Regime Change Prognostic Tool

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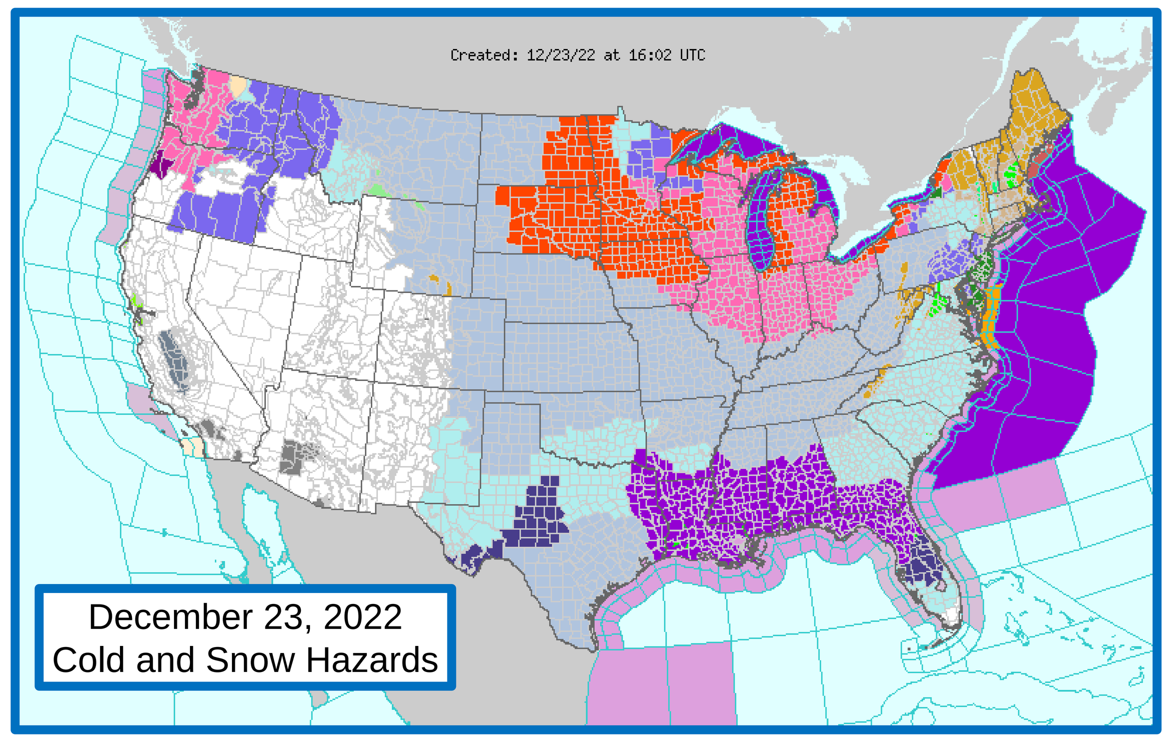
US CLIVAR Workshop on Blocking and Extreme Weather in a Changing Climate

