Week-2 and Week 3-4 Storm Track Outlooks over North Pacific, North America, and North Atlantic

1. Background

Extratropical storm activities have strong societal and economic impacts on mid- and high-latitude regions, including Alaska. To support the NWS Alaska and other regional centers for storm track monitoring and forecast, a suite of week-2 and week 3-4 storm track forecast products has been developed at CPC based on the dynamical forecast of the NCEP Global Ensemble Forecast System version 12 (GEFSv2) and CFS version 2 (CFSv2).

Extratropical storms are detected and tracked using 6-hourly sea level pressure (SLP) data from the operational GEFSv12 (16-day and 35-day) and CFSv2 (45-day) forecasts and a storm-tracking algorithm (Serreze 1995). The outlooks include storm activities (storm tracks and track density, storm intensity and duration) which are accumulated using 500-km radius storm statistics, precipitation, SLP and 10-m winds, and day-to-day variance of SLP over North Pacific (which is an Eulerian storminess metric), North America, and North Atlantic for both week-2 and week 3-4 total and anomaly fields. In addition, probabilistic forecasts of precipitation and 10-m wind speed exceeding 75th and 90th percentiles, and storm intensity lower than 990, 980, 970, and 960 hPa are provided. The week-2 and week 3-4 outlooks also consist of regional storminess index forecast over North Pacific and Alaska. Verifications for the real-time forecasts are conducted using the NCEP Climate Forecast System Reanalysis (CFSR). The storminess outlook is daily updated.

The forecast skill displayed below is assessed using 21-year (1999-2019) GEFSv12 and CFSv2 hindcast data. A certain level of skill is found for storm track density over the mid- and high-latitudes and better skills for day-to-day SLP variance and mean SLP. Combining the GEFSv12 with the CFSv2 (on the basis of equal weight for each ensemble member) leads to an overall higher sub-seasonal storminess forecast skill than the two individual model forecasts.

A more detailed description of the methods, as well as hindcast evaluation based on ERA5 data, can be found in Chang et al. (2022). Model hindcast climatologies and biases with respect to ERA5 data can be found in the Supplementary Material of that paper. Note that we expect operational forecasts to exhibit higher skill than the hindcasts because the operational forecasts have more ensemble members than the hindcasts. As will be shown below, we find that models exhibit better skill in predicting the SLP variance (Eulerian) storminess index than cyclone track statistics, and that the SLP variance index has been shown to be highly correlated with precipitation and strong winds (see Chang et al. 2022, Yau and Chang 2020), we encourage users to consider using the forecast of that metric to represent storminess activity unless there is an explicit need for information about cyclone frequency or amplitude.

2. Data and Methods

2.1 Data

- Model forecast/hindcast (6-hourly):
    - GEFSv12 operational 16-day (124 members) and 35-day forecasts (31 members)
    - CFSv2 operational 45-day forecast (16 members)

    - GEFSv12 16-day (5 members) and 35-day (11 members) hindcasts: 1999-2019, 21 years
    - CFSv2 45-day hindcast (4 members): 1999-2019, 21 years
- Observations:
    - Verification: CFSR real time
    - Skill assessment: CFSR archive (1999-2019, 21 years)

2.2 Week-2 and week 3-4 storm track outlooks and CFSR verifications

- Storm detecting and tracking are based on the algorithm developed by Serreze (1995), with a criterion of storm center SLP ≤ 1000 hPa:
    - Using 6-h SLP data on 2.5°x2.5° grid
    - Center SLP ≤ 1000 hPa
    - Center SLP at least 1 hPa lower than surrounding grid points
    - Maximum distance a storm can move is 800 km/6 hr
- Week-2 and week 3-4 storm track density, storm intensity (center SLP) and duration
    - Storm track density is defined as total number of storm centers within 500-km radius of each grid point divided by ensemble members.
    - Storm intensity denotes the mean storm center SLP within 500-km radius.
    - Storm duration is the average of lifetime of all storms within the domain of 500-km radius of each grid point.
- Week-2 and week 3-4 total precipitation, mean SLP and 10-m winds
- Probability forecast (based on distribution of individual member forecasts)
    - Precipitation and 10-m wind speed: exceeding 75^{th} and 90^{th} percentiles
    - Storm intensity: lower than 990, 980, 970, and 960 hPa
- Week-2 and week 3-4 day-to-day SLP variances
- Regional storminess index forecasts over N. Pacific and Alaska for storm track density, precipitation, SLP, and day-to-day SLP variance
- CFSR verifications of the storminess forecasts: a 16-day delay for the real-time week-2 forecast and 29-day delay for the real-time week 3-4 forecast

