Mesoscale Wind Atlas of South Africa

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Stellenbosch Seminar
27 March 2009

Presentation Overview

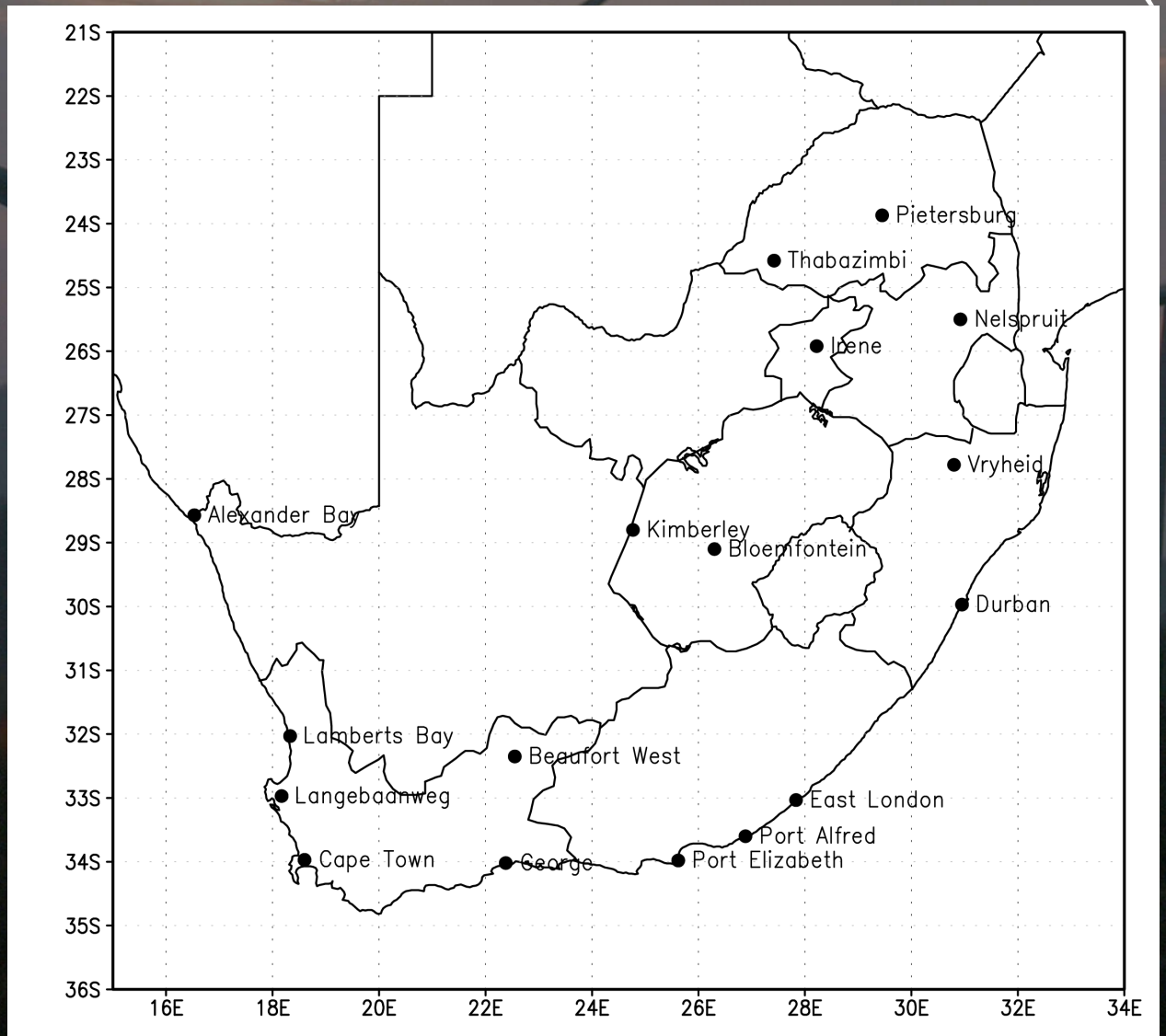
- Summary of my entire PhD (breadth, not depth)
- Run MM5 at 18km resolution over SA
- Part 1) How model data was derived
  - Validation, optimisation of time period and configuration
- Part 2) Mesoscale Wind Atlas Results
  - Uncertainty, resource maps, potential estimation

Model Introduction

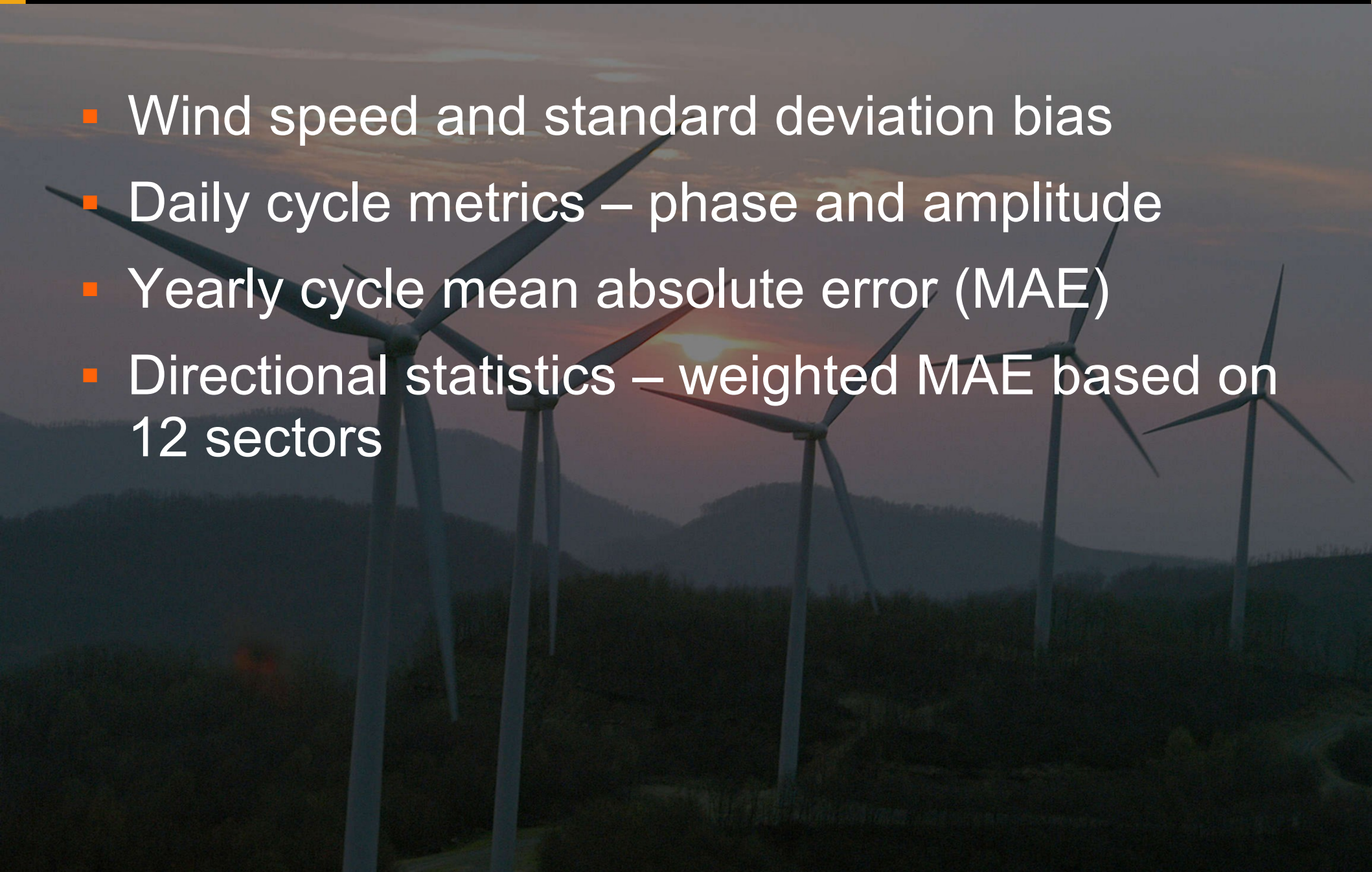
- MM5 – non-hydrostatic regional/mesoscale climate model
- Community model developed at Penn State University (forecasting and climate research)
- Fully dynamic (time dependent) wind, temperature, pressure and humidity
- Takes into account MANY surface parameters (topography, roughness, albedo etc.)

