

Climate Science and its relevance to Renewable Energy

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Presentation to Climate Services in
Support of the Energy Sector in a
Changing Climate. ESIG 2020 Meteorology
& Market Design for Grid Services
Workshop

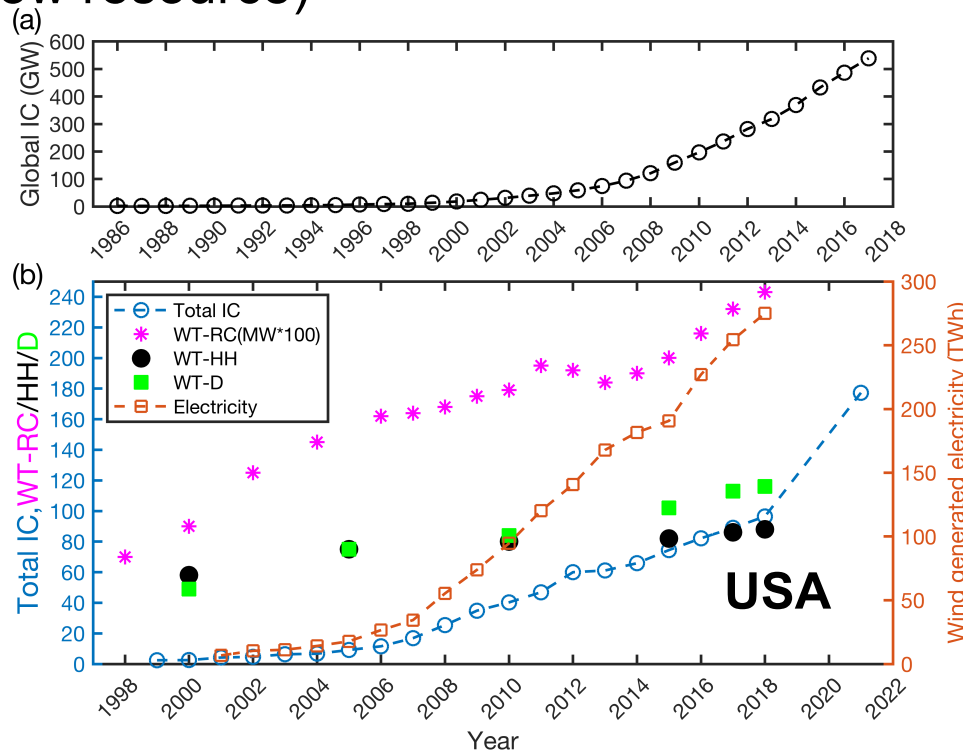
Funding support: U.S. Department of Energy (DoE) (DE-SC0016438 and DE-SC0016605)

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& DoE (DE-AC02-05CH11231).**



Wind energy & climate change

- Wind energy: LCoE (SGP) < \$50/MWh
 - GLOBAL IC: Grew at annualized rate of 20% to approx. 600 GW (2018). Projected +50% inc. 2019-2023.
 - 2017: 6% global electricity. Projections for upto 33% by 2050 (well below resource)



