

# *Wind Speed in Mountainous Terrain*

*- On Finding Potential Wind Turbine Sites -*

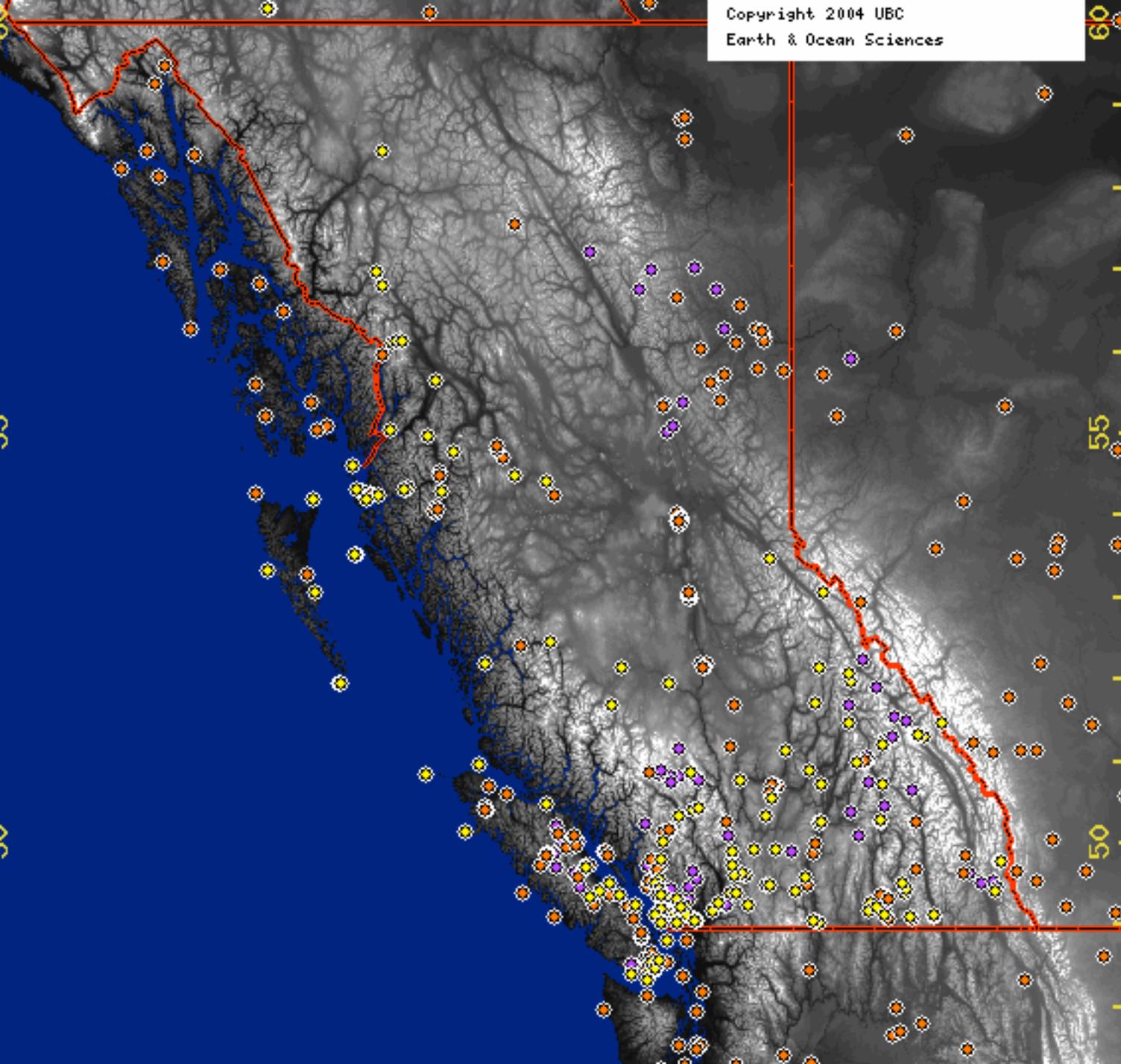
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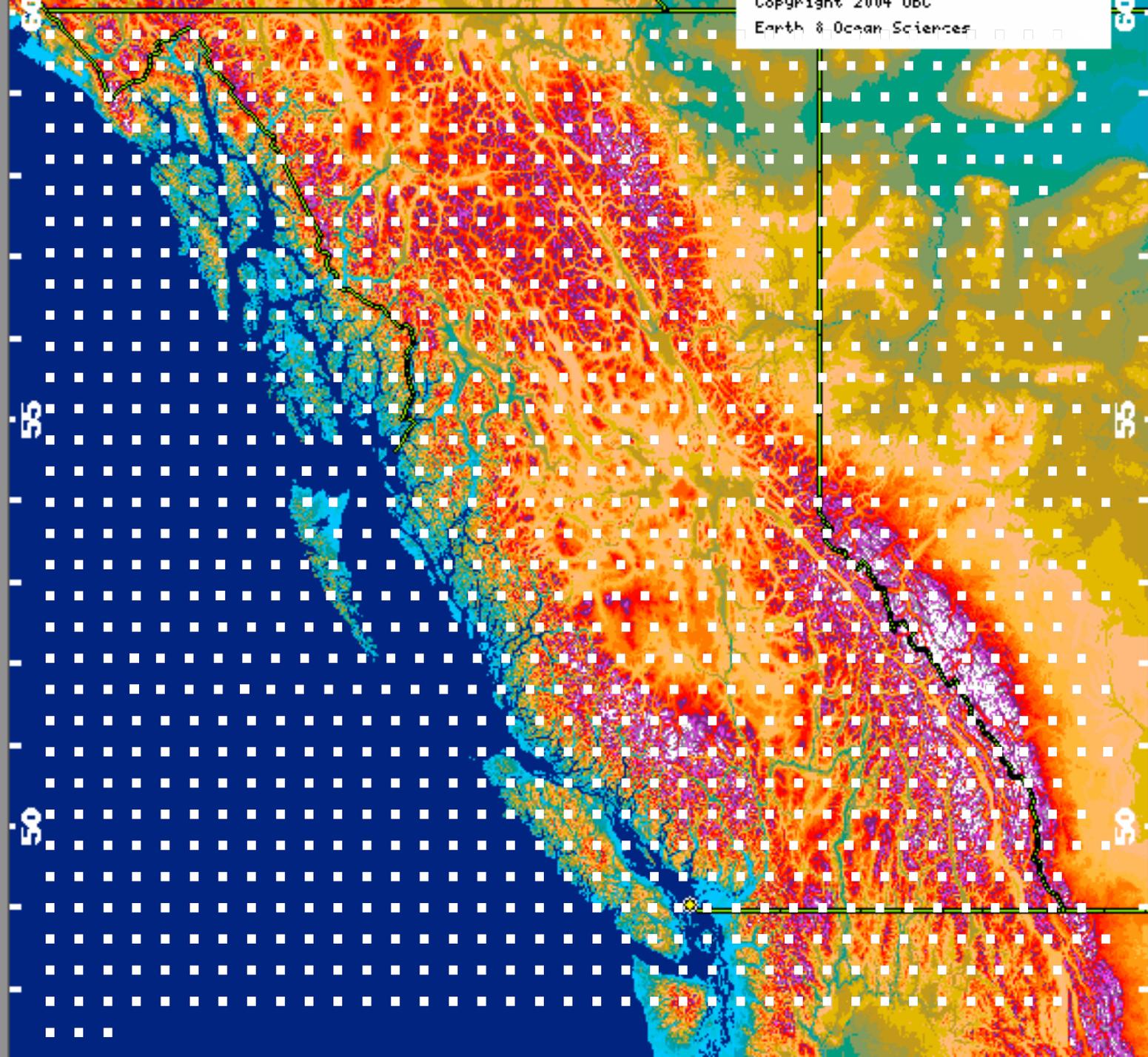
rstull@eos.ubc.ca <http://weather.eos.ubc.ca/wxfcst/>