Model Validation - Observations

- Use most reliable 17 SAWS stations (10m)



Model Validation - Statistics



- Wind speed and standard deviation bias
- Daily cycle metrics – phase and amplitude
- Yearly cycle mean absolute error (MAE)
- Directional statistics – weighted MAE based on 12 sectors

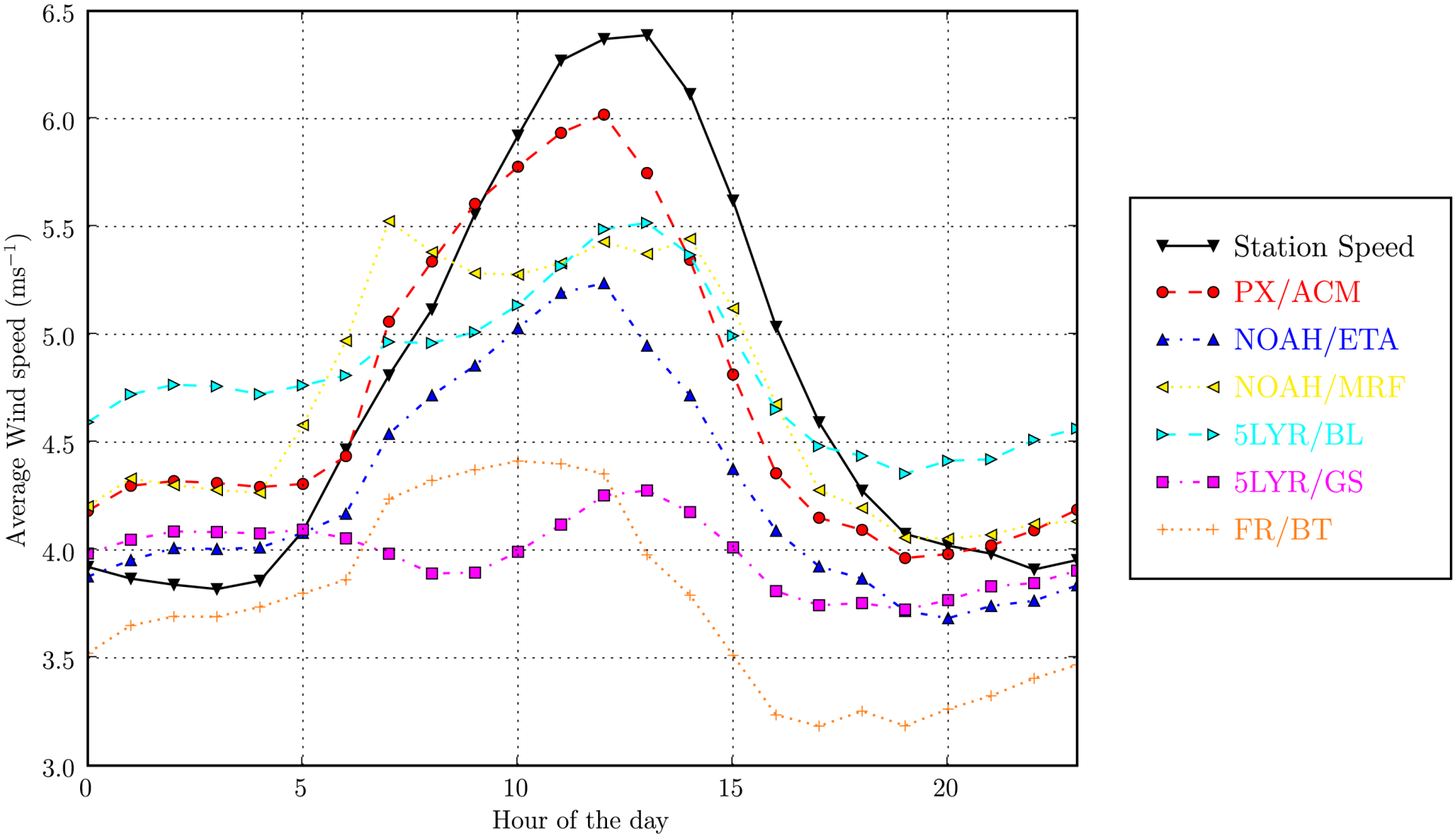
Time Subsetting

- Cannot run model for 10-20 years at desired resolution
- 1 year too short, not representative...
- Solution: find ”optimal 365 day time period”
  - Details in my PhD
  - Best match: 20 March 1996 – 19 March 1997
  - Cross validation with 17 stations 1993-2004 => 0.2m/s systematic bias, may be corrected later