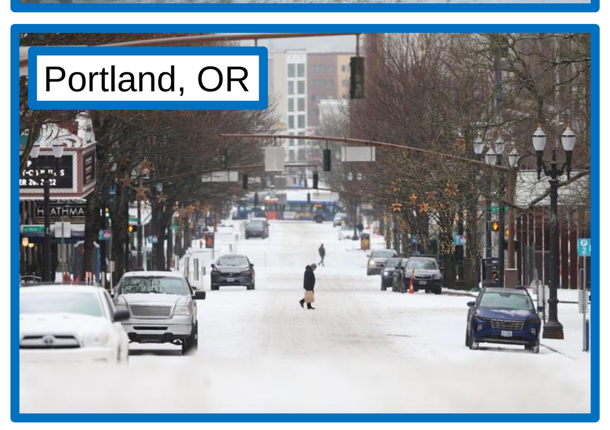
Boulder, CO
March 18-20, 2024

Project Background & Motivation

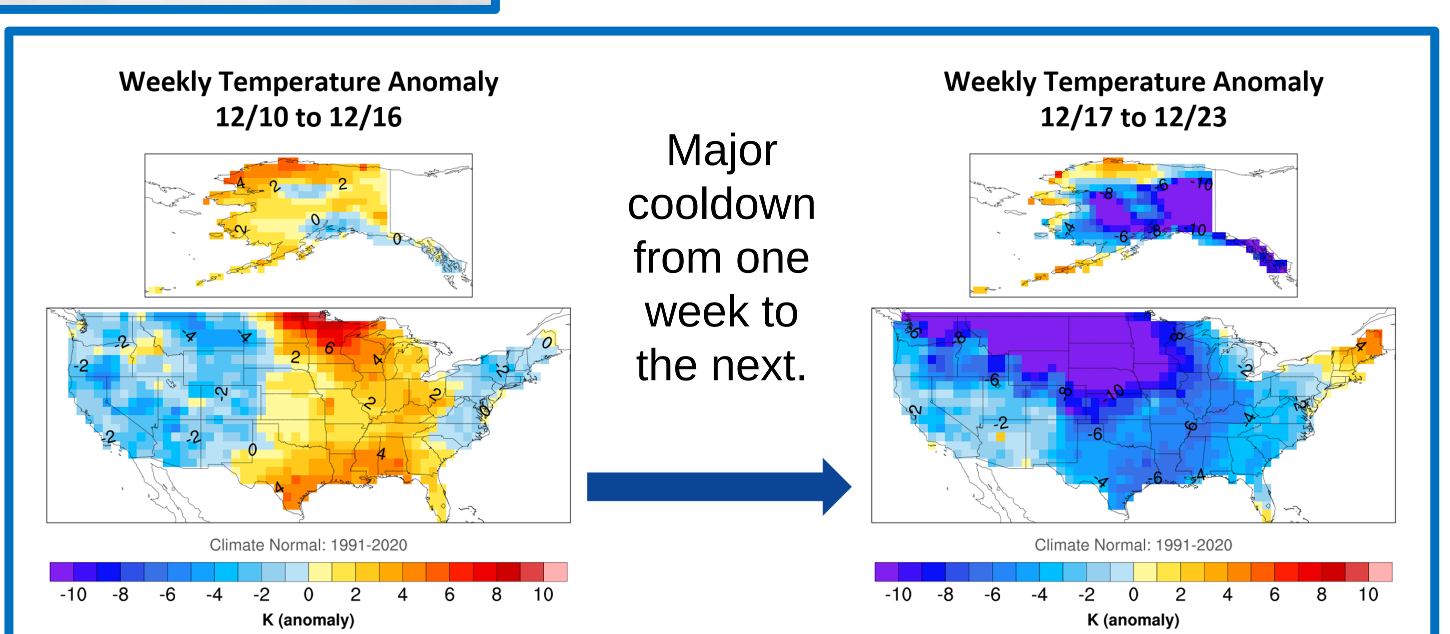
Mid-December 2022 - Arctic Air Outbreak

An abrupt but short-lived Arctic air outbreak impacted much of CONUS during mid-December 2022.



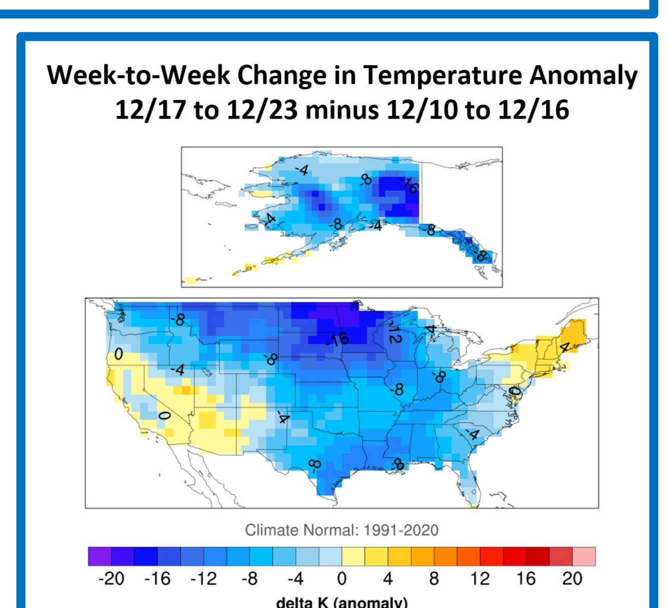


Hazardous impacts were far-reaching and amplified during the busy holiday travel season.



