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CFORCE: Creating the Next Generation Datasets for Forcing Ocean – Sea-Ice Coupled Models

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A CLIVAR Ocean Model Development Panel (OMDP) Effort

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Why ERA-5?

- A trusted reanalysis product.
- High spatial and temporal resolutions suitable for forcing high-resolution (e.g., eddying, coastal) ocean and sea-ice models. (0.25° and hourly)
- The reanalysis is up-to-date / near real time. (daily)
- Going back in time as far back as possible. (1940 – present)
- Buy-in, support, and collaboration from the ECMWF group producing the reanalysis product.
- Institutional commitment for continued production of the reanalysis datasets.
- No redistribution issues.

ERA-5 Correction Strategy

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JRA-55 based surface dataset for driving ocean–sea-ice models (JRA55-do)

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CFORCE largely follows the process described in Tsujino et al. (2018) with some updates.

- Adjustments of main variables;
- River and glacier runoff / discharge; and
- Global heat and freshwater (balance) adjustments, but with a strategy to capture the historical warming trend.

Adjustments (All Completed)

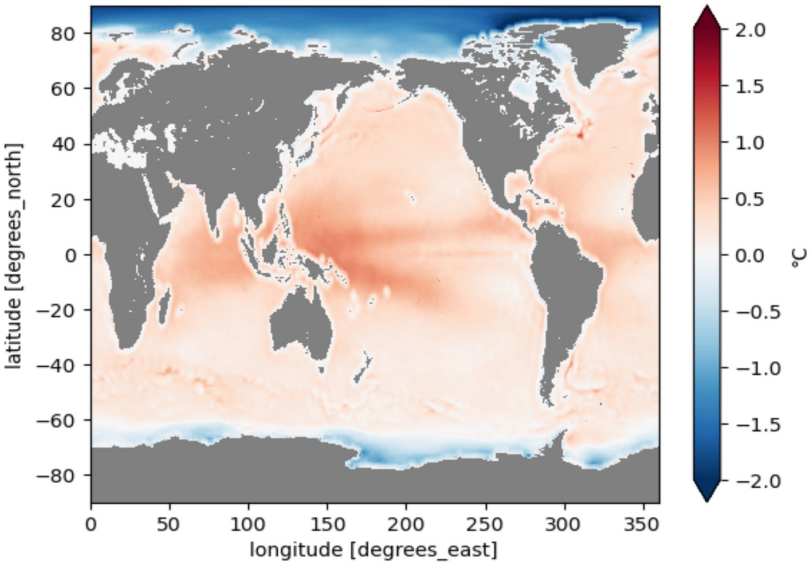
Variable	Reference Datasets	Base Period	Adjustment Type	What's new compared to JRA55-do
Downward shortwave & longwave radiation	CERES-EBAF v.4.2	2000-2024	Multiplicative scaling	Updated version of reference dataset
Air temperature & Specific humidity	Weighted multi-reanalyses ensemble	1980-2015	Additive offset (T2M) Multiplicative scaling (Q2M)	Expanded and updated reanalysis ensemble
Wind speed and direction	CCMPv.3.1 (Cross Calibrated Multi Platform Satellite Product)	1993-2024	Vector adjustments via scaling + rotation	Cross-calibrated product replaces separate QuikSCAT and SSM/I datasets
Precipitation	ERA-5		No correction	No correction (in this dataset version)
River runoff	ECMWF CaMaFlood-based system (forced by ERA-5)	1940-present	Added (not provided in ERA-5)	CaMaFlood forced by ERA5 instead of JRA55
Greenland runoff	Mankoff et al. (2020) regional model-based product; Schmidt et al. (2025)	Reference datasets cover 1940-present	Added (not provided in ERA-5)	JRA55-do used Bamber et al (2018)
Antarctica runoff	Schmidt et al. (2025) dataset; based on satellite data	1997-2021	Added (not provided in ERA-5)	Replaces 2009 snapshot from Depoorter et al. (2013)

