Validation of a 14-year High-resolution WRF Dataset for Wind Resource Assessment over Alaska

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9th Conference on Weather, Climate, and the New Energy Economy • Talk 1.4
98th AMS Annual Meeting • Monday 8 January 2018 • Austin, TX

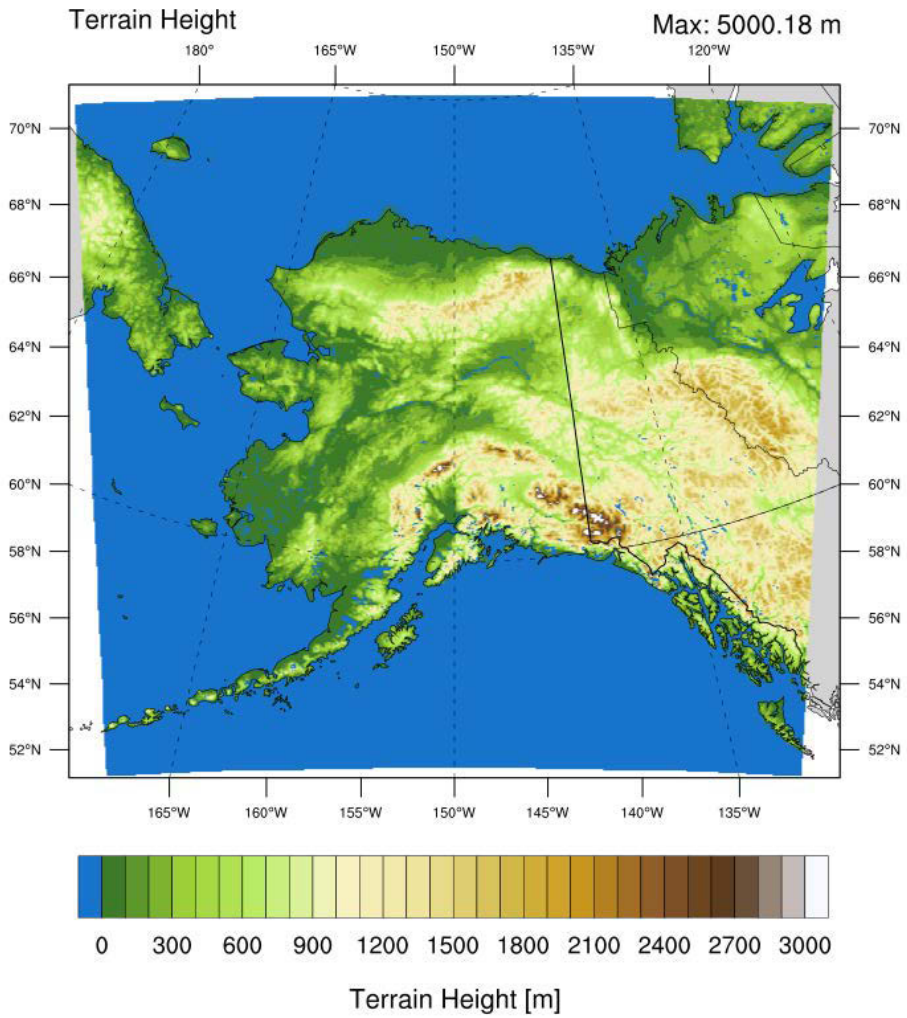
NREL/PR-5000-70785

Motivation

- Alaska only has three utility-scale wind plants (62 MW capacity)
- Physical challenges to expanding wind power in Alaska
  - Geographical, climatic, cultural
- No long-term wind resource assessment in Alaska, both statewide and offshore

Source: The Telegraph (UK)

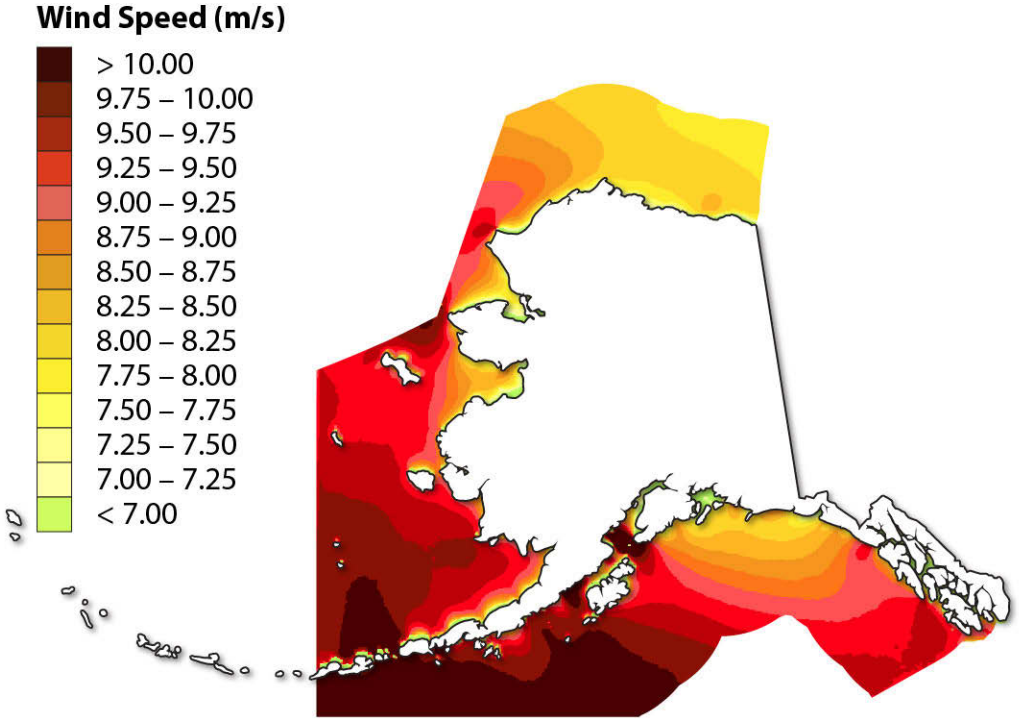
Weather Research and Forecasting (WRF) model configuration



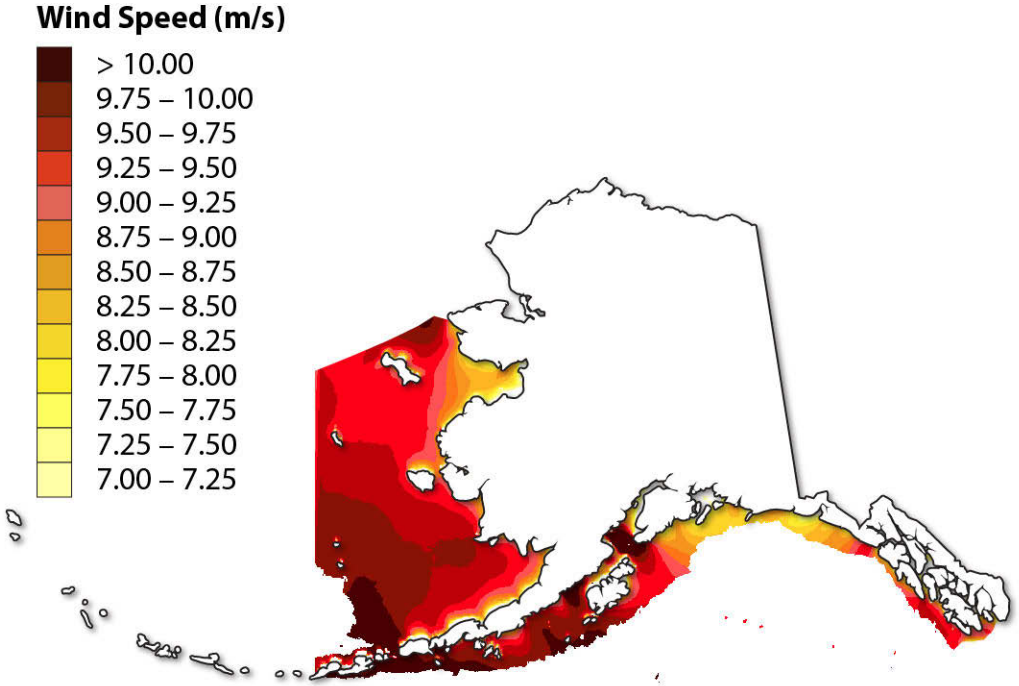
- WRF historical climate simulation from 15 Aug 2002 – 31 Aug 2016 (Monaghan et al. 2018, *J. Appl. Meteor. Climatol.*, in press)
  - WRF-ARW v3.7.1
  - Δx = 4 km, 49 vertical levels
  - Initial and lateral boundary conditions from ERA-Interim reanalysis dataset
  - Noah-MP land surface model
  - Thompson microphysics
  - RRTMG radiation
  - YSU boundary layer / MM5 surface layer
- Compared against available wind speed obs from 1 Sep 2002 – 31 Dec 2014
- Select fields publicly available for download and analysis at doi:10.5065/D61Z42T0

14-year WRF mean 100-m wind speed

All offshore areas within WRF domain and exclusive economic zone (EEZ) boundaries



After filtering out unsuitable wind speed, sea ice, and bathymetry conditions



Figures from Doubrawa, P., G. Scott, W. Musial, L. Kilcher, C. Draxl, and E. Lantz, 2017: Offshore Wind Energy Resource Assessment for Alaska (Technical Report No. TP-5000-70553). National Renewable Energy Laboratory.

Observation Info

- Radiosonde data (12-hrly)
  - Alaska only (i.e., no Canada)
  - Lowest 500 m AGL
- Surface data from MADIS (1-hrly)
  - METAR, Mesonet, Maritime
  - Full domain coverage
- For offshore model validation, focus on stats for Maritime obs
- Discarded obs with bad MADIS QC values and gross error check failures
- If multiple obs within an hour at same location, kept only the observation closest to top of the hour

Source: NOAA NDBC

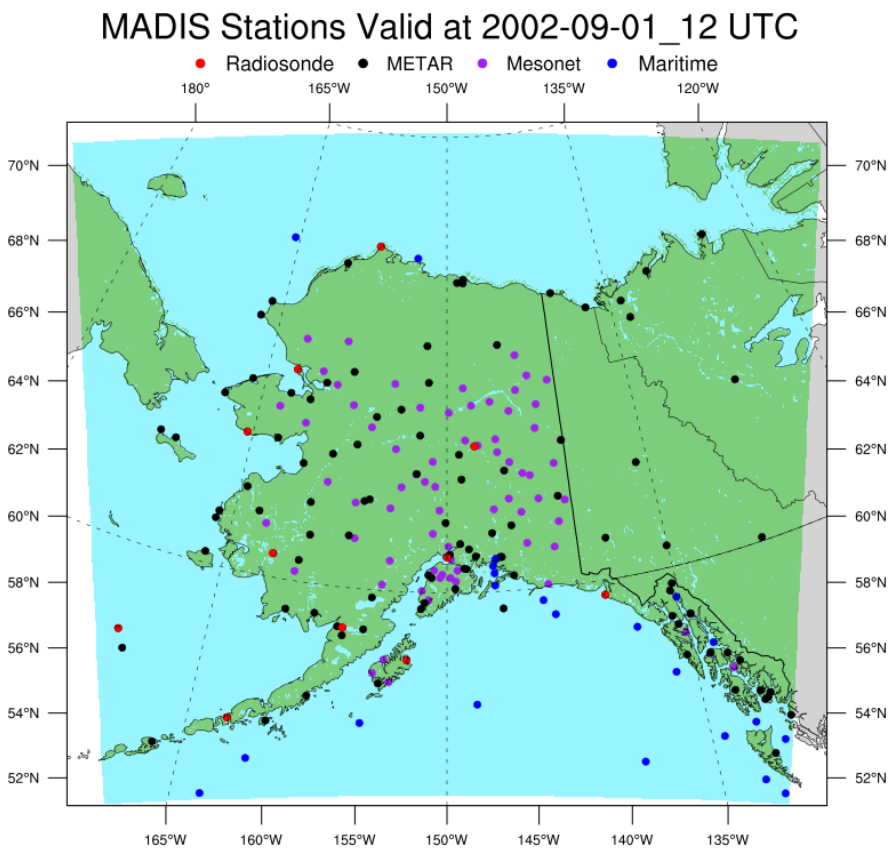
Observation statistics

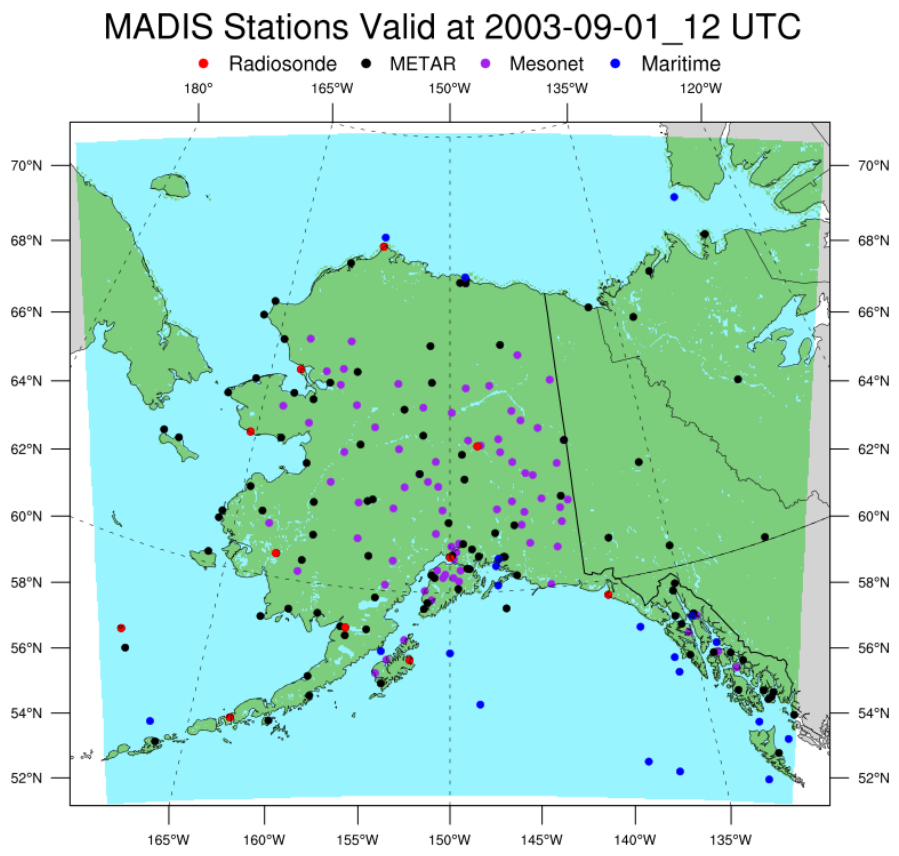
- Both within each Energy Region (defined by Alaska Energy Authority, extended offshore by NREL) separately and domain-wide, computed these stats:
  - RMSE
  - MAE
  - ME (Bias)
  - Nash-Sutcliffe Efficiency
- Compiled hour-by-hour stats, then averaged into daily means, then averaged into monthly means, then averaged into calendar yearly mean values

$$NSE = 1 - \frac{(f_m - f_o)^2}{\left(f_o - \overline{f_o}\right)^2}$$

- Nash-Sutcliffe Efficiency (NSE) assesses predictive power of models
  - First developed for hydrologic models
  - Range of [-∞, 1]
- E = 1: perfect match between model and obs
- E > 0: model is better predictor of than the mean of the obs
- E < 0: mean of the obs is better predictor than the model

Domain and valid stations by network





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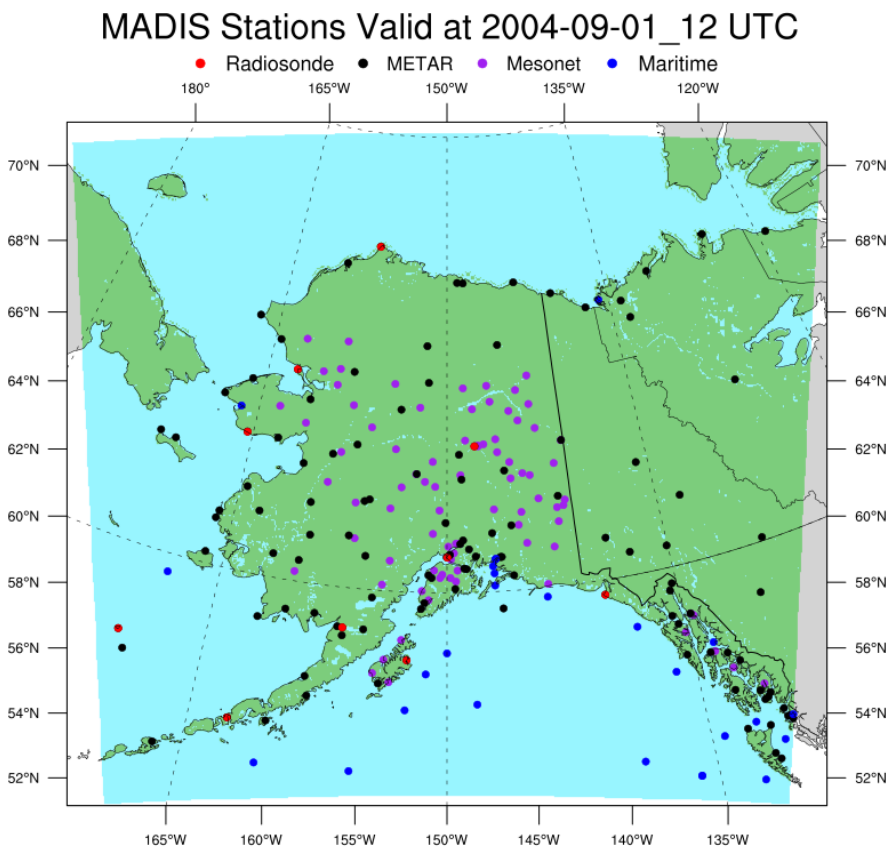

