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Statistical Prediction Model for Daily Means of PM10

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Contents

- Situation in Graz, Klagenfurt, Bozen
  - Meteorological factors
  - Anthropogenic factors
- Statistical Prediction models
  - Quality of the models
  - Practical experience in Graz

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The general Situation

- Unfavorable meteorological conditions
  - Low wind velocities
  - Low precipitation
  - Days with temperature inversion
- Anthropogenic factors
  - Traffic, domestic fuel, industry
- Consequence
  - Threshold value exceeded regularly

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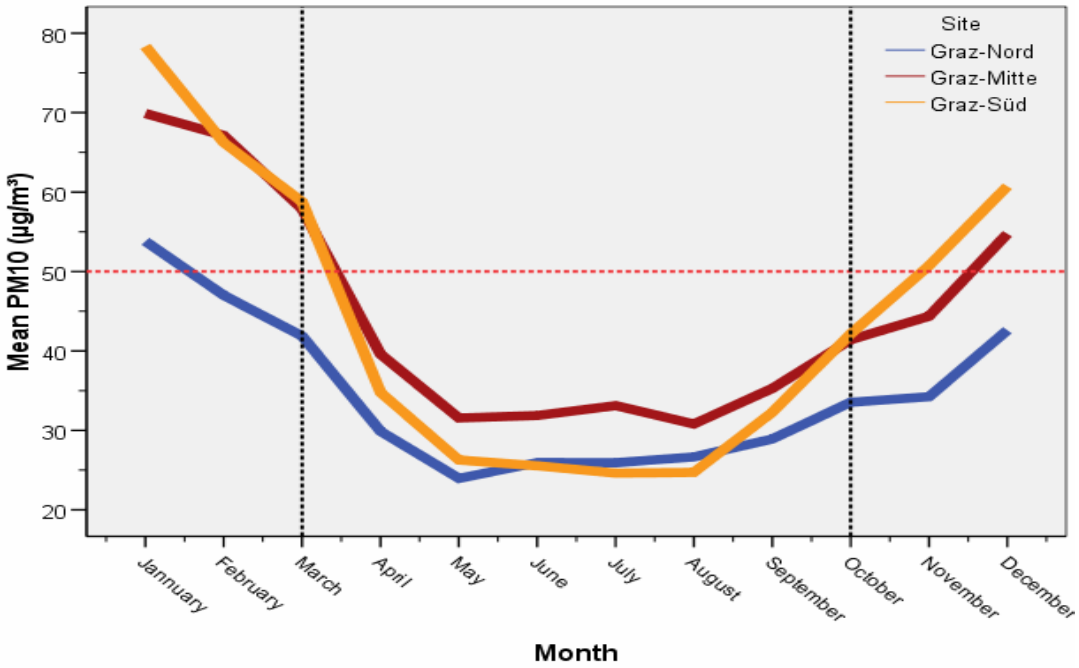
Monthly Mean values of PM10 in three areas of Graz

2003-2006



residential area| inner city area| industrial area

Similar characteristics in Klagenfurt and Bozen

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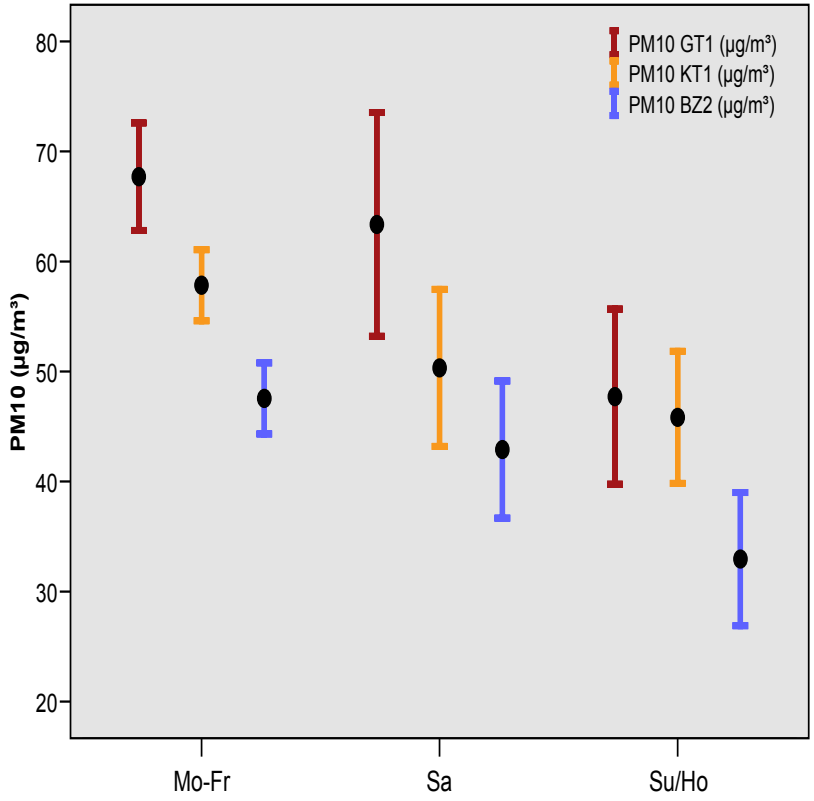
Human impact

- Domestic fuel
- Industry
- Traffic
  - Indicator
    type of day
  - Sunday/Holiday

Traffic ≈ 60-70%

PM10 ≈ 70-80%

Graz Klagenfurt Bozen



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Temperature Inversion

- Most important factor
- Temperature on ground lower than above ground
  - Implies bad air convection
- Inversion ≈ 30-50% of winter days
- Graz/Klagenfurt: suitable measuring point (360m/390m above ground)
- Bozen: not suitable (1590m above ground)

