Performance of NWP-based ice loss predictions for resource assessment

A roadmap for improved validation as a crucial element in the model development process

Winterwind 2016 Åre, Sweden

Gemma Daron and Daran Rife

10 February 2016

Ungraded

Motivation

- **Advancing development and validation of turbine ice modeling methods for resource assessment**

Ungraded

Icing loss modeling: Current state-of-the-art

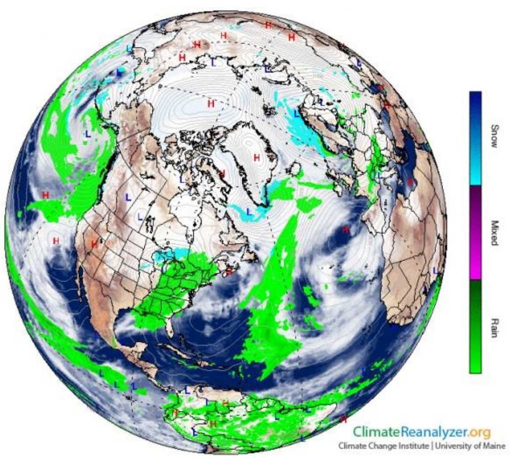
- Empirical (purely data driven)
- Statistical / machine learning
- **Mesocale NWP models**
- Combinations of the above

