OCEAN OBS'19
AN OCEAN OF OPPORTUNITY
September 16-20, 2019

Journées scientifiques LEFE/GMMC, Toulon, 12-14 juin 2019

Ship-Based Contributions to Global Ocean, Weather, and Climate Observing Systems

Shawn R. Smith, **Gaël Alory**, Axel Andersson, William Asher, Alex Baker, David I. Berry, Kyla Drushka, Darin Figurskey, Eric Freeman, Paul Holthus, Tim Jickells, Henry Kleta, Elizabeth C. Kent, Nicolas Kolodziejczyk, Martin Kramp, Zoe Loh, Paul Poli, Ute Schuster, Emma Steventon, Sebastiaan Swart, Oksana Tarasova, Loïc Petit de la Villéon, and Nadya Vinogradova-Shiffer

- Historically, from sailing ships observations for day-to-day operations to global network for weather forecasting, safety at sea, commercial ventures, ocean/atmosphere research
- Today, commercial ships for repeated sampling along commercial lines, research vessels for wider range of observations outside shipping lines
- Focus: automated/manual physical/biogeochemical measurements in near-surface ocean/atmosphere from all kind of ships

Ship-observed Essential Ocean/Climate Variables (EOV/ECV)

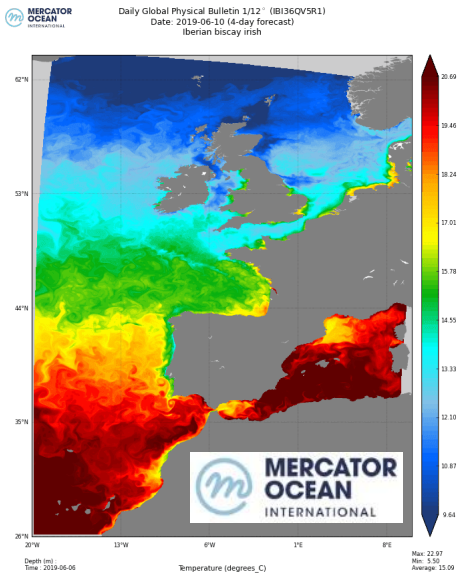
ECV/EOV	Obs Method [1]	Ship Type [2]	Since
Air Temperature	A, M	C, R, P, G, Y	1784
Water Vapor	A, M	C, R, P, G	1873
Atmospheric Pressure	A, M	C, R, P, G, Y	1785
Wind Direction and Speed	A, M, V	C, R, P, G, Y	1750
Radiation	A	C, R, G	1970
Precipitation	A	C, R, P, G	1970
Cloud Properties	M	C, R, P, G	1852
Sea Water Temperature	A, M	C, R, P, G, Y	1816
Salinity	A, M	C, R, P, G, Y	1873
Inorganic Carbon	A, M	C, R, P, G, Y	1958
Dissolved Organic Carbon	A	R, G	1990
Nutrients	A	R, G	1921
Nitrous Oxide	A	R	2000
Oxygen	A	R	1900
Ocean Color	A	R	1954
Transient Tracers (e.g., CFC11)	M	R	1982
Aerosols	M	R	1995
Sea State	A, M, V	C, R, G	1876
Surface/Subsurface Currents	A	C, R, G, Y	1920/1985

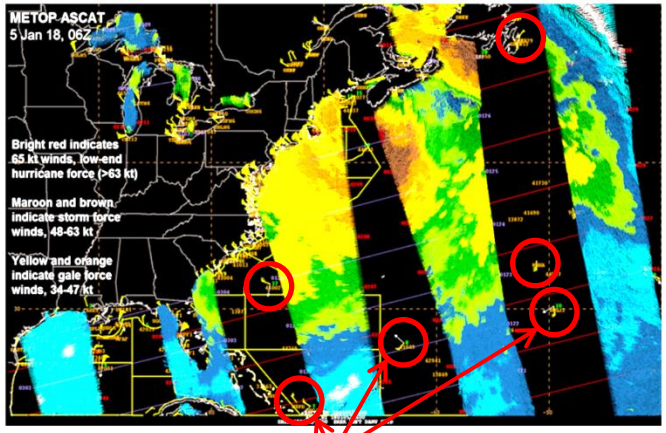
1 Observation Method: **A**utomatic/**M**anual/**V**isual

