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# The Arctic Subpolar gyre sTate Estimate(ASTE)

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Estimating the Circulation and Climate of the Ocean  
*Annual Meeting 25-26 Jan 2023*



The University of Texas at Austin  
Oden Institute for Computational  
Engineering and Sciences



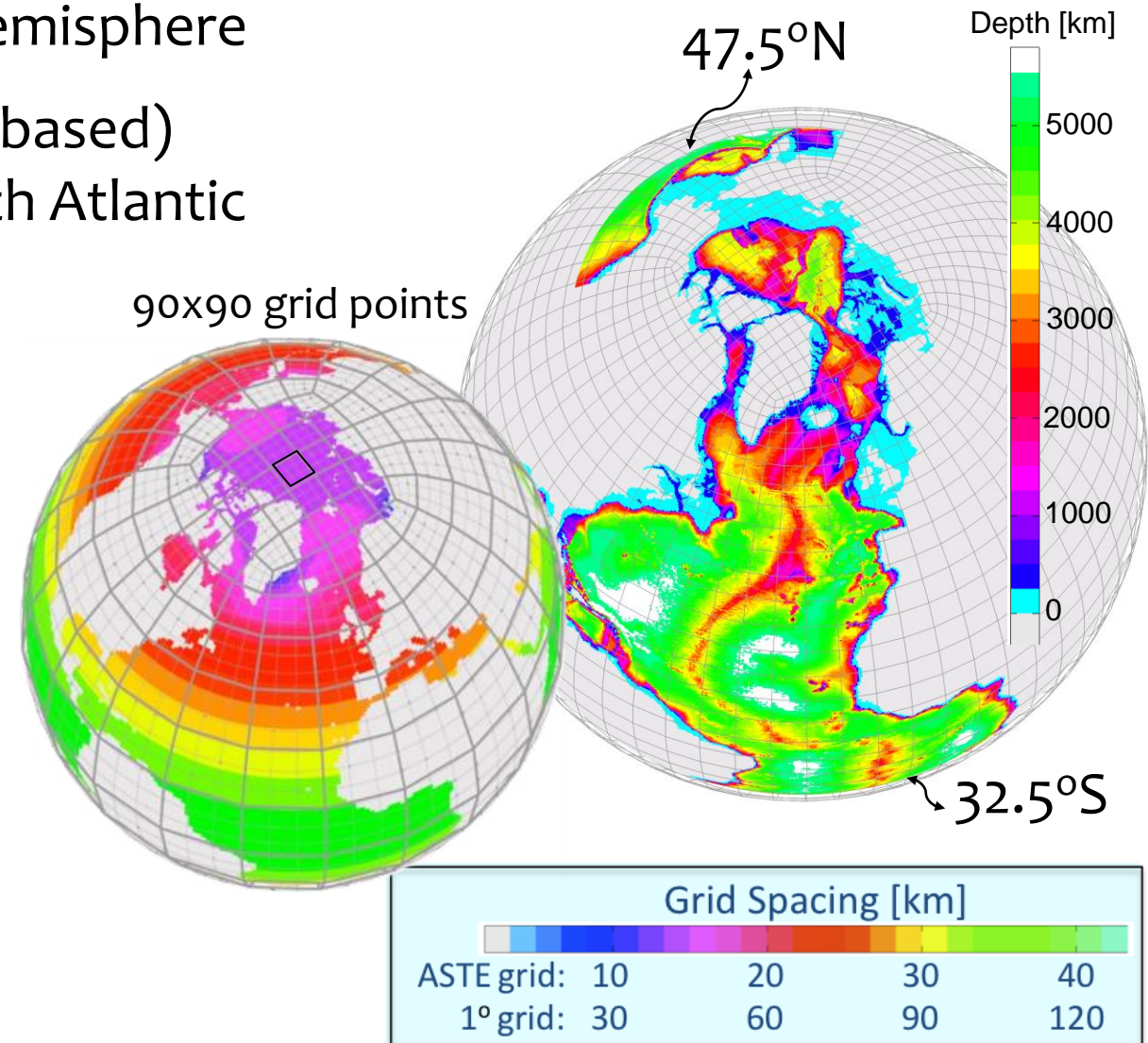
# Outline

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- ASTE updates (since ECCO meeting in 2018)
  - Release 1 Solution
  - ASTE as a tool
- Developments
- Feedbacks with ECCO central production