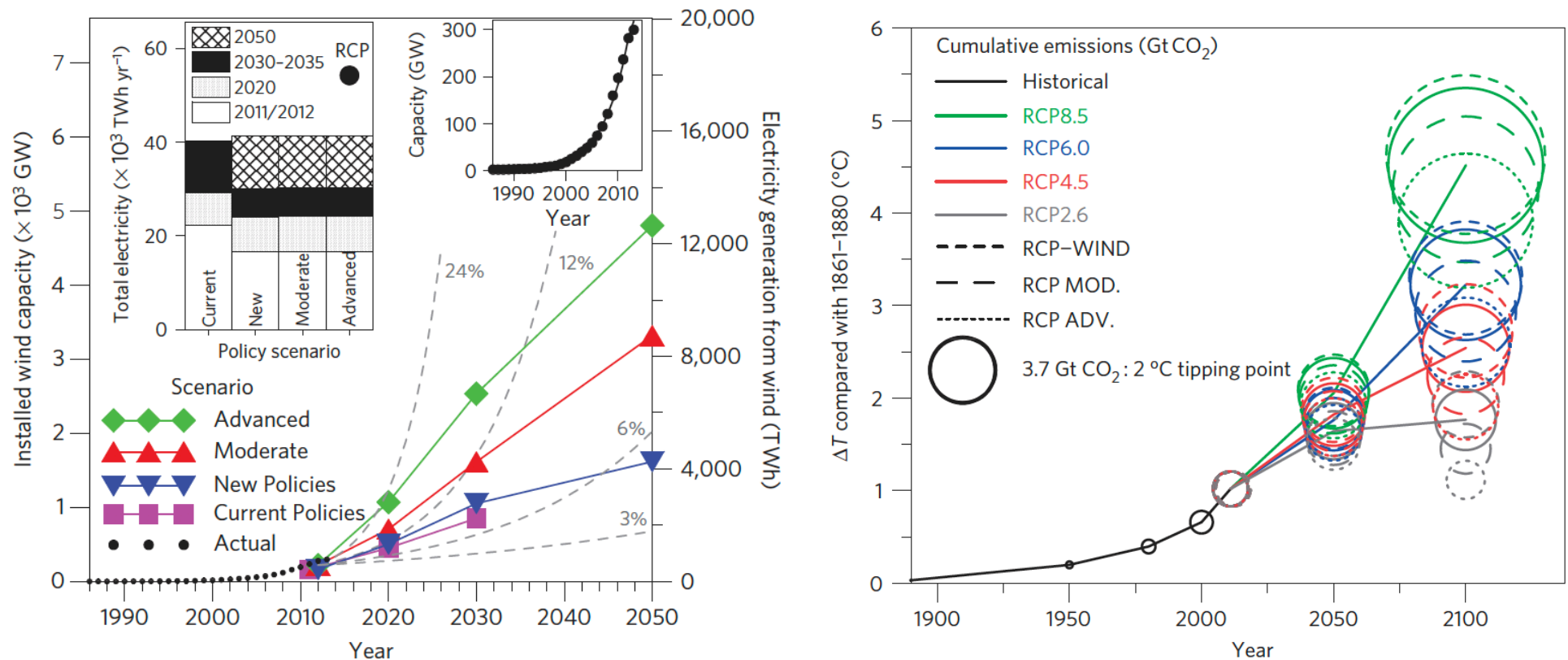
Pryor S.C., Barthelmie R.J. and Shepherd T.J. (2020): 20% of US electricity from wind will have limited impacts on system efficiency and regional climate. *Nature: Scientific Reports* 10 541

- Reciprocal relationship:
 - Mitigation of climate change (reduce CO₂ emissions)
 - Sensitive to climate change (resource & operating conditions)



Climate change mitigation potential

- Achieving 33% global electricity from wind by 2050 reduces global warming at 2100 by 0.3°C



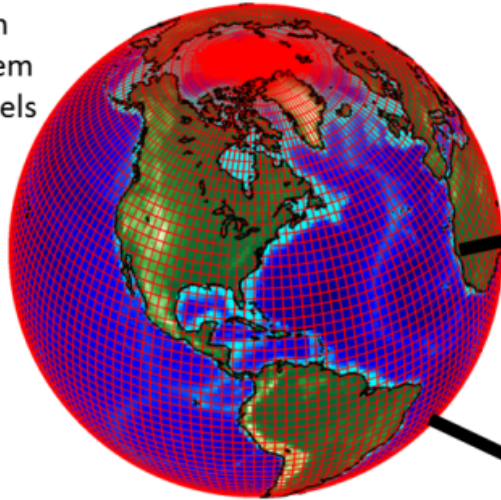
Barthelmie R.J. and Pryor S.C. (2014): The potential contribution of wind energy to climate change mitigation *Nature Climate Change* 4 684-688.



How might climate change impact wind energy?

