



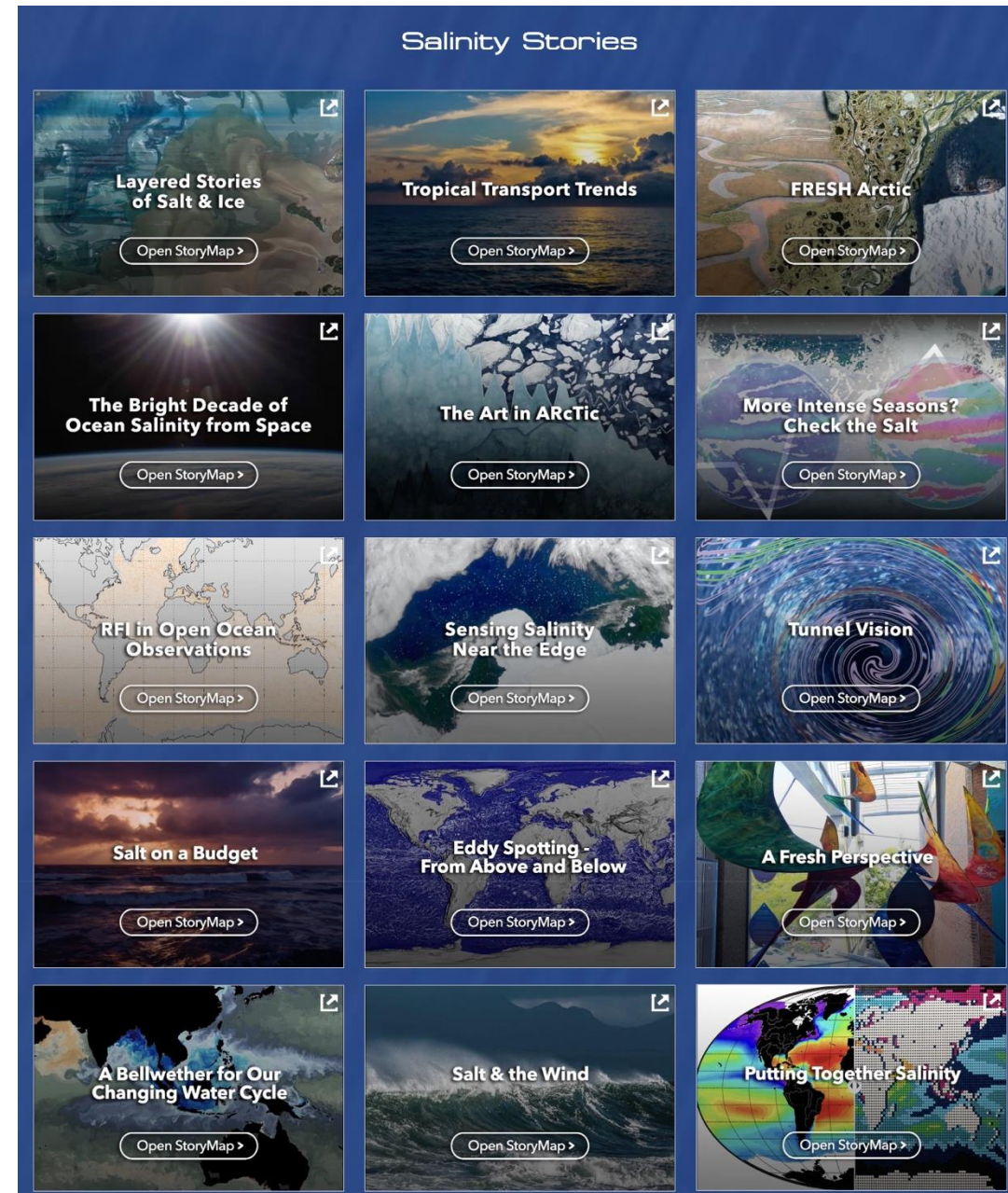
NASA Salinity website at a glance

- 40 archived meetings
 - 1217 presentations
- 1164 publications
- 48 Research one-Pagers

Let's focus on Salinity Stories

- 25 StoryMaps
- ~119,000 views
- Easy to embed on other websites
- Look good from widescreen to mobile

salinity.oceansciences.org



What's the Story Behind Making StoryMaps?

- Contact author(s) of papers we think would be a good addition to the *NASA Salinity* website
- Ask for “take home” messages & if there has been any press
- Within a week or so, we ask for specific images and/or data
- Develop content to provide context for non-experts
- After ~2 weeks, we share a draft StoryMap for feedback
- Iterate the final content over email
- Put it on the *NASA Salinity* website

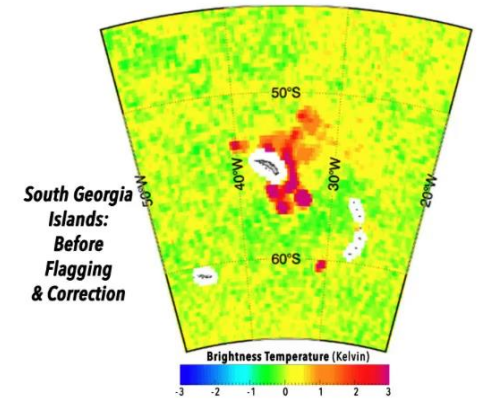


Let's look at some examples...

