SOCAT version 2020: Key in the value chain of surface ocean CO_2 measurements

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Abstract - The Surface Ocean CO_2 Atlas (SOCAT, **www.socat.info**) documents the increase in surface ocean CO_2 (carbon dioxide), a critical measure as the oceans are taking up one quarter of the global CO_2 emissions from human activity[b]. Synthesis and gridded, quality-controlled products in SOCAT version 2020 contain 28.2 million *in situ* surface ocean fCO_2 (fugacity of CO_2) measurements for the global oceans and coastal seas with an accuracy < 5 µatm, while a further 2.3 million fCO_2 values with an accuracy of 5 to 10 µatm are made available separately. The SOCAT community-led synthesis product is a key step in the value chain based on *in situ* inorganic carbon measurements of the oceans, which provides policy makers with essential information on ocean CO_2 uptake in climate negotiations. The global need for accurate knowledge of ocean CO_2 uptake and its variation makes sustained funding for *in situ* surface ocean CO_2 observations imperative.

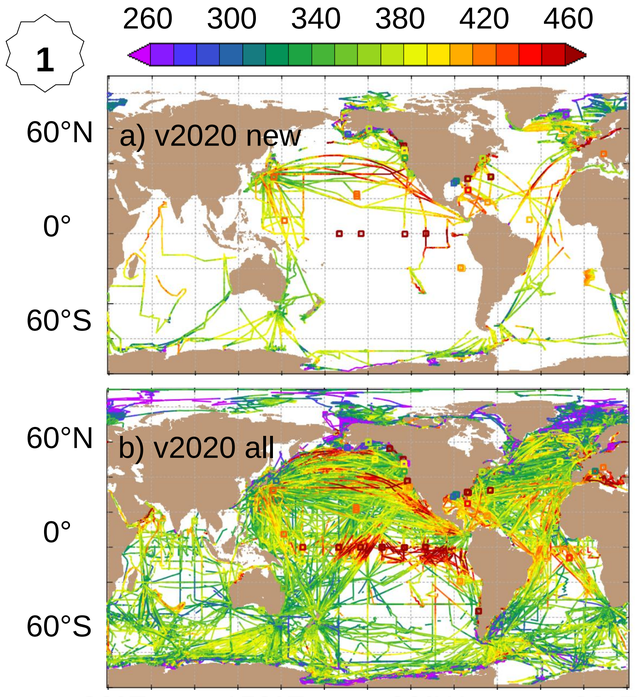


Fig. 1. *a) Newly added and b) all in situ surface water fCO_2 values (colour coded, µatm) with an estimated accuracy of < 10 µatm in version 2020. Squares indicate moorings.*

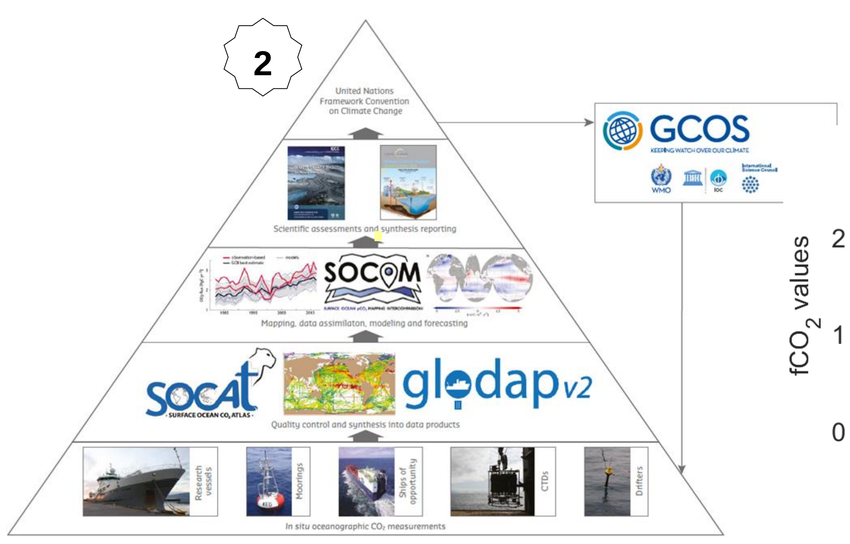
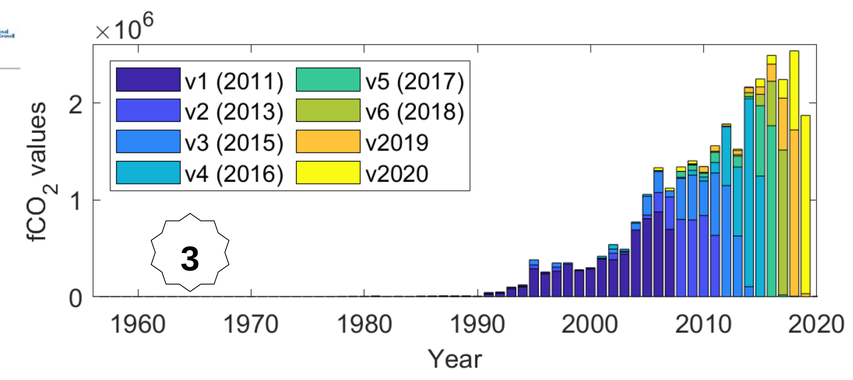