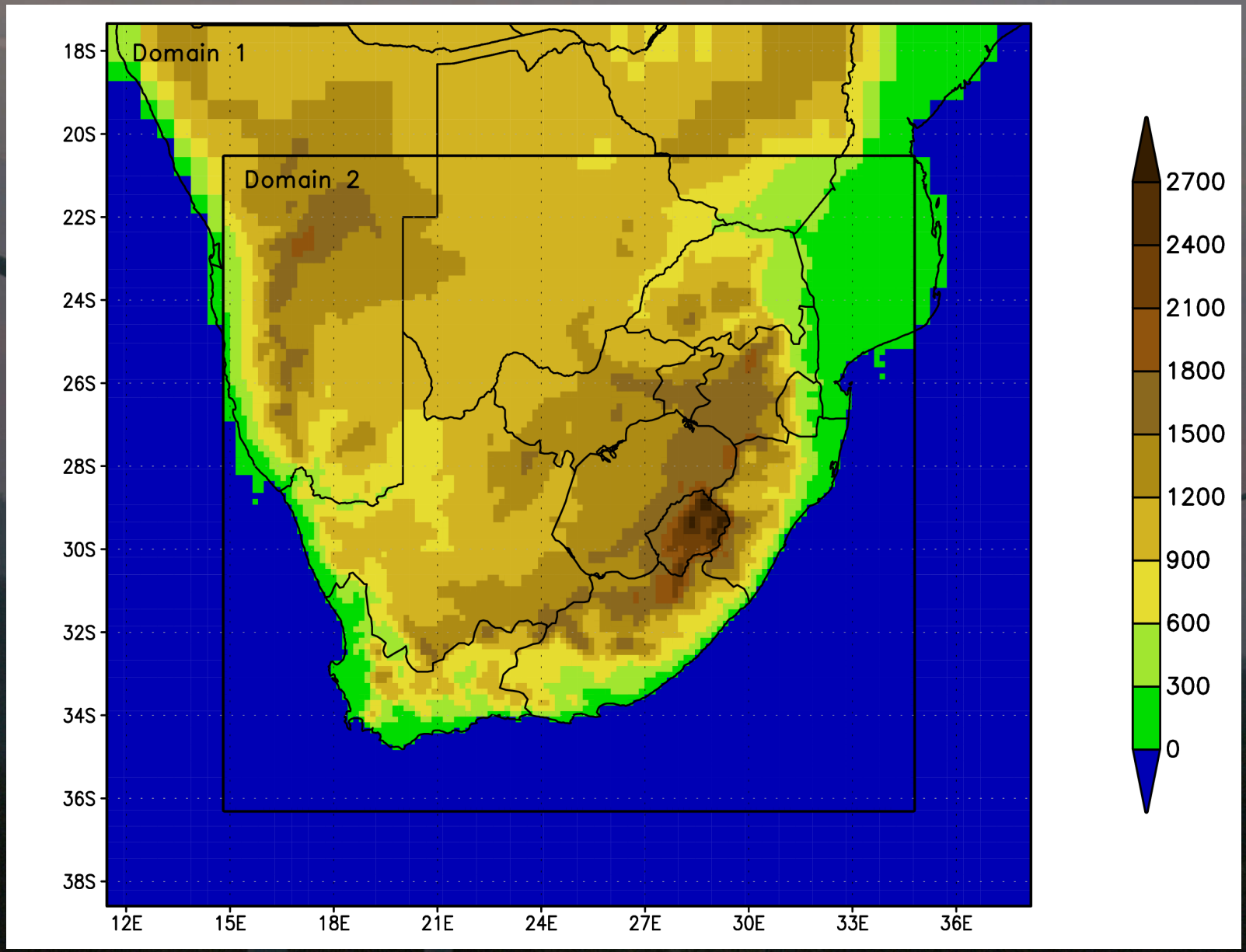
Parametrisations – overview

- Large effort spent on determining ”optimal” configuration of model
- Dozens of ”sensitivity runs” over limited EC domain
- Investigating performance in terms of:
  - All validation statistics
  - Model factors such as LSM/PBL combinations
  - Grid FDDA, observational nudging, cumulus

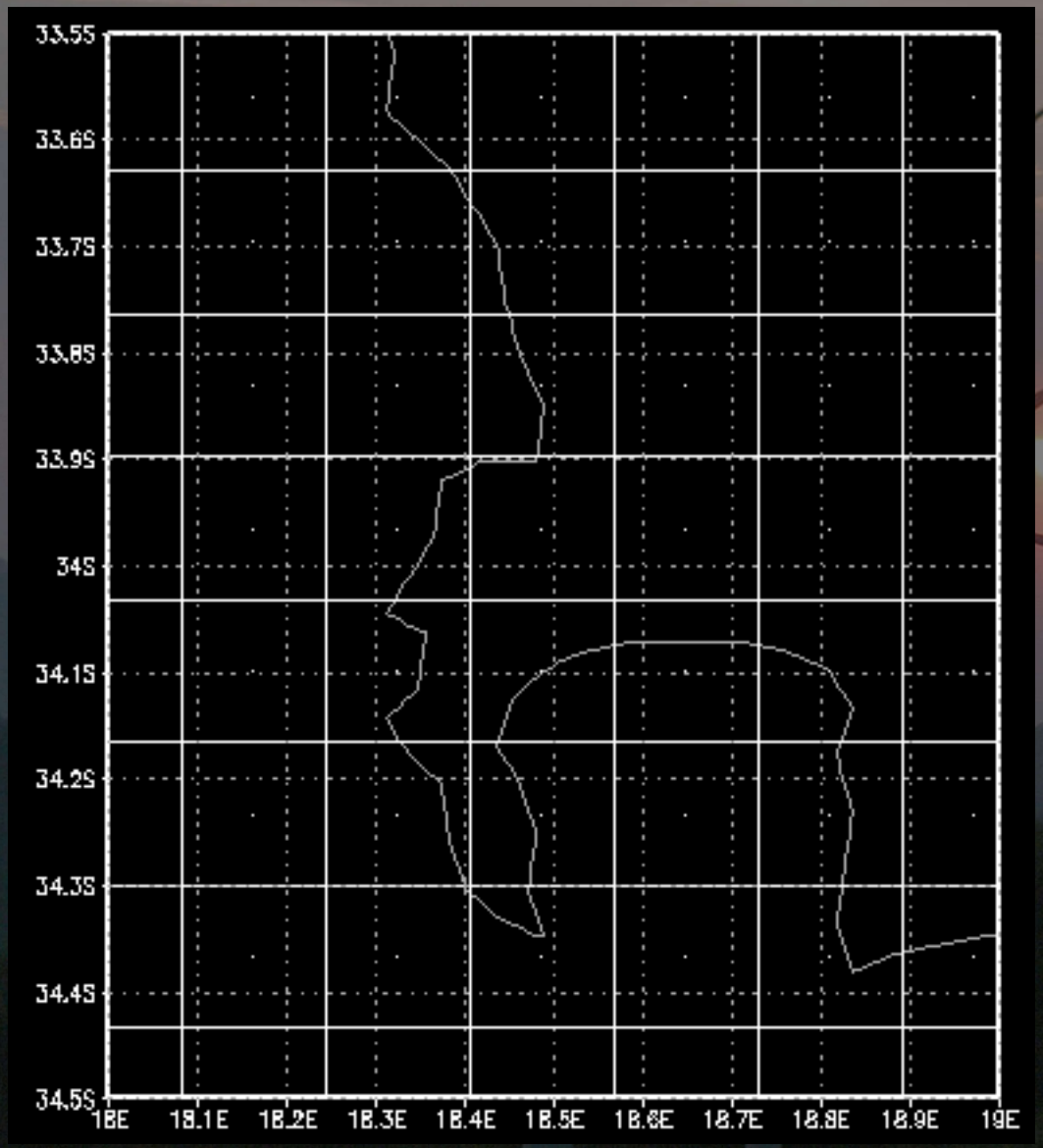
Parametrisations – LSM/PBL East London daily cycle