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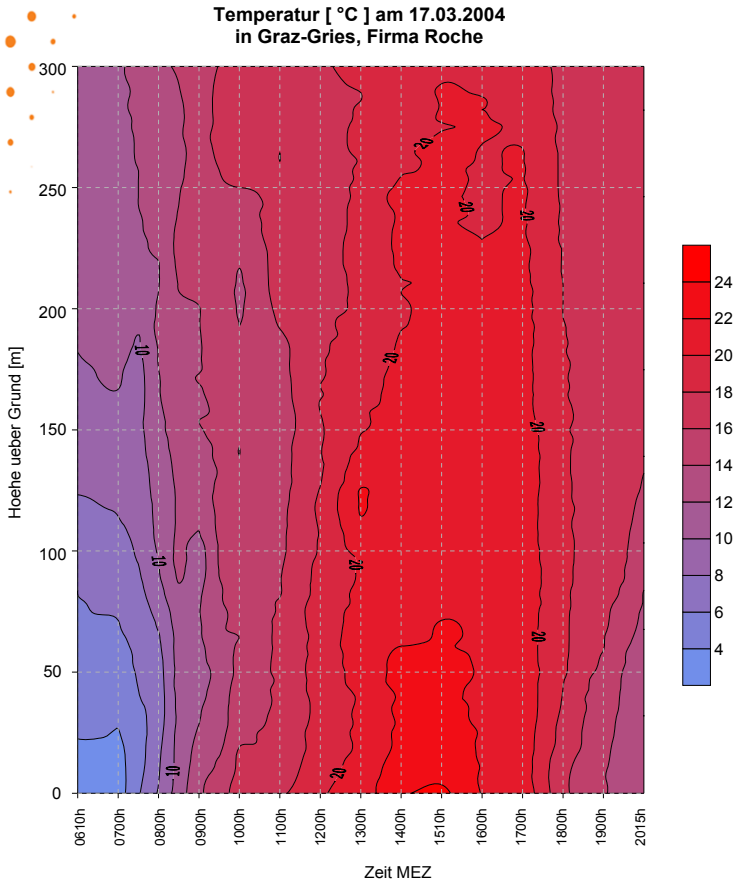
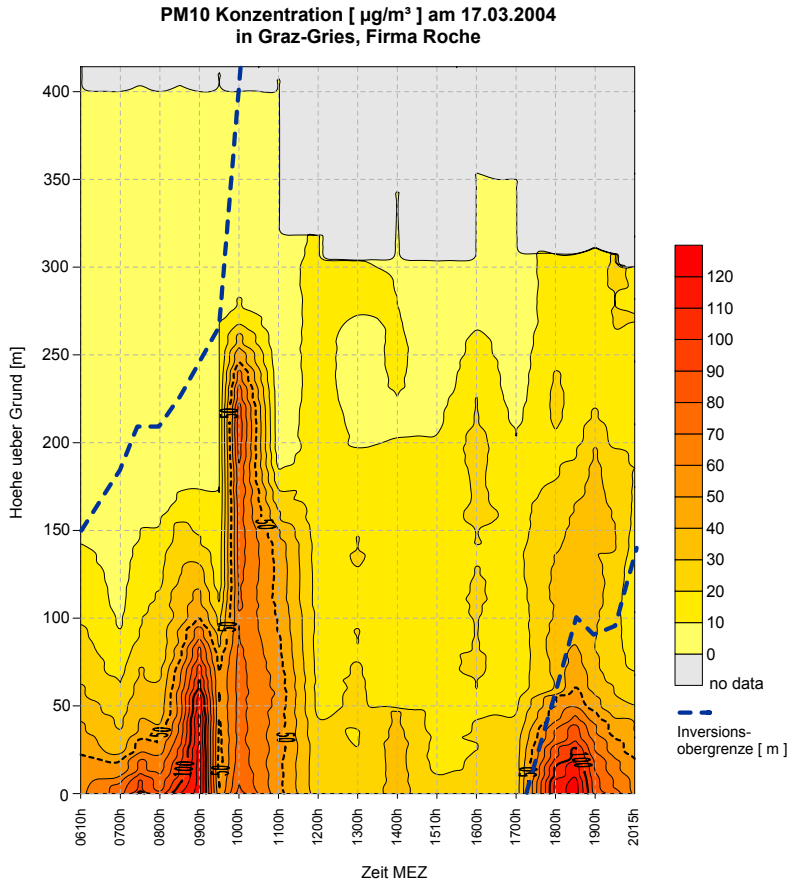
Graz-West
Balloon probe of ZAMG (6 am – 8 pm)





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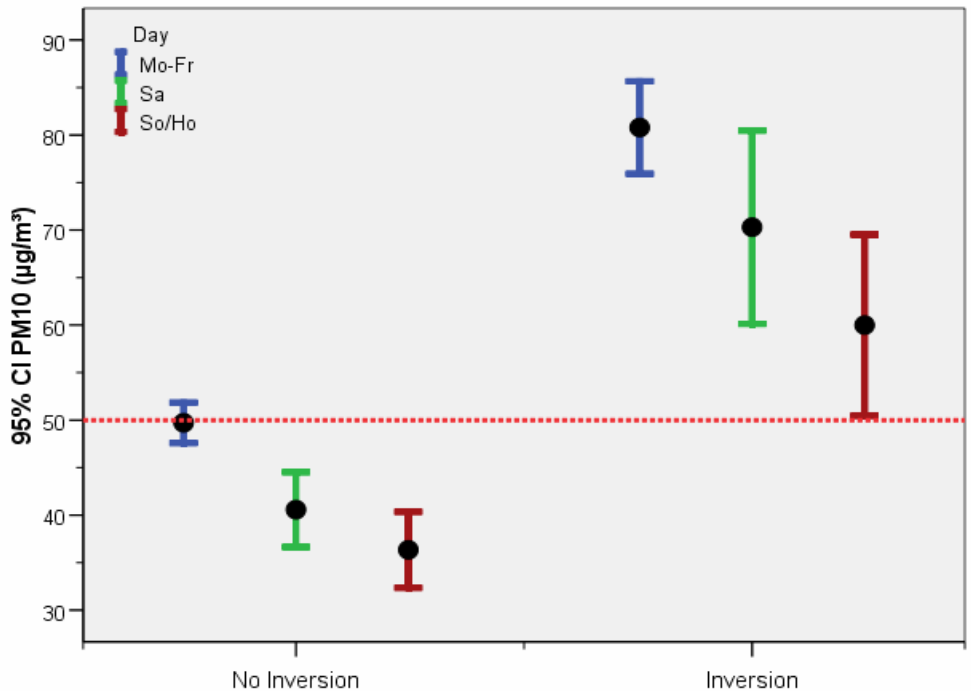
Inversion and Human Impact

Graz-Mitte: 5 Winter seasons (1.10.–31.3.)



No Inversion: 40% lower than Inversion

Sun/Holiday: 30% lower than Working Day

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Precipitation and Wind

- Both reduce load of PM10
- But in Graz and Klagenfurt
  - low wind velocities
  - rare days with precipitation

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Statistical Prediction Model

- Prediction of PM10 load of next day based on information of current day
- Predictions for Graz, Klagenfurt, Bozen in the winter season
- Models simple and practicable
- Reliable but not necessarily precise

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Multiple Linear Regression Models
√PM10 mean of the next day

- Models with 6 parameters ($r^2 \approx 0.55 – 0.64$)
  - Metric variable
    - PM10 mean of last 24 hours from 12am-12am
  - Categorical variables
    - Type of day (1=Mo-Fr/2=Sa/3=Su-Ho)
    - Month (1=October/.../6=March)
  - Meteorological forecasts
    - Precipitation (0=no/1=yes)
    - Wind velocity (mean of the next day in m/s)
    - Inversion (temp(ground) - temp(above ground))
- → *No traffic frequencies needed*

