



Das Lebensministerium

**Forschungs- und Entwicklungsvorhaben  
des Sächsischen Landesamtes für Umwelt und Geologie**

**Modellierung  
der Sekundärpartikelbildung und -ausbreitung  
von Großfeuerungsanlagen  
in Sachsen**

**Vortrag MTK 06-05**

**Wolfgang Poppitz**

**LfUG, Ref. 22, Luftqualität**

## Inhalt des Vortrages

- **Ausgangspunkt und Aufgabenstellung**
  - **Modellbeschreibung**
- **Eingangsparameter und Szenarien**
  - **Validierung des Modells**
  - **Ergebnisse**



## Ausgangspunkt und Aufgabenstellung

1

- ➔ **Istzustand:** signifikante Überschreitung der EU-weit vorgegebenen **Immissionswerte für PM<sub>10</sub>** in mehreren sächsischen Ballungsräumen
- ➔ **zz.:** Erarbeitung und Beginn der Umsetzung von Luftreinhalteplänen in mehreren sächsischen (Groß-)Städten
- ➔ **nach wie vor notwendig:** vertiefte Klärung von Verursacher und Prozessketten
  - **Punkt- und Flächenquellen**
  - **primäre und sekundäre Emissionen**
  - **Nah- und Ferntransport**



## Forschungsvorhaben:

- **genaue Prognostizierung des Gesamt-Beitrages der beiden größten GFA in Sachsen an der Feinstaubimmission in den urbanen Zentren in Sachsen durch mathematische Modellierung**



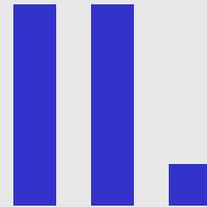
## Vergabe 04-08:

# ➔ Leibniz - Institut für Troposphärenforschung e.V., Leipzig

- Prof. Dr. Eberhard Renner
- Dr. Detlef Hinneburg
- Dr. Ralf Wolke

➤ Abschlussbericht 05-10

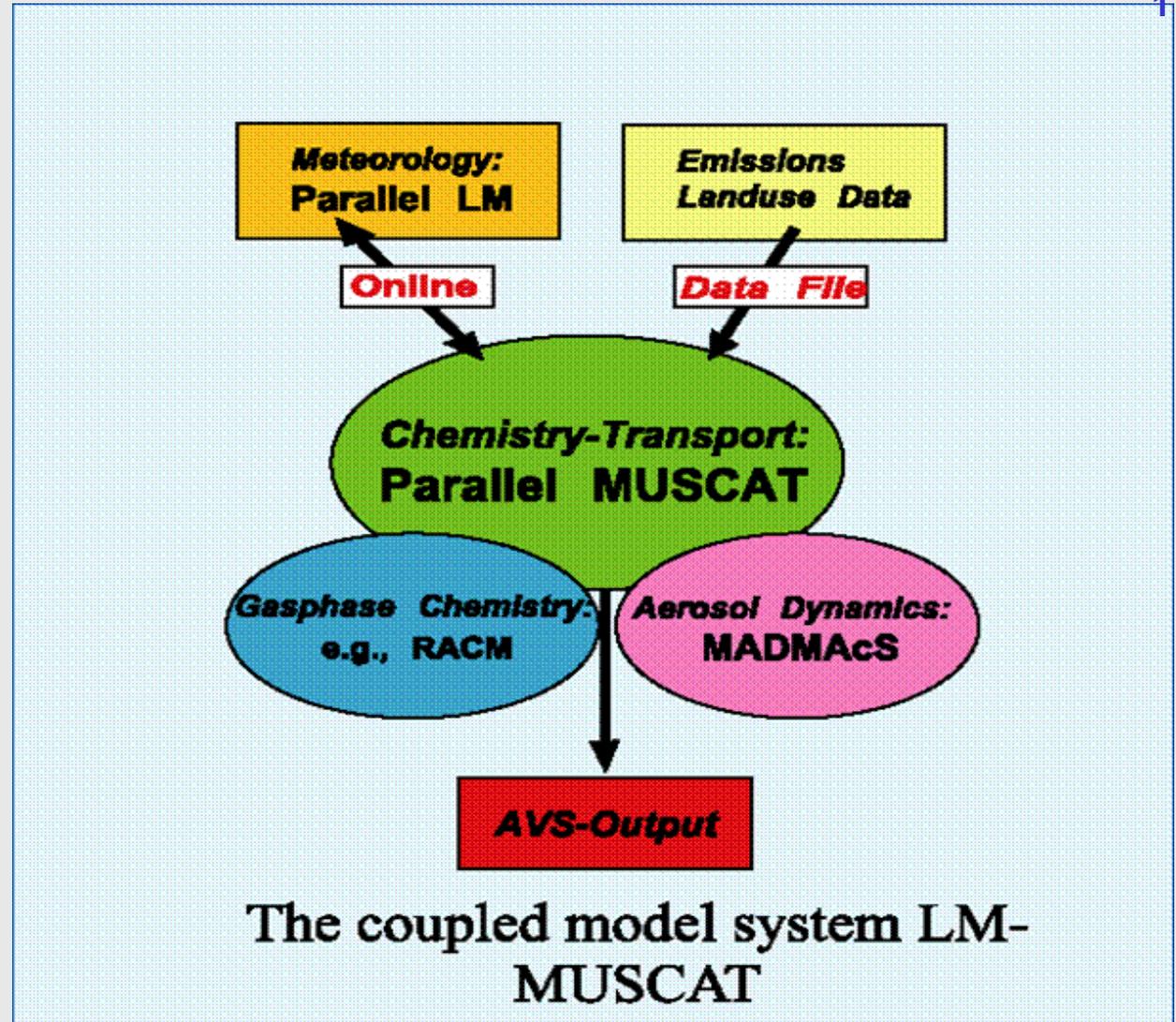




# Modellbeschreibung



# Modellbeschreibung



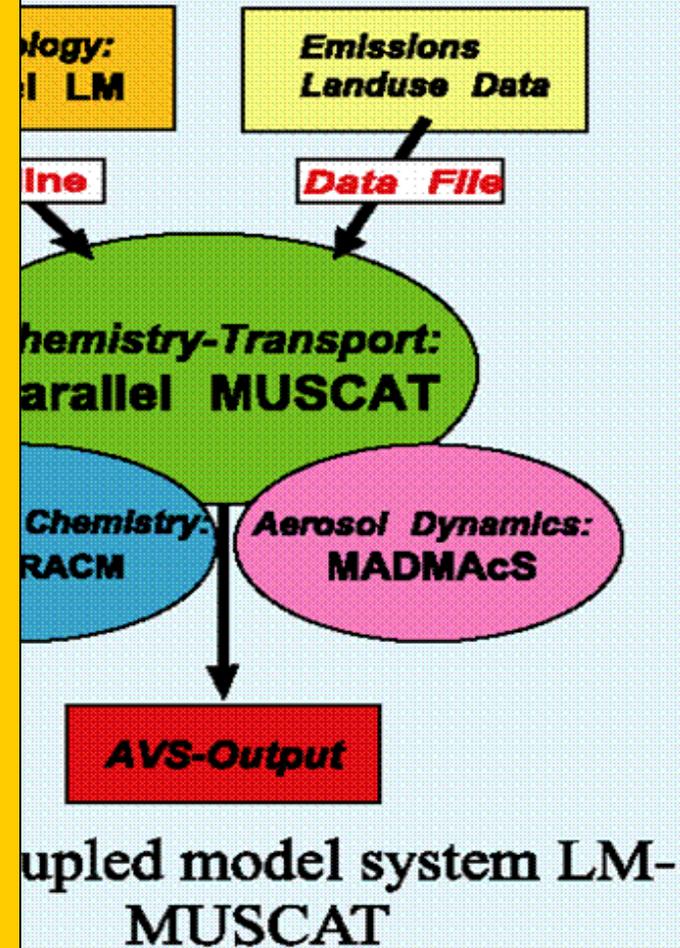
## Meteorologie-Modell

operationelles  
lokales Vorhersagemodell **LM**  
des DWD



globales Vorhersagemodell **GME**  
des DWD

- umfassende Modellphysik der Troposphäre
- meso- und mikroskalig (100 m – 100 km)
- 50 orographiefolgende Schichten (u.: 65 m)
- Reanalyse des Wettergeschehens vieler Jahre  
→ meteorologischer Treiber des Modells



# Meteorologie-Modell

## komplexes Emissionsmodul

einschließlich:

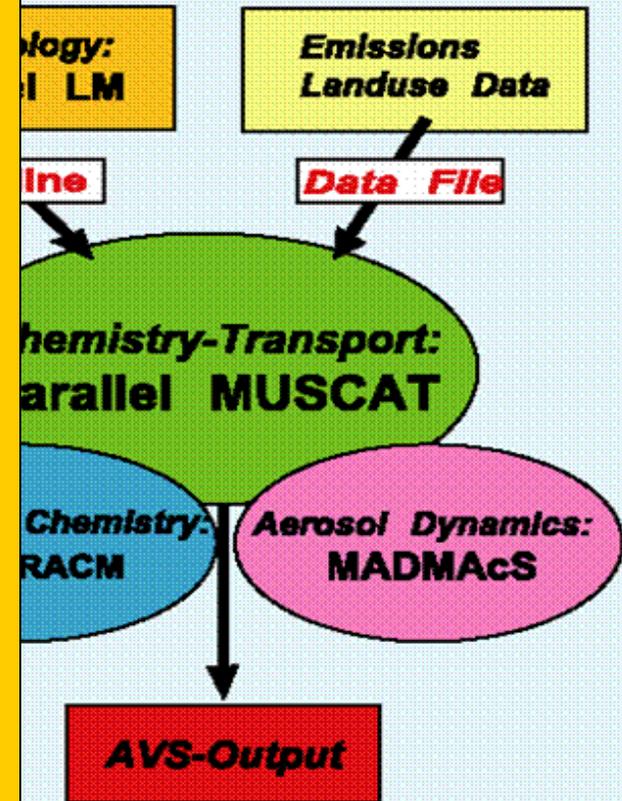
## Kühlturm-Überhöhungs-Modell

- meso- und mikroskalig (100 m – 100 km)
- 50 orographiefolgende Schichten (u.: 65 m)
- Reanalyse des Wettergeschehens vieler Jahre  
→ meteorologischer Treiber des Modells

LM

GME

shäre



coupled model system LM-MUSCAT



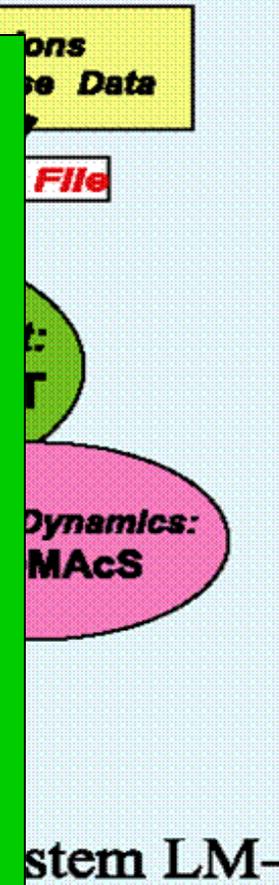
## Meteorologie-Modell

### Chemie-Transport-Modell

#### MUSCAT

(Multi-Scale Atmosphäric Transport Modell)

- hochaufgelöste online-Verknüpfung in „Echtzeit“
- Steuerung der physikalisch-chemischen Emissions-, Transport- und Umwandlungsprozesse
- äußerst variable und unabhängige Teilprozeduren
- Verarbeitung hochgradig nichtlinear gekoppelter Gleichungen und unterschiedlicher Zeitskalen
- variable, von LM unabhängige, horizontale und vertikale Nestung



## Meteorologie-Modell

## Chemie-Transport-Modell

MUSCAT

## Gasphasenchemie-Modul

RACM

- umfasst 76 reaktive Spurengase in 239 Reaktionen
- einschließlich 22 photolytische Reaktionen in Abhängigkeit von Sonnenstand und Bewölkung sowie der weiteren meteorologischen Grundgrößen



## Meteorologie-Modell

## Chemie-Transport-Modell

MUSCAT

## Aerosoldynamik-Modul

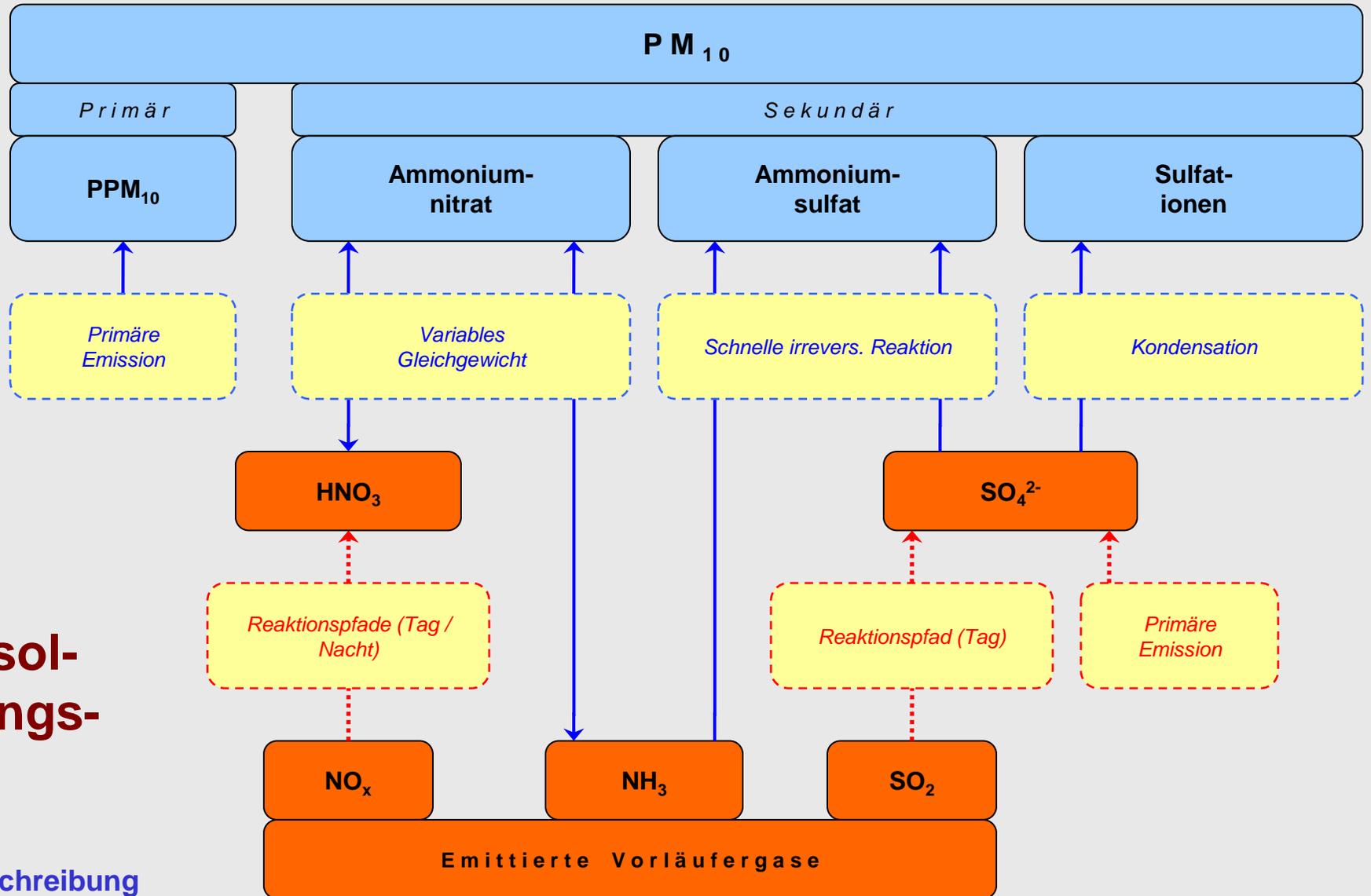
MADMAcS

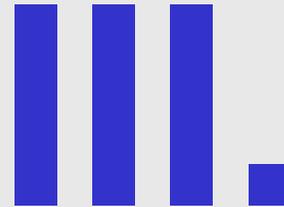
- Modellierung von physikalisch-chemischen Bildung und Wachstum von Partikel - in direkter Wechselwirkung mit der Gasphasenchemie und der Meteorologie
- variable Größenverteilung der Aerosole



# Aerosol- bildungs- pfad

Modellbeschreibung

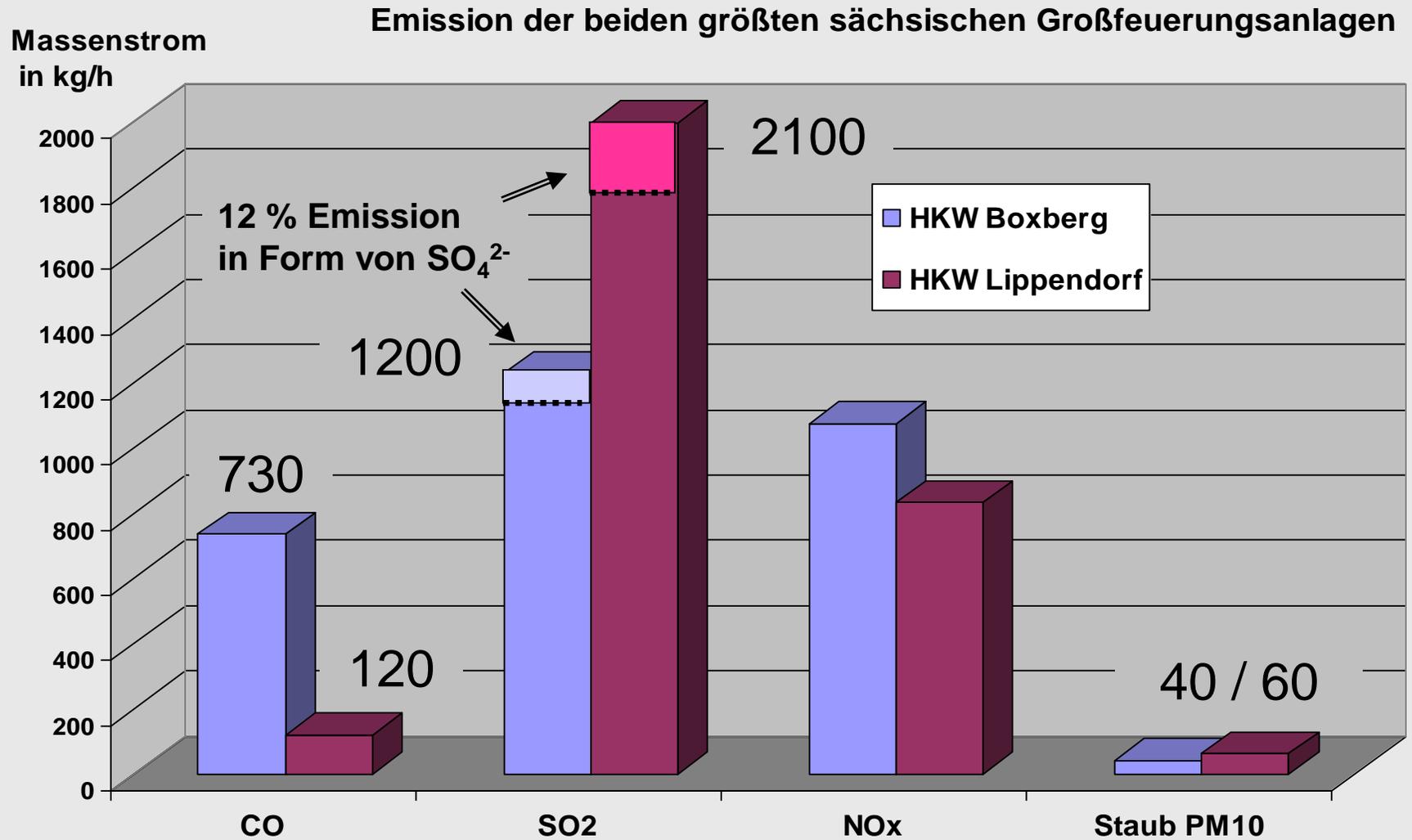


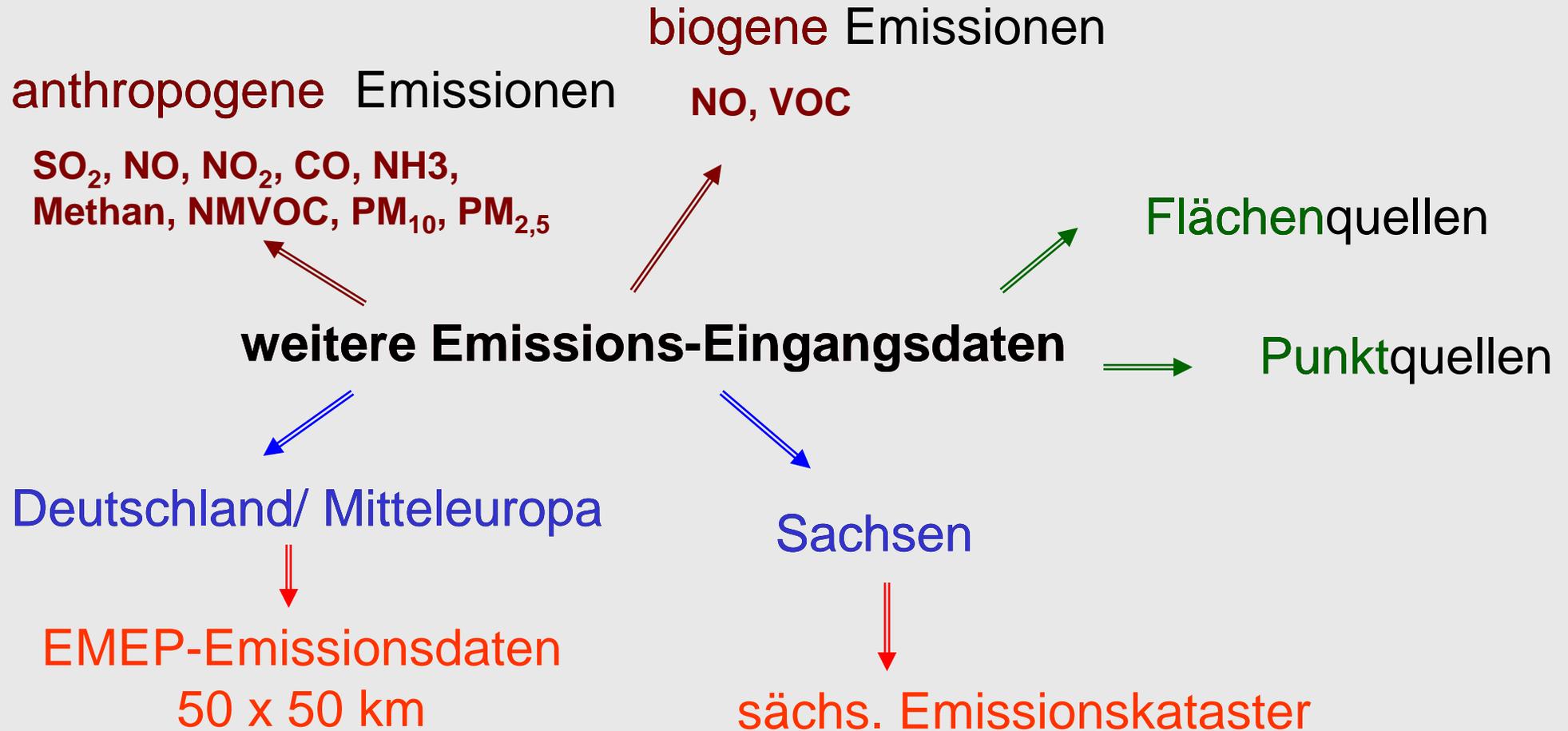


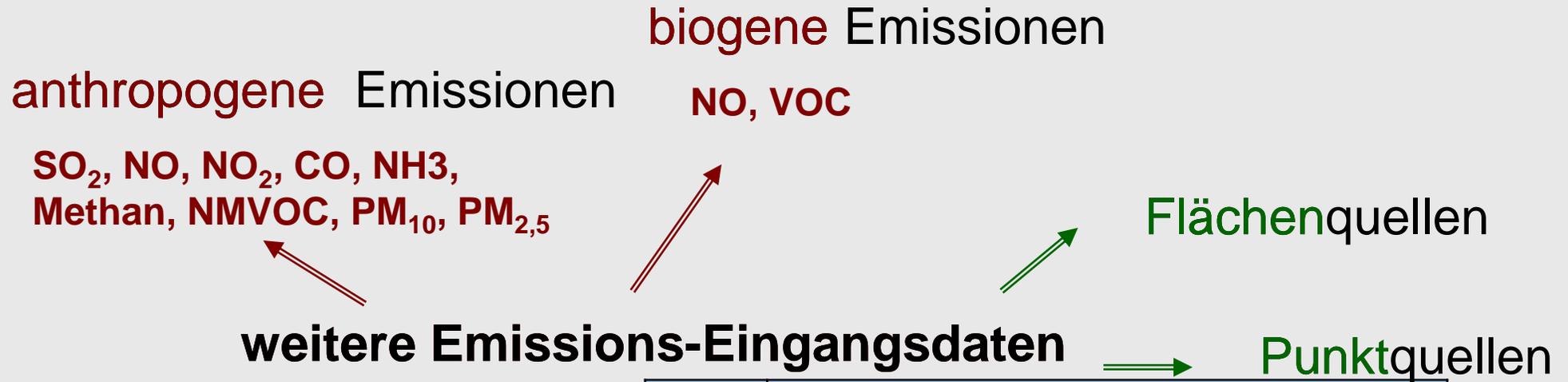
# Eingangsparameter und Szenarien



## Eingangsparameter und Szenarien







Deutschland/ Mitteleuropa

EMEP-Emissionsdaten  
50 x 50 km

SNAP-Klassen

Eingangsparameter und Szenarien

SNAP	Emissionstyp
1	Verbrennungsanlagen in Energie- und Rohstoffindustrie (Kraftwerke)
2	Nicht-industrielle Verbrennungsanlagen (Heizung)
3	Verbrennungsanlagen in der verarbeitenden Industrie
4	Industrielle Produktionsprozesse ohne Verbrennung
5	Förderung und Verteilung fossiler Brennstoffe, geotherm. Anlagen
6	Freisetzung von Lösungsmitteln (Chemieindustrie)
7	Straßenverkehr
8	Schiene-, Schiffs- und Luftverkehr
9	Abfallwirtschaft, Deponien
10	Landwirtschaft



