Verification Notes

April 3, 2019

1 Notes

1. Example figure with one day diurnal cycles for both AWS, Official, ECMWF and ACCESS winds, perturbations, and perturbation climatology. Just one season.

2. Airport breakdown for one season, WPI, CWPI for one season, for both ACCESS and ECMWF. Second season in online supporting material.

3. Example results for straight coastlines - perhaps north, northeast, northwest, south, southeast, southwest? Again, just do one season, include second season in online supporting material?

4. Look at timing results by fitting ellipses and checking orientations of major axes. Just one season - both ECMWF and ACCESS? Maybe just ACCESS if ECMWF results are dodgy?

5. Confirm ACCESS and ECMWF are indeed the msot commonly used model guidance products for winds.

6. I tried modifying the pressure perturbation terms $\frac{A}{\pi} + \frac{A}{2}\cos(\omega t)$ so that the new ellipse fit of equations (**??**) and (**??**) are now solutions to equations (**??**) and (**??**), but with no luck. For example, simply changing to $\frac{A}{\pi} + \frac{A}{2}\cos(\alpha(\psi, t))$ doesn't work, nor does expanding this expression as a Fourier series and solving each term individually. This doesn't really matter anyway as my main argument is that this two-dimensional model cannot capture boundary layer mixing processes.

1. In Cairns and Townsville (austral summer), ECMWF understimates the magnitude of the land-sea breeze, leading to ACCESS resolving the diurnal cycle more accurately. During austral winter ECMWF again underperfoms, but (Townsville) more to do with shape of the hodograph and direction of the sea-breeze. At Cairns, it's essentially again because the ECMWF peak seabreeze is slightly (1 knot) too slow.

2. In Darwin - ACCESS perturbations bizarre during austral summer (wet season), but ECMWF also much too weak (about half the amplitude).

3. In Darwin - during austral winter (dry season) - ECMWF very accurate - gets peak of sea-breeze perfectly correct! Also resolves weird bump at 12 UTC quite well. However, does not resolve bump at 1 UTC at all. ACCESS doesn't either really.

4. Interesting - at Melbourne ECMWF and ACCESS essentially agree, but both underestimate the magnitude of the land-sea breeze. True of both seasons.

5. Adelaide - ACCESS and ECMWF almost match at Adelaide. Amplitudes generally slightly too weak compared to observations however.

6. Need to assume intependence of measurement and rounding error in observations.

2 Paper Summaries

2.1 Bureau of Meteorology (2010)

ACCESS uses the scheme of Lock et al. (2000) for mixing in unstable layers. 7 classification types for boundary layers. Cumulus mixing uses the mass-flux convection scheme. Entrainment rates across the inversion at the top of the boundary layer are parametrised using the eddy diffusivity scheme of Lock (1998; 2001) scaled using cloud-top cooling rates. Mixing in stable boundary layers uses the local Richardson number first order closure of Louis (1979) with stability dependent surface exchanges calculated using Monin-Obukhov Similarity.

2.2 Louis (1979)

2.3 Lock et al. (2000)

2.4 European Center for Medium Range Weather Forecasting (2018)

2.5 Bishop & Abramowitz (2013)

2.6 Basu et al. (2008)

2.7 Kumar et al. (2006)

2.8 Zhang & Zheng (2004)

Great resource on character of diurnal cycle of winds in the PBL. Performs a comparison of five different parametrisation schemes.

2.9 Holtslag et al. (2013)

Great summary article. Discusses evaluation studies of Svensson et al. (2011). "The modeled diurnal cycle of the 10-m wind speed does not resemble the observations in many cases, most models overestimate the wind speed during night, and the speed does not increase enough after the morning transition (Fig. 8b).

2.10 Hoxit (1975)

Provides good figures showing the diurnal evolution of wind speed and direction.

2.11 Englberger & Dörnbrack (2018)

Discusses effect of PBL diurnal cycle on the wake structure of wind turbines and wind farms.

2.12 Liu & Liang (2010)

PBL height.

2.13 Stensrud (1996)

Low level jets.

2.14 Svensson et al. (2011)

Evaluation of model performance. Crucial article.

2.15 ?