NASA Salinity Stories

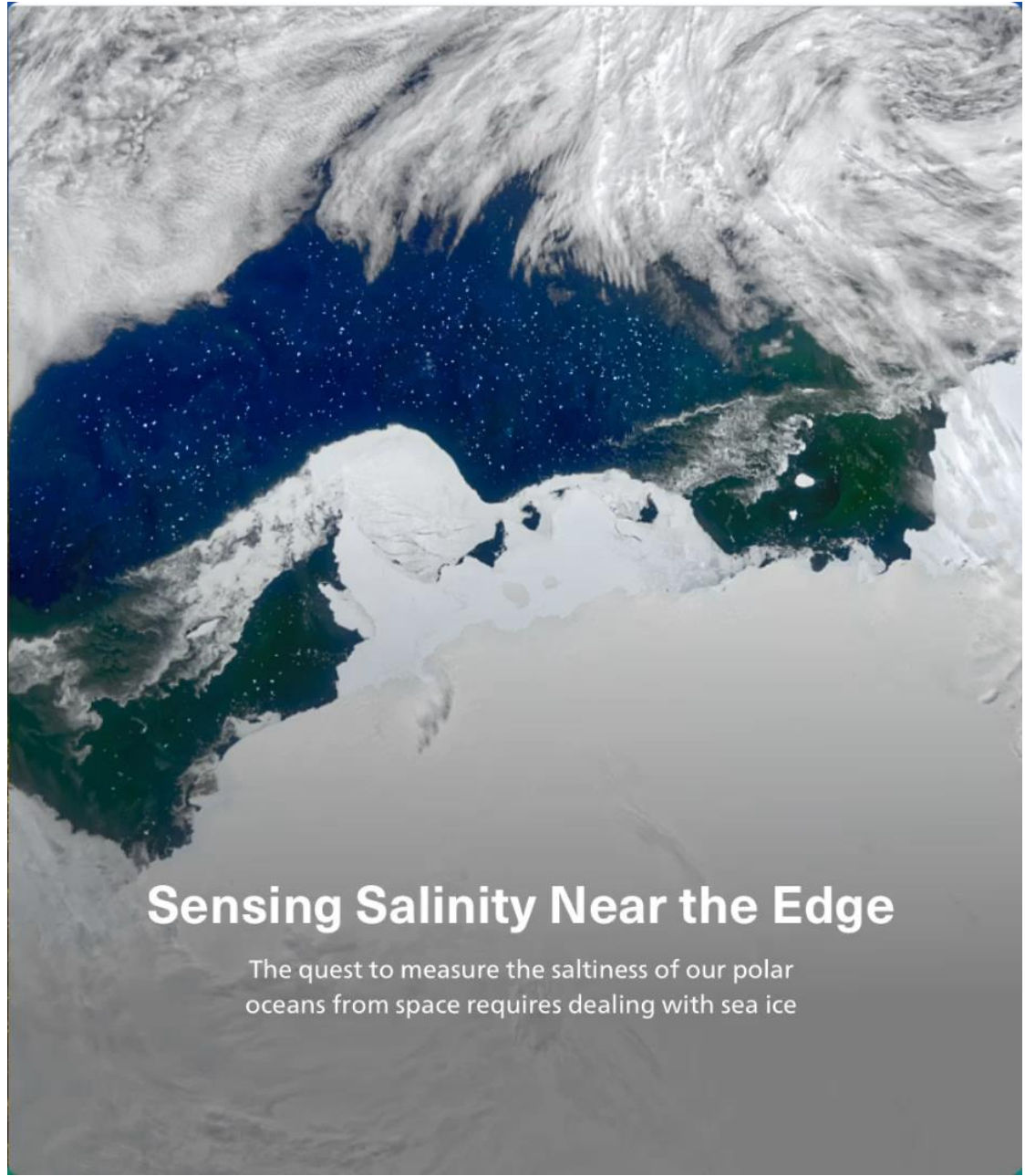
Stories with Key Context for Data Users

- ✓ Clearly state the challenges & proposed solutions
- ✓ Outline the steps taken to correct salinity retrievals
- ✓ Present case studies (e.g., before/after corrections)



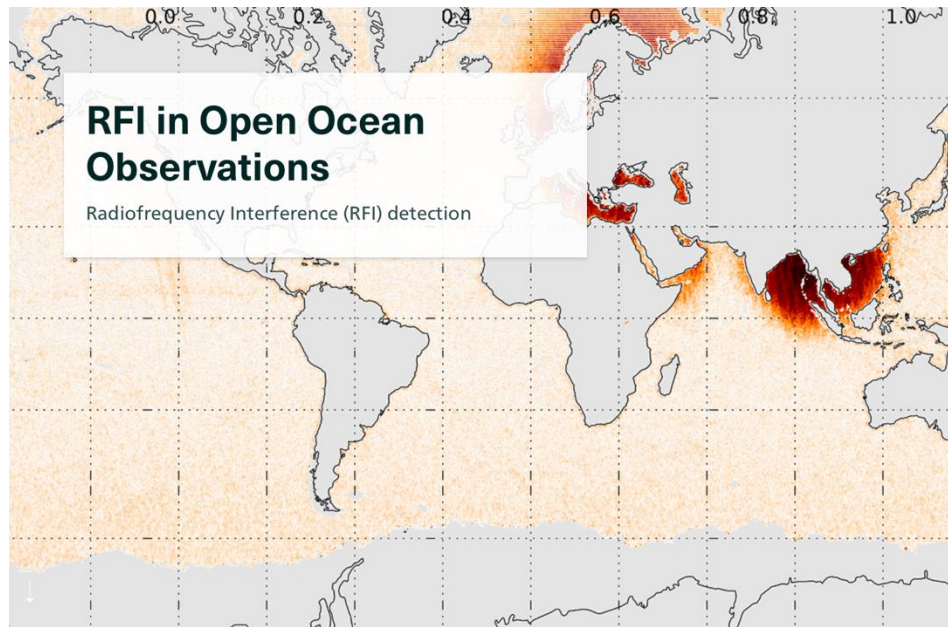
Observations within sea-ice Zones 3 and 4 are omitted from smoothed 70-km averaged data.

