Gridded Data – Speedwell Derived Gridded Products

Introduction

Speedwell Weather offers access to a wide choice of gridded data series. These datasets are sourced from the originating agencies in their native resolution. For many users, these native resolution datasets will be sufficient to meet their needs, however, some projects may require increased spatial or temporal resolution. In order to enhance the native gridded data, Speedwell processes the data through a proprietary methodology to generate a new series at higher spatial resolutions and specific vertical heights. These are called Speedwell Derived Products and can be found in the Speedwell Gridded Data catalogue. The following is a guide to how these are produced.

Background

The term "Gridded data" can mean many things. Here at Speedwell we define gridded data as a geospatial dataset that has been produced via the interpolation of regular/irregular meteorological observations or reanalysis products. Reanalysis is a relatively young field in meteorology and is a product of the development in numerical forecast modelling which relies on establishing a uniform set of initial conditions to run the forecast. It provides a multivariate, spatially complete, and coherent record of the global atmospheric circulation. The two main (but not exclusive) sources for the generation of these hi-resolution derived products are the global North American and European reanalysis **MERRA2** and **ERA-Interim** (transitioning to ERA5) respectively. These two series are selected as they have global coverage at several atmospheric layers (pressure levels). Using these, it is possible to generate higher resolution products anywhere in the world at any height

Note: Speedwell Weather only uses official sources when downloading native gridded products.

Methodology

The production of proprietary high resolution datasets with custom vertical heights follows the following steps.

Step #1
Native resolution gridded datasets are downloaded from the originating institutions. The accuracy of these datasets vs. surface observations are analysed where overlapping data is available. The findings of the analysis are published as a dataset specific white paper available to Speedwell clients.

Step #2
Upon confirming the accuracy (as compared with surface observations) of a dataset we then proceed with generating our own proprietary dataset. The main workflow is:

- Application of a high resolution algorithm that takes into account the spatial gradient in both dimensions XX and YY to generate higher **horizontal resolution** products (high resolution statistical downscale);
- If the derived product is to be set on a specific height other than the surface, then a **vertical interpolation** algorithm is also computed (for example, this technique would be applied when generating wind speed data for wind turbines at various heights above the ground);

Step #3

The accuracy of the high resolution (or vertically adjusted) datasets are then reviewed vs. surface observations. The purpose is to check for added value and for interpolation artifacts, i.e. smoothing data without degrading the native grid extreme values. The findings of the analysis are published as a dataset specific white paper available to Speedwell clients.

Details

Vertical Interpolation

- Vertical interpolation is carried out assuming that some quantities (like wind, temperature, humidity, etc.) vary linearly with log pressure/height. The value of field F at pressure/height p_i is given by the formula:

$$Fi = \alpha F_j + (1 - \alpha) F_j - 1 \quad (1)$$

where j and j_{-1} are levels at which the field F is known immediately above and below level i, and

$$\alpha = \frac{ln\left[\frac{p_i}{p_{j-1}}\right]}{ln\left[\frac{p_j}{p_{j-1}}\right]} \quad (2)$$

For the vertical interpolation, we use model levels instead of pressure levels, as they are terrain following levels, i.e. they take into account the orography effect

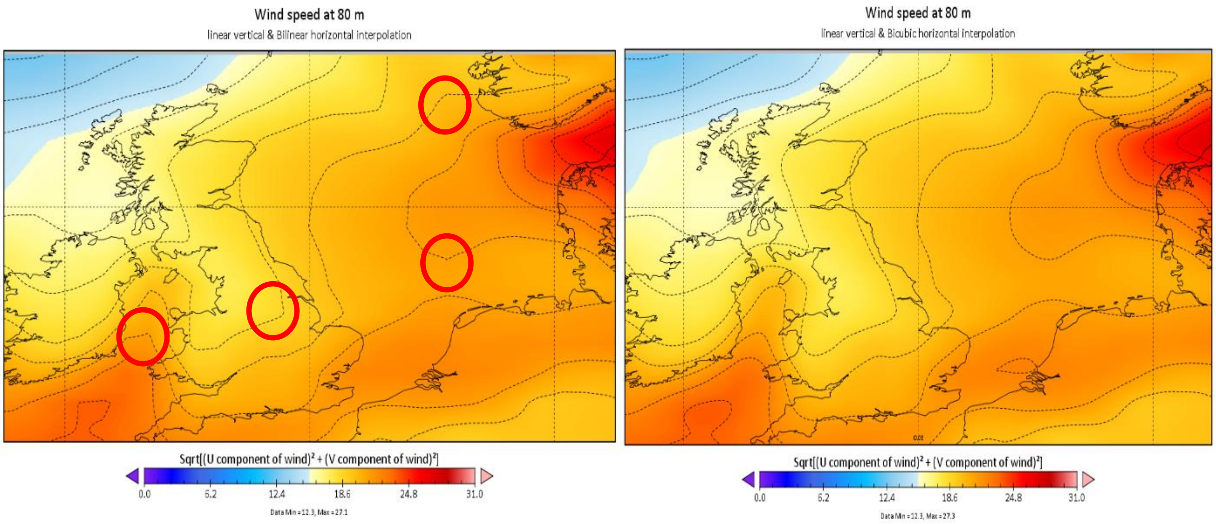
Horizontal Interpolation – Bicubic Interpolation

