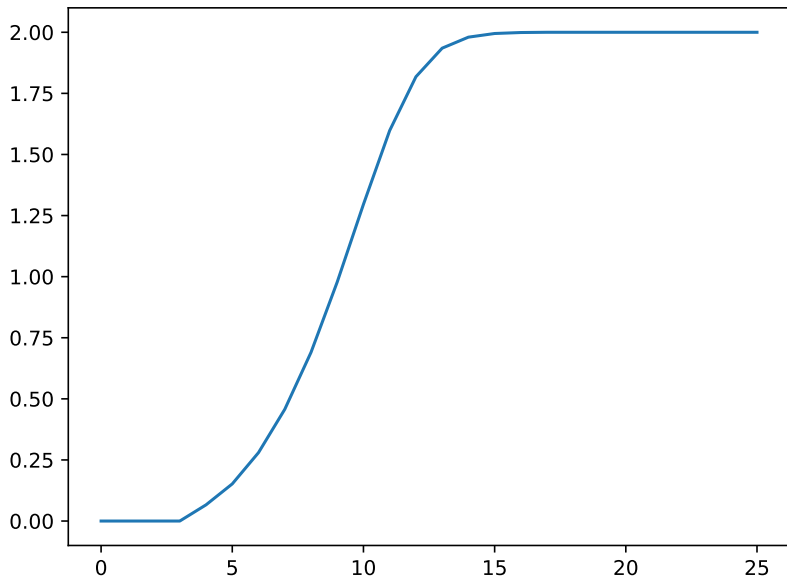


Gaussian Process Farm Wake Model Surrogates

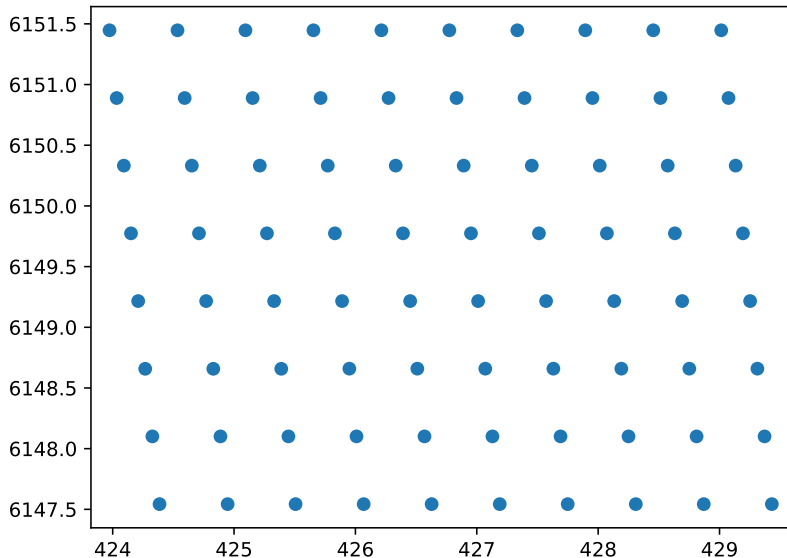
Erik Quaeghebeur

June 5, 2018

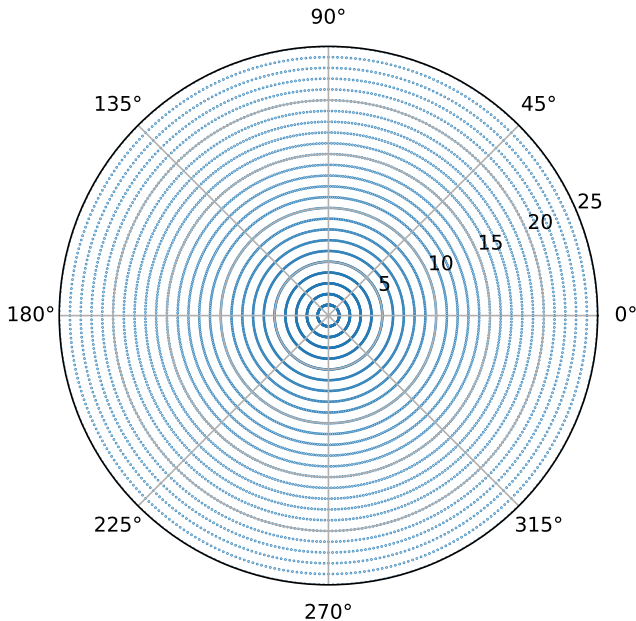
The basic building block: a Wind Turbine