Temperature

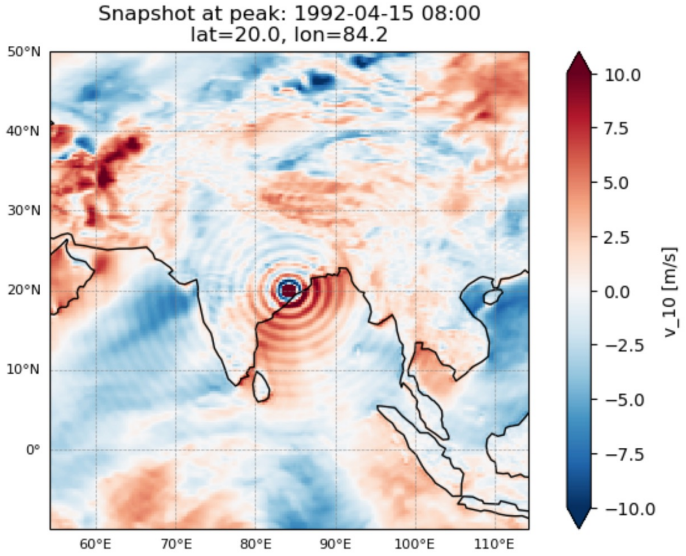
Known issue: Warm bias at high latitudes

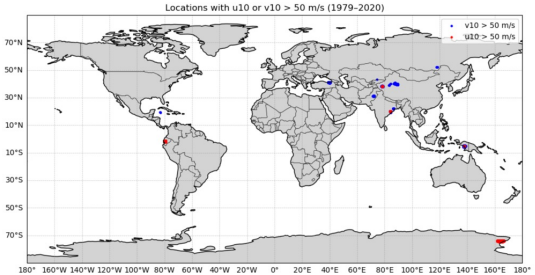
- Compared to multi-reanalyses mean, ERA-5 has warm biases at polar latitudes and cold biases elsewhere.
- Temperature is corrected using weighted mean of several reanalyses products.

Mean Offset Applied to ERA-5 Surface Temperature



Winds





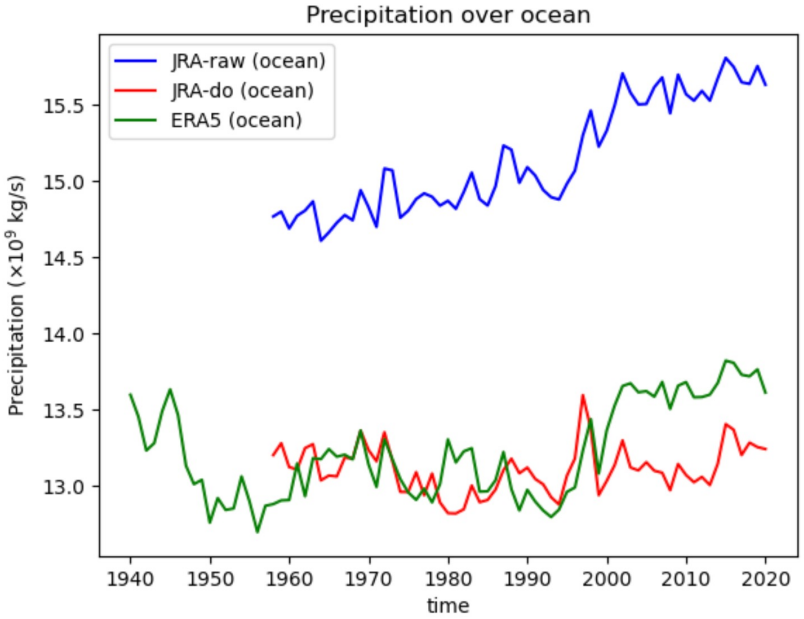
Known issue: rare 10-m wind spikes (up to ~300 m s^{-1}) linked to 4D-Var window edges.

