2019 Joint WRF/MPAS Users' Workshop
13 June 2019
Boulder, CO

Evaluation of HRRR Boundary Layer Structure

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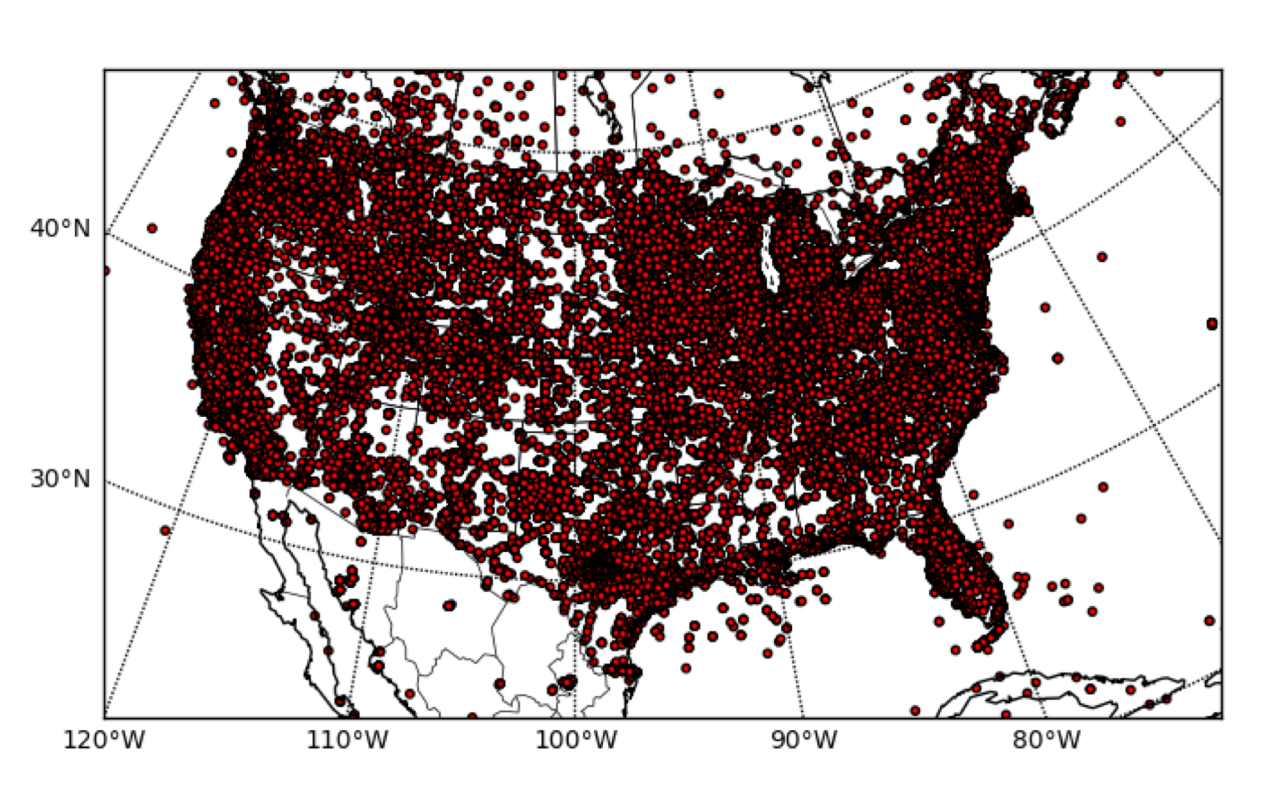
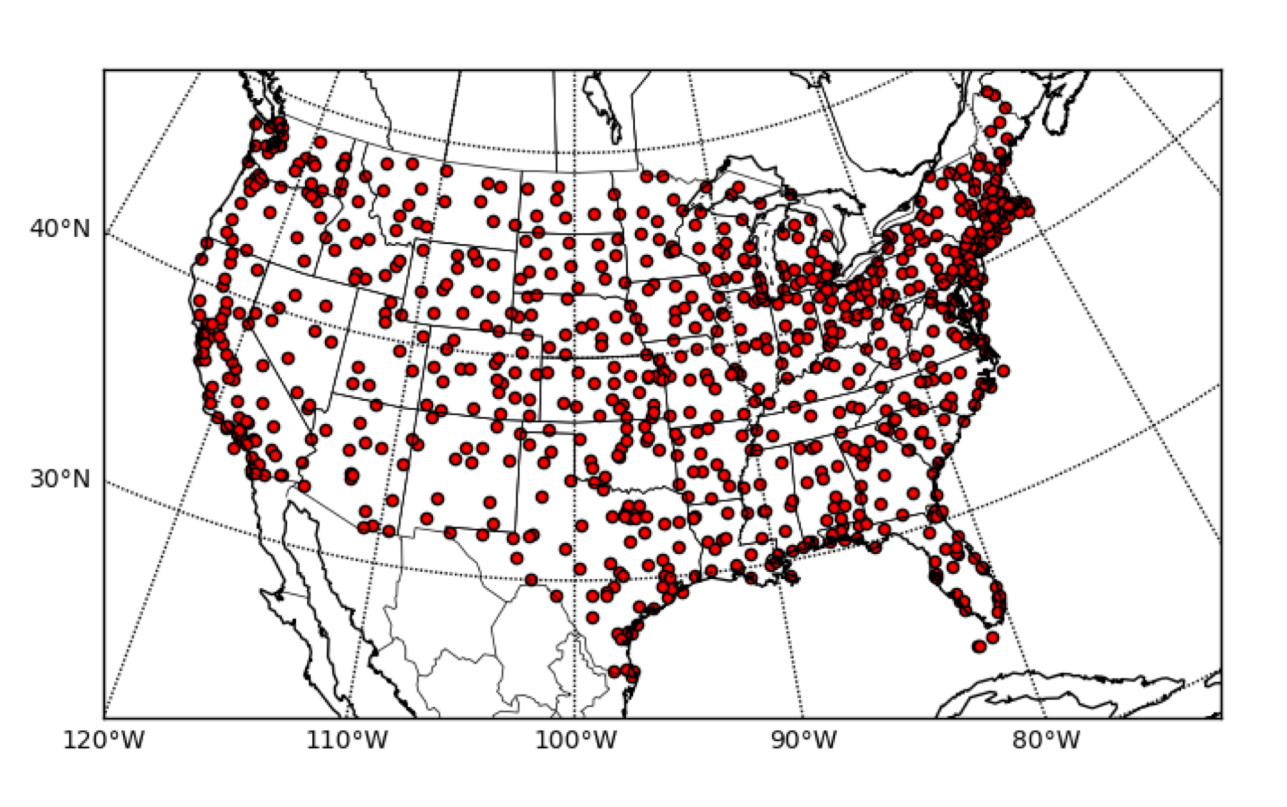
Available surface stations



Includes low quality stations (cf. Fovell and Gallagher 2018)

