Utilizing Climatological Analysis to Improve Forecasting of Offshore Wind Ramps

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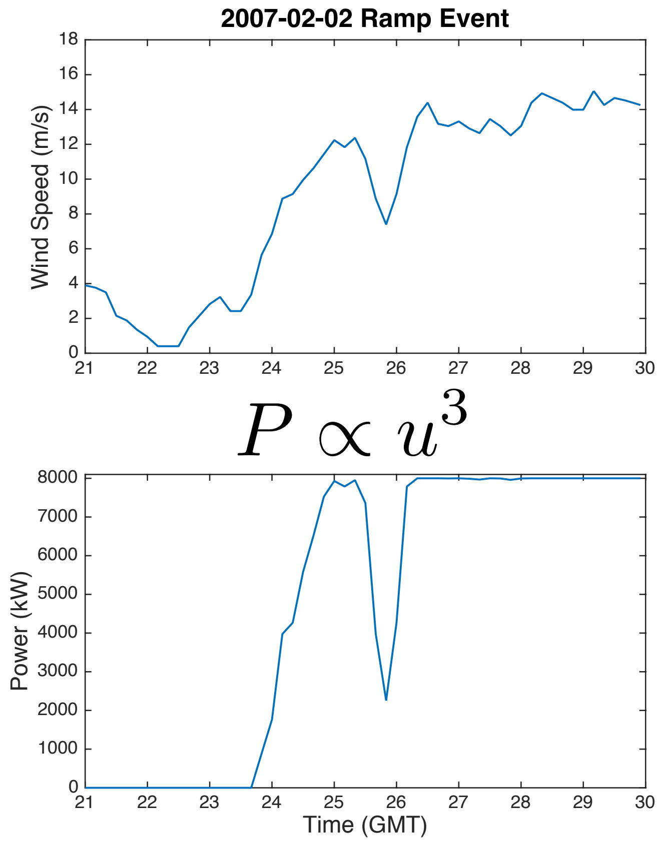
Outline

- Synoptic typing and wind ramps
- Modeling ramps and investigating grid impacts
- Daily mesoscale modeling archive
- Observations v. model
- Case studies
- Next steps

What is a Wind Ramp Event?

- Sudden and rapid change in wind speed
- Results in rapid change to power output
- Tricky to forecast
  - Timing error
  - Intensity error
  - Shape error

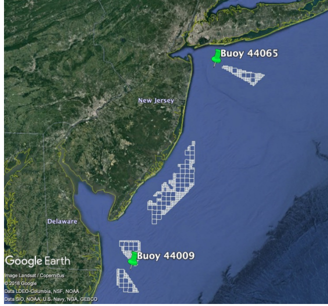


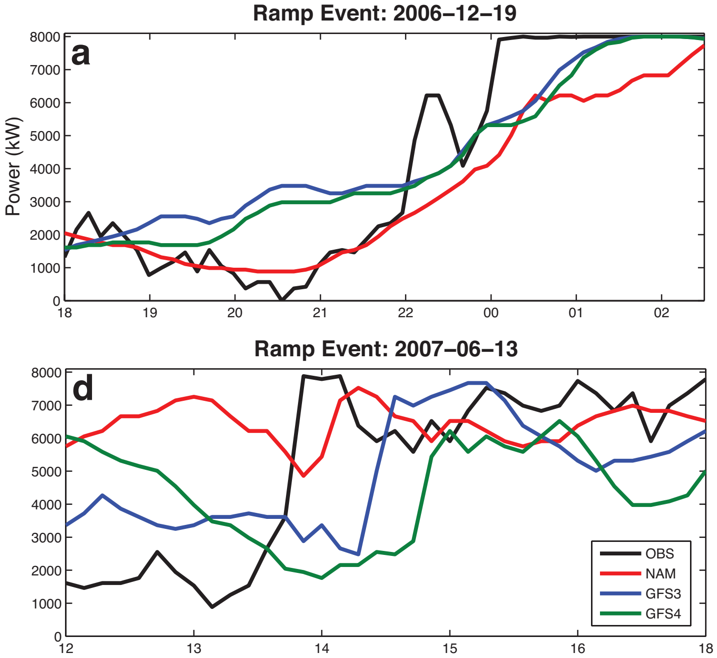
Synoptic Typing

- Technique to objectively quantify overarching synoptic weather conditions
- Connect days with similar conditions as specific types
- Data and method from Suriano and Leathers 2017
- PCA using surface conditions (at PHL; temperature, dewpoint, cloud cover, SLP, winds), combined with synoptic maps (SLP, 500 mb height, precip, temperature)
- Used in various climatological studies (hydroclimatology, lake effect snowfall, ramp events, ozone pollution, coastal storms)