- Detected using a 50 m s^{-1} threshold; 82 events (1979–2024);
- Time–space interpolation applied to u_{10} and v_{10} (±20° footprint); same for T_{10}, q_{10};
- No artifacts in SLP, radiation, or precipitation.

Precipitation

The raw ERA-5 precipitation is rather good over the oceans compared to other observational-based datasets.

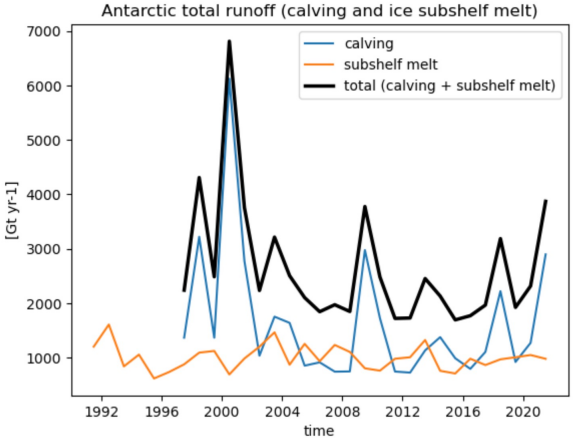
Therefore, no precipitation correction is applied, but refinements may be explored in future versions.

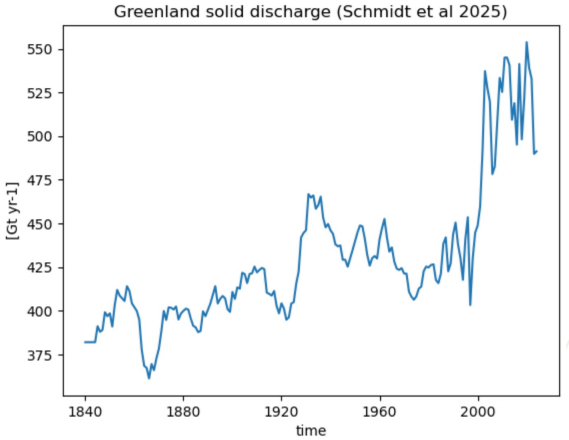


Runoff (solid and liquid)

Antarctic solid & liquid discharge: Schmidt et al. (2025). Due to limited temporal coverage (1997-2021) and strong interannual variability, a mean annual runoff of 0.084 Sv is applied for all years and distributed around the Antarctic, with regional contributions proportional to the climatological pattern.

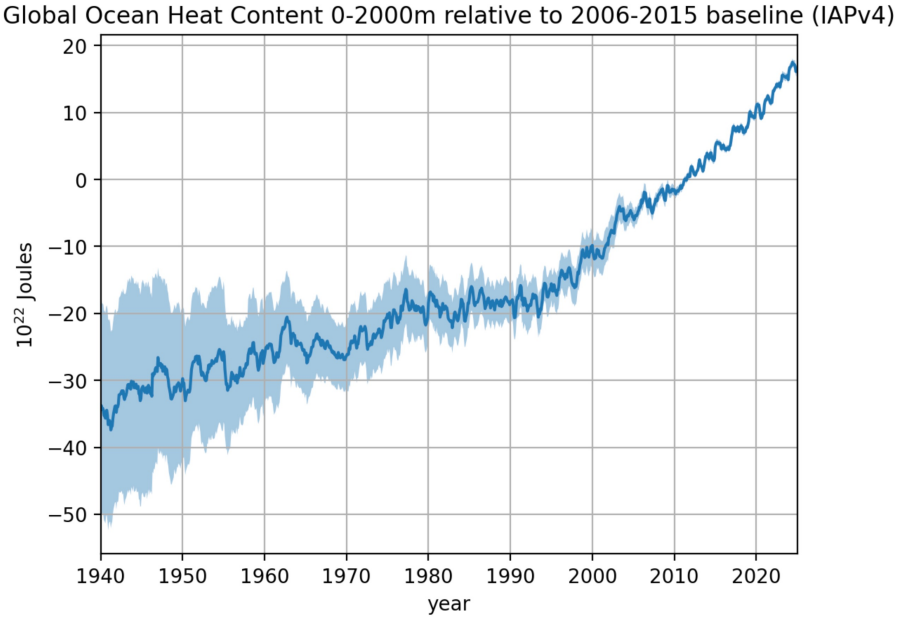
Greenland solid discharge: Schmidt et al. (2025)
Greenland liquid discharge: Mankoff et al. (2020)
River runoff: CaMaFlood simulations forced by ERA-5, excluding Greenland coastal runoff to avoid double counting.

