



Gro sou nea neight rize valie at 20200 rite 500 hPa F120 and verification Heights

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Outline

- Background
- Objectives

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- Data & Methods
 - Case Studies
- Link to Historical Composites
- Summary
- Future Work
 - References

Background

- While forecast skill continues to improve with model upgrades, there are still occasional periods where the forecast skill is significantly reduced, especially on regional scales.
- Regional sector low-skill events were categorized based on 120-h 500-hPa height anomaly correlation coefficient (ACC) and root mean square error (RMSE) and diagnosed to determine causes of operational Global Forecast System (GFS) forecast error since June 2019.
- For this study, 5-day ACC and RMSE were calculated using the most recent 00Z initialization date in the GFS archive for each regional sector.



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Background

The regional sectors included: Eastern North America Western North America North America in general Eastern Pacific Western Pacific Pacific North America Central Asia Europe Atlantic Polar European domain specified by Rodwell et al. (2013)



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Objectives

- Evaluate GFSv15 00Z 120-h 500-hPa low-skill events by identifying the synoptic feature(s)/process(es) that may have contributed to the reduction in forecast skill
 - Identify common patterns that are conductive to low-skill forecasts
 - Apply knowledge of common patterns/processes to improve model and to mitigate future low-skill events
 - Validate low-skill composite work with real-time cases

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Data & Methods

- GFSv15 6-hourly 0 to 5-day 500-hPa forecasts initialized at 00Z
- Associated GFSv15 model analysis/verification
- Evaluated low-skill events by first identifying large errors/pattern differences in the 5-day 500-hPa forecast
- Errors were then traced back in time to their original source region
- These source regions were then compared to a previous study that utilized 15 years of GFSv15 forecasts to composite all identified low-skill cases (ACC≤0.5 and RMSE≥60 meters)

Low-Skill Event Criteria

- ACC<0.5 and RMSE>60 meters
- {ACC<0.5 and RMSE<60 meters}
- {ACC<0.6 and RMSE>60 meters}

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• June 13, 2020 00Z (ACC<0.6 and RMSE>60 m)

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Nov. 23, 2019 00Z Low-Skill Case

 5-day GFSv15 forecast initialized on Nov. 18 00Z and valid Nov. 23, 2019 00Z for the Eastern North America (ENA) sector was associated with an ACC<0.5 and RMSE>60 m



GFS 500 hPa Height F 120 Valid at 2019112300



500 hPa F120 and Verification Heights



Black contours: GFS Analysis Color shading: Forecast minus analysis Red contours: 120 h Forecast Trough/pattern errors over Eastern North America (trough was too slow in forecast)

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GFS 500 hPa Height F 072 Valid at 2019112100



500 hPa F072 and Verification Heights



Black contours: GFS Analysis Color shading: Forecast minus analysis Red contours: 72 h Forecast Errors traced back to a cutoff low over CA & were associated with the trough crossing the Rocky Mountains

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500 hPa F048 and Verification Heights



Black contours: GFS Analysis Color shading: Forecast minus analysis Red contours: 48 h Forecast Errors were traced back further to ridge building in the Pacific

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• June 13, 2020 00Z (ACC<0.6 and RMSE>60 m)

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GFS 500 hPa Height F 120 Valid at 2020012100



500 hPa F120 and Verification Heights



Black contours: GFS Analysis Color shading: Forecast minus analysis Red contours: 120 h Forecast

Trough errors over Eastern North America

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GFS 500 hPa Height F 006 Valid at 2020011606



500 hPa F006 and Verification Heights



Black contours: GFS Analysis Color shading: Forecast minus analysis Red contours: 6 h Forecast Error source region in Central Pacific associated with atmospheric river/ridge

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Black contours: GFS Analysis Color contours: 500-hPa height error Color fill: 0-6 h Precip

Error source region in Central Pacific associated with atmospheric river/ridge

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March 5, 2020 00Z Low-Skill Case

 5-day GFSv15 forecast initialized on Feb. 29 00Z and valid March 5, 2020 00Z for the Eastern North America (ENA) sector was associated with an ACC<0.5 and RMSE>60 m

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GFS 500 hPa Height F 120 Valid at 2020030500

