EWEA Wind Resource Workshop June 2015 – Helsinki

Mesoscale Session – Edited minutes from the discussion.

Chairman: Hans Jørgensen

Discussant: Clive Wilson, Met Office, UK

Panel: Jake Badger, DTU-Wind; Daran Rife, DNV GL; Gil Lizcano, Vortex;
Andrea Hahmann, DTU-Wind

Referent: Ole Rathmann, DTU-Wind.

**Clive Wilson – introduction:**

The following questions, meant to stimulate the discussion, may be a little provocative, but hopefully you will respond to that.

The talks this morning exposed different approaches on the use of mesoscale models, and the discussion - quite a lot of it – raised the question: can you presently afford using mesoscale models all down to microscale?

The use of reanalysis data in the mesoscale benchmarking exercise is worth paying attention to. You can actually show - like what I and others have found – that you do gain by using mesoscale models in combination with downscaling. However, the choice of degree of downscaling depends on computational resources and the detailed method – so what are the current limitations for mesoscale + downscaling applied to siting?

One thing to observe is that data simulation is not used much in benchmarking exercises – whereas in operational weather centers you try to apply as much observational data as possible, and there is a wealth of data of historical forecasts available. The fact they have been produced with models which have been upgraded over time is of course a problem, but since the R2 -values for the correlation with a time series only vary slightly, then in my view this is not a very big obstacle.

Another question about mesoscale models is the limitation on scale touched upon by Gill and others: most models run in the difficult area of 2-5 km where convection and turbulence is only partially resolved or not resolved at all. This may cause the models to misbehave unless you take special measures, so most people would prefer going down to something like 1 km scale if you can spend the necessary computational resource. The problem can be even more significant in case of steep terrain – in general mesoscale models are better at phenomena like sea-breezes and channeled inflow.

The next question is how we can improve these models, pushing them into seamless modelling– Gill’s presentation was a first attempt to answering that. A large increase in computational resources will be needed so it is a question whether users can afford that and how they use the models – all in one step or in separate steps? In addition, at these smaller scales, aiming at modelling more variability data assimilation becomes more difficult – and is an area of active research. Also, ensembles using smaller scales, permitting convection, may be used to estimate uncertainty and variability at these small scales. The question is: where are we going to gain the most in the next coming years?

Finally, there is the question of low-hanging fruits. In talks by Jake and others, the characterization of the surface, the roughness and surface-heterogeneity were mentioned as problematic. So I think one low-hanging fruit is that these characterizations can be improved a lot, especially with new data sets coming on-line now.

The last question is that of stability, which I haven’t mentioned until now.

**Questions from the audience and answers from the panel**.

Question by Idar Barstein, Uni Research, Norway.

Guenter (G. Vahlkampf, Sowitec, Germany) was speaking about refining the scale when going down from mesoscale to microscale, and I think one of the bigger challenges is how to carry the turbulence characteristics over to finer scales, because normally you are restrained to, say, a ratio of 3 when you go from an outer to a nested mesh; may be a higher ratio, but then you risk that you energy balance is off in your finer domain. I think if you want to really make use of LES and these approaches you need to find a way to carry the turbulence characteristics on into the inner mesh without “spinning up” every time you move into a new mesh. Thought and comments on that will be appreciated.

Answer by Gill Lizcano:

In the transition between the PBL to the non-PBL nest, LES is very tricky and there are different approaches, not shown in my very simple presentation of results. In fact, there are a lot of techniques behind, treating the turbulence; we implemented one by creating a transition zone where you perturb the model to make the turbulence perform correctly. But still there is a lot of work to do regarding the transition in the boundary from the PBL-zone to the non-PBL-zone, I agree.

Answer by Daraen Rife:

You have to be very careful about nest-transitions; he (Idar Barstein) was describing the situation that if you go from a coarse grid to a much finer grid, numerically this will act like the (turbulent kinetic) energy is reflected back upward. The trick is then to use multiple (intermediate) nesting to avoid the “energy reflection”; but obviously that becomes much more computationally expensive due to the multiple nests, so there is no easy answer.

Gil described some very good work has done in collaboration with Branko Kosovic at NCAR to sort of “seed” (turbulence) to cope with the following problem: if you run a nested LES within a mesoscale grid without doing anything (extra), the flow coming into the LES-grid will be smoothed and ill not generate turbulence for a very long batch. So the work Gil described (together with Branko Kosovic) where a “device” is implemented to seed turbulence by adding some random perturbations in the grid (transition) zone and stirring up the flow to become unsmoothed and turbulent, looks very, very promising, and produces good-looking spectral characteristics. So I think that (technique) is going to be a key point. Actually, I read that paper twice because it was such a revelation, being the first time ever anybody actually demonstrated the problem that just a nested LES grid inside a mesoscale grid or CFD-grid (without anything extra) doesn’t work: the turbulence characteristics will not look like anything in nature. Even a long upwind fetch will not get you the (correct) spectral characteristics. So, in order to use LES nesting the turbulence-seeding method will be a key element to get the correct turbulence and make it work sufficiently far upstream of the target site in general. That technique will then allow you to shrink your grid (coarser grid, less grid points) and reduce the computational expense.

Answer by Clive Wilson:

We see similar (things) in operational forecast models, namely that the showers don’t spin up as you go from coarser to finer grid, and in the current finer scale meteorological models we now add a random perturbation, trying to stimulate the showers. So, this is a similar technique, where you try to reduce the smoothing effect (of coarse-to-fine grid transition).