3. Evaluation of week-2 and week 3-4 forecasts

Anomaly correlations (AC) of week-2 and week 3-4 storm track density, day-to-day SLP variance, and mean SLP between model 21-year (1999-2019) hindcast and CFSR data indicate a certain level of skill for storm track density over the mid- and high-latitudes (Figs. 1 and 2) and better skills for day-to-day SLP variance (Figs. 3 and 4) and mean SLP (Figs. 5 and 6). Week-2 forecast has a higher skill than week 3-4 forecast. AC skill in winter month (January) is higher than in summer month (July). GEFSv12/CFSv2 combined dynamical forecast has an overall higher sub-seasonal storminess forecast skill than the two individual model forecasts.

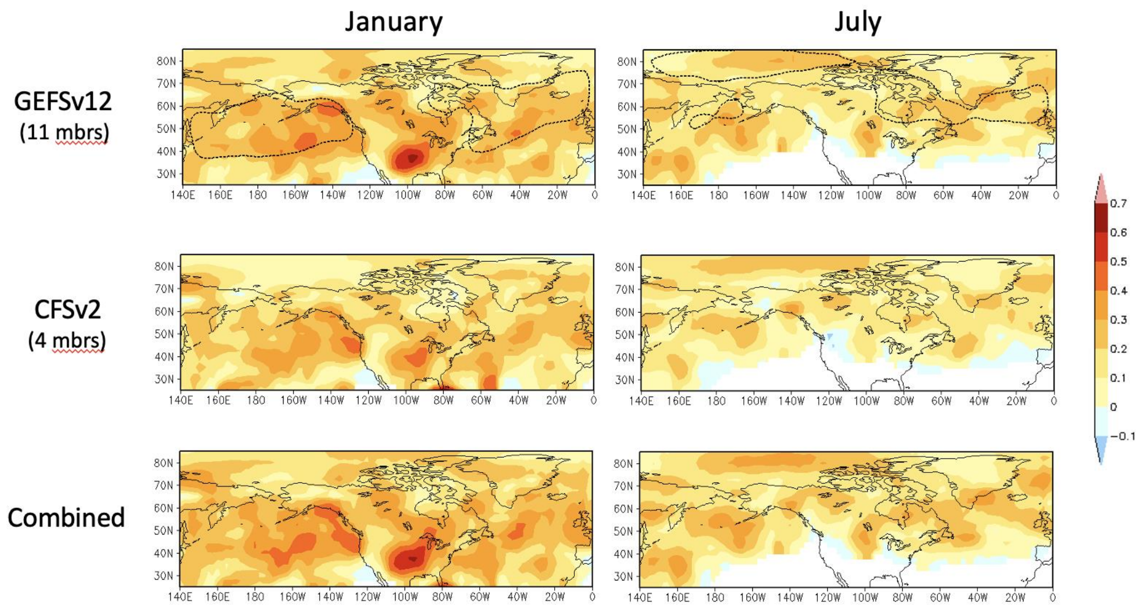

Fig. 1 Anomaly correlation (AC) of week-2 storm track density between CFSR and GEFSv12 (top), CFSv2 (middle), GEFSv12+CFSv2 combined (bottom) over the 21-year (1999–2019) hindcast period for January (left) and July (right). Dash-line circled areas are climatological storm-active regions from CFSR.