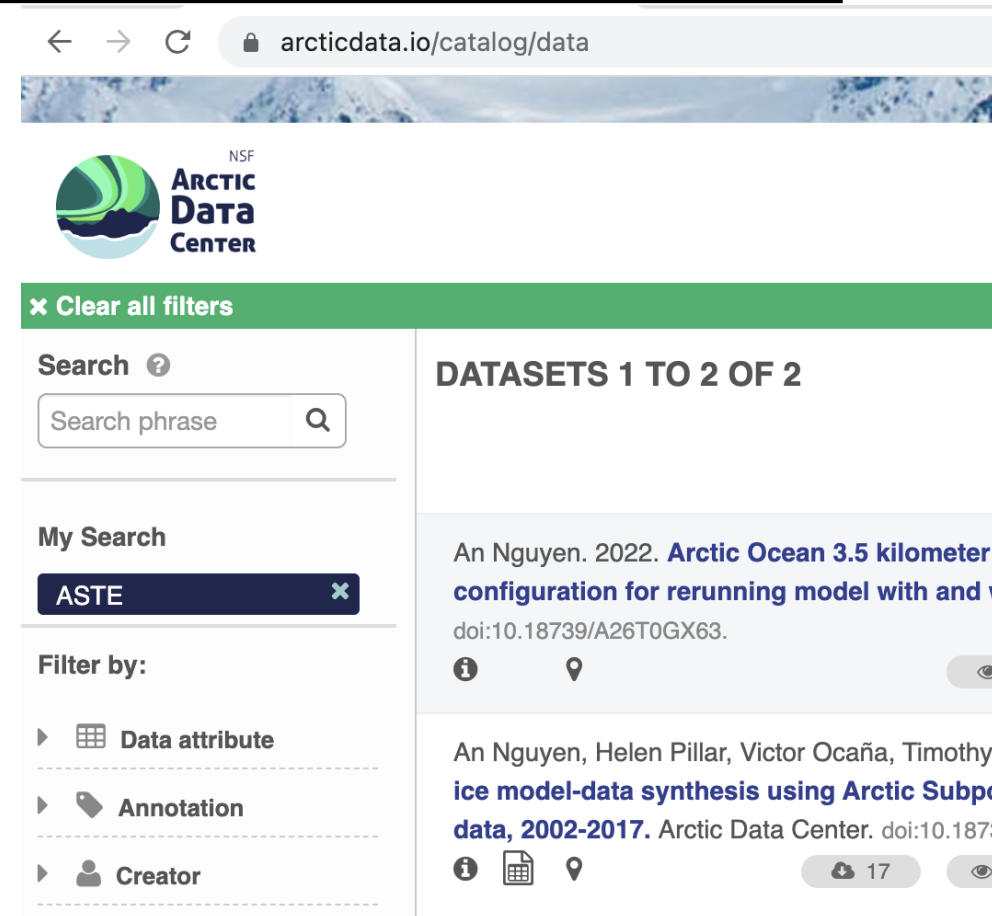
# Arctic Subpolar gyre sTate Estimate (ASTE)

- Equivalent of SOSE for the northern hemisphere
- Higher resolution than ECCOv4 (11c270 based) with focus on Arctic and subpolar North Atlantic
- 14km in Arctic, 17km in Nordic Seas
- Forcing: adjusted JRA55
- OBCs: ECCO 1° global state estimate (ECCOv4R\*)
- **Adjusted parameters:**
  - T/S initial conditions
  - time-varying atmospheric forcings,
  - 3-D ocean mixing parameters



# ASTE Release 1 2002–2017 [Nguyen et al., 2021]

- Uses the same adjoint technology and data as ECCO central state estimate
- Technology developments made in the context of ASTE flow to the central estimate (more later)
- Data distributed at Arctic Data Portal (arcticdata.io) and UT ECCO-mirror site <https://web.corral.tacc.utexas.edu/OceanProjects/ASTE/Release1/>
- ASTE Release 1 solution was named in NASA IDS 2019 call and is used in NASA-funded polar research