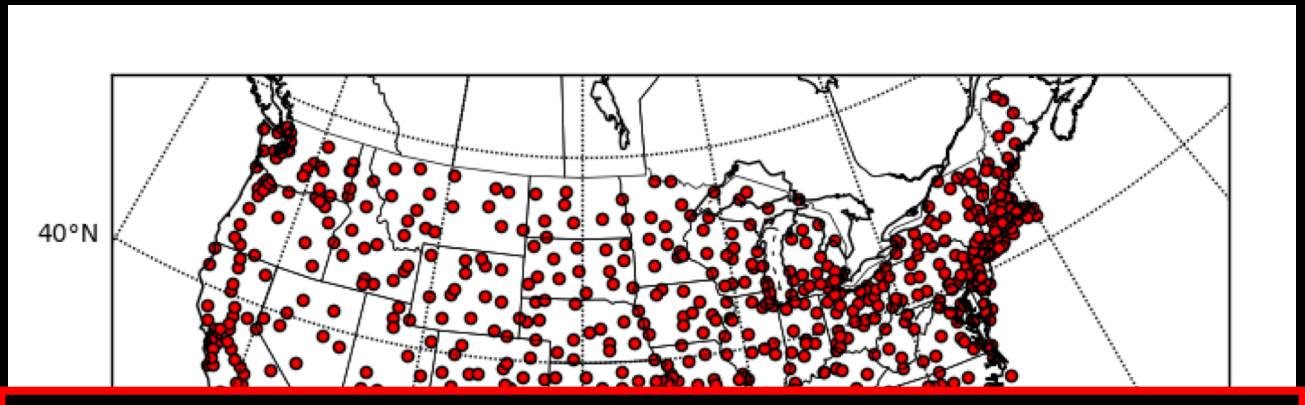
From MADIS, 6 March 2016 at 00Z

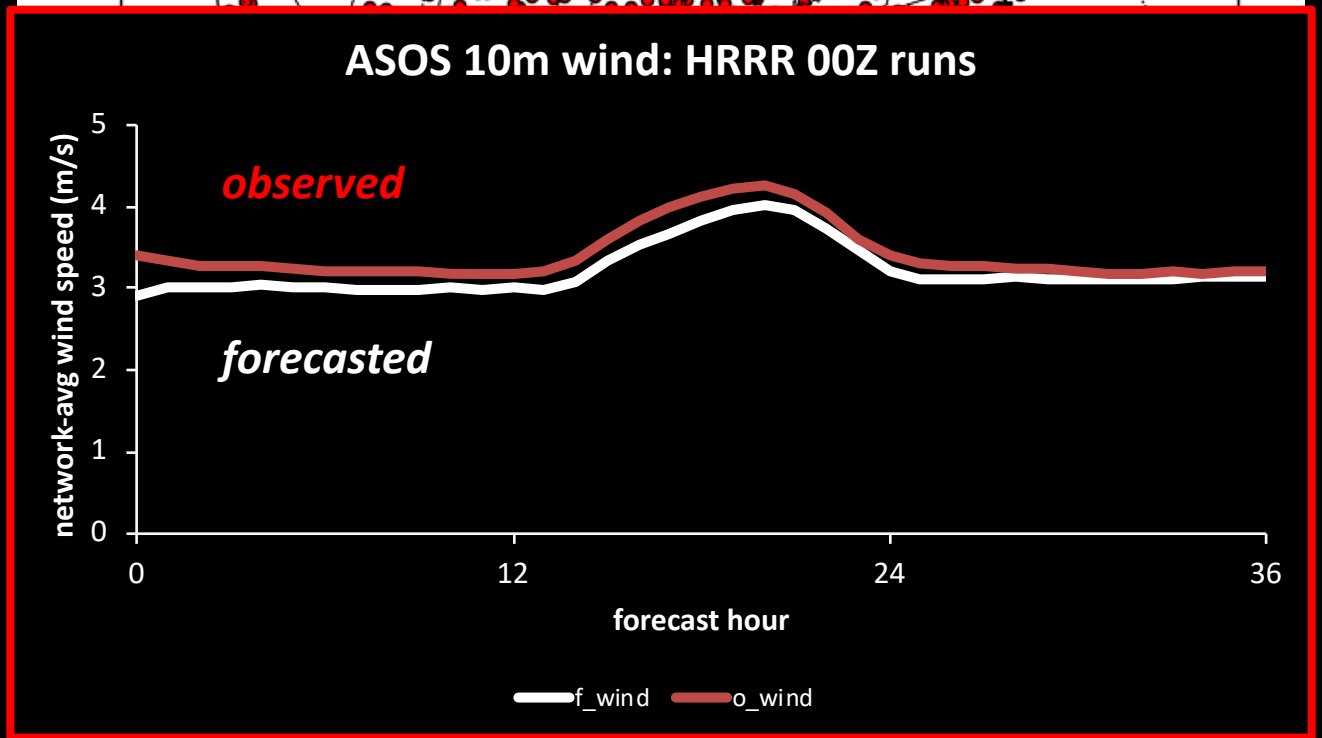
Available ASOS stations



N > 800

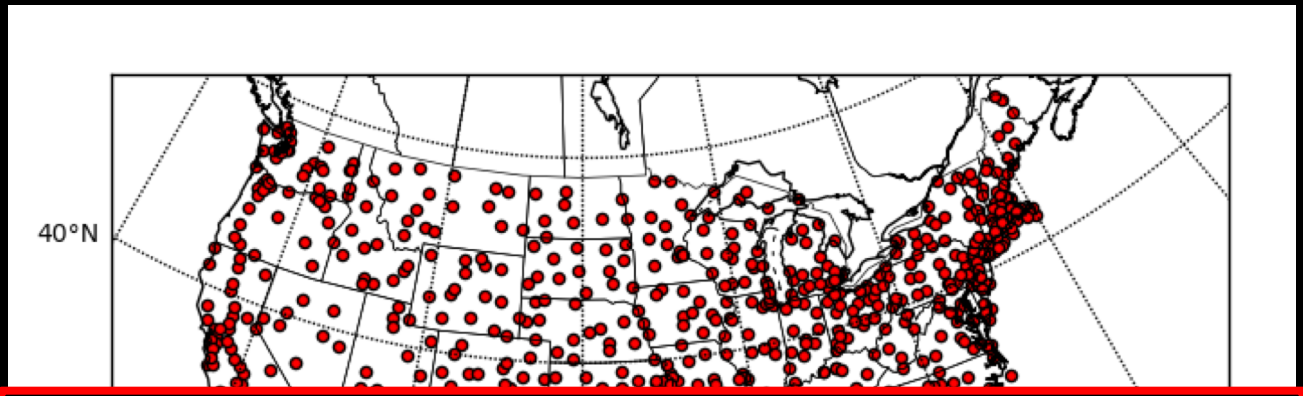
Available ASOS stations

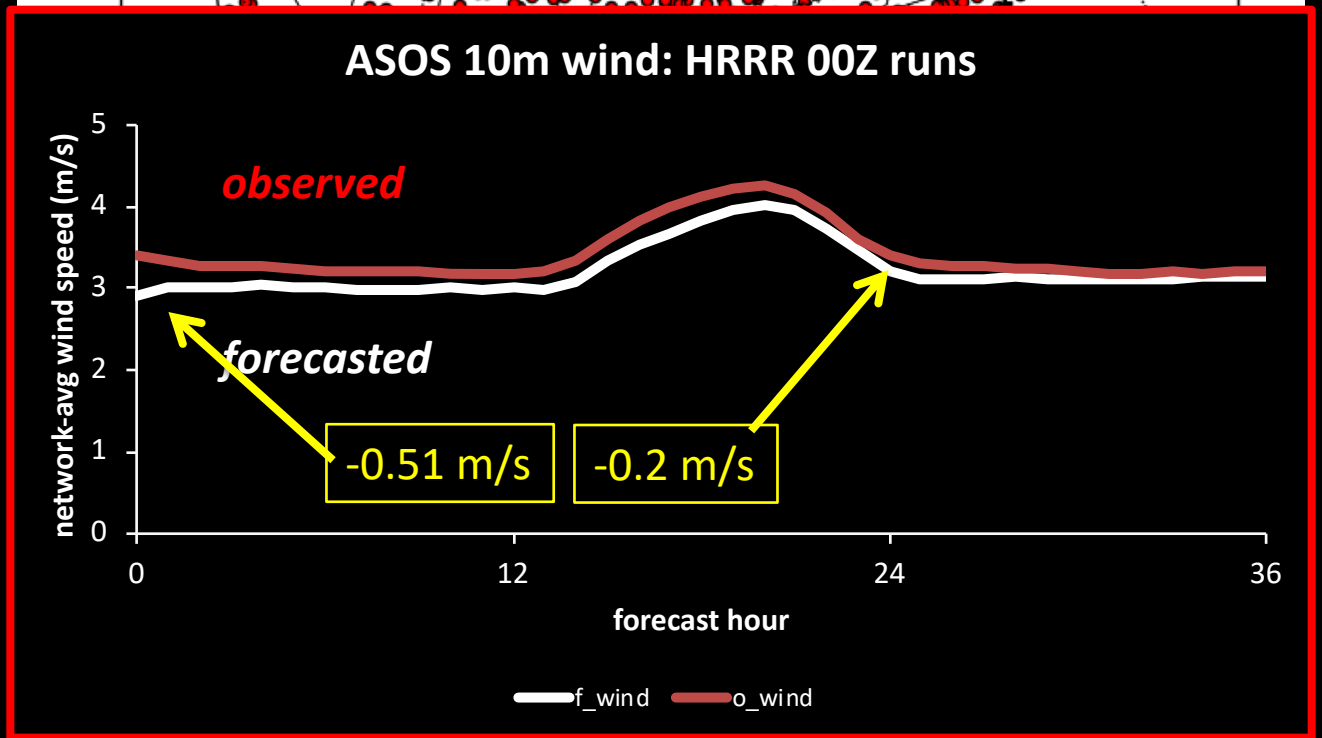




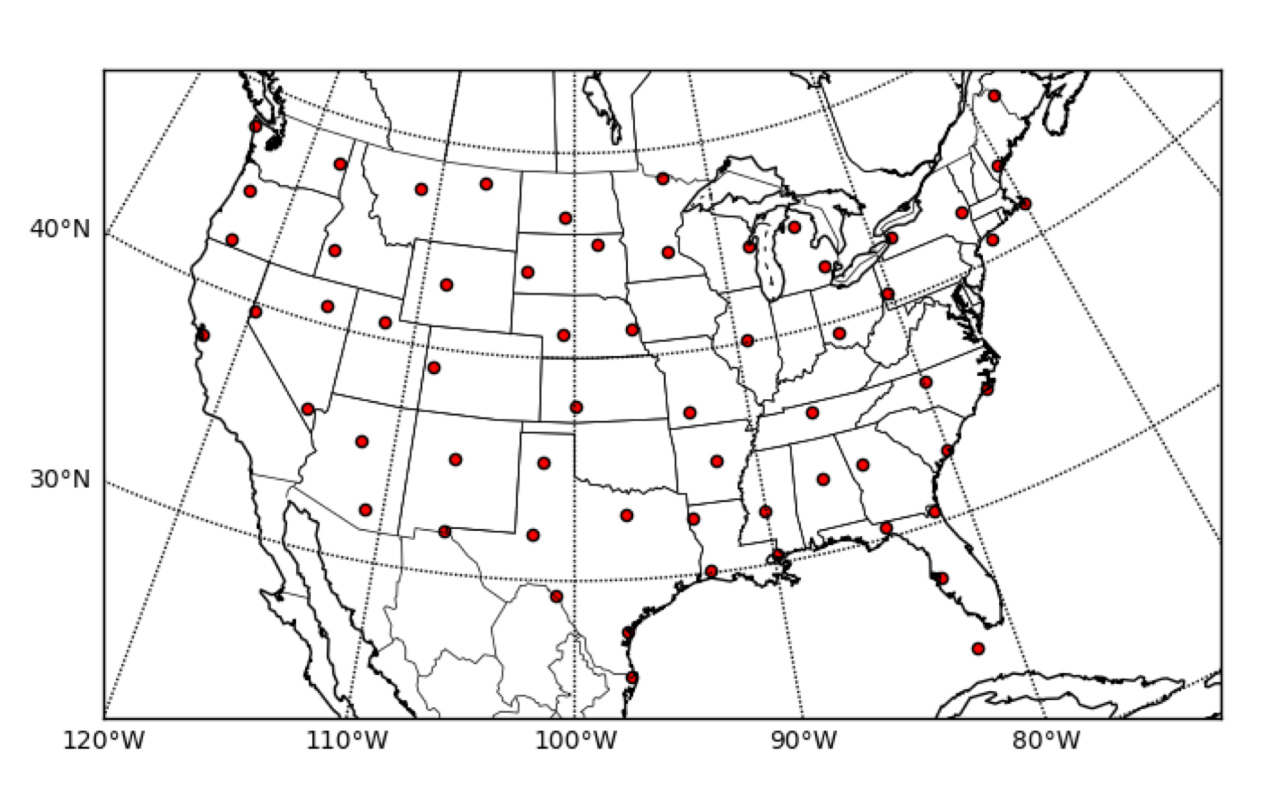
2-month average

Available ASOS stations





Available high-frequency radiosondes



N = 60

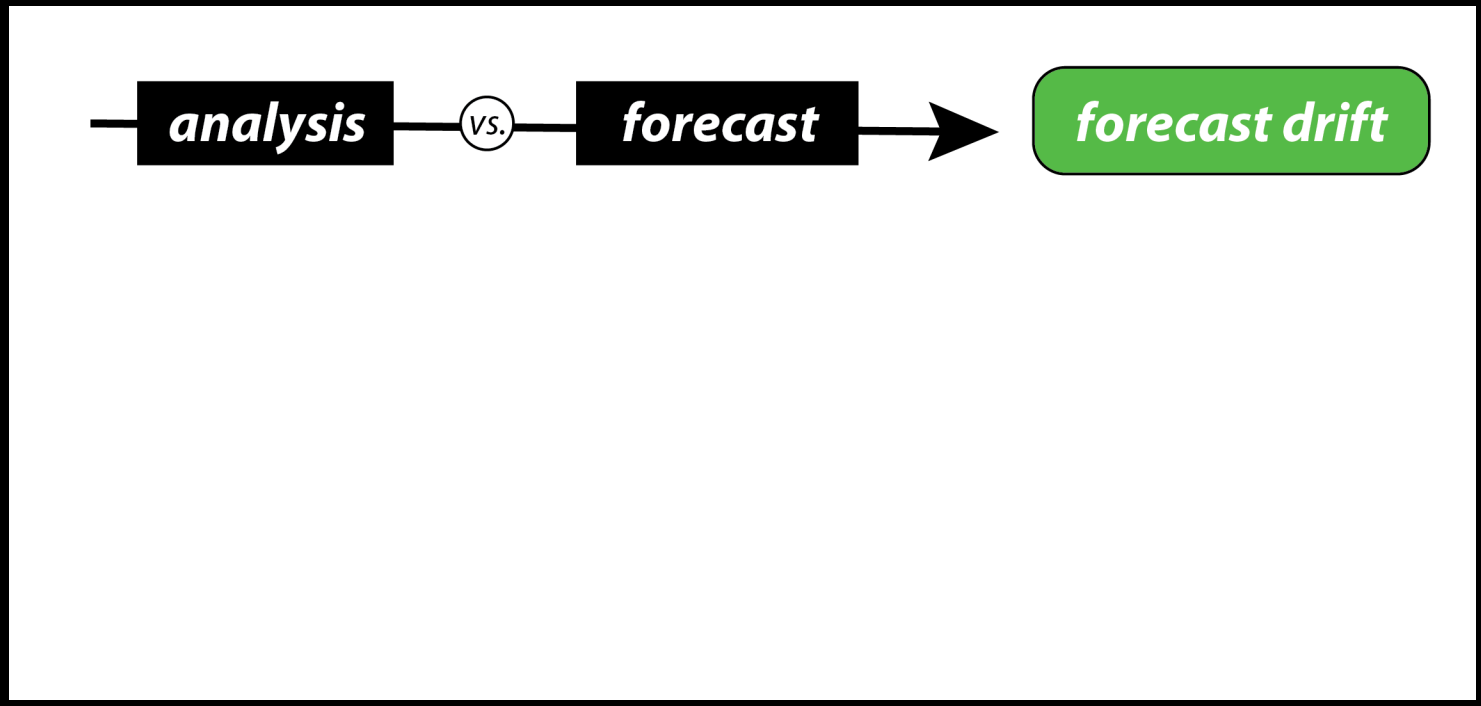
Much fewer observations
Only twice per day
Much more difficult to handle

Some stations do not report to the NCEI archive

Analysis

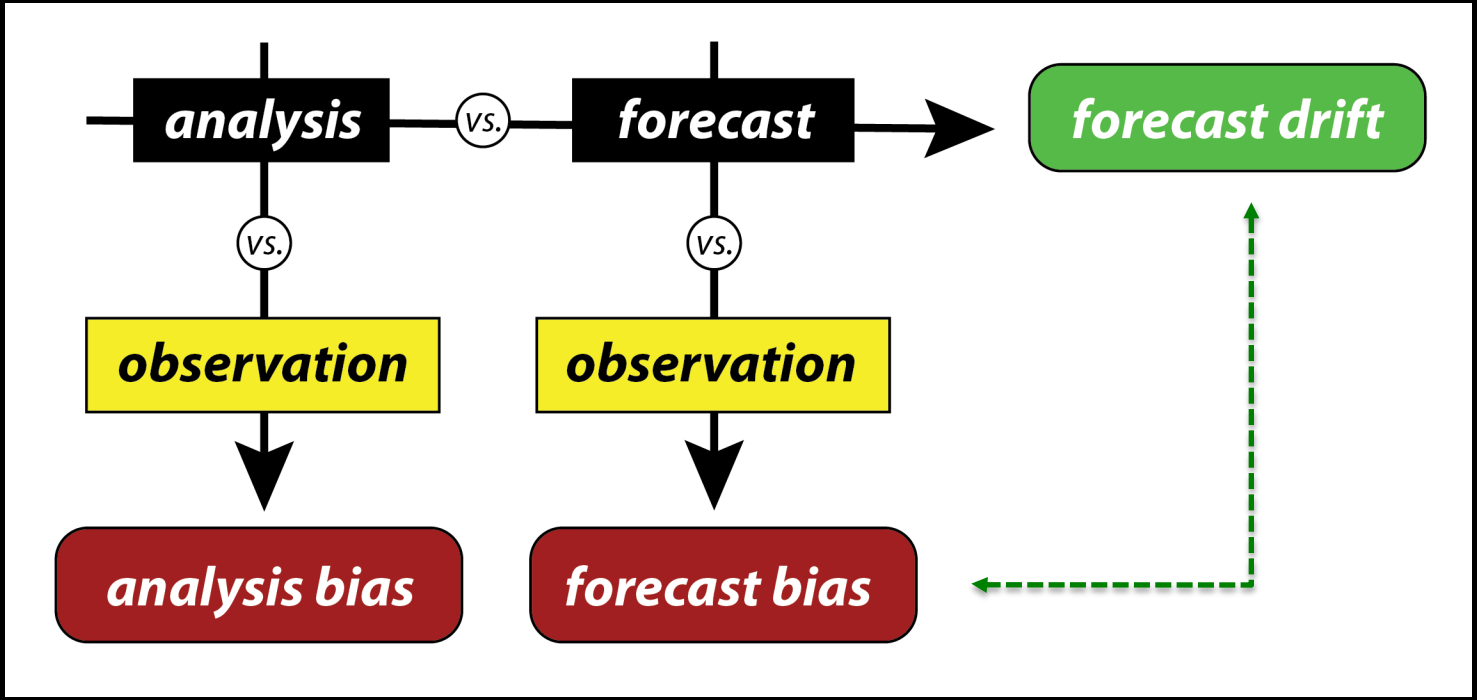
- Operational HRRR analyses and forecasts on native model levels from NCEP [“best”]
- High-frequency radiosonde observations from NCEI [1 second obs ~ O(10 m) Δz]
- April 2019 as an example
- Analysis and 24-h forecasts from 00Z and 12Z model runs

Forecast drift



Comparisons for same set of valid times

Forecast drift ≠ forecast bias



Comparisons for same set of valid times

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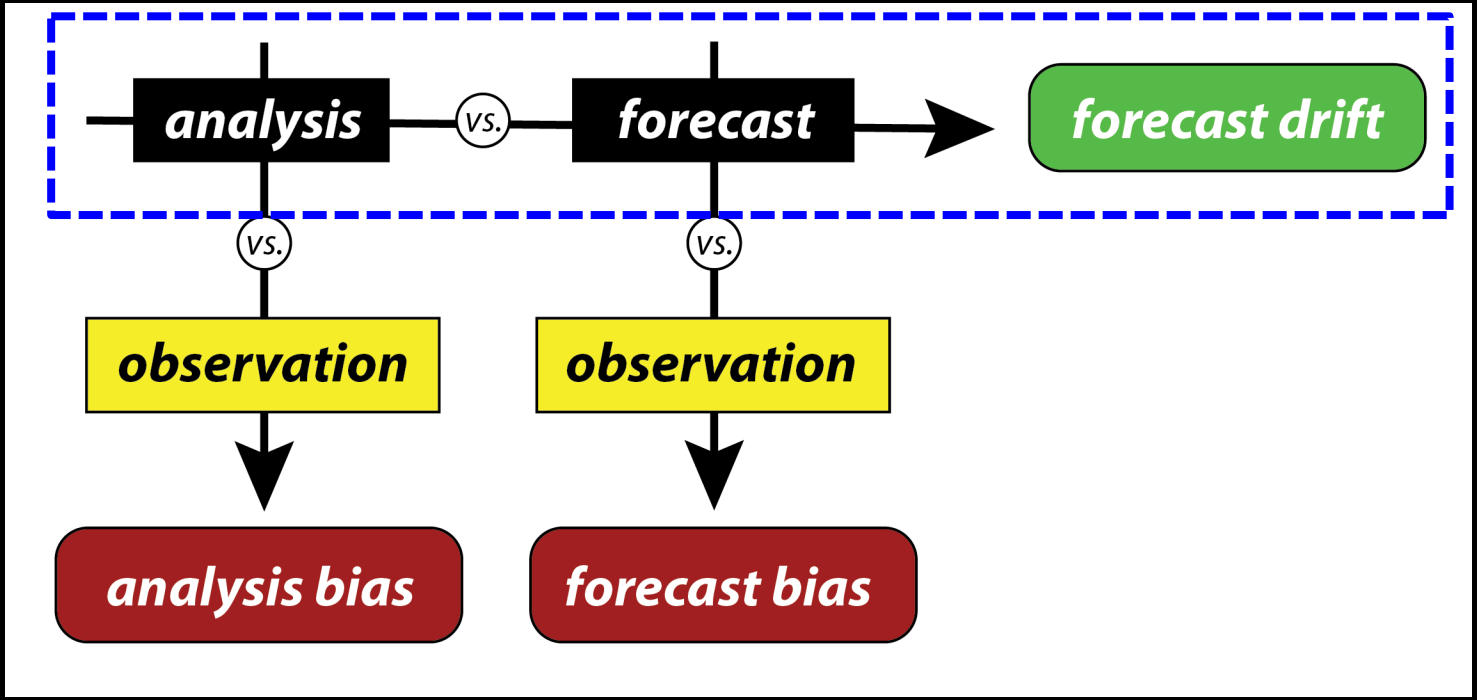
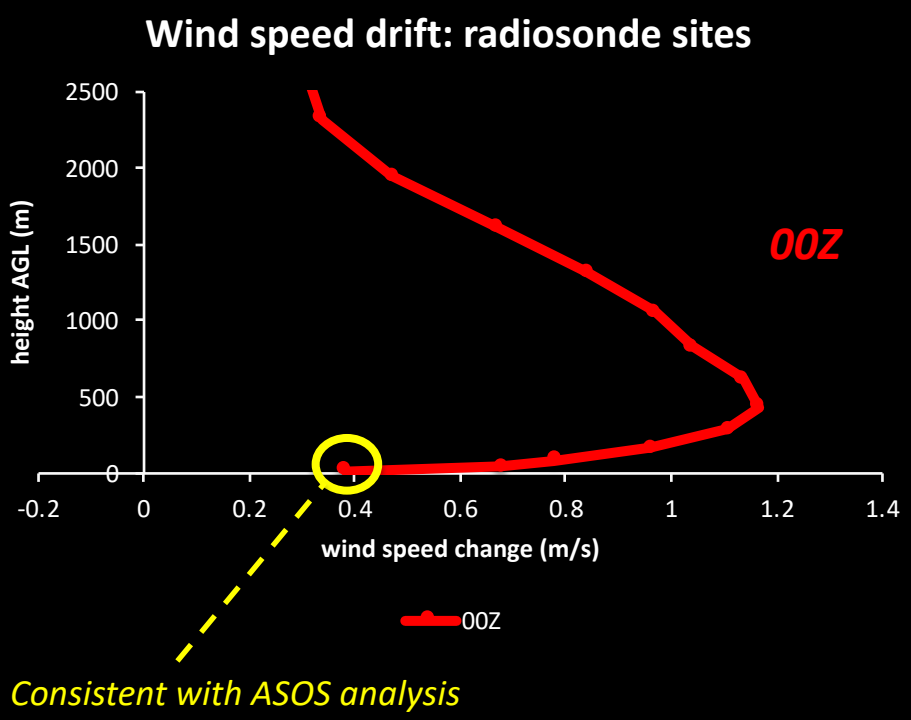
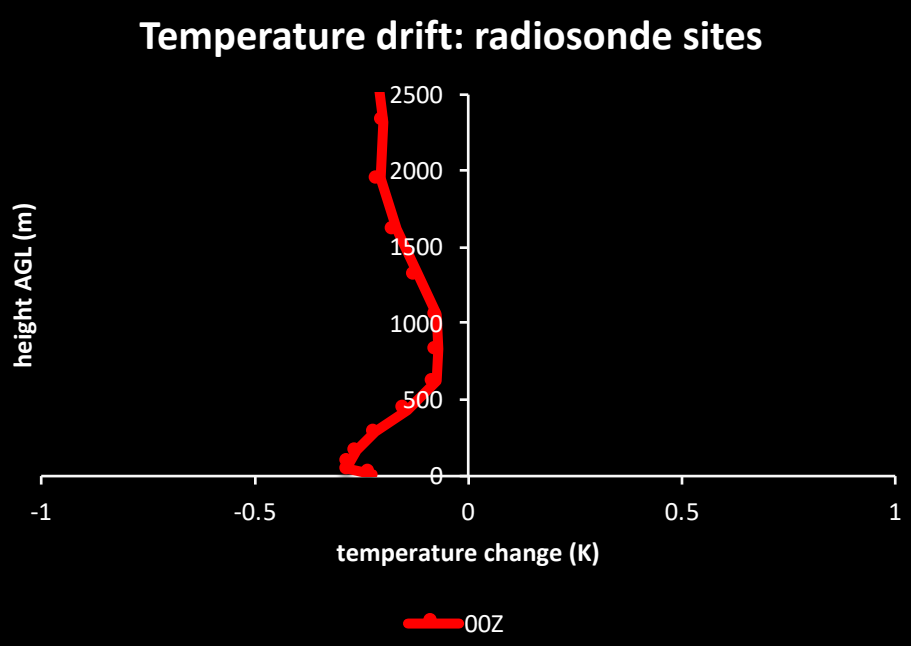


