SOCAT version 2021 for quantification of ocean CO_2 uptake

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Abstract – The oceans are taking up a quarter of the global CO_2 (carbon dioxide) emissions from human activity[c]. The Surface Ocean CO_2 Atlas (**www.socat.info**) documents the increase in surface ocean CO_2 for the global oceans and coastal seas. Quantification of the global ocean CO_2 uptake to better than 0.2 Pg C yr^{-1} requires an accuracy of < 2 µatm for *in situ* surface ocean fCO_2 (fugacity of CO_2) measurements[a]. Quality-controlled, synthesis and gridded products in SOCAT version 2021 contain 30.6 million *in situ* surface ocean fCO_2 measurements with an estimated accuracy of < 5 µatm. A further 2.1 million fCO_2 values with an accuracy of < 10 µatm are also available. Data collection has continued during the pandemic, albeit at a reduced rate. SOCAT-based data products are used for quantification of ocean CO_2 uptake and ocean acidification and for evaluation of sensor data and climate models. The community-led SOCAT synthesis products are a key step in the value chain based on *in situ* inorganic carbon measurements of the oceans[d], which provides policy makers in climate negotiations with essential information on ocean CO_2 uptake. Some regional data collection is variable and at risk for lack of longterm funding. The global need for accurate knowledge of ocean CO_2 uptake and its (future) variation makes sustained funding for *in situ* surface ocean CO_2 observations imperative.

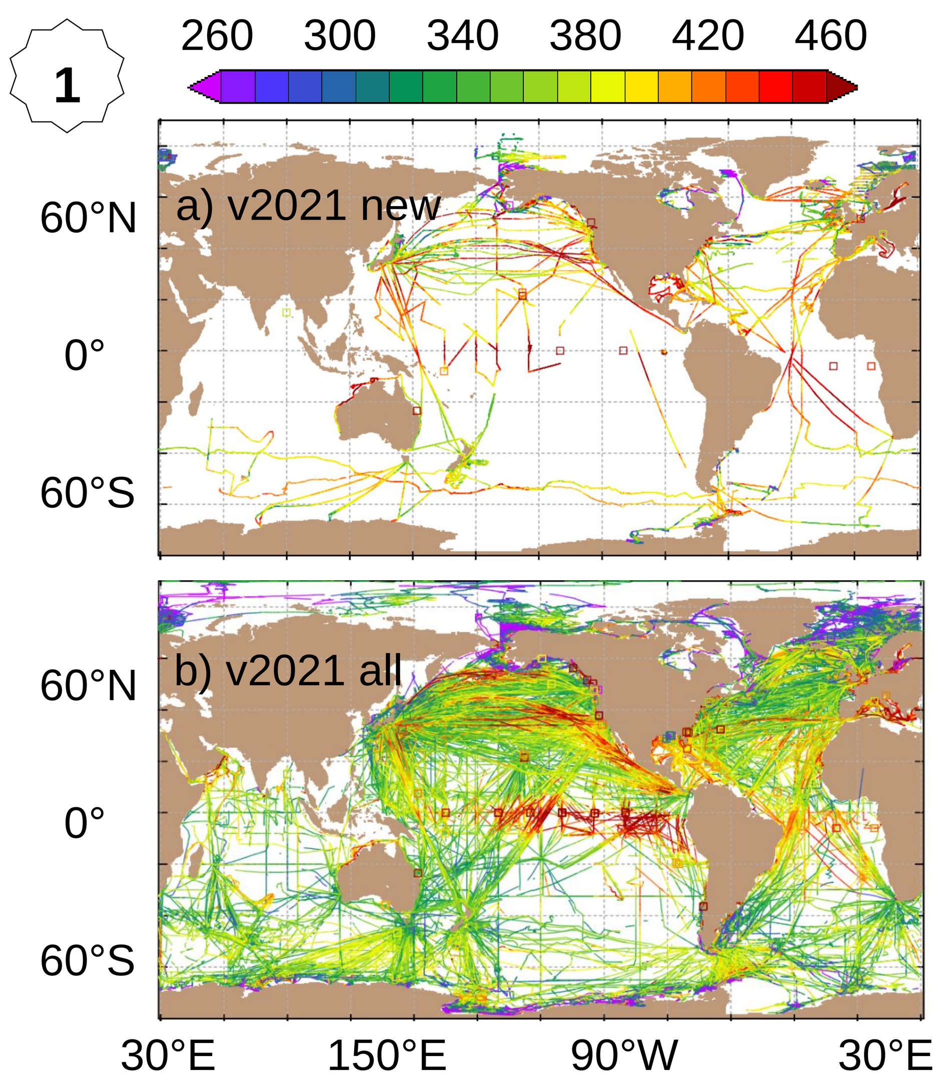

Fig. 1. *a) Newly added and b) all in situ surface ocean fCO_2 values (colour coded, µatm) with an accuracy of < 10 µatm in version 2021. Squares indicate moorings.*