# Emergency Weather Net (EmWxNet)

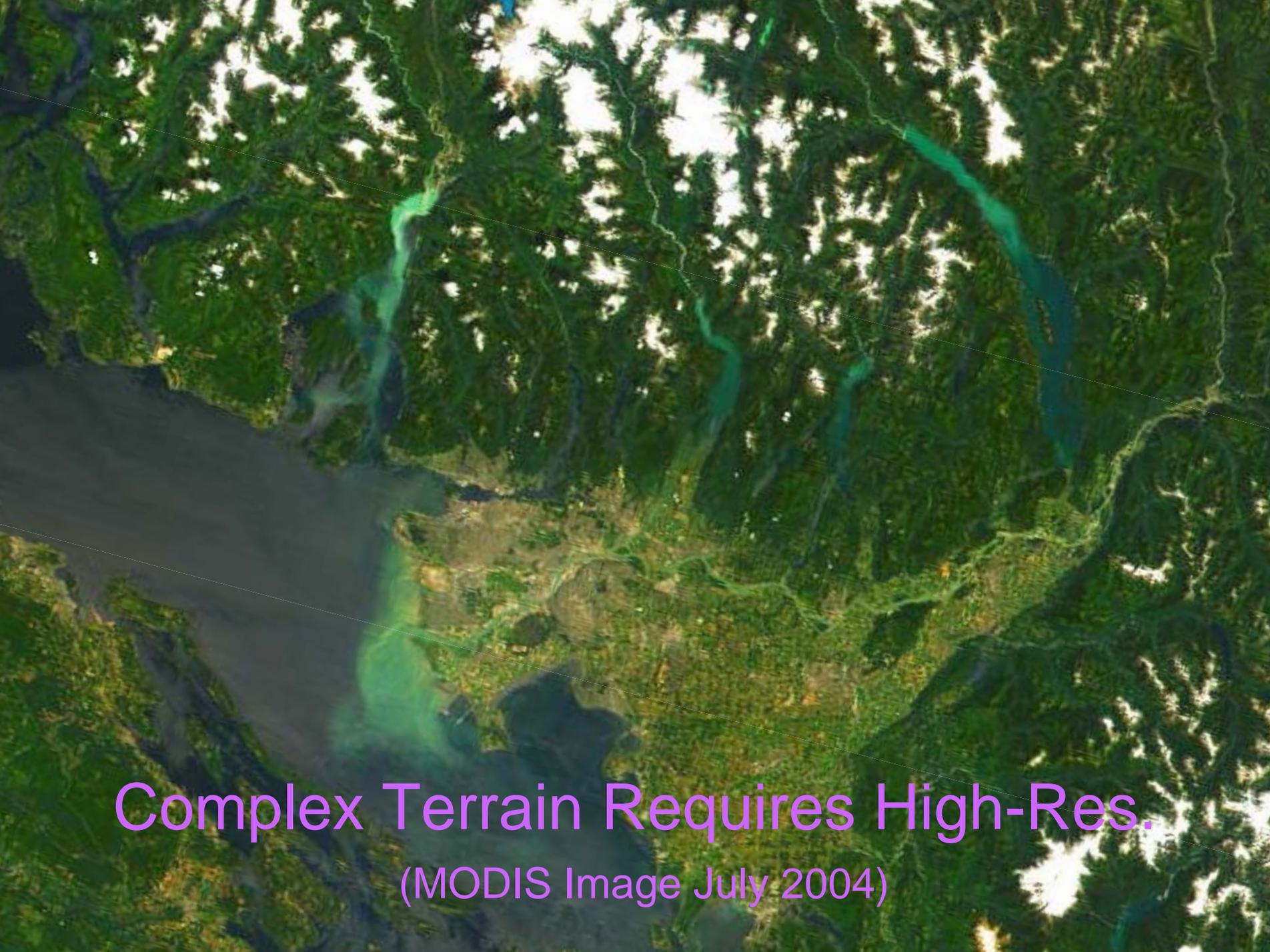
500 surface  
weather  
stations.

But not  
where you  
need them  
for wind-  
turbine site  
selection?  
(Extrapolation  
away from the  
wx. stn. is  
BAD.)



So...  
instead of  
using  
irregularly-  
spaced wx.  
stns., **use**  
**NWP to**  
**predict**  
**winds for**  
**an array of**  
**grid points.**

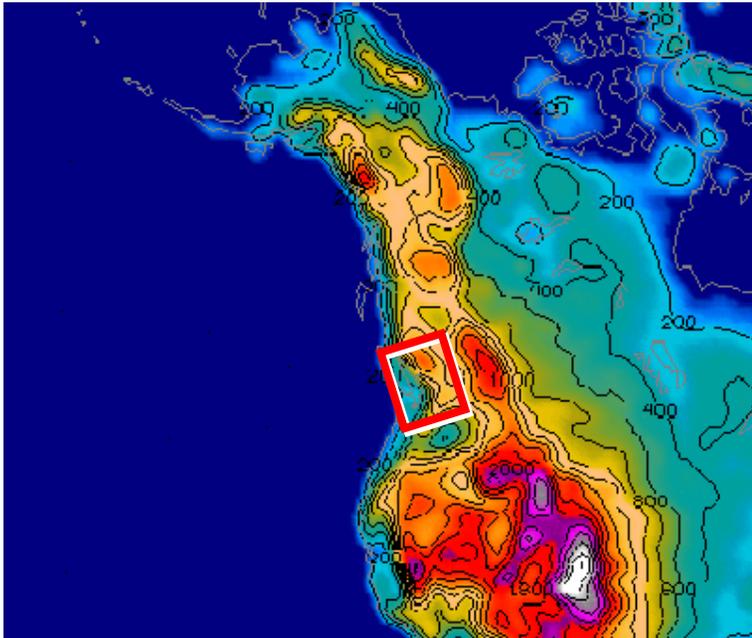
But the 36  
km grid  
spacing  
shown here  
is too  
coarse.



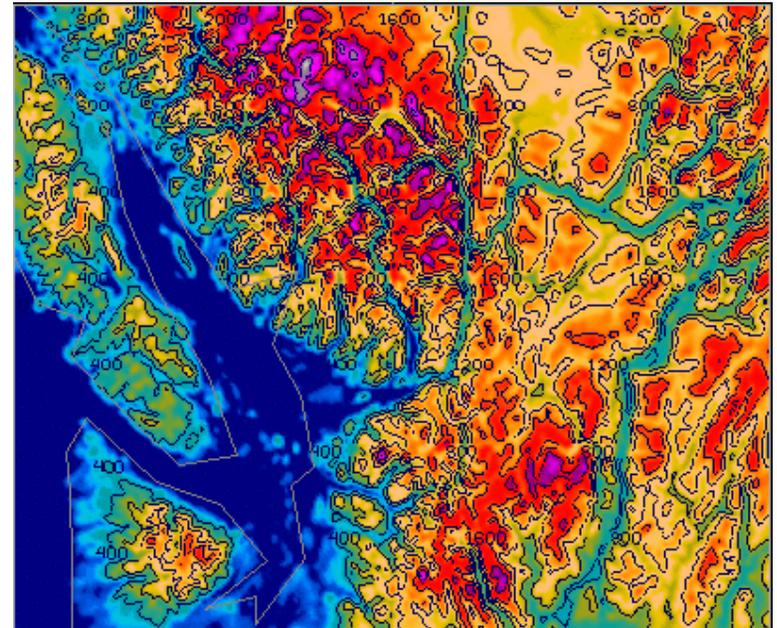
Complex Terrain Requires High-Res.