Comparisons for same set of valid times

April 2019 24-h forecast drift (60 radiosonde sites)



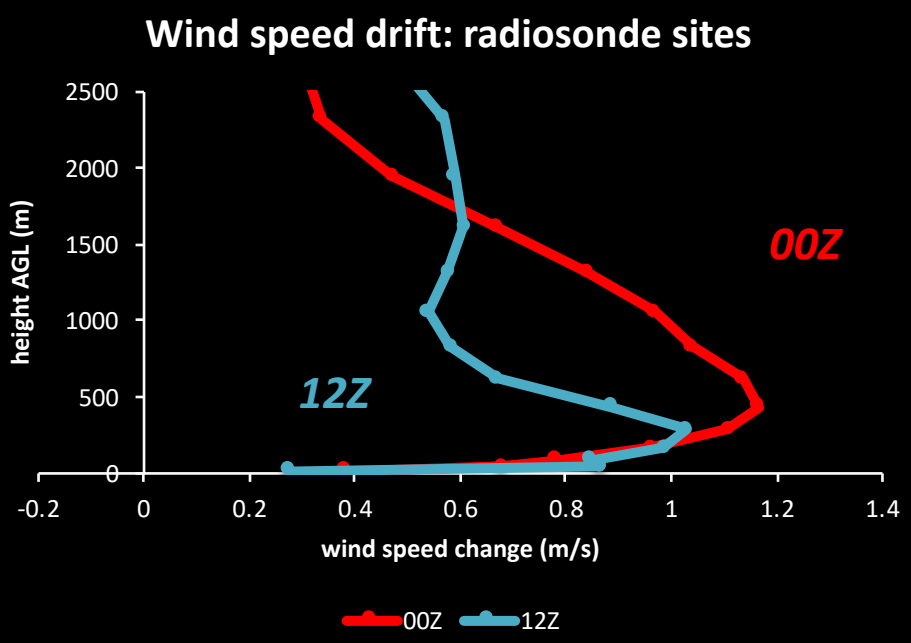
Consistent with ASOS analysis

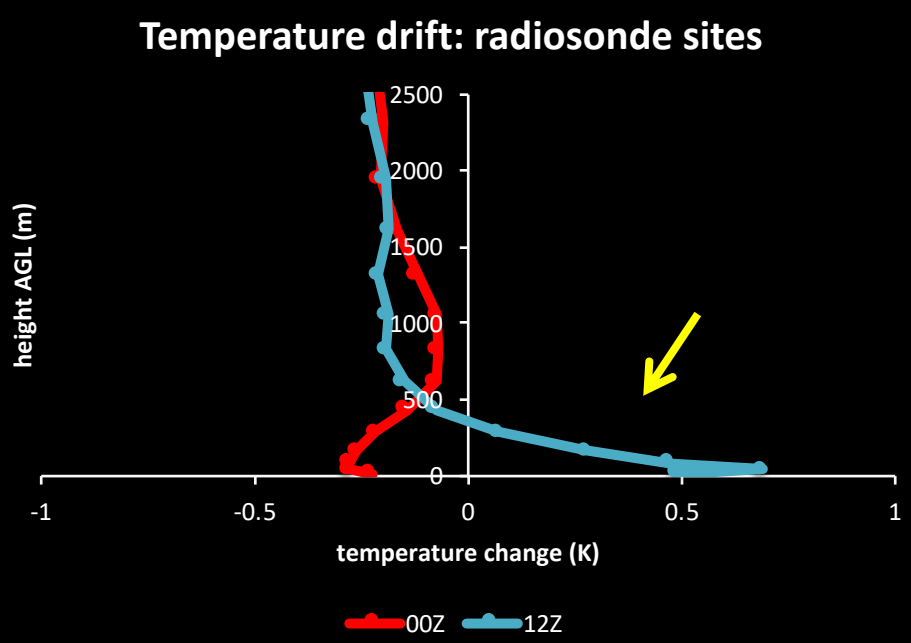


NO OBSERVATIONS DIRECTLY INVOLVED

Height coordinate = average model height AGL

April 2019 24-h forecast drift (60 radiosonde sites)

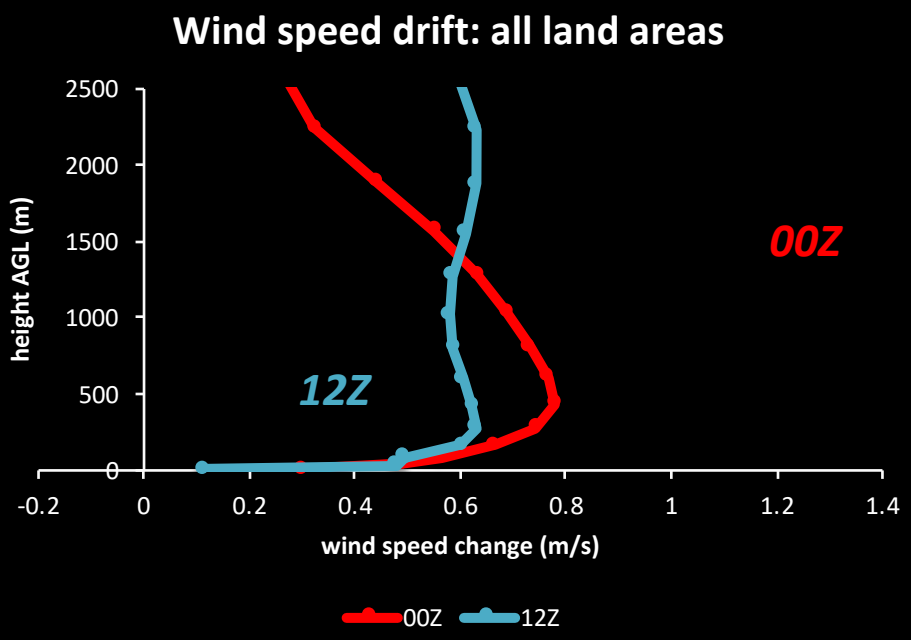


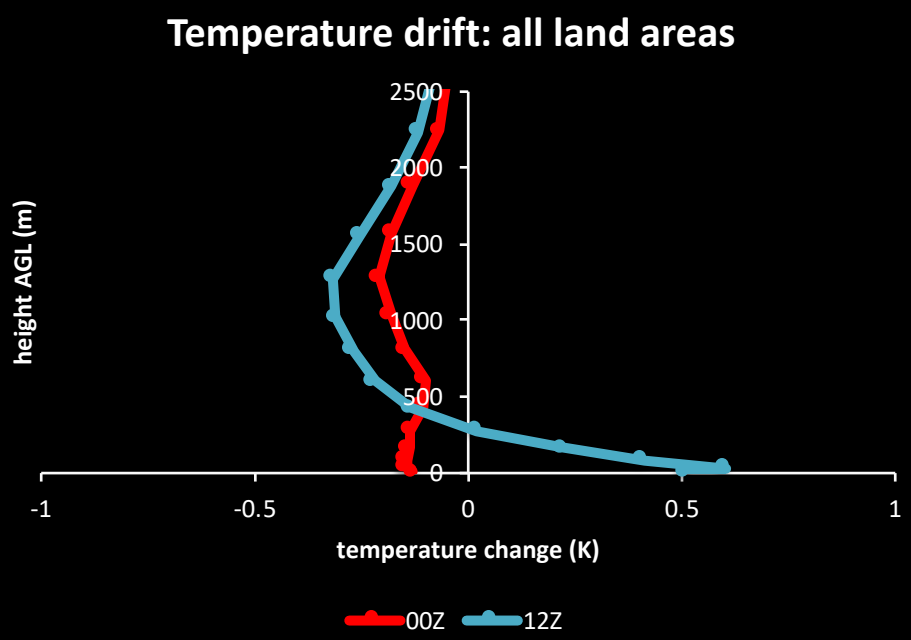


NO OBSERVATIONS DIRECTLY INVOLVED

Height coordinate = average model height AGL

April 2019 24-h forecast drift (all land areas)