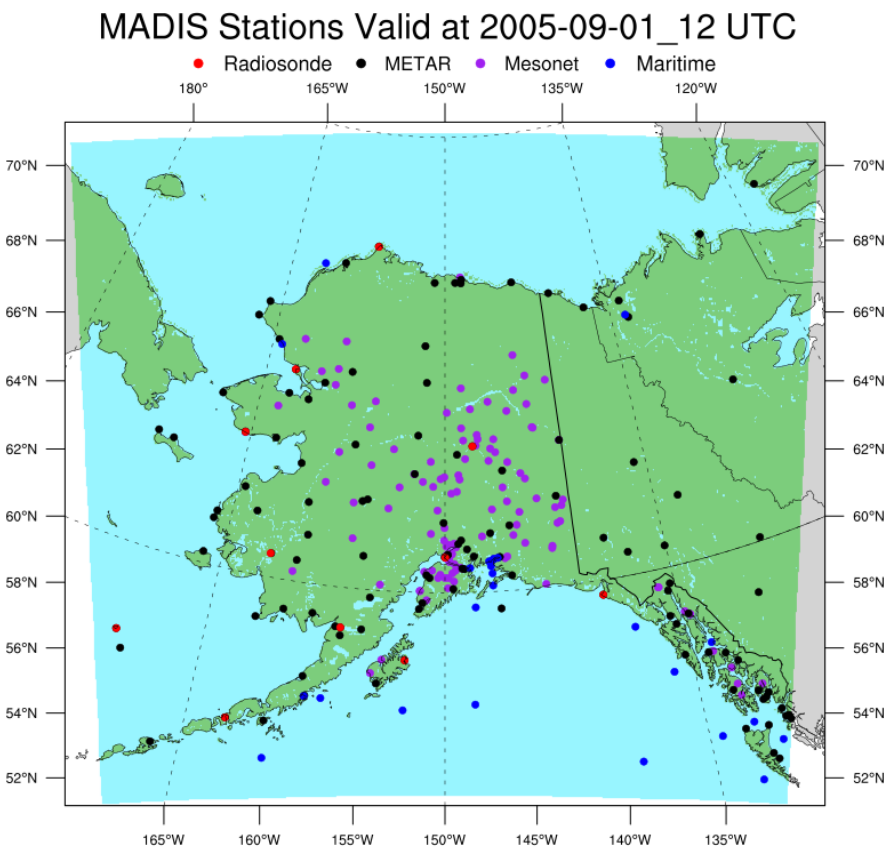

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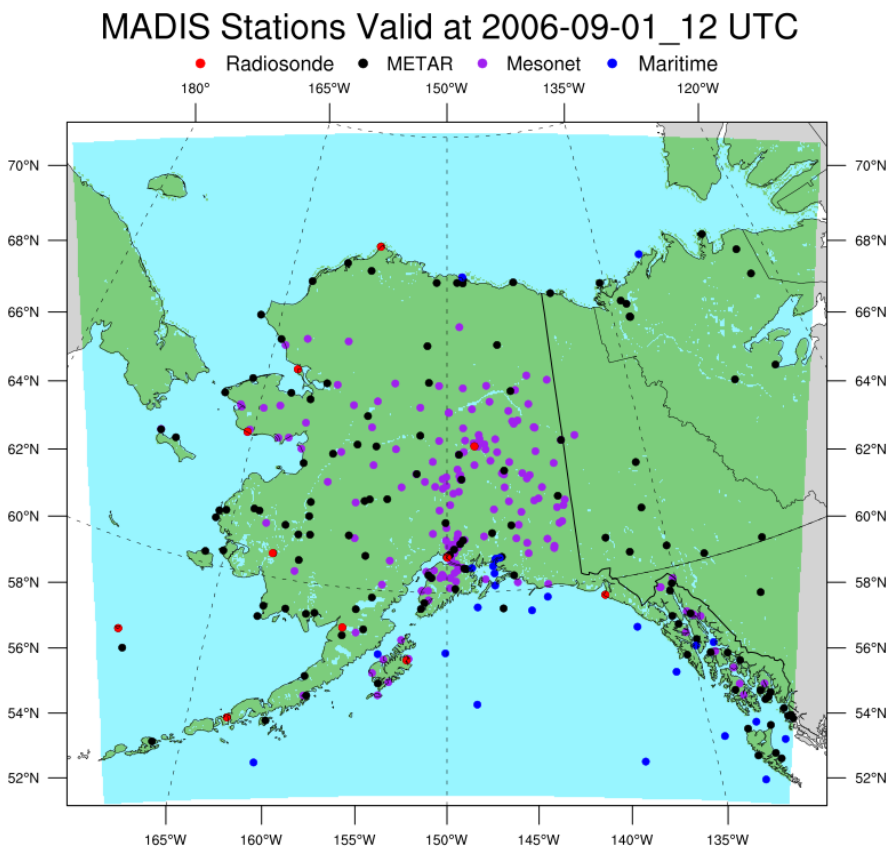

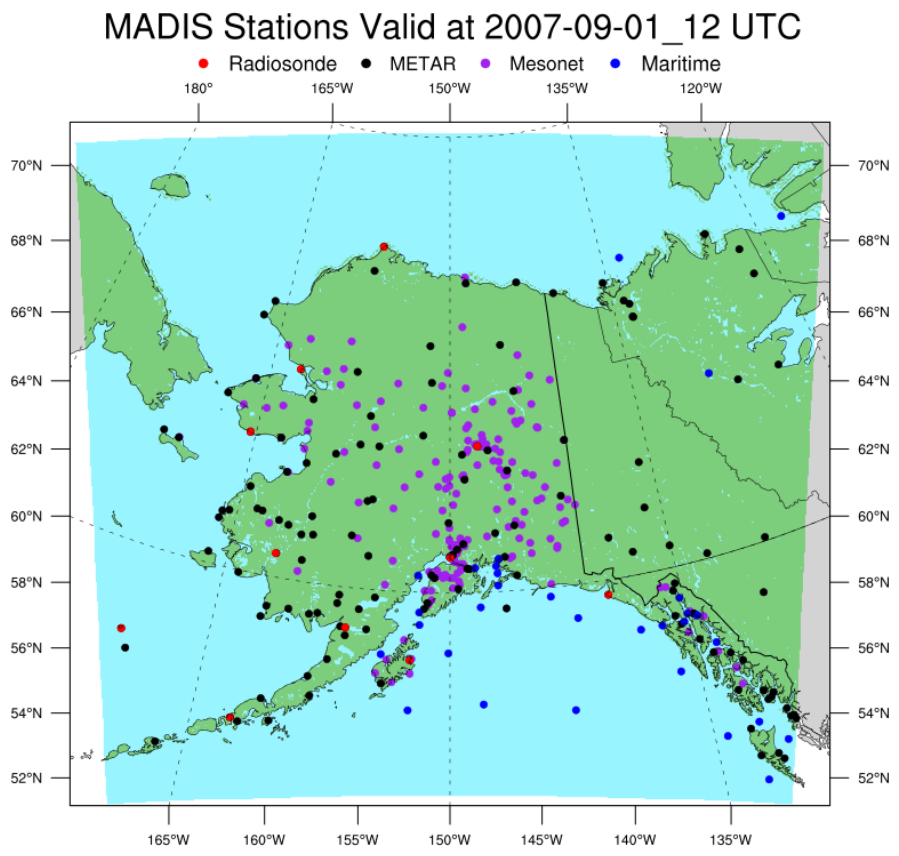

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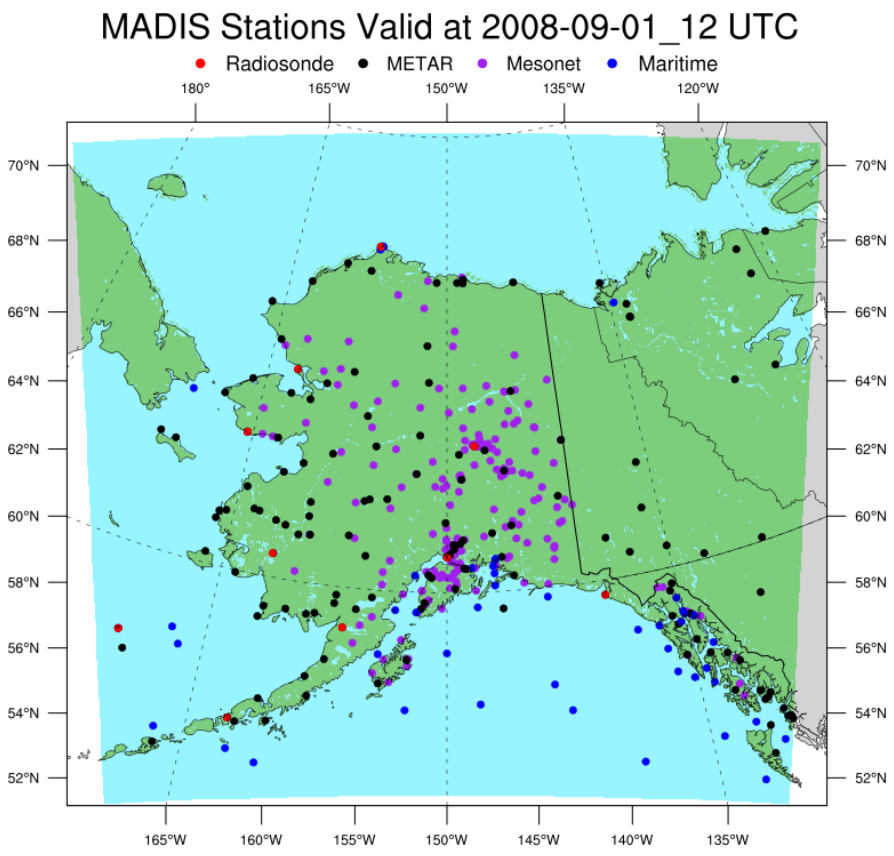

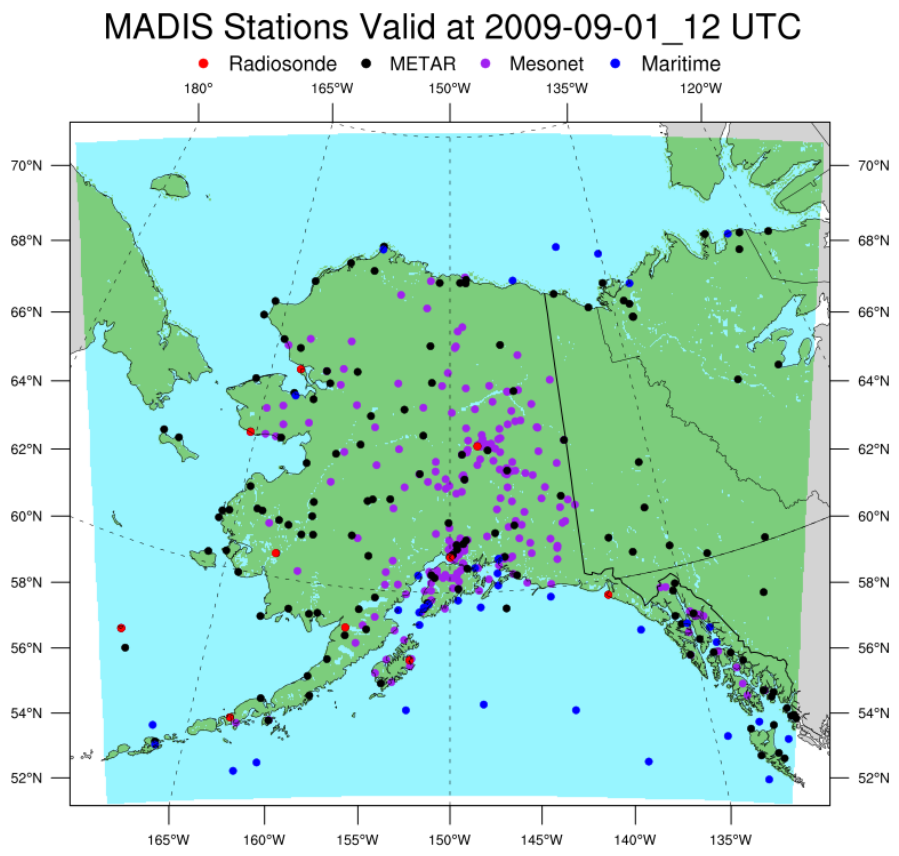

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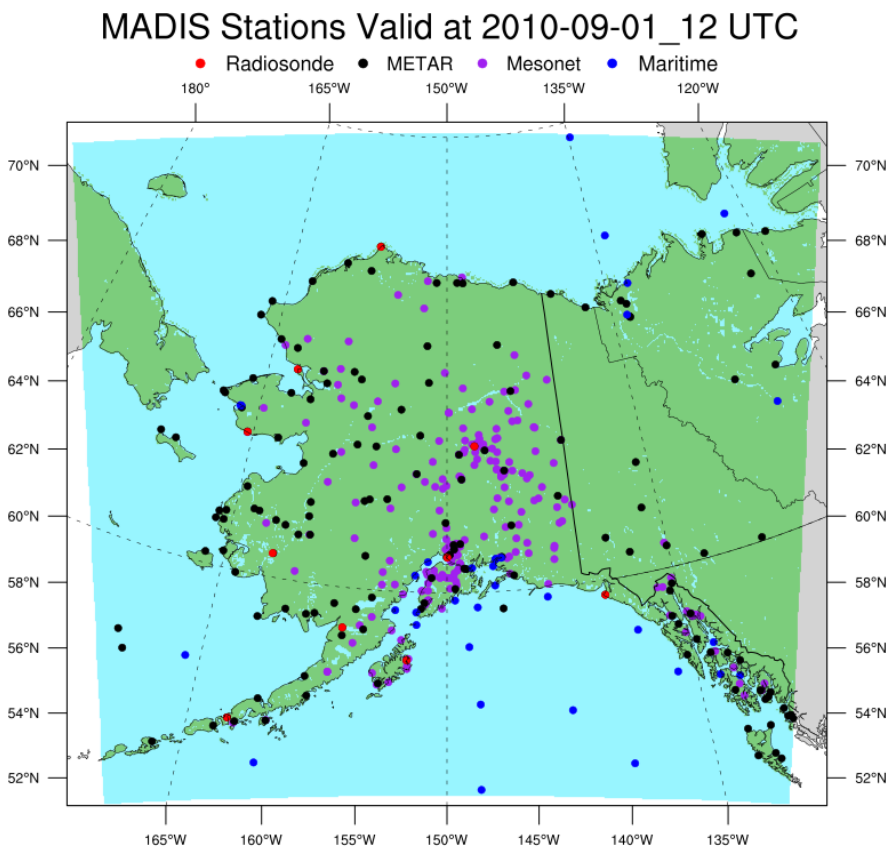

