WFIP 2 Results

Improvements in Skill of NOAA'S RAP and HRRR for Wind Power Applications

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Acknowledgements to NOAA ASRE Team

- Joe Olson
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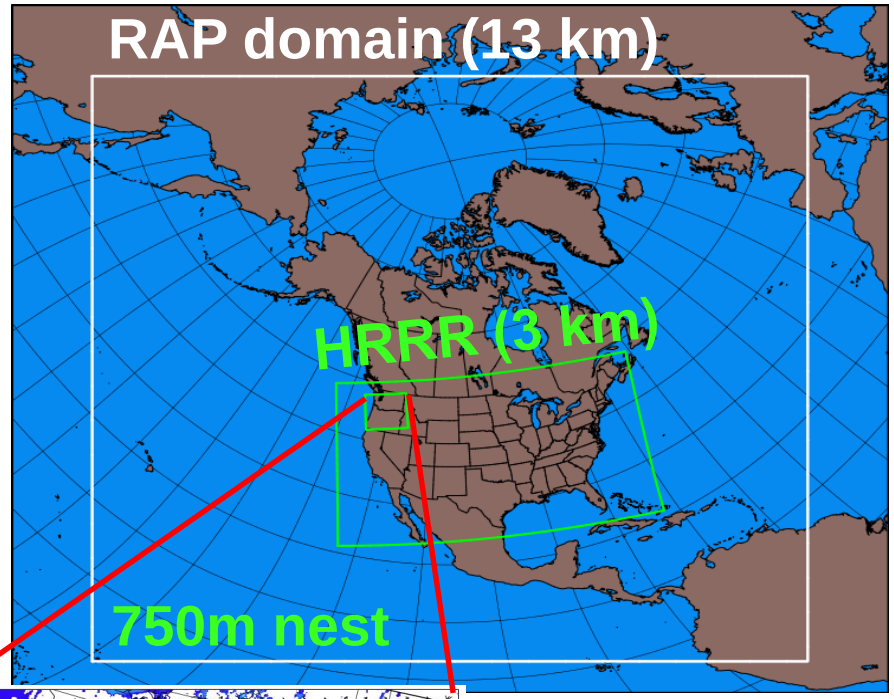
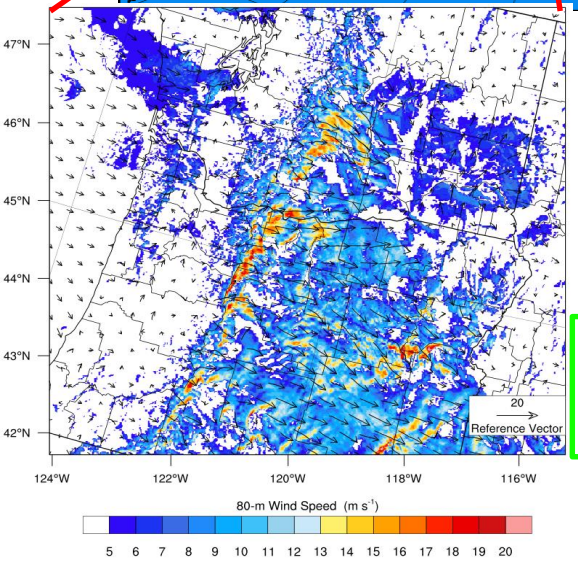
Outline

- Quick reminder about WFIP2 basics
- Weather model improvements for:
  - Warm season
  - Cold season
- Take home message: **The systematic biases associated with westerly gap flows (e.g., marine pushes) and cold pool mix-outs have been reduced, with larger improvement in the latter.**

RAP/HRRR/nest Configuration



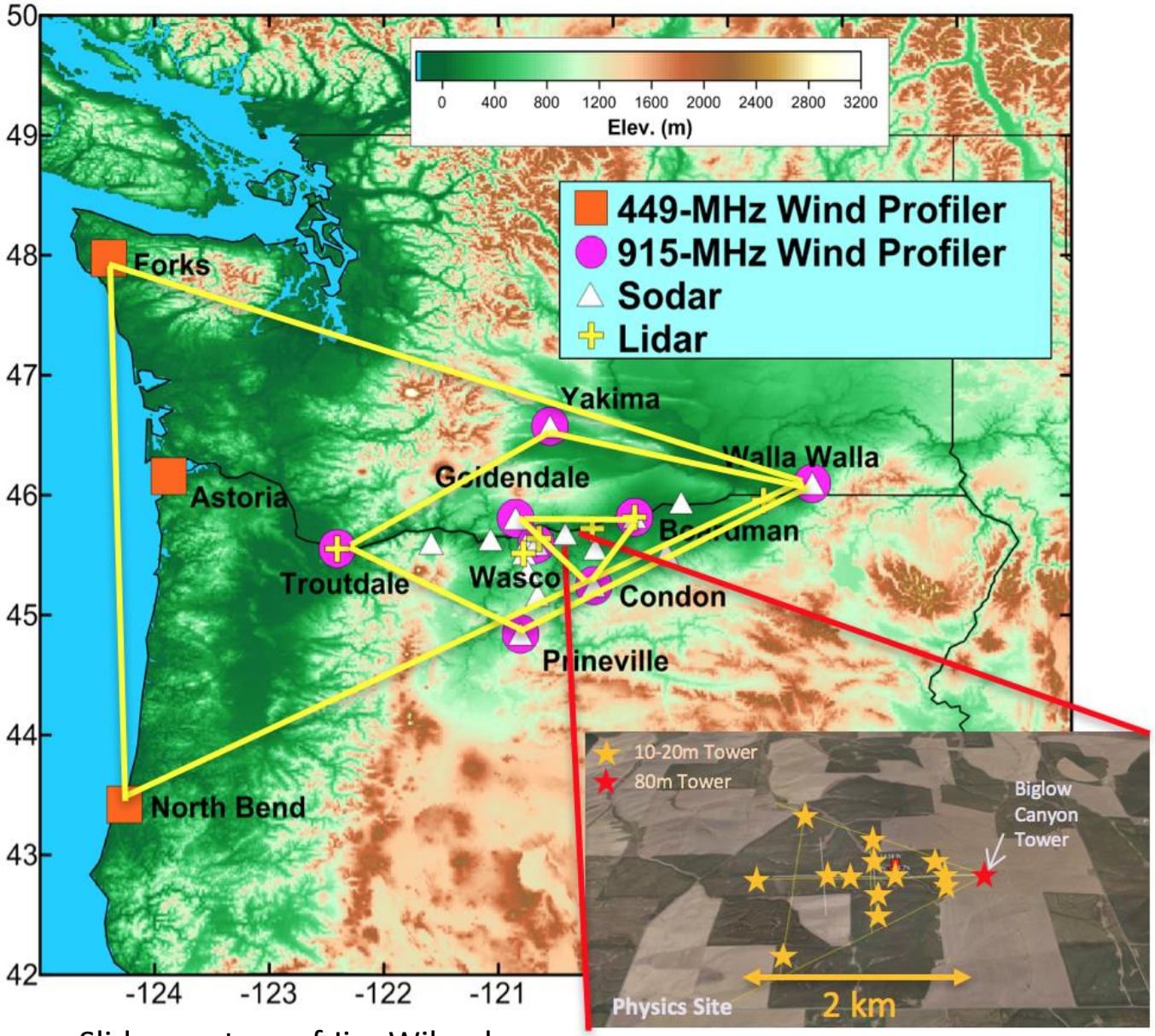


Terrain-specific modifications

Model Component	Control (Original)	Experimental (new)
LSM	RUC 9-level	RUC 9-level
Surface layer	MYNN	MYNN
PBL	MYNN level 2.5	MYNN-EDMF
SW Radiation	RRTMG	RRTMG
LW Radiation	RRTMG	RRTMG
Microphysics	Thompson Aero	Thompson Aero
Deep Convection	Grell-Freitas (RAP only)	Grell-Freitas (RAP only)
Shallow Convection	Grell-Freitas (RAP only)	MYNN-EDMF (all scales)
Horizontal Diffusion	Smag on sigma	Smag on X-Y-Z
Small-Scale GWD and Topographic Form Drag	---	Steeneveld et al. 2007 (JAMC) Beljaars et al. 2004 (QJRMS) (RAP and HRRR only)
Wind Farm Drag	---	Fitch et al. 2012 (MWR)
Vertical Coordinate	sigma	Hybrid sigma-P
Vertical levels	51 levels	51 levels

Slide courtesy of Joe Olson.

Instrument Layout



Slide courtesy of Jim Wilczak.

Instruments Deployed

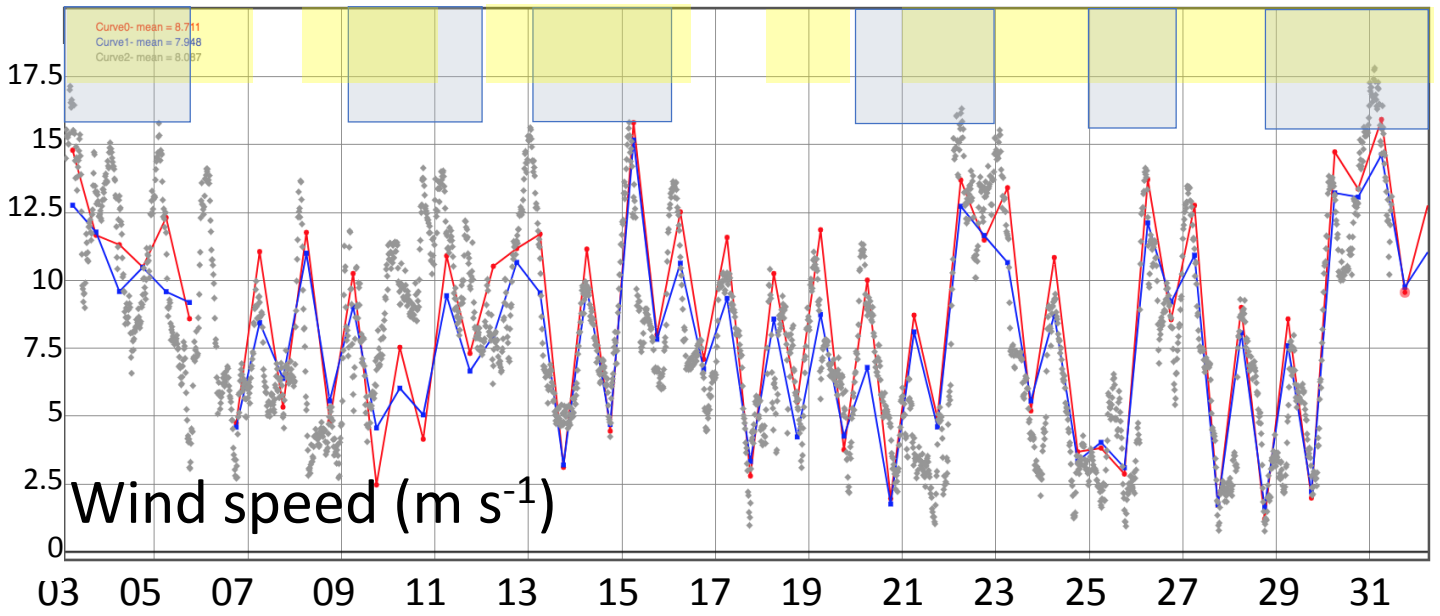
- 11 wind profiling radars
- 17 sodars
- 5 wind profiling lidars
- 4 profiling lidars
- 4 radiometers
- 10 microbarographs
- 1 ceilometer
- 2 scanning radars
- 28 sonic anemometers
- 5 surface energy balance
- 1 SurfRad
- 2 RadSys

Westerly Gap Flow/Marine Push

Impact on July 2016 Reforecasts: 3km HRRR

Forecast hour 18
Avg 40-140 m AGL

Control (3km)
Experiment (3km)
Wasco and
Arlington Lidars

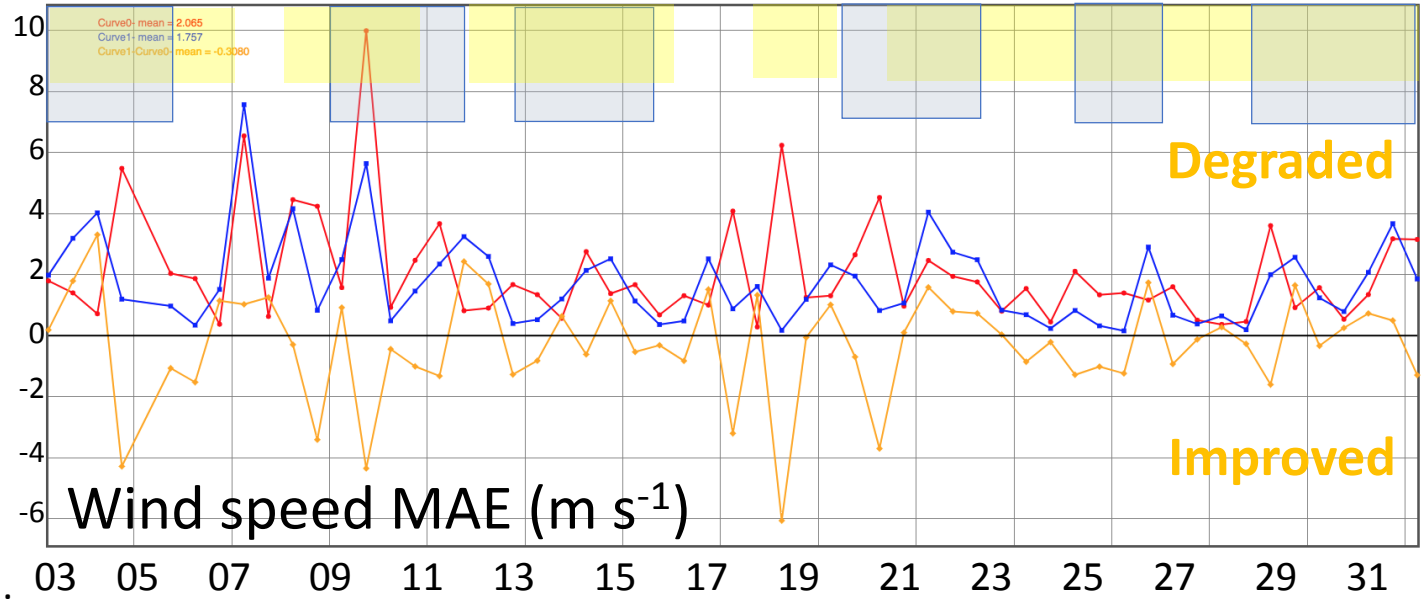


Synoptic gradient
Thermal trough

Day (July)

Fcst hr 18 MAE
Avg 40-140 m AGL

Control (3 km)
Experiment (3 km)
Difference (E-C)



MAE (3km):
Control 2.07
Experiment 1.76
Improvement 15%

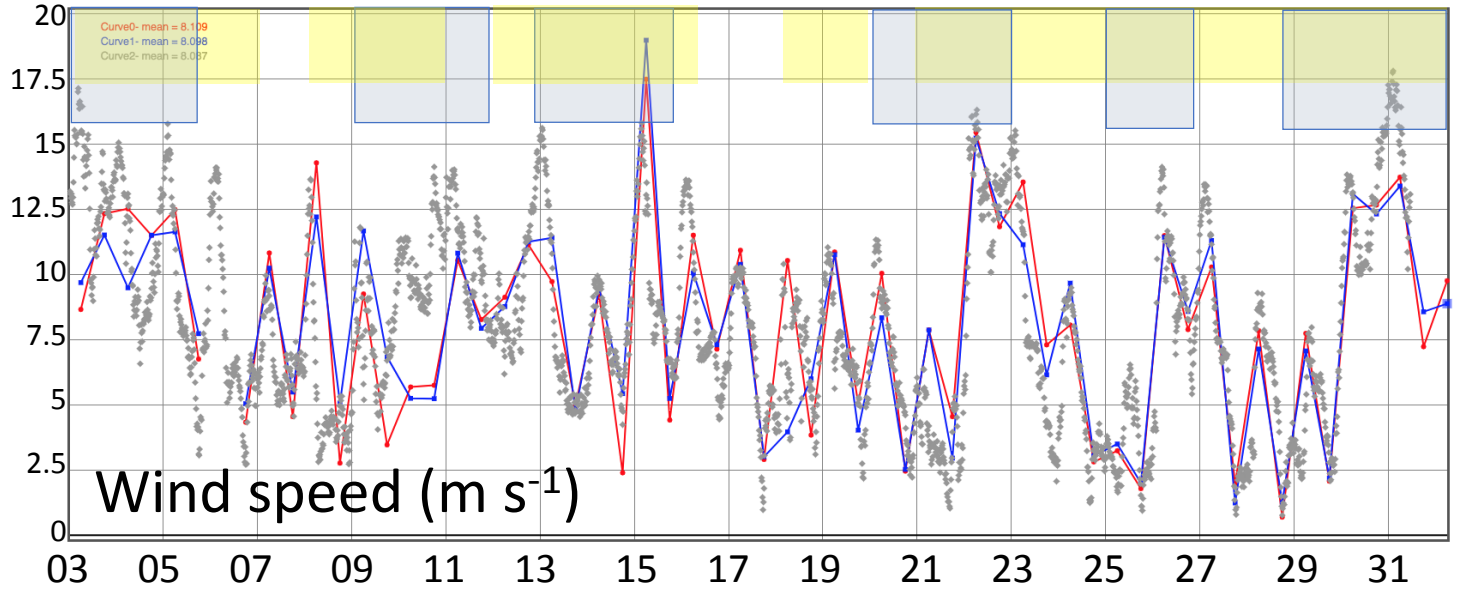
Day (July)

Slide courtesy of Joe Olson.

