Approaches to Developing Meteorological Restrictions for Non-Routine Sour Gas Flaring Management Using the Risk Based Criteria

CPANS Annual Conference, Edmonton

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May 26-27, 2015

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Outline

- Introduction
- Factors to Consider
- Approach and Criteria
- Approach Comparisons
  - 3 Approaches
  - 2 Examples
- Summary

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❖ Introduction

RBC -- the Risk Based Criteria for non-routine sour gas flaring, incinerating and venting

Sulphur dioxide (SO_2), low frequency of emission events

ESRD -- Environment and Sustainable Resource Development

AER -- Alberta Energy Regulator

Directive 60: Upstream Petroleum Industry Flaring, Incinerating, and Venting

RBC for SO_2 of Non-Routine Flaring and Incinerating

Percentile	Averaging Period	RBC for SO_2 ($\mu g/m^3$)
99th	1-hour	450
99.9th	1-hour	900

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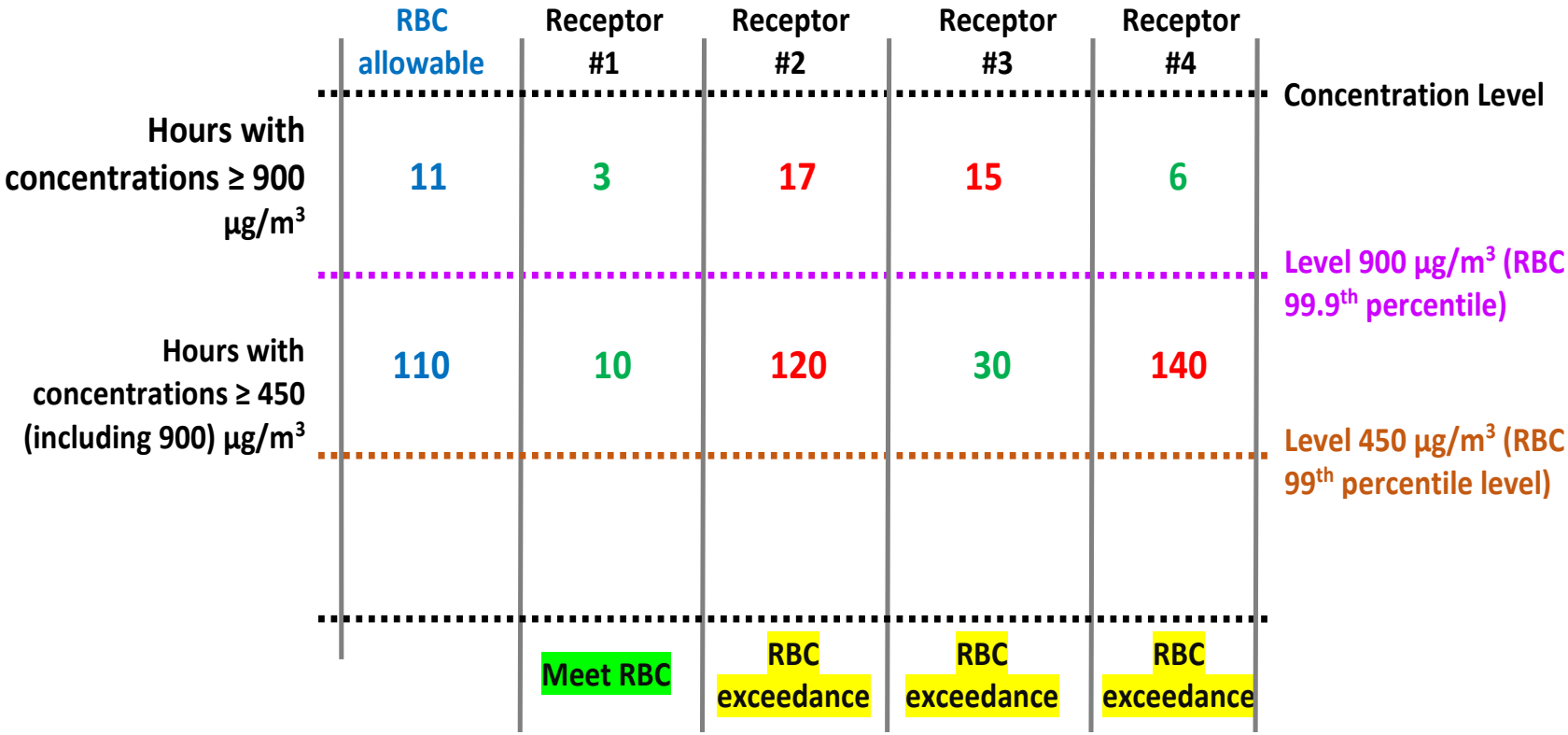
Applying RBC to Each Receptor

Example: Assuming total 11,040 hours modelled, then at each receptor

11 hours with concentrations ≥ 900 µg/m^3 are allowable (99.9th percentile);

110 hours with concentrations ≥ 450 µg/m^3 are allowable (99th percentile).