Fig. 2. *The value chain based on in situ inorganic carbon measurements of the oceans. Measurements of inorganic carbon variables in the ocean are made on research ships, commercial ships, moorings and on drifting and autonomous surface platforms. These data are quality controlled and assembled in the SOCAT and GLODAP synthesis products. Advanced interpolation methods allow quantification of ocean CO_2 uptake. These estimates feed into the Global Carbon Budget[b], IPCC assessments and other high-impact reports that inform international climate negotiations. From[c].*



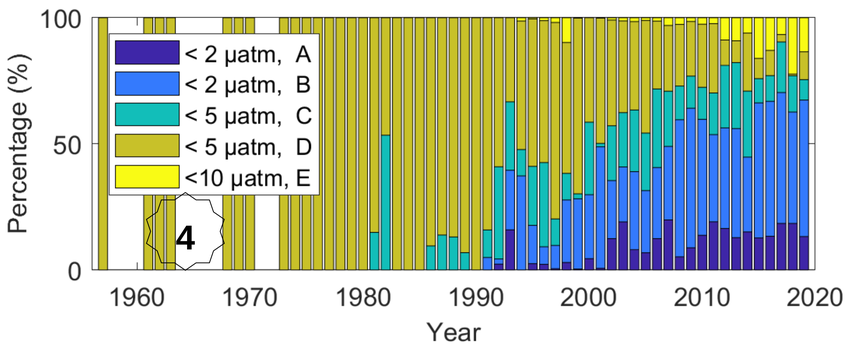


Fig. 3. *Number of surface water fCO_2 values per year with an estimated accuracy of < 10 µatm in successive SOCAT versions.*

Fig. 4. *Percentage of fCO_2 values with an estimated accuracy of < 2, 5 and 10 µatm and their data set flags for years in version 2020.*

Key features

- Community-based 'volunteer' submission and quality control
- Synthesis and gridded, quality-controlled products of *in situ* surface ocean fCO_2 measurements from ships, moorings, drifting and autonomous surface platforms for the global oceans and coastal seas
- With an estimated accuracy of < 5 µatm:
  v2020 : 28.2 million fCO_2, 1957-2020
  v2019 : 25.7 million fCO_2, 1957-2019
  v1 (2011): 6.3 million fCO_2, 1968-2007
- 2.3 million values from alternative sensors with an estimated accuracy of 5 to 10 µatm are made available separately
- Online viewers and data download (**www.socat.info**)
- Limited quality control for sea surface temperature and salinity
- Data submission for v2021 by 15/01/2021, quality control by 31/03/2021

Scientific findings, applications and impact

- Documents the increase in global surface ocean CO_2[e]
- Data gaps in space and time addressed through advanced interpolation schemes[e,h,i]
- Large year-to-year variation in global ocean CO_2 uptake[h]
- Models underestimate variation in ocean CO_2 uptake[i]
- Quantification of ocean CO_2 uptake[b,e,f,h,i], ocean acidification[d,g] and priors for the land carbon sink[h]
- Informs the Surface Ocean pCO_2 Mapping Intercomparison (SOCOM)[i] and the Global Carbon Budget[b]
- Evaluation of sensor data (BGC Argo floats[j], gliders) and models, incl. CMIP[a]
- Cited by >329 peer-reviewed scientific articles and >80 reports
- Annual public releases as a Voluntary Commitment for SDG 14.3 (#OceanAction20464) and 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-v2020:** 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:** Eyring et al., 2016[a]; Friedlingstein et al., 2019[b]; Guidi et al., 2020, doi:10.5281/zenodo.3755793[c]; Jiang et al., 2019[d]; Landschützer et al., 2014[e]; Laruelle et al., 2018[f]; Lauvset et al., 2015[g]; Rödenbeck et al., 2014[h], 2015[i]; Williams et al., 2017[j]. **Affiliations:** [1]UEA, UK (**d.bakker@uea.ac.uk**); [2]NOAA-PMEL & [3]BIOS, USA; [4]UoS, UK; [5]UiB & [6]BCCR, Norway; [7]Marine Institute, Ireland; [8]JMA, Japan; [9]NOAA-NCEI, USA; [10]NORCE, Norway; [11]LOCEAN, France; [12]CIRES, UoC & [13]NOAA-ESRL, USA; [14]NIES, Japan; [15]JISAO, UW, USA; [16]MRI, Iceland; [17]NOAA-AOML, [18]CIMAS & [19]LDEO, USA; [20]CSIRO & [21]AAPP, Australia.