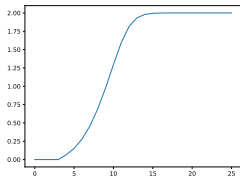
The system of study: an Offshore Wind Farm



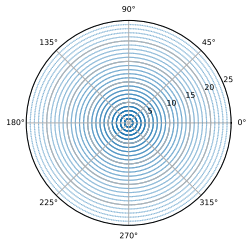
Inputs: a Wind Direction and Wind Speed Grid



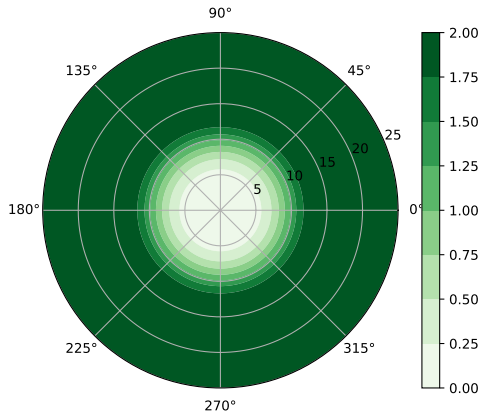
Power Output of an Isolated Wind Turbine



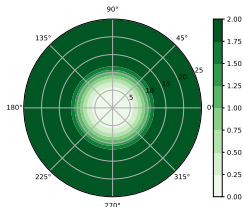
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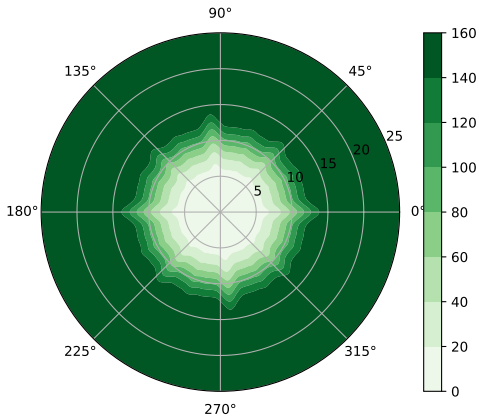
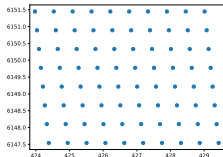


