NORTHERN ARIZONA UNIVERSITY

QUANTIFYING THE UNCERTAINTY IN WIND POWER PRODUCTION USING METEODYN WT

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DEPARTMENT OF MECHANICAL ENGINEERING

CLEAN ENERGY RESEARCH

ENERGY AND COMPUTATIONAL MODELING LAB

ECM

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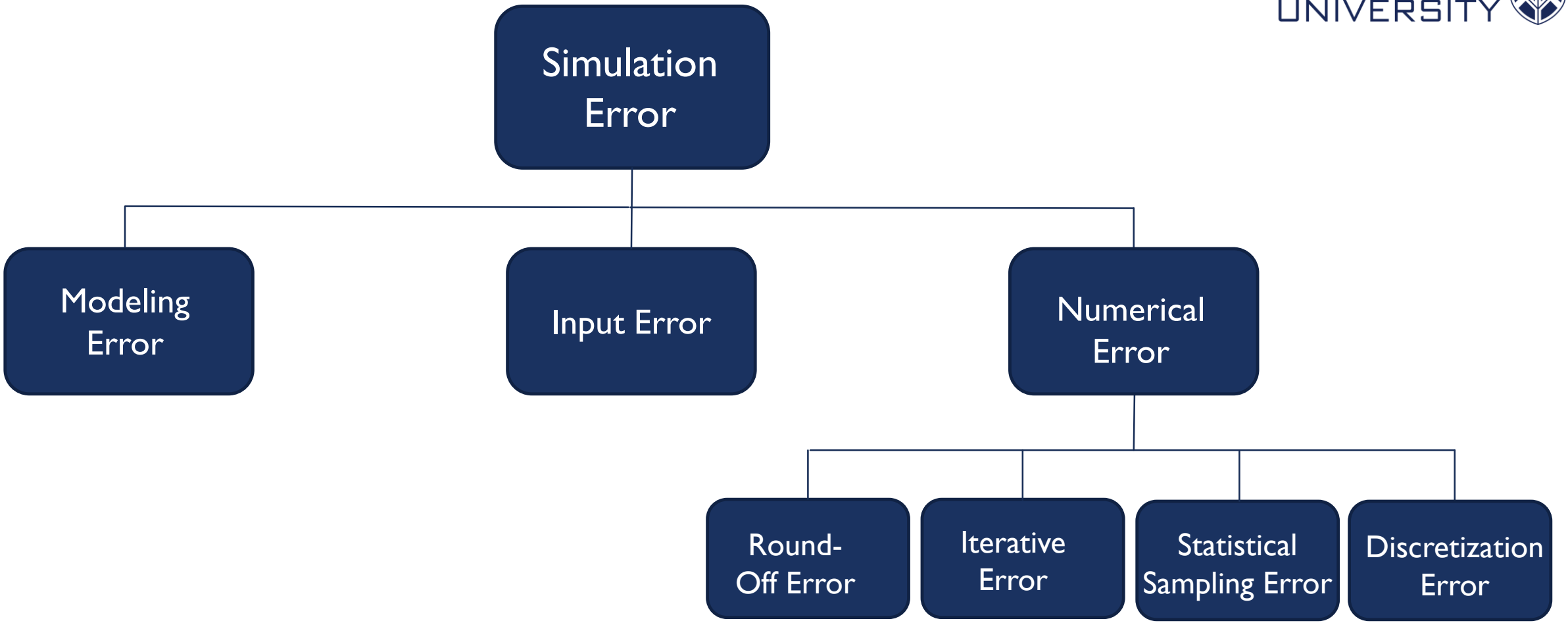
NASA

OBJECTIVES

- **Perform an Uncertainty Quantification in Wind Power Predictions from Meteodyn WT**
  - *Use Computation Resources available at the Energy and Computational Modeling (ECM) Lab.*
- **Determine:**
  - *Numerical Uncertainty in Wind Speed Prediction*
- **Quantify Total Uncertainty in Model Results**
  - *Velocity with 95% Confidence*

