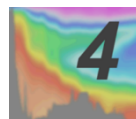
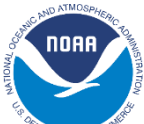


Tracking ocean acidification with the Surface Ocean CO₂ Atlas and the Global Data Analysis Project



*Dorothee Bakker, Nicolas Metz, Are Olsen, Toste Tanhua, Siv Lauvset, Bob Key,
Rik Wanninkhof, Kevin O'Brien, Benjamin Pfeil, Alex Kozyr, Camilla Landa, Nico Lange, Shin-ichiro Nakaoka,
Denis Pierrot, Ute Schuster, Karl Smith, Kevin Sullivan, Adrienne Sutton, Colm Sweeney,
Taro Takahashi, Maciej Telszewski, Bronte Tilbrook, Chisato Wada
and all >100 SOCAT and GLODAP contributors*

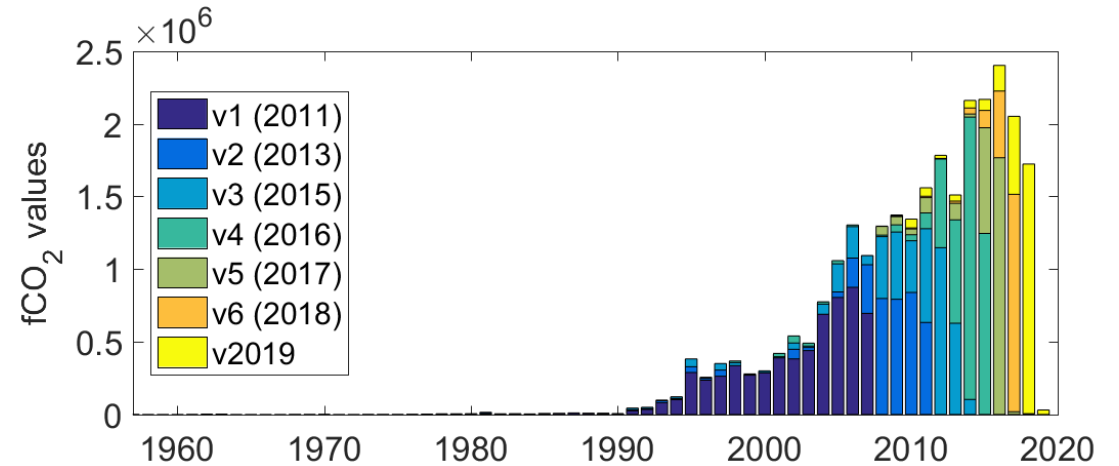
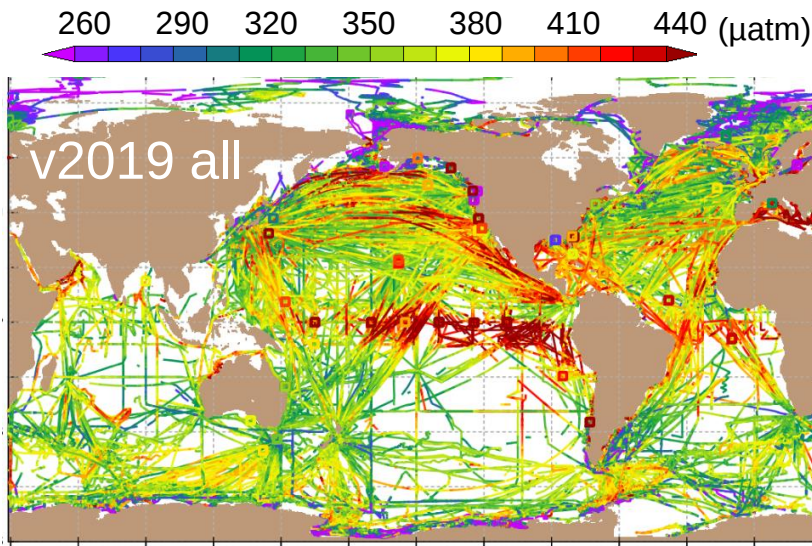
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Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE



Surface Ocean CO₂ Atlas



Global synthesis products of surface ocean fCO₂ (fugacity of CO₂) in a uniform format with quality control; No gap filling; Annual public releases;