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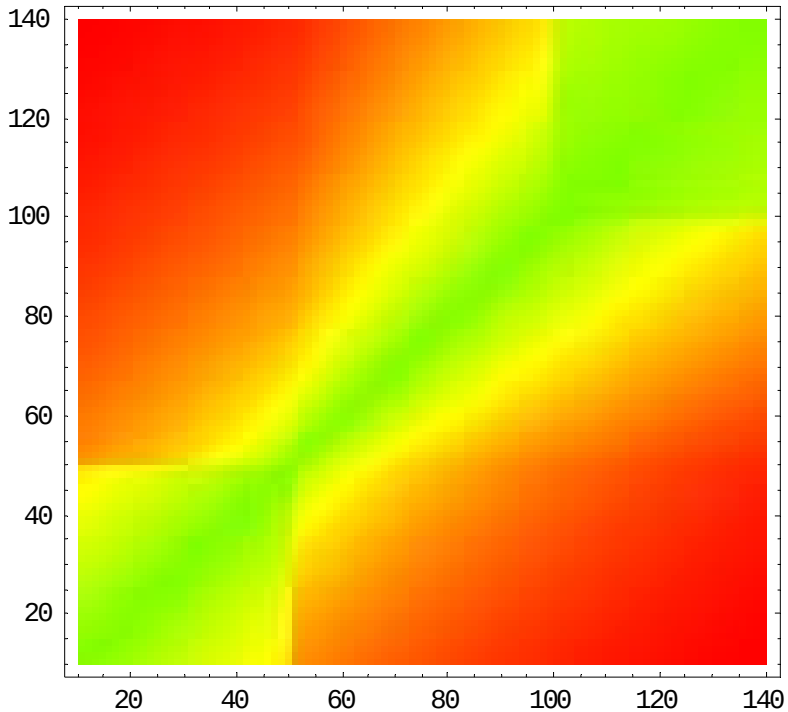
Quality function



Predicted values vs. Measured values

- Quality of prediction: 5 levels
  - green (1=excellent) to red (5=very bad)

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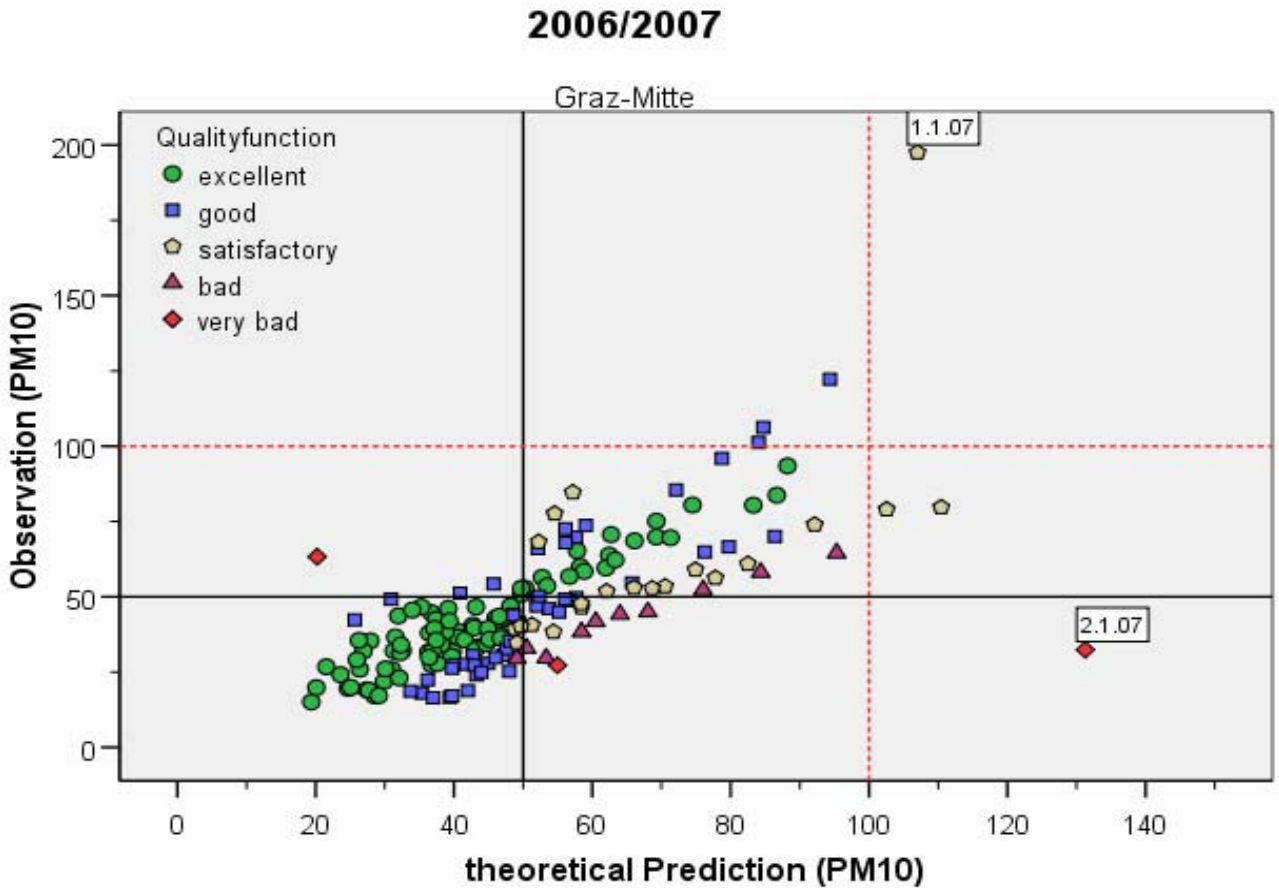
Graz: Quality of Prediction (theoretical)



1: 50.6%, 2: 29.2%, 3: 12.5% → **92.3 %**
4: 6.0%, 5: 1.8%

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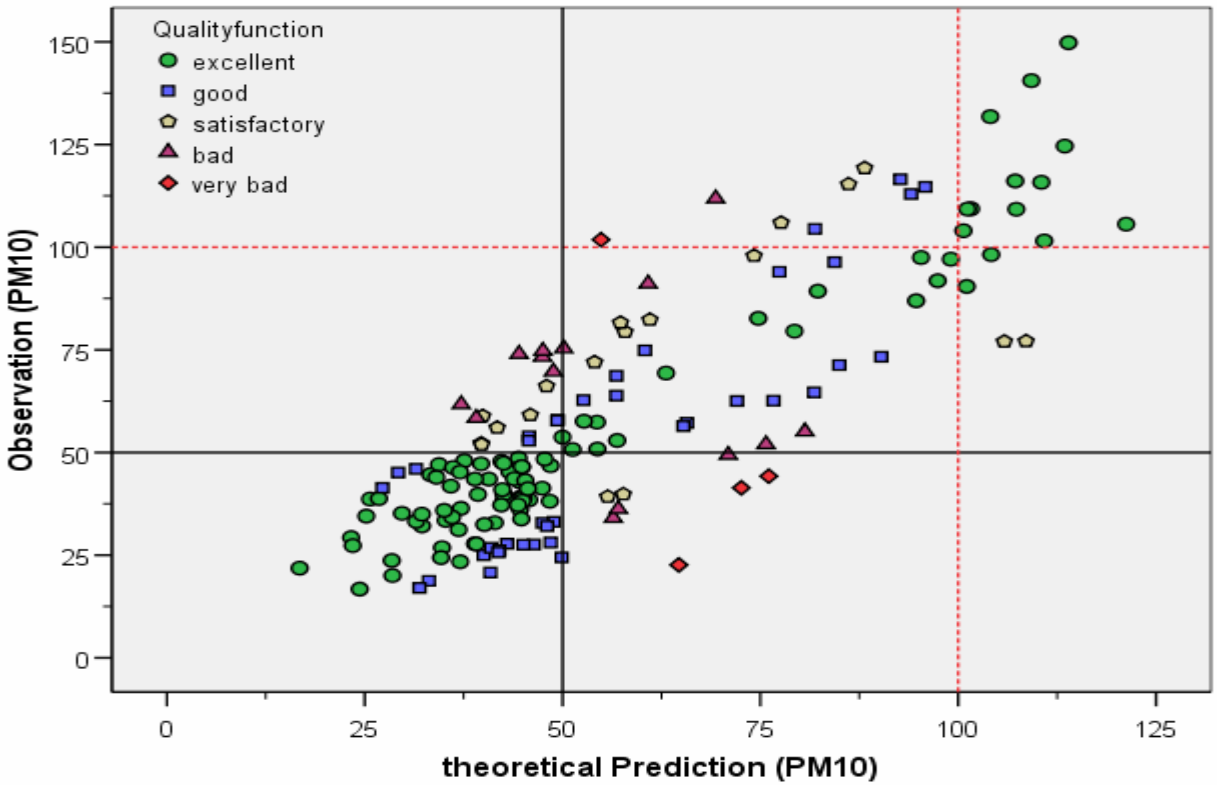
Klagenfurt: Quality of Prediction (theor.)

