Environment and Climate Change Canada | Environnement et Changement climatique Canada

# ECCC seasonal & decadal update

Bill Merryfield

*Canadian Centre for Climate Modelling and Analysis*

WGSIP 24
27-29 March 2023

Canada

# Current ECCC/GPC Montreal seasonal system

| System | Debut | Climate models | NWP models | Ensemble | Coupled? | Range |
|---|---|---|---|---|---|---|
| HFP | 1996 | GCM2 | SEF | 2×6 | N | 3 mon |
| HFP2 | 2008 | GCM2, GCM3 | SEF, GEM | 4×10 | N | 4 mon |
| CanSIPS | 2011 | CanCM3,CanCM4 | - | 2×10 | Y | 12 mon |
| CanSIPSv2 | 2019 | CanCM4i | GEM-NEMO | 2×10 | Y | 12 mon |
| CanSIPSv2.1* | 2021 Dec | CanCM4i | GEM5-NEMO | 2×10 | Y | 12 mon |
| CanSIPSv3 | Mid-2024 | CanESM5 | GEM5.2-NEMO | 2×20 | Y | 12 mon |

HFP = Historical Forecasting Project    CanSIPS = Canadian Seasonal to Interannual Prediction System

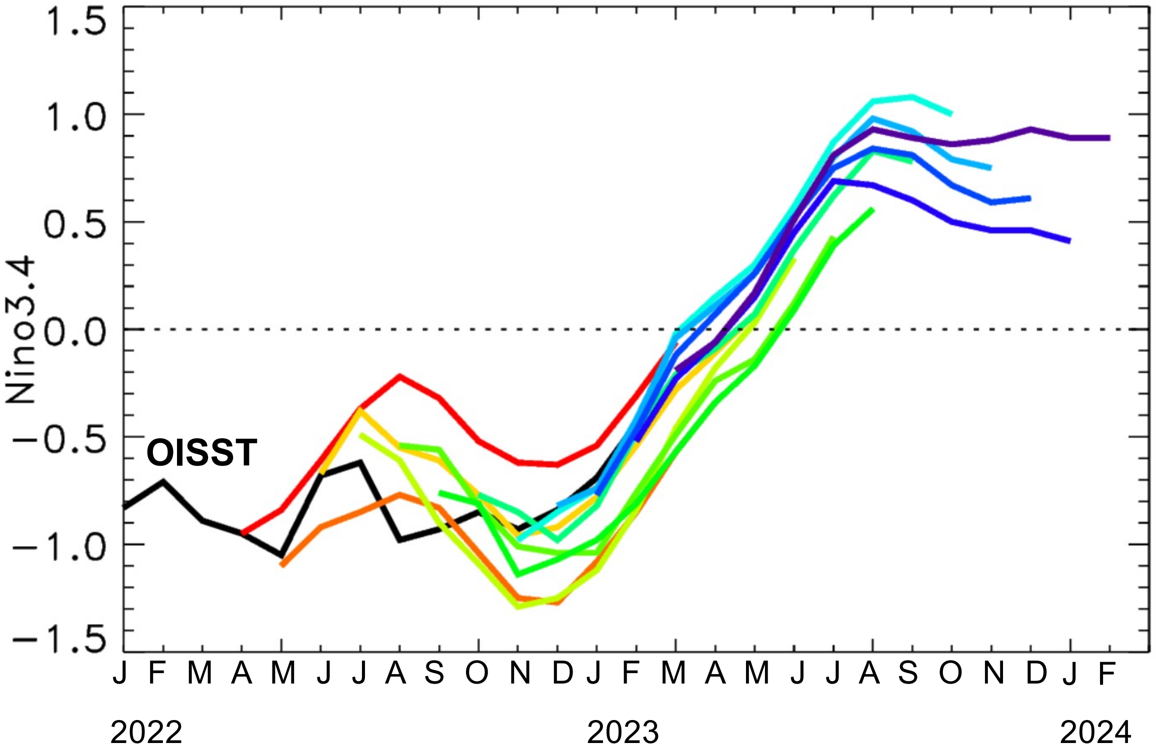
* https://iridl.ldeo.columbia.edu/documentation/Models/NMME/CanSIPS-IC3/technote.pdf

| **Mid-2024: CanSIPSv3** | **Atmos** | **Ocean** | **Sea Ice** | **Land** | **BGC** |
|---|---|---|---|---|---|
| • CanESM5: | CanAM5 T63/L49 | + NEMO ORCA1/L45 | + LIM2 | + CLASS3.6 | + CMOC/CTEM |
| • GEM5.2-NEMO: | GEM5.2 1°/L85 | + NEMO ORCA1/L50 | + CICE4 | + ISBA/SVS | |

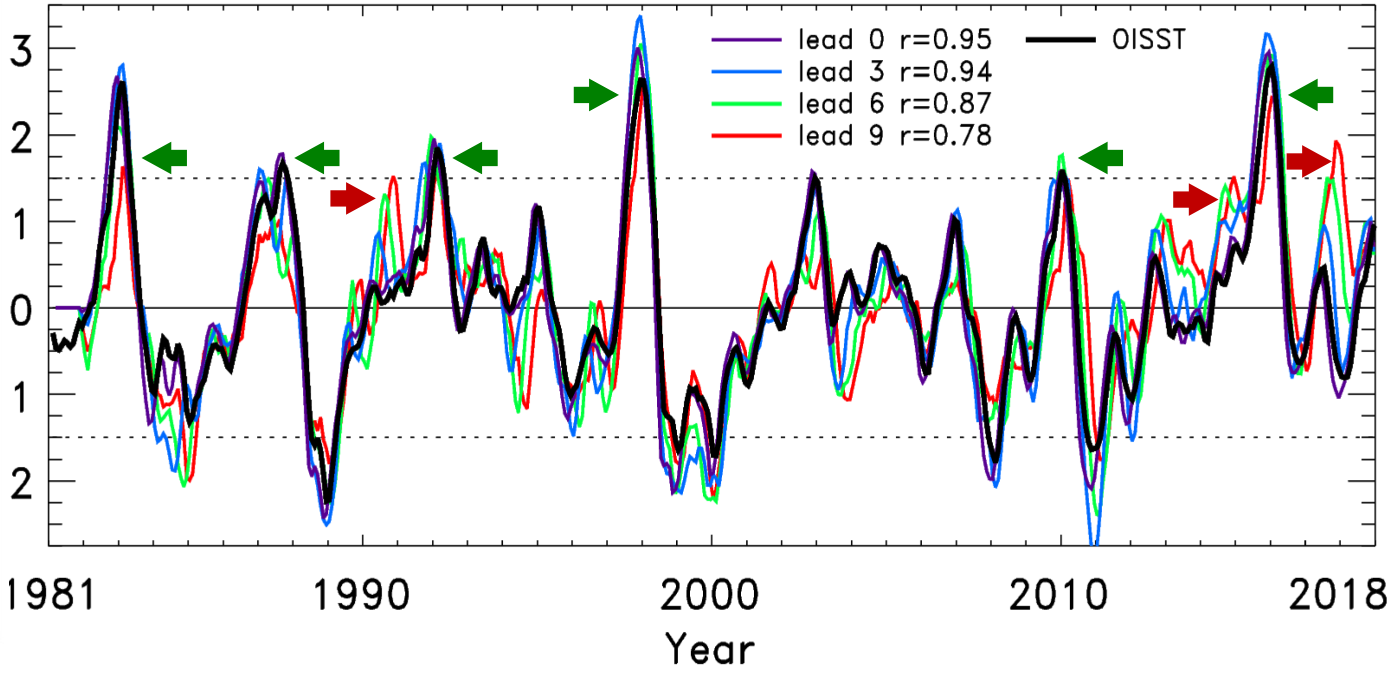
# ECCC long range ENSO outlook

**Short lead** → **Long lead**

**Recent**




**Historical**




**Long-range El Niño hits**

**False alarms**

# New seasonal products based on daily/subdaily data

- Daily/subdaily seasonal hindcast & forecast data for >30 variables provided to Copernicus since mid-2021