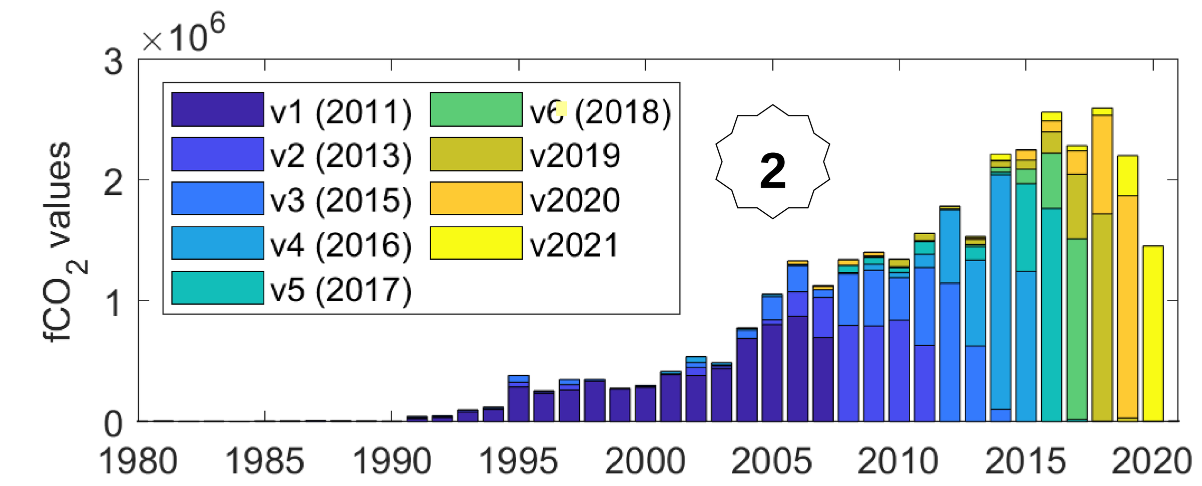

Fig. 2. *Number of surface ocean fCO_2 values with an accuracy of < 10 µatm for years in SOCAT versions 1 to 2021.*

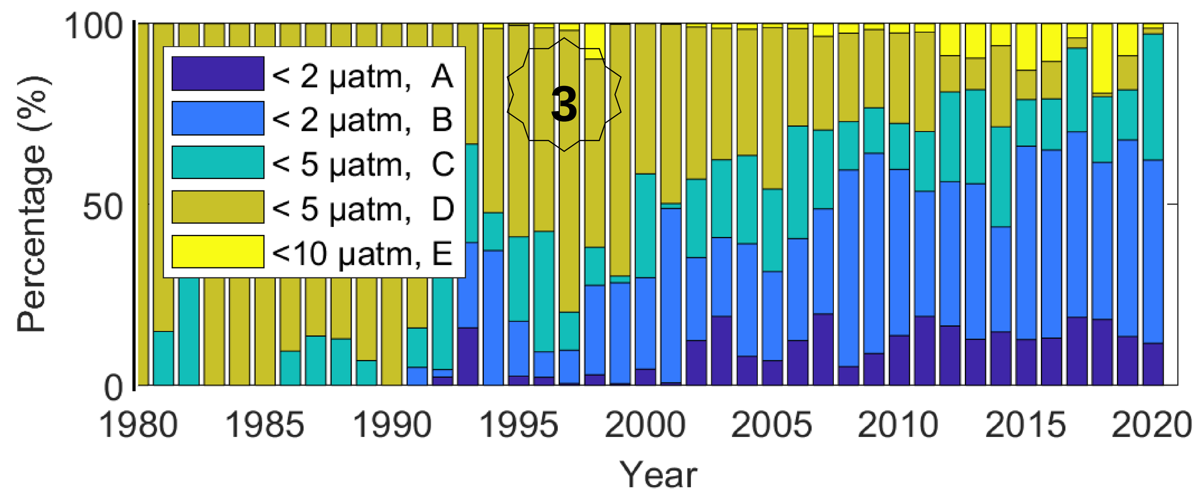

Fig. 3. *Percentage of fCO_2 values with an accuracy of < 2, 5 and 10 µatm and data set flags A to E for years in version 2021.*

