The Arctic Subpolar gyre sTate Estimate (ASTE) Release 1

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Estimating the Circulation and Climate of the Ocean
http://ecco-group.org
ASTE (equivalence of SOSE for the north)

- NSF funded
  - mean & time-varying ocean & sea ice states
  - Arctic – Subpolar gyre exchange

- Optimization period: 2002-2017

- Initial conditions:
  - WOA14 spin-up (ocean),
  - PSC spin-up (ice)

- Forcing: JRA55

- OBCs: ECCO-v4R3

- Control variables:
  - initial conditions
  - time-varying atmospheric state,
  - 3-D ocean mixing parameters
Primary data constraints:

Low latitudes:
- ECCO-v4R3 standard obs. (SSH, SST, Argo, XBT, CTDs, seal, mean DMT)
- Line-W (John Toole), Gulf Stream (Robert Todd)

High latitudes:
- Sea ice concentration (OSISAF, daily, 2002-2017)
- Sea ice thickness (SMOS+CryoSat, ICESat), ice drifts
- GRACE
- moored T/S/U/V & hydrographic section
  e.g., ITP, NABOS/CABOS, BGEP (2002-2017), WHOI & ICES databases
- Arctic main gateways
  e.g., Fram, Davis, Bering straits
Release 1

- linear free surface
- only sea ice "proxy" adjoint
- strong constraint on Florida and Fram Strait transports & Gulf Stream separation (viscosity)
- adjustments: masked out between Florida and Grand Banks: to maintain Gulf Stream separation
- adjustment in precip: removed ~4 m SSH drift
- Sea ice edge, ARGO & ITP misfits: largest cost reduction
- turn off diffkr control after 12 iterations due to degradation of watermass in the Arctic halocline
- controls kap[gm,redi]: important in the Arctic
- closed budget
Release 1: North Atlantic

(Gulf Stream separation: lost after any 2 iterations)
Release 1: Trends and Means

- Vertical diffusivity control can address
Release 1: North Atlantic

Atlantic Meridional Overturning Stream Function 2003--2017
contour: [12 15] Sv

Florida Strait transport

(mean = 25.68 Sv)
Release 1: North Atlantic

pre-release norm misfit T

Release1 norm misfit T

1600-2000m

1600-2000m
Release 1: North Atlantic

Argo cost (T=left, S=right), 12–65.5°N

- Pre-Release 1
- Release 1

Legend:
- 5 - 45m
- 55 - 105m
- 115 - 200m
- 220 - 340m
- 360 - 500m
- 550 - 1000m
- 1100 - 1500m
- 1600 - 2000m
Release 1: Arctic

Constraints:
- Fram Strait Vnorth
- ITP T/S in Canada Basin
- Ice concentration

Controls:
- (viscosity at Fram Strait)
- (viscosity in Nordic Seas)
- isopycnal & bolus velocity (eddy parameterization)
- atmospheric forcing
- initial T/S

z=300m
Fram Strait

Using T/S/U/V (computed quantities) to infer mixing & dissipation (inputs)

Incomplete data coverage, non-unique parameters

circulation altered
Release 1: Arctic (ITP misfits)

control:
• viscosity at Fram Strait
• bolus velocity & isopycnal

460-800m

normT misfit

it48

normT misfit

Release1 (it55)
Release 1: Arctic (ITP misfits)

new log10 framework of diffkr and misfits to drho/dz (A.Bigdeli)
ADjustments: kapgm (m²/s)

z=170m

z=350m
Sea ice concentration

Forcing: JRA55
Release 1:

Summary:
- 2002–2017 optimized solution
- Arctic: consistently reduced misfits to observed ice concentration and hydrography
- North Atlantic: reduced misfits to Argo hydrography, SST, SLA
- Budgets and exchanges: analyses and paper in progress
- Next release: will include sea ice thermodynamic adjoint (A. Bigdeli's talk)

Known issues:
- Transports across the Greenland-Iceland-Faroe-Shetland ridge → add diffkr should help (A. Bigdeli's work)
- Need verification on mapping xx_* fields back to JRA55
Going forward: higher-res adjoint and forward

1. ASTE llc540 (7km in Arctic)
   - −5S in Atlantic, 48.5N in Pacific, 50-lev
   - 720sec, 30x30 tiles, 739 cpus
   - 14-year forward run (2002-2015): 4.82hr/year, 63hrs, 2.6 days
   \[ \rightarrow *8 = 21 \text{ days for 1 adjoint iteration} \]
   - Need divided adjoint and/or high-res forward/low-res adjoint.

2. ASTE-forward, llc1080 (3.5 km in Arctic)
   - 5N in Atlantic, 48.5N in Pacific
   - 240sec, 45x60 tiles, 860 cpus
   - 14-year forward run with tides (2002-2015): only pickups, 8hr/mo = 4 days/yr, 2 months for 14 yrs.

3. ASTE-forward, llc2160 (1.75km in Arctic)
   - Going forward: higher-res adjoint and forward circulation in ASTE-llc540
Release 1:

- Galen McKinley → biogeochemistry
- ARL lab, NERSC: tomography

code:
- modify pkg/ecco/
cost_gencost_sshv4.F to handle monthly misfit calculations.
- update diffkr control to log10
- update cost to include drho/dz in profiles
- sea ice thermodynamics adjoint

Question?