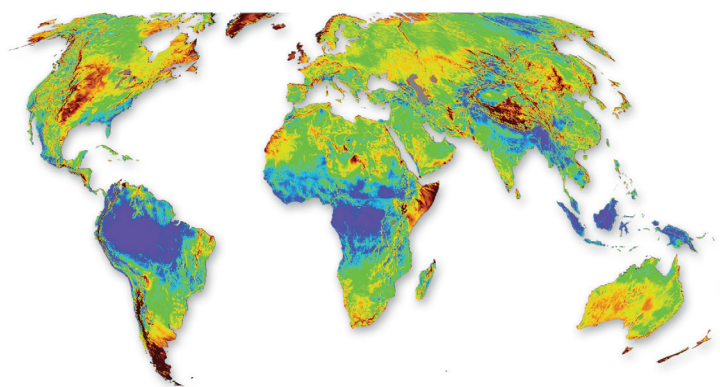


3TIER Global Wind Dataset Annual Mean Validation

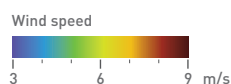


January 28, 2009

White Paper



5km Wind Map at 80m



The 3TIER global wind dataset is the first high-resolution, methodologically consistent wind resource assessment of global extent. Computer simulations using a mesoscale numerical weather prediction model form the basis of the dataset. The dataset contains hourly values over a 10-year period, on a 2-arc-minute (approximately 5 km) resolution grid covering all continental and near-shore areas between 60°S and 70°N.

This dataset can be used for prospecting and initial site assessments at locations where no direct wind observations are available. Depending on the size of a planned wind project, more detailed and expensive studies may still be needed to determine whether sites have sufficient wind energy potential. The dataset is not meant to replace measurements, except for projects that are too small to warrant the expense of a measurement campaign and where no measurements are available nearby. As the first high-resolution global wind dataset, this information shortens the prospecting cycle and allows developers to allocate their resources to the most promising locations.

Regardless of the high resolution of the dataset, small spatial features are not well resolved. As a consequence, isolated bluffs and hills or large clearings in forests likely will have higher wind speeds than estimated in the dataset for that location. Similarly, local depressions and sheltered locations will likely have lower wind speeds. Such differences between 3TIER global dataset values and observed wind speeds are expected to be larger in regions of rough terrain, or regions with large variations of surface roughness, such as near coasts.

To assess the quality of the wind speed estimates provided by the 3TIER global dataset, wind speeds were compared with publicly available wind speed observations from more than 4000 globally distributed meteorological stations from the National Centers for Environmental Prediction (NCEP) Automated Data Processing (ADP) surface observations dataset. The stations were chosen from the subset of NCEP ADP stations with 4-letter ICAO location indicators, which had more reliable data than other stations in the NCEP ADP dataset. Time series from these stations were visually inspected, and stations with obvious data problems were excluded from the validation. The NCEP ADP wind speeds were compared with FirstLook wind speeds at a height of 10 m; however, it is likely that some NCEP ADP station anemometers are at heights lower than 10 m, although few are expected to be higher than 10 m. The NCEP ADP data are expected to be of relatively high quality in North America and Europe, and potentially of lower quality in other parts of the world. Note that the NCEP ADP data are an independent data source, because they have not been used to adjust the FirstLook data in any way.

Figure 1 shows a map of 3TIER minus observed difference in the annual mean wind speed at each NCEP ADP station location; a histogram of these differences

is displayed in Figure 2. The data show that the difference is less than 0.5 m/s at 50% of the stations, and the difference is less than 1 m/s at 78% of the stations. The overall bias is +0.05 m/s relative to NCEP ADP observations, and the root mean square error (RMSE) is 0.93 m/s.

Because meteorological stations measure wind speeds at heights (typically 10 m) that are lower than those of interest for wind energy generation, 3TIER's wind speeds were also compared with wind observations from more than 400 tall towers in the U.S. and Canada with heights between 18 and 100 m. Figure 3 shows a map of 3TIER minus observed difference in the annual mean wind speed at each tower location; a histogram of these differences is displayed in Figure 4. The difference is less than 0.5 m/s at 45% of the towers, and the difference is less than 1 m/s at 70% of the towers. The bias is -0.22 m/s relative to tower observations, and the RMSE is 0.97 m/s. The larger differences

relative to tower observations are likely due to the higher wind speeds at tower observation heights than at NCEP ADP observation heights.

The map in Figure 1 indicates that there are variations in the magnitude of 3TIER minus observed differences from region to region. Figures 5-16 show maps and histograms of 3TIER minus observed annual mean wind speed differences for six regions of the globe. The statistics of the comparisons for each region are summarized in Table 1. Differences are relatively small in North America and Australia, and relatively large in Asia (particularly Japan and Korea), South America (particularly Central America and the Caribbean), and Africa.

The comparison with observations reveals that 3TIER wind speed estimates are particularly good in areas of flat terrain. Differences from observations tend to be larger over rough terrain and near coasts, where there are naturally occurring strong gradients in windspeed.

Table 1. Summary of FirstLook minus observed annual mean difference statistics for specified regions, for the comparison with NCEP ADP station data.