Question by Chi-Yao Chang, Frauenhofer IWES, Germany.

I want to stick with the previous topic dealing with LES and so on. If we look at the basic Smagorinsky LES-assumptions, there are some restrictions about the grid size. How can we make sure that in a mesoscale - LES coupling we will really get the (correct) turbulence that we want to have?

Answer by Gill Lizcano:

In the presentation I showed just results from 100 meteorological solutions. We had another set of runs with 30 meters resolution which are much more ideal for the (turbulence) characterization, and we wanted to test the feasibility to run WRF-LES in an operational use of filthy matters to see whether it might be too CPU-intense to run it.

So we have some runs at 30 meters resolution which probably would give us better and better results, but that still needs to be investigated. But the particular resolution is just as important. However, we need to repeat the above “experiment” with much more vertical levels. As a company and an industry you want a procedure that is feasible, so this could be a control experiment to find out whether you need to run for weeks or you could deliver in days. So, our main discussion with Branko (Branko Kosovic, NCAR) was about that.

Question by Charlotte Hasager, DTU-wind.

I would like to comment on the last point of better surface characterization, which I think means better topography maps or land surface roughness maps, in particular. I think, regarding land surface roughness maps, there could be opportunities to use modern satellite and air-borne remote sensing data to produce such maps, and that would probably improve some of the land-based modelling estimates. The reason is that, in my opinion, there is some uncertainty even on flat simple terrain and part of that is because the land surface maps are, actually, not very good in current settings.

Answer by Jake Badger:

What you mentioned there made me think that in the benchmarking exercise it seemed that the effect of roughness was most prevalent in the onshore sites and that the prediction bias tended to zero when you increased the resolution. It looked like that because the roughness for the off-shore was pretty well represented. If you looked at coastal sites it was interesting that the increasing order of bias was offshore-coastal-land, contrary to what I would have expected, but then according to the wind rose the prevailing wind direction was from the sea, so most of the time the coastal sites were acting much more like off-shore sites than complicated coastal sites.

I think this exercise may make us think about the need to downscale to microscale, because if you took account of the site roughness for the on-land site you would probably remove some of the prediction bias, just by having the right site roughness. So if you did a downscaling using high-resolution roughness information then I would expect the order of bias to be offshore-land-coastal, because coastal sites then become the most complicated and difficult place to model. So I agree that it would be nice to have projects where we have access to the raw satellite data (the individual data channels) enabling us to come up with better ways to classify land covers in terms of our own needs, i.e. roughness.

Another issue is that in the presentations there were different approaches to the challenge of how to model the whole world in one hit, in one methodology, and accepting the limitations. One of the presented methods was an analog method where you leave out mesoscale modelling. It is always a competition between spending resources on doing a lot of simulations or getting long time-series as representatives; so this analog method provides you with a statistical technique to, kind of, enlarge the simulation period. This reminds me of a statistical-dynamical methodology which we (at DTU-Wind) 15 years ago were working with – exactly for the same reasons, namely the very resource-requiring mesoscale modeling. We applied an approach called wind classes, where we took different geostrophic winds and different stability profiles and mesoscale-modelled only these, say, 150 different wind classes to represent the climate. Now we are looking at other statistical ways to get a good balance between the simulation time and the resolution, and I suppose that is also going to be a challenge for the mesoscale-LES when modelling sites, because at some point you must apply some clever statistical method due to the very resource expensive method.

Then about the improvements (to mesoscale modeling) using nested sites, e.g. for complex sites: With changing orography we can expect more microscale impacts, so nesting would be a really nice way to extend mesoscale modeling. Another thing was that the mesoscale modelling has moved from predicting mean winds to also predicting extreme winds, but it could also move towards predicting site conditions, useful for loads; predicting conditions for operation and maintenance; making forecasts including probabilistic forecasts; and also providing uncertainty estimates. I think the real challenge now is to verify all that; so far we have concentrated on verifying mean statistics, but actually the verification of the probabilistic methods and uncertainty estimation will be really challenging, because it will mean a different strategy for setting up measurement masts in your regions of interest.

Question by Per Nielsen, EMD DK:

Just a practical issue; from my work with the mesoscale data for the recent 3 years, my experience is that off-shore predictions works very well, coastal climate predictions are also quite OK, may be with a little overprediction, but in-land mesoscale modelling overpredicts much more. E.g. in Denmark in-land we see that mesoscale data overpredicts by around 3 to 4%, at the German border overprediction increases more and more as you go further south, ending up at 20% overprediction at the southern part of Germany. I think the mesoscale data in general has a kind of coastal versus inland climate problem, in that you get an increasing overprediction the more inland you go. I don’t know whether it is the meteorological data, the model or the handling of the roughness that is the main problem - or a combination. But I think this is one of the low-hanging fruits – a problem that may be should be looked at before looking into the very tiny details we have been talking about so far. We should be able to solve the problem of high overprediction in-land while at the same time having a very god match off-shore, so this would be a good point for researchers to start looking at. I think the above counts for all mesoscale models and therefore may be weighted to the meteorological data (the problem is associated with the meteorological data).

Answer by Andrea Hahmann:

Yes, you are right about that, and one of the questions in the benchmarking exercise was whether you had modified the land-surface and the roughness. In the mesoscale-models, once created, the developers tuned the roughness and the surface parameters to give the correct evaporation, they never intended to get correct wind profiles, at least that was the world where they worked before entering the wind power industry, and you would say wind people would look strangely at me.