Institute for Internal Combustion Engines and Thermodynamics
Section Traffic and Environment

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http://vkm-thd.tugraz.at/

Secondary inorganic aerosols & impact on PM10 background

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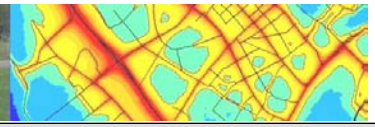
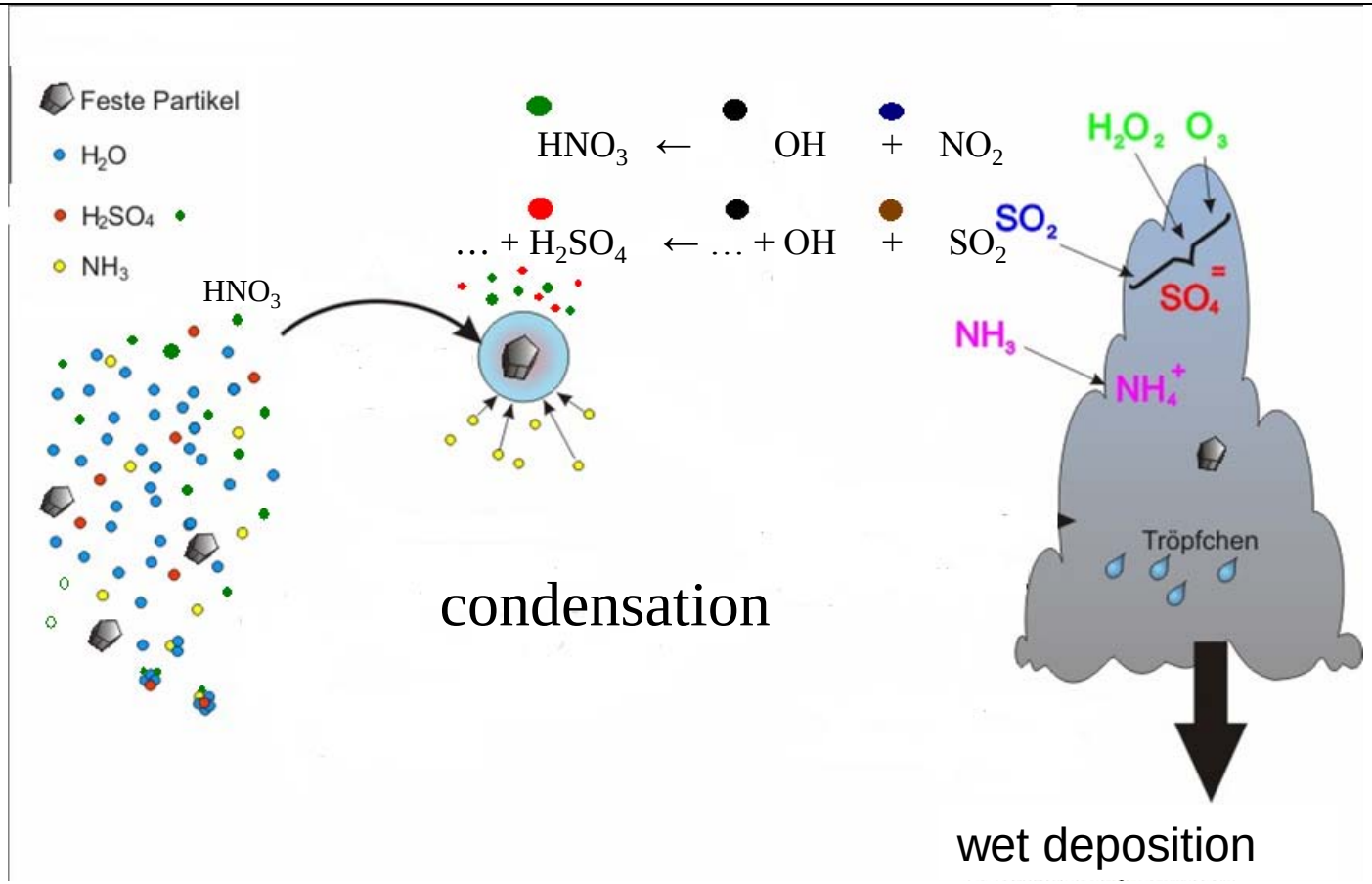
Introduction: Nature & relevance secondary formed particles - growth / mass

- Gas-particle conversion (Condensation)
- Condensation/Evaporation → partly „semi-volatility“
- Links different gaseous precursors species from different sources
- Relevance:
  - Health/Legislation → PM-Mass PM2.5/PM10
  - Climate (optical properties)
  - Eutrophication / Deposition





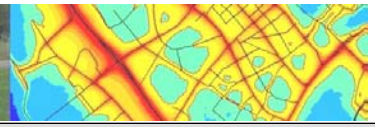
Formation inorganic secondary aerosol



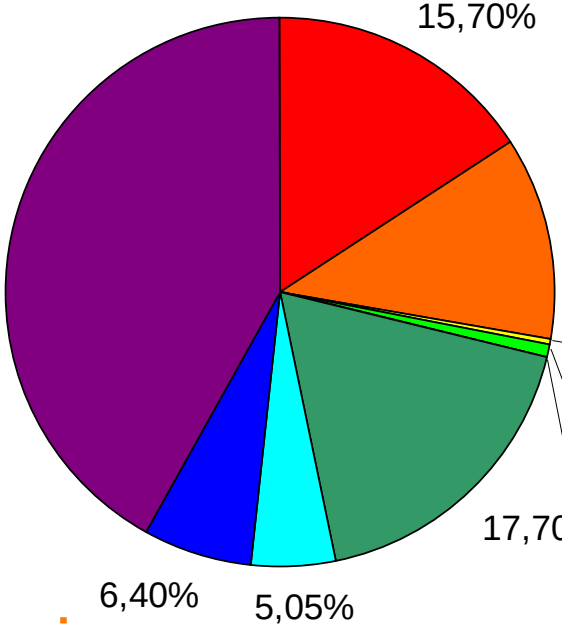
Ammonia - NH_3

- Most important atmospheric alkaline gas
- NH_3-sources:
  - manure, biological soil processes, NH_3-based fertilizers
  - sewage plants, canalisation, gasoline engines
    - traffic emissions: increase with three way catalysts & additional oxidation catalyst
  - molar weight: NH_3 ~ 17 g/mol
  - ↔ HNO_3 ~ 63 g/mol / H_2SO_4~ 98 g/mol