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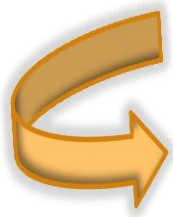
Air Quality Management Plan (AQMP) -- Meteorologically Based

- To limit or avoid operations under the specific meteorological conditions so that the RBC are met

Requirements -- Meteorologically Based AQMP

- Identify specific meteorological conditions that cause potential exceedances
- On-site meteorological monitoring
- Suspend operation under unfavourable meteorological conditions
- Resume operation after meteorological change to favourable conditions



Desired -- for a practical, economic and safe operation

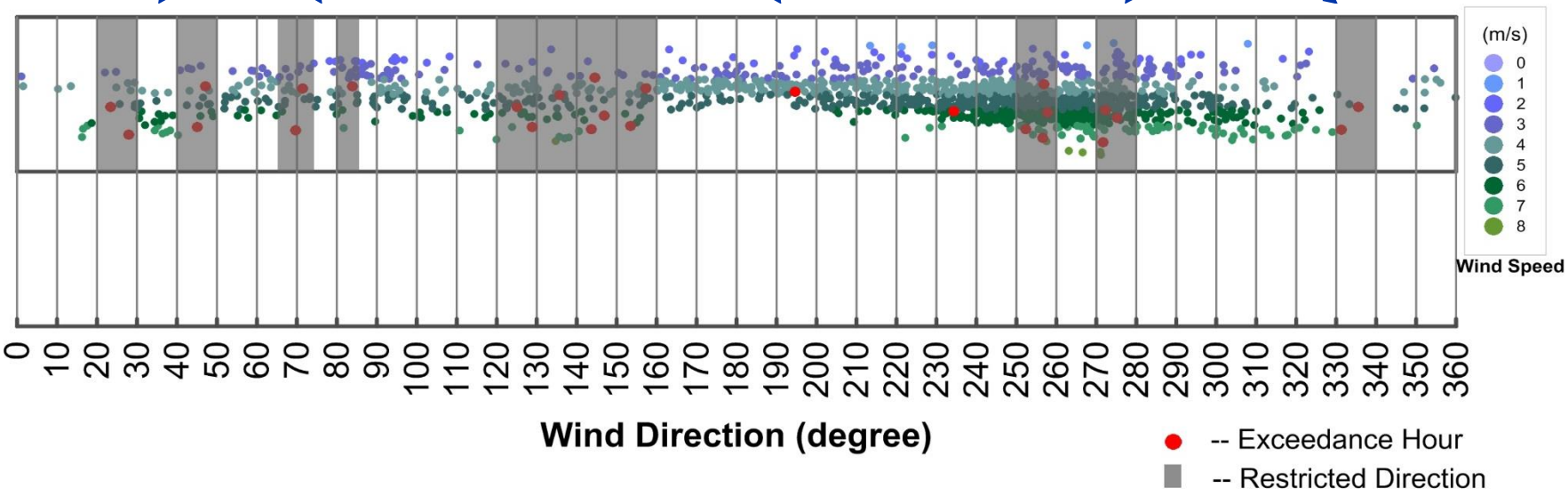
- Less suspension before an operation is completed

- Less meteorological restriction hours as possible
- Bigger operation extent between two restrictions

Less than 10°, difficult to operate

Larger spatial extent, less suspension possibility

The number of meteorological hours in each direction cell are not the same.



Example: Meteorological Hour Distribution and Restricted Wind Direction

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❖ Factors to Consider

1) Numerous Restriction Possibilities

- At 2 percentile levels: the 99.9th and the 99th
- For each receptor (over 1000 receptors) or every point in the modelled domain

Example: 1 year (8760 hours) modelled

	RBC Allowable	Example at one Receptor	Restriction Possibilities
Above 900	8	10	C(10,2) = 45
Above 450	87	100	C(98,11) = 1.1E+14
Below 450	8,665	8,650	

It is impossible to try each approach. While keeping in compliance of RBC, which approach is better?