2005/2006



1: 55.1%, 2: 23.3%, 3: 10.8% → **89.2%**
4: 8.4%, 5: 2.4%

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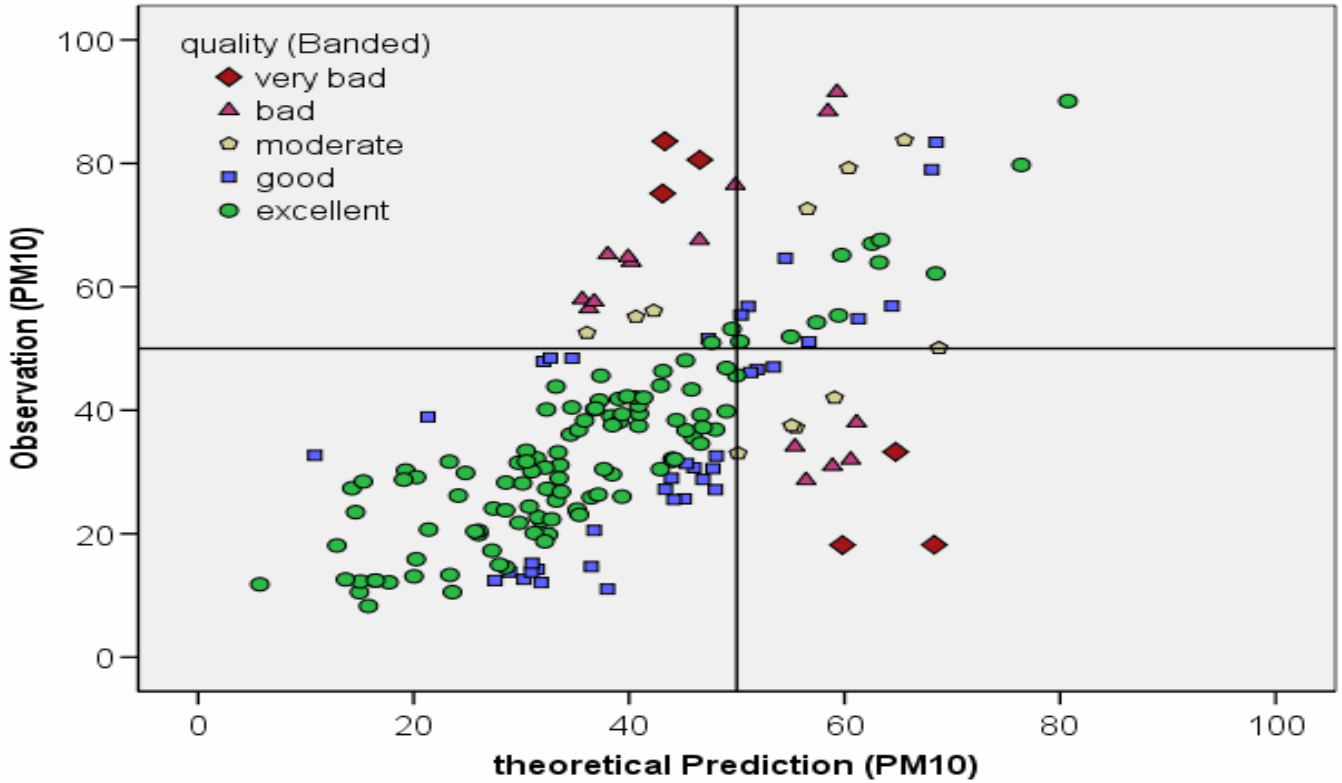
Bozen: Quality of Prediction (theor.)

2005/2006



1: 62.1%, 2: 20.3%, 3: 6.0% → **88.4%**
4: 8.2%, 5: 3.3%

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Graz-Mitte: Practical Experience

- October 16, 2006 – March 15, 2007
- Meteorological forecasts by ZAMG Steiermark in the morning
- Prediction available at 1 pm website as traffic light system

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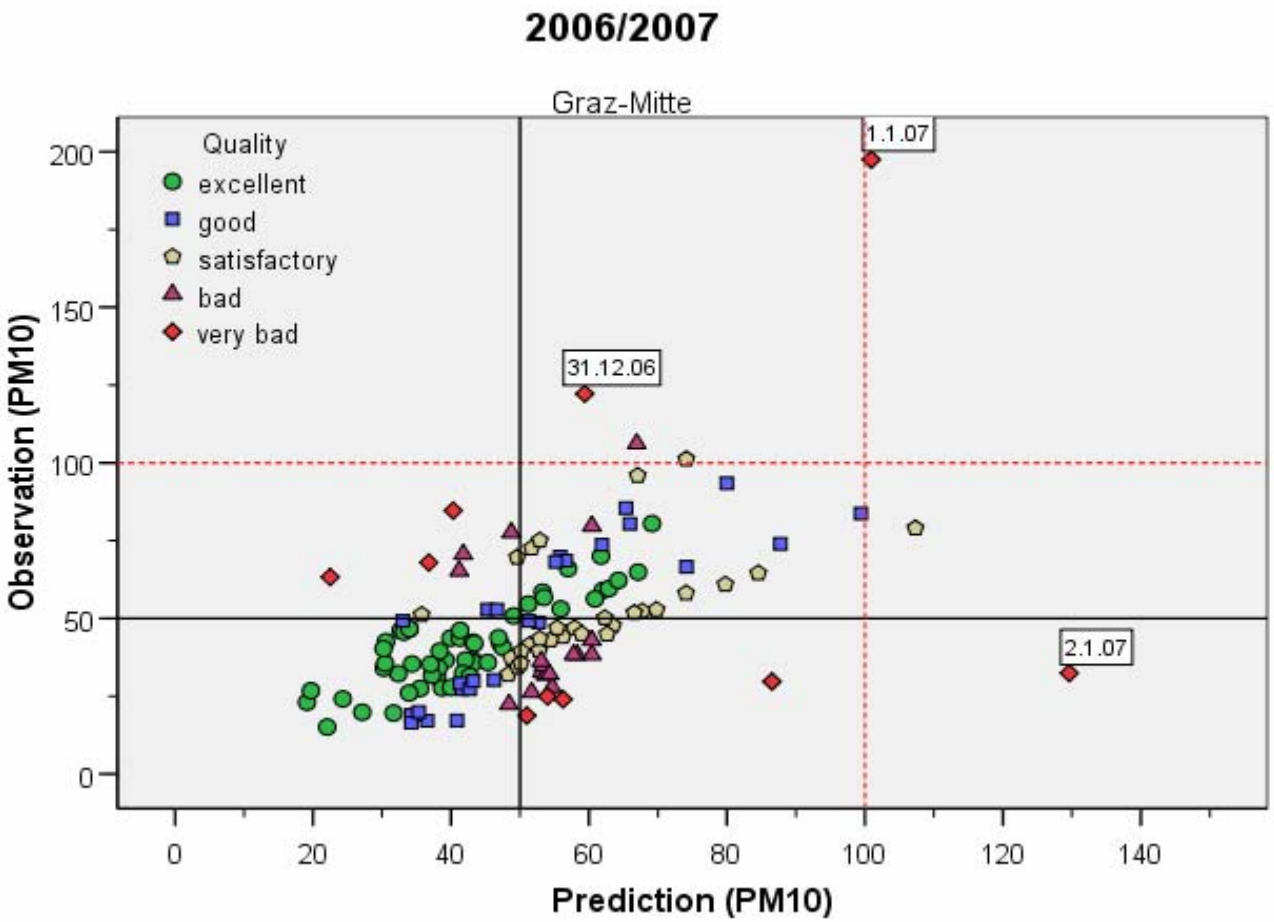
Quality of Prediction with forecast