Impact on July 2016 Reforecasts: 750m HRRRNest

Forecast hour 15
Avg 40-140 m AGL

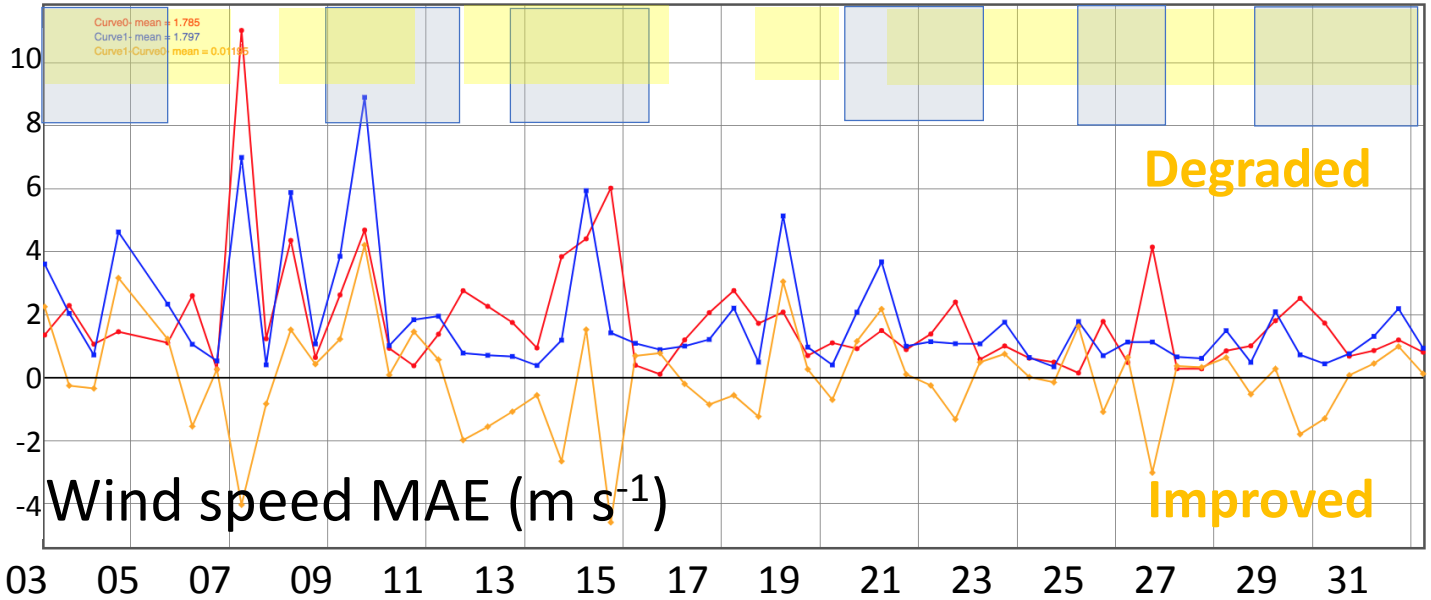
Control (750m)
Experiment (750m)
Wasco Sodar



Synoptic gradient
Thermal trough

Fcst hr 15 MAE
Avg 40-140 m AGL

Control (750m)
Experiment (750m)
Difference (E-C)



MAE (750m):
Control 1.79
Experiment 1.80
Improvement -0.5%

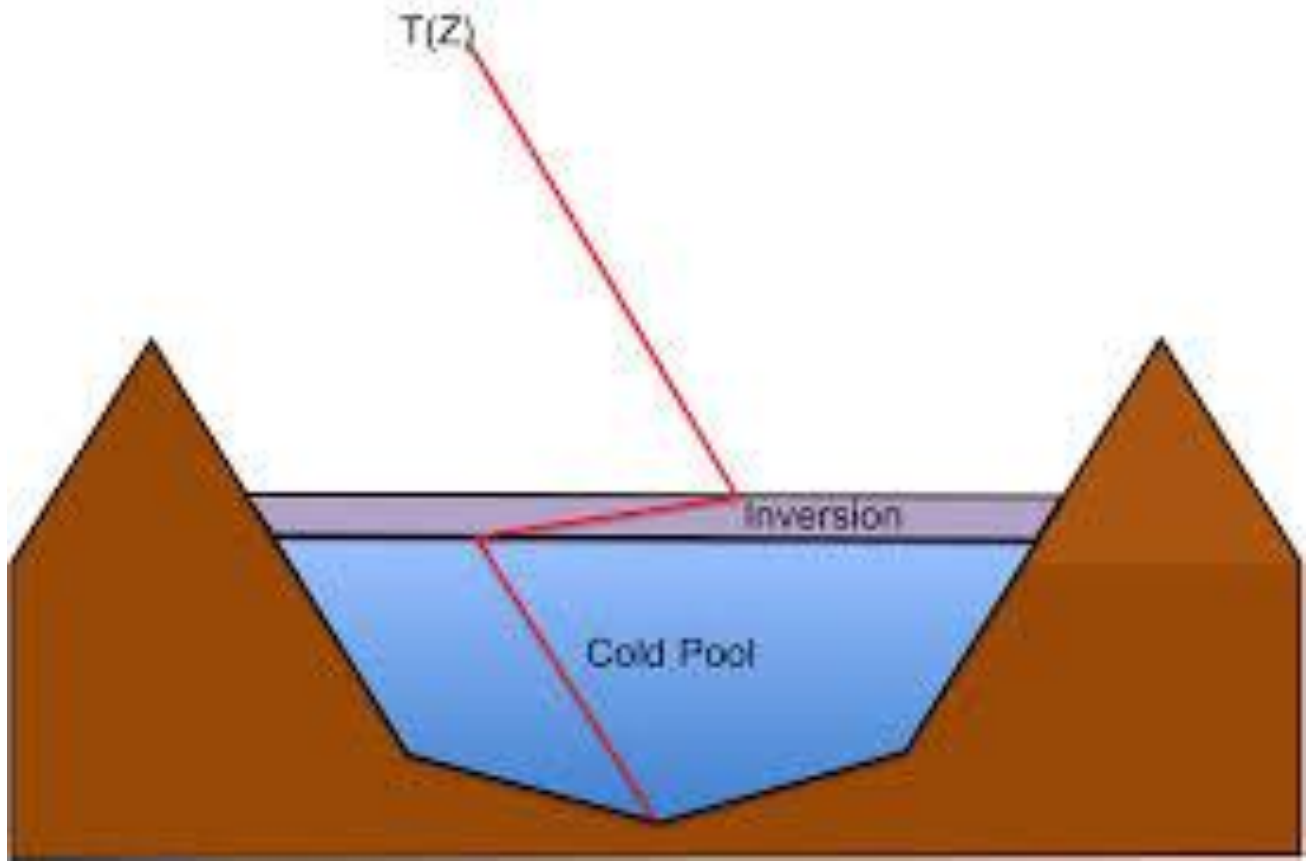
Slide courtesy of Joe Olson.

Results for Warm Season

- The systematic biases associated with westerly gap flows have been slightly improved. For 12-13 July 2016 case:
  - The too-slow westerly gap flow at Wasco (~3 m s^{-1}) was increased by 0.5-1 m s^{-1}.
  - Other westerly gap flow events had similar improvements at night but neutral impacts during the day.
- Overall reductions in the MAE at Wasco, OR in July 2016:
  - 3km HRRR MAE reduced by ~15%
  - 750m nest MAE was not reduced

- The *mean errors* in the control version of the model were smaller in the summer than in any other season, making them much more difficult to improve upon.
  - In much of the daytime, the 80-m wind speed MAE was about 1.5 m/s.
  - That is going to be very difficult to improve upon.

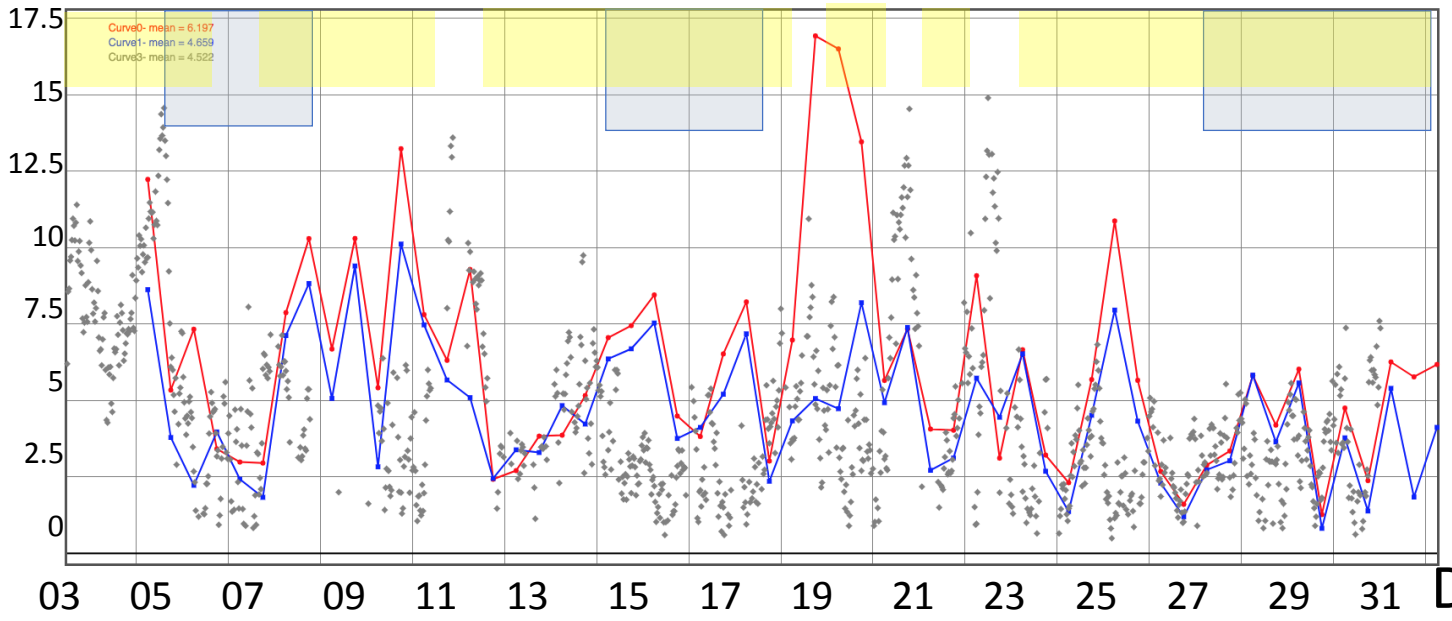
Cold Pools



Impact on January 2017 Reforecasts: 3km HRRR

Forecast hour 18
Avg 40-140 m AGL

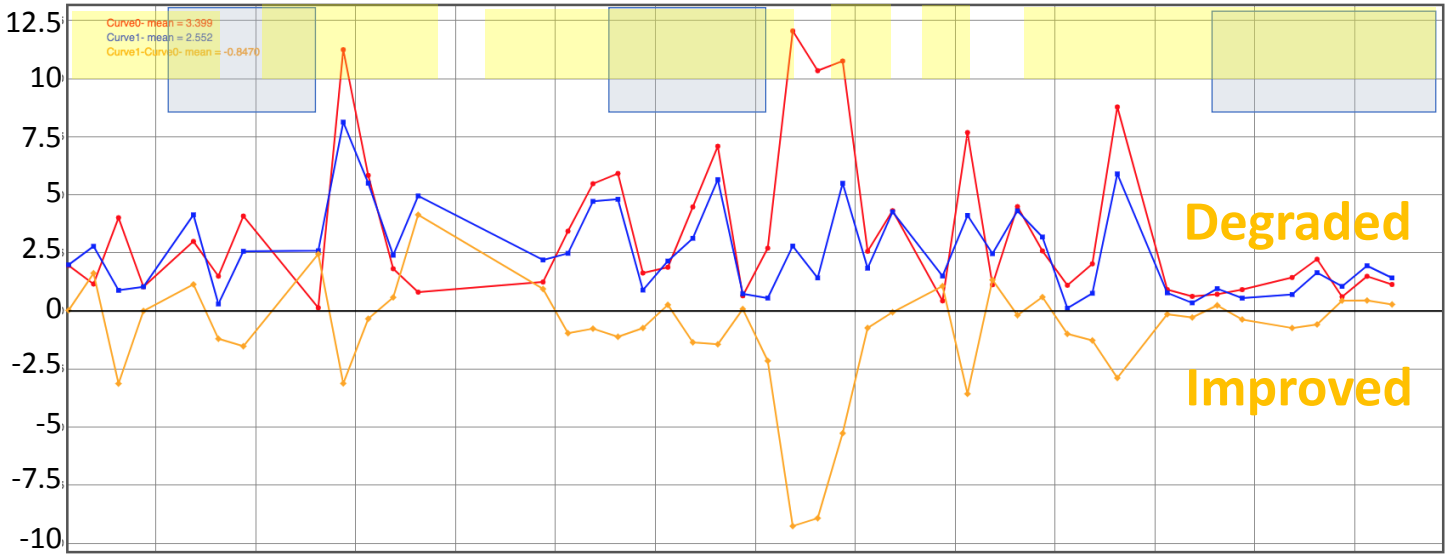
Control (3km)
Experiment (3km)
Wasco Sodar



Easterly Flow
Cold Pool

Fcst hr 18 MAE
Avg 40-140 m AGL

Control (3 km)
Experiment (3 km)
Difference (E-C)



MAE (3km):

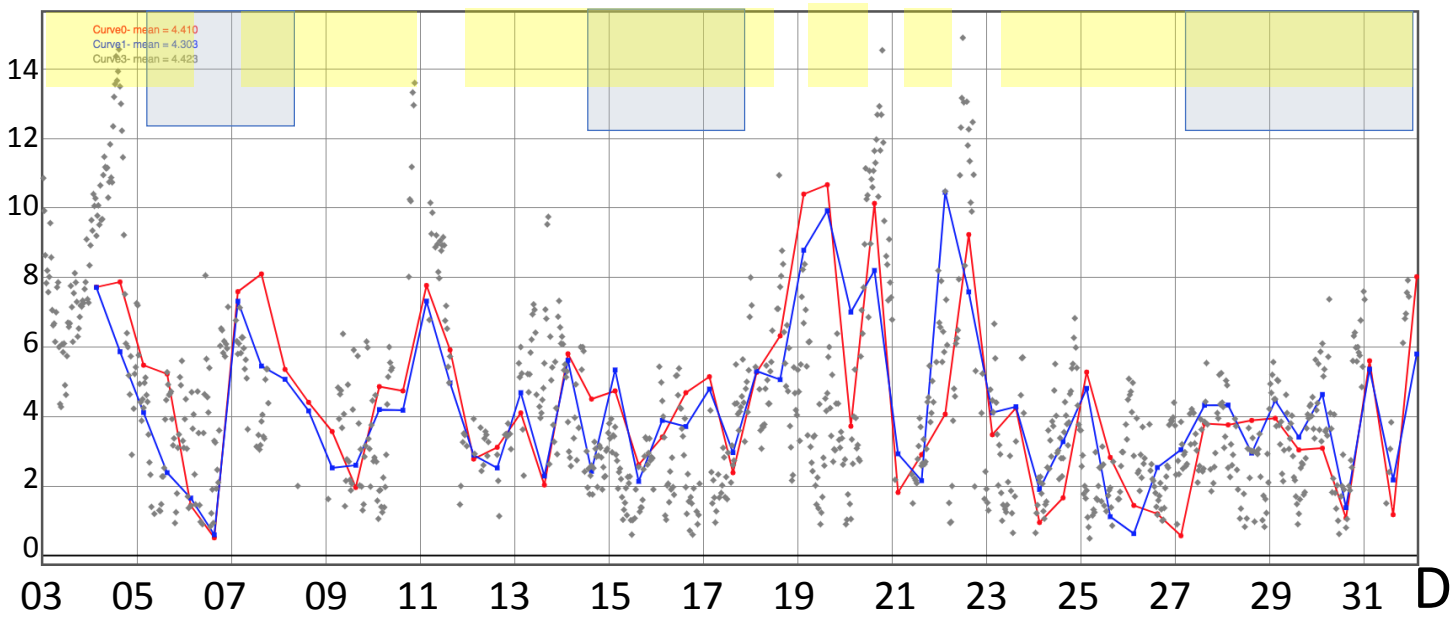
Control	**3.40**
Experiment	**2.55**
Improvement	**25%**

Slide courtesy of Joe Olson.

Impact on January 2017 Reforecasts: 750m HRRRNest

Forecast hour 15
Avg 40-140 m AGL

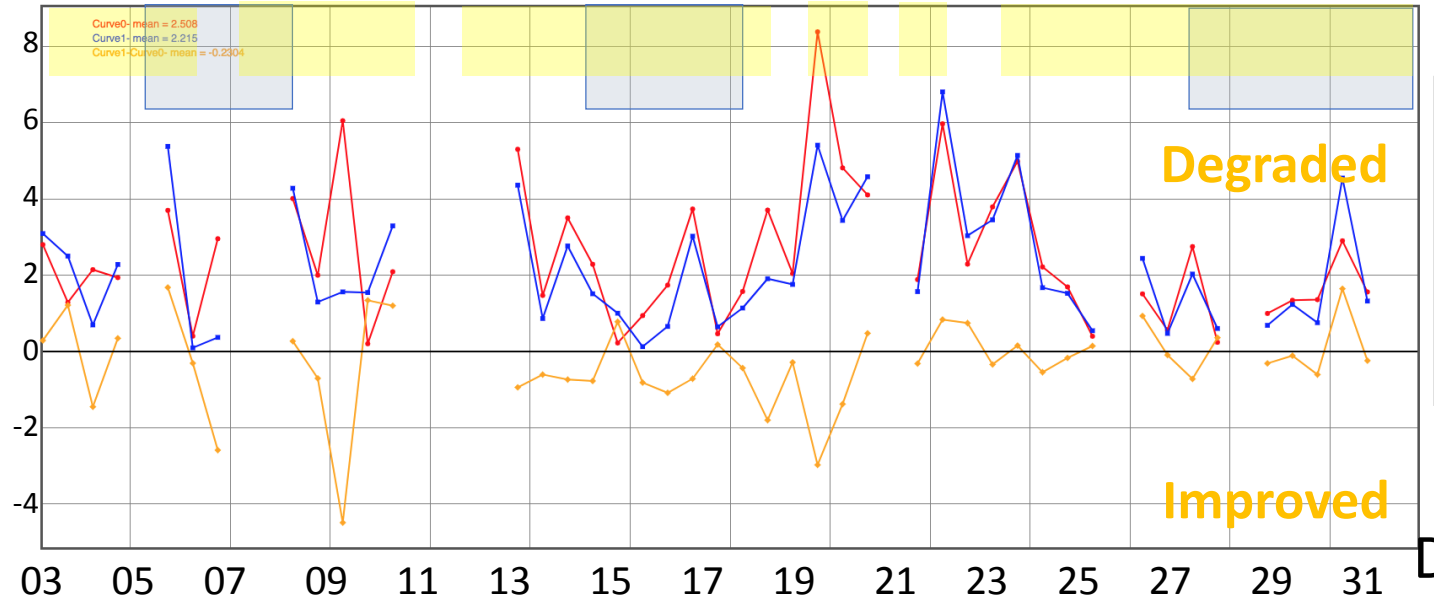
Control (750m)
Experiment (750m)
Wasco Sodar



Easterly Flow
Cold Pool

Fcst hr 15 MAE
Avg 40-140 m AGL

Control (750m)
Experiment (750m)
Difference (E-C)



MAE (750m):

Control	**2.51**
Experiment	**2.22**
Improvement	**11.5%**

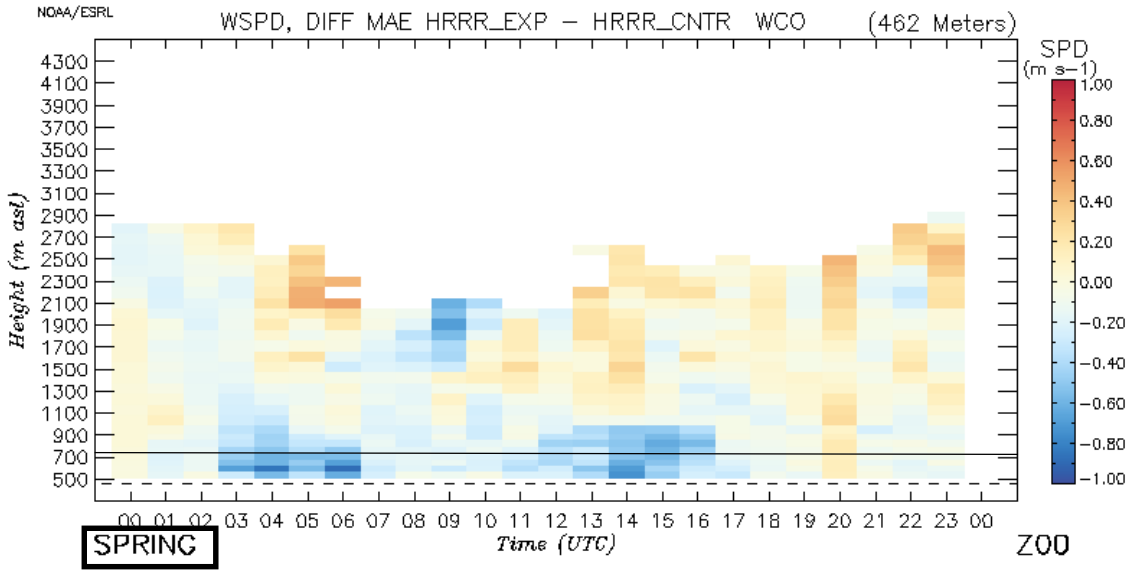
Slide courtesy of Joe Olson.