2 Ship type: **C**ommercial/**R**esearch/**P**assenger/**G**overnment/**Y**acht

Forecasting, Navigation, and Safety

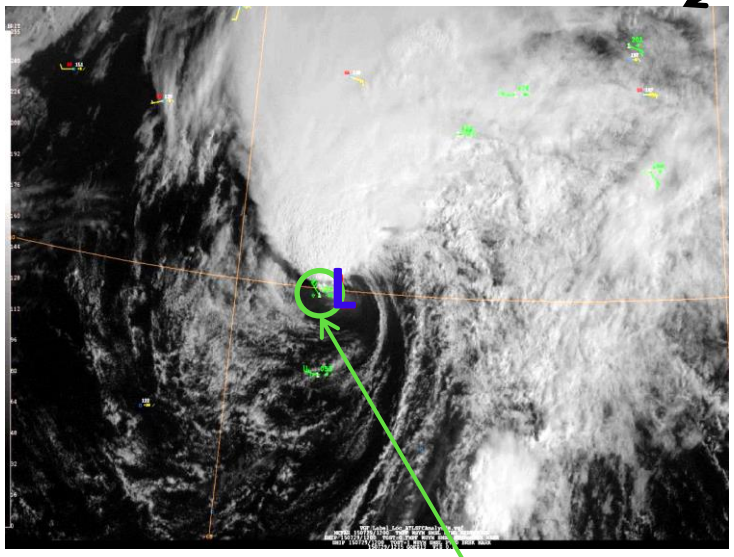
- Meteorological measurements (atmospheric pressure, wind, air temperature, relative humidity, SST, waves) from Voluntary Observing Ships (VOS), set by National Meteorological and Hydrological Services (NMHS), transmitted in real time through Global Telecommunication System (GTS) for numerical weather prediction, ship routing, warnings
- Additional measurements (SST, SSS, currents) feed operational oceanography for blue-growth applications
- Complement satellite obs for some parameters (Patm), in regional gaps, forecast validation



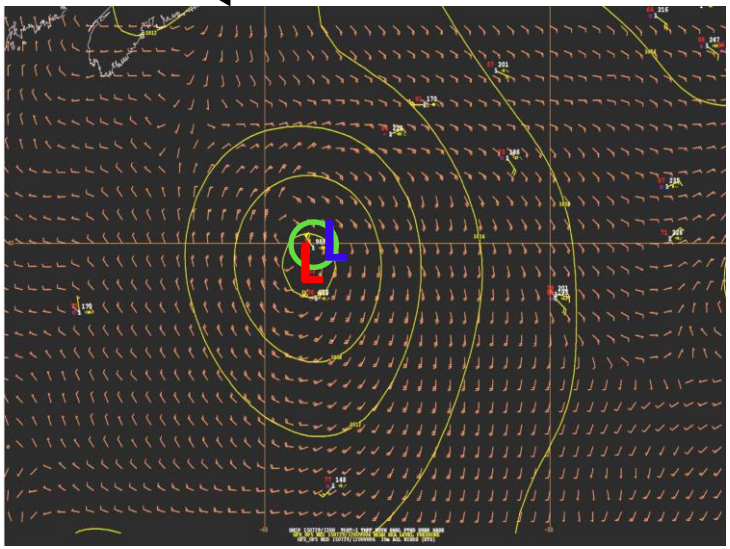


Sea winds : ships *vs* satellite

Central Atlantic Ocean, 29 July 2015 1200 UTC: A hurricane-force wind warning was issued based on observation from a single ship (65 knots), despite weaker winds in the model forecast