- This opens possibilities for developing products such as

  - cooling degree days = accumulation of daily mean temperatures >18°C

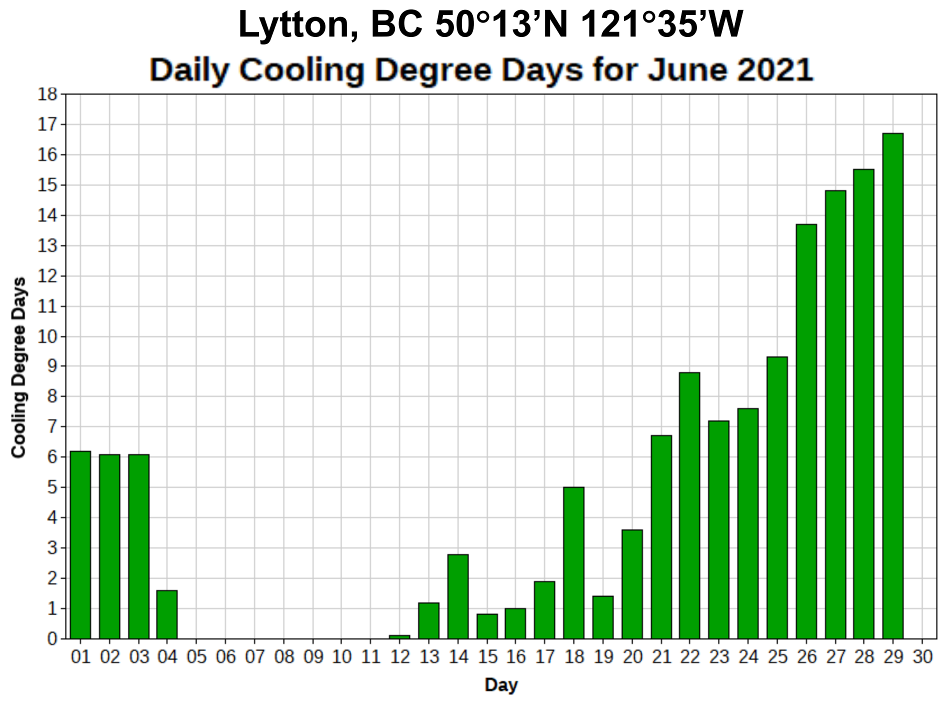
  - heating degree days = accumulation of daily mean temperatures <18°C

  - growing degree days = accumulation of daily mean temperatures <*N*°C, *N*= 4, 5,10…

  - number of wet days exceeding threshold precipitation, e.g. 1 mm

- Potentially useful for energy, agriculture, etc.

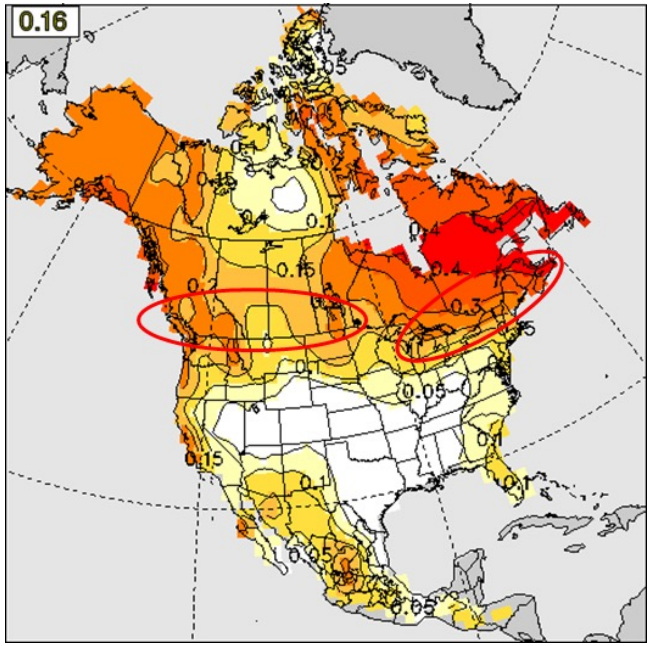
- For DD, add daily T2m anomalies to 5-day smoothed daily ERA5 climatology for 1991-2020



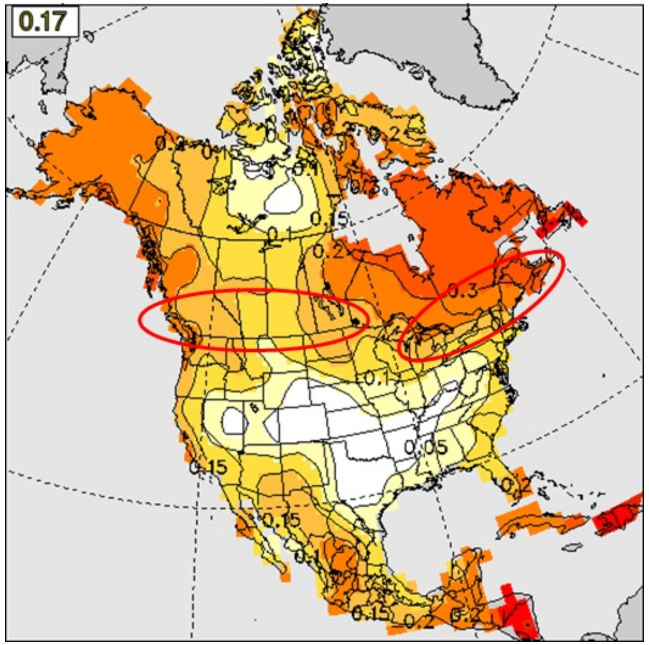
# CRPSS Heating/Cooling Degree Days vs T2m

