Project:
GEOCARBON

Project full title:
Operational Global Carbon Observing System

European Commission - FP7
Collaborative Project (large scale integrating project) - for specific cooperation actions (SICA) dedicated to international cooperation partner countries
Grant agreement no.: **283080**

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Lead beneficiary: UEA
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Actual delivery date (project month): 15

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1. Introduction

1.1 Short summary

We have published the 2012 update of the global CO_2 budget in coordination with the Global Carbon Project. The budget was launched simultaneously as a commentary in the journal Nature Climate Change (Peters et al. 2013) with full data released by the journal Earth System Science Data Discussions (Le Quéré et al. 2012). With collaborators around the world, we issued press releases in the UK, France, Germany, Norway, the US, China, and Australia. All press releases can be found on the web site of the Global Carbon Project (http://www.globalcarbonproject.org/carbonbudget). We also released a powerpoint presentation with 40 slides, references and explanations of the highlights (also available on the web site above). An initial summary of the media coverage is provided in Appendix A.

The budget was presented to policy makers at the Doha COP meeting by GEOCarbon PI Riccardo Valentini, in a side session co-organised by GEOCarbon entitled ‘Deforestation Emissions in the Global Context’.

Regional budgets for 2011 were presented only in part in the Le Quéré et al. (2012) paper. This year we have published an analysis for all land and oceanic regions for 1990-2009 in Sitch et al. (2012). We include below the CO_2 budget for large terrestrial and oceanic regions for up to 2011, updating and expanding on the results presented in Sitch et al. (2012).

1.2 Rationale for this deliverable

This deliverable helps address the following objectives of GEOCarbon:

• Provide an aggregated set of harmonized global carbon data information (integrating the land, ocean, atmosphere and human dimension)

• Provide comprehensive and synthetic information on the annual sources and sinks of CO2 for the globe and for large ocean and land regions

1.3Problems encountered and envisaged solutions

For the oceanic regions, the data-based analysis provided by WP4 could not be used to assess CO_2 fluxes up to year 2011 as the input data were not yet available and the analysis did not yet provide sufficiently credible results. We are working on this and hope to resolve the issues to at least provide an estimate to 2010 next year. Instead here we compared regional CO_2 fluxes from forced models provided with the Le Quéré et al. (2012) global CO_2 budget, and compare those to an atmospheric inversion.

2 Full description

2.1 Updates on the terrestrial carbon budgets of Europe, China and Russia

Han Dolman, You-Ren Wang, Philippe Ciais, Frederic Chevallier, Shushi Peng, Guido van der Werf and Wouter Peters

Version 1.0, 24-12-12

The baseline for these updates is the set the papers published through RECAPP on Europe (Luyssaert et al., 2012), Russia (Dolman et al., 2012) and China (Piao et al., 2012). The “data” used is model output from the LSCE inversion (the Chevallier 4DVAR inversion), the CarbonTracker (NOAA version and EU version) and CASA runs performed by van der Werf at VUA that also give biomass burning estimates. The grid masks used conform to the RECAPP land masks. Note that the CASA estimates assume a steady state in the carbon balance between respiration and GPP, so cannot be used for other purposes than interannual variability and trends.

Europe.

Europe (Pg C) Positive fluxes are from atmosphere to land					
	Biomass burning	CASA	LSCE	CT-NOAA	CE-EU
2000	-0.0094	-0.035	0.031	0.444	
2001	-0.0091	-0.051	-0.078	0.394	
2002	-0.0075	-0.009	-0.082	0.386	
2003	-0.0057	0.005	0.009	0.468	
2004	-0.0034	-0.033	-0.047	0.414	
2005	-0.0070	0.020	0.233	0.435	
2006	-0.0059	-0.088	0.225	0.247	
2007	-0.0090	0.036	0.019	0.356	0.306
2008	-0.0072	0.007	0.280	0.336	0.490
2009	-0.0041	0.053	0.363	0.440	0.454
2010	-0.0030	0.023	0.264	0.353	0.346

2011	-0.0030	0.129	0.472

Table 1. Carbon budget estimates for Europe (PgC), Positive fluxes are from atmosphere to land.