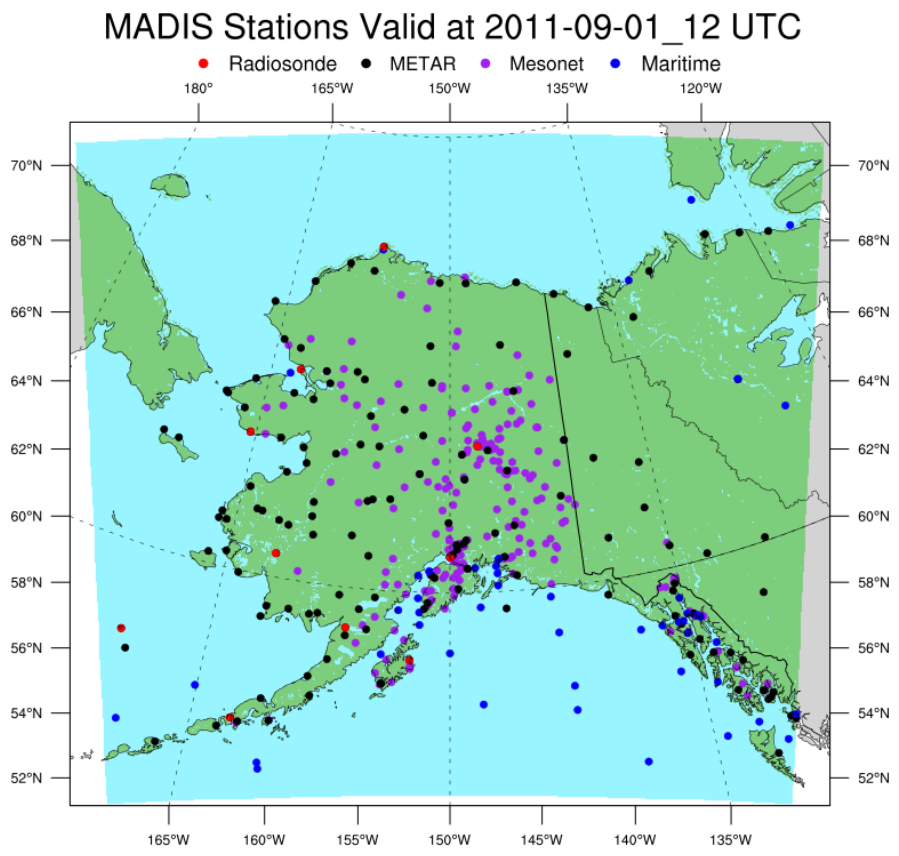

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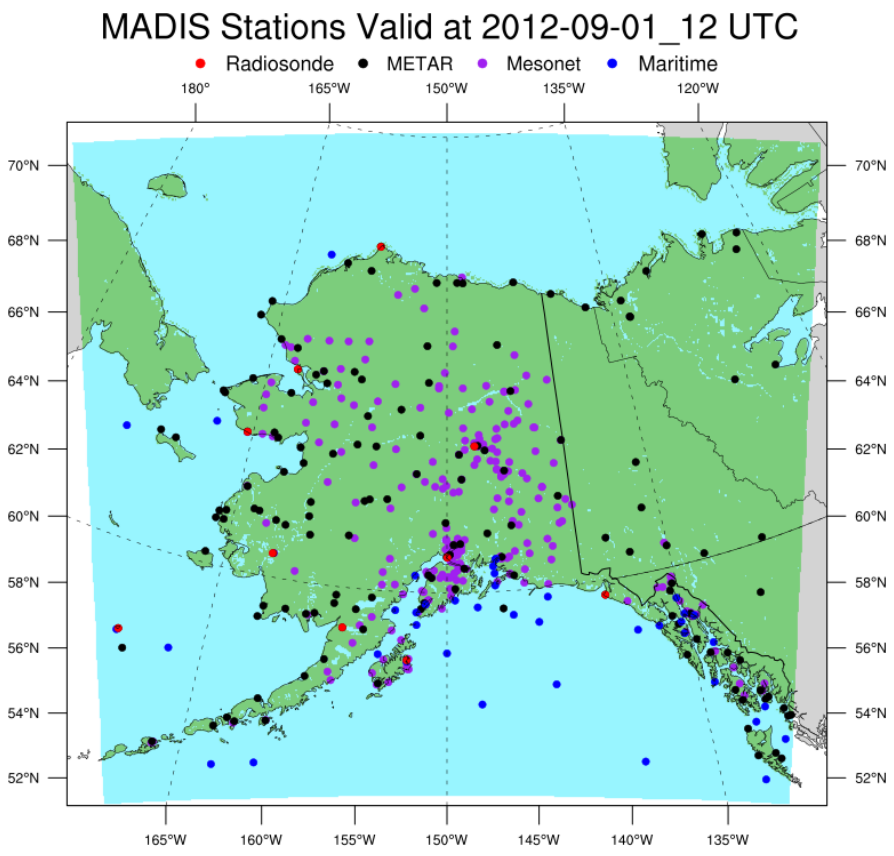
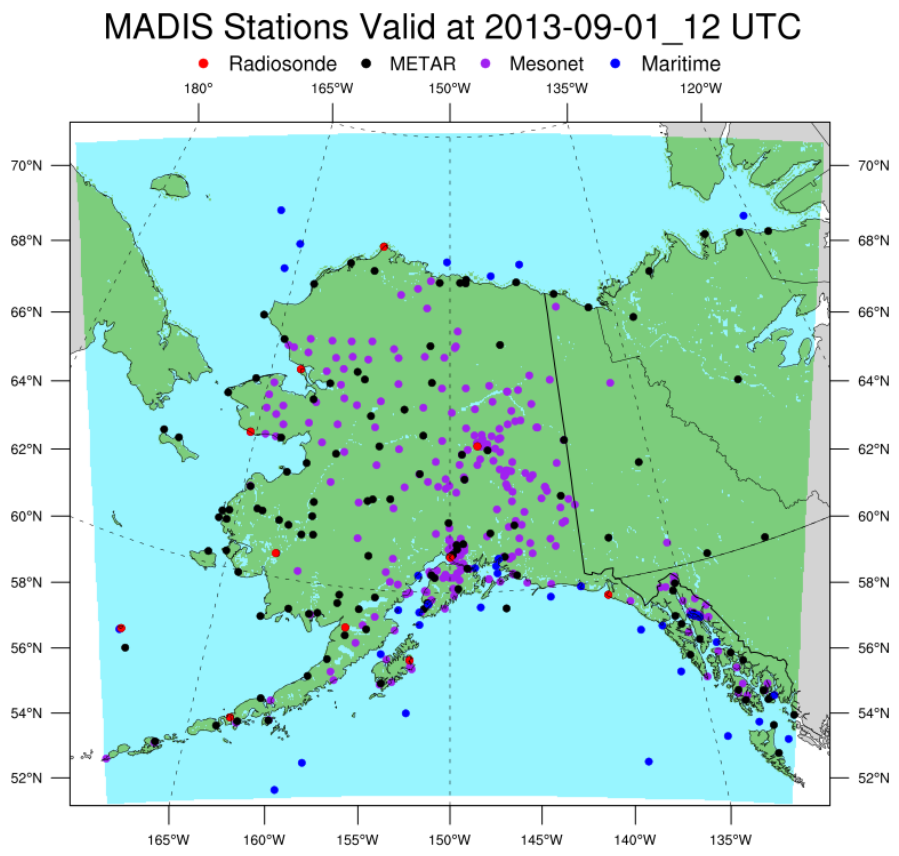
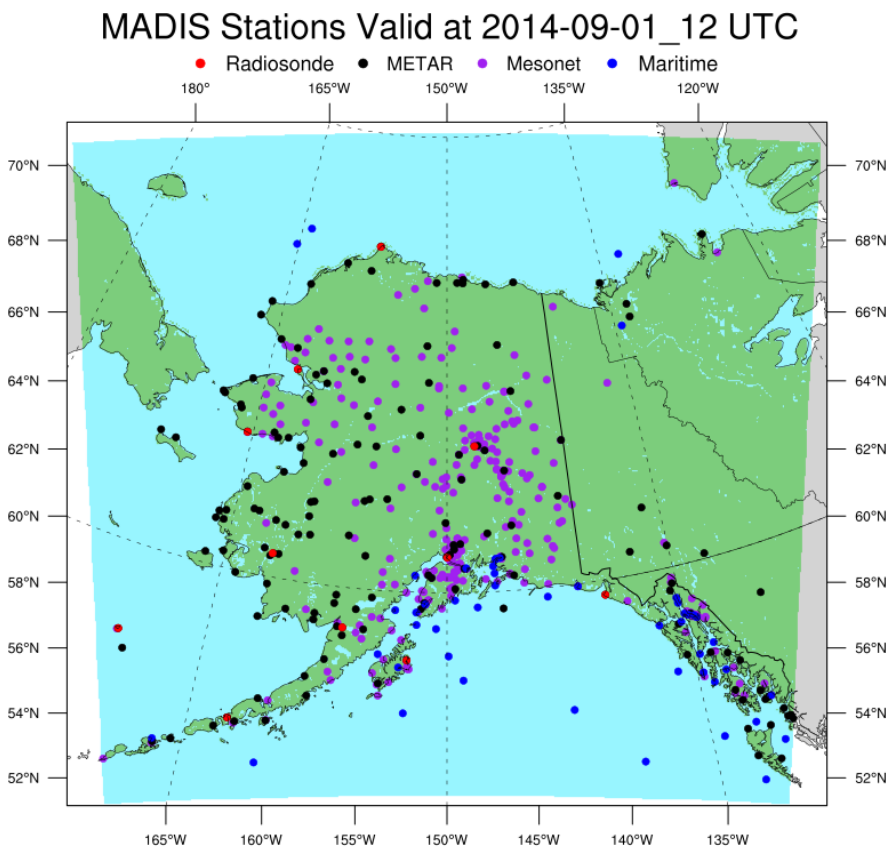
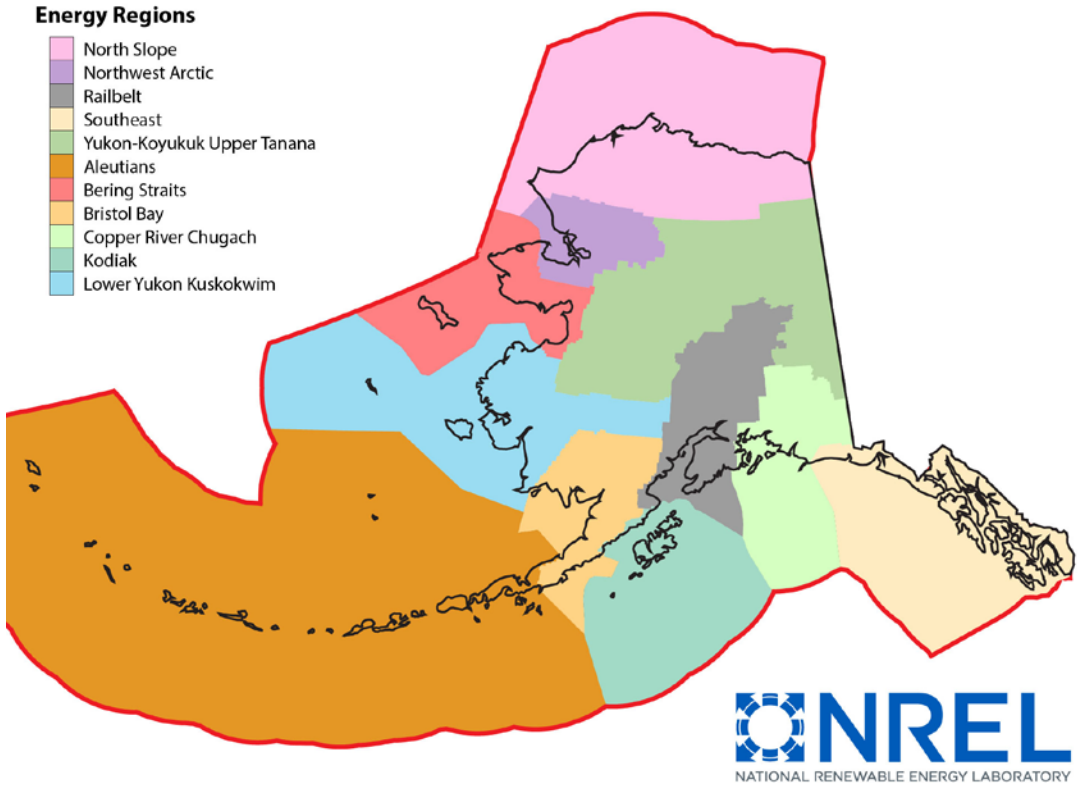


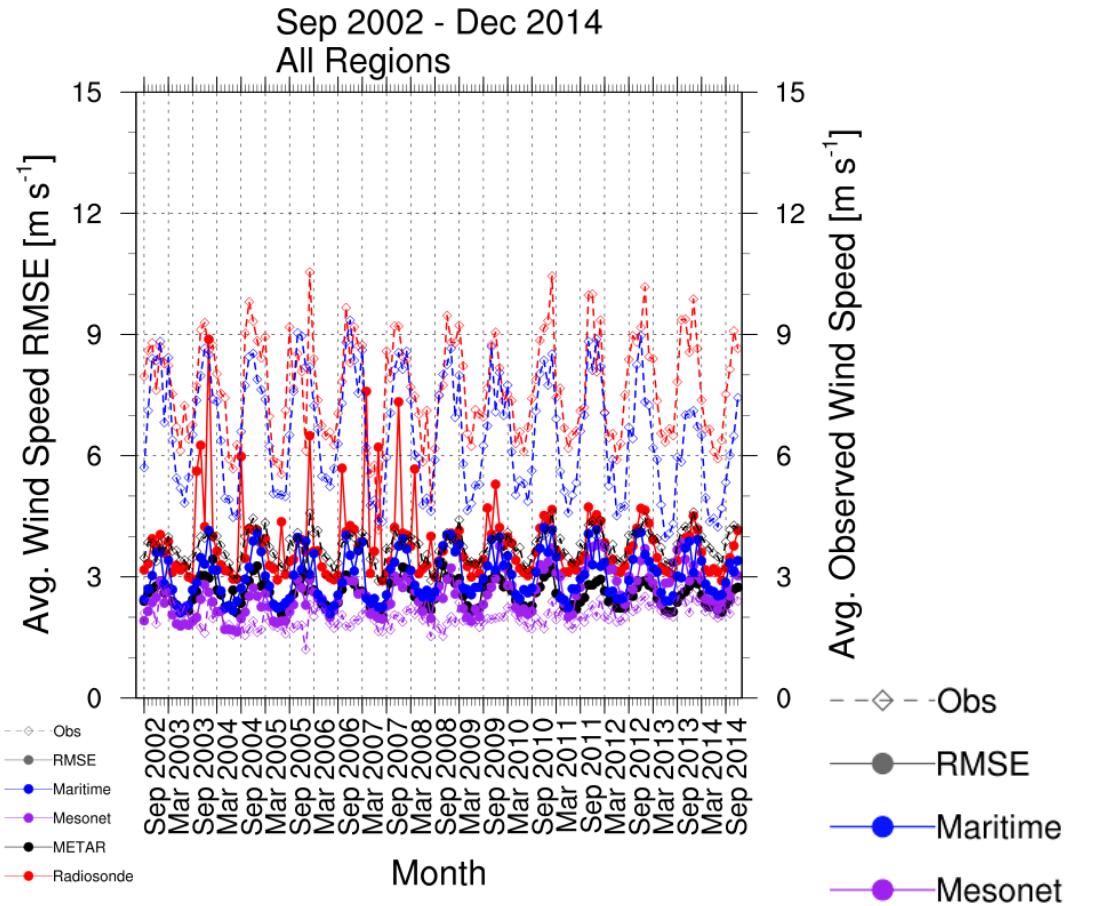


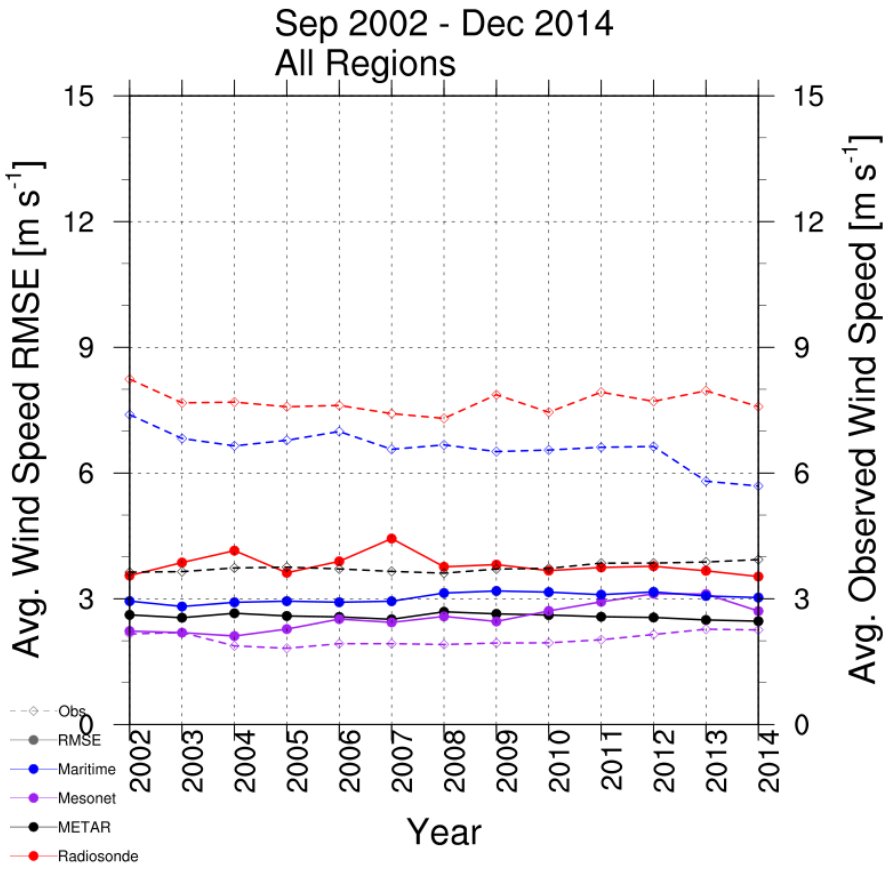
Domain and valid stations & Energy Regions



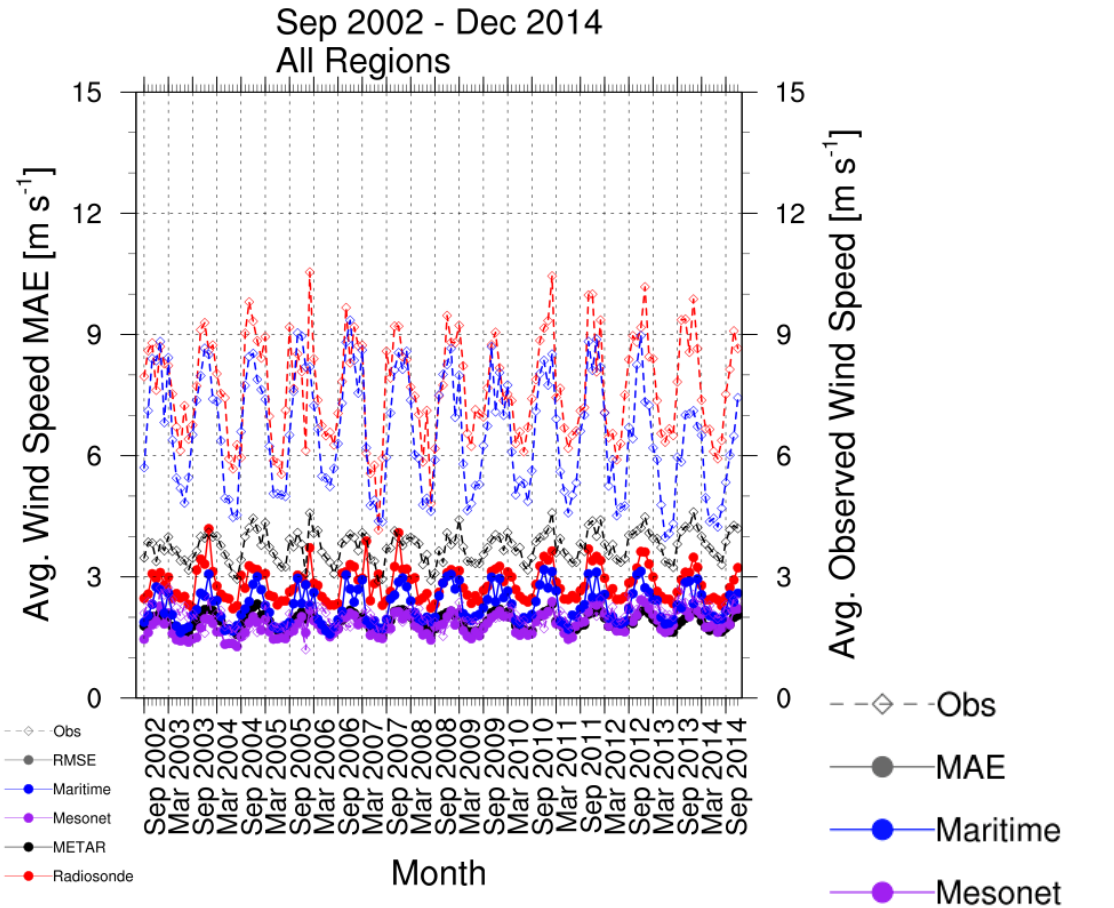


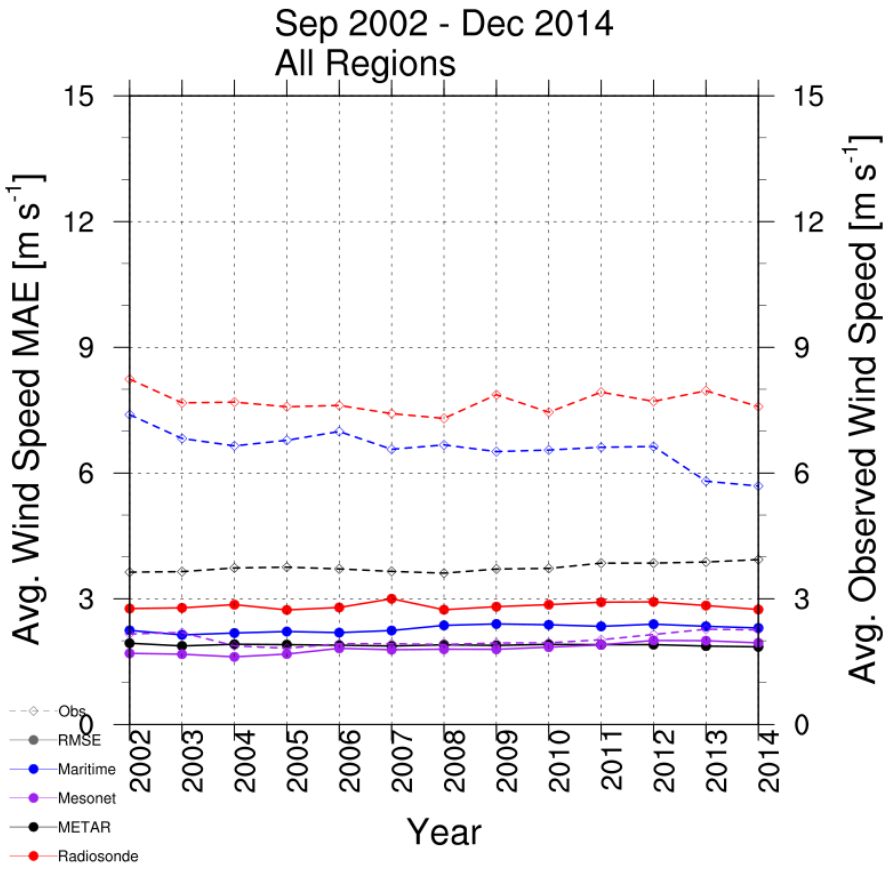
All-domain stats: RMSE (solid), Obs (dashed)