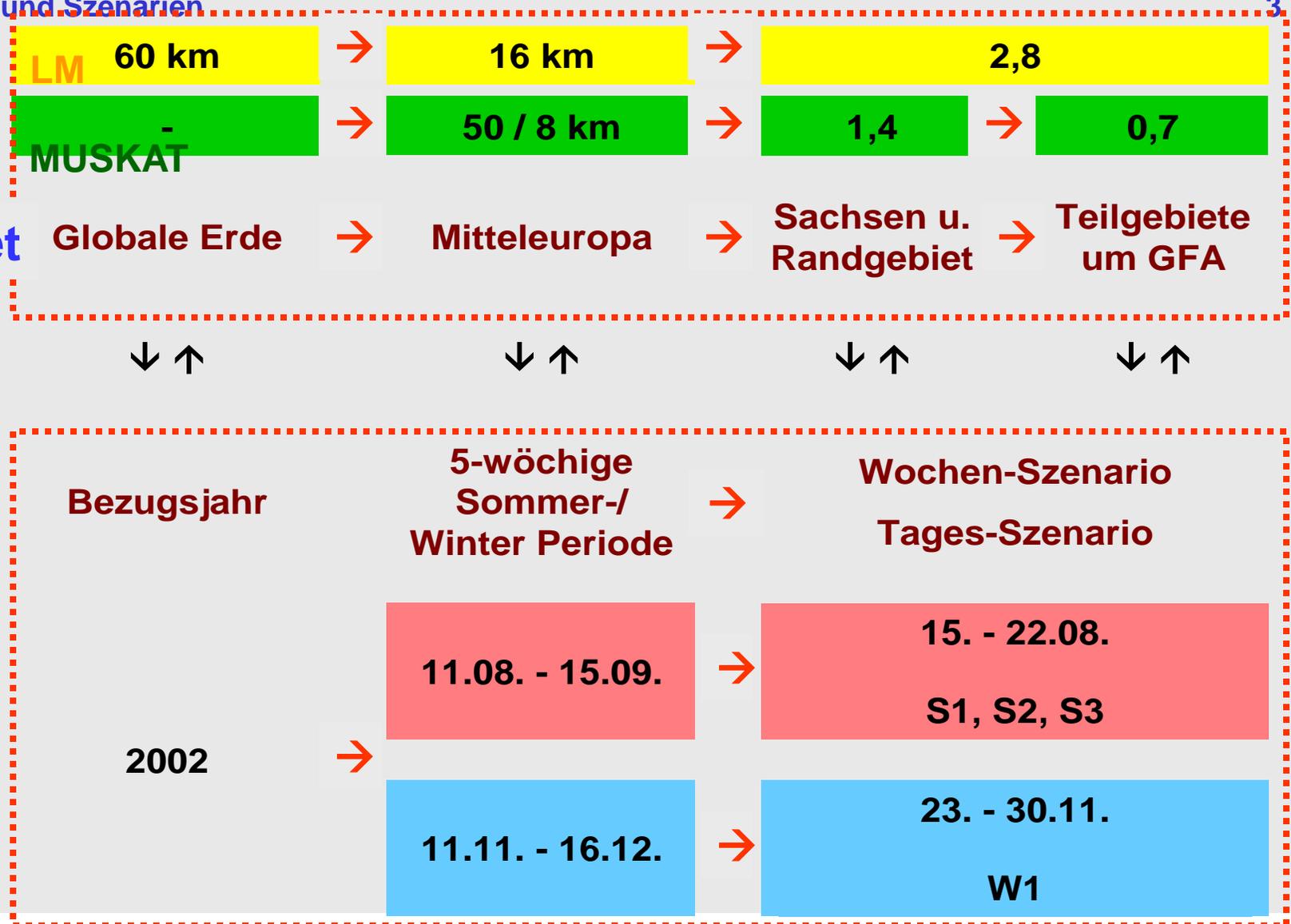
**Eingangsparameter und Szenarien**

**Nestung**

**Modellgebiet**

**Zeitfenster**

**Simulation**



3



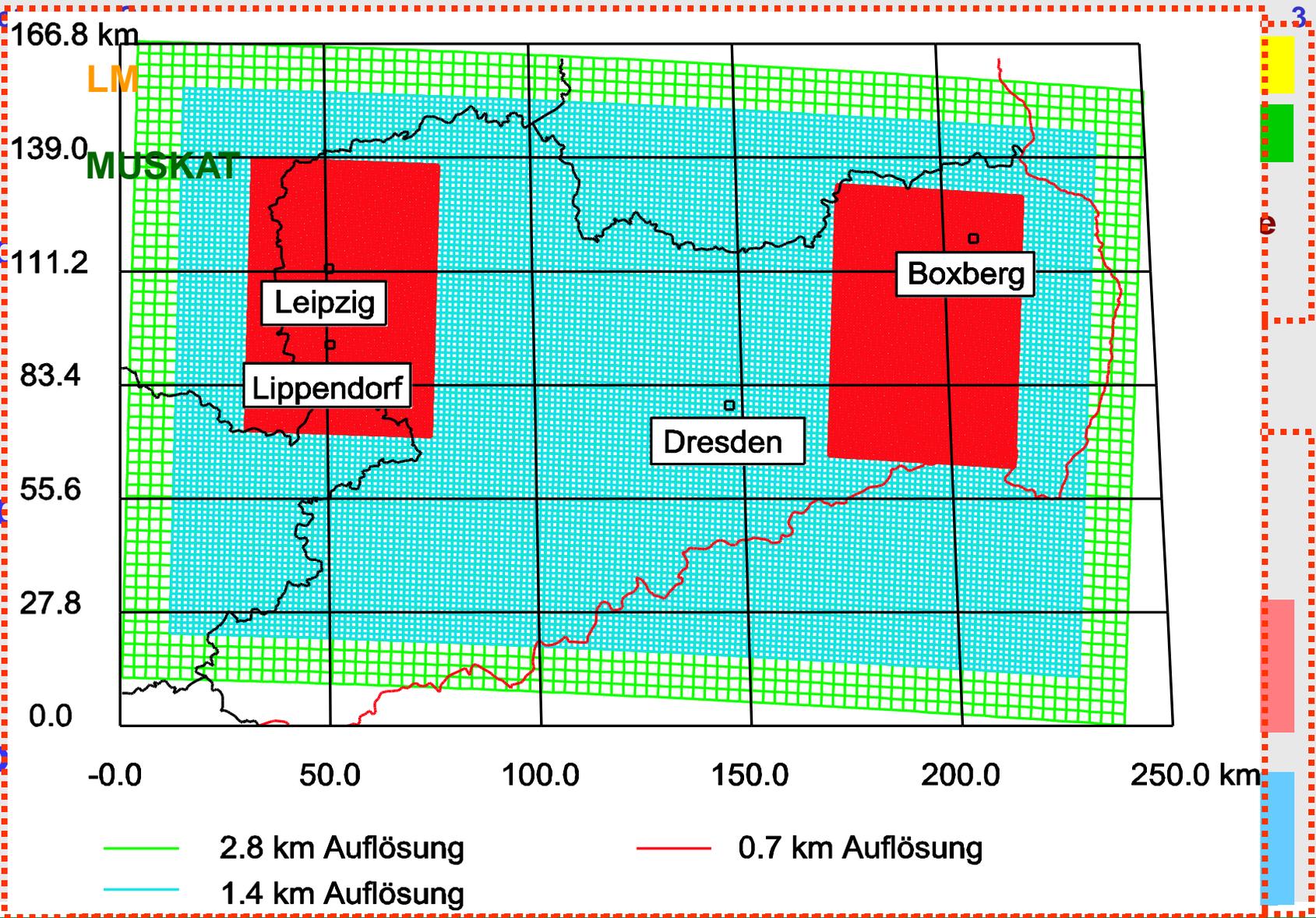
Eingangsparameter

Nestung

Modellgebiet

Zeitfenster

Simulation



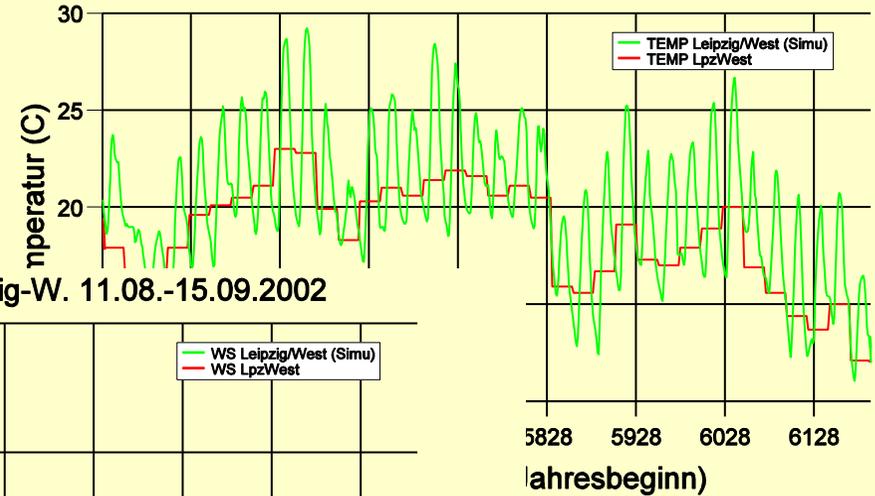
# IV.

## Validierung des Modells

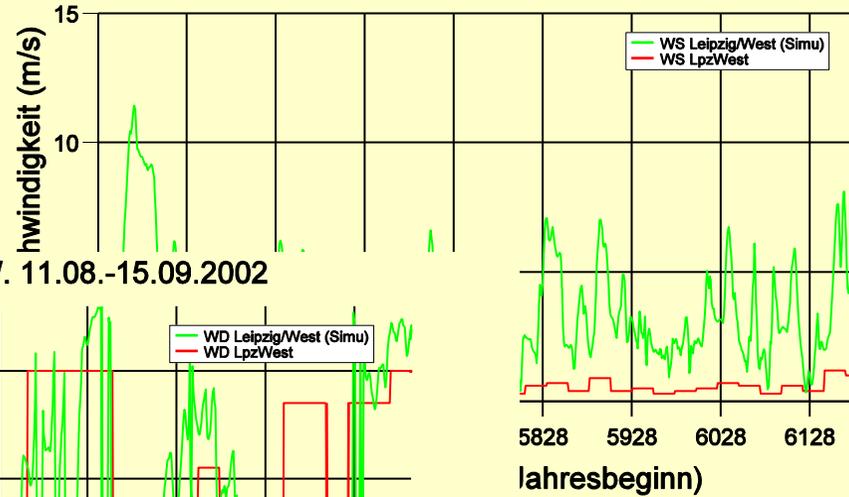


## Validierung des Modells

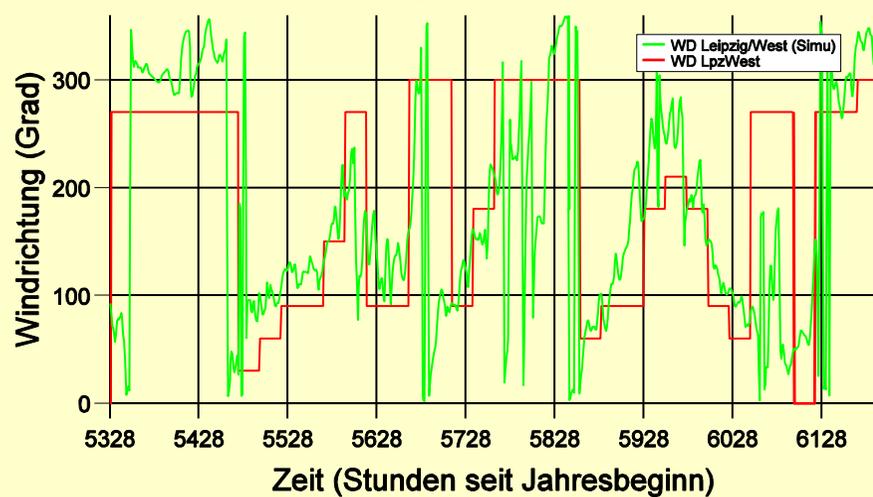
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### Windgeschwindigkeit Leipzig-W. 11.08.-15.09.2002



### Windrichtung Leipzig-W. 11.08.-15.09.2002

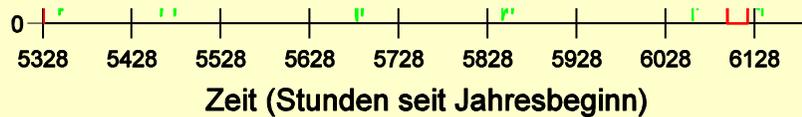
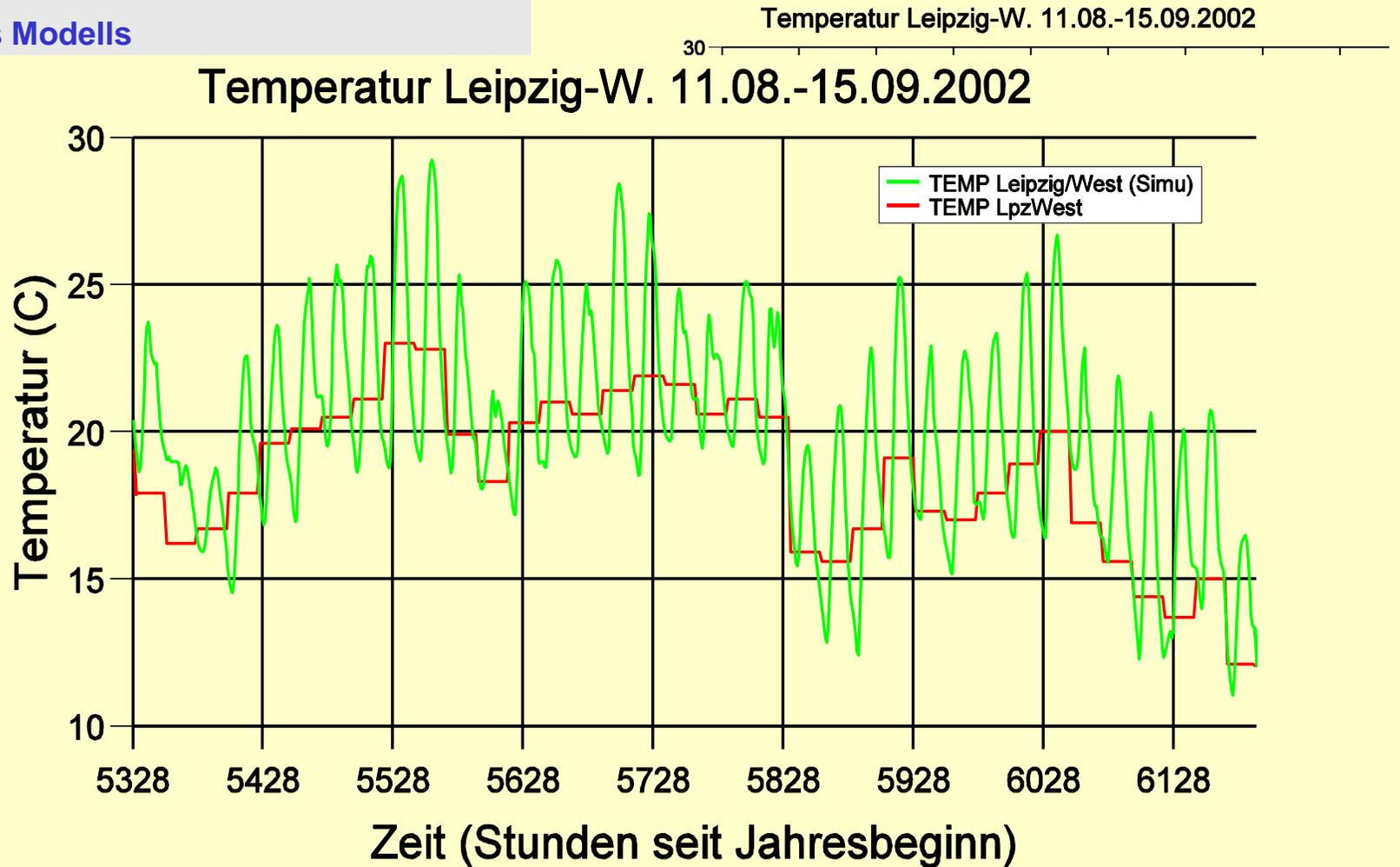


meteorologische Parameter

- Simulation
- Stations-Messwerte



## Validierung des Modells

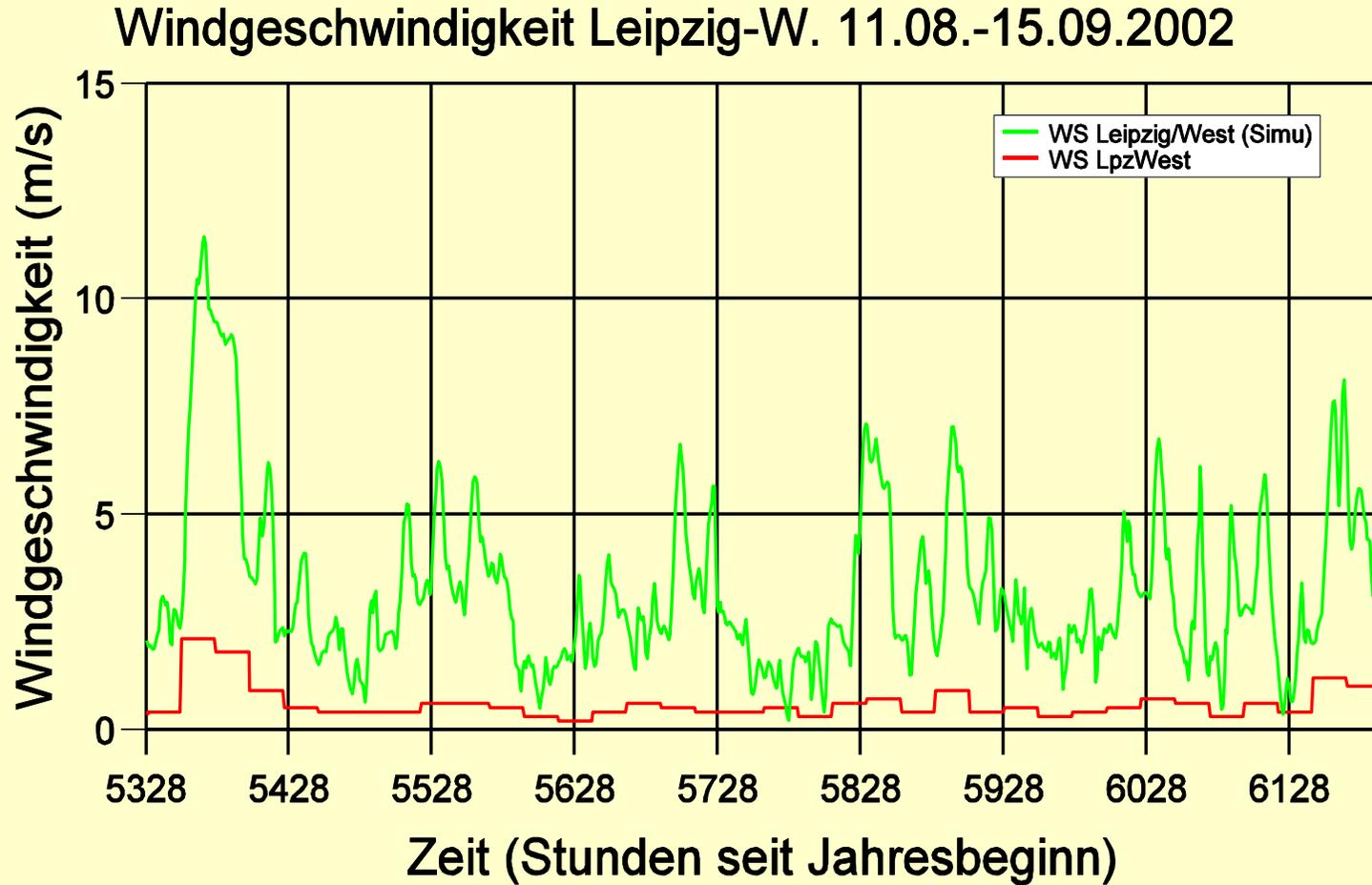


--- Simulation  
--- Stations-Messwerte



## Validierung des Modells

Temperatur Leipzig-W. 11.08.-15.09.2002



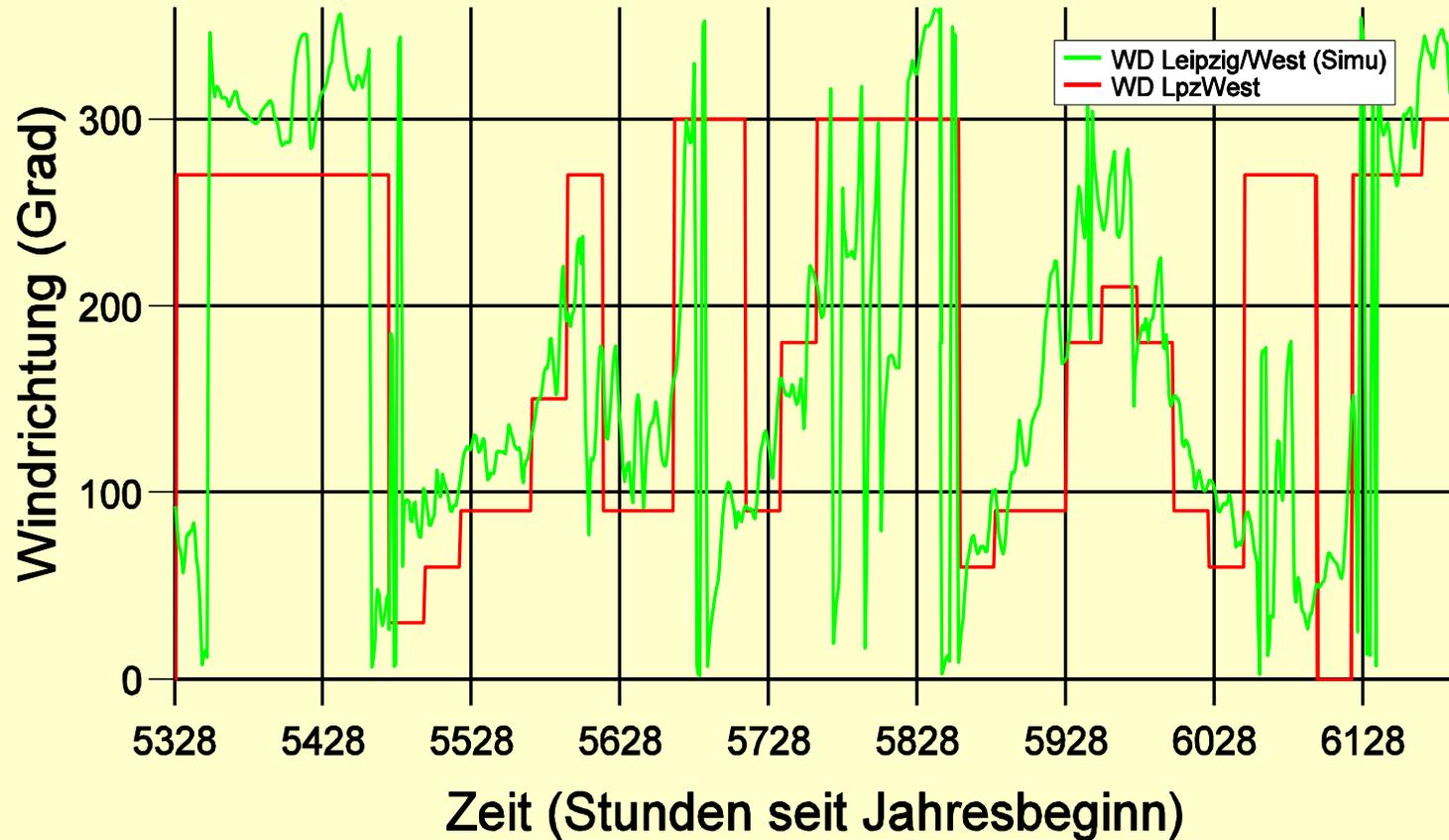
--- Simulation  
--- Stations-Messwerte



## Validierung des Modells

Temperatur Leipzig-W. 11.08.-15.09.2002

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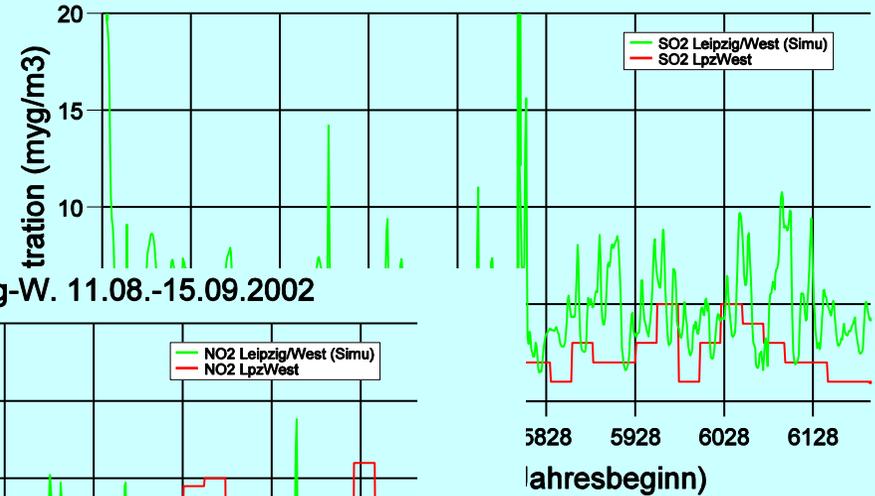


--- Simulation  
--- Stations-Messwerte

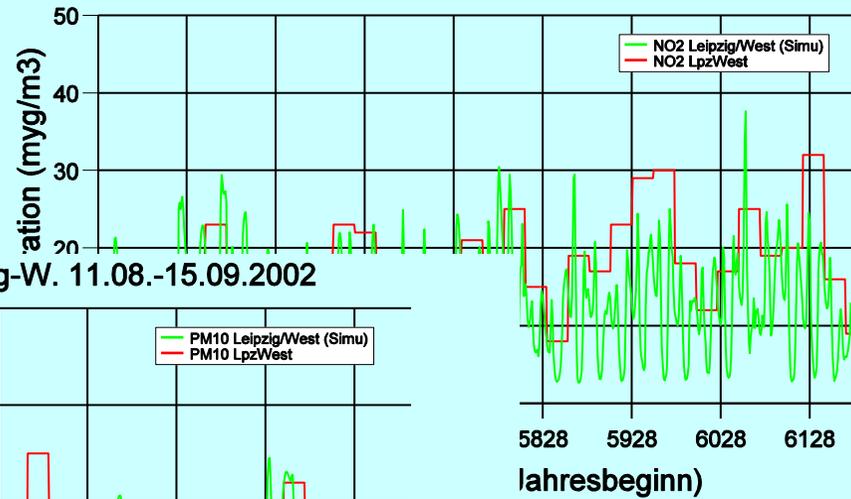


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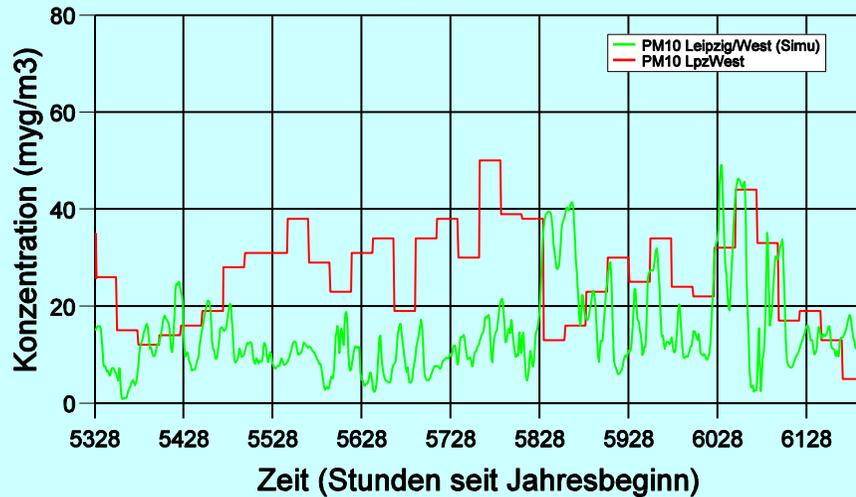
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### NO<sub>2</sub>-Konzentration Leipzig-W. 11.08.-15.09.2002