Final Model Domains



Fundamental Grid Constraints

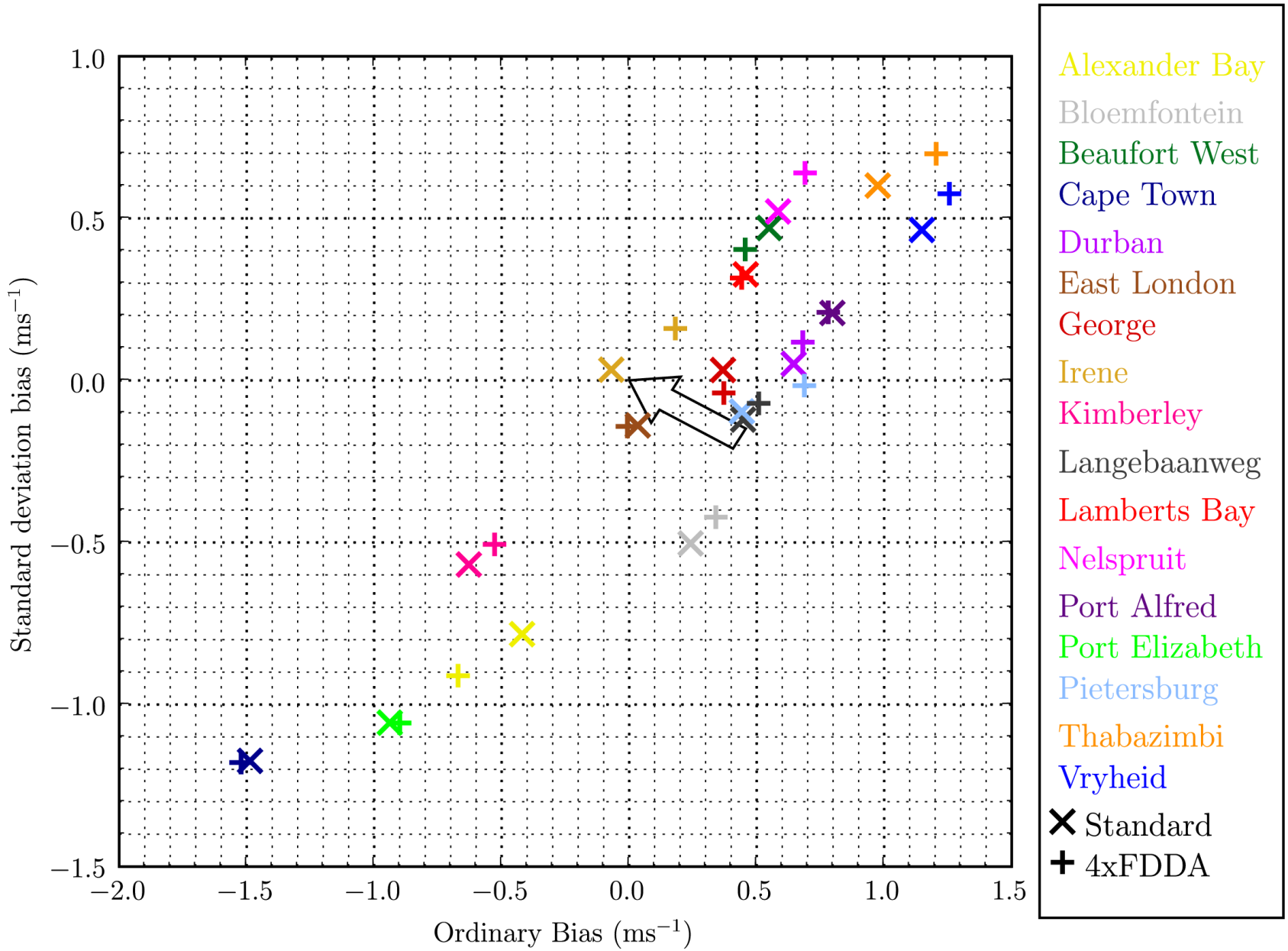


- Surface (topography, roughness etc.) smoothed out (18km)
- Cannot distinguish between points within given grid cell
- Gives good *area average*, not necessarily point estimate