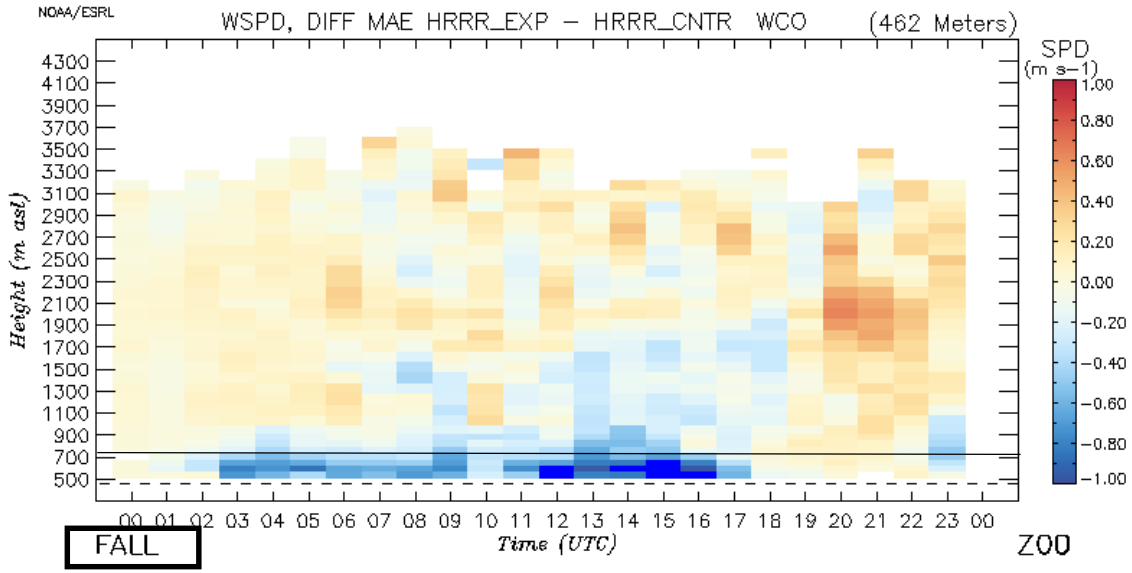
Results for Cool Season

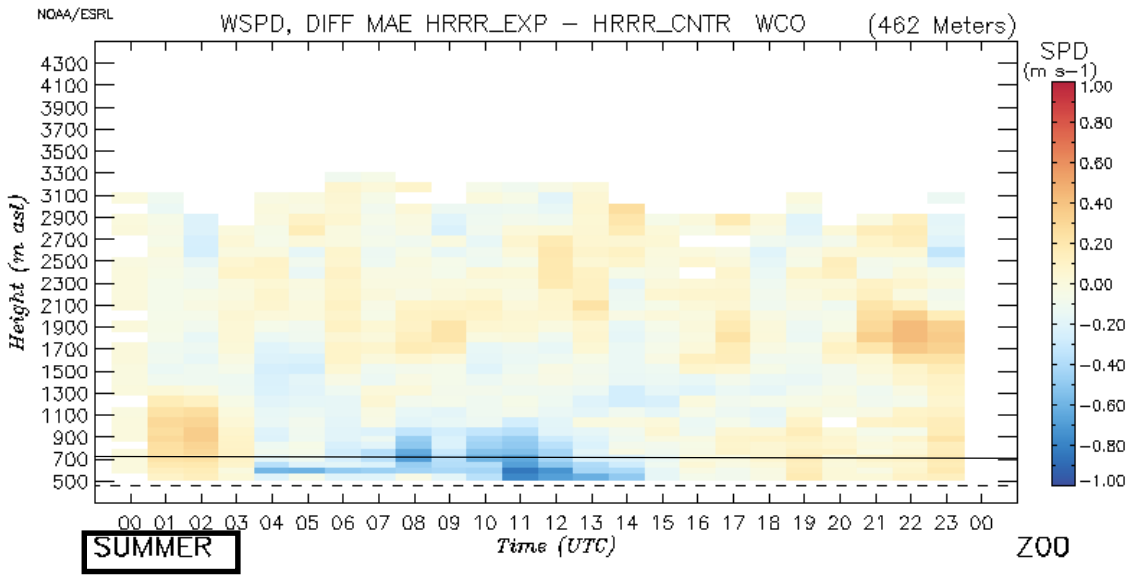
- **The systematic biases associated with cold pool mix-outs have been reduced. Results from the 13 Jan 2016 case show:**
  - **Cold pool at Wasco was 2-3 C cooler and wind speeds in rotor layer were reduced by 3-4 m s^{-1}.**
  - **Other similar cold pool mix-out events had similar improvements.**
- **Overall reductions in the MAE at Wasco, OR in January 2017:**
  - **3km HRRR MAE reduced by ~25%**
  - **750m nest MAE reduced by ~11%**

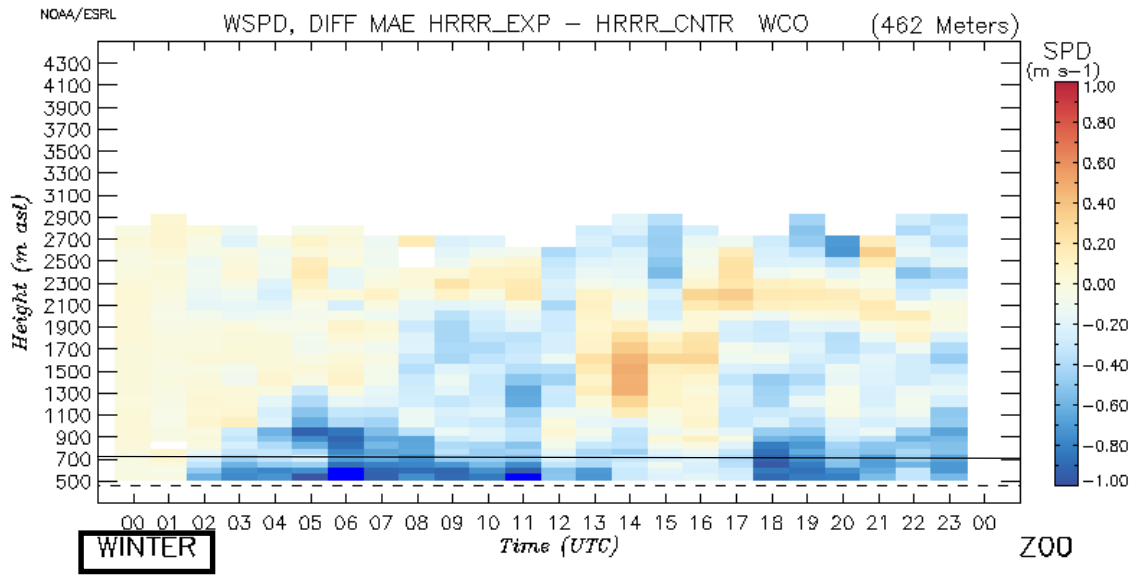
Physics: WCO, WINDSPEED MAE_HRRR_EXP – MAE_HRRR_CNTR (4 six week Reforecasts)

00 UTC Runs only



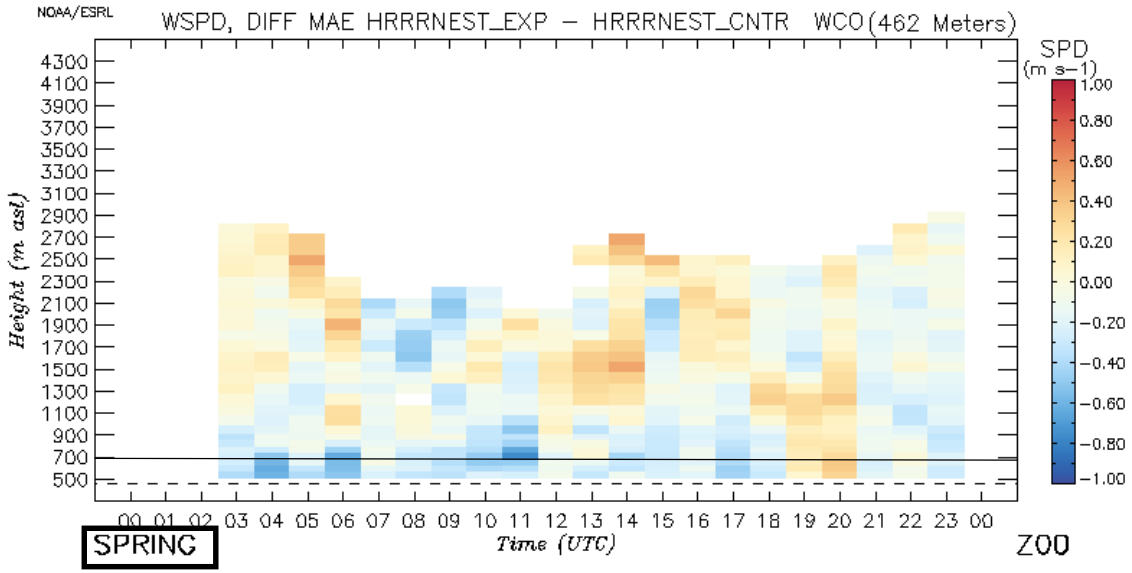


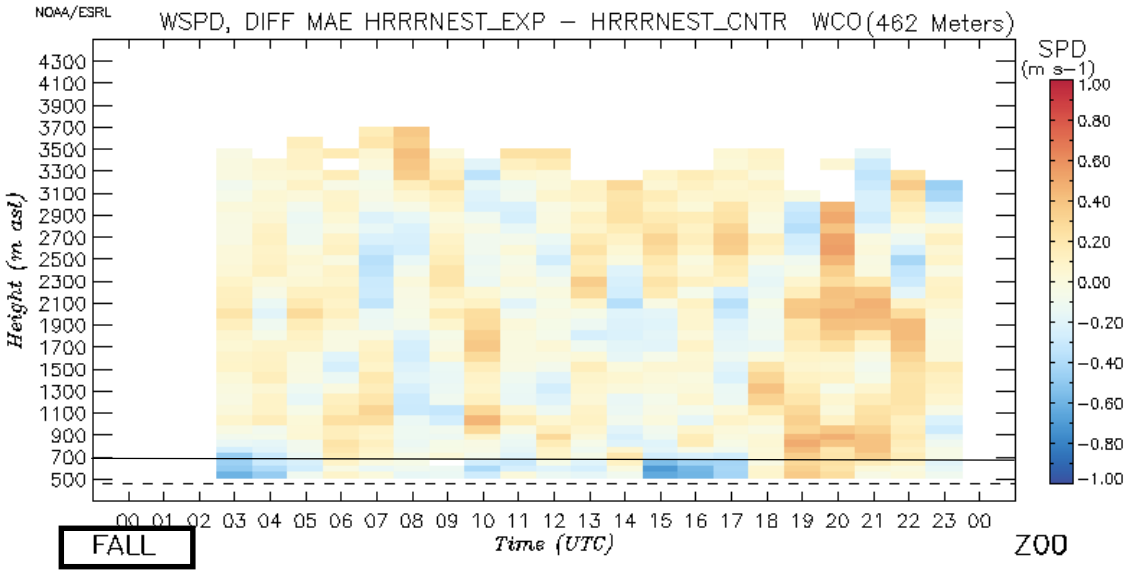


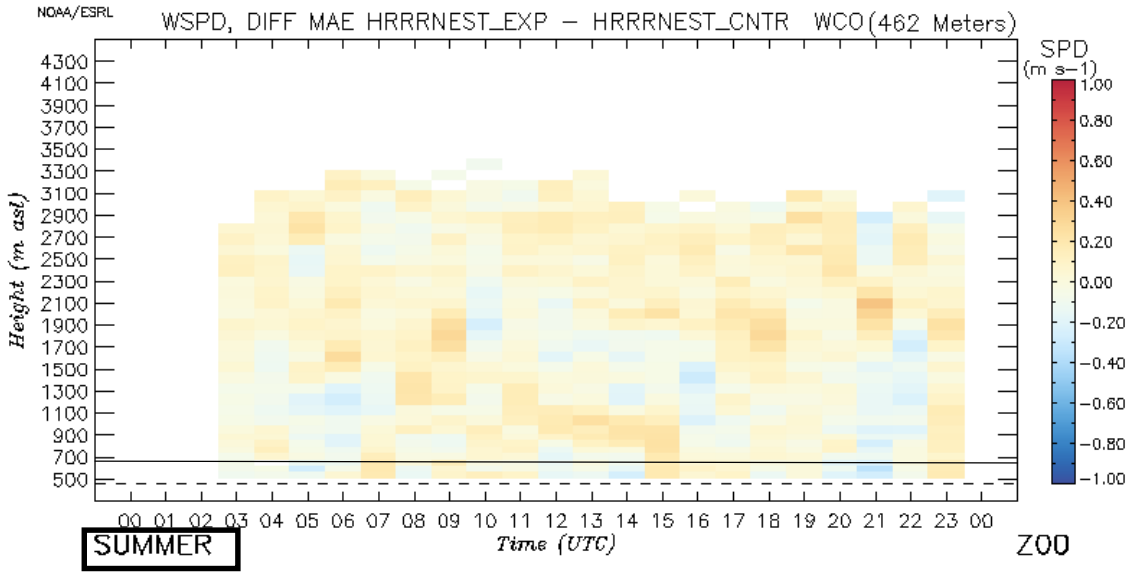


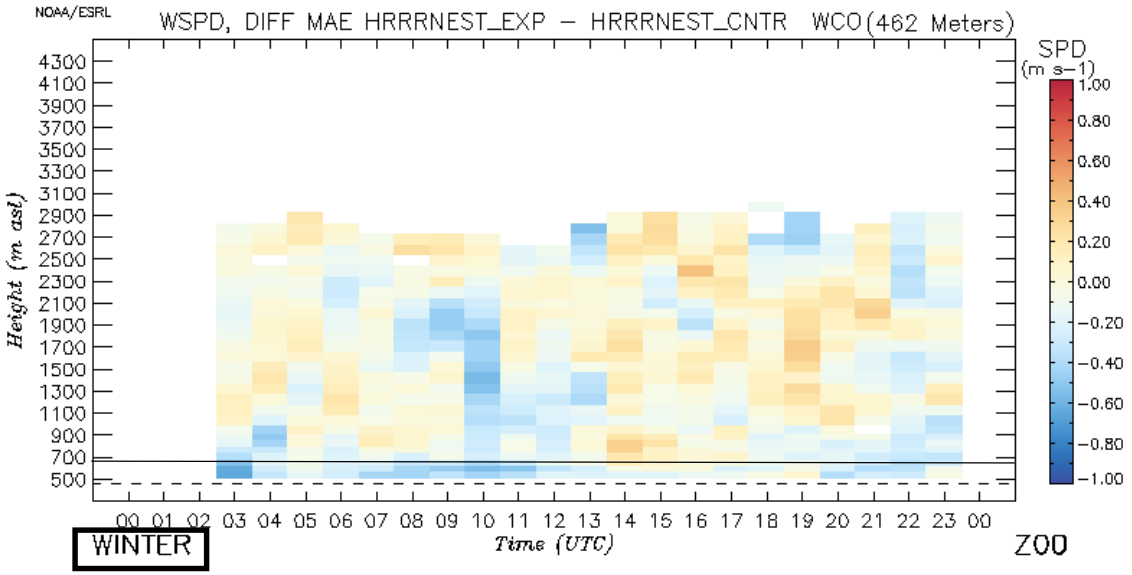
Physics: WCO, WINDSPEED MAE_HRRRNEST_EXP – MAE_HRRRNEST_CNTR (4 six week Reforecasts)