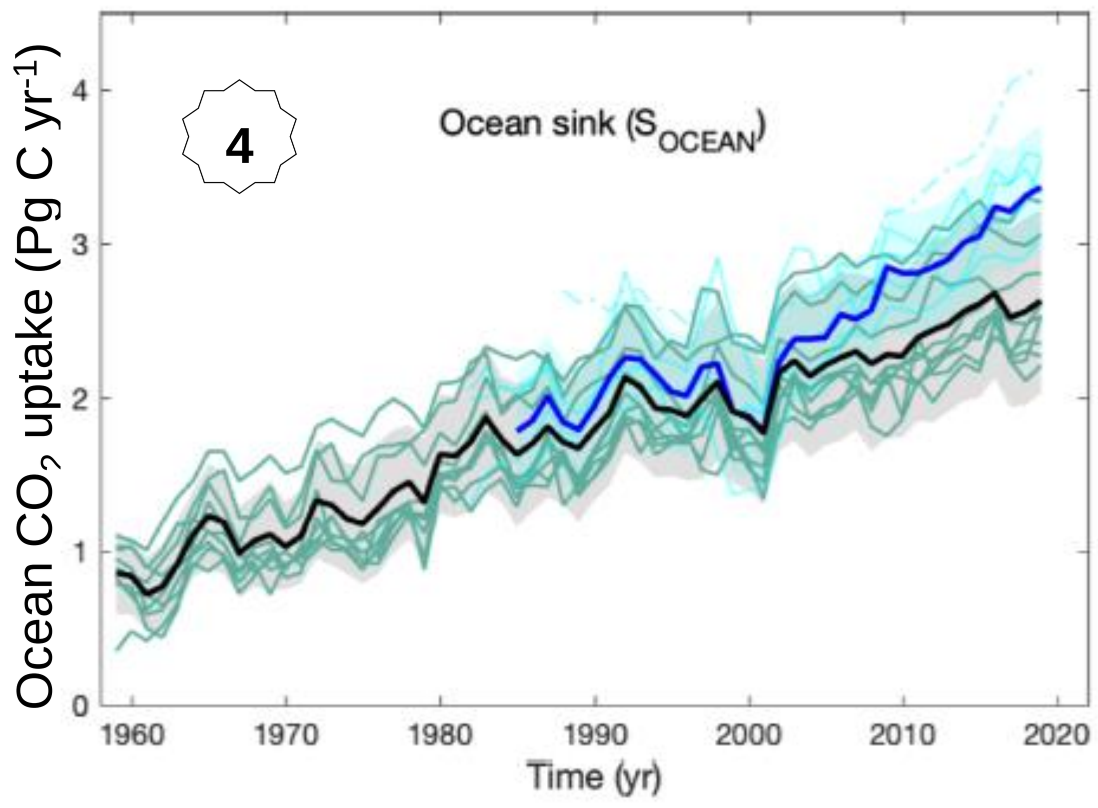

Fig. 4. *Ocean CO_2 uptake in the 2020 Global Carbon Budget[c]. Cyan and blue (mean) lines for SOCAT-based estimates. Blue-green and black (mean) lines for model results. From[c].*