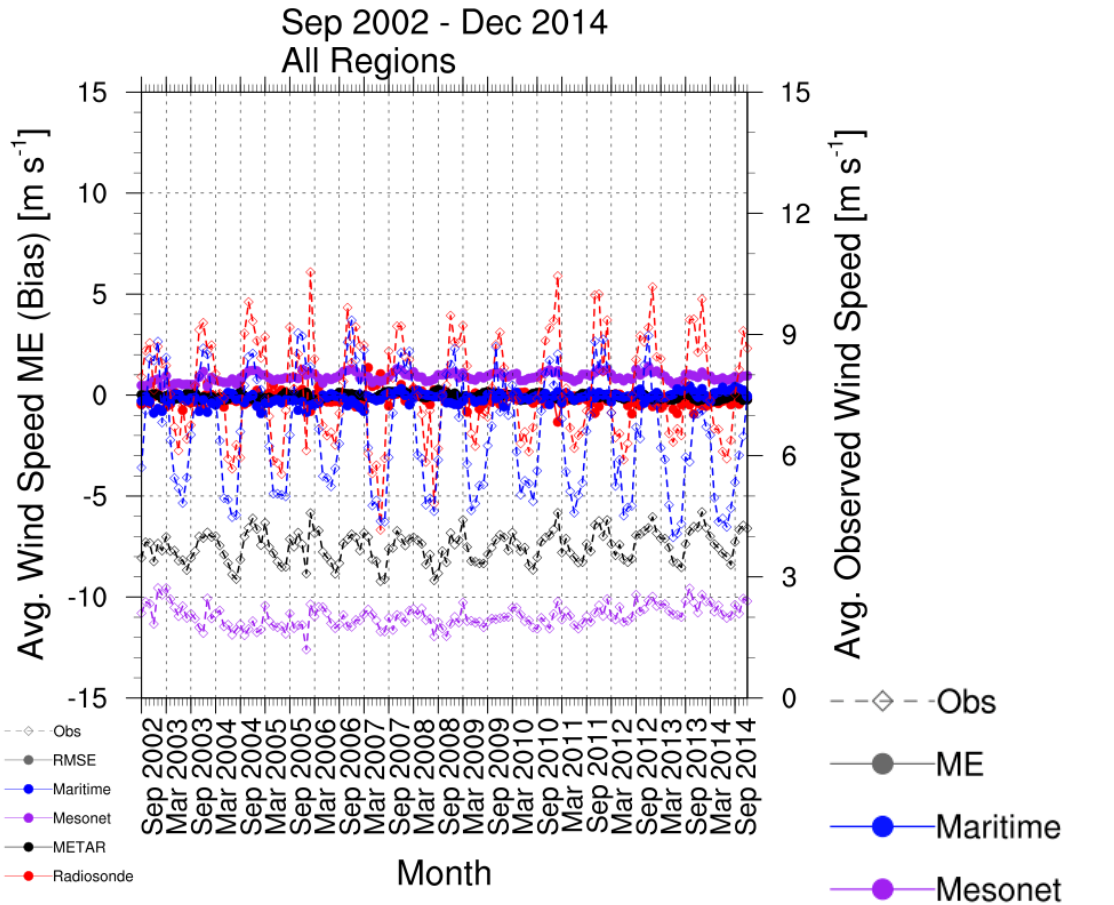
All-domain stats: MAE (solid), Obs (dashed)

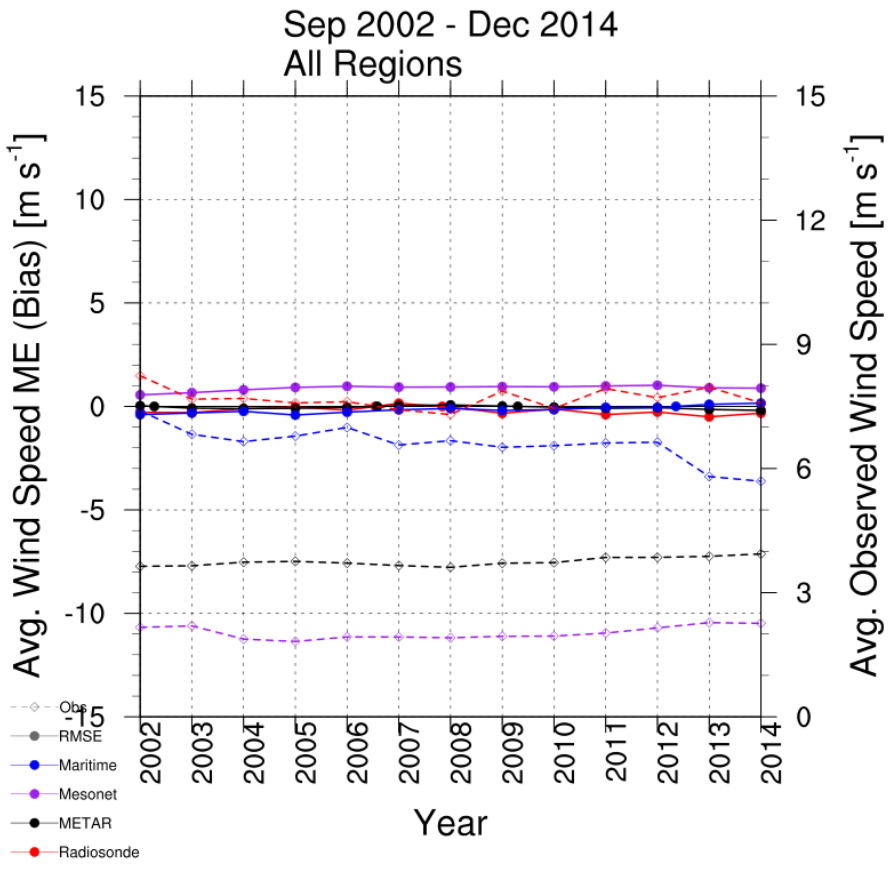




Obs
MAE
Maritime
Mesonet
METAR
Radiosonde

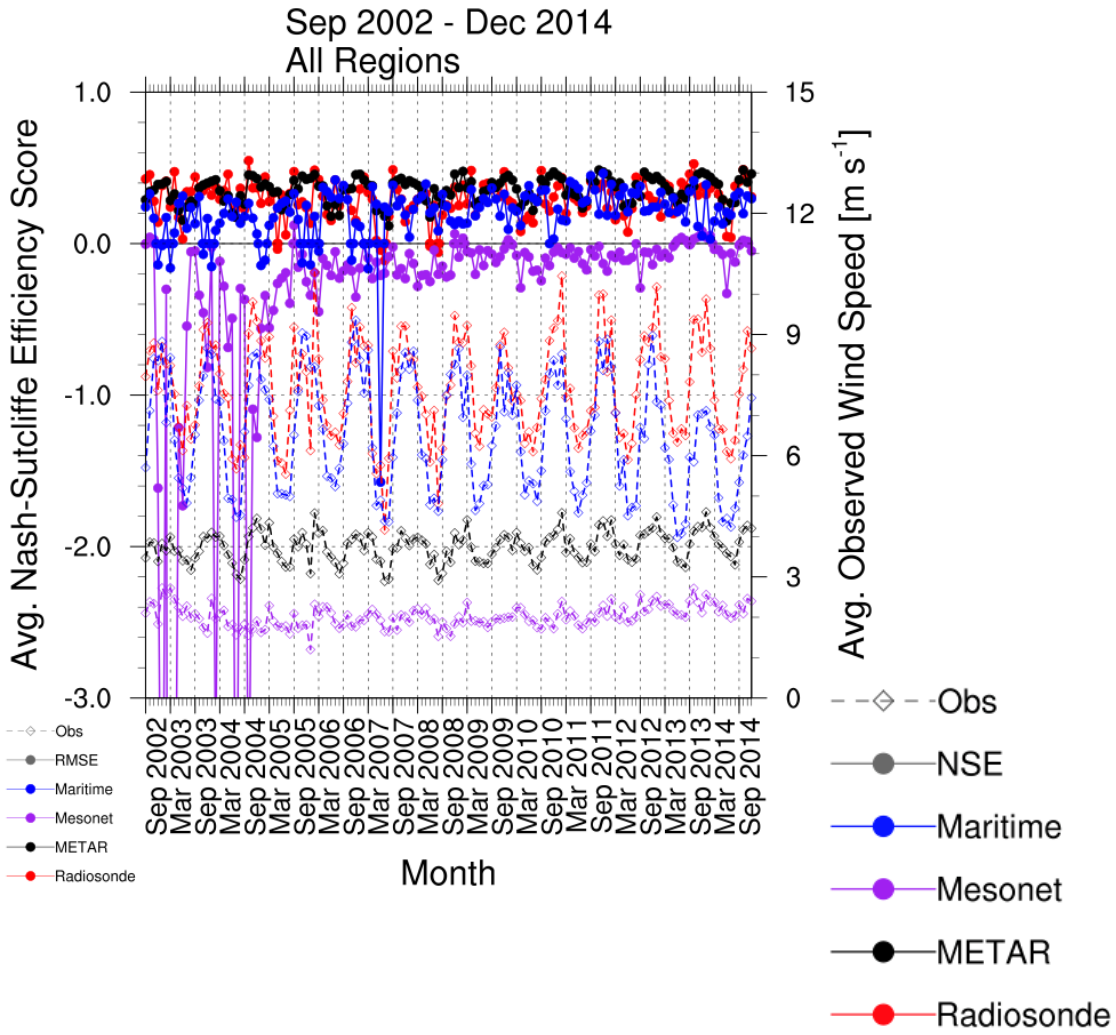
All-domain stats: ME (solid), Obs (dashed)

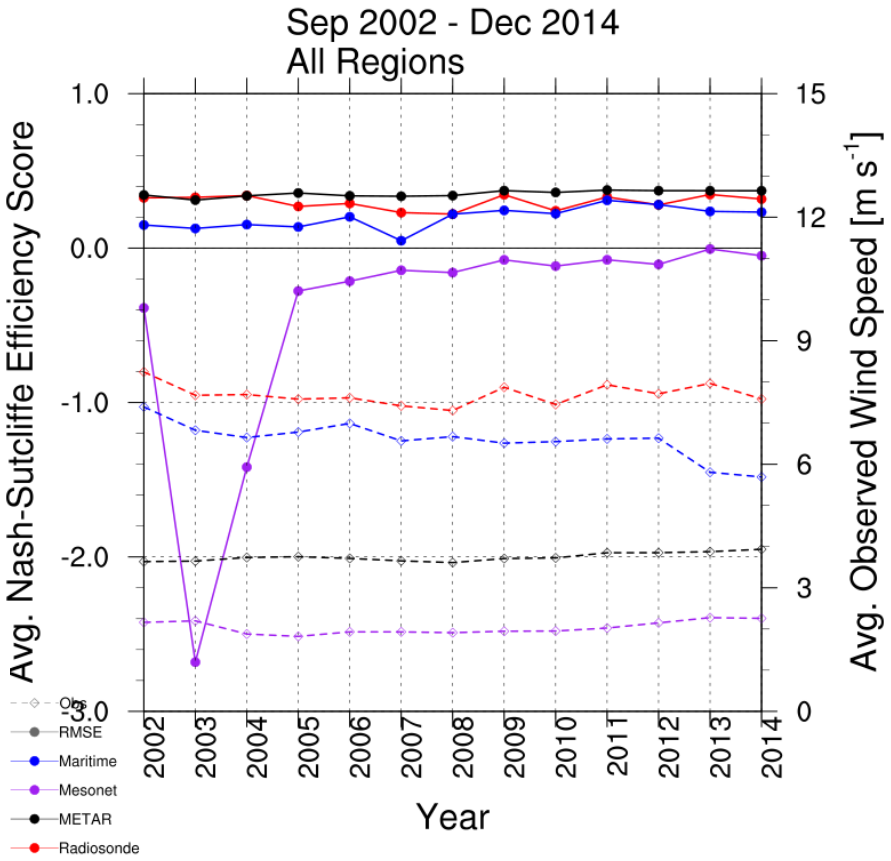




Obs
ME
Maritime
Mesonet
METAR
Radiosonde

All-domain stats: Nash-Sutcliffe Efficiency

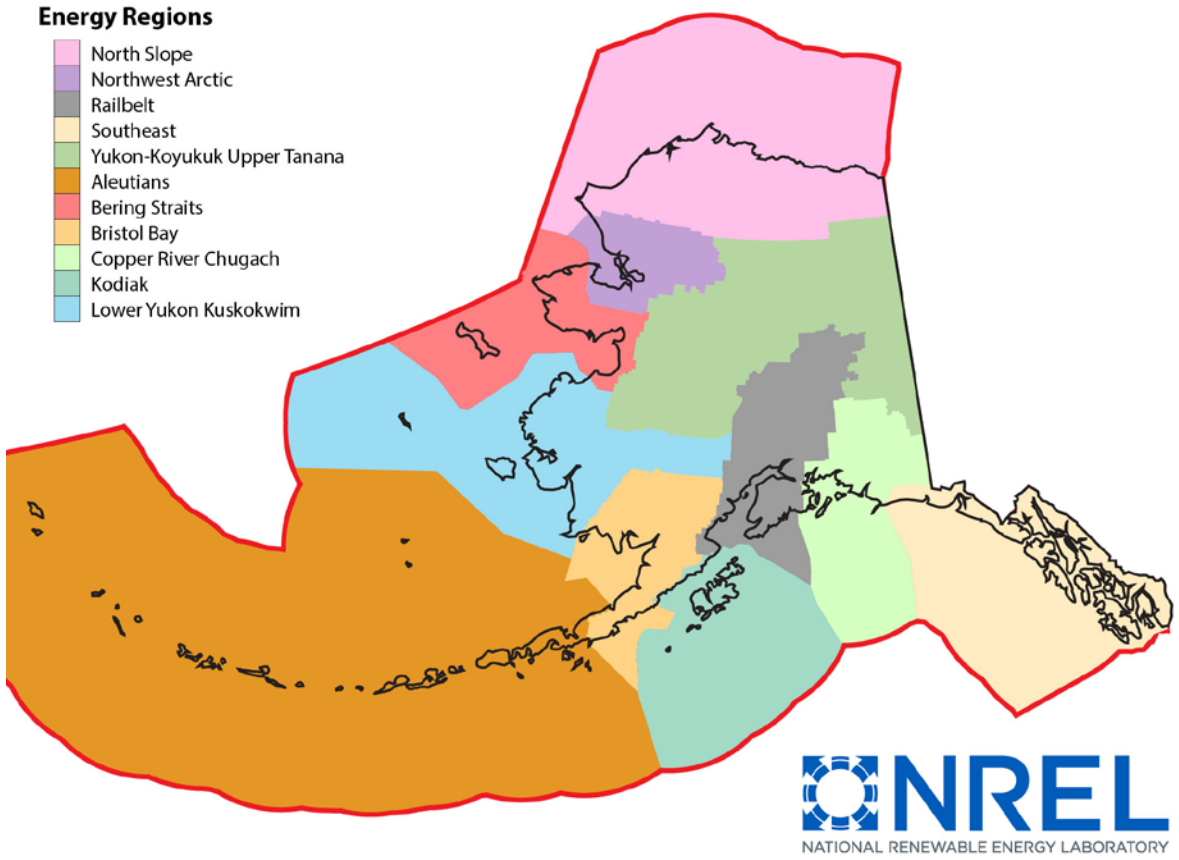




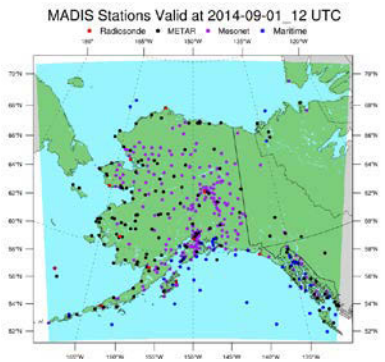
By-region stats

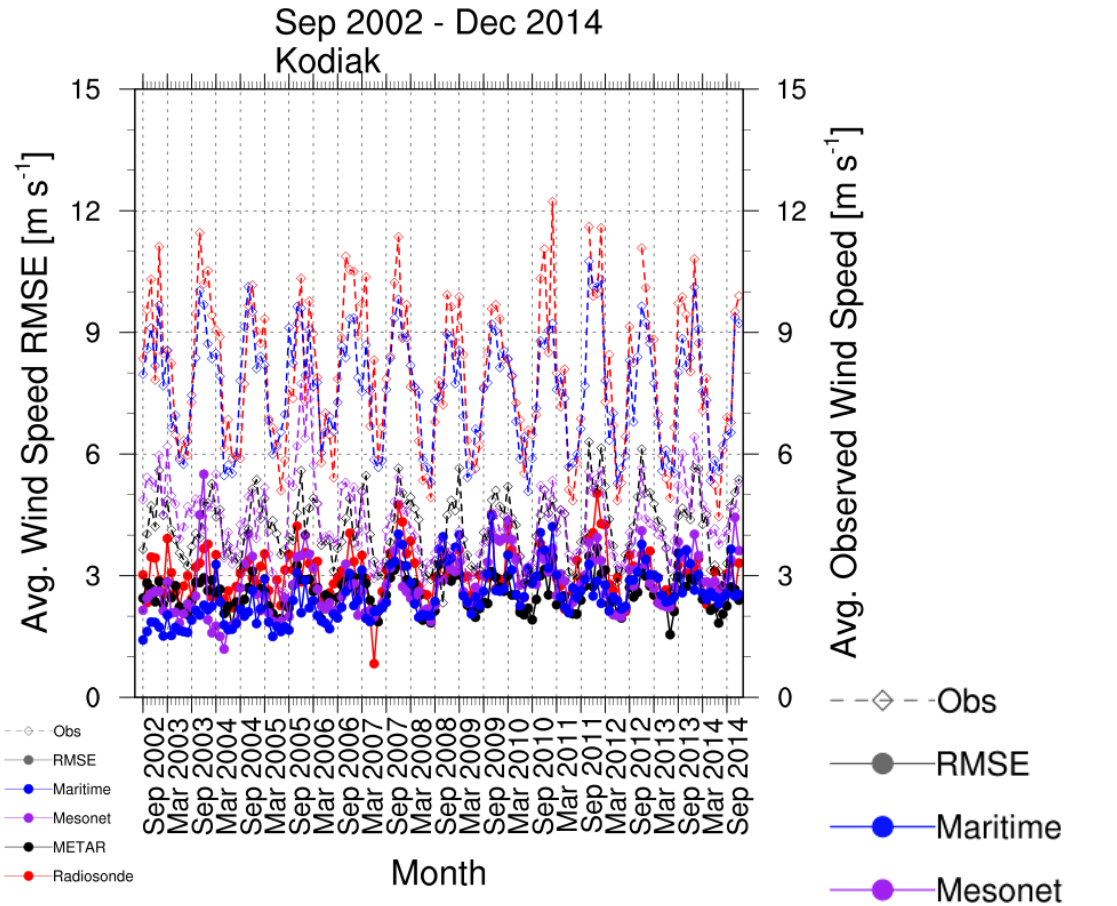
- Region-specific statistics are MUCH noisier than the domain-wide statistics, due to the substantially smaller sample sizes