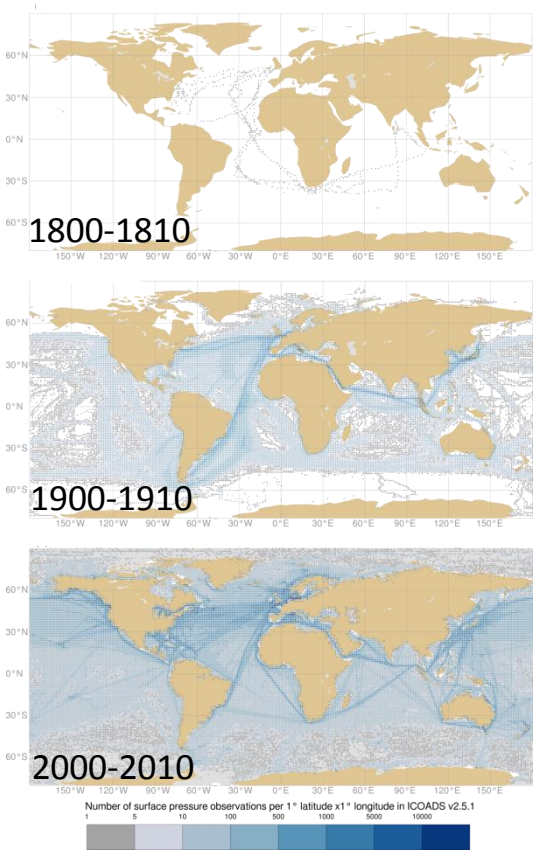
Visible satellite image and ship observations



NCEP/EMC GFS model 6-hour wind forecast and ship observations

Climate monitoring, assessments, and services

- Ships : main source of marine observations until 1980, still an essential component of the Global Climate Observing System (GCOS)
- Provide some of the longest marine climate records (e.g. wind from 1750)
- Need for metadata, quality control, delayed time correction (e.g. wind, SSS) to build climate datasets and monitor long-term trends (e.g. strengthening water cycle)
- Main data source for climatologies and historical ocean/atmosphere/climate reanalyses
- Strong input for climate services (e.g. Copernicus global shipping project)



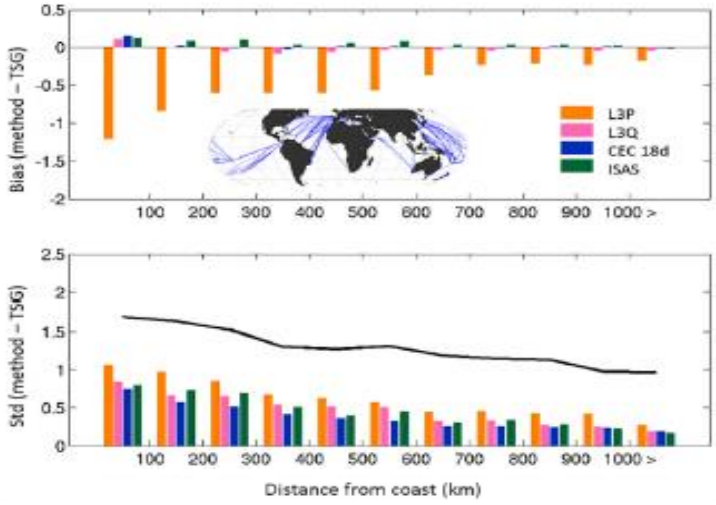
ICOADS p_{atm} obs density

Copernicus Europe's eyes on Earth

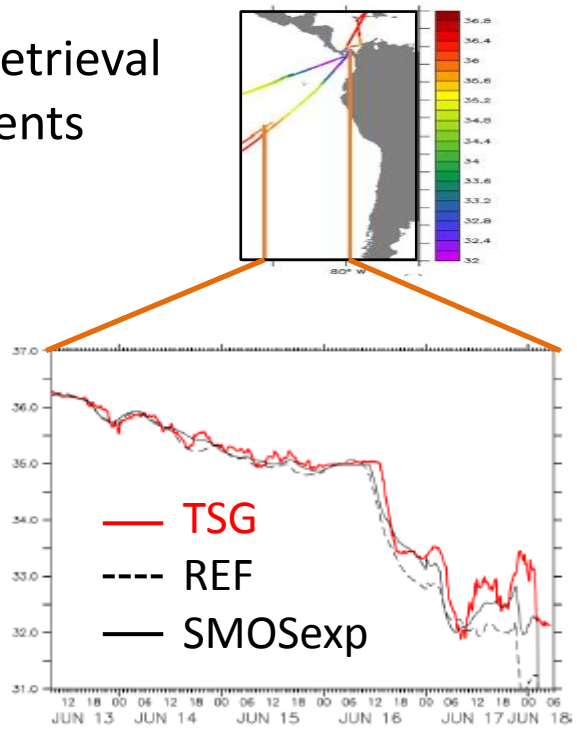
Climate Change Service

Development and Evaluation of Models and Products

- Evaluation of numerical simulations with ship-based observations
- Independent (not assimilated) dataset for evaluation of reanalysis
- Model fluxes evaluation from multivariate ship observations (e.g., wind, SST, air temperature, pressure, humidity)
- Ship-based observations to calibrate satellite retrieval algorithms and to validate satellite measurements