### PM<sub>10</sub>-Konzentration Leipzig-W. 11.08.-15.09.2002



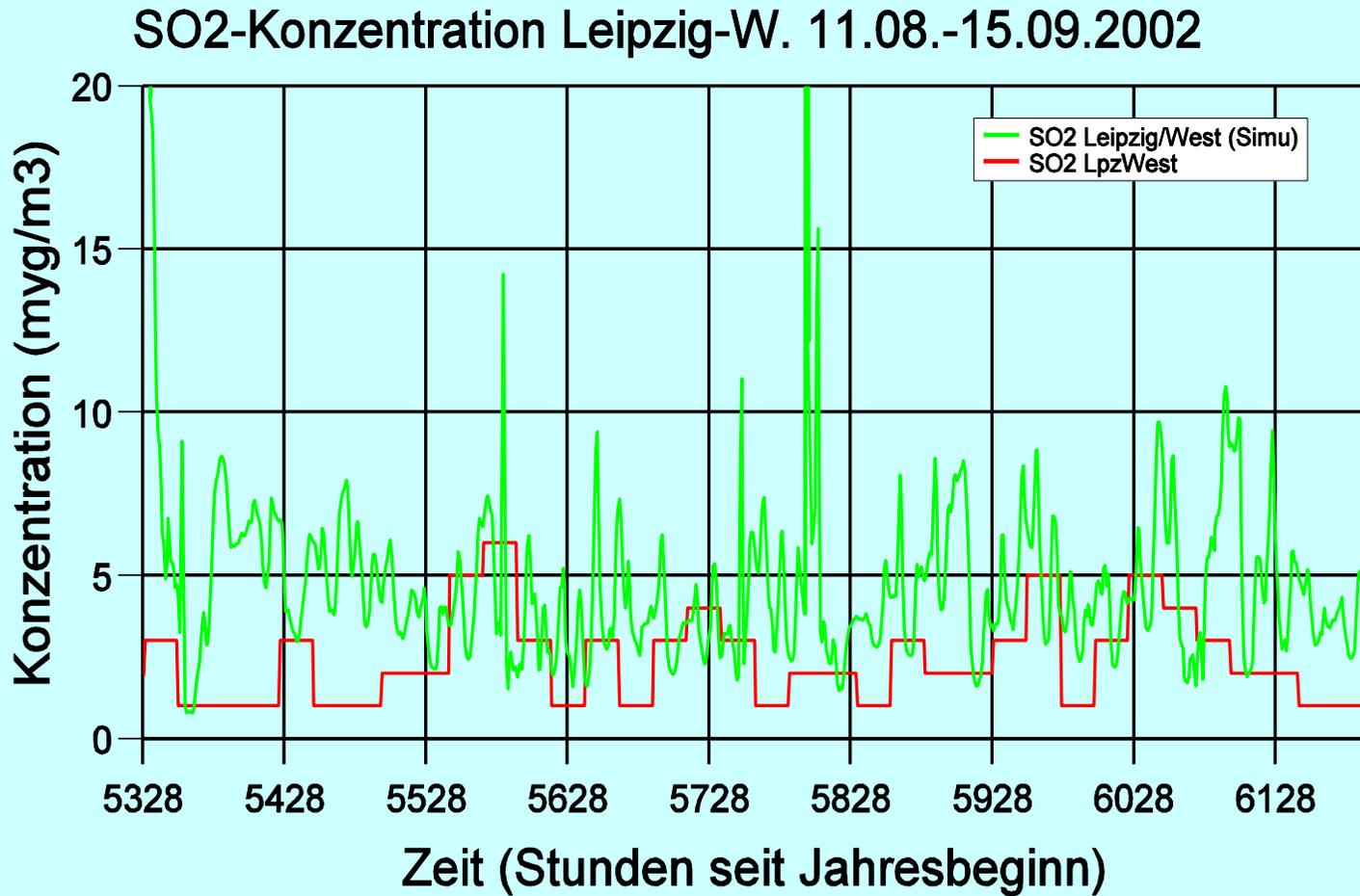
## Schadstoffkonzentrationen

- Simulation
- Stations-Messwerte



## Validierung des Modells

SO<sub>2</sub>-Konzentration Leipzig-W. 11.08.-15.09.2002



5328 5428 5528 5628 5728 5828 5928 6028 6128  
Zeit (Stunden seit Jahresbeginn)

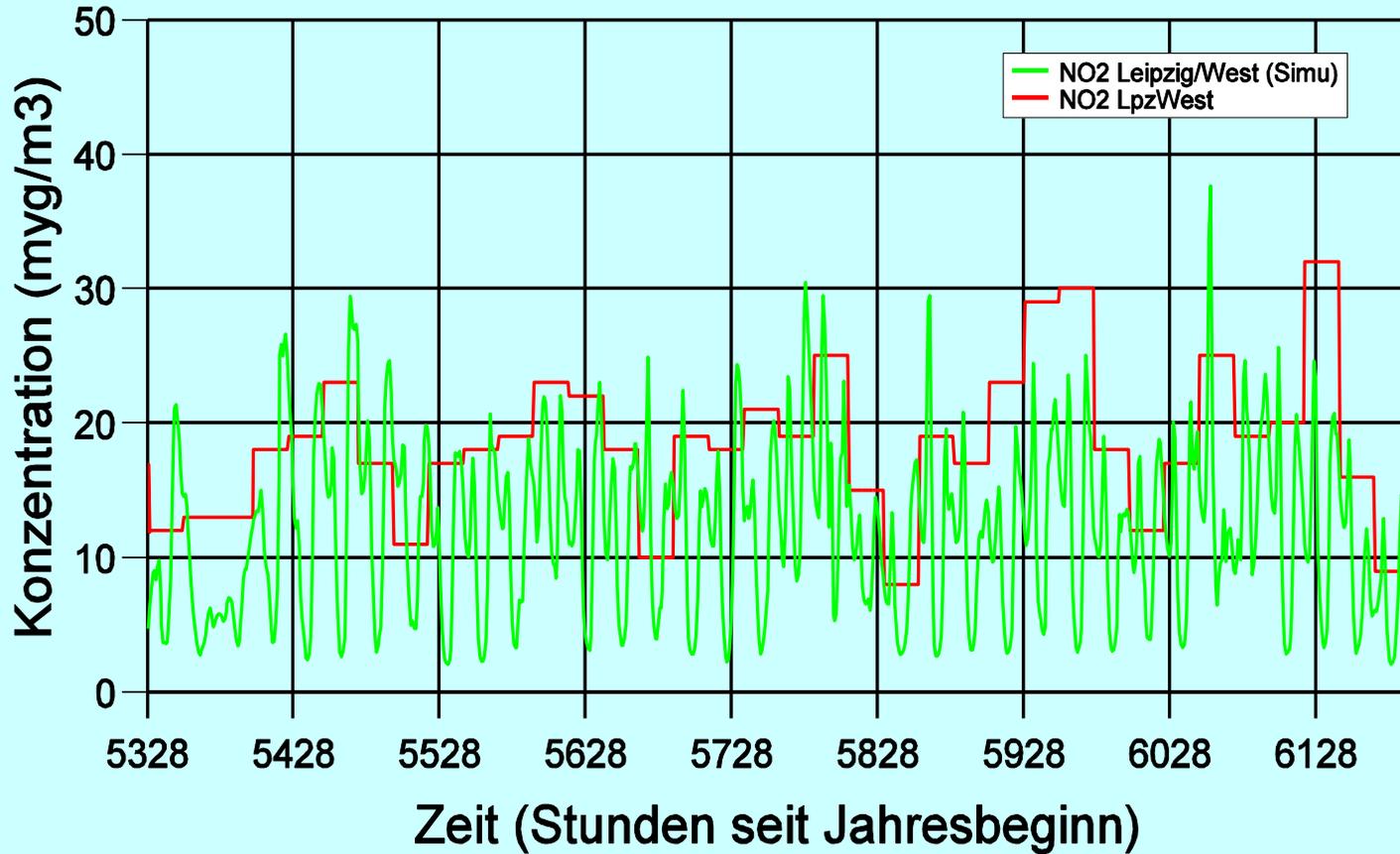
--- Simulation  
--- Stations-Messwerte



## Validierung des Modells

SO<sub>2</sub>-Konzentration Leipzig-W. 11.08.-15.09.2002

## NO<sub>2</sub>-Konzentration Leipzig-W. 11.08.-15.09.2002



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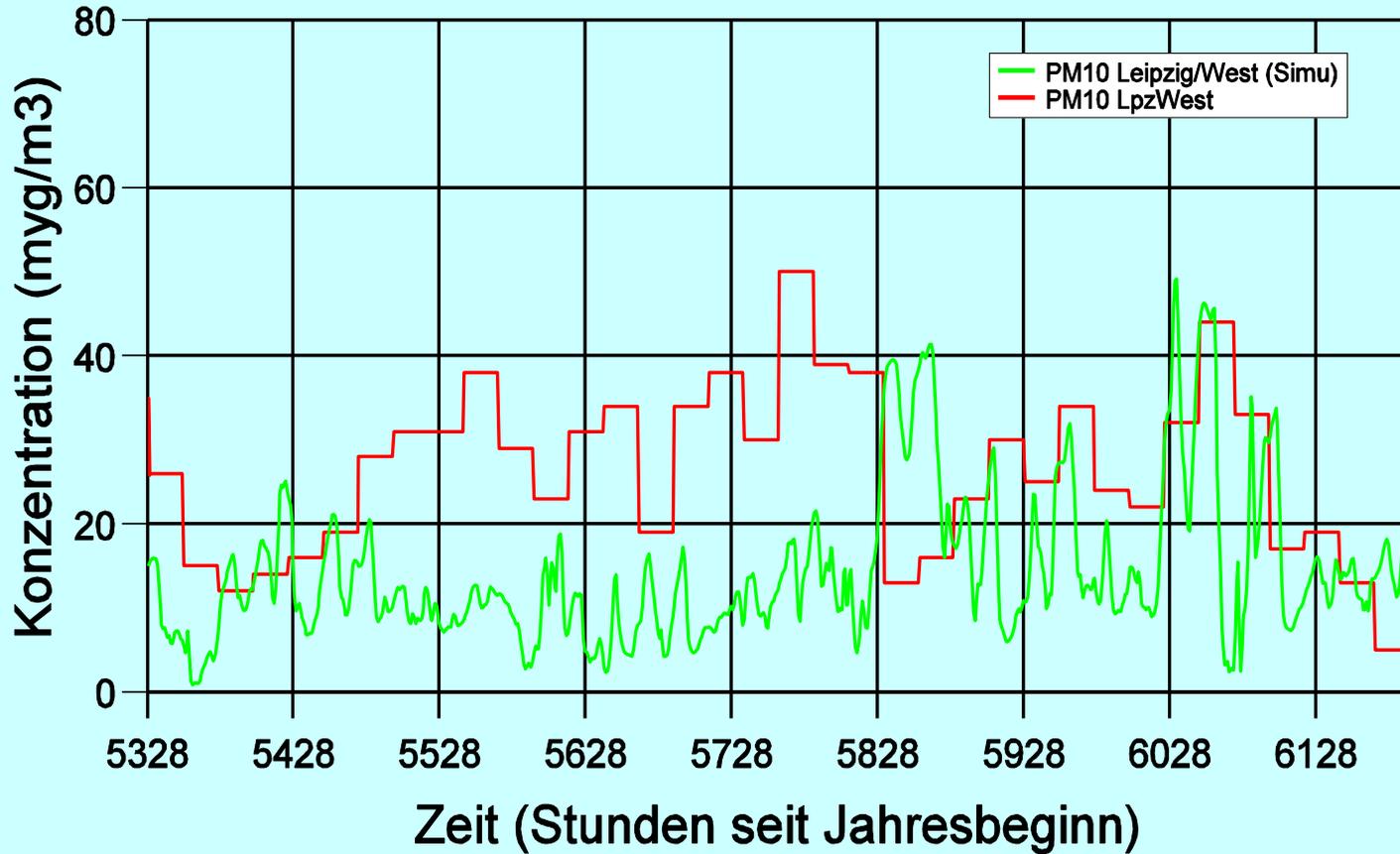
--- Simulation  
--- Stations-Messwerte



## Validierung des Modells

SO<sub>2</sub>-Konzentration Leipzig-W. 11.08.-15.09.2002

### PM<sub>10</sub>-Konzentration Leipzig-W. 11.08.-15.09.2002



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Zeit (Stunden seit Jahresbeginn)

--- Simulation  
--- Stations-Messwerte



V.

Ergebnisse

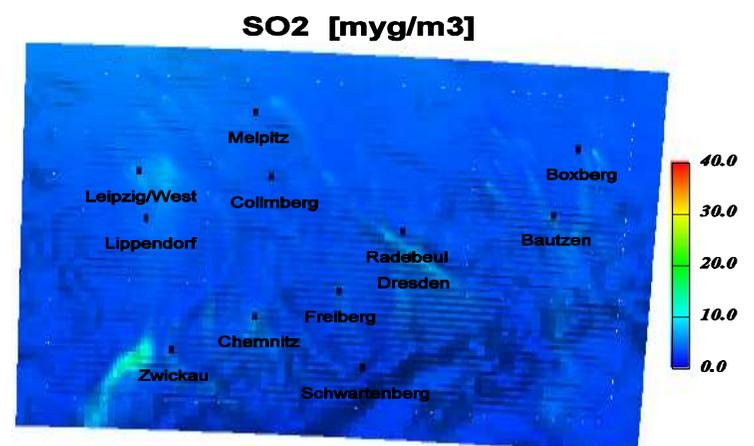
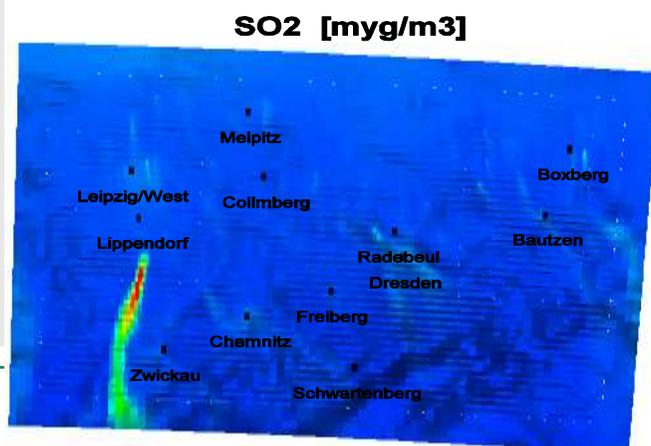
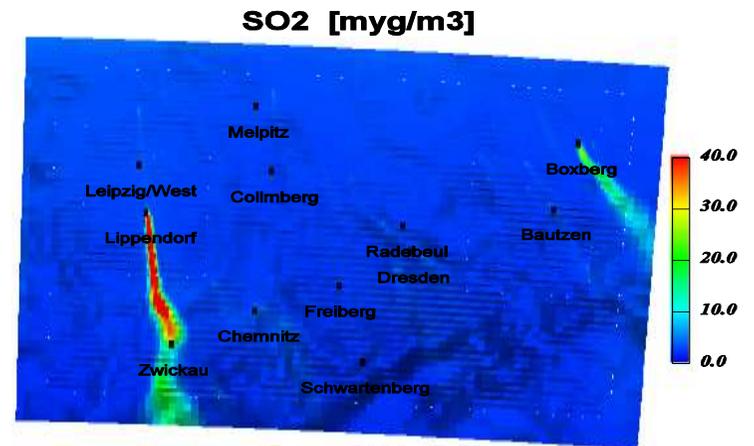
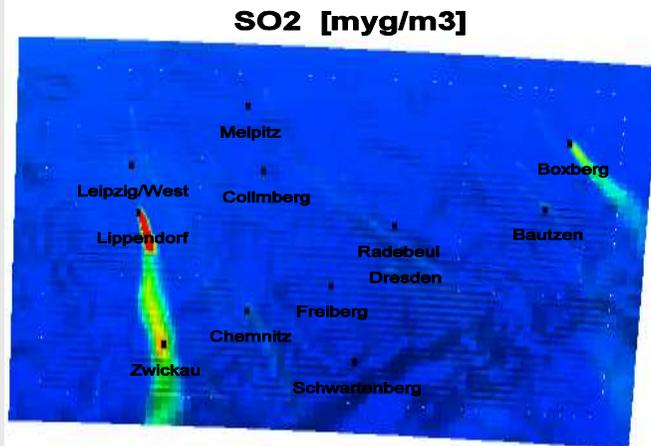
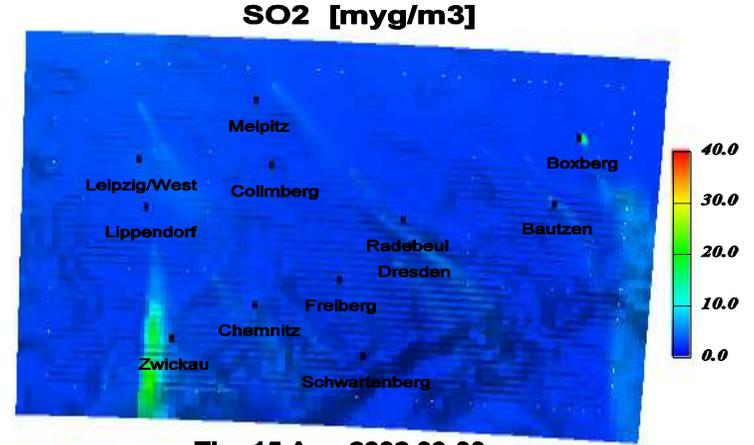
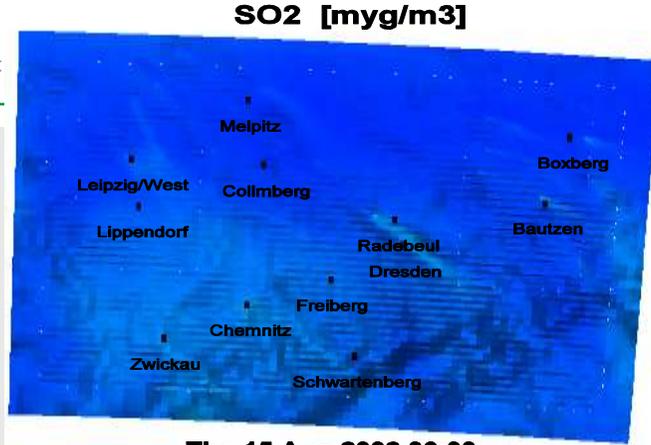


# Ergebnisse

40  
↑  
0  
µg/m<sup>3</sup>

## Sommertag S1

## SO<sub>2</sub> - Gesamt- Immission



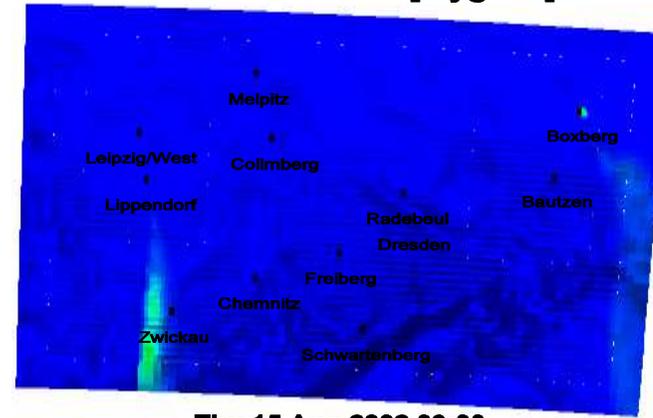
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Thu 15 Aug 2002 06:00

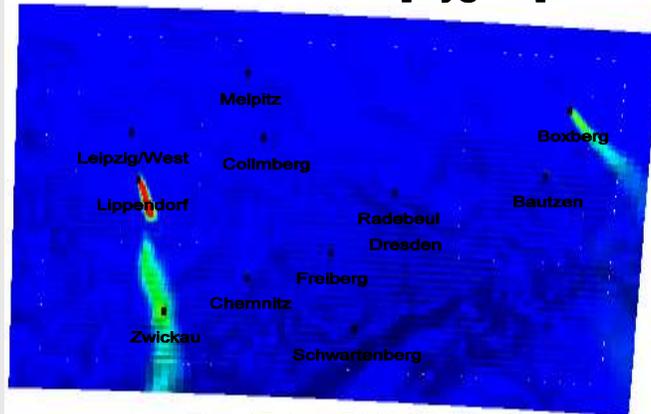
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SO<sub>2</sub>-Differenz [myg/m<sup>3</sup>]



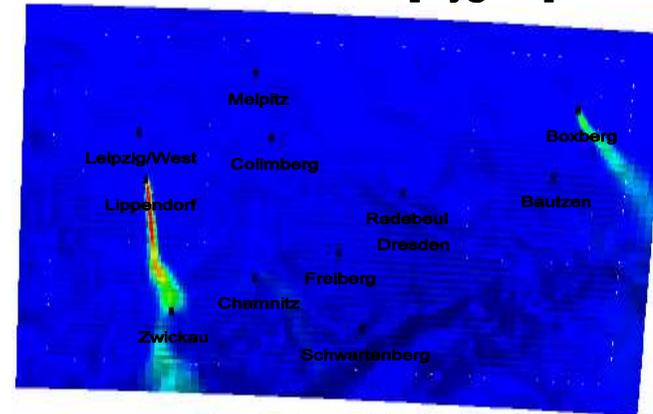
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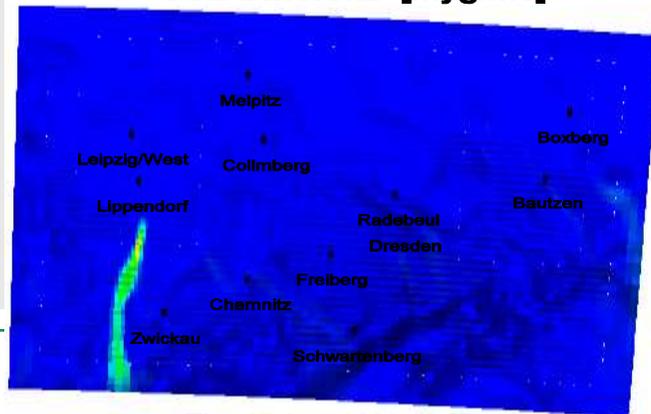
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SO<sub>2</sub>-Differenz [myg/m<sup>3</sup>]

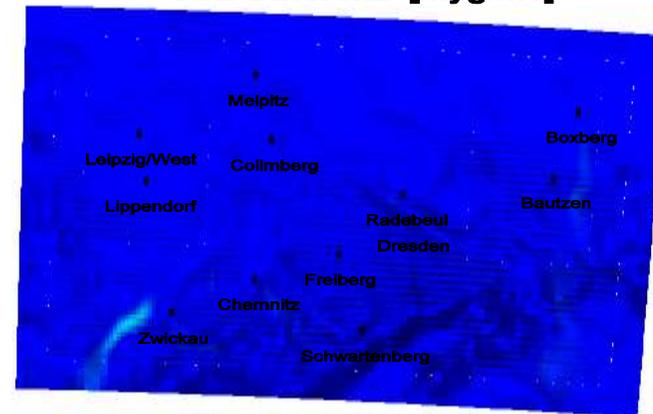


Thu 15 Aug 2002 15:00

SO<sub>2</sub>-Differenz [myg/m<sup>3</sup>]



