OceanFlux Greenhouse Gases Evolution

Jamie Shutler, David Woolf, Andy Watson, Jacek Piskozub, Bertrand Chapron, Phil Nightingale, Lonneke Goddijn-Murphy, Ute Schuster, Fanny Girard-Ardhuin, Jean-Francois Piolle, Mark Warren, Antoine Grouazzel, Peter Land, Ian Ashton

Project endorsed by
OceanFlux Initiative

Reinforce scientific collaboration between ESA and international SOLAS.
Fostering collaboration between different scientific communities.
First phase was developed in close collaboration with international SOLAS.
OceanFlux Initiative

Reinforce scientific collaboration between ESA and international SOLAS.
Fostering collaboration between different scientific communities.
First phase was developed in close collaboration with international SOLAS.

*OceanFlux* has two generic aims:

- Support development of novel products.
- Facilitate and advance integration of Earth observation data into SOLAS process studies.
OceanFlux Initiative

Reinforce scientific collaboration between ESA and international SOLAS. Fostering collaboration between different scientific communities. First phase was developed in close collaboration with international SOLAS.

*OceanFlux* has two generic aims:
- Support development of novel products.
- Facilitate and advance integration of Earth observation data into SOLAS process studies.

Current project is called *OceanFlux Greenhouse Gases Evolution*
Aim

OceanFlux Greenhouse Gases *Evolution*:

– Generate and demonstrate the impact of improved estimates of air-sea CO\(_2\) and other atmosphere-ocean gas fluxes using EO data for use by SOLAS and other air-sea gas flux communities.

– 22 specific requirements from ESA including software development, scientific studies and outreach.
Advancements in air-sea transfer relationships and understanding

Space-based retrievals of air-sea gas transfer velocities using altimeters: Calibration for dimethyl sulfide

Lonneke Goddijn-Murphy, David K. Woolf, Christa Marandino

First published: 24 August 2012  Full publication history
DOI: 10.1029/2011JC007535  View/save citation
Cited by: 1 article  Citation tools
Improvements to estimating the air–sea gas transfer velocity by using dual-frequency, altimeter backscatter

Lonneke Goddijn-Murphy, David K. Woolf, Bertrand Chapron, Pierre Queffélec

http://dx.doi.org/10.1016/j.rse.2013.07.026
Advancements in air-sea transfer relationships and understanding

Remote Sensing of Environment

Volume 139, December 2013, Pages 1–5

Journal of Geophysical Research: Oceans

RESEARCH ARTICLE

A reconciliation of empirical and mechanistic models of the air-sea gas transfer velocity

Lonneke Goddijn-Murphy¹, David K. Woolf², Adrian H. Callaghan³, Philip D. Nightingale⁴, and Jamie D. Shutler⁵

¹ERI, University of the Highlands and Islands, Inverness, UK, ²ICIT, Heriot-Watt University, Stromness, UK, ³Scripps Institution of Oceanography, La Jolla, California, USA, ⁴Plymouth Marine Laboratory, Plymouth, UK, ⁵Centre for Geography, Environment and Society, University of Exeter, Penryn, UK
Advancements in air-sea transfer relationships and understanding

Impact of wind waves on the air-sea fluxes: A coupled model

V. Kudryavtsev¹, B. Chapron¹-², and V. Makin³

¹Satellite Oceanography Laboratory, Russian State Hydrometeorological University (RSHU), St. Petersburg, Russia,
²Laboratoire d’Oceanographie Spatiale, Ifremer, Plouzane, France, ³Royal Netherlands Meteorological Institute, De Bilt, Netherlands
Consolidated description of temperature and salinity handling within gas flux calculations.

The OceanFlux Greenhouse Gases methodology for deriving a sea surface climatology of CO₂ fugacity in support of air–sea gas flux studies

L. M. Goddijn-Murphy¹, D. K. Woolf², P. E. Land³, J. D. Shutler⁴, and C. Donlon⁵

¹ERI, University of the Highlands and Islands, Ormlie Road, Thurso, UK
²ICIT, Heriot-Watt University, Stromness, UK
³Plymouth Marine Laboratory, Prospect Place, Plymouth, UK
⁴University of Exeter, Centre for Geography, Environment and Society, Penryn, Cornwall, UK
⁵European Space Agency/ESTEC, Noordwijk, the Netherlands

Correspondence to: L. M. Goddijn-Murphy (lonneke.goddijn-murphy@uhi.ac.uk)
Climatology of $f\text{CO}_2$ normalised to 2010

mean $f_{\text{CO}_2,\text{cl}}$ (μatm) from SOCAT V2 (std of monthly mean < 25)
FluxEngine – air-sea gas flux toolbox

Toolbox developed for community use:

- Open source license (python and PERL based).
- Standard NetCDF data input and output.
- Net flux tool with traceable land/ocean/basin templates.
- User configurable gas flux calculation.
- Extensively verified using published data.