SOCATv2019

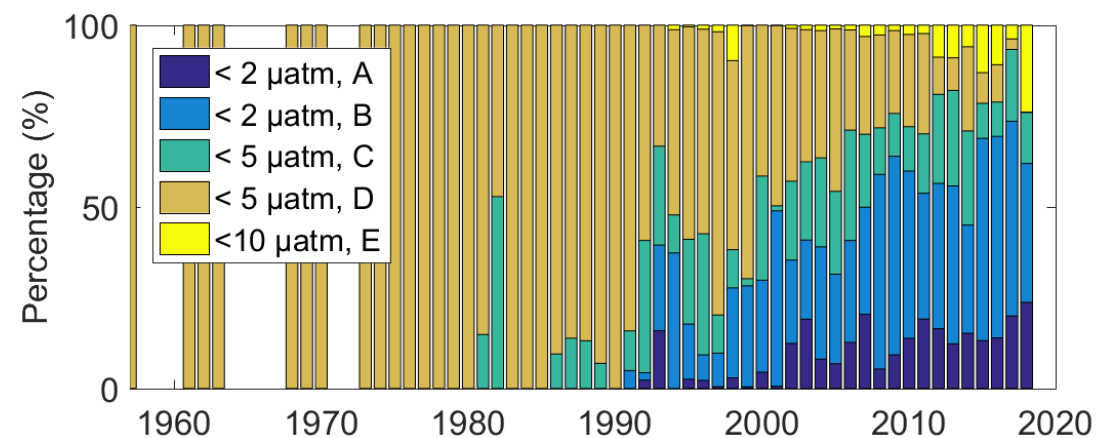
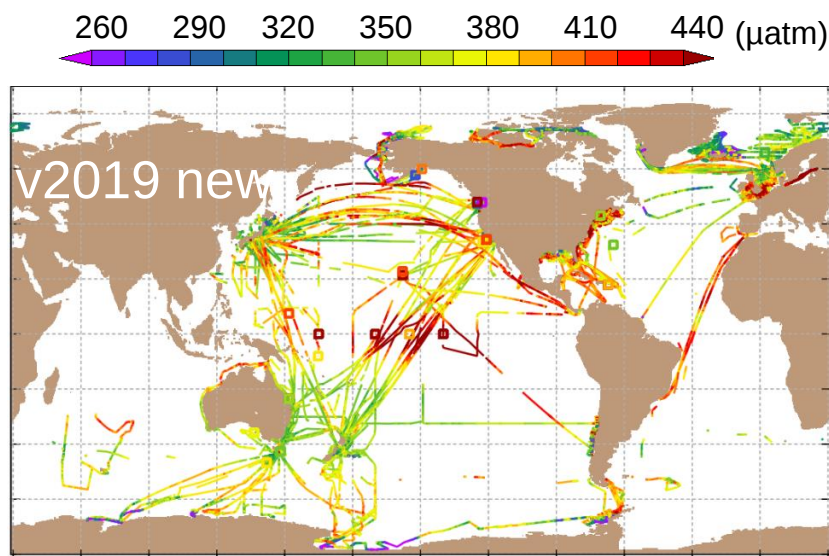
- Released on 18/06/2019
- 25.7 million fCO₂ values from 1957-2019, accuracy < 5 μatm
- Plus 1.7 million sensor data, accuracy < 10 μatm

SOCATv2020

- Data submission by 15/01/2020
- Quality control by 31/03/2020

(Pfeil et al., 2013; Sabine et al., 2013; Bakker et al., 2014, 2016, ESSD)

Surface Ocean CO₂ Atlas



Voluntary Commitment to the 2017 UN Ocean Conference



HOME	ABOUT	PROGRAMME	CALL FOR ACTION	PREP PROCESS	SDG 14	VOLUNTARY COMMITMENTS	DOCUMENTATION	STAKEHOLDER ENGAGEMENT	EVENTS	NEWS & MEDIA
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Annual, public releases of the Surface Ocean CO₂ Atlas (SOCAT)