Region	n	±0.5 m/s	±1 m/s	Bias	RMSE
North America	2420	54%	82%	-0.14 m/s	0.85 m/s
South America	304	43%	73%	+0.26 m/s	1.13 m/s
Africa	229	39%	71%	+0.34 m/s	1.03 m/s
Europe	871	46%	75%	+0.25 m/s	0.94 m/s
Asia	289	37%	64%	+0.61 m/s	1.15 m/s
Australia	42	55%	76%	-0.19 m/s	0.77 m/s
Global	4155	50%	78%	+0.05 m/s	0.93 m/s

Figure 1

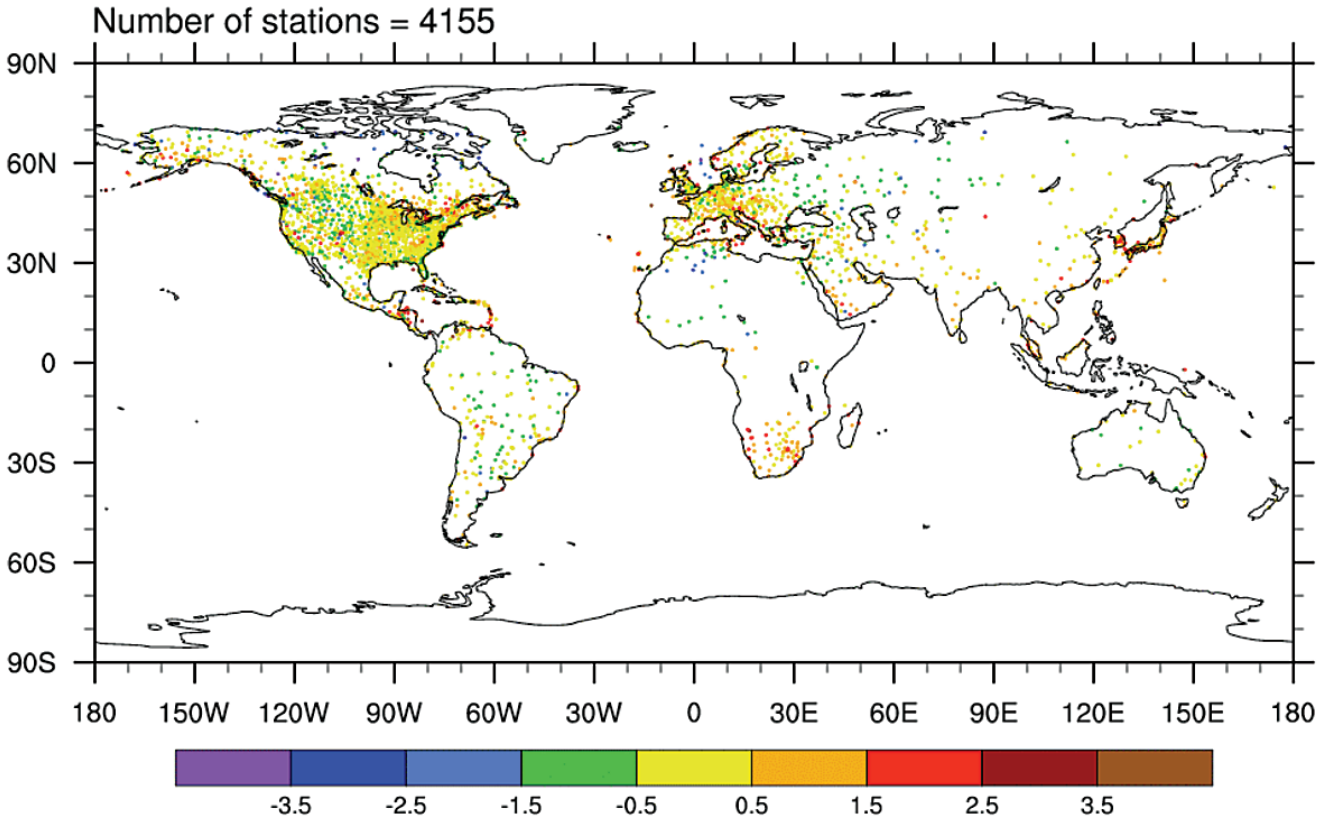


Figure 1. Map of 3TIER minus NCEP ADP observed annual mean wind speed differences (m/s), for the 3TIER global wind dataset.

Figure 2

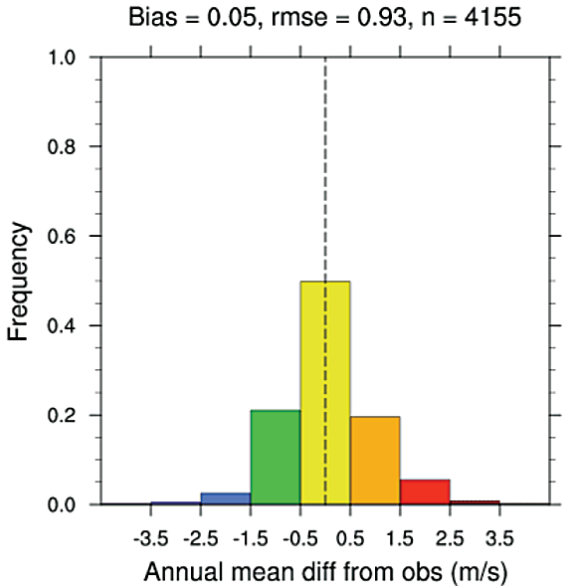


Figure 2. Histogram of 3TIER minus NCEP ADP observed annual mean wind speed differences (m/s), for the 3TIER global wind dataset.