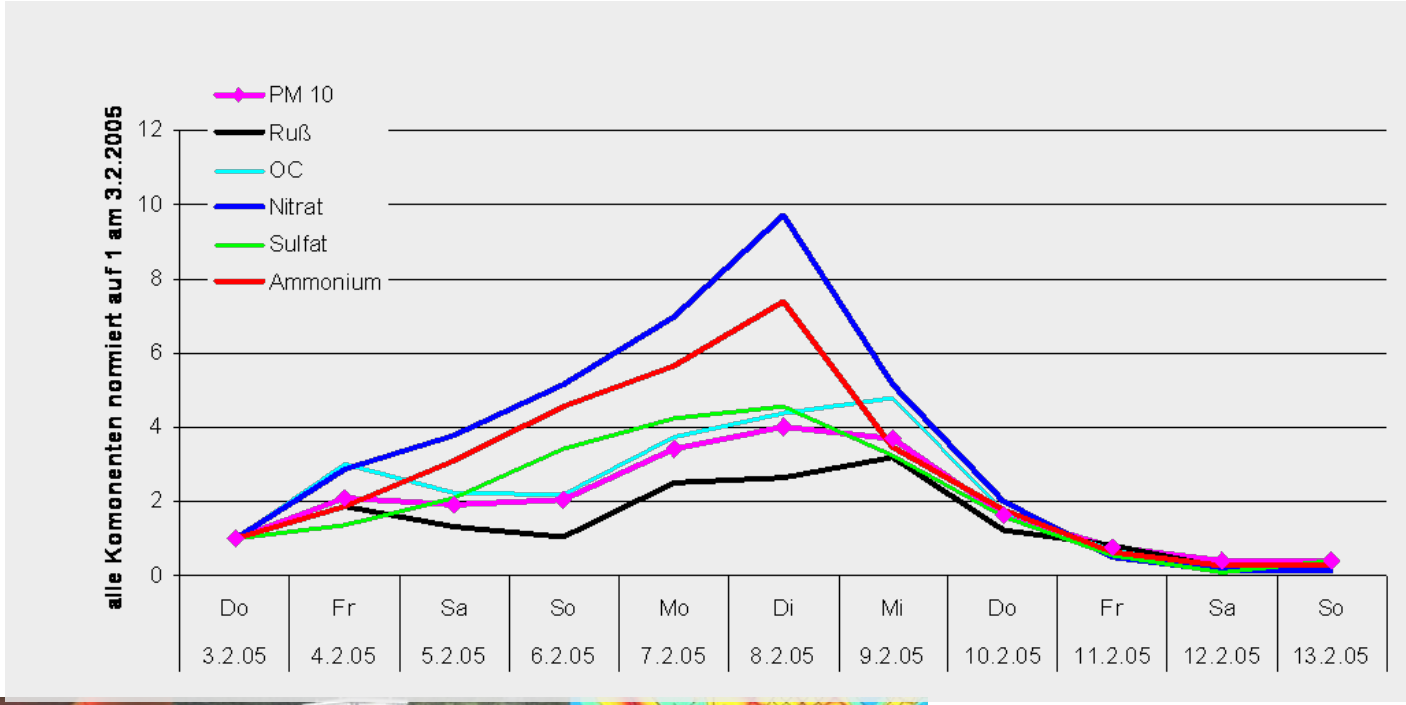
Study of an episode: PM10 Composition 05.02.05 Stuttgart Neckartor DTV 55000 vehicles per day!



Ref: Lump LUBW

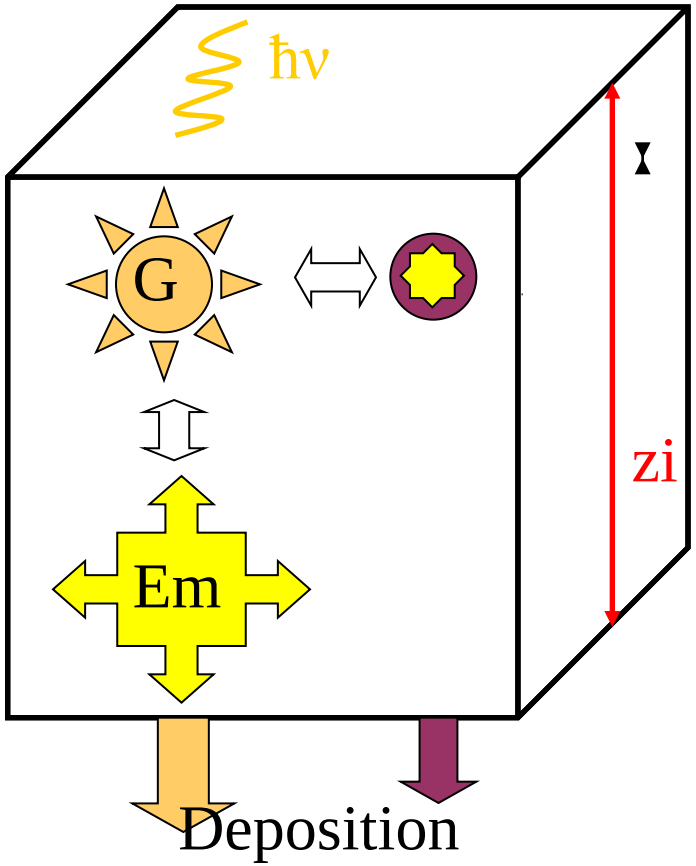
Study of an episode - exceedance limit values PM10 Stuttgart (S) Feb 2005

- Build-up PM10 Stuttgart **>** rural environment
- In **S:** increase PM (NH_4^+, NO_3^-, SO_4^-/SO_4^{2-}) **>** PM & soot



Modell set-up RACM-ISORROPIA

(Stockwell et al., 1997 - Nenes et al., 1999)



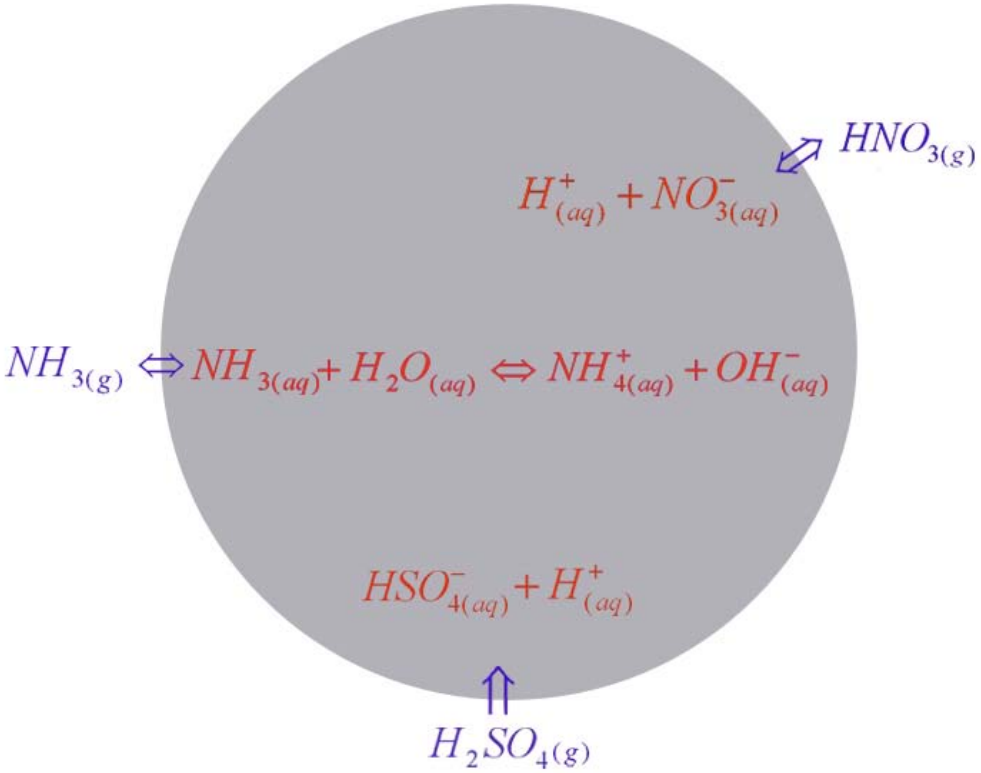
RACM

ISORROPIA

HNO_3, H_2SO_4, (NH_3), HCl

emissions: NO_x, NH_3, NMVOC, SO_2, CH_4, CO, UMEG (2004)