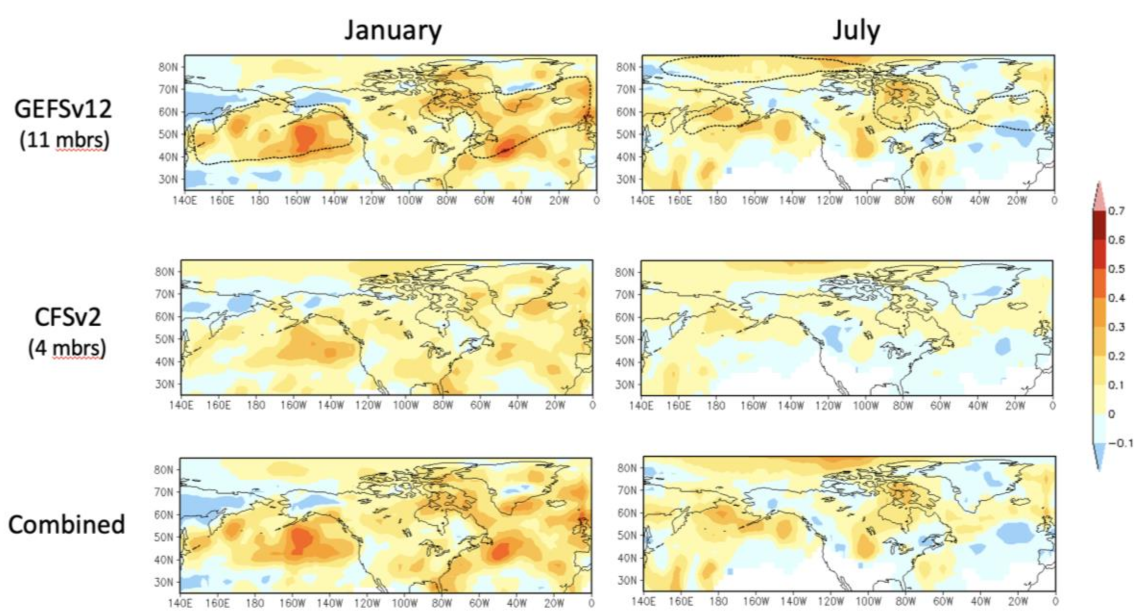

Fig. 2 Anomaly correlation (AC) of week 3-4 storm track density between CFSR and GEFSv12 (top), CFSv2 (middle), GEFSv12+CFSv2 combined (bottom) over the 21-year (1999–2019) hindcast period for January (left) and July (right). Dash-line circled areas are climatological storm-active regions from CFSR.

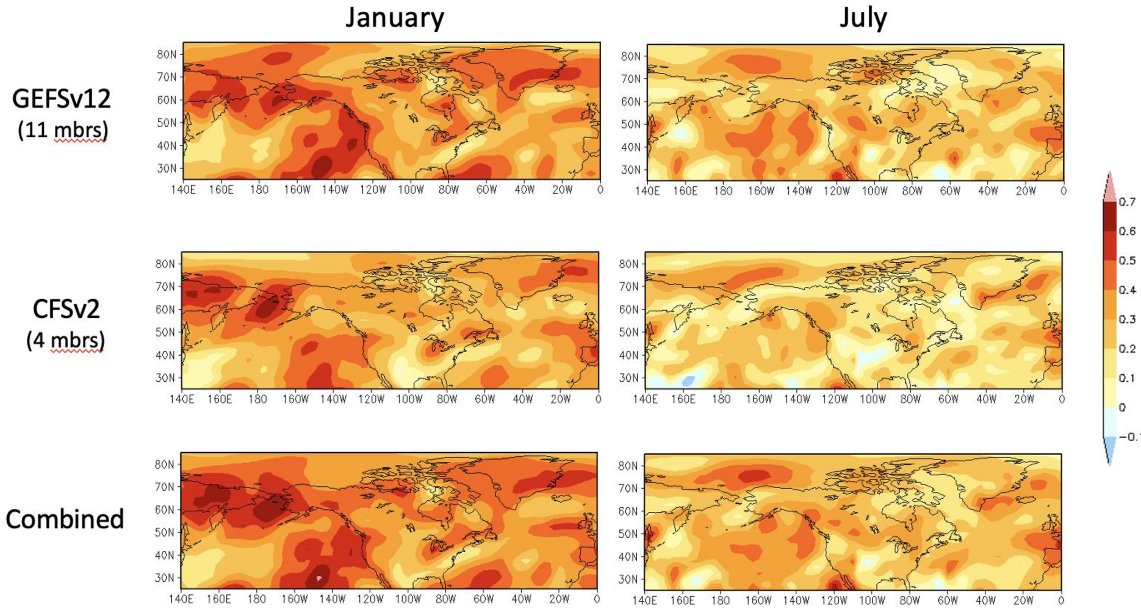

Fig. 3 Anomaly correlation (AC) of week-2 day-to-day SLP variance between CFSR and GEFSv12 (top), CFSv2 (middle), GEFSv12+CFSv2 combined (bottom) over the 21-year (1999–2019) hindcast period for January (left) and July (right).