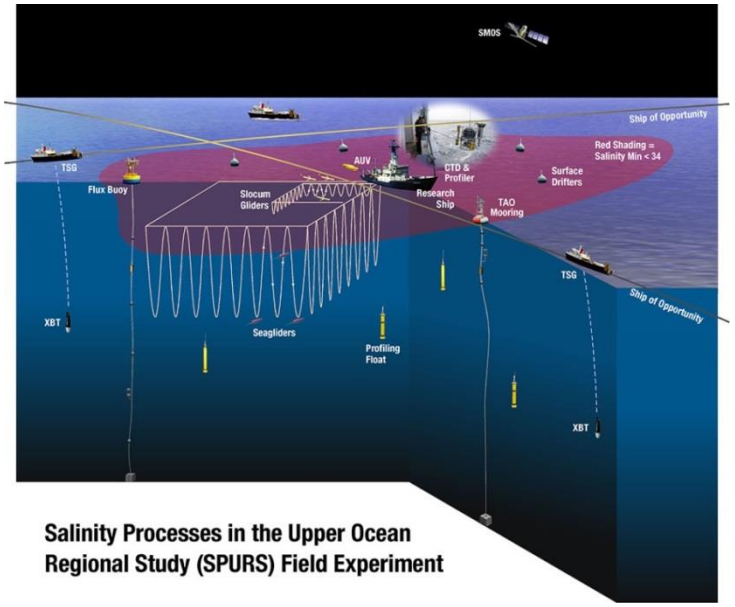
Evaluation of coastal bias corrections in SMOS products with TSG data (*Boutin et al., 2018*)



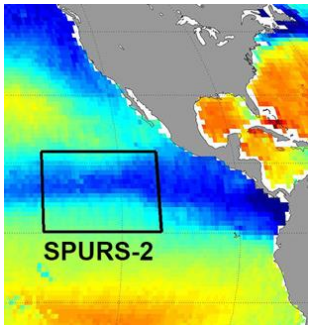
SSS comparison between TSG and Mercator reanalyses *(Tranchant et al., 2019)*

Monitoring and Process Studies

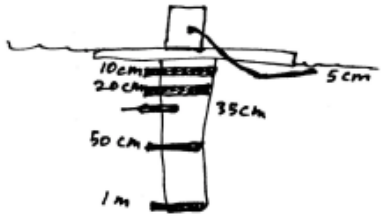
- Ships: only way (with moorings) to continuously monitor ocean-atmosphere fluxes that need multi-parameter observations (e.g. heat, CO_2)
- Only way to access marine environment properties that need manual sampling (e.g. aerosol, nutrients, trace metals, isotopes, plastics)
- Access to small scales processes at ocean-atmosphere interface (e.g. diurnal heating, near-surface stratification)