BACKGROUND


Simulation Error
Modeling Error
Input Error
Numerical Error
Round-Off Error
Iterative Error
Statistical Sampling Error
Discretization Error

SOFTWARE

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ArcGIS® ESRI

- Geographic Information System (GIS)
- Used to develop the elevation file

meteoDyn WT meteorology & dynamics

- Computational Fluid Dynamics (CFD) Software
- Solves the Nonlinear, Steady, incompressible, isothermal Reynolds Averaged Naiver Stokes (RANS) equations.
- Uses a one-equation closure model

MATLAB

- Matrix Laboratory
- Used for data reduction and visualization

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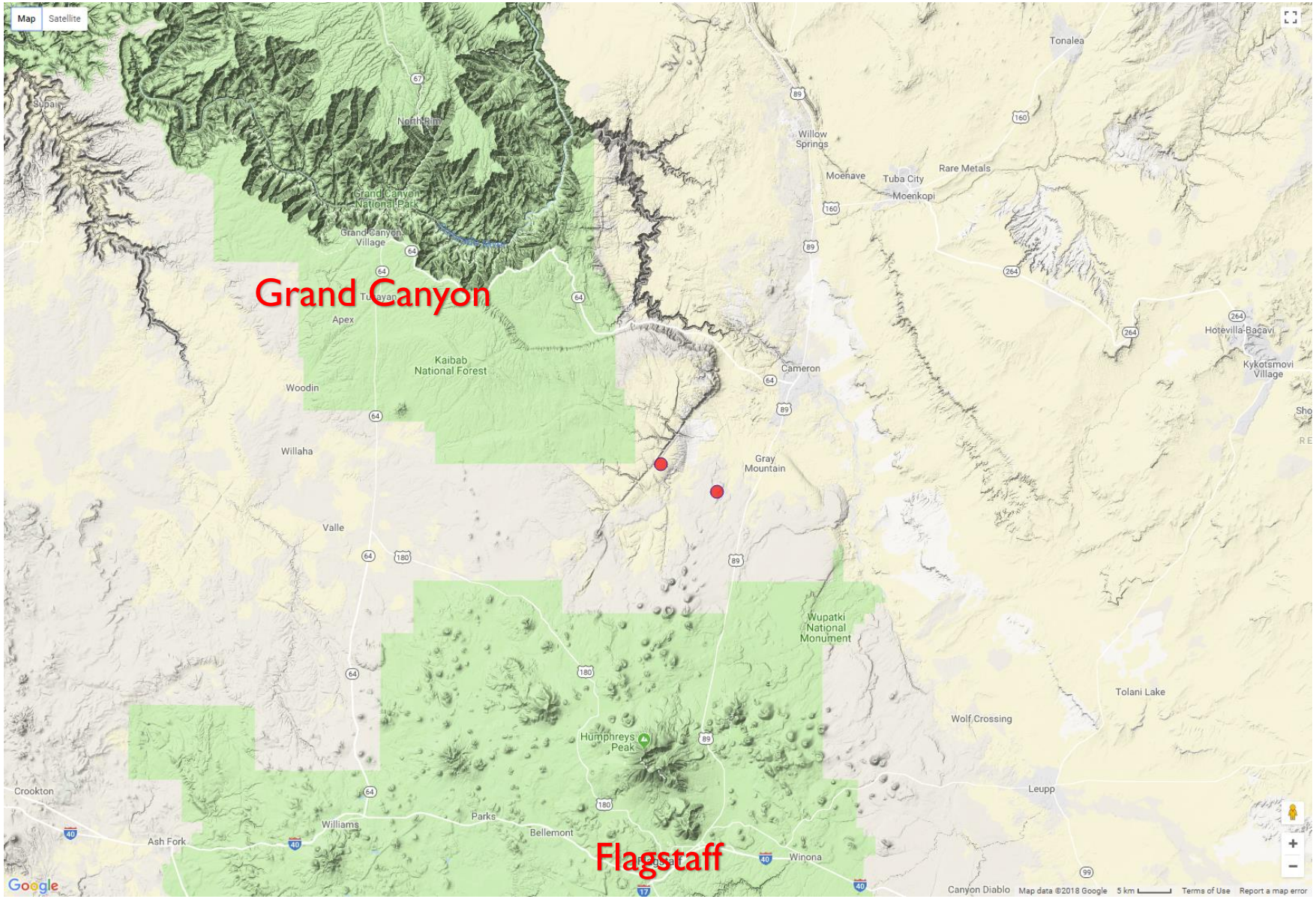
LOCATION