<< Sensing Salinity Near the Edge (based on Meissner and Manaster, 2021)



Sensing Salinity Near the Edge

The quest to measure the saltiness of our polar oceans from space requires dealing with sea ice



1. Introduction

NASA's SMAP L-band radiometer (Eunghi et al. 2010) has been supplying the scientific community with high-quality measurements of sea surface salinity (SSS) since 2015 (Froese et al. 2016; Meissner et al. 2016; Ford et al. 2020). Starting in 2023, there has been an increasing level of radio frequency interference (RFI) contaminating SMAP ocean observations which results in spurious retrieved SSS values. The areas that are most affected are the Bay of Bengal, Gulf of Thailand, Mediterranean Sea, North Sea, Norwegian Sea, Barents Sea, Black Sea, Caspian Sea, Arabian Sea, and South China Sea.

Although the SMAP radiometer operates within the Earth Exploration Satellite Service (eS3) 1400–1425 MHz band provided under the radioprotection RFI exemptions of SMAP observations can be caused by unauthorized sources that transmit within this protected bandwidth or by leakage from coast-to-coast transmitters that operate at adjacent frequencies. RFI contamination originating from various sources has also been observed with the SMOS (Oliva et al. 2016; de Maricourt et al. 2017; Stopponi et al. 2019) and Aquarius (Le Vine and de Maricourt 2014; Le Vine et al. 2016; Meissner et al. 2018)

L-band radiometers. To avoid and mitigate the impact of RFI, the SMAP science team employs advanced methods to detect RFI and filter it from its data (Mera et al. 2019, 2021; Proffner et al. 2019; Johnson et al. 2016; Meissner et al. 2016; Saska et al. 2018, 2019; Proffner et al. 2019; Le Vine and de Maricourt 2014; Wang et al. 2018). The SMAP RFI detection combines several criteria: (time-downward) detection, cross-frequency detection, horizon detection, and polarization detection (using the SMAP dual and north-south antenna temperatures). These detection and filtering methods, which are implemented during ground and earth-orbit processing, are largely based on the fact that most RFI signals exhibit a certain signature in the time and frequency domain at their natural and polarimetric properties (Meissner et al. 2018). The observed RFI contamination in the SMAP ocean data starting in 2023 is believed to be predominantly caused by Global Navigation Satellite System (GNSS) jamming within the frequency band that is contained in the eS3 band of population. These jamming signals have very high power and are easily detected due to their source due to their high power. However, because they are persistent in time and cover a large range of frequencies, they can easily escape the SMAP RFI detection filter over the ocean, where considerable power from the side-lobe enters the SMAP antenna field of view due to the relatively low beam efficiency (about 95%). As a consequence, transmitters operating at a distance from the observation cell can cause significant RFI contamination.

It is therefore necessary to develop additional methods that detect, flag, and remove RFI in the SMAP ocean observations.

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NASA Salinity Stories

Stories that Break Down Complex Content

- ✓ Animated diagrams help explain physics
- ✓ Data look great on interactive globes!
- ✓ Simple prompts work well: Where? When?

<< *More Intense Seasons? Check the Salt*
(based on Bingham and Bayler, 2025)

- ✓ Quotes can be thought provoking 🤔
- ✓ We also break down complicated figures (next example)

More Intense Seasons? Check the Salt

Salinity observations from satellites support predictions of an accelerating water cycle

Tropical Transport Trends

Near-surface salinity in the Southeast Indian Ocean is closely linked to freshwater from the Maritime Continent

Salinity Trends What's Behind the Trends? Finding Answers with ECCO

Yet what is any ocean, but a multitude of drops? David Mitchell

IGR Oceans
RESEARCH ARTICLE
10.1029/2025JC022733

Maritime Continent Water Cycle as a Key Forcing for Decadal Variation of Upper-Ocean Salinity in the Southeast Indian Ocean

Sudheeka Jangala¹, Tong Lee², Ou Wang², and Severin Forner¹

¹Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

Abstract Argo measurements illustrate pronounced decadal variation of salinity in the southeast Indian Ocean (SEIO) that is coherent in the upper 70 m, with freshening during 2004–2010 followed by salinization during 2011–2019. The SEIO decadal salinity variation contributed to over half the magnitude of decadal sea level variation in this region. Previous studies suggested several possible factors contributing to SEIO decadal salinity signal: SEIO local winds, remote winds in the tropical Pacific forcing the Indonesian Throughflow (ITF) that advects salinity signal into the SEIO, SEIO local freshwater flux, remote freshwater flux over the Maritime Continent (MC), These studies did not agree on a key forcing mechanism. Here, we attribute decadal variation of SEIO salinity by isolating the contributions of freshwater and wind stress forcings through sensitivity experiments using the ocean modeling and state estimation system of the Estimating the Circulation and Climate of the Ocean (ECCO) project. Our causality analysis reveals that Maritime Continent surface freshwater flux is the key for decadal variation of SEIO salinity. Decadal variation in local or remote winds and SEIO local freshwater flux, implicated to be important by some previous studies, play little role. Salt budget analysis suggests that the advection of the salinity gradient, induced by the decadal variation of freshwater content over the MC, into the SEIO is the main oceanic process transmitting the MC water cycle effect to the SEIO.