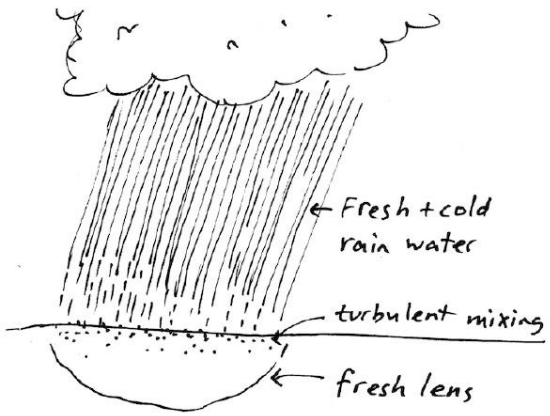


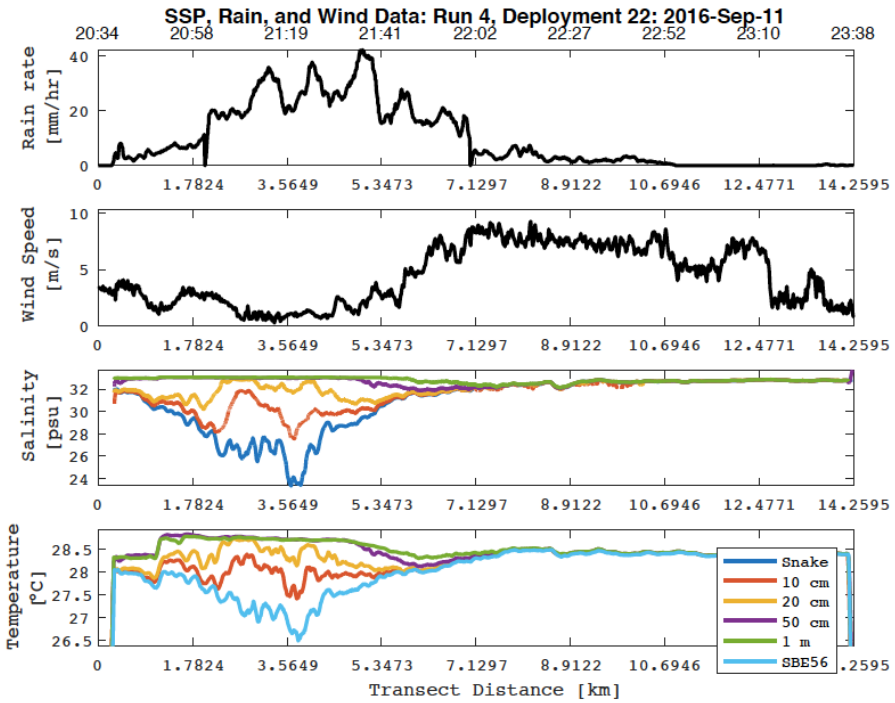
Salinity Processes in the Upper Ocean Regional Study (SPURS) Field Experiment