U.S. and Canada Tall Towers

Figure 3

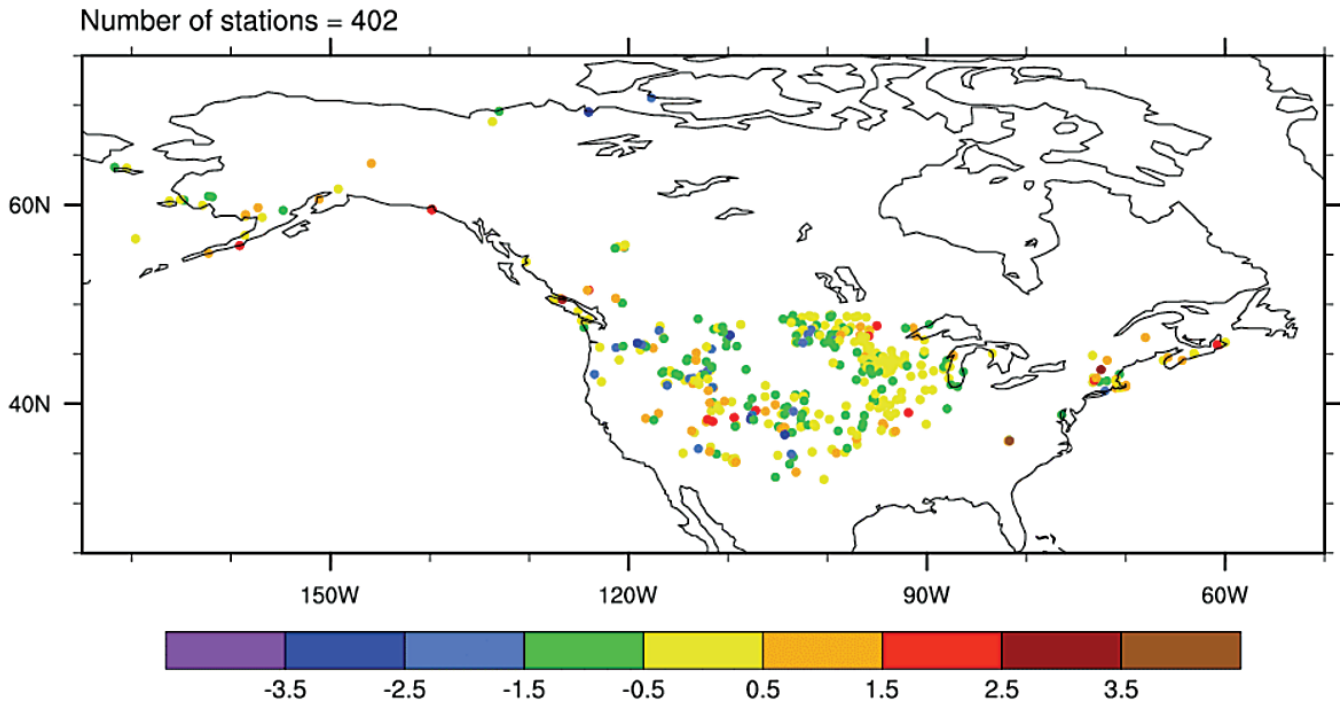


Figure 3. Map of 3TIER minus tall tower observed annual mean wind speed differences (m/s), for the U.S. and Canada from the 3TIER global wind dataset.

Figure 4

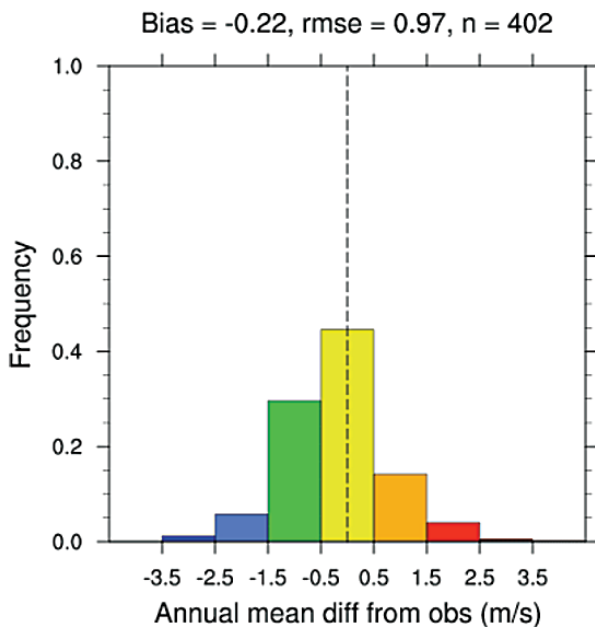


Figure 4. Histogram of 3TIER minus tall tower observed annual mean wind speed differences (m/s), for the U.S. and Canada from the 3TIER global wind dataset.