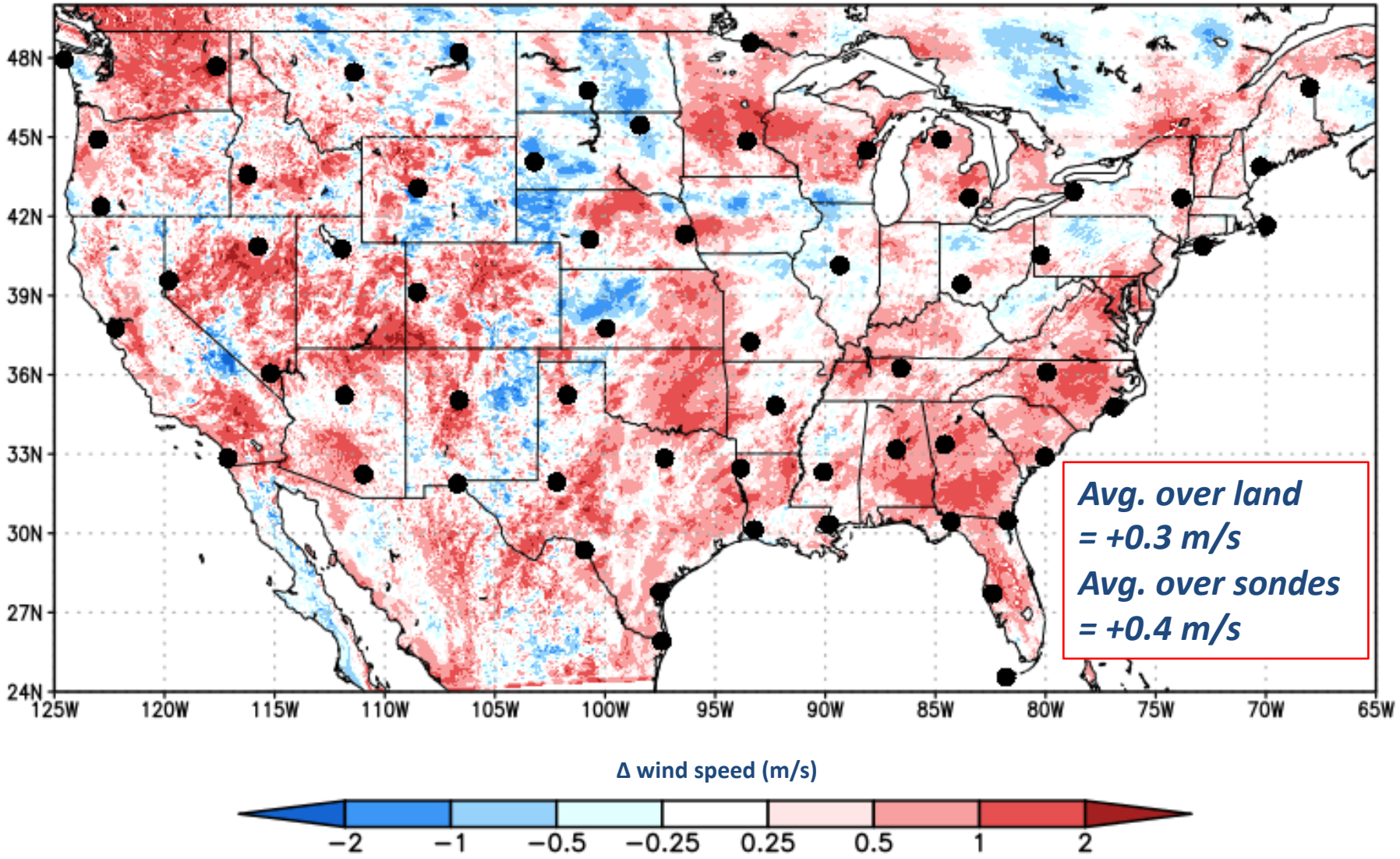




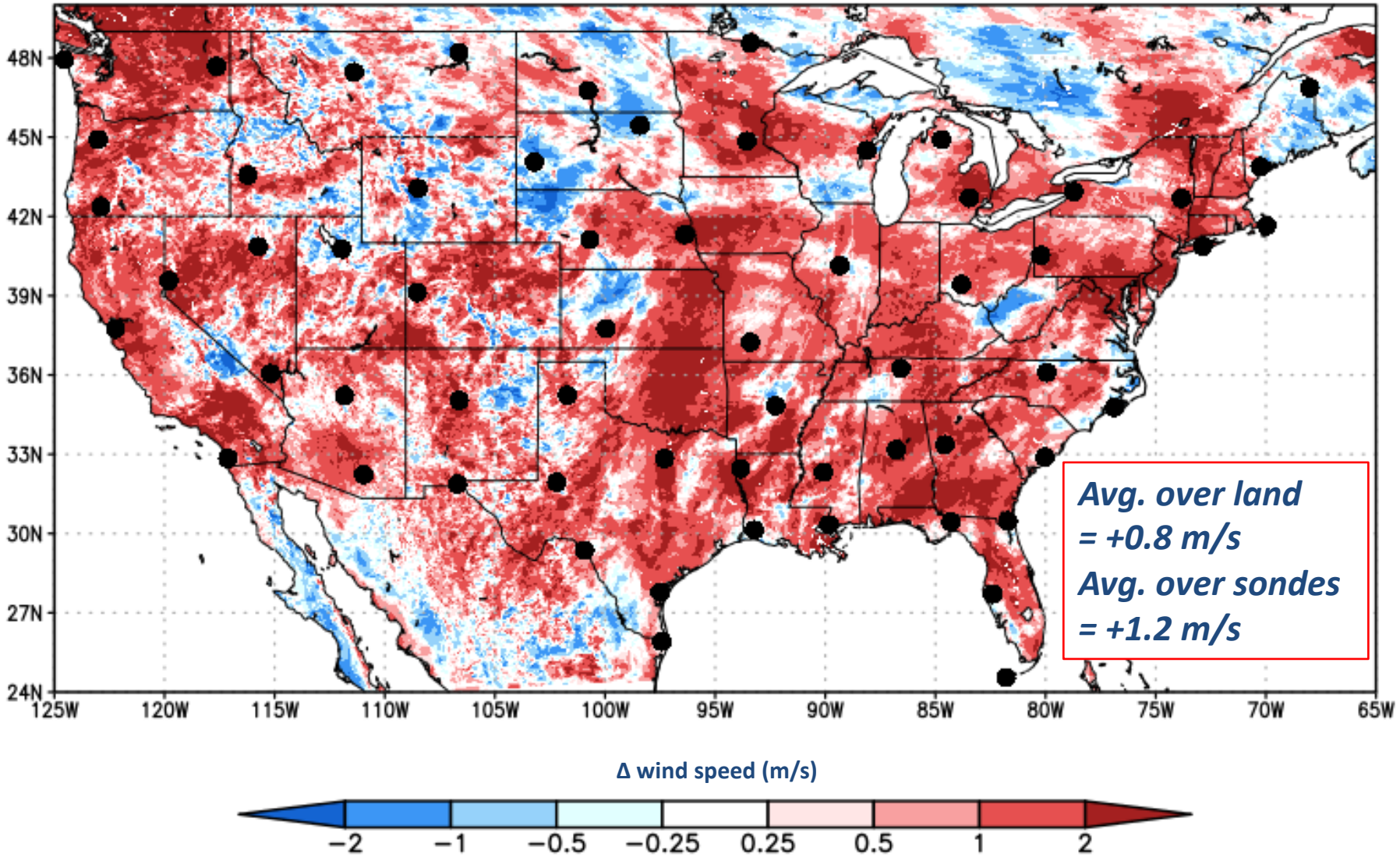
NO OBSERVATIONS DIRECTLY INVOLVED

Height coordinate = average model height AGL

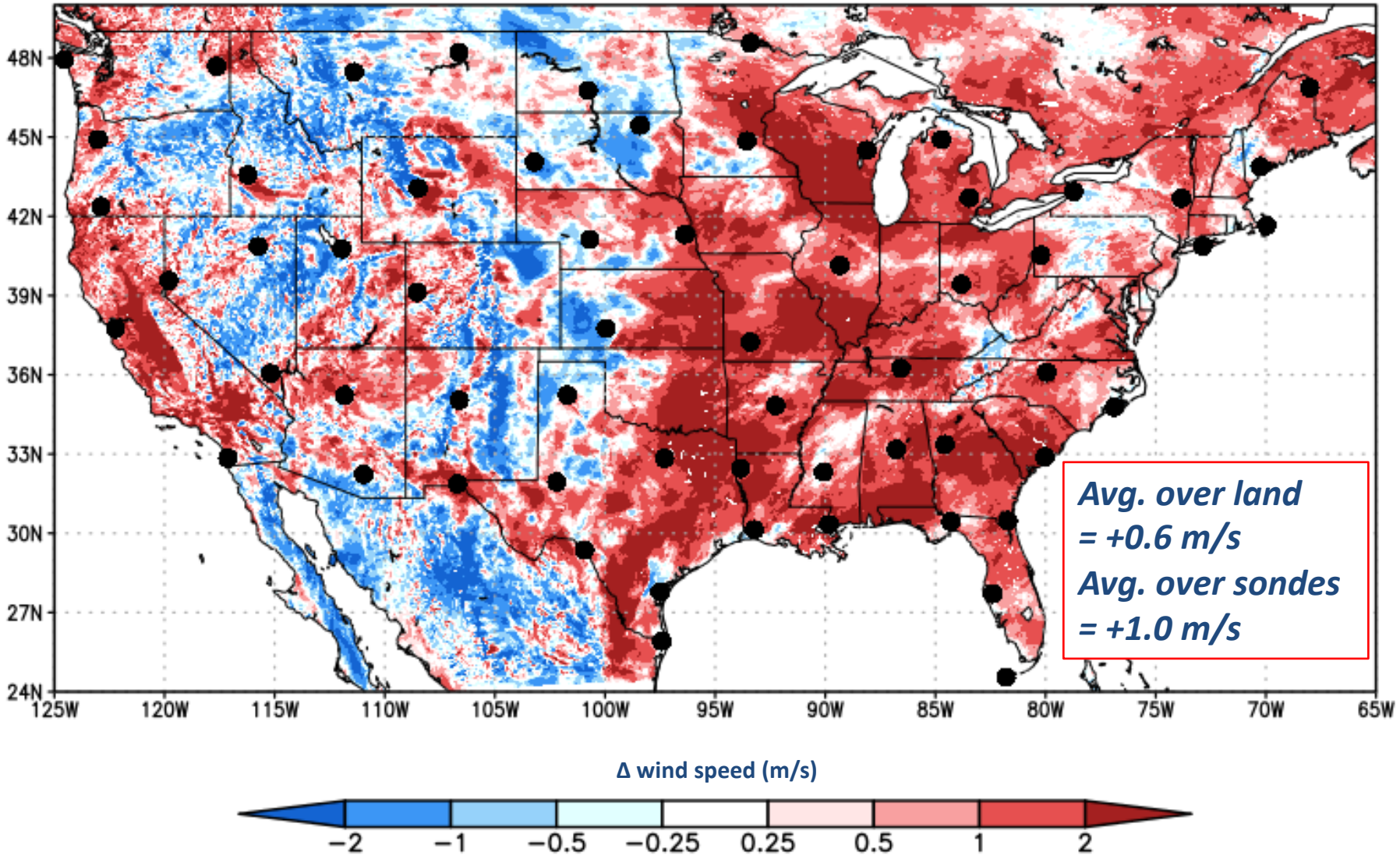
00Z
24-h wind speed forecast drift: model level 1 (~10 m AGL)



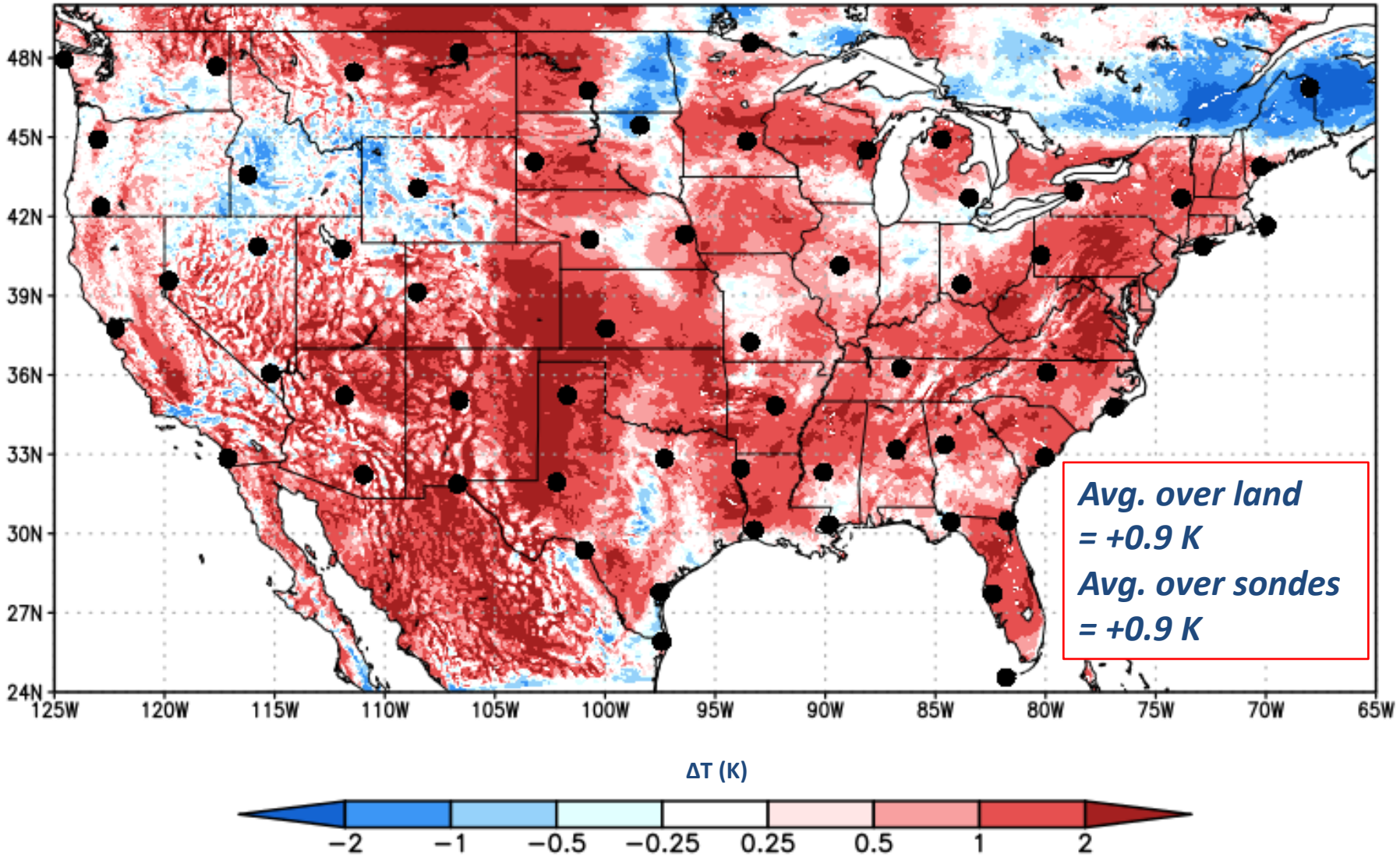
00Z
24-h wind speed forecast drift: model level 6 (~430 m AGL)



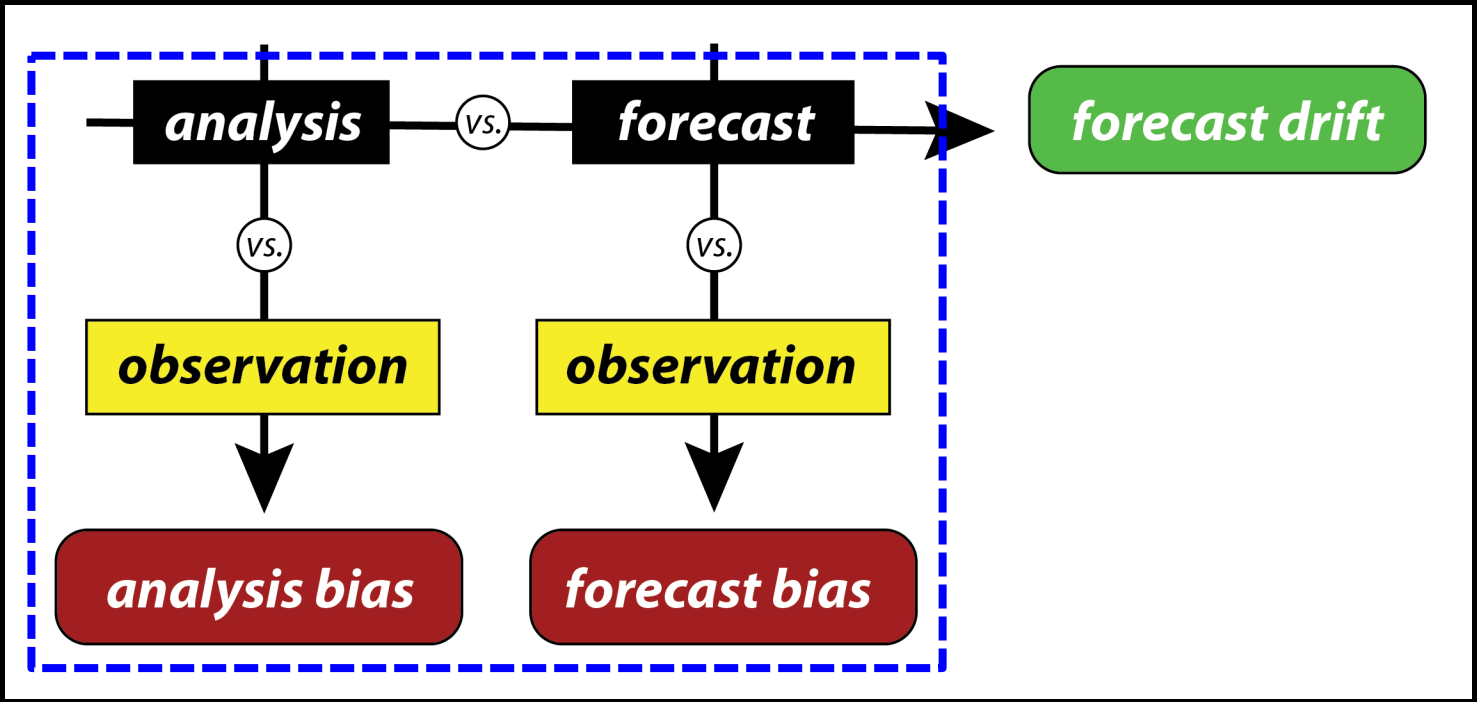
12Z
24-h wind speed forecast drift: model level 5 (~276 m AGL)



12Z
24-h lapse rate forecast drift (below 1.3 km)



