A comparison of aircraft-based surface-layer observations over Denmark Strait and the Irminger Sea with meteorological analyses & QuikSCAT winds

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Study Details

• A compilation of aircraft observations of the atmospheric surface layer over Denmark Strait, the Iceland Sea, and the Irminger Sea are compared against several meteorological analyses and QuikSCAT wind products.

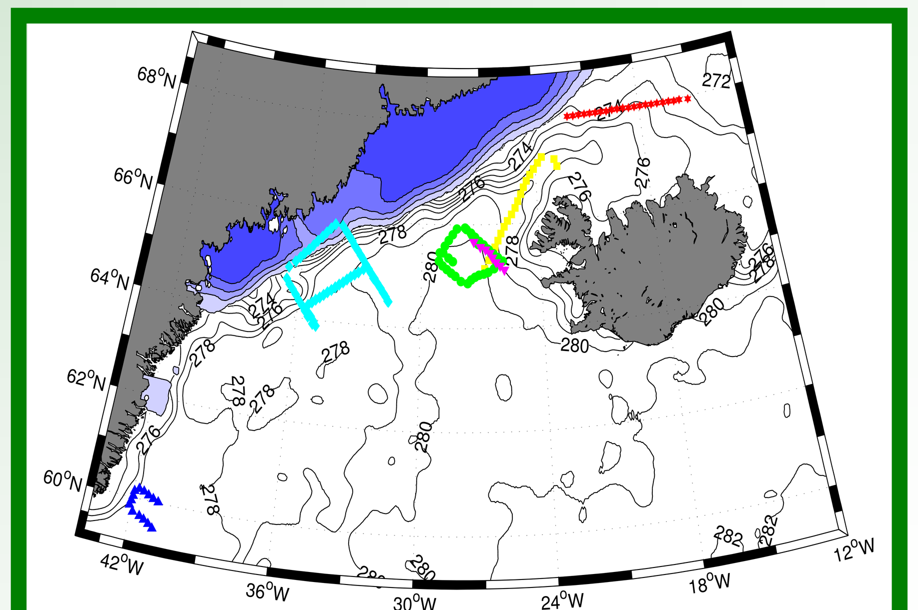
• About 150 data points spread over six days are used, with each data point derived from a 2-minute run (equivalent to a 12 km spatial average).

• The observations were taken 30-50 m above the sea surface and are adjusted to standard meteorological heights for the comparison.

• The observations were taken during the Greenland Flow Distortion Experiment, in February and March 2007, during cold-air outbreak conditions and moderate to high wind speeds, see Renfrew et al. (2008) for an overview of GFDex.

• The model timeseries are extracted from:

- ECMWF-T511/N400 & ECMWF-1deg operational analyses
- NCEP Global Reanalyses & NCEP North American Regional Reanalyses (NARR)
- Met Office North Atlantic-European operational analyses (NAE)
- MM5 hindcasts with OSTIA SSTs.
- QuikSCAT winds with RSS & NASA-DIRTH retrieval algorithms



Locations of the observations from the low-level legs of flights B268 (blue triangles), B271 (red stars), B274 (yellow squares), B276 (cyan diamonds), B277 (magenta triangles) and B278 (green circles). SST and sea-ice concentration from the OSTIA.