North America

Figure 5

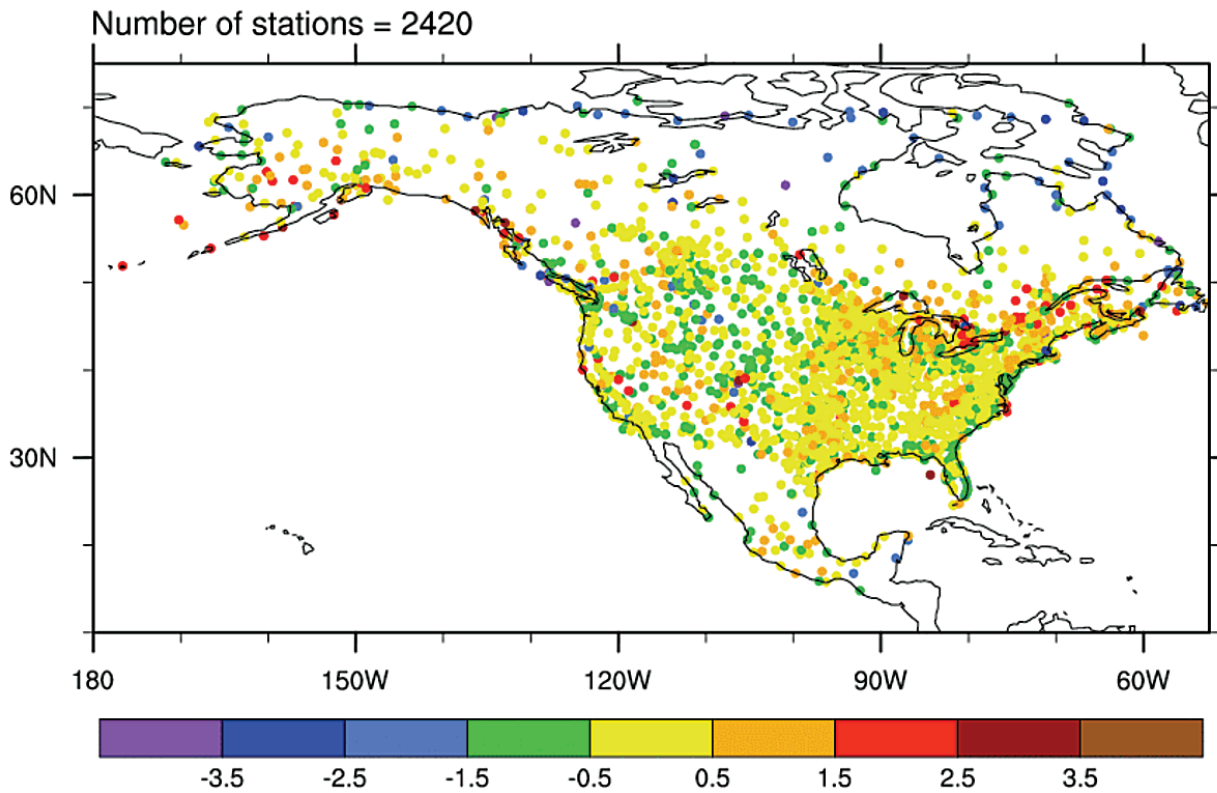


Figure 5. Map of 3TIER minus NCEP ADP observed annual mean wind speed differences (m/s), for the North America region (U.S./Canada/Mexico) from the 3TIER global wind dataset.

Figure 6

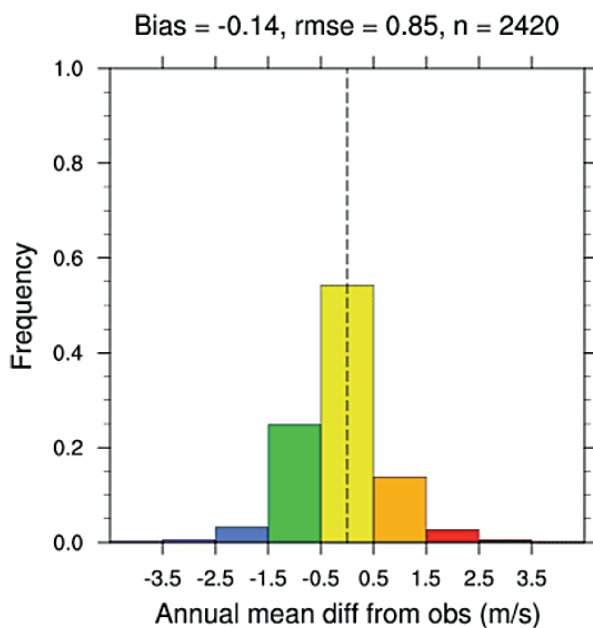


Figure 6. Histogram of 3TIER minus NCEP ADP observed annual mean wind speed differences (m/s), for the North America region (U.S./Canada/Mexico) from the 3TIER global wind dataset.