#OceanAction20464

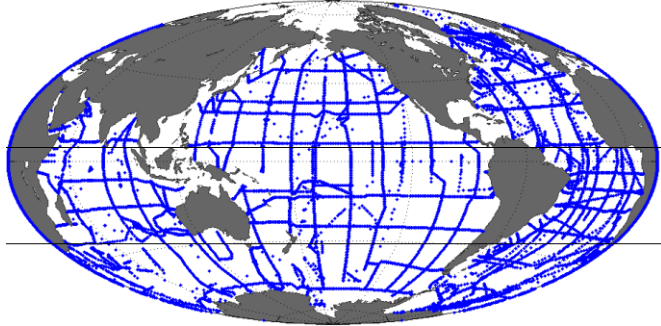
by SOCAT scientific community (Scientific community)

Global Data Analysis Project Version 2

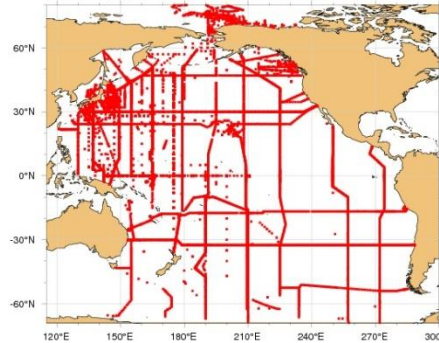
(Interior ocean carbon and other observations)

glodap_{v2}

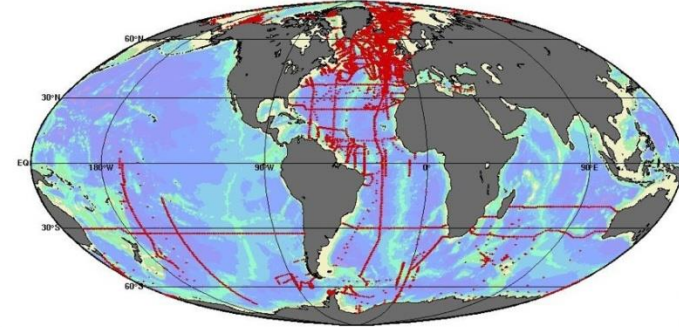
GLODAP (1985-1999)
(Key et al., 2004)



PACIFICA
(Suzuki et al., 2013)



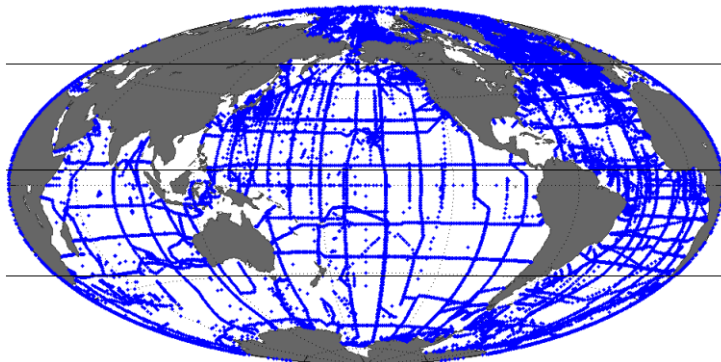
CARINA (1977-2006)
(Tanhua et al. 2009)



GLODAPv2.2019 (1972-2017), 840 cruises;
GLODAPv2 (1972-2013) (Olsen et al., 2016)

Release on 26 March 2019

- Uniform, bias corrected;
- Core: T, S, DIC, Alk, oxygen, nutrients, freons;
- Also: pH, carbon isotopes, organic carbon and nitrogen, tritium, helium;
- Bi-annual updates, decadal releases.



Tracking the increase in surface ocean CO₂

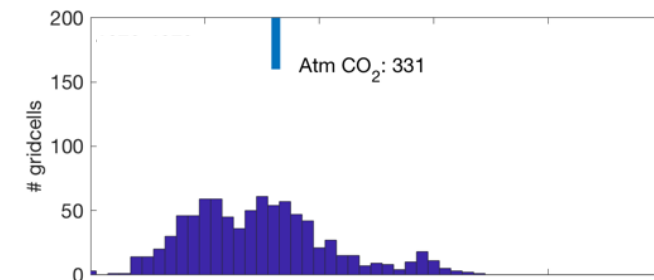
Number of decadal mean values per 4 μatm range in gridded SOCAT v6 product.

Atmospheric mole fraction at Mauna Loa ($\mu\text{mol mol}^{-1}$).