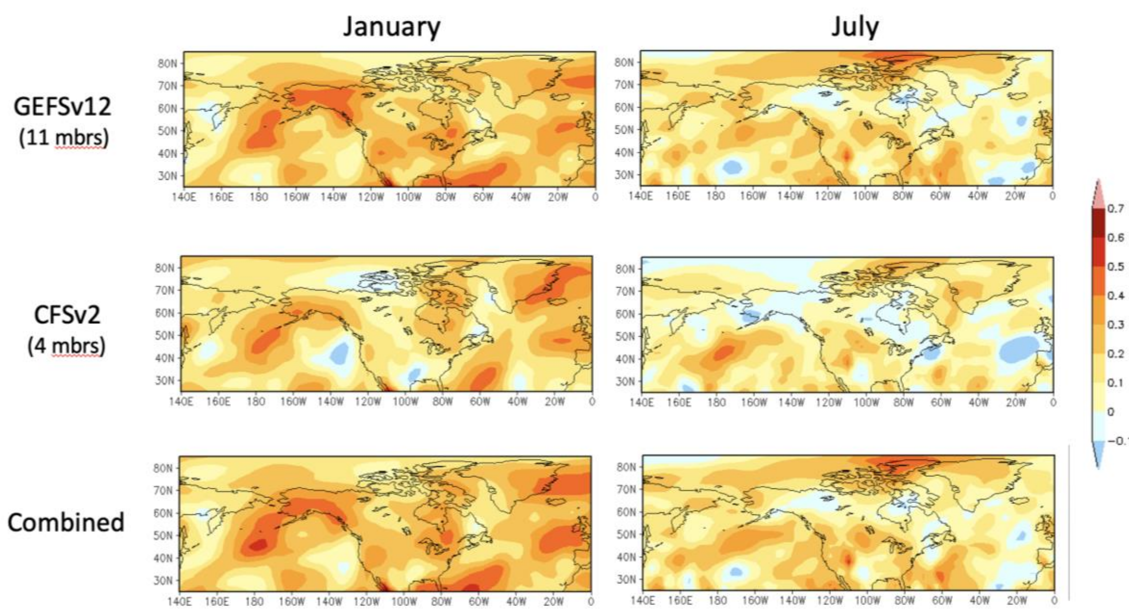

Fig. 4 Anomaly correlation (AC) of week 3-4 day-to-day SLP variance between CFSR and GEFSv12 (top), CFSv2 (middle), GEFSv12+CFSv2 combined (bottom) over the 21-year (1999–2019) hindcast period for January (left) and July (right).