- Bicubic interpolation is cubic interpolation in two dimensions. In contrast to bilinear interpolation, which only takes 4 points (2×2) into account, bicubic interpolation considers 16 points (4×4). Data resampled with bicubic interpolation is smoother and have fewer interpolation artifacts, and preserves fine detail better than the common bilinear algorithm :

$$g(x,y) = \sum_{i=0}^{3} \sum_{j=0}^{3} a_{ij} x^i y^j$$

Image #1

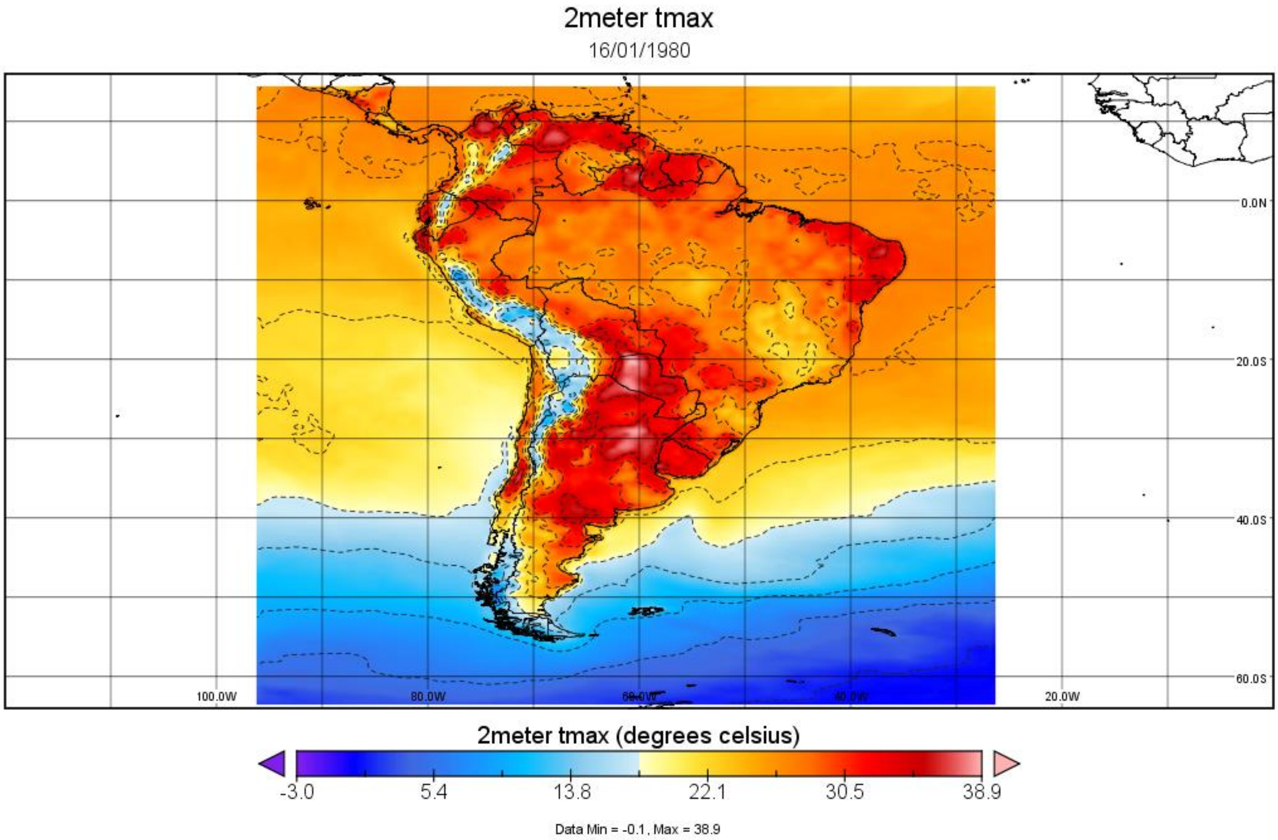
The two images below demonstrate the difference between bilinear (left) and bicubic (right) interpolation for wind at 80m height:

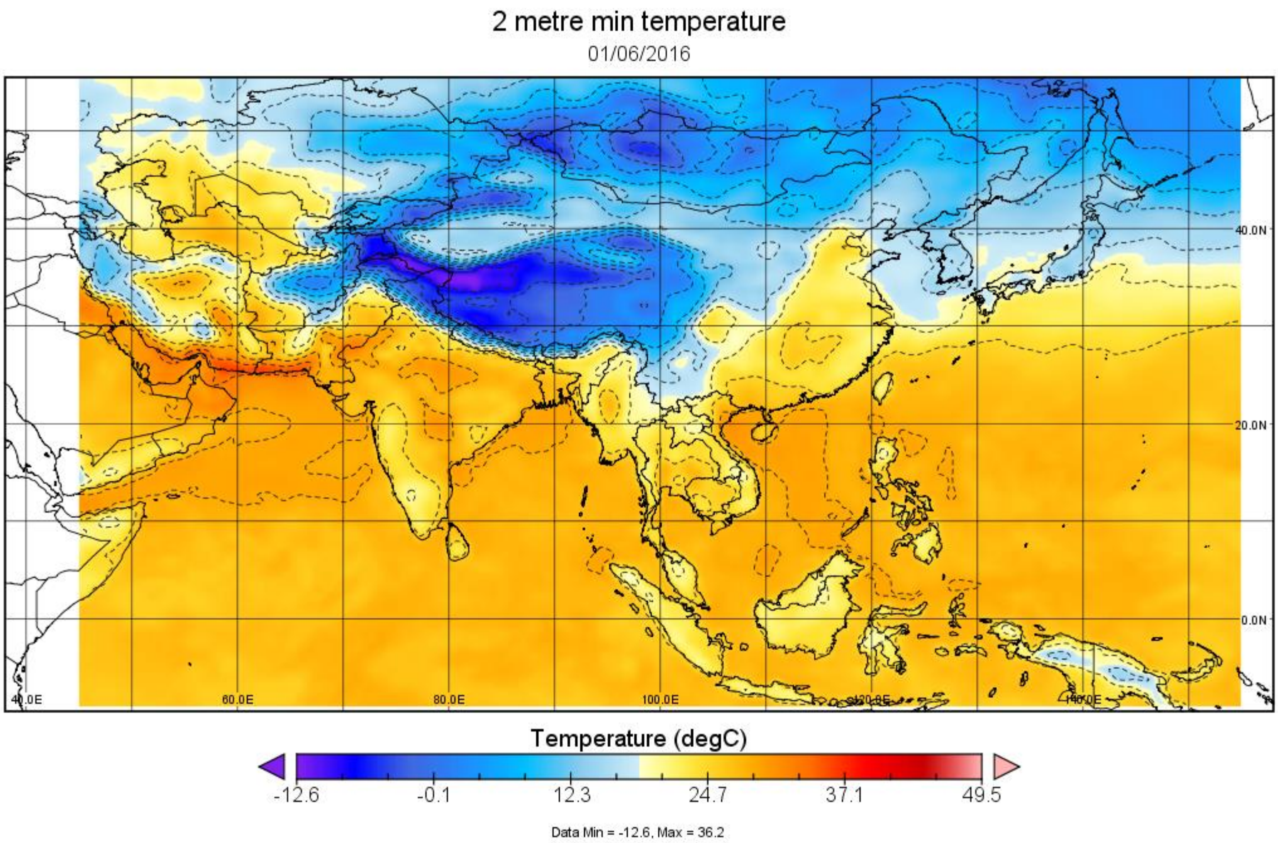


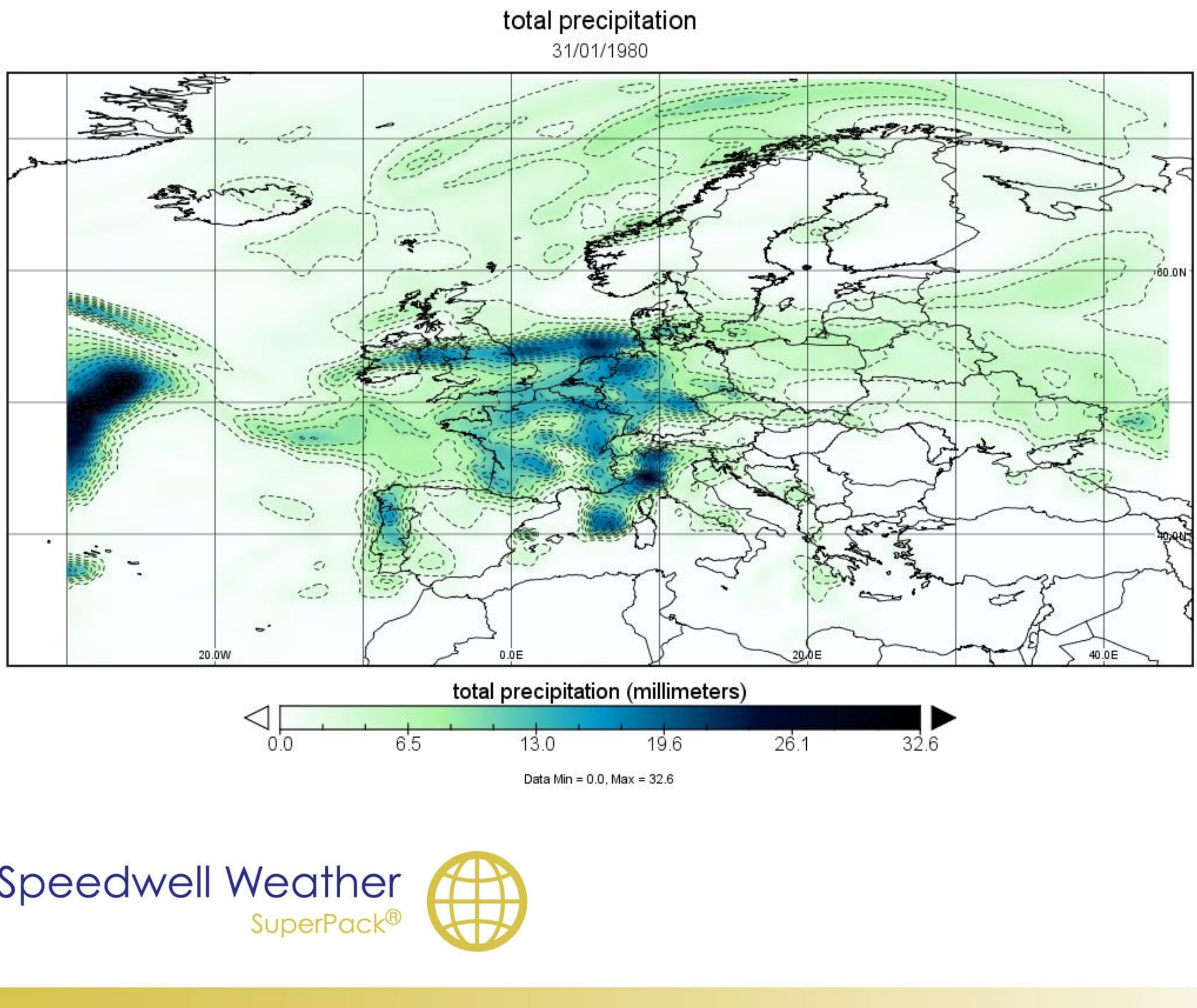
Red circles illustrate some of the smoothing problems with bilinear interpolation that are not present in the bicubic. Hence bicubic interpolation is able to smooth data without degrading extreme values.