Table 1 gives the estimates for Europe. The time evolution is depicted in the top panel of Figure 1. Luyssaert et al found good agreement between the GHG balances of Europe for fluxes (353 ± 149 Tg C yr^{-1}), inventories (354 ± 55 Tg C yr^{-1}) and inversions (330 ± 110 Tg C yr^{-1}). Their analysis did not include European Russia, as this was dealt with separately by Dolman et al. (2012). Focusing on the last few years and Figure 1a) we notice that 2010 generally presents a somewhat lower estimate than 2011 and the previous year 2009. 2009 clearly was a higher productivity year, while 2010 suffered, like 2003, from droughts. 2011 in the LSCE inversion shows a rather high uptake, this is also noticeable in CASA and this probably reflects good climatic conditions in 2011 for enhanced uptake.

Russia

Dolman et al. (2012) determine the net land to atmosphere flux of carbon in Russia, including Ukraine, Belarus and Kazakhstan, using inventory-based, eddy covariance, and inversion methods. Their low boundary estimate is 342 Tg C yr−1 from the eddy covariance method, and this is close to the upper bounds of an inventory-based Land

Russia (Pg C)					
	Biomass burning	CASA	LSCE	CT-NOAA	CE-EU
2000	-0.1443	0.046	0.862	0.565	
2001	-0.1155	0.080	1.098	0.676	
2002	-0.1973	0.140	1.167	0.615	
2003	-0.3339	0.167	0.902	0.663	
2004	-0.0203	-0.119	1.190	0.624	
2005	-0.0549	0.133	1.443	0.679	
2006	-0.1032	-0.016	1.176	0.708	
2007	-0.0542	0.072	1.411	0.756	0.830
2008	-0.1732	-0.022	0.943	0.619	1.059
2009	-0.0730	0.255	1.499	0.690	1.099
2010	-0.0908	0.141	0.832	0.686	0.814
2011	-0.0931	0.129	0.511		

Table 2. Carbon budget estimates for Russia (PgC), Positive fluxes are from atmosphere to land.

Ecosystem Assessment and inverse models estimates. A high boundary estimate is provided at 1350 Tg C yr−1 from the inversion models. The average of the three methods is 613.5 Tg C yr−1. The CT-NOAA estimate is close to their average value and confirms the observation of little interannual variability. In contrast the CT-EU estimate is higher and show the expected lower estimate of 2010. The LSCE inversion shows considerable more interannual variability and, importantly, suggests a declining trend over the last 4 years.

China

Piao et al (2012) estimate the magnitudes of East Asia's terrestrial carbon at −0.293 ± 0.033 PgC yr−1 from inventory–remote sensing model–data fusion approach, −0.413 ± 0.141 PgC yr−1 (not considering biofuel emissions) or −0.224 ± 0.141 PgC yr−1 (considering biofuel emissions) for carbon cycle models, and −0.270 ± 0.507 PgC yr−1 for atmospheric inverse models. These numbers agree with the current estimates. 2010 is a somewhat lower estimate, also indicated by CASA as a source, while the CT-EU estimates indicates larger interannual variability than the other CT-NOAA inversion. The LSCE inversion shows some more interannual variability and agrees very well with the new CT-EU results.

China (Pg C)					
	Biomass burning	CASA	LSCE	CT-NOAA	CE-EU
2000	-0.0162	-0.076	0.291	0.186	
2001	-0.0042	-0.023	0.399	0.194	
2002	-0.0044	0.094	0.325	0.124	
2003	-0.0253	-0.021	0.189	0.175	
2004	-0.0068	0.029	0.354	0.181	
2005	-0.0057	-0.044	0.152	0.142	
2006	-0.0088	0.021	0.437	0.133	
2007	-0.0067	0.052	0.316	0.116	0.214
2008	-0.0100	0.026	0.508	0.102	0.363
2009	-0.0095	0.049	0.620	0.186	0.526
2010	-0.0074	-0.044	0.231	0.152	0.219
2011	-0.0015	0.065	0.571		

Table3. Carbon budget estimates for China (PgC), Positive fluxes are from atmosphere to land.