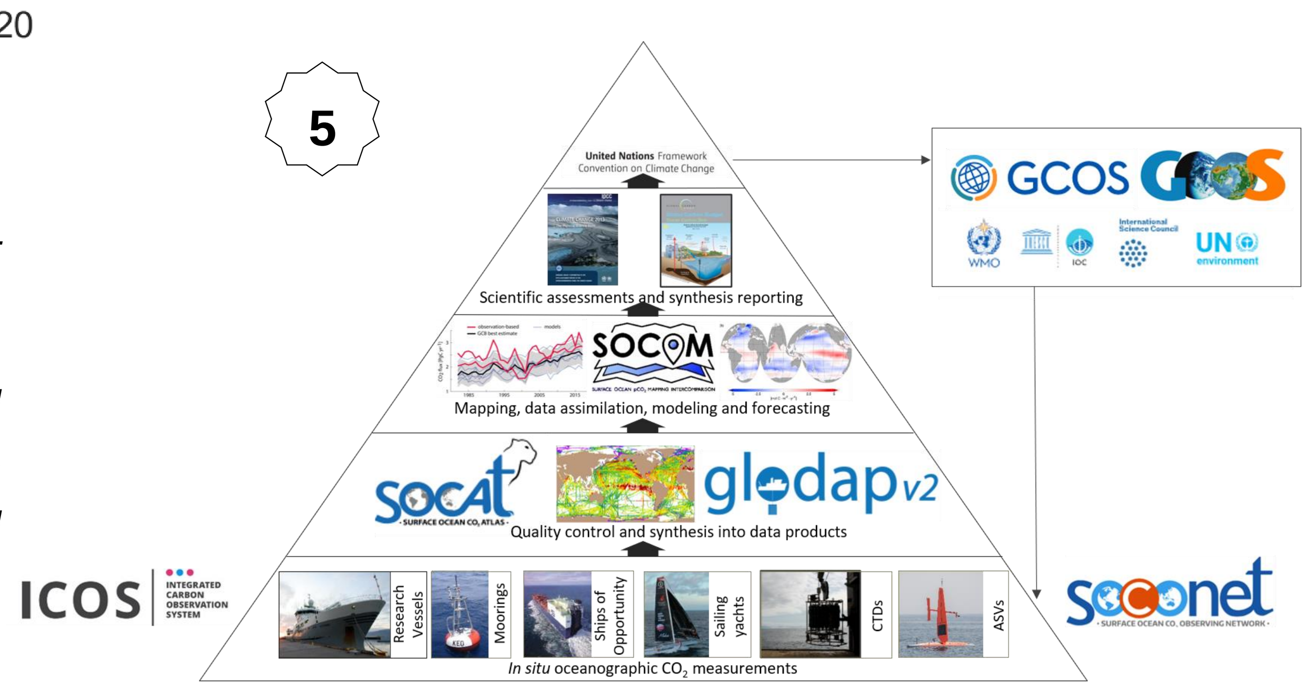

Fig. 5. *The value chain based on in situ inorganic carbon measurements of the oceans. Modified from[d].*

Key features

- Community-led, 'volunteer' data submission and quality control
- Quality-controlled, synthesis and gridded products of *in situ* surface ocean fCO_2 measurements on ships, moorings, autonomous and drifting surface platforms for the global oceans and coastal seas from 1957 to 2021
- 30.6 million fCO_2 values with an accuracy of < 5 µatm in main synthesis and gridded products, plus 2.1 million fCO_2 values with an accuracy of < 10 µatm separately available
- Accuracy of fCO_2 estimated during quality control
- Limited quality control for sea surface salinity
- Online viewers and data download (**www.socat.info**)
- Regional data collection at risk for lack of funding
- Data collection during the pandemic, albeit at a reduced rate
- Data submission and quality control for v2022 by 14/01/2022 and 31/03/2022

Scientific findings, applications and impact

- Documents the increase in global surface ocean CO_2[f]
- Data gaps in time and space addressed through advanced interpolation schemes[f,i,j]
- Year-to-year and decadal variation in global ocean CO_2 uptake[j]
- Models underestimate variation in ocean CO_2 uptake[j]
- Quantification of ocean CO_2 uptake[c,f,g,i,j] and ocean acidification[e,h]
- Informs the Global Carbon Budget[c]
- Evaluation of sensor data (BGC Argo floats[k], gliders, moorings) and models, incl. CMIP[b]
- Used in hundreds of peer-reviewed scientific articles and reports
- Annual public release contributes to UN Sustainable Development Goals (SDG) 13 and 14 (#OceanAction20464) and to the UN Decade of Ocean Science for Sustainable Development

Data Use: To generously acknowledge the contribution of SOCAT scientists by invitation to co-authorship, especially for key data providers in regional studies, and/or reference to relevant scientific articles. **Acknowledgements:** We thank the numerous contributors, funding agencies, IOCCP, SOLAS and IMBER. **Documentation v3-v2021:** Bakker et al. (2016) ESSD 8: 383-413; **v2:** Bakker et al. (2014) ESSD 6:69-90; **v1:** Pfeil et al. (2013) ESSD 5:125-143; Sabine et al. (2013) ESSD 5:145-153.

References: Bender et al. 2002, LSCOP[a]; Eyring et al., 2016[b]; Friedlingstein et al., 2020[c]; Guidi et al., 2020, doi:10.5281/zenodo.3755793[d]; Jiang et al., 2019[e]; Landschützer et al., 2014[f]; Laruelle et al., 2018[g]; Lauvset et al., 2015[h]; Rödenbeck et al., 2014[i], 2015[j]; Williams et al., 2017[k].

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