(MODIS Image July 2004)

Without high-res. spacing of grid points, the NWP winds are for unrealistically smoothed topography.



36 km grid spacing



2 km grid spacing

# Opportunities & Issues

- Use ensemble, high-resolution, real-time Numerical Weather Prediction (NWP) to build wind climatology maps.
- Use ultra-high-resolution NWP for closer study of selected wind-power sites.
- Be wary of the reduction in forecast quality in Western Canada due to the Pacific Data Void.

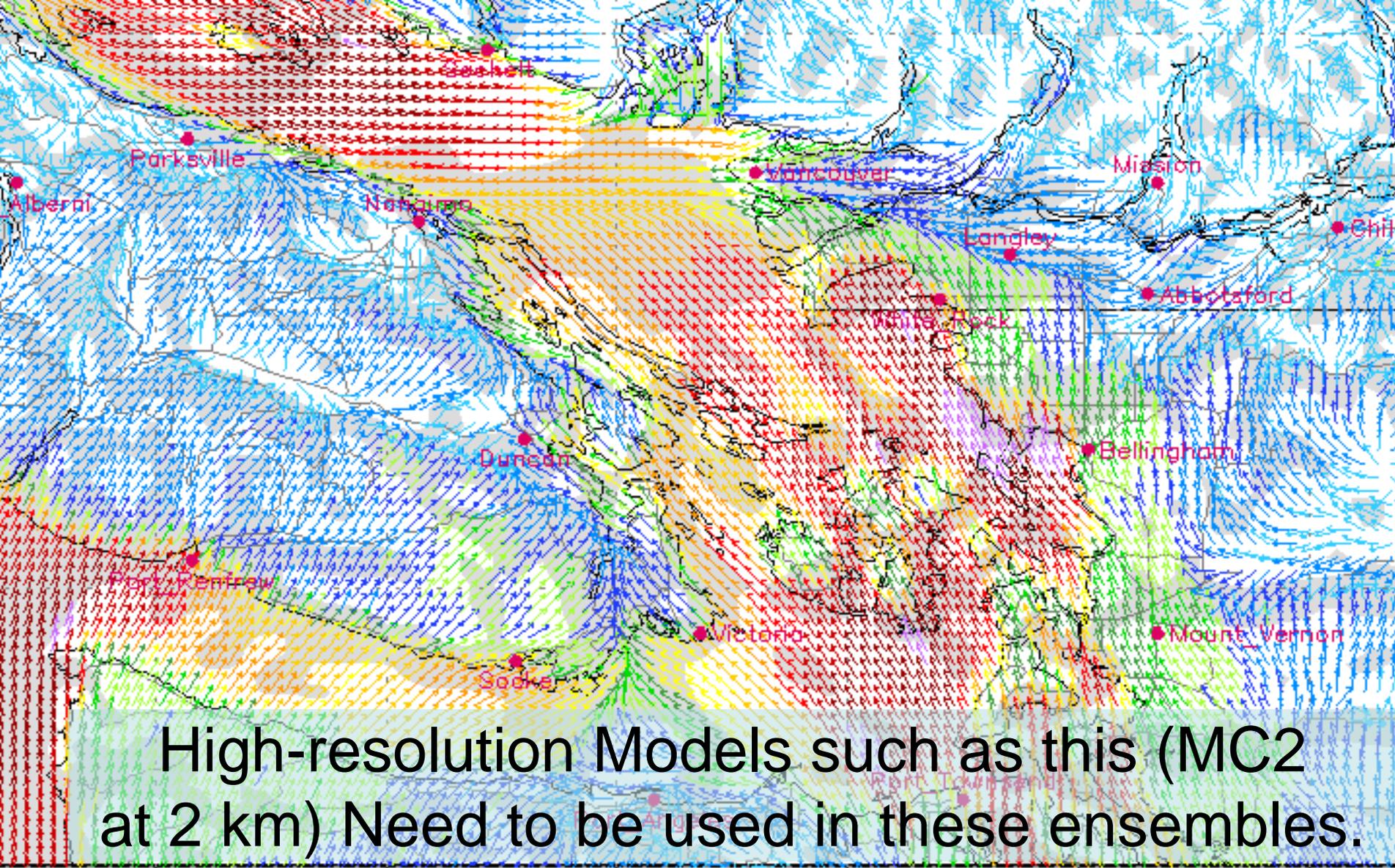


# Ensemble, High-resolution NWP

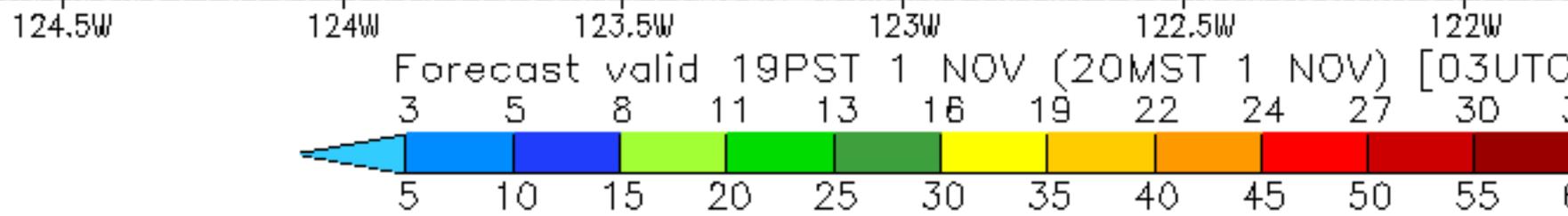
- Ensemble forecasts are many different NWP fcsts averaged together.
- **Multi-model ensembles produce the most accurate & skillful short range fcsts.**
- At UBC, we do multi-model NWP fcsts.

← **Models** →

Type \ Model	MC2	MM5	NMS	WRF	ENS
Grid @ Ensemble	N/A	N/A	N/A	N/A	<a href="#">Open</a>
Grid @ 108 km	<a href="#">Open</a>				
Grid @ 36 km	<a href="#">Open</a>				
Grid @ 12 km	<a href="#">Open</a>	<a href="#">Open</a>	<a href="#">Open</a>	<a href="#">Open</a>	N/A
Grid @ 4 km	<a href="#">Open</a>	<a href="#">Open</a>	<a href="#">Open</a>	N/A	N/A
Grid @ 2 km	<a href="#">Open</a>	<a href="#">Open</a>	N/A	N/A	N/A
Profiles	<a href="#">Open</a>				
Meteograms	<a href="#">Open</a>				



High-resolution Models such as this (MC2 at 2 km) Need to be used in these ensembles.