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2) Exceedance Hours Can Be Independent

- Each exceedance hour → corresponding to a meteorological condition
- Exceedance hours of one receptor can be independent to other receptor exceedance hours
  - Different location relative to source (distance, direction)
  - Different geographical feature (terrain, landuse)

➔ sporadic restriction

3) Meteorological Hours Not Evenly Distributed

- Each cell has different number of meteorological points
- Selection optimization

➔ to avoid over-restrictive

➔ to have a better restriction

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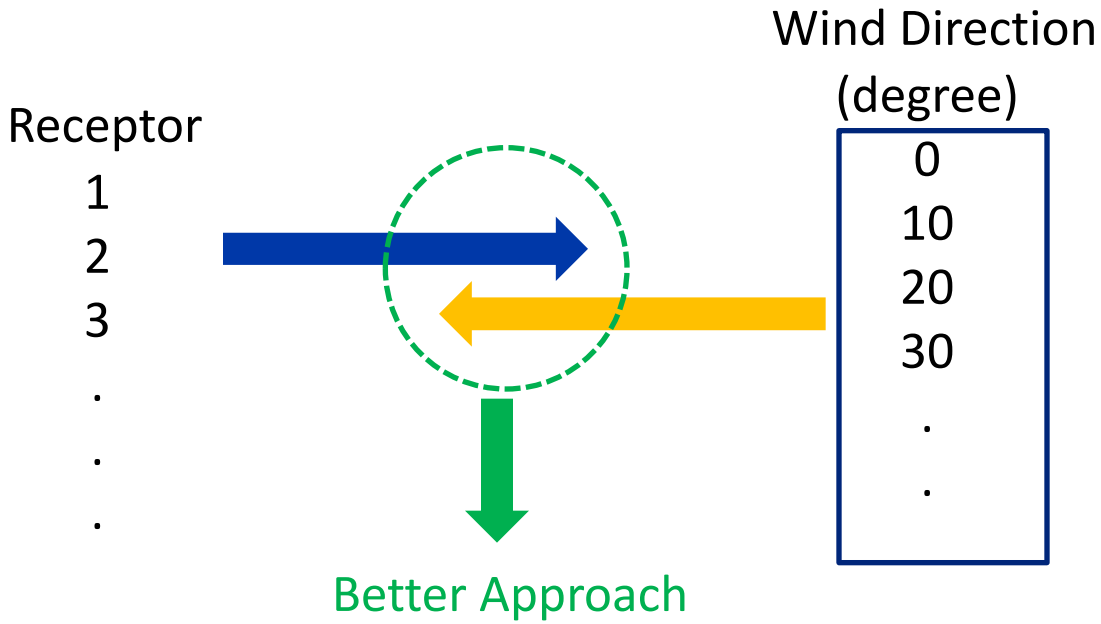
❖ Approach and Criteria



If from receptor → restriction

- Direct approach, but sporadic and most likely over-restrictive

If from meteorological condition → restriction

- Difficult to meet RBC

Criteria for Approach Comparison

- Compliance Factor

  C = 1 meet RBC after restriction

  C = 0 does not meet RBC after restriction

- Integral Coefficient

  Ci = 1/ (1+number of restricted direction blocks)

  the more restricted blocks, the less the integral coefficient

- Non-Restriction Hour Ratio

  Cr = non-restricted hours/total hours modelled

  Cr as big as possible, not overly restrictive

- Comprehensive Score

  = 1000*C*Ci*Cr

❖ Approach Comparisons

Approach 1: All meteorological hours with predicted concentrations over 450 are restricted.

Approach 2: Exceedance hours with top ranked concentrations for each receptor are restricted.

Approach 3: Exceedance hours with large correlations to the predicted exceedances of other receptors based on meteorological conditions and, with low restriction ratio are restricted.

Example 1: 15% H_2S, Flow rate= 150 e^3 m^3/d;