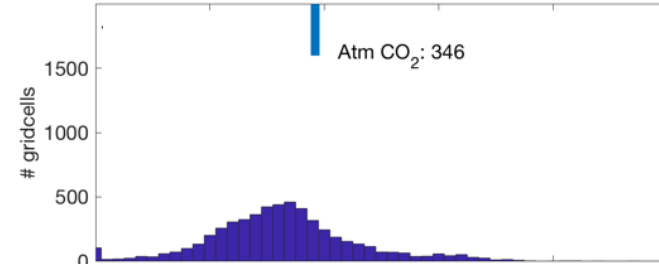
Subtracting 6 $\mu\text{mol mol}^{-1}$ from the mole fraction roughly gives $f\text{CO}_{2\text{air}}$.

(By Are Olsen)

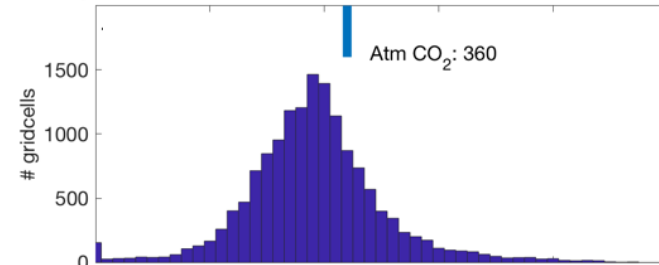
1970-79



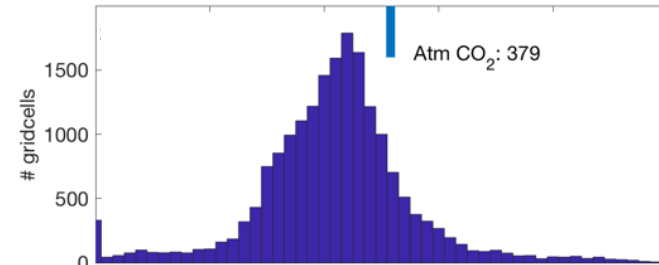
1980-89



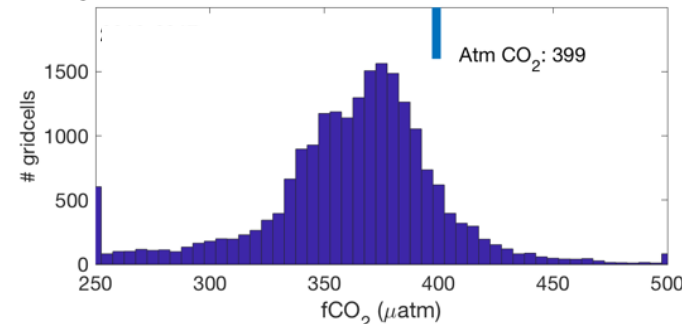
1990-99



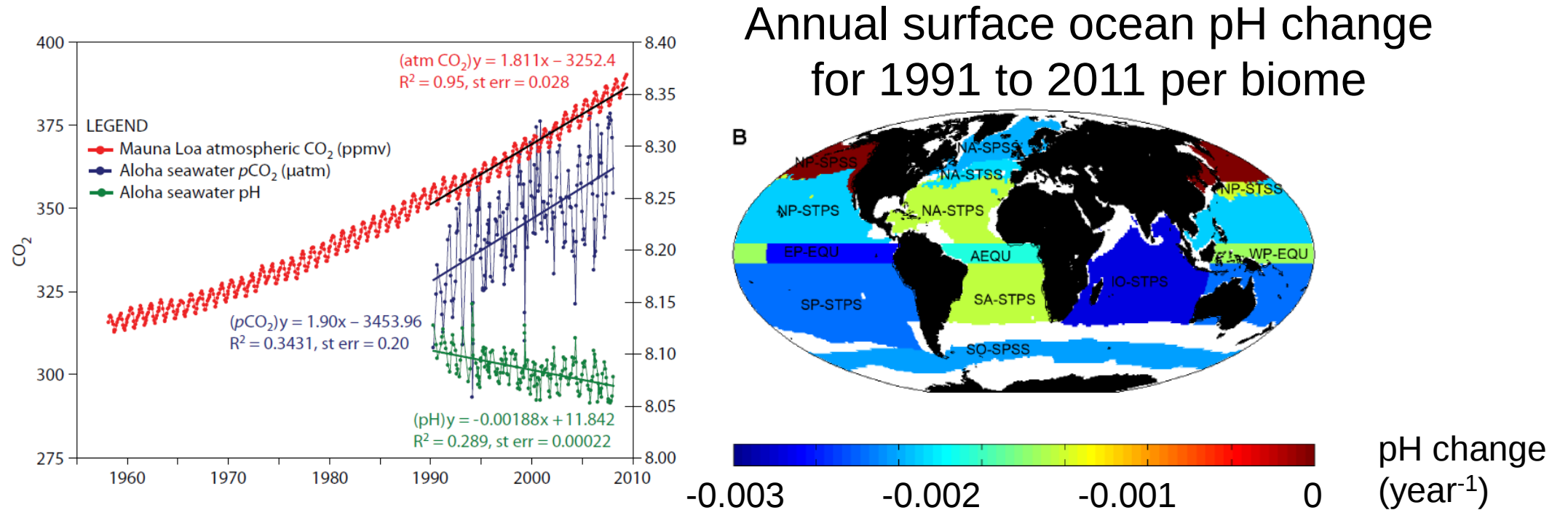
2000-09



2010-17



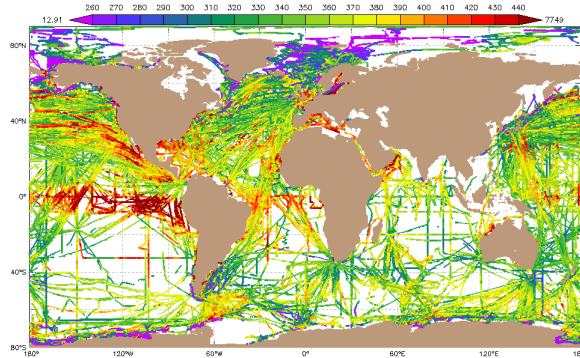
Ocean acidification from SOCAT