Forecast bias

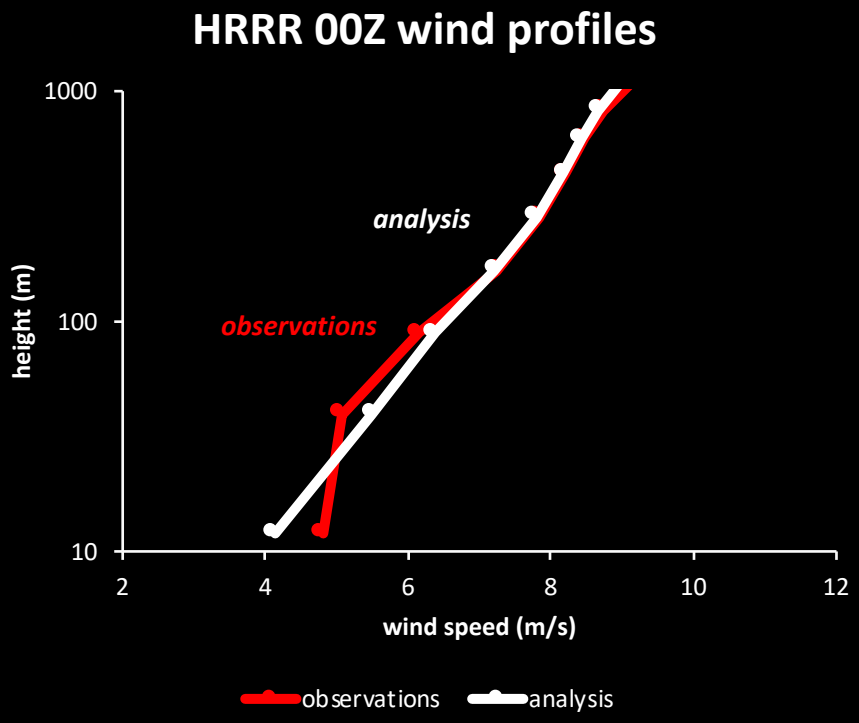


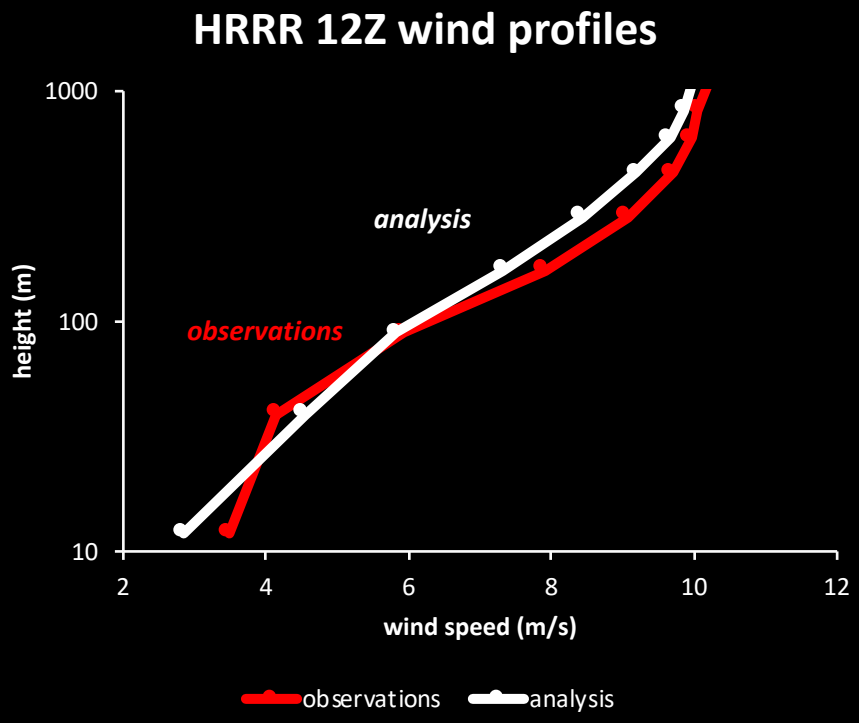
Comparisons for same set of valid times

Forecast bias

- **Forecast bias** = (forecast – observation), averaged for each model level across 60 high-frequency radiosonde sites
- 1-sec radiosonde observations interpolated to HRRR model levels at each location and time, averaged over both
- Important and serious issues (partial list):
  - Balloon release height AGL needs to be determined
  - Discrepancies exist between actual and HRRR elevations
  - Not all releases are from ground level & not all barometer readings are from surface (worst offender: Albany, NY)
  - Pressure- and GPS-derived heights MSL do not agree
  - Pre-release observations need to be removed
  - Residual pendular motion may remain in filtered winds
  - Most balloons launched 50+ min prior to nominal times (00Z, 12Z) [Coniglio et al. 2013; Evans et al. 2018]
    - "standard" vs. "shifted" assessment

Vertical profile of wind at 60 radiosonde sites: April 2019

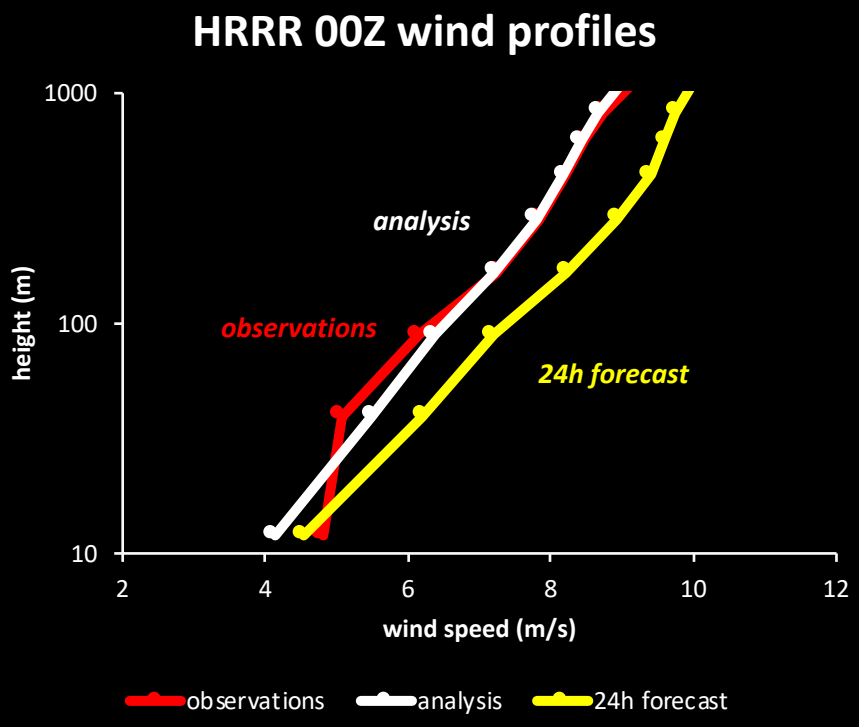


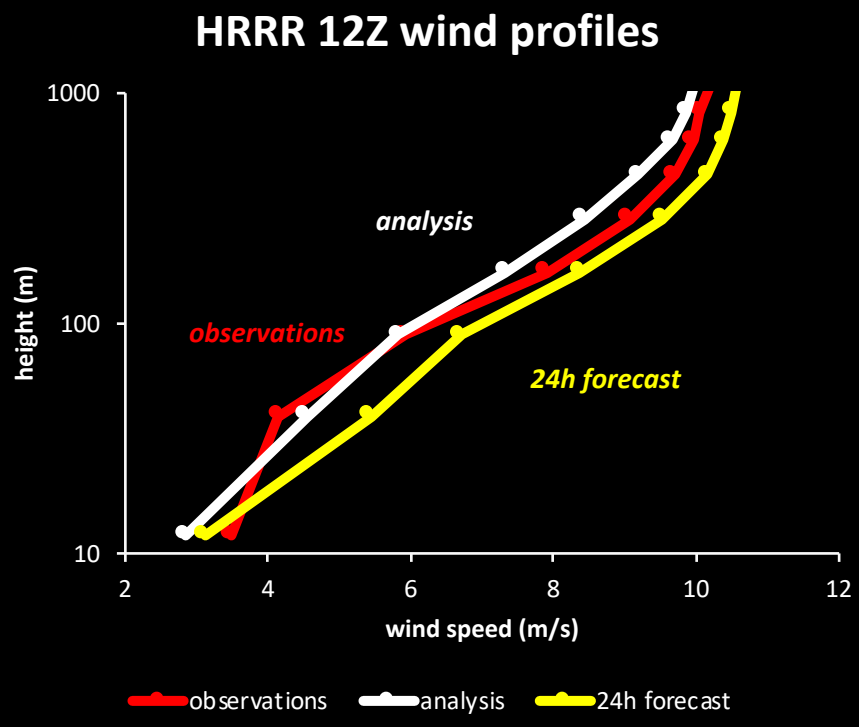


Analysis follows observations well, so anticipate *forecasts* will have high wind bias

"Kink" in observations is very persistent but may be artifact

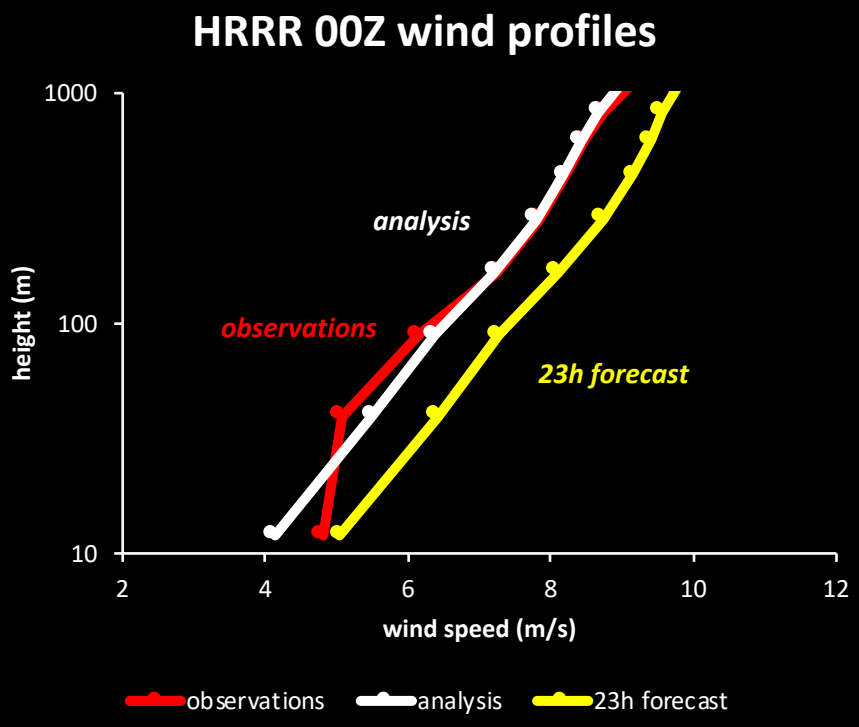
Vertical profile of wind at 60 radiosonde sites: April 2019

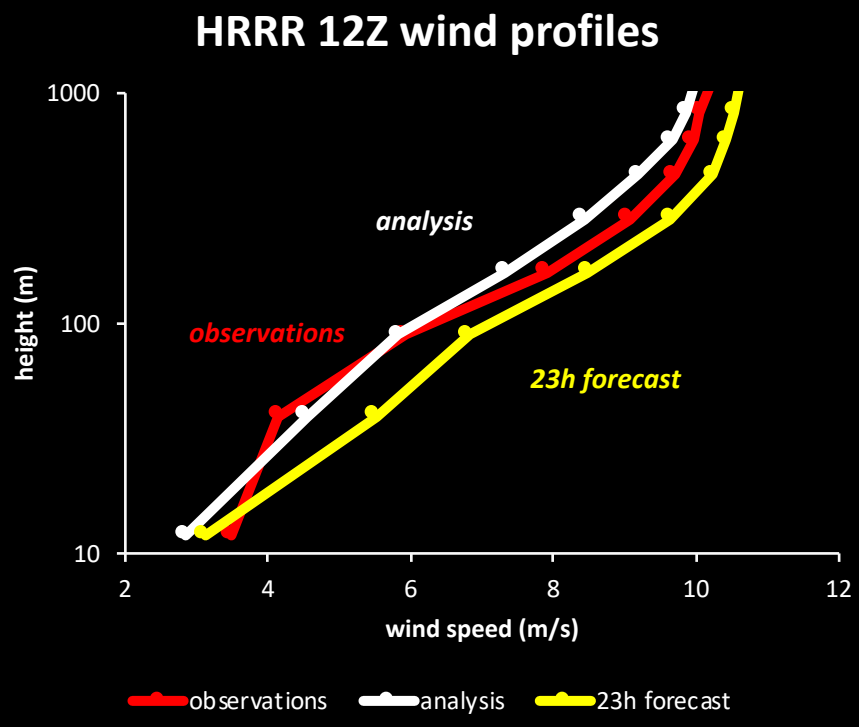




STANDARD analysis: compare to 24 h forecasts

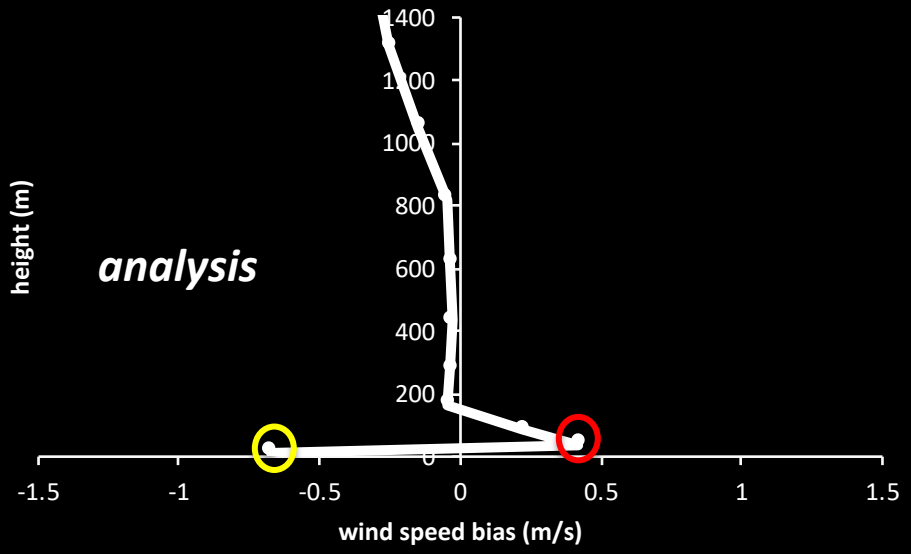
Vertical profile of wind at 60 radiosonde sites: April 2019





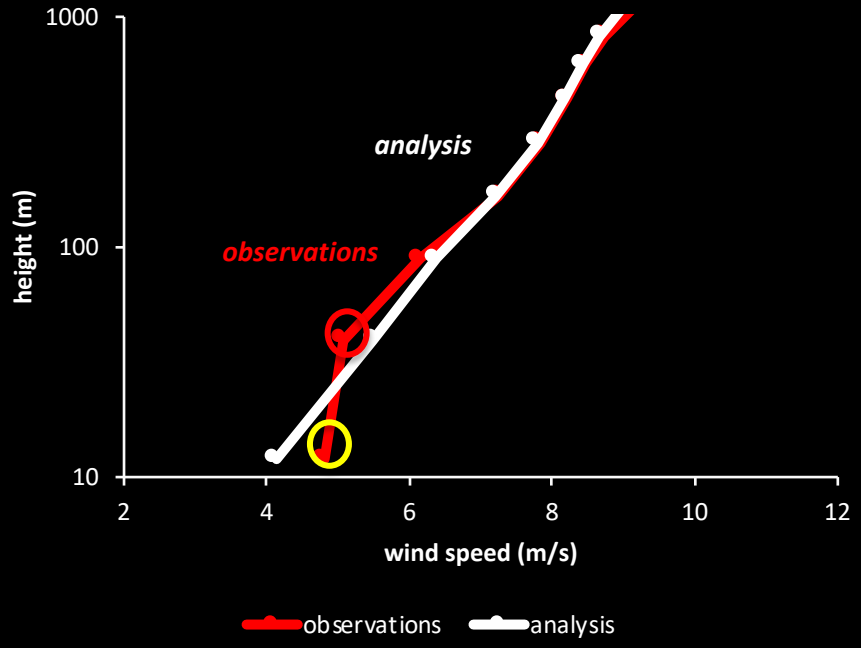
SHIFTED analysis: compare to 23 h forecasts