Modeling of ramp events

- 428 ramp-ups (>50% increase in power in 1 hour) observed in 7 year time period
- Modeled 12 “monthly analogs” and 12 “extreme events”
- WRF more likely to predict ramps more early, more gradual, and with a higher wind speed before the ramp, and entirely missed 3





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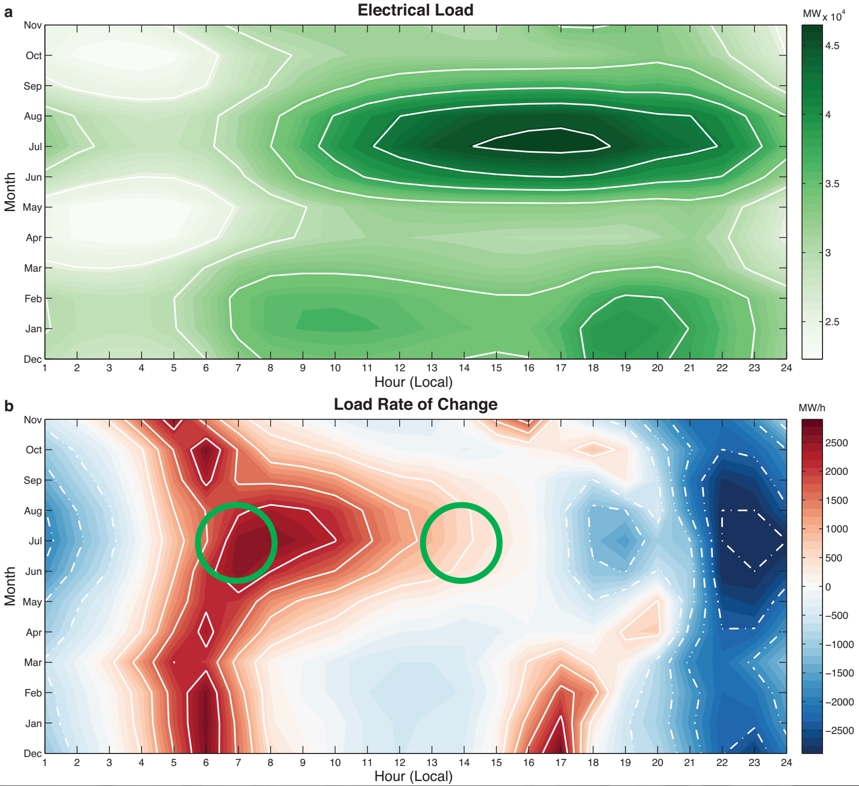
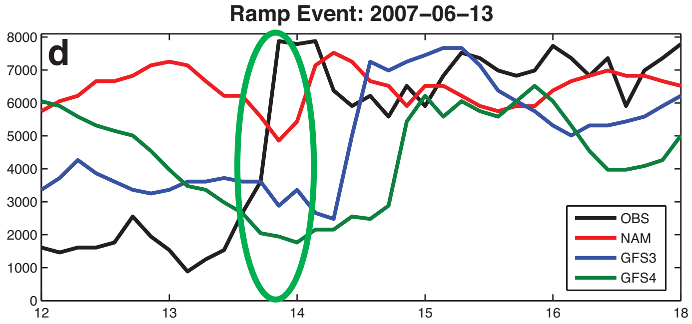
But the time of the event matters





- Power deficits were more significant, due to causing large changes in net load (change in load plus model error)
- Improved model performance in summer morning and winter evening would be most beneficial, based on case studies
- But what about everyday model performance?