Combine SOCAT fCO₂ with salinity-derived alkalinity.
Global surface ocean pH decreases by 0.002 year⁻¹ from 1991 to 2011.
SOCAT enables quantification of regional trends in surface ocean pH.

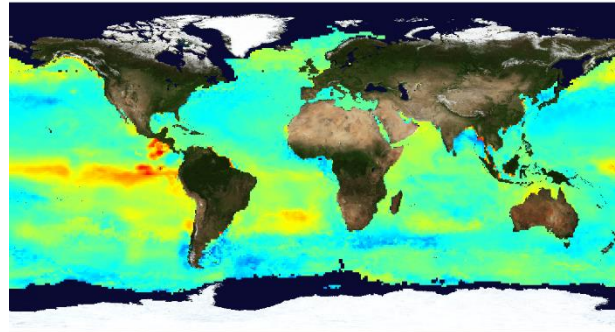
(Feely et al., 2009; Lauvset et al., 2015 BG)

Surface ocean pH from SOCAT CO₂



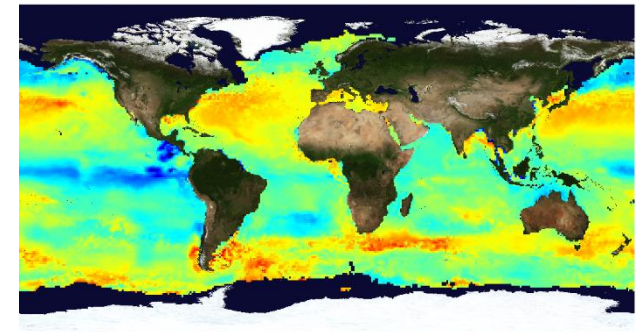
A SOCAT synthesis product

Mapping



Monthly surface water pCO₂

With alkalinity (from T, S)