2.16 Pinson & Hagedorn (2012)

Proposes station-oriented view of the verification problem (which is what we are doing). Notes that there is a "representativeness issue" in that station-data is resolving processes at physical scales the model is infact not intended to resolve. Notes that from the users perspective this is irrelevant. *How could forecasters or post-processing incorporate this uncertainty into the forecast?* Discusses in detail the bilinear interpolation process for downscaling forecast data to location of stations. *What is Jive's procedure for doing this?* Forecasts are benchmarked against 1-6 climatology based forecasts. Notes that observational uncertainty is known to be non-negligible, while surface effects introduce additional noise beyond what the numerical models intend to represent (or are capable of representing.) Representativeness issue ignored here for above reasons. Notes one method of dealing with observational uncertainty when performing ensemble (probabilistic) forecast verification is by transforming observations into random variables. Impact of observational uncertainty can then be assessed using methods like those of Pappenberger et al. (2009). Note that Pappenberger still applies only to probabilistic forecasting.

Very important - notes that the most poorly performing locations across Europe are the Alps and coastal regions, and that "This could be expected since near-surface local effects [e.g. mountain and sea-breezes] are difficult to resolve at the fairly coarse resolution (50 km) of the ECMWF ensemble prediction system. [What is the spatial resolution of the ECMWF, ACCESS data used in GFE?] Authors comment on "...questionable quality of the ensemble forecasts, for instance due to local effects not represented in a model with such a coarse spatial resolution". Could also be ensemble averaging process suppressing local processes.

Key discussion - "The periodic nature of the RMSE curves is linked to the diurnal cycles in the wind speed magnitude, the amplitude of such periodicities varying throughout Europe. To identify better the effect of the diurnal cycle on verification statistics, one may refine the analysis performed here by verifying forecasts depending on the time of the day (instead of the lead time), or by making a difference between forecasts issued at 0000 and 1200 UTC." So diurnal cycles are mentioned in passing here - good reference to make.

Regarding observational uncertainty - the effect of uncertainty diminishes as the number of stations or the length of the evaluation period increases. "This effect was observed to become negligible if looking at more than 100 stations over periods of more than a month (with two forecast series issued per day). For certain sites with strong local regimes though, one retrieves a more intuitive result that ensembles significantly underestimate wind speed.

2.17 Lynch et al. (2014)

Focuses more on longer term forecasts. Interesting note that there is little difference in performance between 10m and 100m winds. Applies verification to forecast anomalies (from seasonal and diurnal cycles). SImilar approach to me, but work out average for each hour for each day of year, averaged over 32 years of ERA-Interim record. Note that I'm also avoiding the "aritificial skill" associated with the seasonal cycle by restricting to just a particular season. I'm not convinced that seasonal skill is necessarily "artificial" however! Both pinson and lynch use the CPRS score. Interesting notes on the large costs associated with wind farm station maintenance, and the need for probabilistic forecasts in order to manage these costs.

2.18 Ebert (2008)

Not easy to prove the value of mesoscale forecasts using traditional point-by-point verification results. At small scale features unpredictable - e.g. intermittant convective rainfall - in the example of winds the cold pool dynamics. Mesoscale forecasts typically verified against high-resolution gridded datasets, e.g. radar mosaics or reanalysis. Spatial verification techniques that do not require the forecasts to exactly match the observations at fine scales. Use of "object oriented" techniques. The term 'fuzzy' is consistent with the general concept of 'partial truth' introduced by Zadeh. Does Ebert's fuzzy scheme require gridded data? No. "Fuzzy verification assumes that it is acceptable for the forecast to be slightly displaced and still be useful. Fuzzy concept can be applied in space or time. Really we're doing "upscaling" rather than "fuzzy" verification. Uncertainty in the observations represented by using neighbouring grid boxes. Less useful to me because "event" framework not entirely appropriate to diurnal cycles. I am using an "upscaling" approach. "From the perspective of the forecast user, fuzzy verification gives important information on the scales and intensities at which the forecasts should be trusted."

2.19 Ebert & McBride (2000)

N/A

2.20 Yates et al. (2006)

N/A

2.21 Mason (2008)

Discusses practical methods for identifying in a yes/no sense whether a sea-breeze will occur. Discusses techniques for diagnosing speed and direction. Paper pretty old - would be good to have some references for up to date practices.

2.22 Ferro (2017)

Presents mathematical results regarding the calculation of verification statistics in the presence of observational error.

2.23 Wilks (2011)

Practical way to deal with autocorrelation is to think in terms of "effective sample size"

$$n' \approx n \frac{1 - \rho_1}{1 + \rho_1}. \tag{1}$$

Simply replace n with n' in appropriate places in t-test.

2.24 Miller et al. (2003)

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