Ungraded

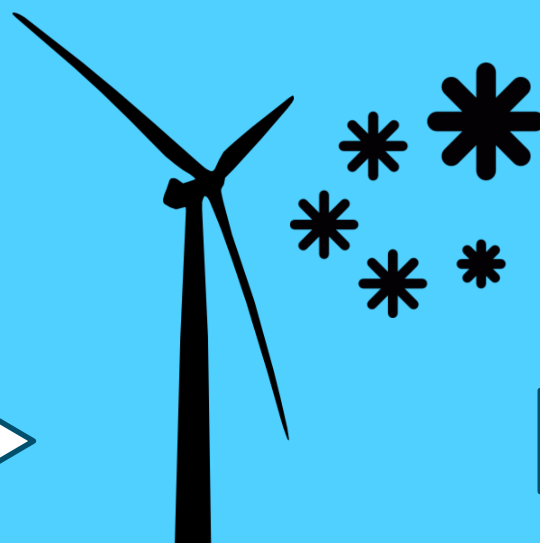
DNV·GL

The icing loss modeling chain

NWP model



Ice load model



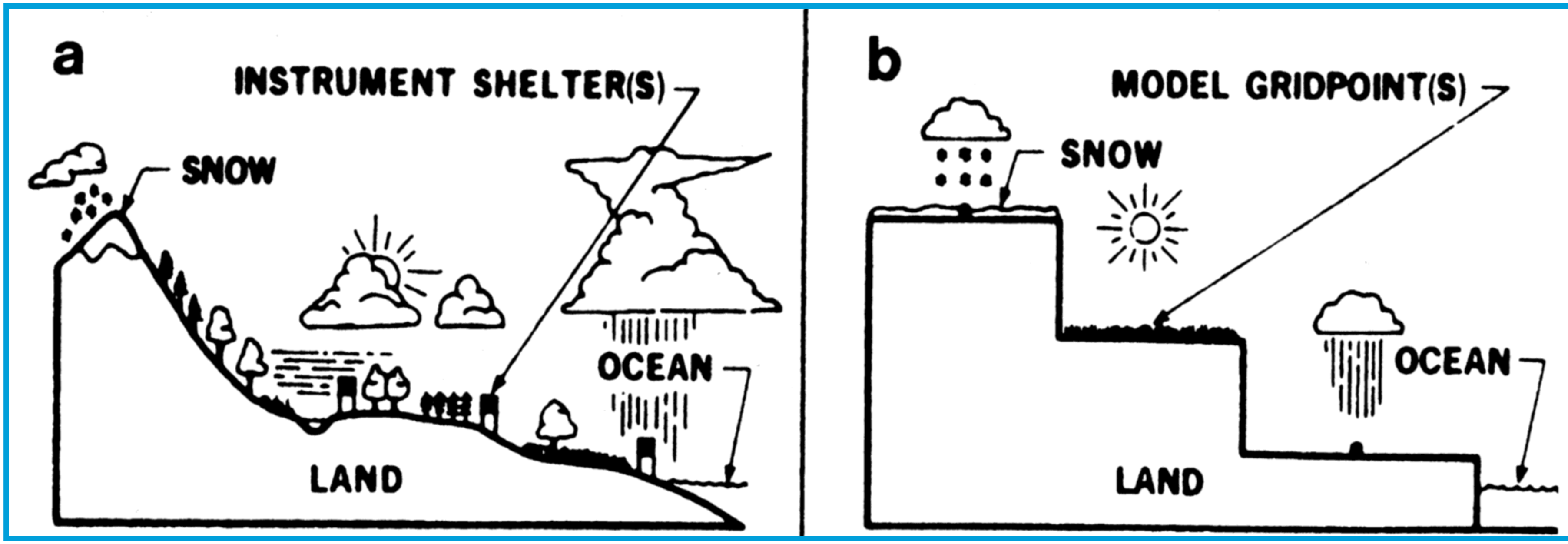
Production loss model

Ungraded

 Some icons on this page designed by Freepik

Limitations of NWP Models: The big picture

Real world | Model representation



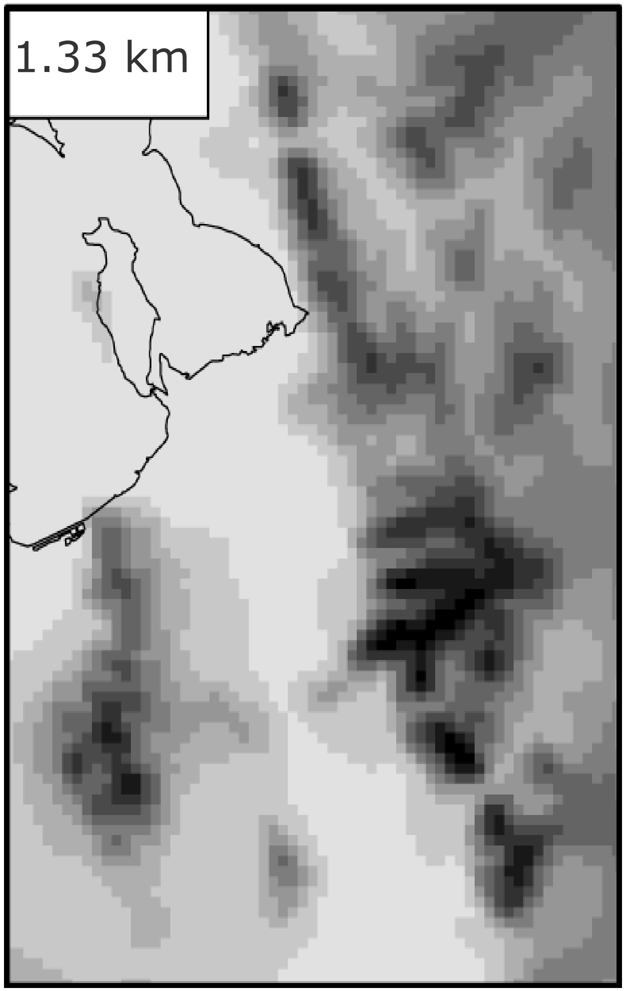
Imperfect representation of physical process, very small scale features poorly represented.