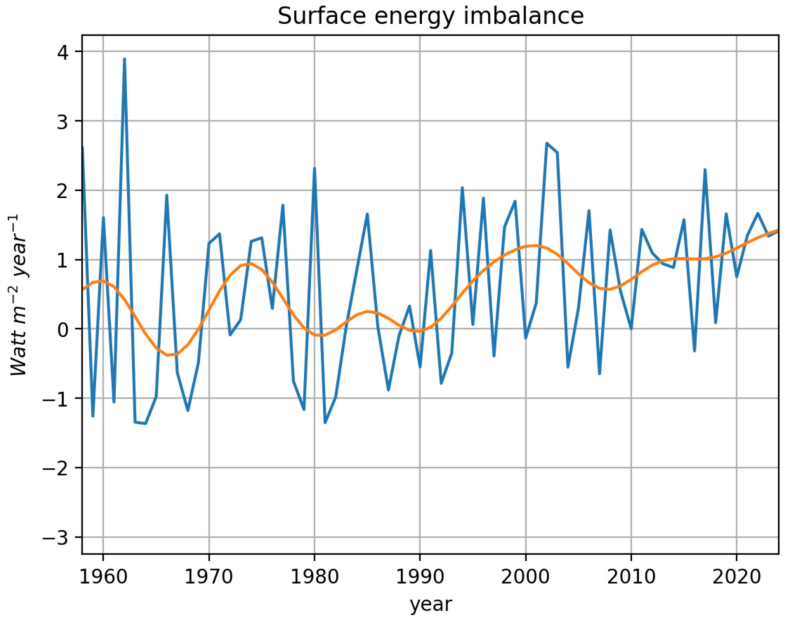




Global Balance Adjustment

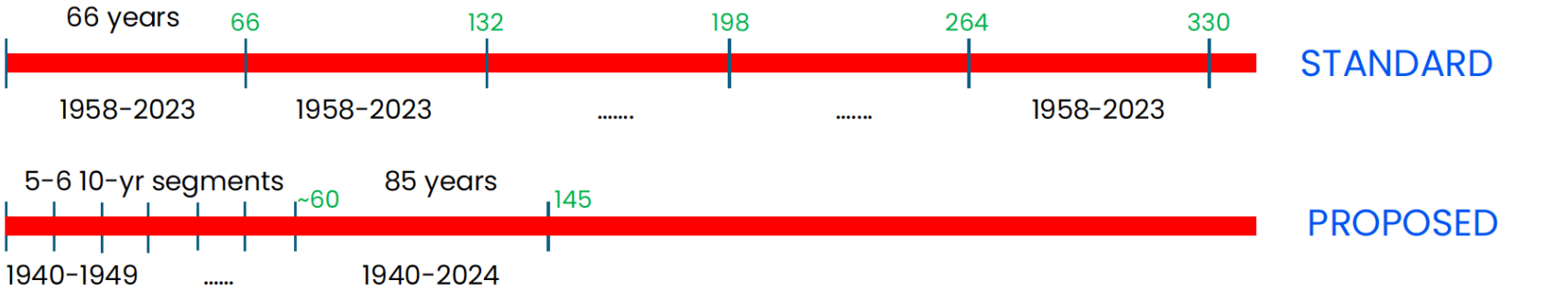
$$a(Q_{SW} + Q_{DLW}) + Q_{ULW} + Q_{LAT} + Q_{SEN} + Q_{T+E+R} + Q_{IO} = \text{historical ocean surface energy imbalance (IAPv4)}$$





Balancing to zero for the 1940-1980 period using monthly adjustments (a).