Power Output of a Wind Farm



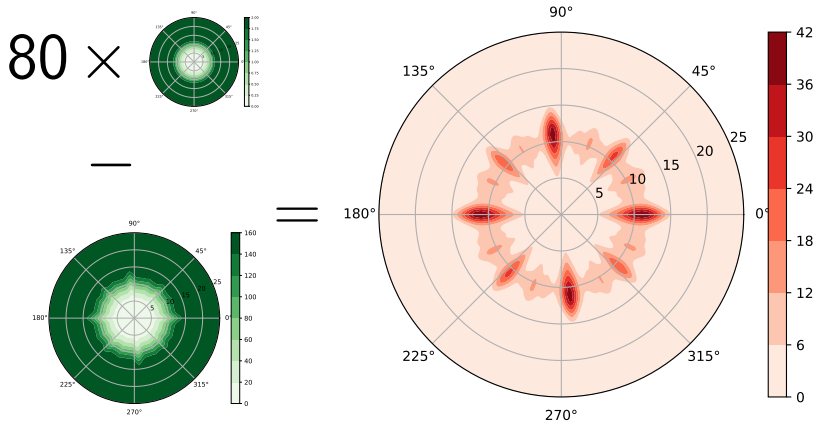
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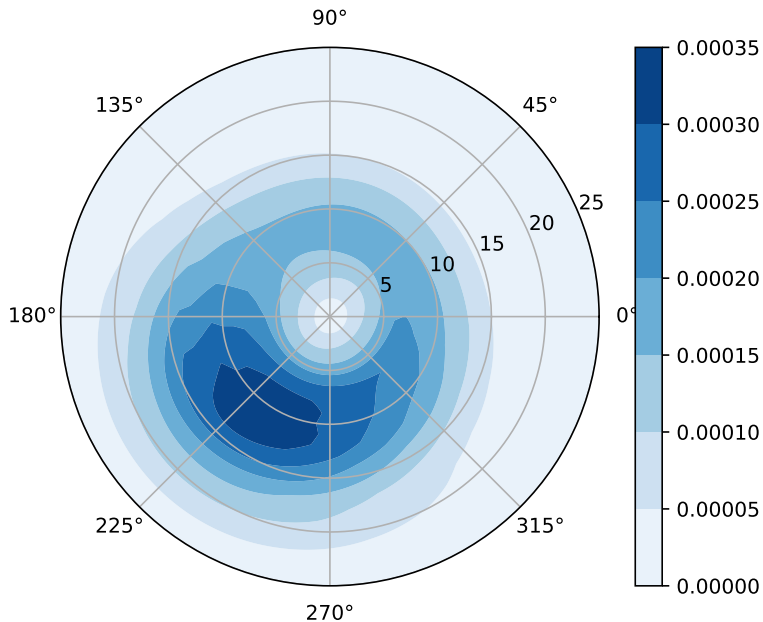


[Thanks to Kostas Gkoutis > Bo Hu > Sebastian Sanchez.]