Plain Language Summary Long-term ocean observations reveal a decreasing trend in the upper 70 m ocean salinity in the southeast Indian Ocean (SEIO) during 2004–2010, followed by a steady increasing trend during 2011–2019. There is no clear consensus on the processes driving decadal variability in SEIO salinity, as different studies propose varying mechanisms. Some highlight the importance of local wind forcing, while others suggest local freshwater flux. Some also point to remote freshwater flux from the Maritime Continent (MC) and remote wind forcing from the western tropical Pacific Ocean. To bridge this knowledge gap, we utilize ECCO model to perform sensitivity experiments to isolate the impacts of freshwater and wind forcings. We find that surface freshwater flux over the MC plays a crucial role in driving the decadal variability of SEIO salinity, while wind forcing has no significant impact. We demonstrate that in decadal timescales, the anomalously low or high salinity waters are carried from MC by the Indonesian Throughflow and transported into the SEIO region. This main oceanic process is responsible for the decadal freshening and salinization of the SEIO upper ocean.

1. Introduction
Upper ocean salinity has proven to be a key indicator for change in the global water cycle, providing important insights into shifts in climate patterns and ocean dynamics (Yu et al., 2020; Zhang et al., 2018). Spatial patterns and trends in global sea surface salinity (SSS) since the 1960s, in conjunction with the changes in freshwater fluxes such as evaporation and precipitation, suggest intensification of the global hydrological cycle in response to a warming climate (Danabasoglu, 2015; Danabasoglu et al., 2012). The multidecadal trends observed in the SSS in global tropics show that the salty regions are getting saltier and the fresh regions are getting fresher. These long-term trends in SSS are linked to changes in the surface freshwater flux (evaporation minus precipitation), driven by anthropogenic climate warming, resulting in a “dry getting drier” and “wet getting wetter” pattern. On shorter timescales (interannual to decadal), varying by the region, the upper ocean salinity is significantly influenced by oceanic processes, such as horizontal advection, mixing, and entrainment, alongside the freshwater flux (Yu, 2011). The variability of upper ocean salinity on interannual to decadal timescales and across regional patterns remains poorly understood due to the complexity of the underlying driving mechanisms.

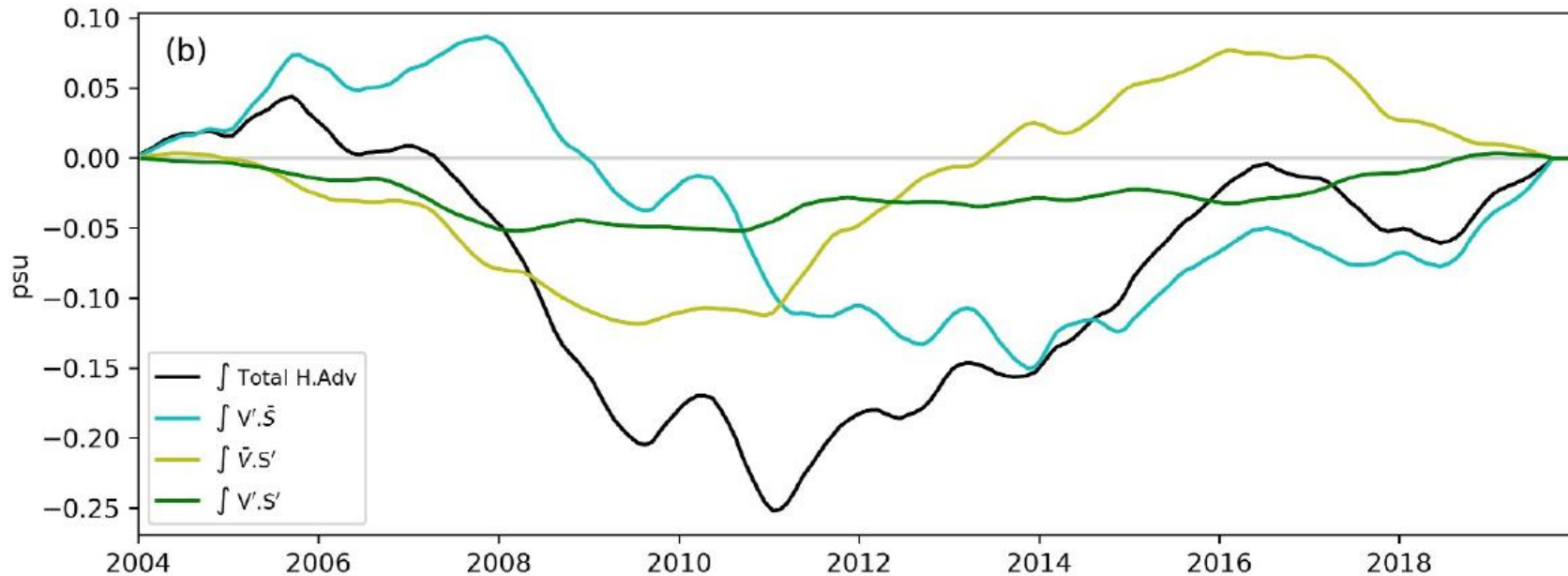
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AGU ASSOCIATED PRESS AND SPACE WEATHER