1: 39.0%, 2: 19.9%, 3: 21.3% → **80.1%**
4: 12.5%, 5: 7.4%

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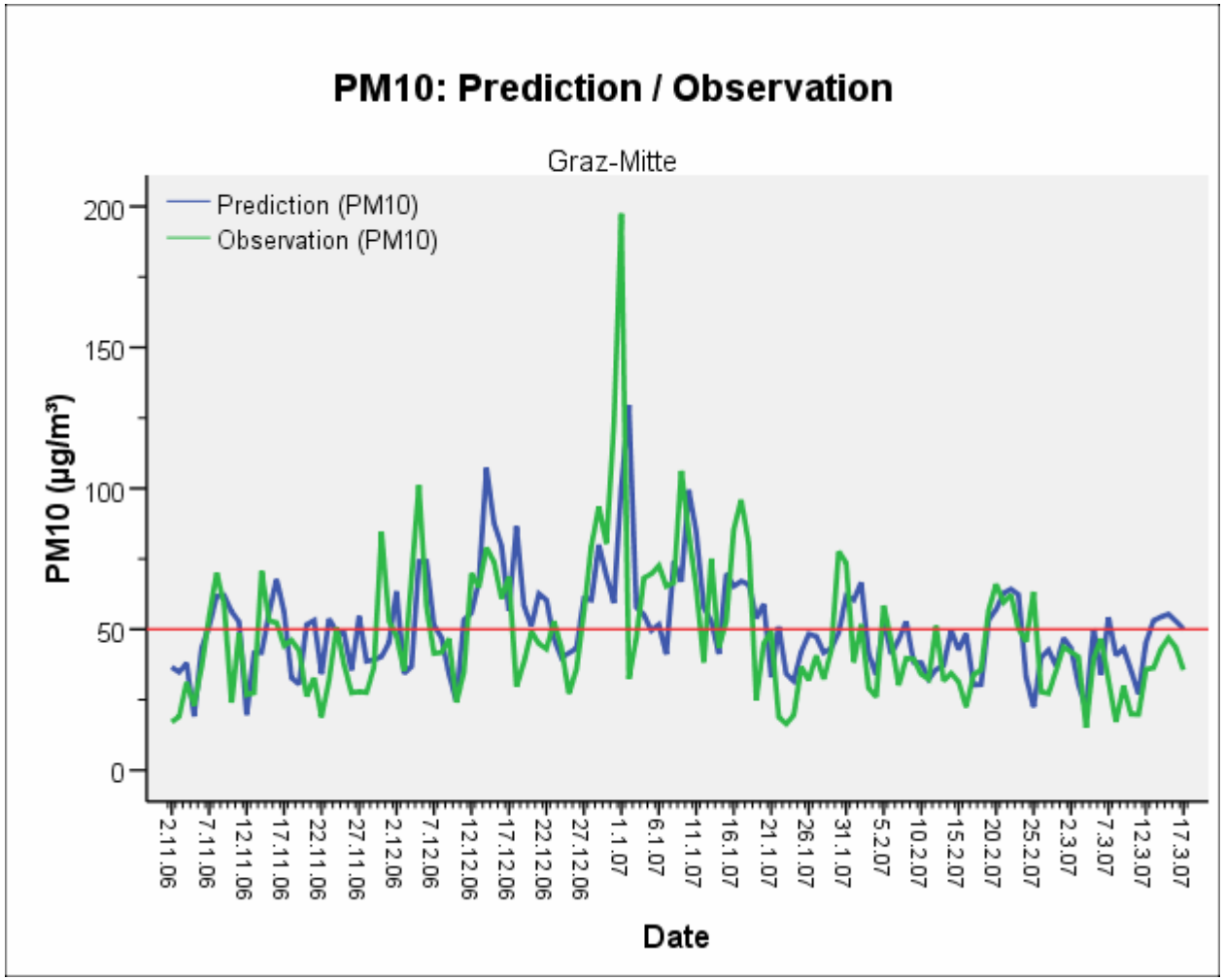
Model with meteorological forecasts