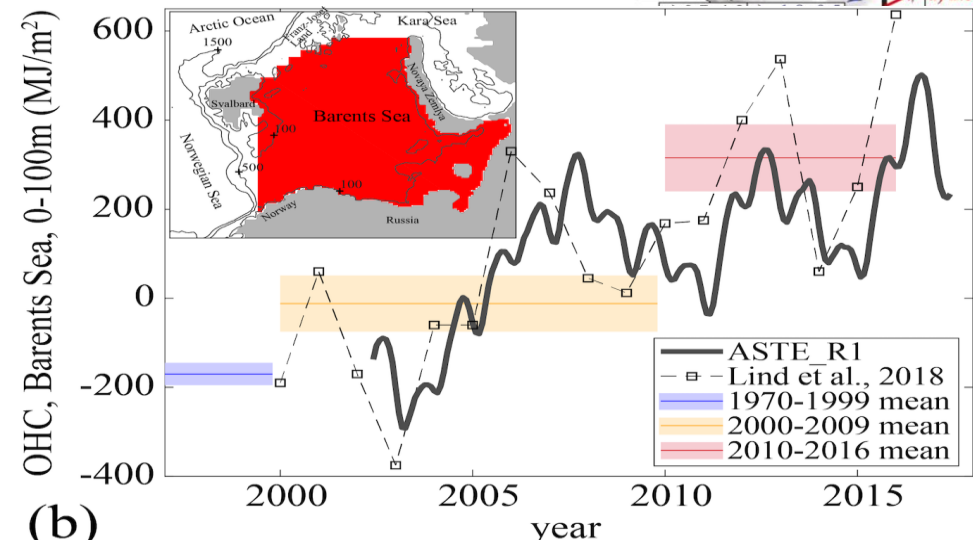
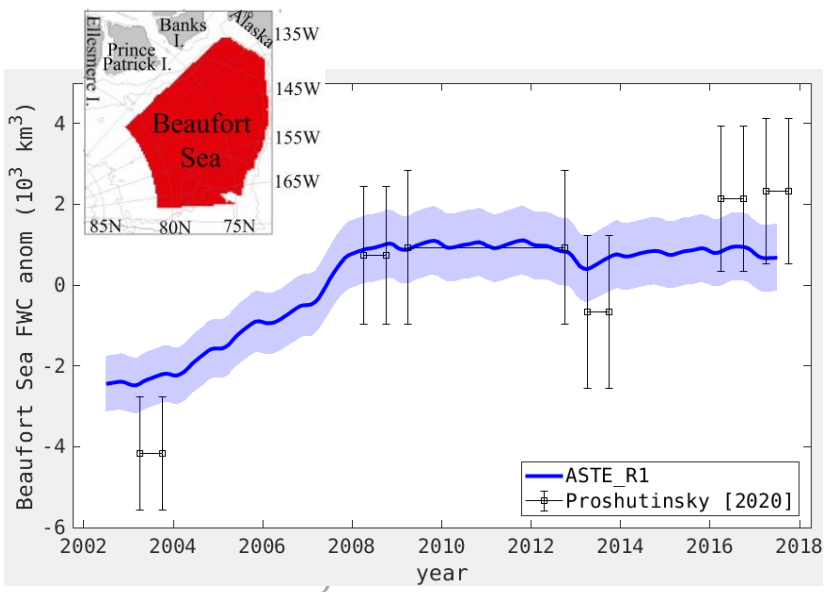
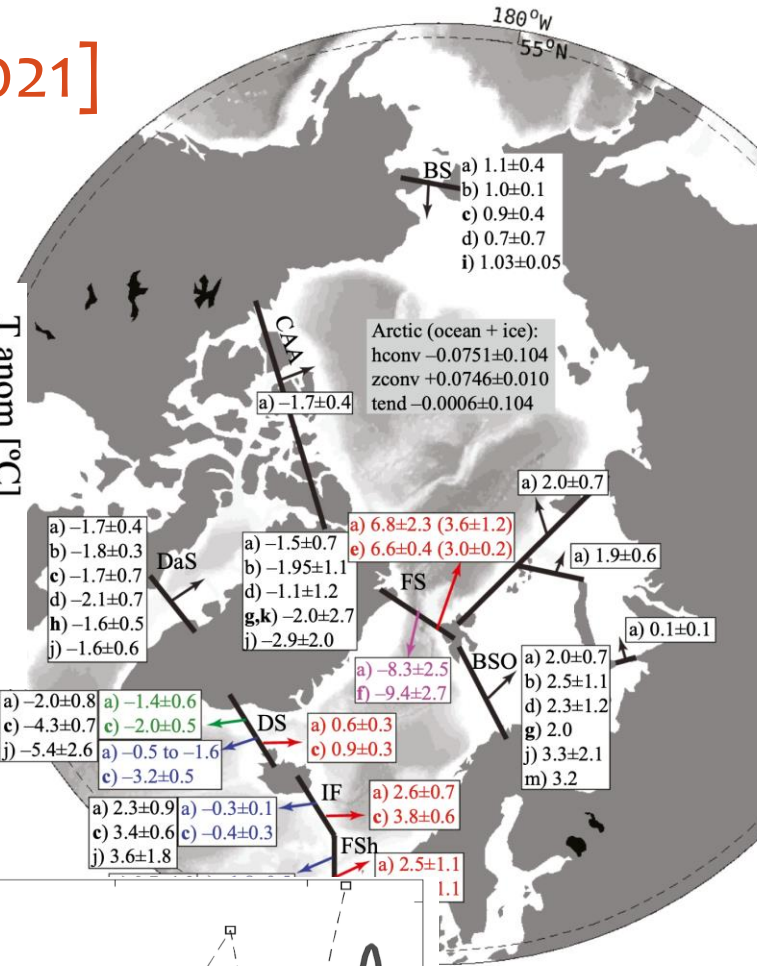
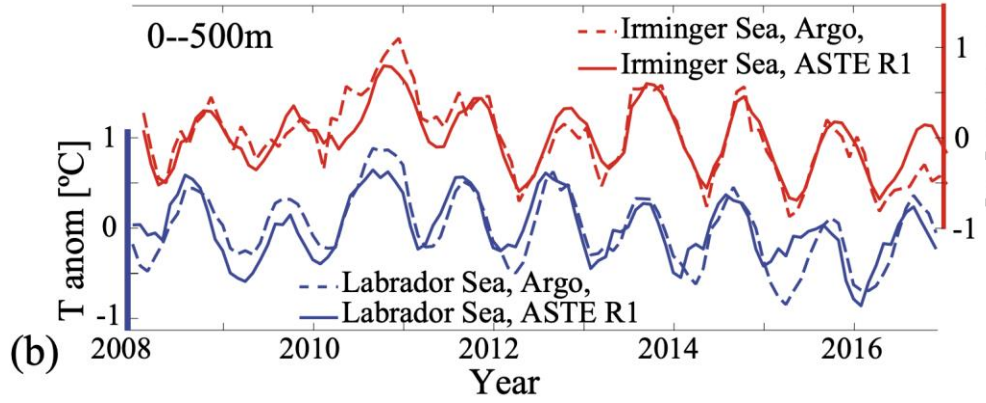
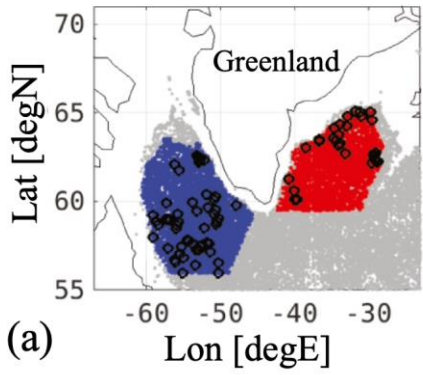
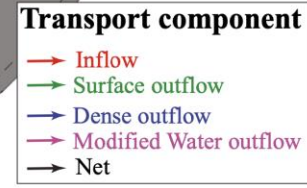
The screenshot shows the Arctic Data Center website interface. At the top, the URL is arcticdata.io/catalog/data. The Arctic Data Center logo is visible, along with the NSF logo. A green bar contains a "Clear all filters" button. Below this is a search bar with the text "Search phrase" and a magnifying glass icon. A "My Search" section shows a dropdown menu with "ASTE" selected. A "Filter by:" section lists "Data attribute", "Annotation", and "Creator". On the right, the "DATASETS 1 TO 2 OF 2" section displays two dataset entries. The first entry is "An Nguyen. 2022. Arctic Ocean 3.5 kilometer configuration for rerunning model with and" with a DOI of 10.18739/A26T0GX63. The second entry is "An Nguyen, Helen Pillar, Victor Ocaña, Timothy ice model-data synthesis using Arctic Subpolar data, 2002-2017. Arctic Data Center. doi:10.18739/A26T0GX63." with a DOI of 10.18739/A26T0GX63. Both entries have icons for information, location, and download.