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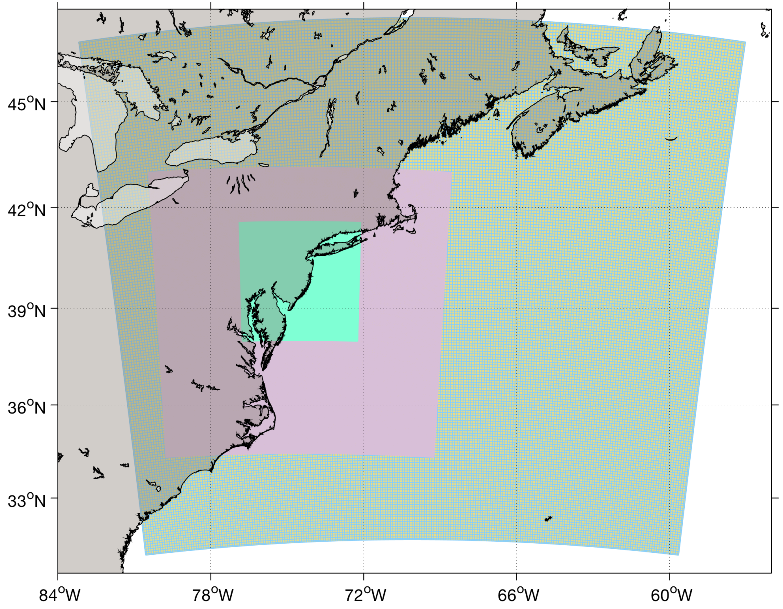
Daily Mesoscale Modeling with RU-WRF

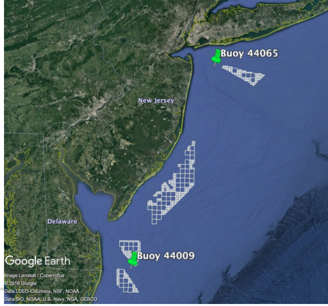
- Run Continuously 2011 – Present
- Triple nested: 9km-3km-1km
- Hourly forecast initialized at 00Z:
  - 9km: out 5 days
  - 3km: out 2 days
  - 1km: out 1 days
- Lateral Boundary Conditions:
  - 9km: 0.25 degree Global Forecast System
  - 3km: RU-WRF 9km
  - 1km: RU-WRF 3km
- Vertical Levels:
  - 40 levels more tightly packed near the surface.
- Surface Boundary Condition:
  - RUCOOL Coldest Dark Pixel Composite