Proposed Spin-up Strategy



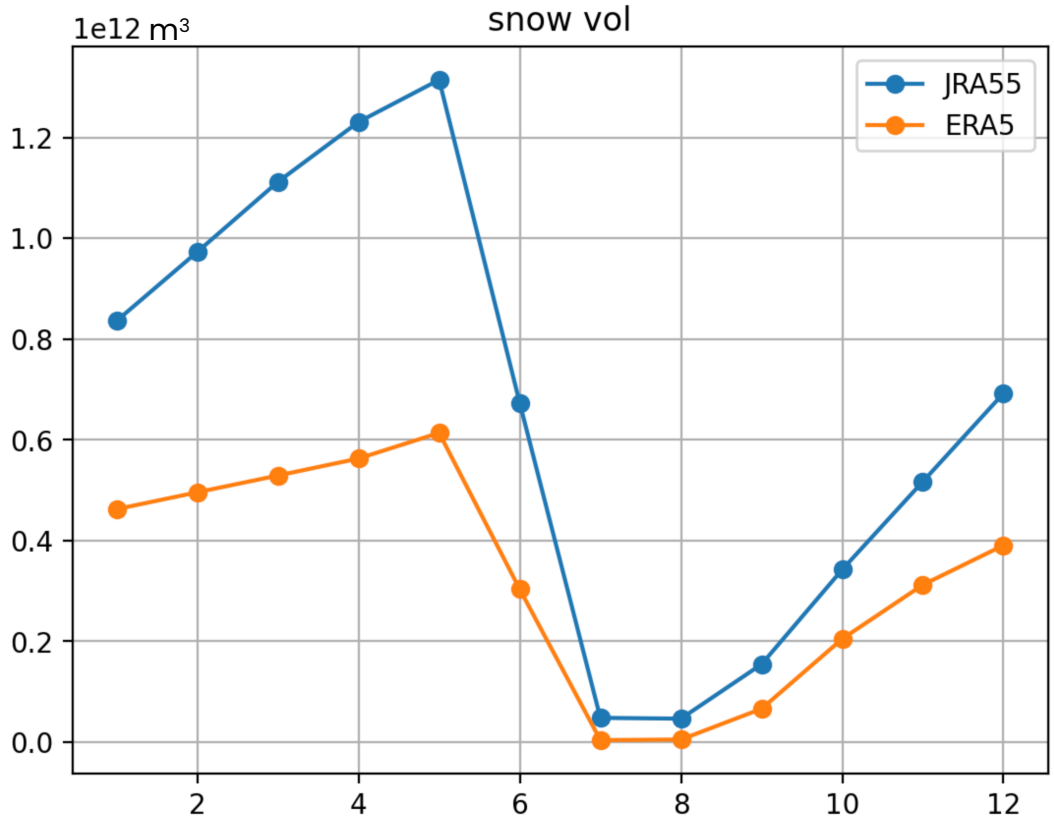
Aims to reduce end-of-cycle artifacts and reduces computational time

Another goal is to capture the historical warming trend!