00 UTC Runs only





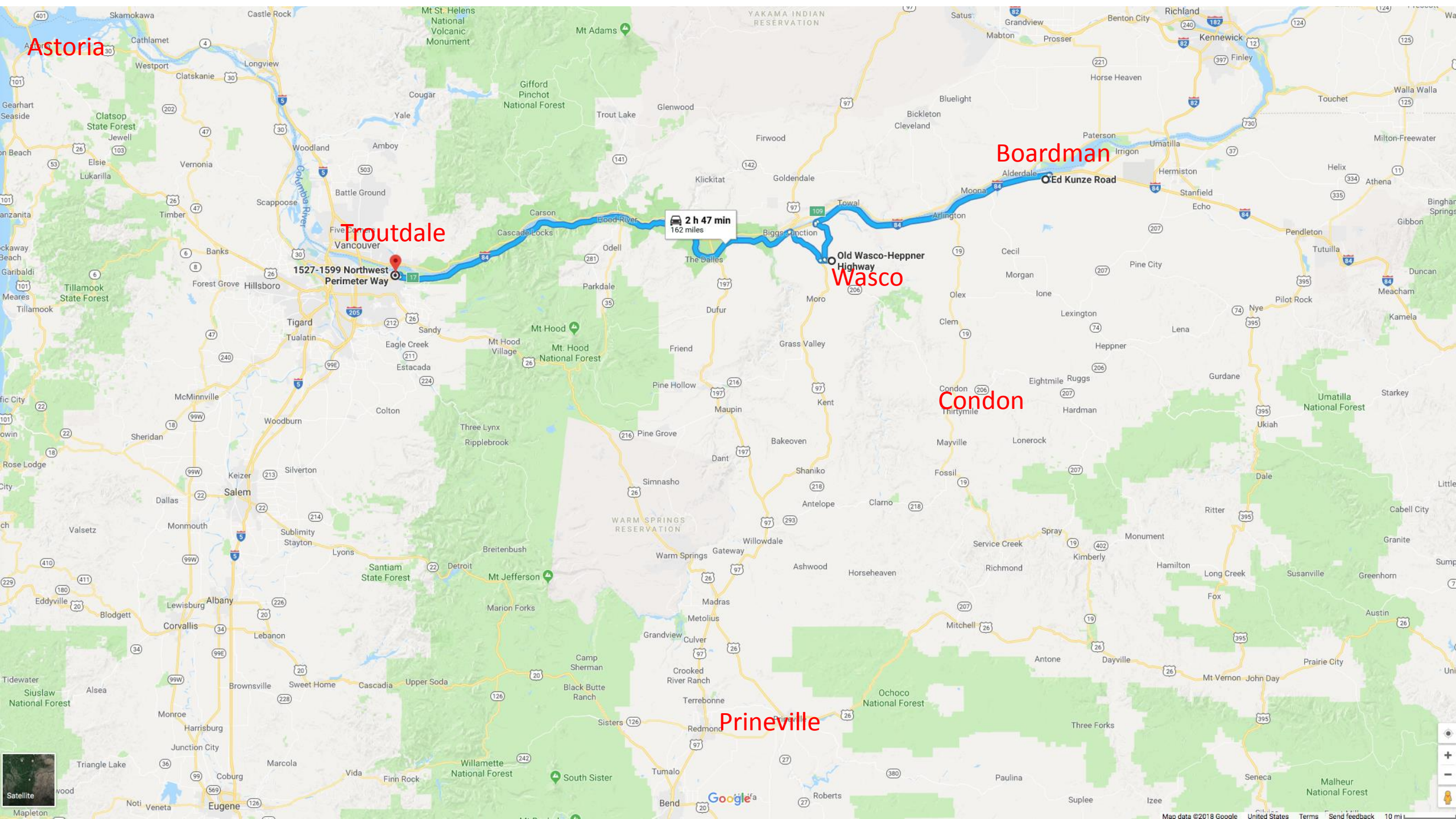




Summary/Conclusions

- The systematic biases associated with westerly gap flows and cold pool mix-outs and have been reduced, with greater improvements in the winter than in the summer.

Back Up Slides


Astoria
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Boardman
Wasco
Condon
Prineville
2 h 47 min
162 miles
1527-1599 Northwest Perimeter Way
Ed Kunze Road
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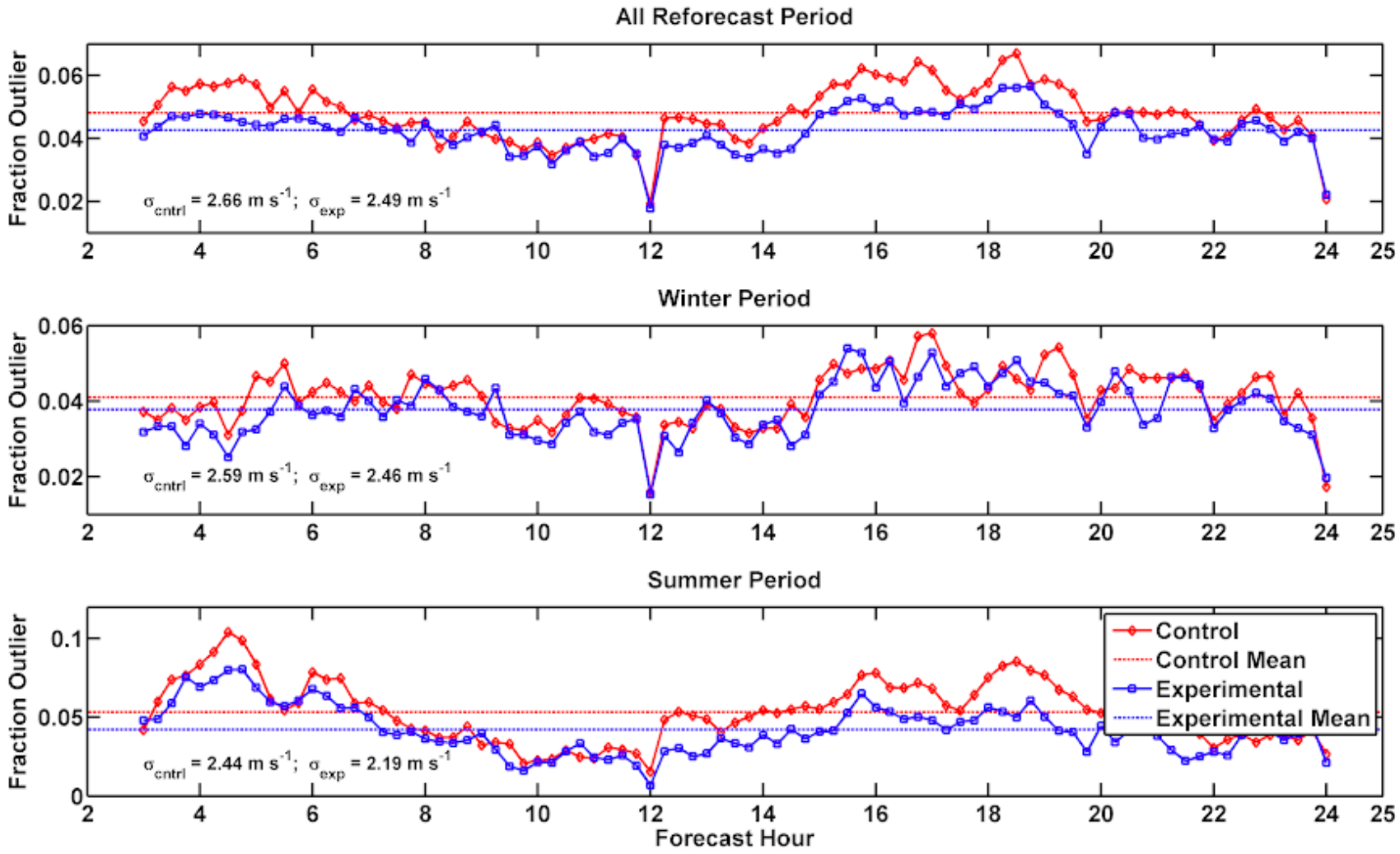
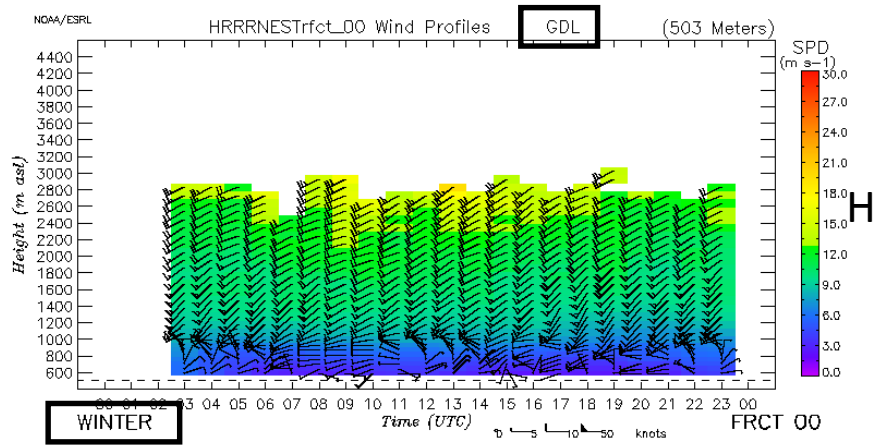
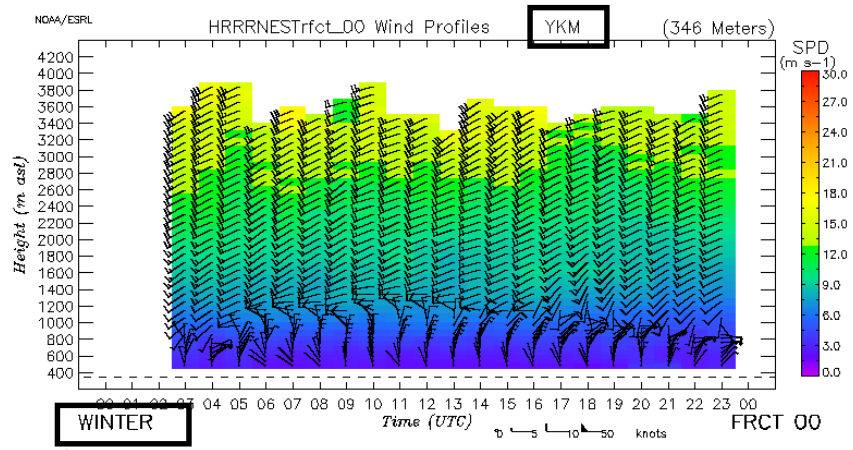
Satellite
Google
Map data ©2018 Google
United States
Terms
Send feedback
10 mi

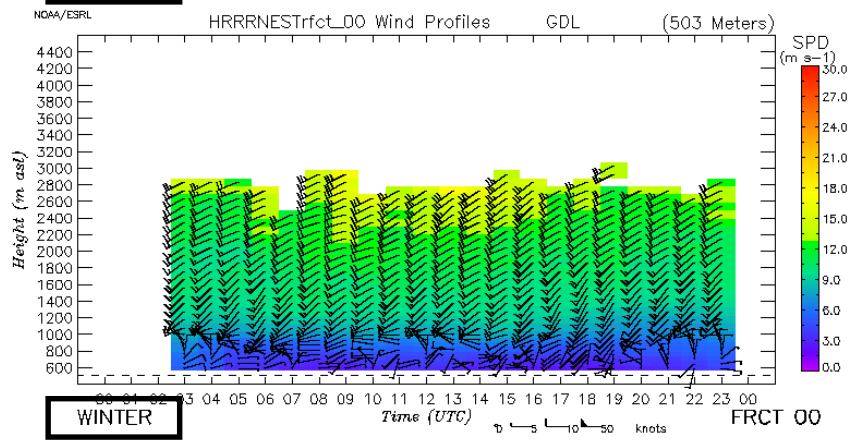
Reduction of large errors (>2 std. dev.)



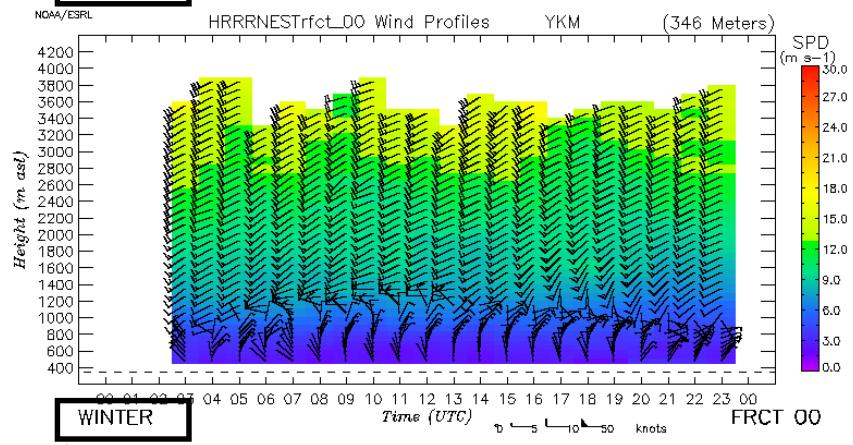


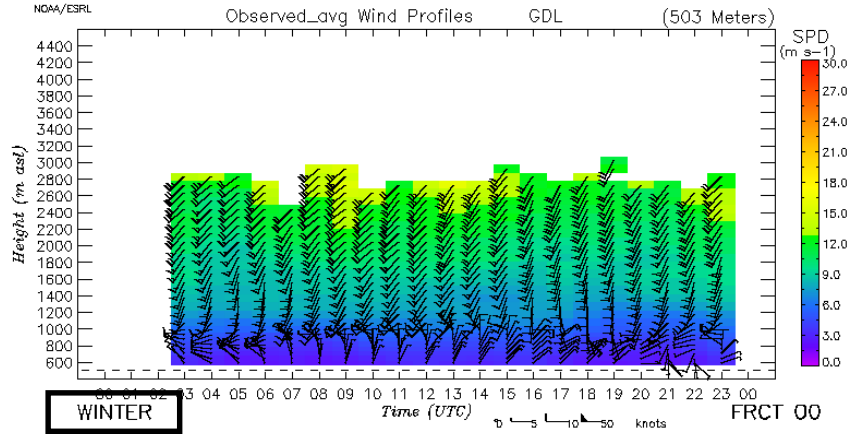
HRRRNEST_CNTR



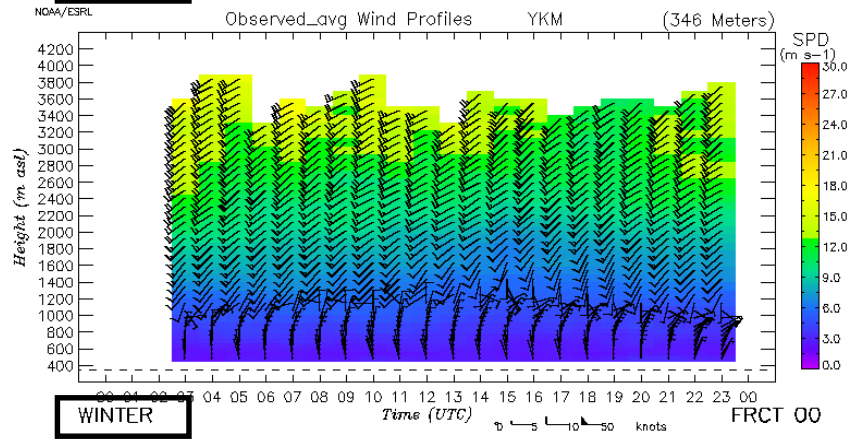


HRRRNEST_EXP



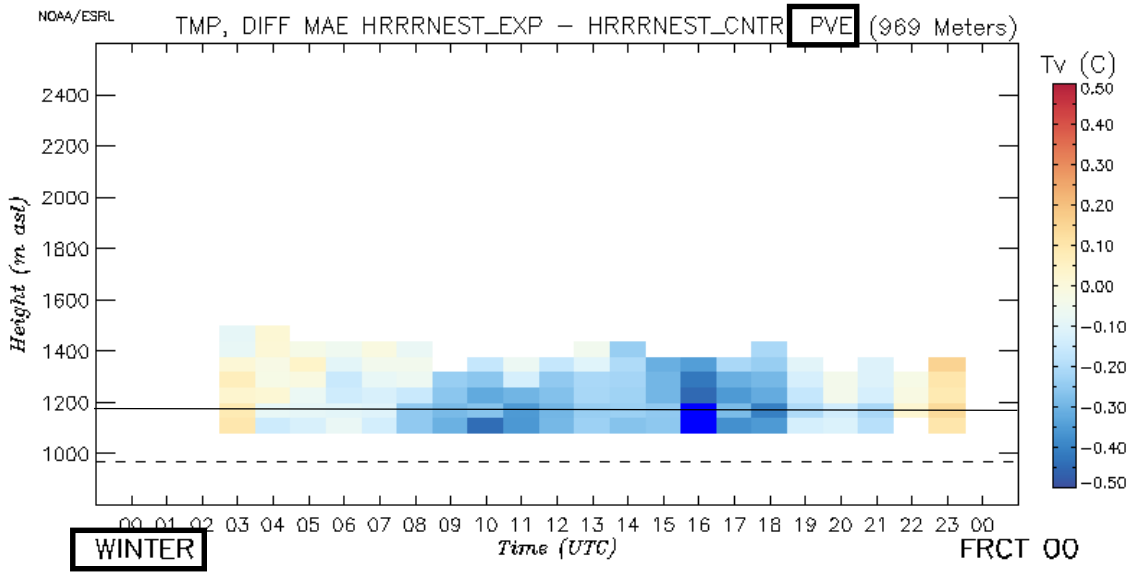


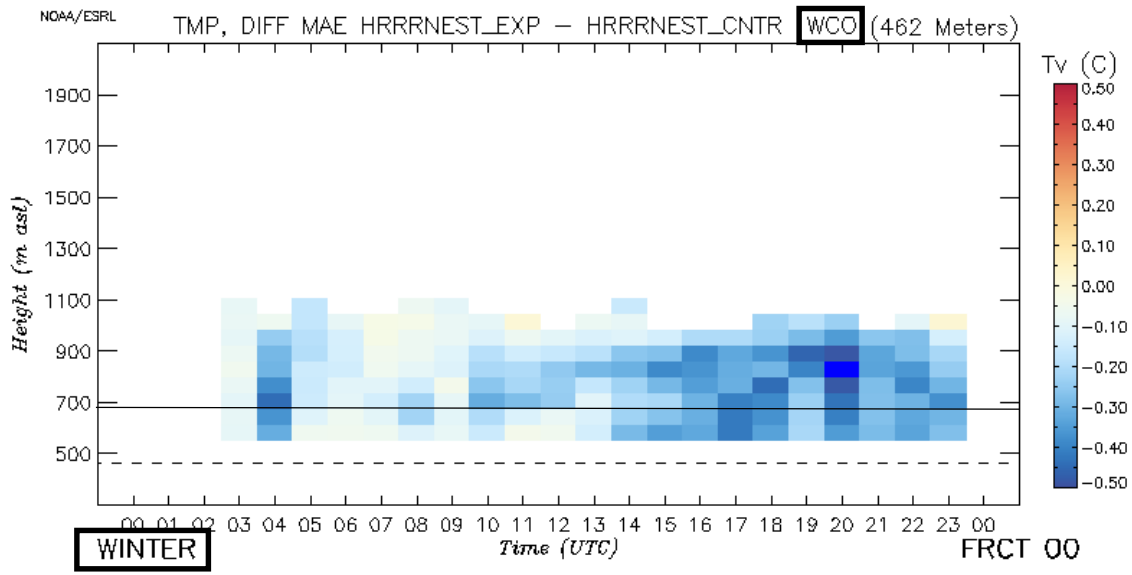
OBSERVATION

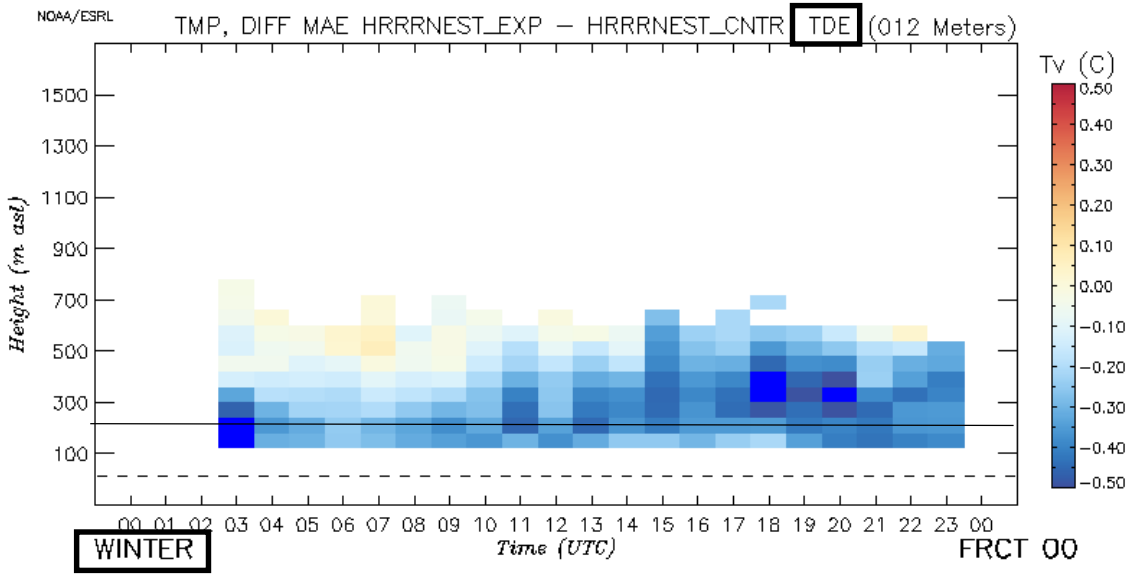


Physics: TEMPERATURE MAE_HRRRNEST_EXP – MAE_HRRRNEST_CNTR (Winter Reforecasts)