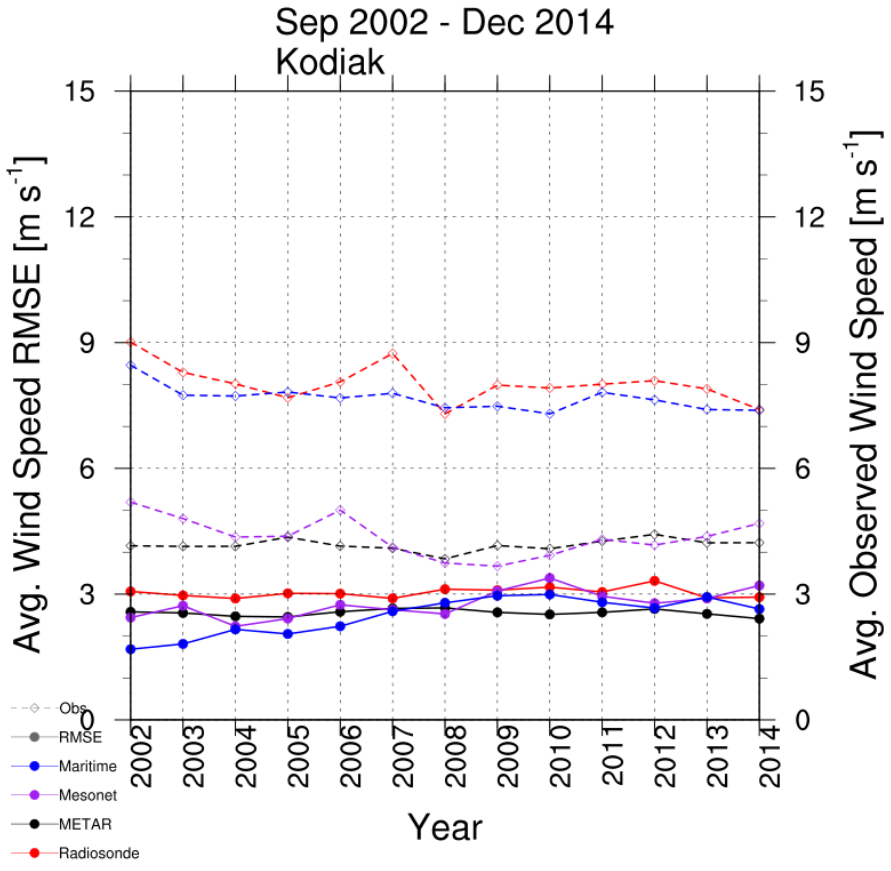
- RMSE & ME will be presented in the following slides for NREL Energy Regions across southern Alaska: Aleutians, Bristol Bay, Kodiak, Railbelt, Copper River Chugach, and Southeast



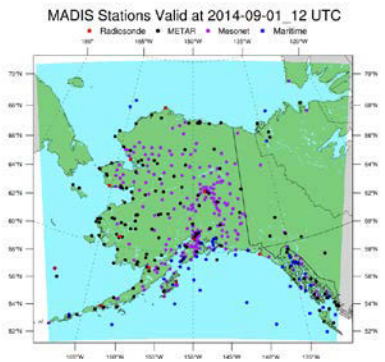
Kodiak stats: RMSE

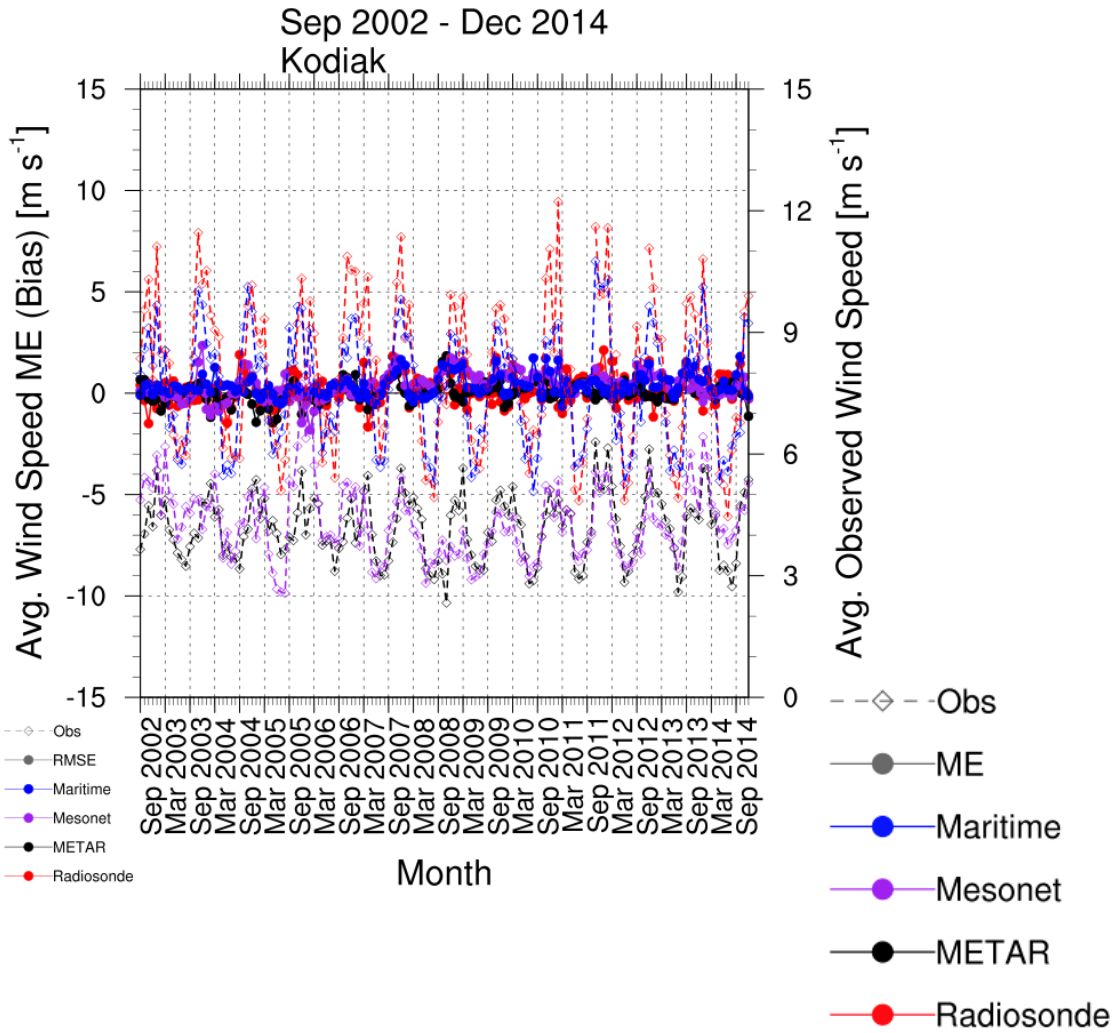


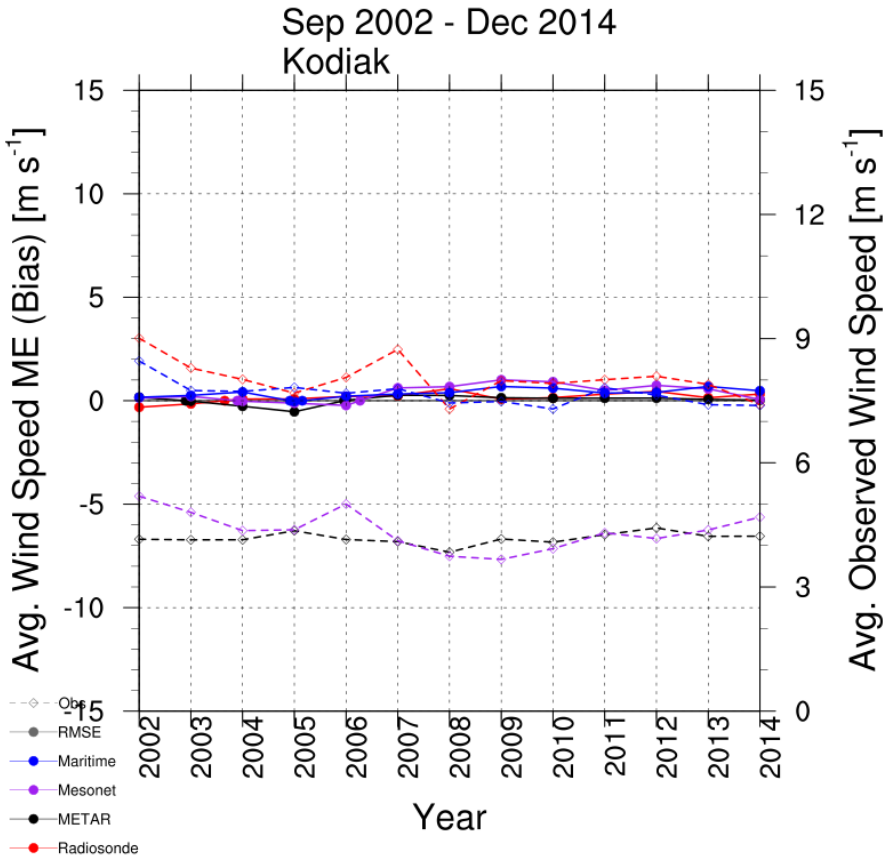




Kodiak stats: ME (Bias)

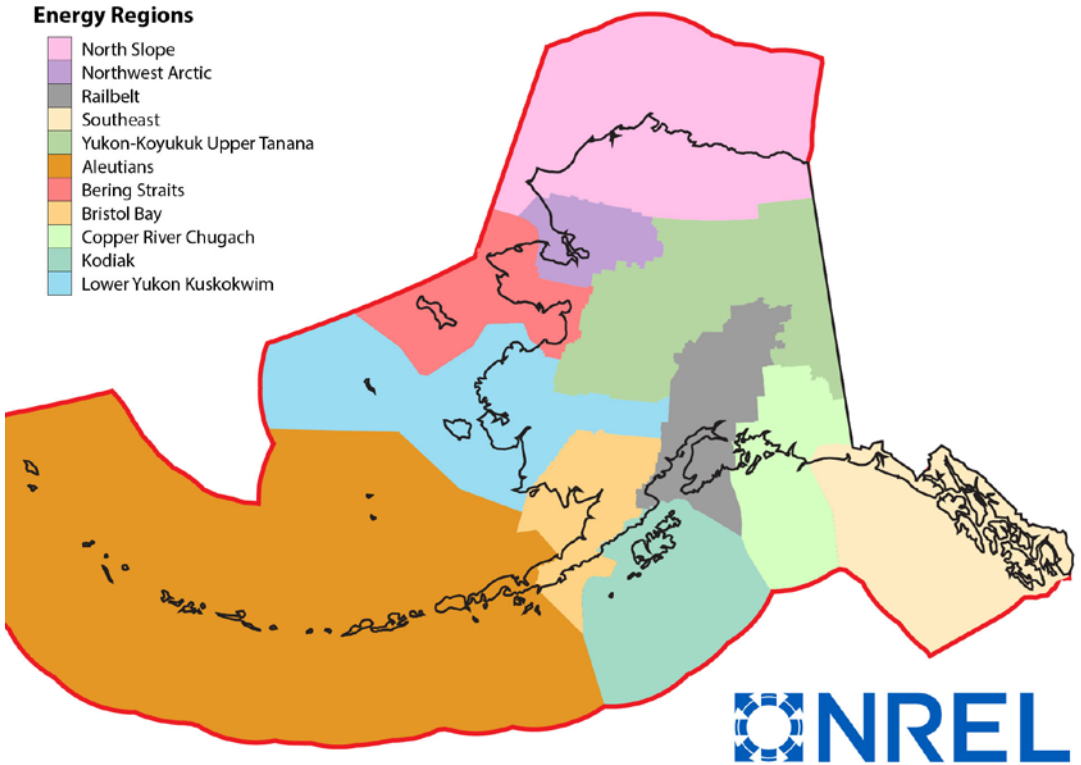






Summary and conclusions

- For offshore wind, lowest RMSE and near-zero bias in Aleutians, Kodiak, & Southeast regions
  - Partially due to greater number of observations and fewer terrain impacts on WRF simulation than in other regions examined
- Domain-wide, Mesonet obs usually had lowest avg. RMSE, but also lowest avg. observed wind speed and a consistent ~+1.0 m/s avg. bias
  - Also had negative Nash-Sutcliffe Efficiency scores, meaning the observed mean is a better predictor than WRF, on average
- Domain-wide, Radiosonde, METAR, & Maritime all had near-zero avg. bias
  - Also had positive Nash-Sutcliffe Efficiency scores, meaning WRF is a better predictor than observed mean, on average
- **This publicly available 14-yr WRF regional climate simulation is skillful and suitable for use for both hydromet and wind assessment**



Thanks for listening!

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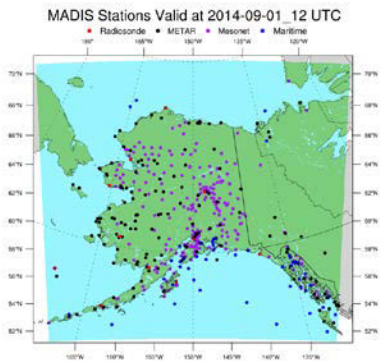
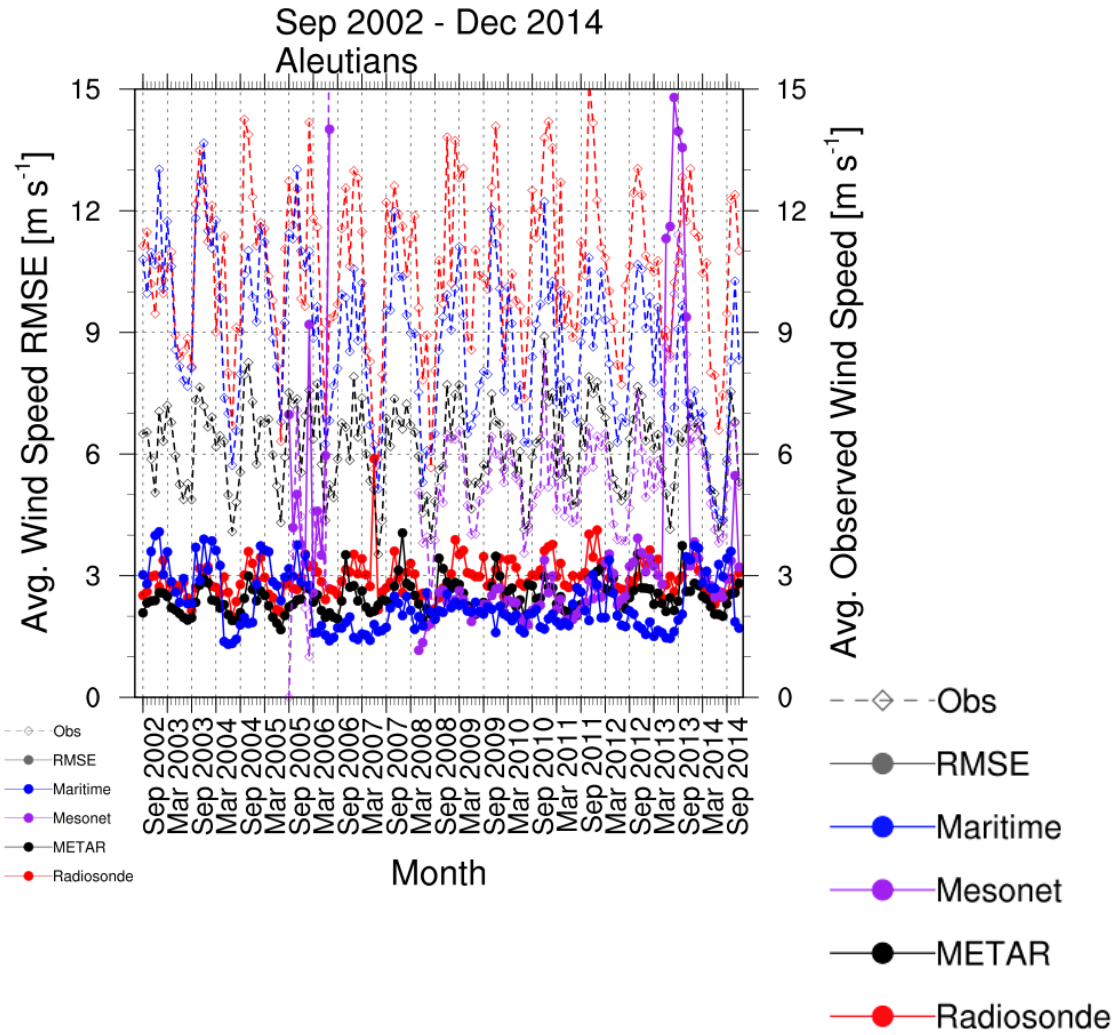
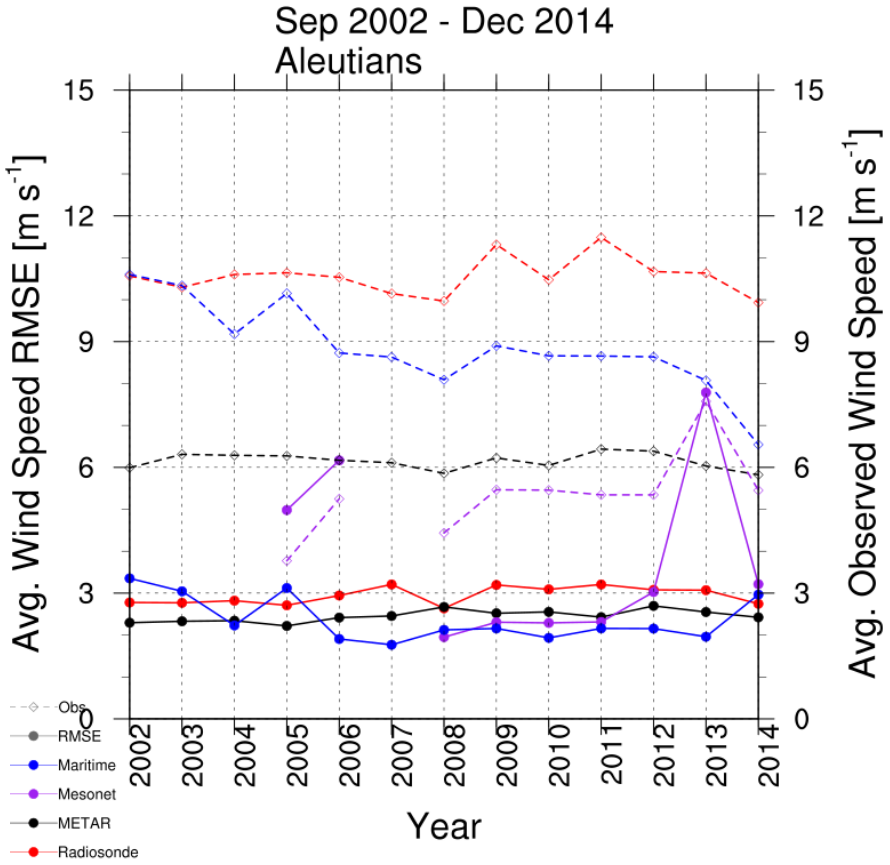
doi:10.5065/D61Z42T0