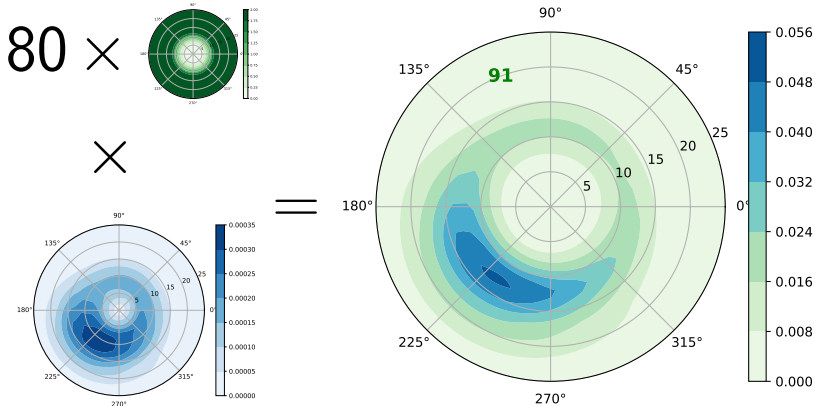
Power Deficit Due to Wakes



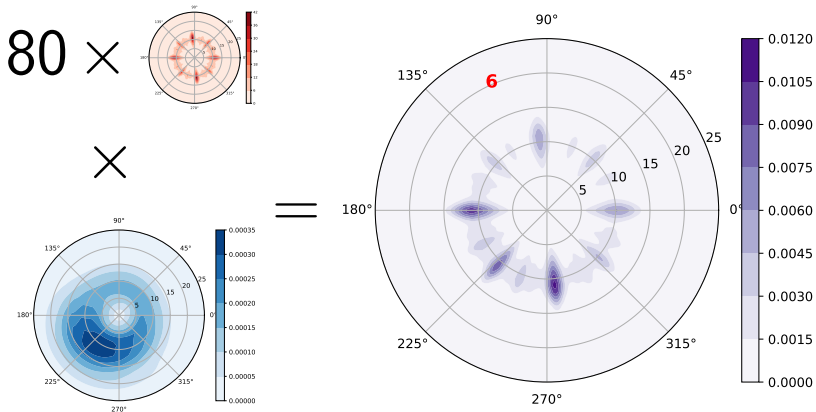
The Wind Resource



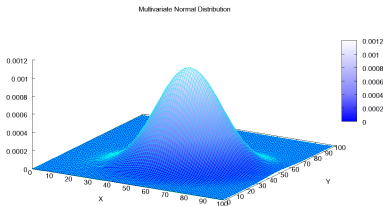
Expected Output without Wakes



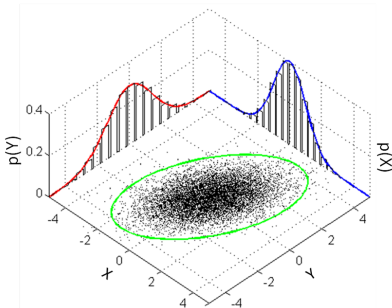
Expected Wake Deficit



Gaussian Processes (GPs) are 'big' Multivariate Gaussians

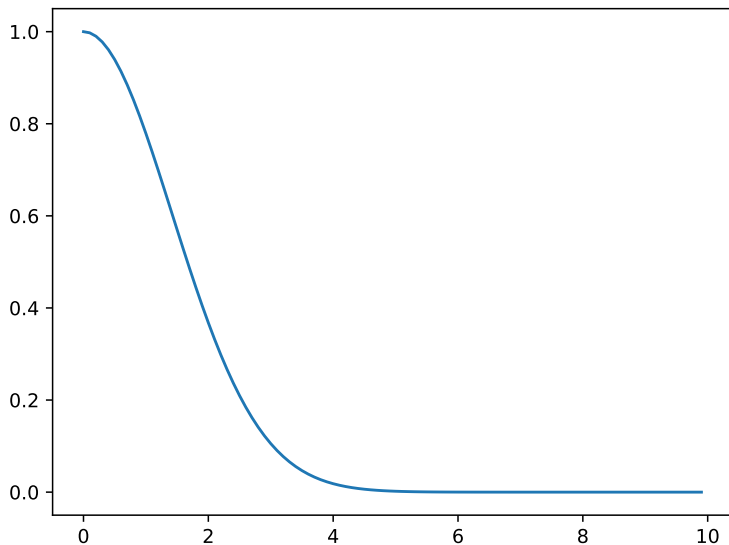


[CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=1260349>]

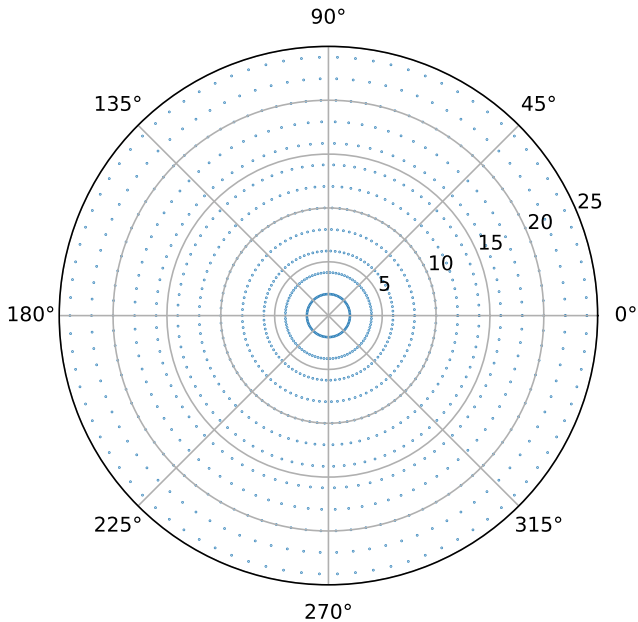


[Bscan, CC0, <https://commons.wikimedia.org/w/index.php?curid=25235145>]

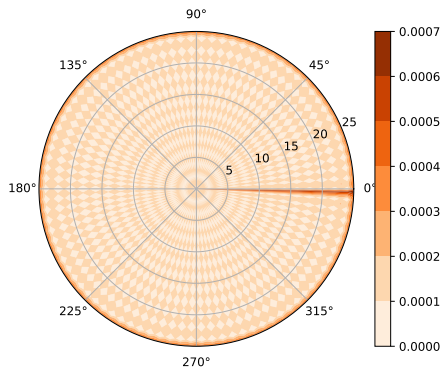
Defining a GP through its Covariance Function