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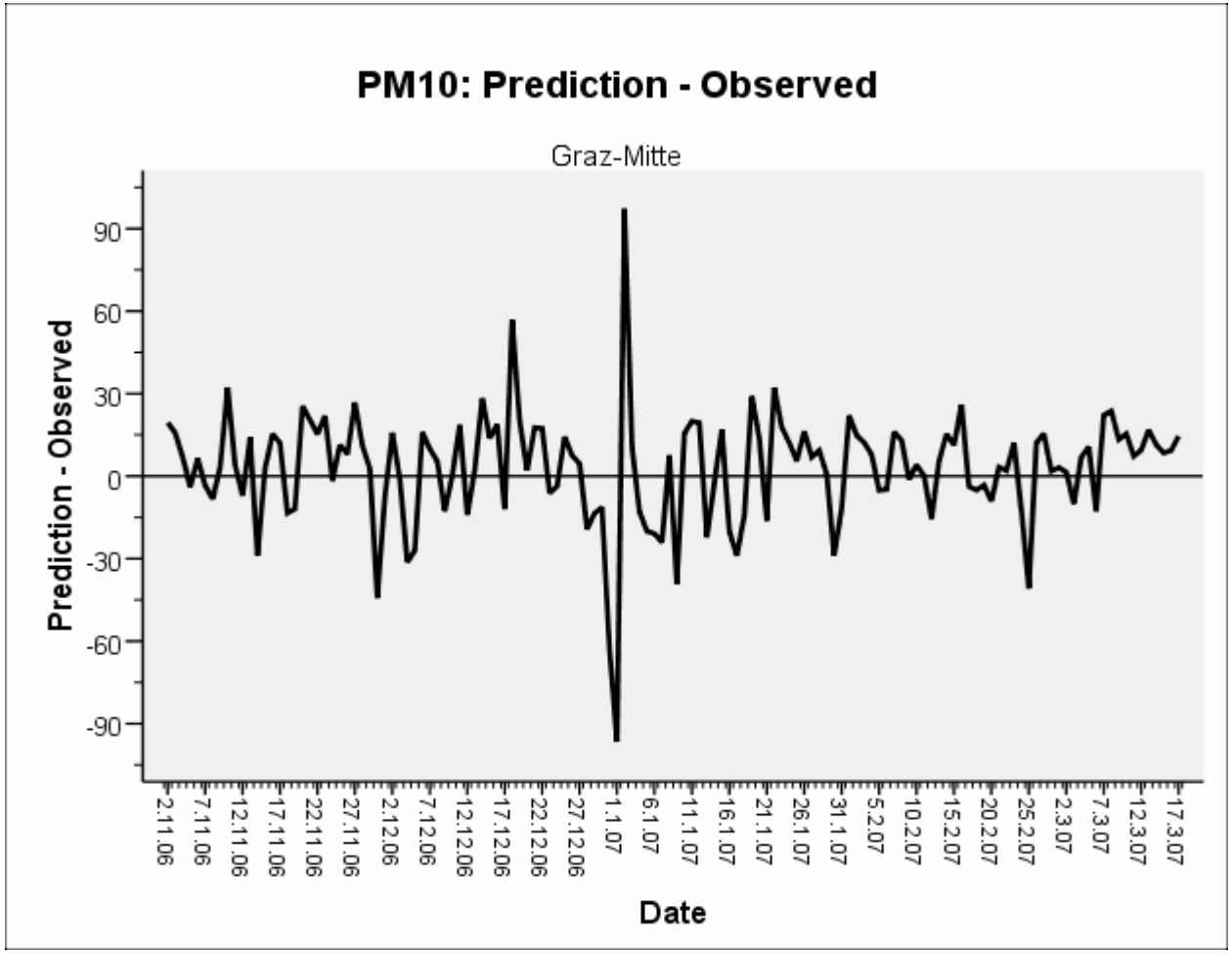
Prediction error



Small deviations except Silvester effect

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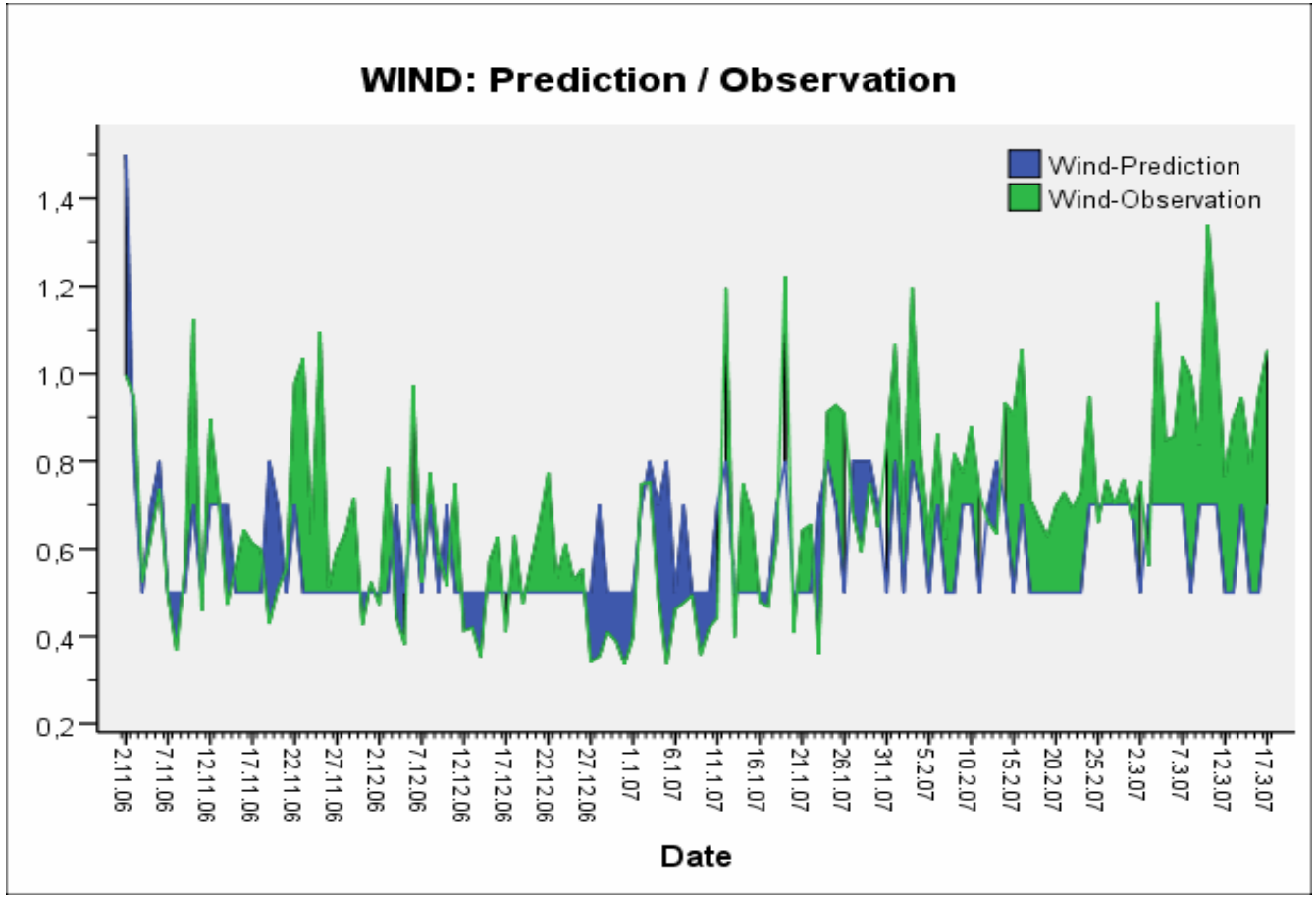
Forecast of Wind in 4 categories



