A Comprehensive Assessment of Aeolus Wind Impact on NOAA Global Forecast

Hui Liu\textsuperscript{1,2}, Kevin Garrett\textsuperscript{1}, Kayo Ide\textsuperscript{2}, Ross N. Hoffman\textsuperscript{1,2}, and Katherine Lukens\textsuperscript{1,2}

\textsuperscript{1}NOAA/NESDIS/Center for Satellite Applications and Research (STAR)
\textsuperscript{2}Cooperative Institute for Satellite Earth System Studies (CISESS), University of Maryland

Acknowledgements: Trish Weir (NOAA/NESDIS)

Aeolus 3\textsuperscript{rd} anniversary Conference, Taormina, Italy, March 29, 2022
Objectives and Outlines

- Assess and optimize impact of Aeolus winds on NOAA global and synoptic scale forecast

Specifically:
- Speed-dependent biases in the innovations of Aeolus vs. NOAA/GFS model and an additional bias correction
- Error estimation of Aeolus winds for assimilation with NOAA GFS model
- Rayleigh winds retrieved using NOAA/GFS T/P/wind
- Forecast impact of Aeolus winds on NOAA global and extreme event forecast
Aeolus Level-2B HLOS Winds

- Reprocessed Aeolus winds with M1 bias correction (B10) for Aug 2 – Sept 30 and Nov 20 – Dec 30, 2019
- Rayleigh clear sky and Mie cloudy winds
- ECMWF recommended QCs
- Outlier check of Aeolus winds vs. NOAA/GFS background winds

Also
- A GFS version of Rayleigh winds obtained using GFS background T/P/wind
Aeolus Wind Assimilation Experiments (OSEs) (1)

• NOAA global assimilation system, GFS v15.2 (4D-EnVar) at 25km/L64 resolution
• Assimilation experiments for Aug 2 – Sept 16 and Nov 20 – 28, 2019

• BASE : Rayleigh/Mie winds monitored
• AEOM : Assimilation of Rayleigh/Mie winds
• AEOT : Assimilation of Rayleigh/Mie winds w additional TLS bias correction
Handling of Biases in Aeolus Winds vs. GFS

- Evident speed-dependent biases in O-B of Aeolus – GFS (Sept 1-7, 2019)
- Developed a Total-Least-Square (TLS) bias correction

Before TLS bias correction (Descending orbits)

After TLS bias correction
Specification of Aeolus Wind Errors in Assimilation

- Obtained from O-B of Aeolus – GFS using Hollingsworth-Lonnberg (H-L) method

The H-L errors include representativeness error between Aeolus and GFS resolution (25km)

Similar vertical distribution as L2B uncertainty
Forecast Impact Summary Assessment Metrics (Aug 2-Sept 16)

**Variables**

- Positive impact on all variables at all levels in all regions
- Additional TLS bias correction enhances Aeolus impact after Day-2

**AEOM/AEOT vs. BASE**

- Positive impact on all variables at all levels in all regions
- Additional TLS bias correction enhances Aeolus impact after Day-2
Tropical Cyclone 6-Day Forecast Track Error
(Aug 2 – Sept 30, 2019)

TC cases: Gil, Henriette, Ivo, Juliette, Akoni, Kiko, Mario, and Lorena (E. Pacific);
Dorian, Erin, Fernand, Gabrielle, Humberto, Jerry, Imelda, Karen, and Lorenzo (Atlantic).

Dash lines in top panel: Confidence intervals at 95% level
A Record-Breaking Winter Storm in the US

Nov 26-28, 2019

- The storm landed at the West-coast at Nov 26 and moved to the interior of US in next a few days
- Record of 171 km/h wind gust in the West-coast
- 3-4 ft of snow in the US

Nov 27, 2019 GOES-16/17 image
Aeolus winds with TLS correction improve medium-range forecasts of the storm
Day-7 Mean Preci. Forecast of a Record-Breaking Storm
(validated at Nov 26-28 2019)

Aeolus (AEOT) improves preci. forecast location/amount
(scores closer to 1, w marginal 95% significance)

Mean 24h Preci. accumulation

CONUS Preci. Skill (ETS and Bias)

Aeolus (AEOT) improves preci. forecast location/amount
(scores closer to 1, w marginal 95% significance)
Rayleigh Wind’s Sensitivity to NOAA GFS T/P/Wind

- Considerable mean and random differences in T/P and wind in ECMWF - GFS background
- Rayleigh winds retrieved using GFS T/P (L2B L3.30)
- M1 bias correction using GFS background wind

Latitudinal variations (at 15km, ascending orbits, Aug 2 – Sep 16, 2019)
Aeolus Wind Assimilation Experiments (OSEs) (2)

- NOAA global assimilation system, GFS at 25km/L64 resolution
- Assimilation experiments for Aug 2 – Sept 16, 2019
- TLS bias correction is applied

- Ray : Assimilation of ECMWF version of Rayleigh winds
- RayGFS : Assimilation of GFS version of Rayleigh winds
- Mie : Assimilation of ECMWF version of Mie winds
Forecast Impact Summary Assessment Metrics (Aug 2-Sept 16)

Ray/RayGFS/Mie vs. BASE

RayGFS enhances Aeolus impact after Day-5

Mie winds show small positive impact in the Northern Hemisphere
Summary

- Aeolus winds improve NOAA/GFS global forecast including TC track and winter storm snow
- Additional TLS bias correction improves impact of Aeolus winds
- Rayleigh winds retrieved with GFS T/P/Wind further improve the forecast impact
- Mie winds show small positive impact, mainly in the Northern Hemisphere

References:
- Aeolus impact on NOAA global forecast: *QJRMS* (in review)