# ASTE Release 1 2002–2017 [Nguyen et al., 2021]

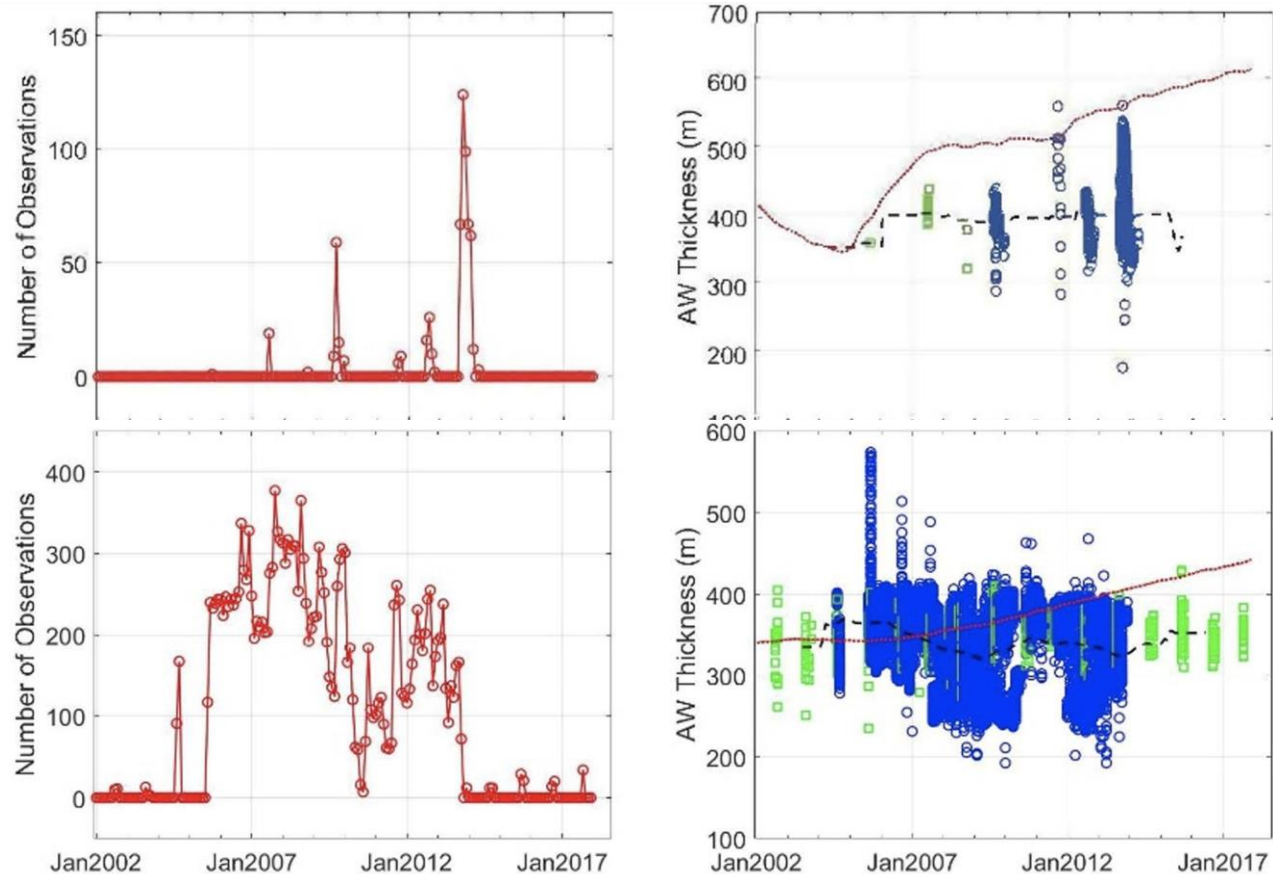
## Extensive analyses on misfits, bias, budgets