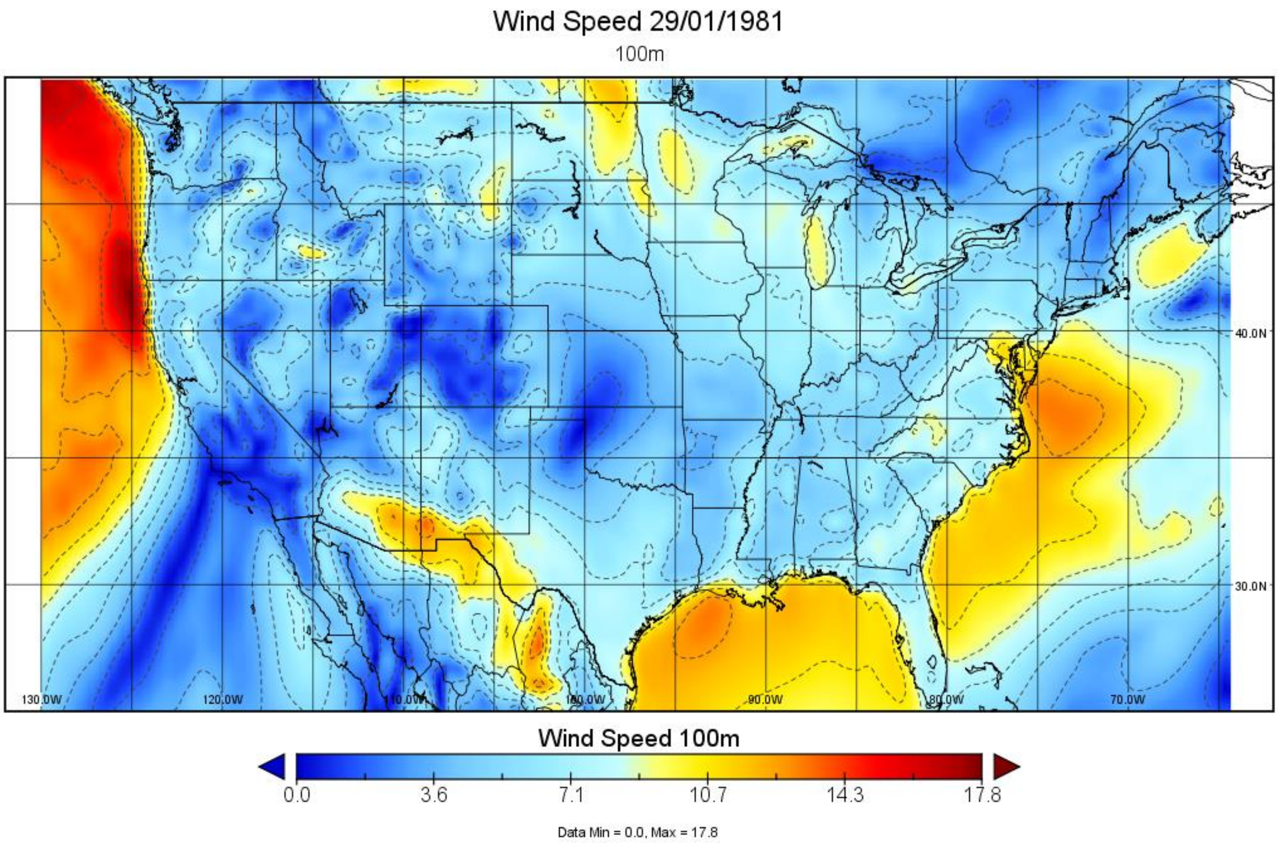
Image #2

The following images depict 5km x 5km resolution Speedwell derived gridded datasets.




2 metre min temperature
01/06/2016
40.0N
20.0N
0.0N
40.0E
60.0E
80.0E
100.0E
Temperature (degC)
-12.6
-0.1
12.3
24.7
37.1
49.5
Data Min = -12.6, Max = 36.2


total precipitation
31/01/1980
60.0N
40.0N
20.0W
0.0E
20.0E
40.0E
total precipitation (millimeters)
0.0
6.5
13.0
19.6
26.1
32.6
Data Min = 0.0, Max = 32.6