Ungraded

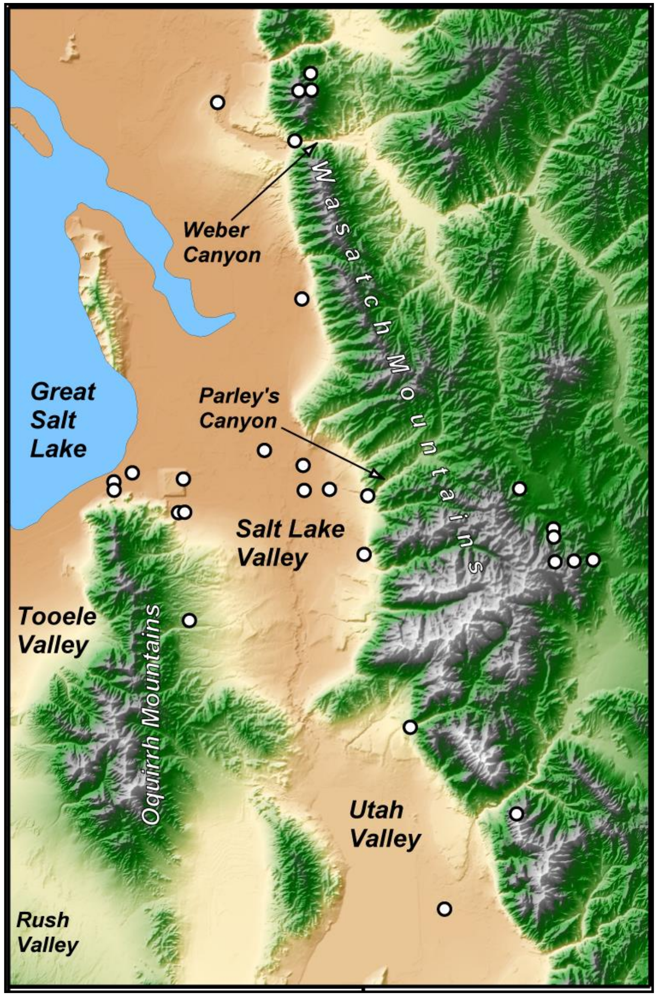
DNV·GL

Limitations of NWP Models: Spatial discretization

Model topography



Actual topography



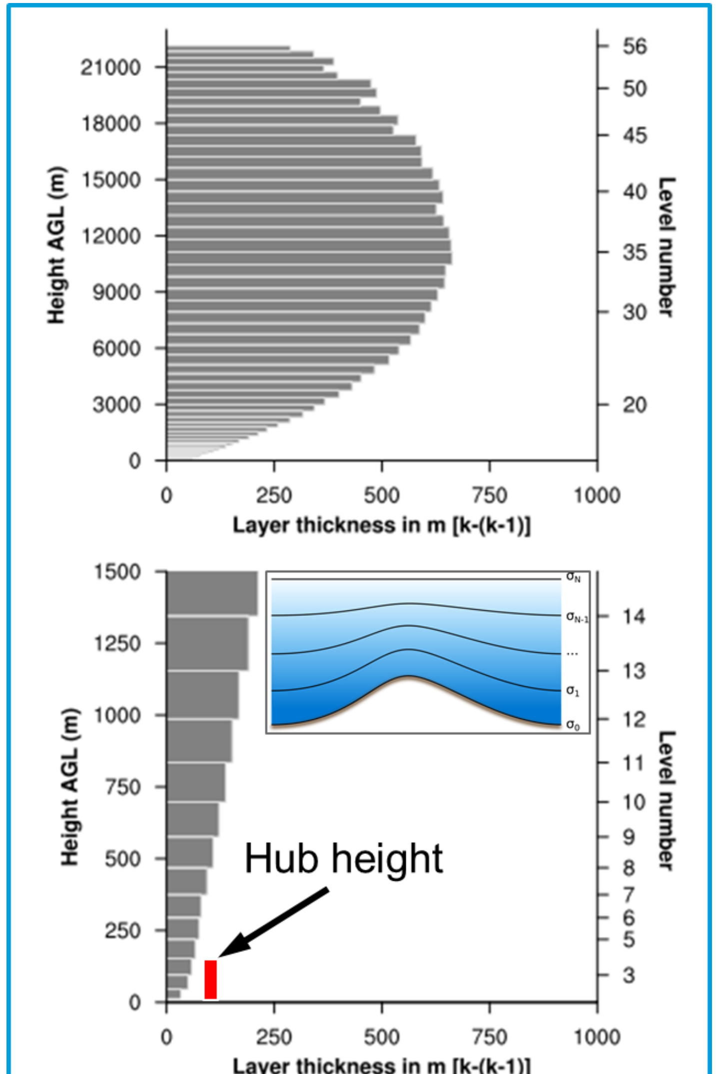
From Rife et al. (2004)

Ungraded

Limitations of NWP Models: Atmospheric vertical structure

Typical discretization of atmospheric vertical structure in mesoscale models.

The real atmosphere is a fluid continuum!