00 UTC Runs only







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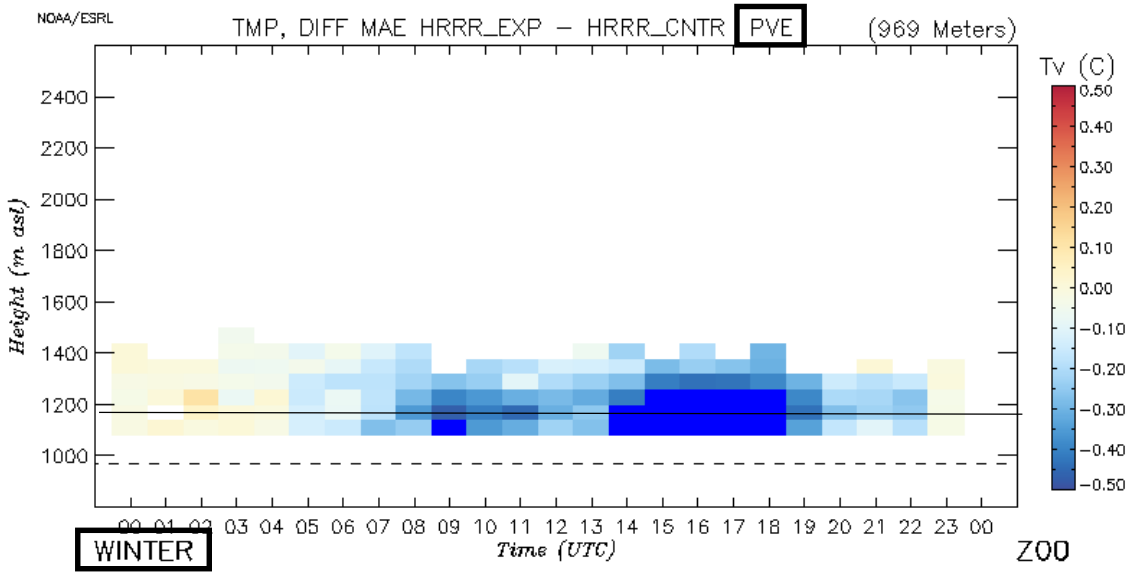
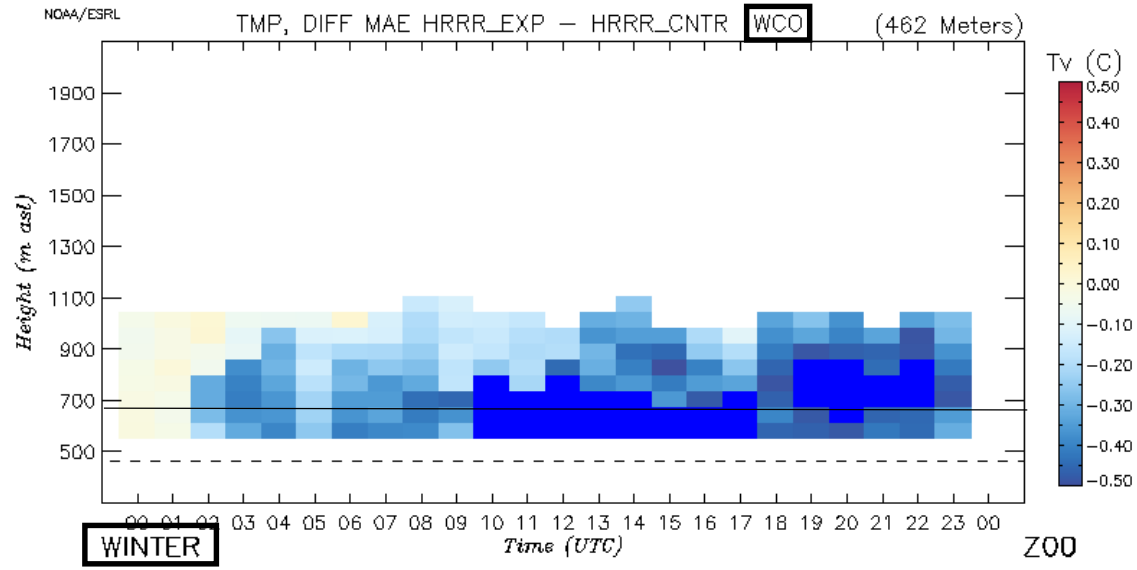
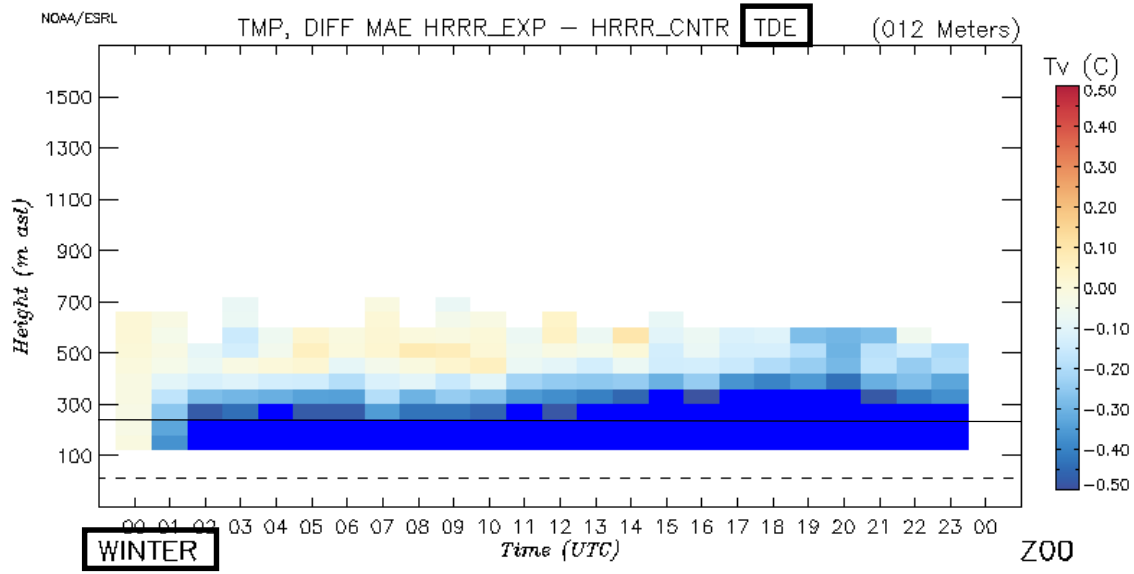
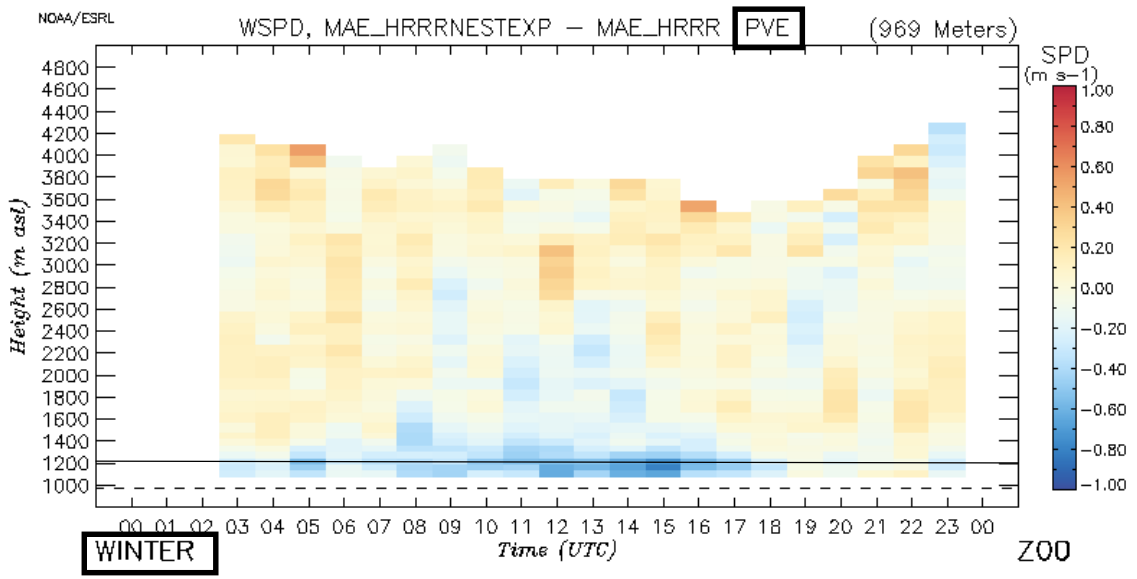


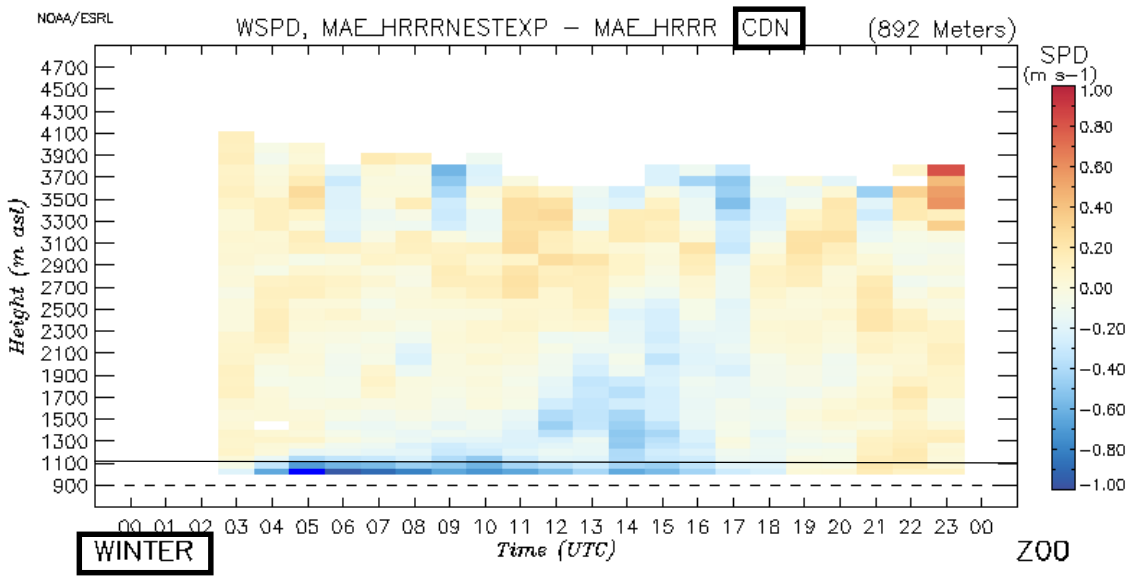


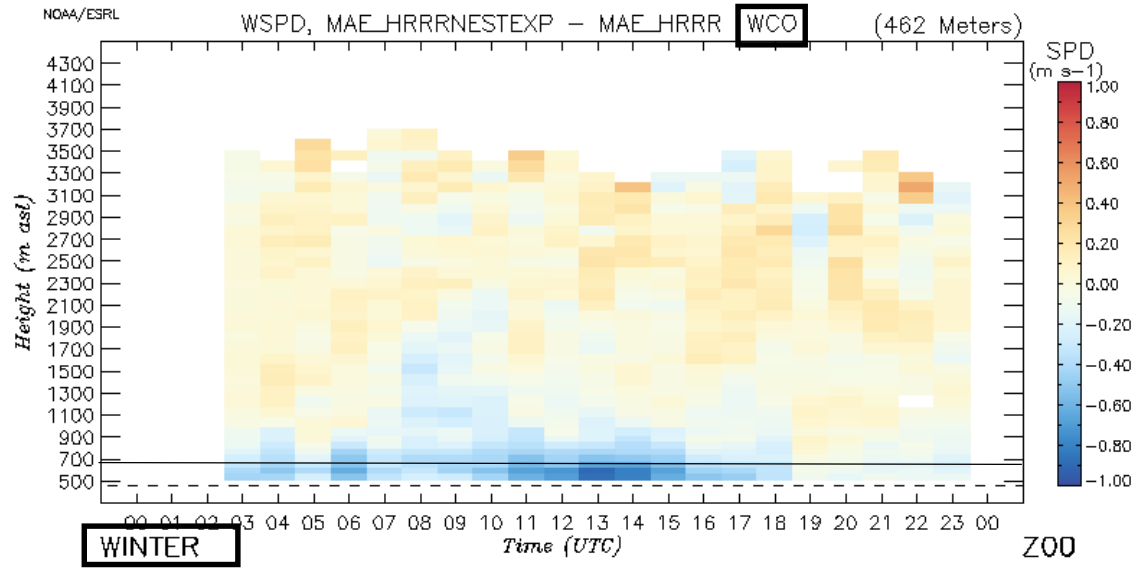


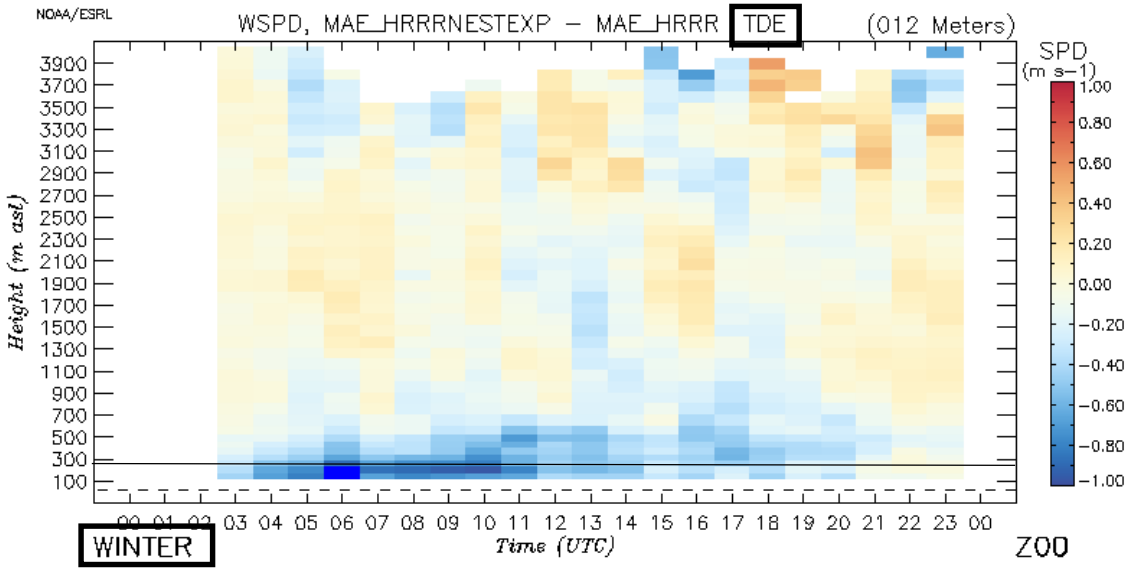
Physics+Resolution: WINDSPEED MAE_HRRRNEST_EXP – MAE_HRRR_CNTR (Winter Reforecasts)