NASA Salinity Stories

Before

$$H_{adv} = \frac{H}{\text{Vol}} \left[\int \bar{u}_w (\bar{S}_w - \bar{S}_{ref}) dy - \int \bar{u}_E (\bar{S}_E - \bar{S}_{ref}) dy + \int \bar{v}_s (\bar{S}_s - \bar{S}_{ref}) dx - \int \bar{v}_N (\bar{S}_N - \bar{S}_{ref}) dx \right]$$
$$+ \frac{H}{\text{Vol}} \left[\int u'_w (\bar{S}_w - \bar{S}_{ref}) dy - \int u'_E (\bar{S}_E - \bar{S}_{ref}) dy + \int v'_s (\bar{S}_s - \bar{S}_{ref}) dx - \int v'_N (\bar{S}_N - \bar{S}_{ref}) dx \right]$$
$$+ \frac{H}{\text{Vol}} \left[\int \bar{u}_w (S'_w - S'_{ref}) dy - \int \bar{u}_E (S'_E - S'_{ref}) dy + \int \bar{v}_s (S'_s - S'_{ref}) dx - \int \bar{v}_N (S'_N - S'_{ref}) dx \right]$$
$$+ \frac{H}{\text{Vol}} \left[\int u'_w (S'_w - S'_{ref}) dy - \int u'_E (S'_E - S'_{ref}) dy + \int v'_s (S'_s - S'_{ref}) dx - \int v'_N (S'_N - S'_{ref}) dx \right]$$



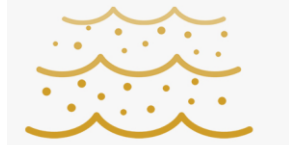
NASA Salinity Stories

After

Horizontal motion can be decomposed into:

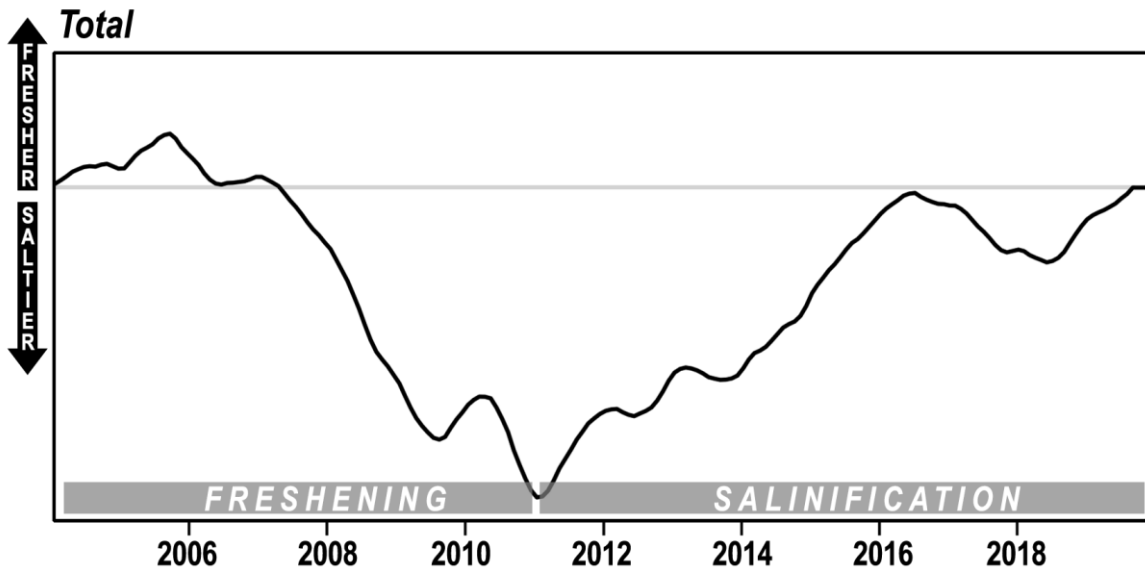


Velocity

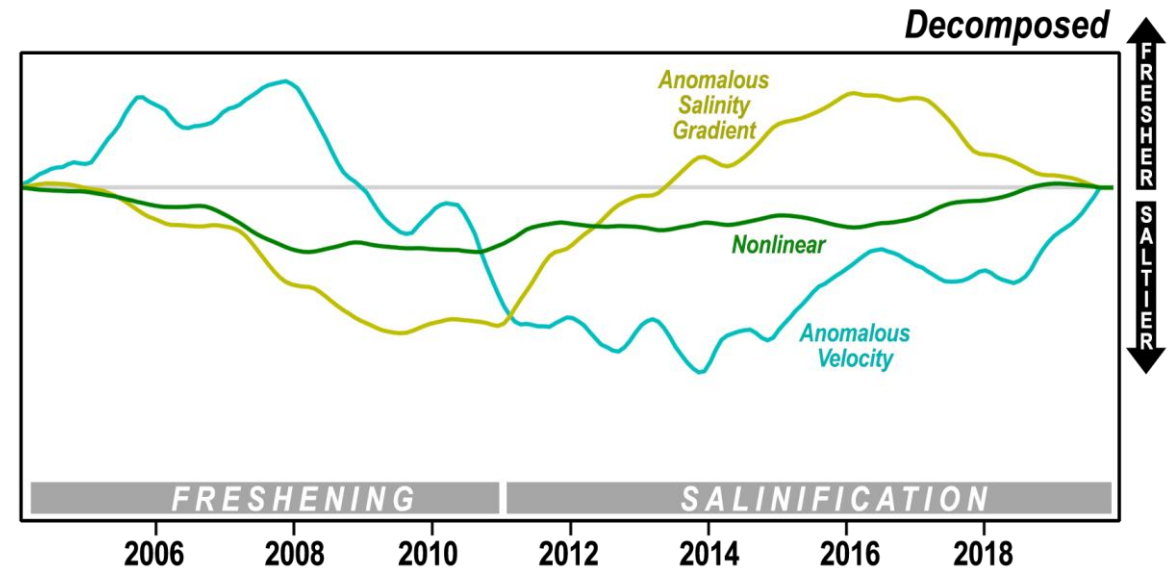


Salinity

Horizontal Ocean Motion



Horizontal Ocean Motion

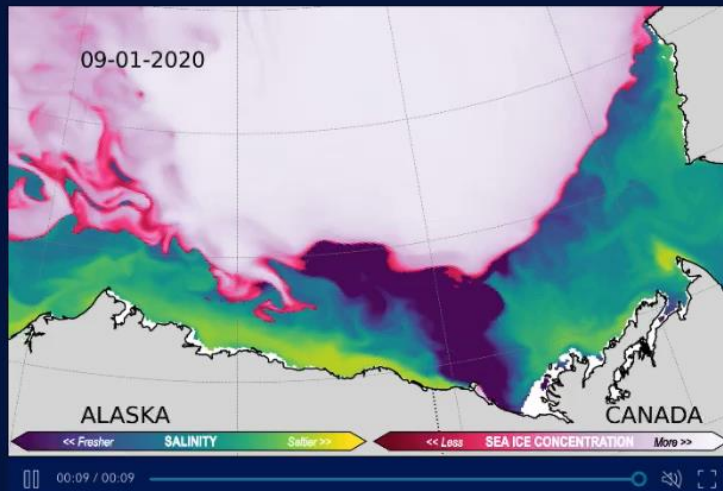


NASA Salinity Stories

Sea Ice Two Ways | A River Runs Into It

ECCO Coupled Ocean-Sea Ice Model

A high-resolution version of the ECCO coupled sea-ice model was developed for SASSIE. Each grid cell (~3.5 square km or ~1.4 square mi) includes 90 vertical levels, from the sea surface to the seafloor. The data animation below shows salinity and sea ice concentration from the beginning of September to the end of November 2020. Note the level of detail revealed by the SASSIE ECCO model that isn't visible in [satellite data](#).



With this high-resolution SASSIE ECCO model:

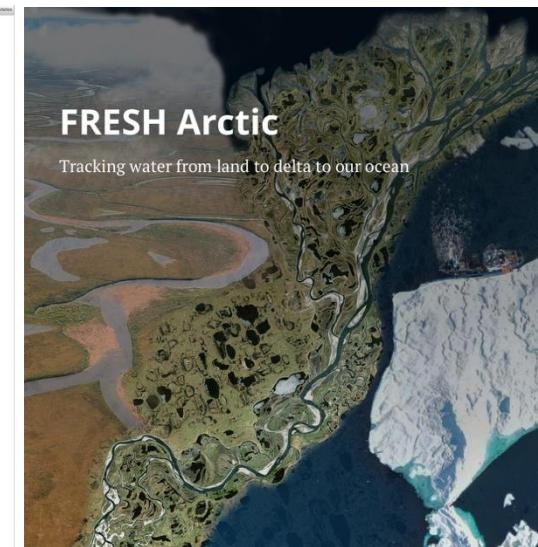
- **We focused on fall freeze-up** by analyzing daily mean model output *after* the September sea ice minimum date
- **Masked ice-covered areas** by excluding grid cells with more than 15% sea ice concentration (on the sea ice minimum date) to isolate open-water regions
- **Analyzed upper ocean conditions and sea ice formation** to evaluate where and when sea ice forms in previously ice-free areas

Zooming out to include the entire Arctic Ocean, this version of the SASSIE ECCO model shows salinity and sea ice concentration data during the full year of 2020. **Note that ice bridge formation over the Mackenzie River Plume is observed during all seven years of the model (2014-2020).**

Stories can be Tied to Field Projects (& Combined)

- ✓ **SASSIE & FRESH Arctic**
- ✓ **Stories cover multiple publications**
- ✓ **3D diagrams can complement data plots**
- ✓ **Can include data visualizations beyond the original paper**
- ✓ **Can be featured on other sites (e.g., ECCO)**

<< **Layered Stories of Salt & Ice**
(based on [Houndegnton et al., 2026](#) and [Zahn et al., 2026](#))



NASA Salinity Stories

A Bellwether for Our Changing Water Cycle

Why it's important to monitor salinity changes along our coasts

Stories with Broad Appeal for Non-experts

- ✓ Provide background information
- ✓ Address the societal importance of salinity
- ✓ Add photos to diagrams can make examples feel “real”
- ✓ Emphasize the ocean’s ties to the water cycle

<< *A Bellwether for Our Changing Water Cycle*
(based on Fournier et al., 2023)

remote sensing 

Review
The Bright Decade of Ocean Salinity from Space
Roberto Sabia ^{1,*}, Jacqueline Boutin ^{2,3}, Nicolas Reul ³, Tong Lee ⁴ and Simon H. Yuth ⁴

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Abstract
Sea Surface Salinity is a crucial climatic variable due to its twofold role as both a passive and an active tracer of oceanic processes. Despite its relevance, however, it could not be measured from space, mainly because of technological limitations, until 2009. Since then, the generation and assessment of satellite salinity has become a game-changer in physical and biogeochemical oceanography, as well as in climate science. Three satellite sensors with salinity-measuring capabilities (SMOS, Soil Moisture and Ocean Salinity, Aquarius, and SMAP-Soil Moisture Active Passive) have been launched in the previous decade, each characterized by specific measurement concepts and features and ad hoc validation approaches. The increasing usage of spaceborne salinity products has produced a variety of results and applications, which are here summarized under three specific domains: climate, scientific, and operational. Finally, short-to-mid-term perspectives, indicating both the expected improvements in terms of algorithms and also looking at novel mission concepts (that will provide continuation of these measurements in the decade to come) have been described.