Periods with under-estimation of wind velocities

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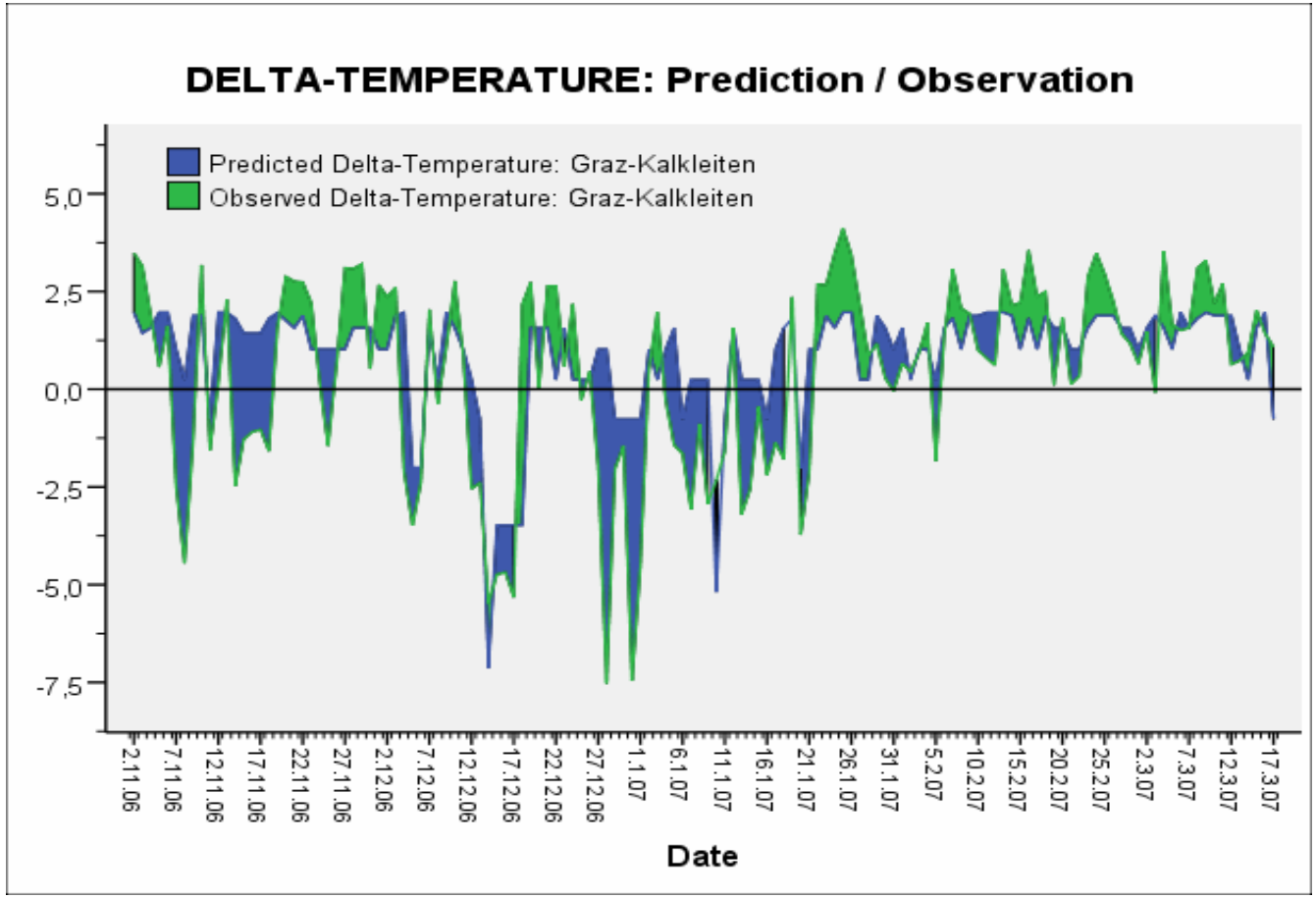
Forecast of Delta-Temperature



Acceptable forecasts except for extreme situations

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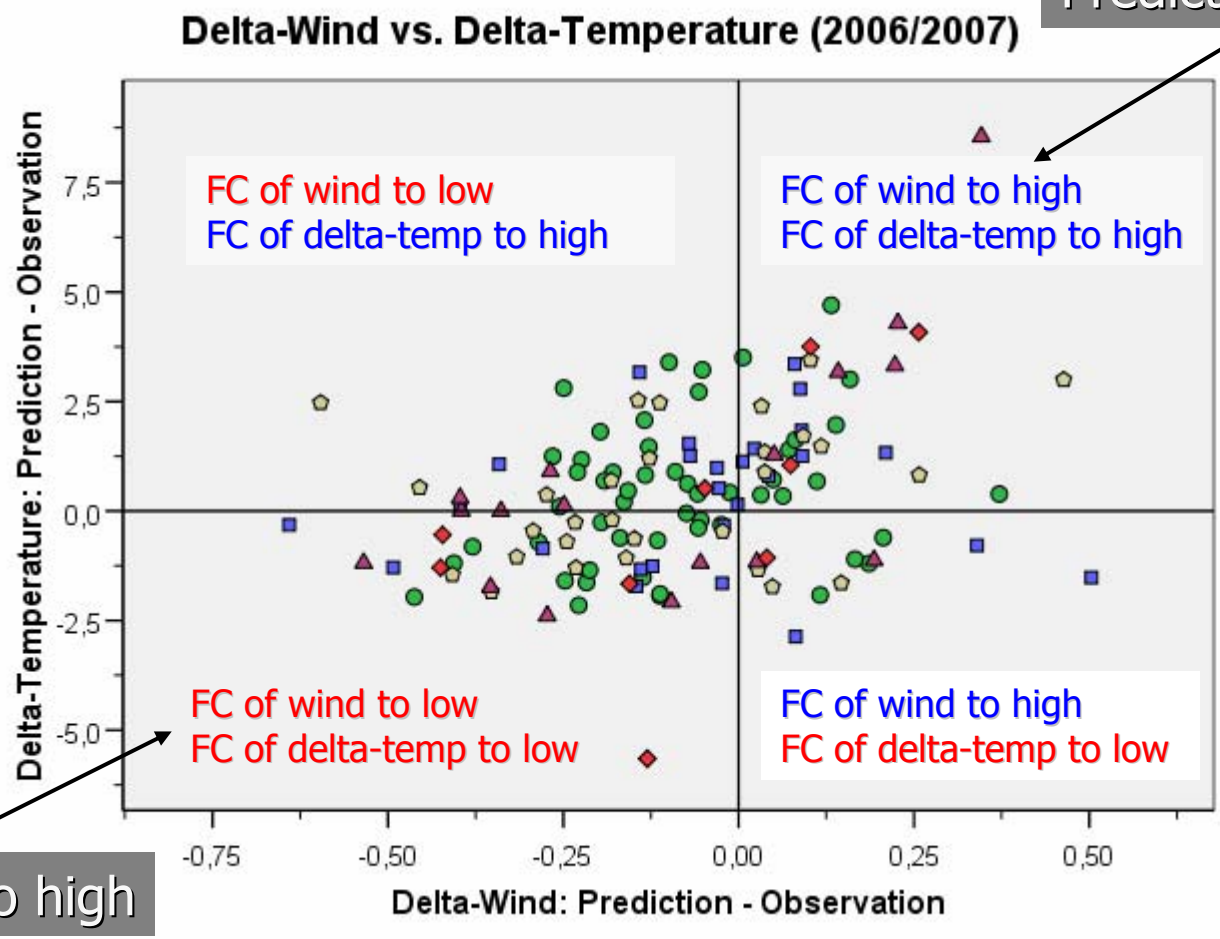
Forecast errors: Wind vs. Delta-Temperature