Supplemental Slides

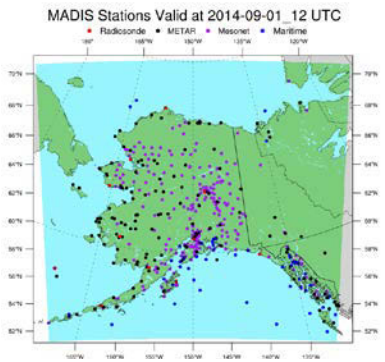
Aleutians stats: RMSE

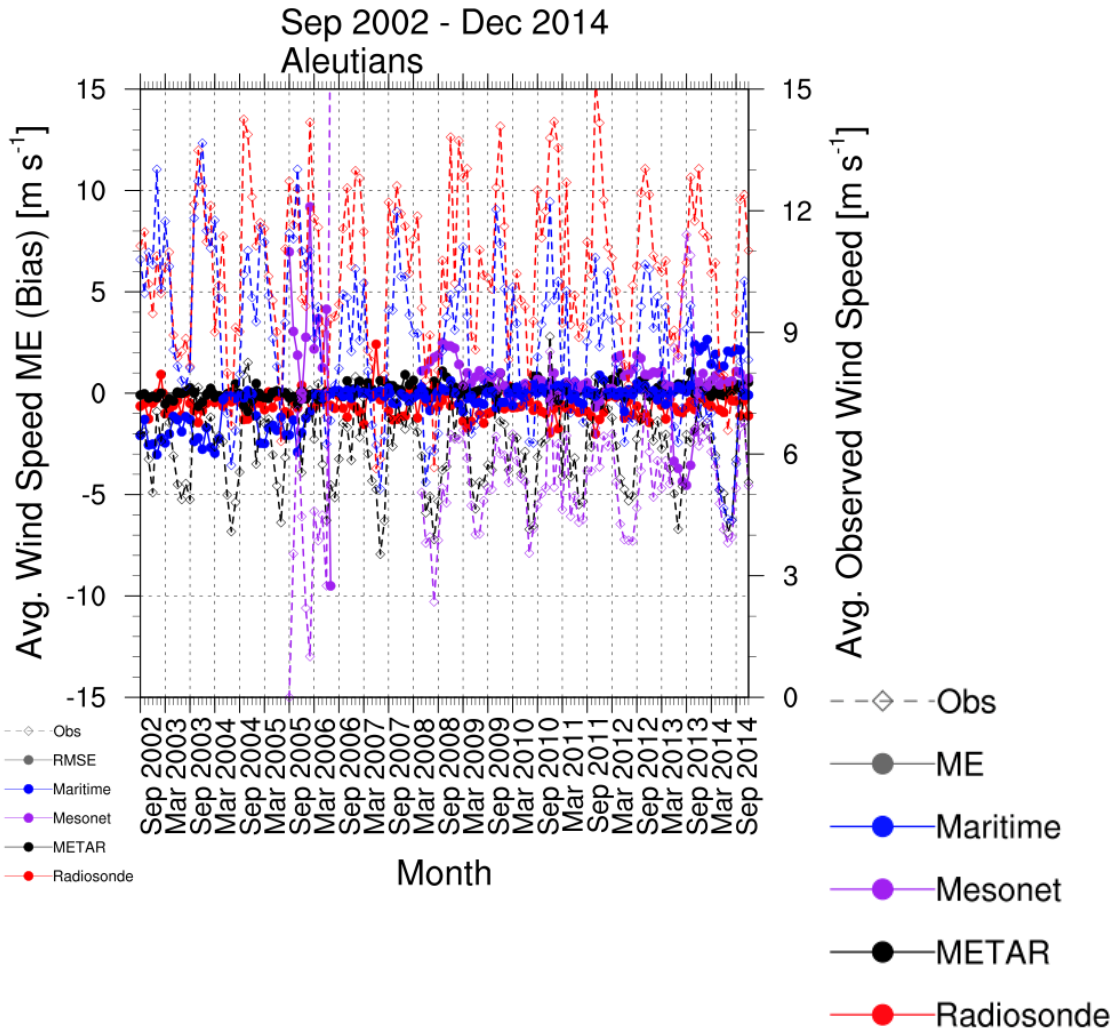


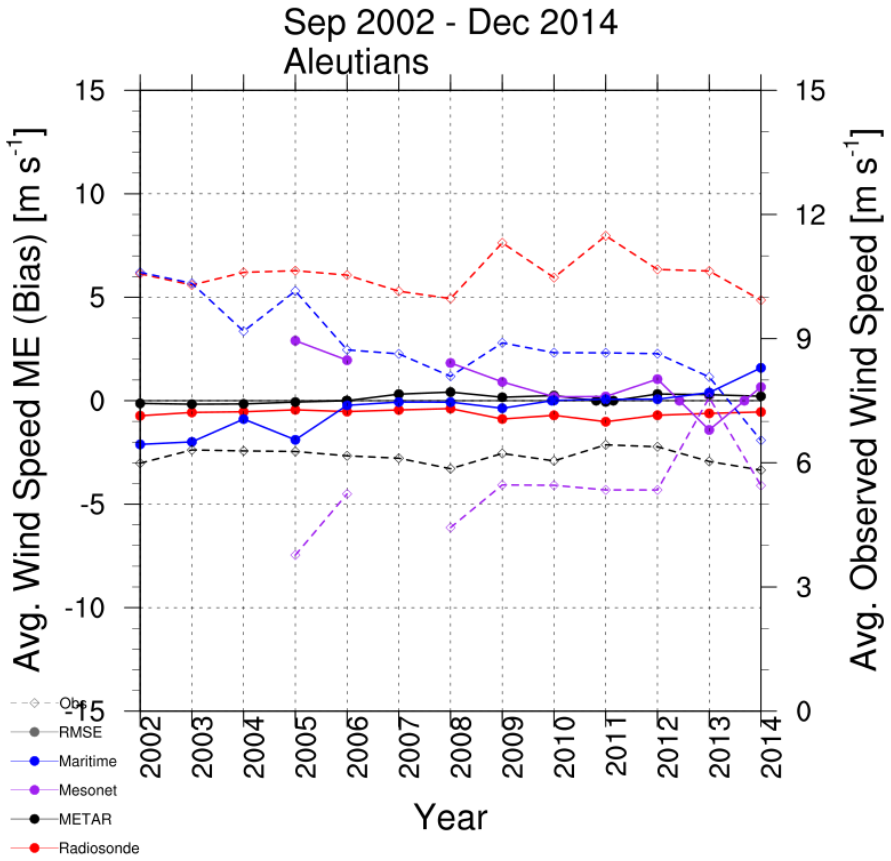




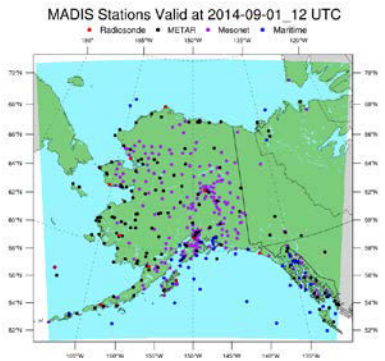
Aleutians stats: ME (Bias)

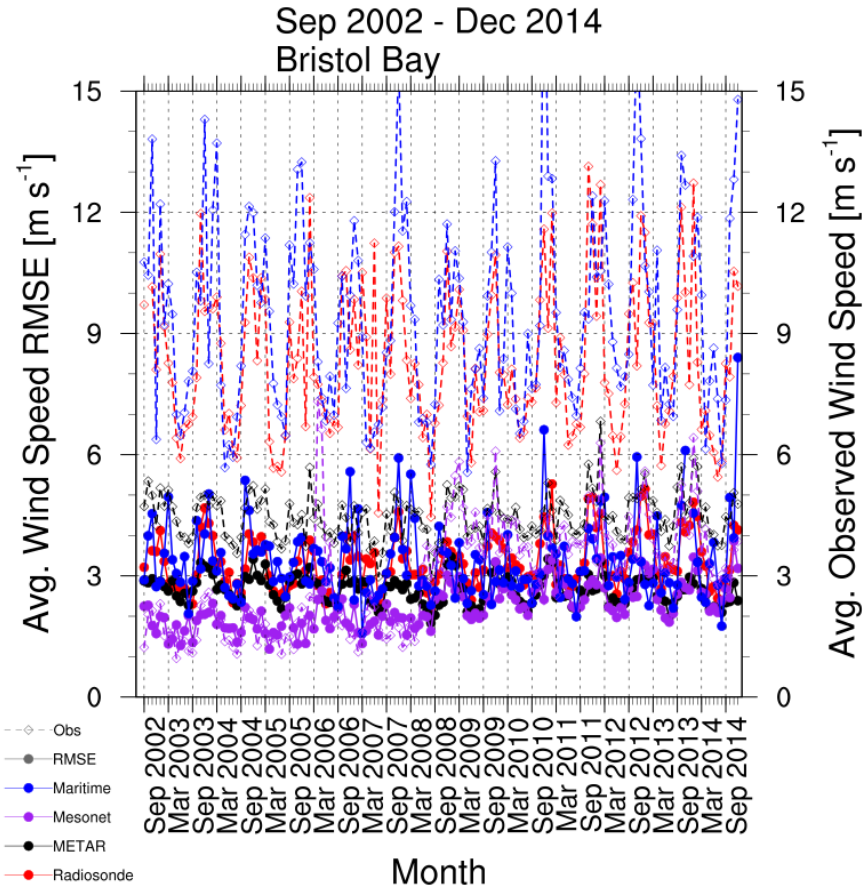


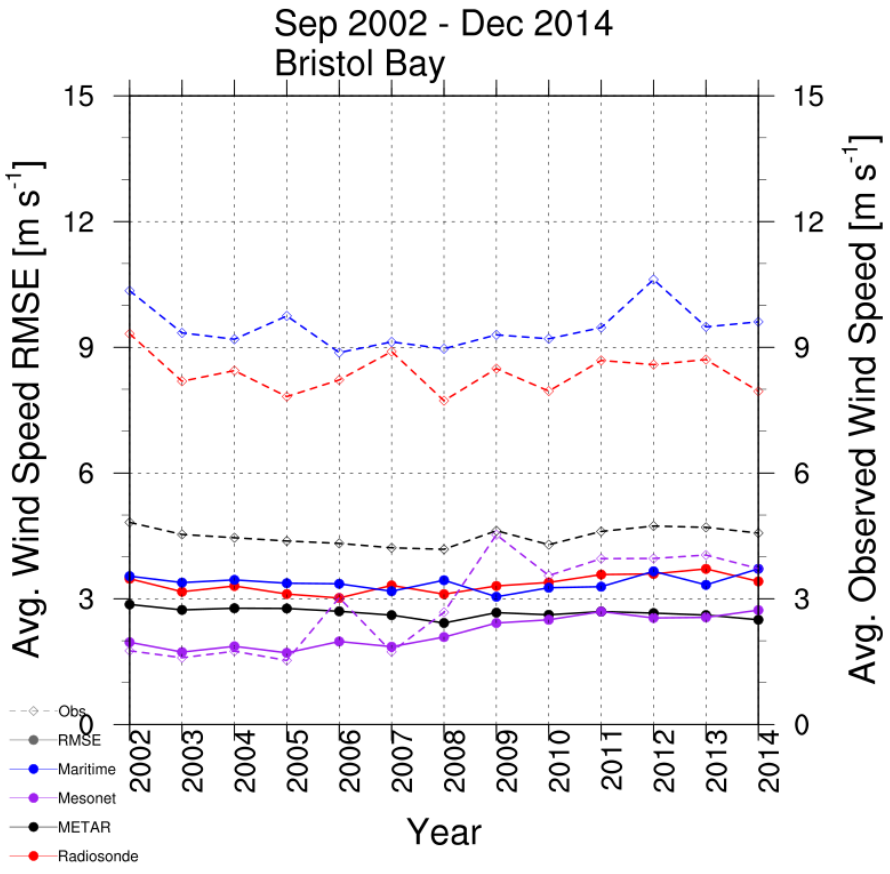




Bristol Bay stats: RMSE

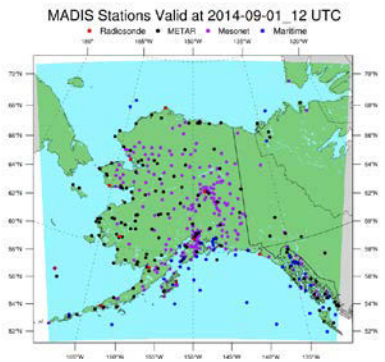


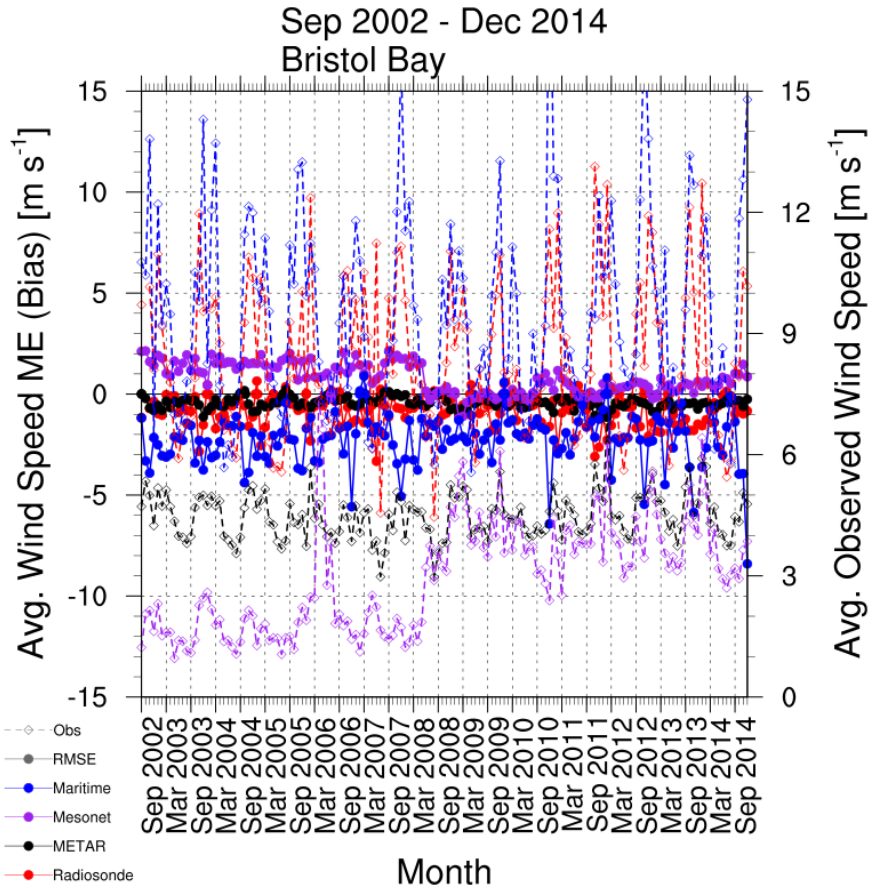


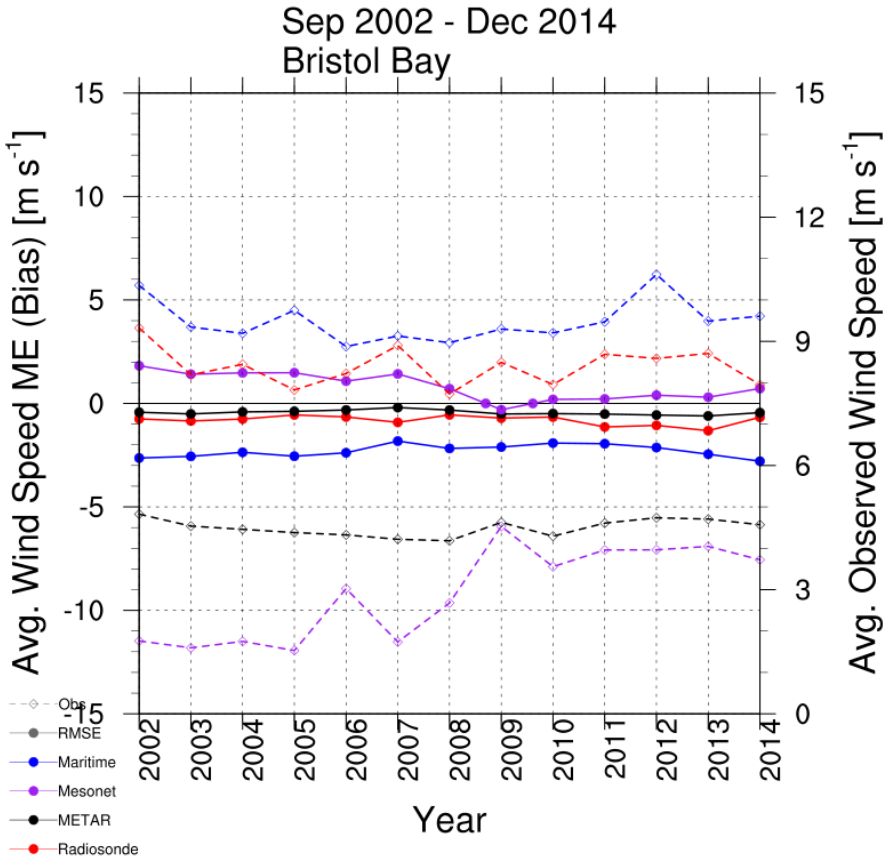


Definitely a big change in the Mesonet network in this region in 2008–2009!
Most likely due to several new Mesonet stations regularly reporting.