References

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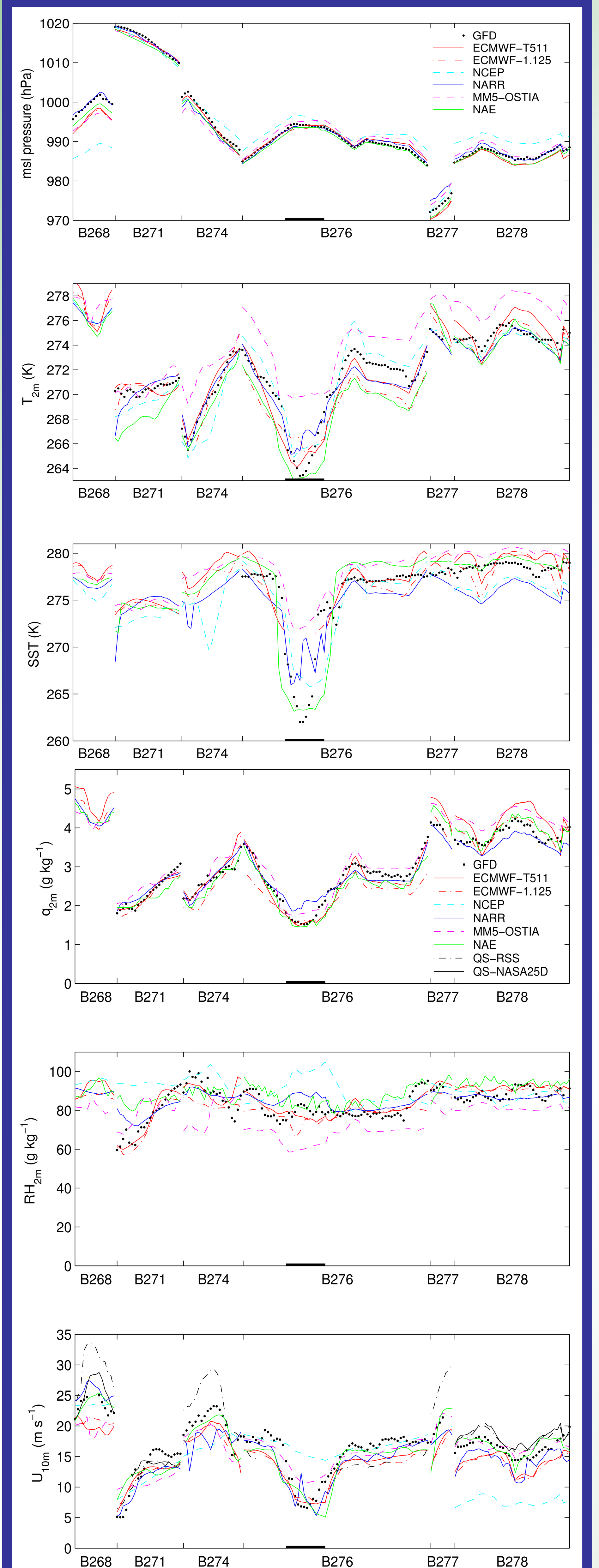
• Donlon et al. 2007: The Global Ocean Data Assimilation Experiment High-resolution Sea Surface Temperature Pilot Project. *Bull. Amer. Meteorol. Soc.*, **88**, 1197–1213.

• Renfrew, I.A. , G.W.K. Moore, P.S. Guest, and K. Bumke, 2002: A comparison of surface-layer and surface turbulent-flux observations over the Labrador Sea with ECMWF analyses and NCEP reanalyses, *J. Phys. Oceanogr.*, **32**, 383-400.

• Renfrew et al., 2008: The Greenland Flow Distortion experiment, *Bull. Amer. Meteorol. Soc*, **89**, 1307-1324.



Spatial "timeseries" plots showing observations (dots) and model or satellite products for the 6 low-level flights. A bold horizontal line on each panel marks where the data are from over observed sea ice.

A summary of model performance

• The **ECMWF model** does not capture the highest windspeeds observed, despite a horizontal resolution equivalent to ~40 km in the T511/N400 truncation. This suggests mesoscale atmospheric flow features are being 'smoothed out' (see also Chelton et al. 2006). At T511/N400 the model produces good estimates for the surface-layer temperature and humidities, despite a large scatter in SST. But at lower resolution there is a bias of -0.7 K in T_{2m}.