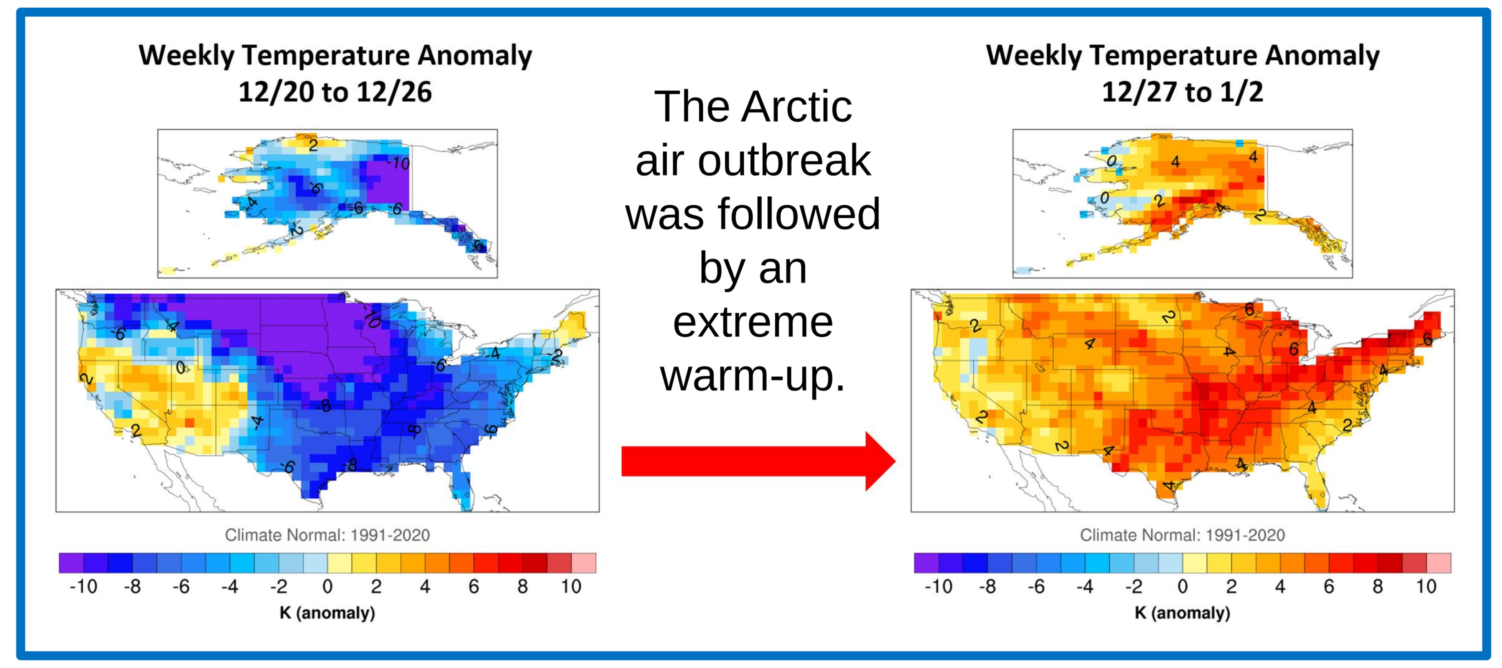
Questions:

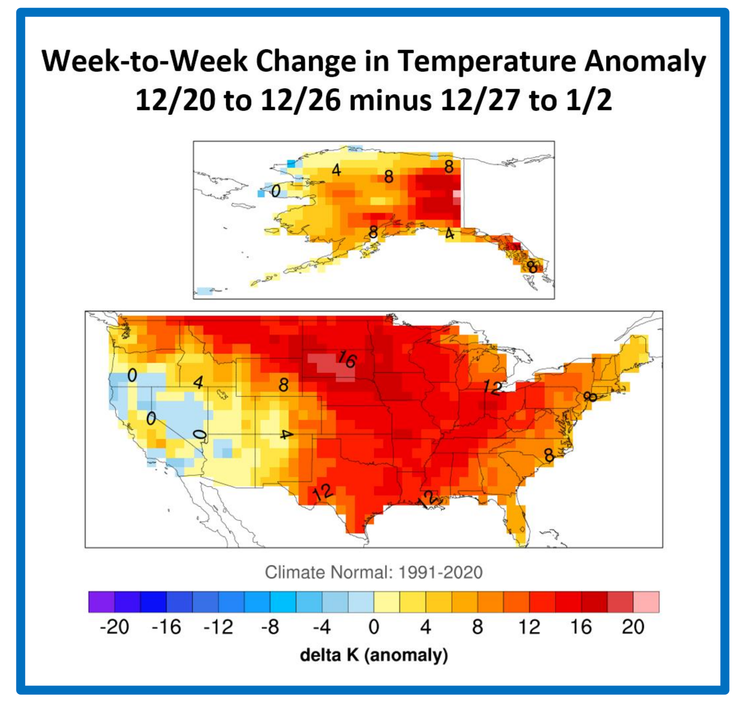
- Was the timing, magnitude and duration of this Arctic air outbreak predictable in probabilistic space by the subseasonal dynamical models?
- How well did we message the Arctic air outbreak and its hazardous impacts?