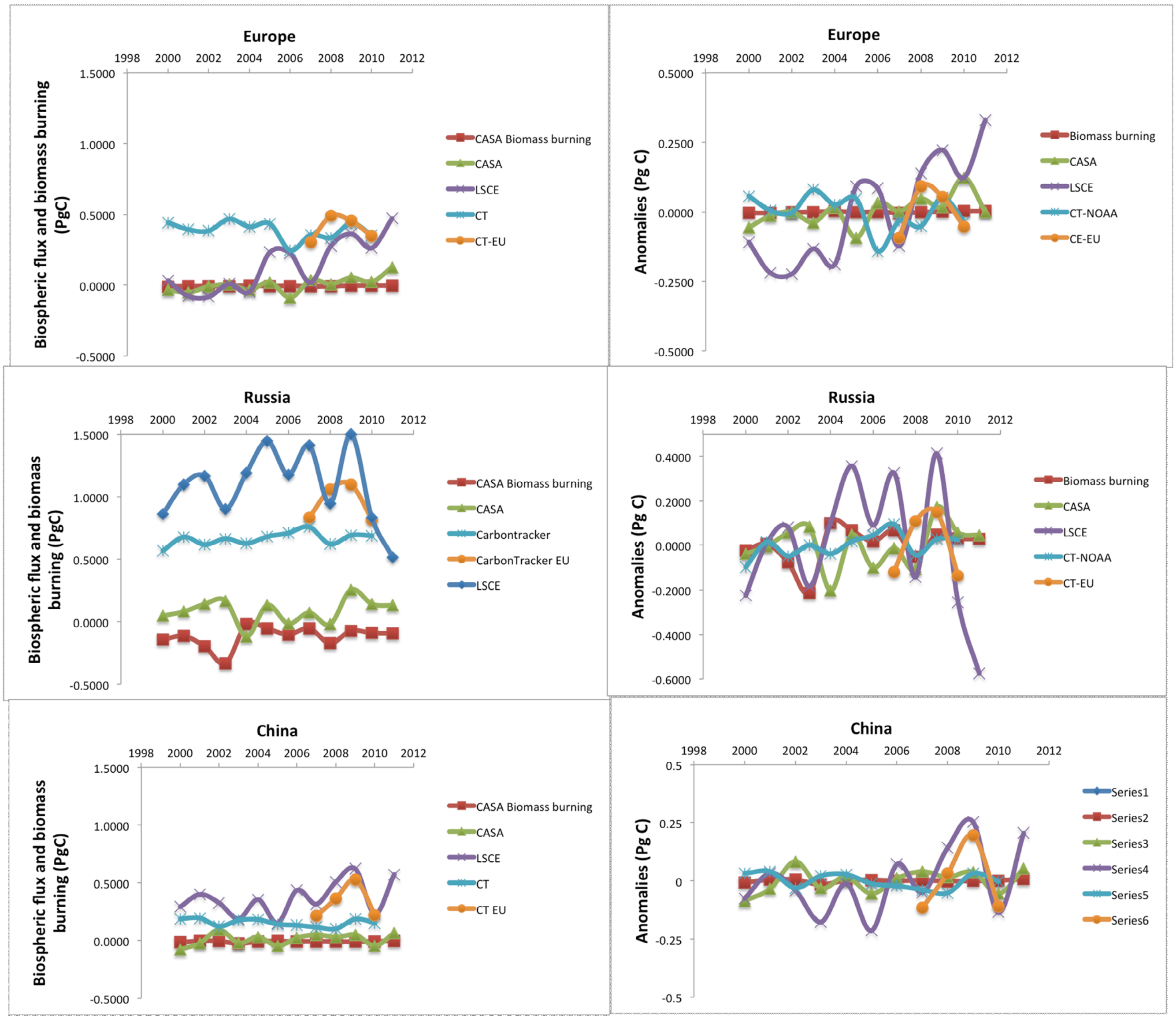

Figure 1. Biospheric and biomass burning fluxes (right panels) for Europe (top) , Russia (middle) and China (bottom) and anomalies compared to the 200o-2010 average in Pg C (left panels).

2.2 Updates on the carbon budgets over large oceanic regions

Steve Jones and Corinne Le Quéré

The baseline for these updates is the set in Sitch et al. (2012) published through RECAPP.

Air-sea CO_2 fluxes have been calculated for four forced ocean biogeochemical models (Bergen MICOM-HAMMOCC [*Assmann et al. 2010*], LSCE [], UEA NEMO-PlankTOM5 [*Le Quéré et al. 2010*] and WHOI BEC [*Thomas et al. 2008*]) and one atmospheric CO_2 inversion model [*Chevallier et al. 2005*]. In 2011, the ocean was a CO_2 sink in all models, with a mean sink of 2.35 ± 0.59 Pg C. All models exhibited an increased sink over 2010; three models (Bergen, WHOI and Chevallier) showed a significantly larger change in sink than in previous years, although the large changes occurred in different regions in each model indicating that these large increases are due to variability between models rather than any changes in the real air-sea flux.
All models have shown an increase in sink over the 1999-2008 long term mean sink in both 2010 and 2011 with the exception of Chevallier which was level with the long term mean in 2010.