00 UTC Runs only

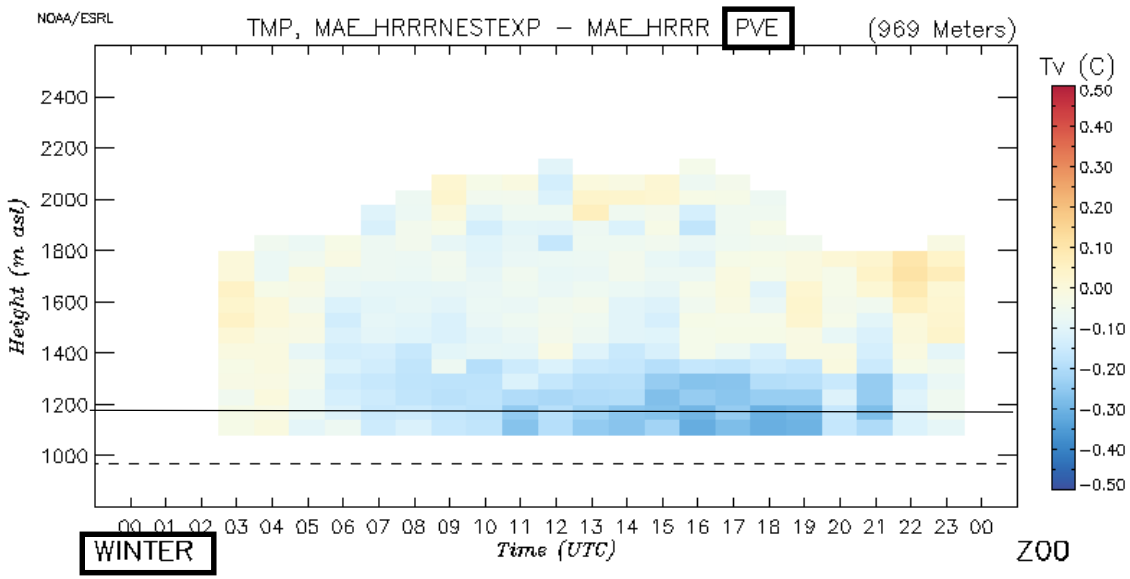


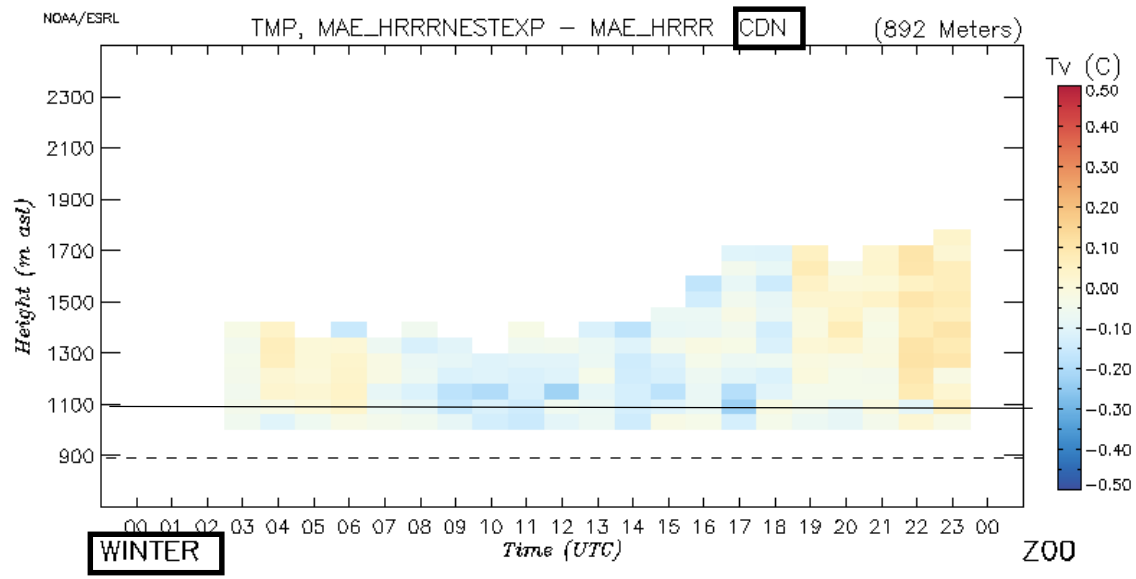


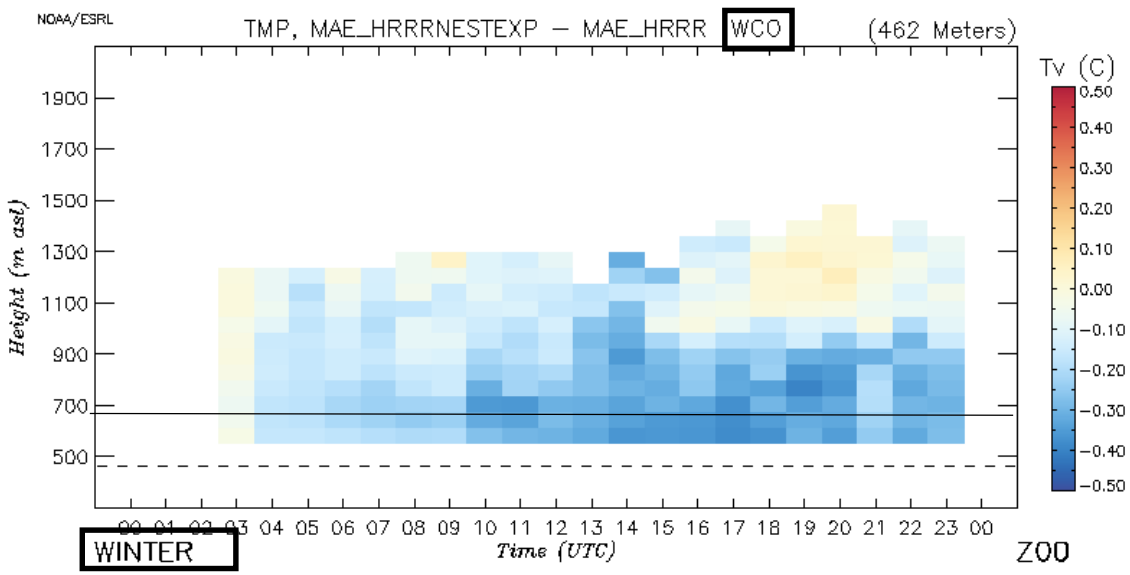


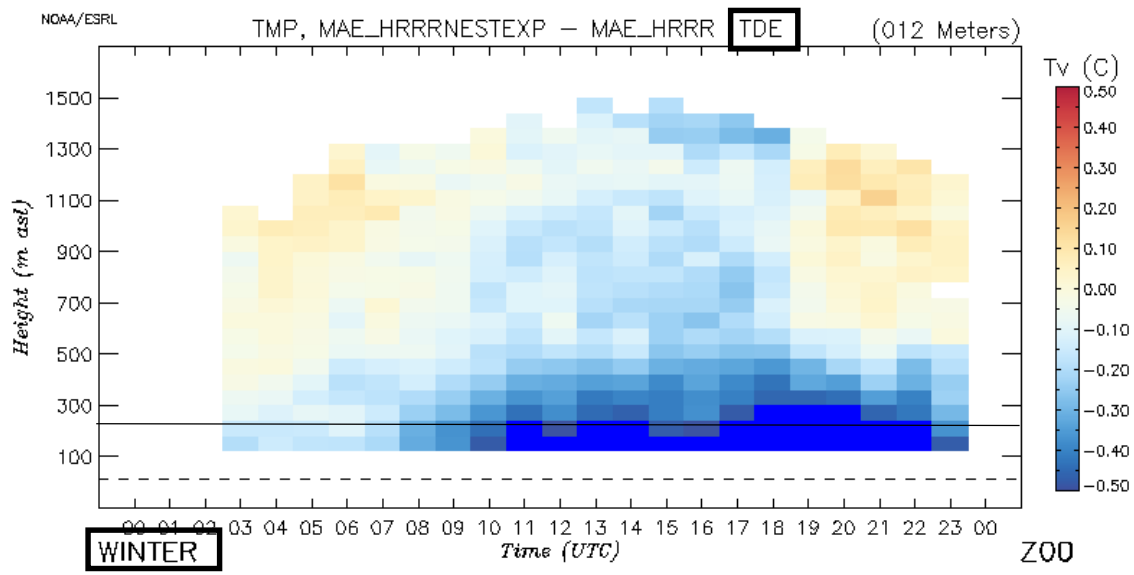


Physics+Resolution: TEMPERATURE MAE_HRRRNEST_EXP – MAE_HRRR_CNTR (Winter Reforecasts)

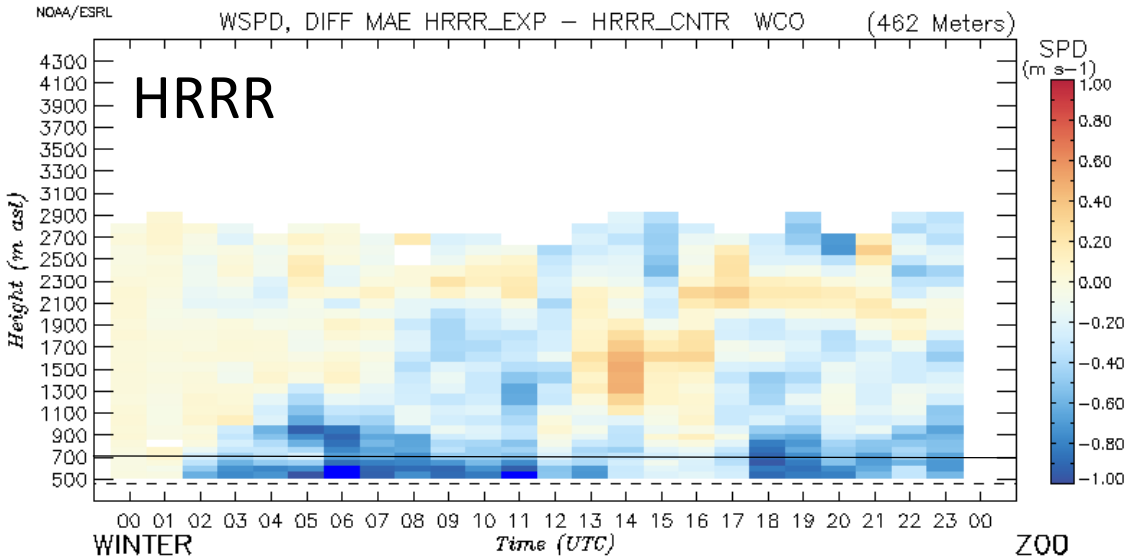


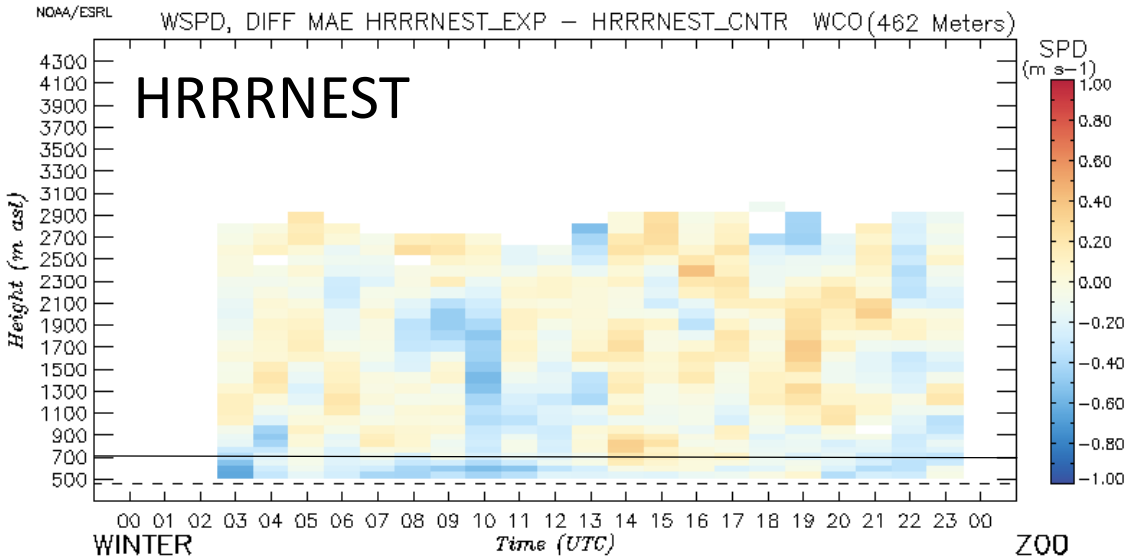




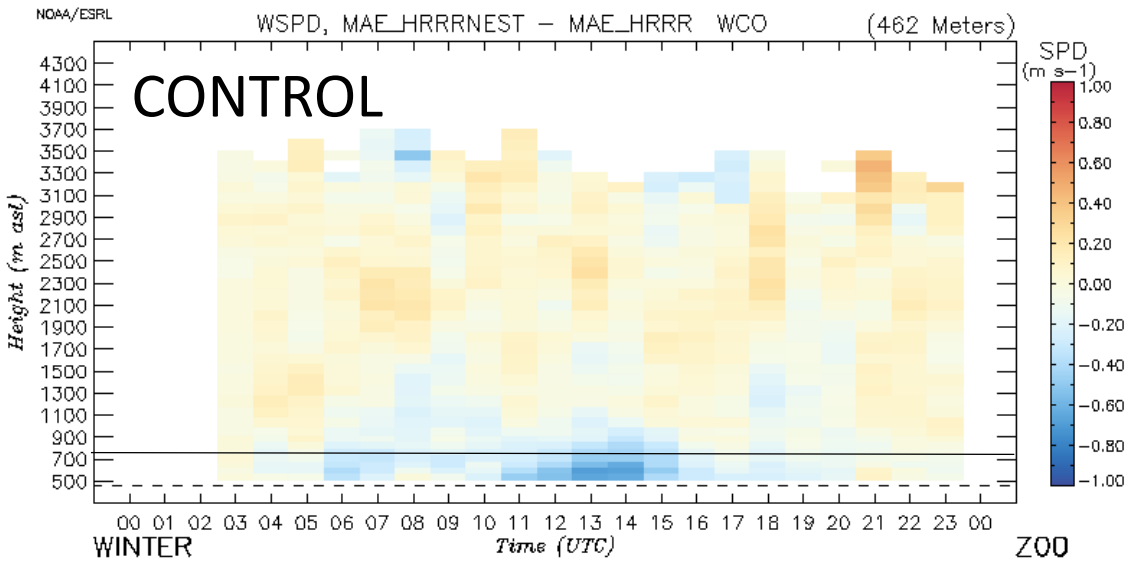


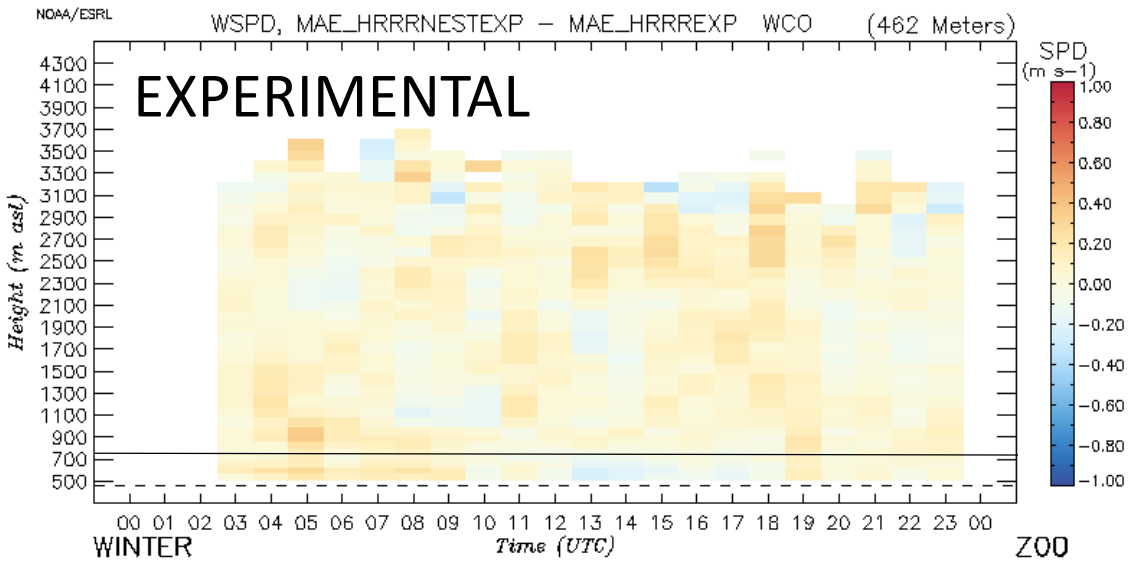
Wind Speed WCO improvement due to **physics**



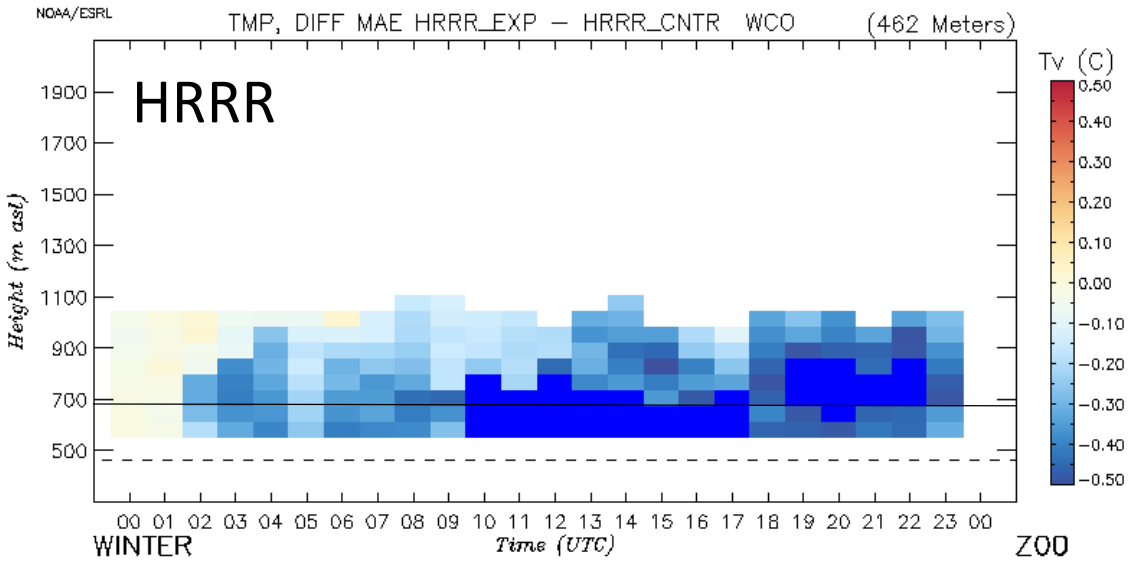


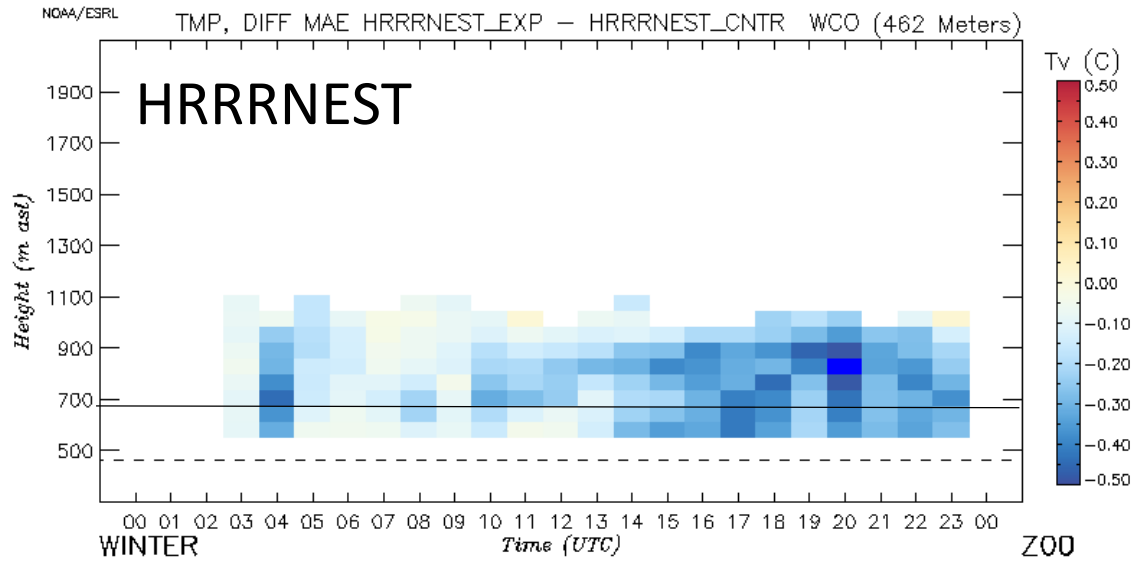
Wind Speed WCO improvement due to **resolution**