Prediction to low



Prediction to high

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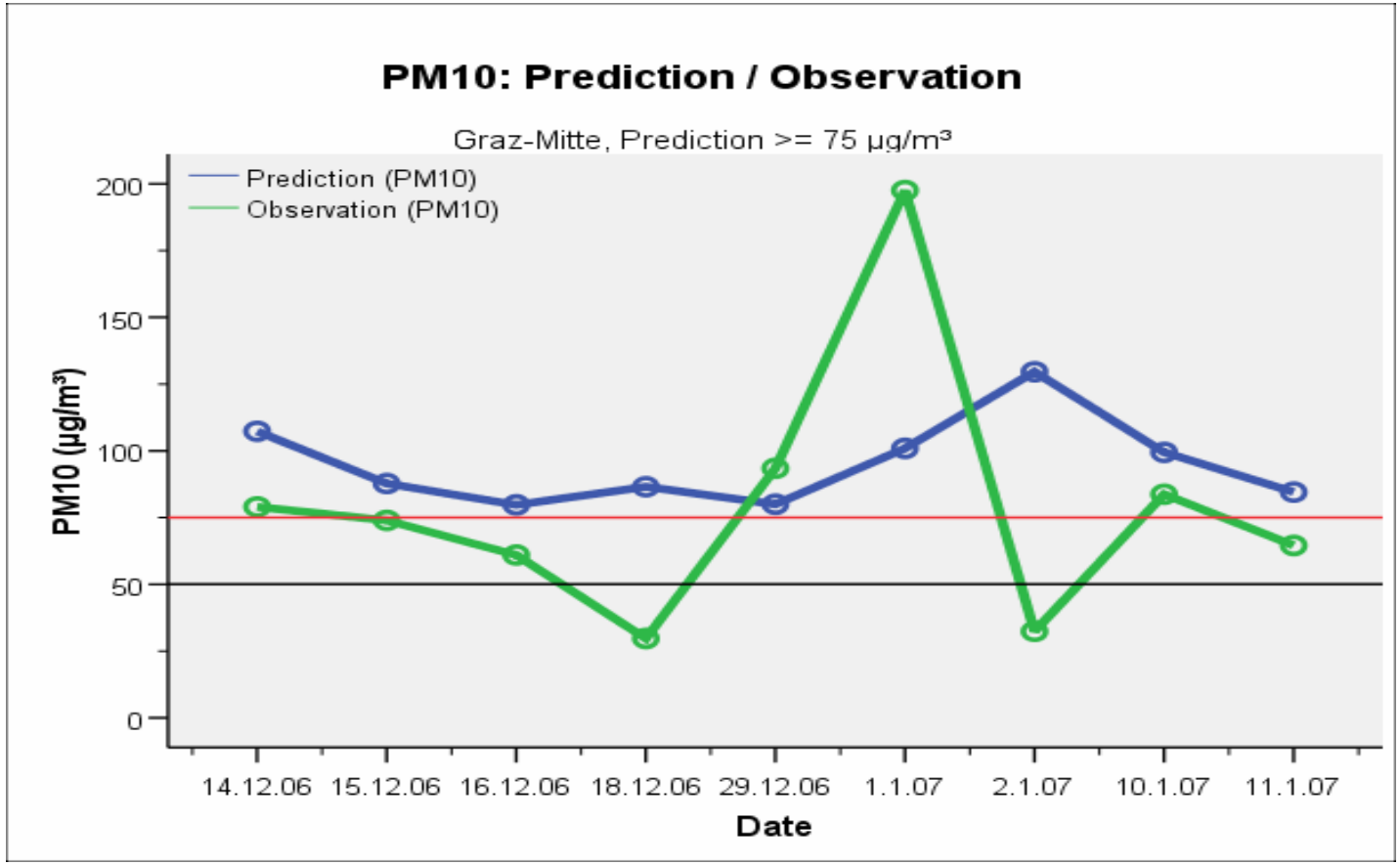
9 days with prediction PM10 ≥ 75 µg/m³



Good prediction, if observed value PM10 > 50 µg/m3

→ 2 Predictions two high

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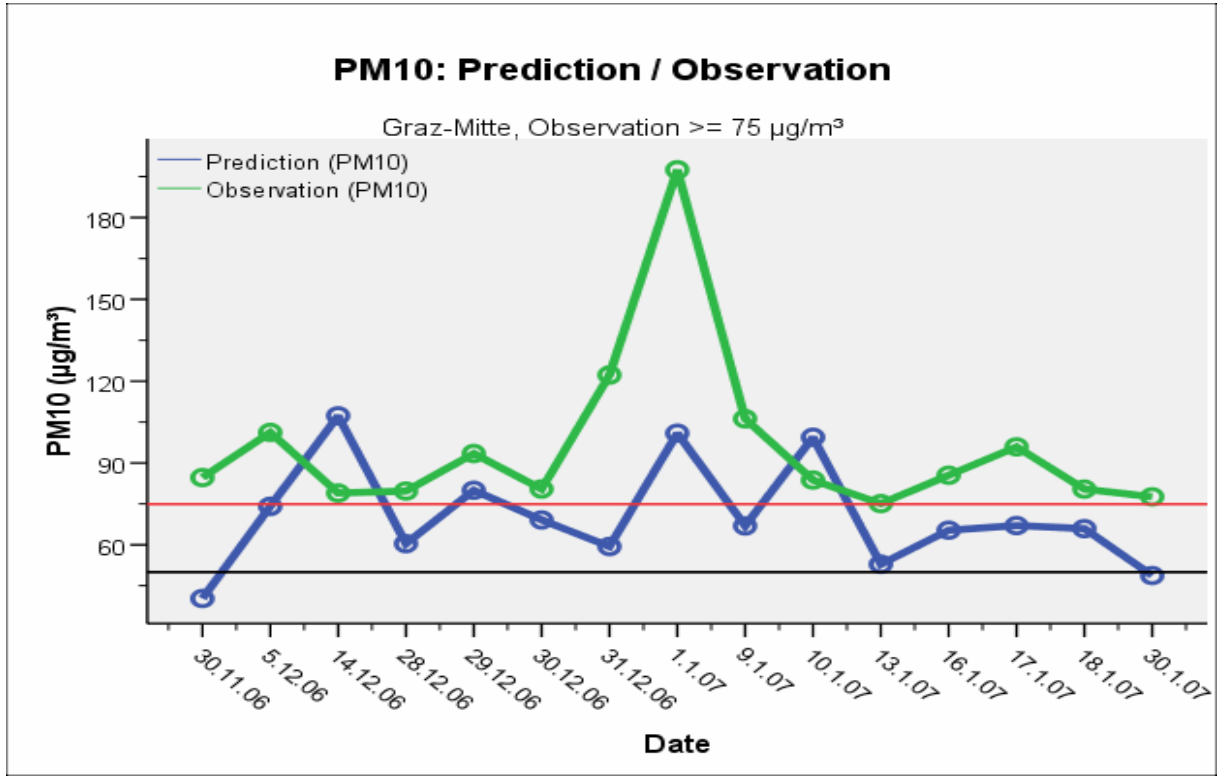
15 days with observation PM10 ≥ 75 µg/m³



4 days: Prediction PM10 > 75 µg/m³ (red)

9 days: Prediction PM10 > 50 µg/m³ (orange)

2 days: Prediction PM10 < 50 µg/m³ (green)

→ 2 Predictions to low (30.11., 30.1.)

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Summary Prediction Models for PM10

- Graz Mitte, Graz Süd
  - Models & Test runs: 3 winter seasons 2004/05 – 2006/07
  - with weather forecast ≈ 80% reliable predictions
- Klagenfurt Völkermarkterstraße
  - Model with known wheather ≈ 90% reliable predictions
- Bozen BZ5, Meran1
  - Models with known wheather ≈ 90% reliable predictions