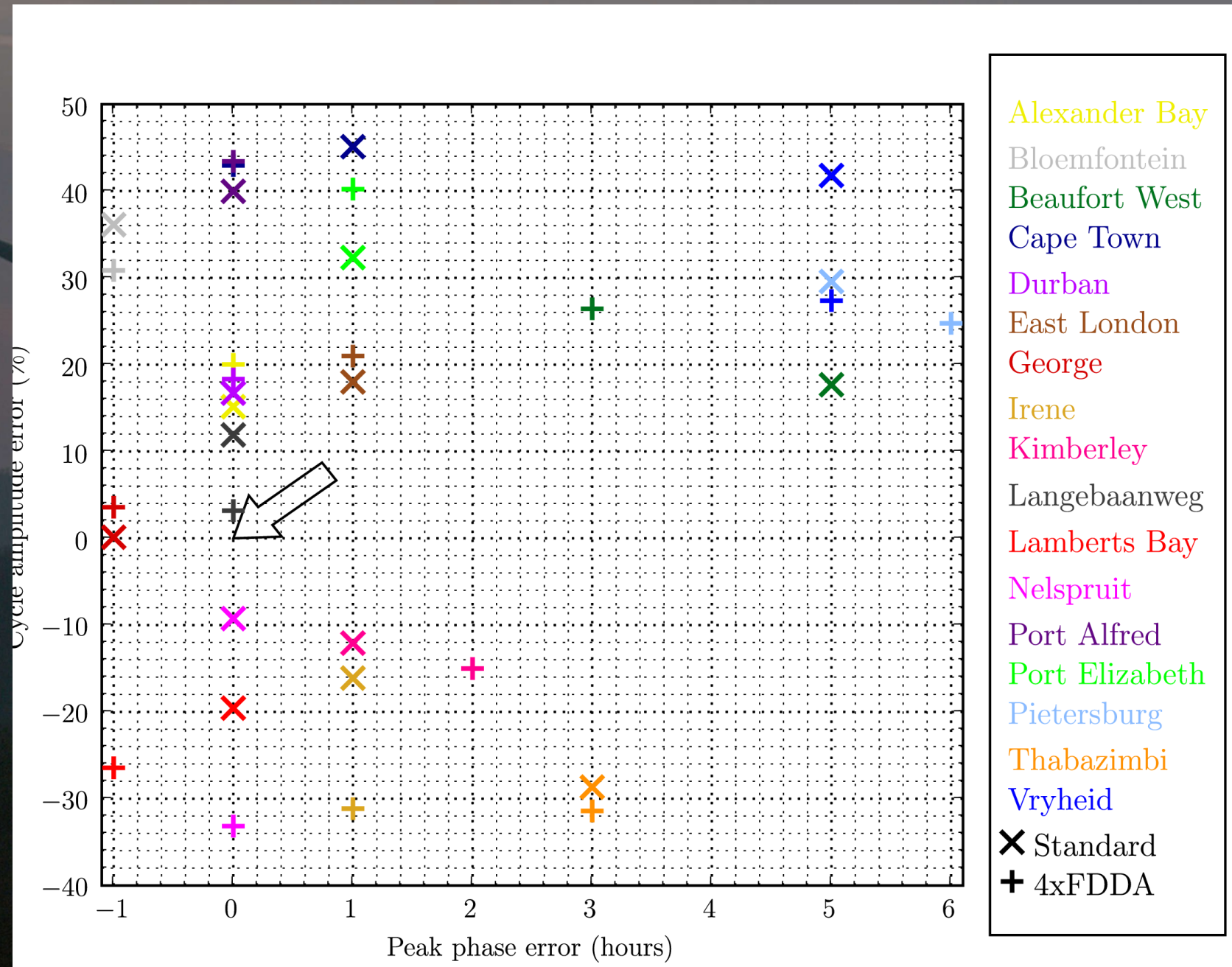
Data availability

- 1 year (representative of climatology)
- Hourly wind speed and direction
- 10m, 60m, 80m and 100m above ground (any other 10m < height < 10km extractable)
- Coverage: entire South Africa (including offshore)
- Time series, summary statistics, GIS raster maps and much more