Thu 15 Aug 2002 18:00



Thu 15 Aug 2002 21:00

# Ergebnisse

40  
↑  
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µg/m<sup>3</sup>

Sommertag  
S1

SO<sub>2</sub>-  
Imm-  
Zusatz-  
belastung

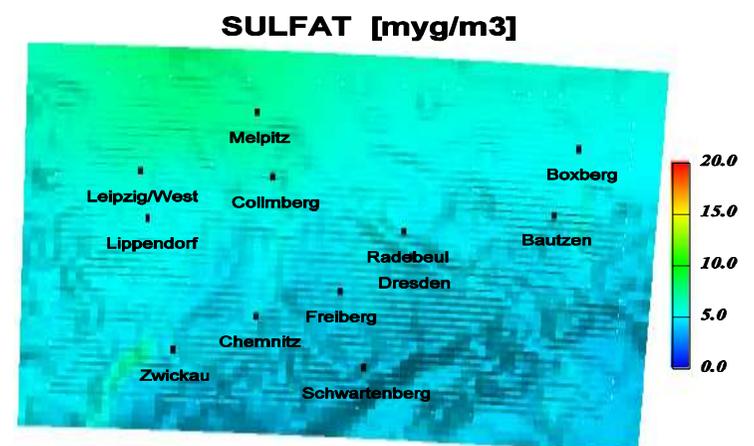
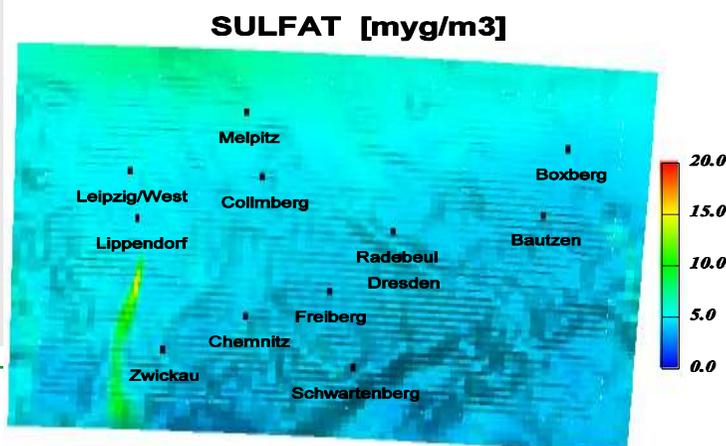
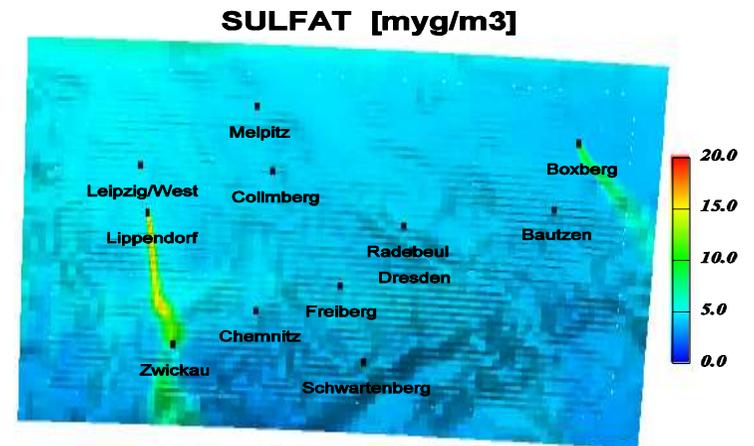
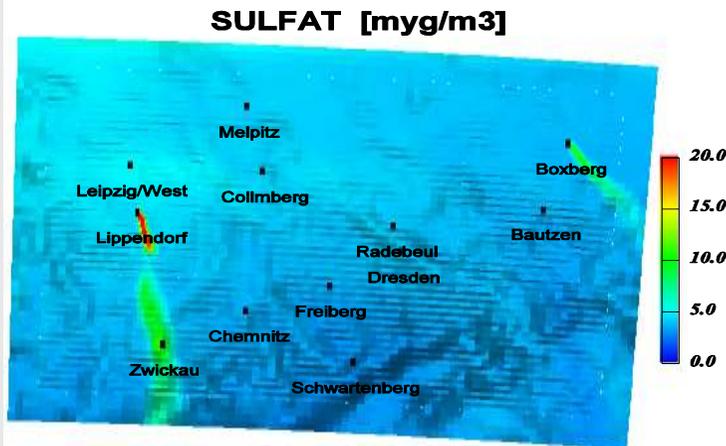
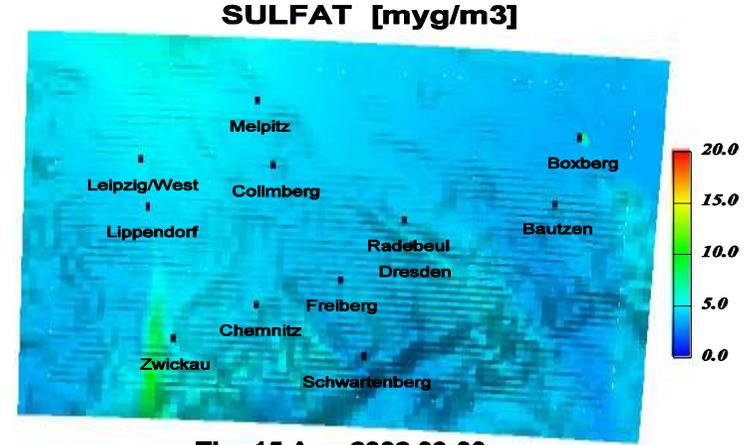
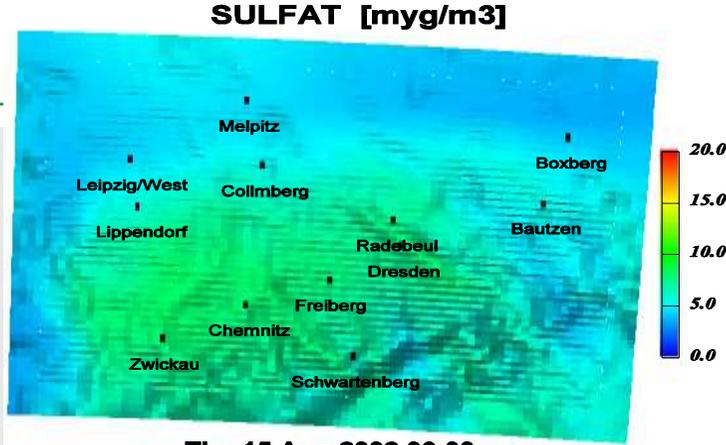


# Ergebnisse

20  
↑  
0  
 $\mu\text{g}/\text{m}^3$

Sommertag  
S1

SULFAT-  
Gesamt-  
Immission



**SULFAT-Differenz [myg/m3]**

**SULFAT-Differenz [myg/m3]**

**Ergebnisse**

10  
↑  
0  
µg/m<sup>3</sup>

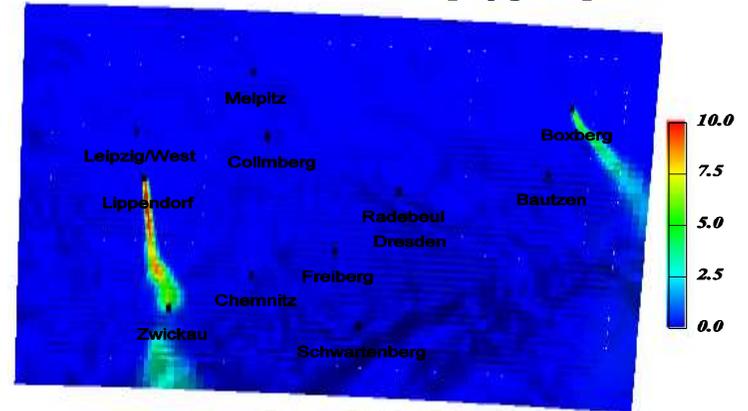
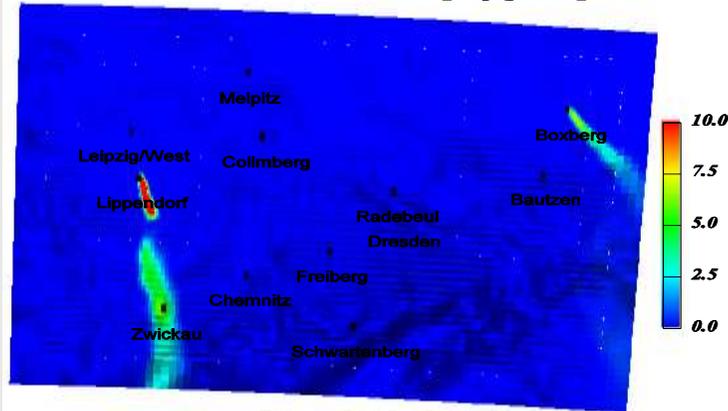


Thu 15 Aug 2002 06:00

Thu 15 Aug 2002 09:00

**SULFAT-Differenz [myg/m3]**

**SULFAT-Differenz [myg/m3]**



Thu 15 Aug 2002 12:00

Thu 15 Aug 2002 15:00

**SULFAT-Differenz [myg/m3]**

**SULFAT-Differenz [myg/m3]**



Thu 15 Aug 2002 18:00

Thu 15 Aug 2002 21:00

Sommertag  
S1

SULFAT-  
Imm-  
Zusatz-  
belastung

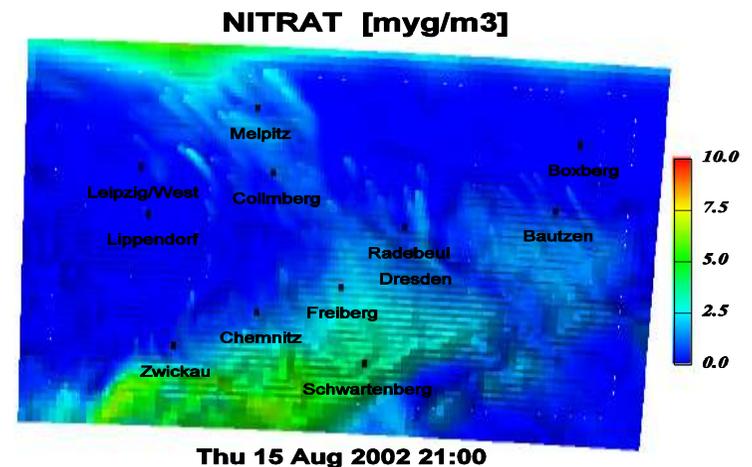
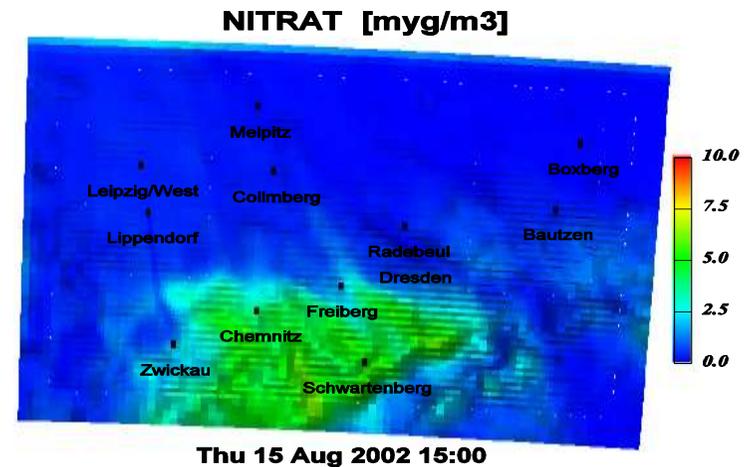
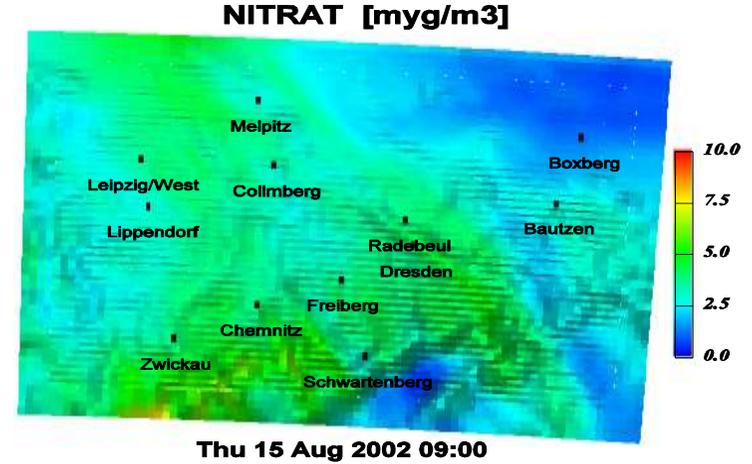
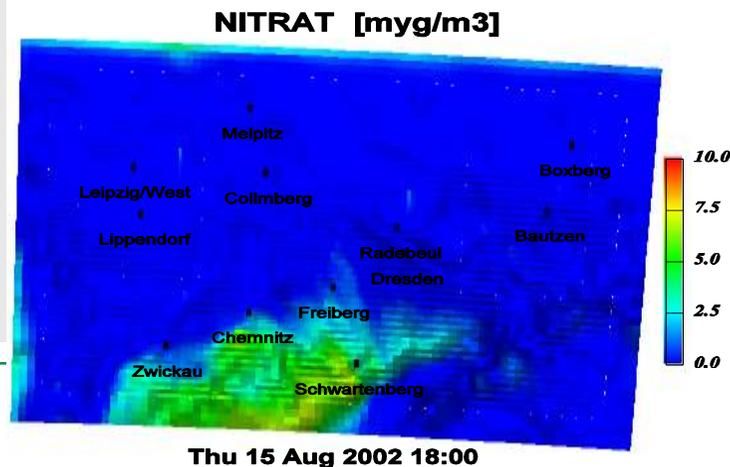
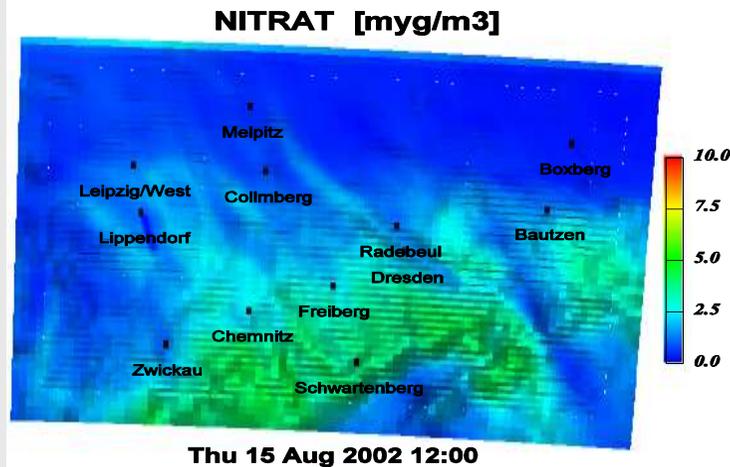
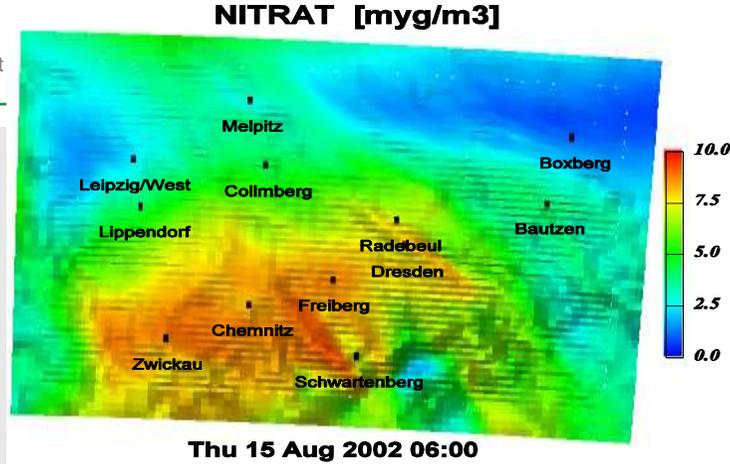


# Ergebnisse

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µg/m<sup>3</sup>

## Sommertag S1

## NITRAT- Gesamt- Immission

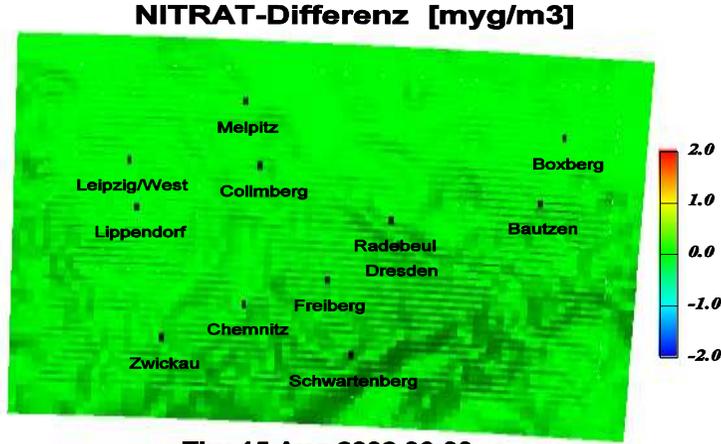


# Ergebnisse

2  
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µg/m<sup>3</sup>

Sommertag  
S1

NITRAT-  
Imm-  
Zusatz-  
belastung



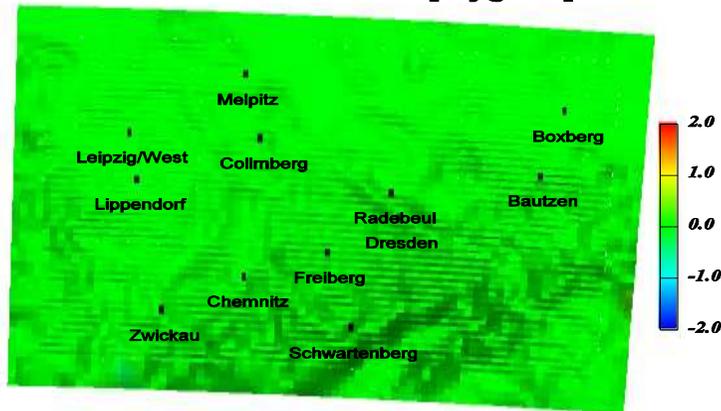
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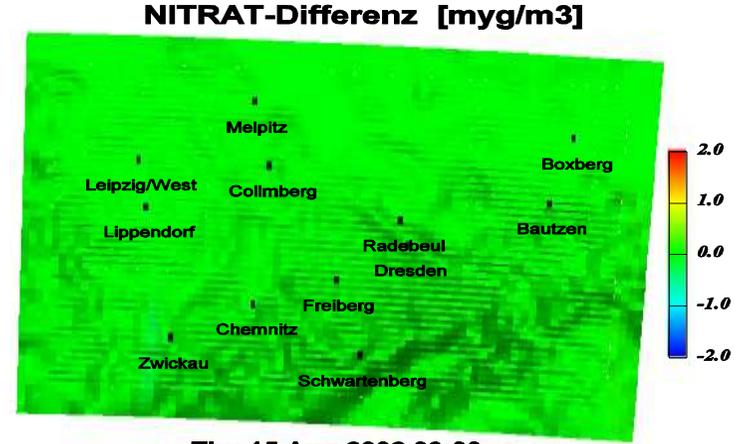


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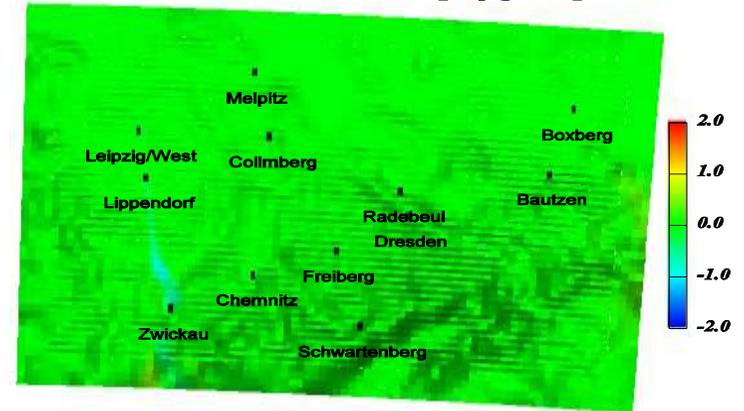


Thu 15 Aug 2002 18:00



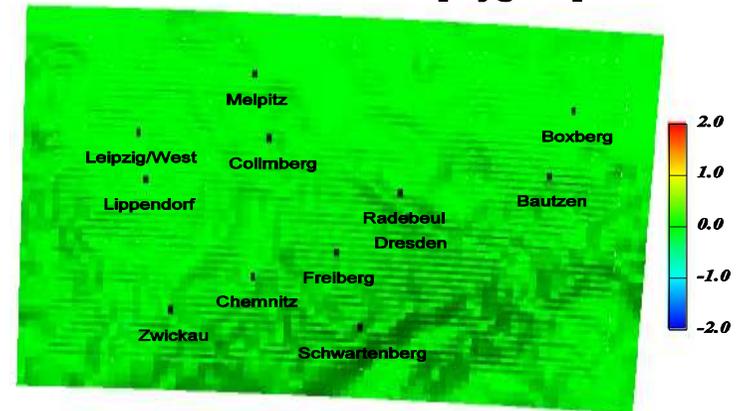
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NITRAT-Differenz [myg/m3]



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NITRAT-Differenz [myg/m3]



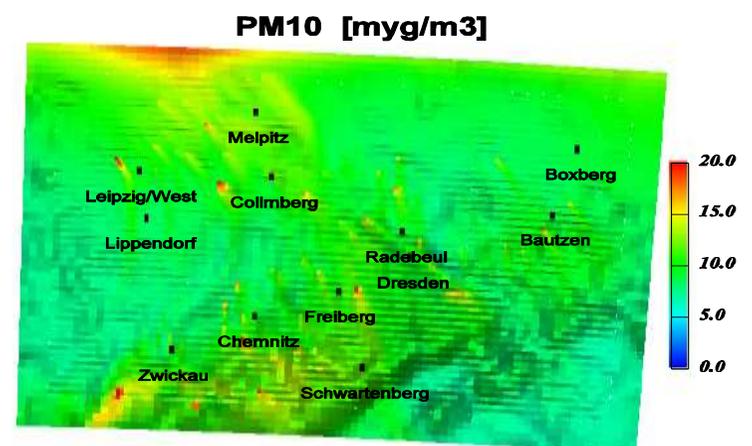
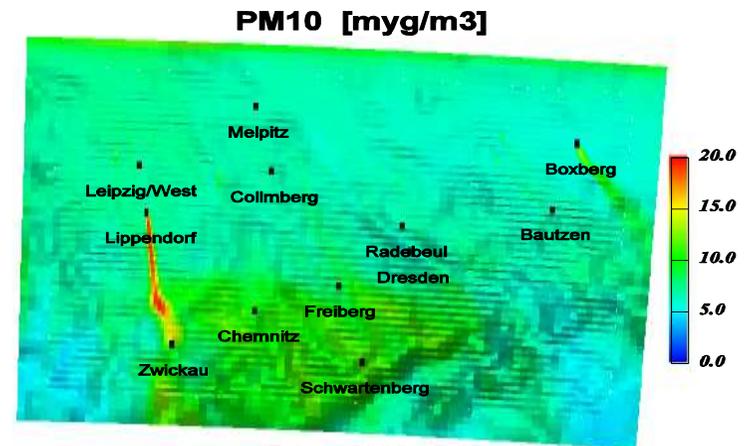
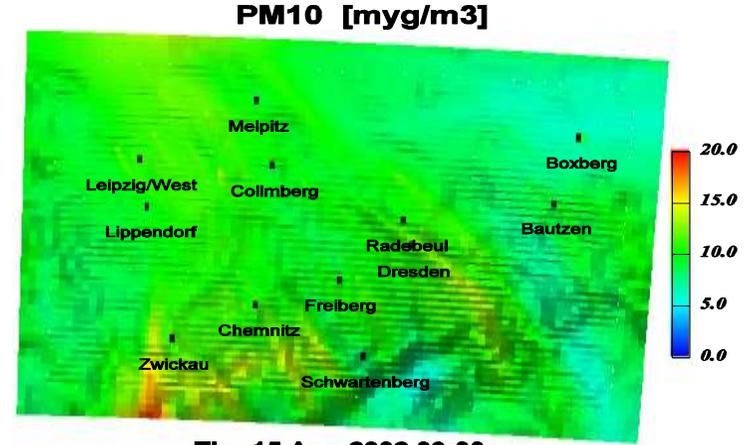
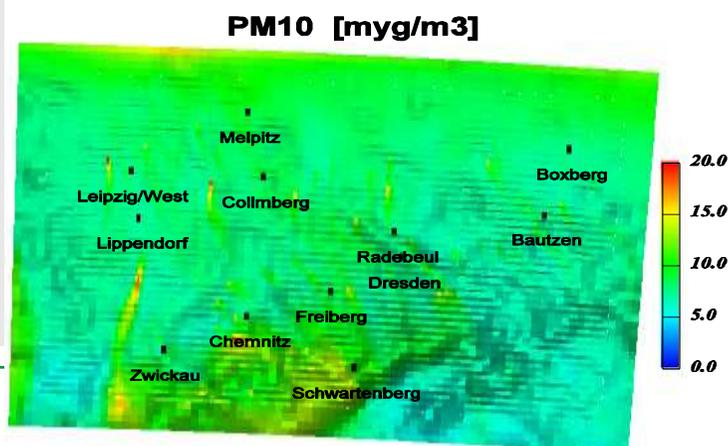
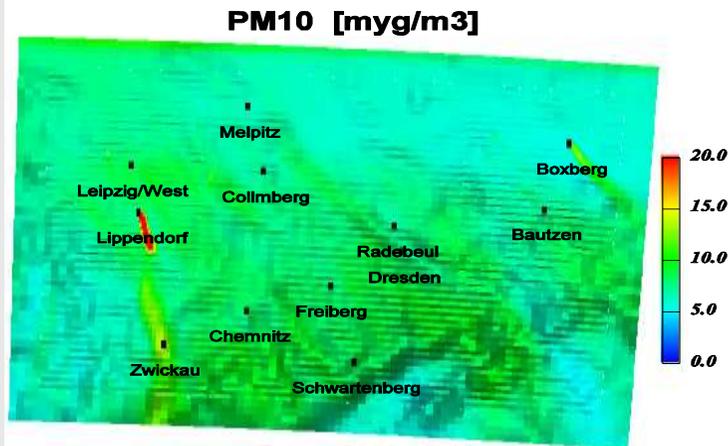
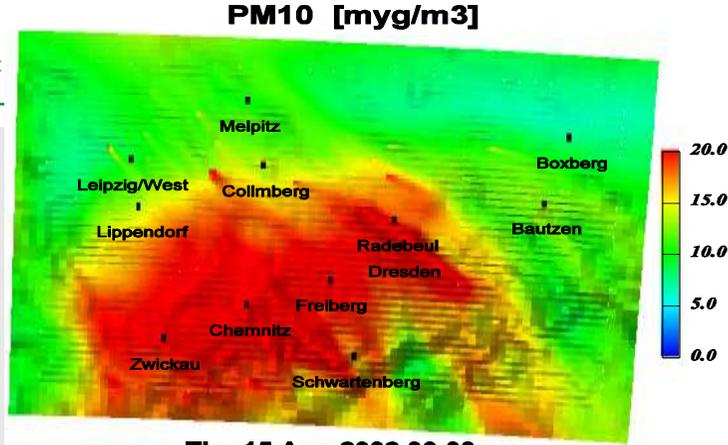
Thu 15 Aug 2002 21:00