Map
Satellite
Grand Canyon
Flagstaff
Tonalea
Willow Springs
Moenave
Tuba City
Rare Metals
Moenkopi
Grand Canyon National Park
Grand Canyon Village
North Rim
Supai
Tusayan
Apex
Kaibab National Forest
Woodin
Willaha
Valle
Cameron
Gray Mountain
Hotevilla-Bacavi
Kykotsmovi Village
Wupatki National Monument
Tolani Lake
Wolf Crossing
Leupp
Humphreys Peak
Crookton
Williams
Ash Fork
Parks
Bellemont
Winona
Canyon Diablo
Map data ©2018 Google
5 km
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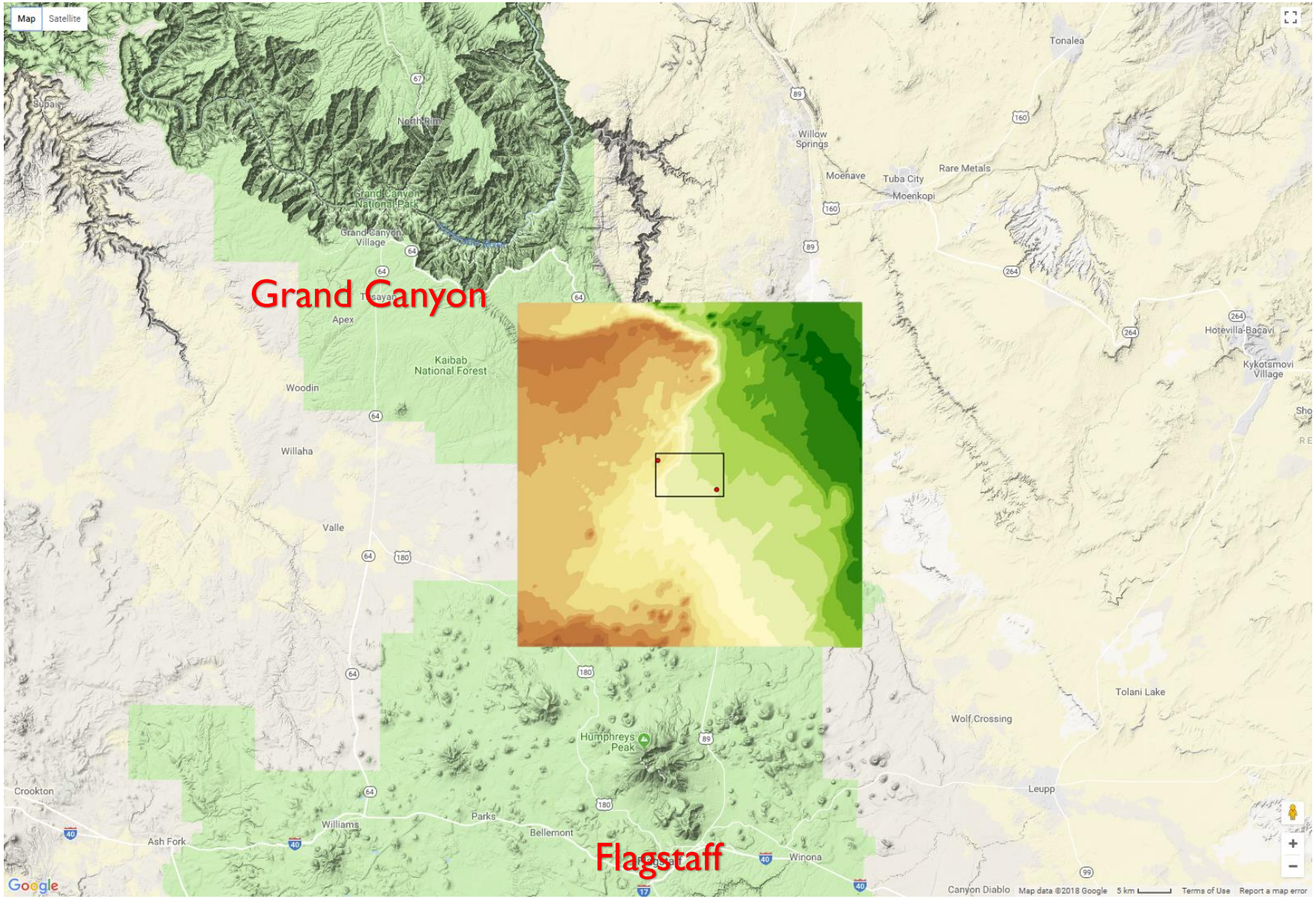
LOCATION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Crookton
Williams
Parks
Bellemont
Ash Fork
Winona
Canyon Diablo
Map data ©2018 Google
5 km
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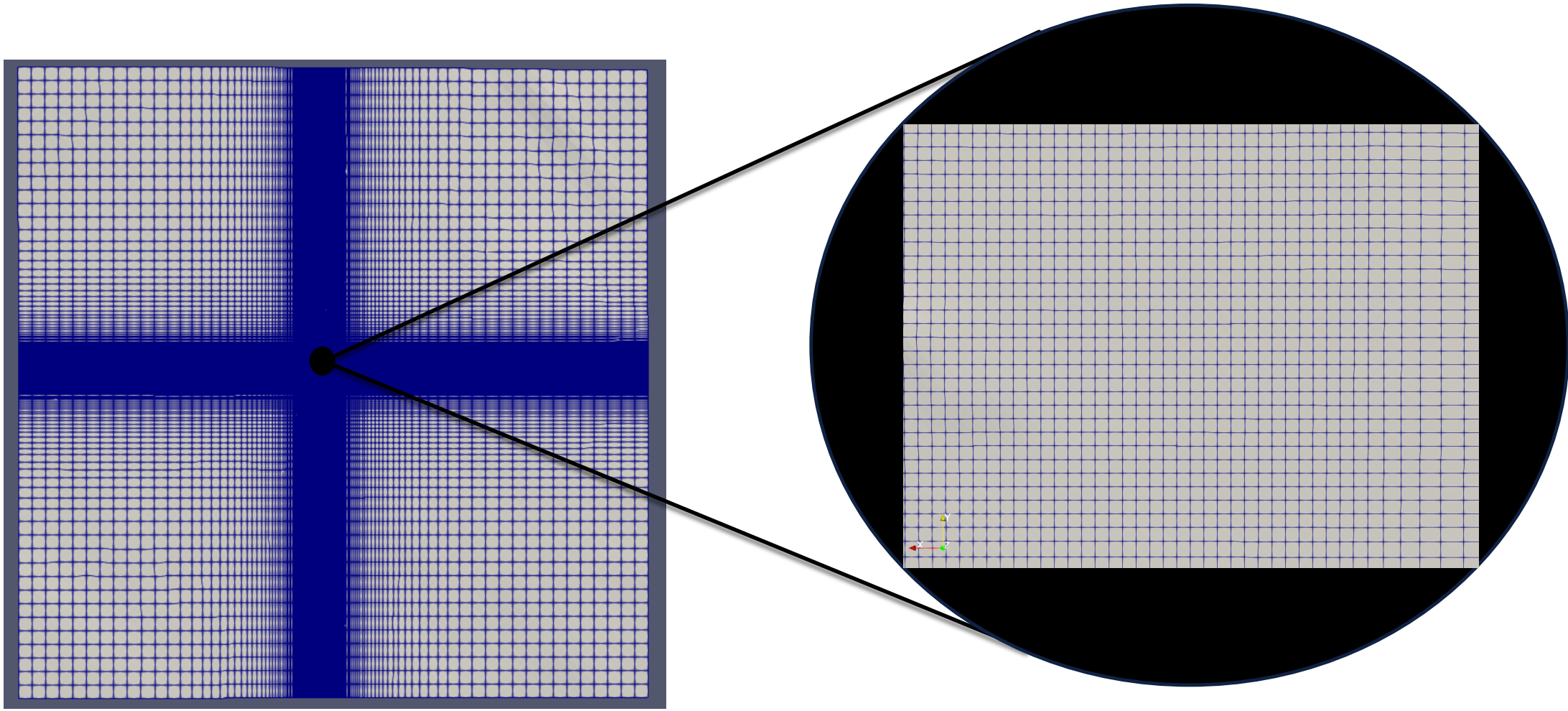
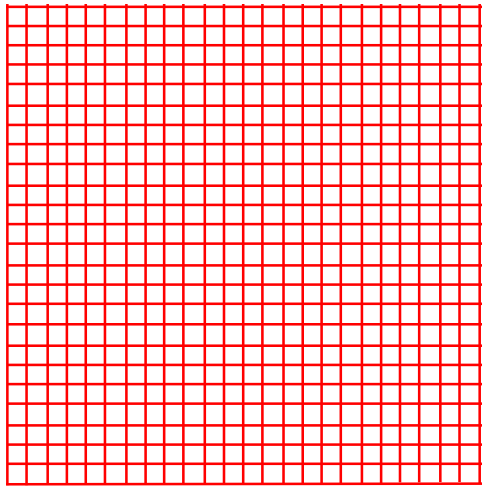
MESH

