EWEA Wind Resource Workshop June 2015 – Helsinki

Mesoscale Session - 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:**

These questions we thought could stimulate the discussion, so I might say something a little bit provocative, and hopefully you would respond to it, or you may say something to it the other way around.

And from the talks we had this morning there are different approaches how the mesoscale models can be used. Then there is quite a lot of discussion about whether you can afford the mesoscale model, can we go all down to microscale, so what is the current situation we are at the moment. There wasn’t a direct comparison, and I think it is a good idea to pay attention to the reanalysis data in the mesoscale benchmarking exercise. I have looked a bit into this in the past and others have as well, and you can actually show that by using the mesoscale models you do gain by using it and that downscaling is a good idea. For how long you want to do that downscaling is a question of resources and just how you do it. So what is the current limitation for that when you then apply it for siting, how far can you actually use the mesoscale?

 Now, one of the things that most people don’t do in these exercises is using data simulation. I come from an operational weather center where we try to apply as much observational data as possible, and in an observational center there is a wealth of data of history of forecast. But of course the problem is that they change, they are not produced by the same model all the time, we upgrade all the time so there is a question of consistency. And particularly when you look at the correlations on a time series you will see that the R2 values will change slightly, so that is thought to be a big obstacle for using those models. My view is that it there is not such as big obstacle as there is made out of it. We might want to come back to that.

The other things about mesoscale models, I think are what the limitations is; Gill touched upon this and many told about the grey zones or “terra incognito”, that is that most of the models that you run for the moment are in a very difficult area for modelling around 2-5 km where we are not handling well the convection; you only partially resolve the convection and the turbulence or you don’t resolve them at all. So one of the problems with that is that you tend to get the models misbehave unless you take special measures, and it is a bit of a fudged area, so most people would say we should jump over that and go down to something like 1 km scale, generally - but then there is the question of how much you can spend on it. That problem can be quite significant as well when you come to steep orography. Complex terrain and steep orography you are not handling well at those scales. You can get a lot of problems with that. So that is the drawback of mesoscale models. They are better at things like sea-breezes and channeled inflow, generally, so there are a lot of positives from using mesoscale models.

Coming on to the next question: How can we improve these models – referring to what I have said previously – how far can we push them into seamless modelling – Gill’s presentation was a first attempt to that. It is a much bigger increase in resources you need so how long can you afford to do that modelling and how are you going to use those models – can you do it all in one go? And of course the more variability you are looking for the more difficult it is using data assimilation as well. So data assimilation methods going down to these scales to use the observations are an area of active research. And also for uncertainty – Darrel mentioned this about using ensembles – you can do ensembles that include convective permitting scales as well, so you can get an idea of just where the variability is in those smaller scales.

But where are we going to gain the most in the next few years? What is the feeling from people, how we can go to that.

And then finally there is this expression of low-hanging fruits. (Usually ow hanging fruits often get a bit moldy.) But there are some things, probably, we can easily ace-win, and I think they were touched upon in several of the talks by Jake and others, the surface characterization and the roughness and how you deal with hedge- heterogeneity of the surface. So I feel we can do a lot better there and there are a lot of data sets coming on-line now that you can use, so probably that is the obvious one.

The other thing I haven’t mentioned is stability; the stability question which I - kind of - only just standardly dealt with.

I’ll leave it there and let you, the audience, respond and see what you think.

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

Question by Idar Barstein, Uni Research, Norway.

I think 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, finer scale, because normally you are restrained to, say, a ratio of 3 when you nest, may be higher, but then you risk that you energy balance is off in your finer domain. And 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 nest to the non-PBL, the one you employ, LES is very tricky, there are different approaches, and in our case, because my presentation was very simple, just so-and-so results, there is a lot of techniques behind, we implemented some development to treat the turbulence so it had to create a transition zone where you perturb the model to try to treat this turbulence. (161:35) But still there is a lot of things to do in terms of the transition between how the boundary is from the PBL-zone to the non-PBL-zone. There is a lot of work to do there, I agree.

Answer by Daraen Rife:

You have to be very careful about nest-transitions; he was describing the situation that if you come from a coarser grid, if your finer grid has a grid size that is much, much smaller than the parent that is feeding it what will happen numerically is that it acts like it reflects the (turbulent kinetic) energy back upwards; the trick there is then that if you nest to avoid that it becomes much more expensive, obviously, because you need to have multiple nests, so there is no easy answer to that. And Gil was describing some very good work that has been done, he has collaborated with Branko Kosovic at NCAR to sort of “seed”. The problem is namely that if you just take a mesoscale grid and run a LES within it and don’t do anything (extra) the flow coming into that LES-grid is going to be smoothed, and it won’t actually generate turbulence for a very long batch. So I think the work Gil was describing (paper made together with Branko Kosovic) where they actually have a little thing that seeds, does some random perturbations and actually get things stirred up, become unsmoothed and turbulent, from laminar to turbulent, in the grid zone, it looks very, very promising, and get spectral characteristics that look really good, so I think that is going to be a key point. Actually when I read that paper twice because it was to me such a revelation, and it was the first time anybody ever actually demonstrated the problem, that you cannot just stick with the LES grid inside a mesoscale grid or CFD-grid and expect that you will get turbulence characteristics that looks like anything in nature, it doesn’t work. And even with a long upwind fetch you don’t get the (correct) spectral characteristics etc. So in order to move that way (LES nesting) that method is going to be a key element to get the correct turbulence and get it going far enough upstream of the site in general. What that will allow you to do then, with that technique, is shrink your grid down, reduce the computational expense.