Project Background & Motivation <continued>

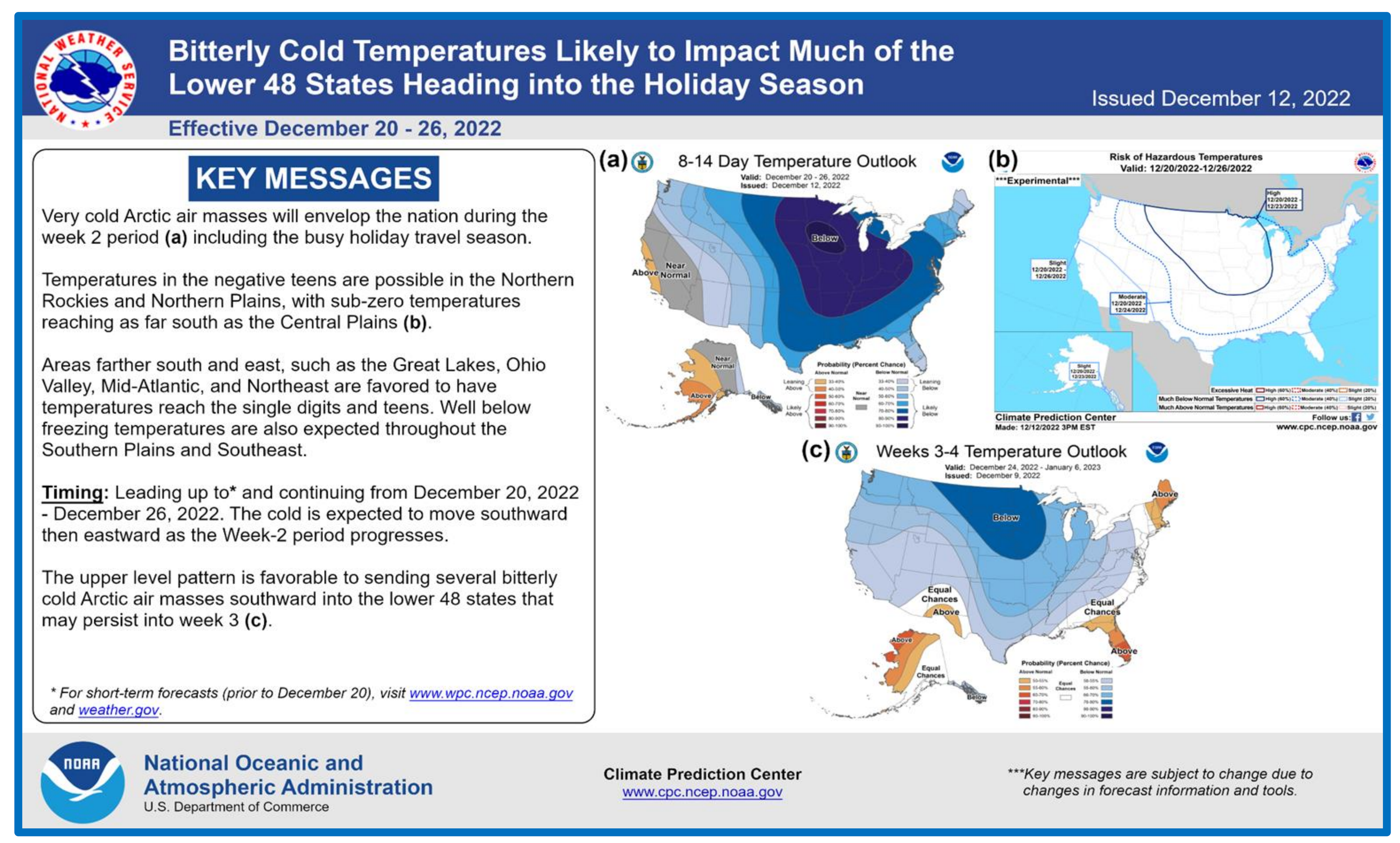
Mid-December 2022 - Arctic Air Outbreak





Questions:

- Was the end of the Arctic air outbreak and the magnitude of the change back to anomalous warmth predictable in probabilistic space by the subseasonal dynamical models?
- How well did we message this extreme regime change in the Weeks 2-4 period?