**DJF 1991-2020**
**Lead 0 months**

**CanSIPSv2.1**
**HDD**

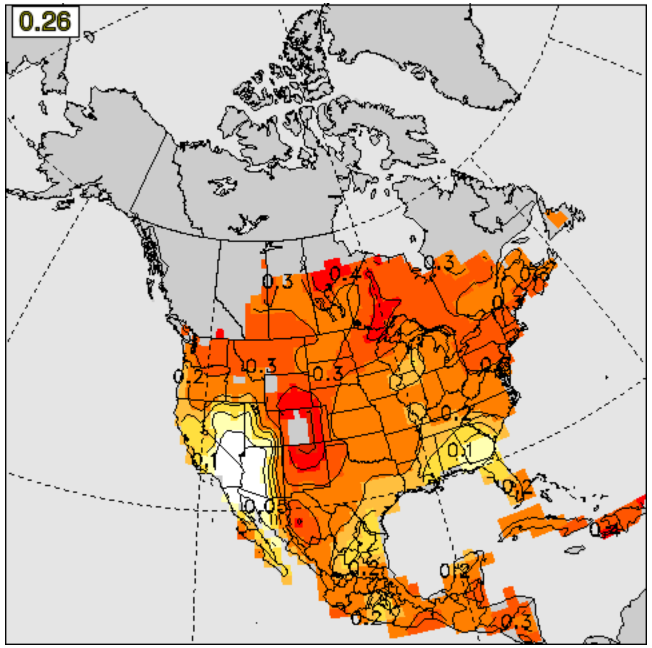



**CanSIPSv2.1**
**T2m**

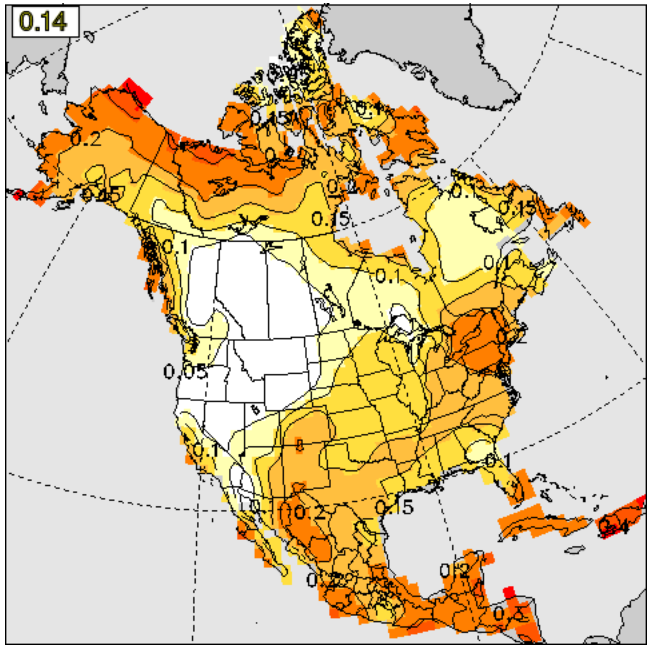



**SON 1991-2020**
**Lead 0 months**

**CanSIPSv2.1**
**CDD**



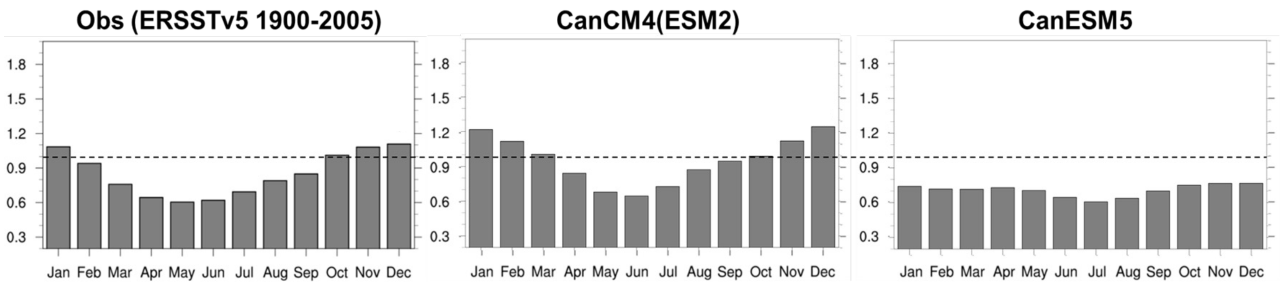

**CanSIPSv2.1**
**T2m**



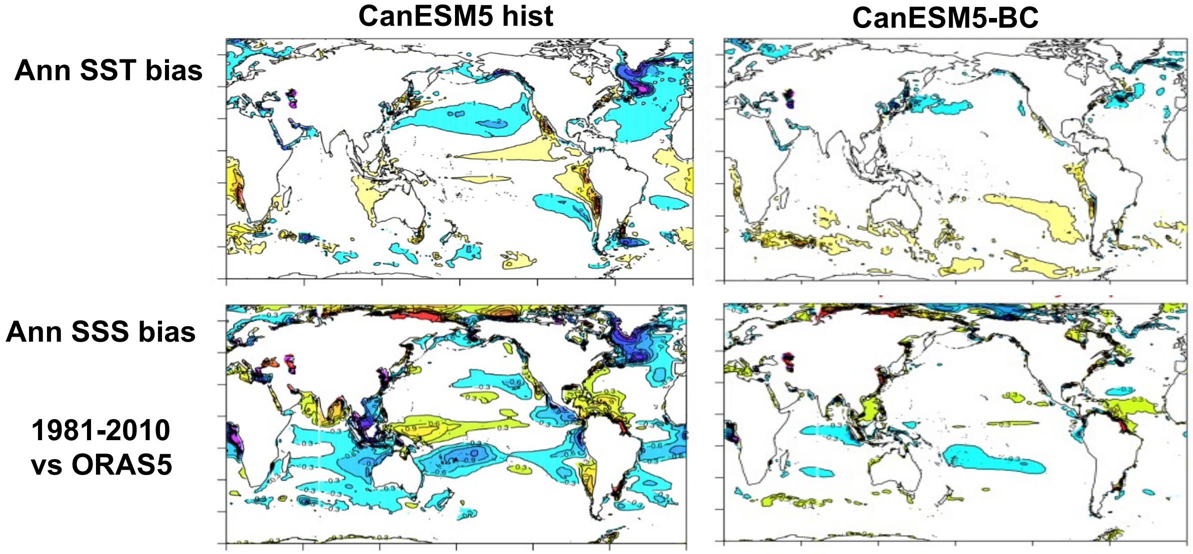
# CanESM5 development for seasonal forecasting

- CanESM5, CCCma's CMIP6 ESM, has been "slow-tracked" for seasonal/decadal operations due to
  - ➢ Very high equilibrium climate sensitivity (5.6°C)
  - ➢ Inaccurate ENSO amplitude and seasonality →

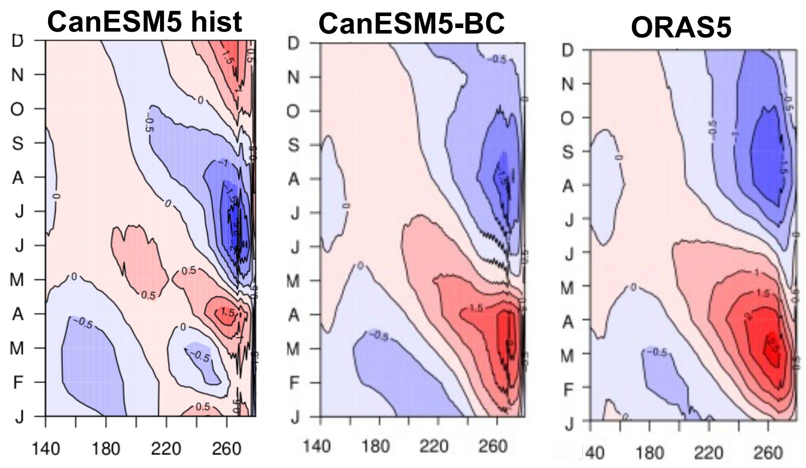
Nino3.4 standard dev vs month




- Have experimented with **online atm/ocn bias correction** using method of Kharin and Scinocca (GRL, 2012)
  - ➢ Nudge atmosphere to ERA5, ocean T/S to ORAS5, calculate 1981-2010 monthly climatology of nudging terms
  - ➢ Apply as non-interactive adjustments to tendencies




Eq Pacific SST seasonal cycle 1981-2010




- Bias correction improves CanESM5 seasonal skills, which compare well to CanCM4i (except for ENSO)