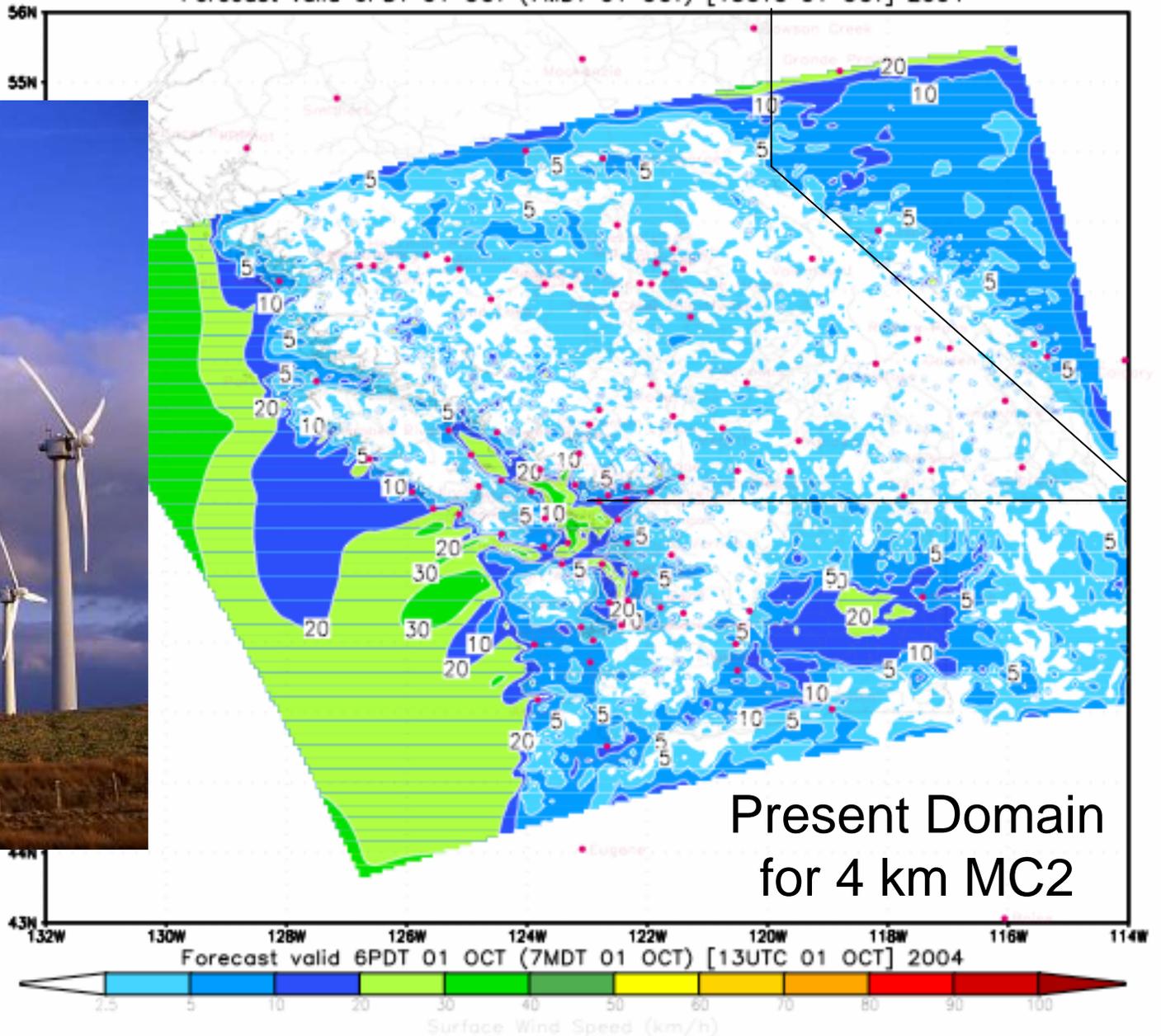


Model: MC2  
4 km grid

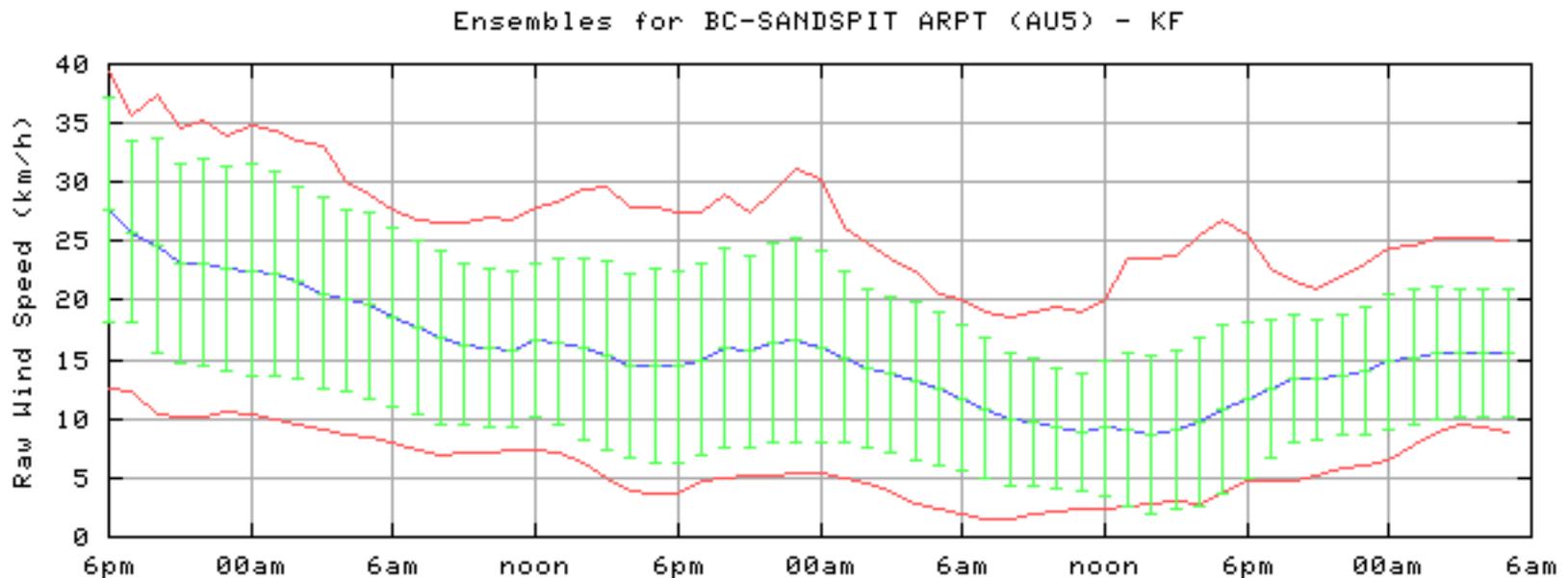
initialized: OUTC, 0

### Surface Wind Speed

Forecast valid 6PDT 01 OCT (7MDT 01 OCT) [13UTC 01 OCT] 2004



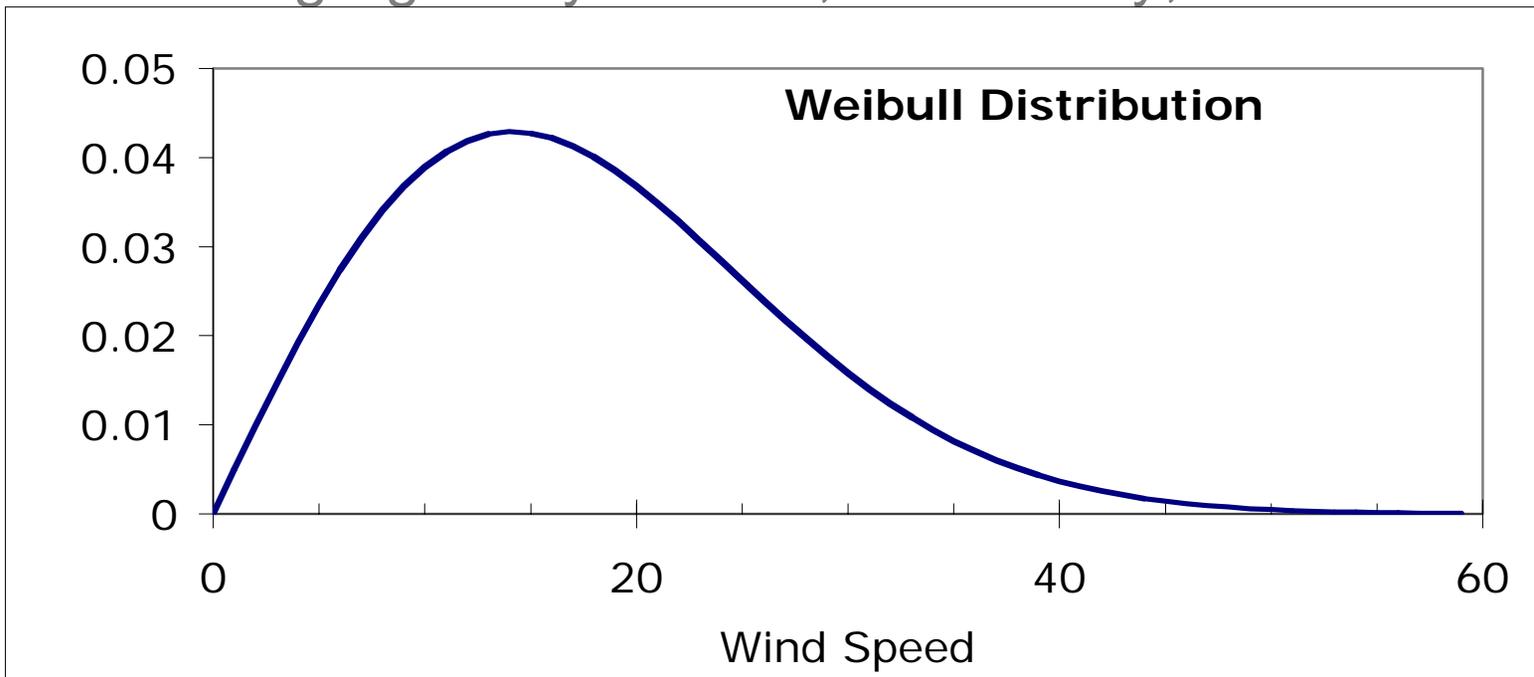
Procedure: Run NWP fcsts  
Every Day, and Build  