Bitterly Cold Temperatures Likely to Impact Much of the Lower 48 States Heading into the Holiday Season

Issued December 12, 2022

Effective December 20 - 26, 2022

KEY MESSAGES

Very cold Arctic air masses will envelop the nation during the week 2 period **(a)** including the busy holiday travel season.

Temperatures in the negative teens are possible in the Northern Rockies and Northern Plains, with sub-zero temperatures reaching as far south as the Central Plains **(b)**.

Areas farther south and east, such as the Great Lakes, Ohio Valley, Mid-Atlantic, and Northeast are favored to have temperatures reach the single digits and teens. Well below freezing temperatures are also expected throughout the Southern Plains and Southeast.

Timing: Leading up to* and continuing from December 20, 2022 - December 26, 2022. The cold is expected to move southward then eastward as the Week-2 period progresses.

The upper level pattern is favorable to sending several bitterly cold Arctic air masses southward into the lower 48 states that may persist into week 3 **(c)**.

** For short-term forecasts (prior to December 20), visit www.wpc.ncep.noaa.gov and weather.gov.*

(a) 8-14 Day Temperature Outlook

(b) Risk of Hazardous Temperatures

(c) Weeks 3-4 Temperature Outlook

National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Climate Prediction Center
www.cpc.ncep.noaa.gov

***Key messages are subject to change due to changes in forecast information and tools.*

Very little probabilistic information is provided in this Key Message about timing, magnitude, or duration of the regime change. Nothing is said about the historic warm-up. The Regime Change Prognostic Tool aims to address these shortcomings.

Goal: To provide enhanced messaging of the timing, magnitude, and duration of major, impactful regime changes

Target audience/stakeholders: All users of CPC's outlooks: Days 6-10, Week 2, Weeks 3-4, Monthly, Hazards, Drought, and Key Messaging products

Collaborators: CPC staff / NWS regions / Stakeholders

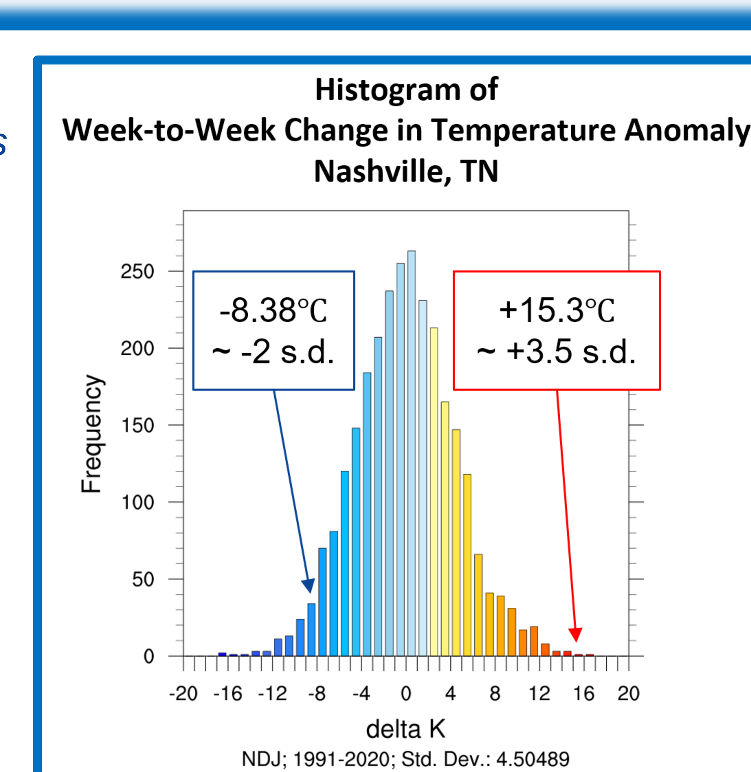
Observational Results

Grid-Point and Season-Specific Distributions

Result: Grid-point and season-specific distributions of week-to-week changes in temperature anomaly have been gathered.