System behaviour inorganic secondary aerosol



H+↑ → p_{sol}HX ↑ $p_{sol}$$NH_3$↓

HX → gas phase

NH_3 → particle phase

& vice versa

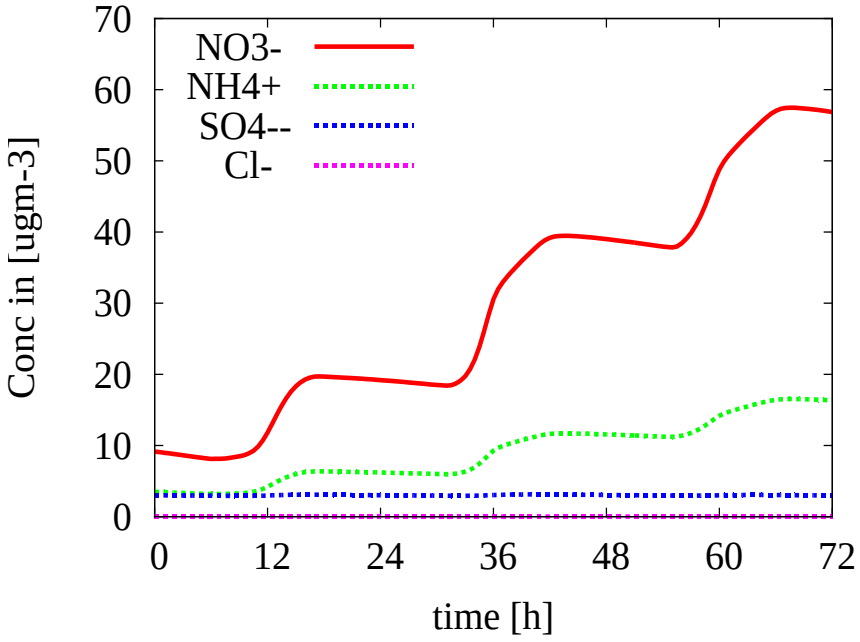
HX: HNO_3, H_2SO_4, HCl

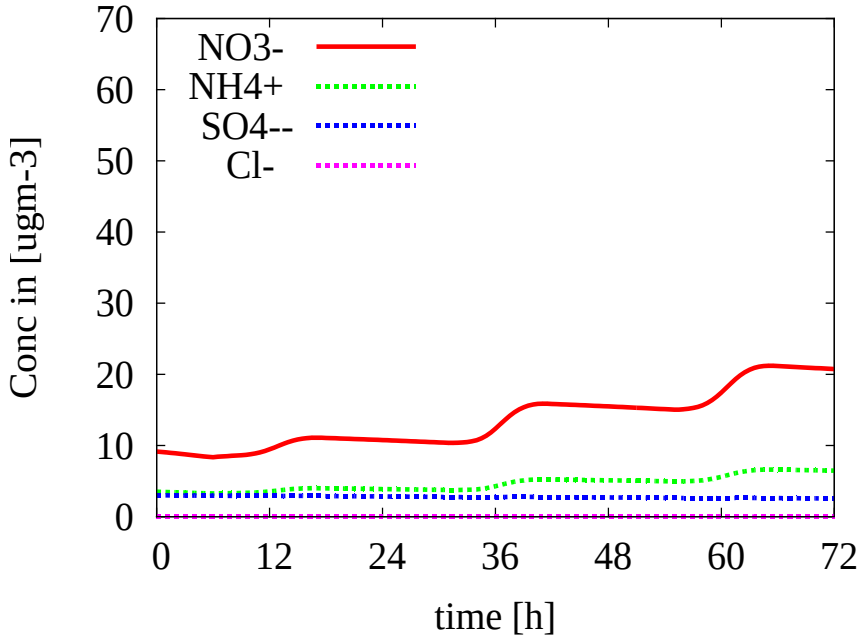
T ↓ RH ↑ → particle phase & vice versa

NH_3 small molar weight

→ large effect H+/OH- Conc ↔ NO_3/SO_4 mass

Particle growth (ions) Stuttgart & rural env

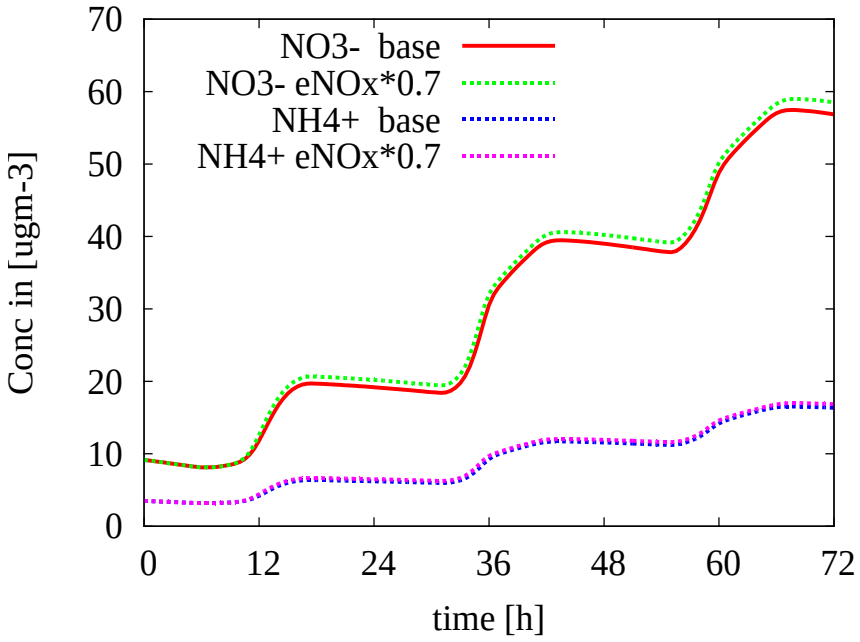




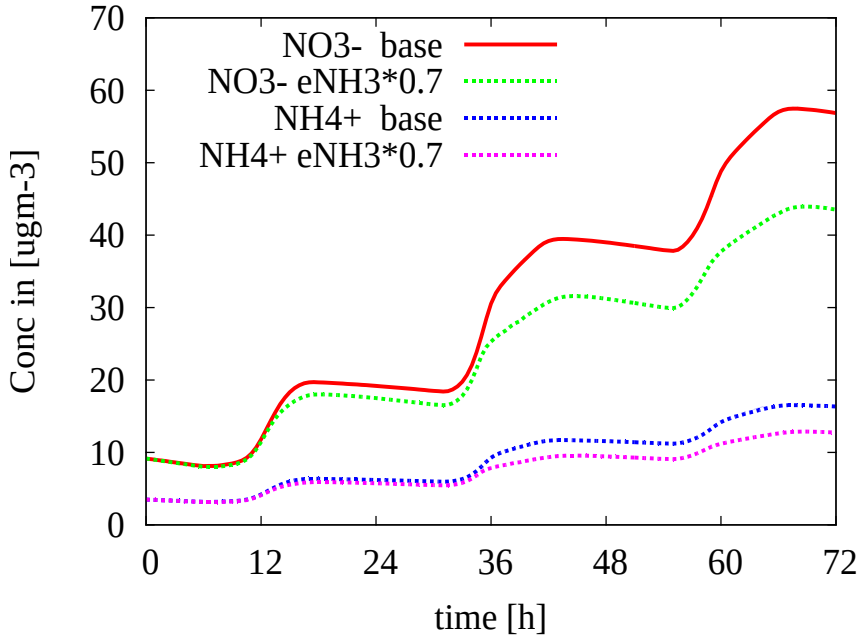