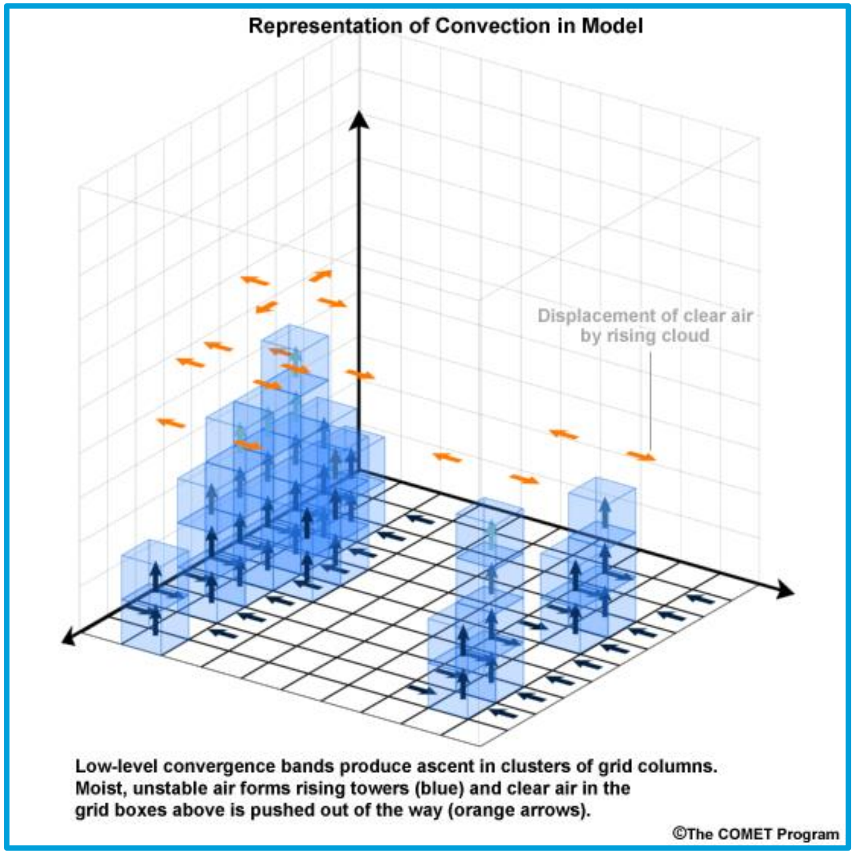


Ungraded

Limitations of NWP models: Representation of clouds

Nature

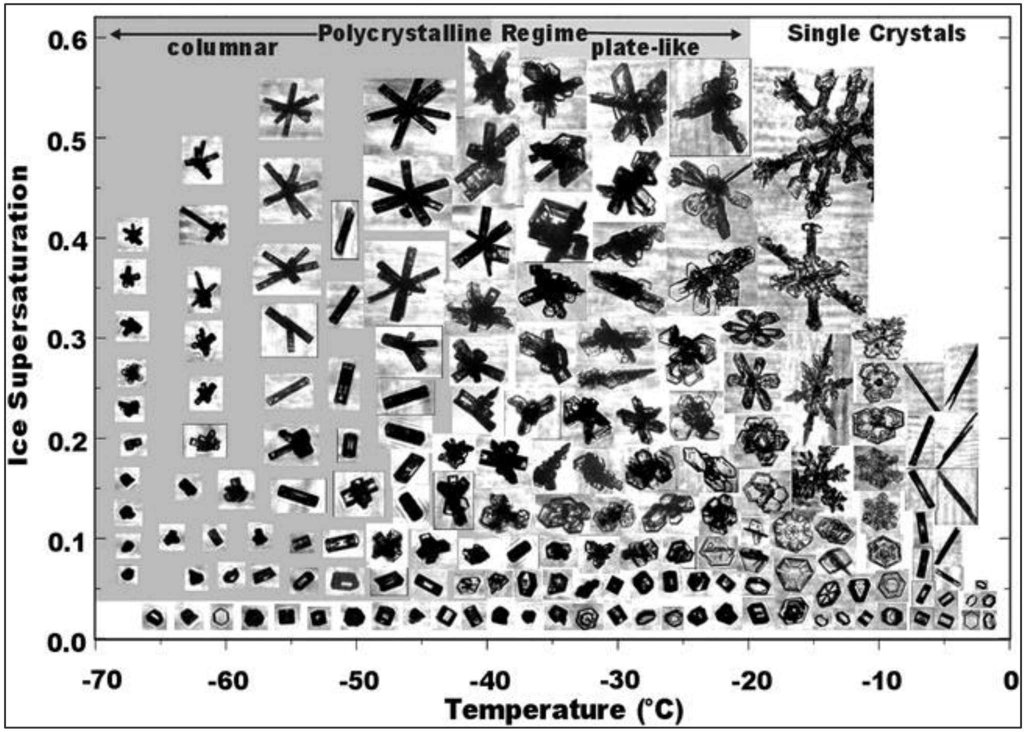
Model



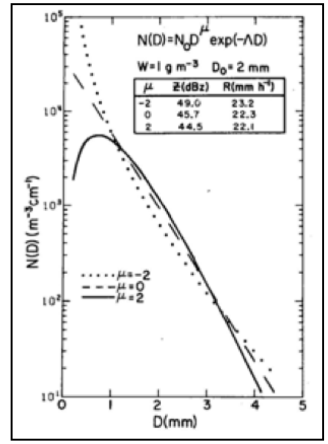
Ungraded

Limitations of NWP models: Representation of cloud microphysics

Representing all these processes in a cloud… …with two parameters!