Climate forcing: Representative Concentration Pathways (RCP)

Earth System Models



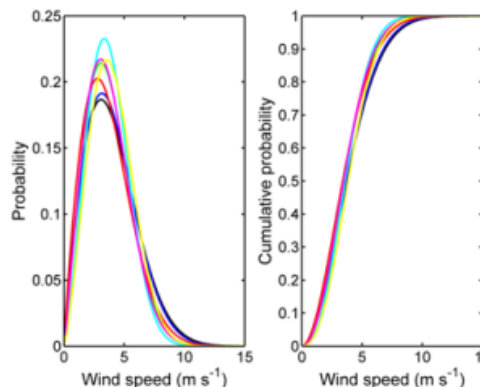
Dynamical downscaling

Statistical downscaling

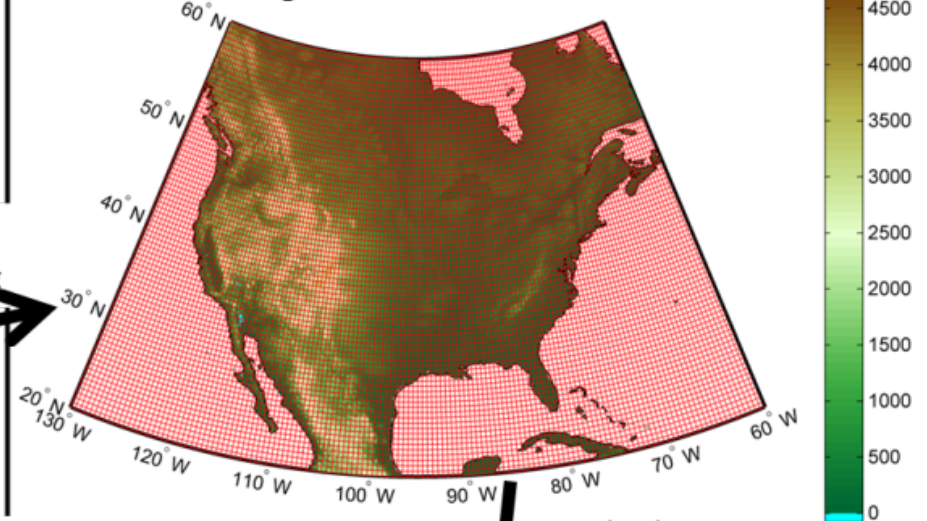
Multiple RCPs/ESMs $\Rightarrow$ Uncertainty

Uncertainty: can't map whole uncertainty space

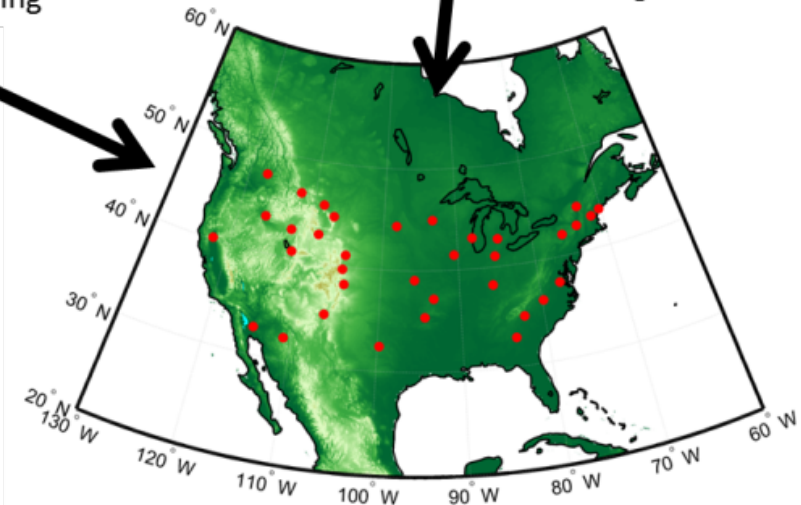
- Value: f (incomplete determination of particular results)
- Structural: f (incomplete process understanding)
- Also some from partially chaotic nature of system