Bristol Bay stats: ME (Bias)







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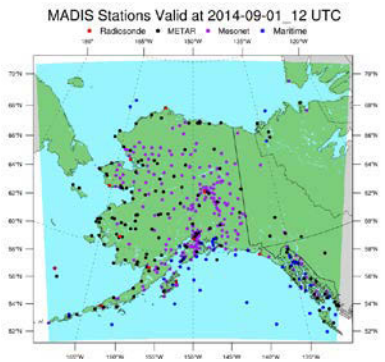
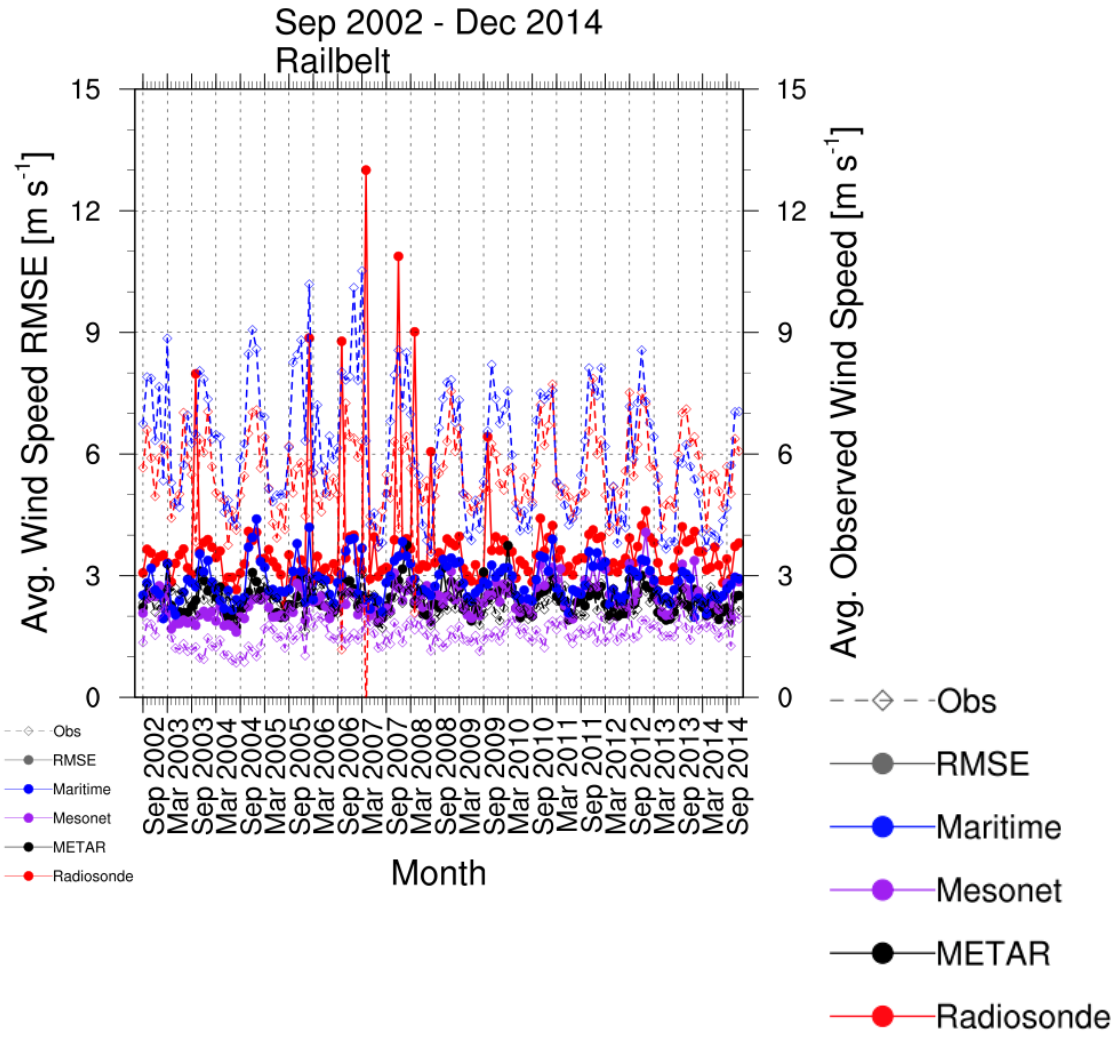
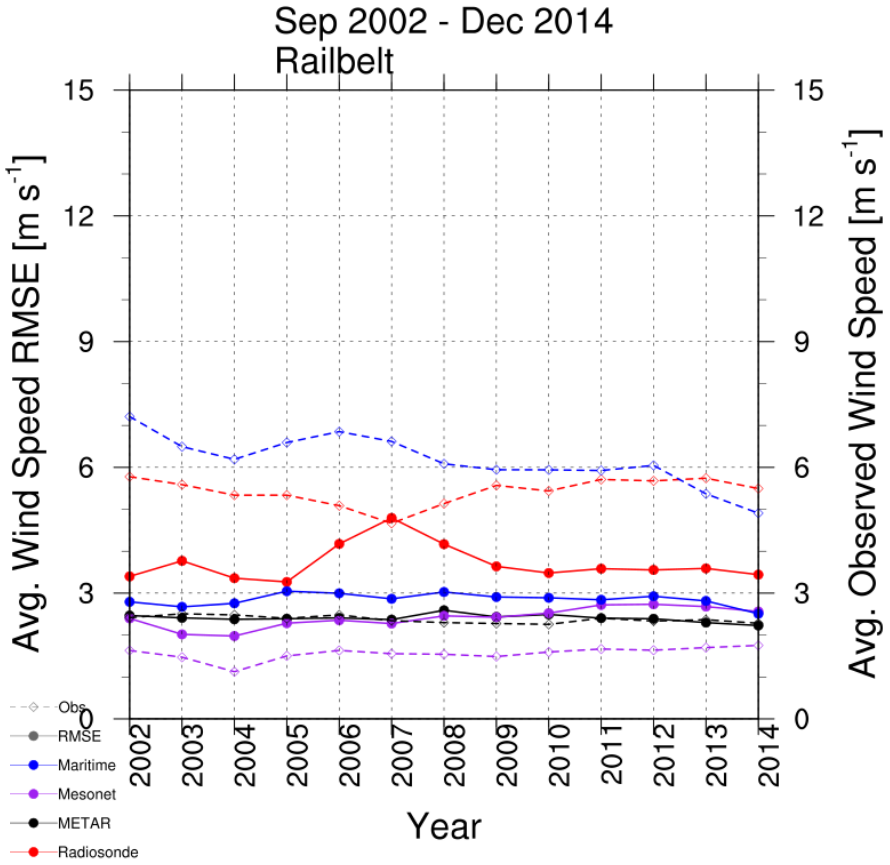
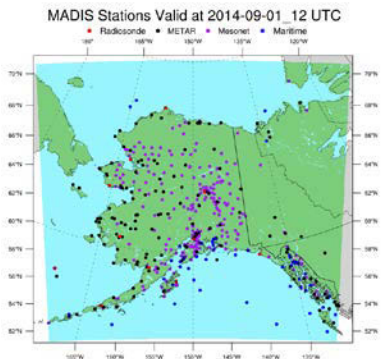
Railbelt stats: RMSE

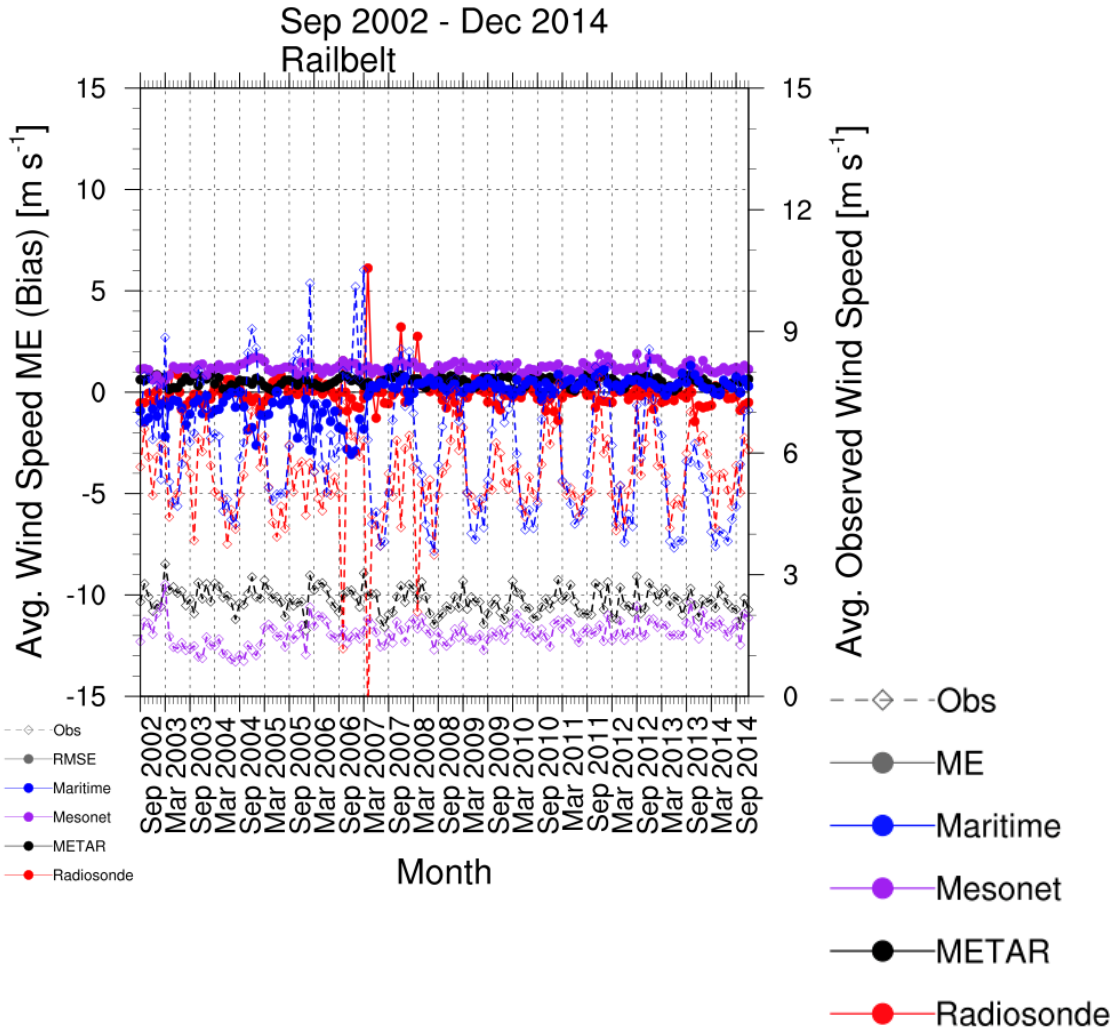


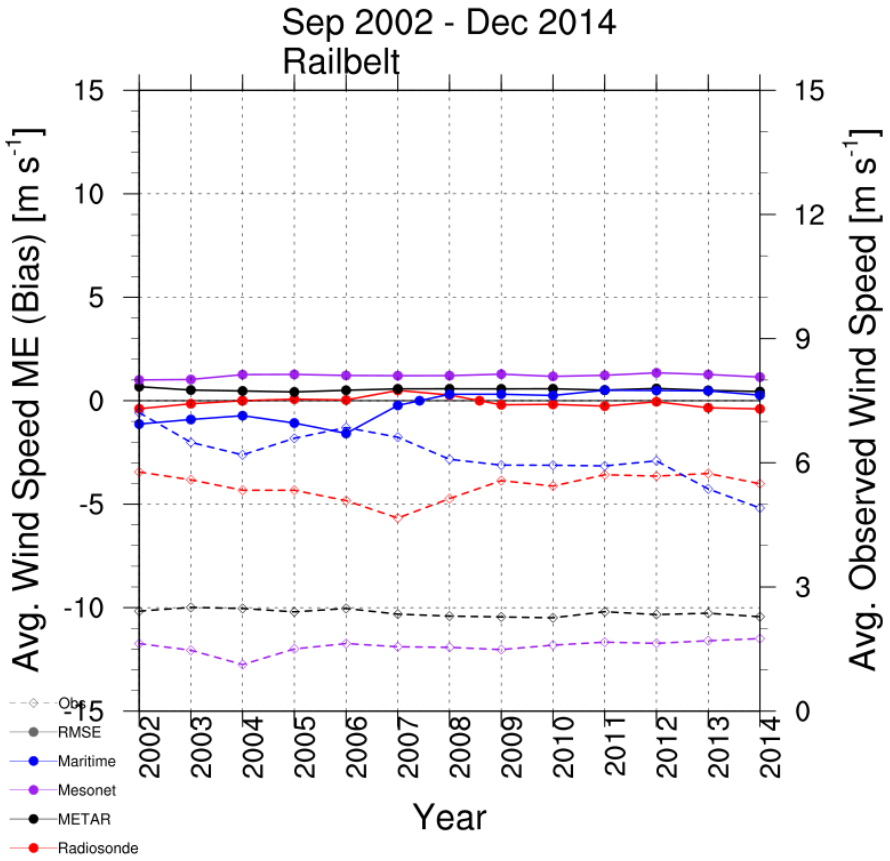




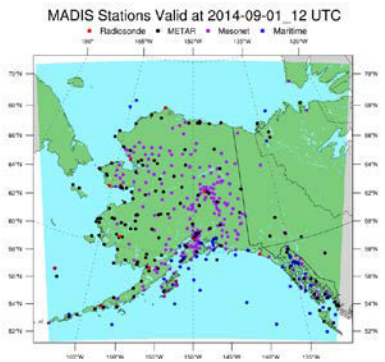
Railbelt stats: ME (Bias)