South America

Figure 7

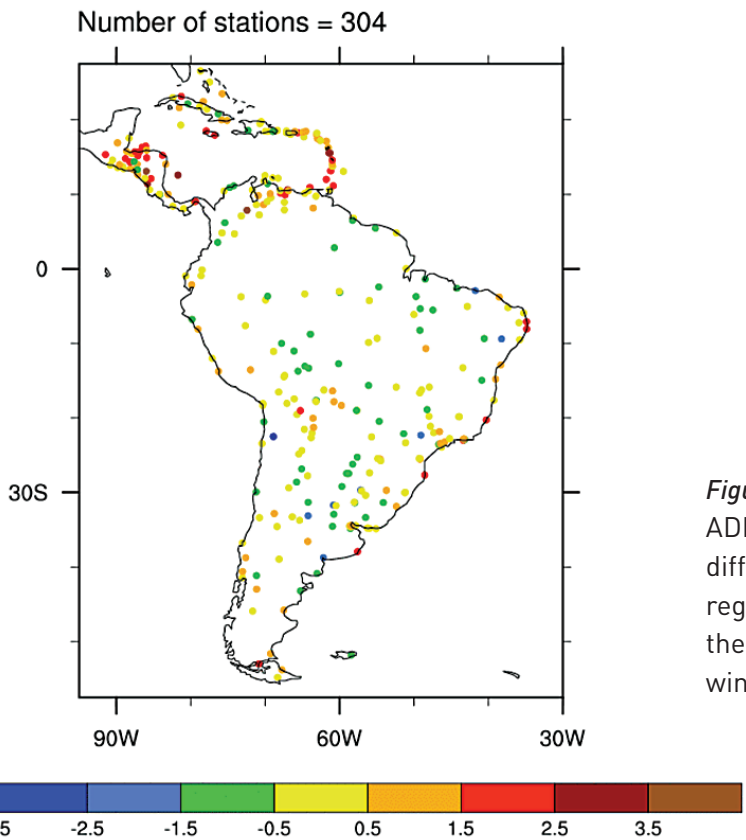


Figure 7. Map of 3TIER minus NCEP ADP observed annual mean wind speed differences (m/s), for the South America region (including Central America and the Caribbean) from the 3TIER global wind dataset.

Figure 8

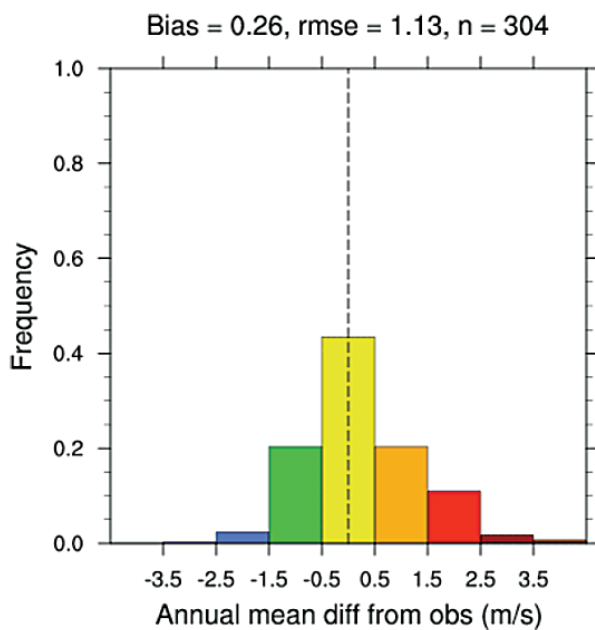


Figure 8. Histogram of 3TIER minus NCEP ADP observed annual mean wind speed differences (m/s), for the South America region (including Central America and the Caribbean) from the 3TIER global wind dataset.

Figure 9

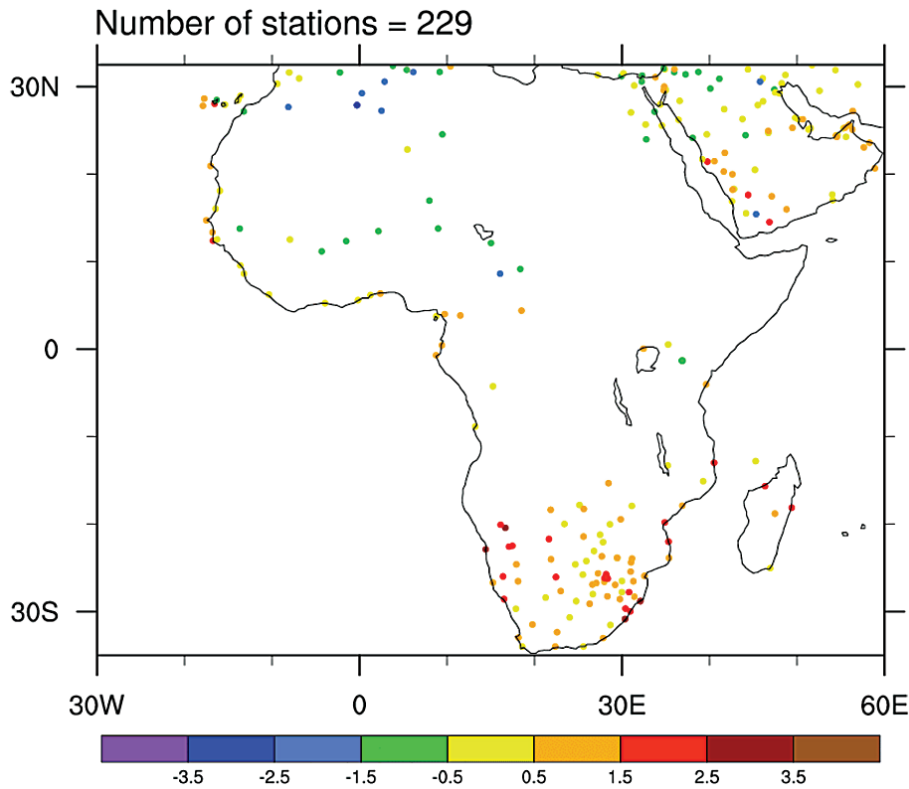


Figure 9. Map of 3TIER minus NCEP ADP observed annual mean wind speed differences (m/s), for the Africa region (including the Middle East) from the 3TIER global wind dataset.