Regional Climate Models



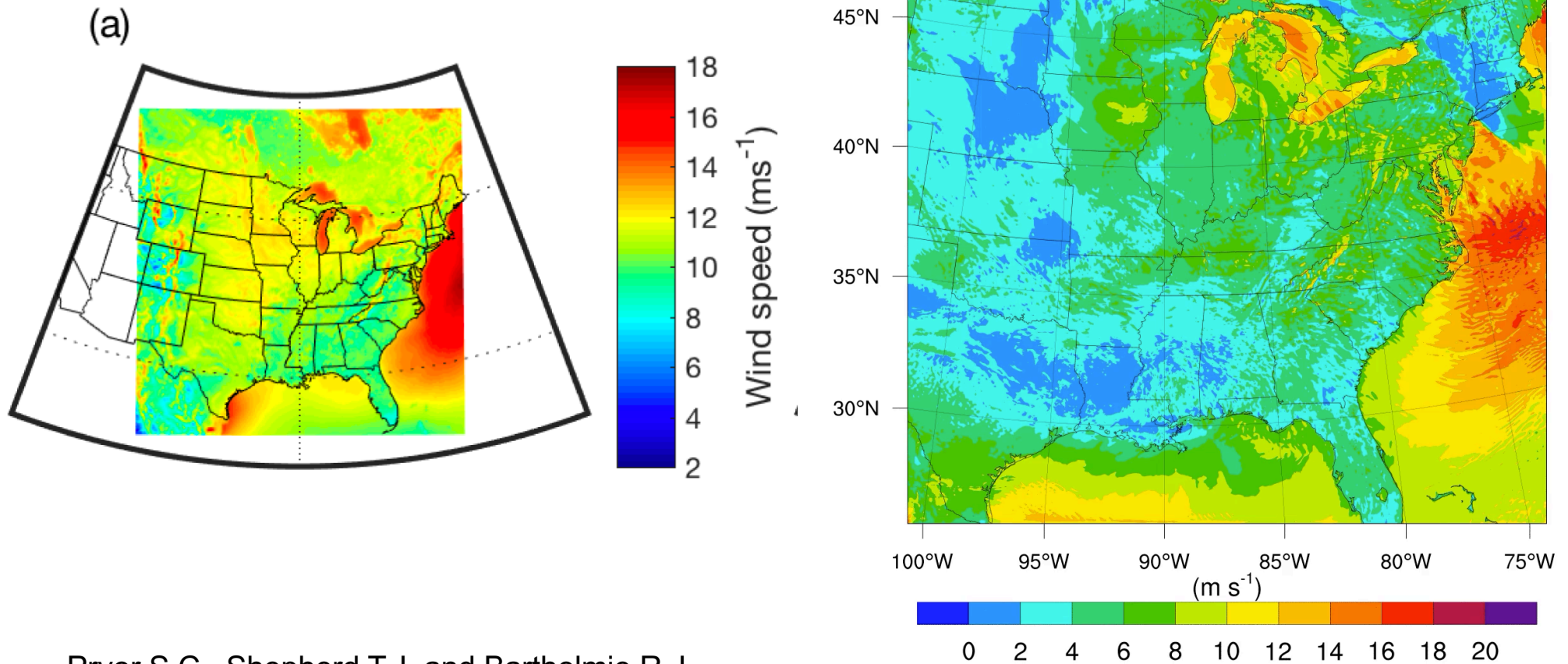
Hybrid downscaling



Multiple downscaling approaches in multiple RCP/ESM realizations $\Rightarrow$ Uncertainty