SPURS-2: near-surface ocean response to rainfall





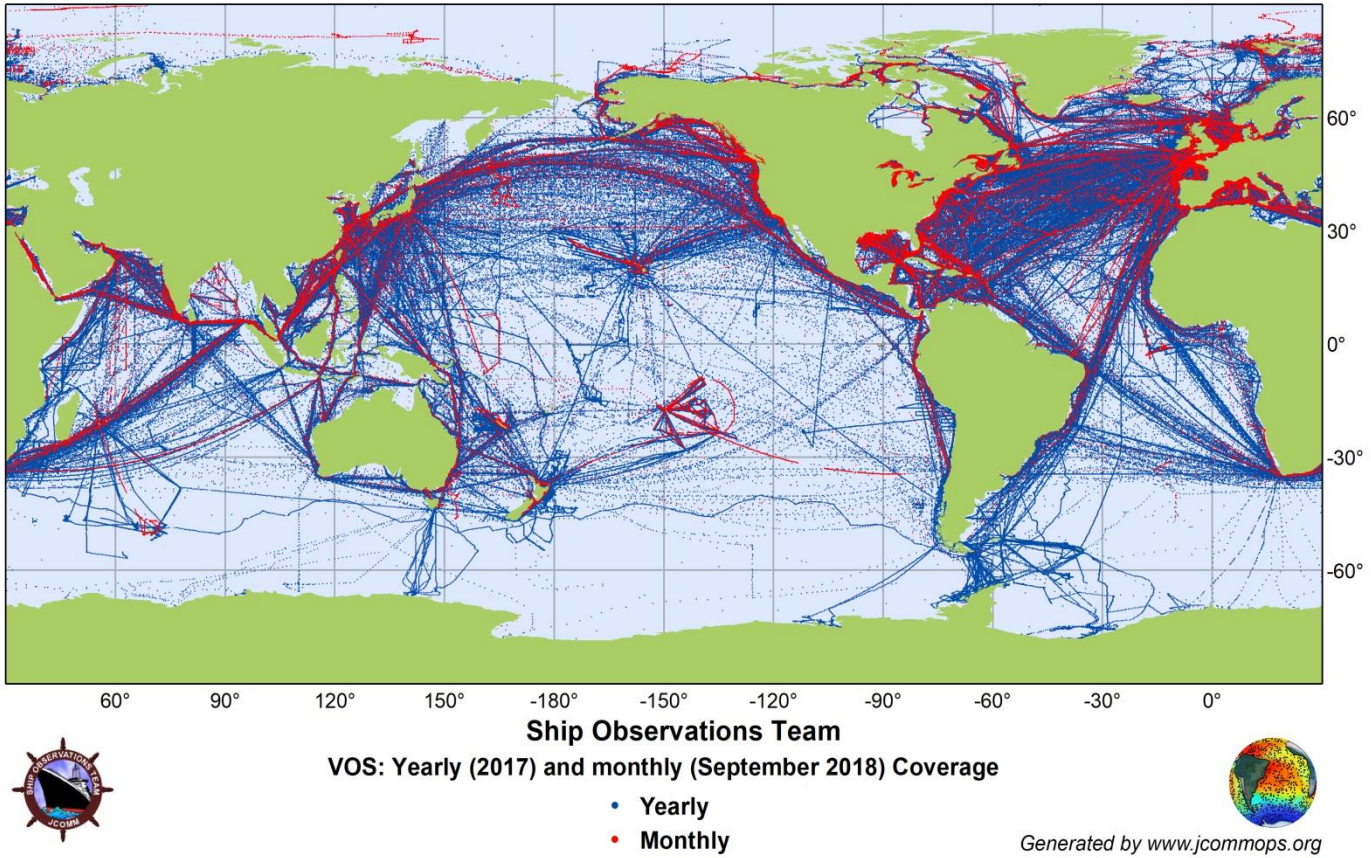


Drushka et al. (2018)

Atmospheric Observations

- VOS (Voluntary Observing Ships) provide real-time meteorological obs
- Declining number of VOS (shipping lines instability, budgetary constraints, ship position confidentiality) but increasing number of reports (automatic weather stations, electronic logbooks, larger bandwith)
- Less standard but more complete obs (fluxes) available from Research Vessel in delayed time, coordinated by SAMOS (Shipboard Automated Meteorological and Oceanographic System)
- Meteorological *vs* climate-quality data

VOS reports
(Patm, wind, Tair, SST, wave, ice)