Wind Speed 29/01/1981
100m
40.0N
30.0N
130.0W
120.0W
110.0W
100.0W
90.0W
80.0W
70.0W
Wind Speed 100m
0.0
3.6
7.1
10.7
14.3
17.8
Data Min = 0.0, Max = 17.8

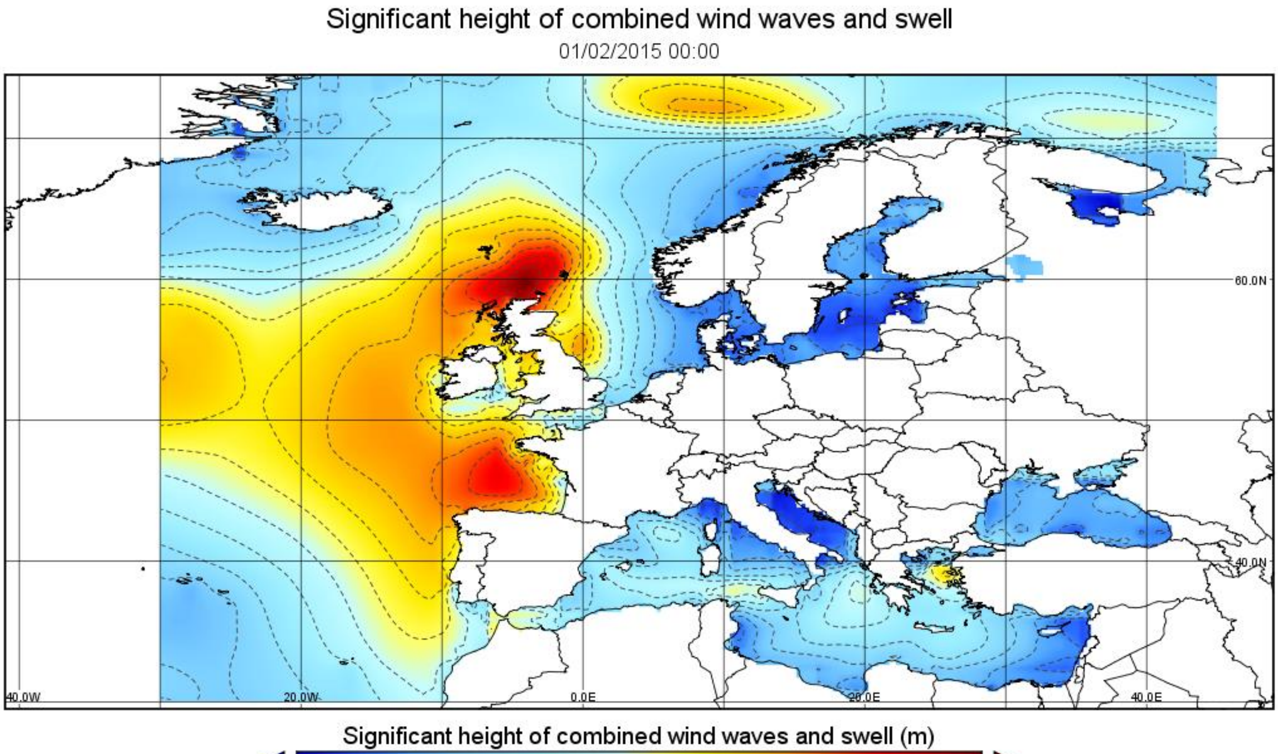
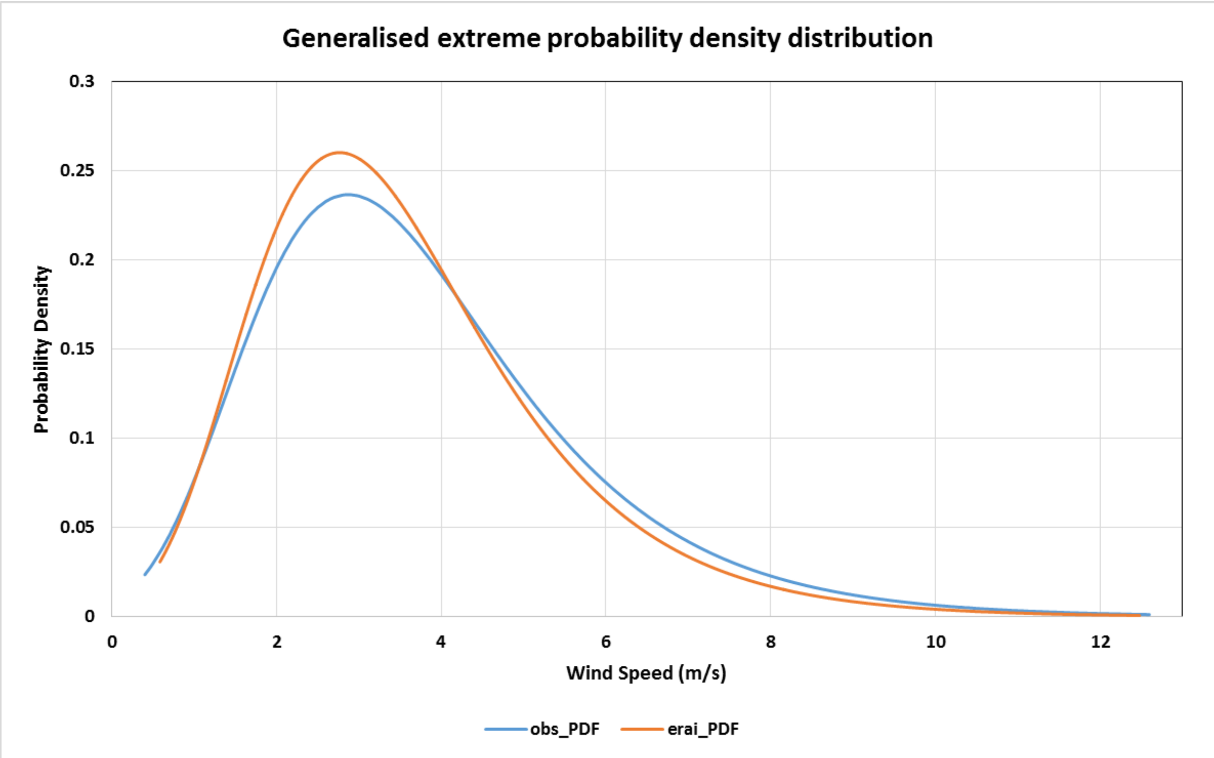