Climatology for  
**EVERY** grid point





# For each Grid Point, Fit a Separate Weibull Distribution to the Winds.

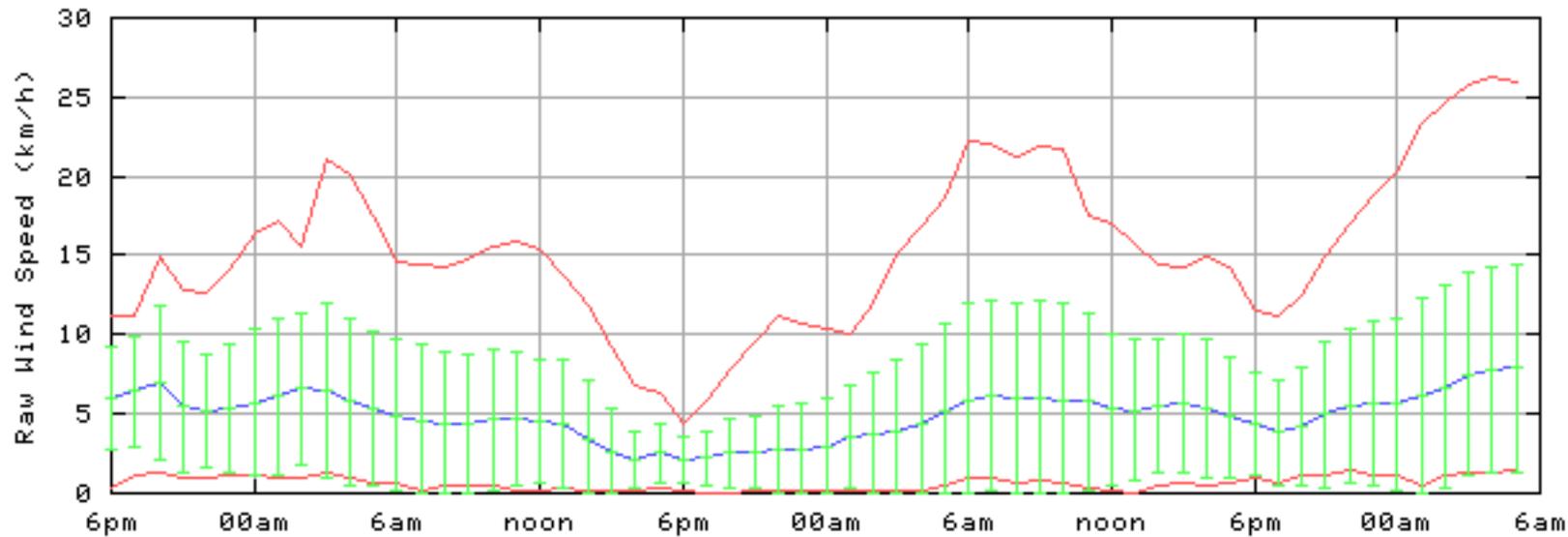
Segregate by season, time of day, etc.



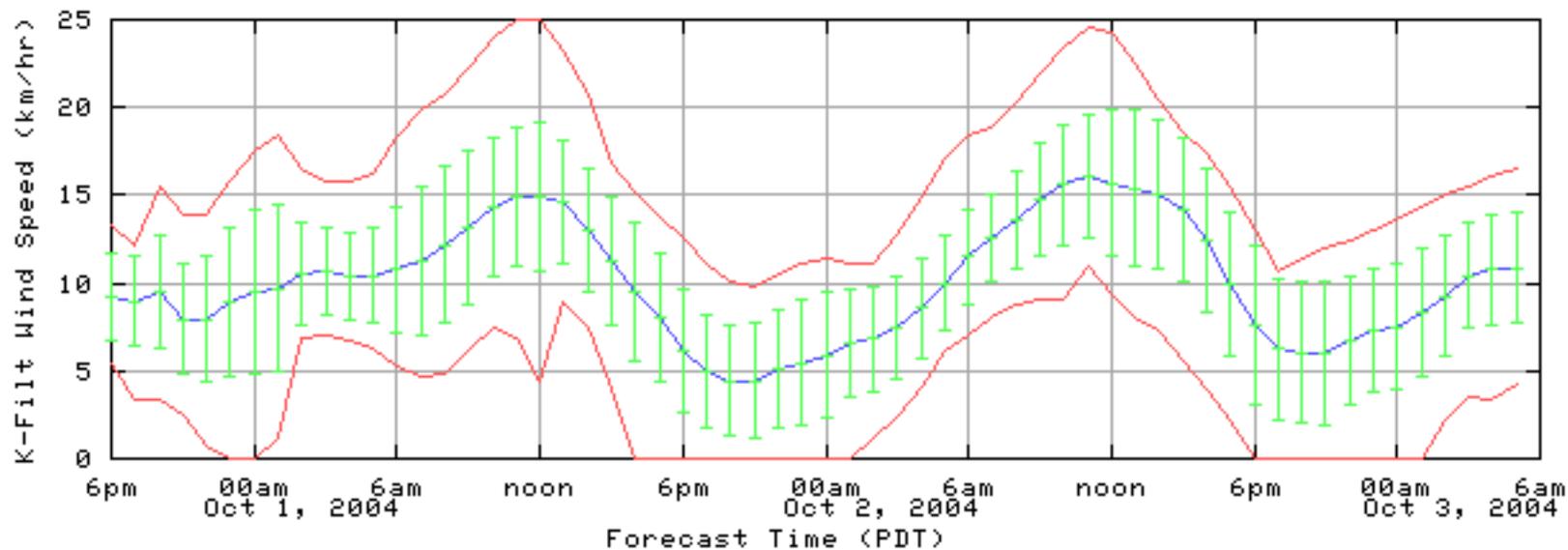
# Use Kalman filter postprocessing as model output statistics (MOS) refinement.