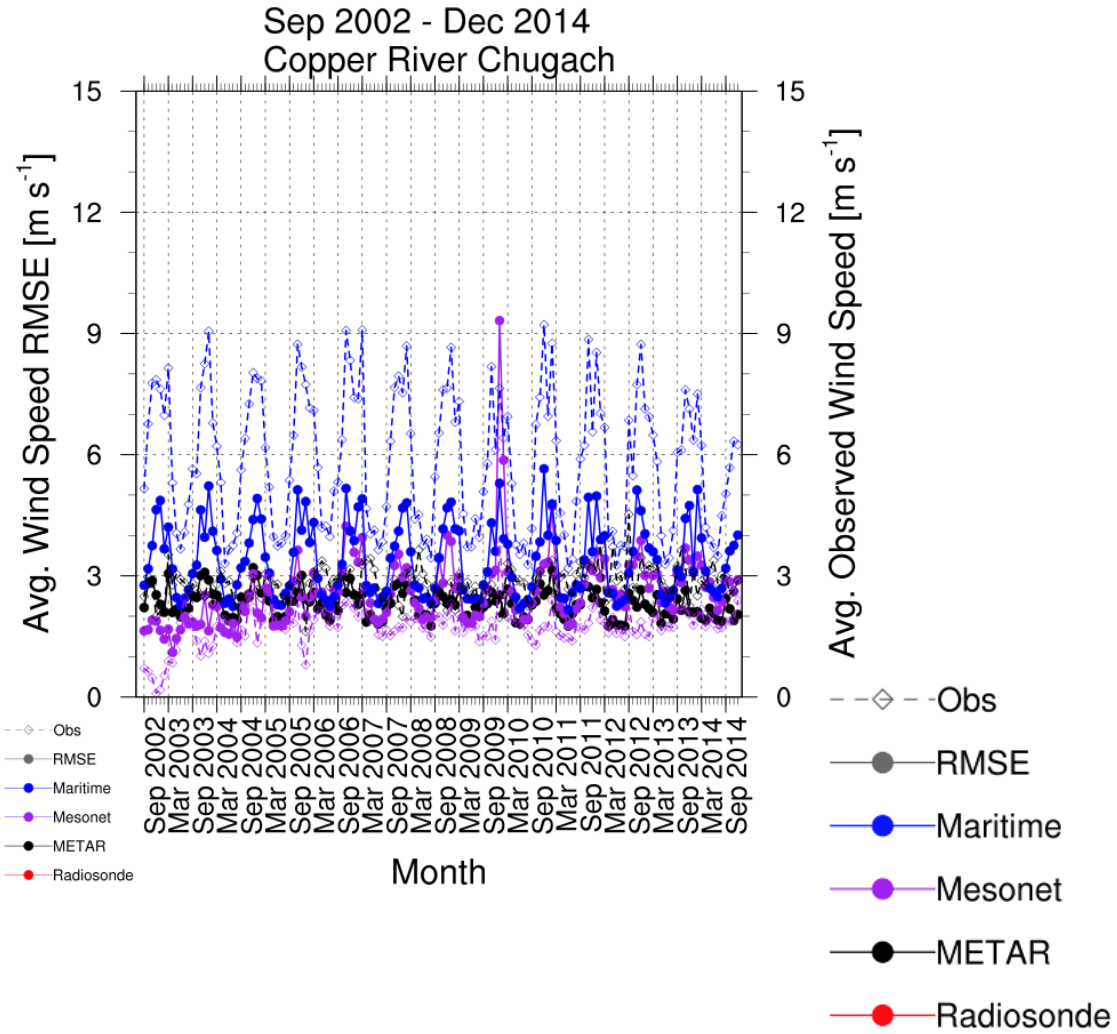


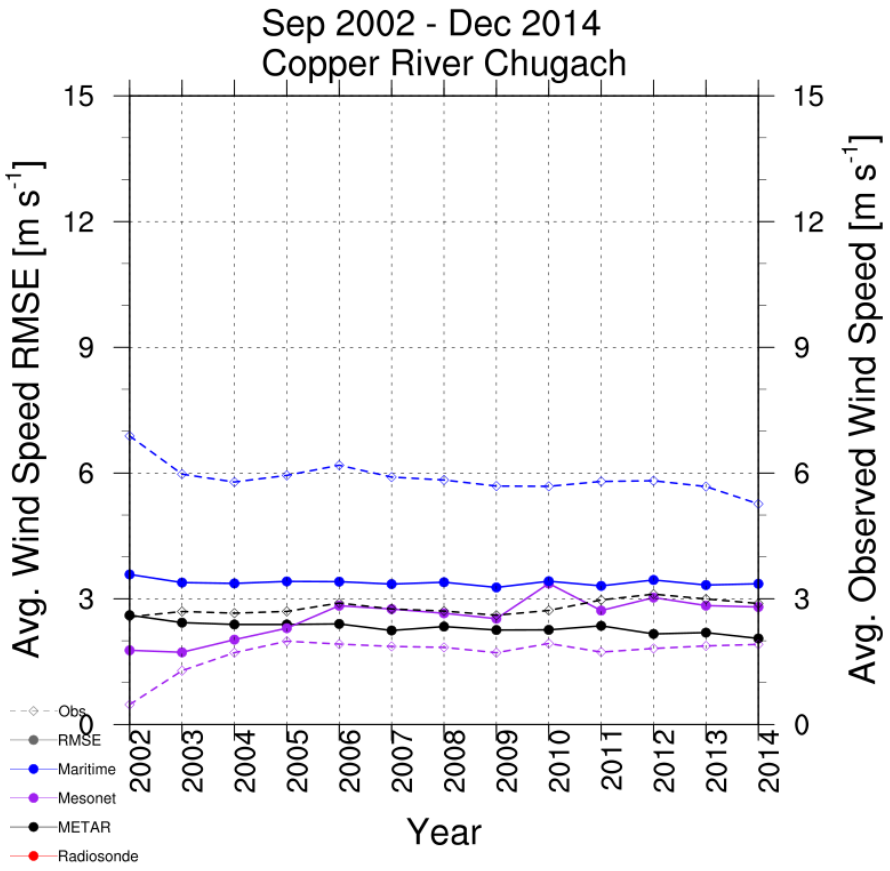




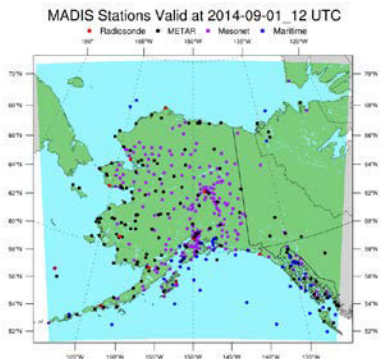
Copper River stats: RMSE

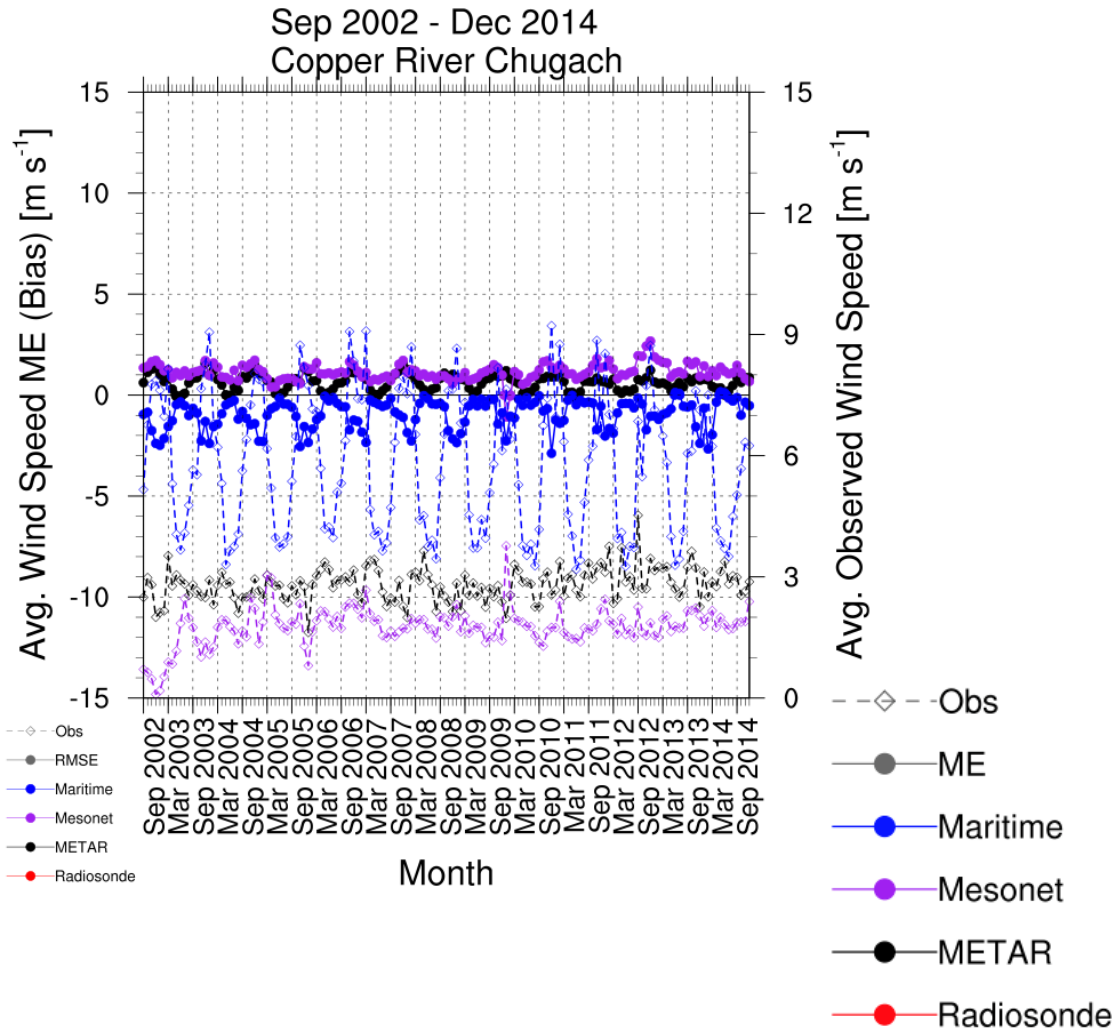


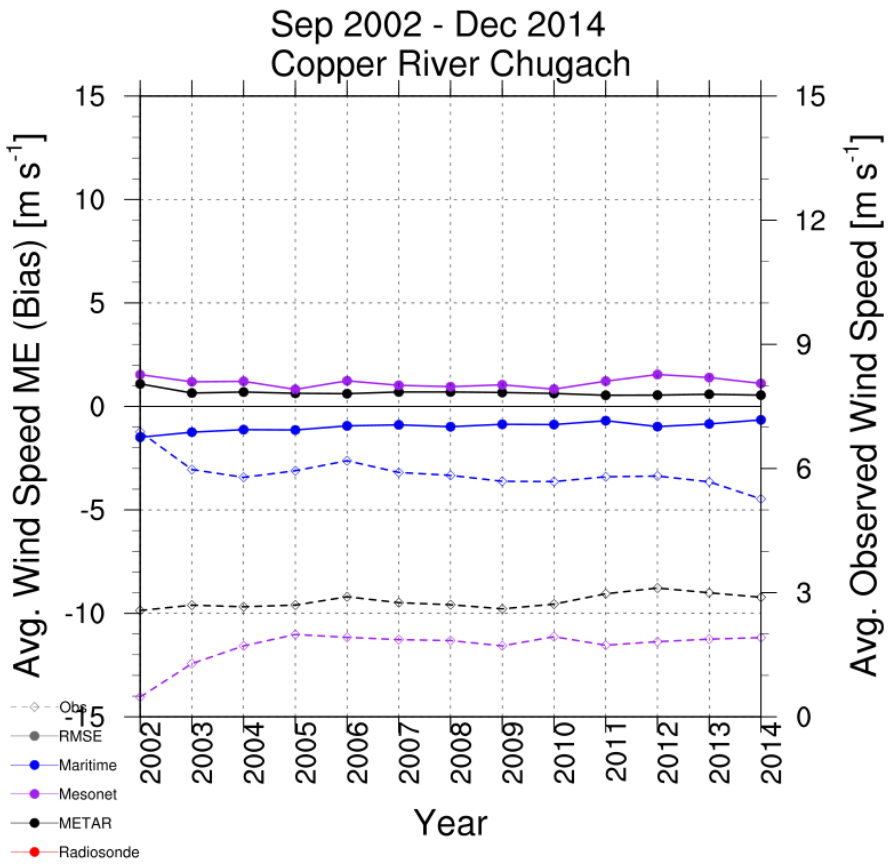




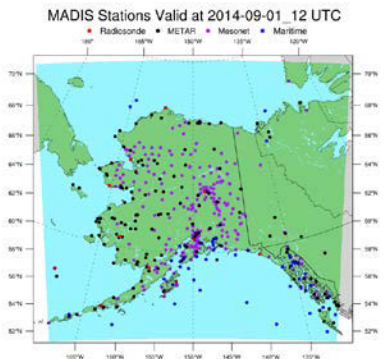
Copper River stats: ME (Bias)

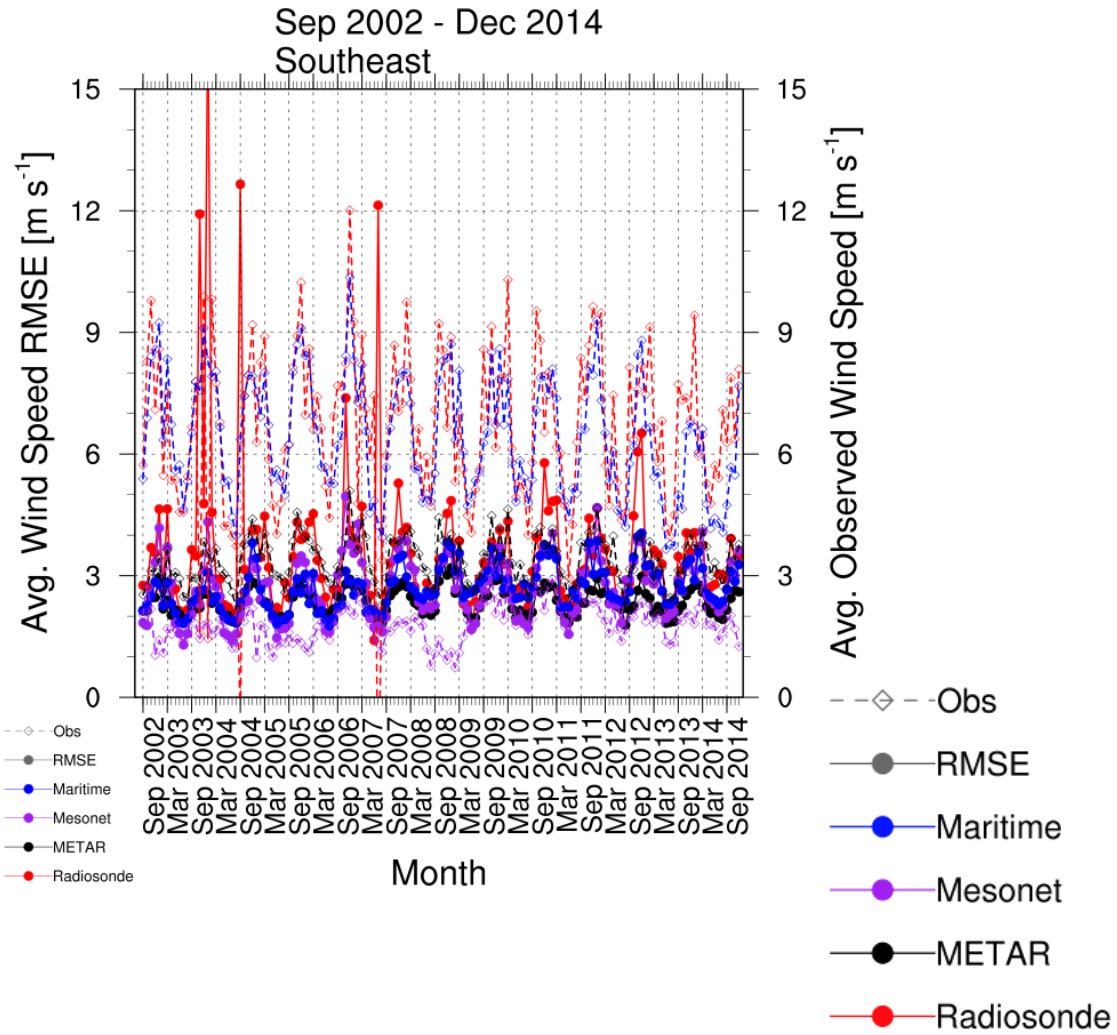


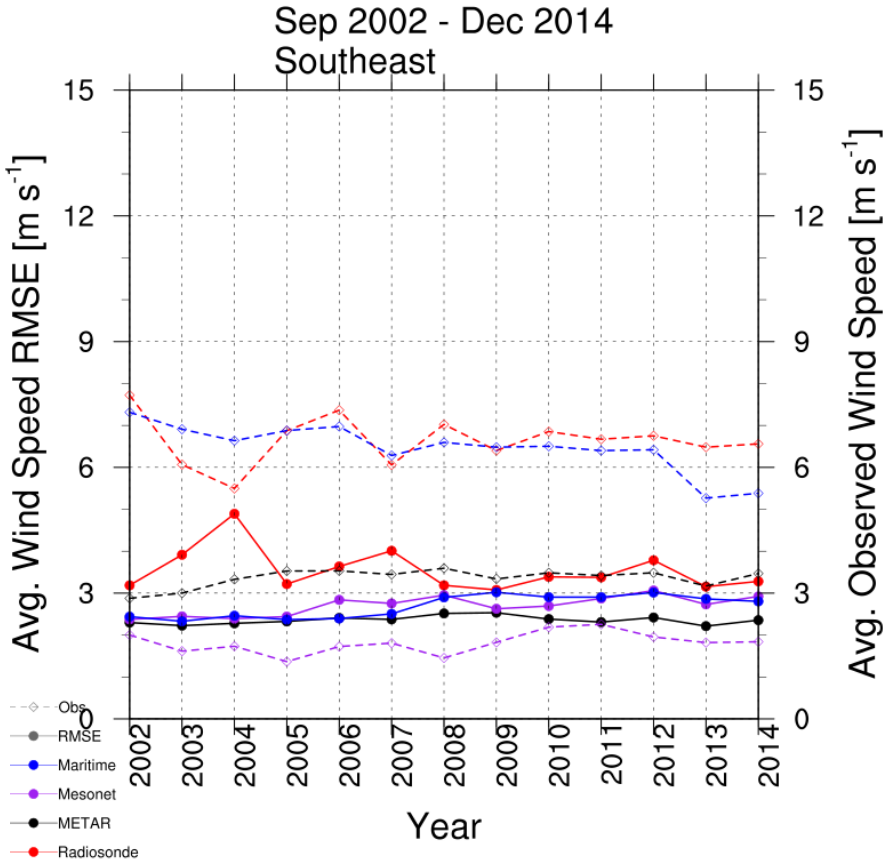
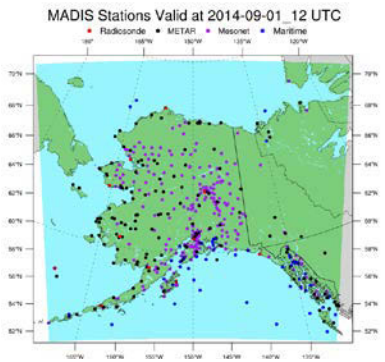
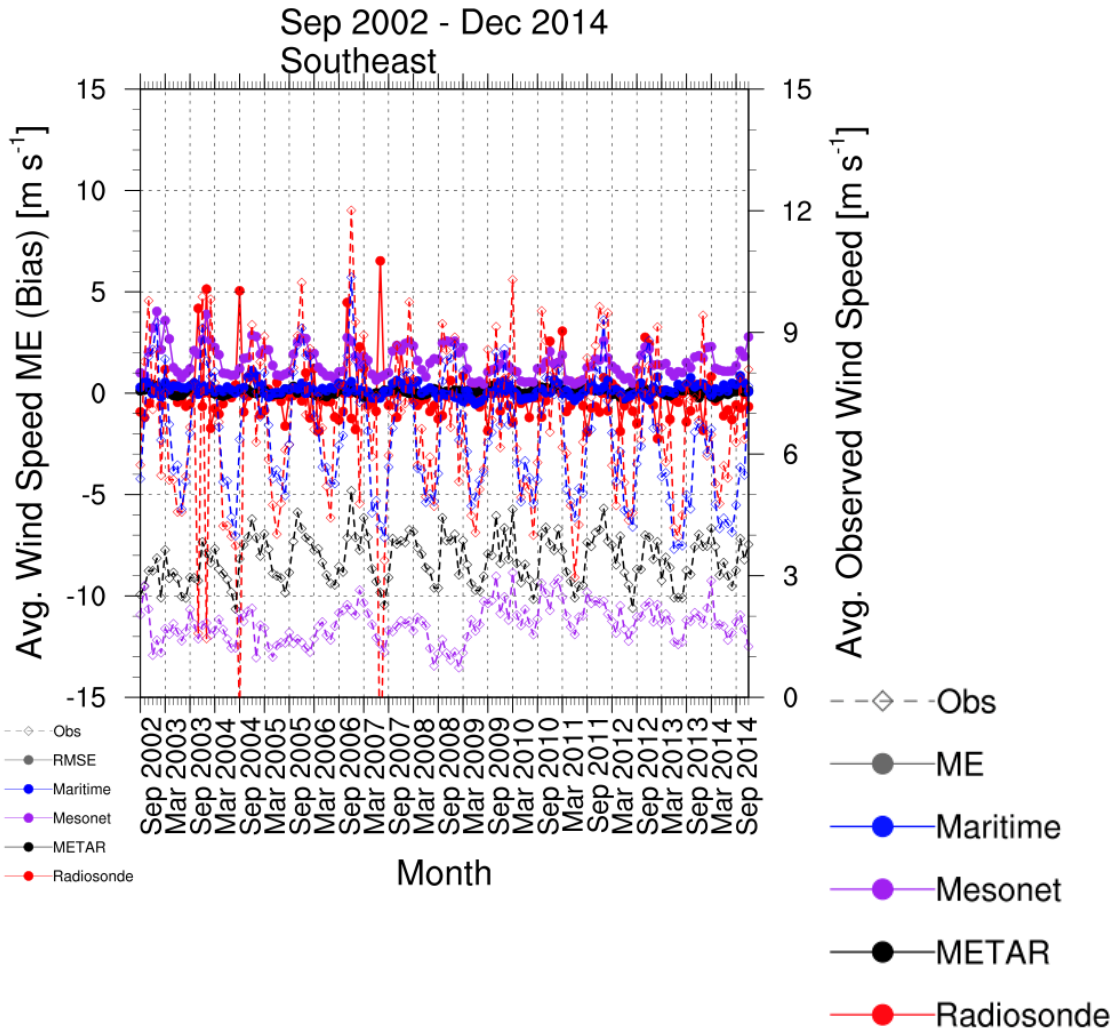
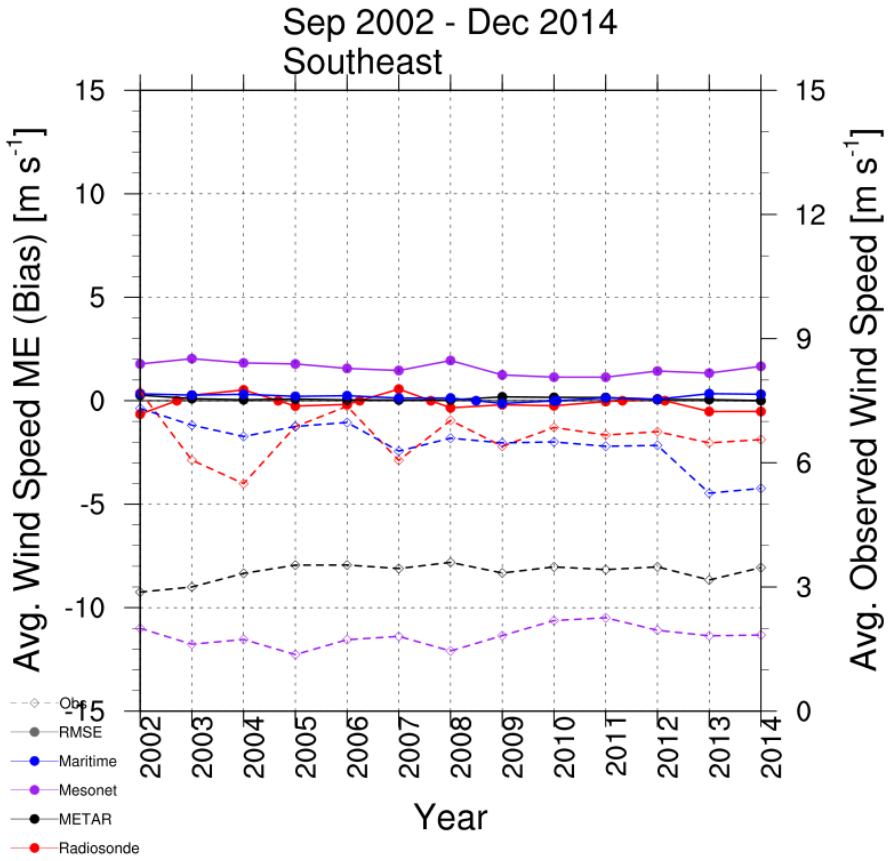




Southeast stats: RMSE







Southeast stats: ME (Bias)