Answer by Clive Wilson:

 We see similar (things) in operational forecast models, that the showers don’t spin up as you go from the coarser grid (to the finer one) and in the current finer scale meteorological models we now put in a random perturbation to try and stimulate the showers, so a similar technique where you actually try to reduce the (smoothing) effect.

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

I want to stick with that topic dealing with LES and so on. If we look at the basic assumptions of LES from the basic Smagorinskysky assumptions there are some restrictions about the grid size, and how can we make sure that if we are dealing with mesoscale coupling with LES that we are really getting the turbulence that we want to have.

Answer by Gill Lizcano:

 In the presentation I showed just results from 100 meteorological solutions. We had another runs with 30 meters (resolution) which are much more ideal for the characterization, but we wanted to test the feasibility to run WRF-LES in an operational use on a still 30 meters (resolution), 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 we still need to investigate on that. But –and I didn’t mention that - the particular resolution is just as important. But we need to go around the same experiment with much more vertical levels. Again, what we want as a company and an industry is something that is feasible, so we are trying to go through what could be a control experiment that you could run for weeks or something that we can deliver in days. And that’s why 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 is, of course, better topography maps or land surface roughness maps, in particular. And I think for the land surface roughness maps there could be opportunities to use sort of more modern satellite remote sensing and air-borne remote sensing data to produce such maps and that would in my opinion probably improve some of the land-based estimates for the modelling. Because I think there is some uncertainty even on flat fairly simple terrain and I think part of that is due to the surface maps being, actually, not very good in the current settings.

Answer by Jake Badger:

What you mentioned there made me think, that when we saw the benchmarking exercise (it seemed) that the effect of roughness was most prevalent in the onshore sites. If you looked at the effect of resolution the bias was going to zero when you increased the resolution and it looked like that because the roughness for the off-shore was pretty well represented. And if you looked at the coastal it was quite interesting that the order went offshore-coastal-land in the bias, which is contrary to what I would have expected, but then (I was thinking) if you look at the wind rose you saw that most of the time the wind was actually coming off the sea, so most of the time it (the coastal) was actually as an offshore site, so it is much more like an off-shore site than a complicated coastal. But then (I was thinking) may be this exercise would make us think about the need to downscale to microscale and what we see there, yes, that is true, because, actually, if you took account of the site roughness for the on-land site (this is speculation) you would remove some of that bias, just by having the right roughness of the site. So if you did a downscaling using high-resolution roughness information then I think the order (of bias) would be offshore-land-coastal, because coastal then becomes the most complicated and difficult place to model at microscale. So I agree, it would be nice to projects where we can look at the satellite data in a more raw sense, look into the individual channels and may be come up with better ways to classify land covers in terms of our own needs, i.e. roughness.

If I can say another thing: From the presentations we heard today everybody was giving a different approach to a challenge, and that was - what I gave – how do you model the whole world in one hit, in one methodology and - of course –accept the limitations. And one method without doing the mesoscale modelling, we hear about, is an analog method; it is always a competition between spending resources on doing a lot of simulations or getting long time-series as representatives; so actually this analog method can provide you with a statistical method to, kind of, enlarge the simulation period. This actually reminds me of 15 years ago we were working with a statistical-dynamical methodology which was – exactly for the same reasons – the mesoscale modeling was very resource-intensive, so we wanted to do an approach called wind classes, where we actually took different geostrophic winds and different stability profiles and mesoscale-modelled in only, say, 150 different ways to represent the climate. Now we are looking at other ways – 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 because at some point you want to have some clever statistical method, because you have a very resource expensive method, so how are you actually going to model sites.

Then there was another thing about the improvements using nested sites, e.g. it could be complex sites because there again – I think – with changing orography then we can expect more microscale impacts, so that would be a really nice way to extend it.

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 more and more, which is useful for loads, also for operation and maintenance, and also for forecasting; and also the idea of probabilistic forecasts, and also uncertainty estimates. I think the real challenge now is to verify that; so far we have concentrated on verifying mean statistics, but actually to verify the probabilistic or an uncertainty is going to be really challenging, because it will mean a different strategy for how you actually set up measurement masts in your regions of interest.

 Question by Per Nielsen, EMD DK:

Just a little practical issue; I have been working with the mesoscale data for the recent 3 years and my experience is that what you see off-shore works very well, going to the coastal climate, also quite OK, may be a little overprediction, but when you go in-land, then the mesoscale modelling starts to overpredict much more, for example going to Denmark we have around 3 to 4 overprediction for the mesoscale data, when we go down at the German border we start overpredicting more and more the further South we go, 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 much higher overprediction the more inland you go. I don’t know if it is the meteorological data or it is the model, the handling of the roughness that is the main problem or it is a combination. But I think that is one of the - may be, I don’t know if it is one of the low-hanging fruits – but I think it is a problem that may be should be looked at before we look at the very, very tiny details that we have been talking about so far; that we should be able to solve this problem that we are overpredicting very much in-land while at the same time things are matching very well off-shore. I think that would be a good point for researchers to start looking at. I think that counts for all mesoscale models and therefore I might think it is weighted to the meteorology (the problem is associated with the data).

Answer by Andrea Hahmann:

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