Stuttgart

rural environment

Sensitivity – NOx & NH3 Emissions
Stuttgart - impact on NO3 & NH4 only

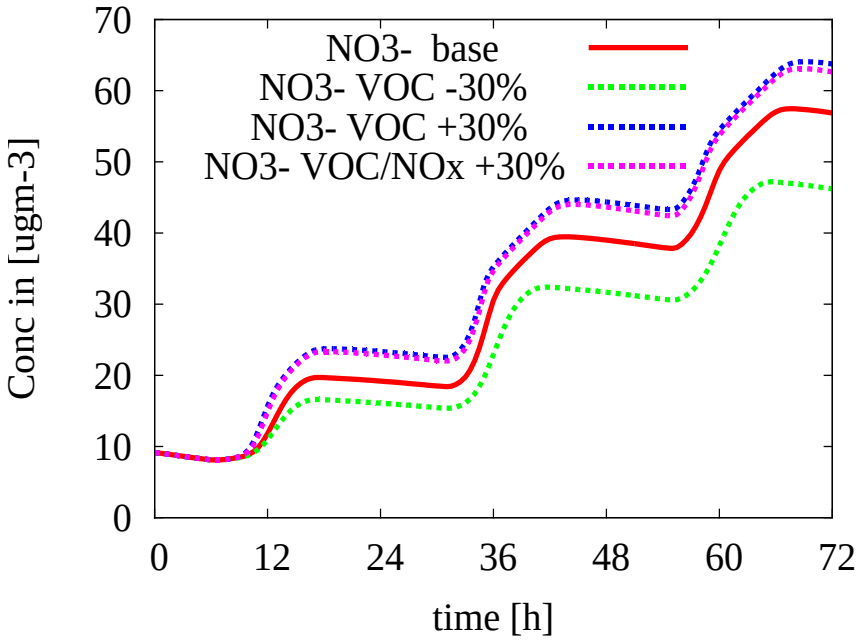


Emis-NO_x ↓

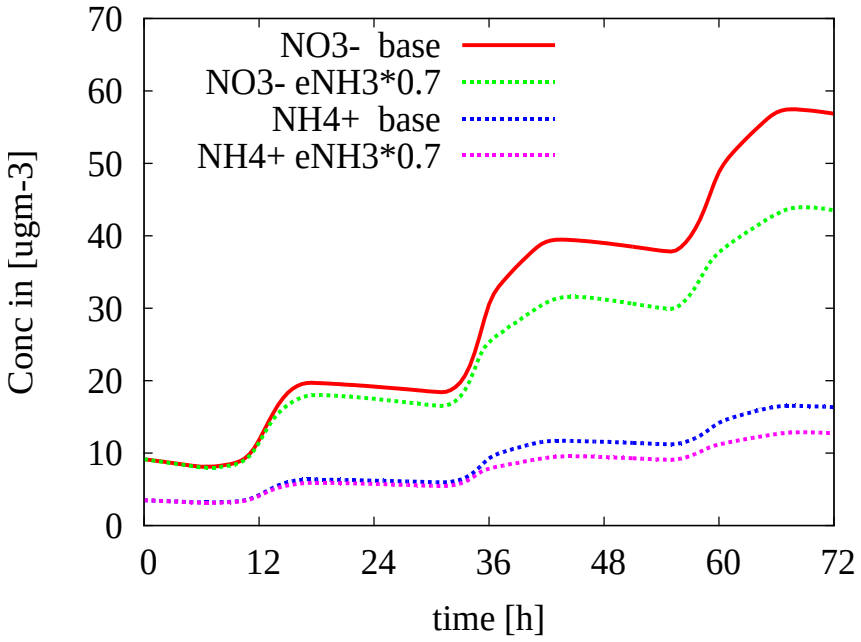


Emis-NH_3 ↓

Sensitivity – VOC Emissions

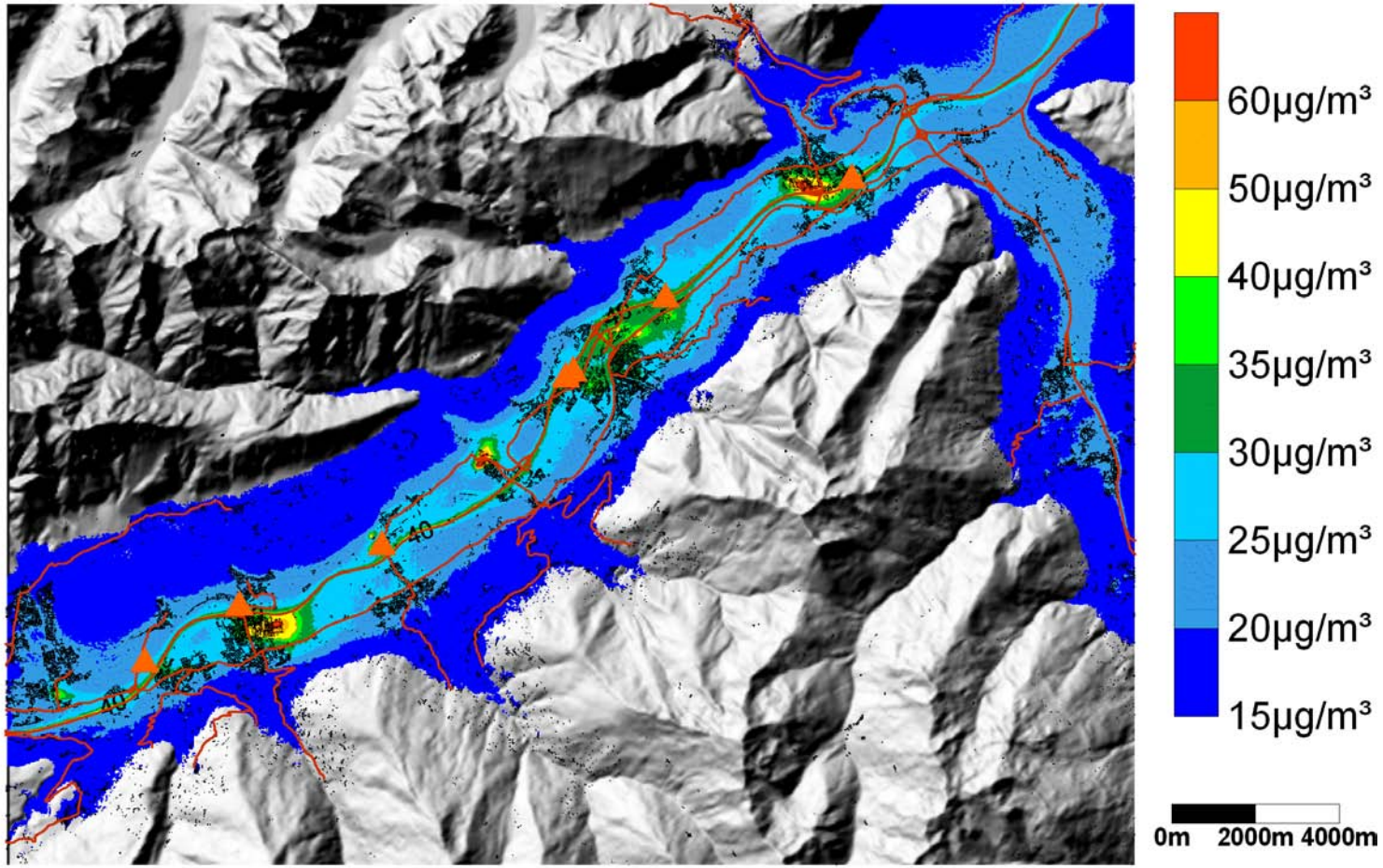


VOC / NO_x ↓↑

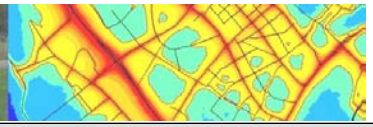


NH3 ↓ (to compare)

ALPNAP DJF PM10 & background – GRAL
(primary emissions traffic, domestic heat, industry)