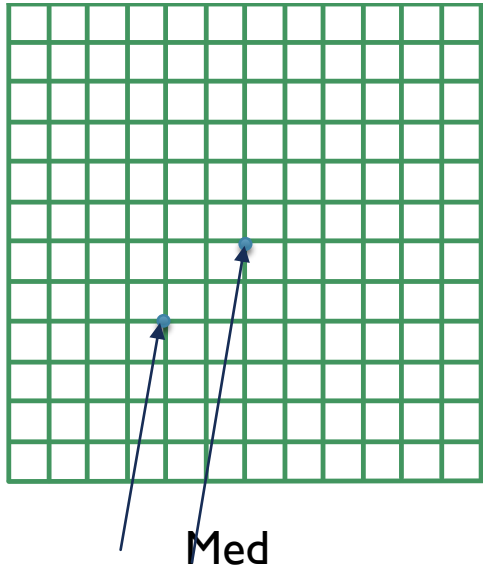


RICHARDSON EXTRAPOLATION

- 3 Systematically Refined Mesh's
- $\hat{p} = \frac{\ln(\frac{f_3 - f_2}{f_2 - f_1})}{\ln(r)}$
- $GCI = F_s \frac{|f_h - f_{rh}|}{r^p - 1}$

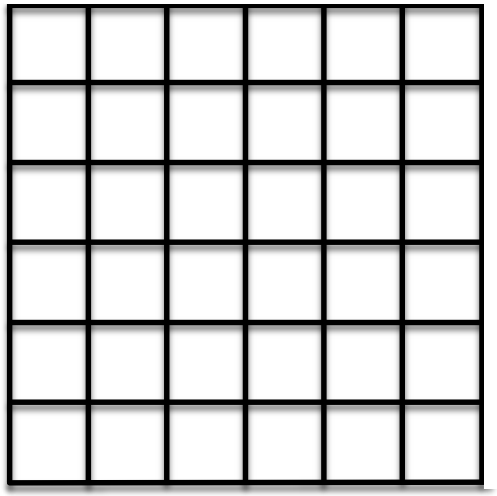


Fine