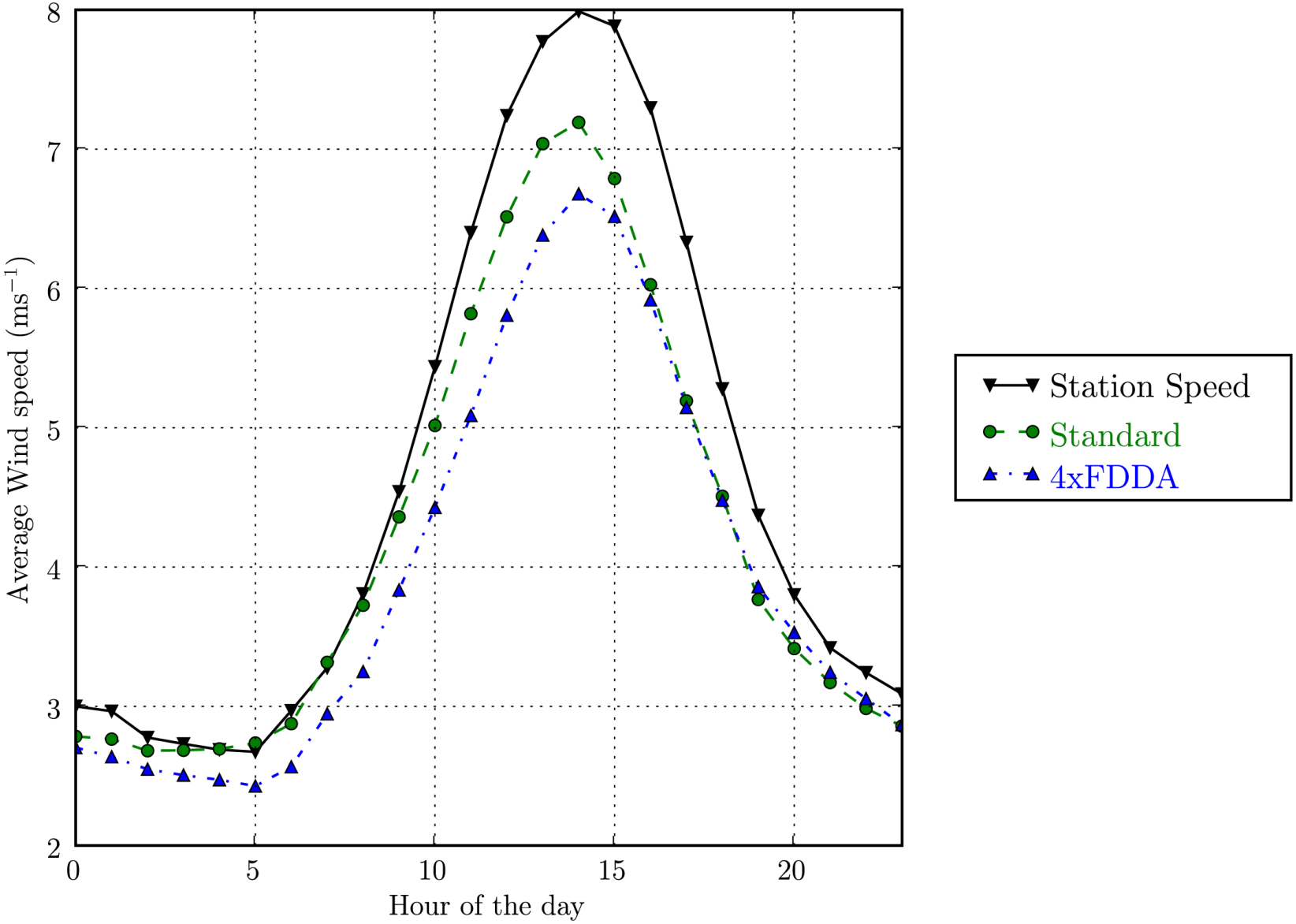
10m Wind Speed Bias



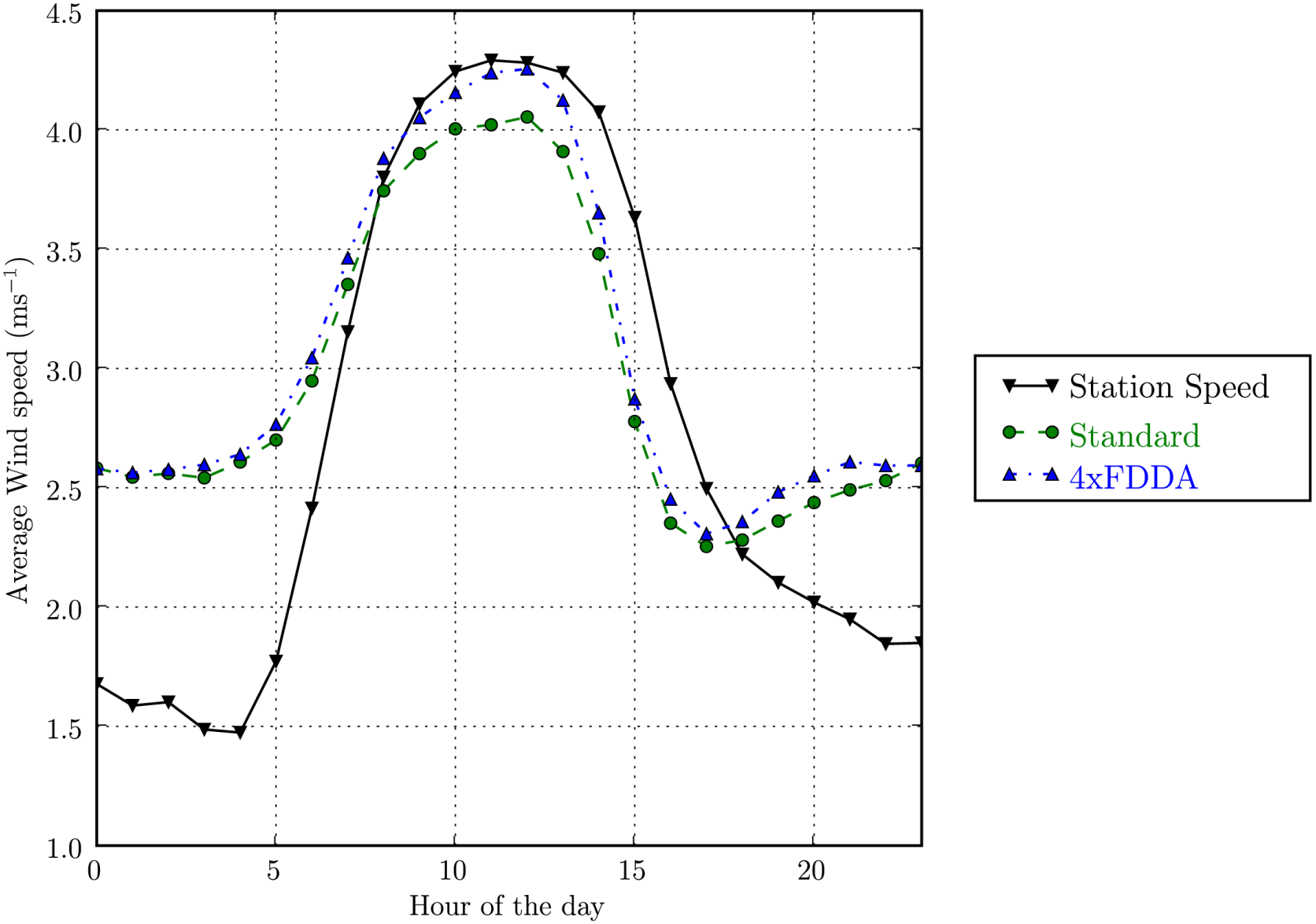
10m Daily Wind Speed Cycles



Coastal Wind Speed Cycle (Alexander Bay)



Inland Wind Speed Cycle (Bloemfontein)