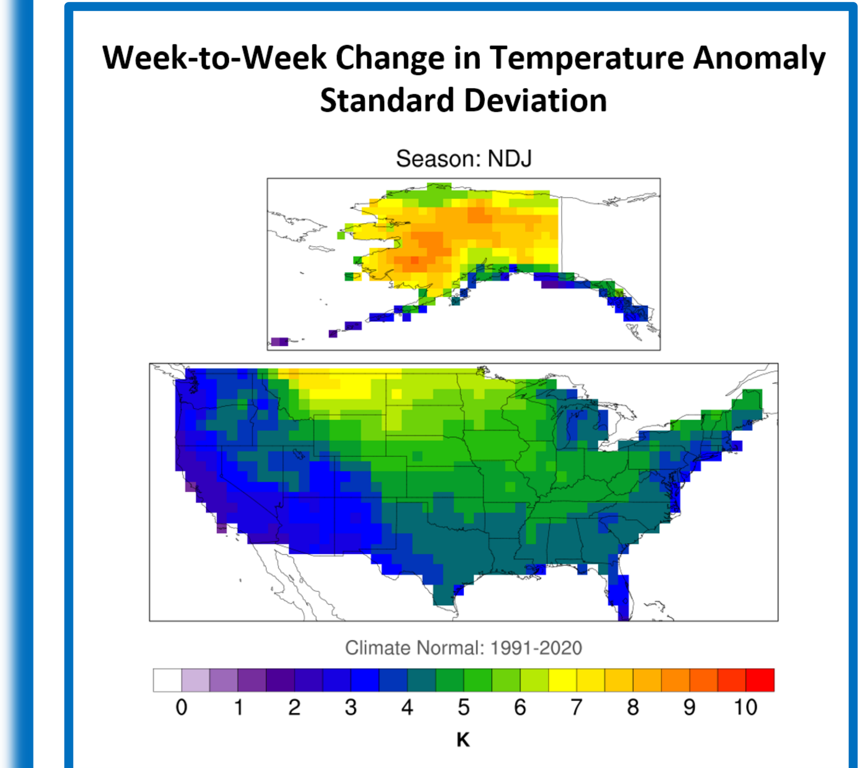
Result: 1991-2020 distributions have been created for all seasons and grid points for T-mean, T-max, T-min, 500-hPa heights, and precipitation for 1-day, 3-day, 5-day, 7-day, 10-day, and 14-day, and 30-day timescales.

Example (right): The week-to-week changes in temperature anomaly for Nashville, TN during December 2022 can be placed in an historical context.



Observational Results

Statistics derived from Grid-Point and Season-Specific Distributions



Result: Statistics have been derived from the grid-point and season-specific distributions. These statistics provide historical context of regime changes.

Result: Statistics that have been calculated include means, measures of variance/spread, percentile thresholds, and tests for normality.

Example (left): As expected, week-to-week changes in temperature anomaly during November-January have the highest standard deviations in Alaska and the Northern Plains.