*Global mean ACC averaged over all target seasons, 0-9 month lead (1991-2020) →*

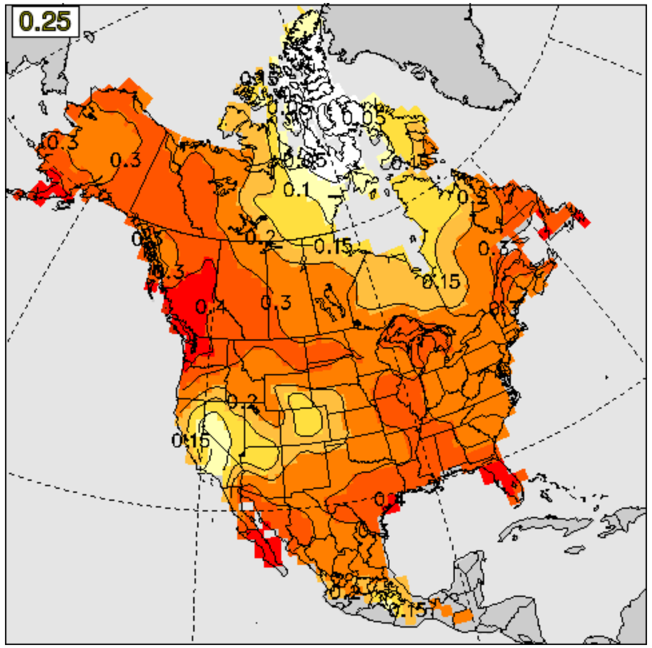
| | CanCM4i | CanESM5 | CanESM5-BC |
|---|---|---|---|
| Nino3.4 | **0.79** | 0.71 | 0.68 |
| T2m land | 0.33 | 0.36 | **0.37** |
| Precip land | 0.101 | 0.096 | **0.117** |

# Extra slides

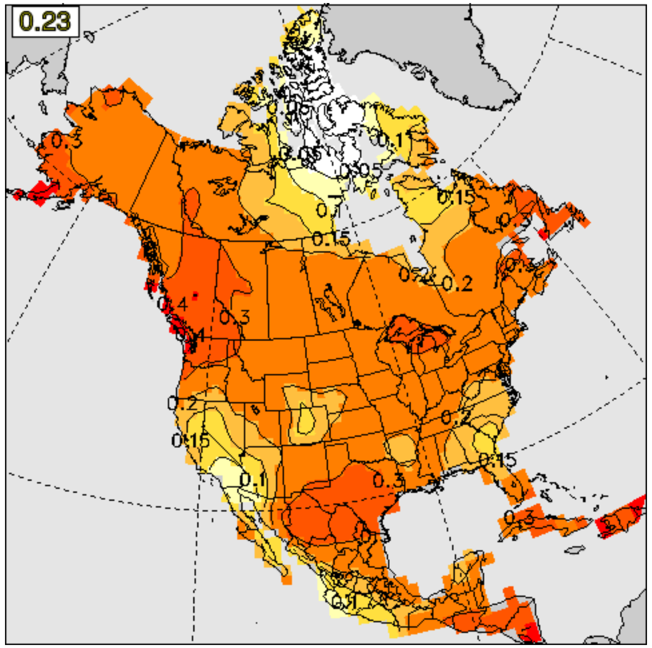
# CRPSS Heating/Cooling Degree Days vs T2m

**MAM 1991-2020**
**Lead 0 months**

**CanSIPSv2.1**
**HDD**

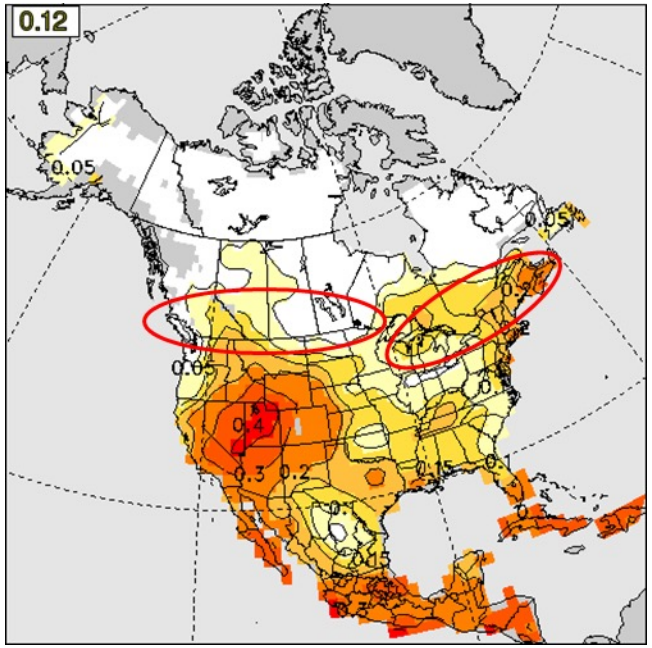



**CanSIPSv2.1**
**T2m**

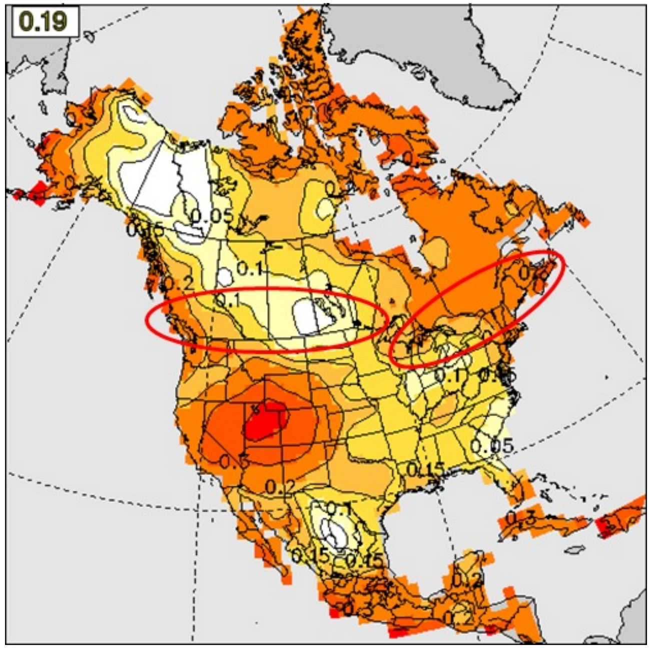



**JJA 1991-2020**
**Lead 0 months**

**CanSIPSv2.1**
**CDD**




**CanSIPSv2.1**
**T2m**



# NOAA Population weighted degree day outlook

https://www.cpc.ncep.noaa.gov/pacdir/DDdir/ddforecast.txt

MONTHLY TOTAL DEGREE DAY FORECAST

BASE 65 F

NWS CLIMATE PREDICTION CENTER COLLEGE PARK MD

300 PM EDT THU 18 AUG 2022

NEW ENGLAND (CT ME MA NH RI VT)

| | | HEATING | | | COOLING | | | NORMALS (1981-2010) | | FORECAST DEPARTURE | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | MONTH | 90% | MEAN | 10% | 90% | MEAN | 10% | HDD | CDD | HDD | CDD |
| 2022 | 9 | 57. | 107. | 149. | 12. | 32. | 66. | 138. | 24. | -31. | 8. |
| 2022 | 10 | 341. | 425. | 503. | 1. | 2. | 3. | 465. | 0. | -40. | 2. |
| 2022 | 11 | 588. | 693. | 785. | 0. | 0. | 0. | 731. | 0. | -38. | 0. |
| 2022 | 12 | 885. | 1037. | 1166. | 0. | 0. | 0. | 1086. | 0. | -49. | 0. |
| 2023 | 1 | 1006. | 1204. | 1421. | 0. | 0. | 0. | 1260. | 0. | -56. | 0. |
| 2023 | 2 | 882. | 1005. | 1144. | 0. | 0. | 0. | 1053. | 0. | -48. | 0. |
| 2023 | 3 | 814. | 893. | 991. | 0. | 0. | 0. | 928. | 0. | -35. | 0. |
| 2023 | 4 | 481. | 546. | 630. | 0. | 0. | 0. | 572. | 0. | -26. | 0. |
| 2023 | 5 | 182. | 256. | 328. | 3. | 9. | 18. | 281. | 7. | -25. | 2. |
| 2023 | 6 | 21. | 47. | 82. | 39. | 80. | 123. | 57. | 65. | -10. | 15. |
| 2023 | 7 | 1. | 9. | 22. | 135. | 207. | 281. | 11. | 180. | -2. | 27. |
| 2023 | 8 | 6. | 20. | 37. | 118. | 175. | 237. | 24. | 147. | -4. | 28. |
| 2023 | 9 | 61. | 113. | 158. | 11. | 31. | 65. | 138. | 24. | -25. | 7. |
| 2023 | 10 | 339. | 426. | 506. | 1. | 2. | 3. | 465. | 0. | -39. | 2. |
| 2023 | 11 | 580. | 686. | 780. | 0. | 0. | 0. | 731. | 0. | -45. | 0. |

...