March, April and May, 2002-2006

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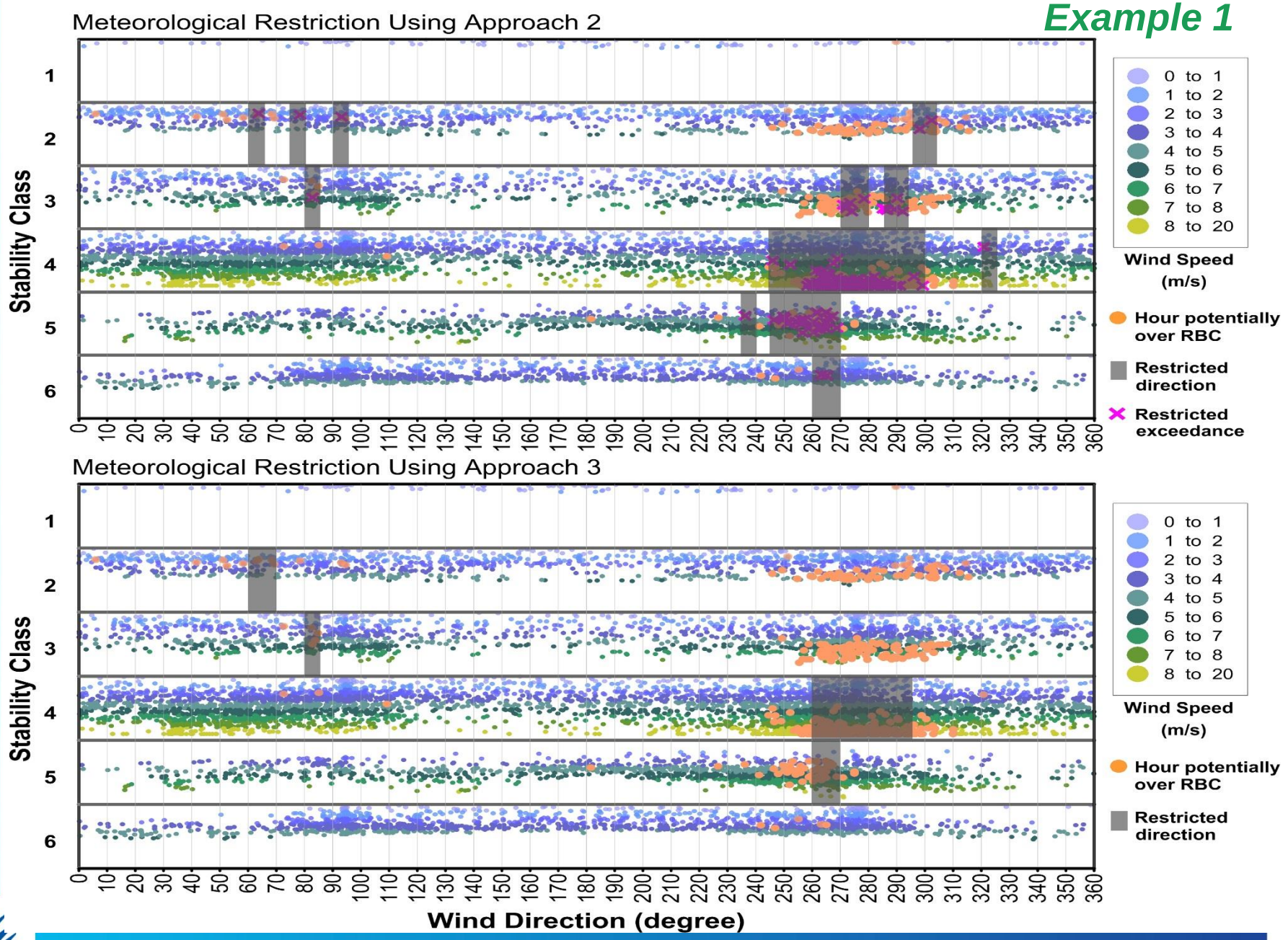
Example 1



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Example 1: Comparison scores for the three approaches

Evaluation Factor\Approach	1 (All over 450 restricted)	2 (Top exceedance hours restricted)	3 (Restriction based on correlation)
Compliance Factor (C)*	1	1	1
Integral Coefficient (Ci)	Restricted Blocks > 12 < 1/13	Restricted Blocks = 12 1/13	Restricted Blocks=4 1/5
Non-Restriction Hour Ratio (Cr)	< 7976/11040	7976/11040	9716/11040
Comprehensive Score	< 55.6	55.6	176.0

(Highest score)

* A post-restriction calculation is required to ensure the RBC are met.

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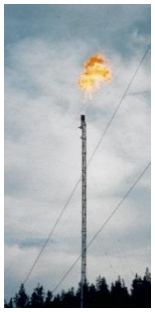

Example 2: 22% H_2S, Flow rate= 33.3 e^3 m^3/d; July, August and September, 2002-2006

Example 2: Comparison scores for the three approaches

Evaluation Factor\Approach	1 (All over 450 restricted)	2 (Top exceedance hours restricted)	3 (Restriction based on correlation)
Compliance Factor (C)*	1	1	1
Integral Coefficient (Ci)	Restricted Blocks > 35 < 1/36	Restricted Blocks = 35 1/36	Restricted Blocks=9 1/10
Non-Restriction Hour Ratio (Cr)	< 1507/11040	1507/11040	4164/11040
Comprehensive Score	< 3.8	3.8	37.2

(Highest score)