500 hPa F120 and Verification Heights

Black contours: GFS Analysis Color shading: Forecast minus analysis Red contours: 120 h Forecast Incorrectly placed trough over ENA, leading to downstream pattern errors

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GFS 500 hPa Height F 066 Valid at 2020030218

500 hPa F066 and Verification Heights

Black contours: GFS Analysis Color shading: Forecast minus analysis Red contours: 66 h Forecast

Forecast errors traced back to a cutoff near CA

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GFS 500 hPa Height F 024 Valid at 2020030100

500 hPa F024 and Verification Heights

Black contours: GFS Analysis Color shading: Forecast minus analysis Red contours: 24 h Forecast

Forecast errors also traced back to ridge building in the Pacific

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June 13, 2020 00Z Low-Skill Case

 5-day GFSv15 forecast initialized on June 8 00Z and valid June 13, 2020 00Z for the Eastern North America (ENA) sector was associated with an ACC<0.6 and RMSE>60 m

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GFS 500 hPa Height F 120 Valid at 2020061300

500 hPa F120 and Verification Heights

Black contours: GFS Analysis Color shading: Forecast minus analysis Red contours: 120 h Forecast

Trough errors over Eastern North America

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GFS 500 hPa Height F 024 Valid at 2020060900

500 hPa F024 and Verification Heights

Black contours: GFS Analysis Color shading: Forecast minus analysis Red contours: 24 h Forecast

Errors associated with trough crossing the Rocky Mountains

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Eastern North America Low-Skill Case Studies

 These ENA low-skill events had very similar characteristics such as errors with trough progression over the Rocky Mountains, cutoff features rejoining the synoptic flow, and atmospheric river/ridge building. It was also found that these recent events had similar characteristics to past cases when error source regions were compared to a previous study that utilized 15 years of GFSv15 forecasts to composite all identified low-skill cases with ACC ≤ 0.5 and RMSE \geq 60 meters (next section).

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 By linking current events to a previous composite study, it was found that operational GFS forecasts produced errors through similar processes.

Eastern North America Processes

- Trough propagation across the Rocky Mountains
- Cutoff lows rejoining the synoptic flow
- Ridge building in the Pacific
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GFS 500 hPa Height F 000 Valid at 2019111800

Black contours: GFS Forecast Color shading: 500-hPa height anomaly (m)

Source region in GFSv15 forecast showed similar pattern as in Q3 ENA composite

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Black contours: GFS Forecast Color shading: 500-hPa height anomaly (m)

Source region in GFSv15 forecast showed similar pattern as in Q3 ENA composite

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GFS 500 hPa Height F 000 Valid at 2020011600 60E 120E 30E 150E 180 30W 150W

90W

120W

-180

Black contours: GFS Forecast Color shading: 500-hPa height anomaly (m)

-360

-300

-240

Source region showed similar pattern as in Q4 ENA composite, highlighting atmospheric rivers & Pacific ridge building as likely issues contributing to low-skill forecasts
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60

120 180

60W

240

300 360

Black contours: GFS Forecast Color shading: 500-hPa height anomaly (m)

Source region in GFSv15 forecast showed similar pattern as in Q4 ENA composite

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60E

60W

240

120 180 30E

30W

300

360

Summary

- Source region comparison with a previous composite study identified that GFSv15 forecasts produced errors through similar processes.
- Low-skill forecasts in the ENA sector displayed similar characteristics if a trough propagated across the Rocky Mountains, cutoff lows tried to rejoin the synoptic flow, and/or ridge building occurred in the Pacific.

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Future Work

- Continue monitoring/evaluating low-skill events in GFSv15 to increase knowledge of causes of low-skill forecasts
- Further investigate source region similarities for other regional sectors
- Diagnose 144-h (6-day) low-skill cases with regional ACC ≤ 0.4 and RMSE ≥ 60 meters (Rodwell et al. (2013) criteria)
- Utilize same methodology to investigate GFSv16 low-skill forecasts

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References

 Rodwell, M. J., and Coauthors, 2013: Characteristics of occasional poor medium-range weather forecasts for Europe. *Bull. Amer. Meteor. Soc*, 94, 1393–1405, <u>https://doi.org/10.1175/BAMS-D-12-00099.1</u>.

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