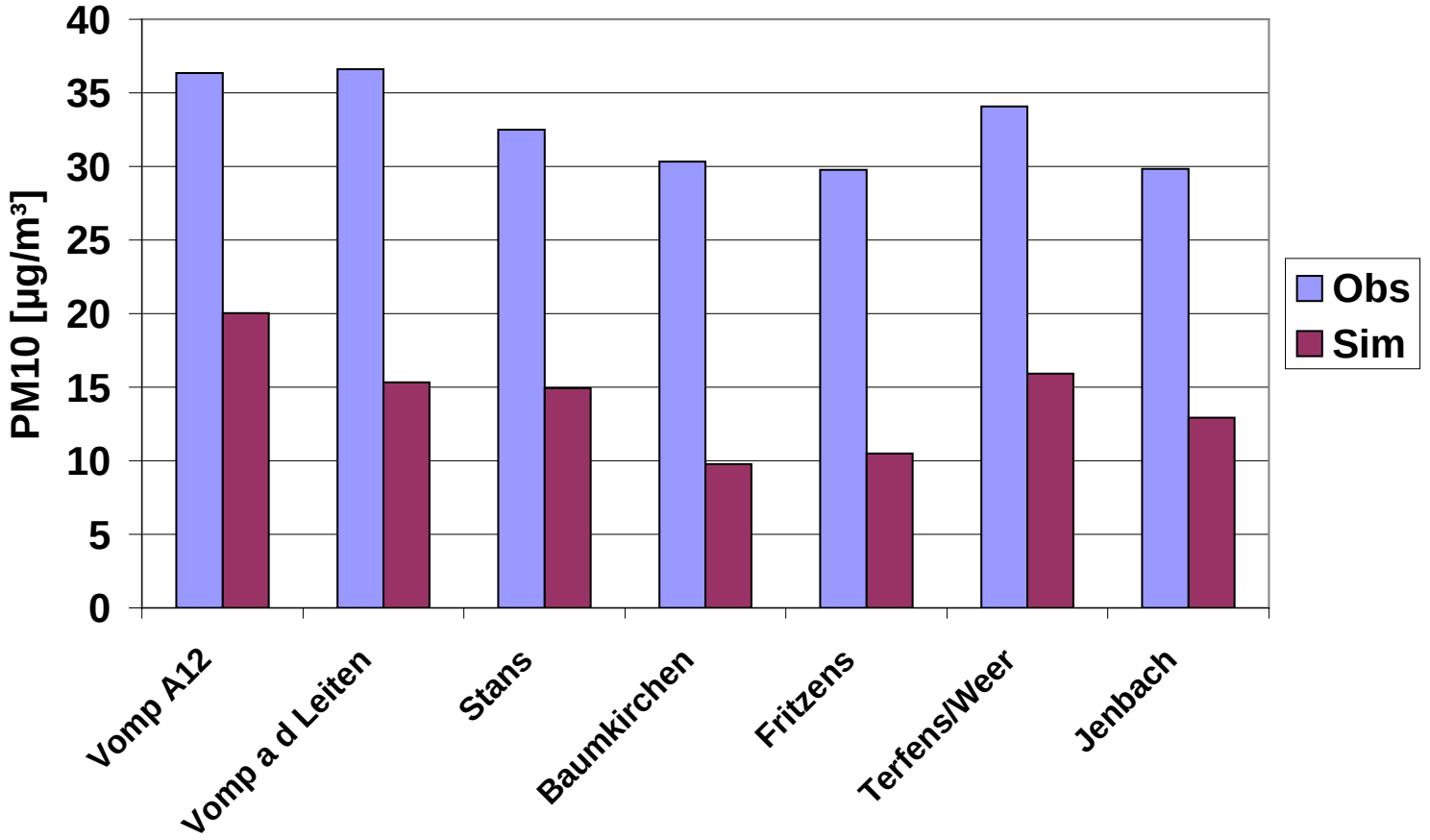




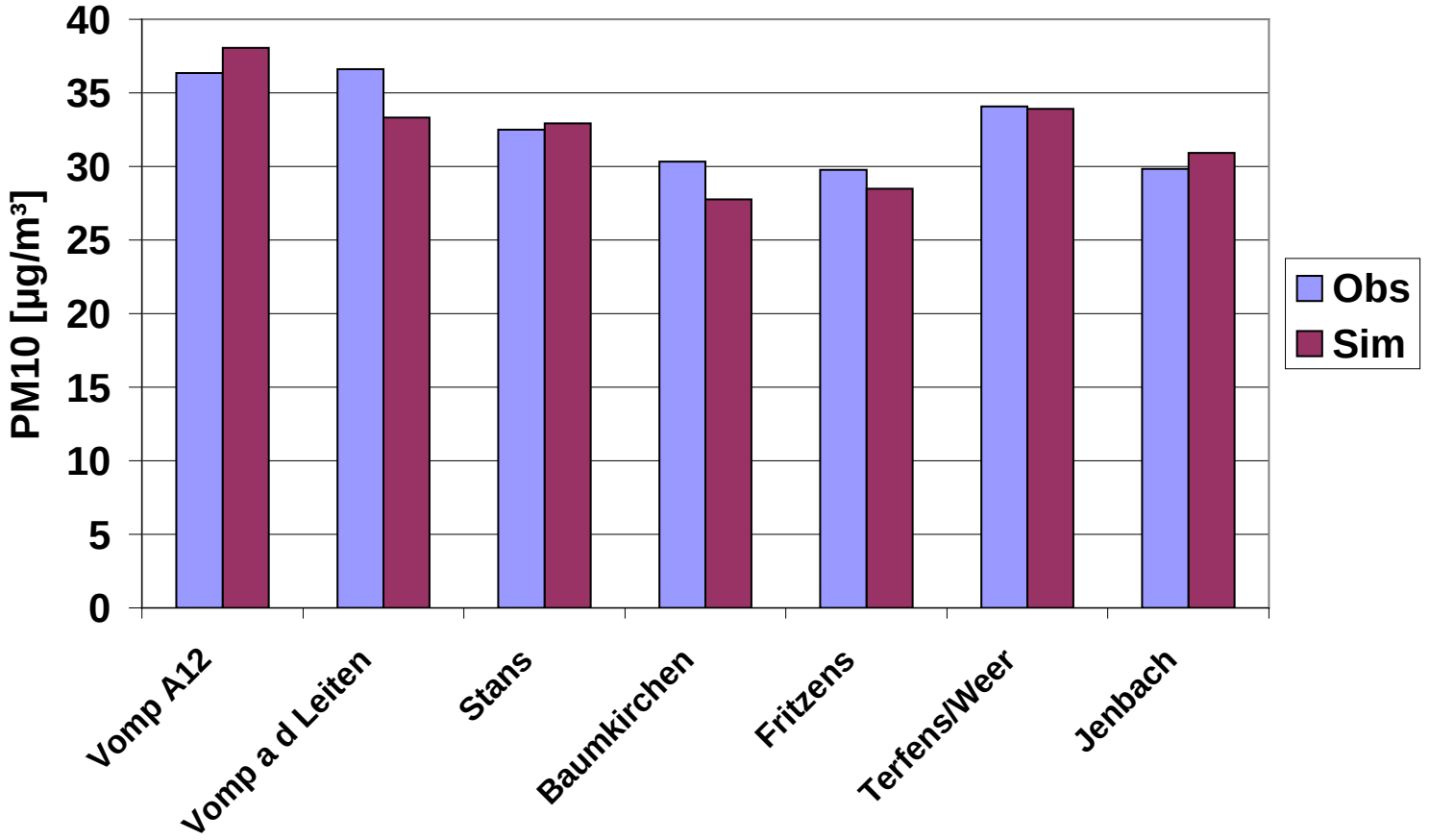
↑ Domain: 20 km x 30 km