Wind speed bias 00Z

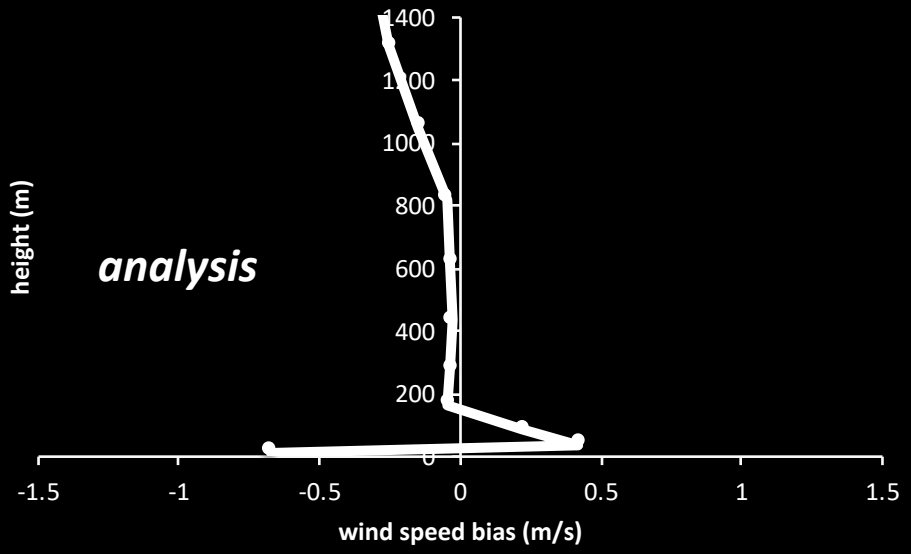


Forecast bias vs. height
April 2019

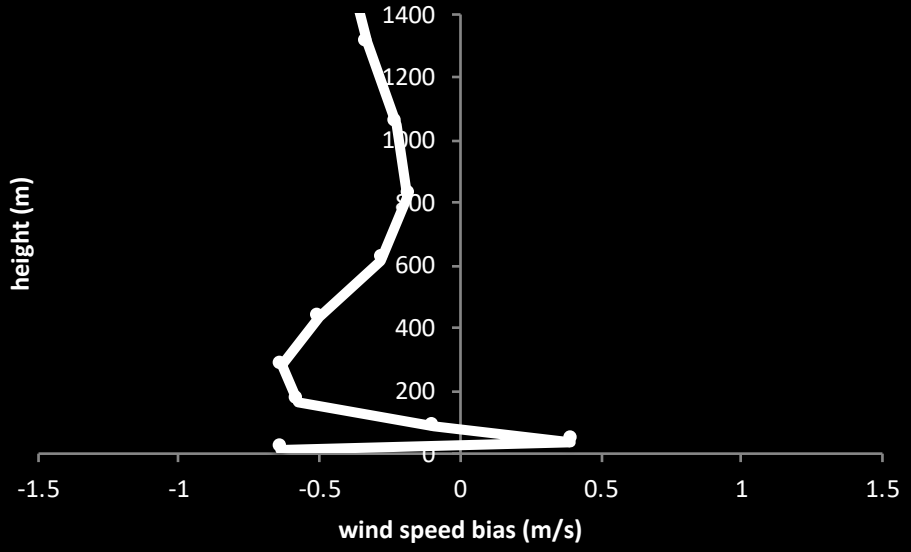
HRRR 00Z wind profiles



Wind speed bias 00Z

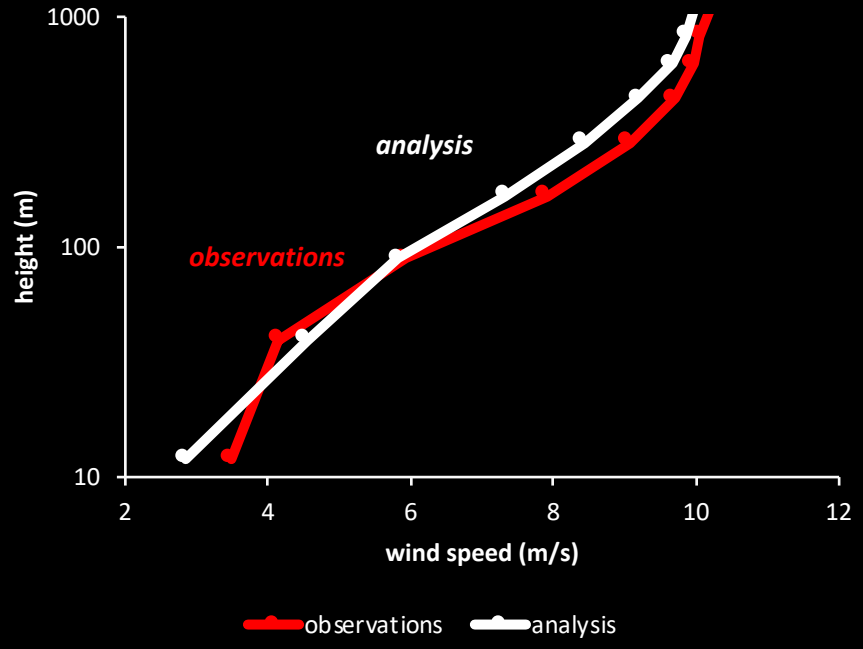


Wind speed bias 12Z

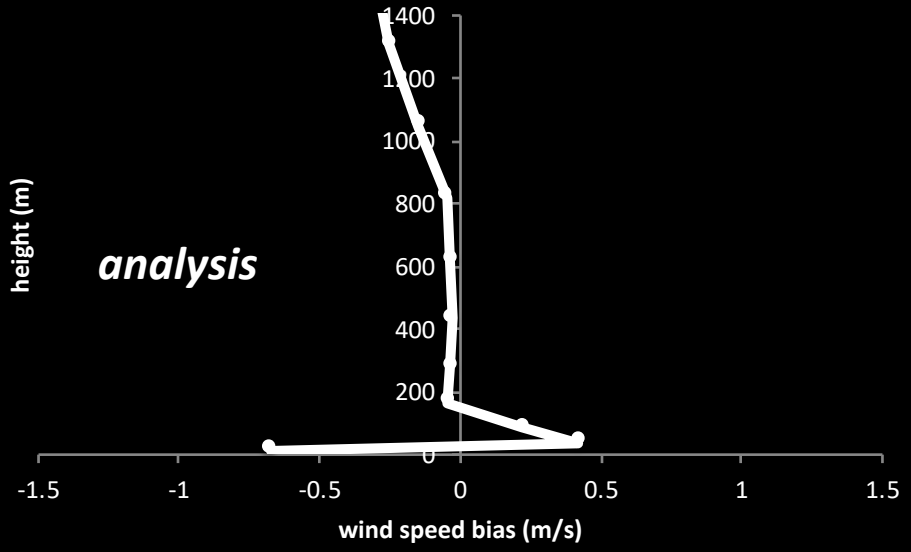


Forecast bias vs. height
April 2019

HRRR 12Z wind profiles

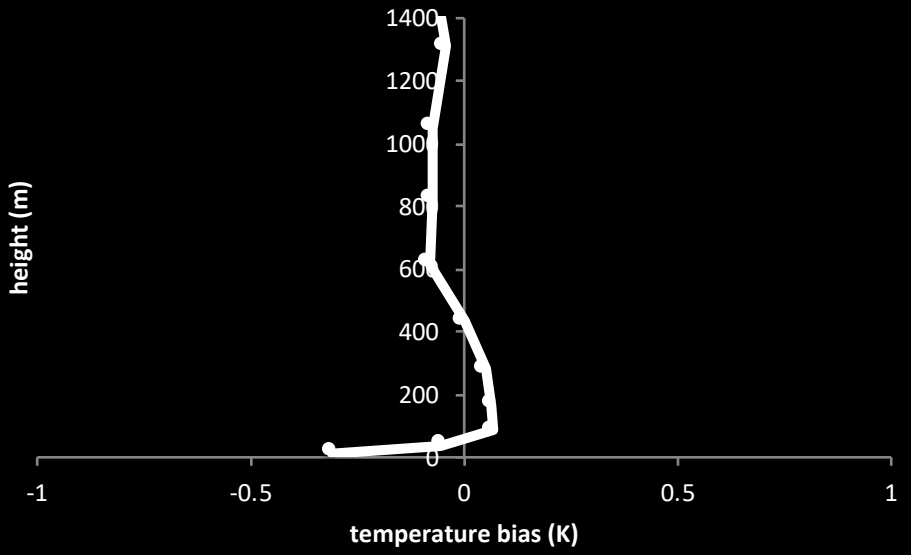


Wind speed bias 00Z

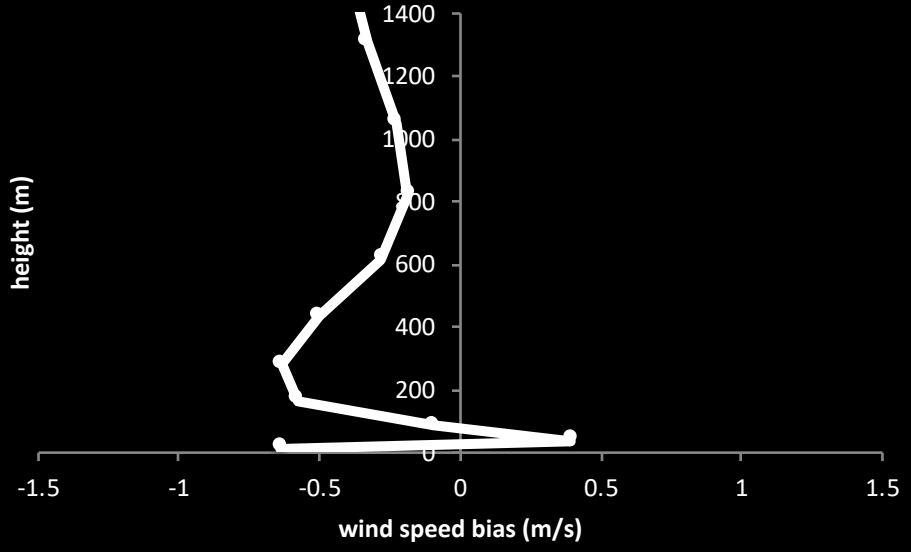


analysis

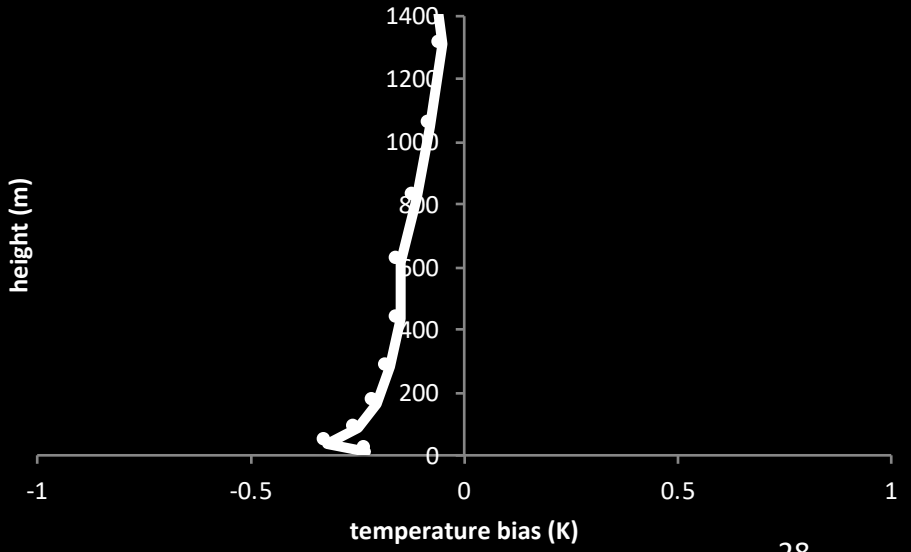
Temperature bias 00Z



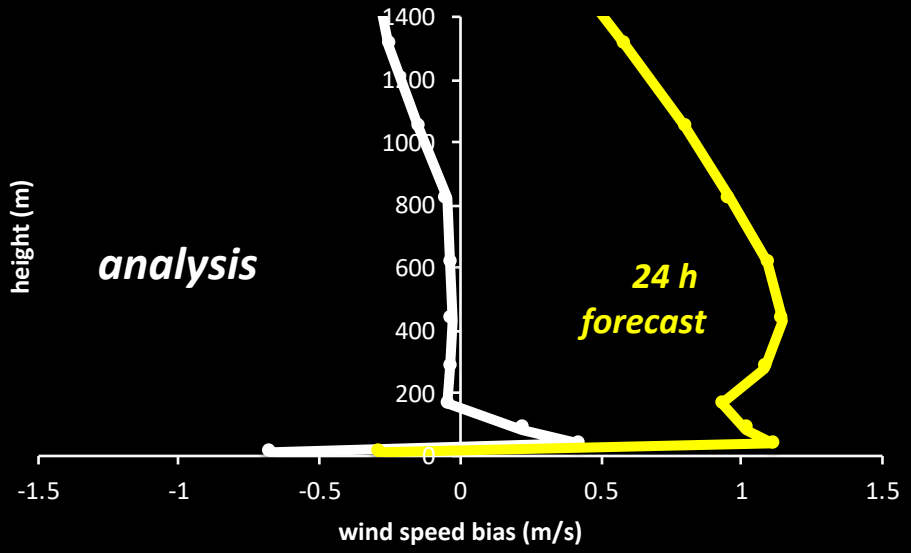
Wind speed bias 12Z



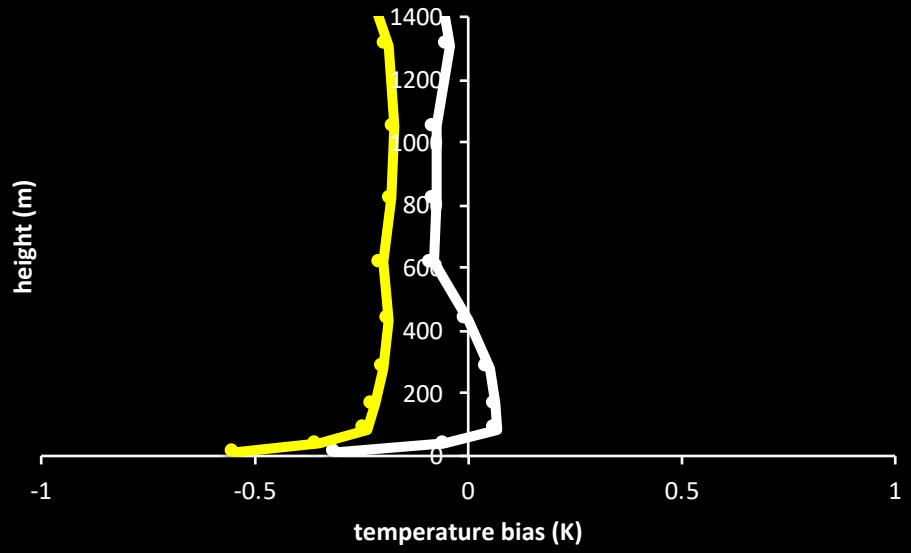
Temperature bias 12Z



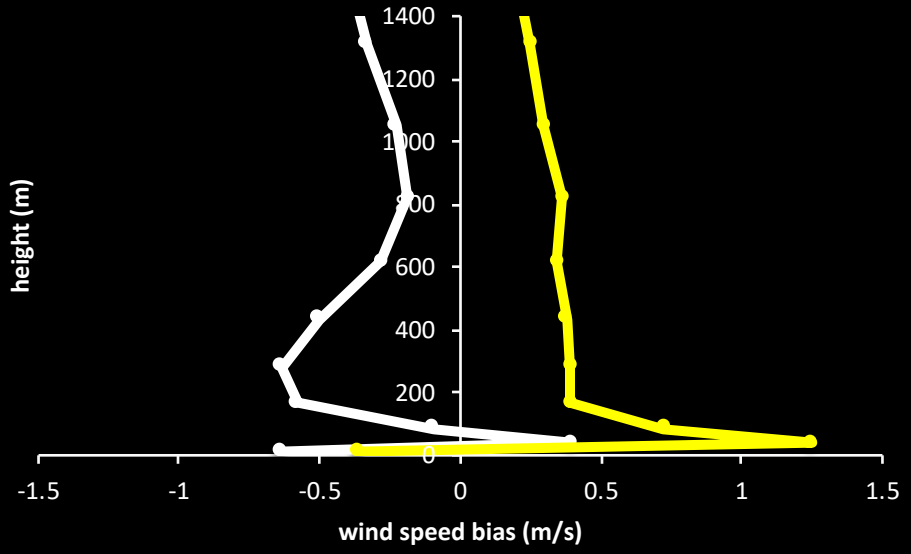
Wind speed bias 00Z



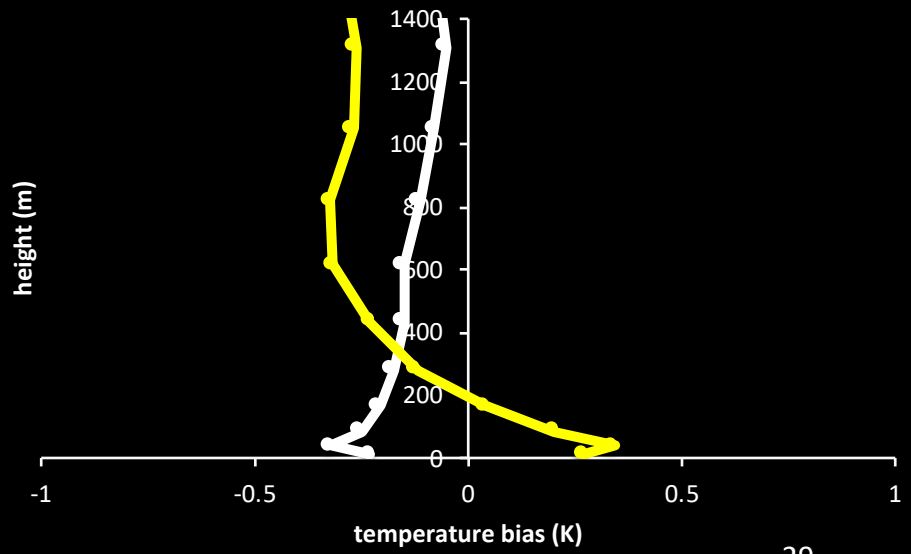
Temperature bias 00Z



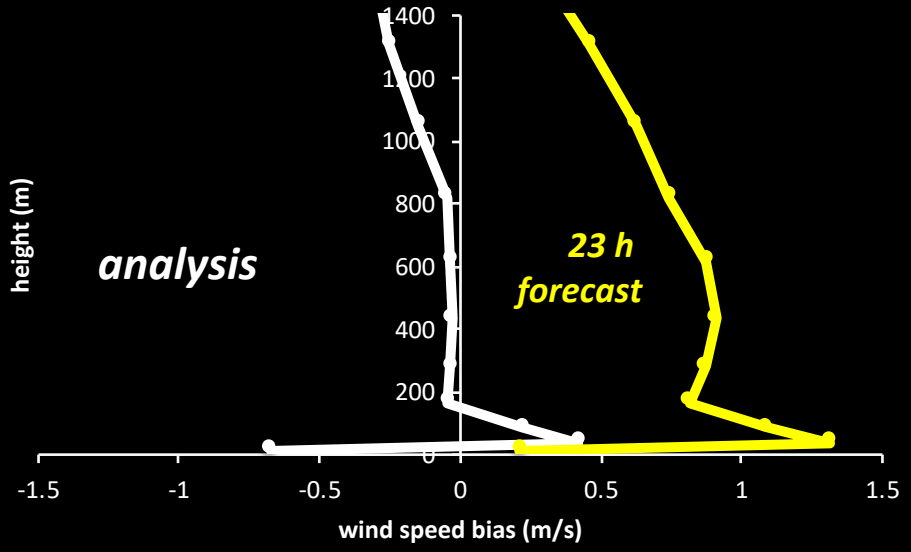