# Probabilistic Ice-Free / Freeze-Up Date Forecasts

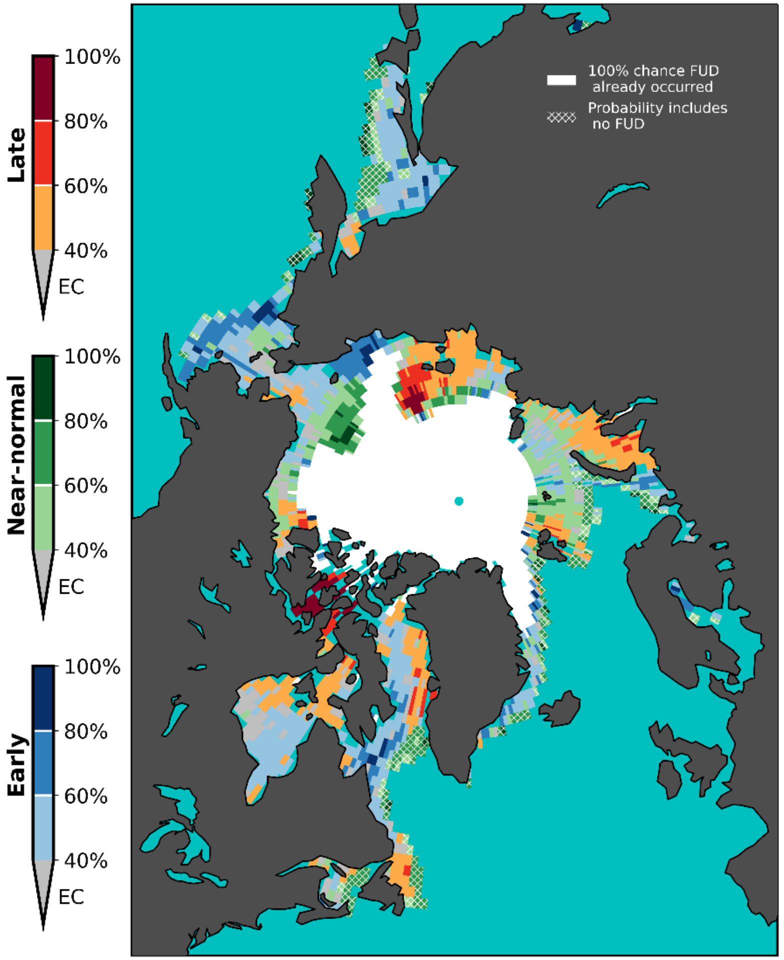
Dates that sea ice concentration falls below / rises above 50%

ARCTIC REGIONAL CLIMATE CENTRE NETWORK
(IN DEMONSTRATION PHASE)

ACF
Arctic Climate Forum

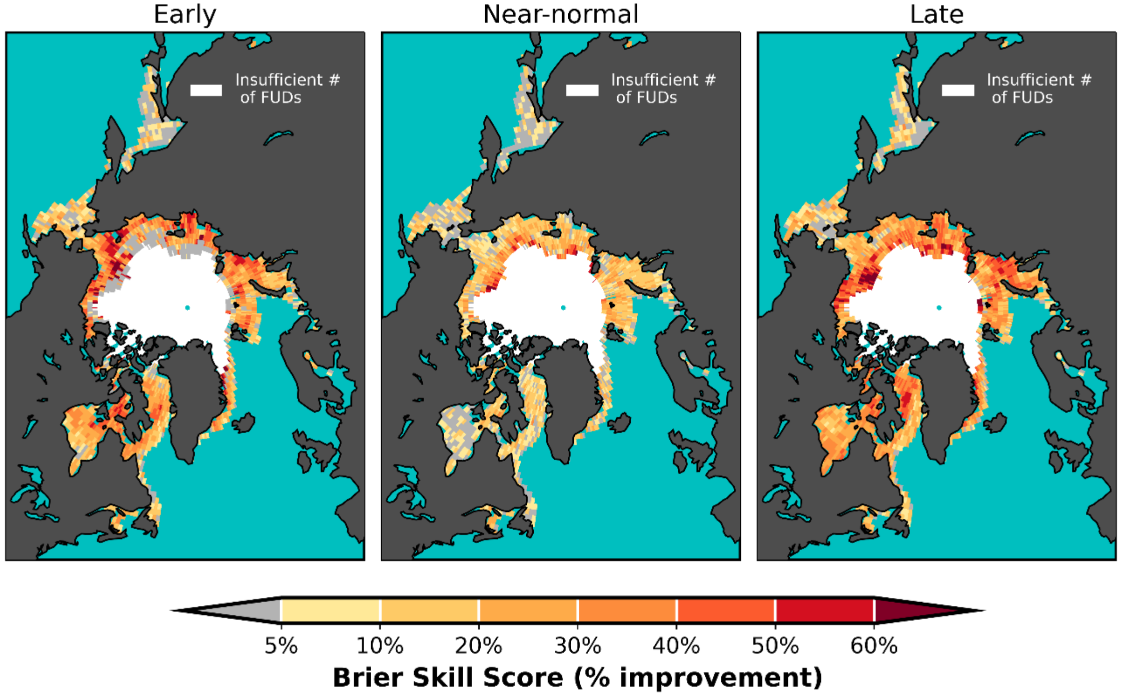
## 2022-23 Freeze-Up Date forecast from 1 Oct

Probability for Early, Near-normal, or Late FUD
CanSIPSv2, init: 10/2022 (cf 2013-2021)