# Ergebnisse

20  
↑  
0  
 $\mu\text{g}/\text{m}^3$

## Sommertag S1

### $\text{PM}_{10}$ - Gesamt- Immission

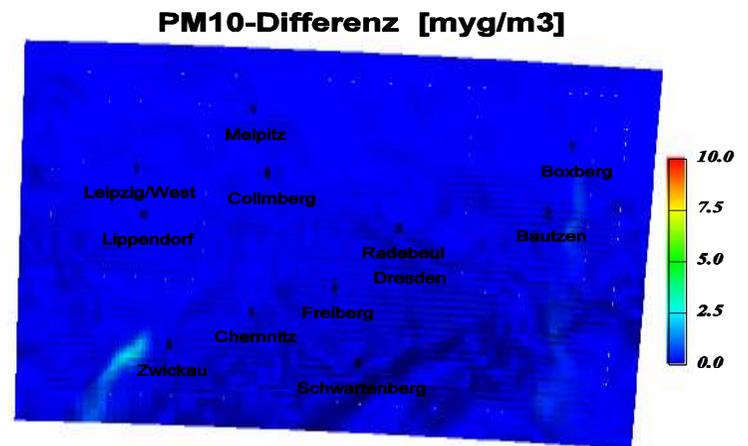
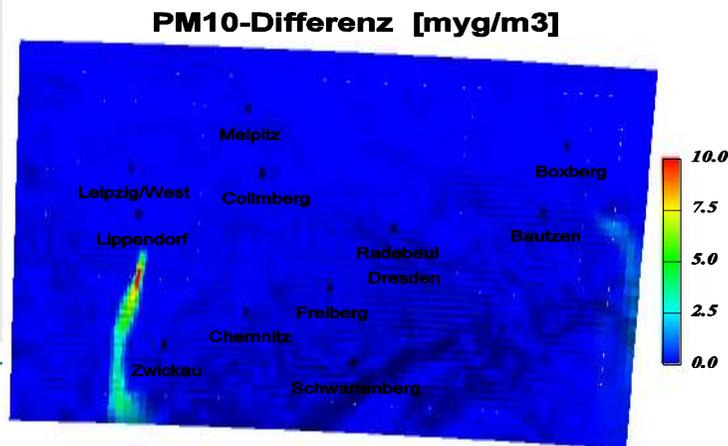
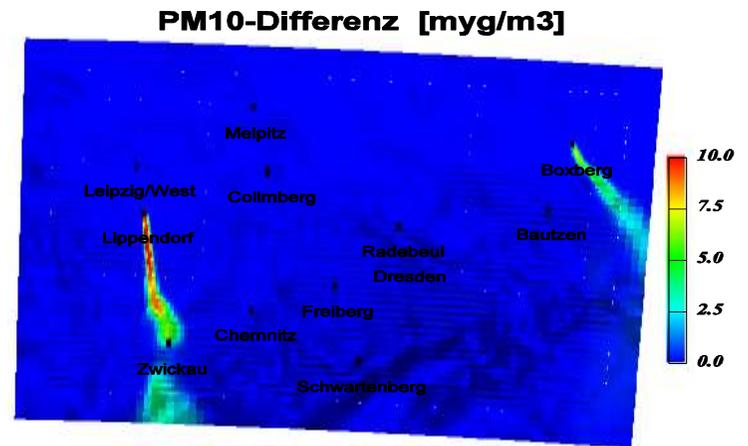
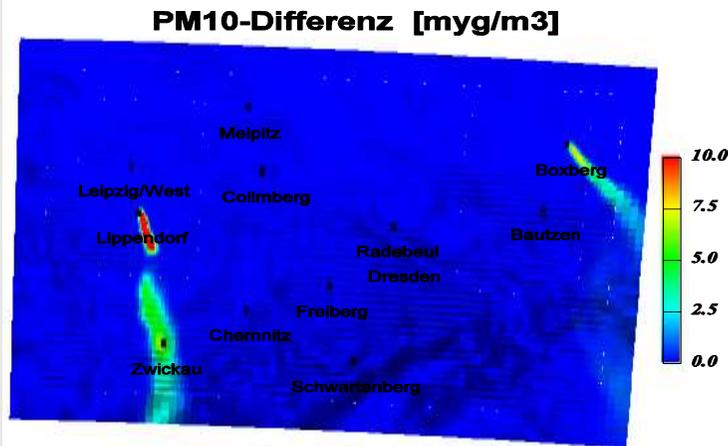
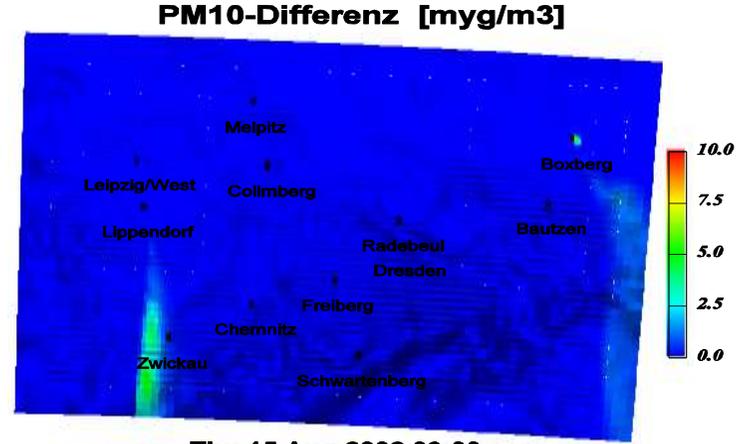
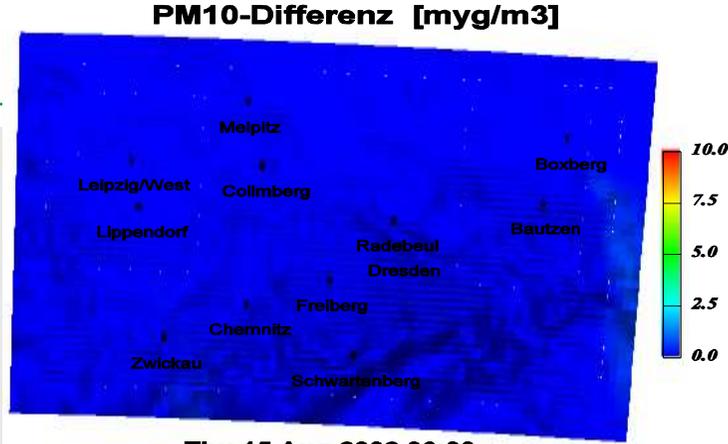


# Ergebnisse

10  
↑  
0  
µg/m<sup>3</sup>

Sommertag  
S1

PM<sub>10</sub> –  
Imm-  
Zusatz-  
belastung

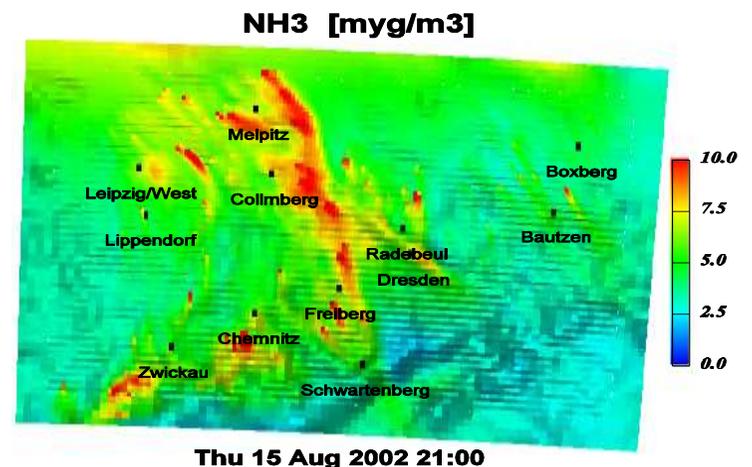
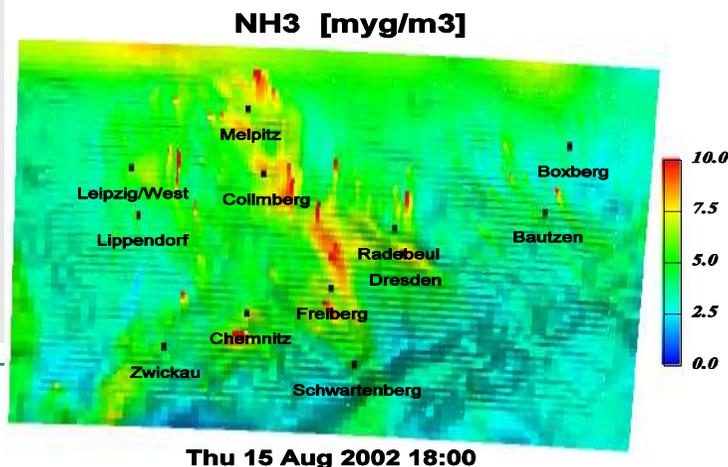
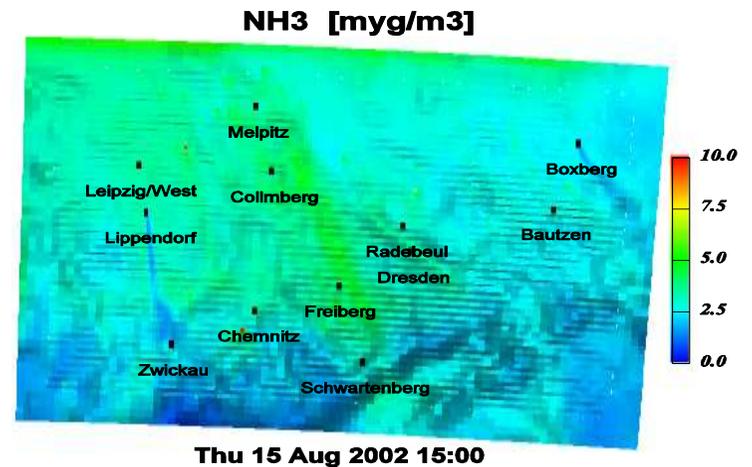
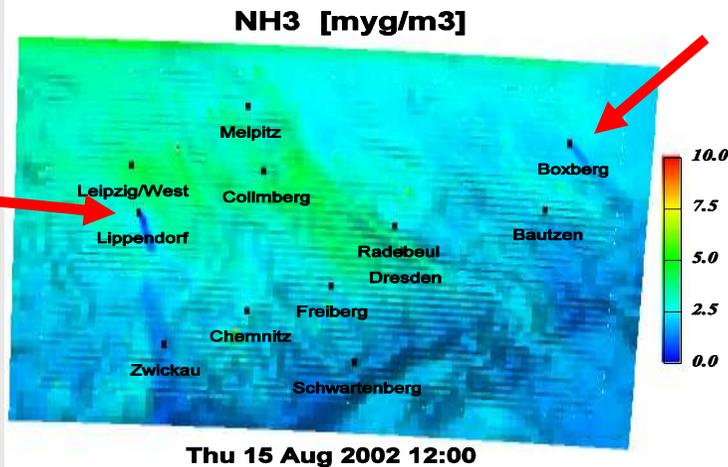
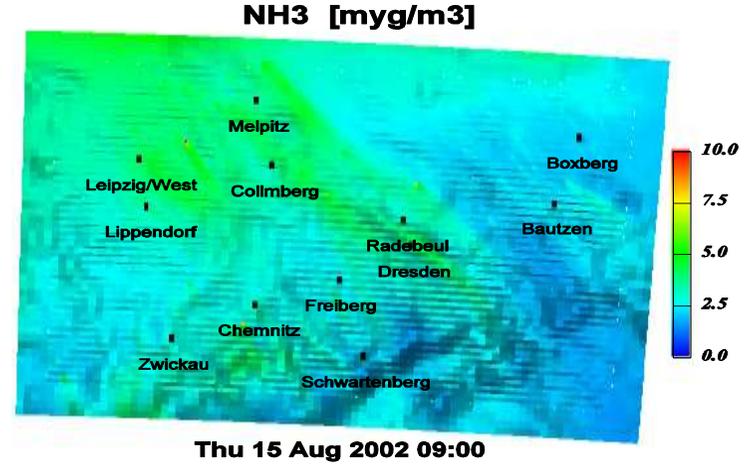
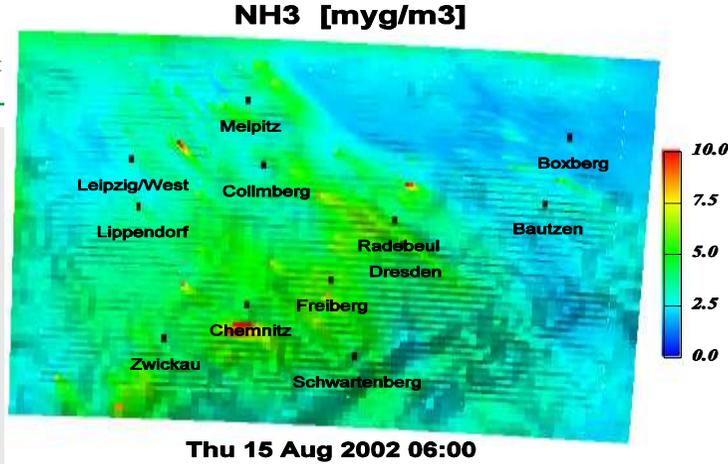


# Ergebnisse

10  
↑  
0  
 $\mu\text{g}/\text{m}^3$

Sommertag  
S1

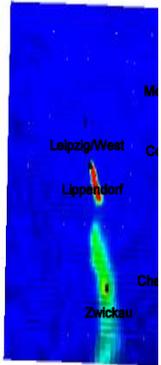
$\text{NH}_3$  –  
Gesamt-  
Immission



# PM10-Differenz [myg/m<sup>3</sup>]

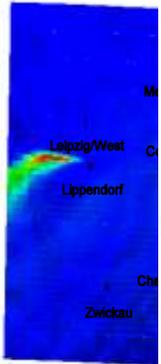
Ergebnis

PM10



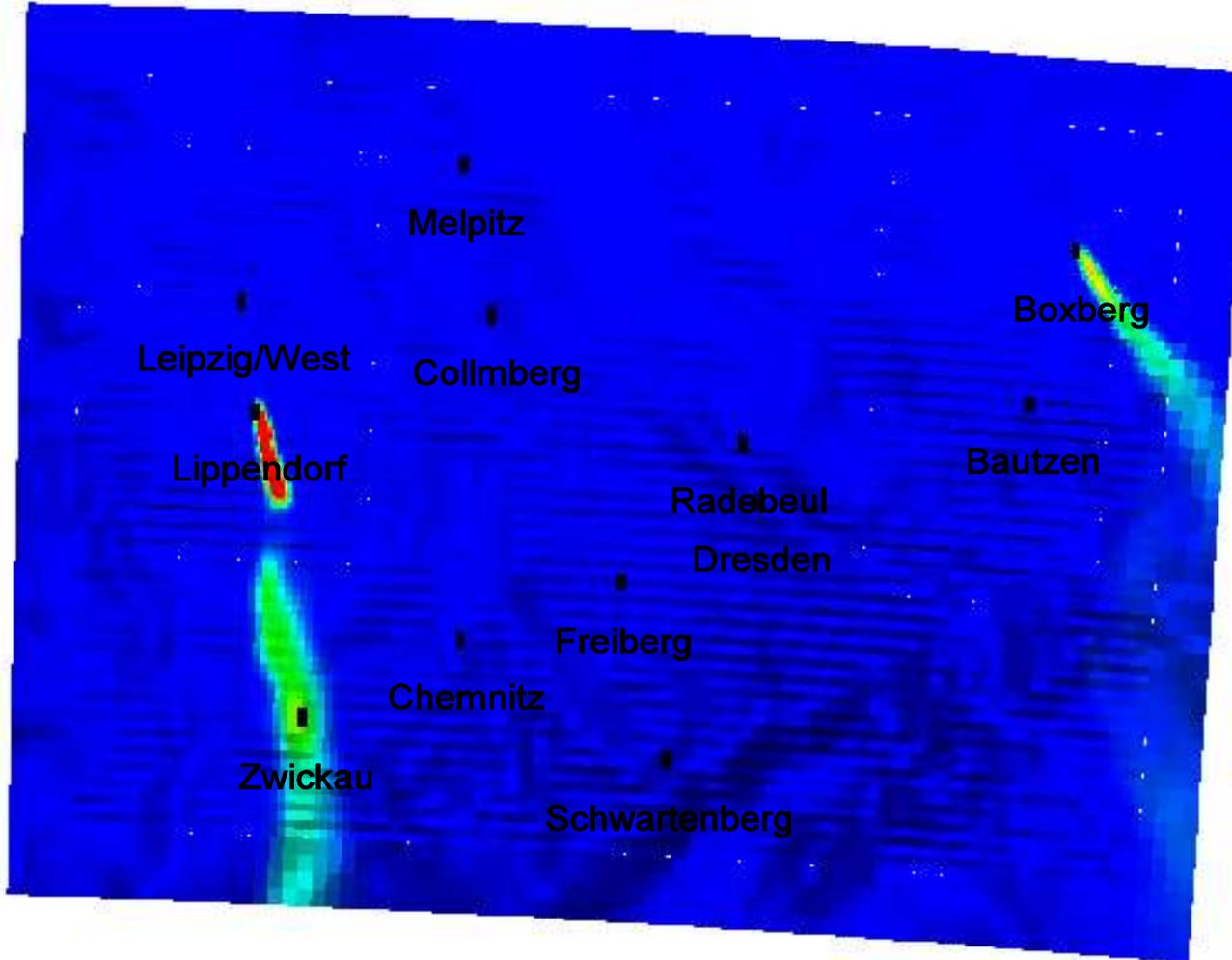
Thu

PM10

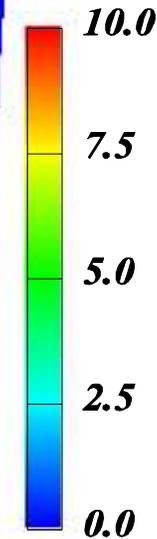


Sat

S

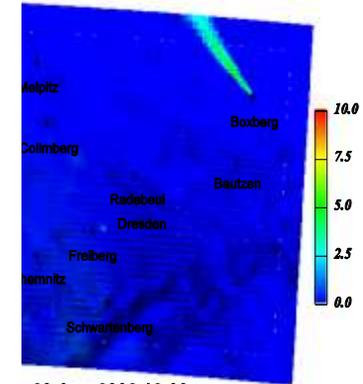


Thu 15 Aug 2002 12:00



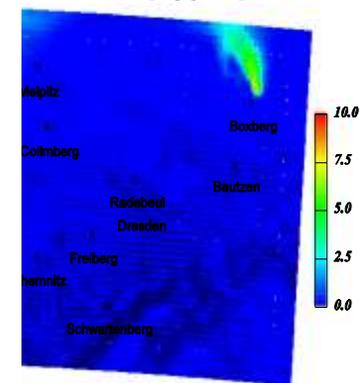
0-Differenz [myg/m<sup>3</sup>]

6



20 Aug 2002 12:00

0-Differenz [myg/m<sup>3</sup>]



22 Aug 2002 12:00

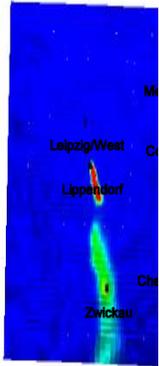
missions-  
elastung



# PM10-Differenz [myg/m<sup>3</sup>]

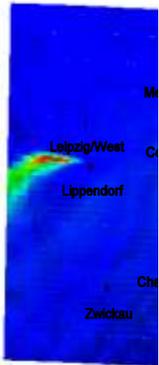
Ergebnis

PM10



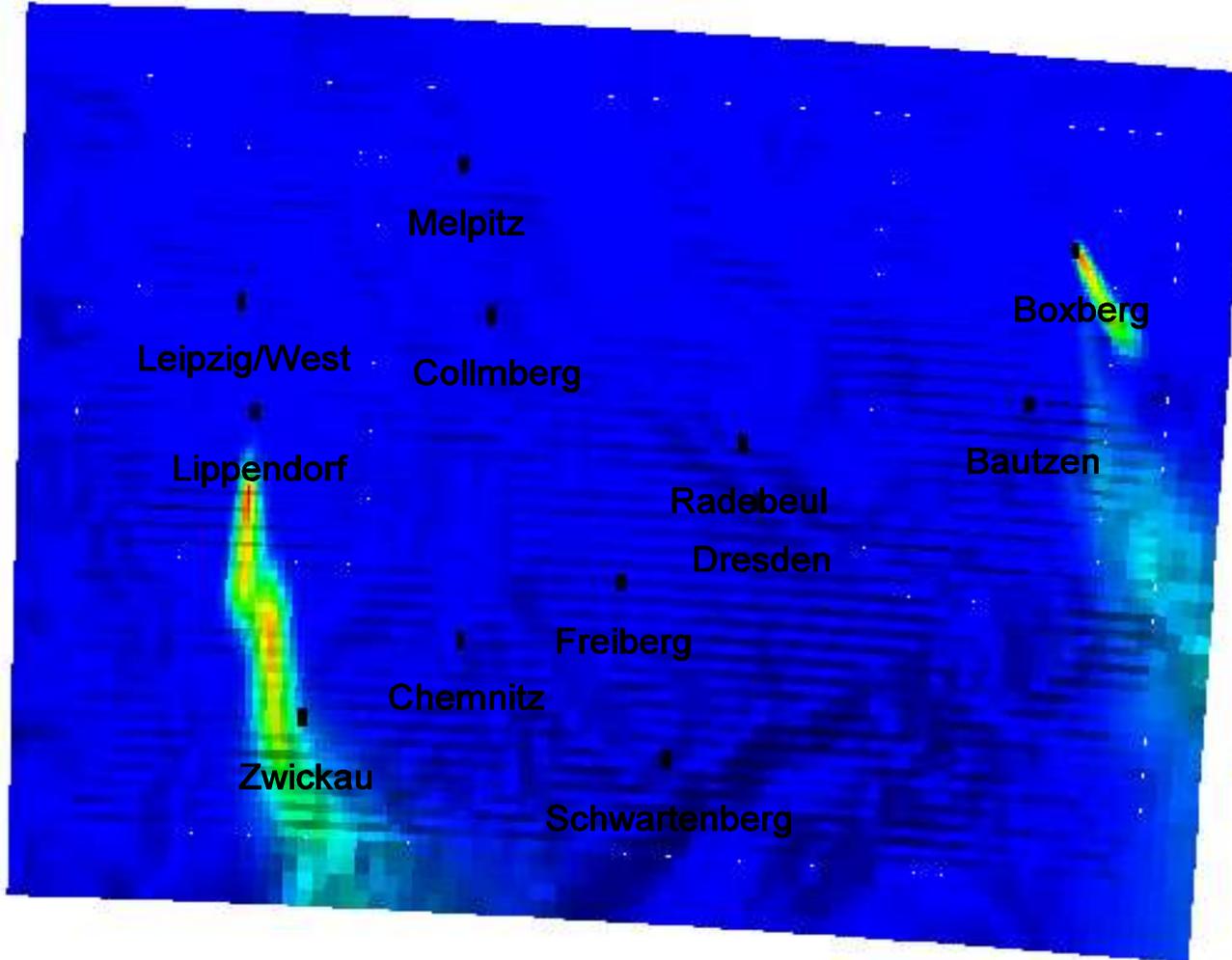
Thu

PM10

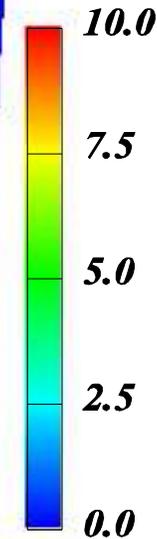


Sat

Son

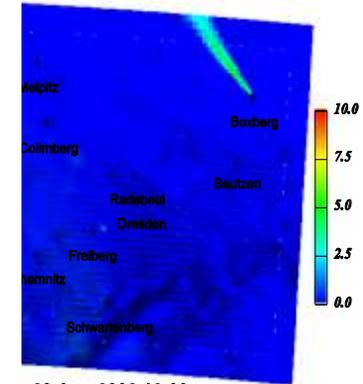


Fri 16 Aug 2002 12:00



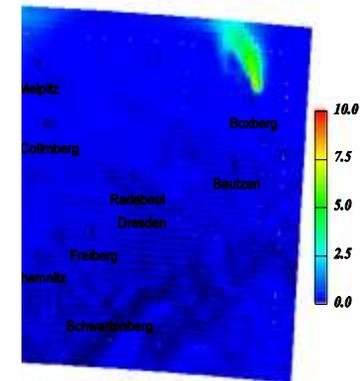
6

0-Differenz [myg/m<sup>3</sup>]



20 Aug 2002 12:00

0-Differenz [myg/m<sup>3</sup>]



22 Aug 2002 12:00

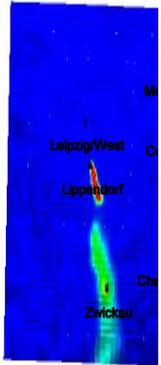
missions-  
elastung



# PM10-Differenz [myg/m<sup>3</sup>]

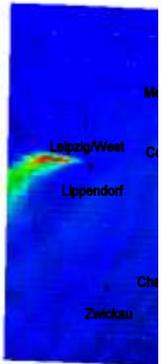
Ergebnis

PM10

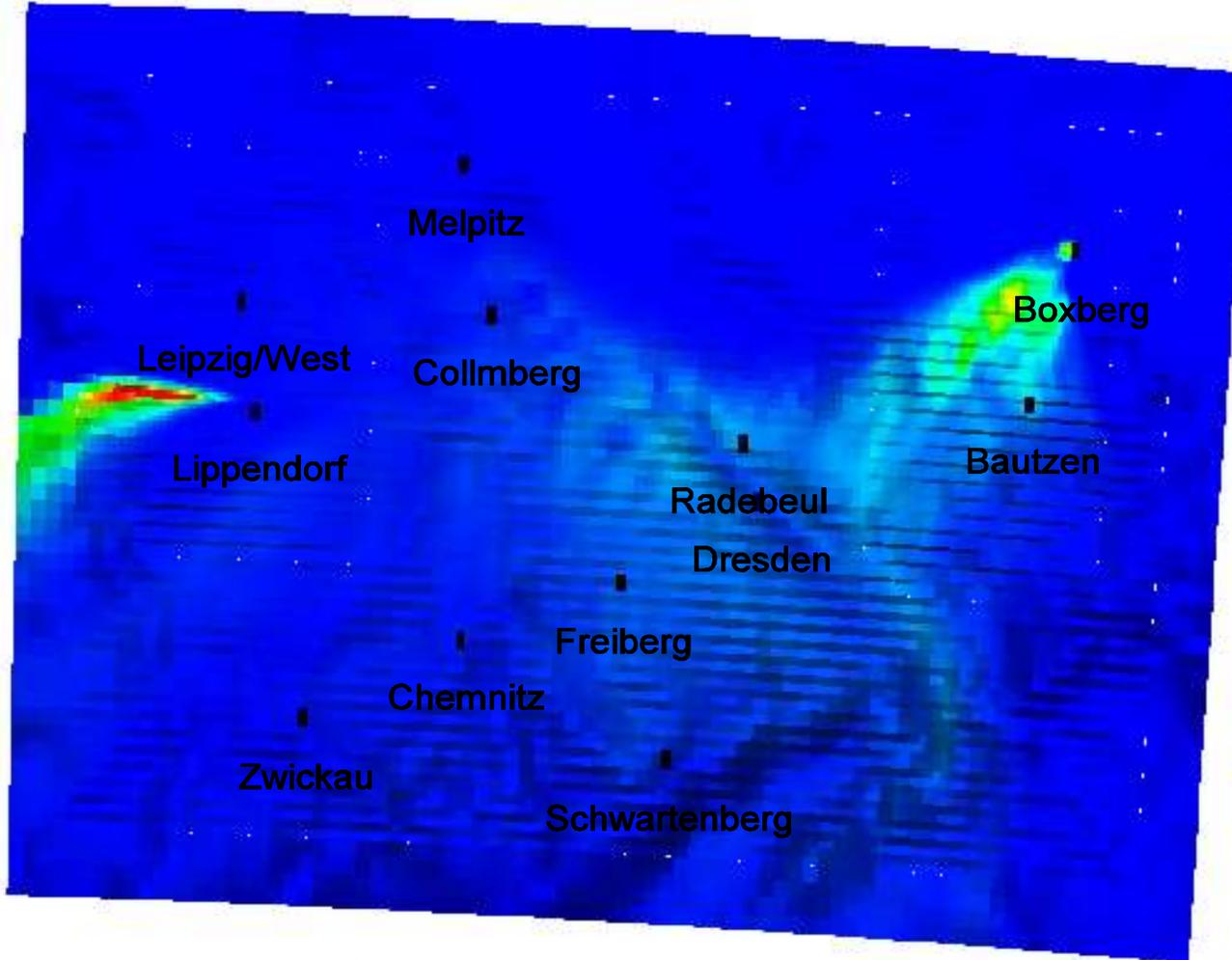


Thu

PM10

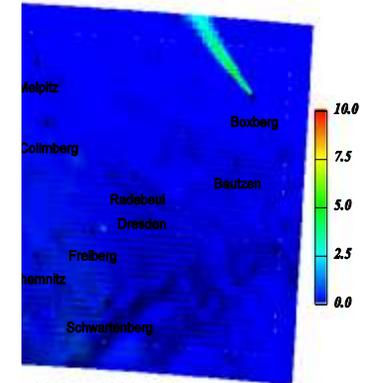


Sat



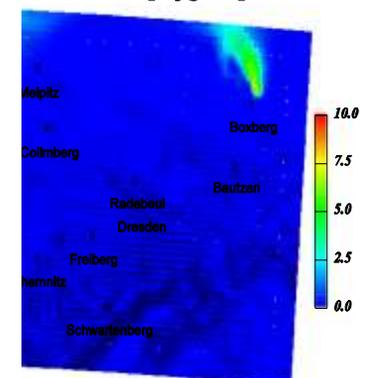
Sat 17 Aug 2002 12:00

0-Differenz [myg/m<sup>3</sup>]