**Reference**  
 a: ASTE R1 (2006-2017)  
 b: Iilikak 2016 (1978-2007)  
 c: Østerhus 2019 (1993-2015)  
 d: Tsubouchi 2018 (09/2005-08/2006)  
 e: Beszczynska 2012 (1997-2010)  
 f: deSteur 2014 (1997-2009)  
 g: Schauer 2008 (1997-2007)  
 h: Curry 2014 (2004-2010)  
 i: Woodgate 2018 (2003-2015)  
 j: Tesdal 2020 (1992-2015)  
 k: Marnela 2016 (1999-2010)  
 l: Rossby 2018 (2009-2016)  
 m: Smedsrud 2010 (1997-2007)

**Gateway**  
 BS: Bering Strait  
 FS: Fram Strait  
 CAA: Canada Arctic Archipelago  
 BSO: Barents Sea Opening  
 DaS: Davis Strait  
 DS: Denmark Strait  
 IF: Iceland-Faroe  
 FSh: Faroe-Shetland

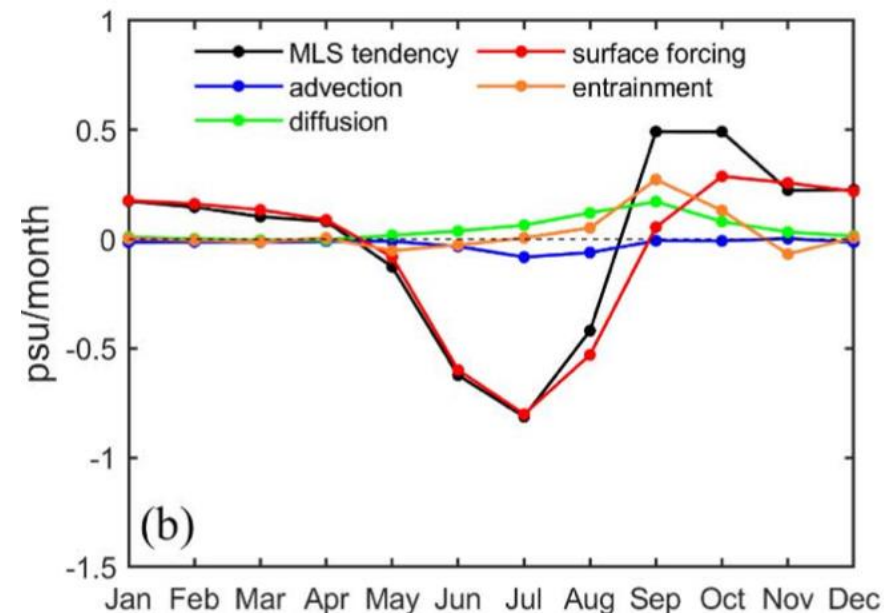


## Grabon et al., 2021 : Atlantic Water



## Zhong et al., 2023 (submitted): Western Arctic ML salinity budget

$$\frac{\partial \langle S \rangle}{\partial t} = \underbrace{\left\langle \frac{1}{s^*} \left[ s \nabla_{z^*} \cdot (s^* \vec{v}) + s \frac{\partial w}{\partial z^*} - \nabla_{z^*} \cdot (s^* s \vec{v}_{res}) - \frac{\partial S w_{res}}{\partial z^*} \right] \right\rangle}_{\text{advection}} + \underbrace{\langle F_S - SF \rangle}_{\text{surface forcing}} + \underbrace{\langle D_S \rangle}_{\text{diffusion}} - \underbrace{\frac{1}{h} \Delta S \frac{\partial h}{\partial t}}_{\text{entrainment}}$$



- Seasonal cycle: dominated by net surf FW forcing
- Interannual variability: entrainment or advection

# ASTE – as a tool

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- Bigdeli et al., GRL 2021: increase  $T_{\text{air}}$  → increase Arctic ice volume!!  
Importance of snow in sea ice–snow system heat budget
- Nguyen et al., 2020 JTECH: “OSSE”  
Arctic Argo data can contribute to improve ASTE even if positions of floats are unknown for extended time
- Nguyen et al., 2020, JGR: adjoint sensitivity study  
Bering Strait transport mechanism : Arctic/Atlantic sector is as or more important than Pacific sector in controlling Bering Strait volume transp variability
- Pillar et al., in prep, “OSNAP obs network assessment”, based on Loose & Heimbach 2020, Loose et al., 2021