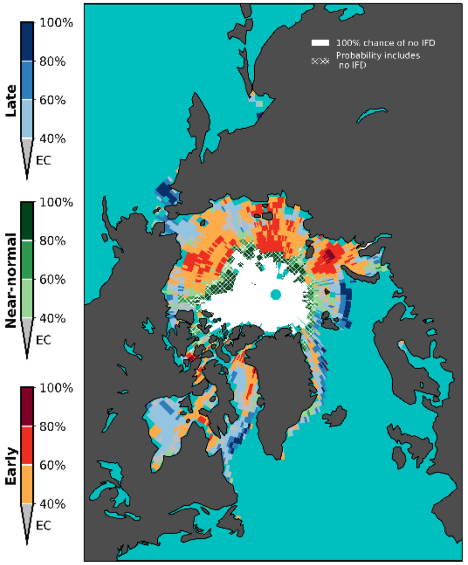

## CanSIPSv2.1 Historical FUD Skill, Init: October 1, 2000-2021

Relative to trend-adjusted climatology

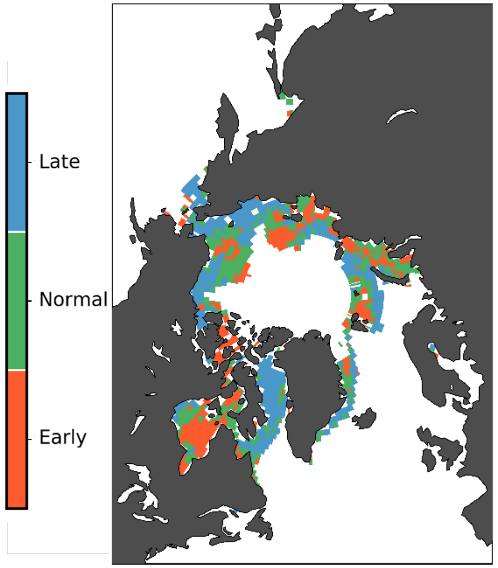



## Verification of 2022 Ice-Free Date** from 1 May

Forecast




Observed




**compared to 2013-2021 average

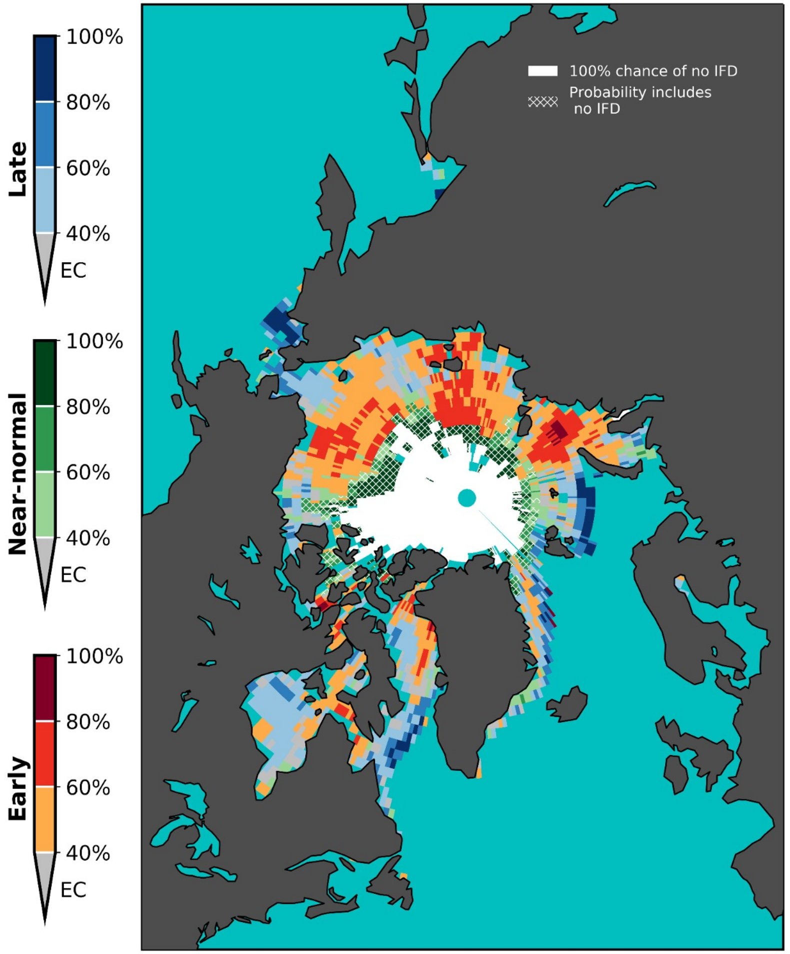

Dirkson, A., B. Denis, M. Sigmond and W. J. Merryfield, 2021: Development and calibration of seasonal probabilistic forecasts of ice-free dates and freeze-up dates. *Weather and Forecasting*, 30, 301-324, https://doi.org/10.1175/WAF-D-20-0066.1.

# Ice-Free / Freeze-Up Dates (Probabilistic)

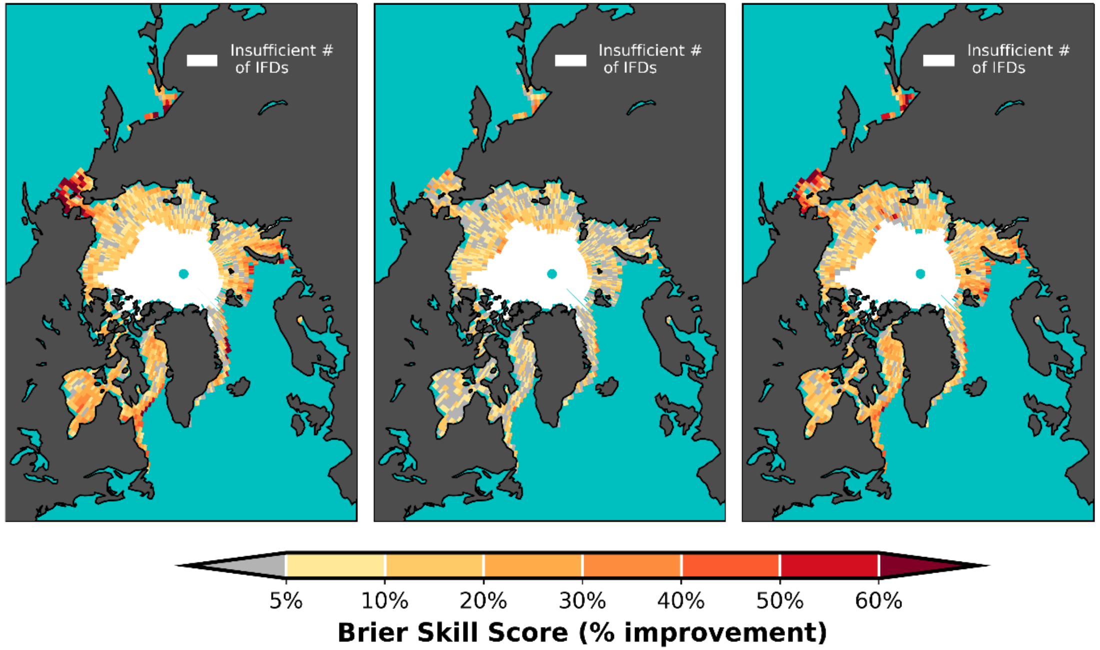
Dates that sea ice concentration falls below / rises above 50%

## 2022 Ice-Free Date forecast from 30 Apr

Probability for Early, Near-normal, or Late IFD
CanSIPSv2, init: 05/2022 (cf 2013-2021)