Therefore the model ensemble indicates that ocean sinks are likely to be exhibiting a long term increase in sink trends independent of interannual variability.

Regional Fluxes

Southern Ocean: All models have shown an increasing sink (or decreasing flux in the case of WHOI), with changes of similar magnitude from previous years indicating stable interannual variability (Table 1).

Atlantic Ocean: All models see a marked increase in fluxes in the Equatorial/South Atlantic compared to both the long-term mean and the 2010 fluxes. All models show a similar increase in 2011 compared to the 1999-2008 mean, although the 2010 fluxes are markedly different indicating that this is more likely to be coincidence that any systematic similarity between models.

North Atlantic: The North Atlantic shows a similar magnitude of increasing flux as the Equatorial/South Atlantic between 2010 and 2011, although the overall level of flux related to the 1999-2008 mean is much more varied. This suggests that interannual variability is a much greater influence on fluxes in this region.

Indian Ocean: All the forced models show an increased carbon sink between 2010 and 2011 in the Indian Ocean, while the Chevallier inversion model has a decrease in sink of similar magnitude. There is no consistency between the models regarding difference in the recent fluxes and the 1999-2008 mean.

South Pacific: The forced models show a range of decreasing sinks in the South Pacific with the exception of Bergen, which has a very slight increase in the sink (Table 1). The Chevallier inversion model contrasts with this, with an increase in sink of a similar magnitude to the decreases seen in the other models.

Equatorial Pacific: All models with the exception of Bergen show that the outgassing increased in 2011. However, the models also show that the outgassing in both 2010 and 2011 was below that of the 1999-2008 mean, which may indicate that the CO_2 fluxes are returning to their 'background' state following the 2009-2010 positive El Niño phase[1].

North Pacific: As in the South Atlantic, the forced models show a decreasing efficiency in the CO_2 sink in the North Atlantic in 2011. However, all showed increased sinks over the 1999-2008 mean in 2010, and only the LSCE model shows a weaker sink than the long-term mean in 2011. This suggests that the sinks in the North Pacific are tending towards a consistently increasing sink. The Chevallier inversion exhibits a very large increase in the sink compared to the forced models, accounting for approximately one third of the model's total increase in sink between 2010 and 2011.

Forced versus Inversion Models: The single inversion model used here shows some stark differences to the results of the forced models in certain regions of the world's oceans, particularly in the South Pacific, North Pacific and Indian oceans. Further investigations, particularly with other inversion models, will be required to determine whether or not these are due to fundamental differences in the nature of the modelling approaches.

[1] See http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

Table 1 Changes in air-sea CO_2 flux between 2010 and 2011 in five models. The top portion of the table list changes in the regions shown in Figure 1, with the 'Other' region showing the change in flux for parts of the ocean not covered by those regions. The last row of the table shows the total global flux for 2011 for comparison with the change in fluxes.

Region	**Bergen**	**LSCE**	**UEA**	**WHOI**	**Chevallier**
Southern Ocean	-0.114	-0.020	-0.008	-0.136	-0.080
Eq/S Atlantic	-0.075	-0.072	-0.051	-0.051	-0.108
North Atlantic	-0.026	-0.037	-0.056	-0.068	-0.060
Indian Ocean	-0.064	-0.003	-0.053	-0.014	**0.037**
South Pacific	-0.008	**0.024**	**0.078**	**0.046**	-0.039
Eq. Pacific	-0.071	**0.048**	**0.019**	**0.038**	**0.038**
North Pacific	**0.048**	**0.162**	**0.028**	**0.041**	-0.117
Other	*-0.013*	*-0.121*	*-0.011*	*-0.008*	*-0.007*
Globe	-0.323	-0.019	-0.054	-0.152	-0.336
2011 Global Flux	-3.328	-2.422	-2.354	-1.684	-1.951

3 References

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Appendix A

Global Carbon Budget 2012

Media Presence (Press, TV, Radio)

Press Agencies and Media Networks:

1. Agence France Presse (AFP)
2. Reuters
3. Bloomberg
4. Australian Associated Press
5. Australian Science Media Centre
6. EurekAlert

AUSTRALIA and NEW ZEALAND:

