesund, Svalbard, Norway and Sweden	78 54'N, 11 53'E, 475.0m	ITM
		Discrete Surface Samples	
BGU_11D0	Begur, Spain	41 50'N, 3 20'E, 30.0m	IC3 & LSCE
BZH_11D0	Portsall, France	48 35'N, 4 40'W, 20.0m	LSCE
FIK_11D0	Finokalia, Greece	35 19'N, 25 40'E, 130.0m	LSCE
JFJ_49D0	Jungfraujoch, Switzerland	46 33'N, 7 59'E, 3580.0m	UBERN
LMP_28D0	Lampedusa, Italy	35 30'N, 12 38'E, 70.0m	ENEA
LPO_11D0	Ile Grande, France	48 35'N, 3 35'E, 20.0m	LSCE
PDM_11D0	Pic du Midi, France	43 4'N, 0 9'E, 2877.0m	LSCE
AZR_01D0	Terceira Island, Azores, Portugal	38 46'N, 27 23'W, 40.0m	ESRL
BAL_01D0	Baltic Sea, Poland	55 21'N, 17 13'E, 3.0m	ESRL
BSC_01D0	Black Sea, Constanta, Romania	44 10'N, 28 41'E, 3.0m	ESRL
HUN_01D0	Hegyhatsal, Hungary	46 57'N, 16 39'E, 248.0m	ESRL
ICE_01D0	Storhofdi, Vestmannaeyjar, Iceland	63 20'N, 20 17'W, 118.0m	ESRL
IZO_01D0	Tenerife, Canary Islands, Spain	28 18'N, 16 29'W, 2360.0m	ESRL
MHD_01D0	Mace Head, Ireland	53 19'N, 9 53'W, 25.0m	ESRL
OBN_01D0	Obninsk, Russia	55 7'N, 36 36'E, 183.0m	ESRL
OXK_01D0	Ochsenkopf, Germany	50 4'N, 11 48'E, 1193.0m	ESRL
PAL_01D0	Pallas-Sammaltunturi, GAW Station, Finland	67 58'N, 24 7'E, 560.0m	ESRL
STM_01D0	Ocean Station M, Norway	66 0'N, 2 0'E, 0.0m	ESRL
ZEP_01D0	Ny-Alesund, Svalbard, Norway and Sweden	78 54'N, 11 53'E, 475.0m	ESRL

CarbonTracker-Europe; Peters et al., GCB, accepted, 2009.



CarbonTracker-Europe; Peters et al., GCB, accepted, 2009.

Sensitivity studies; for year 2005:

Simulation	Forest Tg C/yr	Crop Tg C/yr	Other Tg C/yr	Total Tg C/yr	Deviation (%)
base	-422	107	-51	**-366**	**0**

CarbonTracker-Europe; Peters et al., GCB, accepted, 2009.

Sensitivity studies; for year 2005:

Simulation	Forest Tg C/yr	Crop Tg C/yr	Other Tg C/yr	Total Tg C/yr	Deviation (%)
base	-422	107	-51	**-366**	**0**
B1/M2				-423	-16
B2				-291	21
B3				-535	-46
D2				-333	9
F2				-367	0
O2				-392	-7
O3				-618	-69
O4				**-375**	**-2**
T2				-340	7

CarbonTracker-Europe; Peters et al., GCB, accepted, 2009.

Sensitivity studies; for year 2005:

Simulation	Forest Tg C/yr	Crop Tg C/yr	Other Tg C/yr	Total Tg C/yr	Deviation (%)
base	-422	107	-51	**-366**	**0**
B1/M2	-476	124	-71	-423	-16
B2	-322	78	-46	-291	21
B3	-541	75	-69	-535	-46
D2	-473	200	-59	-333	9
F2	-480	167	-53	-367	0
O2	-404	44	-32	-392	-7
O3	-534	-50	-33	-618	-69
O4	**-504**	**182**	**-53**	**-375**	**-2**
T2	-172	-96	-73	-340	7

CarbonTracker-Europe; Peters et al., GCB, accepted, 2009.

Sensitivity studies; for year 2005:

Simulation	Forest Tg C/yr	Crop Tg C/yr	Other Tg C/yr	Total Tg C/yr	Deviation (%)
base	-422	107	-51	**-366**	**0**
B1/M2	-476(13%)	124(16%)	-71(39)	-423	-16
B2	-322(-24%)	78(-27%)	-46(-10%)	-291	21
B3	-541(28%)	75(-30%)	-69(35%)	-535	-46
D2	-473(12%)	200(87%)	-59(16%)	-333	9
F2	-480(14%)	167(56%)	-53(4%)	-367	0
O2	-404(-4%)	44(-59%)	-32(-37%)	-392	-7
O3	-534(27%)	-50(-147%)	-33(-35%)	-618	-69
O4	**-504(19%)**	**182(70%)**	**-53(4%)**	**-375**	**-2**
T2	-172(-59%)	-96(-190%)	-73(43%)	-340	7

Conclusions

1) Please send me more Ar/N_2, $\delta^{13}CO_2$, $\delta^{18}O$-CO_2 results.
2) Please submit your data **on time = 4 weeks after your analyses!** (Longest Cucumber delay = 133 weeks!!)

   Although I have presented a lot of data, there is still quite a lot that has not been submitted.
3) Both GOLLUM and Cucumber programmes are running smoothly and producing important data. Plan to continue indefinitely.
4) Two labs have complained about the logsheets: I'm happy to discuss alternative formats for receiving data. CSV file, perhaps?
5) The community should make a concerted effort to improve the results from the field stations that are struggling; through WCC's, EMPA, ICOS, etc.
6) We should start thinking about possibilities for "correcting" station data.
7) Thanks to everyone for contributing and making these programmes a success!