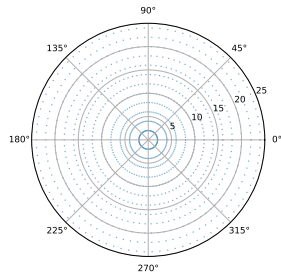
Limit the Number of Model Calls: the Coarser Grid



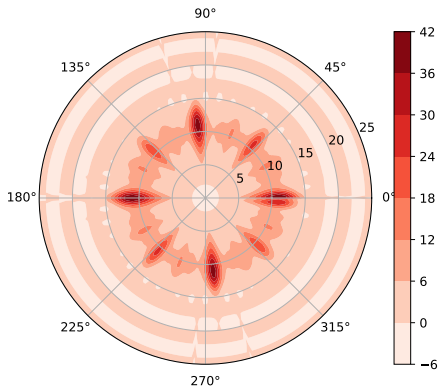
Standard Deviation Function of the Conditional GP



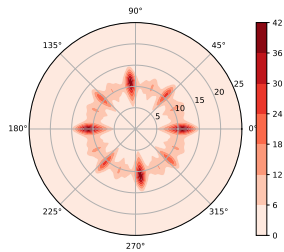
cf.



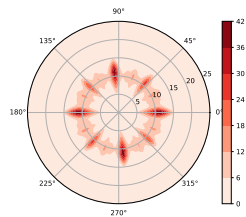
Mean Function of the Conditional GP



VS.

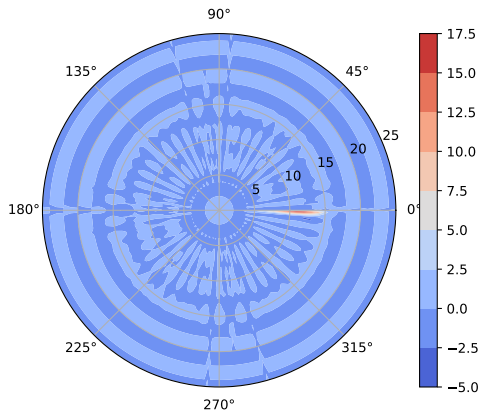
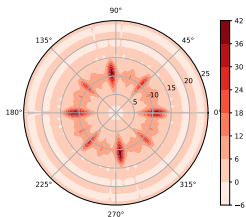


Is the surrogate any good?

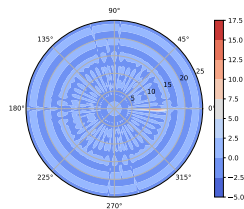


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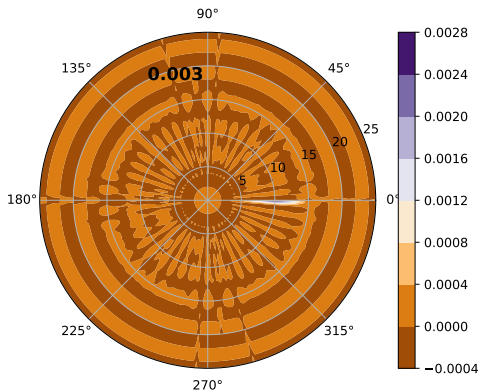
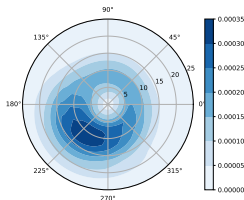


Does the difference matter?



$\times$

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Next Steps & Conclusions

- ▶ Gaussian Process Models can be effective surrogates for farm wake models:
 - ▶ illustrated here,
 - ▶ used for efficient wind farm layout optimization by Kostas Gkoutis in his MSc project.
- ▶ Further improvements possible:
 - ▶ domain-specific covariance functions,
 - ▶ adaptive sampling.
- ▶ Further extensions possible:
 - ▶ addition of extra input or output variables,
 - ▶ addition of uncertainty in covariance function.
- ▶ Gaussian Process Models are generic tools: wide applicability.