20 Aug 2002 12:00

0-Differenz [myg/m<sup>3</sup>]



22 Aug 2002 12:00

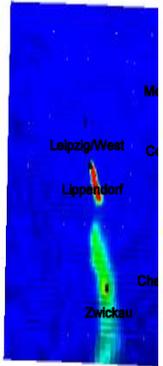
missions-  
elastung



# PM10-Differenz [myg/m<sup>3</sup>]

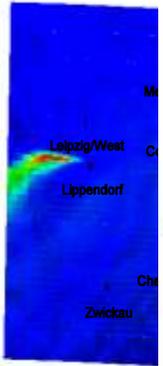
Ergebnis

PM10



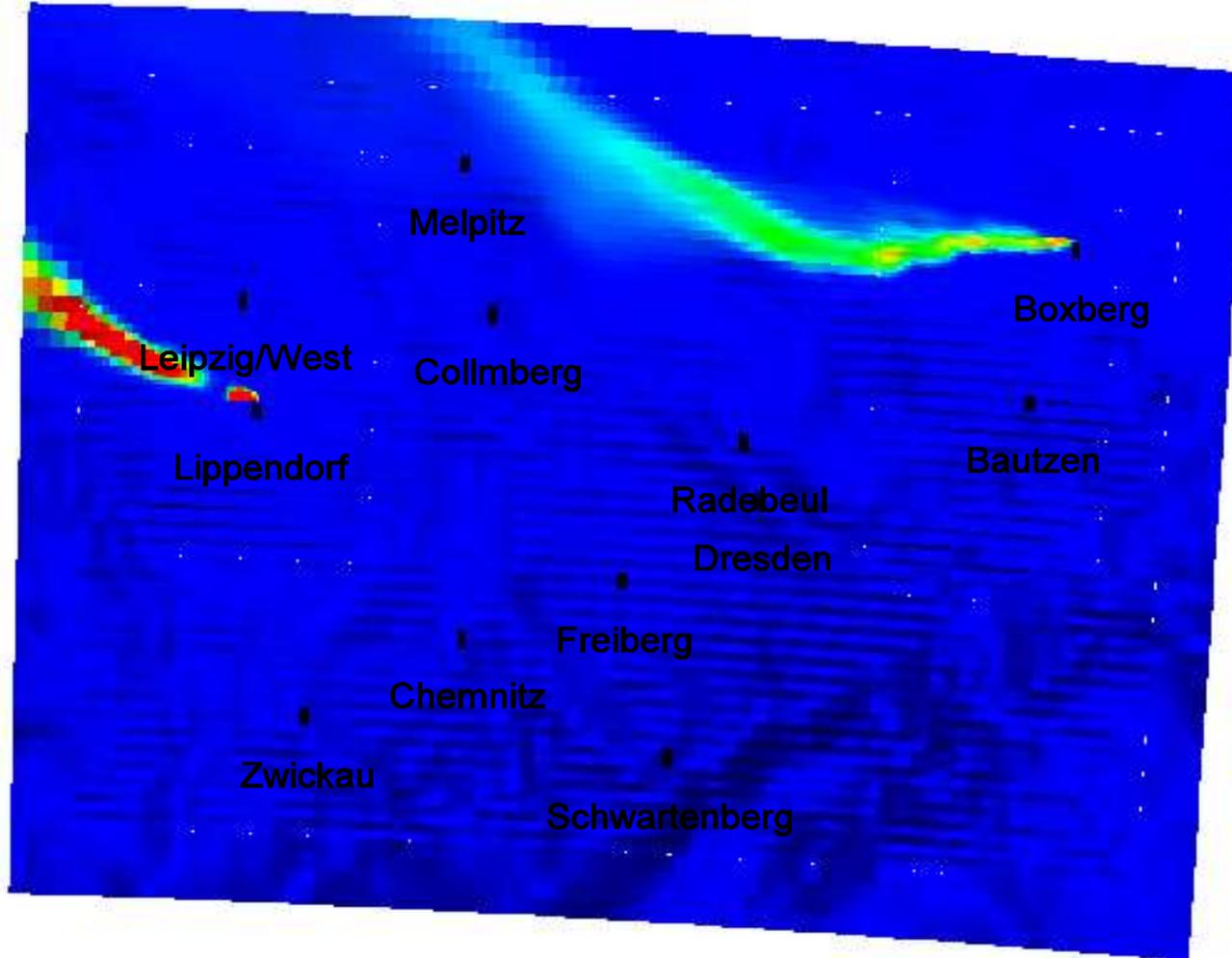
Thu

PM10

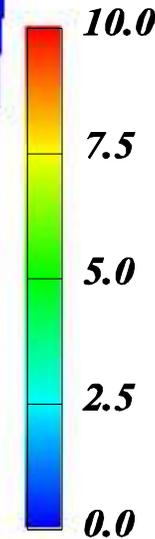


Sat

Son

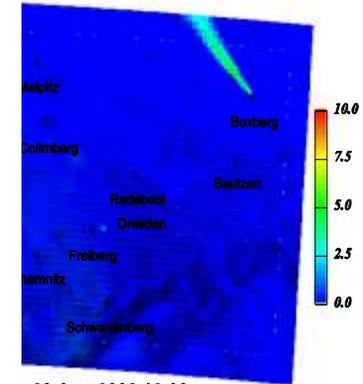


Sun 18 Aug 2002 12:00



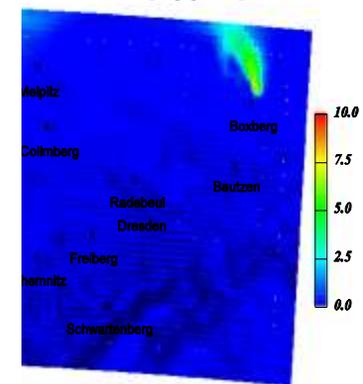
6

0-Differenz [myg/m<sup>3</sup>]



20 Aug 2002 12:00

0-Differenz [myg/m<sup>3</sup>]



22 Aug 2002 12:00

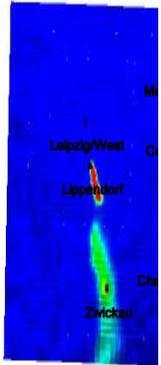
missions-  
belastung



# PM10-Differenz [myg/m<sup>3</sup>]

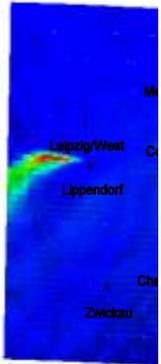
Ergebnis

PM10



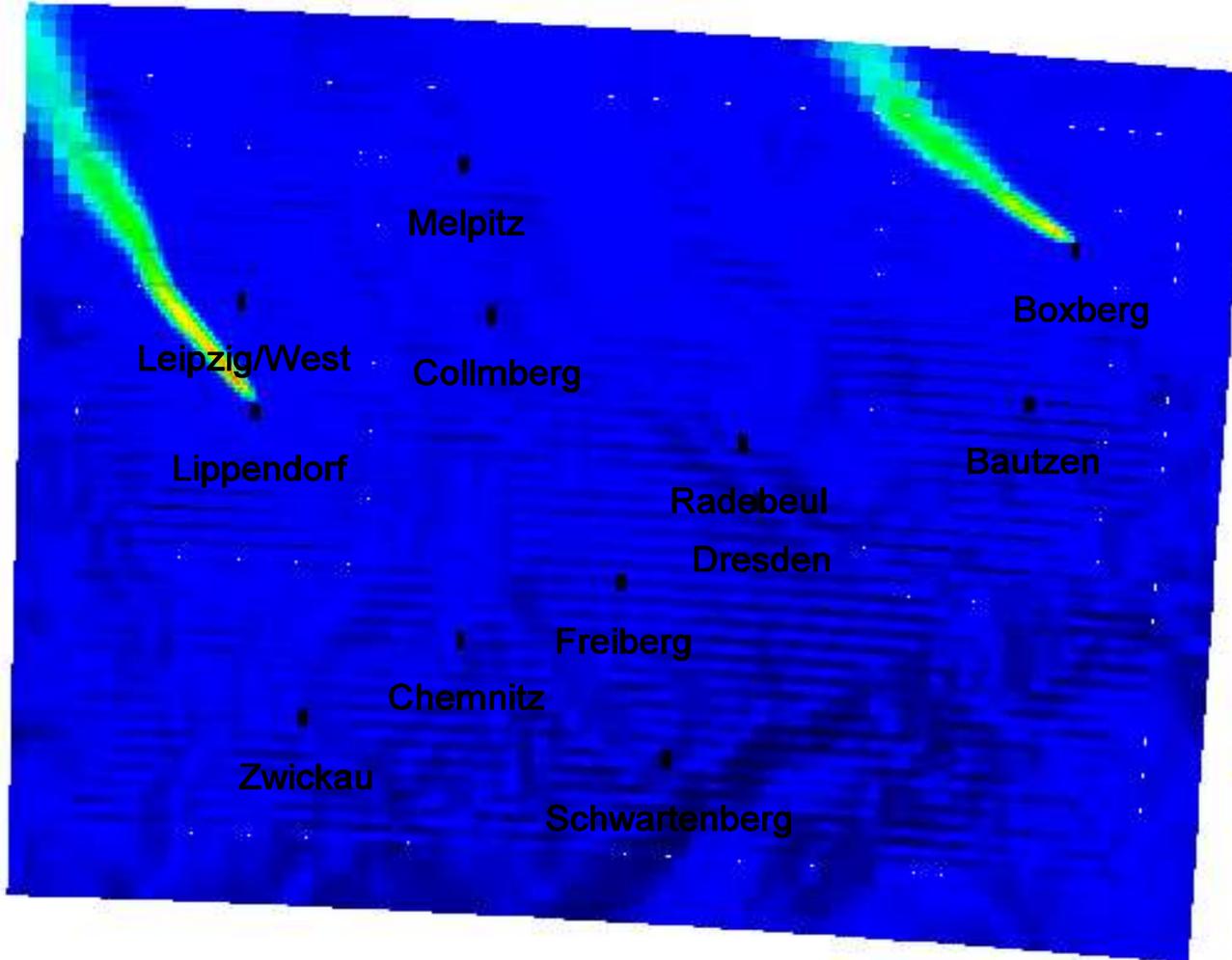
Thu

PM10



Sat

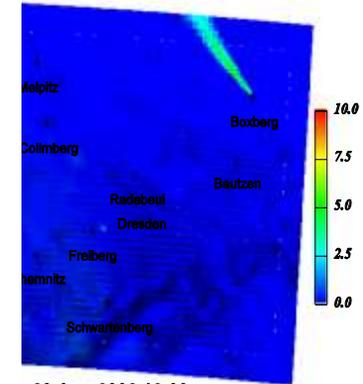
S



Mon 19 Aug 2002 12:00

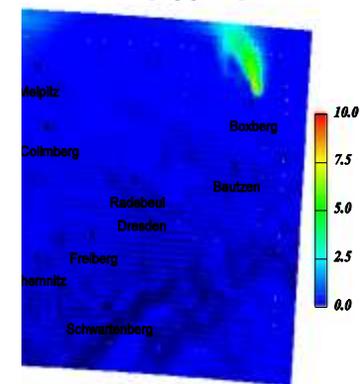
0-Differenz [myg/m<sup>3</sup>]

6



20 Aug 2002 12:00

0-Differenz [myg/m<sup>3</sup>]



22 Aug 2002 12:00

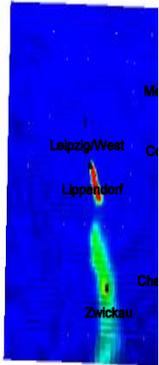
missions-  
elastung



# PM10-Differenz [myg/m<sup>3</sup>]

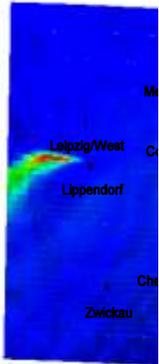
Ergebnis

PM10



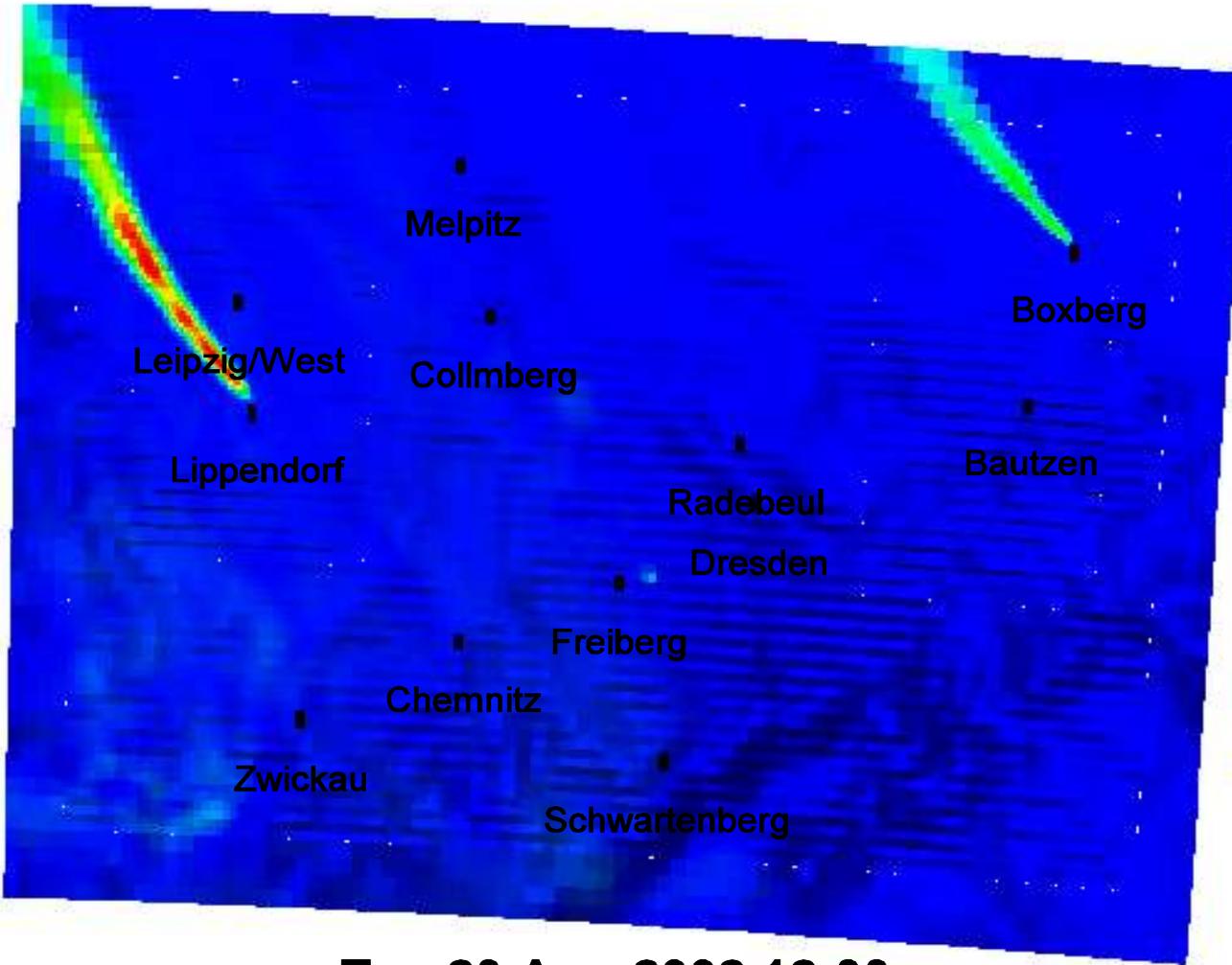
Thu

PM10

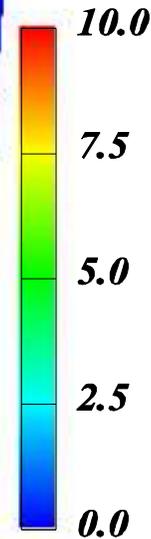


Sat

Son

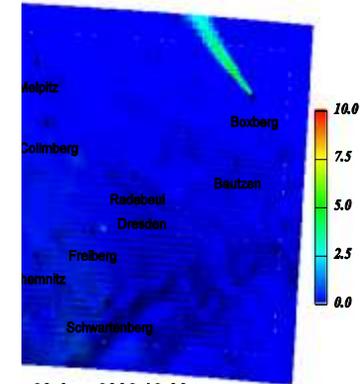


Tue 20 Aug 2002 12:00



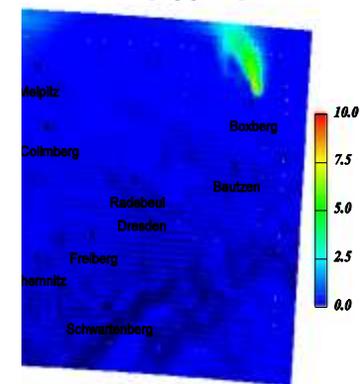
6

0-Differenz [myg/m<sup>3</sup>]



20 Aug 2002 12:00

0-Differenz [myg/m<sup>3</sup>]



22 Aug 2002 12:00

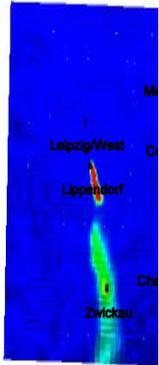
missions-  
elastung



# PM10-Differenz [myg/m<sup>3</sup>]

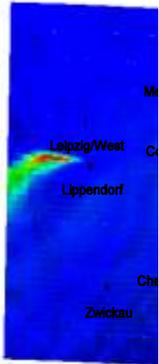
Ergebnis

PM10



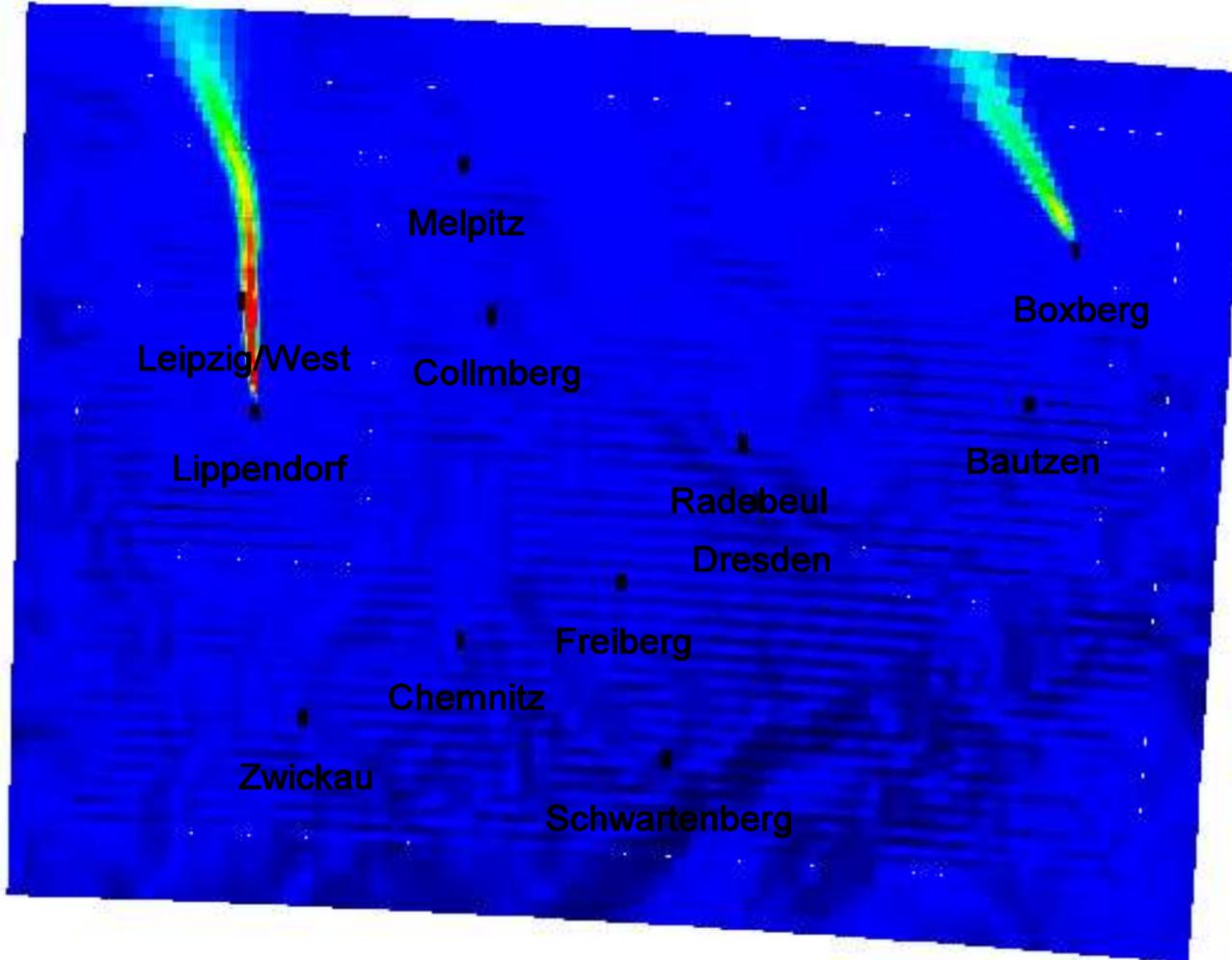
Thu

PM10

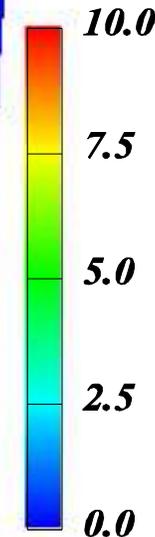


Sat

Son

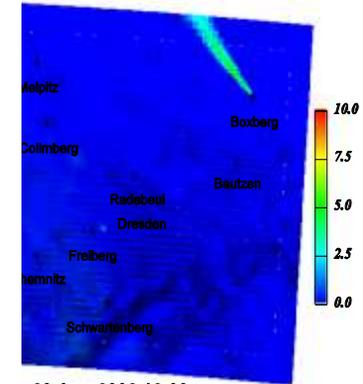


Wed 21 Aug 2002 12:00



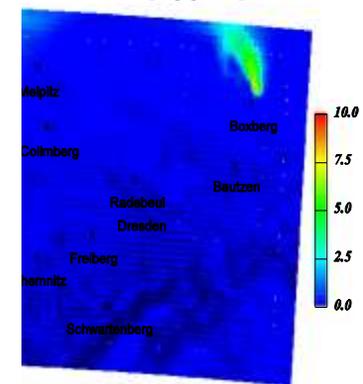
0-Differenz [myg/m<sup>3</sup>]

6



20 Aug 2002 12:00

0-Differenz [myg/m<sup>3</sup>]



22 Aug 2002 12:00

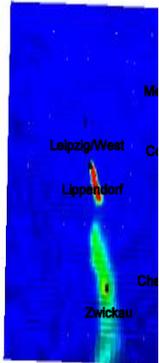
missionselastung



# PM10-Differenz [myg/m<sup>3</sup>]

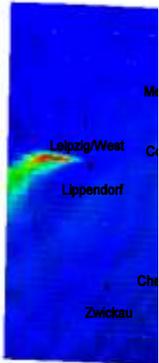
Ergebnis

PM10

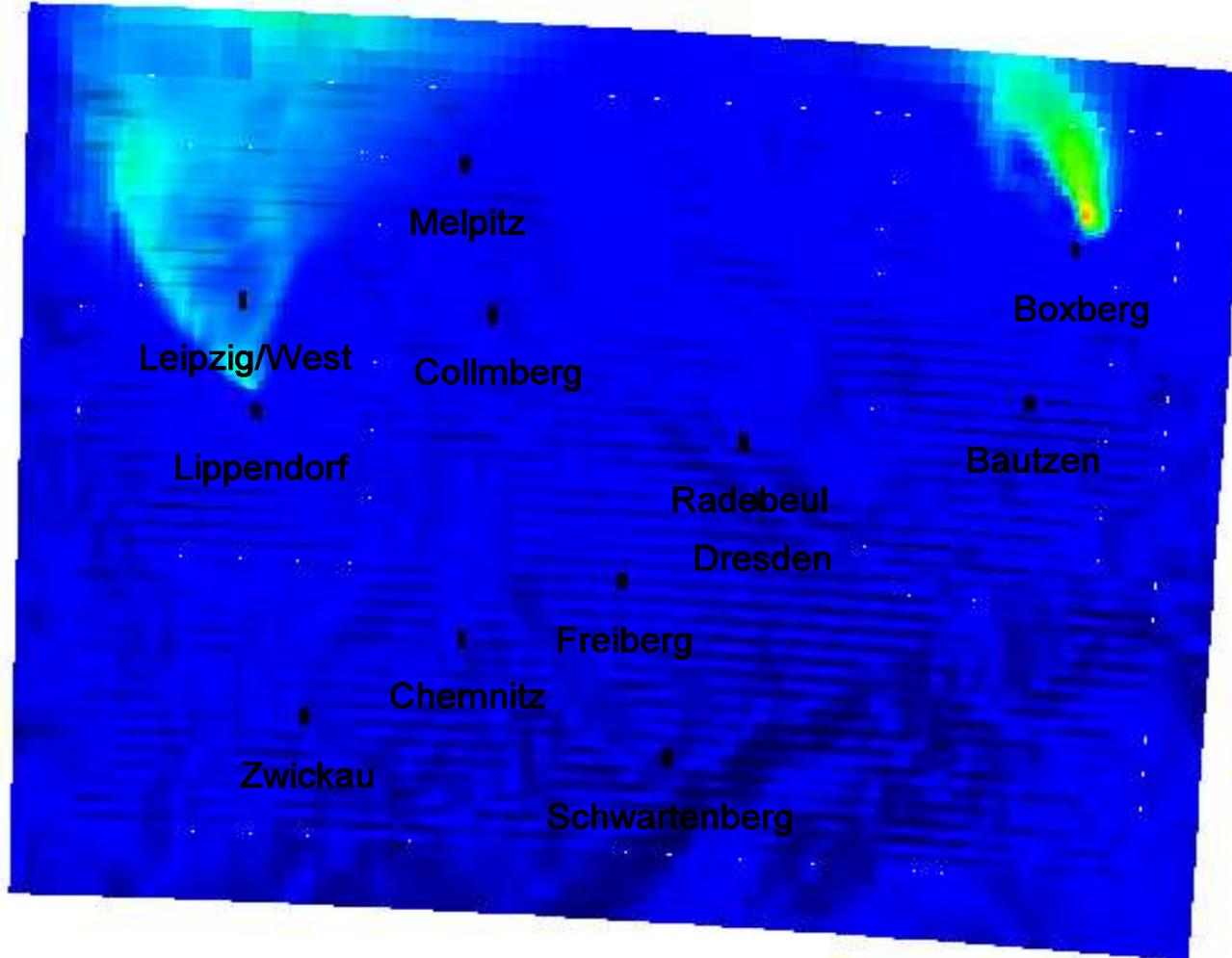


Thu

PM10



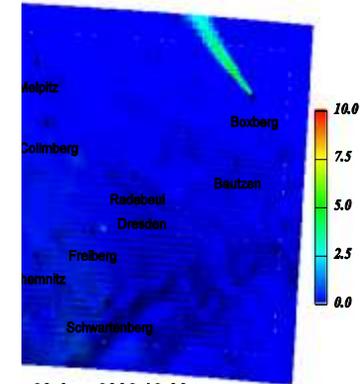
Sat



Thu 22 Aug 2002 12:00

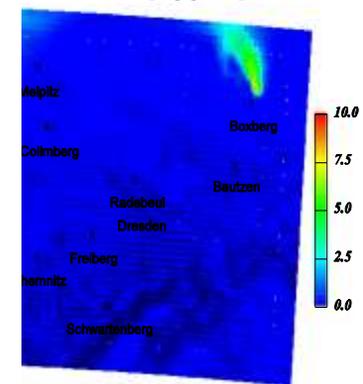
6

0-Differenz [myg/m<sup>3</sup>]