Figure 10

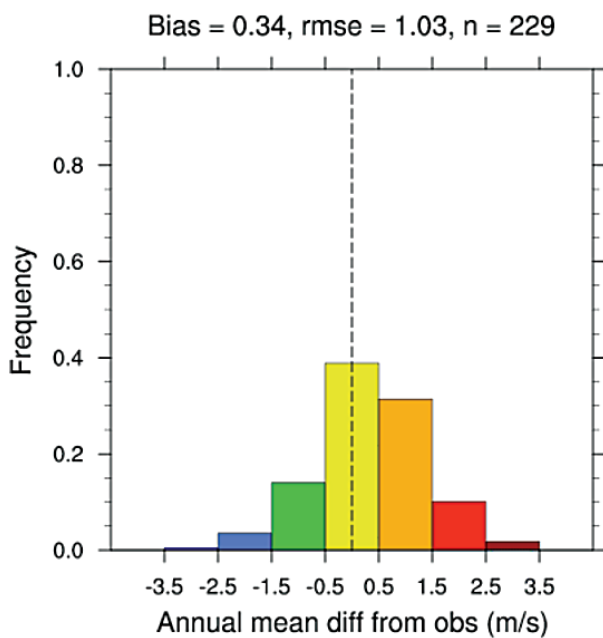


Figure 10. Histogram of 3TIER minus NCEP ADP observed annual mean wind speed differences (m/s), for the Africa region (including the Middle East) from the 3TIER global wind dataset.

Europe

Figure 11

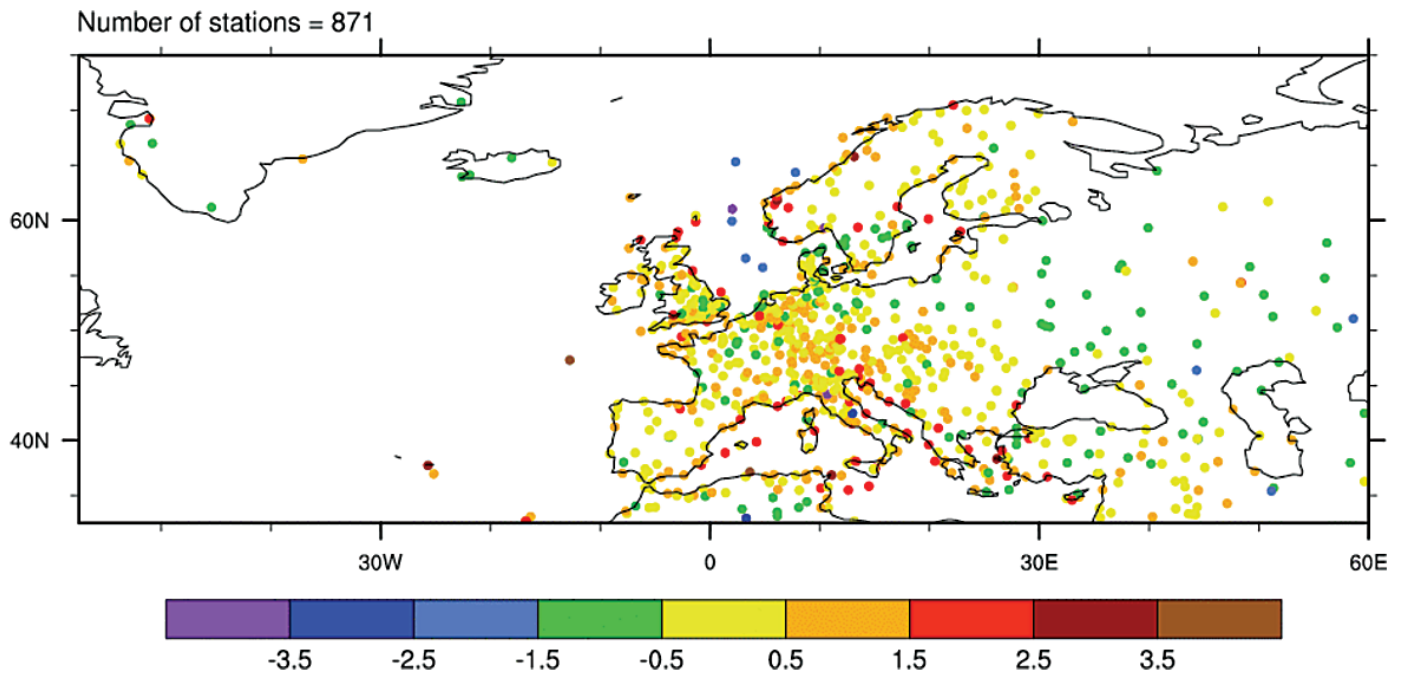


Figure 11. Map of 3TIER minus NCEP ADP observed annual mean wind speed differences (m/s), for the Europe region (including Greenland, far northern Africa, and western Asia) from the 3TIER global wind dataset.