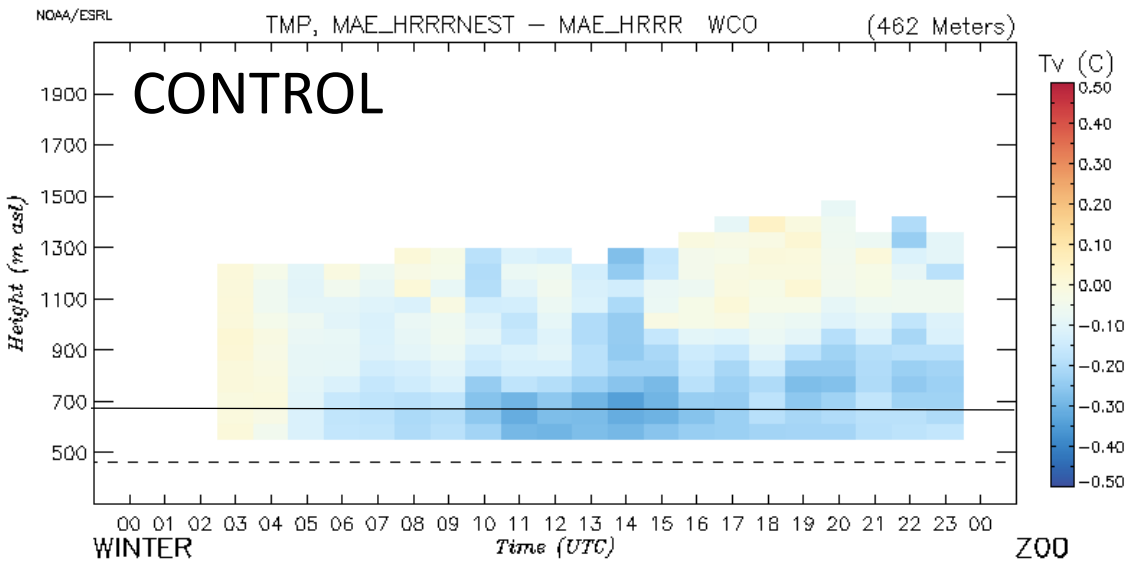


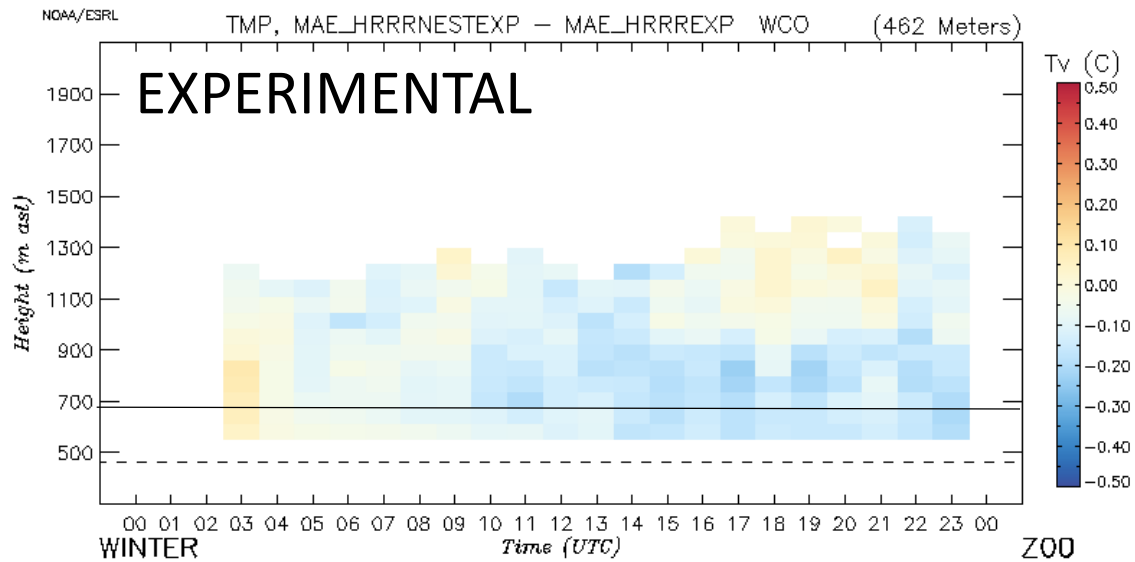
Temperature WCO improvement due to **physics**

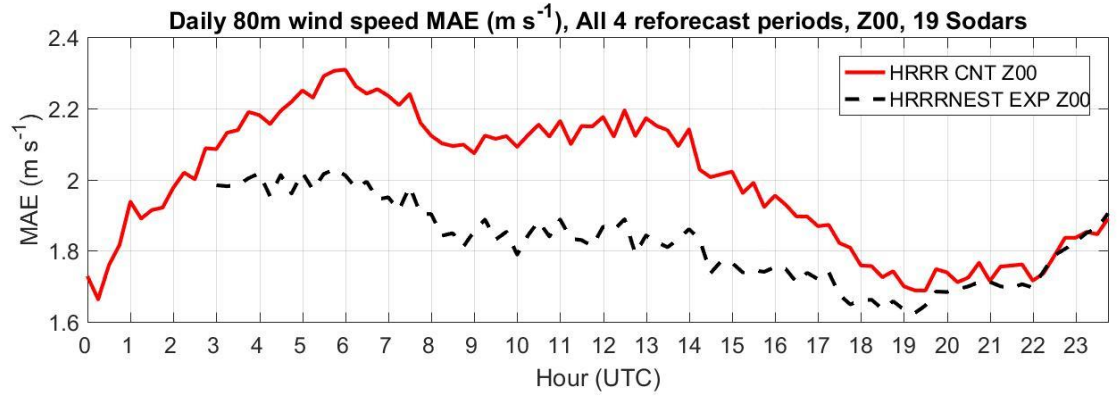


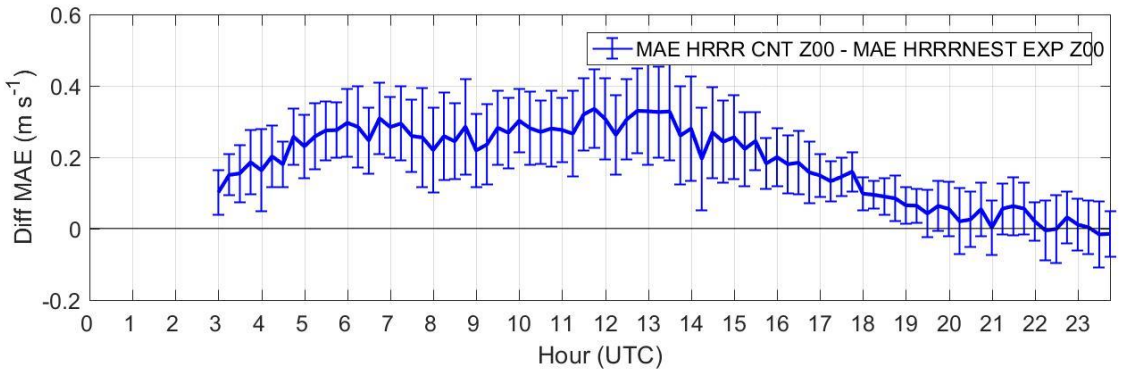


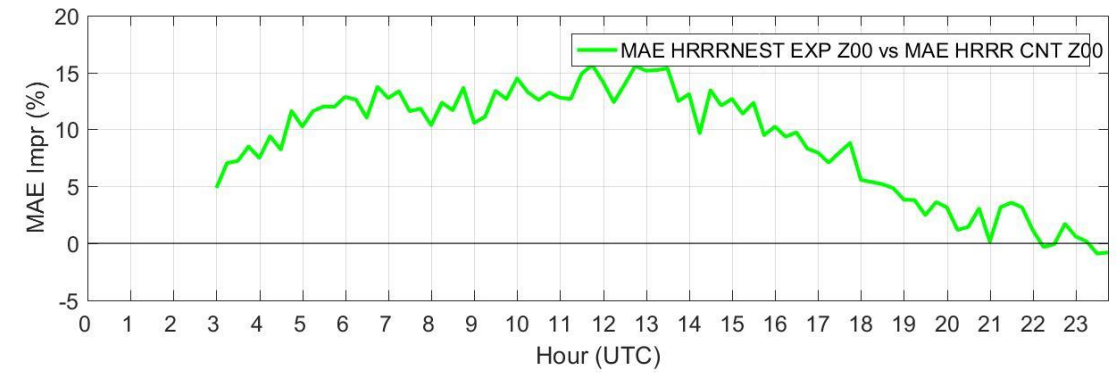
Temperature WCO improvement due to **resolution**

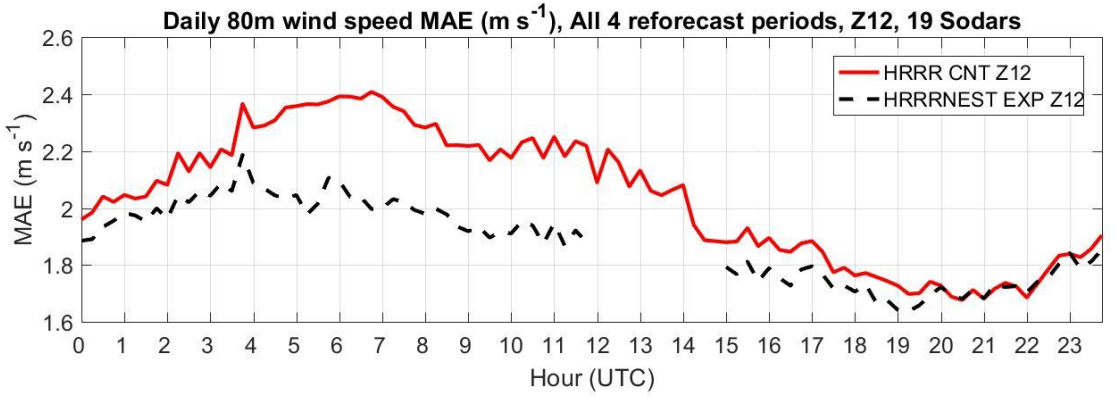


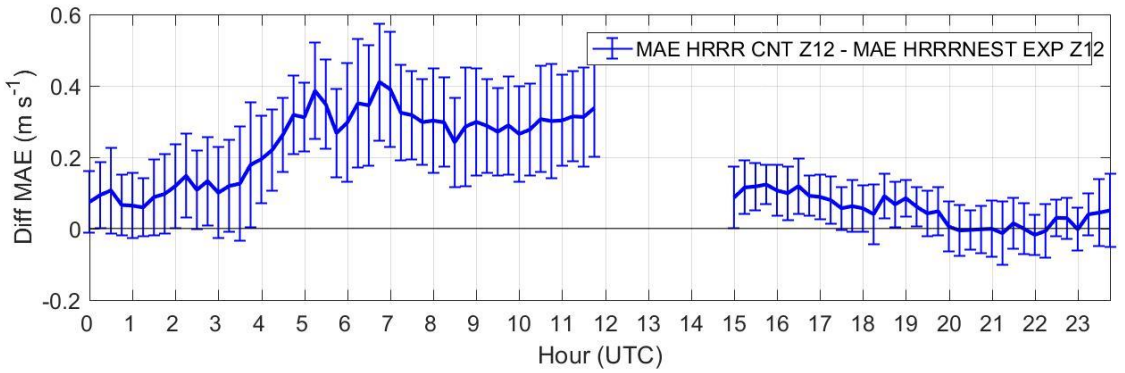


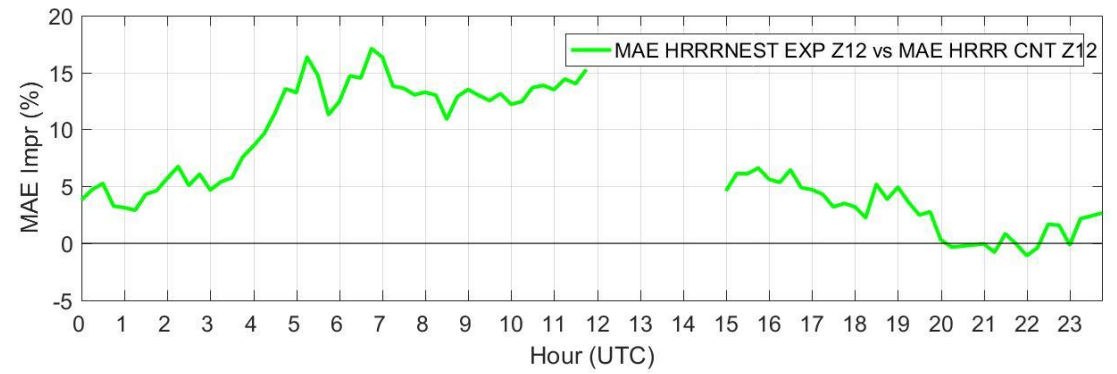

Daily 80m wind speed MAE (m s-1), All 4 reforecast periods, Z00, 19 Sodars
HRRR CNT Z00
HRRRNEST EXP Z00
MAE (m s-1)
Hour (UTC)

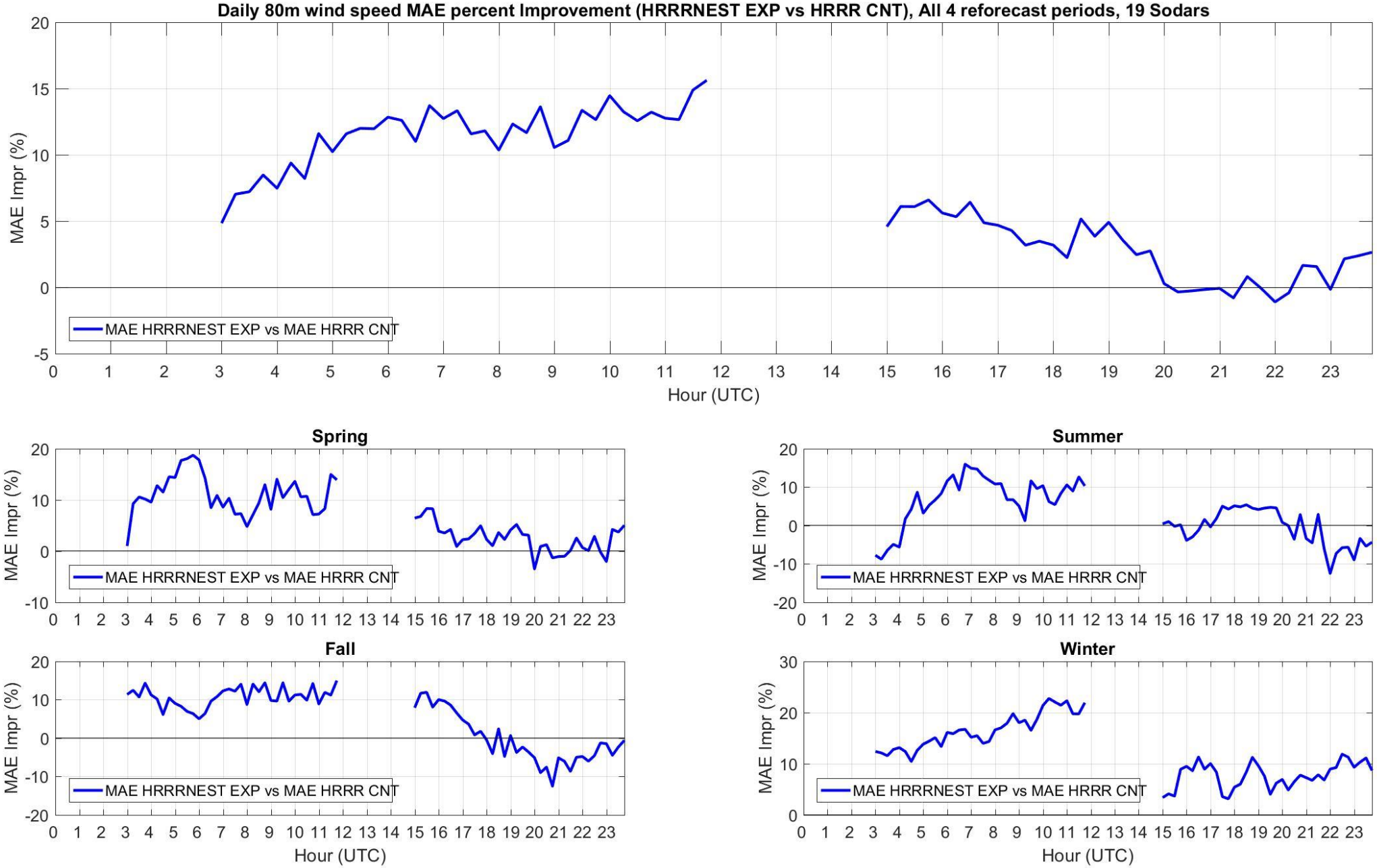

MAE HRRR CNT Z00 - MAE HRRRNEST EXP Z00
Diff MAE (m s-1)
Hour (UTC)


MAE HRRRNEST EXP Z00 vs MAE HRRR CNT Z00
MAE Impr (%)
Hour (UTC)


Daily 80m wind speed MAE (m s-1), All 4 reforecast periods, Z12, 19 Sodars
HRRR CNT Z12
HRRRNEST EXP Z12
MAE (m s-1)
Hour (UTC)