Keywords: Sea Surface Salinity; Earth Observation; SMOS; Aquarius; SMAP; radiometry; oceanography; climate

1. Sea Surface Salinity: Background and Ongoing Efforts
Sea Surface Salinity (SSS) is a crucial environmental and climatic variable due to its twofold role as both a passive and an active tracer of oceanic processes. Despite its relevance, however, it has not been measurable from space, mainly because of technological limitations, up to the advent of the first satellite with this capability, in 2009.
The “Oceans from Space” conference series, which reviews progress and challenges in the satellite oceanography field with a decadal pace [1], tracked the development of SSS remote sensing since its inception. At the conference held in 2009, a friendly wager on the future of spaceborne salinity was made among the conference participants [2], foreseeing a bright future for technologies aiming at addressing SSS from space. At the subsequent 2010 edition, reflections on that wager were elaborated by the Principal Investigators of the recently launched Soil Moisture and Ocean Salinity (SMOS) mission and the soon-to-be launched Aquarius mission, focusing on the challenges and excitement of the first ever salinity measurements from space [3]. At the 2020 conference (deferred to October 2022 due to the COVID-19 pandemic restrictions), a compendium of a full decade of achievements in the broad oceanographic and climate perspective was presented [4], stressing how decisive

Check for updates
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Remote Sens. **2023**, *15*, 2261 <https://doi.org/10.3390/rs15072261>



The Bright Decade of Ocean Salinity from Space

Game Changers Field Campaigns Data Resources Research Advances Bright Future

The cure for anything is salt water: sweat, tears or the sea.
Isak Dinesen

NASA Salinity Stories

Stories with Appeal for Non-scientists

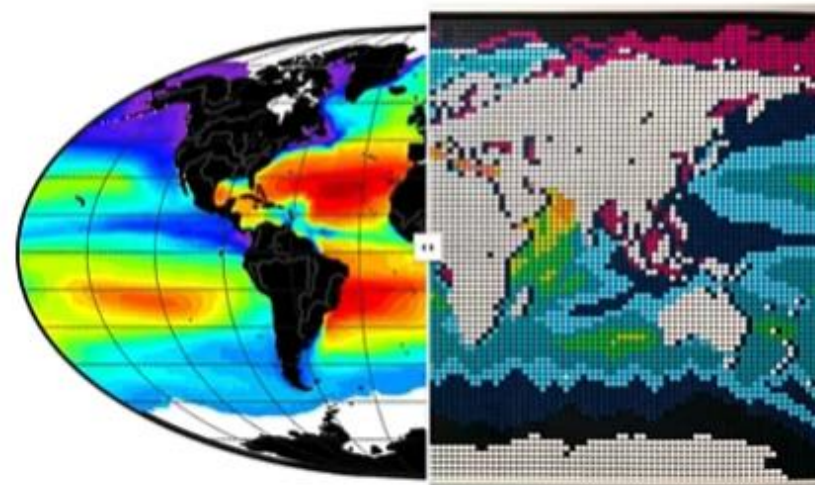
- ✓ Art & science can be synergistic!
- ✓ SASSIE paintings are a beautiful example
- ✓ Warm core ring science inspired wind sculptures
- ✓ OISSS data captured in LEGO art