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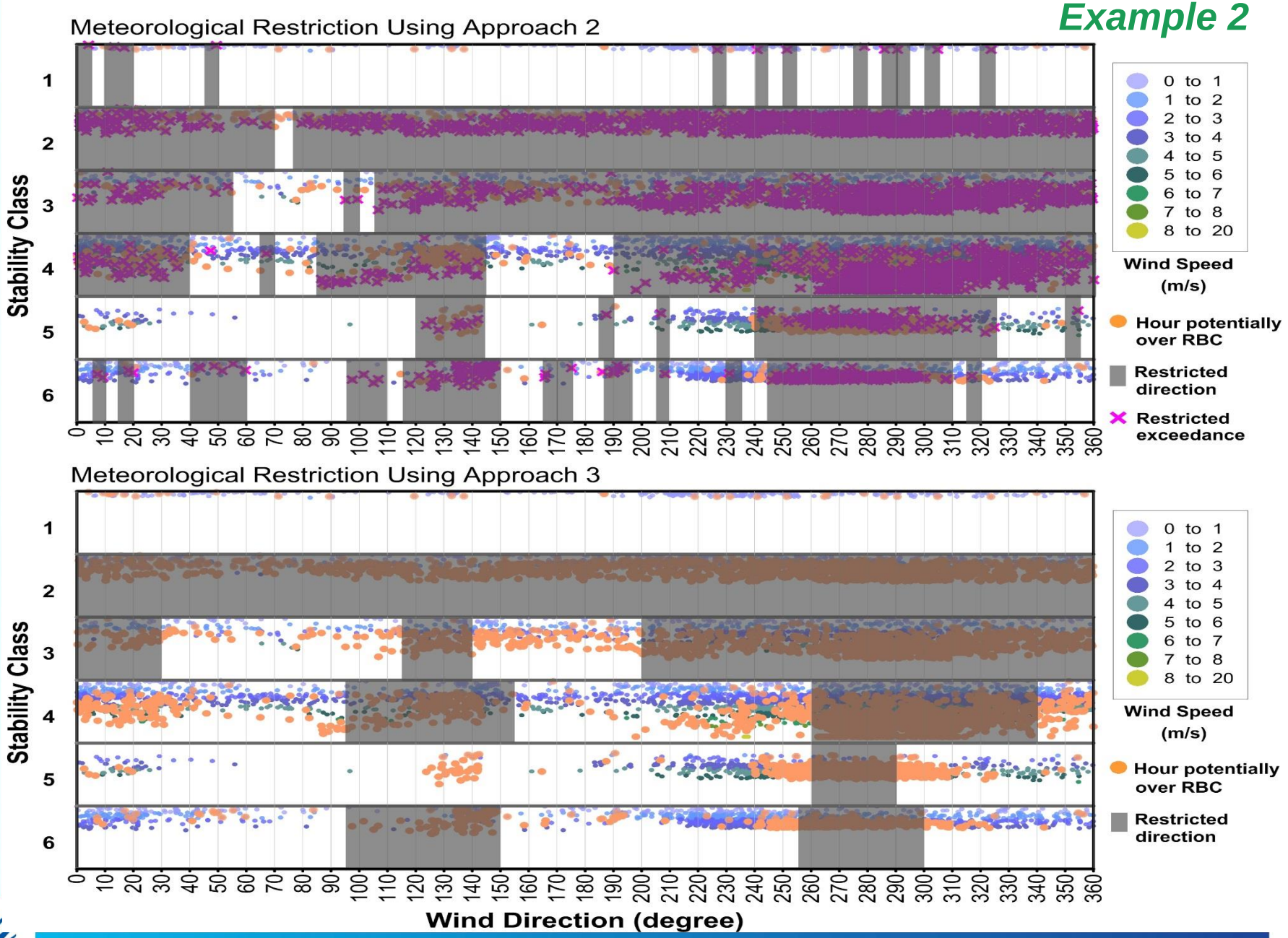
Example 2



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Advantages and Disadvantages for the Approaches

Comparison	1	2	3
Advantages	Simplest to apply.	Direct, applied by top ranked values.	Nicely grouped, practical to operate; the least restrictive while still following the RBC.
Disadvantages	Sporadic restriction, possibly making flaring difficult; Most restrictive AQMP.	Sporadic restriction, possibly making flaring difficult; Slightly difficult to develop.	Difficult to develop – requires an advanced algorithms for calculation.

❖ Summary

- Approach to meteorological restrictions is very important to implement meteorologically based AQMP.
- Different methods can generate totally different restrictions.
- An efficient approach should be practical, economic and safe to operate.
- For creating a better approach, several factors need to be considered.
- Approach 3 produces least restrictive and well grouped restrictions, which can provide more flexibilities for operation while still following the RBC.

Thank you !

Questions ?

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