Regional climate simulations increasingly high resolution

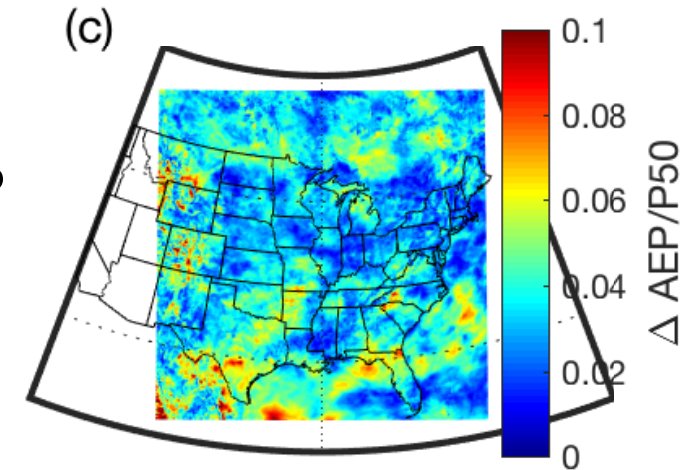
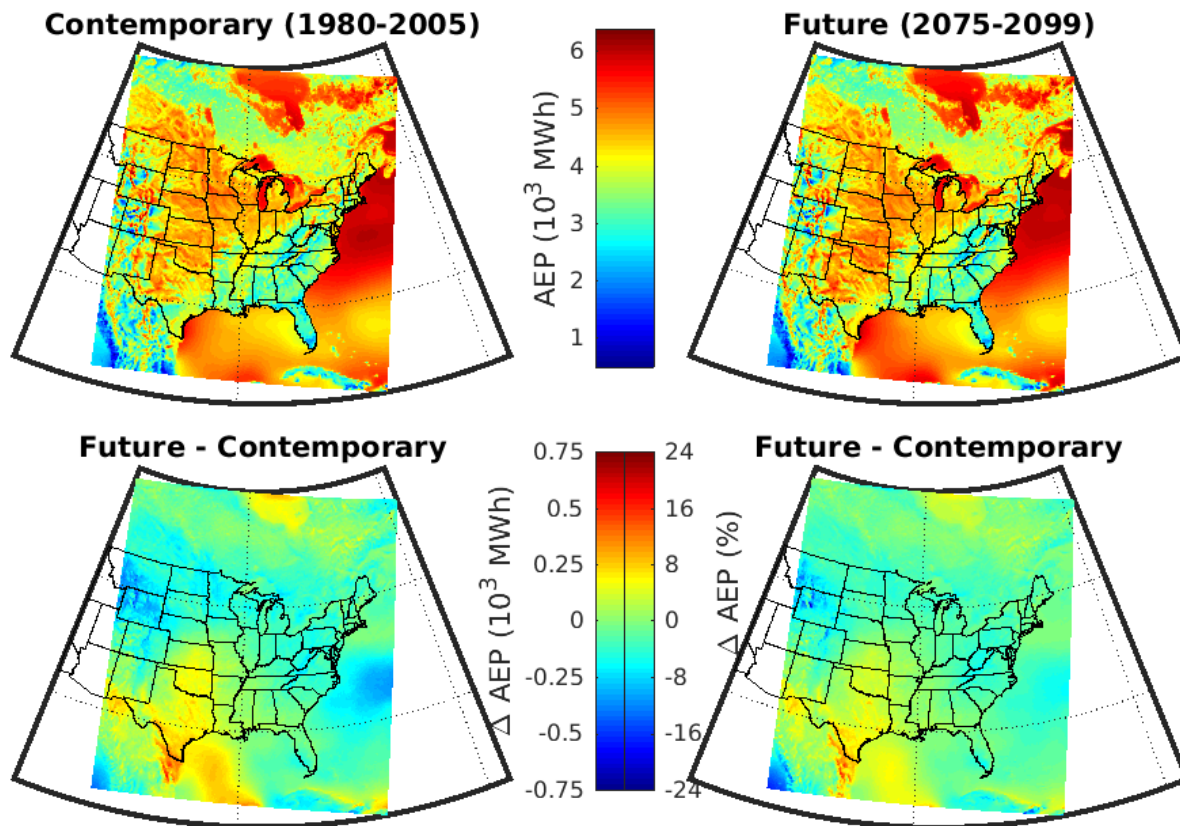


Pryor S.C., Shepherd T.J. and Barthelmie R.J.
(2018): Inter-annual variability of wind climates
and wind turbine annual energy production.
Wind Energy Science **3** 651-665



Changing resources? State-of-the-art

- In high resource areas:
 - Change to 2100 $< 5\%$
 - Natural variability $\gtrsim$ climate change signal
 - Sensitivity (in order): RCM, ESM, res., RCP