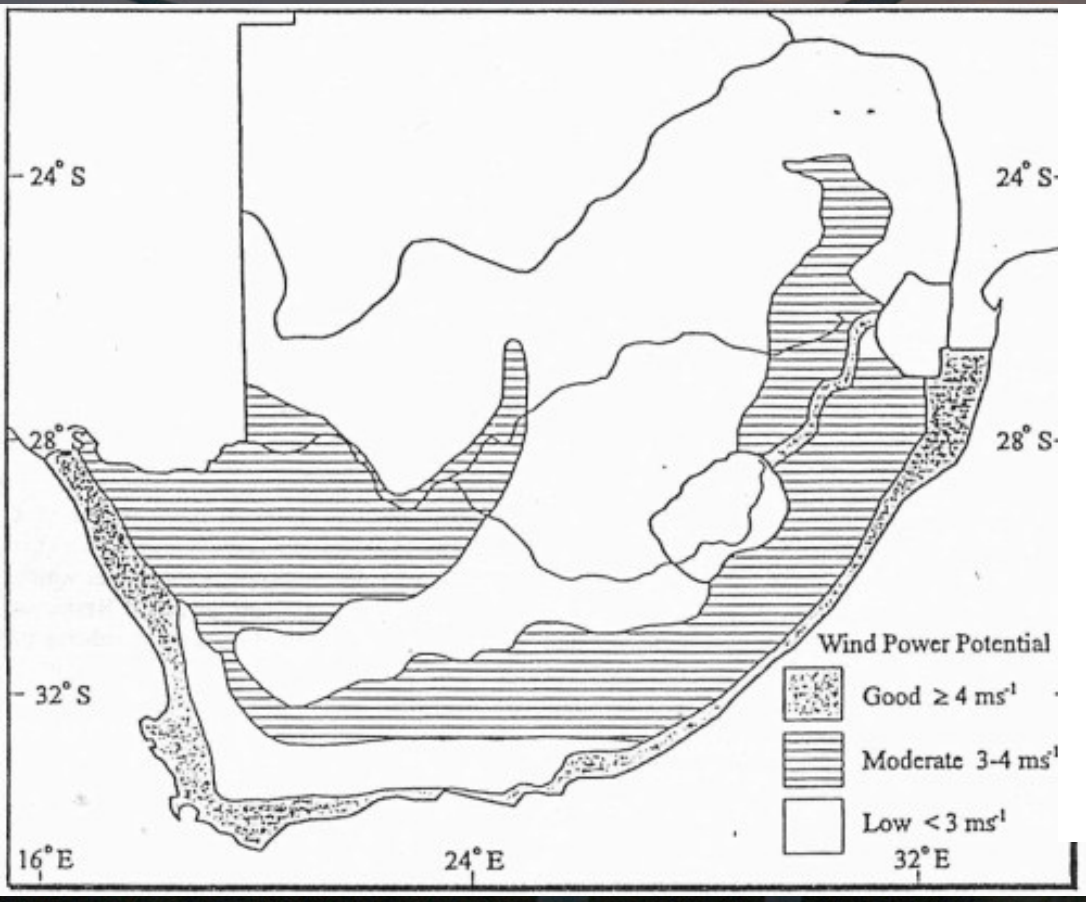


Uncertainty Summary

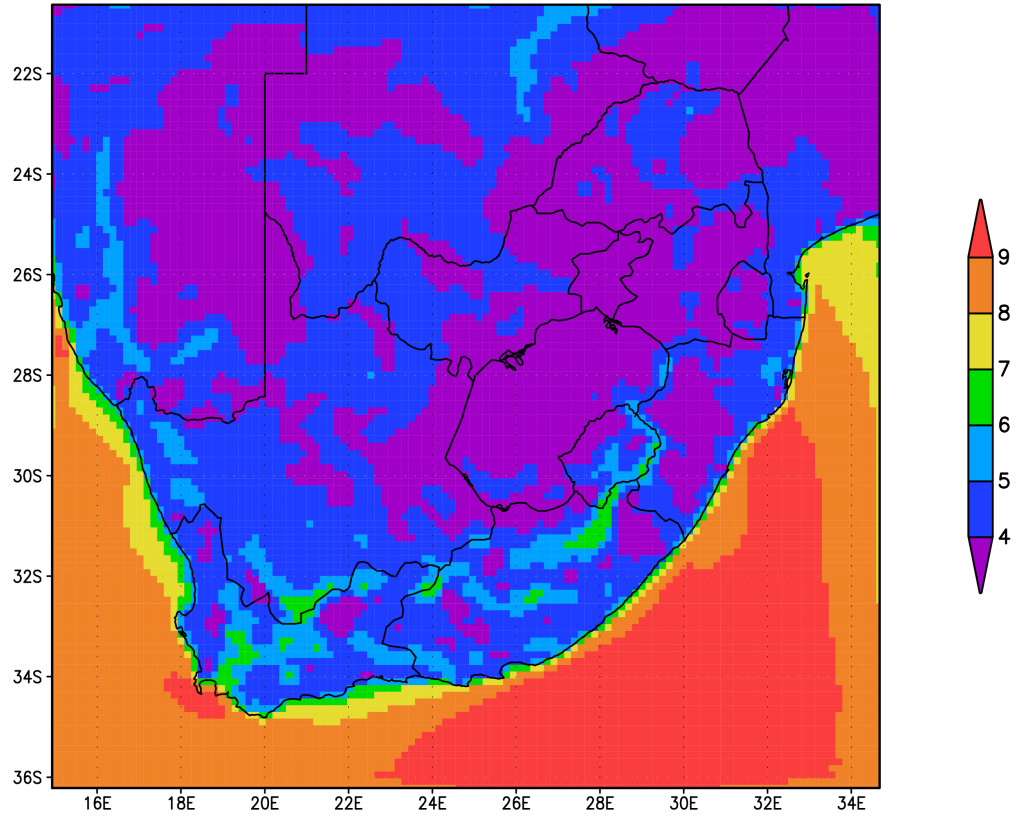
- Wind speed
  - Bias ~ 0.2m/s (model too strong)
  - Error +/- 0.7m/s (68% conf. Int.)
- Daily Cycles
  - Coast within +/- 1h of peak
  - Coast bias 18% of peak, +/- 20% (68% conf.)
  - Inland not reliable
  - => useful enough for daily electricity demand profile calculations (Andrew Marquard)