1. ABC TV – News, Sarah Clarke
2. ABC TV - The Drum
3. ABC TV - 7.30 Report
4. SkyNews TV
5. SBS TV – World News
6. ABC Radio - Sarah Clarke
7. SMH/The Age/WA - Ben Cubby/Tom Arup
8. Australian Financial Review - Marcus Priest
9. Adelaide Advertiser - Clare Peddie
10. The Mercury, Peter Boyer
11. Radio National Breakfast - Gregg Borschmann
12. New Scientist – Michael Slezak
13. The Australian - Graham Lloyd
14. Daily Telegraph - Malcolm Holland
15. Science Show - Robyn Williams
16. ABC Science Online – Darren Osborne
17. Brisbane Courier Mail – Brian Williams
18. Brisbane Times
19. Canberra Times
20. Australasian Science
21. The Conversation
22. Eco News
23. Cleantech
24. Herald Sun
25. Financial Review
26. Climate Spectator
27. World.edu
28. Crikey
29. Nine MSN
30. Galileo
31. World News – The International News Magazine
32. Renew Economy
33. News NZ (New Zealand)
34.The New Zealand Herald (New Zealand)

USA and CANADA:

1. NY Times - Justin Gillis
2. ABCChicago
3. Edmond Sun
4. Science Daily
5. Digital Journal
6. ABC News
7. The Raw Story
8. Richard Dawkins
9. Scientific American
10. Climate Central
11. The American Resolution
12. Watching The Deniers
13. Time
14. Sci-Tech Today
15. The Seattle Times
16. A Newer World
17. UPI.com
18. The Daily Caller
19. Planetsave
20. Greener Ideas
21. Science Recorder
22. The Daily Targum
23. Red Orbit
24. Kaleo
25. TG Daily
26. Think Progress
27. Greenbang
28. Grist
29. The World News
30. The Huffington Post
31. Salon
32. The Boston Globe
33. Marketplace Sustainability
34. Radio The Voice of Russia, American Edition
35. The Princeton Packet
36. Medill Reports Chicago
27. Democracy Now
28. Free Speech Radio News
29. The Week
30. Kennebec Journal
31. The Daily Beast
32. The Star (Canada)
33. The Spec (Canada)
34. Pieuvre (Canada)
35. Radio Canada (Canada)
36. Vancouver Observer (Canada)

UK:
1. BBC News
2. The Telegraph
3. Phys Org

4. The Guardian
5. The Independent
6. Environmental Research Web
7. DocuTicker
8. Planet Earth Online

EUROPE:
1. El Pais Sociedad (Spain)
2. El Tribuno (Spain)
3. Heraldo (Spain)
4. Ecoticias (Spain)
5. Elomundo (Spain)
6. BBC Mundo (Spain)
7. Tendencias (Spain)
8. Saludable (Spain)
9. Diario Siglo XXI (Spain)
10. Spanish China.org (Spain)
11. Kerryman (Ireland)
12. Belfast Telegraph (Ireland)
13. Innovations Report (Germany)
14. TLZ (Germany)
15. Web.de (Germany)
16. Spiegel Online (Germany)
17. DW (Germany)
18. News.at (Germany)
19. Agitano (Germany)
20. Telepolis (Germany)
21. Junge Welt (Germany)
22. Die Welt (Germany)
23. Krone (Germany)
24. Strom Magazin (Germany)
25. RP Online (Germany)
26. Suddeutsche (Germany)
27. Rote Fahne News (Germany)
28. Informationsdienst Wissenschaft (Germany)
29. Citepa (France)
30. Ouest France (France)
31. I’union L’Ardennais (France)
32. Radio Free Europe Radio Liberty (Czech republic)
33. GeoCarbon (Italy)
34. Scienze-Naturali (Italy)
35. Ambiente Rinnovabili (Italy)
36. Green Style (Italy)
37. Lettera43 (Italy)
38. La Presse (Italy)
39. РиА Новости (Russia)
40. Главное (Russia)
41. Market Leader (Russia)
42. Diaro de Pernambuco (Portugal)
43. Outras Midias (Portugal)
44. Teknisk Ukeblad (Norway)

45. Cicero (Norway)
46. Metro (Netherlands)
47. Reformatorisch Dagblad (Netherlands)
48. Blik do nieuws (Netherlands)
49. Scientias (Netherlands)
50. Vroege Vogels (Netherlands)
51. Radio Europa Libera (Romania)
52. Planet Siol (Slovenia)
53. iKypros (Greece)
54. Index (Greece)
55. L'essential online (Luxembourg)
56. Money (Poland)