Intersecting Nodes

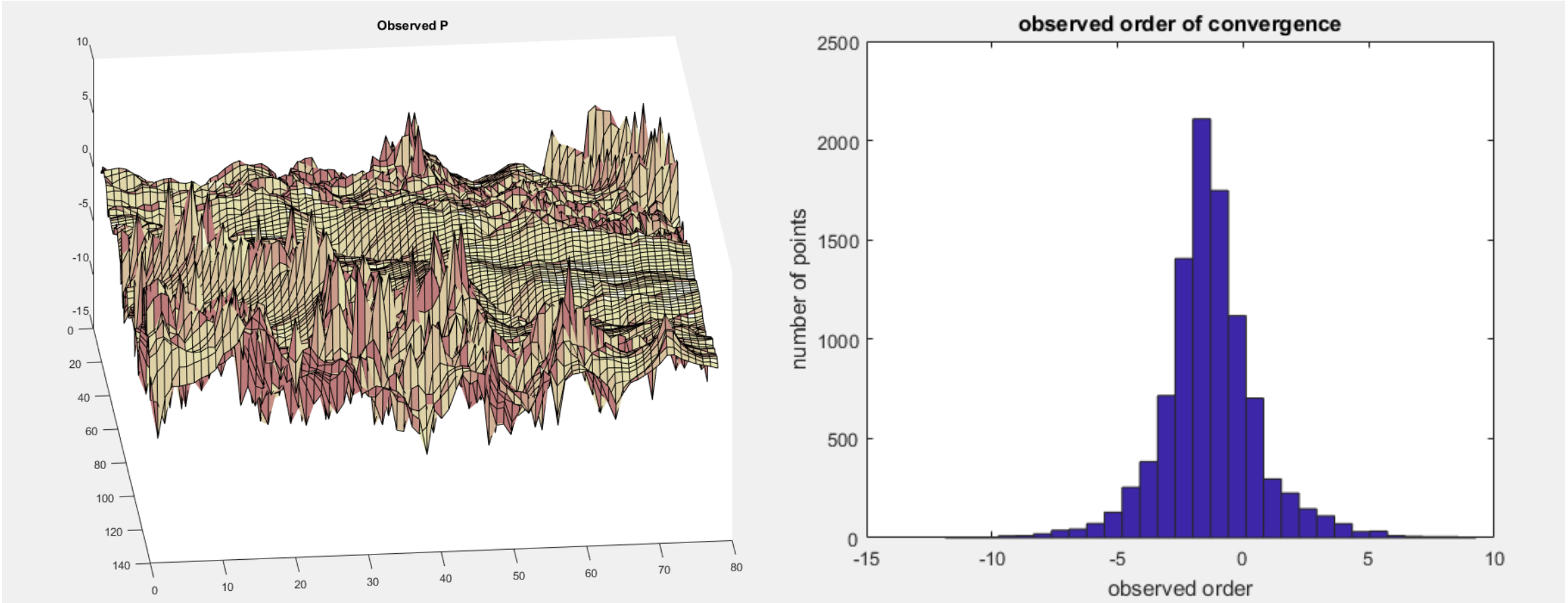
Med



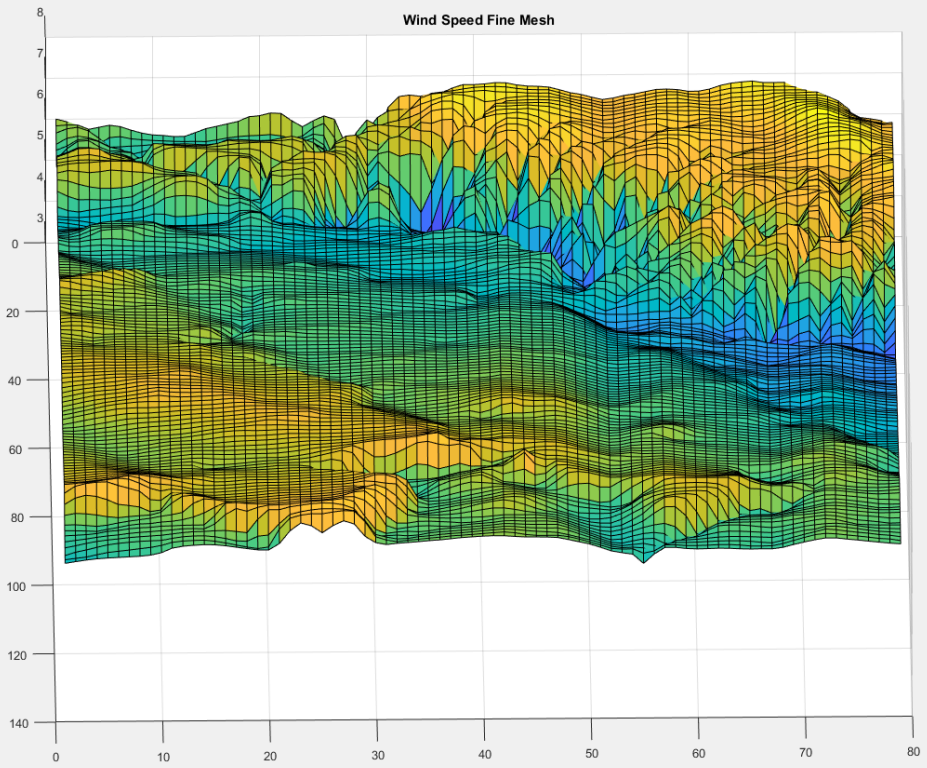
Course

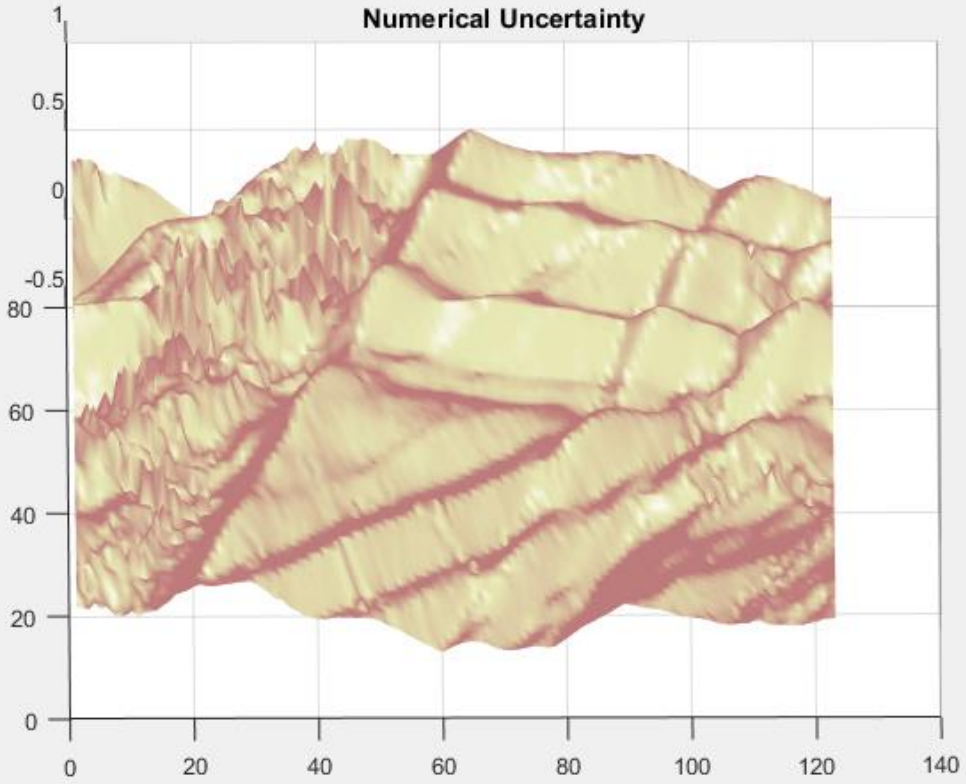
SYNTHESIS RESULTS

Average Order of convergence = -1.33

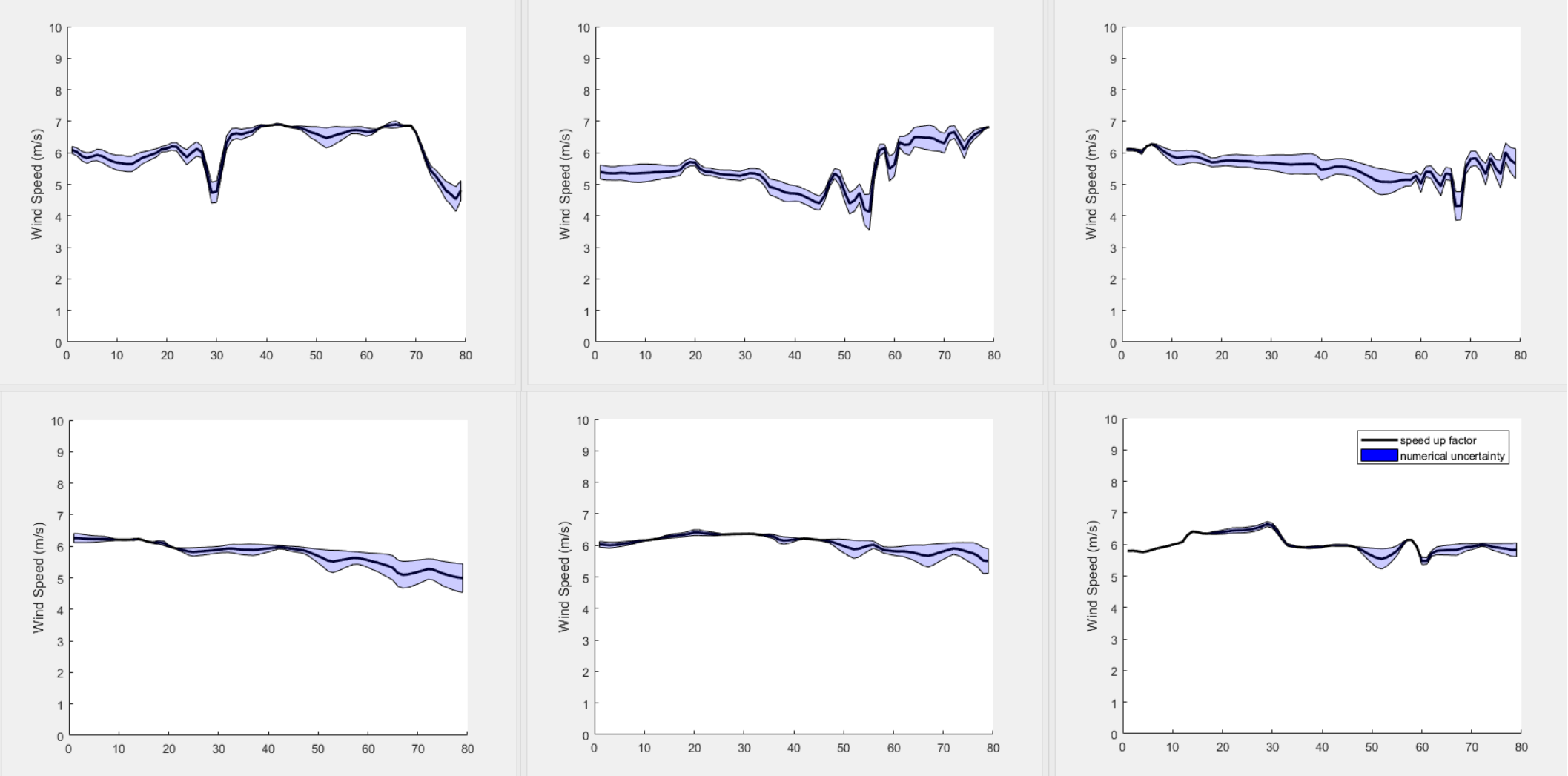


SYNTHESIS RESULTS





SYNTHESIS RESULTS



CONCLUSION

- A significant difference between the theoretical and observed order of convergence
  - Theoretical = 2
  - Observed= -1.33
- Not in the asymptotic range
  - Finer Mesh
- Iterative Error Influence
  - Increase the number of iterations

ACKNOWLEDGEMENTS

- *Dr. Tom Acker*
  - *Energy and Computational Modeling (ECM) Lab*
- *Kathleen Stigmon & Dr. Nadine Barlow*
  - *NAU Nasa Space Grant*

Questions?

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