Ensembles for BC-Alert Bay CWAQ - KF

Raw



KF  
Refined



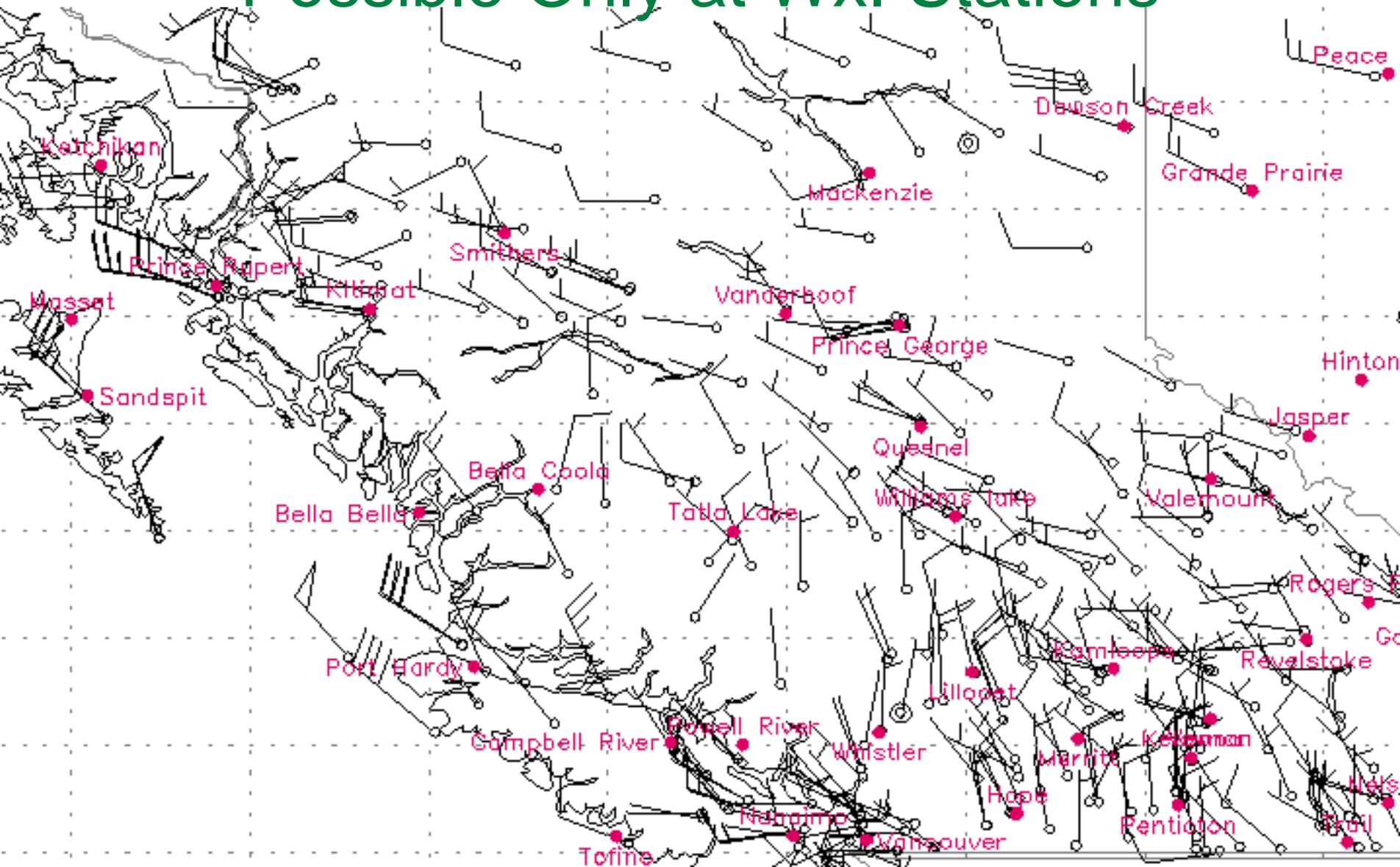
Mean —

Min —

Max —

RMS —

# ...but KF Refinement is Possible Only at Wx. Stations



# Recommended Procedure

1. UBC builds high-res ensemble climatology during year, using real-time fcst for each grid point.
2. At all prospective sites, install remote weather stations.
3. Continue UBC fcsts, but now with Kalman filtering to get more accurate winds. Continue screening for best sites.
4. For short-listed sites, run Clark's ultra-high res NWP.



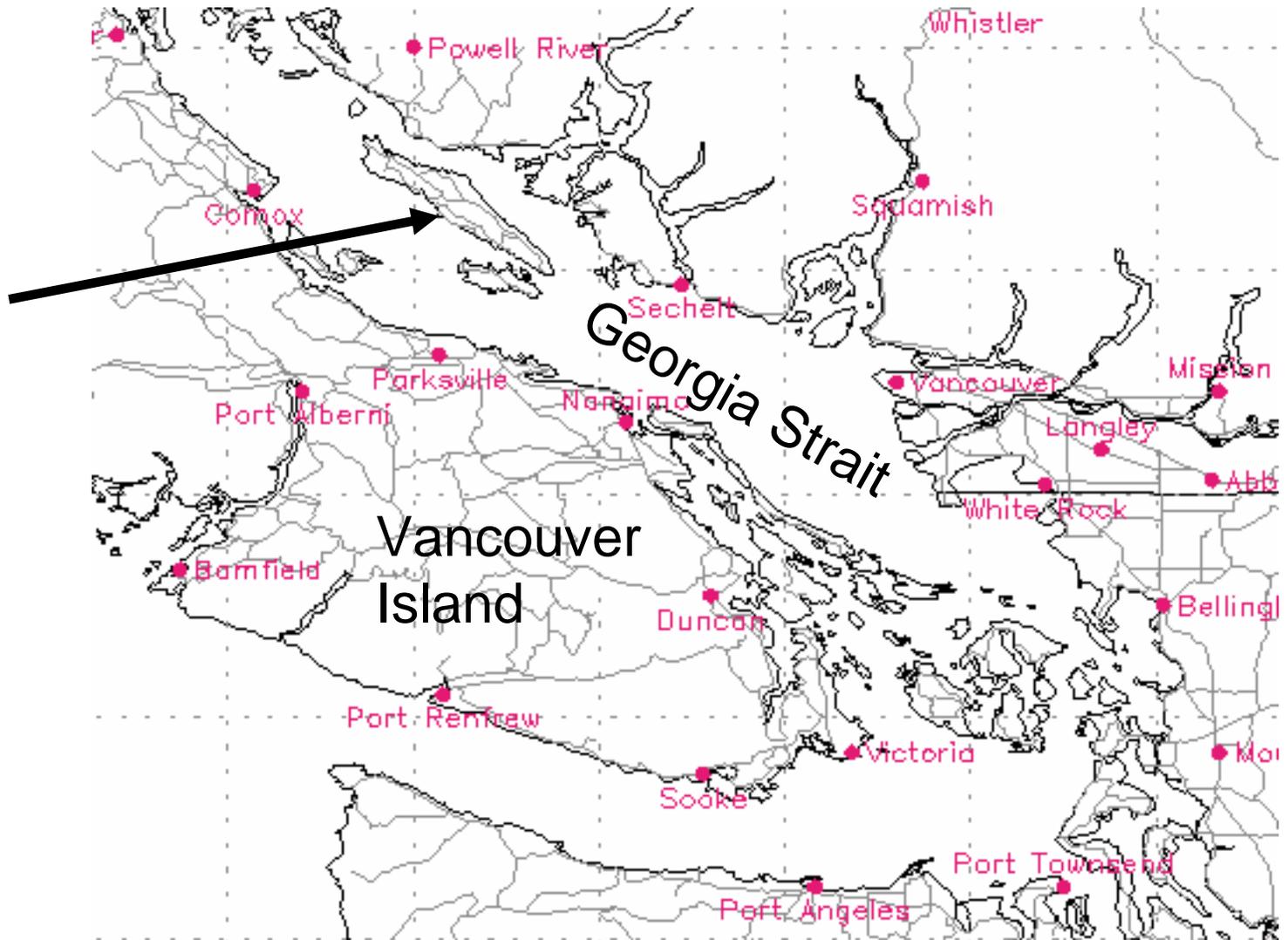
# Consider Wind Turbines in Georgia Strait