ASIA:
1. The Hindu (India)
2. First Post (India)
3. Hindustan Times (India)
4. Silicon India (India)
5. ZeeNews (India)
6. The Times of India (India)
7. IAS100 (India)
8. Indolink (India)
9. Samay Live (India)
10. The Siasat Daily (India)
11. Business Standard (India)
12. ARY News (Pakistan)
13. Manilla Bulletin (Philippines)
14. South China Morning Post (China)
15. The Whole World Overview (China)
16. World Journal (China)
17. Fortune (China)
18. Guancha (China)
19. Epoch Times (China)
20. www.news.cn (China)
21. China Light Industry Internet (China)
22. AFPBB News (China)
23. Sing Tao National Network (China)
24. Berita Satu (Indonesia)
25. DatViet Khoa Hoc (Vietnam)
26. Nguoi Viet (Vietnam)
27. Dat Viet (Vietnam)
28. Khoahoc (Vietnam)
29. Người Việt (Vietnam)

CENTRAL/SOUTH AMERICA:
1. Brasilia em Tempo Real (Brazil)
2. Veja (Brazil)
3. OutrasMidias (Brazil)
4. Diário de Pernambuco (Assinatura)
5. Hoy Digital (Dominican Republic)
6. El Comercio (Ecuador)

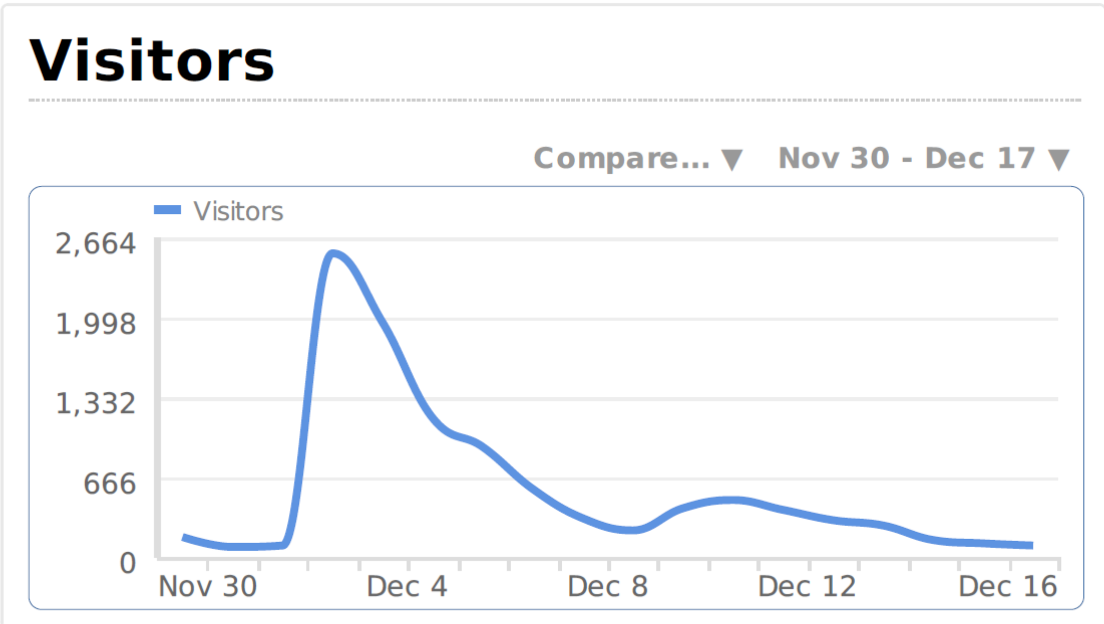
7. Latercera (Chile)
8. El Tribuno (Argentina)

AFRICA:
1. iol scitech (South Africa)

MIDDLE EAST:
1. YNet News (Israel)

UNKNOWN COUNTRIES:
1. Alien Reality (unknown country)
2. GoGreen (unknown country)
3. Watts Up With That? (unknown country)
4. LabSpaces (unknown country)
5. Truth Out (unknown country)
6. News Medical (unknown country)

GCP website Statistics
(www.globalcarbonproject.org/carbonbudget/)
30 Nov - 17 Dec



Visitors & Hits:
3648 unique visitors
552 unique visitors came via a direct web link (eg, emails to GCP database, Climate-L, GEOCARBON)
5900 hits in total

Downloads:
pdf – 576 unique visitors

ppt high res - 492 unique visitors
ppt low res - 178 unique visitors

Visitors by City (Top 10):**
Oslo, Norway - 103
Bellingham, WA, USA - 99
Canberra, Australia - 91
Washington, DC, USA - 87
London, The United Kingdom - 56
Helsinki, Finland - 52
New York, NY, USA - 52
Sydney, Australia - 48
San Francisco, CA, USA - 48
Beijing, China - 44