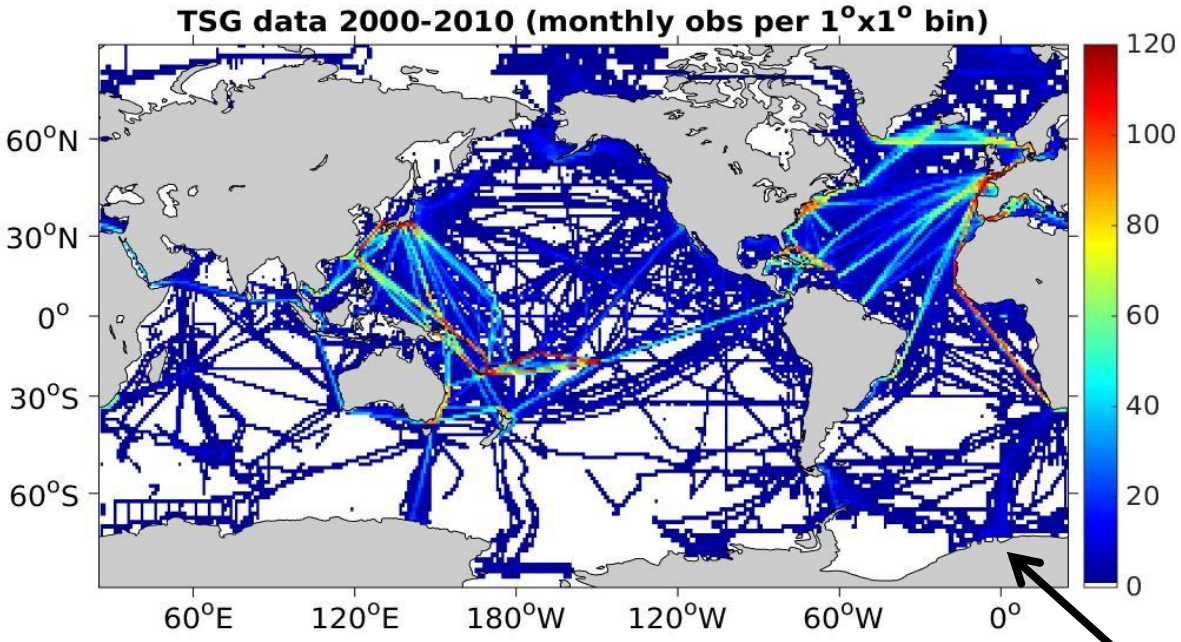


2000 ships globally but 90% of the data from 600 ships

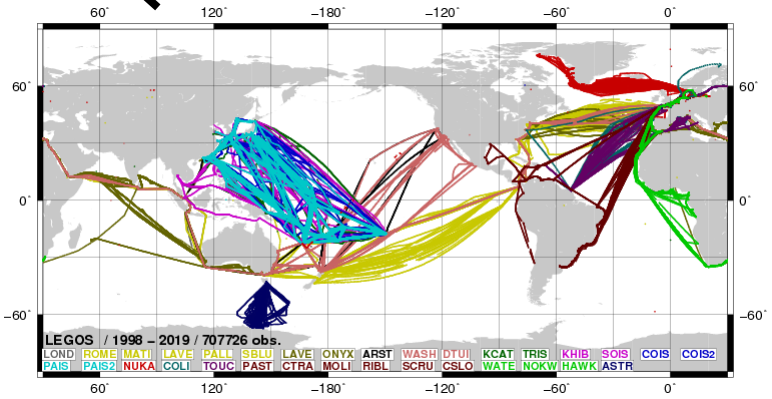
Oceanic Observations

- TSG (thermosalinograph) network from commercial and research ships coordinated by GOSUD (Global Ocean Surface Underway Data), FerryBox
- High-horizontal SSS variations (fronts, sub-mesoscale)
- Intake depth uncertainty on commercial ships *vs* multi-level vertical sampling possible on research vessels
- Delayed time corrections for salinity sensor fouling not widespread
- Sometimes, additional underway measurements (oxygen, fluorescence, CO_2, plankton from CPR)
- Other platforms: sailing ships, drifters, automous platforms (wavegliders, saildrones)

Global TSG network



Major French contribution from SNO SSS



Metadata

- Variable name, platform type/name, position, time, instrument, height/depth…
- Standards defined by WMO/JCOMM, SAMOS, GOSUD
- Important for merging long-term records from different instruments and/or platforms (increasing height, bucket to TSG)
- Ship anonymity *vs* AIS (Automatic Identification System) technology
- Increasing use of discovery metadata (spatio-temporal coverage, licensing rights, dowload site) for better interoperability, to ease users access to data

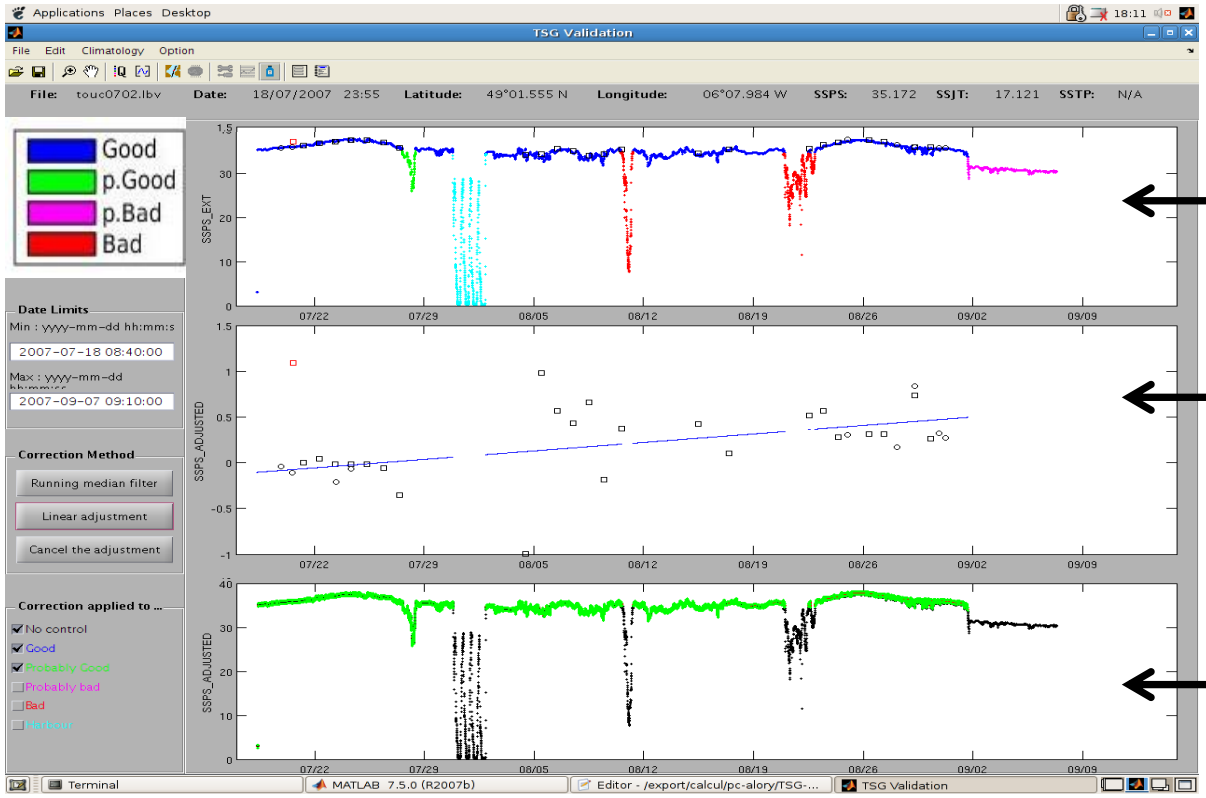
IODE International Oceanographic Data and Information Exchange