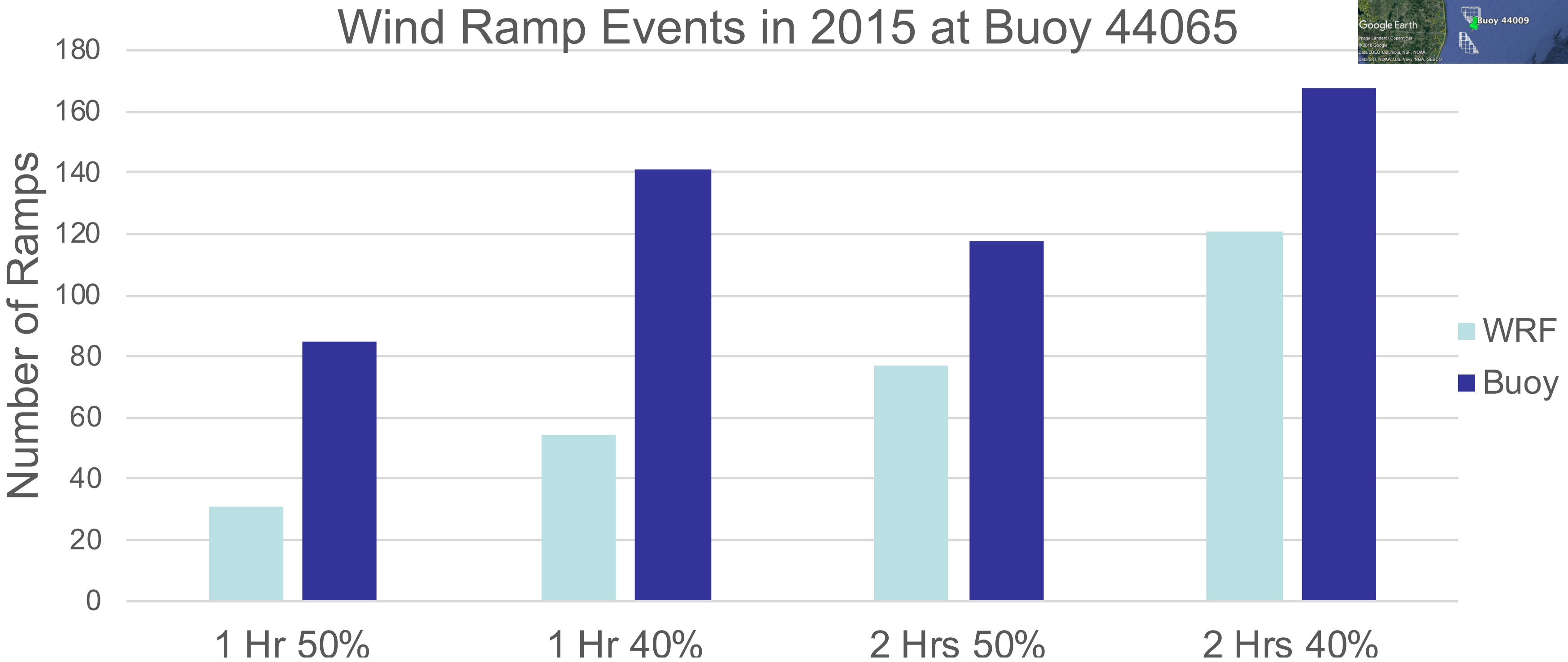


Study Parameters and Questions

- Utilize same algorithm used to detect ramps in observations to detect ramps in daily model output
- How many more/fewer ramps does RU-WRF predict, and with what kind of accuracy?
- Are there patterns to the types of ramps that are predicted well and/or poorly? (i.e. certain synoptic situations, local effects)
- What about the poorly predicted events makes them challenging for the model?
- What might be done to improve it?

RU-WRF Ramps v. Observations





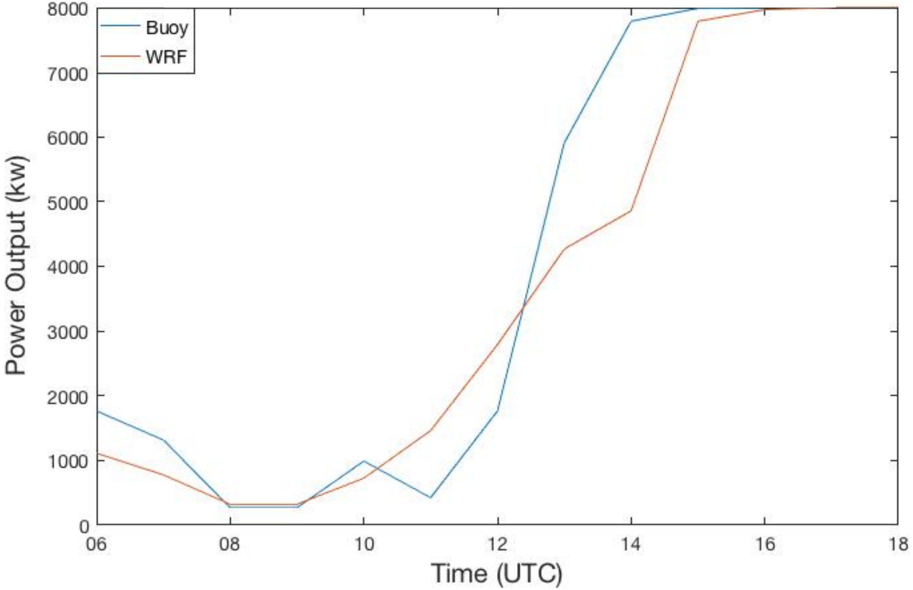
2015 Ramps: Observed v. Predicted

Type	Number
WRF Predicted, Not Observed	42
Observed, Mispredicted in WRF	80
Both Observed and WRF Predicted	35
Total Observed Ramps	115