Thu 22 Aug 2002 12:00

0-Differenz [myg/m<sup>3</sup>]



Sat 24 Aug 2002 12:00

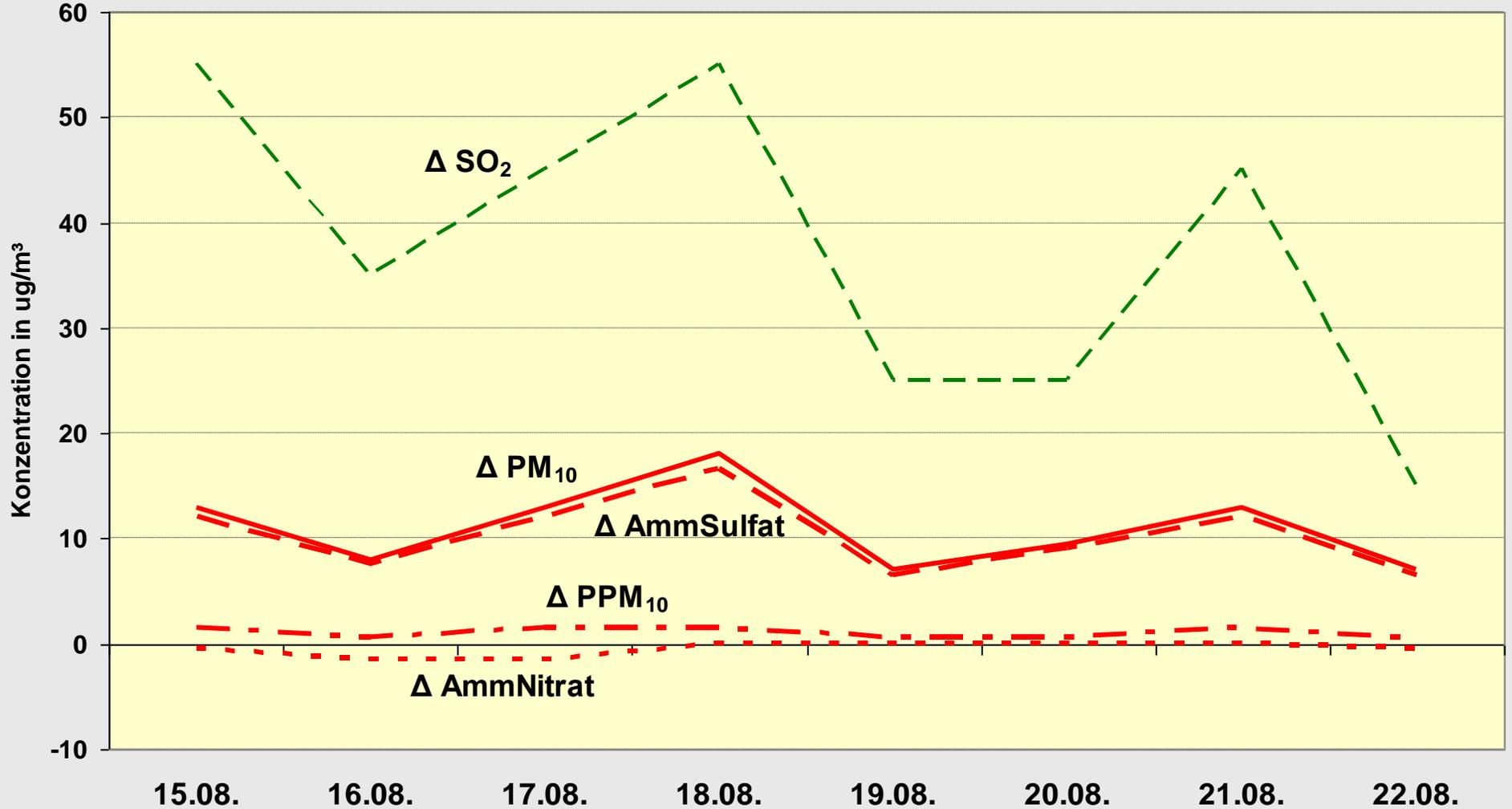
missions-  
elastung



Ergebnisse

**maximale mittägliche Zusatzbelastung  
infolge der GFA-Emissionen im Sommer**

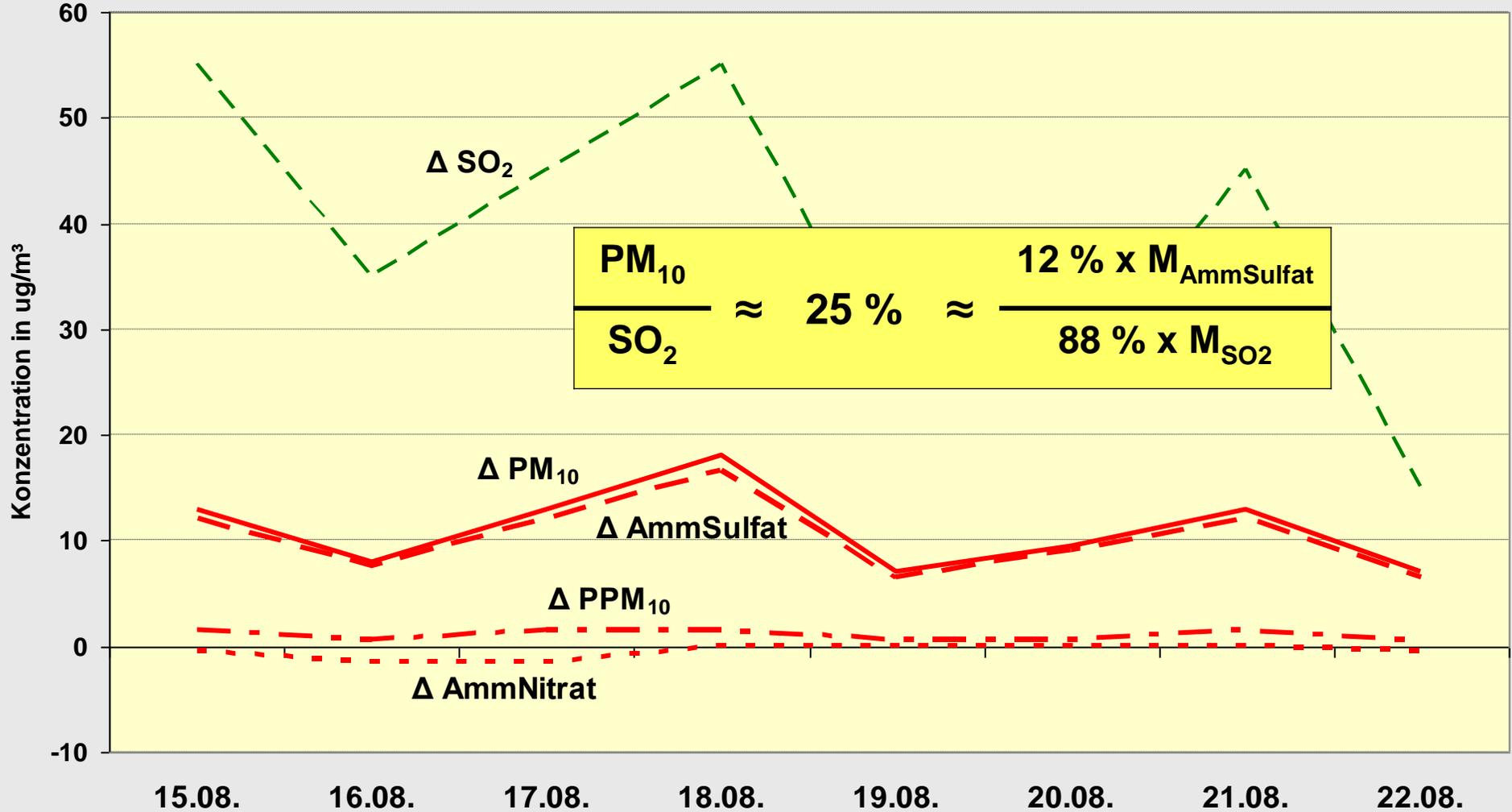
**Wochenszenario**



Ergebnisse

maximale mittägliche Zusatzbelastung  
infolge der GFA-Emissionen im Sommer

Wochenszenario



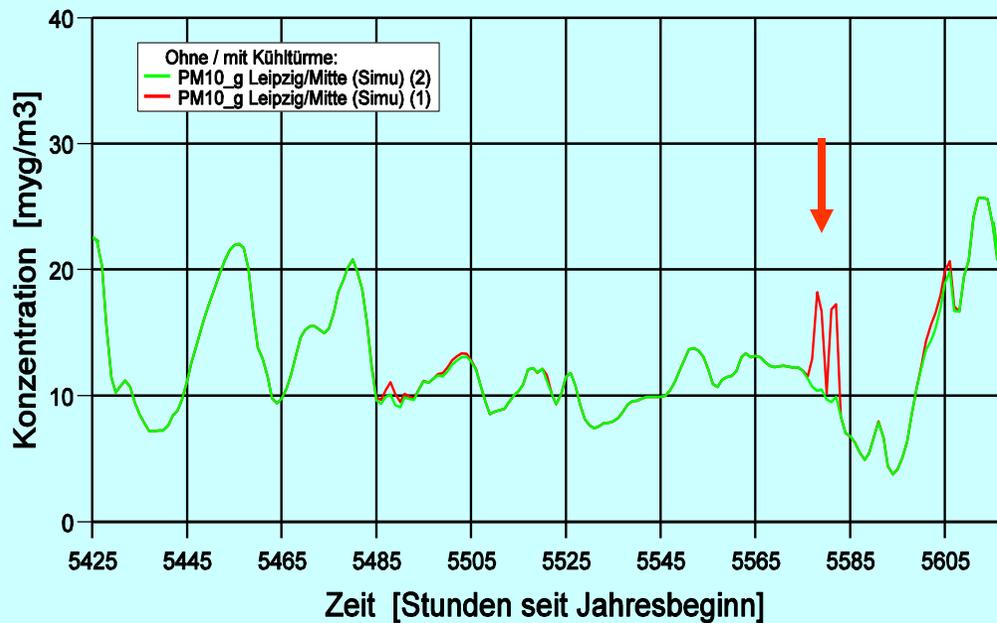


# Ergebnisse

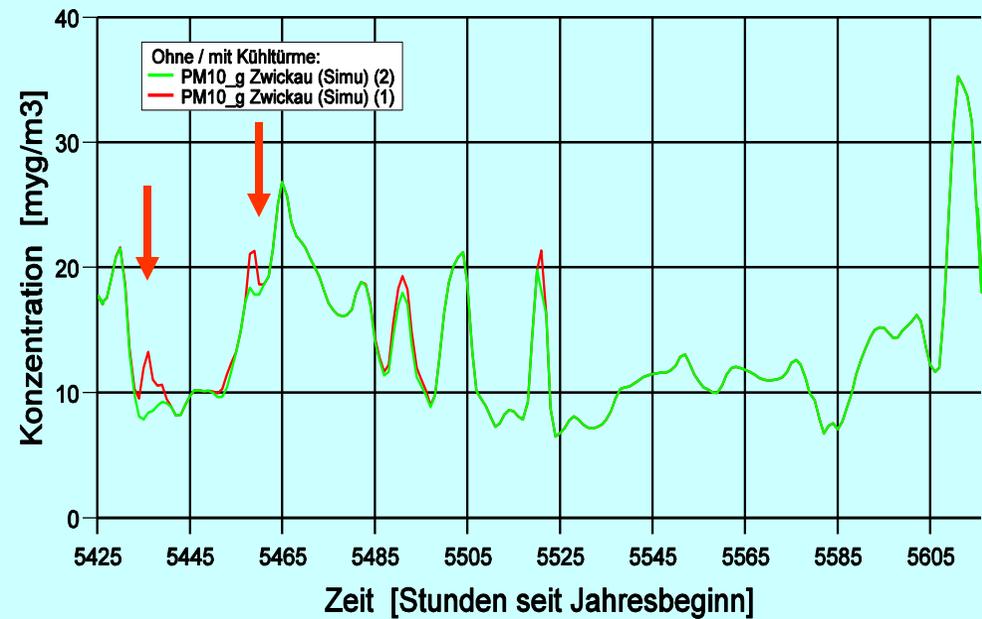
## Prognose von Wochen-Zeitreihen für 9 Immisions-Stationen in Sachsen Sommerzenario

➔ markanteste Ereignisse

15.08.-22.08.2002 PM10 Leipzig-M.



15.08.-22.08.2002 PM10 Zwickau



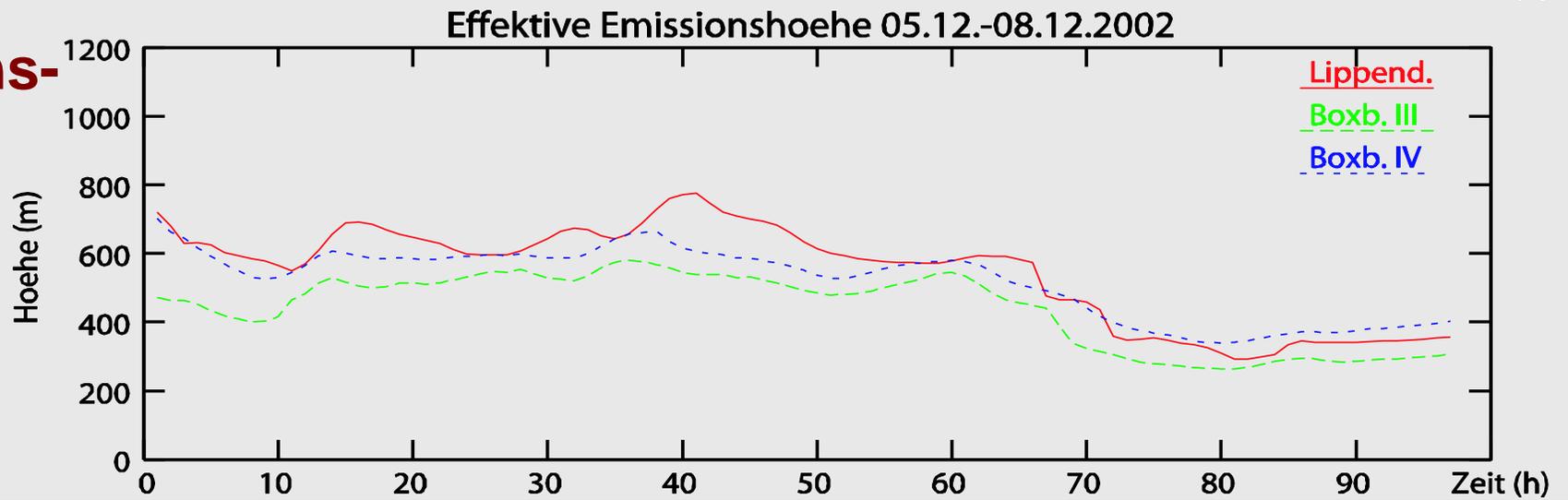
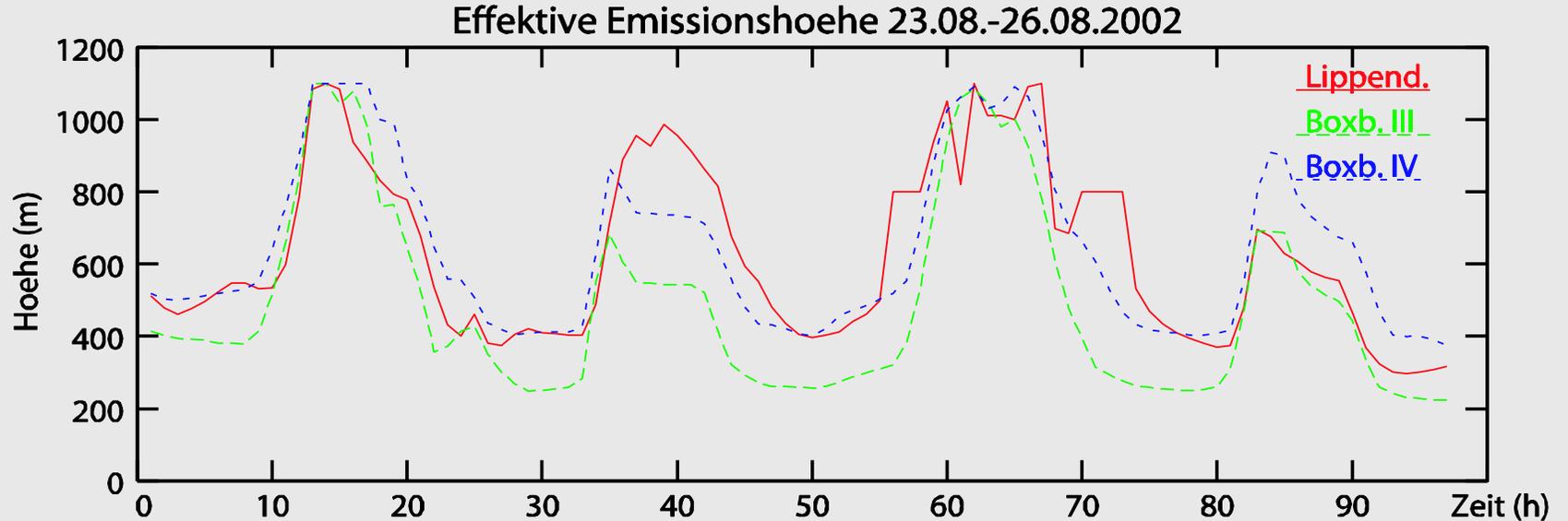
# Ergebnisse

Sommer

Tages-  
gang  
der

Emissions-  
höhe

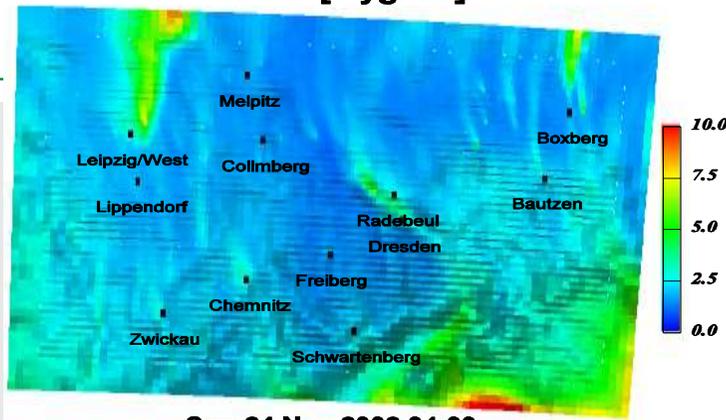
Winter



# Ergebnisse

10  
↑  
0  
µg/m<sup>3</sup>

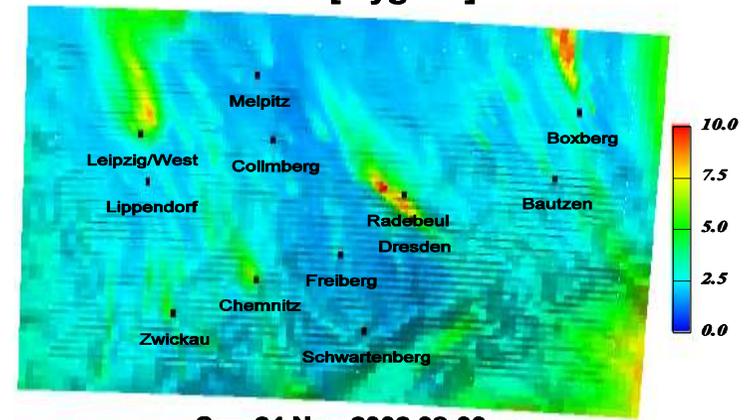
SO<sub>2</sub> [myg/m3]



Sun 24 Nov 2002 04:00

SO<sub>2</sub> [myg/m3]

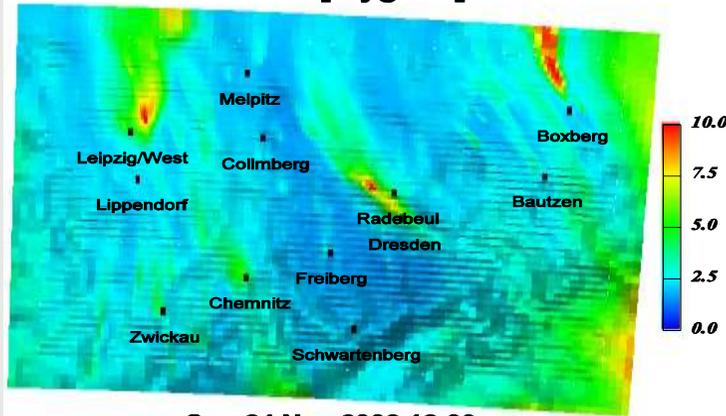
SO<sub>2</sub> [myg/m3]



Sun 24 Nov 2002 08:00

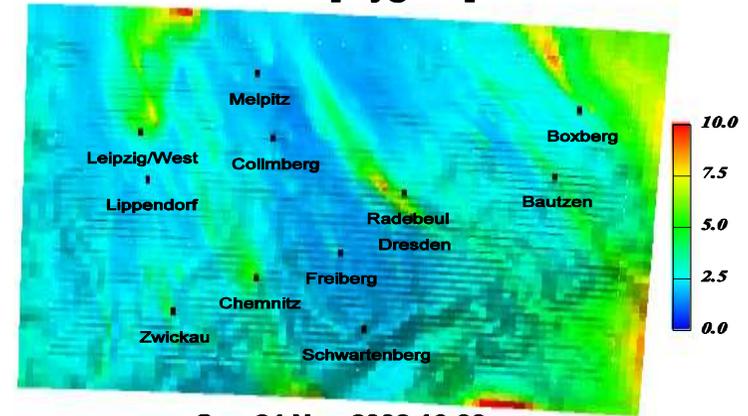
SO<sub>2</sub> [myg/m3]

Wintertag  
S1



Sun 24 Nov 2002 12:00

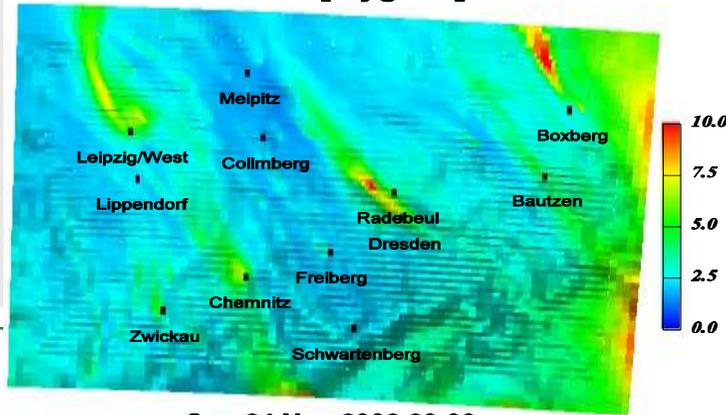
SO<sub>2</sub> [myg/m3]



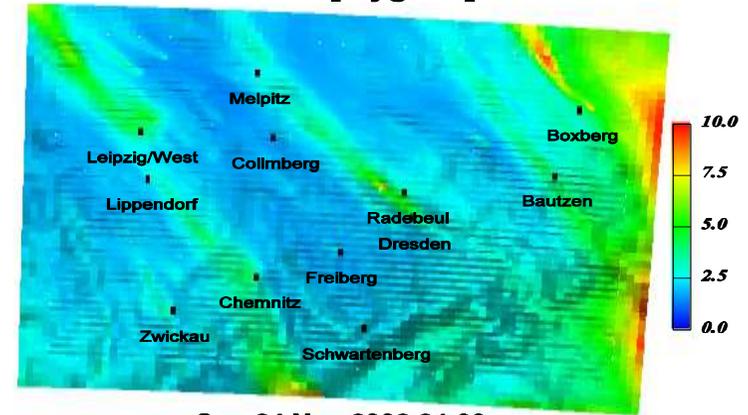
Sun 24 Nov 2002 16:00

SO<sub>2</sub> [myg/m3]