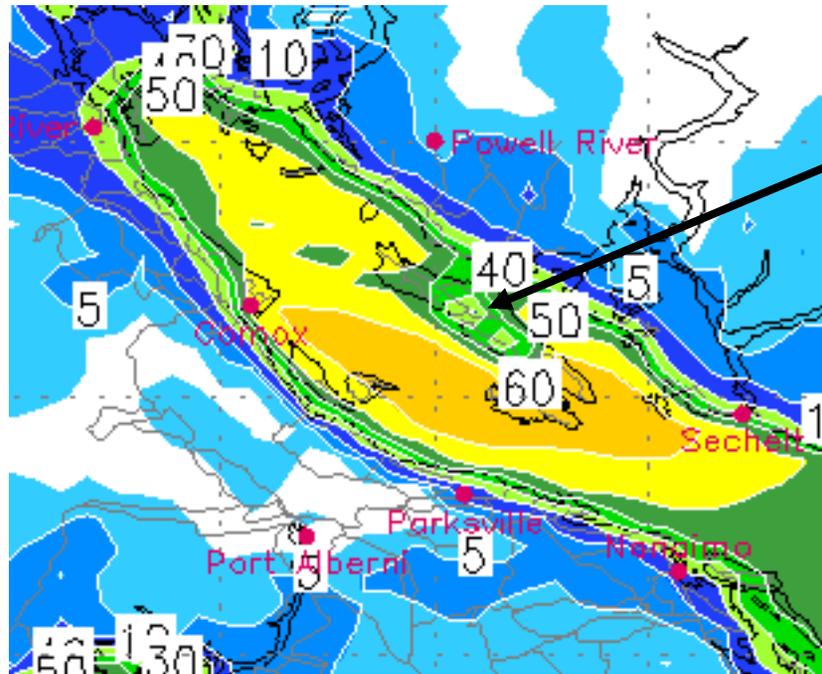
...because it often has fast, persistent winds.