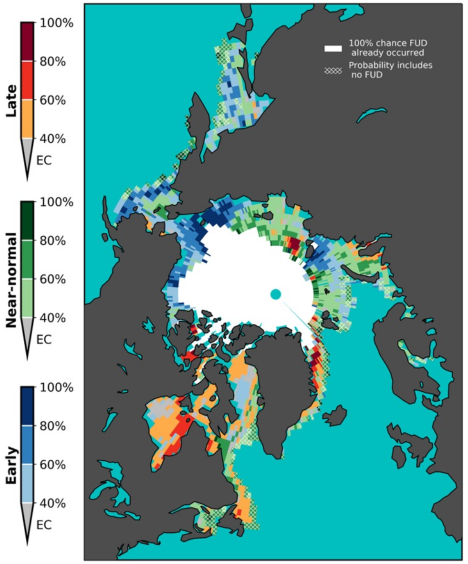



**CanSIPSv2.1 Historical IFD Skill, Init: May 1, 2000-2021**
Relative to trend-adjusted climatology

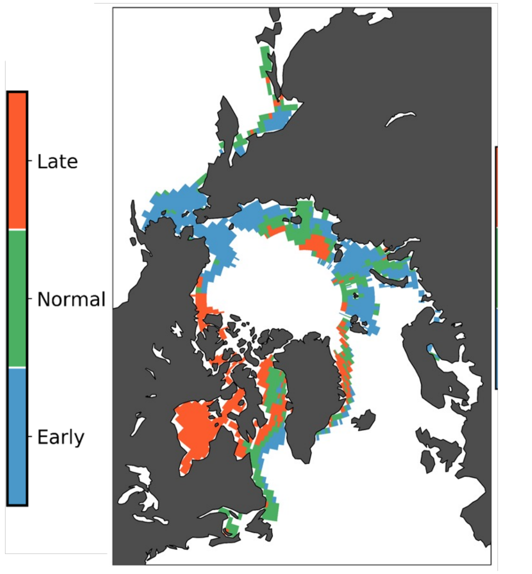



**Verification of 2021 Freeze-Up Date** from 30 Sep**

Forecast




Observed




**compared to 2012-2020 average

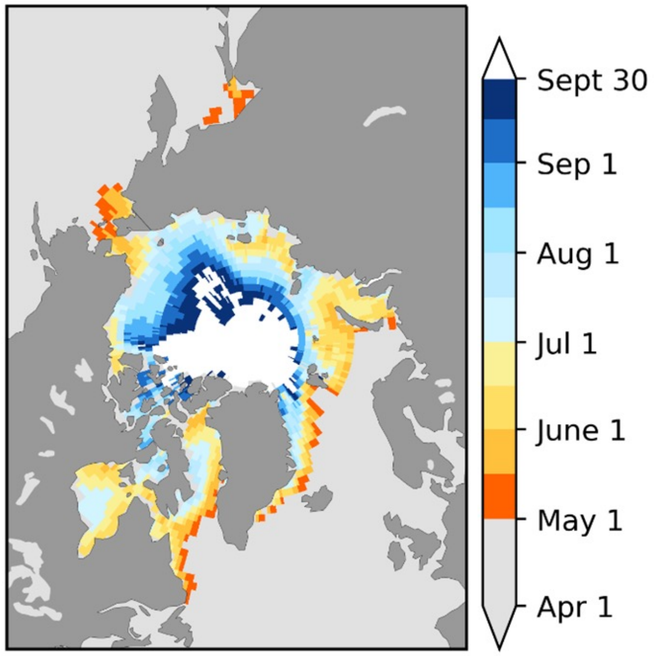
Dirkson, A., B. Denis, M. Sigmond and W. J. Merryfield, 2021: Development and calibration of seasonal probabilistic forecasts of ice-free dates and freeze-up dates. *Weather and Forecasting*, 30, 301-324, https://doi.org/10.1175/WAF-D-20-0066.1.

# Ice-Free / Freeze-Up Dates (Deterministic)

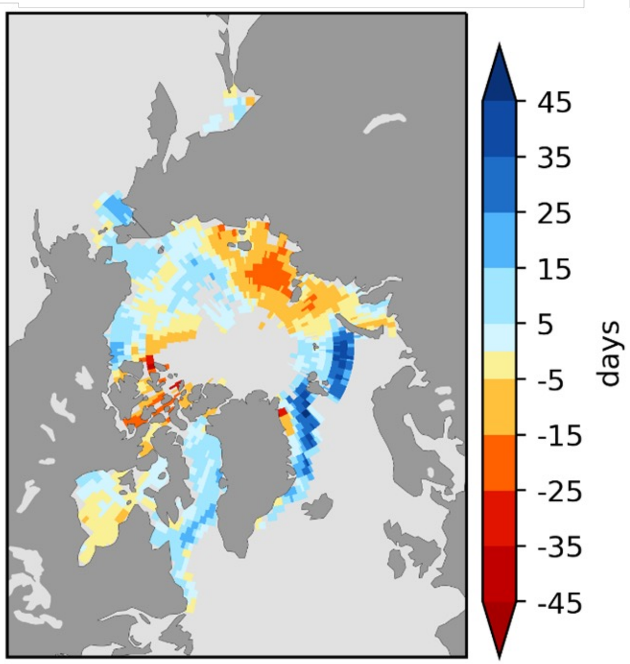
Dates that sea ice concentration falls below / rises above 50%

## 2022 Ice-Free Date forecast from 30 Apr

2022 Ice-Free Date
(bias corrected)

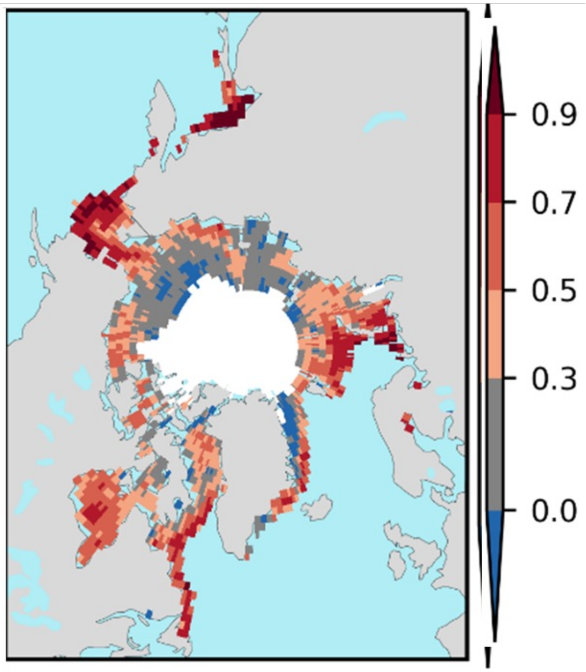



2022 Ice-Free Date
Anomaly*



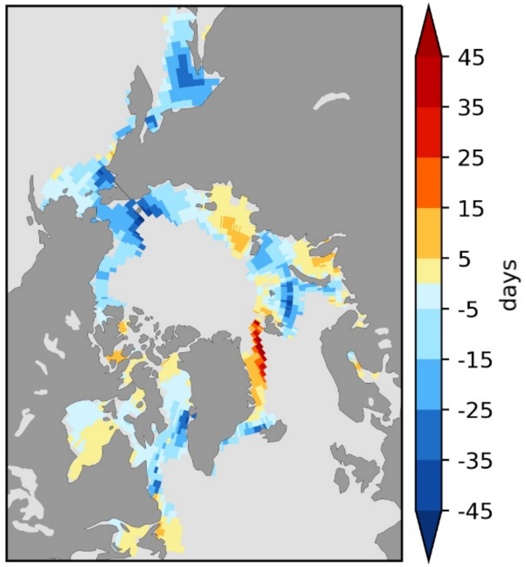

*compared to 2013-2021 average

Historical Skill 1990-2020
(anomaly correlation detrended)