Wind speed bias 12Z



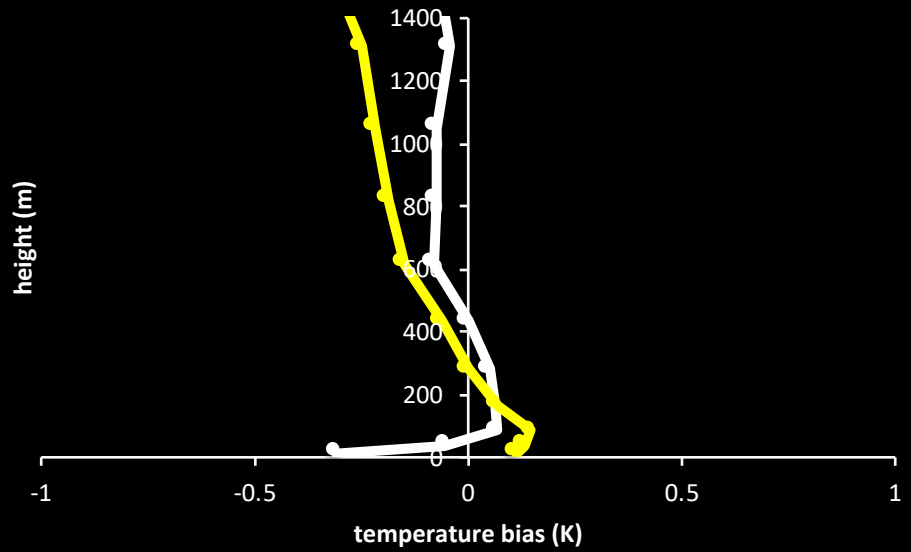
Temperature bias 12Z



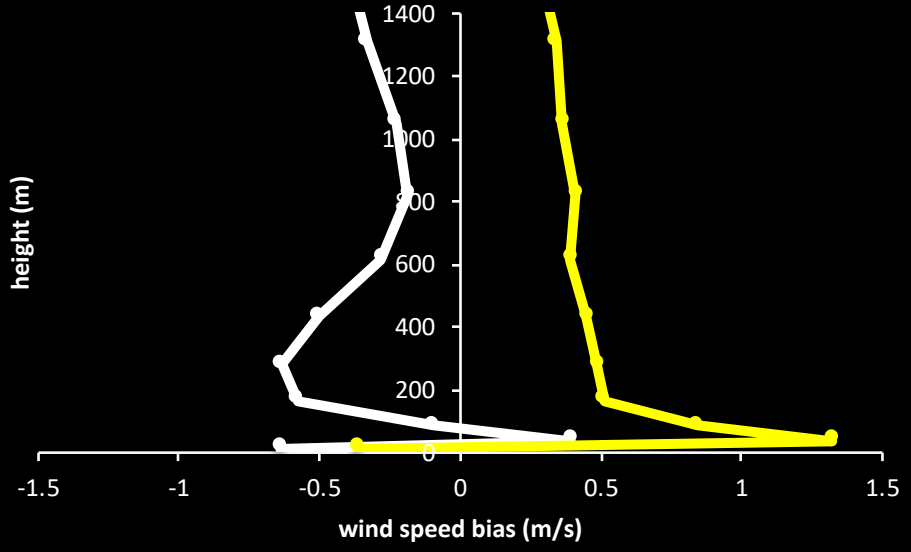
Wind speed bias 00Z



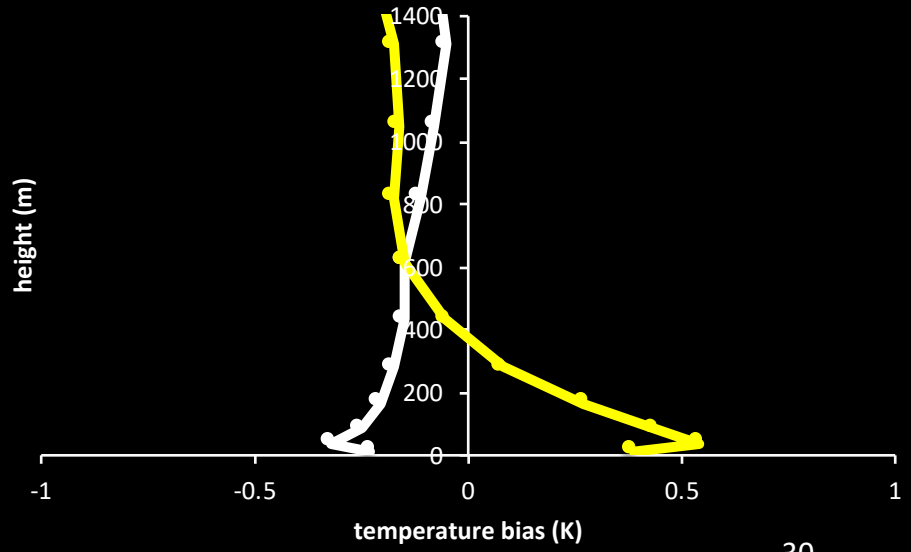
Temperature bias 00Z



Wind speed bias 00Z



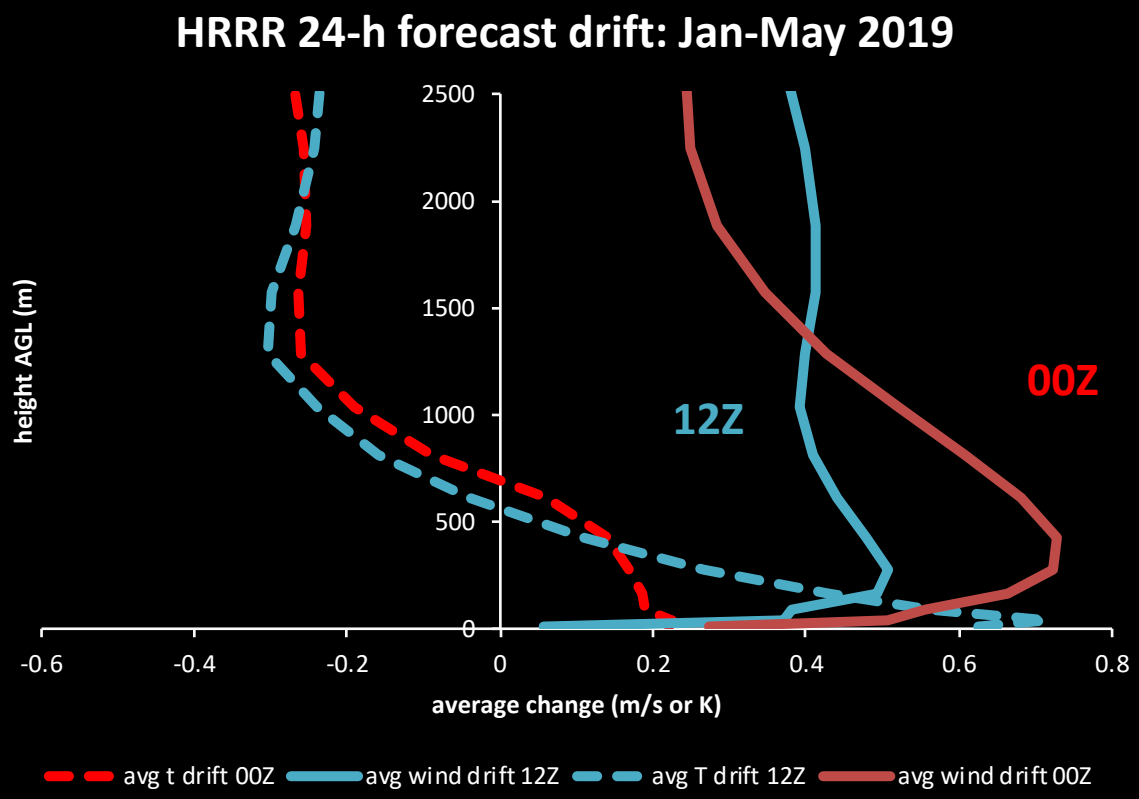
Temperature bias 12Z



Summary

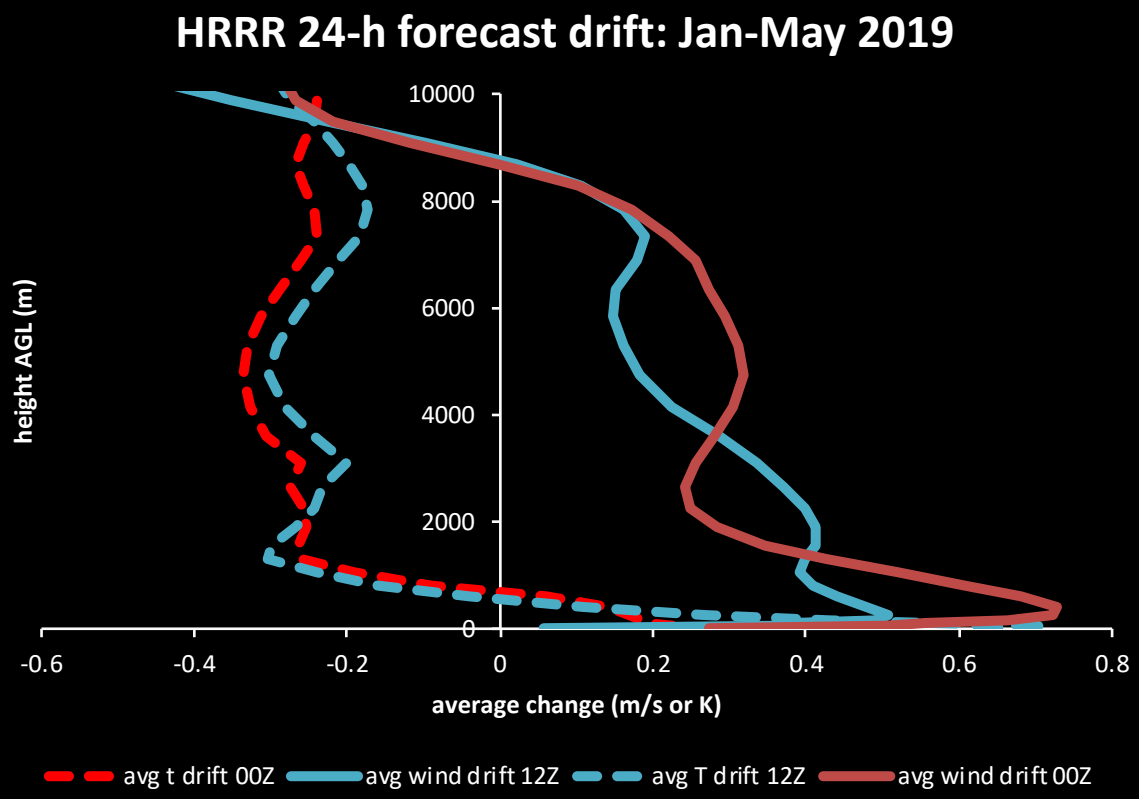
- 24-h forecast drift April 2019:
  - Wind speed increases both day and night (robust)
  - Nocturnal stability decreases near surface
- Radiosonde comparison indicates analysis possesses less bias
- Further analysis suggests fast wind bias emerges quickly & occurs in other months
- Sources of errors/differences: PBL mixing magnitude and depth, surface layer, land surface model, microphysics, clouds & radiation, and larger-scale contributions etc..