# ASTE – Developments

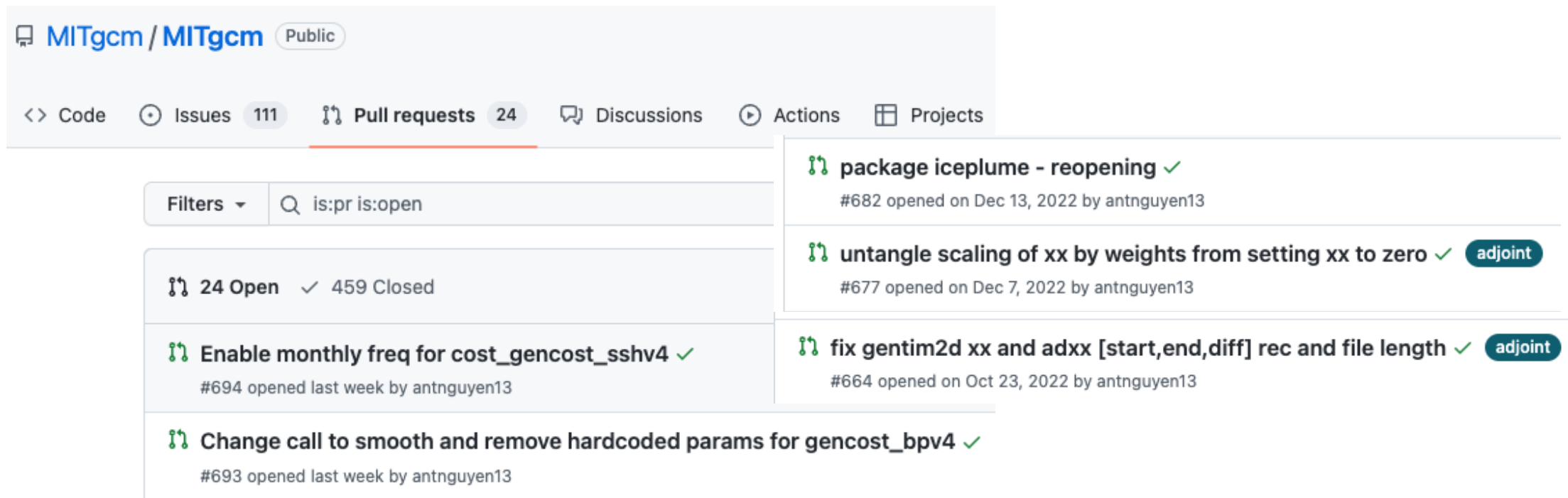
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- Extension to end of 2021, inc. resolution to llc1080-based
- parameterization of Greenland discharge
  - Schulz et al., 2022: Improve parameterization of vertical distribution of submarine melt at glacier vertical fronts in fjord-resolving models (side note: need help closing budget with “addmass”)
  - Next: parameterization of fjord-modified submarine melt and subglacial discharge for coarse resolution models such as ASTE and ECCO
    - Collaboration with Mike Wood in fjord-resolving models
- Watermass transformation:
  - build on Ryan Abernathey pkg/layers, closing budgets, perform watermass analyses
  - means to understand mechanisms (surface forcing, adv, horz. diff, vert. diff)
    - help to also understand control space
- Sea ice adjoint (bug fix of flooding, performing budgets)
- Multigrid
  - following ECCO efforts, also testing tape saving capability (Matt Mazloff’s code)



# ASTE – ECCO central production

- Sea-ice data & Sea-ice parameters as controls
- Multi-grid code and implementation
- Improved physics , e.g., subglacial discharge / submarine melt representation / parameterization
- Code development relevant to ASTE/ECCO production



The screenshot shows the GitHub interface for the MITgcm/MITgcm repository. The repository is public and has 111 issues, 24 pull requests, and 24 projects. The pull requests are filtered to show only open ones. The list of pull requests includes:

- package iceplume - reopening** ✓ #682 opened on Dec 13, 2022 by antnguyen13
- untangle scaling of xx by weights from setting xx to zero** ✓ **adjoint** #677 opened on Dec 7, 2022 by antnguyen13
- fix gentim2d xx and adxx [start,end,diff] rec and file length** ✓ **adjoint** #664 opened on Oct 23, 2022 by antnguyen13
- Enable monthly freq for cost\_gencost\_sshv4** ✓ #694 opened last week by antnguyen13
- Change call to smooth and remove hardcoded params for gencost\_bpv4** ✓ #693 opened last week by antnguyen13