Monthly surface water pH_T

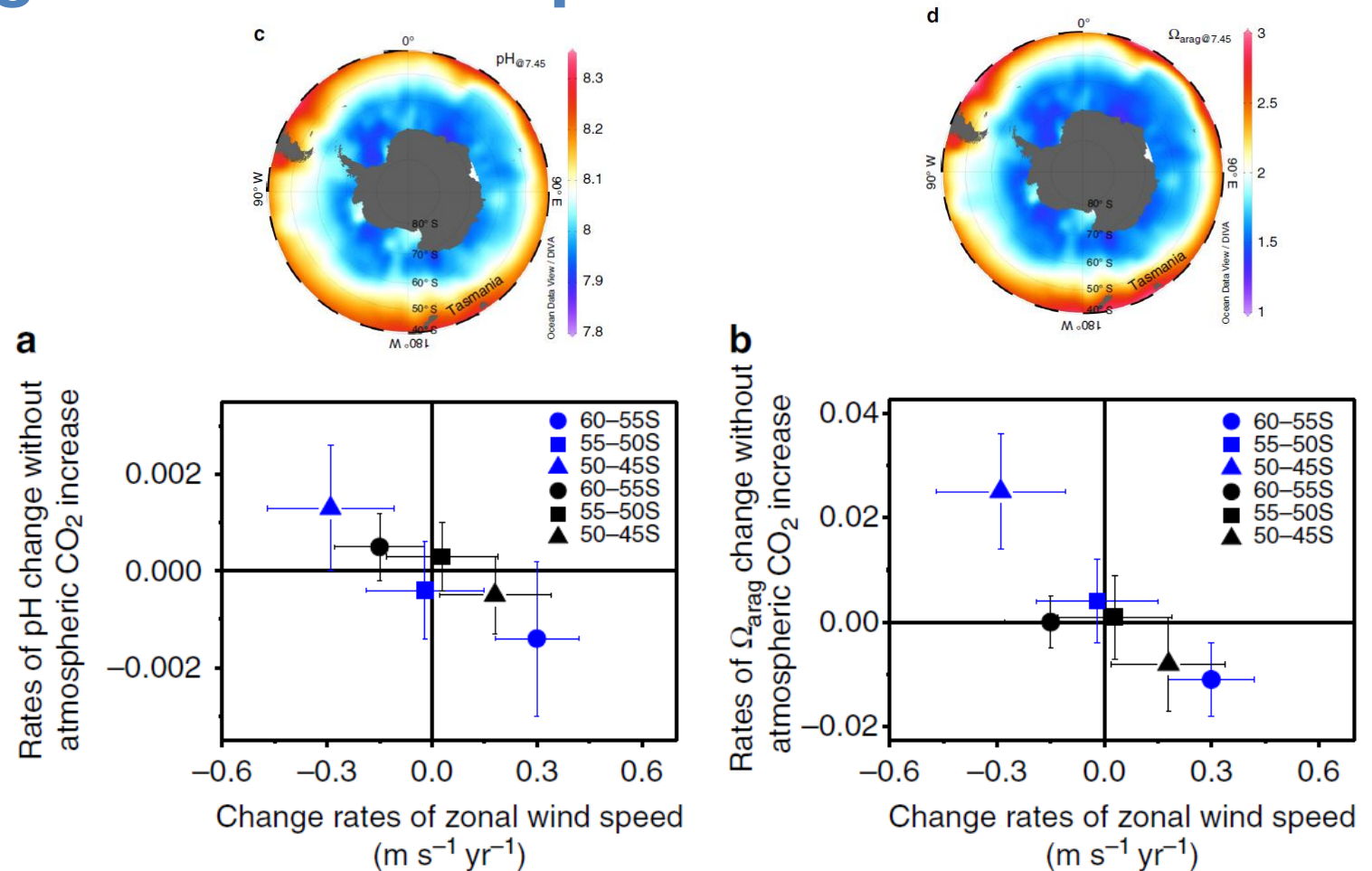
(Bakker et al., 2016; Denvil-Sommer et al., 2019;

<http://marine.copernicus.eu/services-portfolio/access-to-products/>, search keyword: MULTIOBS)