Resolution 10 m x 10 m

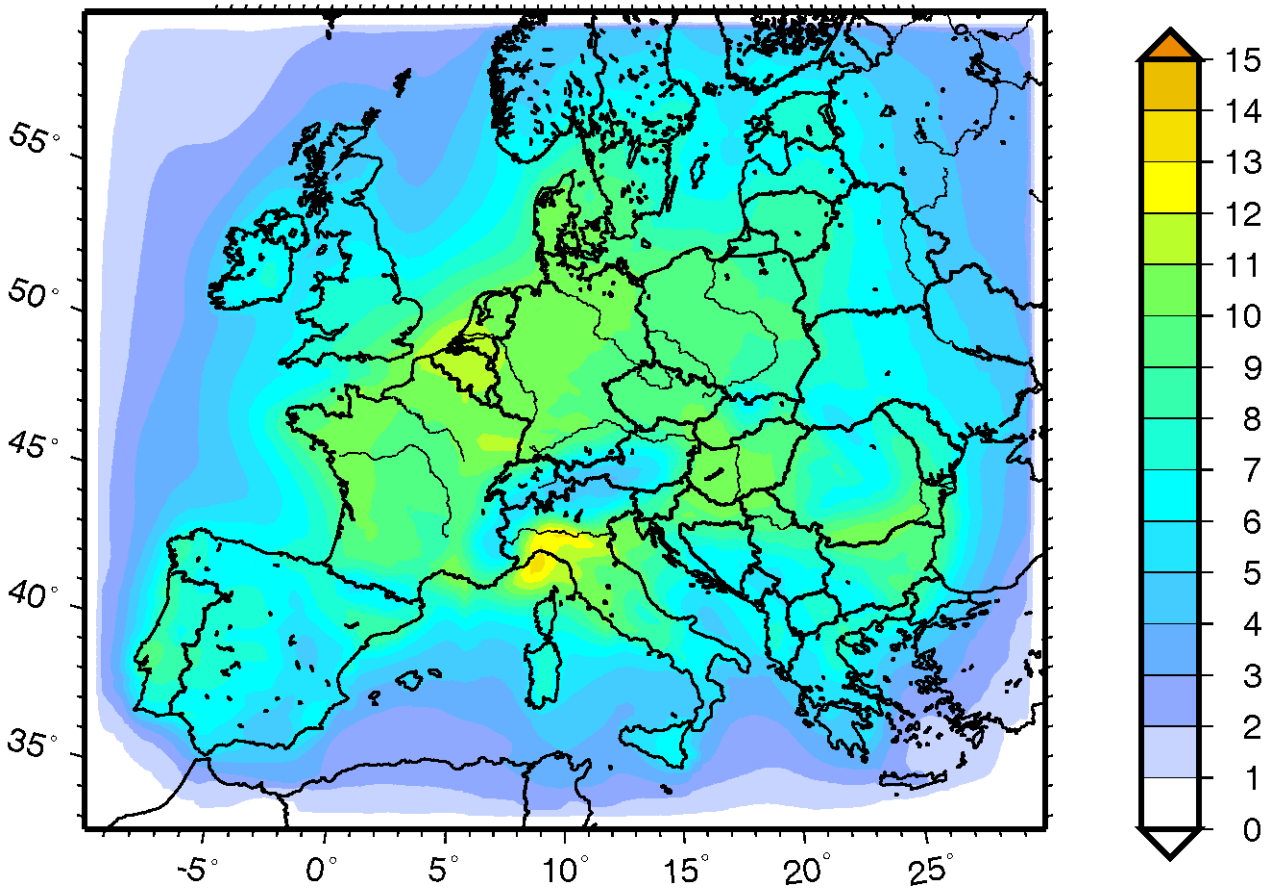
ALPNAP
Observations & Simulations primary PM10