Figure 12

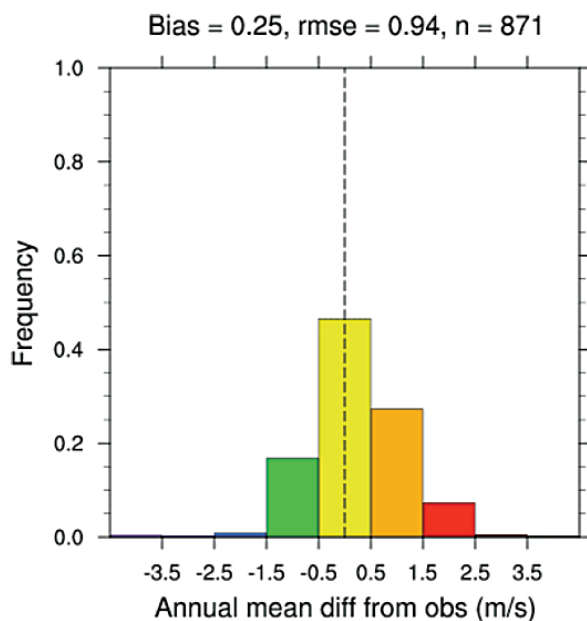


Figure 12. Histogram of 3TIER minus NCEP ADP observed annual mean wind speed differences (m/s), for the Europe region (including Greenland, far northern Africa, and western Asia) from the 3TIER global wind dataset.

Figure 13

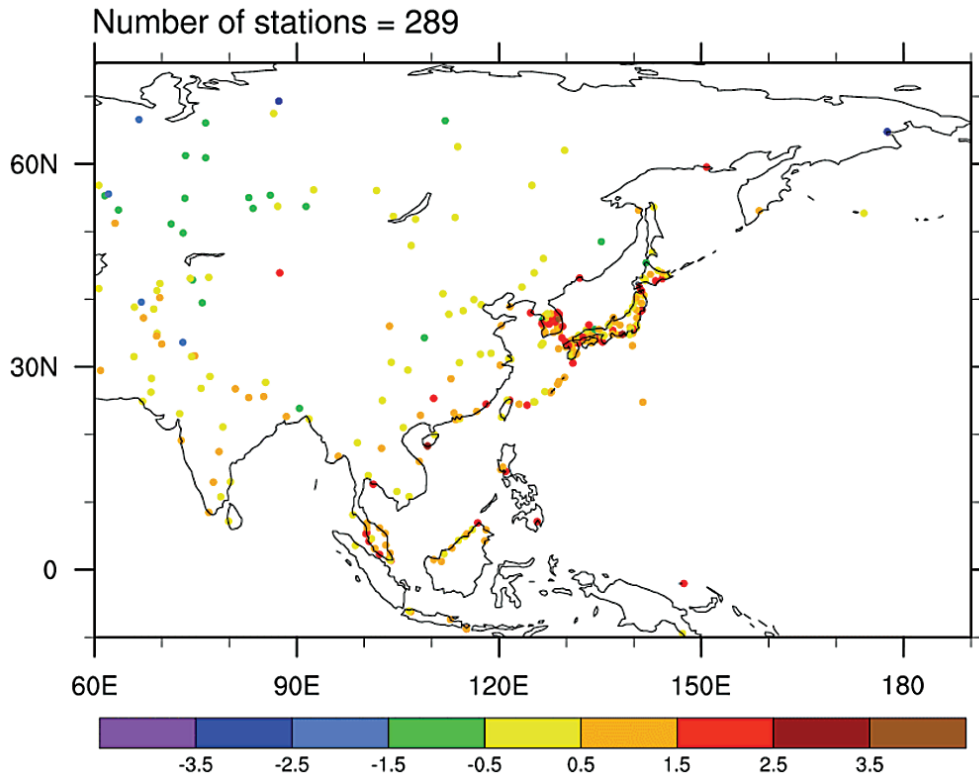


Figure 13. Map of 3TIER minus NCEP ADP observed annual mean wind speed differences (m/s), for the Asia region (including Indonesia) from the 3TIER global wind dataset.