- Uses 2 hour, 50% threshold
- Automated algorithm is not perfect: might classify a fairly good prediction as a misprediction due to threshold cutoff
- WRF predicts ramps better in winter and spring; more likely to predict ramps that don't occur in summer

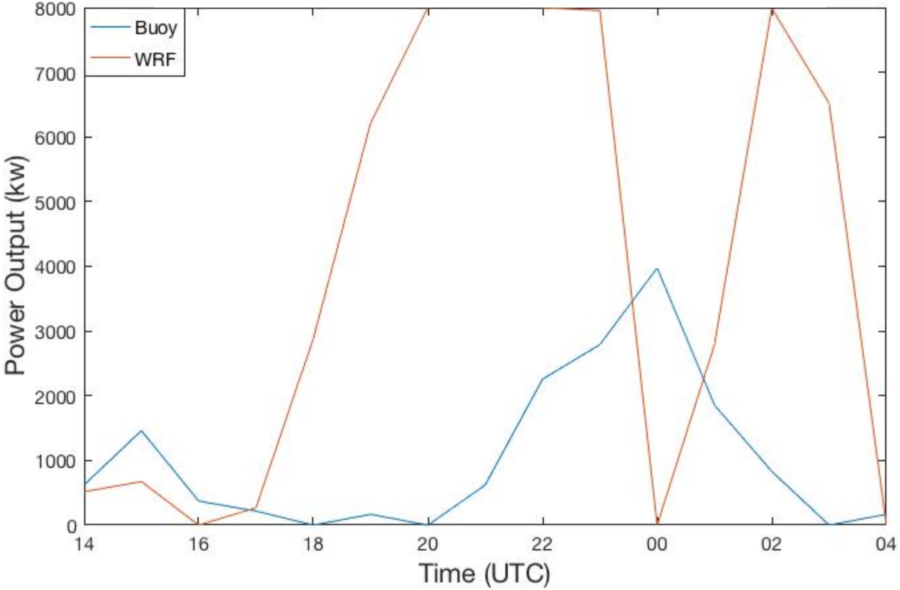
Two Example Case Studies

14 February 2015



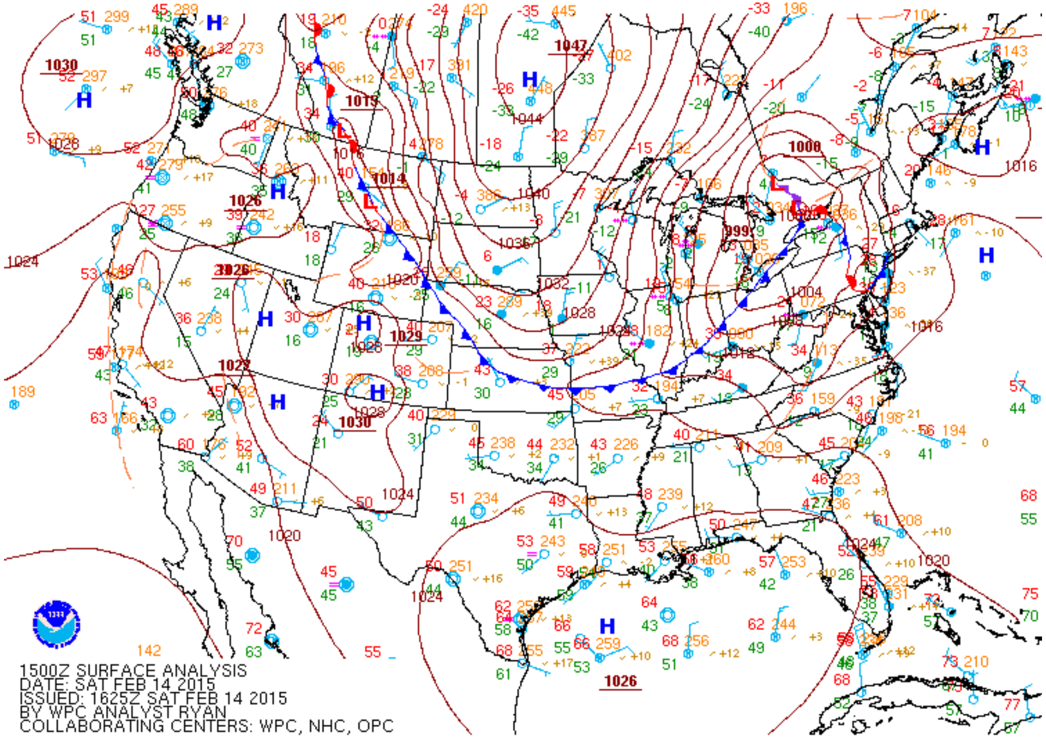
- Reasonably well-predicted
- WRF more gradual; didn't actually meet ramp threshold