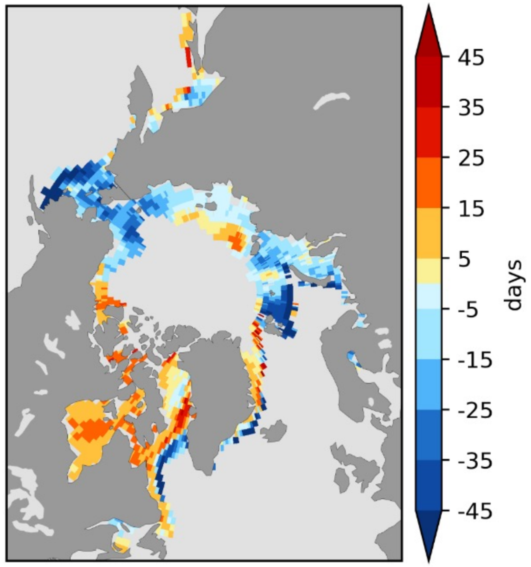



**Verification of 2021 Freeze-Up Date** from 30 Sep**

Forecast




Observed



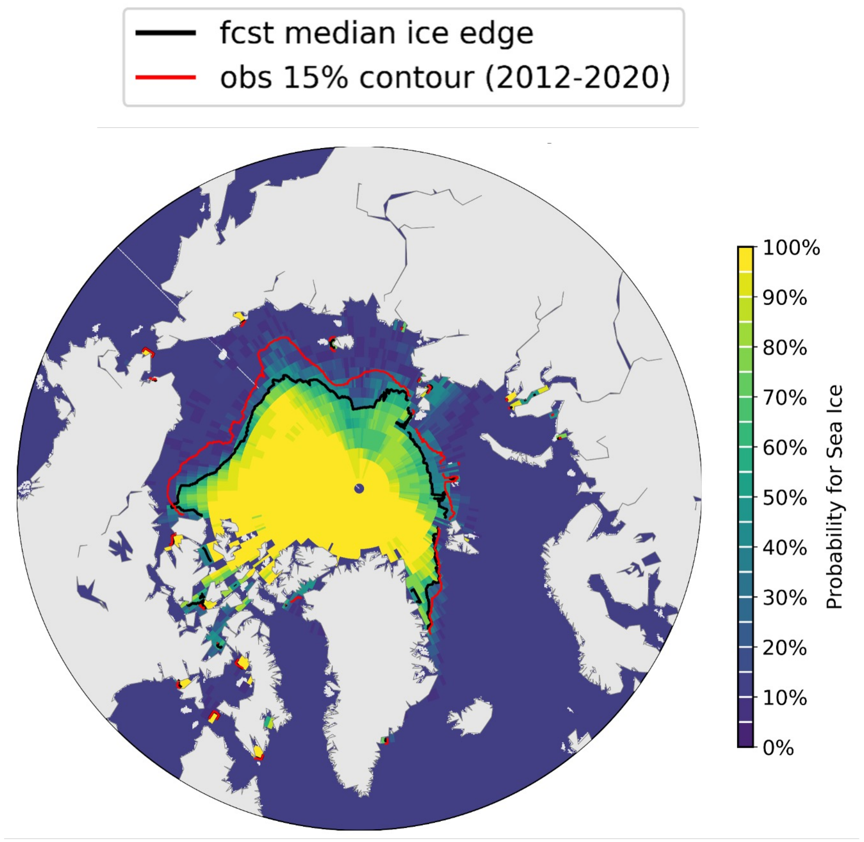

**compared to 2012-2020 average

Sigmond, M., M. C. Reader, G. M. Flato, W. J. Merryfield and A. Tivy, 2016: Skillful seasonal forecasts of Arctic sea ice retreat and advance dates in a dynamical forecasting system. *Geophys. Res. Lett.*, 43, 12,457-12,465, https://doi.org/10.1002/2016GL071396.

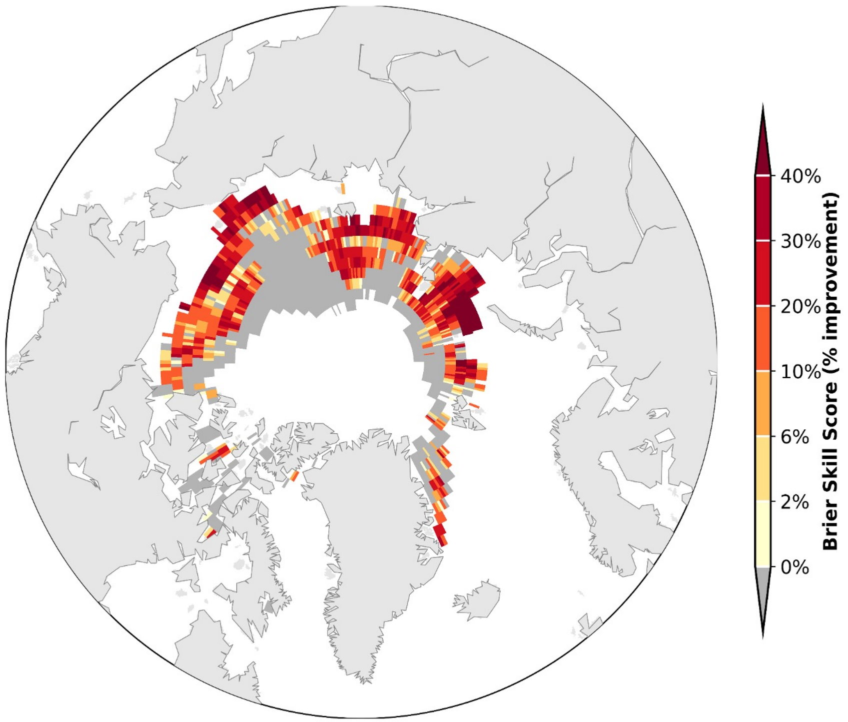
# Sea Ice Probability

## Calibrated probabilities that monthly sea ice concentration exceeds specified threshold

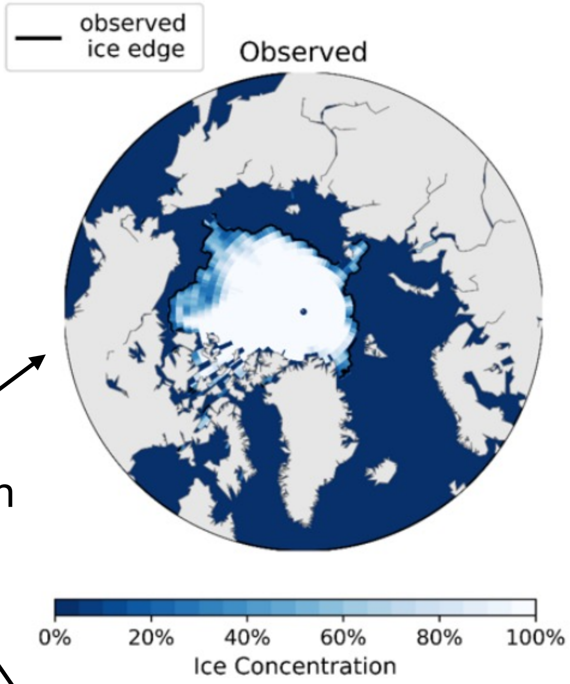
Sep 2021 forecast from 30 Apr

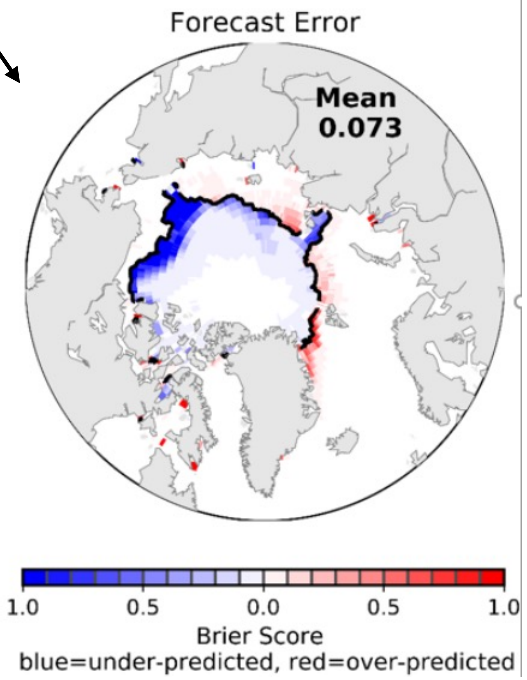



Historical skill (2000-2020) relative to trend-adjusted climatology




Verification




Dirkson, A., W. J. Merryfield and A. H. Monahan, 2019: Calibrated Probabilistic Forecasts of Arctic Sea Ice Concentration. *J. Clim*., 32, 1251-1271, https://doi.org/10.1175/JCLI-D-18-0224.1