# In the Georgia Strait, a Good Location is just west of Texada Island

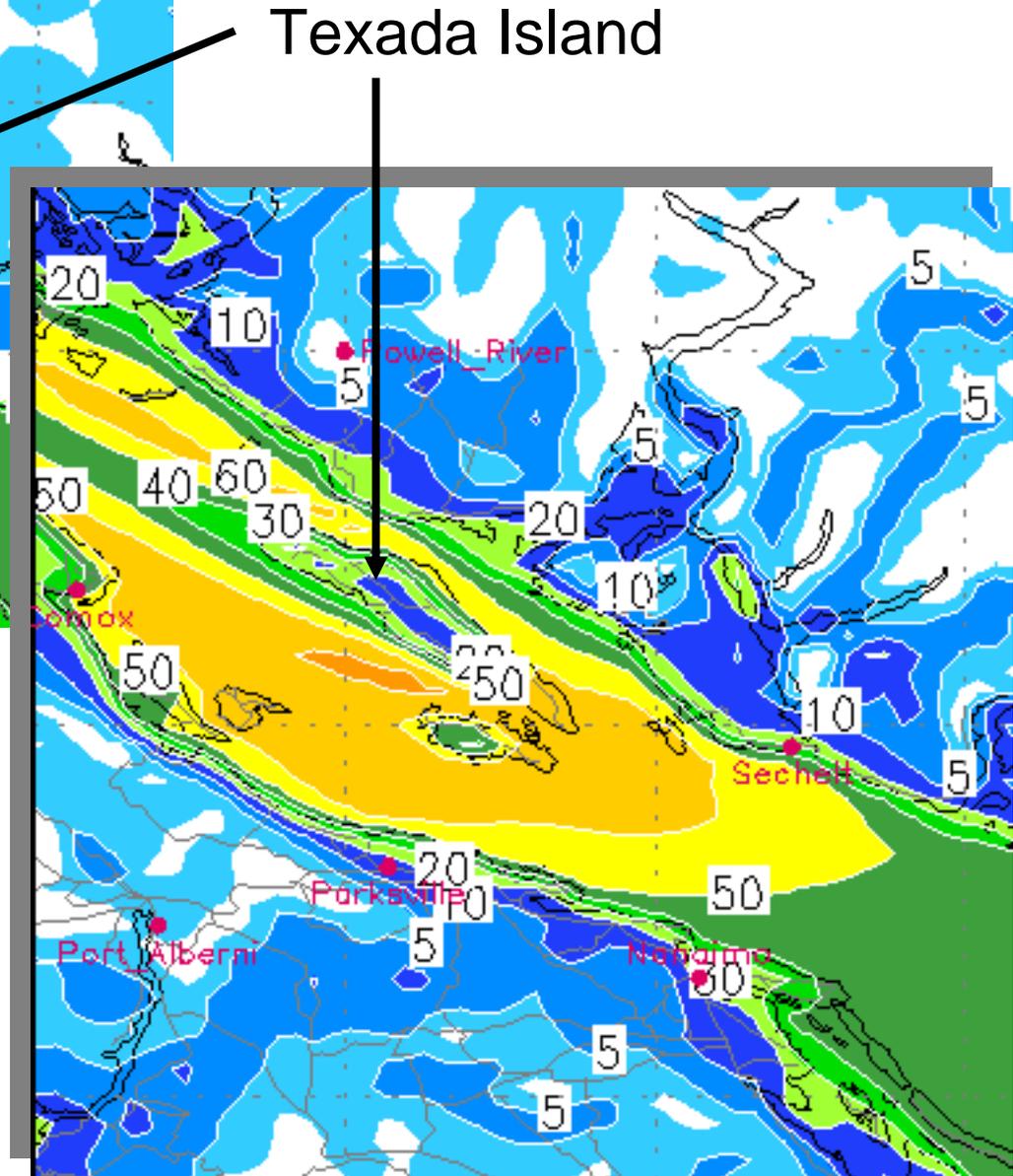
Texada Island



# But you need resolution finer than 4 km



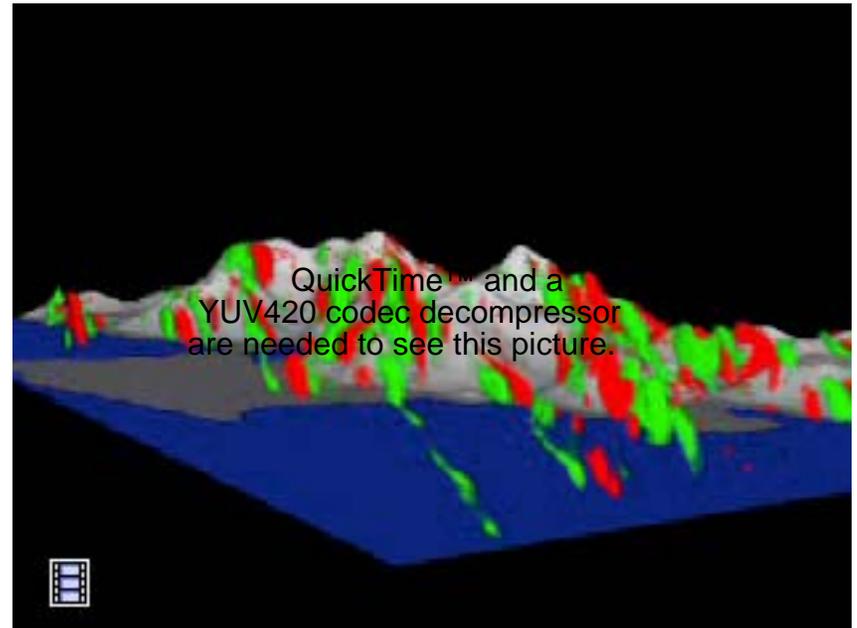
4 km Grid spacing



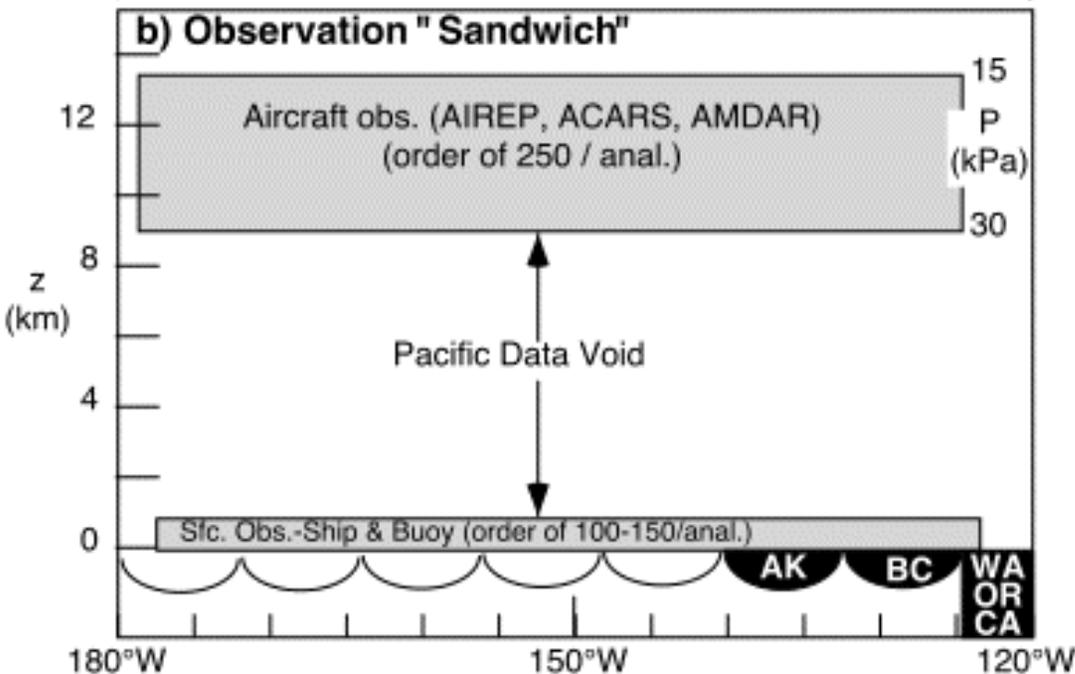
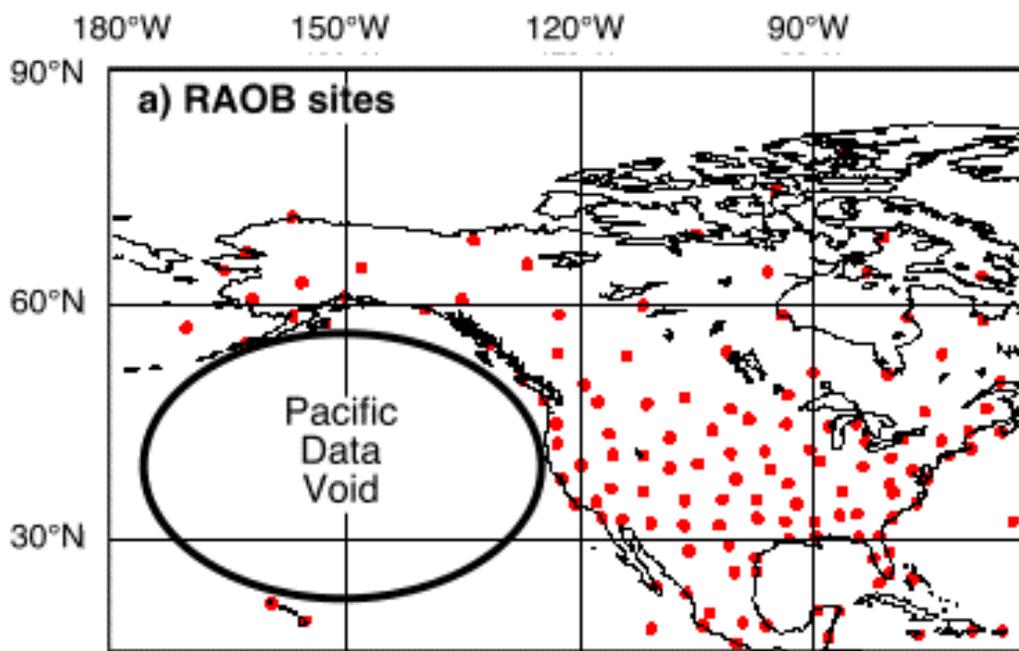
2 km Grid spacing

Texada Island

At prospective wind turbine sites,  
have Terry Clark run his ultra-fine-  
resolution NWP model.



Lantau. Turbulent eddies (vert. vort.)



# The Weakest Link Today (for W. Canada) is the Pacific Data Void

- The upper fig. shows rawinsonde sites
- Over the NE Pacific there are no rawinsonde sites (nicknamed the Pacific Data Void)
- Our weather comes from the west ... duh!

# Recommendations: Wind Speed in Mtns.

- NWP ensemble, high-res.(2 km), multi-model fcsts. can give climatology (Weibull) distr. at every grid point. Allows best screening of potential wind turbine sites, and can provide fcsts during routine operations.
- For short-listed sites, ultra-high-res.(100 m) NWP case studies can give optimum location for turbine sites on individual ridges, as well as vertical profiles, turbulence, etc.
- Fcst quality is poor due to the Pacific Data Void, but Kalman-filter refinement is possible where there is ground truth. Therefore, add weather stations at short-listed sites.

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