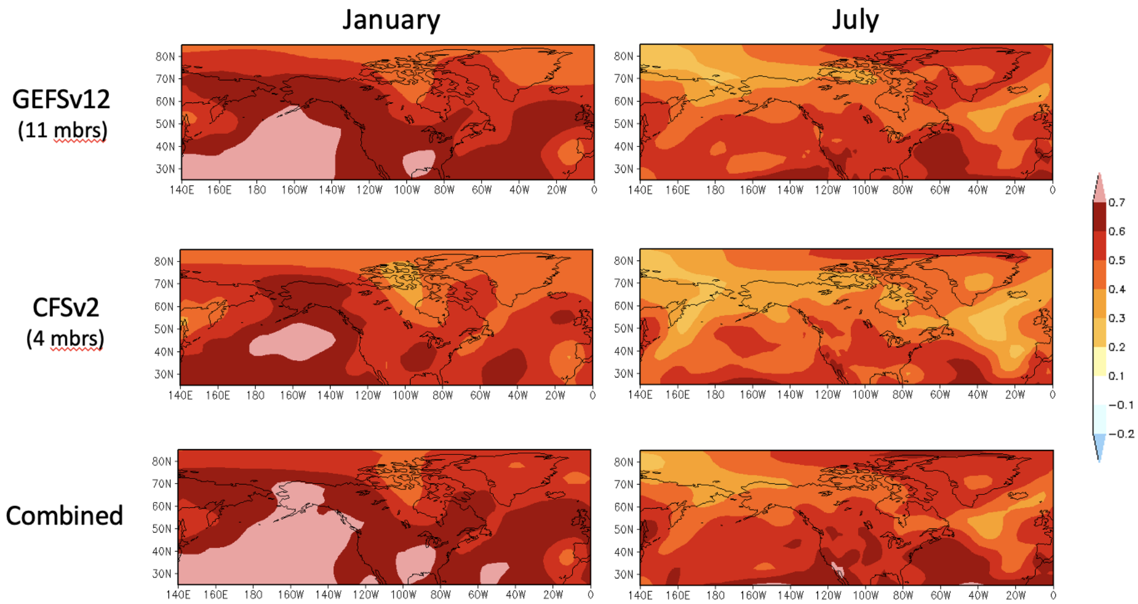

Fig. 5 Anomaly correlation of week-2 mean sea-level pressure between CFSR and GEFSv12 (top), CFSv2 (middle), GEFSv12+CFSv2 combined (bottom) over the 21-year (1999–2019) hindcast period for January (left) and July (right).

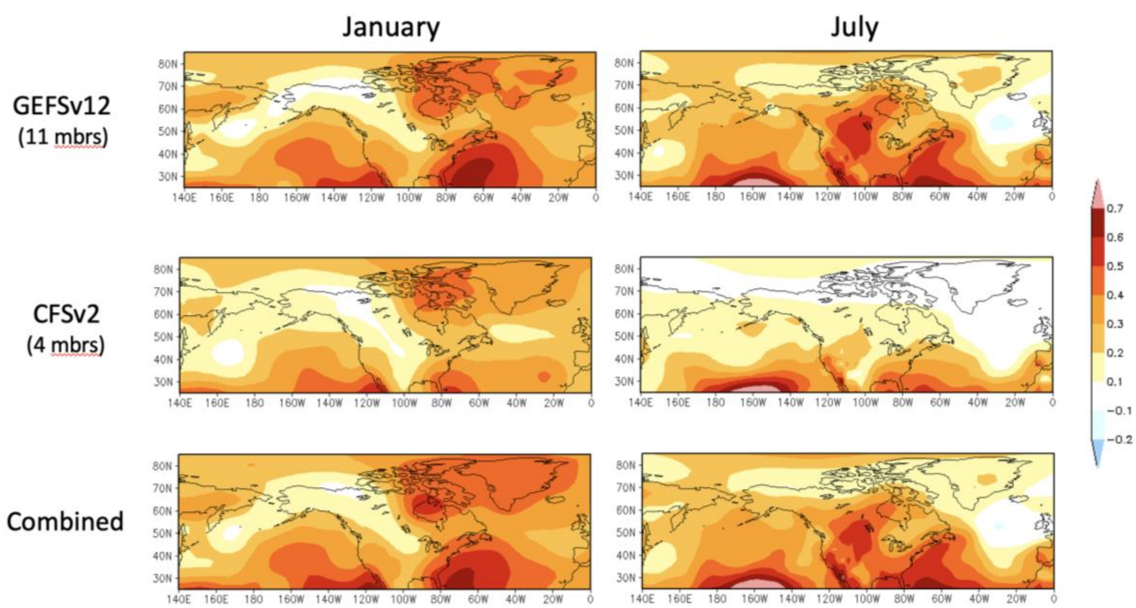

Fig. 6 Anomaly correlation of week 3-4 mean sea-level pressure between CFSR and GEFSv12 (top), CFSv2 (middle), GEFSv12+CFSv2 combined (bottom) over the 21-year (1999–2019) hindcast period for January (left) and July (right).

References

Serreze, M. C., 1995: Climatological aspects of cyclone development and decay in the Arctic. *Atmos.–Ocean*, 33, 1–23. https://www.tandfonline.com/doi/abs/10.1080/07055900.1995.9649522

Chang, E. K. M., Y. Pan, W. Wang, and C. Zheng, 2022: Developing and evaluating a subseasonal outlook tool for extratropical storminess. *Frontiers in Earth Science, section Atmospheric Science*, 10:963779. https://doi.org/10.3389/feart.2022.963779

Yau, A. M.-W., and E. K. M. Chang, 2020: Finding storm track activity metrics that are highly correlated with weather impacts. Part I: Frameworks for evaluation and accumulated track activity. *J. Climate*, 33, 10169–10186. https://doi.org/10.1175/JCLI-D-20-0393.1