<< *The Art in ARcTic*

A Fresh Perspective >>

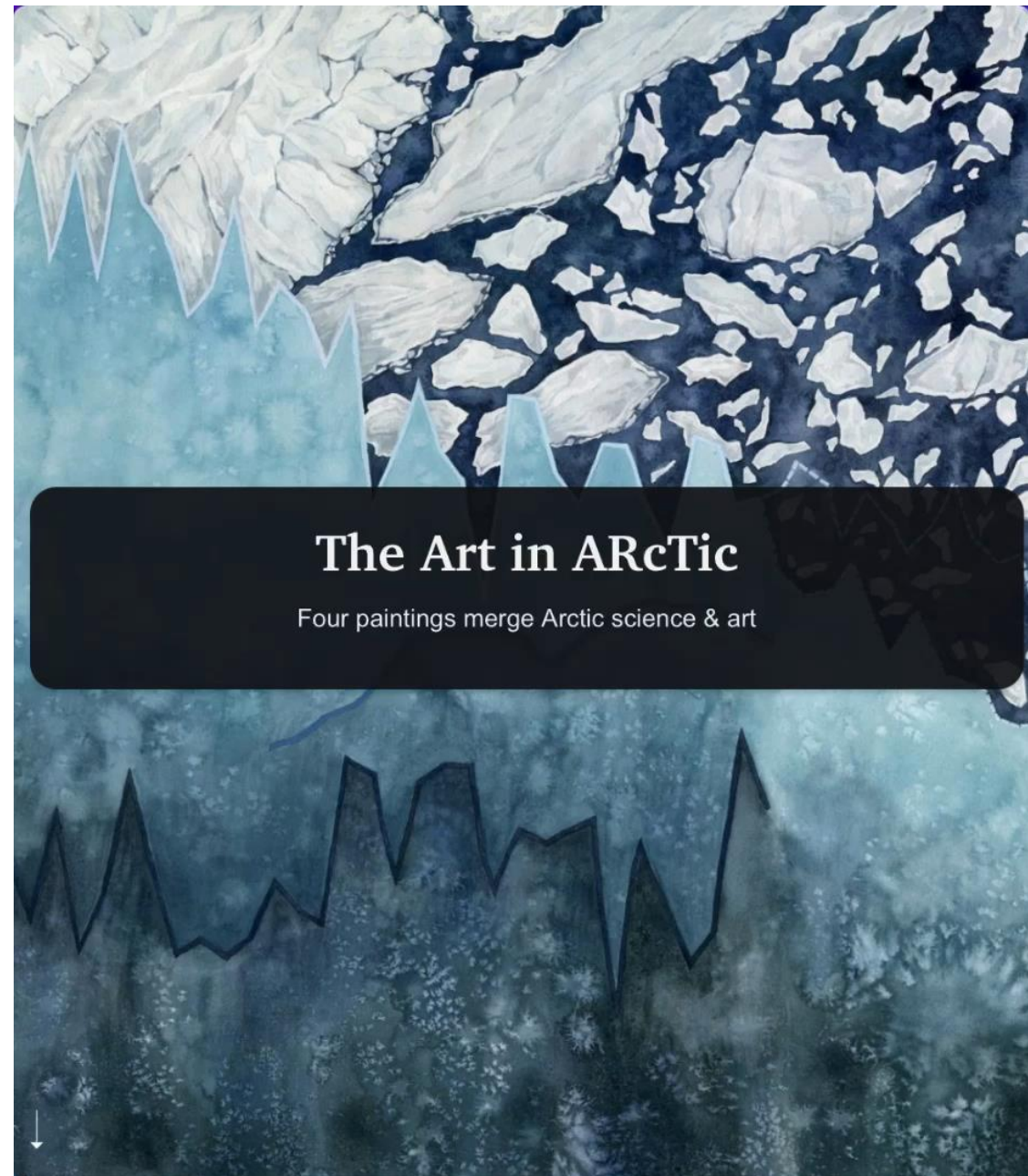
Putting Together Salinity

Can you guess what the right image is constructed from?
(Hint: there are over 11,000 pieces in total)



The Art in ARcTic

Four paintings merge Arctic science & art



Communicating with Non-experts

✓ Text

- Use analogies to explain concepts that may be new to readers
- Quotes can add a human touch

✓ Graphics

- People love videos, diagrams & interactivity!
- De-construct complicated plots into components
- Replace numeric units with relative description when possible (e.g., *higher, lower*)
- Icons help readers quickly grasp what they're seeing

✓ Data

- Provide both metric and English units
- Relate to familiar things (300 m \approx height of the Eiffel Tower)

✓ Science is Serious

- Emphasize the societal relevance of your work
- Try to add a bit of fun to make it more ***memorable***



What's Next?

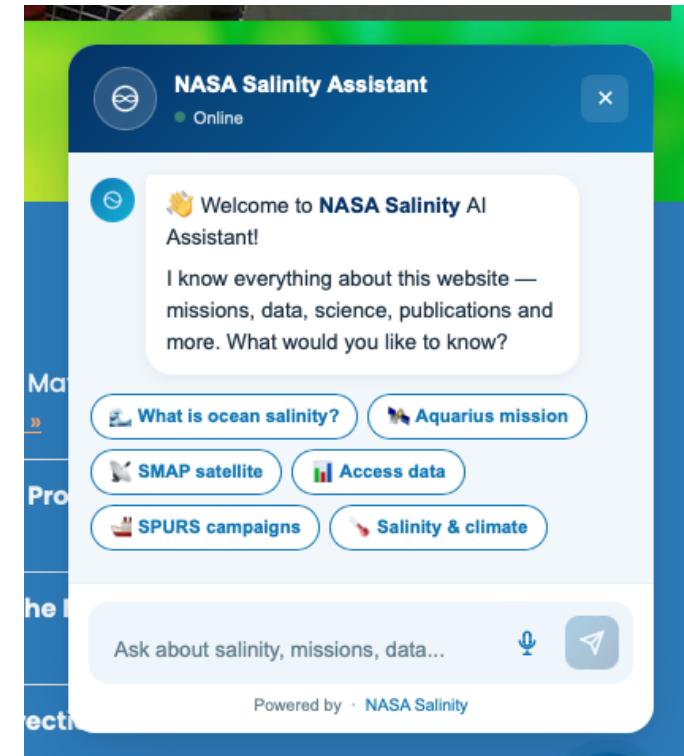
- ✓ Stay tuned for our website's ***AI Assistant!***
 - Being trained on "NASA Salinity" content *only*
 - Optimistic based on initial testing

what pages on this website should I go to to learn more about salinity and seasons

To learn more about salinity and seasonal processes, I would recommend visiting the "HIGHLIGHTS" section of this website, specifically the "Seasons of Salinity" page. This page provides an overview of how salinity changes throughout the year and how it is affected by seasonal variations in precipitation, evaporation, and ocean circulation.

Additionally, you may also want to visit the "SCIENCE" section, where you can find more in-depth information on salinity and its relationship to seasonal processes. The "Salinity Explained" page provides a comprehensive introduction to salinity, including its definition, measurement, and importance in the ocean. The "Research 1-Pagers" and "Publications" pages may also have relevant articles and studies on seasonal salinity variability.

Finally, the "DATA & MAPS" section can provide you with access to salinity data and visualizations, including maps and animations that show seasonal changes in salinity. The "SMAP Maps" and "Aquarius Maps" pages, in particular, offer a wealth of information on salinity patterns and trends, including seasonal variability.



Thank You!

Sharing research findings helps bridge the gap between scientific experts and the general public, promoting greater understanding and engagement with science. – The National Academies

Have an upcoming or recent publication that would potentially make a good StoryMap? Let me know!

Any questions?

avdecharon@gmail.com