From Bailey and Hallet (2009, Journal of Atmospheric Sciences)

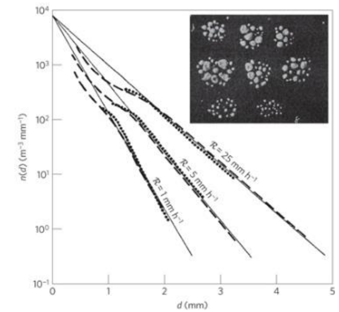


Gamma distribution

This

OR

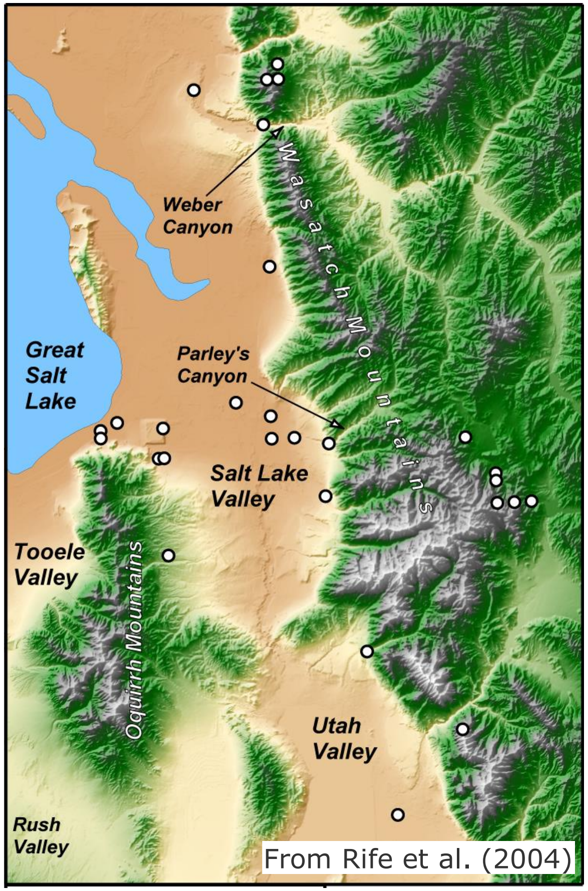
This



Marshall-Palmer distribution

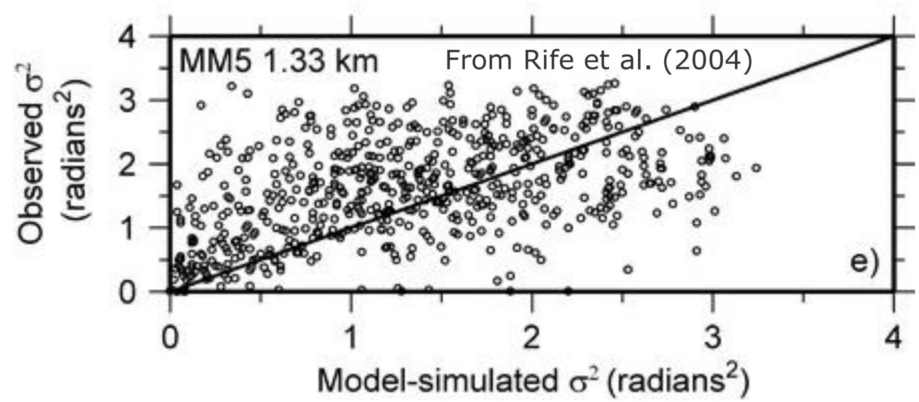
Ungraded

Limitations of NWP models: Spatial and temporal variability



White dots = obs stations

Spatial variance of winds from 1.33 km res model



Even high resolution models under represent true amount of atmospheric variability. CFD is not immune!