Average 10m Wind Speed Maps I

Diab 1995

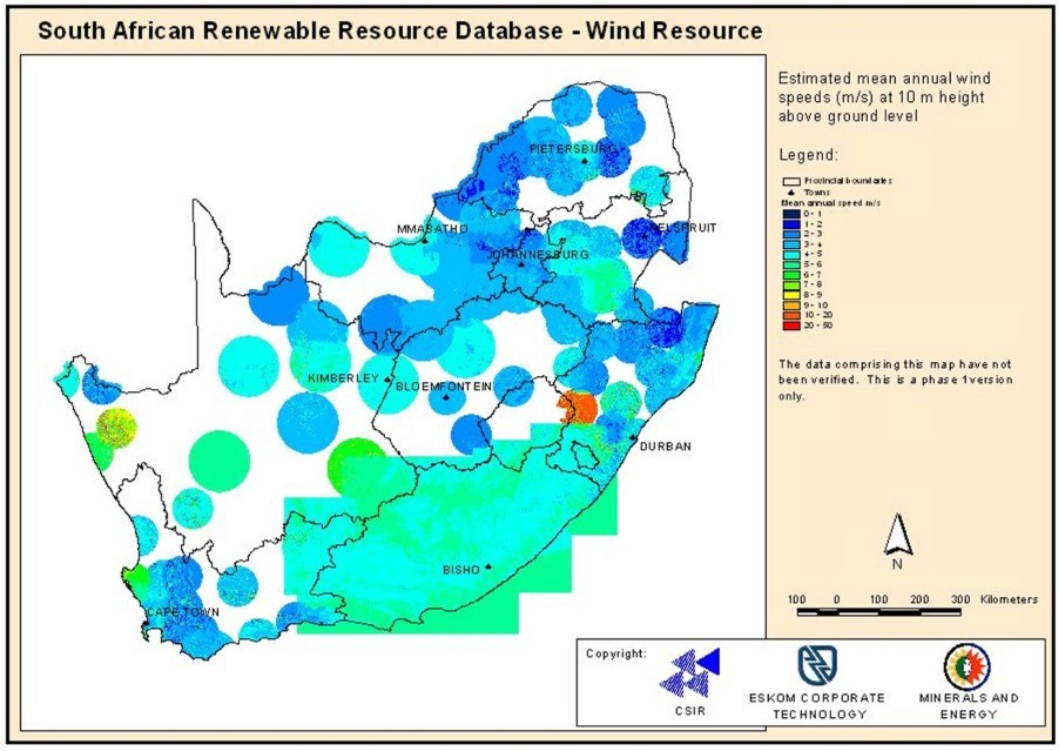


18km MM5 2008

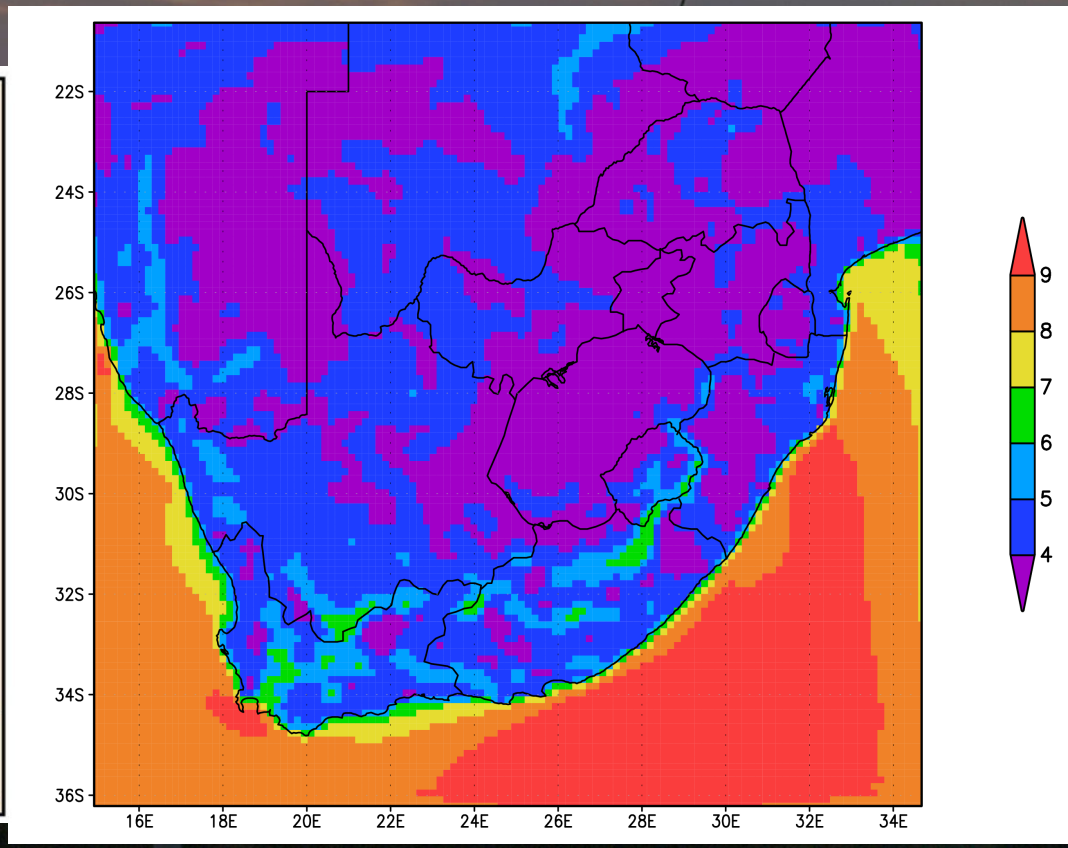


Average 10m Wind Speed Maps II

Eskom/CSIR 2001



18km MM5 2008



Total Potential Calculation

- Integrate total wind potential by considering:
  - Proximity to roads (minimum secondary)
  - Proximity to transmission lines (>=66kV)
  - Minimum capacity factor (2MW Vestas turbine)
  - given hub height (60m, 80m or 100m)
  - Density of 1 turbine per km^2

Total Potential Calculation

- Three scenarios:

Scenario	*Maximum roads distance*	*Maximum transmission distance*	*Hub Height*	*Minimum capacity factor*
pessimistic	3km	3km	60m	35%
realistic	4km	4km	80m	30%
optimistic	5km	5km	100m	25%

Annual Electricity Generation	
20.0 TWh	8.7%
80.5 TWh	35.1%
157.2 TWh	68.5%

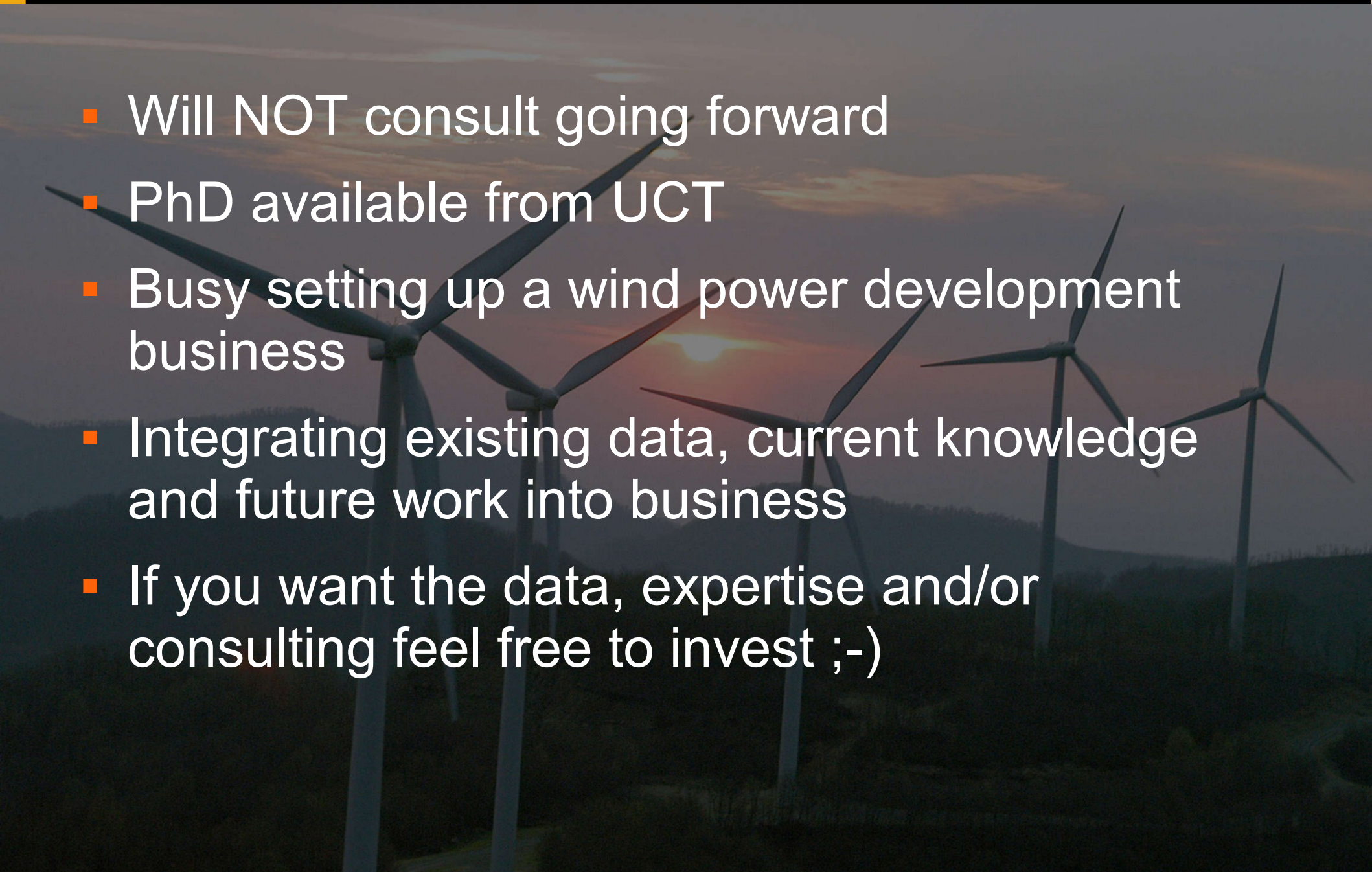
Future Plans

- SAWEP wind atlas project
- R25m, 4 year project
- Multi-stakeholder
  - Risoe, UCT, CSIR, SANERI, SAWEP, SAWS
- Based on measurements AND mesoscale modelling

SAWEP Mesoscale Component

- Phase 1 – known methodology by Risoe
  - First map by next year (?)
- Phase 2 – fully dynamic simulations, new methodology developed by myself, UCT and Risoe
  - To be used all over the world
  - Completed by 2012

My Current Business



- Will NOT consult going forward
- PhD available from UCT
- Busy setting up a wind power development business
- Integrating existing data, current knowledge and future work into business
- If you want the data, expertise and/or consulting feel free to invest ;-)

Questions?

- Fire them to kilian@windpower.co.za ...