20 July 2015



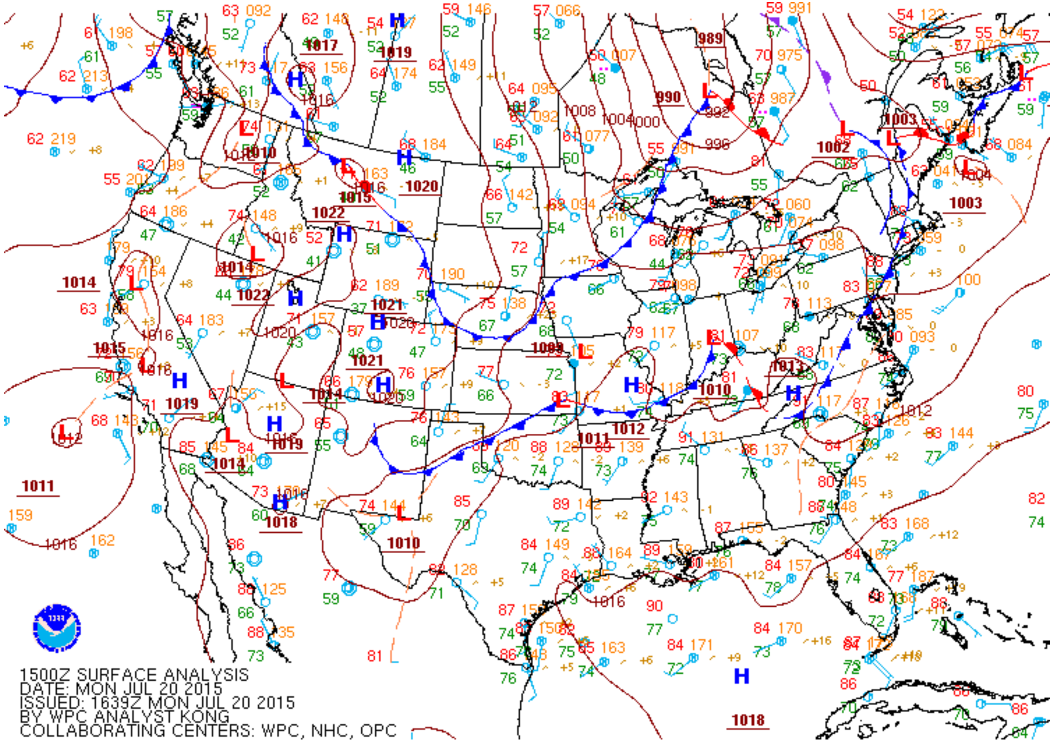
- Weak ramp in observations
- What did WRF see?

Synoptic Conditions: 14 February 2015



- Great Lakes low pressure system
- Strong synoptic forcing which was well-predicted by WRF, and the forcing data (GFS)

Synoptic Conditions: 20 July 2015



- New England low pressure system, with weak, almost stationary cold front
- Weaker synoptic forcing; local effects dominate?

Next Steps

- Explore sea surface temperature's role
- Look at local meteorological impacts, such as sea breezes
- Investigate cases with a coupled model with more frequent data output to evaluate ocean influence and better capture ramps
- Expand and update the dataset used
- Quantify possible low-lying fruit improvement areas, and more long-term improvement possibilities

Thank you!

Questions?

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