Example mean daily flux output

Example process indicator layer output using ESA Climate Change Indices chl-a

Toolbox developed for community use:

- Open source license (python and PERL based).
- Standard NetCDF data input and output.
- Net flux tool with traceable land/ocean/basin templates.
- User configurable gas flux calculation.
- Extensively verified using published data.

FluxEngine – air-sea gas flux toolbox

Toolbox developed for community use:

- Open source license (python and PERL based).
- Standard NetCDF data input and output.
- Net flux tool with traceable land/ocean/basin templates.
- User configurable gas flux calculation.
- Extensively verified using published data.


Software toolbox available for free on github

Now being used for:

1. Research:
   - Two ESA projects.
   - Three PhD projects (2xUK, 1xPoland).
   - Three UK funded research projects (2xNERC, Royal Society Fellowship).
   - To be used to support ICOS (within EU H2020 RINGO).

1. Teaching:
   - One undergraduate degree (Computer Science at Maastricht University, The Netherlands).
FluxEngine – air-sea gas flux toolbox

Toolbox developed for community use:

- Open source license (python and PERL based).
- Standard NetCDF data input and output.
- Net flux tool with traceable land/ocean/basin templates.
- User configurable gas flux calculation.
- Extensively verified using published data.


Software toolbox available for free on github

Now being used for:

1. Research:
   - Two ESA projects.
   - Three PhD projects (2xUK, 1xPoland).
   - Three UK funded research projects (2xNERC, Royal Society Fellowship).
   - To be used to support ICOS (within EU H2020 RINGO).

1. Teaching:
   - One undergraduate degree (Computer Science at Maastricht University, The Netherlands).

http://www.oceanflux-ghg.org/Products/FluxEngine
Involvement and provided data for the SOCOM community inter-comparison

Data-based estimates of the ocean carbon sink variability – first results of the Surface Ocean pCO₂ Mapping intercomparison (SOCOM)

Assessing the importance on rain on global and regional air-sea gas fluxes

Use FluxEngine to estimate the impact of rain on global estimations of CO2 exchange between the ocean and the atmosphere.

Enhanced gas transfer, $k$, and Direct deposition, $F_{DIC}$ applied to multi-year global analysis.

Effective transfer rate calculated using a non-linear relationship with wind:

$$k_{total} = k_{wind} + [1 - \exp(a\beta)] k_{rain}$$

Transfer depends on rain rate, $R_n$ and the partial pressure of CO2 in the air, $pCO_{2A}$.

$$F_{DIC} = R_n \alpha pCO_{2A}$$

Rain terms increase the annual global net CO2 sink by up to 6%. Regionally it can larger (e.g. 15% increase in Pacific annual net sink). Monthly regional net fluxes can be modulated by $> \pm 50\%$.

Other recent progress and current research

• FluxEngine version 2 software now released:
  – Now includes CH$_4$, N$_2$O, rain parameterisations and handling for polar stereographic data.

• Re-analysed SOCATv3 dataset to a common SST.
  – Software and data will become available later this year.

• Initial results from an Arctic study using new satellite capabilities – between ice gas exchange.

• Developing a calibrated bubble-mediated gas transfer relationship.
International Space Science Institute (ISSI) Working Group

Satellite Earth Observation for Atmosphere-Ocean Gas Exchange
How Northern European waters soak up carbon dioxide

By Jonathan Amos
BBC Science Correspondent

© 25 February 2016 | Science & Environment
The OceanFlux Greenhouse Gases project

Aims to improve the quantification of air-sea exchanges of greenhouse gases, of prime importance in the climate system.

SCIENCE WORKSHOP
6 - 9 Sept. 2016
BREST | FRANCE

Scientists and engineers are invited to attend the Science Workshop which will allow the project and other international teams to present their recent advances, it will also provide a forum for the community to plan future aims and collaborations.
Published OceanFlux advances

Advances in methods, tools, assessment, community partnerships and data provision.

**Journal publications**


Published OceanFlux advances

Advances in methods, tools, assessment, community partnerships and data provision.

That’s it!

All of this work was only possible through collaborating with international community and through using EO, models and in situ in synergy.

All publications and data are freely available on the project website: www.oceanflux-ghg.org
The purpose of this working group is to bring together key international researchers working in the field of atmosphere-ocean interaction and satellite Earth observation to i) identify and formulate new multi-satellite, model and in situ data synergies towards improving our understanding of the pathways, sources, sinks and budgets of greenhouse gases and ii) identify a roadmap for routine long-term space-asset-based monitoring of the oceanic sink of CO₂.