Surface ocean pH and Ω_{ar} climatology for 2005

Surface ocean pH and Ω_{ar} from SOCAT fCO₂ and alkalinity from T, S

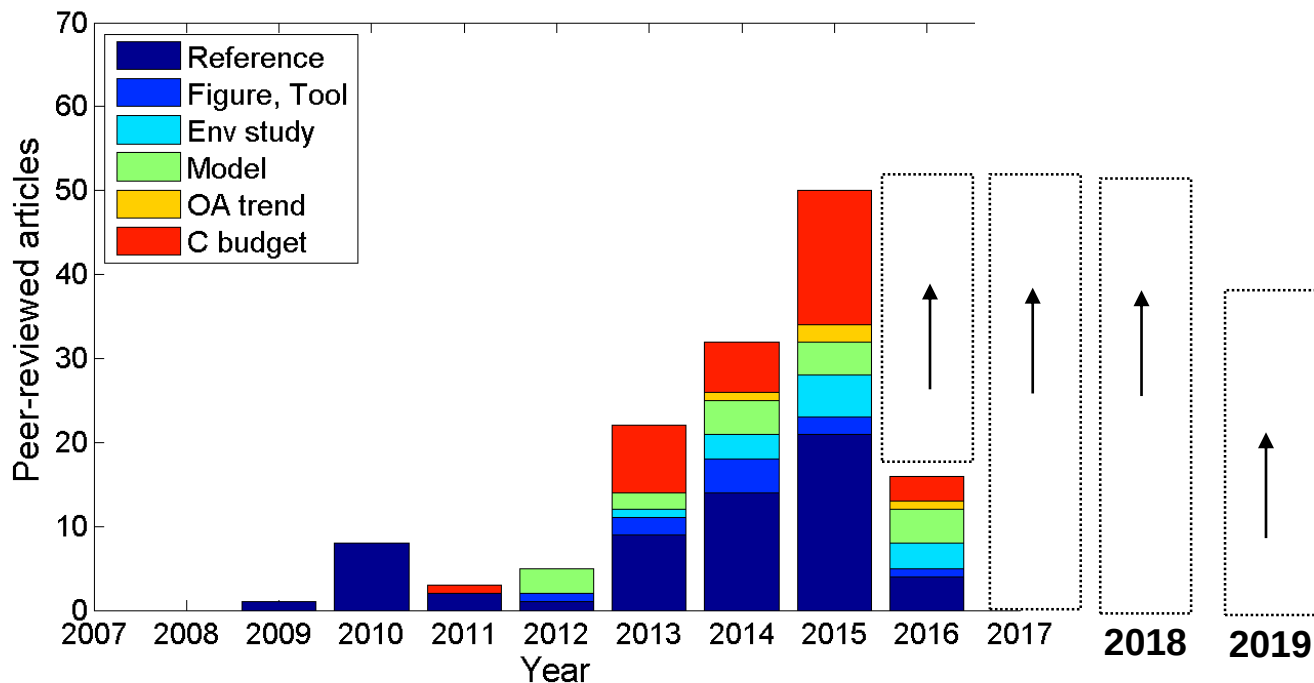
Variation in summertime wind forcing modulates changes in surface ocean acidification.



1991-2000 (blue); 2001-2011 (black)

(Takahashi et al., 2014; Xu et al., 2018 Nature Communications)

Applications of SOCAT



SOCAT is cited in >260 peer-reviewed articles and >80 high-impact reports.

- **Ocean carbon sink** (SOCOM, GCP, BAMS, SOCCR, IPCC)
- **Ocean acidification studies**
- Evaluation of sensors (BGC Argo floats, gliders)
- **Model evaluation** (Obs4MIP, ESMVal, CMIP)

(Bakker et al., 2016)

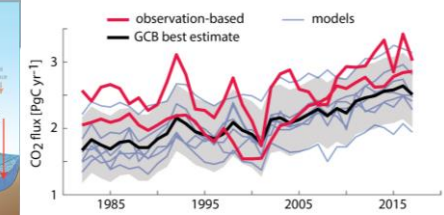
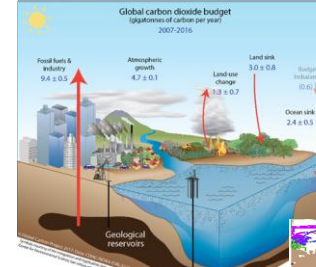


UNFCCC

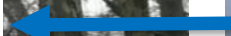
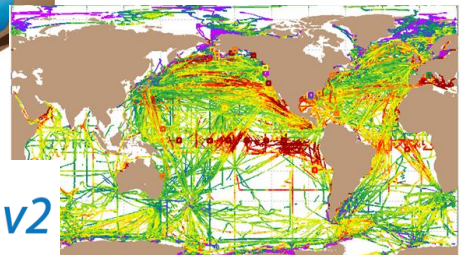
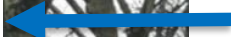


PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

IPCC



Maintenance and annual updates of SOCAT and GLODAP requires sustained funding and community involvement



Problematic data collection in EEZs

Photo by
Olivier Sulpis