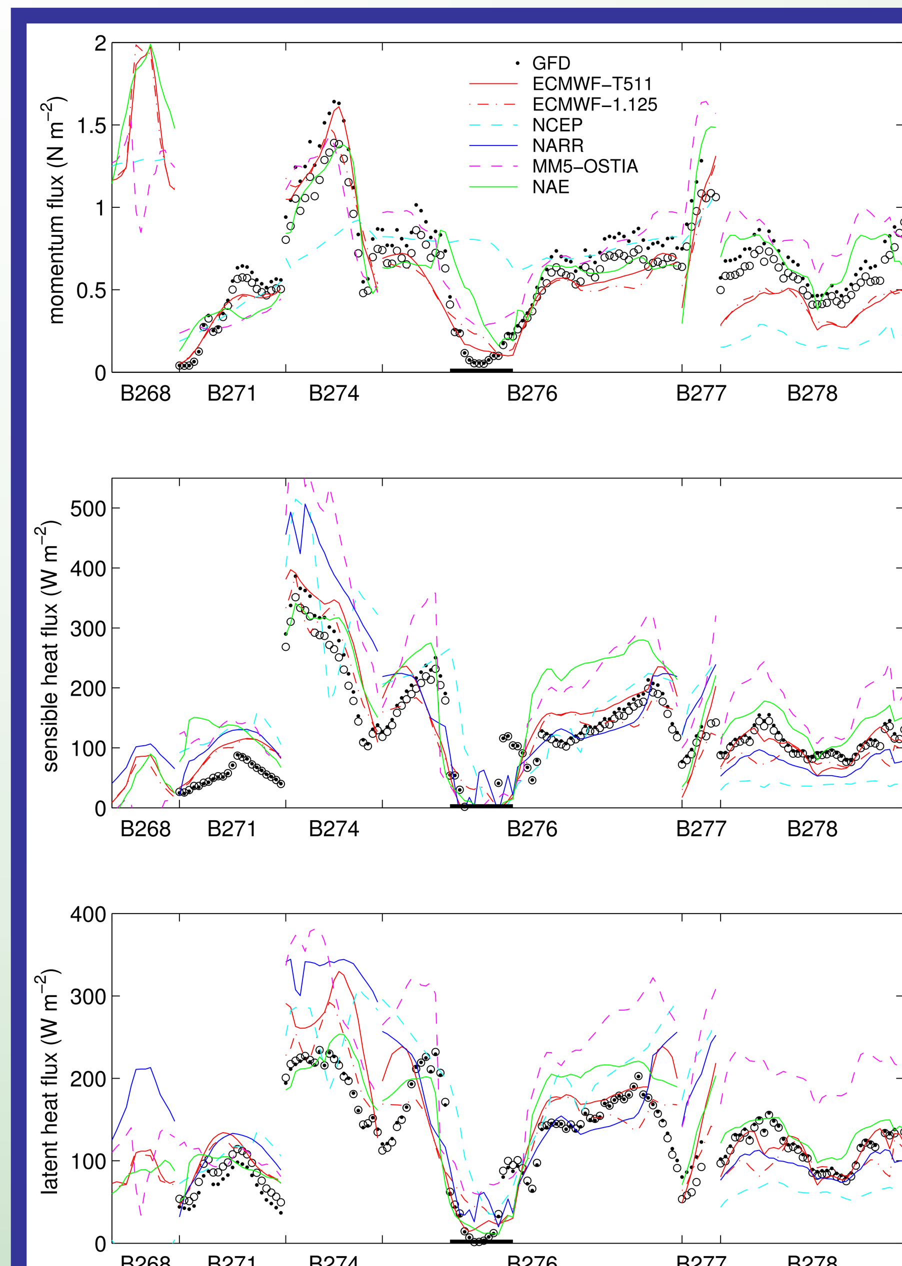
• The **NCEP Global Reanalyses** are simply too coarse to adequately resolve the mesoscale flow features. The correspondence in U_{10m} is very poor. The T_{2m} and SST correspondences are reasonable for the model's resolution, but there is still a positive bias in RH as discussed in Renfrew et al. (2002). The flux correlations are poor.