Figure 14

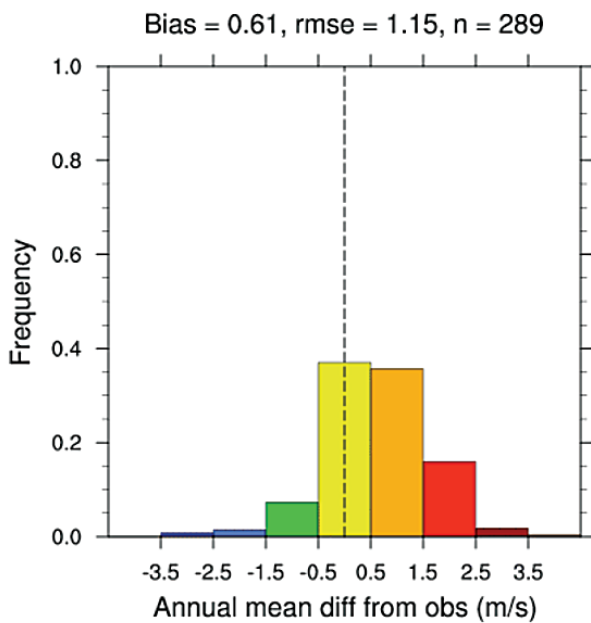


Figure 14. Histogram of 3TIER minus NCEP ADP observed annual mean wind speed differences (m/s), for the Asia region (including Indonesia) from the 3TIER global wind dataset.

Figure 15

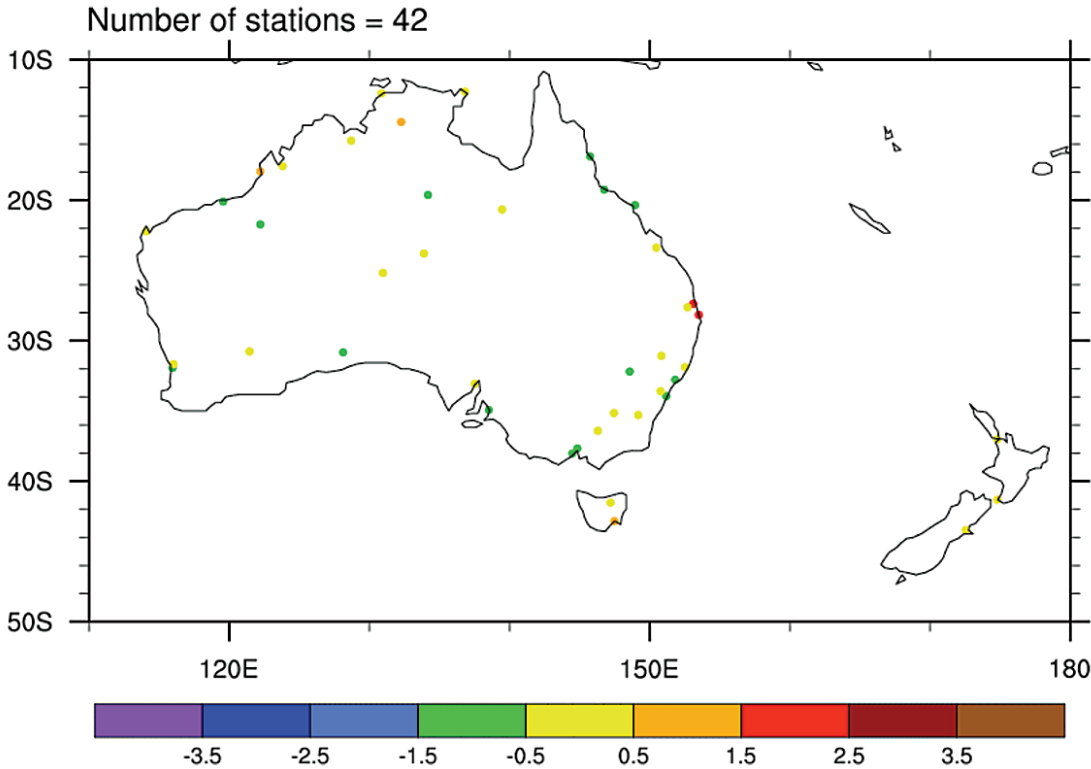


Figure 15. Map of 3TIER minus NCEP ADP observed annual mean wind speed differences (m/s), for the Australia region (including New Zealand) from the 3TIER global wind dataset.

Figure 16

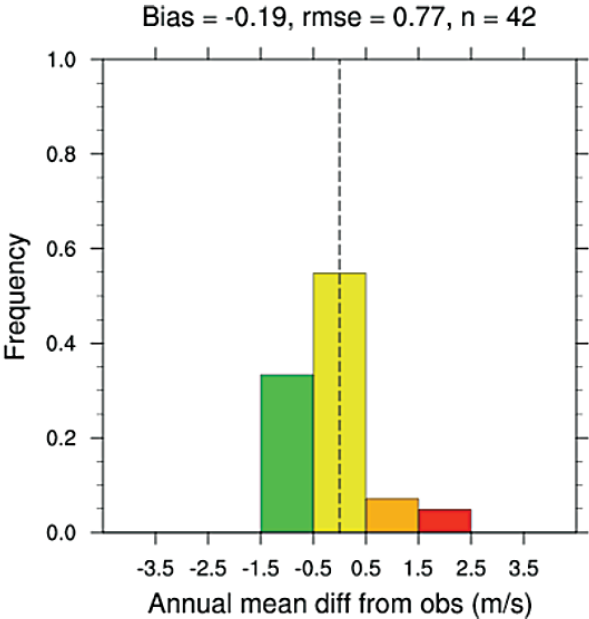


Figure 16. Histogram of 3TIER minus NCEP ADP observed annual mean wind speed differences (m/s), for the Australia region (including New Zealand) from the 3TIER global wind dataset.