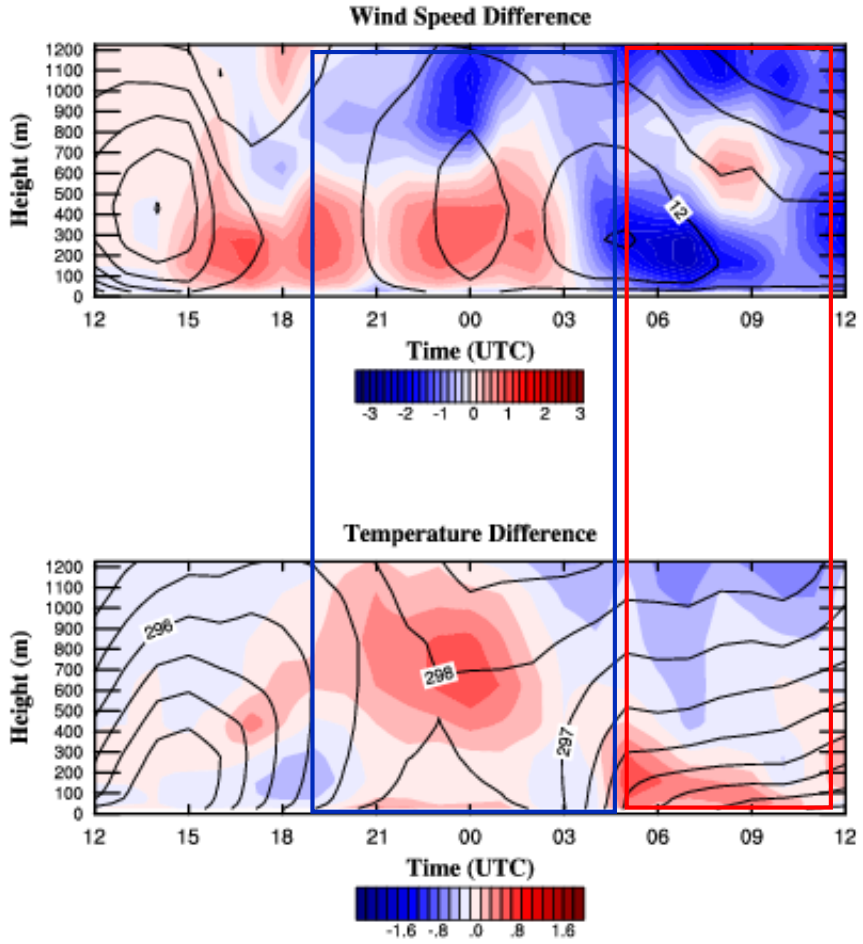

MAE HRRR CNT Z12 - MAE HRRRNEST EXP Z12
Diff MAE (m s-1)
Hour (UTC)


MAE HRRRNEST EXP Z12 vs MAE HRRR CNT Z12
MAE Impr (%)
Hour (UTC)

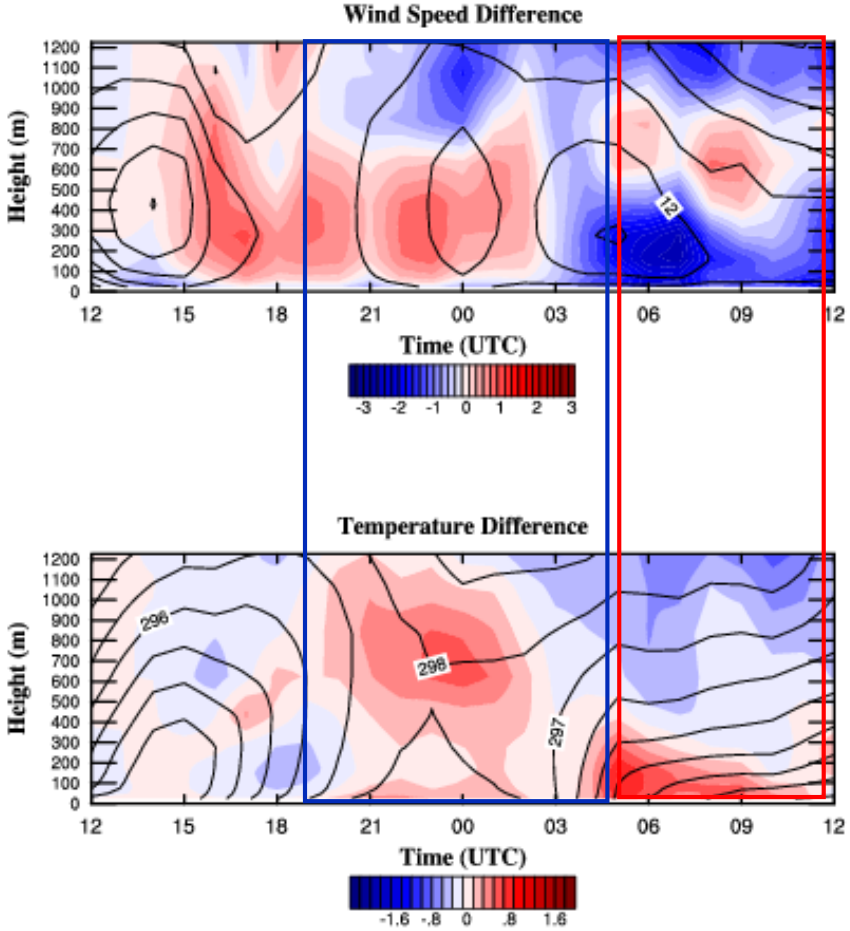

Daily 80m wind speed MAE percent Improvement (HRRRNEST EXP vs HRRR CNT), All 4 reforecast periods, 19 Sodars
MAE Impr (%)
Hour (UTC)
MAE HRRRNEST EXP vs MAE HRRR CNT
Spring
Summer
Fall
Winter

Evolution of Profile Differences at Wasco (3km domain)

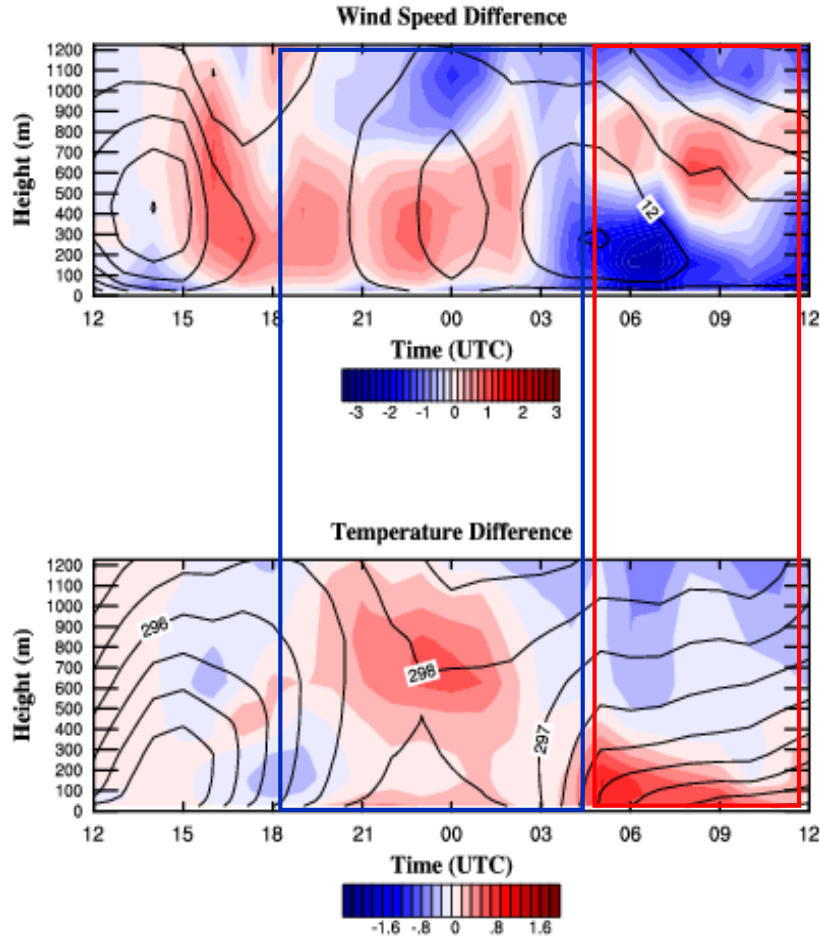
New MYNN - Original



(New MYNN + DO2) - Original

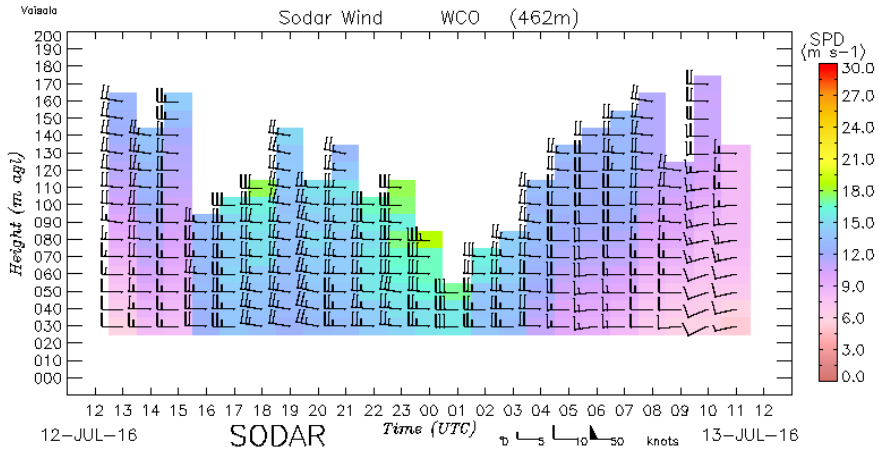


(New MYNN + DO2 + GWD) - Original

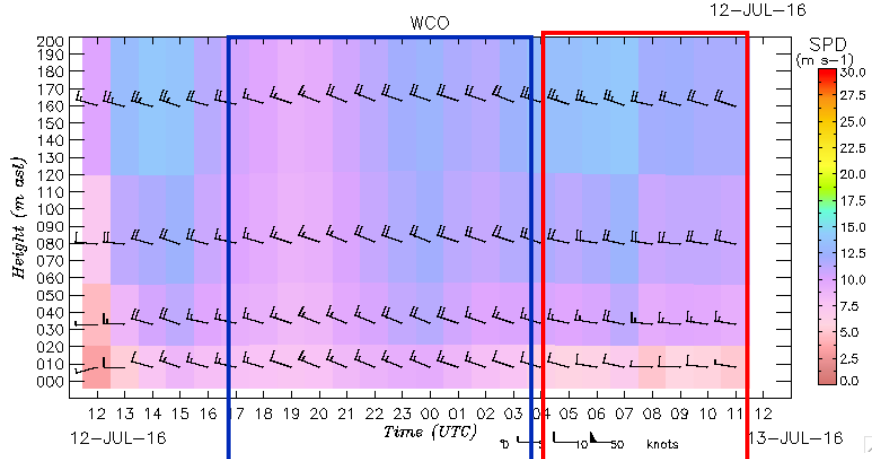


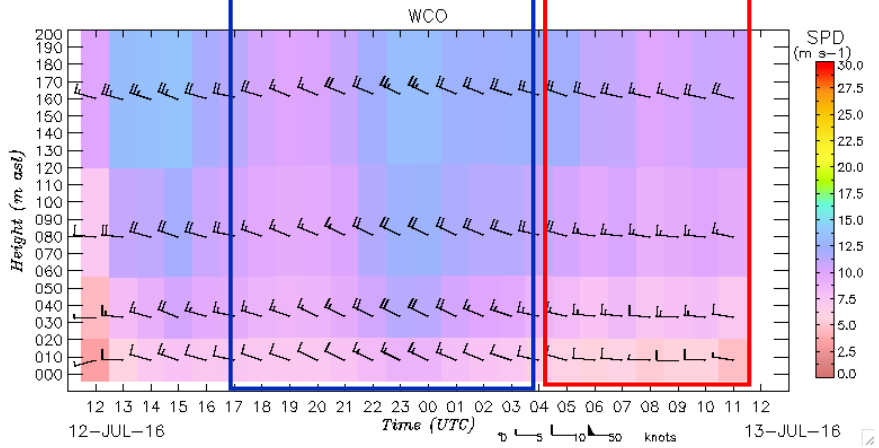
Results: Marine Push of 12-13 July 2016

Wasco, Oregon

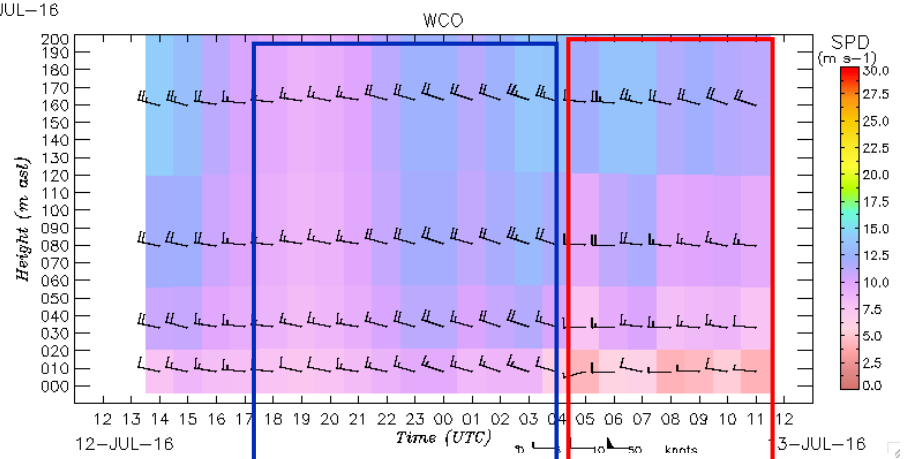


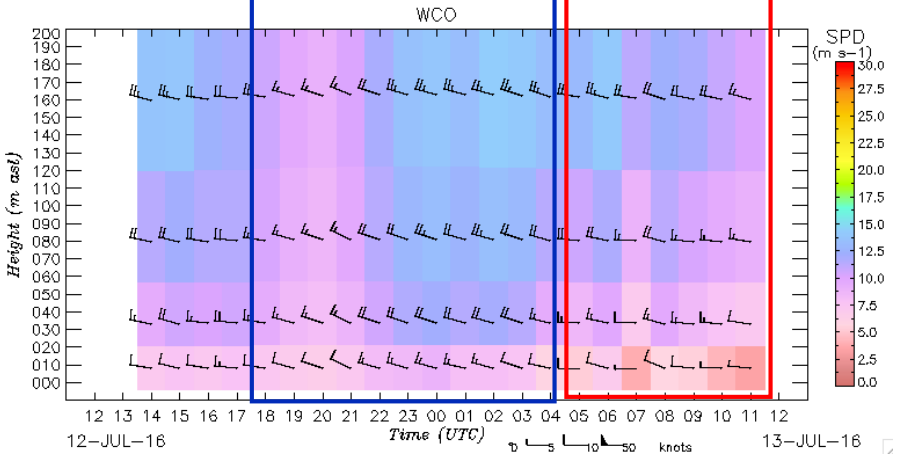
3-km Domain





750m Nest





Original

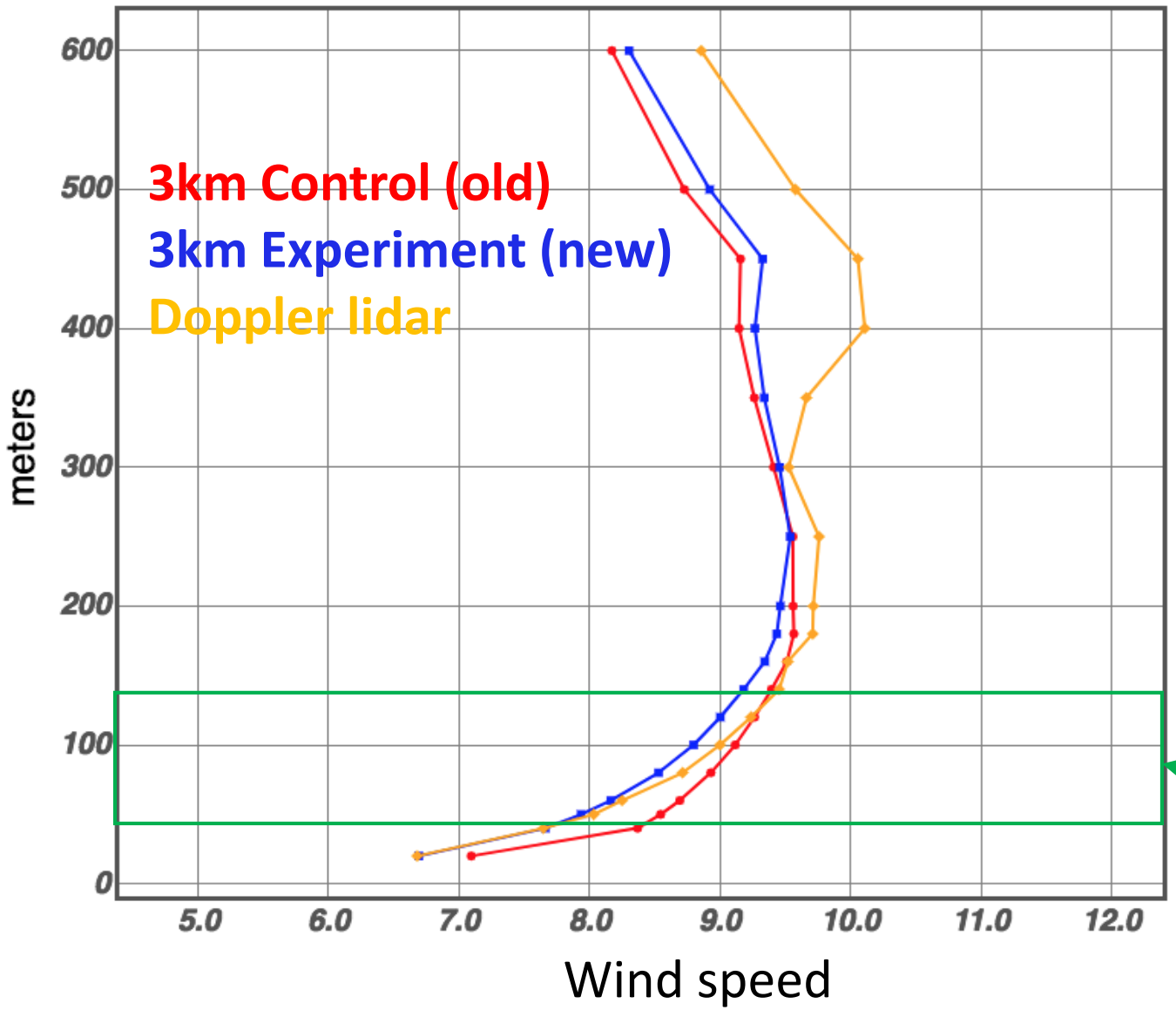
New

MYNN-EDMF

+Hor Diff

+GWD

Mean (Westerly) Wind Speeds at Wasco



Average of all wind speed profiles with wind directions at 80 m AGL between 225 and 315 degrees during **July 2016**.

- Jet maxima are about the same strength
- New MYNN+SSGWD produce:
  1. More shear in the rotor layer
  2. Higher altitude of jet max

Turbine rotor layer