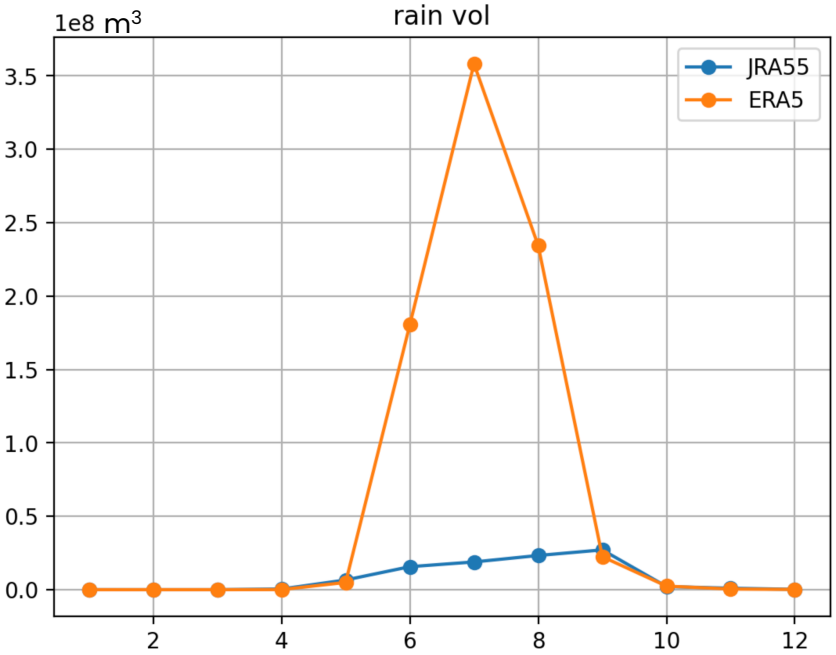
CFORCE Status and Timeline

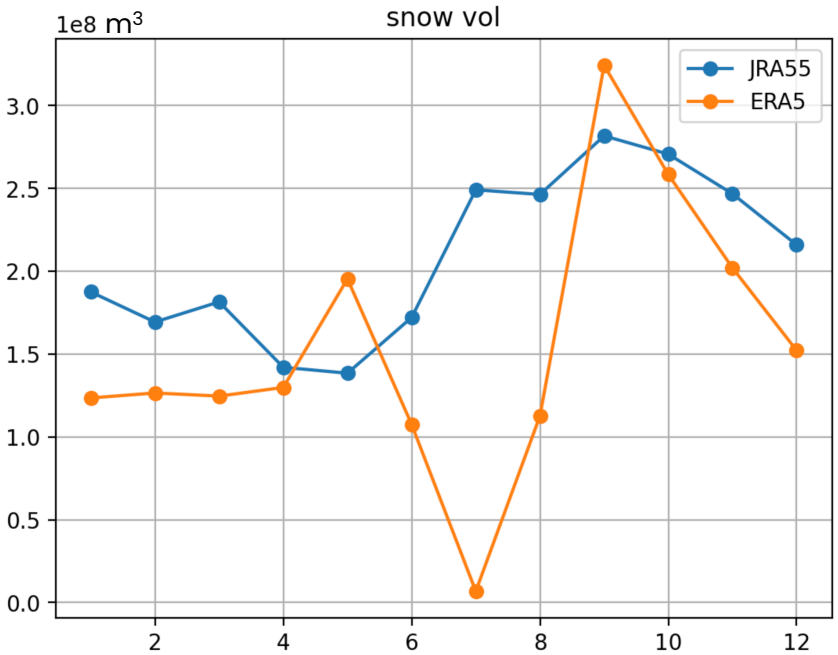
- Conducted many ocean – sea-ice coupled simulations with POP2 to evaluate the solutions with the new forcing datasets against observations and those with the JRA55-do product;
- DOE LANL also used the new forcing datasets to perform a simulation with OMEGA++;
- Tested several time segments for the new spin-up procedure;
- Planned to make the adjusted datasets available to the community about 2 months ago, but;
- Unfortunately, encountered a problem: melting Arctic sea-ice

Snow Volume Seasonal Cycle on Ice North of 80°N



Seasonal Cycle of Liquid and Solid Volume of Precipitation North of 80°N





10m Temperature Seasonal Cycle north of 80°N