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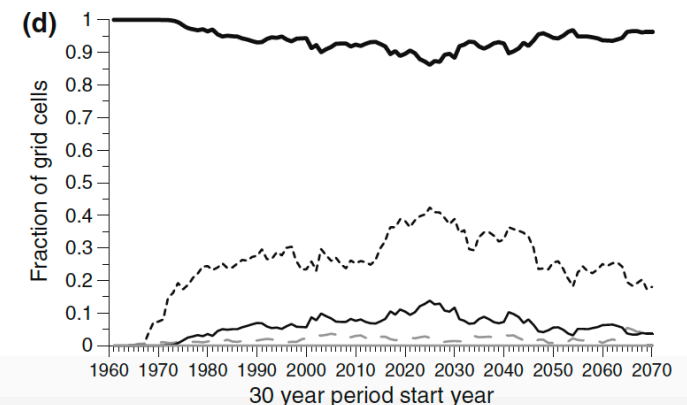
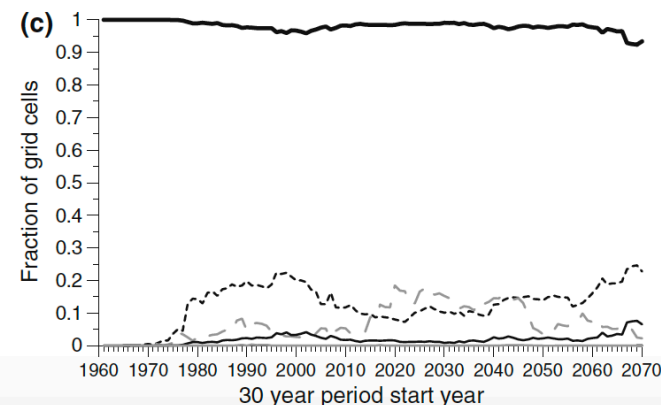
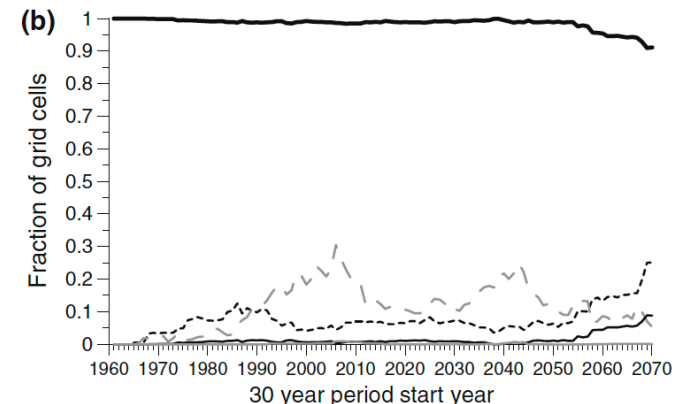
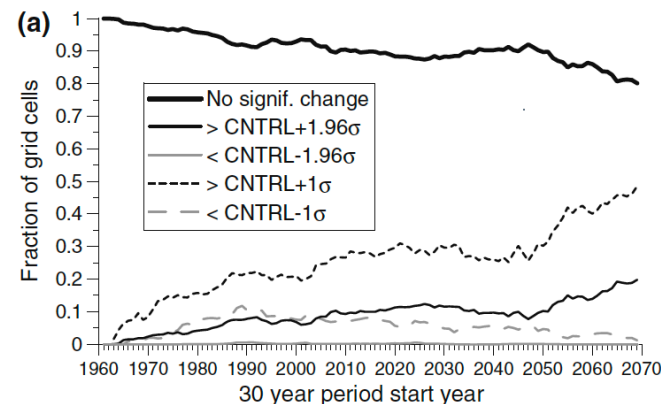
Pryor S.C., Shepherd T.J., Bukovsky M. and Barthelmie R.J. (2020): Assessing the stability of wind resource and operating conditions. *Journal of Physics: Conference Series* **1452** 012084
doi: 10.1088/1742-6596/1452/1/012084.



Changing operating conditions? State-of-the-art

- 50 yr RP wind speed at hub-height.
- In high resource areas
 - Change to 2100 $< 5\%$ ($<$ engineering safety margin)
 - Natural variability $\gtrsim$ climate change signal
 - High sensitivity to model & resolution

Pryor S.C., Barthelmie R.J.,
Clausen N.E., Drew M.,
MacKellar I. and Kjellström E.
(2012): Analyses of possible
changes in intense and
extreme wind speeds over
northern Europe under climate
change scenarios. *Climate
Dynamics* **38** 189-208





Partnership to deliver actionable science

- What do we need from renewable energy industry?
 - Access to data (model evaluation & validation)
 - Transparency about challenges
- What are climate scientists doing?
 - Generating and analyzing larger model ensembles to explore resources/operating conditions to describe 'best guess' and probabilistic range of possible futures
 - Accelerating trend to higher resolution (NB computational resources)
 - Interrogating & demonstrating credibility

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