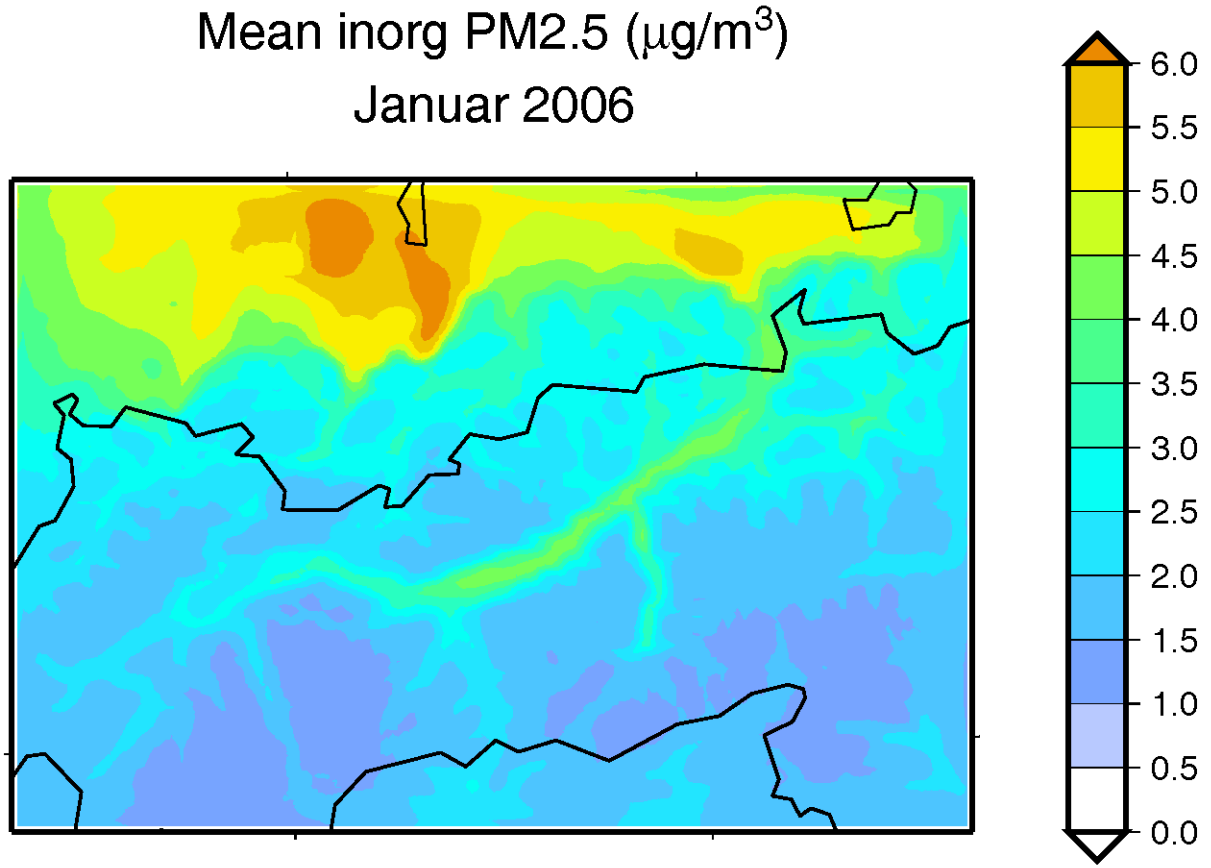
ALPNAP Obs & Sim primary PM10
+18 µg/m³ „background“



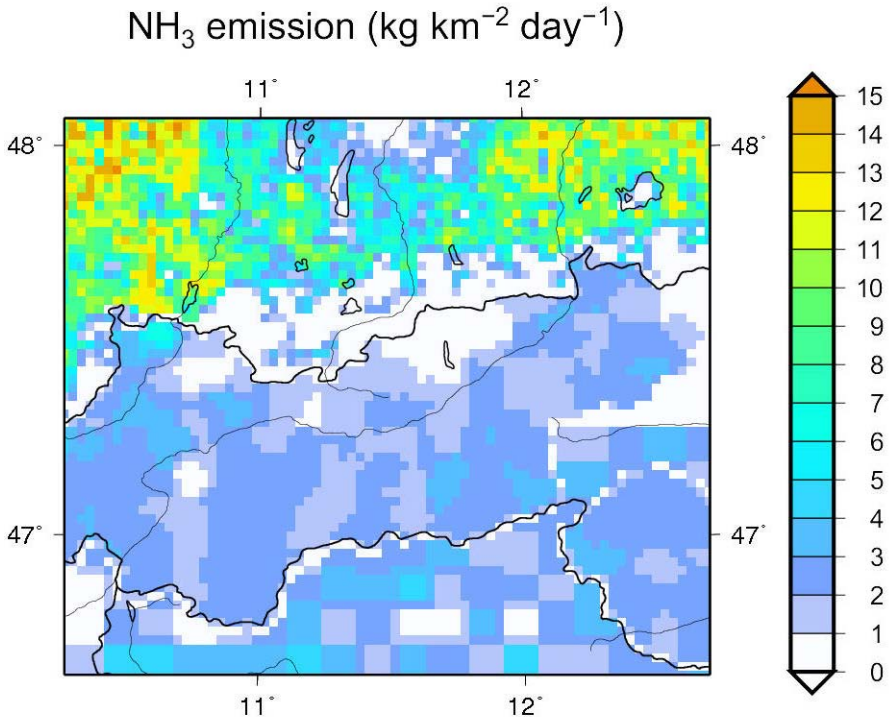
Mean inorganic secondary PM2.5 MM5-MCCM January 2006