SO<sub>2</sub> -  
Gesamt-  
Immission



Sun 24 Nov 2002 20:00



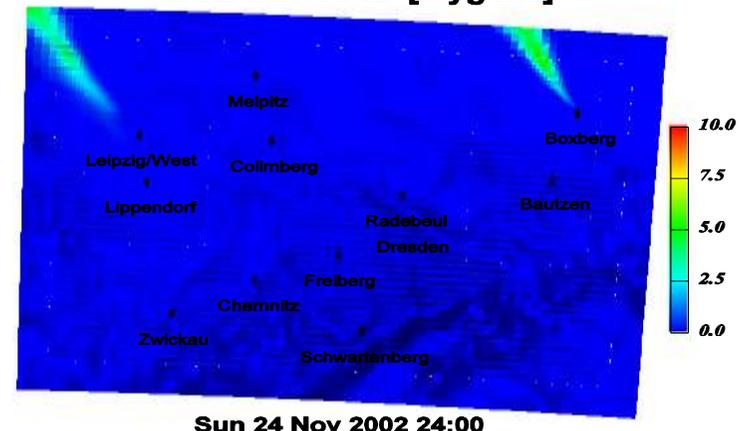
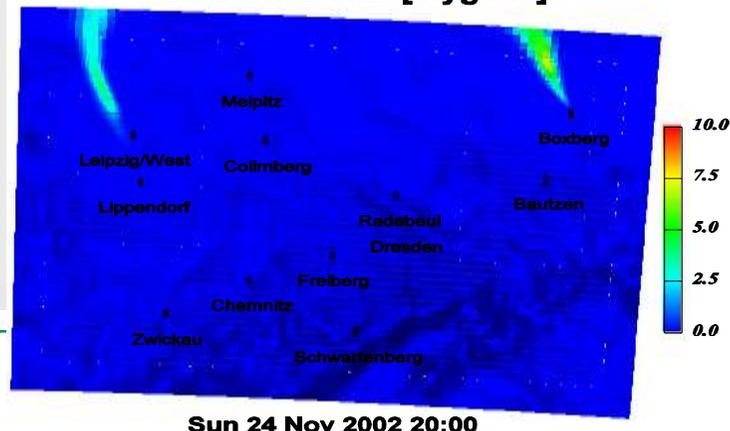
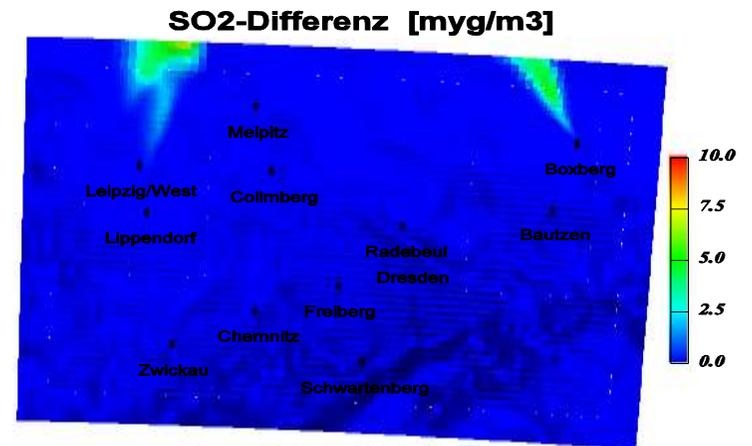
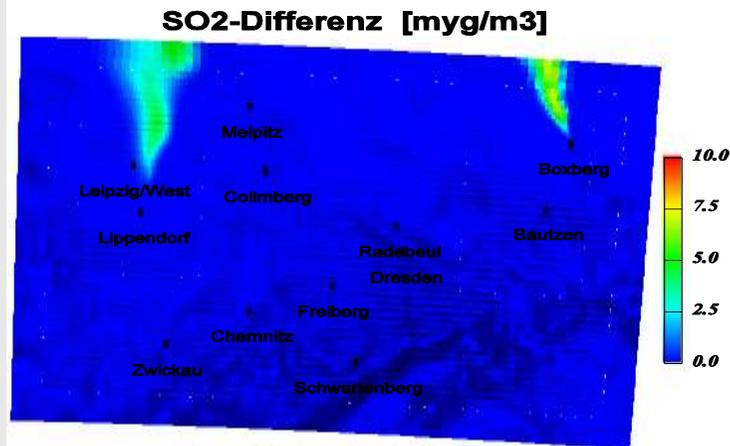
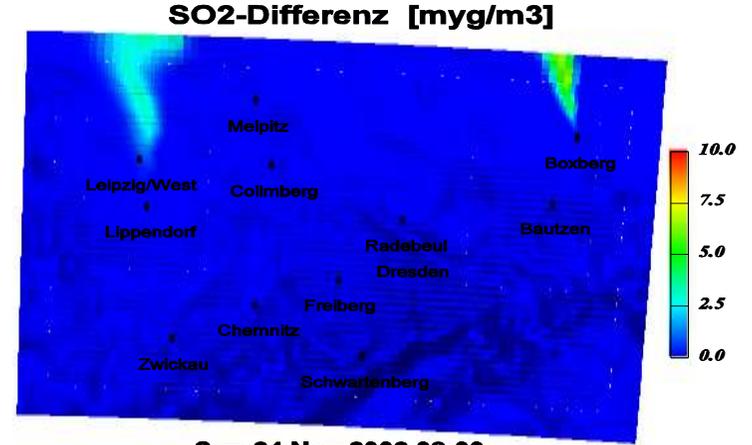
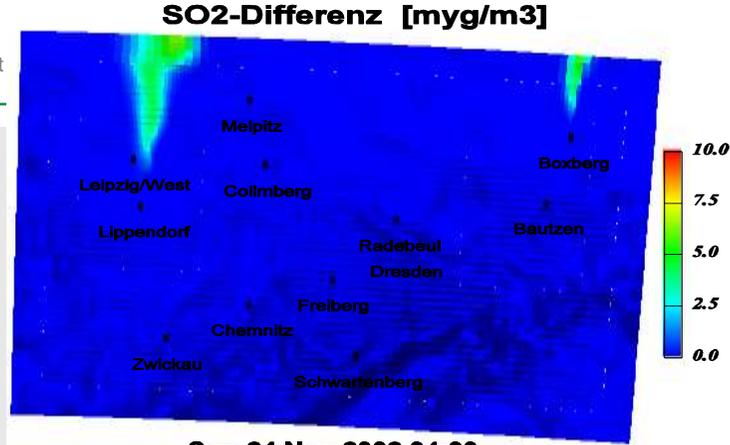
Sun 24 Nov 2002 24:00

# Ergebnisse

10  
↑  
0  
µg/m<sup>3</sup>

Wintertag  
S1

SO<sub>2</sub>-  
Imm-  
Zusatz-  
belastung

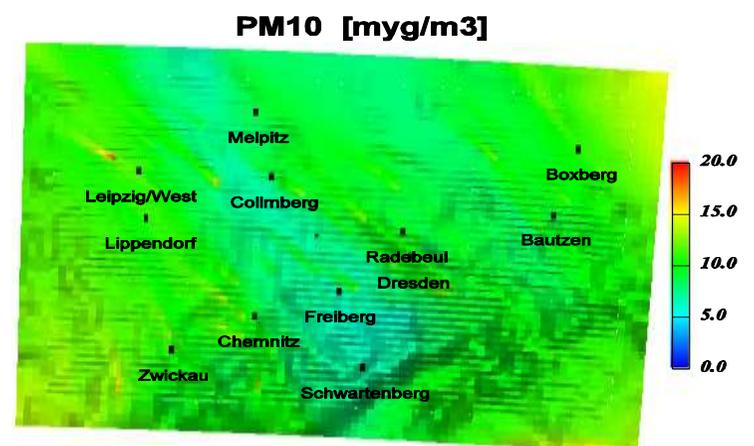
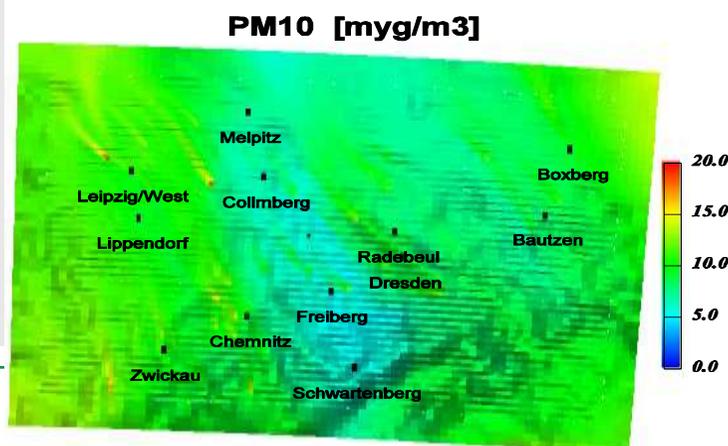
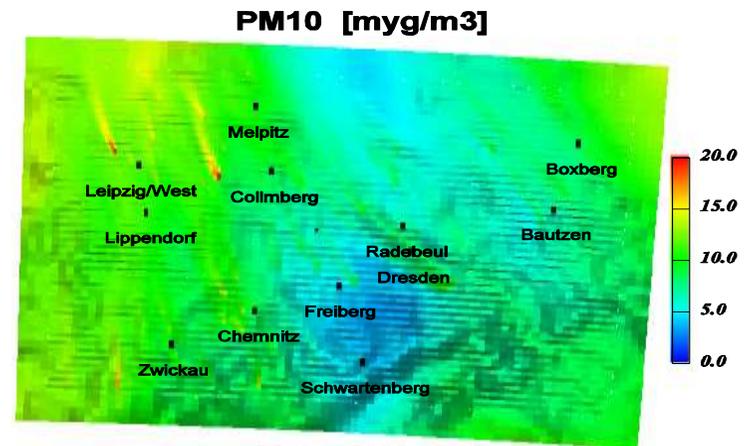
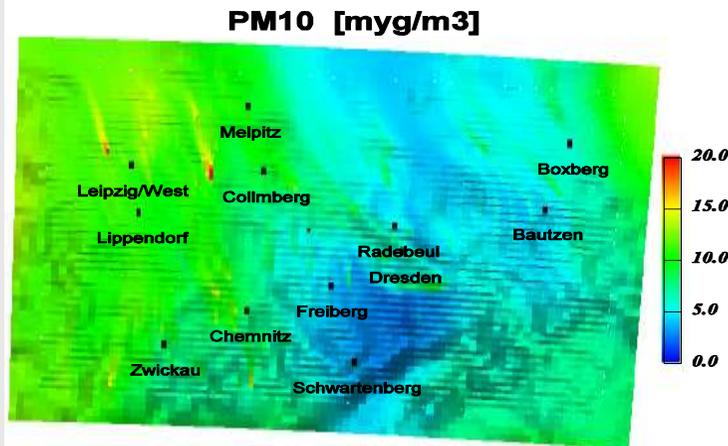
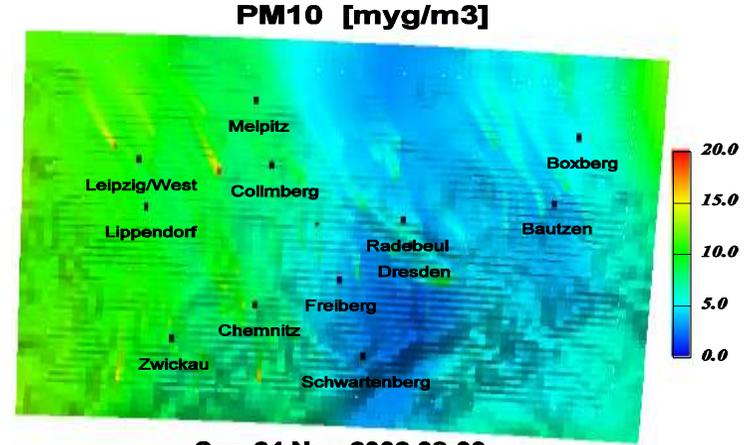
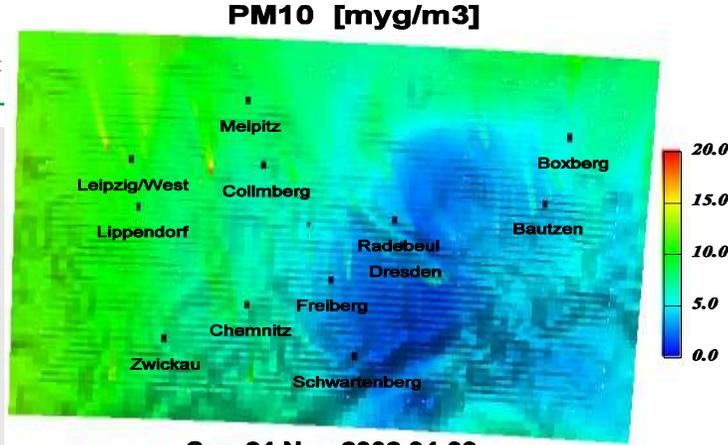


# Ergebnisse

20  
↑  
0  
µg/m<sup>3</sup>

## Wintertag S1

## PM<sub>10</sub> - Gesamt- Immission

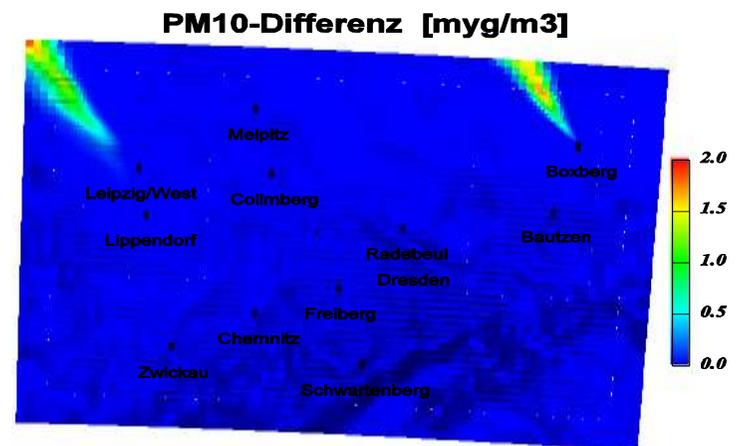
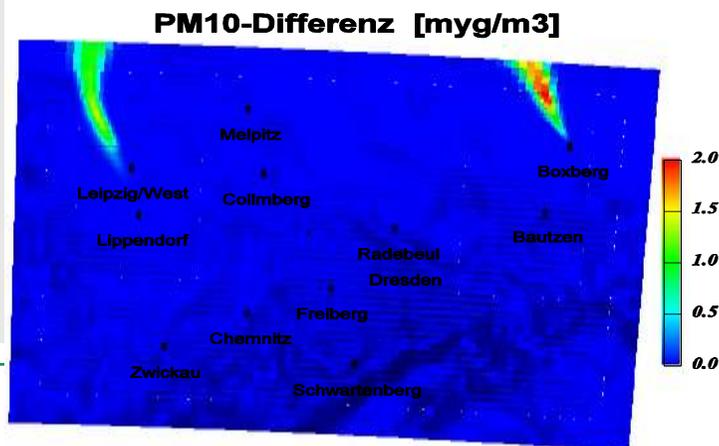
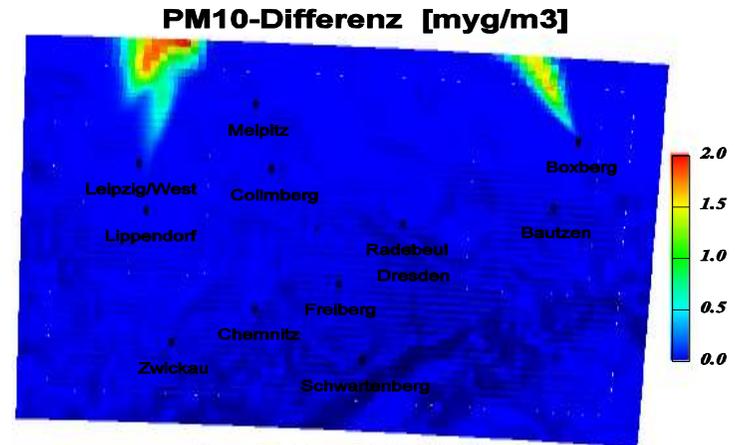
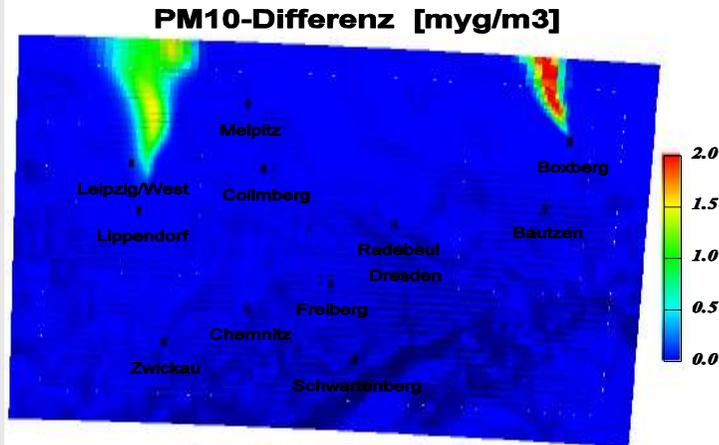
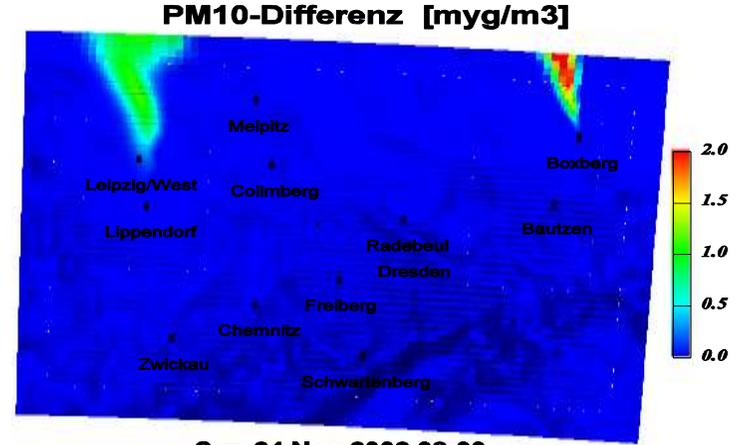
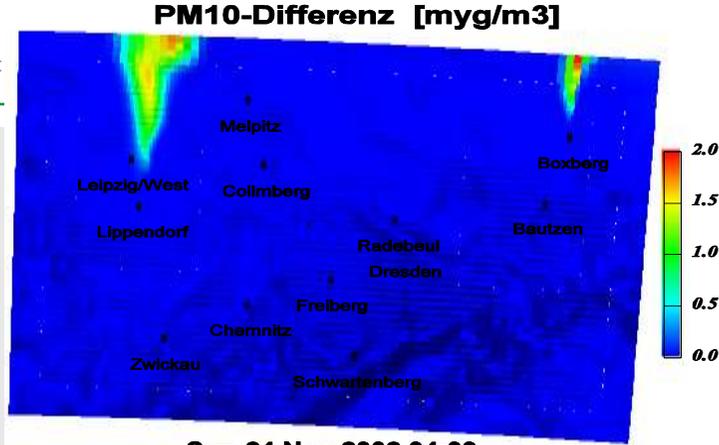


# Ergebnisse

2  
↑  
0  
µg/m<sup>3</sup>

Wintertag  
S1

PM<sub>10</sub> -  
Imm-  
Zusatz-  
belastung

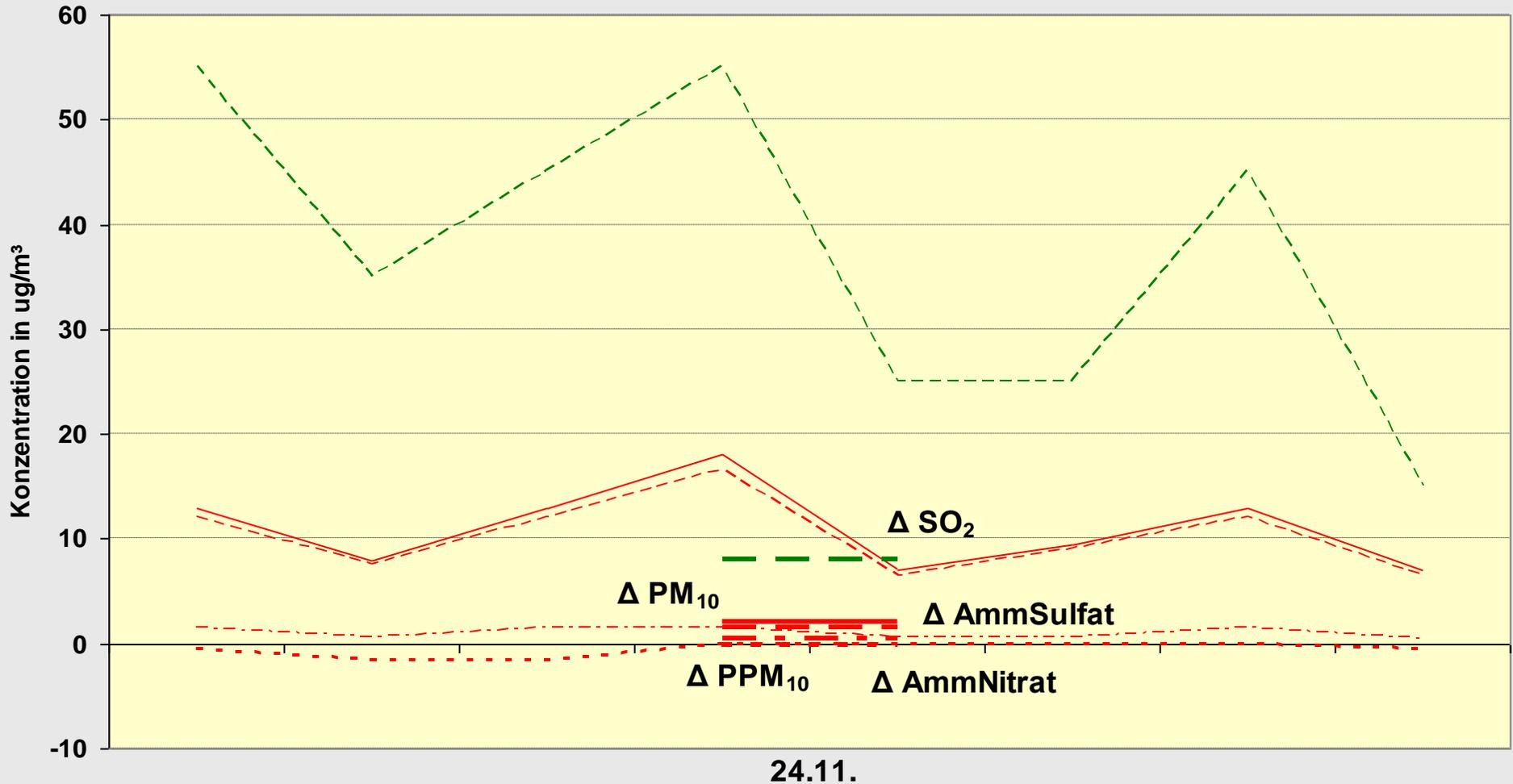


Ergebnisse



**maximale mittägliche Zusatzbelastung  
infolge der GFA-Emissionen im Winter**

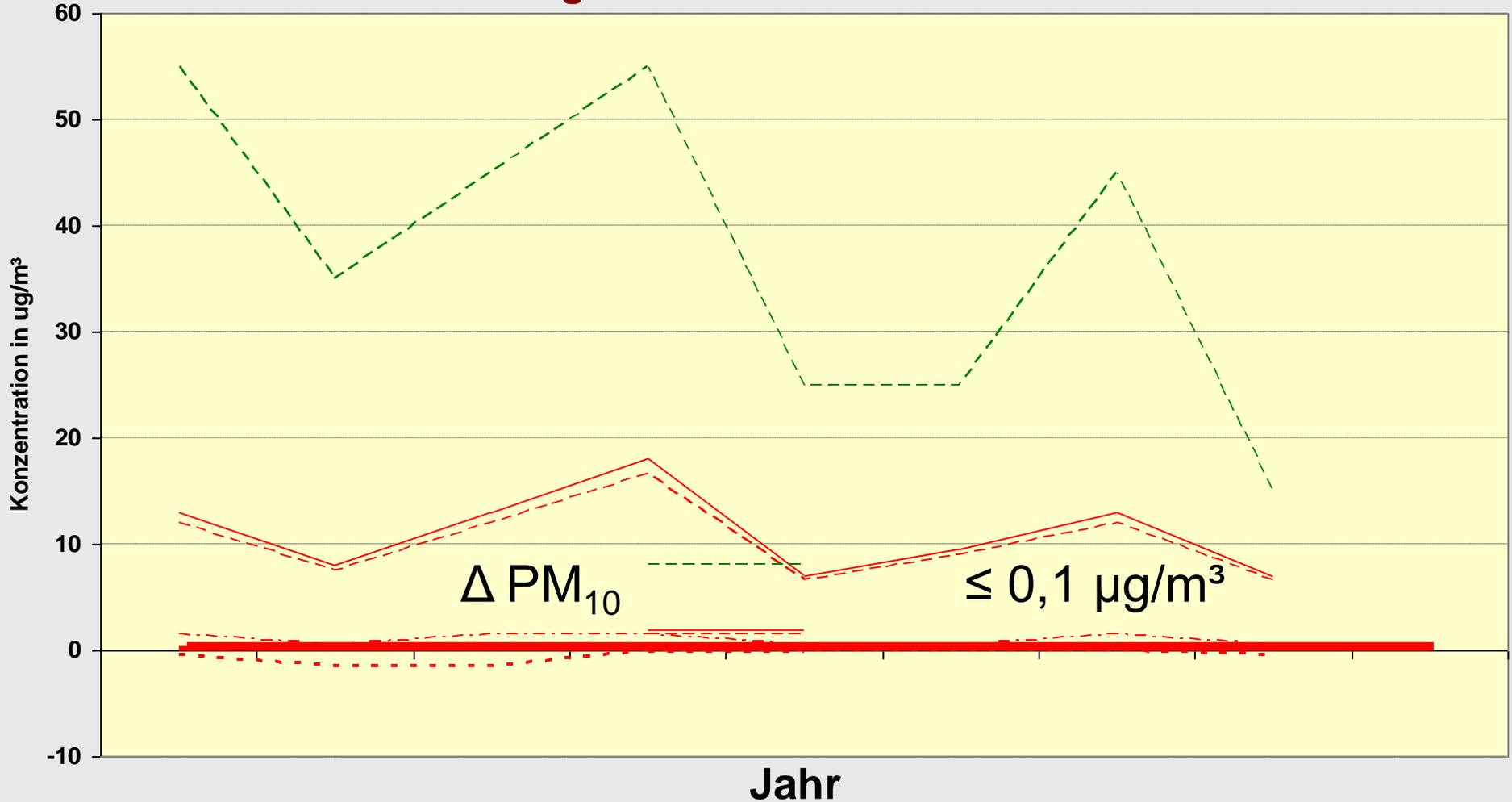
Wochenszenario



Ergebnisse



Schätzwert für die mittlere Jahres-Zusatzbelastung  
infolge der GFA-Emissionen





*Ende*

\*\*\*\* danke fürs Zuhören **und -schauen** \*\*\*\*

