Forecast Horizon of Low-Visibility Conditions at Vienna Airport

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Motivation

• Costs for airports and airlines
• Forecasts available only for few hours
• Longer lead times improve tactical planning

How far into future are low-visibility forecasts useful?
Low-Visibility-Procedure (LVP) States

- **Ceiling**: height of lowest cloud layer within 5 octa
- **Runway visual range**: horizontal visibility at runway

**LVP states** at the Vienna Airport:

<table>
<thead>
<tr>
<th>LVP state</th>
<th>capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>1</td>
<td>70%</td>
</tr>
<tr>
<td>2</td>
<td>60%</td>
</tr>
<tr>
<td>3</td>
<td>40%</td>
</tr>
</tbody>
</table>

Source: [https://www.faa.gov/nextgen/snapshots/assets/img/stories/reduced_visibility_operations-sm.jpg](https://www.faa.gov/nextgen/snapshots/assets/img/stories/reduced_visibility_operations-sm.jpg)
Forecast Period

**Rare occurrence** of LVP states → Generate forecasts only
- For the **cold season**
- At **6 UTC**

Goals

- Identify the **forecast horizon** of the LVP state
- Extract the most important **input variables**
- Analyze the forecast performance with **different inputs**

Inputs for Statistical Models

- **Observations** at Vienna Airport and surrounding
- **Direct model output** (DMO) from the ECMWF HRES model
- **Climatology**
Forecast Model

**Boosting tree**

→ Ensemble method to **grow and merge** decision trees

Lead time: 18h
Forecast Model

**Boosting tree**

- Ensemble method to **grow and merge** decision trees
- Fit a new tree to the **residuals** of the previous model
- **Merge** the tree to the model and **update the residuals**

Source: [http://pngimg.com/img/nature/tree](http://pngimg.com/img/nature/tree)
Different Inputs

- Compare observation and model output based inputs
- Use ranked probability score (RPS) for model validation
Forecast Horizon

• Compare **model output** based forecasts to **climatology**
• Use **ranked probability score (RPS)** for model validation
Variable Importance

- **Automatic, objective** variable selection from boosting
  → Boost until **best forecast performance** is reached
  → Count the **variables** used for splitting in the trees

- **direct model output**
- **observation**

-78h
- boundary layer dissipation
- instantaneous evaporation
- clear sky direct solar radiation
- potential evaporation
- boundary layer height

-30h
- instantaneous evaporation
- visibility
- dew point depression
- boundary layer dissipation
- relative humidity

-18h
- visibility
- potential evaporation
- dew point depression
- ceiling
- low–visibility procedure

-6h
- visibility
- instantaneous evaporation
- sensible heat flux
- ceiling
- low–visibility procedure
Conclusion

Model forecasts **outperform climatology** at all lead times

- Observation-based forecasts better in the first 11 hours
- Higher benefit with direct model outputs for longer lead times

Most important **input variables**

- Lead times $\leq 1$ day:
  - visibility, ceiling, evaporation
- Lead times $> 1$ day:
  - boundary layer dissipation, evaporation, radiation
Thank you for your attention!

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