HRRR forecast drift: Jan-May 2019



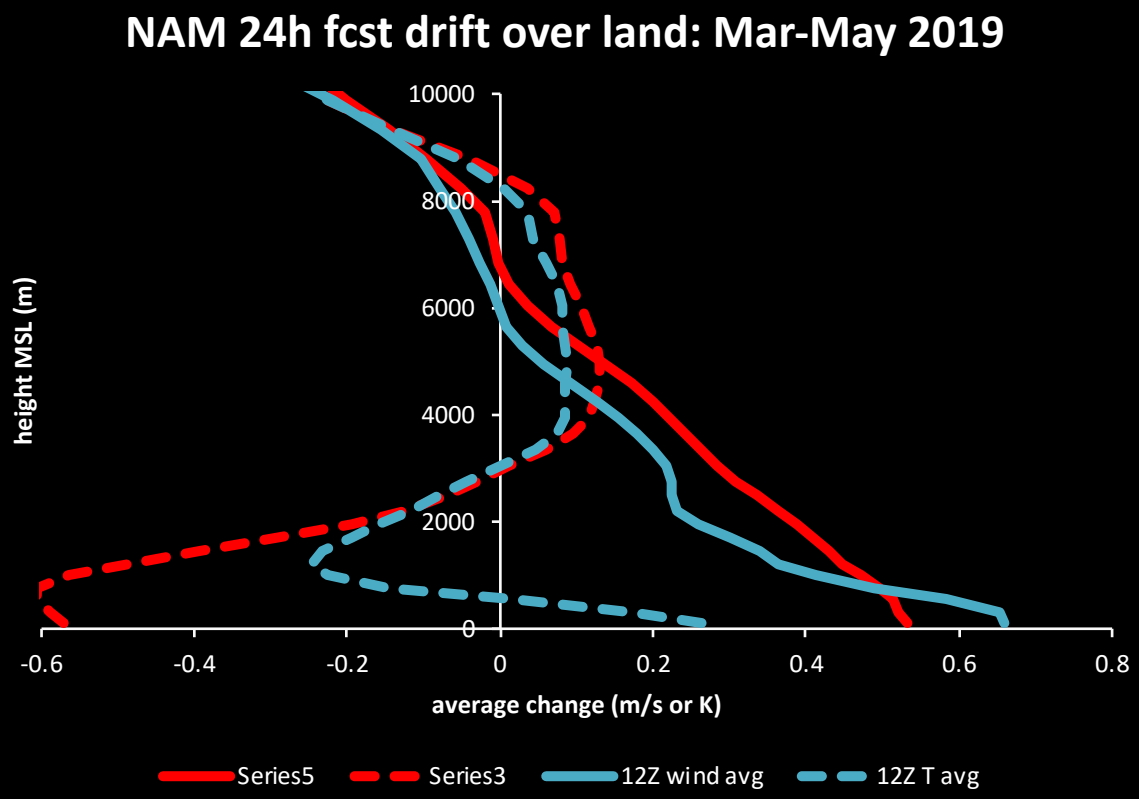
NO OBSERVATIONS DIRECTLY INVOLVED
but analysis bias < forecast bias

HRRR forecast drift: Jan-May 2019



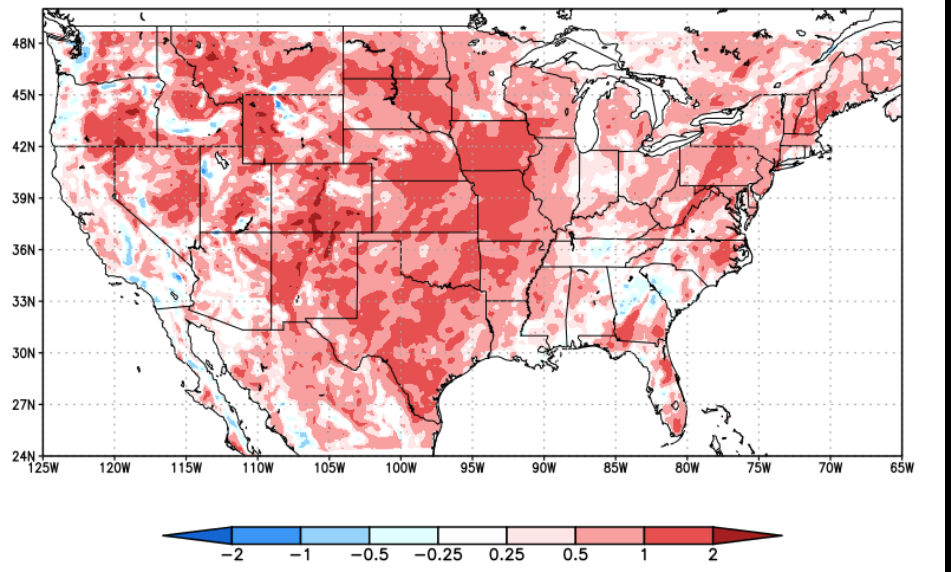
NO OBSERVATIONS DIRECTLY INVOLVED
but analysis bias < forecast bias

NAM forecast drift: Mar-May 2019



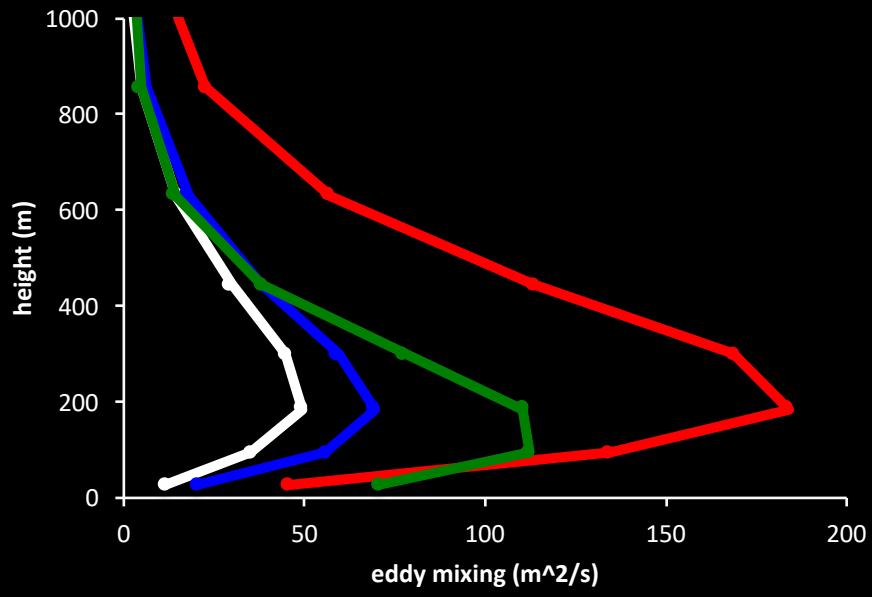
NAM data on pressure levels;
Heights are MSL

Near-surface wind speed difference @ 18Z

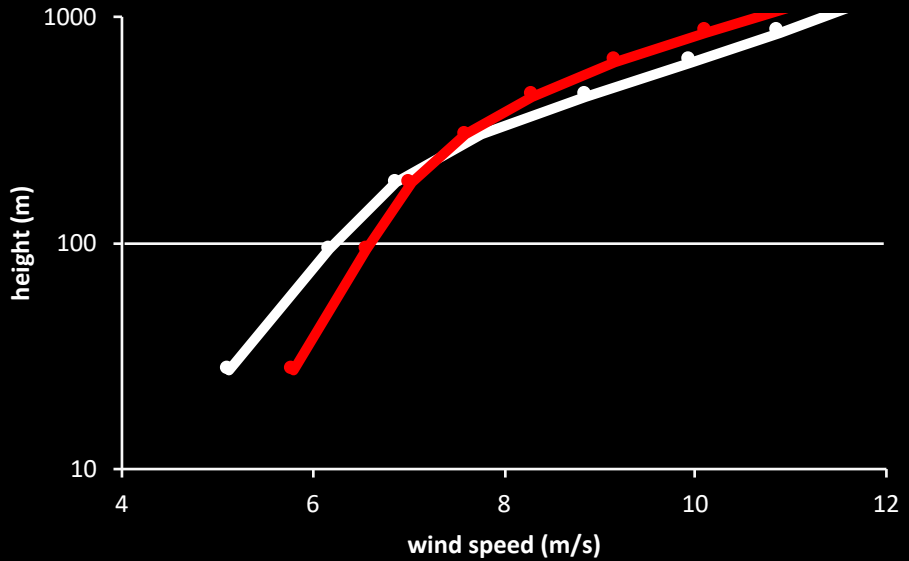


Limited non-HRRR PBL experiment

Average mixing over land at 18Z



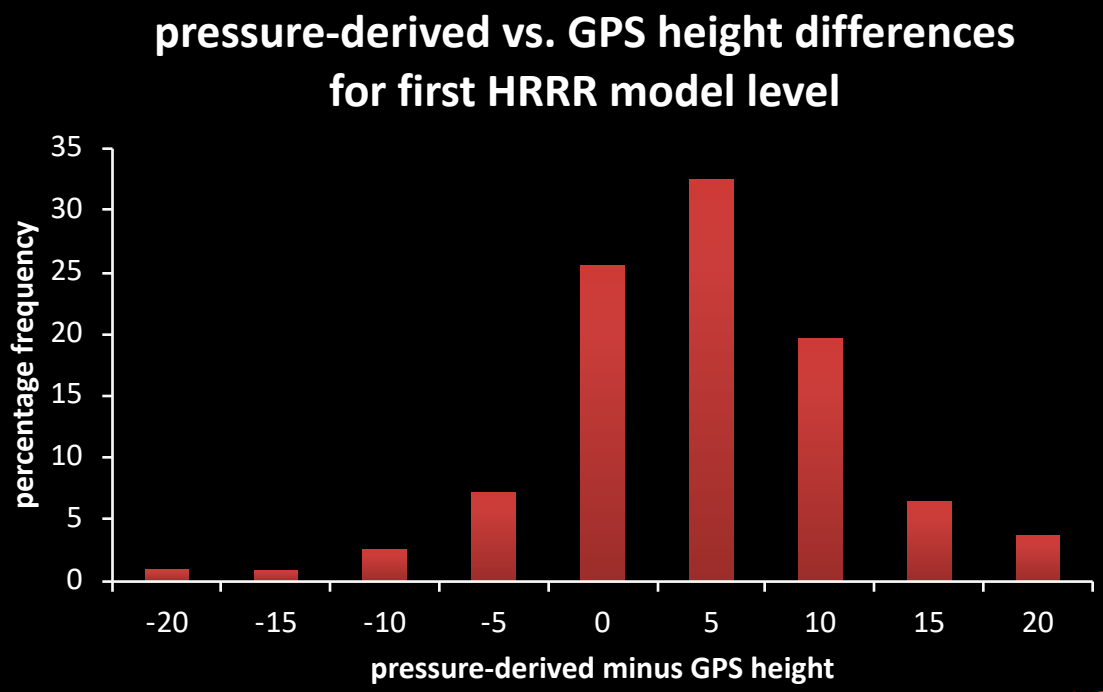
18Z average wind profiles



PBL positive wind bias probably not mixing since it is so deep

[end]

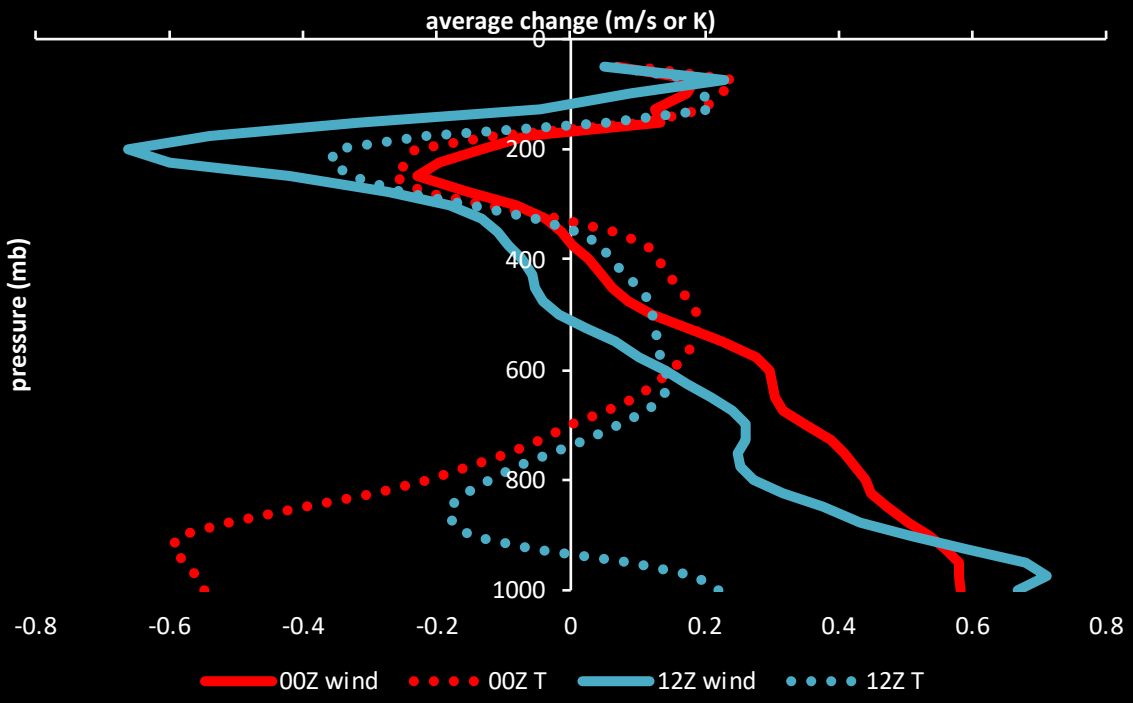
Observation height discrepancies



Mean difference ~2 m

GPS instrument generally gives
lower height estimate

NAM 24h forecast drift over land: May 2019



Comparison with observations

- **Standard** assessment
  - 00Z & 12Z observations compared to 24 h forecasts
  - Ignores temporal shift
- **Shifted** assessment
  - 00Z & 12Z observations compared to 23 h forecasts
  - May overcompensate for temporal shift
- This presumes the *analysis* has properly incorporated the sonde observations