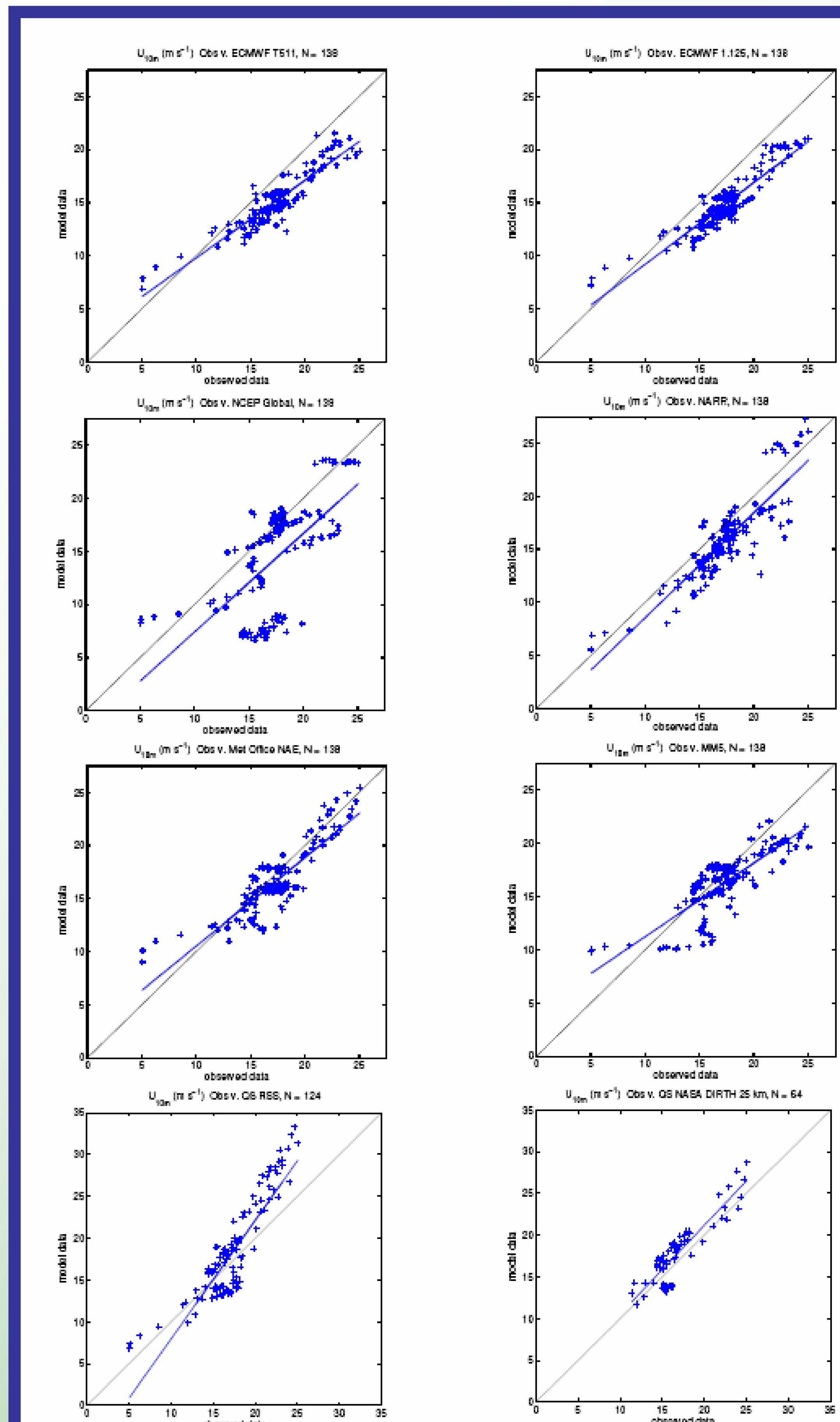
• The **NCEP NARR** comparison is generally good. At this resolution (32 km) the highest U_{10m} can be simulated, although overall there is a negative bias of -1.5 m s^{-1}. The correspondences in T_{2m} and q_{2m} are good, suggesting that the ABL parameterizations are adequate; with the caveat that the slope in the RH_{2m} comparison is too low and ΔT is rather low. The correspondence of the surface heat fluxes is disappointing, suggesting the bulk flux algorithm is *not* optimal.

• The **Met Office NAE operational model** does well at capturing the observed high winds associated with the barrier flows and jets. However adjacent and over areas of sea ice there is a pronounced cold bias in T_{2m} (-1.3 K on average), which is *not* explained by a +1.1 K bias in the SST. This problem may be explained by the model's sea ice being set too thick at 2 m. The NAE RH_{2m} has a similar low-slope problem to the NARR model. The surface turbulent fluxes are generally well-modelled, but the relatively large biases in ΔT and Δq result in relatively large biases in the heat fluxes.

• The **MM5 hindcasts** are able to capture the high windspeed jets, but some times do not. A +1.7 K bias in the OSTIA SST used leads to a positive bias in T_{2m} (2.3 K) and in q_{2m}. The RH_{2m} corresponds poorly to the observations, suggesting little skill for this field during these conditions. The MM5 default bulk flux algorithm results in a poor regression slope and large bias, which leads to large overestimates in the sensible and latent heat fluxes.

• The **QuikSCAT wind comparisons** are poor: the linear regression slopes are too large and the r.m.s. errors – at 3.3 and 1.9 m s^{-1} for the RSS and NASA-DIRTH retrievals respectively – are higher than the instrument's design specifications. The NASA DIRTH algorithm is more conservative, with data only available for 3 flights, while the RSS algorithm appears to be more problematic at high wind speeds.





Scatter plots of aircraft observations versus model 10-m wind speed (U10m) for models and satellite products as indicated.

Conclusions

• To simulate the high winds associated with extratropical mesoscale weather systems – such as tip jets, barrier flows and polar lows – a model resolution of order 20 km is necessary, but is not sufficient, as appropriate ABL and surface flux parameterizations are also crucial.

• In regions of the subpolar seas, close to the sea-ice edge, the current generation of NWP models still have problems in accurately simulating ABL temperature and humidity, perhaps being unable to transit from stable to unstable conditions quickly enough?

• An accurate prescription of the SST is essential, but at the time of GFDex these were generally prescribed at a relatively coarse resolution. The operational use of a new generation of high-resolution SST products (e.g. Donlon et al. 2007) will no doubt improve the quality of SST fields, but there are still likely to be relatively high discrepancies in cloudy areas of high SST gradients.

• The use of surface turbulent fluxes from NWP models is *not* recommended without an investigation of the surface flux algorithm used and validation against observations.