OceanDataPortal Seamless access to ocean data

Quality assurance and control

- Automatic real-time QC based on basic tests (range, position, climatology)
- QC flag attribution *vs* data rejection
- In best cases, delayed-time adjustment relative to pre/post-calibration data or external co-located data, quantification of uncertainty
- Commitment to reference guidelines (calibration, logbook, metadata, data submission, inter-comparison) in international networks (ex: GAW - Global Atmosphere Watch)

SNO SSS delayed-time TSG data processing

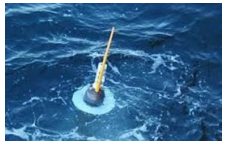


QC flag attribution

- Climatology
- Flow
- Expertise
- Problems observed onboard

Correction relative to

- Water samples
- Co-located Argo data



Error attribution

Based on dispersion of TSG-sample differences

Recommendation #

1. **Expand recruitment of new ships to make observations of EOC/ECV to**
   a. Include recruitment via traditional means, ensuring that all research vessels are contributing to operational and research data collection efforts, and seeking new collaborations with commercial and private ship owners/operators,
   b. Increase and improve communications between the WOC, JCOMM, the research community, and relevant panels/communities in identifying additional ships to make observations, and
   c. **Engage the user community to develop a list of sensors to be widely deployed on ships and to define high-priority regions of the ocean to target for increased sampling.**

Feasible at national level and relatively low cost

Need high level of international cooperation and capital investment

Recommendation #

2. The research vessel community should
   - **a. Provide metadata regarding their observational capabilities to international metadata catalogs,**
   - b. Expand capabilities to conduct direct flux measurements,
   - c. Host new technology to provide a testbed prior to installation on commercial or private ships,
   - **d. Support installation of multiple sensor packages on research vessels,** and
   - e. Ensure that all sensor packages on each research vessel operate on every voyage (to maximize data collection).

Recommendation #

3. Agencies should invest in technology development by, but not limited to
   a. **Establish pilot projects, to include industry, governments, and equipment and software providers, to develop methods to transmit meteorological and oceanographic information via AIS messages,**
   b. Work with sensor manufacturers to develop cost-effective, self-describing sensors that could deliver their metadata in a normalized format,
   c. **Develop automated atmospheric composition sampling systems that could be installed on ships of opportunity,** and
   d. **Develop a web portal and other recruitment tools to support third party data collection.**

Recommendation #

4. Improve data access and interoperability by
   a. Agreeing internationally to a fully open policy for the exchange of and access to data and metadata from ships and
   b. Establishing distributed, but interoperable, regional/global data centers, to catalog, evaluate, and distribute shipboard underway data, including VOS and research vessels, collected in real-time and delayed mode. One center should focus on receiving, processing and evaluating GTS data from multiple NMHS.
5. **Move ship observing networks towards standard quality control and assessment methodology by organizing an international working group to focus on developing and distributing tools and best practices.**


to be discussed in Hawaii…
NOAA
R 334