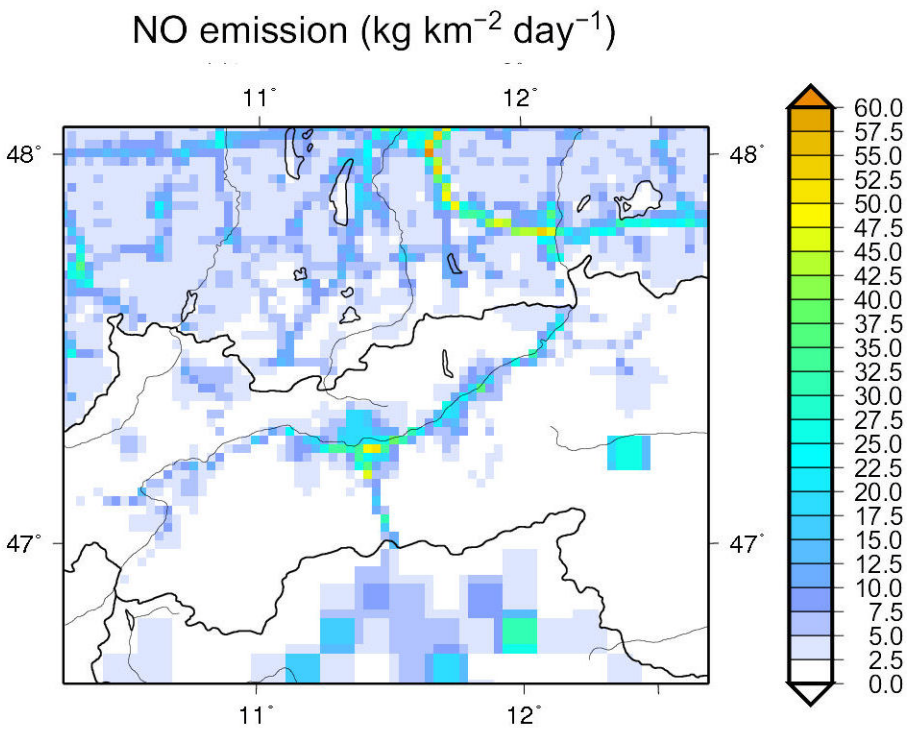


Mean inorganic secondary PM2.5 MM5-MCCM nested Inn-valley domain

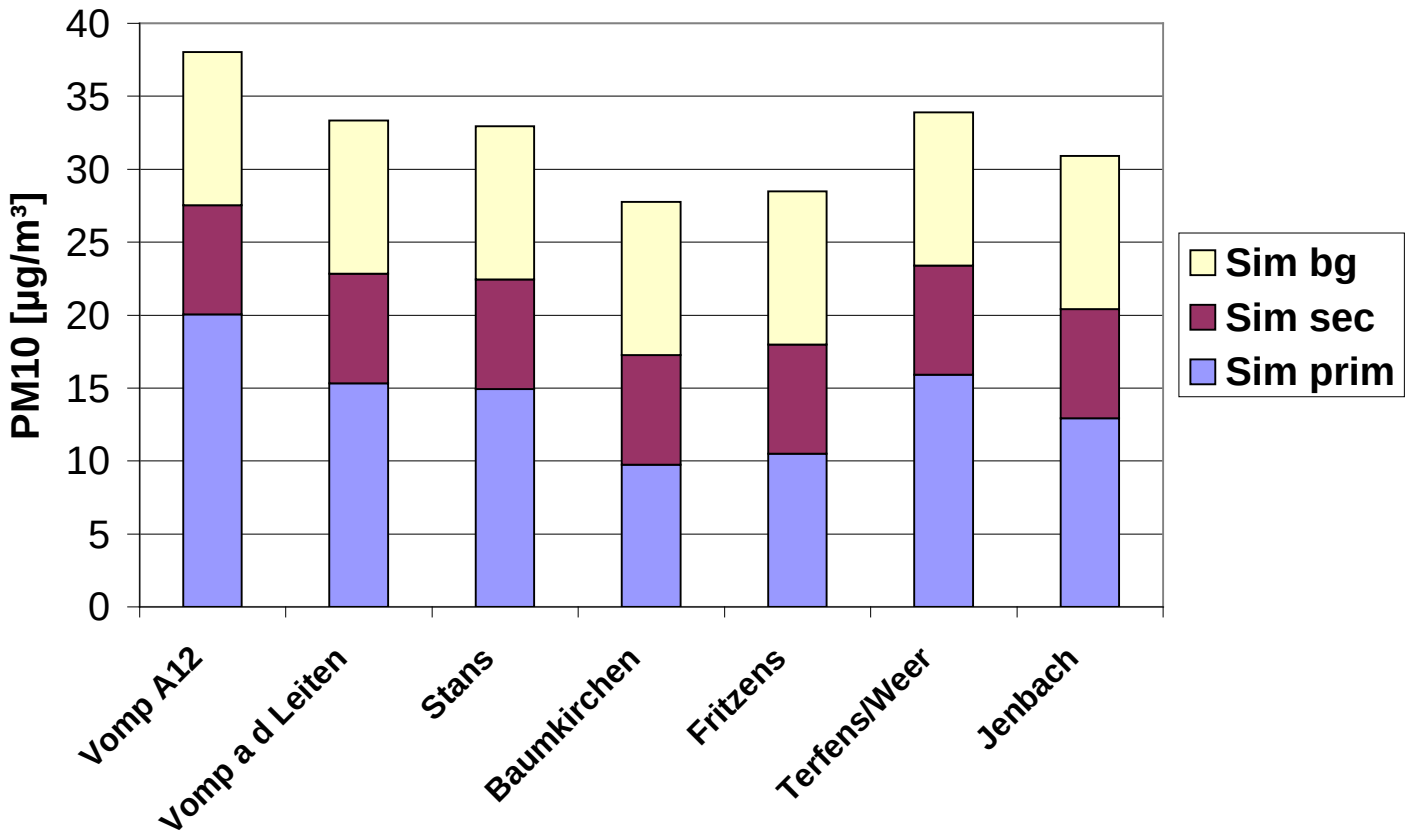


ALPNAP Precursor Emissions
EMEP data – aggregated to 2.4 ·2.4 km²





Assessment secondary formed particles of GRAL background based on MM5/MCCM



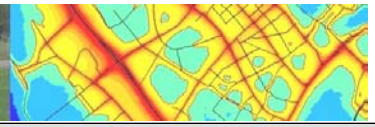
Assumption: MM5/MCCM ~ 5 µg/m³ (sec) PM2.5 ≈ 7.5 µg/m³ PM10

Synopsis Simulations
MM5/MCCM regional & GRAL micro scale

- 1 km x 1 km resolution & close to sources still poor
  → no details visible
- inorganic PM locally formed
- NH_3/SO_2 emissions & others most likely too low → inorganic PM too low

- 10 m x 10 m counting grid
  strong primary PM sources clearly visible
- "evenly" distributed $\Delta C_{obs-sim}$ missing – so called background accounts for:
  - "Inn-Valley-Innsbruck background"
  - Missing/underestimated sources
  - Secondary formed particles

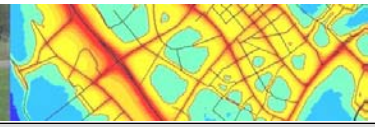




Conclusions

- Composition and growth of so-called PM “background” significantly influenced by local precursor emissions (NO_2, VOC, NH_3 …)
- Reduction measures
  - strong focus on primary emissions (urban scale)
  - re-evaluations by “integral approaches” may reveal that (known) measures are more effective than (previously) assessed - others less
- Precursor emission inventories of major importance!

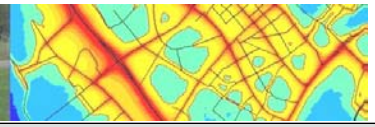




Outlook

- Coupled multi-scale models are required in the near future to evaluate air quality in a better way
  - Model development – “Integral Approach”: combination of both model systems and work on “bottom-up” emission inventories!
- Integral approaches must consider various sources (e.g. odour removal → $NH_3\downarrow$) but source appointment of secondary PM not straightforward!
- PM composition (obs / sim) & size important information about health relevance & efficiency of measures
- Health studies must provide specific evidence on PM composition & size





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