Ungraded

DNV·GL

The need for comprehensive validation

- **Validation is a crucial element in model development**
  - Provides method for objectively measuring improvement and/or choosing between model prediction systems
  - Provides benchmark that serves as a minimum standard
  - Aids understanding of uncertainties in model predictions
  - Helps identify *sources* of systematic errors so they can be remedied or compensated for

Suggested reading: Quality Assurance in Atmospheric Modeling (Warner 2011)

Ungraded

Challenges of current development and validation efforts

- Limited and poorly coordinated
- No benchmark against which to measure benefits of new/improved systems
- Limited to small set of “case studies” for very specific regions, and each developer uses a different set of cases
- No unified set of metrics—Impossible to compare merits of competing systems
- Unclear end goals
- Lacks impartiality—All validation carried out by individual developers

Ungraded

Toward unified and coordinated development of turbine ice modeling systems

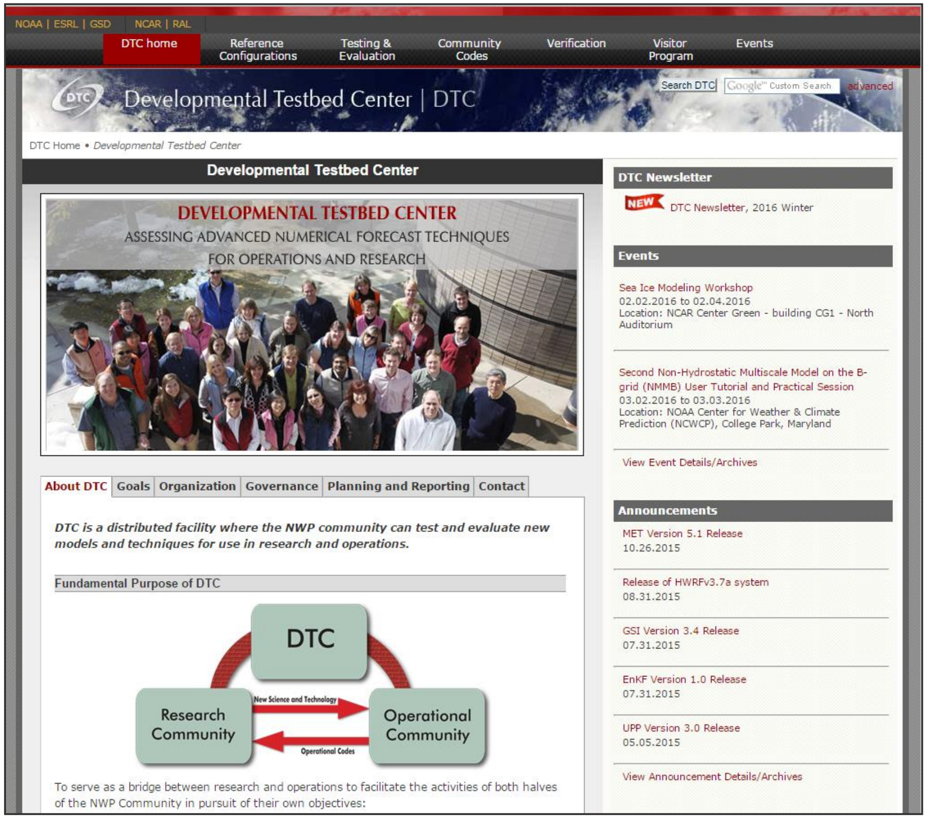
- **One idea:** “Turbine Ice Modeling Testbed”

  Framework for conducting rigorous, replicable, and transparent testing of modeling systems

Ungraded

Examples of highly successful testbeds

Developmental Testbed Center



Joint Hurricane Testbed

Collaborations between national forecasting centers and laboratories, academia, and private industry

Ungraded

Roadmap to Turbine Ice Modeling Testbed

- **Establish a benchmark modeling system or reference**
  - Essential for understanding and quantifying value of new models/methods
- **Establish large set of historical cases spanning multiple geographic regions**
  - Permits extensive testing and evaluation of improvements and new methods
- **Establish "library" of high-quality QC'ed measurements**
- **Establish unified set of metrics applied consistently across all modeling systems**
- **Establish independent non-partisan body to perform validation**

Ungraded

Benefits of a testbed

- **Comprehensive validation will help guide development efforts**
  – Hone in on model deficiencies so they can be understood and remedied
- **By combining forces we can accomplish far more in far shorter time than any individual effort**
- **Elevates the credibility of all players**
- **Help establish global standards and increased consistency in methods**
- **Potential to dramatically increase confidence from investors**

Ungraded

DNV·GL

Thank you! Questions?

Daran Rife and Gemma Daron

daran.rife@dnvgl.com gemma.daron@dnvgl.com

www.dnvgl.com

SAFER, SMARTER, GREENER

Ungraded