Significant height of combined wind waves and swell
01/02/2015 00:00
60.0N
40.0N
40.0W
20.0W
0.0E
20.0E
40.0E
Significant height of combined wind waves and swell (m)
0.3
1.7
3.1
4.4
5.8
7.2
Data Min = 0.3, Max = 7.2

Image #3

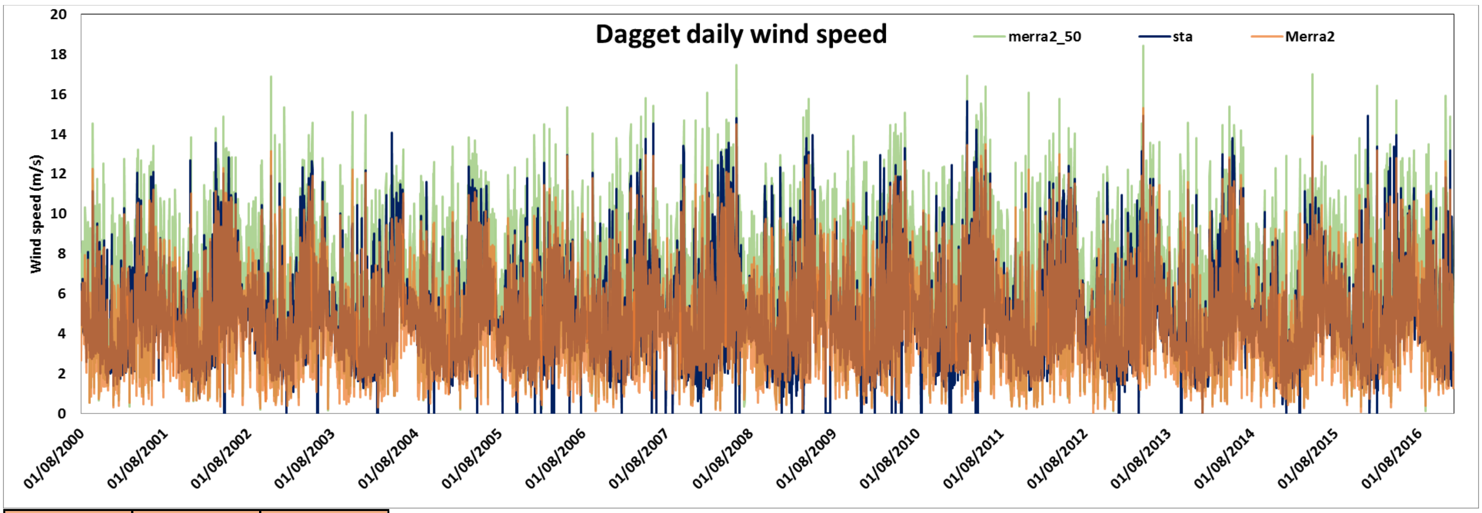
The following images demonstrate the comparison of gridded observations vs. surface observations