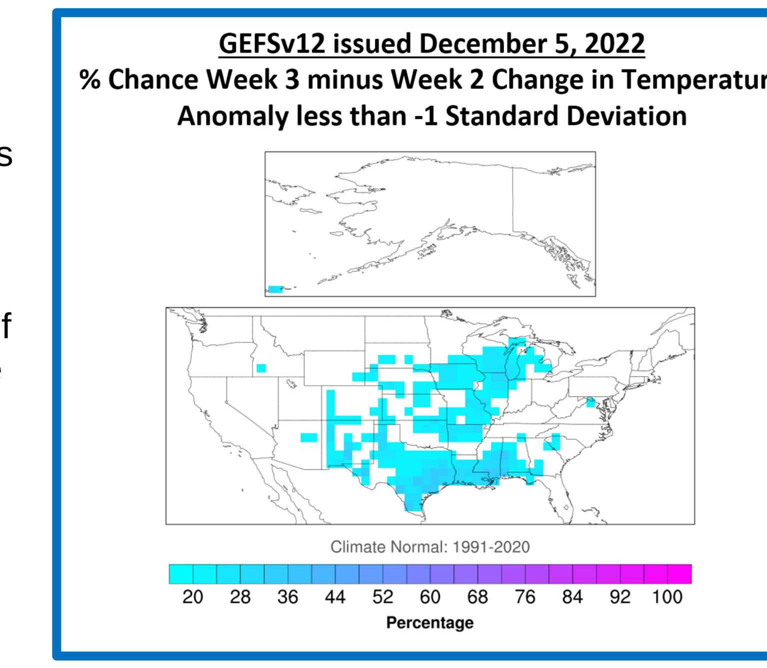
Current Work

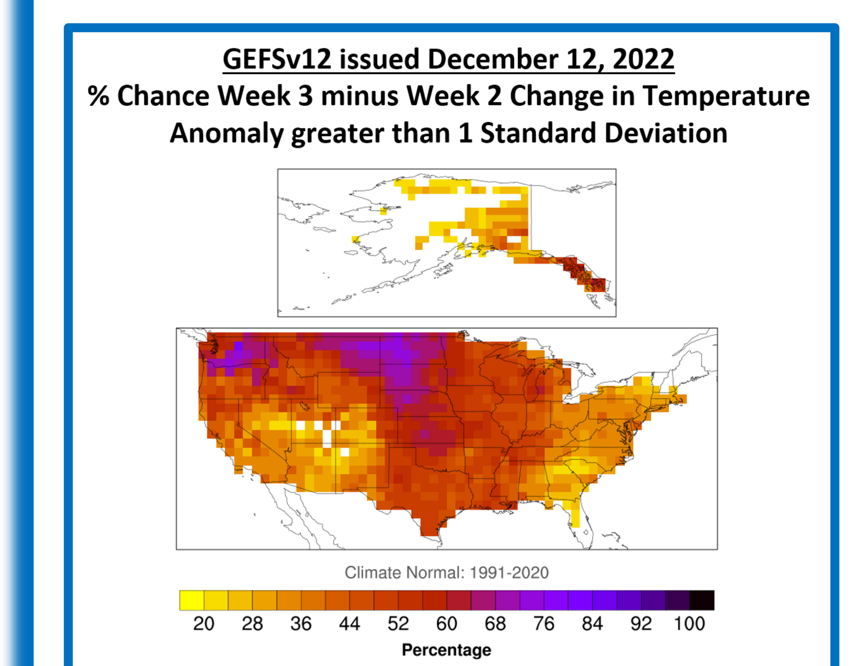
Probabilistic prognostications of regime changes in forecast models

Result: We are developing code to calculate the probability of regime changes for various thresholds across all lead times and timescales from the ensemble suites of the dynamical models.

Result (right): The climatological probability of a week-to-week temperature anomaly change less than -1 Standard Deviation is ~16%.

Thus, the GEFSv12 had some indication of elevated odds for an extreme cool down from Week 2 to Week 3.





Result (left): The climatological probability of a week-to-week temperature anomaly change exceeding 1 Standard Deviation is ~16%.

Thus, the GEFSv12 was very confident of an extreme warm-up from Week 2 to Week 3.

We could have messaged the end of the Arctic air outbreak with high confidence!

Upcoming Activities & Summary

- Present preliminary results at workshops to receive feedback from the scientific and stakeholder communities to tailor the tool toward addressing specific needs.
- Continue the observational study by compositing the frequency of extreme regime changes conditioned on the background climate state.
- Continue to develop code to calculate regime changes in the ensemble suite of dynamical models and perform a retrospective verification.
- Begin prototyping the prognostic tool in an experimental framework to enhance forecast discussions and Key Messaging to NWS regions and stakeholders.
- Make plans to operationalize the tool in Fiscal Year 2025.

Please e-mail **Cory.Baggett@noaa.gov** or **Emerson.Lajoie@noaa.gov** with any questions or feedback.

Date sources:

Copernicus Climate Change Service (C3S) (2017): ERA5: Fifth generation of ECMWF atmospheric reanalyses of the global climate . Copernicus Climate Change Service Climate Data Store (CDS), *2023.* https://cds.climate.copernicus.eu/cdsapp#!/home

Fan, Y., and H. van den Dool, 2008: A global monthly land surface air temperature analysis for 1948-present. *Journal of Geophysical Research*, **113**, D01103, https://doi.org/10.1029/2007JD008470.