Significant Wave height (m) PDF: buoy vs derived 5km, 40km from Ireland shore



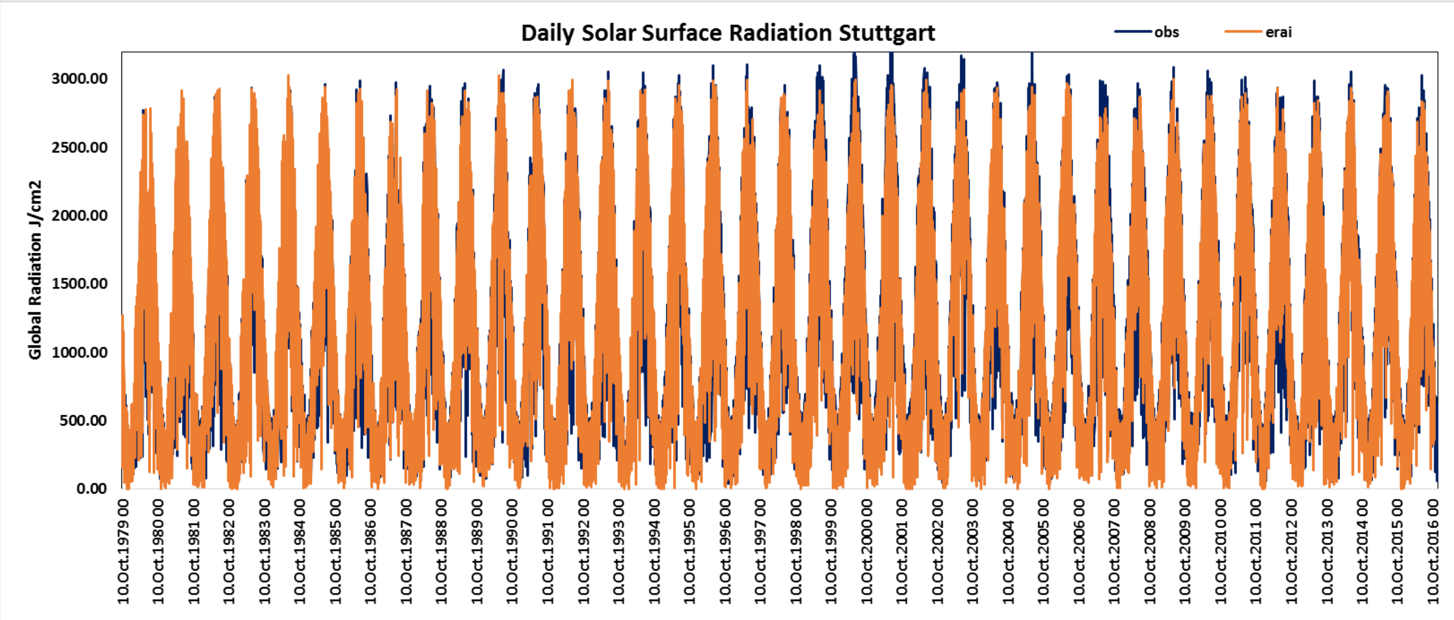
correl	BIAS	MAE
95%	-0.10	0.33

Wind speed at 10 and 50 m (m/s) daily time series series: ground obs10m vs derived10m 5km over Dagget US



BIAS	MAE	CORR
-0.03	1.41	72%

Surface Solar Radiation daily time series (J/cm2): ground obs vs derived 5km over Stuttgart (Germany)



correl	BIAS	MAE
95%	66.01	197.82